HIGH-ENERGY PHYSICS

Troubled by Glitches, Tevatron Scrambles to Retain Its Edge

Scientists working on the newly refurbished Tevatron accelerator are struggling to overcome serious technical problems. If the setbacks aren't resolved soon, researchers warn, the effort to get the accelerator running properly could drain scientific expertise from other projects, and the Tevatron may even fail to meet some of its scientific goals.

Particle accelerators often have trouble when they first start up, so it's no surprise that the Tevatron—which smashes together highly energetic beams of protons and antiprotons—has run into difficulties in the 10 months since its $260 million refit. Scientists are confident that they can eventually fix the Tevatron's problems, but "we wanted to be farther along than we are now," says Mike Witherell, director of the Fermi National Accelerator Laboratory (Fermilab) in Batavia, Illinois, the Tevatron's home. "Things are not going swimmingly," Steve Holmes, head of Fermilab's Beams Division, told a meeting of the High Energy Physics Advisory Panel last week in Washington, D.C.

The amount of scientific data that an accelerator produces is related to its integrated luminosity, a combination of the beam's luminosity (the "brightness" of the particle beam) and the amount of time it runs. According to Tevatron scientists' latest projections, the Tevatron is scheduled to have 2 inverse femtobarns (fb^{-1}) of integrated luminosity by the end of 2004 and, after a change in configuration, 15 fb^{-1} by the end of its run in 2008. Since March 2001, however, the accelerator has produced only 0.02 fb^{-1}. Although accelerators tend to get most of their data near the end of a run, the severity of the problems is worrisome, scientists say. Holmes told the advisory committee that under certain conditions some of the magnets that accelerate and guide the protons and antiprotons have tended to "quench": The superconductor in the magnet has been heating up and losing its superconducting ability. In particular, when Tevatron technicians want to get rid of the beam, they quickly switch the magnetic field at a specific point in the ring to guide the particles into a "beam dump." However, particles were getting into the wrong part of the ring at the wrong time, fouling the switching process and quenching the magnet. "We lost the month of July due to magnet failure for various reasons," says Holmes. "But we're almost out of the woods on that."

Out of the loop. Tevatron's main injector (*left*) is losing too many particles.

Unfortunately, there are many more problems left to troubleshoot. For example, the machine loses a potentially ruinous 70% of its antiprotons as it moves them from the accumulator, where magnets store the newly created antiprotons and focus them into a tight beam, into the main injector, which speeds particles up before guiding them into the main ring. It also loses 20% of the particles while transferring them from the main injector to the main ring of the Tevatron, where the collisions take place. The losses seem to indicate that the particles take on a wider-than-expected range of speeds, which effectively makes the beam wider than the pipe it is supposed to travel through. In addition, the protons and antiprotons, which travel in opposite directions in the same tube, affect each other more than is healthy, causing the beam to spread. "We have to work on a lot of things in parallel," says Mike Church, deputy head of the Beams Division.

Witherell says that Fermilab already has "its proper share of resources," so it will probably not need more money. But scientists at Fermilab are being diverted from other projects to whip the ailing accelerator into shape. Some physicists who are supposed to be designing a major jump in luminosity in 2005, for example, are instead busy putting out the current fires.

And the fires must be put out if the Tevatron is to meet many of its scientific goals, such as accurately determining the properties of the top quark and a force carrier known as the W particle. "The performance requirements are quite demanding, especially on precision measurements," says Daniel Froidevaux, a physicist at the CERN accelerator near Geneva, Switzerland. "For the top quark, an integrated luminosity of a few hundred inverse femtobarns is not sufficient. They need to meet the 2 fb^{-1} target." Measurements of the W particle will be even more difficult, he adds.

Unless the machine can be brought up to peak capacity, the Tevatron will be relegated from a long shot to a noncontender in the race to find the Higgs boson: a huge, undiscovered particle that theory claims is the source of mass. Some physicists are hoping that the Higgs boson will be just within the Tevatron's reach and that the machine can snatch it before CERN's Large Hadron Collider comes online in 2007. "If we push to the limit, and the mass is low, we can get there," says Witherell. But even if CERN prevails, he adds, "there will be terrific scientific progress without the Higgs—on W physics, top [quark] physics, and supersymmetric searches."

Although scientists are nervous, they still believe that the Tevatron will hit its stride.

CREDITS: (TOP TO BOTTOM) FRED ULLRICH/FERMILAB; ULLRICH AND HAHN/FERMILAB

"I'm sure this thing will take off," says Froidevaux. "I really hope so. I really hope so." So does Church. "I'll worry in 6 months if we haven't made significant progress," he says. "If by summer we're still struggling, I don't know." **–CHARLES SEIFE**

STEM CELLS

German Researchers Get Green Light, Just

BERLIN AND BONN—German scientists are thankful for small mercies after their country's parliament last week approved some of the world's strictest regulations covering work with human embryonic stem (ES) cells.

