OAK RIDGE National Laboratory

February 3, 2026

Review of the Neutron Imaging Instrument Suite

Volker Urban

Section Head, Large Scale Structures

U.S. DEPARTMENT of ENERGY

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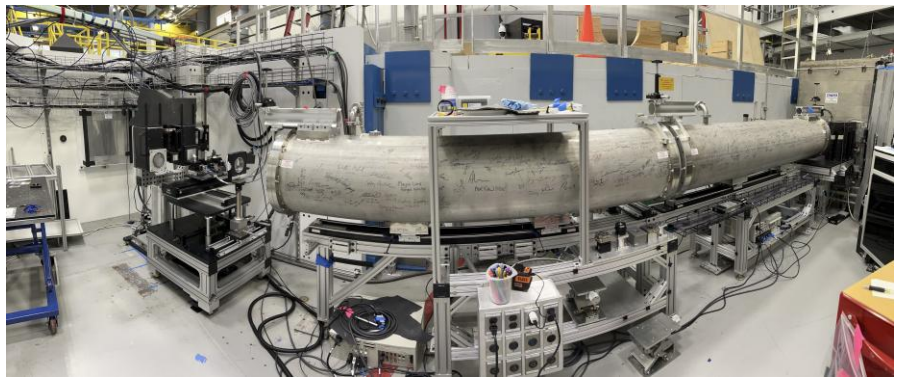
FOR THE US DEPARTMENT OF ENERGY

Outline

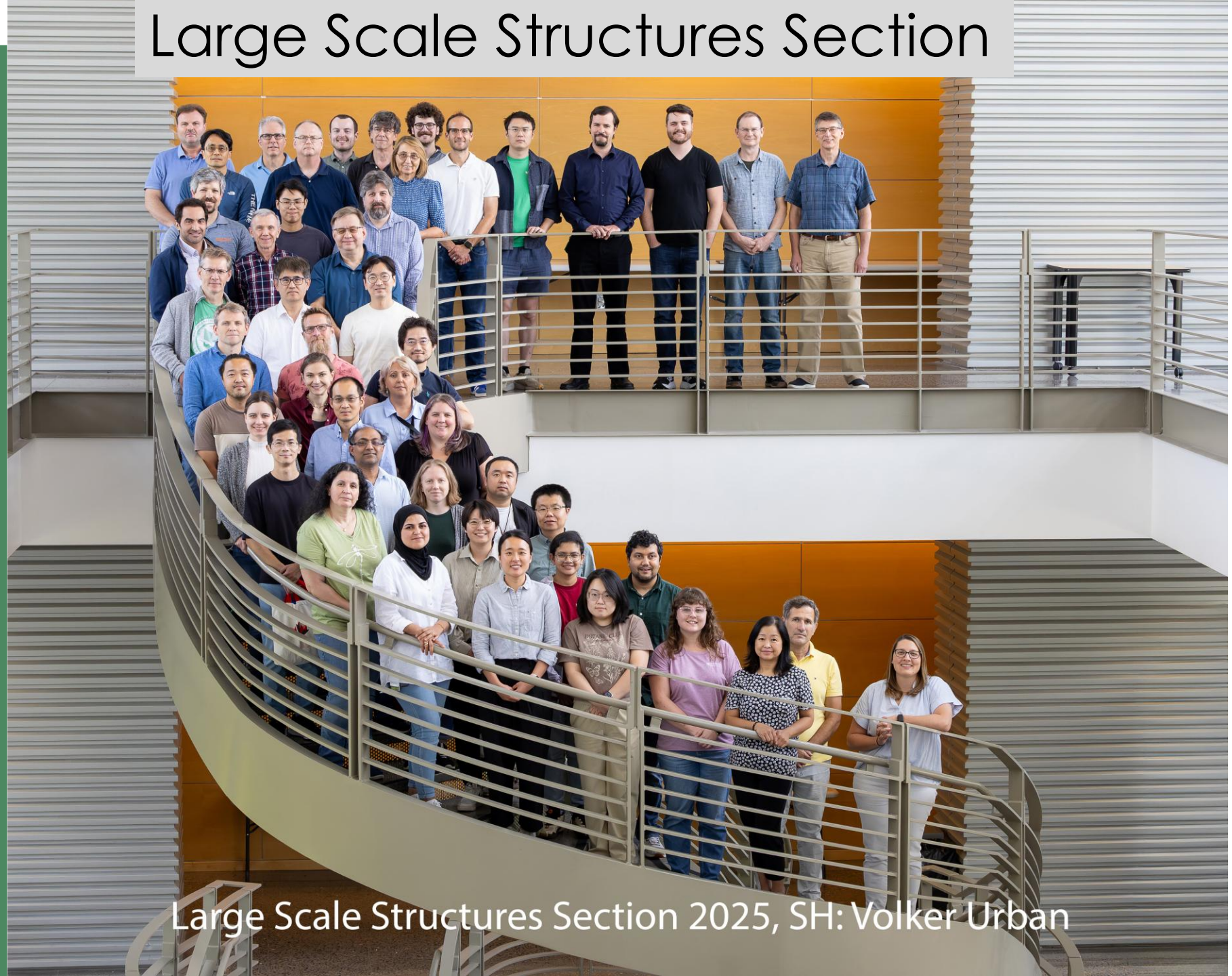
- Introduction of Review
- Large Scale Structures Section Context
- Neutron Imaging at ORNL
- Review Charge Questions
- Agenda & ‘Nuts & Bolts’

