Snowmass Community Planning Meeting - Virtual

Monday 05 October 2020 - Thursday 08 October 2020

Virtual

Book of Abstracts

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Corresponding Author: ntoro@slac.stanford.edu

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#136 - Heavier particle dark matter >10 GeV

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Corresponding Author: erin.osullivan@physics.uu.se

Primary frontier topic:

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Corresponding Author: kadrlica@fnal.gov

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#74 - Atomic to Cosmic: Wave Dark Matter and Beyond

Corresponding Author: grybka@u.washington.edu

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#75 - Cosmic Probes of Dark Matter

Corresponding Author: kadrlica@fnal.gov

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#77 - Quantum Sensors

Corresponding Author: lwinslow@mit.edu

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#97 - Neutrinos and Astrophysics

Corresponding Author: baha@physics.wisc.edu

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108: Accelerator Probes of Light Dark Matter (keV-GeV)

Corresponding Authors: jaehoonyu@uta.edu, alex.sousa@uc.edu

Primary frontier topic:

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109: Determining the Masses and Nature of Neutrinos

Corresponding Author: giunti@to.infn.it

Primary frontier topic:

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110: Baryon and Lepton Number Violating processes

Corresponding Author: lkoerner@central.uh.edu

Primary frontier topic:

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115: Neutrinos, dark matter, and underground facilities

Corresponding Author: gorebigann@lbl.gov

Primary frontier topic:

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119: HEP Workforce, Careers and Training

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124: Lattice Gauge Theory for High Energy Physics

Corresponding Author: baha@physics.wisc.edu

Primary frontier topic:

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126: BSM: direct and indirect searches

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Primary frontier topic:

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Primary frontier topic:

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126: Flavor Physics

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Primary frontier topic:

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126: Naturalness and EWSB

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Primary frontier topic:

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127: Searches for dark sectors

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Primary frontier topic:

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137: High and ultrahigh energy neutrino experiments

Corresponding Authors: erin.osullivan@physics.uu.se, dwschmitz@uchicago.edu

Primary frontier topic:

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29: Low-energy precision experiments

Corresponding Author: newbyrj@ornl.gov

Primary frontier topic:

64. Computing Needs of the Accelerator Frontier / 131

3 minutes summaries of LOIs by topics

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- AI/ML (4 LOIs): Auralee Edelen
- Physics for Conventional Accelerators (5 LOIs) - Cho Ng
- Physics for Advanced Accelerator Concepts (3 LOIs) - Nathan Cook
- Shared Simulation Tools (6 LOIs) - Jean-Luc Vay
- Cross-Cutting Standardization and Practice (3 LOIs) - Axel Huebl

- Community organization (3 LOIs) - David Bruhwiler
- Quantum Computing (1 LOI) - He Zhang

Primary frontier topic:

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3D proton tomography at the EIC: TMD gluon distributions

Authors: Alessandro Bacchetta[1] ; Francesco Giovanni Celiberto[1] ; Marco Radici[2] ; Pieter Taels[3]

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The search for evidence of New Physics is in the viewfinder of current and forthcoming analyses at the Large Hadron Collider (LHC) and at new-generation hadron, lepton and lepton-hadron colliders. This is the best time to shore up our knowledge of strong interactions though and, more in particular, of the hadron structure in terms of parton distributions.
Although significant steps toward the formal definition of quark transverse-momentum dependent distribution functions (TMDs) and their extraction from experimental data through global fits has been made in the last years, the gluon-TMD field represents an almost unknown territory.
With the advent of the Electron-Ion Collider (EIC), a systematic study of observables very sensitive to gluon dynamics will become feasible, thus offering us a unique chance of deepening our knowledge of gluon TMDs, a largely unexplored territory particularly at low-x.
With the aim of fulfilling the need for a flexible model suited to phenomenology, we present a common framework for all T-even and gluon TMDs at twist-2, calculated in a spectator model for the parent nucleon and encoding effective small-x effects from the BFKL resummation. At variance with respect to previous works, our approach encodes a flexible parametrization for the spectator-mass spectral density, allowing us to improve the description in the small-x region.
An extension of our model to include twist-2 T-odd gluon TMDs is underway.
All these prospective developments are relevant in the exploration of the gluon dynamics inside nucleons and nuclei, which constitutes one of the major goals of the EIC project.
We believe that the inclusion of these topics in the SnowMass 2021 scientific program would accelerate progress of our understanding of both formal and phenomenological aspects of the hadron structure in wider kinematic ranges.

Primary frontier topic:

Energy Frontier

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51: Requirements for low background and underground detectors

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Primary frontier topic:

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61: Energy and Power and Time structure goals for Neutrino Frontier programs

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Primary frontier topic:

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72: Dark Energy, Origins (Inflation), and Light Relics

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77: Quantum Sensors for Wave and Particle Detection

Corresponding Author: enectali@northwestern.edu

Primary frontier topic:

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81: Neutrinos and Computing: Preservation, Machine Learning, Uncertainties

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Primary frontier topic:

202. NF Planning / 441

97: Neutrinos as Probes of Standard and BSM Particle Physics

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Primary frontier topic:

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A deci-Hz Gravitational-Wave Lunar Observatory for Cosmology

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We are proposing Gravitational-Wave Lunar Observatory for Cosmology (GLOC) – a first of its kind fundamental physics experiment on the surface of the Moon. The experiment would access gravitational waves in the frequency range of deci-Hz to 5 Hz, a challenging regime for all Earth-based detectors and space missions. We find that such a lunar-based experiment can survey over 70% of the observable volume of our universe without significant background contamination. This unprecedented sensitivity makes GLOC a powerful cosmic probe for Dark Energy, Dark Matter and physics beyond the Standard Model. In particular, it will independently trace the Hubble expansion rate up to redshift $z \sim 3$, provide the strongest limits on the sub-solar Dark Matter candidates and test ΛCDM cosmology up to $z \sim 100$. Furthermore, it will have a unique access to gravitational waves from Type Ia supernovae, thus aiding calibration of the standard candles.

Primary frontier topic:

Cosmic Frontier

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AF Points (#54, #187)

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AF1 - Training & Education - Barletta (MIT), Recruitment & Retention - Fox (Stanford)

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AF1 - Workforce & Diversity - Bai (GSI/U. Bonn) , Facility Summaries - Zimmermann (CERN) , Outreach with Industry - Bruhwiler (RadiaSoft)

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61. Energy and Power and Time structure goals for Neutrino Frontier programs / 324

AF2 Plans and Discussion

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185. High power proton beams for rare searches / 321

AF2 Plans and Discussion

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AF2 Plans and Discussion

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185. High power proton beams for rare searches / 320

AF5 Overview and Plans

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Primary frontier topic:

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AF5 Overview and Plans

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61. Energy and Power and Time structure goals for Neutrino Frontier programs / 323

AF5 Plans and Discussion

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AIFI: Bridging Artificial Intelligence and Fundamental Interactions

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ANNIE and the Future of Hybrid Neutrino Detectors

Author: Mayly Sanchez[1]

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The Accelerator Neutrino Neutron Interaction Experiment (ANNIE) will continue to develop advanced neutrino detector technology in addition to pursuing an ambitious physics program in the Fermilab Booster Neutrino Beam. The current gadolinium-loaded water detector will develop new techniques using Large Area Picosecond PhotoDetectors (LAPPDs) to reconstruct muons from neutrino interactions in the forward direction. This talk describes using ANNIE to take the next step in the development of hybrid (Cherenkov plus Scintillation) optical detectors by replacing the current gadolinium-water target with Water-based Liquid Scintillator (WbLS) to allow reconstruction of neutron capture vertices, and increasing the coverage of LAPPDs to allow multi-track fitting in all directions using fast timing and precision photon location. This is a critical step towards demonstrating the power of hybrid detectors for a new generation of far detectors in long-baseline neutrino oscillation experiments and observatories for low-energy neutrinos.

Primary frontier topic:

Neutrino Physics Frontier

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About Snowmass and Snowmass Planning Meeting

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Accelerator technology development at Russia

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Accelerators & beam physics trends

Corresponding Author: nsergei@fnal.gov

102. The Roles of QIS in HEP / 336

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Additional Time In Session

109. Determining the Masses and Nature of Neutrinos / 335

Additional Time In Session

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Advanced SRF R&D for Higgs Factory Luminosity (and Energy) Upgrades

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Advanced acceleration concepts: DLA

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176. Grand challenges of ultimate beams and ultimate high energy colliders / 368

Advanced beam cooling

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Advances in Event Generation and Detector Simulation: Motivation and Ground Rules

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Advances in Event Generation and Detector Simulation: Open Discussion

132. Collider Data Analysis Strategies / 267

Advances in triggering and data acquisition

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Primary frontier topic:

Community Town Hall / 32

Alpha: Measurement of the fine structure constant as test of the Standard Model

Authors: Holger Mueller[1] ; David Brown[2]

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Comparison of direct measurements of the fine structure constant via measuring the recoil velocity of an atom that scattered a photon from a laser beam, and those obtained from the electron's g-2, are some of the most comprehensive tests of the Standard Model. Based on our 2018 measurement (Parker et al., Science 360, 191), that is currently the most accurate, we report on a project to make a 10-20 fold improvement by taking the control over the spatial structure of the laser beam to the extreme.

