LYNXEYE XE

High-Resolution Energy-Dispersive Detector for 0D, 1D, and 2D Diffraction

The LYNXEYE XE is the first energy dispersive 0D, 1D, and 2D detector operating at room temperature for ultra fast X-ray diffraction measurements.

Developed on the base of the „compound silicon strip" detector technology, the LYNXEYE XE is particularly optimized to meet the increasing demands in X-ray diffraction in terms of highest count rate capabilities, best angular resolution (FWHM), and best energy resolution.
The unique combination of sensor chip and front-end electronics as realized in the LYNXEYE XE makes it the highest performing detector on the market in terms of both data quality and manufacturing quality, as manifested by

- high-speed data acquisition up to 450 times faster than a conventional point detector system
- superb energy resolution making Kß filters and secondary monochromators redundant
- operation with all common characteristic X-ray emission lines (Cr, Co, Cu, Mo, and Ag radiation)
- enabling outstanding angular resolution (FWHM) and perfect line profile shapes
- outstanding peak-to-background ratio for highest sensitivity and data quality
- no defective strips at delivery time - guaranteed

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Specimen fluorescense? You don't need a secondary monochromator!

Secondary monochromators are intensity killers. A typical secondary monochromator causes intensity losses ranging from more than 70% for point detectors and up to more than 90% for one-dimensional detectors, compared to unfiltered radiation. At such losses, a one-dimensional detector loses all its advantages and operates at intensity levels close to traditional point detectors. Counting statistics are poor, resulting in noisy patterns and thus very poor lower limits of detection.

The new LYNXEYE XE overcomes these issues thanks to its excellent filtering of fluorescense and Kß radiation. This is demonstrated in Figures 1-3 for a natural hematite specimen (Fe-fluorescense with Cu-radiation) by comparing data acquired with the LYNXEYE XE and a scintillation counter with secondary monochromator. The same instrument and specimen with identical instrument and measurement parameters have been used.

Figure 1 demonstrates the superb filtering of Kß and fluorescense radiation, at a loss of only 25% of peak intensity, compared to unfiltered radiation. The secondary monochromator data are even not visible at the linear scale of this figure due to the dramatic intensity difference. Figure 2 shows a zoomed region from Figure 1 in square-root scale to also show the secondary monochromator data for the most intense peaks. The enormous advantage of the LYNXEYE XE in terms of counting statistics and thus lower limits of detection is demonstrated in Figure 3. A second phase, calcite, is easily detected using the LYNXEYE XE, but is far below the detection limit in the secondary monochromator data.

The LYNXEYE XE offers lower limits of detection which are greatly improved compared to any other detector currently in use.

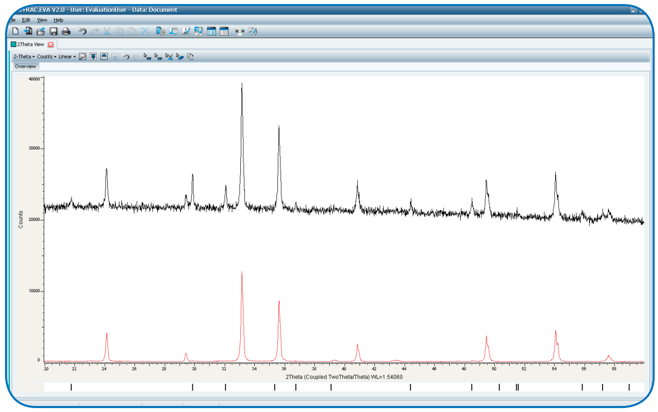

Figure 1: Unfiltered (black line) and filtered (red line) demonstrating the superb filtering of Kß and fluorescense radiation by the LYNXEYE XE. The black stick pattern underneath indicates Kß peak positions. The secondary monochromator data are not visible at that intensity scale.

