Enthusiasm Deepens for US Underground Physics Lab FREE

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For NIF itself, even apart from stewardship, a lack of ignition wouldn't mean failure, Drell said. "As in all projects, you're going to improve and learn something and I'm willing to believe that what we'll learn will be an important step. You look at high-energy physics, and you find out that machines, when you build them, you have to work and tune them up and eventually you find out how to get beyond even what your original goal was. I think that is good science."

Bodner doesn't have that much faith in NIF. "The whole thing, from one end to the other, has problems," he said. "With the end of underground testing, the nuclear weapons program needs cautious, conservative scientists, not optimistic entrepreneurs. It needs stockpile curatorship, not stockpile stewardship. NIF was designed to maintain science at the center of the nuclear weapons program, and I think there is a time when scientists ought to say they shouldn't be at the center."

JIM DAWSON

Enthusiasm Deepens for US Underground Physics Lab

When US scientists want to shield their experiments from cosmic radiation, they usually head to the large underground labs in Italy and Japan. Now, a chance to take over the Homestake gold mine in South Dakota, plus an invitation from the Department of Energy to host experiments in its Waste Isolation Pilot Plant (WIPP), a nuclear waste repository near Carlsbad in southeastern New Mexico, has sparked a groundswell of enthusiasm for establishing a major subterranean lab in the US.

> A cross section of physicists has revived efforts to build a Gran Sasso-style underground facility in the US.

It's too early to say how the idea will stack up against competing physics projects. "There's no proposal on the table," says Brad Keister, NSF's program director for nuclear physics. "The community has our attention, and we are listening." In a few months, a committee of astro-, nuclear, and particle physicists will report to NSF and DOE on the need for a US underground facility, as well as on the cost, radioactivity, and technical features of possible sites—including WIPP, Homestake, and Mt. San Jacinto near Palm Springs, California.

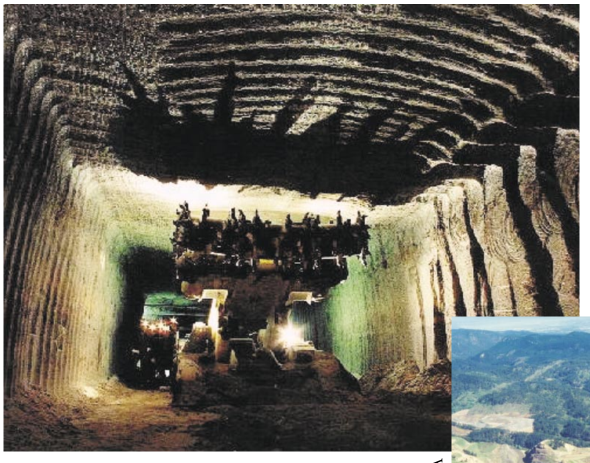
Selling the idea

To be sure, the US has a scattering of underground experiments, including in both WIPP and Homestake. But scientists say they need a dedicated underground facility with shared infrastructure and better visibility—and funding—for their experiments. Says University of South Carolina particle physicist Frank Avignone, "I have worked at Homestake, and there's not enough room. The Soudan mine [in Minnesota] is not deep enough. . . . I've worked in Baksan in Russia, and in an iron mine in Argentina. Gran Sasso [National Laboratory] in Italy is beautiful, but there's no more room. I guess what I'm saying is that I can't find a home. In the US we ain't got nothing."

"We've gone from having no good possibilities to having a couple that are really outstanding," says Wick Haxton, a nuclear astrophysicist at the University of Washington and a member of the underground lab committee. "The real push for all this is not that sites are available, so much as the wonderful science."

A dozen or so experiments, at various stages of contemplation, construction, R&D, and funding, are on the docket for a US underground lab. They include detectors for dark matter, proton decay, and double-beta decay, and for neutrinos from the Sun, the atmosphere, supernovas, and neutrino factories. There is also talk of putting in equipment to purify and store germanium, which cosmic rays make radioactive.

