FY2026 NPP LDRD Type B Pre-Proposal

Development of new techniques to measure high-energy nuclear reaction data at NASA Space Radiation Laboratory

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8 January 2025

FY2026 NPP LDRD Type B Pre-Proposal

Proposal title:

Development of new techniques to measure high-energy nuclear reaction data at NSRL

Primary Investigator(s): Trevor Olsen, Shuya Ota

Other Investigators:

Indicate if this is a cross-directorate proposal: Yes

If yes, identify other directorates/organizations: NNDC (EBNN directorate)

Proposal Term: 2 years From: 1 Oct. 2025 To: 1 Aug. 2027

Brookhaven National Laboratory

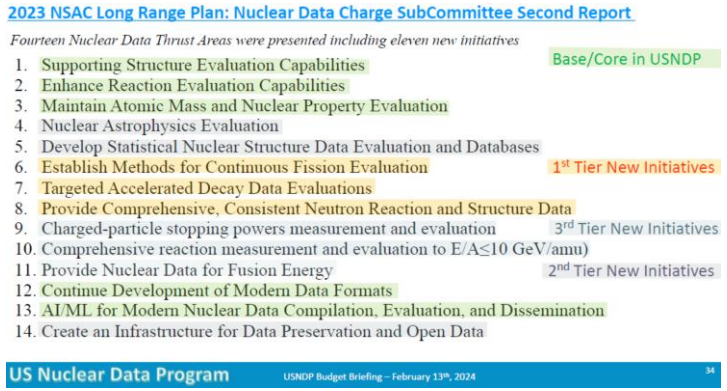
FY2026 NPP LDRD Type B Pre-Proposal

Proposal title and brief abstract: Development of new techniques to measure high-energy nuclear reaction data at NSRL

The NASA Space Radiation Laboratory (NSRL) hosts user experiments for two distinct sectors; NASA Radiobiology and space industry microelectronics testing. Both user bases heavily rely on high-energy nuclear data for radiation transport simulations such as MCNP and Geant4. However, a severe lack of nuclear data are often highlighted by researchers in those sectors.

This project will measure select reaction cross sections for high-energy (1 GeV/nucleon) proton and helium induced spallation reactions at NSRL. Cross-sections can be determined by measuring prompt γ-rays emitted from the produced nuclei decays immediately after a reaction, using high-purity Germanium (HPGe) detectors and light ion fragments will be detector using scintillators. Additionally, we will develop a new “micro-pulsed” slow extraction technique using the recently-installed air-core quadrupole (ACQ) in the AGS booster. The ACQ enables rapid tune manipulation of stored beam, pushing small fractions out of stability (and therefore out to the beamline) in a controlled, deliberate manner. At the conclusion of this project, we will present cross-section data, report on the target room environment, necessary shielding characteristics, and evaluate the quality of the micro-pulsed beam for these experiments.

Program(s): NP, ARDAP(?)



Return on Investment:
The DoE NP program has **regular funding opportunities for nuclear data needs** outlined in WANDA. Work done in this study **creates opportunities for additional experiments** at NSRL through those grants.

Broader impact on the activities at the laboratory:
Within group: NSRL gains a **controlled, micro-pulsed beam** technique and related **controls tools**. This ability could **expand the user community** to nuclear data measurements. Existing microelectronics tester at NSRL could also benefit from this development with increased accuracy in partial spill flux determination (number of events observed in a fractional spill).

Within lab: High energy nuclear data cross sections are used widely across the lab. Increased inter-directorate collaboration.

