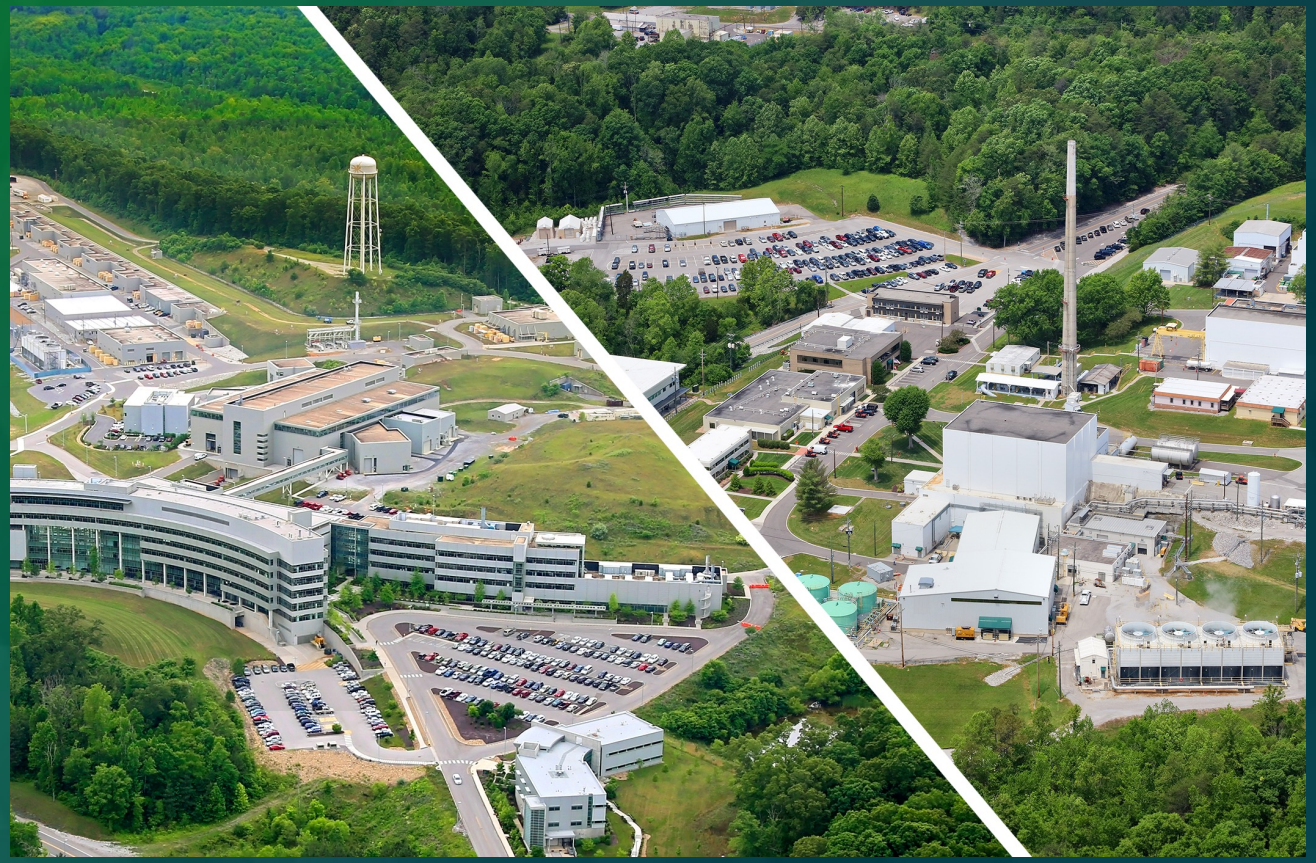
OAK RIDGE National Laboratory | HIGH FLUX ISOTOPE REACTOR | SPALLATION NEUTRON SOURCE

2026 Instrument Suite Review

MARS & VENUS



GL Report

Andrew Payzant

February 3, 2026

U.S. DEPARTMENT OF ENERGY

ORNL IS MANAGED BY UT-BATTELLE LLC
FOR THE US DEPARTMENT OF ENERGY

The Imaging Suite of Instruments - Introduction

- The MATENG Group is home to two imaging instruments
  - CG-1D MARS at HFIR (cold neutron imaging & tomography, nGI)
    - **Yuxuan Zhang**, James Torres, and SA Roger Hobbs
  - BL-10 VENUS at SNS (TOF: B-E imaging, n-resonance imaging, nGI, …)
    - **Hassina Bilheux**, Shimin Tang, and SA Kevin Yahne
  - Shared Staff
    - **Jean-Christophe Bilheux** is the computational instrument scientist for imaging
    - Saurabh Kabra recently (yesterday) joined MATENG and will partly support MARS and HIDRA this year
    - The two instrument teams are highly collaborative and work across both beamlines as needed

a couple of comments:

- **staff in bold are the only ones who were here for the last review in 2020!!!**
- Additional staff from computation sciences (Chen Zhang), NTD, and SE provide essential support
- Hassina has additional BES funded project on AI/ML (with Purdue and BNL)
- Yuxuan has received an Early Career Award to develop new capabilities in nGI

A lot has happened since the last review!

