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Dr. W. Carl Lineberger
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Dear Prof. Lineberger,

Attached to this letter you will find the Committee of Visitors Report of the Division of Physics of the National Science Foundation for the period of 2003-2005 and the completed GPRA template. The Committee met during the days of January 27-29. We have now all concurred on the report and I have electronic mails of every member of the committee with their agreement.

Thank you very much for giving me, as chair of the COV, the opportunity to help in the process of preserving and enhancing the National Science Foundation.

Yours sincerely on behalf of the committee,

Luis A. Orozco
Chair Physics COV 2006

cc Dr. Michael Turner
cc Dr. Joseph Dehmer
cc Dr. Judith Sunley
cc Morris Aizenman,
cc Laura P. Bautz,

Report of the Committee of Visitors

to the Division of Physics

National Science Foundation

January 25-27, 2006

1 Introduction

The Committee of Visitors (COV) for the Division of Physics met for three days, January 25-27, 2006 to review actions taken on proposals handled by the Division during the years 2003, 2004, and 2005, and, to review, in a broader way, the past actions and future plans of the Division. Appendix A contains a list of COV members and Appendix B the agenda. Appendix C contains the charge given to the COV by Dr. Michael Turner, Director. The COV was charged to address:

- the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions;
- the relationship between award decisions, program goals, and Foundation-wide programs and strategic goals;
- the quality and significance of the results of the Division's programmatic investments;
- the Division's balance, priorities, and future directions;
- any other issues that the COV feels are relevant to the review.

The PHY programs under review include:

- Atomic, Molecular, Optical, and Plasma Physics (AMOP)
- Elementary Particle Physics (EPP)
- Gravitational Physics and LIGO (GP)
- Nuclear Physics (NP)
- Particle and Nuclear Astrophysics (PNA)
- Theoretical Physics (TP)
- Education and Interdisciplinary Research (EIR)
- Physics Frontier Centers (PFC)

Subpanels of the COV examined these programs and their reports are part of this COV report.

The COV was also asked by Dr. Turner as part of its charge to "give comments on how the Division reviews and competes large activities, including large group grants and the PFCs." He asked for the advice of the COV on how these activities might be reviewed and competed in the future.

Briefly, the review process proceeded as follows: approximately two weeks before, members of the COV were given access to a web-page that had general material for the review http://www.nsf.gov/mps/phy/cov06/index.jsp. It contained the annual reports of each of the programs of the Division for FY 2003, FY2004 and FY2005, background information and divisional statistical data covering ten years as well as more information on the individual programs, and the previous COV of 2003 report covering 2000, 2001, and 2002. See Appendix D for its contents.

The director of physics in consultation with the Chair of the COV sent a request to eight members of the committee to serve as chairs of the panels reviewing individual programs.

The meeting began with the welcome and Charge by Dr. Michael Turner from the Directorate for Mathematical and Physical Sciences, followed by brief remarks from the COV Chair, including the introduction of the complete COV. Dr. J. Dehmer, the director of the Division of Physics then gave an overview of the division. He touched on the strategic goals of the Division that cover: Intellectual Frontiers, Broader Impacts, Education, and Stewardship. After lunch the subpanels met with the program directors who presented an overview of their programs. Then, for the rest of the afternoon of the first day and the morning of the second day, the COV members studied the "jackets" containing the information on the proposals received and acted upon. Sometimes those jackets were paper documents, but others were the new all electronic e-jackets. The COV enjoyed full access to any packet desired and appreciates the openness and helpful efforts of the NSF program directors and staff. Each COV member studied about ten jackets giving all COV members a reasonable sampling of Division activities.

The afternoon of the second day was taken with preparation of the program reports and a session of the full COV to hear a summary of the findings of each subpanel, followed by a discussion on the issue of large activity grants, group grants, and center grants as charged. In this session, the full COV began to discuss the balance and strategy issues which are summarized in the priority, balance, and strategy section of this report. During this session NSF staff was present to answer any questions and queries of the COV.

On the morning of the third day, the COV met to fill in the COV template, broadening the discussion and highlighting points to present in the closeout discussion in the afternoon. The COV then reviewed and summarized its work. In the afternoon, the full COV held a "closeout" session with Dr. Judith Sunley, who served as a representative of Dr. Turner, and with the Division staff.

Following the COV meeting, the COV completed the sections on "General Conclusions" and "Priorities, Balance, and Strategy" and made final revisions in the subcommittee reports. The revised report was sent to all COV members for approval before submission.

The work of this COV was made much easier by the openness of the Program Directors and the Division Director. They discussed their performance, their successes, and their problems with the COV subpanels and helped with the many questions that each member had. The COV also wants to express its appreciation to the administrative support staff of the Division for their help on the many issues that had to come together to have a fruitful COV. This committee joins previous COVs in commending the entire staff of the Division for their fine work. They work coherently and enthusiastically to achieve the best for the Division.

2 General Conclusions

The COV is pleased with the performance of the Division of Physics and how it works towards the strategic goals of the NSF. The integrity and efficiency of the processes to make decisions on grants are excellent and the COV sees that merit review is working very well.

This COV has seen a significant improvement on the use of the use of Merit Criterion 2 “broader impact of the proposal”) compared to previous COVs. This is in great measure the result of an effort to educate both the proposers and the reviewers on Merit Criterion 2 by the program directors. The results are clear, but we encourage the effort to continue.

While reading the jackets, many of the COV members found that the most informative part was the review analysis written by the program director. The COV would like to ask the Division that if possible they provide the PI with a suitably redacted version of the review analysis.

The statistics on the number of women PIs and CoPIs show a trend of growth that this COV welcomes. It has crossed the 15% mark and shows evidence of increasing. The numbers for other underrepresented groups do not show significant change during the last ten years. The COV encourages the Division to continue its efforts to reach, mentor, and encourage women and underrepresented groups to involve them in the scientific enterprise of the Division.

The COV gives its highest marks to the staff for management of the large and diverse portfolio. The staff in the Division is overloaded and the COV is happy to hear that some new positions will open for permanent staff. The staff consists of rotators and a core of permanent employees. The rotators, being well-connected, established members of research community, are knowledgeable and committed to the programs of the Division, but the institutional memory must be preserved making the role of the permanent staff critical.

During the period of this COV there has been excellent response to new areas: first the program in biological physics and second the program in physics at the information frontier. It is too early to asses their success, but given the proposals that have arrived and the attention they have generated in the community there is good evidence for optimism. The period reviewed by this COV has seen the consolidation of two programs initiated recently in the Division: Particle and Nuclear Astrophysics (PNA) and Physics Frontiers Centers (PFC).

The COV sees that the forthcoming Accelerator Physics and Physics Instrumentation (APPI) program could fill a need for 2 to 100 M$ projects, if it gets to that level of funding, a problem pointed out by the 2003 COV. The APPI does not address the significant needs from individual PI's for instrumentation between 100K$ and 2M$ that does not fit in the MRI program.

The quality and significance of the results of the programmatic investments is excellent. The science supported by the Division is superb. It is helping form the next generation of physicists to face the challenges of the 21st century.

3 Priorities, Balance, and Strategy

The Physics Division has shown vision and stewardship in the management of its activities. It has responded well to new developments in Physics. The scientific priorities of the Division follow the high standards set by the National Science Board (NSB) and the National Research Council, making the NSF a model for other agencies.

The Division should continue its commitment to many exciting facilities which are defining new programs in their fields (Large Hadron Collider [LHC], IceCube, Light Interferometer for Gravitational-Wave Observatory [LIGO]). The operations of these large facilities should be funded without compromising the base programs in the Division. These facilities involve multi-national collaborations and multi-agencies providing the funding. Management plans have to be set clearly to avert problems as those faced in FY2002 when LIGO came on line when the costs of operation had to come from the base. The 2003 COV recommended that the Division works out a concrete public plan for operation of large facilities; the 2006 COV concurs with the recommendation of the previous committee and is worried that this has not happened. This operation plan for large facilities has to be implemented soon with input from the community.

The COV warns that the experience of the Rare Symmetry Violating Processes proposal (RSVP) should not be repeated. To do big projects well, NSF must include adequate up-front engineering support for realistic project cost estimates, include independent up-front project management support, include operations cost in budget and planning ("life cycle costs"), and work closely from the start with any other agencies that provide infrastructure or resources.

The PFC is a very successful program and should continue with competition for award renewal and, when funds are available, should grow in number through an open solicitation. There were plans to grow the program, but budget constraints forced a change in pace. The current structure for the operation and management of the PFCs is appropriate.

The COV recommends that the balance in the Division be such that the individual investigator awards should be above 55%, while the PFCs and similar centers not more than 10% of the total budget. If the Division budget expands, the highest priority should be given to nourishing the base investigator program that has suffered in recent years.

A concern of the COV is proposals that span programs or even Divisions, for example those in AMOP that cross into Condensed Matter and those in PNA that cross into Astronomy. The COV has seen that they have been handled effectively. As the PFC's evolve there may be situations where they become cross-divisional bringing new challenges to the Division for the effective handling of the program.

Dr. Dehmer informed the COV on the first morning of the meeting that there were legal issues that would prevent the COV from looking at the jackets associated with the Deep Underground Science Laboratory (DUSEL) initiative. Nevertheless, the COV is disappointed not to have had the opportunity to evaluate the handling of the proposals for this important future facility.

3.2 The question of Centers.

The COV discussed the question posed by Dr. Turner about grants to large activities using as a guide the documentation of the National Science Board about Centers, in particular the Senior Management Integration Group, June 21, 2005, Principles of National Science Foundation Research Centers (Appendix E), and the Attachment 4 to NSB-05-162, NSB-05-166, December 1, 2005 (Appendix F) . It is not the task of the COV to interpret the definitions and legal consequences of these documents, but to provide guidance for the best science output from the Division.

The COV is convinced that there is room in the program of the Division for collective activities such as the PFC's. These activities span the programs of the Division and have proven to be excellent. The proposals should be subject to competition for renewal at the appropriate time intervals.

The competition among renewing and new PFC proposals is particularly important for the high quality of the resulting portfolio. Proposals have to show a much higher level of synergy and risk taking than individual investigator proposals. They must demonstrate the value added by establishing a PFC as opposed to a series of single investigator grants.

The mechanisms established by the Division for the competition with first a series of ad-hoc reviews followed by a panel of experts with reversed site visits has worked well in the two open competitions. The first renewal competition is being implemented following the same standards. The difficulties of competitively evaluating different activities are large, but Merit Criterion 2 is a valuable guide in comparison. It is important that the Division maintains the highest standards for the selection process and never castigates excellence nor rewards mediocrity in these activities.

Future COV's will review the success of the PFC's and recommend continuation of the program or its decrease. This COV sees the balance between the base of PI and the PFC's as critical for the success of the Division and recommends that the PFC's activities do not grow to more than 10% of the Division budget.

Some members of the COV voiced concern about whether one can end any such activities, as they tend to have large inertia both institutionally and at the Division level. The director of the Division assured the COV that the Directorate closed a few centers in other Divisions that failed in the renewal competition.

3.3 Recommendations for future COV's

This COV has a few suggestions to make the next COV process more effective while keeping it informative and educational:

- Keep the statistics over 10 year period, not just for the Division but for the programs.
- Make sure that the general materials are available several weeks before the meeting. (For COV 2006 the web page opened ten days prior to the meeting.)
- We would like the next COV to have uniform accessibility to the electronic files.
- We recommend that the next COV try to get started on reviewing jackets earlier, and leave the program overview for later, maybe on the morning of the second day.
- Many members of the COV felt that conference calls first with subcommittee chairs, and then within subcommittees to explain the web site, the process, and the charge would be good.
- The Chair benefited from having participated in a previous COV.
- We hope that NSF can implement the use of Fastlane interactive panel system (submit comment feature) to create the subpanel reports.

4 Reports of the Program Subcommittees

4.1 AMOP Program Subcommittee Report

Introduction and general overview

The AMOP Subcommittee reviewed 57 electronic jackets (EJs) provided by the AMOP program managers (D. Caldwell and J. Carlsten), in the sub-areas of Optical Physics, Atomic Dynamics, Precision Measurements, Atomic and Molecular Structure, and Plasma Physics. These jackets were selected by the program managers to represent the spectrum of proposals between "obviously fund" and "absolutely do not fund" cases, with a weighting towards borderline situations. In addition, an extended question and answer session was held between the Subcommittee and Caldwell, Carlsten, and B. Schneider. The Subcommittee felt that the AMOP program is very well run, and that the proposal review process, for both individual investigator grants and centers, is transparent, efficient, and fair. One of the things we found most impressive about the process in this program was the extreme attention paid to the integrity and fairness of the system, and the high quality of the science it funded.

4.1.A Integrity and Efficiency of the AMOP Program Process and Management

4.1.A1 *<u>The effectiveness of the program's use of the merit review procedure</u>*

The system for proposal review is efficient. The panel system represents a significant improvement over the old mail-review-only system, because it allows for a uniform comparison and overview of all proposals submitted in a given funding cycle. It also allows panelists with perspectives outside the subfield of a given proposal to inform and broaden the overall review of that proposal.

With the rise in the number of proposals, the review panel is under increasing time pressure to complete the process. A panel's work typically involves the reading of twelve to eighteen proposals before the panel meeting, followed by an intense three day meeting at the Foundation's headquarters. Our group felt that the panel system is hampered by having to spend time reviewing obvious "fund" and "do not fund" cases. Panels generally spend a fair amount of their limited time discussing these cases, in part because no one wants to create an impression that no proposal is not given equal time. In these cases, we felt that the program officers would be justified in discussing with the panel only issues related to funding levels for the "obvious fund" cases. The panels could also be asked to provide guidance with regard to other issues as well, such as individual funding of personnel, or detailed budget analyses, without going into the rest of the overall proposal.

There was much discussion *viz a viz* the use of quantitative metrics for judging proposals. The ranking system from 1 to 5 ("poor"….."excellent") is less of a quantitative ranking in this regard than a summary of a qualitative analysis made by a reviewer. Obvious possibilities such as, e.g., number of *Physical Review Letters* or number of citations were discussed, and it was felt that any metric of this type essentially allowed the system to be gamed. The evaluation system as it exists does appear to be optimal.

The turn-around time for proposal review is adequate, and is typically 6 months. We felt that timing issues related to proposal turn-around were overemphasized by the Foundation in general. An absolute requirement (or any internal incentive pointed towards the same end) was felt to be counter-productive, in that it tends to limit the programs' flexibility in dealing with individual proposals, and can often lead to a less-than-optimal outcome for both the PI and the program. It can also severely limit interactions of the AMOP Program with other programs within the Foundation. Timing issues were also a concern with regard to the CAREER proposals, because their submission dates are different from those of regular proposals. The separate dates can lead to more than one submission per year to the program by one PI, thus overburdening a system in which the program officers are already overworked.

Funding decisions were well documented, and appeared in all cases to be correct. In several cases, we discussed decisions to decline with the program officers, and concurred with their judgment in the matter.

The only "high-risk" decision by the program that we discussed as such was the decision to fund the ATRAP collaboration. The funding rate was initially high and continues to remain so. The scientific productivity from this collaboration has already been large, though, and, in the panel's view, is just beginning. This is a good example of a programmatic gamble that has paid off well.

We found the EJ system to be efficient and informative. After a brief learning session, the accessing of various electronic files was quick and easy.

4.1.A2 Program's Use of the new NSF Merit Review Criteria

The group feels that in the proposals we reviewed there was adequate response to Criterion 2. Thus the concerns of the COV2003 have been addressed.

4.1.A3 Reviewer Selection

The selection of reviewers was appropriate. The possibility of mixing theorists and experimentalists on the same review panel for proposals in AMOP physics should be considered. This is standard practice for the review of proposals in basic plasma science and engineering, and has been found to be useful in judging proposals with significant connections between theory and experiment. Neither theorists nor experimentalists can do their best work without guidance from the other. The increase in panel diversity obtained by adding several theorists could be a good thing.

4.1.A4 Resulting portfolio of awards

The character of the AMOP program is determined by the proposals it receives. Since the community is young and the overall proposal quality high, the program is flourishing intellectually. Perhaps the best evidence for this is the fact that in the last ten years, ten Nobel Prizes have been awarded to workers in AMOP science, six of whom received funding at one or more times in their careers from the NSF AMOP program. Four MacArthur Award winners in AMOP science have also been named in the last ten years, all of whom have and continue to receive funding from this program. The health of this community has been nurtured by the efforts of the AMOP program officers, who have mentored young scientists writing their first proposals, made funding decisions crucial to the intellectual vibrancy of our discipline, and served to provide a standard of excellence in funding decisions.

The programmatic issue of optimal experimental grant size was considered. Current mean in the program is $135K/year. For a grant with a senior principal investigator, a postdoc, two graduate students and perhaps an REU Supplemental grant for two undergraduate students, a grant size closer to $225K would appear to be appropriate. This larger size would; of course, come with the result that fewer grants overall could be funded. It is likely that this would disproportionately affect smaller grants to younger investigators. Ultimately, the tension between these two must be resolved by the program officers. For very large grants involving three or more senior principal investigators, the group felt that the program officers must remain vigilant to weed out less productive personnel.

In FY2003-2005, there were 16 awards to new young investigators. (Young means 10 years or less from Ph.D.) The panel considers the average of five new awards a year to young investigators to be adequate. The renewal rate for proposals was 78%.

4.1.A5 Management

The AMOP Program should proactively address imminent staff vacancies. Denise Caldwell has become increasingly involved in other programs at the Foundation, and John Carlsten must end his service as a rotator because of the four-year maximum rule. A search to replace these two should begin as soon as possible. Institutional memory and continuity must be preserved in this transition to new staff. Ideally, one of the two new staff members should have some experience in plasma science and/or optical physics. The sub-committee felt that an appropriate staffing level for this program would be a full-time staffer assisted by a full-time rotator or two half-time rotators. Barry Schneider would still be needed for consultation and to provide assistance in the area of plasma physics.

4.1.A6 Interaction with Other Agencies

Recent funding pressure in plasma physics, specifically as a result of the elimination of ONR funding in this area, has made the role of inter-agency cooperation particularly important. The last decadal survey for plasma science deplored the decline in support for university based, small scale, experimental research in basic plasma science and engineering, and recommended that funding agencies cooperate in a program of support for this research. In response the NSF and the DOE created the NSF/DOE partnership for support of basic plasma science and engineering. The partnership recognizes the joint interest and responsibility of the NSF and the DOE to advance this research. All proposals to the partnership are reviewed using the NSF peer review system and are judged according to the NSF criterion for scientific excellence. The DOE does not impose a criterion for relevance to the DOE mission for fusion research. The partnership has played a strong role in reinvigorating small-scale experimental research in basic plasma science. The partnership provides only a small fraction (2%) of the overall support for plasma science and engineering, but generated a disproportionately large fraction (31%) of all plasma related *Physical Review Letters* (for the period 2002 to 2004). Also, the large number of strong proposals to the partnership now greatly exceeds the available funding support. The partnership is a success and the staff at the NSF and the DOE should be congratulated for facilitating the smooth cooperation of two large agencies.

National funding for basic plasma science has suffered disruption in recent years, and the partnership is trying to compensate. An excellent program of basic plasma research supported by the Office of Naval Research was abruptly terminated. A partial mitigation will be an increase of support to the partnership this year from the DOE, but we note that the NSF has not matched the increased contribution from the DOE.