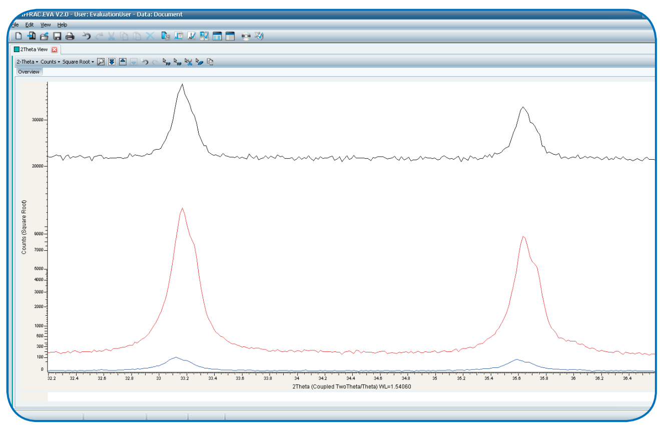

Figure 2: Zoomed region from Figure 1 (32.3° - 36.6° 2θ, square-root scale) to also show the secondary monochromator data (blue line) for the most intense peaks.

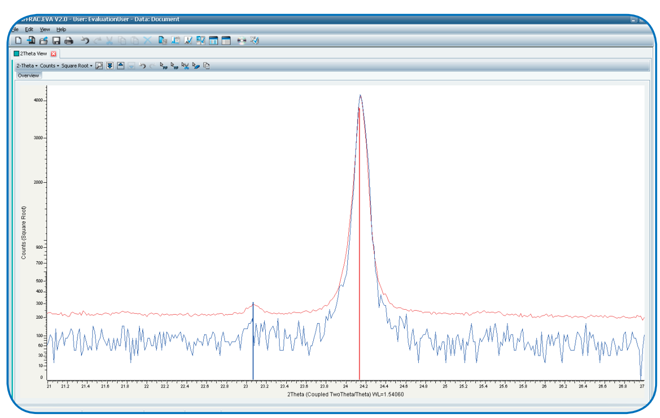

Figure 3: Zoomed region from Fig. 1 (21° - 27° 2θ, square-root scale) illustrating the unparalleled lower limits of detection capabilities of the LYNXEYE XE. Secondary monochromator data (blue line) scaled to the same maximum peak intensity as the LYNXEYE XE data (red line). Calcite (blue stick) is clearly below the detection limit for the secondary monochromator data.

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No more Kß filter artefacts in your data!

There is almost no greater nuisance in diffraction data than artefacts introduced by the Kß filter, specifically absorption edges at the high energy tails of Kα diffraction peaks. Despite that Kß-filters are the most frequently used devices for monochromatization, as secondary monochromators do not represent a true alternative due to the very high intensity losses discussed earlier. As a consequence, absorption edges frequently prevent accurate profile fitting specifically of peak tail regions and the background, and thus often represent a major part of the remaining misfit to the data, specifically for high intense peaks at low angles 2θ.

With the LYNXEYE XE this is no longer the case. This is demonstrated in Figures 4 and 5 for the same two datasets of corundum, NIST SRM 1976a, using Mo radiation. The first dataset (black line) has been acquired with a standard 0.02 mm Zr Kß filter, and exhibits significant absorption edges, accompanied by remnant Kß peaks. Also seen are two corundum peaks sitting right on top of absorption edges, with their intensities being falsified by the edges. The second data set (red curve) has been acquired by taking advantage of the excellent Kß filtering capabilities of the LYNXEYE XE. The data is completely free of absorption edges, furthermore Kß is filtered below the detection limit. In addition the total background is significantly reduced due to improved filtering of white radiation (Bremsstrahlung), resulting in improved peak to background ratios.

