Choosing Detectors for the SSC

SSC officials are inching toward choosing the two large-scale experiments that will be done in the machine—a decision that will influence physics for at least a decade

LAST WEEK A MILESTONE WAS REACHED IN the embryonic history of the Superconducting Super Collider, the most expensive research project ever designed, with a total price tag in the neighborhood of $8 billion. At a meeting in the SSC lab's temporary headquarters near Dallas, the lab's Program Advisory Committee heard proposals for experiments to be installed in the machine when it is built. Three groups, each headed by a man with a distinctly different style, were competing for two slots in which to build a half-billion-dollar instrument. The groups, headed by Michael Marx of Stony Brook, Samuel C.C. Ting of MIT and George Trilling of Berkeley, are huge, international collaborations with hundreds of participants, and the decision will have repercussions within the high-energy physics community for at least a decade. So the stakes were high when the groups arrived in Dallas ready to give their presentations on 13 December.

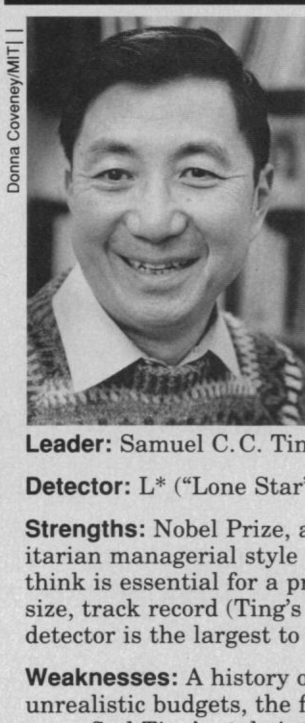
But at the outset of the meeting, SSC head Roy Schwitters surprised most in attendance by declaring that no decision would be announced for at least another week. Some speculated that Schwitters, wary of alienating a large portion of the experimental physics community by cutting one of the three projects outright, was buying time—time in which he could try to encourage groups to merge and form a united front. A united front, that theory went, might be particularly important if funds for the SSC were ever to be threatened.

This latest twist in selecting experiments for the SSC, however, is only one episode in a process that has been under way for about a year—an unusually protracted period that is largely a function of the extraordinary size and complexity of these projects. Experimental teams now resemble multinational corporations, with governing boards and substantial international components. This development culminates the era that 30 years ago was dubbed Big Science and inaugurates an entirely new one—one that might be called Multinational Science. And as the SSC lab discovered, Multinational Science poses many new problems that scientists, lab managers, and policy-makers must now begin grappling with.

Schwitters has been involved with the SSC since its inception. He was one of a group of Fermilab physicists who, at a now-famous meeting of the American Physical Society's Division of Particles and Fields in 1982 in Snowmass, Colorado, proposed a "great leap forward" in accelerator energy—far beyond that of existing machines. The idea of a gigantic accelerator caught on among the physics community and within a year an advisory panel of the Department of Energy gave designers the go-ahead.

Even though Schwitters and his colleagues were enthusiastic about increasing accelerator energies, they were far less sanguine about corresponding increases in luminosity, a key measure of the number of "events" (collisions between particles) per unit time. The reason, they argued, was that existing detectors could not possibly cope with substantially higher event rates than those in machines such as the Tevatron, then being planned for Fermilab.

AUTOCRACY



Donna Coveney/MIT

Leader: Samuel C.C. Ting

Detector: L* ("Lone Star")

Strengths: Nobel Prize, authoritarian managerial style that some think is essential for a project this size, track record (Ting's current detector is the largest to date)

Weaknesses: A history of unrealistic budgets, the fact that some find Ting's style intolerably autocratic

Schwitters now admits that he was "unduly pessimistic" about detector luminosity in those early days. In fact, the luminosity of the SSC will not only match the level Schwitters and his colleagues had deemed impractical, but may exceed it by a factor of 10. This will not be easy to accommodate; at design luminosity almost 10,000,000 collisions will occur inside each detector each second, each producing 100 particles to be tracked through millions of channels of electronics. Figuring out the best way to handle this activity amid tradeoffs involving information, technology, and cost set the design problems for the SSC detectors—its primary scientific instruments.

