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

	Submission Date	3/7/2025
TITLE OF PROPOSAL - LDRD TYPE A	Advancing Photon Detection System for DUNE Phase II	
PRINCIPAL INVESTIGATOR (PI)	Chao Zhang	
DEPARTMENT/DIVISION	PO/NPP	
OTHER INVESTIGATORS	Jay Hyun Jo (PO), Shanshan Gao (PO), Xuyang Ning (PO), Thomas Tsang (IO), Xin Qian (PO), Hucheng Chen (PO), Steve Kettell (PO)	
PROPOSAL TERM (month/year)	FROM: Oct-25	
	THROUGH: Sep-28	

SUMMARY OF PROPOSAL

Description of Project:
The Deep Underground Neutrino Experiment (DUNE) is a flagship U.S. onshore High Energy Physics experiment designed to unravel the mysteries of neutrinos and the universe. The 2023 Particle Physics Project Prioritization Panel (P5) recommended a re-envisioned DUNE Phase-II with an early implementation of Far Detector 3 as one of the highest-priority projects [1]. We propose to **significantly expand DUNE's scientific scope by advancing photon detection system in Phase-II**, enabling precise energy measurements from sub-MeV to multi-GeV scales through light calorimetry. Our approaches integrate GPU-accelerated optical simulations and deep-learning models for unprecedented detector optimization and calibration accuracy. We will develop novel readout solutions and collaborate with industrial partners on state-of-the-art material deposition technologies to enhance photon detection efficiency, dynamic range, and cost-effectiveness. Prototype performance tests will be conducted at testing facilities to demonstrate technical readiness for DUNE Phase-II. The advanced photon simulation and detection techniques will have extensive applications in science and technology, extending well beyond neutrino research, thus aligning strongly with the general characteristics of the LDRD Program, the DOE mission, and BNL's vision.

Expected Results:
We anticipate achieving the following key results: 1) A GPU-accelerated photon simulation software featuring tunable parameters for efficient detector optimization; 2) A novel optical calibration method employing deep learning model and quantum algorithms; 3) Comprehensive physics sensitivity publications detailing the benefits of light calorimetry measurements; 4) New techniques and optimized photon detector system design for DUNE Phase II; and 5) Integration test results to demonstrate technical readiness. Successful completion of this LDRD will strengthen BNL's leadership in photon detection technology, enable significant scientific advancements, and position BNL favorably for substantial future DUNE Phase-II project involvement and DOE funding opportunities.

PROPOSAL

1. Motivation

The Deep Underground Neutrino Experiment (DUNE) is a flagship U.S. onshore High Energy Physics experiment designed to address fundamental questions about neutrinos and the universe, such as why matter dominates antimatter. DUNE Phase-I comprises two 10-kiloton Liquid Argon Time Projection Chamber (LArTPC) Far Detector (FD) modules, with leading contributions from BNL. The planned Phase-II upgrade will add two more FD modules to significantly enhance DUNE's scientific capabilities. The 2023 Particle Physics Project Prioritization Panel (P5) has recommended a re-envisioned DUNE Phase-II with an early implementation of Far Detector 3 as one of the highest-priority projects [1].

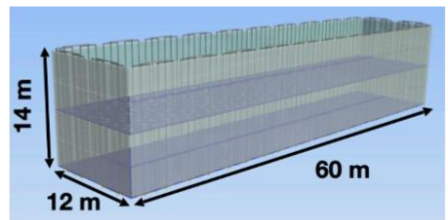

Figure 1: BNL-designed APEX concept for the DUNE Phase-II Photon Detection System

DUNE's Phase-I LArTPCs primarily utilize ionization imaging, while the abundant scintillation light signals from LAr remain underutilized due to challenges in achieving uniform and efficient photon detection at large scale. This LDRD aims to address these challenges by **advancing photon detection system in DUNE Phase-II to enable precision energy measurement from sub-MeV to multi-GeV scales through light calorimetry**, thus substantially broadening DUNE's research potential in neutrino oscillations, supernova and solar neutrinos, nucleon decay, and atmospheric neutrino physics. By leveraging BNL's distinctive expertise in photon detection, cryogenic electronics, and advanced simulations, this project will provide significant technological advancements that directly align with DOE mission priorities and the recent P5 report.