The debate over whether and where to open a national underground lab centers on the question, How deep will do? The answer depends on the particular experiment and is tangled up with costs and technical considerations ranging from excavation to elevator size. The details are fuzzy. Homestake is the US's deepest mine, at 2500 meters, while WIPP is about 650 meters deep. But there are other trade-offs, and both sites have advocates. "If the experimentalists come together and form a consensus and say, 'We should do X,' whatever X is, I will help sell their idea," says John Bahcall, a theoretical astrophysicist at the Institute for Advanced Study in Princeton,



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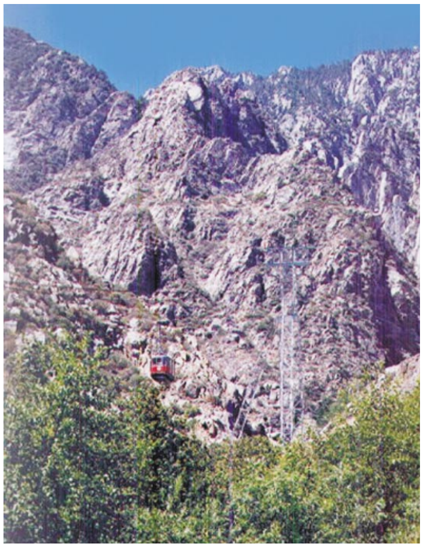


BOB DOLLINS

HOW DEEP? HOW CLEAN? WHAT PRICE? Candidates for a US underground lab include WIPP, the nuclear waste burial site in New Mexico (top left); the soon-to-be defunct Homestake gold mine in South Dakota's Black Hills (above right); and a virgin site in California's San Jacinto mountains (bottom left).

New Jersey, and chair of the underground lab committee.

Mining for sites

The impending shutdown of the Homestake mine at the end of this year means the science community and funders have to act fast: Unless money is found to keep it open, the pumps will be turned off and the mine will flood. "We have a short time window," says University of Pennsylvania astrophysicist Ken Lande, who is leading the efforts to keep the 125-year-old mine open. "We either turn it into a scientific facility or [the company] will seal the shaft, and that option will disappear—once it's gone, the cost of reinventing would be huge. An opportunity for US scientists would die."

Homestake has the lowest cosmic-ray background levels of the potential US sites. For example, at 1475 meters (accounting for the mine's rock density, that's about 4000 mwe, or meters of water equivalent), where Ray Davis's original 1965 chlorine neutrino detector is still in use, the background is about 50 times lower than at 650 meters (2000 mwe) in WIPP. Homestake has some 600 miles of tunnels; dug-out levels every 50 meters; and electrical, communications, elevator, ventilation, and pumping systems.

Eager to save jobs and bring prestige to the area, South Dakota is negotiating to take over the mine. Maintaining Homestake will run \$4–5 million a year, estimates Sherry Farwell, dean of graduate education and research at the School of Mines and Technology in Rapid City, which would assume the day-to-day mine maintenance. The cost of converting it into a full-scale, multiexperiment lab will depend on what's installed. "You don't have to decorate, but you can," says Lande. "It's in move-in condition."

DOE, meanwhile, is keen to host experiments at WIPP. Intended as a permanent burial site for transuranic waste, WIPP has been controversial since digging began there more than 20 years ago (see PHYSICS TODAY, May 1999, page 59). Setting up sensitive experiments would be good for public relations, says chief WIPP scientist Roger Nelson. "Listening for nature's secrets whispered across the galaxies, right next to megacuries of transuranic waste, would send laypeople the message that nuclear waste is not universally bad."

Ironically, WIPP would provide a clean environment. The experiments would be separated from the nuclear waste by about a kilometer of solid salt, which has very low intrinsic radioactivity; it has potassium, but unlike rock mines, no uranium or thorium. Indeed, scientists have been doing low-background tests in WIPP since 1992. But computer facilities, clean rooms, and aboveground labs, among other things, would have to be added to turn the site into a major user lab. Caverns could be dug down to 1200 meters, or nearly twice WIPP's current depth, says Nelson. He adds that salt is easier and cheaper to dig than rock—although it creeps and so must be constantly reexcavated.

In addition to making space for experiments, DOE's Office of Environmental Management, which runs WIPP, would operate the mine and provide power, communications, and other services. It has even offered to help scientists apply for DOE funding for their underground experiments.

WIPP's main attractions are its immediate availability, its low background radioactivity, perks from DOE, and its expected lifetime of 35 years—needed for long-term experiments like looking for supernova explosions. Its main drawbacks are that it is not deep enough for some experiments, particularly those seeking solar neutrinos, and that a lab would take the back seat to the site's main mission of nuclear waste storage. Scientists are also concerned that foreign researchers might have trouble gaining access to WIPP.

