Hardware Triggered Scanning: GDA and DAWN

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Observatory Sciences Limited

Software Stack: Reminder

Data Analysis WorkbeNch
- Analysis and visualization

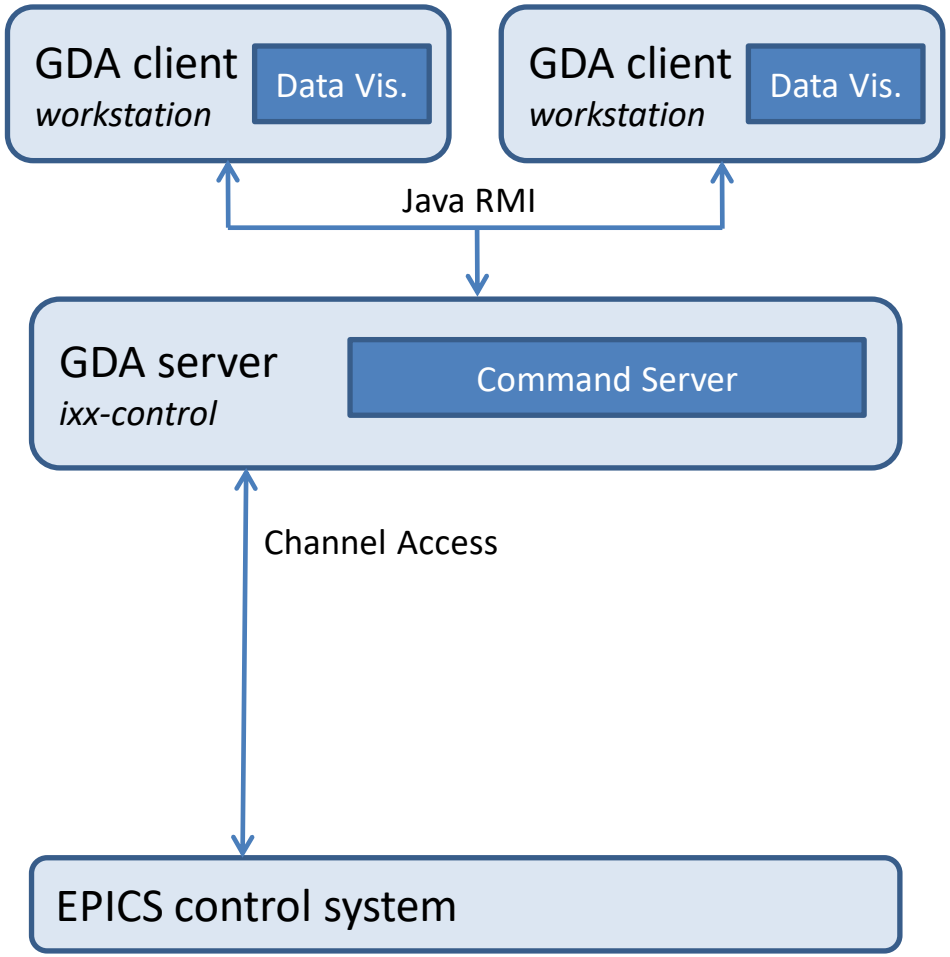
Generic Data Acquisition
- Experiment setup and supervision

Malcolm
- Scan configuration

Experimental Physics & Industrial Control System
- Low level control of hardware

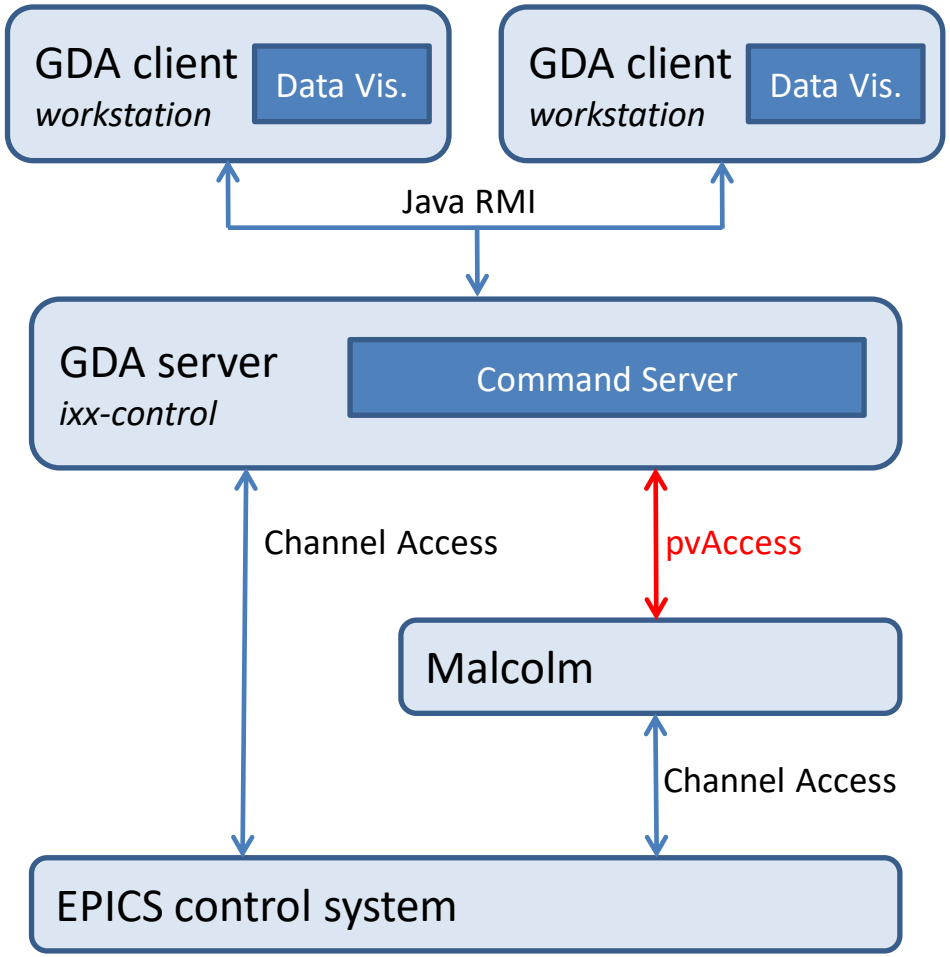
Overview

- Main beamline user interface
- Presents a science based view of experiments
- Client-server design
- *Command Server* provides a Jython interpreter
- Client provides live data visualization



Overview

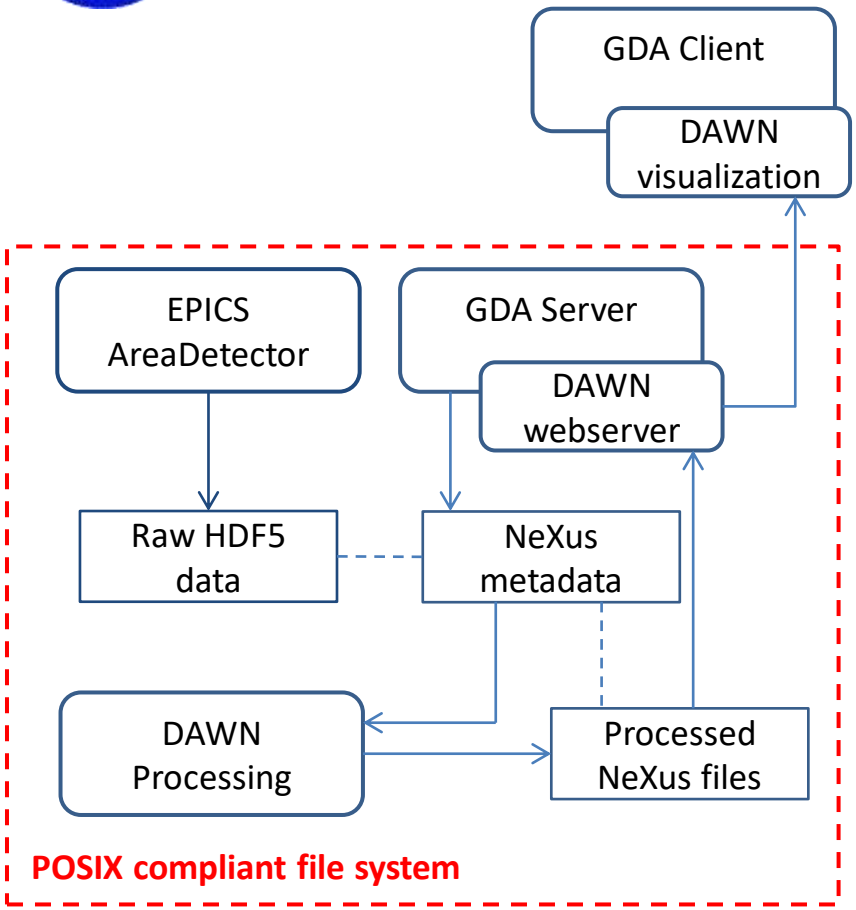
- Main beamline user interface
- Presents a science based view of experiments
- Client-server design
- *Command Server* provides a Jython interpreter
- Client provides live data visualization
- GDA<->Malcolm interface developed to integrate scanning framework



Overview

- **D**ata **A**nalysis **W**orkbe**N**ch
- Sister project to GDA (Eclipse based)
- Provides visualization components to GDA client
- Includes generic data processing tools
- Data processing pipelines can be customized
- Supports multiple file formats, including NeXus
- See https://dawnsci.org/

