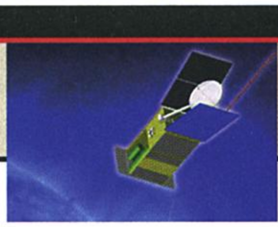

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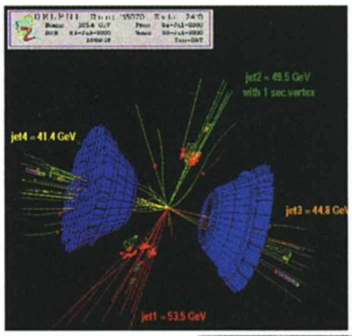
PARTICLE PHYSICS

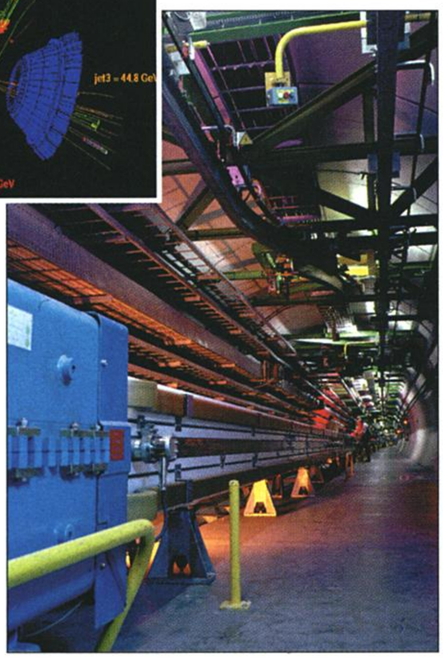
CERN Gives Higgs Hunters Extra Month to Collect Data

All good things must come to an end, and for the largest particle accelerator in the world, that end was meant to come late this month. After 11 years of banging electrons and positrons together at higher energies than any other machine in the world, CERN, the European laboratory for particle physics, had decided to shut down the Large Electron-Positron collider (LEP) and install a new machine, the Large Hadron Collider (LHC), in its 27-kilometer tunnel. In 2005, the LHC will start bashing protons together at even higher energies. But tantalizing hints of a long-sought fundamental particle have forced CERN managers to grant LEP a month's reprieve.

In August, scientists working on LEP's ALEPH particle detector saw intriguing signs that the accelerator might be producing Higgs bosons. In early September a reanalysis of the DELPHI detector's data flagged something similar there, too. The experimenters were excited enough to ask for a stay of execution, and on 14 September, after taking advice from CERN's research board about the lab's long-term interests, CERN director-general Luciano Maiani extended the accelerator's lease on life. But it's a short-term lease. On 2 November, the beams are to be shut down for good, even though evidence for the Higgs will probably still be inconclusive at best. LEP may be in the position of glimpsing, but never actually entering, the promised land of new physics that its makers have been journeying toward for decades. "It's exciting to be close," says Peter Dornan of ALEPH. "Obviously, if after another month one really believes that one is seeing it, then it will be very frustrating [to close down]."

Considering the fuss that physicists make about Higgs bosons, it might seem outrageous that CERN is willing to cut short an experiment that may actually be finding some of them. The perennial next big thing in high-energy physics since the early 1980s, the Higgs is the crucial missing component in physicists' "Standard Model," an assemblage of theory that accounts for almost everything so far observed in the subatomic realm. Interactions with the Higgs account for the masses of other particles, and precise measurements of its behavior promise insights into processes beyond the Standard Model, such as those which would produce new "supersymmetric" particles. Indeed, finding and studying the Higgs is one of the key reasons that CERN's member states, with contributions from the United States and other nations, have committed themselves to the LHC project. And it is to keep that project on track that CERN is committed to shutting down LEP.





Making tracks. Events at the DELPHI detector *(inset)* suggest that LEP, above, is on the trail of the Higgs boson.

The two CERN detectors have seen events in which it appears that a Higgs boson has been created along with a Z boson, a force-carrying particle that LEP was designed to provide by the bushel. Both immediately decay into paired jets of secondary particles. Higgsless events can produce similar sets of jets, but the CERN events occurred well above an expected background rate. The current excess corresponds to a three-standard-deviation signal, meaning that the odds of it arising by chance are less than 1 in 100.

To drive the statistics up to five standard deviations and a mere 1 in a million chance of error—which would count as a copper-bottomed discovery—would take many months. But lengthening LEP's run by even 2 months, as LEP scientists suggested at a 5 September meeting, could have delayed serious LHC work until next year, a move that would have triggered penalty clauses with various contractors. Worse, if the delay had rippled along the LHC's tight construction schedule, it might well have pushed the machine's first operations back from summer 2005. CERN's machines shut down in winter, when the cost of electricity peaks, so that might have meant not starting up until spring 2006—an unacceptable delay.

It may seem odd, if LEP is capable of making Higgs bosons, that it waited until the end of its life to do so. But it is precisely because the plug is about to be pulled that these new events are being seen. Pushing a huge but delicate machine like LEP too hard might curtail its useful life. But staying within the design limits carries a risk of not exploring the machine's full potential. And that can mean lost glory. When the J/ψ particle was discovered at Brookhaven and Stanford in 1974, an Italian accelerator called ADONE had been running for more than a year at energies up to its design limit of 3 giga electron volts (GeV). It was quite capable of the 3.1 GeV needed to produce J/ψ particles—it made some within days of the discovery—but no one had pushed the machine as far as it would go until it was too late.

