INTERNATIONAL COOPERATION

The Sine Qua Non for the Future of High Energy Physics

by S. PETER ROSEN

The Department of Energy's new Associate Director of High Energy and Nuclear Physics discusses the promise and problems of international scientific collaboration.

BY ITS VERY NATURE, physics is a science that knows no national boundaries. Particles move according to the same laws of motion no matter whether they be located in Alaska, Africa, or the South Pole. Quantum mechanics is equally valid in a laboratory in China as it is in Europe. Indeed we believe that the laws of physics, those known today and those yet to be discovered, apply throughout the Universe and govern its destiny. Thus it is not surprising that physicists come from all corners of the globe, and that transnational interactions and collaborations are second nature to them.

Initially drawn together by mutual interest, these collaborations have become more and more necessary as the experimental tools of the field have grown in size and cost. After World War II, for example, the nations of Western Europe recognized that in order to play a significant role in the then burgeoning field of nuclear physics, they would have to pool their resources and work together. In 1954, they signed the convention creating the Conseil Européen pour la Recherche Nucléaire (CERN), which has since become one of the great scientific laboratories of the world and a model for peaceful international collaboration.

Individual nations in Europe did not forswear building accelerators entirely. France and the United Kingdom built proton machines (see the essay by Gordon Fraser on page 12), and Germany the DESY electron synchrotron, but they were of much lower energy than the CERN proton synchrotron. The DESY machine was the highest energy electron machine of its time, and the laboratory has been the most successful one in Europe apart from CERN. As is always the case, friendly competition is a spur to excellence.

TODAY WE ARE EMBARKING ON A NEW ERA of international cooperation, the next step beyond the regional cooperation of which CERN is the prime example. Until now, it has been the practice for regions such as Europe, or super-large countries like the United States and Russia, to build the machines that accelerate particles to higher and higher energies on their own, and for international collaborations to build the detectors that are used to study the collisions of energetic particles and analyze their interactions with all kinds of targets. At Fermilab, for example, the Tevatron was built by the United States government, through the agency of the Department of Energy, but the two detectors, CDF and D0, were constructed with significant contributions from Italy, France, Japan, Russia, and other countries. Similarly, Super Kamiokande, a 50,000-ton water detector designed to detect neutrinos from the atmosphere and the sun, and to search for proton decay, was built by Japan with a significant contribution from American physicists. With the Large Hadron Collider (LHC), however, not only the detectors but also the accelerator itself will be built at CERN by a supranational, interregional collaboration.

In this respect the LHC will not only push the energy frontier far beyond the energy of the Tevatron, but it will also test the ability of different regions of the world, in particular Europe, the United

States, Japan, Russia, India, and other countries, to work together in the creation of major new scientific facilities. Europe will still play the major role, since it is providing the site, the infrastructure, and most of the cost. Nevertheless, the United States and Japan will be responsible for the technically challenging magnets of the interaction region, a key element in the successful utilization of the accelerator, and other non-members will contribute important components in additional areas of the machine.

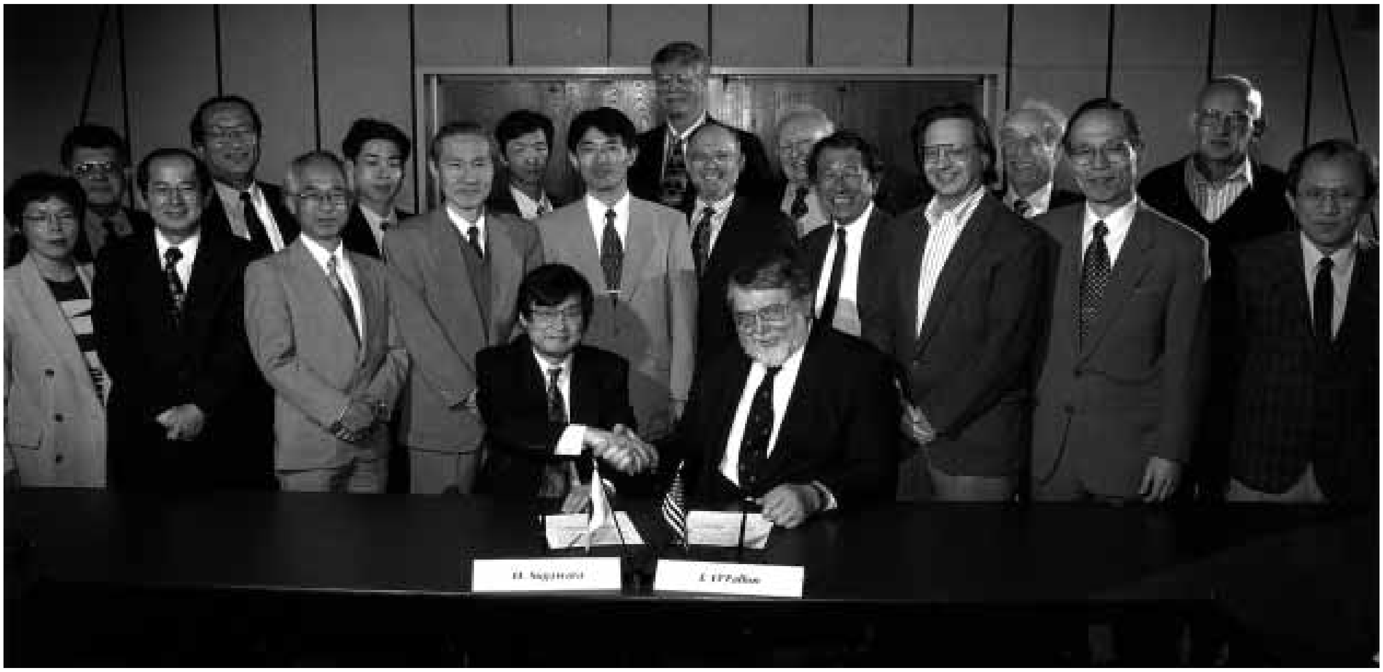
The driving forces behind this move to interregional cooperation are twofold. As high energy physics continues its march towards higher and higher energies in pursuit of the fundamental structure of matter at smaller and smaller distances, it must build larger and larger machines at greater and greater cost over longer and longer periods of time. Obviously cost and time are coupled; the more adequate the money flow, the less time is needed to complete the project. The cost has now become so large that no single country is prepared to build a very large machine by itself on a practical time scale. The sad history of the Superconducting Super Collider (SSC) is sufficient to make the case regarding cost alone. And the speeding up of the LHC completion schedule by three years as a result of non-member contributions speaks to the issue of time. We have reached the point where the entire international community of high energy physicists must work together to achieve its goals on practical time scales.

