In their hands: The future of particle physics

Particle physics is at a critical time, and its future depends on how well scientists can make their case to a diverse National Academy of Sciences panel.

by Mike Perricone

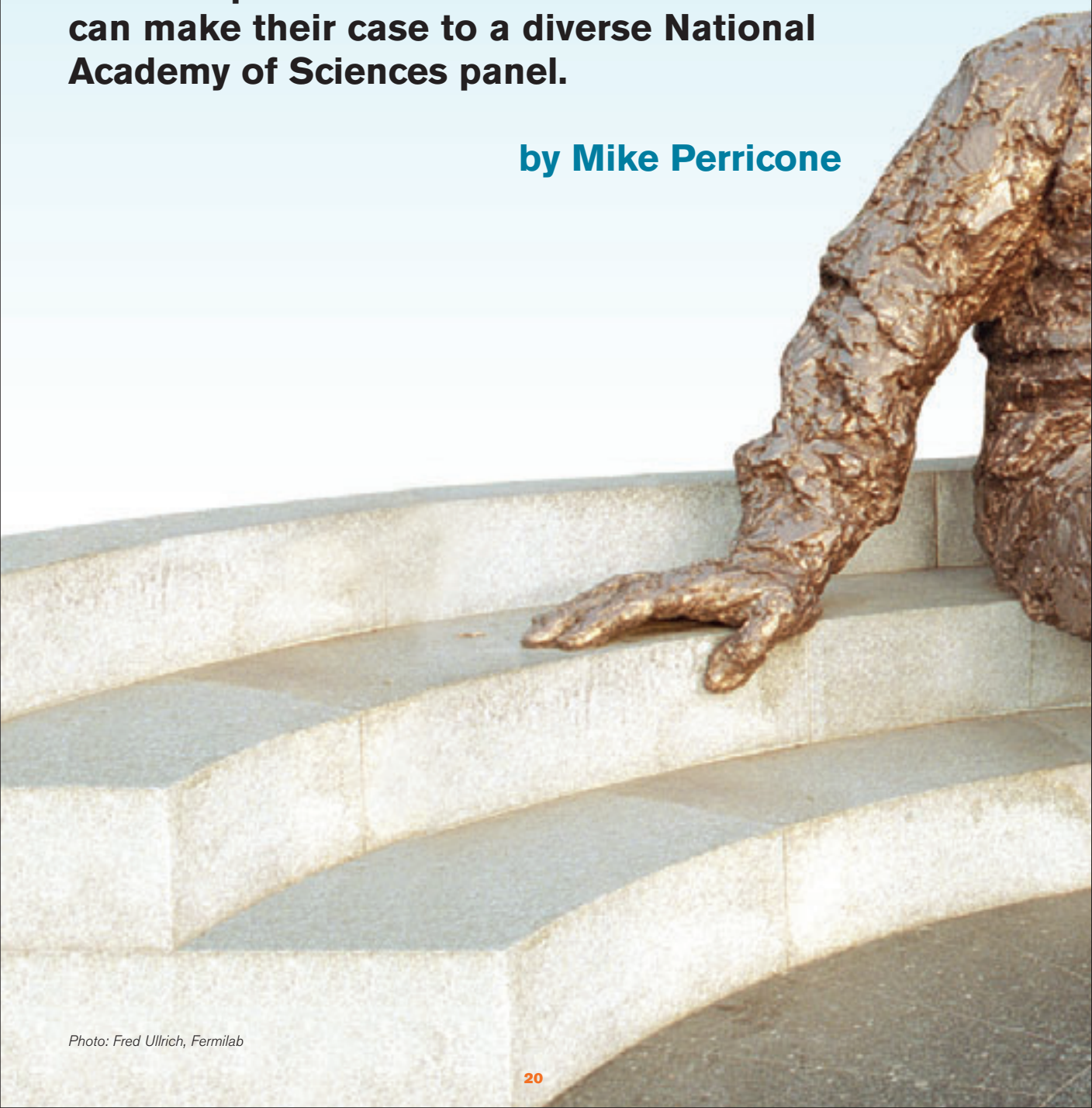

Photo: Fred Ullrich, Fermilab

They are an economist and university president emeritus; an engineer and former CEO of a technology giant; a physicist and former Presidential advisor. They are three Nobel Prize winners (two in Physics, one in Medicine); a Washington, DC, lobbyist; a theoretical physicist; an astronomer; a condensed-matter physicist. They are a former national laboratory director who held simultaneous professorships in physics, chemistry, and electrical engineering and computer science; scientists from Japan and the United Kingdom; and they are a stellar array of particle and accelerator physicists.

