Considerations Related to Health of the Field

Panel Discussion

HEPAP 21 November 2019

Tim Bolton, Prisca Cushman, Sally Dawson, Michael Hildreth, and Steve Ritz (moderator)

Some Goals for the Session

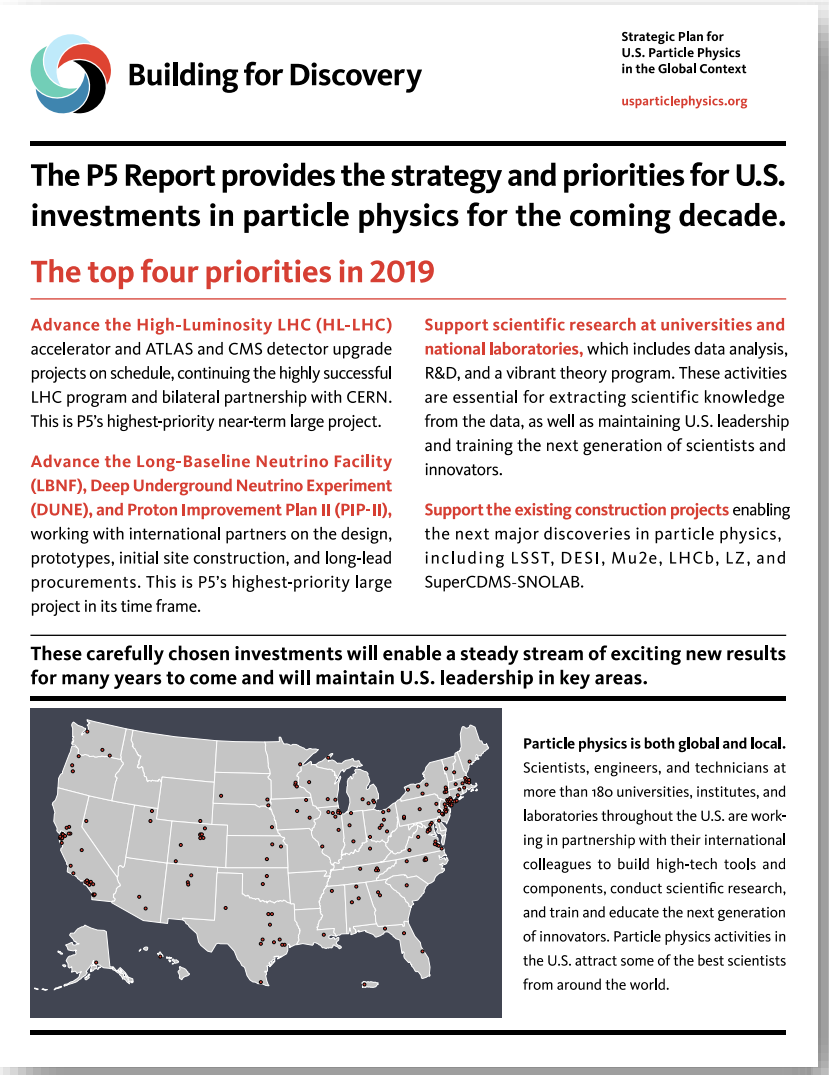
- Help HEPAP collect and define questions related to the health of the field.
  - Building projects moving forward – **MUCH APPRECIATED!** – so focus here is primarily on research support, operations support, and people.
  - Some possible metrics and areas to consider:
    - Scientific productivity
    - Research budget fraction
    - 20-year trends in per-PI support and # of PIs. US program compared with those of other regions: # of post-docs, # of permanent positions, …
    - Diversity, equity, inclusion, and climate
    - Proposal success rates and demographics
    - R&D
    - What else?
  - Try to understand issues for the whole field and in each area. Most productive to focus on how we all work together to address issues.
  - Many voices in the field, not all represented here today.

