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## At DOE, Body Blows to Fusion, Nuclear Physics, and Particle Physics

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Overall, the budget numbers for the Department of Energy's (DOE's) Office of Science, the single largest funder of physical sciences research in the United States, look reasonably good. The office would see its budget climb by 2.4% to \$4.992 billion. Three of the office's six major research programs, however, are slated for potentially devastating cuts. While programs with connections to clean energy technologies come out ahead, the fusion energy science, nuclear physics, and high-energy physics programs suffer.

President Barack Obama has made clean-energy research a priority, and officials at the Office of Science had designated research on advanced materials for energy, advanced biofuels, and high-performance scientific computing as critical areas. Those priorities show through in the budget request released today. The office's single largest program, basic energy sciences, which funds research into condensed matter physics, chemistry, and materials, would see its budget climb 6.6% from its current level to \$1.80 billion. Similarly, the biological and environmental research program, which houses DOE's biofuels research, would get a bump of 2.5% to \$625 million. And the office's program in advanced scientific computing research would get a 3.3% increase to \$456 million. DOE's Advanced Projects Research Agency-Energy (ARPA-E), which aims to quickly develop the most-promising energy related basic technologies, would see its budget rise from \$275 million to \$350 million.

On the flip side, the Office of Science's three other programs suffer cuts that, although seemingly small, could have severe consequences.

In the single most dramatic shift, DOE would pay for an increased contribution to the ITER international fusion project by diverting funds from its domestic fusion programs, including shuttering a fusion experiment known as the Alcator C-Mod at the Massachusetts Institute of Technology (MIT) in Cambridge. Overall, the fusion energy sciences budget falls by 0.8% to \$398 million, but increases the U.S. contribution to ITER to \$150 million, up from \$105 million this year. That shift forced officials to throw some things overboard, including MIT's \$18 million budget for C-Mod. That machine is a donut-shaped device known as a tokamak that uses magnetic fields to trap an ionized gas or plasma and hold it at very high temperature and pressure. C-Mod is one of three tokamaks in the United States and a cousin of the gigantic \$23 billion ITER that researchers are planning to build in Cadarache, France.

"I'm dismayed, but not surprised," says Raymond Fonck, a fusion physicist at the University of Wisconsin, Madison. C-Mod had not yet been mined out scientifically, Fonck says, but there were arguments for keeping up the United States' two other tokamaks—at the Princeton Plasma Physics Laboratory in New Jersey and General Atomics in San Diego, California. Fusion physicists have long worried that the U.S. contributions to ITER would starve the domestic fusion program, and that appears to be happening. In the new budget, fusion research would receive 45% of the money, ITER would receive 45% of the money, and operations of the U.S. facilities would receive just 10% of the resources, a far cry from the roughly 50% considered optimal. "To have a 10% operating budget is kind of insane," Fonck says. "I understand where it's coming from, but we're already under utilizing our facilities."

DOE's nuclear physics program would see its budget fall 3.6% to \$527 million. But even the \$20 million cut would have big consequences. For example, the budget would provide enough money to run an atom smasher known as the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory in Upton, New York, for roughly 10

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weeks—half of the time it will run this year. However, RHIC is already running at 2/3 capacity, and if such foreshortened runs continue, it could be the beginning of a "death spiral," says Steven Vigdor, associate director for nuclear and particle physics at Brookhaven. RHIC recreates a soup of fundamental particles called a quark-gluon plasma that filled the universe a microsecond after the big bang. Similarly, the budget provides \$22 million for development of a new accelerator known as the Facility for Rare Isotope Beams (FRIB) at Michigan State University in East Lansing, instead of the \$55 million university officials were expecting. FRIB would generate exotic nuclei for a wide variety of experiments.

Researchers say that with flat budgets expected for years to come, officials in the nuclear physics program may soon have to sacrifice one of three major projects. In addition to supporting RHIC and FRIB, the nuclear physics program also supports the Continuous Electron Beam Accelerator Facility (CEBAF) at Thomas Jefferson National Accelerator Facility in Newport News, Virginia. CEBAF studies the structure of individual protons and neutrons and of nuclei. "Looking at the numbers, it seems to me that what the nuclear physics officials are trying to do is keep everybody alive, but just barely, this year with an eye to making a decision in 2014," Vigdor says.

The news for high-energy physicists may be even worse. The budget for such research, which explores fundamental particles and forces primarily through particle collisions, would fall 1.8% to \$777 million. That sounds like a mere haircut, but the effect at the United States' last dedicated particle physics laboratory, Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, could be momentous. "At first blush, it looks like a fairly disastrous budget," says Fermilab Director Pier Oddone.

That's because the budget cuts research and development for what would be Fermilab's flagship project in the next decade. Researchers hope to build a gigantic underground particle detector called the Long-Baseline Neutrino Experiment in the abandoned Homestake mine near Lead, South Dakota, to snare particles called neutrinos fired 1300 kilometers through Earth from Fermilab. But plans to develop the mine have stalled and the budget cuts spending on LBNE from \$21 million this year to \$10 million. That cut threatens the entire project, Oddone says. "It seems that we'll have to ramp down spending by more than a factor of two," he says, "which won't leave enough to keep it alive." Overall, cuts in the high-energy physics budget would see Fermilab's budget fall by 5.1% to \$366 million. And if plans for Fermilab's future founder, larger cuts could follow in years to come.

In almost any budget, there are winners and losers. But in the Office of Science budget for 2013, the losers take a real drubbing. It remains to be seen whether Congress will agree with the Administration's priorities.

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