CDW-CDW R&D at NSLS-X16A

IXS BAT meeting

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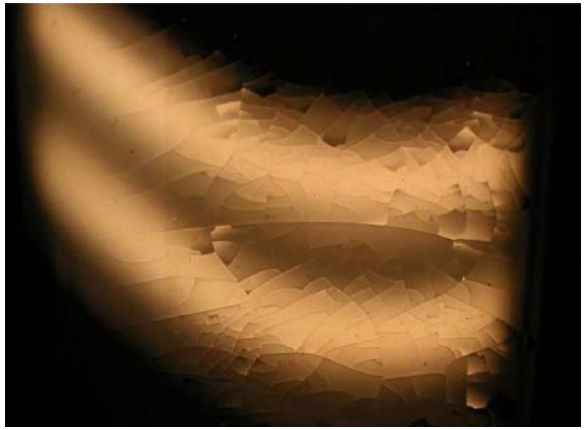
Outline

- Activity Since March
  - Mirror upgrade
  - Test Station improvements
  - CDW-CDW observations
    - Original D crystals
    - New D crystals
- Future Plans
  - Complete new D crystal tests
  - ML mirror tests
  - Improved C/W design
  - New prototype instrument

Mirror Upgrade Result: improved brightness

- Output of DCM (after recalibration):
  - 2.6 eV bandwidth measured using 800 backscatter
  - Vertical divergence ~120 μrad in 100 μm (bender set)
  - Horizontal divergence ~80 μrad (2 mm slit)
  - Flux ~2E+9 phot/s in 2 x 0.5 mm^2 slits
  - *~10x brighter than before! (see below)*
- CDW output vertical divergence measured:
  - 108 μrad (<333> rocking curve)
- CDW-CDW optimized intensity improved:
  - 1st CDW output of ~3-4 E+4 phot/s rose to ~7.5 E+4 phot/s
  - 100-400 phot/s (vs. ~ 10 phot/s previously) also suggests more than 10x brightness improvement



old mirror surface

Estimated brightness change before and after mirror upgrade based on measured DCM output:

	flux	H size	V size	H div.	V div.	BW	brightness
	phot/s	mm	mm	μrad	μrad	eV	phot/s/mm^2/μrad^2/eV
old mirror	2.00E+10	2	2	300	200	8	1.04E+04
new mirror	2.20E+09	2	0.5	80	120	2.6	8.81E+04

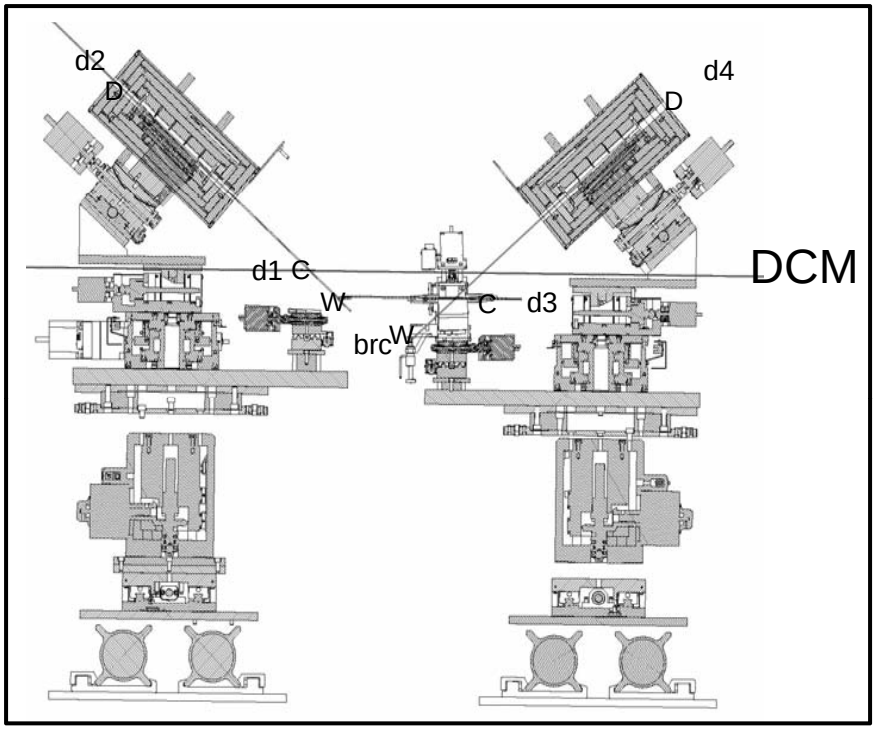
CDW-CDW Test Station

2 CDW stations, including

- 22 DOF crystal positioning
- 4 DOF slits
- 2 DOF bicron positioning
- 4-5 strategically mounted dedicated intensity monitors
- Temperature stabilization enclosure(s)

New Features

- New theta 0.4 µrad resolution motors
- Turntable motors
- Dedicated diode/housing, collimators, and shielding
- Stepper controller boards, EPICS, spec updated



