



# FRIB

## FRIB Status



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15 August 2025



**MICHIGAN STATE**  
UNIVERSITY



**U.S. DEPARTMENT**  
*of* **ENERGY**

**Office of**  
**Science**

This material is based upon work supported by the U.S. Department of Energy, Office of Science, Office of Nuclear Physics and used resources of the Facility for Rare Isotope Beams (FRIB) Operations, which is a DOE Office of Science User Facility under Award Number DE-SC0023633.

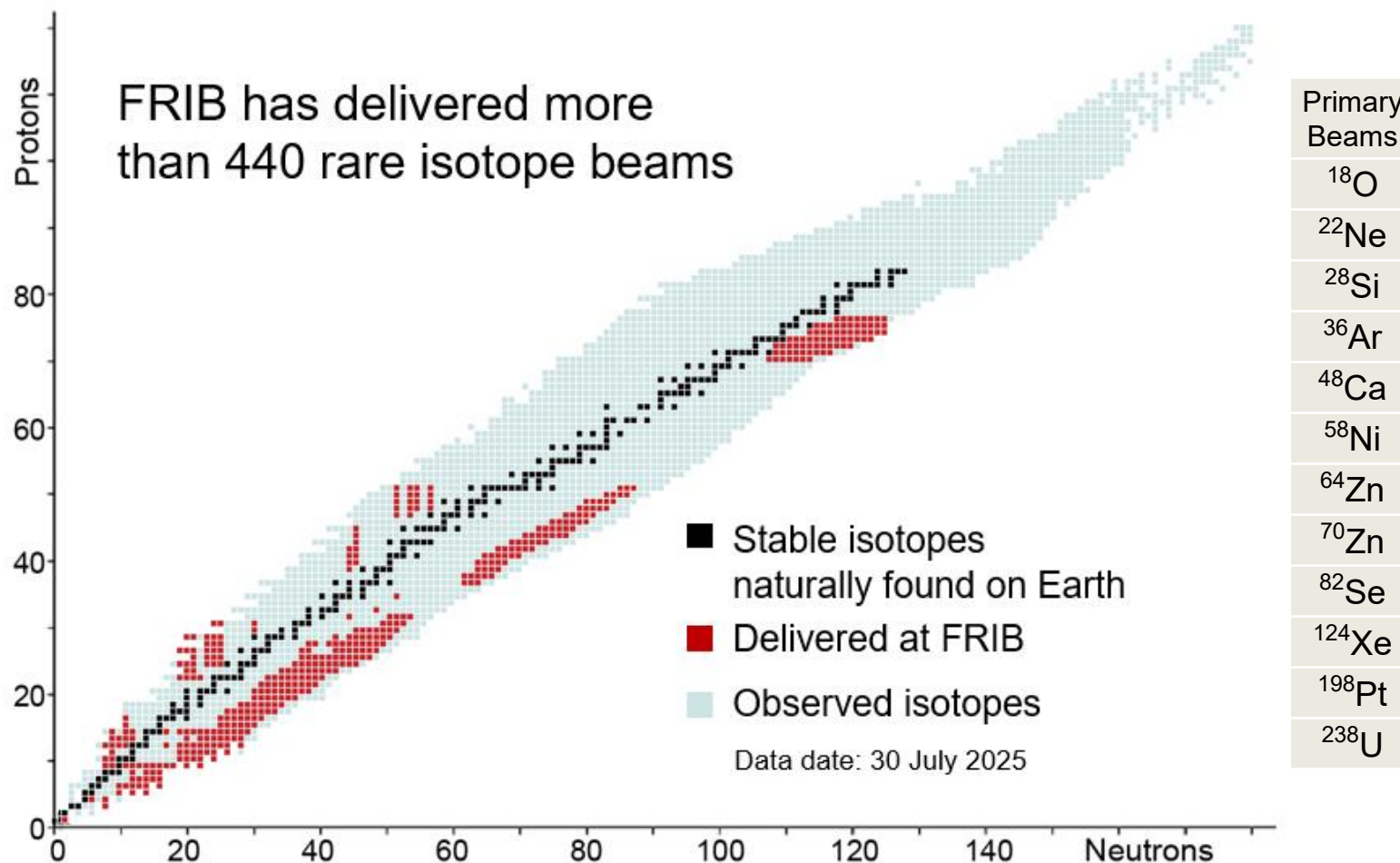
# FRIB's Mission is to Afford World-Leading Discovery Opportunities to Its Users

- User facility making rare isotope beams
- Scientific results being published
- Enhancing discovery opportunities
- FRIB continues to support the community
- Articulating public benefit and retaining the publics' support
- International cooperation
- Supporting national needs



# More than 440 Rare Isotope Beams Delivered and 931 Experimenters Supported

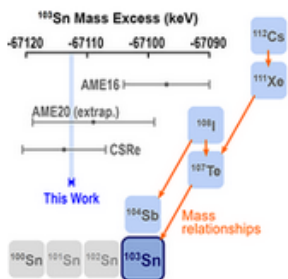
- Since the start of user operation in May 2022, FRIB has:
  - Delivered more than 440 rare isotope beams to experiments
  - Supported 931 unique participants across 174 experiments and 23 countries
- Published results available at [frib.msu.edu/publications](https://frib.msu.edu/publications)
- 27 primary beams from 21 isotopes demonstrated and available, see [frib.msu.edu/user-facilities/frib/beams](https://frib.msu.edu/user-facilities/frib/beams)



# Scientific Results Being Published – Thank You!

All FRIB Publications at [frib.msu.edu/publications](http://frib.msu.edu/publications)

