

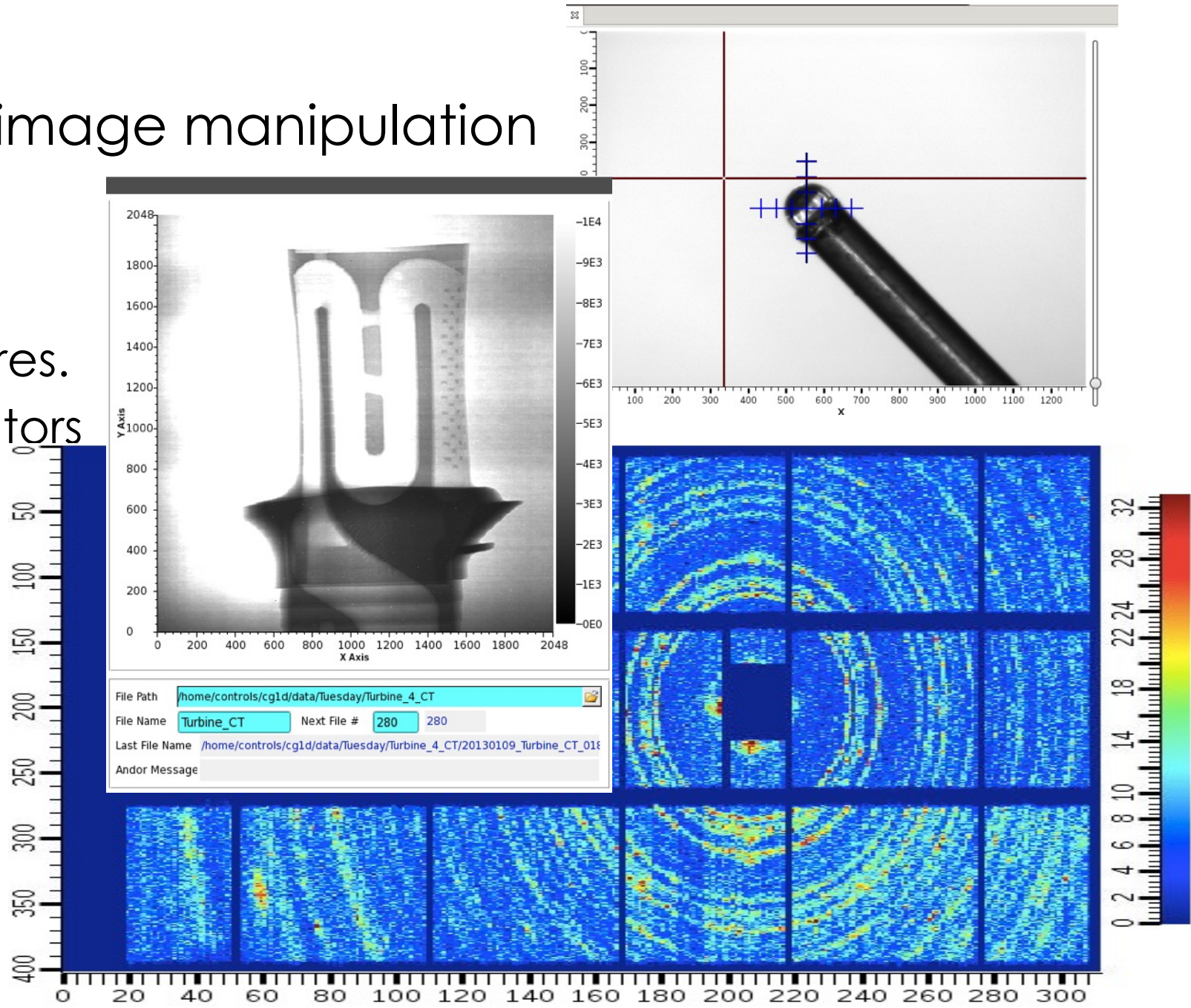
Area Detector

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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 common)
 - $N \leq 10$
 - Custom metadata
- Supports >500 frame/second detectors

