Commentary

What defines a healthy US particle-physics program?

At the 2011 Fundamental Physics at the Intensity Frontier Workshop held in Rockville, Maryland, I was asked to discuss why a healthy particle-physics program is important to the US.

That question raises a much more challenging one: What defines a healthy US particle-physics program, particularly in an era when the most powerful particle collider in the world is in Europe? To advance particle physics in the US, we need to answer both questions.

Let's start with the first one: Why does particle physics matter to the US at all?

The field is valuable because it draws interest to science by asking fundamental questions: What's the nature of the universe? What are we made of? People of all ages and backgrounds can relate to those compelling questions, which have been explored for millennia by every great society. Many factors go into an individual's decision to pursue a career in science, but one enticement is certainly the lure of big questions just waiting to be answered.

Particle physics is also an essential part of the fabric of the physical sciences in the US. It contributes broadly to other disciplines and vice versa. Many accelerator innovations, for example, grew out of particle physics but have led to technical advances in medicine, environmental and materials sciences, and other fields.

The challenge is to define a new role for the US particle-physics community now that the field has evolved from a local enterprise to a global one whose focal point is outside the US. Interestingly, this isn't the first time our community has faced a transition. Decades ago, universities operated the nation's particle-physics accelerators and experiments in local laboratories. Over time, those machines could no longer access the most exciting frontiers of particle physics and were shut down or used for other research, and we transitioned to national accelerator facilities. That change was not easy, but ultimately, both universities and national laboratories had prominent roles. Universities brought intellectual leadership and became the pipeline for young talent, while national laboratories provided major infrastructure and frequent leadership on large projects.

Today, with the increasing cost and scale of the machines that are needed to do cutting-edge particle physics, we face a similar transition, from national to global facilities. With the opening in Europe of the Large Hadron Collider (LHC)—a huge international facility built to reach the high energies needed for the next frontier of discovery—the last operating particle-physics collider in the US, Fermilab's Tevatron, has closed. Much of the US particle-physics community is now working on experiments at the LHC.

As before, the change is not without pain. The closing of US national facilities such as the Tevatron and the B factory has resulted not only in workforce reductions, but also in the need for a robust travel budget—and many hours on airplanes—for those who want to actively participate in scientific discoveries at the global level. But like the universities in the preceding transition, a strong US program can have an important and even leading part in this era of globalization.

First and foremost, the US particle-physics community must aggressively pursue the opportunities that will provide the most transformational scientific advances and attract the best talent. Whether we choose to search for the Higgs boson, understand dark matter and dark energy, or pursue *CP* violation through studies of neutrino mixing, we have many scientific opportunities open to us. But we cannot afford to do them all. We will need to choose, and to unify in support of those choices. In a world of constrained resources, many fields that promise transformational scientific advances are competing for money and talent. There is no entitlement for particle-physics funding.

Another key ingredient in maintaining vibrant particle physics in the US is strong university-based programs to ensure a healthy flow of the best and brightest students into the field. And since we particle physicists do big science with big tools, we need the infrastructure to develop, build, and support large detectors, accelerator components, and large-scale computing facilities. Building and maintaining that level of infrastructure is too much for any one university or even a consortium. Therefore, we will continue to need a strong national lab, such as Fermilab, to house and support substantial infrastructure for the field.

The US must maintain a strong national program in accelerator R&D. The future of particle physics depends on innovations in accelerator science. We need to invest in high-gradient acceleration technologies, including laser and plasma acceleration, that may be a key to building smaller, cheaper, more powerful accelerators. Those investments are vital to our future leadership in the field.

An often-debated question is whether the US needs a major accelerator dedicated to particle physics. For me, the answer is no. I understand that it has always been the operating model for the field, and feelings about continuing that way are understandably strong. However, any discussion about what facilities are needed should start with the science. Does the most exciting science we want to do—and think we can afford—require a dedicated accelerator facility for particle physics in the US? Such a facility should be a priority only if that's what it takes to deliver transformative scientific discoveries, not just to keep the US community relevant. Any other reasoning will be hard to justify and probably unsuccessful.

It is worth noting that we are building and operating many large forefront

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accelerator facilities in the US, probably more than ever before, for research in other fields. Examples include the Linac Coherent Light Source here at SLAC, the Facility for Rare Isotope Beams at Michigan State University, and the National Synchrotron Light Source II being built at Brookhaven National Laboratory.

The final ingredient of a healthy program is a long-term plan that includes an exciting vision for the future. Particle physicists operate on incredibly long time scales. The development of the LHC spanned 24 years from first concept to first beam. Many physicists will spend decades, or even an entire career, on one experiment. They need to know their work will ultimately bear fruit, and that will happen only with a long-term, well-articulated strategy in place.

None of these ingredients is new, but how we put them together does require a fresh perspective. Our future is not going to look like our past. As we make the necessary tradeoffs to keep a healthy and vibrant program in particle physics, we must be realistic in our assessments of budgets and technical progress, and we must always be mindful of where we are going. We should be asking ourselves, What might a healthy particle-physics program in the US look like a decade or two from now? The answer will help guide the decisions we make today.

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Letters

Politics and humility in climate change debate

While I am as dismayed as any civilized person must be by the brutal threats reportedly directed at climate change proposers (PHYSICS TODAY, February 2012, page 22), I am not at all surprised. That kind of behavior is typical in politics, and the climate scientists involved must recognize that when you tell people what they must do, you are practicing politics, not science.

I use the phrase "climate change proposers" to combat the pejorative "climate change deniers" that is commonly used. No one denies that climates change, locally and globally; however, there is a disagreement about how much is due to human activity. Resolution of