

The UNH Closed-Loop Helium Liquefier System for Polarized Targets

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Sustainable Cryogenics for Nuclear Physics

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Advisor: Karl Slifer

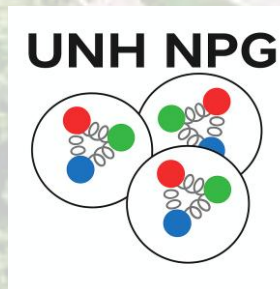
**Department of Physics and Astronomy,
University of New Hampshire**

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UNH Graduate Research Conference 2026



**University of
New Hampshire**



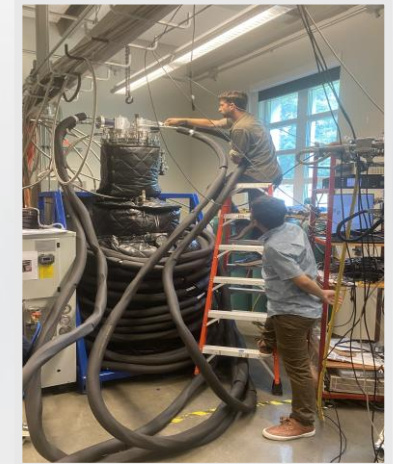
- **UNH Polarized Target System**
- **Global & Facility-Scale Sustainability Efforts**
- **UNH Closed-Loop Helium Recovery System**
- **A Scalable Model for University Laboratories**
- **Sustainability Impact**



HP Gas Cylinders



He Gas Bag



500 L Helium Dewar



Helium Purifier

Courtesy of K. Slifer

- Achieved ~1 Kelvin temperature via Helium-4 evaporation cooling.
- High boil-off from cryostat (magnet and refrigerator).
- Production rate 40L/day with the recapture efficiency >90%.
- 1 week physics and 2-3 weeks of reliquification.

Critical Dependence Across Industries

Medical and Healthcare:

- MRI machine needs ~1,700 L liquid helium
- ~40 million MRI scans/year in the US.

Semiconductor and Technology:

- Intel, TSMC, Samsung for chip fabrication cooling and leak detection.

Space and Defense:

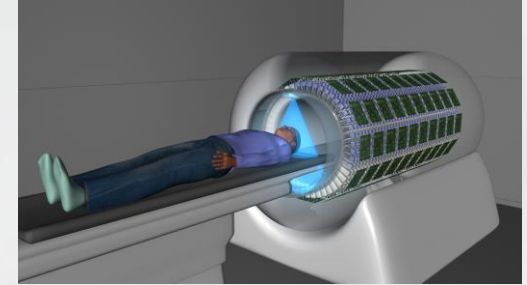
- NASA, SpaceX for pressurizing rocket fuel tanks;
- James Webb Telescope for cryogenic cooling.

Scientific Research and Quantum Computing:

- CERN, Jefferson Lab, Fermilab for accelerator magnets.
- IBM, Google for millikelvin cooling for quantum computers.

Energy – Nuclear Fusion:

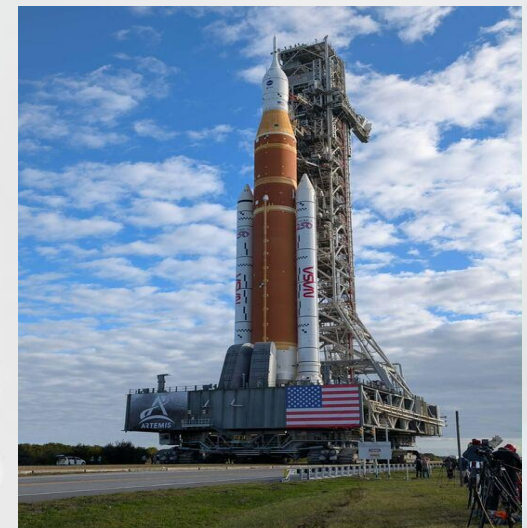
- ITER tokamak for superconducting magnet cooling.



