



U.S. DEPARTMENT OF
ENERGY

Office of
Science

High Energy Physics Program Status

HEP PI Meeting @ DPF
August 1, 2019

Glen Crawford
Research and Technology Division Director
Office of High Energy Physics
Office of Science, U.S. Department of Energy

Director of DOE Office of Science



- ▶ **Chris Fall Confirmed as Director of DOE Office of Science on May 23, 2019**
 - ▶ Previously served as Principal Deputy Director of Advanced Research Projects Agency–Energy (ARPA-E)
 - ▶ Also served in White House Office of Science and Technology (OSTP) and in the Office of Naval Research, including as acting chief scientist



DOE Office of Science Statements on Diversity, Equity, and Inclusion

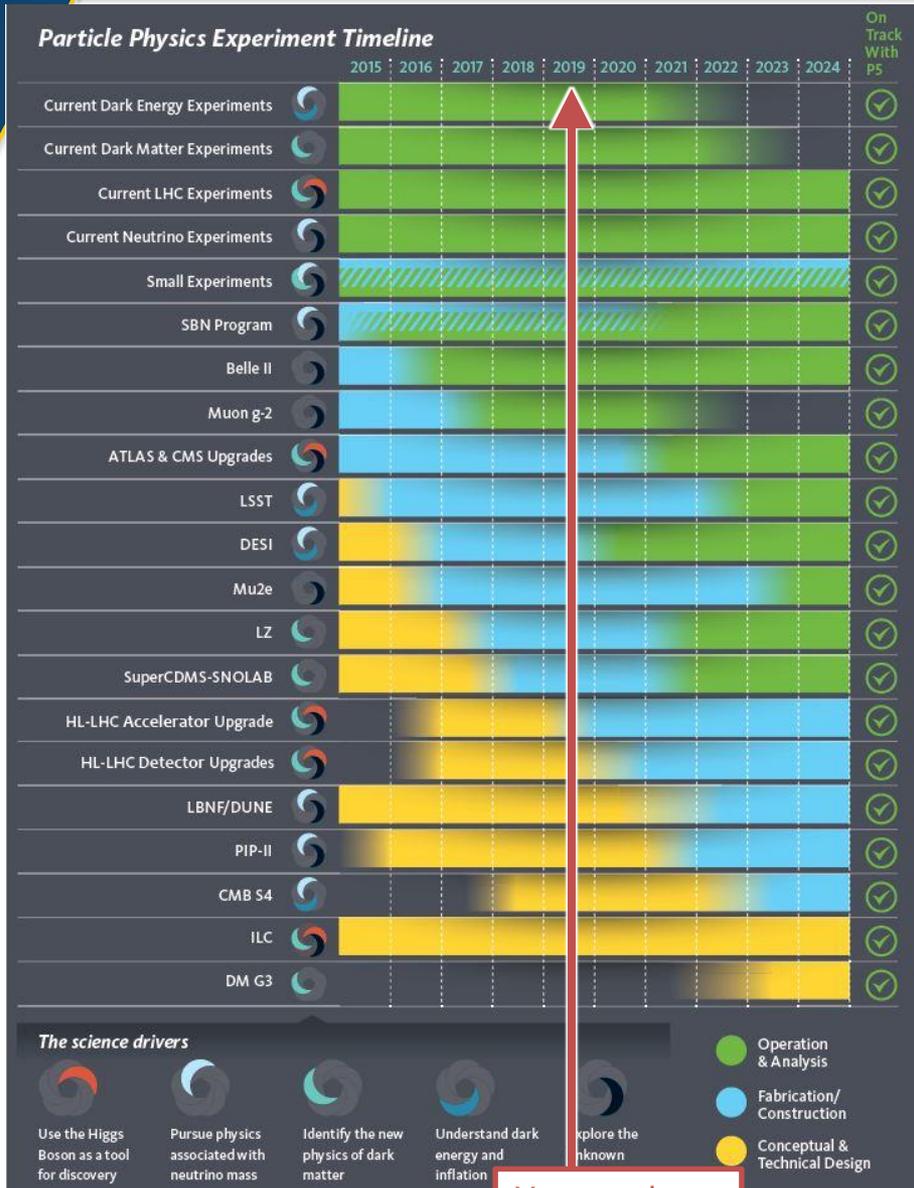
- ▶ The DOE Office of Science (SC) is fully committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity.
 - ▶ Effective stewardship and promotion of diverse and inclusive workplaces that value and celebrate a diversity of people, ideas, cultures, and educational backgrounds is foundational to delivering on the SC mission. The scientific community engaged in SC-sponsored activities is expected to be respectful, ethical, and professional.
 - ▶ <https://science.energy.gov/sc-2/research-and-conduct-policies/diversity-equity-and-inclusion/>
- ▶ Office of Science Statement of Commitment
 - ▶ The DOE Office of Science (SC) is fully and unconditionally committed to fostering safe, diverse, equitable, and inclusive work, research, and funding environments that value mutual respect and personal integrity.
 - ▶ <https://science.energy.gov/sc-2/research-and-conduct-policies/diversity-equity-and-inclusion/sc-statement-of-commitment/>
- ▶ Office of Science Statement on Harassment
 - ▶ Harassment of any kind, including sexual and non-sexual harassment, bullying, intimidation, violence, threats of violence, retaliation, or other disruptive behavior is not tolerated in the federal workplace, including Department of Energy (DOE) site offices, or at DOE national laboratories, scientific user facilities, academic institutions, other institutions receiving Office of Science funding, or at locations where activities are funded by the DOE Office of Science.
 - ▶ <https://science.energy.gov/sc-2/research-and-conduct-policies/diversity-equity-and-inclusion/harassment/>



HEP Budget



P5 Implementation Status – FY 2019



All projects on budget & schedule

- ▶ Projects fully funded as of FY19
 - ▶ Muon g-2: 1st beam 2017
 - ▶ LHC detector upgrades: on track for 2019/20 installation
 - ▶ Mu2e : 1st data in 2020
 - ▶ LSST: full science operations 2023
 - ▶ DM-G2 (superCDMS & LZ): 1st data 2020
 - ▶ DESI: 1st light on lenses, April 2019
- ▶ HL-LHC accelerator and detector upgrades started on schedule
- ▶ LBNF/DUNE & PIP-II schedules advanced due to strong support by Administration & Congress
- ▶ CMB S4: developing technically-driven schedule to inform agencies, NAS Astro 2020 Decadal Survey
- ▶ DM-G3: R&D limited while fabricating G2
- ▶ ILC: cost reduction R&D while waiting for decision from Japan
- ▶ Broad portfolio of small projects running

