Report of the Committee of Visitors

to the Division of Physics

National Science Foundation

February 26-28, 2003

1 Introduction

The Committee of Visitors (COV) for the Division of Physics met for three days February 26-28, 2003 to review actions taken on proposals handled by the Division during the years 2000, 2001, and 2002, 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. John Hunt, Acting Assistant Director. The COV was charged to address:

- the integrity and efficacy of processes used to solicit, review, recommend, and document proposal actions;
- the quality and significance of the results of the Division's programmatic investments;
- the relationship between award decisions, program goals, and Foundation-wide programs and strategic goals;
- 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
- Elementary Particle Physics
- Gravitational Physics and LIGO
- Nuclear Physics
- Particle and Nuclear Astrophysics
- Theoretical Physics
- Education and Interdisciplinary Research
- Physics Frontier Centers

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

Briefly, the review process proceeded as follows: Prior to the meeting, members of the COV were provided with the Division's annual report for FY 2000, FY2001 and FY2002, background information and statistical data on the individual programs, and the previous COV report covering 1997, 1998, 1999.

The week before the meeting approximately 30 members of the COV held a telephone conference call for 90 minutes to highlight issues for the review and to organize the leadership of the subgroups.

The meeting began with a set of presentations given by the directors of the various programs, taking the first morning and part of the first afternoon. During, 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. The COV enjoyed full access to any packet desired and appreciates the openness and helpful efforts of the NSF program directors and staff. Typically each COV member studied about eight jackets thus giving all COV members a reasonable sampling of Division activities.

The afternoon of the second day was taken with preparation of the subgroup reports and sessions of the full COV to review the subgroup reports. 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.

On the morning of the third day, the COV met with Dr. Dehmer to discuss the issues that were identified the previous day. The COV then reviewed and summarized its work In the afternoon, a "closeout" session with Dr. Hunt and the Division staff was held.

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 Committee wishes to thank the administrative support staff of the Division for its help and hospitality throughout this review. We would also like to express our appreciation to the Program Directors and the Division Director for their openness and candor in discussing their own performance and that of the Division. As was the case with the previous COV, this Committee is impressed with the competence, enthusiasm, dedication, and cooperation that we observed throughout the Division, and we commend the entire staff for its fine work.

2 General Conclusions

The major conclusion of the COV is that the division is successful in its performance as it pursues the major goals of the division and NSF. The integrity and efficiency of processes are excellent. In particular we applaud the use of target dates for proposal submission and the increased use of panels throughout the program. The panels are being effectively used to augment the review process.

The quality and significance of the results of the programmatic investments is excellent. Extraordinary science is produced and there are excellent investments in tools for the science of the future. A diverse, globally-oriented workforce of scientists and engineers is one of the results of the NSF investments. We feel that the turnover rate for grant renewals and the threshold set for proposal success are appropriate throughout the division programs.

In general, we see the division as flexible and responsive to emerging trends and needs. Two new programs were started in the period we were reviewing, the program in Particle and Nuclear Astrophysics and the Physics Frontiers Centers. Both are off to an excellent start.

We are pleased to see that the Physics Division is following the advice of the previous COV and has established a new program in biological physics. Progress in biological physics inevitably leads to advances in other fields from biophysics and biochemistry to biology, pharmacology and medicine by providing the quantitative underpinning and new techniques. Close interaction with these other fields is important and the Physics Division has already been successful in forging many of the relevant connections. At present, the biological physics topics supported by the Physics Division are narrow and the number of grants is small. A workshop called by the Physics Division could help define the scope of biological physics, suggest new opportunities, and propose ways to attract more applications.

In addition we heard of nascent plans for a program to support mid-scale instrumentation in the $2-$100M range that falls between the MREFC and MRI programs of the Foundations. This new program would include R&D in accelerator science. We felt that this new program would target an essential need in the community and we support it strongly. We do however see a window of opportunity in the range between 100K$ and 2M$ for a program to support equipment for individual investigators as equipment gets more expensive.

We note the excellent job being done by program officers in all programs of the division. We give very high marks for the outstanding management of the program and the division under difficult conditions resulting from a decade of flat budgets and a critical shortage of staff at time when the diversity and breadth of the portfolio is expanding.

Many examples of significant results from NSF investments are contained in the subcommittee reports and we list below a (somewhat arbitrary sampling):

AMOP -

Following the successful demonstration of Bose-Einstein condensation in dilute atomic gases at JILA, a flurry of experiments have taken place. Matter wave analogues of bright solitons have been studied (Rice). Several groups have created dense, controllable Fermi degenerate gases in ultracold half-integer-spin isotopes of potassium and lithium (Rice, Duke, MIT) – the fermi system provides an important test-bed for exploring the behavior of fermions in a regime where the temperature at which pairing occurs can be adjusted relative to the Fermi temperature. And, in 2001, the Nobel Prize in Physics went to NSF funded researchers Cornell and Weiman (JILA) and Ketterle (MIT).

EPP -

The grid projects iVDGL and GriPhyN, together with the Particle Physics Data Grid (PPDG) has recently coalesced into the single umbrella project Trillium, an event that promises to have wide-ranging impact, perhaps as sweeping as that of the world wide web. Important advances are 1) the achievement of interoperability between US and European Grid projects and 2) the establishment of several grid test beds (ATLAS, CMS, LIGO, SDSS, DØ, Star, Jlab).

Gravitation Physics -

LIGO made its first "science" data-taking run for two weeks in 2002, and scientists of the LSC have analyzed the data for upper limits on four kinds of possible gravitational wave sources: coalescences of compact-object binary stars, spinning pulsars, a stochastic background of gravitational waves from the Big Bang, and unstructured bursts that might come from supernova explosions. While no detections were expected or made, since LIGO is still in its commissioning phase, these are in some cases the best upper limits that have so far been placed on such sources.

NCIC

In an experiment at Brookhaven, the anomalous magnetic moment of the muon has been determined far more precisely than ever before. The result is in disagreement with standard model expectations at the two-sigma level. The results have stimulated considerable interest, including the suggestion that one might be seeing a hint of super symmetry.

Theoretical Physics
Researchers have proposed that if extra dimensions are large, of the order of millimeters, TeV scale black holes can be produced in collisions. They estimate a production rate of 10^7 per year. The holes would radiate symmetrically with a Planck spectrum. If this prediction holds, it will be possible to determine the Hawking Temperature. PHY-9870115, PHY-0098840, PHY-0070787.

PNA
The AMANDA-IIB detector, operating as the pioneering, very high energy neutrino experiment utilizing the South Pole ice as a detecting medium, has set the most restrictive bound on diffuse fluxes of extraterrestrial neutrino fluxes.

There were several issues that the COV felt important to highlight as the Division moves forward.

The Division is committed to many exciting new facilities (LIGO, LHC, RSVP, ICECUBE) which are defining new programs in their fields. The COV raised concerns about how the operations of these large facilities will be funded by the Foundation without damaging the base programs in the Division. We felt that there needs to be an agency wide plan to support the operations of these large facilities.

The danger of not having a plan to manage the operations of large facilities on a foundation wide basis was evident in FY2002 which was the first year that LIGO operations funding was needed. Significant damage was done to the individual investigator program problem, partially as a result of the need to support LIGO operations from the base. The community lost some confidence in the NSF as a result of the severe measures that had to be taken. We support the draconian choices that the Division had to make in FY2002, but feel it is imperative to ensure that such a situation does not arise again. We see promising moves within the foundation to mitigate the problem and provide full life cycle planning for large projects.

The COV noted that within the Physics Division there are examples of a concerted effort to reach out to underrepresented groups. The demographics of the COV is but one example. However we noted that the efforts of the Division in this regard have been met with limited success although some improvement in the numbers of women and minorities is seen. The Division needs to look at the measures and programs that are targeting this difficult problem to make sure that the goals are clear and that there is rigorous assessment to see if the programs are effective.

Each subprogram looked at the awards in the CAREER program. While the subprogram reports contain individual program issues, there is a general sense that the goals of the CAREER program needed some rethinking or at least some clarification, especially considering the status the grants are accorded in the academic community. Furthermore, we encourage the Division to reconsider how the awards are competed so that unsuccessful applicants are not at a disadvantage in the regular grant awarding process.

In all programs in the division we heard that there is inconsistent use of criterion 2 in reviewing the proposals. This was an issue raised by the last COV. Over the course of the period we reviewed we could see improvement. However the expectation for criterion 2 is still not effectively communicated to the reviewers and the proposers. We did note that as the review process comes more in the purview of the Program Officers, for example in the panels, there was more sensitivity and attention paid to criterion 2. We attributed this to the interaction between the Program Officers and the panels. In addition, we felt that the potentially very important impact of criterion 2 on the Division programs and perhaps even Foundation wide was not being assessed effectively.

Within the Foundation and Division there has been a significant increase in the number of mandated programs and new opportunities for funding. Furthermore, large projects and initiatives are being undertaken that need significant oversight from the Program Officers. Some of the programs in the Division have 50% or more of their resources in non-base programming. The management of these diverse portfolios requires significant oversight. The staff in the division are overloaded and we are concerned. We feel that significant assistance is needed to assure continued excellence in the program.

Examples where we felt the staffing shortage was beginning to impact Division programs are:

- We felt that the EIR program has effectively and productively interfaced with other division programs in support of the education mission of the Division and the Foundation, but a reduction in full time staff in this area will hinder this important function. Additional staffing with a full time presence at NSF would be justified.
- To effectively encourage underrepresented minorities to participate in Division programs requires significant time on the part of the Program Officers for encouragement and mentoring. Currently the Program Officers are not able to do that.
- The large number of ITR proposals is placing a significant burden on the Theory program, making it very difficult to maintain the high quality of the program.
- The LHC project involves management and coordination that is international, interagency and interdivision in scope. We do not see the necessary resources in the Division to continue to accomplish this effectively as other large projects (for example, RSVP) are initiated.

A final issue that the COV wished to raise is that we anticipate that the Physics Division, along with the entire NSF, may be poised to see significant budget growth in the coming years. We believe that such an investment, particularly in the physical sciences, is long overdue. The strong conviction of the COV is that as the Division budget expands, it is imperative that the highest priority be given to nourishing the base investigator program which has been consistently eroding for over a decade. Most investigator grants are funded at levels inadequate to accomplish their scientific and societal goals efficiently and effectively. Notable examples are the inadequate level of graduate student or postdoc support per PI, the inadequate level of support for technical infrastructure, and the need for investigators to pursue multiple grants to accomplish their research.

We consistently agreed that, given current funding levels, appropriate choices are being made in thresholds for funding and not funding grants, but in reading through the folders, we noted excellent opportunities that remained unfunded at the decision borderline.

3 Priorities, Balance, and Strategy

The Physics Division management is well informed and responsive to new developments in the programs it manages. In our evaluation of the scientific priorities of the Division, we note that the combination of the National Science Board and the National Research Council set the highest of standards for the quality of the science produced and that the NSF in this way is a model for all other agencies.

The effectiveness of the community input in helping to set scientific priorities varies among the programs in the Division. There are well established mechanisms for EPP (HEPAP) and Nuclear Physics (NSAC) whereby in partnership with the DOE, priorities are set for those fields and the NSF is a full partner in the process. However we see that such priority setting is becoming more important in other fields as well, AMOP is a good example, as resources from base programs are directed to collective efforts such as Physics Frontier Centers. Sub-fields other than EPP and NP do not have a mechanism to set priorities in their field. The Physics Division could start a dialogue with the leaders in these fields to explore if they are interested in setting up mechanisms similar to HEPAP and NSAC.

In any priority setting there can be tension between the scientific priorities of the community and the goals of the agency. As an example, in EPP where large projects such as LHC or a future Linear Collider are the highest priority of the field, there is understandable concern that in such large projects, the NSF investment needs sufficient visibility. We acknowledge these thorny issues exist. We were pleased to hear of the establishment of an Interagency Working Group with NSF, DOE and NASA participation that we feel is a very productive forum for working out issues of this sort.

The COV supports the balance in the Physics Division between the Individual Investigator Program, support of facilities, and the centers (including PFCs). The Physics Frontier Centers (PFC) Program is very new and is in a growth phase. While it is definitely too early to comment on the overall effectiveness of the centers, the COV did look carefully at the current status of this new program, and has several comments on this new Physics Division program. In the opinion of the COV, two essential features of any PFC must be a demonstrable synergism in the center, and a program mix shifted toward higher risk activities than characterizes single investigator grants. It is in these aspects that PFCs broaden the research activities of the Division of Physics.

We commend the physics division for initiating the Physics Frontier Center program. The Division leadership views establishment of such centers as an important component of the overall stewardship of physics, and the COV concurs with this view. Interdisciplinary research activities, as well as opportunities for fostering collaboration within a sub-field clearly have potential to strengthen the programs both from within, as well as through interactions with other scientific disciplines.

In the first call for proposals a large number of pre-proposals were received and, following panel review, some 14 were selected for preparation of full proposals. We found that the quality of the proposals submitted was very high, both in terms of their scientific impact and quality of the PIs. A number of the proposals were excellent in those areas that characterize a center, and several were funded. In some cases, proposed research that was characterized by superlatives such as "fabulous" was not funded, because the reviewers were not convinced of the requisite synergy in the center. This is exactly the result that one hopes to achieve.

The PFC program was initiated in a year in which there were large, unanticipated demands on the Physics Division budget. The Division has wisely decided to stretch out the time scale of future PFC competitions, to allow time to assimilate these new activities. The COV strongly endorses this decision, and adds that the actual number of PFCs must be determined by the intellectual need for the centers.

One important issue concerning PFCs is that the physics community at large has not been brought along philosophically with the goals and potential for this program. The understandable nervousness about what impact this will have on individual PI grants manifests itself in several ways and appears to go somewhat against the attempts of the Physics division to carry out its Stewardship responsibility. The COV recommends that the Division leadership engage the community in discussions of the PFC program and objectives, in order to address these concerns. It is possible that some modification of this program might emerge from these discussions. Such discussions could well be a part of an examination of the PFC program that could be completed before the next round of center competition, in 2005.

To complete our discussion of balance, we reiterate that in our discussions of balance, the single largest issue requiring management attention is the facility operations since if that is required to come out of the Physics Division base, there is no way that a healthy balance in the Division can be maintained.

Finally we comment on the COV process itself. We all found the process informative, educational and well worth our efforts of participation. Some suggestions to help make the process even more effective:

- We needed more time for the discussion of Division level issues.
- We needed more time for reading jackets and felt that less time could have been spent on the presentations the first day.
- The teleconference the week in advance of our meeting was very helpful and future COVs might consider emulating that.
- We would have appreciated copies of some of the national planning documents (e.g. Quarks to the Cosmos) available.
- We would have appreciated some 10 year trend statistics, ideally in advance of the meeting. Some obvious examples are funding trends, ratios of award to request by program, fraction of proposals from underrepresented minorities, etc.

- Finally we felt that the process might have more continuity if there was a bit more overlap with previous COVs and in particular if the chair of the COV had participated in a previous panel.

4 Reports of the Program Subcommittees

4.1 Atomic, Molecular, Optical, and Plasma Subcommittee Report

The AMOP physics program can be characterized as physics at the "eV" scale. It is a multifaceted program including traditional forms of atomic and molecular physics yet spanning such diverse topics as precision measurement, quantum optics including quantum informatics, collisional physics, fundamental plasma physics, physics of ultracold vapors and degenerate systems such as BECs. In the AMO portion of the AMOP program, the NSF is the primary funding source for American scientists. In the P portion of the AMOP program, the Foundation funds a large share of the Nation's fundamental plasma studies, while the field as a whole also enjoys funding from other sources, dominantly the DOE.

A Renaissance in AMO Physics

Over the last decade or so, the field of AMO physics has undergone a renaissance and continues to experience rapid evolution and growth. Developments in the field are driven, primarily, by the coherent sources of light (lasers) and coherent sources of matter (ultracold atoms and BEC) that allow astonishing control of the internal and external states of atoms and molecules. Against this backdrop, the AMOP program at the Foundation has been agile in responding to these developments and the CoV finds that the program's research portfolio has logically developed so as to capture both the excitement and intensity of activities within the field.

Many universities have recognized the accomplishments and the promise of AMOP science and are making new or renewing previous investments in the field. Indeed over the last 5 years we estimate that more than 40 positions in AMO physics alone have been filled at American Universities. The NSF Division of Physics must position itself so that the new ideas generated by this expanding AMOP community can be funded whenever they are at or above the high quality of present programs. A significant challenge for AMOP will be to maintain a programmatic balance as the field grows and further evolves. In order to accomplish this, the CoV encourages the Foundation and the AMOP program staff to continue to identify and nurture bridges between AMOP and allied initiatives such as quantum information science, nano-science and, more generally, to foster cooperative funding strategies with fields such as condensed matter physics.

Natural areas of concern within the AMOP surround the way in which the explosive growth of nascent areas, such BEC, are trading-off against support of other sub-field specialties such as low temperature plasma physics and collision physics in terms of the funding profile. The CoV supports the Division policy in which the balance of areas is primarily driven by the quality and quantity of proposals and is largely determined through the overall review process.

Centers activities in a predominantly single investigator field

At the present, approximately 20 percent of the AMOP budget is used to support two centers, one at JILA in Boulder, also supported by NIST, and the other the comparatively new Center for Ultracold Atoms (CUA) co-located at MIT and Harvard. During the present period the program has also supported the ITAMP center, although all centers will need so seek support as a Physics Frontier Center in their next renewal cycle. The former center CUOS at the University of Michigan has evolved into FOCUS that is one of the Physics Frontier Centers.

