



UNITED STATES GOVERNMENT  
M E M O R A N D U M

DIRECTORATE FOR MATHEMATICAL AND PHYSICAL SCIENCES

**Date:** March 26, 2012  
**From:** Assistant Director, MPS  
**Subject:** **Response to the Division of Physics Committee of Visitors Report**  
**To:** MPS Advisory Committee

Please find attached the MPS Response to the Committee of Visitors (COV) report from the 1-3 February 2012 COV review of the Division of Physics. The review was thorough and insightful, and the findings will be very helpful to me and to the Division of Physics in fulfilling our responsibilities to the scientific community and to the nation.

The Division of Physics drafted the attached Response, and I concur with its content. I therefore adopt it as the official Response of the MPS Directorate. I hope the full MPS Advisory Committee finds this COV review and the MPS Response useful and acceptable.

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Assistant Director

Attachment: Response of the Division of Physics to the 2012 COV Recommendations

## **Response of the Division of Physics to 2012 Committee of Visitors (COV) Recommendations**

The Division of Physics (PHY) wishes to thank the members of the 2012 COV panel for the time and effort that were devoted to an extremely in-depth and detailed review of the activities of the Division during the period FY 2009 through FY 2011. We realize that there was a great deal of material to work through, and we appreciate the care that was taken in examining the material and in asking many probing questions over the three-day period. We also especially thank Dr. Jose Onuchic for agreeing to chair the panel and for bringing the report to a final conclusion in so brief a time.

We are pleased that the Committee awarded the Division such high marks in all aspects of the operations that were under review. We regard the support given in the report as an expression of confidence that the Division is serving the community well. At the same time, we are sensitive to the points that the Committee has raised in which it believes the Division could do better, and we will endeavor to respond to the request made by the Committee that its recommendations be taken as guidance and implemented to the fullest extent possible. The following constitutes a series of steps the Division will undertake to address these recommendations.

### **COV SUMMARY COMMENTS AND *RESPONSES***

#### **II. The review process and management of the Physics Division**

*COV:* While we understand the need for fresh blood to avoid stagnation and that the Division has benefited from excellent rotating program managers, NSF management should also recognize the challenge in continually recruiting such high-quality individuals and the advantages provided by having greater continuity and more experienced program managers.

*Response:* We appreciate the compliments that the COV made on the current DD and DDD appointments. The Physics Division will continue to emphasize a balance between program managers and rotators as the best way to steward long-term projects that are much of what the Division supports, while at the same time bringing the perspective of the community to the actions of the Division. Wherever possible, when programs managers share management of a program, as in Nuclear Physics for example, we will pair one permanent staff person with a rotator to foster both permanency and freshness of approach. Three years ago the Division instituted a massive recruiting process in order to attract high-quality rotators and permanent staff. Through this we have been extremely successful in identifying strong scientists who are committed to the Division and the community and have secured a number of outstanding rotators. The Division has recently hired two new permanent staff, Jean Cottam-Allen and Saul Gonzales, who are assigned to the Particle Astrophysics program and oversight of the LHC, respectively, both of which require continuing long-term management.

## 1. Quality and effectiveness of the review process

COV: Some reviewers, however, had difficulty in properly weighting the “broader impacts” criterion. The level of detail in the postdoctoral mentoring plan varies significantly among proposals. Although much effort has been done in explaining these points to reviewers, we believe that an ongoing effort from the program directors educating the reviewers on both of these points is needed.

*Response:* The Physics Division will prepare a “Dear Colleague” letter separate from those already posted by the NSF that gives examples of the types of actions that the Division, influenced by the input from the community over a period of the last five years, regards as fulfilling the goals of broadening impact. The letter will be posted on the NSF web page in time for the community to take it into account in preparing proposals for FY 2013 funding. We will also work to ensure consistency in instructing reviewers and panels of the importance of these issues and how they are to be treated.

