Building for Discovery

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

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

The top four priorities in 2020

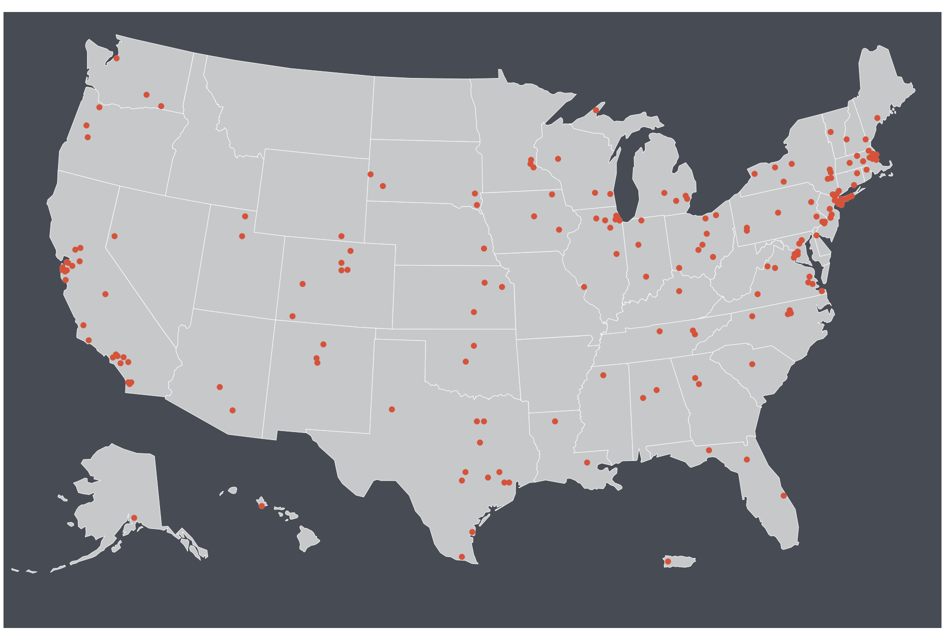
Advance the High-Luminosity Large Hadron Collider (HL-LHC) accelerator and ATLAS and CMS detector upgrade projects on schedule, continuing the highly successful LHC program and bilateral partnership with CERN. This is P5's highest-priority near-term large project.

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.

In addition to the construction projects, 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 other existing projects as they complete construction and begin commissioning, enabling the next major discoveries in particle physics. These include the Rubin Observatory LSST Camera, 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** published a measurement of **oscillations of anti-neutrinos**, a key milestone in their program, and the **T2K experiment** reported evidence that the **neutrino-antineutrino asymmetry** may be non-zero.

The LHC experiments reported many important and precise results, continuing the program of using the **Higgs as a new tool for discovery**. The ATLAS and CMS experiments made the first-ever observations of the scattering of W bosons. The LHCb experiment observed a matter-antimatter asymmetry in charm quark interactions for the first time.

The Dark Energy Survey (DES) completed its data taking and published new combined measurements of cosmological parameters related to dark energy. The ADMX-G2 experiment performed the world's most sensitive **search for axions**, hypothesized to solve one of the most persistent problems in particle physics and which could also be a component of **dark matter**.

Theoretical physicists have characterized new mathematical functions central to precision calculations of processes at the LHC. They also continued to develop new ideas about the quantum structure of spacetime and the nature of dark matter.

Program advances in 2019

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 ProtoDUNE neutrino detector successfully completed its first test run. Phase-I upgrades to the ATLAS and CMS detectors were successfully installed.

Fermilab set a world record of 14.1 Tesla for an accelerator steering magnet, an important achievement toward the next generation of colliders.

The inner detector of the **LZ dark matter experiment** was installed underground in South Dakota and will soon be operational. Two **Dark Energy** experiments progressed well: **DESI** construction was completed, with commissioning now underway; and the huge lenses and all the detector modules for the **Rubin LSST Camera** were completed, with integration and testing proceeding.

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, progressed.

Looking forward

All eyes are on the LHC, as its sensitivity to new physics will continue to improve for many years to come. The National Science Board voted to approve the NSF MREFC for the High Luminosity Upgrades to the ATLAS and CMS Detectors, and these projects are now on track for their DOE baseline reviews and approvals.

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 in interpreting results from current experiments, motivating future experiments, and pursuing answers to the deepest questions.

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

Other regions worldwide are considering hosting next-generation colliders, each of which would provide new opportunities for discovery.

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