In a field whose greatest strength comes from vigorous competition among individual investigators, these centers represent a comparatively large investment, whose aggregate funding is roughly equivalent to 30-40 individual grants. Over the last decade, NSF supported AMOP centers such as JILA, ITAMP and CUOS have had an impressive history. These centers have been responsible for numerous landmark advances in optical science and technology and have fostered excellence in the development of the human resource and scientific manpower, both of which are needed to sustain the program's international scientific leadership and both of which return excellent value to society. The CoV believes that such singularly large center investments must be justified either (1) by clearly identifiable synergistic work from center members, or (2) by traceable risk-taking within the center's activities – that is that the center supports projects that are potentially high pay-off, but that could not be undertaken without the flexibility of center seed support. Preferably the center will demonstrate both components and the CoV recommends regular *external* peer review to monitor performance in these areas.

Plasma Physics and interagency cooperation

Plasma Physics has a large number of practitioners in the United States, for example the second largest divisional meeting of the APS is the DPP (Division of Plasma Physics). There are many fundamental processes under investigation such as plasma turbulence, non-linear wave-particle physics, magnetic reconnection, complex plasma flows, the interaction of plasma with intense laser fields, and sudden changes of state. Research involves plasma source construction, delicate and innovative diagnostics and state-of-the-art computing. The quest for controlled thermonuclear fusion has been the most costly part of the effort and has been funded exclusively by the Department of Energy. Until recently the DOE did not fund any basic plasma physics and the source of revenue was limited to the NSF and the ONR. The ONR has funded plasma science at the level of about 2.5M$/year for close to twenty years, and supported several innovative and highly visible projects. About 10 years ago, the Surko report, commissioned by the NRC, concluded that the field was in deep trouble and that funding levels for University-based basic research in this area should be about 15M$/year. At roughly the same time the DOE came under criticism for not supporting plasma science. The stage was set for the NSF-DOE partnership. The cooperative program's first RFP resulted in 150 proposals, of which 38 were funded. The second RFP in 2000 had another 150 submissions with 35 funded from DOE, AMOP and NSF Engineering. Recently, a new RFP has resulted in an additional 143 proposals which are now under review. There is also review and funding of proposals in years when no specific RFP is made (26 proposals and 8 funded in 2001, 21 proposals 8 funded in 2002) although the primary RFP cycle for the area is every three years. The NSF-DOE partnership has worked very hard to review, fund and share funding whenever possible. The dedication of the program officers on both sides must be commended for making the partnership a success and assuming the extra stress that comes from interfacing two bureaucracies with radically different missions and styles. Presently the DOE-NSF partnership invests approximately 5M$/year in the field. The very large response rate to the RFP's and excellence of a great many of the proposals that are not funded suggest that amount suggested in the NRC Surko report is close to what is required. This year a programmatic decision at ONR has reduced the Navy's funding of basic plasma science to zero. This is a very serious blow (1/3 of the total funding) and in the short term makes matters very difficult. The DOE-NSF program is the only source of support for plasma science and it is imperative that the NSF addresses the ONR shortfall in its future funding profile.

In sum, the NSF/DOE partnership in Basic Plasma Science and Engineering has provided a base of support for fundamental research in plasma physics . The CoV recognizes the value of this joint activity in plasma physics and recommends that the AMOP program strive to maintain this partnership.

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

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

Reviewing begins with written peer review in which a "package" is transmitted to a set of reviewers. Each package consists of packages of about six proposals. There is some intentional package overlap depending on the proposal topics and reviewer specialties. About seventy package reviewers and an equal number of supplemental reviewers are typically used. The practice of having single reviewers examine several proposals at the same time has led to careful and substantive reviews on the whole. In such cases the reviewers are asked not only to give a grade to each proposal, but also to rank the proposals of their group. These package reviews were then used as the starting point for a peer-review Panel meeting. The Panels meet early in the January following the proposal target date and consist of about 8-10 members. The CoV applauds the use of the Panel (1) as it provides a platform of interactive scientific review and discourse not possible when single-author written reviews alone are used, (2) because the Panel discussions contribute to the overall program coherence and (3) because the Panel compensates for missing or minimal reviews generated in the first step. The Panel process also contributed to the already high level of community confidence in the review process. In the final step, the results of both the written reviews and the Panel analysis are used by program staff to make the final funding decisions.

CoV review of jackets

CoV AMOP sub-committee members examined more than 50 AMOP proposal jackets. Care was taken to review jackets from several categories (1) those that were given top scores (and funded), (2) those that were given very poor scores (and not funded) , (3) those that were on the borderline, including both those that were and those that were not ultimately funded, (4) CAREER proposals, and (5) proposals with minority, RUI, group or other special character.

Jackets from the two centers were also carefully reviewed. We found that the majority of package reviews were substantive and useful. Less than 20% seem shallow, possibly correlated with cases where the expertise of PI and reviewer had poor overlap. Less than 15% of the reviews requested were never received.

Time to decision

The time-to-decision has improved since the last CoV review. Although it continues to shorten, almost a third of the proposal decisions take in excess of six (6) months. The CoV sees no indication that this is perceived by the AMOP community as a problem, however the Committee noted that delays in proposal turn around eventually have two important impacts: it cuts short the time available for an unsuccessful proposal to be reformulated and resubmitted for consideration in the following funding cycle and (2) it cuts short the ramp up planning of new projects (student recruitment, pre-award requisitioning, etc.). Efforts to reduce the time need to continue.

Jacket documentation

Documentation of the decisions in the proposal jackets is exceptionally complete. The CoV was impressed by the 1-to-2 page written analysis of the reviews provided by the program staff. The review analysis provides an explicit record of the thought process upon which the ultimate funding decision was made. This is helpful both to support the staff's own recollection as events unfold and as documentation for possible appeals or program audit. The CoV AMOP sub-committee was pleased to find that a part-time rotator has been added to the staff and that he will be actively involved in jacket preparation and management.

Reviewing Action

The CoV found that the renewal rate for AMOP grantees is approximately 80%, indicating a flow-through in the program of 20% or less (not accounting for second round renewal requests). The CoV found that this trend was quite acceptable, particularly given the youthful demographics of the program portfolio and the rapid growth of the field. As with other CoV subpanels in other fields, the AMOP CoV found that the CAREER grant process is complex and not an optimal entry point for many junior investigators in the field. The requirements for an education component were deemed too hard for young researchers to consistently provide, particularly while being responsible for initiating new research programs.

The AMOP CoV also affirmed several **risky** funding decisions, such as the decision to fund a RUI program on experimental BEC. The AMOP CoV appreciated the care taken in reviewing group awards. It also validated the use of one year awards for project renewal bridging.

The AMOP CoV noted that a difficulty in the single investigator program is funding what might be considered otherwise modest scale capital purchases. A typical state-of-the-art lasers system can easily cost on the $200K level or higher, yet is hard to fund as part of a single PI renewal proposal. Instrumentation programs at the NSF should develop programs that recognize this need. The MRI is designed for a group of researchers seeking equipment between $200k and $2M, so an individual PI can not apply to this program.

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

In the group of AMOP jackets that were reviewed, less than 10% of the reviewers explicitly analyzed the proposals in terms of the two review criteria, and of those, essentially no reviews mentioned the weighting of the criteria used in the reviewer's overall analysis. However, half or more of all reviewers did comment on both criteria and/or indicate implicitly in their reviews that both aspects were considered, but they simply did not segregate their analysis. Fortunately, the staff analysis and evaluations consistently addressed both NSF criteria and the evidence is quite clear that the number 2 criteria, particularly student involvement and diversity, are taken seriously and affects the review outcome. In the most recent year, the NSF made it mandatory that proposals include in their summary comments on how the proposed work addresses both criteria, and it will be important in the next CoV review to examine the impact of this requirement.

4.1.A3 Reviewer Selection

As described above, each proposal receives 4 to 6 mail reviews and then a Panel review before a funding decision is made. In cases where two or more first stage reviews are missing, it is natural to suspect that the quality of the program's funding decision may be weakened. The Panel review process now provides a balance for fair treatment of these proposals.

The reviewer list includes over 700 individuals, whose expertise, home institutions and seniority are widely spread. The average review load was about 3.5 reviews per reviewer taking into account that *ad hoc* mail reviewers have a lower reviewing load than package reviewers. The jackets illustrated that review assignments were carefully made and well distributed by program staff, who also pre-filtered most measurable conflicts of interest.

4.1.A4 Resulting portfolio of awards

The resulting portfolio of awards - and results obtained by NSF researchers supported by the AMOP program in this period, was deemed by the CoV to be **outstanding**! Within the portfolio are areas of established national interest that are simultaneously a natural fit to the agency mission. For example, atomic, molecular and optical physics is an area where some of the most exciting "ideas" of the last decade have developed (indeed, the 1997 and 2001 Nobel Prizes in Physics were given to AMO researchers) while AMO physics is vital to advanced technologies such as clocks an quantum sensors, quantum informatics, nano-technology and communications. Plasma physics, particularly the fundamental work supported by NSF is a vital contributor to National energy development as well as to the understanding of complex atomic, ionic and charged fluid physics.

Underrepresented groups

The AMOP CoV notes that the number of women and under-represented minorities among grantees is small, though slowly increasing. This is not a problem confined to AMOP and is not one over which program staff or NSF policies seem to have much influence. Instead, it is a larger problem of professional demographics. In the pool of proposals that received more average reviews there were several cases where proactive action was taken by the program staff to accept the increased risk of funding a more moderately rated proposal in order to provide opportunity for women, underrepresented minorities, RUI researchers (i.e. education driven projects) etc.. In sum, the AMOP CoV found no indication that these proactive decisions in any way had a negative effect on the quality of funded science.

Funding trends

Both the number of grants in AMOP and the dollars-per-grant have increased somewhat in this period. After having been approximately flat for the past decade, average funding in 2002 was approximately 10% over the ten year average. The AMOP CoV noted, however, that the 2001 average award size was approximately equal to that of 1991 in non-inflation corrected dollars. Furthermore, it appears that there was an unfortunate funding hiatus in the middle of the reviewed period due to a change in the status of funds leveraged through the Nano initiative. The most recent funding growth is significantly aided by key leveraging of support from the ITR and the Nanoscience initiatives. The AMOP CoV applauds this trend and urges that it continue. The AMOP CoV recommends that the Foundation take decisive action to ensure that funds brought into the program through foundation-wide initiatives remain in the core AMOP budget even after the initiatives expire.

The number of funded PIs is also notably increasing and was at an all-time high in 2002 with a 20% increase over the ten-year average. AMOP physics is in a time of great intellectual and technological advance, and these investments in the science are producing tremendous returns.

Program agility and content balance

The well-publicized example of Bose-Einstein condensation in atomic vapors and the award of the 2001 Nobel Prize in Physics illustrates the AMOP program's ability to advance vigorously into a new field, respond to excellent proposals and become an international leader in cutting edge science. In terms of overall AMOP portfolio, the AMOP CoV notes that appropriate restraint has been shown: The success rate for proposals in such high-visibility areas is well balanced with the success rates in the rest of AMOP. The AMOP CoV attributes this self-stabilization of program expansion and content development to a desirable synergy of external factors (the opinions of the Panels and the package reviewers) and internal factors (the judgment, knowledge and experience of the program staff).

<u>4.1.A5 Management</u>

The CoV is very impressed with the AMOP management and, in particular, with the program manager, D. Caldwell. Responsiveness, planning and prioritization are well cared for, as described above.

4.1.B Outputs and Outcomes of AMOP Physics Program Investments

4.1.B1 PEOPLE

Public Exposure

The program's investigators enhance the public understanding of science in a variety of ways. Most notably, there is a high level of media exposure received by discoveries in AMOP. AMOP has garnered several covers of prestigious journals such as *Physics Today, Science, and Nature* and have been cited in annual reviews of excellence in society journals such as the *APS News* and the OSA's *Optics and Photonics News.* The Plasma Physics program has generated attention in the popular news. For example there was a full page story in the New York Times science section in March 2002 on the NSF Basic Plasma Science Facility. The careful reporting of such discoveries in the press serves to influence strongly the public perception of scientific progress. The program is expected to continue to provide new spin-off technologies, and educational tools and projects that capture the public imagination. The portfolio of currently funded grants contains several that may lead to commercialization.

Workforce and Graduate Education

The program has a strong impact on the advanced technology workforce. It reflects the role of NSF as the major funding source for the advanced training of scientists for industry, as well as the academy, and has particular relevance to a number of important technologies that are critical to the continued health of the economy. AMOP physics is extremely well-positioned to provide training relevant to industries driving the global economy, for example, telecommunications, semiconductor processing, instrumentation for mineral resource identification, to name a few. Many students involved in fundamental physics research learn both analytical and practical skills that position them uniquely to drive industrial innovation. Of all programs in Physics at the Foundation, the AMOP program has the highest ratio of graduate students per PI, 1.5, and an average of 0.4 undergraduates per PI.

The AMOP CoV finds that there is significant anecdotal evidence to show that Ph.D. students trained in AMOP are having little problem finding employment and that many students take jobs in industry rather than post-doctorals on degree completion. However, the AMOP CoV also believes that it is important to quantify the impact of all NSF programs on the workforce. A possible way to do this might be to document, via annual and final reports, the number of NSF supported students receiving advanced degrees and at least the first step in their subsequent career tracks.

Workforce and Undergraduate Education

The AMOP CoV found insufficient data for the AMOP physics program to evaluate progress toward this goal. Nonetheless, there are number of significant and encouraging developments within the AMOP physics community. The number of REU grant supplements is increasing, with 50 students supported in the last year. This number is 40% of the number of individual PIs receiving grants through the program. The increasing availability of web-based visualization tools developed by AMOP grantees is also encouraging. Notable sites are associated with one of the AMOP centers, JILA, which launched, and now maintains the Physics2000 effort. Also, the PIs in this program participate frequently in lectures and demonstrations to pre-college and community audiences.

The AMOP subpanel believes that this goal may be too specific for the program itself to respond to in a significant way, and that the program should not be evaluated on its own as far as its success in this area goes. Nonetheless, it might be possible to track the program contributions to this area more effectively - for example, collecting data from the annual reporting categories designated for outreach and community activities.

Collective progress

AMOP physics innovations continue to be technologically and scientifically important, leading to the training of significant numbers of scientists in cutting-edge skills. An ironic measure of success of the program's efforts is the difficulty of attracting young scientists to academic positions, including both postdoctoral researchers and new faculty. This is an indirect indication of the value of AMOP training to industry, since recent graduates find both the challenge and range of scientific and technological problems in industry exciting. Of course, the greater remuneration for this work in industry as compared to academe is not lost upon those starting their career.

Future prospects

A continuing strong job market, coupled with the portability of skills, finds AMOP physics well positioned to continue to attract students and train top-rank scientists. This should be seen as an opportunity to increase the number of young people to the field. In particular, there may be a particular opportunity to enhance the participation of minorities and women. One avenue for this is suggested by the success of outreach programs undertaken by individual PIs in the program: AMOP physics is generally considered by high-school and entering freshmen college students to be accessible and exciting by virtue of its small scale and visual impact.

4.1.B2 IDEAS

Discoveries

The scientific achievements of AMOP investigators during this period are truly outstanding on all counts: People, Ideas and Tools. Rapid progress has been made across the spectrum of supported activities, from the ultra fast to the ultracold. The subcommittee chooses the following highlights of the success of NSF investment in the program. The AMOP CoV enjoys the fact that many of these discoveries are from researchers that are less than 40 years old!

- *Plasmas*: Experiments at UCLA which found intense Alfven wave radiation from a dense plasma embedded in a background plasma a result which has significance with respect to space and astrophysical plasmas, as well as to nuclear above atmosphere explosions, solar coronal mass ejections and laser fusion. Laser-plasma interactions have been an active area of research and work on the guiding of intense femtosecond laser pulses in plasma channels (University of Texas at Austin) has implications for accelerator physics, plasma lenses, and energy transport. Experiments have linked asymmetric trapped particle modes and transport in a Non Neutral Plasma (UCSD).

- *Ultracold atoms*: Following the successful demonstration of Bose-Einstein condensation in dilute atomic gases at JILA, a flurry of experiments have taken place. Matter wave analogues of bright solitons have been studied (Rice). Several groups have created dense, controllable Fermi degenerate gases in ultracold half-integer-spin isotopes of potassium and lithium (Rice, Duke, MIT) – the fermi system provides an important test-bed for exploring the behavior of fermions in a regime where the temperature at which pairing occurs can be adjusted relative to the Fermi temperature. The possibility of Cooper pairing has yet to be explored. And, in 2001, the Nobel Prize in Physics went to NSF funded researchers Cornell and Weiman (JILA) and Ketterle (MIT).

- *Quantum optics*: Precise control and measurement of a variety of quantum systems have been demonstrated. Using techniques of cavity QED, quantum feedback has been used to capture and release a quantum state (Stony Brook), techniques for entangling trillions of atoms using laser light have been demonstrated (Rochester), light has been stored in coherent media (ITAMP, Harvard) and landmark studies on decoherence in quantum logic and quantum gates have been made (Michigan). These and other developments have profound implications for several key areas, including nanoscale technology and quantum information science.

