



Automating beam alignment at the European XFEL

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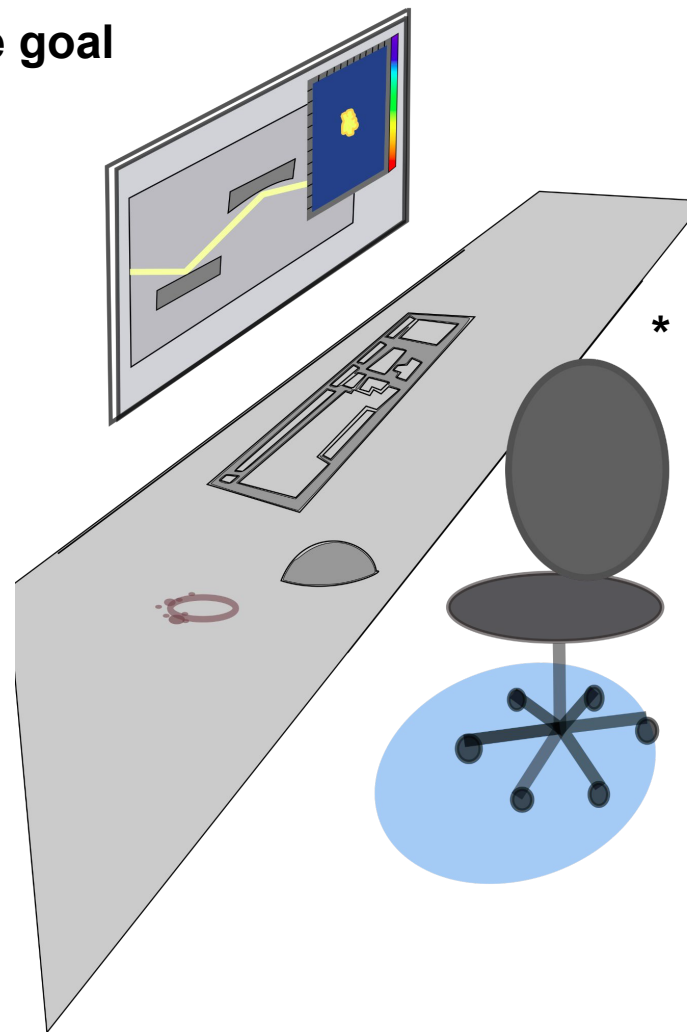
14. Nov 2025

Automation projects: Motivation

How is it now



The goal

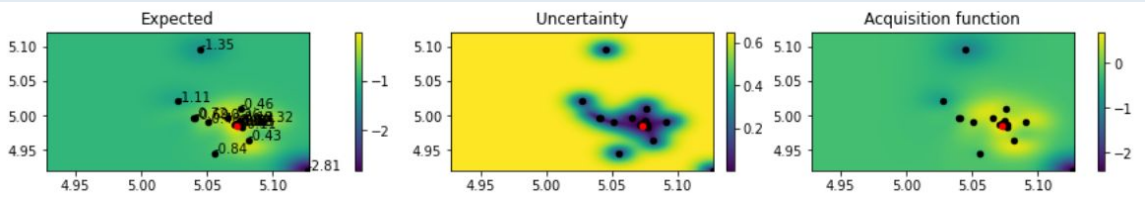


* the guy can be now busy with more interesting stuff

Building blocks

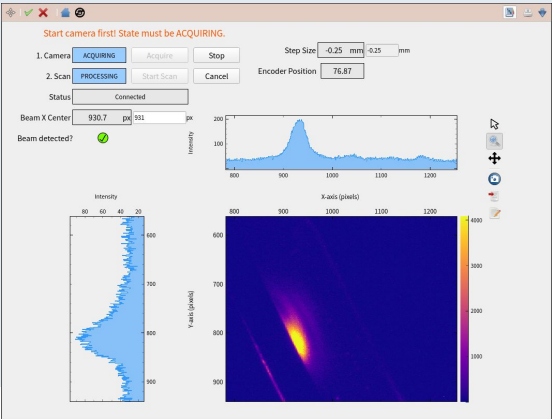
BO

- Bayesian optimization to iteratively find the optimal positions of the motors for alignment setup