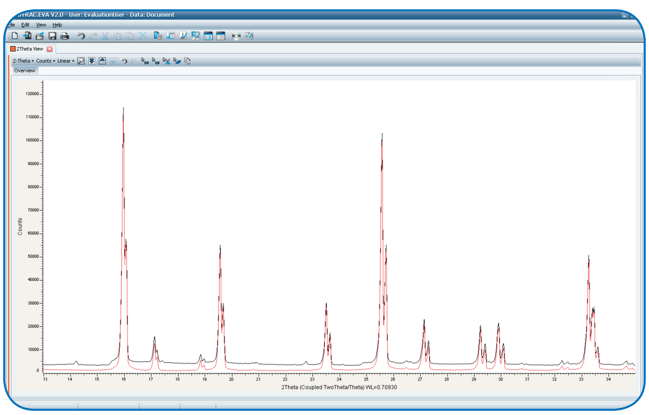

Figure 4: Comparison of corundum data (NIST SRM 1976a) obtained with the LYNXEYE XE detector with a) Zr-Filter (black line) and b) using the LYNXEYE XE filtering capabilities (red line). The improved filtering of white radiation is obvious.

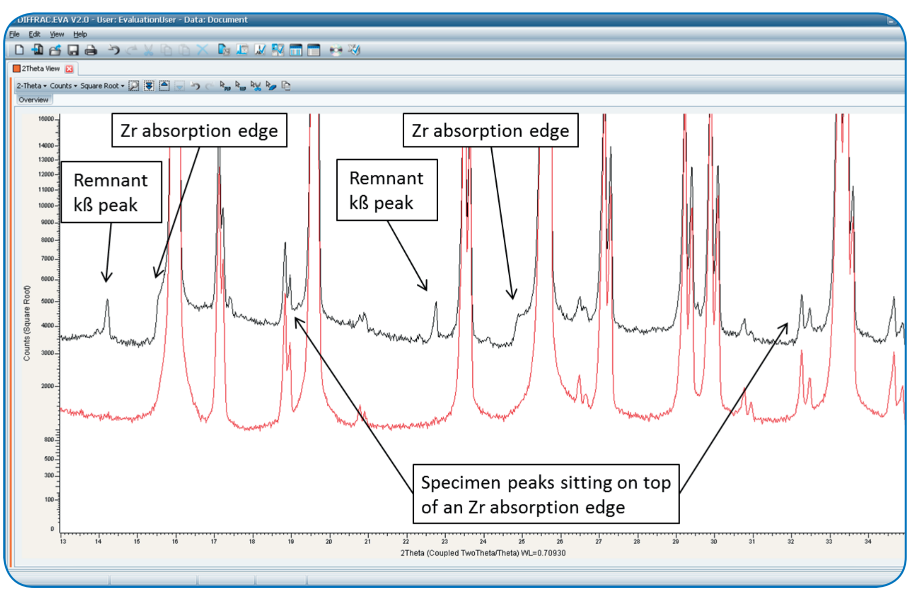

Figure 5: Zoomed region from Figure 4 (square root scale) illustrating remnant Kß peaks, sharp absorption edges and a non-continuous background for the Zr-filtered data (black line). Note the two distorted peaks sitting right on-top of absorption edges at ~18.8° 2θ and ~39.3° 2θ (arrows). The LYNXEYE XE filtered data (red line) are free of issues.

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Highest durability

The LYNXEYE XE detector is radiation-hard by design. Unlike for traditional detectors, specifically pixel detectors, the detector electronics of the LYNXEYE XE is spaced apart from the sensor and protected against radiation damage.

As a consequence, the detector can be equally operated with all common characteristic X-ray emission lines, including, but not limited to Cr, Co, Cu, Mo, and Ag radiation. Detector degradation due to radiation damage is thus of no concern also for higher energies, specifically for Mo and Ag radiation.

As another consequence, the detector's radiation hardness also allows two-dimensional data acquisition using Mo and Ag radiation - without damaging the detector.

