HIGH ENERGY PHYSICS

Europeans Confident in the Battle of the Big Machines

GENEVA—It's lunch break during a high-energy physics conference in the French town of Evian-les-Bains. A group of French physicists are discussing the topic of the day: The proposed European megaproject known as the Large Hadron Collider (LHC). "I'm sure no one in the U.S. Congress has heard of the project," says one. His companions agree. "They think their SSC [Superconducting Super Collider] will dominate the field," adds another. If Congress did know about the LHC, perhaps it might not be so eager to spend $8 billion for a machine that will confirm the dazzling breakthroughs made by our accelerator, they reasoned. A little cheeky, perhaps, but the conversation sums up European physicists' confidence that the LHC will be built, will work, and will probably start running first, leaving to the SSC the detailed analysis of its findings. To add insult to injury, European scientists are quick to point out that the LHC will cost only one-tenth as much as its American rival.

European high-energy physicists are talking from a position of strength. In the early 1980s, their 17-nation Geneva-based collaborative laboratory, CERN (officially the European Laboratory for Particle Physics), pulled ahead of the U.S. competition with the discoveries of the W and Z particles—feats that netted CERN director-general Carlo Rubbia and engineer Simon Van der Meer a Nobel Prize. Now most scientists at CERN assume they will get the final go-ahead for the LHC from CERN's council of member governments by the end of 1993, in time to get it working by 1999. But their brash confidence could yet be dashed. The LHC faces some formidable technical hurdles and an even more daunting financial barrier: CERN still has to raise money to build the LHC's detectors, and a trip around Europe shows that individual nations have their own homegrown projects to worry about and little to spare for CERN.

European particle physicists therefore have a big selling job to do. They are touting the same arguments one hears from SSC enthusiasts: The unexplored energy range of the LHC will open up a window on nature (see box). The biggest difference between the two planned projects is that the LHC will be built in an existing tunnel now housing the LEP, an electron-positron collider considered the premier high-energy machine today. That gives the Europeans a big head start over the SSC's builders, who are starting from scratch, digging a new tunnel and putting together an entire new laboratory on the plains of Texas.

Former CERN director-general Herwig Schopper says he and his colleagues planned the LHC back when they started designing the LEP in the late 1970s. "It seemed natural at the time to make room in the tunnel for another collider," he says. Schopper says he and the other CERN physicists invited the United States to participate in the LHC. The idea was that later, the United States could pursue something complementary and different, such as a linear collider. But, claims Schopper, "America wanted to get the lead back that they thought they lost to CERN." The SSC, he says, was "was sold as a project to reestablish leadership in America, but it was also sold to others as an international project. You can't have it both ways."

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Roy Schwitters, head of the SSC Laboratory, argues that his project will outpower the LHC, forging into a higher energy range and maybe gaining access to discoveries beyond the reach of the LHC. But his rivals are betting that the LHC will cover the territory well enough to have a good shot at stealing all the glamorous discoveries—if it gets running first. Schwitters says the SSC is scheduled to be running by 1999, but few Europeans say they believe that.

It promises to be a tough race. The ready-made 27-kilometer tunnel that gives LHC its head start also imposes constraints that will make the project technically much more risky than its American rival. Even LHC physicists admit it will be quite a feat to achieve collisions energetic enough to compete with the much larger, 84-kilometer SSC. Physicists involved in the LHC see their project as a David competing against the American Goliath. The LHC will use technical finesse to compete against the brute force SSC, which some refer to as a big copy of the Fermilab Tevatron, built in the 1980s.

The challenge, in fact, is so great that some scientists said they initially expected the LHC to founder on the superconducting magnets used to accelerate particles to high energies. LHC needs the most powerful magnets ever designed. When an outside committee recently reviewed plans for the project, chairman Bjorn Wiik, a physicist at the German lab DESY (the Deutsches Elektronen-Synchrotron), deemed the overall design, the injector, and the cryogenic systems "first rate," but he said the magnet design wasn't up to snuff. Now, however, Wiik has changed his tune. The most recent research revealed that engineers can achieve the needed energy with a lower field, 9.5 instead of 10 Tesla, and that, he says, they can do. SSC engineers will still have it easier, however; their machine will use 7.7-Tesla magnets.

