



NSF SEES
SYNCHROTRON EARTH AND ENVIRONMENTAL SCIENCE



APS Upgrade (APS-U) Update for SEES Beamlines

Joanne Stubbs

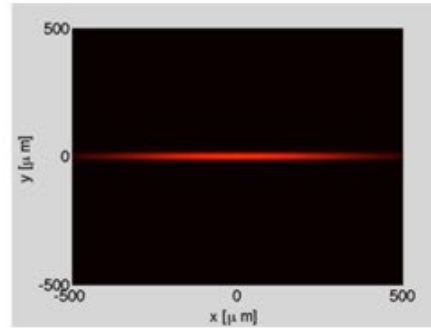
GeoSoilEnviroCARS

The University of Chicago



ADVANCED PHOTON SOURCE UPGRADE

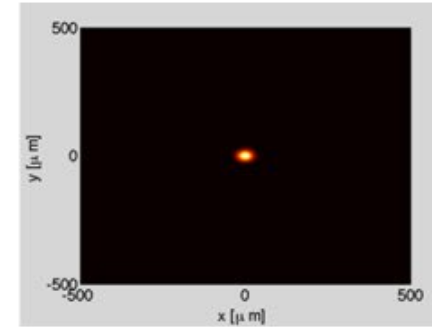
APS Before Upgrade



$\epsilon_0 = 3100 \text{ pm}$

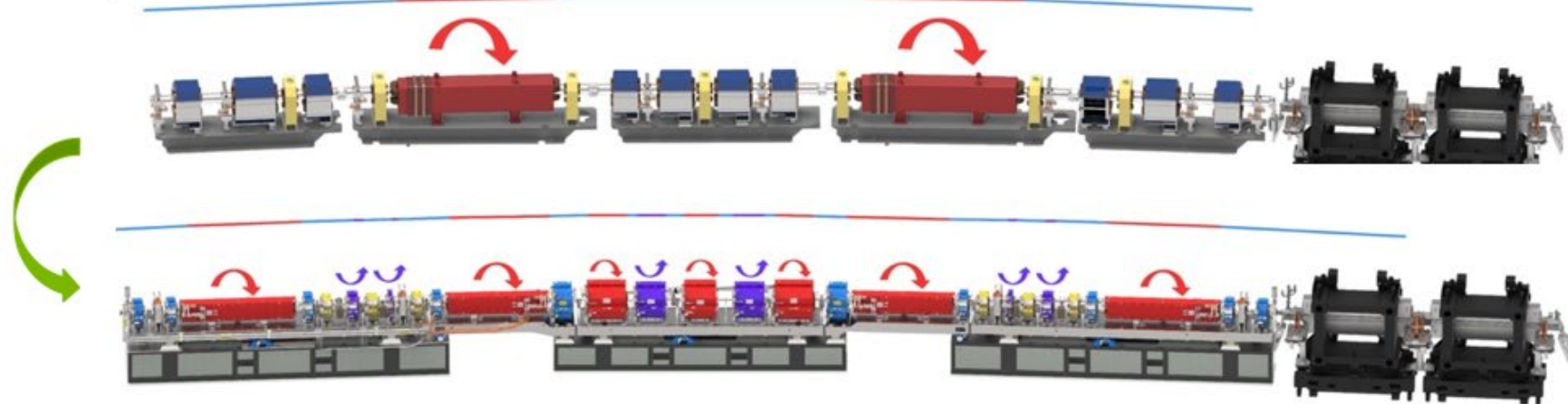


APS Upgrade



$\epsilon_0 = 42 \text{ pm}$

Replace the storage ring to dramatically decrease electron source size





APS-U Timeline

- April 2023 – Shut down original APS facility, began replacing storage ring
- April 2024 – First electrons injected into new APS-U storage ring
- April/May 2024 – Initial storage ring commissioning including world's first swap out capabilities
- June 2024 – Began commissioning beamlines

Beamline Commissioning Process

- Ops Commissioning – First beam and radiation safety shielding verification
- Technical Commissioning – Testing of beamline with beam, no external users
- Scientific Commissioning – Early experiments designed to test and debug beamline capabilities, may include external users
- Resumption of General User Program

BEAMLINE COMMISSIONING PROGRESS

NOVEMBER 4, 2024

KEY 1 Installation Ongoing 2 Installation Complete 3 Ops Commissioning 4 Technical Commissioning 5 Scientific Commissioning and Early Experiments 6 Restart of General User Program