Proposed Agenda for the Session

- Panel intros and agreement on goals of the session (10’)
- Reminder of relevant language in P5 Report and the two-page Progress and Priorities document – S. Ritz (10’)
- Panelists (5’ each) address any of the topics and Q&A (30’ total)
- Synthesis and suggestions for next steps (10’)

Progress and Priorities Document

- See https://www.usparticlephysics.org/wp-content/uploads/2019/03/Particle-Physics-Progress-and-Priorities-2019.pdf



Building for Discovery

Strategic Plan for U.S. Particle Physics in the Global Context

usparticlephysics.org

The P5 Report provides the strategy and priorities for U.S. investments in particle physics for the coming decade.

The top four priorities in 2019

Advance the High-Luminosity LHC (HL-LHC) accelerator and ATLAS and CMS detector upgrade projects on schedule, continuing the highly successful LHC program and bilateral partnership with CERN. This is P5's highest-priority near-term large project.

Advance the Long-Baseline Neutrino Facility (LBNF), Deep Underground Neutrino Experiment (DUNE), and Proton Improvement Plan II (PIP-II), working with international partners on the design, prototypes, initial site construction, and long-lead procurements. This is P5's highest-priority large project in its time frame.

Support scientific research at universities and national laboratories, which includes data analysis, R&D, and a vibrant theory program. These activities are essential for extracting scientific knowledge from the data, as well as maintaining U.S. leadership and training the next generation of scientists and innovators.

Support the existing construction projects enabling the next major discoveries in particle physics, including LSST, DESI, Mu2e, LHCb, LZ, and SuperCDMS-SNOLAB.

These carefully chosen investments will enable a steady stream of exciting new results for many years to come and will maintain U.S. leadership in key areas.

Particle physics is both global and local. Scientists, engineers, and technicians at more than 180 universities, institutes, and laboratories throughout the U.S. are working in partnership with their international colleagues to build high-tech tools and components, conduct scientific research, and train and educate the next generation of innovators. Particle physics activities in the U.S. attract some of the best scientists from around the world.

The P5 strategy has been very successful. Projects are on schedule and within budget.

Recent results

The NOvA experiment has now **seen anti-neutrino oscillations**, with an analysis run in record time on a supercomputer cluster of more than a million CPU cores.

New constraints on the characteristics of the mysterious **dark matter** were obtained by the IceCube, LUX, ADMX, SuperCDMS, XENON1T, and LHC experiments.

The LHC experiments reported many exciting results, including observation of **Higgs boson** interactions with additional known particles, an important and challenging milestone in the program to use the Higgs as a new tool for discovery.

The Dark Energy Survey (DES) released its first supernova-based cosmology results using the first three years of data.

Program advances in 2018

Building upon the historic 2015 and 2017 bilateral U.S.-CERN agreements, U.S. and CERN scientists successfully continued their cooperative partnership at the LHC and the international neutrino program hosted by Fermilab.

The new CMS pixel detector at the LHC began operations, HL-LHC accelerator upgrade construction started, and the HL-LHC ATLAS and CMS detector designs advanced.

The community continues to move rapidly toward a new era of neutrino physics. Development of LBNF and DUNE became truly international, providing a worldwide focus of scientific research hosted at Fermilab. In addition to the planned UK contributions, India recently expanded its bilateral partnership to include LBNF/DUNE and Italy has agreed to collaborate on the development of PIP-II. The protoDUNE detector is now operational.

The Muon g-2 experiment construction was completed successfully, and its first physics run is now underway.

Next-generation dark matter and dark energy experiments progressed. The selected dark matter experiments SuperCDMS-SNOLAB and LZ continued construction. Recent pathfinder experiments, advances in quantum technology, and theoretical insights have opened the potential for dark matter discovery in a mass range once thought inaccessible. DES successfully completed its survey. The Dark Energy Spectroscopic Instrument (DESI) and the Large Synoptic Survey Telescope (LSST) construction projects continued on schedule.

Community efforts are underway to develop the next-generation cosmic microwave background facility, CMB-S4, which will probe in unique ways the physics of the very early Universe at energies far higher than can be achieved in earthbound accelerators and will also reveal neutrino properties.

Looking forward

All eyes are on the LHC, as its sensitivity to new physics will continue to improve for many years to come.