We will achieve our objectives through advanced GPU-accelerated simulations, novel deep-learning-based calibration, targeted optimization of photon detectors, and industry collaborations on new wavelength-shifting technologies. Prototyping and integration tests will validate the proposed technologies, demonstrating readiness for implementation in DUNE Phase-II. BNL is uniquely positioned for this research, currently leading the early design and physics studies for DUNE Phase-II. BNL created the initial conceptual design of Phase-II FD Photo Detection System, called the "Aluminum Profiles with Embedded X-Arapucas" (*APEX*, *Figure 1*), now the reference photon detection system design in the Phase-II white paper [2]. BNL designed the first 65-nm ASIC chips with 250-ns timing (CHARMS) for DUNE Phase-II photon detection system readout [3]. BNL conducted first physics studies demonstrating the advantages of light calorimetry in DUNE Phase-II, including improved measurements of GeV neutrinos through self-compensation [4] and the enhanced detection of MeV neutrinos [5].

On the other hand, significant competitions exist for the DUNE Phase-II FD photon detection system including detector design and electronics, such as the *PoWER* concept led by Brazil [6], and the Phase-I optical readout led by Fermilab [7]. This LDRD will provide important investment to optimize the APEX detector design and BNL's optical readout to demonstrate their advantages over competing technologies. This will position BNL for leadership roles in DUNE Phase-II over the coming decades. The proposed research is timely, aligning well with DUNE Phase-II schedule. Phase-II DOE R&D funding is expected around 2029 as Phase-I project funding ramps down, followed by Phase-II project funding beginning after 2031 lasting 7—10 years. The total Phase-II project funding received by BNL is expected to increase beyond the Phase-I funding of ~$90M. The DUNE photon detection system will introduce a new funding stream for BNL, not available to BNL in DUNE Phase-I, estimated to be around $20M during DUNE Phase-II.

The advanced photon simulation and detection techniques will have extensive applications in science and technology, extending well beyond neutrino research and DUNE itself. For example, it provides opportunities for a new type of compensating calorimeters using LAr scintillation for an EIC detector and Future Colliders to improve their energy measurements [4]. The developed techniques will build a strong foundation to help secure future funding opportunities from Detector R&D, AI/ML, Quantum Information Science programs, and DOE initiatives across HEP, NP, and ASCR. It will also support proposals for future Early Career Awards.

2. Proposed R&D

APEX is a BNL-designed photon detection system concept for the DUNE Phase-II upgrade [2]. The current design expands optical surface coverage to ~60% by installing large-area photon detector modules across the entire field cage walls, significantly improving upon the ~5% coverage in DUNE Phase-I. Initial simulations indicate the APEX design yields about 180 photoelectrons per MeV, similar to liquid scintillator neutrino detectors like Daya Bay [13]. However, significant optimizations of APEX are necessary, including improving the optical readout dynamic range, achieving uniform light yield, enhancing photon detection efficiency, and refining light calorimetry reconstruction. This LDRD addresses these issues through two complementary approaches: developing a fast and tunable optical simulation for DUNE Phase-II and optimizing the APEX detector with photon detector system R&D.

2.1 Developing a Fast and Tunable Optical Simulation for DUNE Phase-II

Modeling photon propagation in large LArTPC detectors is computationally demanding. Liquid argon emits ~25,000 photons per MeV at a nominal electric field of 500 V/cm, meaning a typical 3 GeV neutrino event in DUNE produces around 75 million photons. Simulating the propagation of each photon across a massive detector is computationally prohibitive. To address this, previous LArTPC experiments have relied on pre-generated look-up tables, where the detector is divided into small voxel grids and optical photons are generated in each voxel and propagated to each photon detector using extensive Geant4 Monte Carlo simulations. The probability of a photon reaching each photon detector is recorded in a look-up table to generate readout signals.