RESTART STATUS		RESTART STATUS		RESTART STATUS		RESTART STATUS																		
1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	
1-BM-B,C XSD	●					●						●						●						
1-ID-B,C,E XSD					●																			
2-BM-A,B XSD	●																							
2-ID-D XSD	●																							
2-ID-E XSD	●																							
3-ID-B,C,D XSD					●																			
4-ID-B,G,H:POLAR XSD	●																							
5-BM-B DND-CAT	●																							
5-ID-B,C,D DND-CAT					●																			
6-BM-A,B COMPRES/XSD					●																			
6-ID-B,C XSD	●																							
6-ID-D XSD	●																							
7-BM-B XSD	●																							
7-ID-B,C,D XSD					●																			
8-ID-E,I:XPCS XSD					●																			
8-BM-B XSD	●																							
9-ID-D: CSSI XSD	●																							
9-BM-B,C XSD	●																							
10-BM-B MR-CAT	●																							
10-ID-B MR-CAT					●																			
11-BM-B XSD					●																			
11-ID-B XSD	●																							
11-ID-C XSD	●																							
11-ID-D XSD	●																							
12-BM-B XSD					●																			
12-ID-B XSD					●																			
12-ID-E XSD					●																			
13-BM-C GSECARS					●																			
13-BM-D GSECARS					●																			
13-ID-C,D GSECARS					●																			
13-ID-E GSECARS					●																			
14-ID-B BioCARS	●																							
15-ID-B,E ChemMatCARS	●																							
15-ID-C,D ChemMatCARS	●																							
16-BM-B,D HPCAT-XSD	●																							
16-ID-B HPCAT-XSD					●																			
16-ID-D,E HPCAT-XSD	●																							
17-BM-B XSD	●																							
17-ID-B IMCA-CAT					●																			
18-ID-D Bio-CAT					●																			
19-BM-D XSD	●																							
19-ID-E:ISN XSD					●																			
20-BM-B XSD	●																							
20-ID-D,E:HEXM XSD	●																							
21-ID-D LS-CAT					●																			
21-ID-F LS-CAT					●																			
21-ID-G LS-CAT					●																			
22-ID-D SER-CAT					●																			
22-ID-E SER-CAT	●																							
23-ID-B GM/CA-XSD					●																			
23-ID-D GM/CA-XSD					●																			
24-ID-C NE-CAT					●																			
24-ID-E NE-CAT					●																			
25-ID-C XSD					●																			
25-ID-D,E:ASL XSD					●																			
26-ID-C CNM/XSD					●																			
27-ID-B XSD					●																			
28-ID-B,C XSD	●																							
28-ID-D,E XSD	●																							
28-ID-F XSD	●																							
28-ID-G:CHEX XSD	●																							
29-ID-C,D XSD					●																			
30-ID-B,C XSD					●																			
31-ID-D LRL-CAT	●																							
31-ID-E XSD	●																							
32-ID-B,C XSD	●																							
33-BM-C XSD	●																							
33-ID-C:PTYCHO XSD	●																							
34-ID-F:ATOMIC XSD	●																							
34-ID-E:3DMN XSD	●																							
35-ID-B,C,D,E DCS	●																							



APS graphic updated weekly at <https://anl.box.com/s/rjtjm9d9b5v2gk3510s39zgnagfye757>

Info specific to SEES beamlines at https://seescience.org/aps-upgrade_status/

Beamlines with SEES support

- All have completed shielding verification
- 3 in Technical Commissioning ●
- 3 in Scientific Commissioning ●



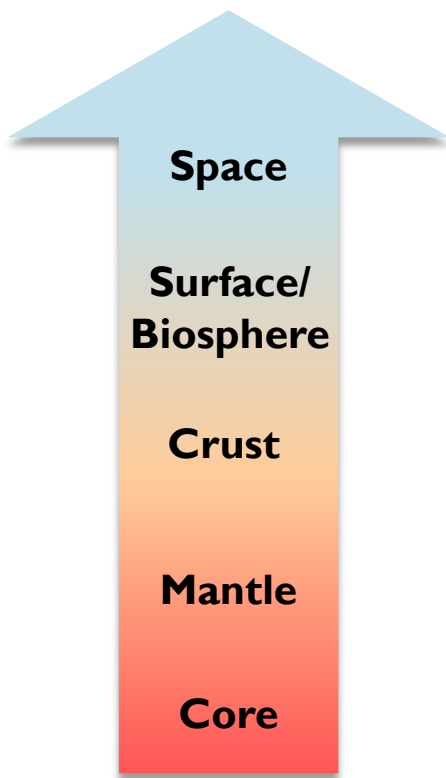
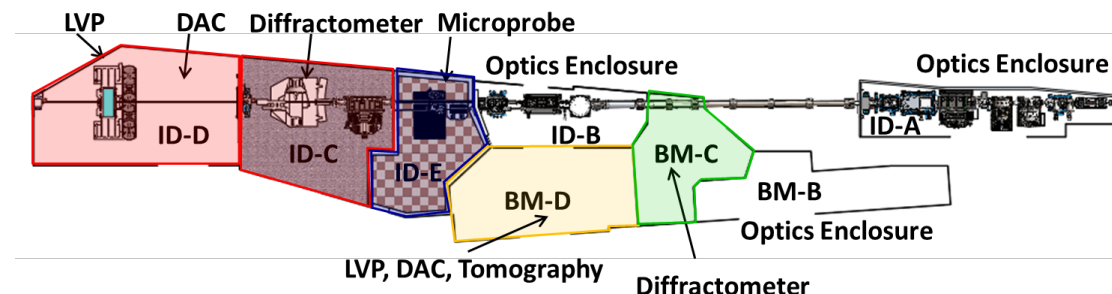
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Sector 13 Overview