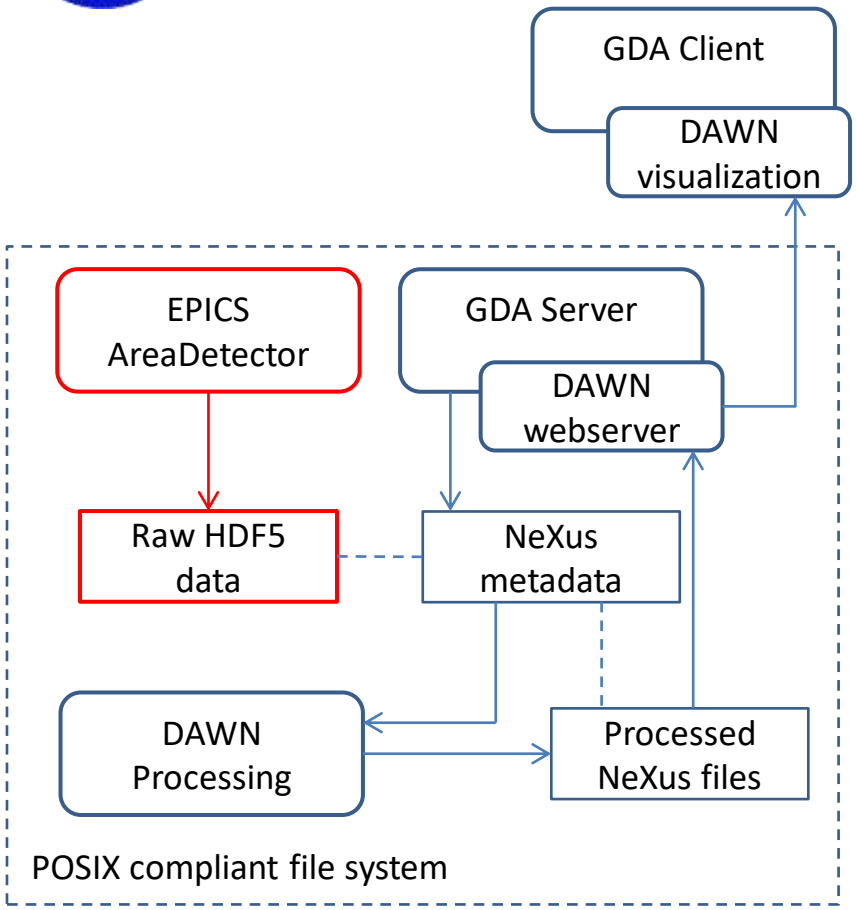
Data Flow



Data written to a POSIX file system

- Enables SWMR mode

Data Flow

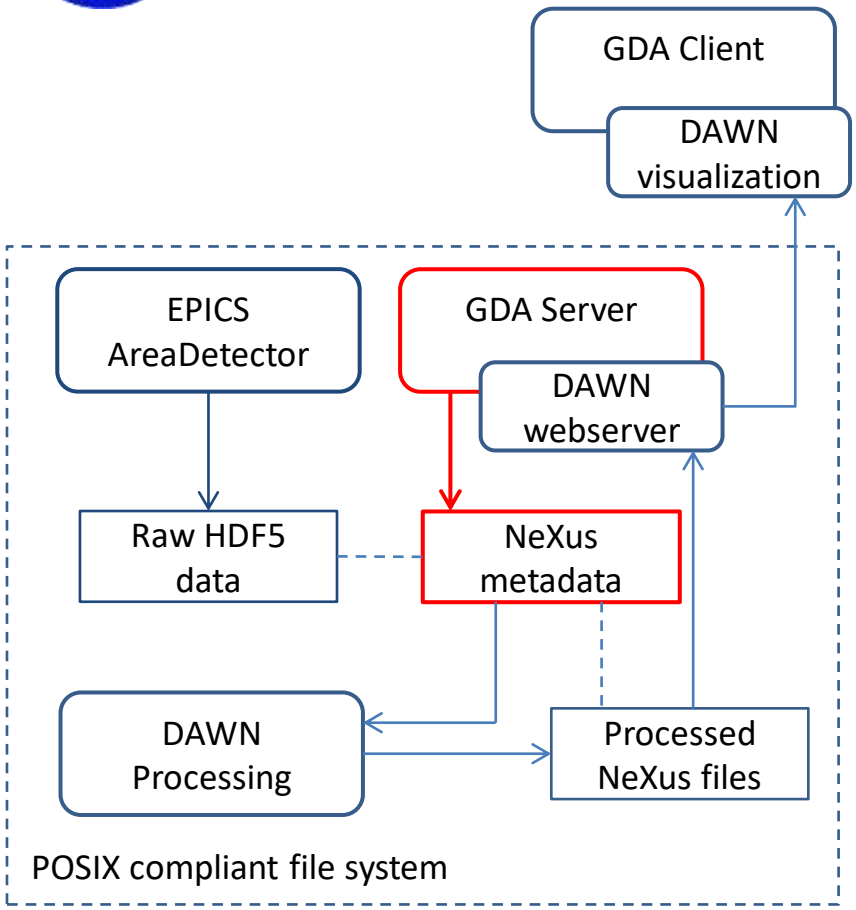


Data written to a POSIX file system

- Enables SWMR mode

1. AreaDetector writes raw HDF data

Data Flow

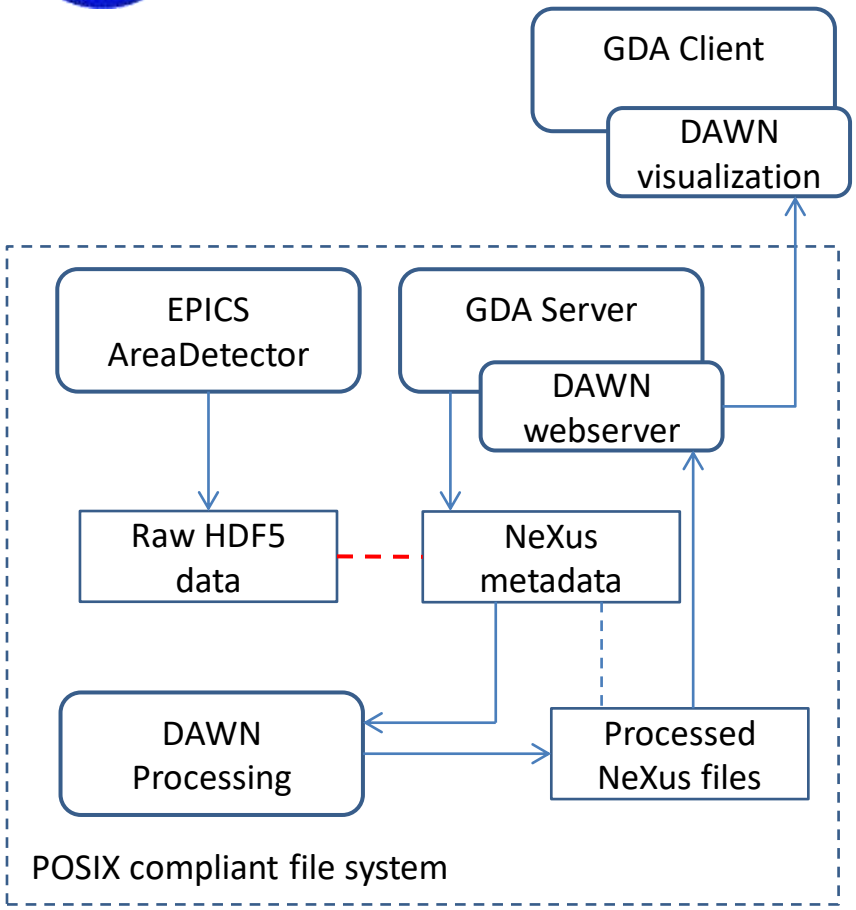


Data written to a POSIX file system

- Enables SWMR mode

1. AreaDetector writes raw HDF data
2. GDA writes metadata to another HDF file

Data Flow



Data written to a POSIX file system

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1. AreaDetector writes raw HDF data
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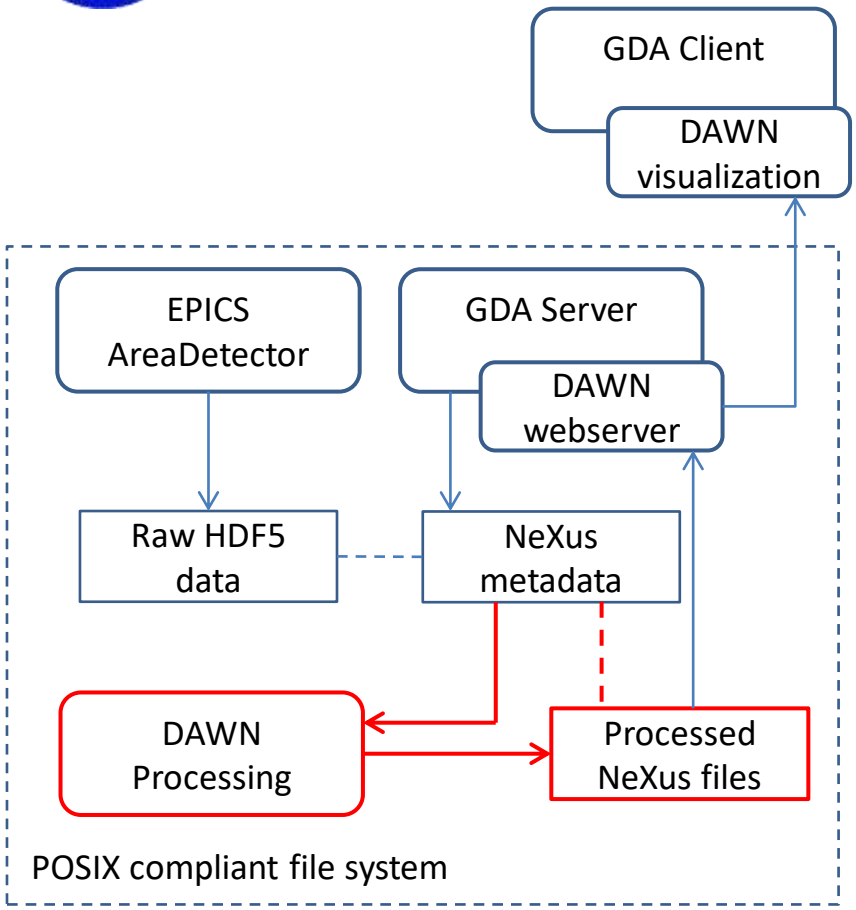
3. The two HDF files are linked

Data Flow



Data written to a POSIX file system

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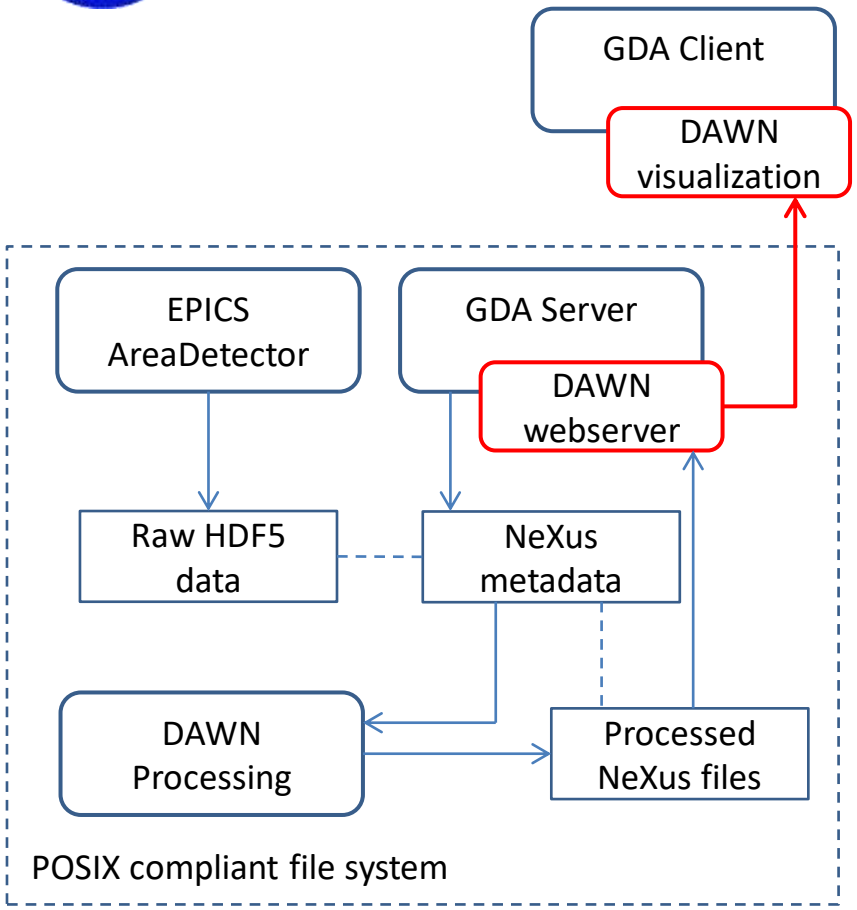


Data written to a POSIX file system

- Enables SWMR mode

1. AreaDetector writes raw HDF data
2. GDA writes metadata to another HDF file
3. The two HDF files are linked
4. DAWN processing reads both file
5. DAWN webserver makes the raw and processed files available to the GDA client outside the POSIX file system

Interface to Malcolm

- Malcolm<->GDA interface uses *pvAccess* (EPICS V4)
- This supports structured data
- Each Malcolm 'device' in GDA maps onto a block:

$(gda_config)/servers/main/live/malcolm_real.xml

```
<bean id="realMalcolmModel" class="org.eclipse.scanning.api.device.models.MalcolmModel">
    <property name="name" value="${PV_PREFIX}-ML-SCAN-01"/>
    <property name="exposureTime" value="0.01"/>
</bean>
```

- This defines the MRI (Malcolm Resource Identifier) for the top level scan block

Interface Customization

$(gda_config)/clients/main/_common/mapping.xml

Axis name labels:

```
<!-- Stage axis names defined as String beans for convenience and to avoid repetition of the same literal value -->
<bean id="x_axis_name" class="java.lang.String" factory-method="valueOf"><constructor-arg value="stagea"/></bean>
<bean id="y_axis_name" class="java.lang.String" factory-method="valueOf"><constructor-arg value="stagex"/></bean>
```

Outer scan axes:

```
</property>
<property name="scanDefinition">
        <bean class="uk.ac.diamond.daq.mapping.impl.MappingScanDefinition">
                <property name="outerScannables">
                        <list>
                                <bean class="uk.ac.diamond.daq.mapping.impl.ScanPathModelWrapper">
                                        <constructor-arg name="name" value="stagez" />
                                        <constructor-arg name="model"><null /></constructor-arg>
                                        <constructor-arg name="includeInScan" value="false" />
                                </bean>
                        </list>
                </property>
        </bean>
</property>
```

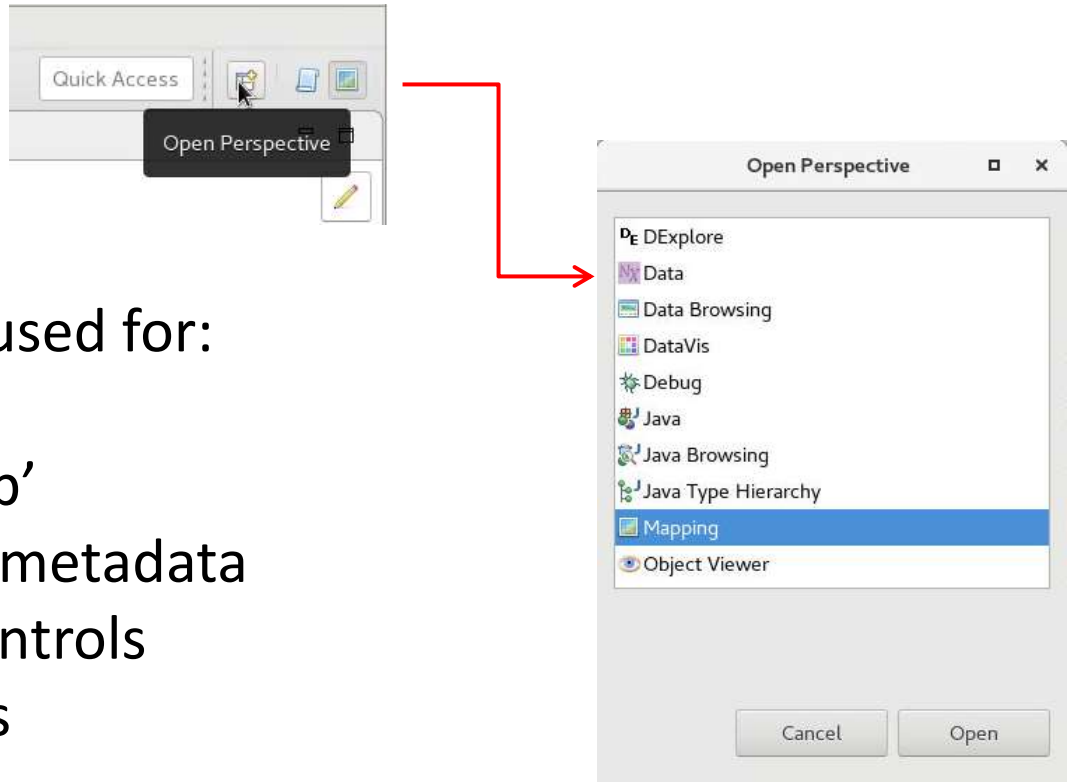
GDA perspectives

GDA has three main perspectives you'll use with Malcolm:

- Mapping
- DataVis
  - Used both of these in Part 1
- Processing

A *perspective* is a collection of related views

Mapping Perspective

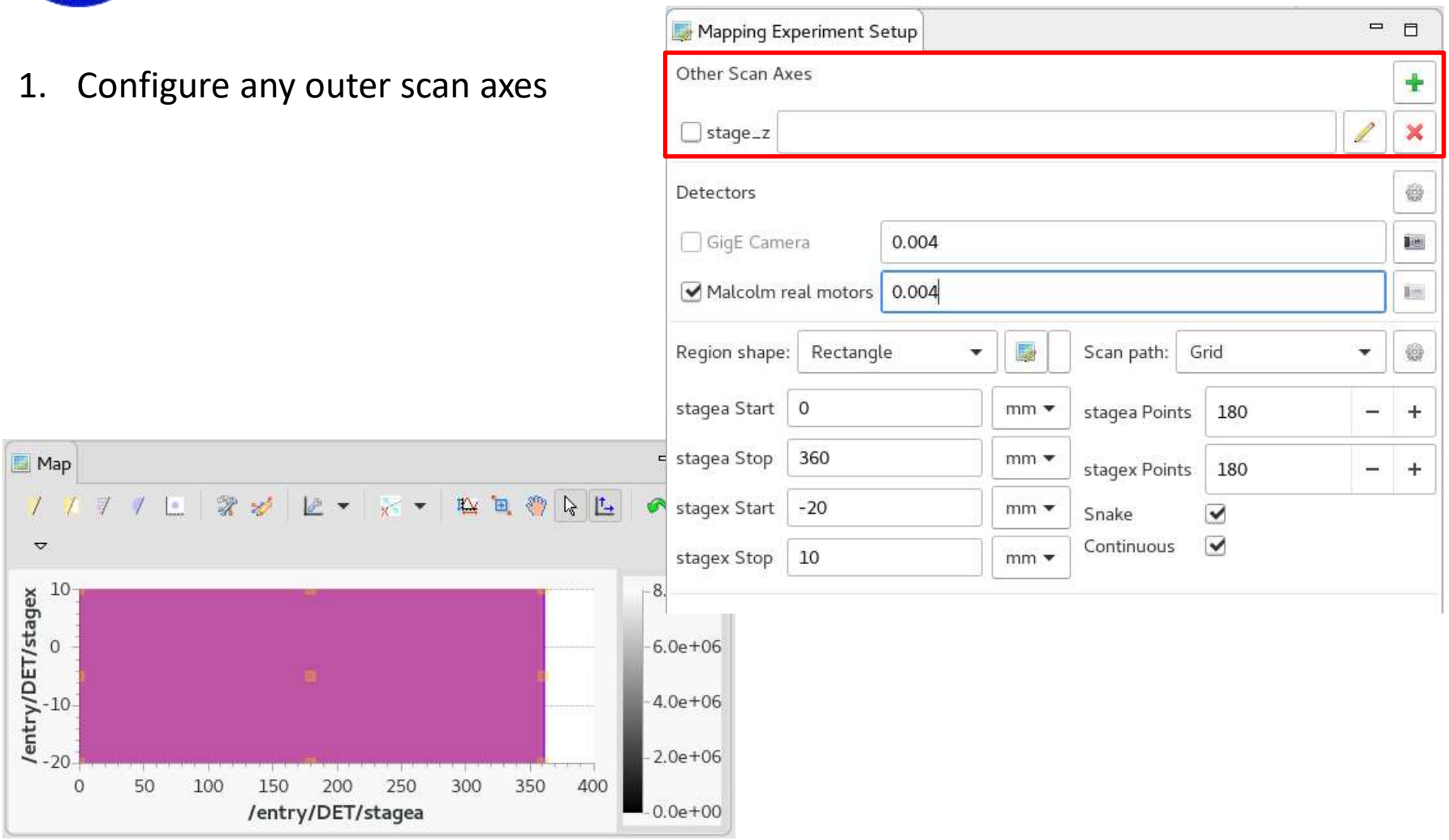


Mapping perspective used for:

- Setting up scan ‘map’
- Configuring sample metadata
- Start/stop/pause controls
- Monitoring progress
- Viewing results

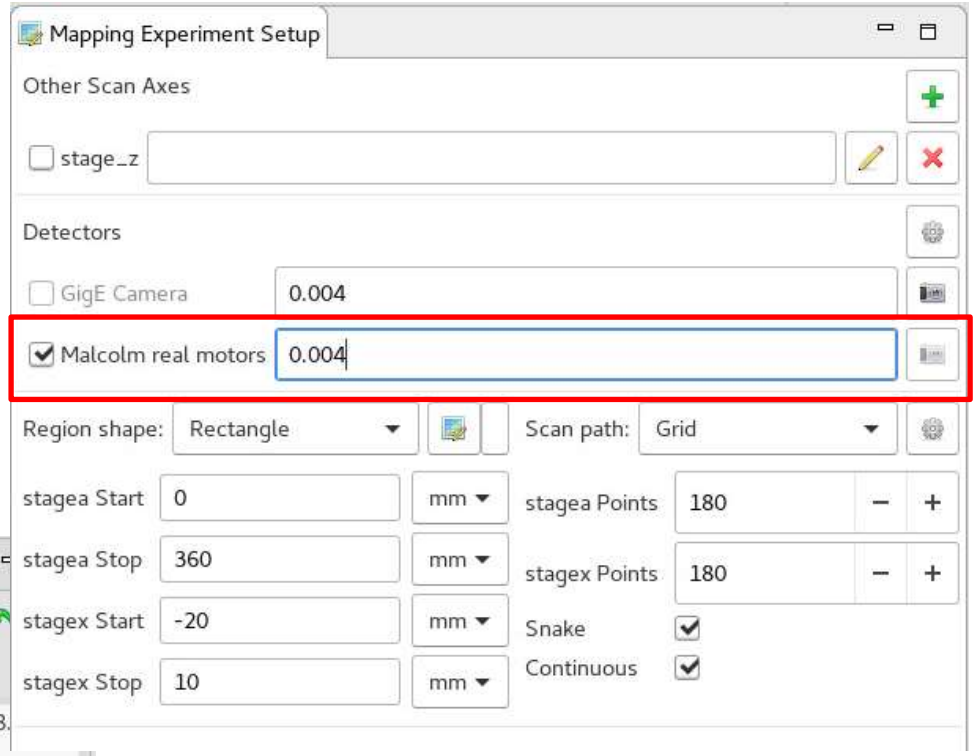
Mapping Experiment Setup

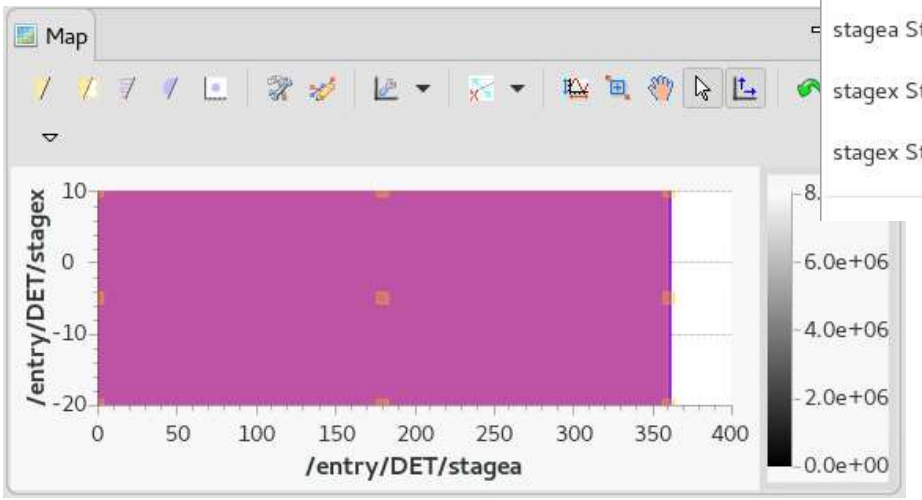
1. Configure any outer scan axes



Mapping Experiment Setup

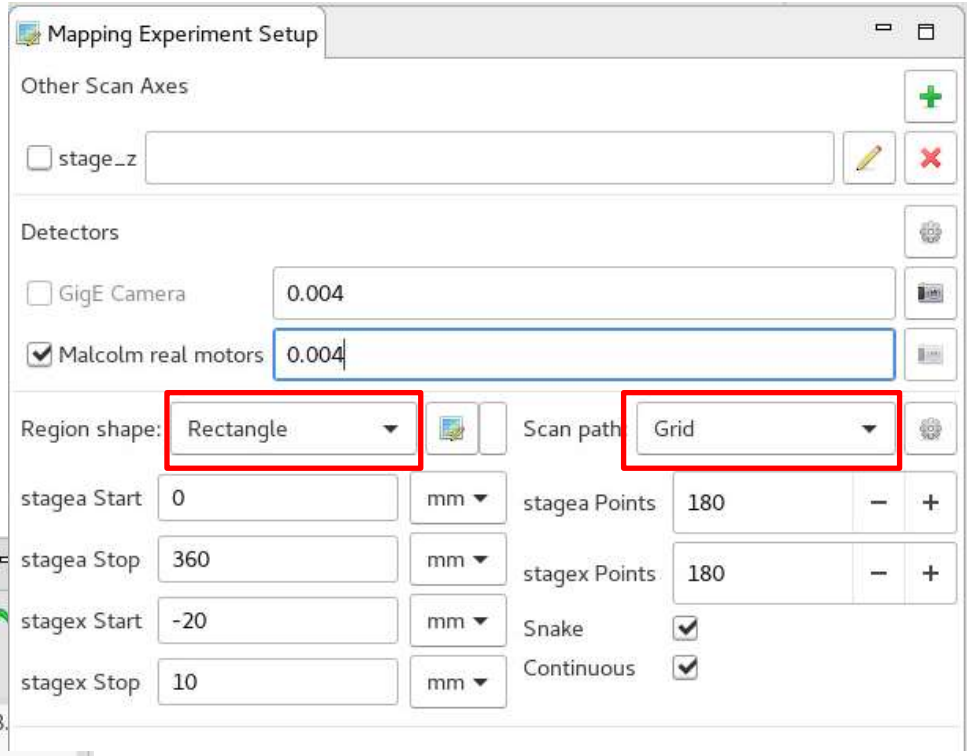
1. Configure any outer scan axes
2. Select the Malcolm device and enter desired exposure time

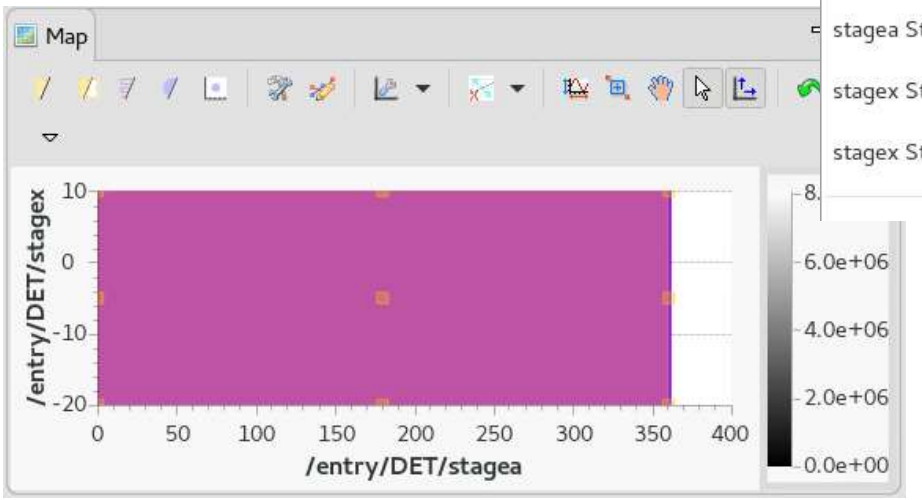




Mapping Experiment Setup

1. Configure any outer scan axes
2. Select the Malcolm device and enter desired exposure time
3. Choose desired region shape and scan path