Another possibility, burrowing to a depth of about 1800 meters (5000 mwe) into Mt. San Jacinto, has metropolitan proximity and horizontal road access going for it. "Anyone who's worked underground knows it's much easier to be able to drive into a site," says Bill Kropp, a particle physicist at the University of California at Irvine who is organizing an engineering study at Mt. San Jacinto. "Another problem is that most mines leak water. With a road you can make a slight slope and use gravity instead of pumps. And I can guarantee it will be cheaper to maintain a horizontal road than a vertical shaft and elevators."

The Soudan mine—which harbors a dark-matter experiment and the Main Injector Neutrino Oscillation Search, or MINOS, a detector for neutrinos that will be shot from Fermilab—is an unlikely national underground lab candidate. It is no deeper than WIPP and lacks the advantage of low intrinsic radioactivity.

Experiments will step up at WIPP one way or another. The choice boils down to settling for relatively shallow—but existing—facilities, or paying to create a deeper one. Says Bahcall, "I think it's very unlikely that both Homestake and San Jacinto would proceed—but it's not unlikely that WIPP and one other might proceed."

Intellectual scope

The biggest experiment on people's lips is UNO (Ultra Underground Nucleon Decay and Neutrino Observatory), a water Čerenkov detector scaled up an order of magnitude from the 50-kiloton Super-Kamiokande in Japan. UNO's main aim would be to look for proton decay. It would also detect neutrinos from supernovas, the atmosphere, and the Sun, says UNO mastermind Chang Kee Jung of SUNY at Stony Brook. "Another major thing is that it could be used as a long-baseline target from a neutrino factory." Jung puts UNO's price tag at roughly \$500 million—far more than the underground lab itself would cost. "The biggest challenge is getting the money. As long as the rock quality is okay to build a large cavern, most sites would do. If we discover proton decay, nobody will protest the amount of money. If we don't, how much is it worth?"

Another project is OMNIS, for which a prototype is in the works at WIPP. The idea is for a 12 000-ton lead and iron target to sit for decades, waiting for signs of supernovas in the form of neutrons knocked out by impinging neutrinos. OMNIS would detect muon and tau neutrinos and antineutrinos, and would reveal their masses, says Ohio State University's Richard Boyd, one of the project's leaders. To help secure funding for those long-term aims, he adds, OMNIS may take a "day job," perhaps as part of a cosmic-ray shower coincidence detector.

Two double-beta decay experiments are also on the physicists' wish list: EXO (Enriched Xenon Observatory) and Majorana. Their goal would be to determine if neutrinos are Majorana- or Dirac-class particles—that is, whether or not neutrinos are their own antiparticles—and to measure neutrino mass. In both cases, the sought-for signal would originate in the detector itself, as spontaneous nuclear decay; EXO would be made from 10 tons of xenon-136, while Majorana would use 500 kilos of germanium-76.

Among the dark-matter searches in sight is a German initiative called GENIUS. It would look for recoil signals from WIMPs (weakly interacting massive particles) in a ton of germanium sheathed by a tank of liquid nitrogen.

And a small, low-energy accelerator to mimic stellar fusion might also go underground. A follow-on to Gran Sasso's LUNA, the accelerator would, in addition to being shielded from cosmic rays, shoot heavy ions onto a light-ion target, thereby keeping reaction products in a narrow angle and upping the signal-to-noise ratio. "We want to simulate the origin of elements in stellar evolution," says University of Notre Dame's Michael Wiescher, one of the project's planners and a member of the underground lab committee. "The reactions are slow, guaranteeing a long lifetime for stars. We need high intensities—we don't have a million years."

All that is just an appetizer. More ideas for experiments are catching hold, fueled by recent spectacular successes in underground physics—notably the 1987 detection of a supernova explosion and strong evidence in 1998 from Super-Kamiokande that neutrinos change flavor. (See the story on page 16.)

The physics successes are also behind the renewed interest in a US underground lab. "The scope of intellectual questions is broader than what can be answered with accelerators [alone]," says Barry Barish, a high-energy physicist at Caltech who is serving on the underground lab committee. "When you move out of accelerators, you cross fields—particle and nuclear physics and astrophysics."