Even with successful magnets, the LHC's designers know they will achieve lower energy. To compensate they must create more than 10 times as many collisions per second in order to increase the odds of making a detectable number of new particles. That will make the job

Exchanging One Tunnel for Another?

Carlo Rubbia

The mention of the name Carlo Rubbia evokes a variety of responses from CERN personnel. Physicists say he holds a powerful, almost magnetic, influence on everyone at the lab. Some say his influence drives the now-common 80-hour work weeks. Today he is a powerful force behind the rapidly progressing LHC, but at the end of 1993 Rubbia's term as director-general ends, and he plans to step down accordingly. "You can't run CERN as a dictatorship," he says. Rubbia says he is planning to move on to another project—an experiment called Icarus that is set to detect proton decay deep in a tunnel called Gran Sasso in his native Italy.

Who is going to succeed Rubbia? DESY physicist Bjorn Wiik was being considered but already declined the overtures in favor of the directorship of his own lab.

An informal survey reveals the front-runner as the popular CERN research director Pierre Darriulat, followed by Oxford theorist Christopher Llewellyn-Smith.

–F.F.

Now for the Hard Ones...

Theorists insist that the spoils in the race between Europe's LHC and the United States' SSC will be rich for the winner. One of the great hopes is that a speculative creature called the Higgs particle will finally be revealed. Proof that this particle exists would, in turn, provide strong evidence for the existence of the Higgs field—an entity that would do for mass what an electric field does for charge. Just as a particle can't tell if it's positive or negative until it enters a magnetic field, particles wouldn't know if they were massive or massless until they entered the Higgs field.

Beyond the Higgs, the big goal for the LHC—and the SSC—is something new and shocking. Physicists say they are getting sick to death of the "standard model," which works so well that even expensive projects as CERN's LEP can't contradict it. Physicists hope for relief, possibly in the form of new particles that give evidence for a class of ideas called supersymmetry. The experimentalists will be searching for signs of "supersymmetric" partners for each known particle, a squark for each quark, a selectron for the electron and so on.

But these frontier discoveries will be much harder to find than particles discovered so far, says CERN physicist Luigi DiLella, who took part in the search for the W and Z in the 1980s. Back then, theorists could make strong predictions about the existence and energy of these particles. But no one knows how much energy the Higgs would have. And to be sure they have found it, experimentalists will have to have hundreds of "signatures"—not just the tens that sufficed for the W and the Z. In DiLella's view, "All the easy things have already been discovered."

–F.F.

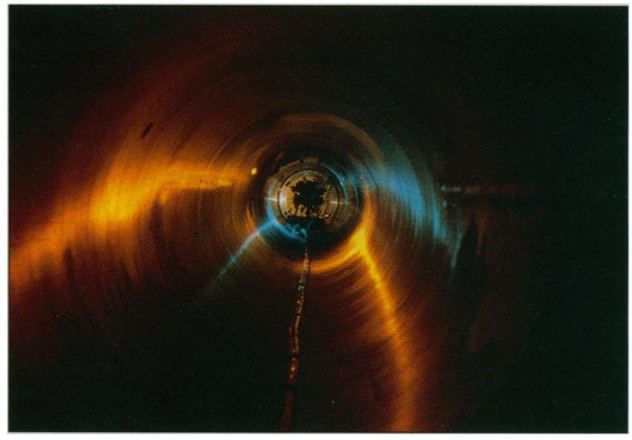
even harder for the detectors, which have to record the resulting millions of debris particles every second. Physicists are still struggling over designs they think can handle that barrage. At the meeting in Evian last month, four "protocollaborations," each made up of around 60 groups, presented early ideas. Rubbia says he plans to use two detectors—though pessimists say lack of money might force them to scrape by with just one.