LEBIT inches closer to  $^{100}\text{Sn}$  –  $^{103}\text{Sn}$  mass measurement became Editors' Suggestion  
- C.M. Ireland *et al.*, PRC 111, 014314 (2025)



EDITORS' SUGGESTION

## High-precision mass measurement of $^{103}\text{Sn}$ restores smoothness of the mass surface

C. M. Ireland, F. M. Maier, G. Bollen, S. E. Campbell, X. Chen, H. Erington, N. D. Gamage, M. J. Gutiérrez, C. Izzo, E. Leistenschneider, E. M. Lykiardopoulou, R. Orford, W. S. Porter, D. Puentes, M. Redshaw, R. Ringle, S. Rogers, S. Schwarz, L. Stackable, C. S. Sumithrarachchi, A. A. Valverde, A. C. C. Villari, and I. T. Yandow

Phys. Rev. C **111**, 014314 (2025) - Published 9 January, 2025

FDSi continues to publish high-impact results – T. Ogunbeku *et al.*, PRL in press (2025)

ACCEPTED PAPER

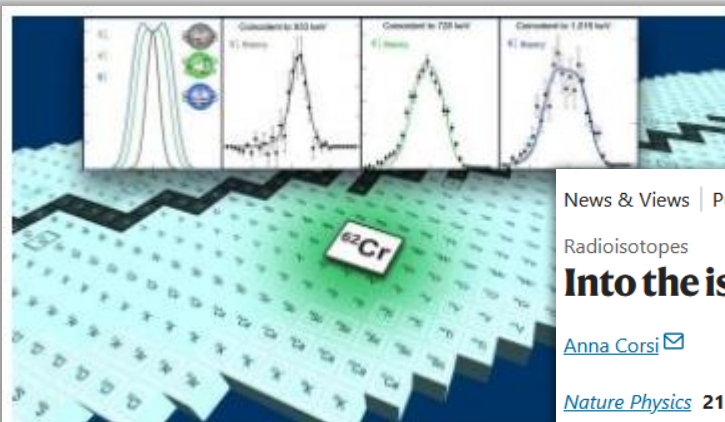
## Universal effective charges in the $sd$ and $fp$ shells

T. H. Ogunbeku *et al.*

Phys. Rev. Lett. - **Accepted** 23 June, 2025

DOI: <https://doi.org/10.1103/75ry-71sj>

First FRIB GRETINA experiment published in Nature Physics and highlighted by DOE-NP and Nature News and Views - A. Gade *et al.*, Nature Physics 21, 37 (2025)



News & Views | Published: 12 December 2024

Radioisotopes

## Into the islands of inversion

Anna Corsi

Nature Physics **21**, 3–4 (2025) | [Cite this article](#)

## Experiment Reveals Competing Nuclear Shapes in the Rare Isotope Chromium-62

Successfully modeling chromium-62 hints at an interesting structure for neutron-laden calcium-60.

> 40 theorists and experimentalist author Major Report -  
B.A. Brown *et al.*, JPG 52 050501 111, 014314 (2025)

IOP Publishing

Journal of Physics G: Nuclear and Particle Physics

J. Phys. G: Nucl. Part. Phys. **52** (2025) 050501 (128pp)

<https://doi.org/10.1088/1361-6471/adb449>

Major Report

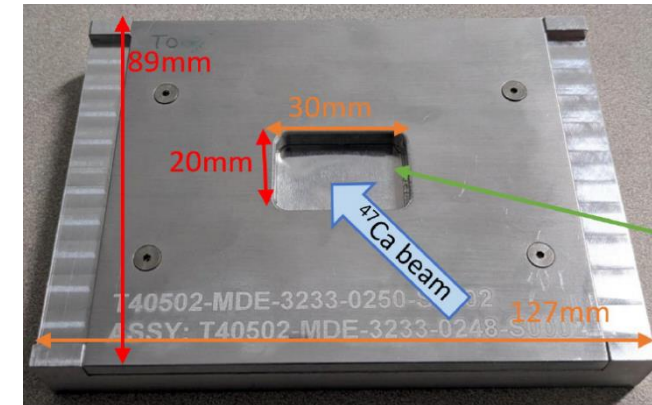
## Motivations for early high-profile FRIB experiments

# FRIB's Scientific Opportunities Continue to Increase



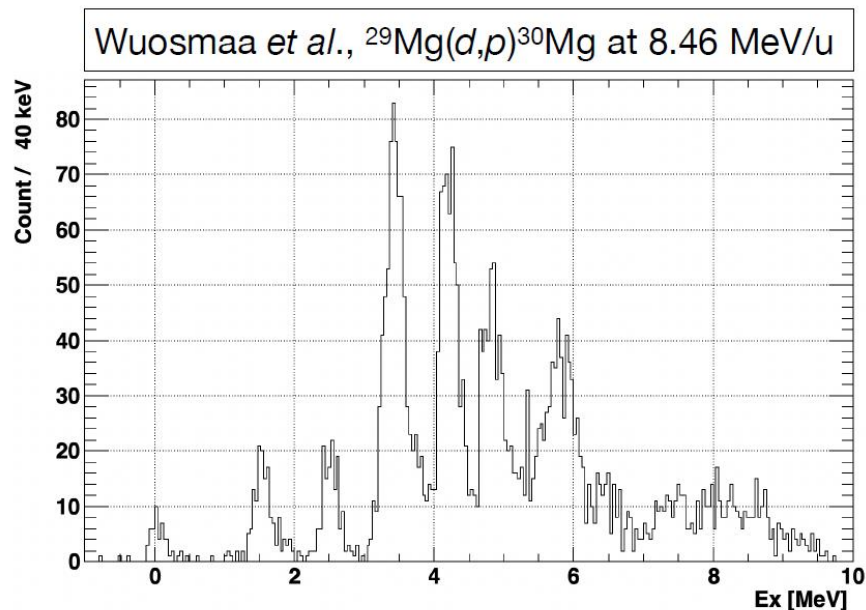
Welcomed back the **MoNA collaboration** for two experiments after completion of **S2 vault** for the study of neutron-unbound states

