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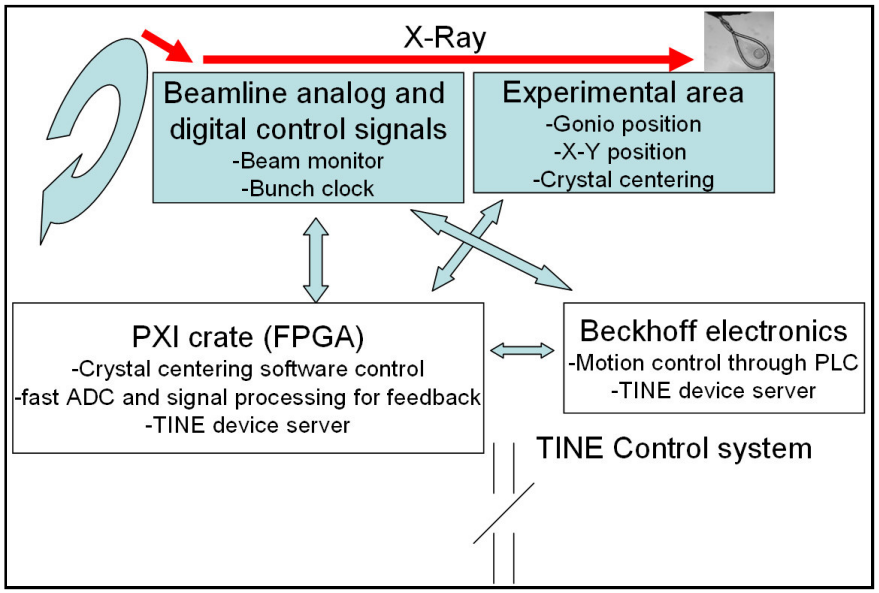
European Molecular Biology Laboratory EMBL, Hamburg Unit, Germany

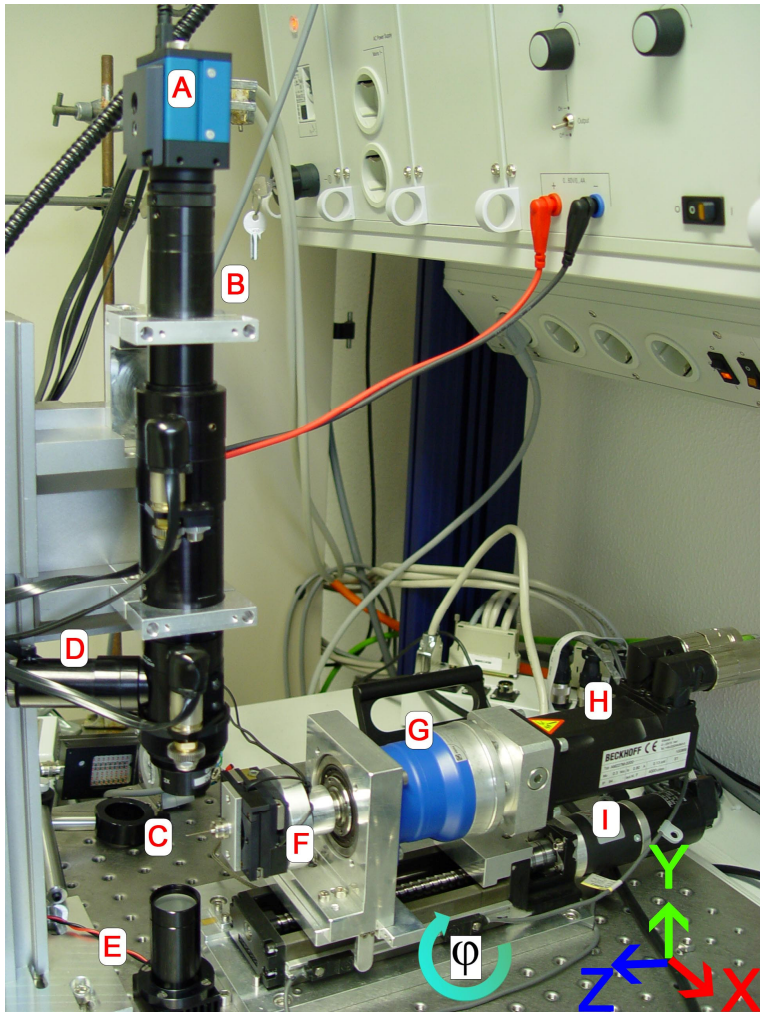
FPGA Based Experiment Control Solution for EMBL Beamline at PETRA III

System Architecture



The future architecture of the system at the beamline

Optical System Set Up for crystal centering



a) MPixel Camera, b) microscope 25:1, c) sample position and holder,
d) coaxial light, e) backlight, f) X-Y Attocube piezo motors, g) gearbox, h) DC motor (gonio),
i) stepper motor for gonio translation. The axis orientation is also shown; X is the beam axis.

