

not afford to support Atlas the way it was planned because the overall stockpile stewardship program was not funded as planned."

In addition to wasting taxpayers' money and aborting an experimental program, shutting Atlas damages US-Russian cooperation, says Irv Lindemuth, who, before he retired from LANL in 2003, was a project leader for pulsed-power science and helped handle collaborations with Russia's nuclear design labs. "We are looking at other venues for the collaboration to continue," says Hockaday. But Lindemuth says that "Atlas is one of the few US facilities of interest to the Russians that they can actually have access to. They are interested in NIF [the National Ignition Facility at Lawrence Livermore National Laboratory], but DOE is not likely to give them access." In the long term, he says, the question "is whether or not the US will provide the unclassified help Russia says it needs to maintain its nuclear stockpile in an era without testing." If not, he adds, "how can we expect Russia to provide help on nuclear issues of most importance to the US—control of Russia's nuclear materials?"

Toni Feder

Report urges major effort to site collider in US

A National Research Council committee, charged with charting the course of US particle physics over the next 15 years, has released its report. Because particle physics is a costly business requiring broad support within the intellectual community—not to mention the government—several of the committee's 22 members, including its chair, economist Harold Shapiro, biologist Harold Varmus, and former Lockheed-Martin CEO Norman Augustine, were not physicists.

Entitled *Revealing the Hidden Nature of Space and Time*, the 125-page report (available from the National Academies Press at <http://www.nap.edu/catalog/11641.html>) contrasts the undeniable excitement and promise of particle physics at the start of the new century with the unmistakable downward trend of experimental facilities and programs in the US. The Superconducting Super Collider was cancelled in 1993 in mid-construction. With the Large Hadron Collider (LHC) about to start operation at CERN, Fermilab's Tevatron is unlikely to outlive the decade. Neither is the PEP-II asymmetric electron-positron collider at SLAC nor the Rela-

Soccer obeys Bessel-function statistics

The soccer World Cup gets under way in Germany on 9 June. For a month, 32 national teams will compete for the world title. Metin Tolan is betting on the home team.

Tolan, an experimental physicist at the University of Dortmund, bases his prediction on an analysis, conducted with three colleagues, of some 34 300 past games—2000 professional games played in Italy, 5300 in England, and 27 000 in Germany. "We approximated a soccer team by a radioactive source. A soccer team emits goals according to Poisson statistics," he says.

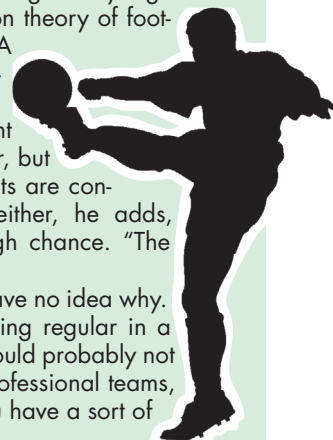
Calculating the probability that a team will win or lose a game by a given number of goals leads to what Tolan calls the "Bessel-function theory of football"—as soccer is called in most places outside the US. A modified Bessel function results from summing over products of probabilities expressed as Poisson distributions.

Tolan's calculations assume that goals are independent of one another, which, he says, "is reasonable for soccer, but not, for example, for basketball, because there the points are connected." The calculations wouldn't work for tennis, either, he adds, because too many points are involved, and not enough chance. "The probability for surprise in tennis is not very high."

But for soccer the Bessel-function fits are good. "We have no idea why. I never would have guessed that you would find anything regular in a chaotic game like soccer," says Tolan. Bessel functions would probably not approximate minor league teams well, he adds. "The professional teams, while not of equal strength, have a certain level, and you have a sort of restricted system where not everything can happen."

For this year's World Cup, Tolan and his colleagues carried out 100 000 simulations based on past performance to get the probability of each team's winning the title. "Statistics cannot predict the results of a specific World Cup," says Tolan. "So this is where the fun begins." The simulations put Brazil's chance at 15% and Germany's at 10.5%, he says. But home teams tend to score an average of 0.6 to 1 additional goal per game. Incorporating that "home advantage," says Tolan, boosts Germany's chance of winning to 33%.

Toni Feder



tivistic Heavy Ion Collider at Brookhaven National Laboratory.

Why should that matter? "Particle physics plays an essential role in the broader enterprise of the physical sciences," says the report. "It inspires US students, attracts talent from around the world, and drives intellectual and technological advances in other fields." As particle physics and its connection with cosmology enter "an era of unprecedented potential, the US should remain globally competitive . . . by playing a leading role in the worldwide effort to aggressively study terascale physics," that is, accelerator-based experiments at collision energies of order 10^{12} electron volts (1 TeV).