COV: There were two general recommendations. First, since the program officers’ evaluation makes a careful analysis of the review process and a clear discussion of the funding decision, we felt that this information, after the removal of any confidential data, should be made available to PI’s. This is especially important for PI’s that were close to the funding range and really could use this information in preparing their resubmission.

*Response:* While all Program Directors are always ready to discuss the outcome of a review when asked, and some Program Directors typically conduct extensive telephone conversations with PIs of declined proposals as a matter of routine, there has been no coordinated effort to implement a practice of the type suggested across the Division. Beginning in FY 2013 the Division of Physics will pilot a process by which at least the primary argument on which a declination is based is included as a Program Officer comment in the electronic file for the proposal, visible to the PI, for all declined awards. We realize that this will add to the Program Director’s workload, so we will be monitoring the effect of this process on the workload as part of the implementation.

COV: Second, several sub-panels raised concern about award sizes. We feel that, in special cases of really great research, larger awards should be made. We understand that this will come at the expense of reducing the total number of awards.

*Response:* The Division is well aware of the concern that award sizes are becoming increasingly marginal, an issue that is becoming more critical in the light of recent budget reductions. It places constant pressure on the Division to confront the need to maintain a balance between the level of funding and the number of awards made. At the same time, the report also praised the fact that the Division has been moving into the most exciting new directions of research, and PHY investments have led to major breakthroughs in these areas. Clearly, adequate funding is needed to achieve this critical role of constantly pushing the frontiers of physics, and the Division will continue to assign the highest priority to achieving this goal. As part of the review process, we will ask the panels as part of their deliberations to inform us whether or not the level of funding

requested is justified in the proposal and is needed and sufficient to carry out the project. In the case of budgets reduced from the request, the Program Directors will be asked to look at the budget impact statement and attest to the fact that those projects for which funds are being awarded can be completed.

## **2. Selection of reviewers**

COV: There was most support for the quality of the reviewers selected. Some subpanels raised the concern that in some highly specialized areas it was very hard to find sufficient reviewers. Even when difficult, the committee felt that a minimum of 3 ad hoc reviews should be requested for each proposal, and at least 2 ad hoc reviews should be received in each case. In the majority of the cases, the program satisfied these conditions.

*Response:* The Physics Division strictly adheres to the NSF general policy that a minimum of three independent assessments of any proposal submitted to one of the disciplinary programs are necessary in order to make a recommendation. This independence is achieved by a combination of ad hoc reviewers and a review panel. For proposals in rather narrow fields of research, or proposals involving major conflicts of interest among the participants and the reviewers, it is true that it is often difficult to secure a large number of ad hoc reviews. Therefore the Division relies on assembling review panels that include a large number of panelists, typically 10-15. In any cases in which the number of ad hoc reviews and the comments of the panel are insufficient to allow the Program Director to make a recommendation, the Program Director will then ask for additional ad hoc reviews prior to taking the final step.

COV: Some minor concerns about conflict of interest were raised. Although this was not a problem in the majority of the cases, some sub-panels observed several cases where conflicts of interest were not uncovered until the review process was under way. The program directors were able to respond quickly and address these issues in real time.

*Response:* Physics Division staff monitors conflicts of interest between PI and reviewers carefully before sending out review requests or assigning proposals to panel members and never makes an assignment without feeling confident that no conflict is at hand. Nevertheless, it can and does happen that conflicts exist that are not included in the normal reporting routine in the proposal. Such conflicts, when identified, will always be immediately marked and resolution sought through the Division Conflicts Officer prior to using an ad hoc review in a recommendation or allowing a panelist to comment on a conflicted proposal.

## **3. Program Balance**

COV: Overall the subpanels were very satisfied with the program's portfolio goals and balance. We were satisfied with the balance of renewals versus new investigators. Details can be found in the subpanel reports.

*Response:* We are pleased that the COV made this finding and will endeavor to ensure that this balance continues.