Primary frontier topic:

Rare Processes and Precision Measurements Frontier

175. Accelerator research centers and test facilities for future accelerators / 200

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Applications emerging from unique plasma-enabled electron beam regimes

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172. Near-term applications of plasma accelerators / 309

Applications of laser-accelerated protons and ions

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172. Near-term applications of plasma accelerators / 308

Applications of plasma-based betatron radiation

Corresponding Author: aehussei@ualberta.ca

102. The Roles of QIS in HEP / 243

Applications of quantum information to quantum gravity, black holes and QFT

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Atomic/nuclear clocks and precision spectroscopy measurements for dark matter and dark sector searches

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Rapid developments of atomic clocks and other precision spectroscopy techniques are making possible phenomenologically interesting searches for bosonic dark matter and new force carriers. Furthermore, it is realistic to expect in the next decade many orders of magnitude improvements in the sensitivity of these experiments. To take full advantage of new opportunities presented by these advances will require experimental and theoretical engagements from both atomic and particle physics communities.

Several directions are being pursued to drastically improve the reach of the clock and other precision spectroscopy experiments for DM detection:
(i) significant improvement of the current clocks, that is expected to rapidly evolve in the next decade;
(ii) development of clock networks at the new level of precision;
(iii) development of new atomic clocks based on highly charged ions (HCI) that have much higher sensitivities to the variation of alpha;
(iv)development of a nuclear clock that is based on a nuclear rather than atomic transition;
(v) dedicated precision spectroscopy experiments sensitive to higher DM masses than clocks;
(vi) development and implementation of new clock-comparison schemes specifically designed to improves reach of oscillatory and transient dark matter searches;
and (vii)˜development of molecular clocks
The experimental effort is strongly complimented by the development of high-precision atomic theory and particle physics model building.

Primary frontier topic:

Cosmic Frontier

124. Lattice Gauge Theory for High Energy Physics / 259

BSM with LGT brief

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173. AF5 organization with contributors / 300

Beamdump Experiments Driven by a Plasma Wake-field Accelerator

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173. AF5 organization with contributors / 299

Belle II/SuperKEKB Upgrades & Overview

Corresponding Author: teb@phys.hawaii.edu

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Break and Chat

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CBETA (Georg Hoffstaetter, Cornell)

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CEPC (already presented on Sep 30, 2020)

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178. Common accelerator goals/technology at the energy frontier / 403

CEPC-SPPC Staging

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Primary frontier topic:

136. Heavier particle dark matter >˜ 10 GeV / 89

CF Overview

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Primary frontier topic:

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CF Points (#69, #70, #71, #74, #137, #140)

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CLIC

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9. IF Intro and LOIs / 239

CPAD Introduction

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Can we handle uncertainties better?

Corresponding Author: kterao@slac.stanford.edu

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Canada

Corresponding Author: brigitte.vachon@mcgill.ca

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Challenges and opportunities for anomaly detection

Corresponding Author: dshih@physics.rutgers.edu

132. Collider Data Analysis Strategies / 268

Challenges and opportunities for trigger-level analyses

Corresponding Author: antonio.boveia@cern.ch

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Challenges of ultimate high energy colliders

Corresponding Author: frank.zimmermann@cern.ch

138. Synergy of astro-particle physics and collider physics / 117

Charm production and IceCube backgrounds

Corresponding Author: mary-hall-reno@uiowa.edu

29. Low-energy precision experiments / 420

Closeout

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Closing Remarks

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132. Collider Data Analysis Strategies / 274

Collider Data Analysis Strategies: Open Discussion

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Collider Data Analysis Strategies: Motivation and Ground Rules

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Colliding beam elastic pp and pd scattering to test T- and P-violation

Author: Richard Talman[1]

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To test T- and P-violation by proton EDM requires an electric storage ring (SR) with simultaneously counter-circulating, frozen-spin proton beams. The CPEDM feasibility study proposes a low-energy prototype ring with superimposed electric and magnetic bending storing frozen-spin 49.65 MeV (clock-wise) protons and pseudo-frozen spin 24.73 MeV (counter-clockwise) protons; pd combinations are also practical and interesting.

Such a SR in the collider mode can be used to search for beyond Standard Model semi-strong T-violation in elastic pp or pd scattering. Suggested by Lee & Wolfenstein, Prentki & Veltman and Okun, as a source of CP-violation, it still awaits the experimentum crucis.

Initial spin states are guaranteed by phase-lock technique developed by JEDI; a comparison of polarization effects in the direct and time-reversed reactions requires matching polarimetry of final-state particles. The notable exception is T-violation in collisions of vector polarized protons and tensor polarized deuterons.

Full final state polarimetry stops the scattered particles in azimuthally symmetric full acceptance tracking chambers of the polarimeter, totaling 3π sr. This high-efficiency polarimetry is feasible only because the scattered particles are soft enough to be stopped in the polarimeter, making collider experiments much superior to fixed target experiments.

Besides a comparison of the analyzing powers to final-state single-particle polarizations, an access to T-violation in double-spin observables will be possible. With a pp luminosity of 0.6 mb^{-1}s^{-1}, producing 10^8 elastic scatters per year, the time-reversal violation upper limits, currently at the level of a few 1%, could be lowered by more than one order in magnitude.

Primary frontier topic:

Rare Processes and Precision Measurements Frontier

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CommF and EC Points (#57, #118, #119)

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Primary frontier topic:

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Community Engagement Across the Frontiers

Discussion with CEF and Other Frontier Liaisons

Primary frontier topic:

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CompF Points (#123)

145. QCD phase transitions and ultra-high density matter / 350

Compact binaries as probes of dense matter and QCD phase transitions

Corresponding Author: pgjlandry@gmail.com

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Computation and algorithm brief

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99. Advances in Event Generation and Detector Simulation / 281

Computational challenges for event generation in view of HL-LHC and beyond

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99. Advances in Event Generation and Detector Simulation / 288

Computational challenges for neutrino event generators

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Primary frontier topic:

81. Computing Requirements/Opportunities NF / 218

Computing Resources and Access

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84. Computing Requirements & Opportunities in Theory / 359

Computing roadmap overview

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Survey of DOE HPC roadmap and programming models

57. Connection with industry / 387

Connection with industry - accelerators

This session invites speakers from industry to present their experience in terms of working with national laboratories and academia, what the strengths in the partnership are, and where improvements can be made. The session is split into two sections, one on accelerator technologies and one on semiconductors.

First section: Flash talks and discussion with Manoj Kanskar (nLIGHT), Antoine Courjaud (Amplitude Laser), Salime Boucher (RadiaBeam), and Alexei Kanareykin (Euclid).

Primary frontier topic:

57. Connection with industry / 388

Connection with industry - semiconductors

This session invites speakers from industry to present their experience in terms of working with national laboratories and academia, what the strengths in the partnership are, and where improvements can be made. The session is split into two sections, one on accelerator technologies and one on semiconductors.

Second section: Flash talks and panel discussion with Bob Patti (NHanced Semiconductors), Brian Tyrell (MITLL), Farah Fahim (FNAL), and Garbriella Carini (BNL).

Primary frontier topic:

187. Machine Detector Interface with plasma lens and plasma accelerators / 389

Considerations on plasma lenses for linear colliders

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Primary frontier topic:

72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72 / 143

Cosmic Origins

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Cosmic Probes / Gravitational Wave (CF5/CF7/TF9) overview

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139. Testing LambdaCDM cosmology at low and high redshifts / 120

Cosmology Intertwined

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Community Town Hall / 103

Culture change is necessary, and it requires strategic planning

Author: Brian Nord[None]

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Racism and other forms of bigotry oppress, disenfranchise, and marginalize scientists of color in high-energy physics (HEP). Actions and patterns of behavior by individuals and groups, as well as policies and procedures of institutions are among the vectors of oppression. The evidence includes the underrepresentation of Black scientists and other scientists of color, regular acts of harassment against scientists of color (including women and people of minoritized genders), and systematic disenfranchisement of marginalized and minoritized people throughout pathways and systems of education.

Research communities have traditionally responded to this problem in a variety of ways, which have often fallen short of creating real change — i.e., when they don't address the deeply rooted source of the problem, and when strategic planning is not engaged. Moreover, these approaches place the purported beneficiaries in harm's way. To achieve a new community through real and sustained change, we therefore recommend 1) long-term strategic planning, 2) new modes of community organizing and decision-making, and 3) partnership with experts and professionals in anti-racism and related areas.

Energy, creativity, and well-understood protocols are used for planning and executing long-term scientific programs and experiments to make discoveries. Therefore, we also call on the HEP community to engage in the effort to drive change with similar imagination and discipline.

