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FY27 NPP LDRD Type B Pre-Proposal

U.S. DEPARTMENT OF ENERGY

A Beam Test Facility at the Booster R-line Complemented with Tracking Stations

serving DOE Nuclear Physics and High Energy Physics detector test needs (i.e. ePIC detector of EIC and HL-LHC detectors etc).

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FY27 NPP LDRD Type B Pre-Proposal

Proposal title: A Beam Test Facility at the Booster R-line (NSRL) Complemented with Tracking Stations

Primary Investigator: Xiaodong Jiang

Other Investigators (None). + 1 BNL dedicated postdoc (after approval).

Collaborators: SBU ATLAS group and other University groups. Other BNL groups.

Indicate if this is a cross-directorate proposal: Yes ___ No__x_

If yes, identify other directorates/organizations:

Proposal Term: From: 10/1/2026 To: 9/30/2028

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FY27 NPP LDRD Type B Pre-Proposal

Title: A Beam Test Facility at the Booster R-line Complemented with Tracking Stations.

Abstract: to add four particle tracking stations with DAQ to the Booster R-line (NSRL) to provide event-by-event tracking capability for detector tests, to fulfill detector beam test needs for DOE Nuclear Physics and High Energy Physics communities (i.e. EIC, HL-LHC).

Program: DOE Office of Science, Nuclear Physics and High Energy Physics.

Return on Investment: **a DOE funded detector beam test facility at BNL.**

Broader impact to BNL: expect significant follow-up investments and support from DOE Office of Science, both HEP and NP program, to serve US detector development community. **The readily available beam test facility will enhance BNL's position as the world leader in new detector technology.**

Total planned funding:
FY27 ($250k): 1 FTE postdoc, 1/4 scientist, equipment and engineer design.
FY28 ($250k): 1 FTE postdoc, 1/4 scientist, equipment, design, test beam time etc.

Urgently Need: Test Beam for Detectors at BNL

Accelerator-based beam facilities are critical for testing components and validating detector technologies, for EIC, HL-LHC etc.

Many test-beam facilities will experience multi-year downtimes over next decade: FNAL, LANL, CERN, DESY.

new detector designs and prototypes urgently need to be tested to feedback on long term critical decisions in DOE projects, such as the ePIC detectors at EIC, and the HL-LHC detectors. The ePIC collaboration: **"a beam test facility at BNL would be a significant reduction of risk for ePIC".**

BNL's Booster R-line (NSRL) will continue to operate during EIC construction (2026-2035).

NSRL available now: a beam line, with protons up to 2,5 GeV (~1E11 /sec), many empty slots in beam time user schedule.
Not available: event-by-event tracking capability.

NSRL can do now: radiation hardness/damage studies
NSRL can not do: tracking quality verification, i.e. position resolution studies

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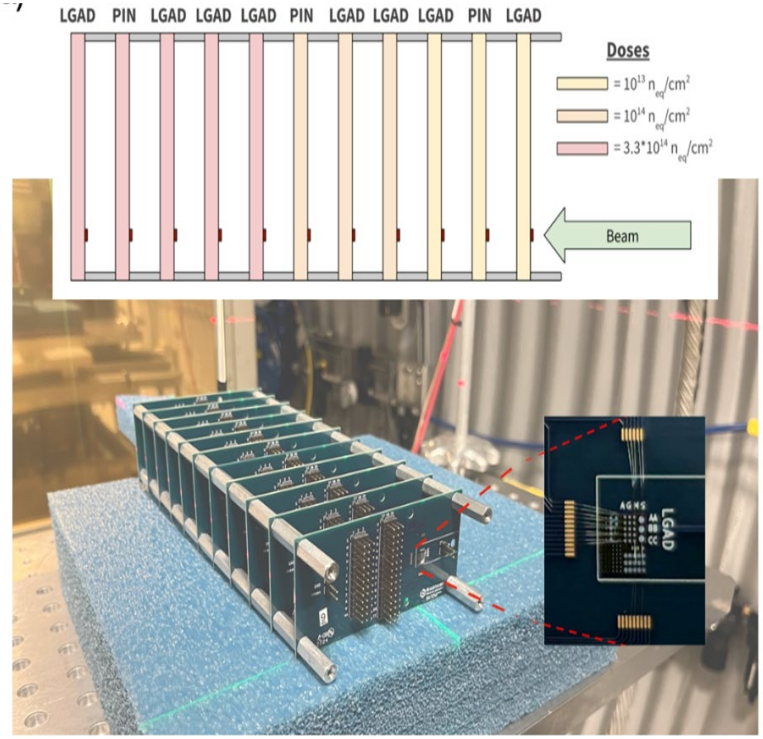
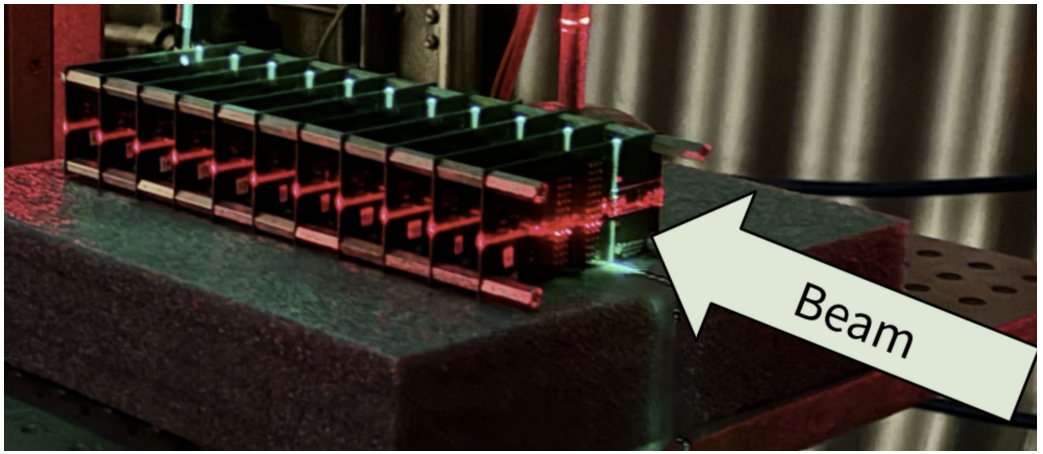
Serving HEP/NP community, **NSRL beam is best suited for tests of charge particle tracking detectors**, radiation hardening of detectors and front-end electronics, etc.

