

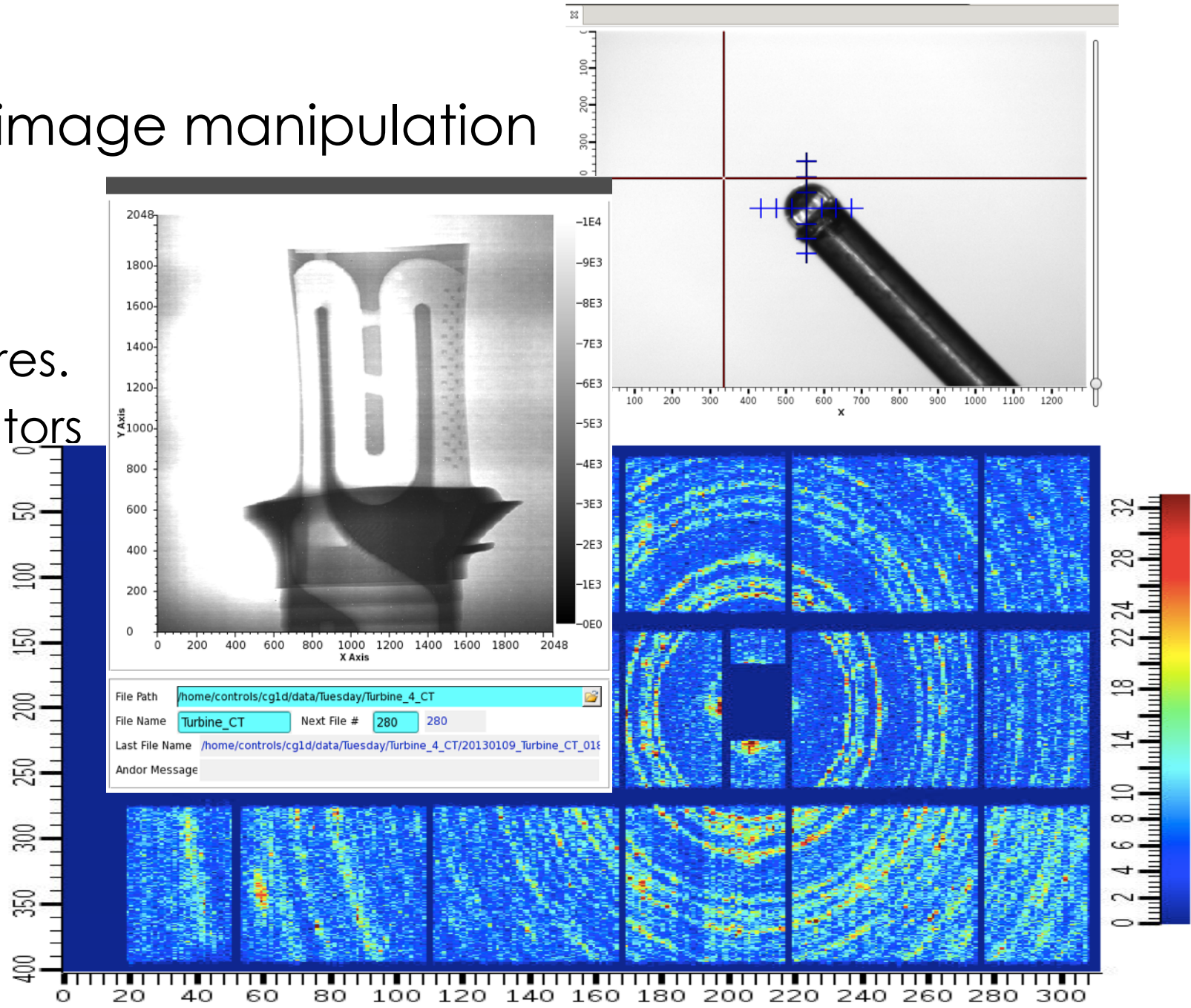
# Area Detector

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based on presentations by Mark Rivers, APS, U. Chicago

# Area Detector

- EPICS framework for image manipulation
- Cameras
  - Cheap “Web Cam”
  - \$\$\$ high speed, high res.
  - Neutron, X-Ray detectors
- Plugins collection
  - ROI
  - Transform
  - ColorConvert
  - Etc.
- Extendibility



# Features

- Maybe the largest shared EPICS Application
- PVs for image settings, shutter, exposure, ...
  - “Simulated” area detector IOC has 6000 records
- N-D data
  - 1D time series data
  - 2D images (most plugins)
  - $N \leq 10$
  - Custom metadata
- Supports  $>500$  frame/second detectors