#### **4. The COV process and Response to previous COVs**

COV: Most of the subpanels have been very satisfied with the responsiveness of the Physics Division handling the requests and recommendations of the previous COV report. Specific details can be found in the subpanel reports.

The only major concern raised during the current COV was regarding the subpanel for computational physics. This panel also addressed the topic of cyber infrastructure, which also reviews computational physics. It was composed of members of other subpanels and so its activities caused some disruption to the activities of those subpanels, which were affected by not having their full membership during some deliberations. Other than that, everybody was extremely happy with the format of the COV and with what we were able to accomplish during these three days.

*Response:* As cyber issues touch upon every program in the Division, this approach was an experimental attempt to make certain that the scientific needs of the various disciplinary communities were suitably incorporated into the discussion on cyberinfrastructure, while keeping the committee to a more manageable size. We apologize that this approach had un-intended consequences. We don't envision this being a problem for the 2015 COV, as a separate cyber review in 2015 is not envisioned at this time.

### **III. Program portfolio and balance – creation of new programs.**

COV: There were concerns about the goals and breadth of the computational physics program and this concern is clearly raised in the subpanel report.

*Response:* As part of an increasing engagement in the CIF21 activity, the Physics Division will review the goals and emphasis of the computational physics program. A revised program description for the program will be issued as part of the overall yearly revision of all program descriptions in the Division in April 2012.

COV: Similarly to the POLS program, we would like to reinforce the need to extend the boundaries between fields that traditionally have not had strong interactions. We were also struck by the high level of relevance of AMO cold atom simulation experiments to significant problems in condensed matter physics, and the close collaborations between some CMP theorists and AMO experimental groups. We agree that this aspect should be encouraged. The AMO subpanel report provides more details on how to improve this connection.

*Response:* The Division agrees that this overlap should be encouraged and is already engaged in conversations with the Division of Materials Research as to how to foster connections between the two programs.

COV: There was strong support for the Physics Frontier Centers program. This program clearly fosters major advances at the intellectual frontiers of physics and has been one of the flagships of the Division. The subpanel report describes the many achievements of this program. It is important, however, to highlight one crucial recommendation. We recommend that the NSF charge an appropriate high-level body, possibly the National Academy of Sciences, to conduct a retrospective review of the PFCs, outside of the context of a funding competition for renewal and new starts.

*Response:* The Division agrees that, after ten years of being in effect, a review of the program itself is in order. We have already begun discussions as to whether this can best be accomplished through a special NSF-appointed panel or through the National Academy and what would be the appropriate time frame for the review so as not to interfere with the FY 2014 recompetition that begins in August 2013 and still have a report available for the 2015 COV to examine. A review in the spring of 2013 carried out by an NSF-appointed panel would fulfill both needs, and we select that as the first option. We will endeavor to carry out this review on this time scale, but cost may be an issue, especially given the recent restraints imposed on NSF oversight travel. If the cost becomes prohibitive, we will plan on conducting the review in the spring of 2015. In that case, we would not be able to have a report to the 2015 COV, but it would be available for the 2018 COV.

## **V. Special focus in addition to the required assessment.**

### **1. Interdisciplinary programs and participation in Division-wide programs**

COV: We were mostly happy with the efforts of the Physics Division in being proactive towards participation in NSF-wide programs. Careful analyses have been made to understand the value for the Division and how and if they should participate. There were a few cases like SEES where the committee believed that there were many important aspects suitable for the Physics Division in which no appropriate Response took place. We recommend a more organized effort responding to all these calls in order to avoid missing opportunities like this one.

*Response:* The role of the Division in the Research at the Interface of the Biological, Mathematical and Physical Sciences (BioMAPS) activity has been highlighted in the PoLS subpanel report. For the past decade the Division has been a major proponent of this connection, as evidenced by the formation of the Biological Physics (now Physics of Living Systems) program in FY 2005. The Physics DDD is the MPS representative to the group of three DD- and DDD-level individuals who oversee the BioMAPS program for the Foundation and guide the members of the MPS-BIO-ENG working group that prepares recommendations for the conduct of this cross-Directorate effort.