- *Metrology, Clocks and precision measurement:* A stunning breakthrough over the last several years has come from the marriage of ultra-fast lasers with highly stabilized lasers resulting in new approaches to realization of all optical clocks with promise of unprecedented accuracy (JILA). Meanwhile, state control of atomic collisions has been used at Yale/Penn State to show that an atomic clock based on rubidium atoms can outperform the widely accepted cesium standard. Both of these techniques are being adopted in laboratories worldwide. Most recently, anti-hydrogen has been created and observed by the NSF supported ATRAP collaboration.

Collective progress

The NSF AMOP Physics Program is the core source of support for the AMOP community. The program sustains a very active and interactive collection of scientists and is critical to the success of the field. This is evident in the number of advances that have been made over the past three years with the support of the AMOP physics program.

Future prospects

The program is well positioned for continuing the track of discoveries, with an appropriate balance of risky as well as high-profile, high-momentum projects. For example, work on Fermi systems in the cold atom community and atosecond pulsed lasers are close to being a reality. NSF AMOP researchers are a mainstay of work in advanced information technologies and nanoscience. In sum, it is crucial that the number of awards to individual investigators is at least sustained at the present level, and increased in the future, in order to maintain a community of such critical size that the current rate of innovation can be maintained.

4.1.B3 TOOLS

Use of Discoveries

The AMOP physics program has a direct impact on new technologies. The nature of the work (widely geographically distributed, small-scale laboratory experiments makes the potential for innovation high. The panel identified the following inventions as illustrative of different aspects of the program's portfolio:

- *Individual PIs:* “Atom chips” have been used to transport a BEC-on-a-chip at MIT, exploring the new technology for realizing advanced atom-optical devices such as rotation sensors. The application of spin-polarized gases to Magnetic Resonance Imaging continues to be developed by investigators from the ultracold atom community.

- *Center programs:* The Center for Ultra fast Optical Science (CUOS), now FOCUS, has developed new laser systems that use ultra short optical pulses for surgery. One of the CUOS designs has been commercialized by a company spun-off from the Center. More applications are envisaged for the new table-top soft X-ray sources also being developed at JILA (Kapteyn-Murnane).

- *Interaction with government laboratories:* JILA, a center funded (in part) by the Foundation, has close ties with nearby NIST laboratories to their mutual benefit. A particularly revealing example is the collaboration of University of Colorado and NIST researchers in the development of highly stabilized mode locked lasers for use in precision measurement applications, such as the development of clock standards. The collaboration with DOE on plasma physics has been very good for the community.

- *Cross-program impact:* Technology arising from work originally funded through the program continues to have a significant impact on other programs within the Physics Division. An important example of this is the work at LIGO. This work, funded by the Gravitational Physics program, highlights the fruitful interaction of different programs within physics. Projects funded from the ITR and Nano Initiatives are highlights in the AMOP program including a center at Harvard/MIT (Westervelt) and the ITR Center for Bits and Atoms (Gerschenfeld).

Despite the power of these examples, there exists little quantitative data on the ways in which discoveries from the program are put to use in the service of society, or the time frame over which this occurs. The AMOP CoV believes that it is important to quantify the impact of the program more systematically. In particular, data about intellectual property (e.g., patents, licensing agreements, invention disclosures, etc.) should be made available by PIs and Centers in their annual reports.

4.2 Elementary Particle Physics Subcommittee Report

The EPP subcommittee examined 25 jackets of successful, declined, and withdrawn proposals, a few of which were examined by more than one subcommittee member. The subcommittee finds that the EPP program remains a strong component of the MPS Physics Division intellectually, scientifically, and in the training of young scientists. This program has been developed through high quality reviews of proposals including panels and excellent direction by NSF program management. Some improvements in the process with respect to the application of Criterion 2 are suggested. The EPP program has also benefited greatly from the wise application of MREFC, MRI, and PFC awards. The subcommittee strongly endorses the use of review panels as an effective way to help set priorities. We strongly support the use of CAREER grants to give promising young people scientific autonomy early in their careers. However, the subcommittee believes that the goals of the education component of CAREER grants need to be clarified. Finally, should increased funding become available, the subcommittee strongly recommends that grant sizes to individual investigators be increased before the EPP Program entertains new initiatives. Increased grant sizes are necessary to strengthen the base program and thereby make more effective use of the nation's considerable intellectual capital.

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

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

The EPP subcommittee judges the program's management and review procedures to be highly effective. We applaud the use of panels in assessing the merit of proposals and find panel reports to be valuable in providing a comparative evaluation of a large set of proposals. Comments from panel and mail reviewers addressed the intellectual merit of the work with great attention, highlighting both the strengths and the weaknesses of the proposed work.

We note that in constituting panels the EPP Program aims for breadth and inclusiveness, which is a laudable policy. However, the subcommittee felt that this sometimes yielded panels with less experience than might be desired, especially the chair. One possible suggestion is to seek a chair with sufficiently broad experience not only of the field but also its culture. Inclusiveness is desirable, but younger members of the community need explicit mentoring into positions of leadership.

As did the previous COV, the subcommittee concurs with all decisions documented within the jackets examined, both successful and declined. We commend the Program Officers for the consistently excellent documentation of their decisions. We are particularly impressed by the sophistication with which Program Officers assess reviewers' reports. Given the constraints imposed by budgets, the determination of award scope, size and duration is generally good.

The average time of about 7.4 months between receipt of a proposal by the Foundation and a decision is better than the 8 months that was reported by the previous COV. However, the subcommittee feels that further improvement is necessary. Also, we welcome the improvement in the operation of FastLane.

4.2.A2 Program's use of the new NSF Merit Review Criteria

We concur with the finding of the previous COV that the intellectual merit of proposals is addressed well by reviewers. However, we find that in the case of umbrella proposals reviews tended to be relatively superficial compared with those of "single project" proposals. Writers of umbrella proposals should be instructed to state clearly the contribution of each member of the proposal and reviewers should be asked to draw attention to proposals that fail to do so.

Reviewers are addressing "broader impacts", that is, Criterion 2, better than was reported 3 years ago, but there is still considerable room for improvement. Moreover, the quality and depth of reviews of Criterion 2 varies considerably. There is evidence that neither proposal writers nor reviewers are completely clear about the precise goals of Criterion 2. The subcommittee is concerned that the absence of clearly defined goals in conjunction with the absence of rigorous, professional, assessment of the impact of Criterion 2 leaves the Foundation uninformed about the societal impact of the use of this criterion. It may well be that Criterion 2 is having a desirable societal effect; however, the lack of formal evaluation makes its success difficult to gauge.

4.2.A3 Reviewer selection

The selection of reviewers is generally very good, and *ad hoc* panels are typically well balanced and carefully constructed. We find that the reviewers generally highlighted similar issues and concerns, but occasional disparities between a reviewer's comments and the ranking he or she assigned were noted.

4.2.A4 Resulting portfolio of awards

This subcommittee commends the leadership of the Program Officers to balance their support between mid-size and large-scale experiments, throughout all phases of the project – from construction to final analysis. We applaud the Program Officers' sponsorship of new, sometimes risky, experiments and their vigorous resourcefulness in pursuing additional funding through the MREFC and MRI accounts. We are pleased to see efforts to encourage and support under-represented groups.

We find, as did the previous COV, that the quality of the science supported by the EPP Program is excellent. The science is varied, exciting and attracts favorable public attention. The Program has strengthened its support of both the analysis and analysis preparation phases of experiments, a development we wholeheartedly welcome and view as essential to maximize the scientific output of the experimental tools at, or soon to be at, our disposal. To that end, the MREFC and MRI funding mechanisms have played an absolutely crucial role in fueling significant technical advances targeted specifically at analysis, such as the work towards a global computational grid through projects like iVDGL and GriPhyN. MREFC and MRI funding has, in addition, enabled significant improvements in flagship projects such as DØ, CDF, CMS and ATLAS. Moreover, EPP Program officials have demonstrated their firm commitment to first-rate medium scale projects, a policy consistent with recommendations of high-level panels such as HEPAP. This commitment has led to support of projects that include IceCube, RSVP and MiniBooNE, all of which were judged excellent by various panels.

This happy outcome is a direct result of the vigorous and creative leadership of the EPP Program Officers and their adroit use of the MREFC and MRI accounts. This COV subcommittee acknowledges the Program Officers considerable efforts on behalf of the EPP community. Furthermore, Program Officers have worked extremely hard to reach out to and support under-represented groups. Their most significant success is the PFC award to Hampton University, a historically black college (HBCU) and Hampton's creditable involvement in ATLAS construction. We wish, however, to draw attention to the fact that outreach to under-represented groups is very labor intensive and that the heroic efforts of EPP officers cannot be sustained indefinitely without cost to the overall program.

We believe that the EPP Program adequately supports scientifically risky projects. Examples of these include the LHC and RSVP. Owing to its size and complexity, as well as the level of financial and intellectual resources committed by the EPP Program, the LHC project represented a significant risk to the Program. We are therefore happy to report that the project appears to be managed well and we are gratified by the close cooperation between officials of the Department of Energy and the National Science Foundation.

We note that construction funding for LHC-related projects ceases in fiscal 2003. We wish therefore to call attention to the need for operations funding beyond 2003 if the EPP Program is to reap the benefit of its considerable investment in the LHC. Operations funding is a Foundation-wide issue that looms large for several projects and must be addressed.

4.2.B Outputs and Outcomes of the Elementary Particle Physics Program Investments

4.2.B1 PEOPLE

The LHC project is an excellent example of the successful development of a truly global scientific and engineering workforce. Moreover, this has been achieved without sacrificing the funding of groups in "smaller" colleges such as Wayne State and Duluth. The CLEO experiment continues to produce a steady stream of highly sought after and effective researchers, as do all the other projects supported by the EPP Program.

4.2.B2 IDEAS

We list a few examples of significant scientific achievements during the 3-year period under review.

1. First statistically significant observation of CP-violating asymmetries in B meson decays by BaBar.
2. Observations of numerous new states by CLEO as well as rare B meson decays.
3. First useful limits on the existence of extra spatial dimensions by DØ.
4. NuTeV's most accurate measurements of the weak mixing angle and nucleon structure.

4.2.B3 TOOLS

Several new or upgraded research tools have come to fruition during the period under review. Particularly noteworthy are:

1. MiniBooNE, which will provide a definitive answer to the putative LSND oscillation signal.
2. BaBar, which will, and has already, provided definitive answers to questions about the asymmetry between matter and anti-matter.
3. CDF and DØ, which have significantly enhanced capability (with respect to Run I) to explore the energy frontier before the advent of the LHC in 2007.
4. CLEO is upgraded, operational, and performing superbly.
5. The grid projects iVDGL and GriPhyN, together with the Particle Physics Data Grid (PPDG) has recently coalesced into the single umbrella project Trillium, an event that promises to have wide-ranging impact, perhaps as sweeping as that of the world wide web. Important advances are 1) the achievement of interoperability between US and European Grid projects and 2) the establishment of several grid test beds (ATLAS, CMS, LIGO, SDSS, DØ, Star, Jlab).

4.2.C Other Topics

4.2.C1 Comments on program areas in need of improvement

Panels are an excellent innovation and their use should be broadened. They provide timely and complementary information to the mail-in reviews, which nonetheless are vital and should be maintained. Also, the feedback relating to Criterion 2 obtained from panel reviewers was observed to be more thorough, reflecting the valuable input and guidance provided by the Program Officers.

Like the previous COV, this subcommittee strongly supports the use of CAREER grants as a mechanism to give the most promising young PIs scientific autonomy at the beginning of their careers. However, we are concerned that the education criterion of CAREER grants tends to be interpreted by the community as requiring the delivery of an “innovative” education component. While some young people can do better than their senior colleagues, in this regard, many otherwise excellent candidates for a CAREER grant are ill-prepared to develop an education component that is both innovative and viable. The subcommittee recognizes, and accepts, the goal of making education an integral part of scientific culture. However, we believe that the emphasis should be to encourage best practice in education rather than innovation.

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

The QuarkNet program has the potential to make a broad impact on the education of the K-12 community. However, education and outreach activities need a clearer statement of goals coupled with professional assessment. While some assessment has occurred, much more needs to be done. The reality is that the field is engaged in a series of *ad hoc,* uncoordinated programs with respect to education and outreach. It may be helpful for the EHR division to get involved in the task of goal setting and assessment because few physicists have the appropriate expertise.

We have noted above the concerted effort being made by EPP Program Officers to reach under-represented groups. The subcommittee was pleased to see the support of physicists and undergraduates at predominantly undergraduate institutions. However, without in any way diminishing the successes wrought by EPP officials during the period under review, the subcommittee sees scant evidence of a statistically significant increase either in the number of proposal applications from under-represented groups or in the participation of members of such groups in Program supported projects. This failure is not due to the EPP Program officials, but rather reflects societal realities beyond their control. That being said, the EPP Program would benefit from the development of clearer goals and the rigorous assessment of its education mission.

Although the following is a well-known problem, it needs to be restated: Grants are generally not large enough to allow small groups to be as effective as they could be. The ability of a small group to contribute effectively, and visibly, in the development of new research tools depends not only on the quality of its scientists but also on their access to skilled technical personnel.

We recognize the Foundation's need to do new things, and we applaud its attempt to try to do so whenever possible, within the context of its existing programs. In particular, the subcommittee commends the EPP Program Director's ability to extend the reach of elementary particle physics beyond the NSF EPP budget, while sustaining the base program of the EPP. We welcome the official use of HEPAP as a high-level advisor and we acknowledge the EPP Program's responsiveness to HEPAP's advice.

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

Should increased funding become available, we recommend that the base program be strengthened, with particular attention paid to individual investigators before the implementation of new initiatives. The subcommittee's view is that the current level of funding per investigator is insufficient to make maximal use of the nation's intellectual capital, which is considerable. The fundamental problem is the inability of many excellent institutions to provide in-house training of experimental particle physicists in the art and science of modern instrumentation. Science cannot advance without significant developments in instrumentation, the development of which provides young experimental physicists with invaluable opportunities for innovation. Opportunities are being missed to make better use of universities in areas such as:

1. Advanced accelerator research.
2. Advanced detector development.
3. Ultra high-speed data acquisition systems.

Advanced detector development at universities has the potential to yield many innovations and provide an ideal way to train the next generation of experimental particle physicists. Universities that are so empowered would be better able to offer real-world experience of cutting-edge research and development to the nation's science teachers through the QuarkNet program. Anecdotal evidence from, together with some preliminary assessment of, QuarkNet suggests that science teachers find such experiences tremendously empowering. Such an emphasis could provide a positive, beneficial, impact on society by targeting the teachers of our young people.

4.3 Gravitational Physics Subcommittee Report

Gravitational physics continues the dramatic evolution that was noted in the 2000 COV report, an evolution that has been made possible by the strong physical understanding of general relativity that was supported by NSF over many decades. It has become a field in which experimental activity works in close partnership with theoretical work. LIGO is close to its initial target sensitivity and is turning its attention to operations, data analysis and source modeling. Ultra-high precision laboratory experiments are being stimulated by new theoretical ideas in string theory about the fundamental nature of gravity. Observations of the cosmic microwave background from the ground complement the space-based WMAP observatory in measuring the geometry and early history of the Universe to an unprecedented accuracy. Theoretical investigations of quantum geometry show promise of unveiling physics near the Big Bang and inside black holes.

The field continues to develop in exciting ways, many of which were highlighted in the NRC "From Quarks to the Cosmos" study. LIGO has applied for funding for its long-planned upgrade to Advanced LIGO. NASA is planning, with its European partner ESA, to launch the LISA gravitational wave detector in 2011. 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 but growing support of gravitational physics in NASA, 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 with NASA; research links with string theory, mathematics, astrophysics, information technology, computational science, and technology development.

To deal with these developments the committee raises the following points:

- The directors of the gravitational physics program have done an excellent job in managing this diverse program. The program directors in post at the beginning of this review period retired and have been replaced by new directors who have continued the high standards of their predecessors. Their reputation in the community of scientists working in the area is high, and their judgment is trusted.

- As LIGO initial construction and commissioning finishes, it is important to budget adequately for the operations phase, while still allowing room for PI grants to support LIGO data analysis and source modeling (which is largely done in the university community outside the project), as well as the rest of the diverse portfolio. The upgrade to Advanced LIGO must also be planned for; 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 that can improve LIGO's detection capabilities for black holes and neutron stars by providing reliable waveform patterns to search for. It will also be essential for interpreting observations. The field is very active in the US and internationally, but it must develop further before it can realize its full scientific return. We welcome the developing cooperation between NASA and NSF, as recommended by the "From Quarks to the Cosmos" report. The COV recommends that this avenue be used to open up additional support for numerical relativity, since one of the main goals of LISA is to observe colliding black holes. Proposals should be encouraged that are collaborative in nature, with the intention of building groups of a critical size.

- International collaboration is an increasing feature of gravitational wave research. LIGO is forming close international partnerships, and LISA is shared equally by NASA and ESA. The COV recommends that NSF work to foster international cooperation at both the PI and facility levels, through supporting workshops, exchanges, international topical schools for graduate student training, and even joint research projects.

- The COV notes with pleasure the increasing number of new positions at universities in gravitational physics. Many of these universities are small or have lower research profiles. The NSF has been able to provide support for several new faculty recently. This trend in new appointments is likely to continue in the future, and therefore it is important to ensure that there is adequate provision for the new faculty. This is of particular concern because meritorious proposals are already being declined because of limitations in resources.

