

National Synchrotron Light Source II



Temperature Control of Crystal Optics

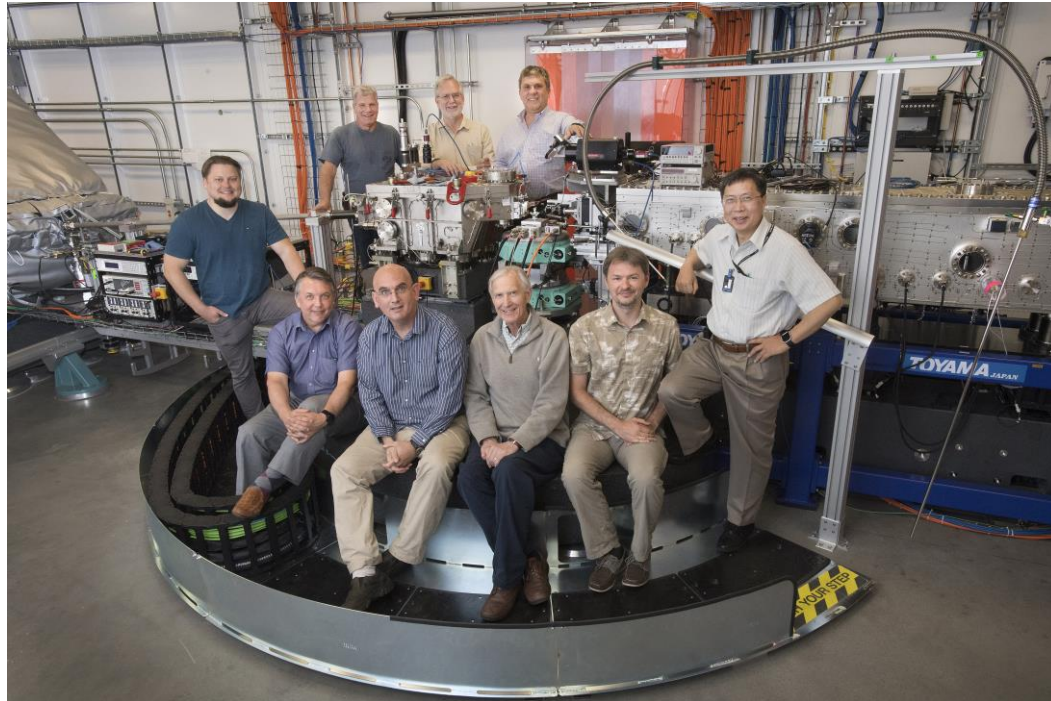
The meV-resolved Inelastic X-ray spectrometer at NSLS-II

Kazimierz Gofron

EPICS Collaboration Meeting
Ljubljana, Slovenia
September 21, 2022

Inelastic X-ray Spectrometer (9.1keV)

