Control and timing system of a synchrotron X-ray chopper for time resolved experiments

U. Ristau , V. Palnati, D. Jahn , J. Meyer and S. Fiedler

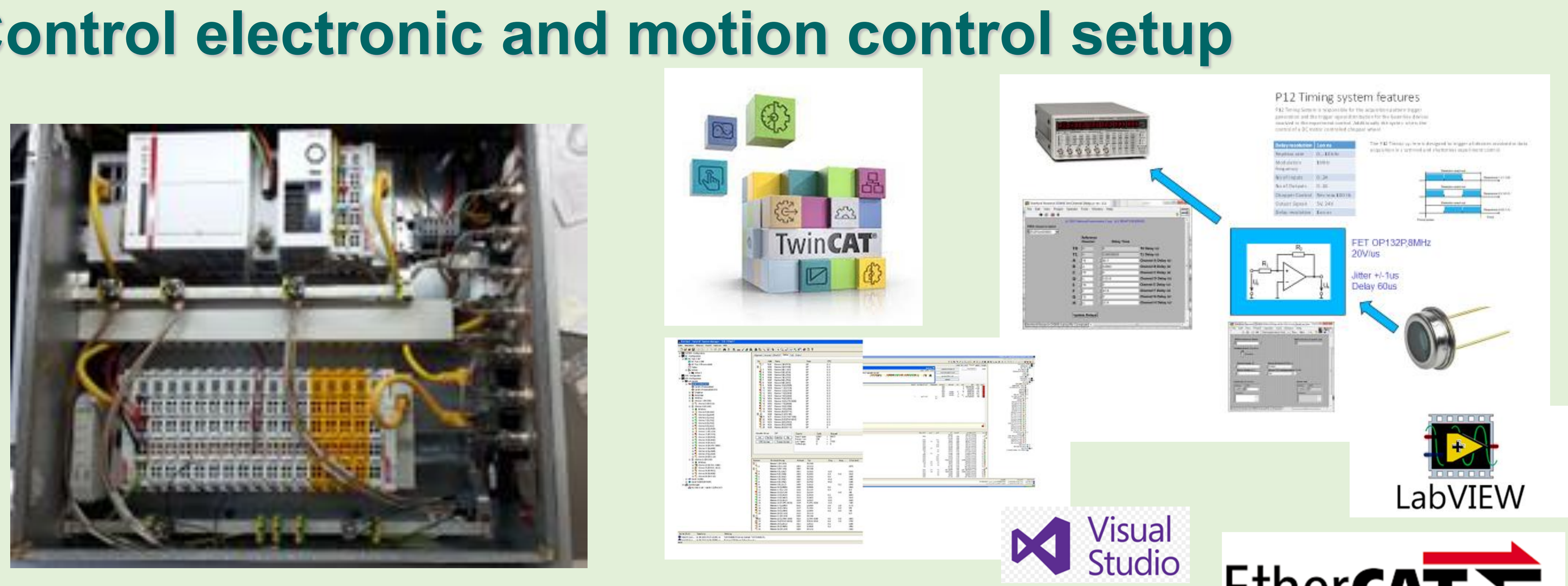
EMBL Hamburg, c/o DESY, 22603 Hamburg, GERMANY

