BROOKHAVEN NATIONAL LABORATORY
LABORATORY DIRECTED RESEARCH AND DEVELOPMENT PROGRAM
LDRD TYPE B – PROPOSAL INFORMATION QUESTIONAIRE

	Submission Date tap to enter date
TITLE OF PROPOSAL - LDRD TYPE B	Development of a Generic 4D Telescope Platform
PRINCIPAL INVESTIGATOR (PI)	Gabriele D'Amen (NPP), Shaochun Tang (NPP)
DEPARTMENT/DIVISION	NPP
OTHER INVESTIGATORS	Haider Abidi (NPP)
PROPOSAL TERM (month/year)	FROM: Oct-25
	THROUGH: Sep-27
EARLY CAREER ELIGIBLE: YES ☒ NO ☐	

SUMMARY OF PROPOSAL

Description of Project:
We will design a powerful, portable, and affordable general-purpose particle detector capable of providing high resolution time- and space- measurement of particles in laboratory and at test beams. We will design and develop a new hardware platform for the readout of Ultra-fast 4D sensors, based on the existing CaRIBOu software and firmware. The Generic 4D Telescope Platform will be able to provide a plug-and-play way to add 4D capabilities to a wide range of experiments and R&D efforts.

Expected Results:
We will develop a platform for readout of AC-LGAD sensors based on CaRIBOu technology. By adapting the capabilities of CaRIBOu software and firmware environment, this platform will provide a plug-and-play way to add 4D tracking capabilities to a wide range of experiments and applications. The system will be composed of a Xilinx FPGA, and high sampling rate ADC channels to sample the amplitude of AC-LGAD signals and a fast TDC for particle time-of-arrival measurement. The system will be designed using off-the shelf components and provide robust data acquisition capabilities running on a dedicated SoC. The successful development of this telescope platform will strengthen BNL leading role in versatile readout systems for particle detectors; enable our silicon R&D efforts to exploit an advanced readout environment; provide a plug-and-play and high-precision 4D telescope system to a wide range of HEP and non-HEP users.

***Note:** The above items should not exceed one page

INSTRUCTIONS

Under **Description of Project**, provide a summary of the scientific/technological concept of the proposed project including the motivation for the research and the approach that will be used to conduct the investigation. *Briefly explain in a paragraph or less the competitive advantage of your approach.* Also indicate how the project meets the general characteristics of the LDRD Program and how it is tied to the DOE Mission.

Under **Expected Results**, clearly state the expected results and how they will impact our understanding of the science/technology.

These items should not exceed one page. The content should be understandable by a non-expert. This will greatly improve your chances of success. Please define all acronyms initially.

Follow the **Summary of Proposal** with a proposal not to exceed three pages that includes a concise state-of-the-art review, well supported by references, which do not count toward the three-page limit. Please include high-level deliverables and milestones (including your plans to communicate the results) for the duration of the project in the proposal and success metrics. The milestones are of great importance for setting realistic expectations for the project and for keeping the research on track. (Note that a mid-year review is required, and milestones will be reviewed then.)

Complete the Questionnaire, paying close attention to Items 1 "Alignment with the Mission and Vision" and 2 "Potential Future Funding." Since the primary purposes of Type B LDRD funding are to develop science/technology areas for new directions and position the researcher for funding about a year after the project concludes, both of these will be important considerations during the selection process. Estimates of the financial return on investment are expected in the Potential Future Funding section (Item 2). Proposals will be returned if these sections aren't completed. Since the objective of the Type B call is also to encourage future Early Career Award applicants, please fill out item 3, if applicable. Postdocs are eligible to submit as co-PIs; they are eligible to submit as PIs, if they are transitioning to a staff position.

In addition, **please fill out Items 4 and 5, which are a "Budget Justification" and the "Name of Suggested BNL Reviewers."** Attach a budget in the suggested template, indicating the intent to use collaborators, postdoctoral research associates, and/or students, and obtain the required approvals.

Also, in the **Approvals section is a determination (highlighted in yellow) delegated to the Principal Investigator's Chair/Division Manager if the project is a sensitive technology under the S&T Risk Matrix**. No other attachments are needed. Go to BNL | Laboratory Directed Research and Development (LDRD) | Home for further information.