Optical physics, which had also enjoyed significant support at the ONR, has suffered as well. It has been enjoying a very productive period of ever-shorter pulses and smaller nanostructures with better control of quantum properties. Quantum entanglement is being demonstrated and controlled. Single-atom and single-dot emitters of nonclassical light have been fabricated, and a single-atom coherent emitter may not be far away. Unlike plasma physics, however, no solution equivalent to the DOE partnership with NSF has arisen to maintain earlier funding levels.

4.1.B Outputs and Outcomes of the AMOP Program Investments

4.1.B1 PEOPLE

The AMOP program has placed high priority in the training of students. The ratio of graduate students to senior personnel in the program is approximately 2:1. This is significantly higher than the ratio for the Physics Division as a whole. Graduate students are often the key part of a research program, and take on leadership roles in the experiments. Approximately 60 undergraduates are supported through the program's REU supplements. This is in addition to others who participate through established REU sites. The inclusion of undergraduates has been effective in providing research opportunity at a variety of institutions in wide geographical areas.

Given the “small-scale” nature of AMOP research, students and postdocs receive training in an important variety of tasks: design and building of experiments, taking and analyzing data, and publishing their results. Thus AMOP physics is particularly well suited to fulfill the needs for a highly trained technical work force and for recruiting the next generation of scientists. The AMOP Program at the NSF is supporting this effort as a high priority, and has been singularly successful in this regard.

The AMOP program has been exceptionally successful in supporting outstanding forefront research. In the last decade, 10 AMO physicists received the Nobel Prize in physics, and six of these were NSF grantees. Four MacArthur fellows come from the NSF AMO grantee ranks, and three of these are women.

4.1.B2 IDEAS

AMOP is an enabling science that cross-pollinates many other fields of physics and technology. Cold atoms, Bose-Einstein condensates, quantum information, anti-hydrogen and non-neutral plasma physics have captured the public’s interest and imagination. An impressive set of outcomes have flowed from the AMOP Program’s supported research:

Femto-second laser frequency comb work has completely revolutionized the measurement of length and time. It has significant impact on atomic clocks, global positioning system, and precision experiments testing the fundamental theories of nature. Its applications range from basic explorations to national defense. The 2005 Nobel Prize in Physics was awarded for this work to John Hall and Theodor Hänsch.

NSF-AMOP has been at the forefront in funding cold atom BEC research. The payoff has been substantial. The 2001 Nobel Prize in physics was awarded to the BEC work of Carl Wieman, Eric Cornell and Wolfgang Ketterle. The ability to control BEC and BCS behavior in atoms and molecules has enabled discoveries across the frontiers between AMO physics and condensed matter physics.

In tests of fundamental physics principles, NSF directly supports the efforts of AMOP scientists in the ATRAP collaboration at CERN to test CPT using 1S-2S laser spectroscopy of anti-hydrogen, and supports a wide range of non-neutral plasma physics that enables both the ATRAP and the ATHENA experiments. These experiments drive a rich cross fertilization between atomic and optical physics, non-neutral plasma physics, and particle physics.

Optical physics has been enjoying a very productive period of ever-shorter, attosecond laser pulses, petawatt power, and the physics of extreme uv to soft x-ray lasers. AMO physics combined with nano-physics has allowed for the fabrication of increasingly smaller nanostructures for the better control of quantum properties. Quantum entanglement is being demonstrated and controlled in both atomic and solid-state-optical implementations. Single-atom and single-dot emitters of nonclassical light have been fabricated, and a single-oscillator coherent emitter may not be far away. Vacuum Rabi splitting with a single stationary oscillator in a small-volume cavity has been demonstrated using both a trapped atom and a single quantum dot.

Improved understanding of the self-organization of plasmas has been a common theme for several advances in basic plasma science. Examples include: Coulomb crystal structures in laser cooled pure ion plasmas and in dusty plasmas, magnetic reconnection and dynamo action, vortex crystals that appear in decaying turbulence, and propagation of an intense laser beam through a self-generated guide channel in a plasma.

4.1.C Other Topics

During its discussions, the AMOP sub-group identified several issues where the improvements could be made, either across the Physics Division, or in the AMOP Program.

4.1.C1 Funding for Instrumentation

The Accelerator Physics and Physics Instrumentation program (APPI) addresses equipment needs above $2M. However, capital equipment needs of the typical AMOP (or Condensed Matter) laboratory are significantly smaller than this. A typical large laser set-up will cost between $100 and $250K. If a grant has two or three PIs, reasonable capital expenditures can approach $1M. Because of budget constraints, the AMOP Program managers have felt the need to limit capital equipment purchases in a given grant to $80K. Our sub-committee strongly urges the Directorate to lower the lower limit of proposals in the APPI to the $80K level.

4.1.C2 Balance Between Centers and Individual Investigator Grants

The AMOP subpanel recommends that the individual investigator (or few PI) core programs should be maintained at a minimum of 60% of the total Physics Division funding. A good balance between core and center activities has served the community well and will ensure future vitality and the diversity of the field. One or two investigator grants have always been the core of the AMOP program, and the sub-panel expects that this situation will continue.

4.1.C3 CAREER Awards

The CAREER awards, while generally a good idea, are problematic in two ways. The first is related to the timing issues discussed above. Secondly (and in doing so, we reiterate what our predecessors on the COV2003 subpanel had said), we feel that the outreach requirements placed on new Assistant Professors are too time-consuming. New assistant professors are required to get a lab started and do a credible job of teaching one or more classes, both of which are very time-consuming. The requirement of a significant and innovative teaching and outreach commitments is just too much. A good way to ameliorate this problem would be to not require an outreach component until the initial CAREER grant is renewed, i.e., rolled over into a regular grant.

4.1.C4 Physics Division Portfolio Balance

Finally, we must address the issue of balance in the Physics Division portfolio. In his opening address to the COV, Dr. Dehmer showed a graph of the funding history of the various programs in the Physics Division over the last 10 years (see Figure AMOP-1). Since 2003, the AMOP Program has suffered a drop in funding qualitatively larger than the other programs that also experienced decreases: Gravity, Nuclear Physics, and Theory. The rest of the Division's programs have enjoyed increases over the same period. While this drop in the AMOP Program is in part due to the movement of PFCs out of the AMOP Program budget, it is still remarkable that the program representing a field as dynamic as AMOP, which has been awarded 10 Nobel Prizes in the last ten years (six of these Laureates have received funding from the AMOP Program), is receiving significantly larger cuts than the rest of the Physics Division programs.

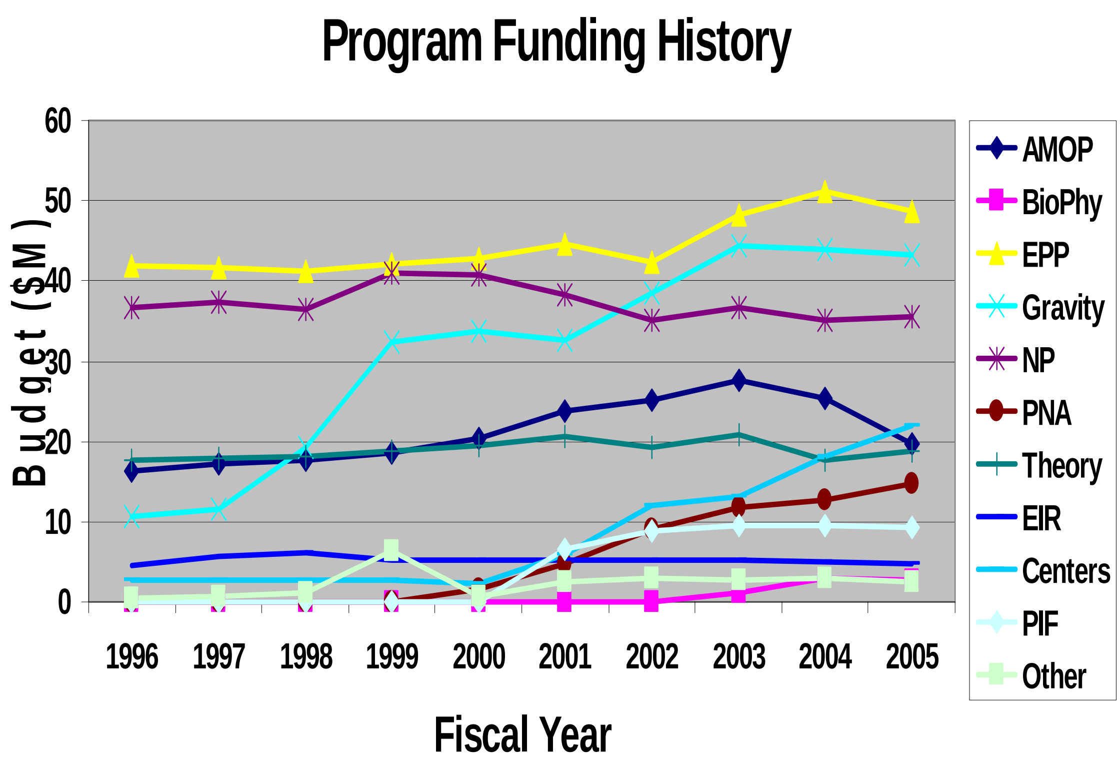

Figure AMOP-1.

4.2 Elementary Particle Physics Subcommittee Report

The EPP program funding was $48.75M in FY05 for experimental, accelerator-based particle physics. In addition, the Physics Division provides $10M for particle theory and $15M for non-accelerator particle-nuclear astrophysics (PNA), a recent spin-off from EPP and NP. There is another $14M in EPP allied funding, for example in Physics Frontier Centers, various GRID and computing programs, MRI and ESIE, and the ICE CUBE project, which received almost $48M in MREFC funding in FY05. Thus the total value of the EPP portfolio, including related areas, is over $135M. The EPP program is managed by one federal NSF employee, four full-time rotators and one part-time rotator.

Proposals to EPP are reviewed by panels, supplemented by mail-in ad hoc reviews and site visits. This system works very well, involving a large pool of reviewers with appropriate expertise and demographics. Review panels are asked to prioritize proposals for different budget scenarios. This is a key aspect of the review process since it requires the review committee to deal with the hard choices that the Program Officers face. The success of this system is evident in the fact that the program managers follow the panels' advice closely.

We particularly commend the EPP program officers for their proactive management of the portfolio, which has kept it lean and competitive. This requires that they make hard decisions at times, including significant cuts to the grants of groups with reduced productivity. While difficult, this is absolutely necessary in order to carve out room in the budget to fund young faculty and start new projects.

We also commend the EPP program officers for their creative interactions with other NSF programs and Divisions. Their efforts have been mutually beneficial, especially in outreach and broader impact areas. In the course of informal discussions with the staff, we heard several interesting new ideas for program management and development. We encourage the continuation of this fresh and innovative thinking, and support their efforts to implement new approaches to scientific management. This will ensure that management of the EPP program never becomes stale and ossified.

One problem we noted is related to the three-year grant cycle. If a group's proposal is evaluated during a difficult budget year, the award will reflect the budget problem for the next three years. The program officers are aware of this and have worked to ameliorate this problem; however it does remain as an issue of fundamental arbitrariness in the system.

We also noted that the relatively low value of funded MRI proposals in EPP during the past two years, and suggest that these (and other) NSF funding opportunities be announced to the broader community using the APS Division of Particles and Fields (DPF) and Division of Physics of Beams (DPB) email distribution lists.

The committee was somewhat concerned about the heavy reliance of the EPP on a single federal employee. It would be wise to hire an additional permanent NSF employee (perhaps shared with PNA) to provide continuity and to provide succession planning.

Finally, the cancellation of RSVP has raised some important issues for the management of large projects at NSF. We summarize our recommendations for the improvement of the MRE process and the management of large NSF projects in section C3.

4.2.A The Integrity and Efficiency of the Program's Processes and Management

4.2.A.1 The quality and effectiveness of the program's use of the merit review procedures

The EPP Program Officers use a variety of reviews to guide them in developing their program and determining levels of support. These include panel reviews, external e-mail reviews, site visits and internal reviews and discussions. They also participate in joint reviews with DOE and with other organizations in NSF.

A well-defined process is used to acquire guidance on university base support. Much of this support takes the form of “continuing grants” typically covering a three-year period. EPP solicits proposals in the fall of each calendar year. It appoints a panel of physicists drawn from universities and laboratories that meets for several days, usually in December, to evaluate these proposals. Before the meeting, EPP conducts e-mail reviews of the proposals and makes the results available to the panelists. Program Officers provide the panelists with detailed budget guidance and with NSF/EPP's vision and priorities for the program. This is a key aspect of the panel review process since it requires the panel to deal with the hard choices that the Program Officers will face. The committee discusses and reviews the proposals, ranks them, and suggests specific funding levels. There is a written evaluation of each proposal that represents the consensus of the committee. Since the EPP budget is not completely known at the time of the review, the committee often deals with more than one funding scenario or a range of available funding. A final written report summarizes the recommendations of the panel.

The committee reviewed about 40 of the jackets associated with the base grants. Both paper copies and "E-jackets" (electronic versions) were provided. The documentation was well organized and complete. The electronic reviewing system works well and is efficient; documentation was readily available to us in most cases and program managers provided all additional information we requested.

There were typically a few responses to the e-mail review out of an average of 5 requests included together with the panel recommendations. The Program Officer’s response to the report and a record of his/her final recommendation and resulting actions were included in the jackets. In general, the committee process seems to work well. The panel reviews indicate thorough evaluation of each proposal. The Program Officers take the reviews very seriously and usually follow them. Where they depart significantly, they indicate in their report why they chose to do so. Often, they make adjustments based on the actual funding situation or because some special circumstance has arisen since the review. Rejections are transmitted in the spring, accompanied by a letter including the comments from the panel. Program officers often provide feedback on how to improve the proposals that were declined. Acceptances take some time because they require a clear understanding of the EPP budget, which often doesn't occur until the spring.

The funding rate for competitive awards varies depending on the EPP funding level. For the period of this review, it was 46% (26/57) in 2005, 67% (28/42) in 2004, and 61% (25/41) in 2003.

CAREER awards are especially important because they nurture the next generation of university faculty who will be leaders of the field. They have been handled in various ways, including review by the EPP Panel that deals with the Base Program, a separate panel, and an email-only review. The quality of the proposals is quite high and the choices are difficult. The success rate for CAREER awards is typically ~20%. The EPP now times the selection process so that young PIs who were not chosen for CAREER awards will have time to submit proposals as part of the annual base program cycle. This is obviously a commendable practice, as many excellent proposals cannot be funded by the CAREER program. Currently, EPP uses an ad hoc mail-in system to evaluate CAREER awards. We suggest that a panel appointed by EPP specifically to review CAREER proposals might be a better approach.

EPP has some university groups that receive very large grants that are regularly renewed over periods of many years. EPP exercises special oversight to ensure that these groups maintain very high quality to justify the large investment. This usually takes the form of site visits by special ad hoc committees. Site visits are also used when special problems arise. In a recent round, the same visiting committee visited two sites with very large grants, enabling a direct comparison of how NSF resources were being employed by the some of its largest recipients.

There is clear evidence that EPP pays close attention to the productivity of its more veteran PIs, to the evolution of their groups, and to the nurturing of the careers of younger physicists. NSF also supports a number of small university groups and undergraduate only research groups; both of these are unique roles.

Overall, the use of the merit review process is effective, efficient, and fair and assists in producing an excellent program.

4.2.A.2 Implementation of the NSF Merit Review Criteria

The EPP panels appear to do a good job of addressing both intellectual merit and broader impacts. In particular, they are very sensitive to educational outreach to minority and underprivileged areas. EPP has been a pioneer in the area of broader impact and has been very successful at leveraging its efforts by initiating productive collaborations between branches of NSF.

Reviewer comments on the broader impacts of proposals included these examples:

"The PIs have had a strong commitment to innovative teaching at the undergraduate level.… Through Quarknet and special lecture programs the group has engaged in outreach to high school science teachers and the general public."

"…the proposal will engage undergraduate students in all aspects of the design, construction and operation …It will provide a way of exposing young physics students … to the breadth and excitement of experimental high-energy physics and beam physics, which is very good for the future of the field."

4.2.A.3 Reviewer selection

The selection of reviewers used from FY03-05 by EPP is large (383 individual reviewers) and well balanced, including well-qualified people from not only from many types of academic institutions and national labs across the US, but also some scientists from industry, Europe, and Canada. The conflict of interest system appears to work. Most panels had documented and properly dealt with conflicts of interest, which were most common on larger proposals.

4.2A.4 Resulting portfolio of awards

In FY06, the EPP program was divided among the University PI program (40%), CESR (30%), LHC operations (25%) and the new Accelerator Physics and Physics Instrumentation (APPI) program (5%). The University PI grants support work on the CDF and D0 experiments at the Fermilab TeVatron (1/3), the CMS and ATLAS experiments at the LHC (1/3), and a variety of other efforts including the neutrino experiments MINOS and MiniBoone and research at DESY, BNL/TJNAL, CLEO and SLAC. In all, about 20 university groups doing research in accelerator-based particle physics are supported by EPP. The portfolio is well-chosen and generally reflects the scientific priorities of the field.

The awards made in the three years under review included two to RUI institutions, out of a total of 5 RUI PIs submitting proposals. There were 10 awards to female PIs (13% of the 78 total awards). The success rate for women was 67%, compared to 55% for male PIs, showing that the program managers have been supportive of women PIs. There is a Physics Frontier Center (COSM) located at Hampton University, an historically black university with an active program of research on LHC that serves students from a number of HBU's.

Some general trends noted over the past few years include the decrease of support for CESR as the CESR-c program begins to ramp down, and the increase in support for LHC operations as it ramps up in preparation for the LHC turn-on in 2007. The APPI program is a small but increasing component of the program, and we encourage its continued growth.

An important issue for the next three years will be the management of the Cornell group as they make the transition from an accelerator facility to a university user group. In particular, EPP must determine the appropriate level of support after CESR operations cease. The accelerator physics expertise at Cornell is a valuable asset for the national program, and this resource must not be lost.

Another issue is how EPP will participate in the national program of International Linear Collider (ILC) accelerator and detector R&D. The appropriate level of funding and the mechanism for coordination with the DOE in managing this component of the program are issues that must be decided.

There will also be opportunities for EPP to invest in the next round of neutrino experiments, once the NuSAG committee completes its report and P5 makes its recommendations for the overall balance of the field. There are a number of attractive opportunities for investment in experiments at reactors, accelerators and in underground labs. While the program will continue to be grant-driven, a coherent approach is desirable in which EPP and PNA coordinate their efforts and also work closely with DOE to ensure that the US continues to have a leadership role in neutrino physics.

EPP is handicapped by a structural problem in the NSF grant system. MRE grants are for projects over $100M. The MRI program is for amounts less than $2M and is intended for university-based infrastructure improvements. There are many worthy projects that fall between these limits. An example in the past three years was a $2M proposal for the Minerva neutrino experiment, submitted by a collaboration of university PIs. This proposal was declined despite its scientific excellence, because there was no possibility for EPP to accommodate such a large funding request without doing great damage to the university base program. However, it was too small to qualify for MREFC funding and did not satisfy the requirements for MRI of being located at a university. These small to medium size experiments are also not being adequately supported by DOE, due to its obligations to support the national laboratories and accelerator facilities. NSF needs to find a way to support projects that are in this intermediate range in cost.

4.2.A.5 Program management

EPP relies on rotators, with only one permanent NSF federal employee. The advantage of this approach is that EPP has been able to recruit well-connected, established members of research community who are knowledgeable and committed to the programs in which EPP invests. The downside is that the Program Office may lack continuity. This makes the role of permanent staff even more critical in preserving institutional memory and continuity.

