

TwinCAT – EPICS with motion timestamping

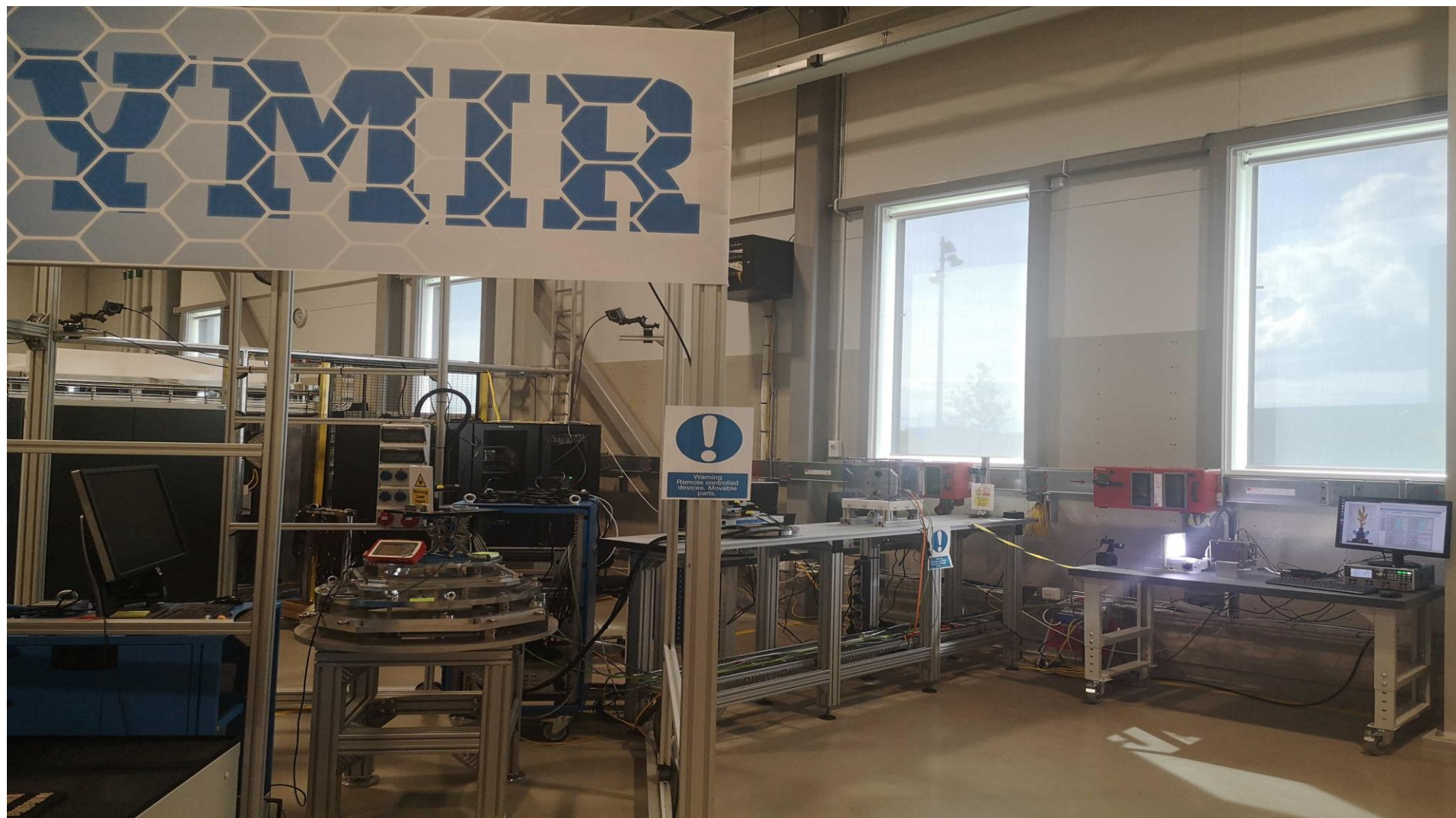
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www.europeanspallationsource.se

