BROOKHAVEN NATIONAL LABORATORY
PROPOSAL INFORMATION QUESTIONNAIRE
LABORATORY DIRECTED RESEARCH AND DEVELOPMENT PROGRAM

PRINCIPAL INVESTIGATOR	Marc-André Pleier (PO-Omega)	**PHONE**	x4249
DEPARTMENT/DIVISION	PO/NPP, AM/ATRO	**DATE**	06/17/22
OTHER INVESTIGATORS	Kétévi Assamagan (PO-Omega), Elizabeth Brost (PO-Omega), Viviana Cavaliere (PO-Omega), Angelo Di Canto (PO-EDG), George Iakovidis (PO-Omega), Brett Parker (AM), Robert Szafron (PO-HET)		
TITLE OF PROPOSAL	Capturing Leadership at the Future Higgs Factory for BNL		
TYPE A			
PROPOSAL TERM (month/year)	From 10/2022	Through	09/2025

BROOKHAVEN NATIONAL LABORATORY
PROPOSAL INFORMATION QUESTIONNAIRE
LABORATORY DIRECTED RESEARCH AND DEVELOPMENT PROGRAM

SUMMARY OF PROPOSAL

Description of Project:

The Higgs boson is the final puzzle piece in our current understanding of nature expressed in the Standard Model of particle physics, and it is responsible for giving all fundamental particles their mass. BNL's Omega group was a leader in the discovery effort, nearly 10 years ago at the Large Hadron Collider at CERN, Geneva, Switzerland. The Higgs boson is the latest tool in unraveling the mysteries of our universe such as dark matter and dark energy, which make up 95% of the cosmos.

The High Energy Physics community has identified a "Higgs Factory" as the highest-priority next collider facility [1,2], enabling unprecedented precision measurements of Higgs boson properties in the clean environment of electron-positron collisions. BNL has a unique opportunity to be a part of, and more importantly, to take leadership in this emerging field. We will be building on well-established ties with CERN through the ATLAS collaboration, where BNL led the US contribution to the original construction and is now the host laboratory, leading operations and detector upgrade programs.

We propose to establish a program of Higgs boson property studies at a prospective Higgs Factory to inform detector development and optimization. Building on the expertise of the investigators, this program uses three complementary physics analyses to ensure no stone will be left unturned at the future Higgs Factory in our quest to enhance our understanding of the universe. Focusing on tracking and timing detectors, noble-liquid based calorimetry, and on the data-acquisition architecture, we will provide the necessary detector parameters to ensure as broad and powerful physics reach as possible.

This program will establish BNL's leading role in the Higgs Factory physics and detector communities, leveraging our involvement in ongoing detector R&D programs at CERN and complementing the ongoing accelerator feasibility studies outlined in an addendum to the DOE-CERN cooperation agreement and a CERN-BNL Memorandum of Understanding (involving CAD and ATRO), both in place since 2020.

Expected Results:

The expected result is a public document detailing the interdependence of physics sensitivities and detector parameters (such as tracking, timing and energy resolutions) and a public software package enabling further studies.

- **Intellectual Impact:** long-term High Energy Physics leadership for BNL, beyond the High Luminosity-Large Hadron Collider program
- **External Funding Impact:** expect the US to invest of order $500M per Higgs Factory detector, followed by a ~$20M/year operations program (including appropriate computing (Tier 1) and software infrastructure support) and additional funds for detector upgrades.
- **DEI Impact:** significant contribution to developing a diverse, equitable, and inclusive workforce (e.g. via African School of Fundamental Physics and Applications pipeline) and workplace, and mentoring of early career researchers
- **Community Impact:** strengthen BNL's external relations with universities and global collaborators

PROPOSAL

1. Overview

A Higgs Factory at an electron-positron collider was identified in the 2020 Update of the European Strategy for Particle Physics as "*the highest-priority next collider*" [1], and the International Committee for Future Accelerators (ICFA) reconfirmed in April 2022 "*the international consensus on the importance of a Higgs Factory as the highest priority for realizing the scientific goals of particle physics.*" [2]. The European Strategy update calls for collider feasibility studies to "*be established as a global endeavor and be completed on the timescale of the next Strategy update*", which is expected in 2026. In response to this call, DOE and CERN augmented their cooperation agreement in 2020 for the US to participate in the Future Circular Collider (FCC) feasibility study, for both sides to benefit from the "*unique opportunities to advance next-generation accelerator technologies and extend the scientific discovery potential for the field of particle physics*". In that same spirit, CERN and BNL established a Memorandum of Understanding (involving BNL's C-AD and ATRO) that same year, to participate in these accelerator studies.

This LDRD aims to augment the ongoing FCC accelerator studies with a three-year program of Higgs boson property studies at the prospective electron-positron FCC (FCC-ee) Higgs Factory [3] to inform detector development and optimization. Using three complementary physics analyses, the PIs will determine the detector parameters to ensure a broad and powerful physics reach for the FCC-ee. Now is the perfect time to pursue this endeavor, giving BNL a seat at the table for the 2026 European Strategy update, when a decision on the next facility is expected, and to build on the momentum of the US Community Study on the Future of Particle Physics (Snowmass 2021), which is currently wrapping up. While the proposed studies will be performed in the context of the FCC-ee, their results will be applicable also to other Higgs Factory options such as C^3, CEPC, CLIC or ILC [4,5,6,7].

The FCC-ee collider design is based on well-established technologies and is planned for construction in a tunnel of approximately 90 km length around Geneva, Switzerland. It will enable precision studies at various center-of-mass energies, including Higgs coupling measurements at the sub-percent level and searches for new particles [3]. The PIs will build on well-established ties with CERN and other (inter)national partners through the ATLAS Collaboration at the Large Hadron Collider (LHC), where BNL led the US contribution to the original construction and is now the host laboratory, leading operations and detector upgrades.

This project leverages the PIs' leadership in High Energy Physics and in ATLAS — using the Higgs boson as a tool for discovery and exploring the unknown — as well as their expertise in optimizing tracking and timing detectors, noble-liquid based calorimetry, and data-acquisition architecture. It is synergistic with CERN R&D collaborations that some of the team are involved in: Liquid Argon calorimetry (Begel, Chen, Pleier) and Low Gain Avalanche Detectors (Tricoli).

The three planned physics analyses address Higgs boson properties that are poorly accessible at the LHC:

1. Study of the Higgs decay into two charm quarks, which is not observable/testable at the High Luminosity-LHC (HL-LHC) due to its challenging hadronic production environment [8],

2. Study of the Higgs boson's coupling to itself, which can only be poorly constrained at the HL-LHC, but where even a tiny change has dramatic consequences for our understanding of the evolution of the Universe [9],
3. Study of the Higgs boson decay rate into invisible final states beyond Standard Model predictions, which can only be poorly constrained at the HL-LHC, but could solve the puzzle of dark matter [10].