In FY 2012 the Division inaugurated a much more intensive effort in the CIF21 activity and expects to take a leading role in the development and implementation of new actions that address needs for data management and computational advances that are critical to the success of the Division's programs. The Division has formed a working group to

represent the Division in all aspects of the CIF21 portfolio. The members of this group are also actively involved with the Foundation-wide working groups in ACI, SI<sup>2</sup>, CDS&E, and Data. Program Director Jean Cottam-Allan has also assumed an active role in the MPS CIF21 working group in the preparation of documentation and in heading this group in the absence of the chair.

The Division has two programs that support activities that are related to SEES, PoLS and Plasma Physics. Beginning in FY 2013 program managers from these two programs will be tasked to work with the MPS and Foundation SEES groups to identify roles and actions that the Division can take in supporting, and if appropriate, leading new SEES activities.

COV: Two new efforts are either underway or proposed to improve the support structure for interdisciplinary research:

- Beginning in 2012, CREATIV (Creative Research Awards for Transformative Interdisciplinary Ventures): a pilot grant mechanism under the Integrated NSF Support Promoting Interdisciplinary Research and Education (INSPIRE) initiative to support bold interdisciplinary projects in all NSF-supported areas of science, engineering, and education research was launched.
- Under consideration by the Physics Division is the identification of “a Program Officer who will act as an "ombudsman" to keep an eye on interdisciplinary proposals and help the POs who handle them find appropriate POs at NSF to complement the managing PO’s expertise.”

We applaud both of these new efforts, and have recommendations as follows:

For the Program "ombudsman", we recommend that the Division create a fund specifically held in reserve to supplement Cross-Disciplinary grants. This will create an incentive for the POs of regular programs to pursue cooperation with the Cross-Disciplinary PO.

*Response:* We are pleased to report that the Division is currently considering at least two possible CREATIV actions and views this program as an effective means of stimulating interactions among programs. Although the Division has identified a Program Director to act as an ombudsman in fostering the co-review of proposals that might otherwise fall through the cracks, the Division will continue to act on proven experience that long-lasting results are only achieved when Program Directors agree between themselves to work together and establish the basis of a more permanent relationship. The role of the ombudsman is to assist in making the appropriate connections among Program Directors with the needed expertise and, along with the DDD, in interacting with the Office of Multidisciplinary Activities (OMA) unit in the MPS AD’s office. Support for these activities will be provided through funding allocations in the programs, thereby ensuring that the funds are available to sustain the activity past the initial phase.

At the program-program level, numerous interactions already exist between various Physics programs and programs across NSF, especially programs in the Division of Astronomical Sciences (AST) and the Division of Molecular and Cellular Biosciences

(MCB) and the Directorate for Education. The Physics Frontier Centers (PFC) program includes a significant investment of funds from the AST, the Division of Materials Research (DMR), MCB, and the Directorate for Computer and Information Sciences and Engineering (CISE), and smaller amounts from the Division of Chemistry (CHE) and the Office of Polar Programs (OPP). The Division will continue to emphasize person-person interaction among Program Directors and will consider this as a key element in the evaluation of Program Directors who devote time and effort to doing this.

## **2. Facilities and instrumentation**

COV: There was an enormous consensus supporting an instrumentation program across a scale that could benefit all disciplinary programs by all subpanels. Different programs have different needs for this new program but they all highlight that much is missing without it. The subpanels give specific reports for the needs of the different programs. The report by the APPI subpanel is particularly instructive and summarizes the importance of such a program and the recommendations of our committee. Let me summarize the action items proposed by this subpanel:

- There is a sense in certain program communities that there are very limited funds for instrumentation at NSF. Physics and all the members of the COV should inform the community that there is money for equipment requests as part of the science proposals as long as the proposal is clear that the instrumentation is necessary for the success of the science.
- Physics should consider writing a Dear Colleague Letter to make sure that the community is aware that they can request equipment money in their science proposals.
- Observation: It is necessary to increase the documentation on how the allocation of the resources toward co-funding of science awards happens.
- Special attention should be given to make sure that such a program does not affect the balance between theoretical and experimental funding.