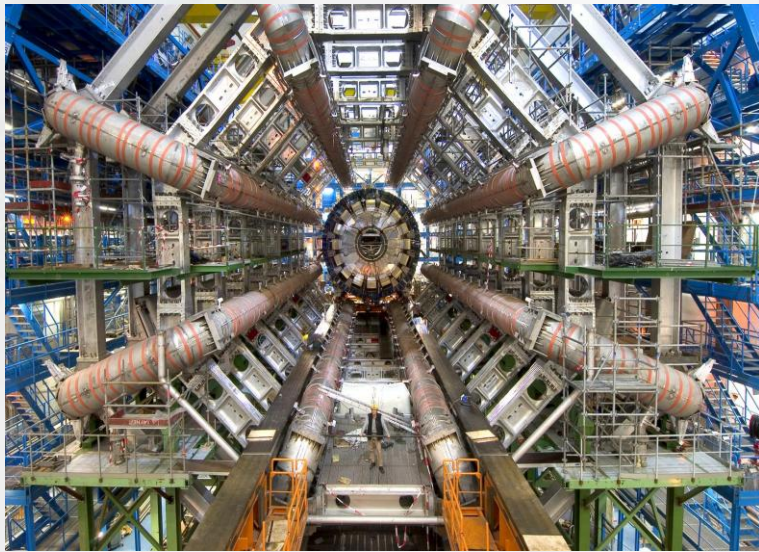
MRI Scanner



Chip Fabrication



Artemis II



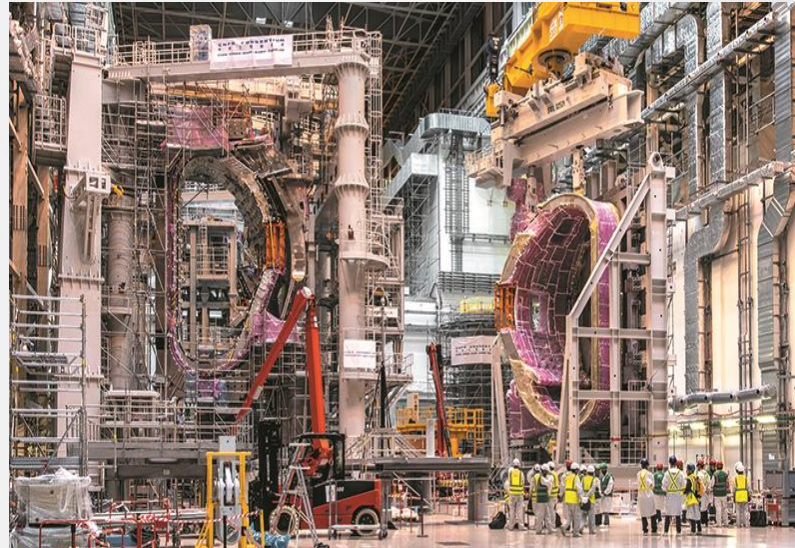
ATLAS Experiment, CERN



Hall-B Experiment, Jefferson Lab



SpinQuest Experiment, Fermilab



ITER Fusion Reactor, France

Sustainability Drivers

- Superconducting magnets and polarized targets require stable cryogenic environments
- Open-cycle helium usage leads to high losses and rising operational costs
- Global helium supply constraints threaten long-term experimental programs

Facility-Scale Solutions

- Closed-loop helium recovery and purification systems
- Integration of liquefiers directly with experimental cryostats
- Real-time monitoring of boil-off and recovery efficiency



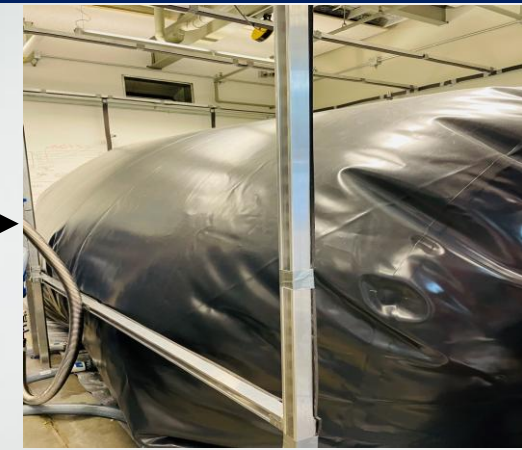
Mother Dewar



Cryostat



Collection Manifold



Gas Bag



Liquefier



Purifier



Gas Banks(48 cyl.)



gHe Compressor
Courtesy of C. Lama

<https://inspirehep.net/literature/2940489>

- UNH's closed-loop helium liquefier follows the same sustainability model
- Enables extended experiments with >90% helium recapture
- Scalable solution for university-based nuclear physics programs



Scalable Design

Quantum Technology systems scale from 20 to 200 L/day — suitable for single-instrument labs to multi-cryostat facilities.



Supply Independence

Closed-loop operation insulates labs from helium market volatility, shortages, and geopolitical supply disruptions.



Environmental Responsibility

Recovering a non-renewable resource aligns with institutional sustainability goals and reduces the carbon cost of helium transport.

- Moderate footprint – fits typical university lab space.
- Hands-on cryogenics training for graduate & undergraduate students.
- Minimal daily supervision once commissioned.
- Direct preparation for careers at national labs and industry.