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Crystal centring Steps:

- Background removal
- Automatic coaxial light and backlight adjustment for crystal illumination
- Alarms implemented to detect non standard crystal mounts
- Crystal support centring using the National Instrument Vision software algorithms tools
- XREC crystal detection and centring into the beam axis at high zoom level

Crystal centring highlights:

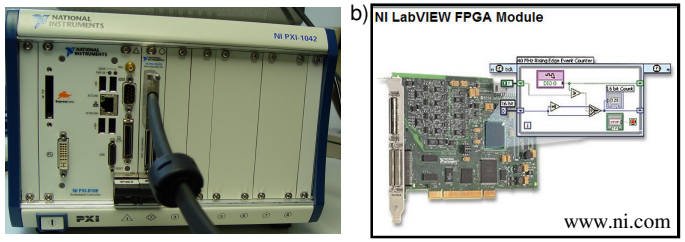
- The system is calibrated to work properly at each level of magnification
- The possibility to centre manually the crystal is also provided
- Auto focus capability
- Barcode reader (for identification of barcodes printed on caps and puck)
- Different images processing functionalities

FPGA Control:

- *40 MHz real time loop*
- *Labview programming language*
- *PID feedback loops*
- *Image acquisition and compression*

NI FPGA PXI-7831R

a) b)



a) The National instrument PXI Real time controller equipped with the PXI-7831R FPGA used for this work, b) the FPGA board running in real time at 40 MHz.

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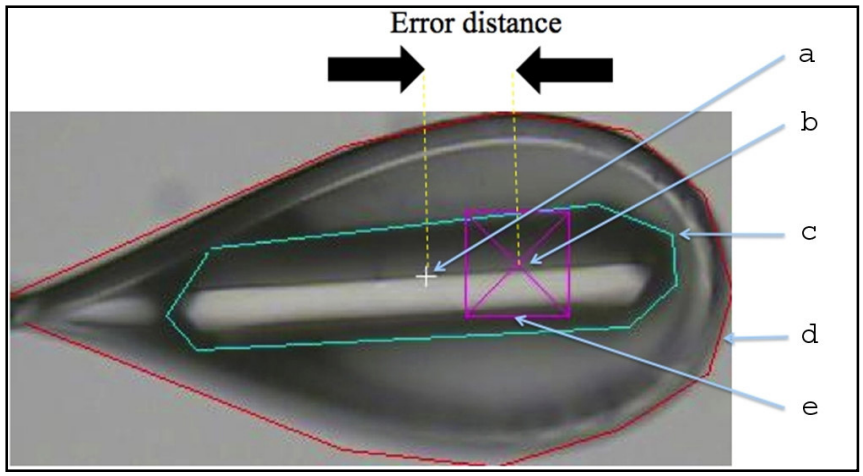
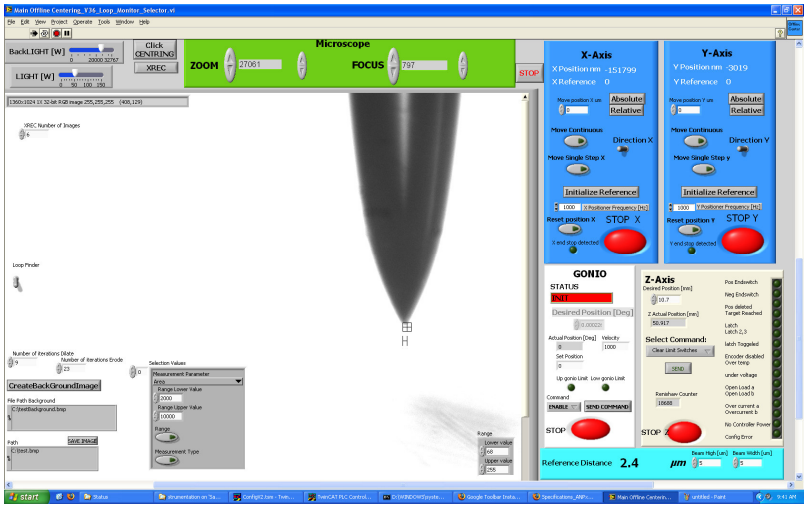
XREC dll running on Labview



XREC example result on a crystal mounted on a cryo-loop: a) Centre of the crystal polygon, b) detected crystal centre: individual 2D detections are corrected to fit a circular trajectory during rotation, c) crystal polygons, d) loop polygons, e) crystal diameter. In this example the difference between the crystal centre and the detected one is 10 µm.

GUI for system commissioning



Labview user interface to commission the system. The tiny 5 µm needle used to calibrate the system is also shown.

Main goals achieved

- Fully automatic crystal centring
- Auto focus capability
- Barcode reader (for identification of barcodes printed on caps and puck)
- Different images processing functionalities
- Automatic crystal illumination
- Feedback loops for experiment control (FPGA)

Future development

- Optimization of XREC for the existing crystal environment conditions
- FPGA feedback loops with beamline hardware monitoring signals
- On axis view

At the start in user operation of the DORIS beamline 7B the users will find a fully automated beamline and with a state-of-the-art automated crystal centring.