# Talos on-line help manual   --   User interface

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# 1   User Interface

The user interface consists of a number of separate elements. We can divide these into different categories:

- The **Main program**. This consists of the program title, menu bar and toolbar. It basically is a shell that allows the user to define the where, what and how of the other user interface elements. The user interface provides a number of fixed layouts (view modes) with rapid switching between them.
- The **Control panels**. These are sets of controls that belong together and that are displayed in a fixed window. Control panels are grouped in worksets which can be selected via a tab at the top of the area with the Control panels.
- The **Information panels**. These consist of a set of windows displayed near the bottom of the screen. They contain binding, microscope status information and messages or questions from the microscope to the operator.
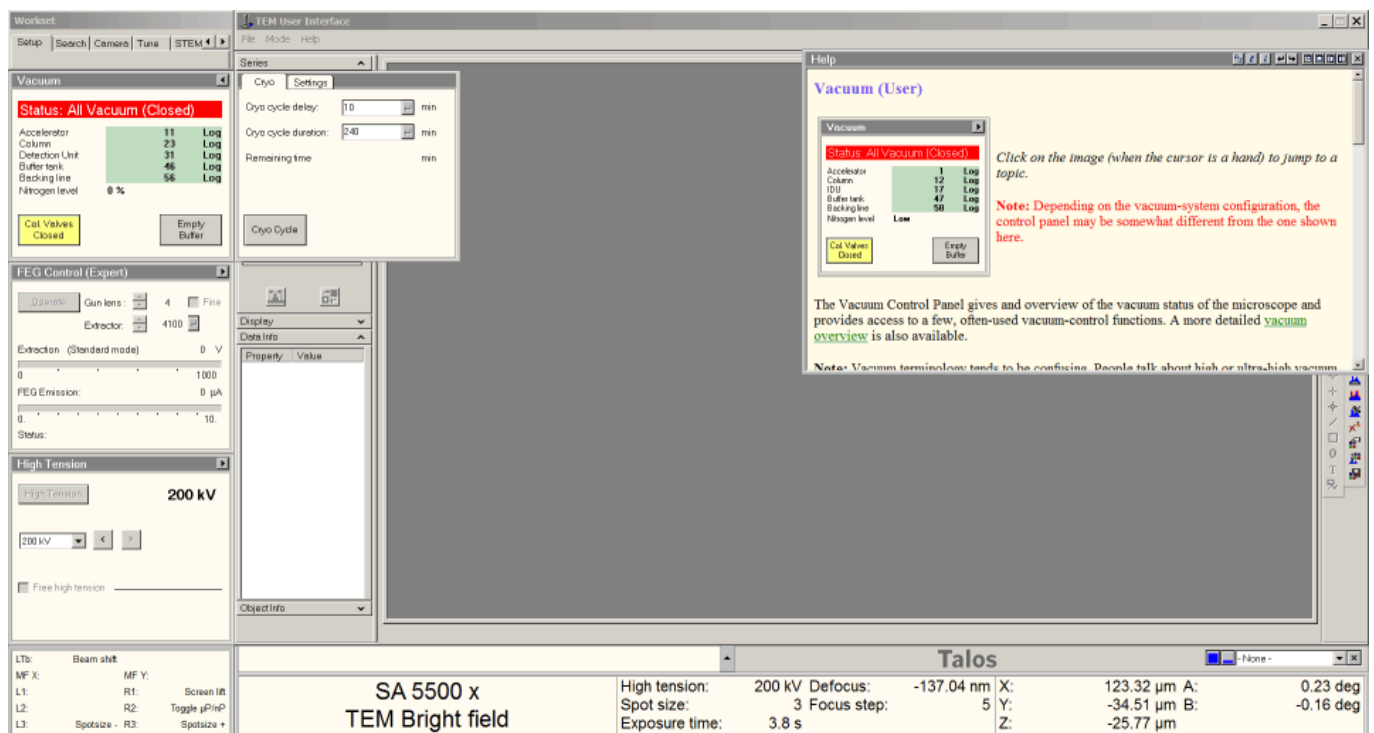


The empty area to the right is reserved for data like images, spectra, etc. Currently it shows the flap-out of the topmost Control panel as well as the minimum-size help window.

**Menu**
There is one special menu item, Mode. This will switch between "Normal" and "Grayscale". Normal will use the normal coloring scheme, with yellow buttons being yellow, etc. When the Mode is switched to Grayscale, colored buttons are shown with a different coloring scheme that is used for Rapid or TARO remote connections with grayscale colors. This special scheme is used there because normally yellow, white or orange are virtually indistinguishable from gray when seen in gray scale mode.

## 1.1 View modes

The microscope user interfaces supports two different viewing modes:
- Standard open-frame view (data area left open).
- Taskbar only (user interface hidden except for a small band at the bottom).

A rapid way of switching between Full size open frame en Task bar only is provided by a button next to the list of popup panels.

The button with the square blue block (far left) brings up the Application Selection Control Panel, while button with the L shape switches to Full size open frame mode.

The button with the square blue block (far left) brings up the Application Selection Control Panel, while button with the _ shape switches to Task bar only mode.

## 1.2 Workset tabs

At the top left of the user interface is a small window containing a (user-defined) number of tabs. Each of these tabs controls access to a number of Control panels (typically a set of three). Click on any of the of tabs to access it workset. Workset configuration (contents, name, order, color selection) can be default or as defined by the user.
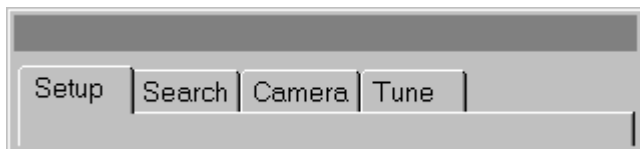
Worksets are intended to be arranged in sets that reflect a certain stage of operation of the microscope (but of course you are free to arrange them in any manner that you find suitable for the work you do). Thus the Setup workset could contain those controls needed when starting a microscope session (vacuum, high tension and FEG control). The Search workset provides controls that are useful when searching around the specimen for areas suitable for further investigation (the Stage control panel, for example, allows storing and recall of specimen-stage positions).

Control-panel access is also possible through the popup-panel selection (see section 1.4). Most control panels can only be selected for popup when they are already somewhere located in a tab.

**Modifying the worksets**
The worksets are defined using the Workspace Control Panel (because of its size accessible only in the popup selection).

## 1.3 Control panels

Control panels are small windows, typically arranged in sets of three above one another on the left-hand side of the screen (some Control panels are double-height and can therefore only be combined with one additional panel). Each Control panel contains a coherent set of microscope controls (like vacuum system, electron gun or stigmators). A combination control panels forms a workset, defined by name and accessible through a tab in the workset selection window above the Control panels themselves.
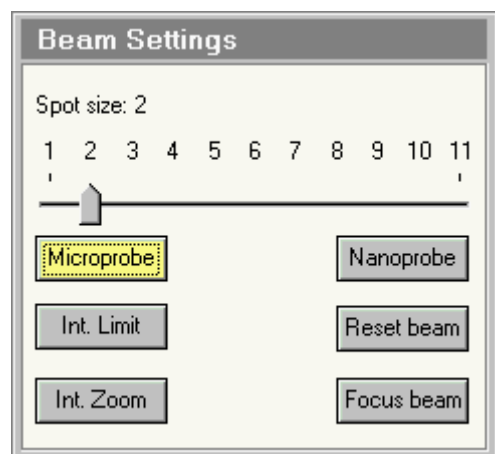
*The Beam settings Control panel.*

The rationale behind the Control panels is to give rapid access to elementary (often-used) microscope functionality. Selection of microscope settings (used much less often) is not accessible through the Control panels themselves but is accessible in flap-outs.

**Panel flap-out**
Some Control panels (like the Beam Settings Control panel) are simple and have no 'hidden' settings. Other panels are equipped with so-called flap-outs: additional panels that appear to the right of the main panel. Panels with flap-outs are recognizable by the flap-out arrow button at their top right.
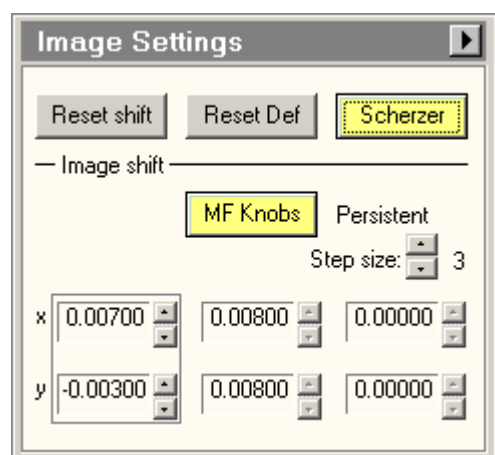


*The Image Settings Control panel with the flap-out button (arrow pointing to the right at top right).*

When the flap-out button is pressed, the flap-out panel appears. This panel has one or more panels itself, combined through the use of tabs. Click on a tab to access that particular panel. If the total series of tabs doesn't fit in the panel, left-right arrow buttons at top right allow shifting of the whole series of tabs to left or right.
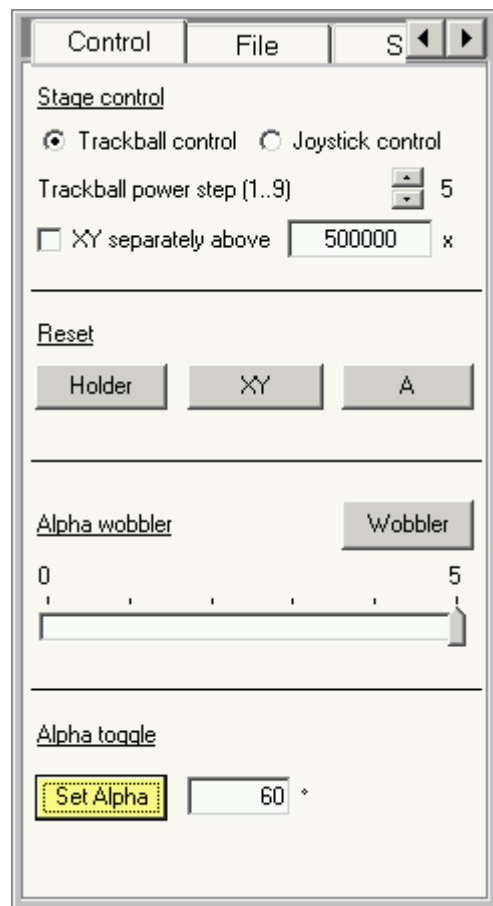
*The Control tab of the Stage Control panel flap-out.*

Flap-outs remain visible until they are closed again (with the flap-out button which has reversed its pointing direction). They disappear from view when another workset is chosen but will reappear when the workset with the 'flapped-out' Control panel is chosen again.

**On-line Help**
Each Control panel has its own on-line help, accessible by clicking somewhere inside the Control panel, and then pressing F1. The Alignments Control panel and Direct Alignments Control Panel additionally have on-line help pages for each of the alignment subprocedures or direct alignments.

## 1.4 Popup panels

At the bottom right-hand side of the screen (right next to the microscope name) is a drop-down list box with a small 'x' button next to it (in other views than the standard frame it may be located elsewhere on the screen).

The drop-down list gives access to Control panels that will be displayed in the corner just above the list box itself. The selection of these 'popup' panels includes a number of Control panels that cannot be assigned to worksets (because of their size). The selection also includes those Control panels that are not currently visible on the screen. This means, for example, that you can have the microscope display the CCD camera control panel to have rapid access to the CCD camera settings, without changing from the current workset tab. As soon as the workset tab is changed to one containing the panel visible as a popup, the popup panel will disappear.

The popup is hidden again when:
- the small 'x' button is pressed.
- - None - is selected in the popup.
- the currently visible Control panel is already present in the workset tab being selected.

**Special popup panels**
Three popup Control panels are worth mentioning here since they can only be accessed in the popup because they are too large to fit inside the space normally reserved in the worksets for Control panels: the Vacuum overview, the Workspace lay-out and the System Status. The on-line help for these panels is once again accessible by clicking in them and pressing F1.

The Vacuum Overview Control Panel displays a graphical overview of the current status of the vacuum system.
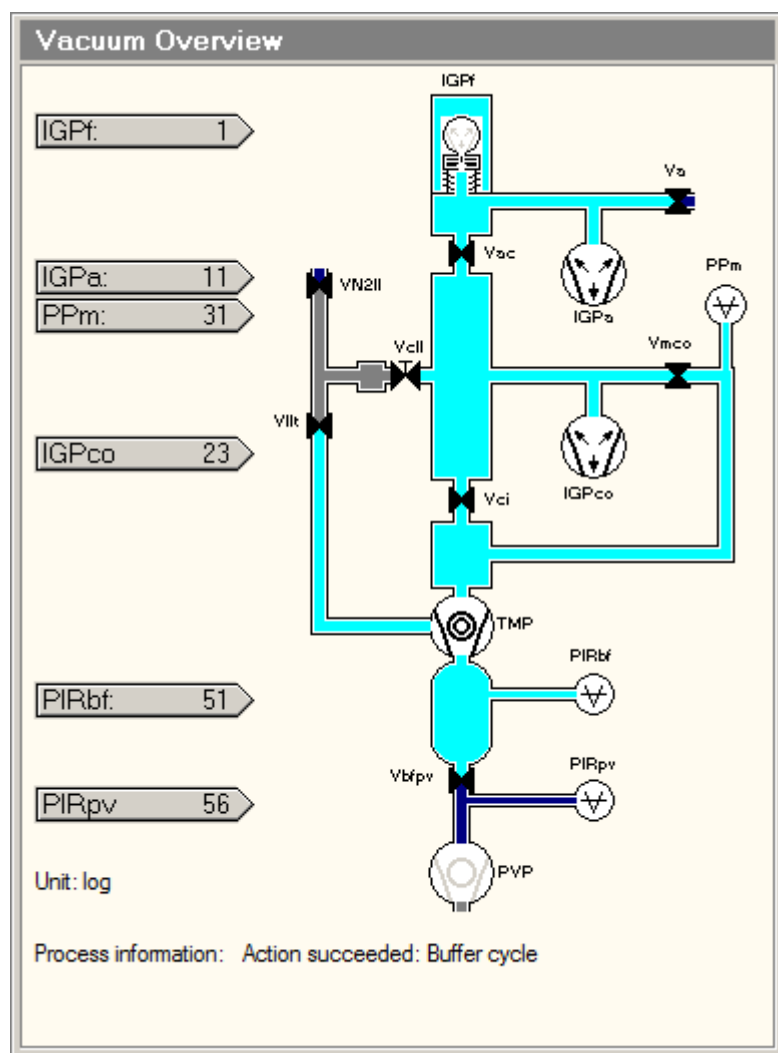


*The Vacuum Overview Control Panel.*

The Workspace Lay-out Control Panel provides the tools for customizing the worksets: Control-panel selection, color selection, etc.
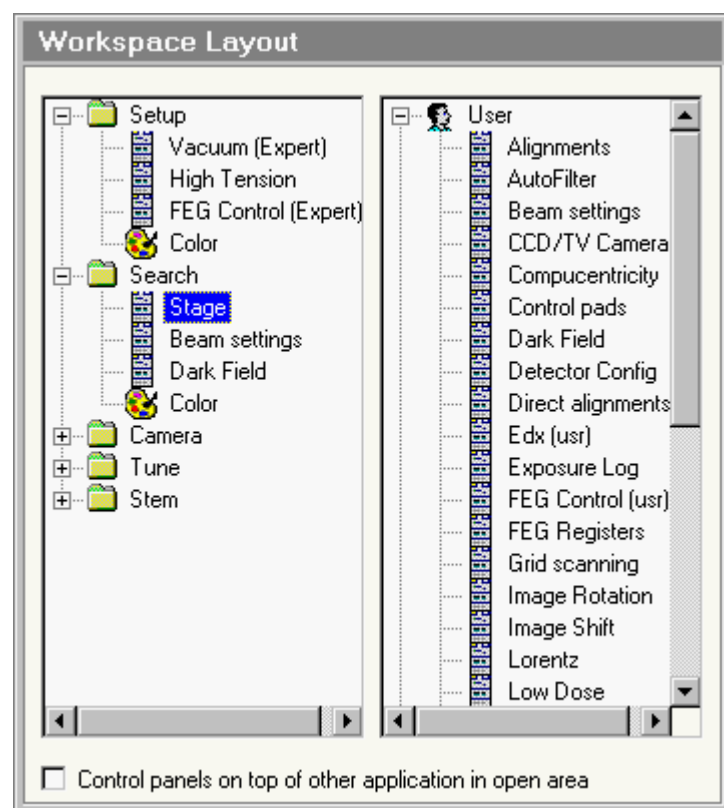


*The Workspace Layout Control Panel.*

The System Status Control Panel provides an overview of the (software) settings of all lenses and deflection coils.

## System Status

Measure currents        ○ Continuously        ○ One loop

### Lens

| | |
|---|---|
| Spot size | 23.85 % |
| Intensity | 97.73 % |
| Minicondenser | 83.92 % |
| Objective | 87.49 % |
| Lorentz | 0.00 % |
| Diffraction | 54.15 % |
| Intermediate | 14.89 % |
| Projector 1 | 3.58 % |
| Projector 2 | 85.23 % |

### Gun deflector

| | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| Gun tilt | -0.3005 | -0.3005 | | | U-X | 0.1643 |
| Gun shift | 0.0300 | -0.1000 | | | U-Y | 0.4149 |
| Spot-dep. shift | 0.1062 | -0.0144 | | | L-X | 0.3947 |
| Gun tilt pp | 5.8600 | 5.8300 | | | L-Y | 0.1351 |
| Gun shift pp | 4.0000 | 4.0000 | 0.0000 | 0.0000 | | |

### Beam deflector

| | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| DF tilt | 0.0000 | 0.0000 | | | U-X | -0.1246 |
| User shift | 0.1600 | 0.0030 | | | U-Y | 0.0634 |
| Rot Center | 0.0300 | -0.0200 | | | L-X | 0.0240 |
| Align shift | -0.0600 | -0.0500 | | | L-Y | -0.0172 |
| Beam tilt pp | 3.8207 | 3.8203 | | | | |
| Beam shift pp | 5.0602 | 5.0599 | 0.0002 | 0.0003 | | |

### Image deflector

| | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| User diff. shift | 0.0000 | 0.0000 | | | U-X | -0.0097 |
| User image shift | 0.0000 | 0.0000 | | | U-Y | -0.0091 |
| Align diff. shift | 0.0100 | 0.0140 | | | L-X | 0.0103 |
| Align image shift | 0.0003 | -0.0007 | | | L-Y | 0.0133 |
| Diff. shift pp | 3.8408 | 3.8417 | | | | |
| Image shift pp | 4.7388 | 4.7412 | 0.0003 | -0.0002 | | |
| Magn. corr. | 0.0010 | -0.0020 | | | | |
| Det. alignment | 0.0000 | 0.0000 | | | | |
| X-over corr. | 0.0000 | 0.0000 | | | | |

*The System Status Control Panel.*

## 1.5   Display

The microscope user interface provides a series of panels containing microscope status information. These cover the binding display, message area and microscope status display.

### 1.5.1   Binding display

The binding display panel shows how the user-assignable knobs and buttons on the left-hand and right-hand Control Pads are linked to microscope functions. These knobs and buttons are:

Left-hand trackball (typically assigned to beam shift)
Multifunction X
Multifunction Y
User button L1
User button L2
User button L3
User button R1
User button R2
User button R3

| LTb: | Beam shift | | |
|------|------------|------|------------|
| MF X: | Beam shift X | MF Y: | Beam shift Y |
| L1: | | R1: | Screen lift |
| L2: | | R2: | Toggle uP/nP |
| L3: | Spotsize - | R3: | Spotsize + |

The selection of the assignments displayed is up to the user. A typical selection could be displaying two columns:

Depending on the number of items present, the display will contain one (with subcolumns for knobs/buttons; their functions) or two columns (2x knobs/buttons; their functions). Empty lines can be used to give a balanced display selection.

✔ All worksets

&lt;Empty line&gt;
User key L1
User key L2
User key L3
Left Trackball
Multi function X
Multi function Y
User key R1
User key R2
User key R3
Right Trackball
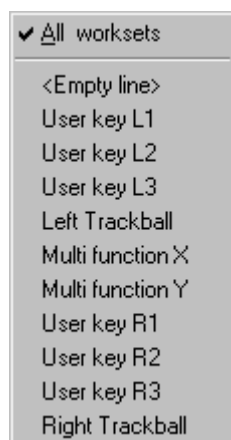
**Adding items**
Click with the right-hand mouse button on a part of the binding display panel that holds the names of knobs and buttons (the far left or the left-hand side of the second column). A popup menu will appear.

Click on the item required and it will be added to the current selection. The All worksets item can either be checked (in which case the selection displayed is the same for all worksets) or not (in which case each workset can have its own selection). Note that the actual knob or button functionality selected is not dependent on the workset (only what is displayed).

**Removing items**
Click on the desired item and drag it out of the binding display panel.

| ✔ Auto bind MF y | None |
|---|---|
| None | Clear |
| Clear | |
| | Intensity zoom on/off |
| Beam shift X | Intensity limit on/off |
| Beam shift Y | TEM/STEM |
| Image shift X | Spotsize - |
| Image shift Y | Spotsize + |
| Diffr shift X | Screen lift |
| Diffr shift Y | Microprobe/Nanoprobe |
| Stage control X | Normalize condenser |
| Stage control Y | Normalize intensity |
| | Normalize objective |
| | Normalize illumination |
| | Normalize projector |
| | Normalize all lenses |
| | Normalize all |
| | Alpha Wobbler |
| | Reset Defocus |
| | Dim screen |
| | Screen Off |
| | Ccd Insert/Retract |
| | Beam Blank |
| | Piezo Reset X |
| | Piezo Reset Y |
| | Piezo Reset Z |
| | Piezo Jog Stop |
| | Joystick Stage/Piezo |
| | MF Piezo Move/Jog |
| | Beam stop |

**Changing a function assignment**
Click with the right-hand mouse button on a part of the binding display panel that holds the function description for the knob or button required (the right-hand side of the first column or the far right). A popup menu will appear, whose content will depend on the type of knob/button selected (trackball, multifunction knob, user button). In the case of the Multifunction knobs, near the top of the popup menu is an item Auto bind MF y (when the MF-X selection is clicked) that, when checked makes the Multifunction knobs follow each other (that is, when the Multifunction knob X is given to the x parameter of a function, then Multifunction Y will automatically assume the y parameter of that function).

**Note:** The Stage control is available only if the right-hand control pad is not equipped with a joystick.

**Multifunction knob assignments**
The Multifunction knobs have a wide range of functions. All functions (wobbler, stigmators, dark field, alignment, etc.) that assign functionality to the multifunction knobs also release that functionality when the particular function is switched off again (after which the multifunction knobs regain their previous functionality). The functions are typically assigned whenever needed (e.g. during alignment). The user can also assign functions to the knobs (these functions will be overruled when necessary). There are two possibilities:
- The assignment is **persistent** (these functions will be overruled when necessary but the function is always returned when automatic assignments are taken off).
- The assignment is **temporary** (these functions will also be overruled when necessary and the function is not returned when automatic assignments are taken off).

A persistent assignment can only be made when the Multifunction knobs are not currently occupied by an automatic assignment, otherwise the assignment is temporary.

Examples
- The Multifunction knobs are currently assigned to the Stage axes (a user assignment). The user clicks with the right-hand mouse on the Binding display panel and chooses another function. This assignment is persistent.
- The Multifunction knobs are currently assigned to the Wobbler (after the Wobbler button has been pressed). The user clicks with the right-hand mouse button on the Binding display panel and chooses another function. This assignment is temporary (comes on top of the automatic Wobbler assignment) and will disappear when the Wobbler is switched off.

**The None and Clear functions**
The popup menu that allows setting of the binding configuration can have two functions, None and Clear. None is always enabled, Clear only when the current assignment is temporary. If None is selected, all functions are removed, independent of the nature of the current assignment (persistent, temporary or automatic). If Clear is selected (thus only possible if the assignment is temporary), the knob or button reverts to its prior automatic setting. Thus if you assigned the Beam shift function to the Multifunction knobs in an alignment procedure and then select None, the Multifunction knobs are completely cleared of all functions. Whereas if you used clear, the Multifunction knobs get back their setting from the alignment procedure.

**Changing the relative position of items**
Click on an item with the left-hand mouse button and drag it to a new position.

### 1.5.2  Messages
Messages by the microscope are shown in a dedicated part of the information area (above the status panel that typically contains the magnification and operating mode). Messages can have three different levels. Since only one message can be displayed at a time, important (higher level) messages will displace simple information messages.



The different levels are indicated by different icons:

      Error

      Warning

      Information
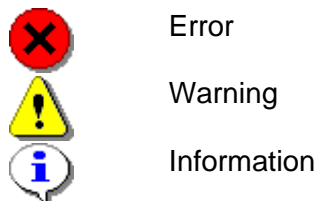
If the message requires confirmation, it will stay displayed until the Enter button is pressed. Some other messages automatically disappear after a minute. All messages are kept in a list which becomes visible when the Up button on the right-hand side of the message area is pressed:
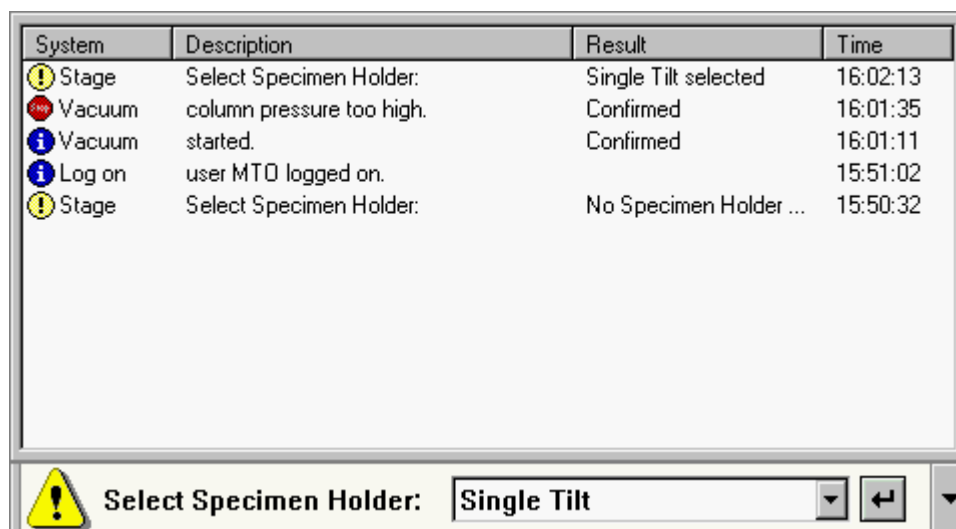


To close the list click the Up button (now changed to a down arrow) again.

### 1.5.3    Status displays

Up to three status display panels (in the minimum-size info area view this number is reduced to one). These status display panels can display a wide range of user-selectable microscope settings.

| SA 97000 x | HT: | 190 kV | Defoc: | -13.00 um |
|---|---|---|---|---|
| TEM Bright field | Spot size: | 3 | Focus step: | 5 |

The left-most typically will display the microscope magnification and mode. This panel is also the one displayed in the minimum-size info area view. The two others are up to the user (by default they will contain the settings shown at the right of the picture above, while the third panel will display the specimen-stage position). All settings can be changed by the user.

**Note:** The magnification/camera length displayed depends on the position of the viewing screen. If the viewing screen is raised, the magnification/camera length values are those of the plate camera. If the viewing screen is down, the values are those as seen on the viewing screen.

**Removing settings from status panels**
Click on a setting in the status panel and drag it outside the panel.

✔ All worksets

<Empty line>
High tension
Spot size
Focus step
Magnification
Magnification mode
Stage                          ▶
Dark field
Intensity limit
Intensity zoom
Emission value
Emission step
Defocus
Exposure time
Measured Exposure time
Lens                           ▶
Deflector                      ▶
Stigmator                      ▶
Vacuum                         ▶

**Adding settings to status panels**
Click with the right-hand mouse button on the status panel in the position where a new settings must be added. A popup menu will appear:

At the top of the menu (All worksets) the user selects (by checking or unchecking the item) whether the configuration as currently displayed is valid for all worksets (checked) or whether each workset can have its own settings. The other selections in the popup menu enter the required value into the status panel (in some cases one has to select via a submenu - move to the right where the small, right-pointing arrows are displayed). Empty lines can be added to give a balanced display. The font size will be adjusted automatically to the amount of space available.

### 1.6    Help window

The Help window, used for displaying the on-line help, is displayed in the area reserved for data (the empty area in the user interface). When F1 is pressed in the TEM User Interface the help window becomes visible near the top left of the screen. Four views of different sizes are selectable through small buttons at the top of the Help window.

The window sizes (as well as some other functions) are controlled with the buttons that are present in the window title bar.
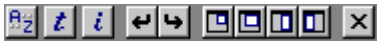
From left to right these buttons are:
- Load alphabetical index (a..z)
- Load topics index (t)
- Load main page (i)
- Back
- Forward
- Small help window
- Full help window
- Long help window on the left
- Long help window on the right
- Close help window

Back and forward work like in a normal Internet browser.

**Note:** The content of the Help window depends on the position of the cursor (if the cursor is over a main control panel, the help page of the main panel is shown; if it is over a flap-out panel, the you get the help of that panel - even if the original click with the left-hand mouse button was in the main panel). For proper operation of the help system, do not move the cursor out of the area for which help is requested until F1 has been pressed.

**How does on-line help work?**
The on-line help system consists of a series of html (Hypertext Mark-up Language: Internet browser) files. The contents of these files are displayed in the on-line help window of the TEM User Interface. (But they can equally well be 'browsed' off-line using an Internet browser. The entry point is a file called Index.htm.)
In order to minimize the number of pages involved, many topics are arranged together with related topics on a single page. To allow rapid selection of relevant topics on such pages, they have been equipped with bookmarks (hyperlinks to the topics further down the page). The hyperlinks are clearly recognizable as such in the case of text (the unused hyperlinks are green, the used ones take the default color of the browser). It may also happen that hyperlinks are present on images, for example of control panels. Move the cursor over the image and hyperlinks will show up by the changing of the cursor to a hand.

For each topic lower on the page there is an up button: ▲ When the Up button is pressed, the page jumps back to the top. Technically speaking the Up button is again a hyperlink to a bookmark, but it doesn't show a hyperlink border.

The Help window can have three different formats, small, long and full. The 'small' help window covers a 1/4 area at top right. The 'long' window covers the vertical 1/2 area either on the left or on the right. The 'full' window covers the data window.

# 2   System settings and logging off

When you log off from the microscope (close the TEM User Interface) you will be asked if you wish to save system settings or not. What are these 'system settings'? They are not the changes you have made to the TEM User Interface layout like the selection of control panels and their arrangement over the tabs and the color selections made in Workspace Layout. Those changes are saved immediately as you make them.

What is saved under system settings is the following:

**Column**
* Operational settings (modes, spotsize, intensity,...)
* Normalization settings

**Note:** In order to get the microscope at log on always to an easily usable state, the microscope will always switch out of Dark field, STEM, EFTEM and Lorentz microscopy when logging on, even if that was the state the microscope was in while logging off.

**Detectors**
* Detector selection
* Contrast, brightness and filter settings per detector
* STEM acquisition settings
* EDX acquisition settings
* PEELS acquisition settings
* CCD acquisition settings

**Knobs**
* User settings on L1..L3, R1..R3
* User settings on the Multifunction knobs
* User settings on the trackballs

**Vacuum**
* Vacuum display units
* Airlock time
* For supervisor the visibility of the Camera Air button

# 3   Windows controls

The user interface of the TEM contain a number of Windows control elements like buttons, etc. For those unfamiliar with the terminology, these controls are listed below.
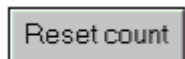
**Button**

Press it to have the program to something. If the function cannot be done under the current conditions, the button is greyed.
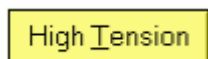
**Three-state button**

In addition to the normal and greyed states, this button has a yellow state which indicates that the function is on.
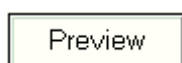
**Four-state button**

In addition to the normal and greyed states, this button has a white state which indicates that the selection is on and a yellow state which indicates that the selection is on and the function is active.

**Label**

Simple text in a window. Display only.
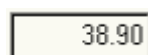
**Edit**

Allows insertion of text or numbers. Only used if there is some other way of having the program act on the change.

**Check box**

Selects (a cross is displayed in the square) or deselects a particular option. It also works when you click on the caption of the check box (so not only when you click inside the box itself).
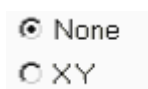
**Radio buttons**

Makes a selection from a series of mutually exclusive options. Clicking an unchecked option, checks that options and unchecks all others. Also works when you click on the caption of a radio button (so not only when you click on the circle itself).

**Drop-down list**

A list of items from which a selection can be made. In order to save space, the whole list only becomes visible when the arrow on the right is clicked. If text or a value can be entered at the top line, it is called a drop-down combo box.

**Spin buttons**

Change a number up or down by clicking on the up or down buttons. The numbers will spin faster if you keep one of the buttons pressed instead of giving single clicks.

**Enter button**

Confirm changes by pressing the enter button (pressing the button on the keyboard does the same).
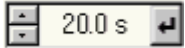
**Spin-enter-edit**

An edit control with spin buttons to change the value and an enter button to confirm the change (after which the program will act on it). The enter button indicates the status of the value. When the enter button is enabled, the value has been changed but not yet updated in the microscope (the update is done by pressing the enter button). When the enter button is disabled, the value indicated is the same as that on the microscope. When you use the spin buttons the value is directly transmitted to the server and the enter button will remain disabled. When you change the value by typing, the enter button will become enabled and you have to force the update by pressing the enter button.

**Spin-label**

A control with an indicated value and spin buttons. Here the value can only be changed with the spin buttons.

**Track bar**

Drag the grey handle to another setting to change a value. You can also click to the left or right of the handle to make it jump one step.

**Progress bar**

Displays progress of a process or the current status as a fraction of the total range.
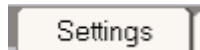
**Tab**

Allows selection of one of a series of displays.

**Bitmap button**

A button with a picture on it. These are used for the flap-out buttons, but also in toolbars, etc. They usually work the same as normal buttons, except that some toolbars buttons are flat (only show their outline when the cursor hovers above them) and can show an 'on' state by remaining 'pressed down'.

```
⊞ column
⊞ column Image P
⊞ column LM
⊞ column LM BT P
⊞ column Mh
⊞ column NanoPro
⊞ column Stigmatc
⊞ gun
   stem
```
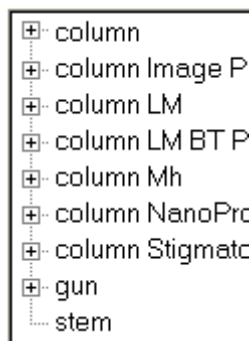
**Treeview**

Display a list of items, some of which (marked by a '+' sign) can be expanded to show their sub-items, and so on. Expansion happens when you click on the '+' (it will contract again when you click on the '-' sign that will take the place of the '+'). Alternatively you can expand by double-clicking on the caption (not double on the '+', that expand and contracts again). Select an item by clicking on the caption.

```
Copy        Ctrl+C
Paste       Ctrl+V
Reset       Ctrl+Z
Copy 2 to 1
Copy 2 to 3
```
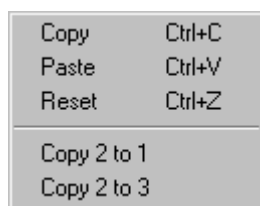
**Popup menu**

A single-column menu that becomes visible when the right-hand mouse button is clicked.
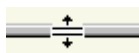
**Splitter**

A bar separating two areas in a window that allows changing the size of the two areas. The cursor show two lines drawn apart by two arrows.

# 4   Control panels

**Note:** The following Control Panels may not all available to all users on your microscope because:
- Some panels differ according to user level (User, Expert, Supervisor)
- The required hardware (STEM, Energy Filter) may not be present on the microscope.

The order in which the control panels are covered is alphabetically.

# 5   Alignment procedures

The alignment procedures of the TEM are accessible through the Alignment control panel. The procedures, split into logical units such as Gun, Beam HM-TEM, Image HM-TEM, etc., are displayed in a treeview. Each procedure contains subprocedures that are accessible by clicking on the '+' in front of the procedure name (or double-clicking on the procedure name).

Alignments can be stored to file and wholly or in part restored to the microscope. Each alignment part corresponds to an alignment procedure (such as Gun, HM-Beam, HM-Image, etc.). Alignments for all users are located together and listed in the list of available alignments. The controls for saving and restoring alignments are found in the Alignment File Control Panel.

For more background information on how the microscope works with alignments, see Alignments in the TEM (section 5.3).

A few rules:
- You do not change any alignments by walking through a procedure. Only when you change a setting in a step (usually with the Multifunction knobs, but in some cases also the Focus or Intensity) do you change alignments. Changes become operational immediately. They are stored when the alignment procedure is exited (Done).
- Start a procedure by clicking on the title of the first subprocedure (or the individual subprocedure required if not the whole procedure is needed). Stop a procedure by pressing Done, or Previous while in the first subprocedure step, or Next on the last subprocedure step. Going to another tab (where the Alignment Control Panel is no longer visible) also exits the alignment procedures.
- Navigation through a procedure is normally done with Next or Previous (the buttons on the control panel or R1 and L1 on the Control Pads). Using these buttons proceeds through the 'short' procedure, automatically skipping less-often used alignments (like pivot points). The skipped subprocedures can be accessed only by clicking on the title of the particular subprocedure. Navigation then may proceed to other, less-often used subprocedures. Subprocedures that are skipped are indicated by a different icon (blue arrow, on yellow, pointing down) and which are not (blue arrow, on white, pointing to the right).
- Each subprocedure can contain several steps (which are listed as '1 of 4' or '2 of 3'). You cannot go directly to a 'hidden' step because the first step sets the microscope in an appropriate condition for the alignment. In some cases first steps are skipped when using Next (because the previous subprocedure already put the microscope in the proper operating conditions so it doesn't need to be done again).
- Each (main) procedure is stand-alone in the sense that you cannot move automatically from one procedure to another by using Next or Previous, only with the mouse.
- Alignment procedures may differ depending on the level of user, with experts and supervisor levels having more alignments accessible than users.
- All subprocedures have on-line help pages that describe the purpose and operation of the particular alignment. Press F1 while a subprocedure is active and the proper page should come up. If another page comes up instead, the Alignment control panel was not the last window used. Click on the panel and press F1 again. When the Auto help check box is checked, the help pages are displayed and updated automatically.
- You can move to another control panel as long as you stay within the current tab (you can also pop-up panels on the lower right), but if you move to another tab, then the alignment is exited.
- In many the alignments steps the microscope is switched to specific magnifications, intensity settings, spot sizes, etc. There is however no protection against changes (sometimes a procedure step warns against staying within the current magnification range).

**Note:** The rotation center alignment is part of the 'Beam' procedures, not the 'Image' procedures (it is based on tilting the beam to the optical axis).

**Tip:** In some cases it may be useful to be able to see the settings of the most important lenses (C2, Obj, Diff). If the Alignments control panel is inserted in the user interface under a workset tab, define the status panel display (typically the one on the right) to have these settings listed.

*The Alignment Control Panel.*
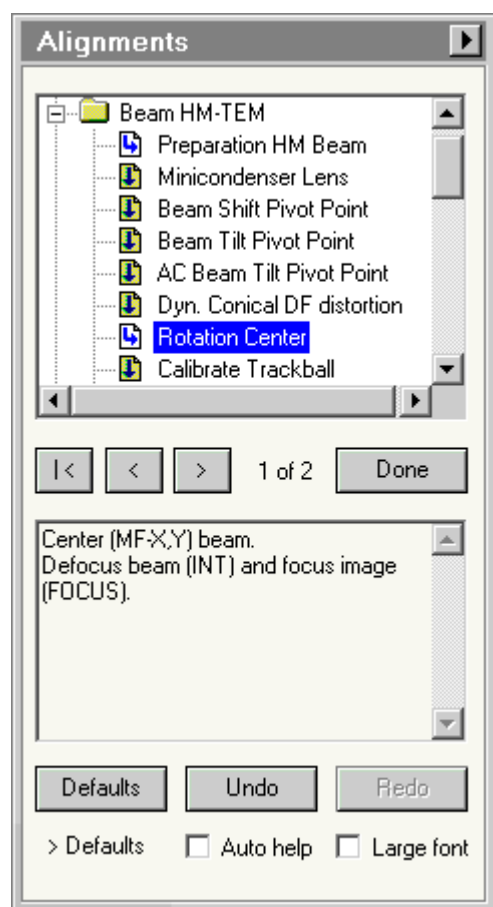
**Procedure selection**
Selection is done in the treeview that lists the procedures. Click on the '+' in front of the procedure name (or double-clicking on the procedure name). The treeview branch of the procedure will open and display the subprocedures. Click on the first subprocedure visible or any other subprocedure if only part of the alignment needs to be (re)done.

Subprocedures that follow the standard sequence (that is, they are not skipped) are designated by the icon with the blue arrow (on white) pointing to the right (into the subprocedure), whereas skipped subprocedures are designated by a blue arrow (on yellow) pointing down.

**|<**
Pressing the '|<' button moves to the first step of the alignment procedure (back to the very beginning).

**<**
Pressing the '<' (Previous) button steps one step back in the alignment procedure. If the current step is a first step of a subprocedure, the step always goes to the first step of the previous subprocedure (you cannot step backwards through one subprocedure to another). This button is equivalent to the L1 user button on the right-hand Control Pad.

**>**
Pressing the '>' (Next) button steps to the next step of the alignment procedure.

**xx of yy**
Indicates the current page of the subprocedure (xx) and the total number of pages (yy).

**Done**
Switches alignment off.

**Procedure instructions**
This field displays the instructions for the current alignment step.

**Defaults**
Pressing the defaults button resets the current alignment setting to that of the next higher level (depending on availability supervisor, service, factory, defaults). The level reverted to is indicated below the button (> Defaults in the example shown).

**Undo**
Pressing the Undo button resets the currently selected alignment to the setting it had when the step was entered. It allows you to undo any changes you made in the current step.

**Note:** The Undo and Redo functions apply only to the optical settings connected to the MultiFunction knobs, not settings (temporarily) connected to other knobs like Focus or Intensity.

**Redo**
Pressing the Redo button resets the currently selected alignment to the setting it had before you pressed the Undo button. It allows you to undo the effect of a Undo.

**Auto help**
When the Auto help function is on, the on-help topic for the particular subprocedure is displayed automatically alongside (and also updated when a new subprocedure is started).

**Large font**
When the Large font option is checked, the instructions are displayed in a much larger (more easily readable) font (the downside is that the instruction will often not fit into the area available and the scrollbar on the right-hand side must be used to scroll the rest of the instructions into view).

**Flap-out button**
The flap-out button leads to the Alignment control panel flap-out containing the Deflectors and File control panels.

## 5.1 Alignment deflectors

*The Alignment Deflectors Control Panel.*

The Alignment Deflectors Control Panel displays the calibrated values of settings of various deflections used. These settings are adjusted when they are calibrated in the beam shift, beam tilt, image shift and diffraction shift calibration procedures.

**Note:** In order to have realistic and accurate values for beam shifts and tilts and for image and diffraction shifts (e.g. for measuring) it is important to calibrate these settings.

**Beam shift**
Beam shift values are listed in micrometers for X and Y.

**DF (beam) tilt**
Dark field (beam) tilt values are listed in various ways:
- Separate X and Y values (items #3 and #4 for the Beam Deflector).
- A total dark field tilt angle and a rotation angle (items #5 and #7).
- The d spacing corresponding to the total dark field tilt angle (item #6)

The d spacing is calculated from the dark field tilt angle and the high tension of the microscope. The high tension defines the electron wavelength, which allows conversion of an angle (in this case the dark field tilt) into a d spacing through Bragg's Law $2 \sin\theta = \lambda / d$.

**Image shift**
Image shift values are listed for the total shift (item #1 for the Image Deflector, having X and Y combined) and X and Y separately (items #2 and #3).

**Diffraction shift**
Diffraction shift values are listed in various ways:
- Separate X and Y values (Image Deflector items #3 and #4).
- The d spacing corresponding to the total dark field tilt angle (item #5).
- A diffraction shift rotation angle (item #6).

A shift of the diffraction pattern corresponds to a certain diffraction angle (for example, if you shift the pattern from the central, transmitted beam to a diffracted beam, you have shifted the pattern by the

Bragg angle of the diffracted beam). The d spacing corresponding to the diffraction angle is calculated from the diffraction shift angle and the high tension of the microscope. The high tension defines the electron wavelength, which allows conversion of an angle (in this case the diffraction shift) into a d spacing through Bragg's Law $2 \sin\theta = \lambda / d$.

## 5.2   Alignment file
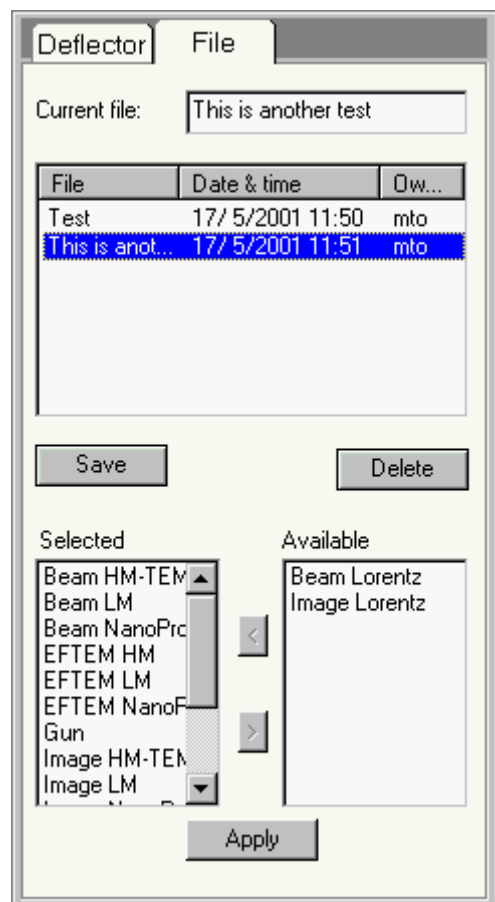


*The Alignment File Control Panel.*

The Alignment File Control Panel contains the controls for saving alignments to and loading them from file. Alignments can be stored to file and wholly or in part restored to the microscope. Each alignment part corresponds to an alignment procedure (such as Gun, HM-Beam, HM-Image, etc.). Alignments for all users are located together and listed in the list of available alignments.

There are a few simple rules concerning alignments:
- You can load any alignment present in the list.
- You can create any number of alignments yourself.
- You can delete your own alignments (and the supervisor can delete all alignment files).
- You cannot delete alignments from another user.
- You cannot overwrite alignments from another user (which would effectively be the same as deleting it and using the same name for your own alignment).

**Current file**
For creating a new alignment type a name in the edit control. The characters in the name must all be valid for filenames (so do not use characters like * / ? or \). If an alignment is selected in the file list, its name is automatically filled in under current file.

**File list**
The file list contains all available alignments. The alignments are listed with their name, their date and time of creation and the owner (creator of the alignment). Initially the list is sorted alphabetically on alignment name,  but the sorting order can be changed by clicking on the buttons above the columns (File, Date & time, Owner). Clicking the same button again reverses the sorting order.

The width of the columns of the list can be adjusted by clicking at the boundary between the buttons at the top of the columns (the cursor changes to a vertical bar with two arrows pointing sideways) and dragging it sideways.

Multiple entries can be selected (for deletion only, you can of course not reload multiple alignments) by clicking on more than one name with the Ctrl key on the keyboard pressed (each click selects - or deselects again - a single entry) or by first clicking one name and then clicking on another name with the Shift key (selects all entries between the two names at top and bottom as well).

**Save**
When the Save button is pressed an alignment is saved under the name defined. The Save button is only enabled when it is valid for the user to save an alignment (a valid name has been entered that is not the same as that of another alignment from a different user). If you are overwriting an existing alignment, you are asked for confirmation.

**Delete**
When the Delete button is pressed the alignment(s) selected is (are) deleted. Users (other than the supervisor) cannot delete other users' alignments so the Delete button is enabled only when the alignment(s) selected belong to you.

**Selected list**
When an alignment from the list is selected, the microscope compares the date of the alignment with the date for your current alignment. If elements (currently only Gun or Column) of the alignment stored are more recent than your alignment, those elements are inserted in the Selected list. If the stored alignments are older, they are inserted in the Available list on the right. Alignment elements can be moved from one list to the other with the < and > buttons. The elements in the Selected list are restored to the microscope when the Apply button is pressed.

**Note:**
- When you press Ctrl + A after clicking in the Selected or Available lists, all items are selected and are more easily transferred from one list to the other.
- You can drag with the mouse while pressing the left-hand mouse button to select a range or all items in the list and then move it to the other list with the **<** and **>** buttons.
- You can double-click on an item and it will move the other list.

**Available list**
When an alignment from the list is selected, the microscope compares the date of the alignment with the date for your current alignment. If elements (currently only Gun or Column) of the alignment stored are older than your alignment, those elements are inserted in the Available list. If the stored alignments are more recent, they are inserted in the Selected list on the left. Alignment elements can be moved from one list to the other with the < and > buttons. The elements in the Available list are not restored to the microscope when the Apply button is pressed.

**Note:**
- When you press Ctrl + A after clicking in the Selected or Available lists, all items are selected and are more easily transferred from one list to the other.
- You can drag with the mouse while pressing the left-hand mouse button to select a range or all items in the list and then move it to the other list with the **<** and **>** buttons.
- You can double-click on an item and it will move the other list.

**< >**

Alignment elements can be moved from the Selected to the Available list and vice versa. Click on an element in one of the lists (the element becomes highlighted) and press the < or > button (with the direction of movement indicated by the < and >). Only the elements in the Selected list are restored to the microscope.

**Apply**
When the Apply button is pressed, the alignment elements in the Selected list are restored to the microscope. If the Selected list is empty, the Apply button is disabled.

## 5.3   Alignments in the TEM

When a user logs into the microscope (by starting the TEM User Interface), the microscope will recall the necessary alignments. The microscope will follow a fixed procedure in restoring these alignments:
- Look if a particular alignment exists for the user and, if so, load it.
- If no user alignment exists, look if the alignment exists for the supervisor and, if so, load it.
- If no supervisor alignment exists, look if the alignments exists for service and, if so, load it.
- If no service alignment exists, look if the alignments exists for factory and, if so, load it.
- If no factory alignments exists, load default settings.

Alignments will exist for a particular user if the user has ever executed (part) of an alignment procedure. Alignments are as much as possible saved as a single parameter (except in the case of linked parameters like pivot points or x-y values which are always kept together). A complete alignment for a user may thus consist of a mix of user-aligned values and values from other levels (supervisor, ...). A user who has never done a gun alignment thus inherits the alignment from supervisor or higher. If the filament (on LaB6 or W) or FEG tip has been changed and a new alignment done by the higher level, the user will automatically get the new, correct alignment.

When alignments are stored in a file, they are stored completely (thus not only the user's own values). Upon restore the microscope will compare the values being reloaded. If the values are identical to the values in the next higher existing level, the values are not stored in the user's own alignments.

# 6        Apertures
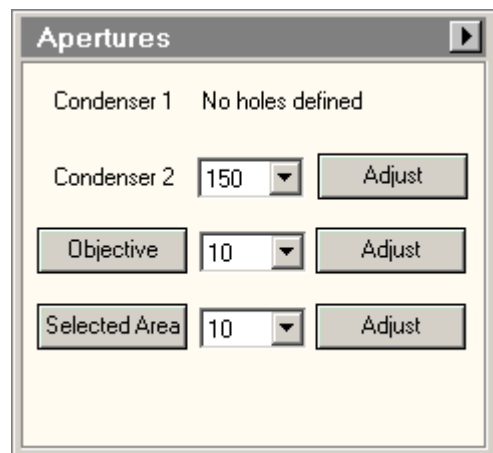


*The Apertures Control Panel.*

The layout and contents of the Apertures control panel is strongly dependent on the configuration of the microscope (which apertures are located where) and the current status of each aperture. Sometimes apertures are not enabled (Condenser 1 in the picture above) or manual (not motorized, Condenser 3 above) and their controls (or absence of controls) reflect that. Potentially there are up to five different aperture mechanism with motor control, Condensers 1, 2, 3, objective and selected area. The selected-area aperture mechanism also may contain the biprism for holography.

**Warning:** On microscopes equipped with the S-TWIN or X-TWIN lenses the objective aperture is in the same space as the specimen holder and, when it is inserted, may hit the specimen holder, resulting in a damaged aperture blade. The CompuStage and aperture software checks against this and may block objective aperture movement. If this happens, first tilt back to a low tilt (<20), insert or move the aperture and then tilt back to the previous tilt angle.

Each aperture that is currently controllable displays a drop-down list with the sizes of the apertures. Sizes may exist in duplicate (if more apertures of the same size have been installed). The list may also display "slit" or "biprism".

**Note:** Misaligned apertures can be one reason for not being able to see the electron beam (other reasons are closed column valves, beam shifted off the screen, beam focused on a specimen grid bar, small spot nearly invisible, etc.). To make sure none of the apertures is actually blocking the beam, change the selected aperture (and back, if necessary). For Condenser 1, select 2000 (but go to another aperture first). For Condenser 2 and 3 change to a large aperture size (if already at the largest, go to another aperture first). For insertable apertures, first insert and then again retract them.

**Aperture disabled**
When an aperture is disabled, its positions cannot be selected. After the name of the aperture is an explanation why the aperture selection drop-down list and the Adjust button are absent.

**Aperture enabled, always inserted**
Apertures that are enabled come in two flavors, ones that are always inserted (one of the aperture is always in the beam) and ones that can be retracted or inserted. The Condenser 2 mechanism is always in the beam so the mechanism displays the name, the aperture selection drop-down list and the Adjust button.

**Aperture selection list**
The aperture selection list contains the sizes (in micrometers) of all available apertures for the mechanism. When a selection from the list is made that differs from previous, the aperture mechanism will move to the newly selected aperture position. While the aperture is moving, the drop-list stays accessible so if you change the selection again, the aperture will immediately start moving to the new selection (it does not need to drive to the first selection, then on, etc.).

**Aperture insertable**
If an aperture can be inserted or retracted, the name of the aperture mechanism appears on a button. If the button is pressed (when gray), it will become yellow and the aperture is inserted. If the button is pressed when it is yellow, the aperture is retracted and the button becomes gray again.

**Adjust**
For proper operation it is often necessary to center an aperture. When the aperture is not centered properly, click on the Adjust button for the aperture required. The Multifunction knobs of the microscope will be linked to the aperture mechanism and you can move the aperture to its proper position by turning the knobs. Once the aperture is centered, click on the button again and the knobs will be disconnected again. The center position of the aperture has now been updated.
While the Adjust button is yellow, the other controls for the particular aperture mechanism are disabled.

**Flap-out button**
Pressing the flap-out button displays the flap-out with the Enable, Reset, and Options Control Panels.

## 6.1     Motorized Apertures

The motorized apertures have motors that drive the aperture holder in two perpendicular directions, called X and Y.

The X direction is defined as being perpendicular to the wall of the microscope (and typically is the direction of the row of apertures), while the Y direction is parallel to the wall of the microscope.
Some aperture mechanisms are not retractable (they cannot be moved out of the beam) such as the condenser aperture(s). Other mechanisms are retractable. The retraction direction (and as a consequence retraction distance and time required) may differ from one mechanism to another. The Selected Area mechanism is always retracted sideways (the Y direction). In the case of the objective aperture it depends on the type of mechanism, sideways for some four-aperture holders such as with the TWIN lens or outwards in the case of eight-aperture blades as on the S-TWIN.

