

Young Physicists' Forum

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The Young Physicists' Forum was an opportunity for the younger members of the particle-physics community to gather at Snowmass 2001 and to study and debate major issues that face the field over the next twenty years. Discussions were organized around three major topics: outreach and education, the impact of globalization, and building a robust and balanced field. We report on the results of these discussions, as presented on July 17, 2001.

While the field of high-energy particle physics (HEP) has a clear plan for the coming decade, the period beyond that is uncharted territory. Based on existing measurements and theories, we expect that there are exciting new phenomena that could be discovered very soon – new particles that may be observed at the Tevatron or the Large Hadron Collider (LHC), CP violation in the b -quark system observed at B factories, and neutrino mixing seen in both accelerator and non-accelerator experiments. These and other topics make for a very rich program of study in the coming years. But the next generation of facilities and experiments that will be needed to explore these new phenomena are technically challenging, and are expected to cost billions of dollars. They will require a large number of accelerator and experimental particle physicists to build and operate them, and a strong community of theoreticians to help interpret the results and suggest new lines of exploration. In addition, these facilities will be built in a new social and political climate. It is unlikely that any single country can build and operate any such facility alone, so a greater level of cooperation will be required across national and continental boundaries. Financial resources are limited, so difficult decisions will have to be made about which facilities are built, and how to set priorities for their use. Finally, governments and the general public will have to be convinced that such expensive undertakings are worthwhile and in their interest.

It is the young physicists of today – students, postdocs, and junior faculty – who will be leading these efforts in the long-term future, and it will be their task to advance the field of particle physics in this new environment. Decisions that are taken now could affect this generation for the duration of their careers. To give the younger members of the community a voice in these decisions, the Snowmass 2001 Organizing Committee scheduled a “Young Physicists' Forum” as part of the workshop. Here, we report on the studies and discussions that were held for that event [1]. More than 200 young physicists participated in the Snowmass workshop, and many were engaged in the activities of the Forum.

The Forum was organized by a broad-based committee of students and postdocs, chaired by K. Bloom. The committee included theoretical, experimental, and machine physicists, working in a variety of subfields, with representatives from the United States and abroad. After some initial discussions, working groups were formed to explore three major topics. These were:

1. Outreach and Education – How can we communicate the excitement of the field to the general public and influential groups? How can we develop their support so that particle physics will be a robust and growing field in the long-term future?
2. Globalization – How will the field operate in a more global and diverse setting in the future? What new organizational structures are needed? How does the U.S. maintain a strong program in this context?
3. Balancing and Building the Field – What kind of physics and facilities do we want in the next twenty years, and what choices must we make to get them? What disciplines do we need to promote to achieve these goals? Where will these facilities be? How do we attract and keep people in the field so that we maximize the use of new facilities?

The working groups, led by J. McDonald, J. Krane, and Z. Sullivan, did background research and prepared documentation on their topics in advance of Snowmass. This work, along with an introductory talk by High-Energy Physics Advisory Panel (HEPAP) long-range-planning subpanel member K. McFarland, was presented at an introductory meeting for young physicists on July 3, which was attended by about 100 people. There,

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the working groups expanded, and prepared for a “Vermont-style,” young-physicists-only town meeting that was held on July 10. In contrast to typical HEP town meetings, with a scripted speaker list, no particular topical focus, and no resolution of any issues, the 100 participants at this meeting had focused discussions on the three major topics, guided by questions that the working groups had prepared. In many cases, straw-poll votes were taken to gauge whether there was any consensus of opinion on each topic. Meanwhile, throughout the Snowmass workshop, the Young Physicists Panel (YPP) [2] was conducting a wide-ranging survey [3] of the entire community on similar topics, reaching over 1500 physicists. The results of all of these studies, surveys and discussions were presented to the Snowmass workshop on July 17, in an evening session that attracted about 200 attendees, young and not-as-young, who engaged in constructive debate on these topics.

The following sections explore each of the three major topics, presenting our research and outcomes of various meetings.

I. OUTREACH AND EDUCATION

A. Introduction

There is general agreement in our field that efforts to educate the public about particle physics, usually called “outreach,” are worthwhile and important for the long-term future of the field. The American public is more likely to support our research if they understand what we are trying to do and what makes it interesting. We participate in particle-physics research because we are excited about understanding the fundamental nature of matter, space, and time, and a properly informed public should be excited too. We have an excellent product, but we have to start and maintain a strong effort to sell it.

This outreach effort, like everything else, requires money and people. Does our allocation of resources to outreach match our needs? Here, we review outreach activities taking place at various institutions, report the results of discussions about outreach at Snowmass, and present a plan of action for future activities.

B. Background

There are many existing outreach activities in HEP that build the foundation for a greater involvement of young physicists. These activities include outreach to the general public; outreach to Congress, the funding agencies and the media; and teaching and mentoring. This outreach work is usually not an integral part of our research programs, and is therefore contingent upon the volunteer efforts of especially motivated people, and sometimes upon special sources of funding.

Outreach to the general public has many aspects, all of which cannot possibly be enumerated here. We highlight some of the higher-profile activities at national laboratories and universities. University open houses and lab tours provide great opportunities for public outreach. They enable the public to see first-hand our facilities, our scientific accomplishments, and the people behind the scenes. These activities reach several tens of thousands of people a year.

Other public outreach activities include a vast network of Web sites and interactive visitor centers hosted by labs and university groups. In addition to exploring the physics of the standard model, accelerators and detectors, virtual visitors can run remote simulations and control online detectors. These Web sites educate and convey excitement about HEP, and visits often result in follow-up questions which are sent to designated people.

Much of the outreach to Congress and the funding agencies is conducted by people at the level of lab directors, who make frequent visits to Washington, DC. Similar visits by groups of physicists take place annually or semi-annually. These visits are most effective when they are well-planned and scheduled shortly before relevant legislation is debated and enacted. The physicists need to have a clear idea of the message they want to convey and be well-rehearsed and equipped to make the desired impression. According to people who have been on such visits, a greater effect is achieved when young physicists take part in the actual contact with members of Congress and staffers. Another form of outreach to Congress involves letter-writing campaigns, which are advertised in the HEP community in times of need. It is not known how many physicists actually send in such letters.

Labs and universities maintain personal contacts with local media representatives through public relations offices. Interesting results and important discoveries are released and communicated to the press by these offices in a timely manner. In addition, labs publish their own periodicals which are sent to thousands of subscribers, including some Congressional offices and physics teachers.