- 2020:
  - we had just recovered from an 11-month unexpected HFIR shutdown the previous year
  - We had just started VENUS construction project
  - … and then COVID hit!!!
- 2021-25:
  - We have had to manage with limited HFIR fuel cycles, except in 2024
  - We have had a 6-month SNS outage (for PPU) which did not impact our imaging program
- 2026 outlook:
  - Moving to 2 MW operation at SNS over the next year
  - We are looking ahead to the Cold Source (Feb 2028 – Apr 2029) and HBRR outage (starting Oct 2029)
  - New HFIR CGH Layout post-HBRR, new MARS at NB-4 beamline
  - STS moving forward – possible new imaging beamline CUPID

Comparable Programs at Peer Facilities

- DINGO (ANSTO)
- RADEN (J-PARC) – only comparable TOF beamline
- NEXT (ILL)
- NNIF (NCNR) – did not run during the review period
- IMAT (ISIS)
- PSI (ICON)
- CSNS (ERNI)

Scientific Productivity

Do the scientific productivity and impact of the imaging program compare favorably with programs at peer facilities?

	MARS	NEXT	DINGO	ICON		SNAP/VENUS	RADEN	IMAT
2020	5	2	15	13		1/1	9	6
2021	6	7	12	5		3/0	11	9
2022	7	13	7	9		0/0	10	1*
2023	11	9	8	14		1	12	*
2024	12	17	16	16		1/1	14	*
2025	10	16	12	8		2/1	7	*

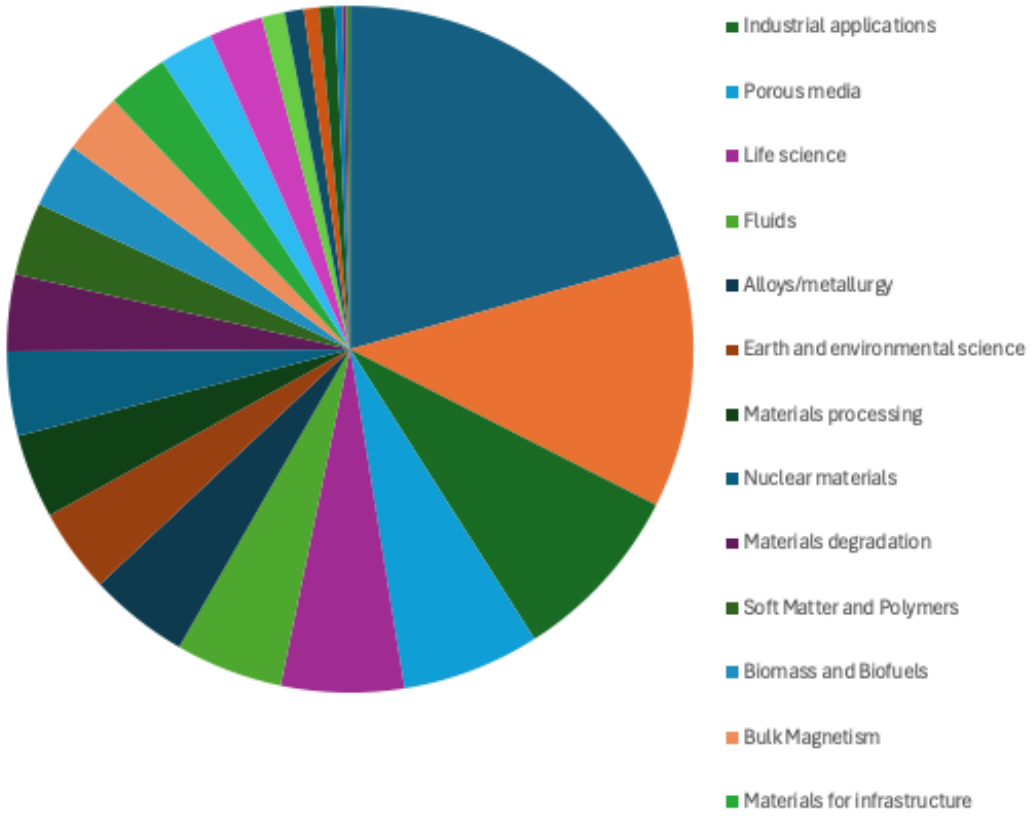
– Peer-reviewed journal publications only (incomplete data from IMAT, sorry)

VENUS completed construction and commissioning last year and we expect the output to ramp up in the net two years.

