

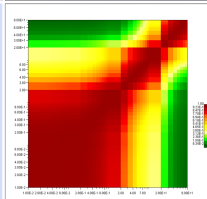
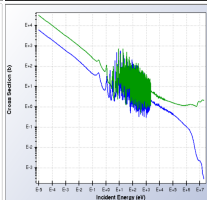
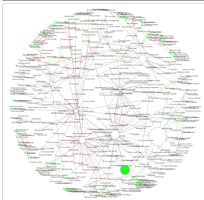
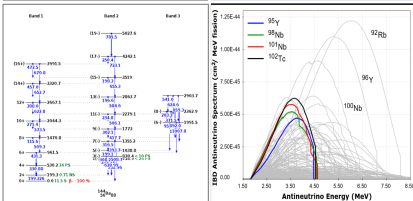
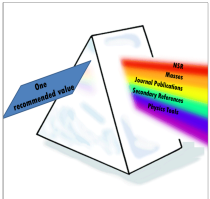
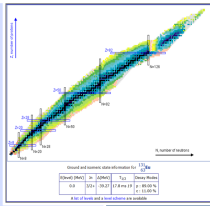
United States Nuclear Data Program

Work Plan for Fiscal Year 2023

This document describes the activities that US Nuclear Data Program members are planning to do during the Fiscal Year 2023.

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Introduction

The work plan described in this document has been developed to cover work to be performed by the U. S. Nuclear Data Program (USNDP) during Fiscal Year (FY) 2023 that begins on October 1, 2022. Previously, 23 work plans have been prepared for the nuclear data program covering FYs 2021-2022. This plan has been prepared in consultation with the members of the Coordinating Committee who represent the organizations participating in the program. Each Coordinating Committee member prepared a draft plan for his/her organization. Each contribution was integrated into a unified work plan. The draft plan was then circulated to the Coordinating Committee for comments and corrections before the final document was submitted to the U.S. Department of Energy (DOE).

As was done in previous years, the tasks proposed by the various organizations were reviewed internally according to the following criteria, which were developed considering the mission and goals outlined in past review panel reports and oversight committee discussions, and in consultation with the DOE program manager.

1. A task should be consistent with USNDP mission statement and meet one of the four program priorities:

- a) Compilation of experimental results and relevant information published in the literature.
- b) Evaluation of the nuclear structure and decay and nuclear reaction data, including improvements of the evaluation methodology.
- c) Archival and dissemination of nuclear data to the user community.
- d) Addressing specific data needs and gaps in nuclear data through targeted experiments.

2. A task should be useful to at least one major user community.

3. A task should not duplicate efforts within or outside the program.

The plan is divided into six major components. Specific tasks have been assigned to them. They are as follows:

- I. NNDP Facility Operation
- II. Coordination
- III. Nuclear Physics Databases
- IV. Information Dissemination
- V. Nuclear Structure Physics
- VI. Nuclear Reaction Physics

The following section details the proposed work plan for FY2022, defining tasks, organizational responsibilities, and planned activities. Incorporated in the National Nuclear Data Center (NNDP) plan is a group of subcontracted external scientists, including nuclear structure evaluators and compilers.

For FY 2023, we expect that:

- Compilation and dissemination activities will be fully supported.
- Development of nuclear reaction codes will continue focusing on evaluation methodology (fission, prompt fission neutron spectra, inelastic scattering, angular distributions and covariances).
- Internationally coordinated activities related to the new XML format for ENDF/B will be carried out.
- Dissemination of the nuclear data will continue approximately on the same level.
- Modernization of the ENSDF library evaluation methods and procedures will continue.

The priority nuclear data activities remain:

- Compilation of literature (NSR) nuclear structure (XUNDL) and reaction (EXFOR) data.
- Evaluation of nuclear structure and decay data (ENSDF).
- Evaluation of nuclear reaction data (ENDF).
- Development of nuclear theory codes in support of data evaluation.
- Development and maintenance of evaluation-related software, formats, and manuals.
- Data archival and dissemination.

The following section details the proposed work plan for FY2023, defining tasks, organizational responsibilities, and planned activities. Incorporated in the NNDC, LBNL, and ORNL's plans is a group of subcontracted external scientists, including nuclear structure evaluators and compilers. The present work plan was prepared assuming a FY2023 budget to be a cost-of-living adjusted FY2021 budget, which in turn, is assumed equal to the FY2022 budget shown in Table 1.

Table 1: Summary of the USNDP funding and metrics.