There are many teaching and mentoring programs that offer opportunities to students and teachers of all levels. For instance, QuarkNet [4] is a flagship program of the National Science Foundation (NSF) and the Department of Energy (DOE) that facilitates the involvement of high-school teachers in HEP research, through summer internships with active experiments. Some 40 institutions participate in the program, each receiving one year of funding plus some lead-in and follow-up money. Other activities include “Saturday Morning Physics” lecture and demonstration programs for high-school students, summer programs for undergraduates such as Research Experiences for Undergraduates [5] and internships for minority students. In addition, many individuals in national labs and universities conduct their own outreach and education activities, with very little or no financial support. The magnitude of such activities is difficult to assess.

Many physicists recognize the importance of outreach and education, and several programs facilitate outreach activities. However, the HEP funding levels for outreach are dismal when compared to those of NASA, for example. Due to legislation enacted in the mid-1990’s, DOE can no longer explicitly support pre-college education and outreach, resulting in the cancellation of several K-12 programs. The national laboratories do provide some outreach funding from their general operating funds at the level of 0.25-0.75% of their operating budgets, totaling about \$3 million. In comparison, NASA spends 2.2% of its operating budget on education and, in addition, individual research grants are required to support outreach at the 1-2% level.

NSF has no restrictions on education, and its support of education programs throughout the sciences totals about \$600 million annually. This support is not tied to NSF research grants. In addition, Fermilab has a donor organization, the Friends of Fermilab, that raises about \$300,000 per year. It is much more difficult for small university groups to obtain outreach support if they are not part of an established program, such as QuarkNet.

C. Results of the Town Meeting

During the young physicists’ town meeting at Snowmass, we polled the approximately 100 attendees and asked for their opinions regarding outreach and education. The questions asked were mainly intended to spark discussion, but ultimately generate either an affirmative or negative response. Several questions were intended to generate discussion only.

1. Role of Outreach

The initial set of questions asked dealt with the role of outreach in high-energy physics:

1. *Does HEP have a responsibility to do outreach?*
2. *Does HEP have an outreach problem? Are we doing enough?*

There were 92 affirmative and one negative responses to these questions. The majority of young physicists felt that there is an obligation to do outreach and that we are not doing enough. Most felt that outreach is not acknowledged as a part of our job and that supervisors fail to regard time spent on outreach and education activities as valuable. One person commented that there is no reward for those who do outreach and education. Excellence in this capacity should be acknowledged and rewarded.

A dissenting view was made regarding the claim that outreach will generate more support for HEP, pointing out that a correlation between outreach and increased funding levels had not been proven.

3. *How much time would you be willing to commit to outreach personally? (1%, 5%, 10%?)*

The clear majority (80.5%) of people attended were willing to dedicate about 5% of their time to outreach and education. 13.5% were willing to commit of order 10% of their time, and 6.5% were willing to commit about 1% of their time (Figure 1). Those who abstained were not explicitly counted in this vote, but we estimate the number to be less than ten, based upon total head counts.

Similar results were found from the YPP survey [3]. Two questions were asked regarding outreach in high-energy physics: (1) Are we doing enough outreach to funding agencies (Figure 2) and (2) Are we doing enough outreach to the general public (Figure 3)?

2. Tools and Mechanisms

Outreach and education require a highly-organized effort in order to effectively target and generate an excited audience. The following questions were presented to the young physicists at Snowmass:

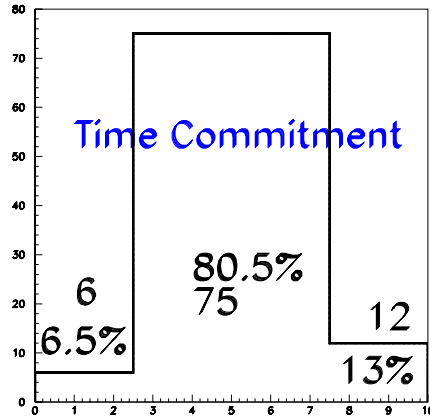


FIG. 1: A histogram displaying the number and percentage of young physicists willing to commit 1%, 5% or 10% of their time to outreach.

1. *Who should be in charge of organizing outreach? Physicists? Professionals? Do we need an official organization (DPF) to coordinate outreach?*

The majority of responses to these questions were that we need assistance in organizing the outreach activities. The comments from the audience were that we should arrange to have professionals organize our activities, but that physicists should do the outreach and have the actual contact with the target audience.

2. *Would you find outreach and education workshops useful? Would you attend and contribute?*

This question provoked a positive response as well. The majority said that they would find such workshops useful and would attend and contribute. It was commented that such workshops should attempt to unite physicists with science teachers so the groups can share ideas and discuss pertinent issues. Convenience is also a consideration. It was pointed out that holding such workshops in advance of usual physics gatherings would maximize attendance.

3. *Would you support grants or award incentives for people who perform outreach/education? Should it be considered when making a new hire?*

The majority felt that dedication and excellence in outreach should be rewarded and should be a consideration when a new position is filled.

3. Funding Issues

The following questions were presented regarding funding of outreach and education:

1. *Do you support raising HEP outreach funding to the level of NASA (2-4%)?*

There were 88 people who supported raising the level to that of NASA and 5 who were against doing so.

2. *Would you endorse DOE funding tagged specifically for outreach and education? Should the DOE mission statement be modified?*

A majority (89 in favor and 4 against) were in favor of modifying this guideline to allow DOE to support line-item outreach and education activities.

3. *If additional funds could not be located, what would you be willing to sacrifice to promote education and outreach? Any ideas for additional support?*

This question was meant to spark comments from the audience. People were in general unwilling to sacrifice physics activities for the increased funding levels of HEP outreach.

