

# Experiment Control and Analysis for High-Resolution Tomography

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# Introduction

Experiment control software for X-ray Computed Tomography (XCT).

XCT is a powerful technique for imaging 3D structures at the micro- and nano-levels.

Faster detector and added complexity because of experimental components requires use of automated software.

Rich feature set with the ability to control complete experimental workflow, i.e., from acquisition to analysis.



# Outline

Features

System Architecture

Reconstruction Pipeline

Automation

# Features - Overview

Histogram and Color Transfer Function

Offline Data View

Live Acquisition

Acquisition Settings

Image Annotation

Area Detector IOC settings

The screenshot displays the X-Ray Tomography software interface. On the left, three histograms (red, green, and blue) are shown, each with a color transfer function curve and a zoom slider. The main window is titled 'X-Ray Tomography' and shows a live acquisition of a tadpole image. Below the image, there are acquisition settings for sensor size, binning, ROI, exposure time, and data type. On the right, a panel titled 'Tomography' contains acquisition type settings (Single Image, Multiple Image, Continuous Image, Scan) and various parameters like Number Of Images, Pre Dark Samples, Pre White Samples, Start Rotation, Stop Rotation, and Number of Projections. The bottom of the interface shows the file path and a button for 'Auto Levels'.

File View Help

Color / Contrast E...

/home/oxygen/FKHAN/Desktop/tadpole.tiff

Live Acquisition

Zoom (%) : 85

Tomography Annotations

Acquisition Type:

- ☐ Single Image
- ☒ Multiple Image
- ☐ Continuous Image
- ☐ Scan

Number Of Images: 100

☐ Use Chain for scan?

