TINE/ACOP state-of-the-art video controls at Petra III

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Data Acquisition and Transport

☑ Image grabber server in C++, pre-processing (compression)

☑ TINE transport protocol

- ✔ High-Resolution images, user configurable up to 2 megapixels, with IMAGE data type
- ✔ allows network optimizations: multicasting, unicast UDP and TCP
- ✔ easily up to 10 frames per seconds

Image Visualization Component

☑ Java based client solution

- ✔ Platform independence strong requirement
- ✔ Takes care of video analysis, processing and display

☑ AcopVideo component, part of Acop family of Java widgets

- ✔ Displays TINE video channel and still images (TINE format or loaded as JPEG or PNG files)
- ✔ Image visualization and enhancements
  - different color modes for luminosity data
  - histogram equalization
  - aspect ratio changes and zooming
  - additional display of meta information

Image Processing and Analysis

☑ Done by analysis module on client side within AcopVideo component or within central image analysis server.

☑ Strong constrain to be done fast, within image stream frame rate.

☑ Statistical analysis:

- ✔ Simple statistical algorithm for approximation with elliptical shape, produces: mean value and standard deviation of the beam profile, rotational parameter of the beam ellipse. And in addition:
  - Side profile data
  - Analysis of two 1-dimensional side-view projection of beam.
- ✔ AcopVideo visualize (approximated ellipse, crosshair marker) these parameters together with the live image, side projections are plotted at the bottom and side of the image.

☑ Improvements of statistical analysis

- ✔ Region of Interest (ROI) - cuts off irrelevant or noisy surrounding area, improves analysis speed.
- ✔ Threshold value, pixels below are discarded - eliminates low amplitude noise in background (gray background)
  - Value specified by the user or calculated for each frame, user specifies a region where mean pixel value is calculated.
- ✔ Background image subtraction.
  - Eliminates irregular static background artifacts.
  - User can choose pre-stored image from the file system or grab a live image from the TINE channel
- ✔ Smoothing algorithm
  - For extremely noisy images.
  - For each pixel the new value is calculated as the average value of a few points around it.

