What the NSAC Subcommittee Needs from You

- Charges (From DOE/NSF, from NSAC)
- Background
- Committee Status & Plans
- Website:
  - http://cyclotron.tamu.edu/nsac-subcommittee-2012/

Charge to NSAC

and the
National Science Foundation

April 5, 2012

Dr. Donald Geesaman
Chair
DOE/NSF Nuclear Science Advisory Committee
Argonne National Laboratory
9800 South Cass Avenue.

We seek advice from NSAC on implementing the priorities and recommendations of the 2007 Long Range Plan in light of projected budgetary constraints and for guidance on developing a plan to implement the highest priority science in the context of likely available funding and world-wide capabilities. We request that NSAC examine the existing research capabilities and scientific efforts, assess their role and potential for scientific advancements, and advise the two agencies regarding the time and resources needed to achieve the planned programs. Your report should describe how to optimize the overall nuclear science program over the next five years (FY 2014-2018), under at least the following funding scenarios for the nuclear science budgets at the two agencies: (1) flat funding at the FY 2013 request level, and (2) modest increases over the next five years.

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Charge to Subcommittee

Prof. Robert Tribble
Cyclotron Institute
Department of Physics and Astronomy
4242 Texas A & M University
College Station, TX 77843-4242

Dear Bob,

As you know William Brinkman, Director of the Office of Science at DOE, and Edward Seidel, Associate Director for the Directorate of Mathematical and Physical Sciences at the NSF, have

future of nuclear science, both for the U.S. and the international science community. Based on the priorities and opportunities identified and recommended in the 2007 Long Range Plan, the report should discuss what scientific opportunities will be addressed and what existing and future facilities and instrumentation capabilities would be needed to mount a productive forefront program for each of the funding scenarios. It should also present what opportunities would be lost in each scenario. These opportunities should include the impact on education and training of the workforce in nuclear science.

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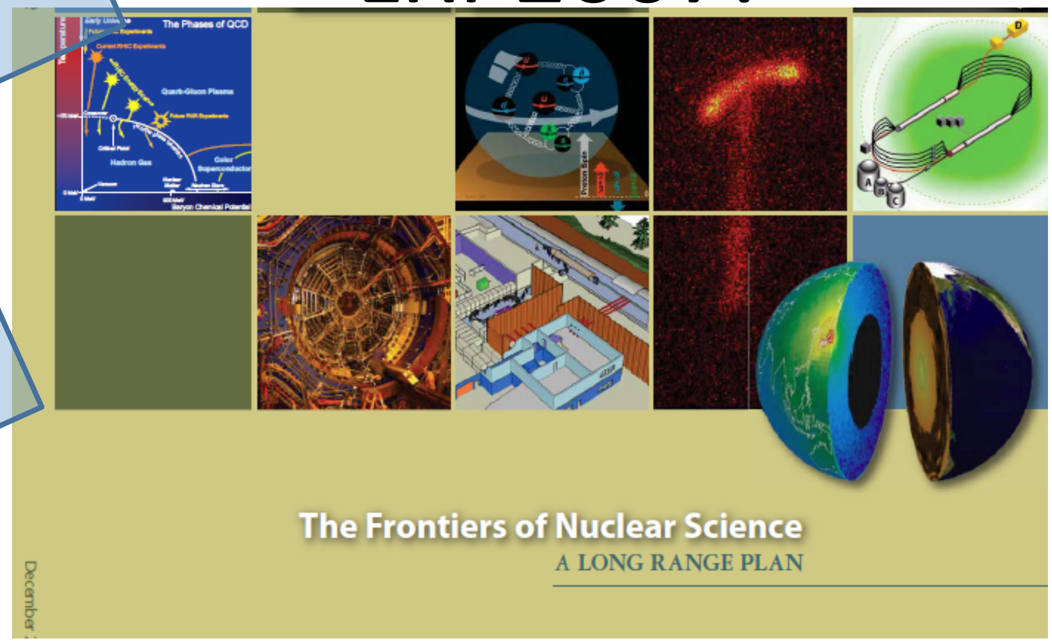
The time scale of the charge requires NSAC to submit its report by January 2013. Therefore I must ask your subcommittee to submit its report to NSAC by 7 January 2013. I realize this is a heavy responsibility. I and our whole community will, once more, owe you an enormous debt of gratitude.