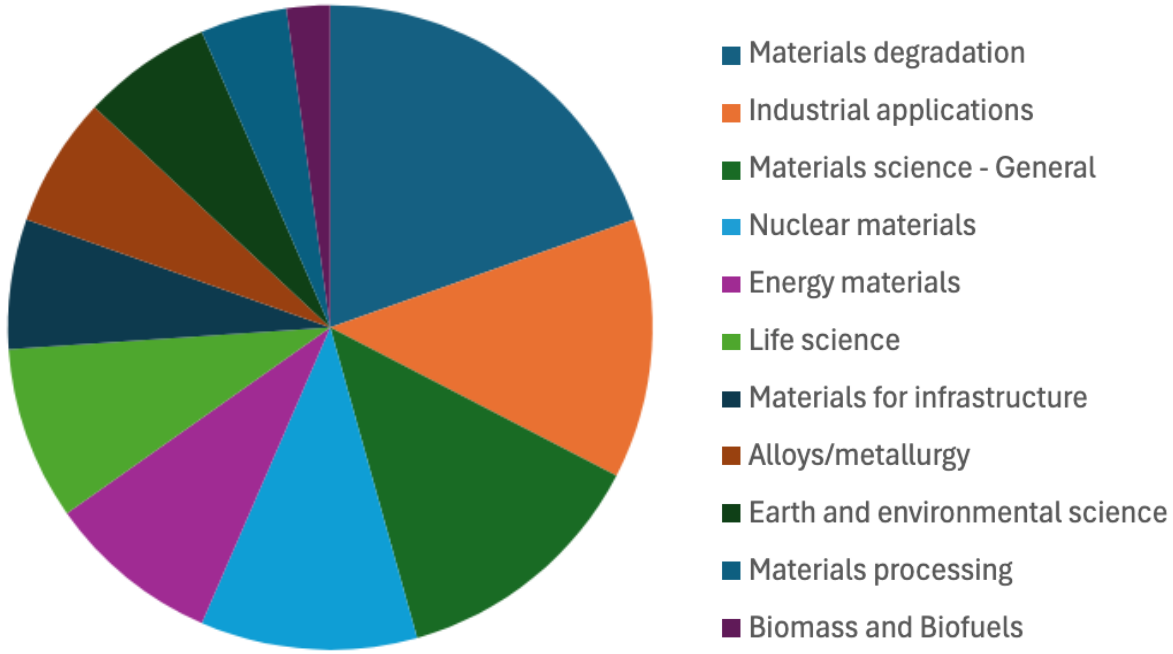
How about the strength of the Imaging User Community?

INCREDIBLE DIVERSITY!!!!