Alfred Mann, a particle physicist at the University of Pennsylvania, spearheaded a failed effort to get a US underground lab in the early 1980s, around the same time that Gran Sasso opened in Italy. "There was not a great deal of interest—there never is when you want to do something new," he says. Things went as far as selecting a site. But when it came time to dole out money for large-scale equipment, says Mann, the idea for an underground lab lost out to accelerator physics.

If the idea has any viability this time, says Barish, "it's because it addresses fundamental questions in several different areas."

Toni Feder

Holt Holds onto Congressional Seat, Keeps Science in Politics

Holt

As Congressman Rush Holt (D-N.J.) looked at the final vote tallies in his unnervingly close reelection bid in November, his thoughts turned to measurement design theory and the role of noise in ballot tabulations. This was political science with a twist, because Holt is the Princeton University plasma physicist who won a seat in the House of Representatives in 1998, and he can't help but approach politics with a great deal of science. Vern Ehlers (R-Mich.) is the only other physicist in Congress.

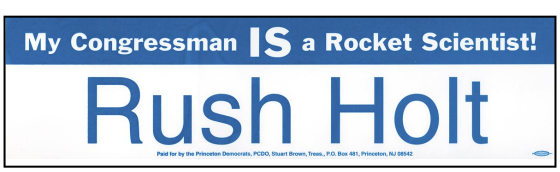
Holt kept his seat from New Jersey's 12th district by surviving a strong challenge from Republican Dick Zimmer, who had held the same seat for three terms in the early and mid-1990s. The 30 000 voters in the district gave Holt the victory by a mere 500 votes and, in an echo of the presidential drama in Florida, Zimmer insisted on a recount.

"Each day of the recount I gained votes and when the margin grew from about 500 to 750, he pulled the plug," Holt said of Zimmer. Holt said he has already drawn up legislation calling for a commission to come up with recommendations of ways to standardize voting procedures in federal elections. His goal, he said, is to come up "with a lower noise measurement system" for voters.

Beyond that, Holt said he wants to double federal nondefense R&D spending, make the R&D tax credit permanent, improve and expand programs for science and math education in the public schools, and rekindle the debate over the need for a progressive federal energy policy.

As he watched CNN coverage of the Bush–Gore battle in Florida, Holt explained the difference between hard science and political science: "In science you're supposed to follow the evidence wherever it leads and let the chips fall where they may. But where the chips fall is what politics is all about."

Jim Dawson



UK Boosts Pay, Joins ESO, in Science Spending Spree

The UK government has announced substantial new money for higher education, academic salaries, and research. Over the next three years, the science budget will increase by 26% from £1.7 billion (about $2.5 billion) to £2.15 billion, while education will get an 18% increase to £6.4 billion. The majority of the new science funding will be spent on either life sciences or interdisciplinary programs. However, the Particle Physics and Astronomy Research Council (PPARC) has done particularly well compared to the last spending review three years ago, when it was the only research council that received no funding increase above inflation. Its budget will go up 20% from £194 million to £232 million by 2004. "This new funding will ensure our physicists and astronomers remain at the forefront of international research," says Ian Halliday, PPARC CEO.

Thanks to lobbying by astronomers, £10 million of the new PPARC money will go to joining the European Southern Observatory (ESO) in Chile (see Physics Today, September 2000, page 55). "This is excellent news for UK science and lays the foundation for cutting-edge research over the next 10 years," says Mike Edmunds, chairman of the Astronomy Vision Panel, PPARC's long-term planning committee for astronomy. "British astronomers will be delighted by the government's rapid and positive response to their case."

The money will buy UK astronomers 20% of the time on the Very Large Telescope as well as time on the Atacama Large Millimeter Array being built in Chile. Despite the good news, cuts of more than £5 million a year in the UK's astronomy program will have to be made over the next 10 years to afford the £70 million joining fee that comes on top of the £12 million annual membership dues. Recommendations for the cuts will be made public in February.

PPARC also won a £26 million grant for two projects from the Department of Trade and Industry's "e-science" program. That money will fund research into the creation of Astro-grid, a virtual observatory combining astronomical data from many space- and ground-based observatories, and DataGrid, a network system for analyzing data from CERN's Large Hadron Collider.