

PHYSICS COMMUNITY

CERN Reaches Consensus on Two-Stage LHC

Despite tough financial constraints, CERN will go ahead—if absolutely necessary, with no funds from non-member states—and build the world's most energetic proton-proton collider. American physicists hope that US contributions will guarantee their active participation in the project.

While many people anticipated that 1994 would be a “year of decision” for the Large Hadron Collider, few thought that the decision on whether or not to build the machine would be delayed until the mid-December meeting of the CERN council. (See *PHYSICS TODAY*, February 1994, page 93, July 1994, page 51, and November 1994, page 80.) Ultimately, however, the council—knowing that the US canceled its Superconducting Super Collider not only because of escalating costs but also because no strong foreign commitment was forthcoming—approved by consensus the construction of a 2.6 billion Swiss franc (about \$2 billion), European-funded, two-stage LHC.

The two-stage plan for the proton-proton collider spreads its cost and construction over a longer time. At the first stage, which should be finished by 2004, the accelerator—to be installed within the existing 27-kilometer circular tunnels of CERN's Large Electron Positron collider—will reach an energy of 10 TeV in the center of mass. A few years later CERN will shut down the machine for a year for the upgrade to the full 14 TeV, which the lab plans to achieve in 2008.

CERN's director general, Christopher Llewellyn Smith, explained the reasoning to *PHYSICS TODAY*: “We were asked to show that, inside a very tight, worst-case financial scenario, there was a project—a good project—that could be done on European resources alone. And we looked at all possible options and found the only way we could do it would be by building the machine in two stages.” The “we,” of course, is CERN management, with the implicit “them” being CERN's 19 member states. As discussed previously

in these pages, however, conditions set by various member states—especially Germany and the United Kingdom—had to be satisfied before an agreement could be reached.

Each member state pays a share of CERN's budget based on its gross national product. When Germany's GNP increased at reunification, its share of the CERN budget should have risen from 22.5% to the maximum permitted by CERN rules, 25%. Instead the fraction was set to remain at 22.5% for a trial period of 1994–96; then a review would have decided if payment at the lower rate could continue through 1998. Now, as part of the LHC agreement, Germany's share will remain at 22.5% through 1998.

Germany and the UK also had specific ideas about additional costs to be borne by France and Switzerland, who will pay more under the new agreement because of the economic benefits of being CERN's host countries. With CERN straddling the French-Swiss border near Geneva, their citizens presumably receive many more CERN-related contracts and jobs than do citizens of other member states. (Or, as one CERN employee put it, “There're 9000 people on the site, and they all have to buy lunch somewhere.”) Together France and Switzerland have agreed to contribute about an extra 200 million Swiss francs over the period of the LHC's construction, almost 8% of the total cost.

When reached immediately after the decision, a tired Llewellyn Smith said that the member states—after failing to vote approval in June and again in September—were presented with what they considered an acceptable package only toward the end of November. (The delays and the fatigue speak to the complexity of parallel negotiations with 19 different countries.) CERN council has introduced a double-majority voting requirement to insure the stability of the new financial arrangements: Before a recommendation from CERN's finance committee can even come before the council, not only must a numerical majority (that is, 10 of the 19 member states) vote for presentation of the recom-

mendation, but the contributions of that majority must sum to at least 70% of CERN's annual budget. Therefore any two of the major contributors—Germany, the UK, France and Switzerland—voting together can prevent consideration of major financial changes.

Llewellyn Smith said that the member states' caution arose from their recognition of the long-term nature of the commitment, and he believes that “the positive side of the difficulty we had in getting approved is that now approved, the LHC will be finished.”

Building the LHC in two stages will mean taking a technical approach that has been considered before. Llewellyn Smith told *PHYSICS TODAY* about the “missing magnet” scheme through which the two-stage plan will be implemented: “Now, if you go down that route, there's actually only one choice. Each of our half-cells of magnets has three large 14-meter dipoles, and the only option you have is to leave out one-third of the dipoles, the middle one in each string of three.”

From a management perspective, said the Stanford Linear Accelerator Center's deputy director, Sidney Drell, the decision to go with the two-stage approach “makes perfectly good sense.” To get the European governments to commit to the project, the CERN management had to present a plan that accounted for all the needed funds in terms of foreseeable European resources. Given a spending profile and a requirement to build a machine, “it is a sound decision,” said Drell, “to build it at a rate so that ten years from now we'll be doing physics there.”

Staging a play?

But will there be a 10-TeV machine? Several high-energy physicists in America think that the two-stage business is artificial. Bill Willis of the Nevis Laboratory at Columbia University is the coordinator of the US group involved in the ATLAS detector, one of the two main LHC experimental facilities. He spoke to us about “some kind of hypothetical air” to the two-stage plan. George Trilling of the Lawrence Berkeley Laboratory, the chair of

the executive committee of the US LHC Collaborators Organization, said that "this two-stage approach, if it were to become reality, would be extremely undesirable," because the overall project would cost more and take longer.