Disclaimer

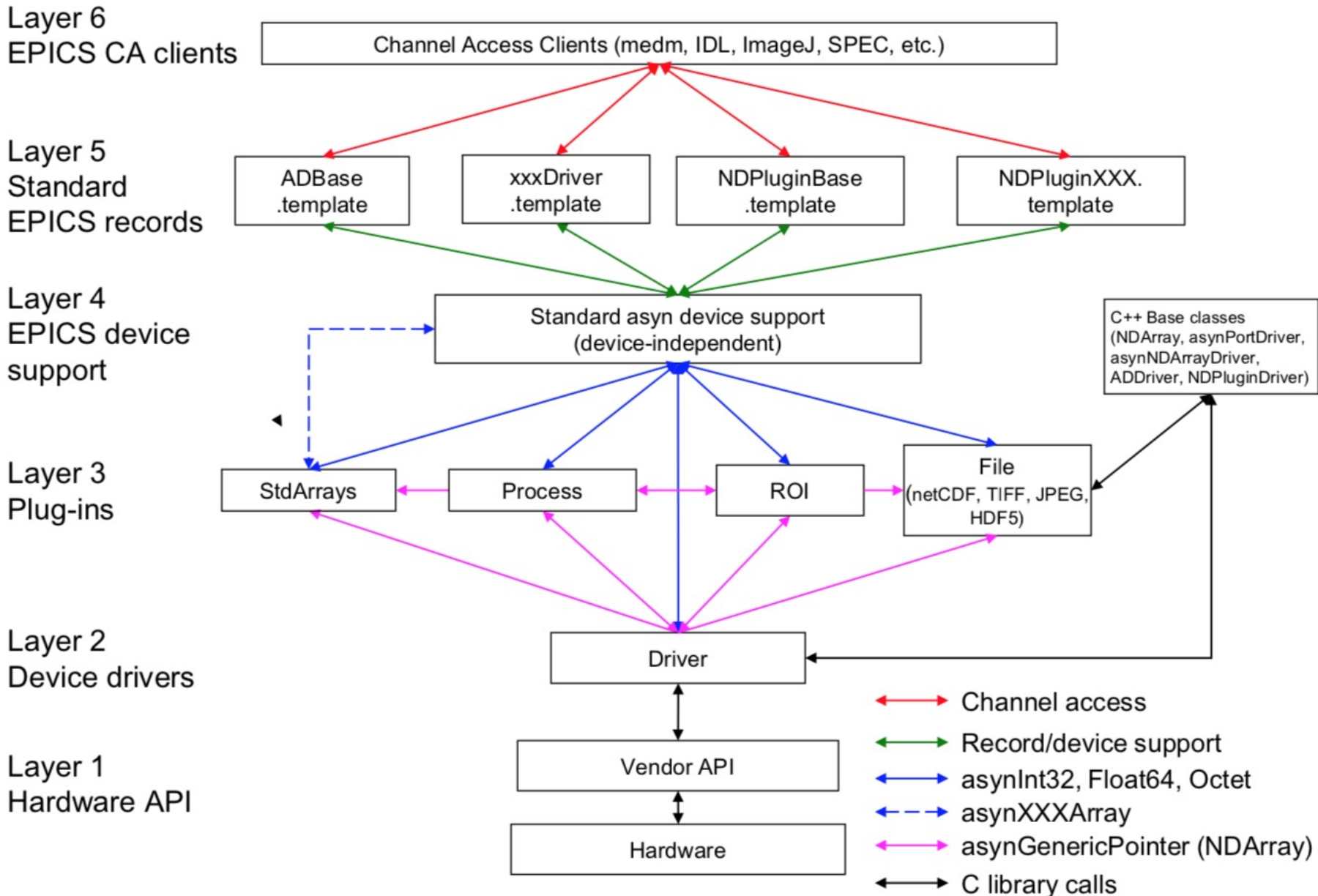
This will only scratch the surface.

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

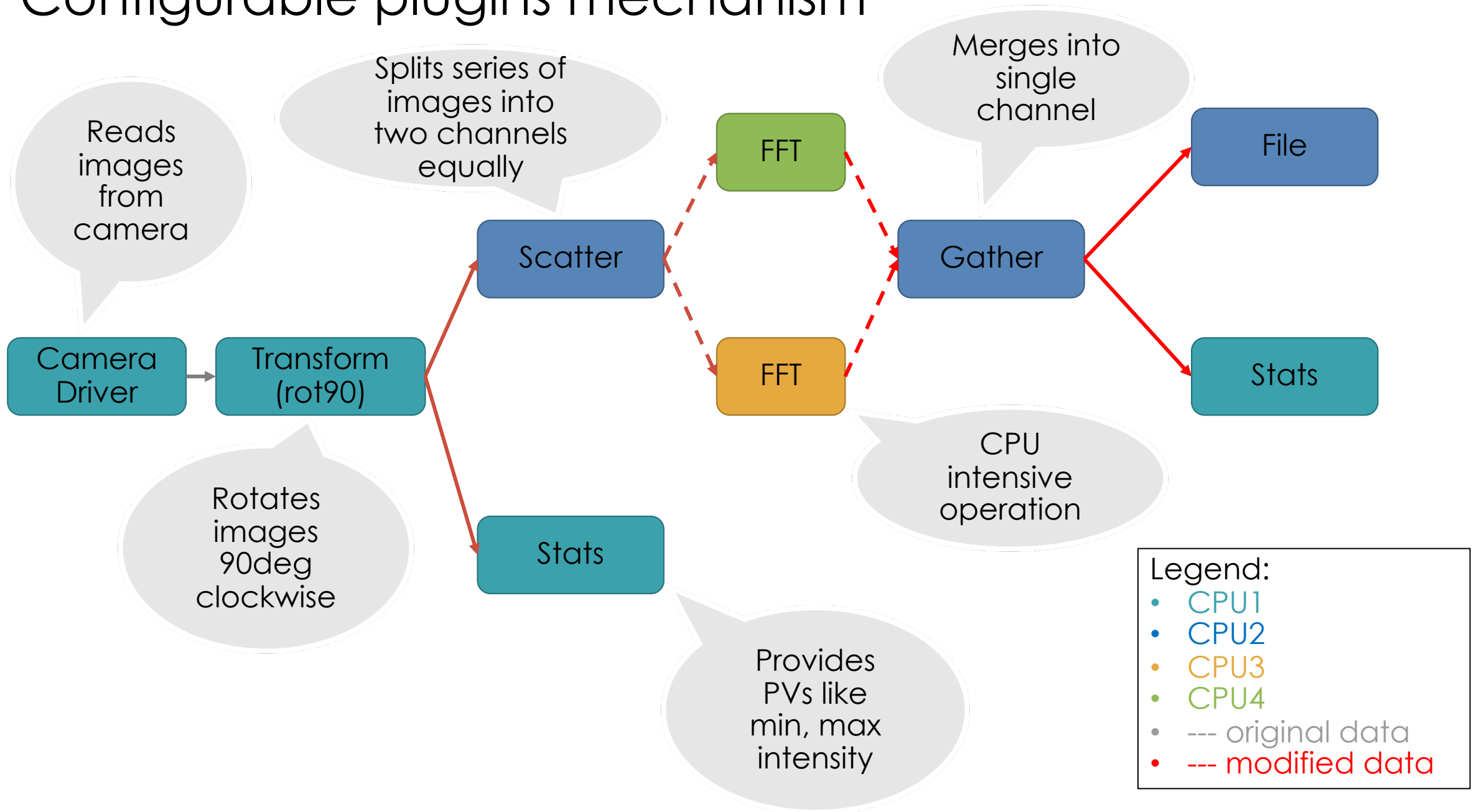
Vocabulary

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

EPICS AreaDetector Architecture



Configurable plugins mechanism



Using 'ADSimDetector'

