

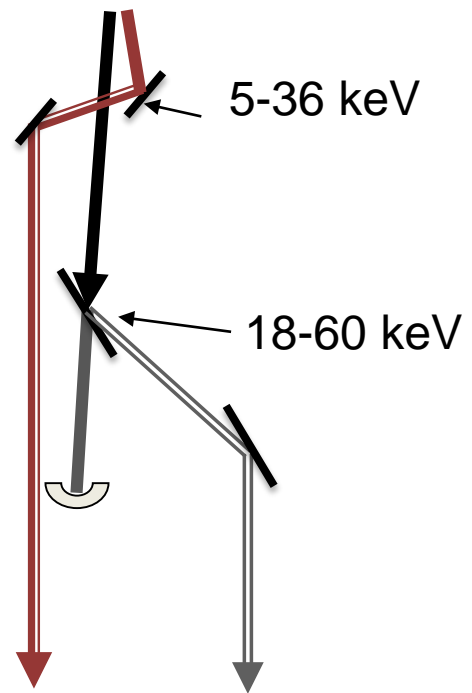
# Hardware-based fly scan capabilities at HPCAT

TWG 20 April 2017

Jesse Smith  
HPCAT

# HPCAT – four dedicated HP beamlines

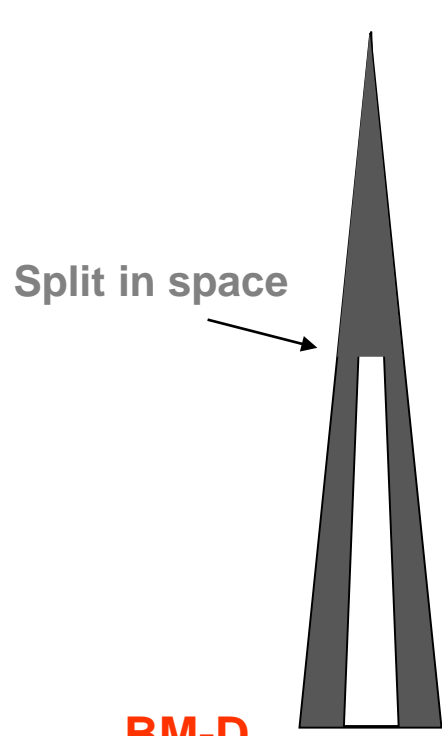
## Sector 16 Canted undulator beamlines



**ID-D**  
Spectroscopy  
*XES, IXS – 1eV*  
*NRXS – 2meV*

**ID-B**  
Micro-diffraction  
*Laser heating*  
*Cryostat*

## Sector 16 Bending magnet beamlines

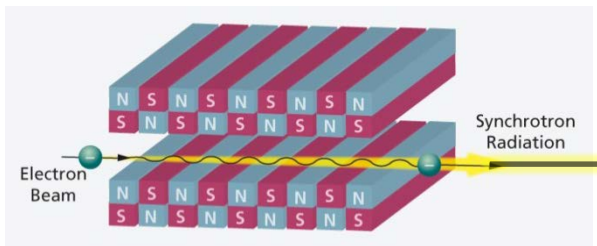


**BM-D**  
Micro-diffraction  
XANES

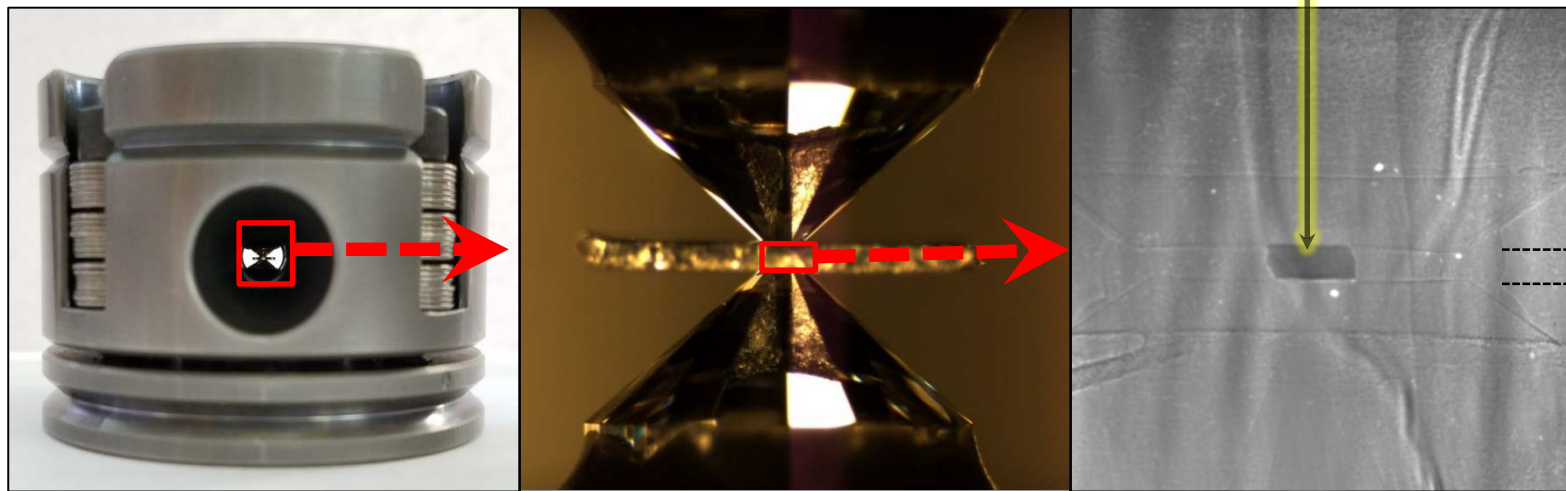
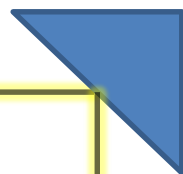
**BM-B**  
White Laue  
PEC

... to advance compression science in multidisciplinary fields using synchrotron radiation

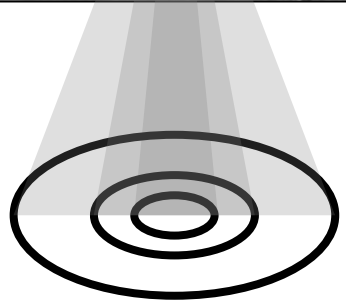
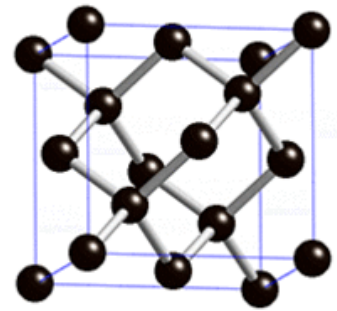
# High Pressure XRD with a diamond anvil cell