## 6.2     Apertures Enable
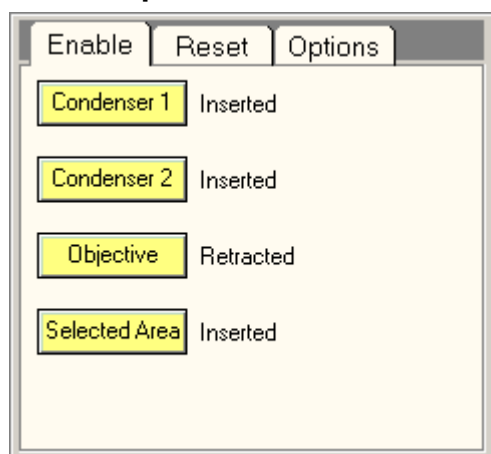


*The Apertures Enable Control Panel.*

In the Apertures Enable Control Panel the controls for enabling and disabling aperture positions are located.

**Aperture buttons**
The aperture buttons control whether an aperture is or is going to be enabled (the button is yellow) or disabled (the button is gray). When is aperture changes from disabled to enabled, it may need to be homed. Both axes are driven to fixed, recognisable positions that are used as reference positions by the aperture mechanism to ensure the apertures are found at the same positions each time the aperture mechanism is enabled, .

**Aperture status**
The aperture status can have various values such as Inserted, Disabled or Moving.

## 6.3      Apertures Reset



*The Apertures Reset Control Panel.*

In the Apertures Reset Control Panel the controls for resetting aperture positions are located. Aperture positions consist of two settings, one the absolute position (defined by factory or service), the second a user-defined offset (fine-tuning). Each aperture has only one offset, with the exception of the C2 apertures on Talos where there are separate offsets for Microprobe, Nanoprobe and LM.

**Reset**
Pressing the Reset button resets the offsets on the position values for all apertures of the mechanism selected.

## 6.4      Apertures Options
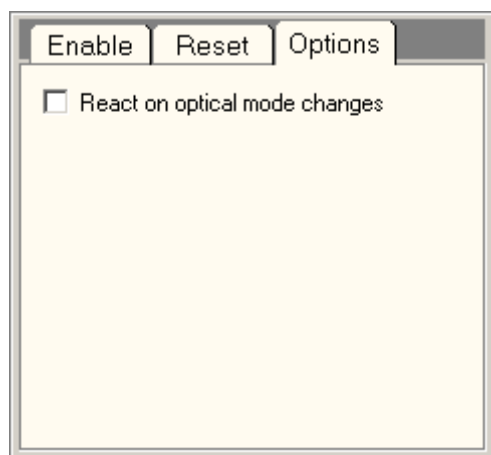


*The Apertures Options Control Panel.*

In the Apertures Options Control Panel you can define how the apertures react to mode changes.

**React on optical mode changes**
When the react on optical mode changes selection is on, the microscope will react to changes in the mode by inserting or retracting apertures and/or selecting apertures last used in the particular mode. The behavior is according to the table shown below.

### 6.4.1        Reacting on optical mode changes

The behavior of the apertures during mode switches with the React on optical mode changes option enabled is given by the table below. In this table, the meaning of the behavior per aperture mechanism is as follows:

**Out** Retract aperture
**In**    select aperture last used by the user in that mode
**None**     no automatic user selection possible*

| Modes | C1 | C2 | Obj | SA |
|---|---|---|---|---|
| LM | None | In | Out | In |
| LAD | None | None | None | Out |
| HM Microprobe | None | In | In | Out |
| D Microprobe | None | None | Out | None |
| HM Nanoprobe | None | In | Out | Out |
| D Nanoprobe | None | None | Out | None |
| LM-STEM | None | In | Out | Out |
| Microprobe STEM | None | In | Out | Out |
| HM-STEM | None | In | Out | Out |

* Although in the microscope software this means resetting the aperture to the configured position (for the particular mode), in practice it means that nothing happens, because the "None" selections are always for the same mode (you can only go to diffraction in Microprobe from imaging in Microprobe, not directly from LM or Nanoprobe).

## 6.5   Phase Plates
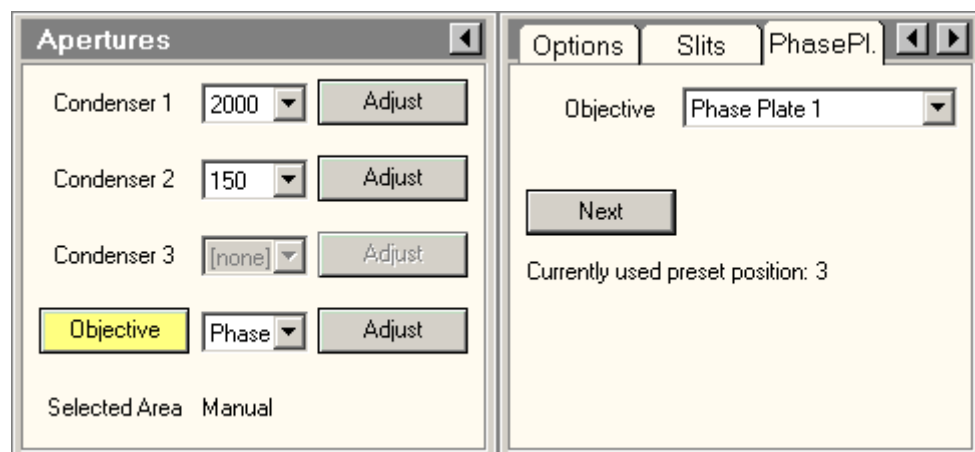


In the Phase Plates tab of the Apertures Control Panel you can select a Phase Plate slot and move within the usable area of the Phase Plate. The Apertures strip contains one Phase Plate Grid which accommodates six Phase Plate slots. The six Phase Plate slots can be selected in the drop-down list (in a similar way as Apertures).
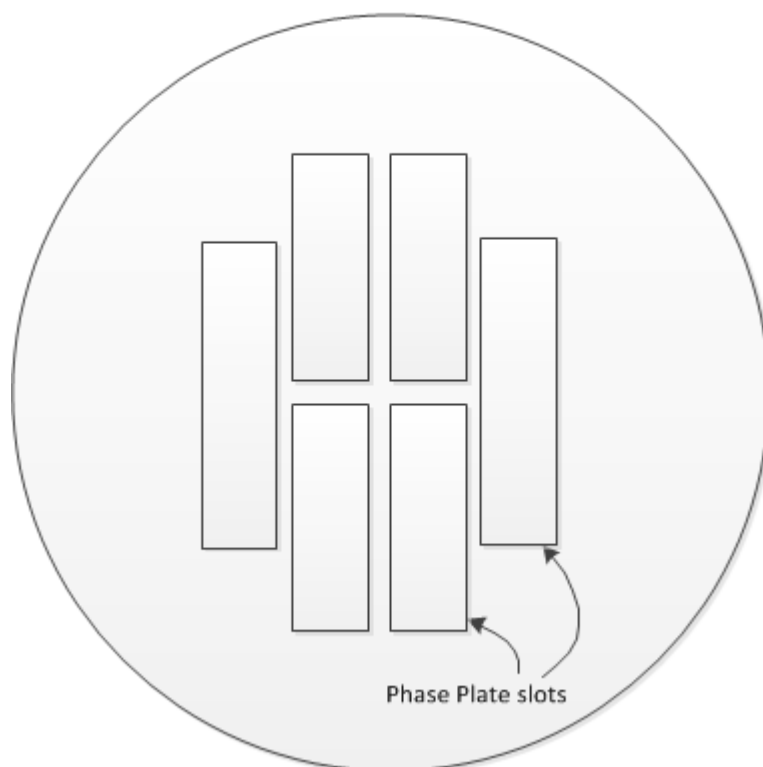


Within each Phase Plate slot is a line of preset positions defined. The Next button can be used for moving to the next preset position of the selected Phase Plate slot. After the last preset position the first one is selected again. The index number of the selected Phase Plate preset position is displayed in the Control Panel. The number of preset positions on a Phase Plate slot depends on its size.

# Phase Plate Slot
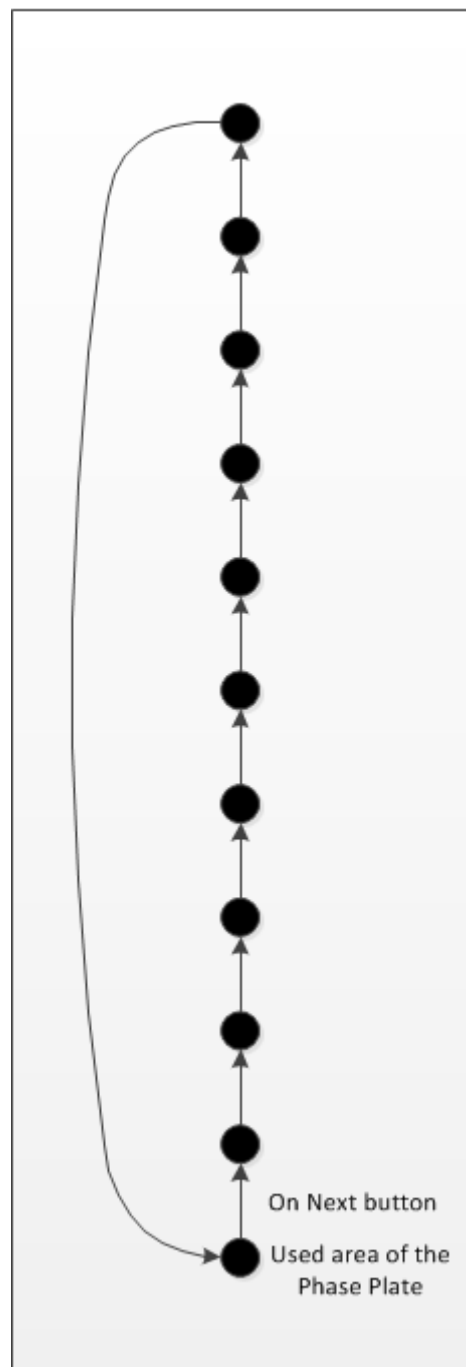
When Adjust is pressed, the Multifunction knobs will control the position of the Phase Plate. This functionality can be used for temporarily working on another part of the Phase Plate. When Next is clicked, the Phase Plate will be positioned on the next preset position again.

On Next button

Used area of the Phase Plate

# 7   Application Selection
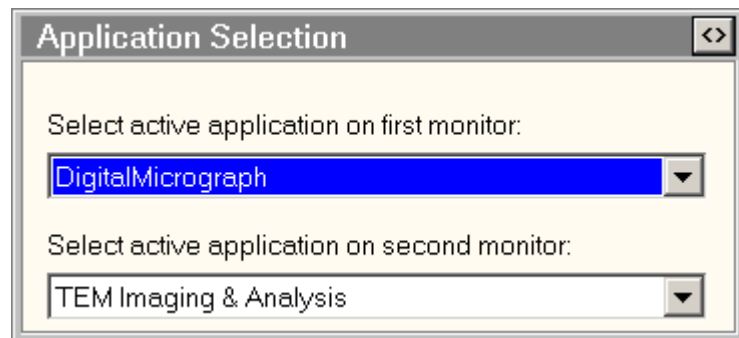


The Application Selection Control Panel provides the tools for adjusting applications to fill either the data space of the TEM User Interface or a second monitor. Choose the applications for the first and second monitor from the two drop-down lists.

The Application Selection Control Panel is brought up by clicking on the (left-most) "square" blue button in the popup selection panel (bottom right of the TEM User Interface).

The <> button (top right) switches to the Application Preferences Control Panel.

## 7.1   Application Preferences
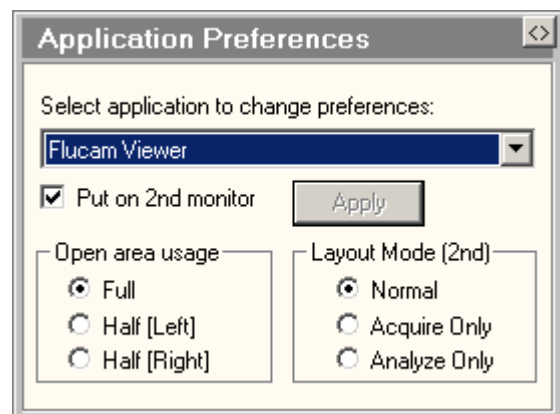


The Application Preferences Control Panel is used to determine where selected applications will be shown, in the data space of the TEM User Interface or on a second monitor.

Select an application form the drop-down list and change the setting of the check box Put on second monitor. Press Apply to activate the changed setting.

For the open area you can define whether you want the application to fill the whole area (Full) or just the left- or right-hand half. The latter are only really useful if the microscope is equipped with very large large monitors so the open area is large.

For TIA (TEM Imaging & Analysis) you can also define the layout mode: how the window is shown on the second monitor, either normal (Acquire mode when TEM User Interface is in Full-size mode; Analyze mode when TEM User Interface is in Taskbar-only mode) or fixed acquire or Analyze mode. Acquire mode for TIA means only a thin frame and no menu, while Analyze mode has a normal window with title, menu and toolbars.

The <> button (top right) switches to the Application Selection Control Panel.

# 8   AutoLoader Life Science
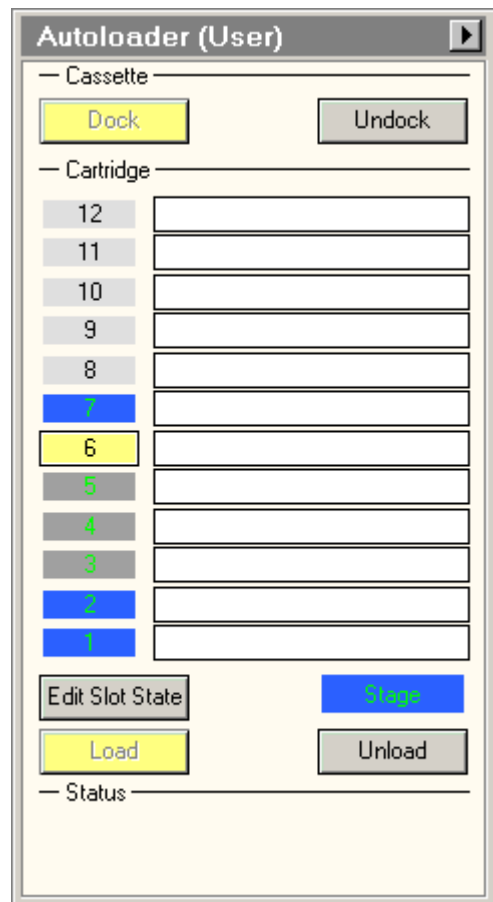


*The AutoLoader Control Panel.*

The AutoLoader Control Panel provides functionality to control the AutoLoader. The AutoLoader is a device mounted on the column opposite the CompuStage that makes it possible to transfer samples automatically into the microscope column onto the CompuStage and back out. By placing a NanoCab with cassette on the AutoLoader, cassettes can be transferred into the AutoLoader. A cassette can contain one to twelve cartridges and each cartridge contains a specimen. These cartridges can be transferred automatically from the cassette to the CompuStage and vice versa.

The AutoLoader Control Panel offers five major functions:
- Dock: transfer a cassette from the NanoCab into the AutoLoader.
- Undock: transfer a cassette from the AutoLoader to the NanoCab.
- Edit Slot State: manually set the cassette inventory. Slots are blocked for further use, if the system detects a different slot state than the user indicated.
- Load: transfer a cartridge from the selected cassette slot to the CompuStage.
- Unload: transfer a cartridge from the CompuStage to the cassette slot it was originally located at.

**Tool tips**
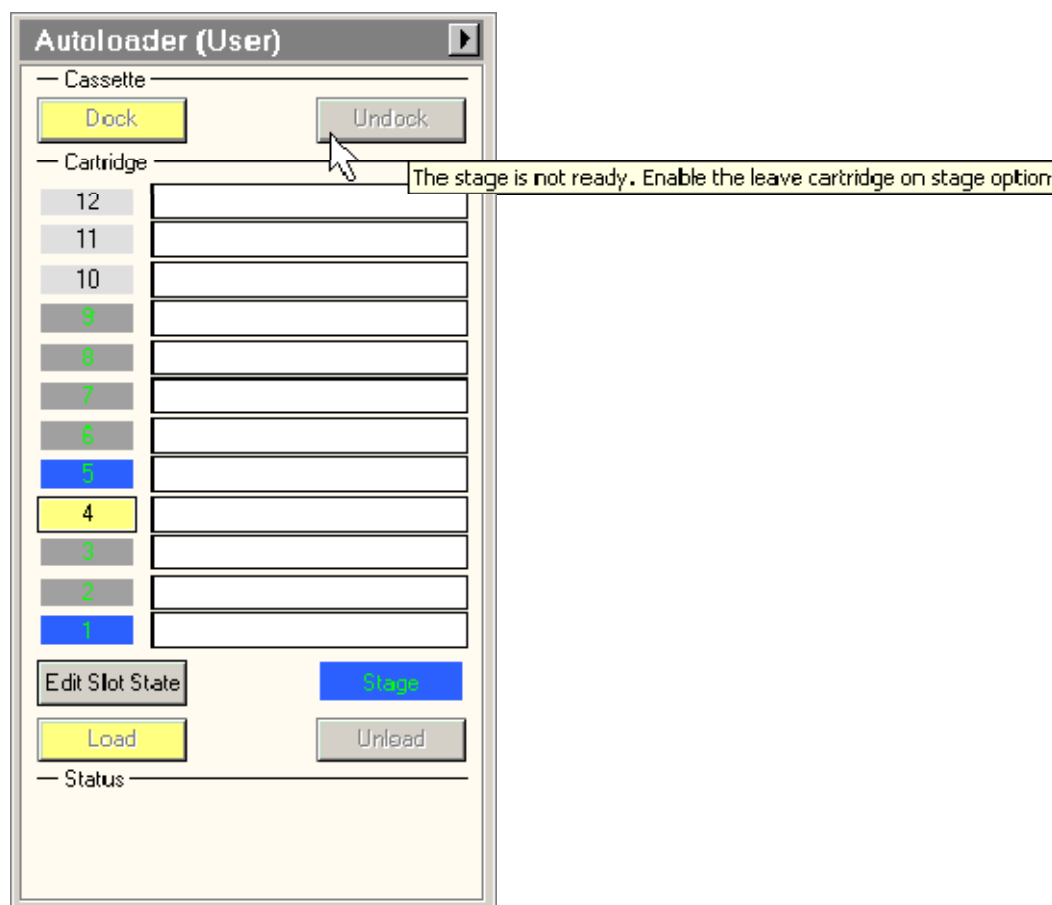


A function button is not available if not all preconditions are met. Tool tips indicate why a grayed-out button is not available. If one slides the mouse pointer over a disabled button, the tool tip becomes visible. Note that the Autoloader Control Panel must be active before the tool tip becomes visible. This is done by clicking once on an arbitrary point in the Panel.

**Dock**
The first step in transferring samples to the CompuStage is docking the cassette. Pressing the Dock button results in locking the NanoCab followed by transferring the cassette from the NanoCab into the AutoLoader. The Dock button is disabled if there is no NanoCab placed. Note that the NanoCab is unlocked once the cassette has been docked in the AutoLoader. The NanoCab is unlocked, so it can be refilled with liquid nitrogen.

**Undock**
When finished analyzing all cartridges in the cassette, another cassette can be docked. In order to do so, the currently docked cassette must be undocked first. This can be achieved by pressing the Undock button. The Undock button is disabled if there is no NanoCab placed.

Pressing this button may result in the following behavior, depending on the state of the system:
• The cassette is immediately undocked when the CompuStage is empty or the Leave cartridge on CompuStage checkbox is checked
• If there is a cartridge loaded on the CompuStage, first this cartridge is unloaded to the cassette before the cassette is actually being undocked.

- When it is unknown whether there is a cartridge loaded on the CompuStage, first an inventory of the CompuStage is performed before the cassette is actually being undocked.
- The reason for this is that there might be a cartridge loaded on the CompuStage, which must be unloaded to the cassette before the cassette is actually being undocked.

Note that the NanoCab is unlocked once the cassette has been undocked to the NanoCab. The NanoCab is unlocked, so it can be refilled with liquid nitrogen.

**Edit Slot State**

In the Edit Slot State, the user has the possibility to manually enter the inventory of the cassette. This state is entered by pressing the corresponding button, the button becomes yellow. Initially, all slots are unknown, click on a slot to go through the different states of empty, filled, unknown etc... Leave the Edit Slot State by pressing the button, so it becomes grey again.
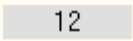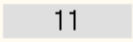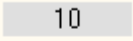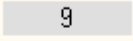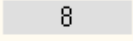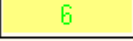
When the AutoLoader accesses a slot and detects a different inventory state than the manual inventory state, the slot is blocked for further use.

The text field next to the slot can be used to enter a description of the cartridge that is present in the slot.

Manually entering the slot states increases the reliability of the AutoLoader. Especially in case cartridges are falsely not detected due to bad placement in the cassette.

## 8.1 Cassette overview

The cassette overview visualizes the contents of a docked cassette. This cassette overview becomes visible when a NanoCab is placed. There are a number of colors used to indicate the status of a cassette slot:

| | Slot characteristics | Explanation |
|---|---|---|
| | Light gray color | Slot content is unknown |
| | Blue color | Slot is occupied |
| | Dark grey color | Slot is empty |
| | Black slot number | No inventory of slot has been done by the AutoLoader hardware |
| | Green slot number | An inventory of this slot has been performed by the AutoLoader hardware |
| | Yellow slot color | Cartridge from this slot is either in the progress of being loaded / unloaded or is loaded on the CompuStage |
| | Red cross | Slot blocked for further use |
| | Green checkmark | Manual and AutoLoader inventory are consistent |

When the user has manually added slot states there are also see green checkmarks or red crosses visible. The green checkmark means that the manually indicated slot inventory matches the inventory detected by the AutoLoader. A red cross means the state detected by the AutoLoader does not match the inventory indicated by the user. The displayed inventory is always the user state. So in the picture the user indicated slot 2 was empty but the system detects the slot occupied. Inconsistent slots cannot be loaded.

Besides these colors there is one special color: red. A red cassette slot means there was a mismatch during cartridge detection (an inventory of a cassette slot was done and identified as occupied, but when loading the cartridge from this slot, the cartridge gripper appears to be empty; this is a mechanical error).

**Stage Overview**
The stage overview visualizes the contents of the stage. The same color coding as for cassette slots is used.

Stage    The stage content is unknown; no stage map has been performed

Stage    The stage contains no cartridge

Stage    The stage contains a cartridge

**Load**
There are two approaches when a cassette has been docked:
1.  Before loading a cartridge to the CompuStage, first perform a complete inventory of the cassette by pressing the Inventory button. When all cassette slots have a known state, select an occupied slot and press the Load button. As is the case for pressing the Undock button, pressing the Load button may result in different behavior, depending on the state of the system:
    - If it is unknown whether there is a cartridge loaded on the CompuStage, an inventory of the CompuStage is performed first before the selected cartridge is actually being loaded. The reason for this is that there might already be a cartridge loaded on the CompuStage, which must be unloaded to the cassette first before a new cartridge can be loaded.
    - If there is a cartridge loaded on the CompuStage, first this cartridge is unloaded to the cassette before the selected cartridge is actually being loaded.
2.  Instead of first performing a cassette inventory, it is also possible to select a cassette slot with an unknown state (light gray colored slot). Selecting a cassette slot with an unknown state followed by pressing the Load button results in an attempt to load a potentially available cartridge from the selected cassette slot. If there appears to be a cartridge in the cassette slot, the cartridge is loaded to the CompuStage. If no cartridge is detected, the cassette slot is marked as empty. In fact, by following this approach an inventory of the cassette is implicitly performed.

**Unload**
Pressing the Unload button results in unloading the cartridge from the CompuStage to the cassette slot it was loaded from.

**Flap-out button**
The flap-out button leads to the Options tab of the AutoLoader Control Panel.

## 8.2 AutoLoader Options Life Science
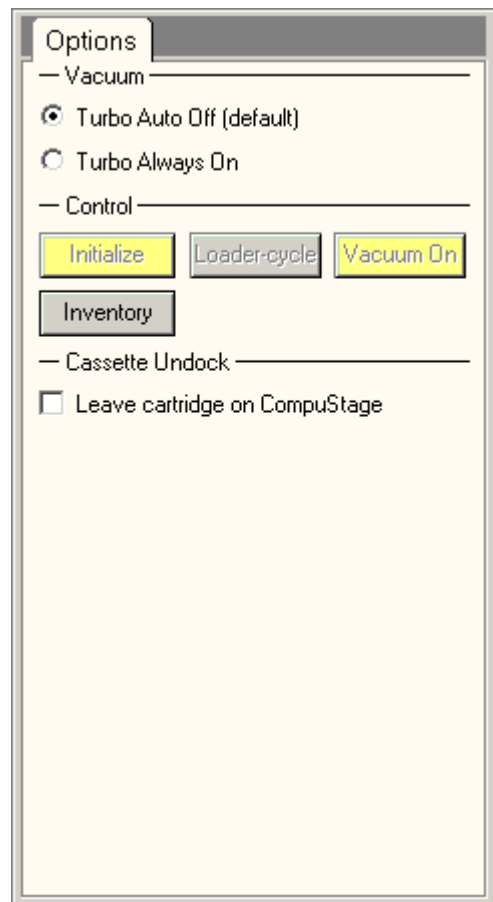
*The AutoLoader Life Science Options Control Panel.*

The Options flap-out provides functionality to influence the behavior of the AutoLoader.

### 8.2.1 Vacuum

**Turbo Auto Off**
This option is default selected, the AutoLoader vacuum is switched to the so-called STANDBY state when the microscope liner valves are opened. In STANDBY state, the AutoLoader vacuum turbo pump is switched off, but it is switched on occassionally to maintain good vacuum (the AutoLoader vacuum is monitored such, that when the AutoLoader vacuum pressure rises above a certain threshold the AutoLoader turbo pump is switched on for a while to obtain good vacuum). If the microscope liner valves are already opened at the moment this option is selected, the AutoLoader vacuum is immediately switched to STANDBY state.

**Turbo Always On**
When this option is selected, the AutoLoader vacuum is switched to the so-called ACTIVE state, meaning that the AutoLoader turbo pump is switched on. The AutoLoader vacuum remains in the ACTIVE state even if the microscope liner valves are opened (i.e. the AutoLoader turbo pump is continuously on). Note that selecting this option results in immediately switching on the AutoLoader turbo pump, while selecting the Turbo Auto Off option does not have immediate effect, except when the microscope liner valves are already opened (see above).

### 8.2.2   Control

**Initialize**
Pressing this button initializes the AutoLoader. This button is only available when the AutoLoader is in the 'Not initialized' state.
Note that this button is only available when the Autoloader vacuum is active and ready.

**Inventory**
Pressing the Inventory button results in examining all cassette slots that have an unknown state to see whether there is or isn't a cartridge in the slot. When the Inventory button has been pressed, its name changes into 'Stop inv.'. This makes the button a toggle button: pressing the 'Stop inv.' button results in stopping the ongoing inventory. 'Stop' means that the current action is nicely finished. It does not mean that the process is immediately aborted (it is not an 'emergency stop'). Once stopped, the button name changes back into 'Inventory'.

**Loader Cycle**
Pressing this button, the AutoLoader turbo pump is temporarily turned on. The AutoLoader will return to the STANDBY state again when the vacuum level in the AutoLoader is low enough, unless the microscope liner valves are closed, then the vacuum stays in the ACTIVE state.

**Vacuum On**
Pressing this button, switches the AutoLoader vacuum on. This button is only available when the AutoLoader vacuum is in the so-called OFF state. A button push actually results in a transition from the OFF state to the ACTIVE state (see Turbo Always On option).

### 8.2.3   Cassette Undock

**Leave cartridge on CompuStage**
There is the possibility to undock the cassette while leaving the cartridge on the CompuStage. Normally, when a cartridge is loaded on the CompuStage, pressing the Undock button results in first unloading the cartridge from the CompuStage to the cassette followed by undocking the cassette to the NanoCab. However, for cryo AutoLoaders, cooling the docker after an undock takes a significant amount of time. In order to avoid this, the Leave cartridge on CompuStage option can be selected. The cassette can already be undocked while the last cartridge of the cassette is being analyzed.

**Note that:**
- Unloading the cartridge to a newly docked cassette will only succeed if there is at least one empty cassette slot available. Typically, a cassette inventory is needed first in order to successfully unload the cartridge. The Inventory button can be pressed for this purpose.
- With this option a cassette can be undocked even if access to the CompuStage is not possible.
This option is persistent, meaning that its value is stored and that the last stored value applies each time the server software is started.

# 9 Beam Settings
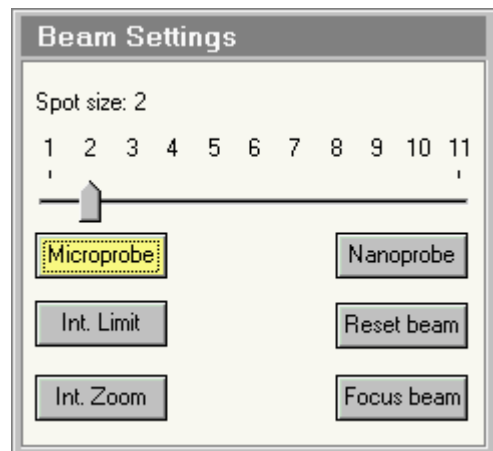


*Beam Settings Control Panel.*

In the Beam Settings Control Panel various settings related to the illumination system are controlled. In addition a control is present to reset the defocus display of the system to zero.

**Spot size**
The TEM has eleven fixed settings for the spot size (the first condenser lens or C1). The numbering is such that spot 1 is the largest and spot 11 is the smallest spot. The actual spot size also depends on the microscope mode, with larger spots in the microprobe mode and smaller spots in the nanoprobe mode. The spot size is changed by moving the scale indicator along the track bar.

**Intensity Limit**
In order to prevent damage to a specimen by unintentionally focusing the beam too much, it is possible to block focusing the beam (Intensity) further than a certain point with the Intensity Limit function. Set the Intensity (either underfocus or overfocus - overfocus being clockwise with the knob when the beam has gone through focus) to the maximum degree of focusing desired and press the Intensity Limit button. The button will become yellow (active). Henceforth it is not possible to focus the beam more than that setting. To switch Intensity Limit off, click on the button again.

**Note:** The Intensity Limit function only works after the Spotsize-Intensity calibration has been done in the Alignment procedures.

**Intensity Zoom**
When the magnification is changed, the field of view changes and the screen intensity will be going down (high magnification) or up. To keep the same screen intensity, the operator can adjust the Intensity setting. The TEM can also automatically change the Intensity setting as a function of magnification, spreading the beam when the magnification is lowered and focusing it when the magnification goes up. To select this function, define a good Intensity setting for the current magnification and then click on the Intensity Zoom button. The button will become yellow (to indicate Intensity Zoom is active). From then on the microscope will keep the screen Intensity constant.
At very high magnifications, it may not be possible to achieve the same screen intensity anymore because the beam is already completely focused. In that case the Intensity Zoom will stop and resume again when the magnification is lowered.
Intensity Zoom can be used at the same time as Intensity Limit. In that case, the Intensity Limit defines the maximum focusing of the beam.

**Note 1:** The Intensity Zoom function only works after the Spotsize-Intensity calibration has been done in the Alignment procedures.

**Note 2:** The Intensity Zoom function is decoupled between LM, Microprobe (HM) and Nanoprobe (that is, it can be on or off in any of the three independently). When switching between LM and HM, the

Intensity Zoom functions reverts to its previously defined state (when going to Microprobe, if Intensity Zoom was off in Microprobe it will be off, and vice versa).

**Reset beam**
When the Reset beam button is pressed, the user beam shift (as normally set with the left-hand trackball) is reset to zero. The beam will then be in the position defined in the alignments.

**Focus beam**
When the Focus beam button is pressed, the Intensity setting is changed to the value at which the beam is focused. This value is defined in the Spotsize-Intensity calibration procedure and the function will only work when this procedure has been done.

**Microprobe / Nanoprobe**
Microscopes equipped with a TWIN-type objective lens have two operating modes of the lens, the microprobe and nanoprobe modes. The difference between these modes lies in the way the minicondenser lens is used. In the microprobe mode, the minicondenser acts in the opposite direction of the main field of the objective lens, creating a separate lens. In nanoprobe, the minicondenser works in the same direction as the main field and no separate lens field exists.

Switching between the two modes is achieved by clicking on the microprobe or nanoprobe buttons. The active mode is highlighted by the yellow color of its button.

The main characteristics of the two modes are:

| Characteristic | Microprobe | Nanoprobe |
|---|---|---|
| Purpose | TEM imaging | Analysis, STEM, CBED |
| Spot size (appr.) | ~25 to 1 nm* | ~2 to 0.2 nm* |
| Field of view | >largest area seen at lowest Ml magnification | Appr. 1/40 of the size of the condenser aperture* |
| Convergence angles | Low (millirads) | High (tens of millirads) |

* somewhat dependent on the type of objective lens

# 10 CCD / TV Camera
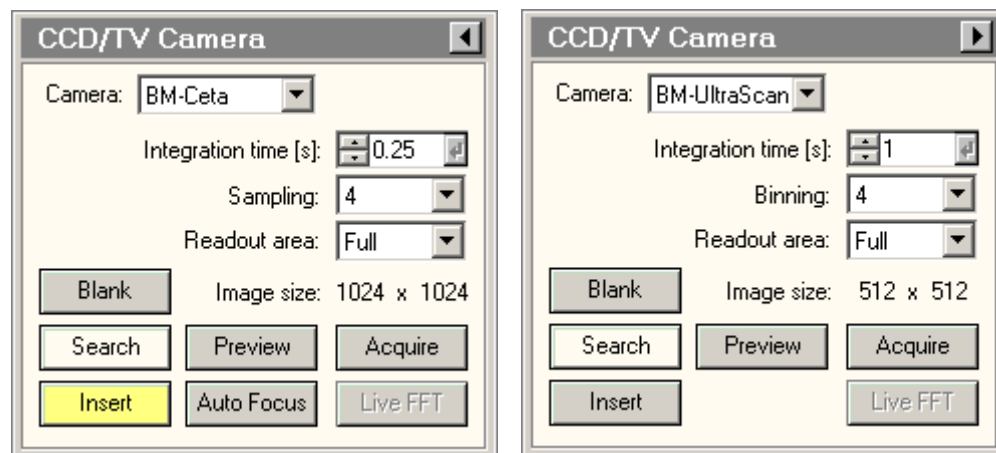


The CCD / TV Camera Control Panel allows control over image acquisition using cameras. In order to allow acquisition TIA must be running. Because the various available cameras have different parameters, the control panel can have different formats.

**Note about DigitalMicrograph:** Gatan DigitalMicrograph cannot be controlled directly from the TEM user interface. The CCD/TV Camera control panel only acts in combination with TIA. You can, of course, use DigitalMicrograph to acquire images, etc. but you then have to do the acquisition from DigitalMicrograph itself, using the functionality as supplied there. The same applies to Imaging Filter functionality such as acquiring elemental maps.
The exception to not having control of DigitalMicrograph from the TEM UI are in two options, Low Dose and TrueImage which do support direct image acquisition in DigitalMicrograph.

**Search, Preview, Acquire**
For easy operation, the CCD / TV acquisition system has three preset acquisition modes with their own buttons, Search, Preview and Acquire. Each of the three can have its own, separate settings (Integration time, Frame size, Binning), allowing rapid switching between different settings. The actual settings are up to the user. Typical settings could be:
- Search : Integration time 0.1 seconds, Image frame 512*512, Binning/Sampling 8.
- Preview : Integration time 0.25 seconds, Image frame 1024*1024, Binning/Sampling 2.
- Acquire : Integration time 1 second, Image frame 4096*4096, Binning/sampling 1.

By definition Search and Preview are continuous acquisition, while Acquire acquires a single frame and stops (to allow the operator to save the image). Exception is the Falcon camera where both Search and Preview are always single-frame (to avoid unnecessary continuous exposure).

**Camera**
If more than one camera is present (e.g. one below the projection chamber or in the wide-angle TV port above the projection chamber, and an Imaging Filter), the camera to be used can be chosen from the drop-down list with cameras.

**Note:** On some Gatan CCD systems the camera has a normal and a cinema mode. These two modes are accessible in TIA through "different" camera selections.

**Integration time**
The integration time sets the camera integration time for the currently active acquisition mode (Search, Preview, Acquire). Not active for TV-rate camera acquisition.

**Sampling/binning**
The Sampling/binning drop-down list box allows selection of one of the available sampling/binning rates.
Sampling is used on cameras that support frame summing (Ceta), binning is for CCD cameras.

**Readout area**
The readout area allows simple selection of the whole camera or subparts (half, quarter, 1/8 or, if
available, custom). Subparts (except custom) are always centered.

**Image size**
The image size for the currently selected preset is displayed.

**Blank**
The CCD/TV Imaging Control Panel provides a function for blanking of the electron beam to avoid beam
damage or other undesired effects when the beam remains on the specimen. The beam is blanked when
the button is yellow.

**Search**
Pressing the Search button :
- When the button is gray, switches the acquisition settings to those of the Search mode and starts
  acquisition.
- When the button is yellow, pauses the acquisition.
- When the button is white, resumes the acquisition if possible. If the start command could not be
  given to the CCD/ TV controller, the button will remain white.
By definition Search is continuous acquisition.

**Preview**
Pressing the Preview button :
- When the button is gray, switches the settings to those of the Preview mode and starts acquisition.
- When the button is yellow, pauses the acquisition.
- When the button is white, resumes the acquisition if possible. If the start command could not be
  given to the CCD/ TV controller, the button will remain white.
By definition Preview is continuous acquisition.

**Acquire**
Pressing the Acquire button :
- When the button is gray, switches the settings to those of the Exposure mode and starts acquisition.
- When the button is yellow, pauses the acquisition.
- When the button is white, resumes the acquisition (but starting with a new frame) if possible. If the
  start command could not be given to the CCD/ TV controller, the button will remain white.
By definition Acquire acquires a single frame and stops.

**Insert**
When the camera is insertable, the Insert button allows insertion (button is yellow) or retraction (button is
gray) of the camera.

**Auto Focus**
Auto Focus automatically brings the sample into focus if the microscope is in TEM mode. When the Auto
Focus button is pressed, the button becomes yellow. Below the button a progress bar appears,
indicating how far the routine is. Pressing the yellow button will abort the routine and returns the original
settings.

The Auto Focus routine uses camera images to determine if the sample is already in focus or not. The images are acquired with the currently active camera and camera settings. For an optimal speed – accuracy performance an image size of 1024*1024 is advised, although other image sizes will also work.

Note:  The Auto Focus applies a beam tilt to determine the current defocus. To relate the beam tilt to the defocus the focus calibration must have been done for the current TEM mode and HT. If there is no calibration available Auto Focus will return an error.

**Live FFT**
Live FFTs can be started and stopped when Search or Preview acquisition is active.

**Flap-out**
Pressing the arrow button displays the flap-out with the CCD / TV Camera Settings, Bias/Gain and Shutter Control Panels.

### 10.1.1  Troubleshooting

There are two possibilities for CCD troubleshooting:
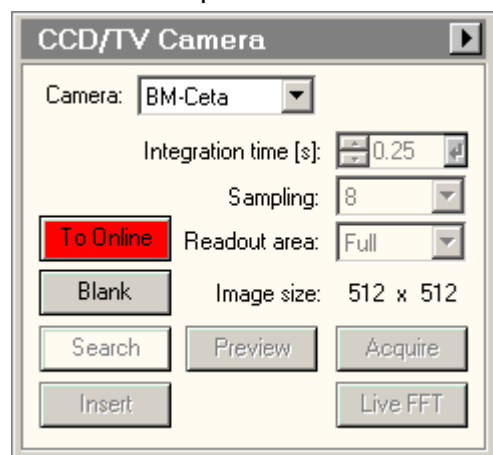
If the connection to the camera is lost, a red button "OnLine", located above the Blank button will become visible. Press the OnLine button to try and restore the connection to the camera.
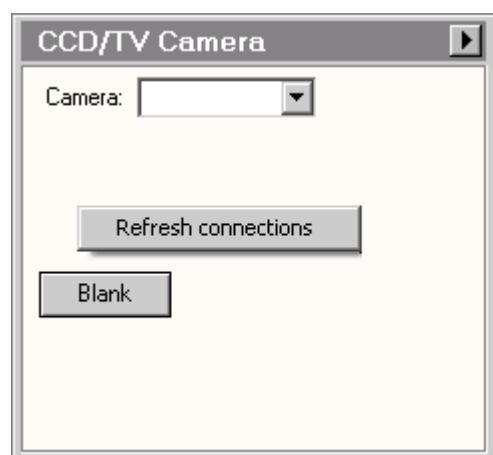
If there is no connection to the camera, you may be able to activate the camera by right-clicking on the CCD/TV control panel and a button Refresh connections may be visible. Press the button to try and activate the camera.

This may also be seen if TIA is not running.

## 10.2 CCD/TV Camera Settings
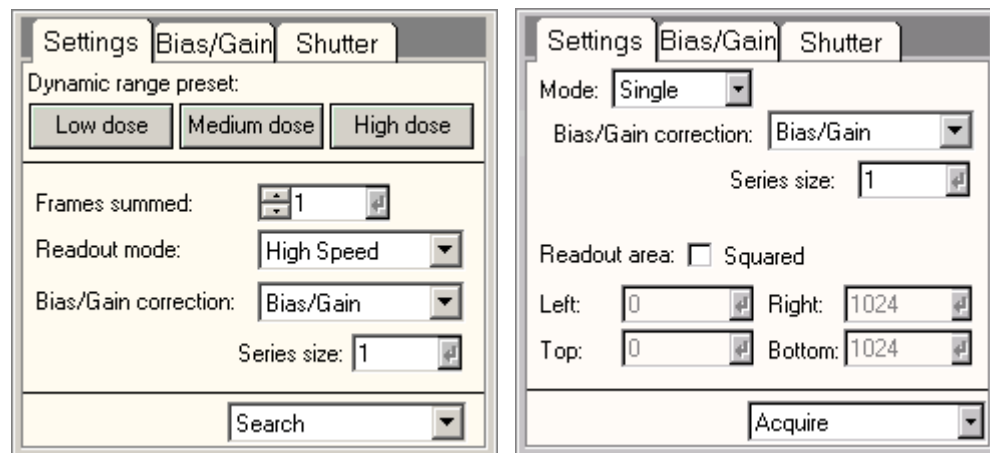


In the CCD/TV Camera Settings Control Panel the CCD/TV camera acquisition parameters are defined. As with the main panel, the functionality will depend on the type of camera.

**Dynamic range preset**
The Low dose, Medium dose and High dose buttons set the Frames summed to the values 1, 4 and 18, respectively. Low dose is typically used when the signal is very low in which case a single readout (frame) provides the optimum setting to reduce readout noise. High dose is used when the signal is very high. In this case the signal in the image can go above the "normal" 16-bit limit of ~65000. Medium dose is comparable to regular CCD cameras. The signal here will be limited to about ~65000. (Note that because of the gain correction, higher values for the image maximum can occur.)

**Frames summed**
The amount of frames to sum during the acquisition. The frame summing occurs at real time inside the camera, effectively increasing the dynamic range without additional overhead in the acquisition.

**Readout mode**
The readout mode (High Quality, High Speed) is selected through the drop-down list. High Quality should be used to get the best image quality and High Speed can be used during continuous acquisition to get a higher frame rate (impact on image quality).

**Mode**
Under Mode the acquisition mode (continuous or single) is selected. In 'Continuous' the image is acquired continuously until the user stops acquisition. In 'Single' one image is acquired after which acquisition stops. Search and Preview are typically set to continuous, while Acquire is set to single.

**Bias/Gain correction**
The type of correction (None, Bias, Bias/Gain) is selected through the drop-down list. The correction applies to the currently active preset (Search, Preview, Exposure). Gain correction is only possible if the gain reference has been acquired.

**Series size**
Under Series size the number of images acquired in a TIA series is defined.

**Readout area**
The readout area of the CCD/TV camera can be set by entering appropriate numbers (after selecting the Custom setting - and pressing the Enter button when a number has been changed) or pressing one of

the buttons (Quarter, Half, Full). If the CCD/TV camera is not square, the Squared checkbox allows you to force the system to use square image size (so, e.g., if the CCD/TV has 1500 x 1024 pixels, the resulting Full image will be 1024x1024 and centered in the horizontal direction).

**Note:** Not all cameras support the custom readout area.

**Squared**
The Squared option is available for non-square CCD cameras. If this option is switched on, the readout area selection is forced to square images.

**Acquisition mode**
In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and by pressing the equivalent button in the main control panel is that the drop-down list selection selects the mode but does not automatically start acquisition.

## 10.3 CCD/TV Camera Bias/Gain
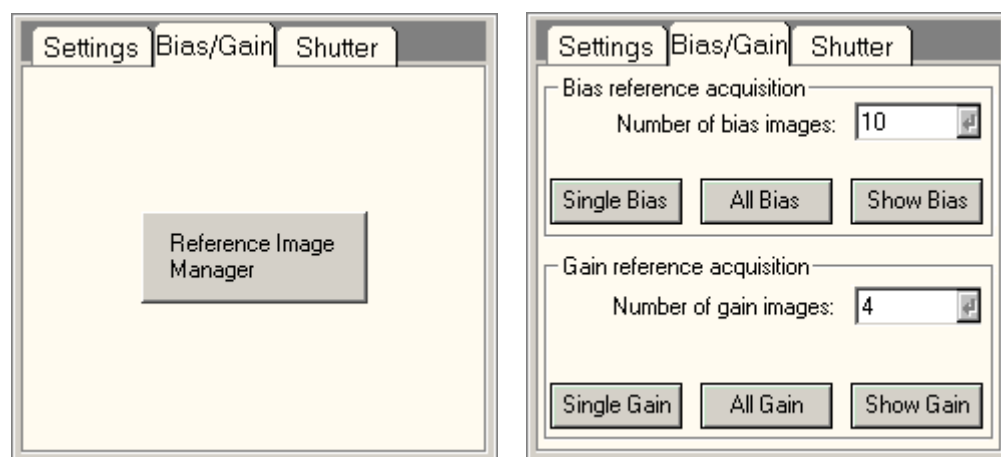


In the CCD/TV Camera Bias/Gain Control Panel various settings related to camera bias/gain image acquisition are defined. The controls present depend on the type of camera. For Gatan CCDs the bias and gain corrections are done through DigitalMicrograph, not through the TEM user interface.

**Reference Image Manager**
This button starts the separate reference image manager application.

**Number of bias images**
Under Number of bias images is defined the number of images that is averaged for the final bias image. Typically an average of 4 is used.

**Single Bias**
Pressing Single Bias starts acquisition of the bias-correction image for the current acquisition settings (frame size and binning).

**All Bias**
Pressing All Bias starts the automatic procedure that acquires the bias-correction images for all necessary CCD acquisition settings.

**Show Bias**
Show Bias displays the current bias-correction image used.

**Number of gain images**
Under Number of gain images is defined the number of images that is averaged for the final gain image. Typically an average of 4 is used.

**Acquisition of gain images**
During gain-correction image acquisition, the microscope should be in a suitable condition, with flood-beam illumination of sufficient intensity, spread such that the illumination distribution is flat (typically achieved at lower magnifications). Make sure no specimen is visible on the area covered by the CCD.

**Single Gain**
Pressing Single Gain starts acquisition of the gain-correction image for the current acquisition settings (frame size and binning).

**All Gain**
Pressing All Gain starts the automatic procedure that acquires the gain-correction images for all necessary CCD acquisition settings.

**Show Gain**
When the Show gain button is pressed, TIA will display the gain image (for inspection).


## 10.4 CCD/TV Camera Shutter
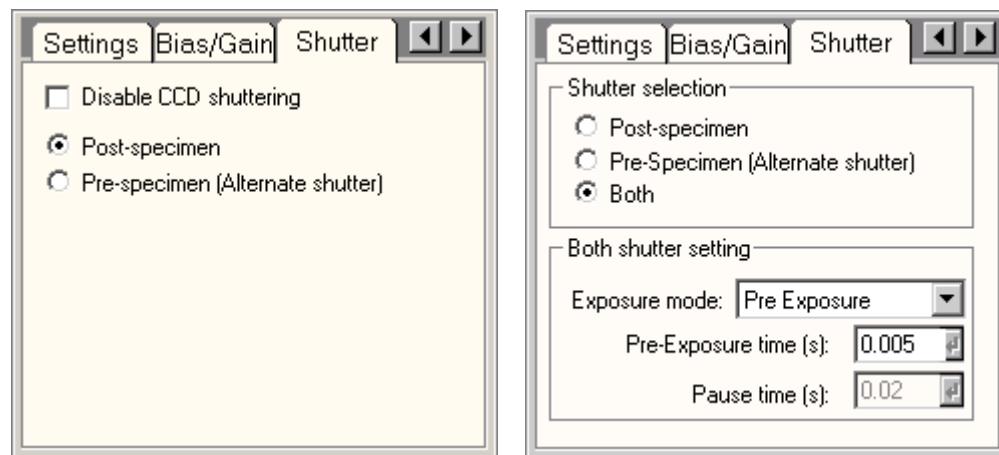


In the CCD/TV Camera Shutter Control Panel the shutter used by the camera during image acquisition is defined. The controls present depend on the type of camera.

**Shutter selection**
Under Shutter selection you choose which of the shutters (post- or pre-specimen or both) is used for image acquisition. The post-specimen shutter (usually the shutter located in the projector system of the microscope column) is typically used with specimens that are not sensitive to beam damage. Because the beam remains on the specimen even when no acquisition is taking place, there are no problems with charging-induced drift. The pre-specimen shutter is located in the gun and blanks the beam before the specimen. Options may change depending on the CCD camera present.

**Both shutter setting**
Some CCD cameras allow manipulation of both shutters simultaneously. In all cases the speed-limiting shutter will be the post-specimen shutter. When using both shutters, there are three possible modes:
- Simultaneous - both shutters are used at the same time.
- Pre Exposure - the specimen is exposed to the electron beam (pre-specimen shutter opens) for a user-defined time, while the post-specimen shutter prevents the beam from reaching the CCD.
- Pre Exposure with Pause - the specimen is exposed to the electron beam (pre-specimen shutter opens) for a user-defined time, while the post-specimen shutter prevents the beam from reaching the CCD. Just before the actual exposure the pre-specimen shutter closes for the user-defined Pause time.

**Disable CCD Shuttering**
Disables the CCD shutters to allow acquisitions with third party detectors that require the shutters to be open. Caution, this can lead to damage to any inserted detector.

## 10.5  Camera types

Currently there are two types of cameras in use, the (older) CCD camera and the CMOS camera (for the latter e.g. the Falcon and Ceta cameras). Both types of cameras consist of two-dimensional arrays of light- or electron-sensitive elements. Generally the electrons from the beam are first converted into light by a scintillator mounted above the camera. The light is detected by the camera and converted into electrons whose charge forms the basis of the signal read-out. The disadvantage of the conversion by the scintillator is that the light generated is emitted in all directions, plus the electron generating the light will scatter inside the scintillator and can move quite bit sideways in doing so. Some of the light will end up in the camera pixel just below the point where the electron entered the scintillator, but in part it will spread beyond that, reducing the effective resolution (or Modulation Transfer Function – MTF). Thicker scintillators give better electron-to-light conversion but worse resolution (the light can spread more).

Direct-detection cameras like the Falcon skip the conversion step. It makes them far more sensitive and gives better resolution, but the camera can also be damaged if a too-intense electron beam is allowed to fall on the camera.

### 10.5.1  CCD camera

On a slow-scan CCD camera an image is acquired by letting the electrons from the beam strike the camera for the full integration time (so an image is acquired in a single cycle; TV-rate CCD cameras also exist). The read out is done by an Analog-to-Digital Converter (ADC) that lies at the end of a special row on one side of the light-sensitive element array. The result is a digital signal (a value) for each element.
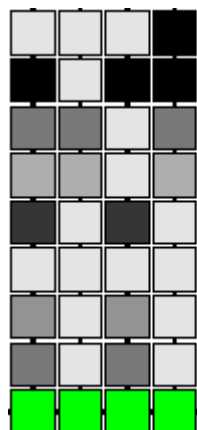
*Schematic diagram of part of a CCD camera. The green elements are the pixels of the read-out line from where the signal is shifted to the ADC(red), while the gray elements are the image pixels, showing different image intensities.*

In a CCD camera the elements are connected in one direction by 'wiring'. Through the connections the whole image can be shifted row by row. During read-out the whole array is shifted

one row down so the contents of the last row move into the read-out line. The contents of the read-out line are then moved sideways into the ADC where each pixel is read out individually. Then the whole array is shifted down again, and so on.

Pixels of CCD cameras can be binned. Binning is the process whereby the signal from several pixels is combined, e.g. 2x2 or 4x4 pixels. The binning is done through the hardware, so the contents of the individuals pixels are not read-out, only the combined signal. The consequence is that the signal in the binned pixel increases by the square of the binning. So for binning 2, you can expect a four times higher signal. Normally the exposure time must be reduced to compensate for the binning, otherwise the camera will saturate at the high binning settings.

Because the whole image is shifted during read out, the camera must be blanked during the read-out, otherwise image acquisition continues during the image shifting and the image will be blurred in one direction. There are also cameras where the acquisition part lies next to an equal-sized array that is covered. During the read-out the image is shifted in one go into the covered part from where it is read-out. These cameras therefore do not need a shutter.

### 10.5.2 CMOS camera

The CMOS camera works differently from the CCD camera. Each pixel has its own read-out element that is wired to the outside. Binning through hardware therefore does not as such exist on CMOS cameras. Instead the signal is combined through software (simply adding the contents of several pixels together). It is also possible that pixel skipping is used during read-out. In that case the contents of a number of pixels is simply thrown away. For example, "binning" 4 might consist of adding pixels with even sums of the indices in a four-by-four array - so (1,1 = 2), (3,1 = 4), (2,2 = 4), (2,4 = 6), etc. while skipping the pixels in between (effective a combination of 2x software binning and pixel skipping). Because software binning does not result in signal saturation (unlike hardware binning on CCD cameras) it is technically possible just to the add the signal. Generally though, the signal is divided by the number of pixels to give an effect that is similar to hardware binning on CCD cameras (because most users are used to this effect).
Another difference of CMOS cameras is that their so-called well depth cannot hold as much signal as CCD cameras so a single frame of longer duration is typically read-out as a number of added subframes. For CMOS cameras this is not a problem because the signal is not shifted sideways during read-out so no blanking is needed between the subframes, plus the read-out is much faster that on CCD cameras. Because of the possibility of the addition of subframes, the user has a choice. If the signal is low (e.g. during Low Dose imaging) so a longer (1 second) exposure will not result in overexposure), acquiring a single frame is beneficial because it reduces the amount of (read-out) noise. If the signal is high, subframes must be added to avoid overexposure.

### 10.5.3 Camera parameters

**Bias (Dark current)**
The dark current is a current that is present even when no signal falls onto the camera. The dark current builds up slowly in the camera elements. It is therefore dependent on the integration time. For high-quality imaging the dark current is subtracted from the image as read out. When the same integration time is used, the dark current will remain the same, so the dark current is typically only read out only when the integration time is changed and no 'dark-current image' (an image read out after an integration time in which no signal is allowed to fall on the camera) is already present.

**Gain**

There is some variation between different elements in a camera, so if uniform illumination falls on a camera there are still differences in signal intensity between the different pixels. This variation is due to variations in size or effectiveness of the elements (high-frequency variation) and due to the fact that scintillator is not completely homogeneous (low-frequency variation). These variations can be corrected by collecting a gain image (an image taken with uniform illumination and then recalculated to the inverse of the maximum intensity in the image - that is, find the maximum in the image collected and for each pixel divide that value by the actual value of the pixel) and multiplying each image collected with the gain image (multiplication is done rather than division because that is faster on a computer, so the division is done only once, when the gain image is acquired).

Gain images are stored on disk and retrieved automatically by the software. The gain images should be checked and, if necessary, updated on a regular basis. It is easy to judge if it necessary to acquire new gain images. Simply collect an image with no specimen visible (e.g. in a hole) with uniform intensity. If the image only shows noise, the gain images are still good. If features are seen in the image, the gain correction must be updated.