Fiscal year	USNDP funding (\$K)	Change (%)	Compilations	Evaluations	Disseminations (in thousands)	Articles	Invited talks
2001			7,139	334	667	25	22
2002	4,890		6,159	300	799	40	22
2003	4,932	+0.9	4,975	260	966	40	23
2004	5,015	+1.7	6,241	276	1,212	36	43
2005	5,437	+8.4	6,623	422	1,642	59	42
2006	5,099	-6.6	4,936	318	1,863	60	48
2007	5,841	+14.6	5,355	366	2,239	56	51
2008	5,967	+2.2	5,104	385	2,996	72	68
2009	6,267	+5.0	4,047	400	3,294	61	56
2010	6,549	+4.5	4,662	395	2,843	83	51
2011	6,534	-0.2	4,662	479	3,252	96	67
2012	6,785	+3.8	5,221	209	3,013	90	48
2013	6,249*	-7.9	4,925	282	3,447	84	79
2014	7,032*	+12.5	3,738	166	3,411	107	81
2015	7,381*	+5.0	4,949	271	4,246	98	50
2016	7,597*	+2.9	3,936	375	4,655	82	72
2017	6,953	-8.5	3,684	404	4,730	95	51
2018	8,496 ^a	+22.2	4,097	221	4,722	79	58
2019	8,797 ^b	+3.5	3,663	203	5,148	67	60
2020	9,344 ^c	+6.2	3,603	159	5,678	63	49
2021	9,435 ^d	+0.99	5,380	273	7,297	71	59
2022	10,290 ^e	+9.06	3,988	292	9,016	71	71

*: It includes \$500K of Early Career Award (LANL).

a: It includes the following (a) FIRE collaboration funding \$100K (LLNL), (b) LAB17 call funding: \$325K (ANL), \$220K (LANL), (c) LAB18 call funding \$26K (ANL), \$282K (BNL), \$120K (LANL), \$75K (LBNL), \$100K (LLNL), \$372K (ORNL).

b: It includes the following (a) FIRE collaboration funding \$100K (LLNL), (b) LAB17 call funding: \$325K (ANL), \$220K (LANL), (c) LAB18 call funding \$27K (ANL), \$289K (BNL), \$120K (LANL), \$75K (LBNL), \$50K (LLNL), \$373K (ORNL), (d) WANDA organization: \$25K (ORNL).

c: It includes the following (a) FIRE collaboration funding \$100K (LLNL); (b) LAB calls funding: \$354K (ANL), \$619K (BNL), \$120K (LANL), \$75K (LBNL), \$50K (LLNL) and \$375K (ORNL); (c) WANDA organization: \$150K (ORNL) and \$20K (LLNL).

d: It includes the following (a) FIRE collaboration funding \$100K (LLNL); (b) LAB calls funding: \$884K (ANL), \$717K (BNL), and \$173K (ORNL).

e: (b) LAB calls funding: \$950k (ANL)

Detailed Work Plan for Fiscal Year 2023

I. NNDC Facility Operation

A. Management

This task includes planning, budgeting, personnel, interaction with BNL management, and interaction with funding authorities.

B. Library

NNDC maintains an archival collection of low- and intermediate-energy nuclear physics publications. This library supports the NNDC compilation activities, the U.S. nuclear reaction and nuclear structure data evaluation, and international nuclear structure evaluation effort.

C. Computer Operation

The NNDC operates several servers running Red Hat Enterprise Linux in support of its compilation, evaluation, database maintenance, and information dissemination functions. In addition, each staff member has a PC that supports an interface to these Linux servers and supports administrative functions, such as word processing and email. Furthermore, MS Windows servers provide centralized backup, printing and file serving for the PCs. This task includes software upgrades, hardware and software procurements, machine operations and internal user support for both the Linux and Windows platforms.

BNL Planned Activities
In collaboration with ITD, ensure continuous availability of mission-critical Web services and the USNDP collaboration platform through full compliance of NNDC's computers with DOE cyber security requirements.
Provide technical computer support to NNDC staff, visitors, and external collaborators to enable them to effectively and securely use NNDC computing resources as well as procure computer hardware, software and support services to meet NNDC's computing requirements.
Upgrade hardware and software of NNDC/NE cluster to enhance computing performance.

II. Coordination

A. National Coordination

National coordination is required for activities under the USNDP as well as Cross Section Evaluation Working Group (CSEWG). This is mostly performed by the NNDC, with contributions from other laboratories (USNDP Working Groups and Task Forces as well as CSEWG Committees).

ANL Planned Activities

Coordinate ANL nuclear data activities with the USNDP and ANL leadership; Help organize the Nuclear Data session at the LRP Town Hall meeting on “Nuclear Structure, Reactions and Astrophysics”

BNL Planned Activities

Prepare and organize USNDP budget briefing.