~30 keV



*Structure and properties of materials under extreme conditions*

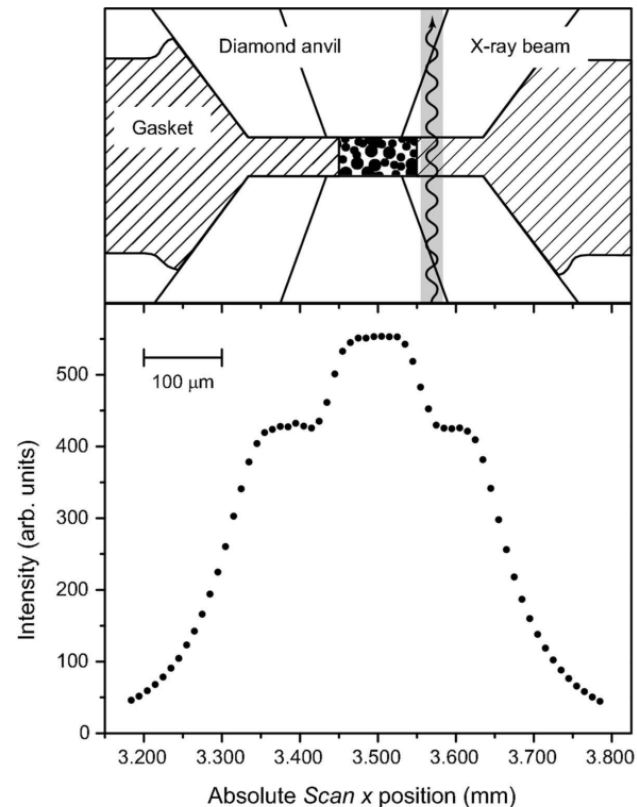
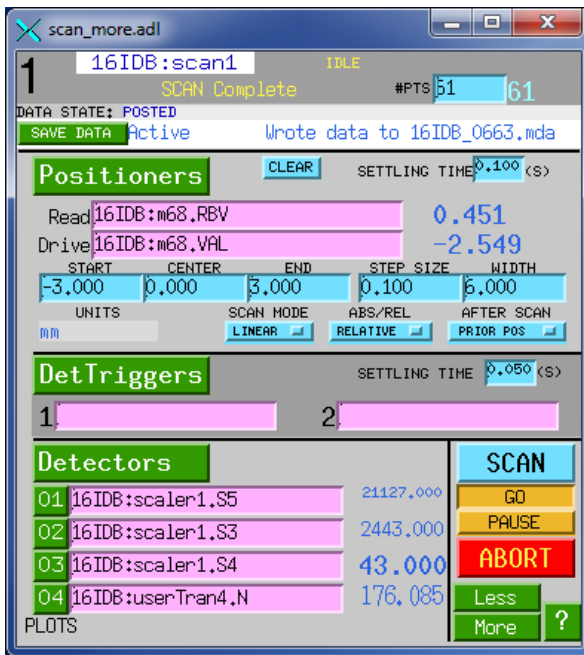


Large-format area detector

# Conventional step scan (with a DAC)

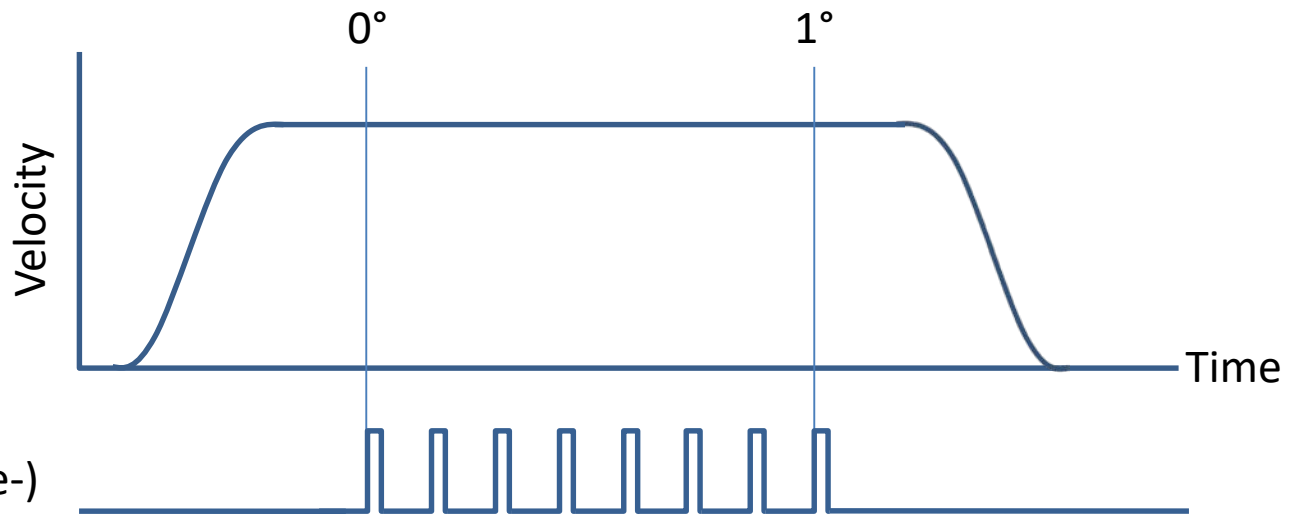
- **One-dimensional scan** (stolen from Tim Mooney's EPICS training presentation)
  - Do NPTS times
    - *Set conditions*
    - *Trigger detectors*
    - *Acquire data*
  - Write data to disk

e.g., move motor, wait for move done  
e.g., start scaler, wait for counting done  
e.g., read out detector(s), store data in array



# Fly scan

- **One-dimensional scan** (stolen from Tim Mooney's EPICS training presentation)
  - Do ~~NPTS times~~ **one time**
    - *Set conditions* e.g., move motor, wait for move done
    - *Trigger detectors* e.g., start scaler, wait for counting done
    - *Acquire data* e.g., read out detector(s), store data in array
  - Write data to disk



Position- (or time-)  
based pulse output

# Fly scan – collect data during stage motion

## *Hardware-based fly scanning*

Core components (examples in this presentation)

- Trigger pulses from motion controller (OMS, Newport)
- Detectors with little/no dead time (Struck multichannel scaler, PILATUS)
- Scan client (Python GUI using PyEpics for channel access)

Complementary stuff (examples in this presentation)

- Manage pulses from multiple sources (softGlue)
- Pulse conditioning, line drivers (Pulse Research Lab)