In February 1990, the SSC lab issued a call for "Expressions of Interest" in designing detectors. Fifteen proposals from various groups were received; in June, the Program Advisory Committee heard oral presentations from those groups. It quickly became apparent that the scope of the decision was so great that the selection process would have to be considerably extended. But even at the beginning of the process, the committee made four far-reaching decisions.

The first was that initially only two full-scale detectors would be chosen. That decision set the stage for an intense six-month competition between the largest teams. The second decision specified the types of detectors: one would be a "general purpose" detector with the capability to handle a broad spectrum of physics; the other would emphasize "robust muon detection and calorimetry" (a more specific capability suited for high luminosities).

The committee also laid down rules regarding time and money. The cost of each detector was capped at $250 million from U.S. sources, to be augmented by an equal amount of foreign funds, for a grand total of half a billion dollars. That decision forced each group to develop—if it hadn't already—a large network of international collaborators to drum up money abroad. Then the committee picked three of the largest groups to receive enough funding to prepare follow-up "Letters of Interest" to be presented at the lab on 13 December. Expectations were that the final decision would follow a few days later.

In the finals of this super competition, the Program Advisory Committee not only had to evaluate the design put forward by each collaboration, it had to evaluate the collaboration itself: the group's caliber and depth, its management skills, its ability to carry out a huge project at the required cost and speed. This evaluation was made even more difficult by the fact that the three collaborations had entirely different managerial styles.

Ting's proposed detector is known as L*, or "Lone Star," and the collaboration is dominated by his personality and scientific vision. Ting, one of the most powerful and ambitious figures in high-energy physics, won the NobelPrize in 1976 for discovering a particle known as the J/Psi by tracking electrons with unprecedented precision. Since then Ting has been building ever-bigger versions of the same basic detector. Even before the SSC lab put out its call for proposals, Ting had a scheme to scale up his current detector at CERN, called L3, by 50% to fit into the SSC. Like its predecessors, L* is designed for excellent coverage of leptons (electrons and muons).

That sounds promising, but Ting is famous for his ability to put a favorable gloss on very risky projects. His budgets, for example, have been unrealistic. The American contribution to L3, which was supposed to have been $19 million, shot to $55 million and is still climbing. Furthermore, many in the physics community think L3 was a disappointment: Far more costly than other CERN detectors, it hasn't yet produced superior physics.

Then there's the Ting personality. Not shy about his ambitions, he put a map of the globe on the cover of his proposal; the first illustration inside was the plot of his Nobel Prize–winning discovery. The conclusion of the document celebrated Ting's track record. "Taste, experience, and judgment in experimental physics come slowly with time," it began, a pat on his own back that some found distasteful. The collaboration Ting leads is a bit like an army—during group meetings he slowly paces the aisles, dressed in a dark suit, hands clasped behind his back, like a general reviewing his troops.

That style is both a strength and a weakness. Some believe that Ting's authoritarian flair is absolutely indispensable for mounting a project of this size. And surely SSC officials realize that this man would make a formidable adversary—or a powerful ally if the SSC ran into trouble in a cost-cutting Congress. Yet others find his style intolerably autocratic. Any discussion about Ting among physicists inevitably elicits stories about scientists whose careers—or spirits—were broken by Ting.

George Trilling, who heads the rival SDC ("Solenoidal Detector Collaboration"), is worlds away from Ting in terms of personal style. A Polish-born, French-raised American, he is an amiable and highly regarded figure in the physics community. The collaboration he leads has something of the flavor of a bureaucracy, governed by a set of formal bylaws that establish, among other things, an executive and an institutional board.

The technology that this bureaucracy is betting on is one that has formed the backbone of particle detection for decades. Large detectors have always emphasized the tracking of individual particles. That tracking has been accomplished by filling the interaction area with something to make the tracks visible and surrounding that medium with a magnet to bend the particle paths, revealing the particles' mass and momentum and making it possible to reconstruct the original event. The most effective way to cover a large area with a strong, uniform field was by means of a solenoidal magnet; the first large detector to do so was the Mark I detector at the Stanford Linear Accelerator Center.

When the SSC was announced, a number of different groups began studying prospects for a large solenoidal detector, and in September 1989, those groups merged under the direction of Trilling, who had worked on the Mark I. Because they are an established detector technology, solenoids are low risk. Moreover, many physicists, including several SSC officials, are experienced with solenoids. A popular and safe bet, the SDC appeared to be a shoo-in.

