U.S. DEPARTMENT OF ENERGY | Office of Science

High Energy Physics Program Status

HEPAP Meeting
29 November 2018

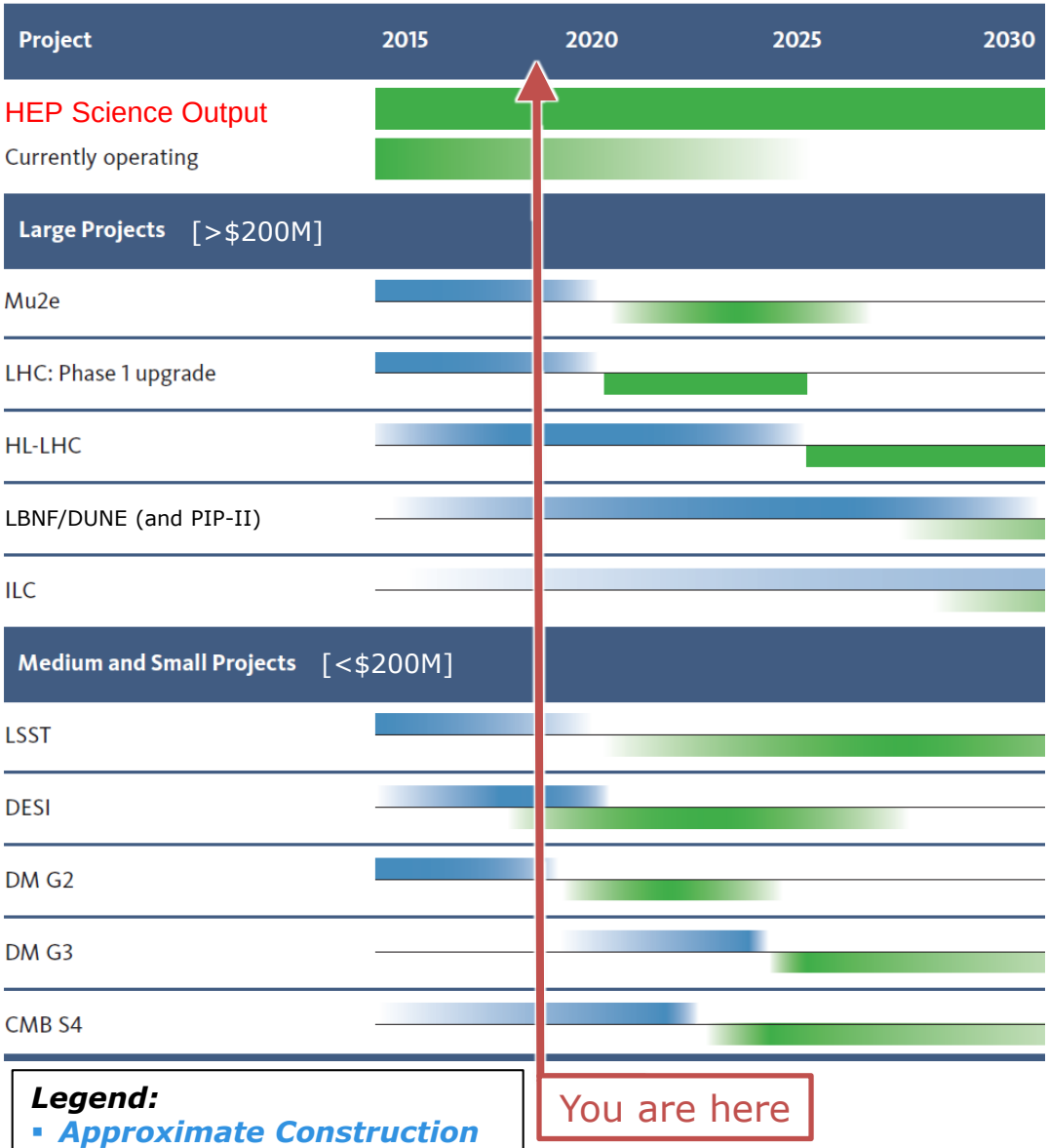
Jim Siegrist
Associate Director for High Energy Physics
Office of Science, U.S. Department of Energy

FY 2019 HEP Enacted Budget

HEP Funding Category ($ in K)	FY 2017 Actual	FY 2018 Actual	FY 2019 Enacted	FY 2019 vs. FY 2018
Research	344,043	359,177	380,847	+21,670
Facilities/Operations	258,696	270,488	260,803	-9,685
Projects	222,261	278,335	338,350	+60,015
Total	**825,000**	**908,000**	**980,000**	**+72,000**

- FY 2019 Appropriations supports the SC and P5 priorities
  - SC: interagency partnerships, national laboratories, accelerator R&D, QIS
  - P5: preserve vision, fine-tune execution
- FY 2019 HEP Budget continues support for P5-guided investments in mid- and long-term program
  - "Building for Discovery" by supporting highest priority P5 projects to enable future program
  - Research support advances P5 science drivers and world-leading, long-term R&D in Advanced Technology, Accelerator Stewardship, and Quantum Information Science
  - Operations support enables world-class research at HEP User Facilities
- ***More budget details in Alan Stone's HEPAP presentation***

P5 Implementation Status – FY 2019



All projects on budget & schedule

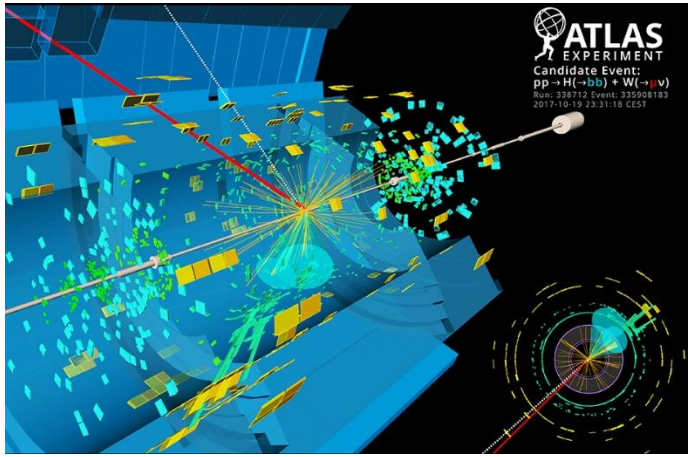
- Projects fully funded as of FY19
  - Muon g-2: 1st beam 2017
  - LHC detector upgrades: on track for 2019/20 installation
  - Mu2e : 1st data in 2020
  - LSST: full science operations 2023
  - DM-G2 (superCDMS & LZ): 1st data 2020
  - DESI: 1st light 2019
- HL-LHC accelerator and detector upgrades 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