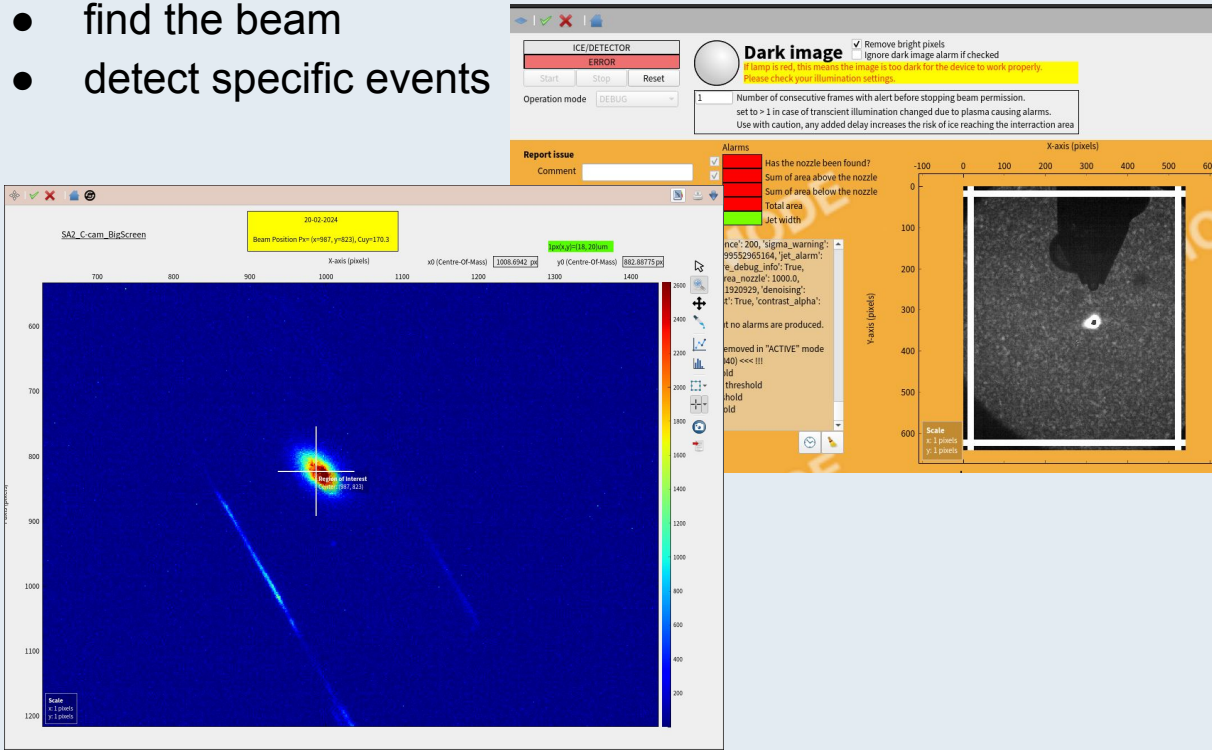
Control system implementation

- Karabo



Computer vision techniques

- find the beam
- detect specific events



Use cases

other

- Preventing detector damage by identifying the occurrence of specific event

alignment

- Optical laser alignment
- X-ray focusing mirrors alignment
- X-ray beam alignment
- HIREX - spectrometer