Yet even SDC isn't entirely unproblematic. While solenoids work very well in low-luminosity electron accelerators, they are less effective in machines with higher luminosities. Not only is tracking rendered far more difficult, but low-energy particles spiral, obliterating other tracks; the dense lines and swirls may resemble a Jackson Pollack more than they do a nice, clean bubble-chamber photo. And a proposed upgrade of SSC luminosity—by a factor of 10—would pose serious problems. The designers of the SDC, however, are confident that they can use new techniques to overcome these obstacles.

The third collaboration, EMPACT ("Electrons, Muons, Partons with Air Core Toroids") is a long shot that grew directly out of the shortcomings of solenoidal detectors. In January 1989, Trilling asked Michael Marx, a young physicist with a reputation for producing classy detectors within budgetary and equipment constraints, to study the problem of where in the SDC to put the solenoid. Marx concluded that the correct answer was: "Nowhere." Unable to convince Trilling, Marx proposed the idea of an entirely different magnet system.

That system is predicated on the argument, advanced by some in the physics community, that the scale of contemporary accelerators has rendered solenoids obsolete. The larger the detector, this argument goes, the less feasible particle tracking becomes and the more promising is calorimetry (measuring particles not by individual tracks, but by how much total energy is deposited in an absorbing material). The EMPACT collaboration focuses on calorimetry and achieves its muon resolution through the use of toroid magnets, whose flux lines circulate around the particle beam line rather than running parallel to it, as in the case of solenoids. It is a technology borrowed from plasma fusion research; one of the EMPACT collaborators is the Grumman Corporation, which built air core toroids at Princeton's TFTR fusion reactor.

The EMPACT system trades in some ability to track individual particles for several advantages, including the fact that it can readily handle the high luminosities that will be typical of the SSC. In spite of those virtues, EMPACT at first made little headway—partly because it was unfamiliar, partly because it was competing against heavyweights Trilling and Ting. But the SSC lab's decision to support only three projects encouraged mergers—and several experienced groups joined EMPACT, bolstering its expertise. The decision to cap costs also helped,

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Lawrence Berkeley Laboratory

Leader: George Trilling

Detector: SDC (Solenoidal Detector Collaboration)

Strengths: Trilling is an amiable and well-regarded figure, the technology is well established, SDC appears to be a shoo-in

Weaknesses: Technical problems adapting the technology to the proposed upgrade in SSC luminosity because it forced the others to downsize and leveled the playing field. Furthermore, the warm collegial atmosphere among the young physicists on the EMPACT team contrasts sharply with that of the other two. As Thursday, 13 December, approached, EMPACT was still an underdog, but perhaps no longer a long shot.

As the proceedings began in a warehouse on the outskirts of Dallas that has temporarily been converted into SSC office space, Schwitters dropped his bombshell—by announcing there would be no immediate announcement. "Don't hang out on Sunday," he said. "We'll get back to you." But if, as some said, Schwitters put the decision off in an attempt to get competitors to merge, the presentations that followed revealed that he faces an uphill battle.

Trilling went first. Confident and avuncular, he had not the slightest doubt he would be one of the elect. "I do not plan to hang out until Sunday," he said. Trilling has a square, clean shaven, trustworthy face; thick glasses, bushy eyebrows, graying hair, and the remarkable ability to grin broadly with his mouth entirely level. Neatly dressed in a bright blue sweater, he lumbered across the stage, gesturing with his hands and using his wooden pointer as a cane. He had brought along a sample of his most difficult technology—a long black tracking tube used for identifying particles close to the interaction point. He leaned over encouragingly toward each questioner, few of whom were unfriendly. He got into hot water only when pressed about the capacity of his device to handle the proposed upgrade in luminosity at the SSC—but was rescued by Schwitters, who stepped in to remind the audience that the first order of business was handling the initial design luminosity.