The Instructions should be removed before submitting

PROPOSAL

Motivation and state-of-the-art

The ability to precisely measure the time and position of passage of single particles is an essential requirement for many areas of research and development in science and technology. Many R&D efforts in High Energy Physics, Nuclear Science, Medical Science and more rely on the precise measurement of the 4-dimensional coordinates of particles from a test-beam interacting with a material sample under study, a new sensor to characterize, a biological tissue.

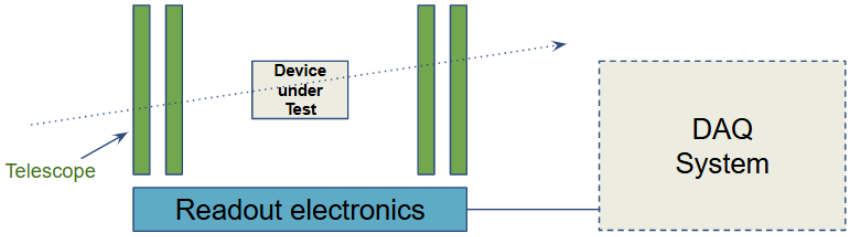


Figure 1: Particle telescopes can reconstruct the position (and sometimes Time-of-Arrival and Time-of-Flight) of incoming particles, allowing for single-particle discrimination.

Unfortunately, very few beam facilities around the world are currently fitted with permanent *"particle telescopes"* capable of such measurements, especially outside of the European continent. When present, these particle telescopes are often based on old CERN leftover technology and are rarely capable of achieving the precision bleeding-edge detectors are capable of. Researchers are often forced to develop custom solutions, with a considerable expense in terms of money, time, and effort. When targeting outstanding results, equally outstanding measurement capabilities are required. In addition to this, the scarcity of test-beam facilities foreseen to be operational in the next decade is only expected to exacerbate the problem. Fortunately for us, most of the test-beam capabilities at BNL are expected to remain operational during that period.

Main goal

Our plan is to **design and develop a 4D telescope**, a detector capable of reconstructing with high precision both the 3D position and the time-of-arrival of passing particles. This device will allow research groups and experimental efforts to save considerable resources, time, and person-power that would normally be used for the development of similar systems in applications where precise 4D information is crucial. It will also enable beam facilities at BNL to offer such capabilities to users, attracting a wider audience interested in R&D, measurement, and characterization applications.

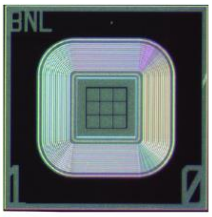
Ultimately, we want this telescope to be:

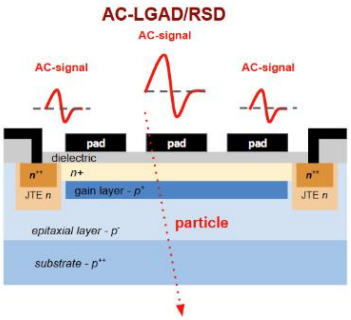
- **Powerful** (<50ps time resolution/<10um space resolution), using bleeding-edge technology developed with the Electron Ion Collider and the Future Circular Collider experiments in mind
- **Affordable** (<20k USD/telescope layer), accessible by smaller groups with limited funding
- **Standardized**, to allow for sharing of operational knowledge
- **Portable**, to facilitate applications at test beams and in laboratory

Proposed work

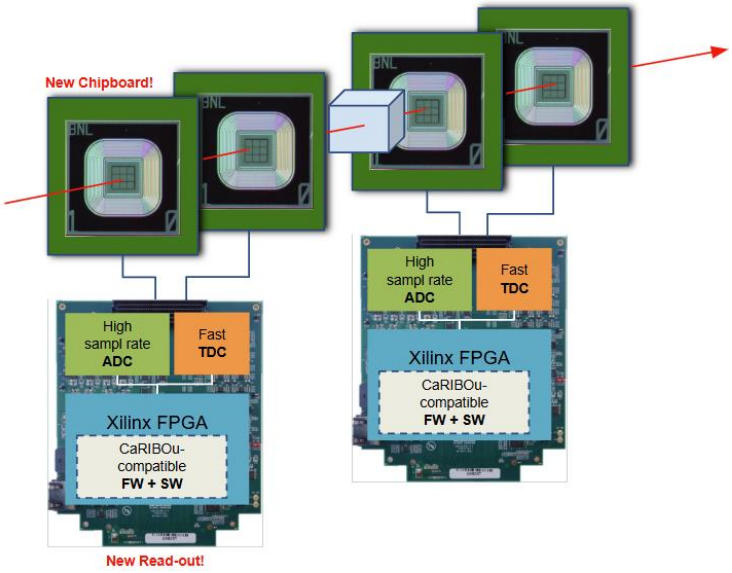
We will design a platform for the readout of ultra-fast 4D sensors based on the technology developed for the CaRIBOu system. CaRIBOu is a modular system developed for the readout of the upcoming ATLAS ITk detector but later adopted by a multitude of collaborations (CERN R&D50, EP R&D, and AIDAinnova among others) for silicon sensor R&D at laboratories and high-rate beam facilities [CAR0]. The CaRIBOu