calibration

- Automated calibration of X-ray spectrometer

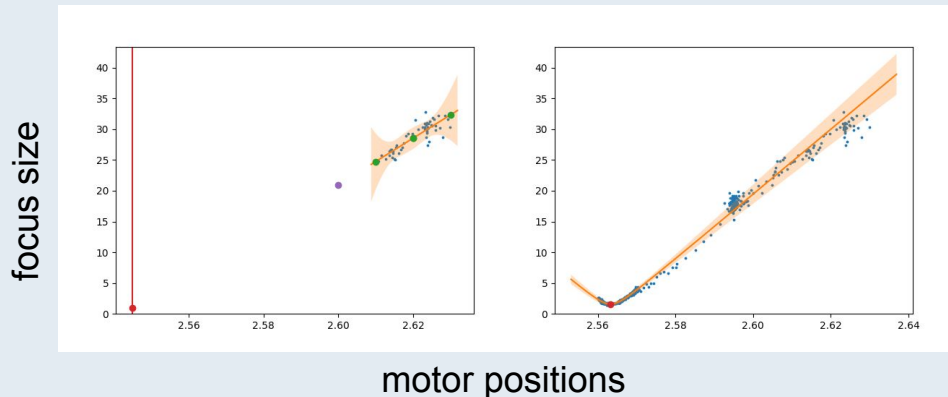
X-ray focusing mirrors alignment & Optical laser alignment

Goal

- optimize the focus size
- integrate into the control system

Method

- the approximation with a hyperbolic curve
- ~ 5 steps per axis for finding focus!
- 2 axes in total



Motivation

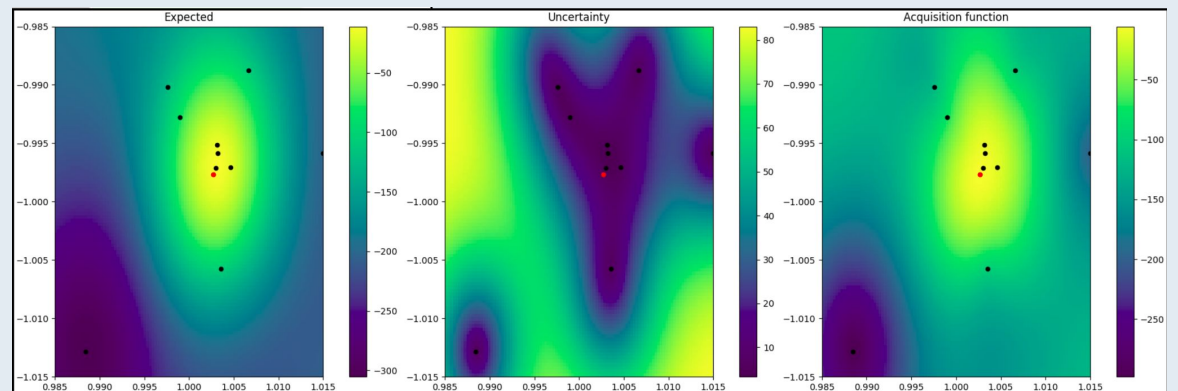
- 10 to 30 min focusing
- 1 per day to 1 per hour

Goal

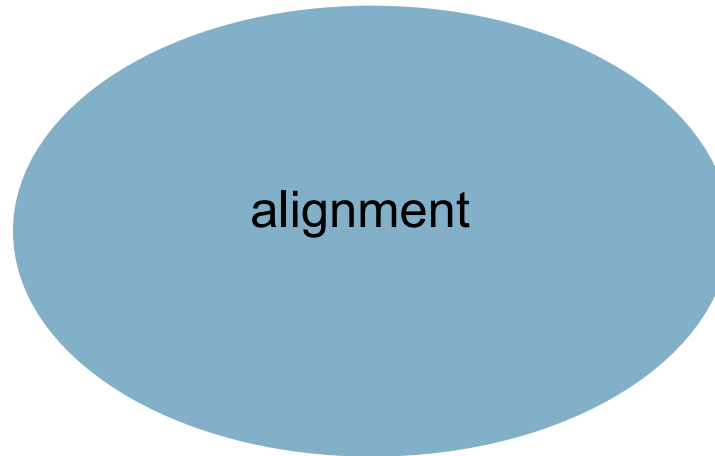
- align the optical laser

Method

- Bayesian optimization to iteratively find the optimal positions of the motors for the laser alignment setup



Use cases



- Optical laser alignment
- X-ray focusing mirrors alignment
- X-ray beam alignment
- HIREX - spectrometer