Prepare USNDP reports and work plans.

Organize and chair CSEWG meeting at BNL.

Organize and chair USNDP meeting at BNL.

Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings. -

Maintain CSEWG and USNDP websites.

Organize mini-CSEWG meetings in the summer if needed. Host and help organize NDAC meeting.

Assist in organization of Nuclear Data session at the LRP Town Hall meeting on “Nuclear Structure, Reactions and Astrophysics”

LANL Planned Activities

Organize and chair CSEWG Evaluation Committees meeting at BNL.

Organize and chair CSEWG Covariance Committee meeting at BNL.

Organize and chair Nuclear Reaction Working Group.

LBNL Planned Activities

Help organize WANDA meeting.

ORNL Planned Activities

Coordinate and outreach USNDP Nuclear Astrophysics activities.

TUNL Planned Activities

Organize and chair USNDP Nuclear Structure Committee.

B. International Coordination

ANL Planned Activities

Contribute to IAEA-led nuclear data activities.

Lecture at the joint ICTP-IAEA nuclear data workshop in Trieste

BNL Planned Activities

Contribute to IAEA-sponsored nuclear data activities.

Contribute to NEA WPEC annual meeting.
Contribute to IAEA CRP and technical meetings.
Continue to Contribute to training/mentoring of new ENSDF evaluators through collaborative work.
Lecture at the joint ICTP-IAEA nuclear data workshop for ENSDF evaluations

LANL Planned Activities
Contribute to IAEA-sponsored nuclear data activities.
Contribute to NEA WPEC annual meeting.

LBNL Planned Activities
Contribute to IAEA-sponsored nuclear data activities.

MSU Planned Activities
Contribute to IAEA-sponsored nuclear data activities.

TAMU Planned Activities
Contribute to IAEA-sponsored nuclear data activities.

TUNL Planned Activities
Contribute to IAEA-sponsored nuclear data activities.

III. Nuclear Physics Databases

A. Nuclear Science References (NSR)

The NNDC is responsible for NSR, the bibliographic database for nuclear physics research. This task includes quality control, file update and maintenance, and file distribution to collaborators. Updates are performed on a continuing basis. The preparation of NSR entries is given under Nuclear Structure Physics.

BNL Planned Activities
Distribute database to collaborators.
Perform database updates and maintenance.
Continue joint project with the NRDC network to transfer missing nuclear reaction references to NSR.
Study in depth the possibilities of using AI and ML techniques in NSR, in collaboration with LBNL.

B. NucScholar Development

LBNL Planned Activities

Continue to develop the Nucscholar Natural Language Processing tool to enable nuclear data evaluation and research (<https://nucscholar.lbl.gov/>) in collaboration with researchers from the NNDC and IAEA.

C. Experimental Nuclear Structure Data (XUNDL)

The NNDC is responsible for maintaining and providing access to the XUNDL database. This database contains compilations (in ENSDF format) of recently published or completed level-structure data for high-spin and low-spin physics. The NNDC coordinates this work and updates the database as new/ revised data sets are received from collaborators.

BNL Planned Activities
Perform weekly updates of the database using input received from compilers.
Distribute database yearly to the NSDD network.

D. Evaluated Nuclear Structure Data File (ENSDF)

The NNDC is responsible for ENSDF, a database of evaluated experimental nuclear structure and decay data. The NNDC is responsible for the format and content checking, preparation of the manuscript, and quality control (review) of evaluations submitted for inclusion. The NNDC maintains the database, which includes database updates and distribution to collaborators. Corrections are implemented on a continuous basis.

BNL Planned Activities
Maintain ENSDF database, includes continuous updating.
Process evaluations received from NSDD evaluators.
Distribute ENSDF database to collaborators on a monthly basis.
Proceed with the ENSDF modernization project.

E. Numerical Nuclear Data (NuDat)

The NNDC is responsible for NuDat, which consists of a database and a suite of codes that access it, allowing web users to search for level and γ -ray properties extracted from ENSDF, ground and metastable state properties (Wallet Cards), and atomic and nuclear radiations derived from ENSDF. Additionally, NuDat contains an interactive Chart of Nuclides and interactive level schemes.

BNL Planned Activities
Update NuDat database as necessary.

