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 μΩ can be tolerated, but resistances up to 70 μΩ 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} $cm^{-1}s^{-1}$.

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** ■

web watch

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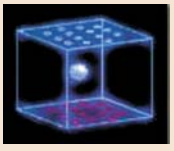

Spotlight on Optics provides accessible summaries of interesting and significant papers that appear in the 13 journals published by the Optical Society of America. The summaries appear about three times a week.

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.

http://underthemicroscope.com/

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.