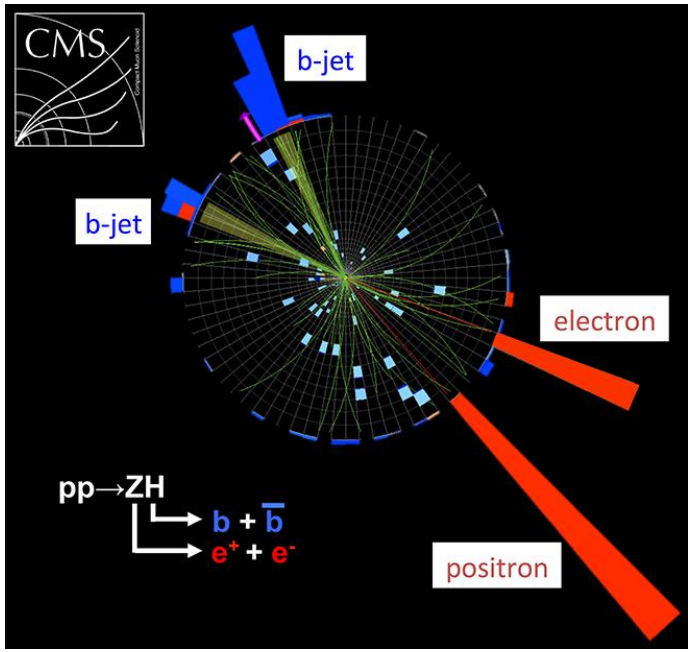
Science Highlights

HEP QIS program information in Lali Chatterjee's HEPAP presentation

Higgs to bb Observation

- August 2018: ATLAS and CMS experiments at the LHC independently observed the Higgs boson decaying to bottom quarks
  - ATLAS combination yields observed (expected) significance of 5.4σ (5.5σ)
  - CMS combination yields observed (expected) significance of 5.6σ (5.5σ)
    - arXiv: ATLAS 1808.08238, CMS 1808.08242
- Observed Higgs boson channels now include:
  - Production with top quarks
  - Decays to photons, pairs of Z or W bosons, and tau leptons
- Results so far consistent with Standard Model predictions, within uncertainties
  - Precision measurements of Higgs properties will continue to explore for new physics





PROSPECT

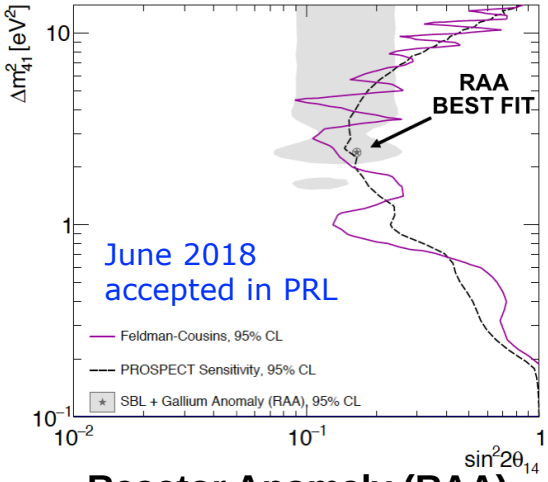
- Precision Oscillation and Spectrum Experiment
  - Segmented Detector
  - ^{6}Li-doped liquid scintillator
  - ~4 ton, 14x11 segments
  - ~4.5%/√E resolution

PROSPECT $\bar{\nu}$
prospect.yale.edu

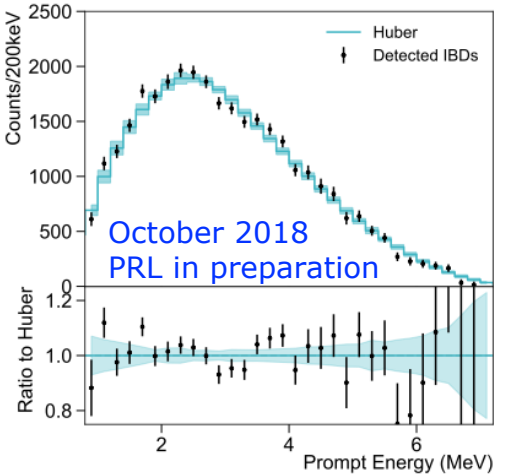
HEISING-SIMONS FOUNDATION

- Physics Objectives
  - Search for short-baseline oscillation at <10m
  - Precision measurement of ^{235}U reactor $\bar{\nu}_e$ spectrum

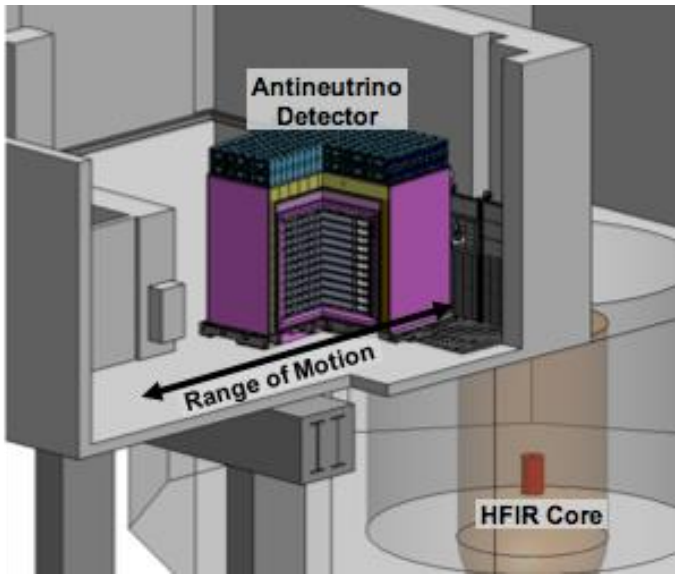
- Started data taking in March 2018
  - Best signal/background for antineutrino detection ever on-surface
  - > 5σ reactor neutrino detection in <2 hrs on Earth's surface