Doing Enough Outreach to Funding Agencies

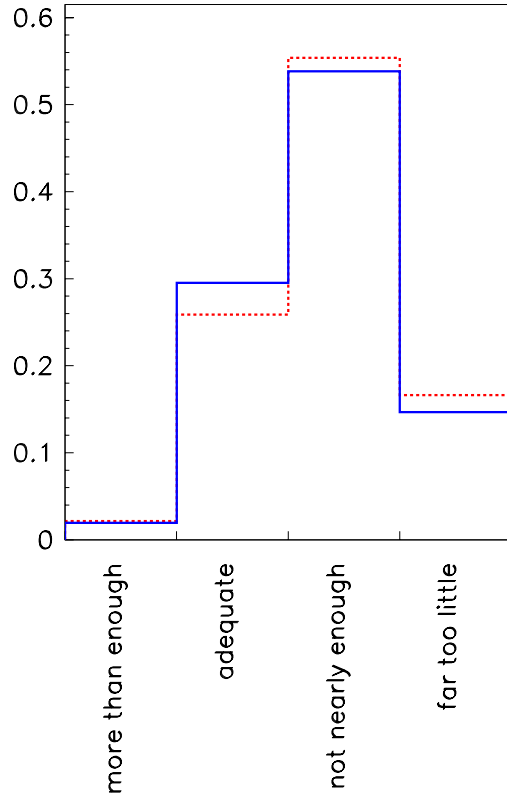


FIG. 2: Are we currently doing enough outreach to funding agencies? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

Doing Enough Outreach to the General Public

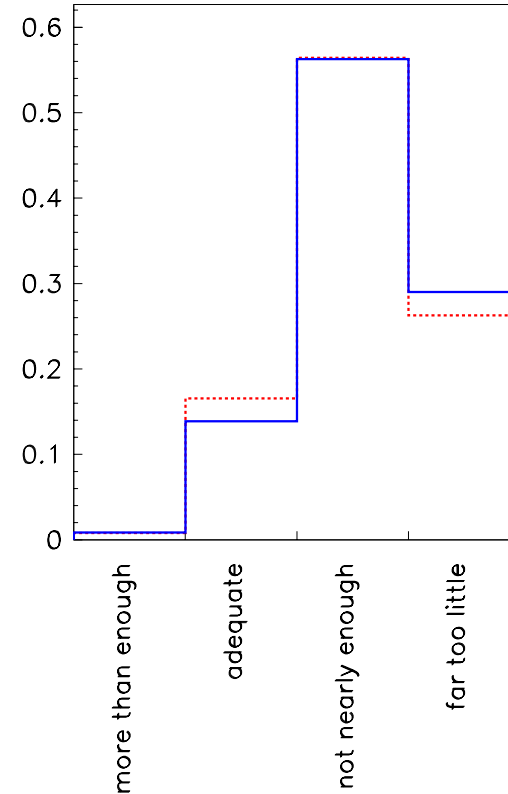


FIG. 3: Are we currently doing enough outreach to the general public? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

D. Conclusion: Our Commitment to Outreach and Education

The young physicists at Snowmass have advocated spending 5% of their time, or approximately one day a month, on outreach and educational efforts, in the belief that these activities are vital to the future health of particle physics, and of physics and science in general.

To maintain momentum and the interest in outreach after Snowmass, we young physicists are organizing our activities through the Young Physicists' Outreach Program (YPOP). Our goal is to form seed groups at labs and universities to discuss ideas and organize outreach activities. To facilitate communication between the involved individuals and groups, Web pages are being created, where people can share their ideas and experiences, post materials and tools, and maintain effort and interest levels.

The ultimate goal is to build a network of people that will make it easier for anyone to create or join an outreach project by building on the resources and support of others. Such a support network will make it easier for physicists to get involved, despite their tight schedules and other commitments. Here are some specific things that any physicist, individually or as part of a group, regardless of affiliation, can do:

It is very important to open lines of communication with our governments. Congress should be an important focus, as it has the final say on funding for our field, but it is also useful to teach state and local governments about the benefits of physics to their constituents. Every university and national laboratory has an office that is responsible for government relations. Contact your government liaison, and learn how you can communicate the importance of science to our political leaders. These liaisons will know who to talk to, how to talk to them (what preparations you need to make for a visit, whom and what to bring with you), and when to talk to them. They can help you establish relationships with people who are in a position to make a difference.

Young physicists have typically made a very positive impression on government leaders. To make the most of this, a group of us are currently working with Lewis-Burke Associates, a scientific-lobbying firm, on a letter to Congress in support of high-energy physics. This letter will be circulated widely in our community for signatures.

In your local communities, you have many opportunities to interact with the general public. University-based researchers meet with some members of the public every day – our students. By working with lecture-demonstration staff, you can integrate particle-physics demonstrations into introductory courses. You can be a resource for the local Society of Physics Students chapter, and promote the opportunities of particle physics. You can be a mentor to undergraduates, or even high-school students, getting them into your lab to see how research is done. Many of us are in the field today because a senior physicist reached out to us.

We are making efforts to contact science teachers and parents at all levels in the public and private school systems. Our goal is to provide a means for science teachers and parents to gain access to the physicists who actually do the research. Plans include making contact with the American Association of Physics Teachers lead teachers, learning from them what their needs are, bringing demonstrations and new ideas into the classroom and working to increase science literacy among parents. We have begun to contact school principals in our local areas and are working together with them on carrying out this vision. Emphasis is placed on active learning techniques to encourage the development of science in the classroom. YPP members are applying to the NSF for funding to develop a set of instructional kits for students in grades six through twelve, which would give them a hands-on introduction to the tools and concepts of particle physics [2].

The NSF has expressed support for outreach to groups which are traditionally under-represented in science. We are doing ourselves a disservice if we do not get a wider range of people interested in, and then involved in, scientific research. We must cast our nets as broadly as possible to bring in the brain power needed to understand the physical world more thoroughly. Programs focused on these groups can make a difference for the field, and for the lives of those involved. But since members of under-represented groups can be found just about anywhere, any activity that reaches a very broad spectrum of the public will touch people who do not think about physics in their daily lives. Any large event, such as a community festival or a county fair, can be an opportunity to promote science to the larger world.

To reach a much larger audience, you can get involved with print and broadcast media. Meet the staff at your local newspaper, and encourage them to write about science, focusing on research at your lab or university. You can write opinion articles on physics or any science-based topic that you are comfortable with. Many local radio stations, especially public stations, produce programs that sometimes focus on science. You can volunteer to be a guest, or to steer them toward interesting topics. Some people are thinking really big, producing “particle commercials” to appear on broadcast television, and the APS helped the producers of “The West Wing” with a story line about particle physics. Such projects are very beneficial, but you do not have to think that big to make a difference in your own community; a simple letter to the editor gives a voice to science and its practitioners.

The new research initiatives discussed at Snowmass will require resources – both financial and human – beyond anything that our field has known to date. They will also require us to develop stronger relationships with communities to host these new facilities. If we want particle physics to have a robust long-term future, each of us must take the time to reach out to the public and convince them of the excitement and utility of our research. Even the simplest effort counts toward creating the future.