EMBL

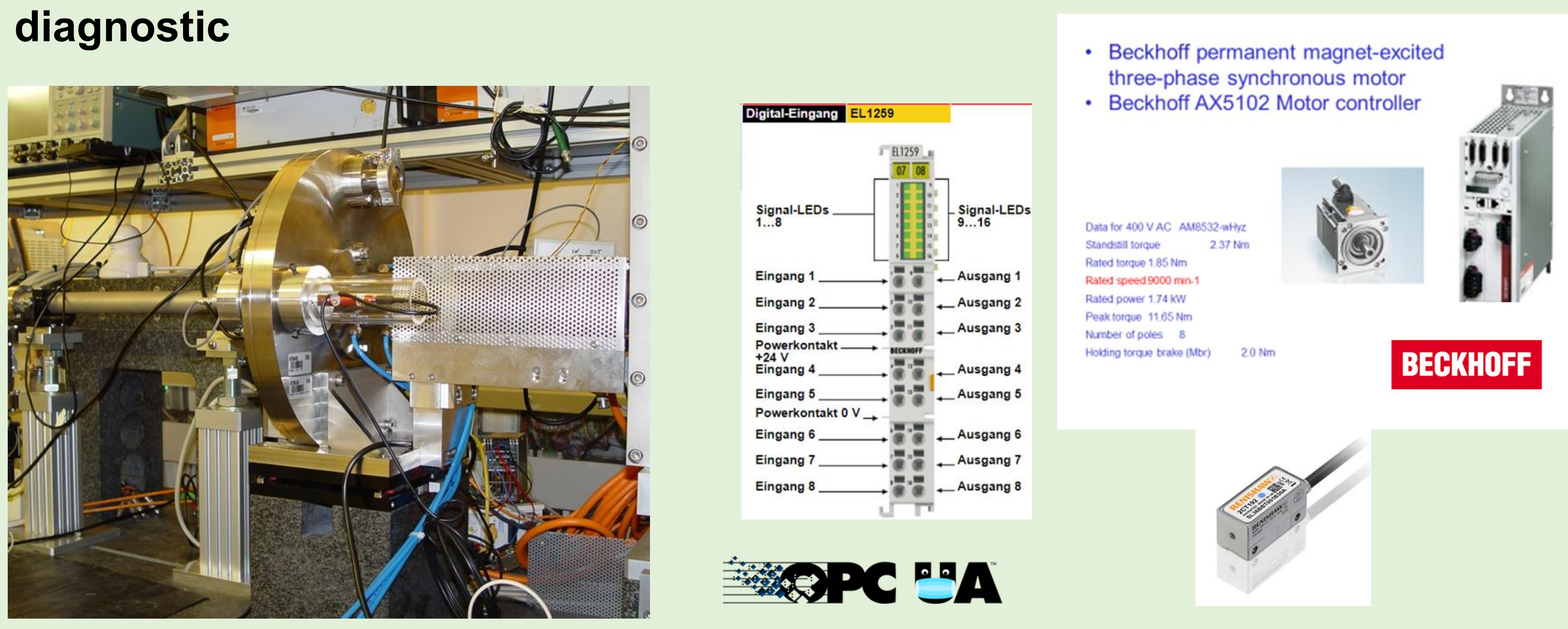
Setup description

- A mechanical X-ray chopper for one of the synchrotron beamlines operated by the EMBL Hamburg Unit at the PETRA III storage ring on the DESY campus has been developed.
- In experiments, the structural changes of protein in solution is studied. The scattering of the sample is recorded with a fast area detector as a function of time after a reaction has been triggered. As the samples are sensitive to radiation damage, it is desirable to minimize the exposure to the X-ray beam between two frames. This achieved with the chopper that can be adjusted to variable duty cycles.
- The beam chopper consists of a rotating disk with grooves at the outer diameter. When the disk rotates the x-ray is being chopped with the desired opening/closing time. The correct dimensioning of the grooves and the angular velocity provides the maximum opening time