Reactor Anomaly (RAA) best-fit point disfavored at > 95% CL

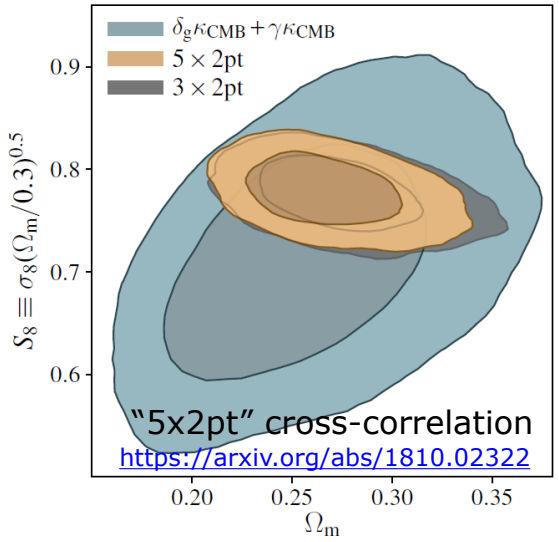


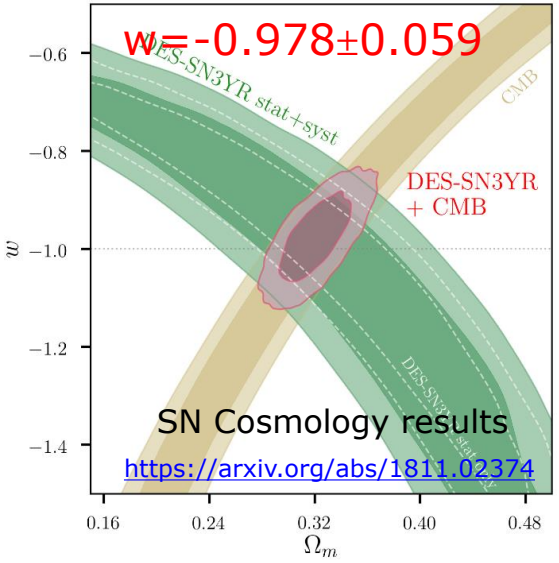
High-statistics ^{235}U spectrum measurement



Dark Energy Survey

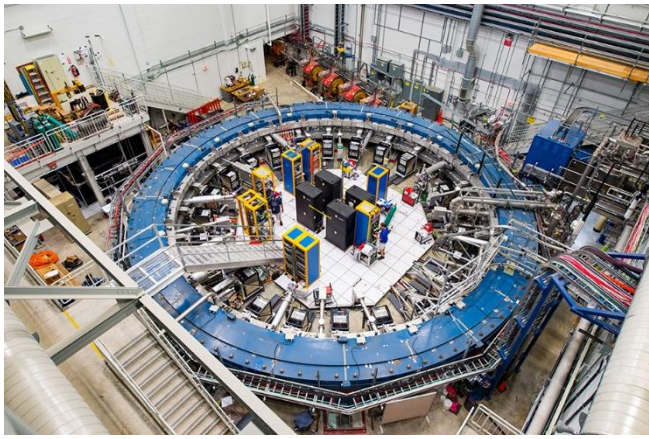
- DES studies Dark Energy via survey of 300 million galaxies, 3,000 supernovae with 570-megapixel Dark Energy Camera on Blanco telescope in Chile
  - Funded extension to Season 6, survey ends Jan. 2019
- Oct 2018: Constraints on cosmic matter density (Ω_m) and matter fluctuation amplitude (σ_8)
  - Uses cross-correlation of weak lensing, galaxy clustering, CMB lensing to place constraints
  - Joint large scale structure analysis measured using three different cosmological surveys (DES, SPT, Planck), spanning redshifts from z=0 to z~1100
  - Combined probes are an important demonstration of the power expected for LSST
- Nov 2018: First supernova cosmology results
  - From the first 3 years of data, constraining the dark energy equation of state w and Ω_m
  - Results consistent with a cosmological constant model and demonstrate the high constraining power (per SN) of the DES-SN sample





Muon g-2 Prediction

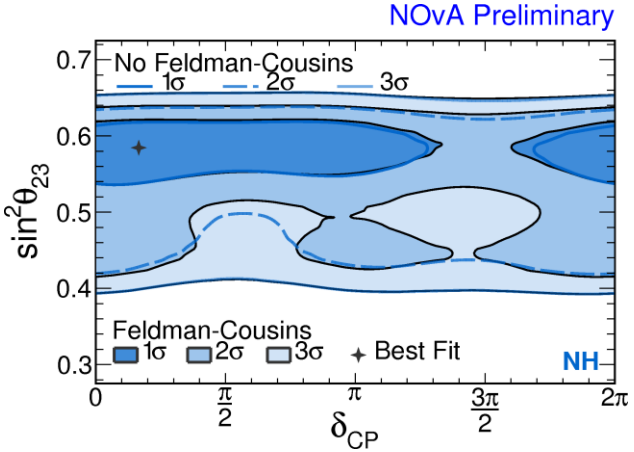
- Theorists make most precise prediction of how muons wobble as they travel in a powerful magnetic field
- Precise comparison between the prediction and the measurement of the muon's magnetic moment provides a stringent test of the Standard Model
- A team of physicists improved this prediction using Lattice QCD, modeling all the possible particle interactions on supercomputers at the Leadership Computing Facility at Argonne National Laboratory and Brookhaven's Computational Sciences Initiative
  - Team led by BNL with contributions from the RBC Collaboration (RIKEN BNL Research Center, Brookhaven Lab, and Columbia University) and the UKQCD collaboration
  - Combined the simulations with related experimental measurements to produce the highest overall precision prediction to date
  - Produced first-principles lattice QCD+QED calculation at physical pion mass of the leading-order hadronic vacuum polarization contribution to muon g-2
- DOI: 10.1103/PhysRevLett.121.022003