Primary frontier topic:

Community Engagement Frontier

72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72 / 146

Dark Energy

125. EFTs for new physics sensitivity studies / 185

Dark Matter EFT

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DarkQuest and LongQuest at the 120~GeV Fermilab Main Injector

Author: Nhan Tran[1]

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Expanding the mass range and techniques by which we search for dark matter is an important part of the worldwide particle physics program which has been specifically emphasized in the DOE Basic Research Needs for Dark Matter New Initiatives report. Accelerator-based searches for dark matter are a uniquely compelling part of this program as a way to both create and detect dark matter in the laboratory and explore the dark sector by searching for mediators and excited dark matter particles. Our proposal focuses on developing the DarkQuest experimental concept and related enhancements collectively referred to as LongQuest. DarkQuest is a proton fixed-target experiment with particular sensitivity to an array of visible dark sector signatures in the MeV-GeV mass range. Because it builds off of existing accelerator and detector infrastructure, it offers a powerful but low-cost experimental initiative that can be realized on a short timescale.

Primary frontier topic:

Rare Processes and Precision Measurements Frontier

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Data Preservation

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Data preservation and reinterpretation

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Detecting keV-range super-light dark matter using graphene Josephson junction

Authors: Doojin Kim[1] ; Doojin Kim[2]

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Understanding the nature of dart matter has been a long-standing conundrum in particle physics. While most theoretical and experimental efforts in the search for dark matter have been focused on the weakly interacting massive particles, the fact that there have been no conclusive signal observations increasingly motivates searches for other dark-matter candidates. Of them, keV-scale super-light dark matter is receiving particular attention, as its existence is a crucial criterion to determine the "coldness" of dark matter in cosmological history. However, the direct probe of such super-light dark matter has been an experimentally challenging task primarily due to the difficulty in achieving an extremely small energy threshold ($E_{\rm th}$) as low as $\mathcal{O}$(meV). Very recently, a technological breakthrough for this experimental challenge has been reported in condensed matter physics, the graphene-based Josephson junction (GJJ) bolometer technology (arXiv:1909.05413, Nature accepted). The device using this "state-of-the-art" technology has shown the highest sensitivity to $E_{\rm th} \sim 0.1$ meV. We demonstrate that the adoption of this GJJ-based bolometer can lead to an immediate and unprecedented sensitivity in exploring keV-range super-light dark matter, improving the minimum detectable mass by more than three orders of magnitude over the ongoing experiments (arXiv:2002.07821). We then report the current status of doing the first experiment with existing devices fabricated for the study in arXiv:1909.05413, and briefly mention other high energy physics applications, e.g., detection of cosmic neutrino background and search for other well-motivated super-light particles such as axion, sterile neutrino, and dark photon.

Primary frontier topic:

Cosmic Frontier

172. Near-term applications of plasma accelerators / 307

Development and applications of a Compton X-ray light source driven by a laser-plasma electron accelerator

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Differentiable programming

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Direct Detection (CF1/TF9) overview

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Direct searches for neutrino masses

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Discovering quark-matter cores in massive neutron stars

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140. Future medium to ultrahigh energy gamma-ray detectors - #cpm_session_140 / 412

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Input from community

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182. Energy and power limits for plasma accelerators / 393

Discussion

A overview presentation will be followed by community discussion on potential energy reach of plasma based colliders at scales to and beyond 10 TeV. Comments from the community, both based on LOI's discssed at the AF6 September worskhop (https://indico.fnal.gov/event/45651/) and new comments, are encouraged.

This session will be in addition to a more general session, A10 Physics limits of Ultimate Beams (colliders: e+/e-, mu/mu, p/p, p drivers, etc) which will address overall considerations. As such, A26 will be aimed at specific plasma based collider issues.

Energy reach considerations include scattering, hosing, radiation, focusing and interaction point physics. Efficiency considerations include structure efficiency, interaction point geometry to maximize interaction, and energy recovery. The extent to which plasma based concepts (both established and new) may have properties that either improve on conventional machines or present limits will be discussed. The goal is outline the status of issues that have been analyzed and discuss needs for further research that should be addressed to move forward collider designs based on these concepts.

110. Baryon and Lepton Number Violating processes / 279

Discussion

102. The Roles of QIS in HEP / 246

Discussion

127. Searches for dark sectors / 232

Discussion

127. Searches for dark sectors / 231

Discussion

127. Searches for dark sectors / 230

Discussion

127. Searches for dark sectors / 229

Discussion

127. Searches for dark sectors / 228

Discussion

127. Searches for dark sectors / 227

Discussion

41. Anomalies in Flavor Physics / 221

Discussion

77. Quantum Sensors for Wave and Particle Detection / 205

Discussion

125. EFTs for new physics sensitivity studies / 187

Discussion

Extended discussion after 1:30pm CDT in separate Zoom room:
https://pitt.zoom.us/j/98818754052
Meeting ID: 988 1875 4052
Passcode: 125

128. From Amplitudes to Precision Theory for Future Colliders / 172

Discussion

128. From Amplitudes to Precision Theory for Future Colliders / 170

Discussion

128. From Amplitudes to Precision Theory for Future Colliders / 168

Discussion

128. From Amplitudes to Precision Theory for Future Colliders / 166

Discussion

69. Instrumentation for Future Optical Surveys - #cpm_topic_69 / 161

Discussion

72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72 / 147

Discussion

44. New accelerator concepts for high intensity muon beams / 127

Discussion

136. Heavier particle dark matter >˜ 10 GeV / 90

Discussion

108. Accelerator Probes of Light Dark Matter (keV-GeV) / 237

Discussion (10')

84. Computing Requirements & Opportunities in Theory / 363

Discussion and Next Steps

54. Machine Detector Interface for Future Colliders / 344

Discussion and plan

122. Capabilities needed to execute underground experiments in a broad range of research categories / 340

Discussion of Underground Facilities and Needs

101. Higgs as a probe of new physics / 112

Discussion on Higgs Potential

Corresponding Author: dmorri@triumf.ca

101. Higgs as a probe of new physics / 110

Discussion on Higgs Potential

Corresponding Author: michele.selvaggi@cern.ch

101. Higgs as a probe of new physics / 111

Discussion on Higgs and Flavor

Corresponding Author: yg73@cornell.edu

101. Higgs as a probe of new physics / 109

Discussion on Higgs and Flavor

Corresponding Author: valentina.maria.cairo@cern.ch

145. QCD phase transitions and ultra-high density matter / 353

Discussion session

Corresponding Author: jacquelyn.noronhahostler@rutgers.edu

141. Gravitational wave source modelling / 347

Discussion session

119. HEP and Accelerator Workforce, Careers, and Training / 401

Discussion/ Next Steps (slack channel #cpm_topic_119)

Primary frontier topic:

1. EF Intro (#cpm_ef_intro) / 138

EF Activities and Focus Questions

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136. Heavier particle dark matter >˜ 10 GeV / 88

EF Overview

Corresponding Authors: liantaow@uchicago.edu, caterina.doglioni@hep.lu.se

Primary frontier topic:

201. EF Planning (#cpm_ef_planning) / 142

EF Planning and Community Feedback

Corresponding Author: meenakshi_narain@brown.edu

209. IF Planning / 421

EF and RF Points (#26, #130 ,#131)

130. Enabling technologies for low mass and ps timing detectors / 249

EF perspective

Corresponding Author: maxim.titov@cea.fr

108. Accelerator Probes of Light Dark Matter (keV-GeV) / 236

EF10 Light dark matter at high energies (15' + 5')

Corresponding Author: suchita.kulkarni@gmail.com

129. Higgs Factories / 160

ERL-based FCCee

Corresponding Author: vl@bnl.gov

Primary frontier topic:

178. Common accelerator goals/technology at the energy frontier / 404

ERL–Based Circular Higgs Factory

Corresponding Author: roser@bnl.gov

Primary frontier topic:

128. From Amplitudes to Precision Theory for Future Colliders / 167

EW effects in parton showers at high energy

Corresponding Author: webber@hep.phy.cam.ac.uk

119. HEP and Accelerator Workforce, Careers, and Training / 400

Early Career Perspective

Corresponding Author: vvelan@berkeley.edu

201. EF Planning (#cpm_ef_planning) / 140

Early Career activities in EF

Corresponding Authors: gec8mf@virginia.edu, aroepe@fnal.gov

99. Advances in Event Generation and Detector Simulation / 284

Electroweak effects and/or multi-boson processes

Corresponding Author: stefan.prestel@thep.lu.se

130. Enabling technologies for low mass and ps timing detectors / 252

Enabling technologies for low mass trackers

Corresponding Author: affolder@ucsc.edu

130. Enabling technologies for low mass and ps timing detectors / 251

Enabling technologies for picosecond timing detectors

Corresponding Authors: aseiden@ucsc.edu, abs@scipp.ucsc.edu

127. Searches for dark sectors / 195

Energy Frontier Probes (EF9/AF5)

Corresponding Author: j.beacham@cern.ch

182. Energy and power limits for plasma accelerators / 392

Energy and power limits of plasma accelerators

Corresponding Author: cbschroeder@lbl.gov

Plenary / 24

Engaging the Community to Define the Future (1)

Corresponding Author: ritz@scipp.ucsc.edu

Plenary / 25

Engaging the Community to Define the Future (2)

