Hardware-based fly scan capabilities at HPCAT

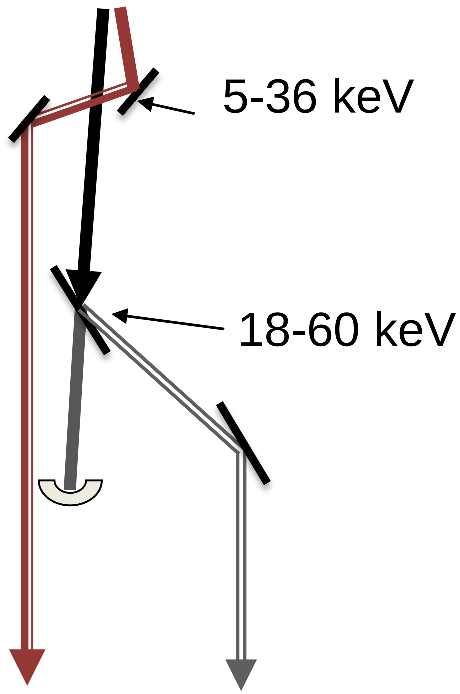
TWG 20 April 2017

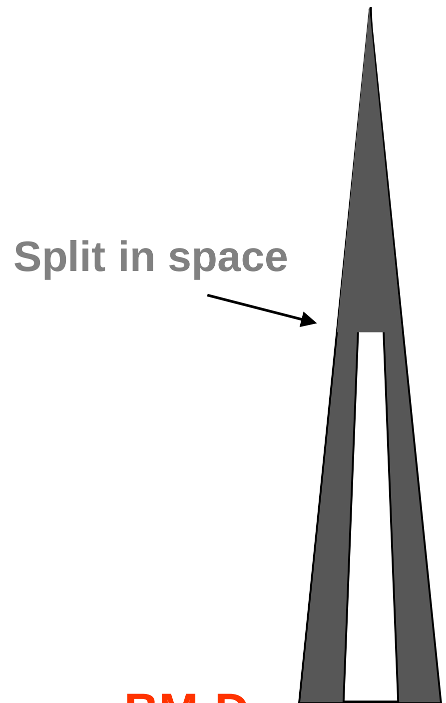
Jesse Smith
HPCAT

HPCAT – four dedicated HP beamlines

Sector 16
Canted undulator beamlines

Sector 16
Bending magnet beamlines





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

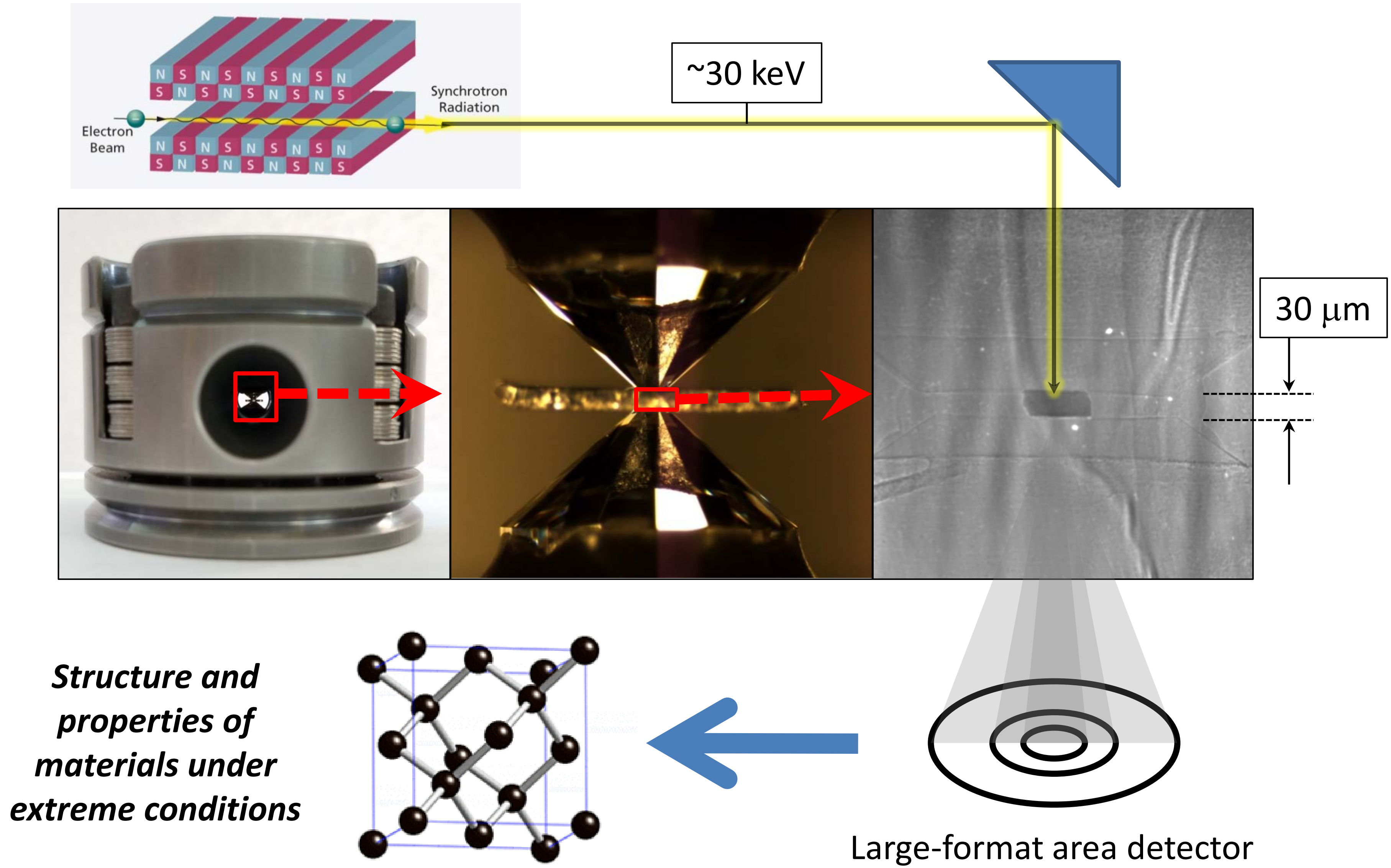
ID-B
Micro-diffraction
Laser heating
Cryostat