# Disclaimer

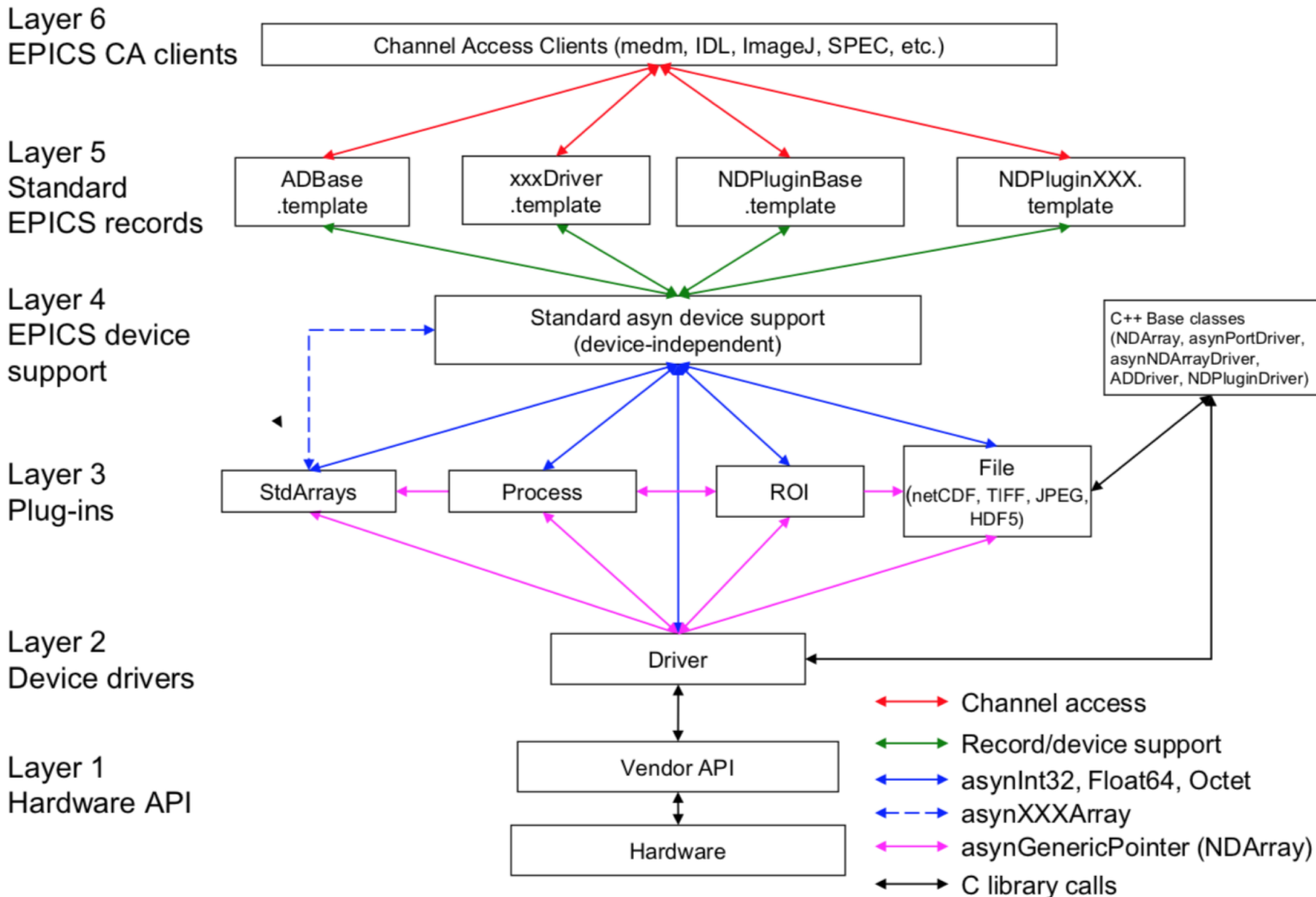
This will only scratch the surface.

EPICS web site has several days of training material if you are serious about using the A.D.