Total planned funding per year in FY26 and FY27: Year 1 $180k (labor & procurement), Year 2 $250k (labor & beam time), Total: $430k

Proposal Motivation…

OFFICE OF SCIENCE

Pressing The Effort to Advance Nuclear Data
A Perspective from DOE NP

February 26, 2023

Tim Hallman
SC AD for Nuclear Physics

Outlook

- **Nuclear data plays a critical role in all areas of nuclear science, nuclear engineering, and applications of nuclear technology**
- **Specific targets for increased investment and enhanced stewardship include:**
  - Workforce development
  - On-going fission evaluations
  - Accelerated decay data evaluations
  - Improved reaction modeling with better links to nuclear structure
  - Neutron induced data from low- to mid-energies
  - High energy reactions and material stopping power

Opportunities Identified For Increased Impact/Stewardship

Opportunity 2: Space Exploration

- **Recent NP outreach to NASA** led to needs in space exploration in human spaceflight, electronics protection, and planetary exploration
- **Human Spaceflight** requires high energy data due to galactic cosmic rays hitting spacecraft → dose to astronauts
- **Electronics Protection** requires data on advanced electronics materials (GaAs)
- **Planetary Exploration** requires data on a variety of elements that could be found on the Moon, Mars, and beyond
- **Aligns With Administration Priority on** return to the moon and on to Mars

FINAL RECOMMENDED REACTIONS

Fe,Si,O,He + H,C,Al,Fe → ^{1,2,3}H, ^{3,4}He (isotopic dd & total reaction σ)

3 GeV/n, 1.5 GeV/n, 800 MeV/n, 400 MeV/n dd = double differential

The **need for nuclear data** of this type is specifically **called for by DoE/Tim Hallman** at the 2024 Workshop for Applied Nuclear Data Activities.

As few beamlines are capable of reaching these experimental conditions. As a domestic heavy ion beam line, **NSRL is an excellent choice to support these experiments** and **this LDRD enables it**

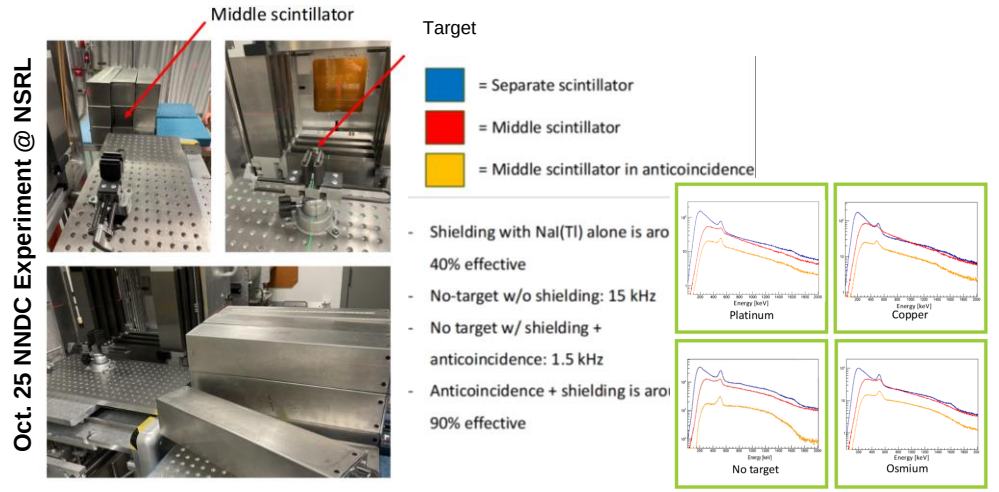
Overview

Nuclear data needs are constantly growing, especially in an energy regime relevant to space applications where very few measurements exist. New measurements to address those needs are lacking.
Part of the issue is accessibility to an accelerator capable of performing these studies.

NSRL is underutilized for nuclear data measurements.

Approach

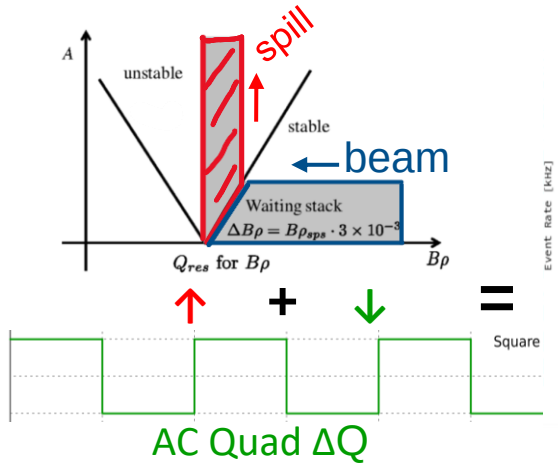
An NNDC experiment at NSRL on Oct. 25 briefly measured the NSRL target room background with beam on, observing count rate.
→ Safe for HPGe… if shielded appropriately (borated poly and W)

