

cation that couldn't have been foreseen at the project's outset: A prototype system deployed at the airport in Albuquerque, New Mexico, to screen carry-on luggage has been able to discriminate potentially dangerous liquids from benign ones. The lab boasts that its "MagViz" system could make current travel restrictions on liquids obsolete.

Modeling a cleanup

Roger Aines, one of the inventors of the LLNL process used to clean up the Visalia pole yard, credits the LDRD with financing the development of models predicting how the toxic pollutants move through the ground. A second LDRD project at the lab provided the basic chemistry that produced the process that cleansed groundwater at the site. The cleanup processes have been used at several DOE and DOD cleanup sites. The largest application is under way at DOE's Savannah River site, where the contaminant is the industrial solvent trichloroethylene.

The largest-ever LDRD undertaking at LLNL involved 50 staffers and cost \$7 million a year for three years. Completed this past March, the transformational materials initiative was a collection of projects linked by the common theme of reducing the cost and improving the efficiency of nuclear stockpile maintenance, says Robert Maxwell, the

principal investigator. In one effort, researchers studied the feasibility of recycling the high explosives that are removed from nuclear weapons during dismantlement for reuse in conventional munitions or in future nuclear warheads. Another group developed diagnostic devices that could be retrofitted onto warheads so that lab experts might be alerted immediately when a deployed weapon required servicing.

Some of those diagnostics could have applications outside the stockpile, Maxwell explains. A microelectromechanical stress detector is now being tested in animals with funding provided by DOD. It may improve the understanding of how shock waves from blasts are transmitted or diffused by helmets and other battlefield personal armor (see also page 20). "You put these sensors between the personal protective equipment . . . and the body," Maxwell says. "Then you expose the animal to shock and look at how well the shock is transmitted or diffused. It helps you understand how the shock is transmitted to the various parts of the human body." He adds that DHS is evaluating a gas-detection sensor developed by the project for potential use in homeland security applications.

Energy and security overlap

McBranch says that LANL tries to se-

lect LDRD projects that address multiple missions. Thus, while \$87 million of its \$127 million LDRD program for this year will be relevant to homeland security issues, \$71 million of the total expenditure also is relevant to energy challenges. Improvements to the nation's electric grid should make it more resilient to a terrorist attack or to natural disasters, he notes. Actinide materials chemistry addresses both nuclear energy and nonproliferation, and materials science and nanotechnology find uses in both national security and renewable energy applications.

One LANL group is attempting to bring network theory to bear in solving what McBranch describes as a general applied mathematics problem: the distributed grid that will be required to accommodate the big growth that's expected in wind and solar power generation. That effort will incorporate usage data supplied by an electric co-op in Taos, New Mexico, that has recently installed more than 12 000 "smart meters" and 10 MW of photovoltaic capacity. Another LDRD project at LANL, McBranch says, aims to engineer intelligent and adaptive wind systems by improving the understanding of how turbulence, twisting forces, and other stresses can accelerate wear on turbine bearings and affect efficiency.

David Kramer

Mostly recovered, the LHC readies for restart

The LHC will run at reduced energy until its superconducting magnets are retrained and the connections between them fixed.

Just nine days after it was first turned on in September 2008, the Large Hadron Collider at CERN was brought to a standstill when an improperly soldered splice connecting two superconducting cables failed (see PHYSICS TODAY, November 2008, page 24). When it starts back up in November, the plan is to test and debug both the LHC and

its experiments for a while at 3.5 TeV per proton beam, then to ramp up to perhaps 5 TeV, hopefully sometime in 2010. Some lingering problems still need to be solved to make it safe to go to the design goal of 7 TeV, or 14-TeV center-of-mass collision energy.

"The first job is to rediscover the standard model," says LHC project

leader Lyn Evans. "Produce the top quark, measure its mass, and use the data to calibrate all the physics we know from the Tevatron," which produces 2-TeV collisions at Fermilab near Chicago. Adds Tejinder Virdee, spokesman for the LHC's Compact Muon Solenoid experiment, "It's important to get going."

CERN



The busbars (below) in the Large Hadron Collider's connectors (left) must all be made to have sufficiently low resistance, and about a third of the magnets have to be retrained before the machine's design collision energy can be reached.



In preparation for the collider's restart, three of the four LHC experiments have checked their instruments using cosmic rays. "This has allowed us to measure the performance parameters of all the component detectors of CMS, such as resolution in space and time, alignment, calibration, energy and momentum resolution, and efficiency," Virdee says.

Even at 3.5 TeV, he says, "we do expect new physics, because the standard model breaks down." At that and higher energies, he adds, the LHC may reveal the origin of mass—"the Higgs is the favored mechanism, but we do experiments to see what nature has done. There may be new symmetries. There may be new forces. There may be extra dimensions. We are going to unexplored territory."

