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Beam Position Feedback System Supported by Karabo at European XFEL

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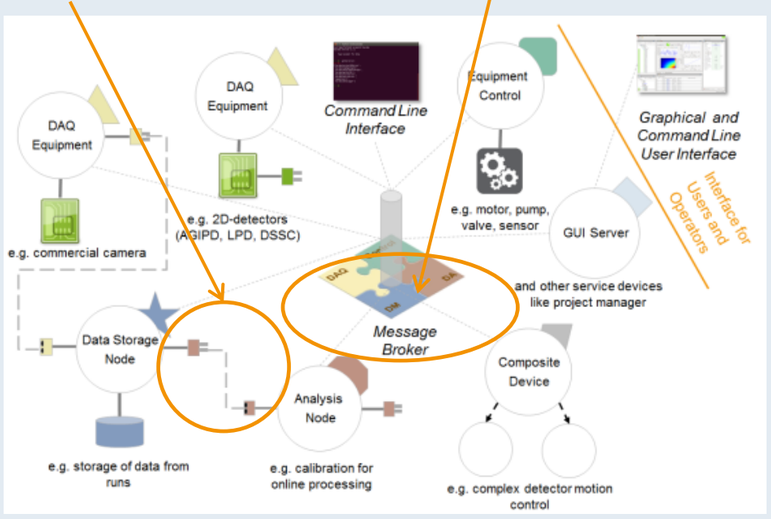
Abstract

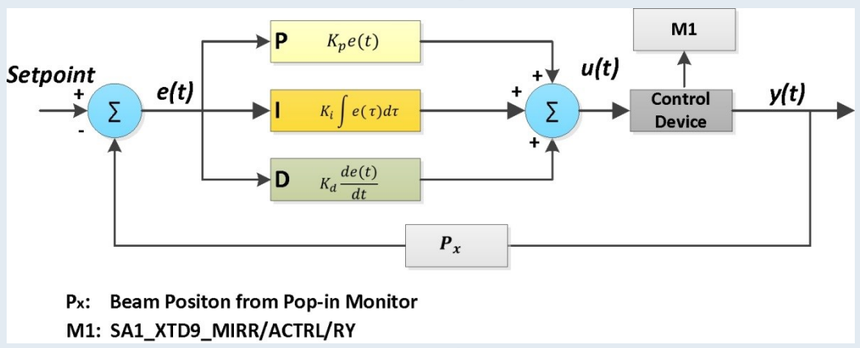
The *XrayFeed* device of Karabo[1, 2] is designed to provide spatial X-ray beam stability in terms of drift compensation utilizing different diagnostic components at the European XFEL (EuXFEL). Our feedback systems proved to be indispensable in cutting-edge pump-probe experiments at EuXFEL. The feedback mechanism is based on a closed loop PID control algorithm[3] to steer the beam position measured by a so-called *diagnostic devices* to the desired centered position via a defined actuator adjusting the alignment of X-ray optical elements, in our case a flat X-ray mirror system. Several *diagnostic devices* and actuators can be selected according to the specific experimental area where a beam position feedback is needed. In this contribution, we analyze the improvement of pointing stability of X-rays using different diagnostic devices as an input source for our feedback system. Different types of photon diagnostic devices such as gas-based X-ray monitors[4], quadrant detectors based on avalanche photo diodes[5] and optical cameras imaging the X-ray footprint on scintillator screens have been evaluated in our pointing stability studies.

Karabo in a Nutshell

Karabo is designed to provide supervisory control and data acquisition for the EuXFEL. Hardware devices and system services are represented by Karabo devices distributed among various control hosts. Devices communicate via a central message broker using language (C++ and Python) agnostic remote procedure calls (RPC). The Karabo design is event-driven, offering subscription to (remote) signals to avoid polling for parameter updates. Large data from detectors and for online monitoring the experiment is transported via flexible data pipelines using direct TCP connections.



