P5 Townhall Virginia Tech

Tuesday, June 27, 2023 - Tuesday, June 27, 2023

Book of Abstracts

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Cross-Frontier Probes for Fundamental Physics: Quantum Sensors and Space Missions for Dark Matter, Neutrino, and Gravity

Authors: Yu-Dai Tsai[1]; Luca Visinelli[2]; Youjia Wu[3]

[1] *University of California, Irvine*

[2] *Shanghai Jiao Tong University*

[3] *University of Michigan*

Corresponding Author: yudait1@uci.edu

I will explore the "elusive universe," where dark matter, neutrinos, and gravity sculpt our observed nature, leaving many open questions.
Our work focuses on opening up new directions to answer these puzzles. I will present two approaches:
1. Using precision astrometry and space mission data to study general relativity, dark matter, cosmic neutrinos, and fifth forces [1, 2].
2. By deploying quantum sensors on spacecraft, inspired by NASA's Deep
Space Atomic Clocks and the Parker Solar Probe, we explore the gravitational interaction of ultralight dark matter bound to the sun [3].
The projects are in collaboration with NASA, ESA, and NIST. They can be extended to studying interstellar objects, primordial black holes, Planet Nine, and topological defects, and were highlighted by the DOE Office of Science.
[1] Tsai et al., https://arxiv.org/abs/2210.03749.
[2] Tsai et al., https://arxiv.org/abs/2107.04038, JCAP (2023).
[3] Tsai et al., https://arxiv.org/abs/2112.07674, Nature Astronomy (2023), https://www.nature.com/articles/s41550-022-01833-6.

Topic of submission:

Theory

Contributed talks / 2

Complementarity of Dark Matter Studies

Authors: Alex Drlica-Wagner[1]; Caterina Doglioni[2]; Lindley Winslow[3]; Natalia Toro[4]; Slatyer Tracy[3]; Yu-Dai Tsai[5]

[1] *FNAL*

[2] *University of Manchester and Lund University*

[3] *MIT*

[4] *SLAC*

[5] *University of California, Irvine*

Corresponding Authors: caterina.doglioni@cern.ch, yudait1@uci.edu, tslatyer@mit.edu

The fundamental nature of dark matter is a central theme of the Snowmass 2021 process, extending across all Frontiers. In the last decade, advances in detector technology, analysis techniques, and theoretical modeling have enabled a new generation of experiments and searches while broadening the types of candidates we can pursue. Over the next decade, there is great potential for discoveries that would transform our understanding of dark matter.

In this contribution, we will summarise the cross-frontier efforts towards taking full advantage of this complementarity in dark matter searches. We outline a road map for discovery developed in collaboration among the Frontiers. A strong portfolio of experiments that delves deep, searches wide, and harnesses the complementarity between techniques is key to tackling this complicated problem, requiring expertise, results, and planning from all Frontiers.

Topic of submission:

Small projects portfolio across frontiers

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DAMSA, A Novel Dark Sector Particle Search Experiment Proposal at Fermilab PIP-II LINAC

Authors: Jaehoon Yu[1]; juan estrada[2]

[1] *University of Texas at Arlington*

[2] *fermilab*

Corresponding Author: jaehoonyu1@gmail.com

The neutrino oscillation needs parameters to be measured precisely to provide essential information for a modification of the Standard Model. Accomplishing this novel goal in future neutrino experiments requires high flux neutrino beams and powerful combination of near and far detectors. Fermilab's PIP-II LINAC is an essential element in providing high flux protons to the Long Baseline Neutrino Facility (LBNF) for the neutrino experiments. The PIP-II LINAC can provide 2mA of proton current with 800MeV energy. The Dump produced Aboriginal Matter Search at Accelerators (DAMSA) a small scale experiment which proposes to take advantage of this large proton flux in search of dark sector particles (DSP). In this presentation, I will discuss DAMSA experiment and its expected sensitivity reach in dark sector particle search using the high intensity PIP-II LINAC.