FRIB radiochemists and fragment separator group performed first **isotope harvesting at FRIB** (harvesting of  $^{47}\text{Ca}$  in a solid)



- $^{47}\text{Ca}$  is generator for  $^{47}\text{Sc}$  for nuclear medicine
- UTK/FRIB-led harvesting of  $^{197}\text{Pt}$  in a solid completed

Successful **SOLARIS ReA6 experiment** concluded the running period before the 2025 summer shutdown



- Upcoming: Test of first production of Th isotopes from U fragmentation and its gas-stopping on the fall schedule (important for FS program)
- FRIB started to receive GRETA

# Internal Approach to Enhancing Discovery Opportunities Further

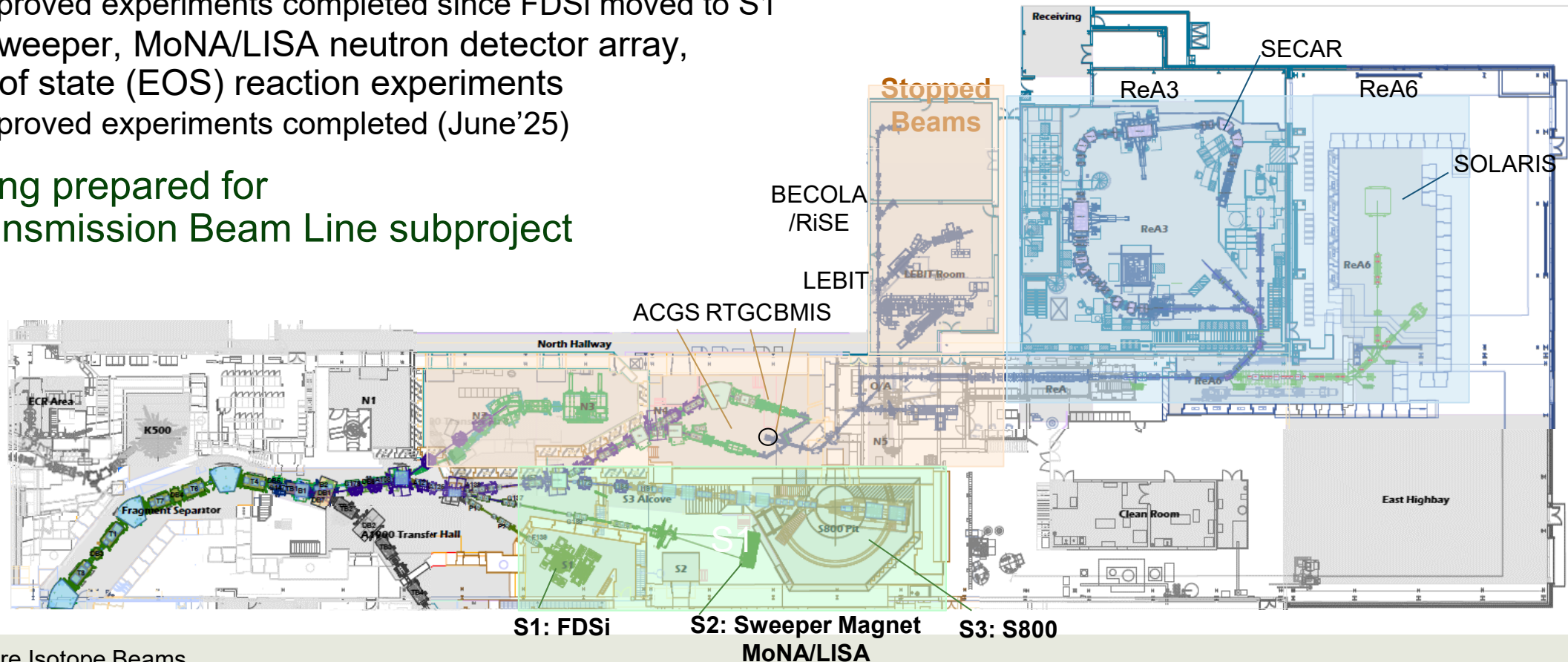
- Operate safely and anticipate and avoid adverse events
  - Experiencing and learning from actual adverse events comes at a great cost to science
- Increase secondary beam rates
  - Increase primary beam intensity safely
    - » Tested systems for 30 kW operation in July 2025, implement 25 kW routine operation in FY 2026
  - Multi-charge state acceleration routine
  - Specific beam currents by isotope and energy at [frib.msu.edu/users/beams/](https://frib.msu.edu/users/beams/)
- More machine time for science
  - Primary beam re-development has become highly efficient
  - Secondary beam development becoming more efficient
- Increased focus on experiment readiness