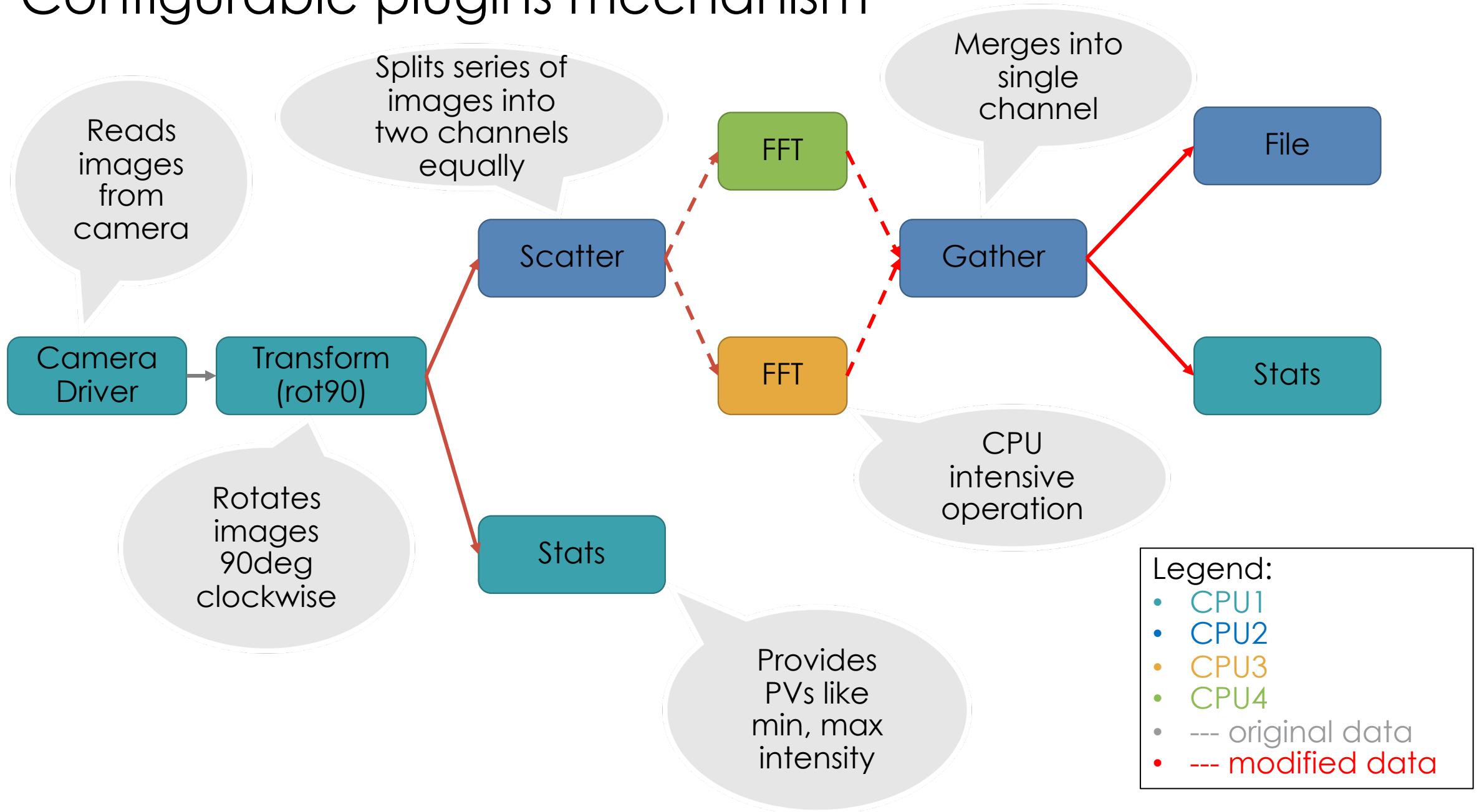
# Vocabulary

- Driver
  - Interface to camera
  - Vendor libraries, custom protocols
  - Creates NDArray
- Pugin
  - Manipulates NDArray data
  - May change data
  - May send data to other plugins
    - No-copy if not changed
- NDArray
  - Structure holding data
  - N-dimensional array
    - $N=2$  for basic greyscale image
    - $N>2$  for color, detector with “depth”
- NDArryAttribute
  - Metadata attached to NDArray
    - Motor position, temperature, shutter,...
  - Added by driver, from PVs, Plugins...
- NDArrayPool
  - Pool of NDArrays to reduce memory allocation

# EPICS AreaDetector Architecture



# Configurable plugins mechanism



# ADSimDetector

- Simulated images

```
cd ~/epics-train/examples/AreaDetector  
./start_sim_ioc.sh
```

- Open the AreaDetectorDemo.bob
  - On “Detector” page,  
“Start” the SIM1 detector

The screenshot displays the control interface for the AreaDetector. At the top, there is a blue "Collect" button. Below it, several parameters are shown with their current values and target values in blue text:

- Exposure time: 0.500 (target 0.500)
- Acquire period: 0.005 (target 0.005)
- # Images: 100 (target 100)
- # Images complete: 48895
- # Exp./image: 1 (target 1)
- Image mode: Continuous (dropdown menu)
- Trigger mode: Internal (dropdown menu)

Below these parameters, there is a "Collecting" status indicator in yellow. Underneath, there are "Acquire Start" and "Acquire Stop" buttons. Further down, more parameters are shown:

- # Queued arrays: 0
- Wait for plugins: No (dropdown menu)
- Acquire busy: Acquiring (green text)
- Detector state: 1 (green text)
- Time remaining: 0.000
- Image counter: 0 (current) / 48895 (target)
- Image rate: 2.00

At the bottom, there is an "Array callbacks" dropdown menu set to "Enable" and a corresponding "Enable" button highlighted with an orange border.



# NDPluginStdArrays

- Serves image as Channel Access waveform

- On Detector, Plugins, All, find NDPluginStdArrays

- Port = "SIM1"
- Enable

- AreaDetectorDemo.bob shows image

- PV: 13SIM1:image1:ArrayData
- Width x Height: 1024 x 1024
- Unsigned

13SIM1: Common Plugins									
Plugin name	Plugin type	Port	Enable	Blocking	Dropped	Free	Rate		
Image1	NDPluginStdArrays	SIM1	Enable	Enable	No	0	20	2.00	More

## Area Detector Demo

Setup

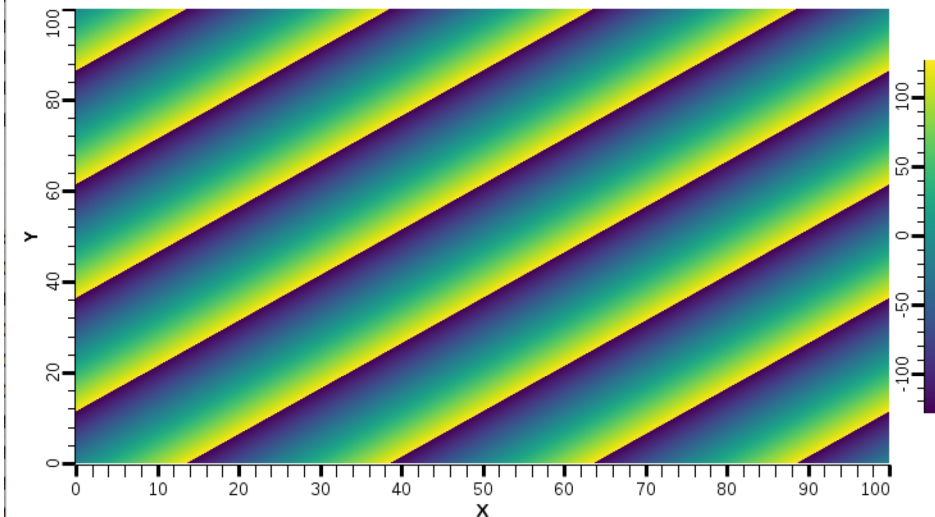
Detector

- 1) cd /home/training/epics-train/examples/AreaDetector  
.start\_sim\_ioc.sh
- 2) Open Detector page
- 3) Press Connect.. "Start"
- 4) Open Plugins.. "All" and "Enable" the NDPluginStdArrays