ORNL Neutron Imaging Suite Review

- Welcome!
- Review date: Feb 3-4, 2026
- Reviewers
  - Adrian Brügger, Columbia University
  - Burkhard Schillinger, Heinz Maier-Leibnitz Zentrum, TUM
- Instruments
  - MARS, CG-1D, HFIR
  - VENUS, BL-10, SNS



Large Scale Structures Section



Four Groups

Materials Engineering

Andrew Payzant

Neutron Reflectometry

Jim Browning

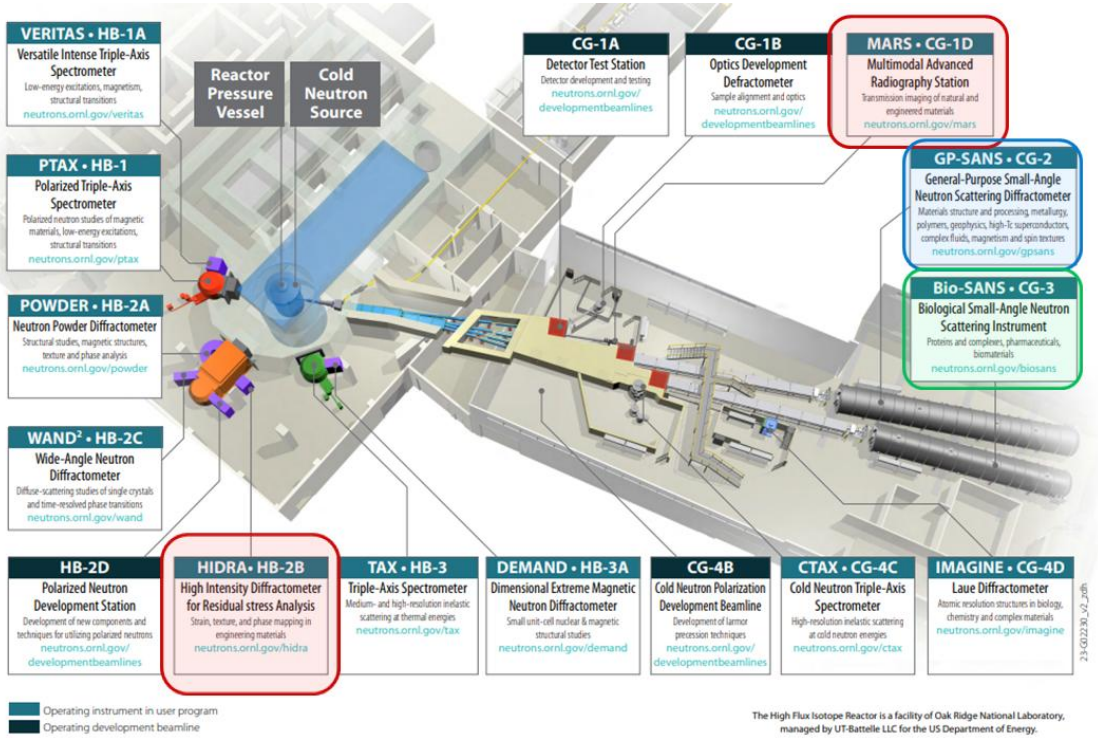
SANS & Spin Echo

William Heller

Biological Labeling and Scattering

Hugh O'Neill