FY 2020 HEP Budget Request

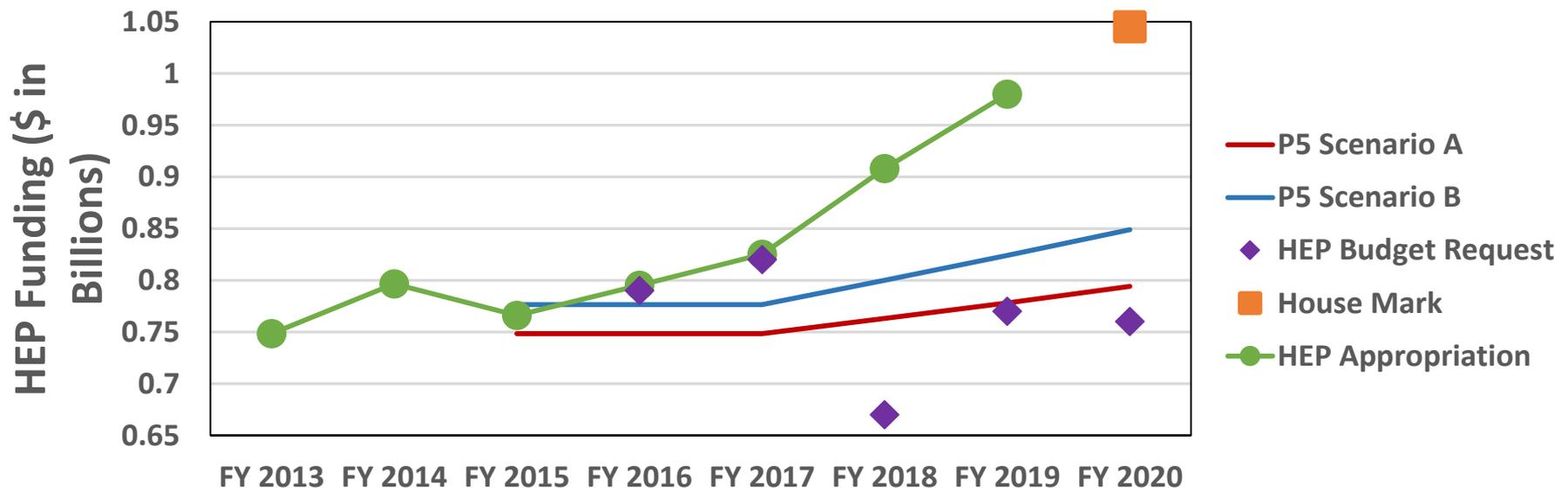
HEP Funding Category (\$ in K)	FY 2018 Actual	FY 2019 Enacted	FY 2020 Request	FY 2020 vs. FY 2019
Research	359,177	380,847	301,357	-79,490
Facilities/Operations	270,488	260,803	239,746	-21,057
Projects	278,335	338,350	226,935	-111,415
Total	908,000	980,000	768,038	-211,962

- ▶ FY 2020 President’s Budget Request is overlay of Administration, SC, P5 priorities
 - ▶ SC: interagency partnerships, national laboratories, accelerator R&D, QIS, AI/ML
 - ▶ P5: preserve vision, modify execution
- ▶ FY 2020 HEP Budget continues support for P5-guided investments
 - ▶ Research support advances P5 science drivers and world-leading, long-term R&D in Advanced Technology, Accelerator Stewardship, and Quantum Information Science
 - ▶ “Building for Discovery” by supporting HL-LHC, LBNF/DUNE, and PIP-II
 - ▶ Operations support enables research at HEP User Facilities and science ops. of P5 experiments
- ▶ The Administration and Congress support the overall P5 strategy
 - ▶ FY20 House Mark for HEP: **\$1,045,000,000** ; FY20 Senate Mark not yet released



U.S. Congress Supports P5 Strategy

- ▶ Recent appropriations reports include language recognizing community's efforts:
 - ▶ FY19 Senate EWD: "Four years into executing the P5, the Committee commends the Office of Science and the high energy physics community for achieving significant accomplishments and meeting the milestones and goals set forth in the strategic plan..."
- ▶ FY 2020 appropriations process is progressing
 - ▶ Senate Mark not released; still awaiting final Congressional actions for FY 2020
 - ▶ **Final language of appropriations bill/report impact how funding is directed**



The Challenges

Most of the recent HEP budget growth is in Projects, without similar increases in Operations and Research

- ▶ HEP-style Projects depend heavily on Research and Ops support for R&D, QA/QC, integration, installation, and commissioning
- ▶ Given that there is a lot of current Research and Ops effort committed to active experiments, this is not optimal for successful project execution
- ▶ **Balancing Research and Ops with the needs of current and future projects will require careful prioritization**

This is a complex interlocking problem with many contributing factors

- ▶ Cannot simply “trim the big projects” (or other “simple” solutions) without having impacts elsewhere
- ▶ **HEP PMs work on this ~every day**



Compounding Effects of Success

- ▶ A number of smaller issues have created a cumulative effect that impacts the Core Research program
 - ▶ Cost of doing business has increased significantly, year by year, reducing the buying power of research dollars
 - ▶ The community has grown, which adds more competitors to the pool for comparative review
 - ▶ Research efforts necessary to support large projects are increasing as the projects ramp up
 - ▶ Operations costs necessary for experiments are increasing as P5 projects are successfully completing and starting to take data
- ▶ These effects are tied to the high level of support received through appropriations based on the very successful execution of the P5 strategy so far
 - ▶ FY 2020 House Marks and Report language suggest that the message is getting through that healthy growth of the program requires Research and Operations growth in addition to Project support



Funding Opportunities and Workshops



Notional Timeline for New DM

- ▶ March 2017: Community-led workshop collected ideas
 - ▶ White paper at <https://arxiv.org/abs/1707.04591>
- ▶ Late 2018: Basic Research Needs (BRN) study for Dark Matter New Initiatives
 - ▶ Identified three Priority Research Directions for exploring new ideas in DM with small experiments
 - ▶ Report available at: <https://science.osti.gov/hep/Community-Resources/Reports>
- ▶ **2019: Support conceptual development of small experiments/projects through dedicated FOA/LAB Announcement (*DE-FOA-0002112 & Lab-19-2112 closed May 30, 2019*)**
 - ▶ Aim to develop concept studies and near-term technology R&D that respond to high impact opportunities described in the BRN
- ▶ 2020+: Select concept(s) for fabrication (possibly in stages)
 - ▶ Continue to support theory studies, research efforts, tech. R&D needed to support project(s) as necessary and appropriate