To that end, the report makes three principal recommendations to US funding agencies: They should undertake a "comprehensive program to [make the US] the world-leading center" for developing the science and technology of the International Linear Collider—a proposed TeV e^+e^- collider—and "do what is necessary to mount a compelling bid to build the proposed ILC on US soil." Furthermore, they should "fully exploit the opportunities afforded by the LHC"

by adequately supporting US groups that will soon be taking data at the 14-TeV proton-proton collider. Finally, lest these programs at the terascale frontier cause neglect of very important particle physics at lower energies, the report urges the expansion of particle-astrophysics programs and the pursuit of "an internationally coordinated, staged program in neutrino physics."

The ILC is the highest-priority facility on the US particle-physics community's wish list. After the LHC has surveyed the first rough outline of the terra incognita beyond 1 TeV, an e^+e^- collider would carry out the precision measurements that are thought to be essential for extracting the full meaning of the LHC discoveries. The report does not quote an explicit cost for building the ILC. But with an estimated price tag on the order of \$10 billion, the 30-km collider would obviously have to be thoroughly international from the start. Two years ago, a panel of the International Committee for Future Accelerators settled on superconducting RF acceleration technology for the ILC (see PHYSICS TODAY, October 2004, page 34).

It is expected that the host country would have to pay about half the ILC's construction cost. But the alternative to bearing that expense would require a generation of US particle physicists to do their experiments abroad. More important, says committee member Jonathan Bagger of Johns Hopkins University, would be the consequent loss of US leadership in this field. The committee's report urges a concerted effort to avoid that prospect. "What we've recommended," says Sally Dawson, a committee member from Brookhaven, "is the thoughtful pursuit of a high-risk, high-reward strategy." But even riskier, thinks chairman Shapiro, would have been "to continue on the current trajectory without doing anything."

Bertram Schwarzschild

Politicians skeptical about need for ARPA-E

"We live in a truly magical time," said physicist Steven Chu, director of Lawrence Berkeley National Laboratory, as he opened his testimony in March before the US House of Representatives Committee on Science. "With the flick of a finger, the power of 10 horses flows from a small wire in the wall of our homes to clean our carpets." Chu was trying to convince skeptical committee members to support the creation of the Advanced Research Projects Agency-Energy (ARPA-E) as an innovative way to help solve the growing US energy crisis.

Chu, one of the authors of last December's National Academy of Sciences' report *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future* (available from the National Academies Press at <http://www.nap.edu/catalog/11463.html>) that recommended the creation of ARPA-E, continued to extol the virtues of energy for the committee, noting that abundant energy supplies have allowed us to "live well beyond the dreams of Roman emperors."

But after waxing poetic, Chu got down to business, telling the committee members that worldwide consumption of energy has nearly doubled between 1970 and 2001 and is expected to triple the 2001 demand by 2025. "The extraction of oil, our most precious energy source, is predicted to peak sometime in 10 to 40 years, and most of it will be gone by the end of this century," he said. "What took hundreds of millions of years for nature to make will have been consumed in 200 years."

As a result, he said, the US must move aggressively to develop new technologies to supply the US with clean and sustainable energy, and the creation of ARPA-E within the Department of Energy's Office of Science would help do just that. ARPA-E, as proposed in the *Gathering Storm* report (see PHYSICS TODAY, December 2005, page 25), would sponsor generic energy research "where risks and potential payoffs are high, and where success could provide dramatic benefits for the nation." It would be modeled after the highly successful Defense Advanced Research Projects Agency. DARPA identifies and funds innovative research for the military, but its independence from the traditional military command has allowed it to support risky, long-term research over its nearly 50 years.

Although science committee chairman Sherwood Boehlert (R-NY) and most other members of the committee strongly endorsed the *Gathering Storm* report, several expressed significant skepticism about ARPA-E at the hearing. Boehlert noted that many energy technologies are "just sitting on the shelf," and the creation of yet another government agency doesn't guarantee they will get to the marketplace.

Rep. Judy Biggert (R-IL), chairman of the science committee's energy subcommittee, was more dubious than Boehlert. "Why am I so skeptical? Let me count the ways," she said. "First, it is not clear what problems we are trying to solve with the creation of an ARPA-E." If it is the lack of private-sector investment in basic energy research, she asked, then how does creating a new agency to distribute scarce federal money help? If it is a failure by the federal government to fund transformation research, she continued, how do ARPA-E supporters explain the DOE's hydrogen initiatives, or US participation in ITER, or the proposed global nuclear energy partnership?

If DOE isn't transferring existing technology to the marketplace, she added, why not fix that problem instead of creating a new agency? "In short," Biggert concluded, "is [ARPA-E] a solution in search of a problem?"

Boehlert reminded Chu and others who testified at the hearing that federal funding is extremely tight and, with new funding not likely, asked if they would support taking money from other Office of Science programs. Rep. Bart Gordon (D-TN), the ranking minority member on the committee and sponsor of a bill to establish ARPA-E, said choosing between ARPA-E and the

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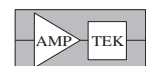
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