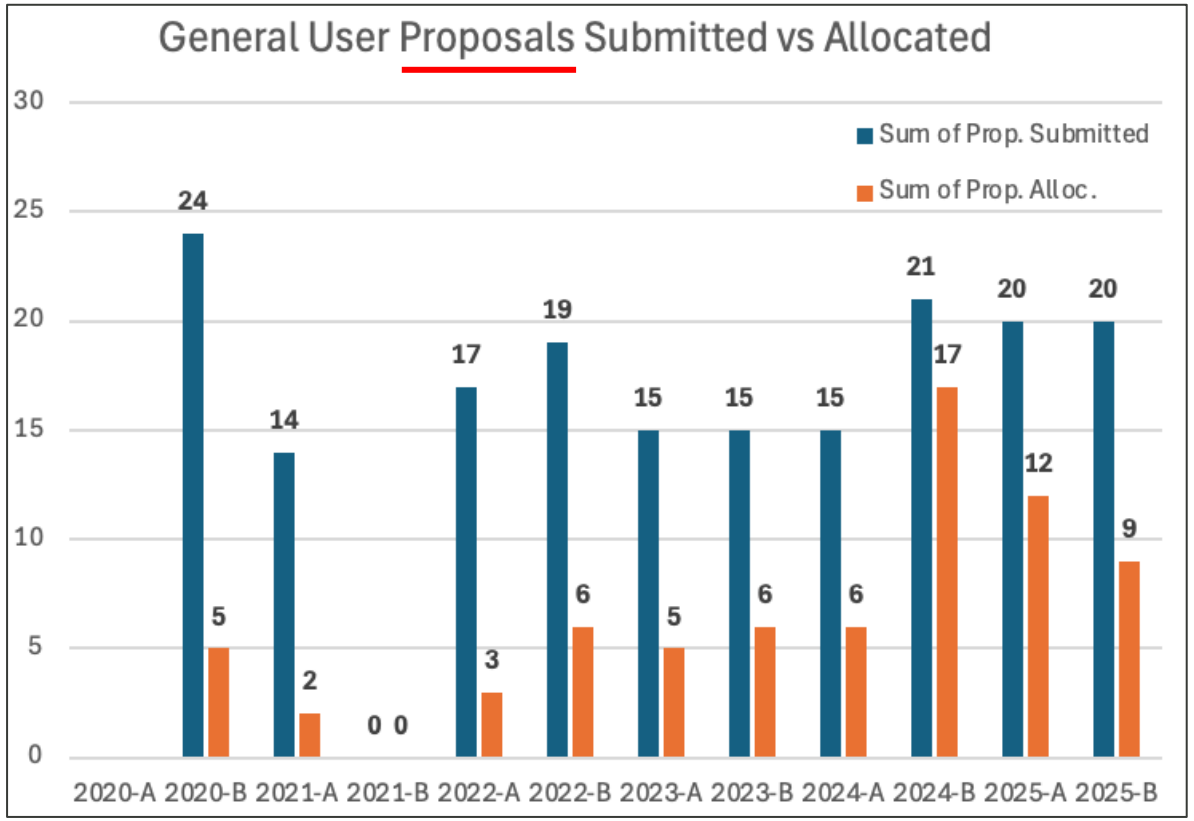
MARS

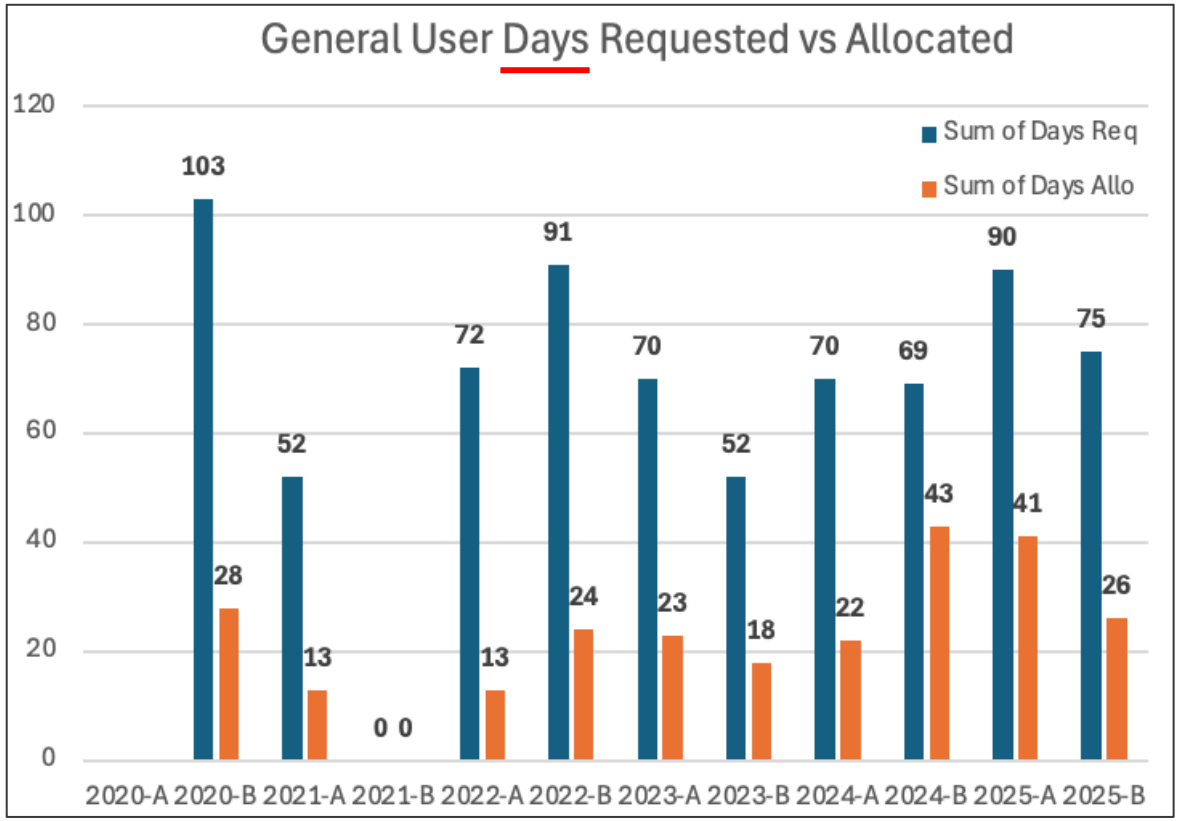


