

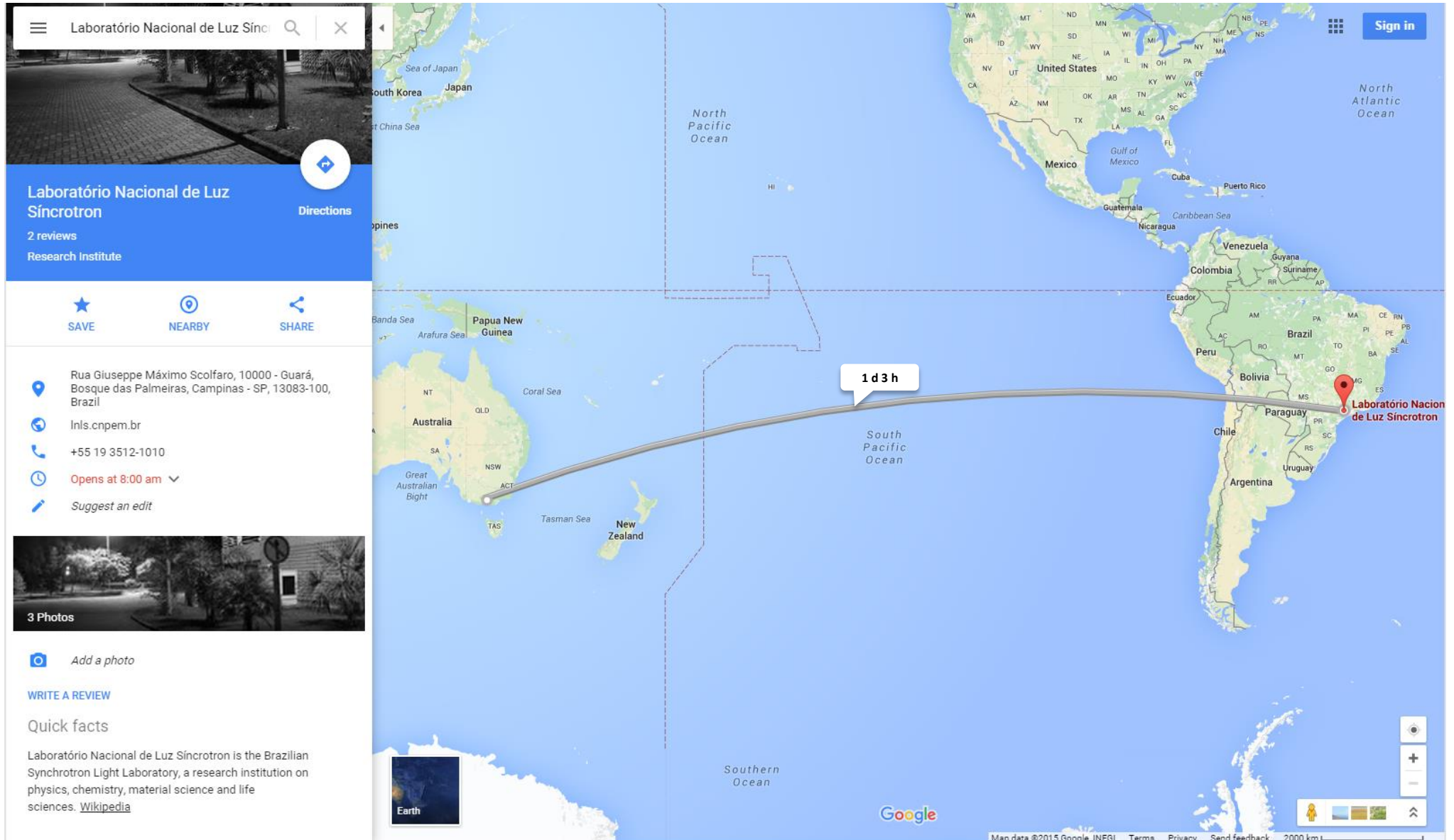


ON-THE-FLY SCANS FOR FAST TOMOGRAPHY AT LNLS IMAGING BEAMLINE

Gabriel B. Z. L. Moreno

X-Ray Imaging Beamline Group, LNLS

Experiment Control, ICALEPCS 2015



Laboratório Nacional de Luz Síncrotron

2 reviews
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Quick facts

Laboratório Nacional de Luz Síncrotron is the Brazilian Synchrotron Light Laboratory, a research institution on physics, chemistry, material science and life sciences. [Wikipedia](#)

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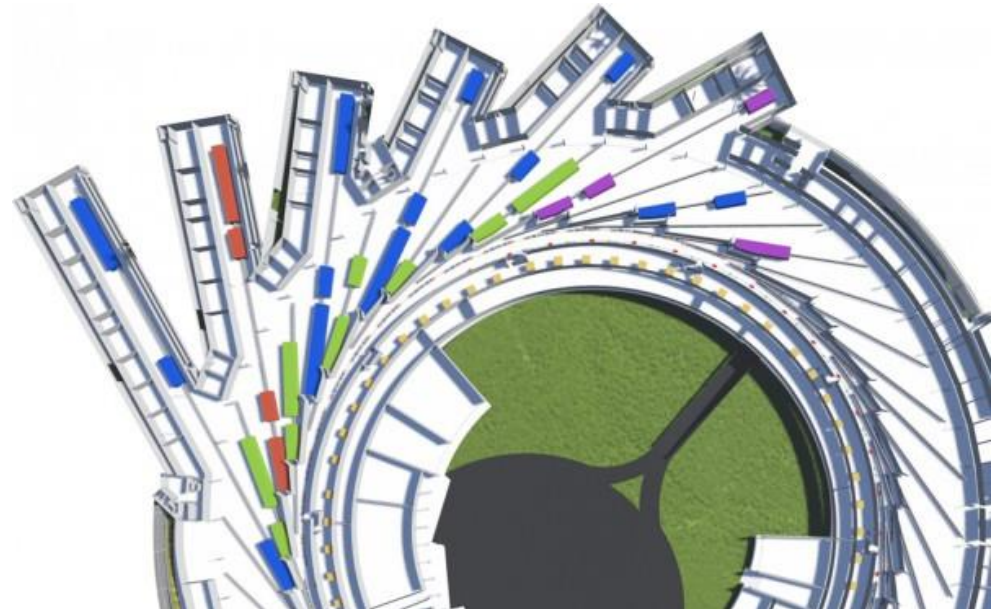




- Future Experiments at Sirius's Imaging Beamline (Mogno)
- Today's LNLS Standards
- Fast Experiment Sequence
- Data Acquisition Architecture
 - Overview
 - CS-Studio Interface
 - Scan Sequencer (Hyppie Module)
 - Galil DMC4183 Implementation
 - Network Considerations for Camera Control PC
- Demo Test and Results
 - Conventional vs HW Point-to-Point
 - Conventional vs Fly-Scan
- Conclusions

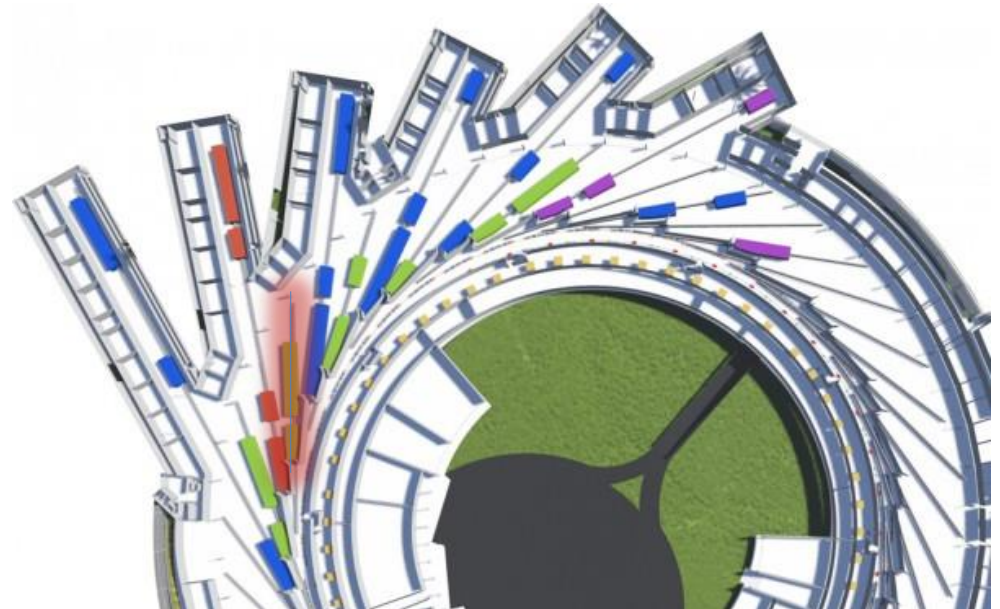
- Mogno (Micro and Nano Tomography Beamline)
 - Beam flux 2 to 3 orders of magnitude higher than IMX
 - Higher energy range (30 to 100 KeV)
 - Nanometric resolution
 - Time-Resolved Experiments!!