- The number of graduate students supported by NSF has not kept pace with the recent increases in employment opportunities in this field. There are consequent shortages of qualified people for postdoctoral positions and even for new faculty positions. The NSF should increase its support for graduate students to remedy this shortfall.

Now we address the specific issues we were asked to review.

4.3.A Integrity and efficiency of the program's processes and management

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

a) Reviews are now conducted largely by panels convened to assess particular subfields. We welcome this development but note that the program is so broad that some proposals will continue to require mail reviews because the number of proposals will not justify convening a suitable panel. We found the review process to be well-designed.

b) The review process was very effective in selecting the best proposals for funding. We examined about 40 covers 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 work has gone without support.

c) The program was efficient in processing proposals in a timely way. Program officers maintained close contact with proposers and kept them aware of what was happening to their proposals.

d) The program officers provided excellent summaries and analyses of the reviews, and documented the factors leading to their decisions.

e) There were no program-specific guidelines for reviewers or proposal solicitations. Reviewing was consistent with general NSF criteria.

4.3.A2 Use of NSF merit review criteria

a) Reviewers mainly addressed the criterion of intellectual merit in their reviews. This is not surprising for a fundamental field like gravitation. Proposals generally included a discussion of the broader impact, especially the larger proposals.

b) We have no special suggestions to make on implementation.

4.3.A3 Reviewer selection

a) An adequate number of reviewers was used in most of the cases we examined. However, given the breadth of subjects covered by this field, we encourage 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.

b) The reviewer quality was excellent in general.

c) The reviewing was as balanced as possible, given the demographics of the institutions and the people in the field.

d) Conflicts of interest were avoided in the selection of reviewers. In the occasional case where a conflict was subsequently identified, it was dealt with correctly by the program officers.

4.3.A4 Resulting portfolio of awards

a) The overall quality of the science was extremely high across a very diverse range of activities. A number of meritorious proposals could not be funded.

b) The program officers made good decisions about the scope, size, and duration of awards. There were a number of examples where the program officers iterated with P.I.'s to focus their proposals in response to the reviews. This mentoring was generally done sensitively.

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 is fairly high in the short run, but at the sensitivity of Advanced LIGO the risk will be much smaller. There are high-risk but high-payoff theoretical programs as well, particularly in the quantum theory of geometry. In a fundamental area such as gravitation, it is very appropriate to have a significant high-risk component.

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 includes a large number of innovative projects. These include:

- Coordinated observing between the Allegro bar detector and LIGO.
- Support of several high-precision experiments on short-range gravitation.
- Polarization of the cosmic microwave background and large-scale structure in the CMB.

f) The program supports a diversity of sizes of groups. It contains one PFC (not supported by program funds), supports a major facility (LIGO), many long-established research groups, and several new faculty working individually at smaller universities.

g) The program has responded well by supporting new investigators at a number of universities that have hired new faculty in gravitational physics.

h) The geographical distribution is wide. Most regions of the United States are represented, from Maine to California, Washington to Texas and Florida.

i) In recent years a number of new PIs at smaller and less well-known universities have been awarded grants.

j) Education and outreach is a widespread activity in gravitation theory. LIGO, for example, maintains an extensive program of student visits, undergraduate employment, and teacher training.

k) The program has been effective at identifying emerging opportunities in the field. For example, it responded rapidly to opportunities to establish the new "Lazarus" research group at University of Texas at Brownsville when the opportunity arose to attract that group to the US from Germany. Brownsville is a largely Hispanic university, so the development is doubly commendable. The program also responded quickly to assist LSU in establishing a research group in association with LIGO. The LIGO Science Collaboration (LSC) continues to support new groups using LIGO and has become a focus for international collaborations.

l) Although small, the program has a growing number of PIs from underrepresented groups, particularly women and Hispanics.

m) The program supports national priorities in the pursuit of an understanding of the foundations of the physical world, in the training of skilled scientists, and the provision of opportunities for the development of new technologies. An example is the adaptation by General Electric of a mode-cleaner developed by Stanford University for the LIGO project to testing and quality control of advanced military aircraft, with huge savings of money as well as large gains in measurement accuracy. Another example is the patent of the Fast Chirp Transform by the LIGO data analysis group led by T Prince at Caltech, a technique that has potential application in the fields of communication and remote sensing.

4.3.A5 Management of the program

a) The program is being managed very well and with sensitivity to the needs of the very diverse group of scientists in this field.

b) The program is very responsive to emerging research needs, as illustrated by the fact that it has been funding new research groups and supporting more and more LIGO/LSC groups.

Program prioritization has been carried out 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. We are concerned that the increasing workload on the program officers makes such visits harder and harder to make.

Financial planning beyond the horizon of expiration of grants is weak, and this seems to be a feature of the NSF overall. It is very important that NSF make forward projections of demands from projects for operating costs and further development, so that these can be fit into a reasonable spending profile that preserves enough room for individual grants.

4.3.B RESULTS: OUTPUTS AND OUTCOMES OF NSF INVESTMENTS

4.3.B1 PEOPLE

Due in large part to the extreme difficulty of carrying out experiments in gravity, this sub-activity has and will continue to contribute to a cadre of young, highly-trained experimental physicists and engineers with unique talents. These difficult projects are pushing the envelope of technology, and they provide a superb training ground for graduate students and postdoctoral students. This training is unique: it is inter-disciplinary in physics and engineering. Historically, students trained in this area have acquired the knowledge, tools, and confidence to succeed in inventing new technologies. Many of these students move into technology industries, corporations and Wall Street, enhancing our nation's competitiveness.

The science in this field sparks the imagination of all people, and the Gravitational Physics division's participation in education and outreach programs has been vigorous.

- LIGO has been a major participant in the Research Experiences for Undergraduates (REU) program at its Caltech, MIT, and the Hanford and Livingston LIGO sites. Many participating students come from small institutions with limited or nonexistent campus research opportunities.

- A recent paper in Nature published by the University of Colorado group of J Price reports the best limit so far on deviations from Newtonian gravity at short distances; it carries REU undergraduate student Allison Churnside as a co-author.

- Gravitational physics has also supported outreach to high school teachers through the RET program. Ongoing research collaborations between LIGO Hanford Observatory and regional science teachers have involved high-school classes in characterization of the LIGO seismic environment, long-term monitoring of earth tides, and the influence of man-made environmental noise. The LIGO Educational Outreach Program also hosts in-school and on-site lectures, tours and science demonstrations by working LIGO scientists and graduate students for elementary school classes in the vicinity of LIGO sites and campuses.

- LIGO co-founder Kip Thorne has placed a comprehensive and ambitious set of lectures on gravitational radiation on the web, complete with digitized video. Many guest lecturers participated. This will assist university students elsewhere to gain an understanding of this emerging field.

- The new gravitational physics group at the mainly Hispanic University of Texas, Brownsville, are beginning to involve undergraduates in aspects of LIGO software development.

4.3.B2 IDEAS

Gravitational physics is one of the most profound developments in our understanding of the forces of Nature and of the Universe. All aspects of research in this field impact deeply on fundamental ideas.

- LIGO made its first "science" data-taking run for two weeks in 2002, and scientists of the LSC have analyzed the data for upper limits on four kinds of possible gravitational wave sources: coalescences of compact-object binary stars, spinning pulsars, a stochastic background of gravitational waves from the Big Bang, and unstructured bursts that might come from supernova explosions. While no detections were expected or made, since LIGO is still in its commissioning phase, these are in some cases the best upper limits that have so far been placed on such sources. The science run and data analysis involved also the European GEO detector, which undertook coordinated observing; the data analysis teams were fully international. This activity represents a major intellectual advance, and establishes that the software and cooperation protocols are now in place for the analysis of data when LIGO and its partner detectors reach their design sensitivity.

- As mentioned earlier, John Price (U. Colo.) has recently published in Nature the best limits on deviations from Newtonian gravity at sub-mm distances. A year earlier the University of Washington group of Eric Adelberger had published tight limits on somewhat longer length scales. These results constrain string theory. Experiments of this kind have the potential to reveal the first measured deviations from Einstein's theory of gravity.

- The NASA mission WMAP has made the best maps of the anisotropies of the cosmic microwave background to date and has pinned down the values of cosmological parameters with unprecedented accuracy. We note with satisfaction that this landmark project is a direct descendent from the support the gravitational physics program has provided for many years for the Dicke-Wilkinson group at Princeton, support which still continues. WMAP has confirmed that the expansion of the Universe is accelerating and that only 4% of the Universe is composed of ordinary matter.

- Investigations of quantum gravity at Penn State University by the group of A Ashtekar have indicated that the Universe does not reach a true singularity at the Big Bang and that it may indeed have made a transition through the Big Bang from another kind of universe.

- Work by S Shapiro and T Baumgarte have provided scientists with an exceptionally stable formulation of the Einstein equations for numerical simulations. This has enabled simulations of colliding black holes to run much longer before developing problems. Baumgarte has just been appointed to a tenure-track position at Bowdoin College and has been given a three-year award to continue his research there and involve undergraduates in it.

- Simulations of giant r-mode waves on the surface of a newly born neutron star by the Caltech and LSU groups have identified a possible source of strong gravitational waves and have pointed to a narrow frequency range in which to look for them. This frequency, around 950 Hz, is within the LIGO observing band.

4.3.B3 TOOLS

Once a purely intellectual activity, gravitational physics is now a field in which substantial tools are needed and are being developed. Gravity, fourteen billion years after the Big Bang, is such a weak force that experiments to test gravity and detect gravitational waves push the frontier of technology. This in turn results in new technology spin-offs.

LIGO is the program's primary tool, and it is developing many associated technologies. These include high-power ultra-stable lasers, large optics with sub-Angstrom smoothness, and new kinds of software for data analysis. Particularly notable is the use of LIGO's mode-cleaner optics to produce a stable laser that was used to scan the skin of an experimental military aircraft to establish is micro-roughness and figure. General Electric Corp, which did the scan with the borrowed equipment, will be adapting the design for future commercial use.

4.3.C Other Topics

The COV believes that gravitational physics has a broad and coherent research portfolio. As mentioned above, longer-term financial planning is required to anticipate the needs of projects like LIGO when they finish construction and enter an operations phase, or when upgrades can be anticipated. Without such planning, PI grants are always in danger of being reduced to cover inevitable fluctuations in project commitments.

4.4 Nuclear Physics Subcommittee Report

The NSF Nuclear Physics (NP) program has a strong portfolio, spanning the various sub-fields of nuclear physics. One significant change since the last COV is that nuclear astrophysics has been split out of the NP program and is now part of a new program, Particle and Nuclear Astrophysics(PNA). We endorse this change, which reflects a broad trend towards interdisciplinary research. There are, however, other opportunities for enhancing the NP portfolio. The previous COV report highlighted the relatively small role of the NSF in the RHIC program, compared for example to its role in Jefferson Lab (Jlab). We note that RHIC research still presents unrealized opportunities in one of the major national nuclear physics efforts. The proposed National Underground Science and Engineering Laboratory (NUSEL) will provide additional opportunities, particularly in medium-scale instrumentation. We were especially happy to see the creation of the COSM Physics Frontier Center, which is having double impact in nuclear physics: supporting forefront research, and enhancing the opportunities for underrepresented groups.

The Nuclear Science Advisory Committee (NSAC) regularly produces a Long Range Plan (LRP) for the nuclear science community. Overall, the NSF has responded to the LRP advice and priorities. There are examples, however, where division-wide priorities have had negative impact on the nuclear physics program with respect to the LRP, and it is crucial to ensure that new initiatives not crowd out use of the investment made. The first priority in the LRP is to make use of the existing investment in facilities such as Jlab, RHIC and the Coupled-Cyclotron Facility at Michigan State University. With restricted funding, the financial demands of these major facilities, and of the physics frontier centers, have been disruptive to some user groups. It appears, however, that the directorate is sensitive to, and addressing, this issue.

The LRP also identified NUSEL as a high priority; exploring this opportunity is of great importance to the Division. The Division appears to be following a path meant to ensure that this new large facility, if pursued, would not unduly distort the existing program. We remain excited by the potential of NUSEL, and applaud the Division's strategy in exploring this exciting possibility.

We continue to be concerned about the need to balance initiatives, facilities and support for individual investigators, especially in view of the erosion of individual investigator purchasing power. Many investigators are significantly under-funded, resulting in an undesirably low ratio of graduate students and post-docs per principal investigator, and a severe lack of technical infrastructure support. Furthermore, the number of investigators has decreased due to funding constraints, particularly in FY02. This limits the ability of the NP program to support new principal investigators.

We note that new initiatives in Nuclear Physics that might have been made possible by the IUCF closure, and anticipated in the previous COV report, did not take place, as the resources were reallocated at the Divisional level.

The current Nuclear Physics Program Office staff consists of one full time person (Dr. Bradley Keister) with assistance (at about 2/3 of his time) from Dr. Richard Boyd, who is also assigned as the program manager for Particle and Nuclear Astrophysics. The task of properly evaluating and reviewing incoming proposals is an enormous effort with excellent results. However, time and resources available for interaction with the community to develop the program are extremely limited. As the previous COV stated, we recommend that a second full time position be filled as soon as possible. It appears that proposal handling has significant dead time due to budget uncertainties. This could be reduced by delaying the target date for proposal arrival from September to the end of October.

We share the concern expressed by many members of the COV that the CAREER program is not fulfilling its intended purpose to assist and encourage incoming faculty to the field. The proposals require a substantial component in education and outreach, well beyond that of a regular proposal, which many young investigators are not yet sufficiently experienced to provide.

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

4.4.A1 Quality and Effectiveness of the Program's Use of Merit Review Procedures

All proposals in the Nuclear Physics program, with the exception of those from the largest facilities, receive ad-hoc reviews and are then submitted to panels, which rank them according to the merit review criteria. This process is appropriate for the Nuclear Physics portfolio and is seen to be both efficient and effective. We believe that it is important to maintain both parts of this process. Generally, the ad-hoc reviewers provide a more in-depth review than is possible for the panel. However, funding decisions are now so competitive that it is difficult to see how the Program Managers would be able to move forward without the collective wisdom and intellectual breadth of the panels. The reviews are consistent with priorities and guidelines provided by the program.

The panel summaries are thoughtful and clearly written. They provide a solid basis for the Program Managers' decisions and do provide sufficient information for the principal investigators to understand the basis of the recommendation. We looked especially carefully at borderline and unsuccessful proposals in this regard.

The files that we reviewed were complete, and provided sufficient information and justification for the decisions taken. The state of the files reflects very well on the diligence and dedication of the program managers and the support staff of the Division.

The average time-to-decision is longer than the goal of six months set by the Foundation. We found that, for the Nuclear Physics Program at least, the review process was generally complete well within the target. Final decisions are frequently delayed by weeks or months pending final passage of the annual spending Bills, completion of budget allocations within the Foundation, etc.. In most years, the target date could be moved back by a month or more without any delay to the final decision.

4.4.A2 Implementation of the NSF Merit Review Criteria

There is quite some variation in how criterion 2 is addressed in the ad-hoc reviews. Improvement was noted from 2000 to 2002, but significant inconsistencies remain. We suggest that crisper instructions to reviewers be posted on the FastLane site. The same description of criterion 2 that was presented to the COV might be used. Even better, perhaps, comments on criterion 2 could be divided into three subsections in the on-line form. We suggest:

- How well does the proposed activity advance education and training?
- How well does this activity broaden the participation of underrepresented groups (e.g. according to gender, ethnicity, disability, geographic region, etc.)?
- What other benefits does this activity offer to society?
- How does the proposed activity have broader impact in science?

The situation is much better in the panel reviews. The panel summaries address both of the merit criteria in a consistent way and the review analyses do an excellent job of addressing the merit criteria, and, especially, in pulling together the disparate handling of criterion 2 by reviewers.

Finally we were pleased to find examples of proposals where criterion 2 was clearly an important factor in the final decision.

4.4.A3 Selection of Reviewers

The use of three ad hoc reviewers followed by a panel review provides a thorough and effective review process. Since the panel serves collectively as an additional reviewer, the review is also adequate in cases for which only two ad hoc reviews are available.

The reviewers selected were well qualified and we found that the selection of reviewers was balanced among institutions and underrepresented groups. However, we are concerned that the very laudable attempts to provide balance in the review process may be overburdening some individuals in these groups.

We commend the program officer for his sensitivity to conflicts of interest, and for his efforts to resolve such conflicts in a manner that does not compromise the scientific review.

4.4.A4 Quality and Balance of the Portfolio

We found the overall quality of the research and education projects supported by the Nuclear Physics Program to be outstanding. Unfortunately, the size of the awards is just too small and many excellent investigators are now scrambling to put together multiple proposals to support a bare-bones research effort. It appears that the importance of the physical sciences to the overall economic health of the nation is finally being recognized at the highest levels of government. We urge that a significant portion of the increase in NSF funding be applied to the PI program to address the issue of award size.

The Nuclear Physics Program has supported an appropriate number of high-risk proposals in recent years, including extremely challenging experiments in parity violation and neutrino physics. Some of these high-risk activities are significantly behind schedule. While commending the program for supporting difficult experiments with outstanding potential, we also believe that the problems are not always in the scientific and technical domains. It is very important that the program ensure that project management is in place that is appropriate for scale of the project.

Many of the most exciting problems of modern physics lie at the intersection of Nuclear Physics and other fields. The Nuclear Physics Program is supportive of multidisciplinary programs and we commend the Physics Division for the creation of the program in Particle and Nuclear Astrophysics.

