Laboratório Nacional de Luz Síncrotron

CNPEM Centro Nacional de Pesquisa em Energia e Materiais

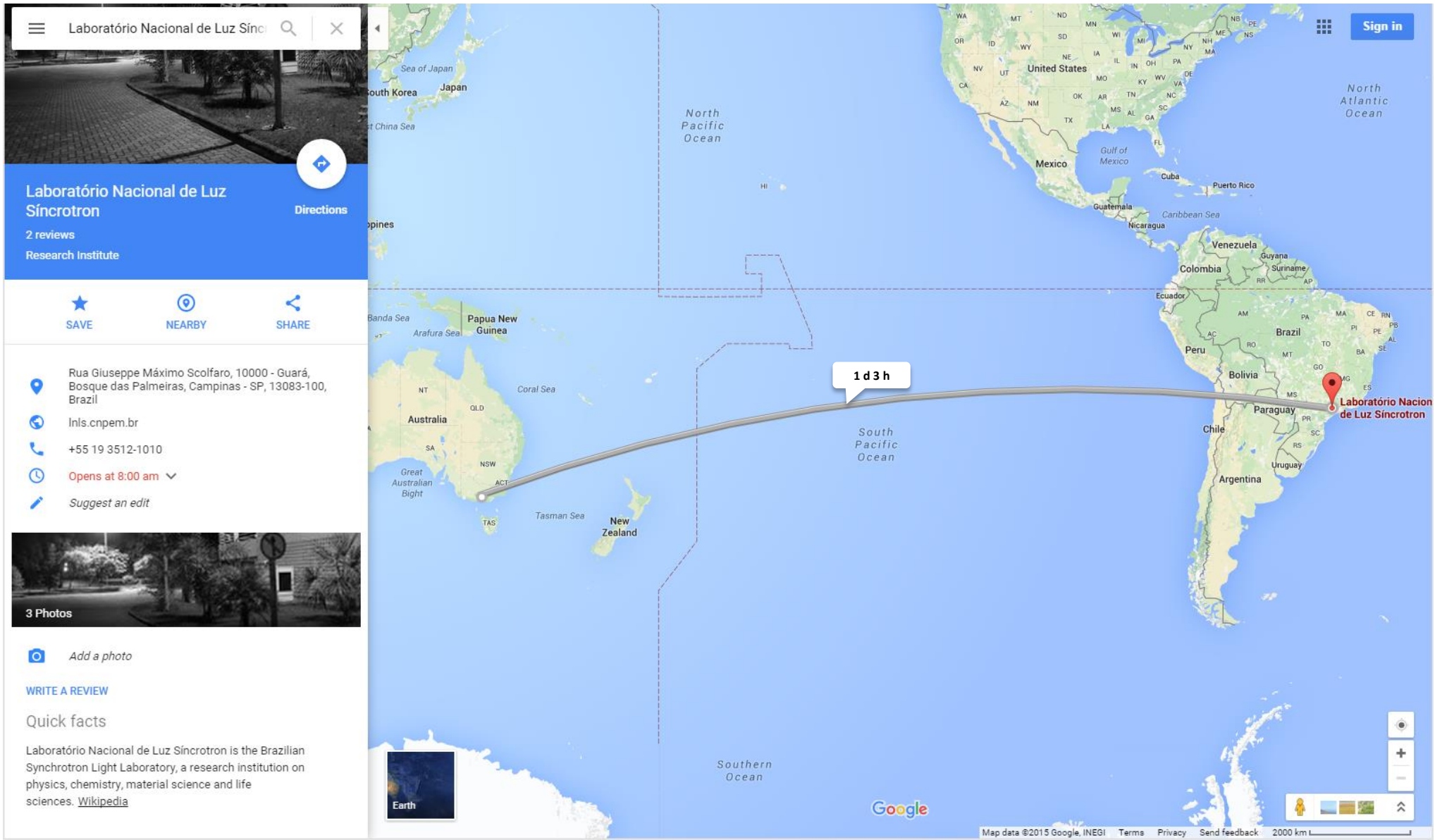
2015 ICALEPCS melbourne • australia

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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Sirius Construction Site (July'15)

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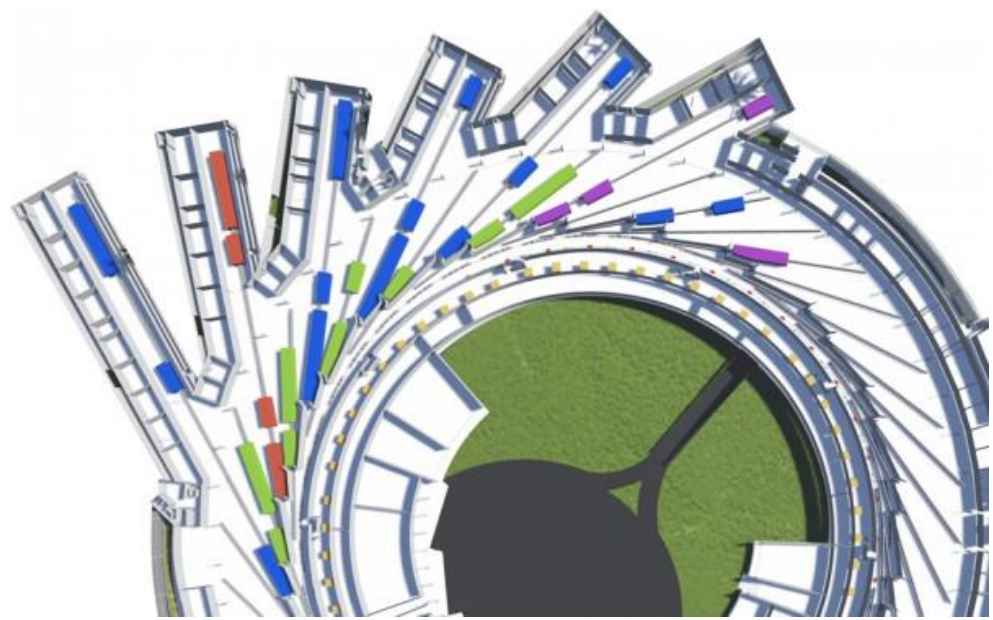
Outline

- 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

Future Experiments at Sirius

- 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



Sirius Storage Ring Schematics with first Beamlines: Available at [http://lnls.cnpem.br/sirius/beamlines/]

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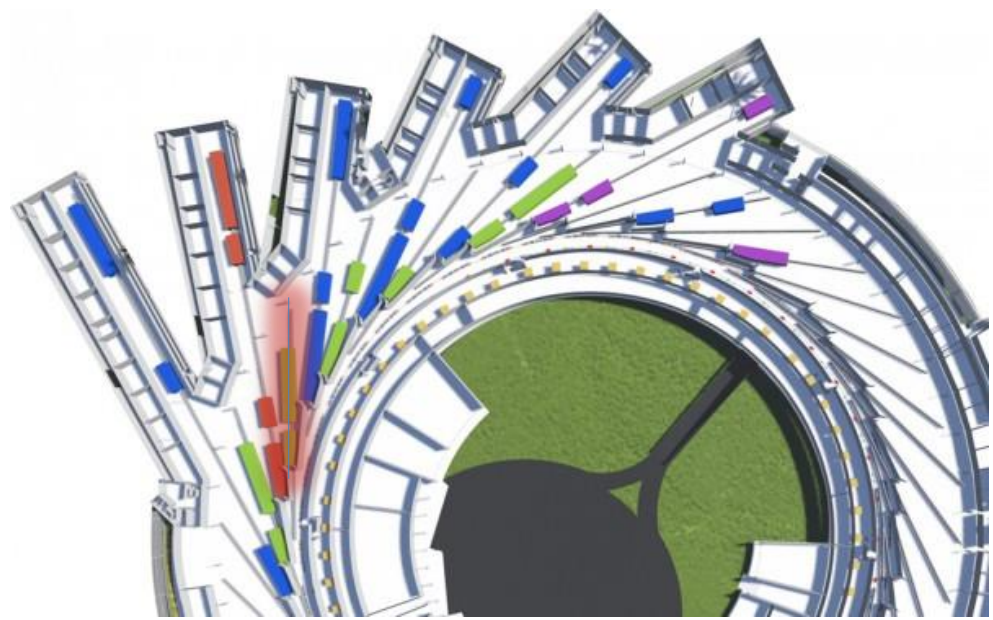

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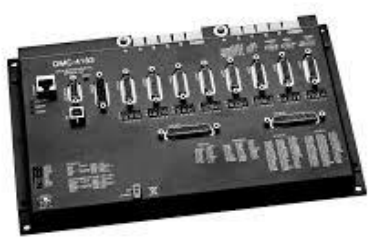
Today's LNLS Standards

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!!