Compact Accelerators for Security and Medicine

May 6-8, 2019 Tysons, VA

- ▶ There is a long history of applying accelerator technology to address national security and medical issues
 - ▶ Accelerator technology advances of the last decade are not fully adopted in the field
 - ▶ New applications have emerged
 - ▶ Want to understand the highest impact applications enabled by R&D to-date, and develop a list of Priority Research Directions for the future
- ▶ Co-sponsored by DOE-SC, NIH-NCI, DHS-CWMD, DOE-NA21, DOE-NA22, and DOD-ONR
- ▶ Charge: Develop R&D Business Case and Priority Research Directions for six application areas in security and medicine identified by the sponsoring agencies
 - ▶ Restricted to “compact accelerators” and technologies that can reach TRL-4 within 5 years. One working group charged to look at the long-term future.
 - ▶ 112 Participants: 23 University, 20 Industry, 19 SC Lab, 11 Defense Labs, 30 Federal Observers, 8 International, 1 NGO
- ▶ **Workshop Report will be published this summer**



Image credit: University Health Network of Canada



Image credit: Idaho Accelerator Center



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Future Basic Research Needs Workshops

- ▶ **BRN Process and Structure**
 - ▶ Targeted topics defined by, and workshop charge issued by, SC program office
 - ▶ Attendance is limited and by invitation
 - ▶ Typical structure: Opening plenary sessions, panel breakout sessions that develop priority research directions, closing plenary session, and extended writing session – draft report completed before departure!
 - ▶ Prompt output: final report released typically 60-90 days after the workshop
- ▶ **BRN reports are expected to serve as reference documents with a long shelf life, and to be readily accessible**
 - ▶ Post-workshop outreach activities often include communication of the results to the broader community by co-chairs and the SC program, and briefings by federal staff to other interested federal parties (within and beyond DOE)
 - ▶ BRNs may, individually or collectively, serve as the basis for subsequent funding opportunities
- ▶ **Next HEP BRN will focus on opportunities in Detector R&D**
 - ▶ Workshop planned for Dec 2019
 - ▶ Co-Chairs: Bonnie Fleming (Yale) and Ian Shipsey (Oxford)
 - ▶ Further details in Detector R&D PI meeting presentation



Research Consortia

- ▶ Research consortia are a possible mechanism for funding where a single proposal is created by multiple institutions
 - ▶ One member of the consortium serves as the prime recipient/consortium representative (lead organization).
 - ▶ Consortia must provide a collaboration agreement which sets out the rights and responsibilities of each consortium member, including:
 - ▶ Management structure
 - ▶ Method of making payments to consortium members
 - ▶ Means of ensuring and overseeing members' efforts on the project
 - ▶ Provisions for members' cost sharing contributions
 - ▶ Provisions for ownership and rights in intellectual property developed previously or under the agreement
 - ▶ Note that a consortium is applied for in one application and results in one award with subawards to consortia members
- ▶ This mechanism could allow research efforts with specific timelines and goals to provide the “big picture” for consideration, rather than “puzzle pieces” from separate individual institution proposals
 - ▶ A consortium approach may benefit specific topics in future FOAs
 - ▶ This has already been “piloted” in the QuantISED and Stewardship FOAs



FOA and Workshop Summary

- ▶ All FY 2019 FOAs and LAB Announcements are now complete or in the final stages of processing
 - ▶ FY19 included: U.S.-Japan, QuantISED, Comparative Review, Accelerator Stewardship, SC Early Career, Dark Matter New Initiatives, Traineeship in Accelerator Science & Engineering
 - ▶ ***Many thanks to community members who helped review proposals from one (or more!) of these announcements***
 - ▶ Aiming to have all FY19 comparative review awards out soon
- ▶ Hope to return to normal schedule in FY 2020
 - ▶ Aim for FY20 Comparative Review FOA release after Labor Day
 - ▶ General SC FOA [for supplements, conferences, etc.] always open:
 - ▶ https://science.osti.gov/-/media/grants/pdf/foas/2019/SC_FOA_0001968.pdf
- ▶ Basic Research Needs Workshops are playing a growing role in shaping aspects of the HEP Research program
 - ▶ Community is encouraged to continue participating in generating and responding to these reports



Other News



Office of Science Website Updates

- ▶ The old science.energy.gov site has been replaced with:
 - ▶ A public-oriented energy.gov with Science Highlights, Program News, and more
 - ▶ A PI-oriented OSTI site (previous science.energy.gov content) with FOAs, etc.

<https://www.energy.gov/science/hep>

<https://science.osti.gov/hep>

The screenshot shows the new public-oriented website for High Energy Physics (HEP) on energy.gov. The header includes the ENERGY.GOV logo, Office of Science, and navigation links for About Us, INITIATIVES, MISSION, SCIENCE & INNOVATION, FUNDING, and RESOURCES. A search bar is located in the top right. The main content area features a large image of a particle detector with the title "High Energy Physics" and three sub-sections: "Science of High Energy Physics", "Impact of High Energy Physics", and "Funding Opportunities". Below the image, there is a paragraph of text describing HEP's mission and a section titled "What's New" with the status "Coming soon".

The screenshot shows the PI-oriented website for High Energy Physics (HEP) on science.osti.gov. The header includes "SC Home", "Organization", "Jobs", and "Contact", along with a "DOE Home" link. The main content area features a large image of a particle detector with the title "High Energy Physics (HEP)" and a list of navigation links: "About", "Research", "Facilities", "Science Highlights", "Benefits of HEP", "Funding Opportunities", "Advisory Committees", "High Energy Physics Advisory Panel (HEPAP)", and "Community Resources". Below the image, there is a paragraph of text describing the field of high energy physics and a section titled "What's New" with the status "Coming soon".

Comings & Goings

- ▶ **Outgoing:**
 - ▶ Bruce Strauss (Fed) [March '19], Kevin Flood (IPA), Tom LeCompte (Detailee) [August '19]
- ▶ **DOE Federal Position for Intensity Frontier**
 - ▶ Anticipate opportunity in the near future. All interested candidates should apply!
- ▶ **DOE Federal Position for SURF Program Manager**
 - ▶ Expect a posting soon!
- ▶ Always looking for IPA/Detailee candidates to help with critical tasks
 - ▶ Interested parties should contact HEP Management!