High Flux Isotope Reactor

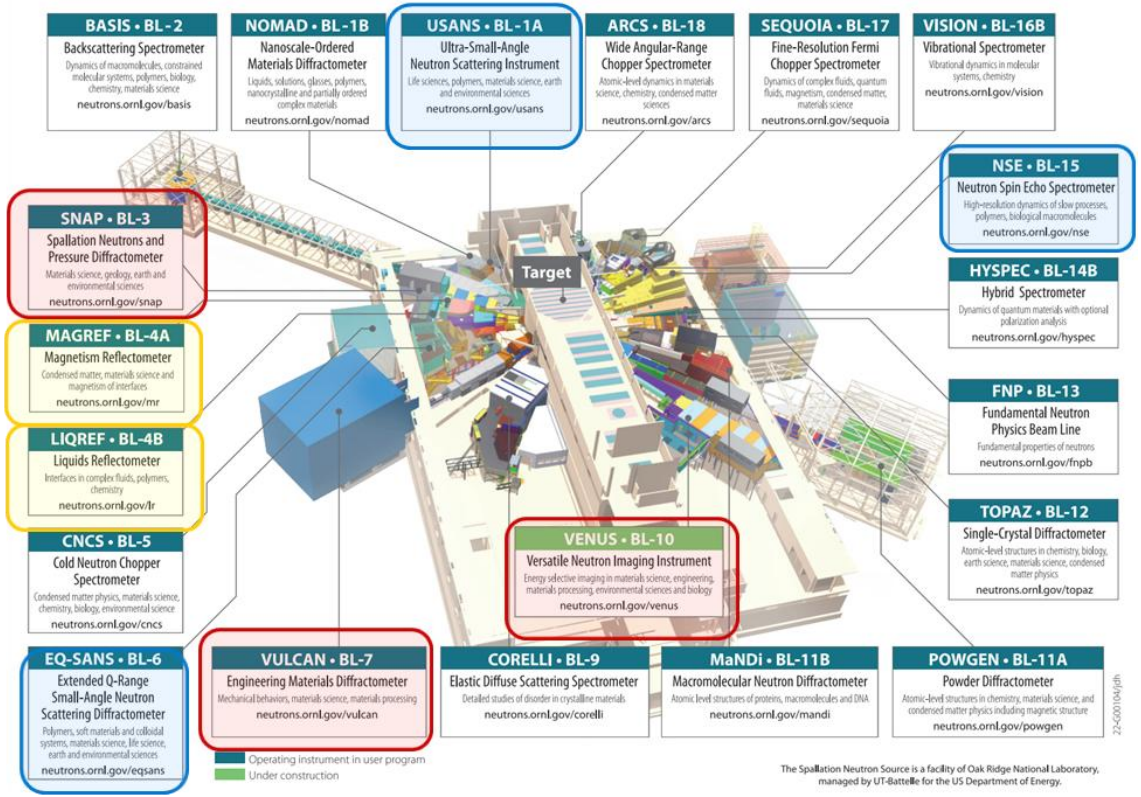


- 4 Groups
  - Materials Engineering, A. Payzant
  - Neutron Reflectometry, J. Browning
  - SANS & Spin Echo, W. Heller
  - Biological Labeling and Scattering, H. O'Neill

Large Scale Structures Section

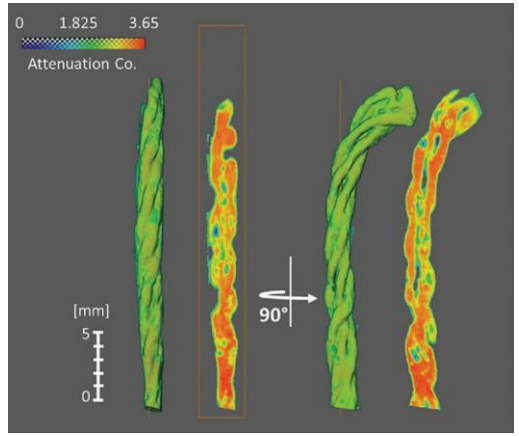
- 12 Instruments
  - 4 at the HFIR
  - 8 at the SNS

Spallation Neutron Source



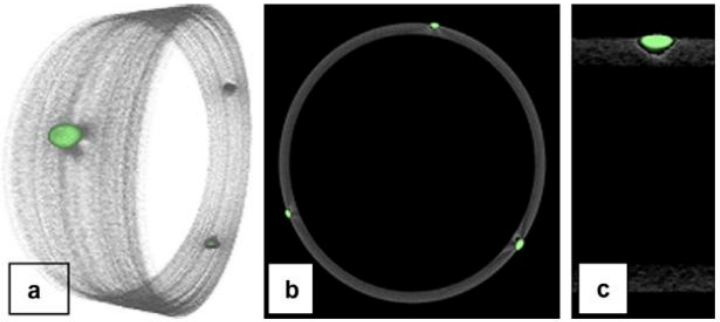
OAK RIDGE National Laboratory | SPALLATION NEUTRON SOURCE