- Push for:
 - Better motion systems
 - Faster and More Efficient Detectors
 - Higher Data Throughput Capacity
 - Higher Data Storage Capacity

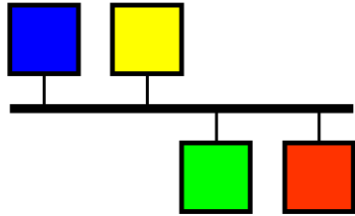


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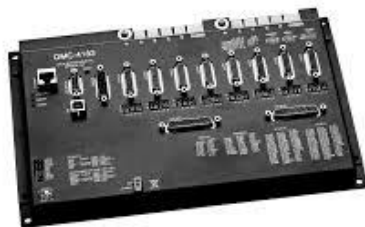


EPICS



EPICS as Middleware for communication over distributed systems

LabVIEW as Development Tool for Drivers and Instrument integration in Driver Level



Galil DMC-4183 as Main Motion Controller For Today's Applications. Even Advanced ones!!

Outer loop Controlled in EPICS Layer

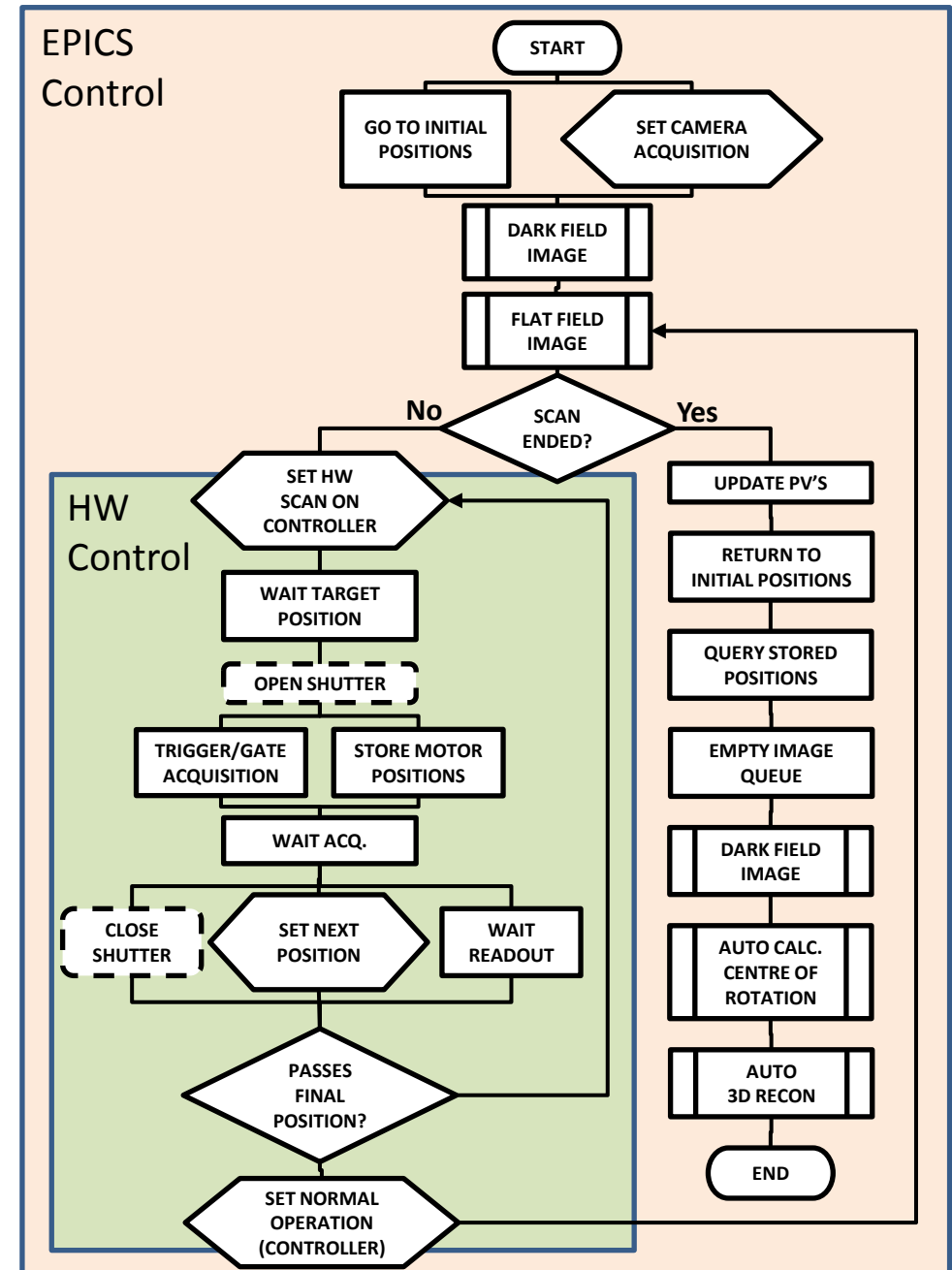
- Single, unrepeated tasks
- Triggering wouldn't affect Performance drastically
- Efficiency enhanced by Automation

Inner Loop Controlled via Hardware

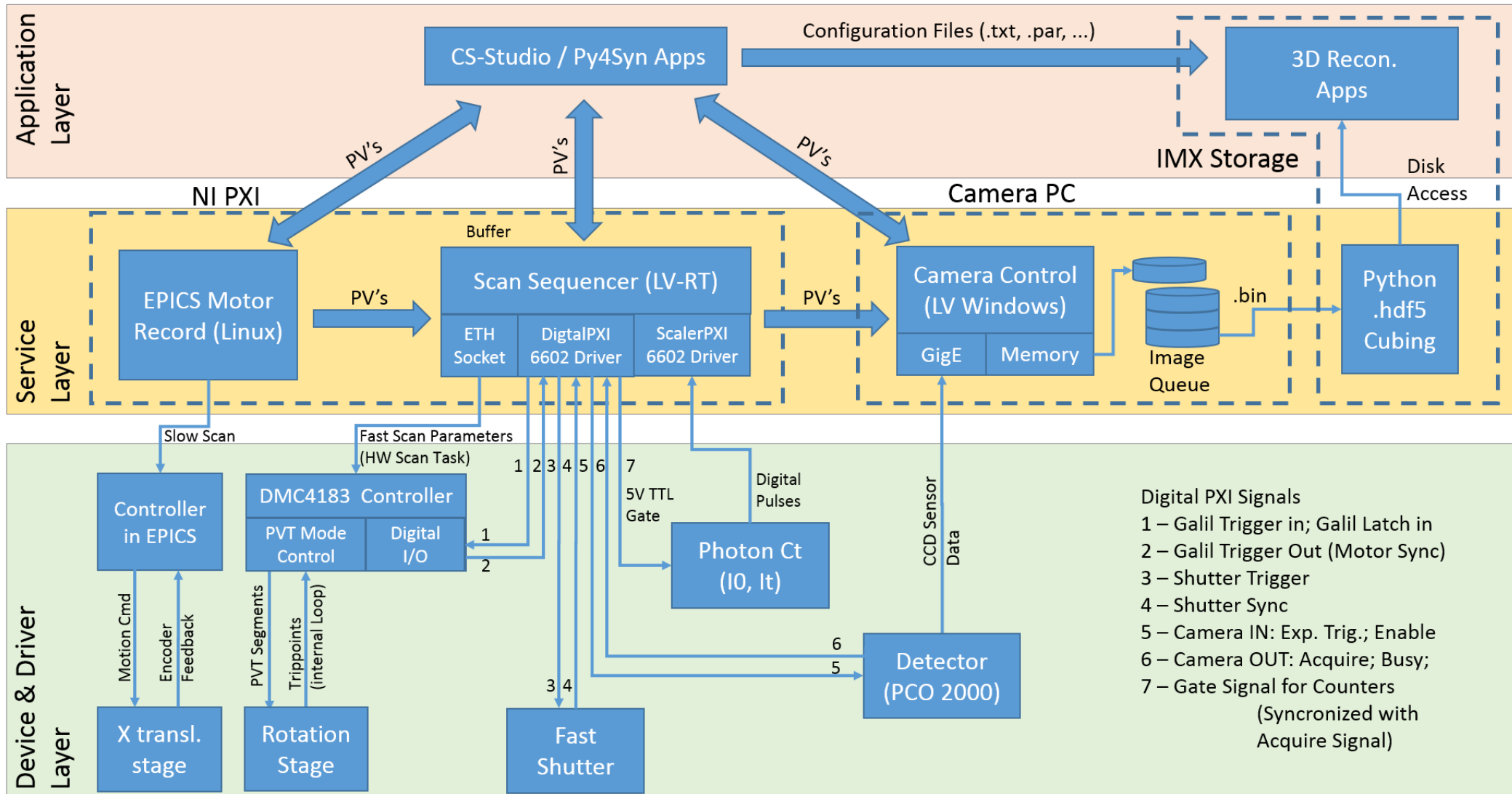
- Sequential, repetitive tasks
- Reduction on Period time impacts directly on experiment duration
- Instruments Triggered by 5V TTL signals