- DCM piezo driver supply replaced
- Upstream C/W crystal replaced June
- Ovenless D crystal mount(s), “open” enclosure, new D crystals installed 8/25

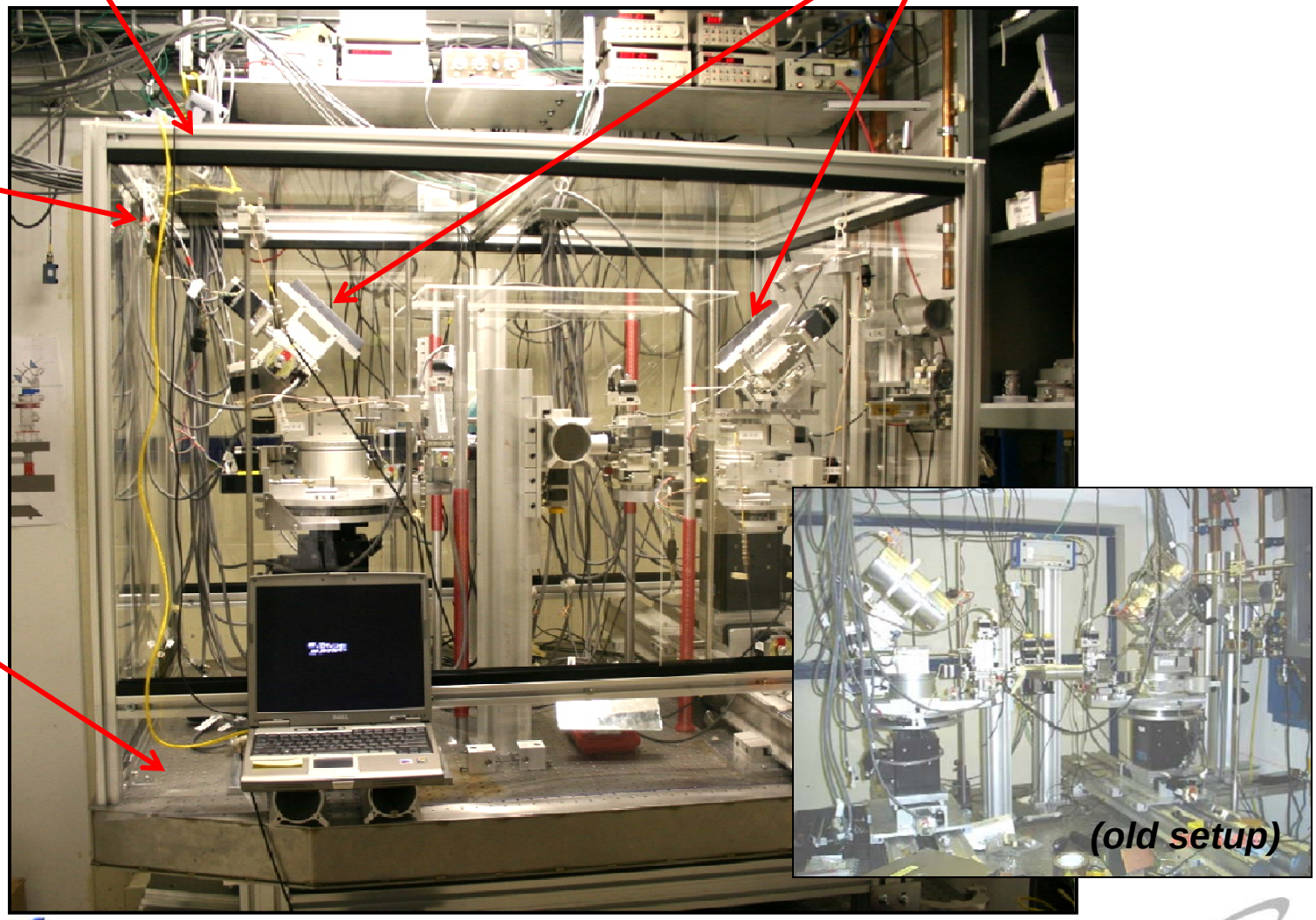
“open” enclosure

“dog house” frame

New D crystals

cable stays

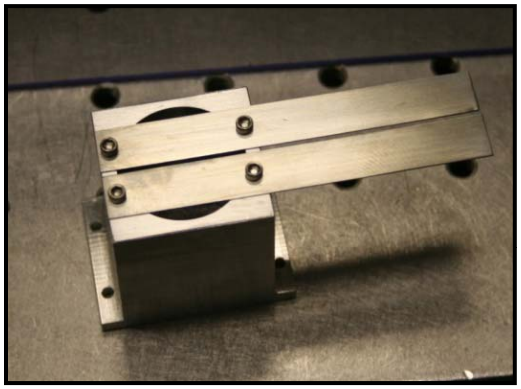
curtains



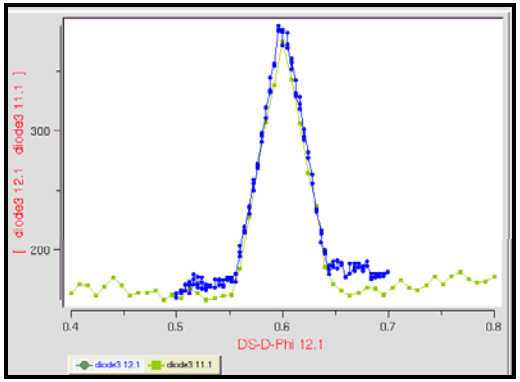
Alignment and Optimization Considerations