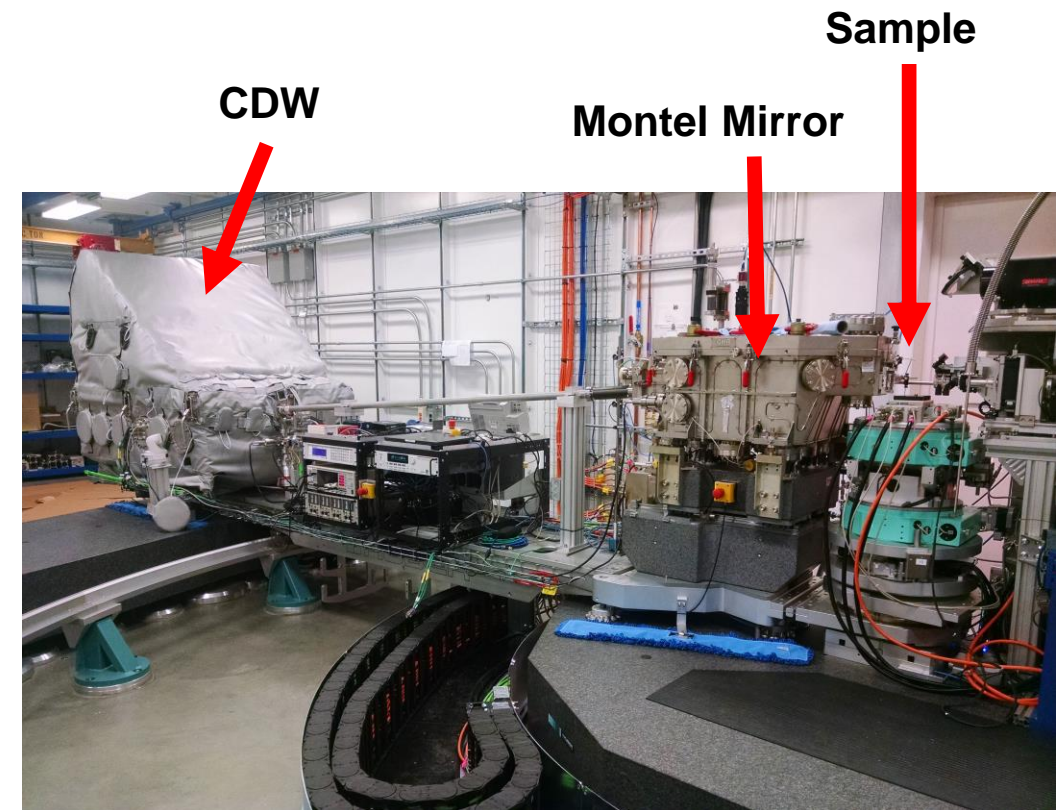
PRESENT AND FORMER TEAM MEMBERS



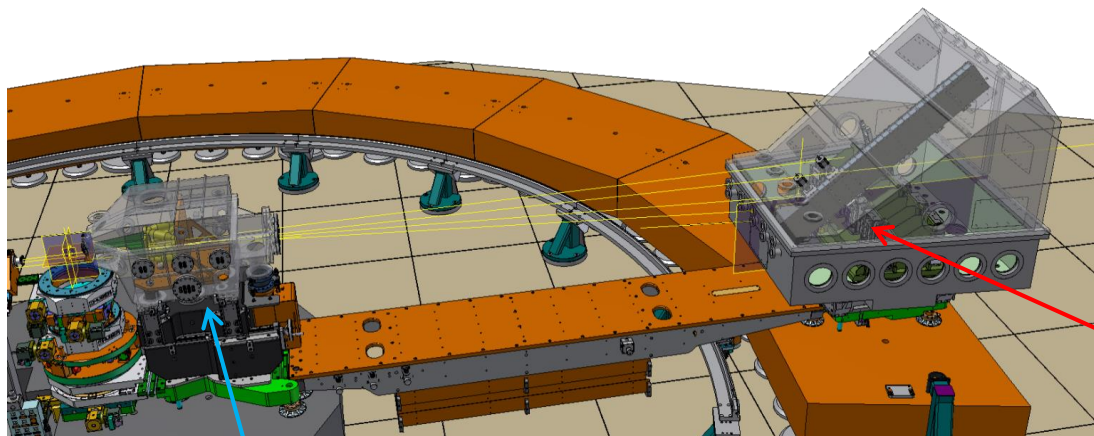
- **Back Row (L-R):** Dima Bolmatov, Rick Greene, Scott Coburn, Kazimierz Gofron
- **Front Row (L-R):** Alexey Suvorov, Alessandro Cunsolo, Ron Pindak, Misha Zhernenkov, Yong Cai

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Analyzer Optics



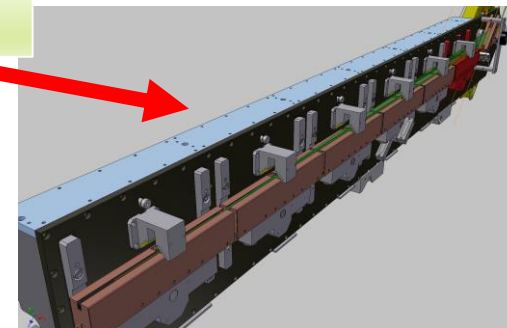
Optical Layout of Montel-CDW IXS Analyzer