# Trigger pulses from motion controller

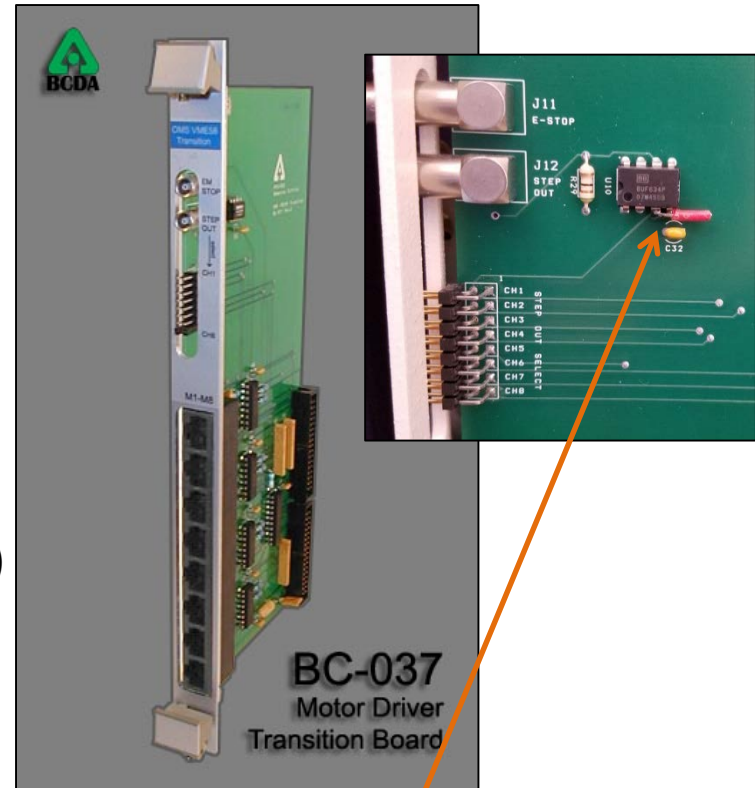
**Newport XPS  
(closed-loop)**



PCO (dedicated output based on encoder)

GPIO2, pin12, Pulse: A 1  $\mu$ s pulse with 5V peak voltage is sent for every time interval

**OMS, Max-V  
(open-loop)**



**BC-037  
Motor Driver  
Transition Board**

Modified BC-037 can provide step out for any/all axes Directly from selector pins (jump pins 3 & 4 on U10 chip as shown)

# EPICS support for pulse generation

PCO (dedicated output based on encoder)

GPIO2, pin12, Pulse: 1  $\mu$ s pulse with 5V peak voltage is sent for every time interval

XPSPositionCompare5.adl

| Motor Description | Mode    | Minimum Position | Maximum Position | Step Size | Pulse Width (us) | Settling Time (us) |
|-------------------|---------|------------------|------------------|-----------|------------------|--------------------|
| XPS Cen X         | Disable | 0.0000           | 0.0000           | 0.0000    | 0.2              | 0.075              |
| XPS Cen Y         | Disable | 0.0000           | 0.0000           | 0.0000    | 0.2              | 0.075              |
| XPS Sam Z         | Disable | 0.0000           | 0.0000           | 0.0000    | 0.2              | 0.075              |
| XPS Omega         | Disable | 0.0000           | 0.0000           | 0.0000    | 0.2              | 0.075              |
| GP Omega          | Disable | 0.0000           | 0.0000           | 0.0000    | 0.2              | 0.075              |

profileMove.adl

### XPSProfileMove

# Profile points: 2000    Current: 0  
 # Output pulses: 2000    Actual: 0  
 Move mode: Absolute  
 Pulse range: Start: 1    End: 2000  
 Time mode: Fixed  
 Fixed time per point: 1.000    Plot time:   
 Acceleration time: 0.500   

|           | Move axis? | Current Pos. | Plots |
|-----------|------------|--------------|-------|
| XPS Cen X | No         | 1.8525       |       |
| XPS Cen Y | No         | 0.2424       |       |
| XPS Sam Z | No         | 0.0473       |       |
| XPS Omega | No         | 0.000        |       |
| GP Omega  | No         | 0.000        |       |

| Command  | State    | Status            |
|----------|----------|-------------------|
| Build    | Build    | Done    Undefined |
| Message  |          |                   |
| Execute  | Execute  | Done    Undefined |
| Message  | à        |                   |
| Abort    | Abort!   |                   |
| Readback | Readback | Done    Undefined |
| Message  |          |                   |

*Electro Standards Laboratories*



deviceCmdReply.adl

deviceCmdReply 1

Format output string

DOUBLE VARIABLES: PV NAME: aa    VALUE: 0.00000

STRING RESULTS: 0.00000

Send/Receive Port:

Output:

Input:

Length: Requested: 0    Actual: 0

Timeout: 1.000 (sec)    Status: NO\_REPLY    Severity: NO\_REPLY

Parse reply string

DOUBLE VARIABLES: PV NAME: aa    VALUE: 0.00000

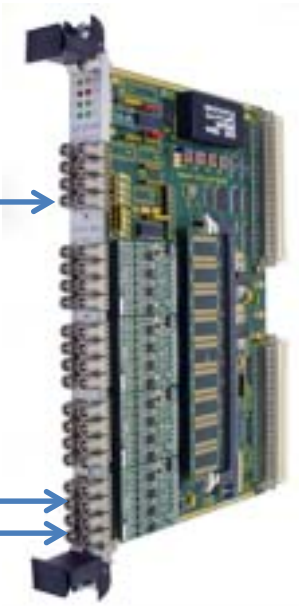
STRING RESULTS: 0.00000



# Detectors with little/no dead time

## Struck multichannel scaler (SIS3820)

Channel advance from motor pulse output



Counter inputs from V-f converter

SIS38XX.adl

SIS3820/3801 MCS Control 16TEST1:SIS1:

Start Stop Acquire  
Erase/Start Erase

Done Status  
1.25 Elapsed time  
0.000 Preset time  
5.000e-001 Dwell time  
1 Ext. prescale  
External Channel advance source  
No Count on start  
Advance Software chan. advance  
Int. clock Channel 1 source  
Low/OFF User output/LED  
3 MUX output(1-3)

MCS Acquire mode  
Mode 3 Input mode  
Mode 3 Output mode  
Normal Output polarity  
Disable LNE output stretcher  
Inverted LNE output polarity  
0.0000e+000 LNE output delay  
1.0000e-006 LNE output width  
Passive Read rate Read