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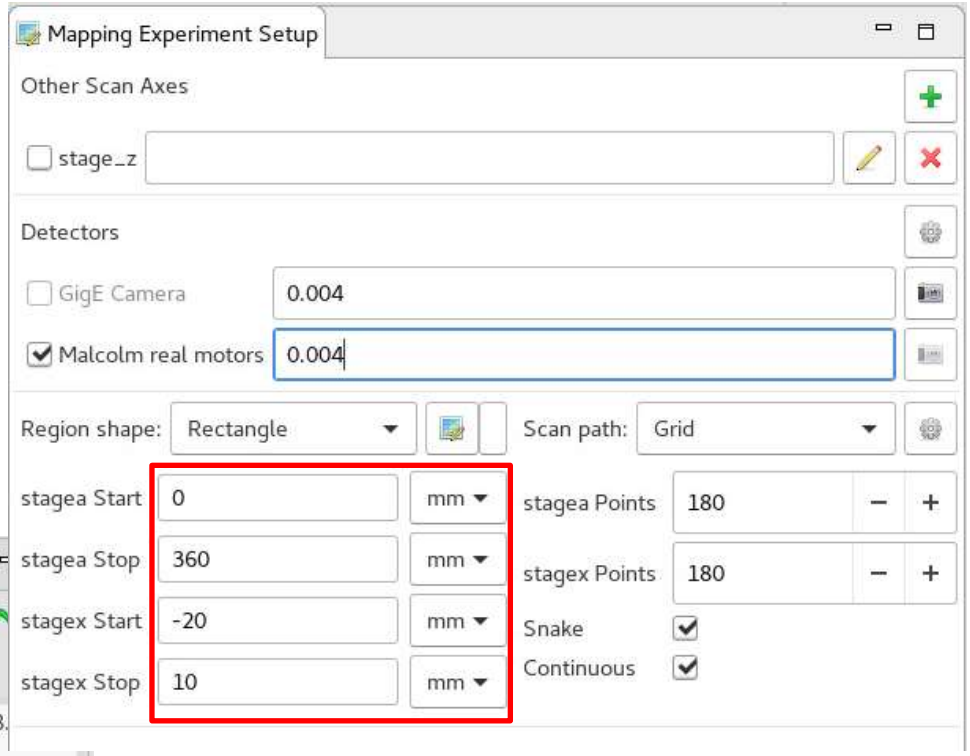

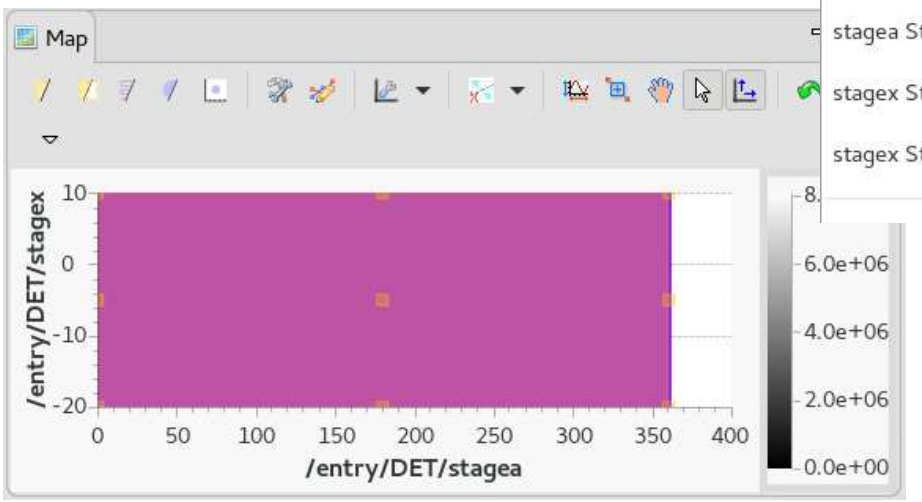

4. Configure the map region
   a) Manually

Mapping Experiment Setup

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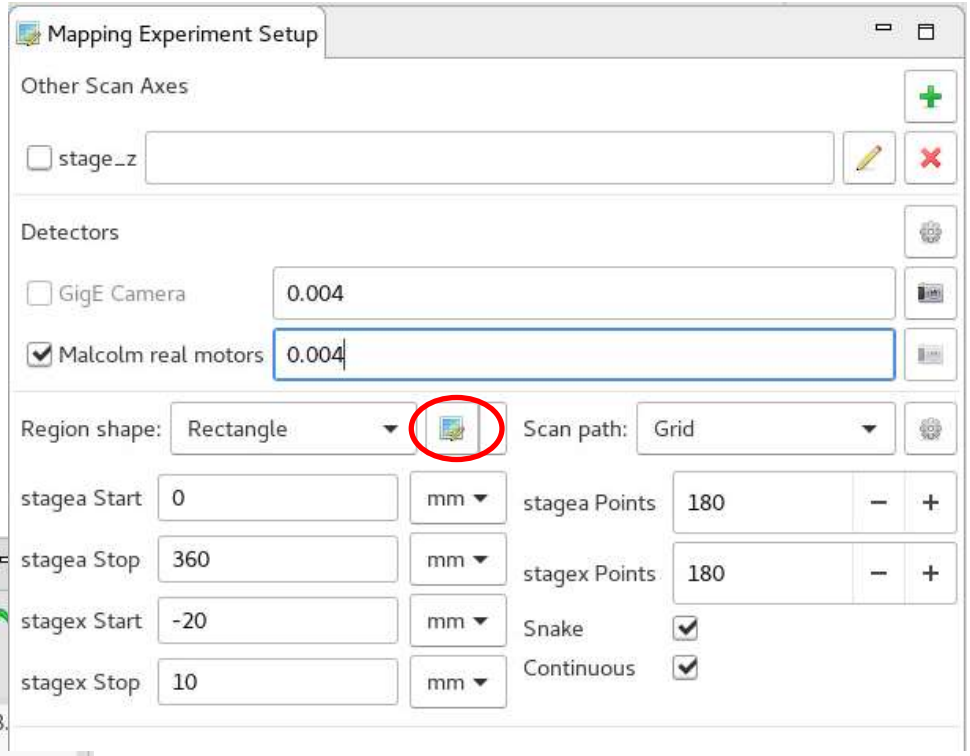
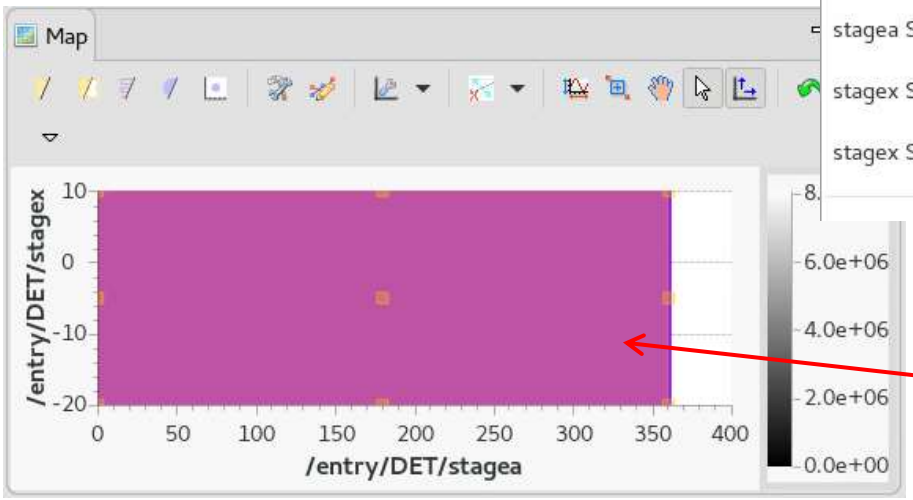