Closing Remarks

- ▶ Excellent science results continue to be produced from our operating experiments!
- ▶ Broad support is enabling us to implement the P5 strategic plan and achieve its vision
 - ▶ Thanks to DOE Management, Administration, and Congress for support
- ▶ The particle physics community continues to perform well on delivering projects, a foundation of the long-term strategy
- ▶ Community continues to be unified in support of P5 strategy





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Strategic Planning



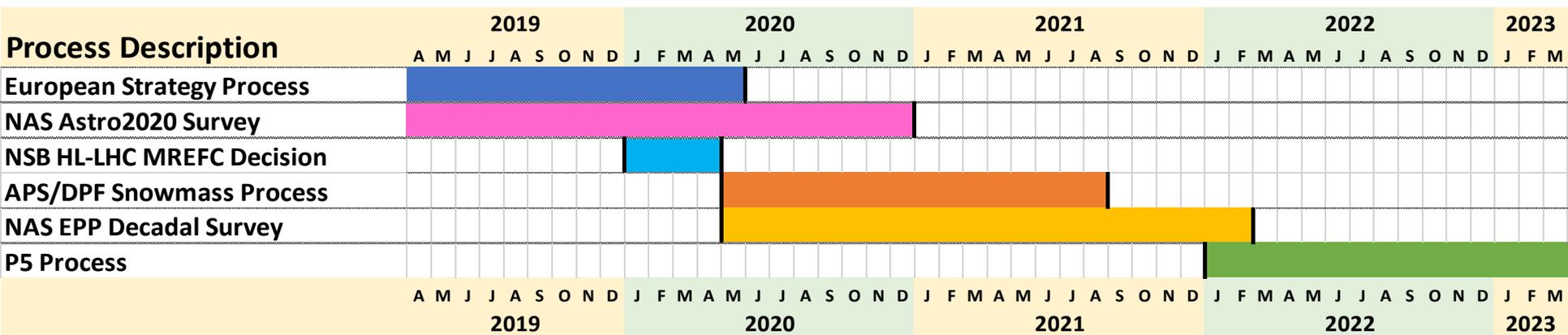
Timeline for Updating the U.S. Strategy

- ▶ **The May 2014 P5 report was successful because it was well informed by the science community**, including information from:
 - ▶ 2010 New Worlds, New Horizons in Astronomy and Astrophysics
 - ▶ 2012 Report of the Subcommittee on Future Projects of High Energy Physics (Japan)
 - ▶ 2013 European Strategy for Particle Physics Report
 - ▶ 2013 U.S. Particle Physics Community-driven “Snowmass” process
- ▶ The timeline of processes that impact the next strategic plan:
 - ▶ 2018-20: New NAS Astronomy and Astrophysics Decadal Survey
 - ▶ 2018-20: European Strategy for Particle Physics Process
 - ▶ 2019/20: Anticipated Japanese decision on ILC
 - ▶ 2020: Earliest opportunity for National Science Board to approve obligating HL-LHC MREFC
- ▶ **From a DOE perspective, the earliest that new APS/DPF Snowmass, NAS Elementary Particle Physics Decadal Survey, and P5 processes could begin is 2020**
 - ▶ **Relative timing of Snowmass, P5, and NAS EPP Decadal Survey to be determined**
 - ▶ **Enables receiving next P5 recommendations by March 2023, in time to inform FY 2025 budget formulation**



Possible Strategic Planning Timeline

- ▶ To provide timely input to the FY25 budget formulation, the next P5 report will be required by March 2023
- ▶ U.S. Community considering Snowmass process with major meeting occurring in summer 2021
- ▶ Potential timeline for the next NAS EPP Decadal Survey
 - ▶ Overlap with Snowmass could enable synergy with Snowmass processes and delivery of report as P5 process begins



Community Participation

- ▶ Broad community participation in the U.S. particle physics strategic planning process is essential
 - ▶ The 2014 P5 report was successful because it built upon a solid foundation of community effort
- ▶ PIs are encouraged to be active in all phases of the process:
 - ▶ Submit whitepapers to the NAS Astro2020 and possible EPP decadal surveys
 - ▶ Actively participate in the DPF-led Snowmass process
 - ▶ ***Attend the Snowmass discussion today during lunch!***
 - ▶ Develop new concepts for future projects
- ▶ PIs on HEP research grants may contribute to planning processes as aligned with scope of work
 - ▶ Discuss any questions with your Program Manager!

