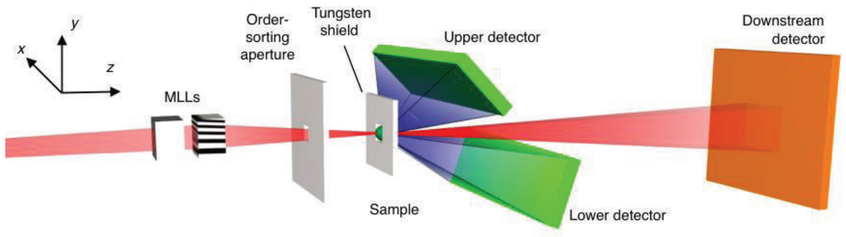
Control Systems for X-ray Imaging Experiments at CFEL.

Dmitry Egorov*, Sasa Bajt, Henry Chapman, Ivan De Gennaro Aquino, Holger Fleckenstein, Philipp Middendorf (CFEL, DESY, Hamburg)

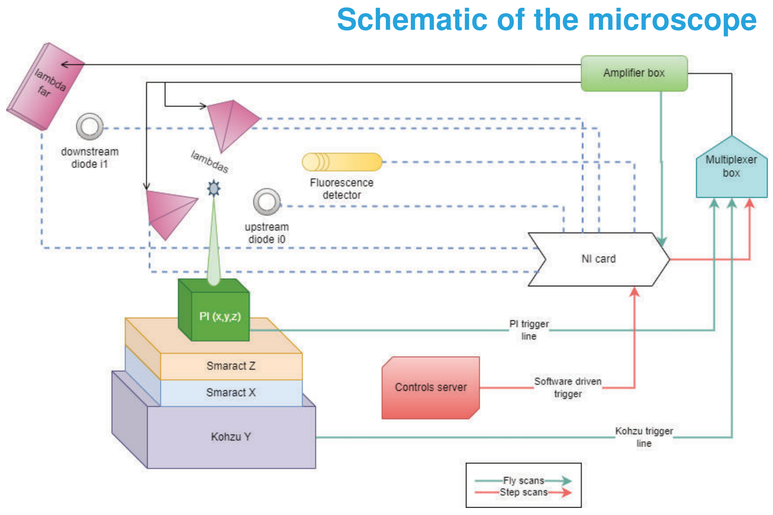
Abstract

The use of X-ray imaging techniques in scientific research has significantly increased in recent years, resulting in a growing demand for advanced control systems that can enhance the accuracy, efficiency, and reliability of the experiments. The development and implementation of such systems allow researchers to automate and customize the various components involved in X-ray imaging experiments, including detectors and motor stages. The current implementation of the control system is based on the Kamzik3 framework, which was developed especially for these experiments. There is ongoing work to migrate the existing system to the Tango Controls framework, utilizing macros executed by Sardana. It will simplify the integration process of the experimental setup into beamlines on different synchrotron sources and allow the usage of community-developed tools.

Compton X-ray microscopy



Schematic of the microscope

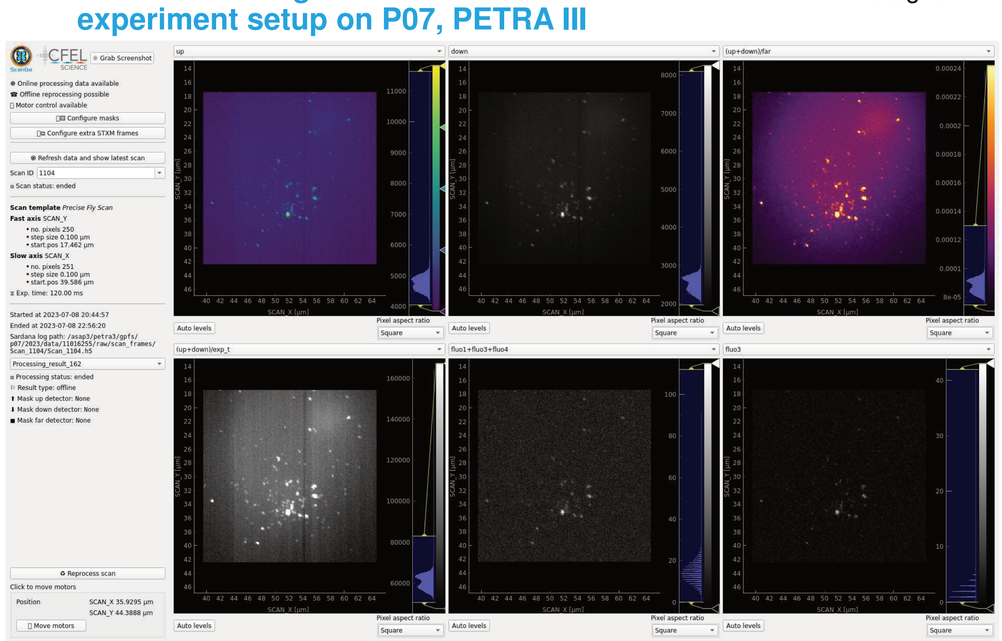


Software and signals scheme for the experiment setup on P07, PETRA III

In this setup there are Kohzu and Smaract stages for non-precise overview scans and PI P-616 NanoCube nanoposiitioner.