BM-D
Micro-diffraction
XANES

BM-B
White Laue
PEC

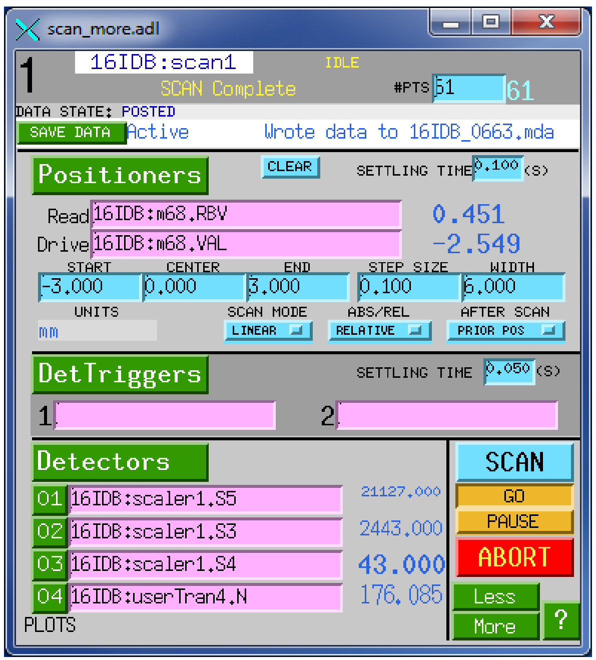
. . . to advance compression science in multidisciplinary fields using synchrotron radiation

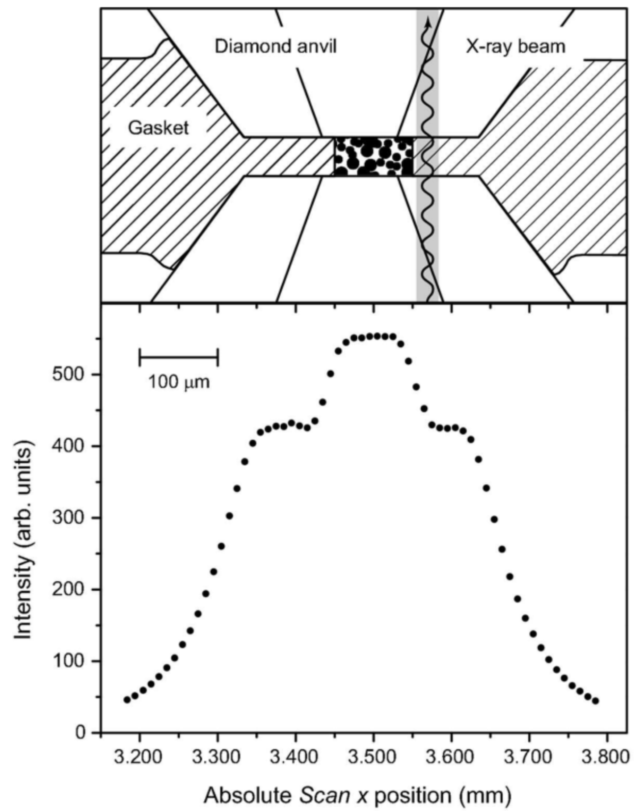
High Pressure XRD with a diamond anvil cell



Conventional step scan (with a DAC)

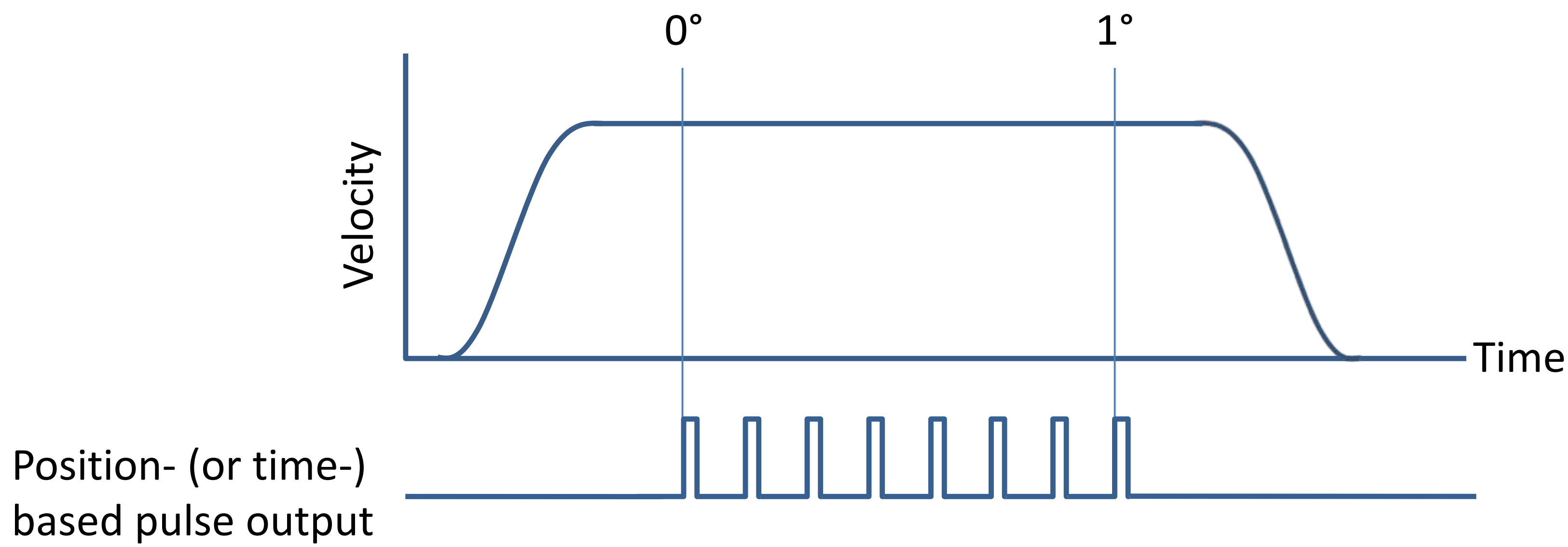
- ***One-dimensional scan*** (stolen from Tim Mooney's EPICS training presentation)
  - Do NPTS times
    - *Set conditions* — e.g., move motor, wait for move done
    - *Trigger detectors* — e.g., start scaler, wait for counting done
    - *Acquire data* — e.g., read out detector(s), store data in array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





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



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)