Topic of submission:

Small projects portfolio across frontiers

Contributed talks / 4

Statement in favor of continued operation of DESI

Authors: Adam Myers[1]; Alexie Leauthaud[2]; Anthony Pullen[3]; Antonella Palmese[4]; Camille Avestruz[5]; Charles Baltay[6]; Christopher J Miller[5]; Constance Rockosi[7]; Daniel Eisenstein[8]; David H. Weinberg[9]; David Kirkby[10]; David Rabinowitz[6]; Douglas Finkbeiner[8]; Dragan Huterer[5]; Eduardo Rozo[11]; Eric F. Bell[5]; Gregory Tarlé[5]; Hee-Jong Seo[12]; Jeffrey Newman[13]; Jeremy Tinker[14]; John Moustakas[15]; Klaus Honscheid[9]; Kyle Dawson[16]; Lado Samushia[17]; Marcelle Soares-Santos[5]; Martin White[18]; Masao Sako[19]; Michael Lesser[11]; Michael Schubnell[5]; Monica Valluri[5]; Mustapha Ishak[20]; Nikhil Padmanabhan[6]; Paul Martini[9]; Peter Behroozi[11]; Rachel Bean[21]; Regina Demina[22]; Richard Pogge[9]; Risa Wechsler[23]; Robert Kehoe[24]; Segev BenZvi[22]; Steve Ahlen[25]; Tim Eifler[11]; Uros Seljak[26]; Xiaohui Fan[11]; Zachary Slepian[27]; Zheng Zheng[16]

[1] *University of Wyoming*

[2] *University of California Santa Cruz*

[3] *New York University*

[4] *Carnegie Mellon University*

[5] *University of Michigan*
[6] *Yale University*
[7] *UC Santa Cruz, SCIPP*
[8] *Harvard University*
[9] *Ohio State University*
[10] *University of California Irvine*
[11] *University of Arizona*
[12] *Ohio University*
[13] *University of Pittsburgh / PITT PACC*
[14] *New York University*
[15] *Siena College*
[16] *University of Utah*
[17] *Kansas State University*
[18] *University of California, Berkeley*
[19] *University of Pennsylvania*
[20] *University of Texas at Dallas*
[21] *Cornell University*
[22] *University of Rochester*
[23] *Stanford University*
[24] *Southern Methodist University*
[25] *Boston University*
[26] *University of California Berkeley*
[27] *University of Florida*

Corresponding Author: cavestru@umich.edu

Dear Particle Physics Project Prioritization Panel (P5),

As faculty members from the universities listed below, we write to you to express our strong support for the continued operations of the Dark Energy Spectroscopic Instrument (DESI) and its extension into DESI-II.

DESI has been an incredibly important tool for each of our universities'research on dark energy, and will be instrumental in advancing our understanding of this fundamental component of the universe. The data collected by DESI has already helped us to make significant progress in our efforts to better understand the large-scale structure of the universe, and to uncover new insights into the nature of dark energy. DESI has exceeded our expectations both in performance and in scientific reach. We expect DESI with its proposed extension, DESI-II, with operations into the next decade, to address important scientific questions including the neutrino mass hierarchy, measures of dark energy at both early and late times, the physics of the early universe including primordial inflation, and the physics of dark matter. DESI-II spectroscopy will also provide important synergies with LSST imaging data.

Furthermore, DESI has played a crucial role in supporting the education and training of the 116 U.S. PhD students involved in the project. The hands-on experience provided by working on DESI has been invaluable for these students, allowing them to gain practical skills and experience that will serve them well in their future careers. These are unique experiences that can be provided by a nimble experiment such as DESI.

In addition to supporting our research and training efforts, DESI has also been an important driver of instrumentation development and advanced methods in computation at several of our universities. The project has brought together a diverse array of experts and researchers, leading to numerous breakthroughs in the development of cutting-edge instrumentation and software tools that can be applied in future experiments.