New method: d3 slits

- Forces beam from downstream unit to return parallel to DCM beam (40 mm lower)
- Used to set ddphi

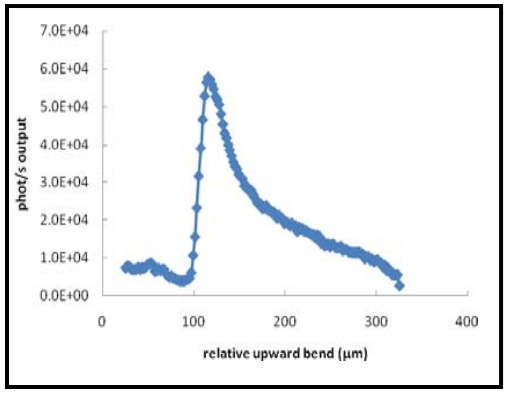


Diode collimator/slits assembly

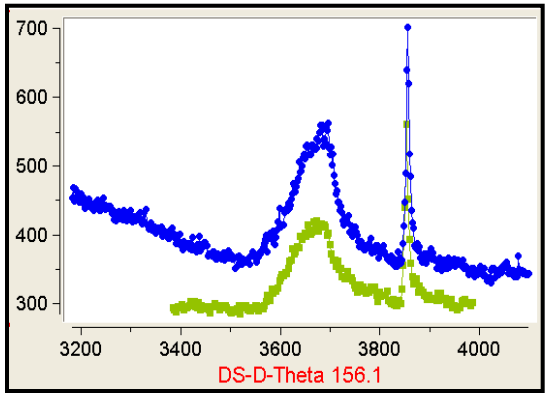


(Triangular beam shape)