# Experimental Areas for User Experiments

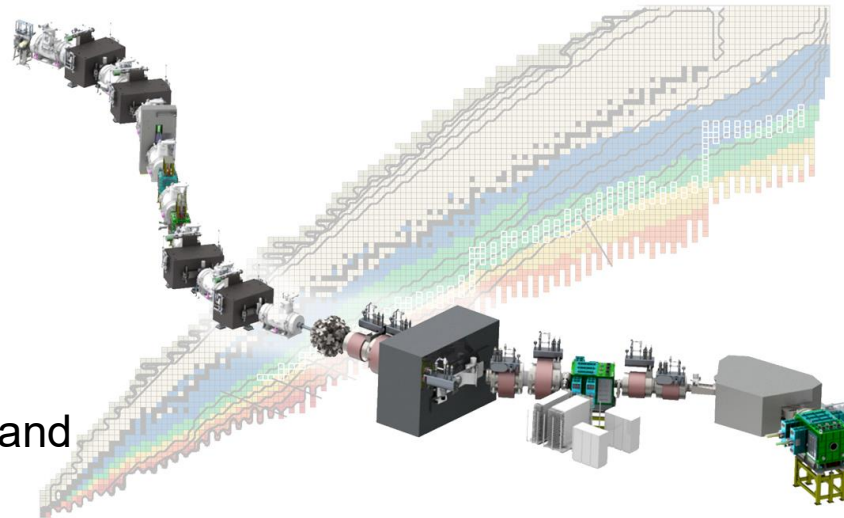
## S1 and S2 Vaults for Fast Beam Experiments Completed

- **S1 and S2 vault experimental areas for fast beam studies completed and operational since early 2025**
  - S1 vault for FRIB Decay Station Initiator FDSi
    - » Five PAC approved experiments completed since FDSi moved to S1
  - S2 vault for Sweeper, MoNA/LISA neutron detector array, and equation of state (EOS) reaction experiments
    - » Two PAC approved experiments completed (June'25)
- **HRS vault being prepared for HRS High Transmission Beam Line subproject**



# High Rigidity Spectrometer Delivered as Two Subprojects: HTBL under Construction, SPS Completing Design

- Status
  - High Transmission Beam Line (HTBL) started construction in February 2025
  - Spectrometer Section (SPS) completing design
- HRS will have a significant benefit for FRIB's scientific program, in particular with regard to **extending the scientific reach to neutron-rich isotopes by a combined production-rate and luminosity increase of up to a factor of more than 100**
- Delivered as two subprojects:
  - High Transmission Beamline (HTBL)
  - Spectrometer Section (SPS)
- HRS enables broad science programs with the furthest reach, able to accommodate scientific program after FRIB 400 MeV/u upgrade
- The community is energized
  - HRS working group has members from 20 U.S. universities and 5 U.S. national laboratories (meets regularly)
  - User community of over 500 scientists for HRS is expected
  - International interest and coverage: [Nuclear Physics News](#)



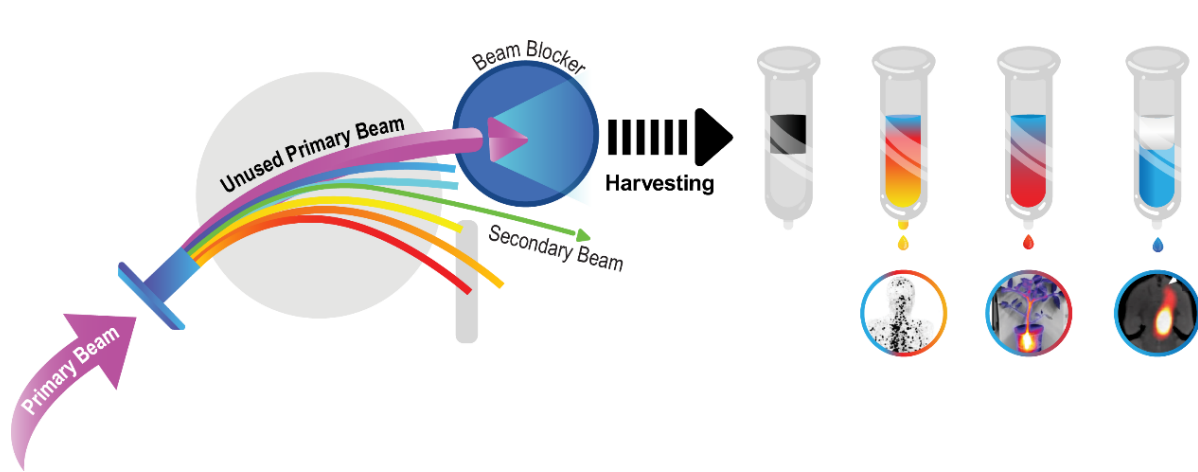
HRS White Paper available on LBNL-hosted HRS website:  
[hrs.lbl.gov/documents](https://hrs.lbl.gov/documents); HRS Preliminary Design Report  
released: [frib.msu.edu/users/instruments/projects/hrs.html](https://frib.msu.edu/users/instruments/projects/hrs.html);

*The Nuclear Science Advisory Committee's "A New Era of Discovery: The 2023 Long Range Plan for Nuclear Science," released on 4 October 2023, calls for investments in additional projects and new strategic opportunities that advance discovery science. Instruments aspired by the community for FRIB, such as the High Rigidity Spectrometer, the Gamma-Ray Energy Tracking Array, the FRIB Decay Station, and the Isochronous Spectrometer with Large Acceptance, feature in the science sections of the 2023 Long Range Plan for Nuclear Science*



# FRIB Isotope Harvesting Can Quickly Create Research Quantities of Any Rare Isotope for Multiple Fields of Study

- FRIB's isotope harvesting program will capitalize on unused isotopes from routine operations — with no disruption to FRIB's primary users
- Enables research in medicine, biochemistry, materials science, and environmental research
- Recommended by the Nuclear Science Advisory Committee Isotopes, a federally chartered advisory committee to DOE
- Isotope harvesting whitepaper published (J. Phys. G: Nucl. Part. Phys. 46 (2019) 100501)
- Isotope Harvesting Vault project completed, supported by DOE Isotope Program
  - » System commissioning underway with sample harvesting to begin in early 2026