For example, BNL group completed a SiC tracking detectors radiation damage test.





August,2024, radiation tests at NSRL(12 hrs, supported by BNL-LDRD, Physics Dept.).

SiC operate at room temperature eliminate cooling systems, reducing material budgets and improving performance

A stack of 4H-SiC low gain avalanche detectors and complementary PiN diodes were irradiated with 2.5 GeV protons at fluences up to **3.33×10^{14} p/cm^2** (arXiv:2507.23062 BNL, LBNL, North Carolina State).

However, **NSRL beamline currently has no tracking capability**.
Not able to perform tracking quality studies, quantify position resolution as a function of radiation exposure, corresponding to 5yr, 10yr HL-LHC operation.

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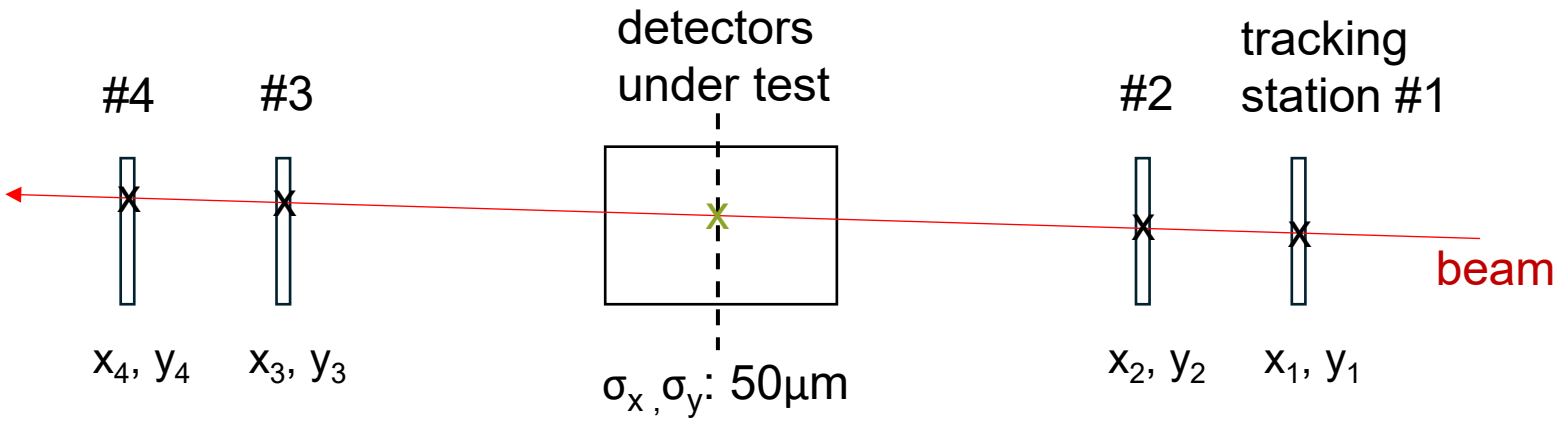
Proposed work: to reproduce Fermilab test beamline's reference tracking capability at BNL.



Add four silicon tracking stations (with a DAQ sys), 50 μm pitch in (x,y), over 1 m distance, 50 cm space in between for "detectors under test".

NSRL detector beam test facility (high flux proton up to 2.5 GeV) is best suited:

- verify tracking detector design and performance (efficiencies, resolutions).
- optimize detector and read-out electronics operation under extreme conditions.
- assess radiation degrading/damage for detectors and electronics, etc.

Deliverables:

FY27: a prototype tracking telescope, covers ~cm^2, with DAQ capacity 10 kHz.
FY28: four tracking stations, cover 10cm x10cm, with DAQ capacity up to1 MHz.
(use off-the-shelf commercial components and/or decommissioned BNL equipment)

Summary

There's an urgent need of test beam for detectors at BNL

Booster R-line (NSRL) will operate during EIC construction (2026-2035).

Adding tracking capability, NSRL beamline can serve DOE Nuclear Physics and High Energy Physics detector test needs (i.e. ePIC and HL-LHC etc).

Return of Investment: **a DOE funded detector beam test facility at BNL.**
Best use of BNL resources, fill empty NSRL beam time slots.

Availability of a beam test facility for detectors at BNL would be a tremendous boon to particle physics and would provide a testbed for innovative ideas in instrumentation

Enhance BNL's capacity as a world leader in:

- new detector technology developments.
- training of next generation particle detector experts.

In the full proposal:
initial design specifications, technical expertise, procurements and budget estimates for different detector and DAQ options: 1. ATLAS prototype tracker (SBU group), 2. commercial trackers (TimePix3), 3. other decommissioned trackers (BNL).

Backup Slide:
from ePIC collaboration meeting, 2025.

The Great Hadron Drought of 2026+

- We are entering a true drought in hadron beam facilities starting 2026
- Even if all facilities come back on time, they will be seriously overbooked
- A (hadron) beam test facility at BNL would be a significant reduction of risk for ePIC
  - Ease of access, low transportation time, cost and risk
  - Continuous verification of production samples
  - Relatively ease of multi-detector setup

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