Eagerly anticipated new data from operating experiments will advance the understanding of the intertwined Science Drivers identified in the P5 Report.

The particle physics theory community will continue to play key roles interpreting results from current experiments, motivating future experiments, and pursuing answers to the deepest questions.

Japan is considering hosting the International Linear Collider (ILC), which would provide new opportunities for discovery.

Theoretical and experimental particle physicists are advancing Quantum Information Science (QIS), providing solutions to problems in computation, data analysis, sensors, and simulations.

U.S. researchers are pursuing R&D on advanced technologies to enable future generations of accelerators and detectors with a wide variety of applications.

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Note the new top-priorities bullet last year, top right:
"**Support scientific research at universities and national laboratories,** which includes data analysis, R&D, and a vibrant theory program. These activities are essential for extracting scientific knowledge from the data, as well as maintaining U.S. leadership and training the next generation of scientists and innovators. "

Updating this document again now. Suggestions welcome!

As usual, also consulting with DPF Exec, Users Groups, …

From the P5 Report P9

- Increasing the project fraction will necessarily entail judicious reductions in the fractions of the budget invested in the research program and operations. In addition, for the research program, which has seen reductions in recent years, flat-flat budgets are substantially detrimental over time due to escalation of real costs. To limit reductions in research program funding, we adopted a guideline that its budget fraction should be >40% in our budget planning exercises. The three main budget categories are project construction, the research program, and operations.
- The particle physics research program supports activities that give meaning to the data. These include analyzing the data directly, developing and refining sophisticated computer models to compare the data with theoretical expectations, synthesizing the knowledge gained from experimental discoveries and constraints, and looking forward by developing ideas that lead to new scientific opportunities.
- Graduate students and postdoctoral researchers have essential roles in all aspects of this world-leading research. In turn, these young researchers obtain scientific and technical training. This develops the next generation of scientific leaders and provides to society a cadre of young people with extraordinary skills and experience.
- The U.S. has leadership in diverse areas of theoretical research in particle physics. A thriving theory program is essential for both identifying new directions for the field and supporting the current experimental program. Theoretical physicists are needed for a variety of crucial activities that include taking the lead in the interpretation and synthesis of a broad range of experimental results, progress in quantum field theory and possible new frameworks for a deeper understanding of Nature, and developing new ideas into testable models. Theoretical research both defines the physics drivers of the field and finds the deep connections among them. As experiments have confronted the Standard Model with increasing sophistication, theoretical research has provided extraordinary advances in calculation techniques, pushing the leading edge of both mathematics and high performance computing.

From the P5 Report P9

- Particle physics is a remarkably dynamic field, with researchers nimbly changing course to invent and pursue great new opportunities. It is appropriate that priorities in the research program should be aligned with the science Drivers and the investments in projects. At the same time, it is essential to preserve a diversity of scientific approaches, support, and training for young researchers, as well as leadership and forward thinking in theoretical and experimental research. It is the research program's flexibility to support new ideas and developments outside approved projects that will position the field to develop and pursue the next generation of science Drivers.
- **Recommendation 6: In addition to reaping timely science from projects, the research program should provide the flexibility to support new ideas and developments.**
- The research program is the intellectual seed corn of the field. Properly cared for, the program will yield a bounty of future discoveries and innovations within and beyond particle physics. However, the community has been coping with a sequence of recent cuts in the research program budgets, and there is a strong sense that further erosion without careful evaluation will cause great damage.
- **Recommendation 7: Any further reduction in level of effort for research should be planned with care, including assessment of potential damage in addition to alignment with the P5 vision.**
- In the constrained budget Scenarios, the funding for the research program plus operations is set by the budget fraction devoted to project construction to maintain the pace of discovery and leadership in key areas. Especially in the lowest budget Scenario, it may be unavoidable that there will be some years of flat-flat budgets for the research program. However, the effect of such declines in effort should be carefully assessed and appropriately balanced with other reductions, including those in the ongoing operations budgets, given the priorities of the science Drivers.

Panel Discussion (30’) and Next Steps (10’)

- Some possible metrics and areas:
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