F. Experimental Reaction Data File (EXFOR)

The NNDC is responsible for maintaining the EXFOR database at BNL. This database contains experimental nuclear reaction data for incident energies below 1 GeV, including neutron-induced reactions and reactions with incident-charged particles of mass $A \leq 12$. Many groups worldwide compile experimental

data and send it to the central database in Vienna in the EXFOR format. Then, each center is responsible to update its own database. The effort described here includes quality control, file update, and data transfer activities. The NNDC database is updated as compilations are exchanged and checked from the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

BNL Planned Activities
Update EXFOR database with compilations from cooperating centers (500 entries expected). The NNDC compilation work can be found under Nuclear Reaction Physics, Section V of the present document.
Contribute to WPEC Subgroup 50 on creating a critically reviewed version of EXFOR.

G. Evaluated Nuclear Data File (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The work is organized under the CSEWG, coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident-charged particles and photons are also included. The data are stored in the ENDF format developed at NNDC in the 1960s and adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control of the U.S. ENDF/B library, the distribution of this database in the U.S. and the exchange of libraries internationally. New evaluations for the next release of the library, following ENDF/B-VIII.0, are assembled, tested and made available to users through NNDC's Web servers and GitLab collaboration server at git.nndc.bnl.gov.

BNL Planned Activities
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, Section IV.)
Maintain and extend ADVANCE, the ENDF continuous integration system that continually checks for modification to the ENDF database then runs all available tests on the changed data files.

H. Database Software Maintenance

This activity includes software bug fixes and enhancements for the six nuclear physics databases maintained by NNDC.

BNL Planned Activities
Fix software bugs and develop enhancements for the six nuclear physics databases maintained by NNDC.

I. Future Database Systems Development

BNL Planned Activities
Upgrade the Linux/MySQL server software to fix bugs, provide new functionalities, and improve the system's performance, security and reliability.

IV. Information Dissemination

The goal of the dissemination activities of the USNDP is to provide scientists and engineers with nuclear data from the USNDP-maintained nuclear databases in a variety of user-friendly formats and media.

A. Nuclear Data Sheets

The USNDP provides some paper publications as well as electronic access to the nuclear physics databases that it maintains. This includes the Nuclear Data Sheets journal published by Elsevier and various versions of the Nuclear Wallet Cards.

BNL Planned Activities
Prepare issues of Nuclear Data Sheets for publication.
Work on a new version of Nuclear Wallet Cards.
Work on a new version of Handbook of Radioactive Nuclei.

MSU Planned Activities
Continue development of software for Nuclear Data Sheets publication.

B. Customer Services

This task accounts for the non-electronic services which the USNDP renders to customers. At the scientific staff level, this means direct assistance to users needing advice from nuclear data experts or advice on solving complex queries via electronic access to the database. The NNDC staff allocation at the support level is for maintaining a "help desk" as well as for administrative/clerical support of its customer services.

BNL Planned Activities
Provide technical support to nuclear data end-users as necessary.

C. Web Site Maintenance

The NNDC provides electronic access to the nuclear physics databases that it maintains on behalf of the USNDP as well as access to other nuclear physics information through its website. Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

BNL Planned Activities
Solicit user suggestions on enhancements to the ENSDF, NSR, NuDat, and Sigma web interfaces and be responsive to those needs. Expand search and plotting capabilities for ENSDF data.
Maintain web interfaces for ENDF and EXFOR databases.
Maintain currency of the CSEWG, USNDP and the NNDC websites, proactively respond to users' requests.
Maintain the NNDC Web Services availability on the 99% and higher level.
Strictly follow all BNL and DOE cybersecurity rules and regulations during the Web application design, development and implementation. Address issues that arise during BNL scans.

Upgrade GitLab server software to provide more powerful and advanced functionalities in the NNDC collaboration services.
Make progress with modernization of the website, enhancing capabilities and follow industry best practices.
Continue development of mobile applications targeting highly used databases.

ORNL Planned Activities
Incorporation of new mass compilations and new rate libraries into online collections.
Improve computational backbone of online nuclear astrophysics software system.

TUNL Planned Activities
Provide access to present and past evaluations of Energy Levels of Light Nuclei for A=3-20 nuclides, including associated figures and energy-level diagrams and tables.
Provide access to compiled and evaluated data on light nuclei related to p-, alpha- and n-capture reactions, and ground-state decays.
Provide access for TUNL dissertations collection.

V. Nuclear Structure Physics

A. NSR Abstract Preparation

The literature search and preparation of KEYWORD abstracts for publications included in NSR require scientific expertise. BNL continues to have the overall responsibility for this database. Similar contributions from other external collaborators are expected. These will be checked and edited by BNL as necessary before being added to the database.