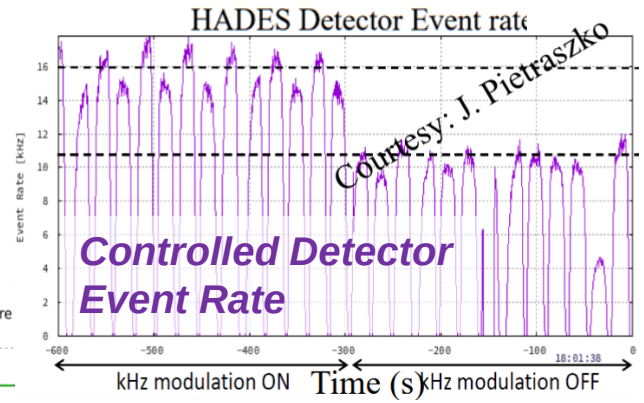


HPGe prompt gamma measurements of Pb thin target reaction products. → Aims to reduce uncertainty on single isotope x-secs

Measure light ion production (H, He) double diff. x-sec for thick target Si and Fe. → Targets light ion fragment production…
of high interest for DoE and NASA

MHz scale micro-pulse beams of cyclotrons work well for HPGe detector dead times and ToF analysis.
→ Apply “square-wave” modulation to ACQ
“feed forward” correction function

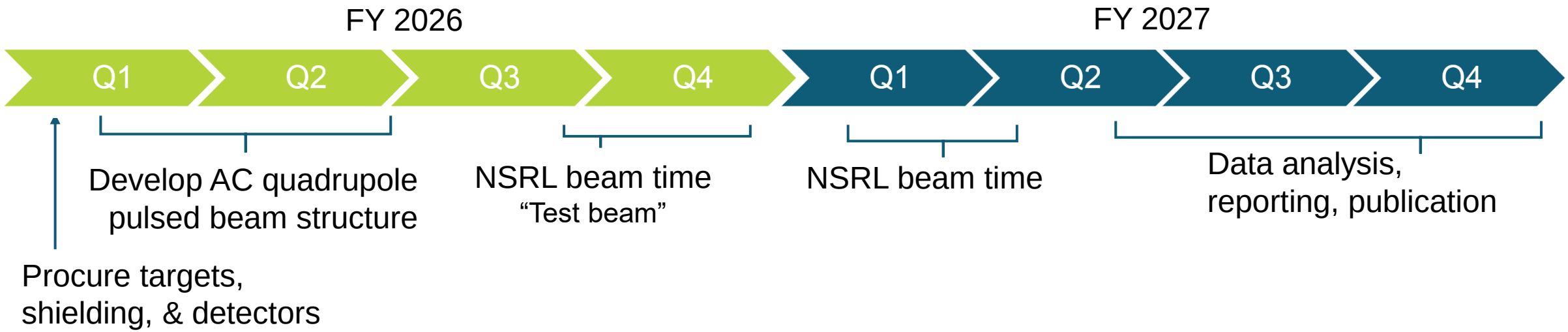




Anticipated Project Timeline

Leveraging ongoing efforts at the NSRL/CAD…

- 2022-2024, booster/NSRL slow extraction simulation model (BMAD)
- During Fy25, CAD controls and operations will begin commissioning the AC quad
- Fy25 Q4, tune AC quad function for spill smoothing in normal NSRL spill



"Deliverables"

At the conclusion of this proposal… produced cross-section data, new beam delivery technique for NSRL, and report on the necessary experimental setup recommended for future experiments.