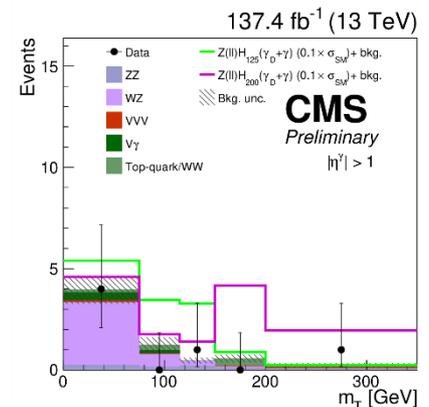
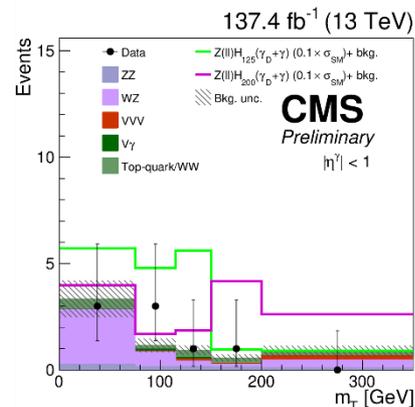
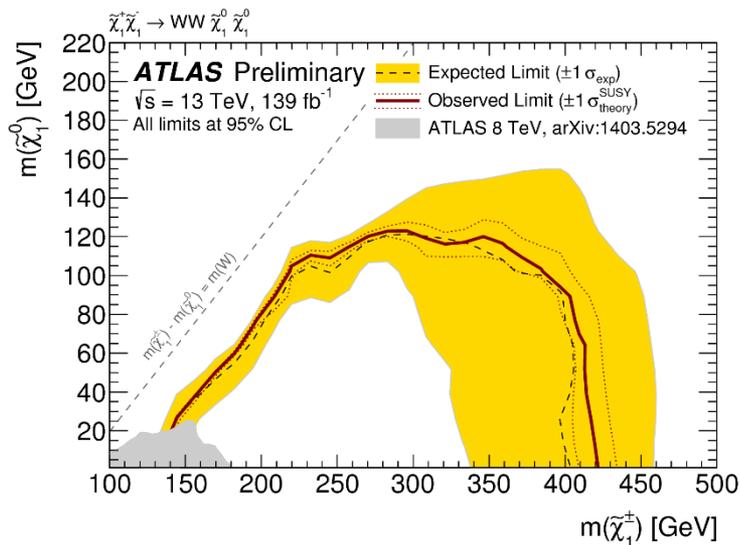
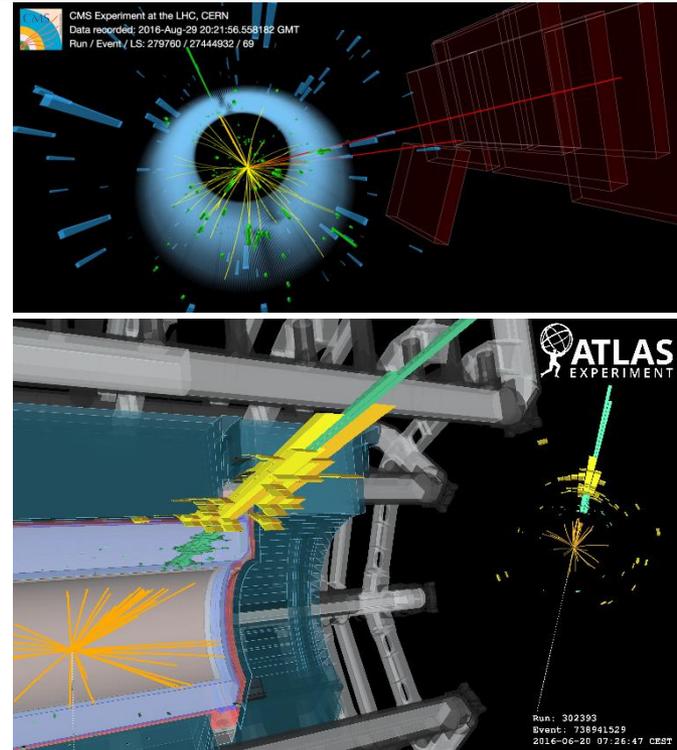


Program Highlights



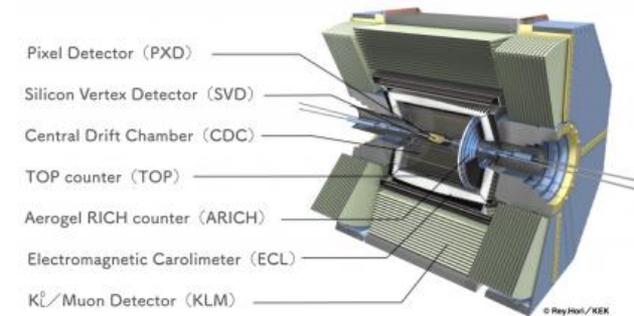
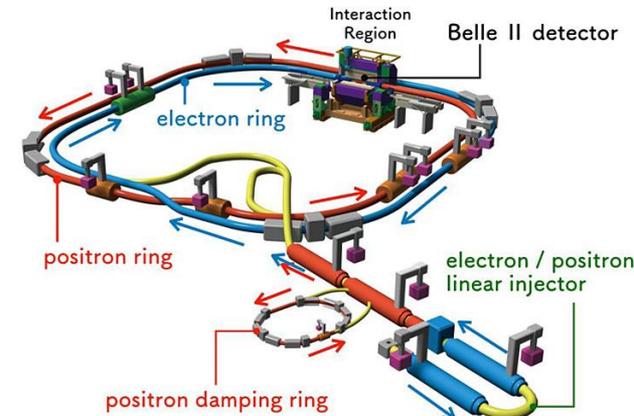
Dark Matter Searches at the LHC

- ▶ LHC Experiments continue to set constraints on dark matter while using Higgs as a tool for discovery
- ▶ New ATLAS results set constraints on supersymmetric dark matter candidates
 - ▶ Bottom squark pairs to states with Higgs bosons, b-jets, missing transverse energy [[ATLAS-CONF-2019-011](#)]
 - ▶ Charginos and sleptons to two leptons and missing transverse momentum [[ATLAS-CONF-2019-008](#)]
- ▶ CMS explores Higgs boson as "messenger" between the standard model particles and dark matter
 - ▶ Higgs decays to photon and massless "dark photon"
 - ▶ <https://cms.cern/news/no-sign-dark-light-higgs-boson>



SuperKEKB Phase 3 Operations

- ▶ SuperKEKB began Phase 3 operations successfully on March 11, 2019
- ▶ This will begin the physics run for the Belle II experiment, which will start taking data with a fully instrumented detector
- ▶ SuperKEKB aims to provide 40 times the luminosity of KEKB to enable Belle II to search for new physics in rare particle decays



Proton Improvement Plan II (PIP-II)

- ▶ PIP-II Groundbreaking held on March 15, 2019
 - ▶ Attended by many stakeholders from U.S. and international partners contributing to PIP-II
- ▶ P5 report recommended that PIP-II proceed immediately in order to provide increased proton beam intensity (of > 1 megawatt) for LBNF
 - ▶ Replace the existing 50 year old linear accelerator with a higher power; one powered by superconducting radiofrequency cavities
 - ▶ Supports longer-term physics research goals by providing increased beam power and high reliability for future experiments at Fermilab, including LBNF/DUNE