Projected Longitudinal Length
@ 40 μm Transverse Acceptance

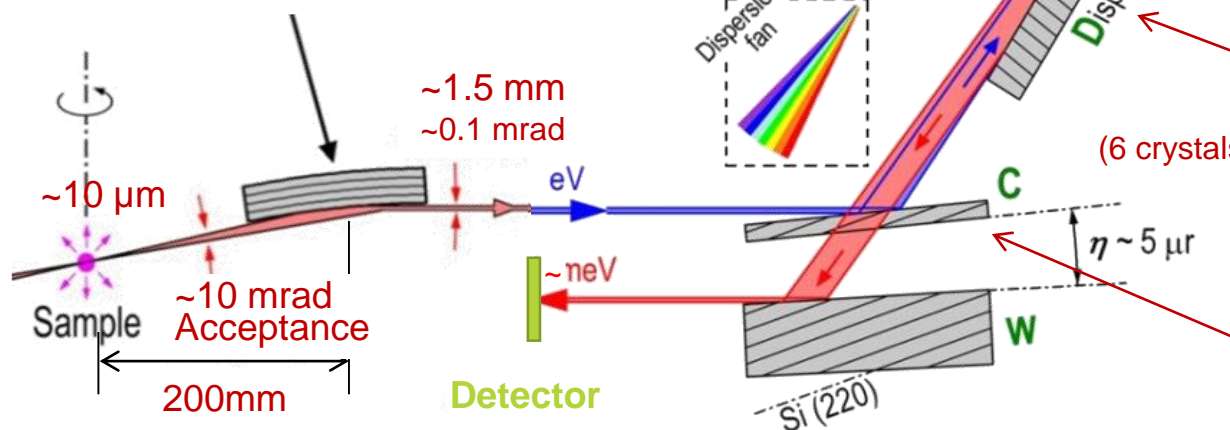
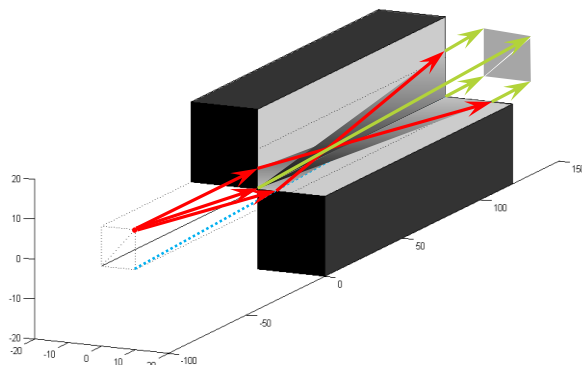
- Operation energy: 9.1 keV – Si(008) back reflection
- Angular acceptance : ~ 7.5 (V) $\times 15$ (H) mrad^2

Temperature < 1 mK

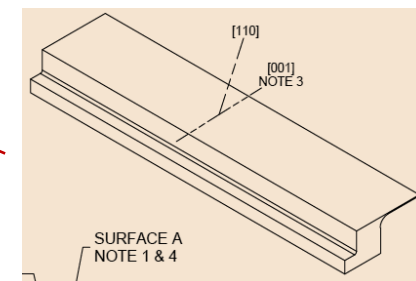


Montel Mirror

Multilayer Mirror (Montel)



1.2 m
(6 crystals of 200mm each)



Thickness $\sim 200 \mu\text{m}$

Angular dispersive optics with post-sample collimation

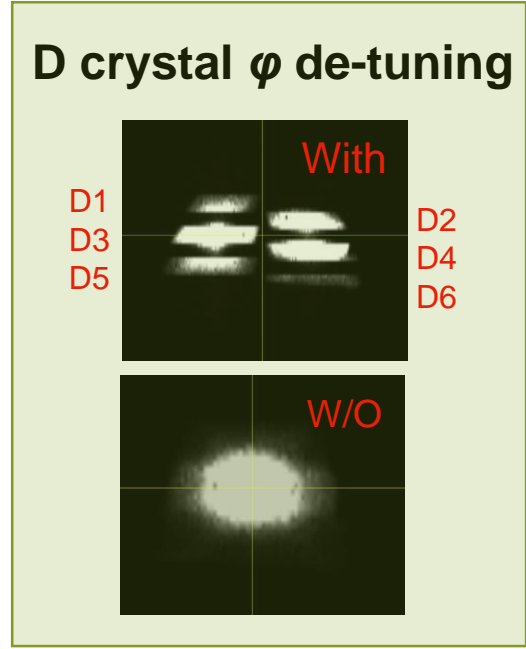
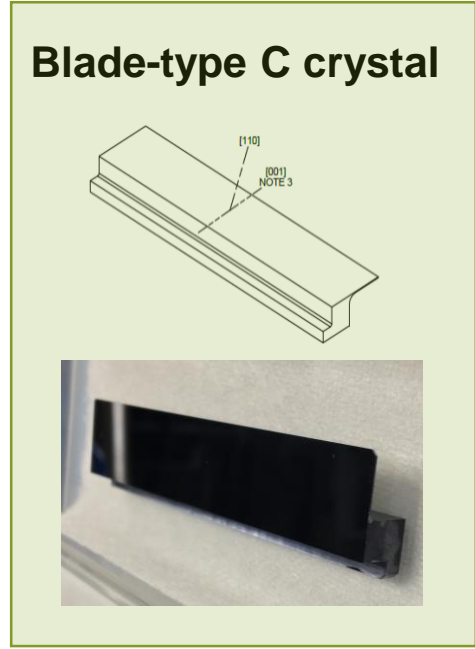
Inelastic X-ray beams from 6 D-crystals