Start

Stop

Enable



Images: 51911 155.00 Hz

# NDPluginOverlay

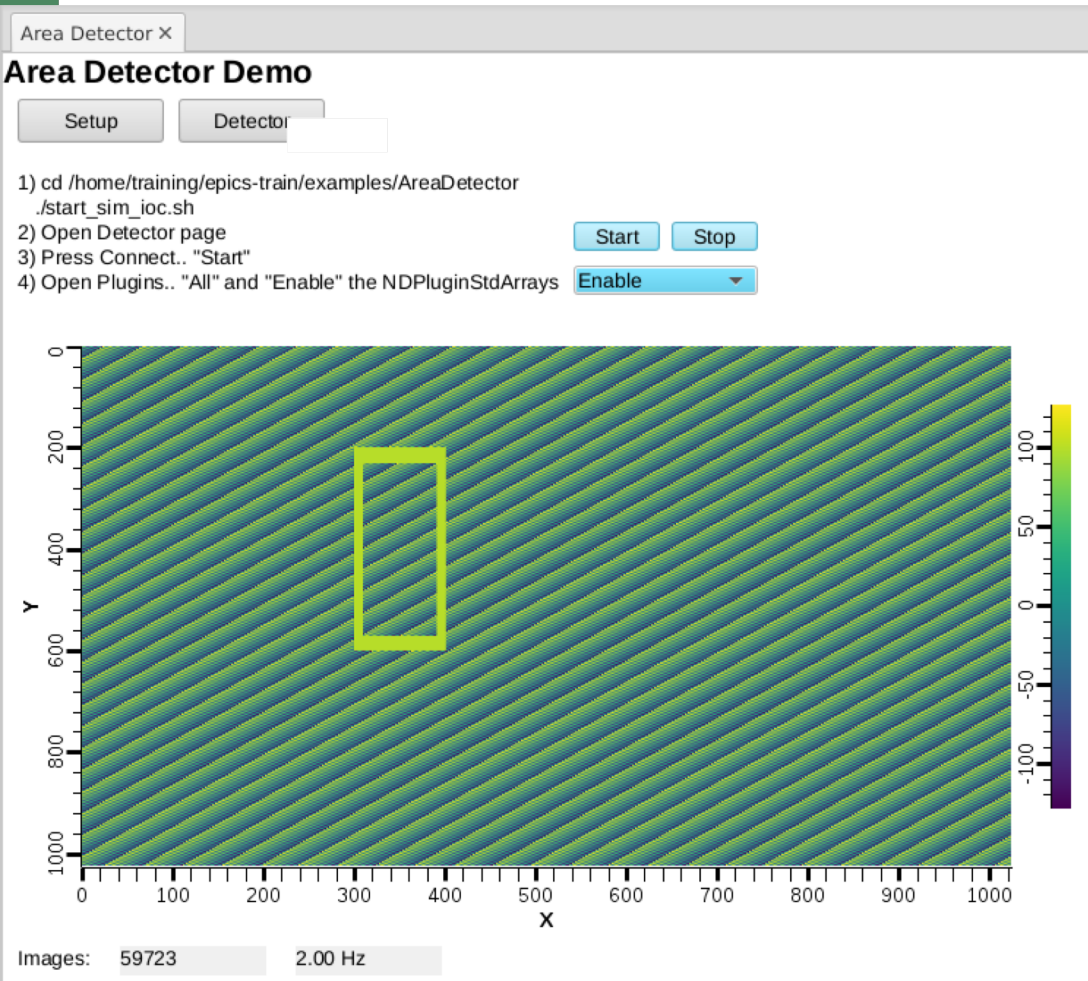
- Adds rectangles, text etc. to image
- On Detector, Plugins, All, find NDPluginOverlay “OVER1”
  - Set its Port to “SIM1”, Enable
  - Change NDPluginStdArrays’s Port to “OVER1”

13SIM1: Common Plugins									
Plugin name	Plugin type	Port	Enable	Blocking	Dropped	Free	Rate		
Image1	NDPluginStdArrays	OVER1	Enable	Enable	No	0	20	2.00	More
<13SIM1:Pva1:Port	<13SIM1:Pva1:PluginType_R	<13SIM1:P	<null>	<13SIM1:Pva	<null>	<13SIM1:Pva	<13SIM1:Pva	<13SIM1:Pva	More
PROC1	NDPluginProcess	SIM1	Disabl	Disable	No	0	20	0.00	More
TRANS1	NDPluginTransform	SIM1	Disabl	Disable	No	0	20	0.00	More
CC1	NDPluginColorConvert	SIM1	Disabl	Disable	No	0	20	0.00	More
CC2	NDPluginColorConvert	SIM1	Disabl	Disable	No	0	20	0.00	More
OVER1	NDPluginOverlay	SIM1	Enable	Enable	No	0	20	2.00	More

- Press “More”, select first of the “Individual Overlays”

