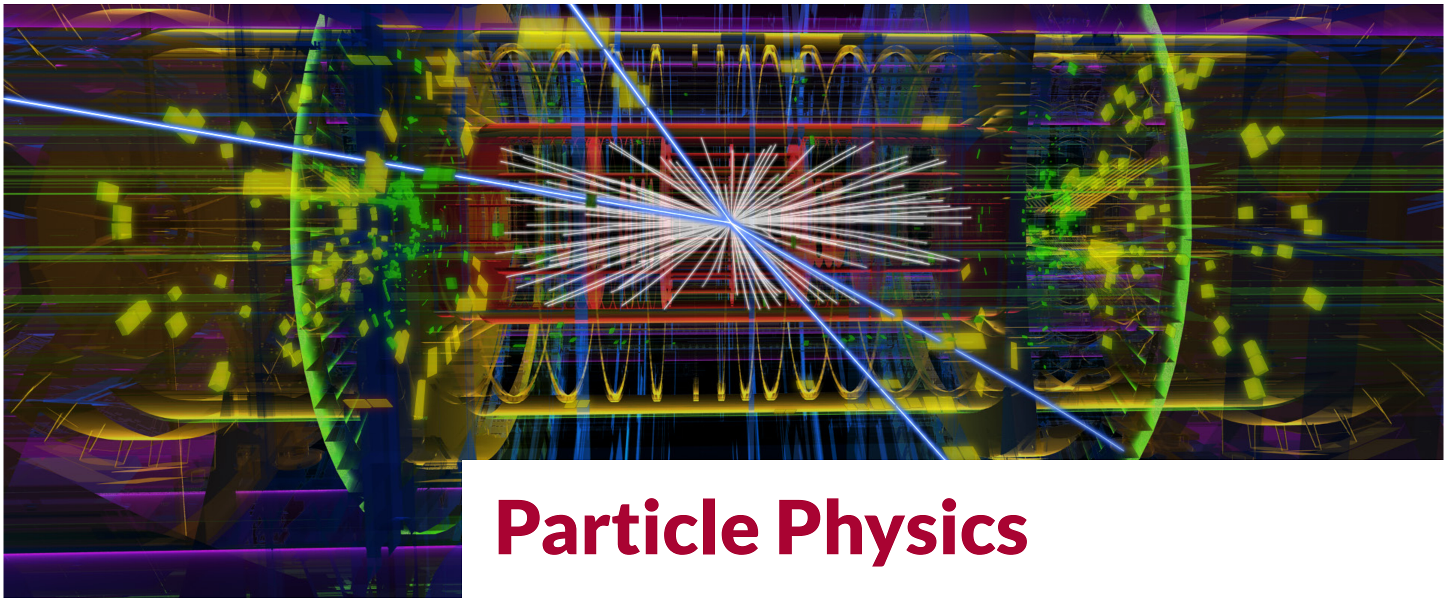


Particle Physics

slac.stanford.edu

Working at the forefront of particle physics research, SLAC scientists use powerful particle accelerators to create and study nature's fundamental building blocks and forces, build sensitive detectors to search for new particles and develop theories that explain and guide experiments.

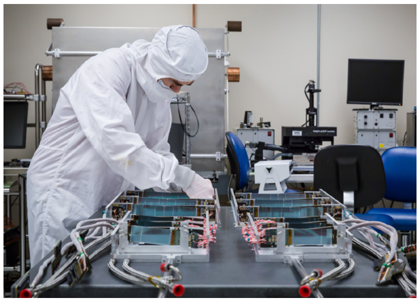
Top National Priorities

SLAC's particle physicists pursue research in areas identified as top priorities for U.S. high-energy physics for the next decade. They want to understand our universe – from its smallest constituents to its largest structures. Several of these research topics are also covered by SLAC's astrophysics and cosmology program.

The Higgs Boson and Beyond

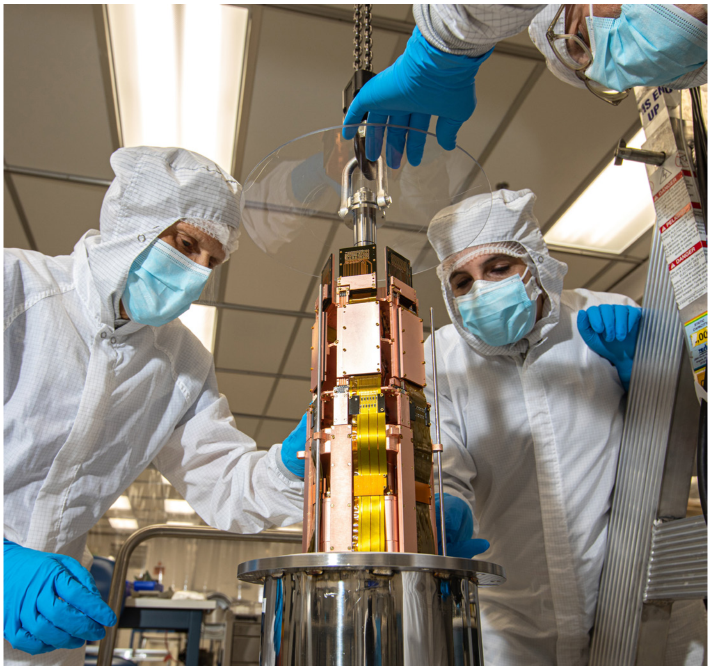
At CERN's Large Hadron Collider (LHC), the world's largest and most powerful particle collider, researchers smash proton beams into one another at record high energies and analyze the debris to reveal some of nature's best-kept secrets. They already discovered the Higgs boson in 2012, a particle that explains why other fundamental particles have mass. Now they study it in detail to better understand its properties. Particle physicists also search for exotic new particles. Some of these could explain the nature of dark matter, the invisible substance that makes up 85 percent of all matter in the universe.

