REPORT TO THE NUCLEAR SCIENCE ADVISORY COMMITTEE

Submitted by the SUBCOMMITTEE ON PERFORMANCE MEASURES

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Table of Contents

Executive Summary 3

Introduction 5

Context of Performance Measures in Basic Research 5

Planning Context and Assumptions 8

Nuclear Physics Performance Measures 11

Nuclear Physics Milestones under OMB Budget Assumptions 15

A. Hadronic Physics 16

B. Physics of High Temperature and High Density Hadronic Matter 18

C. Nuclear Structure and Astrophysics 19

D. Neutrinos, Neutrino Astrophysics and Fundamental Interactions 21

What Opportunities Will Likely Be Missed in This Scenario? 23

Summary 24

References 25

Appendix I: Charge to NSAC 27

Appendix II: NSAC Charge to Subcommittee 29

Appendix III: Subcommittee Membership 30

Executive Summary

In September 2003, the Department of Energy and the National Science Foundation charged the Nuclear Science Advisory Committee (NSAC) to provide an assessment and recommendations to the Office of Science regarding performance measures for the Nuclear Physics Program. The performance measures are intended to focus on outcomes and meaningfully reflect the purpose of the program, to guide program management and budgeting, and to promote results and accountability. Assessments of progress towards meeting the goals are to be made every five years and some appropriate milestones have been requested by the Office of Management and Budget (OMB) to judge the quality of the progress that has been made. NSAC was requested to submit a report with comments on the appropriateness of these measures, that these measures are suitably ambitious and validly encompass the DOE Nuclear Physics program, with recommendations for appropriate milestones for each of these measures. NSAC formed a Subcommittee on Performance Measures to consider this charge and report back to NSAC.

Many potential concerns arise with the concept of performance measures in basic research. Fundamentally, the optimum path forward at the frontiers of knowledge is uncertain and the process must allow for the flexibility to deal with new insights, discoveries, and the reality that in many areas our knowledge is incomplete. Nuclear Physics must deal also with projects requiring widely varying scales of time and resources. Much of the research is international in character. These considerations all lead to elements of risk that are carefully managed but can place the achievement of milestones, in part, beyond the control of the Department of Energy and the U.S. research community.

The Subcommittee on Performance Measures has reviewed the OMB performance measures for the Office of Nuclear Physics of the Office of Science of the Department of Energy. It reaffirms that the fundamental basis for performance evaluation of basic science must be expert review. It also reaffirms the vision and guidance of the research agenda provided by the NSAC 2002 Long Range Plan.

The Subcommittee was directed to evaluate performance measures and recommend milestones based on the funding level of the FY03 Department of Energy Nuclear Physics budget, and to extend this funding in the out years with increases only at the level of the OMB inflators. In this context the Subcommittee was forced to base its recommendations on a future where the major recommendations of the 2002 Long Range Plan were unlikely to be able to be implemented within the next ten years. As the milestones will make clear, this is still a forefront program that will make very significant progress. However, if other nations choose to invest more heavily in nuclear research, as is expected with a number of ongoing and planned initiatives, the priority of the U.S. research agenda must adapt. At the same time, resource limitations in the face of the initiation of the recommendations of the long range plan will also force a reexamination of the specific milestones to optimize the long term scientific program.

The Subcommittee recommended some wording changes to benchmarks associated with the performance measures, in part to include information from the recent report of the NSAC Subcommittee on Fundamental Physics with Neutrons. In the context of the report, given the goals of nuclear science, the uncertainties inherent in carrying out basic research at the cutting edge of knowledge, and the budget assumptions under which committee was guided to work, the Subcommittee concluded that at this time these performance measures are appropriate and suitably ambitious. Given the restriction of short summary statements, they cannot literally encompass the full range of research avenues that the field must follow to progress, but the spirit and guiding principles of the measures provide the core of the issues that encompass the program. The Subcommittee concludes that these measures provide clear and sufficient guidance for peer and expert review panels to meaningfully evaluate the performance of the program.

After reviewing the performance measures, the Subcommittee has developed a set of recommended performance milestones that can be used to characterize progress towards these performance measures and towards the overarching scientific goals of the field.

It is self-evident that any such performance measures and milestones must not be static. Major research advances will likely reveal entirely new pathways to the scientific goals of nuclear science. To provide the program and performance direction for the future as the field evolves, the Subcommittee makes the following recommendations:

- **It is essential that the nuclear science community, as represented by NSAC, regularly provide input on the performance measures and milestones to allow the nuclear science program to capitalize on new knowledge and experience. An appropriate time scale for this input is twice the frequency of the NSAC long range plans.**
- **The NSAC long range planning process has demonstrated its effectiveness in shaping a vibrant and productive nuclear science program over a period of nearly 25 years. These twice-a-decade plans must continue to be the basis for the long-term vision, goals and planning of nuclear science and be used as an essential input for the periodic assessment of the performance measures and milestones.**
- **The performance measures and milestones are ambitious and adequate resources must be provided in order to meet them. The Office of Nuclear Physics should, with suitable justification, be allowed to adjust these milestones on a yearly basis to adapt to the realities of federal budget actions and international support.**

The Subcommittee has also noted the significant fraction of the major scientific advances anticipated by the NSAC 2002 Long Range Plan that will not be possible under the budget constraints of this exercise. These advances are essential to fully answer the fundamental questions of nuclear science and to maintain the worldwide leadership in knowledge of the substructure of the atom that the United States now holds. The Subcommittee urges that the recommendations of the 2002 Long Range Plan be incorporated into the research agenda of the nation.

Introduction

The United States Federal Government has a legal mandate for stewardship of basic research in nuclear physics. It also has a legal mandate to ensure to the nation that its programs are effective and efficient. The Government Performance and Results Act of 1993 (GRPA) and *The President's Management Agenda*, dated Fiscal Year 2002 and issued by The Executive Office of the President, Office of Management and Budget, require the setting of program goals and the measuring of program performance against these goals.

On September 13, 2003, The Nuclear Science Advisory Committee (NSAC) was charged by the Department of Energy and the National Science Foundation:

" NSAC is requested to provide an assessment and recommendations to the Office of Science regarding performance measures for the Nuclear Physics program. The performance measures are intended to focus on outcomes and meaningfully reflect the purpose of the program, to guide program management and budgeting, and to promote results and accountability. Office of Management and Budget (OMB) guidance for these measures and the proposed Nuclear Physics measures are given in the enclosure. Assessments of progress towards meeting the goals are to be made every five years and some appropriate milestones have been requested by OMB to judge the quality of progress that has been made. NSAC is requested to submit a report with comments on the appropriateness of these measures, that these measures are suitably ambitious and validly encompass the DOE Nuclear Physics program, and with recommendations for appropriate milestones for each of these measures. Your report should be submitted before the end of November 2003."