Beam Position Feedback System

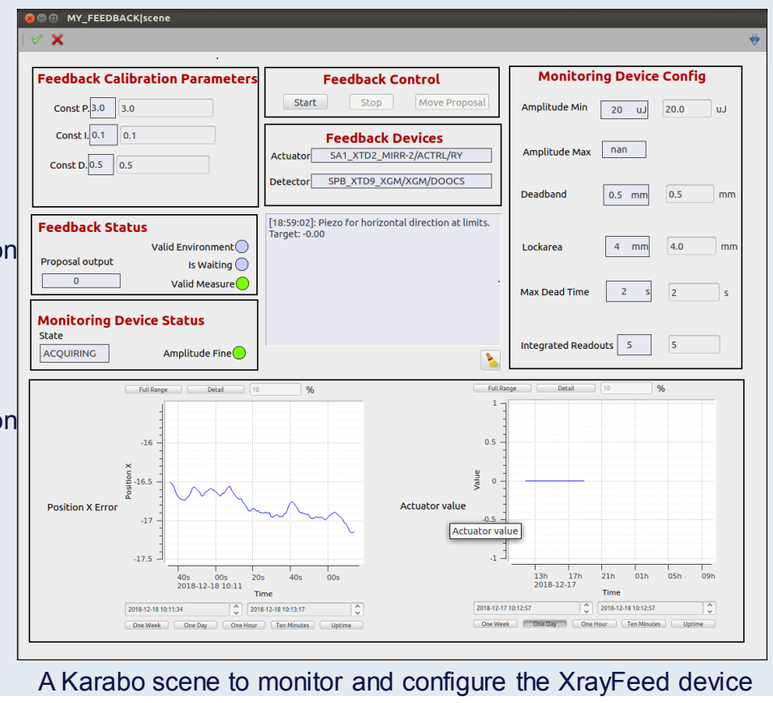


Px: Beam Positon from Pop-in Monitor
M1: SA1_XTD9_MIRR/ACTRL/RY

Working principle of PID controller

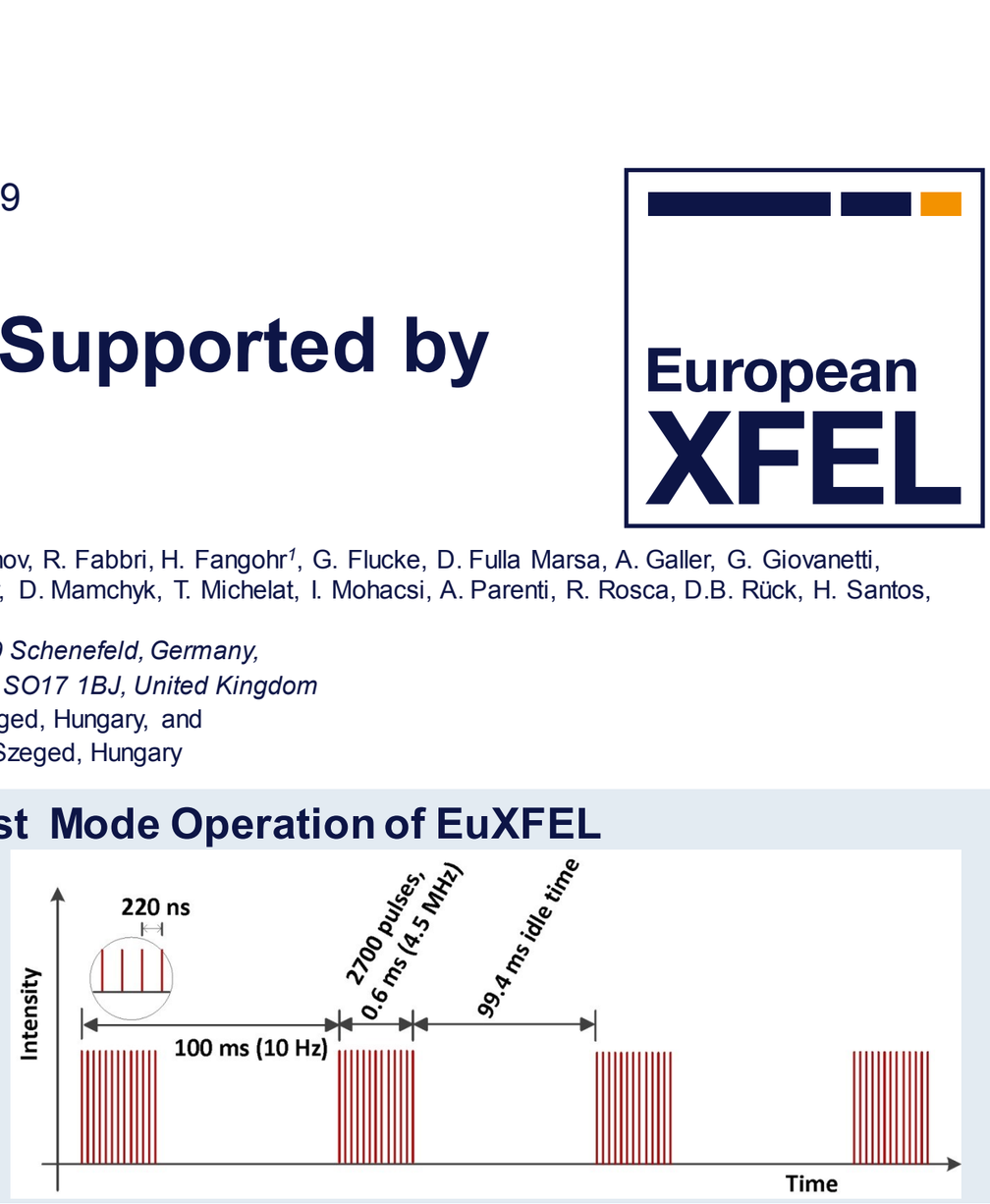
Graphical User Interface

- Amplitude Min and Max seen by diagnostic devices to validate beam
- Dead Band: the range of values for the beam position considered as accepted by the feedback control
- Lock Area: the range of values for the beam position which are rejected by the feedback control
- Integrated Readouts: number of readouts to consider in the running average