☑ Best Fit Analysis

- ✔ Statistical methods does not tell when result is bad or inaccurate.
- ✔ Least square curve fitting algorithm on beam image horizontal and vertical side projections fixes this.
  - Gauss function with linear background: $y = A \cdot e^{-\frac{(x-\bar{x})^2}{2\sigma^2}} + k \cdot x + n$, $A, \bar{x}, \sigma, k, n$ are the fitted parameters.
  - Levenberg-Marquardt algorithm used to find numerical solution.
  - Starting value is seeded by results for statistical analysis, subsequent seeds are previous frame results.
- ✔ More reliable results than statistical analysis. When combined with the background image and threshold calculation, the algorithm produces very stable and accurate results.
- ✔ Algorithm is processing power demanding: up to 2 frames per second can be processed, intermediate frames are dropped.
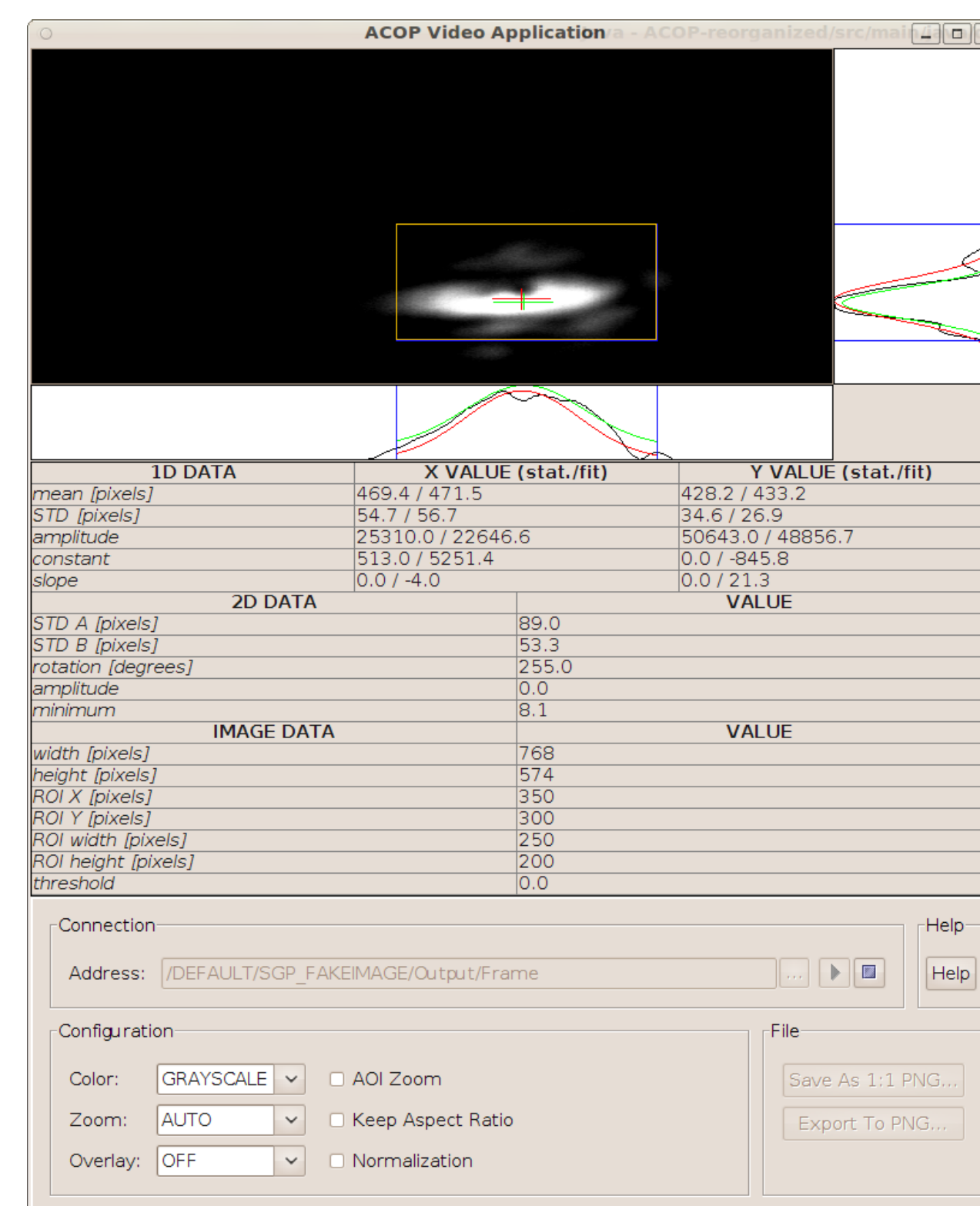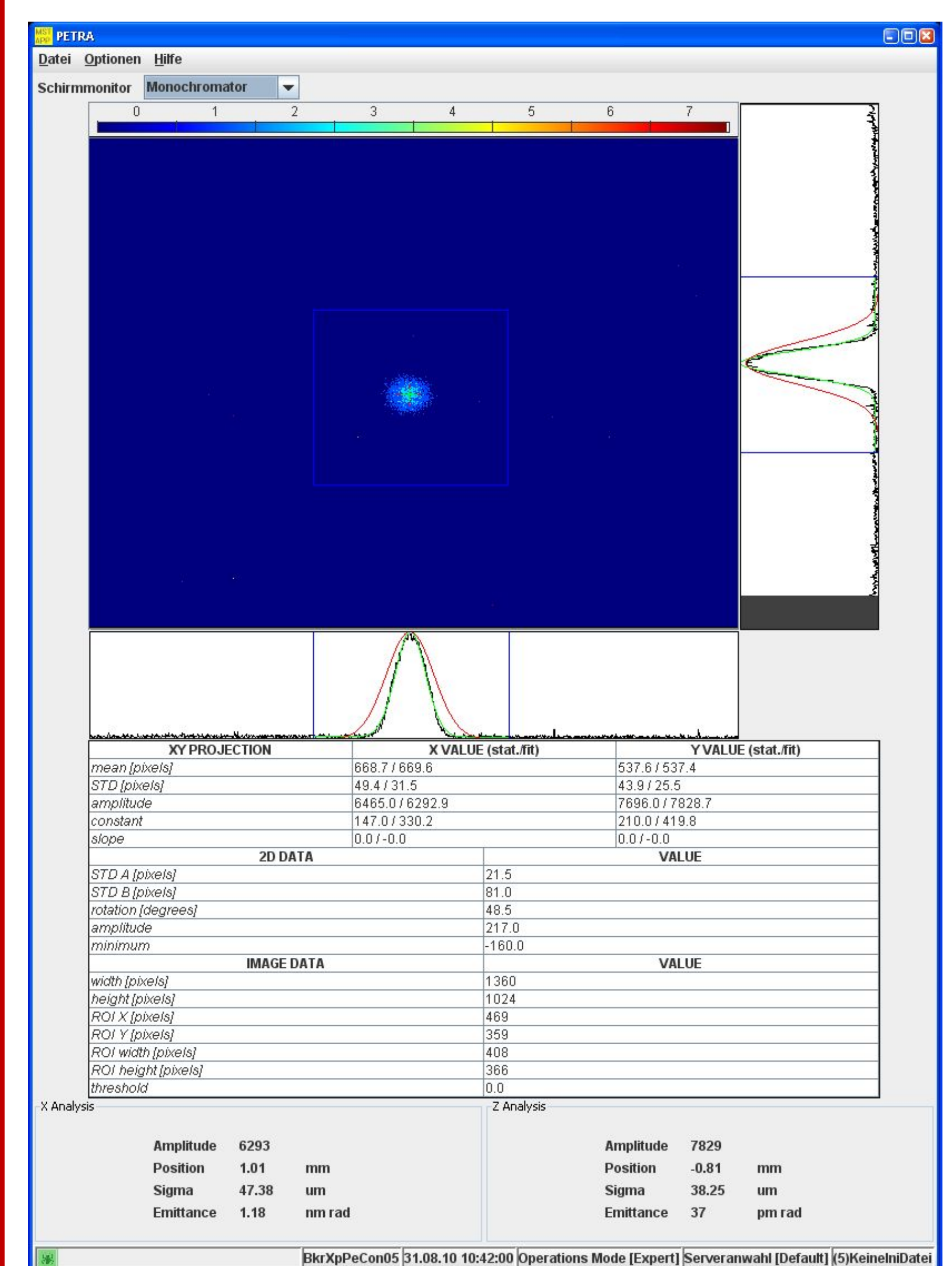