Fast Experiment Sequence

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

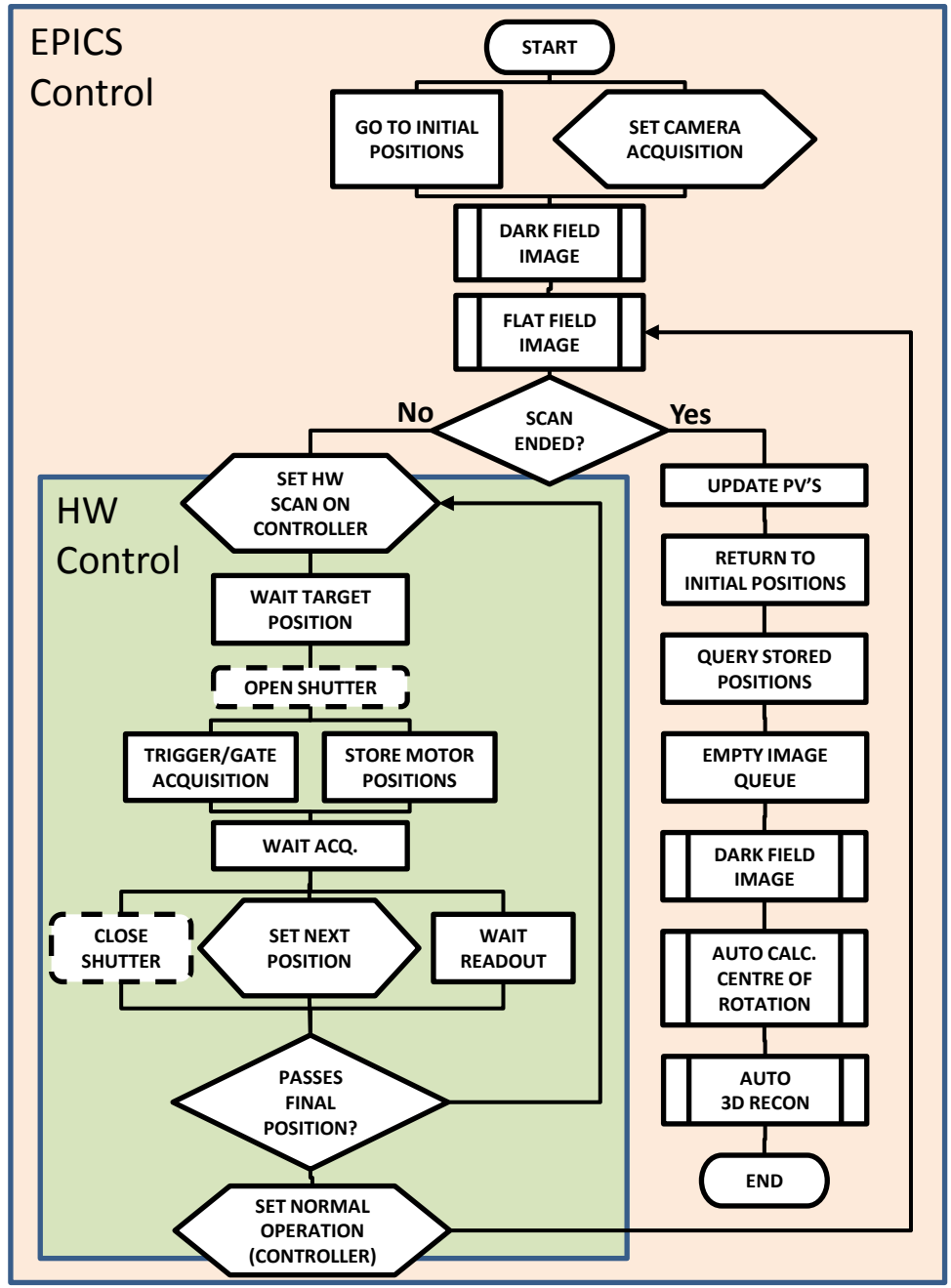
- Reduction on Period time impacts directly on experiment duration

- Instruments Triggered by 5V TTL signals

Parallel tasks to HW Control

- Wait for images

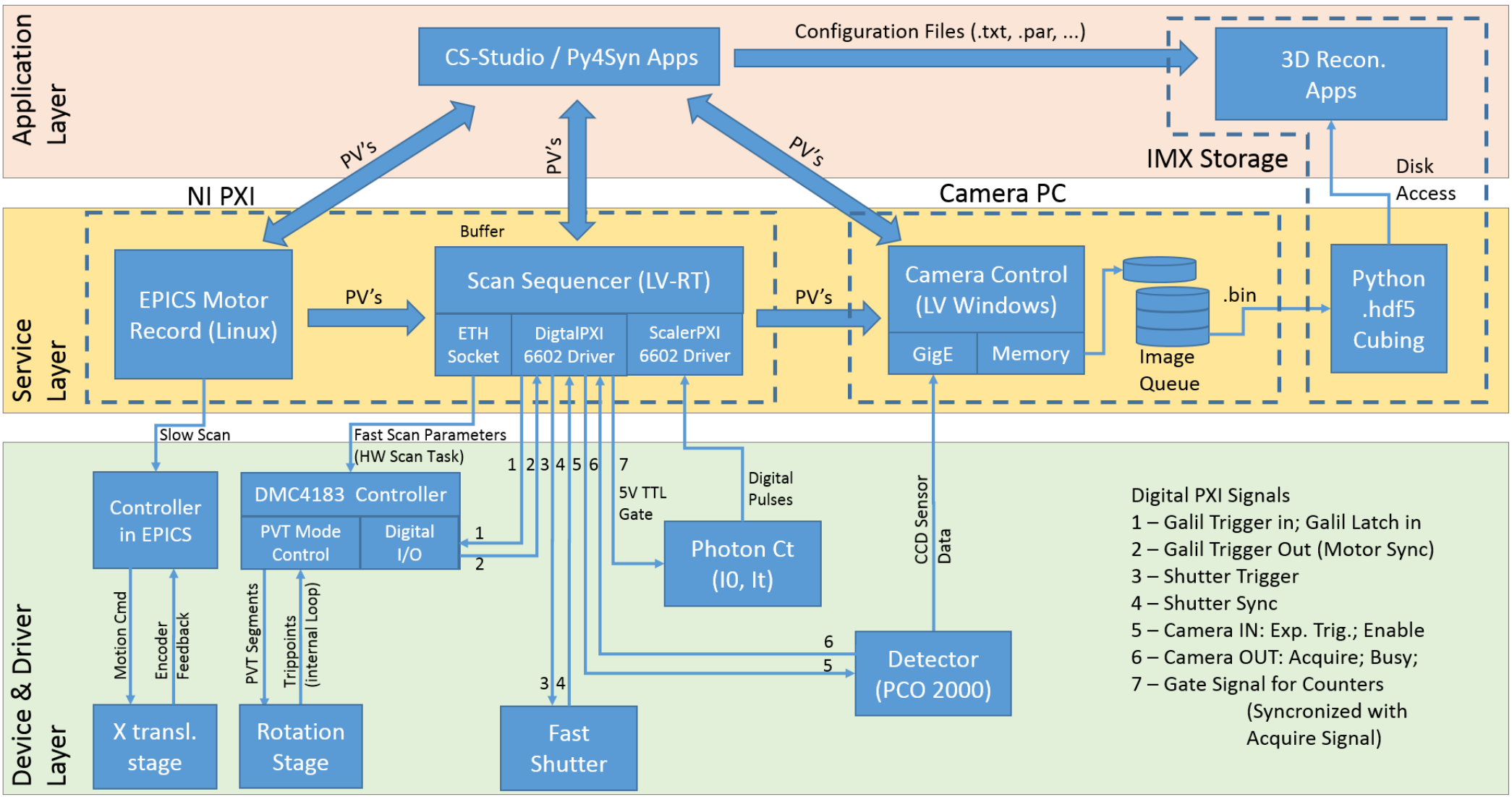
- Update Motor Positions



Moreno, G.B.Z.L., et al., "On-the-Fly Scans For Fast Tomography at LNLS Imaging Beamline", ICALEPCS 2015, Melbourne, VIC, Australia, THHB3O03

System Architecture

Experiment Context Diagram:



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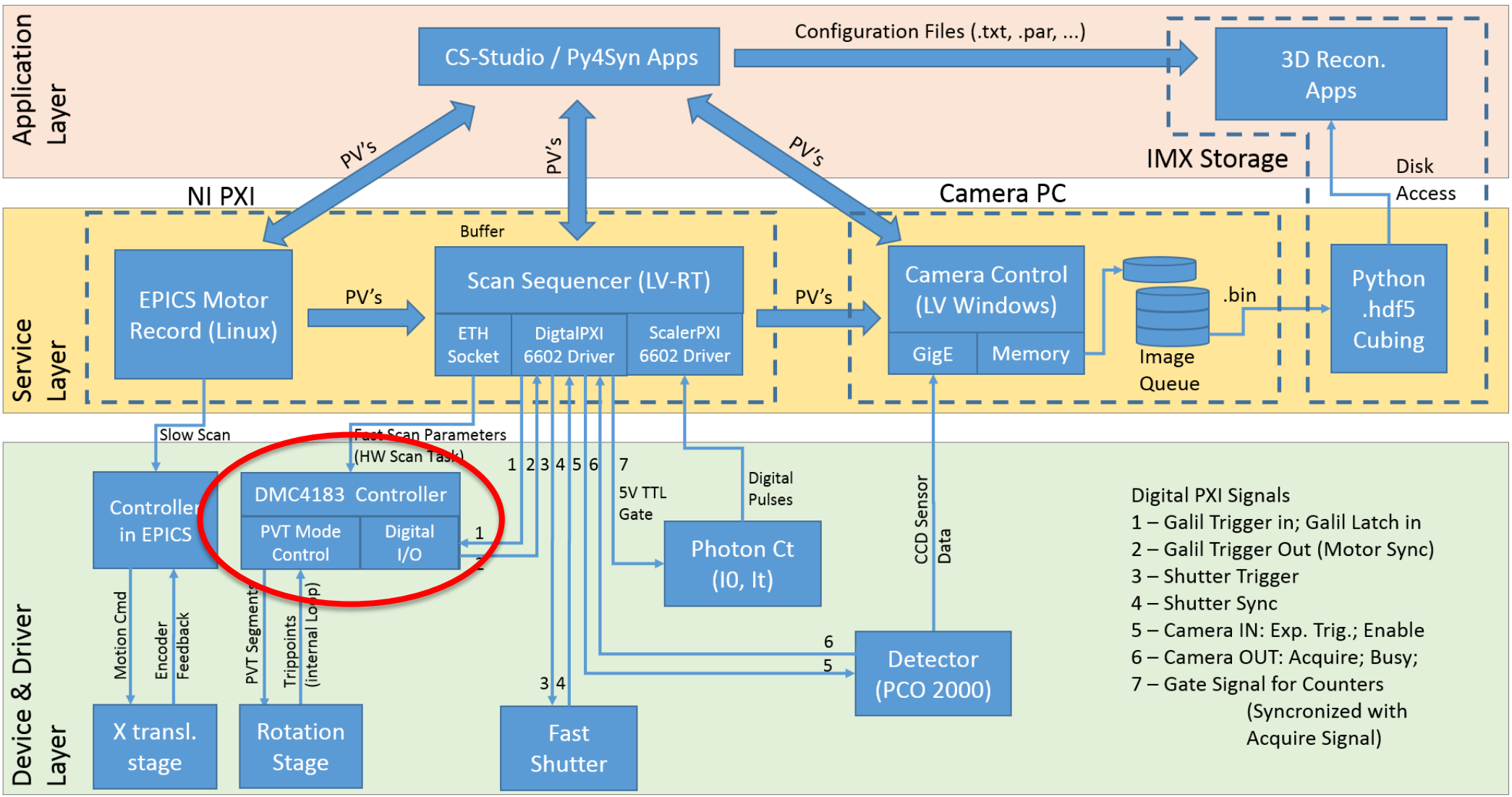