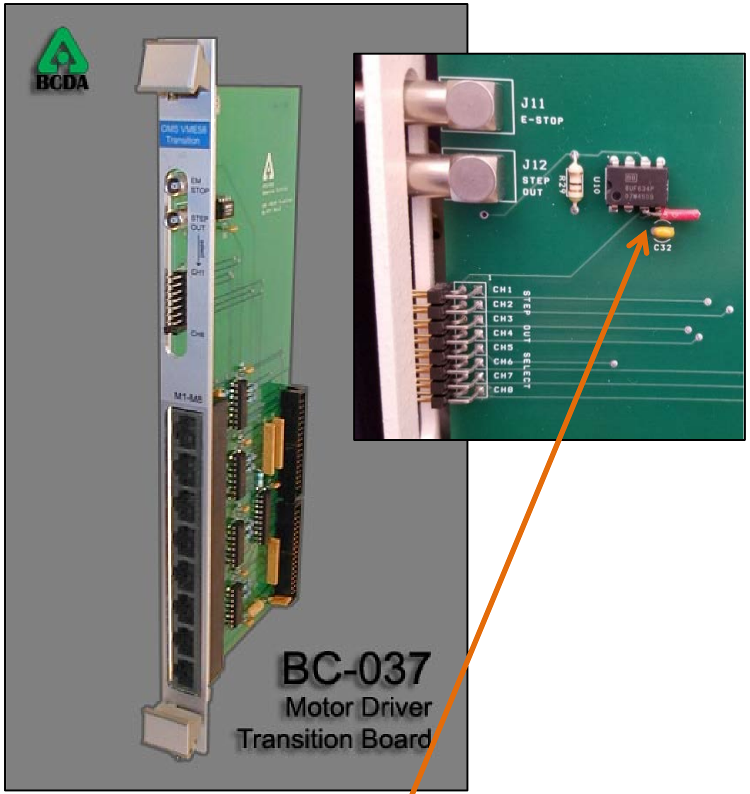
Trigger pulses from motion controller

Newport XPS (closed-loop)

PCO (dedicated output based on encoder)

GPIO2, pin12, Pulse: A 1 µs pulse with 5V peak voltage is sent for every time interval

OMS, Max-V (open-loop)

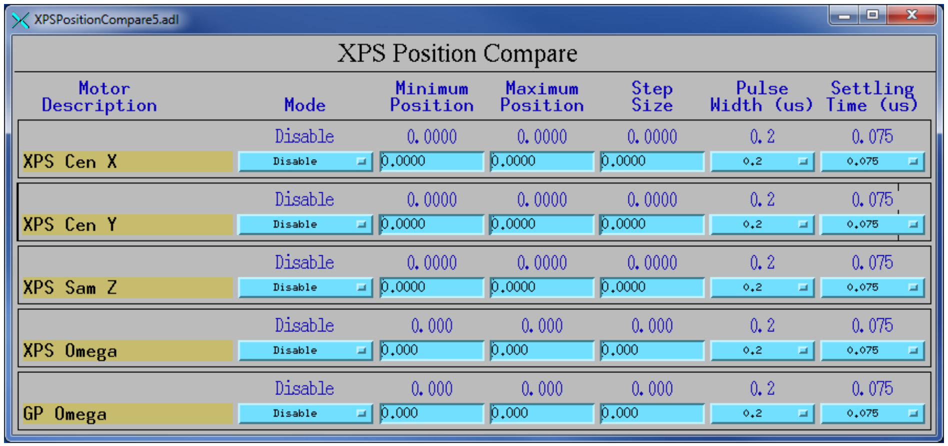


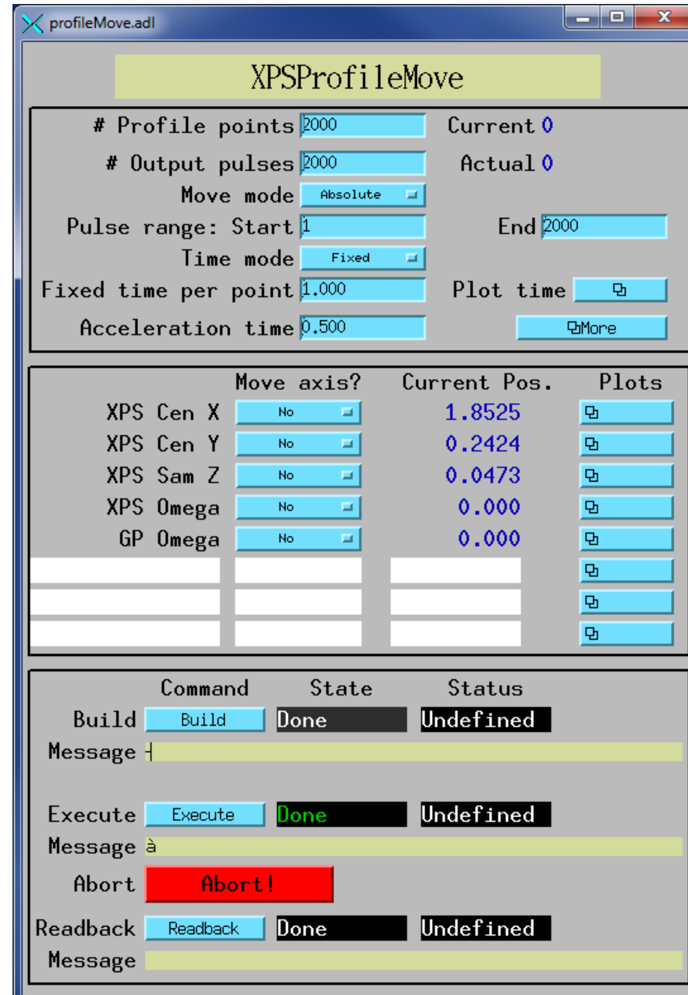
Modified BC-037 can provide step out for any/all axes Directly from selector pins (jump pins 3 & 4 on U10 chip as shown)

EPICS support for pulse generation

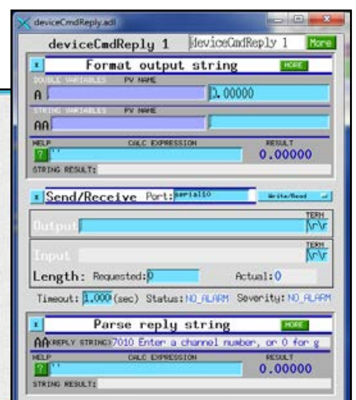
PCO (dedicated output based on encoder)

GPIO2, pin12, Pulse: 1 µs pulse with 5V peak voltage is sent for every time interval