# NDPluginOverlay.. Overlay #1

Set Use: Yes, Shape: Rectangle, set X and Y as shown



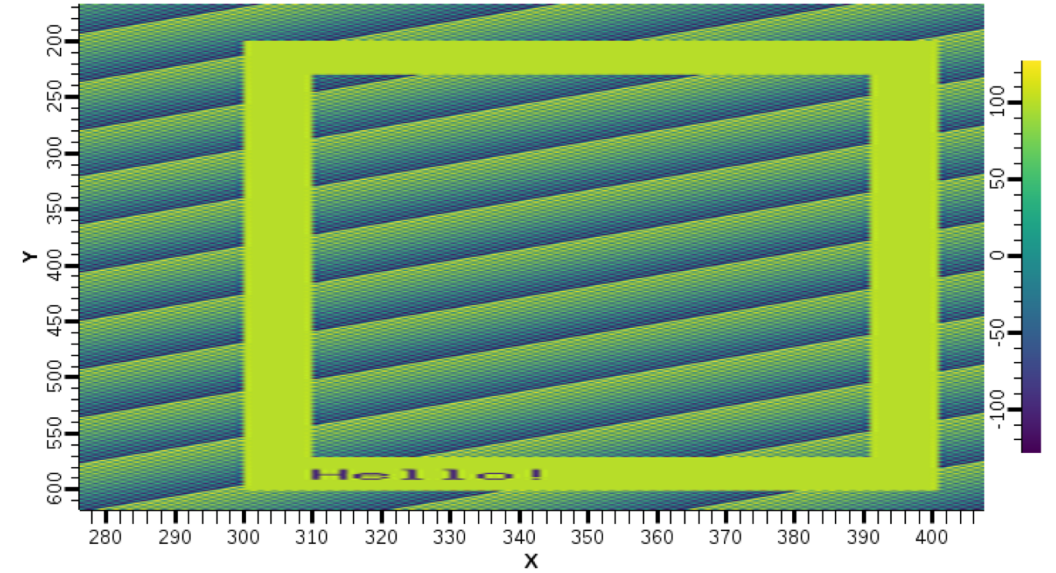
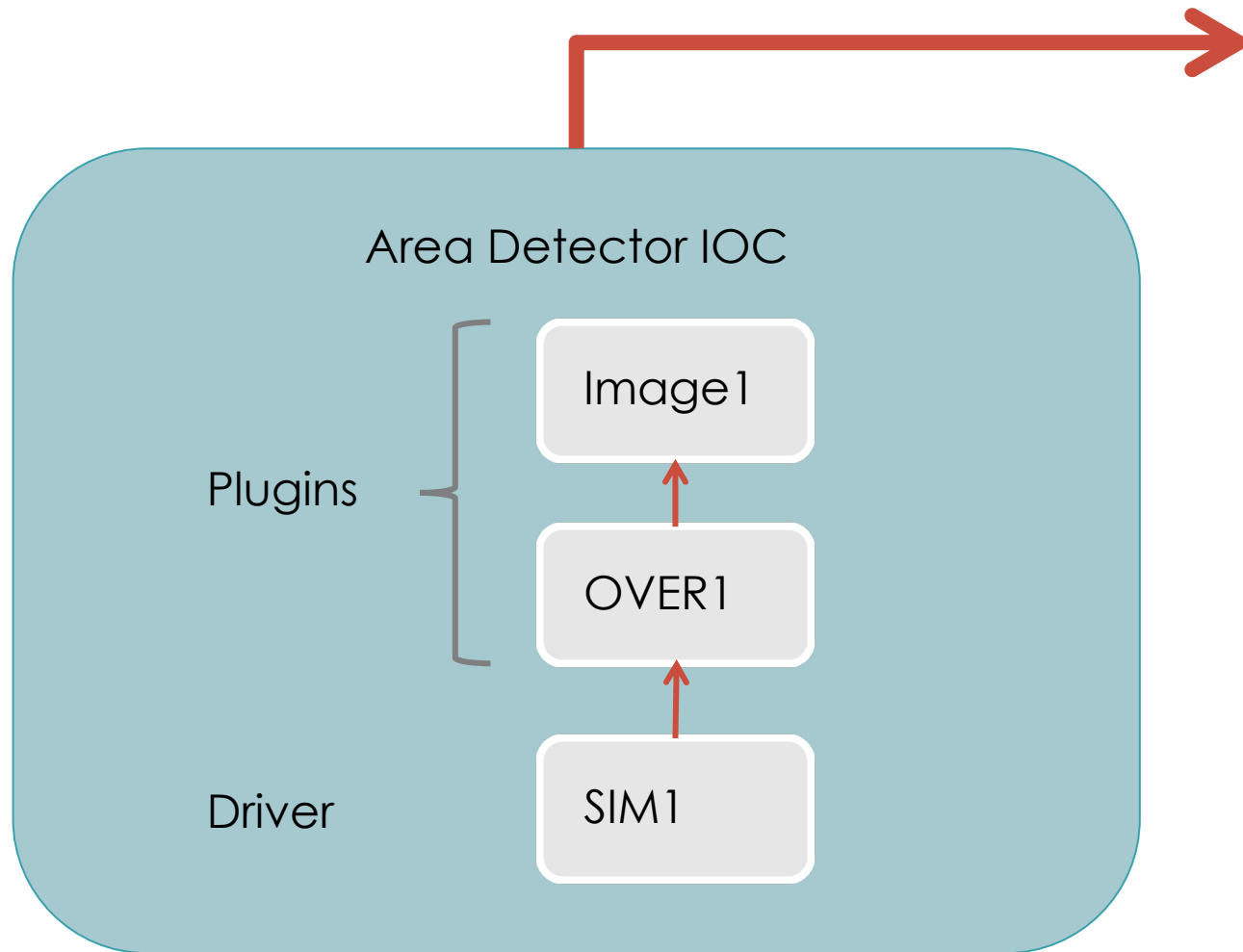
NDOverlayN X