C / W optimization using DCM



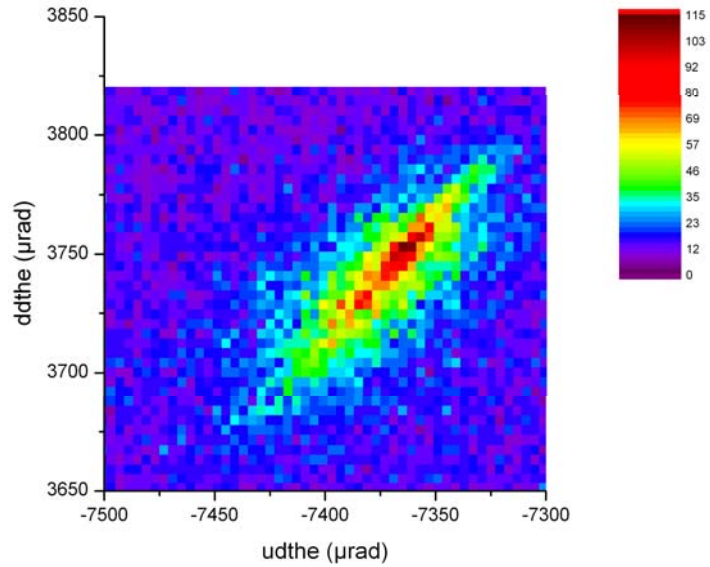
CDW output: bender tuning

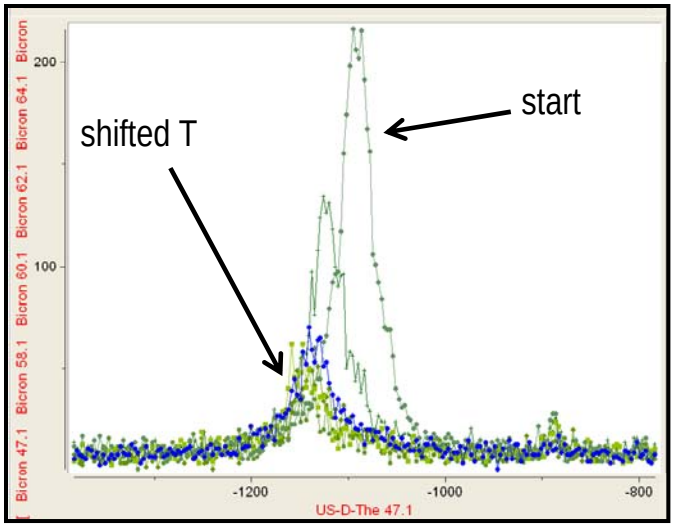


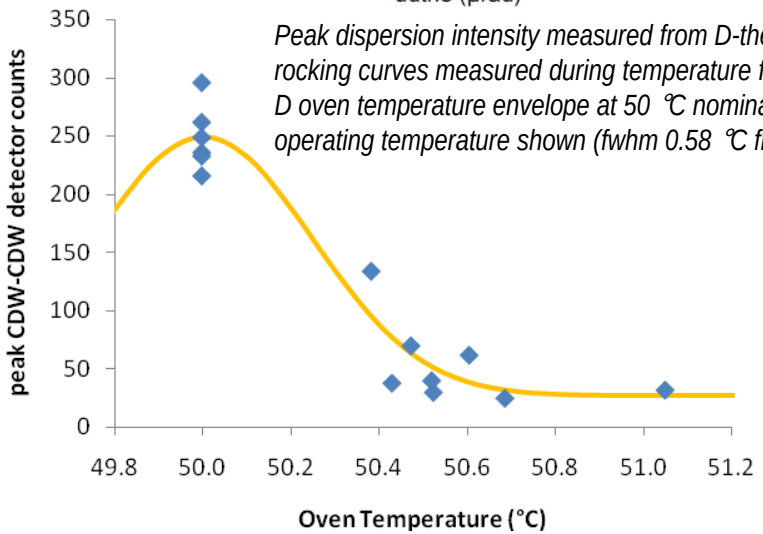
D reflection transmitted through C crystal (detector between C and W): find Θ_D

Energy selection and optimization

- D-theta / D-theta scan (resolution vs energy)
  - Use global peak
- D-theta / ΔT data (ovens operated)
  - Resolution is independent of temperature mismatch (there is temperature uniformity of each D independently)
  - Temperature change causes energy mismatch, and therefore lower efficiency, as expected



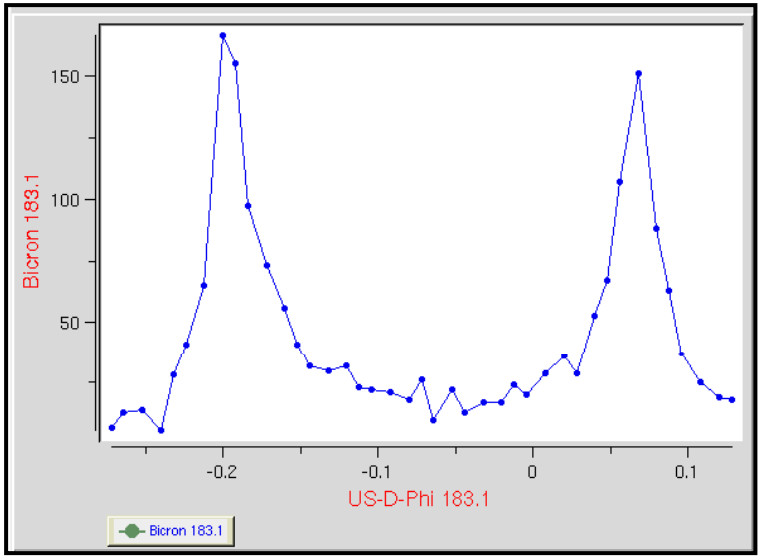


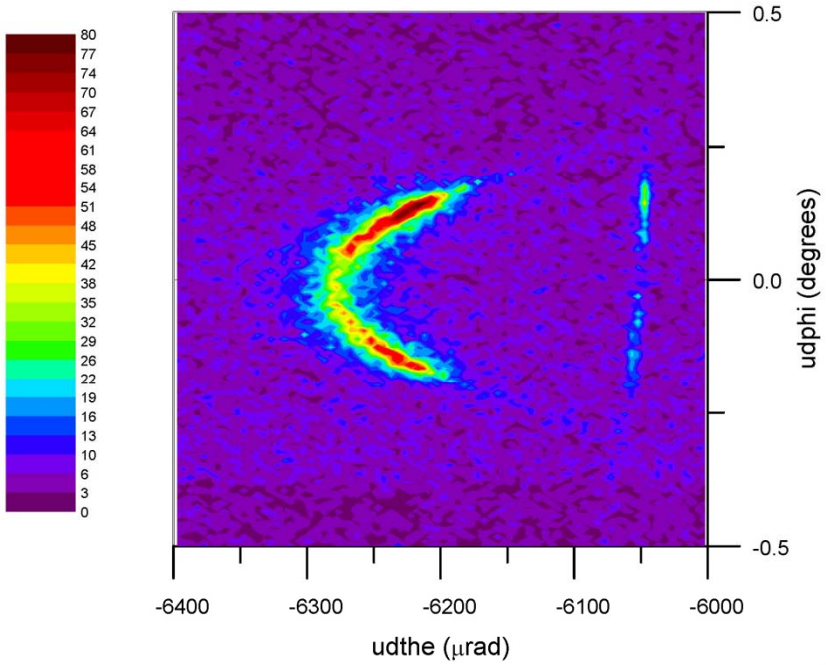


Peak dispersion intensity measured from D-theta rocking curves measured during temperature fluctuation: D oven temperature envelope at 50 ℃ nominal operating temperature shown (fwhm 0.58 ℃ fit)