Sincerely yours,

Donald F. Geesaman

Background - LRP2007:



RECOMMENDATION I

We recommend completion of the 12 GeV CEBAF Upgrade at Jefferson Lab. The Upgrade will enable new insights into the structure of the nucleon, the transition between the hadronic and quark/gluon descriptions of nuclei, and the nature of confinement.

JLAB

RECOMMENDATION II

We recommend construction of the Facility for Rare Isotope Beams (FRIB), a world-leading facility for the study of nuclear structure, reactions, and astrophysics. Experiments with the new isotopes produced at FRIB will lead to a comprehensive description of nuclei, elucidate the origin of the elements in the cosmos, provide an understanding of matter in the crust of neutron stars, and establish the scientific foundation for innovative applications of nuclear science to society.

FRIB

RECOMMENDATION III

We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet-unseen violations of time-reversal symmetry, and other key ingredients of the New Standard Model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to U.S. leadership in core aspects of this initiative.

US!

RECOMMENDATION IV

The experiments at the Relativistic Heavy Ion Collider have discovered a new state of matter at extreme temperature and density—a quark-gluon plasma that exhibits unexpected, almost perfect liquid dynamical behavior. We recommend implementation of the RHIC II luminosity upgrade, together with detector improvements, to determine the properties of this new state of matter.