*Response:* The Accelerator Physics and Physics Instrumentation (APPI) program was created within the Division to address the critical need for instrumentation that is essential for scientific progress but which is of a level that is not easily affordable by an individual disciplinary program. In the “Dear Colleague” letter announcing the target dates for FY 2013 funding, the Division has added the sentence: “Proposals that require special instrumentation may include a request for this instrumentation as part of the proposal, taking care to justify the need for the equipment as essential to the project, especially if the instrumentation costs are significantly larger than what is typical for a normal award in the program.” Program Directors have also been advised that they can alert their respective communities to this possibility.

Although it is the intent of the Division to ultimately build APPI up to a level that will allow the Division to address broad mid-scale needs, an assessment across the community indicates that the funding levels currently available to the program do not support the rapid influx of proposals that would follow the release of a special announcement of the availability of funds. The Division will continue to submit requests

to increase this funding as part of the budget development process and will take action to open the APPI program to competition once sufficient funds warrant doing so.

We are pleased that the committee supported the approach the Division has taken thus far in having the science reviewed through the disciplinary program and using the APPI funds as a one-time source of support for a well-defined instrumentation need. This way we can be assured that the funds are always addressing the highest-quality scientific activities. Beginning in FY 2012 the Division will prepare a Diary Note to be included in all award files that use APPI funds explaining how the APPI allocations were arrived at.

The Division Director has already informed the COV that special attention will be given to ensuring that support for theory will not be compromised by the emphasis on instrumentation (see subpanel report).

### **3. Broadening participation**

COV: Although the Physics Division has put much effort toward increasing broadening participation, there was a general consensus in the committee that much more needs to be done. There was a general agreement that the number of woman PIs appears to be increasing to appropriate levels in a slow and consistent way. The news appears to be good but we recommend that continuing efforts toward this goal are needed. The situation for underrepresented minorities, however, is very problematic. This is not a problem singular to the Physics Division but clearly much more needs to be done. There was much discussion in all subpanels (as can be seen in their specific reports) and by the committee at large. The EIR subpanel has done a careful job describing the committee recommendations and I highlight them here:

The Physics Division is tackling broadening the participation of PIs and reviewers, a complex challenge. The Division should focus on its own practices as well as try to leverage change through partnerships where possible. Actions the Division can take include:

- Improve demographics data collection / sharing
  - Reviewer demographic data wasn't easily accessible for the COV, due to the separation of the PARS and Fastlane database systems. Data from these systems should be shared across the system to better assess the demographics of the reviewers.
  - REU participant information is collected in Fastlane through self-reporting by students. This information, however, is not available to the PI and does not appear easily accessible to POs. Thus communication between Fastlane, the PIs and the POs could be improved to better assess REU participant demographics.
- The Physics Division broadening participation report prepared for the COV indicates that POs provide information about potential funding opportunities to faculty at small institutions in order to foster successful submissions. This could be broadened to provide several options for improving proposal preparation, such as:

- Suggesting successful “proposal writing” mentors who have a strong track record of writing high quality proposals in that field.
- Making unsuccessful new PIs aware of the ROA program that could facilitate mentoring relationships between young faculty at institutions that do not have strong research traditions and established researchers.
- Making young PIs aware of ongoing “How to build research programs at small colleges” workshops (for example, those held by the Council on Undergraduate Research - CUR).
- Mentors should develop their skills, such as through the NSF-supported Research Mentor Training seminar program. The physics community, possibly through APS/AAPT, could help to make these opportunities available to new PIs.
- New REU site proposals could be broadened through a similar mentor model with established REU sites.
- The PHY broadening participation working group is encouraged to work with the MPS broadening participation working group to share ideas and practices across divisions.