SciDAC: HEP Data Analytics on HPC

PI: J. Kowalkowski (FNAL)

- NOvA Neutrino + Antineutrino Analysis
  - Large-scale analysis campaigns carried out at NERSC for the first time, in support of the first set of electron antineutrino appearance results shown at the Neutrino 2018 conference
  - Impact: Most precise measurement of antineutrino oscillations to date, with 8x higher resolution than any prior NOvA result
  - 50x faster than any previous result: reviewed by collaboration in <24h
- LHC Generator Tuning
  - Addressing need for tuning and parameter space exploration with high precision simulations
  - Providing HPC-capable data parallel application of Pythia incorporating matrix element calculations



Corrected contours reveal large islands in parameter space where sensitivity is greatly improved.

http://news.fnal.gov/2018/07/fermilab-computing-experts-bolster-nova-evidence-1-million-cores-consumed/

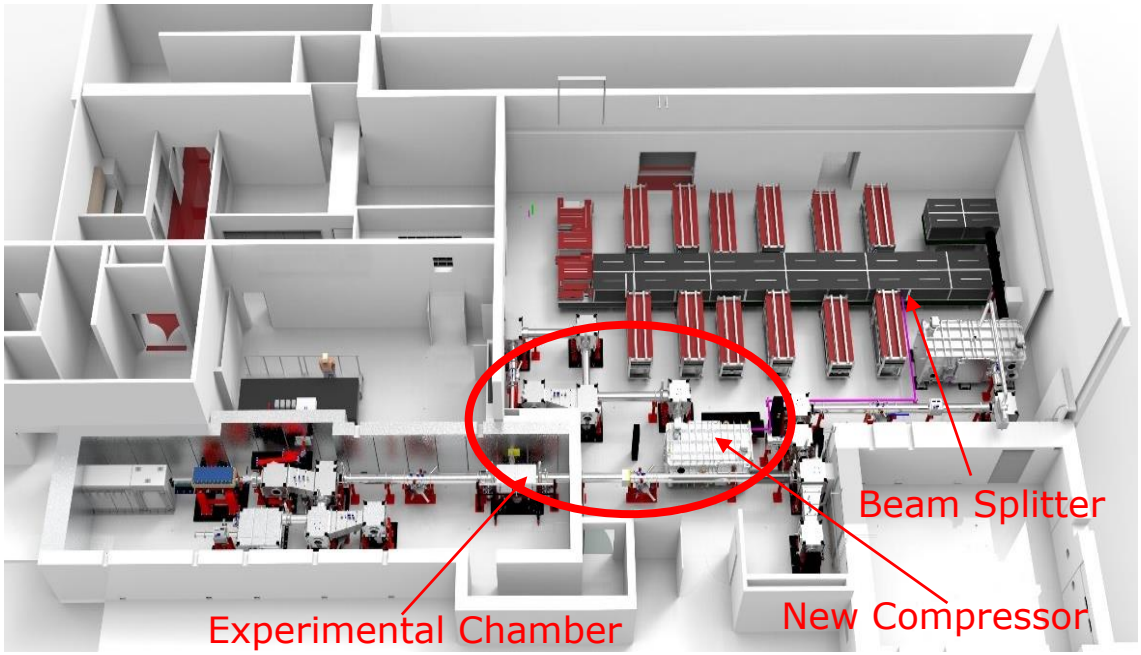
- Project Experiment Collaborators
  - NOvA - A. Sousa (University of Cincinnati)
  - DUNE - A. Norman (FNAL)
  - ATLAS – P. Calafiura (LBNL)
  - CMS – S. Mrenna (FNAL)
- ASCR Partners
  - MATH: Rational approximation of multi-dimensional functions, Optimization with surrogate models for generator tuning
  - CS: Data parallel tools and object stores

Fermilab Argonne NATIONAL LABORATORY Lawrence Berkeley National Laboratory University of CINCINNATI Colorado State University

Facilities Improvements

Berkeley Laboratory Laser Accelerator (BELLA) Second Beamline Accelerator Improvement Project (AIP)

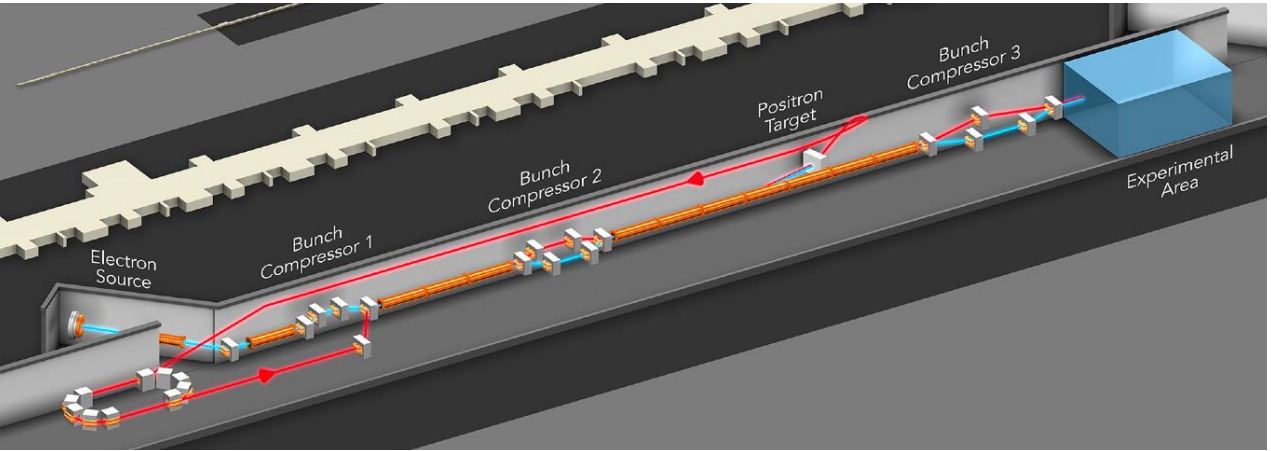
- Berkeley Laboratory Laser Accelerator (BELLA) LBNL will continue its world-leading activity in laser-driven plasma wakefield accelerator (LWFA) research
- Due to a new DOE requirement to fully-fund AIP projects >$5M, **HEP fully funded the BELLA Second Beamline in FY 2018 ($7.7M)**