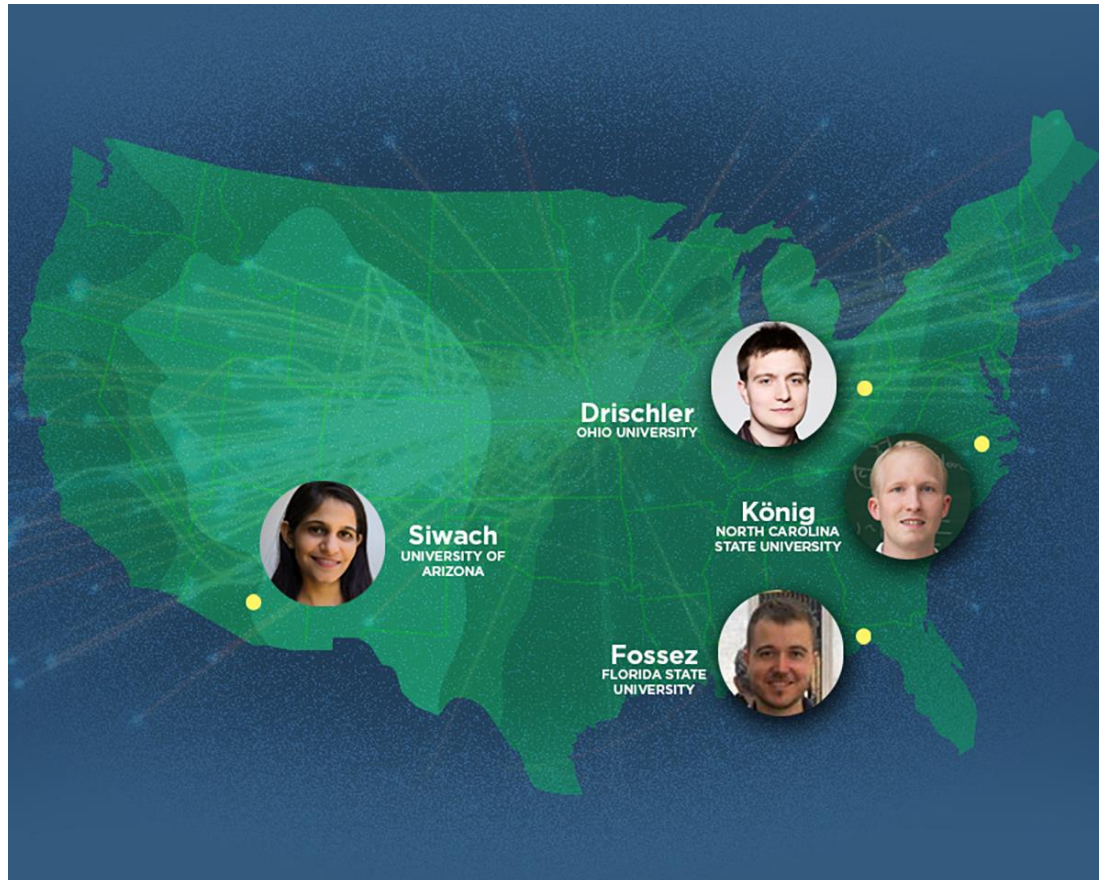
# FRIB Continues to Support the Community

- Experimental Bridge Faculty Initiative – two faculty members started at Mississippi State and University of Kentucky,
  - Third institution selected: NC State. Search will be restarted for the next FY assuming the NC State hiring freeze ends by then
- FRIB Achievement Award for Early Career Researchers recognize one outstanding experimentalist and one outstanding theorist in nuclear science who have made a significant contribution toward FRIB science
- Continued support for FRIB Users Organization and its working groups
- Continued in 2025: Graduate student support to travel to the LECM
- Community leadership in instrument development



# FRIB Theory Alliance Supports a Healthy U.S. User Community

## ■ FRIB TA Bridge Faculty



## ■ Current and starting FRIB TA Fellows – 5-year postdoc position preparing for faculty/staff positions

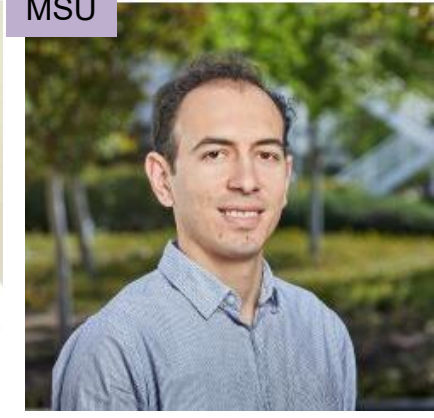
ORNL



LANL



MSU



UW



MSU



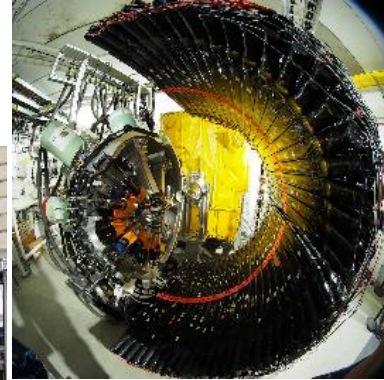
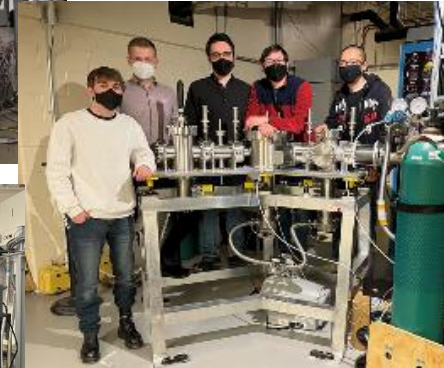
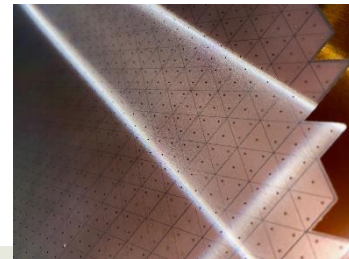
## ■ FRIB TA Topical Programs and Summer Schools