They hold in their hands the future of the field of high-energy particle physics in the United States. In conducting their research over the past six months, the 22 members of the panel called "EPP2010: Elementary Particle Physics in the 21st Century" have come to realize that if US particle physics is not a field in crisis, it is nonetheless a field that has reached a critical point where the science prospects far outstrip the planning and resources.

"What I've found is that my outlook is changing, not so much on the significance of particle physics—it has always held a high rank in my own perspective on science," says economist and EPP2010 chair Harold Shapiro, president emeritus of Princeton University. "What has changed is a fuller realization of the fact that we are at a very important strategic moment. A number of very wonderful large experiments are coming to an end, and since we did not go ahead with the SSC [Superconducting Super Collider] several years ago, there is no obvious strategic thrust that has been

Albert Einstein, who is memorialized by a sculpture outside the National Academies of Sciences in Washington, DC, would have been interested in reading the report of the EPP2010 panel.

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Michael Turner, NSF

agreed on, including by the funders, for the next generation. Therefore, I am more aware and sensitive to the fact that in the next few years, if we are to sustain the vitality of this scientific community in the US, we have to develop a new strategic set of plans that will make it exciting for young people to come into the field and work in it. I hadn't fully understood just how critical these next few years are in the US for particle physics."

The short decade

The National Academies, comprising four organizations—the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, and the National Research Council—periodically bring together committees of experts in all areas of science and technology. These experts serve pro bono to address critical national issues and give advice to the federal government and the public. The Academies' National Research Council reviews each field once in each decade. The last study of particle physics was issued in 1998, but as panel member Jonathan Bagger, a particle physicist at Johns Hopkins University, has explained: "There have been significant changes since then—dark energy and connections with astronomy; the discovery of neutrino mass and connections with nuclear physics; precision electroweak measurements, and world consensus on a linear collider."

Meanwhile, five years of flat federal funding has left particle physicists grasping at straws as well as at any stray dollar. The result: Robin Staffin, Associate Director-High Energy Physics, US Department of Energy Office of Science; and Michael Turner, Assistant Director for Mathematical and Physical Sciences, National Science Foundation, saw the need to advance the scheduling of a new study. Their charge to a new panel: "Identify, articulate, and prioritize the scientific questions and opportunities that define elementary-particle physics. Recommend a 15-year implementation plan with realistic, ordered priorities to realize these opportunities."

Turner stresses that the presence of so many experts from outside the field of particle physics gives the panel a level of credibility that reviews internal to the field cannot match. He also sees a model in the Academies' decadal study of astronomy, with its highly-regarded emphasis on setting strategic priorities for the field—a component lacking in previous particle physics decadal studies. "In writing the charge, Robin and I made a point

Photo: Reidar Hahn, Fermilab

Jonathan Bagger (left) and Barry Barish are veterans of many advisory committees. Bagger's work in EPP2010 will look to the future of projects such as the ILC, for which Barish heads the Global Design Effort.

Left to right: Harold Shapiro; Charles Shank; Sally Dawson.

Photos: Reidar Hahn, Fermilab

to focus on prioritization, of both the science and the implementation plan," Turner says. "By laying out the revolutionary scientific breakthroughs that elementary-particle physics is poised to make, and the prioritized implementation plan needed to achieve them, EPP2010 will provide policy-makers and funding agencies with both the case for making large investments in this field of discovery science and a roadmap for making the most strategic investments."

Shapiro acknowledges the difficulty in setting priorities, but he also considers the eventual alternatives: either someone with knowledge and a commitment to the field will help set priorities; or, policy-makers, often with much less knowledge and commitment to the field, will set priorities. "So we're trying to drive toward priority decisions despite the difficulty and uncertainty that are involved," Shapiro says.

Credibility from diversity

Staffin, whose office funds virtually the entirety of US particle physics, regards EPP2010 as a critical step in any process toward a multinational, megadollar project such as the proposed International Linear Collider. "A couple of million to $10 million, we can handle that OK at the Office of Science," he says. "Hundreds of millions—that takes some coordination. At the multibillion-dollar level, you are competing with a whole lot of other priorities, throughout society as a whole. That's why we thought it was important to go to the National Academies. EPP2010 gives us a broader base. The people on that committee can open doors that are not easily opened, by their prominence and their credibility."