What	Goal
Science	Demonstrate staging of two LWFA modules to achieve 10 GeV energy gain
Peak Power	2 x 0.5 PW (variable splitting ratios)
Repetition Rate	1 Hz
Pulse Duration	< 45 fs (FWHM) at optimum compression
AIP Duration	18 months
Scope	Design, build and install a new • laser beam transport system including beam splitter, delay line, deformable mirror • laser pulse compressor • focusing and beam delivery system to bring beam to the staging experiment

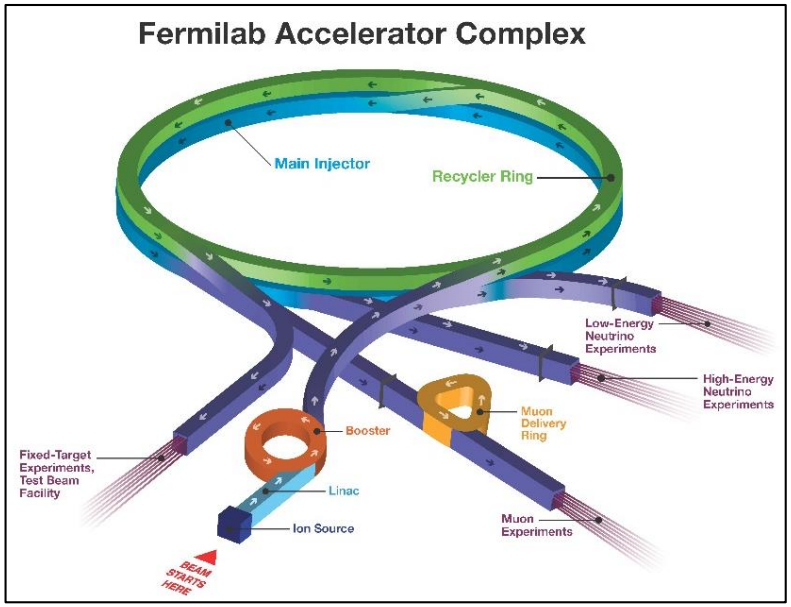
FACET-II: An SC User Facility

- FACET-II will enable research for a broad user community
  - Only facility in the world where positron PWFA R&D is possible
- Timeline:
  - CD-2/3 Apr. 2018
  - Commissioning Q4 FY 2019
  - Experimental program starts FY 2020
- R&D Goals will address key issues in PWFA
  - High brightness beam generation
  - Beam quality preservation, characterization
- Future Goals:
  - e^+ acceleration in e^- driven wakes
  - Staging challenges with witness injector
  - Generation of high flux gamma radiation



Fermilab Accelerator Improvements and Upgrades

- Goals of Fermilab Accelerator Complex Improvements and Upgrades
  - Get as close as possible to 1000 kW with NuMI accelerator
  - Maintain/improve 8 GeV (Booster Accelerator)
  - Improvements/upgrades compatible with PIP-II
  - Funded via Accelerator Operations
- Strategy
  - A NuMI target station that is robust at 1 MW
    - **Fully Funded AIP in FY 2019 at $5.6M**
  - Increase rep rate from 15 Hz to 20 Hz
    - Requires control system changes, RF upgrades
  - Increase intensity from Proton Source
    - Requires improvements to sustain beam quality while reducing beam loss (%)
  - Shorten MI cycle time from 1.333 to 1.2s
    - May use this mode between g-2 & Mu2e operation
- Existing Linac becomes obsolete when PIP-II comes online



Integrated Engineering Research Center

SC Science Laboratories Infrastructure (SLI) Line Item – $86M TPC

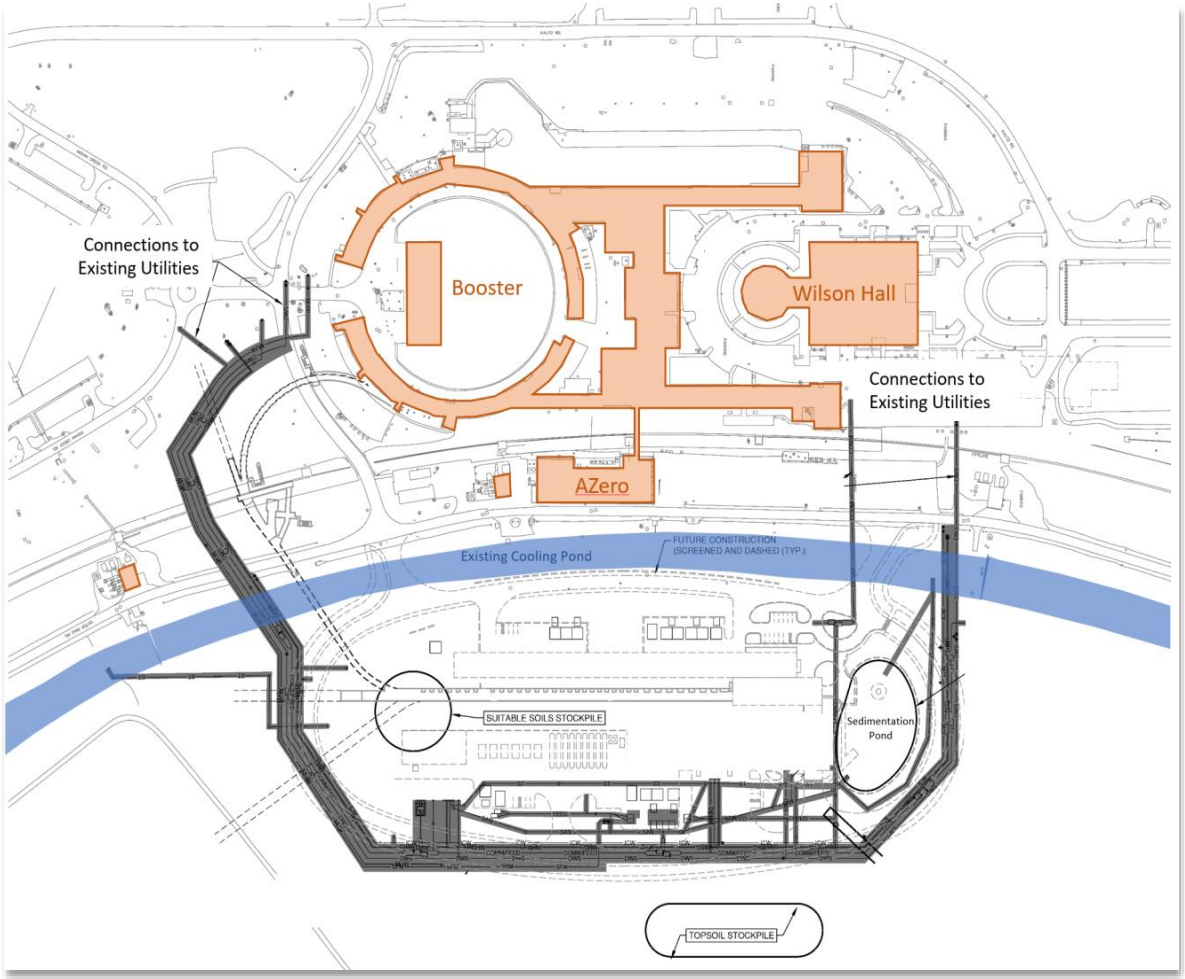
- 3-year construction funding profile
  - **FY19 funding at $20M**
  - Funding need of $42.5M in FY20 for the final year of construction
- IERC laboratory and multifunctional space supports:
  - Fermilab's role as host laboratory for LBNF/DUNE
  - Fermilab's partnership with CERN on the HL-LHC
  - New initiatives such as Quantum Information Science

