Nuclear Data in the 2023 NSAC Long Range Plan

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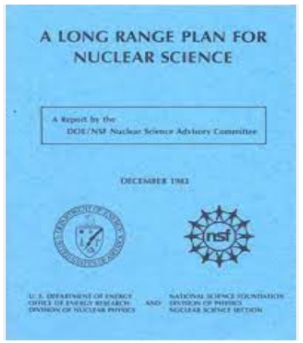
A NEW ERA OF DISCOVERY

THE 2023 LONG RANGE PLAN FOR NUCLEAR SCIENCE

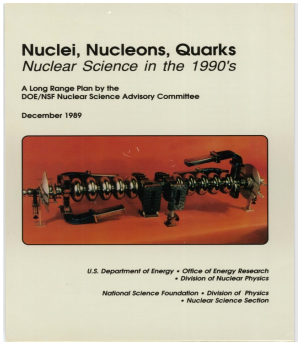
Successful History of Long Range Planning in Nuclear Science

- Since 1979 the Department of Energy Office of Science and the National Science Foundation periodically have charged the Nuclear Science Advisory Committee, NSAC, to provide a framework for coordinated advancement of the Nation's nuclear science research program
- NSAC charge for the 2023 Long Range Plan issued July 2022
- NSAC engaged the community though town meetings organized by the Division of Nuclear Physics of the American Physical Society
- A consistent, strategic plan for investments was developed by the writing committee

1979



1983



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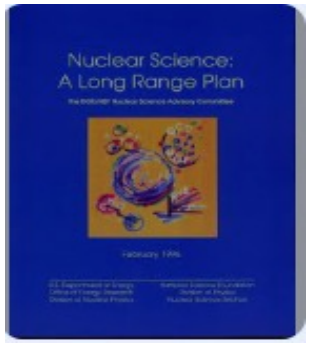
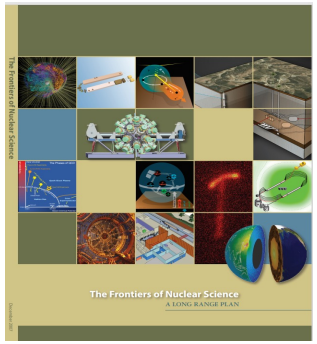
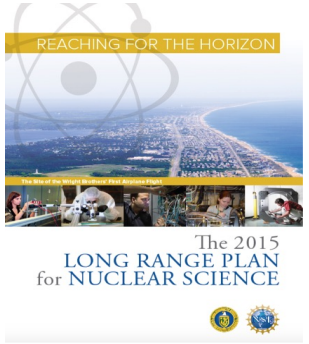


1996

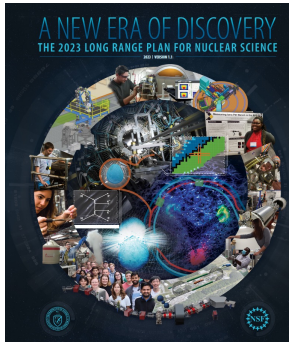
2002



2007



2015



2023

Broad Community Input Organized by APS DNP

2022 Town Hall Meeting on Hot and Cold Quantum Chromodynamics

September 23–25, 2022 Massachusetts Institute of Technology

Conveners: **Bjoern Schenke** (Brookhaven National Laboratory), **Anne Sickles** (University of Illinois), **Feng Yuan** (Lawrence Berkely National Laboratory), **Xiaochao Zheng** (University of Virginia)

Website: https://indico.mit.edu/event/538/

NSAC Long Range Plan Town Hall Meeting on Nuclear Structure, Reactions, and Astrophysics

November 14–16, 2022 Argonne National Laboratory

Conveners: **Alex Gade** (Michigan State University), **Sofia Quaglioni** (Lawrence Livermore National Laboratory), **Grigory Rogachev** (Texas A&M University), **Rebecca Surman** (University of Notre Dame)

Website: https://indico.phy.anl.gov/event/22/

Fundamental Symmetries, Neutrons, and Neutrinos Town Meeting

December 13–15, 2022 University of North Carolina at Chapel Hill

Conveners: **Leah Broussard** (Oak Ridge National Laboratory), **Vincenzo Cirigliano** (University of Washington), **Jon Engel** (University of North Carolina at Chapel Hill), **Lindley Winslow** (Massachusetts Institute of Technology)