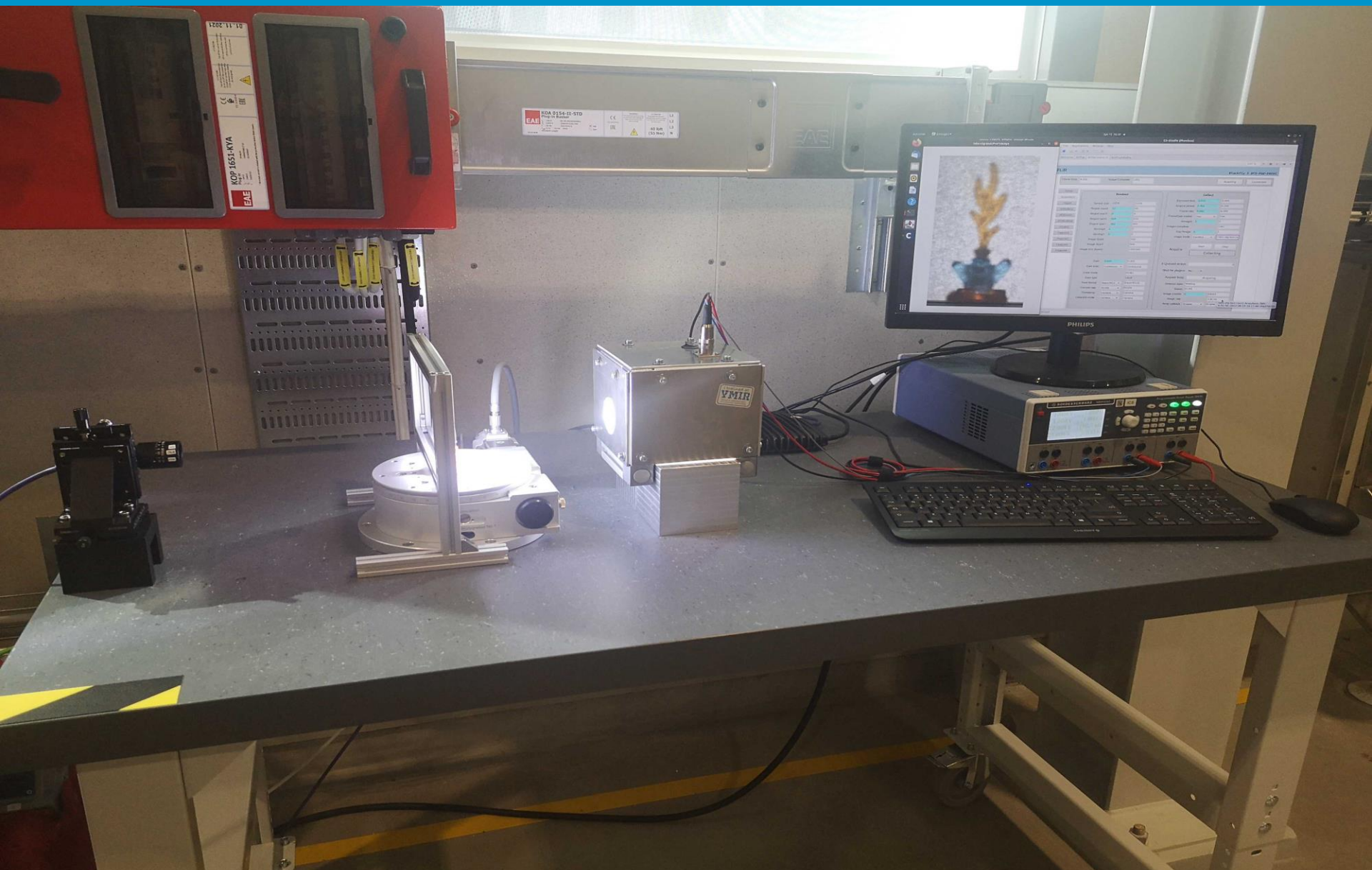
Buzz words

- Imaging+scanning (tomography)
- All data in Apache Kafka
- Facility-wide timing system ("MRF")
- Precise Timing Protocol
- TwinCAT
- Motor position timestamping in the controller
- EPICS IOC