Electro Standards Laboratories

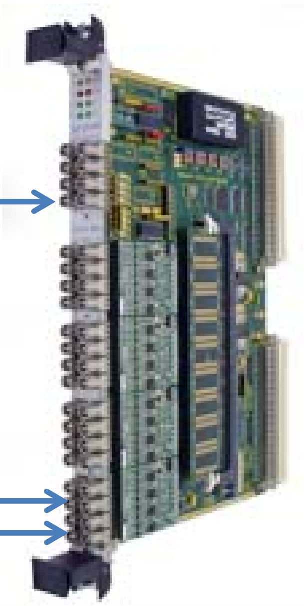


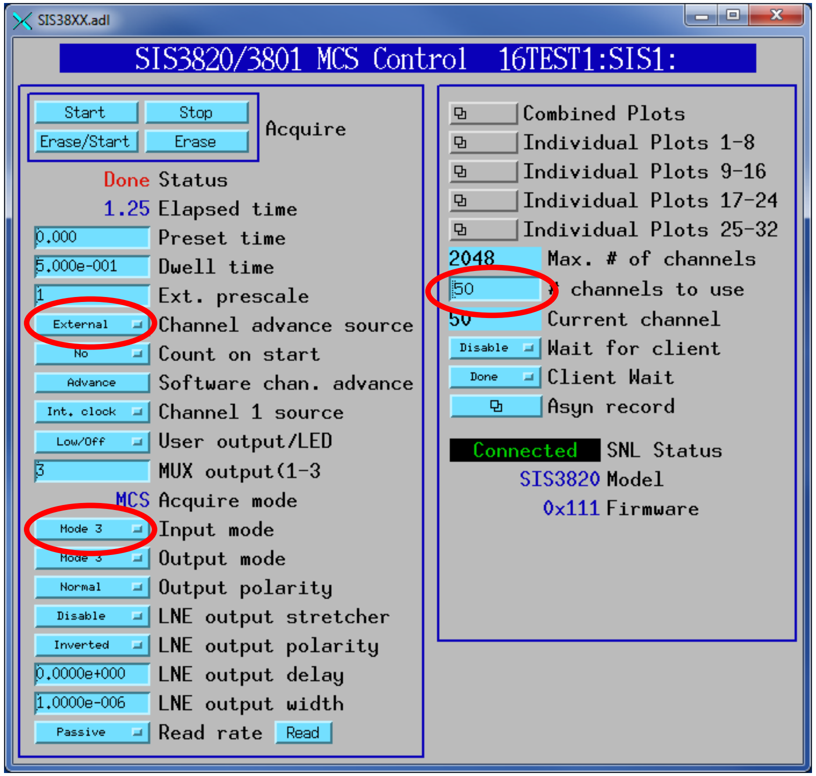
Detectors with little/no dead time

Struck multichannel scaler (SIS3820)