RHIC

2007 LRP “Whale Chart”

DOE-NP

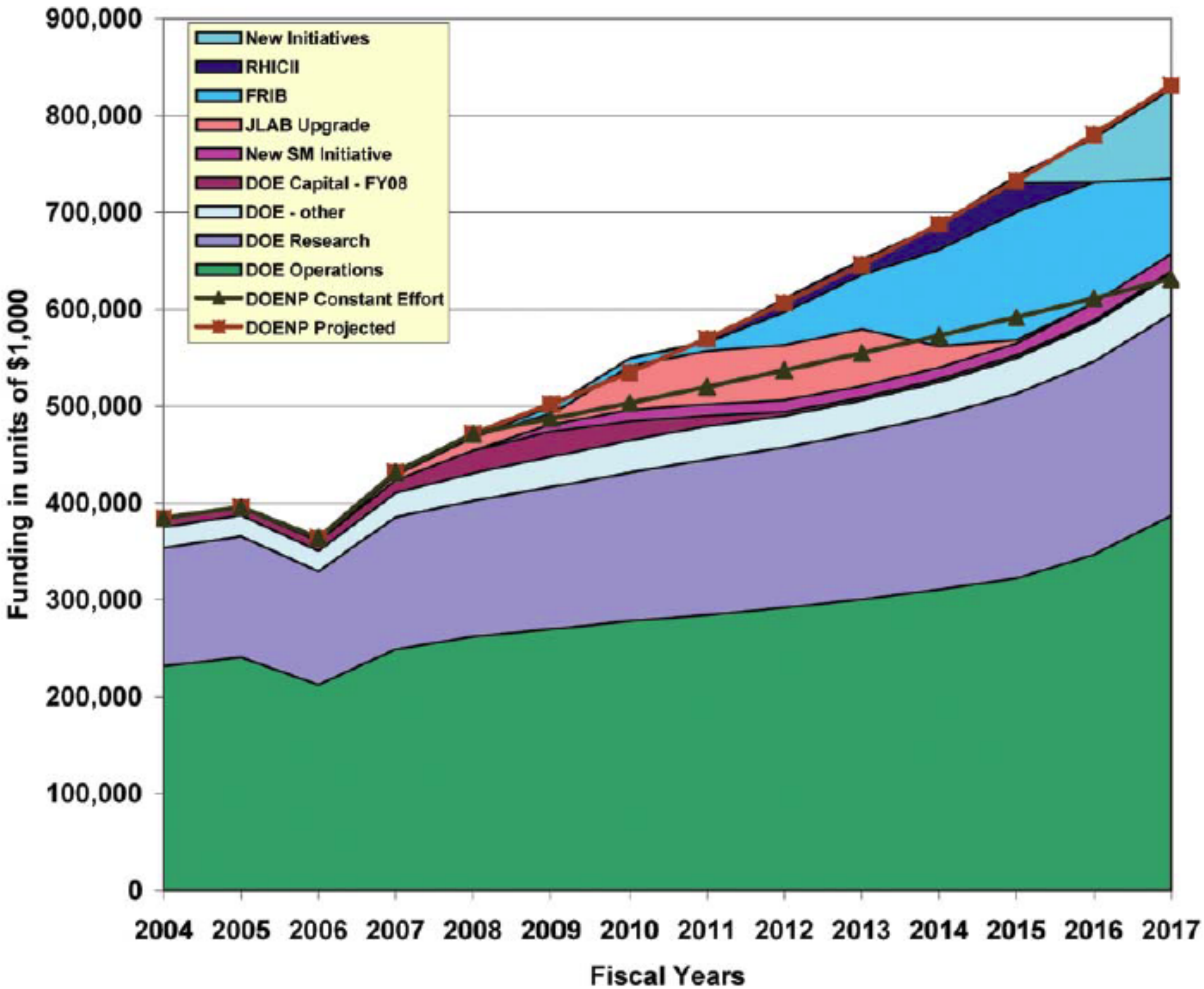


Figure 7.5: DOE budget projections (in as-spent dollars). The line that connects the triangles represents a constant effort budget.