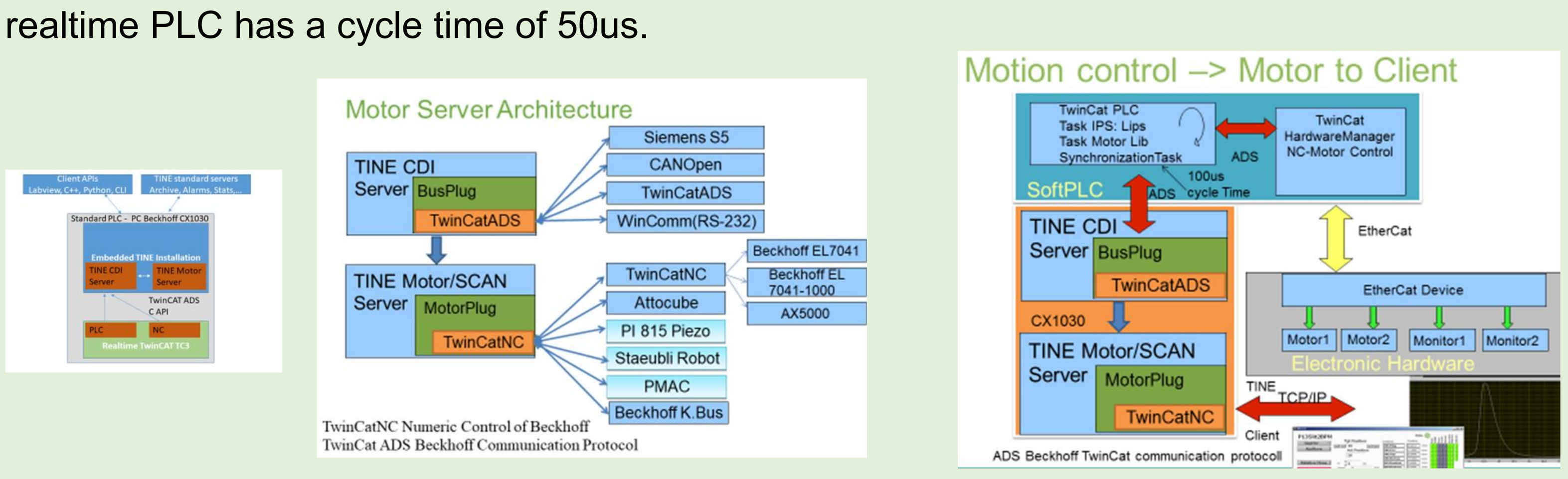
Control electronic and motion control setup