Corresponding Author: sylvester_gates@brown.edu

102. The Roles of QIS in HEP / 244

Entanglement, tensor networks and complexity

99. Advances in Event Generation and Detector Simulation / 283

Event generators for NNLO/NLL and beyond

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Plenary / 2

Exciting Physics Before Us

Corresponding Author: hewett@slac.stanford.edu

41. Anomalies in Flavor Physics / 175

Experimental overview (10'+5')

128. From Amplitudes to Precision Theory for Future Colliders / 165

Extending subtraction schemes to N3LO

Corresponding Author: caola@pha.jhu.edu

138. Synergy of astro-particle physics and collider physics / 118

FASER, FASERnu, and the Forward Physics Facility (FPF)

Corresponding Author: jlf@uci.edu

54. Machine Detector Interface for Future Colliders / 343

FCC MDI

Corresponding Author: manuela.boscolo@lnf.infn.it

129. Higgs Factories / 156

FCC-ee

Corresponding Author: frank.zimmermann@cern.ch

Primary frontier topic:

141. Gravitational wave source modelling / 346

Field theory approach to the two-body problem

Corresponding Author: walter.goldberger@yale.edu

Primary frontier topic:

188. Plasma Acceleration for fixed target experiments / 391

First HEP applications of plasma wakefield acceleration

Primary frontier topic:

128. From Amplitudes to Precision Theory for Future Colliders / 169

Five-point QCD amplitudes at two loops

Corresponding Author: harald.ita@physik.uni-freiburg.de

173. AF5 organization with contributors / 301

Fixed-Target Searches for New Physics with O(1 GeV) Proton Beams at Fermi National Accelerator Laboratory [+O(10 GeV) LoI)]

Corresponding Author: toups@fnal.gov

187. Machine Detector Interface with plasma lens and plasma accelerators / 390

Food for thought & discussion

Primary frontier topic:

141. Gravitational wave source modelling / 345

From scattering amplitudes to relativistic two-body problem

Corresponding Author: alessandra.buonanno@aei.mpg.de

Primary frontier topic:

124. Lattice Gauge Theory for High Energy Physics / 257

Fundamental Symmetries brief

Corresponding Author: tanmoy@lanl.gov

Community Town Hall / 36

Future Information and Communications Technologies for HL-LHC Era: Beyond CMOS and Beyond the Shannon Limit

Author: Harvey Newman[1]

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The revolutionary developments underway to overcome the looming barriers in electronic and photonic systems, and hence in computing and communications systems, to maintain progress and economies, offer unprecedented opportunities for our field. These include

•o Nanophotonics, plasmonics, and/or spintronics for ultrafast low energy signaling
o Beyond CMOS: memory, logic devices, integrated electronic/photonic systems
o Beyond Shannon long haul optical communications systems and methods: multicore fibers, spatial division multiplexing, orbital angular momentum and other degrees of freedom
o Metamaterials and devices: To shape and direct light, form wavefronts and frequency dependent beams; + programmably, on several time + distance scales

HEP, and community planning have until now taken only limited account of these Revolutions which will which affect more than computing: TriDAS, all communications, intelligent "coherent" systems; as well as our working + home environments

There will be great design and physics opportunities at the HL-LHC in 2030-38, and beyond for future experiments and accelerators.

The conclusion that follows from the above is that as a community we need to follow, join and lead some of these forefront developments, as part of our longterm experimental roadmap and our "frontiers". The above technologies and new directions will have an increasing role in the 2020s, and dominate the 2030s.

The issues, barriers, next generation technologies and opportunities are introduced and discussed further in this presentation, a short version of which was presented at the Snowmass Computational Frontier Kickoff Meeting on August 11 2020:

https://www.dropbox.com/s/61ym4u4gl3oayi7/FutureICTfor%20theHLLHC_2020to2030andBeyond_LongVersionhbn081020.p

Primary frontier topic:

Computational Frontier

64. Computing Needs of the Accelerator Frontier / 130

Future computer & programming trends

Corresponding Author: axelhuebl@lbl.gov

175. Accelerator research centers and test facilities for future accelerators / 190

GARD test facilities (Vitaly Yakimenko, SLAC)

Community Town Hall / 102

Gas TPCs with directional sensitivity to dark matter, neutrinos, and BSM physics

Authors: Diego Aristizabal Sierra[1] ; Connor Awe[2] ; Elisabetta Baracchini[3] ; Phillip Barbeau[2] ; Bhaskar Dutta[4] ; Warren Lynch[5] ; Neil Spooner[5] ; James Battat[6] ; Cosmin Deaconu[7] ; Callum Eldridge[5] ; Majd Ghrear[8] ; Peter Lewis[9] ; Dinesh Loomba[10] ; Katie J. Mack[11] ; Diane Markoff Markoff[12] ; Hans Muller[9] ; Kentaro Miuchi[13] ; Ciaran

O'Hare[14] ; Nguyen Phan[15] ; Kate Scholberg[2] ; Daniel Snowden-Ifft[16] ; Louis Strigari[17] ; Thomas Thorpe[18] ; Sven Vahsen[19]

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There is an opportunity to develop a long-term, diverse, and cost-effective US experimental program based on directional detection of nuclear recoils in gas TPCs.

Smaller, 1 m^3 scale detectors could detect and demonstrate directional sensitivity to Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) at either NuMI or DUNE. This technology is also sensitive to beyond the Standard Model (BSM) physics in the form of low-mass dark matter, heavy sterile neutrinos, and axion-like particles. For every factor ten increase in exposure, new measurements are possible. A 10 m^3 detector could produce the strongest SD WIMP-proton cross section limits of any experiment across all WIMP masses. A 1000 m^3 detector would detect between 13 and 37 solar CEνNS events over six years. Larger volumes would bring sensitivity to neutrinos from an even wider range of sources, including galactic supernovae, nuclear reactors, and geological processes. An ambitious DUNE-scale detector, but operating at room temperature and atmospheric pressure, would have non-directional WIMP sensitivity comparable to any proposed experiment, and would, in addition, allow us to utilize directionality to penetrate deep into the neutrino floor.

If a dark matter signal is observed, this would mark the beginning of a new era in physics. A large directional detector would then hold the key to first establishing the galactic origin of the signal, and to subsequently map the local WIMP velocity distribution and explore the particle phenomenology of dark matter.

To understand and fully maximize the physics reach of gas TPCs as envisioned here, further phenomenological work on dark matter and neutrinos, improved micro-pattern gaseous detectors (MPGDs), customized front end electronics and novel region-of-interest triggers are needed. We encourage the wider dark matter, neutrino, and instrumentation communities participating in Snowmass to come together and help evaluate and improve this proposal.

Primary frontier topic:

Cosmic Frontier

128. From Amplitudes to Precision Theory for Future Colliders / 173

General discussion and closing remarks

175. Accelerator research centers and test facilities for future accelerators / 201

General discussions

54. Machine Detector Interface for Future Colliders / 339

Goal of the session

Plenary / 52

Goals of the CPM and Snowmass Timeline

Corresponding Author: ykkim@hep.uchicago.edu

176. Grand challenges of ultimate beams and ultimate high energy colliders / 367

Grand challenges

Corresponding Author: nsergei@fnal.gov

176. Grand challenges of ultimate beams and ultimate high energy colliders / 327

Grand challenges

72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72 / 144

Gravitational View of the Early Universe

119. HEP and Accelerator Workforce, Careers, and Training / 398

HEP - Career Pipeline & Development (CommF2)

Corresponding Authors: jmhogan@fnal.gov, jmhogan806@gmail.com

Primary frontier topic:

119. HEP and Accelerator Workforce, Careers, and Training / 399

HEP - Education (CommF4)

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119. HEP and Accelerator Workforce, Careers, and Training / 397

HEP - Workforce, Training and Education (CEF)

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Primary frontier topic:

26. Energy Frontier discovery machines / 330

Hadron and lepton-hadron colliders with energies above 3 TeV

Corresponding Author: frank.zimmermann@cern.ch

Primary frontier topic:

124. Lattice Gauge Theory for High Energy Physics / 255

Hadron structure and spectroscopy brief

Corresponding Author: hueywen@msu.edu

124. Lattice Gauge Theory for High Energy Physics / 261

Hamiltonian simulation and sign problem

Corresponding Author: davoudi@umd.edu

Community Town Hall / 65

Heterodyne Detection of Axion Dark Matter via Superconducting Cavities

Authors: Asher Berlin[1] ; Christopher Nantista[2] ; Jeffery Neilson[2] ; Kevin Zhou[3] ; Natalia Toro[2] ; Philip Schuster[4] ; Raffaele D'Agnolo[5] ; Sami Tantawi[2] ; Sebastian Ellis[2]

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We will present a novel approach to detecting dark matter axions in a Superconducting RF cavity. The approach relies on axion-mediated transitions between nearly-degenerate resonant modes, leading to parametrically enhanced signal power for light axions. This approach could probe axion masses across fifteen orders of magnitude, all in a metre-scale cavity.