VENUS

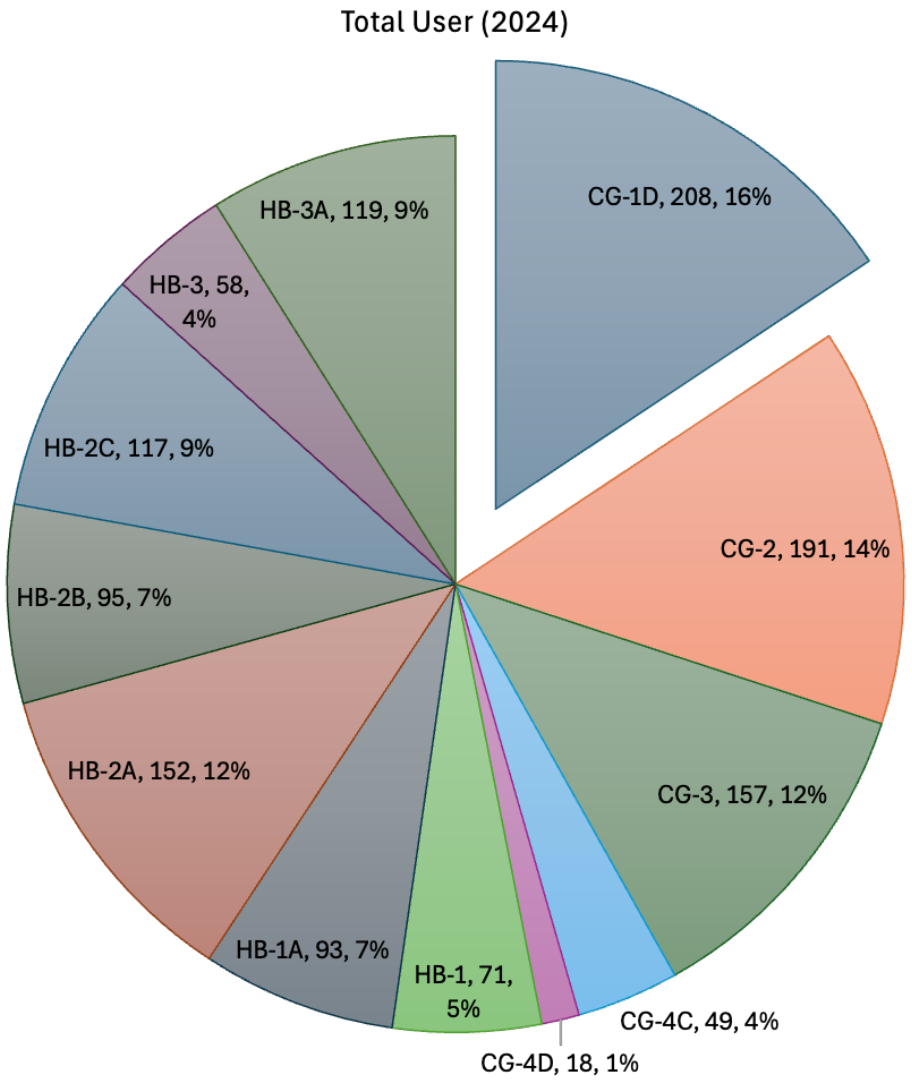