New potential problem

In last year's accident, says Evans, "it was a simple splice that gave way, but it did a lot of collateral damage." Due to heat not being dissipated speedily enough, and to a pressure wave generated by overheated helium, 53 magnets had to be removed and the electrical, vacuum, and cryogenic connections between them redone. Spare magnets were used, and the ones that were removed are now being fixed to be spares. The total cost of the repairs, not including CERN staff salaries, was 40 million Swiss francs (roughly \$37 million).

Since the mishap, scientists and engineers have tested some 20 000 splices in the LHC. They fixed two faulty ones in the machine and one from the spare lot, added pressure relief valves, and made changes so that in the event of a quench—when a superconducting magnet goes normal—the energy will be removed quickly. "The worst case we can imagine is the quenching of a magnet adjacent to a bad joint," says Evans. "Even then, we will have no problem with the machine with the modifications [we have made to] the speed of descent of the power supply."

Although the splices are no longer a threat, another problem emerged during the thorough going-over of the machine: The resistance of some of the busbars that connect magnets is too high. Copper sits next to superconducting cable in the busbars and will carry the current if the cable quenches. The higher the beam energy, the lower the busbar resistance needs to be—for 7 TeV, only about 15 $\mu\Omega$ can be tolerated, but resistances up to 70 $\mu\Omega$ have been measured.

Magnet memory loss

Also limiting the LHC energy are the

magnets themselves. "The surprise we got," says Evans, "is a loss of memory in the magnets from one of the manufacturers." Retraining those 400 magnets—a third of the total number in the LHC—involves increasing the current through them until they can tolerate the required fields. At present, Evans says, no magnet will quench at currents needed to reach 5 TeV. Getting up to 6.5 TeV will go quickly, he adds. "But from previous experience we know that from about 6.6 TeV to 7 TeV will be trickier."

"It's not a big issue, but it's annoying," Evans says. Fingers are not pointing as to the cause of the memory loss, but among the theories are that one of the suppliers is to blame or that the magnets were damaged by sitting outside in a CERN parking lot for a couple of years. The plan is to retrain the magnets to 7-TeV beam energies after the 5-TeV run. And in 2014, an upgrade will take the machine to beyond its design luminosity of 10^{34} $\text{cm}^{-2}\text{s}^{-1}$.

CERN experiments usually don't run in the winter, and running the LHC beginning next month will add about €15 million (\$21.5 million) in electricity costs. "If you polled anyone involved," says Jeff Spalding, a Fermilab researcher who works on CMS at CERN, "they would say the most important goal is to complete commissioning the accelerator with beam. There is a lot to be learned." In the grand scheme of things, he adds, a year's delay doesn't hurt science. And "an initial period at 3.5 TeV is not a loss. But the delay can be serious on a personal level for young scientists who need publications." The LHC's delay does keep the Tevatron in

the spotlight, and if, as Fermilab now hopes, it gets funding to stay on through 2011, it would double the Tevatron's data set.

Toni Feder

news notes

Women in astronomy.

The International Astronomical Union (IAU) passed its first-ever resolution on women on 13 August. It says that members should encourage and support the female astronomers in their communities and should work to break down barriers so that men and women have equal opportunities at all levels in the pursuit of a career in astronomy.

The resolution grew out of the "She is an Astronomer" cornerstone project of the International Year of Astronomy 2009 (see *PHYSICS TODAY*, April 2009, page 20). Helen Walker of the Science and Technology Facilities Council's Rutherford Appleton Laboratory in the UK put forward the resolution to the IAU. Involved in the IYA2009 project, she says that although the women who were profiled as part of the project "mostly think they are not discriminated against on an individual basis, they note that many places do not have women at senior levels."

Walker says she hopes the resolution will spur organizers of IAU-related meetings to create a better balance of speakers, session chairs, and nominees for committees, awards, and prizes. "The 'She is an Astronomer' website will include some ideas," she says, "but each member and each national organization knows what can work in their communities." **TF ■**

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<http://www.nv.doe.gov/library/films/testfilms.aspx>

From the National Nuclear Security Administration's Nevada Site Office comes an online collection of **Historical Test Films**. The films cover the first US nuclear test, Trinity, in July 1945, through to the last US atmospheric test, Operation Dominic, which ended in November 1962.

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The stories in **Under the Microscope** are written by and about women in science and encompass a wide range of experience, from being a lab assistant in Princeton in the late 1940s to running a recycling program in Los Angeles today. Originally developed by IBM, the collection is published by the Feminist Press at the City University of New York and supported by NSF.

