Panel Contemplates Choices on Snowmass Menu

By Michael Lucibella

The federal government's recent High Energy Physics Advisory Panel meeting offered insight into the future of federally sponsored physics projects. Neutrino detection and the search for dark matter will dominate much of the foreseeable future of high-energy experiments in the US, while physicists work to develop designs and technology for the next generation of particle accelerators.

The September HEPAP meeting was largely an overview of discussions at the Community Summer Study 2013, held in Minneapolis in late July, popularly known as "Snowmass on the Mississippi." Snowmass laid the groundwork for the DOE's recently formed strategic planning panel. By early next year, the Particle Physics Projects Planning Panel, usually referred to as P5, is charged with delivering its roadmap for the next 20 years of high-energy physics.

Researchers participating in Snowmass created a list of major scientific questions facing the high energy physics community and possible experiments to answer them. This list includes questions on the nature of the Higgs boson, neutrinos, dark matter and dark energy, whether there are more undiscovered fundamental forces in the universe, if there are extra dimensions, and what is the origin of the matter-antimatter asymmetry. The P5 panel will use that as a resource to prioritize those questions and provide guidance for the Department of Energy and the National Science Foundation as they develop plans to fund a range of experiments.

"Snowmass is providing the menu," said Jonathan Feng, of the University of California Irvine. "Someone has to go through and actually pick the meal. That would be P5."

Future budget constraints are a concern for the planners, and their final report will reflect that. Years of flat federal budgets have reduced the scope, or caused the outright cancelation, of many physics projects. The P5 will produce three recommendations, one based on essentially a flat budget for the next ten years, one with slight increases over the same time period and an unconstrained, "pie in the sky" budget to prioritize all possible projects.

"Uncertain budget scenarios makes planning more difficult," said Jim Siegrist, the Associate Director of the DOE's Office of High Energy Physics. "It makes it hard for the labs especially, but also the university groups."

The organizers of P5 emphasized that they wanted input from the physics community while they worked. They will soon have a website set up to disseminate news and solicit input.

For some years, the Department of Energy has divided high energy physics into three categories, or "frontiers." Generally speaking, the "Energy Frontier" looks for new discoveries hidden in the powerful collisions inside of particle accelerators. Experiments aimed at the "Cosmic Frontier" look for exotic particles and signals coming from space. The "Intensity Frontier" is more broadly defined, focusing on sifting through massive amounts of data searching for extremely rare events and particle decays using very intense sources and sensitive detectors.

Several panel members and presenters at the HEPAP meeting said that there was a growing concern in the community that dividing the field into such categories would result in "stovepiping." They feared it would be difficult to fund research that didn't fit neatly into one of the three categories, and scientists might interact less across the different boundaries. However, there is no indication at present that the DOE will change these categorizations.

Since the last predicted particle in the standard model, the Higgs Boson, was discovered last year, the energy frontier lacks a single clear and obvious objective to work towards. Physicists plan to continue to study the Higgs in great detail, but as a whole, the field has moved into an area not well defined by theory.

"Confirming the Standard Model is no longer a goal… Now we're exploring," said Chip Brock from Michigan State University, "We're on a road now to figure out what particle physics means now that we've discovered the Higgs particle."

Scientists are also trying to figure out what the US will contribute to the field in the upcoming years. Likely it will play a supporting role in the Energy Frontier for the foreseeable future. CERN's Large Hadron Collider is the undisputed leader for high energy particle collisions, and many US laboratories and scientists are part of the international collaborations that use it. The biggest accelerator on US soil, Fermilab's Tevatron, was shuttered two years ago.

One suggestion from Snowmass is that DOE scientists develop next-generation detector and accelerator technologies and work on designing the successor to the LHC. During his presentation, Nick Hadley of the University of Maryland highlighted a list of recommendations from Snowmass that included "Develop technologies for the long-term future to build multi-TeV lepton colliders and 100 TeV hadron colliders."

Researchers in the Cosmic Frontier seem to have a clearer path forward. The big questions facing the community largely circle around the nature of dark matter, dark energy and cosmic neutrinos, for all of which there are already an array of experiments in progress and in development.

Researchers in the field have expressed the view that the next ten years will be the "decade of dark matter detection". Jonathan Feng highlighted how complementary direct and indirect detection experiments seem to be on the verge of finding the elusive particles. Currently running programs like the CDMS-II dark matter detector, the VERITAS gamma-ray telescope, and IceCube's Deep Core neutrino detectors already have planned successors like SuperCDMS, CTA and PINGU, respectively.

Dark energy is a thornier problem, but also one with a self-evident roadmap for the near future.

"Right now there is no compelling theoretical idea," Feng said. He added that while physicists continue to lack an explanation as to why the universe's expansion is accelerating, they are in good shape to use new astronomical observations to pin down exactly how fast it's speeding up. In the next ten years, researchers should be able to determine the rate of expansion down to a few percent.

The intensity frontier is full of many medium-sized experiments and detectors spread across the globe looking for a variety of new physics. Many are based in the United States, and those that aren't often have US funding and researchers.

Many of the same questions facing researchers at the intensity frontier linger from the previous P5 report in 2008. In the time since then, the mixing angles of neutrinos have been measured; however, questions persist about neutrinos' mass, whether they are Majorana particles and if there are more flavors.

"We have a clear path forward for precision tests of the three flavor paradigm, and exploration of anomalies building off these successes," said Harry Weerts of Argonne National Labs.

The biggest project to address these questions is the Long Baseline Neutrino Experiment with detectors in South Dakota on the receiving end of a neutrino beam originating at Fermilab's Project X. Its backers have described the project as the most important neutrino experiment in the works, but budget constraints may prevent its detectors from being located deep underground, shielding them from cosmic rays. Planners are still hoping to find ways to make up the $150 million shortfall needed to locate the experiment deep in the mine.

Smaller and midsized projects are also planned. These include searches for axions at ADMX, rare kaon decays at ORKA, and proton decays at Super-K and the planned Hyper-K detectors, among other experiments.

The final, 350-page report from "Snowmass on the Mississippi" is due out in early October. The P5 recommendations will be sent to HEPAP by March of next year, which will review and sign off on the plan by May.

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