CD-1 Approved	**April 2017**
Preliminary Design	**Current Status**
Construction Start	**Summer 2019**
CD-2/3 Anticipated	**Q4 FY19**

Fermilab Utility Corridor Upgrade (HEP-GPP)

- Increases reliability and capacity of the existing sitewide utilities in the Main Ring
- Includes the extension of:
  - Domestic water service
  - Industrial cooling water
  - Sanitary sewer
  - Chilled water
  - Communications utilities
  - Electrical duct bank
- Portions of the existing 50+ year old cooling pond network will be upgraded to support current and future accelerator operations

Fully funded in FY 2019 at $8M



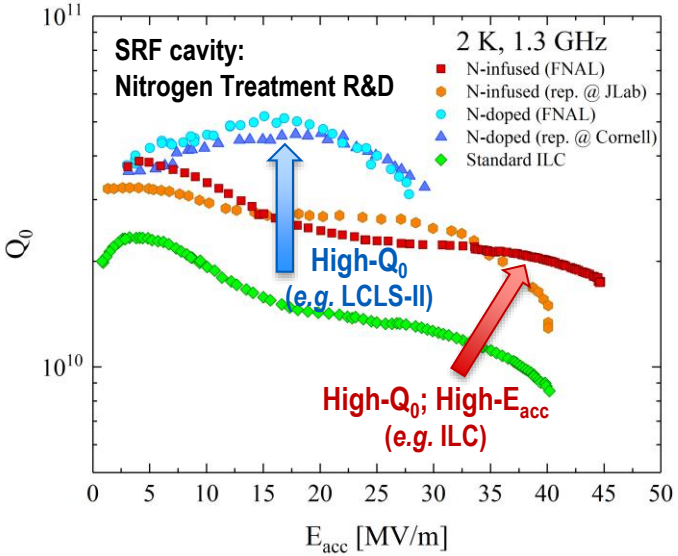
Fostering the Future

CMB-S4 Timeline and Coordination

- CMB-S4 was recommended by P5
  - DOE and NSF communities and expertise formed a CMB-S4 collaboration
- AAAC approved the CMB-S4 Concept Definition Taskforce subpanel report in Oct. 2017
  - Plan has array of telescopes located at South Pole and Chile working in tandem
  - Strawperson technical design, cost, schedule
- Pre-Project Design Group (chair Jim Yeck) set up and working with Collaboration to progress forward
- Further developing concept with a technically limited schedule
  - Planning submission to the National Academies Astronomy and Astrophysics Decadal Survey committee 2019
- DOE and NSF (AST, PHY, and OPP) are having coordination meetings
  - DOE is supportive of CMB-S4's plan, including aiming for CD-0 in FY19

Future Colliders

- DOE coordinating with international community towards development of the next collider program
  - U.S. looks forward to a decision this year by Japan to host the ILC as an international project
  - Global strategy for circular collider awaits 2020 European Strategy Update for Particle Physics
- Interest from HEP community to pursue R&D studies for future collider options
  - Circular collider: DOE efforts focused on high-field magnet technology to enable higher energy
  - ILC: DOE efforts focused on cost reduction R&D, *e.g.*, nitrogen treatment in SRF cavities has potential for up to 10% cost reductions in 3-5 years, up to 15% in 5-10 years
- Under any fiscal constraints in the Energy Frontier program, near-term priorities will aim to support the LHC program as well as R&D for the HL-LHC upgrades