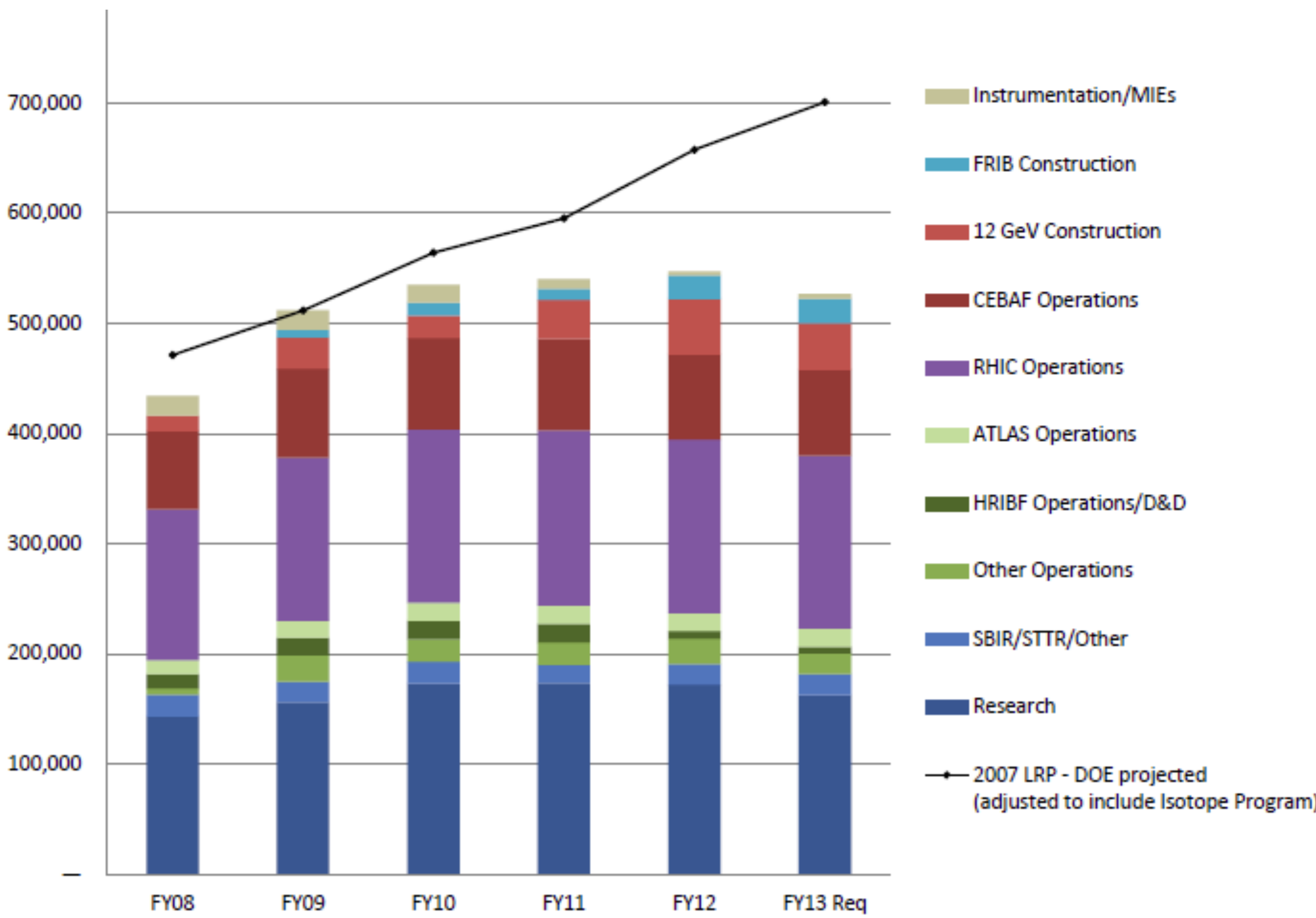
The Problem: Budget Realities sets in…

Tim Hallman (DOE Nuclear Physics Assoc. Director) talk at BNL 6/13/12

Nuclear Physics Funding Distribution (DOE)

FY 2008 – FY 2013

(NSF ~ 10% DOE)



The 1.4B$ Problem for Nuclear Physics (shortfall by 2018) AND no DUSEL

How did we get into this mess??

Assumed resources for 2007 LRP:

of the National Academy's report *Rising Above the Gathering Storm*. In contrast to many previous studies warning of problems engendered by stagnant funding for the physical sciences, and the dire consequences for future economic growth, the National Academy study stimulated an immediate response. Follow-up discussions with leaders in Congress and the nation's industries led President Bush to announce the American Competitiveness Initiative in January 2006. The administration requested in its FY2007 budget proposal that Congress double the budget for research in the physical sciences over the next decade.

What are priorities of the field?

- NP ~ 4 sub-fields
  1. Cold QCD & Structure of Hadrons
     - JLAB + other
  2. Hot QCD and Quark-Gluon Phase Transition
     - RHIC + Heavy Ion LHC + other
  3. Nuclear Structure & Nuclear Astrophysics
     - FRIB + Argonne ATLAS + other
  4. Neutrinos & Fundamental Symmetries
     - Majorana Demonstrator + nEDM + 1Ton $0\nu\beta\beta$ + other

What is $$ scale of new projects?