### 13SIM1:Over1:1:

Use? <b>Yes</b> <input type="checkbox"/> <b>Yes</b>		
Name <b>ROI1</b>		
Shape <b>Rectangle</b> <input type="checkbox"/> <b>Rectangle</b>		
Draw mode <b>Set</b> <input type="checkbox"/> <b>Set</b>		
Red <b>1</b> <input type="checkbox"/> <b>1</b>		
Green (mono) <b>100</b> <input type="checkbox"/> <b>100</b>		
Blue <b>1</b> <input type="checkbox"/> <b>1</b>		
Display Text		
Time format <b>%Y-%m-%d %H:%M:%S.%03f</b>		
Format example <b>%Y-%m-%d %H:%M:%S.%03f</b>		
Font <b>6x13</b>		

	X	Y
Position	<b>300</b> <input type="checkbox"/> <b>300</b>	<b>200</b> <input type="checkbox"/> <b>200</b>
Position link	<input type="checkbox"/>	<input type="checkbox"/>
Center	<b>350</b> <input type="checkbox"/> <b>350</b>	<b>400</b> <input type="checkbox"/> <b>400</b>
Center link	<input type="checkbox"/>	<input type="checkbox"/>
Size	<b>100</b> <input type="checkbox"/> <b>100</b>	<b>400</b> <input type="checkbox"/> <b>400</b>
Size link	<input type="checkbox"/>	<input type="checkbox"/>
Width	<b>10</b> <input type="checkbox"/> <b>10</b>	<b>30</b> <input type="checkbox"/> <b>30</b>
Width link	<input type="checkbox"/>	<input type="checkbox"/>

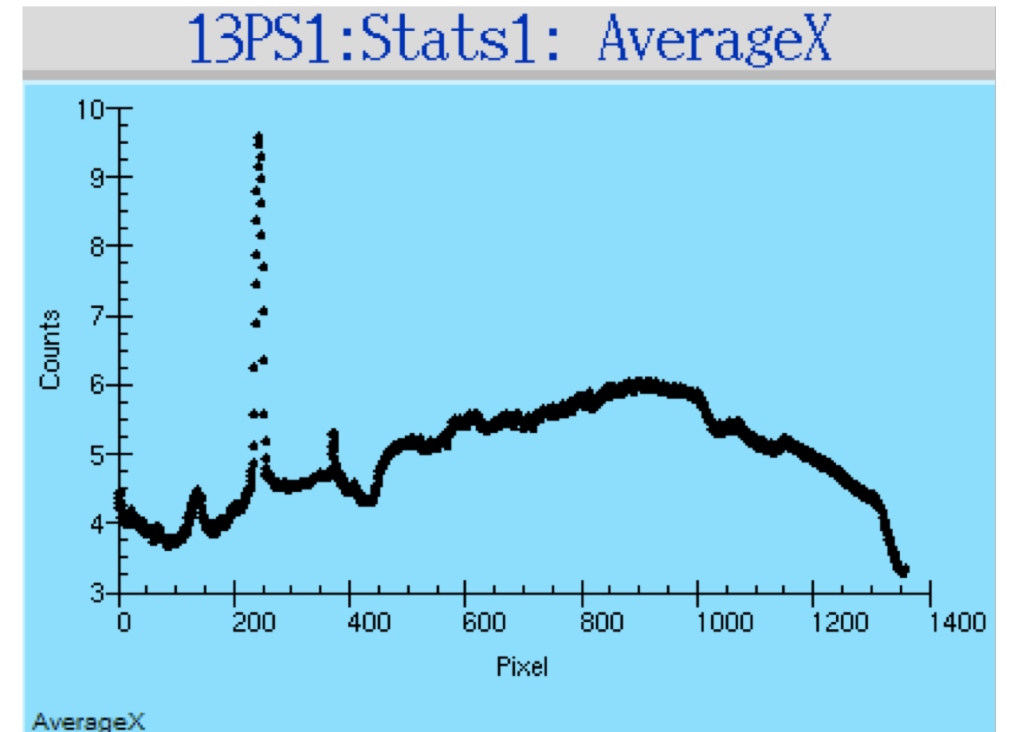
# What we did



- OVER1 offers 8 overlays:
- 1) Rectangle
  - 2) Text "Hello"
  - 3) ...