There have been complaints about the length of time proposals stay in the system before they are acted upon. The “dwell time” for proposals has improved from 9 months in 2003 to 6 months in 2005, as shown in the table below. The NSF EPP program managers are to be commended for this improvement.

FY	# of proposals	Average (months)	Std_dev (Months)	0-6 Months	>6 – 9 Months	>9 –12 Months	>12 Months
2005	58	5.98	6.77	86%	7%	2%	5%
2004	42	6.80	3.78	45%	29%	17%	10%
2003	44	9.22	3.75	11%	32%	43%	14%

Maintenance and operation of CMS and ATLAS, the two large LHC experiments in which the US is involved, present very special problems to the US HEP community and to the NSF. The construction project has been a big success and has provided a model for NSF-DOE collaboration on large projects. There is already a joint DOE/NSF group, the Management and Operations Evaluation Group (MEG), that provides oversight of the program. NSF has already taken a leadership role in the new phase of LHC operations and physics research by providing Tier 2 computing facilities for LHC data analysis and in software development for LHC analysis grids. The successful exploitation of the large investment in the LHC depends on both a strong M&O program and strong support for LHC experimenters through the base program. Strong and continuous communication with the user community will be required. EPP should consider whether any additional mechanisms are needed to ensure success.

4.2.B Results of NSF Investments in the Elementary Particle Physics Program

4.2.B.1 People

NSF EPP clearly makes a serious effort to foster diversity in the workforce. There is a significant effort to allow opportunities for new groups to get funding as well as providing continuing support for established groups. The CAREER grants provide resources and opportunities for public exposure for early career faculty. Women and minorities receive preferential consideration

“This is an urban university where the proposers are able to attract students from a large population of people from various backgrounds in [an] inner city.”

“There is a[n] … outreach component to this work in terms of involving undergraduate and Hispanic students”

“The most commendable feature of the … program is the outreach effort, specifically through the research opportunities given to undergraduates at a non-PhD granting university.”

Undergraduates and even high school students have the opportunity for involvement in cutting edge research through NSF-supported institutions. David Kelly, a high school student working on the e-bubble project at Columbia is an Intel Finalist for “Quantum Tunneling Effect of Electron Bubbles at the Liquid Vapor Interface in Liquid Neon and its Application to a Time Projection Chamber Neutrino Detector”.

4.2.B.2 Ideas

There have been many interesting new results and publications from the EPP program during the past three years. We list a few examples of significant scientific achievements by EPP funded scientists:

- CESR/CLEO's new "CLEO-c" D-meson and charm quark configuration has allowed many advances in this sector. Knowledge of f_D has improved and the h_C charmonium state discovered (Tigner, Cornell-PHY0202078); f_{D+} extracted, measurements of decay parameters from the newly available high-statistics D^+ and D^0 decays, and non DD-bar transitions from $\psi(3770)$ discovered (Stone, Syracuse-PHY0353860).

- BaBar data has provided a new precision measurement of Λ_c (Burchat, Stanford-PHY0354874).

- ZEUS polarized electron/positron scattering data has verified the standard model predictions of cross section as a function of polarization (Oh, Penn State-PHY0245522).

- The Tevatron at Fermilab and the D0 and CDF detectors have been upgraded and the first Run II data taken.
    - CDF has improved top quark mass measurement (Shochet, Chicago-PHY0456688, Kim, Chicago-PHY0310494).
    - D0 has measured the (Z+b-jet)/(Z+all-jet) ratio (Grannis,SUNY-SB-PHY0354761); $Z/\gamma^*(\rightarrow e^+e^-)$ jets (Varelas, UIC-PHY0354950); the top quark pair production cross section (Gerber, UIC-PHY0233716); set limits on Randall-Sundrum extra dimensions (Landsberg, Brown U.-PHY0239367), single top quark production (Baringer, Kansas-PHY0354836), higgsino-like charginos and gaugino-like charginos (Blazey, Northern Illinois-PHY0243692) and scalar top quarks, and found B_s decays to dimuons (Claes, Nebraska-PHY0400369).

- KTeV K_L decay data was re-examined to resolve the two sigma deviation from unitarity in the first row of the CKM matrix (Shochet, Chicago-PHY0456688).

- NuTeV's precision measurement of $\sin^2\theta_w$ differs by three sigma from the standard model, a possible sign of life beyond the SM (Conrad, Columbia-PHY9804051; Caldwell, Columbia-PHY0098826; Koutsoliotas, Bucknell-PHY0205838; Johnson, Cincinnati-PHY0070413; McFarland, Rochester-PHY0134988)

- MiniBooNE has taken a whole lot of data to probe the LSND anomaly, $5x10^{20}$ protons on target, and is doing a careful "closed box" analysis given the potentially huge implications of a positive result (Conrad, Columbia-PHY9804051; Caldwell, Columbia-PHY0098826; Koutsoliotas, Bucknell-PHY0205838; Johnson, Cincinnati-PHY0070413; McFarland, Rochester-PHY0134988).

- The first months of the NuMI beam have been successfully observed by the MINOS experiment, achieving a world-record exposure of $1x10^{20}$ protons on target (Wojcicki, Stanford-PHY0089116; Habig, Minnesota-Duluth-PHY0354848).

- e-bubble has characterized the properties of liquid Ne and He in order to construct a prototype cryogenic pp solar neutrino experiment (Columbia University - PHY-0436250);

- Advances in accelerator technology were made in "reentrant" superconducting cavities (Cornell University - PHY-0131508) and understanding of the longitudinal beam profile in Fermilab's Booster (Spentzouris, IIT-PHY0237162) and CESR-c (Holtzapple, Alfred University-PHY0348827).

- The Particle Data Group compiled a new print edition in 2004 and a web-only update in 2005 (Miquel, LBNL-PHY0355084)

4.2.B.3 Tools

This period was one of both accomplishment and loss in the area of tools and facilities. On the positive side, the CLEO-c conversion was completed, and they have had a successful data-taking run. LHC construction was also successfully completed, and the operations phase commenced in anticipation of LHC turn-on in 2007. Another achievement was the completion of the MINOS experiment and its first data run, and the successful data-taking run of the MiniBoone experiment. The iVDGL project, a component of the Trillium GRID collaboration, has developed and deployed the tools needed to manage large datasets and produce huge simulated datasets via distributed GRID computing, and is being used to produce LHC Monte Carlo data.

Regrettably, several major projects in which EPP had made significant investments were cancelled during this period, including the CDF and D0 run IIb upgrades (cancelled by the Fermilab Director), the BteV experiment (cancelled by the DOE HEP office) and RSVP (cancelled by NSF due to cost over runs). We discuss the lessons learned from the RSVP cancellation in more detail in section C3

4.2.B.4 Organizational Excellence

The organization of the EPP program is generally very good. The program managers do an excellent job of managing the EPP portfolio with a small staff. As noted above, proposal dwell time has improved from 9 months to 6 months during the past three years. The EPP program managers work closely with the PNA staff, and also coordinate with DOE on projects of mutual interest. We have already commented above on our concerns regarding the reliance of EPP and PNA on one permanent NSF employee.

We found that the electronic e-jacket system is a big improvement over paper, and urge the NSF to take full advantage of its capabilities by generating program statistics and trends in a uniform format for all programs. More suggestions along this line are in section C5.

4.2.C Other Topics

4.2.C.1 Comments on program areas in need of improvement

One problem is related to the three-year grant cycle. If a group's proposal is evaluated during a difficult budget year, the award will reflect the budget problem for the next three years. The reverse can, of course, also be true. If the budget situation in the year in which the proposal is evaluated does not reflect the average situation over the three-year period, then an imbalance occurs based only on when a group comes up for renewal. To the researchers who depend on NSF/EPP funding, this makes the proposal process seem capricious and not always strictly related to merit. The EPP Program Officers do what they can to provide some leveling by accepting supplemental requests in the out years, but there is only a limited amount that they can do to maintain a balance. This is a structural problem that they cannot resolve but can and do try to ameliorate.

4.2.C.2 Comments on the program's performance in meeting program specific goals and objectives not covered by the above questions

We heard that the Program Officers believe that their constituency does not take good advantage of the MRI Program, which could provide additional funding for equipment at universities. We recommend that EPP announce MRI solicitations more widely, perhaps through the DPF and DPB mailing lists.

4.2.C.3 Agency-wide issues that should be addressed by NSF to help improve the program's performance

The cancellation of RSVP was a tragedy – the loss amounted to millions of dollars, hundreds of person-years, credibility with foreign partners, and credibility of MPS with the NSB. Although RSVP was an MREFC and therefore outside of EPP, it originated in EPP and was reviewed here. However, the lessons learned from the cancellation of RSVP go well beyond EPP and are relevant for NSF as an agency.

NSF must learn to think big if it wants to do big projects well and prevent such tragedies in the future. Some of the lessons we have extracted from this regrettable experience include the following.

- The initial PI cost estimates were optimistic because they were not based on well-engineered designs. A mechanism to fund preliminary engineering studies and do a proper baseline review before submitting an MRE proposal to the NSB must be identified and become a required part of the process.
- Closer cooperation with other agencies providing facilities or infrastructure is needed from the very beginning. Even though RSVP was to be hosted at a DOE facility, the first DOE Lehman review of the project came in 2004 (four years into

the project). Some of the cost overruns were related to the need to refurbish the AGS extraction line, and earlier involvement by DOE experts would have caught this problem much sooner.

- Both of the above problems would have been identified sooner had an independent project management office been provided to support the PI-led scientific management from the beginning. The pattern of significant cost increases over the initial PI estimate has been observed in numerous MRE projects, but in other cases project management was on board before the projects were brought to the NSB
- Operations and other "life cycle" costs must be included in the budgeting and planning, and care must be taken that such large ticket items do not adversely impact the divisional core PI support.
- A delay of several years between MRE approval and the start of funding is very unhealthy and efforts should be made to reduce this lag.

We suggest that an NSF office for large projects be established in order to provide sufficient support and oversight, and to ensure that this history is never allowed to repeat.

4.2.C.4 Comments on any other issues the COV feels are relevant

4.2.C.5 Comments on how to improve the COV review process, format and report template

Taking advantage of the new electronic documentation system, we suggest that a standard set of statistics should be made available to COV reviewers, in the spirit of the limited set of 10-year funding trends we were given this time. Useful numbers (overall and by program) would include:

- Award distributions
  - Average award per faculty
  - Grant size distribution
- Success rate, renewal rate, number of new PIs per funding cycle
- Demographics
  - Group size
  - Distribution of PIs, students, postdocs (gender, ethnicity)

We also suggest that a phone conference meeting to get the COV oriented and better able to digest the background material on the website would have been helpful. This would be particularly useful for the committee chairs so that they have a clear idea of what they are expected to do and can get their committee organized early in the review.

We were satisfied with the review format. There was enough time to look at the selected jackets, but only just enough.

4.3 Gravitational Physics Subcommittee Report

Gravitational physics is undergoing a revolution. LIGO is poised to detect gravitational wave signals in the next few years. Cosmology has been transformed into a precision science, with remarkable new features of physics being revealed. Ultra-high precision laboratory experiments are being stimulated by new theoretical ideas in string theory about the fundamental nature of gravity. Theoretical investigations of quantum geometry show promise of unveiling physics near the Big Bang and inside black holes. These are among the most dramatic results of the evolution of a field that has been supported by the NSF over many decades.

The future of the field is exciting. LIGO is on track for its long-planned upgrade to Advanced LIGO. NASA is planning, with its European partner ESA, to launch the LISA gravitational wave detector in 2015. Universities are hiring more and more young researchers in gravitational physics to tenure-track positions. Undergraduates and high-school students and their teachers are drawn to outreach programs in this field by the clear prospects for fundamental discoveries.

The growth and changing nature of research in gravitational physics present challenges to the NSF. Apart from the small support of gravitational physics in NASA, and even more limited funding from DOE, the NSF is the only source of research funding for this field. The Gravitational Physics program therefore supports the broad sweep of activity from abstract theory to large-scale experiment. Many activities in between are on a large scale: numerical simulations of black hole collisions challenge the largest and fastest supercomputers; data analysis for LIGO involves the storage and movement of terabyte-scale data sets; gravitational-wave observations require coordinating LIGO operations with those of detectors in Europe and Japan. At the same time, many small university groups—often single faculty scientists—make vital contributions to these activities. There are clear advantages to the field in having a single agency that has a comprehensive oversight of its development, but NSF’s stewardship requires that it be sensitive to the vast differences in scale within its portfolio. Added to that are many interfaces that NSF must keep healthy: international collaborations; interagency coordination; research links with string theory, mathematics, astrophysics, information technology, computational science, and technology development.

In response to these developments the committee makes the following points:

- The director and staff of the gravitational physics program have done an excellent job in managing this diverse program. Having a separate program director for LIGO is crucial, and the two directors work closely together. The NSF moved expeditiously to replace the program director for LIGO when that position became vacant.

- As LIGO has moved from its commissioning phase to science runs, the gravitational physics program has managed to keep a reasonable balance between supporting operations and supporting PIs doing advanced detector research and development, data analysis and source modeling (with one exception highlighted in the next point). The upgrade to Advanced LIGO must be implemented carefully; this long-planned upgrade is essential if the initial large investment in LIGO is to realize its potential, but adequate provision must be made to avoid damaging cuts on the rest of the program.

- Numerical relativity is a key research area necessary to achieve one of LIGO's main scientific goals, the confrontation between theory and experiment in the strong-field domain of black holes. It is also essential for maximizing the scientific payoff from observing neutron star inspirals and mergers. Yet progress in numerical relativity, while substantial in recent years, still lags behind progress toward detecting waves. The two priorities in gravitation singled out in the "Physics of the Universe" report were Advanced LIGO and numerical relativity. Numerical relativity is currently an unfunded mandate, and if this continues, the effectiveness of LIGO could be threatened. A joint NASA-NSF task force recommended increasing the funding level for this area from about $1M per year to about $5M (for all areas of source modeling, with the bulk being for numerical relativity). Considering that the total federal expenditure on LIGO and LISA over a ten-year period for each project will be well over a billion dollars, the concomitant spending on theoretical support is woeful. The prospects for increased support from NASA are uncertain for the near term, but this is something that needs to be addressed now.

- Associated with the ongoing revolution in gravitational physics, an increasing number of new positions at universities have opened up. The program provided about five new awards per year (out of 25 total per year) in each of the past three years. This trend in new appointments is likely to continue in the future, and it is important to ensure that there is adequate provision for the new faculty. This is of particular concern because very high quality proposals are being declined because of limitations in resources (see next point).

- Especially in FY04 and FY05, an unusually large fraction of highly-ranked proposals were not funded because of a lack of funds. In FY04 17 proposals were funded, while 33 were declined. In FY05 the numbers were 12 funded, 27 declined. While LIGO critical path science was funded (with some modest cuts), and other experimental proposals managed to survive, theory proposals were very severely impacted. The impact appears to be much greater than the Division-wide increase in the rate of rejections for those years. This situation needs to watched carefully if a healthy balance is to be maintained, both with respect to gravitation theory and experiment on the one hand, and gravitation theory and other theory on the other hand.

4.3.A Integrity and Efficiency of the Program Process and Management

4.3.A1 Effectiveness of the program's use of merit review procedures

a) Reviews are now conducted by panels convened to assess particular subfields (gravitation theory and experimental gravity/LIGO support) supplemented by mail reviews from additional experts. We found the review process to be effective in selecting the best proposals for funding from a diverse array. We want to emphasize the importance of continuing to keep mail reviews as an integral input to the panel reviews.

b) We examined 48 jackets selected from successful, rejected, and borderline proposals. We consistently agreed with the often-difficult decisions that were made by program officers. However, the level of funding was not sufficient to support all the meritorious proposals, and important and high-quality work has gone without support.

c) The program was efficient in processing proposals in a timely way. The program officer maintained close contact with proposers and kept them aware of what was happening to their proposals. She provided useful summaries and analyses of the reviews, and documented the factors leading to her decisions.

d) There were no program-specific guidelines for reviewers or proposal solicitations, except that proposals from members of the LIGO Scientific Collaboration (LSC) underwent a preliminary review at the LIGO Laboratory to assess the relevance of the proposal to the project's critical path. Reviewing of all proposals was consistent with general NSF criteria.

e) The program officer made good decisions about the scope, size, and duration of awards, in some cases making innovative or risky choices that ultimately paid off. In one case, a proposal was considered by the panel to be below the line for funding, in part because of skepticism that one of the proposed measurements could be achieved. The program officer instead approved a small grant for a focused demonstration of a key part of the proposal. That demonstration succeeded, and in a subsequent round, the PI's renewal application was one of the top ranked proposals. In another example, a proposal ranked at the "fund if possible" level was funded by sharing the burden with NASA. The PI recently achieved the first key milestone promised in the proposal.

f) Within the tight financial constraints, there was a good balance between awards to first-time proposers (16 over the three-year period reviewed) and awards to researchers who had received prior NSF funding (57). In some cases this meant making difficult decisions to end funding for senior researchers deemed to be less vigorous.

4.3.A2 Use of NSF merit review criteria

Proposals generally included a discussion of the broader impact along with the intellectual merit, and, while reviewers mainly addressed the criterion of intellectual merit in their reviews, most reviewers commented on the broader impact. Program officers' summaries also included a discussion of the broader impacts of each proposal.

4.3.A3 Reviewer selection

a) An adequate number of reviewers was used in all of the cases we examined. Given the breadth of subjects covered by this field, the 2003 COV encouraged the program officers to solicit mail reviews from scientists outside the program area in allied subjects like string theory, astrophysics, computational science, and technology, where appropriate. This has been implemented effectively.

b) The reviewer and panelist quality was excellent in general. The reviewing was as balanced as possible, given the demographics of the institutions and the people in the field. Panel members represented a balanced cross-section of the field, were geographically diverse, with suitable representation by women and minority researchers.

c) Conflicts of interest were avoided in the selection of reviewers and panelists.

4.3.A4 Resulting portfolio of awards

a) The overall quality of the science was extremely high across a very diverse range of activities.

b) In the gravitational theory area, in FY 2004 and 2005, a disturbingly large number of strong proposals addressing important science questions could not be funded, despite positive, "definitely fund" recommendations from the review panels. We believe that the level of support in this area during these two years, if not addressed, will be inadequate to maintain a vigorous gravitational theory program. It is not clear to us that this problem can be solved within the gravitational program, given the external constraints. We have no arguments with any of the specific funding decisions we have examined. But the inability to fund gravitational theory—an area in which the NSF is by far the largest source of support in the US—is a source of deep concern.

c) The program has a very large component that could be called high-risk and has a high potential payoff: the LIGO detector. The risk that sources will be too weak to detect at the sensitivity of Advanced LIGO will be much smaller. This is partly because astrophysical estimates of event rates have been going up, especially in view of the recently discovered double binary pulsar.

d) The program includes multidisciplinary investigations in technology development within and for LIGO, and in information technology in the development of Grid techniques.

e) The program is a diverse one in a number of ways. In addition to a major facility (LIGO) and a PFC in Gravitational-Wave Physics (not supported directly by the program), it contains many long-established research groups, and several new faculty working individually at smaller universities. It is represented in most regions of the United States from Maine to California, from the Midwest to Florida, from urban centers to small college towns. Eight female and seven Hispanic PIs are supported by the program.