One effect of the application of the gain correction is the appearance of a negative gain correction image when the camera is saturated (too much beam intensity or integration time too long). If you see features that look like the gain correction image (very often circular bands or a hexagonal chickenwire pattern) and gain correction is on, very likely the camera is saturated. Decrease the integration time or reduce the beam intensity. (The circular bands come from the scintillator; the chickenwire pattern from the fiber-optic coupling between the scintillator and the camera chip: bundles of optical fibers that ensure a high efficiency of transfer of light from the scintillator to the camera.)

**Blooming**
Because the elements of the CCD must be connected in the direction of the columns (otherwise it would be impossible to read out the CCD), charge from one element can overflow into adjacent elements along a column. Along rows this effect is much less because the columns are typically separated by so-called trenches that prevent charge flowing in the row direction.

Blooming is often seen with very high-intensity beams (central beam in a diffraction pattern or the small, focused beams as used during analysis) on the CCD camera, giving a pattern like a very elongated, white ellipse. Avoid this situation as much as possible (the intense beams can leave 'ghost' images that remain visible for a long time unless the cooling of the CCD is switched off). If weak diffraction spots must be recorded, either shift the diffraction pattern so the intense central beam does not hit the CCD camera or collect multiple images with a shorter integration time and add them together to improve the signal-to-noise ratio).

**Cooling**
In order to reduce the dark current, cameras are typically cooled. Because it can take a while for a camera to cool down to its working temperature, it is generally best to keep the cooling on all the time. It may be necessary to switch the cooling off for a while if persistent 'ghost' effects remain visible in the images (easy to check by collecting images with the camera not in the beam or the screen down if the camera is located below it). If the 'ghost' effects cannot be erased by flooding the camera with a high but uniform intensity, switch the cooling off for several minutes while collecting images with no beam on the camera.

# 11 Control Pad Lighting

The left-hand and right-hand pads have background lighting available to make it easier to locate the controls on the pads when working in the dark. The lighting of both pads can be switched on and off. The status of the background lighting is saved when the TEM user interface is closed and restored when the user interface is started.

In addition (dependent on the hardware configuration on TEMs) the intensity of the LEDs (the status lights on the System On/Off Panel) can be adjusted to the room lighting conditions.

To switch the lighting on or off, click on the control panel list in the lower bottom right of the screen (in normal status display).



Select the item listed as 'Control Pads'. Dependent on the configuration one of the following control panels will pop up.
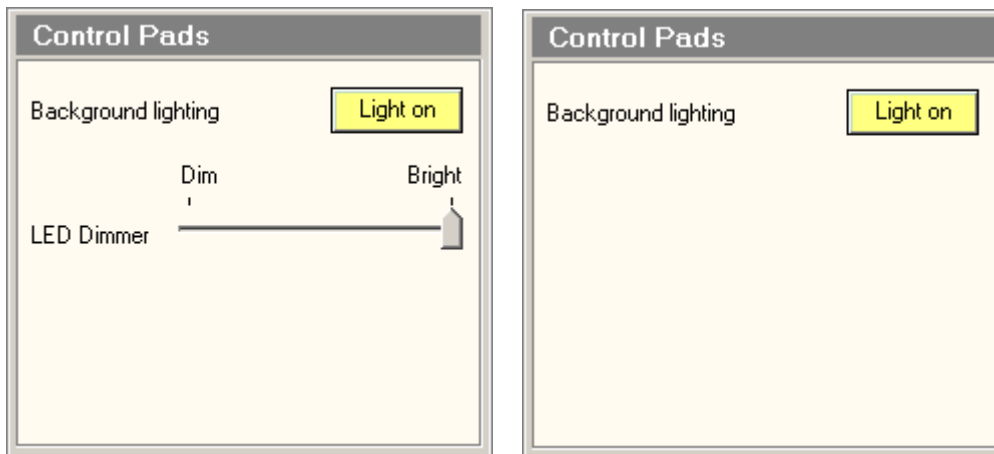


Press the button to switch background lighting on (button becomes yellow) or off. Move the track bar to the left to make the LEDs dimmer and to the right to make them brighter.

# 12 Dark Field
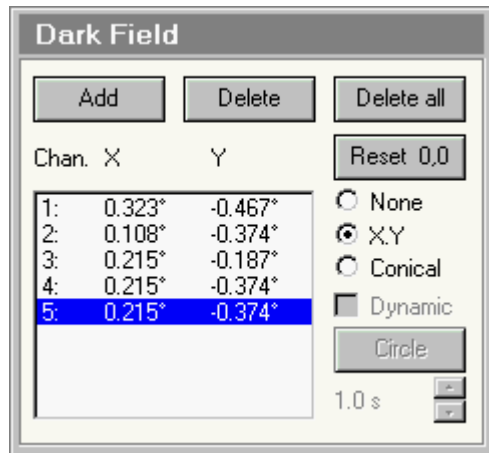


*The Dark Field Control Panel.*

The Dark Field Control Panel allows control of dark-field imaging. The beam tilts are set with the Multifunction-X,Y knobs.

**Add**
Add a channel to the list. The new value will be equal to the currently active tilt setting.

**Delete**
Deletes the currently active channel from the list.

**Delete all**
Clears the whole list of stored dark-field tilt settings.

**Channel**
An unlimited number of dark-field tilt settings can be stored. Each setting is stored in a channel.

**Reset 0,0**
Resets the currently active channel to 0,0 tilt (that is, no beam tilt).

**None**
Switch Dark Field off (the equivalent of pressing the Dark Field button on the right-hand control pad).

**XY**
Tilt the beam in X-Y mode, where a beam tilt in one direction (X) is set with the Multifunction-X knob and the tilt in the perpendicular direction is set with the Multifunction-Y knob.

**Conical**
Tilt the beam in conical mode, where a tilt angle is set with the Multifunction-Y knob while turning the Multifunction-X changes the azimuth angle of the tilted beam.

### 12.1.1 Dynamic conical dark field

On STEM systems, it is possible to have the microscope drive the beam, around in conical dark field (dynamic conical dark field or hollow-cone illumination).

**Note 1:** For dynamic conical dark field the AC (STEM) beam deflection coils are used instead of the DC (TEM) beam deflection coils (because it is not possible to control the DC coils with an external signal). This has a number of consequences:
- TIA (Tem Imaging &amp; Analysis) must be running because this is the software that drives the beam in a circle.
- The pivot points and other adjustments like calibrations are independent of those of the DC coils used for static dark field and must be set separately.
- The switch between static and dynamic conical dark field means switching between the DC and AC coils. The software will keep the tilt angle as must as possible identical but differences may occur.
- The maximum tilt angle in static conical dark field is quite a bit larger than for dynamic conical dark field.
- Dynamic conical dark field is not supported (no alignment possibilities) in LM (since the dark-field tilt angles there are so small that there is no point in supporting dynamic conical dark field).
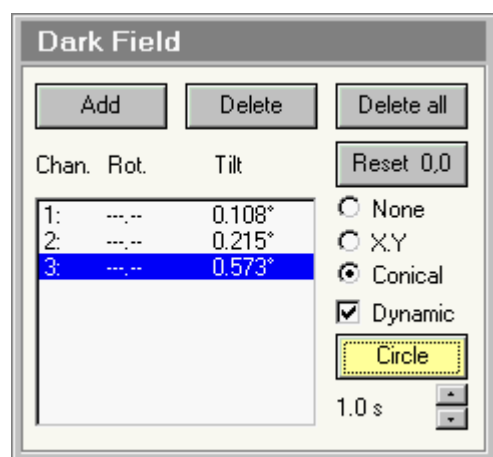


To switch to dynamic conical dark field, first go to static conical dark field (press the Conical radio button). Check the Dynamic checkbox. The system will now have switched from DC to AC coils. Press Circle to start and stop movement.

**Dynamic**
Switches the microscope from DC to AC (when checked) and back.

**Circle**
Press Circle to start and stop movement.

**Speed**
Defines the speed with which the beam drives around in a circle.

# 13 Detector Configuration
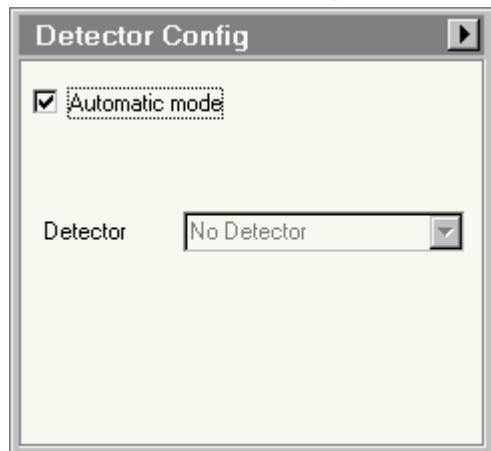
*The Detector Configuration Control Panel.*

The Detector Configuration Control Panel provides control over the manual or automatic detector shifts executed by the microscope.

**Introduction to detector shifts**
Underneath the projection chamber, the microscope has three possible mounting positions for detectors:
- On axis
- Near-axis (~3 cm to the WNW) - the position of the STEM Bright-Field / Dark-Field detector assembly.
- Off-axis (~7 cm to the ENE) - a possible position for a TV-rate camera.

When the off-axis positions (near-axis and off-axis) are occupied by detectors, the microscope can shift the image or diffraction pattern automatically to the detector when the viewing screen is raised. The automatic shifts will be executed when the proper detector configuration settings have been set. The actual value of the shifts (which are dependent on the magnification or camera length) are set in alignment procedures.

**Note:** the detector shift is activated only if the viewing screen is raised.

**Automatic mode**
When Automatic mode is checked, the off-axis shifts are executed automatically, dependent on the current microscope setup. For example, when STEM is active with the Bright-Field (BF) or Dark-Field (DF) detector as the selected detector, the diffraction pattern will be shifted automatically to the near-axis position when the viewing screen is raised.

**Detector selection**
When Automatic mode is off (not checked), the choice for the detector selection can be set manually by selecting a detector from the list.

**Flap-out**
The Flap-out out button leads to the Detector Configuration flap-out with the Detector Configuration Options control panel.

**When an off-axis TV camera and an on-axis CCD camera are present**
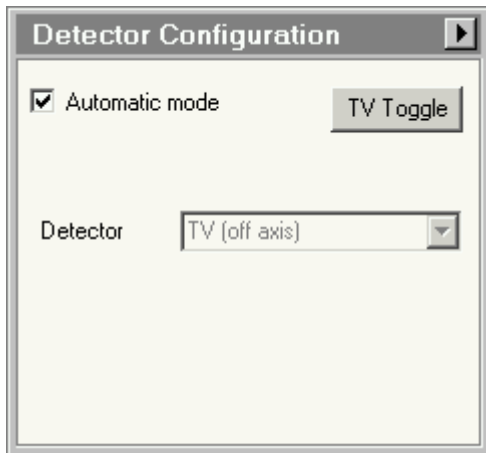
Because the TEM cannot predict which of these two cameras you want to use when you lift the screen, a function TV Toggle is provided that allows rapid toggling between the two through a button on the control panel.

The button is present :
- In automatic mode, when the viewing screen is lifted.
- In manual mode, always

## 13.1 Detector Configuration Options
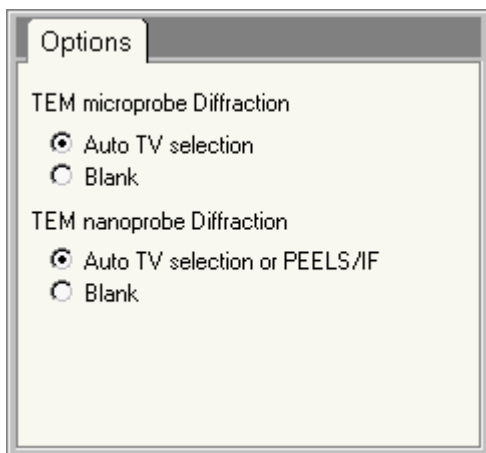
*The Detector Configuration Options Control Panel.*

The Detector Configuration Options Control Panel allows selection of a number of settings pertinent to the detector configuration. The options control the action of the detector configuration in diffraction when a TV camera is present on the system (Note: this applies to a TV-rate camera without any protection of its own; Slow-scan cameras normally have their own protection that keeps the shutter closed unless an image or diffraction pattern is being acquired). Since diffraction patterns can have very intense beams, there may be some concern with regard to possible damage of the TV scintillator or fiber optic. With the detector configuration options, the user can choose to have the beam blanked automatically when the screen is lifted in diffraction mode.

**TEM Microprobe diffraction**
The TEM Microprobe diffraction radio buttons choose between Auto TV selection (the diffraction pattern is allowed to fall on the TV camera) and blank (the microscope shutter - below the specimen - is closed).

**TEM Nanoprobe diffraction**
The TEM Nanoprobe diffraction radio buttons choose between Auto TV selection or PEELS/IF (the diffraction pattern is allowed to fall on the TV camera or the PEELS or Imaging Filter) and blank (the microscope shutter - below the specimen - is closed).

# 14  Direct alignments
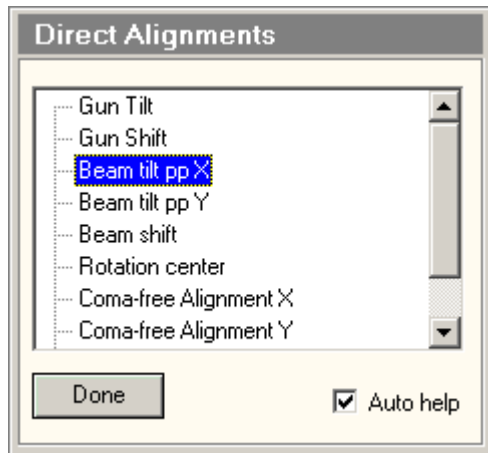


*The Direct alignments Control Panel.*

The Direct Alignments Control Panel offers access to the microscope's direct alignments. In addition to the alignment procedures where the operator is taken through a set of alignments in a structured way, the TEM microscope provides (rapid) access to a restricted set of direct alignments. In contrast with the procedures, direct alignments do not switch the microscope to predefined states but instead are applicable to the current microscope state. The direct alignments are shown in a list. Which alignments are available depends on the microscope mode.

Alignments are stored immediately (in the registry, not a file) when Done is pressed or the Direct Alignments control panel is closed (e.g. by going to another tab). Note that the storage is not into a file. For storing into a file (Supervisor, Service or Factory only) you will need to go to the File tab of the Alignment Control Panel. <u>Normal microscope users cannot store alignments in standard alignment files. Instead the user can store the alignments done, together with all other relevant settings in FEG Registers.</u>

A few rules:
- You do not change any alignment by activating it (but activating an alignment may reset a user setting like user beam shift). Only when you change a setting with the Multifunction knobs, do you change alignments. Changes become operational immediately. They are stored when the alignment is exited (Done).
- Direct alignments may differ depending on the level of user, with experts and supervisor levels having more alignments accessible than users.
- All direct alignments have on-line help pages that describe the purpose and operation of the particular alignment. Press F1 while a direct alignment is active and the proper page should come up.
- You can move to another control panel as long as you stay within the current tab (you can also pop-up panels on the lower right), but if you move to another tab, then the alignment is exited.

**Direct alignment selection**
Selection is done in the list of alignments. Click on a direct alignment to activate it.

**Done**
Switches alignment off and saves alignments in registry.

**Auto help**
When the Auto help function is on, the on-help topic for the particular subprocedure is displayed automatically alongside (and also updated when a new subprocedure is started).

## 15 EDX
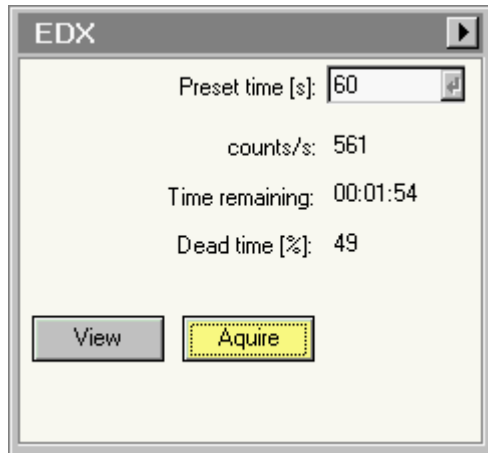


*The EDX Control Panel.*

In the EDX Control Panel the controls for (single) EDX spectrum acquisition are located.

**Preset time**
The Preset time sets the acquisition time for the currently active acquisition mode (View, Acquire).

**Count/s**
During acquisition the count rate (in counts per second) is displayed.

**Time remaining**
During acquisition the time remaining before acquisition is finished is displayed.

**Dead time**
During acquisition the detector dead time is displayed. At high dead times the background of the label becomes red, otherwise it is green.

**View**
Pressing the View button:
- When the button is gray, switches the EDX acquisition settings to those of the View mode and starts acquisition.
- When the button is yellow, pauses EDX acquisition.
- When the button is white, resumes EDX acquisition (but starting with a new spectrum) if possible. If the start command could not be given to TIA, the button will remain white.

By definition View is continuous acquisition.

**Acquire**
Pressing the Acquire button:
- When the button is gray, switches the EDX acquisition settings to those of the Acquire mode and starts acquisition.
- When the button is yellow, stops EDX acquisition.
- When the button is white, resumes EDX acquisition (but starting with a new spectrum) if possible. If the start command could not be given to TIA, the button will remain white.

By definition Acquire is single acquisition.

**Flap-out**
Pressing the arrow button displays the flap-out with the EDX Settings Control Panel.

## 15.1 EDX settings
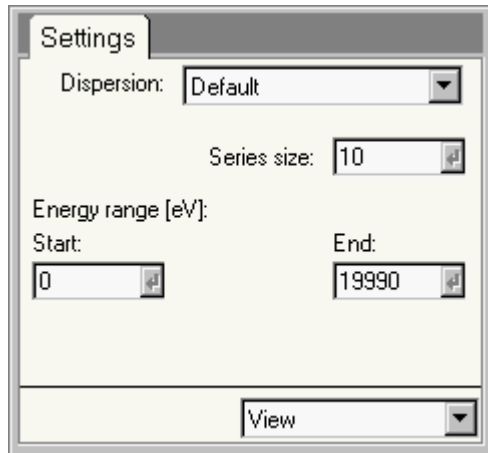
*The EDX Settings Control Panel.*

In the EDX Settings Control Panel the EDX acquisition parameters are defined.

**Dispersion**
The drop-down list contains the accessible dispersion settings for the EDX detector (depend on the type of EDX detector present). This list corresponds to the list of the More EDX Dispersions tab in TIA.

**Series size**
Under series size the size of the acquisition series for the currently active acquisition mode is set. Please note that for Acquire, the series size doesn't do anything unless the TIA option "Reuse display window" is active.

**Energy range**
The Start and End values define the start and end energy (in electronvolt) of the spectrum.

**Acquisition mode**
In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and by pressing the equivalent button in the main control panel is that the drop-list selection selects the mode but does not automatically start acquisition.

# 16 Experiments
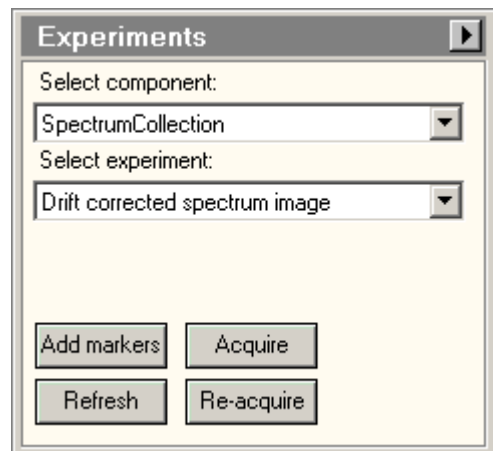


*The Experiments Control Panel.*

In the Experiments Control Panel several types of experiments are controlled. For the tomography experiments, please see the tomography documentation. This section deals with the spectrum collection experiments.

The spectrum collection experiments are based on a STEM image. In the STEM image you define lines or areas where you can collected various types of data, depending on the types of hardware present. For each of the experiments, you define which settings and detectors to use in the Settings flap-out of the control panel.

**Components**
The drop-down list allows selection of a type of experiment component (spectrum or CCD diffraction-pattern acquisition).

**Experiments**
The drop-down list allows selection of a type of experiment.

**Add markers**
To make sure the proper markers are present in the STEM image, you press the Add markers button. This will have the following effects:
- If the proper markers are already present (recognized on the basis of marker style or name), nothing will happen. The one exception is in the case of a "Spectrum positions" or "Drift-corrected spectrum positions" experiment. Pressing Add markers will always add a new spectrum position marker to the image (the drift correction area marker will only be added once, if necessary).
- If one or more required markers are not found, new markers will be added to the image.
- If markers were present and recognized as such but originally had the wrong name or style, the name and style of the markers will be changed.

**Acquire**
Pressing the Acquire button :
- When the button is gray, start the experiment acquisition.
- When the button is yellow, stops the experiment acquisition.
- When Acquire is used and the current display window had already been used before for experiment acquisition and "Reuse display window" is not checked, a copy is made of the current display window and the acquisition is done in the copy.

**Refresh**
Pressing the Refresh button restarts acquisition of the main STEM image (using the conditions defined for the currently active mode in the STEM Imaging control panel; thus it can happen that you used Acquire for the image initially, but if in the meantime you used Search, the Search conditions - but single

frame) will be used). This function allows a refresh of the STEM image so you can check that all markers are still in their correct positions before really starting the experiment.

**ReAcquire**
Pressing the ReAcquire button :
- When the button is gray, start the experiment acquisition.
- When the button is yellow, stops the experiment acquisition.
- When ReAcquire is used the acquisition is done in the current display window (thus overwriting what had been acquired before).

**Flap-out button**
Pressing the flap-out button leads to the flap-out with the Settings control panel.

## 16.1 Experiment behavior - Reuse display window or not

The behavior of the spectrum collection experiments depends on the way you handle the actual acquisition. The two extreme cases are:
Each new experiment is recorded in a completely new display window (tabs in TIA). Acquiring another one means that the last experiment display window is copied and the new acquisition is done in that copy. For this case, use the Acquire function in the control panel.
Each new experiment is recorded always in the same display window. No new display windows are created. For this case, use the Refresh and ReAcquire functions.

## 16.2 Using existing display windows as a template

You can use existing display windows (e.g. saved and re-opened) as a template for acquiring experiment data. Make sure that the template and current experiment selection match, and with the template display window selected use the Refresh function to re-acquire the STEM image, reposition the required markers and then either Acquire or ReAcquire.

## 16.3 Available experiments

Currently the experiments cover :
- Spectrum positions - acquire the chosen signals for the positions defined in the STEM image by beam-position markers ✛ .
- Spectrum profile - acquire the chosen signals for a user-defined number of positions along a line marker in the STEM image.
- Spectrum image - acquire the chosen signals for a user-defined number of X, Y positions in an image-selection marker in the STEM image.
- Drift-corrected spectrum time series - acquire a series of chosen signals for the position
- Drift-corrected spectrum positions - acquire the chosen signals for the positions defined in the STEM image by beam-position markers ✛ with drift correction at user-defined intervals. If more than one beam-position marker is present in the image, the last one visited is kept and the other ones removed.
- Drift-corrected spectrum profile - acquire the chosen signals for a user-defined number of positions along a line marker in the STEM image with drift correction at user-defined intervals.
- Drift-corrected spectrum image - acquire the chosen signals for a user-defined number of X, Y positions in an image-selection marker in the STEM image with drift correction at user-defined intervals.

**Note:** Before an experiment can be started, you must at least once have acquired a STEM image. When you select a profile or image experiment, the required markers will automatically be placed in the STEM image if they are absent.

## 16.4 Drift correction

For drift correction the experiment will repeatedly acquire a STEM image and measure the shift relative to a similar image acquired at the start of the experiment. Any shift detected is compensated (with the scan signal, not the DC beam shift). The compensation is limited to the area covered by the starting image (STEM magnification). If high drift is encountered, reduce the STEM magnification, if possible, to have the STEM range cover a larger area.

In order to make it easy to recognize the markers, they will be given different styles (in previous versions the markers were always the default style, typically thin red). In the current version the data positions are distinguished by a thick orange style (e.g. the data collection are in the image below is inside the orange box), while the drift correction area typically is distinguished by a thick yellow style.
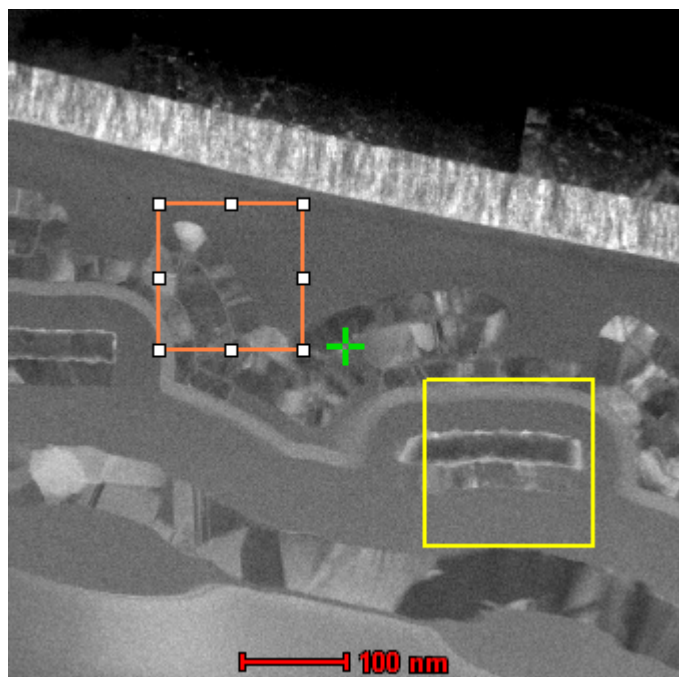


The markers also have distinctive names, but this is not essential. E.g. if you add markers manually and you give them the required style, TIA will recognize them. Also, if you change the names according to the default, TIA will also recognize them.
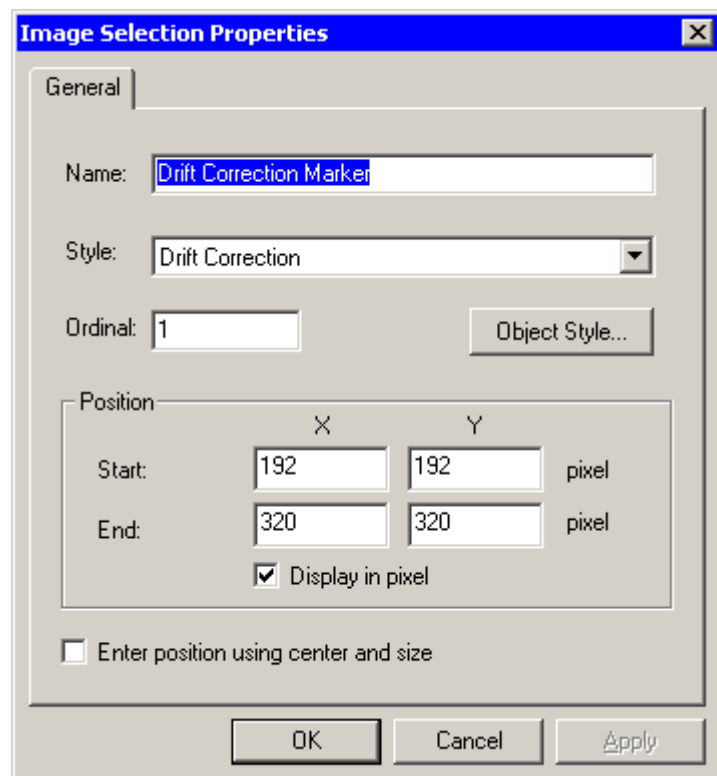
If you do not like the style of the markers (e.g. in the image you typically have, the colors chosen are not well visible), you can change the style of the markers (double-click on the marker or right-click and select properties). If you go through Object Style, only the properties of the selected marker will be changed.
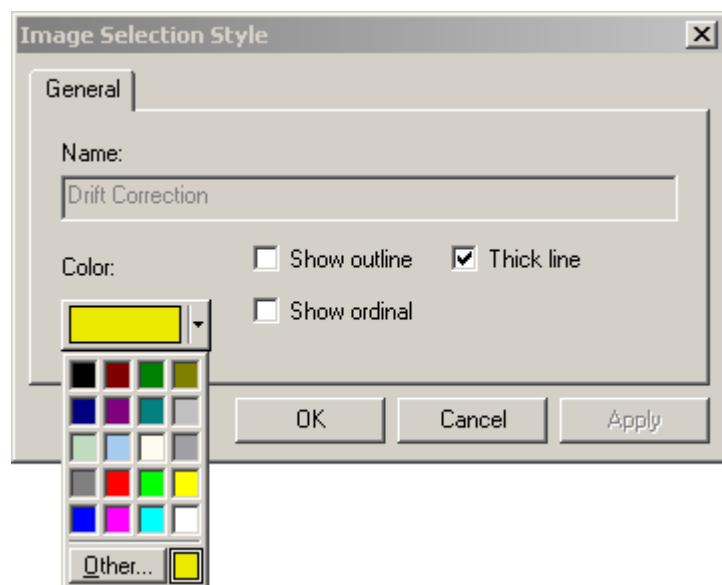
If you want to change the style of the markers persistently, go to TIA Analysis mode and in the menu select Edit, Styles. Find the required type of the marker in the dialog and select the marker style. Through Properties you can adjust the style.
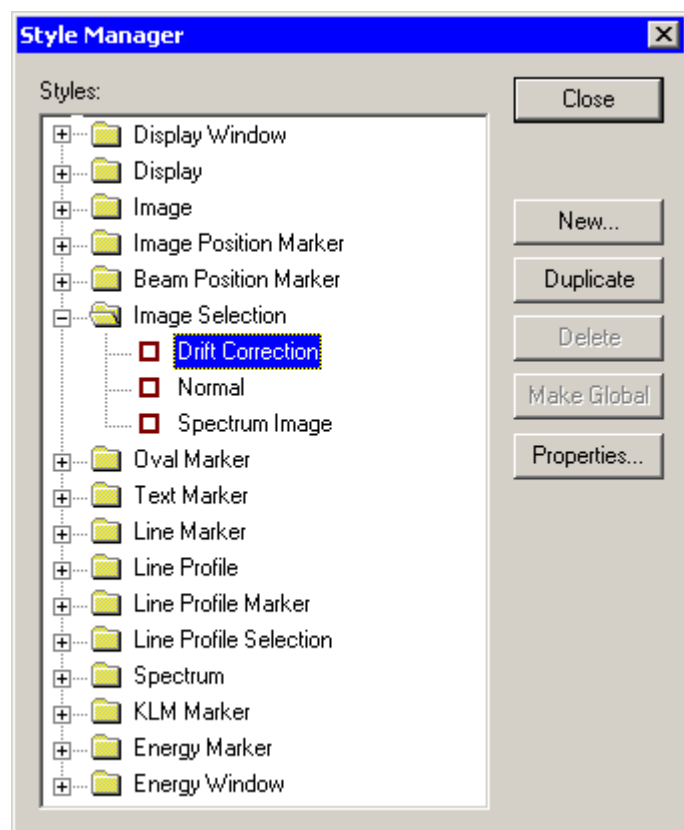


**Note:** Spectrum position experiments with drift correction will move the beam back to the 1st marker when it performs the cross-correlation to determine drift. This could damage your specimen at the 1st marker position when your specimen is beam sensitive. To avoid this, put the 1st marker at a position which is less important.
For non-position (line, area) experiments: Use a beam position marker to define the rest position.

For additional information, please also refer to the TIA manual (TIA.pdf)

## 16.5    Experiments Settings
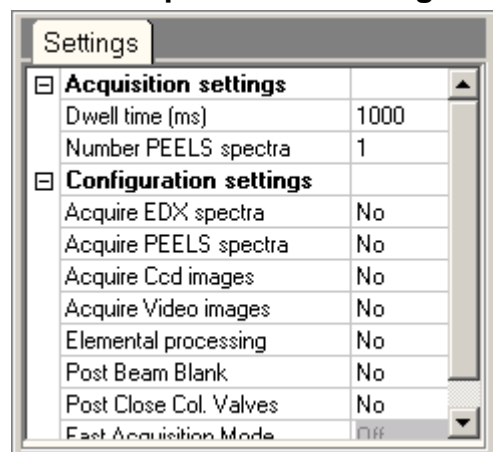


*The Experiments Settings Control Panel.*

**Note:** The Settings remain empty until a TIA experiment has been selected in the main control panel. Settings do not apply to Tomography experiments.

In the Experiments Settings Control Panel the acquisition parameters for the experiment are defined. The settings are displayed in a so-called property editor. This is a two-column grid, listing the setting on the left-hand side and its value on the right-hand side. You can change the settings by clicking on the value. Sometimes you have to type in a number or other setting. In the case where a limited selection is possible (for example with Yes or No) a small down arrow on the right-side allows selection of the one of the possibilities. Setting changes are updated as soon as you move to another setting value (e.g. by pressing the down or up arrow). Settings are grouped under headers (like Acquisition settings). You can open or close a group by clicking on the + or - sign to the left of the group name. Settings that are grayed out are disabled under the current combination of settings selected.

There are three categories of settings:
*   Acquisition settings, which differ for spectrum positions, line profiles and images.
*   Configuration settings.
*   Correction settings.

### 16.5.1      Acquisition settings

### 16.5.1.1    Spectrum position acquisition settings
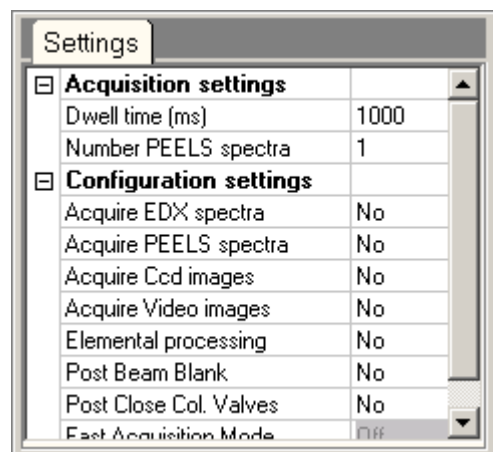
| Settings | |
|---|---|
| **⊟ Acquisition settings** | ▲ |
| Dwell time (ms) | 1000 |
| Number PEELS spectra | 1 |
| **⊟ Configuration settings** | |
| Acquire EDX spectra | No |
| Acquire PEELS spectra | No |
| Acquire Ccd images | No |
| Acquire Video images | No |
| Elemental processing | No |
| Post Beam Blank | No |
| Post Close Col. Valves | No |
| Fast Acquisition Mode | Off ▼ |

**Dwell time**
The amount of time in milliseconds used to collect the signal(s) at each point.

**Number of PEELS spectra**
How many spectra are to be acquired within the dwell time set (these spectra are added together).

### 16.5.1.2    Spectrum profile acquisition settings

| Settings | |
|---|---|
| **⊟ Acquisition settings** | ▲ |
| Profile size | 100 |
| Dwell time (ms) | 1000 |
| Number PEELS spectra | 1 |
| **⊟ Configuration settings** | |
| Acquire EDX spectra | No |
| Acquire PEELS spectra | No |
| Acquire Ccd images | No |
| Acquire Video images | No |
| Acquire STEM image(s) | No |
| Elemental processing | No |
| Post Beam Blank | No ▼ |

**Profile size**
The number of points along the profile line.

**Dwell time**
The amount of time in milliseconds used to collect the signal(s) at each point.

**Number of PEELS spectra**
How many spectra are to be acquired within the dwell time set (these spectra are added together).

| Settings | |
|---|---|
| ☐ **Acquisition settings** | |
| Image size (X) | 50 |
| Image size (Y) | 50 |
| Fixed direction | none |
| Dwell time (ms) | 1000 |
| Number PEELS spectra | 1 |
| ☐ **Configuration settings** | |
| Acquire EDX spectra | No |
| Acquire PEELS spectra | No |
| Acquire Ccd images | No |
| Acquire Video images | No |
| Acquire STEM image(s) | No |

## 16.5.1.3    Spectrum image acquisition settings

**Note:** The spacing between the acquisition positions is identical in both (X and Y) directions.

**Image size X**
The number of points in the image in the horizontal direction.

**Image size Y**
The number of points in the image in the vertical direction.

**Fixed direction**
X, Y or none. If either X or Y is chosen, that direction is made the same as the other (so the image automatically stays square). In case of one, the image selection marker size is adjusted to reflect the X and Y dimensions whenever you change a dimension in the control panel (there is no feedback from the marker back into the control panel).

**Dwell time**
The amount of time in milliseconds used to collect the signal(s) at each point.

**Number of PEELS spectra**
How many spectra are to be acquired within the dwell time set (these spectra are added together).

## 16.5.2      Configuration settings

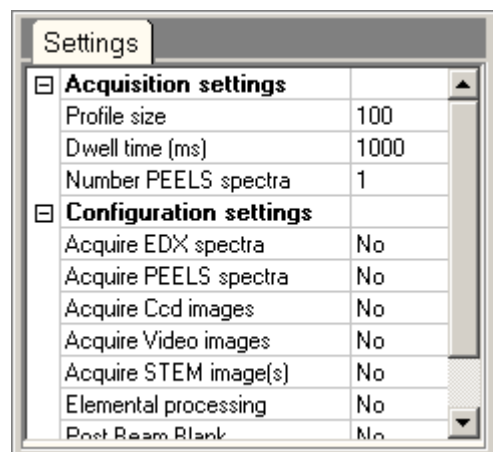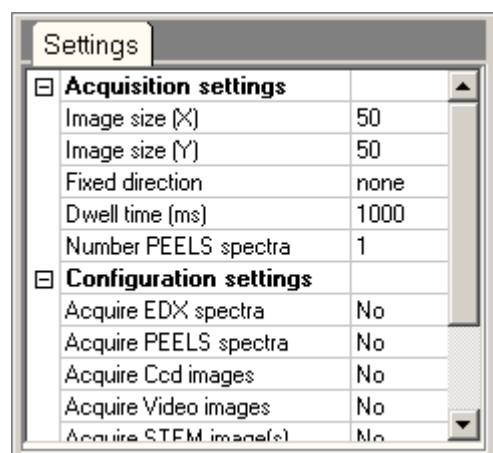| Settings | | |
|---|---|---|
| □ **Configuration settings** | | ▲ |
| Acquire EDX spectra | No | |
| Acquire PEELS spectra | Yes | |
| Acquire Ccd images | No | |
| Acquire Video images | No | |
| Acquire STEM image(s) | No | |
| Elemental processing | No | |
| Post Beam Blank | No | |
| Post Close Col. Valves | No | |
| Fast Acquisition Mode | Off | |
| Run buffer when starting slice | | |
| □ **Correction settings** | | ▼ |
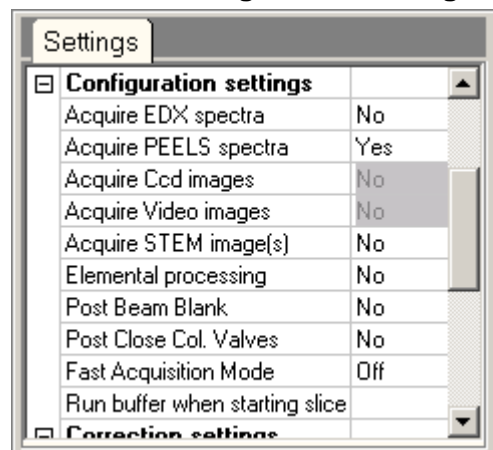
**Note:** Some acquisition settings are mutually exclusive because they make use of detectors that are located at different physical locations, where one detector (e.g. a CCD) blocks the view of the other (e.g. PEELS) or a detector is used for more than one type of data and only one can be selected at a time (e.g. an Imaging Filter CCD to acquire diffraction patterns as well as PEELS spectra). Excluded detectors are shown disabled (grayed).

**Acquire ... spectra, images**
For each of the available detectors, select Yes or No. Remember that CCD image acquisition means you are recording diffraction patterns. Also be aware that CCD images contain a lot of data and that large CCD image sizes (as defined in the CCD/TV control panel for the Acquire mode) for a large number of point may exceed TIA's capacity to handle them.

**Note:** Depending on the number of detectors selected as well as any processing active during acquisition, it may happen that TIA cannot keep up with acquisition and processing at the same time. In that case acquisition may become unreliable (the beam doesn't move any more after moving a few pixels along a scan line - you can observe this because e.g. the spectrum or STEM image signal remains the same except for some noise variation, or by going out of diffraction and observing the movement of the beam on the fluorescent screen or flu cam). Either increase the dwell time so TIA has more time or remove some of the processing or signals (e.g. STEM detector).

**Elemental processing**
When Yes is selected, elemental processing based on energy windows in EDX or EELS spectra will be done. See the note above.

**Post Beam Blank**
When Yes is selected, the beam will be blanked when the experiment has finished. You can use this function to safeguard the specimen integrity (the beam will no longer be on the specimen) after a time-consuming experiment run unattended or overnight.

**Post Close Col. Valves**
When Yes is selected, the microscope's column valves are closed when the experiment has finished. You can use this function to safeguard the microscope and specimen integrity after a time-consuming experiment run unattended or overnight.

**Fast Acquisition Mode**
The Fast Acquisition Mode options determines how the CCD (or Enfina) is controlled. Single acquisitions (Start single acquisition and wait for it to stop; then start a new acquisition) generally run more slowly than continuous acquisition where TIA decides to match each image or spectrum received with a beam position.
Available settings are:
- Off : For each point a new single image or spectrum acquisition is started.
- On : CCD or Enfina acquisition runs continuously. At each point the image or spectrum is used where the whole acquisition took place while the beam was in its proper position.
- Int. : CCD or Enfina acquisition runs continuously. At each point the first available image or spectrum is used so the data may have been collected while the beam was moving.

In its most simple Int. will be faster than On which will be faster than Off.

Typical deviating situations:
- For longer exposure times (several seconds) Off may actually be faster than On because it doesn't need to wait for the current frame to finish acquisition.
- Dose considerations: in either On or Int. the acquisition runs continuously so if beam blanking is used for shuttering, the specimen is exposed continuously to the electron beam while for Off it is exposed only during the actual exposure.

**Run buffer when starting slice**
This option controls the running of the buffer cycle. You can choose between Never (the experiment will not start a buffer cycle) and If req. (if required: the experiment will start a buffer cycle if the pressure in the buffer tank is such that the vacuum system thinks a buffer cycle is needed).

### 16.5.3      Correction settings
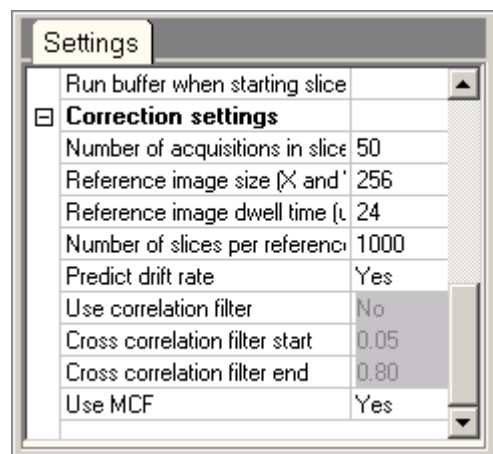


**Number of acquisitions in slice**
A slice is the period between successive checks of the drift, so the number of acquisitions in the slice is the number of data acquisitions done before a new drift check is done.

**Reference image size**
The size in pixels of the reference image.

**Reference image dwell time**
The dwell time in microseconds used for (STEM) acquisition of the reference image.

**Number of slices per reference**
The slices per reference parameter defines the number of drift correction measurement cycles after which the drift correction data base is reset (it is always reset as well at the start of an experiment).

**Predict drift rate**
When the Predict drift rate is selected, the drift correction will apply a drift correction to individual spectra within a drift correction slice on the basis of the historically measured drift rate (otherwise the drift correction is applied once per slice).

**Use correlation filter**
Determines whether the next parameters are to be used. Only available for the standard cross-correlation (Use MCF is No).

**Cross-correlation filter**
The start and end parameters of the cross-correlation filter define two settings used to filter the drift-correction images. The filtering is used to make drift measurement more reliable. The filter is a band-pass filter that removes the low and high frequencies from the image. Cutting off the low frequencies is important because they do not contribute to accurate drift measurements (the distances they represent are too large) and they can lead to erroneous cross-correlation peak measurements. The high frequencies are generally dominated by noise and thus only cause imprecision in the drift measurement. In general the settings are only important for noisy images, where some adjustment may be necessary for drift measurement to work. If (in exceptional cases) there is only low-frequency contrast (e.g. only a single grain boundary visible), it may be necessary to adjust the Start parameter down.

**Use MCF**
The MCF (Mutual Correlation Function is a modified cross-correlation that is better at handling images from specimen with repeating features - like high-resolution images or low-magnification images of cross-gratings). If necessary, you can switch the cross-correlation type to be used from normal to MCF.

# 17 Falcon Protector Status



*The Falcon Protector Status Control Panel.*

**Introduction**

The Falcon camera is a direct-electron detection camera : it is directly exposed to the electron beam so instead of converting electrons to light with a scintillator (the normal way of using TEM cameras), the electrons themselves are detected. The major advantage of direct detection is that the signal is much better defined because there is no spreading of electrons in the scintillator and adjacent assemblies. The disadvantage is that high-electrons damage the camera. The damage to the camera has been limited by hardening the detector, but still it is possible to damage the camera by seriously overdosing (e.g. with a focused electron beam). In order to protect the camera against such overdoses, a special protection function controls the use of the camera.

The Falcon Protector becomes active when the Falcon camera is inserted into the beam. There are two sources of information on the Falcon Protector status, the Falcon Protector Status control panel and information available in the status information bar of the TEM user Interface.

**Note :** When a problem occurs with the connection to the Falcon camera (see picture below), e.g. the camera is being serviced and not attached to the system anymore, by default, the protector will look at the last known insertion status. If this is not retracted, then it is assumed that the protector needs to be protected (only when dose is too high and flu screen is retracted). If the user is not a service or factory engineer, please contact service.
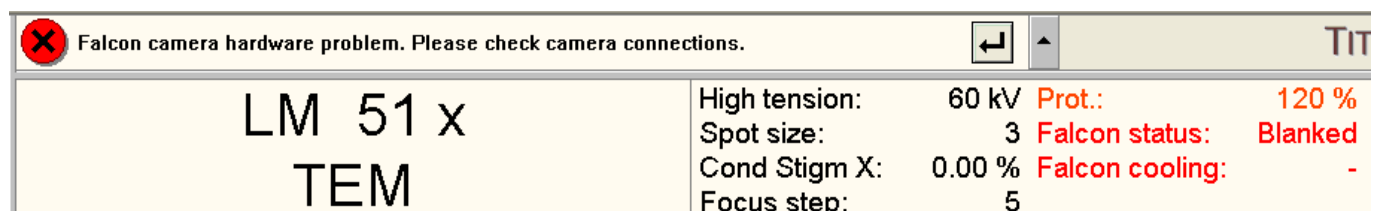


**Status**

The main status field indicates the current status of the Falcon. Its background is green if the status is safe, otherwise it is red.

**Hardware status**

The hardware status indicates the status of the Falcon camera itself.

**Falcon dose limit**

The Falcon dose limit either indicates a dose (a percentage of the allowed dose on the camera) or other information in case the dose cannot be determined.

**Information**

The information field presents more detailed information.

**Flapout**

The flapout button leads to the Hardware and Calibration tabs of the Falcon Protector Status Control Panel.

## 17.1  Protector Status

Overall protector status can be:
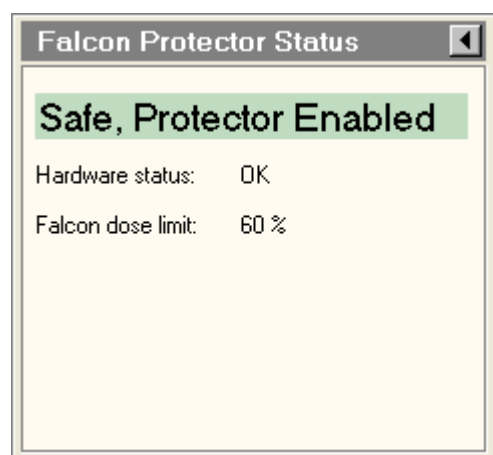
Safe, Protector Enabled : The protector is keeping track of safety, and no actions are taken.
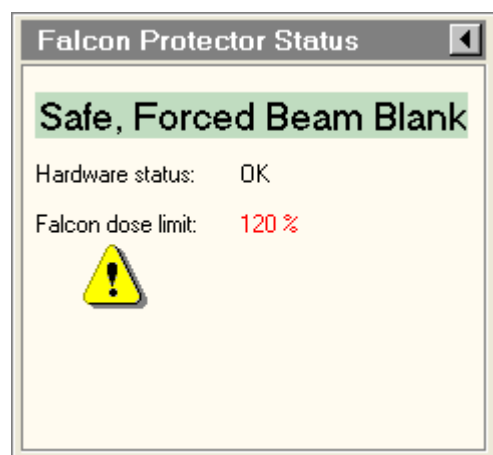
Safe, Forced Beam Blank : The protector is blanking the beam using the post-specimen shutter.

**Falcon Protector Status** ▶

**Protector not active**

Hardware status:    OK

Falcon dose limit:   Calculation error

⚠️
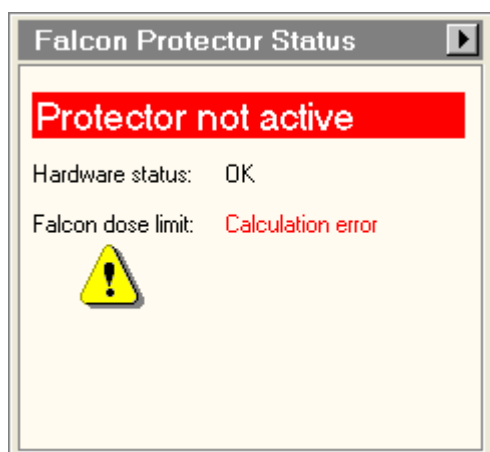
Protector not active : when protector is switched off (will only happen during specific tasks to allow higher dose usage).

**Falcon Protector Status** ▶

**Error, Retract falcon**

Hardware status:    Error

Falcon dose limit:   120 %

⚠️
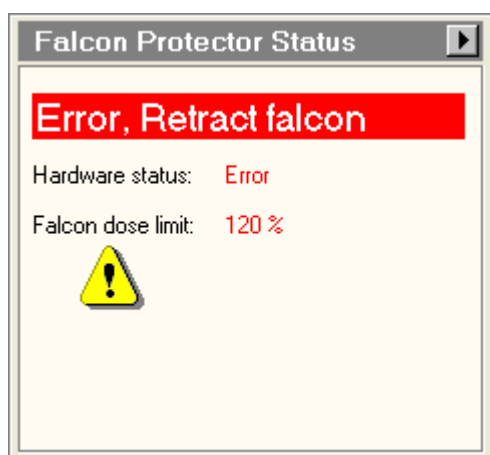
Error, Retract Falcon camera: when something goes wrong with the system (e.g. blanking is not working) and protector is not able to protect the Falcon camera.

**Falcon Protector Status** ◀

**Safe, Protector Enabled**

Hardware status:   Check Falcon insert

Falcon dose limit:   80 %

⚠️
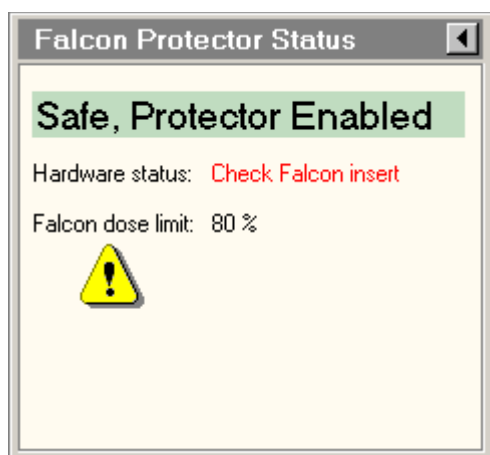
Hardware status unknown :
When the Falcon has not been initialized or a hardware error has occurred. Insert and retract the Falcon to allow the system to determine its hardware status.
In that case the status and last known insert status will both be unknown, as shown in the hardware tab of the flap-out.

| Hardware | Calibration | Service |
| --- | --- | --- |

Forced blanking:            Off

┌ Falcon ──────────────────────┐
Status:                    Unknown
Last known insert status:   Unknown
└──────────────────────────────┘

FluScreen:                 Inserted
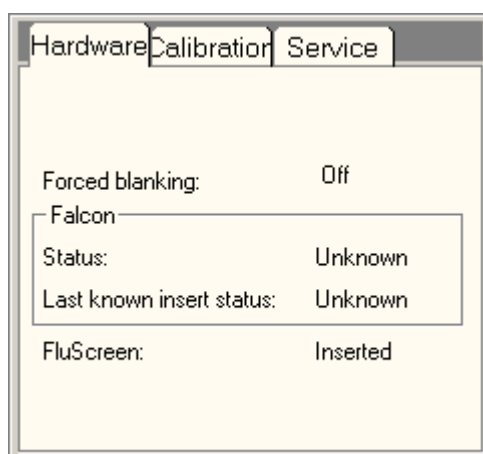
## 17.2 Falcon dose limit

This dose limit shows whether current conditions would be ok to acquire images with the Falcon, even when the Falcon is not in the beam. The percentage shown is the percentage of the maximum allowed dose suited for the Falcon. The number becomes red in case a percentage bigger than 100% is shown, indicating that this is a dose which is too high to be able to acquire images with the Falcon.

When the dose cannot be calculated the following will be shown:



Configuration not supported : In case a Falcon is installed on a system that is not supported.

Unsupported configurations are Probe corrector (Titan) and/or Monochromator.
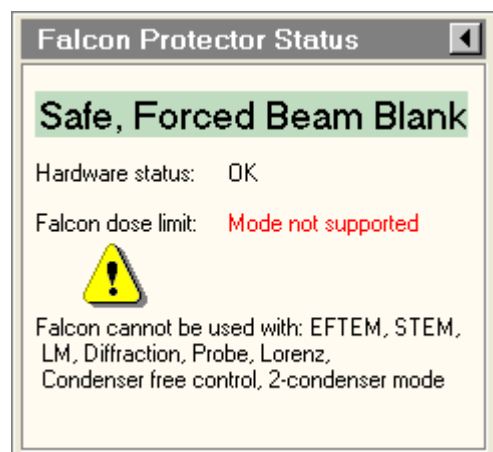


Mode not supported : In case a mode is chosen that is not supported for Falcon.

Unsupported modes are: EFTEM, STEM, LM, Diffraction, Nanoprobe (Talos), Probe (Titan), Lorenz, Condenser free control (Titan), 2-condenser mode (Titan).
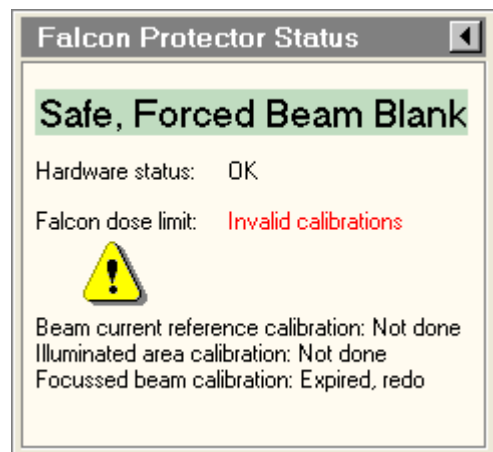


Invalid calibrations : In this case dose cannot be calculated because calibrations are not valid.

Calibration details can be found in the calibration tab, or in the guidance area of the main panel.
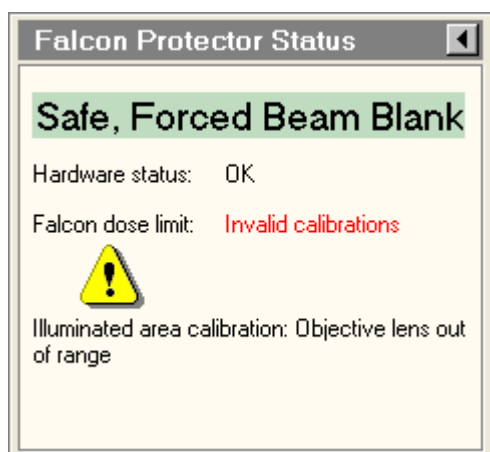
Invalid calibrations : Objective lens out of range.