4. Configure the map region
   a) Manually, or
   b) By drawing desired shape

Mapping Experiment Setup

5. Choose a processing template

6. Add scan to queue

Map points calculated automatically

Save/load/copy command to clipboard

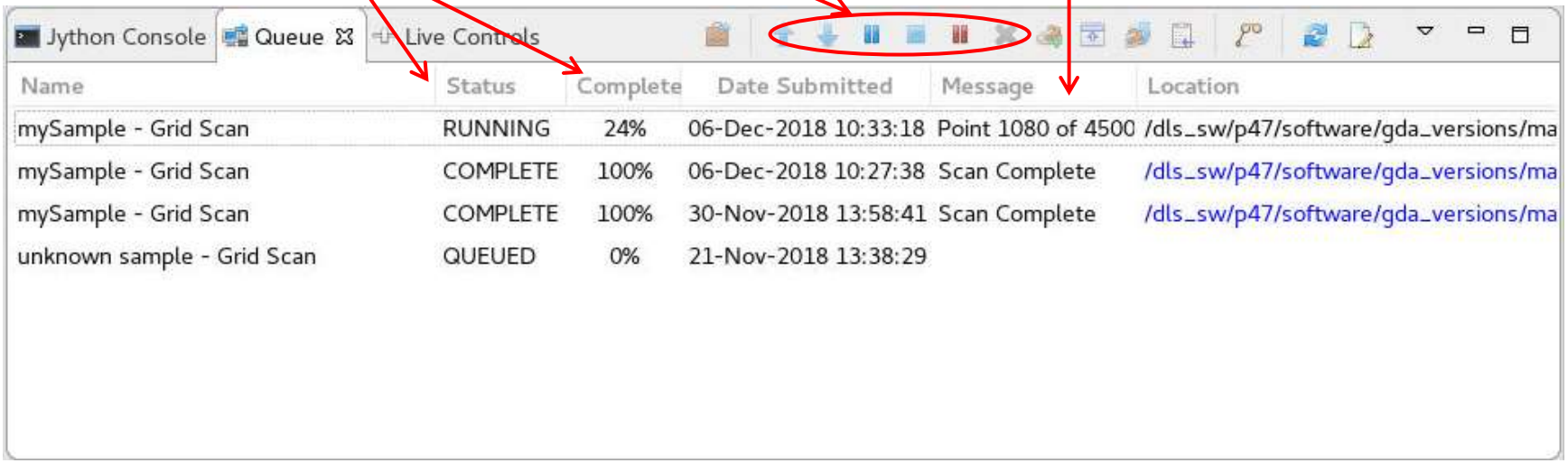
Mapping Queue

Scan ‘jobs’ are put into a queue and started automatically

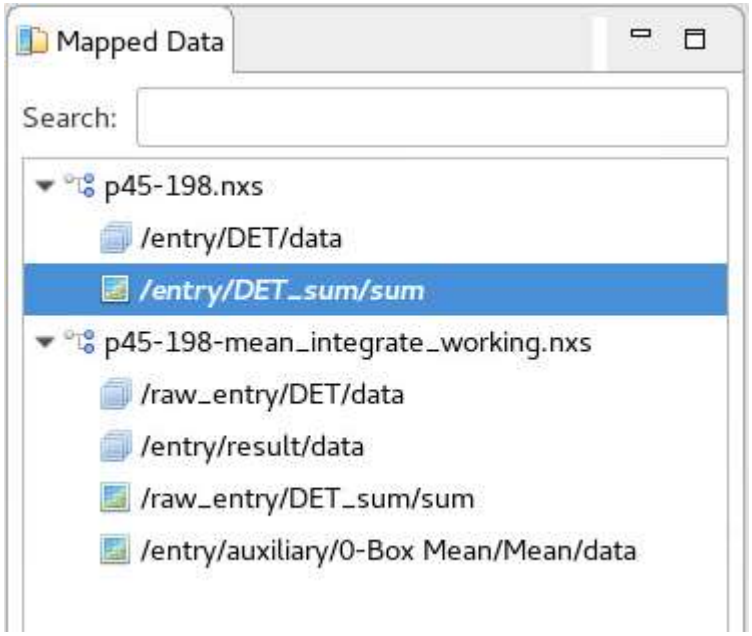
View status and progress

Re-order / pause / abort jobs

Error messages displayed here

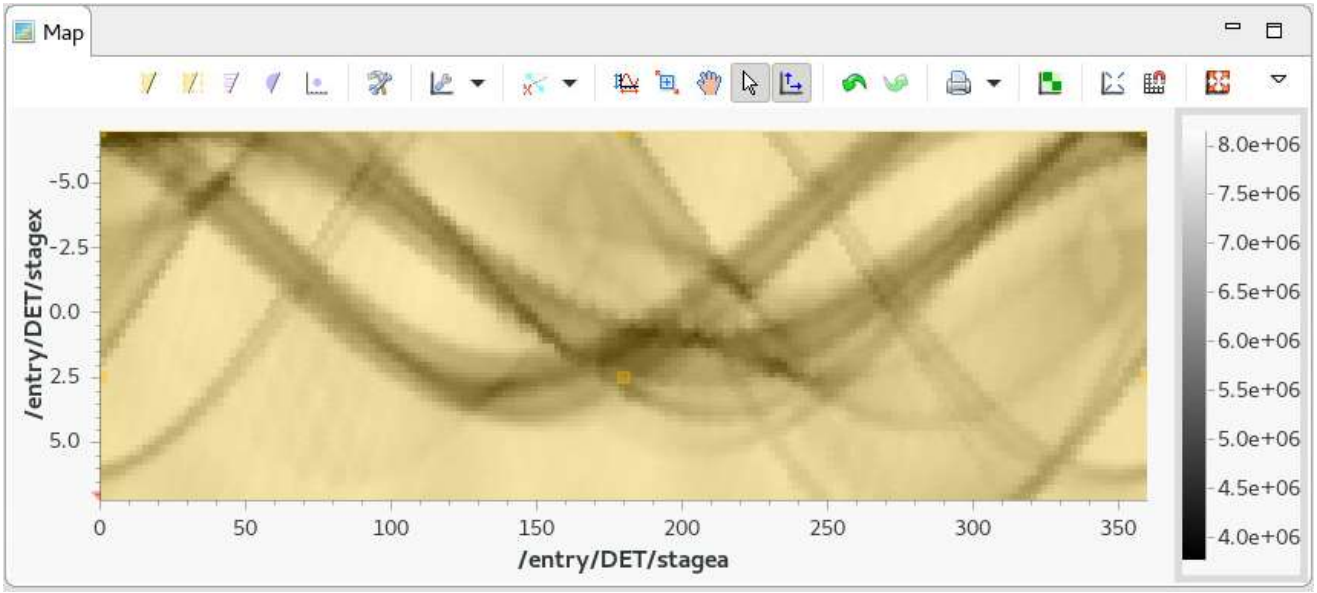


Mapped Data View



- Lists the generated NeXus (.nxs) files
- The *sum* dataset is created by summing the pixel values over the whole image
- If processing was selected, a processed file is also generated

Map View

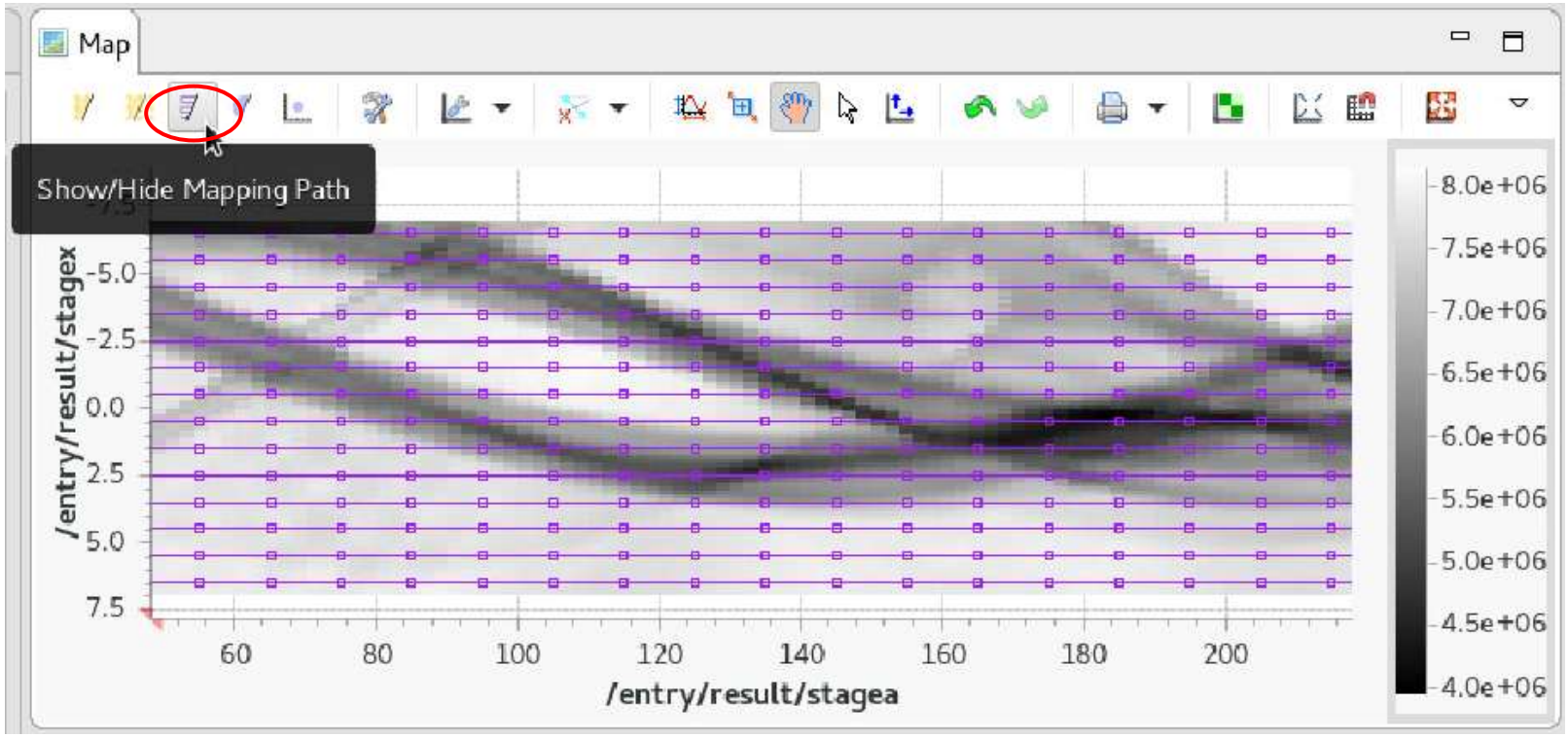


Example: representation of the *sum* (total intensity) data set

- Displays single pixel per scan point
- As the sample is rotated, the camera captures a different angle
- This results in an approximate sinewave for each sample ‘stick’

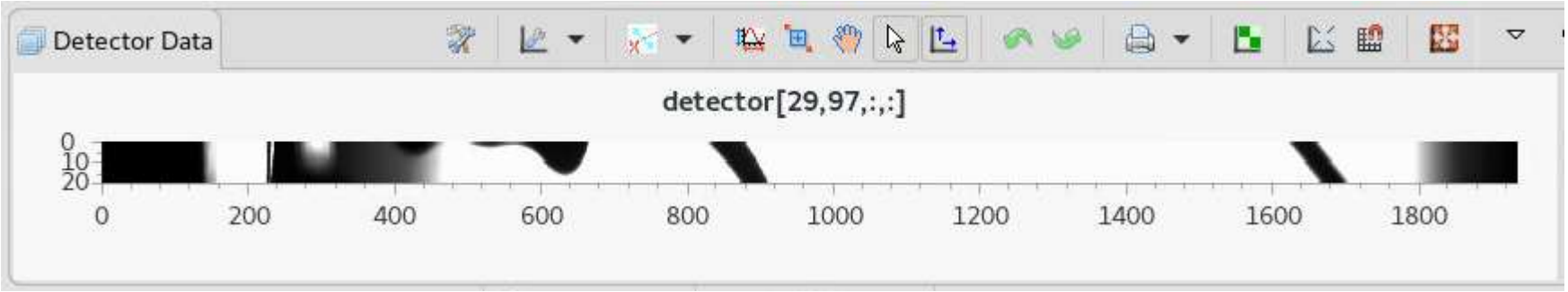
Map View

- Scans can be performed over the top of each other
- Use case: scan a small area in higher resolution



Detector Data View

- Click a point in the map view
- Detector data view updates to show corresponding detector frame



Live Mapping

- The mapping perspective updates raw and processed data as the scan progresses
- This is done via a *DataServer* on ixx-control (localhost on the test rig)
- Can check this using http requests in a browser:

  http://localhost:8690/**tree**/?path=<path2nxsfile>

  - Displays the NeXus tree as XML

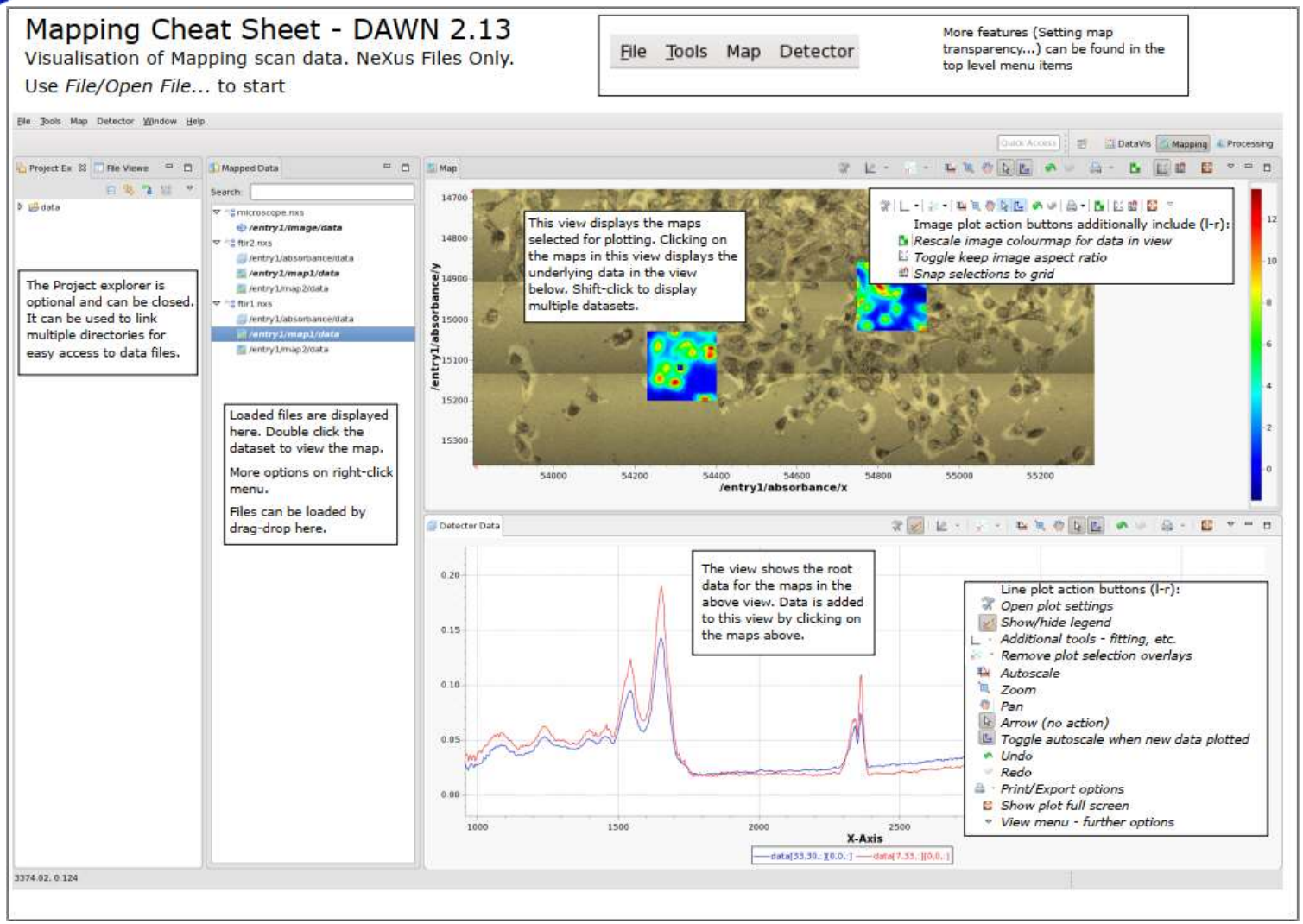
  http://localhost:8690/**info**/?path=<path2nxsfile>&dataset=<dataset>

  - Displays information about the specified dataset e.g. /entry/DET/data

  http://localhost:8690/**slice**/?path=<path2nxsfile>&dataset=<dataset>&slice=[0,0,:,:]

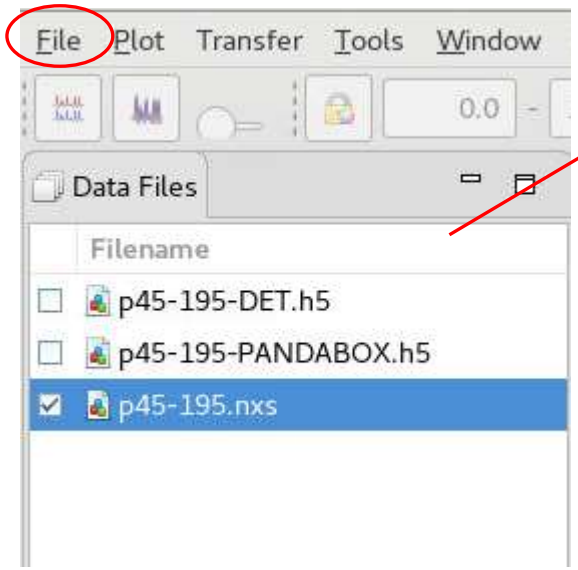
  - Downloads data in specified slice as zip file
- When scan finished, file loaded directly from disk