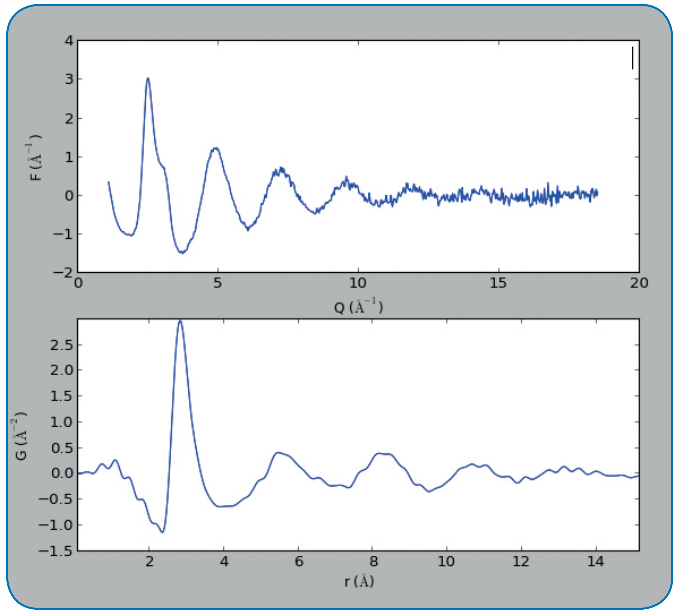

Figure 6: PDF data of Ga-In liquid metal alloy, measured in reflection mode with Ag radiation and LYNXEYE XE, 1 hour measurement time. PDFgetX3 was used for data correction and display.

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Highest efficiency

Detector efficiency invariably depends on sensor thickness, as per Beer's law, and thus is lower for higher energy radiation. Most strip and pixel detectors only feature 300 µm sensors, which is perfectly sufficient for Cr, Co and Cu radiation, featuring almost 100% efficiency. For Mo and Ag radiation, efficiency is increasingly low, resulting in up to ~80% intensity loss for Ag radiation.

For applications benefitting from higher energy radiation, such as structure determination, retained austenite analysis, or PDF analysis, the LYNXEYE XE is also available with a 500 µm sensor. The increased sensitivity of this sensor results in an intensity gain of about 50% for both Mo and Ag radiation. In combination with a multilayer mirror, measurement times may be reduced by an order of magnitude when using Mo or Ag radiation. E.g. measurements for PDF analysis can be reduced from several days down to several hours.

Efficieny of silicon strip and pixel detectors:

Sensor thickness:	Cr	Co	Cu	Mo	Ag
300 micron	>99%	>99%	>98%	~35%	~20%
500 micron	>99%	>99%	>99%	~50%	~30%

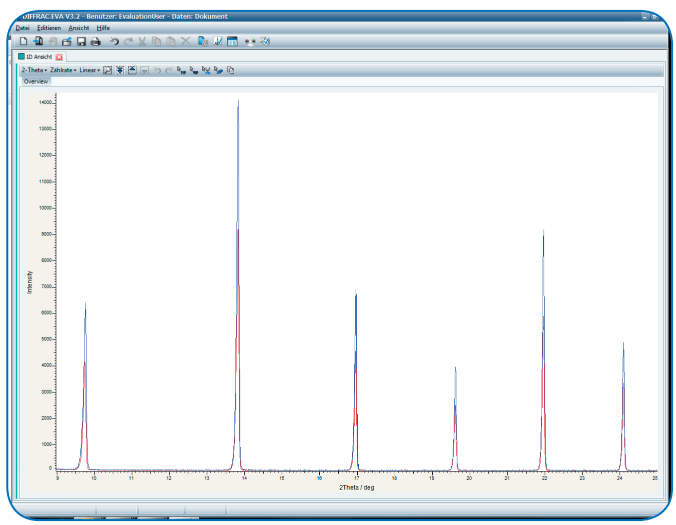

Figure 8: LaB_6 data collected with Mo radiation and LYNXEYE XE. About 50% higher intensity is collected with the 500 µm detector sensor (blue) compared to 300 µm detector sensor (red).