Website: https://indico.phy.ornl.gov/event/209/

2023 Long Range Plan Working Group Members

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Ani Aprahamian, *U Notre Dame*
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Lee Bernstein, *LBNL*
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Michael Carpenter, *ANL*
Kelly Chipps, *ORNL*
Vincenzo Cirigliano, *U Washington*
Ian Cloët, *ANL*
Andre de Gouvea, *Northwestern U*
Romualdo deSouza, *Indiana U*
Gail Dodge *(Chair)*, *Old Dominion U*
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Renée Fatemi, *U Kentucky*
Alexandra Gade, *Michigan State U*
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Susan Gardner, *U Kentucky*
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Austin Harton, *Chicago State U*
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Calvin R. Howell, *Duke U*
Yordanka Ilieva, *U South Carolina*
Barbara Jacak, *U California, Berkeley and LBNL*
Cynthia Keppel, *Jefferson Lab*
Oliver Kester, *TRIUMF*
Joshua Klein, *U Pennsylvania*
Krishna Kumar, *U Massachusetts Amherst*
Kyle Leach, *Colorado School of Mines*
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Shelly Lesher, *U Wisconsin–La Crosse*
Chen-Yu Liu, *U Illinois Urbana-Champaign*
Jorge Lopez, *U Texas at El Paso*
Cecilia Lunardini, *Arizona State U*
Richard Milner, *MIT*
Filomena Nunes, *Michigan State U*
Daniel Phillips, *Ohio U*
Jorge Piekarewicz, *Florida State U*
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Jianwei Qiu, *Jefferson Lab*
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Fred Wietfeldt, *Tulane U*
John Wilkerson, *U North Carolina at Chapel Hill*
Richard Wilson, *ANL*
Lindley Winslow, *MIT*
Sherry Yennello, *Texas A&M U*

How Does Nuclear Data Fit Into This Process?

Before the NSAC LRP Charge:
Nuclear Data Charge to NSAC: April 13, 2022

Convene subcommittee to assess challenges, opportunities, and priorities for effective stewardship of nuclear data. Two reports were requested –

First: an assessment of the status of the US Nuclear Data Program (USNDP), including accomplishments and needs in basic science and several key applications

Second: describe challenges to nuclear data stewardship and formulate a strategic plan to guide federal investment in USNDP

Subcommittee Chair: Lee Bernstein (UC-Berkeley/LBNL)

Subcommittee Members:

Friederike Bostelmann (ORNL), Mike Carpenter (ANL), Mark Chadwick (LANL), Max Fratoni (UC Berkeley), Ayman Hawari (NC State), Lawrence Heilbronn (UT-Knoxville), Calvin Howell (Duke), Jo Ressler (LLNL), Cynthia Keppel (Jefferson Lab), Arjan Koning (IAEA), Ken LaBel & Tom Turflinger (NASA & Aerospace), Caroline Nesaraja (ORNL), Syed Qaim (FZJ), Catherine Romano (Aerospace), Artemis Spyrou (MSU), Sunniva Siem (Univ. of Oslo), Cristiaan Vermeulen (LANL), Ramona Vogt (LLNL/UC Davis)

(Names in red were on the LRP writing committee)

Subcommittee made 14 recommendations in 2nd report

Recommendations in 3 parts (shown in the next 3 slides):

- 3 on existing USNDP capabilities
- 8 for new cross-cutting initiatives involving measurement, theory, and evaluation to address outstanding nuclear data needs
- 3 to modernize and increase the efficiency of the nuclear data infrastructure

Recommendations meant to lay out a strategic plan to enhance and advance DOE-Nuclear Physics stewardship of nuclear data.

Recommended initiatives will require approximately $6.5M annual increase in NP support of the USNDP in FY23 dollars

- The reports and recommendations were presented to Asmeret Berhe (head of Office of Science) by Tim Hallman

Existing USNDP capabilities

1) Support the nuclear structure evaluation workforce to improve the currency, consistency, and accessibility of the Evaluated Nuclear Structure Data File (ENSDF)

2(Enhance nuclear reaction evaluation within the USNDP in support of the Evaluated Nuclear Data File (ENDF) through expansion of the workforce and integration of high performance computing, automation, and machine learning

3) Establish recommended values for fundamental nuclear properties, such as the atomic mass evaluations complied in the AME, NUBASE and similar databases.