GSECARS operates APS Sector 13 for benefit of Earth and environmental science community

- Two independent undulators (canted)
- Bending magnet fan split in two
- 4 simultaneous experiments in 5 stations



Sector 13 Techniques

Surface/Interface Studies: diffraction & spectroscopy at mineral surfaces and interfaces

In-situ Powder X-ray Diffraction: rapid, non-destructive, structural characterization of minerals under complex conditions

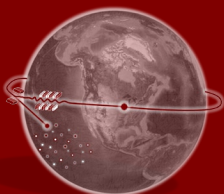
X-ray Microprobe: submicron beams for mapping & micro- X-ray fluorescence spectroscopy, X-ray absorption spectroscopy, X-ray diffraction

Tomography: transmission & element-specific CT scans at micron-scale resolution

Large Volume Press: diffraction, spectroscopy, & imaging at high pressure and temperature

Diamond Anvil Cell: diffraction & spectroscopy at high pressure and temperature

GSECARS
GeoSoilEnviroCARS



13-BM Beamlines – Status Update

13-BM-C: Scientific Commissioning

- All major systems tested and working
- First user experiments (Diamond Anvil Cell) October 2024, expect return to General User Operations 2025-1

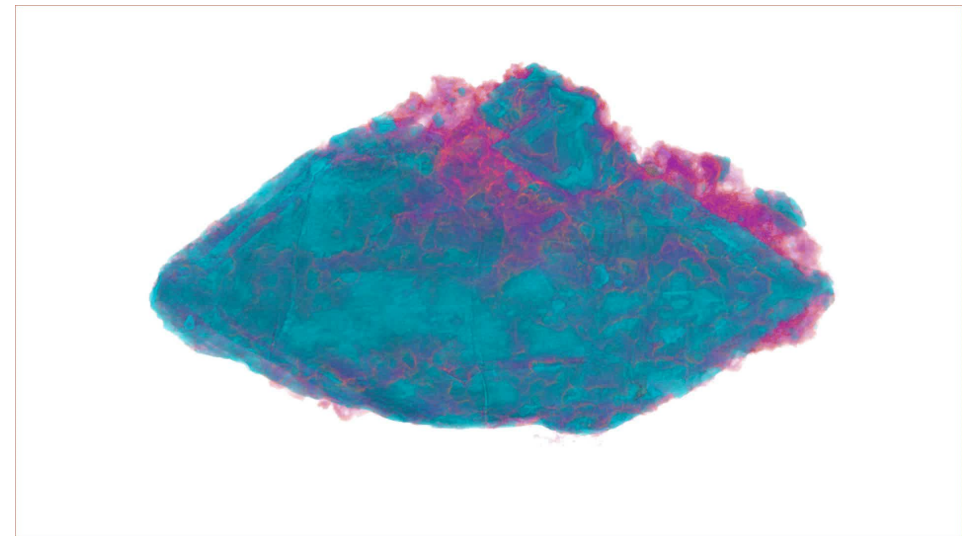
13-BM-D: Scientific Commissioning

- Most major systems tested and working
- Awaiting delivery of vertical focusing mirror (expected November 2024)
- First user experiments (Tomography, Large Volume Press) October 2024, expect return to General User Operations 2025-1

Since October 1, seven external user groups have visited 13-BM. Six more are scheduled with additional experiments to come.

