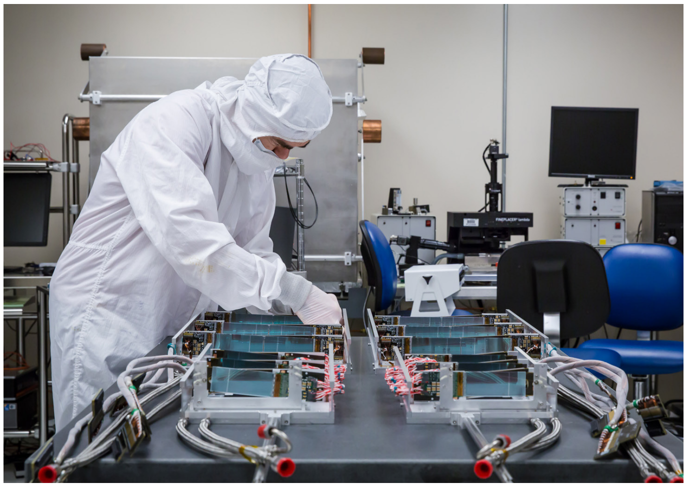
SLAC Science
Particle Physics



Top: 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. Bottom: 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)

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.

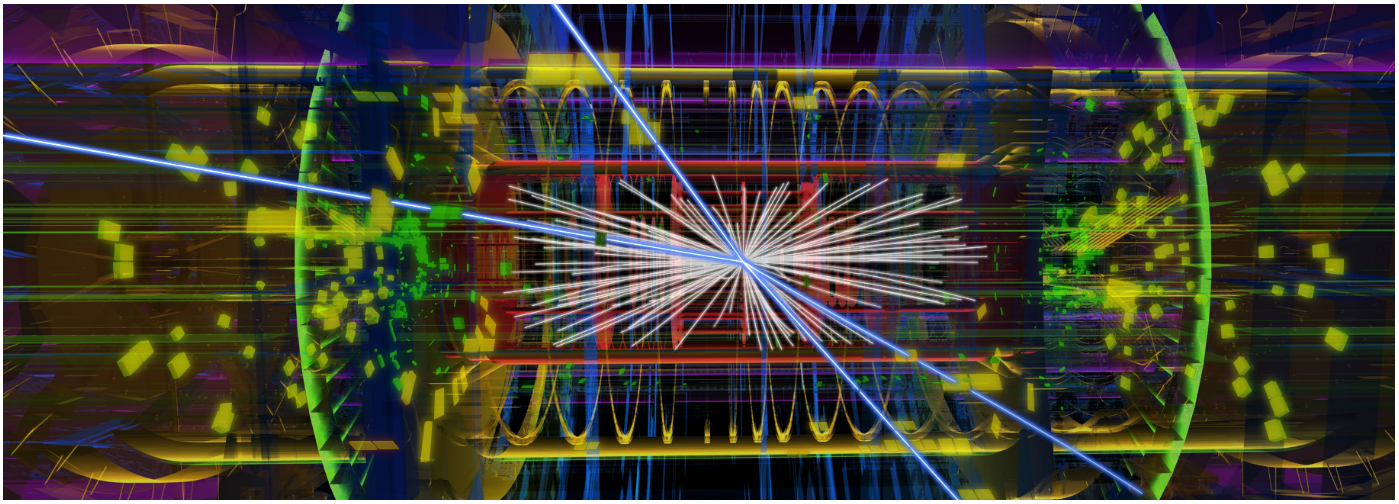
Top National Priorities

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.

SLAC builds and operates detector components for ATLAS, one of the two experiments involved in the Higgs discovery. We also develop sophisticated tools to analyze complex proton collisions and host a computing center for ATLAS data.



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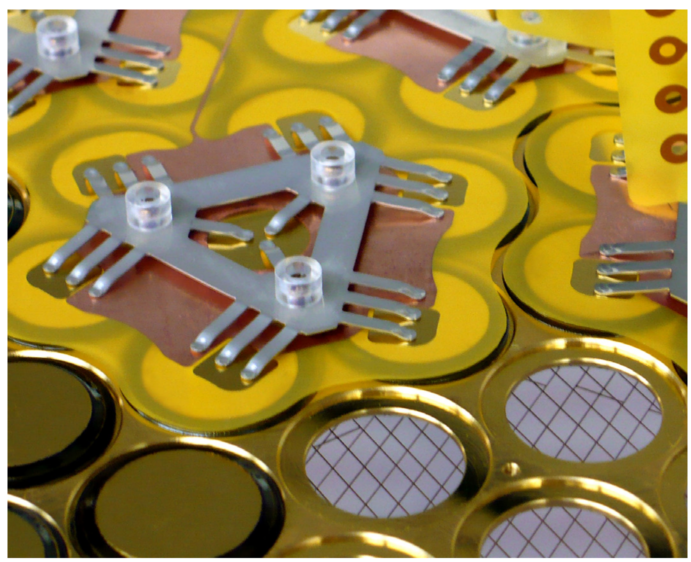
Above: SLAC physicists develop theories for particle physics, particle astrophysics and cosmology. Below: Close-up of a detector element of the Enriched Xenon Observatory, an experiment that could shine light on the properties of elementary particles known as neutrinos. (EXO Collaboration)



Particles of Dark Light

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 as a key player in the Heavy Photon Search (HPS), an experiment at Jefferson Lab in Virginia. HPS is searching for a dark, heavy version of particles of light known as photons. These dark photons could be potential carriers of dark forces between dark matter particles. SLAC designed and built a crucial part of the HPS detector. SLAC researchers also developed the theories that led to HPS and other heavy photon searches around the world.

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 four neutrino experiments. They led the construction of the underground Enriched Xenon Observatory (EXO) in New Mexico and participate in MicroBooNE and the future ICARUS at Fermilab in Illinois. They are also involved in planning the Deep Underground Neutrino Experiment (DUNE), which will send neutrinos 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. These theories advance our understanding of nature, from the properties of tiny particles to the expansion of the entire universe.

SLAC is operated by Stanford University for the U.S. Department of Energy Office of Science

105005-09-2015