Many scientists at the meeting mocked the expected price tags of approximately 400 million Swiss francs per detector as wildly optimistic. Even so, that's a big chunk of the annual CERN budget of 945 million francs. This additional money will have to be raised outside CERN's usual funding channels, directly from the countries and institutions backing the collaborations, including non-CERN members.

Funding pinch. The cash isn't flowing very freely, even from some of the member states, however. In Britain, one of the big four CERN contributors, the money allotted to science is already stretched thin, explains Douglas Yarrow, an official at Britain's Science and Engineering Research Council. He lists on a blackboard all the projects and labs that need money, and shows how the £88 million allotted to particle and nuclear physics gets divvied up. Most of it goes to CERN, and Yarrow says it would be stupid to pay all that just to stay in the club and end up with no money for British scientists to participate in CERN's dazzling new project.

Germany, the biggest contributor at 22%, is in the same boat. It is feeling the financial pains of reunification and the budget for high-energy physics is stretched to the limit. Moreover, Germany is trying to juggle its contributions to CERN with support for its domestic high-energy facilities, DESY, now boasting a brand-new accelerator project, and HERA (Hadron Electron Ring Accelerator).

DESY is the second largest high-energy physics lab in Europe. Like CERN, most of its projects are done through international collaboration. But unlike CERN, DESY remains at heart a German lab. HERA, now within weeks of completion, will hurl high-speed electrons against the much more massive protons. The idea behind this asymmetrical approach, says research director Albrecht Wagner, is that the collisions may reveal another layer of substructure within quarks and electrons.



CERN PHOTO

Light at the end? Inside the LEP tunnel.

Like a mirror image of Yarrow, Wagner lists on his blackboard all the places that need funding. There's still just enough to go around, though he admits that if the LHC suddenly jumps up in cost, they would be "in trouble."

Spain has a different problem. Rubbia himself pointed out at the Evian meeting that Spain has few scientists working at CERN despite paying high dues. That means the Spanish aren't getting their money's worth, says CERN theorist Alvaro De Rujula, a native of Spain. "They pour money into CERN but get nothing back for their own science or education." Spain doesn't have much of a particle physics community, and there are few opportunities for its members within the country, he says. To stimulate more Spanish physics, the government is pushing for a medium-priced Spanish accelerator called a Tau-Charm factory. De Rujula endorses this approach as "the only way out of an untenable situation," and an important experiment to boot.

In spite of these difficulties, Rubbia is determined that a united Europe can get the LHC ready by 1999, which he assumes will be ahead of the SSC. At the Evian meeting, he said he wanted a detailed plan ready for approval before his term as director-general is up at the end of 1993. He made it plain why he didn't want delays: Any time lost would let more good scientists slip out of their hands and over to the other side. "People want to know whether to go to Europe or the USA," he says.

Despite all the nationalism that went into the selling of these projects, most of the scientists themselves are neutral. In fact, there's likely to be considerable transatlantic traffic—in both directions. Plenty of Europeans will help get the SSC going, and a good-sized group of Americans will cross over to the LHC. "We just want to go where the interesting physics will be," says Richard Harder, who is leading a group at the University of California, Davis, that is collaborating on an LHC detector. And University of California at Los Angeles's Peter Schlein is proposing a smaller experiment on the LHC after a similar proposal was rejected at Fermilab. Most physicists do get competitive, not for their countries, but for whichever projects they put their time and sweat into.

But scientists are already getting tired of international competition. Physicists are now dreaming of a huge linear collider that might come next. This, the physicists say, will be far too expensive to build as anything but a worldwide collaboration. The only hitch—the thing has to be built somewhere. Germany, the United States, and Japan are already staking claims.

–Faye Flam