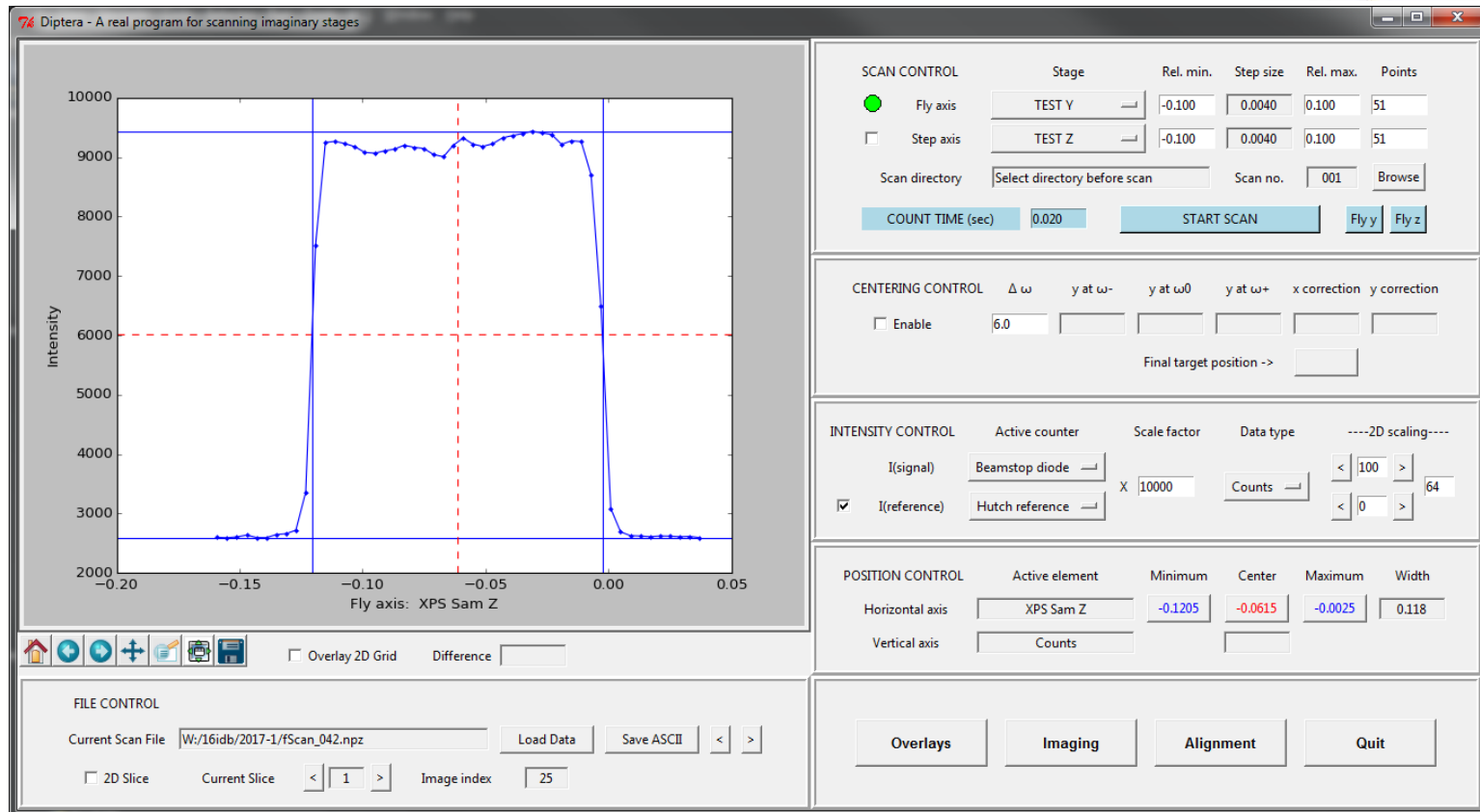
Combined Plots  
Individual Plots 1-8  
Individual Plots 9-16  
Individual Plots 17-24  
Individual Plots 25-32  
2048 Max. # of channels  
50 channels to use  
50 Current channel  
Disable Wait for client  
Done Client Wait  
Asyn record

Connected SNL Status  
SIS3820 Model  
0x111 Firmware

# Fly scan client

## Diptera

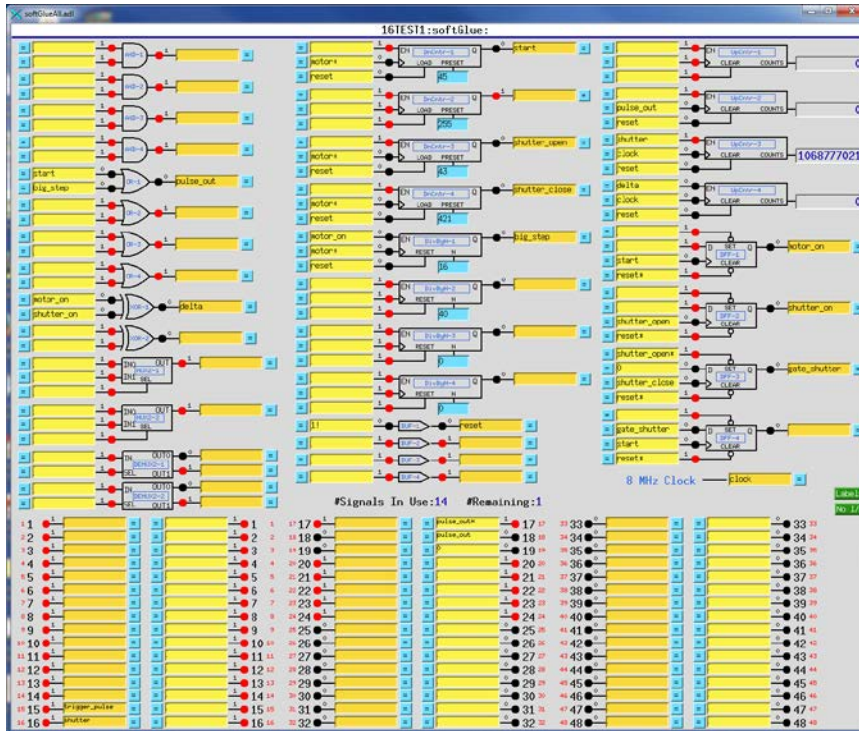
True flies are insects of the order *Diptera*, the name being derived from the Greek *di* = two, and *ptera* = wings



Written in Python 2.7 using Tkinter UI and PyEpics  
Independent controller, viewer, data/file manipulation

# Manage pulses from multiple sources

*softGlue*



Two basic configurations:  
Step: every Nth pulse after accel  
XPS: one pulse in, one pulse out