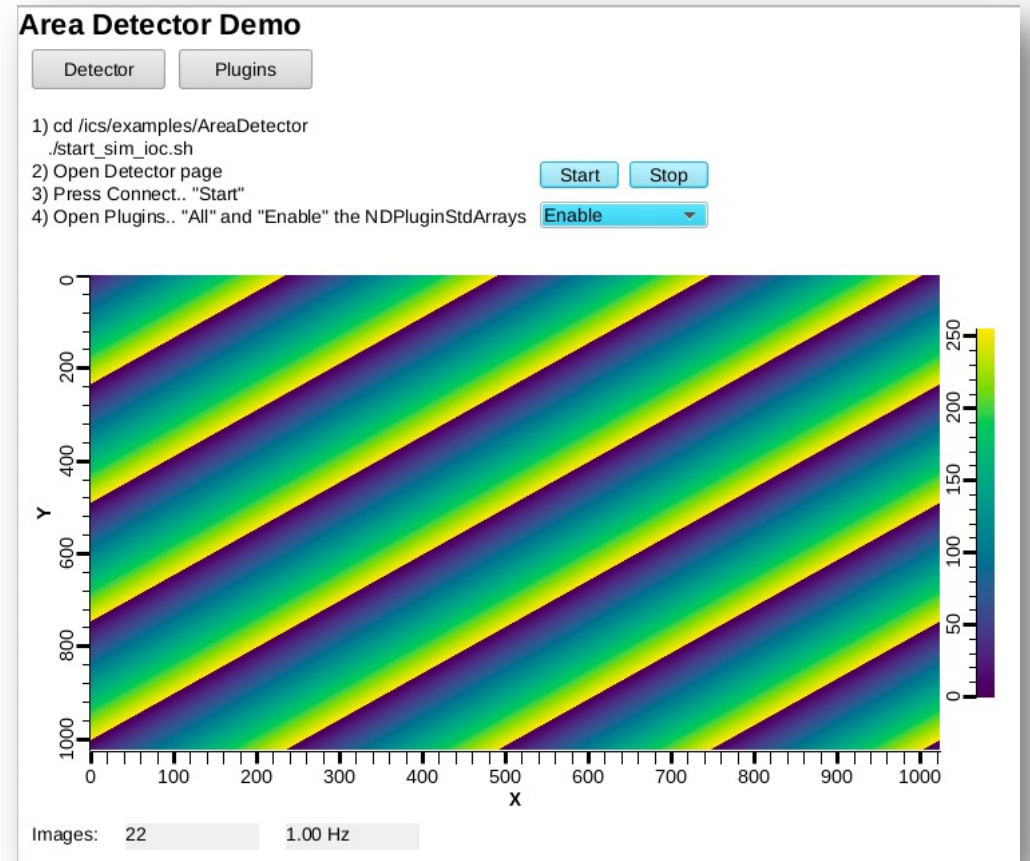
- Start IOC

```
cd /ics/examples/AreaDetector
./start_sim_ioc.sh
```

- Open Display

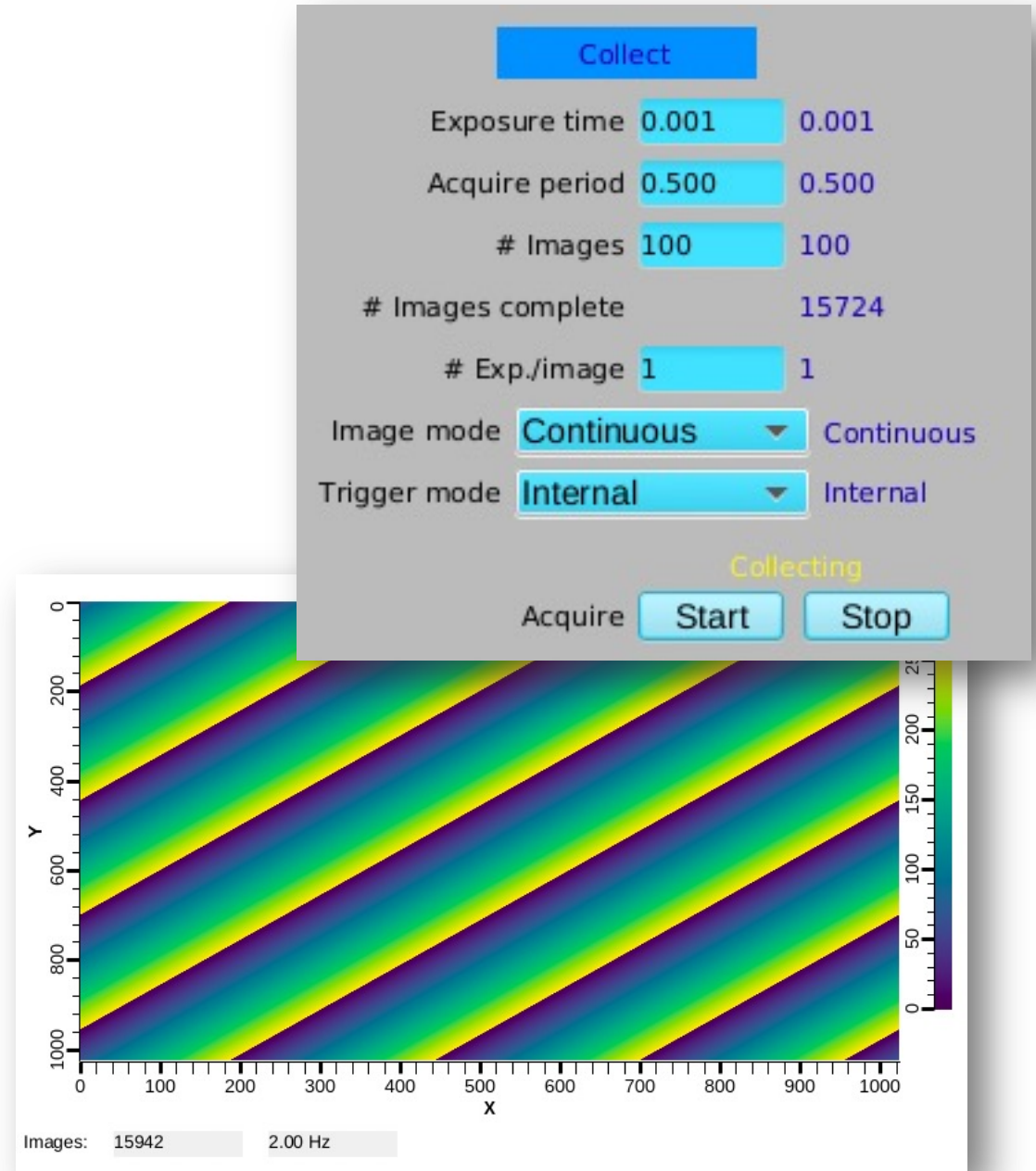
```
css -resource /ics/examples/AreaDetector/AreaDetectorDemo.bob
```