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Lowest background

Data acquisition at low angles smaller than ~20° 2θ requires some sophisticated beam conditioning to minimize instrument background (mostly air scatter), which otherwise is the most prominent contribution to the data. This is of particular concern at very low angles smaller than ~5° 2θ, the small angle X-ray scattering (SAXS) domain, where background suppression is of highest importance.

The unique Variable Active Detector Window™ feature of the LYNXEYE XE allows to most successfully suppress low angle background scattering. This is achieved by the fully automatic, software-controlled change of the active detector window size as a function of 2θ: At 0° 2θ, the active detector window is closed, and gradually opens as the detector moves to higher angles 2θ, without any user-intervention. As a consequence, the use of beamstops becomes obsolete, and high quality data with virtually no instrument background can be collected starting at angles as low as 0.15° 2θ.

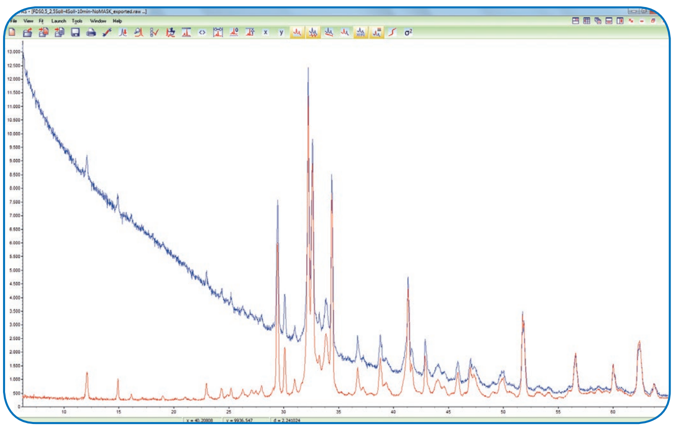

Figure 7: NIST SRM 8486 (Ordinary Portland Clinker) without (blue scan) and with MotorizedAnti-Scatter Screen (red scan). All other measurement conditions left identical.

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Quality by Design

The LYNXEYE XE detector is a paradigm changer in all X-ray powder diffraction application areas. It is not only unique in terms of functionality and versatility, but also in terms of manufacturing quality.

Quality by design - In contrast to traditional one- and two-dimensional strip and pixel detectors, the LYNXEYE XE detector is guaranteed to be free of defective strips or even dead areas at delivery time. This unique guarantee, together with a factory-made calibration, makes it particularly suited for one- and two dimensional fixed mode measurements. Reliable and complete data sets are obtained with the LYNXEYE XE, without any missing data points and thus any need for data interpolation.

- No defective strips at delivery time
  - Covered by instrument warranty
- Data acquisition without missing or interpolated data points
- Highly uniform active area, highest data quality

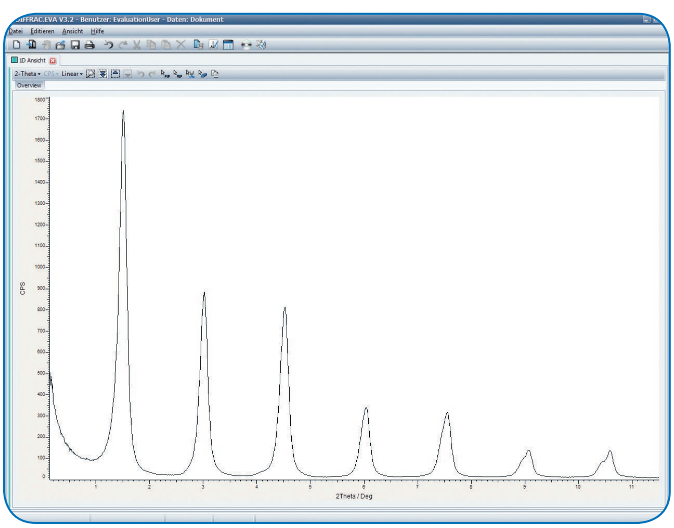

Figure 9: Low angle data collected on silver behenate. Thanks to the Motorized Anti-Scatter Screen and the Variable Active Detector Window™ of the LYNXEYE XE the instrument background is extremely low.