4.3.A5 Management of the program

a) The program is being managed very well in the face of tight financial constraints.

b) It is essential that the program have a manager to deal with LIGO and its issues. The COV is pleased to note that such a Program manager is working with the program and will soon be officially on board.

c) Program prioritization has been carried out so far in a way that matches reasonably well the priorities of the community. The program officers remain in close touch with the research community by attending conferences and visiting research groups and facilities, which is an invaluable activity. However, given the continuing growth of the field, and the likely acceleration of that growth after the detection of gravitational radiation, it may become desirable to establish an ongoing external advisory mechanism for gravitational physics, to help the program officers establish priorities for the field. This should be looked at by the next COV.

4.3.B Outputs and Outcomes of Program Investments

4.3.B1 PEOPLE

The past three years have seen a rapid expansion of opportunities in gravity, due in a large part to the excitement of LIGO and to recent advances in cosmology. A significant number of new faculty has been hired in gravity, many in institutions that have not previously had anyone working in this field. The NSF has responded by offering 16 first-time awards in gravity in 2003-5, a difficult task in a period of flat budgets. These new grants have supported excellent research in both experimental and theoretical gravitation.

The field continues to attract a group of young, talented, and highly-trained experimental and theoretical physicists, and provides a superb training ground for graduate and postdoctoral students. This training is often uniquely interdisciplinary, involving physics, mathematics, engineering, and computer science, and it prepares students for a wide variety of careers. Graduate students and postdoctoral students, and in some cases undergraduates, have played integral roles in NSF-funded research in gravity, developing their expertise and gaining hands-on experience while at the same time making valuable contributions to science. With the new expansion of faculty positions, including some in undergraduate institutions, this student involvement should grow. Historically, many of these students have used their skills to move on into jobs in high tech industries, corporations, and Wall Street, enhancing our nation's competitiveness.

Gravitational physics is becoming an increasingly important part of undergraduate education as well. New textbooks—one by an NSF-supported author—have made it easier to incorporate this exciting field into the undergraduate curriculum. Undergraduates are increasingly involved in real research, as well; in 2005, NSF funding supported 36 undergraduates in gravitational physics, in addition to those supported through the REU program.

The 2005 World Year of Physics and the Einstein Centenary have amplified what was already strong public interest in this field, and the Gravitational Physics program has participated vigorously in education and outreach. Perhaps the most visible activity has been Einstein@Home, which is described elsewhere in the report. The LIGO Science Education Center, under construction at the Livingston, Louisiana site, will provide hands-on training for teachers and students throughout the area; a temporary exhibit is already drawing a steady stream of visitors. LIGO has been a major participant in the Research Experiences for Undergraduates (REU), bringing in many students from small institutions with limited campus research opportunities. The Center for Gravitational-Wave Physics at Penn State has a substantial outreach program. Many gravitational physics PIs engage in outreach, educational and public lecture activities. This was particularly notable during the World Year of Physics, when experts on Einstein were in great demand for public lectures. One gravitational physics PI made a four-week, 21-city speaking tour of Canada at the behest of the Canadian Association of Physicists, while others participated in the Speakers Bureau sponsored by the APS Topical Group on Gravitation and the Division of Astrophysics. Another participated in organizing the Einstein exhibition at the American Museum of Natural History that will have been seen by over a million people by the time it finishes traveling.

4.3.B2 IDEAS

The study of gravity, the weakest of the four fundamental forces, presents us with some of the most challenging areas of theoretical and experimental physics. The results of such research profoundly impact our understanding of the Universe. Recent exciting developments in this area include the following:

- The LIGO detectors have reached, and slightly surpassed, the design requirement in sensitivity as specified in 1996, namely to achieve a strain sensitivity of 10^{-21} rms integrated over a 100 Hz bandwidth centered around maximum sensitivity. The 5^{th} Science run, which will be an extended observing run with the goal of obtaining a year's worth of coincident data, started in November 2005. The LIGO Scientific Collaboration (LSC), whose US groups are supported by the NSF, has produced several observational upper limits papers from previous science runs, including two Physical Review Letters on limits of gravitational wave emission from pulsars and on a stochastic background of gravitational waves.

- Einstein@Home, a program to use computers' idle time to search for spinning neutron stars of unknown position and frequency using data from the LIGO and GEO (German/UK) detectors, now has 75,000 users in 167 countries. A report on the results of the Einstein@Home search using the 3rd LIGO Science run data was presented at the 10th annual Gravitational Wave Data Analysis Workshop by Allen (U of Wisconsin Milwaukee), the LSC leader of this initiative.
- In numerical relativity there has been a breakthrough in stable simulations of binary black holes. Pretorious (Caltech, now U Alberta) demonstrated a simulation that, for the first time, followed the system through the plunge and merger phase without crashing the code. This work has opened the door to binary black hole simulations limited only by computer time with the capability of providing waveforms useful for gravitational wave detection.
- In the next generation of lunar laser ranging, measurements at the mm scale in the distance to the Moon are now possible using new abilities to collect orders of magnitude more returning photons. Unique periodicities should allow extraction of general relativistic tests despite modeling uncertainties. (Murphy, UCSD)
- This year saw publication of the first results from CAPMAP, a ground-based study of cosmic microwave background (CMB) polarization (Staggs, Princeton). This polarization can identify the CMB fluctuations arising from different early Universe processes including primordial gravitational waves. The detection, using the first year of data, was made at the approximate angular scale where models predict the peak of the stronger E-mode signal. This gives promise for future detection of the weaker B-mode signal that should contain gravitational wave information.
- Progress has been made on two fronts in the long-standing question of whether quantum gravity can resolve the singularities of general relativity. Using the formalism of loop quantum gravity, Ashtekar (Penn State) and collaborators have found strong indications that quantum effects may eliminate both black hole and cosmological singularities, replacing them by nonsingular but highly nonclassical regions. Starting with a string theoretical approach to quantum gravity, Horowitz (Santa Barbara) and collaborators have found evidence for a nonsingular final state that might replace the black hole singularity, and for other stringy effects that may remove the big bang singularity.
- New limits on deviations from $1/r^2$ gravity over distances of 6-20 microns have recently been published (Kapitulnik, Stanford). The group used apparatus that can measure attonewton-scale forces between gold masses separated by distances of order of 25 μm using a micromachined silicon cantilever sensor and fiber interferometer readout. This experiment set new bounds on the magnitude and length scale of Yukawa-type deviations whose presence could indicate new physics such as large extra dimensions or new ultra-low-mass scalar particles.

Future prospects

Now that the LIGO detectors have achieved their design sensitivity and embarked on an extended observing run with the goal of obtaining a year's worth of coincident data, the search for gravitational waves has entered a new era. In parallel, research and development towards Advanced LIGO is proceeding well, and Advanced LIGO is included in the President's FY 2006 budget for an FY 2008 start of funding. In nine hours of data taking Advanced LIGO should be able to achieve the same event rate as expected for one year of LIGO data. LIGO could possibly detect a signal during its current observing run. Advanced LIGO is aimed at achieving a sensitivity at which at least several signals per month should be detected. Thus the prospects for the future field of gravitational wave astronomy are very exciting.

Even though Einstein's theory has been around for 90 years, we still do not understand many of its properties. Recent advances in our ability to solve complicated equations by computer simulation will allow us to uncover some of these properties. For example, the existence of critical behavior under certain conditions was discovered numerically. And the importance of numerical simulation for the success of LIGO and LISA has already been mentioned.

Perhaps the most fundamental theoretical problem confronting this field is the quantization of general relativity. Work on this issue dates back more than 75 years, and it is unlikely that a final answer will be found in the very near future. Important progress is being made, however, in a number of promising approaches: string theory, loop quantum gravity and spin foams, and a collection of methods in which spacetime is replaced by a discrete structure. For the first time, several research programs are able to concretely address some basic conceptual issues of quantum gravity, including the quantum states of the black hole and the "information loss problem," the fate of singularities in quantum gravity, and the nature of diffeomorphism-invariant quantum observables. At the same time, there are interesting new ideas about the possibility of a "quantum gravitational phenomenology," which could test or at least exclude certain classes of models. The field has attracted a good number of bright, active young people, and the next few years should be interesting ones.

4.3.B3 TOOLS

LIGO is the program's primary tool, and has developed many associated technologies. These include high-power ultra-stable lasers, large optics with sub-Angstrom smoothness, advanced techniques for vibration isolation, and new kinds of software for data analysis.

Work in numerical relativity has developed computational tools for numerical solutions of Einstein's equations, including applying and extending techniques from other branches of computational science (adaptive mesh refinement, high-resolution shock capture), and visualization tools for displaying the complex data in forms that enhance understanding. Some of the computational tools developed are now being used in other areas of science.

In experiments to test the inverse-square law at ultra-short distances, some of the devices built to measure the attonewton scale forces benefit from advances such as STMs in condensed-matter and materials physics, and may in turn cross fertilize these fields.

The Physics Frontier Center for Gravitational Wave Physics at Pennsylvania State University has been very successful. Significant accomplishments have been made in numerical relativity, in gravitational-wave phenomenology and in gravitational wave data analysis, benefiting from the focused activity of the faculty, post-docs, students and visitors enabled by the Center. In addition, the Center has organized several important and influential conferences or workshops on gravitational radiation topics, and has a very strong public education and outreach program.

4.4 Nuclear Physics Subcommittee Report.

The Nuclear Physics (NP) subprogram at the NSF encourages and supports an extremely strong research program. Nuclear research in the U.S. is funded primarily by the NSF and the Department of Energy. Both agencies make very advantageous use of the joint NSF-DOE Nuclear Science Advisory Committee to obtain advice about the broad directions of the field, and, on occasion, on specific scientific initiatives. This allows the two agencies to act in an exceptionally coordinated fashion. The NSF funds the MSU National Superconducting Cyclotron Laboratory's Coupled Cyclotron Facility, the only facility for fast-beam fragmentation studies of nuclear structure and nuclear astrophysics in North America. The Department of Energy funds four major user facilities. The NSF NP program supports very significant research in all the major research areas identified by NSAC.

The programs cover a broad range in scale: one major facility, three university accelerators, group grants, and grants to a number of individual investigators. This mixture is appropriate to the span of research initiatives where individual experiments can range in size from a few to a thousand collaborators. There is no question that a one-size-fits-all approach is not appropriate and the program office should be commended for treating the different research scales fairly and effectively. We strongly support the commitment of the program to individual investigator grants.

We note that two of the Physics Frontiers Centers, the Joint Institute for Nuclear Astrophysics at Notre Dame and the Center for Origin and Structure of Matter at Hampton University represent very significant additions to the nuclear physics enterprise at NSF.

4.4.A Integrity and Efficiency of the Program Process and Management

4.4.A1 The effectiveness of the program's use of the merit review procedure

The COV examined forty jackets. These included proposals from university facility laboratories, from large groups, small groups and individuals, and from undergraduate institutions. Twenty seven proposals were successful (albeit not all at the requested level), and thirteen were declined. All proposals (except supplementary budget requests) were reviewed by ad-hoc reviewers and by a subsequent panel review team. Site-visit reviews were conducted for the facilities and for the larger group projects; conducting a site visit is at the discretion of the program manager.

Detailed and informative ad-hoc reviews were received from greater than 98% of the reviewers contacted, indicating the importance with which this task is viewed by the nuclear physics community, and signaling the community's trust in a fair outcome to the whole peer review process.

The time to decision varied broadly. Some decisions were made in one month (primarily small supplementary proposals) and others took nine or ten months. The time to make seventy percent of the decisions has been getting shorter (7.9, 6.8, 5.2 months for FY03, FY04, FY05) and indeed most decisions are made in the fifth and six months. But a considerable number of decisions are still being made in months seven, eight and nine. We understand these decisions may involve budget negotiations within the agency and with the PI's, and that there are also delays in receiving congressional budget approval. The period between submission and panel review is approximately 3 ½ months and is needed to obtain ad hoc mail reviews followed by site visits for larger grants. It is difficult to see how this 3½ month time scale can be shortened. We consider two months following the panel review should be adequate to complete the decision to fund for the large majority of proposals consistent with the FY05 performance.

The jacket documentation was extensive, including ad-hoc review reports, site visit reports, panel summaries, brief diary entries by the program manager, and finally a detailed report by the program manager summarizing all of the information – pro and con- leading to the final funding decision. We found diary entries - particularly for the longer running projects - to be very helpful in gaining insight into the history of a project; we recommend increased use of this feature. This would appear especially helpful for bringing new NSF personnel up to speed. While the rationale of the decision to fund or not fund is quite well documented, when funding is reduced compared to proposed amount we would like to see more uniform documentation of the rationale for the final budget decision included in the review analysis.

The COV noted that a single disciplinary panel may not necessarily appreciate all aspects of a multi-field proposal. Proposals spanning multiple fields (NP, PNA, Theory) should be reviewed by panels with the appropriate expertise. We examined several proposals where this was done effectively. We highlight the issue here simply to reiterate the importance of ensuring interdisciplinary issues are properly considered.

While renewal rates for continuing groups and individuals are high, new grants are being awarded, and the managers are sensitive to maintaining funding opportunities for new faculty. Appropriately, a new faculty member joining an existing facility or group is reviewed on his or her individual merits, and is not automatically funded by default.

We encountered proposals that could be deemed "high-risk, high pay-off". We were pleased to see that the managers were by no means averse to funding them, making difficult calls with conflicting review reports.

4.4.A2 Program's Use of the new NSF Merit Review Criteria

Some Ad hoc reviewers continue to have difficulty responding systematically to the 'broader impact" criterion. However, the panels do an excellent job interpreting the reviews, and their reports make some effort to find appropriate metrics. The last COV suggested posting more detailed instructions. We see improvement in proposals in addressing this criterion as the community understanding improves. We concur that emphasizing the three areas of impact- educational, societal, and scientific - should help focus proposal writers and reviewers better.

4.4.A3 Reviewer Selection

Ad hoc reviews are obtained from acknowledged experts. Most are from the US, but about ten percent of reviews are obtained from non-US experts where it is understood that these people have familiarity with the US funding system. Based on the jackets we reviewed, the managers do an excellent job identifying good reviewers. The panels are able to reconcile contradictory advice and function well.

Efforts to include input from investigators from liberal arts institutions during the review of proposals from other similar institutions is appreciated and needed. Certainly, there are tasks that an undergraduate student cannot independently complete. However, reviewers and panels should assume that if the PI has the needed experience (both with the project and with undergraduate mentoring) they should be able to work with and direct the student efforts successfully. In the Research in Undergraduate Institutions (RUI) proposals and in proposals that include undergraduate student participation, reviewers should be asked to confirm that students are involved in effective and significant ways

4.4.A4 Resulting portfolio of awards

Based on our review of the reports in the jacket, we find that the US nuclear physics community has great confidence in the high quality of the NSF nuclear physics program. We concur with this finding. One of the strengths of the NSF program is its ability to respond quickly to new opportunities. The program is agile and in balance with the DOE portfolio of activities in all areas except possibly relativistic heavy ion research at RHIC. This issue was noted in the previous COV report. We find the NSF recognizes the value of relativistic heavy ion physics. The portfolio is growing, and good proposals are definitely recognized and funded.

The pressure for funding is intense, especially with recent cuts in the individual investigator programs. For example in FY05, program officers were able to fund only 80% of the highest rated activities. This puts the prinicipal investigators in the position of compromising their leadership role in present activities or seriously reducing their investments for the future.

4.4.A5 Management

The program is exceptionally well managed and operates efficiently. The staff of the Nuclear Physics program office is 1.25 FTE, currently in 3 individuals. The program directors view this as a reasonable match to the current workload. Since two of the individuals are rotators, attention always needs to be paid to a smooth transition. The one permanent program officer currently splits his time with the theory program. The subcommittee regards this as a positive influence, ensuring that nuclear theory and experiment are focusing well on the same overarching goals. If additional attention is to be devoted to facility operation and project management, there is no question additional personnel would be needed. Regular program director presentations to the community at APS Division of Nuclear Physics and NSAC meetings are widely appreciated and have great value in communicating NSF priorities and initiatives. For example, the purpose of merit criterion 2 has been regularly discussed.

4.4.B Output and Outcomes from Program Investments

4.4.B1 PEOPLE

The Nuclear Physics Program is well aligned with the physics goals articulated by the Nuclear Science Advisory Committee and other advisory activities. In addition, education and investment in people is an important component of the program. Such investment is essential for long-term viability. In FY2005, 174 senior personnel, 74 post-doctoral associates, 186 graduate students, and 152 undergraduate students received support.

It is a positive feature of the program that in the last three years, 16 new researchers (25% female PI's) have received support for their work. This is a sign of a healthy field since there are opportunities for new people to enter while established programs continue to receive support. Of note is that some of these 16 people have joined existing research groups while some will operate independently.

It is affirming when people supported by Division funds receive external recognition. A recent example is the 2005 APS Outstanding Doctoral Thesis Research in Beam Physics Award from the American Physical Society. This prize was awarded to Eduard Pozdeyev for his graduate work at the NSCL. His computer modeling led to the construction of a small isochronous storage ring that allows for accurate experiments on space-charge effects.

The Nuclear Physics program supports a significant number of graduate students in this discipline; about 1/3 of the number in the U.S. These students receive a very well rounded graduate education that includes training in many aspects of the experimental process: equipment operation, detector development, acquisition, analysis, modeling, and interpretation.

The number of undergraduate students supported by the program in experimental nuclear physics is comparable to the number of supported graduate students. While most of these undergraduate students will not continue in the field of nuclear physics, involving these people in quality research certainly provides a pool from which nuclear physics graduate programs can recruit. Two aspects deserve specific mention.

- The Conference Experience for Undergraduates (CEU) program is one of the highlights of the Fall American Physical Society Division of Nuclear Physics meeting each year. The quality of both the undergraduate work and their presentations is impressive. This program provides incentives to students, highlights the best work that can be done with undergraduate students, and provides a way to effectively identify and recruit these strong students into the field.

- Two notable initiatives supported by nuclear physics that involve undergraduate students are the MoNA project (recently highlighted in Physics Today) and the HYCAL detector at PRIMEX. The MoNA group is developing effective ways of integrating undergraduate students into research programs building on the success of the collaborative construction of the device. Undergraduate students are certainly involved in the running of the various experiments involving MoNA but now a number of the students are actively carrying on the analysis of data in a distributed fashion all coordinated by one of the undergraduate faculty collaborators. A noteworthy aspect of the HYCAL effort was the contributions of undergraduate students from HBCU institutions along with international researchers.

Continued vitality of the field depends on balanced support of established researchers, new, younger researchers, graduate students and undergraduate students. This starts with the REU supplements and the CEU program, continues with significant support for graduate students, facilitates new researchers, and sustains established programs in a continuous way. We believe this balance has been well struck in Nuclear Physics

4.4.B2 IDEAS

The 2003 through 2005 period has seen new discoveries which demonstrate the breadth and reach of the PHY Nuclear Physics program. Following are brief highlights of some of these discoveries.

The half-life of an exotic, doubly magic nucleus, ^{78}Ni, was measured by a group at the National Superconducting Cyclotron Laboratory (Gelbke, 0110253). Eleven ^{78}Ni nuclei were produced, enough to determine that the half life is about a tenth of a second, much shorter than previously thought. The decay of ^{78}Ni is a key link in the rapid neutron capture (r-) process, which is responsible for producing about half of all the heavy elements found today in nature. The shorter half life of ^{78}Ni means that nature can produce heavy elements faster than previously thought. Several of the researchers participating in this project are members of the Joint Institute for Nuclear Astrophysics (JINA), an NSF Physics Frontier Center.