We very strongly support the efforts of the Nuclear Physics Program to fund centers such as the Physics Frontier Center at Hampton University. However, we find that the demands on the program manager are quite different for proposals of this kind than for management of the PI program. We believe that the program would be more effective at developing these centers if there were a second permanent program manager (as recommended also by the last COV).

In general, we feel that there is a good balance of institutional types. However, we note that the number of facilities supported by the NSF has dropped considerably in the past decade. While this is an inevitable consequence of the development of the field, the result is that substantial fraction of the Nuclear Physics program is now dedicated to a single facility (NSCL/CCF). There is a strong concentration of NSF supported PI's working at Jefferson Lab. The long term health of this program will only be assured if it has adequate scientific diversity. In this context, we are pleased to see the growth in participation at RHIC and believe that there may be other opportunities for the program to diversify, examples of which can be found in the recent NSAC long-range plan. NUSEL will also provide opportunities for diversification.

Finally, we note that the program portfolio has made progress in the participation of underrepresented groups (especially the formation of the Hampton Center) but much remains to be done. We are convinced that program management is absolutely committed to doing everything possible in this area. However, some of the reviews of proposals indicate that there is more that could be done some of the larger institutions in the program.

4.4.A5 Program Management

The Nuclear Physics Program manager is doing an outstanding job under considerable pressure. However, it is very difficult for one full-time manager and a part-time rotator to manage the PI program, a large national user facility, and many complex experiments (some of them international), while at the same time providing outreach to the community to develop new initiatives such as the physics frontier centers. As mentioned above, we believe that the addition of a second full-time manager would greatly help the program to address emerging opportunities and issues of balance. The last COV made the same recommendation.

The program manager works closely with the Nuclear Science Advisory Committee to ensure that the Committee addresses matters of importance to the NSF program. We applaud the major charge in education recently submitted to NSAC for which the impetus came from the NSF.

4.4.B Outputs and Outcomes

We have selected a number of examples, or "nuggets" of outstanding recent outcomes in the Nuclear Physics Program.

4.4.B1 PEOPLE

Measurement of Nuclear Moments Using Beta-NMR/LMR and Transient Field Spectroscopy.
W. F. Rogers (PHY-0072915, Westmont College)

The Conference Experience for Undergraduates (CEU) program, under the direction of Prof. Rogers, provides undergraduate students who have conducted research in nuclear physics the opportunity to present their research to the larger professional community, and to learn about graduate school opportunities through interactions with faculty and senior scientists. CEU events at the annual conferences of the American Physical Society Division of Nuclear Physics include a poster session for the presentation of student research and special introductory talks by leading nuclear physicists. Typically about one-third of the CEU students are from underrepresented groups (73 students participated in CEU02 at the Fall 2002 DNP meeting). The response from both students and faculty has been enthusiastic.

Center for the Study of the Origin and Structure of Matter (COSM)
O. K. Baker (PHY-114343, Hampton University)

The COSM Physics Frontier Center is based at Hampton University, one of the leading Historically Black Colleges and Universities (HBCU's). The mission of COSM is to conduct forefront research into the nature of matter through the development of detectors, software, and simulations for nuclear and particle physics, and through a program of experimentation, education, and outreach. COSM is designed to be a doorway for empowering a network of Historically Black Colleges and Universities (HBCU's) to participate in these highly visible science projects, which will help to develop a diverse workforce.

4.4.B2 IDEAS

Charge and magnetization currents in the proton.
C. Perdrisat, et al. (PHY-9901182, College of William and Mary)

In a series of experiments at JLab, it has been discovered that the ratio of the electric and magnetic form factors of the proton, G_E^p/G_M^p, is a strongly decreasing function of momentum transfer Q^2. Previous measurements had been consistent with the notion that the ratio G_E^p/G_M^p was constant with Q^2. The new results are challenging existing theory concerning the structure of the nucleon, and bringing new insight into the details of the nucleon's quark wave functions.

g-2 of the muon
D. Hertzog et al. (PHY-0072044, Illinois) and B. L. Roberts et al. (PHY-0100468, BU)

In an experiment at Brookhaven, the anomalous magnetic moment of the muon has been determined far more precisely than ever before. The result is in disagreement with standard model expectations at the two-sigma level. The results have stimulated considerable interest, including the suggestion that one might be seeing a hint of super symmetry.

The contribution of strangeness to the magnetism of the proton
R. McKeown (PHY 0071856, Caltech) and D. Beck (PHY-0072044, Illinois)

Results from the SAMPLE experiment at Bates have shed new light on the level at which strangeness contributes to the magnetic moment of the proton. The experiments involve studying parity violation in the scattering of polarized electrons from unpolarized hydrogen and deuterium targets.

Results from RHIC provide new insights into quark-gluon plasma
NSF supports a major role in the PHOBOS detector (F. Wolfs, PHY-0072204) and two groups in the STAR collaboration (Humanic and M. Lisa, PHY-0099456; and D. Cebra, PHY-9971845).

The first two runs of RHIC have provided exciting new data on hot dense matter. For example, evidence of early pressure buildup and collective flow of matter has been observed. Hydrodynamics with a quark-gluon plasma equation of state can describe the collective flow and particle spectra (including that measured by Wolfs and collaborators), but the initial state dynamics is more complicated as indicated by the correlation results of Lisa and Humanic.

Left and right-handed nuclei
D. Fossan et al (Stony Brook)

Measurements of high-spin nuclei have shown the existence of chiral doublets in triaxial nuclei. This is the first time that chiral symmetry breaking, a common attribute in objects such as molecules, has been observed in nuclei.

4.4.B3 TOOLS

MSU National Superconducting Cyclotron Laboratory Coupled Cyclotron Facility

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 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. The facility is expected to tackle many key problems in nuclear astrophysics.

STAR Endcap Calorimeter at RHIC

The addition of the STAR endcap electromagnetic calorimeter makes it possible to use STAR detector at RHIC to study ΔG, the gluon contribution to the nucleon spin. This is an important part of the "RHIC-Spin" program, which, among other things, is the natural next step in determining the origins of the nuclear spin.

G0 spectrometer at JLab

The G0 spectrometer will open a new window into the study of parity violation in electron-nucleon scattering. The device incorporates both the ability to study forward scattered recoil protons as well as backward scattered electrons, and uses time-of-flight for energy resolution. The large coverage in both angle and momentum transfer will allow separation of the weak form factors, and enhance our understanding of the flavor decomposition of the nucleon's properties.

4.5 Particle and Nuclear Astrophysics Subcommittee Report

This constitutes the first review by a CoV sub-committee of the new Particle and Nuclear Astrophysics program. The creation of the PNA program and its portfolio arose from an awareness in the NSF, and in the broader scientific community, of the growing links among particle physics, nuclear physics and astronomy. In considering the prospect that the Division was preparing to create a new program to foster new discovery opportunities of this link, the previous CoV(2000) had this to say:

"This astrophysics initiative crosses a number of boundaries, including astronomy, nuclear and particle physics, and the Office of Polar Programs, and should over time be brought under one program umbrella, but with interdisciplinary links. Further, good interagency cooperation between NSF, DOE, and NASA will be important for maximizing the success of this program."

Subsequent to the initiation of PNA, the wisdom of its creation has been confirmed by two NRC/NAS reports ("Connecting Quarks to the Cosmos: Eleven Science Questions for the New Century" (2002) and "Neutrinos and Beyond: New Windows on Nature" (2002)) in which the scientific opportunities of such associations are examined. Earlier, the Panel on Particle, Nuclear and Gravitational-wave Astrophysics of the decadal Astronomy and Astrophysics Survey Committee also recognized the importance of these growing links and recommended acting upon them.

These suggestions have been acted on and the present sub-committee is thus reviewing the first three years of operation for this initiative. In general, our assessment is that the Division has developed and is supporting a strong program of particle and nuclear astrophysics at the cutting edge of the field. The Program Officers should be commended for their work and accomplishments in making this happen. It is clear that this program has a bright future within the Division and the Agency.

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

The PNA program review sub-committee examined 24 jackets which were a mix of successful, declined and withdrawn proposals. The majority was provided to us by the Program Officer as representative samples; however, additional ones were readily provided to us at our request to study some issues further.

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

The mechanisms used for review of proposals were fully appropriate and consisted of a mix of mail (or ad hoc) reviews as well as panel reviews. Typically, there were three mail reviews for each proposal followed by a panel (five or more persons) considering a cluster of proposals in the field. The sub-committee feels this new combination leads to a fair and high quality evaluation for selecting the best science and investigators to be supported. It should be remarked that in the development of the program's present portfolio, and its proposal reviews, there has been an apparently seamless and efficient cooperation among the several Program Officers from this program and those related to it in producing excellent documentation for their decisions to all concerned. This part of the review process (mail and follow-on panel) appears to be relatively efficient and timely.

However, the sub-committee is concerned that the cross disciplinary nature of the science may add extra levels and hence longer dwell times before decision and subsequent arrival of funds to the approved projects. For example, a majority of the approved projects presently in the portfolio were additionally reviewed by the interagency panel for non-accelerator physics: SAGENAP; although that panel provides valuable assessment for NSF guidance it's periodic meeting schedule may not always mesh well with proposal deadlines.

We also note that many projects are collaborative among groups and institutions so it is sometimes difficult for reviewers to be fully informed as to how this individual PI's base grant or project fits into the goals of the larger collaboration. We suggest that proposers be required to provide this information (e.g., relation to the critical path; any participation by other agencies; etc.) in the proposal document.

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

The Criterion #1, concerning intellectual merit, is universally used by all reviewers. Criterion #2, concerning the broader implications to diversity, education and society; was used by reviewers as often in the breach as in the observance. Which aspect of the criteria each emphasized varied widely. In comparison to the findings of the previous CoV (2000) we judge that there has been significant improvement on this but that further progress is still needed. It is our observation that in the panels there is improved attention to Criterion #2 perhaps due to the presence of the Program Officer at the panel sessions.

4.5.A3. Reviewer selection

The reviewers for both the mail and panel reviews were very well chosen with respect to their area of knowledge, expertise and the other criteria of balance. They took their assigned tasks very seriously and were on the whole very thorough. We saw no evidence of conflict of interest. The panels, especially, were well balanced with respect to characteristics such as geography, type of institution and underrepresented groups. Particularly in the mail reviews the sub-committee felt increasing the participation by some of the younger scientists in the field might be desirable to add another perspective in the mix.

4.5.A4. Resulting portfolio of awards

Overall, the quality of the research projects supported in the program is excellent and represents an appropriate mix of cutting edge topics in the area of particle and nuclear astrophysics. These projects reflect well the emphasis urged by the two NRC/NAS reports mentioned earlier. For example, of the "Eleven Questions for the New Century" seven of them are directly appropriate to a program such as envisioned for this PNA and they are specifically represented in the present portfolio by supported projects in high energy gamma rays, high energy cosmic rays, searches for dark matter, accelerator and non-accelerator nuclear reaction physics, properties of neutrinos (via oscillations and double beta decay) and neutrino astronomy, both galactic and extra-galactic. For such a young program this is quite an impressive achievement.

Some of the projects originated in the EPP, NP and AST (partially) programs and were transferred when PNA began. Others, which now make up the bulk of the program portfolio, are either new starts or considered renewals with three year cycles. This has allowed an important influx of new ideas and projects.

Although the duration to completion of several of these experiments is appreciably greater that three years we feel that a three year funding cycle to renewal is not unreasonable provided that interruptions or delays in funding are not introduced as a consequence.

Even though most awards were funded at an appropriate level there were examples of proposals reviewed to be excellent but which were given inadequate funding. Possibly these were a consequence of the particular difficulties of the Division's budget those years (particularly in FY2002) but this under-funding should be remedied in the future in order to stabilize the base program.

The program has included some projects with a calculated risk associated with a substantial discovery payoff. We examined the jackets for two of these projects: one in operation and one still under construction. Both projects are in the medium-large $5M range and were collaborative --- one predominantly domestic and one international. They provided useful examples. Both have excellent physics goals and were very well reviewed with acknowledgement of the physics discovery potential and risk. To insure continued success with these types of projects we agree with the more recent policy for new, similar collaborative projects of this size to require a clearer MOU to be devised at the earliest stages, that a management structure of appropriate scale be utilized (e.g., not the full scale WBS procedure of large projects) and that all agencies foreign and domestic commit to be on-board .

Another area where good risk opportunities may exist concerns young investigators. We perceive that more thought should be given on how to support exceptional young investigators in the crucial years before tenure and for whom tenure at the present institution is not certain. Whether or not the person will receive tenure at the originating institution should not be a major criterion in evaluating the proposal; the excellence of the proposed work should have precedence. We see this as an area where there is a shortfall between the CAREER grants and the recommendation of the 2000 CoV to provide individual PI awards for young people and to encourage them to apply for regular grants.

With respect to the balance between Centers and individual investigator awards (IIA's), the sub-committee suggests that because this is a new sub-program in the Division extra caution be exercised in the relative proportion of effort and funding between Centers and individual awards so that the field develops in a healthy manner.

There is significant involvement in education with much of the research program. Of particular note are several RUI's as well as the ASPIRE and CROP projects. Now that some experience has been achieved with these diverse programs it may be time to consider whether or not there is something additional to be gained by urging collaboration or more coherence among some of them.

We note in passing that several of the PI's of the individual awards are women; we did not identify any ethnic minorities with PI awards.

The sub-committee determines that a goal of 30% turnover of grants in this field is not appropriate. This is largely due to the long duration of the experiments and their construction. This finding agrees with that of the 2000 CoV in reviewing the individual programs in these areas which are now combined in P & NA.

4.5.B. Results: Outputs and Outcomes of the Particle and Nuclear Astrophysics Program Investments

4.5.B1 PEOPLE

With respect to the formation of a diverse cadre of such persons the program is off to a good start: there are a significant number of projects lead by women and many women participate in the various experiments funded; the ASPIRE and CROP education projects appear to be effective in reaching a broad spectrum of pre-college students of diverse backgrounds.

Many of the experiments are not only international collaborations but are actually carried out at non-U.S. sites around the globe ---- Antarctica, Argentina, Italy, and Japan, to name four. Many of the participants are leaders at international conferences and workshops as well.

The science represented in the PNA portfolio and its related areas of cosmology and astronomy are of enormous continuing interest to the public and the participants in these programs appear to be doing an excellent job in satisfying this interest. Perhaps more important to the goal of providing a future workforce of well trained scientists is the attraction this field has for graduate students. Recent experience shows that the opportunities to study in these areas are among the most sought after by both graduate and undergraduate students.

4.5.B2 IDEAS

– Two projects developing new ideas for high energy gamma ray astronomy have now proved the method, are running and beginning to produce results. (STACEE and MILAGRO). STACEE, with its exceptionally low energy threshold, will investigate gamma rays from distant sources increasing our understanding of Nature's particle accelerators as well as the early Universe. MILAGRO, with a >90% duty factor and ~2 steradian field of view, will search for transient sources of high energy gamma rays, whose observation will test theories of quantum gravity.

- HIRES, in ultra high energy cosmic rays, is now running and taking data. Monocular results have recently been presented and stereo operation just begun. HIRES, with its large collection area and excellent energy resolution, will explore whether new astrophysics and/or new particle physics theories are required to explain the spectrum of the highest energy cosmic rays.

- Super-Kamiokande, is now repaired and back online. Its earlier results still continue to provide new constraints on interpretation of solar results and to confirm the interpretation as due to neutrino oscillations. In addition to its detection of non-terrestrial neutrinos, Super-K will now resume its long baseline “K2K” experiment which is well on its way to confirming their earlier remarkable discovery of atmospheric neutrino oscillations.

-CDMS-I, operating at shallow depth provided new limits in direct detection of dark matter and its successor, CDMS-II, now being installed in the deeper Soudan mine will extend the reach of this technique even further.

- Nuclear physics experiments, being carried out at NSF funded accelerators, are probing reactions relevant to stellar energy generation and nucleosynthesis.

- For the future there are many new ideas for experimentation, which are likely to find their way as proposals to the NSF. They are in areas such as larger scale dark matter and double beta decay searches, solar/stellar neutrinos, low energy nuclear accelerator physics as well as reactor neutrinos and high energy cosmic and gamma rays.

4.5.B3 TOOLS

- Two projects (AMANDA and AUGER) which are entirely new and large scale instruments for pushing the frontiers in high energy neutrino astronomy and cosmic rays are proving the efficacy of these new tools and are taking either physics or engineering data.

- AMANDA’s success in pioneering neutrino astronomy in the South Pole ice indicates that we can look forward to achievable technical goals for the new ICECUBE project.

- VERITAS prototypes have been constructed showing the potential for this project to make significantly better measurements of high energy gamma rays and to nicely complement the energy and sensitivity reach of GLAST.

- As indicated above, and in the NRC/NAS report “Neutrinos and Beyond”, there are anticipated several future opportunities in particle/nuclear astrophysics for which a National Underground Science Laboratory could be an important resource for these experiments and for the future PNA program. Access to underground facilities is a necessity for a significant portion of the field and should be regarded as a tool like optical or radio telescopes for astronomy or like accelerators at national laboratories for nuclear and particle physics.

- The sub-committee applauds the suggestion presented by NSF staff at this CoV review for a possible new initiative in mid-scale instrumentation ($2 – $100M). This could fit very well with the emerging style and size of PNA experimentation.