*Future directions in nuclear  $\beta$ -decay at FRIB, 9/8/25 – 9/19/25*

*Emergence of collective motion in atomic nuclei, 8/19/25– 8/22/25*

# New Scientific Instrumentation Realization with Community Engagement and Leadership - Examples

- **FRIB Decay Station initiator (FDSi)** - led by ORNL
  - Phase 1 complete and four successful FRIB PAC experiments
  - Phase 2 complete and five successful FRIB PAC experiments
- **SOLARIS: SOLenoid spectrometer Apparatus for Reaction Studies** – led by ANL
  - Phase 1 complete and several successful experiments at ReA6
    - Phase 2 (dedicated Si-array) in progress
  - Data acquisition for SOLARIS realized by FSU
- **RiSE: Collinear laser Resonance Ionization Spectroscopy at BECOLA** – led by MIT
  - Successful demonstration of  $^{229}, ^{232}\text{Th}$  laser spectroscopy
  - Charge radii of a bubble nucleus candidate  $^{34}\text{Si}$  successfully measured
- **SALER – Superconducting Array for Low-Energy Radiation** – led by Colorado School of Mines
  - First quantum sensing experiments “on-line” at any rare isotope beam facility
  - Superconducting Quantum Sensor Spectrometer delivered
  - SC Tunnel Junction expertise provided through LLNL
- **Equation-of-State Active-Target Time-Projection Chamber (EOS-TPC)**
  - TAMU is leading effort
  - Whitepaper completed



# FRIB Preparations for GRETA Underway

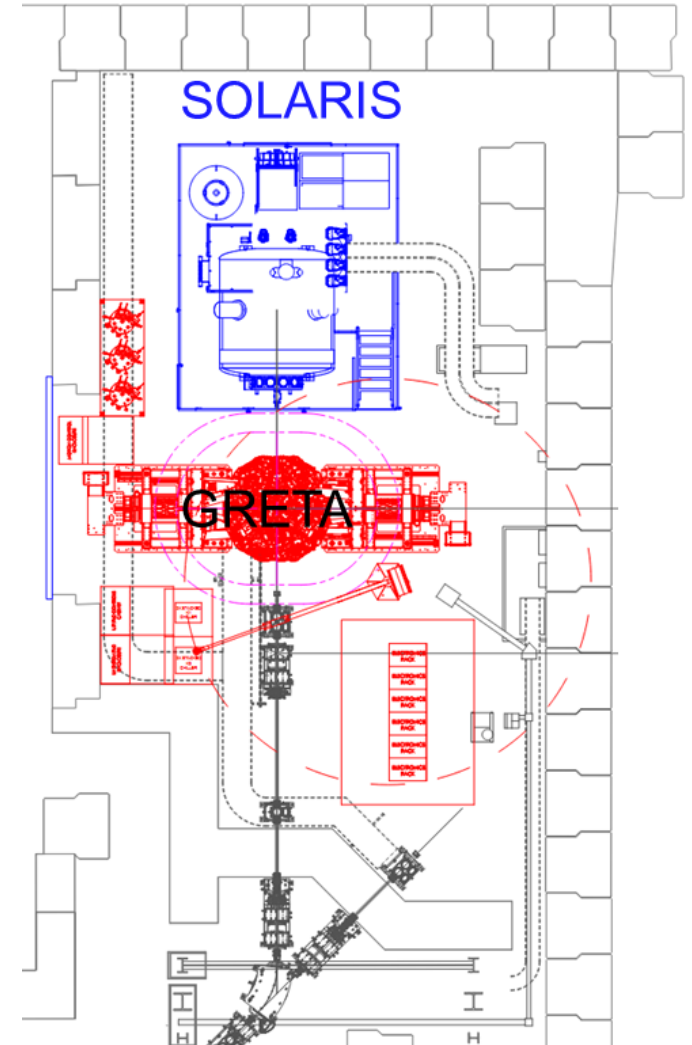
- The US nuclear science community made the science case for GRETA at FRIB using fast and reaccelerated beams
  - FRIB will enable both
- Congratulations to GRETA project team on achieving CD-4A
- Locations for GRETA at FRIB
  - Fast beams
    - » Short-term: GRETA at S800
    - » Mid-term: GRETA at HRS and S800
    - » Long-term: GRETA also at HRS with FRIB400
  - Reaccelerated beams
    - » Short- to mid-term: GRETA at ReA6
    - » Long-term, aspirational: GRETA at ReA9-12



# GRETA at FRIB – High-level Notional Timeline

## Subject to Optimization/Modification Based on Federal Funding

- **July/August/September:** Receive GRETA (~6 trucks from LBNL)
- Set up GRETA for offline commissioning in the ReA6 vault over the fall
  - Goal: Gain operational experience with GRETA
- **Early 2026 – Fast Beams:** Set up GRETA at the S800 in the modified GRETINA frame and commission in-beam performance
- **Not before Summer 2026:** PAC4 including GRETA at S800 and ReA6, assuming GRETA is commissioned by then in both places
- **Not before late 2026:** Experiments with GRETA at the S800 possible
- **Possibly sometime in 2027 – Reaccelerated Beams:** Move back to ReA6 for experiments (by then, all GRETA quads should have arrived)