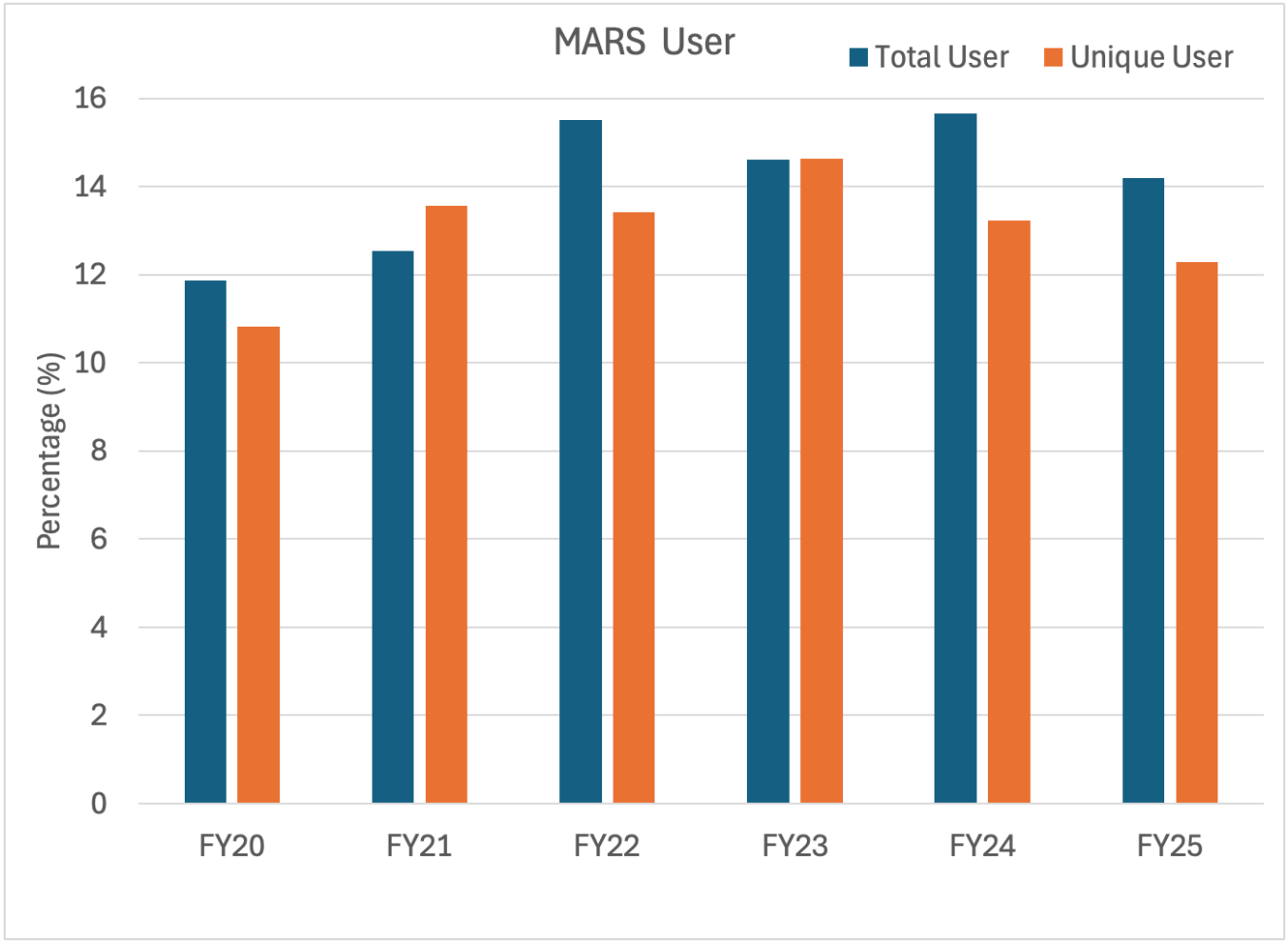
MARS Oversubscription rate, average ≈ 2.96