The G0 experiment concluded a major data taking run in May 2004, and published its first results on the neutral current parity violating electron scattering asymmetry in September 2005. The experiment reveals the presence of strange quarks in the structure of the proton. The next phase will allow separation of electric and magnetic components of this structure. NSF grantees working on this project come from the University of Illinois (Beck, spokesperson, 0244889), Maryland (Roos, deputy spokesperson, 0456476), Virginia Tech (Pitt, 0457163), Louisiana Tech (Johnston, 0244998), Caltech (McKeown, 0244899), and the College of William and Mary (Finn, 0400583).

The Relativistic Heavy Ion Collider program (RHIC) has now completed five major running periods, colliding beams of gold nuclei (Au-Au), protons (p-p), gold and deuterium (d-Au) and most recently copper nuclei. The four experiments have now established with significant confidence, that in the very high temperatures and densities achieved in colliding these heavy nuclei, nucleons apparently dissolve into a form of matter that resembles a liquid of quarks and gluons with a very low viscosity. The NSF nuclear physics program supports three university investigator grants whose research is dedicated to the RHIC program (Humanic, Ohio State, 0355007, Cebra, UC Davis, 0457324, and Murray, Kansas, 0449913) and several other individuals in some of the larger group grants.

Direct determination of the electron's response to the weak force is an extraordinarily clean way to probe for new physics beyond the scope of the Standard Model. A team of scientists from both particle and nuclear physics recently completed a precision measurement of parity-violating Møller scattering (electrons scattering from atomic electrons in hydrogen) at the Stanford Linear Accelerator Center (SLAC). The result is a determination of the "weak mixing angle", $\sin^2\theta_W$, at an energy scale very different than that probed in high energy physics experiments. Final results from the experiment agree with theoretical expectations to about one standard deviation and help limit new physics. Groups funded from the NSF Nuclear Physics Program were leading members of the experiment. (Hughes, Caltech, 0244245 McKeown, Caltech, 0244899, Decowski Smith College, Kolomensky, U.Cal.-Berkeley, Arnold, Mass.)

A common characteristic of mean field behavior in any many body system is that the single particle strength is renormalized by correlations. For nuclei near stability this renormalization factor is about 0.6-0.7. Recent nucleon knockout experiments at the National Superconducting Cyclotron Laboratory suggest the renormalization changes markedly in nuclei away from the valley of stability, ranging from 0.9 in very weakly bound valence systems to 0.3 in very deeply bound valence systems. (Gelbke, 0110253)

4.4.B3 TOOLS

The Coupled Cyclotron Facility (CCF) at the NSCL has come into operation during the past three years. By coupling the K500 and K1200 cyclotrons, beams have been accelerated with higher energy than had previously been possible with either machine alone, and, more importantly, higher intensities. The facility can now be used to produce secondary beams containing short-lived isotopes far from stability by fragmentation of the primary beam. These short-lived isotopes can be readily separated for study, and forthcoming results will address key problems in nuclear structure and astrophysics.

A decade of experiments in nuclear and particle physics has established that very little of the proton's spin comes from a net orientation preference among the spins of all its quarks and antiquarks. Now, a team of nuclear physicists at RHIC, led by Indiana University, has developed a new component of the STAR detector which will be used to measure the polarization of the gluons, using polarized-proton collisions. The new detector, called the Endcap Electromagnetic Calorimeter (EEMC), was constructed through an 1999 NSF-MRI grant to Indiana University. The EEMC was successfully commissioned with both p+p and Au+Au collisions at RHIC in 2003 and 2004 and is now ready to collect data from the first long polarized proton run at RHIC. The STAR spin program is also supported by the NSF through investigator grants to Caltech (Hughes, 0244245), Indiana (Vigdor et al, 0457219), and Penn State (Heppelmann, 0244946).

Ten colleges and universities have collaborated in the construction of the Modular Neutron Array (MoNA) at the NSCL. MoNA is designed to detect high energy neutrons from unbound, neutron-rich nuclei, and will be seven times more efficient at single-neutron detection than existing detectors. The modular design of the detector allowed the bulk of the construction and testing to be done by undergraduates at ten different colleges and universities. The project was funded at $0.9 M with a collaborative MRI award in 2001. The detector construction was completed in 2004 and installed at the NSCL. The initial complement of experiments began in 2004.

A radioactive beam facility has been completed at Florida State University's Superconducting Accelerator Laboratory. In the new facility, called RESOLUT, exotic ions are produced in flight by bombarding stable targets with specific beams. A superconducting radio frequency resonator is used to "cool" the ions, sharpening their energy distribution for improved resolution in the experiments to be carried out. The combination of the cooled beam and a superconducting solenoid will provide a wide variety of beams of light isotopes in order to study some of the important reactions that fuel these stellar explosions. The RESOLUT facility was completed in November 2004, and experiments began in 2005.

SeGA is an array of eighteen 32-fold segmented high-purity Germanium detectors optimized for in-beam gamma-ray spectroscopy with beams of rare isotopes, coming into operation at the NSCL. By electronically partitioning each crystal into 32 segments, the energy and interaction points of gamma-rays emitted from fast-moving rare isotopes can be measured, allowing the reconstruction of the energy of the gamma-ray in the frame of the moving particle. SeGA is the largest operational germanium detector array optimized for gamma-ray spectroscopy with fast beams of rare isotopes. One experiment at the NSCL Coupled Cyclotron Facility that has used the SeGA array was a study of the shell structure of a "magic" heavy isotope of silicon, published in Nature in 2005.

An effort has recently been initiated at the PULSTAR research reactor North Carolina State University to develop a new source of ultracold neutrons that has the potential to be comparable in density to the best facilities in the world. Such a facility will enable fundamental tests of nature's symmetries and improved measurements of fundamental constants. This highly interdisciplinary project is a unique new opportunity because of the establishment at North Carolina State University of a new group that includes key members with experience in these experiments (Huffman and Young, 0314114), one of the world's experts in UCN physics (R. Golub), and a partnering with the Nuclear Engineering department that supports the research reactor. R&D efforts relevant to this source are also being carried out at Indiana University by new faculty member C.-Y. Liu (Vigdor, 0457219).

4.4.C Other Topics

Agency-wide issues that should be addressed by NSF to help improve the program's performance.

There are significant tensions in the program related to the funding of facility operations relative to investigator proposals. Currently the NSCL operating budget is the major factor and is managed at the Division, not the program level. The proposed Deep Underground Science Laboratory (DUSEL) could have a significant impact as this world-class facility moves forward. The committee is concerned there still does not seem to be a coherent and public Division plan for funding both the operation of facilities and the major research initiatives of the facilities as called for in the 2003 COV report. For example, in addition to its operating budget, several of the DUSEL experiments are in the few tens to hundreds of million dollar scale. The DUSEL situation may be particularly complicated since the experimental program will span nuclear physics (e.g. neutrino-less double beta decay), particle and nuclear astrophysics (solar neutrino physics, supernova searches, dark matter searches) and particle physics (nucleon decay). We reiterate the 2003 recommendation to encourage the Physics Division to have plans for managing and funding new operating facilities well in hand, even recognizing the uncertain timescale of future initiatives. A second issue, repeated from previous COV reports is the need for a mechanism to fund projects in the $2M-$100M range. The Division has indicated some new approaches to partially address the issue.

4.5 Particle and Nuclear Astrophysics Program Subcommittee

Introduction

The Particle and Nuclear Astrophysics (PNA) program is relatively new at NSF and this review is only its second since its inauguration six years ago. The stated goals for the Division's PNA program include a stress for balance across a diverse set of experiments, investigators and institutions, and it manages its program through prioritization and phase-out of completed program components, with the strong input of the community, and seeks partnerships within and outside of the NSF. In addition to the education of graduate students, the program seeks to enhance the participation of undergraduates in research and to increase the value of the program to the nation through increased education/outreach activities that are built into major research projects. In our review we strive to evaluate how well it is functioning to fulfill those goals.

General overview

The Particle and Nuclear Astrophysics program of the NSF Physics Division is the program most closely linked to the major inter-agency initiative "Physics of the Universe". As such it encompasses a wide range of very diverse activities with proposals and projects ranging from astrophysical applications of geochemistry to ultrahigh energy neutrino detectors embedded in the South Polar ice. The content of the PNA Program is mainly concentrated in five areas identified by the community that the program serves. They are:

- High-energy particle and cosmic ray astrophysics;
- Gamma-ray particle astrophysics;
- Neutrino physics and astrophysics;
- Dark matter and dark energy searches; and
- Nuclear Astrophysics

This interdisciplinary variety of experimental approaches requires a high level of open-mindedness and technical expertise from both the program managers and the groups of reviewers selected to judge incoming proposals. As the program expects to grow in the coming years, to name one example --- in the direction of underground physics with the establishment and management of a Deep Underground Science and Engineering Laboratory (DUSEL) --- the complexity of the program is likely to increase.

The PNA program also includes significant educational and public outreach activities associated with its major experiments. It has been a pioneer in establishing new methods of interagency cooperation and program management.

In brief, as stated in the FY2005 PNA Annual Report, we note that the PNA Program was funded at the $14.7M level and oversaw 51 grants involving a total of ~ 280 persons (faculty, senior scientists, post-doctorals, graduate and undergraduate students).

Centers and Individual Investigators

The funding is currently invested with individual investigator and multiple investigator programs and in the instruments required for science. Funded separately are two Physics

Frontier Centers with intellectual interests (cosmology and nuclear astrophysics) close to those of the PNA program; none of the $14.7M is devoted to them.

4.5.A Integrity and Efficiency of the Program Process and Management

4.5.A1 The effectiveness of the program's use of the merit review procedure

COV review of jackets

Each of the 4 sub-committee members read an average of 12 jackets. All requests for information on any part of the Program process and management were quickly and readily provided by the Program Officers. We were impressed with how well the process is working. This was true across the board including individual and ad hoc reviews, Panels, Program Manager actions and for both the funded and declined proposals.

Time to decision
Except for proposals requiring a NUSAG-type panel review for the entire US program, the typical dwell time is approximately 6 months which seems acceptable and appropriate.

Jacket documentation
Very good and the e-jacket system works better than we had expected.

Reviewing Action

The new funding and renewal success rate is high (~2/3) but this seems appropriate given the stage of development of this new program. This is its 6th year. We looked at 4 funded proposals deemed "risks" by the Program Officers. These were all very favorably reviewed by referees and panels and were so identified as risks worth taking due to potential pay-off in physics-reach. Typically, they were not with large budgets but all were on important physics issues and were innovative. We like the approach of the program to risk opportunities which favors providing R&D capability to these proposals. We found no evidence of any equipment funding problems in this review period.

4.5.A2 Program's Use of the new NSF Merit Review Criteria

Both criteria were adequately addressed by all Panels and most reviewers and were always addressed by the proposers.

4.5.A3 Reviewer Selection

Reviewers were fully appropriate and well qualified. No unfair reviewing nor conflicts of interest were observed. We note with satisfaction the inclusion of a significant number of young scientists as reviewers as recommended by the COV2003.

4.5.A4 Resulting portfolio of awards

The resulting portfolio admirably combines and spans the spectrum from low energy nuclear astrophysics through the highest energy cosmic and gamma rays and neutrinos and on to cosmology. Some of the grants are already producing important results in these areas (see below).

Underrepresented groups

While there are several women PI's with successfully funded proposals there is clearly room for improvement. It is not the case that there is a significant pool of women-lead proposals which were declined; it is clear that as a community we need to be increasing the available pool. We welcome the various NSF efforts to do so.
We were not aware of any under represented minorities with proposals in the program.
We applaud the Physics Division for specifically setting aside a fund to augment or assist in the funding of proposals with PI's from underrepresented groups.

Funding trends

For a new and expanding program, the funding trends appear to be responsive to the high quality of the proposals and the importance of the science to be addressed. These trends are a positive response by the NSF to the recommendations of the various NAS/NRC, OSTP and general scientific community recommendations for new opportunities at the particle/nuclear astrophysics frontier.

Program agility and content balance

As noted above the funding trends provide favorable evidence for agility. The present resulting portfolio represents an appropriate Division of resources among the current opportunities. The Program Managers are doing an appropriate and intelligent job of balancing the natural tensions among facility, equipment and people needs in such a diverse program and within the constraints of fluctuating budgets. They appear ready to be able to make hard decisions relative to completing some projects to make possible new opportunities.

4.5.A5 Management

The following comment is not meant as a criticism of the Program Managers who have shepherded this nascent portfolio to its present successful level. However, we are concerned that, in the future, this diverse and growing program needs to have a Program Manager Group with a stable continuity of individuals. We feel that a mix of several permanent NSF staff and long-term rotators is needed; especially with the demanding and imminent DUSEL process and the management of other large facilities.

4.5.B Outputs and Outcomes of Program Investments

4.5.B1 PEOPLE

Public Exposure

The nature of the subject matter of this PN&A portfolio ---- basically, a major portion of "the physics of the universe" --- lends itself naturally to the interest and education of the general public. All of the major grants, including related Centers, have active and imaginative outreach and education programs in place (e.g, Aspire, CROP).

Workforce and Graduate and Undergraduate Education

The NSF funding leads to the involvement of about 1.5 graduate students and 1.5 undergraduates per faculty member. As with the general public the nature of the subject matter lends itself to involving undergraduate research opportunities and we feel there could be a larger such involvement than at present. Additionally, there are ~ 0.5 post-docs per faculty member.

Workforce and Undergraduate Education

Please see above.

Future prospects

Many academic institutions see the fields represented by the science in the PNA program as an opportunity to hire new faculty either as retirement replacements or as additions to their physics department. In recent years such hires have provided the departments involved the opportunity to introduce new areas of research to their own portfolios.

4.5.B2 IDEAS

Discoveries/Milestones

There already are several important discoveries and milestones reached in this review period:

- The convergence of results from HiRes and AUGER on the fundamental question of the GZK-bound and the existence of UHECR sources beyond it.

- The accelerator laboratory at Notre Dame continued their successful program in Nuclear Astrophysics with an important measurement of the lifetime of the 4.033 MeV state in Ne-19 thereby reducing long-standing uncertainties in the theoretical description of nova and x-ray burst nucleosynthesis.

- The CDMS-II new limit on WIMP dark matter. It surpasses in sensitivity by an order of magnitude all previous competing results thus moving the field into a position to directly test particle models.

- The discovery by MILAGRO of >TeV diffuse gamma rays from the galactic plane and the Cygnus region in particular; this opens a new spectral window on the galaxy.

- The smooth transition of AMANDA into ICECUBE and the recent successful installation of an additional six detector strings in the recent Austral summer. This is a significant achievement for a new technique in the remote and insalubrious climate of the South Pole.

Collective progress

The program is well integrated. The synergy and cooperation between different instruments has increased.

Future prospects

Many of these projects, even those mentioned in the discovery section above, clearly have further discovery potential. The newer, younger projects (e.g., VERITAS, AUGER) in all areas have discovery potential as provided by the new results and questions raised by recent discoveries in the fields encompassed. Additionally the projects now in R&D (e.g., dark matter and double beta decay) are progressing well and if successful are expected to advance the program. A decision to proceed with the NSF's DUSEL initiative (an initiative important to a significant portion of the PNA program) will open additional new opportunities. Especially for facilities, we encourage the NSF to require discussion at the proposal stage for future operating and decommissioning tasks. NSF should plan for provision of appropriate funding to decommission those projects that at their conclusion may require the removal of major equipment and infrastructure initially deployed.

4.5.B3 TOOLS

Use of Discoveries

The program provides funding for innovative techniques through its R&D efforts and construction of facilities which allow it to effectively operate at the cutting edge of the frontier. Examples of theses would be include xenon and other novel dark matter detection ideas at the R&D level and for facilities: AUGER, ICECUBE,VERITAS, BOREXINO.

- *Center programs:*

We did not review any of the PFC programs; both related PFC's are also relatively new.

- *Interaction with government laboratories:*
  In those projects where government laboratory interactions have had the opportunity to occur, we perceive that this cooperation is working well and enhances NSF resources.

- *Cross-program impact:*
  As a strongly inter-disciplinary program PNA naturally impacts and is impacted by other programs in Physics Division (e.g., EPP and NP) as well as the Astronomy Division.

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4.5.C Other Topics

4.5.C1 Comments on program areas in need of improvement

a) Early management oversight of large projects.

b) The interdisciplinary aspects of the PNA program require additional effort. This program's overlap with particle physics, nuclear physics, and astronomy are the most obvious; however, some projects also overlap with geology and biology as well. For example, a proposal on the temporal evolution of the cosmic ray flux proved difficult to review with a properly broad perspective. At the extreme of large projects, DUSEL, already a cross-Divisional initiative, will also benefit from even broader expert scientific advice and review.

c) Several PNA proposals also involve interagency collaborations with DOE and NASA. These collaborations are key to obtaining sufficient funding for mid to large cost projects. NSF and DOE are working together to form Scientific Advisory Groups to guide funding decisions. Currently, the NuSAG is investigating topics in neutrino physics, and a dark matter advisory group is planned for the near future. The active collaborations between NSF and DOE within PNA are generally working well. Future collaborations with NASA require increased dialog between NSF and NASA at all levels. Particularly for ad hoc and panel reviews it would be valuable to involve some active scientists with experience within the NASA system.

d) As noted in the COV 2003 report, PNA has many proposals on the horizon or recently funded that would benefit from a program to manage mid range (>2M$) projects. We encourage the NSF to go forward with a plan to facilitate projects in this range as these size projects are difficult to fund out of PNA and require additional management oversight that such a program could provide.

4.5.C2 Comments on the program's performance in meeting program specific goals and objectives not covered by the above question

The VERITAS air Cherenkov telescope promises to be one of the field's most important and promising instruments when it is completed and operating in a permanent site. As the first two completed dishes have shown, they perform as to specifications. Work is pushing forward on construction of the remaining components; however, a permanent final site has not yet been approved. We strongly support and encourage the negotiations so that a final site can be selected and the project can move forward to completion and subsequent data taking. This will insure continued US leadership in high energy gamma ray astronomy.

We note that within the Particle & Nuclear Astrophysics program a significant portion of the present and expected future experiments require locations underground in order to control backgrounds. The experiments are on topics considered among the most important in particle, nuclear, astrophysics and cosmology; to cite a few: dark matter, double beta decay, geo- and solar neutrinos. The NSF's has begun a cross-Divisional initiative to create a DUSEL which would greatly benefit the present and growing PN&A program. We strongly commend this initiative and encourage careful planning for its creation and operation so that its successful passage through the long review process is assured.

4.6 Theoretical Physics Subcommittee Report

Introduction

The Theoretical Physics subcommittee reviewed the process used to evaluate proposals and the quality of the outcomes of awards in Theoretical Atomic, Molecular, Optical and Plasma (TAMOP), Nuclear Theory (NT), Elementary Particle Theory (EPT) and Mathematical Physics (MP). For TAMOP, NT and EPT, two members of the committee examined the proposal files; for MP, one member of the committee examined the files. The NSF process for evaluating these proposals involves three steps:

1.) Solicitation of external reviews by three or four experts, depending on subprogram
2.) Review and ranking of proposals in a given program by a selected panel of experts who meet at the NSF to examine the proposals and the external reviews.
3.) Preparation of a review analysis by the Program Director that recommends award (with appropriate funding level) or declination of each proposal.

The subcommittee members reviewed 78 jackets in order to assess the integrity of the evaluation process. The quality of the external reviews was found to be very good, with appropriate attention to the Intellectual Merit criterion and much improved attention to the Broader Impacts criterion. In most cases, appropriate external experts were selected, especially for the panels. In the words of one subcommittee member, "it was a high-quality, careful and thoughtful process".