The range of usable objective-lens settings is limited to 10 or 20 μm overfocus (dependent on the mode) and 220 μm underfocus. These ranges are defined by the focus setting for eucentric focus defined during the calibration procedures.
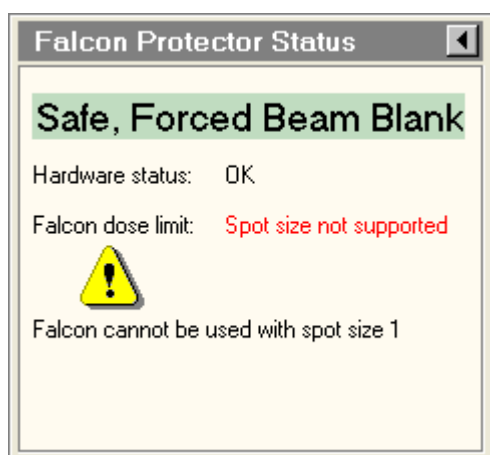


Titan only : Spot size not supported: In case spot size 1 is selected (spot size 1 is not supported).
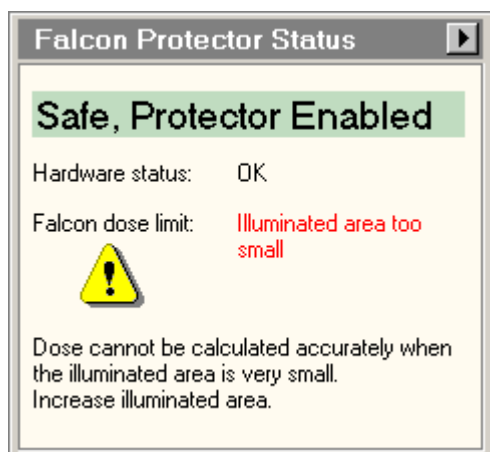


There is a lower limit to the absolute size of the estimated illuminated area. In order to prevent problems resulting from calibration inaccuracies, the illuminated area must have at least a certain minimum size. On the Titan this is a fixed value, while on the Talos it depends on the magnification (the higher the magnification, the larger the uncertainty and the larger the illuminated area must be).
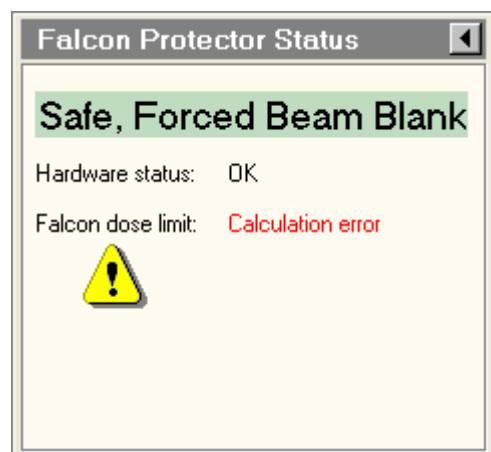
Calculation error : In case dose estimation went wrong because state of unknown calibration state.

## 17.3  Status information bar

There are status items available in the status area of the Microscope User interface to show protector related status. Right-clicking in the status area gives the option to make the status items **Falcon status**, **Protector** and **Falcon cooling** visible.
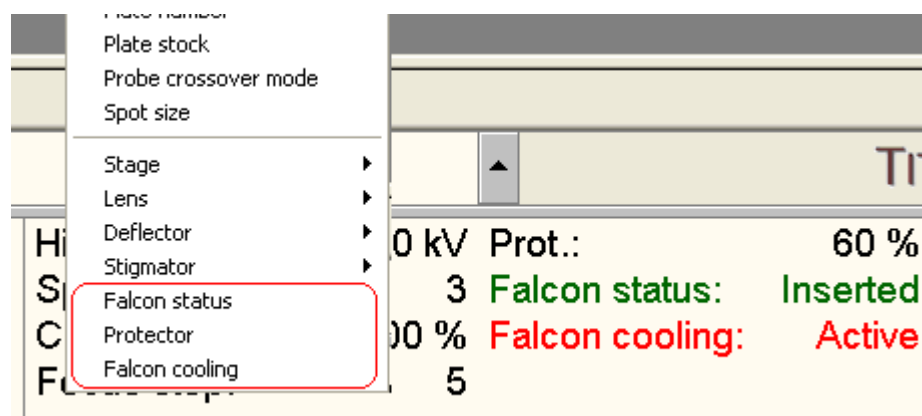


Labels of these status items will be shortened in case available text space is too small for the full label. An example of the short labels is shown here.

The **Falcon status** item shows :

Fluscreen : when fluscreen is inserted

Inserted/Retracted : when fluscreen is retracted, and protector is not blanking

Blanked : when protector is blanking

Unsafe : when protector is switched off

The **Protector** item shows :

The percentage of the maximum allowed dose on the Falcon in green or red, in case dose can be calculated (green when dose is ok, red when dose is not ok). The number is shown even when column valves are closed, Falcon is retracted and/or flu screen is inserted. This shows the same value as is shown on the main panel of Falcon Protector Status (Falcon dose limit).

Change mode : Is shown when a mode is chosen that is not supported for Falcon (not supported modes are: EFTEM, STEM, LM, Diffraction, Nanoprobe (Talos), Probe (Titan), Lorenz, Condenser free control (Titan), 2-condenser mode (Titan)).

Change spot : Is shown when spot size 1 is selected (spot size 1 is not supported - Titan only).

Change focus : Is shown when objective lens current is too far off from the value used during calibration. Adjust focus or redo calibration.

Bad config : Is shown when a Falcon is installed on a non supported system configuration (not supported configurations are Probe corrector  (Titan) and/or Monochromator)

Do calibration : Is shown when a calibration is not valid anymore; for specific reasons, look in the Calibration tab of the Falcon Protector Status.

? : Is shown when the protector is not active; No information can be given related to valid modes, configurations, calibrations or estimated dose.

## 17.4 Falcon Protector Status Hardware
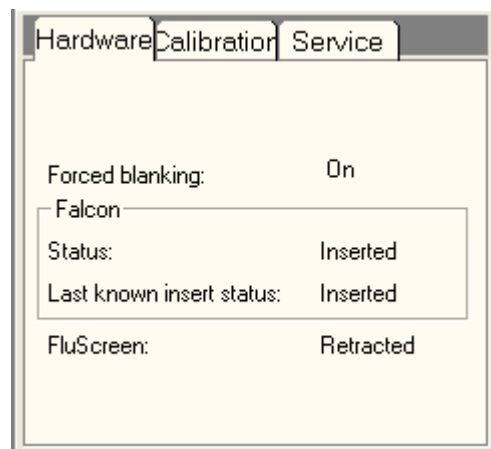
The Hardware Control Panel gives more details on the hardware status of the Falcon camera.

**Forced blanking** : Is the protector blanking or not; possible values:
1. Off: forced blanking using post-specimen shutter is not active
2. On: forced blanking using post-specimen shutter is active
3. Undefined: there is a problem with the communication to the post-specimen shutter; current state cannot be determined anymore

**Falcon Status** : Inserted/Retracted or Error in case there is a communication error with the camera (e.g. may happen when Tia is stopped); possible values:
- Inserted
- Retracted
- Inserting
- Retracting
- Error

**Falcon last known insert status** : In case communication with camera is not possible, the Last known insert status is used by the protector to determine final protection state. (If camera is retracted the protector will not have to blank); Possible values are the same as the Falcon Status values

**Fluscreen** : shows insertion state of the flu screen. If flu screen is inserted, the protector will not have to blank (since it will block the Falcon). Possible values:
1. Inserted
2. Retracted
3. Inserting
4. Retracting
5. Error

## 17.5 Falcon Protector Status Calibration

| Hardware | Calibration | Service |
| --- | --- | --- |

Calibrations are performed in the
"Falcon Protector Calibration" panel

Beam current ref. OK

Illuminated area: OK

Focused beam:  OK
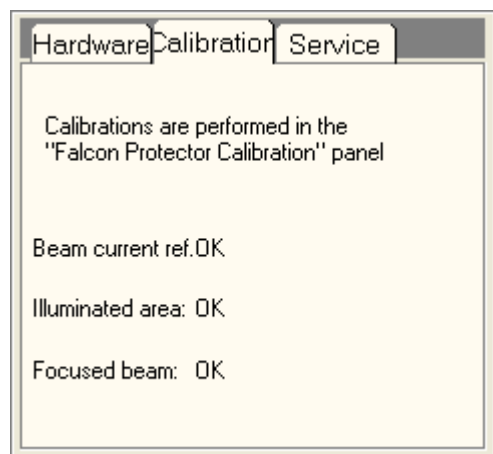
The Calibration Control Panel gives details on the current status of the calibrations. For more information, see the Falcon Protector Calibration Control Panel.

# 18 Falcon Protector Calibration



*The Falcon Protector Calibration Control Panel.*

**Introduction**
The Falcon camera is a direct-electron detection camera : it is directly exposed to the electron beam so instead of converting electrons to light with a scintillator (the normal way of using TEM cameras), the electrons themselves are detected. The major advantage of direct detection is that the signal is much better defined because there is no spreading of electrons in the scintillator and adjacent assemblies. The disadvantage is that high-electrons damage the camera. The damage to the camera has been limited by hardening the detector, but still it is possible to damage the camera by seriously overdosing (e.g. with a focused electron beam). In order to protect the camera against such overdoses, a special protection function controls the use of the camera.

**Note:** Because of the potential for damage the Falcon camera is not a general-purpose camera. Another camera is always present on the system for that. Always remember to use that other camera unless the Falcon is needed for a specific purpose (high resolution, high sensitivity, low dose conditions).

## 18.1 Falcon protection principles
The protection of the Falcon is based on a number of principles that combine safeguards against damage with ease of use. These principles are described below.
- The protection software checks a number of system settings that are inherently safe: column valves are closed, Falcon is retracted, high tension or FEG are off, main screen is down. In those cases the protection takes no action.
- The operational mode of the Falcon is the HM image mode (Microprobe and Nanoprobe). The use of the Falcon is limited by the dose on the camera as described below.
- In modes where the Falcon cannot be used but the mode itself is a logical extension of the HM image mode, the Falcon will not be retracted but the beam will be blanked and the Falcon will not be able to acquire images. This applies to LM image mode (e.g. to check specimen positions) or diffraction (to check e.g. on the objective aperture).
- In all modes where the Falcon is obviously not the camera to be used, the Falcon will be retracted (if it was inserted). During retraction the beam is blanked. This applies to modes like EFTEM (the CCD of the Filter would be the one to use), STEM (if you want to record diffraction patterns, use another camera), Lorentz mode, the illumination mode other Titan other than the Parallel mode, etc.

### 18.1.1 Working with the HM image mode

It is not really practical to check each optical setting (e.g. on another camera) before it can be used with the Falcon, so the Falcon protection relies on some principles to make sure the optical settings are compatible with the use of the Falcon. The protection system relies on an estimation of the electron dose on the Falcon based on the beam current and the size of the electron beam. If the calculated dose is less than the allowed value, the Falcon can be used. If the dose is higher, the beam will be blanked if the Falcon would otherwise be exposed to the beam and no acquisition can be done.

The size of the electron beam (on the Falcon, not on the specimen) is calculated from a number of optics settings in combination with three calibration procedures:
- Illuminated area
- Focused beam for all spot sizes
- Beam current

The results of the calibrations for 1 and 2 are stored, with each calibration being specific for high tension, FEG extraction voltage and gun lens. If you have different settings, recalibration is needed. The control panel displays a list of available calibrations. The beam current is calibrated repeatedly. It must be done at the start of each session and whenever the protection detects a change in relevant optical parameters like gun tilt.

**Important note :** The calibrations must match with a number of stored optical parameters (which ensures that the calibrations are in fact valid). If the optical parameters do not match, the calibrations must be redone (as practical aside, the whole calibration procedure takes just a few minutes) - or, preferably, load the alignments that match with previous calibration settings.

In general it is best to:
- Use only one or a limited set of gun settings.
- Make sure you use only one alignment file. If necessary store FEG Registers for each setting and set these back.

The Talos illumination system is far simpler and is only dependent on the value of the minicondenser lens.

**Calibrate**
When the Calibrate button is pressed the calibration procedure selected in the list is started (if the button was gray, it will become yellow) or canceled (if the button was yellow).

**Calibration list**
The three possible calibrations, Illuminated Area, Focused beam and current, and Beam current, can be selected from the list. The current selection in the list is the one that should be done for the current system settings. If a calibration that is higher up the list has not been done yet, that will automatically be selected if the selection is changed.

**Instructions**
The instructions list what the user must do to proceed through the calibration procedure.

**Next**
When required, the Next button is used to step through the procedure.

**Flapout**
The flapout button leads to the Settings tabs of the Falcon Protector Calibration Control Panel

## 18.2 Calibration procedures

The essence of the calibration procedure is the prediction of the dose on the Falcon camera so that it is not necessary to inspect the dose every time a setting has changed. To that extent we need to know a few variables :

- The size of the illuminated area (together with the magnification that defines how large the beam is on the Falcon).
- The relations between spot 3 (the spot size as the reference) and the other spot sizes.
- The beam current for a set of defined conditions.

The first two are relatively fixed and can be calibrated once (though after some time the calibrations elapse to make sure that slow system changes do not affect the accuracy of the dose predictions). The beam current can change from day to day. It will also change when the gun tilt alignment is changed. The beam current is therefore always calibrated when the TEM UI is started and must be recalibrated when the gun tilt alignment is changed.

**Note:** Normal users (TEM Users and TEM Experts) can only to the beam current calibration, the other calibrations requires user level of supervisor or higher.
If a user encounters the problem that the optics do not match and an alignment file must loaded, it may happen that the Falcon Protector Calibration control panel does not see the update in status. Change the gun lens one step and back and the panel will recheck the calibrations.

### 18.2.1 Illuminated area

**Titan**
The Titan has a complex illumination system and we have to rely on the optical setting of the illuminated area. However, this setting is strongly dependent on the alignment and inaccurate. The calibration settings that have been stored before must therefore match the current alignment (tip: store the alignment in a file and read it back when needed). Also during the calibration the illuminated area values read out should not deviate significantly from the correct values. If you focus the beam for spot 3 and the illuminated area display value is more than a micrometer different from 0 nm, you will not succeed with the calibration. Also if the focused beam values for the other spot sizes deviate, the calibration (focused beam and current) will not be accepted. You have to redo the condenser calibration and make sure that the values are close to what they should be.

For the alignment :
- Make sure the illuminated area for focused beam is close to 0 nm. If not, redo the condenser alignment.
- If the condenser alignment is correct, the only thing that needs changing when the gun settings (extraction voltage and gun lens) are changed is the gun cross-over alignment (gun procedure).

**Talos**
The Talos illumination system is much simpler and it is sufficient to know the C2 value. The minimum illuminated area on the flu screen is 40 mm with a correction factor for a potential error from the calibration. This means that at a magnification of 50kx, the beam must be larger than 40 mm, at lower magnifications is can be slightly smaller, while at higher magnifications it must be larger (50 mm at 100kx and 130 mm at 500kx).

**Common**
The range of allowed objective lens values is limited. For Titan there are separate ranges for parallel illumination (and spreading) and for condensing. In condensing mode, the size of the electron beam is influenced by the objective lens and you cannot go further underfocus than -20 mm (in parallel you can go to -220 $\mu$m). For Talos there are only upper and lower values and the size of the beam is always influenced by the objective-lens value to the effect is calibrated in addition.

These ranges are separate for Microprobe and Nanoprobe and relative to the eucentric focus defined at the start of the calibration procedure.

**Allowed defocus ranges**
- Titan, Microprobe and Nanoprobe -220 $\mu$m in parallel mode (lower limit), -20 $\mu$m in condensing mode, +20 $\mu$m upper limit.
- Talos Microprobe -220 $\mu$m to +20 $\mu$m, Nanoprobe -200 $\mu$m to +10 $\mu$m.

### 18.2.2  Focused beam and current

The focused beam and current calibration procedure determines the offsets of the focused beam condition and the relative beam currents for all spots relative to spot 3.

### 18.2.3  Beam current

The beam current calibration determines the beam current reference factor. The microscope is switched to a relatively low magnification, largest C2 aperture. Make sure the whole beam is visible on the screen.

## 18.3  Falcon Settings
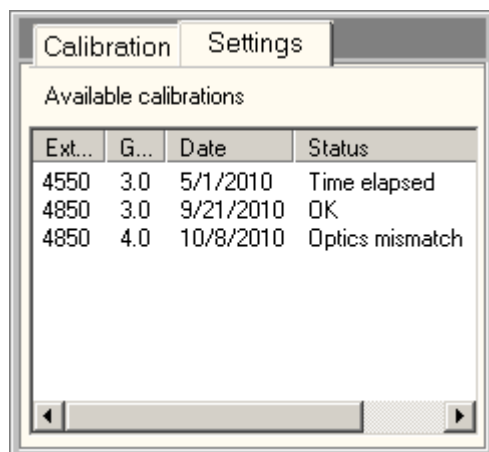


*The Falcon Protector Calibrations Settings Control Panel.*

The Falcon calibrations are specific for high tension, extraction voltage and gun lens setting. If there are no calibrations for the current settings, you can check in the list what is available and change the FEG settings accordingly. Existing calibrations may not be operational because the optical parameters must also match.

Calibrations elapse after a set time. Also calibrations become invalid after a tip change. The status setting of the calibrations (optics no match, elapsed, tip change) is indicated. In the case of non-matching optics you can try to match by loading a suitable alignment file. In the case of tip change or time-elapsed calibration, the calibration must be redone (the indication is there so you realize why a pre-existing calibration no longer is available).

# 19 FEG Control (User)
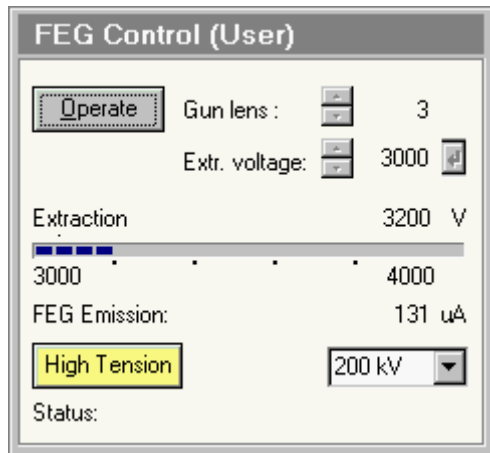


*The FEG Control Control Panel.*

The FEG Control Control Panel provides control over the Field Emission Gun and high tension.

**Operate**
The Operate button switches between the Operate and Standby FEG states. The button is only enabled when the FEG is on.

**Gun lens**
The Gun lens setting can be changed with the spin control within the range 1 to 8.

On X-FEG systems the Gun lens setting has two modes, normal and fine. Fine is available when the Fine checkbox is checked. In normal mode the gun lens setting can be changed with the spin control within the range 1 to 8. In fine mode, the step size decreases to 0.2, giving intermediate steps.

**Extr. voltage**
The Extraction voltage is set with the spin control. Spin the value to the required setting. The value of the Extraction voltage cannot exceed the Extractor limit set by the supervisor. When the Enter button is enabled (which occurs after the value has been changed by the user), the value currently displayed can be sent to the server by pressing the button (as long as the button is enabled, the server has not been updated).

**Note:** For X-FEG the recommended optimum extraction voltage is shown briefly in a tooltip when the cursor moves over the extraction-voltage value field.

**Extraction voltage display**
The Extraction voltage display shows the value of the extraction voltage. The value is displayed in numerical format on the right as well as in a progress bar. The progress bar always has a range of 1000 Volts, changing dynamically from 2000-3000 to 3000-4000, etc.

**FEG Emission**
The FEG Emission current display shows the value of the emission current. The value is displayed in numerical format on the right.

**High tension**
Pressing the High tension button switches the high tension on and off. The high-tension setting is is the one shown in the drop-down list box on the right. The High tension button has three possible settings:
- The high tension is enabled but off: the button is 'normal' gray.
- The high tension is on: the button is yellow.
- The high tension is disabled: the text in the button is gray.
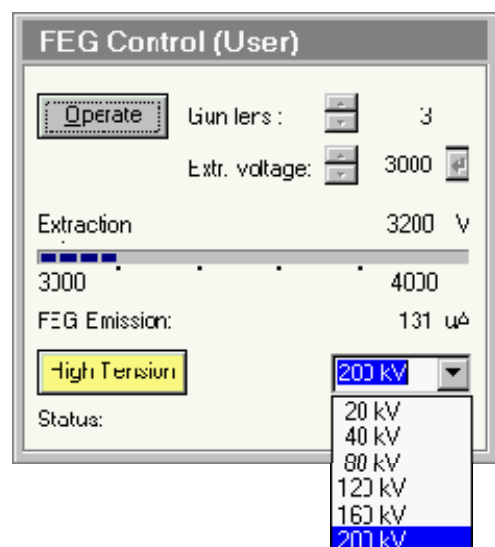
**High tension setting**
The high tension setting is by clicking in the drop-down list box and selecting the required setting (a range of fixed settings, comprising 20, 40, 80, 120, 160 and 200 kV).

**Status**
Changing FEG settings is subject to delays necessary to safeguard the emitter. These delays are shown in the message display area. The delays used for changing extraction voltage depend on the height of the starting and ending extraction voltage.

### 19.1.1  Standby and Operate

Note: Under normal circumstances it is not necessary to switch either FEG or Power off. When not in use, the FEG is normally switched to Standby (press the Operate button). If required for stability, the FEG may also be left in the operating conditions overnight.
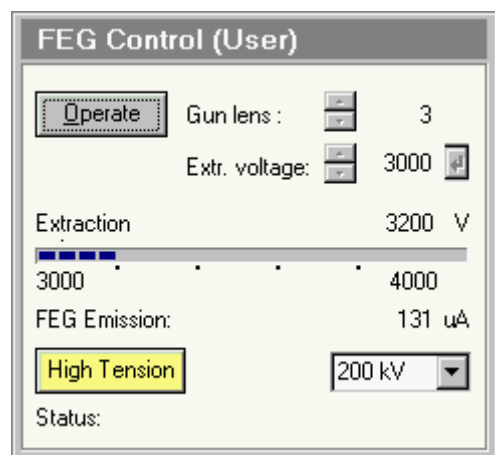


**Standby**: a FEG-on substate with a fixed extraction voltage (3950 V on S-FEG, a system setting on X-FEG) and slightly lowered filament temperature (not for X-FEG). The Operate button is gray.

**Operate**: a FEG-on substate with user-defined extraction voltage and normal filament temperature. The Operate button is yellow.
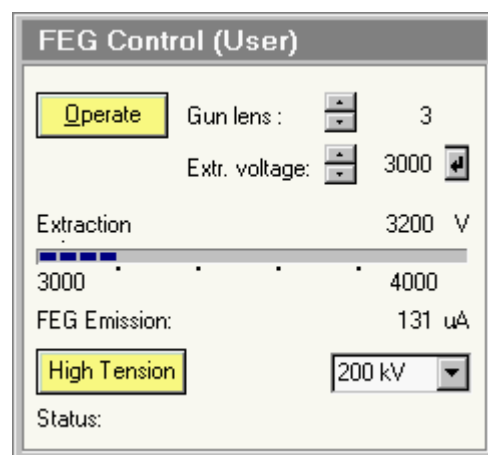
# 20 FEG Control (Expert/Supervisor)

*The FEG Control Control Panel.*

The FEG Control Control Panel provides control over the Field Emission Gun and its setting.

**Operate**
The Operate button switches between the Operate and Standby FEG states. The button is only enabled when the FEG and high tension are on.

**Gun lens**
The Gun lens setting can be changed with the spin control within the range 1 to 8.

On X-FEG systems the Gun lens setting has two modes, normal and fine. Fine is available when the Fine checkbox is checked. In normal mode the gun lens setting can be changed with the spin control within the range 1 to 8. In fine mode, the step size decreases to 0.2, giving intermediate steps.

**Extr. voltage**
The Extraction voltage is set with the spin control. Spin the value to the required setting. The value of the Extraction voltage cannot exceed the Extractor limit set in the FEG Options Control Panel. When the Enter button is enabled (which occurs after the value has been changed by the user), the value currently displayed can be sent to the server by pressing the button (as long as the button is enabled, the server has not been updated).

**Note:** For X-FEG the recommended optimum extraction voltage is shown briefly in a tooltip when the cursor moves over the extraction-voltage value field.

**Extraction voltage display**
The Extraction voltage display shows the value of the extraction voltage. The value is displayed in numerical format on the right as well as in a progress bar. The progress bar always has a range of 1000 Volts, changing dynamically from 2000-3000 to 3000-4000, etc.

**FEG Emission**
The FEG Emission current display shows the value of the emission current. The value is displayed in numerical format on the right as well as in a progress bar.

**Status**
Changing FEG settings is subject to delays necessary to safeguard the emitter. These delays (minutes in the case of start-up procedures; seconds in the case of changes of extraction voltage) are shown in the message display area. The delays used for changing extraction voltage depend on the height of the starting and ending extraction voltage.

**FEG flap-out**

Pressing the arrow button displays the flap-out containing the Options and Timers control panels.

### 20.1.1 Standby and Operate

**Note:** Under normal circumstances it is not necessary to switch either FEG or Power off. When not in use, the FEG is normally switched to Standby (press the Operate button). If required for stability, the FEG may also be left in the operating condition overnight.
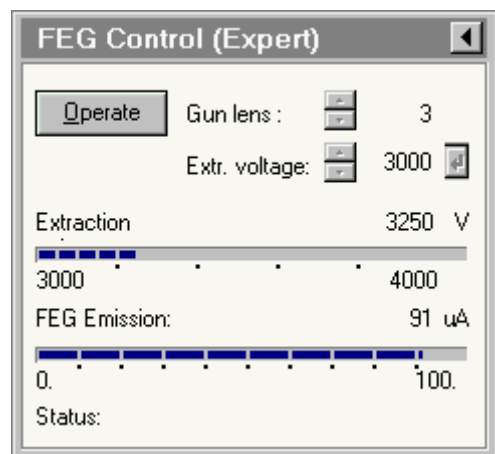
**Standby**: a FEG-on substate with a fixed extraction voltage (3950 V on S-FEG, a system setting on X-FEG) and slightly lowered filament temperature (not for X-FEG). The Operate button is gray.
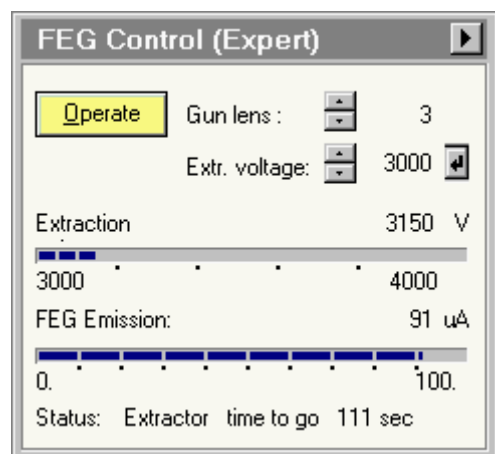
**Operate**: a FEG-on substate with user-defined extraction voltage and normal filament temperature. The Operate button is yellow.

## 20.2 FEG Options
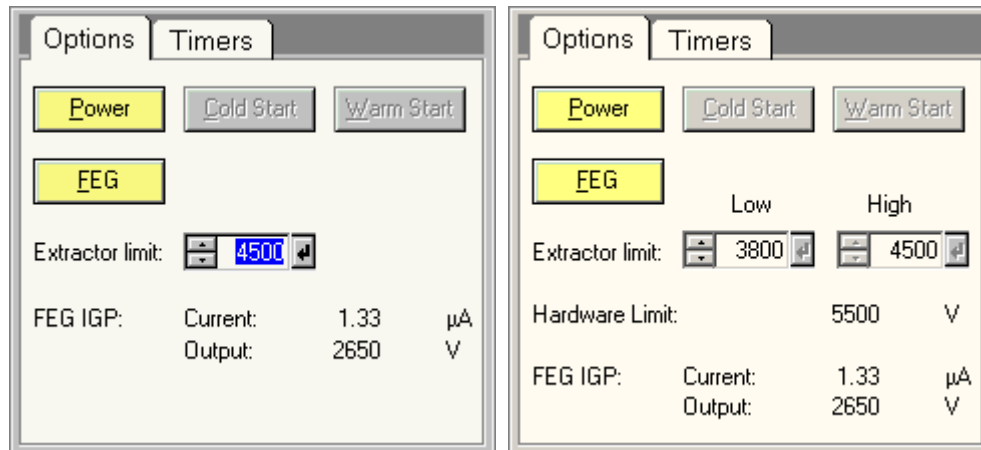


*The FEG Options Control Panel.*
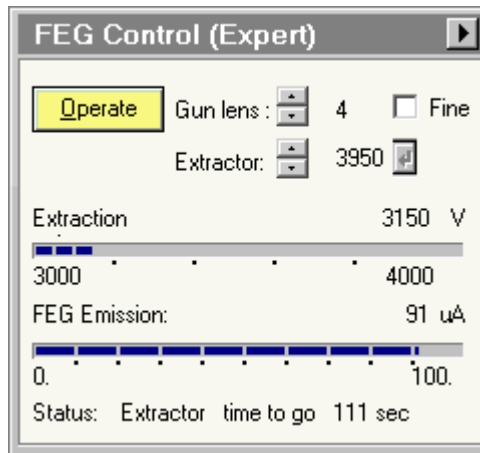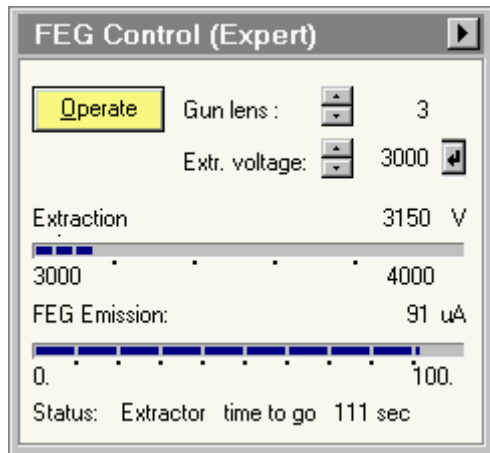
The FEG Options Control Panel provides control over the Field Emission Gun and its setting.

**Note:** Until the FEG has been started - through either the Warm or Cold Start procedure, it is not possible to switch the high tension to more than 120 kV.

### Power

The Power button switches power to the FEG on or off. When Power is on, pressing the button requires confirmation before the power is switched off. The button changes to two buttons with 'V' (OK) and 'X' (Cancel) marks. The cursor is positioned exactly between the two new buttons (to prevent accidental double-clicks from pressing either).
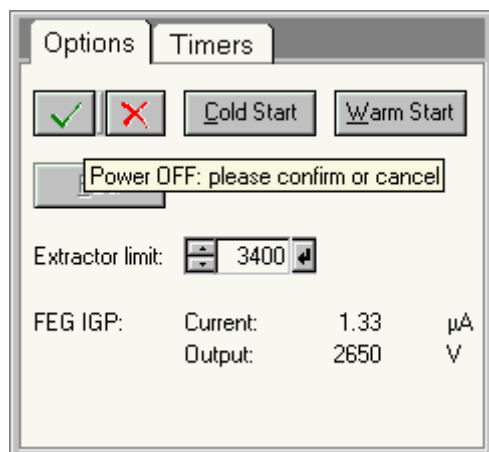


Press the 'V' to switch Power off or the 'X' button to Cancel.

### Cold Start

Once Power has been switched on (and IGPa and IGPf are running), the FEG can be started either by the Cold Start or Warm Start procedures. See the detailed instructions on start-up below. The Cold Start procedure takes about 100 minutes. It is only required if IGPa has been off for more than 48 hours for S-FEG or 24 hours for X-FEG. Pressing the Cold Start button during the Cold Start procedure (when the button is yellow) stops the Cold Start.

### Warm Start

Once Power has been switched on (and IGPa and IGPf are running), the FEG can be started either by the Cold Start or Warm Start procedures. See the detailed instructions on start-up below. The Warm Start procedure takes about 25 minutes for S-FEG and 35 minutes for X-FEG. It is the normal procedure

for starting the FEG (to be used if IGPa has been off for less than 48 hours for S-FEG or 24 hours for X-FEG). Pressing the Warm Start button during the Warm Start procedure (when the button is yellow) stops the Warm Start.

**FEG**
The FEG button becomes yellow (on) automatically at the end of the Cold Start or Warm Start procedure. When it is yellow, it is possible to switch the FEG off by pressing the button (subject to confirmation, similar to Power off). Switching FEG off leads to the Power on state. The difference between FEG Off and Power Off is that IGPf is running in the FEG Off state and not in the Power Off state.

**Extractor limit / low, high**
The Extractor limit sets a limit on the extraction voltage that can be set in the FEG Control Panel. Use the spin buttons to change the value of the extractor limit and then press the Enter button to update the value to the gun.
If just a single value is specified (S-FEG), the limit is the upper extractor limit. For X-FEG there will be an upper and a lower limit. These limits are system-dependent and are set by the factory or service engineer.

**Hardware limit**
The hardware limit displays the maximum extraction voltage which is allowed by the hardware. This is an emitter-dependent value which is set by the factory or service engineer.

**FEG IGP**
The FEG IGP display shows the voltage running through IGPf. Starting the FEG (Cold or Warm Start) is subject to current having run through IGPf after start-up (when the vacuum in the gun is very low, IGPf may not display any current during operation).

### 20.2.1 Power and FEG

The FEG has a number of operational states, described by the following conditions:

- Power on: IGPf is running (or attempting to start up), but otherwise all FEG electronics are off. The Power button is yellow, the FEG button is disabled. Warm and Cold Start are enabled once IGPf is running.
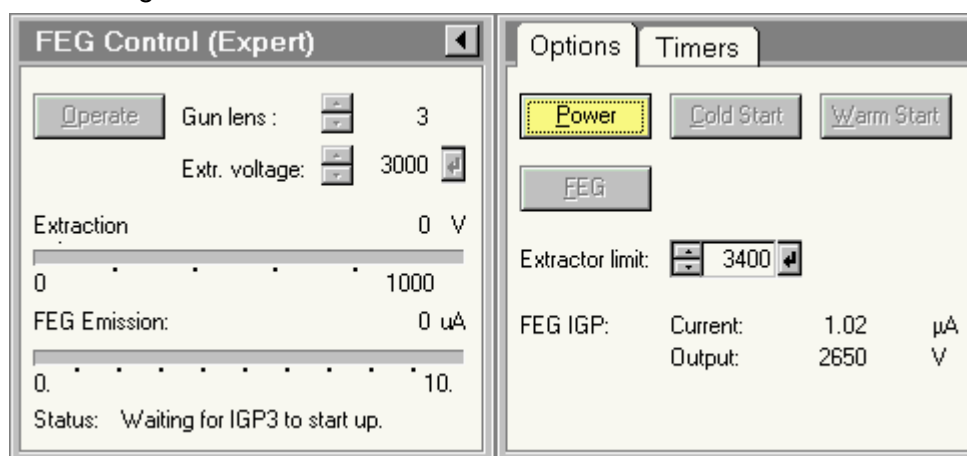
- Cold Start or Warm Start: FEG Start-up procedures, leading to FEG on.
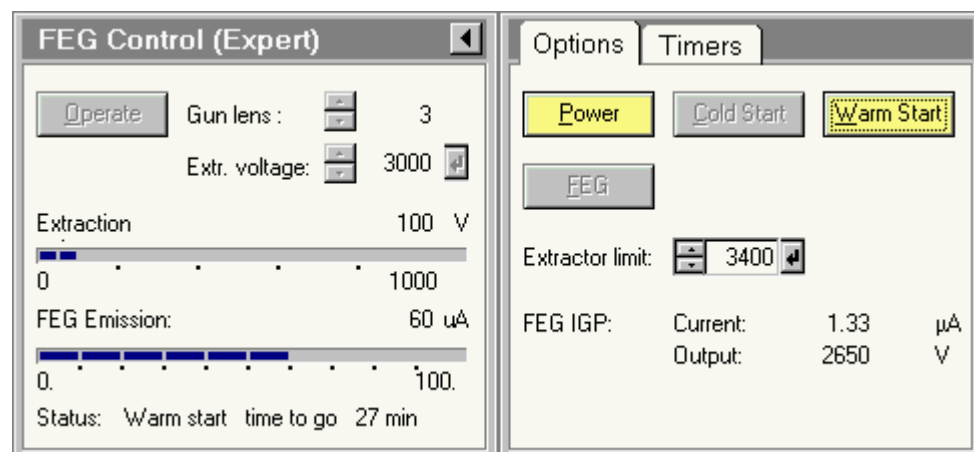


- FEG on: all electronics are on. The Power and FEG buttons are yellow.
  1. **Standby**: a FEG-on substate with a fixed extraction voltage (3950 V on S-FEG, a system setting on X-FEG) and slightly lowered filament temperature (not for X-FEG). The Operate button is gray. It is disabled when the high tension is off and enabled when the high tension is on.
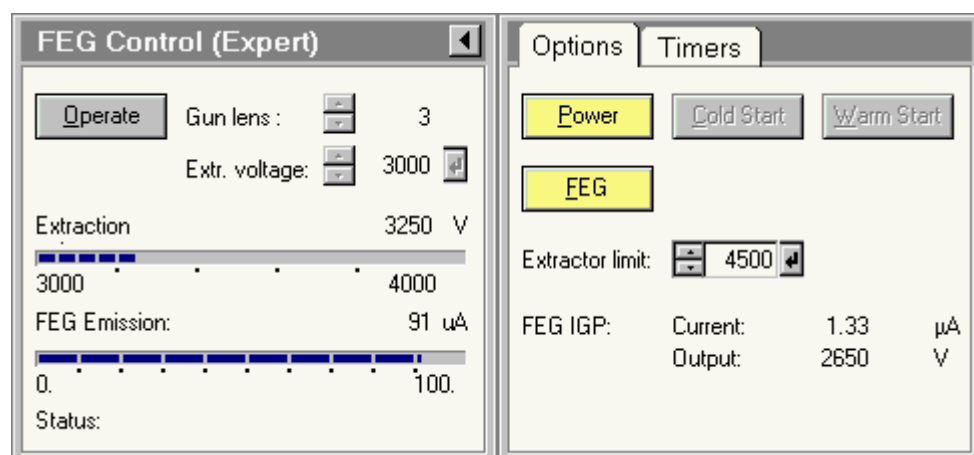


  2. **Operate**: a FEG-on substate with user-defined extraction voltage and normal filament temperature. The Operate button is yellow.
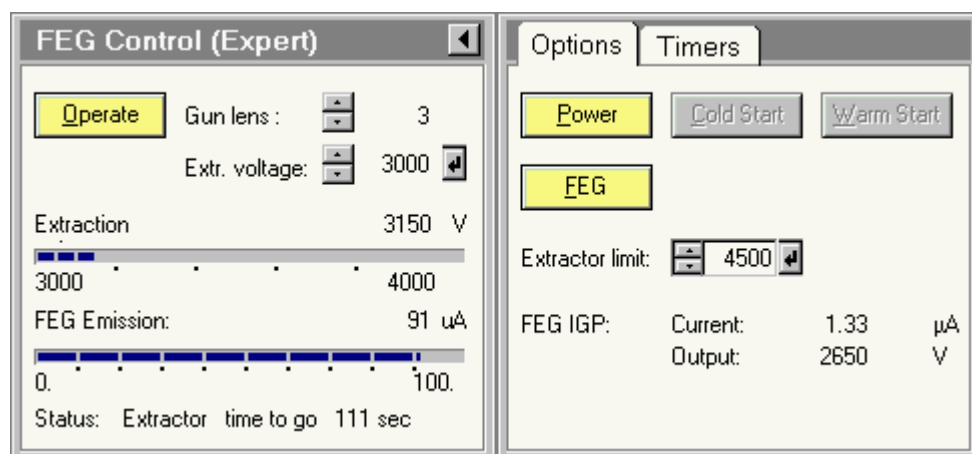
### 20.2.2 Starting the FEG

**Note:** Until the FEG has been started - through either the Warm or Cold Start procedure - it is not possible to switch the high tension to more than 120 kV.
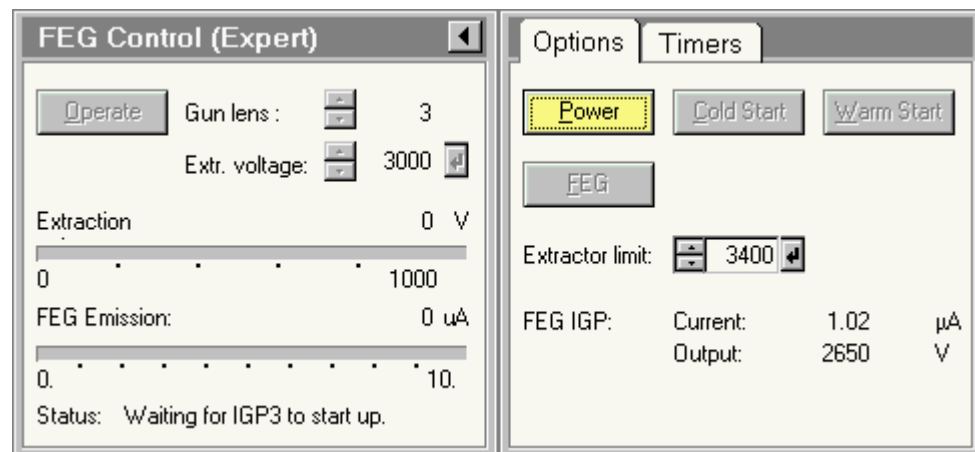


- Press the Power button. The software will now start IGPf (the Cold Start and Warm Start buttons will not be enabled until a current has been measured on IGPf; after the initial current in IGPf, the value may drop to zero, but the initial current shows that the pump is truly running). If IGPf doesn't start within a certain amount of time, the software will switch off IGPa. This will slightly deteriorate the vacuum and make it easier for IGPf to start up. When IGPa is switched off, the system will display an error message 'Gun pressure too high' which can be ignored (click on the Enter button to remove it). Once IGPf has started, the software will (if it had been switched off) restart IGPa. Once IGPa is running again (checked by a significant lowering of the IGPf pressure), the system is ready for a Warm Start or Cold Start.

  For X-FEG the Warm and Cold Start procedures are stopped if the FEG IGP pressure exceeds the value of the 1 mA. it is recommended to let the pressure decrease to values below 0.5 $\mu$A (preferably lower) before the X-FEG is started via a Cold or Warm Start.
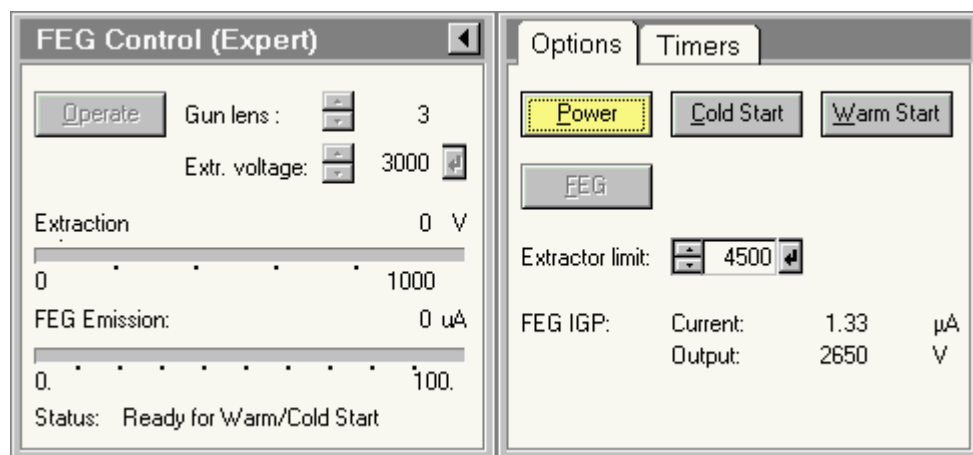


- Press the Warm Start (normal procedure if IGPa has not been off longer than 48 hours for S-FEG or 24 hours for X-FEG) or Cold Start to begin the FEG start procedure. The time required (under normal conditions) for the procedure is displayed.

- The start-up procedure will lead to the FEG on, Operate state.
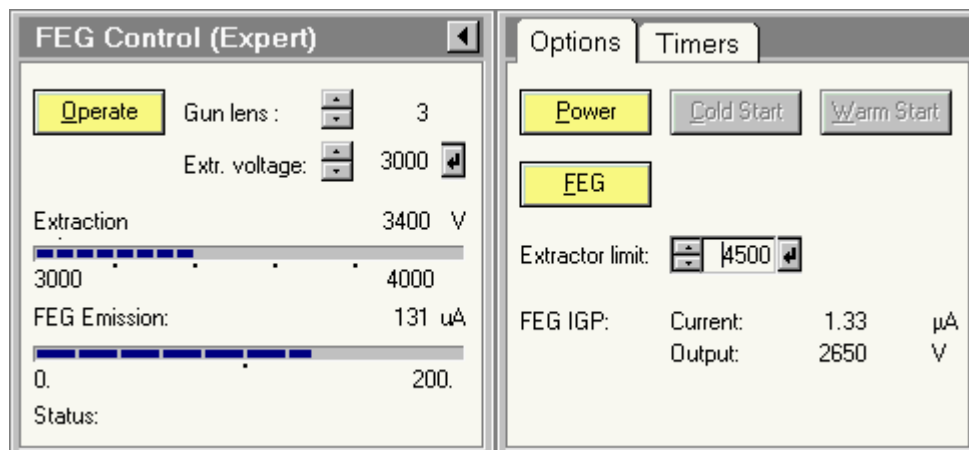


- Set the Extractor limit to the value required for normal operation, with the spin buttons and confirm by pressing the Enter button.
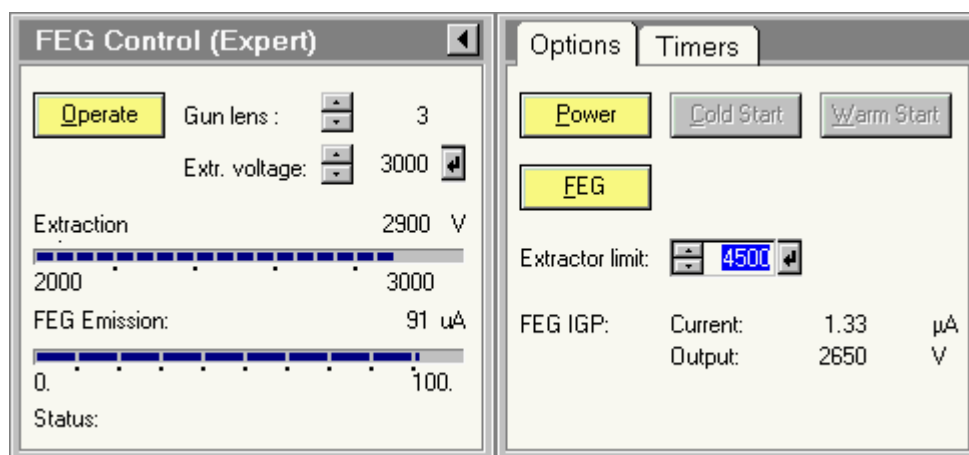


- Change the Extraction voltage and gun lens settings to the values required for operation.

   **Note:** For X-FEG the recommended optimum extraction voltage is shown briefly in a tooltip when the cursor moves over the extraction-voltage value field.
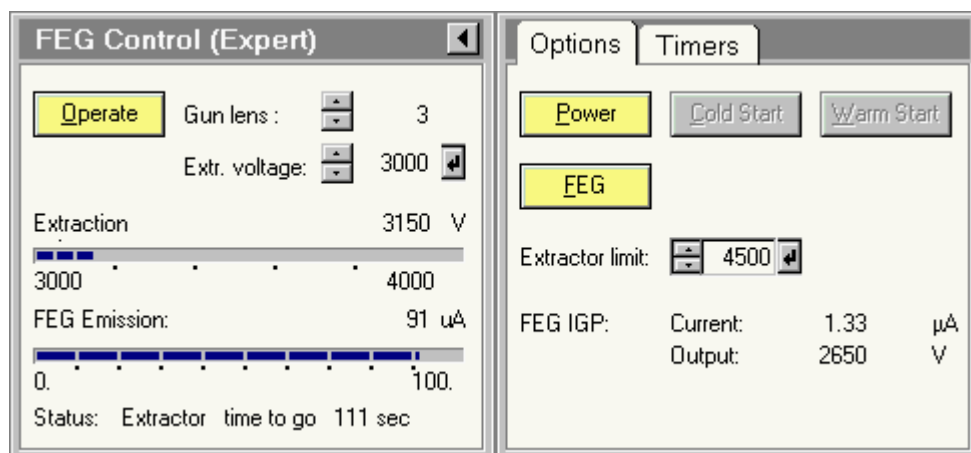
### 20.2.3 Shutting the FEG down

**Notes:**
- Under normal circumstances it is not necessary to switch either S-FEG or Power off. The S-FEG may be left in the Operate state when the microscope is not being used.
- For X-FEG, it is discouraged to leave the FEG at an extraction voltage in Low Mode (low extraction voltage) when the microscope is not in use. The Operate button can be used to switch between the operating condition and the Standby substate, which is at the optimum extraction voltage (Voptimum). The FEG automatically leaves Low Mode and switches to Standby after a certain amount of time or when the column valves have been closed for two hours. If the extraction voltage is in the Standard mode, the FEG may be left in the Operate state.

The FEG can be shut down partially (all electronics except the power to IGPf off) or completely. To shut the FEG down but keep IGPf running, press the FEG button (this action must be confirmed before it is executed). To shut the FEG down completely, press the Power button (also subject to confirmation). When the high tension is higher than 120kV, the high tension will switch off automatically. At or below 120kV, the high tension can remain on.

## 20.3 FEG Timers (Supervisor/Expert)

| Options | Timers | | | Options | Timers |
|---|---|---|---|---|---|
| Date: | 1 / 22 / 2000 | | Date: | 4 / 17 / 2009 |
| Time Standby: | 932.4 h | | Time Standby: | 0.5 h |
| Time Operate: | 529.0 h | | Time Operate: | 533.4 h |
| | | | Standard extraction: | 459.2 h |
| | | | Low extraction: | 74.2 h |
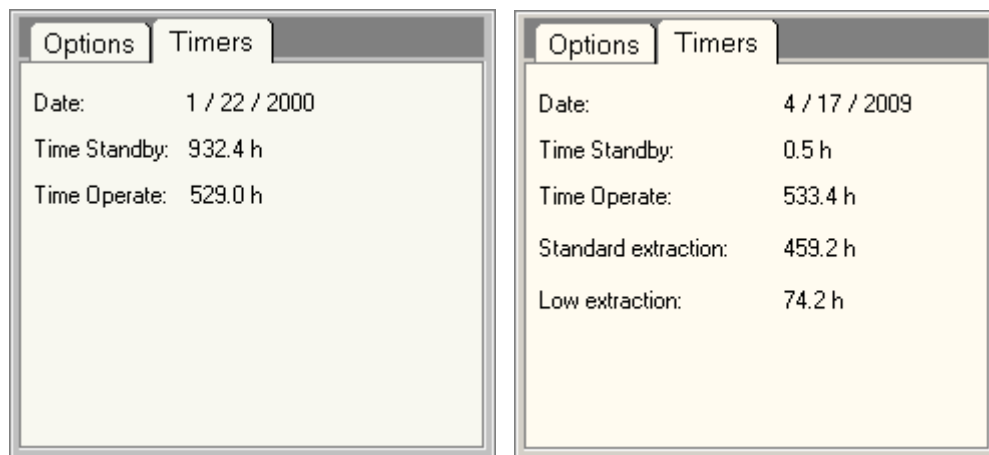
*The FEG Timers Control Panel.*

The FEG Timers Control Panel displays the date the timers were started (FEG tip installation) and the hours the FEG tip has run in Standby and Operate modes. The timers can be reset only by service.

For Dual-mode systems, the standard and low extraction times are also displayed.

# 21 FEG Registers
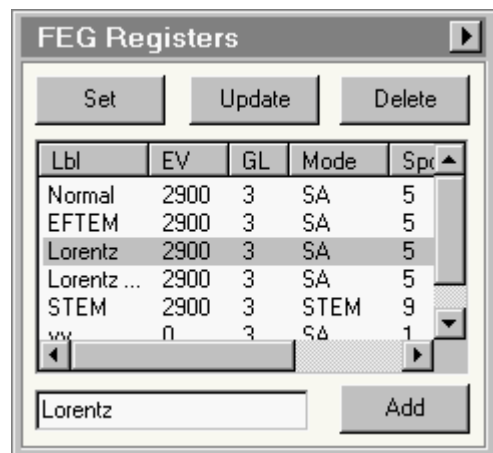


*The FEG Registers Control Panel.*

## 21.1 Introduction

The control of the FEG is somewhat complicated because of the wide range of settings under which the gun can be used and the nature of its construction. Two elements that can be varied, the extraction voltage and the gun lens setting, are located above the alignment coils and therefore the alignment of the gun doesn't stay the same when these parameters are changed (the high tension used in turn affects the way the extraction anode and gun lens are used, adding another complication). In some types of application the FEG is only used in one or two specific settings. In these cases (e.g cryo work in Life Sciences), there is little need for frequent changes of the gun settings and the normal method of alignment save and recall in the microscope software will be adequate. In other cases, frequent adjustments are made to gun settings, e.g. changes of extraction voltage and gun lens when switching between normal or high-resolution TEM imaging and small-spot analysis, diffraction or STEM imaging. In the latter case the frequent realignment (or alignment recalls) makes use of the FEG cumbersome, especially since in addition to the alignment recalls several other factors (such as mode, spot size and condenser stigmator settings) are not set along with the alignment. It is in these cases that FEG Registers will be helpful. FEG Registers stores and recalls a number of microscope settings, making it easy to switch between previously defined settings.

Each user can store any number of settings under a user-defined label. These settings are saved in a file (one for each user) under the Windows user name preceded by usr_. Whenever the user logs in, the settings are loaded from the file. Each of the settings can be selected in the list and set to the microscope. Settings can also be updated and deleted. They can also be saved to and recalled from files with user-defined names.

## 21.2  The settings

The following settings are stored for each register.

| **Settings** | **Talos** |
|---|---|
| FEG | • Extraction voltage<br>• Gun lens<br>• Gun tilt<br>• Gun tilt pivot points<br>• Gun shift<br>• Spotsize-dependent gun shift |
| Monochromator<br>(on monochromator<br>systems only) | • Potential<br>• Excitation<br>• Monochromator settings (file) |
| Microscope mode | • TEM / STEM<br>• LM, SA, Mh, LAD, D<br>• Microprobe / Nanoprobe<br>• Lorentz<br>• Dark field, including effective dark-field tilt angle<br>• Normal / EFTEM |
| Illumination | **Note:** The C2 aperture is only relevant for Automated-Aperture systems. The C2 aperture must be enabled, otherwise it will be ignored.<br>• C2 Aperture selected and position<br>• Spot size<br>• Intensity |
| Magnification | • Magnification (TEM or STEM)<br>• Camera length |
| Direct alignments | • Spot-size dependent intensity correction<br>• Beam shift<br>• Beam tilt pivot points<br>• Rotation center<br>• Diffraction shift<br>• Dynamic conical dark field pivot points |
| Condenser stigmator | • List of condenser stigmator settings (all spot sizes)<br>• (If present) 3-fold condenser stigmator setting |
| Stigmators | • Objective stigmator setting<br>• Diffraction stigmator setting<br>Which of the two (if at all) will be determined by the active mode, the stigmator being set only in modes where this is relevant (Objective stigmator for HM imaging, LAD diffraction; diffraction stigmator for HM diffraction and LM imaging). |

Apertures                        If automated apertures are present on the system, it is possible to select setting of C1, Objective and SA apertures.
The particular aperture must be enabled, otherwise setting the aperture is ignored.