system provides a robust DAQ system which can be easily adjusted to the needs of different detectors [CAR1].





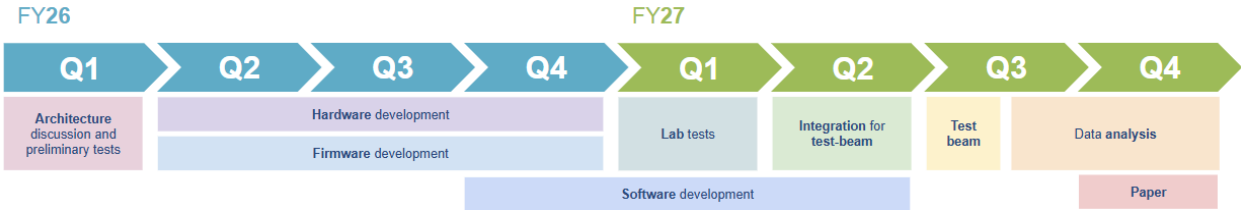
Our modified CaRIBOu system will read-out signals from a silicon sensor capable of high 4D performances. Among the various options, our sensor of choice for this application is the AC-LGAD, a type of silicon sensor capable of excellent 4D performances. AC-LGADs are capable of timing measurements with a resolution of 30 ps or better [ACL1] and a micron-level space resolution thanks to their peculiar signal-sharing feature: signals generated in particle interactions are shared among multiple pads, allowing for a space resolution beyond the limitations of typical silicon sensors [REF]. The result of each particle interaction is an ultra-fast signal on all sensor pads, each with an amplitude proportional to the distance to the particle interaction point.



In order to exploit Signal Sharing, it is therefore necessary to maintain the analog information from each signal; the CaRIBOu-compatible readout system of the telescope will be equipped with a powerful Xilinx FPGA with high sampling rate channels (>= 10 GS/s) of 8 bit/12 bit ADC, that will allow to sample the amplitude of AC-LGAD signals. The system will be also equipped with a fast TDC for particle Time-of-Arrival measurement. The usage of a Xilinx FPGA will allow us to maintain compatibility with the CaRIBOu software and firmware. Additionally, we will design a chipboard PCB specifically tailored to electrically bias and readout AC-LGAD sensors. Signals from AC-LGADs mounted on these chipboards will be acquired and digitized via the high-sampling rate ADC and TDC channels of the Xilinx FPGA. CaRIBOu's firmware and software will be expanded and optimized for AC-LGAD operations. The readout system will be built using off-the-shelf components and provide robust data acquisition capabilities to the end users.

This project plays on the synergy between two of Brookhaven's strengths, fast timing silicon technology and readout electronics, and helps us strengthen our leadership in both. We already possess both the expertise, and the facilities needed to successfully realize this project. The Generic 4D Telescope Platform will be able to provide a plug-and-play way to add 4D capabilities to a wide range of experiments and R&D efforts.