Since FY20, MARS users = 12-16% of HFIR users



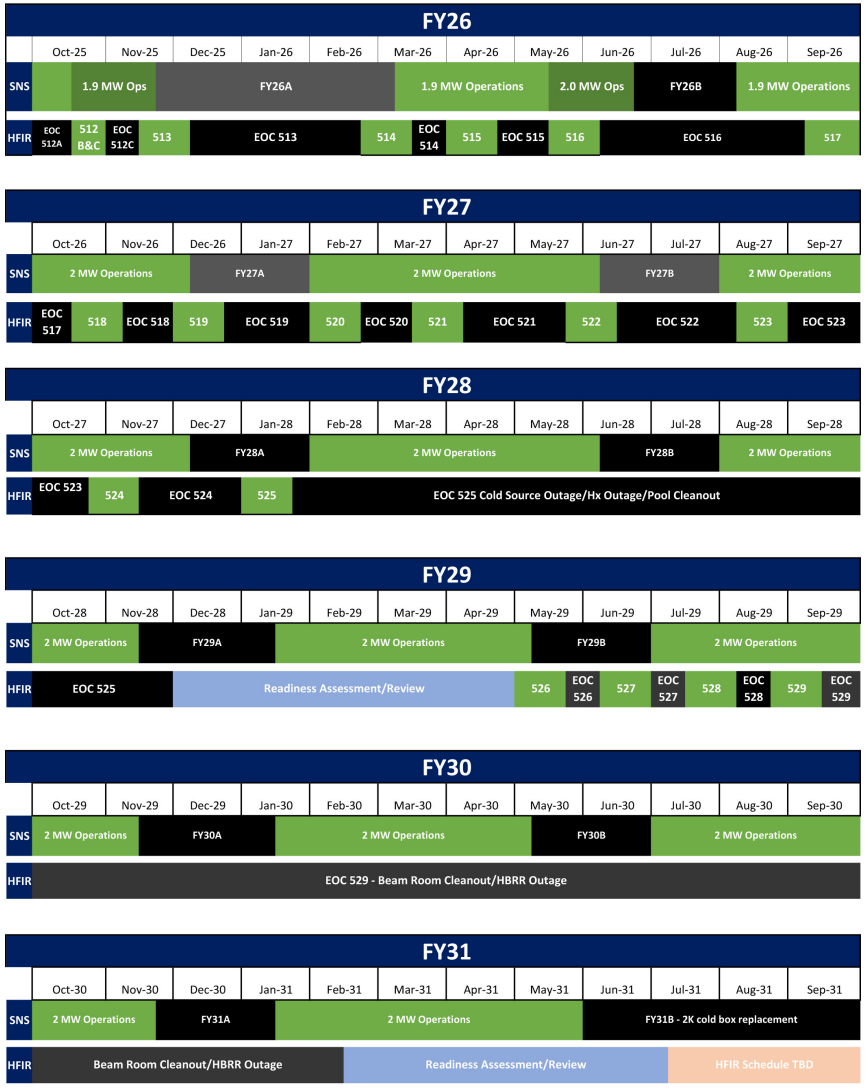


Expectations for Future Demand

- Imaging/Tomography is a widely-applicable technique that can be applied to problems in many fields of research
  - Chemistry, Physics, Materials Science, Structural Biology, etc.
- Cold neutrons provide unique information
  - Contrast variation methods and isotopic labeling
  - No radiation damage
  - Excellent penetration power through robust sample environments that can recreate real world conditions
- TOF imaging opens a new array of unique capabilities
  - Bragg Edge Imaging
  - Resonance Imaging/Tomography

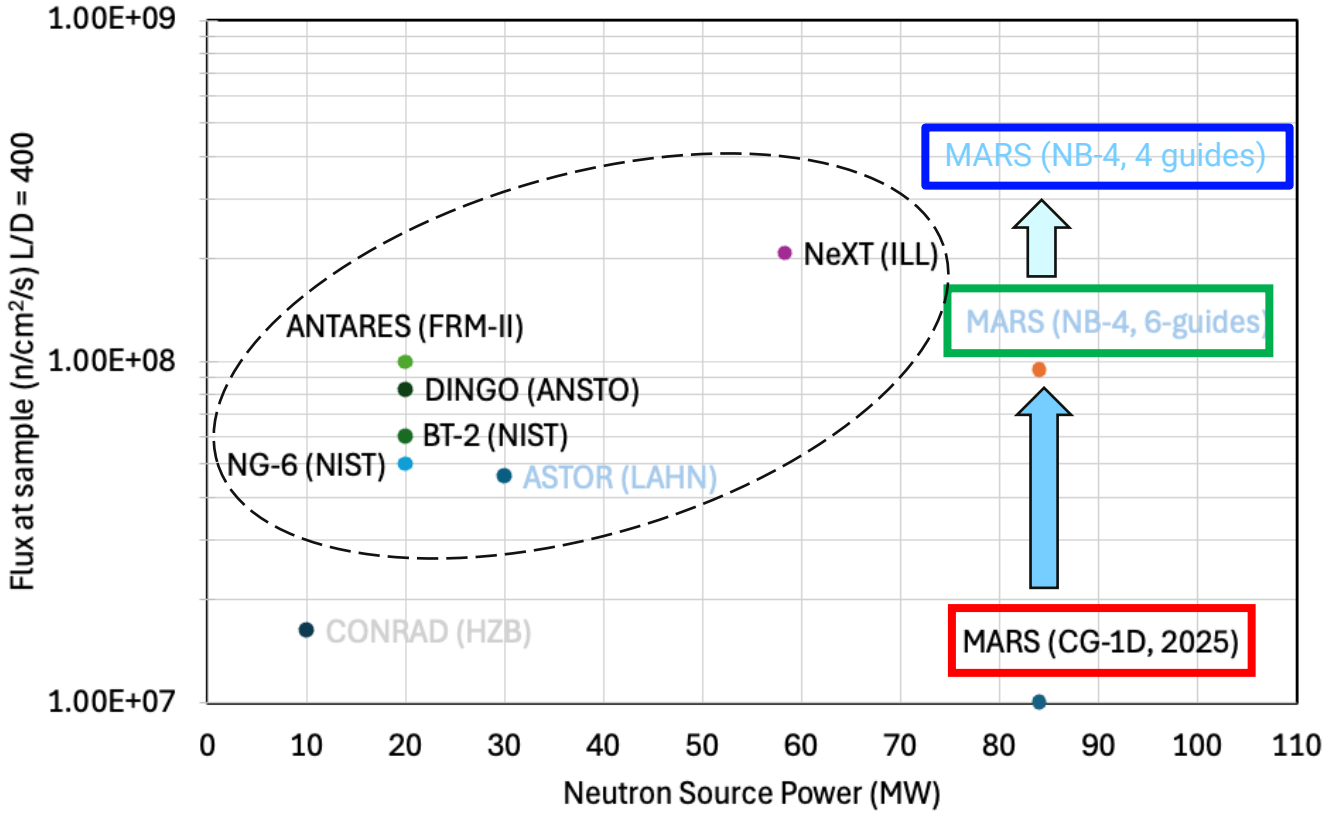
Two sources provide robust support for community