Channel advance from motor pulse output

Counter inputs from V-f converter

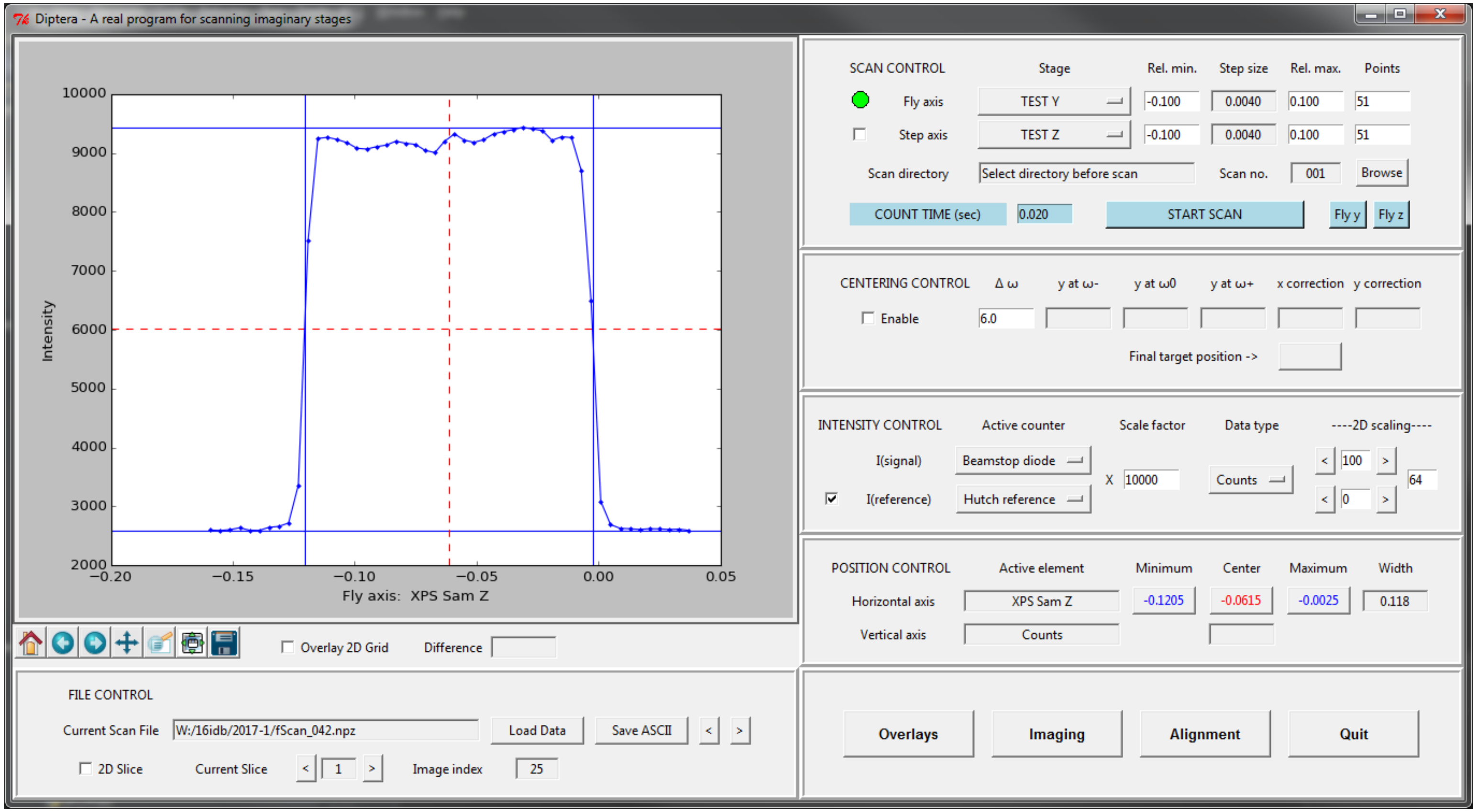




Fly scan client

Diptera

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

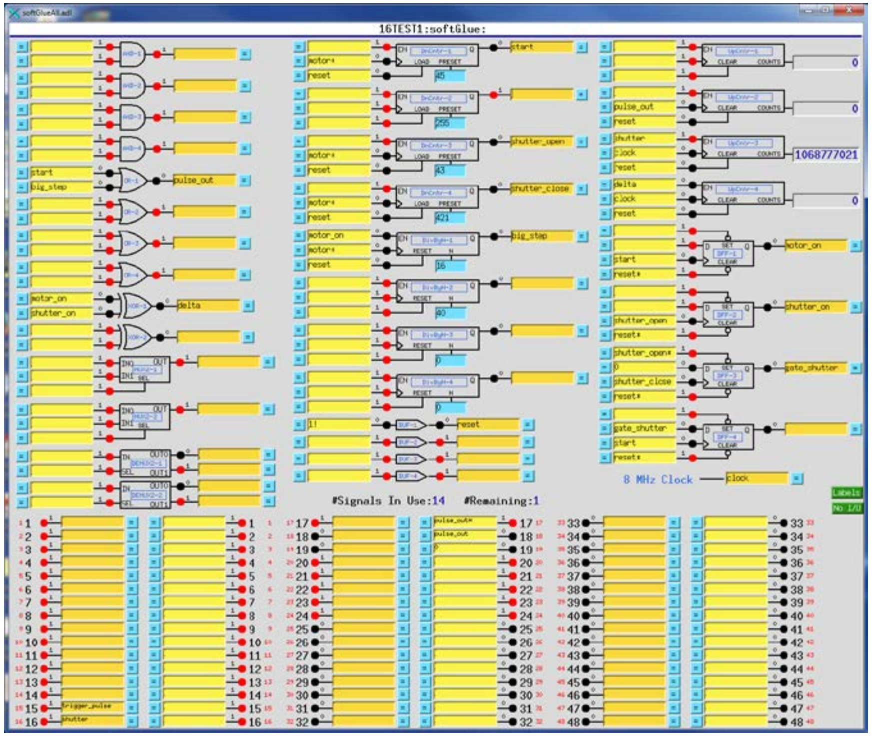


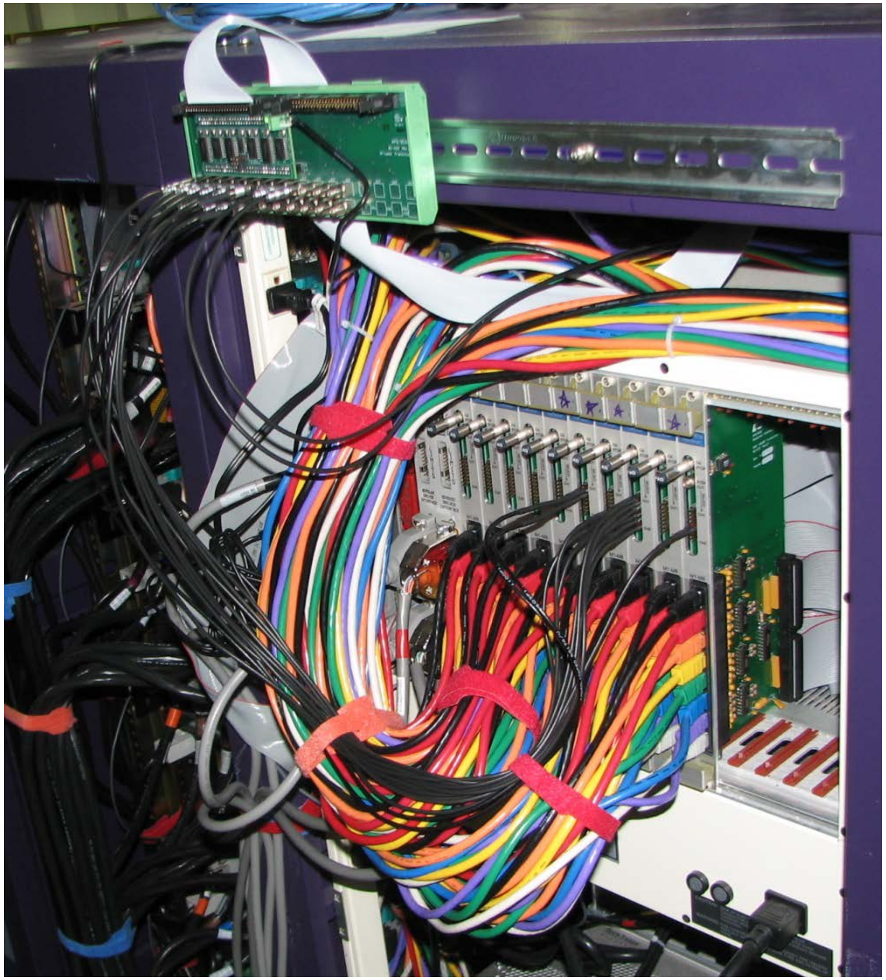
Written in Python 2.7 using Tkinter UI and PyEpics

Independent controller, viewer, data/file manipulation

Manage pulses from multiple sources

softGlue



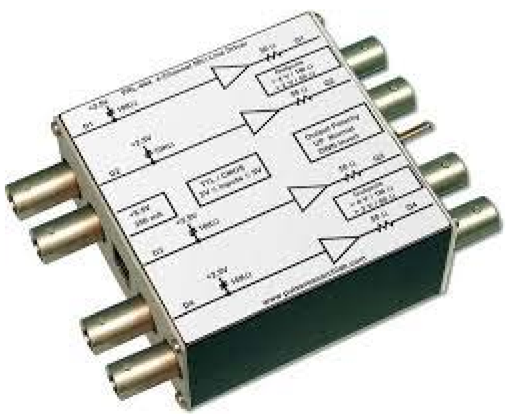


Two basic configurations:
Step: every Nth pulse after accel
XPS: one pulse in, one pulse out