Pre Dark Samples: 10

Pre White Samples: 10

Start Rotation: 0.00

Stop Rotation: 100.00

Number of Projections: 50

Sensor Size 640 X 480 Y

Binning 1 1 1

ROI Start 0 0 0

ROI Size 640 480 480

Image Size 640 480

Gain 10.000 10.0000

Exposure Time 0.001 0.0010

Acquire Period 0.005 0.0050

Data type: UInt8 UInt8

Image Mode: Multiple Multiple

Name temp1 temp1\_33.h5

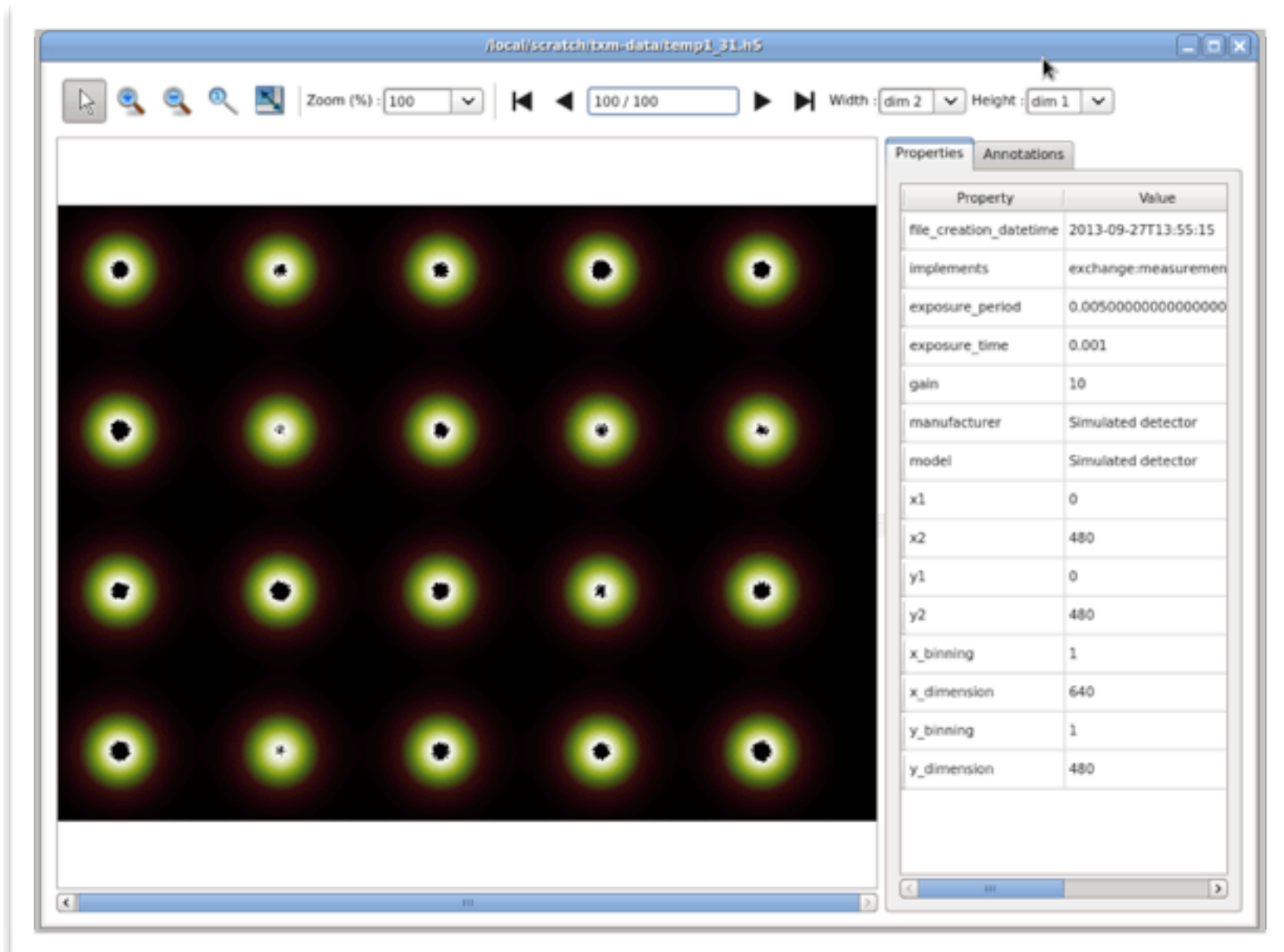
Path /local/scratch/txm-data/ /local/scratch/txm-data/