4.5.C. Other Topics

- We encourage, and feel it very important to the health and effectiveness of this program, that the NSF nurture and maintain a close cooperation and communication with all the other agencies (DOE and NASA) or Divisions who have interests and activities in P & NA. This should happen at an early stage in the projects and involve not only Program Officers but also higher management so that the review process and subsequent funding is timely and efficient. The sub-committee is encouraged by the recent establishment of the interagency committee of Division Directors from the three agencies who are to explore the appropriate means to achieve these desired goals.

- Members of this sub-committee praised the highly successful POWRE program in initiating the careers of several women who are now leaders in the field of P & NA. We were disappointed in the discontinuation of the POWRE program and hope the ADVANCE program can fill the needs of young women to obtain small grants which are important in starting their careers.

4.6 Theoretical Physics Subcommittee Report

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

4.6.A1 Quality and Effectiveness of the Program's use of Merit Review Procedures

The TP program officers have experimented with several mixes of ad hoc mail-in reviews and review panels. They have settled upon mail-in reviews as initial evaluation data with a panel of experts reviewing the mail-in evaluations. The panel then makes recommendations regarding funding categories and may or may not provide a rank ordering. This processes works well, the best specialists are consulted, their judgments are reviewed in a communal setting providing ample opportunity for discussion, and recommendations are made to knowledgeable program officers. These officers then make informed recommendations based upon mail-in reviews and panel oversight. The subpanel was impressed by the thoroughness and professionalism of the review process as reflected in the proposal jackets. It is our perception that the community recognizes the fairness and objectivity of this procedure.

The subpanel compared the award decisions across the five subfields, atomic, molecular and optical theory; high energy physics, both fundamental and phenomenological theory, nuclear theory, and mathematical physics. Despite the great diversity of these areas there was remarkable consistency in the award decisions. The funding cutoffs were very similar in all subfields. It is a significant management accomplishment to get such a high degree of consistency and excellent science across the various subfields of theory.

The review process is highly effective. The same procedures that have contributed to the high level of integrity also produce a high level of effectiveness. Each proposal is thoroughly reviewed so that they are accurately placed in the various funding categories. Inevitably, there are proposals that land at the border between "fund" and "don't fund". We looked as some proposals at this boundary. In each case we found that the program officers made appropriate and well-informed decisions on the awarding of grants.

The proposal jackets provided by the program officers and additional ones requested by the subpanel were the primary source of information about the program management. In all 69 jackets were available to us. We did not keep statistics on the numbers that were actually looked at by someone on the subpanel, but it appears that almost all of the 69 jackets were examined. With only one or two exceptions, the jackets were in excellent condition; the ad hoc reviews were identified, panel summaries were readily available as were additional forms indicating time of submission, communications with the PI and other procedural matters. Needless to say, the excellent condition of the jackets greatly facilitates the subpanel's review task.

In the exceptional cases, the initial ad hoc reviews were not in the jackets that, however, contained review summaries. Upon requests to the program officers, these initial ad hoc reviews were provided.

There were no solicited proposals in the programs that we examined. The review process for unsolicited proposals is consistent with the guidelines.

4.6.A2 The program's implementation of the NSF merit review criteria.

a) The review procedure depends upon the judgments of the ad hoc reviewers, the panels and the program officers. All reviewers effectively addressed the first merit criteria. Excellent science was identified uniformly across proposal types. We were impressed that the RUI proposals, like those from research institutions, ranked well on the first criteria.

b) With the procedures that are now in place, a panel uses the ad hoc reviews to categorize proposals. In all instances where this procedure was employed, the panels did consider both merit review criteria. In many cases the second criteria was not weighed as heavily as the first, but the panels did consider it. The same cannot be said for the mail-in reviews. There was little evidence that the reviewers paid attention to or understood the basis upon which judgments were to be made. It does appear that the fraction of reviewers who address the second criteria has increased over time. This may be related to the fastlane review system. One must enter text in the second criteria box in order to submit a review.

The crisis in the Individual Investigator Awards (IIA) engendered by the financial strictures of the '02 budget cycle has caused some in the community to question the NSF's priorities.

There are some examples that illustrate the damage that can be done to the confidence and support that the agency receives by such actions. For example, there were P.I.s whose grants were denied funding in the hyper-restricted environment of 2002. Some of these were later able to successfully seek funding from the DOE at relatively more generous levels. Other P.I.'s were later funded in a subsequent fiscal year by the NSF itself. While this last example might be thought of an endorsement of the nimble way in which the NSF is able to act, from the point of view of the P.I. it raises questions about the fairness of the initial denial and consistency of support.

The panel is also concerned that appointees starting their academic careers are at a disadvantage due to their relative inexperience and may submit grants that are likely to end up in the border region between "fund" and "do not fund". Recent appointees that are denied funding represent lost opportunities to invest the in the future health of the field. The program officers recognize this and in some instances award small grants to recent appointees when their proposals land on the border. The CAREER grants, which are restricted to recent hires, formally addresses this issue, however, the present program only complicates the problem in that these proposals are seen to require much more attention to innovative teaching and outreach activities than is advisable for junior researchers. In addition, the CAREER proposals must be funded at levels that are about double the average of the individual PI grants in the theory program so that recipients of CAREER grants are almost assured that funds will be reduced later in their career when they apply for individual grants. Also, it is not possible to apply for CAREER and individual PI grants simultaneously, so that if new hires are denied CAREER grants they are, in effect, also denied individual grants.

4.6.A3 Reviewer selection

An adequate number of reviewers, usually four or five, were used. A uniform procedure has been established that works well, perhaps even optimally when the combination of ad hoc mail reviews plus panel is used. The panel system without mail in reviews was regarded as less desirable.

We found that the reviewers were knowledgeable and took the reviewing task seriously. Generally, the judgments of reviewers regarding research quality were consistent. In the case of RUI proposals there was some sharp divergence of opinion regarding the education component of the proposals. In these cases, the program officers exercised tact and judgment in arriving at an appropriate funding decision.

Conflicts of interest were resolved by having reviewers leave the room when proposals from their home institution or close collaborators were discussed by the panel.

4.6.A4 Resulting portfolio of awards

The portfolio in Theoretical Physics is outstanding. It is includes a wide range of programs that respond well to advances within the various subfields. Important advances are being made by NSF funded researchers across the full range of the TP program. The challenge is to maintain this quality as new initiatives emerge. Knowledgeable program officers who have some time to pursue their own research are an essential ingredient here. Keeping current with the field is necessary to best evaluate the many new opportunities, e. g. computational physics, information technology and nanoscience, that are emerging.

The theory grants are about 1/2 the size, on average, of those funded by DOE and by NSF in the quantum chemistry program. The choice here is between not funding many very good proposals or funding at the present level where there is about 1/2 a student and .3 of a postdoctoral assistant per PI. To some extent, this means that theory students and postdocs must shoulder teaching duties in addition to research. Indeed, this may be the norm for NSF theory, but it is detrimental to the training of theory students and to the value of theory programs in physics departments. However, the panel found that the funded research was of high quality, so that any change of the grant size would require a deliberate decision to not fund many good research proposals. We are reluctant to recommend that course of action. We recognize, however, that a simple recommendation to increase grant size has little credibility unless that is made a top priority. At least temporarily, the number of funded proposals will need to be reduced in order to increase the grant size. The quantum chemistry program affords an example of this strategy. Grant numbers were reduced in order to bring grant size into accord with those of other agencies or areas. We see no consensus in the community for this course with regard to the theory program.

Balance was judged favorable on all accounts, with the possible exception of the new investigator category. Appropriate statistical data were not available to evaluate how many new investigators were funded.

Awards to individuals represent the core of the theory program, although there are also two centers. The ITP at Santa Barbara has a truly world leadership position in theory and has attracted top people, media attention, and private funds. It is a notable success story.

The Institute for Theoretical Atomic, Molecular, and Optical Physics at the Harvard-Smithsonian Institute for Astrophysics is another such center, although it is much smaller and has a more limited scope. This institute has been effective in providing a focus for AMO theory, in providing an environment where postdoctoral associates can flourish, and in hosting workshops on a wide variety of theoretical topics. The postdoctoral fellows have been very successful in obtaining faculty positions, which was one of the desired outcomes for the institute. It meets a need that cannot be provided by individual grants and is generally well regarded by the AMO community.

There is some concern about the impact of the new centers planned for the future on individual PI's. The negative impact on individual PI's in 2002 caused by NSF initiatives and centers was regarded as very damaging to the program and should be avoided with highest priority in the future.

The program has a good balance across institutional types, with forefront research being conducted at both research institutions and RUI's. We are unable to assess the geographical distribution, although we note that the EPSCOR program does have a small impact.

There appear to be no structural impediments to the increased participation of woman and underrepresented minority groups. The TP program appears to have extra review mechanisms in place to carefully scrutinize proposals submitted from this group. This includes proactive behavior by the POs and division director.

There has been some progress in increasing the role of women. In the area of elementary particle physics there has recently emerged in positions of leadership a number of female PIs. Two such notable examples are Mirjam Cvetic (PHY-0203585) and Renata Kallosh (PHY-9870115).

By way of contrast, we did not note any significant progress in increasing the role of minorities. However, the factors leading to this appear far beyond the control of this program.

There is excellent quality of science across the five subfields of theory. The information technology initiative could have an impact on the theory program since theory proposals may often have an IT component. Conversely, IT proposals may also have a physics component. For example, software for visualization of microscopic dynamics and modeling of quantum computing schemes are two areas where there is a potential for physics to contribute to IT and computational physics. Because the foundation-wide number of IT proposals is large (~1500) and each one must be given some consideration, however brief, by Program Officers for

Theoretical Physics, the workload of program officers is greatly increased. Thus, despite the excitement of this new area and the opportunities that it may afford for theoretical physics, it is essential that the workloads of program officers not become so onerous that the excellent core program is adversely impacted or opportunities in this new initiative are missed. The panel recommends that serious consideration be given to the workload associated with new initiatives and make appropriate adjustments through new hires, if necessary.

There is also a computational physics initiative which we did not evaluate owing to the newness of the program. It does interact with the IT initiative and may have a significant impact in the future.

4.6.A5 Management of the program under review.

Overall the management of the theoretical physics program, given the diversity of the field, favorably impressed us. The program officers have done a truly outstanding job. They fund a strong core program which responds quickly to new research directions and is attentive to education. In all of this they have been guided by the present well-functioning review system. They are also responding to the IT initiative and are cognizant of its potential impact on the program.

The COV subpanel for theory noted a major funding problem in 2002 owing to unforeseen requirements of other programs. The resulting program cuts and funding delays damaged the image of the NSF. The panel recommends that steps be taken avoid a repetition of this and similar problems in the future.

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

4.6.B1 PEOPLE

Seed funding of the ITP by NSF brought private funds into the mix of projects at the Institute. The ITP is internationally recognized for the excellent research and education opportunities centered there. Proposal PHY-0098395 (Sugar).

4.6.B2 IDEAS

a) Electron cloud spinning above the surface of a metallic carbon nanotube.

Brian Granger and Hossein Sadeghpour at ITAMP have proposed that electrons may be bound to metallic carbon nanotubes in orbits around the nanotube. These structures could be used as microscopic traps for electrons and ions. Such technology may be employed in certain quantum computer schemes. PHY-0140320 Kirby

b) Production of Black Holes at Future Colliders:

Dimopolos Arkani-Hamed and Dvali have proposed that if extra dimensions are large, of the order of millimeters, TeV scale black holes can be produced in collisions. They estimate a production rate of 10^7 per year. The holes would radiate symmetrically with a Planck spectrum. If this prediction holds, it will be possible to determine the Hawking Temperature. PHY-9870115, PHY-0098840, PHY-0070787.

c) Lattice QCD and quark confinement.

Carleton DeTar and Robert Sugar have completed lattice QCD calculations of quark confinement and the structure of nucleons. Their summary statement reads "Thus our picture of how QCD works has been verified by direct numerical simulations." This is an important milestone for the standard model. PHY-0139929

4.6.B3 TOOLS

M. Pindzola and F. Robacheux have accomplished time dependent simulations of the fragmentation of helium atoms into their basic constituents, namely, two electrons and an alpha particle, at Auburn University. Such simulations of time-dependent microscopic dynamics allow for the visualization of processes involving dynamics on the microscopic scale, which can readily be used for educational and informational purposes. PHY-0098185

4.6.C Other topics:

- The workload of program officers is a concern since the management of new initiatives takes time away from management of core programs. This is particularly noticeable in the theory program which has some connection with the IT program. The excitement generated by that initiative is evident by the agency wide reception of 1500 proposals. Even a cursory consideration of these proposals requires a considerable time investment. It is imperative that the workload produced by new directions not result in personnel burnout.

- The disaster of 2002 adversely affected the confidence of the theory community in NSF management. Steps to insure that similar glitches are avoided in future should be implemented.

- We believe that less redundancy in the report template would be helpful. There seems no point in answering different questions phrased in only slightly different ways. Conciseness is a virtue that would help the panel get through three rather intense days with a minimum of wasted effort. It would also be helpful if the report template allowed for responses intermediate between yes and no.

4.7 Educational and Interdisciplinary Research Programs Subcommittee Report

Education and interdisciplinary research is integrated into all of the physics programs of the Physics Division. However, physics does not always fit neatly into existing categories and the EIR program allows the Physics Division to fund important physics research that is outside of the boundaries defined for the other programs. The EIR program can also serve to nurture emerging fields of physics. This was recently demonstrated in the case of Biological Physics which has now become its own program within the Physics Division. The COV concurs with this reorganization and applauds this program for its successful support. We believe that focused funding through this program can result in the same successful nurturing of the field of Physics Education research. In this report we agree with much of the report of the previous COV on the importance of a steadily increasing support of Biological Physics, Physics Education Research, and the REU/RET program while remaining open to the individual investigators proposing interdisciplinary research.

Overall, this program has a direct responsibility for maintaining the interface between the Physics Division's contributions to discoveries at and across the Frontier of Science and Engineering, as specified in NSF's Government Performance and Results Act (GPRA) plan, and the other three elements of the plan: Connections between Discoveries and their Use in Service to Society; A Diverse, Globally-Oriented Science and Engineering Workforce; and Improved Mathematics and Science Skills by All Americans. To accomplish these goals, the EIR program must remain flexible and interested in forming alliances with other programs in the Physics Division, other Divisions within NSF, and other funding Agencies. The COV recognizes that the leadership of this program has done an outstanding job in meeting these goals by leveraging the strengths of the physics research community represented primarily by the other programs in the Division.

Biological Physics

The goal of biological physics is the discovery of the physical concepts and laws that underlie living systems, from biomolecules to cells to organs, using experiment, theory, and computation. As an example, consider proteins, the building blocks of living matter. They are prototypes of complex systems; they are complex enough so that laws of complexity can be explored yet simple enough so that they can be understood. The goal of biological physics is conceptually different from that of biophysics where tools from physics are used to study biological and medical phenomena. The training of biological physicists and biophysicists is different. Biological physicists are fully trained as physicists, but study biological systems. The education of biophysicists involves less physics, but much more biochemistry and biology. Biological physicists are housed in physics departments, while biophysicists often have an own department or are members of biochemistry departments. At present, biological physicists often have a problem finding support from sources that understand their goal. Here is where the new NSF program can have an enormous influence by supporting research directed at exploring the fundamental physical aspects of biological systems.

While the goal of biological physics is new physics, progress in biological physics inevitably leads to advances in other fields such as biochemistry, biology, pharmacology, and medicine by providing the quantitative underpinning and new techniques. Close interaction with these other fields is important. The Physics Division has already been successful in forging many of the relevant connections. Biological Physics is a rapidly expanding field, as witnessed by the Biological Physics Division of the American Physical Society which has grown by about 15 %

during the last two years and now counts over 1500 members. Where biological physics groups have been established, they have proved very popular with physics students.

At present, the biological physics topics supported by the NSF are narrow, the number of grants is small, and the expertise in biological physics in the division in is limited. An ad-hoc advisory group or a workshop could help define the scope of Biological Physics to be funded by the Physics Division.

Physics Education Research

Physics education research is the systematic study of efficient and effective ways of teaching physics by physicists within the discipline of physics. The American Physical Society has recognized this research as a branch of physics and a growing number of physics departments at major research universities now award a Ph.D. for work done in physics education research. These graduates are highly sought after faculty members in the physics departments of colleges and universities because their research programs have direct consequences for the quality of the physics education at those institutions. As pointed out by the previous COV this research field is "intimately tied to the content and skills of physics and the improvements in physics education which are important for the health of physics." Although the previous COV, urged the Division "to consider increasing its support of PER substantially", this has yet to occur. We reiterate the position of the previous COV. Currently only one program is funded in this category.

To enlarge the proposal base for this research, we believe that the Division needs to more carefully define the type of research that is likely to be funded as Physics Education research. It is important to recognize the difference between PER and the delivery of education. Activities such a curriculum restructuring, materials development, forming alliances with schools, or outreach are indeed education and valuable to physics and the nation but are not PER. Examples of PER might include investigations of the causes of the "leaky pipeline" in physics especially with respect to underrepresented populations or investigations centering on the efficient delivery of the physics curriculum at all levels to determine the important parameters of that system. In particular we urge the Division to expand its funding of large, well focused, university based programs of Physics Education research to more than one group as well beginning to fund a large and diverse portfolio of smaller single purpose grants.

