Fundamental Symmetries and Neutrinos Workshop - White Paper Status

Vince Cianciolo, ORNL

DNP Town Meeting, 10/2012

Recommendations

- Sketched out at Workshop
- Fleshed out over the next two weeks
- Sent to Workshop mailing list and Tribble Committee
- A few minor comments received/incorporated

Recommendation 1: Fundamental Symmetries and Neutrinos figure prominently in the 2007 NSAC Long Range Plan and subsequent assessments of the field, such as the 2012 NAS Nuclear Physics Report, the 2011 NAS Assessment of Science Proposed for DUSEL, and the 2011 NSAC Neutron subcommittee report. The community strongly endorses the recommendation of the 2007 NSAC Long Range Plan: *"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 workshop identified that this subfield is vibrant and continues to address compelling scientific issues with considerable discovery potential. In particular, for the short to medium term timescales, the workshop strongly endorses neutrinoless double β-decay, neutron EDM, parity violating electron scattering, and the g-2 experiment. In addition, we note that progress has been made toward establishing an underground laboratory for science within the U.S.; at the Sanford Underground Research Facility, the Davis Campus at 4,850 feet is operating and being used as a home for the MAJORANA DEMONSTRATOR as well as the (HEP funded) LUX dark matter experiment.

The targeted program of experiments to investigate neutrino properties and fundamental symmetries is envisioned to include next-generation neutrinoless double β-decay experiments, with one domestically led, that will extend our sensitivity to lepton-number violation by an order of magnitude, and a measurement of the neutron electric dipole moment with two orders of magnitude improvement over the current experimental limit.

Further supporting prose highlighting the leveraging of facility costs.

Recommendation 2: **The federal research investment in Fundamental Symmetries and Neutrinos should be commensurate with its tremendous scientific opportunities and discovery potential.**

The second recommendation follows the 2012 NAS Nuclear Physics Report in recognizing the need to balance research funding and construction of new facilities. Fundamental Symmetries and Neutrinos has traditionally not required a large facility operations budget, and therefore represents a cost effective way to obtain tremendously valuable science. However, substantial investments are critical for some of the next-generation experiments needed to maintain scientific momentum and world competitiveness.

Recommendation 3: **In order to ensure the long-term health of Fundamental Symmetries and Neutrinos research, it is necessary to establish and maintain a balance between funding construction of new experiments and facilities with the needs of university and laboratory-based research programs performing existing experiments and developing new ideas and measurements that may have high impact.**

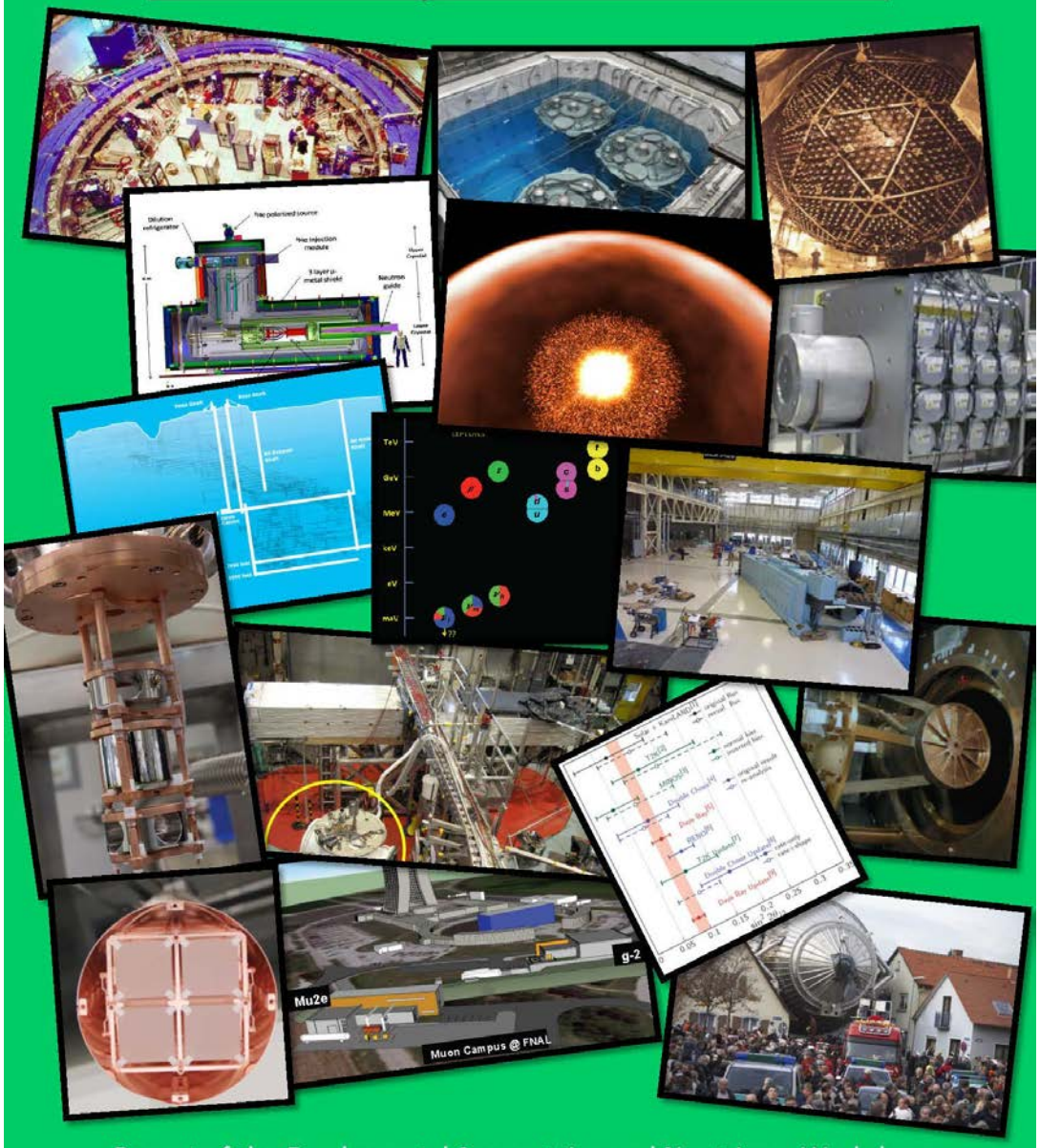
It is important to fund small R&D efforts to establish the feasibility of new ideas. These ideas range from measuring sterile neutrino signals at the Spallation Neutron Source, to small-scale experiments at reactors to understand reactor neutrino flux predictions and spectra, and to measure salient features of neutrino oscillations and investigate coherent neutrino scattering, to initial R&D towards a proton ring for measuring the proton electric dipole moment.