Examples of Imaging "Cross-Section" Synergy



- Yue Yuan PhD Dissertation, NC State U, 2021: *Enzyme Immobilization in Biobased Polymeric Fibrous Matrices for Biocatalytic Textiles: Material Innovation, Mechanistic Studies and Applications* CG1D (**MARS**), CG3 (**Bio-SANS**)

- Brianne Heisinger PhD Dissertation, UTK 2021: *Non-Destructive Characterization of Zircaloy-4 Nuclear Fuel cladding Using Neutron Scattering Techniques*
  BL-7 (**VULCAN**), CG-2 (**GP-SANS**), CG-1D (**MARS**)

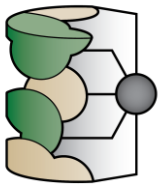


- Nandhini Raju Ph.D. Dissertation, U of Central Florida, 2024: *Improving Structural Integrity of Additively Manufactured High-Temperature Gas Turbine Component*
  HB-2B (**HIDRA**), CG-1D (**MARS**)

- C. D. Hughes, et al., *Polarized neutron measurements of the internal magnetization of a ferrimagnet across its compensation temperature,* J. of Magnetism and Magnetic Materials 629, 173273 (2025) BL-15 (**Neutron Spin Echo**), CG-1D (**MARS**)

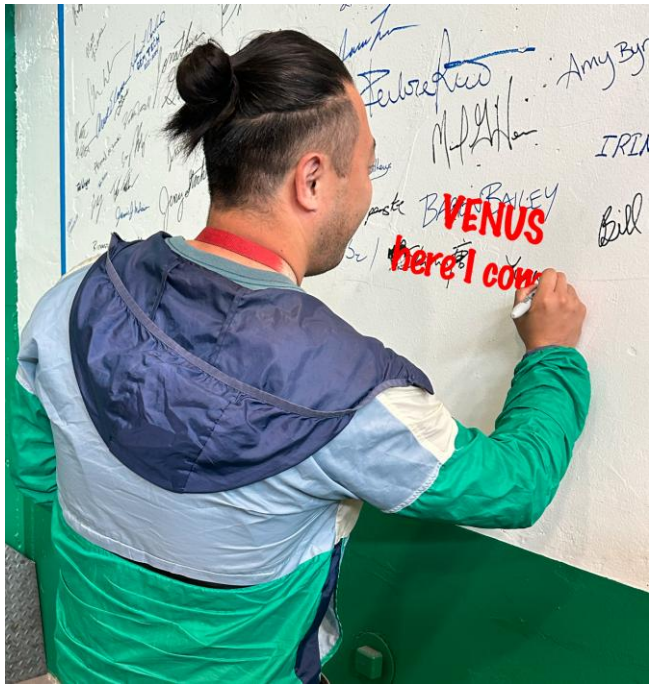
Neutron Imaging at ORNL

- Started as test/demonstration in the early days of the new HFIR cold guide hall CG-1 (2009)
- Has really taken off … MARS + VENUS 2025.
- Some indicators of alignment with DOE mission:
  - DOE BES funded AI project with Purdue University and Brookhaven National Laboratory:
    - HyperCT AI project (PI: Hassina Bilheux) – FY21-23
    - HyperCT strain AI project (PI: Hassina Bilheux) – FY 24-26
  - FY 2026, DOE Early Career Award, PI Yuxuan Zhang