System Architecture

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)
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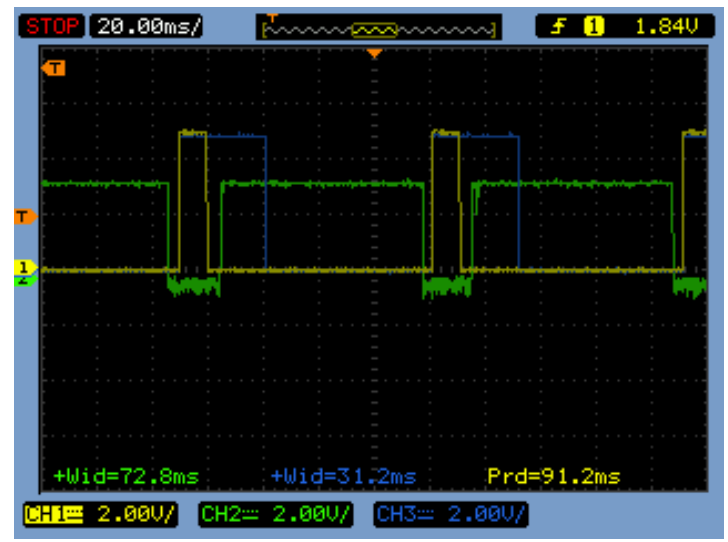
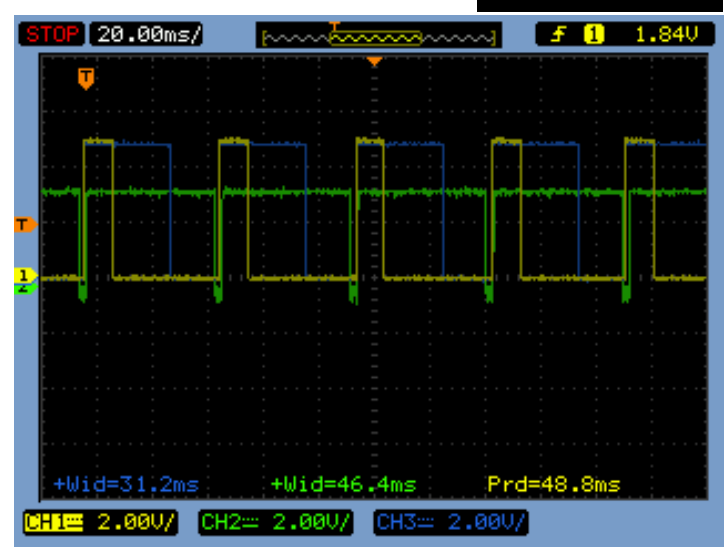


Motor Signal
Exposure Signal
Camera Readout



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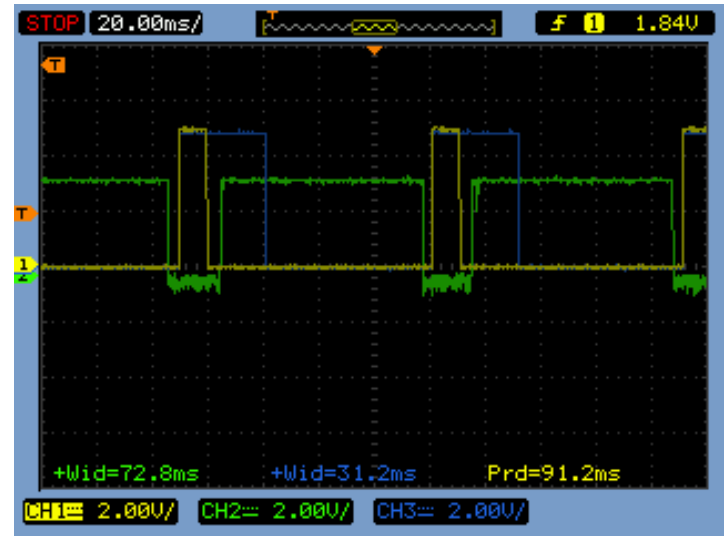
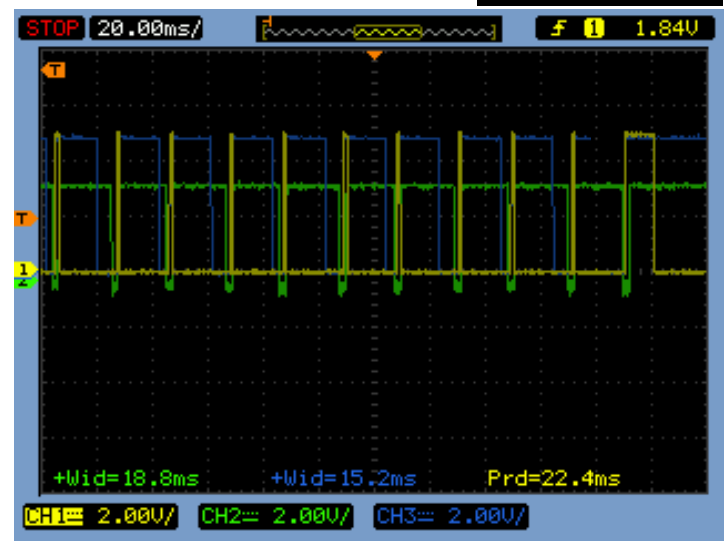


~50 Hz Capable with PCO2000!

Motor Signal
Exposure Signal
Camera Readout



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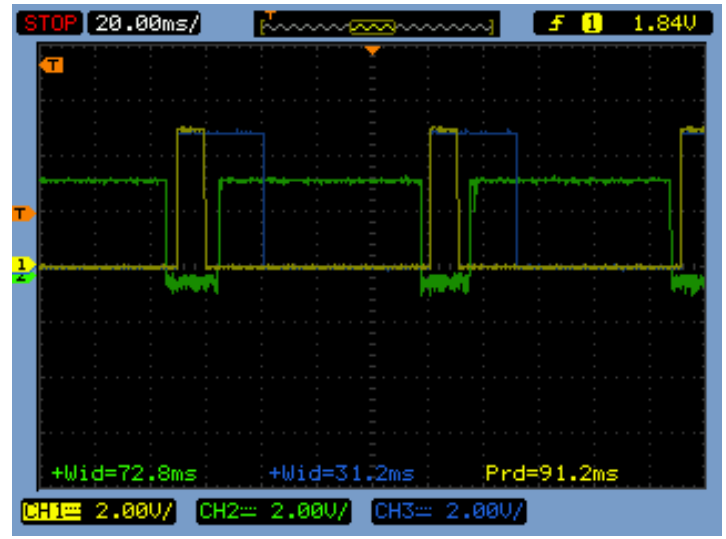

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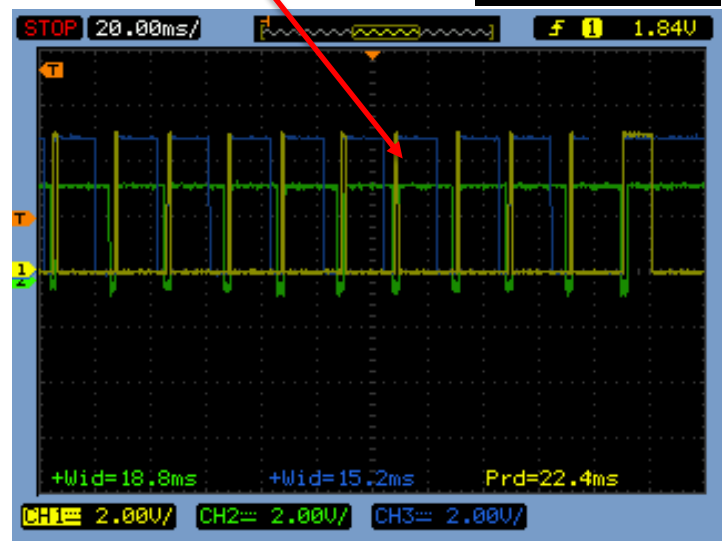

