

deposited in the ocean should be similarly confined is still an open question, she says. Unrestrained, the material might become incorporated in regrown sea ice that, due to its higher albedo, should melt more slowly than normal newly formed ice, perhaps acting more like multiyear ice, Field says.

Field estimates it would take \$500 million in materials to cover 50 000 km², an area roughly the size of the ice loss experienced in 2000, which was an order of magnitude smaller than this year's decline. The cost obviously grows if the materials need to be contained or retrieved. And shipping and deploying adds fur-

ther costs, she says. Because Field insists that any geoengineering be readily reversible, she says it might be advisable for a strategic placement of soot to be readied to counteract the geoengineered albedo enhancement. Field acknowledges she has yet to have her research published in a refereed journal.

Apart from the uncertain environmental impacts of releasing so much material into the ecosystem, the potential fouling of the floating glass by marine organisms, which would reduce their reflectivity, could be another drawback of the Ice911 approach.

David Kramer

Dark-matter search gets started deep in Sanford Lab

If more experiments, in particular the Long-Baseline Neutrino Experiment, go forward, what scientists had hoped to get in one go will instead be realized incrementally.

The outlook for building a US underground laboratory nosedived in late 2010 when NSF pulled out of the project. But quietly and with little fanfare, such a lab is being realized in the defunct Homestake gold mine, thanks to unwavering support from the host state of South Dakota and philanthropist T. Denny Sanford and to the Department of Energy. In August 2011 DOE stepped up with operations money to keep alive two experiments in the mine: the Large Underground Xenon (LUX) search for dark matter and the Majorana Demonstrator for neutrinoless double beta decay (see PHYSICS TODAY, February 2011, page 21, and August 2011, page 23).

"DOE had thought of itself as putting experiments in the facility," says Los Alamos National Laboratory's Steven Elliott, spokesman for the Majorana Demonstrator. "Taking responsibility for the facility itself was different." Tensions were high for a while, he says. "But the longer we are there, and DOE supports us, the more confident we become. We hope we are not the turkey before Thanksgiving." DOE is so far ponying up \$15 million a year; its activities at the lab are overseen by a team based at Lawrence Berkeley National Laboratory.

Now known as the Sanford Underground Research Facility, the site has been excavated, renovated, and outfitted using some of the \$70 million from Sanford and \$40 million from South

Dakota, and the governor has requested another \$2 million in state funding for the next fiscal year. The Sanford Lab celebrated its opening on 30 May 2012. The next day, experiments began moving in.

Both the Majorana Demonstrator and LUX were poised to begin collecting data as PHYSICS TODAY went to press. And on 10 December 2012, the DOE granted preliminary approval to the Long-Baseline Neutrino Experiment (LBNE), in which intense beams of neutrinos would be shot 1300 km from Fermilab to the Sanford Lab. "That is a very big deal," says LBNE spokesman Bob Svoboda of the University of California, Davis. "Ongoing projects weather things like continuing resolutions better than new [projects]." Moreover, the prospect of the Sanford Lab hosting the LBNE, with its 20-year lifetime, could well attract to the site other experiments that require shielding from cosmic rays.

Getting started

The LUX detector is located 4850 feet deep in the Davis campus—named for Ray Davis Jr, whose pioneering solar neutrino experiment began running in the Homestake mine four decades ago. The dark-matter detector consists of 350 kg of xenon in a cryostat suspended in a 70 000-gallon tank of purified water. Experimenters are looking for a recoil signal—of both light and charge—when weakly interacting massive particles pass through. The WIMPs

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would have a characteristic energy deposition of about 10 keV. "After a few weeks, we will have surpassed the combined sensitivity of all other dark-matter experiments," says spokesperson Daniel McKinsey of Yale University. "We have a bigger detector, and the detector itself has low radioactivity." Whether or not dark matter is spotted, the plan is to run LUX through early 2015, with hopes to then scale up to a larger xenon detector, dubbed LZ.

The Majorana Demonstrator is testing its first detectors. Germanium-76 is both the source and detector for neutrinoless double beta decay, and the experiment hinges on reducing the background (see PHYSICS TODAY, January 2010, page 20). To reduce radiation from the apparatus itself, the copper cryostats and other components are being electroformed underground in a clean room at the Sanford Lab. For increased sensitivity, three-quarters of the 40 kg of germanium is being enriched at \$90 per gram from its natural abundance of 7.5% to 86% ^{76}Ge . "We will either see or place a limit on the rate of double beta decay," says Elliott. "But what DOE has mandated us to do is to measure the background in the relevant energy region"—a 4-keV spread around 2039 keV.

That, he says, will take about three years. "Then we will compare with the GERDA experiment being built in Europe [in Italy's Gran Sasso National Laboratory] on a similar time scale," Elliott says. "We hope to compare background rates, and then for the two collaborations to come together and cherry-pick technologies that work best and propose a larger, ton-scale double beta decay experiment."

Determining whether neutrinos are Majorana—that is, their own antiparticles—is likely to require a larger detector. But even with 40 kg of ^{76}Ge , scientists expect to test the controversial Heidelberg-Moscow claim in which a subset of scientists in an experimental collaboration claims to have seen lepton number violation.

The Sanford Lab site is also host to a smattering of other experiments in geology, physics, engineering, and biology. Instruments are located at multiple levels, says lab spokesman Bill Harlan. "Mostly they are small experiments and don't require a lot of infrastructure."

Another potential tenant is DIANA, the Dual Ion Accelerators for Nuclear Astrophysics. Two underground accelerators covering the energy range 50 keV to 3 MeV would measure various nu-

clear reactions that occur in the Sun and stars. "The reactions have extremely low cross sections. That is why stars live so long," says project principal investigator Michael Wiescher of the University of Notre Dame. The roughly \$50 million DIANA does not yet have funding. The Sanford Lab is one of three possible sites, along with an active lime mine in Kimballton, Virginia, and the Soudan mine in Minnesota.