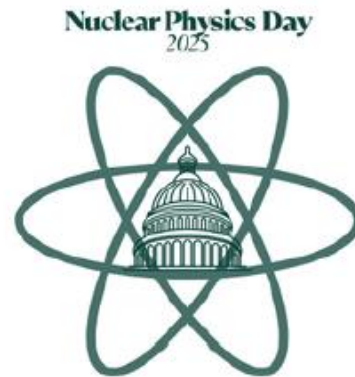
# Articulating Public Benefit and Retaining the Public's Support for Nuclear Science [1]

## ■ Nuclear Physics Day 2025 - organized by MSU

- 30 April 2025
- 22 states represented
- 103 attendees
- 33 Senate meetings
- 37 House meetings
- Representing all 5 community user groups: RHIC, EIC, ATLAS, FRIB, JLAB

**NUCLEAR  
PHYSICS DAY  
2025**

Representing the Nuclear Science Community  
on Capitol Hill

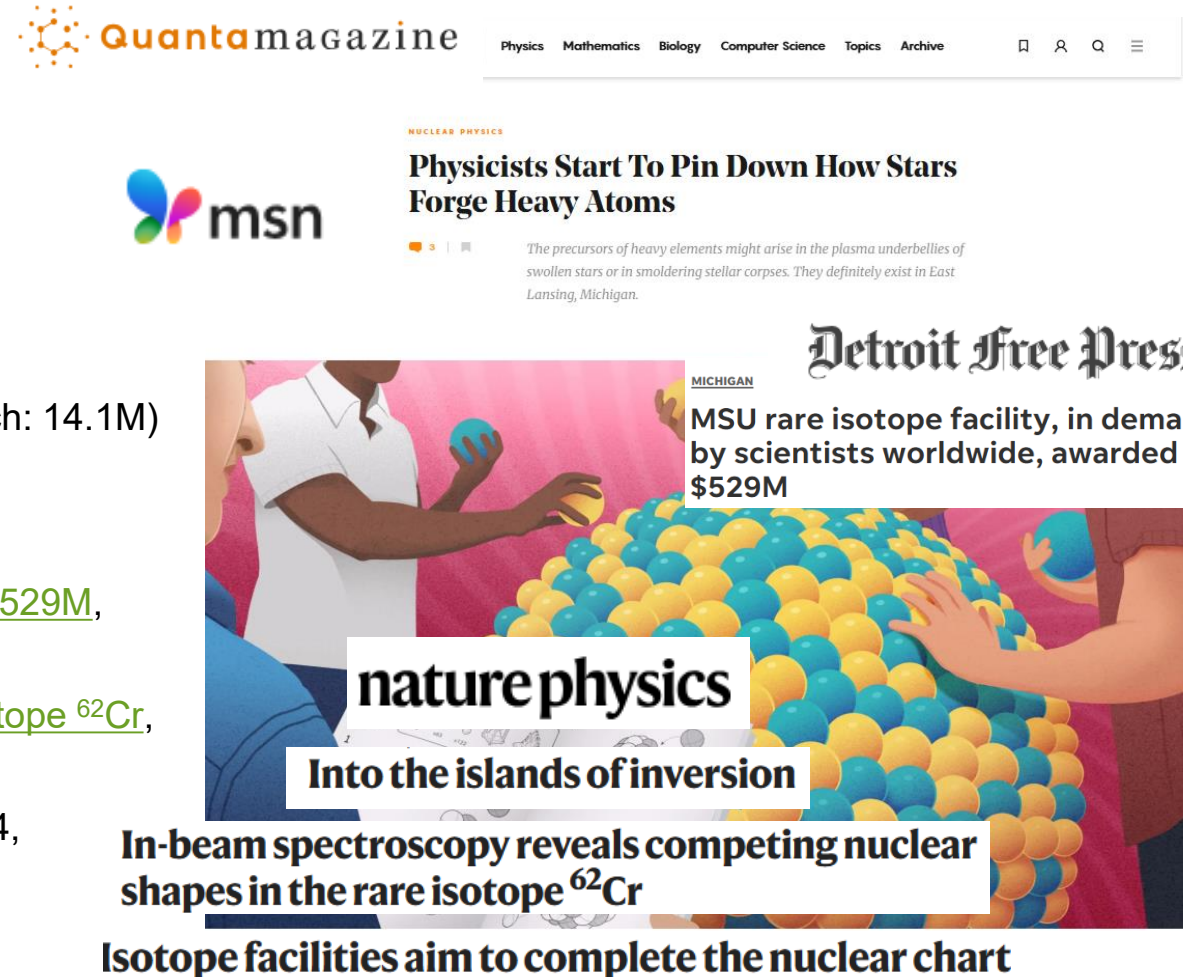


# Articulating Public Benefit and Retaining the Public's Support for FRIB Science [2]

- Select stories on FRIB science results and capabilities in popular press

- 6 examples highlighted here
- 105M people potentially saw this content
  - » [Physicists start to pin down how stars forge heavy atoms](#), 2 July 2025, Quanta Magazine (Reach: 268K)
  - » [Into the islands of inversion](#), 12 December 2024, Nature Physics\* (Reach: 14.1M)
  - » [Isotope facilities aim to complete the nuclear chart](#), 10 December 2024, Nature Physics\* (Reach: 14.1M)
  - » [MSU rare isotope facility, in demand by scientists worldwide, awarded \\$529M](#), 30 November 2024, Detroit Free Press\* (Reach: 796K)
  - » [In-beam spectroscopy reveals competing nuclear shapes in the rare isotope  \$^{62}\text{Cr}\$](#) , 18 October 2024, Nature Physics\* (Reach: 14.1M)
  - » [Scientists accelerate uranium beam with record power](#), 10 October 2024, MSN News (Reach: 61.6M)