The look-up table approach is not well-suited for optimizing the detector design at the current stage of DUNE Phase-II. Key parameters, such as the photon detector placement, granularity, timing resolution, and detector component selection must be fine-tuned through simulation to achieve the optimal light reconstruction and physics sensitivity. Additionally, the look-up table is inadequate for calibration between data and simulation. LAr optical modeling is highly complex, with many poorly constrained properties that require tuning to match experimental data. The detected photon detector signal is influenced by factors such as Rayleigh scattering and absorption length of LAr; surface transmissivity, reflectivity, and roughness; detector acceptance and quantum efficiency — many of which vary with wavelength. As a result, the look-up table approach lacks the flexibility needed for both detector optimization and data-simulation calibration.

To address these limitations, we propose the following software developments:

1. **Develop a comprehensive APEX photon detector system simulation software with tunable optical and geometric parameters for detector optimization**. The propagations of optical photons will be accelerated with the NVIDIA OptiX GPU ray-tracing technology, providing large parallel-processing advantages compared to traditional CPU-based methods. This work will build upon the open-source *Opticks* software [8], initially developed for liquid scintillator neutrino detectors and increasingly used in other communities, including EIC [9]. We expect close collaboration with the *Opticks* community, targeting a simulation speedup of a factor of 100 compared to the current DUNE optical simulations. By fully parametrizing the detector design options, this GPU-accelerated simulation software provides a foundation for the detector optimization work described in Section 2.2.
2. **Develop a deep-learning model to replace the look-up tables for optical calibration**. By selecting a suitable network architecture, this machine learning approach can significantly reduce the parameters needed compared to the look-up table without losing precision [10], therefore is scalable for DUNE. Additionally, ionization imaging in LArTPC can provide labeled data from experimental events (e.g., cosmic-ray muons) to directly train the model, bypassing complex optical simulations. We also propose **exploring Quantum Machine Learning**, taking advantage of its high efficiency in learning, to further reduce training dataset sizes. This approach potentially offers one of the first practical applications of quantum machine learning in particle physics (an idea proposed for the Quantized 2.0 FOA [11] by the PI) given the recent significant advancement in quantum computing hardware and quantum algorithms.
3. With the developed simulation software, **conduct comprehensive physics sensitivity studies** to evaluate the benefits of light calorimetry across MeV to GeV energy scales. These studies will cover neutrino oscillations, atmospheric neutrinos, supernova neutrinos, nucleon decay, and solar neutrinos. This research will further justify the DUNE Phase-II photon detection system upgrade and provide critical insights for detector optimization.

2.2 Optimization of the APEX Detector and photon detector system R&D

Assisted by the accelerated optical simulation software developed in Section 2.1, we propose the following APEX detector optimization and photon detection system development to enhance DUNE Phase-II physics:

1. **Develop new readout methods to accommodate the large dynamic range** necessary for precise light calorimetry from sub-MeV to multi-GeV scales. Achieving over four orders-of-magnitude dynamic range in LArTPCs is unprecedented but will significantly enhance the low-energy and high-energy physics measurements. We will explore two strategies:
    a. <u>Optimized grouping of Silicon Photomultipliers</u> (SiPMs): In the current design, each photon detector module contains 80 SiPMs to maximize signal acceptance. These 80 SiPMs are grouped together to minimize the number of electronic channels. We will study the optimization of SiPM grouping strategy to improve dynamic range while balancing data throughputs.
    b. <u>Dual-gain readout</u>: The BNL-designed 65nm front-end ASIC (CHARMS) is adapted for both charge and optical readout, supporting multiple gain configurations for each channel. We will study the feasibility of dual low-gain and high-gain readouts and the optimized configuration to extend the dynamic range while balancing data throughputs.

    The optimized solution will be determined through simulation studies and bench tests to inform design requirements for possible ASIC revisions.