- Select "Start" and "Enable"



ADSimDetector

- Open the “Detector” Page
- Under “Collect”, set the “Acquire Period” to 0.5
- Observe counter for images and rate on main page



NDPluginStdArrays

- Serves image as Channel Access waveform

- On Detector, Plugins, All, find NDPluginStdArrays

- Port = "SIM1"
- Enable

- AreaDetectorDemo.bob shows image
 - PV: 13SIM1:image1:ArrayData
 - Data Width x Height: 1024 x 1024
 - [x] 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

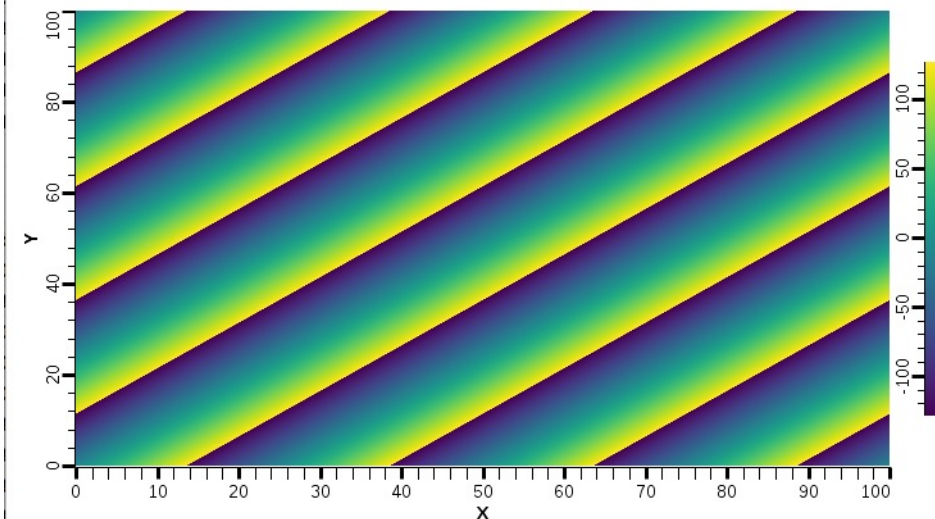
Setup

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”

Plugin name	Plugin type	Port	Enable	Blocking	Dropped	Free	Rate	
Image1	NDPluginStdArrays	OVER1	Enable	No	0	20	2.00	More
CCZ	NDPluginColorConvert	SIM1	Disable	No	0	20	0.00	More
OVER1	NDPluginOverlay	SIM1	Enable	No	0	20	2.00	More

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

NDPluginOverlay.. Overlay #1

Configure as shown:

Area Detector X

Area Detector Demo

Detector Plugins

1) cd /ics/examples/AreaDetector
.start_sim_ioc.sh

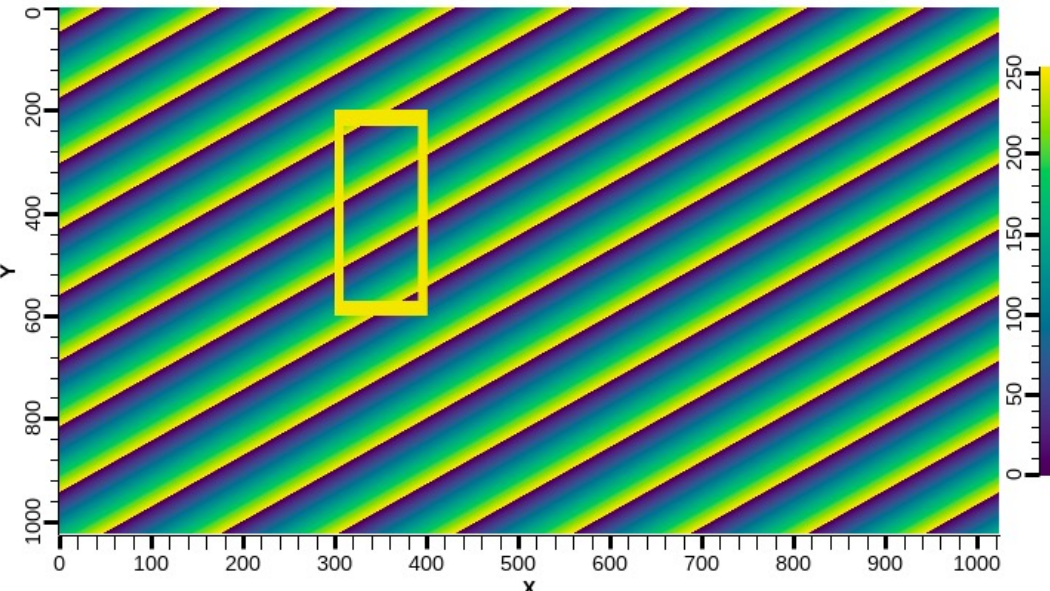
2) Open Detector page

3) Press Connect.. "Start"