Primary frontier topic:

Cosmic Frontier

129. Higgs Factories / 150

Higgs Factory, the next steps for EF/AF/TF

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Primary frontier topic:

129. Higgs Factories / 149

Higgs properties projections at future e+e- Colliders

Corresponding Author: tian@icepp.s.u-tokyo.ac.jp

129. Higgs Factories / 148

Higgs properties projections for the HL-LHC

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9. IF Intro and LOIs / 240

High-level Summary of IF LOIs

Corresponding Author: psbarbeau@phy.duke.edu

178. Common accelerator goals/technology at the energy frontier / 408

Higher Gradient Expectations for SRF for ILC Energy Upgrades

Co-author: Hasan Padamsee [1]

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Primary frontier topic:

128. From Amplitudes to Precision Theory for Future Colliders / 171

Higher-order corrections for HZ production and related techniques

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9. IF Intro and LOIs / 238

IF Introduction

Corresponding Author: zhangjl@anl.gov

129. Higgs Factories / 155

ILC

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54. Machine Detector Interface for Future Colliders / 341

ILC MDI

Corresponding Author: twmark@slac.stanford.edu

123. Data Handling and AI/ML / 114

Infiltration of AI/ML in Particle Physics

Corresponding Authors: vlimant@cern.ch, jvlimant@caltech.edu

Primary frontier topic:

Community Town Hall / 91

Initiative for Dark Matter in Europe and beyond

Authors: Caterina Doglioni[1] ; iDMEu EoI Proponents[None]

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The European committee for Future Accelerators (ECFA), the Nuclear Physics European Collaboration Committee (NuPECC) and the Astroparticle Physics European Consortium (APPEC) have established a seminar to allow astroparticle, nuclear and particle physics researchers to peek into each other's activities, called the Joint ECFA-NuPECC-APPEC Seminar (JENAS) at Orsay, in October 2019. The identified overlapping challenges might transform via joint programs into stronger opportunities to further our understanding of nature.

In the spirit of further exploring topical synergies between these disciplines, APPEC, ECFA and NuPECC have issued a call for novel Expressions-of-Interest (EoI), seeking bottom-up and community thoughts expressed in a non-binding EoI for further discussion within the APPEC, ECFA and NuPECC committees or consortia. These thoughts can revolve around potential synergies in technology, physics, organization and/or applications. The submitted Expressions of Interest can be found here: http://nupecc.org/jenaa/?display=eois.

The initiative for Dark Matter in Europe and beyond (iDMEu) is such an expression of interest, which collects more than 300 signatories to date, including Snowmass participants. It aims to create a permanent and common platform to exploit synergies and complementarities in dark matter searches across different communities, as a broad and common approach to dark matter research is necessary given the nature of this challenge. We will discuss the origin of this initiative and its possible future evolution, as well as its plans to build an online meta-repository for dark matter resources.

Primary frontier topic:

General

132. Collider Data Analysis Strategies / 272

Interface of theory calculations with experimental methods

Corresponding Author: simone.marzani@ge.infn.it

175. Accelerator research centers and test facilities for future accelerators / 191

International test facilities (Ralph Assmann, DESY)

140. Future medium to ultrahigh energy gamma-ray detectors - #cpm_session_140 / 410

Intro

Jim Beatty, Ke Fang, Kirsten Tollefson

26. Energy Frontier discovery machines / 42

Intro Talk

Primary frontier topic:

74. Atomic to Cosmic: Wave Dark Matter and Beyond / 414

Introduction

26. Energy Frontier discovery machines / 329

Introduction

Corresponding Author: denisovd@fnal.gov

Plans for the session

Plenary / 312

Introduction

Corresponding Author: quinn@phy.olemiss.edu

97. Neutrinos as Probes of Standard and BSM Particle Physics / 254

Introduction

Corresponding Author: ium4@psu.edu

127. Searches for dark sectors / 188

Introduction

by all the convenors of this session

75. Cosmic Probes of Dark Matter Physics - #cpm_topic_75 / 151

Introduction

64. Computing Needs of the Accelerator Frontier / 128

Introduction

Corresponding Authors: jlvay@lbl.gov, cho@slac.stanford.edu

Primary frontier topic:

115. Neutrinos, dark matter, and underground facilities / 122

Introduction

Corresponding Authors: gorebigann@lbl.gov, tbolton@ksu.edu, hlippincott@ucsb.edu, dspelle1@jhu.edu

123. Data Handling and AI/ML / 113

Introduction

Corresponding Authors: acostad@ufl.edu, daniel@uci.edu

175. Accelerator research centers and test facilities for future accelerators / 189

Introduction (Zhirong Huang et al.)

180. SRF and magnets for Higgs factories / 354

Introduction to Superconducting Undulators

Corresponding Author: crboffo@fnal.gov

124. Lattice Gauge Theory for High Energy Physics / 263

Introduction to the session

Corresponding Author: davoudi@umd.edu

119. HEP and Accelerator Workforce, Careers, and Training / 394

Introduction: Accelerator Frontier 1: Beam Physics, Accelerator Education, Outreach & Diversity

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92. Non-perturbative QCD dynamics at colliders / 292

Introduction: EF05/06 Letters of Interest on nonperturbative effects in high-precision QCD predictions

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We introduce Letters of Interest submitted to the EF05 and EF06 topical groups and dedicated to the treatment of nonperturbative effects in high-precision QCD computations and parton showering programs.

Primary frontier topic:

176. Grand challenges of ultimate beams and ultimate high energy colliders / 377

Joint discussion

176. Grand challenges of ultimate beams and ultimate high energy colliders / 373

Joint discussion

176. Grand challenges of ultimate beams and ultimate high energy colliders / 370

Joint discussion

173. AF5 organization with contributors / 298

LANSCE-PSR Short-Pulse Upgrade for Improved Dark Matter and Sterile Neutrino Searches

Corresponding Author: vdwater@lanl.gov

125. EFTs for new physics sensitivity studies / 181

LHC EFT studies

Corresponding Author: kristin.lohwasser@cern.ch

147. Novel Ideas in Astronomical Observations / 337

LOI Discussion

51. Requirements for low background and underground detectors / 135

LOI/Snowmass summary to date

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186. High field (Schwinger limit) physics with intense electron and laser beams / 448

LUXE experiment

Corresponding Author: beate.heinemann@desy.de

28. Theory Challenges in Precision Measurements / 318

Lattice QCD's role in precision measurements

Corresponding Author: ruthv@fnal.gov

26. Energy Frontier discovery machines / 332

Lepton and gg colliders with energies above 3 TeV

Corresponding Author: daniel.schulte@cern.ch

Primary frontier topic:

99. Advances in Event Generation and Detector Simulation / 289

Leveraging new computational architectures and strategies

Corresponding Author: cgleggett@lbl.gov

72. Dark Energy, Origins (Inflation), and Light Relics - #cpm_topic_72 / 145

Light Relics

Corresponding Author: bwallisch@ias.edu

Light Relics and Dark sectors

124. Lattice Gauge Theory for High Energy Physics / 256

Light and heavy flavor physics brief

Corresponding Author: smeinel@email.arizona.edu

Plenary / 53

Local Organizing Committee Welcome and Meeting Logistics

Corresponding Author: boj@fnal.gov

125. EFTs for new physics sensitivity studies / 183

Low-energy SMEFT

Corresponding Author: jdevries@umass.edu

175. Accelerator research centers and test facilities for future accelerators / 196

Low-energy test facilities (Edith Nissen, Jlab)

99. Advances in Event Generation and Detector Simulation / 285

Machine learning for detector simulations

Corresponding Author: pedrok@fnal.gov

183. Intermediate lepton collision energies between 500 GeV and 3 TeV / 223

Machine options

Corresponding Author: sgess@slac.stanford.edu

173. AF5 organization with contributors / 297

Magnet R&D for Low-Mass Axion Searches

Corresponding Author: aleder@mit.edu

138. Synergy of astro-particle physics and collider physics / 242

Measurement of the pp cross section at \sqrt{s} ~ 100 TeV

Corresponding Author: mary-hall-reno@uiowa.edu

138. Synergy of astro-particle physics and collider physics / 119

Measuring very forward hadrons at the LHC

Corresponding Author: albrow@fnal.gov

Community Town Hall / 59

Metastable Water: Breakthrough Technology for Dark Matter & Neutrinos

Author: Matthew Szydagis[1]

[1] *UAlbany SUNY*

Corresponding Author: mszydagis@albany.edu

We will present a discussion of a new detector technology, the "Snowball Chamber," which is based on the phase transition (of liquid to solid) for metastable fluids. A water-based supercooled detector has the potential to move past the Neutrino Floor, and extend the reach of direct detection dark matter (DM) experiments to low-mass WIMP candidates for both spin-dependent (on the proton) and spin-independent interactions. The detector concept also has applications within coherent elastic neutrino-nucleus scattering experiments. Some of the foreseeable, potential pitfalls will be presented, alongside a brief vision of an R&D program toward the maturation of this technology.