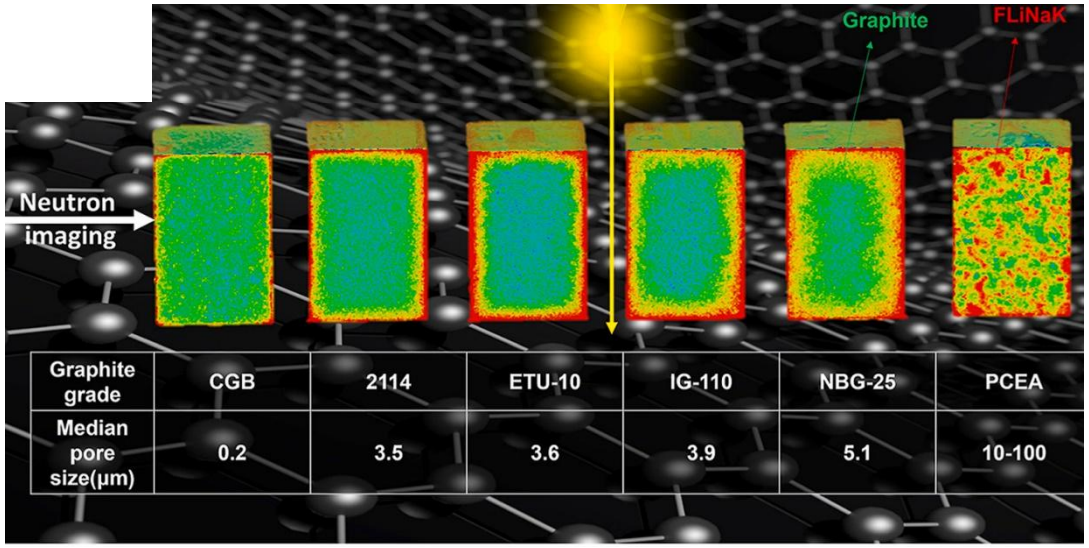


Development of Neutron Dark-Field Tomography to Map Nanostructures in Bulk Systems

Goal: To develop neutron dark-field tomography (nDFT), leveraging the unique time-of-flight (TOF) characteristics offered by the SNS and the advanced microfabrication capability at the CNMS, and exploiting the wave-particle duality of neutrons to simultaneously map structural details across multiple length scales in 3D. This will position SNS as an international leader in TOF nDFT.



Fluoride Salt (FLiNaK) Intrusion in Nuclear-grade Graphite



Graphite grade	CGB	2114	ETU-10	IG-110	NBG-25	PCEA
Median pore size(μm)	0.2	3.5	3.6	3.9	5.1	10-100

Neutron tomography results for selected graphite grade in this study. Virtual cut has been applied at the center to expose the internal salt distribution (blue/green: low salt conc., yellow/red: high salt conc.). The median pore size and graphite grade is listed in the table. FLiNaK salt intrusion was conducted at 750 ℃, 5 bar for 12 hrs.

Jisue Moon, Nidia C. Gallego, Cristian I. Contescu, James R. Keiser, Dino Sulejmanovic, Yuxuan Zhang, and Erik Stringfellow, *Carbon*, **213**:118258, (2023).

Work performed on MARS, HFIR CG-1D

Scientific Achievement

The infiltration profiles of molten salt in nuclear-grade graphite were visualized and show that salt coverage (0.98%) at the center of historic-grade graphite (CGB) is much less than the 20.2% found in porous graphite (PCEA).

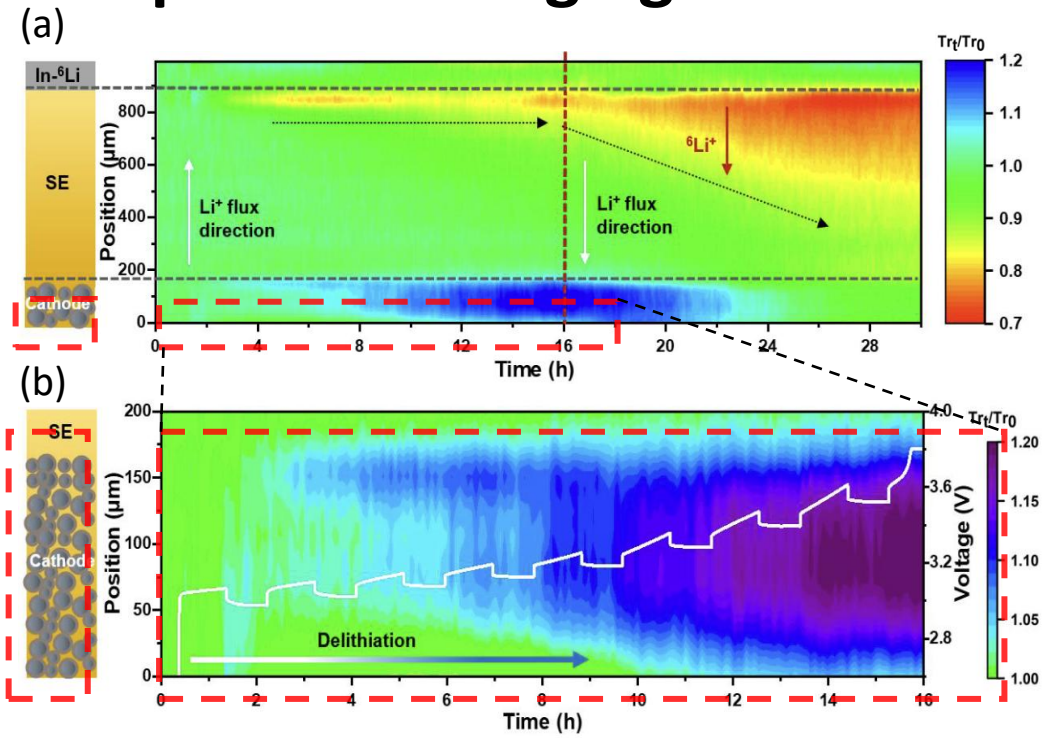
Significance and Impact

The work demonstrates a powerful technique to determine nondestructively salt distribution in nuclear reactor materials and the specific findings advance understanding of the relationship between graphite microstructure and salt penetrability, guiding the materials selection for molten salt reactors (MSR).