System Architecture

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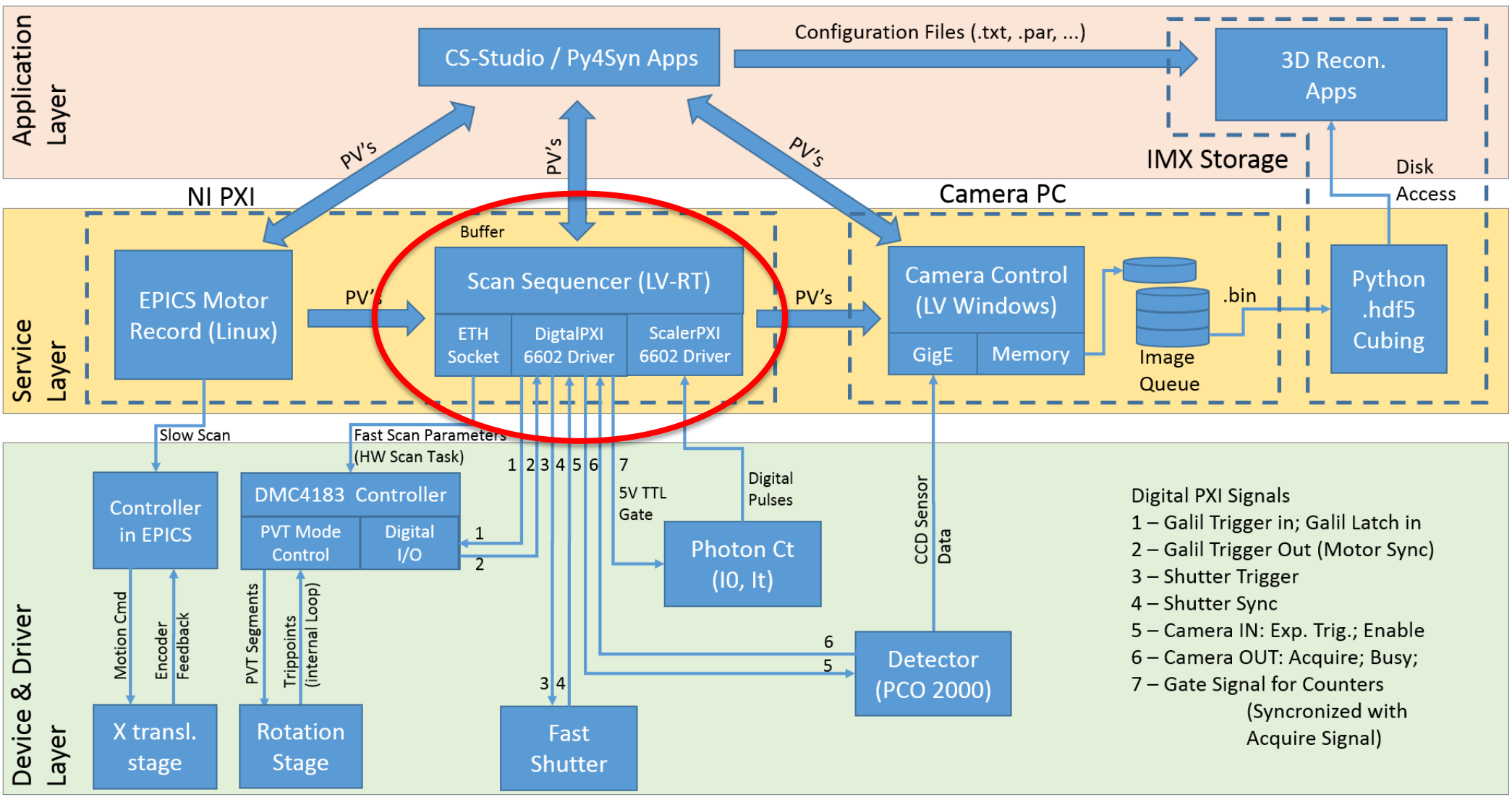
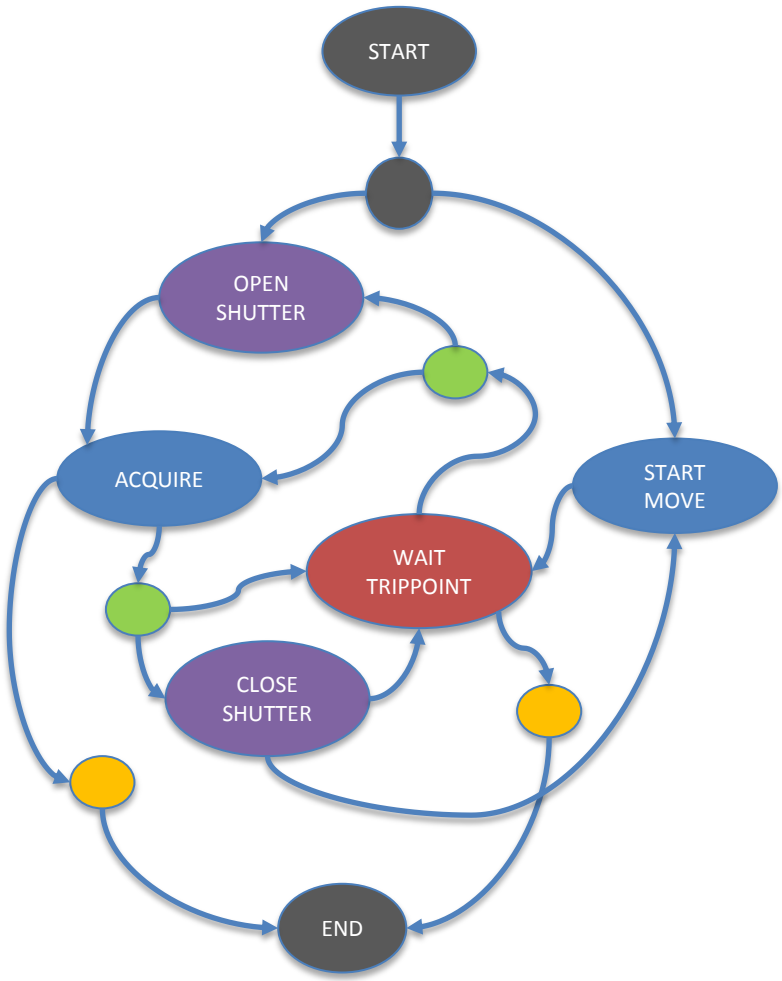


System Architecture

Scan Sequencer:

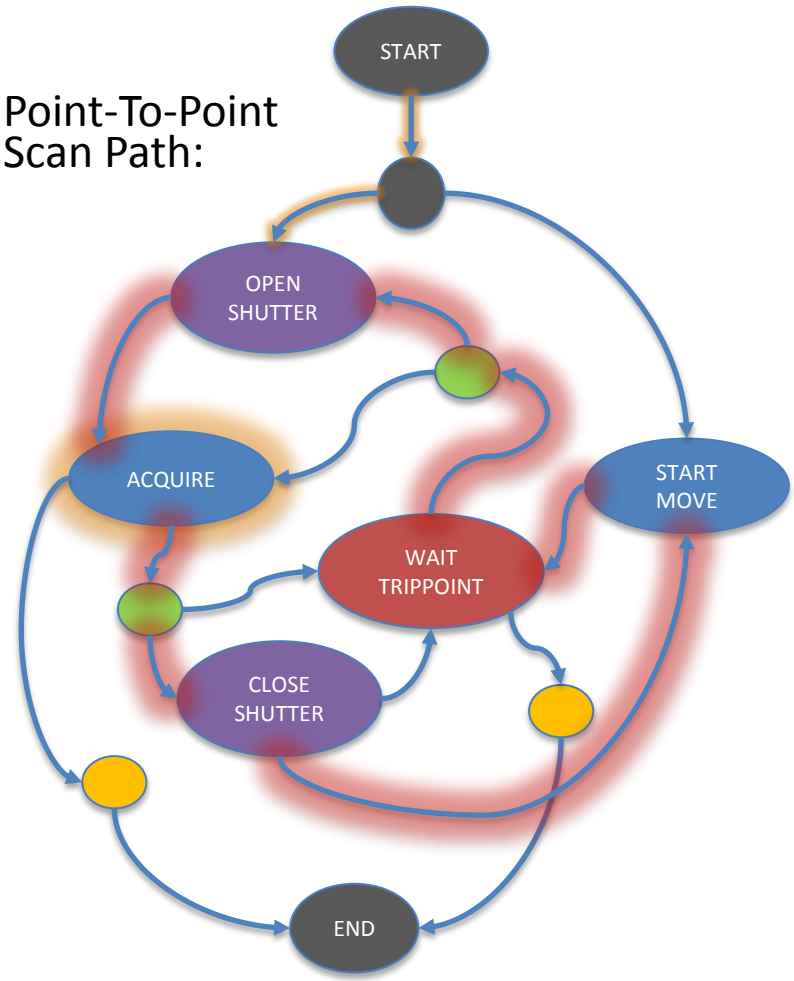


- Runs as Hyppie Module
- State Machine with Pre-programmed sequences
- EPICS communication reduced to Necessary-Only when scanning
- All trigger signals centered on PXI board NI-6602

System Architecture

Scan Sequencer:

Point-To-Point Scan Path:



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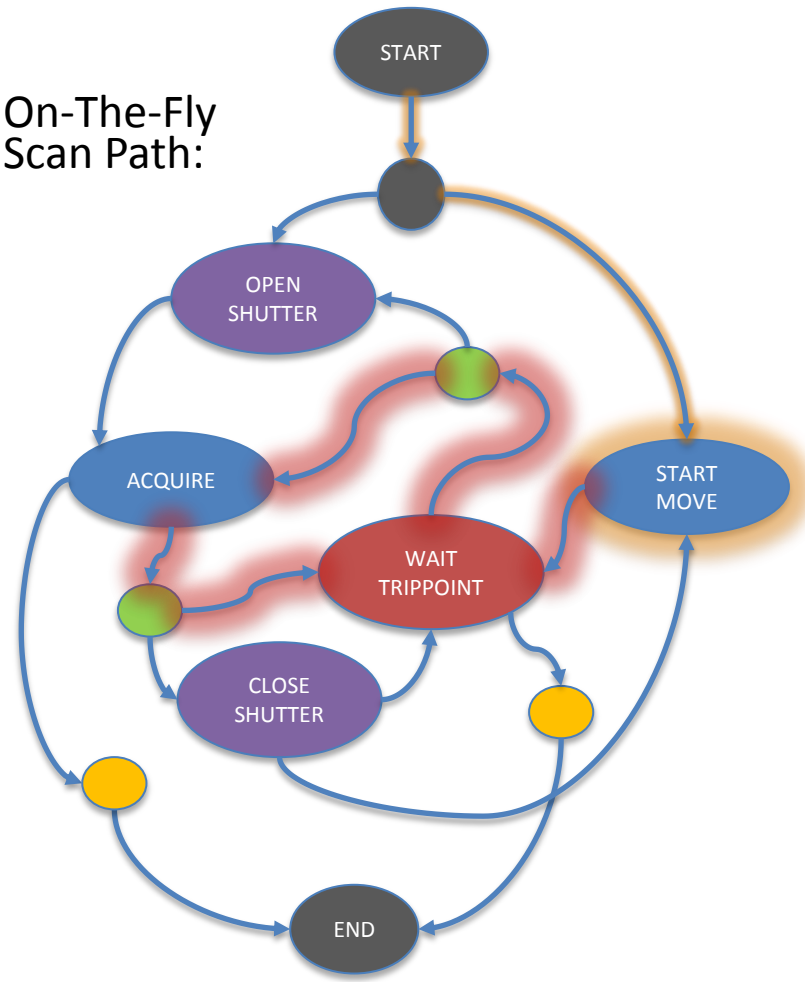
System Architecture