- Complete JLAB upgrade to 12 GeV ~ 125M$
  - Operate at 12 GeV ~ +20M$/yr
- Build FRIB (500M$) & operate ~ 50M$/yr
- Run RHIC (include detector upgrades) ~ +50M$
- Neutrinos/Fundamental Symmetries
  - Majorana Demonstrator ~ 20M$, nEDM ~ 50M$

    Build 1Ton $0\nu\beta\beta \sim$ 300M$
- Maintain Research
- **Which of above can be done with flat$$????**

The Process: the Subcommittee

JLAB	RHIC
FRIB	ν/FundS

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Professor Michael Wiescher
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Chapel Hill, NC 27599

18 Members at Universities
4 Members at Natl. Labs

Meeting 1

NSAC Subcommittee Meeting
May 15, 2012

Meeting schedule:

08:00 – 0:830 – Welcome and introductions – Don G., Robert T. and subcommittee members

08:30 – 0:915 – Mission, Vision, and Research – T. Hallman

09:15 – 10:05 – Facilities and Initiative – J. Gillo

10:05 am – 10:30 – Break

10:30 am – 11:15 – NSF Program and Budget – B. Keister

11:15 – 11:45 – Subcommittee Discussion – What presentations are needed at next meeting?

11:45 – 13:00 – Subcommittee Discussion – What questions need to be answered during talks at the next meeting?

13:00 – 13:30 – Subcommittee Discussion – When and where should we have next meeting?

13:30 – 14:00 – Subcommittee Discussion – What community input is needed and what mechanism should be used to get it?

14:00 – 14:20 – Subcommittee Discussion – Who is the audience for report?

14:20 – 15:00 – Develop draft outline and make subcommittee homework assignments

Meeting 2

- Sept. 7-9 in Rockville Maryland
- 3 days long (~ 3.75 hrs each subfield)
  - Day 1 = RHIC + ν/FundSym
  - Day 2 = JLAB + FRIB
  - Day 3 = otherLE,NucAstro,Theory,computation + Exec Session

Meeting 3

- After the Nov. election
  - probably late Nov./early Dec.
- ~ 3 day "shootout" to resolve priorities
  - Some tough decisions will likely be required
  - Essential to highlight what is lost/gained under various budget scenarios
  - Report to NSAC in early Jan. 2013

So…What are we here for??

- Discuss Science accomplishments and opportunities
- Try to address questions from TribbleComm (see next)
- Formulate a start to hardcopy input to the TribbleComm (White Paper?)
- “To prioritize or not to prioritize that is the question”

Where do we start?

- Context of our discussion must be 2007 Long Range Plan
  - 17 page chapter entitled "In Search of the New Standard Model"
  - Outlined landscape and discussed opportunities…

Recommendation 3 (p. 7)

We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet unseen violations of time-reversal symmetry, and other key ingredients of the new standard model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to US leadership in core aspects of this initiative.

The discovery of flavor oscillations in solar, reactor, and atmospheric neutrino experiments – together with unexplained cosmological phenomena such as the dominance of matter over anti-matter in the Universe – call for a new standard model of fundamental interactions. Nuclear physicists are poised to discover the symmetries of the new standard model through searches for neutrinoless double beta decay and electric dipole moments, determination of neutrino properties and interactions, and precise measurements of electroweak phenomena.

What?

Where?

The Deep Underground Science and Engineering Laboratory will provide the capability needed for ultra-low background measurements in this discovery-oriented program. Experiments also will exploit new capabilities at existing and planned nuclear physics facilities. Assembling the new standard model using the breadth of new experimental results will require enhanced theoretical efforts.

More Details in Text:

Neutrinos/Fund. Symm. LRP 2007

- **Neutrinos and Fundamental Symmetries**
- **Introduction:** Why we need a new Standard Model and why nuclear science is poised to make key contributions to finding out what it is. Emphasize connections with cosmology and astrophysics.
- The key questions we address: Lepton number violation and the nature of the neutrino; CP-violation and the origin of baryonic matter; neutrino mass and mixing; the "footprints" of new physics that emerge in precise, indirect tests.
- Recent accomplishments, highlighting: solar and reactor neutrino oscillations, muon g-2, MiniBoone, PV Moller.
- Unique strengths that nuclear physics brings to the search for the new standard model.
- The New Standard Model Initiative: What it is, including the role of DUSEL.