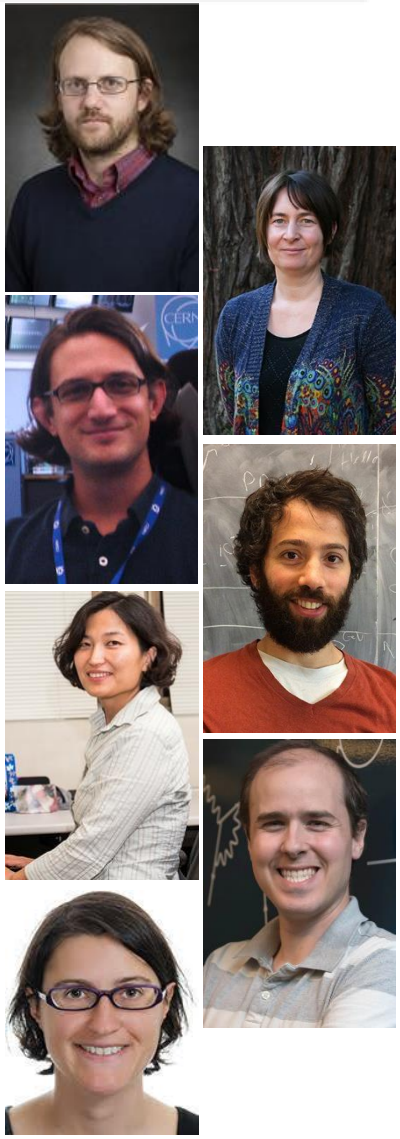


Future Computing Update

- The fields demands for computing and supercomputing are growing
  - See Jim Siegrist's May HEPAP presentation: https://science.energy.gov/hep/hepap/meetings/201805/
  - As an example, this year NERSC requests were up 50% over 2018
  - ASCR's Exascale Computing project will play an important role in satisfying this demand, but much of HEP code is not ready for Exascale
- We have charged the Center for Computational Excellence (CCE) to be a matchmaker between HEP and ASCR experts to look at several example codes
  - Assess the level of effort needed to make HEP code ready for Exascale
  - Assess the degree the issues and potentially solutions are shared
    - Across experiments and Frontiers
  - We have invited the Laboratories to submit Field Work Proposals (FWPs) for this activity
  - CCE leadership will provide a program plan in near future
  - NSF launched the Institute for Research and Innovation in Software for High-Energy Physics (IRIS-HEP) to tackle similar issues from the university perspective
- The first "pre-Exascale" computer, Summit, has been delivered to Oak Ridge and is in "Early Science" phase (open to regular use next year)
  - The follow-on, Aurora, is planned for 2021
- Storage and networking is next on our agenda

FY 2018 Early Career Awards: Univ.

- Thomas Faulkner, University of Illinois
  - New perspectives on QFT and gravity from quantum entanglement
- Alexie Leauthaud-Harnett, University of California, Santa Cruz
  - Exploiting Synergies Between Lensing and BAO Surveys for Improved Cosmological Constraints
- Themis Mastoridis, California Polytechnic State University
  - Optimal Design of Radio Frequency Algorithms and Models for Next Generation Accelerators
- Benjamin Safdi, University of Michigan
  - Particle Dark Matter Across Scales
- Hee-Jong Seo, Ohio University
  - Optimal and robust reconstruction of BAO, redshift-space distortions and the Alcock-Paczynski effect
- David Simmons-Duffin, Caltech
  - Precision Computations in Strongly Coupled Conformal Field Theories
- Rachel P. Yohay, Florida State University
  - Probing New Physics with Tau Leptons using the CMS Detector



FY 2018 Early Career Awards: Labs

- Artur Apresyan, FNAL
  - Exploring the Lifetime Frontier with New Detectors and New Searches
- Daniel Bowring, FNAL
  - Microwave Single-Photon Sensors for Dark Matter Searches and Precision Neutrino Measurements
- Daniel A. Dwyer, LBNL
  - Improving Neutrino Detection in DUNE with Pixel Sensors
- Michael Kagan, SLAC
  - Exploring the Higgs Sector at the Energy Frontier with Bottom Quarks, Machine Learning, and the Upgraded ATLAS Pixel Detector
- Aritoki Suzuki, LBNL
  - Development of high throughput techniques for SC microfabrication, assembly and deployment for future high energy physics experiments
- Kazuhiro Terao, SLAC
  - GPU/FPGA Accelerated Deep Learning Technique Development for Discovering Physics in Liquid Argon Time Projection Chambers
- Javier Tiffenberg, FNAL
  - Towards table-top neutrino detectors: A 10 kg Skipper-CCD experiment

HEP Early Career FY10-18 Demographics

M= Male
F= Female

Subprogram Awards	FY10 (M/F)	FY11 (M/F)	FY12 (M/F)	FY13 (M/F)	FY14 (M/F)	FY15 (M/F)	FY16 (M/F)	FY1 (M/	FY18 (M/F)	Total (M/F)
Energy	3 (2/1)	3 (2/1)	1 (1/0)	2 (1/1)	2 (1/1)	0 (0/0)	2 (2/0)	2 (2	3 (2/1)	15 (11/5)
Intensity	2 (1/1)	1 (1/0)	3 (1/2)	1 (0/1*)	1 (1/0)	2 (2/0)	1 (0/1)	2 (2	2 (2/0)	14 (10/4)
Cosmic	2 (2/0)	3 (3/0)	3 (2/1)	2 (2/0)	1 (1/0)	0 (0/0)	1 (1/0)	2 (1	2 (0/2)	15 (11/4)
HEP Theory	6 (6/0)	4 (3/1*)	3 (3/0)	3 (3/0)	1 (1/0)	3 (2/1)	1 (1/0)	2 (0	3 (3/0)	25 (21/4)
Detector	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/0)	0 (0/0)	1 (1	2 (2/0)	3 (3/0)
Accelerator	1 (0/1)	2 (2/0)	2 (2/0)	1 (1/0)	1 (0/1)	0 (0/0)	2 (2/0)	2 (2	1 (1/0)	10 (8/2)
QIS	NA	NA	NA	NA	NA	NA	NA	NA	1 (1/0)	1 (1/0)
HEP Awards	14 (11/3)	13 (11/2)	12 (9/3)	9 (7/2)	6 (4/2)	5 (4/1)	7 (6/1)	11 (8/3	14 (11/3)	91 (71/20)
Proposals	**154 (131/23)**	**128 (110/18)**	**89 (75/14)**	**78 (64/14)**	**77 (62/15)**	**73 (57/16)**	**84 (65/19)**	**83 (59/**	**92 (72/20)**	**858 (695/163)**

*** Two awards funded by DOE Office of Basic Energy Sciences (BES) as an EPSCoR [Experimental Program to Stimulate Competitive Research] award with grant monitored by DOE Office of High Energy Physics (HEP).**