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Scanning two-dimensional diffraction

Equipped with Bruker's patented 0°/90° mount, the LYNXEYE XE can be used for 0D and 1D data collection (0° orientation), as well as 2D data collection (90° orientation).

Employing the LYNXEYE XE detector for 2D diffraction applications allows to take advantage of every single detector property also available for 0D- and 1D data collection, resulting in superior data quality not available with any other two-dimensional detector currently on the market:

1. Energy resolution:
Collection of 2D diffraction data at better than 680 eV energy resolution, taking advantage of the same filtering capabilities as for 0D and 1D data collection. Superb filtering of fluorescense and white radiation, best peak to background without the need for filters or monochromators.

2. Operation with all common characteristic X-ray emission lines:
In addition to commonly employed Cr, Co, and Cu radiation, 2D data collection is also explicitely supported for Mo and Ag radiation, thanks to the radiation hardness of the detector. The choice between 300 µm or 500 µm sensor thickness allows to optimize the detector efficiency for the preferred radiation.

3. Highest data quality
The absence of any defective strips or dead areas leads to the most uniform active detector area available on the market. The obtained diffraction data are not affected by any data interpolation as there are no missing data points.

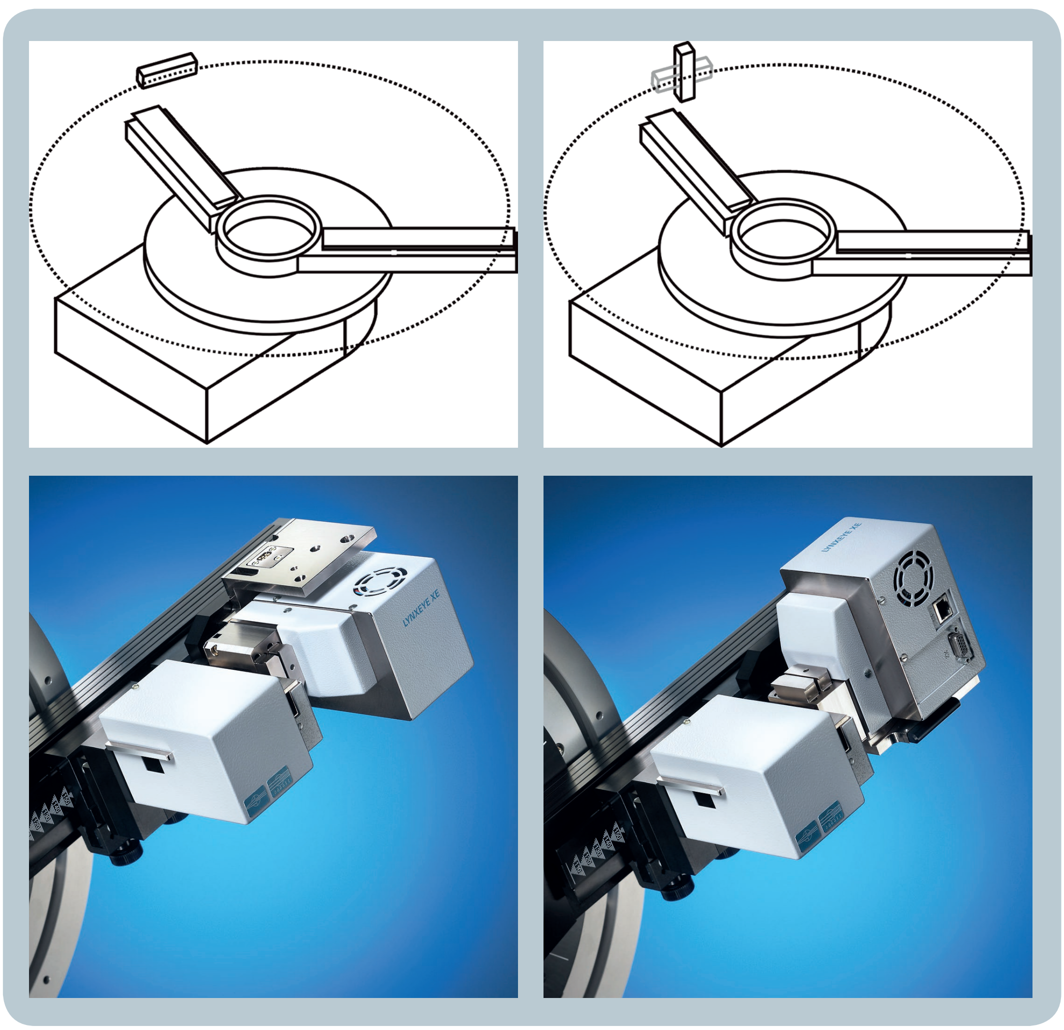

Figure 10: Left - 0° orientation for 0D and 1D data collection
Right - 90° orientation for 2D data collection

4. Versatility:
Variable sample to detector distance to optimize 2θ- and γ-coverage and peak resolution.

5. Software integration:
Full integration into the DIFFRAC.SUITE software package for both 2D data acquisition and evaluation.