To avoid a similarly disappointing denouement, LEP operators decided at the end to throw caution to the wind. This summer, like Nigel Tufnel in the movie *This Is Spinal Tap*, they turned their amp up to 11—or, to be technical, their beams up to just over 103 GeV each—for that extra push over the cliff. And that made all the difference. With 100 GeV in each beam—the level the machine was designed for—there was simply not enough energy for a colliding particle pair to make a 91-GeV Z and a 114-GeV Higgs,

CREDITS: (LEFT TO RIGHT) COURTESY OF THE DELPHI COLLABORATION/CERN; CERN-GENEVA which is what the new sightings suggest is going on. With 206 GeV, there's just enough.

The extra month of research is meant to double the amount of data taken at this highest energy. That's almost certainly not enough to settle things for sure, but it might add more hints of a 114-GeV Higgs—or, if no further events are seen, rule out the possibility. As John Ellis in CERN's theory division explains it, "What you are looking at is not a paper saying 'Discovery [of a Higgs].' But if the effect is repeated you might get a paper saying 'Evidence ... ,' while at the moment all you could get would be a paper saying 'Indications. ...' " Dornan, though, points to the possibility of a "golden event" in which the Z decays into a pair of electrons or muons. A distinctive signature unlike anything expected in the background, that event would cry out for a Higgsian explanation. Such events are expected only about an eighth as often as the four-jet events, so the chances of seeing one in the next month may not be good. But if one were to turn up before 2 November, there might be a case for running LEP longer still. "How the management would take such a case," Dornan says, "is unclear. We've been told that there's no way it could be kept on after [2 November]. But we'd have to see."

Barring a golden event, the likelihood now is that any "Discovery" paper will come not from CERN but from the Fermi National Accelerator Laboratory (Fermilab) near Chicago. Next year scientists there will start using their improved Tevatron. This accelerator works at much higher energies than LEP, but because it uses protons and antiprotons, which are composed of quarks, rather than electrons and positrons, which have no subcomponents, its collisions are messy and only a fraction of the beam energy goes to producing new particles. The upgraded Tevatron's beams are meant to be 100 times brighter than before, and this means it may produce a measurable number of 114-GeV Higgs bosons.

According to Mel Shochet of the University of Chicago, who is part of the CDF detector team at the Tevatron, it will take a year or more to know for sure whether LEP did indeed glimpse something in its last few months. If that happens, and Fermilab discovers the Higgs, expect diplomatic niceties over the credit due to the LEP experimenters—niceties in which the distinction between the indications seen today and the evidence that might be seen by the end of October could play a crucial role. And expect excitement over the LHC, which operates at energies 10 times greater than the Tevatron's, to escalate further. As Ellis points out, a Higgs at 114 GeV would effectively guarantee that the Standard Model breaks down at energies easily accessible to the LHC, and thus that the new machine will be exploring rich realms of discovery from day one—with no pesky time limits. —**OLIVER MORTON**

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NIH

Imaging Institute Picks Up Momentum

The National Institutes of Health (NIH) may soon have a new offspring. Last week a House panel approved the creation of the National Institute of Biomedical Imaging and Bioengineering (NIBIE) despite pleas from top NIH officials that such a move will balkanize research. The bipartisan proposal, which is also backed by Democratic presidential candidate Al Gore, may have enough momentum to sail through Congress by the time it adjourns early next month. Even if it falls short, NIBIE reflects the growing desire of segments of the biomedical community to have their own address on the Bethesda campus.

Two for one. A combined PET and CT scan of a patient with lung cancer (red spot) illustrates a technology stemming from the type of basic research a new imaging institute would fund.

CREDIT: IMAGE REGISTRATION VIA MIAMI FUSE, C. MEYER/UNIVERSITY OF MICHIGAN MEDICAL SCHOOL

"Imaging is used as a tool in all the institutes, but there is no home at the NIH for the basic research that is essential to develop new imaging techniques and technologies for the 21st century," University of Pennsylvania radiologist Nick Bryan, a former head of imaging research at NIH's clinical center, told the House Commerce Committee on 13 September, 1 day before its health and environmental subcommittee approved the measure. "Imaging is based on mathematics and physics, not the biological sciences that underlie most of the research in the current institutes."

A separate institute "makes no sense," argues Marvin Cassman, director of the National Institute of General Medical Sciences, one of 25 NIH institutes and centers. NIH already makes allowances for those differences, he says, and its organization by major disease or biological system better addresses societal goals. In addition, he notes, radiologists aren't alone in feeling that their needs aren't being met. "There isn't a field of science that NIH supports that does not feel it is neglected, underfunded, or in some way mistreated," Cassman says.

The House bill, H.R. 1795, is a marriage of proposals from Representative Richard Burr (R–NC), who wanted to give his medical-imaging constituents a bigger piece of the NIH pie, and Representative Anna Eshoo (D–CA), who was looking out for bioengineers in her home state. The bill would authorize spending at current levels for bioimaging and bioengineering, which NIH estimates stood at $840 million in 1998. Last year a congressional spending panel signaled its support, warning NIH that "the present organization does not accommodate basic scientific research in these fields and encourages unproductive diffusion of imaging and engineering research." The lobbying effort includes 40 professional societies representing more than 100,000 physicians, radiological technicians, bioengineers, and imaging scientists, and has signed up 169 co-sponsors. Vice President Gore has even tucked the idea into his 191-page economic plan, as part of a discussion of the role of technology in improving health care.

NIH has not been oblivious to all this political interest in a red-hot research area. In 1997 then–NIH director Harold Varmus linked the relevant pieces on campus into a Bioengineering Consortium (*Science*, 5 June 1998, p. 1516). This spring NIH raised the profile of the field by creating an Office of Bioengineering, Bioimaging, and Bioinformatics (OB3) that reports to acting NIH director Ruth Kirschstein. But propo-