BNL Planned Activities
Prepare entries for approximately 3,100 new references and keyword abstracts for 2,000 of them. Provide coverage for 80 major journals, including complete coverage of Physical Review C and Nuclear Physics A.

B. Compilation of Experimental Nuclear Structure Data

This activity involves compilation of recently published or completed experimental nuclear structure data for inclusion in XUNDL. The compilation is managed by the NNDC.

ANL Planned Activities
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.

BNL Planned Activities

Compile new B(E2) experimental data. Continue work on a B(E2) evaluation project in collaboration with McMaster University.
Compile new double-beta decay experimental data. Start working on a data project with Kiev Institute for Nuclear Research.
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.
Review compiled datasets submitted by other data centers prior to inclusion in the XUNDL database. Work with PRC and EPJA to check and compile data prior to publication.
Compile new mass measurements and submit data file to nuclearmasses.org webpage at ORNL.

LBNL Planned Activities
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.

MSU Planned Activities
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.
Work with PRC and EPJA to check and compile data prior to publication.

TUNL Planned Activities
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.

C. A-Chains and Nuclides Evaluations for ENSDF

USNDP evaluates nuclear structure and decay data for inclusion in the ENSDF database. This effort includes the critical analysis of all available experimental nuclear structure and radioactive decay data for a nuclide or a group of related nuclei to deduce recommended values from the measured data and prepare a file in ENSDF format that is the basis for publications in Nuclear Data Sheets and is used to update the contents of the USNDP nuclear structure and decay database, ENSDF.

ANL Planned Activities
Evaluate at least one mass chain from the ANL region of responsibility.
Review mass chain evaluations, as requested.

BNL Planned Activities
Evaluate at least four mass chains or their equivalent nuclides.
Review at least four mass chains or their equivalent nuclides.

Update ENSDF for the identification of new nuclides and for the first publication on the findings of the excited states of nuclides.
Edit all evaluations submitted for publication, including checking their format and physics content.
Continue mentoring new ENSDF evaluators.

LBL Planned Activities
Evaluate the equivalent of at least two mass chains (20 nuclides), including a minimum of one from the A=21-30 region. Emphasis will be placed on evaluating data of current interest to the nuclear structure and nuclear application communities.
Review mass-chain evaluations, as requested.

MSU Planned Activities
Evaluate the equivalent of at least two mass chains.
Review one mass-chain evaluation.

ORNL Planned Activities
One equivalent mass chains and the data for new nuclides will be evaluated.
Review mass-chain evaluations, as requested.

TAMU Planned Activities
One large mass chain, or equivalent nuclides, will be evaluated.
Review one mass-chain evaluation, as requested.

TUNL Planned Activities
Evaluate about one A-chains per year for publication in Nuclear Data Sheets and inclusion in the ENSDF database. An objective is to produce two A-chain evaluations per year.
Evaluate and update ENSDF for A=2-20 near drip-line nuclides, especially for first observations or when ENSDF has no previous dataset.

D. Ground and Metastable State Properties

ANL Planned Activities
Compile and evaluate atomic masses and complementary nuclear structure data for the Atomic Mass Evaluation and the NUBASE evaluation of nuclear properties.

BNL Planned Activities
Develop new database for ground and metastable state properties (WalletCraft).
Begin evaluation process to provide recommended ground and metastable state properties.

E. Non-ENSDF Decay Data Evaluations

ANL Planned Activities

Contribute to the IAEA-led project on "Evaluated Decay Data Library for Monitoring Applications."

BNL Planned Activities

Contribute to the beta-delayed neutron emitters IAEA CRP.

LBNL Planned Activities

Work with researchers at Pacific Northwest National Laboratory on the development of a numerical database with complete Gamma-ray-X ray coincidence data in a joint effort with the Defense Threat Reduction Agency. The database will be benchmarked against existing decay data from ENSDF as well as recently published datasets not yet included in ENSDF. These efforts will be coordinated with the ENSDF modernization initiative led by BNL.

Produce and maintain a Global Heavy Charged-Particle Decay Database arranged by Z, A and Isospin projection in support of research at radioactive ion beam facilities. This database will be updated as new papers are published. Information from this database can currently be downloaded as a pdf document.

MSU Planned Activities

Contribute to the IAEA-led project on "Evaluated Decay Data Library for Monitoring Applications."

F. Neutron-induced g-Ray Data Evaluation**LBNL Planned Activities**

Continue updating the Inelastic Scattering of Reactor Fast Neutrons Database (e.g., the "Baghdad Atlas") with modern ENSDF data, as a validation database for $(n,n'\gamma)$ as well as with additional sources of energy differential $(n,n'\gamma)$ data from GELINA at Geel, neutronELBE at HZDR, and the GENESIS array at LBNL. Extract information from ENDF needed to produce flux-weighted partial gamma-ray cross sections and comparing the result to values in the Atlas.