In addition to building detector components and developing sophisticated data analysis algorithms for ATLAS, SLAC is leading accelerator R&D for the next step beyond the LHC, which is critical to enabling precision measurements of the Higgs boson and high energy searches for new particles.



Top: the ATLAS detector at CERN's Large Hadron Collider records the debris produced when powerful proton beams collide. This is how scientists study the properties of fundamental particles and forces and try to find new ones. (ATLAS/CERN)

Above: SLAC built a crucial detector component for the Heavy Photon Search, an experiment at Jefferson Lab that is looking for dark forces that affect dark matter particles.



Researchers examine one of four SuperCDMS detector towers, which were built at SLAC. (Jacqueline Ramseyer Orrell/SLAC National Accelerator Laboratory)

Members of SLAC's LZ team with the loom they used to weave high-voltage grids for the next-gen dark matter experiment. (Farrin Abbott/SLAC National Accelerator Laboratory)

Searching for Dark Matter

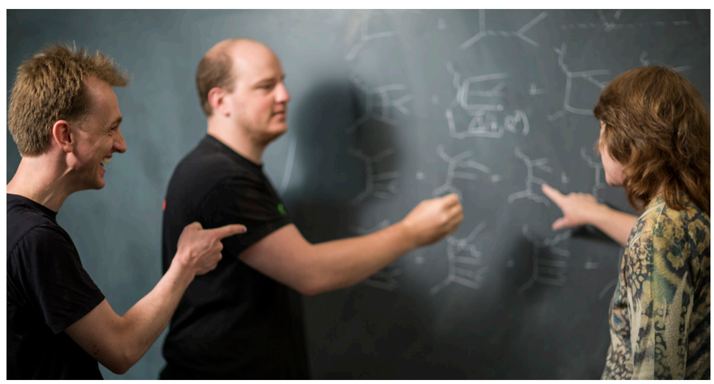
Scientists know from the motions of galaxies that the universe contains about five times more dark matter than visible matter, but don't know much about the form it takes. Undiscovered dark matter particles could also be attracted, repelled or otherwise affected by unknown dark forces.

SLAC wants to find out more. For years, SLAC has played central roles in the LZ and SuperCDMS dark matter detection experiments. It is also a key player in the Heavy Photon Search (HPS), an experiment at Jefferson Lab in Virginia searching for a dark, heavy version of particles of light, or photons. Looking forward, SLAC researchers are spearheading the proposed Light Dark Matter Experiment and Dark Matter Radio, which will look for dark matter in the form of dark-sector particles and axions, respectively, as well as investigating new probes of dark matter with astrophysical data.

Understanding Neutrinos

Of all particles known to scientists, neutrinos are among the most mysterious. They are extremely difficult to study because they can pass through a layer of lead nearly 6 trillion miles thick without leaving a trace. SLAC researchers want to answer fundamental questions about neutrinos: What is the mass of the three known types of neutrinos? Is there a fourth type that could be linked to dark matter? Could neutrinos explain why there is more matter than antimatter in the universe? Are neutrinos their own antiparticles?

SLAC physicists are taking on key roles in a number of neutrino experiments, including contributing to the Enriched Xenon Observatory's (EXO) successor, nEXO, and the ICARUS experiment at Fermilab. They are also involved in planning and developing detectors for the Deep Underground Neutrino Experiment (DUNE), which will detect neutrinos sent 800 miles through the Earth from Fermilab to South Dakota.



The Theoretical Foundation

Theory is the fundamental tool that explains what scientists observe in experiments and gives them a better idea of where to look for the next big discovery. SLAC theorists explore important topics in particle physics, particle astrophysics and cosmology, including searches for new phenomena, extra dimensions, collider physics, neutrino physics, dark matter and cosmic inflation. They also work out complex detailed calculations of known theories to enhance our interpretation of new experimental data. These theoretical investigations advance our understanding of nature, from the properties of tiny particles to the expansion of the entire universe.