Data Acquisition
with 2D Detectors at the ESRF

Laurent Claustre
Sebastien Petitdemange
Emmanuel Papillon
Alejandro Homs-Puron
Roberto Homs-Regajo

on behalf of the
Beamline Control Unit – Software Group
Instrumentation Services & Development Division
ESRF
Talk outline

- Introduction
  - ESRF BL control system
  - 2D detector control
- The LIMA project
  - Goals & Features
  - Detectors & Applications
- Next generation
  - Current limitations - New functionality
  - Foreseen detectors
ESRF BL control system

- Distributed hardware
- TACO/TANGO middleware
- Device servers
- User control workstation
  - Experiment orchestrator
  - SPEC
  - Hardware coordination
  - GUI panels
Controlling 2D detectors

- About 20 different detectors
- High performance PCs
  - 90 - 150 MB/s
- Generic interfaces:
  - SPEC image abstraction
  - TACO/TANGO interface
  - LibCCD
    - Difficult back-port
- Explored areaDetector
  - Intrinsic EPICS dependency
LIMA Goals

- Library for Image Acquisition
- Control system-independent
- Oriented to high-speed detectors
  - Favour the use of detector optimizations
  - Highly multi-threaded
  - Minimize memory copy operations
- Common control functionality
  - Provide software alternatives to “missing” hardware capabilities
- Modular design for simpler integration of extensions
- C++, Python/SIP
Library structure layout

Application

Control Layer
- Display
- Saving
- Accum
- Image
- Acq
- Buffer

Hardware Interface
- DetInfo
- Sync
- Buffer
- Optional
- Rol
- Bin
- Video
Image Reconstruction

- Data readout sequence does not follow real geometry
  - Detector specific
  - Before any other manipulation
Pixel Accumulation

- Limited hardware integration: either in time or capacity

- Detect saturation (each frame) to signal non-linearity
- Intensity threshold ⇒ sensor protection
Image transformations

Photons on detector
Hardware RoI + V.Flip
Software RoI
Rotation
Background sub.
Stripe Concatenation

- High frame rate
- Powder diffraction, imaging and absorption spectroscopy
Data reduction

- Multi-RoI Statistics ⇒ Scalar counters
- Centroid (Beam Position Monitoring)
- Flat-field normalisation
- Image Mask
- Spatial distortion correction
- pyFAI ⇒ Fast Azimuthal Integration in Python
Data saving

• Automatic & manual file saving
  • EDF, CBF
• Different metadata components:
  • Static – detector type
  • Scan – sample name, scan conditions
  • Frame:
    • Internal – timestamp, CPU processing time
    • External – user defined: SR current, monitor intensity
• Data rate
  • 2 – 250 MB/s
Other features

- Basic video interface
  - Common video modes (mono/color)
  - Gain control

- External user processing plug-ins
  - Arbitrary operations
Frame processing & Events

- Hardware interface
  - Software Roi
  - Rotation
  - Background sub.
  - BPM
  - Rol-Count
  - User
  - Display
  - Saving

- Hardware frame ready
- Base frame ready
- Frame ready
- Frame saved
Detectors at the ESRF

- 14 ESRF Frelon
- 14 ESRF Maxipix (Single chip, 2x2, 5x1)
- 10 Dectris Pilatus (300w, 1M, 2M, 6MF)
- 21 Basler
- 3 Prosilica
- 1 IDS uEye
- 2 Andor I-Kon
- 2 XPADE
- 4 PCO.Dimax & Edge
- 2 Perkin Elmer flat panel
- 2 Photonic Science
- 75 Total … and increasing …
LIMA collaboration

- SOLEIL
- PETRA-III / DESY
- FRM-II / TUM
- ALBA
- MAX-Lab
- ADSC
- Rayonix
- CCLRC / STFC
- Nexeya Systems
- ILE/LULI/Ecole Polytechnique
Applications

- In production for about 3 years
  - In more than 20 BLs
- TANGO device servers + SPEC
- Fast imaging & tomography
- Fast spectroscopy & diffraction
- Ptychography
- GISAXS
- Beam Position Viewer & Monitoring
- Sample visualization (microscope)
Current limitations & New Functionality

- Delayed data processing & saving ⇒ dead time between scans
  - Need deferred frame processing
- Buffer memory management:
  - Tracking of frame buffer usage
- Detector per-frame meta-data
- Sinogram (slice concatenation), Azimuthal (polar) RoI counters
- More flexible saving management:
  - Gradual migration to HDF-5 at the ESRF
Foreseen Detectors

- **Legacy:**
  - Sarnoff, Dalsa, Aviex

- **Under development:**
  - Dexela CMOS flat panel
  - XH/XChip3
  - Rayonix HS

- **New:**
  - Pilatus III
  - PSI Eiger
Conclusions

• LIMA is a library for 2D detector control
• Oriented to high performance acquisitions
• Provides common functionality for a variety of detectors
  • Image transformations
  • Data reduction algorithms
• In operation at the ESRF on 20 BLs
• Collaboration community around LIMA
• Developments on new detector plugins and acquisition strategies
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Thank you for your attention!