A copy of the charge letter to NSAC is included as Appendix I. In response to this charge, NSAC created an NSAC Subcommittee on Performance Measures with the charge given in Appendix II. The membership of the Subcommittee is given in Appendix III.

Joel Parriott of the Office of Management and Budget addressed NSAC on this topic at the 13 September NSAC meeting. The Subcommittee solicited broad input from the nuclear community and held a meeting at O'Hare airport on 8 October 2003. At this meeting the committee reached a consensus and formulated its recommendations. A first draft of the report was circulated to NSAC as well as select expert reviewers for comment. The report was transmitted to NSAC on 3 November 2003 and discussed at the November 7-8, 2003 meeting of NSAC.

Context of Performance Measures in Basic Research

The application of performance measures to basic research has been examined by a number of high-level committees. The Committee on Science, Engineering, and Public

Policy (COSEPUP) of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine submitted a status report: *Implementing the Government Performance and Results Act for Research* in 2001 [1].

A Subpanel on Performance Measurement in the Office of Science was charged through the Basic Energy Sciences Advisory Committee (BESAC) to examine the DOE Office of Science's approach to performance measurement. [2]

The difficulties with applying standards of performance measures and milestones to basic research are clear. Basic research fundamentally deals with ideas, techniques and quantitative results. Our ability to predict the ultimate value of new ideas and techniques, both theoretical and experimental, is extremely limited. The very nature of progress in science is to guess (hypothesize) how nature works and then to subject these guesses to stringent examination. Bold new ideas or definitive experimental results can bring major leaps in our understanding and lead to entirely new concentrations of research. Inherently, such major advances can be only dimly envisioned. Many innovations fail under such intense scrutiny, but in the process, science moves forward, both in learning new ways to examine issues and in ruling out the avenues that nature did not happen to follow.

Quantitative results may be most straightforwardly subject to clear performance measures and milestones. However the time scales and uncertainties inherent in basic research lead to wide variance in our ability to capture research objectives. In nuclear science the variations in time scale are dramatic. A new major facility such as the Relativistic Heavy Ion Collider may stretch for 15 years from reaching a high priority in the field's long range planning exercise to the initiation of the research program. The research may require a decade to achieve its initial scientific goals. In such long-term initiatives, some milestones can be clearly set and performance evaluated. In other areas, the time scale from the conception of an experiment to initial results can be a few months. In all cases, exciting ideas and results can initiate major shifts in the research focus on a short time scale to exploit new understanding and new challenges. It must be made clear that such program shifts are always carefully evaluated by peer and expert review, either by Program Advisory Committees or in the course of review of research funding proposals. They are not a failure in planning; they are, indeed, triumphs of the research process.

The basic strategy that the agencies and the field adopt to push back the frontiers of science will also play a major role in determining the expectations for future performance. This has been publicly discussed in the context of the program of NASA: the choice between careful, measured, thoroughly engineered and ultimately more costly progress on a few major initiatives or the avenue of more risky, faster, cheaper and focused, but more widely directed initiatives. As will be discussed below, the intellectual challenges facing nuclear science are broad. In the face of tight resources, our science has often chosen to accept the risk inherent in proceeding with less than optimum resources.

The fundamental principle, reaffirmed by COSEPUP and the BESAC Sub-panel, is that performance of research programs should be assessed in terms of: a) *Quality*; b)

Relevance; and c) *Leadership*. *Quality* is assessed by peer review and expert review. *Relevance* has been interpreted in terms of relevance of the research to progress in the appropriate scientific discipline and to the mission of the agency. *Leadership* is considered to be leadership in both the national and international context.

Peer and expert review is the only accepted standard for implementing this principle. The BESAC Sub-panel stated, "much basic research is better assessed in qualitative terms. While this offers challenges to the concept of being `measurable' this should not lead to the imposition of quantitative goals. To do this would have significantly negative effects on basic research, and would certainly not be consistent with the principle that application of GPRA should 'do no harm'".

The Office of Management and Budget proposed using the guidelines: *Quality, Relevance* and *Performance,* combining both the COSEPUP model and an Army Research Lab model. The *Leadership* concept was considered a potential indicator to demonstrate *Quality* and not as an independent goal. The OMB criteria state, "It is tremendously important that basic research programs are able to demonstrate responsible management of their inputs, in addition to clearly articulating and demonstrating progress towards expected outputs. Yet, outcomes still matter." They recognize that any set of specific output milestones is unlikely to cover 100 percent of a program's research portfolio, nor should it. OMB plans to assume that basic research programs reporting on the results of specific output milestones combined with reporting results-retrospective portfolio reviews will have satisfied the requirement of GPRA.

Planning Context and Assumptions

The scientific goals of basic research in nuclear physics are thoroughly examined by the research community and the federal agencies in the NSAC periodic long range planning exercises that have been carried out approximately twice a decade since 1979. The most recent plan, The 2002 Nuclear Science Advisory Committee report, *Opportunities in Nuclear Science. A Long Range Plan for the Next Decade* [3], establishes the scientific agenda for the field and identifies the core scientific questions

- What is the structure of the nucleon?
- What is the structure of nucleonic mater?
- What are the properties of hot nuclear matter?
- What is the nuclear microphysics of the universe?
- What is to be the new Standard Model?

Nuclear Science is making tremendous strides in answering these fundamental questions. Some notable examples highlighted in the Long Range Plan (LRP) are:

- definitive demonstration that the Standard Model of particles and interactions is incomplete with experimental observations that neutrinos have mass and that there is mixing between neutrinos of different flavors,
- beautiful confirmation that the mechanisms of energy production in the sun are well understood,
- high resolution spatial maps of the structure of the proton that point to an unexpected depletion of charge near its center,
- clear evidence that high energy collisions of gold nuclei have created unusual conditions, very different from those in the collisions of lighter ions, on the path to the discovery of quark-gluon plasma.
- advances in nuclear theory such as ab initio calculations with realistic nuclear forces that offer the promise of a unified description of the nucleus based on the theory of the strong interaction,
- exploration of unknown regions of the nuclear landscape, towards the limits of nuclear existence and the paths of the production of the elements in the cosmos.