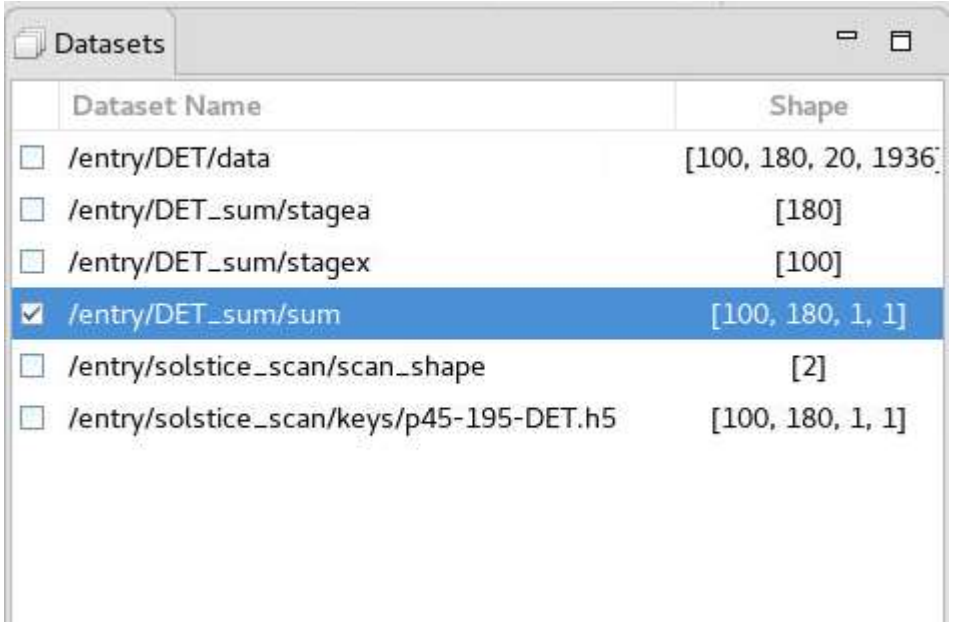
https://dawnsci.org/assets/pages/using_dawn/MappingCheatSheet.pdf



DataVis Perspective

- Standalone perspective provided by DAWN
- Can be used to open any HDF file
- Can also be used at runtime to display additional datasets e.g. UniqueKeys

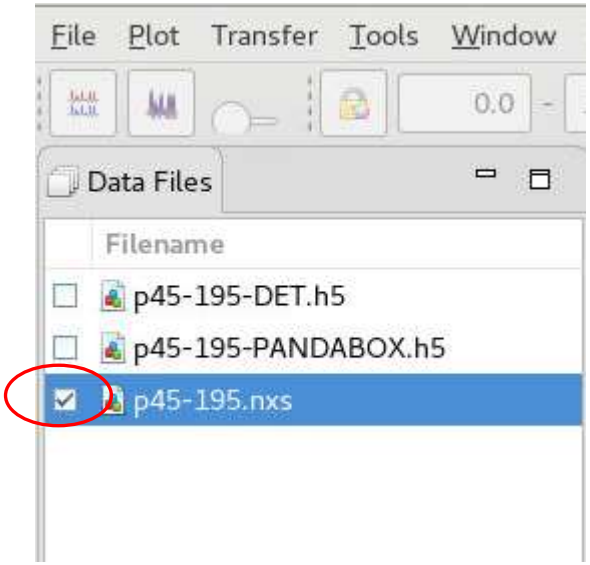


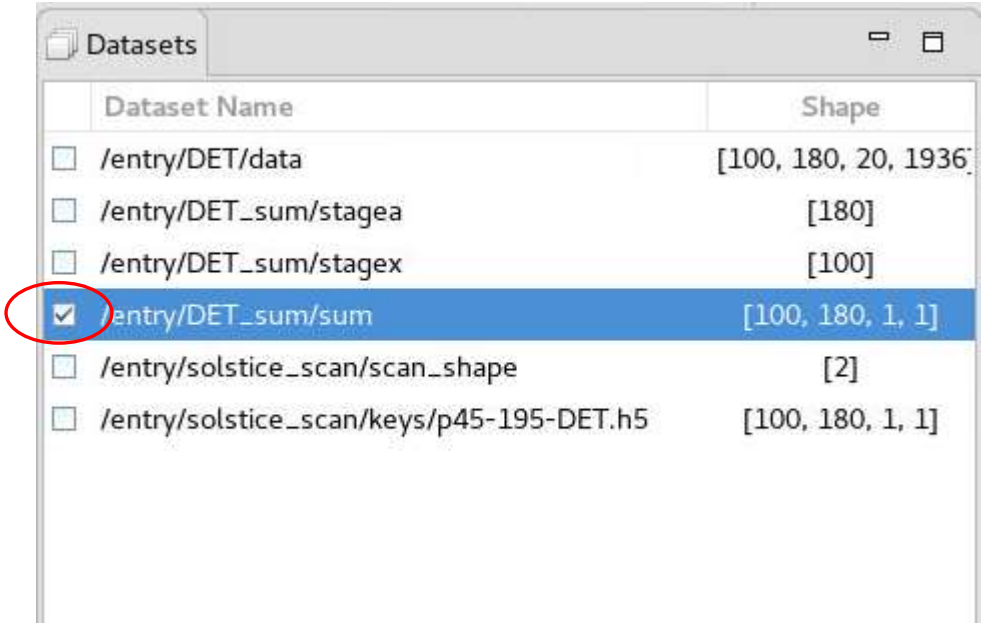


Use the *File* menu to load data files and select for viewing

Datasets view shows the available datasets in the selected file and their dimensions