Computed microtomography at 13-BM-D

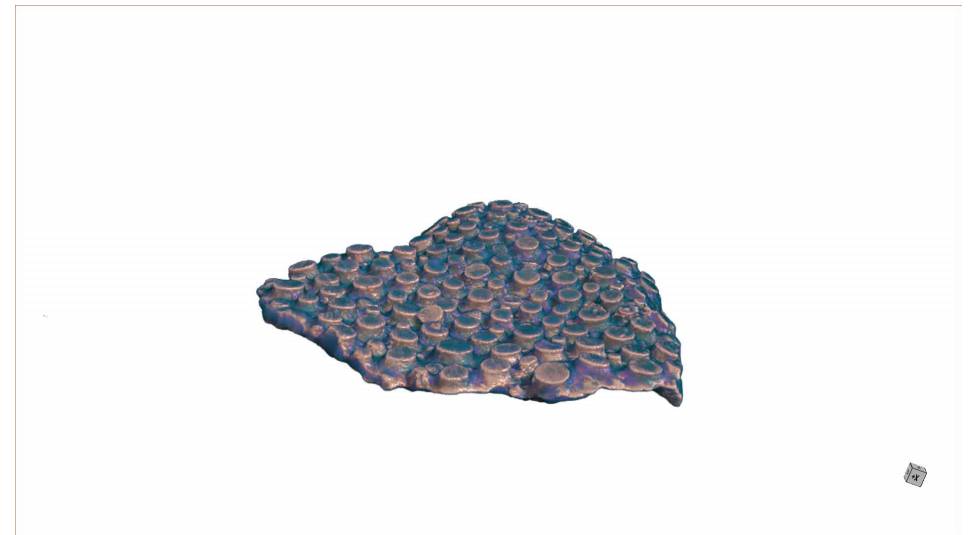
- White beam, 2 mm Al filter
- Pixel size = 1.09 μm
- Horizontal FOV \approx 2.1 mm
- Collection time \approx 1 minute

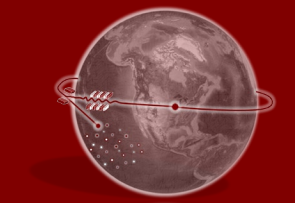


Olivine grain
Phillipp Ruprecht (U. Nevada)



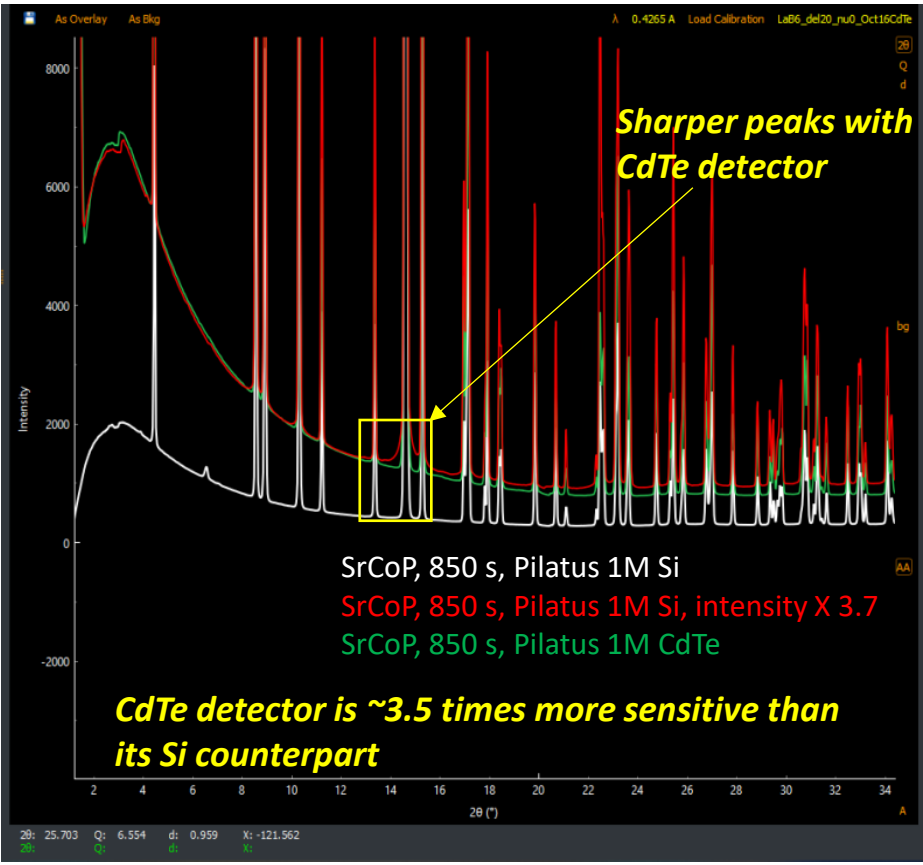
Ancient marine animal fossils, Geological Survey of Canada
Yara Haridy and Patrick La Riviere (U. Chicago)