The fundamental statement for the subcommittee of the priorities and vision of the future for the field is the Long Range Plan. The Long Range Plan made four major recommendations to advance this scientific agenda:

1. **Recent investments by the United States in new and upgraded facilities have positioned the Nation to continue its world-leadership role in nuclear science. The highest priority of the nuclear science community is to exploit the extraordinary opportunities for scientific discoveries made possible by these investments. Increased funding for research and facility operations is essential to realize these opportunities.**
   Specifically, it is imperative to

- **Increase support for facility operations - especially our unique new facilities RHIC, CEBAF and NSCL - which will greatly enhance the impact of the nation's nuclear science program.**
- **Increase the investment in university research and infrastructure, which will both enhance scientific output and educate additional young scientists vital to meeting national needs.**
- **Significantly increase funding for nuclear theory, which is essential for developing the full potential of the scientific program.**

2. **The Rare Isotope Accelerator (RIA) is our highest priority for major new construction. RIA will be the world-leading facility for research in nuclear structure and nuclear astrophysics.**

3. **We strongly recommend immediate construction of the world's deepest underground science laboratory. This laboratory will provide a compelling opportunity for nuclear scientists to explore fundamental questions in neutrino physics and astrophysics.**

4. **We strongly recommend the upgrade of CEBAF at Jefferson Laboratory to 12 GeV as soon as possible.**

If any of these recommendations is not followed, the United States will miss the capability to fully address major issues in nuclear science. Our world leadership in understanding the atomic nucleus and in training the best and brightest young scientists in the tools and techniques of nuclear science to apply to the issues of the nation may be compromised. The Subcommittee urges that the recommendations of the 2002 Long Range Plan be incorporated into the research agenda of the nation.

The charge to the Subcommittee was to evaluate performance measures and recommend milestones based on the funding level of the FY03 Department of Energy Nuclear Physics budget, and to extend this funding in the out years with increases only at the level of the OMB inflators. The 2003 report of the Secretary of Energy Advisory Board's Task Force on the Future of Science Program at the Department of Energy [4] notes that the complexity and sophistication of most research endeavors have caused their real cost to grow more rapidly than traditional measures of inflation. In order to meet the charge, the Subcommittee was forced to base its performance milestones on a future where these LRP recommendations were unlikely to be able to be implemented within the next ten years. As the milestones will make clear, this is still a forefront program that will make very significant progress. However, if other nations choose to invest more heavily in nuclear research, as is expected with a number of ongoing and planned initiatives, the priority of the U.S. research agenda must adapt. At the same time, resource limitations in the face of the initiation of the recommendations of the long range plan will also force a reexamination of the specific milestones to optimize the long term scientific program.

The Subcommittee was charged to report to the Department of Energy Office of Science on performance measures for nuclear science. The National Science Foundation is also a major source of support for the researchers, students and facilities of nuclear science. Progress in the field requires the work of NSF-supported scientists at DOE supported facilities and DOE-supported scientists at NSF-supported facilities. The Subcommittee considered that any attempt to separate the performance milestones between DOE and NSF facilities and researchers was artificial and inappropriate and, hence, considered the U.S. effort as a whole. Here it is explicitly assumed that the NSF nuclear science budgets follow the same budget assumptions as those of DOE.

The challenges of modern nuclear science demand and the community has embraced a broader perspective than the national program. High priority work may be best performed at international or non-nuclear-physics (e.g. High Energy Physics or Basic Energy Sciences) facilities or count on major investments of international users. These considerations all lead to elements of risk that are carefully managed but can place the achievement of milestones, in part, beyond the control of the Office of Nuclear Physics and the U.S. research community.

The mission of the Nuclear Physics program of the Office of Science is:

"to promote nuclear physics research through the development and support of basic research scientists and facilities. Nuclear physics research seeks to understand the fundamental forces and particles of nature as manifested in nuclear matter.

As an essential component of that objective, the Nuclear Physics program educates young scientists, provides intellectual, and technical support for other nuclear based technologies, provides access to our facilities for other disciplines, and creates a flow of technical innovations for use outside the program."

The Subcommittee was directed to evaluate science performance measures and milestones for the basic research program. Quantitative measures for facility operations and performance are to be provided separately by the program office. Two key aspects of this mission are not encompassed by the current performance measures. These are:

- The development of the workforce to address the national need for expertise in nuclear science and technology.
- The development of new technologies and the transfer of knowledge and techniques to the address the needs of the nation.

NSAC was charged to address the issue of education and workforce development by the Department of Energy and the National Science Foundation in February 2002 and an NSAC subcommittee is in the process of responding to this charge. It is appropriate that the development of measures and milestones related to this area be considered in this NSAC activity.

The nuclear science community is actively engaged in the development of new technologies and in technology transfer. This is addressed specifically in the 2002 Long Range Plan and in documents such as the *Report on the Workshop of the Role of the Nuclear Physics Research Community in Combating Terrorism* [5]. The Subcommittee regards this subject as a vital component in the nation's nuclear science program, but because forces beyond the DOE program drive the specific value and need for these activities, the Subcommittee did not consider it appropriate to develop a new measure and milestones in the area.

In summary, the Subcommittee has evaluated the performance measures and recommends milestones based on a specific budget scenario. This must be considered to be a snapshot in the planning for the field with reasonable resolution for the next few years but one that must be reconsidered in the light of progress on new U.S. and foreign initiatives, and fundamental new scientific insights and discoveries. The federal agencies have demonstrated the ability, aided by the peer review process, to successfully guide this highly productive but uncertain path of basic research. They must have the resolve, the resources and the flexibility to continue to perform so effectively in the future.

Nuclear Physics Performance Measures

The basic guidance from the Office of Management and Budget for performance measures is given in Figure 1. Figures 2-5 contain the performance measures submitted to OMB by the Department of Energy Office of Nuclear Physics and the benchmarks proposed to evaluate successful performance. NSAC is asked to comment on the appropriateness of these measures, and whether these measures are suitably ambitious and validly encompass the DOE Nuclear Physics program.

The Subcommittee proposes two changes to the performance benchmarks. The first, given in Figure 6 to replace that of Figure 2, contains small wording changes to make the scope of the benchmark slightly more general. The second, given in Figure 7, is based on the recent (August 29, 2003) report of the NSAC Subcommittee on Fundamental Physics with Neutrons that concluded the stated progress in measurements of the neutron electric dipole moment is unlikely to be achieved within the baseline budget assumptions. Therefore, this element should be removed from the performance benchmark.

In the context discussed above, given the goals of nuclear science, the uncertainties inherent in carrying out basic research at the cutting edge of knowledge, and the budget assumptions under which committee was guided to work, the Subcommittee concluded that at this time these performance measures are appropriate and suitably ambitious. Given the restriction of short summary statements, they cannot literally encompass the full range of research avenues that the field must follow to progress, but the spirit and guiding principles of the measures provide the core of the issues that encompass the program. The Subcommittee concludes that these measures provide clear and sufficient guidance for peer and expert reviews of the performance of the nuclear science program.