A number of excellent outcomes have been identified. A few examples that impressed the committee are mentioned in Sec. 4.6.B of this report.

4.6.A Integrity and Efficiency of the Program Process and Management

4.6.A1 <u>The effectiveness of the program's use of the merit review procedure</u>

The committee reviewed a total of 78 jackets across four theoretical programs. The committee members are unanimous in their opinion that the three-tier review process is thorough and fair. The written reports by the reviewers are in most cases detailed and address both the intellectual merit and the broader impacts of the proposals. Most proposals received three or four outside reports, which was sufficient in almost all cases. For some large group proposals in particle theory the reviewers were unable to provide adequate coverage of all investigators. In such cases it is important to seek additional reviews, perhaps in consultation with prospective panel members; in some cases, one may consider a site visit. The committee noted that the grading system is not transparent and can be confusing to reviewers unfamiliar with the process. Providing statistics from previous years on the correlation of grades and funding decisions would be helpful.

The panels are a critical part of the process. They represent fully the diversity of the research community and add significant value to the process. Since panel members see all the competing proposals, they have the perspective to rank the proposals relative to one another. They also have the necessary breadth of expertise to make up for deficiencies in the external reviews. Panel reviews give serious consideration to proposals from underrepresented groups, investigators from smaller institutions, and new investigators. The panel summaries are often little more than a brief summary of the external reviews. It would be more helpful to the PI's if the summaries provided more insight into the basis of the recommendation, particularly when the proposal is declined.

We found that the review analyses were balanced, detailed and thorough. It is regrettable that these documents are not viewed by the PI's, as they frequently provide the most complete justification for the Foundation's decision. There were a few isolated instances involving large grants in Elementary Particle Theory where final funding levels were larger than recommended by the panel and sufficient justification for this increase was not provided in the review analysis. We note that in reviewing large grants, referees, panel members and program officers carefully consider the productivity of individual researchers. Less productive individuals are removed from these grants or budgets are adjusted downward as appropriate.

We commend the program for the progress in decreasing the dwell time. All four theoretical programs have met or are close to meeting the goal of six months between the deadline for proposal submission and notification of award or declination to the PIs.

4.6.A2 Program's Use of the new NSF Merit Review Criteria

Both the proposers and the reviewers have gotten the message that the broader impact is important. In several cases, the broader impact played an important role in the overall rating of the grant. Nevertheless, the intellectual merit is weighted more heavily in the rankings, as is appropriate.

4.6.A3 Reviewer Selection

The ad hoc reviewers and the members of the review panels are selected from a diverse group, representing the various specialties within each subdivision. They represent a balance among geography and institution type, and serious efforts have been made to include underrepresented groups.

In some cases, reviewers outside the program were chosen in order to provide additional reviews of proposals with interdisciplinary aspects. We believe this use of outside reviewers is appropriate and we recommend continuing this practice.

In a few instances, proposals by junior faculty investigators were reviewed by other junior faculty and/or non-faculty investigators. We would recommend that proposals by more junior faculty go to a mix of junior and senior investigators in order both to bring a balance of openness to new ideas and experience, and to avoid possible issues of competition.

4.6.A4 Resulting portfolio of awards

Only the best proposals get funded, and as a result, the portfolio is excellent. The portfolio has an appropriate balance of awards to young investigators, underrepresented groups, and high risk projects. Funded proposals are well distributed among hot topics and more traditional research. One of the consequences of a constrained funding environment is that young investigators who are not at the very top of the field may be shut prematurely out of funding opportunities, and this is a concern of the committee.

Efforts have been made to identify and fund new multidisciplinary areas of research, such as biological physics and quantum information. However, additional attention should be paid to the area of mathematical physics, which is a particularly fruitful area for multidisciplinary projects and is currently underfunded.

4.6.A5 Management

The COV commends the overall management of the Theoretical Physics Program. This is one of the most difficult programs to oversee, given that it represents four separate subfields. The Program funds large theoretical groups in EPP and two large theory centers in AMO, and this further complicates the distribution of funds.

There is a tension in the TAMOP program having to do with maintaining the proper balance between traditional atomic physics and the opportunities in cold-atom physics, especially in view of the growing interface between cold-atom physics and condensed matter theory. We believe that the program officer deals well with this tension, and the portfolio reflects a healthy distribution among the important scientific questions.

4.6.B Outputs and Outcomes of Program Investments

4.6.B1 PEOPLE

The theory program has made strides in promoting diversity, particularly in gender. For example, the grant to Doreen Wackeroth of SUNY Buffalo enhances an important element of the U.S. high energy theory program. Wackeroth's work on precision calculations in Higgs physics and QCD is important to the upcoming program at the LHC.

The NSF has promoted opportunities for young physicists. Collin Morningstar of Carnegie Mellon University has been awarded a grant to fund a five year postdoctoral position working in lattice QCD. This work is complementary to DOE/SCIDAC investments in lattice QCD, and represents an emerging thrust in nuclear theory.

We noted that reviewers, panels and program officers have been supportive of researchers carrying out high quality research at undergraduate institutions. These include Per Berglund at the University of New Hampshire and Steven Naculich at Bowdoin College, both in string theory. Sabine Jesschonnek in nuclear theory was awarded a grant at the Lima campus of the Ohio State University. Her proposal benefited from her formal connection to an established group at the Columbus campus. This is an example of a good way to support work at an undergraduate institution, i.e., by coupling it strongly to work at a Research I institution.

In the TAMOP subprogram, Mette Gaarde received a CAREER Award in 2004 at Lousiana State University. She investigates the theory of attosecond-pulse generation and related applications.

Graduate education is a strength of the NSF programs in theoretical physics. It is an essential contribution to training the next generation of scientists and also provides some very high quality people to the nation's workforce.

4.6.B2 IDEAS

There have been a number of major new ideas and discoveries which have emerged in the last few years as a result of NSF supported research. In nuclear theory, a dramatic development has been precise calculations for the Carbon 12 nucleus. The Green's function Monte-Carlo method offers a way to solve the nuclear many-body problem. Based on known forces between nucleons supplemented by modest three-body forces, binding energies of all the light nuclei have been reproduced. The method has now been extended to the twelve-body problem by recent calculations for carbon 12. This is a tour-de-force calculation using large computational resources at national laboratories and it exemplifies synergies between the NSF supported work and DOE supported labs. PHY-0098353 V. R Pandharipande, Gordon R. Baym and D. G. Ravenhall, University of Illinois.

In atomic physics, Chris Greene's group at the University of Colorado, along with collaborators at Washington State University and Santa Clara University, investigated the cooling of the relative motion of two trapped atoms via the use of a scattering Feshbach resonance. A magnetic field was used to control the interaction strength near the energy of the pole produced by the Feshbach resonance. Greene and collaborators showed how a series of time-dependent magnetic-field ramps can be used to cool pairs of atoms taken from a thermal distribution. J. W. Dunn, D. Blurne, Bogdan Borca, B. E. Granger, and C. H. Greene, PHY-0245389.

A major development in string theory was the study of the Landscape of String Vacua. Until recently, the only well-understood stable states of string theory were those with unbroken supersymmetry. A group from Stanford University developed earlier ideas of Rafael Bousso and Joe Polochinski (KITP), providing strong evidence that string theory possesses a vast number of metastable, de Sitter and anti-de Sitter ground states. This has stimulated a great deal of work on the possibility that string theory possesses a landscape of vacua, and that the statistics and cosmology of this landscape may yield real predictions. Shamit Kachru, Renata Kallosh, Andrei Linde and Sandip Trivedi PHY-0244728.

In mathematical physics, a major development occurred in the study of the Gross-Pitaevskii equation for cold, rotating Bose gases. It was long understood that the time-independent GP equation correctly describes the density profile of dilute, cold Bose gases in traps – as in current experimental configurations. When the gas is rotated, however, the GP equation starts to have multiple solutions containing vortices, and it was not at all clear that these describe the true physical situation predicted by the unsolvable many-body Schrödinger equation This has now been proved by a collaboration of PI's in two grants of the mathematical physics section, Robert Seiringer, PHY 0353181, and Elliott Lieb, PHY 0139982.

4.6.C Other Topics

4.6.C1 Comments on program areas in need of improvement

The committee strongly supports the Division's commitment to increase base funding by 5% per year in Theoretical Physics.

It would be desirable to have a minimum size for research awards that would allow summer salary for the PI and support of a graduate student (awards at undergraduate institutions being an obvious exception).

NSF plays the role of steward for research in mathematical physics. We note that the success rate for proposals in Mathematical Physics has been quite low for an extended period. We are concerned that this trend may be discouraging applications from qualified researchers. It would be desirable for the Division to have some discretion to make additional awards when deemed appropriate by the review panel and the program officer.

There is an emerging opportunity in EPT to prepare for LHC activities by supporting theoretical work that is related closely to LHC phenomenology.

4.6.C3 Agency-wide issues that should be addressed by NSF to help improve the program's performance.

The Physics Frontier Centers have been discussed by the COV 2006 because they affect the balance of the Division. The recent reorganization to add three longstanding institutes to the newer PFCs has resulted in ten such centers, accounting for about 8% of the Division's budget. The centers play an important role in training postdocs. In particular, KITP is very valuable in theoretical physics because it brings together researchers working on a variety of leading problems and stimulates work in several subfields of physics. The centers generally are very good. A concern is that the overall PFC program should demonstrate that centers can be phased out in order to support newer activities in an opportunistic fashion. We would not like to see more centers added before there is a demonstration that open competitions of PFCs can affect such an outcome.

4.7 Physics Educational and Interdisciplinary Research Programs Subcommittee Report

The EIR program has allowed the Physics Division to pursue NSF goals for physics education and outreach, for broadening physics participation, and in providing a flexible mechanism for considering research proposals that do not fit into other program areas. The potential for the EIR program to serve as an incubator for emerging areas of inquiry and development has been one of its strengths. This was most recently demonstrated in the case of Biological Physics, which has now become its own program within the Physics Division. To function in this role, the EIR program must remain open to new ideas while also adhering to the high-standards of peer-review. EIR should be vigilant and proactive in maintaining and leveraging coordination and cooperation with programs, in the Physics Division, other Divisions within NSF, e.g., EHR, and other funding agencies. The COV recognizes that the management of the EIR program has been challenging these past three years due to the lack of a dedicated Program Director. This should be corrected as soon as possible not only to responsibly manage the resources of this program but to also engage in setting priorities and planning within the program.

We urge the Division of Physics to identify and respond to efforts supporting innovations and improvements to all aspects of physics education and outreach. The EIR program can aid the Division of Physics in becoming more active in thinking strategically, about meeting the changing needs of the discipline and the changing needs of society. The numerous recent reports from national organizations on the importance of science education for maintaining the U.S. competitiveness in a global economy have highlighted the importance of Divisional goals addressing education and broader participation. An EIR program led by a full-time visionary Program Director could take advantage of opportunities presented by such national initiatives and effectively integrate efforts across divisions and programs.

Research Experiences for Undergraduates (REU) Sites

Research Experiences for Undergraduates (REU) is an NSF-wide program with two components: REU Sites and REU Supplements. The Supplements are handled within the disciplinary programs. Proposals to establish or continue REU Sites are managed by EIR. Some proposals are co-reviewed and/or co-funded with other MPS divisions and the International Division (INT) (in FY05 INT became the Office of International Science and Engineering (OISE)) where appropriate. DOD through the Air Force Office of Sponsored Research (AFOSR) participates in the REU site proposal review and funds or co-funds some sites.

The REU Site program represents about 2/3 of the EIR budget. Goals of the REU program include encouraging undergraduates, by involving them in forefront physics research, to consider pursuing graduate school and careers in the sciences, and to increase the diversity of the physics population.

Approximately 50 REU Sites are supported each summer, providing research opportunities to a total of about 500 undergraduate student participants. The program has been very successful, and enjoys immense popularity with the undergraduate physics student population. The REU Sites are located at a wide variety of institutions, including PFCs, university physics departments, four-year colleges, and government labs. Some REU Sites includes Research Experience for Teachers (RET) components, which are funded by OMA.

Measuring the effectiveness of these programs in reaching their goals is a bit difficult. We are pleased to see that, recognizing this fact, the NSF in 2003 contracted with SRI International to perform an external evaluation of NSF efforts in undergraduate research opportunities in the fields of science, technology, engineering, and math (STEM). The report, available at http://www.sri.com/policy/csted/reports/university/#uro), is based on surveys of over 4500 undergraduate students. About half of these students participated in programs at REU Sites or supported via REU Supplements. The findings powerfully support the success of these undergraduate research programs. A few relevant statistics include the fact that 53% of the participants were women, and almost 30% were minorities, indicating that these programs are providing opportunities to a much more diverse population than the general undergraduate STEM population. Concerning the characteristics of their research experience, 86% reported that they collected/analyzed data, 82% understood how their research work contributed to the bigger picture, and 77% reported that they gained increased independence as they progressed. Clearly, these are all very encouraging evaluations. Indeed, only 6% of the survey participants reported that during their work they "did little or nothing that seemed to be real research". Concerning the effects of their experience, over three-fourths of the students reported that it increased their interest in a career in science/engineering either a lot (44%) or somewhat (32%), with only 6% reporting a decrease in interest. Another measure of impact is that 45% reported the expectation that they would pursue a Ph.D. degree, while only 26% reported they had already felt that way before their research experience. The SRI evaluation includes a two-year later follow-up survey of the student participants. This report is currently being drafted and is not yet available.

The REU Site budget has been roughly flat, or slightly decreasing, over the past several years. Since the Site costs are dominated by undergraduate participant support costs, the lack of an inflation adjustment is impacting the number of students who can participate. Given the success of the REU Site program, it would be nice to see some growth. In agreement with the previous two COVs, we believe that the quality of proposals received each year suggests that a modest increase could be supported while maintaining the excellent standards. The ability to grow the program is also supported by the responses in the PI section of the SRI survey, where 78% of NSF Center and REU Site PI's agreed that they would accept more undergraduates into their program should more funding be available.

The RET program for teachers is small compared to the REU program. We agree with the recommendations fro the past two COVs that, given the potential impact on the nation's K-12 program, it should be expanded. As was noted by the 2003 COV, a promising area of growth for the REU program would be sites focused on undergraduates who plan to enter careers in K-12 teaching, for example the TOPS supported by the Center for Ultracold Atoms.

Establishment of a fulltime Program Director for EIR would increase the ability for site visits to REU Sites. This would serve to enhance the monitoring the quality of the sites, allow a centralized collection of concepts that are working well (and those that do not work so well), and provide valuable feedback to the NSF.

Broadening Participation

EIR has provided funding support for conferences aimed to increase the participation of underrepresented groups, including five-year support for conferences sponsored by the National Society of Black Physicists, support for US participation in the Second International Conference on Women in Physics in Brazil in 2005, and matching support for graduate students attending the Canadian, U.S. and Mexican conference (CAM2003) in October 2003. These efforts have been responsive to physics community initiatives and we encourage the program to continue to support such special topics activities.

Physics Education Research

Physics education research (PER), as the systematic study of efficient and effective ways to promote learning in physics, has been established as a vital area of investigation. This is evidenced, for example, by the numerous institutions that now offer PhDs in PER. We concur with previous COVs in recognizing the importance of this activity and encourage its support within the Physics Division. PER funding within the program has not increased dramatically since the last COV. However, based on the proposals reviewed, the current funding activity is appropriate.

Recently the EIR program has worked with Education and Human Resources (EHR) in co-reviewing PER proposals. We support this coordination whole-heartedly. Given that EHR also receives and funds PER proposals, EIR's most productive role may be to consider those PER proposals that may not find a home in EHR. However, ensuring the support of PER should be a high priority for the EIR Program Director, whether the work is funded through EHR or EIR. A formal liaison arrangement with EHR, may be merited to ensure that quality PER projects are not overlooked.

Interdisciplinary Research

The interdisciplinary physics portion of the EIR program portfolio consists of scientific projects that do not fit naturally into other Physics Divisional programs. It has been extremely successful in the past, most notably in the incubation of the Biological Physics effort that has grown into a separate Program in the Division. However, at present this portion of the program portfolio is extremely small, and the Committee encourages the Program to identify and nurture new exciting areas. Having a full-time program director will help greatly in this regard.

In considering examples of the review of the interdisciplinary proposals, it became clear that effective administration of this portion of the program is particularly challenging. The panel feels that it is important to evaluate any interdisciplinary proposals in the context of an appropriate pool of submissions. Doing this may involve the transfer of proposals submitted to this program to another program with close intellectual ties and a larger number of submissions. The panel feels that the mechanisms for deciding whether interdisciplinary proposals submitted to this program would be more appropriate for another program in the Physics Division or elsewhere in NSF should be systematized and strengthened. Because of the risky nature of many interdisciplinary research projects, it is especially important that proposals deemed to be in this category be peer-reviewed regularly.

The "incubator" function of EIR is very valuable to the Division and we encourage the Division to remain attentive to pursuing novel and creative ideas that may not be appropriate for other programs to support.

CAREER Awards

Another part of the portfolio of EIR is the CAREER award for new faculty. This program is extremely important as a way of launching new faculty on a productive career trajectory while promoting the teacher/scholar academic model. These grants are rightly determined by the different programs within the Division. This type of grant also correctly emphasizes the important involvement of faculty in physics education and outreach.

In response to the COV 2003 report, the NSF has made two changes to the CAREER program process and management. First they have changed the timing of consideration of the awards to allow faculty an opportunity to use feedback to apply for other grants. Also, to address the bias against theorists produced by the decision to have a minimum 80K award size, 40K per grant per year is provided by the Physics Division on top of funds allocated to individual programs. We applaud these changes while recognizing that other issues concerning the CAREER awards have yet to be addressed.

Possibilities for further improving the CAREER program were discussed by the COV. Making CAREER awards at an investigator's first renewal might be a more efficient way to support young faculty with a track record of excellence in both education activities and research. One also might consider reviewing the language about educational activities in the CAREER solicitation to favor creative and meaningful adaptation of what has been shown to work in student learning in different environments rather than emphasizing the pursuit of innovations. The most significant contribution needed now for improving student learning and for changing attitudes about science in the public is to foster broad implementation of what works and to support efforts at systemic and sustainable transformations at the departmental and institutional levels.

4.7.A Integrity and Efficiency of the Program's Processes and Management

4.7.A1 Effectiveness of the program's use of merit review procedure

The review procedures used in the selection of REU site awards were exemplary. REU proposals have in recent years been reviewed by a panel. This method allows a valuable side-by-side comparison, and subsequent ranking, of the various proposals. Prior to the panel meeting, each proposal was read by three panelists, who prepared written reviews. At the meeting, the full panel discussed each proposal, and produced a ranked list.

The panels were formed with a reasonable number of members, and represented a broad diversity. Many of the panel members were REU Site managers who were not up for renewal in the year in question, a practice that greatly aids the process of assembling a panel with appropriate expertise and experience. Attention was paid to avoid conflicts of interest.

The CAREER awards are appropriately reviewed within relevant programs.

Most of the proposals in the "broadening participation" subcategory were sent out for mail reviews. This mechanism is appropriate because there was not a set of comparable proposals that would be reviewed usefully by a panel. A small number of proposals in this category were funded without review. The panel feels that the proposals in this program should be subject to peer review, except under exceptional circumstances in which the proposal is for an amount of money that is small compared to typical levels of conference support.