**Note** : If you want to save settings for different high-tension settings, identify them as such by the label. High tension is neither stored nor recalled automatically.
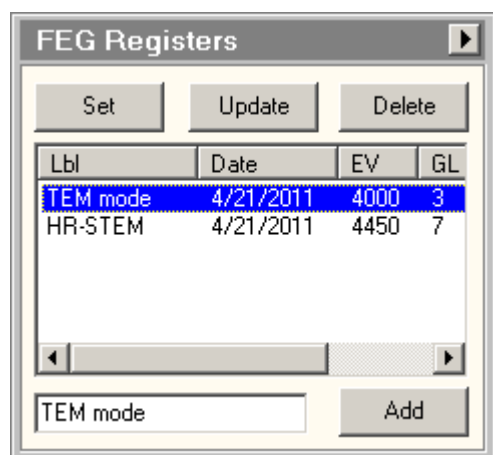


**Set**
When the Set button is pressed the settings from the register currently selected in the list will be set to the microscope.

**Update**
When the Update button is pressed, the selected setting is updated to the settings currently active on the microscope. Typical use of this function would be to select a setting and set it back to the microscope. Then modify any microscope settings needed (e.g. the gun alignment) and then update. Update requires confirmation (since the old setting will be overwritten).

**Delete**
When the Delete button is pressed the setting currently selected in the list will be deleted. To guard against accidental deletion, the Delete button will request confirmation. Multiple settings can be selected for deletion (use Shift+Click to select a range or Ctrl+Click to select individual settings).

**Settings list**
The settings list gives an overview of all settings of the current user. The settings are automatically stored when the user logs off (it is not necessary to save them to file, settings are added simply by Add and removed by Delete). The settings list initially will display the registers in the sequence they have been defined. It is possible to sort the settings in the list differently by pressing one of the buttons at the top of the list (Lbl, EV, GL, ...). At the first press, the settings are sorted in normal order. When the same button is pressed again the sequence is reversed. The width of the columns can be adjusted by moving the cursor to the boundaries between the buttons and dragging the boundary to left or right.
The columns in the list have the following meaning:
- Lbl : user-defined label for the setting.
- Date : the date at which the setting was added.
- EV : extraction voltage.
- GL : gun-lens setting.
- Mode : microscope mode
- Spot : spotsize
On monochromator systems EV and GL are replaced by Pot (Potential) and Exc (Excitation), respectively.

These data are only a subset of the settings stored, but they are the important ones that allow the user to see which setting should be recalled.

A setting is selected for setting to the microscope or updating by clicking the required row. The label of the setting is automatically copied to the settings label edit field to ensure the proper setting is used for updating.

**Settings label**
The settings label defines the name of a new register setting (when Add is pressed). If no text is entered, the software will add a label 'Register' with some number attached.

**Add**
When the Add button is pressed the settings currently on the microscope are stored in a new register which is added to the list.

**Flap-out button**
The flap-out button leads to the Options tab of the FEG Registers Control Panel.


## 21.3 FEG Registers Options
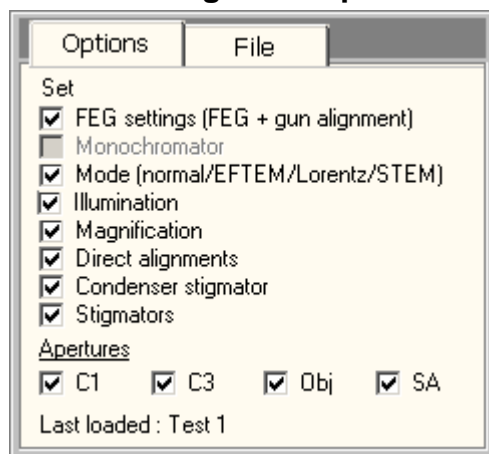


*The FEG Registers Options control panel.*

The Options tab contains the options concerning which settings are restored to the microscope.

**Settings options**
The settings that will be restored to the microscope can be chosen by checking the required check boxes. The categories are listed in the settings table.
Automated apertures that are not available are still shown but the checkbox will be disabled.


**Last loaded**
Last loaded will list FEG Register that was loaded last. Note that this applies only to the current microscope session.

## 21.4 FEG Registers File
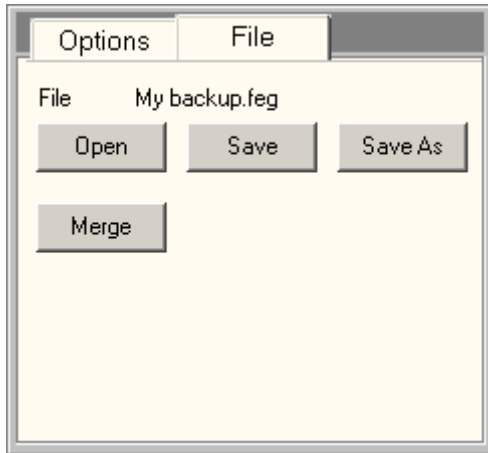


*The FEG Registers File Control Panel.*

The File tab contains the controls for saving the settings to file and loading them from file.

**File Open**
The Open button brings up the standard Open file dialog from which a file can be selected for loading. See the remark above about overwriting the currently existing settings.
**File Save**
The currently existing settings can be saved to file. When the Save button is pressed the settings are saved under a user-defined filename.

**Note:** Under normal circumstances it is not necessary to save settings in a file because a user's settings are saved automatically. Saving files is only useful when a user wishes to have several sets of settings of FEG Registers or for having other users use the settings defined by another user.

**File Save As**
Save as is the same as Save except that another filename can be chosen.

**File Merge**
The Merge button brings up the standard Open file dialog from which a file can be selected for loading. In this case the existing registers are not overwritten but the registers from the file are added to the existing ones. By sorting on name or date you can identify duplicates and remove those by deleting.

### 21.4.1 Settings files

Settings files can be saved under any file name and in any location with the following restriction: filenames with names that start with usr_ and then a Windows username (that is, the name under which users log in) are not allowed. These files will in fact exist for users who have used FEG Registers before and contain their settings. You can open those files and use the settings in there, but you cannot overwrite them.
The location of the user files is by default in a folder \"tem"\data\ (where "tem" is either "tecnai" or "titan") followed by the user name.

Files do not contain a single setting but all settings together. **When you load settings from file you automatically remove all currently existing settings unless you use the Merge function!**

# 22     Filter
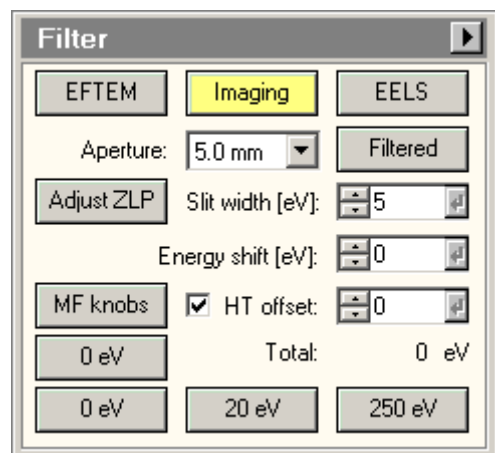
The Filter control panel contains a number of controls for the Imaging Filter. The state of a number of buttons and other controls depends on the current state of EFTEM. For more background information on EFTEM, see the description of the Energy-Filtered TEM (EFTEM) mode.

**Note:** The configuration of the control panel is dependent on the configuration. The same control panel is used for Filters an Enfina spectrometers and some controls may be absent if not supported by the configuration.

**Note about DigitalMicrograph and filtered-imaging functionality:** The Filter control panel provides control over the imaging filter but no longer supports all the functionality that was already present in DigitalMicrograph (and essentially duplicated in the former AutoFilter control panel). Use the DigitalMicrograph for Imaging Filter functionality such as acquiring elemental maps.

**EFTEM**
The EFTEM button controls the microscope status:
- EFTEM off : the button will be gray and the magnification series will be the normal series.
- EFTEM on : the button will be yellow and the magnification series will be the special EFTEM series.

**Imaging**
When the Imaging button is pressed, the Imaging Filter switches to the imaging state (display of image instead of spectrum). To acquire the images on CCD, use the controls in the CCD/TV Camera control panel.

**EELS**
When the EELS button is pressed, the Imaging Filter switches to the spectroscopy state (slit out, display of spectrum instead of image). In order to prevent overloading of the detector, the user interface will display a message "Please make sure you reduced beam intensity". This message must be confirmed (by pressing the button next to the message) before the system will switch to spectroscopy.

To acquire PEELS spectra, use the PEELS control panel.
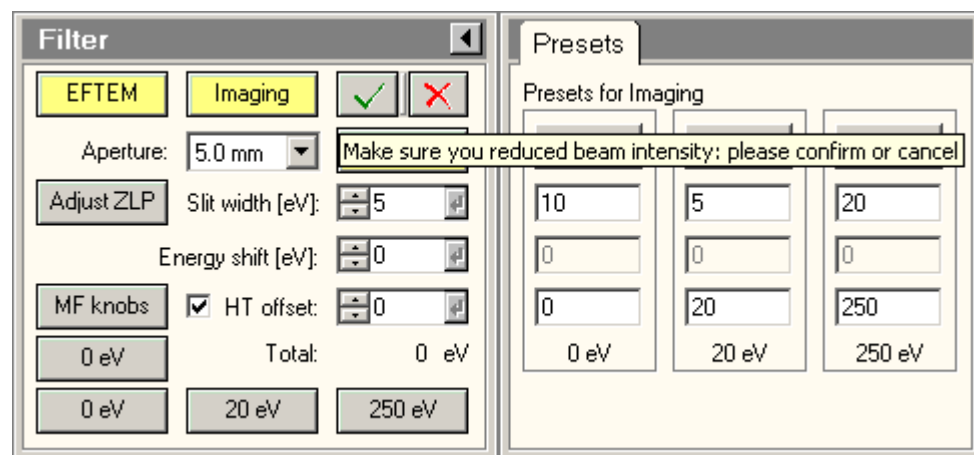
The message in the control panel that must be confirmed (or canceled) for switching to spectroscopy.

**Aperture**
The Imaging Filter has a number of entrance apertures. For imaging you typically use the largest aperture, for spectroscopy one of the smaller ones. Select the required entrance aperture from the drop-down list.

**Filtered**
When the Filtered button is pressed, the Imaging Filter switches between the filtered state (slit in) and unfiltered state (slit out).

**Adjust ZLP**
With the Adjust ZLP, the position of the zero-loss peak can be adjusted. When the button is pressed, it becomes yellow and the Multifunction Y knob is bound to the energy offset. Change the position of the zero-loss peak. Once done, press the button again. It will become gray again and the energy offset is nulled and now the zero-loss peak should be in its proper position.

**Slit width**
The slit width control determines the width of the slit on the Imaging Filter.

**0 eV button**
Pressing the 0 eV button (not on bottom row) forces all energy values to 0.

**Total**
The Total value given is the sum of all the energy shifts applied. If the total does not match the sum of the two values above, it means that there is a non-null value on the value that is not displayed (because it is not appropriate to the mode, see below). This can only happen if the value is set directly in FilterControl.

**Filter Flap-out**
Pressing the arrow button displays the flap-out containing the Filter Presets control panel.

### 22.1.1  EFTEM On
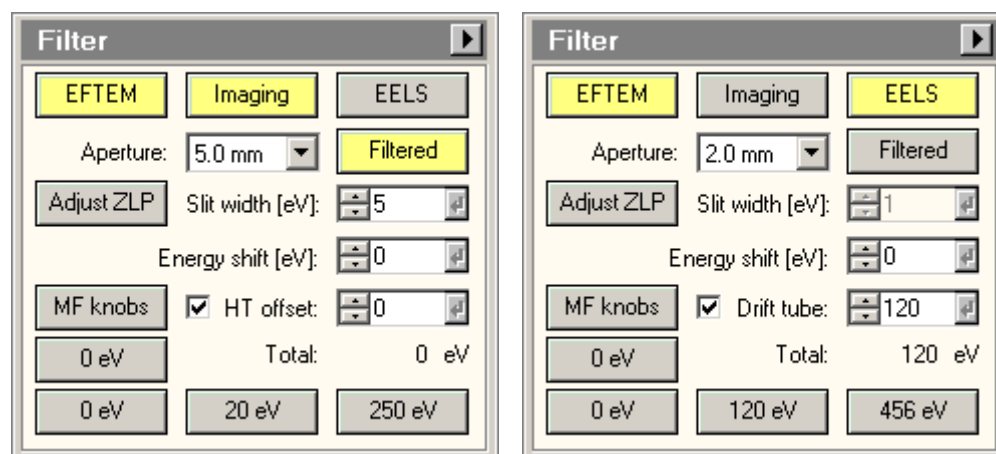


**Energy shift, Drift tube, HT Offset**
On the Imaging Filter there are three ways to change the energy of the spectrum:
- With the current of the energy-loss prism in the Imaging Filter - called Energy shift.
- With the high tension of the microscope - called HT Offset.
- With the electrostatic drift tube of the Imaging Filter - called Drift tube.
The Total value given is the sum of all three values mentioned above.

**Note:** The convention used in the Filter control panel is that positive values always indicate energy losses. Thus a value of 284eV on any of these controls always displaces to the carbon K edge. This usage differs (the energy shift is reversed) from that in Gatan's FilterControl where the behavior is not consistent and therefore difficult to follow.

The HT Offset is normally used in Imaging because in that case when you look at another energy level, the image in the microscope remains in focus (the energy-loss electrons are focused the same as the zero-loss electrons in zero-loss imaging). For spectroscopy, however, using the HT Offset to move the spectrum is not the optimum, especially if the spectrum is acquired in focused-probe mode (the change in high tension will effectively defocus the probe). For spectroscopy at energy changes less than 1000 Volts typically the drift tube voltage is used. When properly calibrated, the drift tube is easy to use and accurate, without significant hysteresis. For higher energy changes, the prism current (Energy shift) is used (possibly in combination with the drift tube).

**Filtered Imaging :** With the HT Offset control, the value of the energy loss is chosen. The control panel keeps separate values for the three preset conditions.

**EELS :** With the Drift tube control, the value of the drift tube voltage (spectrum shift) is chosen. The control panel keeps separate values for the three preset conditions.

**MF knobs**
The Multifunction knobs can be used to control the Energy Shift (MF-X) and the HT Offset or Drift tube (MF-Y).

**Preset buttons**
Pressing the preset button (on bottom row) sets the relevant energy values. These values are defined in the Filter Presets control panel.

## 22.2 Filter Presets

The Filter Presets control panel contains a number of settings for the Imaging Filter. These presets differ between Filtered Imaging and Spectroscopy. The position of the preset values is linked to that in the main control panel (to the left) so the labels (Slit width, etc.) are not repeated in the Presets control panel.

When you change a preset value by typing, the value is activated when the Windows focus is moved to another control (just click anywhere else).

**Update**
Pressing an Update button copies the currently active values to the relevant preset.

**Slit width** (Filtered Imaging only)
The value of the slit width.

**Energy shift**
The value of the energy shift.

**HT offset** (Filtered Imaging only)
The value of the HT offset.

**Drift tube** (Spectroscopy only)
The value for the drift tube.

**Presets**
The name of the preset is linked directly to the sum of the energy values selected. The values are shown underneath the presets list and in the buttons on the main panel.

# 23 Filter Tools
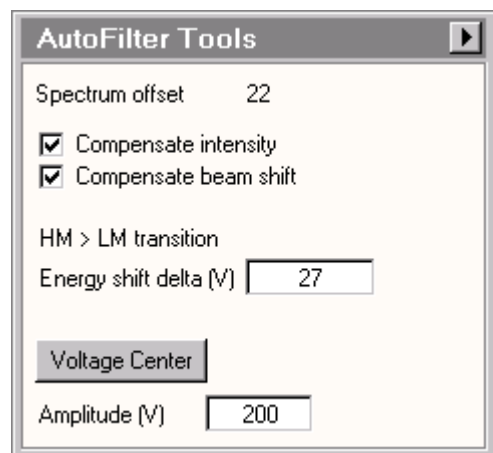
*The Filter Tools Control Panel.*

### 23.1.1 Introduction

The Filter Tools Control Panel provides a number of functions that improve the handling of the Gatan Imaging Filter:

- Compensation of the effect of high-tension change on the illuminated area size and position.
- Compensation of the shift of the spectrum encountered in the transition between energy-filtered imaging in HM and LM.
- Voltage center alignment of the objective lens.

### 23.1.2 Compensation of high-tension change

During energy-filtered imaging the high tension of the microscope is changed by up to 3 kiloVolts without any of the normal compensations that are built in to the microscope when the high tension is changed. The reason the high tension is used this way is simple. If we want to acquire an image at say an energy loss of 500 eV, we can do so by raising the high tension by that amount. Because the microscope optics have been adjusted earlier for an energy loss setting of 0, the offset makes sure that the image at 500 eV loss is now imaged under exactly the same conditions as the 0 eV image earlier: one consequence is that the focus doesn't change.

However, the high tension change does have some effects on the optics. The most noticeable and worrisome effects are a change in the size of the illuminated area as well as a shift of the illumination. The latter is generally small and only starts to be a problem if the energy range during acquisition is large (as is e.g. the case when a series of images is acquired over a large energy range to construct a spectrum image). The change in the size of the illuminated area is more problematic, because it affects the quantification of elemental maps (based on the three- or two-window methods). The inherent assumption in the mapping procedure is that the illumination on the specimen is identical for the edge and the background images. Without compensation this is not the case as the electron dose per unit area changes when the size of the illumination area changes. One way to reduce the effect is to spread the beam so the change in size has little effect, but that comes at the price of either lower signal or longer exposure times. The best way to resolve the problem is to change the intensity to compensate for the change in high tension so that the illuminated area stays the same.

### 23.1.3 Compensation of spectrum shift

When going from HM to LM and vice versa there always is a spectrum shift (typically around 20 eV) or so. This shift is due to a change of the position of the cross-over in the differential pumping aperture. The

result is that the transition always results in a loss of the zero-loss energy-filtered image. In principle the way to compensate such shifts is to use the cross-over correction. Unfortunately the range of the cross-over correction in LM is far too small to be able to compensate the apparent spectrum shift fully. Using the cross-over correction in HM instead is also undesirable because the size of the correction needed is such that the image quality is severely affected. The only practical way is therefore to shift the spectrum one way when going to LM and back when going to HM.

### 23.1.4  Voltage center

Because of the frequent use of changes in high tension during energy-filtered imaging, the optimum way for aligning the objective is through the voltage center method, whereby the effects of a change in the high tension are minimised (the other ways are the current center where the effects of changes in the objective-lens current are minimised, and coma-free alignment which is the proper high-resolution imaging method). Voltage centering can only be done on the TEM by using the energy offset of the Imaging Filter, which changes the high tension on the microscope.

### 23.1.5  The Filter Tools Control Panel

**Spectrum offset**
The spectrum offset indicates the current spectrum offset set by the Gatan Imaging Filter. This value is the change in high-tension from the value for the zero-loss image.

**Compensate intensity / compensate beam shift**
The check boxes for Compensate intensity and Compensate beam shift control whether a change in the spectrum offset is automatically compensated by a change in the microscope's intensity and beam-shift position values. The check boxes are only enabled when the compensation has been calibrated. The microscope will store the calibration when the user interface is closed and reload the values when the user interface is re-opened. It is advised, however, to check the calibration on a regular basis.

If a user has not done the calibration, he/she will inherit any calibration from a higher user level (going from supervisor to service to factory, whichever is found first).

**HM > LM transition**
The spectrum shift caused by the HM <> LM transition can be compensated automatically. If a value other than 0 is entered in the edit control to the right, that offset will be applied . Note that this offset is not the same as the spectrum offset above (which is a high-tension change on the microscope) but a spectrum shift in the Imaging Filter (called Energy shift).

To calibrate the value of the energy shift that must be applied, start with a zero-loss image in HM and execute Align ZLP to make sure the zero-loss peak is centered properly in the slit. With a delta value of 0 eV set in Filter Tools, change to LM. In all likelihood the image has disappeared (the zero-loss peak has shift behind the slit). Change the Energy shift value in the Filter Control Panel, first to obtain light, then fine-tune to center the spectrum properly. Copy the required energy shift value to the Filter Tools Control Panel.

An alternative is to go to spectroscopy in HM imaging and collect a spectrum or watch the image of the spectrum on the TV. Note the position of the zero-loss peak. Switch to LM and move the zero-loss peak back to where it was in HM, again using the energy shift.

**Voltage center**
When the voltage center button is pressed (it becomes yellow), the software will slowly wobble the amplitude of the offset (which controls the microscope high tension between the amplitude defined and a value of 1 (not 0 because then Filter automatically keeps switching the offset off). The Multifunction knobs are now controlling the objective-lens alignment, which you can control in exactly the same way as during rotation centering (minimise image shifts). The Focus Step can be used to change the amplitude of the high-tension wobble (the currently active value is displayed to the right of the edit control in which you can define the wobble amplitude at which the center function starts.
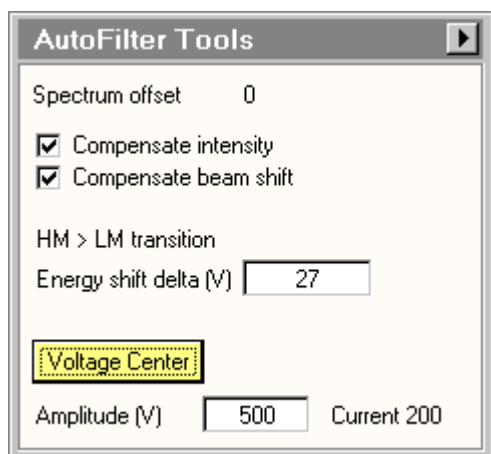


*The currently active wobble amplitude is displayed to the right of the user-defined value when the voltage-center function is active.*

**Amplitude**
The amplitude for the voltage center is defined by the value in the edit control.

**Flapout**
The flapout button leads to the Calibrate tab of the Filter Tools Control Panel.

## 23.2  Filter Tools Calibrate

```
┌─────────────────────────────────────────────┐
│ Calibrate                                     │
├───────────────┐                               │
│                                               │
│ Calibration of intensity and beam shift       │
│ ┌───────────────────────────────────────────┐ │
│ │Select a suitable magnification            │ │
│ │                                           │ │
│ │Focus beam                                 │ │
│ │Center beam accurately (track ball)        │ │
│ │                                           │ │
│ │Press Next to continue                     │ │
│ │                                           │ │
│ │                                           │ │
│ │                                           │ │
│ └───────────────────────────────────────────┘ │
│  ┌──────────┐              ┌──────────┐        │
│  │  Start   │              │  Next    │        │
│  └──────────┘              └──────────┘        │
└─────────────────────────────────────────────┘
```
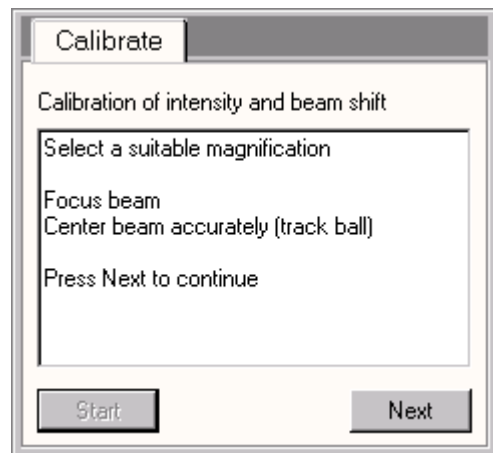
The Filter Tools Control Panel provides the calibration procedure for the intensity and beam-shift compensation. There are two ways to run the calibration:
• Easier but less accurate : lower the main screen and calibrate on there.
• More difficult but more accurate : use the TV or CCD image for the calibration, make sure there is a suitably thick specimen in the beam, and make the beam a bit smaller than the CCD or TV image.

**Instructions**
When the calibration procedure is running, instructions are displayed here.

**Start**
The calibration procedure is started by pressing the Start button.

**Next**
Follow instructions and press Next to go to the next step of the procedure.

# 24 Filter Tuning (User)
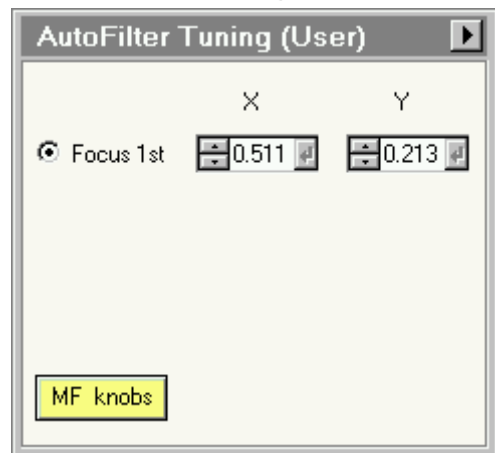


*The Filter Tuning Control Panel.*

The Filter Tuning control panel contains a controls for focusing the Imaging Filter used for EFTEM. For more background information on EFTEM, see the description of the Energy-Filtered TEM (EFTEM) mode. For imaging, the controls can be used for coarse tuning, since the automatic procedures of the Filter are usually adequate for the fine-tuning. For spectroscopy, the controls may be needed to focus the spectrum properly.

The optics of the energy filter produces some geometrical and energy-dispersive plane aberrations in the image plane. The post-column filter can correct these automatically in imaging mode by pressing the align zero-loss and tune GIF button. When pressing the Align zero-loss button in the Filter window the peak of elastically scattered electrons will be centered in the middle of the energy selecting slit. If in unfiltered mode you see the light but in zero-loss filtered mode the image disappears, it may be due to the zero-loss peak misalignment. With the tune GIF button all aberrations within the post-column filter can be minimized. The settings of the post-column filter for each magnification will be stored after the automatic routine has been successfully finished. The next time this magnification is chosen, it will be recalled. Especially the 1st and 2nd order isochromaticity should be corrected once after the installation of the TEM software for each magnification, so that reasonable preset values can be reached in daily work.

The Filter can be used optically in two main ways, one for imaging (recreating an image of what is received at the entrance aperture), the other for spectroscopy. If the Filter settings selected are double-focusing (the image is in focus and the spectrum is focused at the energy-selecting slit), the corrections are usually similar for imaging and spectroscopy. Where no double-focusing is possible (e.g. the larger dispersions in spectroscopy), the aberration corrections will be different.

See the Gatan GMS documentation for further details.

**MF knobs**
The Multifunction knobs can be used the change the settings of the Focus 1st function described above. To connect the Multifunction knobs to one of the functions, select the particular functions through its radio button and press the MF knobs button (it will become yellow). You can change the sensitivity of the MF knobs with the MF - and + buttons.

**Flap-out button**
The flap-out button leads to the Filter Tuning Restore Control Panel.

## 25 Filter Tuning (Expert)
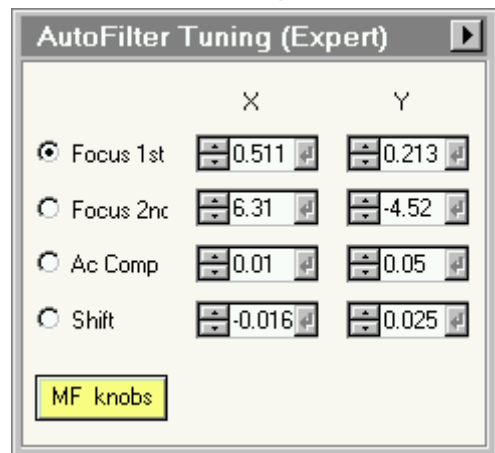


*The Filter Tuning Control Panel.*

The Filter Tuning control panel contains a number of controls for tuning the Imaging Filter used for EFTEM. For more background information on EFTEM, see the description of the Energy-Filtered TEM (EFTEM) mode. For imaging, the controls can be used for coarse tuning, since the automatic procedures of the Filter are usually adequate for the fine-tuning. For spectroscopy, the controls may be needed to focus the spectrum properly.

The optics of the energy filter produces some geometrical and energy-dispersive plane aberrations in the image plane. The post-column filter can correct these automatically in imaging mode by pressing the align zero-loss and tune GIF button. When pressing the Align zero-loss button in the Filter window the peak of elastically scattered electrons will be centered in the middle of the energy selecting slit. If in unfiltered mode you see the light but in zero-loss filtered mode the image disappears, it may be due to the zero-loss peak misalignment. With the tune GIF button all aberrations within the post-column filter can be minimized. The settings of the post-column filter for each magnification will be stored after the automatic routine has been successfully finished. The next time this magnification is chosen, it will be recalled. Especially the 1st and 2nd order isochromaticity should be corrected once after the installation of the TEM software for each magnification, so that reasonable preset values can be reached in daily work.

The Filter can be used optically in two main ways, one for imaging (recreating an image of what is received at the entrance aperture), the other for spectroscopy. If the Filter settings selected are double-focusing (the image is in focus and the spectrum is focused at the energy-selecting slit), the corrections are usually similar for imaging and spectroscopy. Where no double-focusing is possible (e.g. the larger dispersions in spectroscopy), the aberration corrections will be different.

See the Gatan GMS documentation for further details.

**Focus 1st**
The controls for the 1st order achromaticity correction are accessed under Focus 1st X and Y. When the radio button is checked, the MF knobs are connected to these controls (when the MF knobs button is yellow). The controls themselves are standard spin-edit-enter controls.

**Focus 2nd**
The controls for the 2nd order achromaticity correction are accessed under Focus 2nd X and Y. When the radio button is checked, the MF knobs are connected to these controls (when the MF knobs button is yellow). The controls themselves are standard spin-edit-enter controls.

**Ac Comp**
The Ac compensation controls define the Ac (stray field) compensation for the Imaging Filter. The compensation applies a 50 or 60 Hz (dependent on the local situation) frequency in two perpendicular directions, thereby compensating a stray field in the opposite direction. The controls for it are accessed under Ac Comp X and Y. When the radio button is checked, the MF knobs are connected to these controls (when the MF knobs button is yellow). The controls themselves are standard spin-edit-enter controls.

**Shift**
The shift controls allow the user to shift the spectrum. The controls for the shift are accessed under Shift X and Y. When the radio button is checked, the MF knobs are connected to these controls (when the MF knobs button is yellow). The controls themselves are standard spin-edit-enter controls. Note that the shift shifts both slit and spectrum and has no effect when in imaging mode. Normally the shift is used to set the spectrum to such a position that the inserted slit can be seen on the left-hand side of the TV monitor.

**MF knobs**
The Multifunction knobs can be used the change the settings of the four Filter elements described above. To connect the Multifunction knobs to one of the functions, select the particular functions through its radio button and press the MF knobs button (it will become yellow). You can change the sensitivity of the MF knobs with the MF - and + buttons.

**Flap-out button**
The flap-out button leads to the Filter Tuning Restore Control Panel.

## 25.1 Filter Tuning Restore



*The Filter Tuning Restore Control Panel.*

The Filter Tuning Restore Control Panel allows the loading and saving of Imaging Filter setting set via the Filter Tuning control panel. With the settings are stored a comment (entered under Info), the username of the user (the name under which you or another was logged on) and the date and time. All settings are accessible to all users and stored in a single file

**Info**
The Info entered by the user is included with the file and allows the user to store a comment with the settings.

**List**
The list contains an overview of the files with settings available, sorted according to the alphabetical order of the description, username or date/time. You can change the sorting by clicking on the buttons at the top of the list (Description, User, ...). Clicking again reverses the order.

**Load**
When the Load button is pressed, the settings currently selected in the list are loaded and sent to the Imaging Filter.

**Save**
When the Save button is pressed, the currently active settings are stored.

**Delete**
When the Delete button is pressed, the currently selected setting is deleted. Note that there is no protection against deleting other users' settings.

# 26 High Tension (Expert/Supervisor)
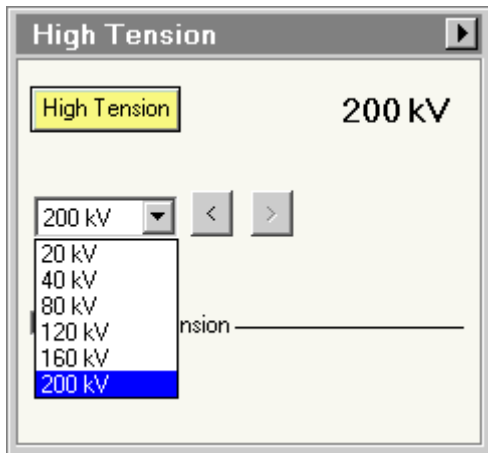


*The High Tension Control Panel.*

The High Tension Control Panel provides control over the high tension and its setting.

**High tension**
Pressing the High tension button switches the high tension on and off. The high-tension setting is displayed on the right. The High tension button has three possible settings:
- The high tension is enabled but off: the button is 'normal' gray.
- The high tension is on: the button is yellow.
- The high tension is disabled: the text in the button is gray.

**Display value**
The high tension display value shows the current high-tension setting. (Note that this is not a measured value.) If the high tension is on the fixed steps, the value is displayed as integer, otherwise (in Free high tension control) it is displayed with three decimals.

**High tension setting**
The high tension setting is selected either by selecting an item in the drop-down listbox (a range of fixed settings, comprising 20, 40, 80, 120, 160 and 200 kV) or pressing one of the "<" ">" buttons (step down or up). Settings other than the fixed high tension steps are available through the Free high tension control.
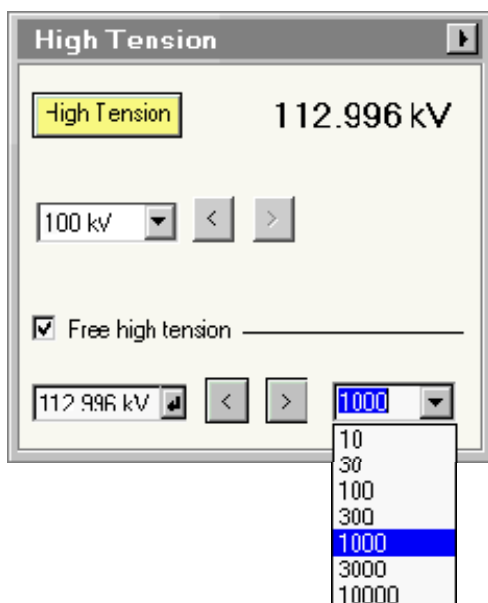


**Free high tension**
Through the Free high tension control any high-tension setting between 0 and 200 kV can be set with a minimum step size of 10 volts. (Note that at very low high-tension settings below 20 kV the high tension may effectively switch off.) To go to Free high tension control, click on the Free high tension check box. The Control panel will change to the following:

**Free high tension value**
The Free high tension value is set by changing the number in the edit control. The value set by the microscope will be as close as possible to the value indicated (within the limitations given by the smallest hardware step for the high tension). The high tension is changed only when the Enter button is pressed.
The maximum value you can change when going up equals the fixed high-tension step applicable to the current setting (so generally 40 kV, except when the high tension is less than 40 kV, when the step will be 20 kV). If the value entered implies a larger

step, the high tension is set to the current value plus the maximum allowed step.

**< >**
Pressing the <> button instructs the microscope to change the Free high-tension value by the step size indicated.

**Free high-tension step**
The Free high-tension steps (used by the < > buttons) can be selected from the step drop-down list.

When the Free high tension is switched off (by clicking on the check box again), the high tension will go the nearest fixed high tension step that is lower or equal to the Free high tension step (so, for example, 80 kV free goes to 80 kV fixed, but 59.340 kV free goes to 40 kV fixed).

**High-tension flap-out**
Pressing the arrow button displays the flap-out containing the Conditioning control panel.


## 26.1  Conditioning
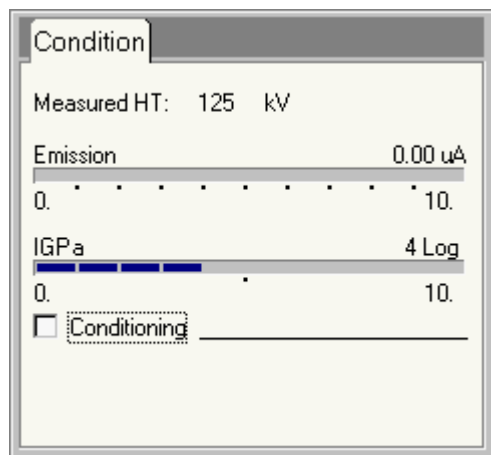


*The Conditioning Control Panel.*

The Conditioning Control Panel provides the controls needed for conditioning the high tension (the high tension of the microscope can be increased to 110% of the normal maximum to allow the high tension hardware to stabilise). During conditioning the high tension should be increased slowly while monitoring the emission current and IGP display for signs of instability. In case of severe instability, the high tension should be decreased quickly to allow the system to recover.

**Note:** During Conditioning both Spotsize (C1) and Intensity (C2) settings are fixed and cannot be changed.

**Measured HT**
The Measured HT shows the current measurement of the high tension. This measurement is not accurate (values can differ by 1-2 kV from the nominal value) and is solely meant as a display that the high tension is actually there.

**Emission display**
The emission display shows the current emission value. During conditioning this display should be monitored for signs of instability.

**IGPa display**
The IGPa display shows the current IGPa value. The IGPa used is the one that is most sensitive to changes when the high tension becomes unstable. During conditioning this display should be monitored for signs of instability.

## Conditioning
When the conditioning check box is checked, the control panel changes and displays the following additional controls:
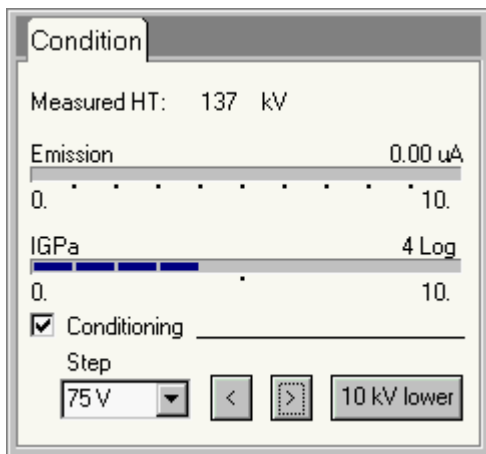


## Step
The step displays the high tension step taken when the < or > button is pressed. Other values can be selected from the list. However, at particular settings of the high tension, the step size will automatically be decreased (for safety) and larger steps will no longer be available.
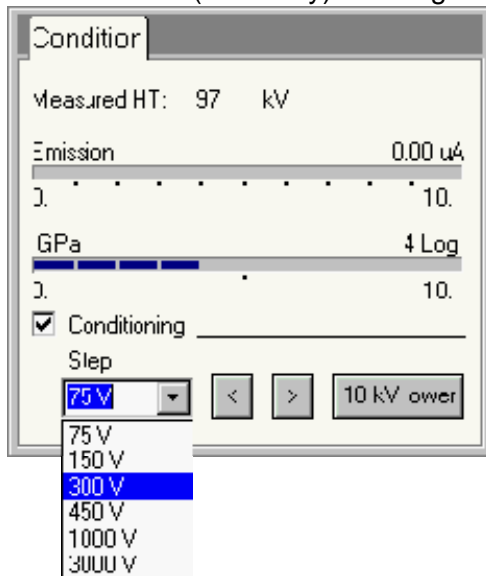


## <
Decreases the current high tension value by the step shown.

## >
Increases the current high tension value by the step shown. The system regulates the frequency of the steps (it doesn't allow too frequent steps shortly after one another).

## 10 kV lower
In case of severe instabilities or flash-overs, the 10 kV lower button allows the user to decrease the current high tension quickly to a setting 10 kV below the current one.

# 27 Image Settings
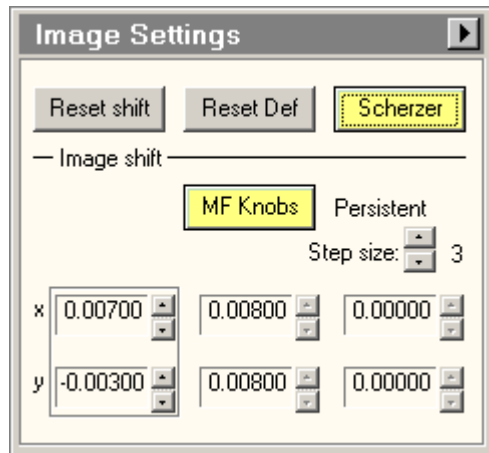


*The Image Settings Control Panel.*

The Image Settings Control Panel contains two sets of controls, general image settings control and the image shift settings.

**Flap-out**
Pressing the flap-out button displays the flap-out containing the Focus control panel.

## 27.1.1 Image settings

**Reset shift**
Pressing the reset shift button reset all relevant shifts. In imaging this applies to any user-defined image shift (user shift and coupled image-beam shift, see below). In diffraction, the diffraction shift is reset.

**Reset Def**
Pressing the Reset Def button resets the defocus display value to 0 (the objective or diffraction-lens current itself is not changed).

**Scherzer/Contrast**
Pressing the Scherzer/Contrast button activates/deactivates the Scherzer or Contrast functions. Which function is used is defined in the Focus control panel of the flap-out. A description of the functions is given below.

**Note:** The Scherzer/Contrast functions are available only in HM. In other modes the button will be disabled. If you switch from HM with Scherzer or Contrast on to another mode, the button becomes disabled but stays yellow (to indicate that the function is still on in HM; functionally it doesn't do anything in the other mode). You can only switch the function off by going back to HM.

**Scherzer function**
The Scherzer function provides a way for quickly switching to the Scherzer focus and back. Scherzer focus is a focus setting often used in high-resolution imaging. It is the focus where the largest number of diffracted beams have the same phase and therefore the image in thin parts of the specimen will look similar to a projection of the structure.

There are three focus settings on the microscope that are important for high-resolution imaging: Gaussian (absolute) focus, minimum-contrast focus and Scherzer focus.
| | |
|---|---|
| Gaussian focus | 0 nm |
| Minimum-contrast focus | ~0.4 * Scherzer |
| Scherzer focus | $-1.2 * (Cs * \lambda)^{0.5}$ |

**Note:** Because some people use a different definition of Scherzer focus (a constant different from 1.2 as used here), for example 1.0 or 1.1, it is possible to change the constant in the Focus control panel.

Of the three focus settings only minimum contrast is recognisable at high magnifications and is therefore the only one that can be used as a reference point. However, it should be realised that the uncertainty in the setting of minimum contrast focus is about 5 to 10 nm.

The Scherzer function should only be activated when the image is at minimum contrast. The microscope will reset the defocus display value to the correct, absolute value of the Scherzer focus. When Scherzer is switched off, the focus will return to minimum contrast and the defocus display will read 0.4 * Scherzer. By pressing the Scherzer focus the defocus display therefore goes from a relative setting (relative to the last time Reset Def was pressed) to an absolute setting.

|  | **Scherzer on** | **Scherzer off** |
|---|---|---|
| Objective-lens focus set | 0.6 * Scherzer | -0.6 * Scherzer |
| Focus display value | Scherzer | D = -0.6 * Scherzer |

If the focus is changed with the focus knob while Scherzer is active, the change in focus will be added to/subtracted from the value displayed for Scherzer focus. If Scherzer is then turned off, the display value will add the defocus difference between Scherzer and minimum contrast focus.

**Contrast function**
By applying a certain amount of underfocus the contrast in the TEM image can be enhanced. The increased contrast comes at the expense if image resolution. How much underfocus to apply depends on personal preference (balancing the amount of contrast enhancement needed and how blurry the image can become without losing information required) and the magnification (what may look alright at low magnification looks terribly blurred at high magnification). The microscope offers an automatic function for contrast enhancement. When activated the microscope will apply a certain amount of underfocus, dependent on the choice of the degree of contrast enhancement (in the Focus control panel) by the user (from very low to very high) and the magnification. The function assumes that the image has been set to Gaussian focus (0 nm) before it is activated. Because of the magnification dependence, the amount of defocus will automatically change when the magnification is changed with Contrast enhancement active.

### 27.1.2  Image shift

**Caution:** There is no software limitation on the amount of image shift allowed (the range of the image deflection coils is the limit). However, it should be realised that working far off-axis can affect the quality of the images due to the normal lens aberrations that occur away from the center of the magnetic lenses (such as coma). For lower-magnification work it is advised not to exceed a few micrometers for recording images, while for high-resolution imaging the image shift should ideally be limited to several hundreds of nanometers (200-300). For looking around the image shift can be used, but it is always advised to record images as close as possible to the center.

**Special function**: Click with the right-hand mouse button on one of the channels to get a popup-menu.

**MF knobs**
Pressing the MF knobs button couples (the button turns yellow) or decouples the Multifunction knobs to/from the Image shift. When the Image shift is controlled with the Multifunction knobs, the nature of the coupling (persistent or temporary) is indicated. Pressing the MF knobs is equivalent to clicking with the right-hand mouse button on the binding panel and selecting Image shift for the Multifunction knobs (coupling) or None/clear (decoupling).

**Sensitivity**
The sensitivity spin buttons set the step size for the image shift. Pressing the Multifunction -/+ buttons is the same as decreasing/increasing the sensitivity when the Multifunction knobs are coupled to the image shift.

**Channel**
Shift settings can be stored in three channels. The active channel is outlined by a frame around it and by the enabled nature of its spin buttons (the arrows are black; those of the inactive channels are gray).

**Spin control**
Use the buttons of the spin control to change the Image shift setting (an alternative to using the Multifunction knobs).
**Popup menu functions**

**Copy**
Copies the contents of the channel in which the mouse was clicked to the clipboard.

**Paste**
Pastes the contents of the clipboard into the channel where the mouse was clicked. This menu items remains grayed (disabled) until a copy action has been done.

**Reset**
Resets the image shift channel to zero.

**Copy ... to ...**
Copies the content of the channel listed first to the channel listed second. The copy action is always from the channel where the right-hand mouse click was done to one of the other channels.

### 27.1.3 The image shift

The microscope is equipped with an image shift effected through the image deflection coils. The image shift has a compensating beam shift to keep the illumination centered on the area of interest. The beam shift compensation must be calibrated for the various modes (Microprobe, LM , Nanoprobe) before it will work properly.
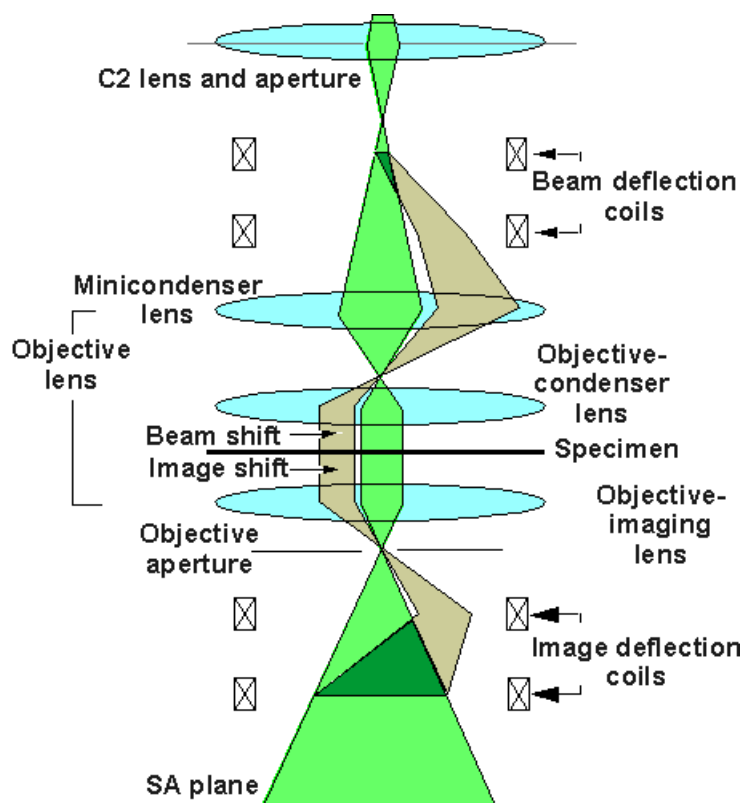
*When the user shifts the image (from the central green ray path to the off-axis, tan ray path), the microscope automatically applies a compensating beam shift.*

**Note:** The settings of the image shift are not persistent (they are not stored by the microscope when a user logs out; all three channels are reset when the user logs in to the TEM User Interface).

## 27.2 Image Settings Focus
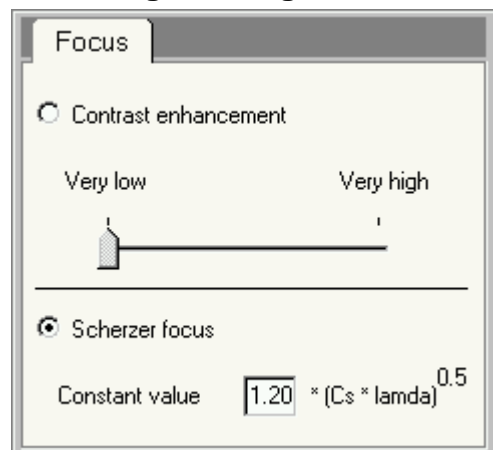
*The Image Settings Focus Control Panel.*

The Image Settings Focus Control Panel contains the parameter settings for the focus functions (Scherzer and Contrast enhancement).

**Contrast enhancement / Scherzer focus selection**
The two focus functions are accessed via the same button in the Image settings control panel (since their effect is similar and their application totally different, there is no point in having both functions directly accessible. Which function is selected is controlled by the two radio buttons (Contrast enhancement and Scherzer focus). You cannot change the selection when the focus function on the Image settings control panel is active.

**Contrast enhancement setting**
The slider defines the strength of the contrast enhancement, in five steps, from very low to very high. Higher contrast comes at the expense of resolution (image blurriness).

**Scherzer focus**
Although Scherzer focus is commonly defined as $1.2 * (Cs * \lambda)^{0.5}$ , some people use other constants (like 1.0 or 1.1). You can change the value of the constant to the value you wish to use in the Scherzer focus edit control.

# 28 Lorentz
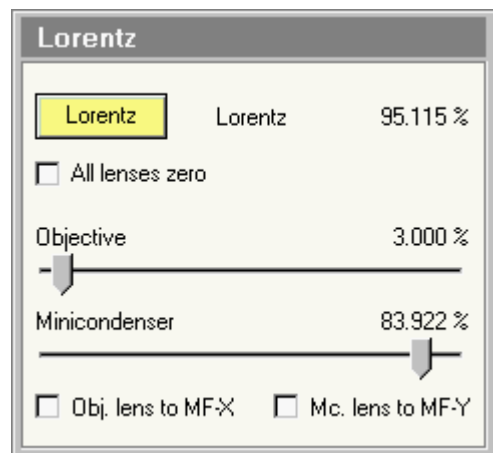


*The Lorentz Control Panel.*

The Lorentz Control Panel contains the controls for the Lorentz mode. In the Lorentz mode the objective-lens function is replaced by the Lorentz lens, a small lens that is located at the bottom of the objective-lens lower pole piece (quite similar to the minicondenser lens, but with the main difference that it has a separate water-cooling circuit).

The Lorentz lens fills an intermediate position between 'objective-lens on' (high magnification values and good resolution) and 'objective-lens off' (low magnification values and poor resolution). Typically attainable maximum magnification values for the Lorentz lens are ~60kx (as opposed to ~3kx for LM) and the resolution is somewhere between 1 and 2 nm. The Lorentz lens thus provides magnifications and resolutions adequate for studying magnetic materials without having the objective lens on (whose field normally wipes out the magnetic structure of the specimen).

The standard mode for imaging is Lorentz microscopy, whereby the magnetic structure is imaged by going under- or overfocus. It is also possible to use the Lorentz lens for Foucault imaging. However in this case an aperture must be used. Since the objective aperture cannot be used due to its position (before the Lorentz lens), the Selected Area aperture must be used. This means changing the optics to bring the Selected Area aperture into the back-focal plane of the Lorentz lens (normally it is in the first intermediate plane) and then changing the Diffraction lens to focus it on the new intermediate image plane of the Lorentz lens. As a rough guide, start off in normal Lorentz imaging. Change the focus step to 9 and go one step underfocus. You should now be close to having a diffraction pattern instead of an image. Fine focus the pattern. Insert the Selected Area aperture to the position needed. Change to diffraction. Set the focus step to 9 and go one step overfocus. You should now be close to focus in a Foucault image. Because of the change in optics the Foucault image is more limited in maximum magnification than the normal Lorentz image.

**Lorentz**
The Lorentz mode is activated by pressing the Lorentz button. The Lorentz mode is only accessible from the HM Microprobe (Mi, SA, Mh) mode.

**Caution:** Switch to the Lorentz mode before inserting magnetic specimens into the microscope.

**Lorentz excitation**
The Lorentz excitation displays the excitation value (on a scale of 0-100%) of the Lorentz lens. The setting is controlled via the Focus knob.

**All lenses zero**
The wall of the microscope column is made of a type of steel that can be made magnetic (as a shielding measure for the inside of the microscope from outside fields). The magnetic fields of all lenses together create a magnetic field at the wall of the column that can be strong enough to destroy or affect the magnetism in specimens when they are inserted into the microscope through the airlock. Always use the

option All lenses zero to switch all lenses to zero when inserting (or removing specimens). Once the specimen is inside the microscope, the wall field will no longer affect the specimen magnetism.

**Objective lens**
For dynamic experiments it is possible to switch the objective lens on with a user-defined field.

**Note:** If the Objective lens is not used during Lorentz microscopy, it is advised to switch the Objective-lens power supply off. This power supply is not ideal for very low outputs and usually oscillates, making a buzzing noise. The oscillation may also cause instabilities in Lorentz imaging.

**Minicondenser lens**
The Minicondenser lens has a weak leak field into the objective-lens gap. It may be desirable to switch the minicondenser lens off. Alternatively the minicondenser lens field can be used to compensate any leak field of the Lorentz lens itself in the objective lens gap. The easiest way to ascertain the presence of leak fields is to tilt a weakly magnetic specimen  and observe the behavior of the domain walls. If the domain walls move, there is a residual field in the objective-lens gap. If not, any such residual field is too weak to be detected.

**Note:** The Lorentz minicondenser lens value is decoupled from the normal microprobe/nanoprobe minicondenser setting (and thus has no effect on that setting).

**Bind to MF-X**
The setting of the objective lens can be coupled to the Multifunction X knob.

**Bind to MF-Y**
The setting of the minicondenser lens can be coupled to the Multifunction Y knob.

# 29 Measuring
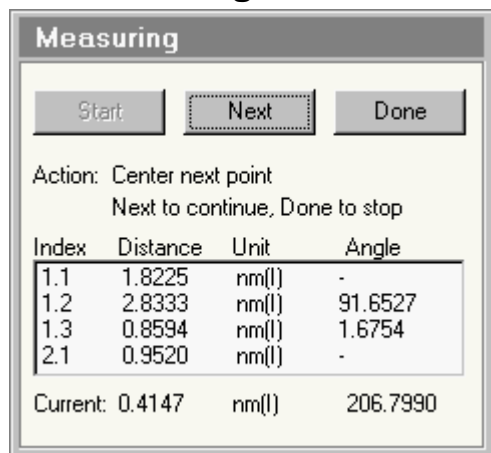


The Measuring Control Panel.

The Measuring Control Panel is used for on-line measuring on the microscope. On-line measuring can be performed in image mode (giving distances in the image and the angles between the distance vectors) and in diffraction (giving d spacings and the angles between the corresponding lattice planes).

**Note:** For accurate measurement it is very important that the image shift calibration and diffraction shift calibration have been done properly.

**Start**
When the Start button is pressed, a measurement cycle is started. Each cycle has its own serial number (the number before the period under Index in the measurement list) and within each measurement cycle individual measurements are also numbered (the number behind the period). Measurement cycles are unique for the current microscope session (the number 1 is used only once, etc.).

**Next**
When the Next button is pressed, the current measurement values are moved to the measurement list and a new (single) measurement is started.

**Done**
When the Done button is pressed, the current measurement value is moved to the measurement list and the current measurement cycle is closed.