*Response:*

With regard to data collection and sharing, the Division appreciates the comments from the panel but is not in a position to undertake any action beyond passing the comments on to the Division of Information Systems, which is the NSF body responsible for maintaining the NSF database.

The Physics of Living Systems program has initiated the idea of mentoring unsuccessful applicants who have good scientific ideas but who have difficulty in writing a successful proposal. PoLS is also exploring the notion of using social networking to track participants who enter and leave a program. The Physics Division working group on broadening participation will be tasked with examining this as a pilot program and suggesting an appropriate mechanism for implementing this more broadly. In so doing, however, the Division will not undertake any actions that would violate the right to privacy of an individual or impinge on the anonymity of the review process.

The Physics Division will upgrade its web page to ensure that attention will be called to such programs as listed above. The Division will also work with the APS to see that the community is better informed about these various activities, using active linking wherever possible.

Program Director Kathleen McCloud will continue to represent the Division within the MPS working group on broadening participation. Kathy has served as chair of this group and has a record of interacting extensively with the Directorate for Education and Human Resources. The MPS group already shares vision and experiences within MPS and NSF as a whole. The group also works closely with the MPS Advisory Committee subgroup on broadening participation. This is expected to continue, especially as the MPSAC working group extends its interactions with a similar working group from the Education

Advisory Committee. They are currently exploring cooperation in the area of Expeditions in Education. Funds from the Broadening Participation program in the Division will continue to be available to pursue promising avenues to enhancing the participation of under-represented minorities in physics.

## **VI. Cyber infrastructure at the Physics Division.**

### **NSF INITIATIVES IN COMPUTING AND CYBER-INFRASTRUCTURE**

COV: The primary program that supports computing activities within Physics is the Physics at the Information Frontier (PIF) program. PIF was originally created as a follow-on to an NSF-wide ITR initiative.

In creating new programs and initiatives, the following points should be considered:

First, the program and review guidelines need to recognize the fact that physics research often provides early real-world applications of ideas and methods that have previously only been prototyped or described theoretically in the computer-science community. Using such methods in the real world to solve physics research problems at the boundaries of knowledge is a necessary step in completing this work and bringing it to fruition. Thus one needs to be cautious about the criticism that the work is "nothing new" or is "not scientifically innovative" because the methods and tools that are being applied are "old hat". In other words, one must recognize that important "scientific computing" activities are often not "computer science".

Second, the programs and review guidelines need to recognize that, as described above, in many cases Physics is already at the forefront in Cyber-related research. Yet this leadership position can make it appear that physics work is "old" in comparison with proposals from other fields that seek to apply such methods in new contexts. Program solicitations should be worded so that they do not penalize physicists who are already at the cutting edge of the field, i.e. "already doing it".

The COV notes that these same issues can arise when physics researchers apply for time at national supercomputing facilities. The review panels used to evaluate those applications should recognize that physics work may be of great scientific interest, even if it "merely" continues work in an area that has "already been explored", or does not break new ground in computational methods.

It is also important to inform and educate the physics community about NSF-wide programs and initiatives that overlap physics interests. In many cases, physics researchers are unaware of these programs and initiatives.

In order to ensure that the physics community benefits from the various cyber-related initiatives and to address the issues described above, we suggest that the Division provide program managers with the time and incentive to take part in the formulation of these programs and solicitations, and with the time and funds to travel to conferences and

meetings where these programs and initiatives can be presented to the research community.

We welcome the increasing emphasis on computation and computational infrastructure across the NSF. The COV encourages the Physics Division to remain closely involved in the development of future NSF-wide or multi-division programs for Cyber and Computational research and development.