Research Details

- FLiNaK(LiF-NaF-KF(46.5-11.5-42mol%)) salt infiltration over different nuclear grade graphite was conducted.
- Neutron-tomography scans of the samples were obtained and analyzed to extract the depths of penetration and salt coverages.

Operando Imaging-Guided Gradient Design for High-Mass-loading Cathodes



(a) Position vs. time plots with the averaged neutron transmission (trans.) changes (Tr_t/Tr_0) represented in color. $Tr_t/Tr_0<1$ indicates reduced trans. due to Li increase or ^{nat}Li replaced by ^6Li, $Tr_t/Tr_0>1$ indicates increased trans. due to delithiation.
(b) Zoomed in on the cathode side. Colormap has been slightly changed to enhance the contrast for better visualization. Voltage vs. time curve is overlayed in white color.

T. Ji , Y. Zhang , J. Torres , A. Mijailovic , Y. Tang , X. Zhao , J. Bilheux , J. Wang , B. Sheldon , O. Oyedeji and H. Zhu, *Nature Communication*, **16**, 7667 (2025), doi:10.1038/s41467-025-62518-y.

Work was performed at MARS, HFIR CG-1D

Scientific Achievement

Directly visualized Li reaction gradients in thick, high-mass-loading all solid-state batteries (ASSBs) cathodes. A Li^+ flux–guided gradient catholyte design was developed, enabling superior rate capability.

Significance and Impact

This work provides the first direct evidence of Li^+ flux mismatch in thick solid-state cathodes and offers a scalable design principle to overcome it.

Research Details

- A 33 mg/cm² NMC811 cathode was monitored using operando neutron imaging. Lithiation inhomogeneity from the solid electrolyte (SE) side to the current collector was observed. A three-layer cathode—graded in SE content from high to low—significantly improved rate performance for NMC811 and lithium cobalt oxide (LCO) cathodes, with up to 171% capacity gain at high current.

Staffing Considerations

- CG-1D MARS: Staffing shortfall: Yuxuan Zhang (ECA), 1FTE (James Torres), 0.5 FTE (Saurabh Kabra, Feb. 2026)
- Imaging at VENUS & MARS: Needs intensive computational development. Requesting a 2nd Imaging CIS.
- Refill Group Leader Position Materials Engineering (Andrew Payzant) in spring 2026

Review Charge Questions

1. Do the technical capabilities and performance of the individual instruments and instrument suites compare favorably with peer instruments at leading national and international neutron facilities?
2. Does the scientific productivity and impact of the instrument programs compare favorably with comparable programs at peer facilities?
3. Do the beamlines meet users' day-to-day needs for data collection, reduction, and analysis? Are planned software developments sufficient to meet anticipated future user needs?
4. Is the current scientific portfolio and business case for each instrument competitive nationally and internationally (e.g., user demand, breadth of scientific applications, scientific impact, mission relevance, agency support, and/or industrial engagement)?
5. Are there a strong and sustainable user community and a clear case for future scientific demand for these instruments? Is the number of beamlines in a suite proportionate to user community demand?
6. Are the plans for development appropriate and well justified to meet current and future user requirements? Please consider aspects of instrument techniques, sample environments, sample preparation and characterization infrastructure, data analysis and modeling capabilities.
7. Are there well-defined and credible plans for future automation and integration of artificial intelligence or machine-learning approaches?
8. Have the strengths, weaknesses, opportunities, and threats for each instrument or suite been clearly identified, and are there realistic plans to address them where feasible?
9. Are there additional developments, capabilities, or provisions that could enhance the capacity, effectiveness, or scientific impact of diffraction science at SNS and HFIR that were not presented by the instrument teams?
10. Any other comments or recommendations the panel wishes to provide to the NScD Associate Laboratory Director?