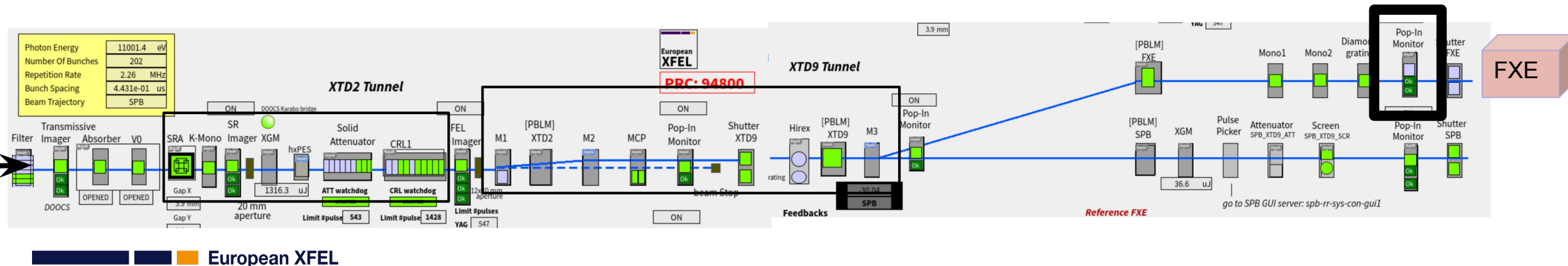
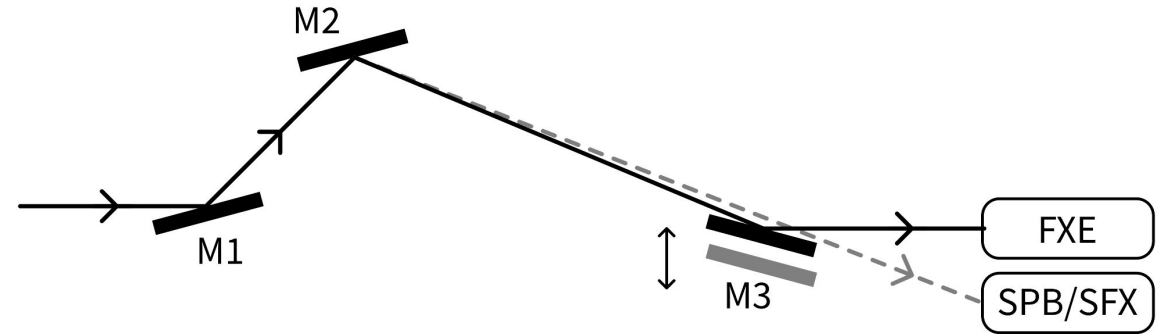
X-ray beam alignment