By practical time scale, I mean the length of time a physicist is prepared to invest in the building of an accelerator and the requisite detectors in order to perform significant experiments. If we take the typical career-span to be forty years, including six to seven years in graduate school, and allow about ten years after the PhD to gain tenure, then an incoming graduate student has about sixteen years in which to establish her- or himself as a physicist of tenurable quality. An established physicist, on the other hand, will not be under the same time pressure, but nevertheless will want to make as significant a contribution to the field as he or she can within the allotted span of time. Students entering the field late in the design and construction of the facility will obviously be in the best position to benefit from its use. Given all of these considerations, I would suggest that we should plan to construct and commission new machines plus detectors within seven to ten years—and no longer—in order to provide a real incentive to physicists to commit themselves to these large projects.

An important issue in the interregional construction of accelerators is going to be the actual location of a major laboratory. As long as the site remains unchosen, all contending partners have a chance of gaining the prize. Once the choice is made, however, does the support for the project by the losing partners begin to soften? Even in large countries like the United States, this becomes a problem, as happened in the case of the SSC. Almost as soon as the Texas site was chosen, political support for the project from other contending states began to disintegrate, and this helped to terminate the project in the end. Could the same behavior occur on the international scene? Certainly, we hope not, and indeed we will need to secure firm commitments ahead of time to ensure that this problem does not arise.

Another important aspect is the nature of the site: do we build upon existing facilities, or do we start with a new "green-field" site? Europe has concentrated most of its resources in one site, namely CERN, and thus has a significant infrastructure upon which to build: the pre-accelerators and injectors, civil facilities, and technical support which are so necessary to the successful functioning of large projects. Clearly this saves a great deal in terms of both cost and time; however, the CERN site is now at its physical limit and is probably at the end of the road unless accelerator technology can be greatly improved. The SSC, on the other hand, was to be located on a green-field site, which obviously required the building of a total laboratory from the bottom up. This adds to the cost of the project and also to the time for completion; but it does provide the opportunity to do everything at the state of the art and to leave room for future extension. In other words an existing site, while it may have the infrastrucure, might not meet all the long-term requirements for a new project.

Besides the physical and technical aspects of a green-field site, there are organizational, or, if you like, sociological issues. What body will be responsible for the new laboratory, and how will individual countries relate to it? How will the laboratory be governed and managed? What scientific staff will it have, and how



Hirotaka Sugawara, Director General of the Japanese High Energy Accelerator Research Organization (KEK), and John O'Fallon, DOE's Acting Associate Director of High Energy and Nuclear Physics, shake hands after signing the U.S./Japan Agreement for Cooperation in High Energy Physics in May 1996 at the 18th meeting of the U.S./Japan Committee. (Courtesy Brookhaven National Laboratory)

will they relate to its user community? Under what conditions will users work at the facility: open access based on scientific merit as envisaged in the ICFA guidelines; or "pay to play," which would require a contribution towards the cost of the facility and possibly consideration of operating costs? What status will employees of the international laboratory have in regard to the host country? What will be the official language of the laboratory? Obviously there are many more questions of this nature that will have to be answered.