Long-term Performance Measures

Does the program have a limited number of specific long-term performance measures that focus on outcomes and meaningfully reflect the purpose of the program?

Purpose of the question: to determine if the program has long-term performance measures to guide program management and budgeting and promote results and accountability. This question seeks to assess whether the program measures are salient, meaningful, and capture the most important aspects of program purpose and appropriate strategic goals.

Elements of a Yes answer: a Yes answer would require identifying a limited number (e.g., two or three) of specific, easily understood program outcome measures that directly and meaningfully support the program's purpose. A "performance measure" is an outcome or output measure. "Long-term" is defined as covering a relatively long period of time relative to the nature of the program but is likely to be on the order of 5-10 years and consistent with time periods for strategic goals used in the Agency Strategic Plan. Programs should have at least one efficiency measure.

Figure 1: OMB Guidance.

- Make precision measurements of fundamental properties of the proton, neutron and simple nuclei for comparison with theoretical calculations to provide a quantitative understanding of their quark substructure.
  - Timeframe – By 2015
  - Expert Review every five years rates progress as "Excellent"
  - Minimally effective – Quark and gluon contributions to the nucleon's spatial structure and spin measured; theoretical tools for hadron structure developed and tested; data show how simple nuclei can be described at a nucleon or quark-substructure level for different spatial resolution of the data.
  - Successful – Quark flavor dependence of nucleon form factors and structure functions measured; hadron states described with QCD over wide ranges of distance and energy; two-body and three-body nucleon-nucleon interactions expressed in a QCD basis; precision measurements of nucleon spin performed.

Figure 2: Performance Measure for Hadronic Physics.

- Recreate brief, tiny samples of hot, dense nuclear matter to search for the quark-gluon plasma and characterize its properties.
    - Timeframe – By 2015
    - Expert Review every five years rates progress as "Excellent"
    - Minimally effective – Existence of hot, high-density matter established; some of its properties (e.g., its initial temperature via the photon spectrum) measured; confinement properties, and energy transport (via jets) explored.
    - Successful – Existence of a deconfined, thermalized medium determined; its properties such as temperature history, equation of state, energy and color transport (via jets), and screening (via heavy quark production) characterized.

Figure 3: Performance Measure for Physics of High Temperature and High Density Hadronic Matter.

- Investigate new regions of nuclear structure, study interactions in nuclear matter like those occurring in neutron stars, and determine the reactions that created the nuclei of atomic elements inside stars and supernovae.
    - Timeframe – By 2015
    - Expert Review every five years rates progress as "Excellent"
    - Minimally effective – Properties of nuclei and reactions near and far from stability measured allowing study of effective interactions, collective behavior, and structural evolution; new weakly bound nuclei observed and the limits of binding explored; some reactions of stellar interest measured.
    - Successful – Extensive measurements on stable and exotic nuclei and the drip lines performed; their structure established and the isospin dependence of effective interactions studied; new nuclei with neutron skins observed and studied; reactions for several astrophysical processes, including some r-process nuclei, measured.

Figure 4: Performance Measure for Nuclear Structure and Nuclear Astrophysics.

- Measure fundamental properties of neutrinos and fundamental symmetries by using neutrinos from the sun and nuclear reactors and by using radioactive decay measurements.
    - Timeframe – By 2015
    - Expert Review every five years rates progress as "Excellent"
    - Minimally effective – Double beta-decay lifetime and neutron electric dipole moment limits extended; participated in low-energy neutrino experiments and beta-decay probing cosmologically relevant neutrino masses; parameters for quark mixing for nuclear beta-decay quantified.
    - Successful – Double beta-decay lifetime and neutron electric dipole moment limits extended 10-fold or more; R&D completed demonstrating if precision pp solar experiment is possible; played key roles in low-energy neutrino experiments and beta-decay probing cosmologically interesting neutrino masses.

Figure 5: Performance Measure for Neutrinos, Neutrino Astrophysics and Fundamental Interactions.

- Make precision measurements of fundamental properties of the proton, neutron and simple nuclei for comparison with theoretical calculations to provide a quantitative understanding of their quark substructure.
    - Time frame – By 2015
    - Expert Review every five years rates progress as "Excellent"
    - Minimally Effective – Quark and gluon contributions to the nucleon's spatial structure and spin measured; theoretical tools for hadron structure developed and tested; data show how simple nuclei can be described at a nucleon or quark-substructure level for different spatial resolution of the data
    - Successful – Quark flavor dependence of nucleon form factors and structure functions measured; hadron states described with QCD over wide ranges of distance and energy; the nucleon-nucleon interaction mechanisms determined from QCD; precise measurements of quark and gluon contributions to nucleon spin performed.

Figure 6: Revised version of Figure 2.
Performance Measure for Hadronic Physics.

- Measure fundamental properties of neutrinos and fundamental symmetries by using neutrinos from the sun and nuclear reactors and by using radioactive decay measurements.
    - Timeframe – By 2015
    - Expert Review every five years rates progress as "Excellent"
    - Minimally effective – Double beta-decay lifetime limits extended; participated in low-energy neutrino experiments and beta-decay probing cosmologically relevant neutrino masses; parameters for quark mixing for nuclear beta-decay quantified.
    - Successful – Double beta-decay lifetime limits extended 10-fold or more; R&D completed demonstrating if precision pp solar experiment is possible; played key roles in low-energy neutrino experiments and beta-decay probing cosmologically interesting neutrino masses.

Figure 7: Revised version of Figure 5.
Performance Measure for Neutrinos, Neutrino Astrophysics and Fundamental Interactions.

Nuclear Physics Milestones under OMB Budget Assumptions

The Subcommittee examined the progress that is anticipated to 2015 and assembled a list of nearly 100 milestones that constitute key steps towards the performance measures considered in the previous section. From that list, approximately ten were chosen in each sub-area as representative of significant elements of the national program. The discussion of the context and planning assumptions highlights the difficulty inherent in such a choice. In areas with major facilities and long-time-scale experiments, achieving these few milestones also directly implies that many other significant physics results are obtained. In an area such as neutrino physics, almost every milestone represents an independent initiative, often international in character. In nuclear structure research and laboratory astrophysics measurements, several smaller accelerator facilities provide the base capabilities. While the general experimental program is clear, the exact choice of measurements can depend critically on what secrets nature chooses to reveal. In all cases the subcommittee could have chosen different milestones. In the context of providing a baseline for performance evaluation, the Subcommittee affirms that each of these milestones represents an important step in our progress. Taken as a whole, they are difficult, but achievable. The Subcommittee recognizes they only represent a fraction of the fundamental advances that nuclear science must make to achieve its goals.