\* Indicates "tier 1" media outlet, as determined by the DOE-SC Office of Communications and Public Affairs; Reach values per Cision media monitoring service



# Strategic Engagement with International Partners Extends FRIB's Global Impact

- French **Centre National de la Recherche Scientifique (CNRS)** established IRL NPA at FRIB
  - Leverages FRIB's unique research capabilities to address nuclear physics and astrophysics research questions
  - Three scientists stationed at FRIB
- Inauguration ceremony with agreement-signing held at FRIB in July 2023; inaugural science meeting in December 2023 at FRIB; French ambassador to U.S. visits FRIB in July 2024
- CNRS has nearly 80 international research laboratories worldwide; IRL NPA at FRIB is first dedicated to nuclear physics and astrophysics



- **UKRI/Science and Technology Facilities Council (STFC)** funds FAUST (Facility for Accelerated-beams for Understanding Science and Technology) instrument which will enable new experiments at FRIB
- This is £3.2M investment benefiting FRIB and its user community
- The UK team visited FRIB in January 2024 and March 2025.
- The first FAUST Science Workshop was held on 14-15 April 2025 at the Institute of Physics in London, UK.

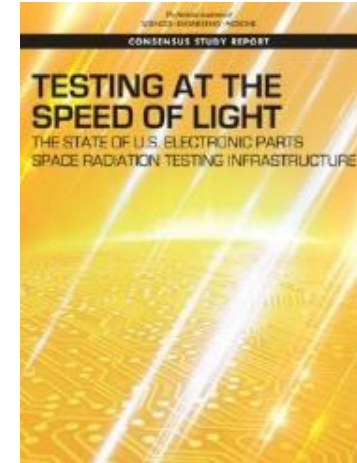


- Discussion with **Italian National Institute for Nuclear Physics (INFN)** exploring Nuclear Structure, Dynamics, and Astrophysics project at FRIB (INFN-NUSDAF)
- Involves five INFN collaborations with multi-purpose experiment setups



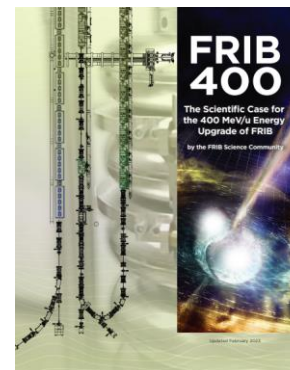
# FRIB Chip-Testing Facilities Respond to National Need and Leverages Accelerator Expertise

- As suggested by DOE-SC, MSU responds to National Academy call to build up national testing capacity and capabilities
  - Constructed new beamline extension from FRIB accelerator (2022)
  - Re-commissioned the K500 cyclotron as a standalone facility (2025)
- Accelerator expertise developed by DOE-SC user facility supports national need; existing facilities are oversubscribed
- FRIB's heavy-ion facilities: FRIB Single Event Effects Facility (FSEE) and new K500 Chip Testing Facility (KSEE) —provide capacity for testing chips used in spaceflight, wireless tech, and autonomous vehicles
- Key element of national infrastructure, serving industry, government, academia
- MSU-funded faculty lines and building addition increases facility capability, capacity
  - » Facility will triple the testing capacity of current chip-testing facility by providing two additional user vaults
- Key facility in workforce development training with academic and industrial partners for training in radiation effects
  - Space Electronics Initiative in MSU College of Engineering



# FRIB400 Energy Upgrade Increases Scientific Reach of FRIB R&D Underway

- The science opportunities afforded by FRIB feature prominently in the 2023 Long Range Plan, including FRIB400 and FRIB instruments, following the continued endorsement by our energized community
- FRIB400 will:
  - Enable significant gains in isotope yields, **nearly doubling the reach of FRIB along the neutron dripline and**
  - **bring into reach critical nuclei relevant to understand the origin of the heavy elements in the Universe and processes in neutron stars**
  - **Create dense nuclear matter** of up to twice saturation density, **critical for multi-messenger astrophysics**
  - Provide **up to two-orders-of-magnitude increase in luminosity** for spectroscopy in key regions of the nuclear chart
  - Expand the scientific impact of harvested isotopes by **increasing the available yield of many isotopes by 10 times**
- FRIB400 opportunity:
  - First accelerator cavities exceed specifications
  - Can be implemented in a phased approach, with gains at every stage
  - Team to build it is in place
- FRIB400 whitepaper (2023 update)  
linked from [frib.msu.edu/frib400](https://frib.msu.edu/frib400)



*Finally, a **timely energy upgrade of the recently completed Facility for Rare Isotope Beams (FRIB400)** offers a golden opportunity to use the collision of heavy ions to probe the equation of state in regions of critical importance for multi-messenger astronomy.*

*Sidebar 5.2 Neutron Star Inspired Density Ladder, 2023 LRP*

*The **FRIB400** project's doubling of the energy available at FRIB would not only increase reaction rates by employing higher luminosities but also would enable new reaction mechanisms to be used*

*4.6 What Happens When Nuclei Collide?, 2023 LRP*



Facility for Rare Isotope Beams  
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[frib.msu.edu](https://frib.msu.edu)

**FRIB400** is explicitly mentioned in the **executive summary following Recommendation IV** which calls for **investments in additional projects and new strategic opportunities that advance discovery science**

# Summary

- User facility making rare isotope beams
- Scientific results being published
- Enhancing discovery opportunities
- Establishing a highly skilled scientific workforce
- Articulating public benefit and retaining the publics' support
- International cooperation
- Supporting national needs
- FRIB400 increases scientific reach of FRIB