Motivation

- done every day at the beginning of a shift
- ~30 min of alignment time

Goal

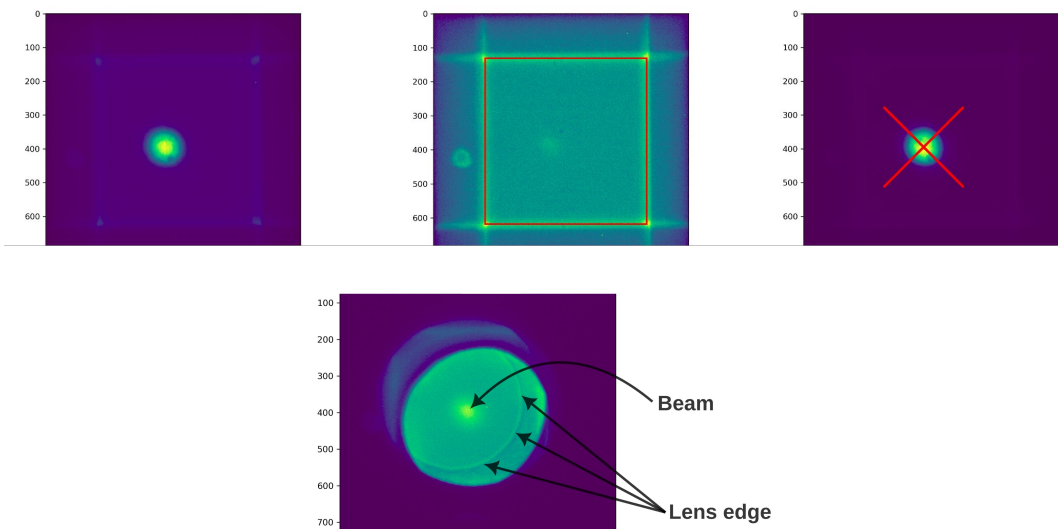
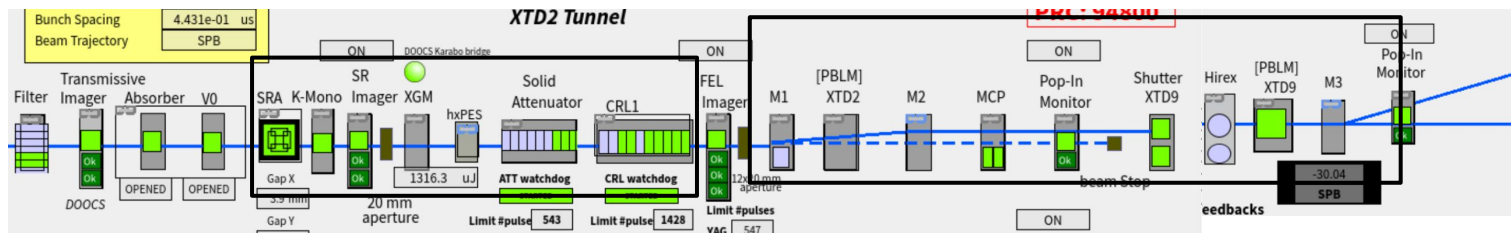
- follow the procedure instrument is using
- align the beam
- identify sub-tasks