A. Hadronic Physics

Physics Goals: The broad goals of research in hadronic physics include linking the physics of nuclei to the fundamental theory of strong interactions, namely, Quantum Chromodynamics (QCD), understanding the structure of protons and neutrons that make up nuclei in terms of quarks and gluons because the latter are the fundamental ingredients of QCD, and understanding the structure of light nuclei both in terms of nucleons at low energy and in terms of quarks and gluons at high energy. These goals require probing nuclei and their constituents with electron and photon beams that are capable of high spatial resolution and high energy so as to be able to produce the excited mesonic and baryonic states of QCD. Form factors determine how the particles are distributed inside nucleons and light nuclei. Structure functions and generalized parton distributions, the latter being a new tool in the field, determine how the quarks and gluons are distributed in nucleons and how the spin of the proton is built up from the quarks and gluons. High-energy proton-proton collisions provide a complementary window into how the quarks and gluons build up the nucleons. Lattice QCD calculations are expected to provide the best theoretical means to compare experiments directly with QCD, however, a variety of theoretical tools are used to model and understand the observed phenomena. Ab initio many-body calculations based on two-nucleon interactions with the addition of modest three-nucleon interactions provide the best theoretical means to understand the low-energy aspects of the structure and interactions of nuclei. The milestones for Hadronic Physics include representative examples of progress in each of these aspects without being inclusive of all relevant work.

Year	**Milestones:**
2008	Make measurements of spin carried by the glue in the proton with polarized proton-proton collisions at center of mass energy, $\sqrt{s_{NN}}$ = 200 GeV.
2008	Extract accurate information on generalized parton distributions for parton momentum fractions, x, of 0.1 - 0.4 , and squared momentum change, –t, less than 0.5 GeV^2 in measurements of deeply virtual Compton scattering.
2009	Complete the combined analysis of available data on single π, η, and K photo-production of nucleon resonances and incorporate the analysis of two-pion final states into the coupled-channel analysis of resonances.
2010	Determine the four electromagnetic form factors of the nucleons to a momentum-transfer squared, Q^2, of 3.5 GeV^2 and separate the electroweak form factors into contributions from the u, d and s-quarks for $Q^2 < 1$ GeV^2 .
2010	Characterize high-momentum components induced by correlations in the few-body nuclear wave functions via (e,e'N) and (e,e'NN) knock-out processes in nuclei and compare free proton and bound proton properties via measurement of polarization transfer in the ${}^4He(\vec{e},e'\vec{p})^3H$ reaction.
2011	Measure the lowest moments of the unpolarized nucleon structure functions (both longitudinal and transverse) to 4 GeV^2 for the proton, and the neutron, and the deep inelastic scattering polarized structure functions $g_1(x, Q^2)$ and $g_2(x,Q^2)$ for x=0.2-0.6, and $1 < Q^2 < 5$ GeV^2 for both protons and neutrons.
2012	Measure the electromagnetic excitations of low-lying baryon states (<2 GeV) and their transition form factors over the range Q^2 = 0.1 – 7 GeV^2 and measure the electro- and photo-production of final states with one and two pseudoscalar mesons.
2013	Measure flavor-identified q and $\bar{q}$ contributions to the spin of the proton via the longitudinal-spin asymmetry of W production.
2014	Perform lattice calculations in full QCD of nucleon form factors, low moments of nucleon structure functions and low moments of generalized parton distributions including flavor and spin dependence.
2014	Carry out ab initio microscopic studies of the structure and dynamics of light nuclei based on two-nucleon and many-nucleon forces and lattice QCD calculations of hadron interaction mechanisms relevant to the origin of the nucleon-nucleon interaction.

B. Physics of High Temperature and High Density Hadronic Matter

Physics Goals: The goal is to create for the first time in the laboratory hot (2×10^{12} K), dense (≥ 30 times normal nuclear density) matter that is predicted to have existed a few microseconds after the beginning of the Universe by colliding heavy nuclei at center of mass energies up to 200 GeV per nucleon pair. These studies will seek to establish properties of this new state (such as initial temperature, pressure, and entropy) and the time evolution of the collision process. They will measure collective phenomena (such as the flow of specific particles) and establish theoretically the dynamics of the process creating these phenomena. The study of penetrating probes such as fast quarks and gluons will provide information on the processes of color and energy transport. Perturbative QCD (pQCD) gives a description of such processes and together with experimental results will shed light on the nature of this strongly interacting matter. We seek to establish whether the temperatures are sufficiently high that the matter consists of weakly interacting quarks and gluons (deconfinement) rather than strongly interacting hadrons, to the extent that the strong color force is sufficiently screened so as to suppress production of bound states of charm and anti-charm quarks (known as the J/ψ family). This research will either verify or nullify the prediction by the Standard Model using QCD on the lattice that a deconfined state of matter, the quark-gluon plasma, exists at high temperatures and densities.

Year	**Milestones:**
2005	Measure J/ψ production in Au + Au at $\sqrt{s_{NN}} = 200$ GeV.
2005	Measure flow and spectra of multiply-strange baryons in Au + Au at $\sqrt{s_{NN}} = 200$ GeV.
2007	Measure high transverse momentum jet systematics vs. $\sqrt{s_{NN}}$ up to 200 GeV and vs. system size up to Au + Au.
2009	Perform realistic three-dimensional numerical simulations to describe the medium and the conditions required by the collective flow measured at RHIC
2010	Measure the energy and system size dependence of J/ψ production over the range of ions and energies available at RHIC.
2010	Measure e^+e^- production in the mass range $500 \leq m_{e+e-} \leq 1000$ MeV/c^2 in $\sqrt{s_{NN}}= 200$ GeV collisions.
2010	Complete realistic calculations of jet production in a high density medium for comparison with experiment.
2012	Determine gluon densities at low x in cold nuclei via p + Au or d +Au collisions

C. Nuclear Structure and Astrophysics

Nuclear Structure & Reactions

Physics Goals: Our understanding of nuclear structure is poised at a new threshold. Detailed studies of rare isotopes will dramatically expand our understanding of the nucleus and nuclear matter and will provide new insights into the nuclear forces by allowing study of particular nuclei and reactions that isolate and amplify specific nucleonic interactions. We will study the limits of nuclear existence and the evolution of structure between these limits. An ultimate goal is a unified microscopic understanding of the nuclear many-body system in all its manifestations, as well as of the remarkable simplicities and collective behaviors that these nucleonic systems display. Complementary studies near stability and the quest to make the heaviest elements form a coherent long-term research program. To achieve these goals across the broad expanse of the nuclear landscape, the program carries out research at a number of smaller facilities, typically in short-term experiments (one to few weeks in nature), whose outcome influences follow-up studies. The character of this research makes it especially difficult for a few, short milestones to broadly capture what is needed to achieve the performance measures. The milestones represent important examples of the significant progress that will be made.