The new measure, approved on 30 January, prohibits scientists in Germany from deriving human ES cell lines and "fundamentally bans" the import of these controversial cells. However, the Bundestag left an opening: Researchers can import ES cells if they can demonstrate that there are no feasible alternative ways to conduct the research. But even that comes with a catch: No imports can be approved until the Bundestag passes a new law establishing a national commission to review all import proposals, and the soonest such a commission could be in place is early summer.

Still, researchers are looking on the bright side. "This is a positive signal to scientists, biomedical research, and in the end also to patients," says developmental neuroscientist Oliver Brüstle of the University of Bonn, although he had hoped for a less restrictive vote. "It is the best we could hope for under the circumstances," agreed Rüdiger Wolfrum, a law professor at the University of Heidelberg and vice president of the DFG science funding agency.

Many scientists hope human ES cells, which can in theory transform into any of the body's cell types, might someday produce treatments for dread diseases such as Parkinson's or diabetes. But the cells have stirred controversy because they are derived from week-old human embryos. In Germany, scientists and politicians have argued that the country's embryo protection law, which forbids research on human embryos, does not bar work with stem cell lines that were derived outside the country. Debate on the issue has raged for more than a year, ever since Brüstle proposed importing human ES cell lines from Israel (*Science*, 14 December 2001, p. 2262).

For four and a half hours, Bundestag members debated three proposals, ranging from a complete ban on any import of human ES cells to few import restrictions. The winning compromise follows a formula established by President George W. Bush in August, when he permitted U.S. government-funded researchers to use only cell lines that had already been established (*Science*, 17 August 2001, p. 1242); German researchers will be allowed to import only cell lines established before last week's vote. "Killing of embryos for research purposes must remain illegal," argued Maria Böhmer of the Christian Democratic Union, one of the co-authors of the winning motion. But "we cannot cancel" the fact that embryos were already killed for existing cell lines, she said.

The art of compromise. German Bundestag members vote to allow restricted import of human embryonic stem cells.

CREDIT: MARKUS SCHREIBER/AP

Legislators on all sides of the debate called for generous funding for research into alternatives to ES cells, including stem cells derived from umbilical cord blood and adult tissues.

A day after the Bundestag vote, DFG announced that it would fund Brüstle's work as soon as the national commission is in place to give its stamp of approval. DFG had agreed several times to delay its funding decision until the Bundestag had debated the issue. Asked whether he regretted waiting, DFG president Ernst-Ludwig Winnacker said the result of the debate "shows that it was right to be patient and cautious in this sensitive field. Freedom of research [enshrined in Germany's constitution] is not absolute but is restricted by other rights."

Bundestag leaders have said they hope to have a draft of a new law ready in a few weeks, with final passage possible in a few months. But several scientists warn that this will not be the end of the debate in Germany. Molecular biologist Detlev Ganten of the Max Delbrück Center for Molecular Medicine in Berlin-Buch, a member of the National Ethics Council, said he will push for a review of the embryo protection law after national elections in September. "The discussion will not end here," he says. "From my point of view, import is a step in the right direction, but it leaves a double standard in place." For now, it seems to be a double standard that a majority of German lawmakers can agree on. **–GRETCHEN VOGEL**

With reporting by Sabine Steghaus-Kovac in Bonn.

CANCER RESEARCH

Leukemia Protein Spurs Gene Silencing

Researchers have identified hundreds of genes that can, when mutated, cause uncontrolled cellular growth and other changes that underlie cancer. But in the past few years, increasing evidence has suggested that mutations aren't the only genetic changes that lead to cancer. The addition of certain chemical groups to genes or their associated proteins can also alter gene activity patterns in ways that result in malignancy, without disrupting gene structures. Exactly how cancer-related genes acquire these so-called "epigenetic" alterations hasn't been clear, however.

Now, a team led by Luciano Di Croce and Pier Giuseppe Pelicci of the European Institute of Oncology in Milan, Italy, provides a possible answer for a blood cancer known as acute promyelocytic leukemia (APL). On page 1079, they report that a mutant oncogenic protein involved in APL development recruits enzymes that attach methyl groups to DNA, in this case to a possible tumor suppressor gene called RARβ2. The addition of these methyl groups silences the gene, and that in turn contributes to the malignant transformation of the leukemia cells, the researchers report.

This finding could lead to better APL