More Details

- **The major discovery opportunities :**
  - Neutrinoless Double Beta Decay Program
  - Electric Dipole Moment Program
- **A targeted program of measurements of neutrino properties:**
  - Neutrino mass via beta-decay
  - Solar neutrinos and implications for the number of neutrino generations
  - Neutrino cross sections (nu SNS) that will be needed for supernova neutrino studies
- **A targeted program of precision electroweak measurements**
  - Muon g-2: why now? What will the physics impact be? Why nuclear physics?
  - Neutron, nuclear, and pion decay as a unique probe of new physics in the charged current sector, emphasizing decay correlations
  - PV Electron Scattering: PV Moller as a powerful probe of new physics in the neutral current sector; PV DIS as a comprehensive probe
- **DUSEL: a vital component for U.S. leadership in core aspects of the initiative**
- **Other experimental opportunities**:
  - Support for research at the interface with other fields: Reactor neutrinos and theta_13; Dark Matter searches; Charged Lepton Flavor Violation; n n bar oscillations
  - Weak probes of the Nuclear Physics, Astrophysics & QCD: PV electron scattering, MuSun, and hadronic PV,Studies of supernova neutrinos and high energy astrophysical neutrinos
- **Theoretical Opportunities**

Questions to address from TribbleComm

General questions for operating facilities and on-going programs

(1) What *major* scientific accomplishments and discoveries have occurred in your research area or at your facility since the 2007 LRP was drafted? **Must Do**

(2a) What compelling and unique science can be carried out at the facility (or in the program) in the next five years assuming support similar to FY13 that includes cost of living increases? **Do if Possible**

(2b) What additional impact would flat-flat funding to FY18 have on (2a)?

(3) What is the minimum level of support (beam hours, upgrades, etc.) needed to maintain a viable program? **Do if Possible**

(4) What workforce is needed to maintain a viable program? **Interesting**

(5) What science would you expect to pursue at your facility (or in the program) in 2020 and beyond. What is needed to support this? What science would you expect to pursue without your facility? **Must Do**

(6) What is role of the science in your research area in the international context? If the US effort in this area were seriously curtailed, to what degree would efforts in other countries fill the gap? And, to what degree would US scientists be able to advance research in this area by working outside of the country? **Must Do**

(7) How does the facility (or program) contribute to the educational mission of training the future workforce in nuclear physics and associated applied areas? **Must Do**

Extra question for Neutrinos and Fundamental Symmetries

(1) What major initiatives, including detector construction projects and facility operations are required to carry out the program in (5) and what are the cost estimates for them? **Do if Possible**

(2) How do the efforts in this area complement and overlap with those in the US HEP program? **Must Do**

Summary: What does the Tribble Committee Need?

1. Strong, well-articulated science case
2. Estimates for required resources
3. Possibly a proposal for priorities
   - Should we go there?
   - We are a somewhat random bunch of physicists
     - Where is the "Neutrinos/Fundamental Symmetries User Group??
   - Should we go beyond this group? How?
4. Plenty to do over the next 2 days!

Backup Slides:
Additional Info From LRP

P. 7-8 (Overview & Recs)

RECOMMENDATION III

We recommend a targeted program of experiments to investigate neutrino properties and fundamental symmetries. These experiments aim to discover the nature of the neutrino, yet-unseen violations of time-reversal symmetry, and other key ingredients of the New Standard Model of fundamental interactions. Construction of a Deep Underground Science and Engineering Laboratory is vital to U.S. leadership in core aspects of this initiative.

The discovery of flavor oscillations in solar, reactor, and atmospheric neutrino experiments—together with unexplained cosmological phenomena such as the dominance of matter over antimatter in the universe—calls for a New Standard Model of fundamental interactions. Nuclear physicists are poised to discover the symmetries of the New Standard Model through searches for neutrinoless double beta decay and electric dipole moments, determination of neutrino properties and interactions, and precise measurements of electroweak phenomena.