Proposal Summary

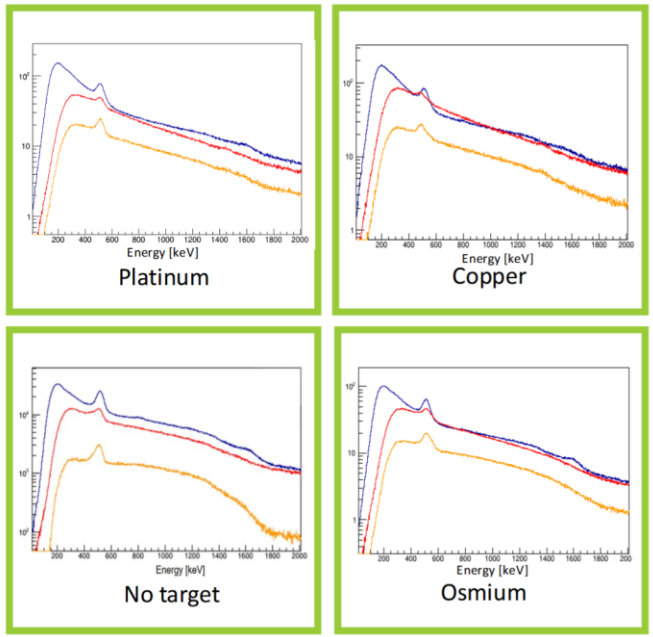
BNL is home to a versatile **high energy, heavy ion beam line** at NSRL and a team of expert nuclear data experimenters at the NNDC.

But NSRL is not designed for nuclear data experiments. This **presents both unique challenges and possibilities** to perform valuable measurements in the future…

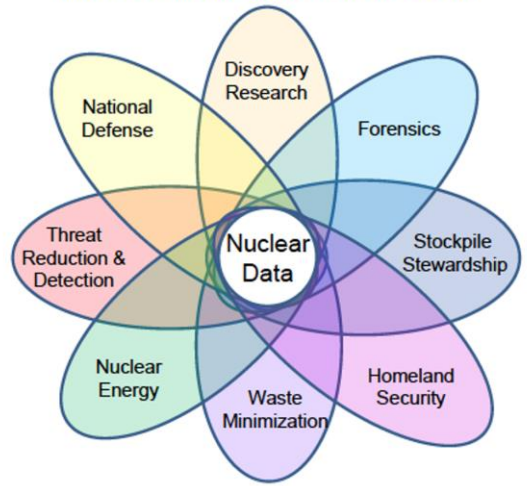
- Develop **novel micro-pulsed spill** technique
- **Characterize** "beam on" target room environment for **in-situ HPGe measurements**
- Measure double diff. **light ion fragments** (identified as highly needed by DoE and NASA) and **prompt gamma reaction** products
- **Integrate cross-section data** into appropriate databases if possible

If successful, this **proposal intends to add new techniques** and **capabilities to an existing beam line** to enable new opportunities for this emerging programmatic need in **support** of **large, administrative goals**.