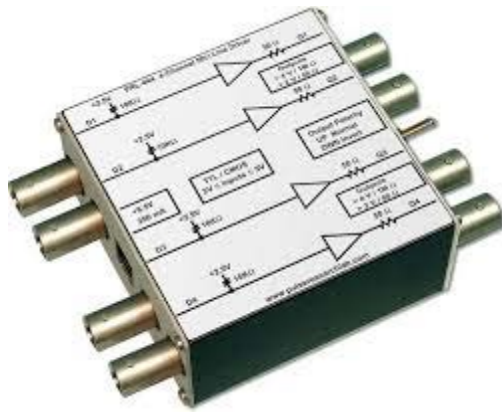


# Pulse conditioning, line drivers

## *Pulse Research Lab*

### **PRL-444**

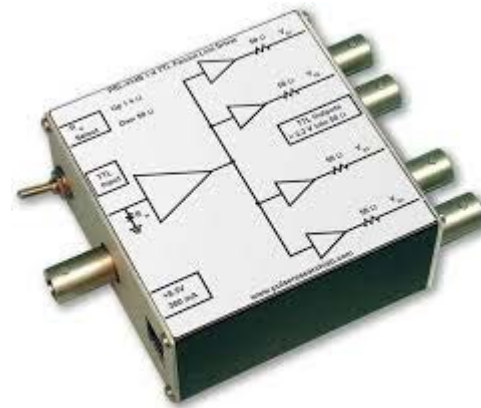
4-channel 50  $\Omega$  output TTL Line Driver



Useful for the Newport XPS, for example, as it can pull up the open collector outputs

### **PRL-414B**

1:4 fanout 50  $\Omega$  TTL Line Driver

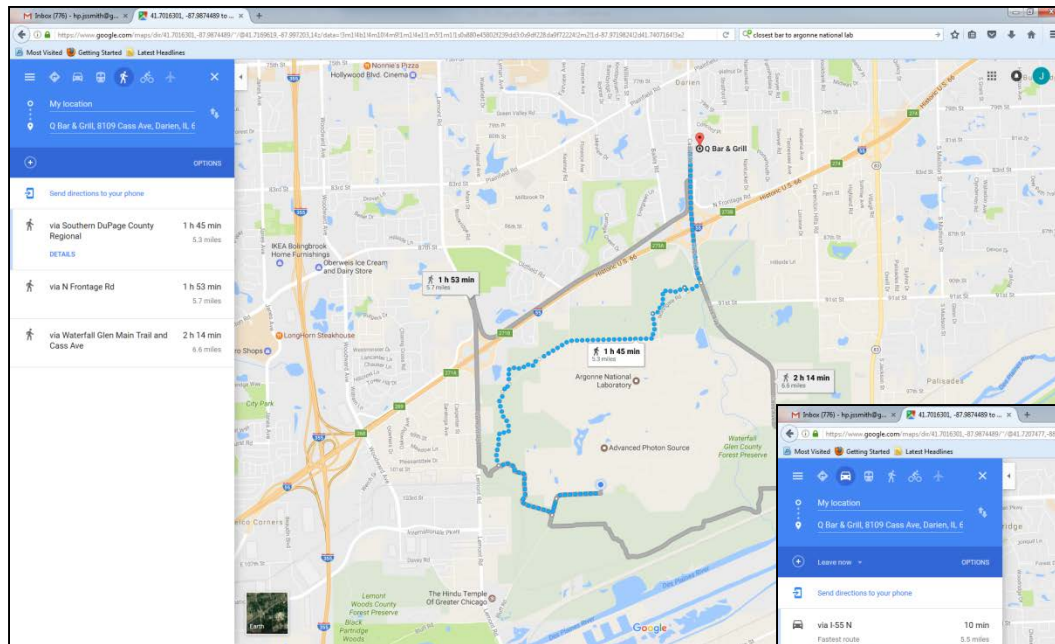


Useful for triggering PILATUS, for example, as it can drive the 50  $\Omega$  trigger input