In general, the marquee DM experiments are each mature, reliable, and expected to reach their sensitivity objectives; however, looking beyond the current generation, the parameter space of DM candidates accessible with current technology is limited. Instrumentation thresholds and the kinematics of elastic scattering constrain the lowest mass dark matter candidates that can be studied. The CEνNS of solar, atmospheric, and diffuse galactic supernova nu's will soon become a background (neutrino floor) that challenges the reach to lower cross-sections, made even more difficult by the required scale of future experiments. Without a new approach for detection technology, experimental searches will remain blind to important regions of parameter space. A new tech which pushes past the neutrino floor, extends sensitivities to low-mass dark matter candidate particles, and is insensitive to the conventional BGs could open up these new horizons. The path forward envisioned here builds on the transformative "Snowball Chamber" technology, a p-rich, supercooled liquid H2O detector. A host of related measurements within neutrino physics, utilizing the CEνNS interaction on O nuclei, and/or the potential of these detectors to track e- interactions, is likewise open to such a technology.

Primary frontier topic:

Instrumentation Frontier

201. EF Planning (#cpm_ef_planning) / 141

Monte Carlo Task Force activities and plans for Production

Corresponding Author: john.stupak@ou.edu

129. Higgs Factories / 158

Muon Collider Higgs Factory

Corresponding Author: mpalmer@bnl.gov

54. Machine Detector Interface for Future Colliders / 342

Muon Collider MDI

Corresponding Author: mokhov@fnal.gov

44. New accelerator concepts for high intensity muon beams / 295

Muon Lifetime Enhancement

Corresponding Author: electrongaugegroup@gmail.com

44. New accelerator concepts for high intensity muon beams / 126

Muons from PSI and other Cyclotrons

Corresponding Author: angela.papa@psi.ch

209. IF Planning / 422

NF Points (#51)

Corresponding Author: mayly@iastate.edu

108. Accelerator Probes of Light Dark Matter (keV-GeV) / 235

NF03 Light dark matter at accelerator neutrino facilities (15' + 5)

Corresponding Author: wyjang@fnal.gov

61. Energy and Power and Time structure goals for Neutrino Frontier programs / 322

NF09 Plans and Discussion

Corresponding Authors: jpochoa@uci.edu, spitzj@umich.edu, ljf26@fnal.gov, alysia.marino@colorado.edu

28. Theory Challenges in Precision Measurements / 315

Need and prospects for improved parton shower Monte Carlos

Corresponding Author: frank.krauss@durham.ac.uk

127. Searches for dark sectors / 197

Neutrino Frontier Probes (NF/AF5)

Corresponding Author: kkelly12@fnal.gov

173. AF5 organization with contributors / 303

Neutrino Minimal Standard Model - a unified theory of microscopic and cosmic scales

Corresponding Author: inar.timiryasov@epfl.ch

109. Determining the Masses and Nature of Neutrinos / 180

Neutrinoless double beta decay

Primary frontier topic:

110. Baryon and Lepton Number Violating processes / 276

Neutrinoless double beta decay experiments

Corresponding Author: jgruszko@unc.edu

109. Determining the Masses and Nature of Neutrinos / 179

Neutrinos in cosmology

Primary frontier topic:

92. Non-perturbative QCD dynamics at colliders / 291

New frontiers in the PDF analysis in the HL-LHC era

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Primary frontier topic:

92. Non-perturbative QCD dynamics at colliders / 378

Nonperturbative aspects of the measurements of the QCD coupling

Corresponding Author: huston@msu.edu

132. Collider Data Analysis Strategies / 269

Object identification and event classification

Corresponding Author: loukas.gouskos@cern.ch

186. High field (Schwinger limit) physics with intense electron and laser beams / 449

One-sliders

29. Low-energy precision experiments / 419

Open discussion

41. Anomalies in Flavor Physics / 176

Open discussion

Primary frontier topic:

64. Computing Needs of the Accelerator Frontier / 132

Open discussion (comments, missing topics, …)

125. EFTs for new physics sensitivity studies / 184

Operator series and theory errors

Corresponding Authors: amarti41@nd.edu, aomartin@fnal.gov

44. New accelerator concepts for high intensity muon beams / 124

Opportunities for Muon Research at PIP-II

Corresponding Author: eprebys@ucdavis.edu

173. AF5 organization with contributors / 311

Overview of Facilities

Corresponding Author: mike.lamont@cern.ch

109. Determining the Masses and Nature of Neutrinos / 177

Overview of Neutrino Masses and the Nature of Neutrinos

176. Grand challenges of ultimate beams and ultimate high energy colliders / 371

Overview of future multi-TeV collider LoIs

Corresponding Author: mpalmer@bnl.gov

108. Accelerator Probes of Light Dark Matter (keV-GeV) / 233

Overview on light dark matter cosmology (15' + 5')

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131. Physics requirements for HEP colliders / 224

Overview: beyond the BRN report

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137. High and ultrahigh energy neutrino experiments - #cpm_session_137 / 247

Panel 1: Detection Techniques

Panelists:
Olga Botner, Albrecht Karle, Abigail Vieregg, Angela Olinto, Stephanie Wissel

137. High and ultrahigh energy neutrino experiments - #cpm_session_137 / 248

Panel 2: Future Observations and Science Discoveries

Panelists:
Hallsie Reno, Carlos Arguelles, Mauricio Bustamante, Tonia Venters

Plenary / 55

Panel Discussion on Future Accelerator Facilities

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Global Accelerator Facilities for Future Particle Physics - Panel members include Fabiola Gianotti (CERN), Masa Yamauchi (KEK), Yifang Wang (IHEP-China), Nigel Lockyer (FNAL), Doon Gibbs (BNL)

124. Lattice Gauge Theory for High Energy Physics / 262

Panel discussion

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Discussions will be organized around the following questions:

1) What areas of the LGT program in general, and the topic you are representing in particular, require a comprehensive study to be conducted as part of the Snowmass process in order to quantify the impact of the LGT results on improving phenomenological constraints and the overall experimental programs. i.e., are there areas for which we need to go beyond the USQCD whitepapers and do a more thorough study?

2) What are the computational, algorithmic, and human resource requirements of the program to achieve the impact identified and quantified in the previous question? What is the best HPC model that facilitates scientific progress in our community? If we were to have an input in the development of the upcoming machines and technologies, what would we propose? What is the significance of new classical algorithms, and how can they be combined with developing paradigms based on Machine Learning and Quantum Computing to expedite our scientific output already in the next decade?

51. Requirements for low background and underground detectors / 137

Panel discussion

115. Neutrinos, dark matter, and underground facilities / 123

Panel discussion

Panel discussion among:
Mary Bishai
Laura Marini
Elaine McCluskey
Sean Paling
Kim Palladino
Nigel Smith
Bob Svoboda

123. Data Handling and AI/ML / 115

Panel discussion of the future of AI/ML

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140. Future medium to ultrahigh energy gamma-ray detectors - #cpm_session_140 / 411

Panel on MeV to EeV Gamma-ray Detectors

Panelists are Carolyn Kierans, Tom Shutt, Jamie Holder, Andrea Albert, Marcus Niechciol

97. Neutrinos as Probes of Standard and BSM Particle Physics / 207

Panel: Neutrinos as Probes of BSM Physics

Marco Drewes, Darren Grant, Doojin Kim, Elisa Resconi

97. Neutrinos as Probes of Standard and BSM Particle Physics / 206

Panel: Neutrinos as Probes of Standard Particle Physics

Panel Members: George Fuller, Rajan Gupta, Alec Habig, Kendall Mahn, Ulrich Mosel, Hallsie Reno

77. Quantum Sensors for Wave and Particle Detection / 203

Particle Dark Matter and Neutrino Needs

Corresponding Author: enectali@northwestern.edu

102. The Roles of QIS in HEP / 357

Particle Physics with Quantum Sensors

75. Cosmic Probes of Dark Matter Physics - #cpm_topic_75 / 153

Path Forward

Community Town Hall / 98

Perspective on a Unified U.S. Particle Physics Program

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HEP finds itself at a most interesting time exploring energy and matter at its deepest level. There is more today that we do not understand about the universe than before and the community is bubbling with new ideas that have the potential to drive a new revolution. Currently, however, the field is dominated by mega-projects that leave little room for a broad spectrum of experimental research. The scientific merit of these large projects is unquestioned. HEP, however, stands to gain tremendously by exploiting non-traditional high-energy facilities to complement and expand its research portfolio. For example, ORNL has been developing the utilization of its neutron facilities for fundamental neutrino science. PROSPECT at HFIR and COHERENT at the SNS have demonstrated that these facilities can deliver world-class neutrino science. Searches for free neutron oscillations at these facilities provide unique opportunities to study other symmetry breaking mechanisms that are complementary and necessary to complete the picture of the fundamental interactions.
An inclusive approach both to the science program and to the development of facilities will allow for significant benefits. Two non-HEP accelerator projects, the proton power upgrade at ORNL, delivering a 2.8MW proton driver in 2025, and the EIC, are projects that can inform the future HEP research program. At ORNL a muon storage facility is being considered as a probe for materials studies and could provide a new source of muons for fundamental physics studies. The Material Plasma Exposure experiment will study materials in extreme radiation environments that could inform targetry for multi-megawatt neutrino sources.
A balanced program consisting of a mix of small and large projects is required for a healthy, broadband high energy physics program. Various opportunities will be identified to complement and strengthen a future high energy physics program for the community to embrace in its upcoming planning exercise.

