National Synchrotron Light Source II

Brookhaven National Laboratory

U.S. DEPARTMENT OF ENERGY

Temperature Control of Crystal Optics

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

Kazimierz Gofron

EPICS Collaboration Meeting

Ljubljana, Slovenia

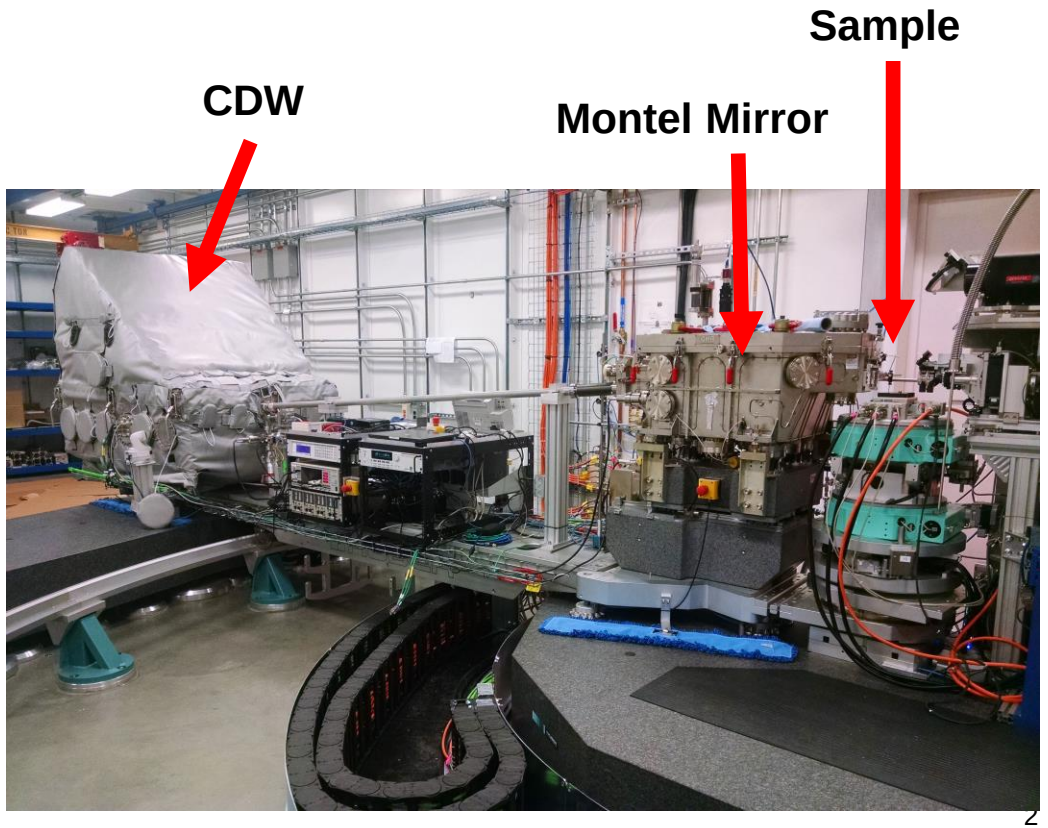
September 21, 2022

Inelastic X-ray Spectrometer (9.1keV)