Index 33

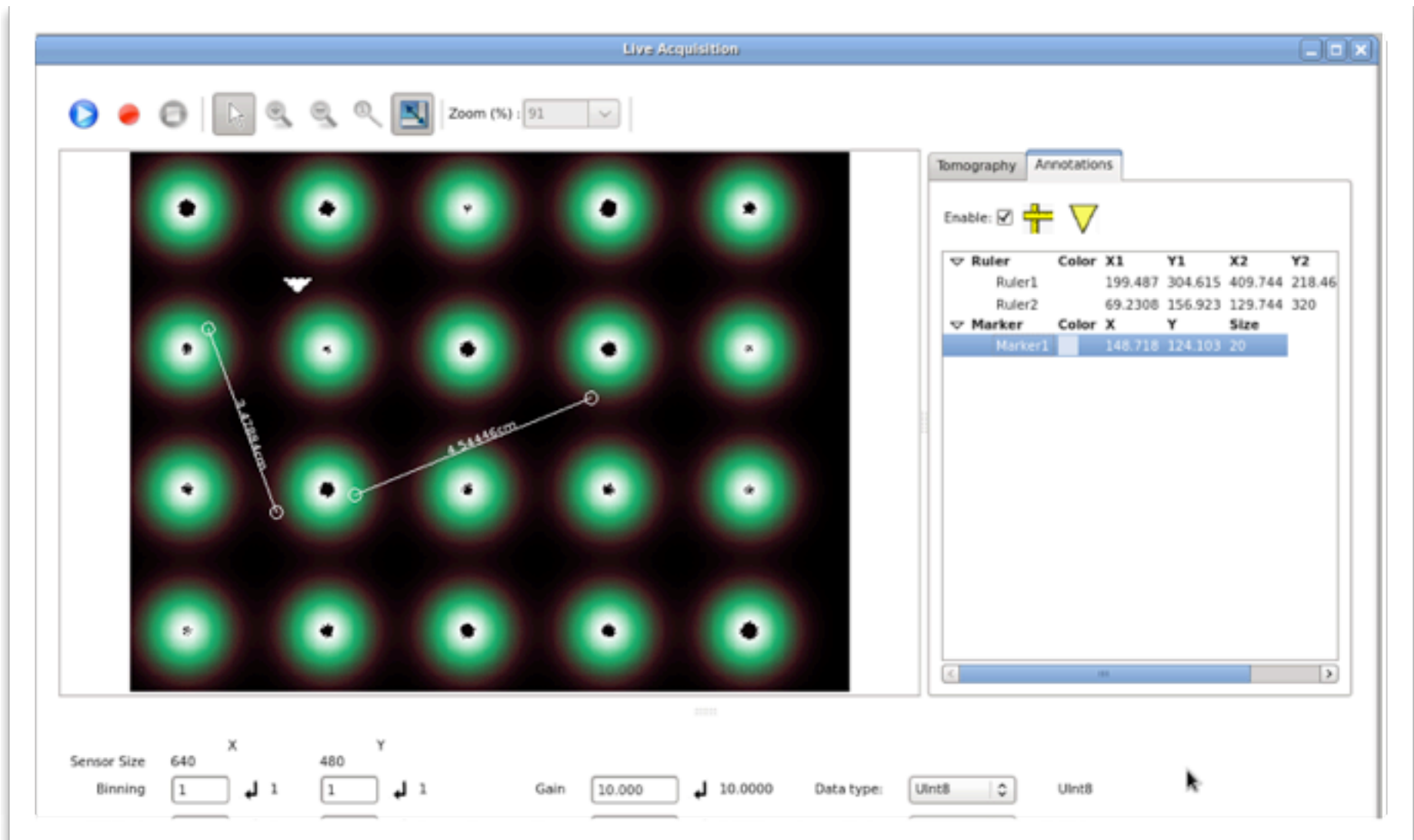
None

Auto Levels

# Features - Data Browser



# Features - Annotations



# Features - Tomography Scan

Tomography Annotations

Acquisition Type:

☐ Single Image

☐ Multiple Image

Number Of Images: 100 100

☐ Continuous Image

☒ Scan

☒ Use Chain for scan?

Pre Dark Samples: 10

Pre White Samples: 10

Start Rotation: 0.00

Stop Rotation: 100.00

Number of Projections: 50

Projections per stride: 1

White samples per stride: 1

Post White Samples: 10

Post Dark Samples: 10

Step Speed: 46.00

Return Speed: 97.00

In Position Out Position

X: 0.00 0.00

Y: 1.00 0.00

Z: 1.00 0.00

Sync Sync

Scan Loop

☒ Count

☐ PV

☐ Multi-PV

Base Name:

	PV	Value	Delay	Enabled	t Delay	Status
0	N/A	0	0	<input checked="" type="checkbox"/>	0	
1	N/A	0	0	<input checked="" type="checkbox"/>	0	
2	N/A	0	0	<input checked="" type="checkbox"/>	0	
3	N/A	0	0	<input checked="" type="checkbox"/>	0	
4	N/A	0	0	<input checked="" type="checkbox"/>	0	
5	N/A	0	0	<input checked="" type="checkbox"/>	0	
6	N/A	0	0	<input checked="" type="checkbox"/>	0	
7	N/A	0	0	<input checked="" type="checkbox"/>	0	
8	N/A	0	0	<input checked="" type="checkbox"/>	0	
9	N/A	0	0	<input checked="" type="checkbox"/>	0	
10	N/A	0	0	<input checked="" type="checkbox"/>	0	
11	N/A	0	0	<input checked="" type="checkbox"/>	0	
12	N/A	0	0	<input checked="" type="checkbox"/>	0	
13	N/A	0	0	<input checked="" type="checkbox"/>	0	
14	N/A	0	0	<input checked="" type="checkbox"/>	0	
15	N/A	0	0	<input checked="" type="checkbox"/>	0	
16	N/A	0	0	<input checked="" type="checkbox"/>	0	
17	N/A	0	0	<input checked="" type="checkbox"/>	0	
18	N/A	0	0	<input checked="" type="checkbox"/>	0	
19	N/A	0	0	<input checked="" type="checkbox"/>	0	
20	N/A	0	0	<input checked="" type="checkbox"/>	0	
21	N/A	0	0	<input checked="" type="checkbox"/>	0	
22	N/A	0	0	<input checked="" type="checkbox"/>	0	
23	N/A	0	0	<input checked="" type="checkbox"/>	0	

Generate

☐ Count

☒ PV

☐ Multi-PV

Base Name:

	PV	Value	Delay	Enabled	t Delay	Status
0	zentr...	0	0	<input checked="" type="checkbox"/>	0	
1	zentr...	1	0	<input checked="" type="checkbox"/>	0	
2	zentr...	2	0	<input checked="" type="checkbox"/>	0	
3	zentr...	3	0	<input checked="" type="checkbox"/>	0	
4	zentr...	4	0	<input checked="" type="checkbox"/>	0	
5	zentr...	5	0	<input checked="" type="checkbox"/>	0	
6	zentr...	6	0	<input checked="" type="checkbox"/>	0	
7	zentr...	7	0	<input checked="" type="checkbox"/>	0	
8	zentr...	8	0	<input checked="" type="checkbox"/>	0	
9	zentr...	9	0	<input checked="" type="checkbox"/>	0	
10	zentr...	10	0	<input checked="" type="checkbox"/>	0	
11	zentr...	11	0	<input checked="" type="checkbox"/>	0	
12	zentr...	12	0	<input checked="" type="checkbox"/>	0	
13	zentr...	13	0	<input checked="" type="checkbox"/>	0	
14	zentr...	14	0	<input checked="" type="checkbox"/>	0	
15	zentr...	15	0	<input checked="" type="checkbox"/>	0	
16	zentr...	16	0	<input checked="" type="checkbox"/>	0	
17	zentr...	17	0	<input checked="" type="checkbox"/>	0	
18	zentr...	18	0	<input checked="" type="checkbox"/>	0	
19	zentr...	19	0	<input checked="" type="checkbox"/>	0	
20	zentr...	20	0	<input checked="" type="checkbox"/>	0	
21	zentr...	21	0	<input checked="" type="checkbox"/>	0	
22	zentr...	22	0	<input checked="" type="checkbox"/>	0	

Generate

# Features - Calibration

Beamline Calibration

**Beam**

Shutter A  
☐ Open ☐ Close

Shutter B  
☐ Open ☐ Close

Pitch  
0.00 0.00 0.0

Energy  
0.00 0.00 0.0

► Calculation

**Monitor**

Flux NA  
X NA  
Y NA  
I NA

**Beam Stop**

X 1.00000 1.00000 Y 0.00000 0.00000  
1.00000 Use 1.00000 Use

**Sample**

X 180.00000 180.00000 Y 1.00000 1.00000 Z 2.00000 2.00000  
1.00000 Use 1.00000 Use 1.00000 Use