Cross cutting initiatives

4) *Astrophysics:* Establish a coordinated effort to improve evaluation and modeling in nuclear astrophysics for stellar dynamics, multi-messenger astronomy and nucleosynthesis
5) Statistical nuclear structure: Develop and maintain nuclear structure evaluations beyond discrete states for improved reaction modeling (nuclear level densities, photon strength functions, optical model parameters and photonuclear data) and exploring nuclear structure at finite temperature
6) *Fission:* Establish methods for correlated fission data evaluations, including cross sections, fragment yields, $\nu(A)$ and $\nu(En)$ for nuclear energy, national security, nonproliferation and basic science
7) *Radioactive Decay:* Strengthen and accelerate measurement, evaluation and dissemination of decay data for targeted nuclides of high-value for national security, nonproliferation and medical applications
8) *Neutron-induced data reactions and structure: C*omprehensive, consistent neutron-induced structure and reaction data for nuclear energy, national security, nonproliferation and planetary nuclear spectroscopy
9) *Charged-particle stopping powers:* Determine charged-particle stopping powers for detector design, space effects and ion beam therapy
10) *Expanded reaction modeling:* Nuclear reaction modeling should include compilation and evaluation of high-energy and charged-particle data for space exploration, radionuclide production and ion beam therapy
11) *Fusion power:* Develop nuclear data for fusion energy systems including tritium production and materials damage cross sections

Modernize and increase the efficiency of the nuclear data infrastructure

12) *Modern Data Formats:* Expand the development of new nuclear data formats to accommodate existing and new nuclear data types and improve access by modern software systems

13) *Artificial Intelligence and Machine Learning (AI/ML) tools:* Develop, design, and incorporate modern methods using AI/ML tools to improve the nuclear data evaluation process

14) *Data Preservation:* Create an infrastructure for open data and data preservation for use by the entire nuclear science community.

Workforce is Key Investment for Long Term Health of Nuclear Data Community

Important part of nuclear data pipeline is the “human pipeline”

Data evaluators can take a long time to train, once they are in the pipeline, retention is imperative

Second report addressed issues that are needed to retain this trained workforce:

- A mutually agreed upon code of conduct to enhance collaboration, communication, and inclusion
- Develop new metrics for evaluator success, including allowing evaluators to work on projects outside of the standard “mass chain evaluation”
- The topical nuclear data collaborations proposed in the 2nd subcommittee report would all involve evaluator training and also broaden the scope of nuclear data activities

Timing of NSAC Nuclear Data Charge was Very Strategic

Nuclear data charge was timed strategically before the NSAC call for the new Long Range Plan

Due dates of reports were such that both reports would be ready before the white papers for the LRP

DNP organized town halls and required conveners to address cross cutting areas, including nuclear data – a member of the ND subcommittee was required to be involved with town hall planning

All three town halls had talks on nuclear data; all three white papers included a section on nuclear data; all three also endorsed a statement on nuclear data

See next 3 slides for each town meeting's nuclear data statement

Nuclear Data Initiative: Hot and Cold QCD Town Hall

Nuclear data play an essential if sometimes unrecognized role in all facets of nuclear physics. Access to accurate, reliable nuclear data is crucial to the success of important missions such as nonproliferation and defense, nuclear forensics, homeland security, space exploration, and clean energy generation, in addition to the basic scientific research underpinning the enterprise. These data are also key to innovations leading to new medicines, automated industrial controls, energy exploration, energy security, nuclear reactor design, and isotope production. It is thus crucial to maintain effective US stewardship of nuclear data.

- We recommend identifying and prioritizing opportunities to enhance and advance stewardship of nuclear data and maximize the impact of these opportunities.
- We recommend building and sustaining the nuclear data community by recruiting, training, and retaining a diverse, equitable and inclusive workforce.
- We recommend identifying crosscutting opportunities for nuclear data with other programs, both domestically and internationally, in particular with regard to facilities and instrumentation.

Resolution 5: Nuclear Structure, Reactions and Astrophysics Town Hall

Nuclear data play an essential role in all facets of nuclear science. Access to reliable, complete and up-to-date nuclear structure and reaction data is crucial for the fundamental nuclear physics research enterprise, as well as for the successes of applied missions in the areas of defense and security, nuclear energy, space exploration, isotope production, and medical applications. It is thus imperative to maintain an effective US role in the stewardship of nuclear data.

- We endorse support for the compilation, evaluation, dissemination and preservation of nuclear data and efforts to build a diverse, equitable and inclusive workforce that maintains reliable and up-to-date nuclear databases through national and international partnerships.
- We recommend prioritizing opportunities that enhance the prompt availability and quality of nuclear data and its utility for propelling scientific progress in nuclear structure, reactions and astrophysics and other fundamental physics research programs.
- We endorse identifying interagency-supported crosscutting opportunities for nuclear data with other programs that enrich the utility of nuclear data in both science and society.