Education

Again we agree the previous COV in urging "the Division to make undergraduate physics education a major priority of its educational efforts. The vitality of the physics research enterprise requires healthy undergraduate physics programs across the nation. Moreover, our future K-12 teachers receive their scientific training as undergraduates, and physics departments must accept more responsibility for seeing that our future teachers have the best possible scientific preparation. Given the critical nature of undergraduate physics for the physics enterprise, we urge the Division of Physics to increase its efforts in encouraging and supporting innovations and improvements in all aspects of undergraduate physics. Cooperation between Physics and EHR is obviously important in seeking coherence of activities aimed at undergraduate physics. We believe, however, that the Division of Physics must become more active in encouraging the evolution of undergraduate physics programs to meet the changing needs of the discipline and the changing needs of society."

The EIR program is doing an outstanding job in improving the undergraduate education of potential physicists through the REU program. This program is a splendid example of teaching by introducing students to the reality of physics by immersing them in frontline research programs. Over half of the physics majors in this country are educated at primarily undergraduate institutions. While those institutions do have some educational advantages, they cannot allow students to experience the reality and excitement of research participation with graduate students, postdocs, and research university faculty. This function is fulfilled admirably by the REU program.

Improvement in the physics curriculum at undergraduate institutions is clearly needed in terms of efficiency, effectiveness, and modernization. A vigorous and diverse physics education research program is needed to supply the intellectual capital to begin this process and such programs across the country have begun to have impact. However, the Physics Division has not yet responded at a sufficient scale to support such efforts and we urge it to do so. There is much education research and development concerning the teaching and learning of physics that can be of specific benefit to the physics community, ranging from improved efficiency in the learning of physics majors, improved recruitment and retention of physics majors, and improved success in teaching our client populations of engineers, biologists, and other scientists.

EIR is making great strides in laying the groundwork for improving mathematics and science skills by all Americans with its attention to integrating K-12 teachers into the mainstream of physics. The COV recognizes the importance of the Research Experiences for Teachers (RET) and its support for the PhysTECH program to increase the contact between physics departments and colleges of education at our universities. We also applaud the support for other, more specific programs to involve K-12 teachers in research such as QuarkNet in other programs in the Division. We also note the existence of a few REU programs that focus on research experience for undergraduates who intend to enter K-12 teaching. This is a promising area of expansion of the REU program. Although these programs will not by themselves improve the quality of mathematics and science teaching in our schools, they are a necessary component. It is almost impossible to imagine teachers making informed decisions about the science and mathematics curriculum in the modern research driven world who have not experienced that world first hand.

Evaluation of education programs is difficult both because the processes and the constraints are complex and because the goals are long term. For this reason the COV applauds the program in having an outside evaluator conduct an assessment of the REU program. Meanwhile, the Committee concurs with the previous COV and "strongly recommends, that the Research Experience for Undergraduates (REU) (which is now a mature program) continue to grow at a modest rate driven primarily by proposal demand. The physics community (and indeed the scientific community at large) now widely recognizes the importance of undergraduate research experiences both for training the next generation of professional physicists and for providing first-hand experience with cutting edge research for students who pursue a wide range of scientific and technical careers. The current suite of REU opportunities-through REU sites, REU supplements, REU positions at the National Labs, and college- and university funded positions -provides summer research positions for a reasonable fraction of undergraduate physics majors at some point during their undergraduate careers. We believe that this level can be increased without sacrificing the quality of the REU programs." This committee also believes that expansion of the REU program would allow earlier entry into the program and a larger number of students who would have more than one summer of research experience. This expanded experience could be particularly important in encouraging underrepresented minorities to pursue a career in physics research.

We also join with the previous COV in recognizing "that the RET program, although relatively new and impacting only a very limited number of high school teachers, nevertheless has the potential of affecting many high school students through continued interaction between the teachers and the physics researchers. We urge the Division to expand the RET program, perhaps by providing RET supplements to NSF-funded research projects just as it now provides for REU supplements. In addition, each REU site might well support one or two RETs." The current COV commends the Division for implementing this recommendation and look forward to its expansion.

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. 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 the education of university students. The major problem with this program is that too few awards are made. Too often high quality proposals are declined. We understand that this results from balancing overall funding priorities. We note two difficulties with this program. The first is timing. An early decision is crucial to new faculty so that they will have time to use feedback and apply for other grants. Unfortunately there is a sizeable lag between when the proposals are due and when the decision is made. This is mostly because of the structure of considering these awards along with all awards in a given program. There are good reasons for this procedure but it does cause a time delay. Another difficulty is paradoxically the large size of CAREER grants. Since they are larger than the average grant for senior theorists, this biases the CAREER awards against theorists. We urge either that all theory awards be increased substantially or that the minimum size of CAREER awards be reduced so that new faculty may more fairly compete for this award.

Major Research Instrumentation Program (MRI) Awards

MRI allows faculty to use research instrumentation and gives their students the opportunity to use this up-to-date instrumentation in their research education. Especially in these times of shrinking budgets, this program is essential to maintain the level of skilled scientific manpower in this country. The MRI program has made good investments in a variety of instrumentation at research institutions and is necessary to continue quality education in primarily undergraduate institutions.

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 mechanism is appropriate except perhaps for the small number of Physics Education Research proposals (see below).

In most cases the reviews are excellent and the feedback to the PIs is valuable. This is especially true in the case of REU proposals. However, the COV found a difficulty in one proposal out of 40 reviewed in detail by the COV. This proposal represented 50% of the Physics Education Research proposals reviewed (both were declined). It also found potential difficulties in the Biological Physics review. In both cases the fields are complex and interdisciplinary and reviewers from other fields can be useful. However, it is important that the physics viewpoint in that field prevail in any review conclusion.

In the case of a physics education proposal we observed that several reviewers stated that they were not qualified to review the proposal but did so anyway. All of these reviewers were physicists with experience in preparing curricular materials but none was a physics education researcher. In this case, none of the reviewers gave a relevant review of the proposal. The decision of the Foundation to decline the proposal was correct, in our view, but the feedback given to the PI based on the review was misleading.

We found that the merit review procedures have been consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines. However, we did find that the most current CAREER program announcement was somewhat misleading about the appropriate kinds of educational activities desired. In section II Program Description, the fourth paragraph is the first to describe possible educational activities.

> "Proposed education activities may be in a broad range of areas and may be directed to any level: K-12 students, undergraduates, graduate students, and/or the general public. Examples include but are not limited to: designing innovative courses or curricula; supporting teacher preparation and enhancement; conducting outreach and mentoring activities to enhance scientific literacy or involve students from groups that have been traditionally underrepresented in science; researching pedagogy or students' learning and conceptual development in the discipline; incorporating research activities into undergraduate courses; linking education activities to industrial, international, or cross-disciplinary work; and implementing innovative methods for evaluation and assessment."

Most of those activities are very important but also very difficult and have a low probability of success. They are typically inappropriate activities for faculty beginning their careers. The next paragraph gives more appropriate and potentially successful educational activities that should be encouraged.

> "Education activities may include designing new educational materials and practices or adapting and implementing effective educational materials and practices developed elsewhere. Such activities should be consistent with research and best practices in curriculum, pedagogy, and evaluation."

We recommend deleting paragraph four since it is misleading to both those writing proposals and those reviewing them.

In all cases we reviewed, the recommendations of the reviewers and program officer were clear and well documented. This record formed the basis for decisions within the Division. In one case for example, for the funding of US participation in an international conference, the reviewers were well qualified and the reviews well thought out. However, their viewpoints appeared to be too narrow about mechanisms necessary for the change of culture that was the subject of the conference. Their reasons for recommending the Foundation decline the proposal could be due to a narrow interpretation of the two criteria of intellectual merit and broader impact. The program officer made a clear decision based on the reviews. That decision was appropriately reversed within the Division.

EIR has a very good time to decision on proposals with about 70% falling within a 6 month window. An exception is the CAREER proposals which, because of the Foundation-wide deadline coupled with a review within other program proposals, causes an unfortunate delay for the new faculty who can least afford it. A faster turn around on CAREER proposals would be desirable.

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

This was always adequately addressed by the proposals and the reviewers. With the proposals in EIR, the expectation of broader impacts is usually central. However, occasionally the intellectual merit criterion is too narrowly interpreted by the reviewers. This was the case in the example of the proposal to help support US participation in an international conference given above. These problems are adequately handled by the review mechanisms in place within the Division.

In programs sponsored by the Foundation such as REU and RET, the intellectual merit and broader impacts have already been determined. Because these programs are all directed toward a common goal, the COV believes that more sharing of information will improved the quality of all proposals. Consequently we recommend that the NSF sponsor a web site to give examples of successful components of these programs so that they can more easily be replicated.

4.7.A3 Reviewer Selection

Because funding has a crucial impact on the direction and progress of a new field of research, choosing reviewers for this proposal must be done with great care. The knowledge of the reviews is important not just for the decision to accept or decline a proposal but also to give feedback that will result in stronger proposals in the future.

This can be difficult because of the nature of proposals to this program and is usually done well. However, occasionally, as in the example of the physics education proposal cited above, the reviewers, no matter how respected for their work in related activities, are not qualified to comment on a proposal. This situation will arise most frequently in a new field with a rapidly expanding knowledge base such as physics education research. This results in a small reviewer pool where members may have specialized and non-overlapping knowledge. Because the field is expanding, the appropriate reviewer pool will also be comprised of younger, less well established researchers. In cases such as this, we recommend that the program officer solicit advice from experienced researchers representing the current diversity of the field (i.e. physics education research) to establish an initial reviewer pool. Reviews should be encouraged to decline to review a proposal if they do not feel qualified to do so.

4.7.A4 Resulting portfolio of awards:

We applaud the decision to have a separate biological physics program. The EIR program should be congratulated for nurturing the research of this rapidly expanding branch of physics.

The balance represented in the REU, ADVANCE, and CAREER programs is reasonable. However, the present topics in biological physics and physics education supported by the Physics Division are narrow and the number of grants is small. A workshop called by the Physics Division could help define the scope of each of these subject areas that will be funded by the Division. These workshops could be valuable in suggesting new opportunities and attracting more applications. In particular, the distinction between the criteria for funding from EIR and EHR should be clarified.

Although the COV does not expect the field of Physics Education research to grow at the same rate or to the same size as biological physics, we do concur with the previous COV that it is an important field that should be supported in the Physics Division. The last COV report contained the following paragraph that is, if anything, even more applicable today:

"The field of physics education research (PER)-the systematic study of how students do or do not learn physics-is a rapidly growing part of the physics enterprise. … Since PER is a research field intimately tied to the content and skills of physics and the improvements in physics education which those studies lead to are important for the health of physics education, we urge the Division of Physics to find ways to support PER activities. We understand that there are some beginning efforts in this direction, which we applaud, but we urge the Division to consider increasing its support of PER substantially."

The current COV sees little progress in this sector. The Physics Division has a reputation as not being open to PER proposals. If this is to change, positive efforts will have to be made to clarify the types of proposals that are fundable in EIR. We especially note that only one real physics education research grant is partially supported by the Physics Division. We urge the Division to widen its portfolio to support other such broad PER efforts as well as adding a significant number of smaller, narrowly directed grants.

There is much education research and development concerning the teaching and learning of physics that can be of specific benefit to the physics community, ranging from improved learning of physics majors, improved recruitment and retention of physics majors, and improved efficiency in teaching our client populations of engineers, biologists, and other scientists. We recommend that the language in the program announcement be modified. Alternate appropriate language could read as follows:

"This program also supports activities in education that primarily benefit the physics community. This includes a wide variety of possible activities ranging from preparing undergraduate students for research through participation in research activities, to research and development that will lead to methods of teaching physics more efficiently."

The greatest impact of the Division in the field of education is its ability to allow students and teachers to work with researchers exploring the frontiers of physics. The Research Experience for Undergraduates (REU) program has expanded and appears to be a well functioning and wide spread program that allows undergraduates to partake in research at the countries major universities and research laboratories. We note that in a recent American Institute of Physics survey, 35% of the senior physics majors in 1999 and 2000, reported that they had an REU experience. This is about half of those that had any undergraduate research experience. Even accounting for reporting bias (it is possible that those who responded are more likely to be those who applied for an REU program), this shows the impact of the REU program on physics majors. Of the seniors planning to pursue graduate studies in physics, 90% reported having a research experience (although the REU experience was not the only experience possible). The AIP report notes that only half of the undergraduates planning to become high school physics teachers had a research experience. This is a problem and we concur with the previous COV that future physics teachers should be a target population for REU programs. Even with the expansion of the REU program, there is still room for significant growth. In addition to increasing the population of future teachers in the program, it would be useful to engage students earlier in their careers (Sophomores) and have enough availability for multiple REU experiences. This strategy has been shown by some of the REU programs to be especially useful for underrepresented minorities. Although REU programs are not designed or equipped to do more than the very useful but superficial formative evaluation of their programs, we applaud the commissioning of an outside evaluation group to access the entire REU program. This type of large scale evaluation should provide valuable information about the impact of the program.

In contrast to the REU program, Research Experiences for Teachers, RET, is still small and new. It gives promise of having a significant impact on the nation's K-12 program. It should be expanded, especially since most high school and middle school physics teachers have no experienced with contemporary physics as practiced in research laboratories. A sustained RET effort over many years that allows teachers to continue in research laboratories for future years would be especially beneficial.

4.7.A5 Management of the program under review.

The management of the EIR program has been outstanding especially given its diverse nature. There is a good awareness of the current state-of-the-art of Physics Education from the reviews of CAREER and ADVANCE proposals. However the COV is concerned that the current program officer who has done an excellent job has returned to his university and is only part time. We believe that the program manager of EIR should be a full time position based at NSF. This is especially important for EIR since the proposals are interdisciplinary and may involve consultations with other programs in the Division, other Divisions within NSF, and other federal funding agencies.

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

4.7.B1 PEOPLE

All programs in the Division directly contribute to developing a competitive workforce of scientists because only by being an "apprentice" in a research group does a graduate student learn to be a scientist. The research groups funded by other programs also contribute to this goal by involving undergraduate students in their research programs. EIR has been part of this Division wide effort by funding research in Biological Physics, turbulence studies, and, to a small extent Physics Education. However, only some of the undergraduate students at graduate institutions are able to participate in frontier research and over half of the physics undergraduates in this country attend primarily undergraduate institutions. EIR directly impacts undergraduate students through the REU site program and indirectly impacts high school students through the RET program. At high school, most students have not yet differentiated between scientists and engineers. It is the actions of these teachers that will determine our having a diverse workforce of scientists and engineers as well as well-prepared citizens.

Examples:

- The REU site awards allow qualified undergraduate students to experience the reality of practicing physics by participating in frontier research. This apprenticeship type of experience is the most efficient way to educate students in the process of doing physics. It communicates both the excitement and challenges of scientific exploration. Because of their location, different sites can target different undergraduate student populations. For example, Wayne State University in Detroit has a very successful program working with minority students from the city. REU sites as a whole have significantly more underrepresented minority students then the general population of students in physics graduate schools. Students in the program become globally connected through research that involves international collaborations. A few REU programs such as those at the University of Michigan make the global connection explicit by having the student research take place at the CERN.

- The RET program involves high school and some middle school teachers in research in a manner similar to the REU programs. Because these are teachers, there is a great deal of leverage in this program. The RET program not only involves teachers in frontier research, it connects them to university faculty, and involves them in the process of reforming their own teaching and, by example, that of their colleagues.

4.7.B2 IDEAS

This is obviously accomplished by the REU and RET programs described above. All of the Biological Physics that was nurtured in EIR and will now be in its own program is also an excellent example of discovery connected, by potential medical applications, to service to society.

4.7.B3 TOOLS

This goal is directly addressed by the MRI program described earlier.

The REU program has resulted in important techniques and procedures for getting different populations of undergraduate students quickly connected to physics research and to the discipline of physics. A centralized web site to disseminate these successful practices would be very useful. As the RET program matures and grows, it will also produce procedures that are useful in connecting teachers and indirectly K-12 students to frontier physics research. This process has already been demonstrated by the successful QuarkNet program. In the case of RET, the procedures may well be different since the research is more centered on single investigator research as opposed to the large collaborations served by QuarkNet.

Other examples from interdisciplinary research from the field of turbulence were given by the previous COV but are still valid. Turbulence is a non-linear phenomena that has immense practical applications since our very existence depends on the fluid we live in, the atmosphere. An interesting example is particle tracking in High Reynolds Number Turbulent Flows (E. Bodenschatz, Cornell U.) uses detectors designed for high energy physics experiments to track detailed movements of particles in turbulent flow. These techniques are relevant to understanding particle transport in the atmosphere.