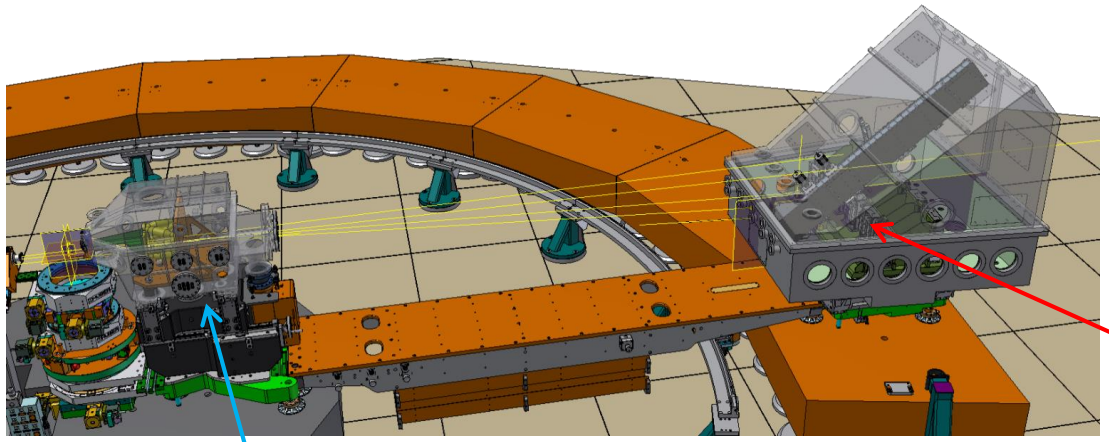
PRESENT AND FORMER TEAM MEMBERS

- **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

Analyzer Optics



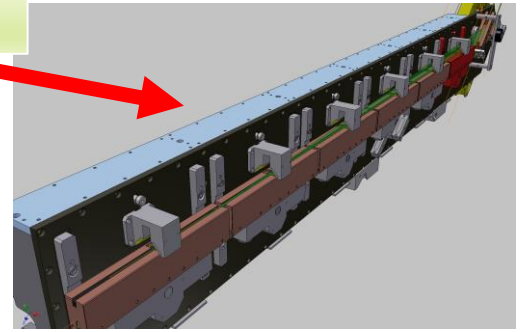
Optical Layout of Montel-CDW IXS Analyzer



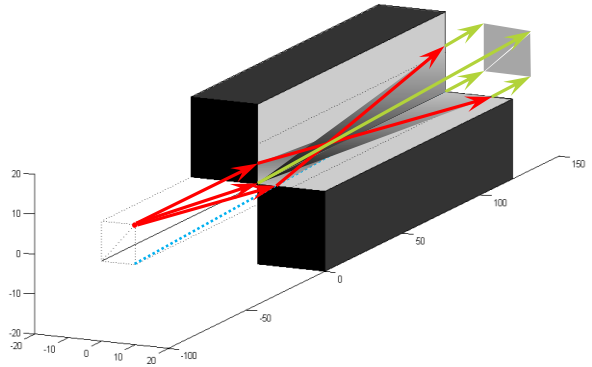
Projected Longitudinal Length
@ 40 um Transerve Acceptance

- Operation energy: 9.1 keV – Si(008) back reflection
- Angular acceptance : ~ 7.5 (V) x15 (H) mrad^2

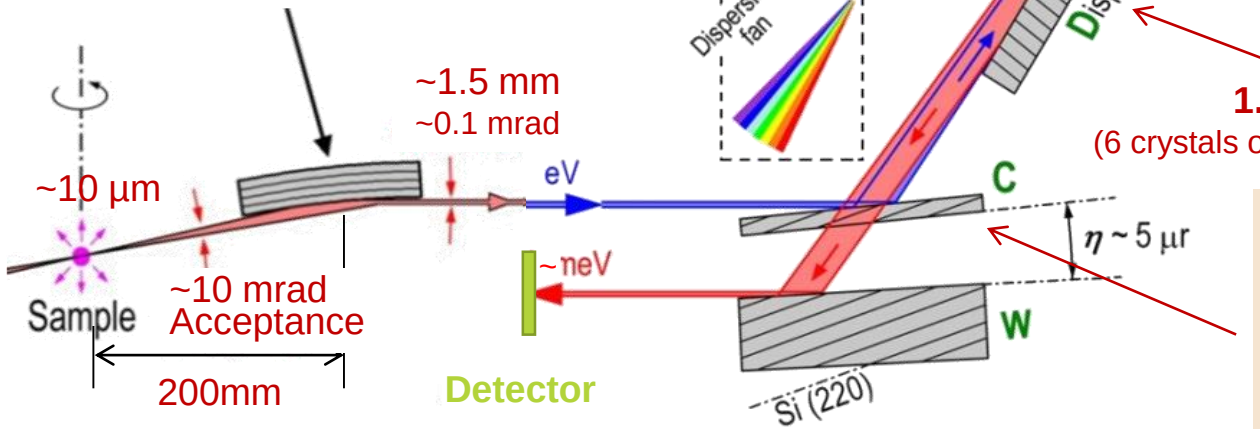
Temperature < 1 mK



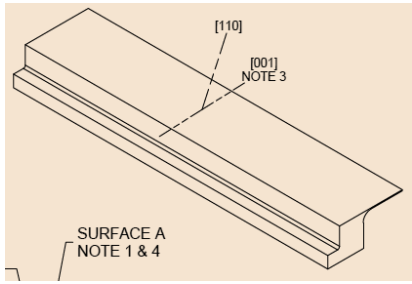
Montel Mirror



Multilayer Mirror (**Montel**)