*Response:* In FY 2012 the Division inaugurated a much more intensive effort in the CIF21 activity, the NSF-wide portfolio of activities that are designed to respond to the growing role of data and computation in the scientific enterprise, and expects to take a leading role in the development and implementation of new actions that address needs for data management and computational advances that are critical to the success of the Division's programs.

The Division has formed a working group to represent the Division in all aspects of the CIF21 portfolio. The members of this group are also actively involved with the Foundation-wide working groups in ACI, SI<sup>2</sup>, CDS&E, and Data. Through these efforts the Division expects to have a much stronger voice in the development of programs and solicitations, as recommended. Assignment to the Divisional working group and the cross-NSF working groups will be considered as part of the performance plans of the program directors who participate.

Physics Division program directors will be tasked to inform their communities about all solicitations and other activities related to cyber infrastructure. With regard to data, several of these communities are already heavily engaged and indeed have made major contributions to the field through such activities as the Open Science Grid. The coming years will focus on expanding these activities and on bringing additional groups into active participation, heavily through working with other Divisions, Directorates, and OCI.

## **THE DIVISION'S BALANCE, PRIORITIES AND FUTURE DIRECTIONS**

### **DATA MANAGEMENT, OPEN DATA AND SOFTWARE**

COV: Addressing these issues is a challenge to the Physics Division in implementing part of NSF's Stewardship mission and responsibilities. We suggest that the Physics step cautiously and thoughtfully in this area, and carefully study the implications of any proposed actions regarding open data and/or software. We recommend following the flexible model implemented in the case of data-management plans, rather than mandating a one-size-fits-all solution.

In cases where long-term, continuing support for dissemination and upkeep of data or software is warranted, the Division should explore possibilities to help bear this cost. In particular, when a software package has become a successful standard tool used by many researchers and research groups, it probably makes sense to look for ways of supporting it. In short we recommend that NSF explore ways to provide structures that support

"software development, packaging and maintenance" which is important for physics but is not in and of itself a research activity. That is to say, the work itself is not discovery, but instead the creation of infrastructure for that process. One understands, however, the difficulties of the current funding situation and also that support for these costs may have to involve other partners in addition to the Physics Division.

*Response:* Open data is a serious issue that concerns all of NSF and one that NSF is taking steps to address. PHY is currently active in discussions regarding open data policies for facilities such as LIGO, LHC, and IceCube. The Division expects to be deeply engaged in what are on-going discussions leading to an overall NSF policy on open data. Indeed, the MPS directorate is taking leadership at NSF in exploring these sensitive issues, working with many stakeholders, including the National Science Board.

The Physics Division has become an active participant in the broad set of activities that are encompassed in the CIF21 activity. One area of current lively discussion is the development and maintenance of software. This is an area that impacts not just Physics but all of MPS. The Division will work with MPS, other Directorates, and OCI in undertaking actions that address this need as they are identified by the working groups involved. In particular, on the issue of software, we agree that this is important and the Physics Division will partner with OCI on the SI<sup>2</sup> program going forward.

COV: One might argue that the need for such software support should extend more broadly, to include tools that facilitate collaboration. An example is the EVO videoconferencing system, used by many scientists working in large collaborations; EVO was developed with a combination of NSF and DOE support. Currently, the Physics Division is ill-equipped to provide such software infrastructure support; the competitive funding model discourages it in favor of work that more directly advances the scientific frontier. In contrast, DOE labs have been successful in providing such infrastructure support. For example Argonne National Laboratory supports and distributes MPICH, a freely available portable implementation of the MPI message-passing standard used for distributed-memory applications in parallel computing.

We encourage Physics and DOE to explore the possibility of working together in the future to ensure that such infrastructure support is available where needed.

*Response:* The Physics Division and the DoE have long-standing partnerships in many areas of physics and will continue these partnerships. For those needs that are critical to fostering collaboration, and which are not broadly available commercially, the Division will continue to work with the DoE in seeing that support for development of such tools is available.