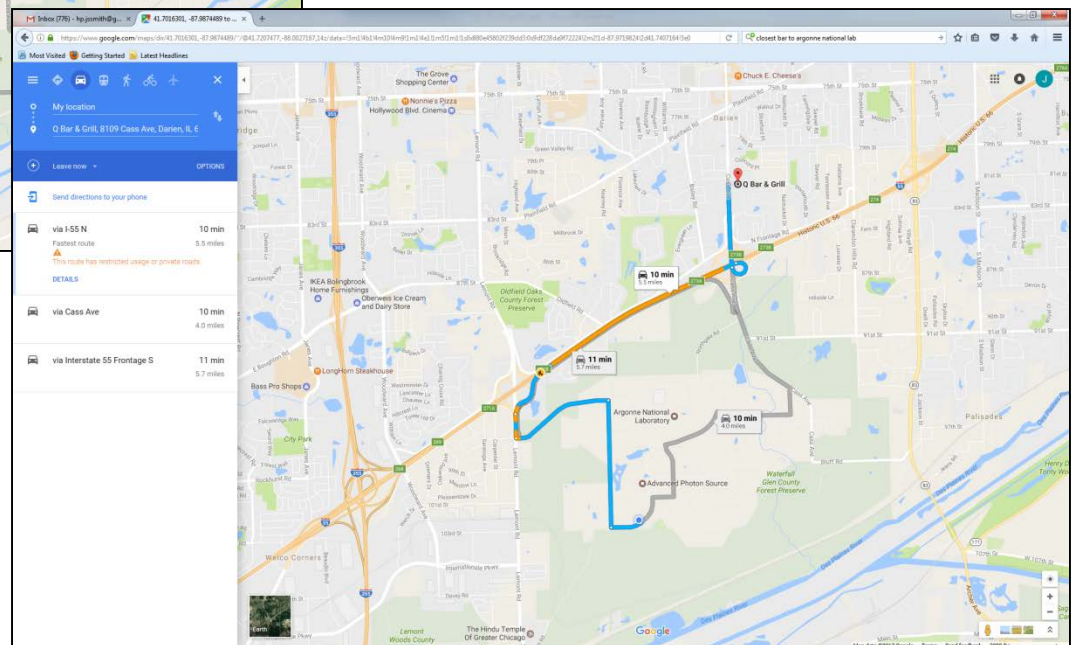
# From possible to practical

Google closest bar to Argonne National Lab → Q Bar and Grill on Cass Ave

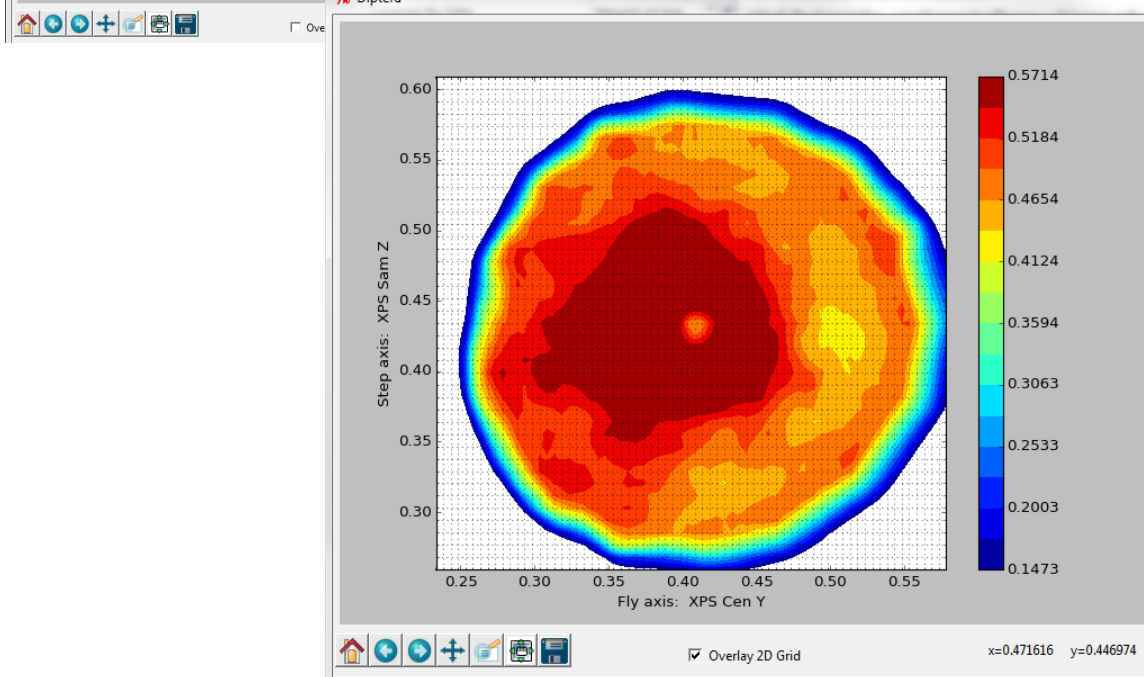
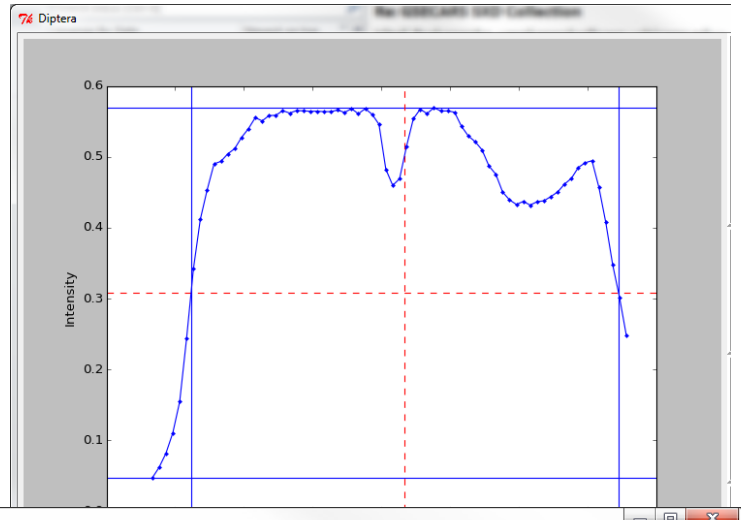
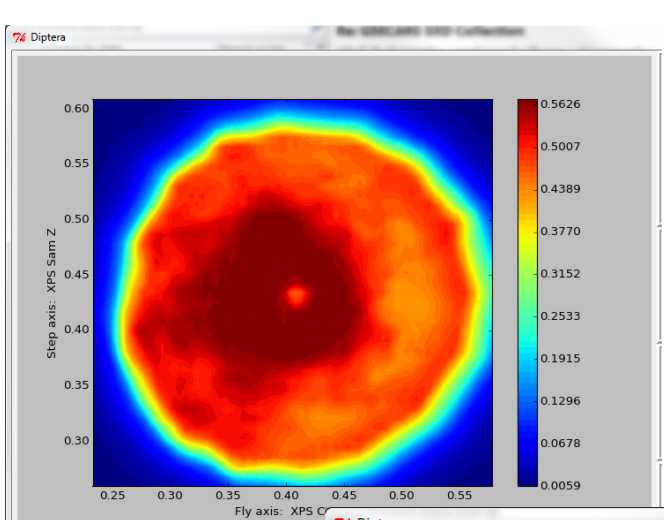


On foot: ~1h 45m

By car: ~10m



# Routine 2D sample mapping → practical



**SCAN CONTROL**

|  | Stage     | Rel. min. | Step size | Rel. max. | Points |
|--|-----------|-----------|-----------|-----------|--------|
| <input checked="" type="checkbox"/> Fly axis | XPS Cen Y | -0.050    | 0.0100    | 0.050     | 11     |
| <input type="checkbox"/> Step axis           | XPS Sam Z | -0.050    | 0.0100    | 0.050     | 11     |

Scan directory:  Scan no.:

---

**CENTERING CONTROL**

|                                 | $\Delta \omega$ | y at $\omega^-$ | y at $\omega_0$ | y at $\omega^+$ | x correction | y correction |
|---------------------------------|-----------------|-----------------|-----------------|-----------------|--------------|--------------|
| <input type="checkbox"/> Enable | 2.0             |                 |                 |                 |              |              |