1.2 m
(6 crystals of 200mm each)



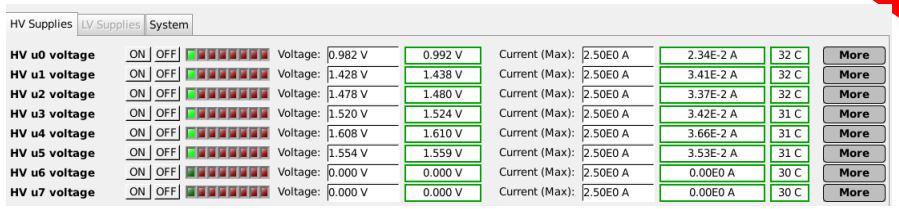
Thickness ~ 200 um

Angular dispersive optics with post-sample collimation

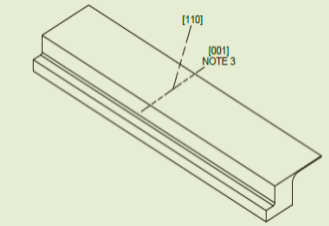
Inelastic X-ray beams from 6 D-crystals

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

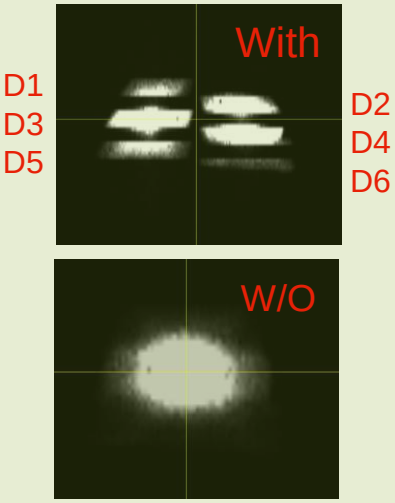
Keithley 3706A
seq ioc



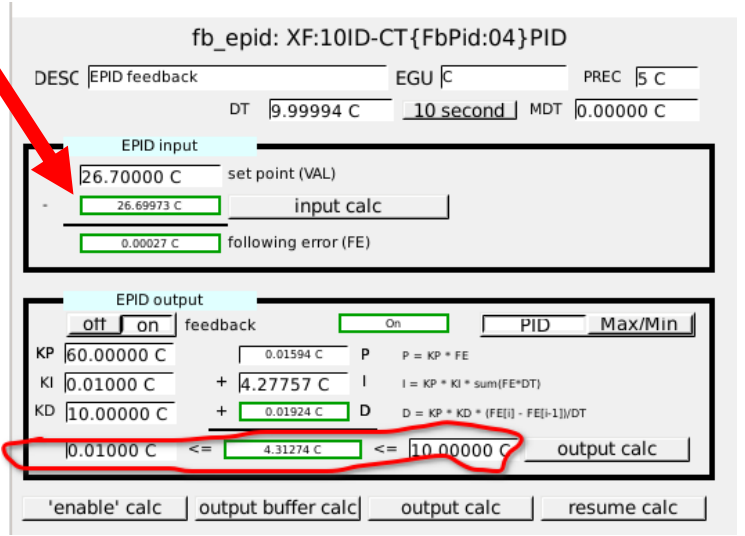
Blade-type C crystal



D crystal φ de-tuning

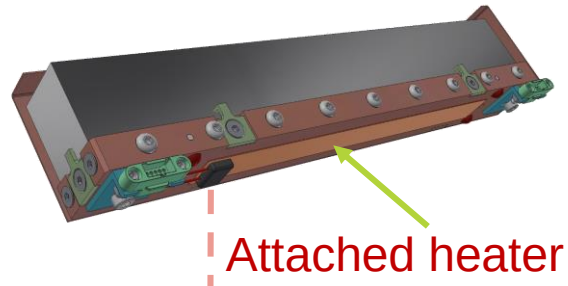


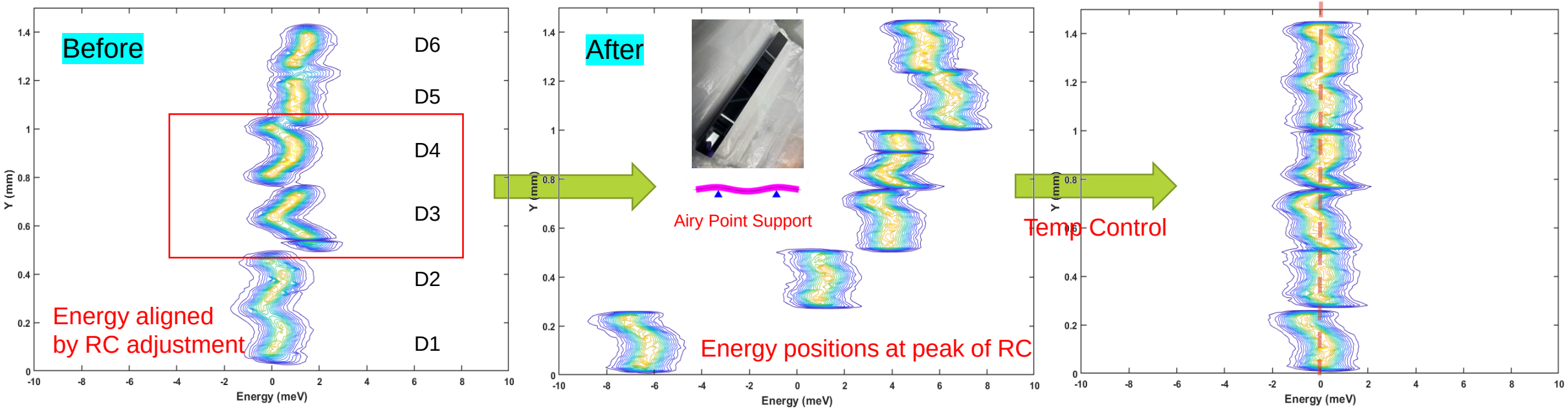