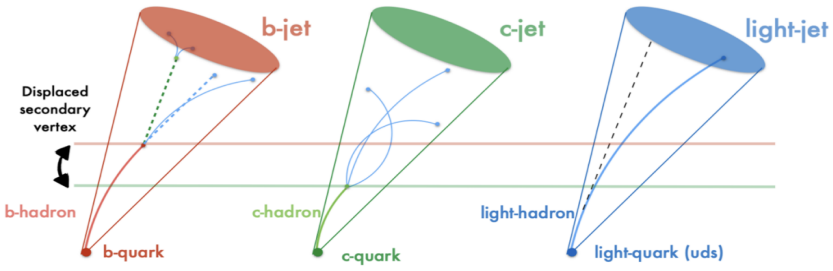
The execution of these analyses and the evaluation of their sensitivities to detector parameters such as tracking, timing, and energy resolutions requires a deep understanding of the underlying physics (both precision calculations and model building) and their simulation, including detector effects, as well as the underlying detector technologies, all of which are areas where BNL has a proven record of leadership. The interface between interaction region magnets (IRMs) and detectors is crucial to determine detector coverage and the radiation environment [11], and will be taken into account through collaboration with BNL's Superconducting Magnet Division, which is involved in the design of the IRMs.

With the Snowmass activities winding down, each staff team member will devote ~20% of their time to this project. In addition, three postdocs, corresponding to two FTEs, will be hired. Each postdoc will work on one of the analyses, while pursuing research on ATLAS data to ensure future career success. Should the hire of the new postdocs delay beyond the project start, current BNL ATLAS postdocs will kick-start the project until the new hires arrive. The effort will also involve domestic and international students through established partnerships of the PIs, for example the African School of Fundamental Physics and Applications, of which two alumni now are employed by BNL as ATLAS postdocs. While this project will be connected with the international FCC-ee organizational structure, including regular reports in the appropriate fora (with corresponding travel funds for the postdocs), we plan to host a series of workshops at BNL to engage the US community, with a view towards future collaboration formation.

2. Proposed Work

2.1 Higgs boson decay into two charm quarks

The study of Higgs boson couplings to charm (c) at the LHC is extremely difficult [12] and will not reach sensitivity to the SM prediction. Access to Higgs boson couplings to second generation quarks is therefore a unique opportunity for lepton colliders. The clean environment and lower background rates, combined with an efficient c-tagging performance, will enable us to disentangle $c\bar{c}$ decays from other copious hadronic Higgs decays. However, the sensitivity is very dependent on vertex detector design and the c-tagging algorithm itself. Like b-jets, c-jets contain long-lived hadrons with a relatively large branching fraction into final states with leptons (see Figure). It is therefore possible to use the same features used in b-tagging, such as track displacement and secondary

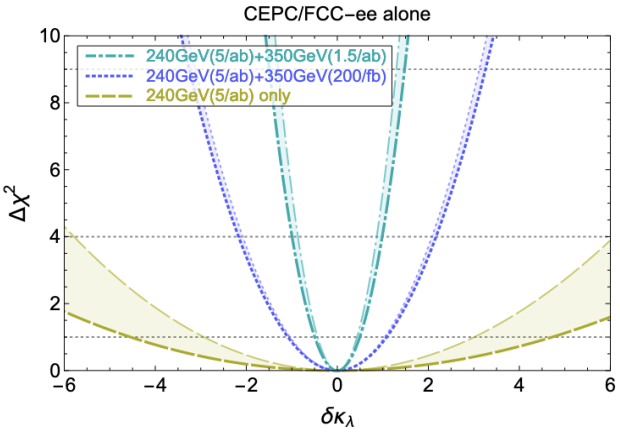


vertex mass, to achieve discrimination against other jets. Thus, the most important detector for *c*-tagging is the tracker, for reconstruction of charged particle tracks and identification of vertices. Optimal performance is achieved if the detector has high impact parameter resolution, so it needs to be as close as possible to the interaction point, needs high hit resolution, and needs a low material budget to avoid multiple scattering of low-p_T particles.

We will establish a charm-tagging algorithm to reduce the uncertainty on $H\rightarrow c\bar{c}$ and test the SM prediction. We will develop an efficient algorithm using modern machine-learning (ML) techniques, and design a tracker layout that maximizes the performance of *c*-jet identification. We will leverage our group's expertise in the application of ML in complex, background-dominated analyses at the LHC [13], in tracking for the trigger [14], and in trackers.

2.2 Higgs boson self-coupling

The Higgs sector is the least well-known part of the Standard Model. The shape of the Higgs potential and the strength of its self-interactions have tremendous implications for understanding the early universe and its ultimate fate. The theory uniquely predicts Higgs boson self-interactions, which have not yet been observed experimentally. The HL-LHC is expected to achieve 50% precision on the value of the Higgs self-coupling [10], using direct [15] and indirect constraints [16].



However, since our understanding of nature is not complete until we test the structure of the Higgs sector, this is an important measurement to target for future colliders. While the energy at the FCC-ee is too small to produce a pair of Higgs bosons directly, it is possible to extract information on the Higgs couplings indirectly from precision single Higgs measurements in combination with higher-order computations within the effective field theory framework. This measurement depends on measurements of the ZH cross section, the WW→H cross section, and Higgs decays to ZZ and WW. The ZH cross section, which will be measured at a ~240 GeV run, is most sensitive to changes in the self-coupling ($\delta\kappa_\lambda$), but reductions in uncertainties on other parameters, from a ~350 GeV run, are necessary for achieving the final precision (see plot above, from [17]). The global fit is expected to reach 34% accuracy [17]. This difficult measurement depends on the detector design to enable precise determination of the Higgs couplings to vector bosons.

2.3 Higgs boson decay into invisible particles, including dark matter

A well-motivated SM extension is the addition of a so-called dark sector (DS), which is only weakly coupled to the SM. Models of the DS aim to explain observed deviations from the SM predictions such as the muon *g*-2 discrepancy [18,19,20] and the astrophysical positron excess [21-25], and provide a dark matter candidate. Models of the weak coupling between the SM and DS which do not violate existing experimental bounds [26,27] typically involve mixing between dark sector vector bosons and photons and *Z*-bosons, and/or between a dark sector

scalars and the SM higgs boson [28]. These models have been searched for at the LHC and other experiments [29]. It is essential for these searches to establish benchmark models that serve as templates of possible experimental signatures and additionally to perform model independent analysis using a universal framework of effective field theory.

The future Higgs factory must be able to establish if the Higgs boson is a portal to the DS. Processes of particular interest include a SM Higgs decaying to stable or long-lived dark sector particles (Higgs to invisible) as well as Higgs boson decays to four SM particles via intermediate DS particles mediated by the SM/DS mixing. The upper bound on the branching ratio for invisible Higgs boson decays, in the vector boson fusion channel, from the full LHC Run-2 data set is on the order of 10% [30] (the detector signature is two forward jets with rapidity gap, accompanied by a large missing energy), and, considering the backgrounds at the LHC, the HL-LHC is expected to reach a 2% accuracy – much above the the 0.1% level expected for the dominant SM contribution $H \rightarrow ZZ^* \rightarrow 4\nu$. The Higgs factory will be able to pinpoint the invisible Higgs decay rate with much better accuracy, using Higgs bosons produced in the $e^+e^- \rightarrow ZH$ process. The subsequent decay of the $Z \rightarrow \ell\ell$ allows us to reconstruct the Higgs boson momentum, without the need to observe its decay products, and thus constrain the $H \rightarrow$invisible [31] rate. Due to the much-reduced backgrounds [32], studies show an expected upper limit for the branching ratio of invisible Higgs boson decays of around 0.2% [33]. Our team's extensive experience with the $H \rightarrow (Z/Z_d)Z_d \rightarrow 4\ell$ analysis, where Z_d is a DS vector boson [34], as well as more general searches for $S \rightarrow X_d X_d \rightarrow 4\ell$, where S is a scalar with mass different from 125 GeV and X_d is an invisible or visible DS state, at the LHC will be a valuable asset in adapting them for the FCC-ee. We will explore potential theoretical scenarios that can be tested at Higgs factories and identify the most promising signatures of the DS. This will enable us to identify key parameters in the detector design, with a particular focus on calorimetry, which are required for the dark sector searches.