DataVis Perspective



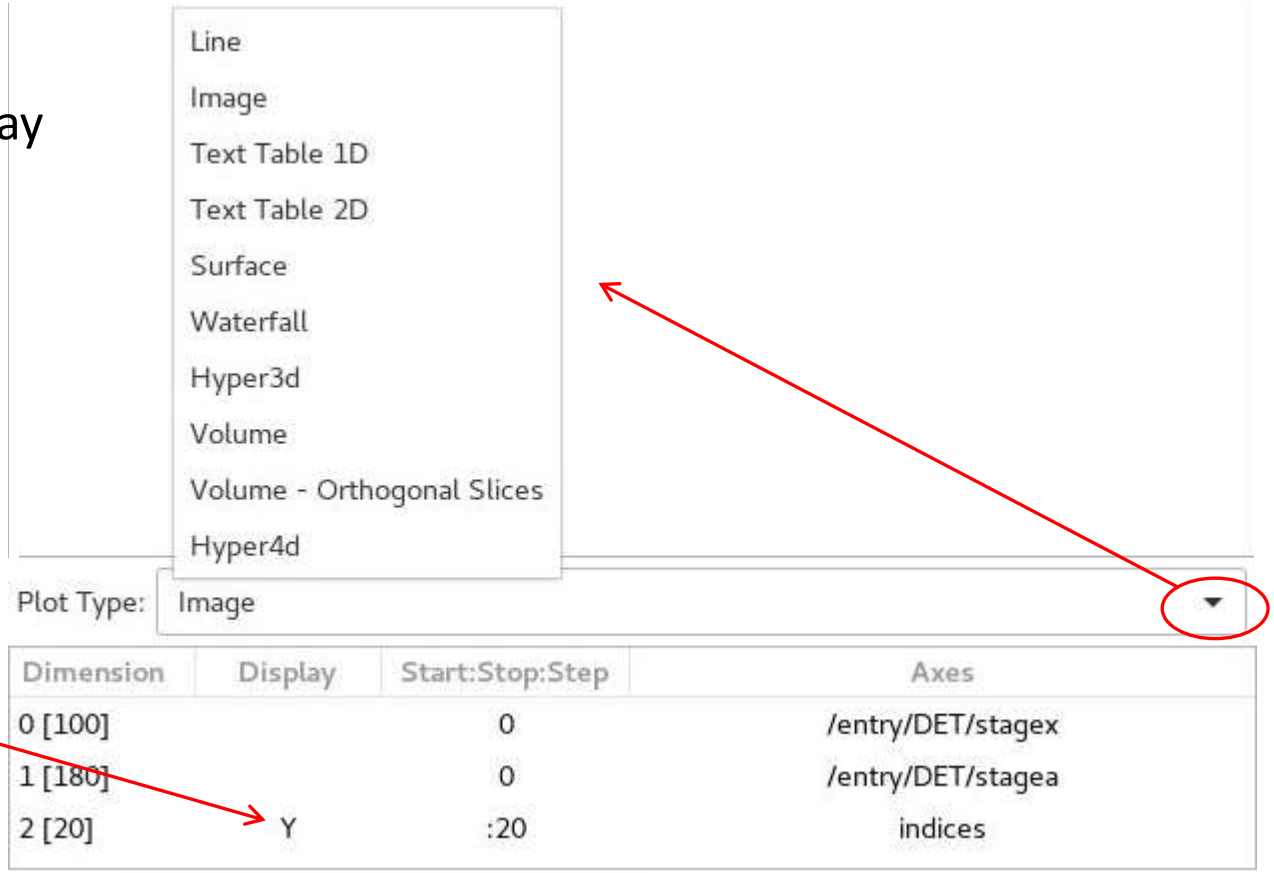


Check the box on both the file AND dataset to activate it for display

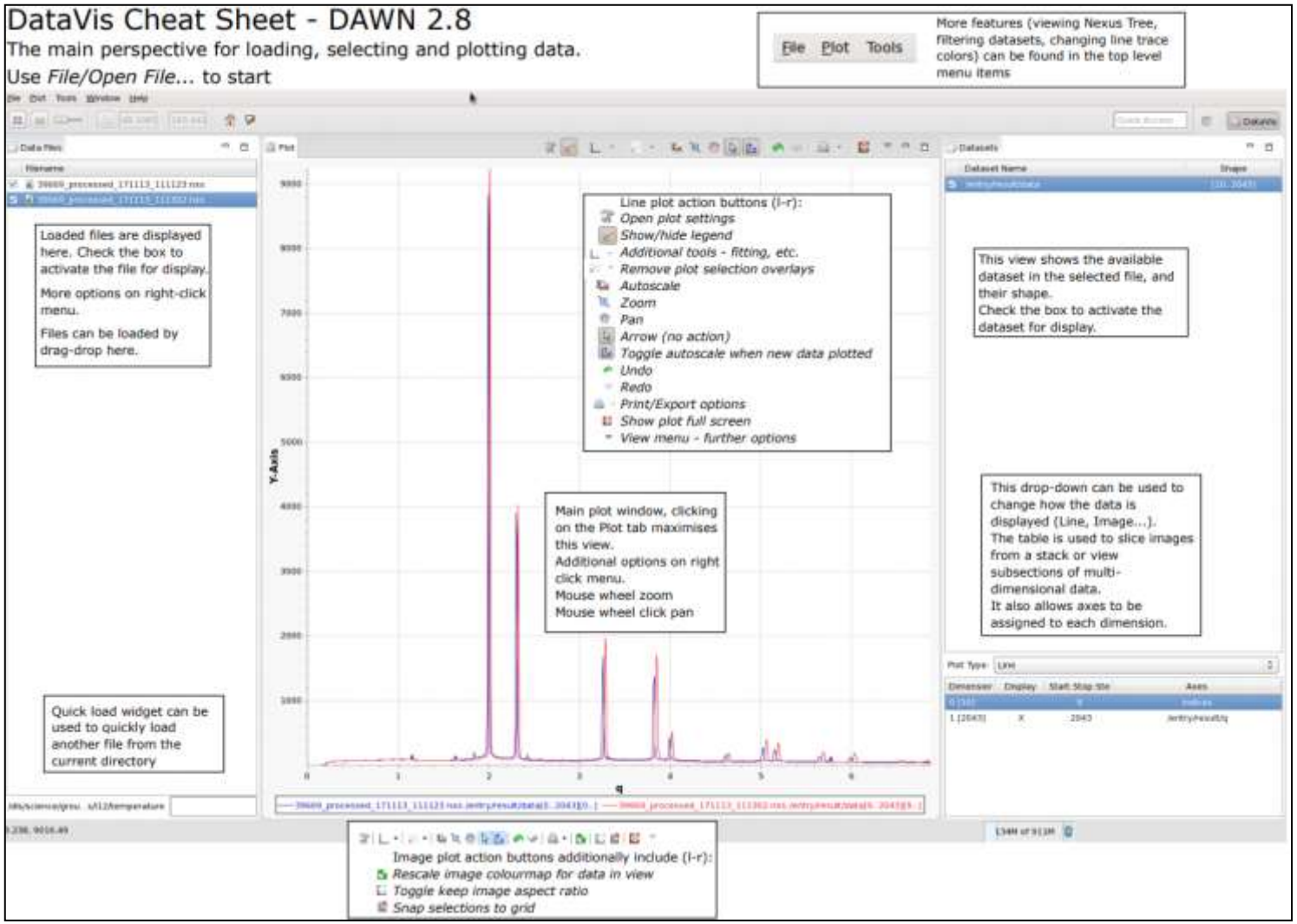
DataVis Perspective

Choose how to display the selected dataset from the dropdown

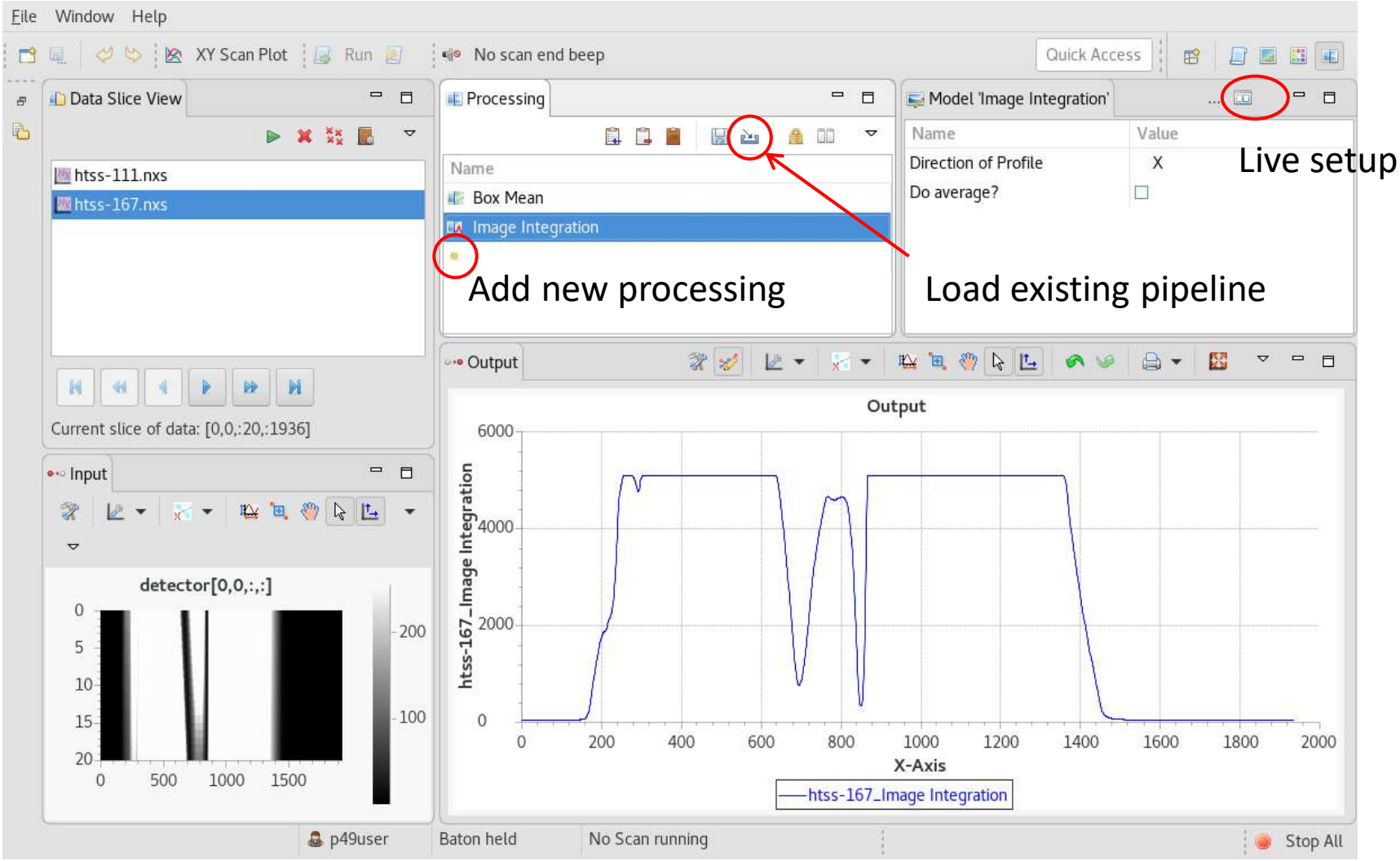
Assign axes to each dimension



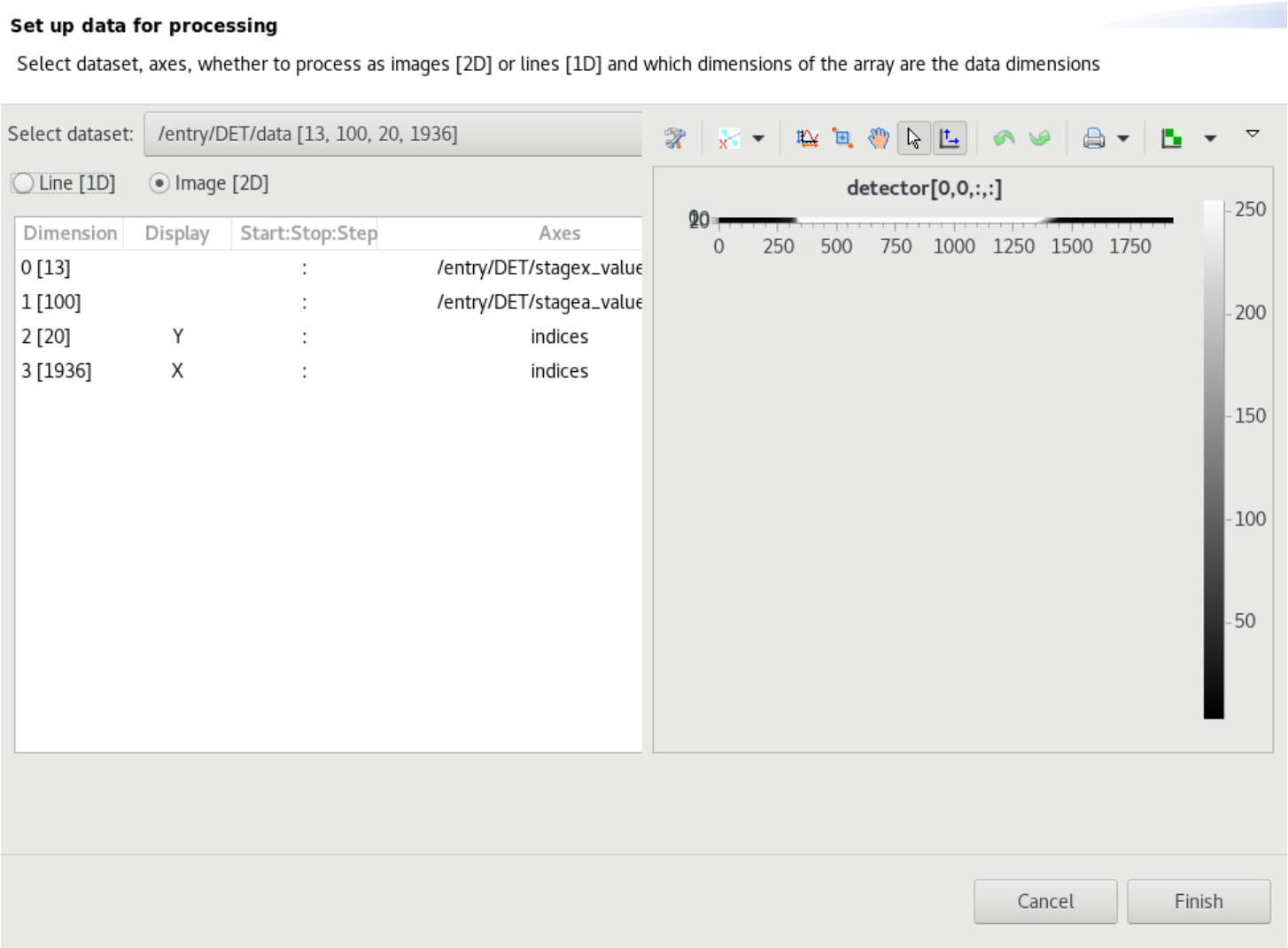
https://dawnsci.org/assets/pages/using_dawn/DataVisCheatSheet.pdf