Review Agenda

Large Scale Structures Beamline Suite Review

Time	Event	Lead	Attendees	Place
Tuesday, February 3, 2026				
8:30 a.m. – 8:45 a.m.	Badging and checking in	Abby Forgety	All	Chestnut Ridge Visitor Center
8:45 a.m. – 9:00 a.m.	Closed Leadership Meeting	Volker Urban	Reviewers, Volker Urban, Mark Lumsden	Spallation Neutron Source; 8600, C-156
9:00 a.m. – 9:30 a.m.	Welcome and NSD Overview	Mark Lumsden	All	Spallation Neutron Source; 8600, C-156 / Microsoft Teams
9:30 a.m. – 10:00 a.m.	Large Scale Structures Overview and Strategy	Volker Urban	All	Spallation Neutron Source; 8600, C-156
10:00 a.m. – 10:15 a.m.	A.M. Break	Volker Urban	All	Spallation Neutron Source; 8600, C-156
10:15 a.m. – 10:45 a.m.	Group Leader Presentation	Andrew Payzant	All	Spallation Neutron Source; 8600, C-156
10:45 a.m. – 11:25 a.m.	Instrument Presentations on VENUS	Hassina Bilheux	Reviewers, Volker Urban, Andrew Payzant, Hassina Bilheux, Shimin Tang, James Torres, Yuxuan Zhang, Jean Bilheux, Chen Zhang, Sam McKay, Kevin Yahne, Harley Skorpenske	Spallation Neutron Source; 8600, C-156
11:25 a.m. – 12:05 p.m.	Instrument Presentations on MARS	Yuxuan Zhang, James Torres	Reviewers, Volker Urban, Andrew Payzant, Yuxuan Zhang, James Torres, Saurabh Kabra, Hassina Bilheux, Jean Bilheux, Chen Zhang, Sam McKay, Roger Hobbs, Mike McDowell	Spallation Neutron Source; 8600, C-156
12:05 p.m. – 1:05 p.m.	Committee Working Lunch - *Committee Members Review Discussion*	Volker Urban	Reviewers, Volker Urban, Andrew Payzant, Shimin Tang, James Torres, Yuxuan Zhang, Sam McKay, Hassina Bilheux, Saurabh Kabra, Jean Bilheux, Chen Zhang, Kevin Yahne, Roger Hobbs, Mike McDowell, Harley Skorpenske, Mark Lumsden	Spallation Neutron Source; 8600, C-156
1:05 p.m. – 1:45 p.m.	Instrument Software Presentation	Jean Bilheux	All	Spallation Neutron Source; 8600, C-156
1:45 p.m. – 2:15 p.m.	Sample Environment Presentation	TBD	All	Spallation Neutron Source; 8600, C-156
2:15 p.m. – 2:55 p.m.	Open Discussions	Volker Urban	All	Spallation Neutron Source; 8600, C-156
2:55 p.m. – 3:25 p.m.	Closed Discussions	Volker Urban	Reviewers, Yuxuan Zhang, James Torres, Saurabh Kabra, Roger Hobbs, Hassina Bilheux, Shimin Tang, Jean Bilheux, Kevin Yahne	Spallation Neutron Source; 8600, C-156
3:25 p.m. – 3:40 p.m.	P.M. Break	Volker Urban	All	Spallation Neutron Source; 8600, C-156
3:40 p.m. – 5:00 p.m.	Committee Report Writing	Volker Urban	Reviewers only	Spallation Neutron Source; 8600, C-156

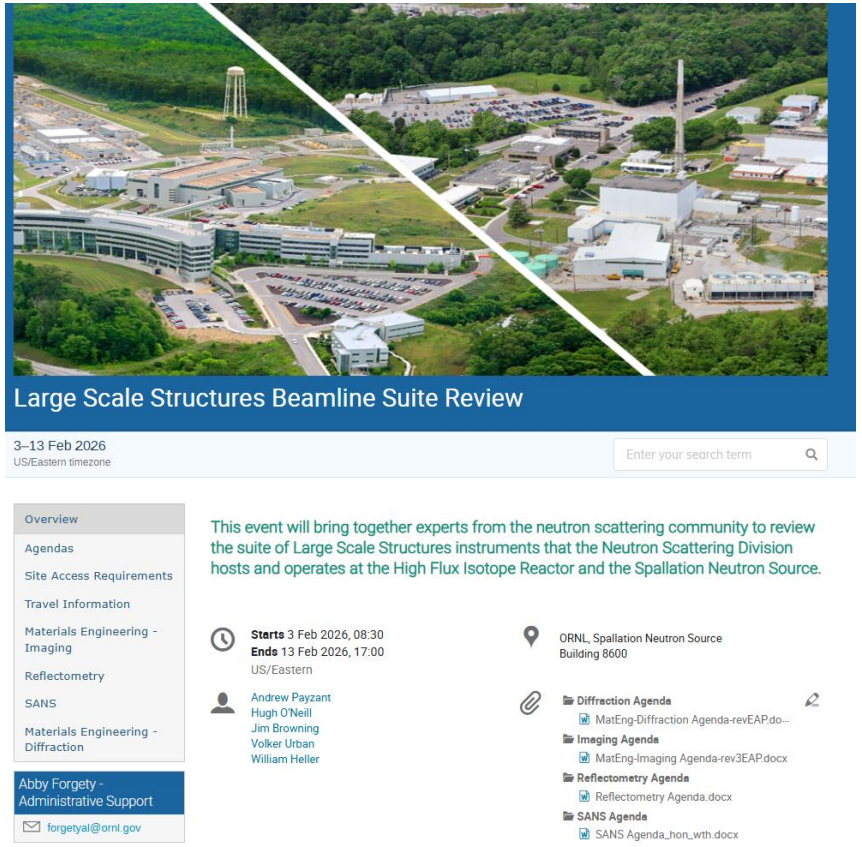
Event contact	Abby Forgety, 865-341-3747 (office); forgetyal@ornl.gov