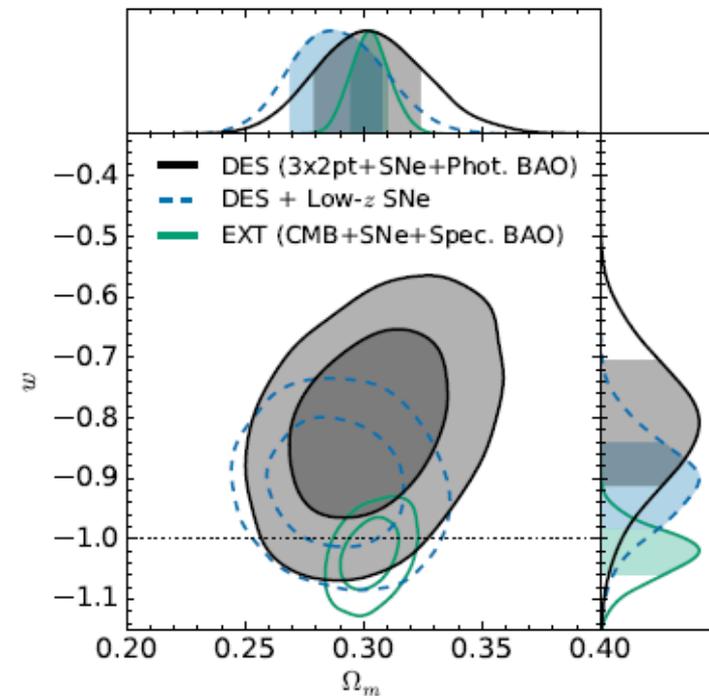
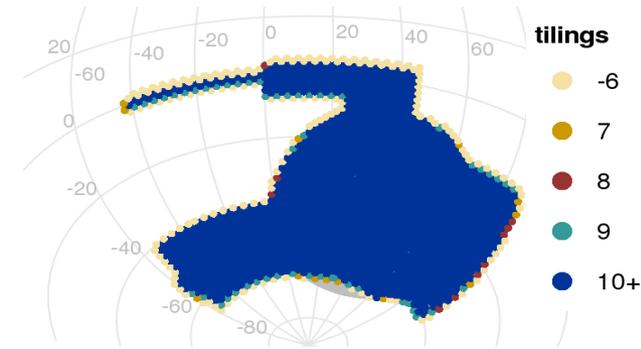
From left: Senator Tammy Duckworth (IL), Senator Dick Durbin (IL), Rep. Sean Casten (IL-6), Rep. Robin Kelly (IL-2), Rep. Bill Foster (IL-11), Fermilab Director Nigel Lockyer, Rep. Lauren Underwood (IL-14), Illinois Governor JB Pritzker, DOE Under Secretary for Science Paul Dabbar, Fermilab PIP-II Project Director Lia Meringa, DOE Associate Director for High Energy Physics Jim Siegrist, University of Chicago President Robert Zimmer, Consul General of India Neeta Bhushan, British Consul General John Saville, Consul General of Italy Giuseppe Finocchiaro, Consul General of France Guillaume Lacroix, DOE Fermi Site Office Manager Mike Weis, DOE PIP-II Federal Project Director Adam Bihary and Consul General of Poland Piotr Janicki. Photo: Reidar Hahn



Dark Energy Survey

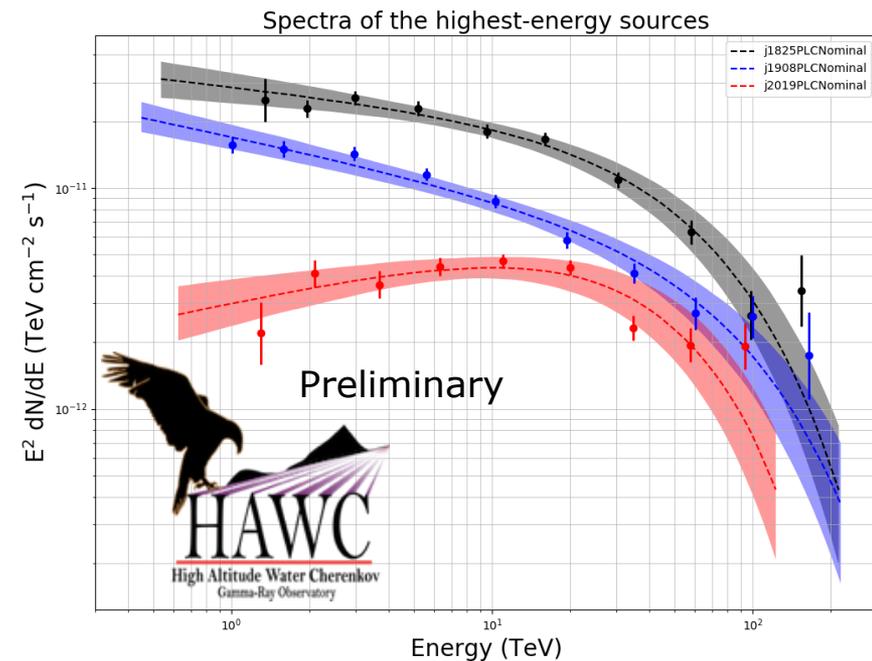
- ▶ **DOE-HEP partnership with NSF-AST**
- ▶ Completed Observations Jan 9, 2019
 - ▶ Year Six included observations and processing of "Deep Fields" to 10x DES wide-field depth
 - ▶ Will reduce weak lensing systematics through improved calibration of photometric redshift and characterization of blending of neighboring galaxies in DES wide-field data
- ▶ Many cosmology results, including:
 - ▶ Combined analysis of DES-Y3 supernovae (SNe), DES-Y1 photometric baryonic acoustic oscillation (BAO), and DES-Y1 weak lensing + galaxy clustering (3x2pt) **detects Dark Energy at 4σ from DES alone**
 - ▶ T. Abbott et al. 2019 (PRL)
 - ▶ Now concentrating on cosmology through Y3 and on producing Y6 data products for analysis; Y6 cosmology to follow

z-band (850-1002 nm)



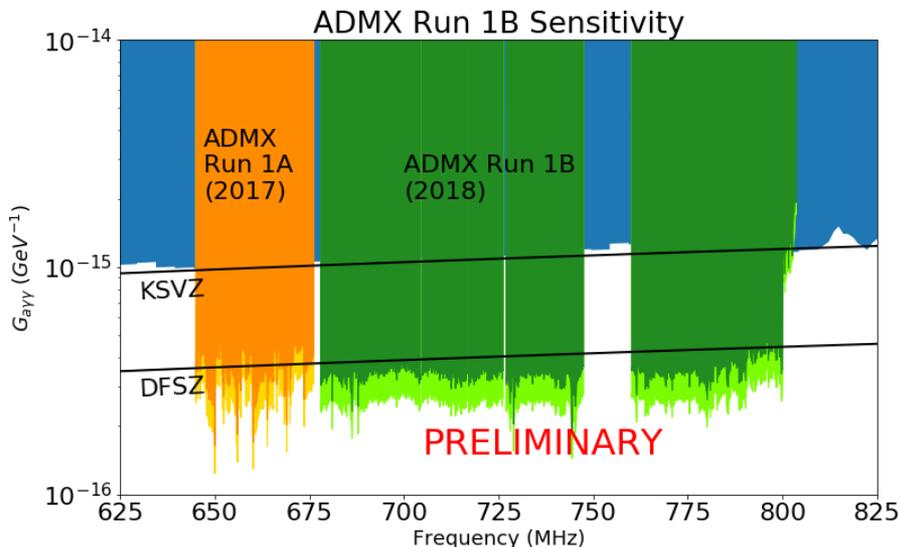
High Altitude Water Cherenkov (HAWC) Experiment