Oct. 25 NNDC Prompt Gamma Measurement @ NSRL



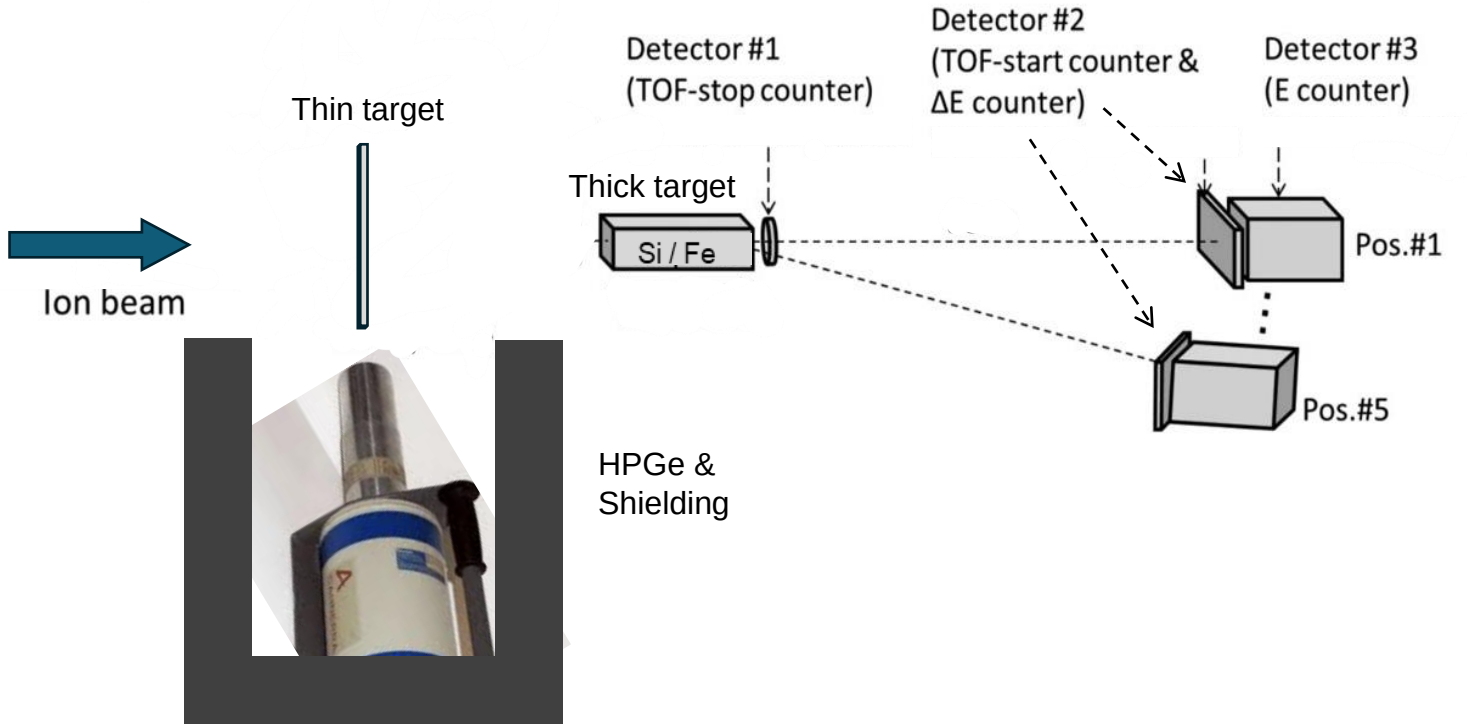
Intersections in Nuclear Data



Dr. Timothy Hallman, Associate Director of the Office of Science for Nuclear Physics
April 5, 2015

Backup Slide:
Example experimental setup

(simultaneous measurement scheme)



Brookhaven National Laboratory

Backup Slide:
Example budget breakdown

1 year Estimate with overhead for:

- 2 x 0.15 FTE
- 20 hours of beam time at current rate
- Will need to add procurement to this after getting quotes

	Total Labor		**59,548**
300	PO Purchases		-
	Total MST		**-**
701	Departmental Org Burdens	**8.85%**	1,568
272	Departmental Org Burdens-Comm	**1.04%**	184
701	Directorate Org Burdens	**4.60%**	815
685/660	Distributed ODC	**4.60%**	815
481	Space (distributed)	**10.52%**	1,864
493	Other Research Machines (NSRL)	$2,873.49	57,469.80
251	Building Power (distributed)	**0.79%**	139.98
250	Machine Power	$277.13	5,542.60
	Total Cost (Excluding Overhead)		**127,947**
745	Procurement	**7.00%**	-
735	VAB G&A	**0.00%**	-
730	VAB Common Inst	**45.00%**	54,936
705	LDRD Burden	**0.00%**	-
	Total G&A	**56.45%**	**54,936**
	Total Project Cost Plan		**182,883**

Backup Slide:
Pulsed beam “Proof of concept”

This method of spill manipulation has been used at GSI SIS18, similar machine to AGS booster for NSRL

Idea formulated after discussions with Kevin Brown (CAD controls) w.r.t. spill ripple control via AC quad

May benefit from newly developed r-line slow extraction BMAD model