Pulse conditioning, line drivers

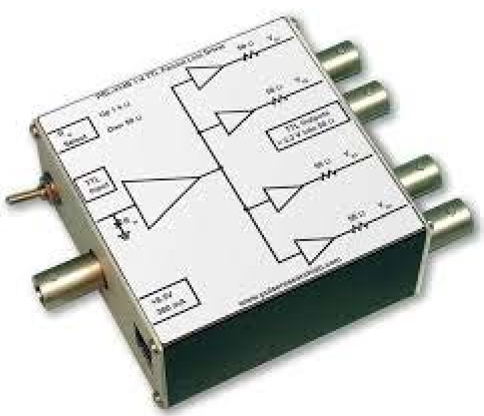
Pulse Research Lab

PRL-444
4-channel 50 Ω output TTL Line Driver



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

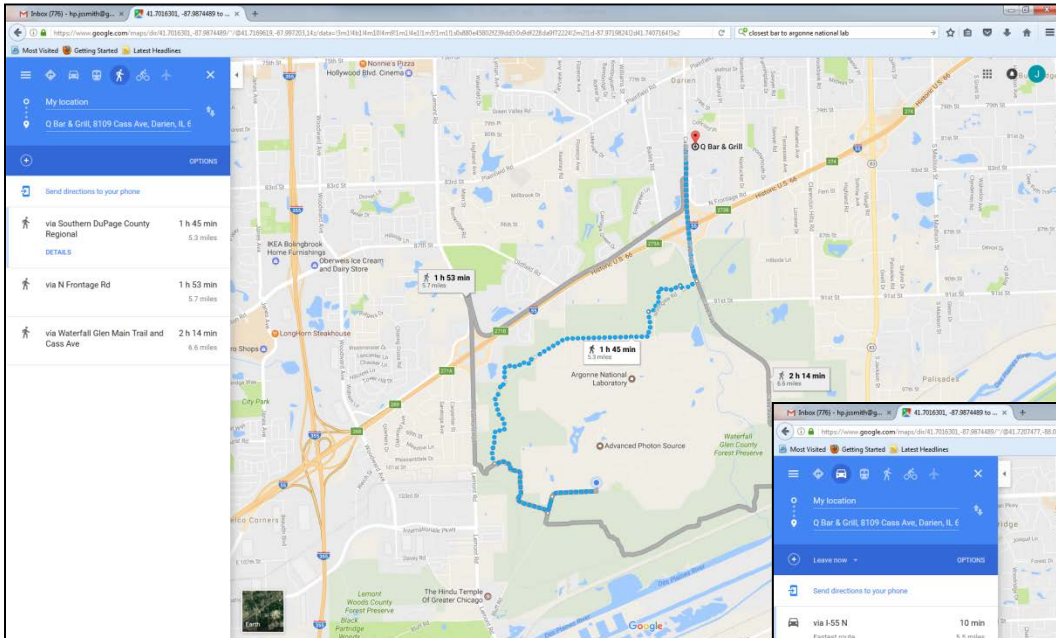
PRL-414B
1:4 fanout 50 Ω TTL Line Driver



Useful for triggering PILATUS, for example, as it can drive the 50 Ω trigger input