3. Project Impact

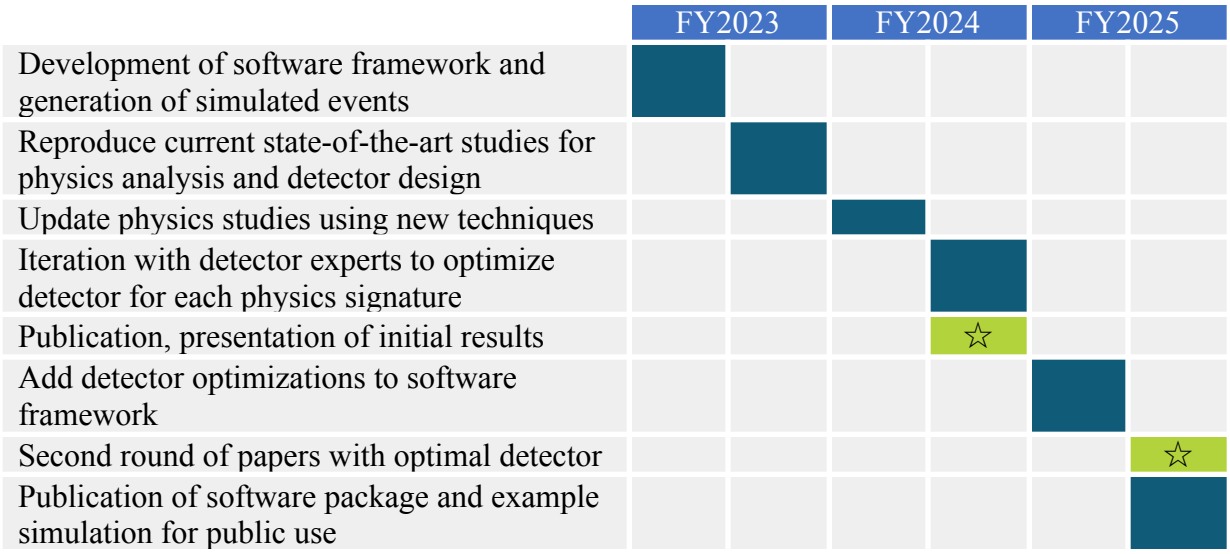
Our research program for a future Higgs Factory addresses three properties of the Higgs boson that can only be studied in a limited way at the LHC: the coupling of the Higgs boson to charm quarks, to itself, and to invisible particles. These studies pose complementary requirements on detector parameters at a future Higgs Factory, and their combined evaluation ensures a broad and powerful physics reach.

- **Intellectual Impact:** long-term HEP leadership beyond the HL-LHC program, which will position BNL as the US host laboratory for one of the Higgs Factory collaborations.
- **External Funding Impact:** expect the US to invest ~$500M per Higgs Factory detector, followed by a ~$20M/year operations and additional funds for an upgrade program. This LDRD is the first step towards BNL capture of this funding.
- **DEI Impact:** significant contribution to developing a diverse, equitable, and inclusive workforce (e.g. via African School of Fundamental Physics and Applications pipeline) and workplace, and mentoring of early career researchers. The experience that the three postdocs and our junior staff gain through this work will position them to lead the development of future collider experiments.

- **Community Impact:** strengthen BNL's external relations with universities and global collaborators through BNL-hosted Higgs Factory workshops and BNL presence in international Higgs Factory working groups.

4. Project Timeline

The timeline and major milestones for this project for fiscal years 2023-2025 are shown in the chart below, with publications indicated by a star:



5. Project Team

The **Principal Investigators** of this proposal are uniquely qualified for its execution. **Dr. Kétévi Assamagan** will lead the searches for dark sector states and broader impact in DEI and community engagement. **Dr. Elizabeth Brost** will lead studies of the Higgs self-coupling, using expertise gained from LHC data analysis. **Dr. Viviana Cavaliere** and **Dr. Angelo Di Canto** will lead the studies on the Higgs to charm coupling, focusing on the final state analysis and charm-tagging respectively. **Dr. George Iakovidis** will work closely with the analysis teams to optimize the tracking detector for each physics signature. **Dr. Brett Parker** will serve as expert for the interface between interaction region magnets and detectors. **Dr. Marc-André Pleier** will lead the overall effort and contribute to the Higgs self-coupling studies. **Dr. Robert Szafron** will provide theoretical calculations needed for simulations related to signals and backgrounds, investigate the potential for New Physics discovery, and explore some specific models of the dark sector to identify potential signatures at the Higgs Factory.

This project benefits from the knowledge and leadership of many **Senior Collaborators**: **Dr. Michael Begel** and **Dr. Hucheng Chen** will contribute to planning for optimization of detector layout and readout with the trigger and data acquisition systems. **Dr. Paul Laycock** will provide consultation on software and computing related topics. **Dr. Scott Snyder** will contribute to detector optimizations for dark sector searches as well as to the design of software used for this work. **Dr. Alessandro Tricoli** will supervise the studies on Higgs to charm and on detector layout.

References

[1] European Strategy Group, "2020 Update of the European Strategy for Particle Physics," 2020, doi: 10.17181/ESU2020.

[2] International Committee for Future Accelerators, "ICFA Statement Regarding Higgs Factory Development and the ILC." Apr. 10, 2022. Accessed: Jun. 11, 2022. [Online]. Available: https://icfa.hep.net/wp-content/uploads/ICFA_Statement_April2022_Final.pdf.

[3] G. Bernardi *et al.*, "The Future Circular Collider: a Summary for the US 2021 Snowmass Process." arXiv, May 04, 2022. Accessed: Jun. 14, 2022. [Online]. Available: http://arxiv.org/abs/2203.06520.

[4] S. Dasu et al., "Strategy for Understanding the Higgs Physics: The Cool Copper Collider." arXiv, Jun. 07, 2022. Accessed: Jun. 14, 2022. [Online]. Available: http://arxiv.org/abs/2203.07646.

[5] The CEPC Study Group, "CEPC Conceptual Design Report: Volume 1 - Accelerator." arXiv, Sep. 01, 2018. Accessed: Jun. 14, 2022. [Online]. Available: http://arxiv.org/abs/1809.00285.

[6] L. Linssen, A. Miyamoto, M. Stanitzki, and H. Weerts, "Physics and Detectors at CLIC: CLIC Conceptual Design Report." arXiv, Feb. 27, 2012. Accessed: Jun. 14, 2022. [Online]. Available: http://arxiv.org/abs/1202.5940.