The Deep Underground Science and Engineering Laboratory (DUSEL) will provide the capability needed for ultra-low background measurements in this discovery-oriented program. Experiments also will exploit new capabilities at existing and planned nuclear physics facilities. Developing the New Standard Model using the breadth of new experimental results will require enhanced theoretical efforts.

In Search of the New Standard Model

OVERVIEW

The quest to explain nature's fundamental interactions, and how they have shaped the evolution of the cosmos, is among the most compelling in modern science. A major triumph in that quest came in the latter part of the 20th century with the development of the Standard Model—a comprehensive and detailed picture of the electroweak and strong interactions. Nuclear physicists have played a key role in that success, starting five decades ago with their observation of parity violation in nuclear beta decay, and continuing to the present day with their increasingly precise experimental tests of the Standard Model's predictions. The model has survived these tests with remarkable resiliency—which is why it is now accepted as the fundamental framework for three of the four known forces of nature.

Despite its successes, however, the Standard Model is at best incomplete. It cannot explain why neutrinos have mass—a fact revealed by the recent discovery of neutrino oscillations. It cannot account for the observed predominance of visible matter over antimatter in the cosmos. It has nothing to say about the nonluminous dark matter that makes up roughly 25% of the cosmic energy density, or the mysterious dark energy that appears to be responsible for cosmic acceleration. And it completely leaves out the force of gravity, which is obviously required for a fully unified theory of fundamental physics.

These and other shortcomings have motivated the search for a larger framework that will address the Standard Model's deficiencies while preserving its successes. Discovering the ingredients of this "New Standard Model" will require progress on the high-energy frontier, where increasingly energetic collisions allow physicists to probe particle structure at smaller and smaller scales. But just as importantly, it will require advances on the low-energy frontier, where nuclear physicists can probe the internal dynamics of particles with exquisite precision. Below we lay out a targeted program of experiments to do just that: a "New Standard Model Initiative" that represents one of the major thrusts in nuclear science for the next decade. This initiative will seek to answer three overarching questions:

- **What is the nature of the neutrinos, what are their masses, and how have they shaped the evolution of the cosmos?**
- **Why is there now more visible matter than antimatter in the universe?**
- **What are the unseen forces that were present at the dawn of the universe but disappeared from view as it evolved?**

Two highlights of this ambitious program—either or both of which could lead to revolutionary discoveries—are the search for neutrinoless double beta decay in atomic nuclei, and the search for permanent electric dipole moments of the neutron, electron, nuclei, and atoms. The neutrinoless double beta decay experiments could determine whether the neutrino is its own antiparticle, and therefore whether nature violates the conservation of total lepton number: a symmetry of the Standard Model whose violation might hold the key to the predominance of matter over antimatter in the universe. Similarly, the discovery of a nonvanishing permanent electric dipole moment would imply the violation of time-reversal symmetry, which could also help explain the matter-antimatter imbalance.

Other experiments in our program will probe neutrino mass and flavor oscillations, low-energy weak interactions of leptons and quarks, and the magnetic moment of the muon—all at unprecedented precision. The results of these experiments, together with the expected direct production of new particles at the soon-to-be-commissioned Large Hadron Collider (LHC), will provide the most important clues into the underlying physics that is the foundation of what we call the New Standard Model. With the guidance from theory, we expect that our experimental program will observe the "footprints" of forces—largely hidden today—that were important at earlier times during the evolution of the cosmos.