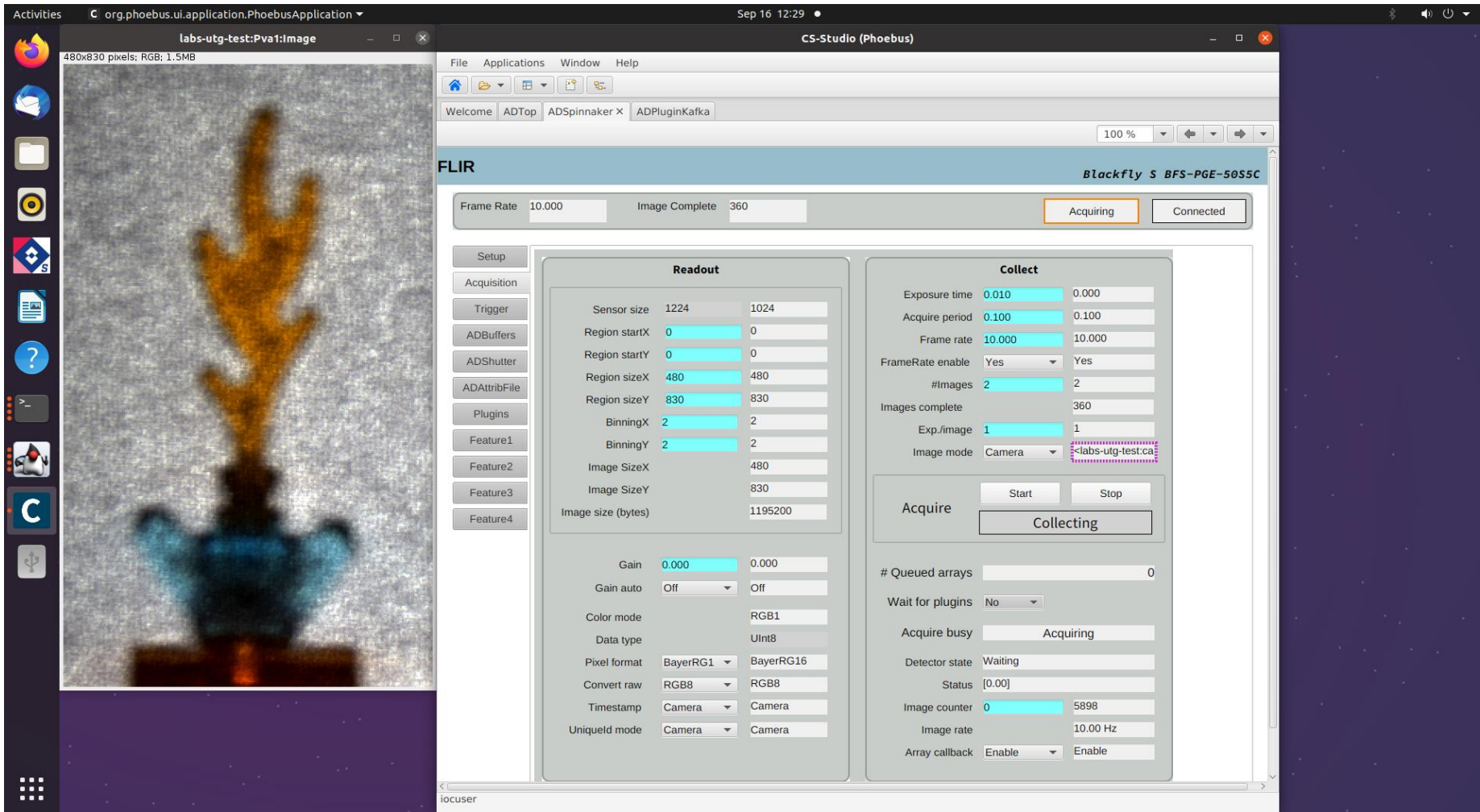
YMIR



Light tomography



Control screen



The screenshot displays the CS-Studio (Phoebus) control interface. On the left, a window titled 'labs-utg-test:Pva1:Image' shows a thermal image of a hand. The main interface is titled 'CS-Studio (Phoebus)' and features a menu bar (File, Applications, Window, Help) and a toolbar. The central panel is labeled 'FLIR' and 'Blackfly S BFS-PGE-5055C'. It includes a status bar with 'Frame Rate 10.000', 'Image Complete 360', and buttons for 'Acquiring' and 'Connected'. The interface is divided into several sections: 'Setup', 'Acquisition', 'Trigger', 'ADBuffers', 'ADShutter', 'ADAttribFile', 'Plugins', and 'Feature1-4'. The 'Readout' section displays sensor size (1224 x 1024), region start coordinates (0, 0), region size (480 x 830), binning (2 x 2), image size (480 x 830), and image size in bytes (1195200). The 'Collect' section shows exposure time (0.010), acquire period (0.100), frame rate (10.000), frame rate enable (Yes), number of images (2), images complete (360), exposure per image (1), and image mode (Camera). The 