

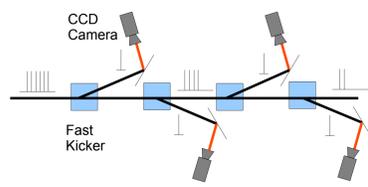
FAST IMAGE ANALYSIS FOR BEAM PROFILE MEASUREMENT AT THE EUROPEAN XFEL

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Abstract

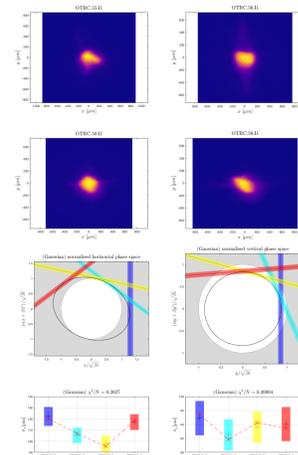
At the European XFEL, images of scintillator screens are processed at a rate of 10 Hz. Dedicated image analysis servers are used for transversal beam profile analysis as well as for longitudinal profile and slice emittance measurement. This contribution describes the setup and the algorithms used for image analysis.



Measurement with Off-Axis Screens

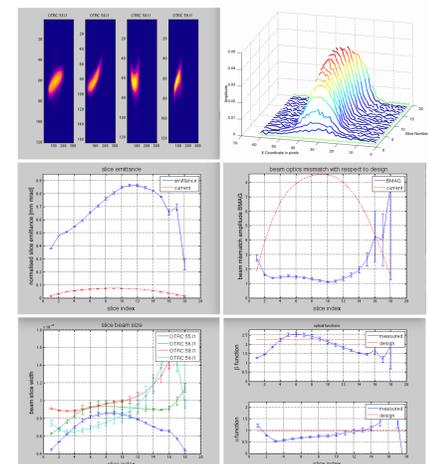
- Bunch trains at 10Hz.
- Single bunches deflected by fast kicker onto off-axis scintillator screens.
- Analysis needs to process several camera images in parallel at 10Hz.

Emittance Measurements



Four-Screen Projected Emittance Measurement

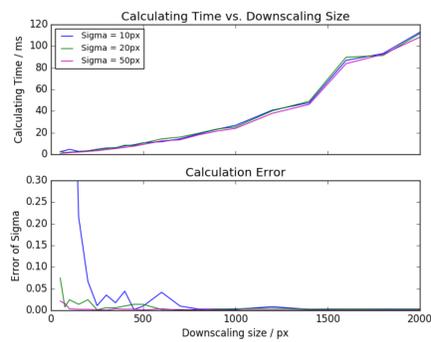
- Gauss Fits and RMS calculations of X and Y projections.
- Statistics over multiple bunches on each screen.



Slice Emittance Measurement

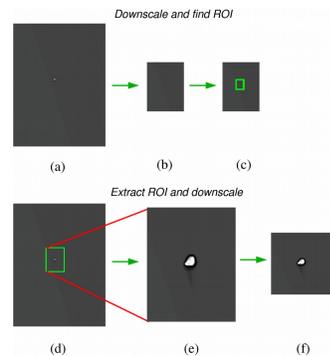
- Beam deflected by TDS.
- Longitudinal profile cut in slices.
- Gauss Fits and RMS calculations of X or Y axis projection of each slice.
- Statistics over multiple bunches on each screen.

Performance Gain vs. Accuracy with Downsizing



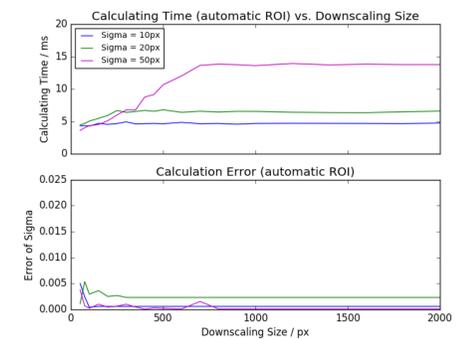
Simple Downsizing

- Downsizing reduces the computing time per analysis effectively.
- However, the accuracy of the results is dependent on the beam size.



Principle of Two-Staged Downsizing

- Original image from the camera, 1750x2330 pixel.
- First downsizing.
- The region of interest (ROI) calculated from downscaled image, based on the calculated beam size (preliminary analysis).
- The ROI is applied to original image.
- The ROI section is extracted.
- The extracted section is downscaled to a given size. The result is used for the analysis.



Two-Staged Downsizing

- The performance gain is comparable to simple downsizing.
- The accuracy is much better and independent of the beam size.

Image Analysis Server

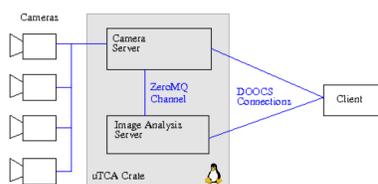
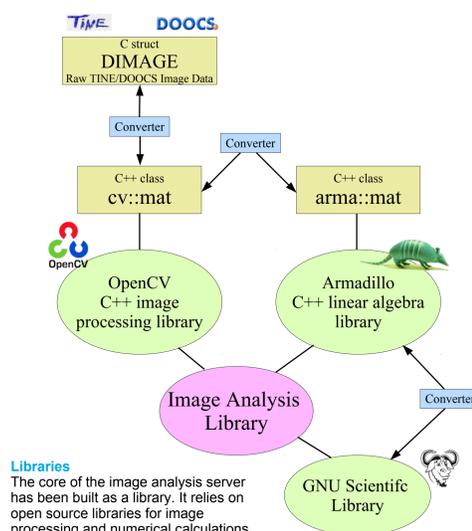


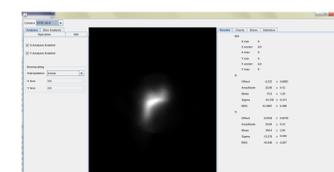
Image Analysis Server

- DOOCS server, written in C++.
- Complements the camera server.
- Runs on a 4-CPU uTCA crate on Linux.
- Images Processed at 10Hz.
- Multiple camera images can be processed in parallel.
- Different types of image analysis:
 - Projection analysis.
 - Slice analysis.
 - Continuous/Single or Sampling/Statistics mode.



Libraries

The core of the image analysis server has been built as a library. It relies on open source libraries for image processing and numerical calculations.



Configuration Tool

- A large set of parameters can be adjusted.
- Effects and results immediately visible.
- Configurations can be stored and recalled.

Conclusion

- The two-staged downsizing method has proved to be highly efficient and produces precise analysis results.
- Beam profile and slice measurements can be performed at 10 Hz with 4 cameras in parallel.
- Image analysis servers are well established at the European XFEL.
- Several thousands of emittance measurements have been made in the commissioning phase.