II. GLOBALIZATION OF HIGH-ENERGY PHYSICS

A. Introduction

All current HEP facilities have risen by means of a single nation or region building and financing each project. The resources required to build a new machine operating on the high-energy frontier appear to exceed what can be provided by one country. Thus the goal of the Globalization Working Group (GWG) has been to examine issues associated with HEP projects on the global scale and how the U.S. HEP community might interact with the international HEP community to bring the next such project to fruition. As young physicists, whose careers and research aspirations are tightly coupled to the development of the next major HEP facility, we believe that now is the critical time to review these issues.

The GWG has focused on the political and scientific structures that can enable planning and funding of large experiments. Particular attention has been paid to the role of existing national laboratories and preserving, or possibly improving, a researcher’s ability to work despite being located a large distance from an experiment. These questions were addressed during the young physicists’ town meeting at Snowmass 2001. The specific topics discussed were international steering, structure of an international laboratory, operation of an international laboratory, and career issues. Here we summarize those discussions and present relevant supporting data from the YPP survey [3].

B. International Steering

Although international collaboration has occurred for years, forming an international consensus in HEP seems quite difficult. From time to time, *ad hoc* committees study the most pressing issues of HEP and make recommendations to the community and funding agencies about potential courses of research. However, once their reports are complete, such groups immediately disband. Long-term planning and continuity is very difficult with just these groups and there is no guarantee that their findings will be widely accepted. Similarly, periodic gatherings of the community such as Snowmass workshops may generate a degree of consensus, but the mechanisms for translating such consensus into a plan of action, however, are unclear. Permanent groups such as the International Committee for Future Accelerators (ICFA) [6] may not have the right structure and political weight to serve as a steering group for the entire HEP community.

To this end, an international steering group, composed of members of the international HEP community along with representatives from the government funding agencies, might provide an effective mechanism to support the development of energy-frontier facilities over the long term. A perceived advantage of such a group is that national funding agencies may give more active support to long-range HEP efforts if they are involved at this level. In addition, it would provide a forum for international coordination among the funding agencies, thus making large projects easier to fund in a coherent manner. It is even conceivable that such a group might eventually manage the distribution of funds for an international project. On the other hand, there is some concern that international coordination of a project may result in a loss of national pride for the individual countries involved. Governments may react adversely to not being in control of such a large project. Finally, the HEP budget for any given country might decrease because other nations are contributing to the same project.

There were three straw poll questions asked to the young physicists at the town meeting related to international steering. The first one was: Should funding agencies rely more heavily on advisory bodies like ICFA? About 50% of the young physicists responded yes, and a few responded no while the rest abstained from answering. The second question was: Do you think an international committee should determine the type/location of the next machine? Again about 50% of the young physicists responded yes, and a few responded no while the rest abstained from answering. The third question was: Should an international group eventually have funding power? In this case, the majority of the young physicists abstained from answering, while a few answered yes, and a few answered no. Apparently, more information is needed about the mechanism of such a funding power in order to answer that last question. Indeed, the many abstentions in this section probably indicate a lack of familiarity with the ideas of international steering in general. We encourage wider discussion of these issues in the HEP community.

C. Structure of an International Laboratory

The funding and management structure of an international laboratory can take several forms, and ICFA has considered the four basic models:

- National or regional facilities (“FNAL/DESY model”): the facility is built and operated by a host country or region. Planning and project definition are handled by an international collaboration.
- Larger facilities (“HERA model”): contributions to construction are made by multiple countries. Operation responsibilities and costs belong to the host country. Planning and project definition are handled by an international collaboration.
- Very large shared projects: all countries involved share the responsibility and costs for construction, operation, and project definition. The facility is the *common property* of all. This option has never been attempted.
- Very large self-organized projects (“CERN model”): the participating countries do not directly manage the lab; rather, they contribute to an international organization which autonomously runs the projects.

When considering these models in the context of the next energy-frontier project, a plurality of the town-meeting participants (40%) favored the solution of a very large shared project. The remainder of the (non-abstaining) participants favored the following either a self-organized structure (CERN model) (13%-18%), or a national organization that receives contributions from international groups (FNAL/DESY model)(13%).

D. Operation of an International Laboratory

In the context of a very large shared project (see above), the operation of an international laboratory offers special challenges. In particular, since many collaborating institutions will contribute to the facility's operation, key personnel resources will not be based at the main laboratory. In response to this issue, ICFA recently appointed a working group to examine whether the implementation of a Global Accelerator Network (GAN) [7], as proposed by Albrecht Wagner (DESY), could provide a viable method for accelerator physicists at widely-separated locations to support the operations of the main laboratory. At the heart of the GAN concept is the idea of remote control rooms located at various regional centers around the world for accelerator operation. These centers would offer a fast, reliable and secure network connection to the main laboratory for safe remote control of the accelerator facility. Advanced communications capabilities would also be available for effective real-time interaction among widely-scattered researchers, particularly when diagnosing problems. The preliminary conclusion of the ICFA working group is that remote accelerator operation presents a number of challenges but can be readily achieved [8].

GWG discussions at Snowmass explored a more general concept of regional centers as locations for remote detector control and data analysis in addition to remote accelerator control. An obvious choice of location for such centers would be existing national labs, where much of the infrastructure required for a regional center already exists. This location would also allow considerable interaction between members of national experiments and the international project. Smaller regional centers organized around universities might also be feasible and would offer greater accessibility for the widely-distributed members of the HEP community. A number of benefits could result from the regional-center concept. It would allow control and responsibility to be distributed among countries other than the host country. The possibility of each regional center periodically assuming primary operational responsibility would highlight national contributions to the project and might particularly appeal to national funding agencies. Regional centers would also help prevent the primary lab infrastructure from being overwhelmed with visiting scientists and be more attractive to students because of easier access. Finally, they would help ensure the continued viability of the HEP community in regions that do not actually host the next large facility. Potential drawbacks are the expense of duplicating the infrastructure needed for control and analysis functions as well as the speculative time frame for viability.

Results from the YPP survey and straw-poll questions posed at the town meeting provide an interesting window on young physicists' perspectives of how the next large international project might work. In the event that the project is not located in the U.S., most physicists, both young and tenured, responded to the survey that the quality of beams and physics results would improve given the availability of regional centers in the U.S.. The survey also showed that most physicists found it desirable to have the same number of regional centers as existing national laboratories, consistent with the fact that the required infrastructure is most easily implemented at the national labs.