They needed to start by opening doors within the committee. "This is a very interesting attempt to bring in views from outside the field, attempting to build a consensus on major construction and reverse some of the trends in the budget," says Charles Shank, who served for 15 years as director of Lawrence Berkeley National Laboratory. Committee members have traded off "tutorials" to establish a baseline of knowledge in particle physics, and in all other fields represented on the committee. Non-physicists are seen as strengthening connections to society at large, sharpening the physics questions, and helping engage other scientific communities; international representatives help place US particle physics in a global context. "It's coming together nicely," says Bagger, a veteran of several physics advisory panels.

The panel's two-year journey through the field began in November 2004 with an assembly at the Keck Center of the National Academies in Washington, DC. Presenters included Turner and Staffin, Patrick Looney of the Office of Science and Technology Policy, and Barry Barish, himself

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a veteran of other advisory panels and now head of the ILC's Global Design Effort. In meetings at Stanford Linear Accelerator Center and at Fermilab in the first half of 2005, presenters included eminent theorists and experimenters as well as the directors of the world's major high-energy research centers (excepting CERN, site of the under-construction Large Hadron Collider): Michael Witherell and director-designate Pier Oddone of Fermilab, Jonathan Dorfan of SLAC, Albrecht Wagner of DESY in Germany, and Yoji Totsuka of KEK in Japan, as well as Ian Halliday, former director of the United Kingdom's Particle Physics and Astronomy Research Council. An August meeting is scheduled at Cornell University; the panel's charge says it will meet "up to five times," then prepare a report for release in 2006.

Focus on questions

Listening and questioning are the panel's priorities during their meetings. They view the right questions as critical to their work. For example, panel member Joseph Hezir of the EOP Group is valued not for his experience as a lobbyist, but for his decade of experience working at the Office of Management and Budget—and for raising the types of questions OMB would be expected to raise. Shapiro observes that the questions raised by non-physicists on the panel differ in specific and important ways from questions raised by the physicists.

"The first difference is in the level of confidence regarding whether or not the proposed technologies involved will actually work," Shapiro says. "In a complex technological environment, there is a certain amount of failure or risk no matter what you do. The history of particle physics suggests that physicists are very inventive in finding ways around failure, and they come out in the right spot eventually. But this is something that I think the outside members are more sensitive to, and they are doing more pushing back on it.

"Also, the external members are somewhat more sensitive to the reality of the Federal budget over the next four to five years," he continues. "We have a very close association with the budget, and I believe we are helping everyone to realize the budget realities. Lastly—the question of: 'Why is this ILC so important? So we find the Higgs, and we know its mass: Why do we need the details for all the couplings? Exactly what is it that makes this so important?' The HEP members are convinced on this issue, but it took a while for them to express their conviction in a way that non-physicists can appreciate. If they want us to be helpful, we must be able to convey the message to a broader policy community that is not made up solely of physicists."

The all-important issue of the ILC is being examined in three components: the physics case (Is it the right machine, and does it address the compelling questions of particle physics?); the R&D plan (What is needed to arrive at a construction decision? Is a reliable cost estimate possible?); and international planning (How can US yearly budget decisions connect with a long-term international project? Why consider hosting the ILC in the US?).

But the panel's final impact might depend on its answer to one of its own questions: While particle physics is poised for revelations in our knowledge of matter, energy, space, and time, are the science of particle physics and the fundamental questions it seeks to solve compelling enough on their own to assure the future of the field?

"They are certainly very compelling questions," Shapiro says. "For anyone who cares about the origin and evolution of the universe and of matter, it's hard to think of more compelling questions. But there are really two associated questions—first, on what time scale is it important to answer these questions; and, second, how much money are we going to spend in order to get these answers? Is it worth the money, in a crass way of speaking? The ILC—whether it's $7 billion or $8 billion—even if the host only puts up half the money, there are a lot of competing claims for $4 billion within science and outside of science."

There is, simply, no avoidance of that one ever-present, everyday reality, felt in every scientific endeavor and every household: there is only so much money to go around.

"Since the resource requirements are very large we have to be able to make a compelling case," Shapiro says. "In the final analysis, policy-makers will have to compare investments in high-energy physics with other national priorities. In my own judgment, given the extraordinary scientific opportunities ahead, it continues to be important for our country to be among the leaders in this important scientific area, and this requires some new strategic decisions. Thus, one of our tasks is to understand both the nature, mix, and level of resources required to play a leadership role in this area of science."

The panel's final report must go beyond ILC, fulfilling its charge to recommend "realistic, ordered priorities" for 15 years.

"If we can provide a template to align science with budget expenditures, and outline a future so compelling that it attracts necessary new investment, I feel we will have made a modest contribution," says Shank. "The challenge will be to find answers that will provide a basis for giving the field a badly-needed boost and a clear future."

EPP2010 committee members

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