Project deliverables & Milestones



- **FY26/Q1: Architecture evaluation** we will evaluate possible architectures and perform preliminary readout tests using available systems. This will define the design strategy and inform us of necessary requisitions
- **FY26/Q2 – Q4: Hardware & Firmware design** we will design the sensor chipboard based on the chosen specifications of the Xilinx FPGA. In parallel with hardware development, we will extend CaRIBOu's firmware to allow for acquisition of AC-LGAD signals and deploy it on the chosen FPGA
    - *Milestone 1 – FY26/Q2:* sensor characterization, first prototypes of chipboards
    - *Milestone 2 – FY26/Q3:* readout system demonstrator
    - *Milestone 3 – FY26/Q4:* complete readout chain
- **FY26/Q4 – FY27/Q2: Software development** as the hardware and firmware systems get finalized, we will develop the data-taking software with efficiency and user-experience in mind
    - *Milestone 4 – FY27/Q1:* system test with injected fast electrical pulses
- **FY27/Q1: Lab Tests** the system capabilities will be evaluated in the laboratory using particles from cosmics, radioactive sources, and an ultra-fast laser for the calibration of the system response as a function of energy, position, timing of incoming particles
    - *Milestone 5 – FY27/Q1:* system test with minimum ionizing particles
    - *Milestone 6 - FY27/Q1:* measurement of time resolution using minimum ionizing particles
    - *Milestone 7 – FY27/Q1:* calibration of AC-LGAD response vs particle position using laser
- **FY27/Q2: Integration for Test-beam** the system will be finalized and prepared for a characterization at a BNL test beam using real particles. Either the Tandem Van der Graaff and the Nasa Science Radiation Laboratory facilities are excellent candidates for this study
- **FY27/Q3: Test-beam** we will install the complete telescope in the test-area of the chosen beam facility and acquire extensive data of interaction of particles with the telescope. This will inform us of the capabilities of the detector in a real test-beam scenario.
    - *Milestone 8 – FY27/Q3:* measurement of tracking capabilities
- **FY27/Q3 – Q4: Data Analysis** we will analyze the data at test-beam and provide a final estimate of the telescope capabilities. We will detail the final results in a dedicated publication
    - *Milestone 9 – FY27/Q4:* paper detailing results

Project Team

The team assembled has the necessary skills and expertise to plan and perform this research.
Dr. Gabriele D'Amen (Co-PI, 0.1 FTE/yr) will provide expertise on the silicon sensors and the way to read-out ultrafast fast 4D signals, as well as the position and timing reconstruction methodology. Dr. Shaochun Tang (Co-PI, 0.1 FTE/yr) will provide hardware and firmware design expertise for implementing the new hardware platform including the readout and chipboard. A Post-doc (1 FTE/yr) will develop the firmware and software based on the existing CaRIBOu system and participate the characterization test in the lab and at beam.

Bibliography

[CAR0] E. Bushman, Status and recent extensions of the Caribou DAQ System for picosecond timing, Journal of Instrumentation vol. 2 (2023), http://dx.doi.org/10.1088/1748-0221/18/02/C02005, DOI: 10.1088/1748-0221/18/02/c02005

[CAR1] T. Vanat, *Caribou — A versatile data acquisition system*, PoS - TWEPP2019 (2020), https://cds.cern.ch/record/2703500, DOI: 10.22323/1.370.0100

[ACL1] A. Apresyan, et al. *Measurements of an AC-LGAD strip sensor with a 120 GeV proton beam*, Journal of Instrumentation, 15(09):P09038–P09038, Sep 2020

ONE-PAGE VITA FOR EACH PRINCIPAL INVESTIGATOR AND CO-PRINCIPAL INVESTIGATOR

Gabriele D'Amen

Professional experience

2023 - Current	Assistant Scientist (RS-3), Brookhaven National Laboratory (US)
2019 - 2023	Research Associate, Omega Group, Brookhaven National Laboratory (US)
2018 - 2019	Assegnista di Ricerca, Istituto Nazionale di Fisica Nucleare, Bologna (IT)

Relevant research activities

- Wide expertise in silicon sensor performance characterization using radioactive sources, probe station, and Transient Current Technique
- Responsible for the characterization and readout of fast timing and 4D-oriented silicon sensors, in laboratory and at test beams
- Commissioning of the ATLAS ITk detector staves at the BNL and at CERN

Education

2014 - 2018	Joint PhD in Physics	Universität Bern (CH) & Università di Bologna (IT)
2012 - 2014	M.Sc. in Physics	Università di Bologna (IT)
2009 - 2012	B.Sc. in Physics	Università di Bologna (IT)

Relevant roles

2024 - Current	International Activity Coordinator for Module Loading for the ITk detector
2023 - Current	US L3 responsible and CAM for Modules production for the ITk detector
2023	Coordinator of Beam Operations for the EDIT School 2023 (BNL)
2020 - Current	Developer of fast silicon detectors for the Electron Ion Collider R&D program (BNL)
2019 - Current	Member of the RD50 and DRD3 collaboration at CERN
2015 - Current	Member of the ATLAS collaboration at CERN