# NDPluginStats

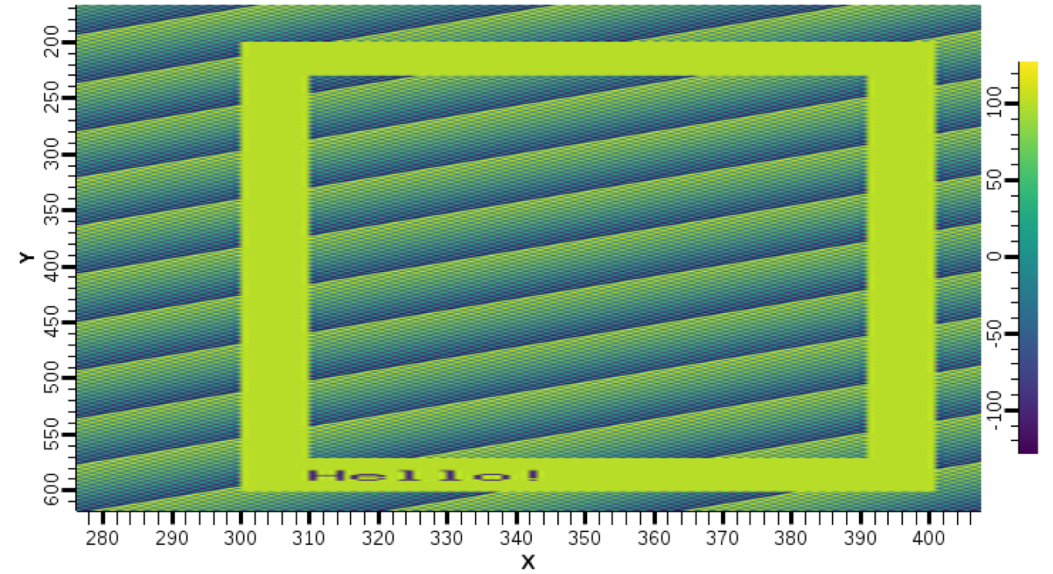
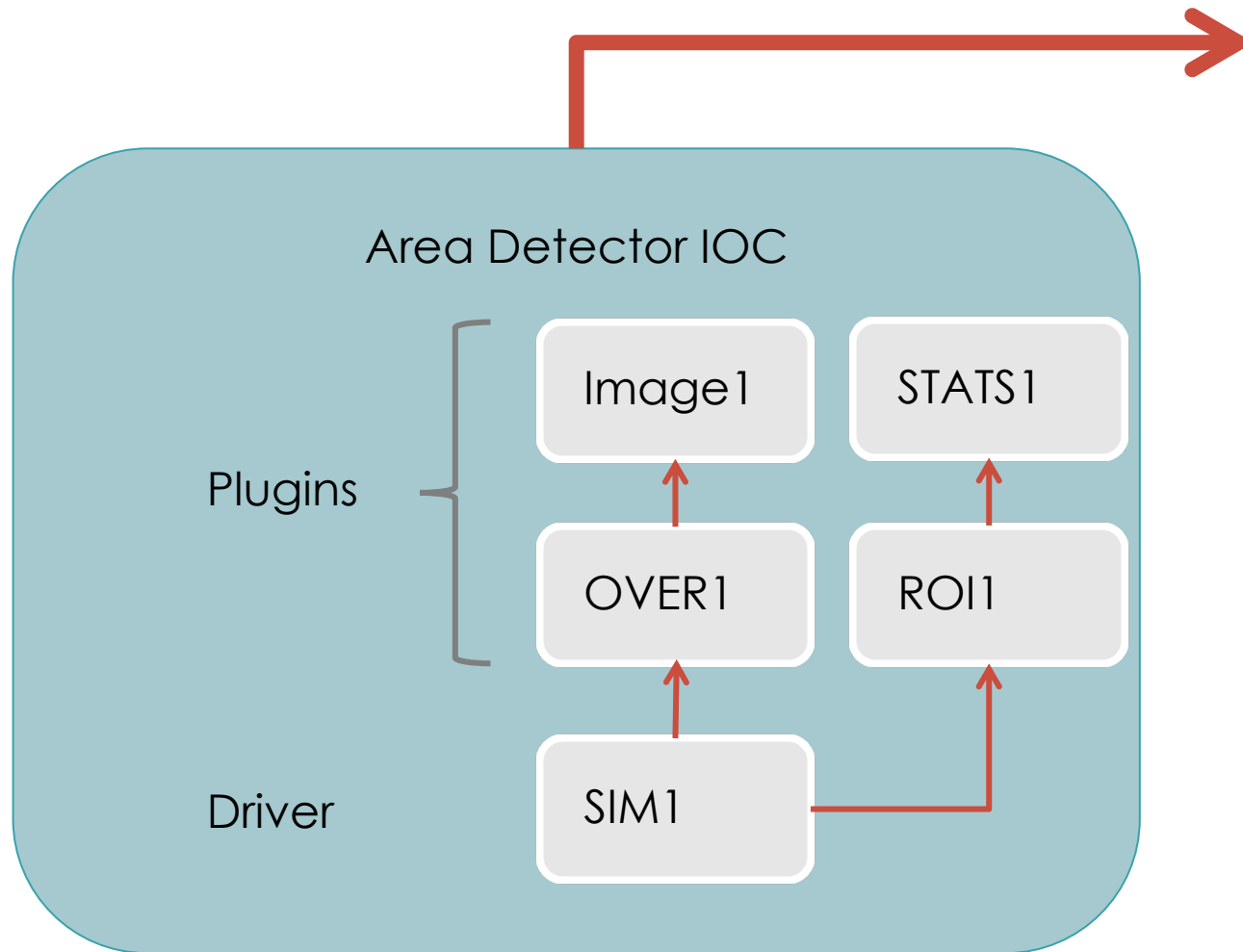
- Computes min, max intensity etc.
- Computes profiles
- Advanced image statistics
  - Excess Kurtosis (flatness)
  - Skewness (symmetry)
  - Centroid & sigma
- On Detector, Plugins, All, find NDPluginStats “STATS1”, “More”
  - Set its Port to “SIM1”, Enable
  - Note how the Statistics show a min..max of 0..255