The panel is concerned that there is not a well-delineated mechanism for deciding whether interdisciplinary proposals submitted to this programs would be more appropriate for another program in the Physics Division or elsewhere in NSF. In addition, a research program can evolve so that a renewal proposal might be more appropriately moved out to another program. In any case, the scientific evaluation process could be enhanced by reviewing isolated proposals with others possessing intellectual overlap.

Because of the risky nature of many interdisciplinary research projects, it is especially important that interdisciplinary proposals be peer-reviewed regularly. In this area, a single program officer is unlikely to have the broad expertise necessary to adequately judge whether a creativity-based renewal is appropriate.

The review of PER proposals has been improved by increased coordination with EHR.

When proposal reviews are available, the program officer typically provides a detailed discussion and rationale for the funding decision. Because this program supports nontraditional activities, sometimes the reviewers have different priorities than the program officers. The review summaries by the Program Directors did a good job of explaining the reasons for the funding decisions if they were at variance with the tenor of the external reviews.

Overall, the use of peer review procedures in this program is very effective. A few problematic cases were uncovered, and the Committee recommends that procedures be strengthened to ensure that appropriate peer review occurs for all proposals.

4.7.A2. The program's use of the new NSF Merit Review Criteria

The quality of the individual reviews that the Committee examined was quite high. The reviews addressed appropriately both review criteria. The reviews were thoughtful and perceptive and provided useful perspective on the strengths and weaknesses of the proposals.

The Program Directors' review analyses were exemplary in applying the criteria.

4.7.A3 Reviewer Selection

The reviewers familiar to the panelists were highly-qualified and appropriate.

Because of the breadth of the proposals examined, the committee did not have a first-hand knowledge of many of the reviewers.

An appropriate balance of reviewers was achieved.

The panel found no evidence of any problems in recognizing and resolving conflicts of interest.

4.7.A4 Resulting portfolio of awards

The EIR program uses two-thirds of its resources to support REU sites. Remaining resources are distributed approximately equally across interdisciplinary research projects, special education and outreach projects and physics education research.

An appropriate balance was achieved geographically and between institutional type and program size in grants to REU sites. The program also achieves a reasonable balance between the renewal of successful REU Sites and the creation of new sites. The panel compares and ranks all proposals together, including renewals and new proposals. The resultant renewal rate is fairly high, appropriately so given the high quality and demonstrated success of the Sites in question. However, typically a few sites each year are declined for renewal and a few new Sites are created. Some growth in REU Site funding would allow the creation of a few more new Sites, and would be very desirable.

The EIR program is a special place in that it has a strong preference for innovative and high-risk projects. The committee feels that the track record for supporting innovation is strong. The current portfolio of grants however, does not have a lot of high-risk, innovative projects. The committee feels that this aspect of the portfolio would be significantly aided by the presence of a pro-active full-time program officer.

The Center-based outreached efforts appear to be well-run and effective. The funding for Center-based projects is provided from Divisional funds, such that these projects do not take resources away from other EIR projects

4.7.A5 Management of the program under review

This program suffers because it does not have a program officer. The other program officers in the Physics Division have done a wonderful job of pitching in.

4.7.B. Results: Outputs and Outcomes of NSF Investments

4.7.B1 People

The projects supported in this program clearly help in recruiting and developing a diverse, intellectually competitive, and scientifically literate workforce, and the next generation of scientists.

The REU site funding in particular contributes to recruiting and preparing a new generation of scientists as well as broadening the participation of under-represented groups in science.

Homer Neal (with co-PI Jean Krisch) leads the University of Michigan's REU site at CERN in Geneva, Switzerland. The 15 US students supported by the REU Site award mingle with a much larger number of mainly European Union students in a summer program run by CERN. The students spend 8-9 weeks at CERN participating in research projects associated with any of the resident experiments. Being in the international research atmosphere of CERN and working on cutting edge problems is an intellectual apprenticeship that produces a student who understands the nature of international scientific collaboration and is able to function effectively in a collaborative environment. This REU site is co-funded by the Division of Physics and the Office of International Science and Engineering. Examples of student projects are "X-ray Scanning Technology," "Top Mass Analysis in ATLAS," and "ALICE Time Projection Chamber."

Ken Libbrecht is the PI for an REU Site associated with LIGO. Approximately 35–40 students, 10–12 supported by the REU Site program and the rest by the LIGO Laboratory, participate in LIGO-related projects at Caltech and at the two LIGO sites of Hanford, WA and Livingston, LA. Student research projects touch upon all aspects of LIGO research such as "Analysis of the Frequency Dependence of the LIGO Interferometer Directional Sensitivity (Antenna Pattern) and Its Implications for Detector Calibration," "Visualization of the Effectiveness and Efficiency of Potential Inspiral Vetoes," and "Noise Budget Development for the LIGO 40 Meter Prototype." The experience includes an end-of-summer visit of the students working at LIGO-Caltech to the LIGO Hanford Observatory (LHO) where they and the LHO-resident students present talks based on their projects.

Claudia Rankins is the PI of the REU Site at Hampton University, an HBCU which is also the home of the Center for the Structure of Matter Physics Frontier Center. The site provides excellent opportunities for students from groups under-represented in physics. The site makes effective use of its location very near the Thomas Jefferson National Accelerator Facility and the NASA/Langley Research Center to provide unique opportunities for students. Students perform research in a wide variety of disciplines, including nuclear, particle, atmospheric, medical, and optical physics. Some activities are conducted jointly with the REU group from the College of William & Mary. At the conclusion of the program, students give a thirty-minute oral presentation and submit a written research report.

The U of Arizona REU Site, organized by Robert Thews, is aimed at students at (primarily local) 2-year colleges. Participating students may choose from a wide variety of forefront physics activities, under the direction of senior faculty members from the Department of Physics or from research groups located in several other university academic units including Astronomy, Optical Sciences, Lunar and Planetary Studies, and Atmospheric Sciences. Special orientation and skills activities are individually tailored during the first two weeks of the program to enhance the ability of the participants to make significant contributions to the research projects. Weekly participant meetings include interim oral reports and lead to a formal presentation and final written report.

Several sites are associated with US government or industrial laboratories, either with an award directly to the laboratory or through a university. Marc Desrosiers (with co-PI Paul Lett) coordinates the REU site at the National Institute for Standards and Technology (NIST)'s Physics Laboratory. NIST student projects cover many aspects of research in atomic, molecular, optical, and radiation physics. Examples of projects include optical tweezers, quantum computing, and ionizing radiation applications in medicine and homeland security. This physics REU program shares many functions and activities with six other REU programs that operate in the other six operational units of the NIST Laboratories.

Pursuing public education and outreach in connection with big science projects (LIGO, LSEC, ICE CUBE, etc.) leverages well these large investments.

The supported conferences sponsored by the National Society of Black Physicists, the Second International Conference on Women in Physics in Brazil in 2005, and matching support for graduate students attending the Canadian, U.S. and Mexican conference (CAM2003) in October 2003, all involved significant underrepresented and/or international groups. (See for example. 0514104, Hartline, Heritage College and 0412849, Collins, Fisk University) and international contacts (0308227, Lerch, American Physical Society and 0514104, Hartline, Heritage College).

4.7.B2 Ideas

The interdisciplinary science supported (PHY-0332405, Bodenschatz, Cornell) is first-rate and contributes to discovery at the frontier of science.

Physics Education Research makes extremely important contributions to the discipline in elucidating what works in learning physics and is a key component of the broader mission of improving physics education at all levels.

4.8 Reports of the Physics Frontier Centers Program Subcommittee

Introduction
Physics Frontier Centers, while not considered “Centers” by the NSF definition, are designed to support large university-based groups to foster transformational advances in the most promising research areas. Based on competitions in 2001 and 2002, and the transfer of three pre-existing entities, there are now ten PFCs in the Physics portfolio. No new proposals were considered in the last three years due to the rather constrained growth in the overall budget of the Division.

General overview
Support for the ten PFCs amounts to about 10% of the total Physics Division budget. The support ranges from $1M to $4M per year. The Centers are designed to address the most exciting frontier areas in all branches of physics represented within the Division. NSF support is provided in the form of Cooperative Agreements with a five year duration. In some cases, based on reviews and site visits, extensions of these agreements have been granted in order to establish a regular review calendar. As a result, five of the PFCs will be up for competitive renewal this calendar year, the other five in 2009. This process is designed to assure that the most successful PFCs receive continued support. Due to budget constraints these competitions will not be equivalent as there will not be a call for new PFCs in the first round.

Centers and Individual Investigators
The PFC concept is based on the premise that the synergy created by the large group support results in added value as compared to spending the same resources on the core program. That some truly transformational frontier research requires the coordinated, often interdisciplinary group attack to catalyze breakthrough.

4.8.A Integrity and Efficiency of the Program Process and Management

4.8.A1 The effectiveness of the program’s use of the merit review procedure

Though no new proposals were considered, nor were there any competitive renewals in the last three years, a number of site visits were organized and held.

COV review of jackets

9 – including 2 declinations

Time to decision
Appropriate

Jacket documentation
Excellent in general. The quality of the Review Analysis improved significantly once one person was in charge of the program. A suggested improvement would be to include this analysis in the e-jacket instead of hardcopy.

No data available on the renewal rate as the program is going to have its first renewal competition this year.

4.8.A2 Program's Use of the new NSF Merit Review Criteria

Adequate

PFC's, probably more than the average grant in the core program, pay careful attention to all Merit Review Criteria, including broader impact, diversity, and educational contributions. In fact the PFC concept lends itself naturally to more focused attention to these considerations. These criteria were central to the site visits conducted last year at five of the PFC's

The major reviews that took place during FY2005 were the site visits to the five PFCs, the CTBP, COSM, the KICP, the CGWP, and FOCUS. As an outgrowth of each site visit, the visiting panel was asked to prepare a site visit report covering the following major topics: A. Research (Scientific Accomplishments to Date); B Impact of Center Structure (What did the Center accomplish that could not have been done without the Center? Is funding through the Center more effective than funding each participant individually would potentially have been? Has the Center begun to be identified as a Center rather than a collection of individuals? Do the Center members interact effectively? How are the postdocs and students impacted by the Center?); C. Education and Outreach (Postdoctoral Program, Graduate and Undergraduate Education, Service to the Scientific Community, Outreach to the Non-scientific Community; D. Management; and E. Facilities and Institutional Support. While items A and C directly relate to the first and second NSF merit review criteria, respectively, the additional items are specific to the Center nature of the project and become critical issues when considering the overall impact of the center mode of funding.

4.8.A3 Reviewer Selection

Adequate

4.8.A4 Resulting portfolio of awards

It is broad spanning all fields of Physics in the directorate. There are currently 10 PFC's in the portfolio:

Center for Theoretical Biological Physics (CTBP	University of California at San Diego
Center for Gravitational Wave Physics (CGWP)	Pennsylvania State University
Center for the Study of the Structure and Origin of Matter (COSM)	Hampton University
Kavli Institute for Cosmological Physics (KICP)	University of Chicago
FOCUS: Frontiers in Optical Coherent and Ultrafast Science	University of Michigan
Center for Magnetic Self-Organization in Laboratory and Astrophysical Plasmas (CMSO)	University of Wisconsin

Joint Institute for Nuclear Astrophysics (JINA)	University of Notre Dame
Kavli Institute for Theoretical Physics (KITP)	University of California at Santa Barbara
Center for Ultracold Atoms (CUA)	MIT/Harvard University
JILA	University of Colorado

As a group, the PFC's represent a stellar collection of outstanding clusters of leading scientists, including multiple Nobel laureates. The impact of the work carried out in the PFC's is expected to be profound.

Underrepresented groups

PFC's have active programs to increase the representation of underrepresented groups. Notable has been the establishment of PFCEON, a network among Education and Outreach Coordinators of all PFC's. Under the leadership of Michelle Larson of the Center for Gravitational Wave Physics, and Christopher Smith of the Center for Theoretical Biological Physics, PFCEON has put together a booth that was shown at the NSBP/NSHP meeting and at the meeting of the Soc. For Advancement of Chicanos and Native Americans last year.

One of the PFCs is the Center for the Study of the Origin and Structure of Matter (COSM) centered at Hampton University. Hampton University is one of the leading Historically Black Colleges and Universities (HBCUs) in the United States. COSMis committed to both the fulfillment of the educational goals of Hampton University and to outreach to other HBCUs as it advances minority participation in nuclear and particle physics research. Key activities at COSM include education through tutoring, summer student and postdoctoral programs, outreach, and a lecture series. The challenges faced by this PFC are large and the NSF is looking at these issues.

Funding trends

Funding for the individual PFC's have been stable for the last three years. The overall funding for the program increased by the transfer of the KITP, JILA, and CUA from the disciplinary units.

Program agility and content balance

The program covers just about the entirety of physics, with some emphasis on AMOP areas, which have undergone a remarkable revolution in the last decade. There is a good balance of theory and experiment.

4.8.A5 Management

NSF improved the management significantly when it put one effective person in charge of it.

The PFC's are closely managed using the Cooperative Agreement mechanism. There is a clear plan to compete them against each other and possible new proposals in groups of 5 every 6 years. Periodic site visits are organized to assess progress and potential weaknesses. Detailed annual reports provide additional periodic measures of productivity.

4.8.B Outputs and Outcomes of Program Investments

4.8.B1 PEOPLE

Public Exposure

A major activity launched in FY2005 is the development of a network among the Education and Outreach Coordinators of the ten PFCs. Although initially suggested by the NSF, the Deputy Director of the CGWP, Michelle Larson, has taken the lead in developing this group into an organization that has already begun to develop and execute plans for working together on specific projects and, what is especially important, for sharing ideas that work and don't work. Helped in great part by Christopher Smith, the EO Coordinator for the CTBP, the group has developed a PFC booth that they have already shown at the National Society of Black Physicists/National Society of Hispanic Physicists meeting in February of 2005 and at the meeting of the Society for Advancement of Chicanos and Native Americans (SACNAS) in Denver in the fall of 2006. The organization, which has named itself the PFCEON, meets monthly by telephone conference. Together with the Exploratorium in San Francisco the group is currently working on plans for procuring funding for development of museum exhibits highlighting the frontiers of physics research.

Workforce and Graduate Education

One of the original notions behind the PFC program was to foster the training of young physicists, first by attracting young people to the programs and then offering them the best training in the most exciting new areas of physics. Based upon the evidence of the site visits, the PFC program is succeeding in this area beyond even what had originally been imagined. On an ongoing basis, the bulk of the funds for any of the Centers, except for the KITP, which conducts a large number of workshops for the community, is dedicated toward the support of students and postdocs. None of the Physics Frontiers Centers distinguishes in practice those students and postdocs directly funded by the Center funds from students and postdocs who work with senior faculty associated with the Center. Rather, all students and postdocs are invited to participate in all activities of the Center. Large numbers of students supported by this program are exposed to a broader set of ideas and a much larger group of mentors than in the usual small-group or single PI setting. With the presence of a critical mass of students in many of these centers, new graduate courses in specialized areas are developed by the participants

Workforce and Undergraduate Education
Many undergraduates have joined in the effort (FOCUS, CUA, JILA, KICP, JINA)

4.8.B2 IDEAS

Discoveries

Laser wakefield acceleration of high-energy quasi-monochromatic electrons: (FOCUS A. Maksimchuk, V. Yanovsky, G. Mourou)

Progress towards acceleration of electrons with lasers continues with thirty femtosecond, 24 TW laser pulses from the Ti:sapphire Hercules laser focused using a f/12 parabolic mirror to an intensity of 6×10^{18} W/cm^2 and delivered to a supersonic He gas jet having electron density ranging from 1.5×10^{19} to 5.0×10^{18} /cm^3. As a result of the interaction, a quasi-monoenergetic electron beam was produced with energy above 200 MeV.

Ion Trapped in a semiconductor Chip *(FOCUS Monroe)*

This group of researches has created the smallest integrated chip trap for ions ever demonstrated and they have shown, against previous experience, very long times of motional coherence in the trap. The architecture that they have created permits to shuttle a single ion between to separate zones, a critical step towards the fabrication of complex quantum circuits on a single chip. The fabrication has been possible by a combination of semiconductor-MEMS technology with state of the art knowledge and understanding of ion traps. Future integrated chips will permit individual ions to be entangled and shuttled through complex electrodes that will form different quantum gates.

Photon recoil momentum in dispersive media. *(CUA Pritchard, Prentiss, and Ketterle)*

Experiments with Rb BEC have addressed experimentally a long standing question (Minkowsky-Abrahams) of what happens to an atom when it absorbs a photon within a medium with an index of refraction n. If one assumes that after absorbing the photon, no motion is left in the medium, then the recoil momentum should be $(h/2\pi)k$. However, the correct answer is that the atom will recoil with a momentum of $n(h/2\pi)k$, which requires particles in the medium to receive a backward momentum (for $n > 1$) due to the interaction of the oscillating dipole moments of the particles in the dispersive medium and the absorbing atom. This has important consequences for atom interferometers using optical waves to manipulate atoms by the transfer of recoil momentum. High precision measurements of the photon recoil are used to determine the fine structure constant α. The accuracy of the best photon recoil measurements are limited by the uncertainty in the correction to the photon recoil due to the index of refraction. The results show that the recoil momentum of atoms caused by the absorption of a photon is $n(h/2\pi)k$.

KICP --A new effort to search for particle dark matter, the Chicagoland Observatory for Underground Particle Physics (COUPP), made its debut at the end of 2004. A specialized bubble chamber sensitive to Weakly Interacting Massive Particles (WIMPs) has been developed by KICP Assistant Professor Juan Collar, postdoctoral fellow Dr. Andrew Sonnenschein and their graduate students and undergraduates.

JINA- New experiments show that ^{19}F is produced in hydrogen-helium burning shells during late stellar evolution of low mass stars. Accelerator studies of nuclear reactions on fluorine have been performed at the Notre Dame nuclear laboratory to simulate the stellar burning conditions. In particular the most important depletion reaction ^{19}F(α,p) has been measured over a wide energy range. Extensive computer simulations of stellar nucleosynthesis based on these data show that the observed fluorine is produced in 3-4 solar mass stars independent of the initial metallicity Z.

4.8.B3 TOOLS

Development of BEC, development of ion chips. Both JINA and KICP have wonderful web sites documenting the research, educational and outreach components. They are easy to navigate and provide comprehensive information.

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4.8.C Other Topics

4.8.C2 Comments on the program's performance in meeting program specific goals and objectives not covered by the above question

There are three groups of PFCs. The three longstanding ones that have been folded into centers have a record of major contribution to science. The next group of centers was approved in 2001 and the final ones in 2002. In the latter two groups of centers there are many innovative, successful outreach and educational activities that would not have happened without the PFC. The situation with research is a little less clear for two reasons. First, some of the centers are newly formed and it may be too early to judge the level of success. The second factor raises some issues about what is expected from PFCs. Should they be doing research that could only be done if the PFC was formed or should they be viewed as places that stimulate and synergize research? In several instances research claims by a center were also claimed by grantees in other programs. If the purpose of the PFC is to stimulate cooperation and collaboration that would be viewed as a great success, but if the result is supposed to have happened only because of the PFC exists it might be viewed that the PFC is just supplementing existing grants. This is an issue that might be clarified by the NSF and might be asked of PFCs on site visits.

4.8.C3 Agency-wide issues that should be addressed by NSF to help improve the program's performance.

It is too early in the process of the PFCs to tell, but the selection of the centers was done well.