ePID



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

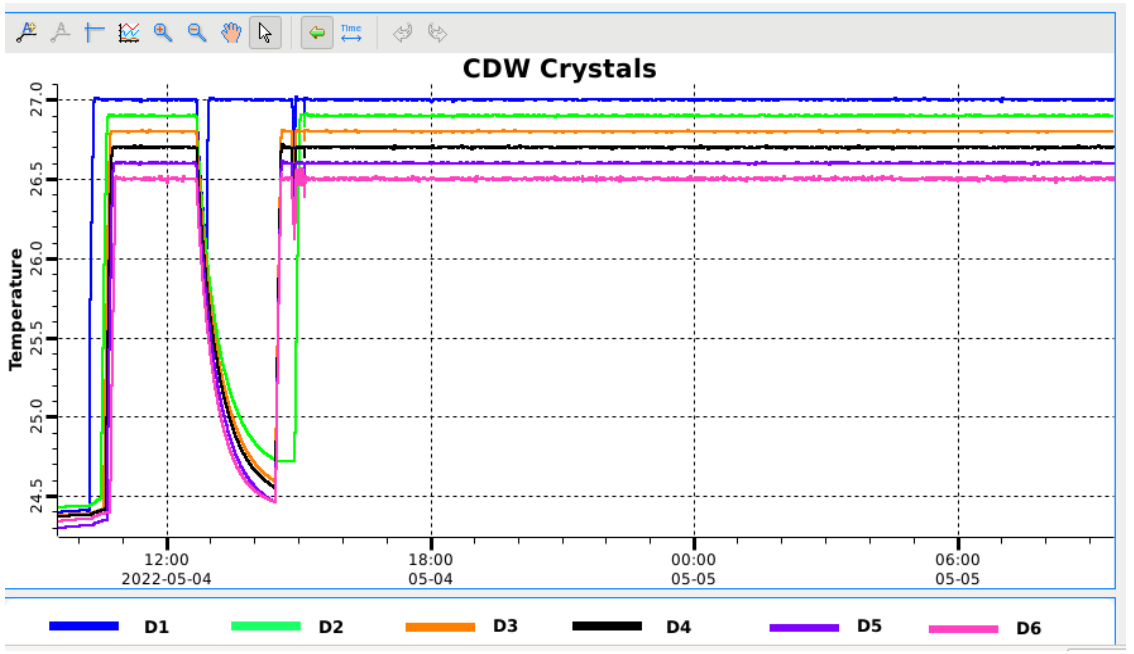


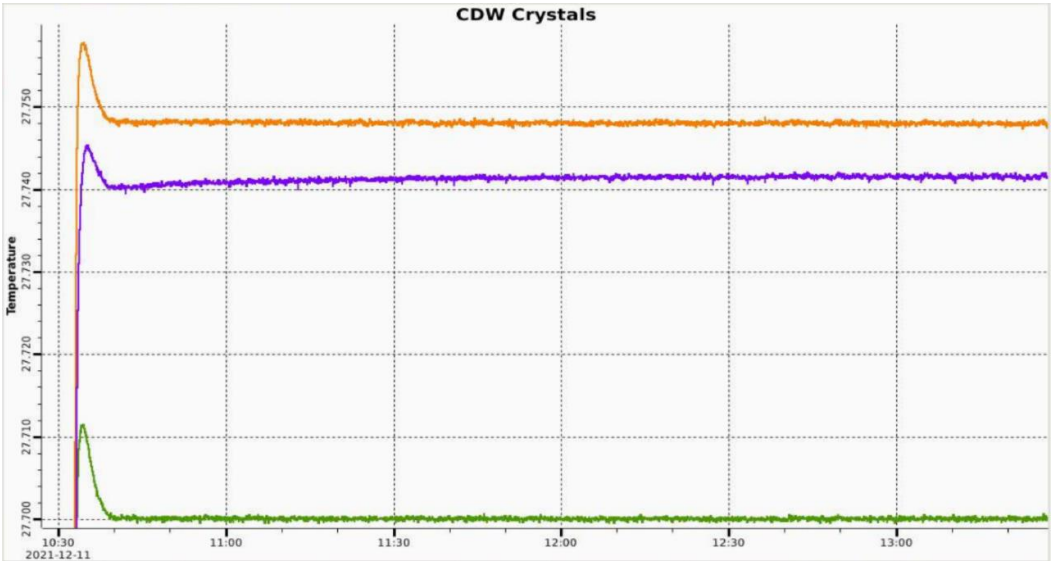


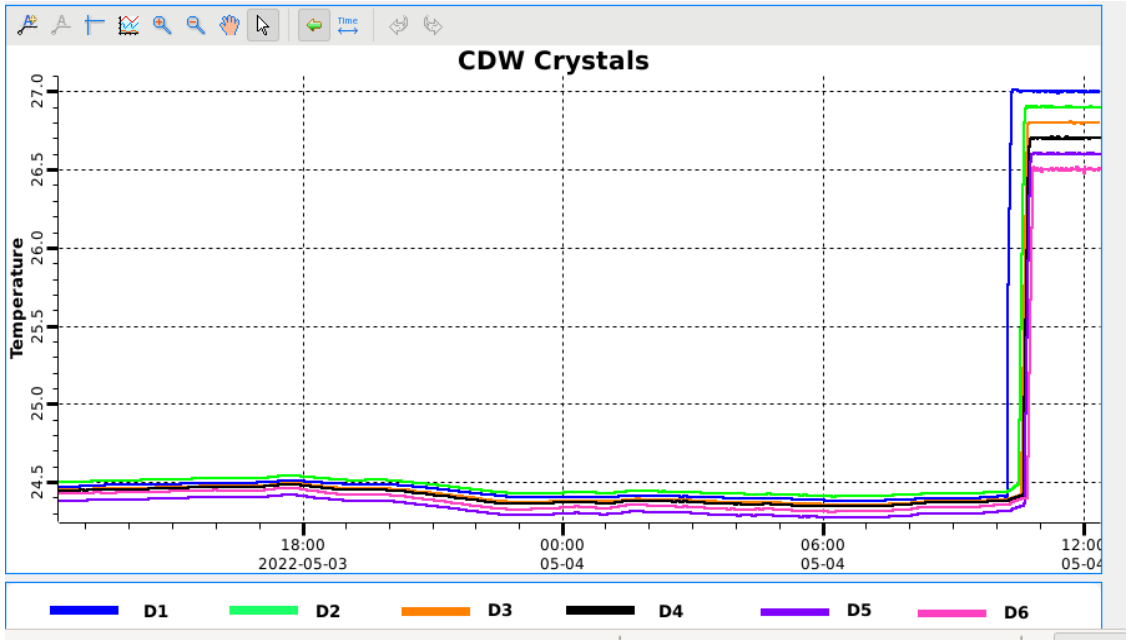
- Current performance limited by crystal quality of the long D crystals.