A DECADE OF DISCOVERY

Nuclear science is in a uniquely strong position to pursue these studies at the precision frontier. Recent experimental and theoretical advances achieved by nuclear physicists studying neutrinos and fundamental symmetries have yielded a number of widely recognized results. Among the most noteworthy are:

- **The discovery of flavor oscillations among solar neutrinos.** For more than 30 years the solar neutrino problem perplexed physicists. The initial observation by Ray Davis, Jr., that only about a third as many electron neutrinos came from the Sun as expected from carefully constructed solar models, such as those of John Bahcall, was finally resolved in 2001 when the

p. 75 Chap. On Neut/Funsym

DEEP UNDERGROUND SCIENCE AND ENGINEERING LABORATORY: DUSEL

DUSEL discussion p. 77

A vital component of U.S. leadership in this field will be the construction of a Deep Underground Science and Engineering Laboratory (DESEL) in the United States, together with the suite of low-background experiments—including neutrinoless double beta decay and solar neutrino observations—that require its shielded, clean environment. As these experiments that are central to the New Standard Model Initiative explore unprecedented sensitivity levels, backgrounds of cosmic origin, especially fast neutrons, pose a serious obstacle to further improvement in the physics reach. Mounting the experiments at great depths can lessen these background effects. The need for a dedicated, deep facility was identified in the 2002 Long Range Plan, and that need has only intensified in the intervening years. The nuclear physics community has once again called for construction of DUSEL, as is explained in more detail in the Chapter 6, "Recommendations."

DUSEL will be a world-leading scientific facility with unique capabilities. It will provide around-the-clock access to locations at several depths in which cosmic-ray backgrounds, radioactive contaminants, and seismic disturbances from mining have all been minimized. Experiments will aim to discover key elements of the New Standard Model by searching for tiny signatures of neutrinoless double beta decay, sterile neutrinos, and dark matter. They will help us explain how the elements were made, measure the energy output of the Sun, and determine the distribution of uranium and thorium in the Earth. Not only physics will benefit, but a wide range of other sciences, including geoscience, geomicrobiology, and engineering, will develop new programs working alongside physicists. Synergies that did not previously exist are already taking shape; geologists and nuclear physicists find themselves tackling the problem of the Earth's internal heat in a collaborative way that was not considered before. The new laboratory will also provide a focus for education and outreach that will draw young people to science at a true frontier.

The National Science Foundation has taken leadership of the process for DUSEL and has recently decided on a site for the proposed laboratory, the former Homestake gold mine in South Dakota. If approved, construction could start in 2011.

p. 95 Chap. Summary

OUTLOOK

The targeted program described above addresses pivotal nuclear science questions in fundamental symmetries and neutrino physics: Is lepton number violated? What is the origin of the observed matter-antimatter asymmetry? What presently unseen forces were at work in the early universe? How are stars born and how do they die? What role do neutrinos play in cosmology and astrophysics? Garnering answers to these questions relies on undertaking a new generation of exquisitely designed, precision measurements, supported by strong theoretical guidance and predictions. The proposed program builds on the remarkable discoveries made in the past decade and the growing community of scientists engaged in these exciting research activities. The answers to these questions will have a profound influence on defining the New Standard Model and ultimately on understanding how nuclear physics shapes our world and the universe around us.

Recs Chap. P. 154.

RECOMMENDATION III

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This initiative builds on the third recommendation of the 2002 Plan that called for the "immediate construction of the world's deepest underground science laboratory." Starting in 2003, NSF began developing plans to construct the multidisciplinary Deep Underground Science and Engineering Laboratory (DUSEL). Four sites for DUSEL were considered in a recent competition, and the Homestake gold mine was chosen. The next step is a full proposal for DUSEL at the Homestake mine. Following submission to NSF, the proposal will be considered by the National Science Board and if approved submitted to Congress for funding.

DUSEL and the experiments that will be carried out in it are vital components of the new initiative. Investments in complementary experiments at accelerator facilities are also integral to the initiative's discovery-oriented program. Particle-beam experiments will exploit new capabilities at the Fundamental Physics Neutron Beam Line at the Spallation Neutron Source at Oak Ridge National Laboratory and the 12 GeV CEBAF Upgrade, while other experiments will capitalize on existing capabilities at Brookhaven, Los Alamos and other facilities.