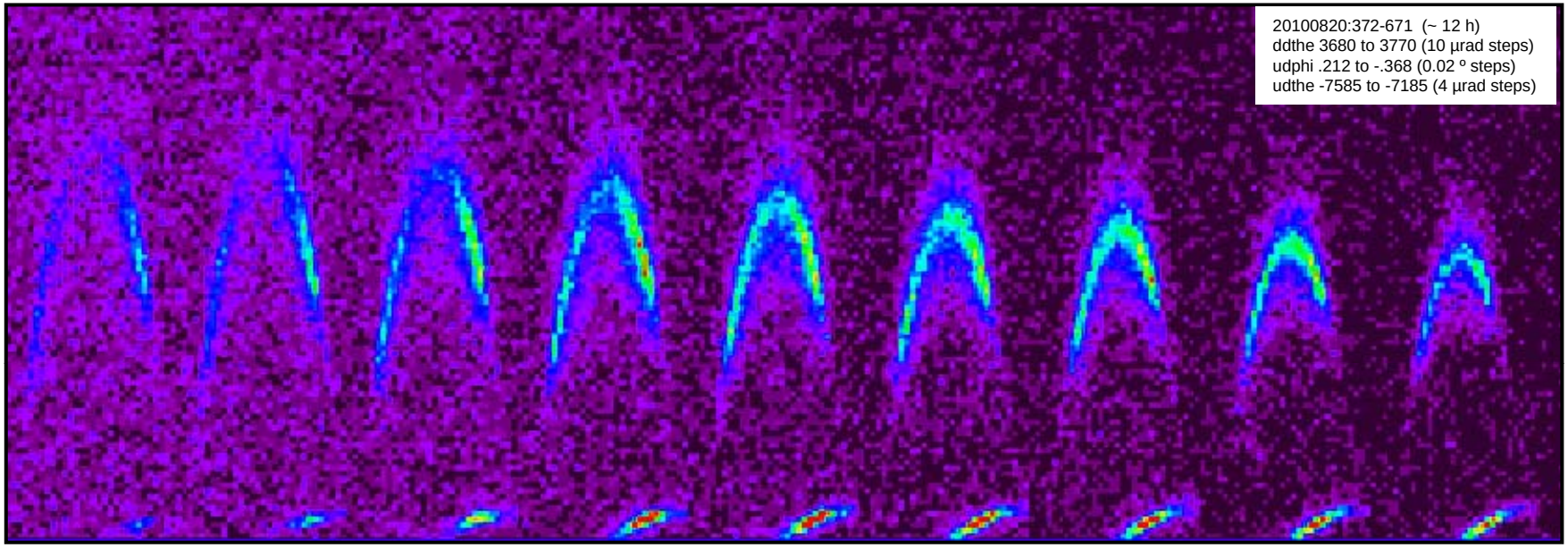
New Observation: double phi peak

- Some phi dependence on D-theta scans was previously observed but not closely examined until this summer.
- **ucchi** or **udphi** scans shows double peak at bicron, suggesting 2-D mapping of phi/theta (new visualization method)
- Latest interpretation: energy mismatch? Multiple beam problem?