Parallel tasks to HW Control

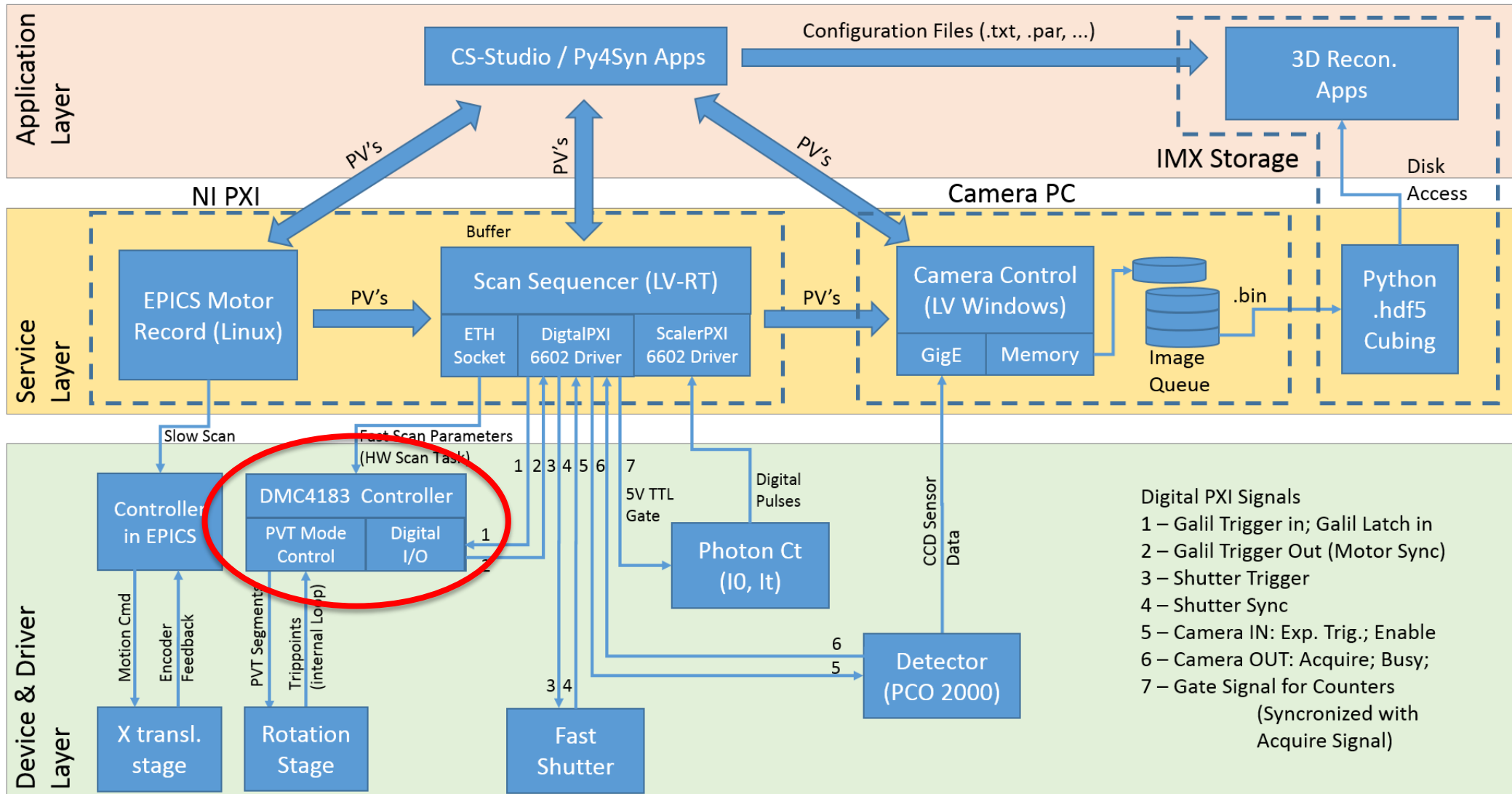
- Wait for images
- Update Motor Positions



Experiment Context Diagram:



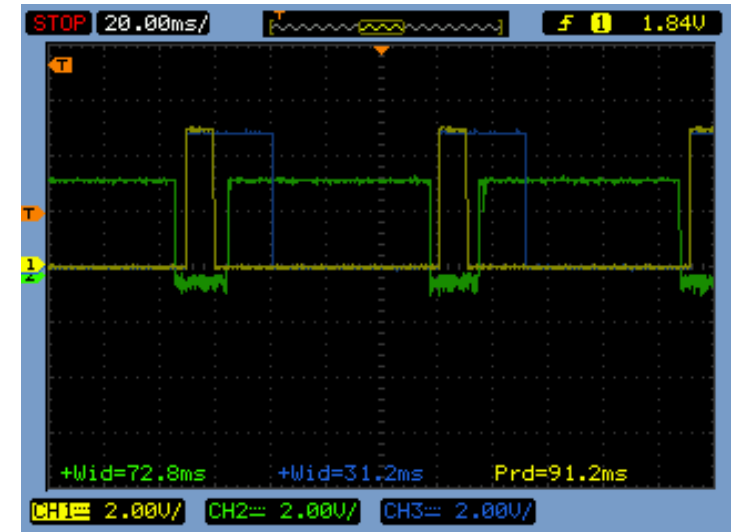
Experiment Context Diagram:



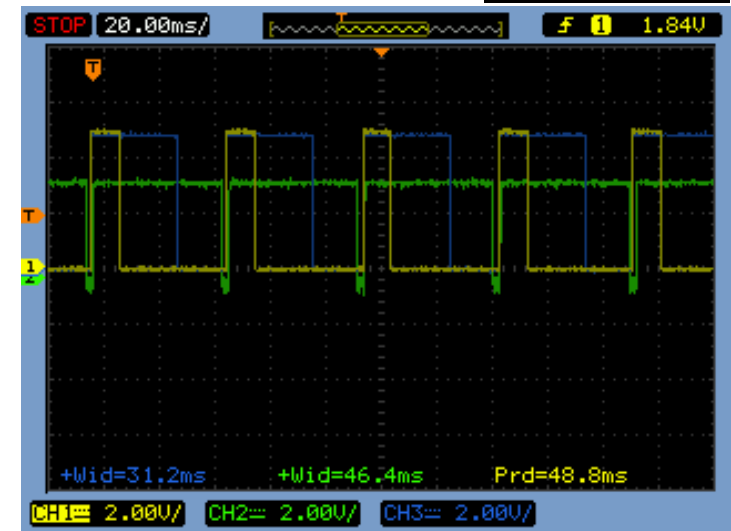
Galil DMC 4183 Implementation:

- Point-To-Point Mode:
 - **Acquisition in charge: Motor as Slave**
 - Wait for Trigger (at the Acq. End) to Move
 - Store Position When receive Trigger (Latch IN)
 - Move Pre-defined Distance (Output Level HIGH)
 - Output LOW when Motion Complete
 - Repeat until the end of Acquisition

- Fly Scan Mode:
 - **Motors in charge: Detectors as Slave**
 - Prepare Trip-points
 - Start Motion Trajectory (Output Level HIGH)
 - Pulse LOW at Trip-point arrival (To Acquire)
 - Store Position When Receive Trigger (Latch IN)
 - Repeat until the end of trajectory



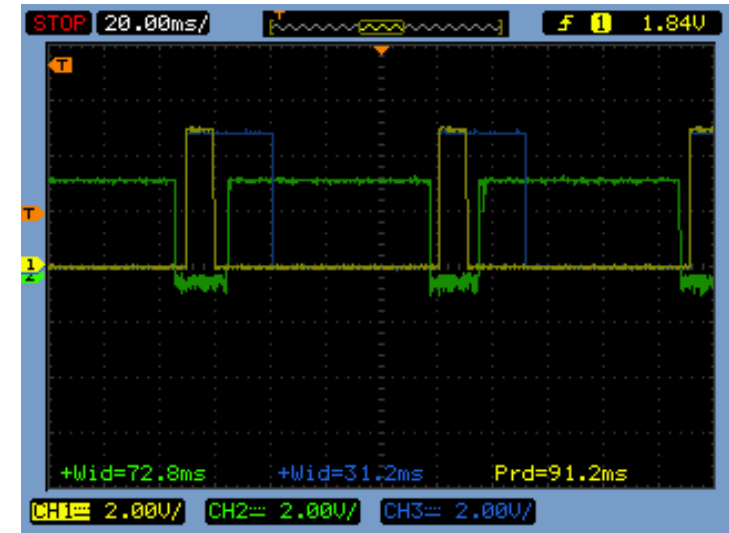
Motor Signal
Exposure Signal
Camera Readout