- ▶ HAWC gamma/cosmic-ray observatory located on the Sierra Negra mountain in Mexico
 - ▶ 5 year ops. started early 2015
 - ▶ Partnership with NSF
- ▶ New result: Testing Lorentz Invariance with Highest Energy gamma rays
 - ▶ If Lorentz Invariance is violated, then gamma-rays can decay into e^+e^- pairs
 - ▶ HAWC's proof of the existence of gamma-rays >100 TeV provides more than an order of magnitude better constraints on superluminal Lorentz Invariance

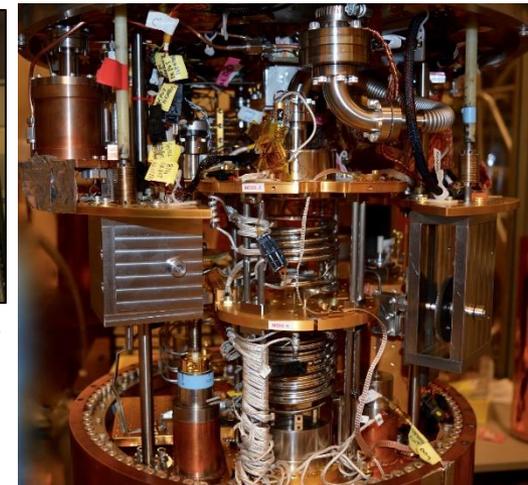


ADMX-G2

- ▶ Axion Dark-Matter eXperiment Generation 2
 - ▶ Located at University of Washington, managed by Fermilab
 - ▶ Primarily DOE supported with contributions from the UK, Germany and Australia; R&D support from the Heising-Simons Foundation
- ▶ Uses a strong magnetic field and resonant cavity to convert dark matter axions into detectable microwave photons
 - ▶ Operations approved to cover range 0.5 to 2 GHz (~ 2 to 8 micro-eV mass) – started Aug. 2016; planned to complete \sim Jan. 2022
 - ▶ **Run 1A** (2017) & **Run 1B** (2018) – both reached “invisible” axion (DFSZ model) sensitivity!
 - ▶ Run 1C starting soon



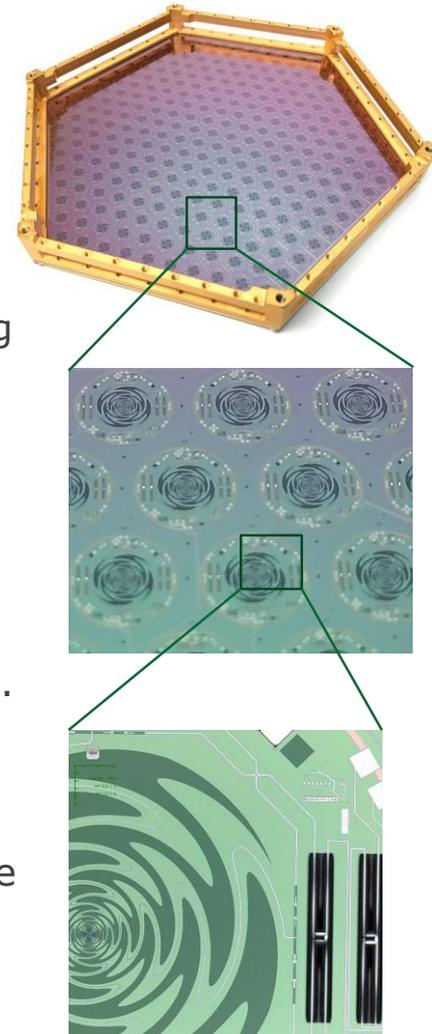
[Right] ADMX experiment insert showing the RF cavity (bottom), dilution refrigerator (above cavity), and frequency-tuning mechanism (left).



See recent article in National Geographic:
<https://www.nationalgeographic.com/science/2018/10/news-admx-dark-matter-detector-physics/>

CMB-S4 Project and Collaboration

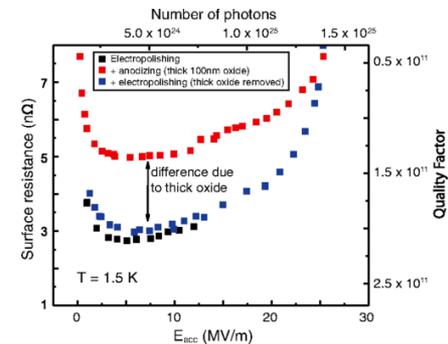
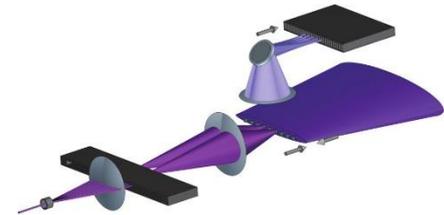
- ▶ CMB-S4 collaboration progress
 - ▶ Focusing on July submission(s) to NRC decadal survey
 - ▶ Continuing work on science, design, and project development
- ▶ CMB-S4 project continuing preparation
 - ▶ Integrated Project Office (IPO) set up under Jim Yeck
 - ▶ Detector fabrication & readout issues at the forefront of R&D/planning
- ▶ Interagency (NSF-DOE) coordination group meeting bi-weekly to share information, monitor, and review.
- ▶ At DOE:
 - ▶ CD0 (almost) signed; waiting for ESAAB to be scheduled; aiming for mid-June.
 - ▶ HEP working with IPO to fund near term R&D for planning and design.
- ▶ At NSF:
 - ▶ MSRI design and project proposal now under review at NSF
 - ▶ Requirements for NSF MREFC process under review, relevant to future CMB-S4 entry.