2. **Conduct R&D to increase photon detection efficiency and reduce costs**. The current photon detection efficiency in DUNE is only about 2%, primarily due to the inefficiency of shifting the 128-nm LAr scintillation light to visible wavelengths, where the SiPMs have higher sensitivity. Recent advances in the industrial OLED technology [12] offer a cost-effective method for uniformly coating wavelength-shifting materials onto various substrates, potentially reducing the reflective interfaces and significantly improving detection efficiency. We will collaborate with industry partners to evaluate the performance of this new coating technique and conduct simulation studies to optimize wavelength-shifting materials, substrate choices, and geometric configurations for a more efficient and cost-effective photon detector design.
3. **Further optimize light yield uniformity and reconstruction**. Achieving a uniform light yield across the entire LArTPC detector is crucial for enhancing light calorimetry energy resolution. This optimization will include the feasibility study on placing photon detector modules on the LArTPC cathodes and anodes, where the light yield is expected to be lowest. Additionally, we'll investigate the use of reflective or wavelength shifting coatings on the detector assembly to improve performance. The granularity of photon detector modules will also be refined to enhance light reconstruction, enabling position-dependent corrections to mitigate residual nonuniformity.
4. **Conduct integration tests of the full optical readout chain**. We plan to conduct prototype integration tests of APEX modules in the third year of the LDRD in collaboration with the DUNE APEX group. The prototype test will implement the full optical readout chain with the optimized photon detector modules at testing facilities. This LDRD will provide important BNL FTEs to lead the integration tests and data analysis. The results will confirm the technical readiness of APEX for DUNE Phase-II.

3. Project Team

We've formed a strong team from the Physics Department and Instrumentation Department, bringing in diverse expertise to the project. Chao Zhang serves as PI and project overseer. Chao Zhang leads GPU-accelerated APEX simulation and Quantum Machine Learning development, with support from simulation expert Xin Qian. Jay Hyun Jo leads the AI/ML development for optical calibration. Shanshan Gao leads optical readout dynamic range improvement. Jay Hyun Jo directs photon detector R&D, supported by device expert Thomas Tsang. Postdoc Xuyang Ning and a new-hire postdoc focus on detector optimization, R&D, and physics sensitivity studies, guided by Chao Zhang and Jay Hyun Jo. Huchen Chen and Steve Kettell provide guidance on DUNE Phase-II requirements within the DUNE project leadership. Chao Zhang coordinates integration tests alongside all project investigators.

4. Deliverables

- A comprehensive GPU-accelerated LArTPC photon detector simulation software featuring tunable optical and geometric parameters for efficient detector optimization.
- A novel optical calibration method employing a deep-learning surrogate model, along with a feasibility study on further accelerating simulations using Quantum Machine Learning algorithms
- Comprehensive physics sensitivity studies with publications detailing the benefits of light calorimetry for neutrino measurements across MeV and GeV energy scales.
- New techniques to build photon detectors for LArTPCs demonstrating significantly improved efficiency and cost-effectiveness.
- An optimized APEX conceptual design for DUNE Phase-II with optical readout requirements.

- Comprehensive integration tests of the full readout chain to demonstrate technical readiness and validate the BNL-developed photon detector system for DUNE Phase-II.

Communication plans: We will maintain active communication with DUNE project leaders to ensure efficient resource sharing and project execution. Progress will be reported weekly at DUNE internal meetings. Additionally, we will present our findings at conferences and workshops to engage with the broader scientific community. To secure future funding opportunities, we will proactively communicate with DOE and relevant stakeholders. We will report the LDRD progress at the monthly meeting with the DOE Office of High Energy Physics and the annual budget briefing meeting with DOE.

5. Milestones and Timeline

The table below outlines the project's timeline and key milestones for fiscal years 2026—2028. Millstones are color-coded as follows: simulation and physics studies (blue), detector optimization (orange), and photon detector R&D and integration test (green). Technical and physics sensitivity publications are expected at the completion of the milestones.