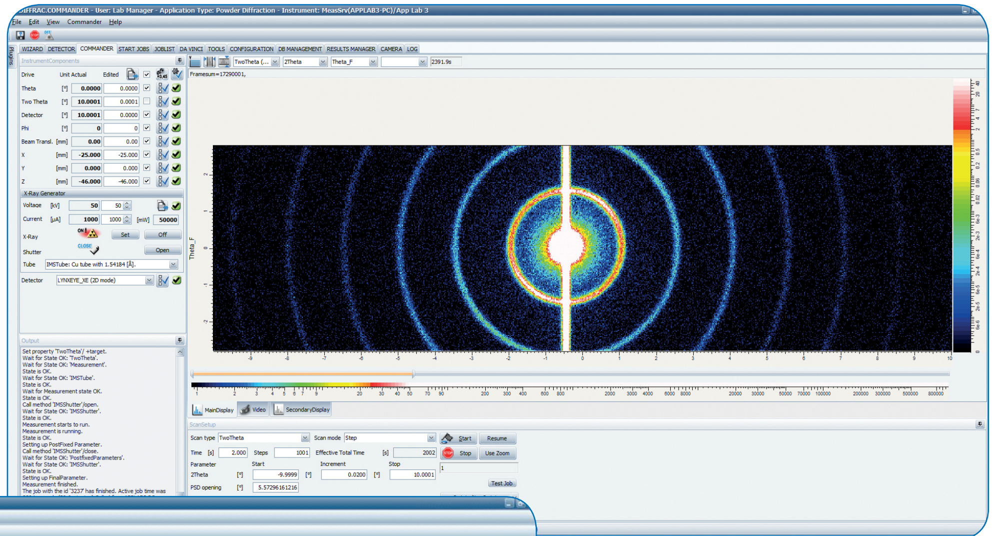

Figure 11: 2D SAXS data collection with DIFFRAC.COMMANDER

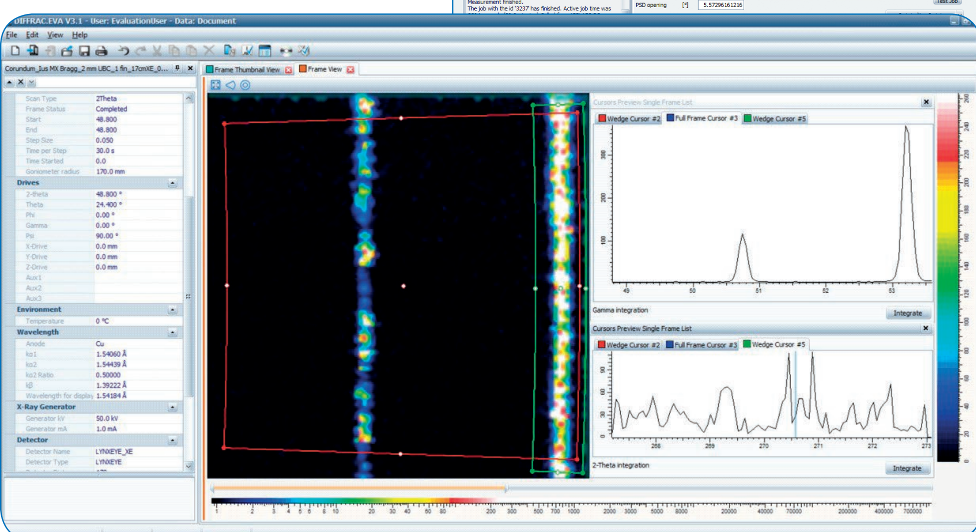

Figure 12: Data integration in DIFFRAC.EVA

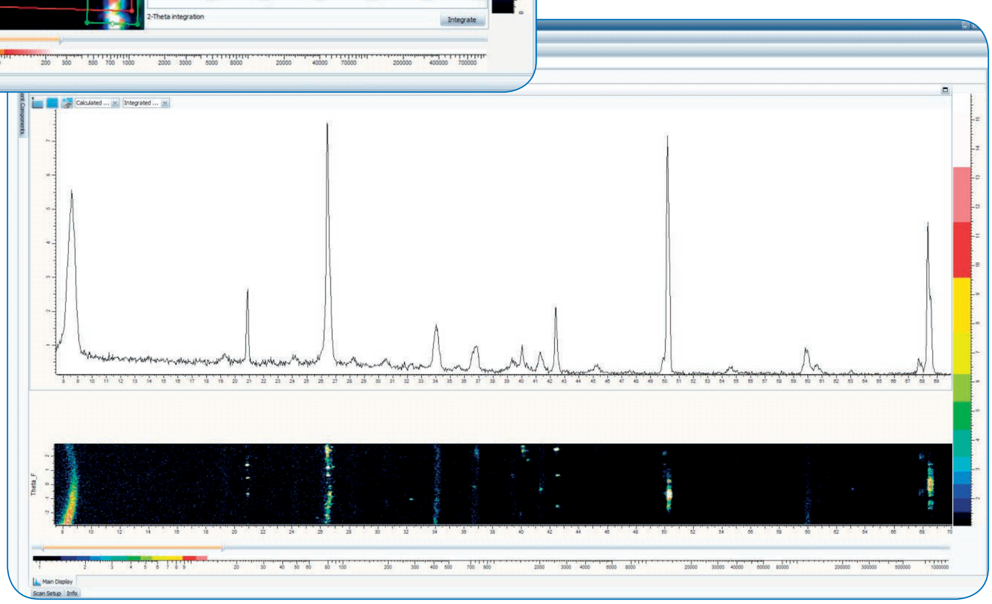

Figure 13: Real-time 2D and integrated 1D data view in DIFFRAC.COMMANDER during measurement

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The highest performance detector in X-ray powder diffraction

Technical data:
„Compound silicon strip“ detector with 192 strips, All strips guaranteed to work at delivery time Up to 15 steps sub-sampling, giving 2880 (15x192) apparent channels
Active window: 14.4 mm x 16 mm
Spatial resolution (pitch): 75 micrometer
Maximum global count rate: >100,000,000 cps
Cr, Co, Cu, Mo, and Ag radiation. Factory settings are optimized for Cu-Kalpha
Sensor thickness: Choice of 300 µm or 500 µm
Radiation-hard front end electronics Two seperate discriminators Proprietary charge-sharing elimination
Energy resolution <680 eV at 8 keV (Cu radiation) at 298K (energy resolution invariably depends on environmental laboratory temperature)
No maintenance
No counting gas, cooling water or liquid nitrogen

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