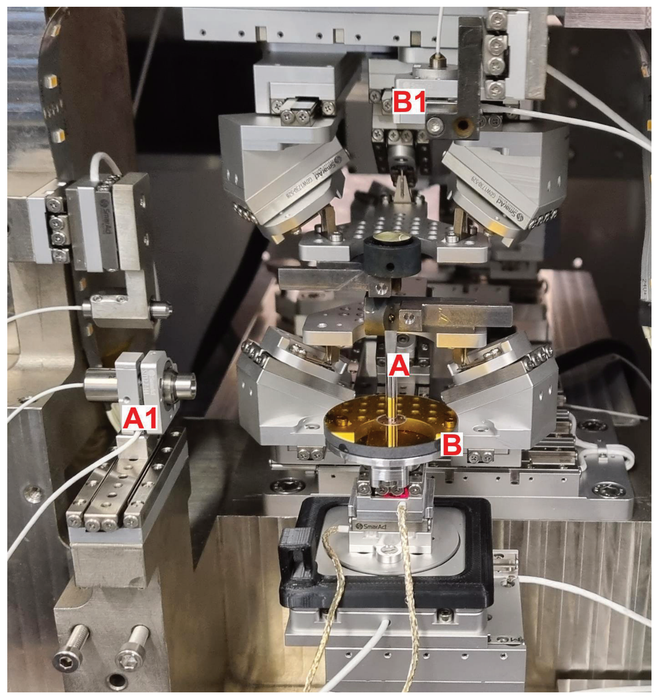
In step scans detectors are triggered by National Instruments card.

In fly (continuous) scans trigger signals are sent by PI or Kohzu stages.



STXM viewer (ScanGo). Membrane with gold particles

Ptychographic X-ray imaging



Imaging setup, sample and lenses stages

In this setup, **Smaract** Piezo Stick-Slip stages are used for sample positioning. One important feature of the setup is the use of **Smaract Picoscale** interferometers. In the image on the right, channel A1 is used to measure the distance to the sample pin A, and channel B1 for the mirror B at the base of the pin.

These measurements are streamed during the data acquisition to know exactly where the sample is at that time. Interferometers are also used for analog feedback for precise positioning. They transmit an analog signal to the sample motor controller **Smaract MCS2**, aligning sample stages, which allows us to achieve resolutions of a few nanometers.

Current control system is based on **Kamzik3** framework, which was developed at **CFEL**.

It has its advantages, such as user-friendly GUI and support for most devices that are used at our experiments.

But it also has limitations, such as fixed scan macros, monolithic architecture and the most important – lack of active core development and active user community.

Current controls GUI (based on Kamzik3 framework)

The long-term plan is to switch our scanning experiments to **Tango Controls** framework.

It is being actively developed and used at many European scientific facilities and well-known at **DESY** beamlines.

Sardana, macro control framework, will be used to run scans.

Serial and Macromolecular Crystallography, CFEL TapeDrive

TapeDrive is the portable conveyor belt-based sample delivery system for multidimensional serial crystallography.

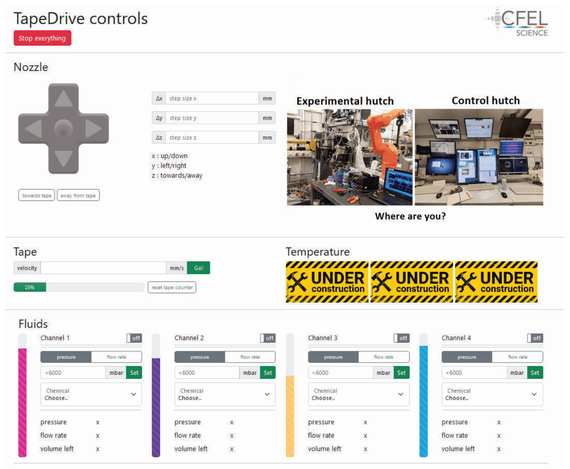
Devices used at **Tapedrive**:

- **Elveflow OB1** – microfluidic flow controller, sample delivery;
- **Maxon Epos2** – motor controller, tape roll motor;
- **Smaract MCS2** – motor controller for 3D-printed nozzle.

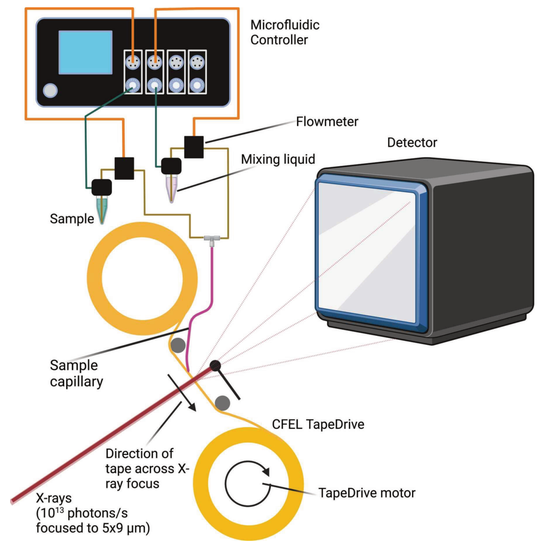
Beamline detector:

- **Dectris Eiger 16M** – photon detector, acquire data in “Streaming mode”.
  Collected data is online processed by the **CrystFEL**.

All devices are now migrated from Kamzik3 to Tango-based control system, which allows us to run and test equipment separately and simplifies integration with beamline controls.



TapeDrive Tango-based web controls



DAQ scheme

New control system has new features, such as PID control of the fluids flow rate, “nozzle-to-crystallization” time calculation, “tape left” calculation, etc.

There are plans to add temperature control device based on Peltier heat pumps.

*Contact: dmitry.egorov@desy.de