Milestones	FY 2026		FY 2027		FY2028	
A full APEX photon detector simulation software	x	x				
GPU acceleration with *Opticks*	x	x				
Optical calibration with Deep-learning models	x	x	x			
Optical calibration with Quantum Machine learning				x	x	x
Physics sensitivity studies on light calorimetry	x	x	x	x	x	x
Detector optimization: readout dynamic range			x	x	x	x
Detector optimization: uniformity and material			x	x		
Detector optimization: light reconstruction			x	x	x	x
Photon detector R&D: wavelength-shifter coating	x	x				
Photon detector R&D: new photon detector design			x	x	x	x
Prototype integration tests					x	x

References

[1] Particle Physics Project Prioritization Panel (P5) report (2023). https://www.usparticlephysics.org/2023-p5-report/

[2] "DUNE Phase II: Scientific Opportunities, Detector Concepts, Technological Solutions", DUNE collaboration, JINST 19, P12005 (2024).

[3] "Cryogenic Front-End ASICs for Low-Noise Readout of Charge Signals," P. Mukim et al., in IEEE Transactions on Circuits and Systems I: Regular Papers, doi: 10.1109/TCSI.2024.3506828 (2024)

[4] "Self-compensating Light Calorimetry with Liquid Argon Time Projection Chamber for GeV Neutrino Physics", X. Ning, W. Shi, C. Zhang, C. Riccio, J. Jo, Phys. Rev. D 111, 032007 (2025).

[5] "Physics Prospects with MeV Neutrino-Argon Charged Current Interactions using Enhanced Photon Detection in Future LArTPCs", W. Shi et. al., arXiv:2502.18498 (2025).

[6] “PoWER: A new concept for the DUNE FD3 Photon Detection System”, https://indico.cern.ch/event/1390649/contributions/6061498/ (2024).

[7] “The DUNE Far Detector Vertical Drift Technology. Technical Design Report”, DUNE collaboration, JINST 19, T08004 (2024)

[8] https://github.com/simoncblyth/opticks

[9] https://github.com/BNLNPPS/esi-shell

[10] “Implicit Neural Representation as a Differentiable Surrogate for Photon Propagation in a Monolithic Neutrino Detector”, M. Lei et.al., arXiv:2211.01505 (2025)

[11] “Quantum Monte Carlo Simulation for High Energy Physics”, C. Zhang, V. Cavaliere, H. Tseng, S. Yoo, T. Wei, M. Neubauer, QuantISED 2.0 proposal for High Energy Physics (2024).

[12] https://global.canon/en/technology/oled-display-2023s.html

[13] “Observation of electron-antineutrino disappearance at Daya Bay”, Daya Bay collaboration, Phys. Rev. Lett. 108, 171803 (2012).

Curriculum Vitae (Chao Zhang)

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Phone: 631-344-8320 | Email: czhang@bnl.gov

Education

2002 – 2010 Ph.D. in Physics, California Institute of Technology
1997 – 2002 B.S. in Physics, University of Science and Technology of China

Employment

2021 – present	Senior Physicist, Brookhaven National Laboratory
2019 – 2021	Physicist, Brookhaven National Laboratory
2017 – 2019	Associate Physicist, Brookhaven National Laboratory
2015 – 2017	Physics Associate III, Brookhaven National Laboratory
2011 – 2015	Research Associate, Brookhaven National Laboratory
2010 – 2011	Postdoctoral Scholar, California Institute of Technology

Research

- Long- and short-baseline neutrino oscillations: member of the DUNE (2010-), MicroBooNE (2013-), SBND (2020-), ICARUS (2019-2023) collaborations.
- Reactor neutrinos: member of the Daya Bay (2010-), PROSPECT (2014-), KamLAND (2004-2011) collaborations.
- Others: statistical analysis, signal processing, particle event reconstruction, machine learning, quantum algorithms.