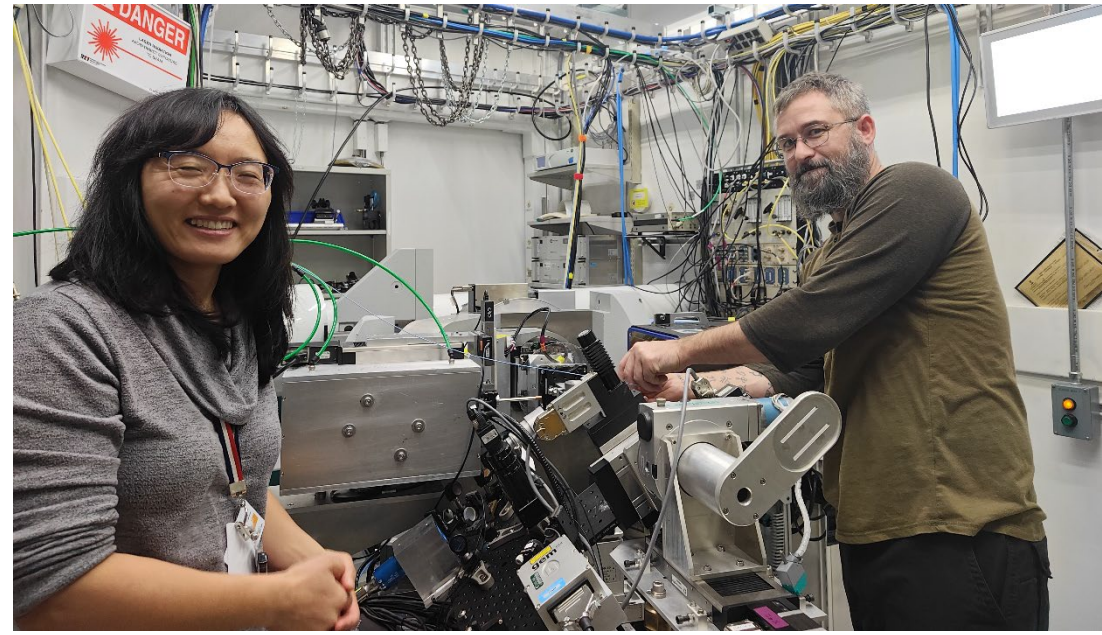
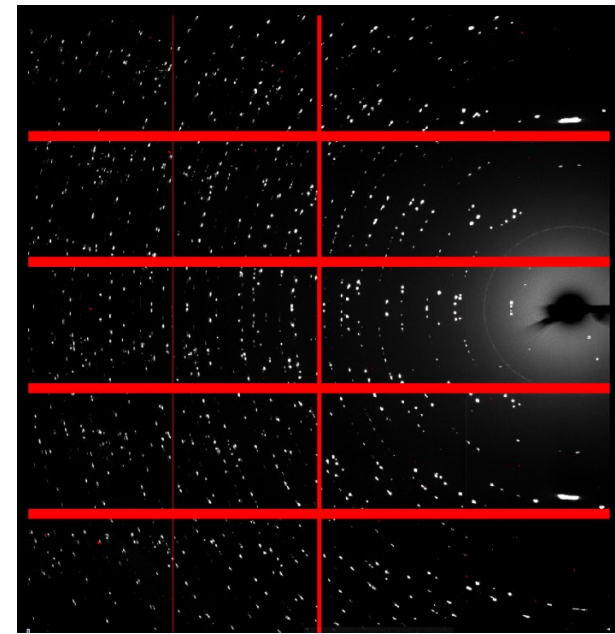


Diamond anvil cell at 13-BM-C

Commissioning Pilatus3X 1M
CdTe area detector



Single crystal NaYbO₂
diffraction image from
the CdTe detector



Wenli Bi and James Petri, U. Alabama
High pressure studies of magnetic materials

13-ID Beamlines – Status Update

13-ID-C/D: Technical Commissioning

- New monochromator – installation nearing completion, commissioning to begin soon
- Large Volume Press program - diffraction and imaging with white beam ready now
- Diamond Anvil Cell – fabrication and assembly of new experiment table and high-precision focusing optics under way, new Eiger 9M detector on hand; initial commissioning will use existing table
- Surface/Interface program – upgrade of diffractometer under way, new focusing optics in 2025; initial commissioning will use existing mirrors
- Expect transition to Scientific Commissioning and first users in 2024-3 or 2025-1



13-ID-C/D Monochromator

Courtesy Peter Eng (GSECARS)