**Sample Top**

X 0 N/A Z 0 N/A  
0.0000 0.0000

**CCD Camera**

X 0 N/A Y 0 N/A Z 0 N/A  
0.0000 0.0000 0.0000

**Path**

Mirrors  
☐ Si ☐ Cr ☐ Rh ☐ Wb

Magnification  
☐ 1x ☐ 5x ☐ 20x

Filters  
☐ 1 ☐ 2 ☐ 3 ☐ 4



# Features - Configurability

Detectors

**Preferences**

☒ SIM

Component	PV Name	Enable
Detector Std Image	zentradi:image1:	<input checked="" type="checkbox"/>
Detector Camera	zentradi:SIM1:cam1:	<input checked="" type="checkbox"/>
HDF5 Writer	zentradi:Nexus1:	<input checked="" type="checkbox"/>

☐ Neo Andor

Component	PV Name	Enable
Detector Std Image	zentradi:image2:	<input checked="" type="checkbox"/>
Detector Camera	zentradi:SIM2:Cam1:	<input checked="" type="checkbox"/>
HDF5 Writer	zentradi:Nexus2:	<input checked="" type="checkbox"/>

☐ PCO Edge

Component	PV Name	Enable
Detector Std Image		<input type="checkbox"/>
Detector Camera		<input type="checkbox"/>
HDF5 Writer		<input type="checkbox"/>

Calibration Widgets

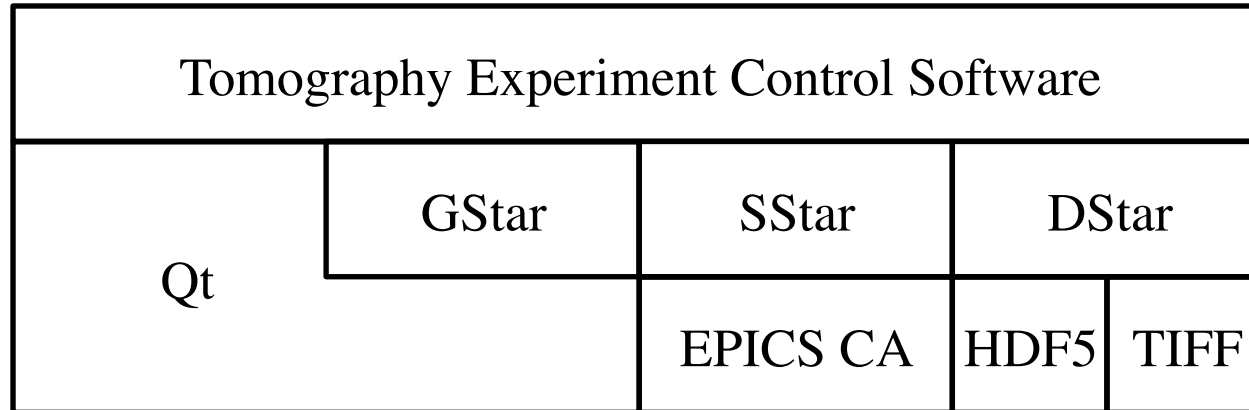
**Preferences**

Component	PV Name	Enable
Beam Stop		
X	zentradi:m38	<input type="checkbox"/>
Y	zentradi:m39	<input type="checkbox"/>
Condenser		
X	zentradi:m40	<input type="checkbox"/>
Y	zentradi:m5	<input type="checkbox"/>
Z	zentradi:m41	<input type="checkbox"/>
P	zentradi:m33	<input type="checkbox"/>
Y	zentradi:m34	<input type="checkbox"/>
Pinhole		
X	zentradi:m6	<input type="checkbox"/>
Y	zentradi:m7	<input type="checkbox"/>
Z	zentradi:m10	<input type="checkbox"/>
Zone Plate		
X	zentradi:m8	<input type="checkbox"/>
Y	zentradi:m9	<input type="checkbox"/>
Z	zentradi:m11	<input type="checkbox"/>
Phase Ring		
Bertrand Lens		
Sample		
Sample Top		
X	zentradi:m24	<input checked="" type="checkbox"/>
Z	zentradi:m26	<input checked="" type="checkbox"/>
CCD Camera		
X	zentradi:m18	<input checked="" type="checkbox"/>
Y	zentradi:m19	<input checked="" type="checkbox"/>
Z	zentradi:m20	<input checked="" type="checkbox"/>
Test123		
P	zentradi:m6	<input checked="" type="checkbox"/>