At the town meeting, it was agreed by a 2-to-1 margin that the concept of remote data-analysis facilities was viable. This seems quite consistent with ongoing efforts to provide remote data processing capability for the LHC experiments. When asked whether remote accelerator operation was viable, the audience was evenly divided. More work to demonstrate the validity this concept is clearly required in order for it to be generally supported. When asked whether remote detector operation was possible, the audience answered "no" by a 2-to-1 margin (with approximately 60% of those present casting votes).

Greater insight into the issue of remote detector operation can be obtained by looking at a survey question asking whether proximity to a detector or one's advisor is more important for a graduate student. The majority of physicists, across all categories sampled (young and tenured, American and non-American), felt that proximity to the detector is more important (Figure 4). Hands-on experience and interaction with local experts are considered a key piece of graduate education (Figure 5). Thus, the training impact of remote versus local operation needs to be carefully considered when exploring the possibility of remote operation of the next large facility. All in all, we strongly encourage continued study of GAN models and how they might be adapted to a future facility as well as detailed tests of remote control from sites removed from the physical laboratory.

E. Career Issues

A final topic of particular relevance to young physicists in an era where large international collaborations are the norm is that of careers which often cross international borders. At the town meeting, a number of young physicists expressed the opinion that Europeans typically have an easier time getting permanent jobs in the U.S. than Americans do in Europe. European Union rules with respect to obtaining university positions were a point of particular concern. We believe that the HEP community needs to understand and review such policies and work to enhance the ability of young physicists to pursue careers within international collaborations

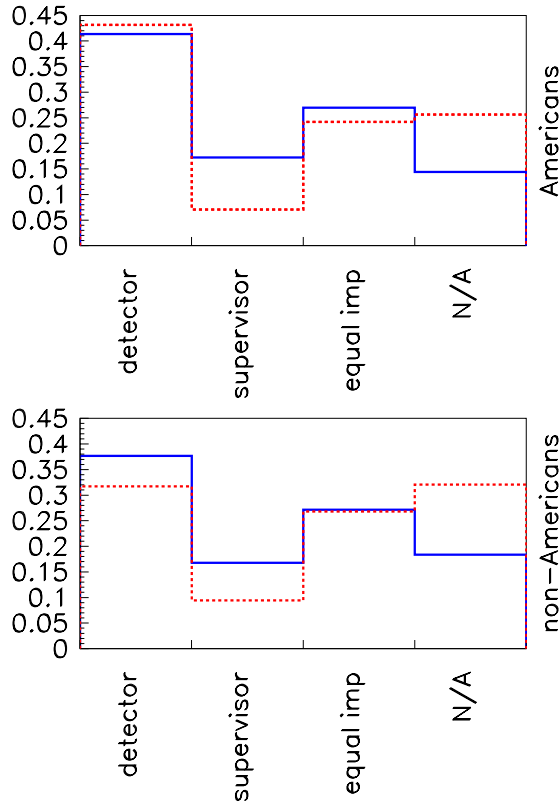


FIG. 4: Given the choice, how do you rate being near your detector versus being near your advisor/supervisor? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

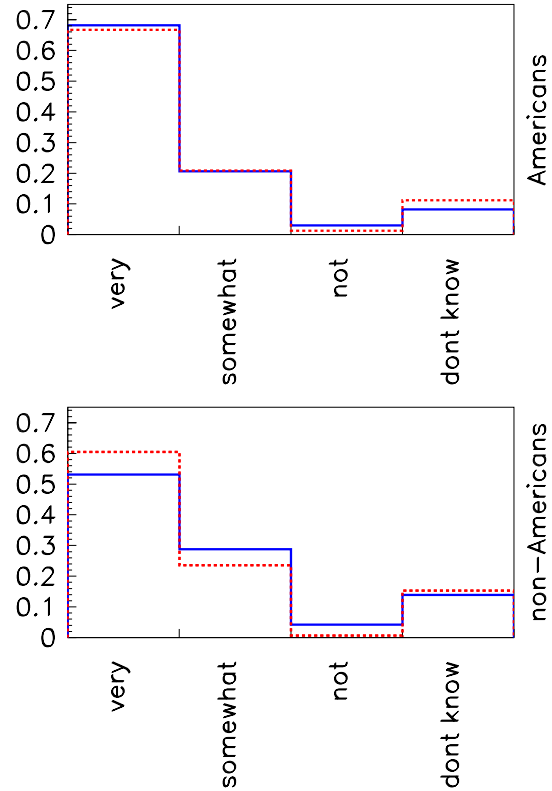


FIG. 5: How important do you feel it is to have hands-on hardware experience? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

without regard to the borders separating the various institutions. In the case of U.S. institutions, it may also be a good idea to revive the second-language requirement as part of the graduate physics curriculum to improve job opportunities for native English speakers in non-English speaking countries.

F. Conclusions

From the town-meeting experience, it is clear that young physicists are relatively unaware of the international groups currently studying the future of our field and how they operate. Wider distribution of information about such groups is the first step to ensuring greater participation of the community. It will also allow the creation or modification of such groups as the need arises.

Young physicists are more certain about what kind of organization would be appropriate for the structure of the next international project. It is interesting to note that young physicists are well aware of the challenges ahead, and seem to favor a completely new type of organization to face those challenges. In terms of the operation of this future laboratory, there was more dissension among the participants, reflecting the same situation among the entire HEP community. What is clear for young physicists is that interacting with the detectors and accelerator, participating in the crucial decisions and exchanging ideas with other physicists about the physics being done is of utmost importance. Hence, the use and structure of regional centers will have to carefully address these fundamental requirements.

The underlying thread of globalization issues in HEP reflects similar trends in our social structures: in order to achieve our physics dreams, we have come to a point where all members of the high-energy physics community, around the world, are needed. Achieving the highest-quality work is a major challenge in these circumstances. There is no doubt that the success of this enterprise will be a motivating example for the rest of society, as science should be.

III. BALANCING AND BUILDING THE FIELD

A. Introduction

The overall goal of the Balancing and Building the Field Working Group is to understand the broad physics interests of the young members of the high-energy physics community, and what specifically the field should do to balance these interests. The working group addressed four main questions facing the field today: How should we define the field of high-energy physics for the next 20 years? What are the physics questions we should address, and how should we prioritize them? What future facilities are needed to address our most important physics goals? Do we have the necessary number and type of scientists to accomplish our goals? We provide a summary of some of the answers to these questions here.