Galil DMC 4183 Implementation:

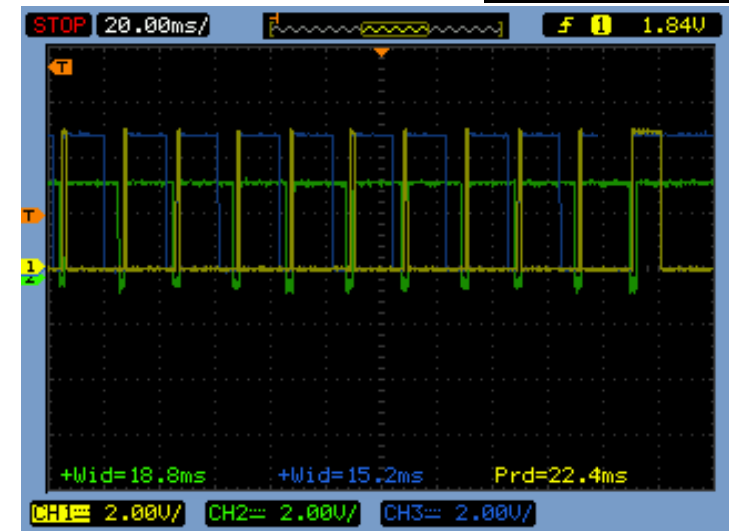
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~50 Hz Capable
with PCO2000!

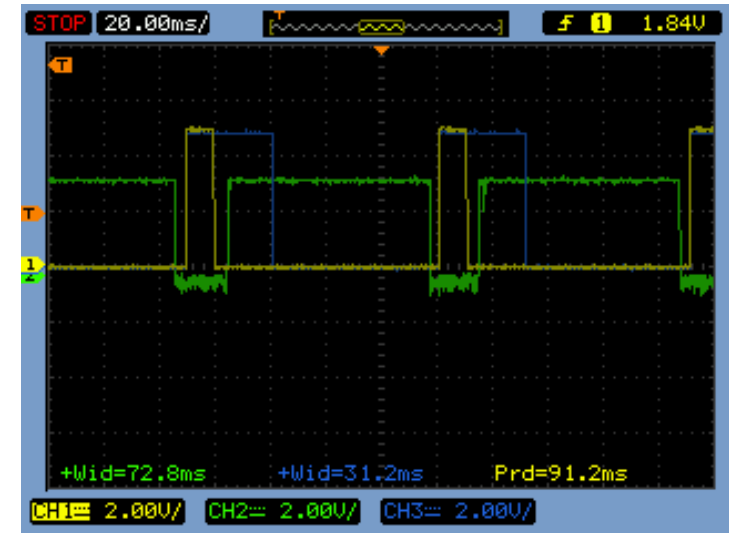
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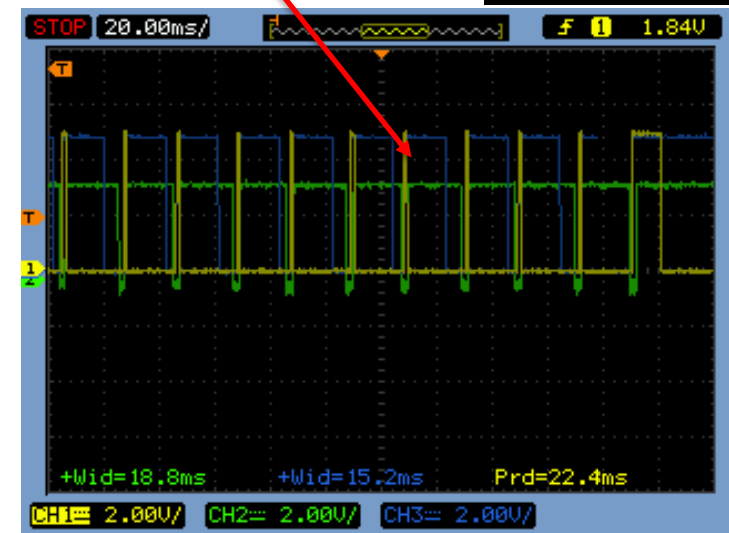
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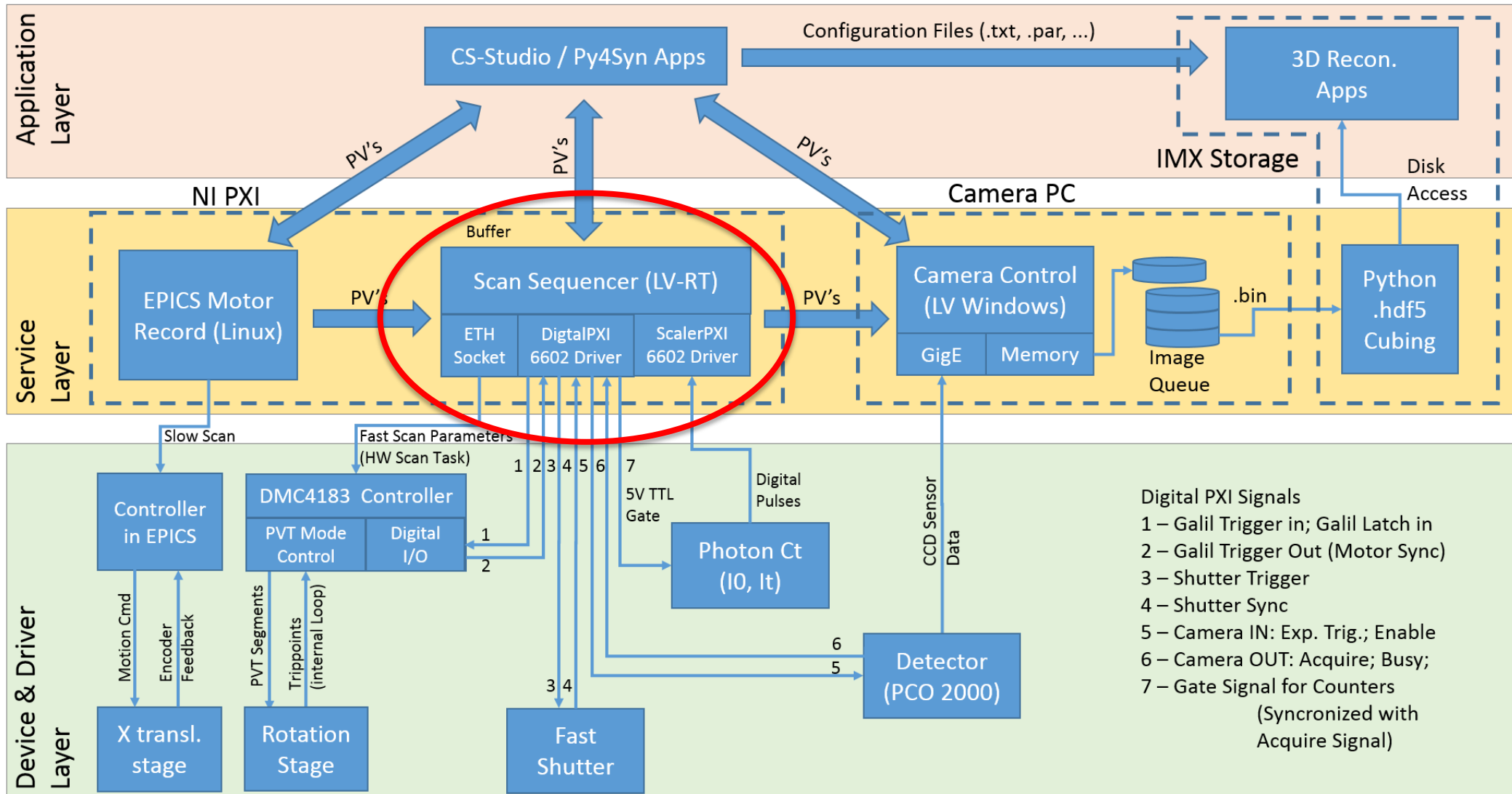