'Acquire' section has 'Start' and 'Stop' buttons, and a 'Collecting' button. The bottom right shows '# Queued arrays' (0), 'Wait for plugins' (No), 'Acquire busy' (Acquiring), 'Detector state' (Waiting), 'Status' (0.00), 'Image counter' (0 / 5898), 'Image rate' (10.00 Hz), and 'Array callback' (Enable).

Timestamping – what, how

- Motor positions and EPICS:
 - Motor positions are “acquired” in MCU
- Visible in EPICS motorRecord (“.RBV”)
- EPICS records are “timestamped” in the IOC, when they are processed.
- Roundtrip times of a poll:
 - 10..20 msec/axis (1st gen: EPICScom module)
 - 5..10 msec/axis (2nd gen: twincat-ads)
 - 5..15 msec all axes (3rd gen: PILS)

Old communication MCU-EPICS

- 10 msec roundtrip / axis:
- We run into a limitation:
8 axes: 80 msec poll time
16 axes 160 msec poll time
- Motor positions of different axes
are "someone somewhere somewhen"

Timestamping – not accurate enough

- For positioning: 100 msec is good enough (many axes)
- E.g. tomography needs something better: specs ???
- `specNotYetFullyDefinedException @ ESS`
- Our assumption:
≤ 1 msec is good enough for scanning