B. Defining the Field

As collider-based programs move to higher energies, the cost and number of people required seem to continually increase. The recognition of this trend prompts us to question whether this is sustainable. Will there be enough funding or enough people to support more than one or two large experiments in the future? Are we limiting the scope of high-energy physics by referring to it as “the energy frontier?” Do we need to broaden our perspective to be particle physicists, not just high-energy physicists?

Nuclear physics today is often called “medium-energy physics” because it operates at energies that were solely the domain of HEP only a few decades ago. These regimes of QCD remain extremely important to the HEP programs. The young community has expressed a great concern that, despite the common interests, there is not enough interaction between nuclear and particle physicists. Some of the comments from the town meeting were:

At the least, for the sake of the science, cross talk between the particle and nuclear fields needs to improve.

Perhaps there should be a more tangible joining of the fields.

Integration of the funding agencies could promote cross talk ... But perhaps it could also negatively impact overall funding levels?

In the United States, there are two successful nuclear programs currently in operation that were funded at the level of \$1 billion each: the Relativistic Heavy Ion Collider at Brookhaven National Laboratory, and Continuous Electron Beam Accelerator Facility at Jefferson Laboratory. The funding for these facilities is considered independent of the funding for particle physics. The DOE has separate particle and nuclear physics divisions that appear to have very little cross-communication. This is in contrast to Europe, where many programs are connected, *e.g.* the LHC will convert to running heavy ions at some point.

Addressing the concerns of balancing scientific goals with funding realities, we asked “Should HEP and nuclear physics join funding efforts?” The overwhelming consensus was “no!” While there is a desire for closer scientific ties to nuclear studies, the programs, while complementary, set out to ask fundamentally different questions.

Given the strong response against joining funding efforts, we also asked “Should we create a formal mechanism to combine HEP with related physics programs, but retain independent funding sources?” The idea was to set up an agency that could facilitate the cross-disciplinary exchange of ideas and data. While there was interest in such a body, the conclusion was that more specific proposals need to be considered.

C. High-Energy Physics and New Facilities

Both the YPP survey [3] and the Forum results indicate that young physicists believe that a major new high-energy physics facility is needed in order to elucidate the most pressing current problems in particle physics. More than 80% of YPP survey respondents who identified themselves as young answered either “yes” or “maybe” to the question.

From the survey results, an overwhelming majority of young physicists consider the understanding mechanism of electroweak-symmetry breaking (EWSB) to be the most important of a large number of subjects to the field. Since the potential for discovering and studying the EWSB mechanism is greater at new, higher-energy facilities, this focus of interest almost certainly explains why so many young physicists believe that a new facility is necessary.

Because physics potential must determine which facilities will be built, many believe that the HEP community should be certain that it has sufficient knowledge to proceed with designing and building a major new facility. At the town meeting, the young physicists in attendance were asked if now is the time to make a decision on the next facility. More than half answered “decide now” while the remainder were split between “abstain” and “wait.” Those answering “wait” were further asked if the reasons for waiting were technologically based, physics based, or both. About half said “physics” while the other half said either “technological” or “both.” Some comments (paraphrased here) preceding the vote included the following:

We will lose accelerator expertise if we wait.

The unexpected brings discovery...decide now!

We should wait to see what the LHC sees!

What if we are looking in the wrong place?

Does the next facility have to be accelerator-based?

But it was also clear that smaller experiments should not be sacrificed in order to obtain this facility. It was felt that a broad and diverse program of physics ought to be maintained both for the health of the field and because many young physicists are interested in physics that cannot be done at a large energy-frontier facility. Indeed, the survey revealed that a significant number of survey respondents find QCD, the neutrino sector, exotic searches, or cosmology to be most personally compelling.

However, EWSB at a major new facility seems to be the clear priority among young physicists. Given that both the Tevatron and the LHC are either already engaged, or soon will be, in the search for the mechanism of EWSB, the question then is what sort of facility is required beyond these hadron colliders.

Table I summarizes the options currently under consideration. Sources include talks addressed to the 2001 HEPAP long-range-planning subpanel [9], various HEPAP reports [10], the TESLA Technical Design Report [11], and the Linear Collider Physics Resource Book for Snowmass 2001 [12]. Further informational resources can be found at New Approaches to a Very Large Hadron Collider [13] and the Neutrino Factory and Muon Collider Collaboration [14]. All estimates have been taken from the documents and resources listed above, but they are necessarily provisional and subject to debate. In particular, accounting systems differ and some estimates may not include labor, detectors, contingency and other costs.

TABLE I: Major new HEP facilities under consideration. Cost estimates are necessarily provisional and accounting systems differ.

Facility	Decision Point	Construction Time	Turn-On	Cost
TESLA	now	8 years	2010?	3.1B eur \approx \$2.7B
NLC/JLC	2003	?	?	\$6B
p Driver	2004	4 years	2008-2010?	\$0.3B
ν Factory	2006	6 years	2013?	\$1.9B
μ Collider	2010-2015	8 years	2018-2025?	?
VLHC	2010-2015	10 years	2020?	\$4B-\$5B

At the town meeting, the young physicists were asked: “What future flagship facility should we build?” The voting options were linear collider, VLHC, muon collider/neutrino factory, or abstain. The votes were 35 (51%) for the linear collider, 5 (7%) for the VLHC, 19 (28%) for the muon collider/neutrino factory with 10 (14%) abstentions. It was further asked if the next machine had to be in the U.S. The answer was overwhelmingly “no,” and when asked if the U.S. should join efforts if the next machine was built outside the U.S., the response was overwhelmingly “yes.” Some comments preceding these votes were:

We should take the path that gets us the best physics on the shortest time scale — regardless of location.

A neutrino factory has the advantage of being a stageable facility.

The most realistic option on the list is TESLA.

The YPP survey asked: “If you had to choose from the following options, which one would you pick?” The options included a new e^+e^- linear collider in the U.S. with continued research in VLHC and muon ring/collider technologies, TESLA in Germany soon with the goal of a VLHC in the U.S., TESLA in Germany soon with

the goal of a muon ring/collider in the U.S., reserve judgment for several years and continue research, or other. The results are shown in Figure 6. Young American physicists are almost evenly split between a linear collider in the U.S., and TESLA in Germany with an eventual muon ring/collider or VLHC in the U.S. The U.S. linear collider option earned a few more votes.