Diversity and Inclusion

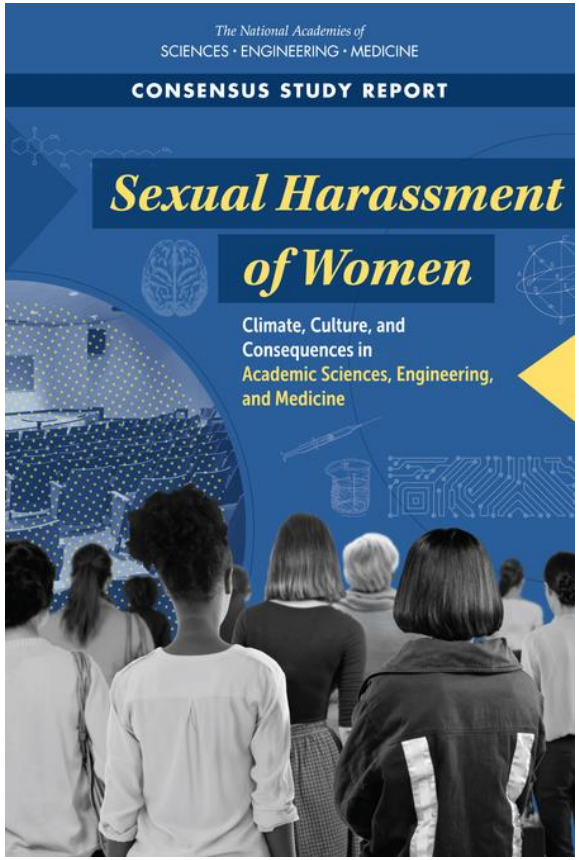
- The **2016 HEP Committee of Visitors** recommended that HEP **"develop a plan for increasing diversity in the programs HEP supports."**
- HEP is working with **Office of Science** management to develop strategies for improving diversity in its research programs
  - HEP is participating in a new SC-wide diversity and inclusion working group that aims to establish shared **best practices across program offices**
  - HEP works with the **DOE National Laboratories** to monitor and encourage diversity and inclusion efforts through its contracts, annual planning processes, and budget briefings
  - HEP participates in **Workforce Development for Teachers and Scientists** programs
    - WDTS supports >1,000 students and faculty annually
- The 2015 GAO report on Women in STEM Research and the 2016 HEP COV recommended that HEP **collect further demographic data** for grant applicants:
  - HEP should **work with the Office of Science to obtain demographic information**, including information at the proposal stage. Inadequate demographic information is available to assess the success rate of different populations that apply for funding by HEP.
  - Implicit bias in reviews is a concern, but conclusions cannot be drawn without data. **Improved demographic information would facilitate tracking of progress in achieving diversity** in particle physics
  - **Grant applicants and contributors can voluntarily supply information in PAMS**

Sexual Harassment

"[S]exual harassment is a serious issue for women at all levels in academic science, engineering, and medicine, and that these fields share characteristics that create conditions that make harassment more likely to occur. **Such environments can silence and limit the career opportunities** in the short and long terms for both the targets of the sexual harassment and the bystanders—with at least some leaving their field. The consequence of this is a significant and costly loss of talent in science, engineering, and medicine.

However, we are encouraged by the **research that suggests that the most potent predictor of sexual harassment is organizational climate**—the degree to which those in the organization perceive that sexual harassment is or is not tolerated. This means that **institutions can take concrete steps to reduce sexual harassment** by making system-wide changes that demonstrate how seriously they take this issue and that reflect that they are listening to those who courageously speak up to report their sexual harassment experiences."

- The National Academies of Science, Engineering, and Medicine, 2018



http://sites.nationalacademies.org/shstudy/index.htm

Dr. Frazier Benya, an editor of this report, will speak tomorrow at HEPAP

Expectations for Professional Behavior

- The Office of Science is exploring the development of an official statement regarding expectations for how individuals it interacts with should conduct themselves
- In the interim, The Office of High Energy Physics embraces the Code of Conduct adopted by the American Physical Society, and it will remind attendees at meetings it convenes, including review panels, site visits, etc., that it expects a standard for professional behavior that is consistent with the APS declaration

The APS Code of Conduct

It is the policy of the American Physical Society (APS) that all participants, including attendees, vendors, APS staff, volunteers, and all other stakeholders at APS meetings will conduct themselves in a professional manner that is welcoming to all participants and free from any form of discrimination, harassment, or retaliation. Participants will treat each other with respect and consideration to create a collegial, inclusive, and professional environment at APS Meetings. Creating a supportive environment to enable scientific discourse at APS meetings is the responsibility of all participants.

Participants will avoid any inappropriate actions or statements based on individual characteristics such as age, race, ethnicity, sexual orientation, gender identity, gender expression, marital status, nationality, political affiliation, ability status, educational background, or any other characteristic protected by law. Disruptive or harassing behavior of any kind will not be tolerated. Harassment includes but is not limited to inappropriate or intimidating behavior and language, unwelcome jokes or comments, unwanted touching or attention, offensive images, photography without permission, and stalking.

Other News

Comings & Goings

- Incoming (since last update, Dec 2017):
  - Karen Byrum (Jan '18; Detailee, Cosmic Frontier)
  - Laurence Littenberg (Apr '18, Detailee, Intensity Frontier)
  - Drew Baden (Aug '18; IPA, Cosmic Frontier)
  - Claudette Rosado-Reyes (Sep '18; AAAS S&T Policy Fellow)
- Outgoing:
  - Brian Morsony (Aug '18; AAAS S&T Policy Fellow)
- DOE Federal Position for Intensity Frontier
  - Expect to have news soon…
- Always looking for 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
  - SC programs in QIS, computing, and SLI provide additional support to enable P5
- The FY 2019 appropriation will enable continued P5 progress
  - Maintaining a healthy research budget is an ongoing challenge
  - Investing in facilities through AIP, GPP, to support the future program
- The particle physics community continues to perform well on delivering projects, a foundation of the long-term strategy
  - Expect greater emphasis on project performance as we enter a time of fewer, larger projects with high visibility
- Community continues to be unified in support of P5 strategy

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