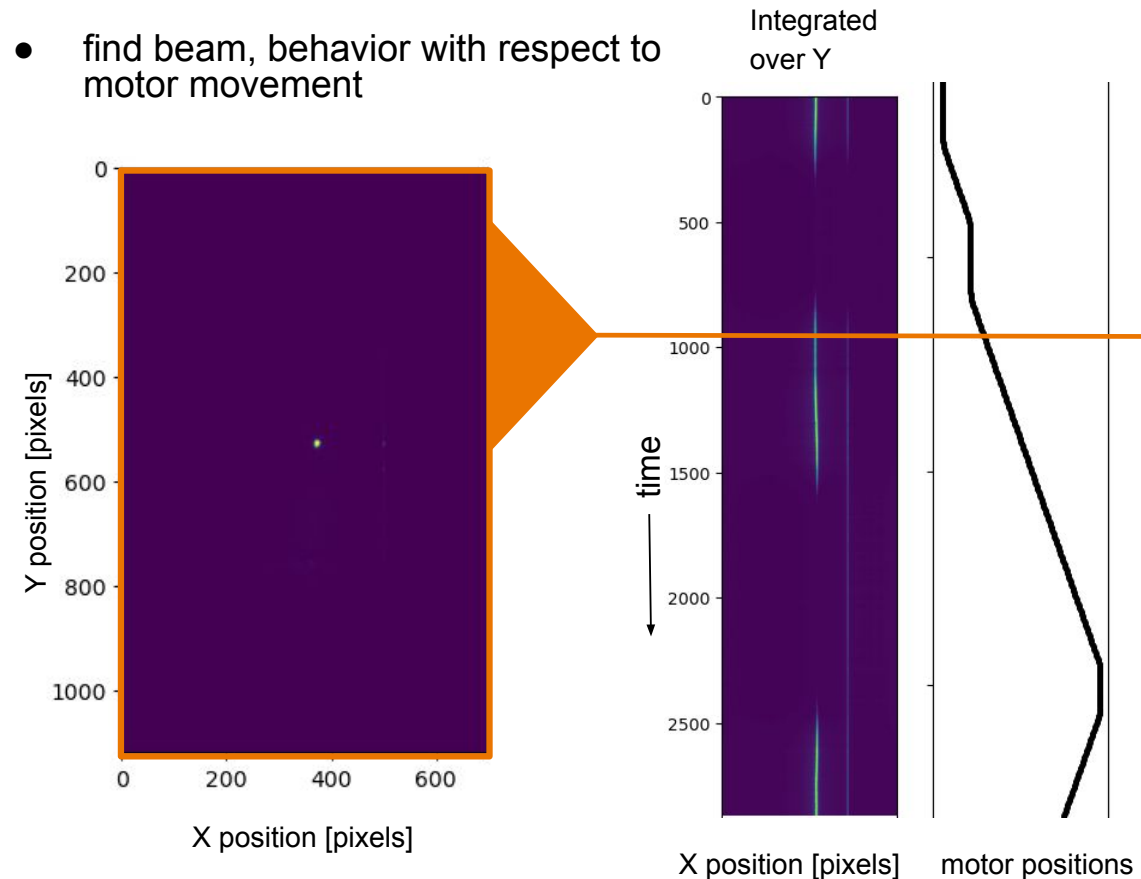
X-ray beam alignment

Goal

- adjust SRA position, beam in the center
- adjust SRA aperture size
- center the beam on CRL aperture

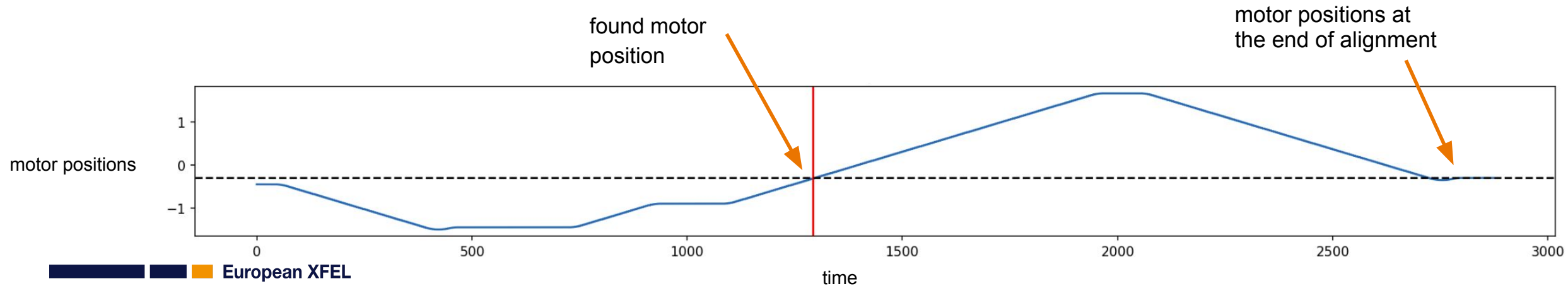
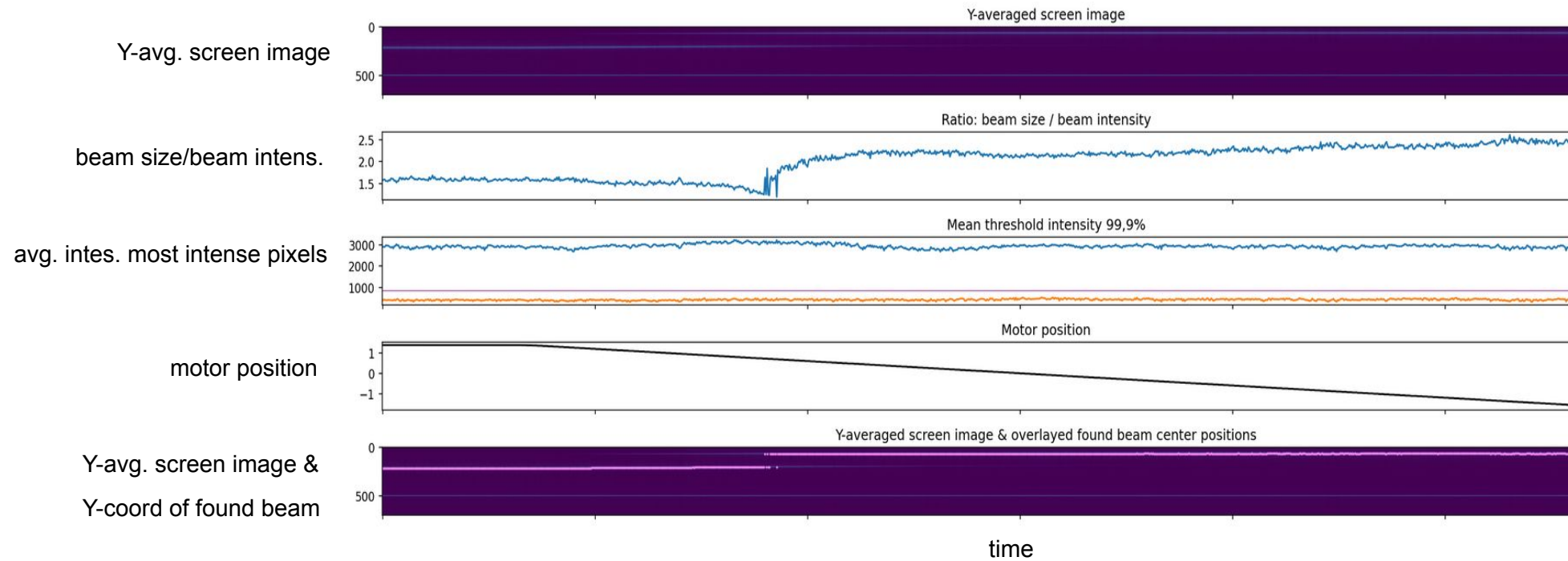