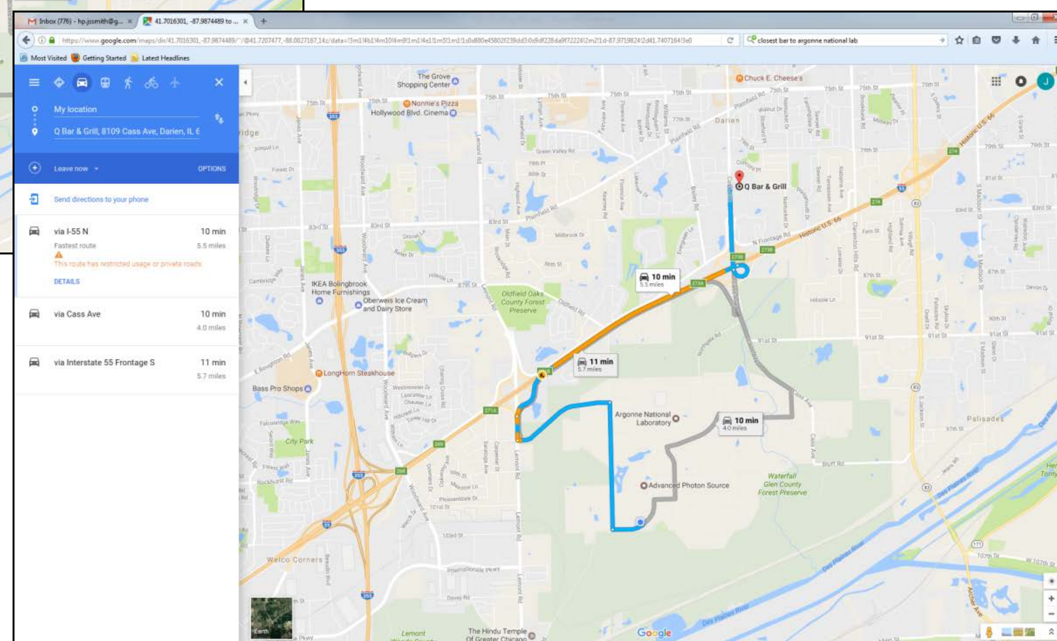
From possible to practical

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

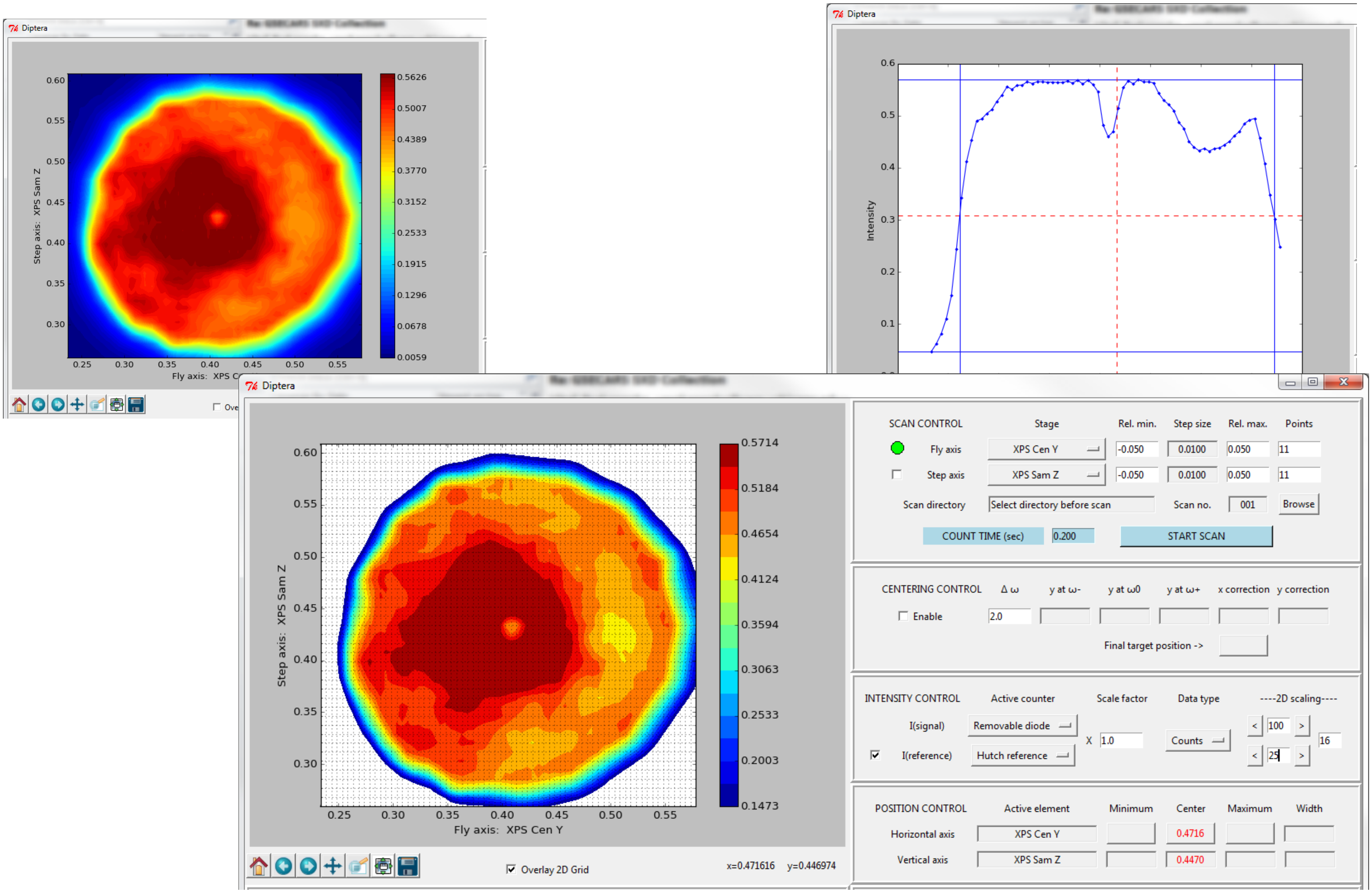


On foot: ~1h 45m

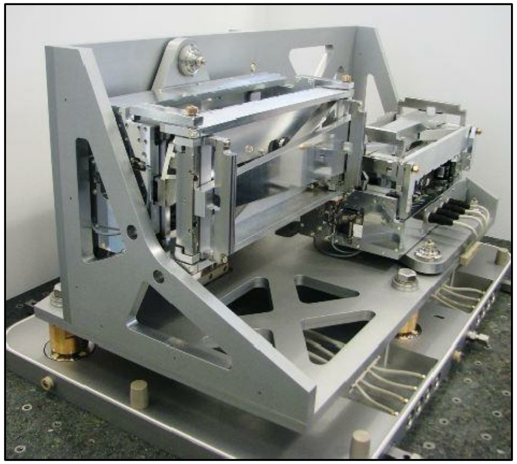
By car: ~10m

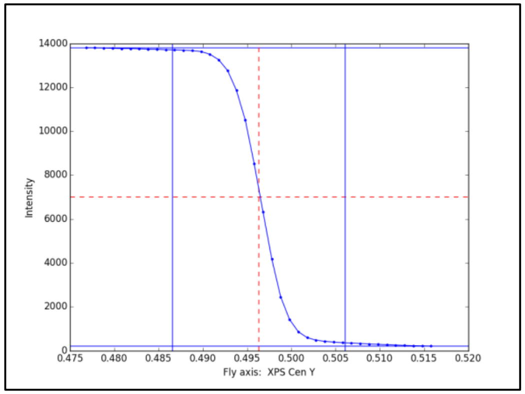


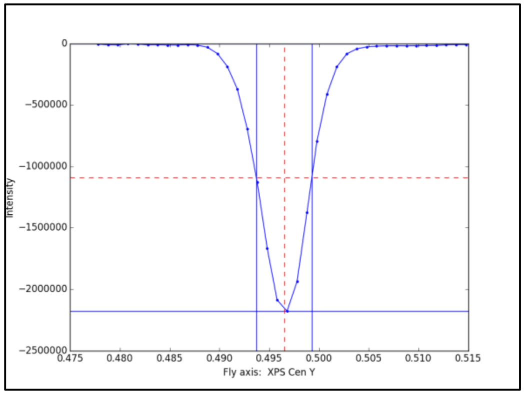
Routine 2D sample mapping → practical

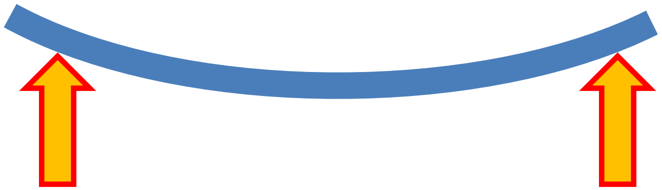


TWG application – KB focusing





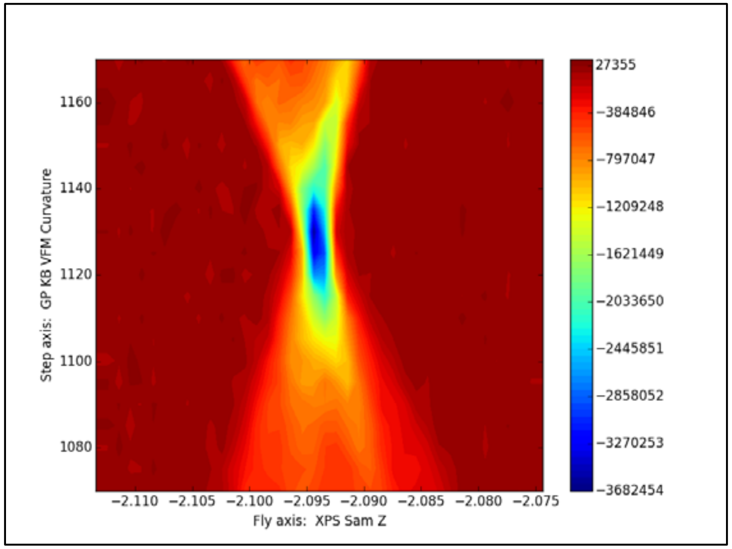


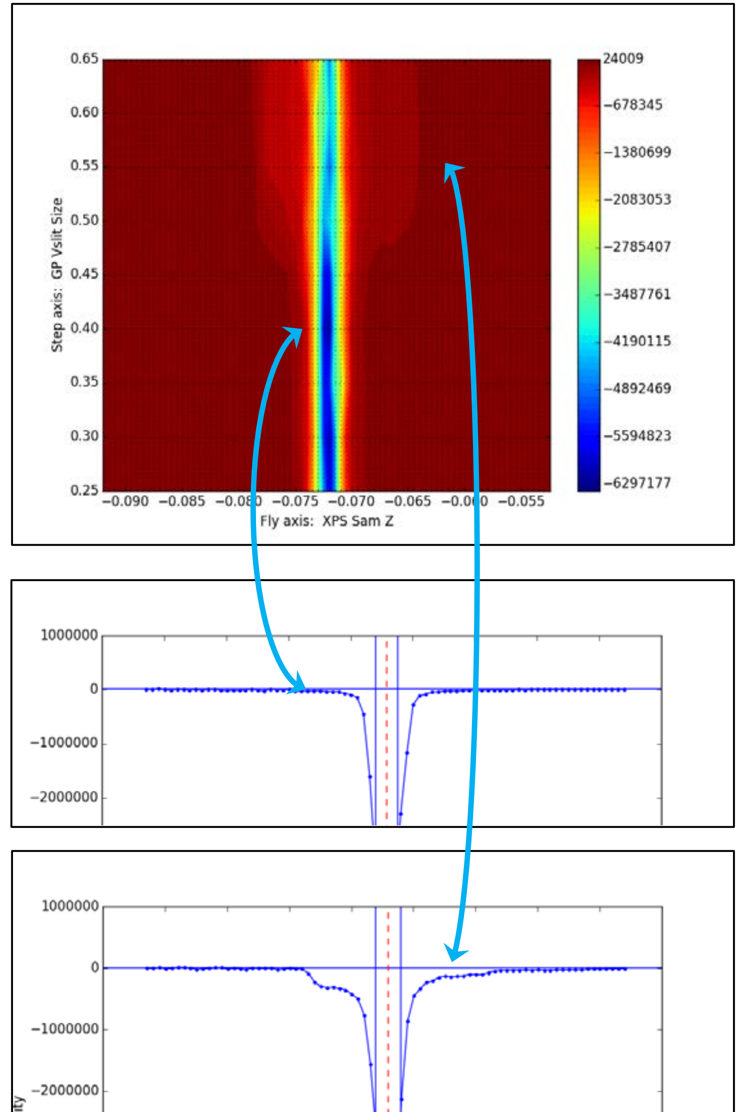


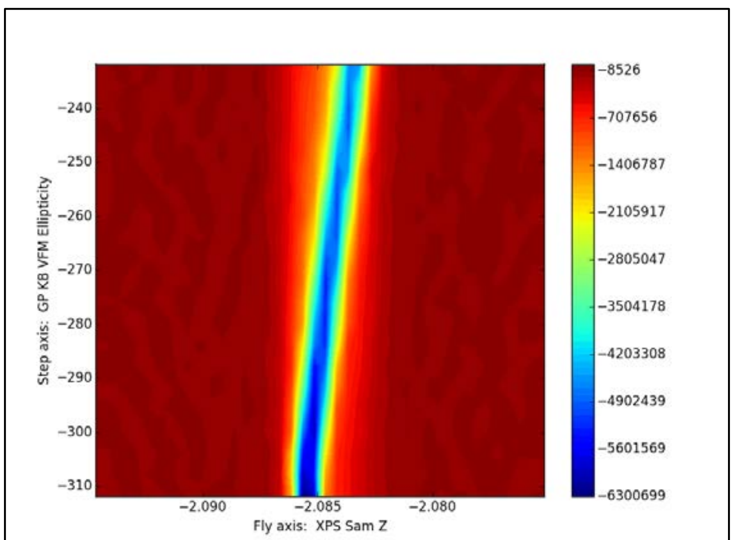
Curvature

Ellipticity