Start benchmarking reaction modeling codes, including Talys and EMPIRE. This work will be performed in collaboration with researchers from the IAEA and Naval Nuclear Laboratory.

Explore the role of quasi-continuum contributions through collaboration with researchers from LLNL and the University of Oslo.

G. Nuclear Structure Data Measurements**ANL Planned Activities**

Contribute to nuclear physics research activities at ANL, MSU, and other nuclear physics user facilities with the main emphasis on decay studies of neutron-rich nuclei, spectroscopy of heavy actinide nuclei, and nuclei far from the line of stability.

BNL Planned Activities

Precisely determine decay schemes of relevant medical isotopes using state-of-the-art gamma-ray spectroscopy.

Contribute to beta-decay measurements at facilities, such as Argonne’s CARIBU, with an emphasis on nuclei relevant to decay heat, antineutrino spectra, and delayed nu-bar.
Perform gamma-ray spectroscopy experiments with GRETINA to remedy data deficiencies uncovered during ENSDF evaluations.
Contribute to nuclear physics measurements at FRIB and ensure new results are promptly incorporated into the databases.

LBL Planned Activities
Perform targeted decay-data measurements to address inconsistencies in decay data using light-ion and neutron activation and the Fast Loading and Unloading Facility for Fission Fragment Yields (FLUFFY) combined with a local array of single-crystal and Clover HPGe detectors. Results from these experiments will be published and updates presented to the ENSDF database manager.

H. ENSDF Physics and Checking Codes

BNL Planned Activities
Maintain and upgrade ENSDF checking and physics programs for format changes as required.
Work on the development of the next generation ENSDF format and develop applications that apply Machine Learning techniques to the new format.

MSU Planned Activities
Maintain and improve the ENSDF utility and analysis codes in Java developed at MSU: McMaster-MSU Java-NDS, ConsistencyCheck, GLSC, Java-RULER, Excel2ENSDF, KeynumberCheck, AME-NUBASE viewer, RadiationReport, AlphaHF.
Develop new Java codes to replace the legacy ENSDF codes in Fortran that lack maintenance and to facilitate and streamline ENSDF evaluation.

LLNL Planned Activities
Collaborate with BNL in the development of the next generation ENSDF format and develop applications that apply Machine Learning techniques to the new format.

VI. Nuclear Reaction Physics

A. Experimental Data Compilation

The NNDC, as part of a larger international cooperation, has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada.

BNL Planned Activities
Compile experimental data for neutron, charged-particle, and photon-induced reactions from 120 publications.
Explore possibilities of recovering previously unobtainable reaction data and proactively respond to users’ needs.

B. ENDF Manuals and Documentation

The NNDC is responsible for maintaining the format and procedures manual for the ENDF system as well as producing the documentation supporting the contents of the ENDF/B library.

BNL Planned Activities
Maintain the GitLab version of the ENDF-6 formats manual current with CSEWG-endorsed format changes. Issue official release of the manual.
Automate the generation and posting of the latest unofficial version of the ENDF-6 formats manual.

C. ENDF Evaluations

Evaluated nuclear reaction data, for applications and basic science needs, are stored in the ENDF database, which is maintained by BNL. As Chair of the CSEWG Evaluation Committee, LANL staff works with BNL to ensure quality control, particularly for new evaluations. New evaluations funded primarily from other sources are prepared for archival in the ENDF library. BNL, LANL, LLNL and ORNL provided neutron, proton, and photonuclear reaction data evaluations.

BNL Planned Activities
Respond to user needs for evaluated nuclear reaction data.
Collect and address users feedback related to the ENDF library.
Prepare, and release for testing, one or more beta releases of the ENDF library in preparation for ENDF/B-VIII.1
Work with CSEWG on upgraded evaluations for future release of the ENDF/B library.
Improve methodology for providing covariance data in the resonance and fast neutron region to the next release of ENDF.
Update the Decay Data Sub-library as new data for neutron-rich nuclides become available.
Improve methodology for generating unresolved resonance region cross section probability distributions.
Maintain the Atlas of Neutron Resonances electronic files in preparation for a future update of the Atlas of Neutron Resonances. Continue working on the use of ML techniques to better determine resonance properties.
Contribute to the Fission Yield evaluation CRP at the IAEA.