AcopVideo demo application showing test beam
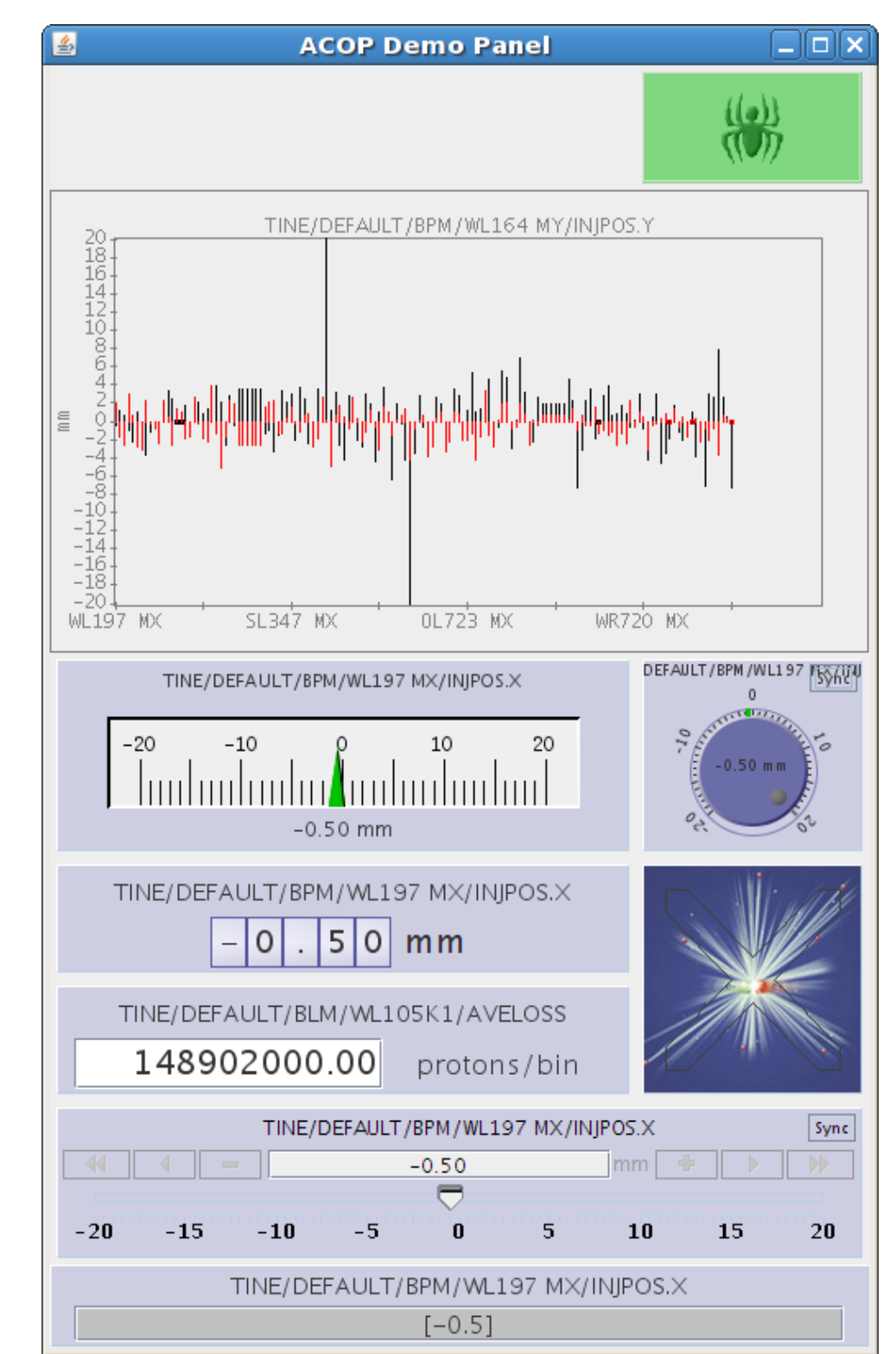
Demo panel with ACOP Java GUI components
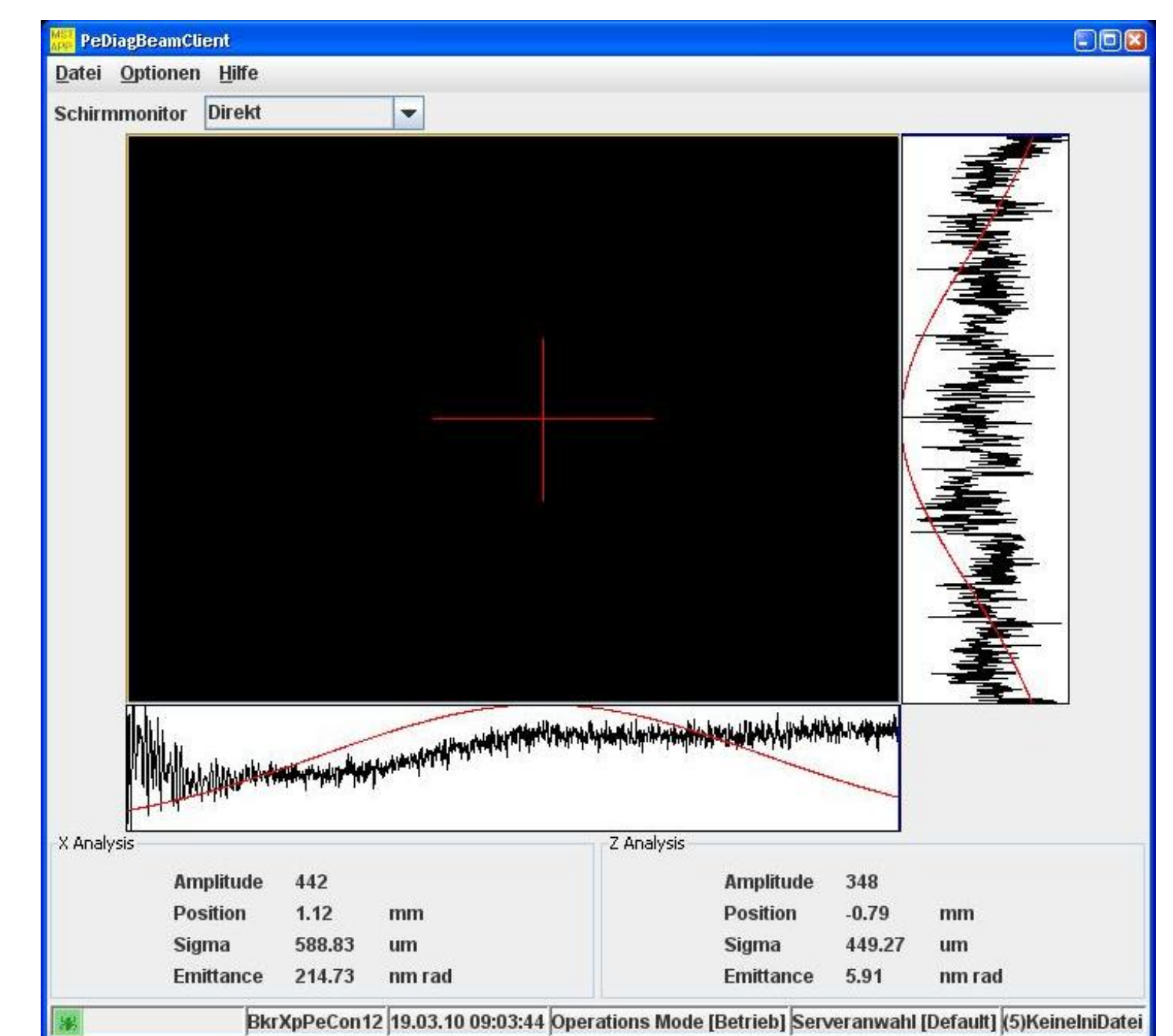
AcopVideo component showing very noisy an irregular but realistic background. If only statistical method is used, then produced result is untrustworthy, like seen in this case. If simple averages are calculated, they tend to be in center of image.

AcopVideo bean displaying a live beam and its profile. A region of interest is chosen around the peak of the beam (blue rectangle). Red curve is the result of statistical analysis; green curve is fitted gauss function. The table is used to show the numerical values of the analysis results.

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