Finally, we would like to emphasize that DESI in just its first year has already been a scientific goldmine, producing a wealth of valuable data that will continue to be analyzed and explored for many years to come. We strongly support extending the DESI program as presented at the P5 Town

Hall on February 22. Given the immense potential of this project, we urge you to recommend to DOE to continue to support its operations into the 2030's, so that we can continue to build on the tremendous progress that has already been made, upgrade the instrument as needed to maintain US leadership, and fully exploit the potential of this exciting new facility.

Topic of submission:

Research and Development

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Is DUNE, DONE?

Author: Teppei Katori[1]

[1] *King's College London*

Corresponding Author: teppei.katori@kcl.ac.uk

Once a flagship next-generation multi-purpose experiment, now the DUNE is a single-purpose experiment with significant delay and significant over-budget, with very poor community support. One of the main problems is there is no exciting phenomenology program to explore new physics with this experiment. I will discuss how one could revive excitement and re-attract interest in the DUNE science.

Topic of submission:

Theory

Contributed talks / 7

Light New Physics at PIONEER

Author: Jeff Dror[1]

[1] *UC Santa Cruz*

Corresponding Author: asafjeffdror@gmail.com

The next-generation rare pion decay experiment, PIONEER, aims to use the intense pion beam at the Paul Scherrer Institut to study many more pion decays at rest than previous experiments. In this talk, I will discuss the opportunities to detect new light particles in pion decays. In particular, I will show that axion-like particles and dark photons are prime targets for the experiment. These searches can be carried out in parallel with the existing efforts to test lepton flavor university.

Topic of submission:

Theory

Contributed talks / 8

US National Lab and University partnerships could define FCC

Author: Christopher Palmer[1]

[1] *University of Maryland - College Park*

Corresponding Author: capalmer@cern.ch

The US has been a very productive contributor to hardware and computing at LHC and in the HL-LHC upgrades owing to the indispensable synergy between universities and national labs. There are numerous examples of HL-LHC upgrade projects for ATLAS and CMS with tight coordination between the two. Often the labs have highly specialized facilities (e.g. SiDet at FNAL) where lab and university faculty can both participate in cutting edge fabrication and construction of new detectors. On the other hand, national labs can support faculty pursuing on-site production with expertise. In either type of partnership, the success of FCC-ee could be defined by US support of labs and universities that leverages on on-going partnerships for detector design, construction, development, and commissioning. Moreover, the access to CERN facilities and collaborators has been beneficial to me and many of my colleagues at the LHC (and LEP before that), and I hope that my students and their students will get that opportunity as well at FCC.

Topic of submission:

Research and Development

Contributed talks / 9

Small Projects Experience from Neutrino Alley

Author: Rebecca Rapp[None]

Co-author: KATE SCHOLBERG [1]

[1] *Duke University*

Corresponding Authors: rrapp@washjeff.edu, kate.scholberg@duke.edu

We would like to highlight some of the reasons to support smaller projects as part of the HEP portfolio with the example of COHERENT, an experimental neutrino physics program that inhabits Neutrino Alley at Oak Ridge National Laboratory at the Spallation Neutron Source.

Topic of submission:

Small projects portfolio across frontiers

Contributed talks / 10

Theory Simulation Tools

Author: Joshua Isaacson[1]

[1] *Fermilab*

Corresponding Author: isaacson@fnal.gov

Large-scale computing is vital to the success of all current and future high-energy physics experiments, through simulating our understanding of the Standard Model. The use of theory simulation tools spans most of the Snowmass frontiers, including the Energy, Neutrino, Rare Processes and Precision Measurements, Theory, and Computational Frontiers. Recently, members of the HEP community submitted an open letter to the Particle Physics Project Prioritization Panel titled "Maximizing the Return on US Investment at the intersection of experiment and phenomenology at the LHC." [1] The open letter advocates for better support of the precision analysis of collider processes and proposes specific actions. The success in this area strongly relies on new approaches to tackle emergent issues in large-scale simulations for numerous precision studies in both experiment and theory. While the letter focuses mainly on the LHC, many of its points apply to the other experimental communities as well. As a theorist working on precision SM calculations, I see both the practical impact and formidable challenges of these efforts. I will highlight the goalposts for the development of modern computational techniques for precision analyses and opportunities for cross-frontier efforts to make far-reaching advances in this area.