Trilling told us that about 500 physicists and engineers in the US, from some 65 groups at universities and national labs, have become involved in the two detector experiments. Trilling also told us that accelerator groups from Brookhaven, Fermilab and Lawrence Berkeley Laboratory have expressed serious interest in participating in the machine's design and construction.

CERN, for its part, officially wants "to welcome friends from other countries," and, as Llewellyn Smith admitted, "It'd be better to do it in one stage, of course." But building the LHC in one stage will only occur if non-member states such as the US, Canada, Japan, China, Russia, India and Israel can contribute funds. If they do so in sufficient amounts, then when the CERN council reviews the LHC's status in 1997 the project will, in CERN's language, "revert" to construction of a 14-TeV accelerator that could be completed by about 2004.

Good physics, better physics

What about working at 10 TeV? If one thinks of the LHC as a "search machine," said Alex Firestone, an Iowa State University physicist who collaborates at CERN, and if one considers only the energy at a given luminosity, "one wouldn't expect a significant difference in the physics reach of a 10-TeV versus a 14-TeV accelerator." But the luminosity of the first-stage machine will also be much less than that of the final product.

The design luminosity of the full 14-TeV machine, $10^{34} \text{ cm}^{-2} \text{ sec}^{-1}$, is a factor of 10 higher than the 40-TeV SSC's would have been. Llewellyn Smith, Drell and Trilling all mentioned that although background and general data analysis problems will be greater than at lower luminosities, improved detectors should enable better exploitation of this large luminosity than would have been expected a few years ago (see PHYSICS TODAY, February 1993, page 17).

Llewellyn Smith and others listed some of the things that could be done at 10 TeV: top- and bottom-quark studies, CP violation analysis and maybe searching for evidence of supersymmetric particles. Furthermore, CERN's heavy-ion program, just begun at a new facility there, will continue its search for quark-

gluon plasmas at the 10-TeV LHC.

At 14 TeV and the LHC's full luminosity, physicists hope to study the origin of mass (the breaking of electroweak symmetry) through the search for Higgs particles. Or, as Drell summarized the difference between the 10- and 14-TeV machines: "There's very good physics to do at 9-10 TeV. There's a lot of still better physics to do at 14 TeV."

Willis took a pragmatic view that limits non-European discussion of this issue. "It's not a question that is going to hit us so much, because it's hard to imagine that the US is not going to put in enough—well, I guess you can imagine it. But it is likely that if we put in some money, it's going to put them over the top and allow construction of the LHC in one stage." If, on the other hand, "they have to do it with European funds, that presumably means we're not taking part, and then it's none of our business."

Is there still a DOE?

Shortly after the cancellation of the SSC, the Department of Energy's High Energy Physics Advisory Panel was asked to create a Subpanel on Vision for the Future of High-Energy Physics. At the end of May last year the subpanel recommended US participation in the then-current incarnation of the LHC. After CERN's December announcement, Drell, the subpanel's chair, said that the stage-2 LHC is the machine considered by the subpanel and that he hoped the US government "will stick with our recommendations."

In anticipation of approval of the LHC, Martha Krebs, director of DOE's Office of Energy Research, had planned a trip to CERN for

July 1994, and then for October; she finally made a brief visit in November as part of a tour of European science centers. Unfortunately, any Washington excitement about the December decision was tempered by postelection stories about cuts being recommended at DOE. In the most extreme versions, elimination of the department has been considered. As of this writing, President Clinton has proposed cutting DOE's budget by \$10.6 billion over five years.

The director of DOE's high-energy physics division, John O'Fallon, was an unofficial US representative at the December council meeting, and was quoted in CERN's official announcement of the decision as inviting the director general "and his negotiating team" to come to Washington to work on "details" of US participation in the project. But since the US has no official position on whether it will participate or not, "negotiation" was too strong a word, as was "details." Now DOE officials say that the purpose of any spring trip to Washington by CERN officials will be to "discuss the framework" of possible future negotiations.

Anyway, a good day

Fermilab's Dan Green, the US spokesperson for the CMS group, which is the other major LHC detector collaboration, took a broad view of the LHC decision: "It is a good day for world science." Green suggested that the "spirit of openness and cooperation" shown by physicists working on the ATLAS and CMS projects "could provide a model for ways to approach problems in science that require worldwide collaboration." His group's interests certainly favor such a suggestion. "The

STAT OF THE MONTH

The members of the American Association of Physicists in Medicine exemplify the diversity of careers pursued by physicists. They engage primarily in clinical work, rather than teaching or research. In fact, nearly 70% work in hospitals or medical schools. The following data are based on a survey of all AAPM members living in the US and Canada.

Primary work activity of AAPM members, 1993

	percent
Clinical	66
Academic	11
Research	6
Regulatory or standards	5
Administration	5
Product development	
or sale	3
Other	4

Primary discipline for AAPM members, 1993

	percent
Radiation oncology	68
Diagnostic radiation	12
Radiation safety or health physics	7
Nuclear medicine	4
Magnetic resonance	4
Engineering	3
Regulatory	2

Source: AIP's education and employment statistics division

US CMS effort will be predicated on US participation" in funding the LHC, Green said, agreeing with Willis that a 2008 schedule would probably mean that the US "is not a player."