Recommendation 4: **The community urges strengthened support for nuclear theory in Fundamental Symmetries and Neutrinos in order to fully exploit, guide, and complement experimental efforts.**

Although relatively few in number, nuclear theorists from both universities and national laboratories have historically played a crucial role in developing Fundamental Symmetries and Neutrinos. Their efforts have been especially important in connecting the results of different experiments and providing an intellectual bridge to astrophysics and particle physics. It is crucial to strengthen these efforts to capture the opportunities this field represents. In addition, training the next generation of nuclear theorists starts at universities and we strongly encourage agency incentives to universities (for example, bridge appointments) in this subfield of nuclear theory.

Discovering the New Standard Model

Fundamental Symmetries and Neutrinos



Report of the Fundamental Symmetries and Neutrinos Workshop

August 10-11, 2012 - Chicago, IL

I Hate The (Sub)title…

- Laundry list
- Reinforces divisions between neutrinos and "everything else"
  - "If we don't hang together, we will surely hang separately."
- Closely related Physics motivations
  - Establish and go beyond the Standard Model
- Similar experimental gestalt
  - Low-energy precision frontier

Original Outline

- Executive Summary / Recommendations
- Scientific Landscape
  - The neutrino landscape
  - The neutron landscape
  - The symmetries landscape
  - Implications of Higgs at the LHC
- Major Accomplishments Since 2007
  - The neutrino landscape
  - The neutron landscape
  - The Symmetries landscape
- Research and the Next 5 years
  - Current neutron experiment plans
  - Current neutrino experiments
  - Preparing for High Priority Experiments
    - Large Scale 0nbb experiment
    - Neutron EDM
  - Parity Violation at JLAB
  - R&D for next generation experiments
    - pEDM
    - Non-oscillation neutrino experiments
    - Oscillations
- Key Facility Assumptions
- International Context

Contributors

- Baha Balantekin
- Vincenzo Cirigliano
- Martin Cooper
- David Dean
- Steve Elliott
- Gabriel Orebi Gann
- Geoff Greene
- Karsten Heeger
- David Hertzog
- Paul Huffman
- Jeff Nico
- Kent Pashke
- Andreas Piepke
- Brad Plaster
- Hamish Robertson
- Yannis Semertzidis
- Kate Scholberg

Draft Version Sent To Writing Committee Early September

- Outline had significant problems
  - missing pieces
  - reinforced divisions w/i the field
- Significant difference in the level of detail in various contributions
- Despite missing pieces it was already too long

- Only Executive Summary and Recommendations sent to Tribble
- Reformulate along physics basis

New Outline

- Executive Summary / Recommendations
- Scientific Landscape
- Physics Beyond the Standard Model – New Phenomena
  - Matter Asymmetry of the Universe
  - Large-scale structure, Origin of ν-Mass
  - Symmetries and Fields of the New Standard Model
- The Standard Model and Beyond – Precision Tests
  - Weak Decays of Quarks
  - Neutral Weak Interactions
  - Lepton Properties and Interactions
  - Weak Interactions Between Quarks
  - Weak Probes of Nuclear Physics and Astrophysics

Status

- Draft exists with a few missing items (volunteers welcome)
  - Symmetries and Fields of NSM (intro text)
  - Dark Photons (missing)
  - EIC $e \rightarrow \tau$ (missing)
  - Weak decays of quarks (intro text)
  - Neutral Weak Interactions, Lepton Properties and Interactions (references)
  - Neutrino supernova experiments (more meat)
  - Neutrino reactor monitors (updated text)
- Sent to contributors last week w/ little comment
- When missing sections are complete I will send around to workshop mailing list for final comments