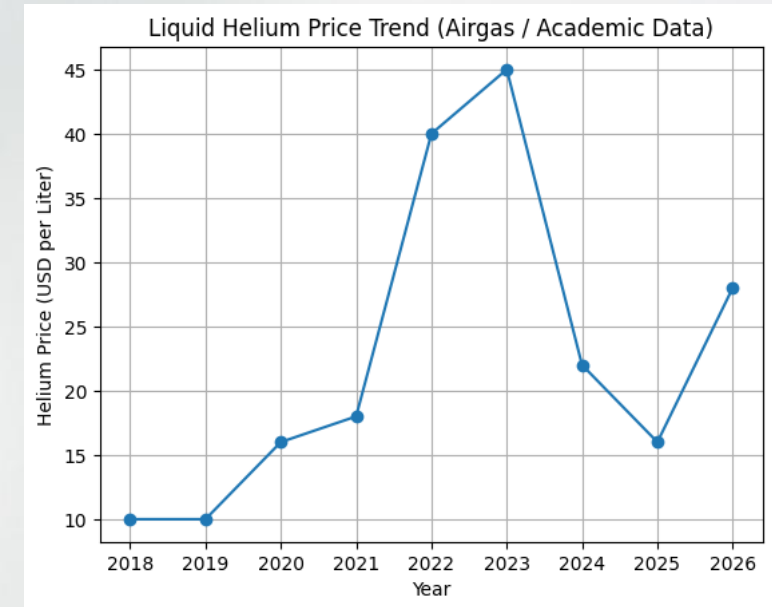
Economic Impact – Sustainable & Cost-Effective:

- Eliminates routine venting of non-renewable helium.
- Helium cost: \$40-50+ per liter and rising.
- Predictable operating costs for better grant planning.
- Eliminates risk from market volatility and shortages.

Scalable Model – Beyond UNH

- Modular design adaptable to any helium-using laboratory.
- Enables research continuity during global supply disruptions.
- If widely adopted, it helps for massive reduction in global helium waste.

➤ **Note: I will also present the UNH sustainability at a Sustainable HEP 2026 – 5th Edition.**





What Happened

- Iran closed the Strait of Hormuz in response to US-Israeli airstrikes (March 2026)
- Missiles struck Qatar's Ras Laffan LNG complex — 17% of Qatar's LNG capacity destroyed
- Qatar Energy halted LNG production; repairs will take 3–5 years
- ~200 specialized helium cryogenic containers stranded in the Gulf (\$1M each)
- Helium containers only hold 35–48 days — after that, product evaporates and is lost



Global Impact

- 33% of world helium supply offline — "Shortage 5.0"
- Qatar produced 63M m³ of 190M m³ global total (2025 USGS)
- Spot helium prices surged 70–100% within weeks
- South Korea: 55% of He from Gulf states; Taiwan: 69%
- Semiconductors, MRI scanners, and space missions all affected
- Semiconductor industry = largest He consumer globally



➤ UNH Polarized Target System:

- Achieves ~1K operation using Helium-4 evaporation cooling.
- High boil-off during extended experimental runs necessitated a sustainable solution.

➤ UNH Closed-Loop Helium Recovery System:

- Fully integrated recovery, purification, compression, and reliquefaction.
- Produces ~40L/day with >90% helium recapture efficiency.

➤ Alignment with Global Best Practices:

- Mirrors sustainability approaches at CERN, Fermilab, Jefferson Lab, and ITER.
- Demonstrates that facility-scale solutions can be adapted to universities.

➤ Broader Impact:

- Reduces operational costs and helium waste.
- Ensures long-term research continuity.
- Serves as a scalable, sustainable model for helium-dependent laboratories worldwide.

Please join the effort:

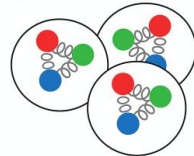
- Karl Slifer (karl.slifer@unh.edu) [Spokesperson of b_1 (E12-13-011) Experiment]
 - **E12-13-011: The Deuteron Tensor Structure Function b_1 .** [Link](#)
- Elena Long (elena.long@unh.edu) [Spokesperson of A_{zz} (E12-15-005) Experiment]
 - **E12-15-005: Measurement of the Quasi-Elastic and Elastic Deuteron Tensor Asymmetries.** [Link](#)