[7] T. Behnke et al., "The International Linear Collider Technical Design Report - Volume 1: Executive Summary." arXiv, Jun. 26, 2013. Accessed: Jun. 14, 2022. [Online]. Available: http://arxiv.org/abs/1306.6327.

[8] ATLAS Collaboration, "Extrapolation of ATLAS sensitivity to H→bb and H→cc decays in VH production at the HL-LHC," ATL-PHYS-PUB-2021-039, Available: http://cds.cern.ch/record/2788490.

[9] J. Alison et al., "Higgs boson potential at colliders: Status and perspectives," Rev. Phys. 5 (2020) 100045, arXiv:1910.00012 [hep-ph]. Available: https://arxiv.org/abs/1910.00012.

[10] M. Cepeda et. al., "Report from Working Group 2: Higgs Physics at the HL-LHC and HE-LHC," CERN-LPCC-2018-04, Available: https://cds.cern.ch/record/2650162.

[11] P. Azzi and E. Perez, "Exploring requirements and detector solutions for FCC-ee," *Eur. Phys. J. Plus*, vol. 136, no. 11, p. 1195, Nov. 2021, doi: 10.1140/epjp/s13360-021-02141-0.

[12] ATLAS Collaboration, "Direct constraint on the Higgs-charm coupling from a search for Higgs boson decays into charm quarks with the ATLAS detector," https://arxiv.org/abs/2201.11428.

[13] ATLAS Collaboration, "Measurements of gluon fusion and vector-boson-fusion production of the Higgs boson in H-> WW* ->eμνμ decays using pp collisions at sqrt(s) =13 TeV with the ATLAS detector," ATLAS-CONF-2021-01. https://cds.cern.ch/record/2759651/files/ATLAS-CONF-2021-014.pdf.

[14] ATLAS Collaboration, "Technical Design Report for the Phase-II Upgrade of the ATLAS Trigger and Data Acquisition System - EF Tracking Amendment," CERN-LHCC-2022-004 ; ATLAS-TDR-029-ADD-1, https://cds.cern.ch/record/2802799.

[15] ATLAS Collaboration, "Projected sensitivity of Higgs boson pair production combining the bb$\gamma\gamma$ and bb$\tau\tau$ final states with the ATLAS detector at the HL-LHC," ATL-PHYS-PUB-2022-005, Available: http://cds.cern.ch/record/2802127.

[16] G. Degrassi, P. P. Giardino, F. Maltoni, and D. Pagani, "Probing the Higgs self coupling via single Higgs production at the LHC," JHEP 12 (2016) 080, arXiv:1607.04251 [hep-ph].

[17] S. Di Vita, G. Durieux, C. Grojean, J. Gu, Z. Liu, G. Panico, M. Riembau, and T. Vantalon, "A global view on the Higgs self-coupling at lepton colliders," JHEP 02 (2018) 178, doi: 10.1007/JHEP02(2018)178.

[18] J. Beringer et al. Particle Data Group Collaboration, "Review of Particle Physics," Phys. Rev. D **86**, 010001 (2012), doi:10.1103/PhysRevD.86.010001.

[19] G. W. Bennett et al. Muon G-2 Collaboration, "Final Report of the Muon E821 Anomalous Magnetic Moment Measurement at BNL," Phys. Rev. D 73, 072003 (2006), doi: 10.1103/PhysRevD.73.072003.

[20] A. Czarnecki and W. J. Marciano, "The Muon Anomalous Magnetic Moment: A Harbinger For "New Physics"," Phys. Rev. D **64**, 013014 (2001), doi: 10.1103/PhysRevD.64.013014.

[21] C. Boehm and P. Fayet, "Scalar Dark Matter candidates," Nucl. Phys. B 683, 219 (2004), doi: 10.1016/j.nuclphysb.2004.01.015.

[22] C. Boehm, D. Hooper, J. Silk, M. Casse and J. Paul, "MeV Dark Matter: Has It Been Detected?", Phys. Rev. Lett. 92, 101301 (2004), doi: 10.1103/PhysRevLett.92.101301.

[23] C. Boehm, P. Fayet and J. Silk, "Light and Heavy Dark Matter Particles," Phys. Rev. D 69, 101302 (2004), 10.1103/PhysRevD.69.101302.

[24] P. Jean, J. Knoedlseder, V. Lonjou, M. Allain, J.-P. Roques, G. K. Skinner, B. J. Teegarden and G. Vedrenne et al., "Early SPI/INTEGRAL measurements of galactic 511 keV line emission from positron annihilation", Astron. Astrophys. 407, L55 (2003), doi: 10.1051/0004-6361%3A20031056.

[25] N. Arkani-Hamed, D. P. Finkbeiner, T. R. Slatyer and N. Weiner, "A Theory of Dark Matter", Phys. Rev. D 79, 015014 (2009), 10.1103/PhysRevD.79.015014.

[26] H. Davoudiasl, H.-S. Lee, and W. J. Marciano, "'Dark' Z implications for parity violation, rare meson decays, and Higgs physics," *Phys. Rev. D*, vol. 85, no. 11, p. 115019, Jun. 2012, doi: 10.1103/PhysRevD.85.115019.

[27] H. Davoudiasl, H.-S. Lee, I. Lewis, and W. J. Marciano, "Higgs decays as a window into the dark sector," *Phys. Rev. D*, vol. 88, no. 1, p. 015022, Jul. 2013, doi: 10.1103/PhysRevD.88.015022.

[28] D. Curtin, R. Essig, S. Gori, and J. Shelton, "Illuminating Dark Photons with High-Energy Colliders," *J. High Energ. Phys.*, vol. 2015, no. 2, p. 157, Feb. 2015, doi: 10.1007/JHEP02(2015)157.

[29] D. Curtin *et al.*, "Exotic Decays of the 125 GeV Higgs Boson," *Phys. Rev. D*, vol. 90, no. 7, p. 075004, Oct. 2014, doi: 10.1103/PhysRevD.90.075004.

[30] ATLAS Collaboration, "Search for invisible Higgs-boson decays in events with vector-boson fusion signatures using 139 fb^{-1} of proton-proton data recorded by the ATLAS experiment," Feb. 2022, doi: 10.48550/arXiv.2202.07953.

[31] ATLAS Collaboration, "Search for associated production of a Z boson with an invisibly decaying Higgs boson or dark matter candidates at $\sqrt{s}$=13 TeV with the ATLAS detector," *Physics Letters B*, vol. 829, p. 137066, Jun. 2022, doi: 10.1016/j.physletb.2022.137066.

[32] P. Azzi et al., "Prospective Studies for LEP3 with the CMS Detector," 2012, doi: 10.48550/ARXIV.1208.1662.

[33] A. Blondel et al., "FCC-ee: Your Questions Answered," 2019, doi: 10.48550/arXiv.1906.02693.

[34] ATLAS Collaboration, "Search for Higgs bosons decaying into new spin-0 or spin-1 particles in four-lepton final states with the ATLAS detector with 139 fb^{-1} of pp collision data at $\sqrt{s}$=13 TeV," arXiv, Oct. 26, 2021. Accessed: Jun. 11, 2022. [Online]. Available: http://arxiv.org/abs/2110.13673.