Appendix A Committee

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Appendix B Agenda

Division of Physics
Committee of Visitors
January 25 – 27, 2006
Agenda

Wednesday, January 25 - Room 555 II

7:30 am	Continental Breakfast
8:00 am	Welcome and Charge to Committee of Visitors (COV) Michael S. Turner, Assistant Director, Directorate for Mathematical and Physical Sciences (MPS)
8:20 am	Introductory Remarks Luis Orozco, Chair, COV
8:40 am	PHY Overview, Priorities, and Directions Joe Dehmer, Director, Division of Physics (PHY)
10:00 am	Break
10:30 am	COV Guidelines Morris Aizenman, Senior Science Associate, OAD/MPS
11:00 am	Response to 2003 COV Report and Instructions for Breakout Sessions – Joe Dehmer, Luis Orozco
11:45 am	Demonstration on the Use of the NSF E-jacket System (Optional)
12:00 pm	Lunch
1:00 pm	Review of Individual PHY Programs (Move to Breakout Rooms) Overview of Program – Program Directors (30 minutes) Examination of Jackets to Address ▪ Integrity and Efficacy of Program Processes for Proposal Actions ▪ Quality and Significance of the Results of Program Investments ▪ Relationship to Foundation-wide Programs and Strategic Goals
5:30 pm	Adjourn for Informal Reception in Room 1020

Thursday, January 26

7:30 am	Continental Breakfast (Room 1020)
8:00 am	Review of Individual PHY Programs (Continued in Breakout Rooms)
10:00 am	Preparation of Individual Program COV Reports
12:00 pm	Working Lunch
2:00 pm	Break and Distribution of Individual Program COV Reports
2:30 pm	Presentation of COV Reports by Program COV Chairs (Room 555 II)
4:30 pm	Introduction to Division-Level Review – Joe Dehmer
5:30 pm	Adjourn

Friday, January 27 - Room 555-II

7:30 am Continental Breakfast (Room 555 II)

8:00 am Division-Level Review - Continued

- Division's Processes, Results, and Relationship to NSF Goals
- Division's Balance, Priorities, and Future Directions
- Any Other Issues the COV Considers Relevant to the Review

10:30 am	Preparation of Division-Level Report
12:00 pm	Working Lunch:
2:00 pm	Complete Draft of Division-Level Report
2:30 pm	Closeout Session with AD/MPS and PHY Staff
3:00 pm	Adjourn

Appendix C Charge

NATIONAL SCIENCE FOUNDATION
4201 Wilson Boulevard, Arlington, Virginia 22230

Office of the Assistant Director
Mathematical and Physical Sciences

December 2, 2005

Dr. Luis A. Orozco
Department of Physics
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Dear Dr. Orozco,
Thank you for agreeing to chair the 2006 Committee of Visitors (COV) for the Division of Physics (PHY). The COV Review will take place at the NSF in Arlington, Virginia, on January 25 - 27, 2006. The COV is an *ad hoc* subcommittee of the Mathematical and Physical Sciences Advisory Committee (MPSAC).

By NSF policy, each program that awards grants and cooperative agreements must be reviewed at three-year intervals by a COV comprised of qualified external experts. NSF relies on their judgment to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. Reports generated by COVs are used in assessing agency progress in order to meet government-wide performance reporting requirements, and are made available to the public. The COV is charged to address and prepare a report on:

- the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions;
- the relationship between award decisions, program goals, and Foundation-wide programs and strategic goals;
- the quality and significance of the results of the Division's programmatic investments;
- the Division's balance, priorities, and future directions;
- any other issues that the COV feels are relevant to the review.

Decisions to award or decline proposals are ultimately made by NSF staff, based on evaluations by qualified reviewers who reflect the breadth and diversity of the proposed activities and the community. Systematic examination by the COV of a wide range of funding decisions by the COV provides an independent mechanism for monitoring and evaluating the overall quality of the Division's decisions on proposals, program management and processes, and results.
The review will assess operations of individual programs in PHY as well as the Division as a whole for three fiscal years: FY 2003, FY 2004, and FY 2005. The PHY programs under review include:

- Atomic, Molecular, Optical, and Plasma Physics
- Elementary Particle Physics
- Gravitational Physics and LIGO
- Nuclear Physics
- Particle and Nuclear Astrophysics
- Theoretical Physics
- Education and Interdisciplinary Research.
- Physics Frontier Centers (PFCs)

I would be particularly interested in your comments on how the Division reviews and competes large activities, including large group grants and the PFCs. The NSF has recently refined the definition of what constitutes an NSF Center (see attached), and the PFCs do not satisfy these criteria. Your advice on how these activities might be reviewed and competed in the future would be appreciated.

The general outline of the meeting will be an introductory session in which the Division Director, Joe Dehmer, will present an overview of the Division's activities, priorities, and directions and information on overall trends and procedures. Following this session, the COV will break into subpanels for each program to examine program documentation and results and to prepare program-level review reports. This is expected to take most of the first two days of the meeting. On the third day, there will be review of the Division as a whole and preparation of a Division-level report, based on the program-level reports and other material as appropriate.

Drafts of the program-level reports and the Division-level report will be completed during the COV meeting. I ask that you finalize and submit the full report by February 17 to allow time for comment and distribution of the report to the full MPSAC prior to their meeting on April 6 - 7, 2006.

Joe Dehmer (703-292-7370, jdehmer@nsf.gov) will send you an agenda and background information to assist you in conducting this review 3 - 4 weeks prior to the meeting. Please feel free to contact Joe or Pat Bautz, PHY Executive Officer, (703-292-7211, lbautz@nsf.gov) if you have questions about the review. The PHY Division Secretary, Denise S. Henry (703 - 292-7386, dshenry@nsf.gov), will contact you shortly with information about making travel and hotel arrangements.

Thank you again for your willingness to participate in this important activity. I look forward to seeing you at the meeting.
Sincerely,

Michael S. Turner
Assistant Director
Enclosures: List of Members of PHY COV 2006
NSF Centers Definition
cc: Dr. W. Carl Lineberger, Chair MPSAC

CORE QUESTIONS and REPORT TEMPLATE
for
FY 2006 NSF COMMITTEE OF VISITOR (COV) REVIEWS

Guidance to NSF Staff: This document includes the FY 2006 set of Core Questions and the COV Report Template for use by NSF staff when preparing and conducting COVs during FY 2006. Specific guidance for NSF staff describing the COV review process is described in Subchapter 300-Committee of Visitors Reviews (NSF Manual 1, Section VIII) that can be obtained at <www.inside.nsf.gov/od/oia/cov>.

NSF relies on the judgment of external experts to maintain high standards of program management, to provide advice for continuous improvement of NSF performance, and to ensure openness to the research and education community served by the Foundation. Committee of Visitor (COV) reviews provide NSF with external expert judgments in two areas: (1) assessments of the quality and integrity of program operations and program-level technical and managerial matters pertaining to proposal decisions; and (2) comments on how the results generated by awardees have contributed to the attainment of NSF's mission and strategic outcome goals.

Many of the Core Questions are derived from NSF performance goals and apply to the portfolio of activities represented in the program(s) under review. The program(s) under review may include several subactivities as well as NSF-wide activities. The directorate or division may instruct the COV to provide answers addressing a cluster or group of programs – a portfolio of activities integrated as a whole – or to provide answers specific to the subactivities of the program, with the latter requiring more time but providing more detailed information.

The Division or Directorate may choose to add questions relevant to the activities under review. NSF staff should work with the COV members in advance of the meeting to provide them with the report template, organized background materials, and to identify questions/goals that apply to the program(s) under review.

Guidance to the COV: The COV report should provide a balanced assessment of NSF's performance in two primary areas: (A) the integrity and efficiency of the ***processes*** related to proposal review; and (B) the quality of the ***results*** of NSF's investments that appear over time. The COV also explores the relationships between award decisions and program/NSF-wide goals in order to determine the likelihood that the portfolio will lead to the desired results in the future. Discussions leading to answers for Part A of the Core Questions will require study of confidential material such as declined proposals and reviewer comments. *COV reports should not contain confidential material or specific information about declined proposals.* Discussions leading to answers for Part B of the Core Questions will involve study of non-confidential material such as results of NSF-funded projects. The reports generated by COVs are used in assessing agency progress in order to meet government-wide performance reporting requirements, and are made available to the public. Since material from COV reports is used in NSF performance reports, the COV report may be subject to an audit.

We encourage COV members to provide comments to NSF on how to improve in all areas, as well as suggestions for the COV process, format, and questions. For past COV reports, please see http://www.nsf.gov/od/oia/activities/cov/covs.jsp.

FY 2006 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

The table below should be completed by program staff.

Date of COV:			
Program/Cluster/Section:			
Division:			
Directorate:			
Number of actions reviewed:	**Awards:**	**Declinations:**	**Other:**
Total number of actions within Program/Cluster/Division during period under review:	**Awards:**	**Declinations:**	**Other:**
Manner in which reviewed actions were selected:			

PART A. INTEGRITY AND EFFICIENCY OF THE PROGRAM'S PROCESSES AND MANAGEMENT

Briefly discuss and provide comments for *each* relevant aspect of the program's review process and management. Comments should be based on a review of proposal actions (awards, declinations, and withdrawals) that were *completed within the past three fiscal years*. Provide comments for *each* program being reviewed and for those questions that are relevant to the program under review. Quantitative information may be required for some questions. Constructive comments noting areas in need of improvement are encouraged.

A.1 Questions about the quality and effectiveness of the program's use of merit review procedures.
Provide comments in the space below the question**.** Discuss areas of concern in the space provided.

QUALITY AND EFFECTIVENESS OF MERIT REVIEW PROCEDURES	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[1]
1. Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments:	Yes

[1] If "Not Applicable" please explain why in the "Comments" section.

2. Is the review process efficient and effective? Comments:	Yes
3. Do the individual reviews (either mail or panel) provide sufficient information for the principal investigator(s) to understand the basis for the reviewer's recommendation? Comments:	Yes
4. Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments:	Yes
5. Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments:	Yes
6. Is the time to decision appropriate? Comments:	Yes
7. Additional comments on the quality and effectiveness of the program's use of merit review procedures: The merit review is working very well. This shows in the excellent quality and significance of the science produced with the investments of the NSF. If possible provide the PI with a summary of the review analysis	

A.2 Questions concerning the implementation of the NSF Merit Review Criteria (<u>intellectual merit</u> and <u>broader impacts</u>) by reviewers and program officers.

Provide comments in the space below the question. Discuss issues or concerns in the space provided.

IMPLEMENTATION OF NSF MERIT REVIEW CRITERIA	YES, NO, DATA NOT AVAILABLE, or NOT APPLICABLE[2]
1. Have the individual reviews (either mail or panel) addressed both merit review criteria? Comments:	Yes
2. Have the panel summaries addressed both merit review criteria? Comments:	Yes
3. Have the *review analyses* (Form 7s) addressed both merit review criteria? Comments:	Yes
4. Additional comments with respect to implementation of NSF's merit review criteria: This COV sees a significant improvement on the use of Merit criteria 2 compared to previous COV's. It commends the division staff for their work in explaining it to the general community, those writing proposals and those reviewing. We recommend continuing with the effort to inform the community of the need to understand both criteria well when writing a proposal and when reviewing a proposal.	

[2] In "Not Applicable" please explain why in the "Comments" section.

A.3 Questions concerning the selection of reviewers. Provide comments in the space below the question. Discuss areas of concern in the space provided.

SELECTION OF REVIEWERS	**YES , NO, DATA NOT AVAILABLE, or NOT APPLICABLE**[3]
1. Did the program make use of an adequate number of reviewers? Comments:	Yes
2. Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments:	Yes
3. Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups?[4] Comments:	Yes
4. Did the program recognize and resolve conflicts of interest when appropriate? Comments:	Yes
5. Additional comments on reviewer selection:	

[3] If "Not Applicable" please explain why in the "Comments" section.
[4] Please note that less than 35 percent of reviewers report their demographics last fiscal year, so the data may be limited.

A.4 Questions concerning the resulting portfolio of awards under review. Provide comments in the space below the question. Discuss areas of concern in the space provided.

RESULTING PORTFOLIO OF AWARDS	APPROPRIATE, NOT APPROPRIATE[5], OR DATA NOT AVAILABLE
1. Overall quality of the research and/or education projects supported by the program. Comments:	Appropriate
2. Are awards appropriate in size and duration for the scope of the projects? Comments: Given the budget constraints.	Appropriate
3. Does the program portfolio have an appropriate balance of: • Innovative/high-risk projects?[6] Comments:	Appropriate
4. Does the program portfolio have an appropriate balance of: • Multidisciplinary projects? Comments:	Appropriate
5. Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments: The COV recommends to keep the individual investigator awards above 55%, while the PFC not more than 10%	Appropriate
6. Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments:	Appropriate

[5] If "Not Appropriate" please explain why in the "Comments" section.
[6] For examples and concepts of high risk and innovation, please see Appendix III, p. 66 of the Report of the Advisory Committee for GPRA Performance Assessment, available at <www.nsf.gov/about/performance/acpga/reports.jsp>.

7. Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments:	Appropriate
8. Does the program portfolio have an appropriate balance of: • Institutional types? Comments:	Appropriate
9. Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments:	Appropriate
10. Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments:	Appropriate
11. Does the program portfolio have appropriate participation of underrepresented groups? Comments: The COV encourages the Physics Division to actively continue to increase the participation of underrepresented groups. The participation of women as PI or CoPIs has crossed 15% and we would like to see it grow more; however, other numbers should be higher the current level.	Appropriate
12. Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments:	Appropriate
13. Additional comments on the quality of the projects or the balance of the portfolio: The science produced by the division is superb. It is helping form the next generation of physicists with extraordinary resources to face the challenges of the XXI century.	

A.5 Management of the program under review. Please comment on:

1. Management of the program. Comments: The COV gives its highest marks to the staff of the Division of Physics. They have been able to keep an exciting program during three years of severe financial constraints.
2. Responsiveness of the program to emerging research and education opportunities. Comments: The division has responded to research in biological physics and in physics at the information frontier. There are now separate programs in these areas and the next COV should look at their development. The Particle and Nuclear Astrophysics program and the Physics Frontiers Centers have been able to consolidate during these three years. The division is seeking a way to partially respond to research needs for instrumentation above 2M$ with the Accelerator Physics and Physics Instrumentation. The APPI does not address the needs from individual PI's for instrumentation between 100K$ and 2M$ that do not fit in the MRI.
3. Program planning and prioritization process (internal and external) that guided the development of the portfolio. Comments: The Division of Physics is very well informed on the external advisory planning groups for the different programs. The scientific priorities derived from the National Science Board and the National Research Council have set the framework to foster the high quality of science supported by the Foundation.
4. Additional comments on program management: The staff in the Division is overloaded and we are happy to hear that some new positions will open for permanent staff. The institutional memory must be preserved. This requires attention to the balance between rotators and permanent staff. The Division has responded well to initiatives and mandated programs, but sometimes these programs take a large effort on the part of the staff. They need assistance to assure the excellence they have achieved.

PART B. RESULTS OF NSF INVESTMENTS

NSF investments produce results that appear over time. The answers to the first three (People, Ideas and Tools) questions in this section are to be based on the COV's study of award results, which are direct and indirect accomplishments of projects supported by the program. These projects may be currently active or closed out during the previous three fiscal years. The COV review may also include consideration of significant impacts and advances that have developed since the previous COV review and are demonstrably linked to NSF investments, regardless of when the investments were made. Incremental progress made on results reported in prior fiscal years may also be considered.

The following questions are developed using the NSF outcome goals in the NSF Strategic Plan. The COV should look carefully at and comment on (1) noteworthy achievements of the year based on NSF awards; (2) the ways in which funded projects have collectively affected progress toward NSF's mission and strategic outcomes; and (3) expectations for future performance based on the current set of awards. NSF asks the COV to provide comments on the degree to which past investments in research and education have contributed to NSF's progress towards its annual strategic outcome goals and to its mission:

- To promote the progress of science.
- To advance national health, prosperity, and welfare.
- To secure the national defense.
- And for other purposes.

Excellence in managing NSF underpins all of the agency's activities. For the response to the Outcome Goal for Organizational Excellence, the COV should comment, where appropriate, on NSF providing an agile, innovative organization. Critical indicators in this area include (1) operation of a credible, efficient merit review system; (2) utilizing and sustaining broad access to new and emerging technologies for business application; (3) developing a diverse, capable, motivated staff that operates with efficiency and integrity; and (4) developing and using performance assessment tools and measures to provide an environment of continuous improvement in NSF's intellectual investments as well as its management effectiveness.

B. Please provide comments on the activity as it relates to NSF's Strategic Outcome Goals. Provide examples of outcomes (nuggets) as appropriate. Examples should reference the NSF award number, the Principal Investigator(s) names, and their institutions.

B.1 <u>OUTCOME GOAL for PEOPLE</u>: Developing "a diverse, competitive and globally engaged workforce of scientists, engineers, technologists and well-prepared citizens."

Comments:
Outstanding

B.2 <u>OUTCOME GOAL for IDEAS</u>: Enabling "discovery across the frontier of science and engineering, connected to learning, innovation, and service to society." Comments: Outstanding
B.3 <u>OUTCOME GOAL for TOOLS:</u> Providing "broadly accessible, state-of-the-art S&E facilities, tools and other infrastructure that enable discovery, learning and innovation." Comments: Outstanding
B.4 <u>OUTCOME GOAL for ORGANIZATIONAL EXCELLENCE</u>: Providing "an agile, innovative organization that fulfills its mission through leadership in state-of-the-art business practices."[7] Comments: Outstanding

[7] For examples and further detail on the Organizational Excellence Goal, please refer to pp. 19-21 of NSF's Strategic Plan, FY 2003-2008, at <http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf04201>.

PART C. OTHER TOPICS

C.1 Please comment on any program areas in need of improvement or gaps (if any) within program areas.

C.2 Please provide comments as appropriate on the program's performance in meeting program-specific goals and objectives that are not covered by the above questions.

The COV wants to make sure that the division continues its commitment to many exciting facilities which are defining new programs in their fields. The COV wants to be assured that the operations of these large facilities will be funded by the Foundation without compromising the base programs in the Division. As the 2003 COV recommended there has to be a concrete public plan.

C.3 Please identify agency-wide issues that should be addressed by NSF to help improve the program's performance.

The COV warns that the experience of RSVP should not be repeated. To do big projects well, NSF must include adequate up-front engineering support for realistic project cost estimates, include independent up-front project management support, include operations cost in budget and planning ("life cycle costs"), and work closely from the start with any other agencies that provide infrastructure or resources.

C.4 Please provide comments on any other issues the COV feels are relevant.

The balance between base program (more than 55%) and PFCs (less than 10%) should be maintained. The PFC is a very successful program and should continue with competition for award renewal and, when funds are available, should grow in number through a solicitation. The value added should always be present in those proposals and their scientific excellence should permit high risk investigations. The current structure for the operation and management of the PFC's is appropriate. COV restates that if the Division budget expands, the highest priority should be given to nourishing the base investigator program that has suffered in recent years.

The COV is disappointed not to have had the opportunity to evaluate the DUSEL initiative due to legal issues.

C.5 NSF would appreciate your comments on how to improve the COV review process, format and report template.

- **Keep the statistics over 10 year period not just for the division but for the programs.**
- **Availability of the materials several weeks before the meeting.**
- **Uniform accessibility to the electronic files.**
- **Try to get started on the jackets earlier.**

- **Conference call to explain web site, process, and charge.**
- **Use of fastlane interactive panel system (submit comment feature) to create reports.**

SIGNATURE BLOCK:

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For the Committee of Visitors of the Division of Physics
Luis A. Orozco
Chair