Primary frontier topic:

General

99. Advances in Event Generation and Detector Simulation / 287

Physics opportunities in neutrino event generation

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Primary frontier topic:

26. Energy Frontier discovery machines / 331

Physics potential of hadron and hadron-lepton colliders with energies above 3 TeV

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Primary frontier topic:

26. Energy Frontier discovery machines / 333

Physics potential of lepton and gg colliders with energies above 3 TeV

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Primary frontier topic:

183. Intermediate lepton collision energies between 500 GeV and 3 TeV / 222

Physics potential.

Corresponding Author: mpeskin@slac.stanford.edu

64. Computing Needs of the Accelerator Frontier / 133

Planning next steps

- Beam and Accelerator Modeling Interest Group meetings
- Workshops?
- White papers: how many? Topics?
- …

173. AF5 organization with contributors / 305

Precision Electroweak Physics with Polarized Beams at SuperKEKB/Belle II

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92. Non-perturbative QCD dynamics at colliders / 294

Precision PDF at the Electron-Ion Collider

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Primary frontier topic:

28. Theory Challenges in Precision Measurements / 316

Precision calculations for EW/Higgs precision physics at lepton colliders

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145. QCD phase transitions and ultra-high density matter / 351

Probing nuclear astrophysics and gravitation with neutron stars

80. Computing Requirements & Opportunities for the Energy Frontier / 365

Programmable Storage

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110. Baryon and Lepton Number Violating processes / 277

Proton Decay experiments

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Primary frontier topic:

Plenary / 40

Q/A w/ Plenary Speakers

Plenary / 39

Q/A w/ Plenary Speakers

92. Non-perturbative QCD dynamics at colliders / 293

QCD at the Forward Physics Facility at CERN

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Primary frontier topic:

209. IF Planning / 428

QIS Points (#77, #102)

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Primary frontier topic:

102. The Roles of QIS in HEP / 245

Quantum Computing

Corresponding Author: mjs5@u.washington.edu

130. Enabling technologies for low mass and ps timing detectors / 250

RF perspective

Corresponding Author: martuso@syr.edu

108. Accelerator Probes of Light Dark Matter (keV-GeV) / 234

RF6 Light dark matter studies at high intensities (15' + 5')

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127. Searches for dark sectors / 199

Rare Process Frontier Probes (RF6/AF5)

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Plenary / 11

Remarks from Funding Agencies to the Snowmass Process: DOE

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Plenary / 12

Remarks from Funding Agencies to the Snowmass Process: NSF

Corresponding Author: sgonzale@nsf.gov

125. EFTs for new physics sensitivity studies / 182

Removing Flat Directions in SMEFT Fits: Complementing the LHC with polarized EIC data

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Plenary / 19

Report from Accelerator Frontier

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Primary frontier topic:

51. Requirements for low background and underground detectors / 134

Report from BRN on Instrumentation

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Plenary / 21

Report from Computing Frontier

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Plenary / 17

Report from Cosmic Frontier

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Plenary / 13

Report from Early Careers

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Plenary / 14

Report from Energy Frontier

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Plenary / 20

Report from Instrumentation Frontier

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Primary frontier topic:

Plenary / 15

Report from Neutrino Frontier

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Plenary / 16

Report from Rare Processes and Precision Measurements Frontier

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Plenary / 18

Report from Theory Frontier

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Primary frontier topic:

Plenary / 22

Report from Underground Facilities and Infrastructure Frontier

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Plenary / 23

Reports from Ethics and Community Engagement Frontier

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Primary frontier topic:

131. Physics requirements for HEP colliders / 225

Requirements from LLP searches

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131. Physics requirements for HEP colliders / 226

Requirements from substructure and jet reconstruction

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Primary frontier topic:

186. High field (Schwinger limit) physics with intense electron and laser beams / 447

SLAC E-320 experiment

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Primary frontier topic:

125. EFTs for new physics sensitivity studies / 186

SMEFT global fits

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180. SRF and magnets for Higgs factories / 349

SRF for FCCee

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180. SRF and magnets for Higgs factories / 348

SRF for Linear Collider Higgs Factories

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186. High field (Schwinger limit) physics with intense electron and laser beams / 446

Schwinger field physics

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Community Town Hall / 54

Searches for Long-Lived Particles at the FCC-ee

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The FCC-ee is a frontier Higgs, Top, Electroweak, and Flavour factory. It will be operated in a 100 km circular tunnel built in the CERN area, and will serve as the first step of the FCC integrated programme towards a 100 TeV and above proton-proton collisions in the same infrastructure. In addition to an essential and unique Higgs program, it offers powerful opportunities for discovery of direct or indirect evidence for BSM physics, via a combination of high precision measurements and searches for forbidden or rare processes, and feebly coupled particles.

The direct search for Long Lived particles (LLPs) in the high luminosity Z run, with 5 x 10ˆ12 Z produced, is particularly fertile; high statistics of Higgs, W and top decays in very clean experimental conditions will also be recorded. This motivates an out-of-the-box optimization of the experimental conditions, which is the object of a letter of intent submitted to EF08, EF09, EF10, and RF6.

Primary frontier topic:

Energy Frontier

Community Town Hall / 35

Searching for millicharged particles with scintillator based detectors

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The successful search for millicharged particles with the milliQan demonstrator has proved the feasibility the detector design as well as providing important lessons for background mitigation and signal performance. For Snowmass, we are planning a publication that will use data and fully calibrated simulation from the demonstrator to provide projections for the reach of full-scale scintillator-based detectors at the LHC and neutrino beam sources (e.g. DUNE, J-PARC). As detailed in the letter of intent (https://www.snowmass21.org/docs/files/summaries/EF/SNOWMASS21-EF9_EF0-NF3_NF0-RF6_RF0_Matthew_Citron-072.pdf) submitted to EF09, this effort will include a comprehensive evaluation of the dominant backgrounds and how they may be mitigated, as well as a full consideration of the performance for signal. On behalf of those involved in this Snowmass project and the milliQan collaboration, I will briefly summarise how scintillator based detectors can be used to search for millicharged particles and how the sensitivity of such detectors at a range of sites will be evaluated.

Primary frontier topic:

Energy Frontier

29. Low-energy precision experiments / 418

Session Intro

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172. Near-term applications of plasma accelerators / 241

Session introduction

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Primary frontier topic:

Community Town Hall / 105

Snowmass as a path towards cultural change, and the role of collaborations

Authors: Kelly Stifter[1] ; Micah Buuck[2] ; Kirsty Duffy[3] ; Alvine Kamaha[4] ; Hugh Lippincott[5] ; Rachel Mannino[6] ; Mark Messier[7] ; Kimberly Palladino[8] ; Sally Shaw[9] ; Erica Smith[7]

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The field of physics has largely failed to provide equitable opportunity to all who have the desire to perform physics research. This is evident in many ways, for example: the underrepresentation of many identity groups in the physics community, and the nearly 75% of undergraduate women in physics who report some form of sexual harassment. Iniquities also exist in society at large, but as physicists, we have an obligation to address the iniquities particular to our field. This is becoming especially relevant as our scientific collaborations continue to grow. Many collaborations have started to rise to the occasion and begun implementing a wide range of initiatives to improve their individual cultures.

These initiatives, while necessary, are not enough, as many issues transcend collaborations. Individual collaborations lack the resources and institutional infrastructure for meaningful enforcement of community standards; for example, they struggle with enforcing Codes of Conduct, which can further contribute to a culture of oppression.

We are not experts in the fields of race theory or sexual harassment, so we must turn to the guidance already laid out in the many summative reports by experts and calls to action by marginalized communities. Collaborations should draw on the recommendations in these reports and work towards more equitable cultures, and must also work with agencies, Universities, laboratories, and professional organizations to implement relevant best practices to effectively address cross-cutting issues.

The problem of inequity in our field will not solve itself. We must confront it every day, well into the future. Every collaboration should be grappling with these issues with the same energy with which they pursue their science. Through the Snowmass process, we have a more direct route to call for change. A long-range plan for HEP must include a plan for systemic and institutional changes to create more equitable and just communities.