Selected publications

- G. Giacomini et al, Spectroscopic performance of Low-Gain Avalanche Diodes for different types of radiation, submitted (2024)
- G. D'Amen et al., Signal formation and sharing in AC-LGADs using the ALTIROC 0 front-end chip, JINST 17 (2022)
- R. Heller et al., Characterization of BNL and HPK AC-LGAD sensors with a 120 GeV proton beam, JINST 17 (2022)
- G. D'Amen et al., Novel imaging technique for alpha-particles using a fast optical camera, JINST 16 (2021)
- A. Apresyan et al., Measurements of an AC-LGAD strip sensor with a 120 GeV proton beam, JINST 15 (2020)
- G. Giacomini et al., Fabrication and Performance of AC-Coupled LGADs, JINST 14.09 (2019)

More than 700 works as member of the ATLAS Collaboration (the full list can be found at https://orcid.org/0000-0002-9742-3709)

Shaochun Tang

Professional experience

2022 - Current: Research Staff 4 at Brookhaven National Laboratory (US)
2017 - 2022: Physics Associate at Brookhaven National Laboratory (US)
2014 - 2017: Research Associate at Brookhaven National Laboratory (US)
2012 - 2014: Senior Hardware engineer at Cisco, Inc. in Shanghai, China

Relevant research activities

- Wide expertise in high-speed high resolution ADC hardware development and testing, Trigger and DAQ hardware system development and firmware design.
- Responsible for the hardware design and testing of Global Common Module for the Global Trigger and FELIX in ATLAS Phase-II
- Responsible for the ADDC mass production for ATLAS phas-1 New Small Whell upgrade
- Responsible for the Hardware design and testing for the gFEX system for L1Calo in ATLAS Phase-1
- Ph.D research of Ultra-High-Speed High-Resolution ADC techniques for Beam Phase and Energy Measurement for CSNS

Education

2007-2012 PhD. of Engineering Electronic Science and Technology University of Sci. and Tech. of China
2003-2007 Bachelor of Science University of Sci. and Tech. of China

Relevant roles

2019-2020 LHC ATLAS ADDC Project L3 Manager
2018 – Current LHC/HL-LHC ATLAS Review Panel
2022 – Current HL-LHC ATLAS FELIX Phase-II Project L3 Manager
2019 – Current Leader of the hardware development of Omega group in BNL
2014 – Current Member of the ATLAS TDAQ collaboration at CERN
2014 – Current Member of the CaRIBOu collaboration at CERN
2022 – Current Member of the DUNE collaboration

Selected publications

- S. Tang et al., "Prototype Design of Global Common Module for ATLAS Experiment's Phase-II Upgrade," in IEEE Transactions on Nuclear Science, vol. 70, no. 9, pp. 2248-2255, Sept. 2023, doi: 10.1109/TNS.2023.3302158.
- S. Tang, F. Bonini, ATLAS TDAQ collaboration. "Prototype hardware design and testing of the global common module for the global trigger subsystem of the ATLAS phase-II upgrade", Journal of Instrumentation 17 (05), C05026, 2022.
- G. Iakovidis et al., "The New Small Wheel electronics" in 2023 JINST 18 P05012
- F. Bonini, M. Begel, H. Chen, K. Chen, H. Liu, D. Matakias, S. Tang, H. Xu, W. Yin, E. Zhivun, "Multiplexing Firmware Prototypes for the Global Trigger Subsystem of ATLAS Phase-II Upgrade", IEEE Transactions on Nuclear Science, 2021.
- S. Tang et al, "Production and tests of the ADDC for the Micromegas detector of the ATLAS New Small Wheel", Journal of Instrumentation 16 (03), P03021, 2021.

- S Tang, etc. "Development and data path integration test of the global Feature EXtractor for the ATLAS Level-1 calorimeter trigger system Phase-I upgrade", in Nuclear Instruments and Methods in Physics Research Section A, 2019.
- S. Tang, et al., "The implementation of Global Feature EXtractor (gFEX)-the ATLAS Calorimeter Level 1 Trigger system for LHC Run-3 upgrade", Journal of Instrumentation 13 (07), P07010, 2018.
- L. Zhao, X. Hu, C. Feng, S. Tang, S. Liu and Q. An, "A 1.6-Gsps High-Resolution Waveform Digitizer Based on a Time-Interleaved Technique", IEEE Transactions on Nuclear Science 60 (3), 2180-2187, 2013.
- S. Tang, L. Zhao, S. Liu, X. Hao, W. Wu and Q. An, "A Beam Phase and Energy Measurement Instrument Based on Direct RF Signal IQ Undersampling Technique", in IEEE Transactions on Instrumentation and Measurement, 2012.

