

Neutrinos and Fundamental Symmetries

Quirky name, **BIG** questions

Accepted theories of the four forces of nature have made many predictions that have been verified with exquisite precision. But many big questions are completely unanswered:

- Why is there any matter in the universe? It should have disappeared shortly after the Big Bang.
- Why do particles have the masses we observe? Current theories treat masses as input parameters.
- Why are the strengths of the observed forces so vastly different? The strong force is a hundred thousand billion, billion, billion, billion times stronger than gravity.

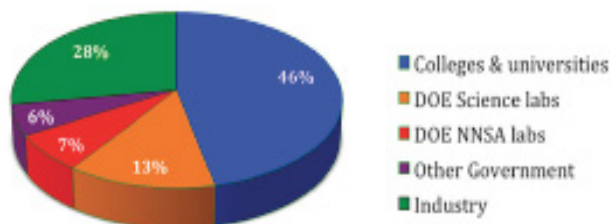
Fundamental Symmetries and Neutrinos researchers aim to provide experimental evidence and theoretical advances required to move beyond our current understanding and answer these big questions. This work is a nation-wide effort that helps train the next generation of scientists and engineers and helps keep the nation competitive by pushing technological boundaries.



Neutrinos and Fundamental Symmetries Research: Pathway to Success Beyond the Laboratory

Zhaowen Tang is an exemplar of how neutrino and fundamental symmetry research fosters the broader nuclear physics needs of the nation. For his PhD (Indiana University, 2014) Zhaowen made ultra-precision measurements of parity violation in neutron interactions. Today he is a research scientist at Los Alamos National Laboratory using proton radiography in support of national and international weapons science and stockpile stewardship.

Researchers in Neutrinos and Fundamental Symmetries like Zhaowen hail from across the U.S. and work in industry, in universities and colleges, and across the federal government.



Career distribution of nuclear science PhD recipients (2006-2009). Adapted from 2015 white paper "Nuclear Science Education and Innovation".

Neutrino Day is an annual science festival in Lead, South Dakota hosted by the Sanford Underground Research Facility. Outreach activities such as these expose even our youngest citizens to the joys of scientific discovery!

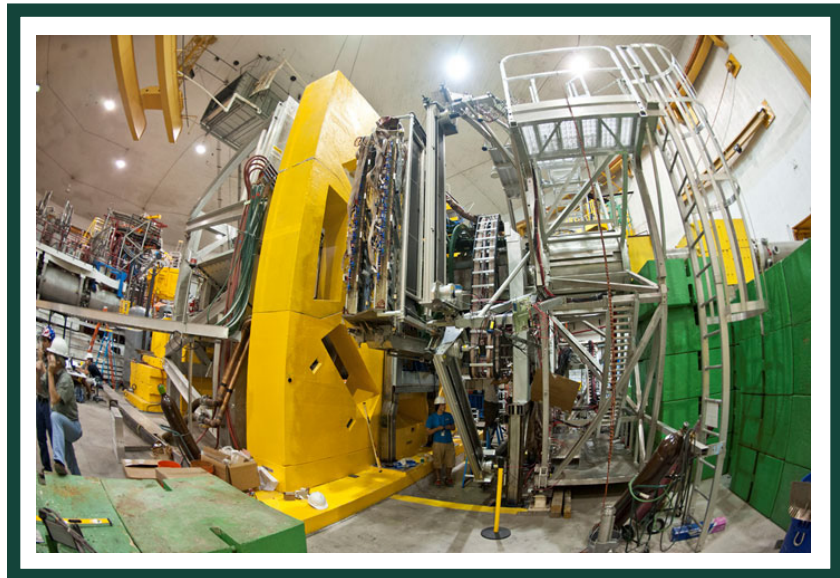


Nuclear Physics DC Day
Washington, D.C. • May 22, 2017



Emerging Initiatives: Two pioneering experiments measuring neutrino properties, both with U.S. participation, were co-awarded the 2015 Nobel Prize in Physics. The results from these experiments open the possibility that neutrinos may be their own anti-particles, a possibility that would manifest itself as an extremely rare nuclear process known as “neutrinoless double beta decay” (0NBD).

The 2015 Nuclear Science and Advisory Committee (NSAC) Long Range Plan for Nuclear Science states “The excess of matter over anti-matter in the universe is one of the most compelling mysteries in all of science. The observation of 0NBD in nuclei would immediately demonstrate that neutrinos are their own antiparticles and would have profound implications for our understanding of why matter exists in the universe. We recommend the timely development and deployment of a U.S.-led ton-scale 0NBD experiment. ... [and]... vigorous detector R&D to prepare for this exciting opportunity.”



Above, the Q-weak experiment at the Thomas Jefferson National Accelerator Facility (TJNAF).



Left, the Majorana Demonstrator experiment on a recent cover of Physics World.

Requested Action: The currently supported and proposed program of experiments and theory in fundamental symmetries and neutrinos is poised to continue to make exciting discoveries while sharpening our understanding of fundamental interactions. These activities directly contribute to the development of both advanced technology and a talented U.S. workforce capable of solving applied and basic research crucial to our national interests. We urge continued support of these students and programs.