Bare-bones long baseline

The version of the LBNE now on the table is a far cry from what scientists are actually hoping to build. In slashing the price tag from about \$1.5 billion to \$867 million as DOE required, says Svoboda, "we went through the budget with a fine-toothed comb. Electronic security system? We put a padlock."

The facility would be central to Fermilab's post-Tevatron strategy to develop a world-leading program in the intensity frontier of particle physics. In



MATT KAPUST/SANFORD LAB

The Large Underground Xenon (LUX) detector (top) is poised to be the first to collect data at the Sanford Lab. The dark-matter detector's xenon is in the central cryostat; the surrounding vessel has now been filled with 70 000 gallons of purified water. The tunnel (bottom) on the left is 4850 feet deep and leads to the Davis campus, where both LUX and the Majorana Demonstrator are located. On the right is a shaft leading back to the surface.

its full glory, the LBNE would have a 34-kiloton underground detector in South Dakota and another detector close to Fermilab to keep tabs on what is actually in the outgoing beam. But to almost halve the price, drastic measures are proposed: Instead of a near detector for neutrinos, the reduced version would have a simpler muon detector, which gives indirect information about what is in the neutrino beam. The Sanford detector would be trimmed from 34 tons to 10 tons, and instead of going underground, it would sit on the sur-

face at the South Dakota site.

"What we did not compromise is the long-distance, upgradeable neutrino beam" at Fermilab, says Svoboda. "You can't add that back." In the bare-bones version, neutrino oscillations could be studied because the incoming neutrinos arrive in pulses and can be distinguished from the background. But a full-sized underground LBNE would have much broader applications. It could be used to look for supernovae, atmospheric neutrinos, and proton decay, among other things. "This is our

frustration," says Jim Strait, LBNE project director. "You could get a lot more science for an incremental amount of money." Putting the detector underground would add about \$130 million.

The LBNE team's plan is to seek non-DOE and international partners to build a near detector, increase the far detector size, and put the far detector underground. "We are beating the

bushes to find other resources," Strait says. For starters, scientists in India have submitted a proposal to their funding agencies to build a near detector, which would help the LBNE oscillation physics studies and be used to make precision measurements of neutrino cross sections and electroweak parameters and to search for new physics.

Toni Feder

Good news for space research in massive defense package

A new law authorizing the Department of Defense and the nuclear weapons operations of the Department of Energy for the current fiscal year includes provisions that loosen controls on international scientific cooperation in space and that encourage establishment of US production sources for a key medical radioisotope. The National Defense Authorization Act (NDAA) also orders DOE's National Nuclear Security Administration (NNSA) to resume construction of a new plutonium pit fabrication plant at Los Alamos National Laboratory, a project the Obama administration had wanted to delay for at least five years. The law authorizes \$70 million in FY 2013 for the project, known as the chemical and metallurgy replacement facility, sets a deadline of 2026 for its completion, and caps its cost at \$3.7 billion.

But the final version of the 680-page NDAA signed into law by President Obama on 3 January did not contain House-passed provisions that would have ordered major changes to the NNSA's oversight of the nuclear weapons laboratories and a major reduction to the NNSA workforce. Those measures, authored by Representative Michael Turner (R-OH), chairman of the Armed Services Committee's strategic forces subcommittee, were aimed at reducing the NNSA's perceived micro-management of the labs (see PHYSICS TODAY, May 2012, page 26). In their place, the act ordered establishment of a congressional commission to study and report on the relationships among the NNSA, the national laboratories, and their contractors and to recommend fixes if deemed necessary.

Space R&D eased

Space scientists and universities applauded a provision that will remove nonmilitary satellite technology from

the International Traffic in Arms Regulations (ITAR), the government's most restrictive export-control regime. Since 1999 all satellite and launch-system hardware, including that used for commercial and research purposes, has been included on the ITAR munitions list, and foreign nationals have been barred from working with or even receiving information about such hardware. US higher education associations have complained that the restrictions hamper US universities' and scientists' participation in many space-related research projects, collaborations, and classes (see PHYSICS TODAY, October 2010, page 23).

Following recommendations from a two-year review by the Defense and State departments, the NDAA directs that space hardware not used for military purposes be removed from the munitions list. As a result, such items as communications satellites, low-resolution remote sensing satellites, and other unclassified components are expected to be moved to the Commerce Department's less restrictive export regime, the Commerce Control List. Although licenses are still required for the export of all or most hardware on the Commerce list, licenses aren't needed to permit foreign nationals engaged in fundamental research to use those devices.

A significant caveat is that ITAR restrictions on space hardware will still apply to China, North Korea, and nations designated by the US as state sponsors of terrorism. The restrictions are problematic for universities because a large proportion of graduate students in the technical fields are Chinese nationals. Thomas Zurbuchen, professor of space science and aerospace engineering at the University of Michigan, says that in one class he teaches, fully half of the students are foreign nationals and one-third of those are Chinese.

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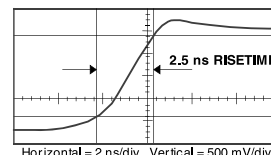
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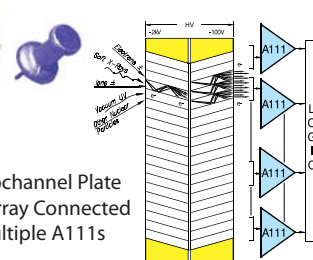
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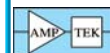


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