More publications could be found here:
https://scholar.google.com/citations?hl=en&user=aPHpoTIAAAAJ

1. ALIGNMENT WITH THE LABORATORY MISSION AND VISION

Type B proposals need to be clearly aligned with BNL's mission and vision. Please refer to the Annual Lab Plan (BNL | Policy & Strategic Planning | Annual Laboratory Plan) to identify how the proposed research aligns with the Laboratory's mission and vision.

2. POTENTIAL FUNDING

INFO ABOUT FUNDING AGENCIES

Finally, adding 4D telescopes to existing BNL test-beam facilities (Van de Graaf, NSRL, …) can attract DOE operation grants (MAGNITUDE?) and additional users interested in exploiting their 4D measurement capabilities: based on estimates from the similar permanent telescope AIDA currently installed at CERN, we can estimate this additional influx of users. AIDA was used for 30 weeks in 2018 for the characterization of fast timing silicon sensors; this would add a potential additional revenue in the order of 2-6 M$/yr (not including lab overhead).

3. POTENTIAL EARLY CAREER AWARD INVESTIGATORS (if applicable)

Co-PI Gabriele D'Amen received his PhD in 2018 and will submit an Early Career Award proposal for FY 2026. He is eligible for three years, until 2028. His application will focus on the usage of Neuromorphic Computing techniques to improve the tracking capabilities of future High Energy Physics experiments by exploiting timing and the 4D capabilities of modern silicon detectors. The construction of the Generic 4D Telescope Platform will allow him to study the impact of these Neuromorphic reconstruction techniques on on-line tracking using real data acquired at test-beams.

4. BUDGET JUSTIFICATION

Include a description of all costs requested in your budget. You do not need to describe the Lab burdens.

5. NAME(S) OF SUGGESTED BNL REVIEWERS

Provide the name of (4) four BNL subject matter experts (SMEs). Two of the SMEs may be contacted as potential reviewers of your proposal. Their reviews will be in addition to those conducted by two members of the Research Staff, not associated with the research.

Name 1: Viviana Cavaliere (NPP)

Name 2: Hucheng Chen (NPP)

Name 3: Gabriele Giacomini (IO)

Name 4: Elizabeth Brost (NPP)

6. EQUIPMENT (reference: DOE Order 413.2C Chg. 1 (Min Chg) for guidance on equipment restrictions)
Will LDRD funding be used to purchase equipment?
☐ Yes or No ☐

If **yes**, provide cost and description of equipment

Year 1 - $_____

Year 2 - $_____

Year 3 - $_____

Description: _____

7. HUMAN SUBJECTS (Reference DOE Order 443.1C)
Are human subjects involved from BNL or a collaborating institution?

☐ Yes or No ☒

Human subjects are defined as "A living individual from whom an investigator obtains either (1) data about that individual through intervention or interaction with the individual, or (2) identifiable, private information about that individual".

If **yes**, attach a copy of the current Institutional Review Board Approval and Informed Consent Form from BNL and/or collaborating institution.

8. VERTEBRATE ANIMALS
Are live vertebrate animals involved?

☐ Yes or No ☒

If yes, attach a copy of approval from BNL's Institutional Animal Care and Use Committee.

9. NEPA REVIEW
Are the activities proposed similar to those now carried out in the Department/Division that have been previously reviewed for potential environmental impacts and compliance with federal, state, local rules, and regulations, and BNL's Environment, Safety, and Health Standards? (Therefore, if funded, proposed activities would require no additional environmental evaluation.)

☒ Yes or No ☐

If **no**, has a NEPA review been completed in accordance with the National Environmental Policy Act (NEPA) and Cultural Resources Evaluations Subject Area and the results documented?

☐ Yes or No ☐

(**Note:** If a NEPA review has not been completed, submit a copy of the work proposal to the BNL NEPA Coordinator for review. No work may commence until the review is completed and documented.

10. ESH CONSIDERATIONS

Does the proposal provide sufficient funding for appropriate decommissioning of the research space when the experiment is complete?