+ - ▲ ▼ Tomo Links

OK Cancel

# Architecture Overview



GStar - A widget library based on Qt<sup>1</sup> provides EPICS aware widgets

SStar - A C++ wrapper around EPICS channel access API<sup>2,3</sup>, provides the core scanning functionality

DStar - Provides single interface to different data format libraries such as HDF5<sup>4</sup>

1. Qt. <http://qt-project.org>.

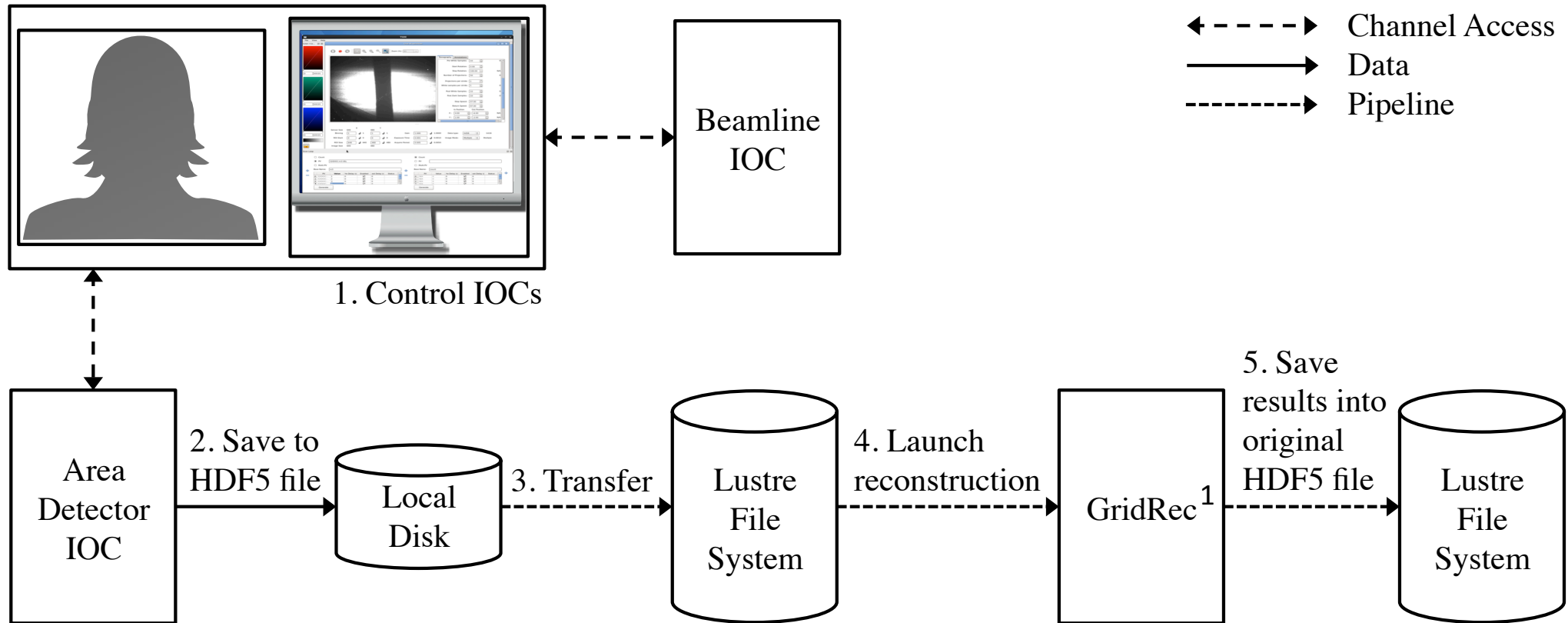
2. EPICS, <http://www.aps.anl.gov/epics>.