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.



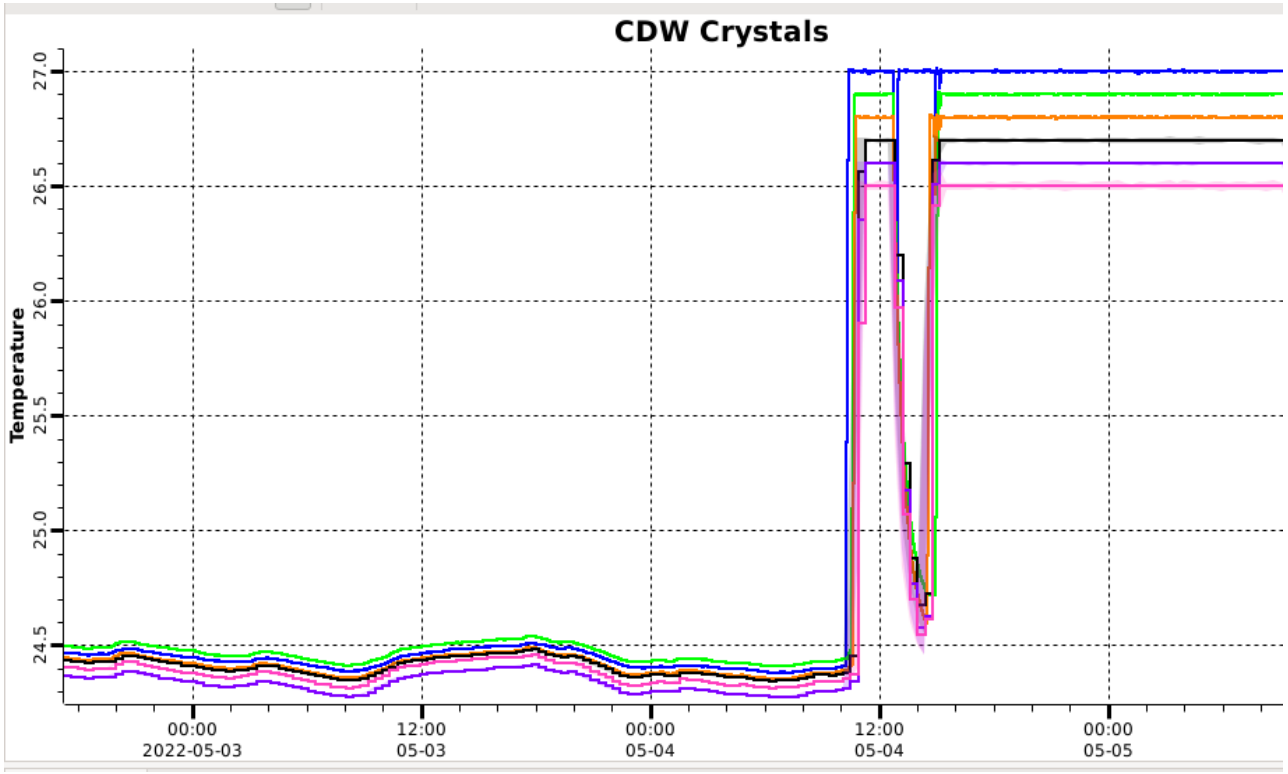




Temperature stability

Required: < 4 mK / 1-week measurement
Before: 100-500 mK
After: ~0.1 mK
Scan: 60 sec

Control sphere	Stability	Contribution
Experimental Hall	+/- 1 K	Day/night cycle; Season and weather cycle
Hutch	+/- 0.5 K	Day/night cycle; Season and weather cycle
Chamber	+/- 0.2 K	Day/night cycle; Season and weather cycle
Crystal	+/- 0.0005K	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.