Final target position ->

---

**INTENSITY CONTROL**

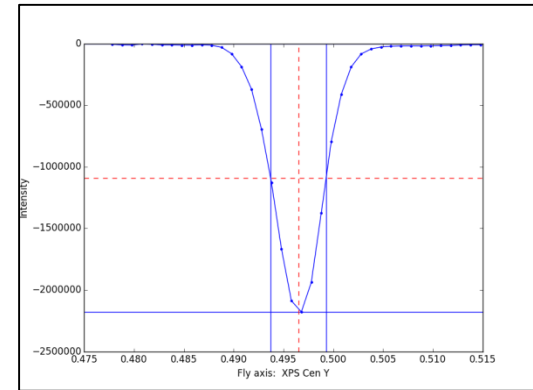
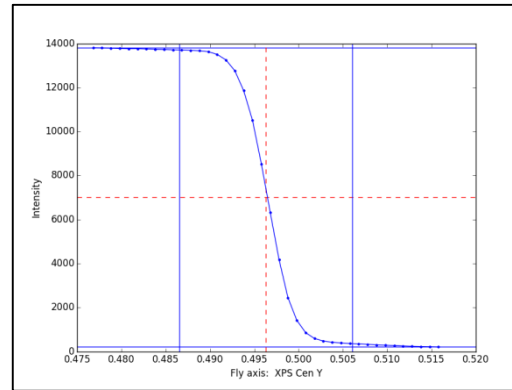
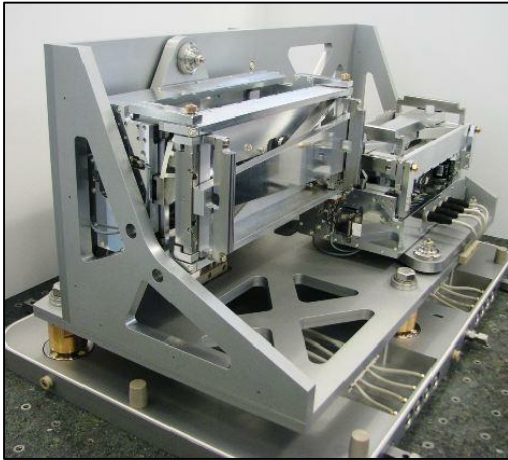
|  | Active counter  | Scale factor | Data type | ----2D scaling----   |
|--|-----------------|--------------|-----------|--|
| <input type="checkbox"/> I(signal)               | Removable diode | x 1.0        | Counts    | <input type="button" value="&lt; 100 &gt;"/> <input type="button" value="16"/> |
| <input checked="" type="checkbox"/> I(reference) | Hutch reference |              |           |  |

---

**POSITION CONTROL**

|                 | Active element | Minimum | Center | Maximum | Width |
|-----------------|----------------|---------|--------|---------|-------|
| Horizontal axis | XPS Cen Y      |         | 0.4716 |         |       |
| Vertical axis   | XPS Sam Z      |         | 0.4470 |         |       |

# TWG application – KB focusing

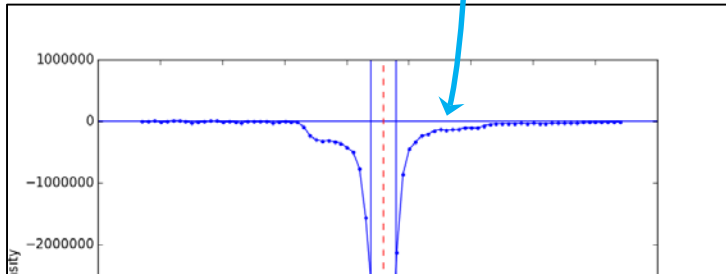
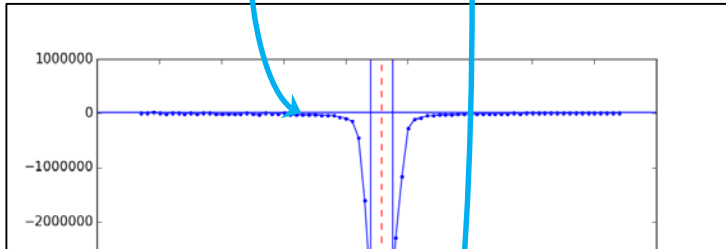
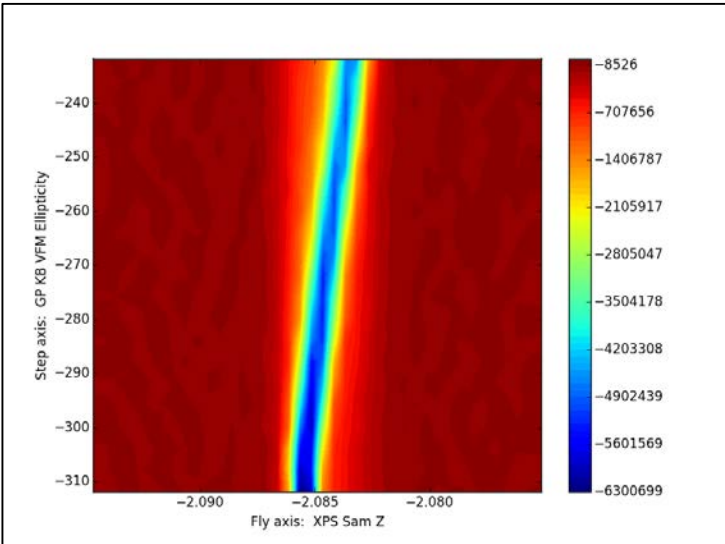
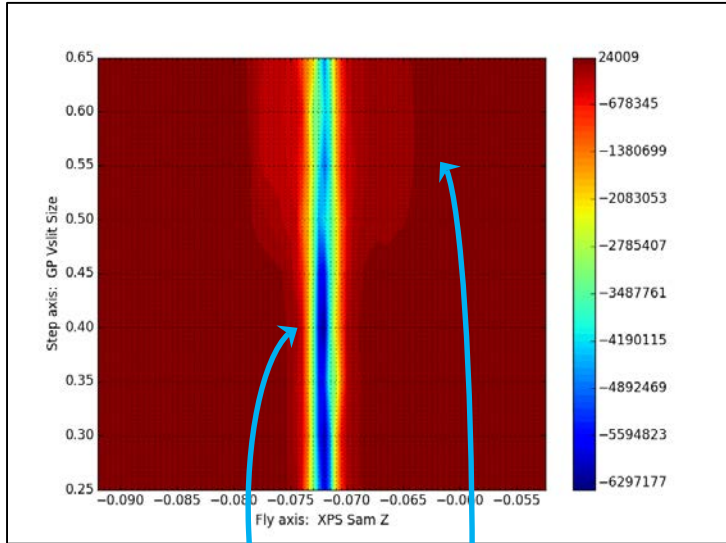
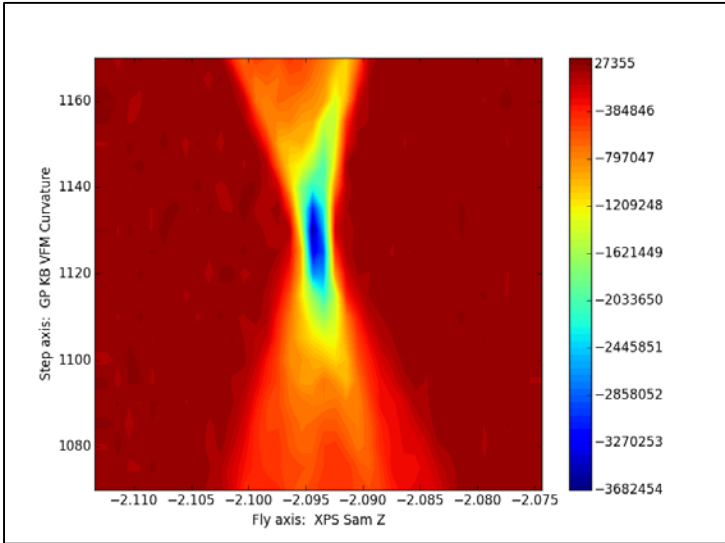