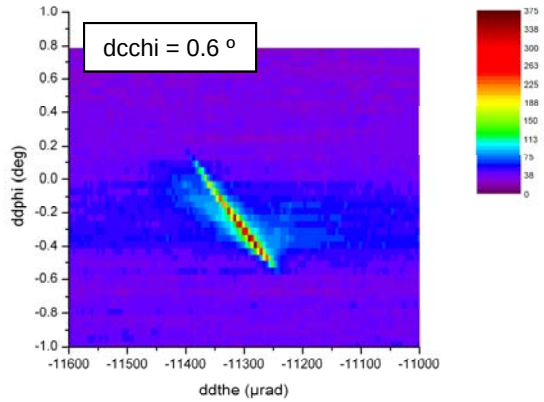


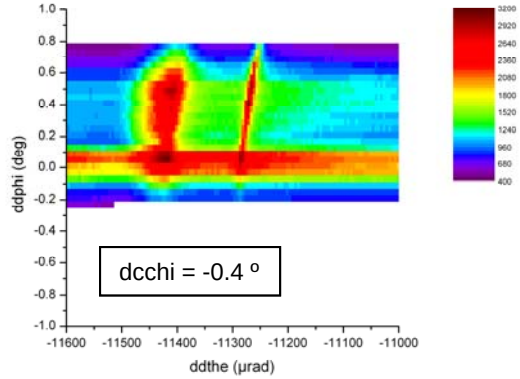


Study of udphi, ddthe, dcchi

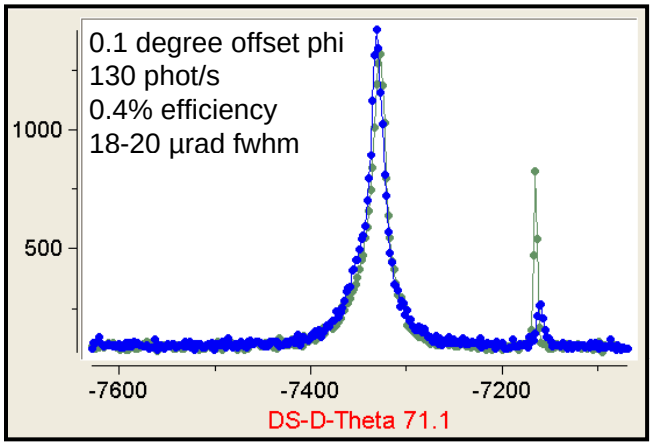


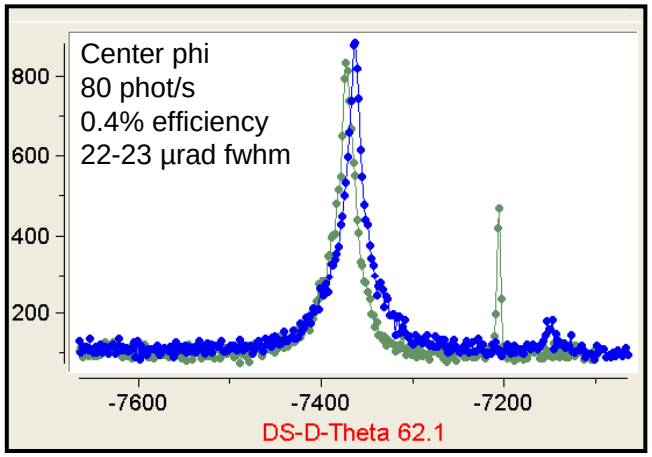
- ddthe sets downstream CDW (monochromator) energy
- C-chi is set to make D-phi non-dispersive