Scan Sequencer:

On-The-Fly Scan Path:



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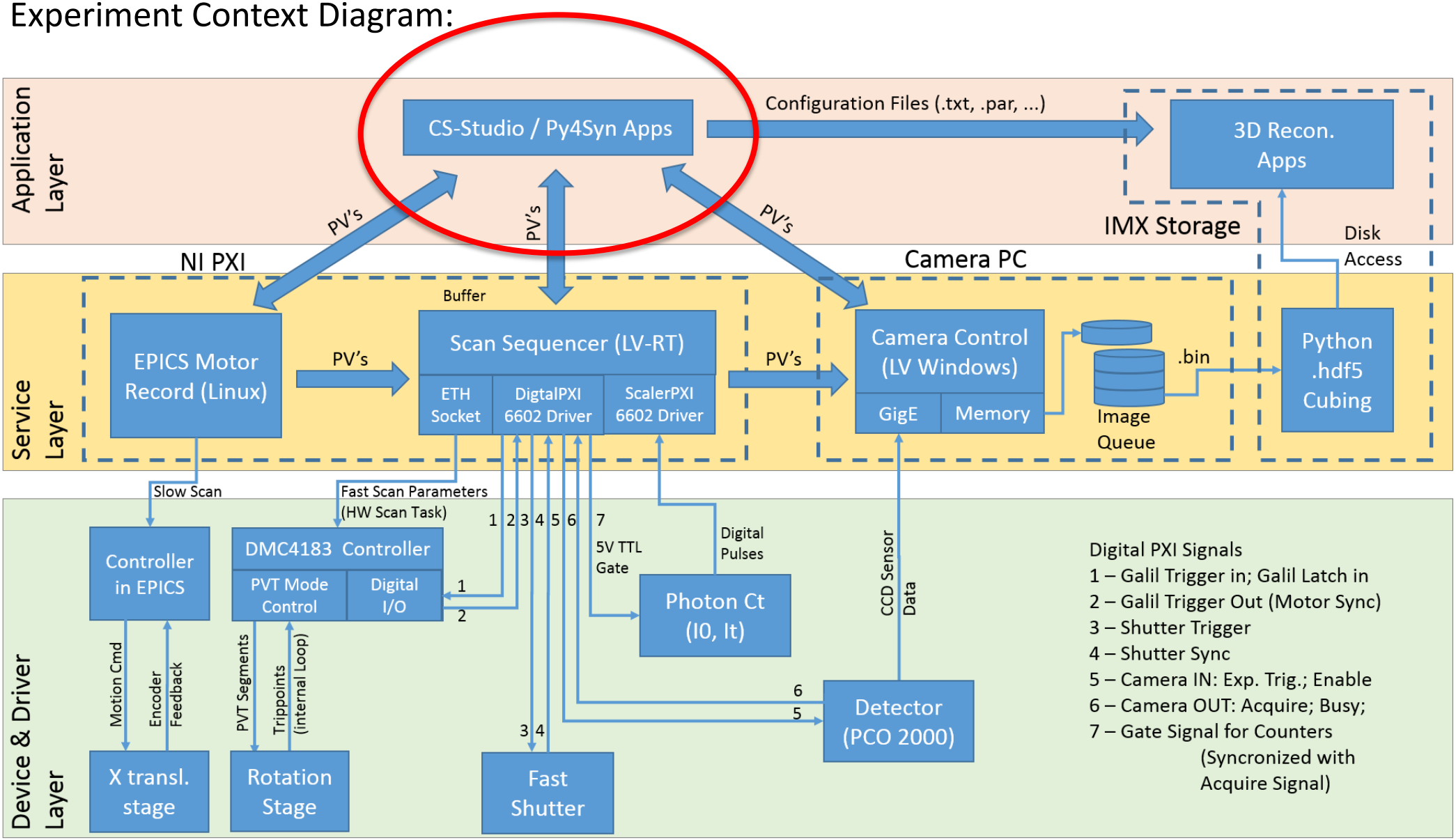
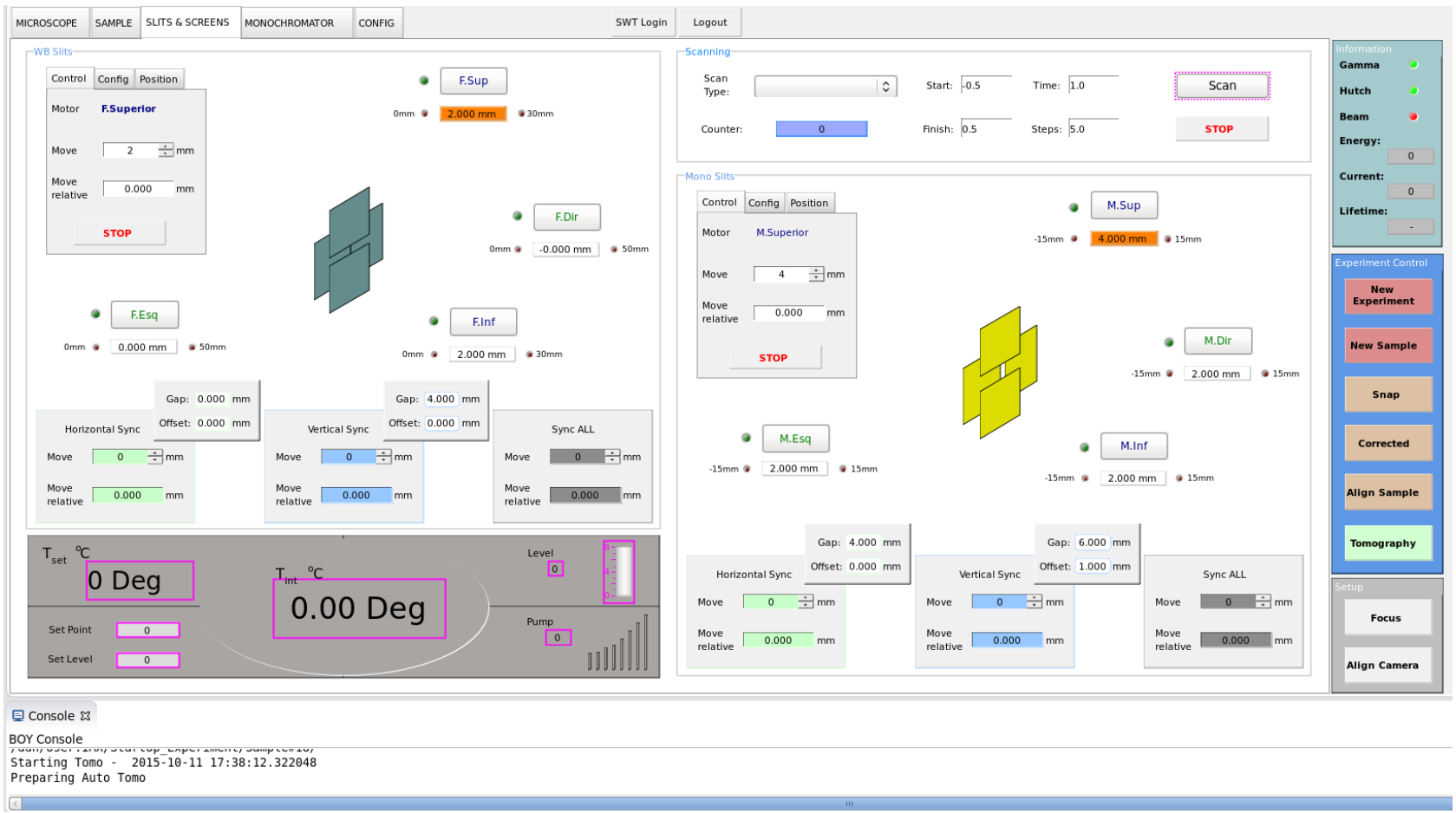


System Architecture

CS-Studio Screens:



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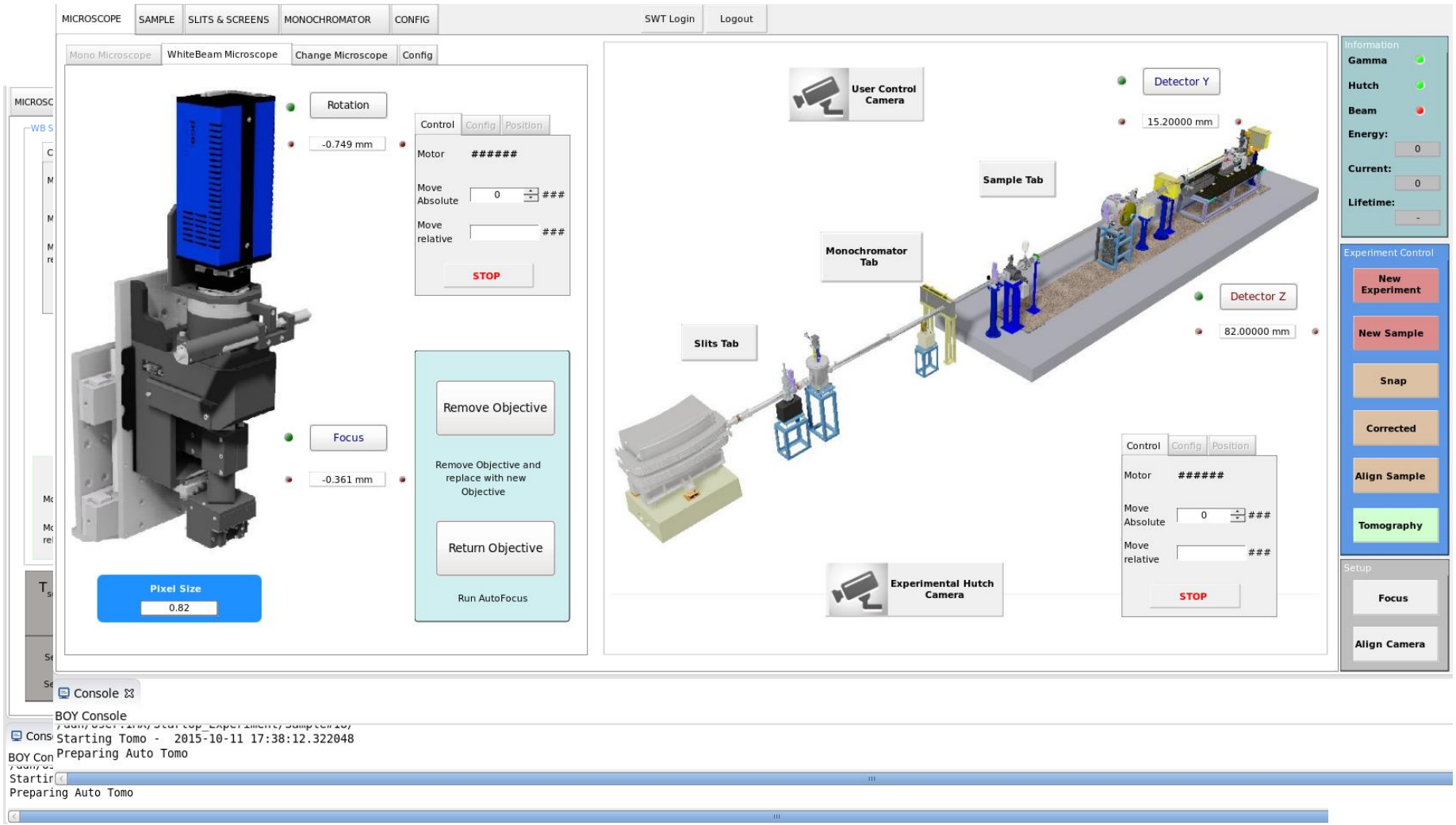

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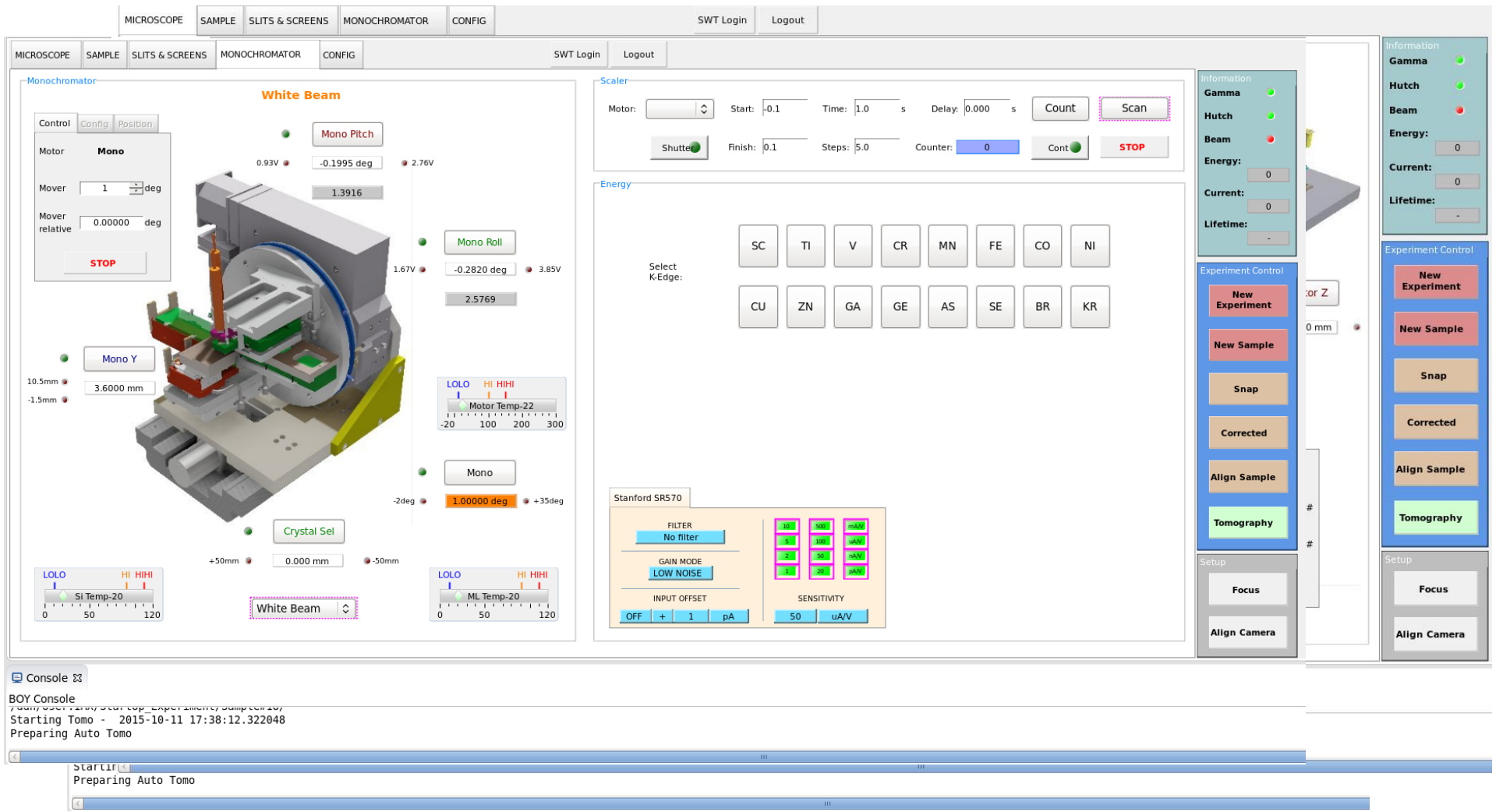

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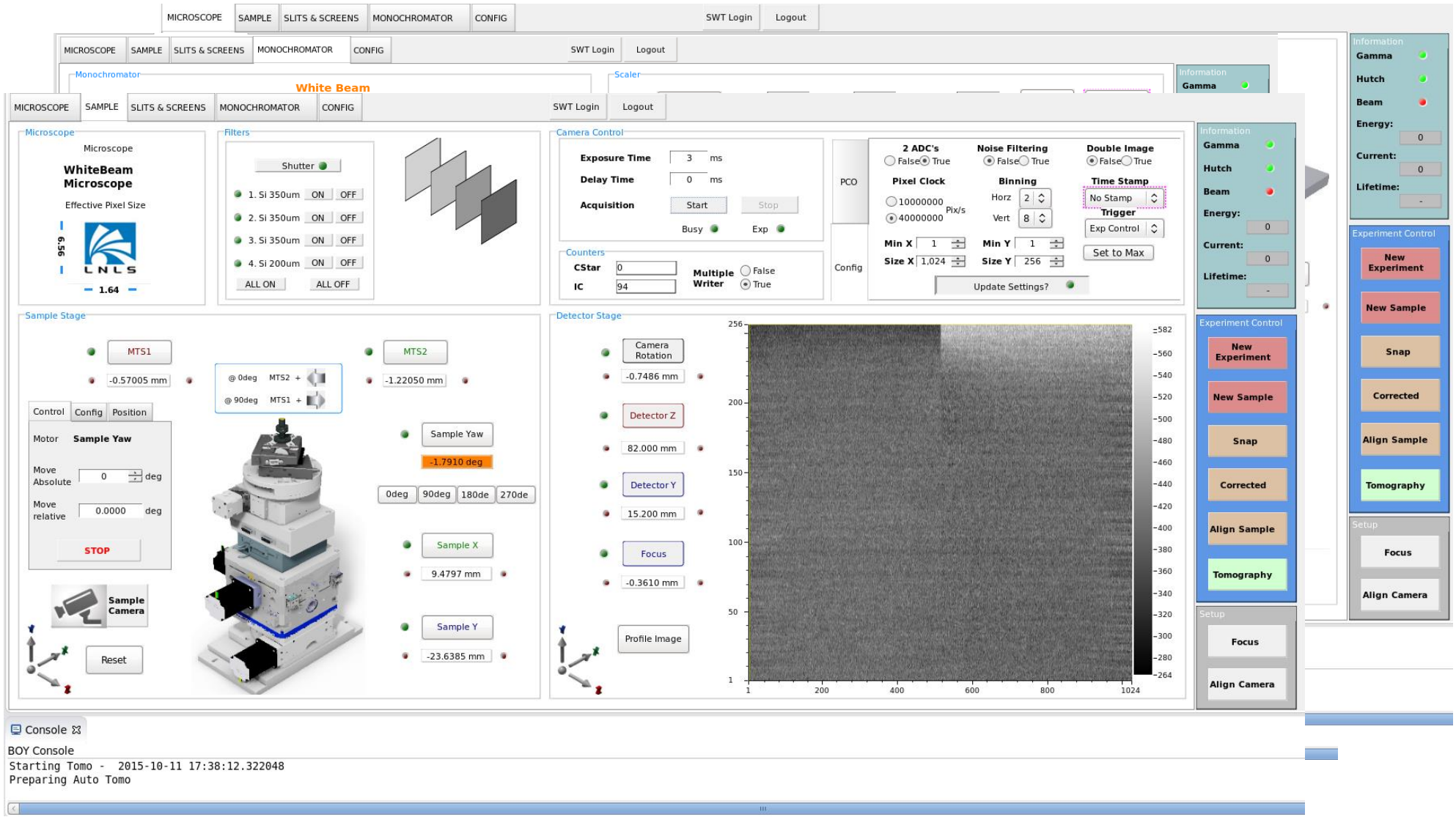

