REPORT TO THE NUCLEAR SCIENCE ADVISORY COMMITTEE

Submitted by the Subcommittee on Fundamental Physics with Neutrons

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

November 29, 2010

Dr. Susan Seestrom
Chair, DOE/NSF Nuclear Science Advisory Committee
Experimental Physical Sciences
Los Alamos National Laboratory
Los Alamos, New Mexico 87545

Dear Dr. Seestrom:

The DOE/NSF Nuclear Science Advi
evaluate the current and proposed res
opportunities for fundamental nuclear
of priorities consistent with projected

Your report should identify the most compelling scientific opportunities, and the infrastructure and effort required to address them. Your assessment should be made in the context of existing and planned scientific efforts and capabilities in the United States and elsewhere. It should establish priorities for these opportunities with constant level of effort for neutron science research at the FY 2011 Congressional Request level, and should recommend priorities for incremental investments beyond this level. An assessment of the current scientific and technical workforce committed to these activities is requested, as well as the incremental workforce needed for further investments. In dealing with the proposed activities at the various funding levels, guidance regarding the appropriate mix of facility operations, research, investments in instrumentation and R&D to optimally exploit these opportunities should be provided. We request that an interim report be submitted by June 1, 2011, and a written report responsive to this charge be provided by September 2011.

Sincerely,

W. F. Brinkman
Director
Office of Science

Edward Seidel
Assistant Director
Directorate for Mathematical
and Physical Sciences

Dec 1, 2011

Committee Membership

Professor Hartmut Abele
Technische Universität Wien (Vienna)
Atominstitut der Österreichischen Universitäten

Professor Alejandro Garcia
Department of Physics
University of Washington

Professor John Hardy
Department of Physics & Astronomy
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Professor Wick Haxton
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Dr. Zheng-Tian Lu
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Professor Michael Ramsey-Musolf
Department of Physics
University of Wisconsin

Professor Michael Romalis
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Scientific focus

- Search for an electric dipole of the neutron (nEDM)
- Neutron decay parameters (A,a,B,b,…)
- Hadronic parity violation
- Neutron lifetime

Subcommittee Activity

Open meetings (O'Hare Hilton):

- April 1-2: focus on nEDM
- April 14-15: all other topics

Subcommittee meetings:

- Feb. – Sept.: ~10 phone conferences
- Early June (INT Seattle): in-person meeting to finalize recommendations

NSAC:

- June 30: presentation of Interim Report with recommendations
- Oct 25: Final subcommittee report submitted to NSAC for comment
- Nov 11: Modified report submitted to NSAC incorporating changes due to comments

Scientific Priorities

The principal *scientific* priorities found by the subcommittee, ranked in descending order, are:

I. The search for a neutron electric dipole moment with the nEDM experiment.
II. Continuation of the UCNA experiment to obtain improved precision on λ, the ratio of the weak axial-vector to vector coupling constants of the neutron.
III. Completion of the NPDGamma experiment to obtain a precision measurement of the weak isovector nucleon-nucleon-pion coupling constant.
IV. Investment in the Nab apparatus with the main goal to determine λ to unprecedented precision, using a complementary observable to that of UCNA.
V. Continuation of the NIST experiment to perform the most precise cold beam-based measurement of the neutron lifetime.

We estimate that these five high priority initiatives might be accommodated within a scenario of funding at constant level of effort, though moderate additional funding may be required. The ranking indicates the priority with which each effort should be supported, in the event of funding below the constant level of effort. The priority of UCNA and NPDGamma should be considered comparable for this purpose.

(Constant effort is discussed in more detail on a later slide…)

nEDM recommendations I

The subcommittee finds that the scientific motivation for EDM searches remains as compelling as ever. In particular, a measurement with sensitivity at the anticipated reach of the US nEDM experiment ($\sim 4\times10^{-28}$ e-cm) would have a profound impact on nuclear physics, particle physics and cosmology, even in the event of a negative result. The US nEDM project is the only technical concept among various worldwide efforts that is explicitly proposed with capabilities to reach this level of sensitivity.

The nEDM collaboration has already resolved many important technical challenges and developed a first-pass engineering design of the apparatus. However, significant further R&D is needed on several issues, such as the HV studies, electric field monitoring, background from irradiation of the electrode coating, and the scintillation photoelectron yield. The subcommittee makes the following five recommendations for the nEDM project:

nEDM recommendations II

1) We recommend that the nEDM collaboration immediately focus the bulk of its efforts on a well-structured and strategically targeted R&D plan to address the outstanding technical issues.
2) We recommend that ORNL and Los Alamos National Laboratory (LANL) jointly establish an external standing Technical Review Committee (TRC) to review the R&D progress and to report periodically to the management of both institutions.
3) We recommend that long-lead-time procurements be contingent upon resolution of the major outstanding technical issues in the measurement technique.
4) We recommend that the agencies provide continued support for a period of two years given implementation of the aforementioned recommendations.
5) We recommend, in the event that major outstanding R&D issues remain unresolved after two years, that consideration be given to discontinuing the Major Item of Equipment (MIE) Project and re-evaluating the US strategy for achieving a precise neutron EDM measurement.

Physics recommendations on other topics

6) We recommend strong support for the NPDGamma experiment as the highest priority measurement in hadronic parity-violation, and urge that every effort be made to reach the design goal, an asymmetry determination of one part in 10^8.
7) We recommend continued support for the UCNA experiment at LANL to improve the measurement precision of the A-coefficient by exploring a cost-effective and expeditious path to the original design sensitivity of 0.2%. We further recommend parallel R&D to develop the experiment to measure the a-coefficient with the Nab spectrometer, with a sensitivity of 0.1%.