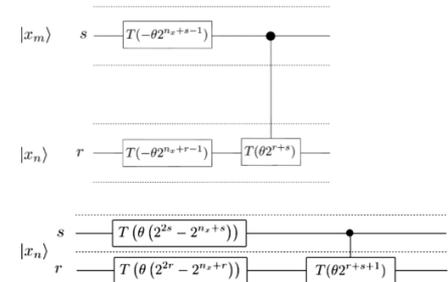
HEP-QIS Research Program Updates

Quantum Information Science Enabled Discovery (QuantISED) for High Energy Physics Highlights

- ▶ Cosmos and Qubits
 - ▶ “Verified quantum information scrambling”
 - ▶ <https://www.nature.com/articles/s41586-019-0952-6>
- ▶ Research Technology for QIST
 - ▶ “Understanding Quality Factor Degradation in Superconducting Niobium Cavities at Low Microwave Field Amplitudes”
 - ▶ [Phys. Rev. Lett. 119, 264801](#)
- ▶ Quantum Computing for HEP:
 - ▶ “Electron-Phonon Systems on a Universal Quantum Computer”
 - ▶ [Phys. Rev. Lett. 121, 110504, 2018](#)
 - ▶ “Digital quantum computation of fermion-boson interacting systems”
 - ▶ [Phys. Rev. A 98, 042312, 2018](#)



$$|x_m\rangle|x_n\rangle \rightarrow e^{i2^{2n}x-2\theta} e^{-i(x_m-2^{2n}x-1)\theta} e^{-i(x_n-2^{2n}x-1)\theta} |x_m\rangle|x_n\rangle$$



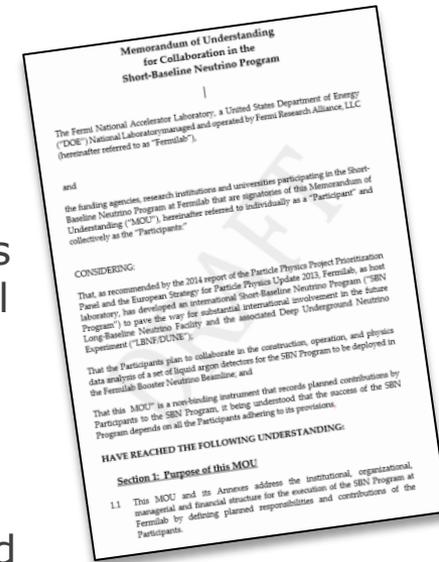
DOE/SC QIS PI Meeting

- ▶ Held January 31 to February 1, 2019
 - ▶ 267 attendees with PIs, observers from all SC programs, and observers from other Federal Agencies
- ▶ Plenary speakers included:
 - ▶ Jake Taylor, OSTP; John Preskill, Caltech; Irfan Siddiqi, LBNL; and David Awschalom, ANL/U Chicago
- ▶ Topical Breakout Discussion Sessions:
 - ▶ Quantum computing for application-specific research: machine learning, data analysis, and related topics
 - ▶ Foundational quantum physics and information theory
 - ▶ Quantum qubits and computing platforms
 - ▶ Advanced synthesis and characterization tools (including validation)
 - ▶ Computer science and applied math challenges for quantum computing
 - ▶ Quantum sensors and detectors
 - ▶ Quantum computing for application-specific research: chemistry, materials, variational techniques, field theories
 - ▶ Analog simulations and quantum simulation experiments
- ▶ SC Program Office Breakout Discussions
- ▶ Lightning round of Quantum Center Pitches



HEP International Agreements Program

- ▶ Written arrangements planned for U.S.-hosted international neutrino program
 - ▶ MOUs for SBN and DUNE experimental programs & Projecting Planning Documents (“MOUs”) are planned to be established for LBNF and PIP-II facilities
 - ▶ For DUNE, LBNF, and PIP-II, such documents allow the projects to adhere to DOE O 413.3b by providing details of international partners’ scope of contributions, associated management and organizational processes, and definition of responsibilities
 - ▶ Includes list of component deliverables planned from partners, milestones, schedules, ... to enable completion of the projects
 - ▶ Such MOUs are planned between Fermilab, host laboratory, and multi-institutional/agencies that are participating in the neutrino programs
 - ▶ Largely analogous to the MOUs established by CERN for the LHC program
 - ▶ Goal to establish in-time of CD-2 (baselining) or CD-3 (start of construction)
- ▶ MOU Working Group formed to enable a streamlined approach and help expedite necessary reviews and approvals within DOE
 - ▶ Includes representatives from DOE Office of General Counsel, DOE Chicago Legal Counsel office, Fermilab Site Office, SC and HEP International Programs
 - ▶ Chaired by Abid Patwa (HEP International Programs)
 - ▶ WG currently deliberating on a draft SBN program MOU, which will serve as a model for subsequent DUNE MOUs and LBNF/PIP-II project planning documents



Recent International Cooperative Engagements



Japan

Response letter sent by DOE Under Secretary for Science in early-March 2019 to Diet Representative Kawamura expressing support for ILC should Japan decide to host the project, and invite discussions for Japanese collaborative engagement in the U.S.-hosted international neutrino program.



Germany

Letter sent by DOE Under Secretary for Science in Feb 2019 to BMBF State Secretary welcoming discussions for collaborative opportunities in the U.S.-hosted international neutrino program.

Response letter received in April indicating interest by Germany to discuss further.



Poland

Letter sent by DOE Under Secretary for Science in March 2019 to Minister of Science in Poland welcoming collaborative opportunities in the U.S.-hosted international neutrino program and PIP-II accelerator project.

Poland's Wrocław University of S&T expressing interest to participate in the collaborative program.



India

Request by HEP for DOE Under Secretary for Science to meet with Indian Ambassador at Embassy of India in D.C. to discuss U.S.-India partnerships; Invitation sent in May 2019 by DOE Under Secretary to India DST Secretary to visit DOE.

Meeting scheduled for June with Indian Ambassador; Response letter received from DST expressing interest to meet.



CERN

In April 2019, completed negotiations and signed a Future Circular Collider (FCC) Addendum ["MOU"] between Fermilab and CERN on high-field quadrupole magnet R&D studies for FCC design configurations.



Spain

Letter sent by DOE Under Secretary for Science in March 2019 to Minister of Science in Spain welcoming discussions for collaborative opportunities in the U.S.-hosted international neutrino program and PIP-II project.

Response letter received in May indicating interest by Spain in the program.



Peru

Letter sent in April 2019 by DOE Associate Director of Science for HEP to President CONCYTEC welcoming collaborative opportunities in, and pursuing written arrangements for, neutrino physics.

Response letter received in May expressing Peru's interest and to send DOE a draft written arrangement in summer of 2019.



Israel

Ongoing coordination with U.S. State Department to pursue establishing U.S.-Israel Science & Technology Cooperation Agreement, and, in the interim, an international Cooperative R&D Agreement between Fermilab and Tel-Aviv University in neutrino science cooperation.