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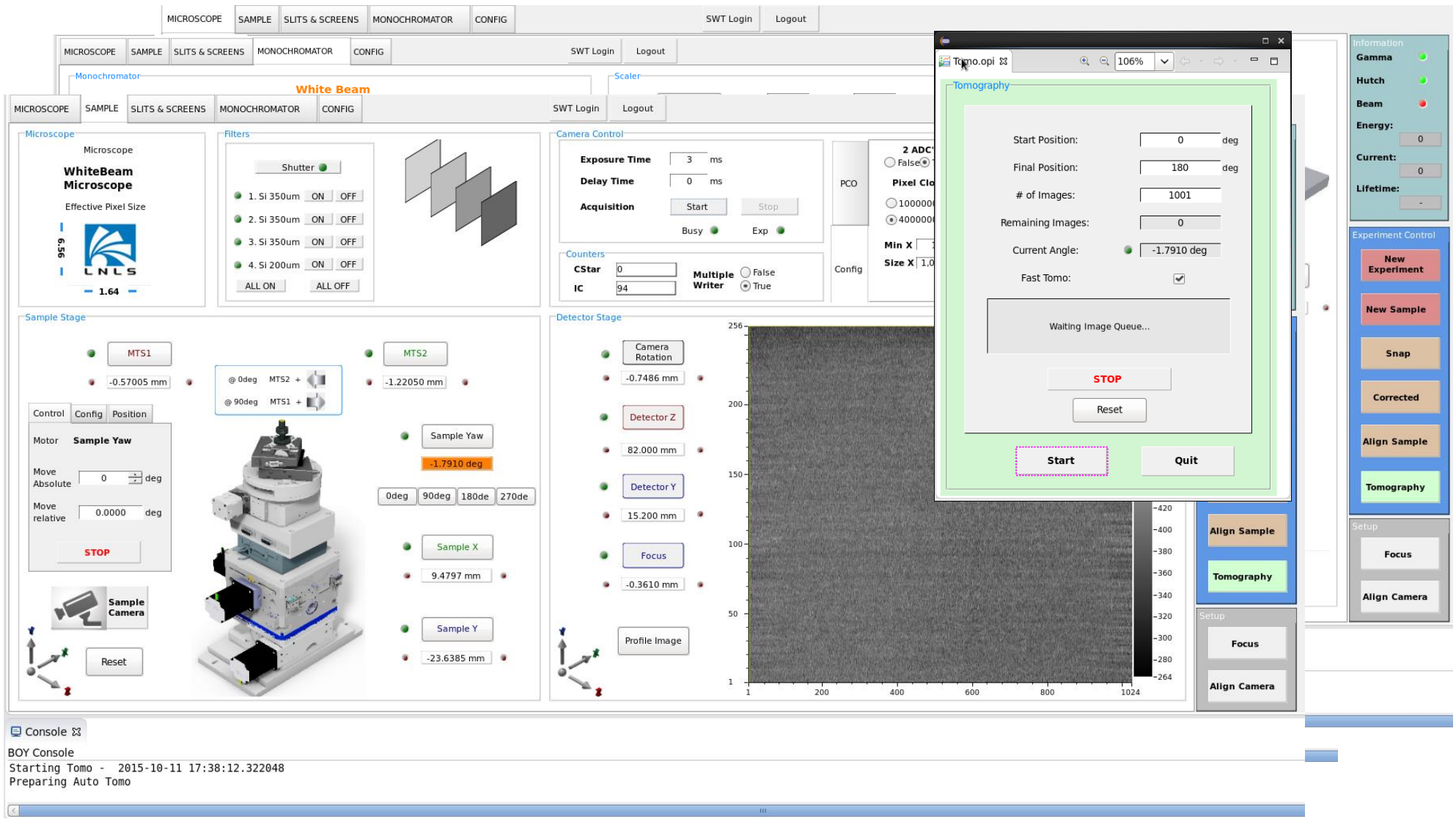

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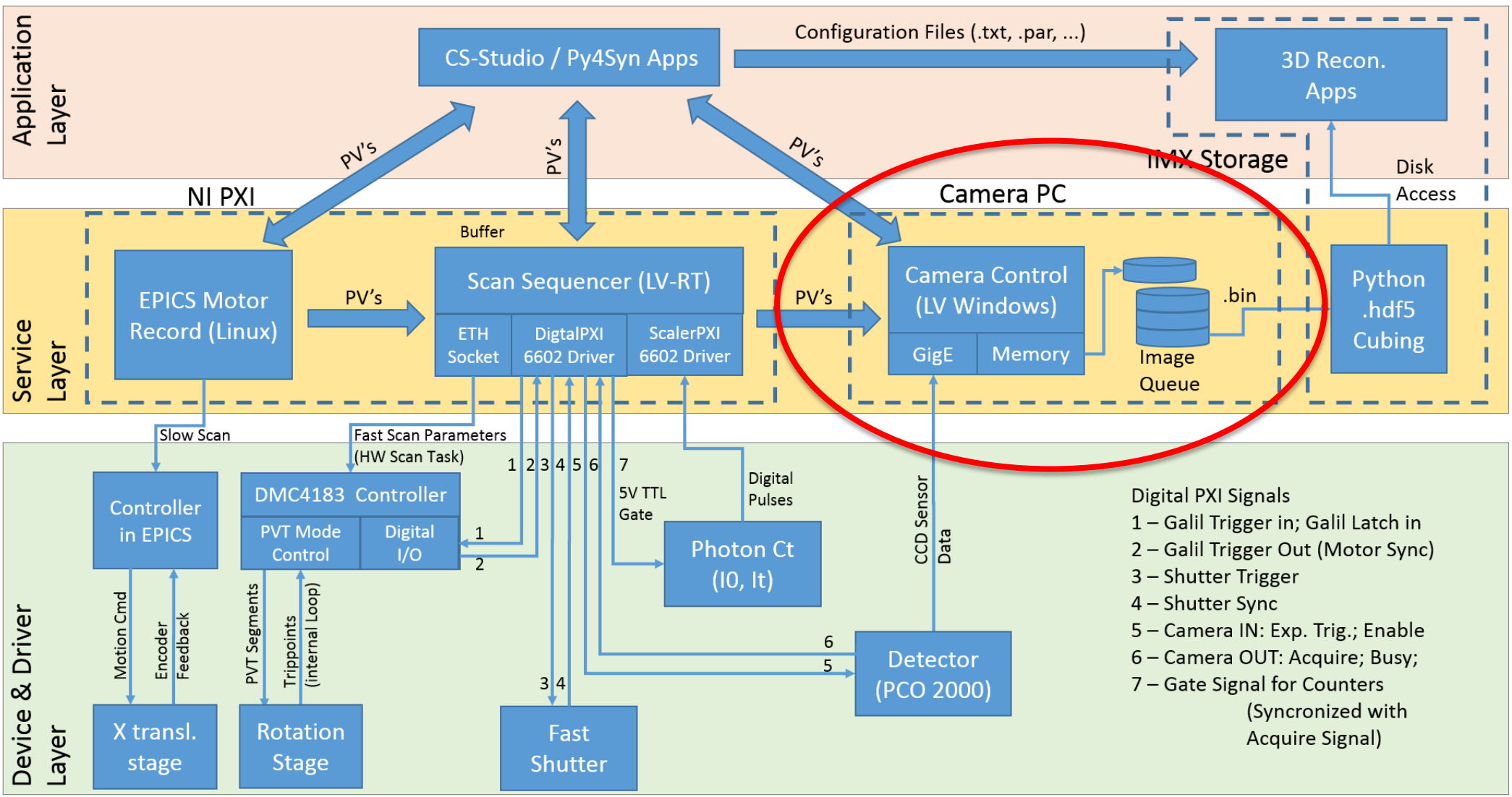


How To Get All This Data???