[1] https://docs.google.com/document/d/1HB19qQN9MJTF2lxxjtClll9JaAP7Cg0FwQ7lyHfzHyQ/edit?usp=sharing

Topic of submission:

Theory

Contributed talks / 11

Noble Liquid Calorimetry as the Basis of a Third e+e- Collider Detector Concept

Author: Elizabeth Brost[None]

Corresponding Author: ebrost@bnl.gov

In 2019, the FCC CDR presented two complementary and mature detector designs (CLD and IDEA) for the FCC-ee. Since then, a new detector concept for future e+e- colliders, built around a noble-liquid electromagnetic calorimeter, has emerged. At this early stage, the technologies for the rest of the detector have yet to be decided. This "third"detector offers a unique opportunity for newcomers, and especially for early-career scientists, to influence the design of a detector concept, build international partnerships, and to assume major roles in its design and construction phases.

Topic of submission:

Research and Development

Contributed talks / 12

The value of small experiments for training early career scientists

Author: Austin Schneider[1]

[1] *LANL / MIT*

Corresponding Author: aschn@mit.edu

Today larger experimental collaborations are the primary focus for new physics searches at the intensity frontier. While these large experimental efforts allow us to leap forward in our understanding of fundamental neutrino physics, they have the disadvantage of decades long timescales, and can leave much to be desired for young physicists in training. There is an often understated value to smaller experimental efforts, in that they allow us to make targeted inroads to the most pressing questions in neutrino physics on a much shorter timescale than larger experiments. Such experiments also provide valuable opportunities to early career scientists like myself, allowing them to make meaningful contributions to the field on shorter timescales, and training them in a wider variety of skills necessary for their long-term success.

Topic of submission:

Small projects portfolio across frontiers

Contributed talks / **13**

Physics Opportunities at a PIP-II Beam Dump Facility and Beyond

Author: Jacob Zettlemoyer[1]

[1] *Fermilab*

Corresponding Author: jzettle@fnal.gov

The accelerator complex at Fermilab is currently undergoing improvements which will increase the available beam power to the complex and is known as Proton Improvement Plan-II (PIP-II). The PIP-II Linac is slated for operation later this decade and will be the main proton driver for Fermilab experiments moving forward and provide the beam to LBNF/DUNE. However, the DUNE physics program requires only ~1% of the available protons provided by PIP-II. The Accelerator Complex Evolution, or ACE, will provide further upgrades in the form of a replacement for the Fermilab Booster which could also include an accumulator ring. PIP-II provides an exciting opportunity to build a beam dump facility that could host a suite of small projects to search for dark sector physics across energy scales with examples being accelerator-produced dark matter, active-to-sterile neutrino oscillations, millicharged particles, and axion-like particles, which can be produced in the proton collisions with a fixed target. In this talk, I will summarize the physics possible at PIP-II and sensitivities to different dark sector physics and other beyond the Standard Model models using detectors spanning from an eV-scale to MeV-scale detection threshold.

Topic of submission:

Small projects portfolio across frontiers

Contributed talks / **14**

TAMBO: Searching for Tau Neutrinos in the Peruvian Andes

Author: Will Thompson[1]

[1] *Harvard University*

Corresponding Author: will_thompson@g.harvard.edu

The detection of high-energy astrophysical neutrinos by IceCube has opened a new window on our Universe. While IceCube has measured the flux of these neutrinos at energies up to several PeV,

much remains to be discovered regarding their origin and nature. Currently, measurements are limited by the small sample size of astrophysical neutrinos and by the difficulty of discriminating between electron and tau neutrinos.