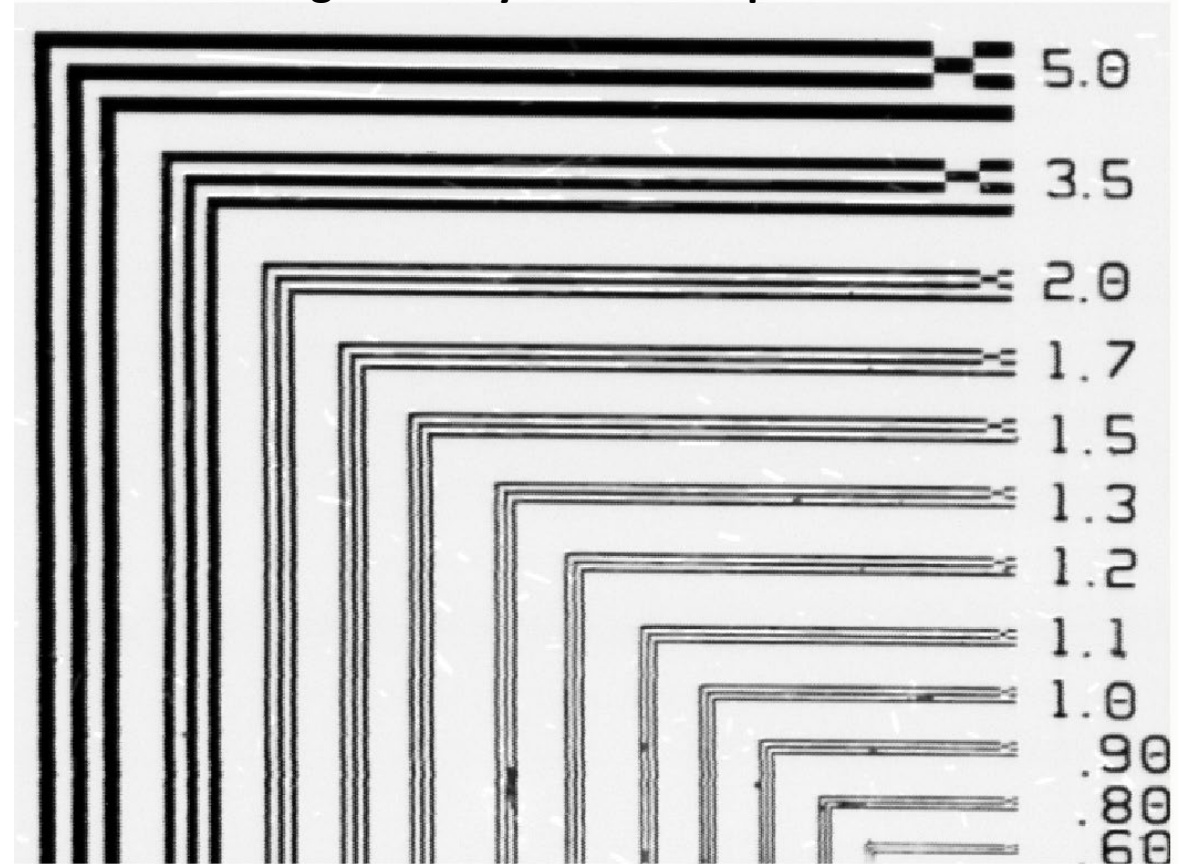


13-ID Beamlines – Status Update

13-ID-E: Technical Commissioning

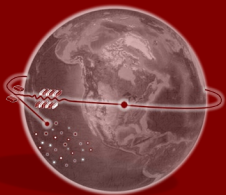
- X-ray microprobe
- Double horizontal mirrors repolished to leverage new source, installed and tested
- Monochromator to be upgraded soon for better thermal management
- New high-precision focusing optics in hand, installation to be completed in coming months; initial commissioning with older, existing KB mirrors
- Expect transition to Scientific Commissioning and first users in 2024-3 or 2025-1

APS-U significantly enhances spatial resolution



- Nickel on silicon, feature sizes (widths/spaces) in microns
- Measured with old KB mirrors (pending installation of new)
- With old APS, horizontal image blurry at 2 μ m; vertical at 1.5

Courtesy Matt Newville (GSECARS)





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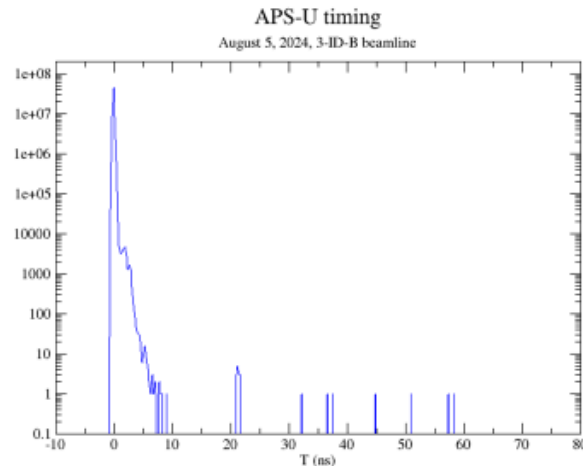


APS 3-ID – Nuclear Resonant Scattering (NRS)

Timing mode of the APSU

1. APSU tested 48-bunch mode with current up to 100 mA.
2. Electron bunch purity was measured for 48-bunch mode of the upgraded APS storage ring at 3ID in August 2024, the measured result indicates much better bunch purity compared with old APS ring. It makes it possible for NRS to narrow the veto window, thus gives much improvement for the nuclear resonant scattering studies. It is good for SEES users to measure the DOS (density of states) and sound velocities of materials at high pressures.