- center beam on each mirror
- find beam, behavior with respect to motor movement

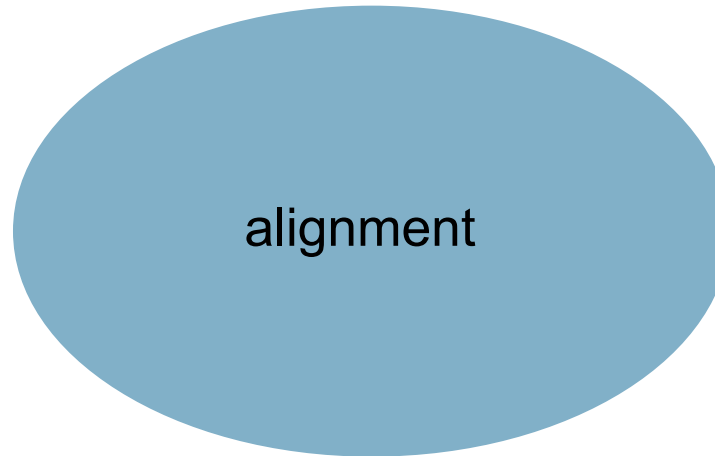


X-ray beam alignment

- find suitable parameters
- try find center point on a mirror
- compare found centered motor position with the one instrument scientists picked
- repeat with different parameters



Use cases



- Optical laser alignment
- X-ray focusing mirrors alignment
- X-ray beam alignment
- HIREX - spectrometer