4) Open Plugins.. "All" and "Enable" the NDPluginStdArrays

Start Stop

Enable



Images: 17539 1.00 Hz

NDOverlayN X

13SIM1:Over1:1:

Use? **Yes** Yes

Name **ROI1**

Shape **Rectangle** Rectangle

Draw mode **Set** Set

Red **1** 1

Green (mono) **250** 250

Blue **1** 1

Display Text

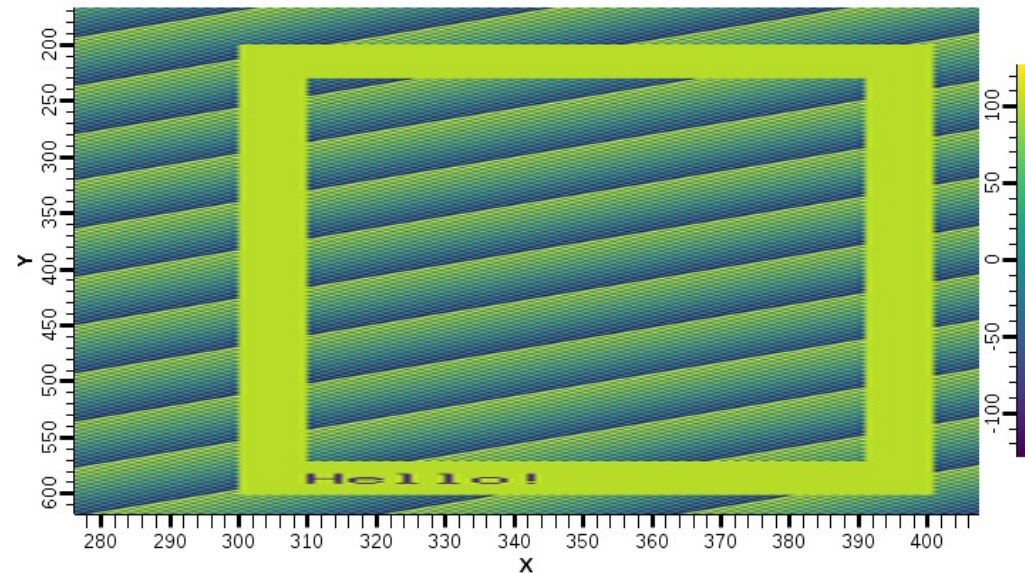
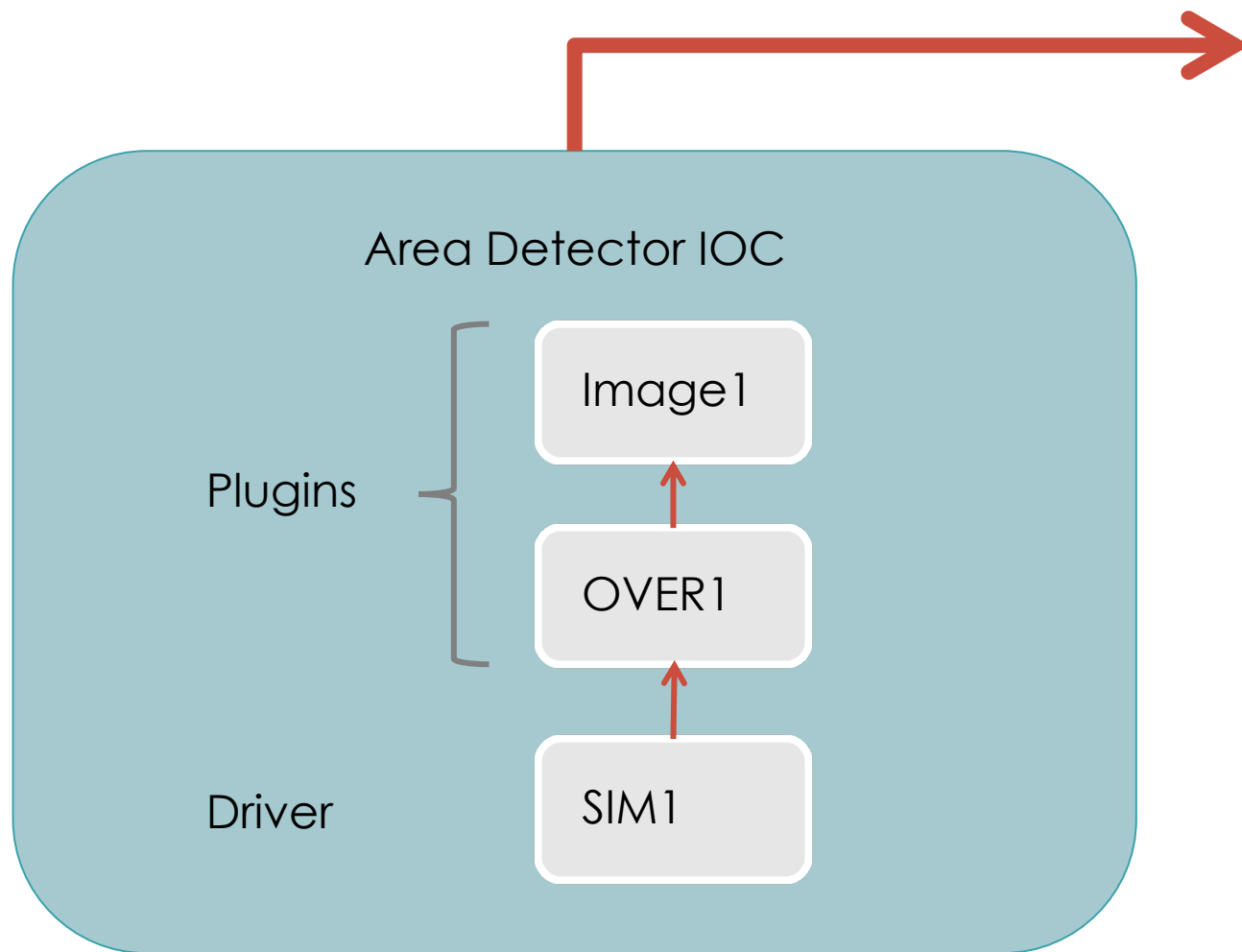
Time format **%Y-%m-%d %H:%M:%S.%03f**