- Lambda (Medapix3) 2D detector imaging (right)
- Temperature feedback of D-crystals (below)



CH	ON/OFF	OHM 4W	RAW	CH
CH 21	ON	OHM 4W	1104.2054880000	Ch21 Units
Ch21 desc	OFF		CALC: 26.6856403040	
CH 22	ON	OHM 4W		Ch22 Units
Ch22 desc	OFF			
CH 23	ON	OHM 4W		Ch23 Units
Ch23 desc	OFF			
CH 24	ON	OHM 4W		Ch24 Units
Ch24 desc	OFF			
CH 25	ON	OHM 4W	1102.5761500000	Ch25 Units
Ch25 desc	OFF		CALC: 26.3457887061	
CH 26	ON	OHM 4W	1102.1713000000	Ch26 Units
Ch26 desc	OFF		CALC: 26.142252889	
CH 27	ON	OHM 4W	1102.5061000000	Ch27 Units
Ch27 desc	OFF		CALC: 26.3528497301	
CH 28	ON	V.DC		Ch28 Units
Ch28 desc	OFF			

Keithley 3706A
seq ioc



HV Supplies	LV Supplies	System	Voltage	Current (Max)	Temperature
HV u0 voltage	ON OFF		0.982 V	2.50E0 A	32 C
HV u1 voltage	ON OFF		1.428 V	2.50E0 A	32 C
HV u2 voltage	ON OFF		1.478 V	2.50E0 A	32 C
HV u3 voltage	ON OFF		1.520 V	2.50E0 A	31 C
HV u4 voltage	ON OFF		1.608 V	2.50E0 A	31 C
HV u5 voltage	ON OFF		1.554 V	2.50E0 A	31 C
HV u6 voltage	ON OFF		0.000 V	2.50E0 A	30 C
HV u7 voltage	ON OFF		0.000 V	2.50E0 A	30 C

ePID

fb_epid: XF:10ID-CT{FbPid:04}PID

DESC EPID feedback EGU C PREC 5 C

DT 9.99994 C 10 second MDT 0.00000 C

EPID input

26.70000 C set point (VAL)

26.69973 C input calc

0.00027 C following error (FE)

EPID output

feedback On PID Max/Min

KP 60.00000 C 0.01594 C P P = KP * FE

KI 0.01000 C + 4.27757 C I I = KP * KI * sum(FE*DT)

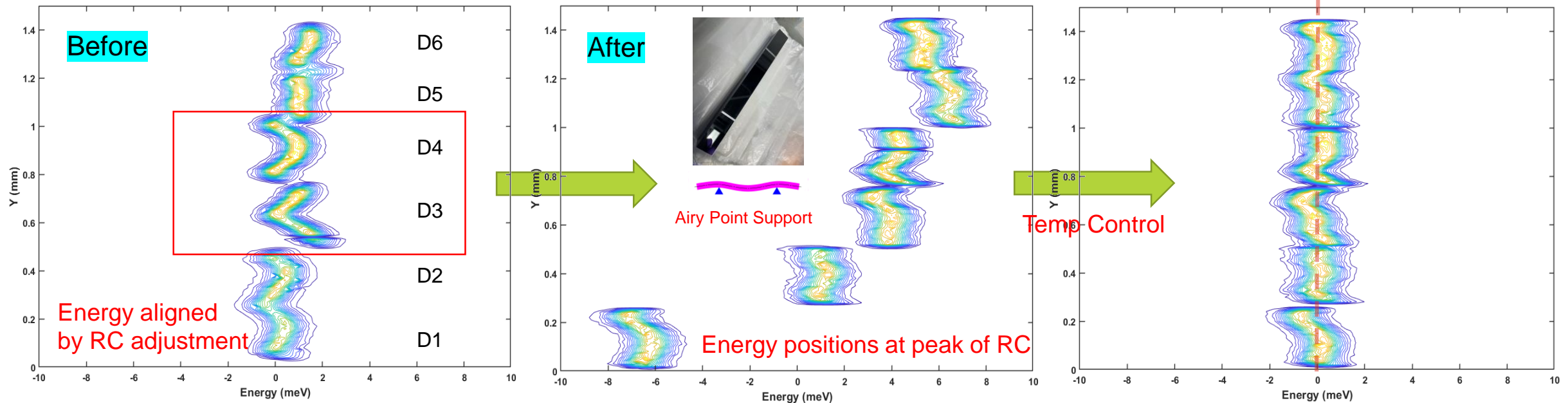
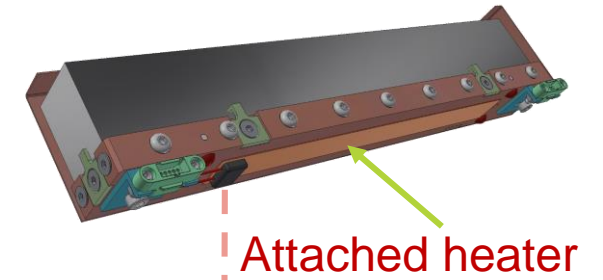
KD 10.00000 C + 0.01924 C D D = KP * KD * (FE[i] - FE[i-1])/DT