☒ Yes or No ☐

Is there an available waste disposal path for project waste throughout the course of the experiment?

☒ Yes or No ☐

Is funding available to properly dispose of project waste throughout the course of the experiment?

☒ Yes or No ☐

Are biohazards involved in the proposed work?

☐ Yes or No ☒

If **yes**, attach a current copy of approval from the Institutional Biosafety Committee.

Can the proposed work be carried out within the existing safety envelope of the facility (Facility Use Agreement, Nuclear Facility Authorization Agreement, Accelerator Safety Envelope, etc.) in which it will be performed?

☒ Yes or No ☐

If **no**, attach a statement indicating what has to be done and how modifications will be funded to prepare the facility to accept the work.

11. TYPE OF WORK

Select:

☐ Basic
☐ Applied
☒ Development

Brookhaven National Laboratory

Project Type:
Initiative:
Department:
Directorate:
Principal Investigator:

TERM #: mm/dd/yy - mm/dd/yy

LABOR

TYPE	YEAR 1 FTEs	YEAR 1 COST	YEAR 2 FTEs	YEAR 2 COST	YEAR 3 FTEs	YEAR 3 COST	YEAR 4 FTEs	YEAR 4 COST	TOTAL
SCIENTIFIC/SENIOR PERSONNEL	-	-	-	-	-	-	-	-	-
POST DOCTORAL ASSOCIATES	-	-	-	-	-	-	-	-	-
OTHER PROFESSIONAL	-	-	-	-	-	-	-	-	-
OTHER	-	-	-	-	-	-	-	-	-
TOTAL LABOR	-	$ -	-	$ -	-	$ -	-	$ -	$ -

OTHER LABOR

TYPE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
CONSULTANTS/COLLABORATORS				-	-
JOINT APPOINTMENTS	-	-	-	-	-
DISTRIBUTED LABOR	-	-	-	-	-
STUDENT CONTRACT			-	-	-
RECHARGES	-	-	-	-	-
TOTAL OTHER LABOR	$ -	$ -	$ -	$ -	$ -

MATERIALS, SUPPLIES & TRAVEL

TYPE	CY RATE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
MATERIALS & SUPPLIES		-	-	-	-	-
TRAVEL		-	-	-	-	-
EQUIPMENT (LOW/HIGH)		-	-	-	-	-
PURCHASE HIGH [illegible]		-	-	-	-	-
TOTAL MATERIALS, SUPPLIES & TRAVEL		$ -	$ -	$ -	$ -	$ -

DEPARTMENTAL OVERHEADS

TYPE	CY RATE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
ELECTRIC	0.00%	-	-	-	-	-
SPACE	0.00%	-	-	-	-	-
WASTE MGMT	0.00%	-	-	-	-	-
ORG. BURDEN	0.00%	-	-	-	-	-
OTHER	0.00%	-	-	-	-	-
TOTAL DEPARTMENTAL OVERHEADS		$ -	$ -	$ -	$ -	$ -

GENERAL & ADMINISTRATIVE OVERHEADS

TYPE	CY RATE	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
TRADITIONAL G&A		-	-	-	-	-
COMMON SUPPORT		-	-	-	-	-
TOTAL G&A OVERHEADS		$ -	$ -	$ -	$ -	$ -

TOTAL PROJECT COST	YEAR 1	YEAR 2	YEAR 3	YEAR 4	TOTAL
TOTAL DIRECT COSTS	-	-	-	-	-
TOTAL INDIRECT COSTS	-	-	-	-	-
TOTAL PROJECT COST	$ -	$ -	$ -	$ -	$ -

NOTE:
Post Doc Rate Exception:
No cost to be incurred on R/C 170 (Relocation Expense)

ITEMIZE CAPITAL INDIVIDUALLY (include item and $ amount)

1. 5.
2. 6.
3. 7.
4. 8.

This a sample of the budget template to be used. Please consult with your Business Operations staff to develop your proposed budget using this template, which needs to then accompany the PIQ when it is submitted.

APPROVALS

Business Operations Manager	**Signature**

Department Chair/Division Manager	**Signature**

To the Department Chair/Division Manager:
Please indicate if this project is a sensitive technology under the S&T Risk Matrix.
(**Note:** Red projects require an Access Management Plan.)

☐Green
☐Yellow
☐Red
☐Not Applicable

Cognizant Associate Lab Director	**Signature**