Live Processing

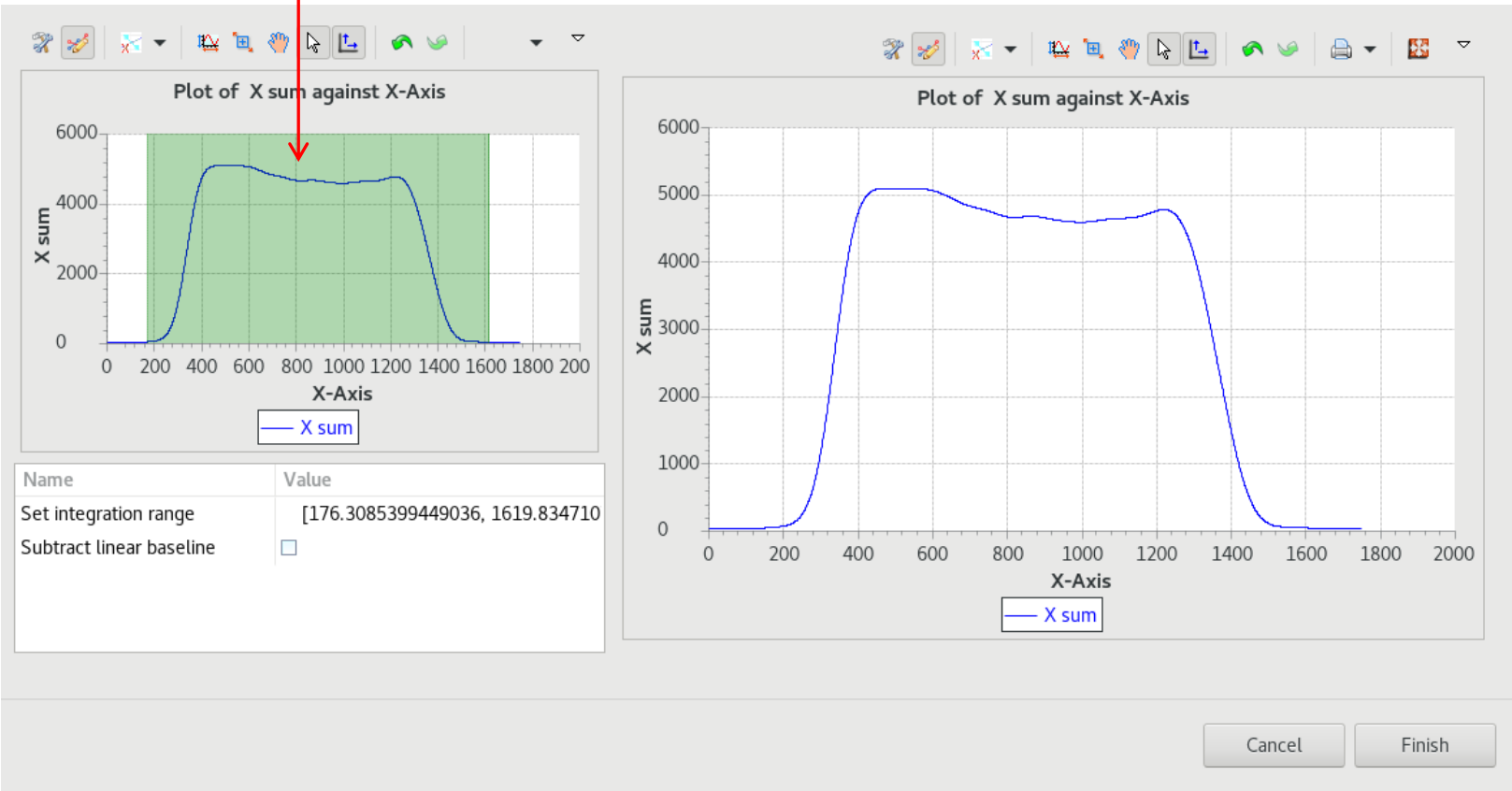


Live Processing

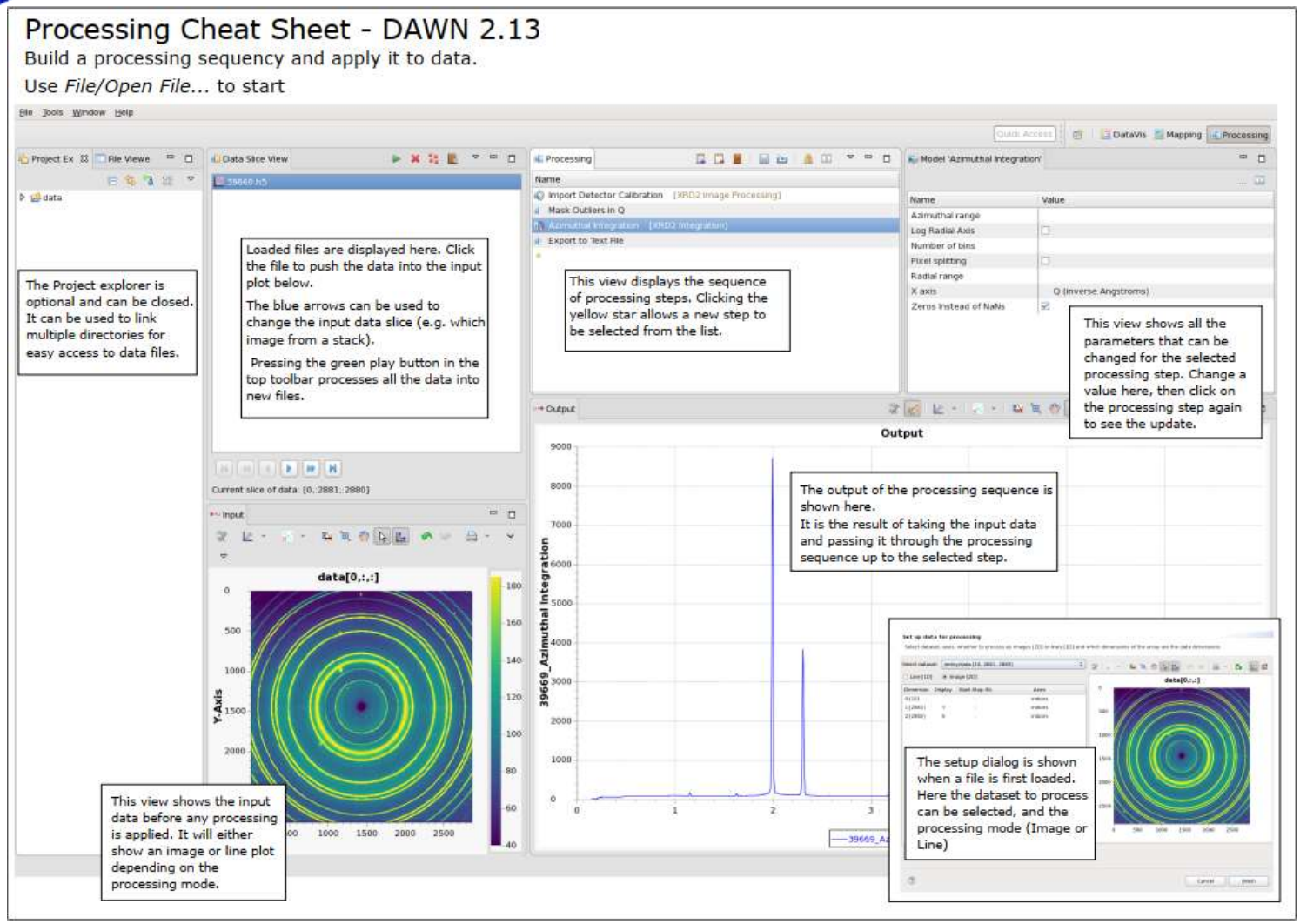


Live Processing

Set range



https://dawnsci.org/assets/pages/using_dawn/ProcessingCheatSheet.pdf

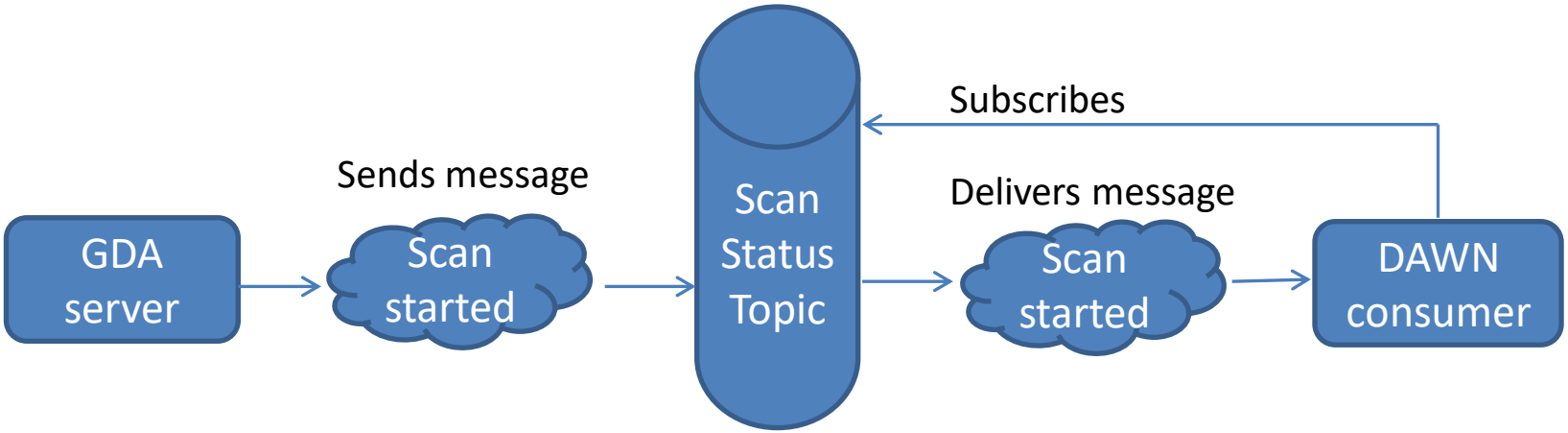


Exercise: Make your own mean integration pipeline

- Open the mean_integrate.nxs file you used for the live processing in Part 1 and inspect it
- Clear the pipeline, and then recreate it using the star button to add processing steps
- Save it with a distinct name somewhere obvious
- Start a new scan using the old mean_integrate.nxs template, and the one you just created
- Hopefully they produce the same result!
- Play around with other processing steps (e.g. Gaussian filter)

Live Processing

- GDA can submit pipelines to DAWN for live processing
- Publish-subscribe mechanism using ActiveMQ
- Other subscribers can also be written e.g. using Python



ActiveMQ
Web console
on port 8161

Scan topic

Processing topic

'Processing finished' message triggers final reconstruction

ActiveMQ™ The Apache Software Foundation http://www.apache.org/

Home | Queues | Topics | Subscribers | Connections | Network | Scheduled | Send | Support

Topic Name [ ] Create

Topics

Name	Number Of Consumers	Messages Enqueued	Messages Dequeued ↓	Operations
org.eclipse.scanning.status.topic	3	863	2580	Send To Delete
scisoft.operation.STATUS_TOPIC	2	112	224	Send To Delete
gda.event.command_server	1	196	154	Send To Delete
org.eclipse.scanning.response.device.topic	0	73	73	Send To Delete
org.eclipse.scanning.request.device.topic	1	73	73	Send To Delete
org.eclipse.scanning.command.topic	3	25	71	Send To Delete
org.eclipse.scanning.ack.topic	0	24	24	Send To Delete
gda.event.GDAMetadata	1	3	3	Send To Delete

Live Processing - Details

- DAWN consumer receives a JSON message on scan start and writes it to disk:
  - {visit folder}/tmp/operationBean.json
- JSON file contains the path to the scan data files
- Consumer then starts a new DAWN process on the cluster which reads the JSON file
- Log files also stored in {visit folder}/tmp
- *Note:* Test rig is setup slightly differently

Live Processing - Details

- On beamlines, the DAWN Consumer and ActiveMQ processes run on ixx-control
- On the test rig, ActiveMQ runs under ProcServ:
  - ioc-connect BL4xP-EA-PRCO-01
  - Ctrl-X to reboot

More flexible processing

- Status information about the scan is sent to an ActiveMQ topic: *gda.messages.scan*
- A script can subscribe to this topic to do arbitrary processing during or after a scan
- See visualhulls for an example
- There is a python3 module called *scansubscriber* to help


```
{
  "status": "UPDATED",
  "scanNumber": 0,
  "filePath": "/dls/htss/data/2019/0-0/htss-299.nxs",
  "detectors": [
    "BL49P-ML-SCAN-01"
  ],
  "scannables": [],
  "swmrStatus": "ACTIVE",
  "visitDirectory": "/dls/htss/data/2019/0-0",
  "scanDimensions": [
    100,
    100
  ],
  "processingRequest": {
    "visualhulls": [
      "/localhome/p49user/vh.json"
    ]
  },
  "percentageComplete": 18.38
}
```

Watchdogs

- *Watchdogs* provide a mechanism to pause and resume a scan based on an external condition
- General case: *ExpressionWatchdog*

ring_current >= 1.0 && !portshutter.equals('Closed')

scannable names — *comparision and logical operators* — *literals*

Scan paused when expression becomes FALSE

- Special case: *TopupWatchdog*

Monitors *SR-CS-FILL-01:COUNTDOWN*

Configurable warmup and cooloff periods (ms)

Configuring Watchdogs

1. Create an instance of *DeviceWatchdogModel*
   - Give it an ID (name)
   - Define the properties (dependent on the type of watchdog)
   - Ensure it's linked to by the GDA server configuration

ExpressionWatchdog:

```
<bean id="noBeam" class="org.eclipse.scanning.api.device.models.DeviceWatchdogModel">
  <property name="expression" value="ring_current >= 1.0"
  <property name="message" value="Beam has been lost"/>
</bean>
```

TopupWatchdog:

```
<bean id="beamTopup" class="org.eclipse.scanning.api.device.models.DeviceWatchdogModel">
  <property name="countdownName" value="machineTopupMonitor"/>
  <property name="message" value="Paused during topup"/>
  <property name="warmup" value="5000"/>
  <property name="cooloff" value="4000"/>
  <property name="modeName" value="ringModeMonitor"/>
</bean>
```

Configuring Watchdogs

2. Create an *ExpressionWatchdog* or *TopupWatchdog* instance and link it to the model

Example: ExpressionWatchdog

```
<bean id="noBeam" class="org.eclipse.scanning.api.device.models.DeviceWatchdogModel">
  <property name="expression" value="ring_current >= 1.0"
  <property name="message" value="Beam has been lost"/>
</bean>

<bean id="expressionWatchdog"
class="org.eclipse.scanning.sequencer.watchdog.ExpressionWatchdog" init-method="activate">
  <property name="model" ref="noBeam"/>
  <property name="enabled" value="true" />
</bean>
```

Watchdogs

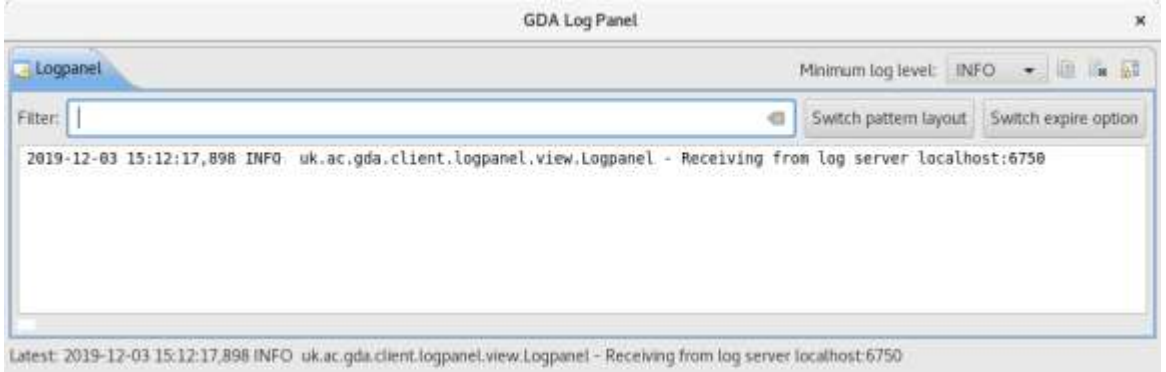
Watchdogs are controlled at run time via the Jython console:

- enableWatchdogs()
- disableWatchdogs()
- listWatchdogs()

Logs

- On the test rig, GDA logs are stored here:
  /dls_sw/p4x/software/gda_logs

- But can use the GDA log monitor from launcher or:
  > module load gdalogpanel
  > gdalogpanel



- EPICS logs are in the IOC:
  /dls/p4x/epics/logs/BL4xP-EA-IOC-01

- DAWN processing logs can be found here:
  /dls/p4x/epics/logs/BL4xP-EA-PRC0-0x

Practical Exercises

The scripts located in /localhome/p4xuser/training each trigger a problem somewhere in the stack…

- Restart the machine to ensure a fresh start and confirm scans are working
- Run one of the scripts
- Start a new scan from GDA
- Try to figure out what goes wrong and how to fix it!
- No cheating!