Services

In Daya Bay, serves as BNL PI, Executive Committee, and Analysis Coordination Committee members.
Reviewers for DOE IF comparative review, ECA, SBIR, SCGSR programs
Reviewers for PRL, PRD, PRC, PRE, PRAppied, RMP, JINST, EPJC journals
Review Editor of Frontiers in High-Energy and Astroparticle Physics

Awards

2017 DOE Office of Science Early Career Research Program Award
2015 Breakthrough Prize in fundamental physics (as member of the Daya Bay collaboration)

Recent Related Publications

- "Self-compensating Light Calorimetry with Liquid Argon Time Projection Chamber for GeV Neutrino Physics", X. Ning, W. Shi, **C. Zhang**, C. Riccio, J. Jo, Phys. Rev. D 111, 032007 (2025).
- "Physics Prospects with MeV Neutrino-Argon Charged Current Interactions using Enhanced Photon Detection in Future LArTPCs", W. Shi, X. Ning, D. Pershey, F. Marinho, C. Riccio, J. Jo, **C. Zhang**, F. Cavanna., arXiv:2502.18498 (2025).
- "Reactor antineutrino flux and anomaly", **C. Zhang**, X. Qian, M. Fallot, Prog. Part. Nucl. Phys. 136, 104106 (2024).
- "Quantum Convolutional Neural Networks for High Energy Physics Data Analysis", Y.C. Chen, T.C. Wei, **C. Zhang**, H. Yu, S. Yoo, Phys. Rev. Research 4, 013231 (2022).
- "Hybrid Quantum-Classical Graph Convolutional Network", Y.C. Chen, T.C. Wei, **C. Zhang**, H. Yu, S. Yoo, arXiv:2101.06189 (2021).

1. ALIGNMENT WITH THE LABORATORY MISSION AND VISION

This proposal supports the laboratory initiative "**Understanding the building blocks of the universe**" and aligns with BNL's mission and vision for advancing U.S. particle physics, as outlined in the 2023 P5 report. This project enhances DUNE's scientific capabilities by utilizing scintillation light as a new signal to understand the mysteries of neutrinos and the universe. It broadens fundamental physics research across multiple domains, including neutrino oscillations, atmospheric neutrinos, nucleon decay, supernova neutrinos, and solar neutrinos. The developed techniques will have broad applications in science and technology beyond neutrino research, such as for EIC and Future Colliders.

2. POTENTIAL FUNDING

Success of this proposal will position BNL for leadership in DUNE Phase-II over the coming decades. Phase-II DOE R&D funding is expected around 2029 as Phase-I project funding ramps down, followed by Phase-II project funding beginning after 2031 lasting 7—10 years. The total Phase-II project funding received by BNL is expected to increase beyond the Phase-I funding of ~$90M. The DUNE photon detection system will introduce a new funding stream for BNL, not available to BNL in DUNE Phase-I, estimated to be around $20M during DUNE Phase-II.

The advanced photon simulation and detection techniques will have extensive applications in science and technology, extending well beyond neutrino research and DUNE itself. For example, it provides opportunities for a new type of compensating calorimeters using LAr scintillation for an EIC detector and Future Colliders to improve their energy measurements [4]. The developed techniques will build a strong foundation to help secure future funding opportunities from Detector R&D, AI/ML, Quantum Information Science programs, and other DOE initiatives across HEP, NP, and ASCR. It will also support proposals for future Early Career Awards.

3. BUDGET JUSTIFICATION

Below is the proposed funding plan over three years, approximately $600k/year. The project team is described in Section 3 of the proposal. The proposed budget is attached as the last page.

- 1.5 FTE Postdoctoral Research Associate
  - Xuyang Ning is our current postdoc working on DUNE. She will have 1.0 FTE in FY26 and 0.5 FTE in FY27 and FY28. DUNE Research funding will cover her other 0.5 FTE in FY27 and FY28 to perform physics analysis on ProtoDUNE data, which well positions her for academic job applications.
  - A new-hire postdoc will start on the second half of FY26 (0.5 FTE), taking into account the time for the hiring process and relocation. The new hire will have 1.0 FTE in FY27 and FY28.
- 0.55 FTE Research Staff
  - Chao Zhang (PI): 0.25 FTE. Oversees the project. Lead simulation, quantum machine learning, and physics studies.
  - Jay Hyun Jo: 0.2 FTE. Lead AI/ML in optical calibration and photon detector R&D.
  - Shanshan Gao: 0.05 FTE. Lead optical readout design and test.
  - Thomas Tsang: 0.05 FTE. Support photon detector R&D.
- 0.1 FTE Mechanical Engineer in FY26 and FY27: design bench test for photon detector R&D.
- 0.2 FTE Electrical-mechanical Technician: set up test stand for photon detector R&D.