Oak Ridge National Laboratory Neutron Production Overview



Revised 12/30/25 . The working schedule for the Spallation Neutron Source (SNS) and the High Flux Isotope Reactor (HFIR) is subject to change in response to evolving operational and project needs. The community will be notified as soon as possible if changes occur.

Where is MARS post-HBRR?



Peak (Å)	Flux at sample ($n/cm^2/s$)	Beam uniformity	Sample positions from pinhole	Max. FOV (mm^2)
~2.6	$\geqslant 3 \times 10^8$ (L/D 400) And can access L/D down to ~100 for highest possible flux	above 70 % of the max intensity, within the central ~100 x100 mm^2	~3m, ~7m, ~11m (if space available)	120 x 120 (100 x 100 if needed to trade flux for FOV)

The Case for Future Imaging Instruments

- Adding a TOF Imaging station at the STS
  - The CUPID beamline concept reviewed well last time, but at least another round of instrument proposals are likely before the final STS instrument layout is settled
  - Success of CUPID will certainly be dependent on demonstrating a robust, relevant, and in-demand science program on both VENUS and MARS over the next 5 years
  - If the demand is demonstrated and the publications are compelling, then the case to build CUPID will be very strong indeed

SWOT Analysis – VENUS

Strengths

- Truly unique capabilities in the Americas
- Broad scientific impact across most scientific fields Capabilities attractive to industry
- Close integration of AI tools into VENUS
- AI collaboration with Purdue U. and BNL
- Strong synergies between the imaging team and ORNL researchers
- Young staff

Weaknesses

- Additional hardware and data acquisition implementations are needed
- CIS support spread thin across the 2 imaging beamlines
- No energy optimization of detectors
- Network infrastructure and data storage
- Young staff

Opportunities

- Mail-in program to increase VENUS productivity
- Leadership in state-of-the-art software tool development for hyperspectral data
- Leadership in AI for neutron imaging (Purdue/BNL)
- Organize training workshops to educate future users
- Partnerships with industry
- Prompt-gamma spectroscopy imaging

Threats

- SNS is now over two decades old and requires regular maintenance and replacement of obsolete components
- Only (at best) one deep in expert staffing
- Sponsor needs to stay engaged in neutron imaging as an essential part of the User Program

SWOT Analysis – MARS

Strengths

- Variety of detectors, motion control systems, and setup hardware
- Can reconfigure instrument flight tubes for complex experiments
- Highly diverse research and unique users
- User-friendly software and online tools
- Ongoing support for software and beamline improvements
- Unique, large scale user experiments, including in-situ/in-operando device and material characterizations (batteries, fuel cells, molten salts) using shared SE equipment

Weaknesses

- Limited CIS bandwidth for MARS and VENUS
- CG-1 neutron guide was built for a spectrometer, not imaging, leading to suboptimal white-beam flux and beam uniformity
- Limited sample environment for soft matter and high pressure
- No velocity selector - needed for quantitative nGI measurements; monochromator upgrade needed
- Space limited for equipment, difficulties in returning user supplied equipment

Opportunities

- Auto data reduction for standard processes (2D normalization, CT reconstruction)
- Mail-in/rapid access program
- AI/ML tools for data acquisition, reduction, and analysis
- Development of advanced optics for beam focusing and magnification
- Increase slits/collimation and assemble larger detector to leverage large ~17cm diameter beam
- Development of a neutron microscope (custom lens system and vibration-free platform)

Threats

- Over 60 year-old reactor with long-term reliability issues
- **High complexity of user experiments creates elevated risk for accidents and materials mishandling**
- Dependence on outsourced and expensive visualization (Amira) and data-correction (BM3D) software
- HBRR risks – e.g., MARS (NB-4) possibly delays in construction and commissioning
- Only (at best) one deep in expert staffing