Primary frontier topic:

Community Engagement Frontier

178. Common accelerator goals/technology at the energy frontier / 402

Staging Aspects for FCC

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178. Common accelerator goals/technology at the energy frontier / 409

Staging of Muon Collider

Corresponding Author: mpalmer@bnl.gov

139. Testing LambdaCDM cosmology at low and high redshifts / 328

Standard Siren Cosmology

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99. Advances in Event Generation and Detector Simulation / 282

State-of-the-art event generators via new techniques and technologies

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132. Collider Data Analysis Strategies / 266

Statistics-limited targets for measurements/searches

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173. AF5 organization with contributors / 302

Storage Rings for the Search of Charged-Particle Electric Dipole Moments

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51. Requirements for low background and underground detectors / 136

Strategic considerations

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Primary frontier topic:

Plenary / 8

Strategies and Plans in Other Regions: Africa and Middle East

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Plenary / 4

Strategies and Plans in Other Regions: Asia and Pacific

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Primary frontier topic:

Plenary / 6

Strategies and Plans in Other Regions: Canada

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Plenary / 3

Strategies and Plans in Other Regions: Europe and Russia

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Primary frontier topic:

Plenary / 7

Strategies and Plans in Other Regions: Latin America

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Plenary / 9

Strategies and Plans in Related Fields: Astrophysics

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Plenary / 10

Strategies and Plans in Related Fields: Nuclear Physics

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Plenary / 313

Structural changes in support of public engagement with science in South Africa

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Primary frontier topic:

140. Future medium to ultrahigh energy gamma-ray detectors - #cpm_session_140 / 413

Summary

Summarize the discussion

74. Atomic to Cosmic: Wave Dark Matter and Beyond / 417

Summary Discussion

26. Energy Frontier discovery machines / 334

Summary and plans for 2021 Snowmass meeting

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Primary frontier topic:

84. Computing Requirements & Opportunities in Theory / 361

Summary of needs in Conformal Bootstrap

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84. Computing Requirements & Opportunities in Theory / 362

Summary of needs in Perturbative Amplitudes

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84. Computing Requirements & Opportunities in Theory / 360

Summary of needs in lattice

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Community Town Hall / 73

Superconducting Qubit Advantange for Dark Matter (SQuAD)

Authors: Ankur Agrawal[1] ; Akash Dixit[2] ; David Schuster[3] ; Aaron Chou[4]

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We describe two complementary strategies that utilize superconducting transmon qubits to enable future dark matter searches. First, we discuss a novel photon counting technique harnessing the quantum non demolition (QND) nature of the qubit-photon interaction, which allows us to subvert the quantum limit. We have demonstrated an unprecedented counting error rate equivalent to noise 15.7 dB below the standard quantum limit. This results in a factor of 1300 speed up of future dark matter searches. Second, we enhance the dark matter induced signal by initializing a microwave cavity in a large n-photon Fock state using the non-linearity of the qubit. With preliminary results in preparing the n=10 Fock state, we expect an enhancement of a factor of 10 in the dark matter induced signal. This transfer of technology from the quantum information community opens up new frontiers for dark matter searches in the 3-30 GHz range.

Primary frontier topic:

Instrumentation Frontier

44. New accelerator concepts for high intensity muon beams / 125

Synergy with Muon Collider R&D

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99. Advances in Event Generation and Detector Simulation / 286

Systematic effects in detector simulations

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132. Collider Data Analysis Strategies / 265

Systematics-limited targets for measurements/searches

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184. Sources and targets for future accelerators / 386

Targets and Sources Plan Discussion

184. Sources and targets for future accelerators / 385

Targets and Sources Plan Presentations

179. AF7_Targets and Sources organization with contributors / 383

Targets and Sources Plan Presentations

179. AF7_Targets and Sources organization with contributors / 384

Targets and Sources Plan discussion

Community Town Hall / 47

Testing Lepton Flavor Universality and CKM Unitarity with Rare Pion Decays

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A next-generation rare pion decay experiment motivated by several inconsistencies between SM theory and data will probe new physics at high mass scales. Using state-of-the-art instrumentation, computational resources, and high-intensity beams, two problems can be addressed with nearly the same apparatus and beamline. The first is a measurement of the charged-pion branching ratio to electrons vs. muons, $R_{e/\mu}$, which is extremely sensitive to new physics effects. At present, the SM prediction for $R_{e/\mu}$ is known to a 2 parts in 10,000, which is 15 times more precise than the current experimental determination. An experiment at a comparable level of accuracy opens a large window to test lepton universality at an unprecedented level, probing mass scales up to 3000 TeV. The second measurement concentrates on the rare process of pion beta decay, $\pi^+ \to \pi^0 e^+ \nu(\gamma)$, as well as various complementary rare decays modes. An order of magnitude improvement in sensitivity will determine V_{ud} in a theoretically pristine manner and test CKM unitarity at the quantum loop level. We will base our design on lessons learned form the recent PIENU and PEN efforts at TRIUMF and PSI. Improved resolution, greatly increased calorimeter depth, high-speed detector and electronic response, large solid angle coverage, and complete event reconstruction are all critical to the design, including a 4π LXe calorimeter, an internal pixelated active stopping medium and electron tracker, as well as a customized beam line.

Primary frontier topic:

Rare Processes and Precision Measurements Frontier

Community Town Hall / 34

Testing SIDM with Realistic Galaxy Formation Simulations

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The nature of dark matter remains one of the most important questions in physics. Because of the tremendous overall successes of the Cold Dark Matter (CDM) model, dark matter has been assumed to consist of a massive, weakly-interacting particle. However, the effort to detect such a particle with experiment have not yet yielded conclusive evidence. Although the CDM paradigm has been successful at describing our Universe on large scales, it has faced challenges on small scales (inside of galaxies and in low mass galaxies)- which has yielded alternative models including Self-Interacting Dark Matter (SIDM). As such, astrophysical measurements represent a compelling means of directly studying the properties of dark matter- in particular, the imprint of dark matter model on dwarf galaxies and their baryonic matter. This project uses state-of-the-art computer simulations of dwarf galaxy formation to test galaxy formation in the LCDM framework and in the SIDM framework, in order to constrain the nature of dark matter.

More technically, the project will result in a suite of high resolution, state-of-the art simulations of galaxy formation within a SIDM paradigm. SIDM preserves the large-scale success of CDM, while opening up the possibility of altering the small scales in testable ways using galaxy observations. We use the N-Body+SPH code ChaNGa to run a series of simulations: (1) "zoom" simulations of individual dwarf galaxies in order to test whether CDM or SIDM can reproduce the diverse range of rotation curves observed in real galaxies and (2) "zoom" volumes that contain dozens of dwarfs from 1000 solar masses to 10ˆ9 solar masses in order to directly compare the observed shapes of galaxies with those predicted in CDM vs SIDM. Analytic models have shown that an SIDM model with an interaction cross-section of ˜3 cmˆ2 gˆ-1 can reproduce the full range of galaxy rotation curves. The project tests this model across a range of galaxy simulations for the first time.

Primary frontier topic:

Theory Frontier

129. Higgs Factories / 159

The Cˆ3 Linear Accelerator Concept and its application to e+/e- colliders and novel g-g colliders

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Primary frontier topic:

173. AF5 organization with contributors / 306

The International Axion Observatory (IAXO) and BabyIAXO

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Primary frontier topic:

110. Baryon and Lepton Number Violating processes / 275

Theories for B and L Violation

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Primary frontier topic:

28. Theory Challenges in Precision Measurements / 319

Theory challenges in heavy flavor decays

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136. Heavier particle dark matter >˜ 10 GeV / 87

Theory motivation and benchmarks

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Primary frontier topic:

41. Anomalies in Flavor Physics / 174

Theory overview (15'+5')

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Primary frontier topic:

Community Town Hall / 101

Towards Future Discoveries at the Energy Frontier

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Collider physics is rich, diverse and versatile, and offers amazing opportunities for advancing our understanding of fundamental physics and for discoveries at the Energy Frontier. Over the last several decades, colliders have played a central role in experimental establishment of the Standard Model. Since the discovery of the Higgs boson, the science drivers at the energy frontier have been study the Higgs boson in great detail and precision, and use it as a new tool for discovery, search and identify the new physics of dark matter, and explore the unknown: new particles, interactions and physical principles.In particular probing new physics particles in the mass range of ˜10 TeV remains one of the highest priorities for the field.

The US should continue strong participation in global Energy Frontier efforts.A collider with energy reach significantly higher than LHC is of great interest, but e+e- Higgs factory is also very critical for deeper understanding of the SM. Several current proposals (ILC, CEPC, CLIC, FCC, MCC,etc) present the idea of hosting the next facilities in Europe or Asia. Strong physics motivation coupled with unique expertise, make it natural for US scientists to play a leading role in the next major Energy Frontier facilities, regardless of where in the world they are hosted.

Primary frontier topic:

Energy Frontier

Plenary / 121

Town Hall Presentations

Mayly Sanchez - ANNIE and the Future of Hybrid Neutrino Detectors
Doojin Kim - Detecting keV-range super-light dark matter using graphene Josephson junction
Rebeca Gonzalez Suarez - Searches for Long-Lived Particles at the FCC-ee
David Hertzog - Testing Lepton Flavor Universality and CKM Unitarity with Rare Pion Decays
Sebastian Ellis - Heterodyne Detection of Axion Dark Matter via Superconducting Cavities
Marcela Carena - Towards Future Discoveries at the Energy Frontier
Philip Harris - DarkQuest and LongQuest at the 120˜GeV Fermilab Main Injector
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Francesco Giovanni Celiberto - 3D proton tomography at the EIC: TMD gluon distributions
Richard Talman - Colliding beam elastic pp and pd scattering to test T- and P-violation
Matthew Szydagis - Metastable Water: Breakthrough Technology for Dark Matter & Neutrinos
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