3. Area Detector, <http://cars9.uchicago.edu/software/epics>.

4. Hierarchical Data Format version 5 (HDF5), 2000-2010. <http://www.hdfgroup.org/HDF5>.

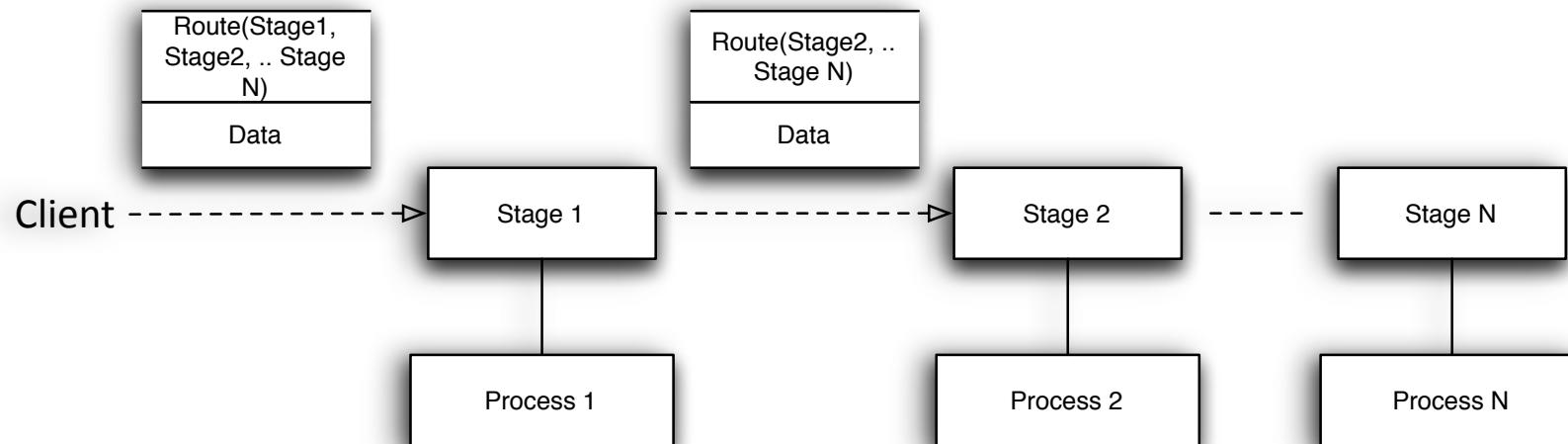


# Reconstruction Pipeline



1. GridRec - M. L. Rivers, "tomoRecon: High-speed tomography reconstruction on workstations using multi-threading," Proc. of SPIE 8506, Developments in X-Ray Tomography VIII, 85060U (2012).

# Analysis Automation



A thin wrapper around user process

A common data format

Client starts the pipeline analysis by constructing a JMS message containing

**input data**<sup>1, 2</sup> - A HDF5 file with input parameters e.g. location of Hadoop file to process

**route** - specify individual processing step

Next stage is triggered by passing a JMS<sup>3</sup> message between the current and the next stage

1. Hierarchical Data Format version 5 (HDF5), 2000-2010. <http://www.hdfgroup.org/HDF5>

2. The Scientific Data Exchange, <http://www.aps.anl.gov/DataExchange>

3. Apache ActiveMQ, <http://activemq.apache.org> based implementation of JMS standard is used.

# Conclusion

Feature rich and configurable control software

Being used at newly upgraded nano-tomography station at APS 32-ID beamline

Integration of the software with reconstruction application lowers the turn-around time between acquisition and analysis

Maximize utilization of the equipment and beam time

Available at:

<https://subversion.xor.aps.anl.gov/TXM/trunk/>



# Thanks

Questions?