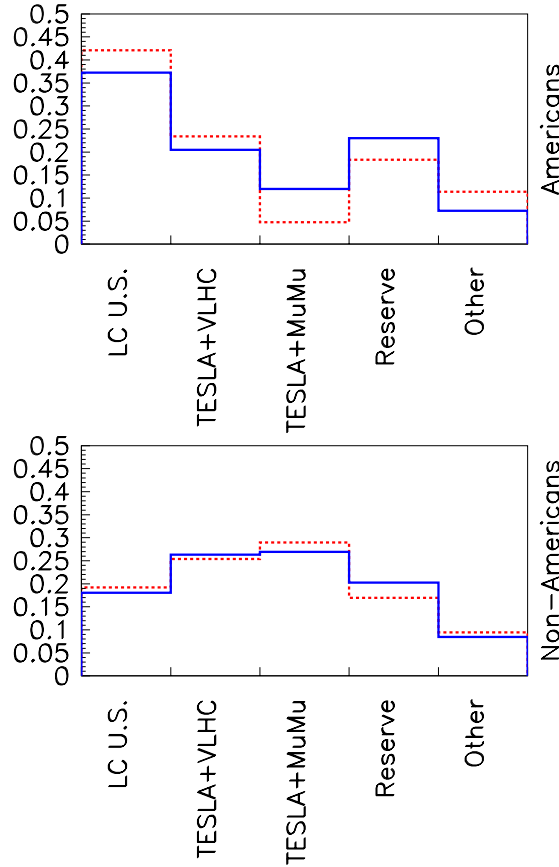


FIG. 6: Responses to the YPP survey question on preferred new facilities. Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

The conclusions to be drawn from the Forum and from the survey are clear. Young physicists believe that HEP needs a linear collider to complement the search for the mechanism of EWSB at the Tevatron and LHC, but that it should not be obtained by sacrificing smaller experiments and other interesting subjects in the field. While no consensus on the location of the linear collider has emerged, the majority of young physicists at the town meeting believe that the time to decide is now.

D. Maintaining the Number of Physicists We Need

The American Institute of Physics has kept statistics on the number of entering physics graduate students for several years. In a recent report [15] it was shown that the number of graduate students from the United States has declined by nearly a factor of two in the past ten years. State universities have had to lobby to change regulations governing the permitted number of foreign graduate students in order to slow the trend of declining enrollments. Even at current levels it is not clear that there will be enough people in the future to accomplish the physics goals of the field.

During the town meeting we asked whether we were retaining enough high energy physicists, and the overwhelming consensus was “no.” As shown in Figure 7, less than 20% of respondents to the YPP survey felt that high-energy physics was retaining enough physicists. The survey asked “What feature of the field do you think might **most** influence young physicists to leave the field?” The responses are shown in Figure 8. The majority of people are leaving because they simply cannot find a permanent position. The other significant cause is a lack of competitive salaries.

Two areas of immediate concern were identified during Snowmass: the loss of experimentalists who do more

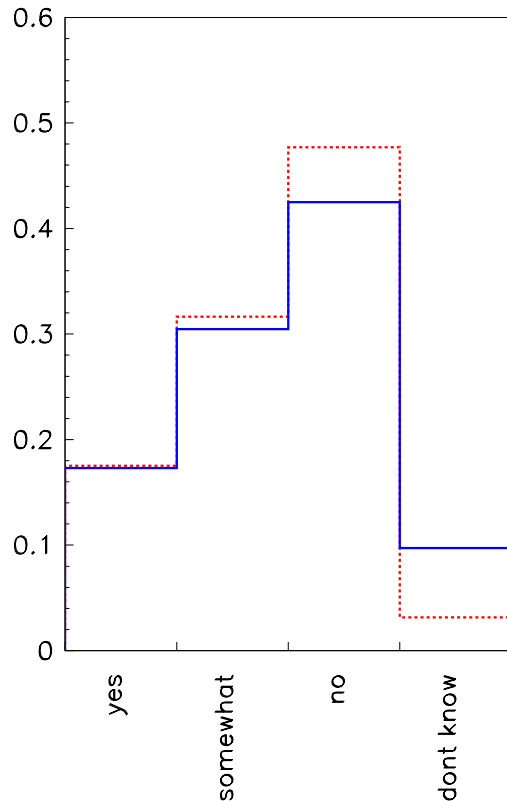


FIG. 7: Do you think we are currently retaining adequate numbers of talented physicists in HEP? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

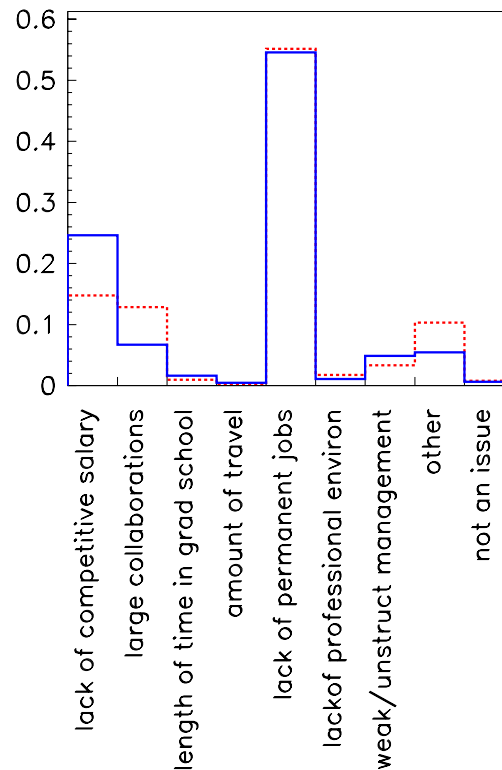


FIG. 8: What feature of the field do you think might **most** influence young people to leave the field? Solid lines are results for those who identified themselves as young physicists, dashed lines are for those who did not [3].

research and development work (R&D) than analysis and the loss of phenomenologists. The attrition rate for both of these groups was considered so advanced that the field already may be in trouble.

At the town meeting, the Advanced Detector Research Project (ADRP) was cited as a good example of what we can do to support detector R&D. The ADRP was begun by the Department of Energy in 2000 with the purpose of “supporting the development of the new detector technologies needed to perform future high-energy physics experiments.” So far six grants have been awarded totaling approximately \$500,000, with a desire to increase the funding to over \$1,000,000 over the next few years. Support for an increase in the number of competitive grants offered to experimentalists who do R&D would send a positive message to departments that these experimentalists are the backbone of the high-energy physics community.