The foci of this work are to identify the evolution of nuclear structure with mass and charge and improve theoretical models to gain a more complete understanding of the nucleus, and to explore nuclei at the limits of existence to establish their properties and test the models of nuclear structure and reactions in currently unmeasured regimes of nucleonic matter.

Year	**Milestones:**
2006	Measure changes in shell structure and collective modes as a function of neutron and proton number from the proton drip line to moderately neutron-rich nuclei.
2007	Measure properties of the heaviest elements above Z~100 to constrain and improve theoretical predictions for superheavy elements.
2009	Extend spectroscopic information to regions of crucial doubly magic nuclei far from stability such as Ni-78.
2009	Extend the determination of the neutron drip line up to Z of 11.
2010	Complete initial measurements with the high resolving power tracking array, GRETINA, for sensitive studies of structural evolution and collective modes in nuclei.
2013	Carry out microscopic calculations of medium mass nuclei with realistic interactions, develop a realistic nuclear energy density functional for heavy nuclei, and explore the description of many-body symmetries and collective modes, and their relationship to effective forces.

Nuclear Astrophysics

Physics Goals: Nuclear processes play a central role in understanding the evolution of the stars, their violent explosions and the synthesis of the elements in these explosions. This chain of events produces the elements of life itself. A rich and multi-faceted research program in nuclear astrophysics is required to decipher the universe in which we live. We will study the physics of core collapse supernovae, hypernovae, and their connection with gamma-ray bursts. These are the most energetic explosions in our universe and factories for formation of a significant fraction of the elements. We will also study the properties of neutron star remnants left behind by these explosions, which serve as cosmic laboratories for high-density nuclear physics inaccessible in terrestrial experiments. We will investigate type Ia supernovae, the standard candles through which extraordinary facts about our universe and its fate have been illuminated. We will also investigate the evolution of stars and other cataclysmic stellar explosions including novae and X-ray bursts. A unifying theme for these focus areas is to precisely understand how a variety of microscopic nuclear physics phenomena come together to guide spectacular macroscopic phenomena such as the evolution and explosion of stars and their production of the elements.

Year	**Milestones:**
2007	Measure transfer reactions on r-process nuclei near the N=50 and N=82 closed shells.
2009	Measure properties of and reactions on selected proton-rich nuclei in the rp-process to determine radionuclide production in novae and the light output and neutron star crust composition synthesized in X-ray bursts.
2009	Perform three-dimensional studies of flame propagation in white dwarfs during type Ia supernovae.
2010	Reduce uncertainties of the most crucial stellar evolution nuclear reactions (e.g., $^{12}C(\alpha,\gamma)^{16}O$) by a factor of two, and others (e.g., MgAl cycle) to limits imposed by accelerators and detectors.
2011	Measure neutron capture reactions, including radioactive s-process branch-point nuclei, to constrain s-process isotopic abundances.
2012	Measure masses, lifetimes, spectroscopic strengths, and decay properties of selected neutron-rich nuclei in the supernova r-process, and reactions to predict radionuclide production in supernovae.
2013	Perform realistic multidimensional simulations of core collapse supernovae.
2013	Perform simulations of neutron star structure and evolution using benchmark microphysical calculations of the composition, equation of state, and bulk properties of dense matter.

D. Neutrinos, Neutrino Astrophysics and Fundamental Interactions

Neutrino and Neutrino Astrophysics:

Physics Goals: The goals of neutrino physics include a complete characterization of the properties of neutrinos and an improved understanding of solar neutrinos. Direct observation of charged- and neutral-current channels is essential to determine the solar neutrino flux of all active flavors. Precise determination of various components of this flux provides stringent limits on neutrino properties (masses and mixings) as well as the theory of the main-sequence stellar evolution. Direct neutrino mass measurements are sensitive to the absolute neutrino mass scale with few, if any, assumptions about neutrino properties. This research will address key issues in understanding the scale of the new physics beyond the Standard Model, provide potential insight into the origin of fermion masses, impact cosmology (hot dark matter, large scale structure formation and anisotropies of cosmic microwave background radiation) and astrophysics (core-collapse supernovae, r-process nucleosynthesis, and the origin of elements). Direct neutrino mass measurements, combined with observables from oscillation and neutrinoless double beta decay experiments, can potentially measure the CP-violating phases in the lepton sector and yield understanding of hierarchy and ordering of neutrino masses.

The neutrino mass scale that is inferred from the solar and atmospheric neutrino experiments implies the possibility of seeing neutrinoless double beta decay with experiments sensitive to masses of about 50 meV. Observation of the zero neutrino mode would establish the Majorana nature of neutrinos (i.e. if the neutrinos are their own antiparticles) and may provide clues to the existence of the CP-violating phases.

When the next Galactic supernova occurs a significant number of neutrino events can be detected at neutrino observatories such as the SuperKamiokande, Sudbury Neutrino Observatory, or KamLAND experiments. Such a measurement will provide important clues to the astrophysics of supernovae as well as to neutrino properties.

Fundamental Interactions

Physics Goals: The goal of investigating fundamental interactions at low energies is to provide an independent window on new physics beyond our current understanding of the interactions of elementary particles. Precision measurements of the beta decays can give strong signatures of new physics beyond the Standard Model (e.g. supersymmetry).

In contrast to the precise predictions of the Standard Model for beta decay, this Model can only crudely characterize the weak interaction when only nucleons are involved (e.g. the non-leptonic interaction). Future precise measurements for few-body nuclei should provide a solid experimental characterization of the interactions that is amenable to theoretical understanding based on the symmetries of QCD.

The violation of CP (Charge-Conjugation times Parity) symmetry for elementary particles during the Big Bang is believed to be responsible for the apparent excess of matter compared to anti-matter that we observe in the universe. While new sources of CP violation are possible in the neutrino sector there could also be larger violations for nucleons due to new physics beyond the standard model. New precise searches for both the neutron and atomic electric dipole moment measurements (EDM) coupled with improvements in the theory could signal a new source of CP violation and better quantify the role of nucleon CP violation in understanding the matter-antimatter asymmetry.