## DIVERSE COMPUTING SOLUTIONS FOR A DIVERSE RANGE OF PHYSICS PROBLEMS

COV: A great deal of physics research work can be done with standard off-the-shelf computing resources: laptops and desktops equipped with low-cost or open-source

software packages. However, other scientific work requires more: small, medium or large-scale clusters of computers or compute-farms, or specialized high-performance supercomputers at various scales. Therefore PHY, and NSF generally, should seek to maintain a balance in the spectrum of computing resources that are available to researchers.

*Response:* The Division will include this as part of its own discussion about the re-alignment of the PIF program. However, as this is an issue that is not unique to physics alone, the Division will introduce the concept into the broader CIF21 discussions as part of its input to that activity. The Division is now playing a key role in the development of a broad roadmap for CIF21 programs in collaboration with other MPS Divisions, OCI, and others across NSF.

COV: Through the Office of Cyber Infrastructure (OCI) the NSF funds a number of national supercomputer centers to provide compute cycles at the largest scale. Compute cycles at these centers can be obtained through a competitive peer-review process. NSF also supports a number of grid- and cloud-oriented computing initiatives, such as the Open Science Grid (OSG) and Teragrid. It is important for Physics to ensure that suitable funding for resources at the small- to large-sized cluster scale is also available. These are more cost-effective for a certain class of problems, and they also function as an essential training ground for students and postdocs, as they allow young researchers to experiment with software and hardware systems in a way that would not be permitted or acceptable on large-scale shared facilities. Funding such systems can be difficult within the scope of a typical single-investigator grant. We encourage the development and perpetuation of suitable programs (for example APPI) for this purpose.

*Response:* PIs supported through the Physics Division have successfully competed for such clusters through the NSF MRI program. Insofar as the PI can make a very strong case for the need for a specific cluster set, such a request is within the scope of the APPI program. However, general requests for a computer cluster in the absence of compelling scientific need will not be part of APPI. However, we will increase emphasis on the need to build bridges between campus level awards for infrastructure and instrumentation and to access national level supercomputer and experimental facilities, focusing in particular on how best to coordinate the sharing of data between these levels.

COV: In a similar vein, the Physics Division should continue to express the need for alternative and novel approaches to provide compute cycles. A good example is public volunteer computing, which can provide very large numbers of compute cycles at extremely low marginal cost. This approach is only appropriate for a particular class of computational problems, characterized by a very high ratio of computing to input/output data, and which are of interest to the general public.

This sort of boutique hardware has also been used within the experimental particle physics, lattice QCD, and gravity communities. The Division should continue to encourage the development of such novel hardware approaches, when they offer substantially more cost-effective ways to study important systems.

As these examples show, novel computational strategies involving boutique hardware, small and large clusters, and volunteer distributed computing enable cost-effective solutions to forefront science problems. It is crucial that the Physics Division continue to fund and encourage NSF-wide support for such endeavors, and appropriately balance their resource demands against those of more visible computational infrastructure, i.e. supercomputers. This will require diligent management, especially given the constraints anticipated on science funding in the near term.

*Response:* Again the Division expects that the broad spectrum of activities within the CIF21 portfolio will include these activities as part of the effort, especially as these needs are not unique to the Physics Division.

## HIGHLIGHTS AND FUTURE DIRECTIONS

COV: For the past few years, Physics has supported the development of a computing grid that is currently being heavily used to analyze the current LHC data. This grid development will need substantial enhancements in the near future to handle the anticipated increase in data as the upgraded LHC will deliver both increased luminosity and energy.

*Response:* The Physics Division maintains careful oversight of all activities related to the LHC. Saul Gonzales, who has had long experience with the LHC, was recently hired as Program Director with major responsibility for the LHC activity. Saul is also extremely knowledgeable in the area of LHC computing. He is a member of the Division's working group on CIF21 and interacts with the broader NSF working groups in this activity. The Division expects that Saul will act to ensure that the LHC computing needs are considered as part of an eventual LHC upgrade.