Beam alignment for HIREX

Motivation

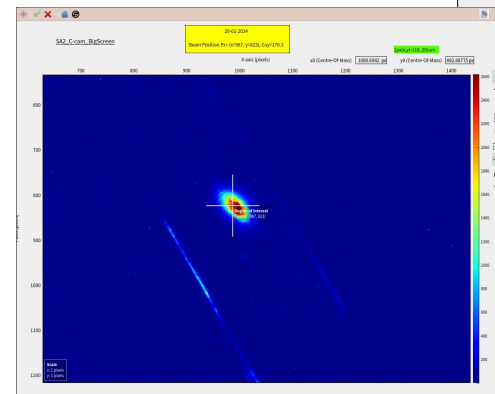
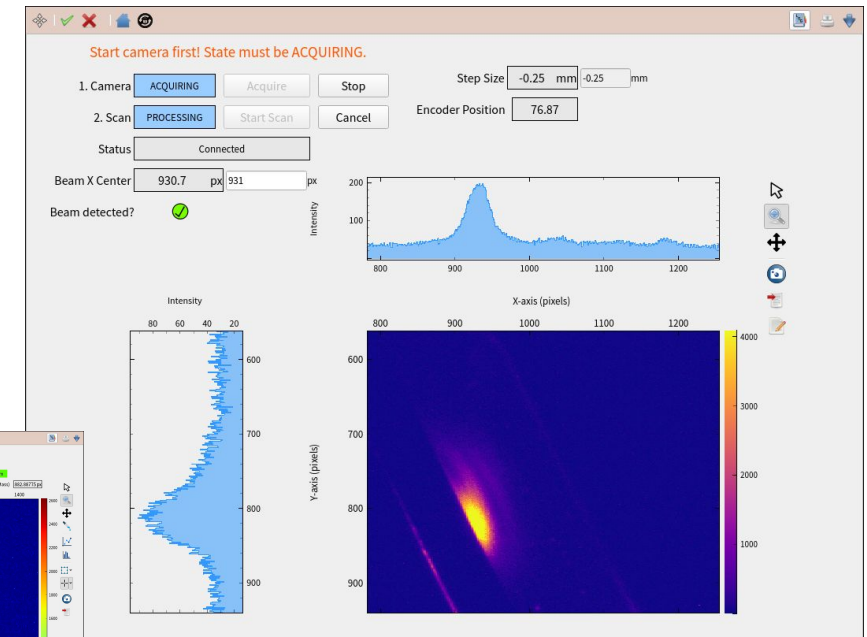
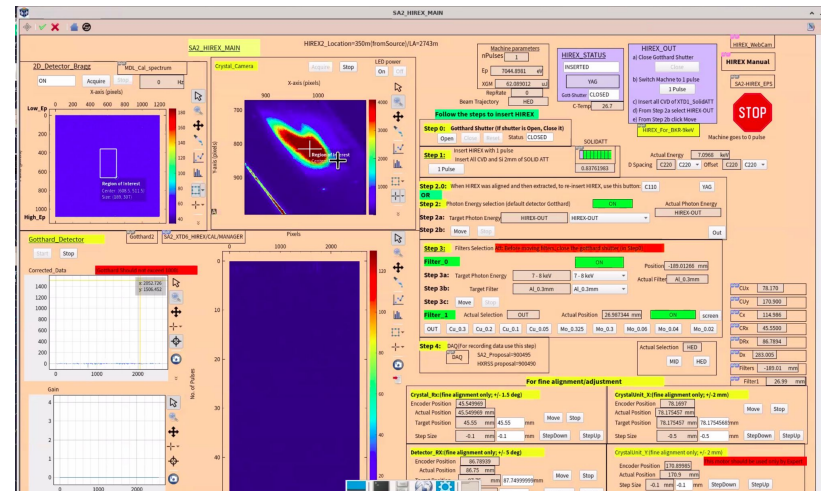
- multiple step process of the alignment - takes time at least once a week
- expert must be available

Approach

- computer vision techniques to find the beam and align to the required position on the screen

Goal

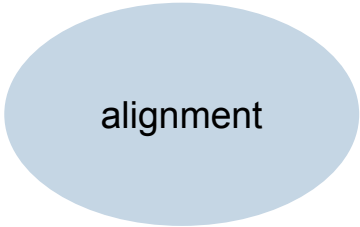
- align beam for online X-ray spectrum measurement
- continuous observation of the online X-ray spectra, warn operators in the case of misaligned beam



Conclusion

- selected projects

Do you have any questions?



alignment

da-support@xfel.eu

- more projects ongoing and planned

Acknowledgments

Combined effort of many facility's stakeholders, without which it could not be possible.

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Thank you for your attention!