Precise investigation of fundamental symmetries for the neutron can be performed with new sources of Cold and Ultra-Cold neutrons (Cold neutrons have wavelengths of 0.5 - 10 nm and Ultra-Cold neutrons have wavelengths > 50 nm). A cold neutron beamline for fundamental physics studies is under development at the Spallation Neutron Source (SNS), operated by Basic Energy Sciences in DOE. Additional funding (beyond constant effort) would likely be needed to develop and complete measurements of the neutron electric dipole moment with Ultra-Cold neutrons to improve the sensitivity by at least an order of magnitude.

Yea r	**Milestones:**
2007	Measure solar boron-8 neutrinos with neutral current detectors.
2008	Collect first data in an experiment which has the potential to observe beryllium-7 solar neutrinos.
2008	Initiate an experimental program at the SNS fundamental physics beam line.
2010	Make factor of 5 improvements in measurements of neutron and nuclear beta-decay to constrain physics beyond the standard model.
2010	Make factor of 5 improvement in theoretical uncertainties for testing the Standard Model via low energy electroweak observables.
2011	Improve the sensitivity of the direct neutrino mass measurements to 0.35 eV.
2012	Extend the sensitivity of searches for neutrinoless double-beta decay in selected nuclei by a factor of ten in lifetime.
2012	Perform independent measurements of parity violation in few-body systems to constrain the non-leptonic weak interaction.
2012	Obtain results from new high-sensitivity searches for atomic electric dipole moments.

What Opportunities Will Likely Be Missed in This Scenario?

The appropriate vehicles to determine the scientific priorities of the field are the NSAC long range planning exercise, the agency program management and peer review of individual programs and proposals. The Subcommittee considers the milestones of the previous section to be realizable under the current priorities and funding levels of the field and to represent very significant progress towards the goals of the field. The charge to the Subcommittee did not include changing the priorities within and between subfields. However in assessing the performance of the field, it is essential to attempt to understand some of the critical scientific opportunities identified in the 2002 Long Range Plan that will likely be missed in this scenario. Here, for continuity, some of the primary opportunities are discussed in the same order as the previous two sections and not the order of prioritization of the LRP (see page 7-8 and the LRP).

In hadronic physics, without the extended kinematic reach and spatial resolution of the Jefferson Lab 12 GeV upgrade, definitive experiments on the structure of novel hybrid particles, that are predicted by the theory of the strong interaction but not contained in the quark model of hadrons, cannot be performed. New theoretical understanding of experimental observables that provide access to the nucleon's correlated quark spatial and momentum distributions will not be properly exploited. Progress in lattice simulations of quantum chromodynamics allows physicists to understand that only with major increases in computing resources can these calculations accurately describe the dynamics of light quarks in the proton.

The first glimpses of the unusual properties of the hot-dense matter formed in high energy heavy ion collisions make it clear that to fully characterize the properties of this new form of matter, one must understand how both heavy and light quarks behave in it. The RHIC II project will provide significant luminosity capability increases for both the RHIC accelerator and detector systems, which are needed to establish the behavior of heavy quarks, such as charm and bottom quarks in this primordial soup. The ability to detect other rare processes will open new windows on the physics of the quark-gluon plasma and other predicted exotic manifestations of quantum chromodynamics.

The Rare Isotope Accelerator would provide, for the first time, experimental access to essentially all the key nuclei involved in the processes that create the heavy elements in the cosmos. The limits of nuclear existence could be experimentally established for much heavier systems. New intense unstable beams would allow new reactions to be employed to produce the long-sought-after shell-stabilized superheavy elements. Progress in nuclear theory has established that identifying the changes in nuclear structure as one changes the ratio of the number of protons to the number of neutrons will allow us to understand how such complex systems derive their properties from the interactions of the individual constituents and why they exhibit such simple features. The steps outlined in the previous section are important beginnings toward these goals, but only with RIA is deeper understanding likely to be achieved. Advanced computing capabilities are required to fully exploit this progress.

The recent developments in fundamental interactions cry out for a series of important experiments. The pattern of mixing of neutrino flavors can only be understood if the mixing of the first and third generation neutrinos is established and new high precision solar neutrino experiments can be performed. The cosmological implications of neutrino masses require new higher sensitivity direct neutrino mass experiments and neutrino-less double beta decay measurements. The implications of time-reversal violation in the neutrino sector and in the hadron sector must be understood to account for the observed excess of particle over antiparticles that makes the existence of human beings possible. Limits on the violation of time-reversal invariance in neutron and atomic electric dipole moment experiments are critical to constrain the new physics beyond the standard model. The 2002 Long Range Plan identified a new deep underground laboratory as a compelling opportunity to provide the infrastructure and unique sensitivity for some of these and many other key experiments.

The Long Range Plan presents a number of smaller scale initiatives, a few of which have advanced sufficiently in the project planning stages of development for their use to be included in the milestones. It is also very important that the field invest in the R&D necessary to support these and other longer term initiatives discussed in the Long Range Plan.

The milestones of the previous section taken together with these potential missed opportunities demonstrate that nuclear science is poised to make major progress on fundamental, important, and challenging questions of nature. Future Long Range Plans must, as each one has in the past, wrestle with balancing the priorities of the exciting opportunities and the implications of resource constraints. Additional resources are highly leveraged to make outstanding new science possible, as they can build on a very strong and focused U.S. nuclear science enterprise.

Summary

The NSAC Subcommittee on Performance Measures has reviewed the performance measures for the Office of Nuclear Physics of the Office of Science of the Department of Energy. It reaffirms that the fundamental basis for performance evaluation of basic science must be expert review. It also reaffirms the vision and guidance of the research agenda provided by the NSAC 2002 Long Range Plan. The Subcommittee recommends that the performance measures given in Figures 3, 4, 6 and 7 be adopted for the field. Under the assumption of a budget at the level of the FY03 budget for nuclear science, projected into the out-years by OMB inflation factors, the Subcommittee concludes that **these four measures are appropriate, suitably ambitious and sufficiently encompassing measures to guide an expert review panel to meaningfully evaluate the performance of the program.**

In the same context, the Subcommittee has recommended a series of performance milestones that characterize progress towards these performance measures and towards the overarching scientific goals of the field.