# NDPluginROI

- Performs Region-Of-Interest calculations
  - Selects part of image
- On Detector, Plugins, All, find NDPluginROI “ROI1”, “More”
  - Set its Port to “SIM1”, Enable
  - Set X and Y size to 10, so ROI is small 10x10 corner of image
- On STAT1, change port from “SIM1” to “ROI1”
  - Note how the Statistics show a varying min..max as the image data rolls through that ROI

# What we did



# More Plugins

- Process
  - Background subtraction, clipping, recursive averaging over N images, ..
- Saving images in various formats
  - Adding data from PVs as “Attributes”
  - PNG, JPEG, TIFF, HDF5, ...
- Serving NDArray via PVA
  - For displays: No need to configure size, data type, ...
  - For ADPvAccess Driver: Process data on different hosts



# NDPluginPVA – Serve PVA ‘Image’

- In Plugins, “PVA1”
  - Set its Port to “SIM1” or “OVER1”, Enable
- PVAccess Tests
  - pvlist
  - pvinfo 13SIM1:Pva1:Image
  - pvget -r 'field(dimension)' 13SIM1:Pva1:Image
- In Display
  - Use “Image” widget
  - Set PV
  - No need to configure data size, data type

# NDPluginPVA – Serve PVA ‘Image’

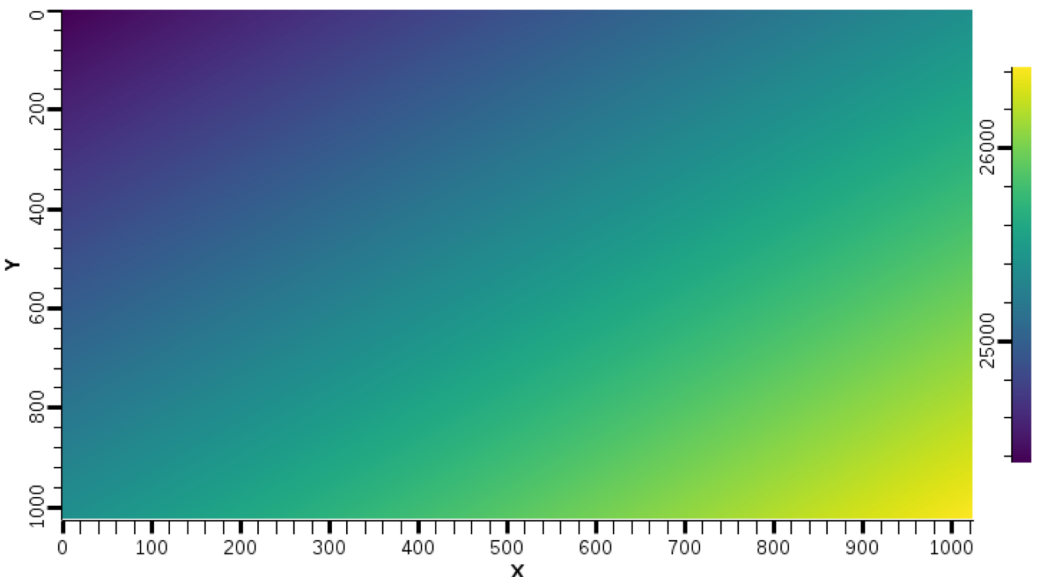
File Browser Area Detector X

### Area Detector Demo

Detector Plugins

- 1) `cd /home/training/epics-train/examples/AreaDetector`  
`./start_sim_ioc.sh`
- 2) Open Detector page
- 3) Press Connect.. "Start"
- 4) Open Plugins.. "All" and "Enable" the NDPluginStdArrays **Enable**

Start Stop



Images: 127104 120.00 Hz

Simulation Detector - 13SIM1:cam1:

Setup

asyn port SIM1  
EPICS name 13SIM1:cam1:  
Manufacturer Simulated detector  
Model Basic simulator  
Serial number No serial number  
Firmware version No firmware  
SDK version 2.8.0  
Driver version 2.8.0  
ADCore version 3.3.2  
Connected  
Connection **Connect** Disconnect

Shutter

Shutter mode **None**  
Status: Det. **Closed** EPICS **Closed**  
Open/Close **Open** **Close**  
Delay: Open 0.000 Close 0.000

Collect

Exposure time 0.001 0.001  
Acquire period 0.005 0.005  
# Images 100 100  
# Images complete 127104  
# Exp./image 1 1  
Image mode **Continuous** Continuous  
Trigger mode **Internal** Internal  
Collecting  
Acquire **Start** **Stop**  
# Queued arrays 0  
Wait for plugins **No**  
Acquire busy **Acquiring**  
Detector state **2**  
Time remaining 0.000  
Image counter 0 127104  
Image rate 120.00  
Array callbacks **Enable** **Enable**

Plugins

All File Menu ROI Menu

Readout

	X	Y
Sensor size	1024	1024
Binning	1	1
Region start	0	0
Region size	1024	1024
Reverse	No	No
Image size	1024	1024
Image size (bytes)		2097152
Gain	1.000	1.000
Data type	Int16	Int16

Attributes

File  
Macros  
Status: File not found

Buffers

Display adapts when image size and data type change

# Area Detector

Ecosystem for handling

- Cameras
- Detectors
- “Images” in EPICS