Large Scale Structures Beamline Suite Review

Time	Event	Lead	Attendees	Place
Wednesday, February 4, 2026				
9:00 a.m. – 9:30 a.m.	Welcome and regroup	Volker Urban	All	Spallation Neutron Source; 8600, C-156
9:30 a.m. – 9:45 a.m.	A.M. Break	Volker Urban	All	Spallation Neutron Source; 8600, C-156
9:45 a.m. – 11:00 a.m.	HFIR Tour	Volker Urban	Reviewers, Volker Urban, Andrew Payzant, Shimin Tang, James Torres, Yuxuan Zhang, Sam McKay, Hassina Bilheux, Saurabh Kabra, Jean Bilheux, Chen Zhang, Kevin Yahne, Roger Hobbs, Mike McDowell, Harley Skorpenske, Mark Lumsden	High Flux Isotope Reactor
11:00 a.m. – 12:15 p.m.	SNS Tour	Volker Urban	Reviewers, Volker Urban, Andrew Payzant, Shimin Tang, James Torres, Yuxuan Zhang, Sam McKay, Hassina Bilheux, Saurabh Kabra, Jean Bilheux, Chen Zhang, Kevin Yahne, Roger Hobbs, Mike McDowell, Harley Skorpenske, Mark Lumsden	Spallation Neutron Source; 8600, C-156
12:15 p.m. – 1:15 p.m.	Committee Working Lunch - *Committee Members Review Discussion*	Volker Urban	Reviewers, Volker Urban, Andrew Payzant, Shimin Tang, James Torres, Yuxuan Zhang, Sam McKay, Hassina Bilheux, Saurabh Kabra, Jean Bilheux, Chen Zhang, Kevin Yahne, Roger Hobbs, Mike McDowell, Harley Skorpenske, Mark Lumsden	Spallation Neutron Source; 8600, C-156
1:15 p.m. – 2:15 p.m.	Committee Meeting with Leadership	Volker Urban	Reviewers, Volker Urban, Andrew Payzant, Mark Lumsden, Jon Taylor	Spallation Neutron Source; 8600, C-156
2:15 p.m. – 3:00 p.m.	Committee Report Writing	Volker Urban	Reviewers only	Spallation Neutron Source; 8600, C-156
3:00 p.m. – 3:15 p.m.	P.M. Break	Volker Urban	All	Spallation Neutron Source; 8600, C-156
3:15 p.m. – 5:00 p.m.	Committee Report Writing	Volker Urban	Reviewers only	Spallation Neutron Source; 8600, C-156
5:00 p.m.	Depart	Volker Urban	All	Spallation Neutron Source; 8600, C-156

Imaging Review – nuts & bolts

- Review Material: Agenda, Presentations, Additional Documentation: https://conference.sns.gov/event/529/
- Some context
  - Previous suite reviews 2017, **2020**
  - DOE reviews: …, 2018, 2023, 2027
- Reviewers:
  - We can arrange additional discussions as needed.
  - We request report in 2 weeks.



A few recurring abbreviations…

- CIS: Computational Instrument Scientist
- SA: Scientific Associate (assigned to a beamline, staff in instrument support section)
- SE: sample environment (generally and specifically SE Section)
- HBRR: HFIR Beryllium Reflector Replacement
- LSS(S): Large Scale Structures (Section)

Questions?

- Next up: Group Leader Presentation, Andrew Payzant

HBRR is critical to HFIR's continued operations

Be embrittles and swells from fast neutron flux

Replace permanent Be reflector, core components, beam tubes, and cold neutron source

Replace cold neutron guide network

Instrument upgrades