Chopper and experiment timing electronic and chopper diagnostic

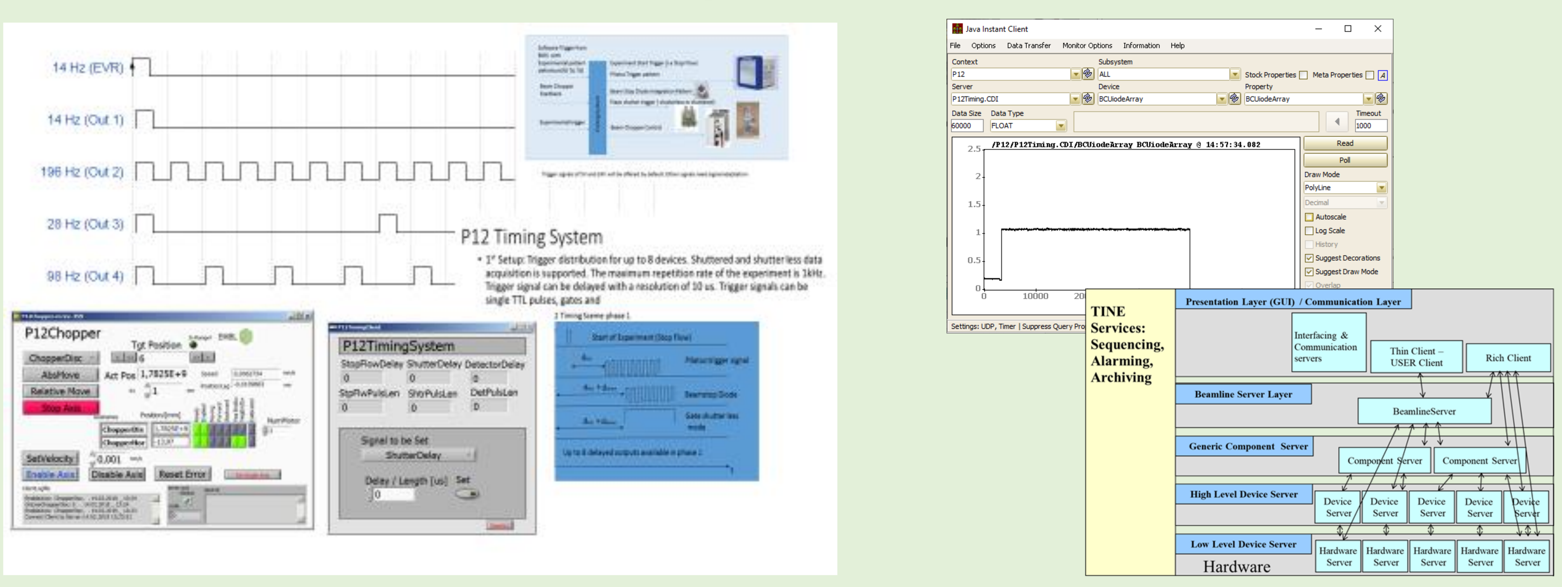


Chopper set up installation at the beamline. The trigger puls and delay distribution is provided by the multi time stamp module EL1258 of Beckhoff. The XFC (extreme fast controls) module offers distributed clock operation in order to achive ns precise timing precission. The soft realtime PLC has a cycle time of 50us.



The Client software is LabVIEW based and connects through TINE to the device servers . The Client allows motion control of the Chopper for rotation speed, wheel positioning in angle and position. The Timing GUI is used to set device triggers and delays of connected beamline devices like the detector, laser, sample changer, shutters,..

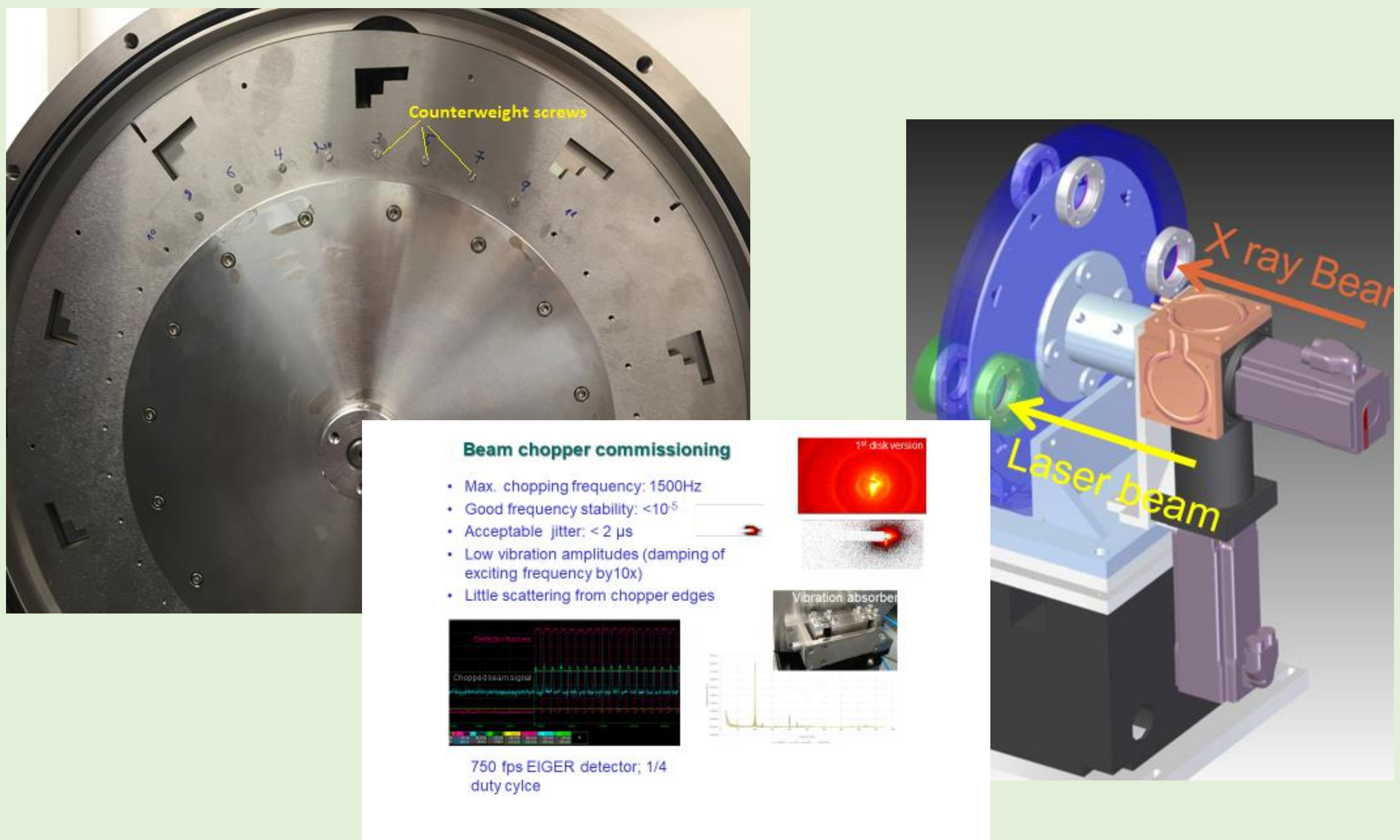
Servers and Clients in operation at the beamline