0.01000 C <= 4.31274 C <= 10.00000 C output calc

'enable' calc output buffer calc output calc resume calc

Improving D Crystal Support with T Control

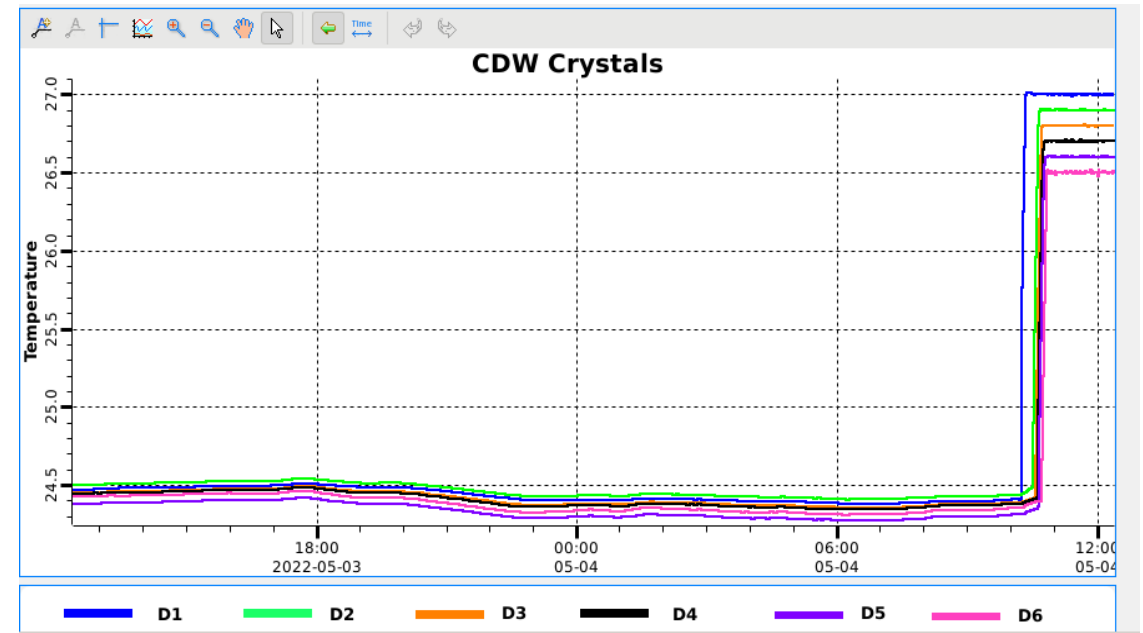
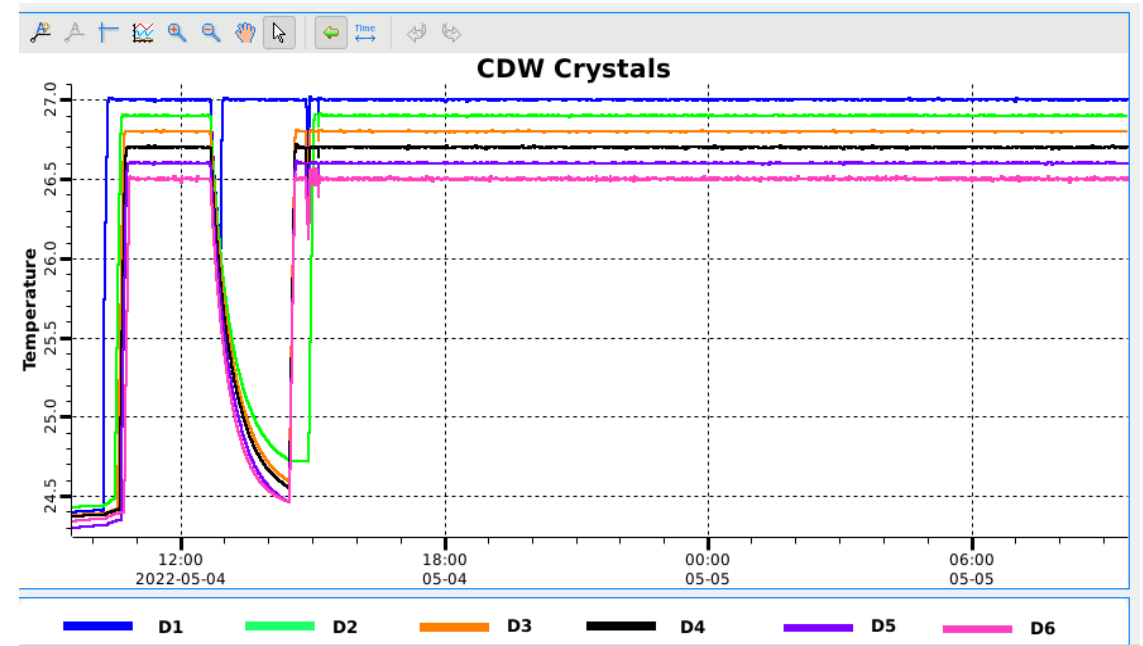
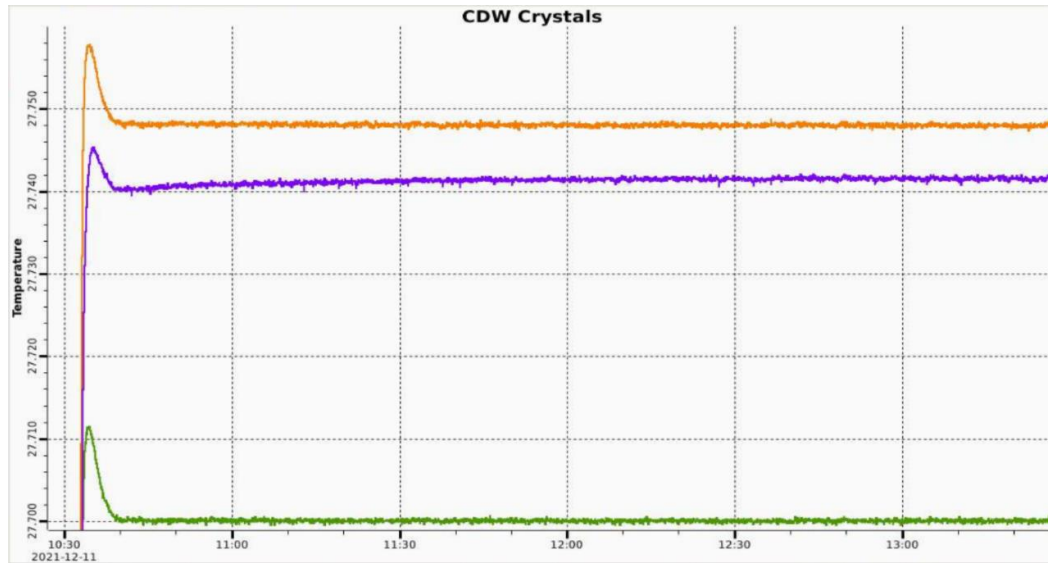
- Supporting D crystals at their Airy points reduces lattice bending by gravity.
- EPICS-based temperature control achieving stability : ± 1 mK/24hr.
- Temperature of all D crystals adjusted to align and maintain diffraction energy and optimize reflectivity



- Current performance limited by crystal quality of the long D crystals.

Temperature Response

- Right: All 6 D-crystals control PT1000 sensors
- Below: One D3-crystal fitted with 3 PT1000 sensors: control PT1000 sensor, and two PT1000 sensors at the crystal ends.