8) We recommend that high priority be given to acquiring new data with the cold beam-based lifetime measurement at the National Institute for Standards and Technology (NIST), following its planned improvements.

Resources: constant effort scenario

DOE:

- FY 11: $9.33M (University research $1.3M, Lab research $3.8M, FNPB ops $0.3M, Capital eq (excl. nEDM) $1.0M, nEDM MIE $2.9M)
- FY12-16: FY11 adjusted for inflation

NSF: $4M/year (nEDM $2M, all other $2M)

We note the following considerations:

1. Capital Equipment does not include funding for the nEDM project. Our definition of "constant effort" underlying the recommendations in this report is based on the assumption that the nEDM Collaboration receives the appropriate level of MIE funding.
2. We further assume that the Nab spectrometer magnet (a major component of the proposed project) will be built using NSF instrumentation funds.
3. FY10 Laboratory Research contains $650K for UCNA, which is not continued in successive years. Continuation of the UCNA experiment to achieve a 0.2% precision in the β-asymmetry parameter A, as recommended in this report, requires additional support at LANL, for scientific staff and for operation of the UCN source. LANL management estimates this additional support to be $1.3M/year.
4. Further R&D and development of other LANL UCN experiments are assumed to be supported by LANL LDRD funds.

Workforce

- All experiments provided FTE estimates for Faculty, Research Staff, Postdocs, PhD students
- Assumed research effort: Faculty 0.5 FTE, all others 1.0 FTE
- No attempt to track effort as function of time

Total workforce:

- Definition of participant in the field: at least 0.2 FTE on one experiment
- Field has 140 participants: 41 faculty, 27 Res. Sci., 25 postdocs, 47 student positions

➔includes NIST effort

Experiments with high scientific priority:

Experiment	Faculty FTE	Research Scientist FTE	Postdoc FTE	Student FTE	Total FTE
nEDM	8.4	5.3	4.8	12	31
UCNA	1.2	0.3	2.6	7.0	11
NPDGamma	6.0	5.0	4.0	7.0	22
Nab	0.9	1.5	2.3	7.5	12
NIST beam τ	2.0	3.0	2.0	1.0	8.0

Neutron physics community organization and resources

The principal US experimental initiatives provide excellent environments for technical innovations and for training of the next generation of scientists. However, we find that coordination of scientific effort and utilization of resources available in this area are not optimal at present. The subcommittee's final recommendation is:
9) We recommend that consideration be given to establishing a standing committee to review and prioritize various initiatives in US fundamental neutron science.

We estimate that the five high priority initiatives enumerated above might be accommodated within a scenario of funding at constant level of effort, though moderate additional funding may be required, as elaborated in the main document. We find that the workforce for fundamental neutron science consists of about 140 researchers, with a roughly three-way split between (a) university faculty, (b) research scientists & postdoctoral researchers and (c) graduate students, which is sufficient to carry out the highest priority initiatives.

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December 1, 2011

Dr. W. F. Brinkman,
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Dr. Edward Seidel,
Assistant Director,
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Dear Dr. Brinkman and Dr. Seidel,

On November 29, 2010, the DOE/NSF Nuclear Science Advisory Committee (NSAC) was charged by you to review and evaluate the current and proposed U.S. research program, scientific capabilities, and opportunities for fundamental nuclear physics with neutrons, and to make recommendations of priorities consistent with projected resources. The scope of the charge included the full suite of fundamental neutron physics research opportunities in the U.S. and internationally, and their evaluation in the broader, world-wide context of fundamental symmetry measurements that test the Standard Model. This review follows a previous NSAC assessment of fundamental physics with neutrons in 2003, as well as the 2007 NSAC Long Range Plan, both of which made specific recommendations for investments in this area.

While your charge letter was addressed to Dr. Susan Seestrom, who is Chair of NSAC, Dr. Seestrom has an active research program in neutron physics and recused herself from participation in the review. I was appointed by Dr. Tim Hallman, of the DOE Nuclear Physics Office, and Dr. Brad Keister, of the NSF Physical Sciences Directorate Nuclear Physics Office, to serve as Acting NSAC Chair for this review.

Professor Krishna Kumar, of the University of Massachussetts at Amherst, agreed to chair the Sub-committee carrying out the review. The ten members of the Subcommittee consisted of leading experts in all major areas of physics addressed by the neutron science under consideration, both theory and experiment, and included one European member for international context. The Subcommittee met thirteen times via phone conference, held two open meetings with presentations from the community, and met once more in person to establish the recommendations. Representatives from the DOE and NSF Nuclear Physics offices were present at all Subcommittee meetings. An interim report from the Subcommittee was presented to NSAC on June 30, 2011, with the final report of the subcommittee sent to NSAC on October 25, 2011.

NSAC finds that the U.S. effort in fundamental neutron physics continues to be world-class, and that there are compelling future opportunities in the U.S. in this area. We have established a rank-ordered list of the five most important scientific priorities, as well as specific recommendations within each sub-area. We find that these five highest-priority initiatives might be accommodated within a constant level of effort, and that the current workforce in neutron physics has sufficient scope and depth to carry them out.

, as outlined in the report and exclusive of MIE construction funding,

Most notably, NSAC finds that the US initiat
(nEDM) at the Spallation Neutron Source (SN
sensitivity that will have profound impact on nuclear and particle physics, as well as cosmology. However, this promising approach still requires significant R&D, and NSAC recommends focussing the current nEDM effort on the most critical outstanding issues.

Accompanying this letter please find the report from NSAC. The draft report was discussed by NSAC on December 1, in Gaithersburg, Maryland, and (….complete once NSAC vote is taken…)

Sincerely,

Peter M. Jacobs,
Lawrence Berkeley National Laboratory
Acting Chair, NSAC