During the town meeting the question was asked: “Should we dedicate additional permanent positions to experimentalists who do primarily R&D work?” Nearly 40% of the audience agreed this was important.

Do we have the right balance of experimentalists, phenomenologists, and formal theorists? The clear consensus at the town meeting was “no!” Concerns were expressed that the field is not supporting the people who make connections between the experiments that are running and the theories we wish to test, while allotting too much of our resources to string theory. Young theorists who have developed much of the current phenomenological technology are being forced to leave the field because they cannot find permanent positions.

In order to judge the depth of the problem, we asked “If you had one permanent position to give away, would you mandate that it went to a phenomenologist?” A surprising 1/3 responded “yes” with most of the rest uncertain. Given that over 70% of the audience said either that the next position had to go to a phenomenologist or experimentalist concentrating on R&D, it is clear that these two groups should be given a priority in hiring until the situation is corrected.

E. Conclusions

The Balancing and Building the Field Working Group has provided a forum for young physicists to express their perspective on where the field is and where it should be going. We recognize that, while the future of the field will include physics “at the energy frontier,” we will also have to leverage the understanding gained in nuclear and astrophysics experiments.

The most important physics questions drive the decisions about what facilities we will need in the future. The majority of young particle physicists believe that electroweak-symmetry breaking is the most important phenomenon to understand. We believe that a linear e^+e^- collider is an essential element in achieving this understanding, and is necessary for the future of our field. However, one machine cannot solve all of the important problems. We must maintain a diversity of experiments.

The working group believes there is a serious personnel problem in high-energy physics. Too many of our essential younger physicists are having to leave the field because there are no permanent positions for them. In particular, we are losing too many experimentalists who concentrate on R&D and theorists who do phenomenological research. A concerted effort should be made to provide more permanent positions for these talented individuals.

The future of high-energy physics is very promising. The next 30 years will hold many surprises, discoveries, and difficult challenges. Young physicists are prepared to lead the field to success.

IV. PERSPECTIVES

In general, the opinions and aspirations of young physicists are not that different from those of older physicists. We are all interested in keeping the field healthy and lively over the coming decades, and have similar ideas on what actions are needed to do so. But the Forum did bring out several interesting points. Young physicists expressed a clear interest in increasing the funding and level of effort for outreach and educational activities, and are willing to put up to 5% of their own time into it, despite concerns about the reward system. They believe that globalized operations through the Global Accelerator Network and regional centers can work, but there are still many questions about the details. They are looking for creative solutions to the “structural” problems of the field, such as the lack of permanent positions, especially for young phenomenologists and detector builders; the possibility that we do not have enough people to achieve our research aspirations; and concerns about the effects of long lead times for experiments. The opinions of young physicists on future experiments and facilities seem to fit in with the mainstream. There is a desire for a balanced program, including astrophysics, with electroweak-symmetry breaking studies as a top priority. An e^+e^- linear collider, built somewhere, somehow, is the preferred next machine. While there is a slight preference among U.S.-based physicists to have the world’s next major facility built in the U.S., it is by no means a requirement.

The Forum had a positive tone, with much constructive discussion and thinking about the long-term future, and we were very pleased by the community’s reaction to our efforts. The Snowmass workshop gave young physicists a chance to get to know each other and build the trust that is necessary for the future of the field. We believe that young physicists are eager to make the case and do the work to understand the fundamental laws of nature, and that our creativity and enthusiasm will keep HEP healthy for a long time. For instance, young physicists were full participants in the Snowmass working groups, and helped produce many of the results in these proceedings. We cannot know yet if we have come up with the “right” answers to the questions facing us, but we are trying to work them out for ourselves.

Young physicists plan to remain engaged in the community. The YPP, which has been renamed the Young Particle Physicists, has reorganized, and is forming new chapters at various universities and labs, such as SLAC and DESY, to work on issues raised for the Forum at the grass-roots level. While the Young Physicists’ Forum ended with the Snowmass workshop, we will carry on future projects with the “spirit of Snowmass” – a spirit of openness and cooperation as we work to create the long-term future of the field.

Acknowledgments

We thank the Organizing Committee for their sponsorship of the Forum, and their efforts to promote the interests of young physicists. Chris Quigg in particular was unstinting in his support of our work. We also thank the APS, DPF, and DPB, and their respective officers, and the NSF for their financial support of young physicists at Snowmass, through the registration-fee waiver and low-cost housing for graduate students and the Melvyn Month and DPF Snowmass Fellowships. Cynthia Sazama, Jeff Appel and the workshop staff helped us

with many logistical arrangements. We are very grateful to the young physicists who participated in the Forum activities, and to the community as a whole for their positive reception of our work.

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- [1] See <http://portia.fnal.gov/~bfleming/snowmassYPF.html> for complete archive of Forum documents and talks.
 - [2] <http://ypp.hep.net>
 - [3] B. T. Fleming *et al.*, “Results of the Survey on the Future of HEP,” hep-ex/0108040. Many figures in this report are drawn from here; refer to this source for important details on the methodology of the survey.
 - [4] <http://quarknet.fnal.gov>
 - [5] <http://www.nsf.gov/home/crssprgm/reu/start.htm>
 - [6] The International Committee for Future Accelerators is a subgroup within the International Council of Scientific Unions which meets twice a year and makes recommendations to various national laboratories and national funding agencies. ICFA information is available at http://www.fnal.gov/directorate/icfa/icfa_home.html.
 - [7] “Accelerators to Span the Globe”, A. Wagner, CERN Courier Vol. 40, No. 5 (2000).
 - [8] “How to Commission, Operate, and Maintain a Large Future Accelerator Complex from Far Remote Sites,” P.Czarapata, *et al.*, Proceedings of the 2001 Particle Accelerator Conference, Chicago, Illinois.
 - [9] http://hepserve.fnal.gov:8080/doe-hep/lrp_panel/index.html
 - [10] http://hepserve.fnal.gov:8080/doe-hep/hepap_reports.html
 - [11] <http://tesla.desy.de/tdr/>
 - [12] <http://www.slac.stanford.edu/grp/th/LCBook/>
 - [13] <http://www-ap.fnal.gov/VLHC/>
 - [14] http://www.cap.bnl.gov/mumu/mu_home_page.html
 - [15] Patrick J. Mulvey and Starr Nicholson, “Enrollments and Degrees Report,” AIP Report R-151.37, American Institute of Physics, August 2001.