Ting presented a great contrast when he followed. Quiet, authoritative, and reserved, he wore a charcoal gray suit. Speaking in a low monotone, he lost no time pushing his experience and designs. He spent a few minutes talking about his career, early experiments, and L3, which he described as the forerunner of L*. His initial "Expression of Interest" had been the most ambitious, so he had the most descoping to do; L* would be only an increase of about a third over L3. Unremittingly formal, Ting used full titles when referring to his collaborators: "Academician" for Russians, "Professor Doctor" for Germans. He passed around a sample of his riskiest technology, a rectangular barium fluoride crystal about a foot long. L* would need several thousand such crystals—and serious doubts exist about whether so many can be grown at a reasonable cost.

The questions following Ting's offering were considerably more hostile than those for Trilling, but he defused each with a mixture of humor and handwaving. He answered a question about L3 cost overruns by attributing most of it to the decline of the dollar. Someone found a discrepancy between L*'s calculation of the number of events at the SSC and everyone else's, inquiring sarcastically, "What did you assume for the number of seconds in a year?" "To be honest, I don't remember," Ting replied, then joked about needing to refer this question to his appropriate expert. When a critic asked what new physics had been uncovered by the expensive L3 detector, Ting acted offended. "I've been doing this all my career," he said. "Sometimes you do discover something new, sometimes you don't. At L3, we haven't yet."

Marx went last—a position he had obtained by deliberately waiting until the last moment to hand in his Letter of Interest. He was less precisely dressed than the others, wearing no glasses and a tie that was a shade of green somewhat paler than the cactus plants that decorated the stage. He had brought nothing to pass around. But he was far more aggressive that his rivals, hammering home the point that EMPACT had been tailored to the specific conditions of the SSC. "This [detector] is designed for the SSC, and is not extrapolated from existing electron or [proton] machines," he said, provoking nervous laughter from members of the other collaborations. By referring to his partnership with Grumman, Marx took a sidelong swipe at Ting's inability to meet budget: "We've had professional cost estimating done by people whose lives depend on getting the cost right." Finally, noting that "the committee's hardest task is to decide which of the three experiments fit in the two categories," he made no bones of the fact that EMPACT was the only one that fit the second category.

The meeting broke around dinner time. The Program Advisory Committee worked on alone for another hour. Trilling and a dozen associates went to dinner. Ting went off by himself. Marx and other EMPACT members retired to a local restaurant where a room had been reserved; the group, swollen by friends and well-wishers, packed the room and spilled over on to additional floors. Much wine was consumed and numerous toasts proposed. More than one person was depressed, however, that Ting, whom they believed to be their principal rival, had managed to deflect all the tough questions, and at least one toast was rounded off by an expression of apprehension that this might be farewell for the group.

The next day the collaborations regrouped at the lab, to answer questions posed by the Program Advisory Committee. On Saturday, 15 December, the committee gave Schwitters a confidential recommendation about which two projects to support; the lab expects to release its final decision this week. If Schwitters does try to combine groups, he will find it difficult, since Trilling's collaboration draws from a deep tradition in detector physics, Ting's is practically an organism itself, and Marx's has emerged as an explicit alternative—scientifically and stylistically—to the others. As a result of these disparities, the groups are likely to resist stoutly any attempt at merging.

But even when completed, the extended, elaborate, politically charged approval process for experiments is only one sign of a significant change in high-energy physics. As the size of detector projects grows, and as they rely more and more on members from many nations, they will encounter a whole new class of difficulties: customs regulations to circumvent, trade restrictions to remove, travel, technology, and employment restrictions to annul, political animosities to defuse. In overcoming such hurdles, a collaboration becomes a political and social force in itself. With the "great leap forward" in detector groups taking place at the SSC, Multinational Science will radically alter the way science is conducted. ■ **Robert Crease**

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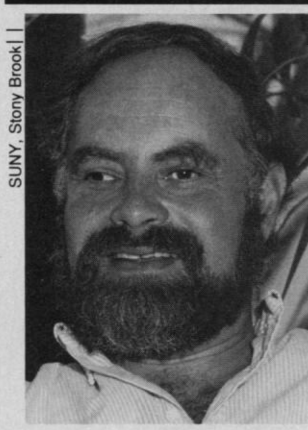
UNDERDOG



SUNY, Stony Brook

Leader: Michael Marx

Detector: EMPACT (Electrons, Muons, Partons with Air Core Toroids)

Strengths: Marx's reputation for producing classy detectors within budget, new technology, young, collegial collaboration

Weaknesses: Riskiness of going with an unproved technology