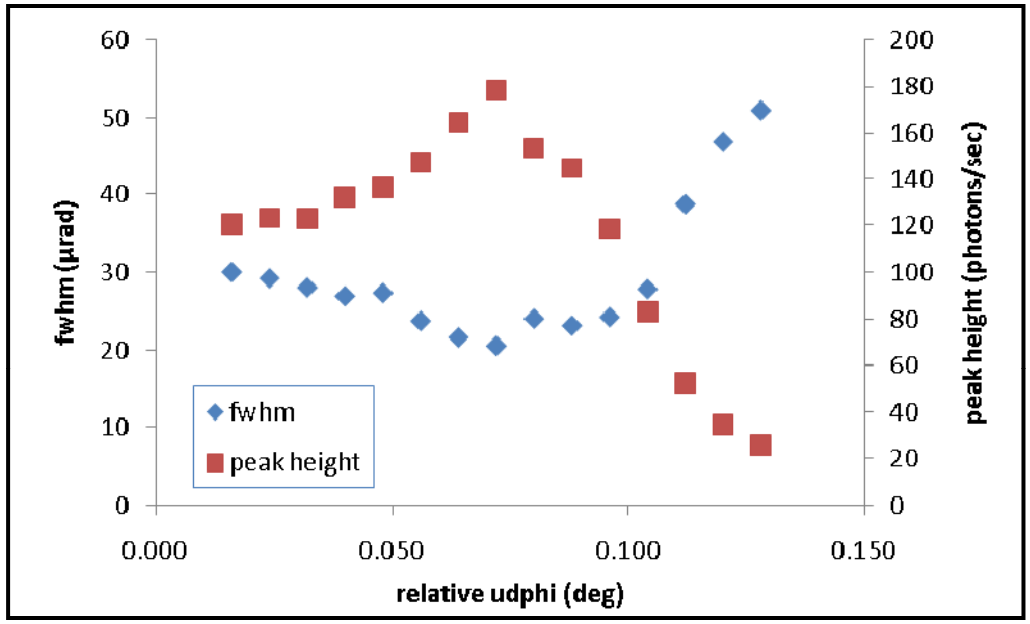




Investigation of impact of phi on resolution



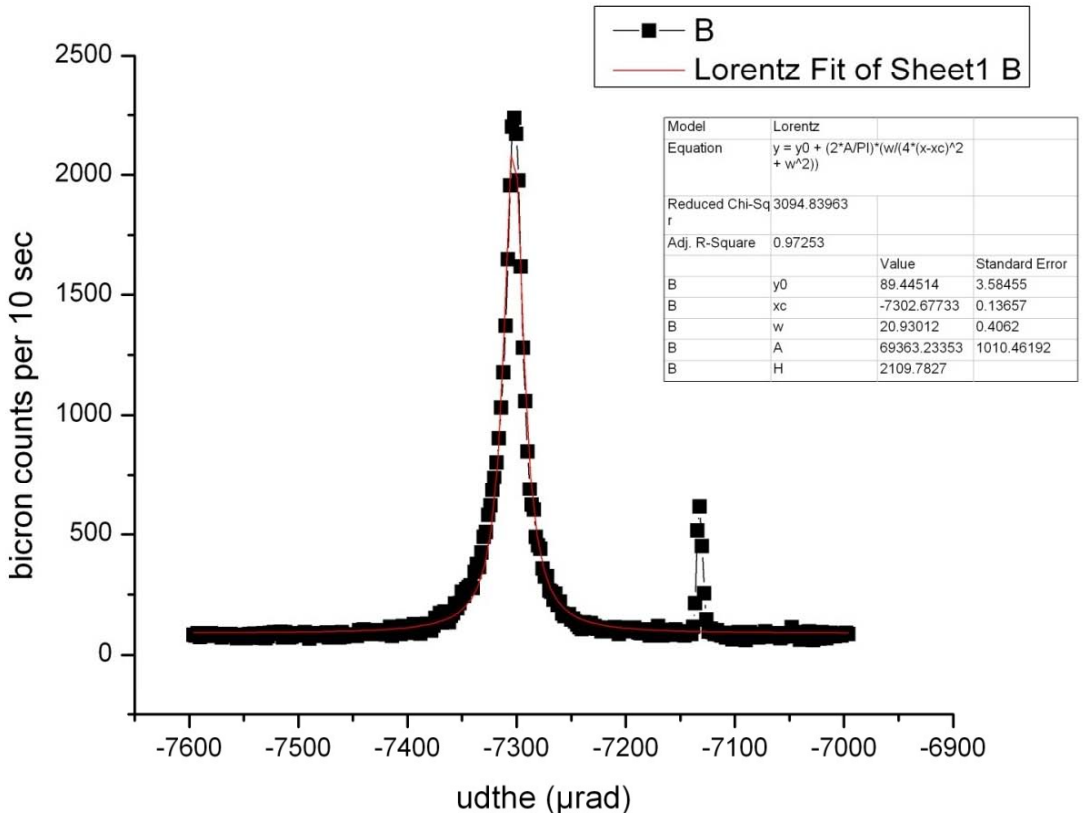




- Best sharpness and intensity at offset phi
- Perhaps this can be improved (see theory)

Resolution data & analysis

(Original crystals, after mirror upgrade and improved alignment)



Model	Lorentz		
Equation	y = y0 + (2*A/PI)*(w/(4*(x-xc)^2 + w^2))		
Reduced Chi-Sq r	3094.83963		
Adj. R-Square	0.97253		
		Value	Standard Error
B	y0	89.44514	3.58455
B	xc	-7302.67733	0.13657
B	w	20.93012	0.4062
B	A	69363.23353	1010.46192
B	H	2109.7827	

(open D crystal mount)

$$\frac{\Delta\Theta}{\Delta E} = \frac{\sqrt{2}\tan\varphi}{E}$$

(individual CDW resolution deconvoluted)

For φ = 88.38°

(1.62° miscut),

ΔΘ/ΔE = 5.5 µrad/meV

20 µrad ➔ 3.7 meV

Or, using known <800> ΔE_R of 30 meV and measured CDW rocking curve width $\Delta\Theta_R$ of 100 µrad:

$$\frac{\Delta\Theta}{\Delta E} = \frac{\sqrt{2}\Delta\Theta_R}{\Delta E_R}$$

(individual CDW resolution deconvoluted)

ΔΘ/ΔE = 4.7 µrad/meV

20 µrad ➔ 4.3 meV

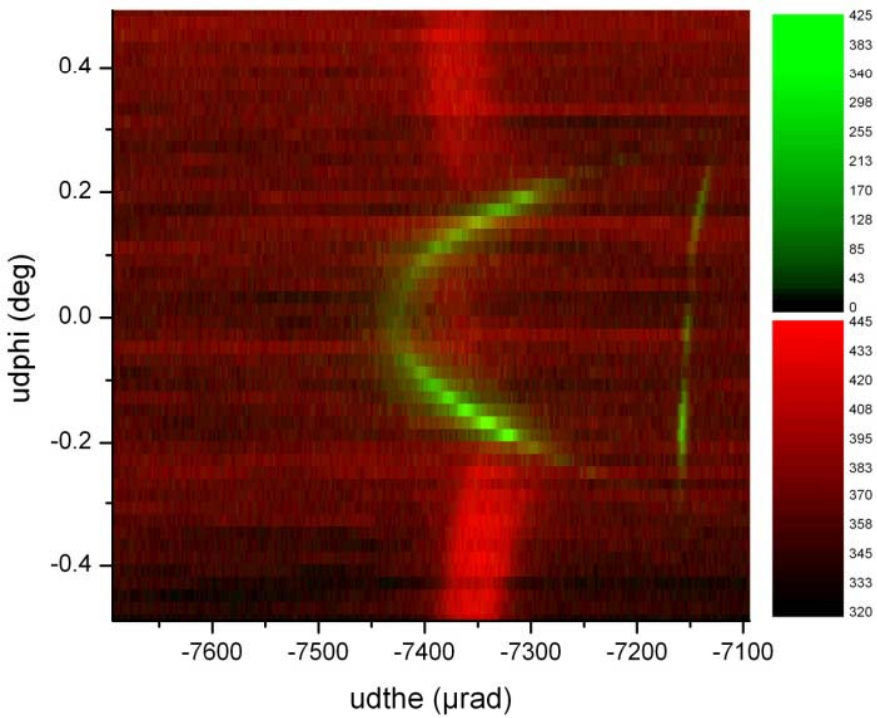
D crystal out of its enclosure

"B" crystal moved from "B" oven to "open upstream" mount

Detector above 2nd D crystal: 25 photons per net count at 10^9 V/A gain

New Observation: upgoing (440) reflections

CDW-CDW intensity correlates with 440 intensity:



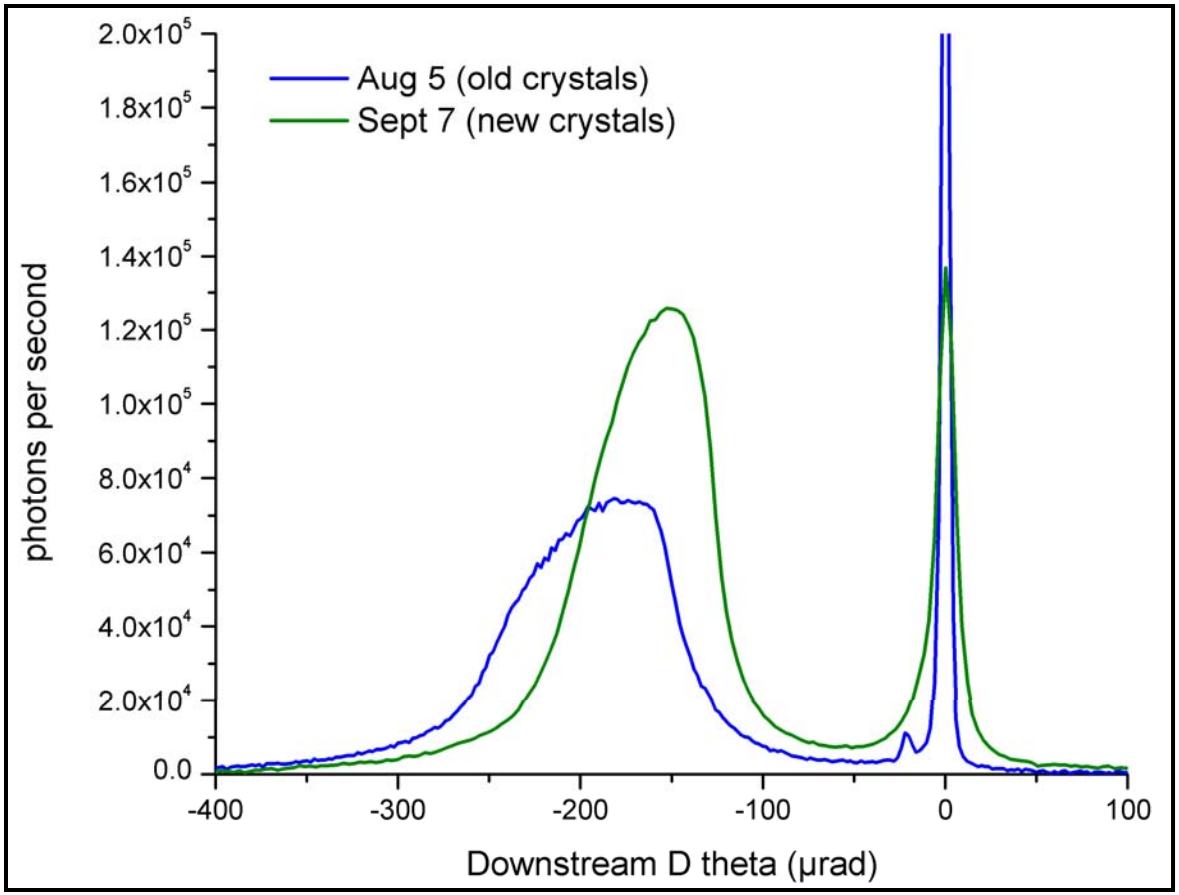
Efficiency data & analysis

(Original crystals, after mirror upgrade and improved alignment)

- Measured beam entering and exiting second (upstream) CDW, at various slit settings, always subtracting background levels
- Results are rather consistent
- Typical signal levels:
  - 34050 phot/second entering upstream CDW
  - 203 phot/second exiting upstream CDW
- Typical result: 0.6%
- Cause for low efficiency under investigation
  - Multiple beam reflection?
  - Crystal quality?

Latest results

- CDW-CDW alignment with new crystals in progress.
- Downstream CDW output significantly higher as expected:



CDW-CDW alignment in progress, resolution / efficiency results forthcoming

Next steps

- Complete testing of new D crystals
  - Individual reflection efficiencies (new C/W diags needed)
  - Refinements to alignment, methods
- Test ML mirror
- Design and build improved C/W mount with integrated diagnostics
  - Independent crystals
  - Integrated diagnostics and/or slits, shielding. Diags locations:
    - Transmission position, with vertical slits option (insert/retractable)
    - Between C and W (remotely insert/retract capable)
    - After W
- Build up and prototype instrument including new designs of mounts and alignment features, plus diagnostics / shielding
- DCM upgrade?