SEES supports
½ FTE and
equipment at
APS Beamline
3-ID

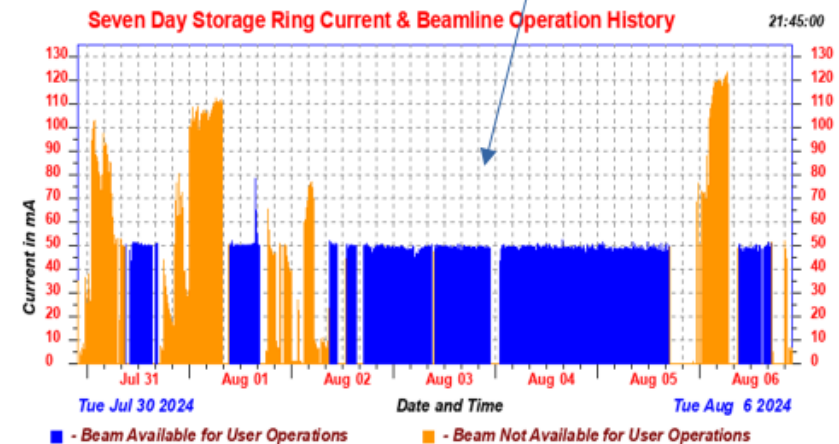


Bunch purity measurement at 3-ID shows better than 10^{-8} purity in the region of interest



Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.

48-bunch mode started



jzhao@anl.gov

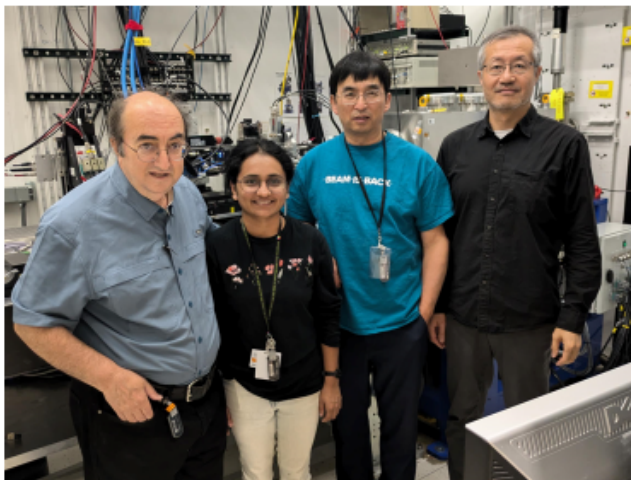


Slide courtesy Jiyong Zhao (APS), Ercan Alp (APS), Barbara Lavina (GSECARS)

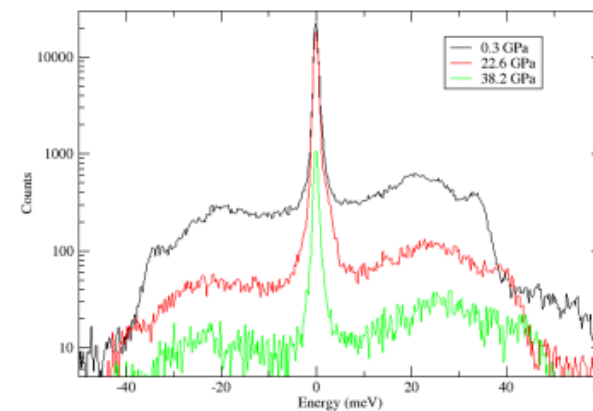


First user experiment at 3ID and plan for the future

3ID beamline has gone through the beamline commissioning phases and has been running the user proposals in 2024-3 (through rapid access proposal) run. With 48-bunch mode running at APS starting Nov 13, 2024, the inelastic scattering of the Nuclear Resonance Scattering program is available for SEES users. With 2025-1 run, APS is planning to run 6-weeks of 48-bunch mode, it will supply good opportunities for SEES user program to be conducted with newly added 1-micron focused beam and many other developments at the beamline.



Nuclear resonant inelastic X-ray scattering of FeSn



The first user experiment at 3ID. The ^{57}Fe Partial phonon Density of States of FeSn up to 38 GPa was taken at 3ID, APS on 8/10/2024, in collaboration with Prof. W.Bi's group (U. Alabama).