Dr. Kétévi A. Assamagan - Curriculum Vitae

Fellow of the African Academy of Sciences, the South African Institute of Physics and the American Physical Society

Brookhaven National Laboratory, Department of Physics , Upton, New York 11973 USA

Tel: (631) 521-5278, E-mail: ketevi@bnl.gov

A. Professional Preparation

- Université de Lomé, Togo Physics Licence (B.S.), 1982
- Ball State University, Muncie IN, USA Physics M.S., 1989
- University of Virginia, Charlottesville, VA, USA Physics Ph.D., 1995
- Hampton University (VA) / JLab / CERN Physics Postdoc., 1995-2001

B. Appointments

- 7/2007-present **Physicist**, Brookhaven National Laboratory, Upton, NY 11973
- 2019-present **Visiting Scientist,** University of South Africa**,** Pretoria, South Africa
- 2017-2019 **Visiting Scientist,** University of the Witwatersrand, Johannesburg, South Africa
- 2012 **Visiting Scientist,** University of Johannesburg, Johannesburg, South Africa
- 2011 **Visiting Scientist**, SACLAY, France
- 2008-2010 **Convener**, the ATLAS Higgs Working Group
- 2004-2007 **Associate Physicist**, Brookhaven National Laboratory, Upton, NY 11973
- 2001-2004 **Assistant Physicist**, Brookhaven National Laboratory, Upton, NY 11973
- 1995-2001 **Postdoctoral Research Associate**, Hampton University, Jefferson Lab, CERN.

C. A few Selected Significant Products

- (i) Products on Physics Education and Outreach in Africa
    - 1. K. A. Assamagan et al. "*A Study / model of COVID-19 pandemic in African Countries*", International Journal of Public Health and Epidemiology, Vol. 10 (8), pp. 001-016, August, 2021; arXiv:2007.10927. Scientific African (2021), https://doi.org/10.1016/j.sciaf.2021.e00987; arXiv:2104.09675.
    - 2. K. A. Assamagan et al., African School of Physics, Activity Report, 2019-2021, arXiv:2109.00509, (2021).
- (ii) Products on Fundamental High Energy Physics Research
    - 1. ATLAS Collaboration, Constraints on new phenomena via Higgs boson couplings and invisible decays JHEP 1511(2015) with the ATLAS 206. detector (2015), arXiv:1509.00672 [hep-ex].
    - 2. ATLAS Collaboration, Search for invisible decays of a Higgs boson using vector-boson fusion in pp collisions at 8 TeV with the ATLAS detector (2015), arXiv:1508.07869 [hep-ex]. JHEP 01(2016) 172; Search for invisible Higgs boson decays in vector boson fusion at 13 TeV with the ATLAS detector, Phys.Lett. B793 (2019) 499-519; http://cdsweb.cern.ch/record/2715447(2020)
    - 3. ATLAS Collaboration, Search for new phenomena in final states with an energetic jet and large missing transverse momentum in pp collisions at 8 TeV with the ATLAS detector, Eur. Phys. J. C75 (2015) no. 7, 299, arXiv:1502.01518 [hepex].

Dr. Elizabeth Brost - Curriculum Vitae

Research Activities:

- Searches for Higgs pair production, both in the Standard Model and beyond the Standard Model - from 2019-2021, I convened the ATLAS DiHiggs physics group, which searches for resonant and non-resonant Higgs pair production
- Trigger and data acquisition for the ATLAS Experiment - I coordinate the ATLAS TDAQ Phase-II Physics Performance and Event Selection group, which studies the physics performance and trigger menu for the HL-LHC era

Education:

- 2016: Ph.D. in Physics from the University of Oregon (thesis title: "Search for the Flavor-Changing Neutral Current in Top Pair Events in $\sqrt{s}$ = 8 TeV Proton-Proton Collisions at the Large Hadron Collider Using the ATLAS Detector")
- 2010: B.A. in Physics and French from Grinnell College

Professional Experience:

- 2019 - present: Assistant, then Associate Physicist, Brookhaven National Laboratory, working on the ATLAS Experiment
- 2016 - 2019: Postdoctoral Research Associate, Northern Illinois University, working on the ATLAS Experiment

Leadership Positions:

- 2020 - present: ATLAS TDAQ Phase-II Physics Performance and Event Selection coordinator
- 2020 - 2021: Member of the US LUA (US LHC User Association) Executive Committee
- 2019 - 2021: Convener of the ATLAS DiHiggs group (the group consists of about 200 people, working in seven analysis teams)
- 2017 - 2018: ATLAS FastTracKer (FTK) Run Coordinator (FTK, a hardware upgrade to the ATLAS trigger system, was designed to use custom and commercial technologies to perform full-scan, nearly offline-quality tracking for each event selected by the Level 1 trigger. As Run Coordinator, I was responsible for leading a team of dozens of experts in the installation, cabling, and commissioning of the FTK with the ATLAS detector and the High Level Trigger during the last two years of Run 2)
- 2016 - 2018: ATLAS HH $\rightarrow \gamma\gamma bb$ analysis contact (I led a team of 30 people in the analysis and publication of a search for HH $\rightarrow \gamma\gamma bb$ in the 2015 and 2016 ATLAS data, and I am working on adding a VBF category to the current full Run 2 analysis)

Publications and Seminars:

- As a member of the ATLAS Collaboration, I am an author on 770 publications since February 2013.
    - I have made significant contributions, either to the physics analysis, to the paper editing, or as a member of the internal review board, to 21 of those publications.
- I have been invited to present talks at international conferences on behalf of ATLAS, and to present seminars and colloquia at labs and universities in the US and in Europe.

Dr. Viviana Cavaliere - Curriculum Vitae

Education:

- 2010: Ph.D. in Physics from the University of Siena, Italy
- 2007: Master degree in Physics (Laurea specialistica in Fisica) from University of Rome, Italy, with final mark 110/110 cum laude.
- 2005: Bachelor degree in Physics (Laurea triennale in Fisica) from University of Rome

Professional Experience:

- 2017-Present: Research Staff at Brookhaven National Lab.
- 2011-2017: Post-doctoral Research Associate at University of Illinois at Urbana-Champaign (UIUC) working on the ATLAS experiment.

Leadership positions:

- Jan 2022- Present : Convener of the Track Seeding and Pattern Recognition Group of the ATLAS Event Filter Tracking Project
- 2018-2021: ATLAS Convener of the Higgs and Diboson Searches Group (group of 400 researchers aiming the publication of about 40 analyses).
- 2015-2017: Trigger Menu Expert: in charge of the development of the online selection criteria (trigger)
- 2015-2016: ATLAS Convener of the Diboson Resonance and Multilepton Group (group of 100 researchers aiming the publication of about 12 analyses).
- 2014-2017: Responsible for the Second Stage Board of the Fast Tracker Upgrade Trigger Project (FTK) integration at CERN. FTK is an upgrade to the current ATLAS trigger system designed to enable early rejection of background events by moving track reconstruction into a hardware system employing massively parallel processing.