The Client software is LabVIEW based and connects through TINE to the device servers .

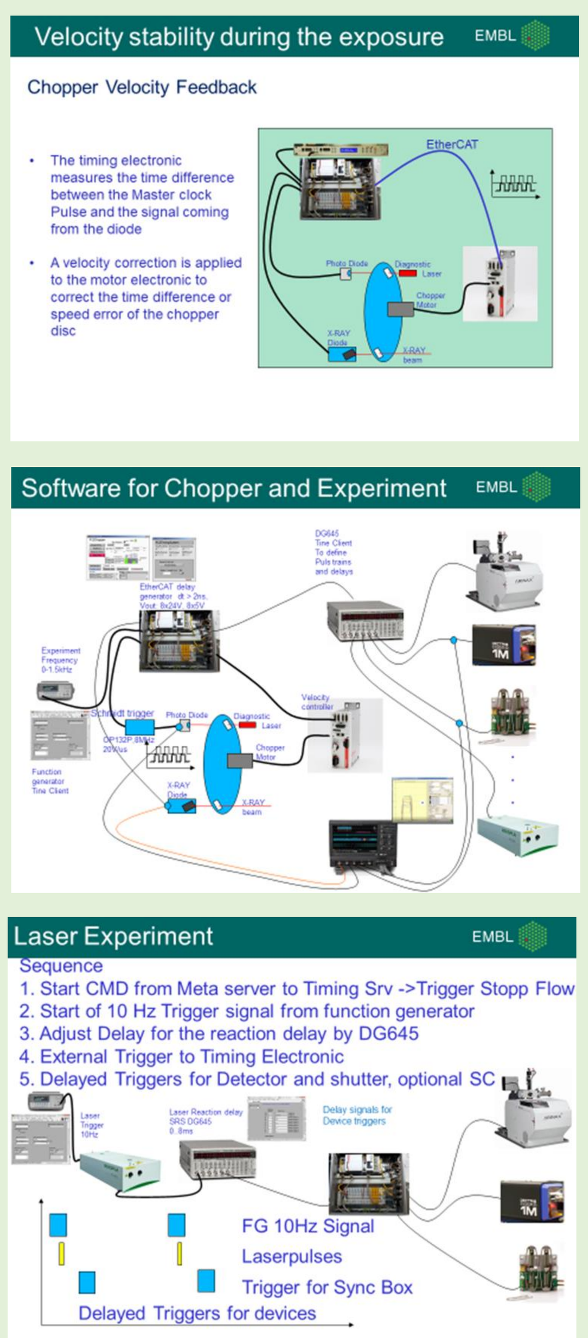
The Client allows motion control of the Chopper for rotation speed, wheel positioning in angle and position. The Timing GUI is used to set device triggers and delays of connected beamline devices like the detector, laser, sample changer, shutters,.. The design of the control server architecture follows the standard architecture of the EMBL.