Looking to Washington, many physicists hope that the Republicans' traditional support for basic research will offset the present hand-wringing over big budgets on Capitol Hill. Still, given the country's experience with the SSC, the Departments of State and Energy will no doubt have many more questions before any decision is made. For example, would the US participate in the 1997 review that determines whether CERN decides to skip stage 1 and go straight to 14 TeV? And if the LHC is to provide a model for US collaborations in large-scale science projects on foreign soil, agreements with CERN may come even more slowly, because a diplomatic analog of "model" is "precedent."

Willis and Trilling independently expressed similar concerns about the political negotiations still needed before formal US participation is possible. "Everything is not over, by any means," said Trilling. "There's still going to be a lot of pushing and shoving before we get there." Willis, who said his group has been living on "borrowed time," sees the same reality: "Of course we're not out of the woods yet. There's no agreement between the US and CERN, and surely there are issues, so we could still be tripped up. Well, that's the way it is."

►DENIS F. CIOFFI

APS Reestablishes Formal Ties with China

APS has signed an agreement with the Chinese Physical Society, in part to establish new collaborations in fertile areas of research and to be properly compensated for its journal subscriptions.

At its meeting in Minnesota in early November the council of the American Physical Society endorsed a memorandum of understanding between APS and the Chinese Physical Society that seeks "to assure the widest possible participation of Chinese and US physicists in the international physics enterprise."

The memorandum was a result of APS's mission to China in mid-October, headed by then-APS President Burton Richter, Vice President (now President) Kumar Patel and APS Director of International Affairs Irving Lerch. Along with the endorsement came controversy, however, as Fang Li-Zhi and Joseph Birman, chair and past chair of APS's committee on international freedom of scientists, respectively, brought before the council the unanimous disapproval of the memorandum by CIFS's membership, who believe that it does not address human rights issues.

Although China produces 500 PhD physicists each year and another 270 or so Chinese graduate from US schools, physicists in China typically endure poor research conditions, low prestige and low salaries—about \$120 per month for professors. (Lerch noted that some Beijing cab-drivers make four times as much.)

Despite these difficulties, Lerch thinks that China is poised to dominate critical areas of Asian science, and that "now is the time to step in." The memorandum of understanding took effect on 1 January and is supposed to hold for an initial period of three years. Either side can make the agreement null and void by giving six months' notice.

The understanding

What exactly was agreed to in the memorandum? The first component of the two-page document is a "proposal to enhance telecommunication access" between the physicists of the two countries. Already Les Cottrell, director of computing operations at SLAC, has agreed to provide a server to function as the US arm of a joint Chinese-US physics electronic bulletin board. The Chinese server will be set up by Xu Rongsheng at the Beijing Electron-Positron Collider Center.

The second component of the memorandum mandates the formation of a "joint expert commission" to increase collaboration between US and Chinese physicists, particularly in subject areas where it has not often occurred before, such as condensed matter, materials science and atomic, molecular and optical physics, which the memorandum mentions specifically. Richter told PHYSICS TODAY that in some of these areas the Chinese have world-class programs, and US scientists will certainly benefit from collaboration.

The memorandum also asks that the Chinese decrease the number of APS-subsidized journal subscriptions

and increase the number of subscriptions by institute and university libraries in China. Put simply, APS wants to be paid for its journals. From all of China, APS receives payment for only seven institutional subscriptions.

Finally, the memorandum urges "open scientific communication." In part, it declares that "the only acceptable criterion for publishing in the scientific literature is scientific merit." This statement thus indirectly addresses the alleged removal of names of Chinese authors from refereed scientific publications for nonscientific reasons. Richter said that one might call this part of the human rights issue "scientific human rights," that is, those that are "within the province of the Chinese scientific community."

Richter, Patel and Lerch also signed a separate "Statement of Concern for the Rights of Physicists," which was given to the Chinese at a private, unofficial session. Lerch told PHYSICS TODAY that the Chinese Physical Society delegation later forwarded the statement to various Chinese government agencies. Asked why the statement was not part of the memorandum of understanding, Lerch replied, "It was clear that there would be no MOU if human rights were specifically included." Richter said that this separate statement addressed "general human rights that lie beyond the authority of Chinese scientists."

Concerns of CIFS

CIFS's Birman, dissatisfied with the contents of the memorandum of understanding, questions "the rush to have an agreement." He said the omission of human rights from the memorandum gives a "clear signal that APS's concern for human rights was really some sort of window dressing." Fang, a Chinese astrophysicist who was placed under house arrest following the Tiananmen Square protests, added that "concern for human rights abuses is a tradition of the physical science community, and it would not be a good model if APS keeps silent, or raises its voice only in private."

Birman also questioned the importance of having ties with CPS, which he called "a largely unknown organization." Notwithstanding its name, CPS is not the analog of APS but rather is a relatively new type of nonprofit business organization that the Chinese call a "social group." The CPS is promoted by the Chinese Academy of Sciences.

Richter said that he fully understood the concerns expressed by