Fellowships and Awards

- 2019: Early Career Award (ECA) from the DOE
- 2018: LDRD on “Real-time particle tracking with Deep Learning on FPGAs"
- 2012: “Marcello Conversi" award for best experimental particle physics thesis by INFN

Publications and Seminars:

- As a member of the ATLAS Collaboration and CDF Collaboration, I am an author on 1084 publications since 2008.
    - I have made significant contributions, either to the physics analysis, to the paper editing, or as a member of the internal review board, to 25 of those publications.
- I have been invited to present talks at international conferences on behalf of ATLAS and CDF, and to present seminars and colloquia at labs and universities in the US and in Europe.

Dr. Angelo Di Canto – Curriculum Vitae

Address: Brookhaven National Lab, 510E 3-195, Upton NY 11973
Email: dicanto@bnl.gov
Phone: (631) 344-8231
Website: https://adicanto.web.cern.ch/adicanto/

Education

- PhD in Physics, University of Pisa, 2012
- MSc in Physics (*Laurea specialistica in Scienze Fisiche*), University of Pisa, 2008
- BSc in Physics (*Laurea triennale in Fisica*), University of Pisa, 2006

Professional Experience

- Research Staff, Physics Department, BNL, 2019-present
- Research Staff, Experimental Physics Department, CERN, 2016-2019
- Research Fellow, Physics Department, CERN, 2014-2015
- Research Associate, Institute of Physics, Heidelberg University, 2012-2013

Highlights of Research Activity

- Convener of the topical group *Weak decays of b and c quarks* in the DPF Particle Physics Community Planning Exercise (Snowmass 2021), 2020-present
- Belle II experiment, 2019-present
  - Member of the Publications Committee, 2022-present
  - Member of the Statistics Advisory Committee, 2019-present
  - Convener of the *Hadron Identification Performance* group, 2019-2021
  - Author of world's most precise charm lifetimes [PRL 127 (2021) 211801]
- LHCb experiment, 2012-2019
  - Convener of the *Charm Physics* group, 2015-2017
  - Convener of the *Charm Mixing and CP Violation* subgroup, 2014
  - Author of 15 papers with world-leading or first-ever measurements of key heavy-flavor observables, including first observation of charm mixing from a single experiment [PRL 110 (2013) 101802], first observation of nonzero mass difference between neutral D-meson eigenstates [PRL 127 (2021) 111801], and first measurement of $|V_{cb}|$ at hadron colliders [PRD 101 (2020) 072004]
- CDF experiment, 2009-present
  - Expert on call for the CDF silicon vertex detector, 2010-2011
  - Author of 4 papers on CP violation of charm and beauty decays, including the first measurements of CP violation in charm mesons with per-mille precision at hadron colliders [PRD 85 (2012) 012009]

Dr. Georgios Iakovidis - Curriculum Vitæ

Professional Experience

01.2020 – present : Physics Associate I - Omega group, Brookhaven National Laboratory (US)
01.2016 – 12.2019: Physics Associate II - Omega group, Brookhaven National Laboratory (US)
10.2014 – 12.2015: Research Associate - Omega group, Brookhaven National Laboratory (US)

Education

2014: Ph.D. in Physics - High Energy Group, Physics Department, NTU Athens (GR)
Topic: R&D in Resistive Micromegas Detector for the ATLAS Upgrade
2009: BSc & MSc - School of Applied Physical Science, NTU Athens (GR)

Leading Positions

2019 – present: ATLAS Project Management Office member
2021 – 2022 : ATLAS Muon Speakers Committee member
2016 – 2022 : ATLAS New Small Wheel Integration & DAQ Coordinator
2016 – 2021 : US-ATLAS L3 Manager for the ATLAS New Small Wheel Integration

Awards

02.2021: ATLAS Outstanding Achievement Award - For outstanding contributions to the development of front-end electronics and readout for the New Small Wheel detector
09.2016: Spotlight Award in recognition of exceptional job performance - For the extraordinary work on the NSW upgrade of the ATLAS detector

Research Activity

- Physics Analysis: Measurements of gluon-gluon fusion and vector-boson fusion Higgs boson production cross-sections in the $H \rightarrow WW^* \rightarrow l\nu l\nu$ decay channel with the ATLAS detector.
- ATLAS New Small Wheel (NSW) Upgrade: Development of the Front-end ASIC, Simulation and Performance, Coordinator of the DAQ and Integration activities.
- ATLAS Inner Tracker (ITk) Upgrade: Integration activities of the strip detectors.
- Electron-Ion Collider (EIC): Research on the DAQ and Front-end electronics.
- Detector R&D: Member of the RD51 collaboration for the advancement of the Gaseous detectors research.

Publication & Talks

- ATLAS Author in 1054 publications, significant contribution to >20 papers.
- Author of 28 papers in detector R&D, reconstruction techniques (including 5 as single author, 10 conference notes, EIC yellow report).
- Publications profile summary on inSPIRE: http://inspirehep.net/author/profile/G.Iakovidis.1
- Multiple Presentations at International Conferences on behalf of ATLAS and within the Detector R&D Communities.

Dr. Brett Parker - Curriculum Vitae

Education and Training:

- Louisiana State University, Baton Rouge, B.S Physics, 1976
- University of Massachusetts at Amherst, Ph. D. Experimental Nuclear Physics, 1985
- Northwestern University, Evanston, Research Associate, Experimental Nuclear Physics 1985 – 1990
- Superconducting Super Collider Laboratory, Dallas, Staff Scientist, 1990 – 1994
- Deutsches Elektronen–Synchrotron, Hamburg, Visiting Scientist, 1994 – 1997
- Superconducting Magnet Division, Brookhaven National Laboratory, Tenured Scientist, 1997 – present

Research and Professional Experience:

Brookhaven National Laboratory, staff, 1997 – present.

- 1997 - 2002: Term Scientific Staff: RHIC Accelerator Commissioning, Design RHIC-AC Dipole, Cognizant Physicist for Design and Production of Superconducting IR Magnets for the HERA-II Luminosity Upgrade
- 2002 - 2017: Promoted to Continuing Staff Scientist: Cognizant Physicist for the following projects – Superconducting IR Magnets for BEPC-II Upgrade, Superconducting Correctors for JPARC, first and second generation superconducting magnets for ALPHA Anti-Hydrogen at CERN, superconducting IR magnet prototypes for ILC IR and member GDE responsible for Machine Detector Interface (MDI), designs for normal conducting magnets for booster extraction and NSLS-II injection, lead responsibility for design of the eRHIC Linac-Ring IR, the superconducting IR magnets for eRHIC Linac-Ring and Ring-Ring options along with MDI, responsible for design and production of superconducting corrector magnets for SuperKEKB
- 2017 - present: Promoted to Tenured Scientist: with continuing responsibilities for the US EIC IR magnets and MDI, R&D, program development of BNL Direct Wind coil production (constant gradient tapered coil magnets with dual helical winding patterns and external field shielding of high gradient Nb3Sn quadrupoles), a third generation ALPHA-g magnets, a NSLS-II superconducting undulator magnet, IR magnet design and MDI support for the ILC in Japan site specific study, SuperKEKB IR magnet vibration stability measurement R&D, and consultant to the IR magnet designs for both the FCC-ee and LHeC collaborations at CERN

Relevant Publications:

THE SUPERKEKB INTERACTION REGION CORRECTOR MAGNETS
B. Parker, et.al., Proc. 2016 International Particle Accelerator Conference,
http://accelconf.web.cern.ch/AccelConf/ipac2016/papers/tupmb041.pdf

DESIGN OF THE SUPERCONDUCTING MAGNET SYSTEM FOR THE SUPERKEKB INTERACTION REGION
N. Ohuchi#, Y. Arimoto, N. Higashi, H. Koiso, A. Morita, Y. Ohnishi, K. Oide, H. Sugimoto, M. Tawada, K. Tsuchiya, H. Yamaoka, Z. Zong (KEK); M. Anerella, J. Escallier, A. Jain, A. Marone, B. Parker, P. Wanderer (BNL)
http://accelconf.web.cern.ch/AccelConf/PAC2013/papers/thpba07.pdf

Dr. Marc-André Pleier - Curriculum Vitae
Brookhaven National Laboratory, Department of Physics, Upton, New York 11973 USA
Tel.: +1 (631) 344-4249, E-Mail: pleier@bnl.gov, Web: BNL Staff Page

Professional Experience:

- Since 2009 Staff Scientist at BNL, USA (tenured in 2015)
- 2005-2009 Research Associate with teaching responsibilities, University of Bonn, Bonn, Germany (habilitation degree in 2009)
- 2003-2005 Feodor Lynen Fellow of the Alexander-von-Humboldt Foundation, University of Rochester, Rochester, USA
- 2002-2003 Post-Doc, MPI for Nuclear Physics, Heidelberg, Germany

Education:

- 2005-2009 Privatdozent (PD), Physics, University of Bonn, Bonn, Germany
- 1999-2002 Dr. rer. nat. (PhD), Physics, MPI for Nuclear Physics, Heidelberg, Germany
- 1993-1998 Physics Diploma, Justus-Liebig-University Giessen, Giessen, Germany

Professional Development:

- 2021 Project Leadership Institute, US Department of Energy & Stanford University
- 2021 Project Management Professional (PMP)®, issued by Project Management Institute

Selected Group Leadership:

- Co-coordinator for the ATLAS "Multiboson Focus Group" within the ATLAS Physics Modeling Group (PMG)
- Co-coordinator for the ATLAS "Di-Boson Taskforce" within the ATLAS PMG
- Co-convener of the ATLAS Electroweak Standard Model working group

Selected Project Management Leadership:

- US ATLAS Phase-I upgrade of the ATLAS detector (volume $41M): overall Deputy Project Manager, Level-2 Manager for the muon New Small Wheel, Level-2 Deputy Manager for Project Management and Cost Account Manager (CAM) for DOE Project Management, Level-3 Manager and CAM for LAr Trigger Digitizer Boards
- Co-Manager for the muon New Small Wheel USATLAS off-project final productions of readout chips and front-end cards (volume $3.6M)
- Member of the ATLAS Project Management Office to monitor and track the Tile and LAr projects within the ATLAS HL-LHC Upgrade

Selected Organizational Leadership:

- Member of International Advisory Board for Multi-Boson Interactions Workshop series (2015 DESY, Germany; 2016 Madison, USA; 2017 KIT, Germany; 2018 Ann Arbor, USA; 2019 Thessaloniki, Greece; 2021 Milano-Bicocca, Italy; 2022 Shanghai, China)
- Local organizing committee member for Higgs 2020 Conference at Stony Brook University (shifted to 2021 due to COVID-19)
- Co-convener of "Precision Electroweak Physics" working group for the 2017 APS Division of Particles and Fields meeting at Fermilab, July 31–August 4, 2017
- Committee chair for inaugural "Multi-Boson Interactions Workshop" at BNL, 2014

Dr. Robert Szafron - Curriculum Vitae

Education:

- 2012: Ph.D. in Theoretical Physics from the University of Silesia, Poland
- 2008: M.Sc. in Physics from the University of Silesia, Poland

Professional Experience

- 2021–present: Assistant Physicist, HET Group, Physics Department, Brookhaven National Laboratory, USA
- 2019–2020: Postdoctoral Fellow, CERN Theoretical Physics Department, Switzerland
- 2016–2019: Postdoctoral Fellow, Department of Physics, Technical University of Munich, Germany
- 2012–2016: Postdoctoral Fellow, Department of Physics, University of Alberta, Canada

Publications

Author of over 40 publications with more than 1500 citations. Selected papers:

- M. Beneke, C. Bobeth, and R. Szafron, Enhanced electromagnetic correction to the rare B-meson decay $B_{s,d} \to \mu^+\mu^-$, Phys. Rev. Lett. 120 (2018) no. 1, 011801
- C. Duhr, A. Huss, A. Mazeliauskas, and R. Szafron, An analysis of Bayesian estimates for missing higher orders in perturbative calculations, JHEP 09 (2021) 122
- M. Beneke, M. Garny, S. Jaskiewicz, R. Szafron, L. Vernazza, and J. Wang, Leading-logarithmic threshold resummation of Higgs production in gluon fusion at next-to-leading power, JHEP 01 (2020) 094
- J. Gluza, T. Jelinski, and R. Szafron, Lepton number violation and 'Diracness' of massive neutrinos composed of Majorana states, Phys. Rev. D 93 (2016) no. 11, 113017
- G. Bambhaniya, J. Chakrabortty, J. Gluza, M. Kordiaczyńska, and R. Szafron, Left-Right Symmetry and the Charged Higgs Bosons at the LHC, JHEP 05 (2014) 033

Scientific Interests

- Collider phenomenology
- QCD and QED factorization and resummation
- QED bound states/exotic atoms
- Flavor physics (quarks, charged leptons, and neutrinos)
- Precision physics at colliders and as a tool to discover New Physics

Synergistic Activities

- Organizer of Mainz Institute for Theoretical Physics workshop: "Power expansion on the lightcone: from theory to phenomenology." February 14-25, 2022; Organizer of Brookhaven Forum 2021, November 3-5, 2021
- Proposal reviewer for funding calls from the Department of Energy and Swiss National Science Foundation. Referee for Physical Review Letters, Physics Letters B, JHEP, Physical Review A, Physical Review D, European Physical Journal C, Canadian Journal of Physics, International Journal of Modern Physics A, Annals of Physics
- Over 50 talks, invited seminars, and lectures.

1. ALIGNMENT WITH THE LABORATORY MISSION AND VISION

Type A proposals need to be clearly aligned with BNL's priority programs and initiatives. For FY23, the highest priorities for Type A proposals (not in priority order) are: Accelerator Science and Technology; Atmospheric and Climate Science; Clean Energy; Discovery Science Driven by Human-AI-Facility Integration; High Energy Physics: Understanding the Origin of Space and Time; Isotope Production and R&D Capabilities; Quantum Information Science and Technology; and Research and Development towards the Second Detector at the Electron-Ion Collider.

The Laboratory Initiatives are in the areas of 1. Nuclear Physics; 2. Clean Energy and Climate; 3. Quantum Information Science and Technology; 4. Artificial Intelligence and Data Science; 5. High Energy Physics; 6. Isotope Production; and 7. Accelerator Science and Technology.

This proposal supports BNL's priority programs and initiatives in High Energy Physics and Accelerator Science and Technology.