Temperature stability

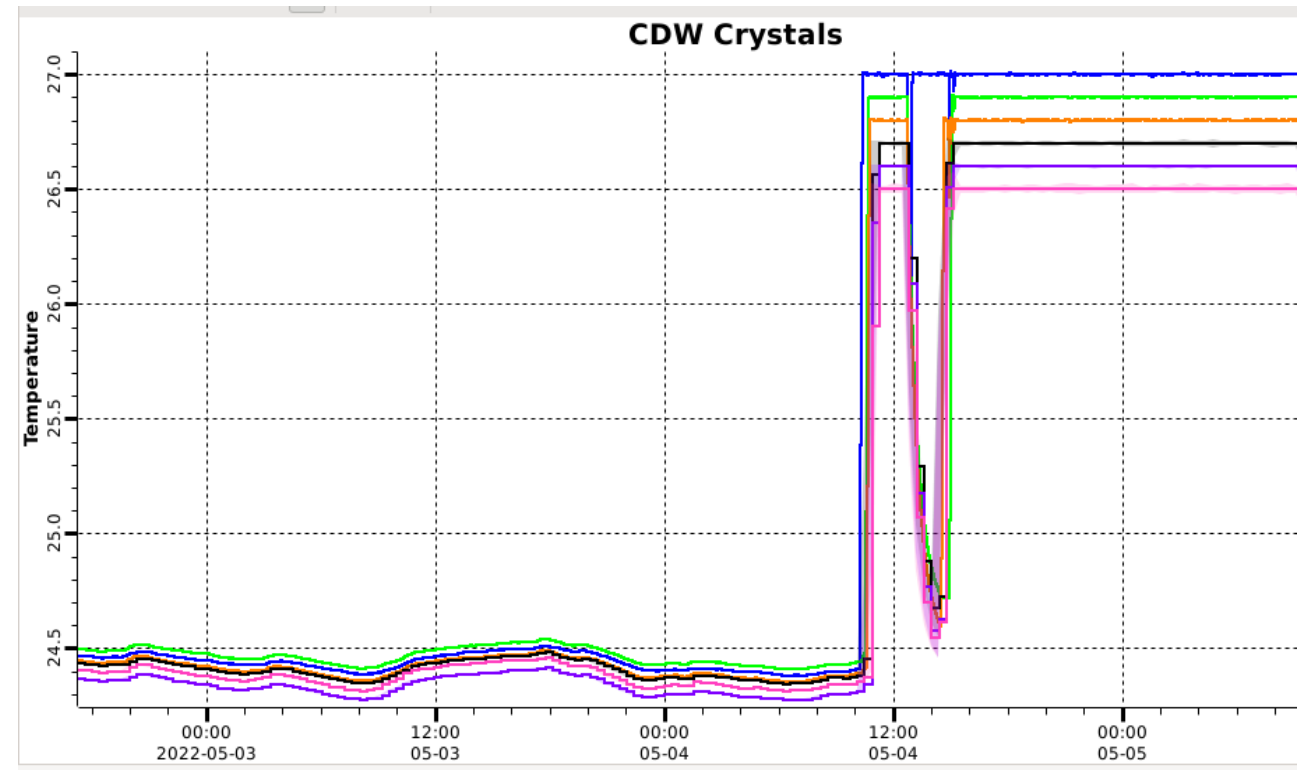
Required: $< 4 \text{ mK}$ / 1-week measurement

Before: 100-500 mK

After: $\sim 0.1 \text{ mK}$

Scan: 60 sec

Control sphere	Stability	Contribution
Experimental Hall	$\pm 1 \text{ K}$	Day/night cycle; Season and weather cycle
Hutch	$\pm 0.5 \text{ K}$	Day/night cycle; Season and weather cycle
Chamber	$\pm 0.2 \text{ K}$	Day/night cycle; Season and weather cycle
Crystal	$\pm 0.0005 \text{ K}$	N/A



Summary

- We have improved the data rate of the meV-IXS spectrometer by more than 13 times and a routine energy resolution at 1.7 meV with sharp tails since 2019, allowing soft matter research to be performed with much enhanced count rate and contrast and enabling science previously impossible (notably, on hard condensed matter).
 - Temperature stability of the crystal optics analyzer played important role in stability.
- Future: Stabilize temperature of crystals for High Resolution Monochromator, using identical system components.