Format example **%Y-%m-%d %H:%M:%S.%03f**

Font **6x13**

	X	Y
Position	300 300	200 200
Position link	13SIM1:ROI1:MinX_RBV CP	13SIM1:ROI1:MinY_RBV CP
Center	350 350	400 400
Center link	CP NPP MS	CP NPP MS
Size	100 100	400 400
Size link	13SIM1:ROI1:SizeX_RBV CP	13SIM1:ROI1:SizeY_RBV CP
Width	10 10	30 30
Width link	CP NPP MS	CP NPP MS

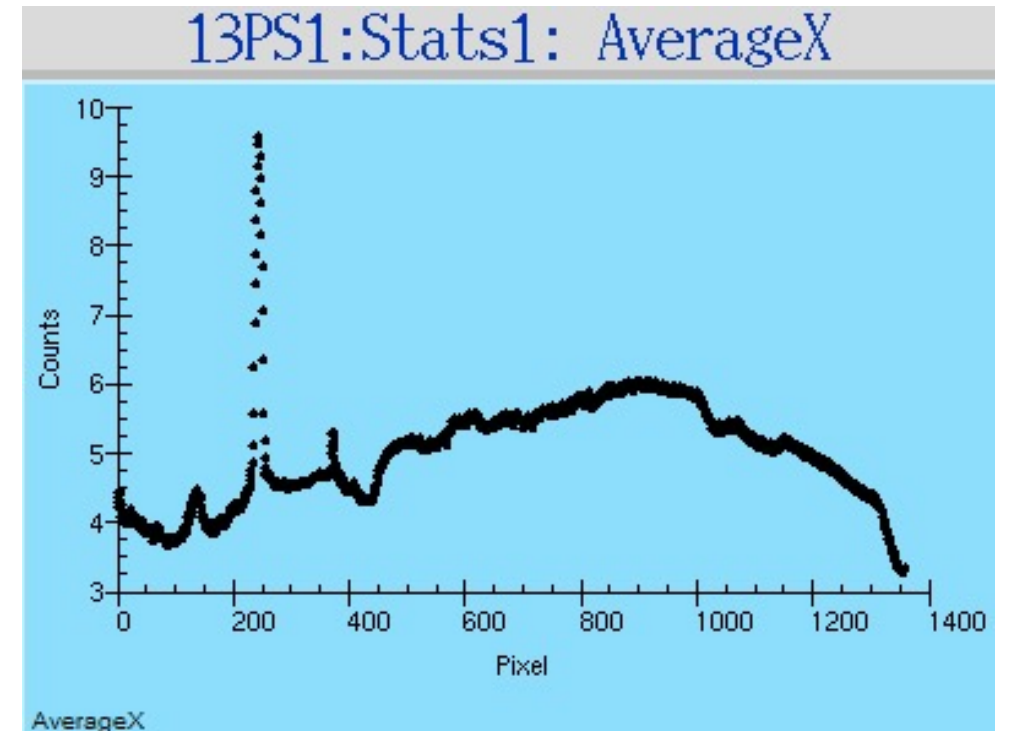
What we did



- 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 min..max of 0..255



Statistics

Compute statistics Yes No

Background width 1

Minimum 0 Maximum 254

Min. X 16 Max. X 15

Min. Y 0 Max. Y 0

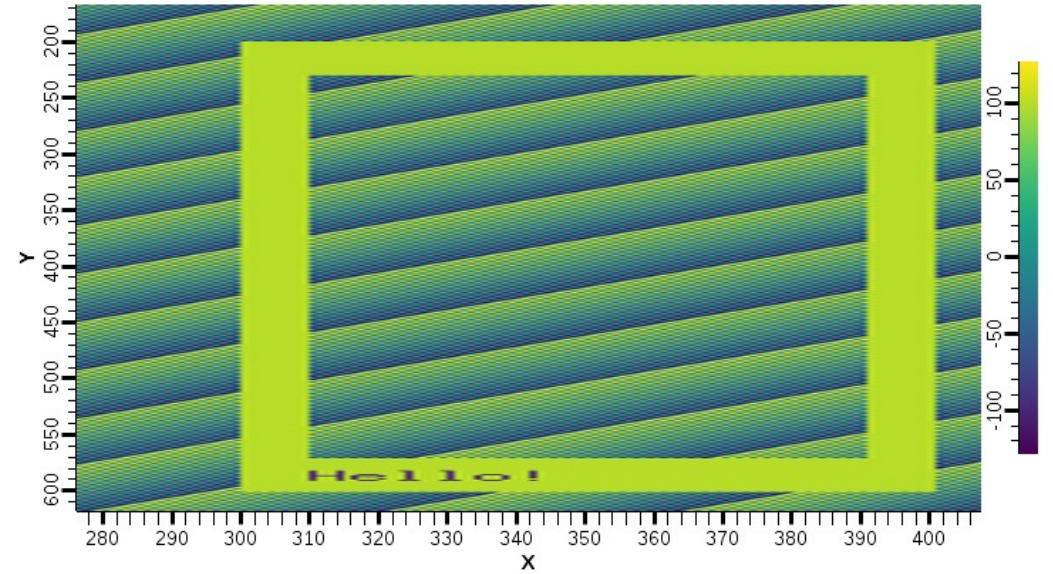
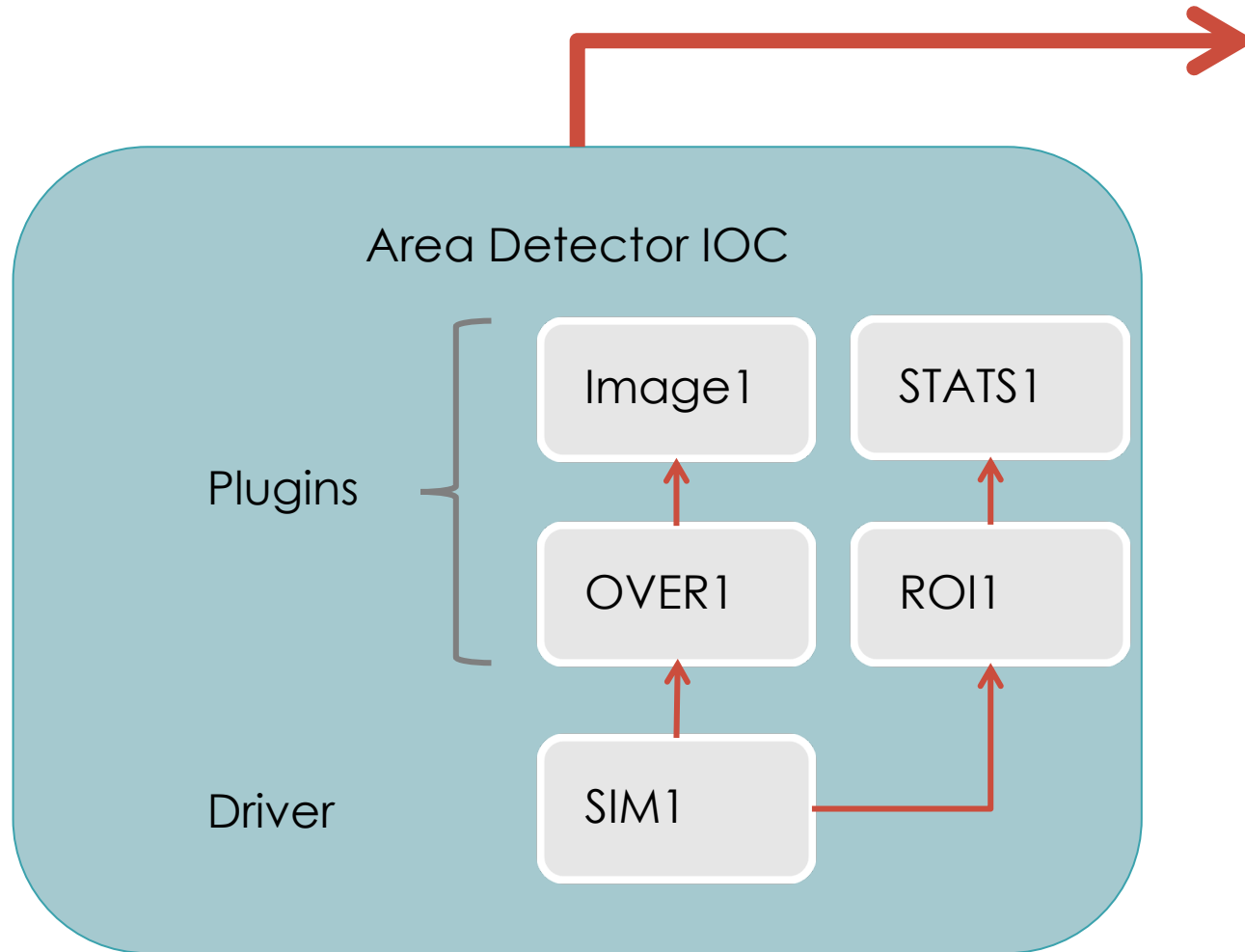
Total 133169152 Net 0

Mean 127 Sigma 73.9

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 ROI size to 10, so ROI is small 10x10 corner of image
- Back in 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’

The screenshot displays the NDPluginPVA software interface, divided into two main sections: 'Area Detector Demo' on the left and 'Simulation Detector - 13SIM1:cam1' on the right.

Area Detector Demo:

- Buttons: **Detector**, **Plugins**
- Instructions:
 - 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
- Buttons: **Start**, **Stop**, **Enable** (dropdown)
- Image Display: A 2D color map with X and Y axes ranging from 0 to 1000. A color scale on the right ranges from 25000 (dark purple) to 26000 (yellow).
- Status: **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
 - Status: **Connected**
 - Buttons: **Connect**, **Disconnect**
- Shutter:**
 - Shutter mode: **None**
 - Status: Det. **Closed**, EPICS **Closed**
 - Buttons: **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
 - Status: **Collecting**
 - Buttons: **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:**
 - Buttons: **All**, **File**, **Menu**, **ROI**, **Menu**
- Readout:**