Appendix A Committee

Dr. Mary Alberg
Department of Physics
Seattle University
900 Broadway
Seattle, WA 98122-4340
alberg@seattleu.edu
(206) 296-5938
(206) 296-2179

Dr. Thomas Appelquist
Department of Physics
Yale University
P.O. Box 208120
New Haven, CT 06520-8120
thomas.appelquist@yale.edu
(203) 432-6969
(203) 432-5419

Dr. Nicholas P. Bigelow
Dept. of Physics & Astronomy
University of Rochester
Bausch & Lomb Hall
Rochester, NY 14627-0171
nbig@lle.rochester.edu
(716) 275-8549
(716) 275-8527

Dr. Gordon D. Cates
Department of Physics
University of Virginia
P.O. Box 400714
372 McCormick Rd.
Charlottesville, VA 22903
cates@pupgg.princeton.edu
(434) 924-4790

Dr. Mario Diaz
Dept. of Physical Sciences
Univ. of Texas, Brownville
Brownville, TX 78520
mdiaz@utb1.utb.edu
(956) 574-6682
(956) 574-6692

Dr. Brenda Dingus
Los Alamos Nat'l Lab
P.O. Box 1663
Los Alamos, NM 87545
dingus@lanl.gov
(505) 667-0400
(505) 667-4120

Dr. Persis S. Drell **(Chair)**
Stanford Linear Accel. Ctr.
MS 75, RD/30A
2575 Sand Hall Rd.
Menlo Park, CA 94025
persis@slac.stanford.edu
(650) 926-8704
(650) 926-8705

Dr. Hans Frauenfelder
Los Alamos Nat'l Lab
MS B258
Los Alamos, NM 87545
frauenfelder@lanl.gov
(505) 665-2547
(505) 665-2659

Dr. Richard J.Furnstahl
Department of Physics
Ohio State University
174 W. 18th Ave.
Columbus, OH 43210
furnstahl.1@osu.edu
(614) 292-4830
(614) 292-7557

Dr. Thomas Gaisser
University of Delaware
Bartol Research Inst.
Newark, DE 19716
gaisser@bartol.udel.edu
(302) 831-8113
(302) 831-1843

Dr. S. James Gates
Department of Physics
University of Maryland
Room 4125
College Park, MD 20742
gatess@wam.umd.edu
(301) 405-6025

Dr. Walter Gekelman
Univ. of Cal., Los Angeles
Plasma Physics Lab
1000 Veteran Ave.
Los Angeles, CA 90095-1696
gekelman@physics.ucla.edu
(310) 206-1772
(310) 206-5484

Dr. Kenneth J. Heller
School of Physics & Astronomy
University of Minnesota
Minneapolis, MN 55455
heller@physics.umn.edu
(612) 624-7314

Dr. Barbara Jacak
Department of Physics
SUNY, Stony Brook
Stony Brook, NY 11794-3800
jacak@skipper.physics.sunysb.edu
(631) 632-6041
(631) 632-8573

Dr. Sally Koutsoliotas
Department of Physics
Bucknell University
Lewisburg, PA 17837
koutslts@bucknell.edu
(570) 577-3105

Dr. Robert E. Lanou
Dept. of Physics
Brown University
Providence, RI 02912
lanou@physics.brown.edu
(401) 863-2632

Dr. William C. Lineberger
JILA, CB440
University of Colorado
Boulder, CO 80309-0440
wcl@jila.colorado.edu
(303) 492-7834
(303) 492-8994

Dr. Joseph H. Macek
Theoretical Physics
University of Tennessee
200 South College
Knoxville, TN 37996-1501
jmacek@utk.edu
(865) 974-0770
(865) 974-6378

Dr. Donald Madison
University of Missouri
107 Physics
1870 Miner Circle
Rolla, MO 65409-0640
madison@umr.edu
(573) 341-4703
(573) 341-4715

Dr. C. Jeff Martoff
Temple University
Barton Hall
1900 N. 13th Street
Philadelphia, PA 19122-6082
cmartoff@nimbus.temple.edu
(215) 204-3180
(215) 204-5652

Dr. June Matthews
MIT - Lab for Nuclear Science
77 Massachusetts Avenue, Rm. 26-505
Cambridge, MA 02139-4307
matthews@mit.edu
(617) 253-7800
(617) 253-0111

Dr. Gregory A. Norton
National Electrostatics Corp.
Box 620310 Graber Rd.
Middleton, WI 53562-0310
nec@pelletron.com
(608) 831-7600
(608) 256-4103

Dr. Luis A Orozco
Dept. of Physics & Astronomy
SUNY, Stony Brook
Stony Brook, NY 11794-3800
luis.orozco@sunysb.edu
(631) 632-8138
(631) 632-8176

Dr. Harrison B. Prosper
Dept. of Physics, Rm. 514 Keen Bldg.
Florida State Univ.
Tallahassee, FL 32306
harry@hep.fsu.edu
(850) 644-6760
(850) 644-6735

Dr. Edward F. Redish
Dept. of Physics
Univ. of Maryland
College Park, MD 20742
redish@physics.umd.edu
(301) 405-6120
(301) 314-9531

Dr. Peter R. Saulson
Dept. of Physics
Syracuse Univ.
Syracuse, NY 13244-1130
saulson@ligo-la.caltech.edu
(315) 443-5994
(315) 443-9103

Dr. Bernard F. Schutz
Albert Einstein Institute
Gravitationsphysik
Schaatzweg 1, D-14473
Postdam, Germany
schutz@aei-potsdam.mpg.de

Dr. Michael H. Shaevitz
Nevis Lab
Columbia Univ.
136 S. Broadway
Irvington, NY 10533
shaevitz@nevis.nevis.columbia.edu
(914) 591-2806
(914) 591-8120

Dr. Suzanne T. Staggs
Physics Dept., Jadwin Hall,
Washington Rd., Box 708
Princeton Univ.
Princeton, NJ 08544-0708
staggs@princeton.edu
(609) 258-5930
(609) 258-6853

Dr. T. James Symons
Nuclear Science Division, B520A-1148
Lawrence Berkeley Nat'l Lab
Berkeley, CA 94720
tjsymons@lbl.gov
(510) 486-5670
(510) 486-4808

Dr. Robert M. Wald
Enrico Fermi Institute
Univ. of Chicago
5630 S. Ellis Ave.
Chicago, IL 60637
rmwa@midway.uchicago.edu
(773) 702-7765
(773) 702-8038

Dr. Vicky White
Fermi National Accelerator Lab
P.O. Box 500
Batavia, IL 60510
white@fnal.gov
(630) 840-39936

Appendix B Agenda

Division of Physics
Committee of Visitors
February 26 - 28, 2003
Tentative Agenda

Wednesday, February 26 - Room 375

7:30 am Continental Breakfast

8:00 am Welcome and Charge to Committee
Adriaan de Graaf, Executive Officer, Directorate for Mathematical and Physical Sciences

8:15 am PHY Overview, Priorities, and Directions
Joe Dehmer, Director, Division of Physics (PHY)

9:00 am Program Overviews (25 minutes each, including discussion)

Atomic, Molecular, Optical, and Plasma Physics (AMOP)
Denise Caldwell, Barry Schneider, and John Carlsten
Elementary Particle Physics (EPP)
Marvin Goldberg, Jim Whitmore, and Alex Firestone
Gravitational Physics (GP) and LIGO
Beverly Berger and **Tom Lucatorto**

10:15 am Break

10:30 am Nuclear Physics (NP)
Brad Keister and Richard Boyd
Particle and Nuclear Astrophysics (PNA)
Richard Boyd, Marv Goldberg, Alex Firestone, and Jim Whitmore,
Theoretical Physics (TP)
Barry Schneider, Fred Cooper, and Earle Lomon
Education and Interdisciplinary Research (EIR)
Larry Brown, Denise Caldwell
Physics Frontier Centers (PFC)
Denise Caldwell

12:30 pm Working Lunch

COV Guidelines
    Morris Aizenman, Senior Science Associate, OAD/MPS
Review of Statistical Information and Procedures
    Pat Bautz, Acting Executive Officer, Division of Physics

1:30 pm Review of Individual PHY Programs (Move to Breakout Rooms))
    A: Integrity and Efficacy of Program Processes for Proposal Actions
    B: Quality and Significance of the Results of Program Investments
    C. Relationship to Foundation-wide Programs and Strategic Goals

6:00 pm Adjourn for Informal Reception in Room 1020

Thursday, February 27

7:30 am Continental Breakfast (Room 375)

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

2:30 pm Break and Distribution of Individual Program COV Reports

3:00 pm Presentation of COV Reports by Program COV Chairs (Room 375)

5:00 pm Adjourn

Friday, February 28 - Room 375

7:30 am Continental Breakfast

8:00 am Division-Level Review
    D. Division's Processes, Results, and Relationship to NSF Goals
    E. Division's Balance, Priorities, and Future Directions
    F. Any Other Issues the COV Considers Relevant to the Review

10:30 am Preparation of Division-Level Report

11:45 am Working Lunch:

2:00 pm Complete Draft of Division-Level Report

2:30 pm	Closeout Session with Adriaan de Graaf and Division of Physics 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

January 6, 2003

Dr. Persis S. Drell
Stanford Linear Accelerator Center
MS 75, RD/30 A
2575 Sand Hall Road
Menlo Park, CA 94025

Dear Dr. Drell,

Thank you for agreeing to chair the FY 2003 Committee of Visitors (COV) for the Division of Physics (PHY). The COV Review will take place at the NSF in Arlington, Virginia, on February 26 - 28, 2003. 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 quality and significance of the results of the Division's programmatic investments;
- the relationship between award decisions, program goals, and Foundation-wide programs and strategic goals;
- 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 based on the informed judgment of 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 2000, FY 2001, and FY 2002. 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

The general outline of the meeting will be an introductory session in which the Division Director, Joe Dehmer, and the PHY staff will present an overview of the Division's activities and plans, a brief overview of each program, and a review of statistical information 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 March 14 to allow time for comment and distribution of the report to the full MPSAC prior to their meeting on April 3 - 4, 2003.

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 bring this material with you to NSF. Please feel free to contact Joe or Pat Bautz, PHY Acting 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,

John B. Hunt
Acting Assistant Director

Enclosure: List of Members of FY 2003 PHY COV
cc: Joseph Salah, Chair MPSAC

FY 2003 REPORT TEMPLATE FOR
NSF COMMITTEES OF VISITORS (COVs)

Date of COV: February 26-28, 2003
Program/Cluster:
Division: Physics
Directorate: MPS
Number of actions reviewed by COV[1]: Awards: 136 Declinations: 132 Other:
Total number of actions within Program/Cluster/Division during period being reviewed by COV[2]: 1709 Awards: 779 Declinations: 928 Other: 1741
Manner in which reviewed actions were selected: By program officers with some requests from the committee

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. Please do not take time to answer questions if they do not apply to the program.

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
Is the review mechanism appropriate? (panels, ad hoc reviews, site visits) Comments: Increased use of panels applauded	Yes
Is the review process efficient and effective? Comments:	Yes

[1] To be provided by NSF staff.
[2] To be provided by NSF staff.

Are reviews consistent with priorities and criteria stated in the program's solicitations, announcements, and guidelines? Comments:	Yes
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
Do the panel summaries provide sufficient information for the principal investigator(s) to understand the basis for the panel recommendation? Comments:	Yes
Is the documentation for recommendations complete, and does the program officer provide sufficient information and justification for her/his recommendation? Comments:	Yes
Is the time to decision appropriate? Comments:	Yes

Discuss issues identified by the COV concerning the quality and effectiveness of the program's use of merit review procedures:
The quality and significance of the results of the programmatic investments is excellent. Extraordinary science is produced and there are excellent investments in tools for the science of the future. A diverse, globally-oriented workforce of scientists and engineers is one of the results of the NSF investments. We feel that the turnover rate for grant renewals and the threshold set for proposal success are appropriate throughout the division programs.

A.2 Questions concerning the implementation of the NSF Merit Review Criteria (intellectual merit and broader impacts) 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
Have the individual reviews (either mail or panel) addressed whether the proposal contributes to both merit review criteria? Comments:	Yes
Have the panel summary reviews addressed whether the proposal contributes to both merit review criteria? Comments:	Yes
Have the *review analyses* (Form 7s) addressed whether the proposal contributes to both merit review criteria? Comments:	Yes

Discuss any issues or concerns the COV has identified with respect to NSF's merit review system. In all programs in the division we heard that there is inconsistent use of criterion 2 in reviewing the proposals. This was an issue raised by the last COV. Over the course of the period we reviewed we could see improvement. However the expectation for criterion 2 is still not effectively communicated to the reviewers and the proposers. We did note that as the review process comes more in the purview of the Program Officers, for example in the panels, there was more sensitivity and attention paid to criterion 2. We attributed this to the interaction between the Program Officers and the panels. In addition, we felt that the potentially very important impact of criterion 2 on the Division programs and perhaps even Foundation wide was not being assessed effectively.

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
Did the program make use of an adequate number of reviewers for a balanced review? Comments:	Yes
Did the program make use of reviewers having appropriate expertise and/or qualifications? Comments:	Yes

Did the program make appropriate use of reviewers to reflect balance among characteristics such as geography, type of institution, and underrepresented groups? Comments:	Yes
Did the program recognize and resolve conflicts of interest when appropriate? Comments:	Yes
Discuss any concerns identified that are relevant to selection of reviewers.	

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, OR DATA NOT AVAILABLE
Overall quality of the research and/or education projects supported by the program. Comments:	Appropriate
Are awards appropriate in size and duration for the scope of the projects? Comments: Most investigator grants are funded at levels inadequate to accomplish their scientific and societal goals efficiently and effectively. Notable examples are the inadequate level of graduate student or postdoc support per PI, the inadequate level of support for technical infrastructure, and the need for investigators to pursue multiple grants to accomplish their research.	Not Appropriate
Does the program portfolio have an appropriate balance of: • High Risk Proposals? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Multidisciplinary Proposals? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Innovative Proposals? Comments:	Appropriate

Does the program portfolio have an appropriate balance of: • Funding for centers, groups and awards to individuals? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Awards to new investigators? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Geographical distribution of Principal Investigators? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Institutional types? Comments:	Appropriate
Does the program portfolio have an appropriate balance of: • Projects that integrate research and education? Comments:	Appropriate
Does the program portfolio have an appropriate balance: • Across disciplines and subdisciplines of the activity and of emerging opportunities? Comments:	Appropriate
Does the program portfolio have appropriate participation of underrepresented groups? Comments:	Appropriate
Is the program relevant to national priorities, agency mission, relevant fields and other customer needs? Include citations of relevant external reports. Comments:	Appropriate

Discuss any concerns identified that are relevant to the quality of the projects or the balance of the portfolio.

The quality and significance of the results of the programmatic investments is excellent. Extraordinary science is produced and there are excellent investments in tools for the science of the future. A diverse, globally-oriented workforce of scientists and engineers is one of the results of the NSF investments.

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

Management of the program.
Comments:
We note the excellent job being done by program officers in all programs of the division. We give very high marks for the outstanding management of the program and the division under difficult conditions resulting from a decade of flat budgets and a critical shortage of staff at time when the diversity and breadth of the portfolio is expanding.

Responsiveness of the program to emerging research and education trends.
Comments:
In general, we see the division as flexible and responsive to emerging trends and needs. Two new programs were started in the period we were reviewing, the program in Particle and Nuclear Astrophysics and the Physics Frontiers Centers. Both are off to an excellent start.

Program planning and prioritization process (internal and external) that guided the development of the portfolio under review.
Comments:
The Physics Division management is well informed and responsive to new developments in the programs it manages. In our evaluation of the scientific priorities of the Division, we note that the combination of the National Science Board and the National Research Council set the highest of standards for the quality of the science produced and that the NSF in this way is a model for all other agencies.

Discuss any concerns identified that are relevant to the management of the program.

Within the Foundation and Division there has been a significant increase in the number of mandated programs and new opportunities for funding. Furthermore, large projects and initiatives are being undertaken that need significant oversight from the Program Officers. Some of the programs in the Division have 50% or more of their resources in non-base programming. The management of these diverse portfolios requires significant oversight. The staff in the division are overloaded and we are concerned. We feel that significant assistance is needed to assure continued excellence in the program.

PART B. RESULTS : OUTPUTS AND OUTCOMES OF NSF INVESTMENTS

NSF investments produce results that appear over time. The answers to questions for 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 FY 2003 Performance 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.

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>NSF OUTCOME GOAL for PEOPLE</u>: Developing "a diverse, internationally competitive and globally engaged workforce of scientists, engineers, and well-prepared citizens." Comments: Outstanding
B.2 <u>NSF 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 OUTCOME GOAL for TOOLS: Providing "broadly accessible, state-of-the-art and shared research and education tools."

Comments: Outstanding

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.

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

The Division is committed to many exciting new facilities (LIGO, LHC, RSVP, ICECUBE) which are defining new programs in their fields. The COV raised concerns about how the operations of these large facilities will be funded by the Foundation without destroying the base programs in the Division. We felt that there needs to be an agency wide plan to support the operations of these large facilities.

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

We anticipate that the Physics Division, along with the entire NSF, may be poised to see significant budget growth in the coming years. We believe that such an investment, particularly in the physical sciences, is long overdue. The strong conviction of the COV is that as the Division budget expands, it is imperative that the highest priority be given to nourishing the base investigator program which has been consistently eroding for over a decade. Most investigator grants are funded at levels inadequate to accomplish their scientific and societal goals efficiently and effectively. Notable examples are the inadequate level of graduate student or postdoc support per PI, the inadequate level of support for technical infrastructure, and the need for investigators to pursue multiple grants to accomplish their research.

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

- We needed more time for the discussion of Division level issues.
- We needed more time for reading jackets and felt that less time could have been spent on the presentations the first day.
- The teleconference the week in advance of our meeting was very helpful and future COVs might consider emulating that.
- We would have appreciated copies of some of the national planning documents (e.g. Quarks to the Cosmos) available.

- We would have appreciated some 10 year trend statistics, ideally in advance of the meeting. Some obvious examples are funding trends, ratios of award to request by program, fraction of proposals from underrepresented minorities, etc.
- Finally we felt that the process might have more continuity if there was a bit more overlap with previous COVs and in particular if the chair of the COV had participated in a previous panel.

SIGNATURE BLOCK:

____

For the Committee of Visitors to the Division of Physics
Persis S. Drell
Chair