Thanks



University of
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Science

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RunGroup Spokespersons

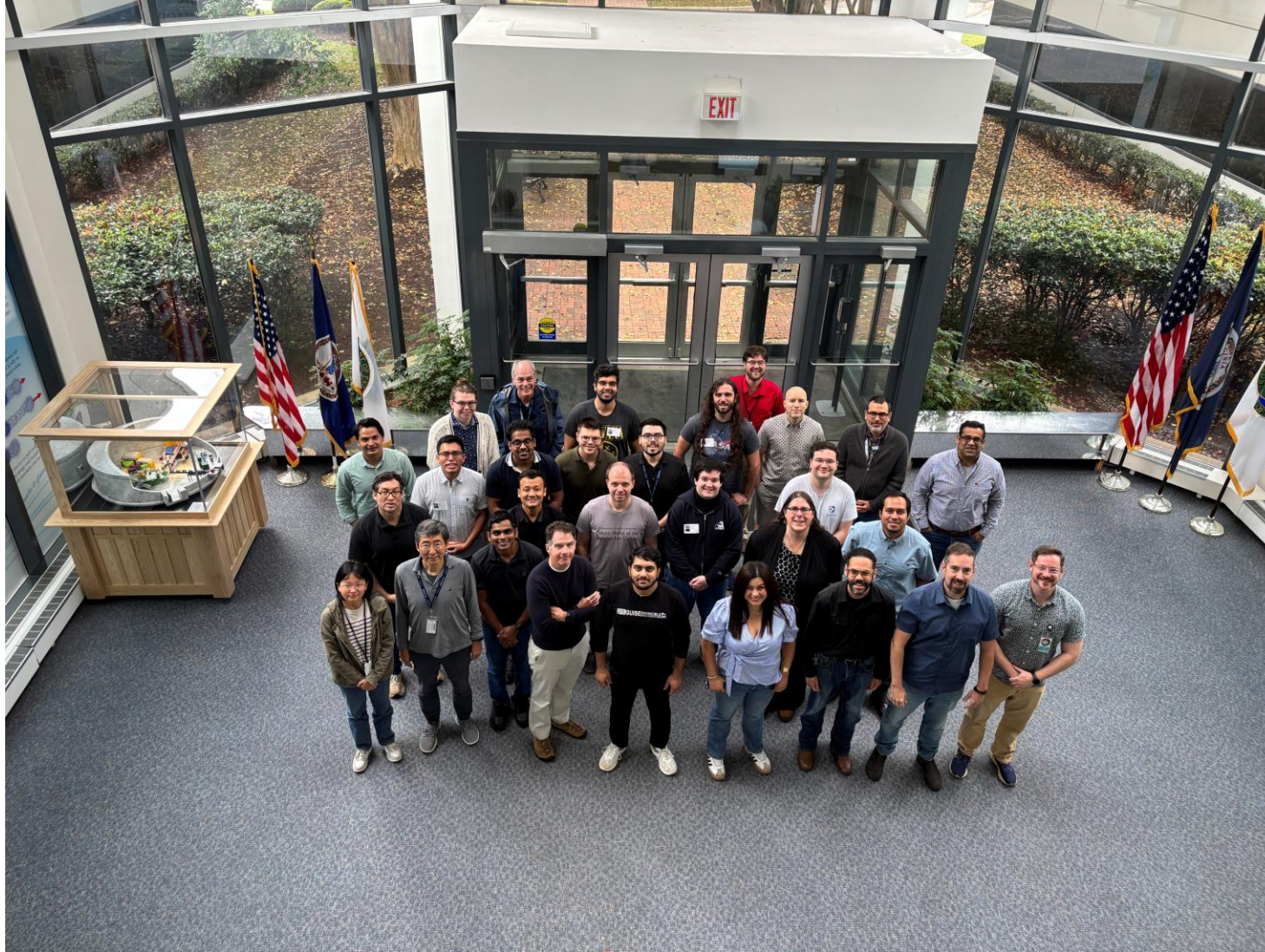
Chen, Day, Higinbotham, Kalantarians, Keller,
Long, Rondon, Santiesteban, Slifer

- 14 different active institutions
- 12 identified PhD students (from 3 universities)
- 3 active post-docs + 1 more expected
- Weekly meetings

Join by going to link <https://mailman.jlab.org/mailman/listinfo/Tensor>

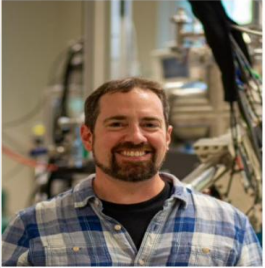
OR

just send an email to karl.slifer@unh.edu to be added



Polarized Target Group at UNH

Professors



Karl Slifer

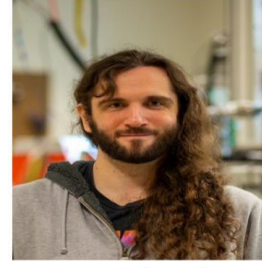


Elena Long



Nathaly Santiesteban

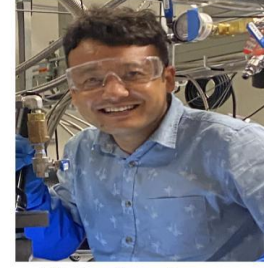
Graduate Students



Michael McClellan



Anchit Arora



Chhetra Lama

Postdocs

Utsav Shrestha

Jan Vanek

Undergraduate Student



Eli Phippard



Zoe Wolters



Muhammad Farooq

Aden Whitney

Benjamin Limric



Hector Chinchay

Samuel Takwirira

2026 UNH Polarized Target Group