**Instructions**
Before and during measurement, instructions are listed in the control panel.

**Measurement list**
The measurement list contains the values of all measurements performed. Each individual measurement occupies a line in the list. Each line contains four items:
- Index: contains the values of the measurement cycle (before the period) and the individual measurement (after the period). Measurements having the same cycle number belong together in a sequence.
- Distance: the distance value measured (distance in image mode, d spacing in diffraction).
- Unit: the unit (micrometer - um - or nanometer - nm) of the measurement and the mode in which the measurement was done, (I) stands for imaging, (D) for diffraction.
- Angle: the angle between individual measurements of a cycle. These values have different meaning in imaging and diffraction, see the description below.

**Current**
The values listed under Current show the values of the measurement currently being done.
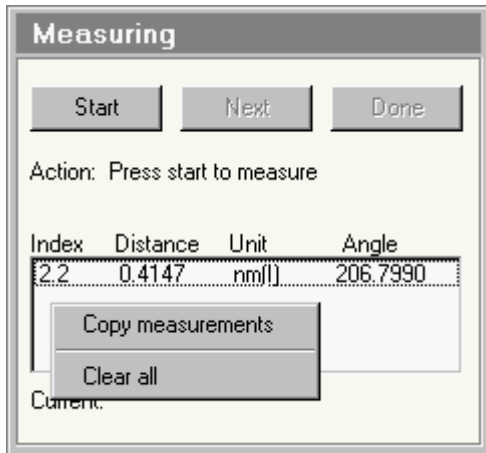
When the right-hand mouse button is clicked on the measurement list, a popup menu becomes visible that allows copying of all the measurements currently in the list to the clipboard (from where it can be pasted into Notepad, for example) or to clear all measurements (empty the list).

### 29.1.1 Measuring in imaging
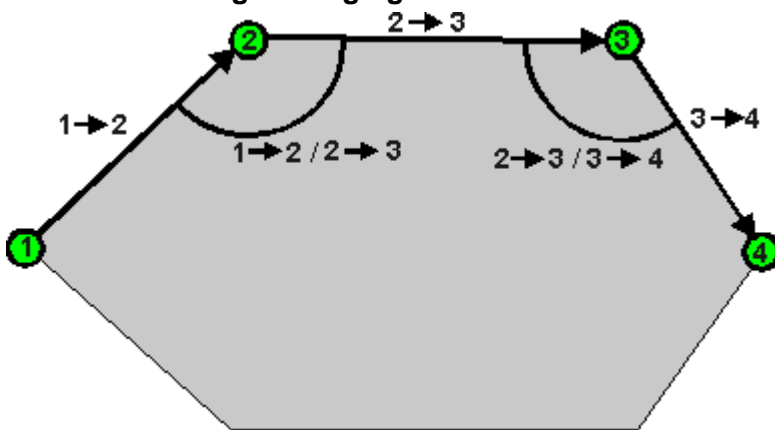
*Schematic diagram of measuring in imaging, showing the vectors of consecutive measurements and the meaning of the angles.*

**Note:** The image shift used for measuring is not the one with the compensating beam shift. During measuring the beam will move off with the image and must be recentered if the measuring goes beyond the edge of the beam.
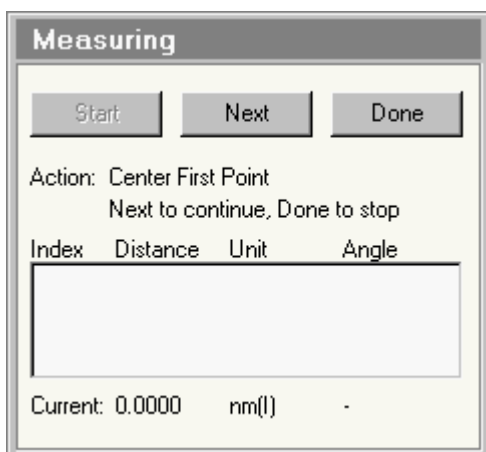
*After the Start button has been pressed, the Multifunction knobs can be used to center a first image feature on the screen. Once the image feature has been centered, the Next button is pressed.*

**Measuring**

| Start | Next | Done |
|---|---|---|

Action: Center next point
         Next to continue, Done to stop

| Index | Distance | Unit | Angle |
|---|---|---|---|
| 1.1 | 1.8225 | nm(l) | - |

Current: 0.0000     nm(l)     -

*When the Next button has been pressed, the measurement is moved to the list and a next feature can be centered.*

**Measuring**

| Start | Next | Done |
|---|---|---|

Action: Center next point
         Next to continue, Done to stop

| Index | Distance | Unit | Angle |
|---|---|---|---|
| 1.1 | 1.8225 | nm(l) | - |
| 1.2 | 2.8333 | nm(l) | 91.6527 |
| 1.3 | 0.8594 | nm(l) | 1.6754 |
| 2.1 | 0.9520 | nm(l) | - |

Current: 0.4147     nm(l)     206.7990

*Measurements can be continued as long as is necessary by pressing Next once each new point has been centered.*

### 29.1.2 Measuring in diffraction

Measuring in diffraction in essence works the same as in imaging, but with one major difference. In diffraction all measurements are done relative to the transmitted (central) beam. In imaging the vectors are 1-2, 2-3, 3-4, etc., while in diffraction they are 1-2, 1-3, 1-4, etc. The reason for this difference is very simple: when defined in this way, the angles are the angles between the lattice planes in the crystal structure.
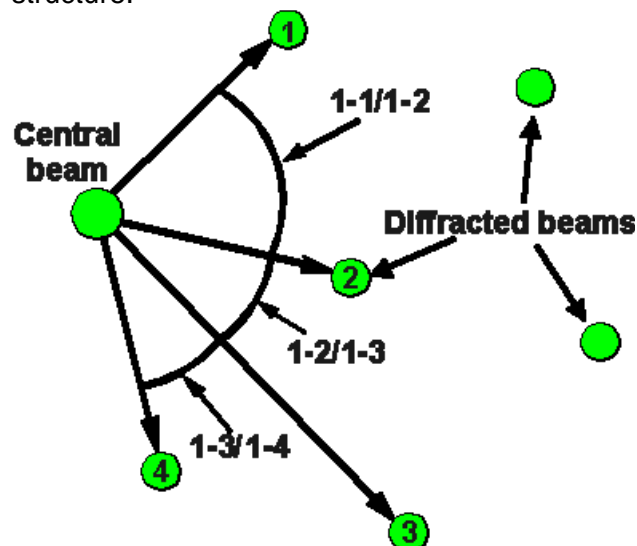
*Schematic diagram of measuring in diffraction. All vectors are relative to the central beam.*

*To measure in diffraction, press the Start button and center the central (transmitted) beam on the screen.*

*Once the central beam has been centered, press Next. Center the first diffracted on the screen and press Next to repeat the measurement for further diffracted beam.*

The images below show diffraction measuring using the beam stop as reference point.
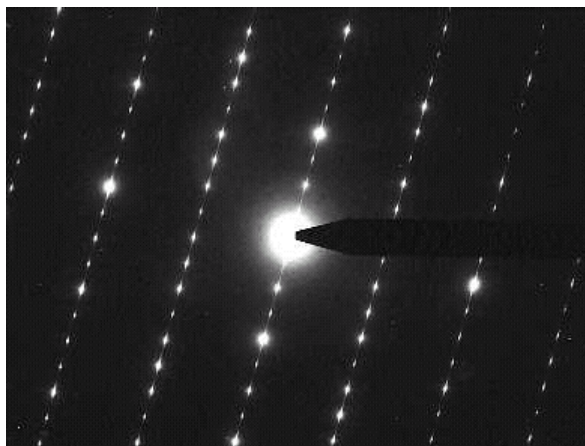


*The central beam has been moved to the tip of the beam stop.*
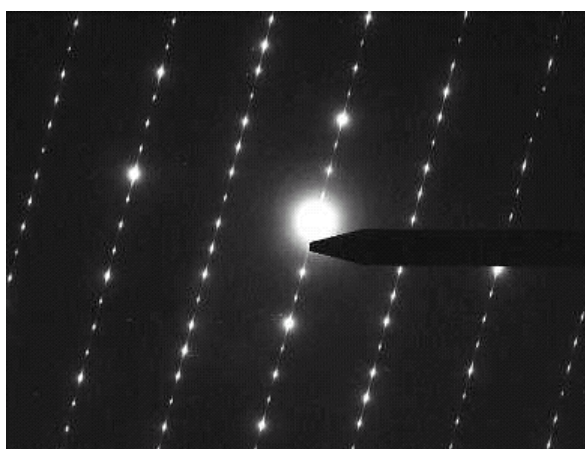


*A diffraction beam has been moved to the beam stop. Now the d spacing for the diffracted is displayed.*
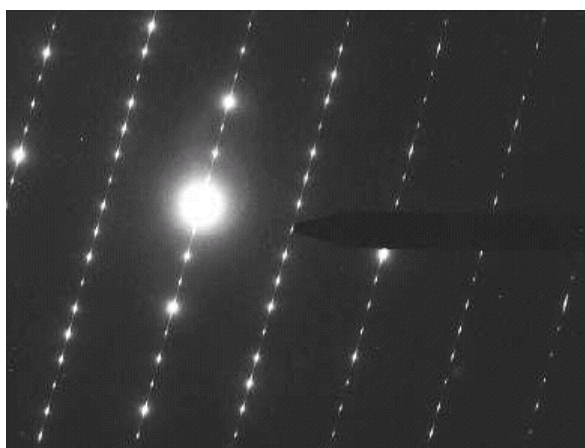


*A second diffracted beam has been moved to the beam stop, and the d spacing of this second beam as well as the angle between diffracted beams 1 and 2 is displayed.*

# 30 Normalizations
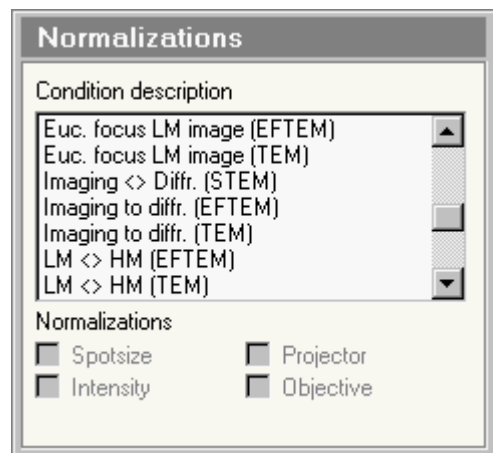


*The Normalizations Control Panel.*

The Normalizations Control Panel provides control over the normalizations executed by the microscope.

### 30.1.1 Introduction to normalizations
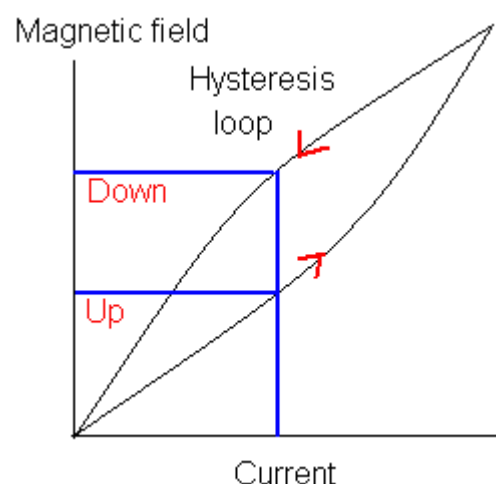


Magnetic lenses suffer from hysteresis, which causes a certain degree of non-reproducibility of the magnetic fields, dependent on the direction of change. The diagram below sketches how the magnetic field changes when the current through the lens coils goes up (lower curve) and goes down (upper curve). When the current goes up, the field increases but 'lags' somewhat behind. The opposite occurs when the lens current goes down. Therefore the effective field is higher when going down than when going up.

Hysteresis can have appreciable effects on the illumination system (C1 and C2 lenses) and the magnification system (Diffraction, Intermediate and Projector lenses) and as a consequence affect the spot position (illumination system) as well as the true magnification or camera length (magnification system). The image or diffraction shifts used for the image/diffraction alignment and the cross-over alignment (for Energy-Filtered TEM) can also be sensitive to the actual values of the magnetic fields of the lenses in the magnification system.

In order to make the lens fields more reproducible, the lens normalization can be executed. In the normalization procedure the lens(es) involved is (are) taken through a sequence completely up - then completely down - completely up again - and then down to the required value. The normalization brings the lenses to more reproducible settings - and, as a consequence, more reproducible magnifications/camera lengths, image/diffraction shifts and cross-over corrections.

Normalizations can be executed by hand (e.g. by assigning projector normalization to one of the Control Pad user buttons) and/or automatically. The automatic normalizations are determined by the settings selected by the user in the Normalizations control panel. Because automatic normalizations can be done for a number of different conditions, it is possible that more than one normalization is done. The system

has been made such that it doesn't start a new normalization while another normalization is still being executed, but only executes one final normalization. Thus, if automatic normalizations occur for each change in magnification step, then a normalization will be done for each individual step only if the magnification is changed very slowly. Otherwise the following happens:

- Change magnification -> execute normalization
- Normalization has started, magnification changed again
- x times magnification changed again, previous normalization still running
- Previous normalization finished, no more magnification changes
- Execute one final normalization

**List of normalizations**
The list of normalizations contains a series of possible conditions (changes in system settings) that can lead to automatic normalizations. Each of these conditions can have normalizations associated for spotsize, intensity, projector and/or objective. Associated normalizations have their check boxes enabled, as in the picture below (otherwise the check boxes remain disabled). All lenses selected for normalization are normalized together.
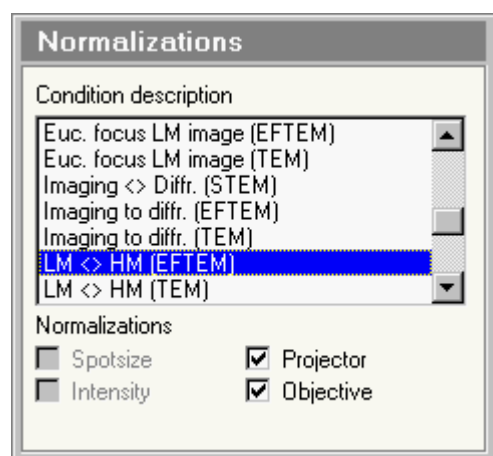


The list is arranged alphabetically, so STEM- and EFTEM-related items can come between the TEM conditions (dependent on the hardware configuration of the microscope). In the table below, the STEM and EFTEM conditions are listed separately from the TEM conditions for clarity.

**Spotsize**
When Spotsize is checked for the normalization condition in the list selected, the Spotsize (C1 lens) will be normalized when the condition (from the list) is encountered.

**Intensity**
When Intensity is checked for the normalization condition in the list selected, the Intensity (C2 lens) will be normalized when the condition (from the list) is encountered.

**Projector**
When Projector is checked for the normalization condition in the list selected, the Projection system (Diffraction, Intermediate, Projector 1 and Projector 2 lens) will be normalized when the condition (from the list) is encountered.

**Objective**
When Objective is checked for the normalization condition in the list selected, the Objective lens will be normalized when the condition (from the list) is encountered.

| TEM Conditions | Description | Default normalizations |
|---|---|---|
| Camera length change (TEM) | When changing camera length | None |
| Diffr. to imaging (TEM) | When going from diffraction (D or LAD) to imaging (Mi, SA, Mh or LM) | Projector |
| Euc. focus HM diffr. (TEM) | When eucentric focus is pressed in HM diffraction (D) | Objective, Projector |
| Euc. focus HM image (TEM) | When eucentric focus is pressed in HM (Mi, SA, Mh) imaging | Objective, Projector |
| Euc. focus LM diffr. (TEM) | When eucentric focus is pressed in LM diffraction (LAD) | Objective, Projector |
| Euc. focus LM image (TEM) | When eucentric focus is pressed in LM imaging | Objective, Projector |
| Imaging to diffr. (TEM) | When going from imaging (LM or Mi, SA, Mh) to diffraction (LAD or D) | Projector |
| LM <> HM (TEM) | When switching between LM (objective lens off) and HM (objective lens on) | Objective, Projector |
| Magn. change (TEM) | When changing magnification (LM, Mi, SA, Mh) | None |
| Mi <> SA <> Mh | When changing between Mi and SA or between SA and Mh | None |
| Spotsize | When changing spotsize setting | Spotsize, Intensity |
| uP <> nP | When changing between microprobe and nanoprobe modes | Spotsize, Intensity, Objective |
| **STEM-related Conditions** | **Description** | **Default normalizations** |
| Camera length change (STEM) | When changing camera length | Projector |
| Euc. focus (STEM Image) Diffr. | When eucentric focus is pressed in STEM (TEM) diffraction | Spotsize, Intensity, Objective, Projector |
| Euc. focus (STEM Image) Imaging | When eucentric focus is pressed in STEM (TEM) imaging | Spotsize, Intensity, Objective, Projector |
| Imaging to diffr. (STEM) | When switching between imaging and diffraction (press Diffraction button) | Projector |
| Spotsize | When changing spotsize setting | Spotsize, Intensity, Objective, Projector |
| TEM <> STEM | When switching between TEM and STEM | Projector |
| **EFTEM-related Conditions** | **Description** | **Default normalizations** |
| Camera length change (EFTEM) screen down | When changing camera length in EFTEM with the viewing screen down | None |
| Camera length change (EFTEM) screen up | When changing camera length in EFTEM with the viewing screen up | Projector |
| Diffr. to imaging (EFTEM) | When going from diffraction (D or LAD) to imaging (Mi, SA, Mh or LM) in EFTEM | Projector |
| Euc. focus HM diffr. (EFTEM) | When eucentric focus is pressed in EFTEM HM diffraction (D) | Objective, Projector |
| Euc. focus HM image (EFTEM) | When eucentric focus is pressed in EFTEM HM (Mi, SA, Mh) imaging | Objective, Projector |

| Euc. focus LM diffr. (EFTEM) | When eucentric focus is pressed in EFTEM LM diffraction (LAD) | Objective, Projector |
|---|---|---|
| Euc. focus HM image (EFTEM) | When eucentric focus is pressed in EFTEM LM imaging | Objective, Projector |
| Imaging to diffr. (EFTEM) | When going from imaging (LM or Mi, SA, Mh) to diffraction (LAD or D) in EFTEM | Projector |
| LM <> HM (EFTEM) | When switching between LM (objective lens off) and HM (objective lens on) in EFTEM | Objective, Projector |
| Magn. change (EFTEM) screen down | When changing magnification (LM, Mi, SA, Mh) in EFTEM with the viewing screen down | None |
| Magn. change (EFTEM) screen up | When changing magnification (LM, Mi, SA, Mh) in EFTEM with the viewing screen up | Projector |
| Mi <> SA <> Mh (EFTEM) | When changing between Mi and SA or between SA and Mh (in EFTEM) | Projector |
| TEM <> EFTEM | When switching between TEM and EFTEM | Objective, Projector |

# 31 PEELS
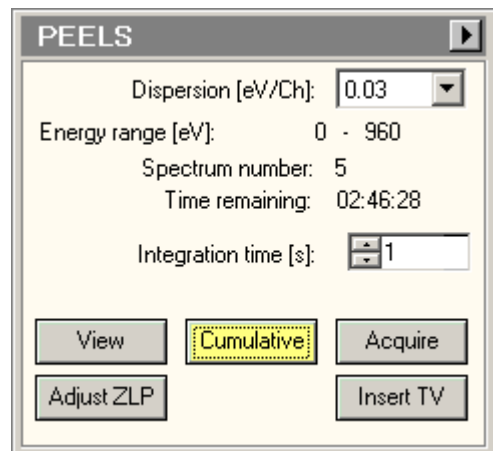
In the PEELS Control Panel the controls for (single-point) PEELS spectrum acquisition are located.

**Note:** TIA must be running. If it is not running, the buttons are disabled.

**Dispersion**
The drop-down list contains the accessible dispersion settings for the PEELS detector. This list corresponds to the list of dispersions in Gatan FilterControl.

**Energy range**
The Start and End values define the start and end energy (in electronvolt) of the spectrum.

**Spectrum number**
During acquisition the spectrum number is displayed when more than one spectrum is acquired in a single acquisition.

**Time remaining**
During acquisition the time remaining before acquisition is finished is displayed.

**Integration time**
The Integration time sets the acquisition time for the currently active acquisition mode (View, Cumulative, Acquire)

**View**
Pressing the View button :
• When the button is gray, switches the PEELS acquisition settings to those of the View mode and starts acquisition.
• When the button is yellow, pauses PEELS acquisition.
• When the button is white, resumes PEELS acquisition.
By definition View is continuous acquisition.

**Cumulative**
The Cumulative acquisition mode continuously acquires spectra and adds them together (the essential difference with View is therefore that in View each spectrum acquired is discarded when the next spectrum comes in, while in cumulative they are all kept).

Pressing the Cumulative button :
• When the button is gray, switches the PEELS acquisition settings to those of the Cumulative mode and starts acquisition.
• When the button is yellow, pauses PEELS acquisition.

- When the button is white, starts PEELS acquisition.

By definition Cumulative is continuous acquisition (until the maximum number of spectra, 10000, has been acquired).

## Acquire

Pressing the Acquire button :
- When the button is gray, switches the PEELS acquisition settings to those of the Acquire mode and starts acquisition.
- When the button is yellow, stops PEELS acquisition.
- When the button is white, starts PEELS acquisition of a new spectrum.

By definition Acquire is single acquisition (but each spectrum itself may consist of multiple spectra)..

## Adjust ZLP

The Adjust Zero-Loss Peak function in spectroscopy is used it to set the scale of the EELS spectrum. Operation of the function is as follows:
- Start spectrum View.
- Make sure that in the Filter Control Panel all energy offsets (Energy shift, Drift tube) are 0.
- Press the Align ZLP button. The MF-Y knob is now connected to the energy adjustment of FilterControl.
- Turn the MF-Y knob to move the zero-loss peak to the 0-volt channel.
- Press the Align ZLP button when done.

## Insert TV

If relevant (the Filter has an insertable TV camera) the Insert TV button allows insertion or retraction of the TV camera.

## Flap-out button

Pressing the flap-out button displays the flap-out with the PEELS Settings Control Panel.

## 31.1 PEELS Settings
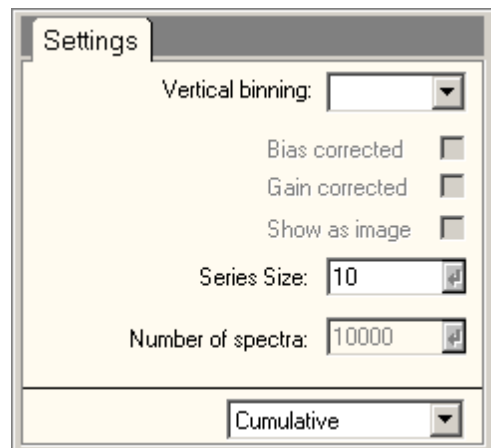
In the PEELS Settings Control Panel the settings used for PEELS spectrum acquisition are defined.

**Vertical binning**
In spectroscopy the filter allows a different binning for the vertical direction (the non-dispersion direction). Setting the vertical binning to higher values speeds up spectrum acquisition but also results in more rapid saturation of the CCD.

**Bias corrected**
Under Bias corrected the dark-current correction of the spectrum acquisition is switched on (checkbox checked) or off.

**Gain corrected**
Under Gain corrected the gain correction of the image acquisition is switched on (checkbox checked) or off. Gain corrected can only be on when Bias corrected is on (the Bias corrected check box becomes disabled when Gain corrected is checked).

**Show as image**
The spectrum is acquired as a two-dimensional image that is integrated into the vertical direction to create a one-dimensional spectrum. Under some circumstances (e.g. for focusing or inspection of residual aberrations) it may be advantageous to have the spectrum displayed as the original two-dimensional image. If the checkbox Show as image is checked the image is also displayed, otherwise it is only the spectrum.

**Series size**
Under series size the size of the acquisition series for the currently active acquisition mode is set. Please note that for Acquire, the series size doesn't do anything unless the TIA option "Reuse display window" is active.

**Number of spectra**
Under number of spectra is defined how many spectra are acquired (added together) during a single acquisition. The control is enabled only when the Acquire mode is selected. For View the number is by definition 1, for Cumulative 10000.

**Acquisition mode**
In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and by pressing the equivalent button in the main control panel is that the drop-down list selection selects the mode but does not automatically start acquisition.

## 32 Phase plate
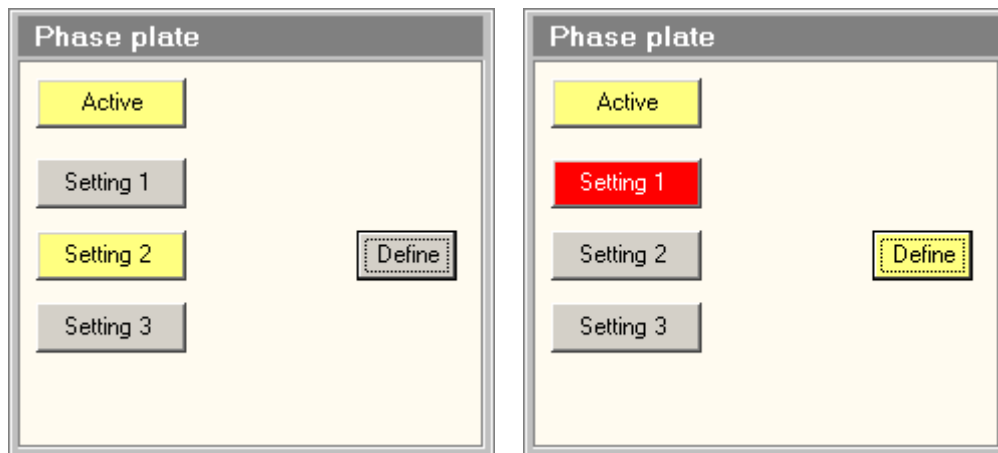
**Introduction**
The Phase Plate allows adding a phase shift to the central (unscattered) beam which enhances low-frequency contrast. In order for the phase plate to work properly, the cross-over in (or near) the back-focal plane of the objective lens must be set as accurately as can be achieved at the phase plate. The Phase Plate control panel aids operation with the phase plate by allowing storage of three sets of optical settings that can be recalled as needed. The settings are stored per (fixed) high-tension step of the microscope.

The settings stored and recalled are:
- Optical mode.
- Spot size.
- Intensity.

**Active**
Before the phase plate settings controls can be used, the phase plate control must be activated by pressing the Active button (which will turn yellow).

**Settings 1, 2, 3**
The three sets of optical settings are accessed through the three buttons Settings (1, 2, 3). When a button is pressed, the particular setting is selected. There are two possible consequences:
1. The button turns red with white text. The particular setting has been selected but there are as yet no optical settings defined.
2. The button turns yellow. In this case the pre-defined optical settings are put into the TEM optics.

**Define**
In order to define the electron-optical settings associated with one of the three settings, select the particular setting (press the button so it becomes red or yellow), press the Define button (if becomes yellow), manually set the optical settings on the microscope, and press the Define button again (it becomes grey again). If the Settings button was red before, it will now turn yellow. This is only possible in an electron-optical mode that is suitable for phase-plate operation.

## 32.1 Phase plate File
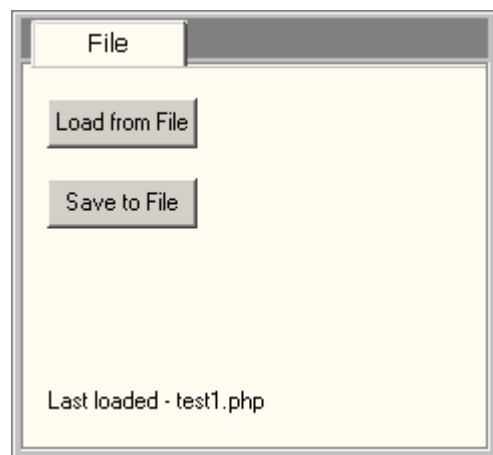


**Introduction**
Phase Plate settings can be stored to file and reloaded. When saved the file contains the three settings of the current high tension. When settings are loaded from file, they are put in the settings of the correct high tension (the one for which they were stored). Only if that is the current high tension do the settings become active (otherwise they become active when the high tension is set to the high tension of the settings in file)..

**Load from file**
Before the phase plate settings controls can be used, the phase plate control must be activated by pressing the Active button (which will turn yellow).

**Save to file**
The three sets of optical settings are accessed through the three buttons Settings (1, 2, 3). When a button is pressed, the particular setting is selected. There are two possible consequences:

The button turns red with white text. The particular setting has been selected but there are as yet no optical settings defined.
The button turns yellow. In this case the pre-defined optical settings are put into the TEM optics.

**Last loaded**
The label displays the name of the file loaded last.

## 33 Piezo
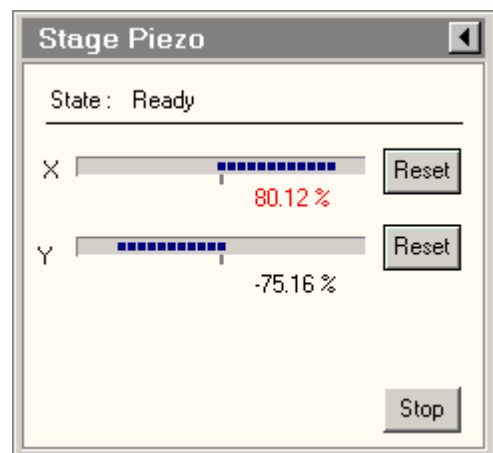


*The Piezo Control Panel.*

### Introduction

The Stage Piezo is an enhancement of the CompuStage. The main functions of piezo extensions to the CompuStage are:
- Fine and comfortable positioning of sample details on the fluorescent screen with variable step sizes ranging between several nanometers and down to sub-Angstrom.
- Manual drift correction for reducing thermal drift effects.

### Jog and move
The piezo's can have two types of movement. When jogging they are moving continuously with a certain speed and will continue to do so until they are stopped. When moving they are in the transition from one position to another. Once the piezo's have reached the required position, they will stop.

### State
The piezo can have the following states:
- Disabled (not operational, all buttons will be grayed out)
- Ready (operational, actuators are idle)
- Jogging (one or more of the axes is jogging)
- Moving (one or more of the axes is moving)

### Piezo position
The current position of the piezo's is relative to the available stroke of the actuator. The position is expressed in percentage with a range of -100% till +100%. When the piezo is reaching the end of its stroke the current position value will be colored red. This is only to indicate limitations of the operational field in which the piezo can be used. When more stroke is required the operator should press the reset button.

### Reset X, Y,
Each axis has a Reset button. When this button is pressed the actuator will be repositioned to the middle (0.0%). During this reset procedure (the image) sample area will stay centered (as well as possible - within the limitations of the stage hardware).
A reset will also stop jogging the axis. When the reset is completed it will stay idle.

### Stop
Clicking the Stop button will stop all axes from jogging and moving immediately.

**Piezo Flap-out**

Pressing the arrow button displays the flap-out containing the Piezo Control, Move and Jog control panels.

## 33.1 Control pads

The piezo's can be controlled with the knobs on the control pads. The table gives an overview of the knobs which can be bound to the piezo functionality.

| Control | Function |
|---|---|
| MF X / MF Y | Jog X / Jog Y<br>Move X / Move Y |
| MF +/- sensitivity | Jog X / Y step size (step 1 till 5)<br>Move X / Y step size (step 1 till 5) |
| Joystick | Jog X / Y |
| Joystick +/- | Jog X / Y step size (step 1 till 9) |
| User buttons | Reset X / Y<br>Toggle MF for Move/Jog<br>Toggle Joystick Stage/Piezo |

## 33.2 Piezo Control
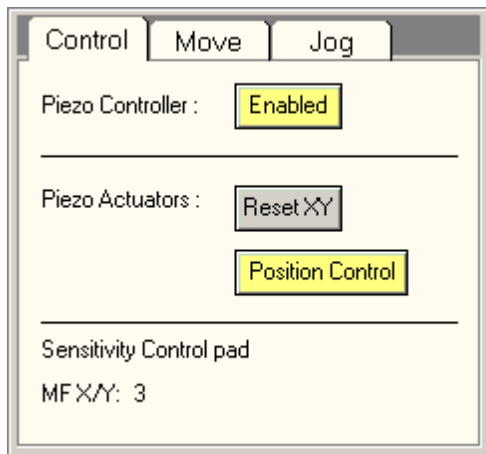
*The Piezo Control Control Panel.*

**Enabled**

The Enabled button indicates if the piezo is operational.

The Enabled button can turn yellow when:
- At startup of the Tem Server the piezo will be enabled.
- When the operator clicks the enable button when its gray and becomes operational.

The Enabled button can turn gray when:
- Operator clicks on the Enable button. The axes will be stopped and the servos are turned off. The controller will be disconnected.
- There is a problem with the controller.

Note that when the Enabled button is gray all other buttons and status reports are disabled.

**Reset XY**

When the Reset XY button is pressed the X and Y actuators will be repositioned to the middle (0.0%). During this reset procedure the (image) sample area will stay centered (as well as possible - within the limitations of the stage hardware).
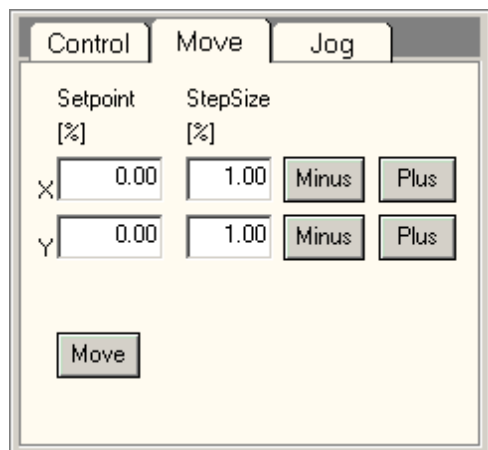
**Position Control**

The Position Control button is only used for ultimate performance in HR- S/TEM imaging like deep Sub-Angstrom imaging and disables the measuring unit of the piezo elements for higher stability. For drift compensation the measuring unit is enabled automatically, when the jog mode is active.

**Sensitivity control pad**

The current sensitivity of the MF X/Y is shown. The settings can only be manipulated from the control pad (MF +/-).

## 33.3  Piezo Move



*The Piezo Move Control Panel.*

**Absolute Move**
An absolute move can be done by filling in the column of Setpoint and clicking the Move button. All axes will execute a move to the given position.

**Relative Move**
A relative move can be done by filling in the columns of Stepsize and clicking on Minus or Plus button. A relative move can only be executed for an individual axis.

**Minus / Plus**
The relative move indicated in the StepSize column will be executed in negative or positive direction.

**Move**
When the Move button is pressed, the piezo axes will move to the Setpoints defined.

## 33.4 Piezo Jog



*The Piezo Jog Control Panel.*

**Current Jog Velocity**
The first column displays the current velocity of each axis. The velocity can be manipulated by the user interface, the control pads or a client application.

**Absolute Jog**
An absolute jog can be done by filling in the second column of Velocity and clicking the Jog button. All axes will execute a jog with the given velocity.
The Jog button is yellow when an axis is jogging.
All axes can be stopped jogging by pressing the Stop button.

**Relative Jog**
A relative jog can be done by filling in the third column of Increment and clicking on Min or Plus button. A relative Jog can only be executed for an individual axis.

**Min / Plus**
A relative jog can be done by filling in the third column of Increment and clicking on Min or Plus button. A relative Jog can only be executed for an individual axis.

**Jog**
When the Jog button is pressed, the piezo axes start jogging.

**Stop**
When the Stop button is pressed all piezo axes stop jogging.

# 34 Stage²
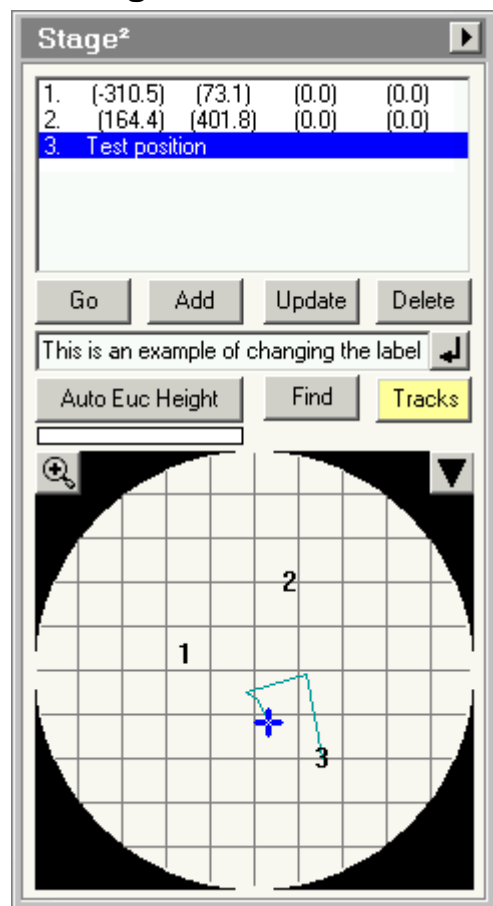


*The Stage² Control Panel.*

The Stage² Control Panel provides functionality for controlling the CompuStage, storing positions and tracks.
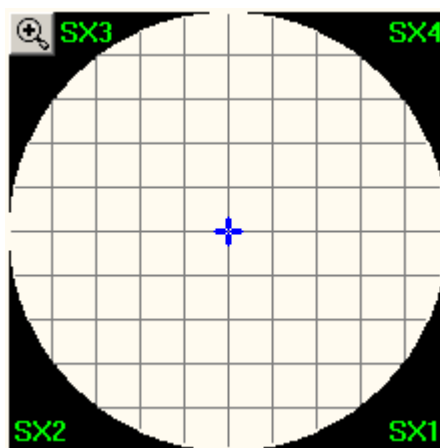


**Note:** On microscopes with SuperX EDX detectors, the location of the individual detectors is displayed in the corners of the display (SX1 through SX4 for the four detectors) when no zoom is applied.

### 34.1.1 Positions

The Stage² control panel allows the user to store stage positions. All positions are stored with five axes (if no $\beta$ tilt is available, $\beta$ will be 0). In addition a series of optics settings are stored :
- Magnification mode and magnification index
- Spot size
- Intensity setting
- Lens series (Zoom or EFTEM) (if available)
- TEM or STEM (if available)
- Lorentz mode off or on (if available)
- Defocus

These settings can be recalled together with the stage position (user-defined option).

Furthermore, the software keeps a label with each stage position (if no label is defined by the user the label will be a serial number plus the stage position).

Finally the software keeps track of plate and camera exposures made at stored positions.

### 34.1.2  Tracks

Tracks are a list of stage positions automatically recorded and drawn as connected lines on the display. You can use tracks e.g. to mark which part of the specimen has been seen or to draw the outline of different areas on the specimen. For the latter, go to the perimeter of a first area, switch tracking on and move around the perimeter of the area until you are back where you started. Switch tracking off and move to the next area. Switch tracking on again and move around the perimeter of the new area. When done, switch tracking off again. Repeat as often as needed. By switching tracking off  when going from one area to another, the tracks of the separate areas will be shown without any connection between them.

### 34.1.3  Confirmation

Several actions require confirmation. This means that the button pressed will disappear and its place will be taken by an a combination of an OK ✓ and a Cancel ☒ button. The Cancel button is given the focus (which means that if you e.g. press the keyboard Enter, you cancel) and the cursor position is moved in between the two buttons (so that you do not accidentally press OK by clicking twice on the original button). The action is performed when the OK button is pressed (this will bring back the original button). Pressing the Cancel button will bring back the original button without performing the action.

### 34.1.4  Files

Stored positions and tracks can be saved to and loaded from file. The file format is for loading is digital only, for saving you can choose digital or text. The digital file format is described separately.

### Positions list

The positions list contains the list of stored positions. These are shown as a serial number plus a label. The serial number is set automatically and is not necessarily consecutive. If you delete stored positions, the numbers will not be redone but stay as they are. So if you have stored 6 positions, then delete 5 and 6, then add a new position, that new position will be number 7.
The serial number only gets reset when all positions are deleted.

### Go

When the Go button is pressed, the stage will move to the stored position selected in the list. If more than one position is highlighted (this is possible with Shift+Click or Ctrl+Click to allow the deletion of more than one position at a time), the position selected is the one that was clicked on first.
The method of movement, Move To or Go To is defined on the Settings Control Panel.

### Add

When the Add button is pressed the current stage position and the optics are stored into a new position.

### Update

When the Update button is pressed the selected position is updated with the current stage position and the stored optics settings. The position update must be confirmed.

### Delete

When the Delete button is pressed, two different things can happen:
If only one position is selected in the list, that position is deleted immediately. There is no confirmation needed.
If more than one position is selected in the list (with Shift+Click or Ctrl+Click), the deletion of all positions selected must be confirmed. To empty the complete list you can use the Delete all button on the File tab.

**Label**
The edit control allows the definition of a label to be used for a stored position. If you wish to change the label of a position, you must enter the text in the edit control and then press the Enter button. The text in the edit control is also used with the Find function.

**Enter button**
The Enter button allows changing the label of the position selected in the positions list. Enter the new label in the edit control and press the Enter button. The changing of the label must be confirmed.

**Auto Euc Height**
Auto Euc Height (only for Talos systems) automatically brings the specimen holder to the eucentric height if the microscope is in TEM mode. When Auto Euc Height is pressed the button becomes yellow. The progress bar below the button fills, indicating how far the routine is. Pressing the yellow button will abort the routine and returns the original settings.
The Auto Euc Height routine uses camera images to determine if the sample is at eucentric height or not. The images are acquired with the currently active camera and settings. For an optimal speed – accuracy performance an image size of 1024*1024 is advised, although other image sizes will also work. The Auto Euc Height calculates how much the stage Z is off from eucentricity by measuring the image shift between two images taken at different stage $\alpha$ angles. The Auto Euc Height routine will only be successful is there is enough overlap between the two images. It is advised to use a low SA or LM magnification if it is unknown if the current specimen position is far from eucentric or not.
The Auto Euc Height routine changes the stage $\alpha$ to calculate the eucentric stage Z position. Default the routine maximally tilts the stage to 15°, however this can be changed to a smaller value with the Wobbler slider in the Stage² Control flap-out.

**Notes:**
1.  The Auto Euc Height can only relate the image shift to the offset from eucentricity when the magnification calibration is done for the current HT. If there is no calibration available Auto Euc Height will return an error.
2.  If the grid bars are visible in the LM TEM image used for eucentric height, the result of the Auto Euc Height function is very likely offset in Z because the foil is on one side of the grid, while the Auto Euc Height result will return the middle of the grid (which is therefore offset by ½ of the grid thickness). It is advised to use the function in LM only as a coarse preset to a finer setting executed in HM TEM.

**Find**
When there are more positions stored than visible in the list (or their labels are so large that they are not visible completely), the Find function allows searching for positions on the basis of text in the labels. Enter the search text in the edit control for the label and press the Find button. The search function will go down the list to the next position that has a match, starting at the currently selected position. If nothing is found further down, the function will continue from the top of the list down. If nothing is found at all (which means that the required text does not exist - with the possible exception of the currently selected position which is not included in the search), the software will sound a beep. If the text occurs in more than one position, you can simply press the Find button again to go further through the list.

**Note:** The separation between the serial number and the rest of the label and stage position values in labels is a tab, not a space. Generally you cannot enter a tab in the edit control with the keyboard (Windows will move the focus to the next control). If you need to search with tabs included, type the text, including tabs in Notepad, then copy the text into the edit control (Ctrl+V).

**Tracks**
Pressing the Tracks button switches tracking on (the button becomes yellow) and off.

**Zoom**
When the Zoom button is pressed, the display zooms in or out, depending on its current status (which can be seen from the plus or minus sign in the magnifying glass).

**Display**
The display shows an overview of stored positions and tracks. Positions are shown by their serial number. Tracks are shown as lines. The current position is shown by a blue cross.

There are two major functions associated with the display :
- When you let the cursor hover over a stored position, a hint will come up that lists the label, stage position (X,Y) plus, if relevant the notice 'Plate recorded' with the plate number or 'CCD image recorded'. If the hint disappears before you have been able to read all, move the cursor a bit off and back and the hint will re-appear.
- When you double-click on a stored position in the display, the stage will go there, including restoring the optics if selected (the function is thus the same as selecting the position in the list and pressing the Go button). When you double-click on the display outside any stored position, the stage will move to that position.

The display has two zoom positions. In the Out position (the magnifying glass in the Zoom button has a plus sign), you see a representation of the whole specimen area - a circle with a diameter of 2 mm. The black edges are outside realistic positions (the stage can move there but the specimen holder will block the beam). The stage X axis is horizontal in the display, while the Y is vertical.

**Note:** The orientation of the display does NOT correspond to what you see on the fluorescent screen. This is done on purpose. Depending on the type of microscope, there may be one or more changes in the orientation of the stage axes on the fluorescent screen (e.g. LM-TEM is typically 180° rotated relative to HM-TEM, with the stage X running in the north-south direction; and in STEM the image can be rotated freely). If Stage² would link its display to the screen orientation, stored stage positions would frequently (and confusingly) change where they are found on the Stage² display.
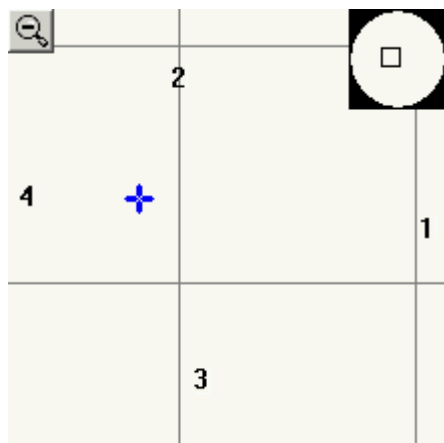


In the **In** position (the magnifying glass in the Zoom button has a minus sign), the size of the area is determined by the minimum and maximum of the stored positions and tracks or by the zoom magnification defined.

**Note that in automatic zoom mode the current stage position may fall outside the area defined. In the top right corner is a small display of the whole specimen (circle with black edges) with a red square marking the zoomed area.**

If a stored position falls either underneath the Zoom button or the overview top right, it is not displayed.

Gray grid lines at 200 um intervals (stage coordinates) may be displayed (user option). If appropriate, a scale bar will be shown at bottom left.

### 34.1.5  Fine stage control

Sometimes it is necessary to control the stage better than can be done through the standard control-pad controls (joystick and Z, A, B controls). For this controls have been implemented that allow fine movements to be made (relative to the current stage position). The controls are accessible by pressing the "Down" button on the stage map. To go back to the stage map, press the "Up" button on the fine control area.



**Note: The relative stage moves will be susceptible to backlash so getting the stage to move may require more than one push on a button.**

**Edit controls**

The edit controls contain the relative stage moves to be executed. The values have lower limits (X,Y depends on the stage type, being 20 or 2 nm; Z is 10 nm, A is 0.001 and B is 0.055°). If you type in a value that is below the limit, the value will be replaced with the lower limit when you use the buttons to move the stage.

**Minus/Plus buttons**

Pressing the Minus/Plus buttons move the stage axis into the negative or positive direction.

**Back to map button**

When you press the button with the "Up" arrow, the Fine controls are swapped with the stage map.

**Flap-out button**

The flap-out button of the Stage² Control Panel opens the flap-out with the Control, File, Set and Settings tabs.

## 34.2 Stage² Control
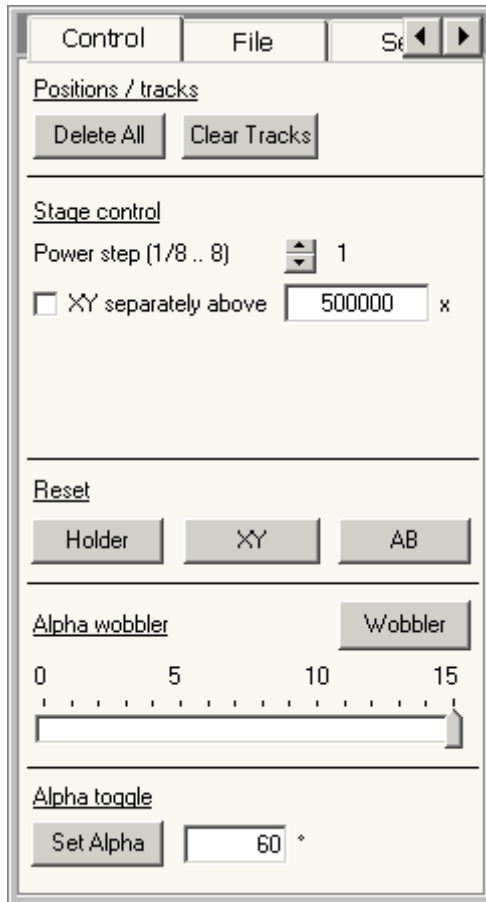
*The Stage² Control Control Panel.*

The Stage² Control Control Panel provides control over stage settings.

**Delete All**
The Delete All button clears all stored positions and tracks (it is thus equivalent to selecting all positions in the list and pressing Delete + confirm plus pressing Clear Tracks + confirm). Delete All requires confirmation.

**Clear tracks**
Pressing the Clear Tracks buttons removes all tracks together (you cannot remove separate tracks). This requires confirmation.

**Power step**
The speed of movement of the CompuStage depends on a number of factors. One of these is the setting of the joystick power, which is defined in 9 steps (1/8, ¼, ½, 1, 2, 4,8) by the buttons on the control pad (left is down, right is up). You can also set the joystick power value with the spin buttons in the Stage² Control Control Panel. The spin buttons also display the currently active setting.

**XY separately**
Generally the movement of the CompuStage when driven with the joystick is in the direction defined by the direction of joystick movement. It is thus a combined X,Y movement. This works well at lower magnifications where the movement on both axes is generally large enough, but at high magnifications one of the axes may no longer be able to make sufficiently small steps (so instead of moving 2+0.5, 2+0.5 for X+Y the stage may do 2+0, 2+1, etc.). The resulting movement is not as predictable in the movement direction. Under these circumstances it may be better to switch to XY separately. In that

mode, only one axis is driven at a time. The joystick movement is divided into segments (north, east, south, west) and the joystick movement only makes the stage move in those fixed directions.
Since the change from XY separately to normal movement and back is largely a matter of magnification, you have the microscope change to XY separately automatically (when a check mark is present in the check box) at the magnification defined.

**Reset holder**
Resets all axes to zero. It is advised to use this function (or at the very least Reset AB before removing a specimen holder from the microscope).

**Reset XY**
Resets the XY position to 0,0.

**Reset A / Reset AB**
Reset the tilts to zero.

**Wobbler**
The Alpha wobbler tool helps in setting the eucentric height. When the wobbler is switched on (the button will turn yellow), the CompuStage will tilt continuously on a from minus to plus by the value set with the alpha wobbler trackbar. By changing the Z height and minimizing the image movement, the CompuStage is set to the eucentric height.

**Wobbler amplitude**
The alpha wobbler trackbar sets the alpha wobble angle. The maximum value is 15 degrees (5 degrees for the U-TWIN lens), but the user can set any angle less than that (except 0 which will lead to a disabled Wobbler button).

**Set alpha**
The Set alpha function provides a rapid toggle between an a angle and back to 0°. This function can be used for different things:
• Inserting a cryo holder with liquid nitrogen in the dewar into the airlock without spilling the nitrogen. Tilt the stage with the Set alpha function to 60°. Insert the holder into the airlock. Once the airlock pumping is finished, hit the Set alpha button again (it will automatically have focus normally so you can also do this by hitting the keyboard Enter button or the spacebar). As the CompuStage tilts back, insert the holder further into the microscope.
• Toggling between a preset angle for EDX spectrum acquisition (typically 10 to 20°) and back to 0°.
To work with the Set alpha function, enter the desired angle. Press the Set alpha button. During movement it will become disabled, but afterwards it will be yellow and have the focus. Hit it again and the stage will tilt back to 0° and the button will become gray again.

## 34.3 Stage² Control (dual-axis tomography holder)
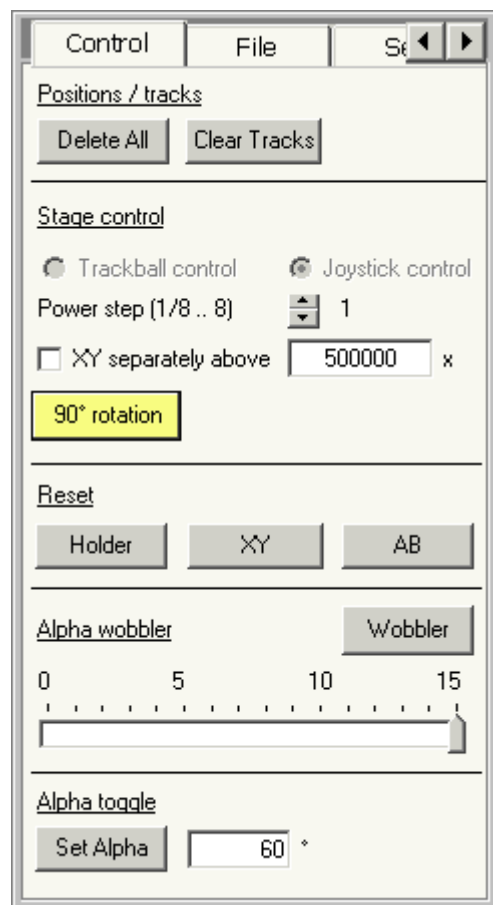
*The Stage² Control Control Panel.*

The Stage² Control Control Panel provides control over stage settings.

**Note:** The dual-axis tomography holder uses the "beta" tilt drive for moving between no rotation and 90°. Stage² is aware of the difference and hence displays a large "beta" angle as rotated (90°) and a small angle as non-rotated (0°). In Stage² you cannot manipulate the rotation by setting a "beta" angle. Instead you have to toggle the 90° rotation button. The TEM user interface is not aware of the difference between a double-tilt holder and the dual-axis tomography holder and therefore it will display real "beta" angles.

**Delete All**
The Delete All button clears all stored positions and tracks (it is thus equivalent to selecting all positions in the list and pressing Delete + confirm plus pressing Clear Tracks + confirm). Delete All requires confirmation.

**Clear tracks**
Pressing the Clear Tracks buttons removes all tracks together (you cannot remove separate tracks). This requires confirmation.

**Power step**
The speed of movement of the CompuStage depends on a number of factors. One of these is the setting of the joystick power, which is defined in 9 steps (1/8, ¼, ½, 1, 2, 4,8) by the buttons on the control pad (left is down, right is up). You can also set the joystick power value with the spin buttons in the Stage² Control Control Panel. The spin buttons also display the currently active setting.

**XY separately**
Generally the movement of the CompuStage when driven with the joystick is in the direction defined by the direction of joystick movement. It is thus a combined X,Y movement. This works well at lower magnifications where the movement on both axes is generally large enough, but at high magnifications one of the axes may no longer be able to make sufficiently small steps (so instead of moving 2+0.5, 2+0.5 for X+Y the stage may do 2+0, 2+1, etc.). The resulting movement is not as predictable in the movement direction. Under these circumstances it may be better to switch to XY separately. In that

mode, only one axis is driven at a time. The joystick movement is divided into segments (north, east, south, west) and the joystick movement only makes the stage move in those fixed directions.

Since the change from XY separately to normal movement and back is largely a matter of magnification, you have the microscope change to XY separately automatically (when a check mark is present in the check box) at the magnification defined.

**90° rotation**
Toggles the rotation between 0 (button is gray) and 90° (button is yellow).

**Reset holder**
Resets all axes to zero.

**Reset XY**
Resets the XY position to 0,0.

**Reset A-rotation**
Reset the A tilt and the rotation to zero.

**Wobbler**
The Alpha wobbler tool helps in setting the eucentric height. When the wobbler is switched on (the button will turn yellow), the CompuStage will tilt continuously on a from minus to plus by the value set with the alpha wobbler trackbar. By changing the Z height and minimizing the image movement, the CompuStage is set to the eucentric height.

**Wobbler amplitude**
The alpha wobbler trackbar sets the alpha wobble angle. The maximum value is 15 degrees (5 degrees for the U-TWIN lens), but the user can set any angle less than that (except 0 which will lead to a disabled Wobbler button).