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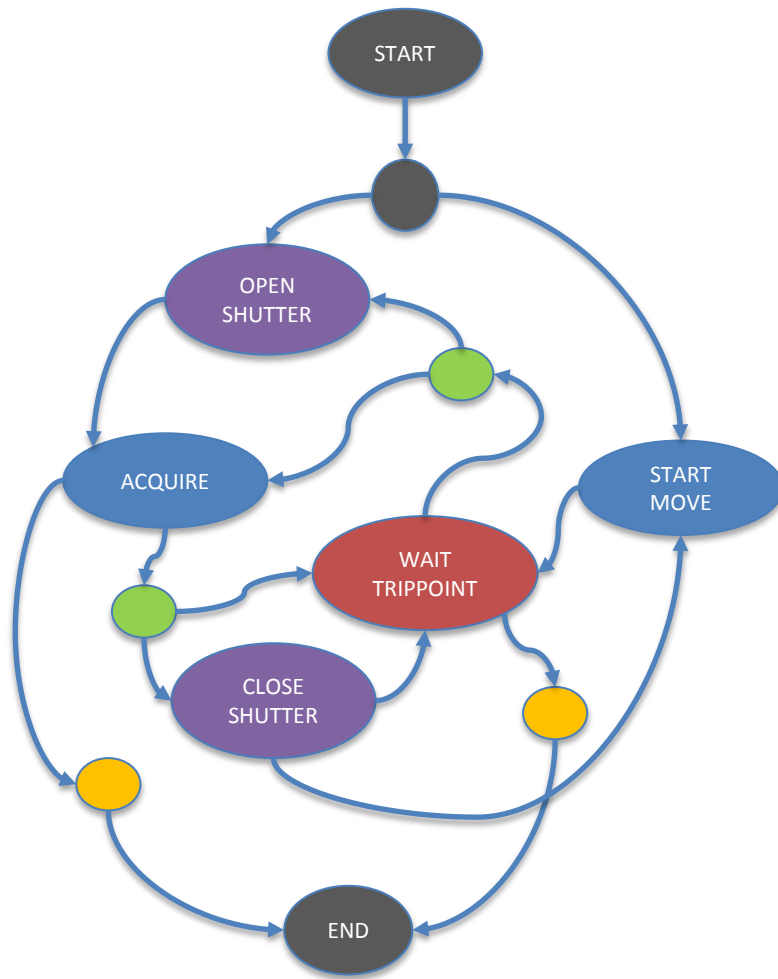
Motor Signal
Exposure Signal
Camera Readout



Experiment Context Diagram:



Scan Sequencer:

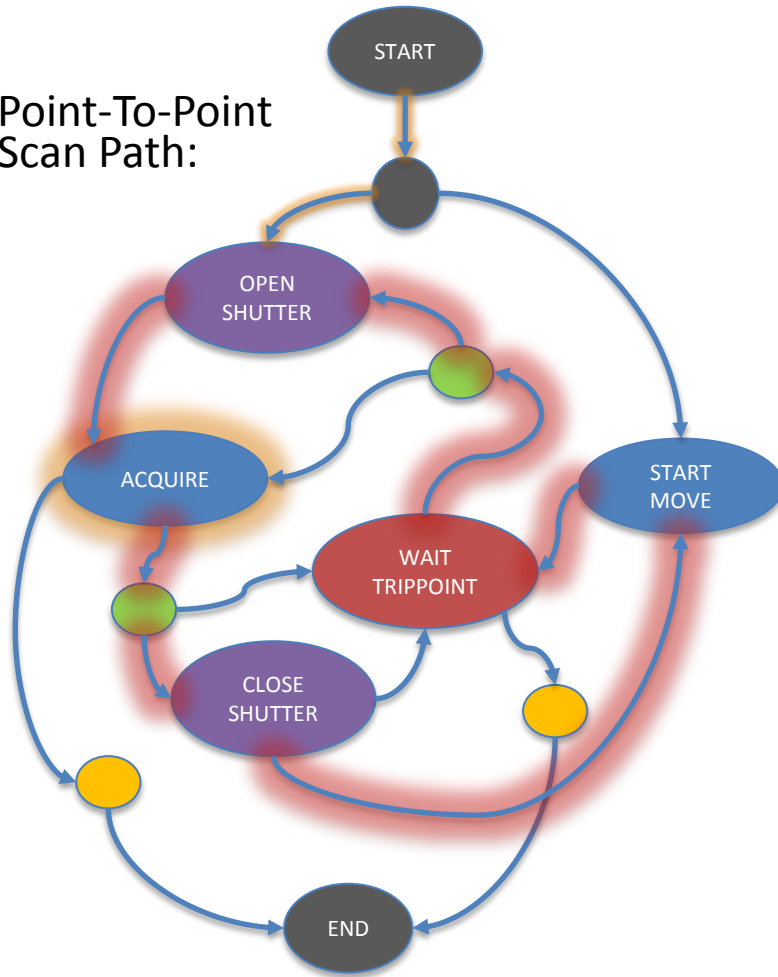


- Runs as Hyppie Module
- State Machine with Pre-programmed sequences
- EPICS communication reduced to Necessary-Only when scanning
- All trigger signals centered on PXI board NI-6602

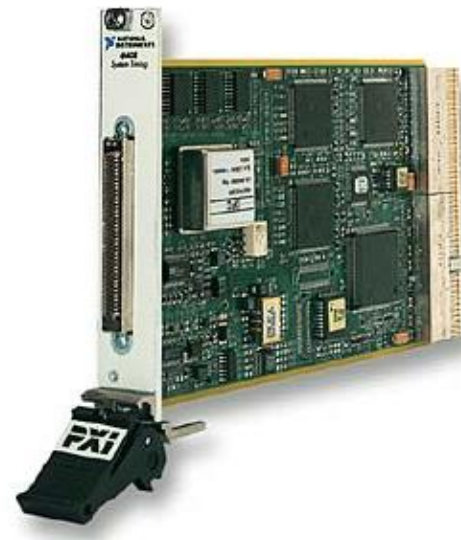


Scan Sequencer:

Point-To-Point
Scan Path:

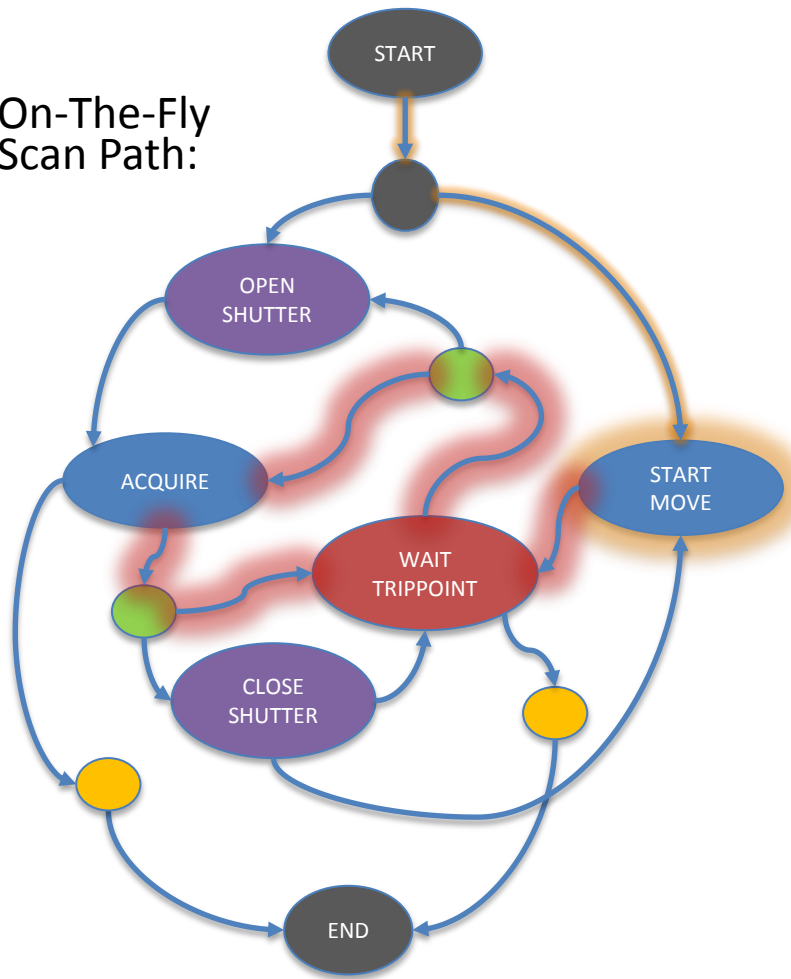


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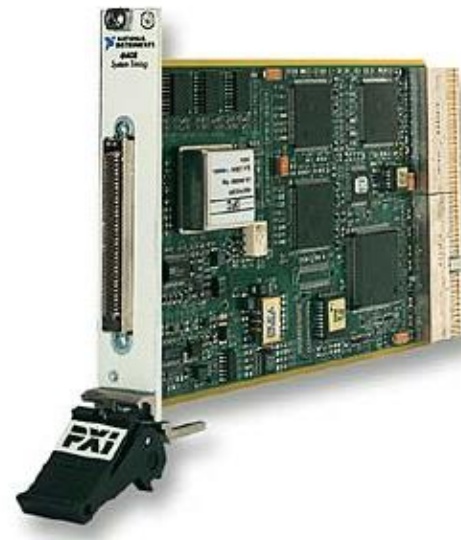


Scan Sequencer:

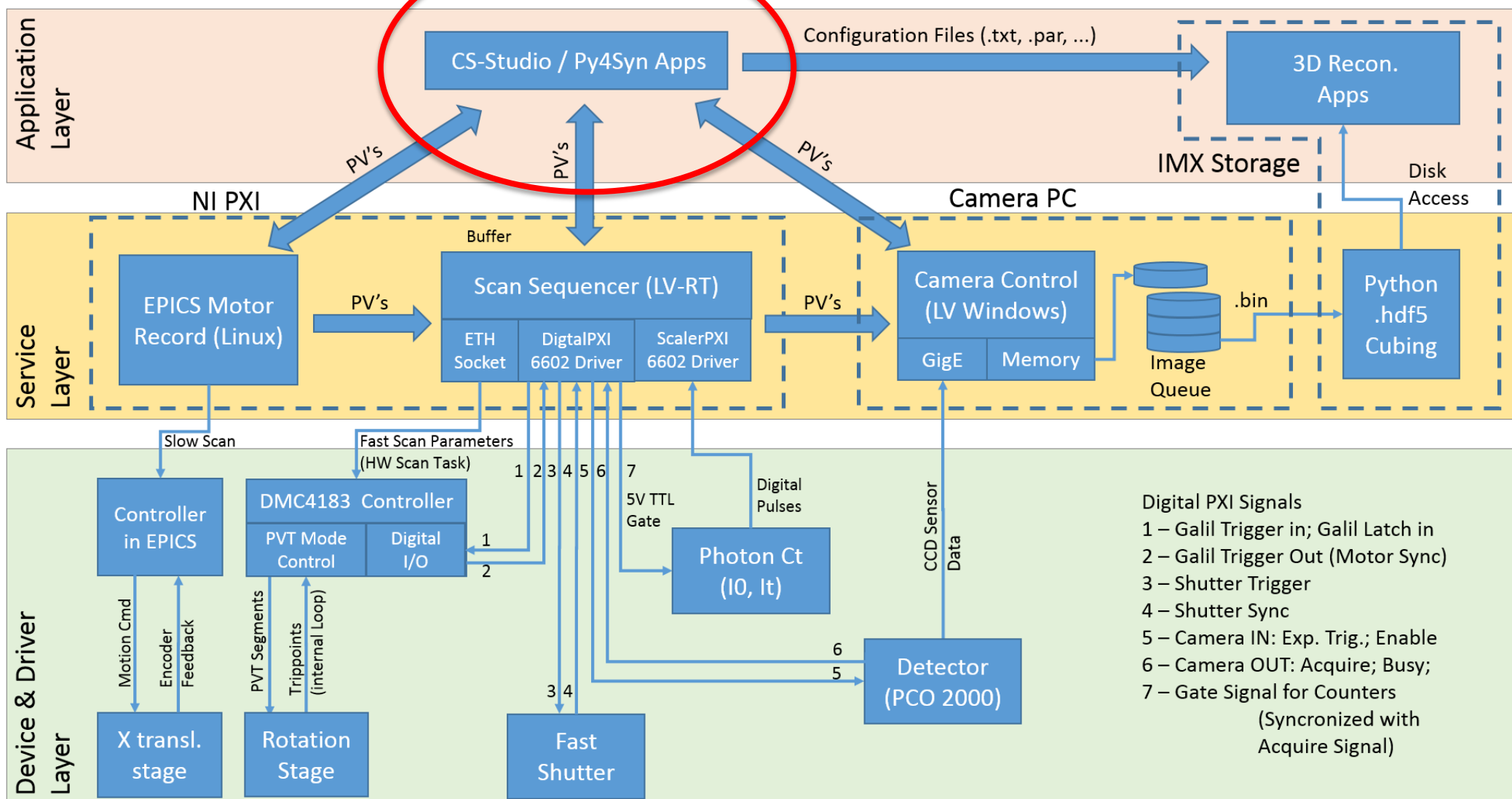
On-The-Fly
Scan Path:



- Runs as Hyppie Module
- State Machine with Pre-programmed sequences
- EPICS communication reduced to Necessary-Only when scanning
- All trigger signals centered on PXI board NI-6602



Experiment Context Diagram:



CS-Studio Screens:

The screenshot displays the CS-Studio control interface, which is organized into several functional areas:

- Navigation and User Interface:** At the top, there are tabs for MICROSCOPE, SAMPLE, SLITS & SCREENS, MONOCHROMATOR, and CONFIG. On the right, there are buttons for SWT Login and Logout.
- WB Slits (Wide Slits):** This section includes controls for the F.Superior motor (positioned at 2.000 mm), F.Dir (positioned at -0.000 mm), F.Esq (positioned at 0.000 mm), and F.Inf (positioned at 2.000 mm). It also features sync controls for Horizontal, Vertical, and Sync ALL, with gap and offset settings.
- Mono Slits:** This section includes controls for the M.Superior motor (positioned at 4.000 mm), M.Dir (positioned at 2.000 mm), M.Esq (positioned at 2.000 mm), and M.Inf (positioned at 2.000 mm). It also features sync controls for Horizontal, Vertical, and Sync ALL, with gap and offset settings.
- Scanning:** This section allows for setting scan parameters such as Scan Type, Start (-0.5), Time (1.0), Counter (0), Finish (0.5), and Steps (5.0). It includes a Scan button and a STOP button.
- Information Panel:** Located on the right side, it displays system status for Gamma, Hutch, Beam, Energy (0), Current (0), and Lifetime.
- Experiment Control:** This panel contains buttons for New Experiment, New Sample, Snap, Corrected, Align Sample, and Tomography.
- Setup Panel:** Located at the bottom right, it includes buttons for Focus and Align Camera.
- Temperature and Level Controls:** At the bottom left, there are controls for T_{set} (0 Deg), T_{int} (0.00 Deg), Level (0), and Pump (0).
- Console:** A console window at the bottom left shows system logs, including the message "Starting Tomo - 2015-10-11 17:38:12.322048" and "Preparing Auto Tomo".

CS-Studio Screens:

The screenshot displays the CS-Studio control interface, which is divided into several functional areas:

- Top Navigation:** Includes tabs for MICROSCOPE, SAMPLE, SLITS & SCREENS, MONOCHROMATOR, and CONFIG. It also features 'SWT Login' and 'Logout' buttons.
- Microscope Control Panel (Left):**
 - Rotation:** A control panel with a 'Rotation' button, a position display showing '-0.749 mm', and a 'STOP' button.
 - Focus:** A control panel with a 'Focus' button, a position display showing '-0.361 mm', and a 'STOP' button.
 - Objective Control:** A panel with buttons for 'Remove Objective', 'Return Objective', and 'Run AutoFocus'.
 - Pixel Size:** A display showing a value of '0.82'.
- 3D Schematic (Center):** A 3D model of the experimental setup with labeled components: 'User Control Camera', 'Sample Tab', 'Monochromator Tab', 'Slits Tab', and 'Experimental Hutch Camera'. It also shows detector positions: 'Detector Y' at '15.20000 mm' and 'Detector Z' at '82.00000 mm'.
- Right Panel:**
 - Information:** Status indicators for Gamma (green), Hutch (green), Beam (red), Energy (0), Current (0), and Lifetime (-).
 - Experiment Control:** Buttons for 'New Experiment', 'New Sample', 'Snap', 'Corrected', 'Align Sample', and 'Tomography'.
 - Setup:** Buttons for 'Focus' and 'Align Camera'.
- Console (Bottom):** A 'BOY Console' window showing system messages: 'Starting Tomo - 2015-10-11 17:38:12.322048' and 'Preparing Auto Tomo'.

CS-Studio Screens:

The screenshot displays the CS-Studio software interface, which is divided into several functional panels:

- Monochromator:** Features a 3D model of the monochromator assembly. Controls include 'Mono Pitch' (0.93V, -0.1995 deg, 2.76V), 'Mono Roll' (1.67V, -0.2820 deg, 3.85V), 'Mono Y' (10.5mm, -1.5mm, 3.6000 mm), and 'Crystal Sel'. Temperature gauges for 'Motor Temp-22', 'Si Temp-20', and 'ML Temp-20' are also present.
- Scaler:** Includes a 'Motor' control, 'Start' (-0.1), 'Time' (1.0 s), 'Delay' (0.000 s), 'Count', and 'Scan' buttons. A 'Shutter' control and 'Finish' (0.1), 'Steps' (5.0), 'Counter' (0), 'Cont', and 'STOP' buttons are also visible.
- Energy:** A 'Select K-Edge:' section with buttons for SC, TI, V, CR, MN, FE, CO, NI, CU, ZN, GA, GE, AS, SE, BR, and KR.
- Stanford SR570:** A control panel for the detector, including 'FILTER' (No filter), 'GAIN MODE' (LOW NOISE), 'INPUT OFFSET' (OFF, +, 1, pA), and 'SENSITIVITY' (50, uAV).
- Information and Experiment Control:** A vertical sidebar on the right containing status indicators for Gamma, Hutch, Beam, Energy, Current, and Lifetime. Below this are 'Experiment Control' buttons: New Experiment, New Sample, Snap, Corrected, Align Sample, and Tomography. A 'Setup' section includes Focus and Align Camera buttons.