- M&S ~$24K/y including
  - 2 domestic trips ($6K) and 2 foreign trips ($8K) for meetings and prototype tests.
  - $10K per year for lab bench test setup, including silicon photomultiplier ($6K), circuit board fabrication and assembly ($10K), power supplies ($4K), optical components and material ($5K), and computer for data acquisition ($5K). They will be purchased in stages to allow incremental tests.

4. 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 - $10,000

Year 2 - $10,000

Year 3 - $10,000

Description: M&S includes silicon photomultiplier ($6K), circuit board fabrication and assembly ($10K), power supply ($4K), optical components and material ($5K), and computer for data acquisition ($5K).

5. 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.

6. 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.

7. 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.

8. 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.

9. TYPE OF WORK

Select: ☒ Basic ☐Applied ☒ Development

Title: LDRD Advancing Photon Detection Systemfor DUNE Phase II
PI: Chao Zang

Resource Category	DESCRIPTION		FY26		FY27		FY28
050	Salary - Scientific		133,505		135,850		141,510
051	Salary - Research Assoc		160,771		166,172		171,988
050	Salary - Professional		12,227		12,654		0
050	Salary -Technical		27,012		27,629		28,713
050	Salary - Management & Admin.		0		0		0
	Total FTEs		**2.36**		**2.35**		**2.26**
TOTAL SALARY/WAGE & FRINGE			**333,514**		**342,305**		**342,210**
various	Hosting Collaborators		0		0		0
280	Foreign Travel		8,000		8,000		8,000
290	Domestic Travel		6,000		6,000		6,000
various	Purchases		10,000		10,000		10,000
TOTAL MSTC			**24,000**		**24,000**		**24,000**
170	Relocation Expense		10,000		0		0
240	Registration Fees		0		0		0
271	Communications		0		0		0
TOTAL COM/MISC			**10,000**		**0**		**0**
TOTAL DIRECT COSTS			**367,514**		**366,305**		**366,210**
251	Electric Distributed (Electric Power Burden)		3,335		3,423		3,422
700/701/481	Organizational Burden		42,631		43,780		43,875
TOTAL ORGANIZATIONAL BURDEN			**45,966**		**47,203**		**47,297**
745	Procurement (Material Handling)		1,680		1,680		1,680
735	G&A Burden		0		0		0
730	Common Institutional Support		184,840		184,812		184,812
722	Safeguards & Security Assess		0		0		0
TOTAL LABORATORY BURDEN			**186,520**		**186,492**		**186,492**
705	LDRD Burden		0		0		0
TOTAL PROGRAM COSTS			**600,000**		**600,000**		**600,000**
740	Full Cost Recovery		0		0		0
TOTAL PROGRAM COSTS			**600,000**		**600,000**		**600,000**

Labor Band	Name	FY26		FY27		FY28	
		FTE	**Amount**	**FTE**	**Amount**	**FTE**	**Amount**
PROF1	Engineer TBD	0.10	12,227	0.10	12,654	0.00	0
RA1	Xuyang Ning	1.00	107,035	0.50	55,391	0.50	57,329
RA1	Post Doc	0.50	53,736	1.00	110,781	1.00	114,658
SCI1	Jay Hyun Jo	0.20	41,635	0.20	42,141	0.20	44,521
SCI2	Thomas Tsang	0.05	13,394	0.05	13,862	0.05	14,348
SCI1	ShanShan Gao	0.05	10,179	0.05	10,535	0.05	10,904
SCI2	Chao Zhang	0.25	68,298	0.25	69,312	0.25	71,738
TECH1	TBD	0.20	27,012	0.20	27,629	0.20	28,713
	Total	2.36	333,514	2.35	342,305	2.26	342,210

APPROVALS

James Desmond	James L. Desmond III
Business Operations Manager	**Signature**

Hong Ma	Hong Ma
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

Abhay Deshpande	A. Deshpande
Cognizant Associate Lab Director	**Signature**