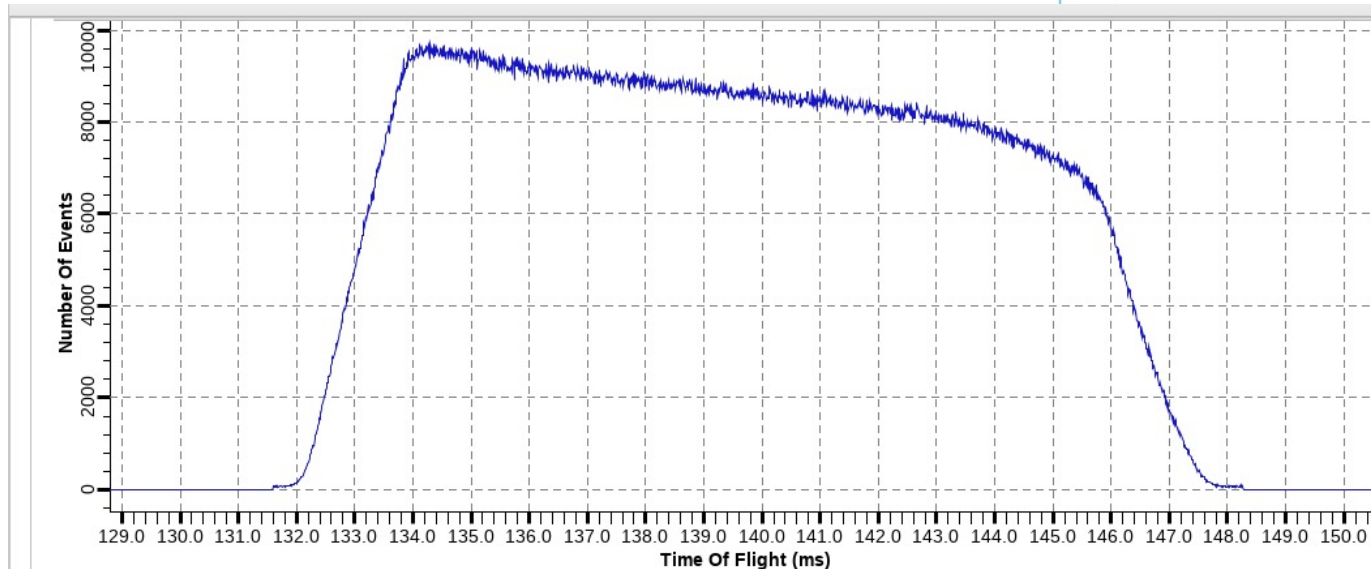
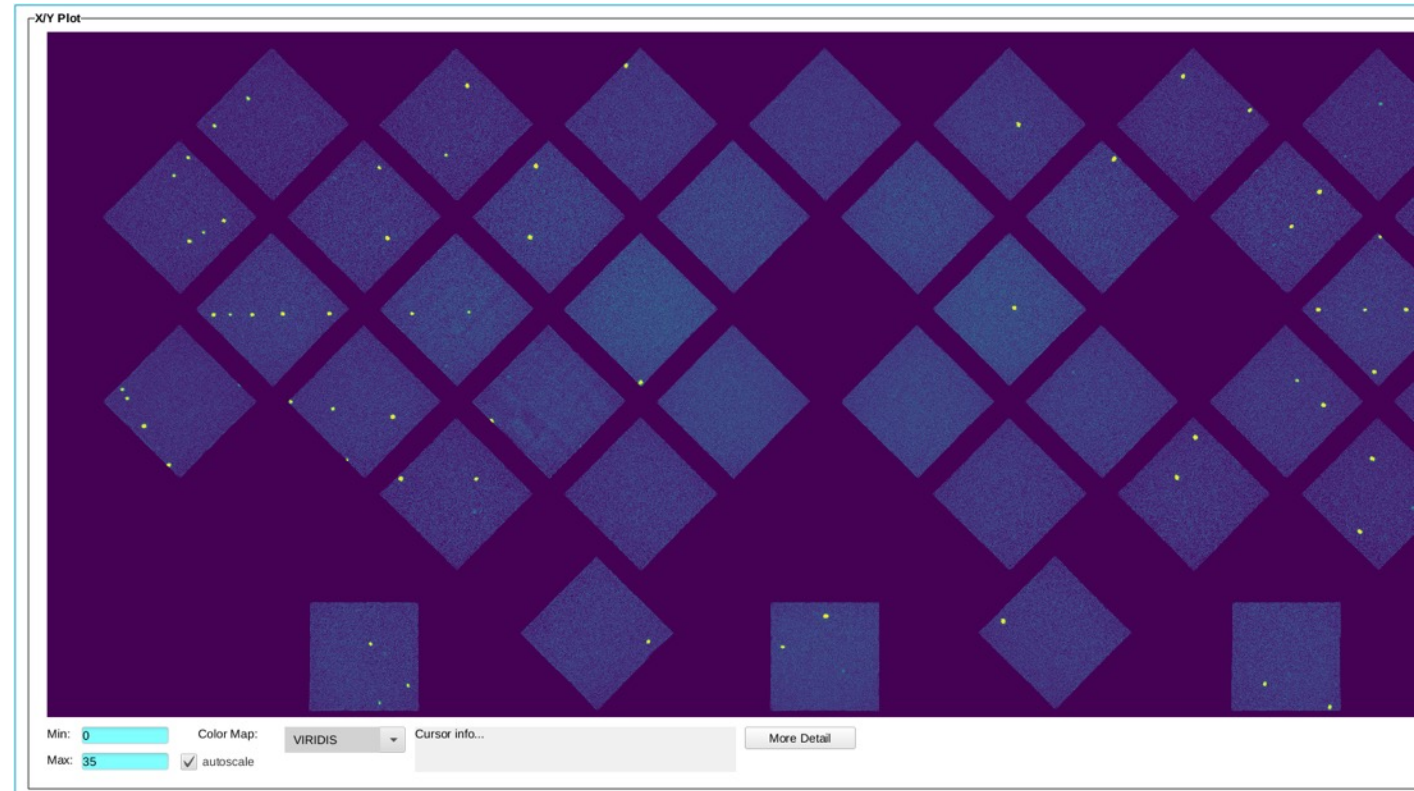
	X	Y
Sensor size	1024	1024
Binning	1	1
Region start	0	0
Region size	1024	1024
Reverse	No	No
Image size	1024	1024
Image size (bytes)	2097152	
Gain	1.000	1.000
Data type	Int16	Int16
- Attributes:**
 - File: [Empty]
 - Macros: [Empty]
 - Status: **File not found**
- Buffers:**

Display adapts when image size and data type change

Area Detector

Ecosystem for handling

- Cameras
- Detectors
- “Images” in EPICS



Divisor Control

Divisor

Min Update Period

Transformation

Post Trans Scale

Post Trans Offset

Clear/Zero Next Array

Manual

Automatic

ROI Filter on Pixels (Uses ROI1)

Filter Control