**Set alpha**
The Set alpha function provides a rapid toggle between an a angle and back to 0°. This function can be used for different things:
- Inserting a cryo holder with liquid nitrogen in the dewar into the airlock without spilling the nitrogen. Tilt the stage with the Set alpha function to 60°. Insert the holder into the airlock. Once the airlock pumping is finished, hit the Set alpha button again (it will automatically have focus normally so you can also do this by hitting the keyboard Enter button or the spacebar). As the CompuStage tilts back, insert the holder further into the microscope.
- Toggling between a preset angle for EDX spectrum acquisition (typically 10 to 20°) and back to 0°.

To work with the Set alpha function, enter the desired angle. press the Set alpha button. During movement it will become disabled, but afterwards it will be yellow and have the focus. Hit it again and the stage will tilt back to 0° and the button will become gray again.

## 34.4 Stage² File

*The Stage File Control Panel.*

The Stage File Control Panel allows saving and reloading of stage positions to and from file. The positions are those as listed in the positions list of the Stage² Control Panel.

**Note:** The positions list and the file format for storing positions is NOT compatible between the 'old' stage control panel and the new Stage² panel. Use one or the other, but not both intermixed.

**Comments**
Comments can be added to files with specimen-stage positions. Enter the comment before saving the file. After opening the file, the comment from the file is listed under the file data.

**Author**
The name of an author (the person storing the positions and saving the file) can be added to the files with specimen-stage positions. When first used, the software will automatically enter your Windows logon name here. Once you change it, the software will remember and re-insert it automatically.

**Save**
When the Save button is pressed, the specimen-stage positions and/or tracks are stored in a file. If a filename had been defined previously (through either Save, Save As or Open), that is the file under which the positions will be saved. If no filename has been defined yet, a standard Save File dialog will come up, where a filename (and folder) can be set.

**Save As**
When the Save button is pressed, a standard Save File dialog will come up, where a filename (and folder) can be set. The current positions list will be saved in that file.

Two file formats can be used for saving files. The Stage² file format can be used for saving and reading stage positions. The tab-delimited file format (text) can only be used for saving (data export). The latter file format can be read in e.g. in spreadsheet programs.

**Open**
When the Open button is pressed, a standard Open File dialog will come up, where a file can be selected for reloading. The current positions list will be cleared and the positions from the file entered in the list.

**File data**
After a file has been opened the essential data of the file are displayed. Note that the path may be in short format (with part of the path - between \\ - replaced by ...) in case the path is too long.

**Automatically store**
The stored positions and tracks may be saved automatically to a temporary file and reloaded when the TEM user interface is closed and re-opened. Note that temporary files are not replaced if there currently are no data (positions or tracks). If there are no data, the file stays as is, so the next opening of the TEM user interface will reload the data from the session before the last one.

## 34.5 Stage² Set



*The Stage² Set Control Panel.*

The Stage² Set Control Panel allows control over specimen-stage positions by entering stage-axis values.

**Set position**
The specimen-stage X, Y, Z, a, b position defines the value (in mm for X, Y, Z, degrees for a, b) for the new specimen-stage position set after the Go To button is pressed. If no value is entered for a particular axis, that axis remains unchanged.

**Current position**
The current position lists the current stage position.

**Undo position**
The undo position lists the position where the stage will go back to when the Undo button is pressed. Note that this movement is the reverse of the Go To, so only those axes used in the Go To will be used in the Undo.

**Tilt beta compucentrically**
If Compucentricity is available on the microscope, tilting on the b axis can be done compucentrically. See the compucentricity documentation for more details.

**Go To**
When the specimen-stage position Go To button is pressed, the specimen-stage is instructed to go to the position as defined by the four (X, Y, Z, a) or five (X, Y, Z, a, b) position edit controls. The button remains disabled until at least one value for a new stage position has been entered. If no value has been entered for a particular axis, the setting of that axis will remain unchanged in the Go To.

**Undo**
When the Undo button is pressed, the specimen-stage returns to the last position set by a Go To.

**Z is relative**
The Z position as reported by the stage is normally defined by the eucentric height (since that is where you should be working). Manipulating the Z then always means you have to start calculations with the Z position for the eucentric height, which may be cumbersome. The "Z is relative" function allows an automatic recalculation of the eucentric Z so this becomes 0 as displayed. All other positions are then displayed in values relative to this.
Note: Only the values as displayed in the Stage² Set Control Panel have their Z values adjusted, NOT any other displayed values (as e.g. in  the general microscope information display).
When Z is relative is activated the current Z position is automatically made the reference. To use an other Z position as the reference, move the stage to that Z position and press the Z = 0 button.

**Z = 0**
Pressing the Z = 0 button makes the current Z position the relative Z reference value.

**Pressing Enter => Go To**
When the Pressing Enter => Go To checkbox is checked, you can press the Enter keyboard key while in one of the edit controls for the stage axes (X, Y, Z, A, B) and this will immediately force a Go To (so the effect is the same as pressing the Go To button). This feature makes it possible to define a stage position and execute a Go To without having to switch from keyboard to mouse.

## 34.6 Stage² Settings

*The Stage² Settings Control Panel.*

The Stage² Settings Control Panel provides access to a number of Stage² options and the function for enabling/disabling the CompuStage.

## 34.7 Specimen-stage Move To's and Go To's

There are two different types of specimen-stage movements (apart from the ones initiated by the joystick) : Move To's and Go To's. The difference between these two is in the procedure followed by the specimen-stage to reach the new position. With Go To's the specimen stage will move on all axes (as far as necessary) at the same time. This is the mode of movement used when the Go To or Undo buttons are pressed. The Go To is more direct and therefore faster than the Move To.

With Move To's a fixed procedure is used to enhance safety during movement (to remove the possibility altogether of a high-speed collision between the moving stage and a fixed part of the microscope). This fixed procedure consists of the following steps:
- Set $\beta$ tilt to zero.
- Set $\alpha$ tilt to zero.
- Go to the new X, Y, Z position.
- Set $\alpha$ tilt to new value.
- Set $\beta$ tilt to new value.

Some of these steps may be absent. For example if a single-tilt holder is used, the b tilt steps are omitted. Or if no new values for X and Y are entered, only a Z go to is done in the third step.

**Note:** The Move To method is strongly advised if large specimen-stage movements are made.

**Go To / Move To**
Defines the type of movement used for recalling stored stage  positions. This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Move XY Only**
When checked, this option will result in move only to the X,Y values of  stored stage positions (thus ignoring Z, a and b). This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Move AB Only**
When checked, this option will result in move only to the a,b values of stored stage positions (thus ignoring X, Y and Z). This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Back to stored optics**
When checked, this setting result in restoring of the optics settings together with the stored stage position, as a result of Go or double-click on the display.  This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Show grid lines**
When checked, the display shows grid lines at 200 um (stage coordinates) intervals.  This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Zoom functions**
The zoom on the main panel can either be determined automatically on the basis of the stored positions and tracks (Automatically determine zoom is checked) or it can be set according to a user-defined magnification. In the latter case the field of view corresponds roughly to that of the large viewing screen at the magnification given and the display is centered around the current stage position. Any change in magnification must be confirmed by pressing the Enter button.

Please note that the display will generally be rotated relative to what is visible on the large viewing screen. On the latter the stage X axis generally is running North-South (rotating ~180° between LM and HM), while on the Stage² display the stage X and Y axes are East-West and North-South, respectively. These settings are stored and automatically recalled when closing and re-opening the TEM user interface.

**User button Add**
The user buttons R1..R3 and L1..L3 can be used for adding the current stage position to the list of stored positions. To use this function, select one of the user buttons in the drop-down list. This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**User button Recall +**
The user buttons R1..R3 and L1..L3 can be used for moving the stage position to next position in the list of stored positions. If the currently selected position is at the end of the list, the selection will automatically wrap around to the first position. To use this function, select one of the user buttons in the drop-down list. This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**User button recall -**
The user buttons R1..R3 and L1..L3 can be used for moving the stage position to previous position in the list of stored positions.  If the currently selected position is at the top of the list, the selection will automatically wrap around to the last position. To use this function, select one of the user buttons in the

drop-down list. This setting is stored and automatically recalled when closing and re-opening the TEM user interface.

**Auto copy**
When checked, the software will automatically copy the currently selected item in the list - if that is a user-defined label, not the stage position as initially inserted - back into the place for the label. From there you can copy it by selecting the text and pressing Ctrl+C.

**Enabled**
The Enabled option allows switching the CompuStage off in case it is on (the Enabled button is yellow) or on when it is off. In general the stage will remain active even when the TEM software (PC) has been shut down and only requires homing if the power has been switched off altogether.

**Note:** There are two types of stage controller, an earlier one and a new one. The latter is from early 2015 onwards.
If the CompuStage is switched off and on, it needs to be homed before it can move (with the newer controller the stage will typically only need homing after a complete power off). The homing procedure (generally) requires removal of the specimen holder.



The homing will take approximately five minutes on a stage with the earlier controller and two minutes on one with the newer controller. During this time the Enabled button will be orange and a timer will indicate the expected time it will take before the homing is finished.

# 35 STEM Imaging (User)



*The STEM Imaging Control Panel.*

The STEM Imaging Control Panel contains the most important STEM controls. For a description of the basic concept of scanning, see the STEM mode description. The details of scanning operation itself are described separately.

For easy operation, the scanning system has three preset modes with their own buttons, Search, Preview and Acquire. Each of the three can have its own, separate scanning settings (Frame size, Frame Time), allowing rapid switching between different settings. The actual settings are up to the user. Typical settings could be:

- Search: Frame size 256*256, Frame time 1 second.
- Preview: Frame size 512*512, Frame time 5 seconds.
- Acquire: Frame size 1024*1024, Frame time 30 to 60 seconds.

By definition Search and Preview are continuous acquisition, while Acquire acquires a single frame and stops (to allow the operator to save the image).

The Focus state is different from the previous three settings. It will display a small window inside an image already collected. Only the image inside the frame is then collected and updated. The frame can be moved around and changed in size to select an area more suitable for focusing.

**STEM**
The STEM button switches the TEM to the STEM mode (the button becomes yellow) and back (the button becomes gray).

**Scan rotation**
The scanning image can be rotated continuously. Click on the trackbar and drag the handle to left or right to change the scan rotation or (as long as the trackbar has the Windows focus - denoted by the dashed lines around it), use the arrow keys on the keyboard to change the rotation angle. You can also type a rotation into the edit control and press the Enter button to set the STEM rotation.
When the button 0 is pressed, the scan rotation is reset to 0. When the buttons 1<, 90<, -1 or >90 are pressed, the scan rotation is changed by the given angle from its current setting to left or right.

**Enable LMscan**
By default, the STEM system will not switch to LM scanning (in which the objective lens is off) when the operator turns the magnification further down than the lowermost scanning magnification step. If you want to go to LM scanning, the checkbox must first be checked. Only then is it possible to change to LM scanning by turning the magnification knob further down. The checkbox is reset to the default (off) each time the TEM user interface is restarted.

**Frame time**
The Frame time indicates the time a single frame will require for the currently active viewing mode (Search, Preview, Acquire).

**Scan frame / pixel size**
The Scan frame and pixel size values indicate the settings of the currently active viewing mode (Search, Preview, Acquire). The two parameters are linked but give different types of information. The scan frame indicates the size in pixels of the image collected, whereas the pixel size indicates how large a single pixel is. The latter value is a useful indication for selecting spot size. For example, if the spot size used on the microscope is much larger than the indicated pixel size, then the effective resolution in the image will be wholly determined by the microscope's spot size. If on the other hand, the indicated pixel size is much larger than the spot size, the spot size could be increased to give better signal without loss of resolution.

**Blank**
The STEM Imaging Control Panel provides a function for blanking of the electron beam to avoid beam damage or other undesired effects when the beam remains on a fixed location of the specimen (that is, while it is not scanning). The beam is blanked when the button is yellow.

**Note 1:** The unblanking of the beam is not instantaneous and may take a short while to become effective. If a scan is started too quickly after unblanking the beam, the start of the image may look distorted.

**Note 2:** The microscope does not check that the beam is unblanked when a scan is started. It is entirely up to the user to make sure that the electron beam can reach the specimen when needed. Only when STEM is stopped or the user interface is closed, is the beam blanking switched off automatically.

**Search**
Pressing the Search button:
- When the button is gray, switches the scan settings to those of the Search mode and starts scanning.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Search is continuous acquisition. The scan parameters are set in the STEM Imaging Scan Control Panel.

**Preview**
Pressing the Preview button:
- When the button is gray, switches the scan settings to those of the Preview mode and starts scanning.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Preview is continuous acquisition. The scan parameters are set in the STEM Imaging Scan Control Panel.

**Acquire**
Pressing the Acquire button:
- When the button is gray, switches the scan settings to those of the Acquire mode and starts acquisition.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Acquire acquires a single frame and stops (to allow the operator to save the image). The scan parameters are set in the STEM Imaging Scan Control Panel.

**Focus**
Pressing the Focus button activates (button becomes yellow) or stops (button becomes gray) the acquisition of the Focus image. When active, the Focus window is displayed in the center of the STEM image. Only the area inside the Focus window is now scanned, the remainder of the image is 'frozen'.



*Part of a STEM image with the Focus window in the center.*

The Focus window can be moved around or changed in size by clicking on it with the left-hand mouse button and dragging between the handles (small squares at corners and centers of the lines) to move it around or dragging a handle to change the size. The focus parameters are set in the STEM Imaging Focus Control Panel.

*The Focus window with handles to change its position or size.*



**Scope**
The Scope button enables or disables acquisition of images with a videoscope signal displayed as well. The videoscope signal shows the full range of signal levels available and the video levels along the lines of the scan. When scan acquisition is not active the scope signal shows the video levels along a line in the center of the image.

**Auto CB**
Press Auto CB to instruct the system to optimize the Contrast and Brightness of the detector selected automatically. The Auto Contrast Brightness function will repeatedly collect an image, determine its range of video levels (for a selected number of points), and adjust the contrast and brightness settings of the detector, until the contrast and brightness are optimized.

**Flap-out**
Pressing the arrow button displays the flap-out with the STEM Imaging Scan and Focus Control Panels.

## 35.1 STEM Imaging Focus (User)
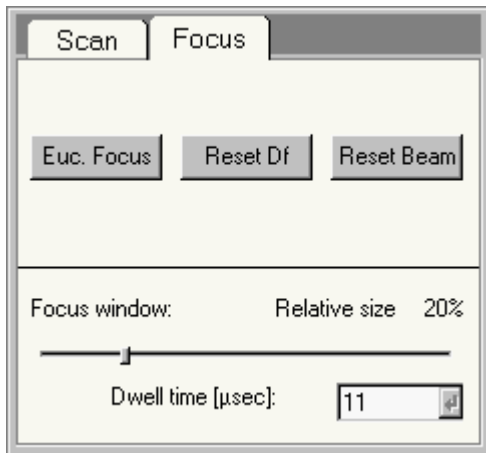


*The STEM Imaging Focus Control Panel.*

In the STEM Imaging Focus Control Panel various parameters related to focusing in STEM are controlled.

**Euc. focus**
Pressing the Euc. focus button executes the Eucentric focus function. In the case of STEM, this function sets the intensity and objective-lens currents to their (pre-aligned) value for focus at the eucentric height and normalizes the lenses.

**Note:** the eucentric focus only sets the objective lens for the eucentric height, not the specimen itself (if the specimen is off the eucentric height, it will then appear out of focus).

**Reset Df**
Pressing the Reset Df button reset the Defocus display value to 0.

**Reset beam**
Pressing the reset beam button reset the user beam shift setting (as set with the trackball) to 0.

**Focus window**
The Focus window parameters defines the size of the Focus window relative to the STEM image.

**Dwell time**
The dwell time parameters defines the dwell time (the amount of time the beam resides at a pixel) for the Focus function.

## 35.2 STEM Imaging Scan (User)
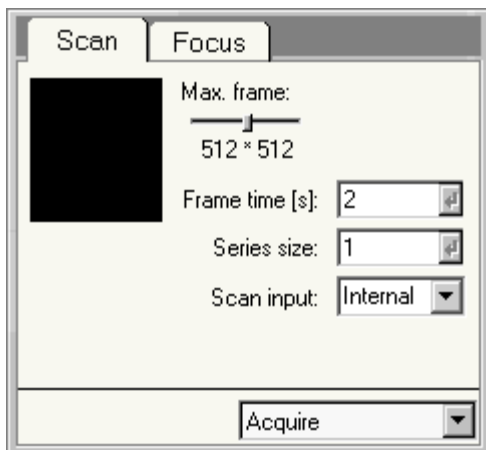


*The Scanning Scan Control Panel.*

In the Scanning Scan Control Panel the scan parameters are defined.

**Max. frame**

The maximum frame parameter defines the size of the scan frame for the currently selected acquisition mode.

**Frame time**

The Frame time for the scan frame is set by changing the value in the spin-enter-edit control. Press the Enter button to set the value.

**Series size**

Under Series size the number of images acquired in a TIA series is defined.

**Scan input**

On Talos microscopes, several scan engines are supported: Internal, External Gen (Generator) and External Res (Reserved for future use). The selection is through the scan input drop-down list. Internal is the default way of operation when using FEI applications. Note that if the system has been switched to an external scan input, acquiring a STEM image in FEI applications will not work. System will remember the last selected scan input and use it when STEM mode is selected. It is the user's responsibility to select the proper scan input.

**Acquisition mode**

In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and by pressing the equivalent button in the main control panel is that the drop-list selection selects the mode but does not automatically start acquisition.

# 36 STEM Imaging (Expert)



*The STEM Imaging Control Panel.*

The STEM Imaging Control Panel contains the most important STEM controls. For a description of the basic concept of scanning, see the STEM mode description. The details of scanning operation itself are described separately.

For easy operation, the scanning system has three preset modes with their own buttons, Search, Preview and Acquire. Each of the three can have its own, separate scanning settings (Frame size, Frame Time), allowing rapid switching between different settings. The actual settings are up to the user. Typical settings could be:
- Search: Frame size 256*256, Frame time 1 second.
- Preview: Frame size 512*512, Frame time 5 seconds.
- Acquire: Frame size 1024*1024, Frame time 30 to 60 seconds.

By definition Search and Preview are continuous acquisition, while Acquire acquires a single frame and stops (to allow the operator to save the image).

The Focus state is different from the previous three settings. It will display a small window inside an image already collected. Only the image inside the frame is then collected and updated. The frame can be moved around and changed in size to select an area more suitable for focusing.

**STEM**
The STEM button switches the TEM to the STEM mode (the button becomes yellow) and back (the button becomes gray).

**Scan rotation**
The scanning image can be rotated continuously. Click on the trackbar and drag the handle to left or right to change the scan rotation or (as long as the trackbar has the Windows focus - denoted by the dashed lines around it), use the arrow keys on the keyboard to change the rotation angle. You can also type a rotation into the edit control and press the Enter button to set the STEM rotation.
When the button 0 is pressed, the scan rotation is reset to 0. When the buttons 1<, 90<, -1 or >90 are pressed, the scan rotation is changed by the given angle from its current setting to left or right.

**Enable LMscan**
By default, the STEM system will not switch to LM scanning (in which the objective lens is off) when the operator turns the magnification further down than the lowermost scanning magnification step. If you want to go to LM scanning, the checkbox must first be checked. Only then is it possible to change to LM scanning by turning the magnification knob further down. The checkbox is reset to the default (off) each time the TEM user interface is restarted.

**Dwell time**
The Dwell time indicates the time needed for acquisition of a single pixel for the currently active viewing mode (Search, Preview, Acquire).

**Scan frame / pixel size**
The Scan frame and pixel size values indicate the settings of the currently active viewing mode (Search, Preview, Acquire). The two parameters are linked but give different types of information. The scan frame indicates the size in pixels of the image collected, whereas the pixel size indicates how large a single pixel is. The latter value is a useful indication for selecting spot size. For example, if the spot size used on the microscope is much larger than the indicated pixel size, then the effective resolution in the image will be wholly determined by the microscope's spot size. If on the other hand, the indicated pixel size is much larger than the spot size, the spot size could be increased to give better signal without loss of resolution.

**Blank**
The STEM Imaging Control Panel provides a function for blanking of the electron beam to avoid beam damage or other undesired effects when the beam remains on a fixed location of the specimen (that is, while it is not scanning). The beam is blanked when the button is yellow.

**Note 1:** The unblanking of the beam is not instantaneous and may take a short while to become effective. If a scan is started too quickly after unblanking of the beam, the start of the image may look distorted.

**Note 2:** The microscope does not check that the beam is unblanked when a scan is started. It is entirely up to the user to make sure that the electron beam can reach the specimen when needed. Only when STEM is stopped or the user interface is closed, is the beam blanking switched off automatically.

**Search**
Pressing the Search button:
- When the button is gray, switches the scan settings to those of the Search mode and starts scanning.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Search is continuous acquisition. The scan parameters are set in the STEM Imaging Scan Control Panel.

**Preview**
Pressing the Preview button:
- When the button is gray, switches the scan settings to those of the Preview mode and starts scanning.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Preview is continuous acquisition. The scan parameters are set in the STEM Imaging Scan Control Panel.

**Acquire**
Pressing the Acquire button:
- When the button is gray, switches the scan settings to those of the Acquire mode and starts acquisition.
- When the button is yellow, pauses the scan acquisition.
- When the button is white, resumes the scan acquisition (but starting with a new frame) if possible. If the start command could not be given to TIA, the button will remain white.
By definition Acquire acquires a single frame and stops (to allow the operator to save the image). The scan parameters are set in the STEM Imaging Scan Control Panel.

**Focus**

Pressing the Focus button activates (button becomes yellow) or stops (button becomes gray) the acquisition of the Focus image. When active, the Focus window is displayed in the center of the STEM image. Only the area inside the Focus window is now scanned, the remainder of the image is 'frozen'.



*Part of a STEM image with the Focus window in the center.*

The Focus window can be moved around or changed in size by clicking on it with the left-hand mouse button and dragging between the handles (small squares at corners and centers of the lines) to move it around or dragging a handle to change the size. The focus parameters are set in the STEM Imaging Focus Control Panel.



*The Focus window with handles to change its position or size.*

**Scope**

The Scope button enables or disables acquisition of images with a videoscope signal displayed as well. The videoscope signal shows the full range of signal levels available and the video levels along the lines of the scan. When scan acquisition is not active the scope signal shows the video levels along a line in the center of the image.

**Auto CB**

Press Auto CB to instruct the system to optimize the Contrast and Brightness of the detector selected automatically.

**Flap-out**

Pressing the arrow button displays the flap-out with the STEM Imaging Scan and Focus Control Panels.

## 36.1 STEM Imaging Focus (Expert)
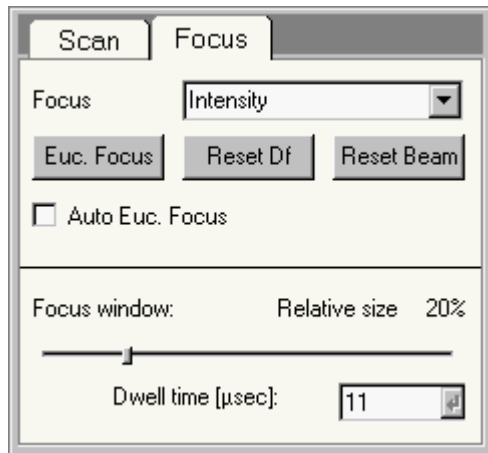


*The STEM Imaging Focus Control Panel.*

In the STEM Imaging Focus Control Panel various parameters related to focusing in STEM are controlled.

**Focus**
The selection of the Focus drop-down list defines how the operator wants to focus in STEM imaging. Possible choices are:
- Intensity - the default setting, the same as the normal user, with the Focus knob controlling the Intensity setting, the objective-lens fixed and the Intensity knob decoupled.
- Objective - the Focus knob controls the Objective-lens setting and the Intensity is fixed, with the Intensity knob decoupled.
- Step-size dependent - the microscope automatically changes the Objective-lens setting for small focusing steps and the Intensity setting for larger focusing steps, both from the Focus knob, while the Intensity knob is decoupled.
- Intensity and objective - both Intensity and Objective-lens setting can be controlled freely, with the Focus knob controlling the Objective-lens setting and the Intensity knob the Intensity setting.

**Euc. focus**
Pressing the Euc. focus button executes the Eucentric focus function. In the case of STEM, this function sets the intensity and objective-lens currents to their (pre-aligned) value for focus at the eucentric height and normalizes the lenses.

**Note:** the eucentric focus only sets the objective lens for the eucentric height, not the specimen itself (if the specimen is off the eucentric height, it will then appear out of focus).

**Auto Euc. focus**
If  the Auto Euc. focus checkbox is checked, the microscope will execute the Eucentric focus function each time when the STEM mode is entered (to reset the focusing conditions to good default values).

**Reset Df**
Pressing the Reset Df button reset the Defocus display value to 0.

**Reset beam**
Pressing the reset beam button reset the user beam shift setting (as set with the trackball) to 0.

**Focus window**
The Focus window parameters defines the size of the Focus window relative to the STEM image.

**Dwell time**
The dwell time parameters defines the dwell time (the amount of time the beam resides at a pixel) for the Focus function.


## 36.2 STEM Imaging Scan (Expert)
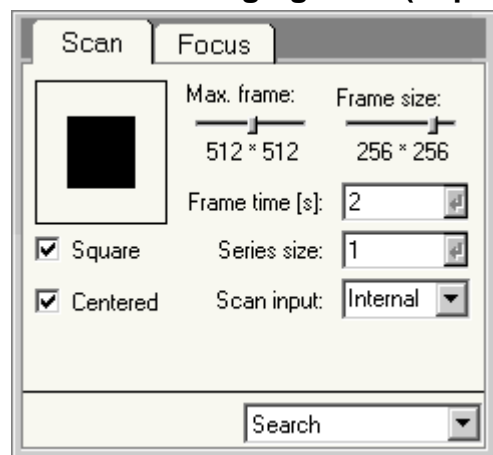
*The STEM Imaging Scan Control Panel.*

In the STEM Imaging Scan Control Panel the scan parameters are defined.

**Scan frame**
The scan frame is a graphic representation of the frame size that allows setting of frame-size parameters with the mouse.
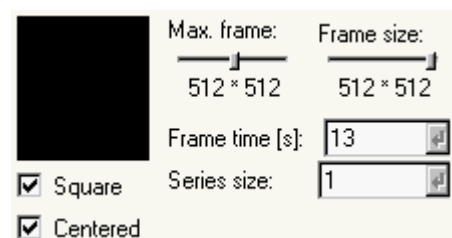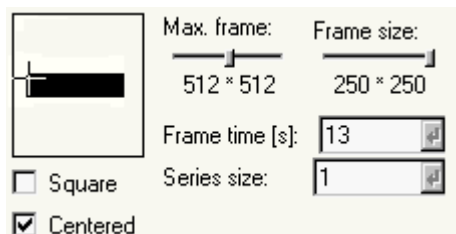
*When the Max. frame and Frame size are equal, the scan frame fills the full frame.*
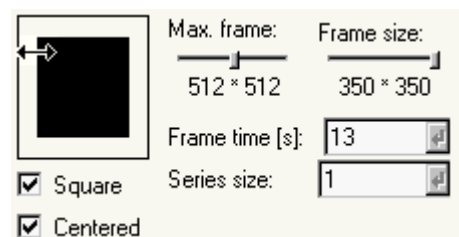
*Move the cursor to the edge of the scan frame. It will change to a Resize cursor (horizontal, vertical or diagonal, depending on the cursor position relative to the frame). Click with the left-hand mouse button and drag to change the size of the scan frame.*
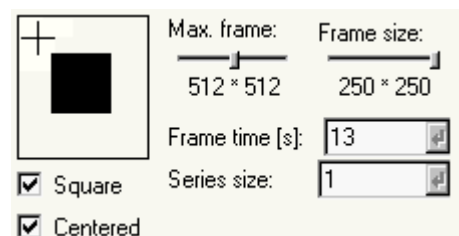
*If the scan frame is smaller than the full frame, the cursor will change to the Precision select cursor inside the full frame but outside the scan frame. Click with the left-hand mouse button and the frame size will 'jump' to the cursor positions. Drag to adjust the scan frame.*
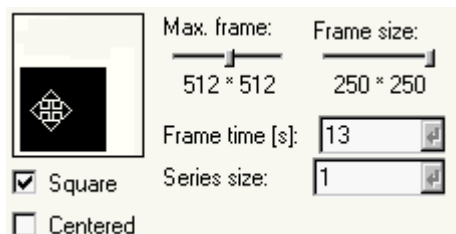
*If square is not checked, the cursor position inside the full frame will determine the scan frame dimensions in x and y as well.*

*When centered is not checked, the cursor will change to to the Move cursor when it is inside the black rectangle representing the scan frame. Click with the left-hand mouse button on the frame and drag it to any position within the full frame.*

## Max. frame
The Max. frame sets the number of pixels (in powers of 2) for the maximum scan range for the currently selected acquisition mode.

## Frame size
The Frame size parameter determines the actual size of the scan frame. The value of the Frame size can be anywhere from the Resolution values downwards. To reset the Frame size to power of 2 values, drag the slider fully to the right and it will clip at the Resolution value. The Square and Centered checkboxes will be checked automatically.

## Square
When Square is checked, the scan frame is forced to be square (x and y dimensions equal). Otherwise the scan frame can have any (rectangular) shape.

## Centered
When Centered is checked, the scan frame is forced to remain centered within the full frame. Otherwise the scan frame can be positioned anywhere within the full frame.

## Frame time
The Frame time for the scan frame is set by changing the value in the spin-enter-edit control. Press the Enter button to set the value.

## Series size
Under Series size the number of images acquired in a TIA series is defined.

## Scan input
On Talos microscopes, several scan engines are supported: Internal, External Gen (Generator) and External Res (Reserved for future use). The selection is through the scan input drop-down list. Internal is the default way of operation when using FEI applications. Note that if the system has been switched to an external scan input, acquiring a STEM image in FEI applications will not work. System will remember the last selected scan input and use it when STEM mode is selected. It is the user's responsibility to select the proper scan input.

## Acquisition mode
In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and

by pressing the equivalent button in the main control panel is that the drop-list selection selects the mode but does not automatically start acquisition.

# 37 STEM Detector (User)
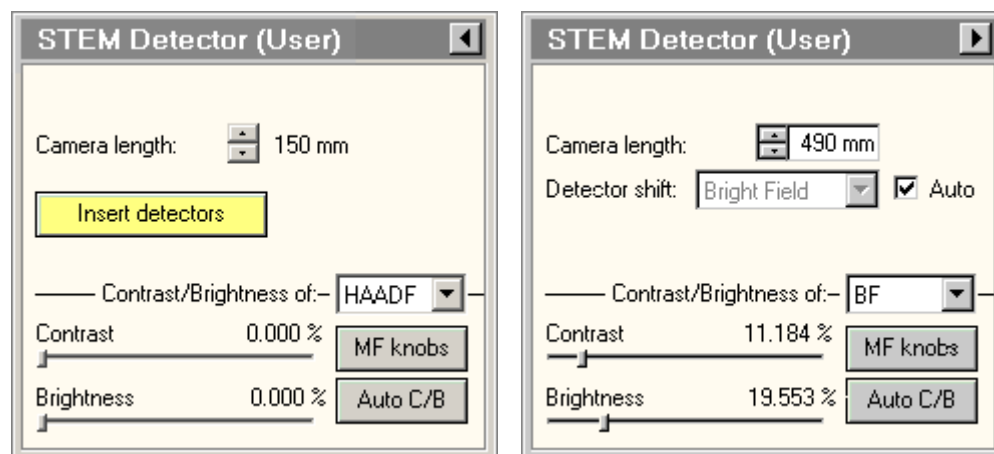


*The STEM Detector Control Panel.*

In the STEM Detector Control Panel various detector settings are controlled.

**Camera length**
The camera length for STEM is set with the spin buttons (there is no other way to control the camera length in STEM because the magnification knob is coupled to the STEM magnification).

**Insert detectors/detector shift**
There are two different systems for detectors. Some detectors are retractable and have to be inserted (e.g. the HAADF). In that case the control panel has a button Insert detectors. Pressing the Insert detectors button inserts or retracts *__all__* currently selected detector(s).
The other system has detectors in a fixed position (typically the bright-field/dark-field detector assembly at the near-axis position). In that case the detector shift (from the screen center to the detector) is done automatically (if the Auto checkbox is checked) when the main screen is raised. When the Auto checkbox is unchecked, the detector shift can be selected in the drop-down list.

**Contrast / Brightness of ...**
In the drop-down list box after Contrast / Brightness of is selected which detector is controlled by the functions underneath (Contrast and Brightness track bars, MF knob control and Auto CB).

**Contrast**
With the Contrast track bar the contrast (gain) setting of the detector is controlled.

**Brightness**
With the Brightness track bar the brightness (offset) setting of the detector is controlled.

**MF knobs**
Press MF knobs to couple the Multifunction X and Y knobs to the contrast and brightness settings of the detector.

**Auto C/B**
Press Auto CB to instruct the system to optimize the Contrast and Brightness of the detector selected automatically. The Auto Contrast Brightness function will repeatedly collect an image, determine its range of video levels (for a selected number of points), and adjust the contrast and brightness settings of the detector, until the contrast and brightness cover specified levels.

**Flap-out**
Pressing the arrow button displays the flap-out containing the STEM Detector Selection Control Panels.

## 37.1  STEM Detector Selection (User)
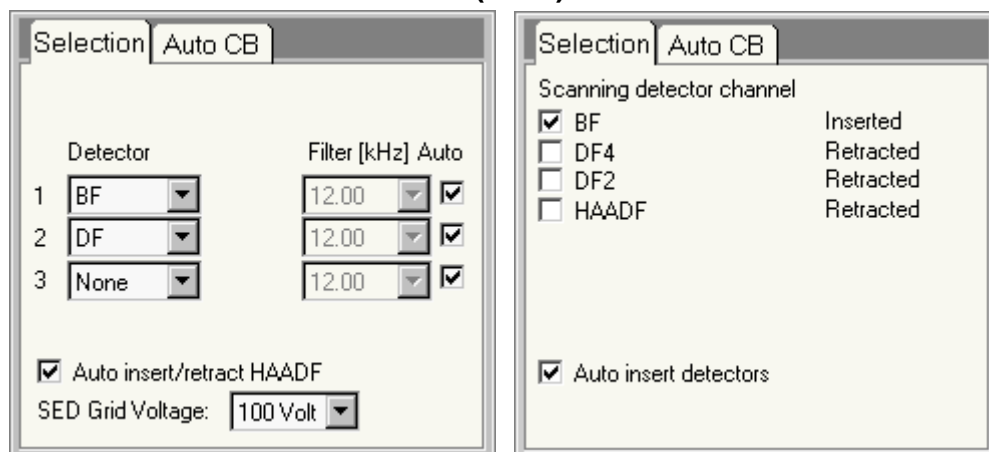


*The STEM Detector Selection Control Panel.*

In the STEM Detector Selection Control Panel the STEM detector(s) to be used are selected and some other detector parameters are defined.

There are two scanning systems in use. In the older system (control panel shown on the left) there are three channels to which a detector can be assigned through a drop-down list. In this system there are video filters for each channels that can be controlled by the user. In the new system (control panel on the right) each detector has its own, fixed channel and selection is done by checking one of the checkboxes.

The physical location of the available detectors is as follows:
- SE (secondary electron) and BS (backscattered electron) detectors are located above the specimen.
- the HAADF detector is located above the projection chamber (you will be able to see its shadow on the main screen).
- BF/DF detectors are located underneath the main screen. On older systems the BF/DF detectors are (typically) located in the near-axis position (shifted towards the right and a little bit up) and therefore this signal can never be combined with any on-axis signal (HAADF, EELS) because the diffraction pattern location differs. On newer systems the BF/DF detectors may be in the central position and their signals can be combined with on-axis signals (though you cannot combine BF with EELS because the EELS spectrometer is located underneath the BF detector and the BF detector blocks the beam for the EELS).

**Detector**
Each of the STEM detectors present can be selected in the drop-down lists (each list represents a video channel) or checkbox. The detectors selected determine which images are displayed in TIA during scanning (all lists in which a detector signal is selected will be displayed). The current insertion status (inserted, retracted) is indicated for the newer system.

**WARNING : POTENTIAL DAMAGE !** The retractable BF detector can be damaged by a very high electron dose. If you are using the detector with a very high beam current (e.g. for X-ray mapping), change to a high camera length so the central-beam disk is large and the electron dose per detector area is not too high.

**Filter**
The Filter defines the setting of the video filter, each for the channel to the left of it. Normally these can be kept on automatic control. There is a range of manual settings, selectable from the drop-down lists (which are enabled only if the Auto checkbox is unchecked; otherwise the settings is adjusted automatically, dependent on the scan speed). In manual control the correct filter setting can be

determined by starting with a high value and lowering it until the image starts to have horizontal streaks (signal variations are smeared out over several pixels). Increase the value again by approximately two steps (or at least until the streaks are completely absent).

### Auto insert/retract HAADF / Auto insert detectors

The Auto insert/retract HAADF determines whether the HAADF detector (old system) or selected detectors (new system) is/are automatically inserted or retracted when appropriate. If not checked, the detector(s) must be inserted or retracted by hand (operator instruction).

### SED Grid Voltage

The SED Grid Voltage setting defines the voltage on the Secondary Electron Detector extraction anode (an anode located just below the upper objective-lens pole piece; on some systems integrated with the Backscattered Electron Detector). The extraction anode allows selection of various ranges of SED energies. If the grid voltage is positive, all secondary electrons are attracted (with the strength of the grid voltage determining how strongly the secondary electrons are attracted). If the grid voltage is negative, low-energy secondary electrons (the bulk of the secondary electrons have energies below 50 eV) are repelled and the image of the SE detector becomes increasingly dominated by backscattered electrons.

This control is only present when an SE detector is present.


## 37.2 STEM Detector Auto CB
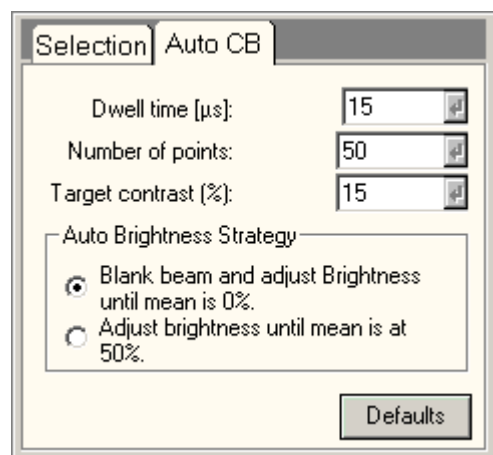


*The STEM Detector Auto CB Control Panel.*

In the STEM Detector Auto CB Control Panel the settings used for the Auto Contrast Brightness function are defined. The Auto Contrast Brightness function will repeatedly collect an image, determine its range of video levels (for a selected number of points), and adjust the contrast and brightness settings of the detector, until the contrast and brightness cover the specified levels (contrast to the target contrast, brightness within the accessible range of video levels).

### Dwell time

The dwell time defines the time per pixel for measuring the video level. Longer times lead to less noisy signal but increase the time necessary for the Auto Contrast Brightness function to finish.

### Number of points

The number of points determines at how many points the video level is measured for each cycle. Increasing the number of points increases the 'relevance' of the Auto Contrast Brightness function but also increases the cycle time. The points are distributed over a whole image. If the total range of video levels is spread out over a whole image with each level present in an area of reasonable size (more than just a few pixels), run the Auto Contrast Brightness function over the image as is. If, however, the video levels change on a small scale (as e.g. with small particles), increase the magnification so just a few particles are visible and/or increase the number of points before running the Auto Contrast Brightness function (otherwise the pixels used for measuring the video levels may miss the small features altogether).

**Target contrast**
The target contrast defines how much of the total available signal range should be filled by the detector signal. Thus 100% would have the lowest signal from the detector at 0 and the highest at 64000. Under normal circumstances a range of 10 to 15% is sufficient (the display software then automatically optimizes the image display from black to white).

**Auto Brightness Strategy**
Adjusting contrast and brightness (electronic gain and bias) of the detectors can be adjusted automatically using two strategies:

- **Blank beam and minimize intensity**
  The beam is blanked (automatically) and the brightness is adjusted until the mean intensity is at 0%. With the beam switched on again scanning is resumed and the gain is adjusted until the contrast of the image is at the preset value (normally 15%).
  The advantage of this method is that the full dynamic range of the detector can be used and that subsequent manual adjustment is simple: only the contrast of the detector needs to be adjusted. For this method to work correctly it is important that no ambient (room) light should hit the detector, as always when acquiring STEM images.
  The control of the detector must have good linearity and no coupling between contrast and brightness. It works well with the HAADF detector but not with the BF/DF detectors.
- **Set mean to 50% of range**
  This method adjusts both brightness and contrast of the detector until the mean intensity is at 50% and the contrast of the image is at the preset value (15%).

**Defaults**
Press the Defaults button to reset all values to their default.

# 38 Stigmator
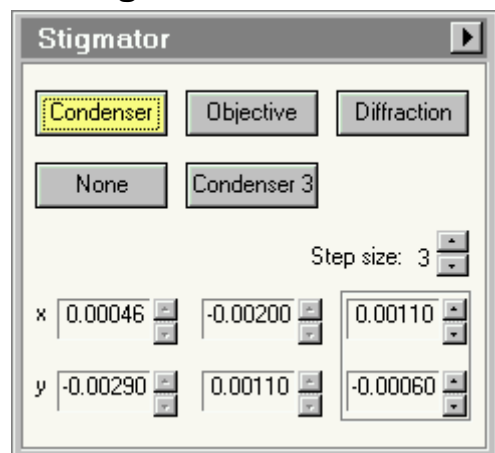


*The Stigmator Control Panel.*

The Stigmator Control Panel allows the operator to control the three stigmators of the microscope.

**Condenser**
The condenser stigmator is used to stigmate the electron beam. It is the default stigmator for modes where the beam is important (like nanoprobe and STEM). Pressing the Condenser stigmator button is equivalent to pressing the Stigmator button on the left-hand control pad plus selecting the condenser stigmator.

**Objective**
The objective stigmator is used to stigmate the HM (high-magnification) TEM image and the LAD (Low-Angle Diffraction) pattern. Pressing the Objective stigmator button is equivalent to pressing the Stigmator button on the left-hand control pad plus selecting the objective stigmator.

**Diffraction**
The diffraction stigmator is used to stigmate the D (high-magnification) diffraction pattern and the LM (low-magnification) TEM image. Pressing the Diffraction stigmator button is equivalent to pressing the Stigmator button on the left-hand control pad plus selecting the diffraction stigmator.

**None**
The None button allows the operator to deselect all stigmators. Pressing None is equivalent to pressing the stigmator button on the left-hand control pad when it is on.

**Condenser 3**
**Optional, not present on all microscopes:** The Condenser 3 stigmator is used to correct 3-fold astigmatism of the probe-forming system. The 3-fold condenser stigmation is done after the 2-fold condenser astigmatism has been corrected (go towards a beam that is as round as possible with the normal Condenser stigmator, then make the beam round with the 3-fold condenser stigmator).

**Notes**
- The 3-fold stigmator only works properly in the Nanoprobe or STEM mode. Although it is available in the Microprobe (TEM) and LM modes, the 3-fold condenser stigmator does not have the working range to have any effect there.
- The normal condenser and 3-fold condenser stigmators have a combined current budget. This means that the maximum value for the 3-fold condenser stigmator depends on the value of the normal (2-fold) condenser stigmator. If the combined value exceeds the maximum allowed, the setting of the 3-fold condenser stigmator will be clipped to the allowed maximum. The value displayed for the 3-fold stigmator settings (in the channels) will then turn red. This value may thus differ from the value originally set by the user. When the 3-fold stigmator setting was clipped and the

normal condenser stigmator value is reduced (and thus more current becomes available for the 3-fold condenser stigmator), the value of the 3-fold condenser stigmator is increased. Once it reaches the user-defined value, the settings in the channel will turn black again.

**Step size**
Each stigmator has its own step size. The step size determines the increment with which the stigmator is changed when the Multifunction buttons are turned or the spin buttons of the channels pressed. The step size is changed either with the spin buttons in the control panel or by pressing the -/+ buttons left of the Multifunction-X knob on the left-hand control pad.

**Channel**
Stigmator settings can be stored in three channels. One possible use of the channels is to use them for optical modes that can be slightly different (such as SA and Mh magnifications, because of the small change in objective-lens current). They can also be used to store intermediate results during stigmation (if you are unsure you can get the astigmatism correction better, copy the contents of the current channel to another and continue stigmation with the other channel. You can then always go back to first channel if it gets worse).

The active channel is outlined by a frame around it and by the enabled nature of its spin buttons (the arrows are black; those of the inactive channels are gray).

**Spin control**
Use the buttons of the spin control to change the stigmator setting (an alternative to using the Multifunction knobs).

**Flap-out**
The flap-out button leads to the Stigmator flap-out with the Stigmator Popup control panel.

**Special function:** Click with the right-hand mouse button on one of the channels to get a popup-menu.

| | |
|---|---|
| Copy | Ctrl+C |
| Paste | Ctrl+V |
| Reset | Ctrl+Z |
| Copy 2 to 1 | |
| Copy 2 to 3 | |
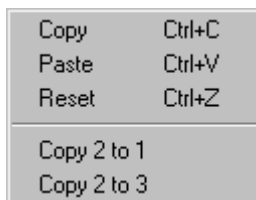
**Popup menu functions**

**Copy**
Copies the contents of the channel in which the mouse was clicked to the clipboard.

**Paste**
Pastes the contents of the clipboard into the channel where the mouse was clicked. This menu items remains grayed (disabled) until a copy action has been done.

**Reset**
Resets the stigmator channel to zero.

**Copy ... to ...**
Copies the content of the channel listed first to the channel listed second. The copy action is always from the channel where the right-hand mouse click was done to one of the other channels.

## 38.1  Stigmator Popup
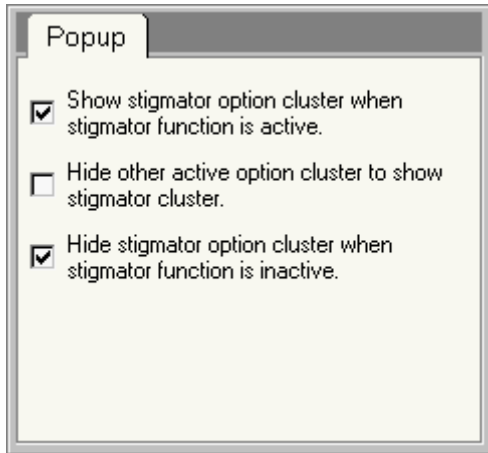
*The Stigmator Popup Control Panel.*

The Stigmator Popup Control Panel contains a number of options related to the behavior of the Stigmator control panel.

**Show .. when .. active**
When checked, this option automatically makes the Stigmator control panel pop up at the standard panel popup position (bottom right - unless it is already visible) when stigmator selection is on (through pressing of the Stigmator button on the left-hand Control Pad).

**Hide other ..**
This option, when checked, makes the Stigmator control panel replace any other control panel currently popped up.

**Hide stigmator ...**
When checked, this option makes the Stigmator control panel disappear again when the stigmator selection is switched off (by pressing the Stigmator button on the left-hand Control Pad).

# 39 Super X EDX
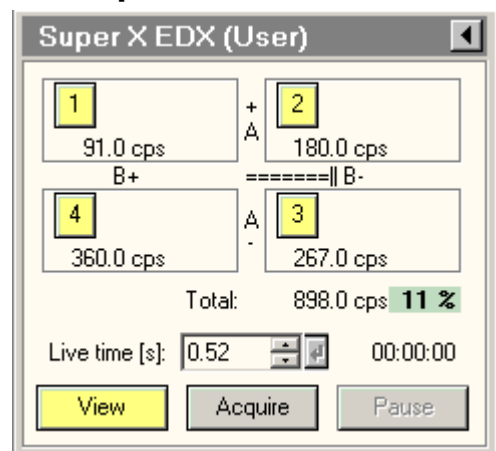
*The Super X EDX Control Panel.*

In the Super X EDX Control Panel the controls for (single) Super X (EDX) spectrum acquisition are located.

The Super X detector consists of four separate Silicon Drift Detectors located around the specimen. The geometry of the detectors is indicated by the A+ / A- and B+ / B- labels between the four detector quadrants, where A and B are the CompuStage tilt axes and + and - indicate the tilting direction. For comparison, the standard EDX detector would be situated at the A+ position, so between Super X detectors 1 and 2.

Because the viewing point for each detector differs, you should test the response for each detector individually before acquiring a spectrum from multiple detectors simultaneously if you are not familiar with the detector response on your system or do not know the geometry of the specimen. Detectors that do not give a good spectrum (e.g. because the specimen or specimen holder shadows the particular detector) should be deselected. Also, never acquire spectra from detectors that would "see" the underside of the specimen (in case the specimen is tilted), because that will result in a disproportionally high background.

Note that combined spectra of more than one detector are unsuitable for quantification because the combined spectrum does not distinguish between X-rays detected on different detectors so the geometry for the detector is undefined.

**Note:** TIA must be running. If it is not running, the buttons are disabled.

**Detector selection (1, 2, 3, 4)**
The buttons numbered 1 through 4 allow selection or deselection of the four detectors. A detector is selected when its button is yellow. During a View or Acquire action the detector selection cannot be changed.

**Count/s**
The count rate (in counts per second) is displayed per detector and the summed count rate is displayed in the Total section..

**Dead time**
During acquisition the average detector dead time is displayed. At high dead times the background of the label becomes red, otherwise it is green.

**Live time**
The Live time sets the acquisition time for the currently active acquisition mode (View, Acquire).

**Time remaining**
During acquisition the time remaining before acquisition is finished is displayed.

**View**

Pressing the View button :
- When the button is gray, switches the EDX acquisition settings to those of the View mode and starts acquisition.
- When the button is yellow, pauses EDX acquisition.
- When the button is white, resumes EDX acquisition.

By definition View is continuous acquisition.

**Acquire**

Pressing the Acquire button :
- When the button is gray, switches the EDX acquisition settings to those of the Acquire mode and starts acquisition.
- When the button is yellow, stops EDX acquisition.
- When the button is white, starts EDX acquisition of a new spectrum.

By definition Acquire is single acquisition.

**Pause**

The EDX acquisition can be paused and continued by pressing the Pause button.

**Flap-out button**

Pressing the flap-out button displays the flap-out with the Super X and Settings Control Panel.


## 39.1 Super X
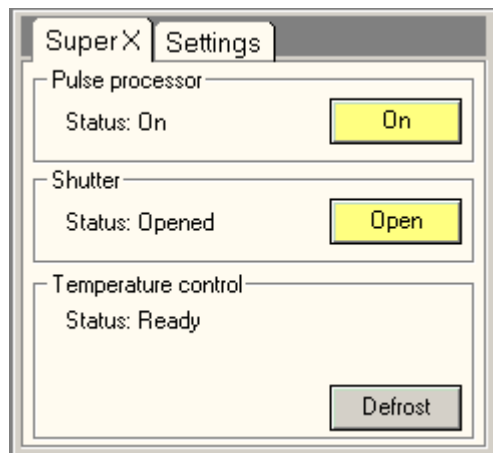


*The Super X Control Panel.*

In the Super X Control Panel the Super X status is controlled.

**Pulse processor status**

The pulse processor status consists of three states : Offline, Standby and On. In Offline the software is connected to the pulse processor. When the state is Standby the software is connected but the bias voltages on the detectors are off. In the On state the bias voltages on the detectors are on and the software is ready for acquisition.

**Pulse processor On**

The On button allows the user to change the pulse processor status to On or Standby. The button is yellow when the pulse processor status is On.
When the column valves are closed or the column vacuum status is not OK the pulse processor status will automatically switch to Standby. If the column valves are opened and the column vacuum status is OK the pulse processor status is set to On automatically.

**Shutter status**
The Super X detectors have mechanical shutters to protect them. There are some TEM/STEM modes (like LM and Lorentz ) where the shutters cannot be opened. In other cases the shutters are opened automatically when acquisition is started and closed some seconds after the acquisition is finished. In case it is necessary to open the shutters before the actual acquisition is started, they can be opened manually using the open button.
To prevent damage to the detectors the shutters are automatically closed when switching between TEM and STEM mode, when closing the column valves or when the input count rate is too high.

**Shutter Open**
When the Open button is pressed, the shutters are opened and the button will become yellow.

**Temperature control status**
The detectors are cooled using the liquid-nitrogen cooled cold trap of the microscope. The status of the temperature controller is displayed.

**Defrost**
In defrost mode the temperature is increased to 20°C to remove any ice from the detectors. The defrost cycle takes 10 minutes and the remaining time is displayed. Defrost can be canceled by pressing the Defrost button when it is yellow.

## 39.2 Super X Settings
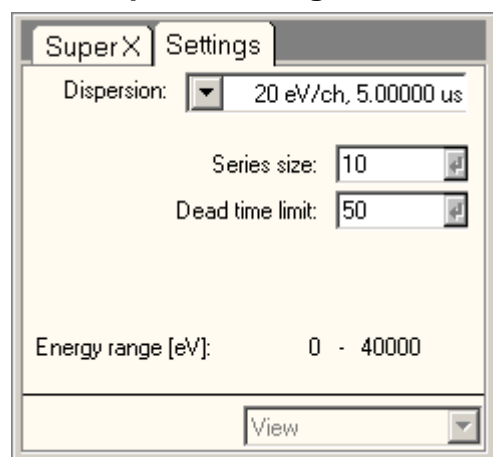


*The Super X Settings Control Panel.*

In the Super X Settings Control Panel the acquisition parameters are defined.

**Dispersion**
The drop-down list contains the accessible dispersion settings for the EDX detector. This list corresponds to the list of the More EDX Dispersions tab in TIA.

**Series size**
Under series size the size of the acquisition series for the currently active acquisition mode is set. Please note that for Acquire, the series size doesn't do anything unless the TIA option "Reuse display window" is active.

**Dead time limit**
The dead limit determines at which dead time percentage the dead-time display background on the main control panel switches from green to red (and vice versa).

**Energy range**
The Start and End values define the start and end energy (in electronvolt) of the spectrum.

**Acquisition mode**

In the acquisition mode drop-down list, the acquisition mode for which the parameters must be defined, can be selected. The difference between selecting the acquisition mode through the drop-down list and by pressing the equivalent button in the main control panel is that the drop-down list selection selects the mode but does not automatically start acquisition.

# 40 System status

**System Status**

**Lens**

| | |
|---|---|
| Spot size | 23.85 % |
| Intensity | 97.73 % |
| Minicondenser | 83.92 % |
| Objective | 87.49 % |
| Lorentz | 0.00 % |
| Diffraction | 54.15 % |
| Intermediate | 14.89 % |
| Projector 1 | 3.58 % |
| Projector 2 | 85.23 % |

| Gun deflector | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| Gun tilt | -0.3005 | -0.3005 | | | U-X | 0.1643 |
| Gun shift | 0.0300 | -0.1000 | | | U-Y | 0.4149 |
| Spot-dep. shift | 0.1062 | -0.0144 | | | L-X | 0.3947 |
| Gun tilt pp | 5.8600 | 5.8300 | | | L-Y | 0.1351 |
| Gun shift pp | 4.0000 | 4.0000 | 0.0000 | 0.0000 | | |

| Beam deflector | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| DF tilt | 0.0000 | 0.0000 | | | U-X | -0.1246 |
| User shift | 0.1600 | 0.0030 | | | U-Y | 0.0634 |
| Rot Center | 0.0300 | -0.0200 | | | L-X | 0.0240 |
| Align shift | -0.0600 | -0.0500 | | | L-Y | -0.0172 |
| Beam tilt pp | 3.8207 | 3.8203 | | | | |
| Beam shift pp | 5.0602 | 5.0599 | 0.0002 | 0.0003 | | |

| Image deflector | X | Y | Perp X | Perp Y | All | |
|---|---|---|---|---|---|---|
| User diff. shift | 0.0000 | 0.0000 | | | U-X | -0.0097 |
| User image shift | 0.0000 | 0.0000 | | | U-Y | -0.0091 |
| Align diff. shift | 0.0100 | 0.0140 | | | L-X | 0.0103 |
| Align image shift | 0.0003 | -0.0007 | | | L-Y | 0.0133 |
| Diff. shift pp | 3.8408 | 3.8417 | | | | |
| Image shift pp | 4.7388 | 4.7412 | 0.0003 | -0.0002 | | |
| Magn. corr. | 0.0010 | -0.0020 | | | | |
| Det. alignment | 0.0000 | 0.0000 | | | | |
| X-over corr. | 0.0000 | 0.0000 | | | | |

*The System Status Control Panel.*

The System Status Control Panel provides an overview of all (software) values of lenses and deflection coils.