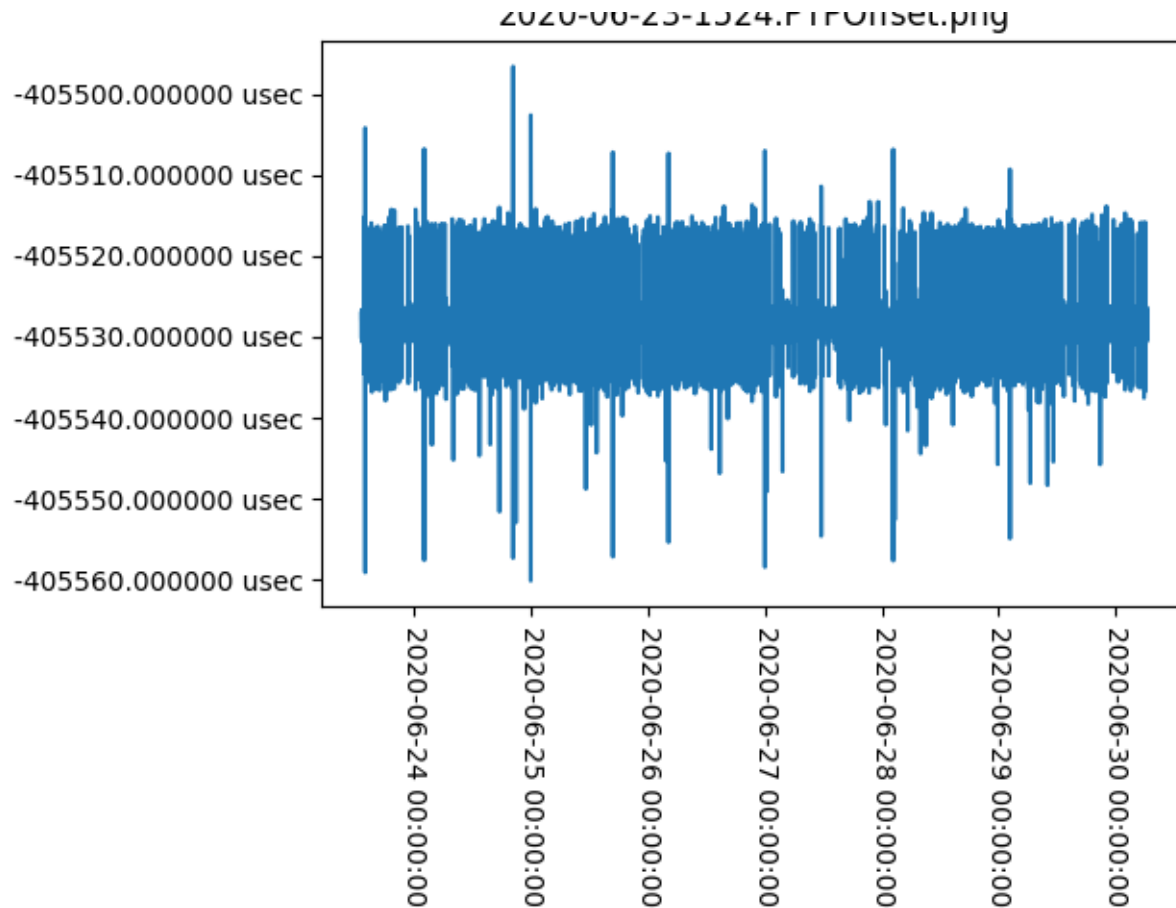
Time stamping in MCU/PLC

- Each PLC cycle (every 10msec):
- Read all motorPositions
- Read status of all axes (error, busy, homed, LS)
- Read other sensors
- Gets UTC from timing system
- Put everything into continuous memory block
- EPICS IOC polls this every 10..1000 msec