TAMBO is a proposed next-generation neutrino observatory designed specifically to detect tau neutrinos in the 1-100 PeV energy range, enabling tests of neutrino physics at high energies and the characterization of astrophysical neutrino sources. The observatory will comprise an array of water Cherenkov and plastic scintillator detectors deployed on the face of the Colca canyon in the Peruvian Andes. This unique geometry will facilitate a high-purity measurement of astrophysical tau neutrino properties. In this talk, I will present the prospects of TAMBO in the context of next-generation neutrino observatories.

Topic of submission:

Open Mic

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A case for more small-scale experiments; a junior faculty member's perspective

Author: Christian Herwig[None]

Co-author: Andrew Whitbeck [1]

[1] *Texas Tech University*

Corresponding Authors: therwig@fnal.gov, whitbeck.andrew@gmail.com

I have been a CMS collaborator for nearly 15 years and an LDMX (Light Dark Matter eXperiment) collaborator for the last five years. While CMS is the epitome of a large-scale experiment, LDMX is a small and vibrant collaboration trying to do world-class science with roughly one year's data. I have been fortunate to have had opportunities to engage with CMS in various ways, including hardware projects in which I learned much about how detector systems are designed and built. However, my experiences with CMS are qualitatively different from my experiences with LDMX. I have found that LDMX has provided me and my students with more opportunities to engage with the experiment. I have also found that my students' experiences on LDMX dramatically enrich their work on CMS and provide them with expertise and knowledge that helps them stand out in a large collaboration. While LDMX offers a world-leading science program, it is also helping to develop our future workforce. My story makes a strong case for maintaining a rich small-scale experimental program that complements large-scale projects.

Topic of submission:

Small projects portfolio across frontiers

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Charged pion precision measurements, instrumentation frontier, and early-career effort in PIONEER

Author: Jennifer Ott[1]

[1] *University of California, Santa Cruz (US)*

Corresponding Author: jeott@ucsc.edu

Small-scale experiments allow the training of new researchers in how an experiment is sketched, built, and eventually run - providing the opportunity to let the next generation of leaders grow with their experiment, in a smaller spotlight and reduced large-scale dynamics and politics compared to most modern collider-based experiments with thousands of collaborators. It also allows the development of technology in a reasonable timescale without the pressing requirements of high and long-term investments. The advantage to the community is then immediate: train the new generation and answer complex physics questions in a reasonable timescale, combined with a lower risk factor for the funding agencies.
One example of such a small experiment which has the potential for a big impact is PIONEER, a next-generation experiment to measure the charged pion decay branching ratio to electrons vs. muons as well as the pion beta decay with an order of magnitude improvement in precision, probing lepton flavor universality, CMK unitarity and |Vud| with unprecedented sensitivity. In addition, the experiment can include searches for various exotic rare decays involving sterile neutrinos and axions.
While PIONEER is located mostly in the Intensity Frontier, the implementation of the detectors needed to ensure the experimental performance is also associated with Instrumentation, most prominently in the development of solid-state 4D tracking detectors for the Active Target detectors. The experiment has a vibrant community of US and international collaborators, and strong contribution from early-career researchers.

Topic of submission:

Small projects portfolio across frontiers

Contributed talks / **18**

Leaping into the future - R&D for next detectors at future colliders

Author: Andreas Jung[1]

[1] *Purdue University*

Corresponding Author: anjung@purdue.edu

The current state of affairs in particle physics is a multitude of probes for new physics and to challenge the Standard Model. The prime instrument is and remains the LHC and its upgrades the HL-LHC. In order to bridge and leap into the future we need to make a sustained effort to support and enhance R&D activities for next detectors at future colliders. Any of the currently envisioned future colliders, i.e. FCC-ee, FCC-hh and muon Colliders pose significant challenges on detectors and require R&D. The remarks discuss along these lines.

Topic of submission:

Research and Development

Invited talks / **19**

Introduction

Corresponding Author: pahuber@vt.edu

Invited talks / 20

P5 process

Corresponding Author: hitoshi@berkeley.edu

Invited talks / 21

Topical collaborations

Corresponding Author: jqiu@jlab.org