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SEES supports Multi-Anvil Press at 6-BM via subaward to Stony Brook University

Instrumentation, Techniques, & Applications at APS 6BM-B



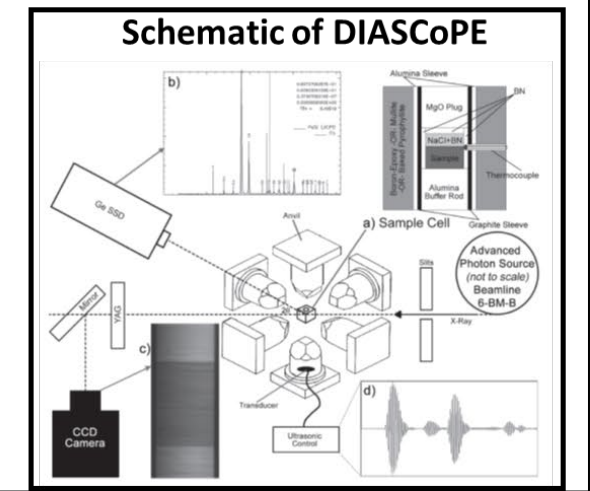
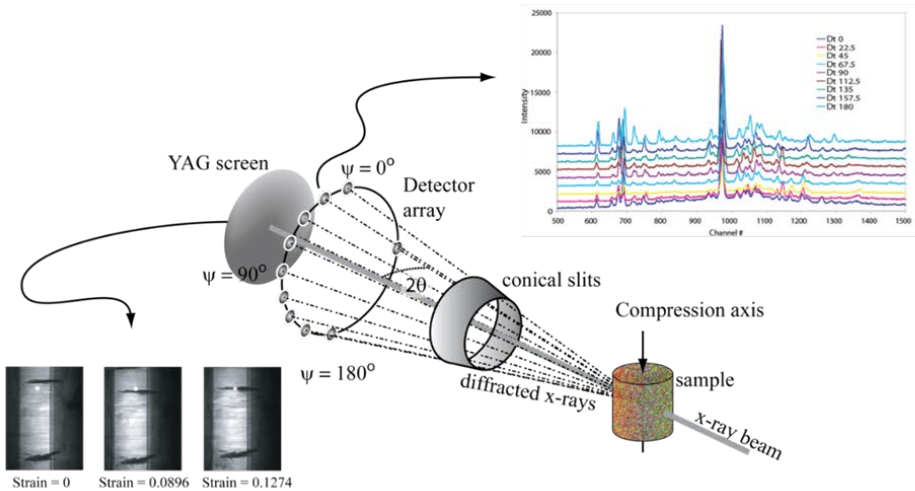
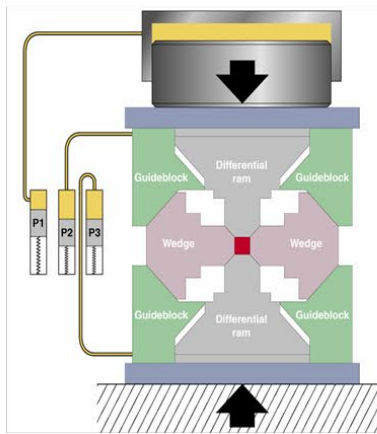
D-DIA

- High Pressure deformation apparatus (D-DIA, RDA)
- Synchrotron energy dispersive x-ray diffraction (ED-XRD)
- Radiographic imaging (YAG scintillator + CCD camera)
- Rapid acoustic velocity measurement (DIASCoPE)
- Phase transitions, EOS, mineral & rock deformations
- Simultaneous measurements in mHz and MHz time



Rotational Drickamer Apparatus (RDA)

Schematic of D-DIA



Slide courtesy Haiyan Chen, Stony Brook University



Readiness of SEES APS 6BM-B Beamline

Upgrades of 6BM-B:

- Upgrade of 10 element Ge detector array electronics
- Replaced old VME crate with Galil and LabJack T8
- Installed new camera (Manta G-507C) to improve resolution
- Installed a new Linux computer (photo in lower right)
- Installed a Dell Precision 5860 workstation and 4-panel monitors



APS Shielding verification: Completed on 09/18/2024

Technical commissioning almost completed: 10/03/2024 to 10/20/2024

- Tested and determined to use Si as filter for proper radiographic imaging
- Aligned front and rear conical slits to designed specifics
 - Diffraction signal on all 10 detectors
 - Aligned angle for all 10 detectors: $6.5011 \pm 0.0015^\circ$ vs 6.5° designed
- Performed a full test run without deformation pump to 4.5 GPa and 1100°C

Scientific commissioning pending:

- Timing for A station technical and / or scientific commission

Readiness for user operation

- Ready to accept Rapid Access Proposal in 2024-3 and normal user from 2025-1 run





Applying for beam time

- New Universal Proposal System - <https://ups.servicenowservices.com/ups>
- All SEES-supported beamlines at APS are accepting user proposals
- 2024-3 Rapid Access available now
- 2025-1 deadline was October 25, 2024
- 2025-1 Rapid Access will open January 2025
- 2025-2 deadline in March 2025

The best way to learn status details about the technique and beamline you are interested in is by contacting the beamline scientist:

<https://seescience.org/people/staff/>