2. POTENTIAL FUTURE FUNDING

Identify below the Agencies and the specific program/office, which may be interested in supplying future funding. Give some indication of time frame. This information is required.

We expect DOE (SC-HEP) to invest of order $500M per Higgs Factory detector, followed by a ~$20M/year operations program (including appropriate computing (Tier 1) and software infrastructure support) and additional funds for detector upgrades.
The FCC Feasibility Study concludes in 2025; with approval before the end of the decade construction can start in the beginning of the 2030s. Once the decision is made, we expect DOE (SC-HEP) to establish a targeted e^+e^- Higgs Factory detector R&D program to enable US participation in a global machine.

3. BUDGET JUSTIFICATION

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

The proposed budget of $500k per year in FY2023-FY2025 will cover the time of key personnel contributing to the project, as well as the purchase of necessary equipment to carry out the proposed research and travel to domestic and international workshops. We also include funding to host physics and detector workshops at BNL each year. The largest part of the budget covers the salary of personnel for the time they will spend on this project — 2.30 total FTE in the first year, 2.33 total FTE in the second year, and 2.30 total FTE in the third year, plus a constant ~5% effort from AM/ATRO throughout the project.

In the first year of the project, we will purchase laptops for the postdocs, and pay their relocation fees. The budget also supports PI Dr. Marc-André Pleier (SCI3, PO-Omega) at 0.05 FTE, co-PI Dr. Angelo Di Canto (SCI1, PO-EDG) at 0.05 FTE, co-PI

Dr. Robert Szafron (SCI1, PO-HET) at 0.20 FTE, co-PI Brett Parker (AM/ATRO) at ~0.05FTE, and three postdocs at 2 total FTE for the work detailed in Section 4 of the proposal.

In the second year of the project, the budget supports PI Dr. Marc-André Pleier (SCI3, PO-Omega) at 0.08 FTE, co-PI Dr. Angelo Di Canto (SCI1, PO-EDG) at 0.05 FTE, co-PI Dr. Robert Szafron (SCI1, PO-HET) at 0.20 FTE, co-PI Brett Parker (AM/ATRO) at ~0.05FTE, and three postdocs at 2 total FTE for the work detailed in Section 4 of the proposal.

In the third year of the project, the budget supports PI Dr. Marc-André Pleier (SCI3, PO-Omega) at 0.05 FTE, co-PI Dr. Angelo Di Canto (SCI1, PO-EDG) at 0.05 FTE, co-PI Dr. Robert Szafron (SCI1, PO-HET) at 0.20 FTE, co-PI Brett Parker (AM/ATRO) at ~0.05FTE, and three postdocs at 2 total FTE for the work detailed in Section 4 of the proposal.

4. NAME OF SUGGESTED BNL REVIEWERS

Provide the name of 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 the Associate Lab Directors and their Deputies and the Directors of the Computational Science Initiative and Advanced Technology Research Office, Members of the Brookhaven Council, and Research Staff not associated with the research.

- Kolja Kauder
- Steve Kettell
- Sally Dawson
- Hooman Davoudiasl

5. EQUIPMENT (Reference: DOE Order 413.2C Chg. 1 (Min Chg) for guidance on equipment restrictions)

Will LDRD funding be used to purchase equipment? ___Y___

If "Yes," provide cost and description of equipment
Year 1 - $13,000
Year 2 - $0
Year 3 - $0
Description: Laptops/Workstations for postdocs

6. HUMAN SUBJECTS (Reference: DOE Order 443.1C)

Are human subjects involved from BNL or a collaborating institution? Human Subjects is 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 copy of the current Institutional Review Board Approval and Informed Consent Form from BNL and/or collaborating institution.

N

7. VERTEBRATE ANIMALS

Are live, vertebrate animals involved? N

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

8. NEPA REVIEW

Are the activities proposed similar to those now carried out in the Department/Division which 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.) Y

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? _____

(**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.)

9. ES&H CONSIDERATIONS

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

Is there an available waste disposal path for project wastes throughout the course of the experiment? N/A

Is funding available to properly dispose of project wastes throughout the course of the experiment? N/A

Are biohazards involved in the proposed work? If yes, attach a current copy of approval from the Institutional Biosafety Committee. N

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? Y

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.

10. TYPE OF WORK Select Basic, Applied or Development Basic & Development

APPROVALS

Business Operations Manager

_____
Print Name

Department Chair/Division Manager
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

_____
Print Name

Associate Laboratory Director
for Nuclear and Particle Physics

_____
Haiyan Gao

LDRD Title
LDRD Type A
M. Pleier

Resource Category	DESCRIPTION	FY23	FY24	FY25
050	Salary - Scientific	58,982	70,118	63,064
051	Salary - Research Assoc	189,261	197,201	203,265
050	Salary - Professional	0	0	0
050	Salary -Technical	0	0	0
050	Salary - Management & Admin.	0	0	0
	Total FTEs	**2.30**	**2.33**	**2.30**
TOTAL SALARY/WAGE & FRINGE		**248,243**	**267,319**	**266,329**
180/185	Consultants/Research Collab	0	0	0
190/191	Contract Labor	0	0	0
201	Scientific Distributed Labor (Brett Parker)	16,000	16,000	16,000
TOTAL PURCHASED LABOR		**16,000**	**16,000**	**16,000**
various	Contracts - Low Value	0	0	0
280	Foreign Travel + Workshop	19,000	25,000	26,000
280	Foreign Travel (Dept AM)	2,500	2,500	2,500
various	Purchases/Freight	13,000	0	0
TOTAL MSTC		**34,500**	**27,500**	**28,500**
170	Relocation Expense	18,000	0	0
240	Registration Fees	0	0	0
271	Communications	600	615	630
TOTAL COM/MISC		**18,600**	**615**	**630**
480	Space	1,500	1,535	1,570
TOTAL SPACE		**1,500**	**1,535**	**1,570**
TOTAL DIRECT COSTS		**318,843**	**312,968**	**313,029**
251	Electric Distributed (Electric Power Burden)	2,482	2,673	2,663
700/701/481	Organizational Burden	30,037	32,346	32,226
TOTAL ORGANIZATIONAL BURDEN		**32,520**	**35,019**	**34,889**
745	Procurement (Material Handling)	2,415	1,925	1,995
710	G&A Burden	0	0	0
720	Common Support	146,222	150,088	150,086
TOTAL LABORATORY BURDEN		**148,637**	**152,013**	**152,081**
705	LDRD Burden	0	0	0
TOTAL PROGRAM COSTS		**500,000**	**500,000**	**500,000**

Labor Band	Name	FY23 FTE	FY23 Amount	FY24 FTE	FY24 Amount	FY25 FTE	FY25 Amount
RA1	Post Doc	1.00	94,631	1.00	98,601	1.00	101,633
RA1	Post Doc	1.00	94,631	1.00	98,601	1.00	101,633
SCI1	Szafron, R.	0.20	36,828	0.20	38,366	0.20	39,545
SCI1	DiCanto, A.	0.05	9,207	0.05	9,591	0.05	9,886
SCI3	Pleier, M.	0.05	12,947	0.08	22,160	0.05	13,632
	Total	2.30	248,243	2.33	267,319	2.30	266,329