At the bottom, a console window shows the following text:

```

BOY Console
Starting Tomo - 2015-10-11 17:38:12.322048
Preparing Auto Tomo
  
```

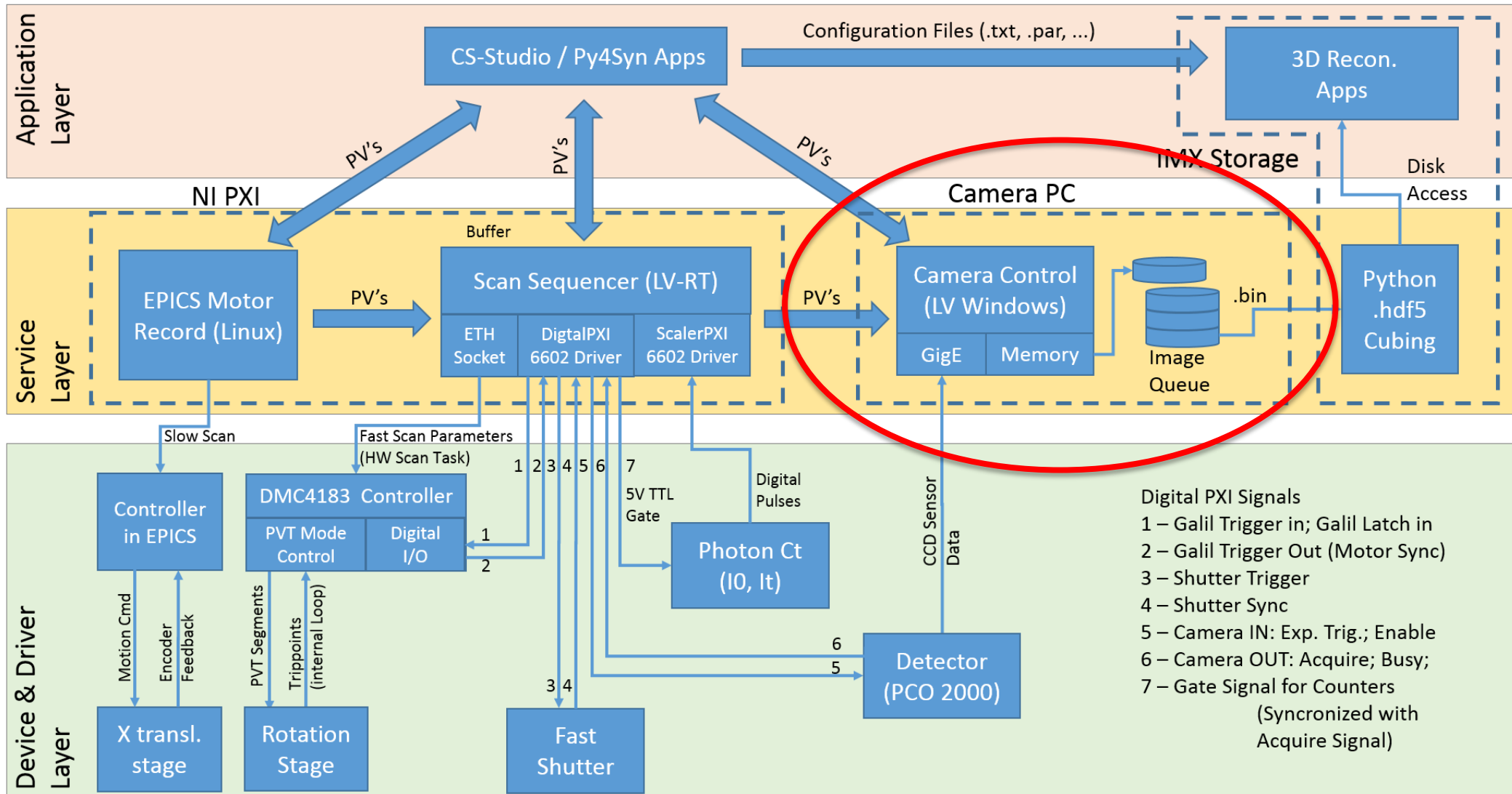
CS-Studio Screens:

The screenshot displays the CS-Studio control interface, which is organized into several functional panels:

- Microscope Panel:** Features a 'WhiteBeam Microscope' section with an 'Effective Pixel Size' of 1.64. It includes a 'Filters' section with four filter settings (1. Si 350um, 2. Si 350um, 3. Si 350um, 4. Si 200um) and a 'Shutter' control.
- Sample Stage Panel:** Controls the 'Sample Yaw' motor, showing absolute and relative movement values. It also displays 'Sample X' (9.4797 mm) and 'Sample Y' (-23.6385 mm) positions.
- Camera Control Panel:** Manages 'Exposure Time' (3 ms), 'Delay Time' (0 ms), and 'Acquisition' (Start/Stop). It includes '2 ADC's' (True/False), 'Noise Filtering' (True/False), and 'Double Image' (True/False) options. Binning is set to 2x8.
- Detector Stage Panel:** Controls 'Camera Rotation' (-0.7486 mm), 'Detector Z' (82.000 mm), 'Detector Y' (15.200 mm), and 'Focus' (-0.3610 mm). A 'Profile Image' is also available.
- Information Panel (Right):** Displays status for Gamma, Hutch, Beam, Energy, Current, and Lifetime.
- Experiment Control Panel (Right):** Contains buttons for 'New Experiment', 'New Sample', 'Snap', 'Corrected', 'Align Sample', and 'Tomography'.
- Setup Panel (Right):** Includes 'Focus' and 'Align Camera' buttons.
- Console (Bottom):** Shows a 'BOY Console' with the message: 'Starting Tomo - 2015-10-11 17:38:12.322048 Preparing Auto Tomo'.

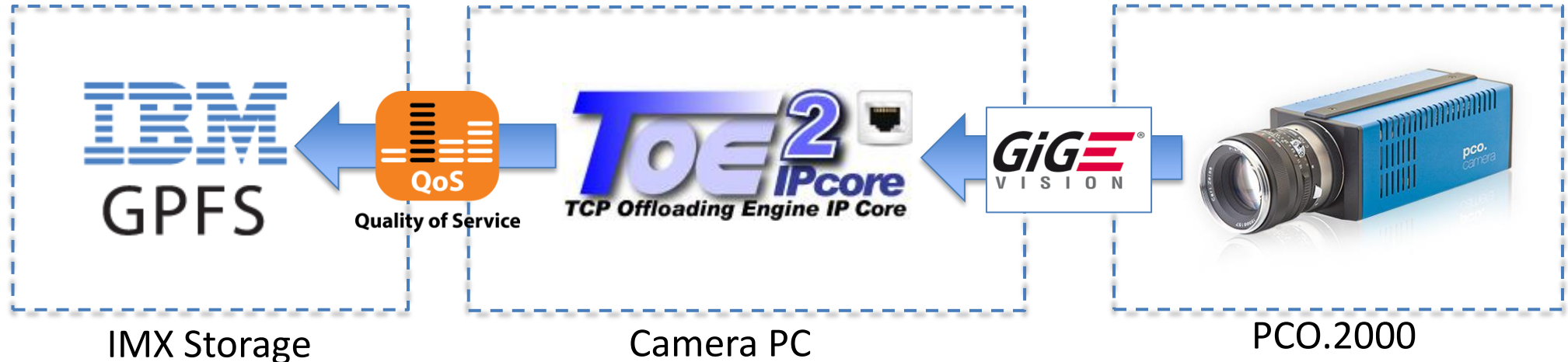
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Experiment Context Diagram:



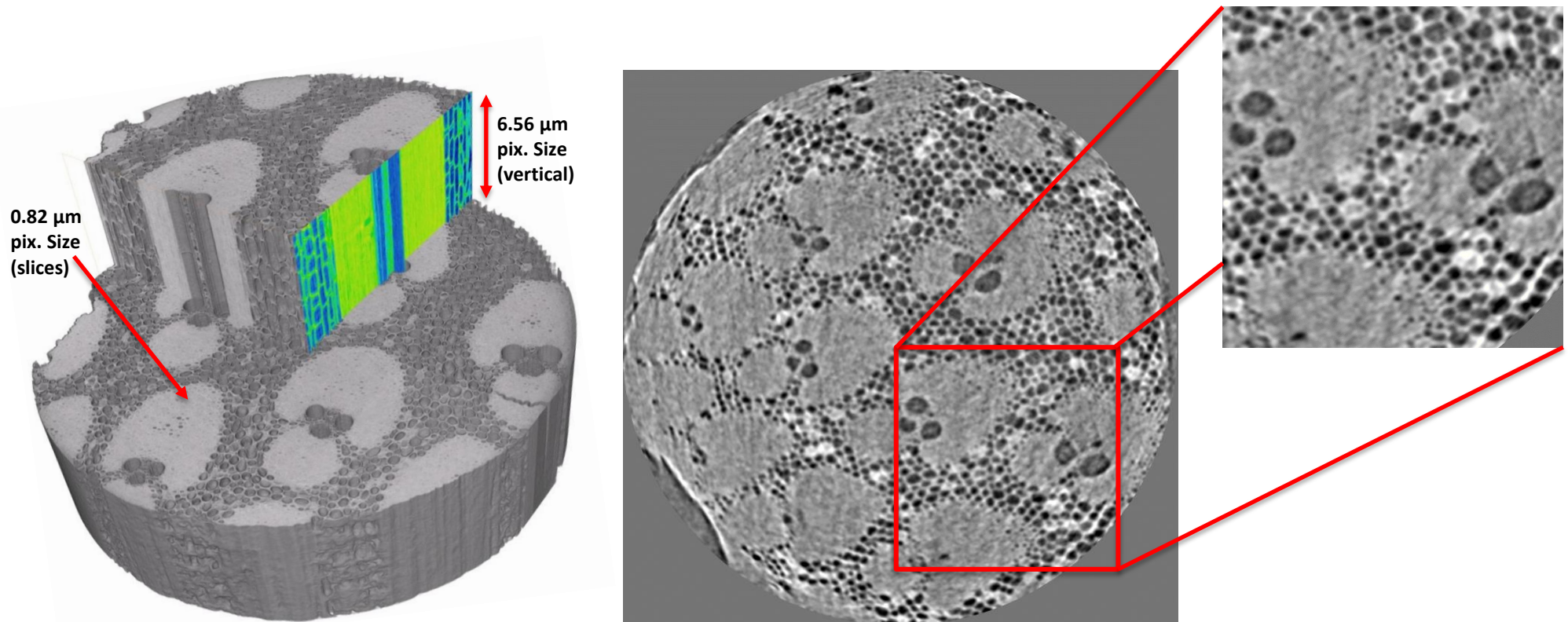
Network Considerations for Camera Control PC:

- Network configuration for Big Data: Jumbo Package Size and Big Coalescence Buffers
- TOE board from Camera to Camera PC
- QoS configuration at all switches until the Storage
- GPFS Storage (Cost-Effective Scalability!!)
- Data Processing done by storage location mounting

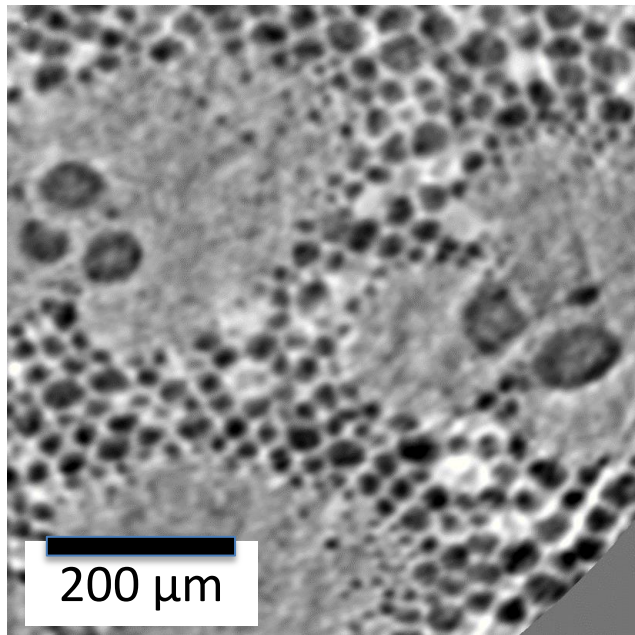


Low Resolution Demo Experiment:

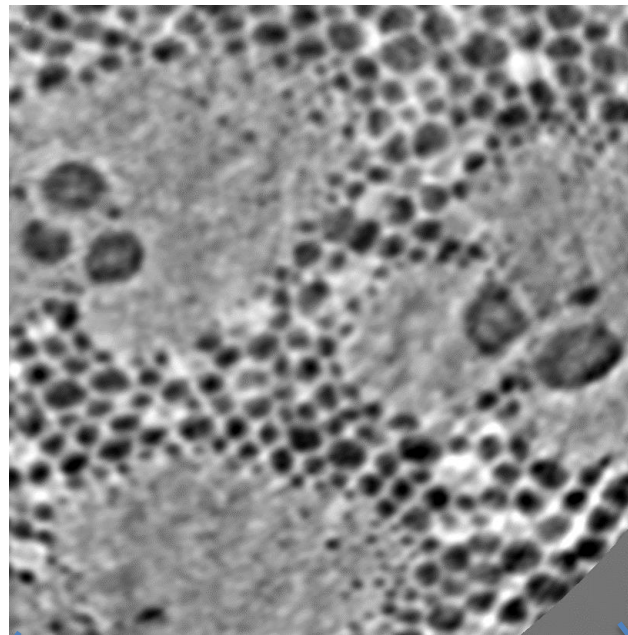
- 1000 Projections, 10 ms exposure time of Bamboo Toothpick
- 2048x256 images, with 1x8 binning (0.82x6.56 microns pixel size)
- Continuous, Point-to-Point, and On-The-Fly Acquisition Modes
- 20 Hz Acquisition, 200 Mb/s data transfer for On-The-Fly Scan



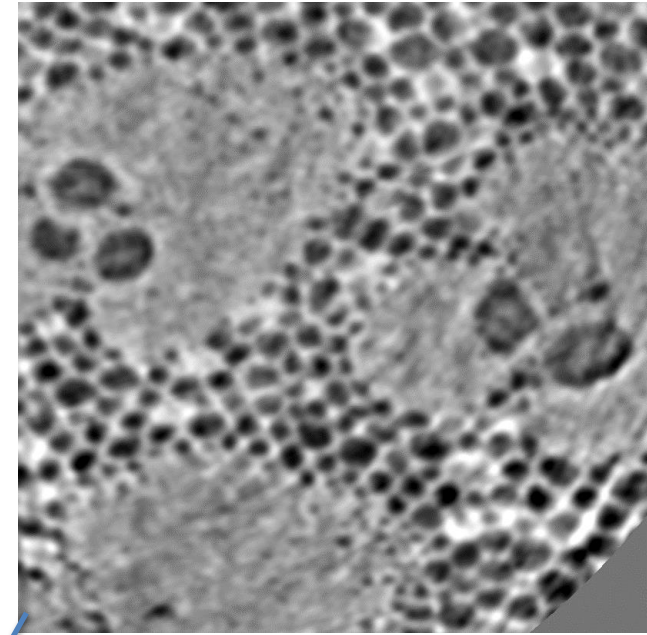
Results



HW Pt-to-Pt (88 sec)



Conventional (8.5 min)

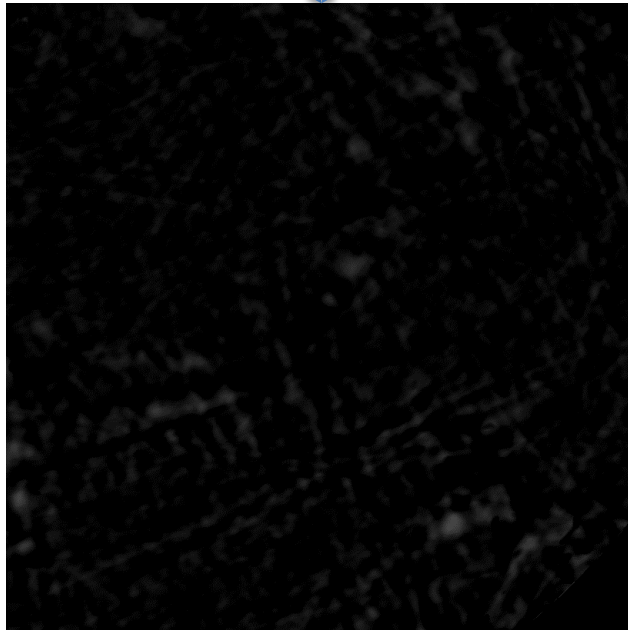


On-the-Fly (49 sec)

~6x Faster!

~10x Faster!

Conventional
minus
HW Pt-to-Pt



Conventional
minus
On-The-Fly



- Reduced Beamtime per user
- Low Res. 4D Tomography Possible at IMX Beamline
- System Capability proved in the unitary millisecond range
- System derivations and Other advanced Developments at LNLS:
 - XRF Beamline: Mapping Scans **ICXOM'15**
 - PGM Beamline: Undulator and Monochromator ad-hoc Continuous Energy Scans **ICALEPCS'15 MOCRAF**
 - SAXS1 Beamline: Experiment Automation **ICALEPCS'15 MOPFG057**
- System Scaling and Upgrades:
 - Faster and More Precise Rotation Stages
 - Faster and More efficient Detectors
 - Continuous Improvement to Hyppie
 - Continuous Improvement to the network capacity

Acknowledgments

IMX Beamline Staff:

Frank O'Dowd;

Eduardo Miqueles;

Nathaly Archilha;

Mateus Cardoso;

Other Contributions:

GAE Group, LNLS;

SIL Group, LNLS;

SOL Group, LNLS;

Harry Westfahl Jr.