Diptera – KB mirror characterization



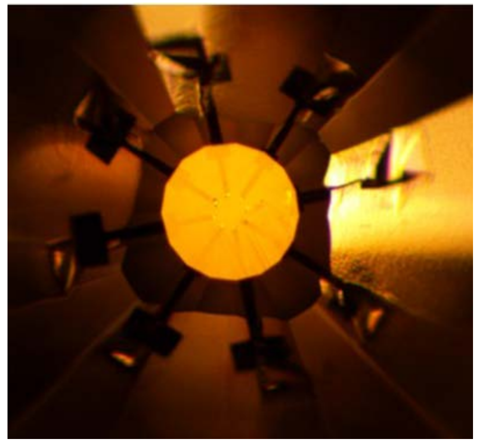




2D image gallery – heterogeneous samples

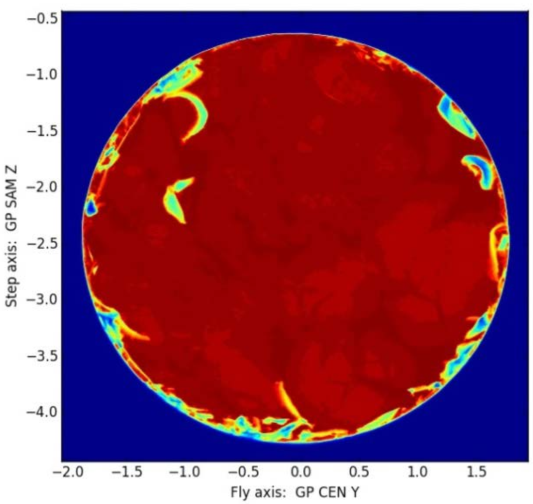
From thousands . . . *to hundreds . . .* *. . . to tens and ones of microns*

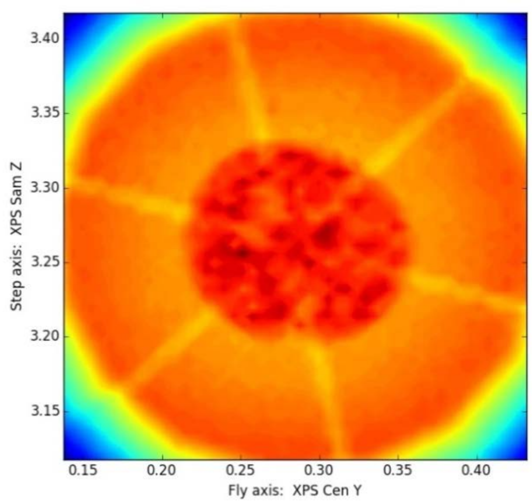
Fussell and Tschauner, unpublished

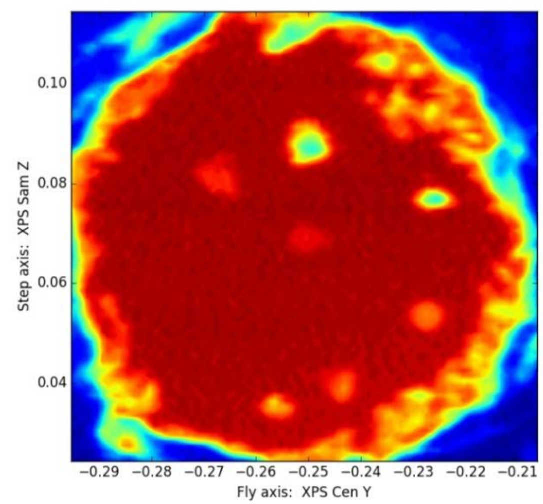


Samudrala *et al., Materials* **8**, 2054-2061 (2015)

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 Hrubiak) 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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