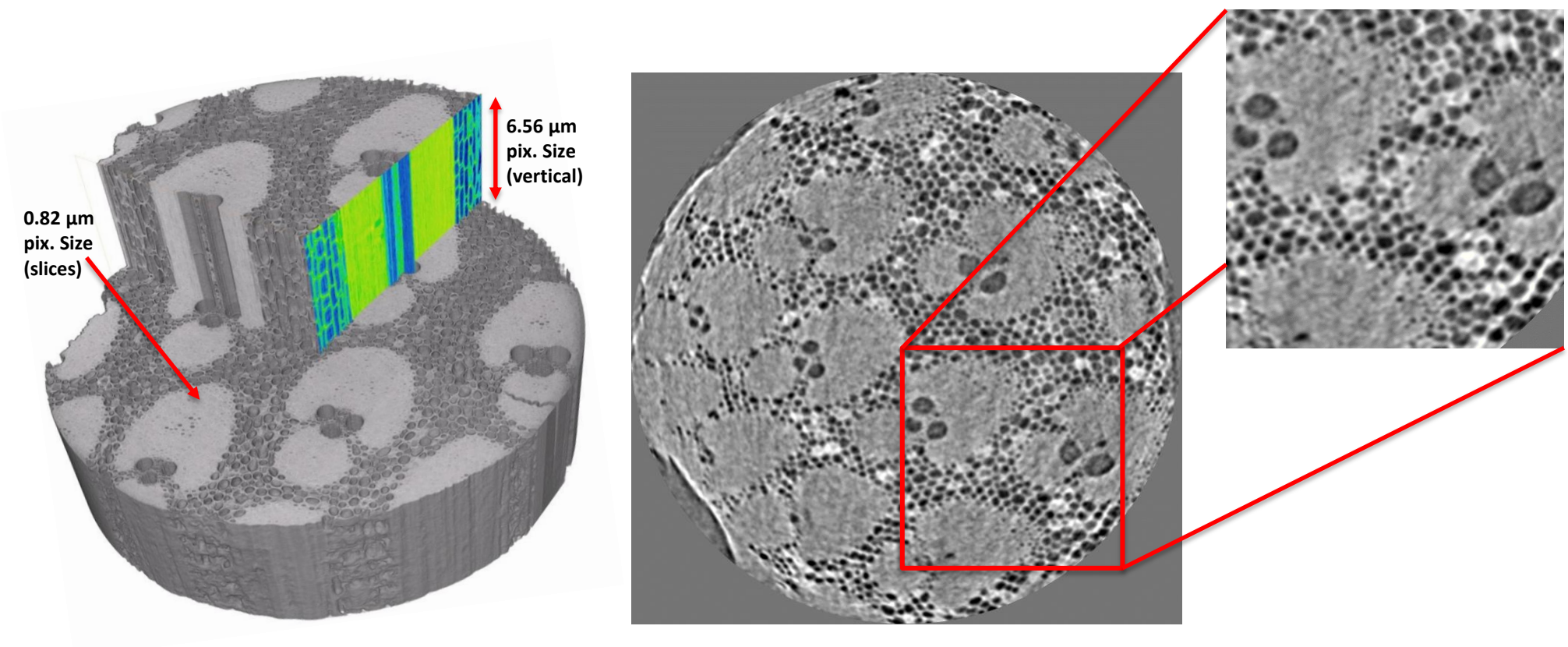
Network Considerations for Camera Control PC:

- 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

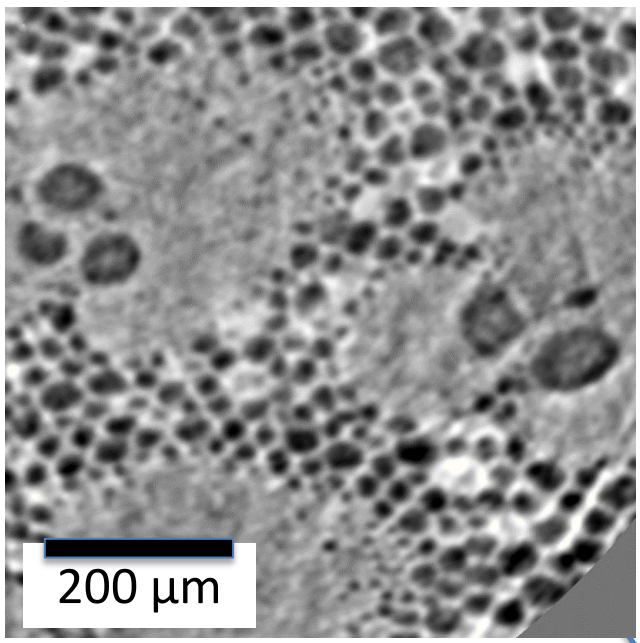
Demo Test

Low Resolution Demo Experiment:

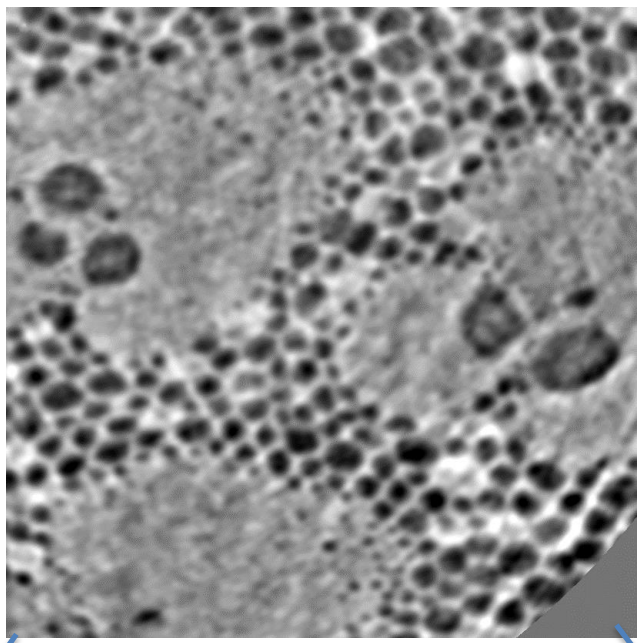
- 1000 Projections, 10 ms exposure time of Bamboo Toothpick
- 2048x256 images, with 1x8 binning (0.82x6.56 microns pixel size)
- Continuous, Point-to-Point, and On-The-Fly Acquisition Modes
- 20 Hz Acquisition, 200 Mb/s data transfer for On-The-Fly Scan



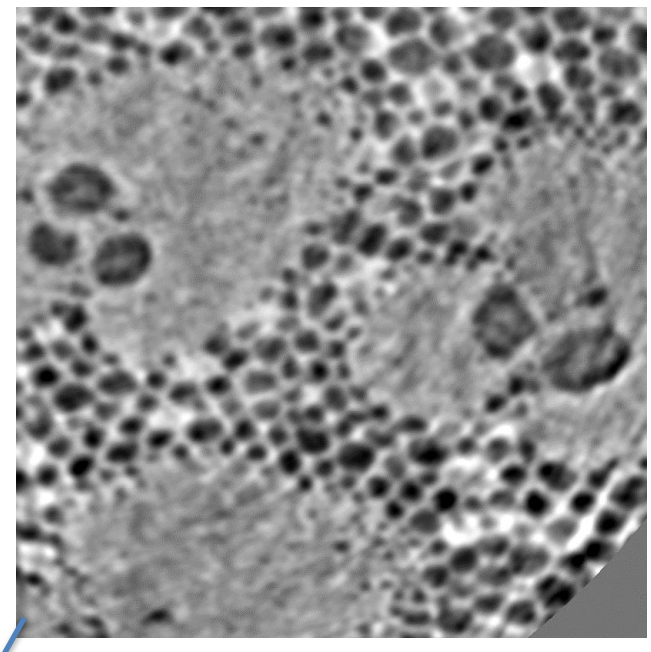
Results



HW Pt-to-Pt (88 sec)

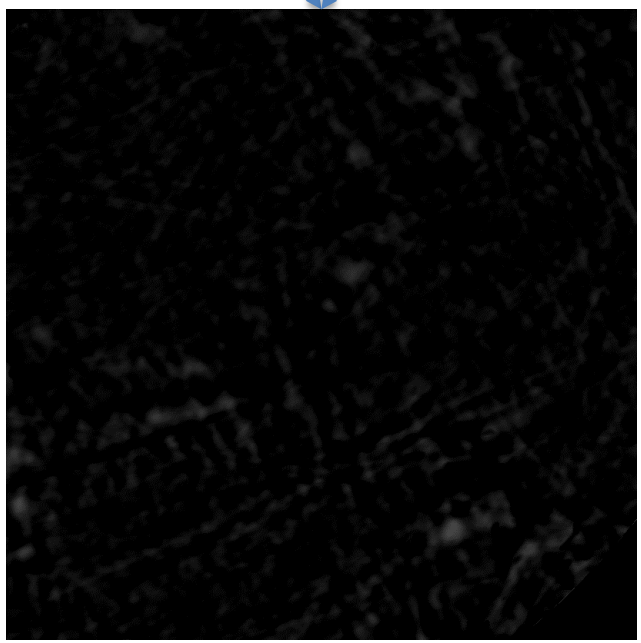


Conventional (8.5 min)

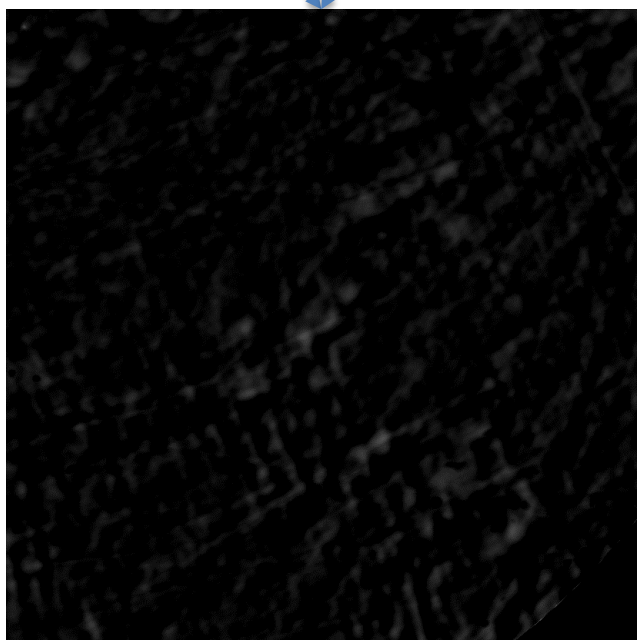


On-the-Fly (49 sec)

~6x Faster!



Conventional minus HW Pt-to-Pt



~10x Faster!

Conventional minus On-The-Fly

CONCLUSIONS

- 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:

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Eduardo Miqueles;

Nathaly Archilha;

Mateus Cardoso;

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GAE Group, LNLS;

SIL Group, LNLS;

SOL Group, LNLS;

Harry Westfahl Jr.