LANL Planned Activities
Upgrade the LANL ENDF evaluations for major actinides as well as some other structural materials that perform well in criticality benchmarks, including new theoretical development of statistical model for deformed systems. Close collaboration with international nuclear data library activities at the IAEA and OECD/NEA.
Provide new evaluations of both the prompt and delayed fission observables, based on the statistical Hauser-Feshbach technique as well as the deterministic method, including pre-equilibrium emissions at high energies.
Improve photon production data for neutron capture and inelastic scattering, which will be used in prompt gamma-ray spectroscopy.

Improve calculations for neutron-induced charged-particle reactions in collaboration with LENZ/LANCE, and produce evaluated files based on these data.
Contribute evaluated angular distributions and energy spectra for charged particle outputs to ENDF/B-VIII.1

LLNL Planned Activities
Perform new evaluations as per LLNL customer requests and submit these as well as other LLNL-generated evaluations into ENDF.
Contribute to the INDEN-Light-Element collaboration at the IAEA.
Perform R-matrix fits for proton and alpha particles incident on selected light-medium-mass nuclei ($A < 20$) to accurately describe low-energy resonances and make candidates for future ENDF/B-VIII evaluations.
Improve transitions from R-matrix resonance regions to statistical models at higher energies, to give better predictions of gamma production.
Add candidate exit distributions of charged-particle productions (for ENDF/B-VIII.1).
Testing beta releases of ENDF/B-VIII.1

D. Nuclear Reaction Standards

Nearly all neutron cross section measurements are made relative to a neutron cross section standard, such as the hydrogen elastic cross section. The primary objective of this task is to ensure accurate and current values for standard cross sections and related quantities. In preparation for the new evaluations of the standards, we are improving the standards database and procedures under the auspices of the IAEA data development project "Maintenance of the Neutron Cross Section Standards." Historically, the standards evaluation activity has included data from other than the cross section standards, i.e., the thermal constants and the ^{252}Cf spontaneous fission neutron spectrum. Recently, the scope has been broadened, largely through the data development project, to include an investigation of possible inelastic scattering cross section reference standards; considering adding additional standards energy ranges for the $\text{Au}(n,\gamma)$ cross section; and proposing updates for the evaluations of the ^{252}Cf spontaneous fission neutron spectrum and the ^{235}U thermal neutron-induced fission neutron spectrum.

BNL Planned Activities
Continue work on standards evaluations through involvement in the IAEA data development project "maintenance of the neutron cross section standards. Checking the literature and other sources for possible measurements related to standards.
Continue involvement with nuclear data groups as a) A member of the program committee of the International Symposium on Reactor Dosimetry's 17th International Symposium on Reactor Dosimetry (ISR-17). Due to concerns about the virus, the ISR-17 meeting will be held May 2021 (instead of 2020) in Lausanne Switzerland. I attended a meeting of the members of the Program Committee on Feb. 2. The agenda included updates on the meeting in May, issues concerning future symposium papers, the location of the meeting in 2023 (in the USA), and assignments for various positions (workshop, poster session and technical chairs) for the 2023 meeting. There are still lingering concerns about the meetings due to Covid-19. b) A member of the International Advisory Board for the 5th International Workshop on Nuclear Data Covariances (CW2020), which was delayed to 2022 and called CW2022 due to the pandemic.

Work will continue on both $6\text{Li}(n,t)$ and $235\text{U}(n,f)$ measurements at NIST with sub-thermal neutrons.
Finish publishing the report on the IAEA Consultants' hybrid Meeting on Neutron Data Standards Oct.18-21, 2020. Work closely with Professor Zhang of the Peking University in Beijing, China on improvements to new measurements at the China Spallation Neutron Source (CSNS). The CSNS is a major facility for making neutron data measurements. Plans are being made for the next standards meeting where more information may be available on when a new standards evaluation can be available.

E. Nuclear Model Development

This task covers activities, such as the development and validation of nuclear reaction models, used for prediction of nuclear reaction cross sections. The two major codes are CoH3 (LANL) and EMPIRE (BNL). Measurements made by ANL, LANL and LBNL, along with other measurements made with DOE low-energy physics funds, will play a crucial role in the validation of the models in these computer codes. LANL participates in the IAEA Coordinated Research Project RIPL that improves the accuracy and reliability of input parameters used in nuclear reaction calculations.

BNL Planned Activities
Study (apparent) non-statistical fluctuations in gamma-width distributions as tabulated in the Atlas of Neutron Resonances.