It is self-evident that such performance measures and milestones must not be static. Major research advances will likely reveal entirely new pathways to the scientific goals of nuclear science. Indeed, new experiments and new understanding may provide the solution to some of these challenging questions much earlier than anticipated here. On the other hand, nature may have chosen to guard her secrets much more closely. To provide the program and performance direction for the future as the field evolves the Subcommittee makes the following recommendations:

- **It is essential that the nuclear science community, as represented by NSAC, regularly provide input on the performance measures and milestones to allow the nuclear science program to capitalize on new knowledge and experience. An appropriate time scale for this input is twice the frequency of the NSAC long range plans.**
- **The NSAC long range planning process has demonstrated its effectiveness in shaping a vibrant and productive nuclear science program over a period of nearly 25 years. These twice-a-decade plans must continue to be the basis for the long-term vision, goals and planning of nuclear science and be used as an essential input for the periodic assessment of the performance measures and milestones.**
- **The performance measures and milestones are ambitious and adequate resources must be provided in order to meet them. The Office of Nuclear Physics should, with suitable justification, be allowed to adjust these milestones on a yearly basis to adapt to the realities of federal budget actions and international support.**

The Subcommittee has also noted the significant fraction of the major scientific advances anticipated by the NSAC 2002 Long Range Plan that will not be possible under the budget constraints of this exercise. These advances are essential to fully answer the fundamental questions of nuclear science and to maintain the worldwide leadership in knowledge of the substructure of the atom that the United States now holds.

References

[1] *Implementing the Government Performance and Results Act for Research,* Committee on Science, Engineering, and Public Policy, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, National Academies Press, (2001) http://books.nap.edu/catalog/10106.html

[2] *Report of the Sub-Panel on Performance Measures in the Office of Science, U. S. Department of Energy*. Basic Energy Science Advisory Committee, (2002), http://www.sc.doe.gov/bes/besac/perf%20meas%20report.pdf

[3] *Opportunities in Nuclear Science. A Long Range Plan for the Next Decade,* Nuclear Science Advisory Committee, (2002), http://www.sc.doe.gov/henp/np/nsac/docs/LRP_5547_FINAL.pdf

[4] *Report of the Secretary of Energy Advisory Board's Task Force on the Future of Science Programs at the Department of Energy*, (2003) http://www.seab.energy.gov/publications/FSPFFinalDraft.pdf

[5] Report on the Workshop of the Role of the Nuclear Physics Research Community in Combating Terrorism, ed. J. Moss, D. Geesaman, L. Schroeder, J. Simon-Gillo and B. Keister, DOE/SC-0062, U.S. Department of Energy, http://www.sc.doe.gov/production/henp/np/homeland/CombatTerrorismFinal110602.pdf

Appendix I: Charge to NSAC

U.S. Department of Energy
and the
National Science Foundation

September 12, 2003

Professor Richard Casten
Chairman
DOE/NSF Nuclear Science Advisory Committee
A.W. Wright Nuclear Structure Laboratory
Yale University
New Haven, CT 06520

Dear Professor Casten:

This letter requests that the DOE/NSF Nuclear Science Advisory Committee (NSAC) establish a Committee of Visitors to assess the operations of the DOE Office of Science Nuclear Physics program, and provide guidance regarding performance measures for the Nuclear Physics program of the Office of Science.

(1) NSAC is requested to establish a Committee of Visitors (COV) that can provide an assessment of process-related matters pertaining to the management of the Office of Science Nuclear Physics program. The COV should review the program management of the Nuclear Physics program to provide an assessment of the effectiveness, efficiency and quality of the processes used to solicit, review, recommend, and document proposal actions and monitor active projects and programs. In addition, the COV should also comment on how the award process has affected the breadth and depth of the Nuclear Physics portfolio elements, and the national and international standing of the Nuclear Physics program. Such an assessment is planned to be requested every three years. You should work with the Associate Director of the Office of Science for Nuclear Physics to establish the processes and procedures so as to enable the first COV to meet before the end of the 2003 calendar year. A report by the COV should be submitted by February 27, 2004.

(2) NSAC is requested to provide an assessment and recommendations to the Office of Science regarding performance measures for the Nuclear Physics program. The performance measures are intended to focus on outcomes and meaningfully reflect the purpose of the program, to guide program management and budgeting, and to promote results and accountability. Office of Management and Budget (OMB) guidance for these measures and the proposed Nuclear Physics measures are given in the enclosure. Assessments of progress towards meeting the goals are to be made every five years and some appropriate milestones have been requested by OMB to judge the

quality of progress that has been made. NSAC is requested to submit a report with comments on the appropriateness of these measures, that these measures are suitably ambitious and validly encompass the DOE Nuclear Physics program, and with recommendations for appropriate milestones for each of these measures. Your report should be submitted before the end of November 2003.

We appreciate NSAC's willingness to take on these important activities, and we look forward to learning of your progress in these important tasks.

Sincerely,

James F. Decker for
Raymond L. Orbach
~~Director~~
Office of Science

John B. Hunt
John B. Hunt
Acting Associate Director for
Mathematical and Physical Sciences

Appendix II: NSAC Charge to Subcommittee

Dear Don,

As you know, Ray Orbach, Director of the Office of Science at DOE, and John Hunt, Acting Assistant Director for the Division of Mathematical and Physical Sciences at the NSF, have charged NSAC to provide advice to the DOE Office of Science regarding Performance Measures for the DOE Office of Science Nuclear Physics Program. In particular, key elements of the charge request NSAC to comment about the appropriateness of Performance Measures that have been developed, and to recommend appropriate milestones that will help assess progress towards the goals of the field. The detailed wording of the charge, which I have previously forwarded to you, gives further and more precise instructions. The deadline for the final report is November, 2003.

I am writing to formally ask you to serve as the Chair of an NSAC Sub-committee to consider this charge and to report back to NSAC. The work of this sub-committee is extremely important since this is our community's opportunity to have substantive input into the processes and standards by which future research in nuclear science is assessed.

There will be an NSAC Meeting in the Washington, D.C. area on November 7,8, 2003 where the Report of your Sub-committee will be discussed. I would ask you to send me your Report in sufficient time before that meeting so that I can distribute it to NSAC for their study ahead of time. At the Nov. 7,8 NSAC Meeting, I would like to ask you to give a presentation on the findings of your Sub-Committee. This will be followed by a discussion of the Sub-committee Report by NSAC, and discussion of transmittal to the Agencies. I will inform you further of the detailed Agenda for the NSAC meeting when it is finalized.

I realize that this task imposes an extra burden on you, especially given the extraordinarily tight time constraints, as well as the difficulty of foreseeing research directions and goals well into the future. Nevertheless, I am sure you and your Sub-committee will succeed in this very important task, which will have repercussions for all of nuclear science for years to come. So, I just want to express in advance my real appreciation to you that you have agreed to take on this responsibility. I will be available to help you in any way I can and will attend the subcommittee meetings in an ex officio capacity.

Best regards,

Rick Casten
Chair, NSAC

Appendix III: Subcommittee Membership

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