At this time CERN itself is one model to follow. It has certainly worked successfully in the physics arena and has much to commend it. Nevertheless, other models should be examined, if only because they might raise important questions that are not readily apparent in the CERN model. Other fields of science—astronomy and space, for example—use models in which use is allocated to individual countries based upon their contribution to the construction of the facility; each country is then free to allocate its allotment to individual scientists on the basis of scientific merit, or other criteria. The Megascience Forum, an activity of OECD to lay groundwork for large international science projects in many fields, is presently engaged in a study of all of these issues as they relate to international cooperation.

IN CONTEMPLATING CONSTRUCTION PERIODS that are long compared to the timescale of electoral politics, it is not unreasonable to ask whether the United States government can be relied on to stay the course once the construction of an international project has begun. One cannot, unfortunately, make any absolute prediction because so many factors can change markedly over a decade: political moods shift and change, and what may be popular today may become anathema tomorrow; the economy may undergo significant changes for the better, or for the worse; the social climate may bring to the fore issues of great moment that may disrupt the smooth flow of life. Barring such dramatic events and assuming that societal life will make a relatively smooth progression from one epoch to another, I believe that the United States can be relied upon as a partner provided that three basic conditions are met.

The first is that the case for building the facility, both the scientific arguments and the attendant benefits to society, must be made honestly and clearly, without hype. We must not promise the moon, either scientifically or in terms of spinoffs, but we can argue for extending the envelopes of science and technology by undertaking challenges that have never been faced before. We cannot predict the outcome, nor the benefits, but history does show that on some time scales, which may be ten years or fifty years, there are real gains to be made in science and in tools useful to society.

An important part of this argument, I believe, is the benefit to other sciences: high energy physics has borrowed techniques from other sciences, but in return, it has provided them with major new tools. Synchrotron light sources, for example, are of ever growing use in biology, chemistry, and materials science, and they are a direct outgrowth of accelerator science pioneered by high energy and nuclear physics.

I also believe that we must begin the effort to develop support for the project at an early stage, not just within the high energy physics community, but also within the broader community of science and the general public. Outreach must be made to Congressional delegations, local citizens, and industry so as to build a consensus strong enough to withstand any vigorous challenges. The American political system works well when consensus exists for a project, but it does not automatically build one. As Neal Lane, Director of the National Science Foundation, has pointed out, leadership from the science and engineering communities requires a much more public and civic persona.

The second condition is that we must do, and be seen to be doing, a thorough job of establishing the total project cost and funding profile. Once we have set these parameters, we must live within them, even if it means that we must do some limited descoping in order to do so. Time, in the form of upgrades and accelerator improvements, is our ultimate contingency, but we cannot afford to give even the slightest hint, after the project has started that the costs are about to escalate out of control. To do so would undermine credibility and invite the same kind of assault that hit the SSC.

Finally, the project must be technically successful, meeting its milestones as close to the planned schedule as possible. We all know that in any major project there will be hitches, to greater and lesser degrees, but as long as we are open and honest about them, and as long as we can show that we are making serious efforts on the appropriate scale, I do not believe that Congress will lose faith in us. Naturally, an overall record of real progress helps enormously in this regard. Thus, I am reasonably sure that Congress will continue to support a large international project as long as we can be seen to be meeting the expectations that we create.

IT IS MY PERSONAL BELIEF that international collaboration in all aspects of high energy physics is the sine qua non for future progress in the field. Because of the universality of physics, such collaboration comes naturally to physicists themselves, but, unfortunately, it does not come so easily to the governments to whom high energy physicists must turn for the resources they need. Governments tend naturally to think in terms of national interest, and so it becomes necessary to convince them that thinking internationally is as much in the interest of national scientific development as it is for trade and for defense.

It behooves us therefore to create institutions within the international scientific community that are truly representative of that community and will have credibility with governments. Such institutions should have high visibility within the high energy community and derive their authority by interacting with it

Zhou Guangzhao, Special Advisor, Chinese Academy of Sciences, and the author sign the U.S./Chinese collaboration agreement in November 1997.

regularly on all issues of great moment. Their major roles will be to develop a consensus for the next step in high energy physics and can make the case effectively for new international facilities. They can also facilitate the early international planning and joint R&D that are keys to success.

The International Comittee for Future Accelerators and the International Union of Pure and Applied Physics can certainly provide a basis for this activity, but they need to be significantly enlarged and become more visible in relation to high energy physics. The Megascience Forum is also a possible vehicle for creating and developing the needed institutions. Other avenues should also be explored.

In conclusion, I would like to say that international cooperation in high energy physics serves a deeper purpose of providing a model for cooperation and reconciliation amongst nations that have, at one time or another, been bitter enemies. This was one of the motivations for the establishment of CERN; the laboratory was able to build upon the natural ties among physicists, and help to bring about reconciliation in Europe. Let us use them for a similar purpose on a global scale.