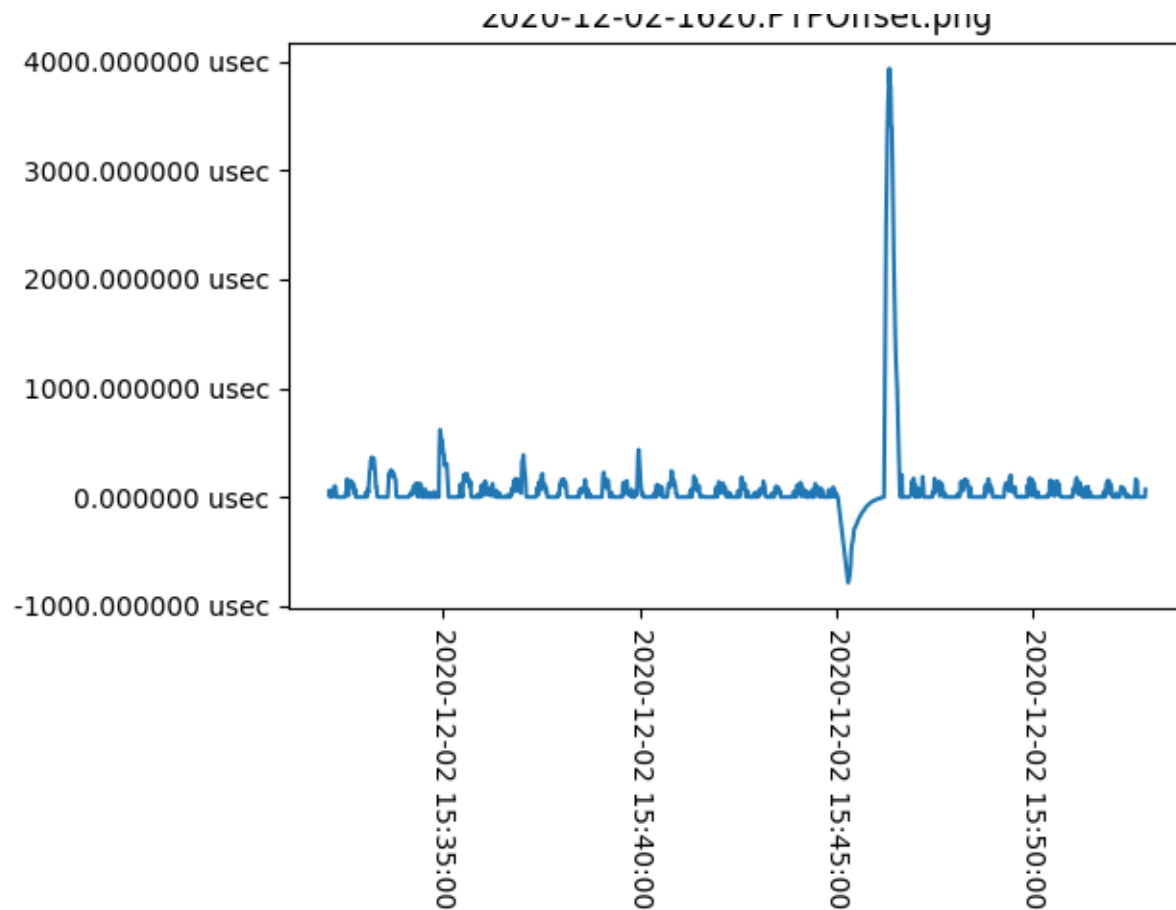
Timing system; PTP

- An EVR acts as a PTP master (chrony on eth2)
- TwinCAT needs a PTP terminal: EL6688
- Needs to be configured (in TwinCAT)
- Needs to be evaluated

PTP Offset master - EL6688



PTP Offset master - glitch



Transport protocol TwinCAT - EPICS

- Raw TCP Socket ? Or: ADS
(locked against PLC cycle)
- ADS_READ (start, length),
ADS_WRITE (start, length)
- Application protocol "on top" : "PILS"
(the 3rd generation)

Memory layout – Runtime data

- Poll data, example:

Date/Time (UTC)

Additional IO

Motor1 (position, status)

Motor2

Motor3

- PILS gives us a description

IOC::asynPortDriver::poll()

- IOC reads all data with every poll()
- Distributes it into the different Records (asyn parameters)
- Calls asyn::setTimeStamp()
- We have additional ai PVs:
 - "\$P\$R-RBV-TSE.VAL" for the motor position
 - "\$P\$R-RBV-TSE.TIME" derived from MRF->PTP

- Credits to:
- PLC Interface Layout Specification
- <https://forge.frm2.tum.de/public/doc/plc/master/singlehtml/#device-address>
- (Introduction/Lessons on request)

Next steps

- Verification that everything works (“kafka has good data”) (motors, detectors, cameras)
- Ongoing project:
Light tomography with a camera

Questions

- hvala
- thanks
- tack
- danke
- Merci

Links

- <https://kafka.apache.org/>
- https://en.wikipedia.org/wiki/Precision_Time_Protocol
- <https://www.beckhoff.com/en-en/products/i-o/ethercat-terminals/el6xxx-communication/el6688.html>
- <https://forge.frm2.tum.de/public/doc/plc/master/singlehtml/#device-address>
- <https://www.ijs.si/time/>