Endorsement: Fundamental Symmetries, Neutrons and Neutrinos Town Hall

Recognizing the relevant of nuclear data for nuclear science, the FSNN working group on nuclear data prepared the following statement, which the larger community endorses:

- Nuclear data play an essential role in all facets of nuclear science. Access to reliable, complete and up-to-date recommended nuclear data is crucial for the fundamental nuclear physics research enterprise, as well as for the successes of applied missions in the areas of defense and security, nuclear energy, space exploration, isotope production, and nuclear medicine diagnostics and treatments. It is imperative to maintain an effective US role in the stewardship of nuclear data.
- We endorse support for identifying and prioritizing opportunities to advance and enhance the stewardship of nuclear data and efforts to build a diverse, equitable and inclusive workforce that maintains the currency and reliability of the nuclear databases.
- We recommend prioritizing opportunities that enhance the currency and quality of recommended nuclear data and its utility for propelling scientific progress in fundamental symmetry, neutrino and neutron projects and the broader nuclear science program.
- We endorse identifying interagency-supported crosscutting opportunities for nuclear data with other programs that enrich the utility of nuclear data in both science and society.

Proposed in the public part of the LRP resolution meeting: Nuclear data deserves its own endorsement in the LRP as well as a mention in the Executive Summary. Why?

The NSAC ND subcommittee reports contain specific recommendations that can stand on their own

This LRP is an opportune moment to highlight nuclear data as an added value to the basic science program

Nuclear data represents one major way that societal benefits of nuclear physics are realized

The broader definition of nuclear data derived from the reports is something that can demonstrate the benefits of nuclear physics overall in the service to the nation

The added value of nuclear data is huge and deserves to be called out

How did we do?

4 Recommendations from the LRP Executive Summary

RECOMMENDATION 1

The highest priority of the nuclear science community is to capitalize on the extraordinary opportunities for scientific discovery made possible by the substantial and sustained investments of the United States. We must draw on the talents of all in the nation to achieve this goal. This recommendation requires:

- Increasing the research budget that advances the science program through support of theoretical and experimental research across the country, thereby expanding discovery potential, technological innovation, and workforce development to the benefit of society.

- Continuing effective operation of the national user facilities ATLAS, CEBAF, and FRIB, and completing the RHIC science program, pushing the frontiers of human knowledge.

- Raising the compensation of graduate researchers to levels commensurate with their cost of living—without contraction of the workforce—lowering barriers and expanding opportunities in STEM for all, and so boosting national competitiveness.

- Expanding policy and resources to ensure a safe and respectful environment for everyone, realizing the full potential of the US nuclear workforce.

RECOMMENDATIONS 2 and 3

Preface: We reaffirm the exceptionally high priority of the following two investments in new capabilities for nuclear physics. The Electron–Ion Collider (EIC), to be built in the United States, will elucidate the origin of visible matter in the universe and significantly advance accelerator technology as the first new particle collider to be constructed since the LHC. Neutrinoless double beta decay experiments have the potential to dramatically change our understanding of the physical laws governing the universe.

Recommendation 2: As the highest priority for new experiment construction, we recommend that the United States lead an international consortium that will undertake a neutrinoless double beta decay campaign, featuring the expeditious construction of ton-scale experiments, using different isotopes and complementary techniques.

Recommendation 3: We recommend the expeditious completion of the EIC as the highest priority for facility construction.

RECOMMENDATION 4

We recommend capitalizing on the unique ways in which nuclear physics can advance discovery science and applications for society by investing in additional projects and new strategic opportunities.

- Opportunities to Advance Discovery: projects like FRIB400, LHC upgrades, JLab positron beams and upgraded energy and many others

- Cross-cutting Opportunities
  - Emerging Technologies: Computing and Sensing

  - Multidisciplinary Centers: addressing issues like multi-messenger astrophysics, double beta decay and other areas that require cooperation between theorists and experimentalists

  - Nuclear Data: Nuclear data from the nuclear physics community is important for medicine, energy, national security, non-proliferation, and space exploration. We endorse collaboratively funded projects that leverage modest investments to address some of the most important challenges and opportunities facing society.

What does it all mean?

TBD, wait and see
Hopefully a bright future for nuclear data