LANL Planned Activities
Continue to develop a microscopic description of the fission process in the fast energy range as well as penetrability calculations through arbitrary fission barrier shapes. Implement the theory into the Hauser-Feshbach code to facilitate actinide evaluations.
Continue to develop a coupled-channels Hauser-Feshbach method for better prediction of neutron-induced reactions on deformed nuclei, with particular emphasis on fission, capture, and inelastic scattering channels.
Continue to develop the Hauser-Feshbach fission fragment decay code for evaluating major actinides, which has a unique capability to produce prompt fission neutron and gamma-ray spectra.
Develop a semi-microscopic model for nuclear structure, which will be incorporated into the reaction calculations.

F. Nuclear Reaction Data Measurements

LANL Planned Activities
Perform precision measurement of the $16\text{O}(n,a)$ reaction using a time projection chamber, SREFT, for improved angular distributions at the neutron energy range of 2 – 15 MeV.
Perform double-differential (n,p) and (n,a) cross sections on 63Cu for the neutron energy range of 0.5 – 20 MeV.
Measure double-differential cross sections of (n,p) and (n,a) reactions on 68Zn and natZn in respect to incoming neutron energies and outgoing particles angles for the neutron energy range of 0.5 – 20 MeV.
Finalize double-differential (n,p) and (n,a) cross sections of 58Ni and 60Ni in respect to incoming neutron energies and outgoing particles angles for the neutron energy range of 0.5 – 20 MeV.
Finalize double-differential (n,p) and (n,a) cross sections of 39K and 40K in respect to incoming neutron energies and outgoing particles angles for the neutron energy range of 0.5 – 20 MeV.

LBNL Planned Activities
Study the $^{56}\text{Fe}(n,n'\gamma)$ and $^{238}\text{U}(n,n'\gamma)$ reactions using the Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering (GENESIS).
Perform energy-dependent measurements of short-lived fission fragments on $^{235,238}\text{U}$ using the Fast Loading and Unloading Facility for Fission Yields (FLUFFY).
Measurement of the decay of $^{68\text{m}}\text{gCu}$ populated via $\text{natZn}(n,px)$ using FLUFFY. This experiment will run "piggyback" on the $^{235,238}\text{U}(n,f)$ measurements mentioned above.

G. Astrophysics Nuclear Data Needs

The objective of this activity is to support the nuclear data needs of the increasingly sophisticated simulations of astrophysical phenomena. The Astrophysics Task Force of the USNDP, presently chaired by ORNL, serves to improve communication and coordination of nuclear data evaluation activities relevant for studies in astrophysics.

ANL Planned Activities
Provide recently compiled and evaluated nuclear data of nuclear physics properties for update of the REACLIB library

BNL Planned Activities
Work on neutron capture and fission integral values and their uncertainties in the energy region of interest for nuclear astrophysics.
Evaluate nuclear astrophysics potential of EXFOR library.

LANL Planned Activities
Continue improvement of neutron capture, beta-delayed neutron and fission modellings for s- and r-process hydro-dynamics simulations.
Develop a Monte Carlo simulation using Geant4, to be implemented for radioactive nuclear reaction analysis at Time of Flight facilities, in the interest of providing direct reaction cross sections for better understanding of heavy element productions.

ORNL Planned Activities
Continue assessments of capture reactions on p-rich unstable nuclides that are important for novae and X-ray bursts. The nuclei to be studied are those planned for measurements at radioactive beam facilities.

H. Covariances Development

BNL Planned Activities
Develop low-fidelity fission yield covariances consistent with the ENDF decay sub-library and with measured yields. This project would allow us to develop expertise for the upcoming Fission Yields CRP.

LBNL Planned Activities
Continue to develop an experimentally driven fission covariance database

I. Reactor Antineutrino Spectra and Decay Heat Calculations

ANL Planned Activities
Contribute to a review article focused on nuclear data for reactor decay heat calculations

BNL Planned Activities
Improve our methods and databases to calculate anti-neutrino spectra for major actinides.
Perform decay-heat calculations in collaboration with experimental groups.
Possibly contribute to relevant experiments.

J. Verification and Validation

Quality Assurance (QA) of a nuclear data library requires that all files are checked for integral consistency and conformance with the adopted format. This part of the QA is called verification and is one of the fundamental functions of the NNDC. Furthermore, checking performance of the library against the integral experiments, known as validation, is also an important step to ensure the usefulness of the library for the end-users. The most extensive validation is performed by LANL and other CSEWG contributors funded with non-DOE-SC sources. The USNDP supports the ultimate validation effort carried out at BNL.

BNL Planned Activities
Deploy into production a computerized system for automatic, real-time verification and validation of new/modified ENDF evaluations submitted to the NNDC GitLab server.