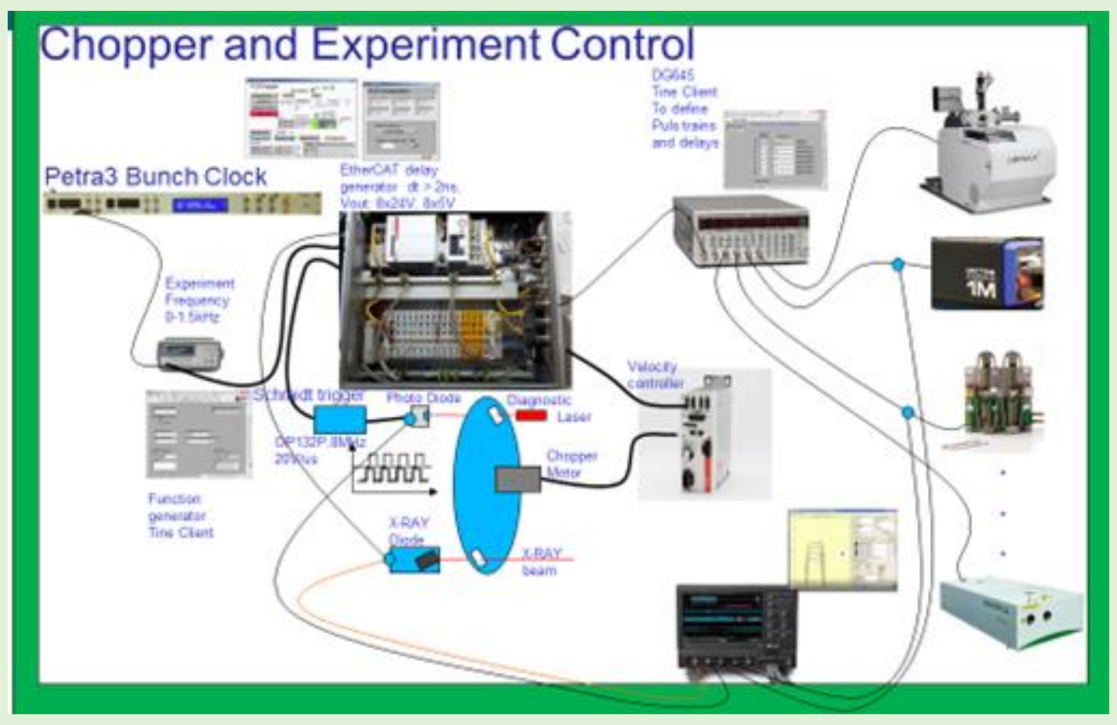
Chopper operation results



- Velocity stabilization of the chopper is archived by the velocity control motion mode of the TwinCAT NC. The motor follows the output frequency of the AX5106 Motor controller which is integrated inside the TwinCAT NC. The motion stability is observed by the diagnostic laser diode and the motor controller output frequency is corrected inside a feedback loop based on the diagnostic signal.

Optional setups for time resolved measurements





- Pump probe measurements can be carried out with this chopper system where the sample is probed with a short X-ray pulse after a laser excitation.
- Storage ring bunch pattern, sample injection, excitation laser pulse, detector trigger, and the chopper revolution frequency that must be kept very constant have to be synchronized.
- The solution chosen for the timing & synchronization system is based on EtherCAT electronics.
- Servers and Clients are integrated into the TINE control system with LabView and TwinCAT.

Conclusion

- The Chopper has proven in first experiments its functionality. The setup is installed inside the P12 Experimental hutch.
- Optional operation with an additional second fast beam shutter to improve the pulse separation is available.
- A prototype of the beam shutter has been designed and build in collaboration with the piezo company SMARACT.
- The shutter opening time is <500us
- Maximum repetition rate >150 Hz.

- In combination with the X-Ray Chopper it is possible to run single exposures limited to the exposure length of the adjusted chopper gap setting.
- The SRS DG645 pulse and delay generator with 4 outputs is available to improve the timing capabilities as described. TINE Server and clients are in place for the DG645 control.

Contact: ristau@embl-hamburg.de

PCAPAC 2022 OCT 4-7 13th International Workshop on Emerging Technologies and Scientific Facilities Controls