**Lens values**
The lens values display the currently active lens settings as a percentage of the lens maximum.

**Deflection coils**
The deflection coils values are shown in non-physical units. These values always lie between -1 and +1, except for the pivot points that lie in the range 2-6.

**X-Y values**
The X-Y values are the values on the X and Y coils, respectively, for the entries listed on the left.

**Perpendicular values**
The perpendicular values display the perpendicular corrections applied to the coils. Only one set of perpendicular values exists for a particular deflection coil (thus the shift and tilt components use the same value).

**All values**
The settings on the deflection coils are first added together. These are then converted by the pivot points into settings applied to upper and lower coils.

**Gun coils**
The settings on the gun deflection coils consist of the gun tilt, the gun shift and the spot-size dependent gun shift.

**Beam coils**
The settings on the beam deflection coils consist of four factors, two user factors (user beam shift as set with the trackball, and dark field tilt) and two alignment factors, the align beam shift and the rotation center. Not listed is the contribution from the image shift - beam shift.

**Image coils**
The settings on the image deflection coils consist of four main factors, two user factors (user image shift and user diffraction shift) and two alignment factors, the align image shift and align diffraction shift. Additionally there are the magnification correction (used for the alignment of the magnifications within a range), the detector alignment (used for the shift to off-axis detectors) and the cross-over correction (used in EFTEM). Not listed is the contribution from the image shift - beam shift.

# 41 Temperature Control

| Temperature Control | ▶ |
|---|---|
| — Status — | |
| All Room Temperature | |
| — Dewar levels — | |
| Autoloader | 0 %    0 h 00 min |
| Column | 0 %    0 h 00 min |
| — Temperatures — | |
| Docker | 295.4 K   22.3 °C |
| Holder | 294.0 K   20.9 °C |
| Cassette gripper | 297.1 K   23.9 °C |
| Cartridge gripper | 296.6 K   23.5 °C |
| Autoloader Dewar | 295.7 K   22.6 °C |
| Column Dewar | 294.5 K   21.4 °C |
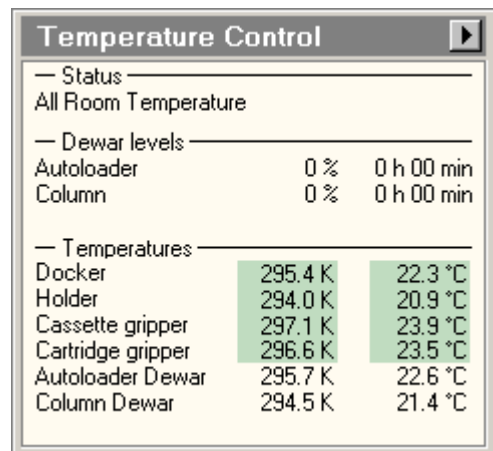
*The Temperature Control Control Panel.*

The Temperature Control Panel allows monitoring and controlling the temperature state of the Life Science system. The temperature control system consists of dewars on both the autoloader and column, connected to a liquid nitrogen storage vessel via the autofill system. It gives the ability to automatically fill and empty the nitrogen dewars. Filling the autoloader dewar will cool and maintain the specimens in the autoloader cassette to near-liquid-nitrogen temperatures. Filling the column dewar will cool and maintain the cryobox and the specimen holder tip to near-liquid-nitrogen temperatures.

**Status**
This part of the control panel shows the current status of the temperature control system. Possible states are:

- **All Room Temperature** : in this state the autofill system is idle. All dewars are empty and all temperatures are around room temperature.
- **All Nitrogen Temperature** : use this state to operate the microscope with frozen samples close to liquid nitrogen temperatures. The specimen holder tip is cooled to near liquid nitrogen temperatures. The cryobox is also cold and shields the holder tip from its surroundings, reducing the change that gases in the column vacuum freeze on the cold sample. The samples inside the autoloader are also maintained near liquid nitrogen temperatures. In this state all temperatures are near liquid nitrogen temperature.

In the above temperature states, the autoloader vacuum is on and the column vacuum is ready, which means that its ion getter pumps (IGP) are on and the column valves can be opened for operating the microscope.

- **Conditioning Autoloader** : use this state to remove any water vapor from the autoloader vacuum which is released when the cold autoloader parts warm up. In this state the autoloader turbo pump (TMP) pumps actively on the autoloader, while heaters in the autoloader dewar warm the autoloader to room temperature. This state affects only the autoloader. If in the preceding state the column dewar was cold, it will remain being filled with liquid nitrogen and the column vacuum remains ready.
- **Conditioning Column** : use this state to remove any water vapor from the column vacuum which is released when the cold column parts warm up. In this state the column IGP's are switched off and the column turbo pump (TMP) pumps actively on the column, while heaters in the column dewar warm the column to room temperature. This state affects only the column. If in the preceding state the autoloader dewar was cold, it will remain being filled with liquid nitrogen and the autoloader vacuum remains on.
- **Conditioning Both** : use this state to condition the autoloader and column simultaneous.

**Dewar levels**
The Dewar levels section shows the actual liquid level in each dewar as measured with the level gauge. The liquid level is depicted as a percentage and as the remaining time before the dewar is empty. Note: The measurements may fluctuate slightly (up to a few percent) due to the nature of the construction of the measurement gauges.

**Temperatures**
Under Temperatures the current temperatures of different parts within the system are displayed in Kelvin and degrees Celsius. There are four temperature sensors inside the autoloader: docker, cassette gripper, cartridge gripper and autoloader dewar. The holder tip is the temperature sensor measuring the temperature near the specimen holder. The column dewar displays the temperature of the bottom of the column dewar.

**Flap-out button**
Pressing the flap-out button displays the flap-out containing the State and Filling control panels.

## 41.1 Temperature Controller State
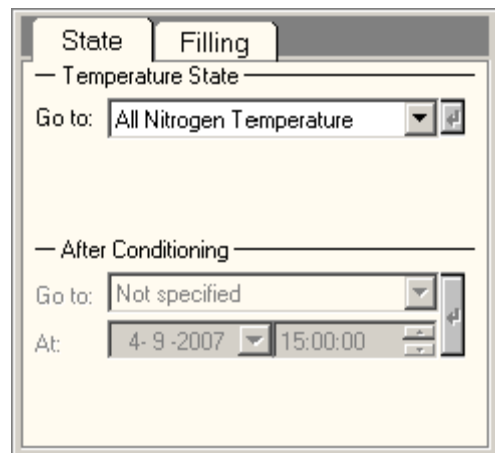


*The Temperature Controller State Control Panel.*

The State flap-out provides the control over the state of the temperature control system.

**Temperature State**
The current temperature state can be changed by selecting a different state from the dropdown list. When the command is given, the temperature control system will automatically execute the required actions. First, temperature control will put the column and autoloader vacuum in the correct state and second, fill or empty one or more dewars.

Note that the dropdown list does not always show all existing temperature states. For example the All Room Temperature state: this state is unavailable if the column dewar is cold. The cryobox is cold and gases are frozen on its surface. On going to all room temperature, the column dewar and cryobox warm up and the frozen gases evaporate, contaminating the column vacuum. Select first the state Conditioning Column or Conditioning Both to remove the evaporating gases. When the column is warmed up the All Room Temperature state becomes available.

**Notes :**
- The AutoLoader must be initialized before another Temperature State can be selected.
- If, due to exceptional circumstances, the temperature control system is in an error state, a recover button will become available here. On pressing this recover button, the temperature control system will try to recover from this error state. In case the error state does not recover, or the error reappears again, customer service must be contacted.
- Dewar increase not detected. This error message appears if temperature control does not measure any liquid nitrogen level increase during filling. In this case it is good to check if the liquid nitrogen storage vessel is empty or closed.

**After Conditioning**
Temperature control gives the possibility to schedule the desired temperature state after conditioning is finished. When the system is put into a conditioning state, these states become available in a dropdown list. At the preset time and date temperature control will stop conditioning and put the system in the desired temperature state.

## 41.2 Temperature Controller Filling
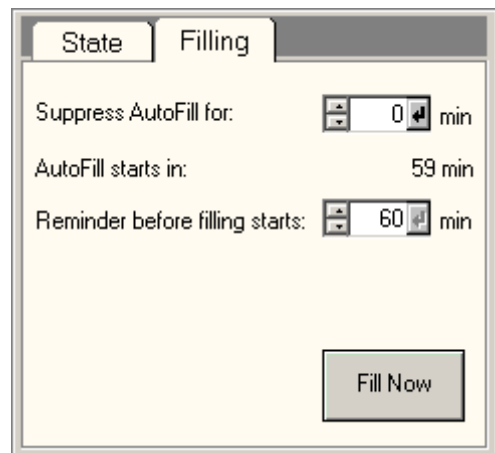


*The Temperature Controller Filling Control Panel.*

The Filling flap-out is dedicated to the liquid-nitrogen autofill system of the autoloader and column dewar.

**Suppress Autofill for**
This option allows continued operation the microscope for a user-defined time without being disturbed by the autofill system. Normally, filling starts if one dewar is almost empty. The Suppress Autofill for postpones filling for the desired period. Note that the cold parts will eventually warm up if the filling is postponed for a long time.

**AutoFill starts in**
This shows the remaining time before the autofill system starts its next filling cycle.

**Reminder before filling starts**
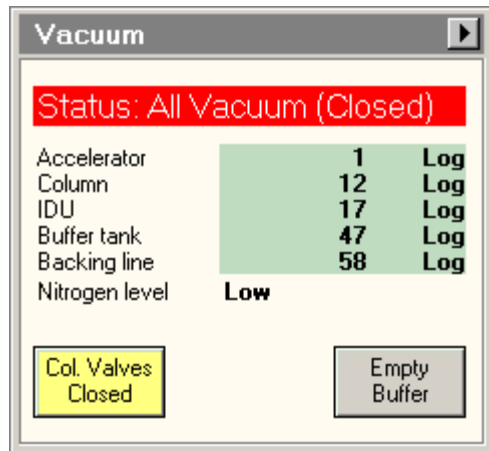The software displays a warning message in the information area of the user interface before the automatic filling starts. The user can specify the amount of time before a refill when this reminder will be given.

**Fill Now**
When the Fill Now button is pressed temperature control will start the autofill process. Note that this button is not available if both dewars are nearly full.

# 42 Vacuum (User)

*The Vacuum Control Panel.*

**Note:** Depending on the vacuum system configuration, the control panel may be somewhat different from the one shown here.

The Vacuum Control Panel gives and overview of the vacuum status of the microscope and provides access to a few, often-used vacuum-control functions. A more detailed vacuum overview is also available.

**Note:** Vacuum terminology tends to be confusing. People talk about high or ultra-high vacuum when they mean very low pressures. Where it could be confusing, vacuum status will therefore be referred to as 'good' or 'poor'.

**Status**
The status line of the Vacuum Control panel displays the status of the vacuum in words. Examples of status values are ready, off, stand-by, and start up. A green status display is used for ready, red status displays for not ready. In the example above, the display indicates that the Column Valves are closed.

**Pressure read-out**
The essential pressures of the microscope are read out, either by pressure gauges like Pirani's or Pennings or by converting the currents going through Ion Getter Pumps to pressures. The important pressures are listed in the Vacuum Control Panel. The pressure units are as set in the Vacuum Settings control panel (or defined by the supervisor for users). Possible units are Pascal, Torr and Log unit. For clarity Pascal and Torr units always go in steps of thousands for the exponent (10-3, 10-6, etc). Log units are defined in such a way that a realistic range of pressures (for that vacuum element) goes from 0 to 100. The advantage of the log units is simplicity and high sensitivity for the good vacuum values (where it matters) and low sensitivity for poor vacuum values.

On the FEG instruments the Gun pressure indicated is measured through IGPa.

**Nitrogen level**
The nitrogen level value indicates the amount of nitrogen remaining in the nitrogen dewar.

**Column Valves Closed**
The Column Valves Closed button closes and opens the two valves in the column separating the column from the projection chamber (Vci) and the column from the gun (Vac). These two valves are always opened and closed together. The high tension and filament can remain on when opening and closing these valves. The functionality of the button is chosen such that it highlights (yellow) when the column valves are closed (as a warning that the beam will not be visible). The same is indicated, when possible, by the status display.

It is good practice to keep these valves closed whenever the microscope is not actively used, to keep the column vacuum at its optimum condition and prevent air from entering the gun area during specimen exchange.

**Empty Buffer**

The Empty Buffer button starts the cycle that empties the buffer tank. This may be useful in cases where it is necessary that the buffer cycle doesn't interrupt operation for a period of time (e.g. when a series of exposures is to be made).

**Vacuum Flap-out**

Pressing the arrow button displays the flap-out containing the Vacuum Cryo and Vacuum Settings control panels.

## 42.1  Vacuum Cryo (User)
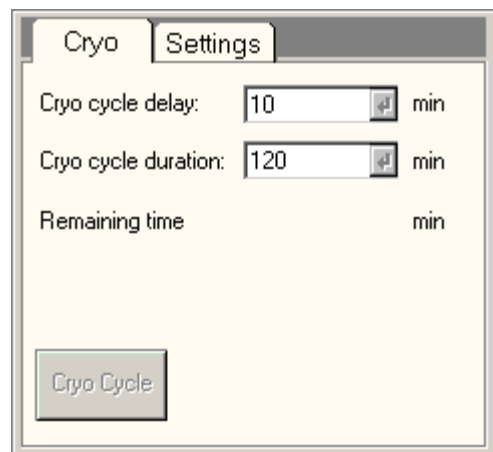


*The Vacuum Cryo Control Panel.*

The Vacuum Cryo Control Panel contains functions for the cryo cycle (for removal of water vapor coming off the cold trap or cryo blades when the liquid-nitrogen cooling is removed).

**Cryo cycle**

The Cryo cycle is a special vacuum procedure for removing the water vapor from the microscope column that is released when the cold trap or cryo blades are being warmed up at the end of a cryo-microscopy session. The IGPco that pumps the microscope column is not a very effective pump for removal of water vapor (and ages more rapidly when it is forced to pump a lot of water vapor repeatedly) and therefore the TMP is used to pump away the water vapor while IGPco is temporarily switched off. After a set time has elapsed, the IGPco is automatically switched on again so the microscope is ready for operation the next morning.

The cryo cycle is based on two settings, a delay time before the function switches IGPco off (Start after) and a running time after which the microscope will (attempt to) switch IGPco on again (Duration). To determine what these settings should be, observe the behavior of the microscope vacuum system after a normal day of cryo-microscopy operation. Stop the microscope session. If you normally remove the liquid-nitrogen dewar of the cold trap, do so now. Record the time until the pressure in the column begins to rise significantly (due to water vapor coming off the cold trap or cryo blades). Take 3/4 of this time as the Start after value. Estimate how it will normally take to evaporate all the water from the cold trap or cryo blades (with the liquid-nitrogen dewar removed this is typically less than 1/2 hour, with it there it may take longer). Select that time (with some margin for variation) as the Duration time.

**Note:** To ensure that the vacuum doesn't deteriorate in case the Start after time is too long, the vacuum system will terminate the Start after period and switch to the real part of the cryo cycle (Duration) when it finds that IGPco is running up significantly. The cryo cycle then continues normally.

During the cryo cycle a number of vacuum controls (column valves, prepump airlock, etc.) are disabled. It is also not possible to change the cryo cycle settings while the cycle is running. The cryo cycle can be switched off by pressing the (now yellow) Cryo Cycle button.

## 42.2 Vacuum Settings (User)
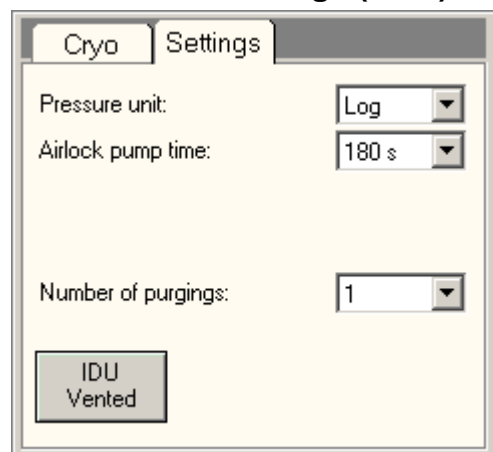
*The Vacuum Settings Control Panel.*

The Vacuum Settings Control Panel provides access to various settings concerning the vacuum system.

**Pressure unit**
Vacuum pressures can be listed in three types of units, Pascal (Pa), Torr and Log unit. For clarity Pascal and Torr units always go in steps of thousands for the exponent (10-3, 10-6, etc). Log units are defined in such a way that a realistic range of pressures (for that vacuum element) goes from 0 to 100. The advantage of the log units (which are similar to the units previously used on CM microscopes) is simplicity and high sensitivity for the good vacuum values (where it matters) and low sensitivity for poor vacuum values.

**Airlock pump time**
Airlock pumping times can be set by the user. The minimum airlock pumping time advised is 60 seconds.

**Number of purgings**
This control is not present for all vacuum-system configurations.
The TMP can be set to pump on the airlock in a single cycle or in more cycles, interspersed by flushing with nitrogen. If a single cycle is set, no flushing takes place, otherwise the systems pumps, flushes, pumps, ... (depending on the number of cycles set).

**Detection Unit Vented**
The Detection Unit Vented button starts (or stops) the venting of the detection unit (projection chamber). This button is not always visible (controlled by the checkbox on the Control tab).

# Vacuum (Supervisor)

*The Vacuum Control Panel.*

**Note:** Depending on the vacuum system configuration, the control panel may be somewhat different from the one shown here.

The Vacuum Control Panel gives and overview of the vacuum status of the microscope and provides access to a few, often-used vacuum-control functions. A more detailed vacuum overview is also available.

**Note:** Vacuum terminology tends to be confusing. People talk about high or ultra-high vacuum when they mean very low pressures. Where it could be confusing, vacuum status will therefore be referred to as 'good' or 'poor'.

**Status**
The status line of the Vacuum Control panel displays the status of the vacuum in words. Examples of status values are ready, off, stand-by, and start up. A green status display is used for ready, red status displays for not ready. In the example above, the display indicates that the Column Valves are closed.

**Pressure read-out**
The essential pressures of the microscope are read out, either by pressure gauges like Pirani's or Pennings or by converting the currents going through Ion Getter Pumps to pressures. The important pressures are listed in the Vacuum Control Panel. The pressure units are as set in the Vacuum Settings control panel (or defined by the supervisor for users). Possible units are Pascal, Torr and Log unit. For clarity Pascal and Torr units always go in steps of thousands for the exponent (10-3, 10-6, etc). Log units are defined in such a way that a realistic range of pressures (for that vacuum element) goes from 0 to 100. The advantage of the log units (which are similar to the units previously used on CM microscopes) is simplicity and high sensitivity for the good vacuum values (where it matters) and low sensitivity for poor vacuum values.

On the FEG instruments the Gun pressure indicated is measured through IGPa.

**Nitrogen level**
The nitrogen level value indicates the amount of nitrogen remaining in the nitrogen dewar.

**Column Valves Closed**
The Column Valves Closed button closes and opens the two valves in the column separating the column from the projection chamber (Vci) and the column from the gun (Vac). These two valves are always opened and closed together. The high tension and filament can remain on when opening and closing these valves. The functionality of the button is chosen such that it highlights (yellow) when the column valves are closed (as a warning that the beam will not be visible). The same is indicated, when possible, by the status display.

It is good practice to keep these valves closed whenever the microscope is not actively used, to keep the column vacuum at its optimum condition and prevent air from entering the gun area during specimen exchange.

**Empty Buffer**
The Empty Buffer button starts the cycle that empties the buffer tank. This may be useful in cases where it is necessary that the buffer cycle doesn't interrupt operation for a period of time (e.g. when a series of exposures is to be made).

**Vacuum Flap-out**
Pressing the arrow button displays the flap-out containing the Vacuum Cryo, Vacuum Settings and Vacuum Control control panels.

## 42.3 Vacuum Control (Supervisor)
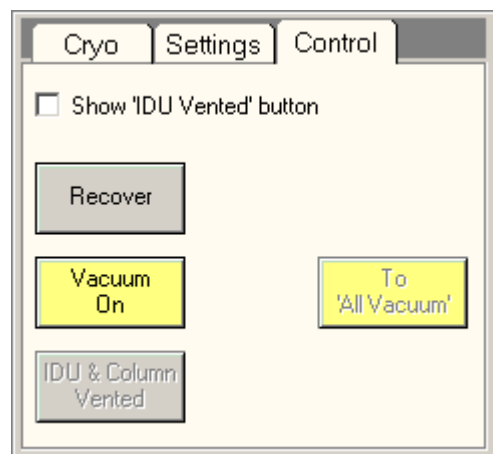


*The Vacuum Control Control Panel.*

The Vacuum Control Control Panel allows the supervisor to control certain elements of the microscope's vacuum system.

**Show 'Detection Unit Vented' button**
The checkbox Show 'Detection Unit Vented' button determines whether the Detection Unit Vented button on the Vacuum Control Panel is visible or not. This option can be set only by the Supervisor and applies to all users (Experts and Users) of the microscope.

**Recover**


**Vacuum on**


**To 'All Vacuum'**


**Detection Unit and Column Vented**
Pressing the Detection Unit and Column vented starts (or stops) the venting of the combined detection unit (projection chamber) and column.

## 42.4 Vacuum Cryo (Supervisor)



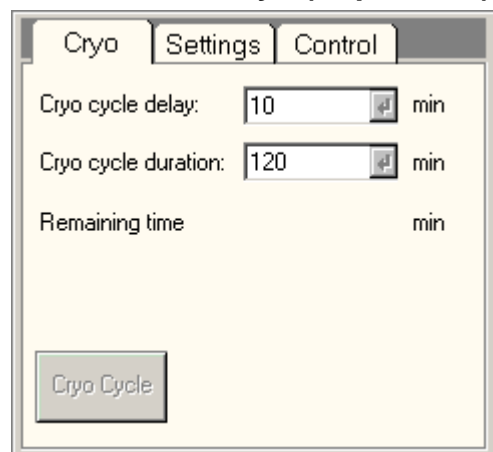*The Vacuum Cryo Control Panel.*

The Vacuum Cryo Control panel contains the functions for the cryo cycle (for removal of water vapor coming off the cold trap or cryo blades when the liquid-nitrogen cooling is removed).

**Cryo cycle**
The Cryo cycle is a special vacuum procedure for removing the water vapor from the microscope column that is released when the cold trap or cryo blades are being warmed up at the end of a cryo-microscopy session. The IGPco that pumps the microscope column is not a very effective pump for removal of water vapor (and ages more rapidly when it is forced to pump a lot of water vapor repeatedly) and therefore the TMP is used to pump away the water vapor while IGPco is temporarily switched off. After a set time has elapsed, the IGPco is automatically switched on again so the microscope is ready for operation the next morning.

The cryo cycle is based on two settings, a delay time before the function switches IGPco off (Start after) and a running time after which the microscope will (attempt to) switch IGPco on again (Duration). To determine what these settings should be, observe the behavior of the microscope vacuum system after a normal day of cryo-microscopy operation. Stop the microscope session. If you normally remove the liquid-nitrogen dewar of the cold trap, do so now. Record the time until the pressure in the column begins to rise significantly (due to water vapor coming off the cold trap or cryo blades). Take 3/4 of this time as the Start after value. Estimate how long it will normally take to evaporate all the water from the cold trap or cryo blades (with the liquid-nitrogen dewar removed this is typically less than 1/2 hour, with it there it may take longer). Select that time (with some margin for variation) as the Duration time.

**Note:** To ensure that the vacuum doesn't deteriorate in case the Start after time is too long, the vacuum system will terminate the Start after period and switch to the real part of the cryo cycle (Duration) when it finds that IGPco is running up significantly. The cryo cycle then continues normally.

During the cryo cycle a number of vacuum controls (column valves, prepump airlock, etc.) are disabled. It is also not possible to change the cryo cycle settings while the cycle is running. The cryo cycle can be switched off by pressing the (now yellow) Cryo Cycle button.

## 42.5 Vacuum Settings (Supervisor)
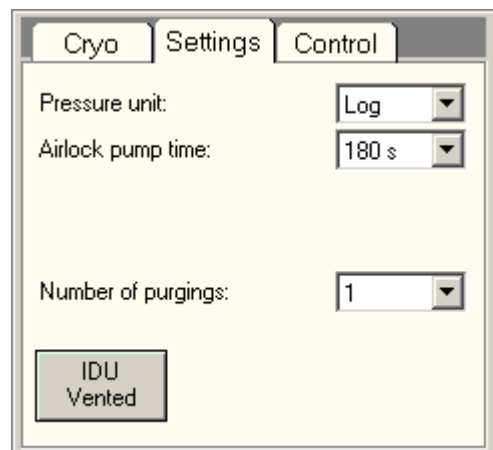


*The Vacuum Settings Control Panel.*

The Vacuum Settings Control Panel allows users and supervisor access to various settings concerning the vacuum system. Settings determined by the supervisor automatically apply to users.

**Pressure unit**
Vacuum pressures can be listed in three types of units, Pascal (Pa), Torr and Log unit. For clarity Pascal and Torr units always go in steps of thousands for the exponent (10-3, 10-6, etc). Log units are defined in such a way that a realistic range of pressures (for that vacuum element) goes from 0 to 100. The advantage of the log units (which are similar to the units previously used on CM microscopes) is simplicity and high sensitivity for the good vacuum values (where it matters) and low sensitivity for poor vacuum values.

**Airlock pump time**
Airlock pumping times can be set by the user. The minimum airlock pumping time advised is 45 seconds.

**Purge cycles**
This control is not present for all vacuum-system configurations.
The TMP can be set to pump on the airlock in a single cycles or in more cycles, interspersed by flushing with nitrogen. If a single cycle is set, no flushing takes place, otherwise the systems pumps, flushes, pumps, ... (depending on the number of cycles set).

**Detection Unit Vented**
The Detection Unit Vented button starts (or stops) the venting of the detection unit (projection chamber). This button is not always visible (controlled by the checkbox on the Control tab).

# 43 Vacuum Overview
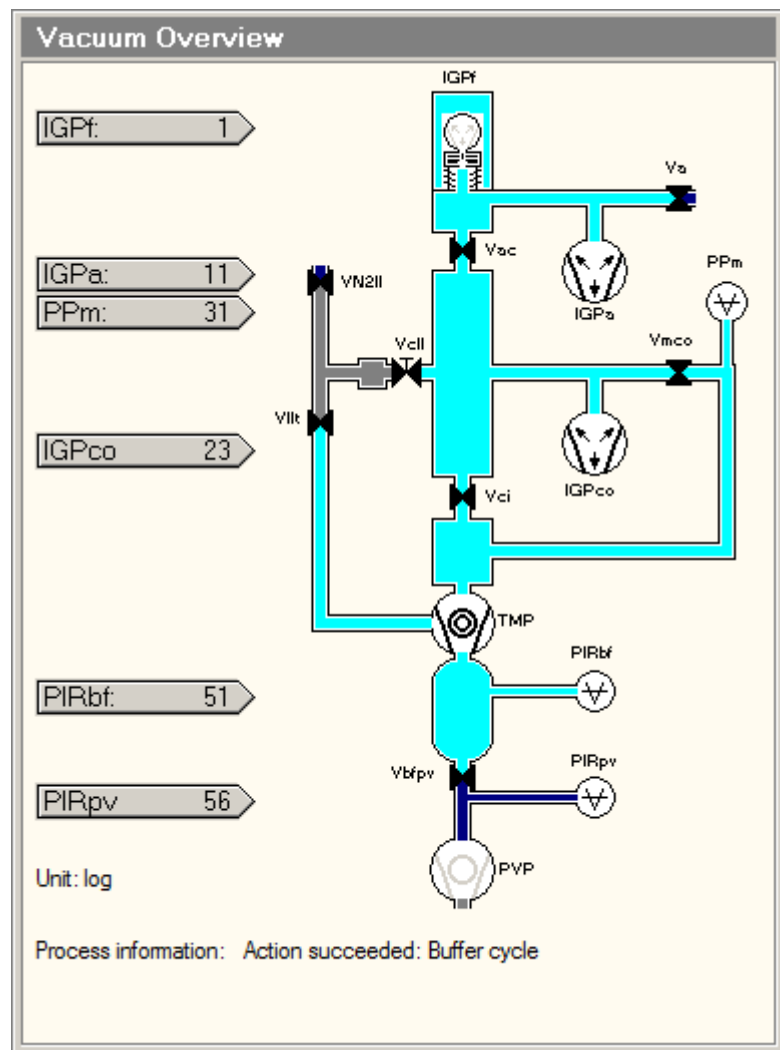


*The Vacuum Overview Control Panel.*

The Vacuum Overview Control Panel is available only under the control panel selection at the bottom right (its size is too large to fit otherwise). The overview display the current status of the vacuum system.

The overview displays the following elements:
- pumps (indicated by their vacuum-technology symbols)
- pumping lines and volumes
- gauges
- valves
- pressure read outs
- process information
- N2 indicates connections for inlet of nitrogen gas when a certain volume is vented (let up to air).

**Pumps**
The microscope contains a number of pumps, of different types. The various pumps are indicated by their vacuum technology symbols:

     Ion-getter pump (IGP)

     Turbo-molecular pump (TMP)

 Rotary or pre-vacuum pump (PVP)

Pumps that are active are shown in black on the inside, inactive pumps in gray.

The microscope contains the following pumps:
- IGPco pumps on the specimen area.
- IGPa pumps on the gun area.
- IGPf pumps on the FEG emitter area.
- TMP (and its backing diaphragm pump; the latter not shown in this diagram) prepumps the column (and gun), pumps on the specimen-holder airlock and pumps the Detection unit (projection chamber).
- PVP pumps on the buffer tank (backing of the TMP).

**Pumping lines and volumes**
Lines and volumes are indicated in colors, with the blue colors indicating active lines and volumes, and a lighter color indicating lower pressure (higher vacuum). Yellow indicates SF6 (in the gun).

**Gauges**
Gauges are vacuum elements that are used to measure pressures (in addition to pressure measurements derived from the current of the Ion Getter Pumps). Three types of gauges exist, Pirani's, Pennings and combined Pirani-Pennings. The following gauges are present in the vacuum system:
- PIRbf  -  Measures pressure in the buffer tank.
- PIRpv  -  Measures pressure in the backing line (line going from main vacuum system to rotary pump).
- PPm  -  Measures pressure in projection chamber.

**Valves**
Valves are indicated by a butterfly-like symbol. In closed valves the 'butterfly wings' touch each other, for open valves there is an opening between the 'wings'. Valves with a 'capital T'-like symbol between the 'wings' indicate a manual valve. Of the valves present in the system, the following have special importance:
- Vac and Vci are the column valves, which are under user control (as well as automatic control by the vacuum system).
- Vcll (the airlock valve) is the valve inside the CompuStage goniometer that is opened and closed by the rotation of the specimen holder during insertion or retraction. It is therefore a manual valve (as indicated by the T on the valve).
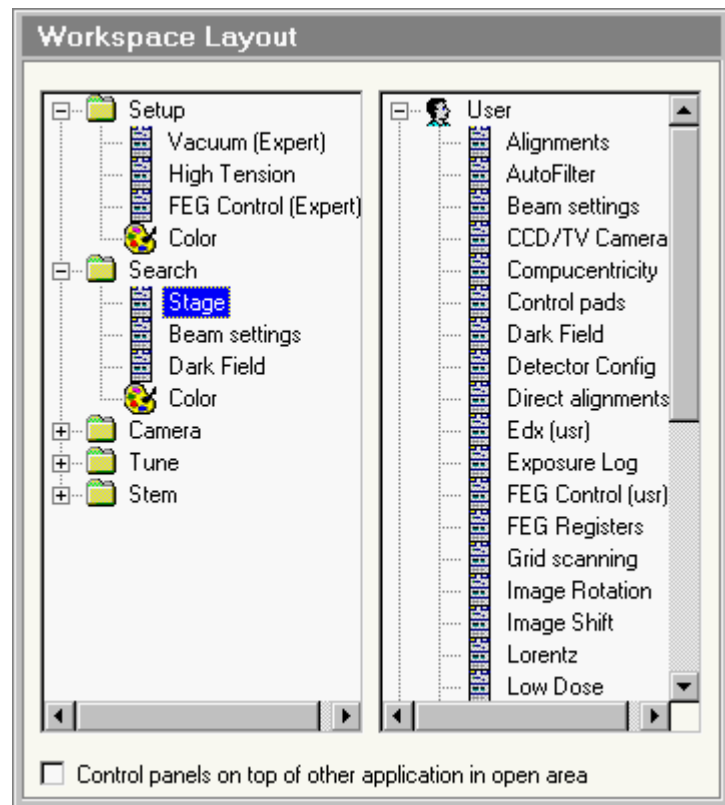
**Pressure read-out**
The gray arrows indicate the values of the pressures read-out (units are as selected in the Vacuum Settings control panel). The arrows roughly point to the vacuum gauge or pump used to read out the pressure.

**Process information**
The process information lists up to four messages about the status of the vacuum system.

# 44 Workspace layout



*The Workspace Layout Control Panel.*

The Workspace Layout Control Panel provides the tools for adjusting the worksets to user preferences.

**Worksets**

The worksets are represented by folder icons in the left-hand treeview. Clicking on the '+' sign (or double-clicking the folder icon) opens the branch of the workset selected, displaying from - top to bottom – a number of control panels, the Binding display panel, three status display (Multiselection) panels and Color control.

The following actions are possible on whole worksets:
- **Change the name** : click with the right-hand mouse button on a workset and select Edit label from the popup menu or click on the name and press Enter, type the new text when the label changes to an edit control.
- **Copy a workset** : click with the right-hand mouse button on a workset and select Copy from the popup menu, or press the Ins(ert) key.
- **Delete a workset** : click with the right-hand mouse button on a workset and select Delete from the popup menu, or press the Del(ete) key.
- **Change the sequence of the worksets** : click on a workset and drag it to another position.

To make a new workset, copy an existing workset. Remove any Control panels not needed (Delete), then drag new Control panels from the repository.

**Control-panel repository**

The treeview on the right-hand side contains a list of all available Control panel (ones that can be inserted into worksets). The panels are separated according to user level (User, Expert, Supervisor) and availability depends on the user levels. Click on the '+' sign or double-click the 'user' icon to expand the particular repository. Control panels can be dragged from the repository into any existing workset.

**Control panels**
The following actions are possible on Control panels:
- **Delete a panel** : click with the right-hand mouse button on the Control panel and select Delete from the popup menu, or click and the press the Del(ete) key.
- **Change the sequence of panels** : click on a panel and drag it to another position.
- **Move a panel** to another workset by dragging it from one workset into another (drop it on the folder icon).

**Color**
When the Color icon of a workset is clicked, the right-hand side of the Workspace layout Control panel changes to the following:
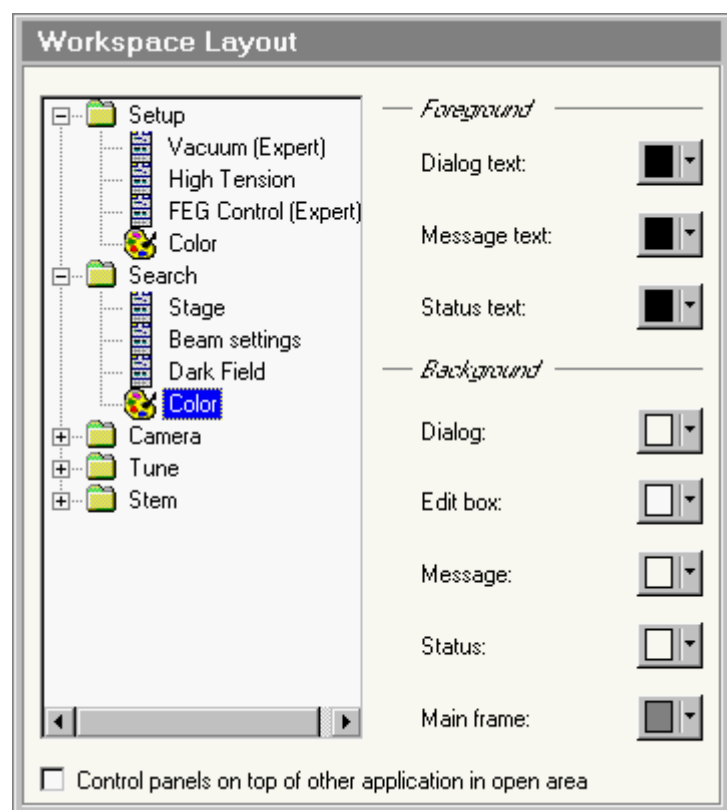


Some of the items listed are standard Windows controls (Dialog, Edit box), other are specific to the TEM User Interface (Message and Status). Note that Control panels fall under Dialog. The down buttons on the controls on the right-hand side give access to a (standard Windows) 16-color palette from which a color can be selected. An example of a (pretty awful) selection that differs from the default is:
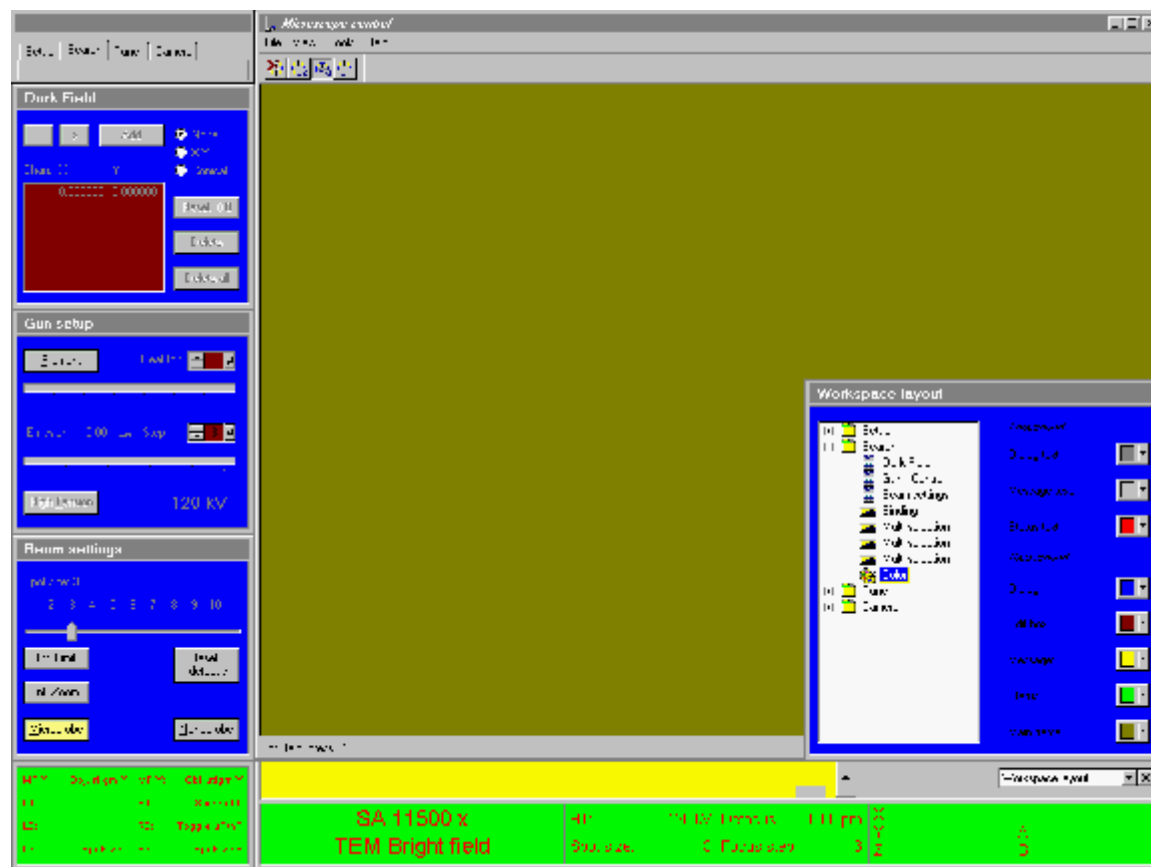
In order to achieve some of these color adjustments the workset temporarily changes the default Windows color selection (if you change the window background - like the olive background in the picture above, other programs will display the same background when the colored workset is active).

Changing colors allows quick adjustment of the amount of light coming from the monitor (without having to fiddle with the monitor controls themselves). It is possible, for example to make a copy of an existing workset and then change the colors in the copy to dark colors for working in dim room lighting while the original could be used for a brighter environment.

**Control panels on top of other application in open area**
In some cases settings in control panel flap-out must be set but the flap-out disappears behind another application (such as TIA - Tem Imaging & Analysis - or DigitalMicrograph). In that case checking Control panels on top of other application in open area will keep the control panel flap-out over the other application. Be aware that this can lead to some bizarre-looking effects due to the limitations of Windows (in positioning windows) and the fact that the on-top effect is applied only to control panels with flap-out. It can also be difficult to get back to the user interface as a whole (to get back, minimize other applications until the whole user interface is displayed). Use the feature when necessary but be aware of its effects.
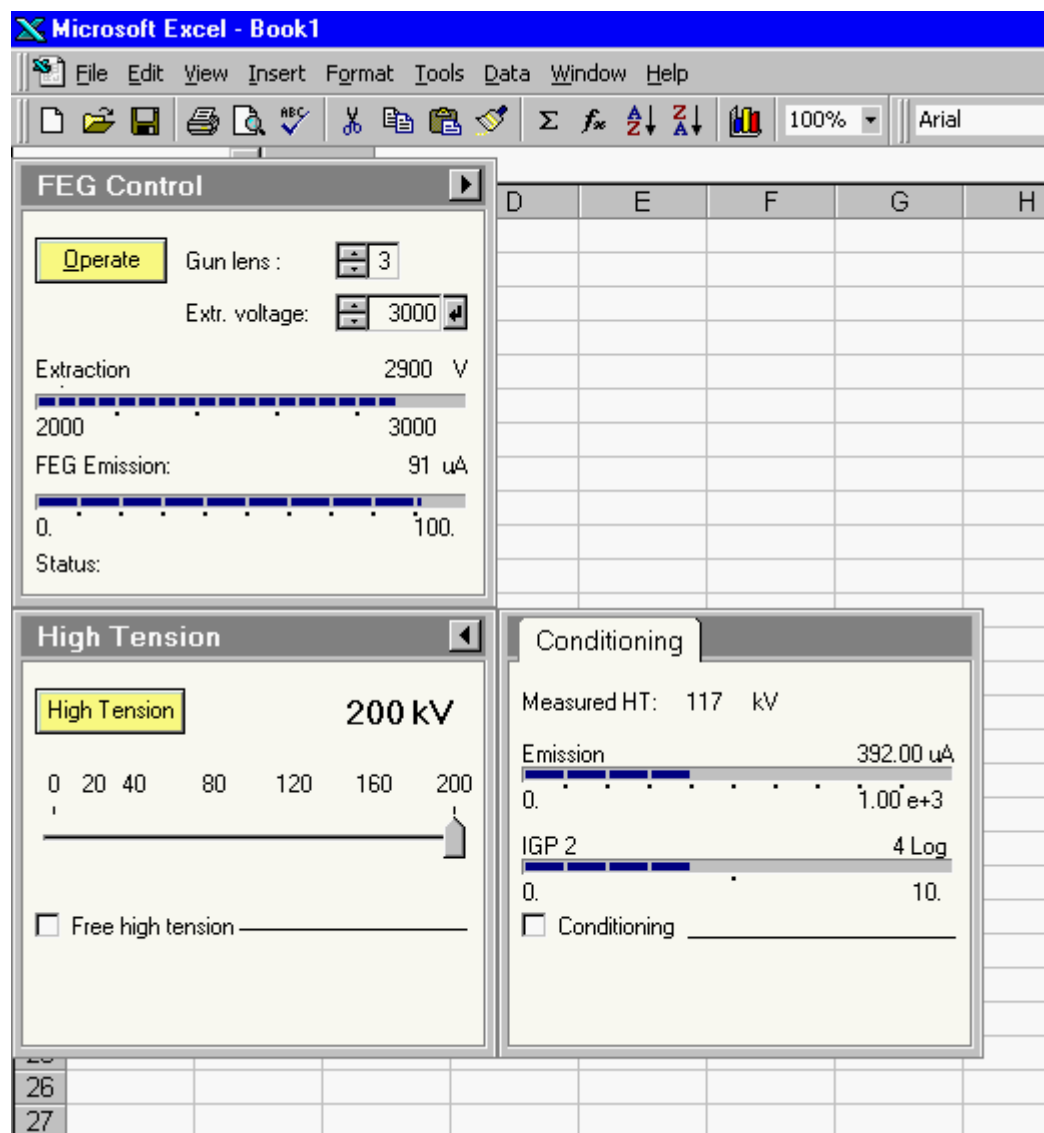
Strange effects can occur when 'on-top' is enabled. Here two TEM control panels float over Microsoft Excel seemingly disconnected from the rest of the TEM User Interface.

# 45 Control Pads

## 45.1 Left-hand Control Pad

The left-hand Control Pad (called that way because it will normally be to the left of the microscope column) contains a trackball, a number of buttons and turn (rotary) knobs, and two tilt switch controls. The functions of some of these controls can be reprogrammed by software. In the overview below the 'standard' functionality is therefore indicated.

The control pads have background lighting available to make it easier to locate the controls when working in the dark.



| Control | Default function |
|---|---|
| Exposure | Executes (or interrupts) a TEM exposure |
| Stigmator | Makes stigmator active or inactive |
| $\alpha$ tilt | Changes $\alpha$ tilt of stage up or down |
| $\beta$ tilt | Changes $\beta$ tilt (only for double-tilt holders) up or down |
| Trackball | Beam shift |
| Multifunction +/- | Changes step size of Multifunction knobs |
| Multifunction X | Variable |
| Intensity Fine/Coarse | Switches Intensity between Fine-Medium-Coarse |
| Intensity | Changes Intensity setting |
| User button L1 | None |
| User button L2 | None |
| User button L3 | Spot size - (to a larger spot size) |

**Exposure button**
The Exposure button starts a TEM exposure on the plate camera. If the viewing screen is down, it will automatically be lifted. The exposure conditions used are those selected previously.
If the Exposure button is pressed again while an exposure is taking place, the exposure is broken off and, if necessary, the plate inserted is removed.

**Stigmator button**
The Stigmator button activates/deactivates the stigmator functionality of the microscope (access to the setting of the default stigmator under the multifunction knobs). The default stigmator is assigned automatically to the stigmator that is used most often in the current microscope mode (objective

stigmator in TEM HM imaging and LAD; diffraction stigmator in HM diffraction and LM imaging, condenser stigmator for nanoprobe and STEM). To switch to a different stigmator, press the corresponding button in the stigmator control panel.

### α Tilt Switch

The $\alpha$ tilt switch controls the $\alpha$ tilt of the CompuStage (the axis along the specimen-holder rod that is the eucentric tilt). The tilt switch is pressure sensitive. The $\alpha$ tilt will tilt faster when the switch is pressed harder.

### β Tilt Switch

The $\beta$ tilt controls the $\beta$ tilt of the CompuStage (the axis perpendicular to the specimen-holder rod that is not eucentric) when a double-tilt holder is used. The tilt switch is pressure sensitive. The $\beta$ tilt will tilt faster when the switch is pressed harder.

### Trackball Left-hand Pad

The left-hand trackball controls the shift of the electron beam. The beam shift operates such that moving the trackball to the right moves the beam as seen on the screen to the right. The speed at which the beam moves is dependent on the magnification and further controlled with the left-hand (speed down) and right-hand (speed up) buttons of the trackball.

### Multifunction knobs

The Multifunction knobs have a wide range of functions. All functions (wobbler, stigmators, dark field, alignment, etc.) that assign functionality to the multifunction knobs also release that functionality when the particular function is switched off again (after which the multifunction knobs regain their previous functionality). The functions are typically assigned whenever needed (e.g. during alignment). The user can also assign functions to the knobs (these functions will be overruled when necessary). There are two possibilities:

- The assignment is persistent (these functions will be overruled when necessary but the function is always returned when automatic assignments are taken off).
- The assignment is temporary (these functions will also be overruled when necessary and the function is not returned when automatic assignments are taken off).

A persistent assignment can only be made when the Multifunction knobs are not currently occupied by an automatic assignment, otherwise the assignment is temporary.

### Examples

- The Multifunction knobs are currently assigned to the Stage axes (a user assignment). The user clicks with the right-hand mouse on the Binding display panel and chooses another function. This assignment is persistent.
- The Multifunction knobs are currently assigned to the Wobbler (after the Wobbler button has been pressed). The user clicks with the right-hand mouse button on the Binding display panel and chooses another function. This assignment is temporary (comes on top of the automatic Wobbler assignment) and will disappear when the Wobbler is switched off.

### The None and Clear functions

The popup menu that allows setting of the binding configuration for the Multifunction knobs can have two functions, None and Clear. None is always enabled, Clear only when the current assignment of the Multifunction knobs is temporary. If None is selected, all functions of the Multifunction knobs are removed, independent of the nature of the current assignment (persistent, temporary or automatic). If Clear is selected (thus only possible if the assignment is temporary), the Multifunction knobs revert to their prior automatic setting. Thus if you assigned the Beam shift function to the Multifunction knobs in an alignment procedure and then select None, the Multifunction knobs are completely cleared of all

functions. Whereas if you used clear, the Multifunction knobs get back their setting from the alignment procedure.

**Intensity**
The Intensity button controls the intensity on the screen (through focusing or defocusing of the electron beam). The intensity step size is controlled by the fine and coarse buttons directly to the left of the knob (there are three settings: Fine - the Fine LED will be illuminated; Medium - no LED is illuminated; and Coarse - the Coarse LED is illuminated).
Turning Intensity clock-wise is going towards overfocus with the C2 lens.

**User buttons Left-hand Pad**
The user buttons can be used to program in specific functionality, either by assigning it by right-clicking in the binding display panel and selecting a function or by connecting the user-button input to user programs.

## 45.2 Right-hand Control Pad

The right-hand Control Pad (called that way because it will normally be to the right of the microscope column) contains a joystick, and a number of buttons and turn (rotary) knobs. The functions of some of these controls can be reprogrammed by software. In the overview below the 'standard' functionality is therefore indicated.



| Control | Default function |
|---|---|
| User button R1 | Screen lift |
| User button R2 | Switch microprobe <-> Nanoprobe |
| User button R3 | Spot size + (to a smaller spot size) |
| Joystick | Stage X,Y |
| Z-axis | Changes Z position of stage up or down |
| Eucentric focus | Sets objective lens focus for eucentric height / Diffraction focus |
| Wobbler | Switches (beam-tilt focusing) wobbler on or off |
| Diffraction | Switches between Image and Diffraction |
| Dark Field | Switches between Dark Field and Bright Field |
| Focus step | Changes the step size of the Focus control |
| Focus | Changes the focus |
| Magnification | Changes magnification or camera length up or down |
| Multifunction Y | Variable |

**User buttons Right-hand Pad**
The user buttons can be used to program in specific functionality, either by assigning it by right-clicking in the binding display panel and selecting a function or by connecting the user-button input to user programs.

**Joystick Right-hand Pad**
The right-hand joystick in its default setting controls the X-Y movement of the CompuStage. The functionality is such that moving the joystick to right moves the stage (as seen on the viewing screen) to the right, etc. The axes of the CompuStage usually coincide with the principal directions of the viewing screen (N-S, E-W), somewhat dependent on the nature of the magnification series (some magnifications may not be achievable without rotation relative to the majority of the magnifications). The joystick buttons (top left and top right of the joystick itself) have the following meaning when the joystick is assigned to the CompuStage movement :
- Left-hand button : CompuStage speed value adjusted one step down.
- Right-hand button : CompuStage speed value adjusted one step up.

**Note:** At the lowermost speed setting the CompuStage will also step by its smallest step, independent of the magnification. At low magnifications these steps may be so small as to be unnoticeable.

**Z-axis control**
The Z-axis control is a double switch that controls the height of the CompuStage (Z axis). It is used to change the specimen height to make the point of interest coincide with the eucentric height.

**Eucentric focus**
The Eucentric focus button sets the objective-lens current to the (pre-aligned) value for focus at the eucentric height and normalizes the objective lens. Different microscope modes, like microprobe and nanoprobe, have their own independent settings.

**Note:** the eucentric focus only sets the objective lens for the eucentric height, not the specimen itself (if the specimen is off the eucentric height, it will then appear out of focus).

The eucentric focus can be used to bring the specimen to the eucentric height easily. Press the eucentric focus to set the objective lens. Switch on the wobbler and focus the specimen by moving the Z height up or down (the wobbler makes it easy to see if the specimen Z height moves in the right direction - the distance between the two wobbler images will become smaller).

**Wobbler**
The Wobbler button switches the (beam-tilt) wobbler focusing aid on and off. When the wobbler is on, the LED of the Wobbler button is lit. When the wobbler is on, its (beam-tilt) amplitude can be changed with the Multifunction-X knob, while the Multifunction-Y knob can be used to rotate the direction of the wobbler tilt.

**Diffraction button**
The Diffraction button switches between image and diffraction modes. When the microscope is in diffraction, the LED of the diffraction button is lit.

**Dark-field button**
The Dark-field button toggles between dark field and bright field. When dark field is active, the LED of the button is lit.

**Focus**
The Focus knob is a double control, with Focus and Focus Step integrated. The focusing function is performed by turning the inner, top-most knob. The step size used for focusing depends on the current focus step which is set by the Focus Step control, the outer, lower-lying ring around the Focus knob itself.

**Magnification**
The magnification knob turns the magnification (imaging) or camera length (diffraction) on the microscope up (when turned clock-wise) or down.

**Multifunction knobs**
The Multifunction knobs have a wide range of functions. All functions (wobbler, stigmators, dark field, alignment, etc.) that assign functionality to the multifunction knobs also release that functionality when the particular function is switched off again (after which the multifunction knobs regain their previous functionality). The functions are typically assigned whenever needed (e.g. during alignment). The user can also assign functions to the knobs (these functions will be overruled when necessary). There are two possibilities:
- The assignment is persistent (these functions will be overruled when necessary but the function is always returned when automatic assignments are taken off).
- The assignment is temporary (these functions will also be overruled when necessary and the function is not returned when automatic assignments are taken off).
A persistent assignment can only be made when the Multifunction knobs are not currently occupied by an automatic assignment, otherwise the assignment is temporary.

**Examples**
The Multifunction knobs are currently assigned to the Stage axes (a user assignment). The user clicks with the right-hand mouse on the Binding display panel and chooses another function. This assignment is persistent.
The Multifunction knobs are currently assigned to the Wobbler (after the Wobbler button has been pressed). The user clicks with the right-hand mouse button on the Binding display panel and chooses another function. This assignment is temporary (comes on top of the automatic Wobbler assignment) and will disappear when the Wobbler is switched off.

**The None and Clear functions**
The popup menu that allows setting of the binding configuration for the Multifunction knobs can have two functions, None and Clear. None is always enabled, Clear only when the current assignment of the Multifunction knobs is temporary. If None is selected, all functions of the Multifunction knobs are removed, independent of the nature of the current assignment (persistent, temporary or automatic). If Clear is selected (thus only possible if the assignment is temporary), the Multifunction knobs revert to their prior automatic setting. Thus if you assigned the Beam shift function to the Multifunction knobs in an alignment procedure and then select None, the Multifunction knobs are completely cleared of all functions. Whereas if you used clear, the Multifunction knobs get back their setting from the alignment procedure.