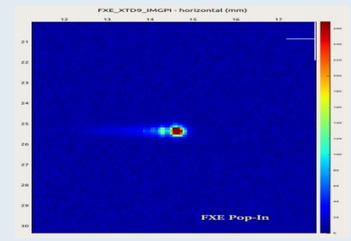
A Karabo scene to monitor and configure the XrayFeed device

Burst Mode Operation of EuXFEL

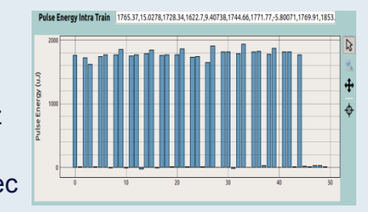


Diagnostic Devices as an Input Source for Feedback System

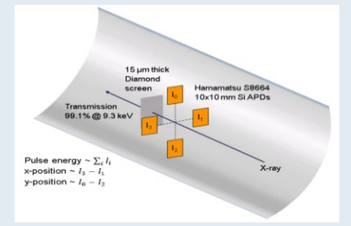
- **Pop-in Monitor (IMGPI)**
  - Basic imagers for beam finding and alignment
  - Characterization of beam properties like position, profile and pointing
  - Sensor size 1640 *1240 pixel
  - Image capturing frequency at 10 Hz



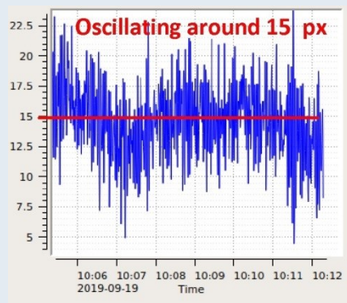
- **X-ray Gas Monitor (XGM)**
  - Non-invasive single-shot pulse energy measurements at 4.5 MHz intra-bunch train repetition rate
  - Average beam position monitoring with the time constant of 10 sec
  - Pulse resolved pulse energy monitoring



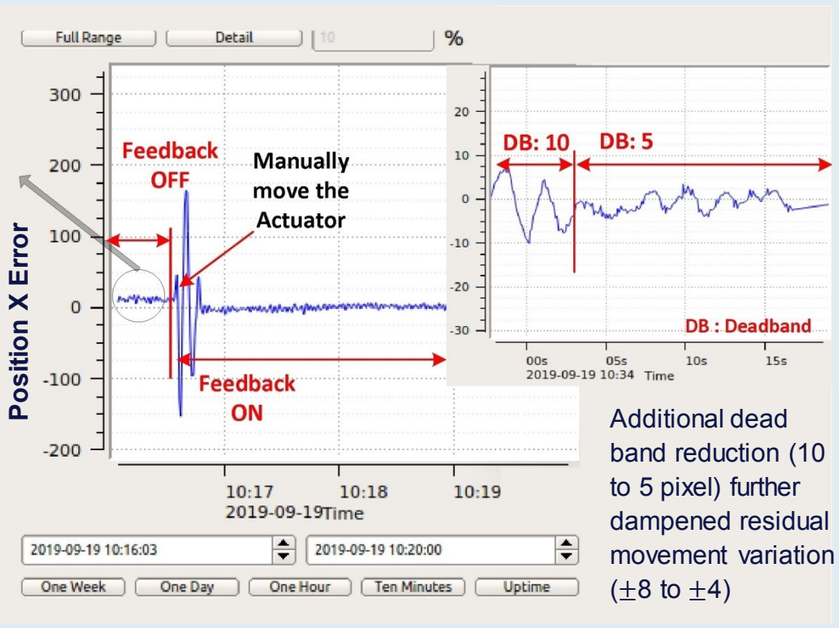
- **Intensity and Beam Position Monitor (IPM)**
  - ADC at 2 GS/s, 12 bit
  - Burst of n pulses at 1.1 MHz repetition rate
  - Single pulse resolved readout
  - Firmware based peak integration



Reduction in Oscillation with Feedback System



Feedback ON corrected position X from ~15 to the desired ~0 pixel



Additional dead band reduction (10 to 5 pixel) further dampened residual movement variation (±8 to ±4)

Effect of feed back on beam position stability using pop-in monitor as diagnostic device
Diagnostic device: FXE_XTD9_IMGPI/SPROC/CAMERA, Actuator: SA1_XTD9_MIRR/ACTRL/RY

Conclusions

We have developed feedback software device, XrayFeed, to provide spatial X-ray beam stability in terms of drift compensation for flat X-ray mirror system. Robustness of the feedback software solution allowed us to use different types of diagnostic devices according to the specific experimental area where a beam position feedback is needed. Our solution provides robust and reliable control with performance characteristics like reaction time and stability with respect to external disturbances which are difficult to achieve when done manually.

References

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