Curvature



Ellipticity

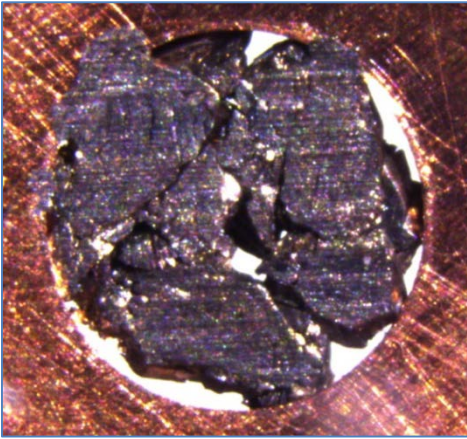
# Diptera – KB mirror characterization





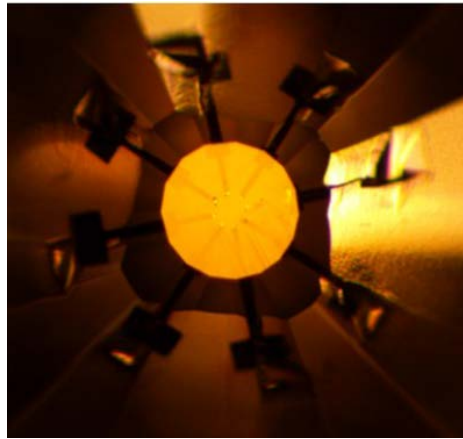
# 2D image gallery – heterogeneous samples

*From thousands . . .*



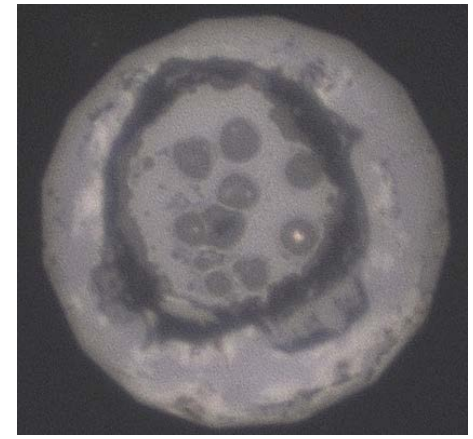
Fussell and Tschauer, unpublished

*to hundreds . . .*

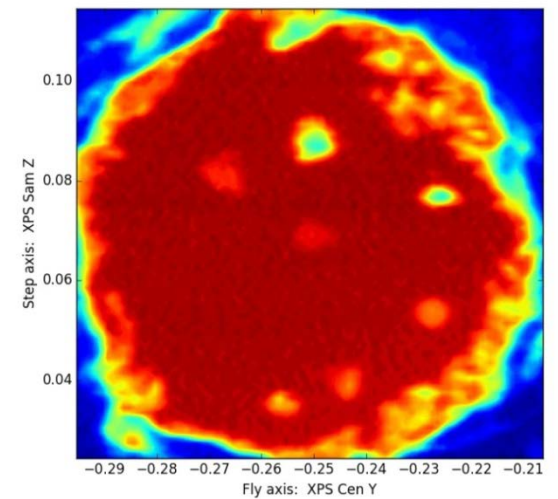
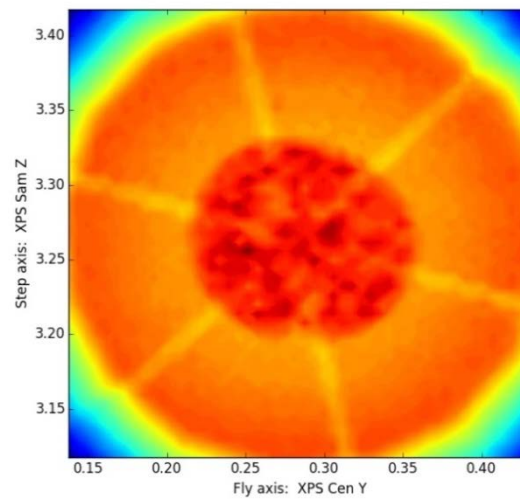
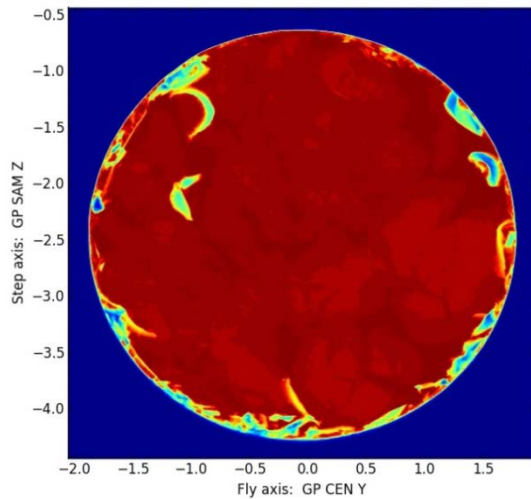


Samudrala *et al.*, *Materials* 8, 2054-2061 (2015)

*. . . to tens and ones of microns*



Bai and coworkers, unpublished



# Related developments

Not shown today . . .

- Adding simultaneous high-frequency x-ray diffraction with PILATUS
- Integrated beamstop diode for combined transmission/XRD measurements
- XDI software (Ross Hrubciak) for analyzing 2D XRD maps
  
- Using fly scan approach for single crystal XRD
- High resolution (ms) synchronization of x-ray shutter with motor position
  
- Automated sample centering with visual reinforcement
  
- Built-in peak fitting for characterizing beam size/focal spot

# Almost done . . .

HPCAT staff, especially

- Eric Rod (design, manufacturing, and integration)
- Arun Bommannavar (some EPICS and controls integration)
- Guoyin Shen (continued support for project and managing the overall scope)

CARS staff, especially

- Matt Newville (primary developer of PyEpics)
- Mark Rivers (**extensive** support, ideas, help, and advice on several aspects)

BCDA staff, especially

- Tim Mooney (primary developer of softGlue)
- Kurt Goetze (BC-037 mod made fly scan possible for open-loop steppers)

Several other staff members and users with help, advice, testing, etc.

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