USNDP Work Plan for Fiscal Year 2019

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Table of Contents

Introduction

The work plan described in this document has been developed to cover work to be done by the United States Nuclear Data Program (USNDP) during fiscal year 2019 that begins on October 1, 2018. Previously, **19 work plans** have been prepared for the data program covering fiscal years 2000 - 2018. 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 Department of Energy.

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 mision 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. NNDC 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 FY2019, defining tasks, organizational responsibilities, and planned activities. Incorporated in the NNDC plan is a group of subcontracted external scientists, including nuclear structure evaluators and compilers.

The present Workplan was prepared assuming that the USNDP budget for FY19 would be the same as FY18.

Table 1: Summary of the USNDP funding and metrics for FY2001- FY2017.

Fiscal Year	USNDP Funding	Change	Compilations	Evaluations	Dissemination (in thousands)	Reports	Papers
2001			7,139	334	667	21	25
2002	$4,890K		6,159	300	799	23	40
2003	$4,932K	+0.9%	4,975	260	966	27	40
2004	$5,015K	+1.7%	6,241	276	1,212	35	36
2005	$5,437K	+8.4%	6,623	422	1,642	74	59
2006	$5,099K	-6.6%	4,936	318	1,863	47	60
2007	$5,841K	+14.6%	5,355	366	2,239	40	56
2008	$5,967K	+2.2%	5,104	385	2,996	48	72
2009	$6,267K	+5.0%	4,047	400	3,294	26	61
2010	$6,549K	+4.5%	4,662	395	2,843	27	83
2011	$6,534K	-0.2%	4,662	479	3,252	29	96
2012	$6,785K	+3.8%	5,221	209	3,013	22	90
2013	$6,249K*	-7.5%	5,165	243	3,447	29	84
2014	$7,031K*	+12.5%	3,788	166	3,411	7	107
2015	$7,381K*	+5.0%	4,849	271	4,246	12	98
2016	$7,597K*	+2.9%	3,936	375	4,655	7	82
2017	$7,123K	-6.2%	3,684	404	4,730	11	95

*: Includes a $500K Early Career Award to LANL.

For FY2019 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 will be carried out with possible extension to all nuclear data libraries.
- Dissemination of the nuclear data will continue approximately on the same level but no major imprvements will be undertaken.

We expect to continue yearly meetings of the Nuclear Data Advisory Committee (NDAC), involving representatives from the major stakeholders across basic and applied nuclear physics, to critically assess current efforts and proposed activities.

The priority nuclear data activities remain:

- Compilation of structure (NSR, XUNDL) and reaction data (EXFOR)

- Evaluation of structure and decay data (ENSDF)
- Evaluation of 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

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 and 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 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.
Upgrade various software running on NNDC's mission-critical servers to meet the U.S. nuclear data community's growing computing needs.
Procure computer hardware, software and support services to meet NNDC's computing requirements.

II. Coordination

A. National Coordination

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

ANL Planned Activities
Perform some coordination activity.

BNL planned activities
Prepare FY2019 work plan for USNDP.
Organize and chair CSEWG Meeting at BNL in November 2018.
Organize and chair USNDP Meeting at BNL in November 2018.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.
Maintain CSEWG and USNDP websites.
Organize mini-CSEWG meeting in the summer if needed.
Host and help organize NDAC meeting.

LANL planned activities

Organize and chair CSEWG Evaluation Committee meeting at BNL.
Organize and chair CSEWG Covariance Committee meeting at BNL.
Organize and chair Nuclear Reaction Working Group.

LBNL planned activities
Organize the Nuclear Structure High Priority List together with A. Negret from Bucharest.

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
Participate in IAEA-sponsored nuclear data activities

BNL planned activities
Participate in IAEA-sponsored nuclear data activities.
Participate in NEA WPEC annual meeting.
Participate in IAEA CRP and technical meetings.
Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work.

LANL planned activities
Participate in NEA WPEC annual meeting.
Participate in relevant IAEA coordinated meetings, such as reference input parameter library, nuclear cross section standards, and photo-nuclear data
Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.
Host a couple of international visitors to collaborate on reaction experiments at LANSCE

LBNL planned activities
Coordinate EGAF and RIPL evaluations with the IAEA.
Coordinate the development of a new continuum reaction/gamma-ray database with the IAEA and researchers at the Oslo Cyclotron Laboratory. Also coordinate to create a (n,n') database with the IAEA.
Coordinate LBNL/Budapest/FRM-II/Julich TransActinide Nuclear Data Evaluation and Measurement (TANDEM) collaboration to measure actinide neutron cross sections.

MSU planned activities
Participate in IAEA-sponsored nuclear data activities.

ORNL planned activities
Participate in IAEA-sponsored nuclear data activities.

TAMU planned activities
Participate in IAEA-sponsored nuclear data activities.

TUNL planned activities
Participate in 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 done 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.

B. 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 update of the database using input received from compilers.
Distribute database twice a year to the NSDD network.
Coordinate with nuclear physics journals to merge XUNDL compilations with their review process.

C. 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 format and content checking, preparation of 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 continuing 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.

D. Numerical Nuclear Data File (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 meta-stable state properties (Wallet Cards), atomic and nuclear radiations derived from ENSDF, and thermal neutron cross sections and resonance integrals. Additionally, NuDat contains an interactive Chart of Nuclides and interactive level schemes.

BNL planned activities
Update NuDat database as necessary, about 10 times a year.

E. Neutron Reaction Data Bibliography (CINDA)

The NNDC continues to contribute to the CINDA database that contains references to nuclear reaction data in the published and unpublished literature. Since 2004, CINDA also contains bibliography information on charged-particle and photonuclear reactions. The database serves as an index to the data contained in the experimental database, EXFOR. The database is maintained by the Nuclear Data Section, IAEA Vienna.

BNL planned activities
Contribute to CINDA by compiling experimental cross-section data to the CSISRS and NSR databases.

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 ≤ 12. Many groups worldwide compile experimental data and send it to the central database in Vienna in the EXFOR format. Then, each 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, chapter V of the present document.

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 Cross Section Evaluation Working Group (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 about 35 years ago, 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 for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. New evaluations for the next release of the library, ENDF/B-VIII.0, are assembled, tested and made available to users through NNDC's Web servers and GForge collaboration server.

BNL planned activities
Maintain Linux/MySQL database system.
Maintain GForge/Subversion system for tracking development of the ENDF/B library.
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter 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 five nuclear physics databases maintained by NNDC.

BNL planned activities
Fix bugs and develop enhancements for the six nuclear physics databases maintained by NNDC.

I. Database Systems Development

The multi-year effort to migrate the USNDP databases to a LINUX/MySQL environment was completed in FY2009. Afterwards, several follow-up tasks needed to be performed. A new web interface, complementary to the existing one, should be developed to facilitate the retrieval of experimental data in EXFOR by non-ENDF users, such as nuclear astrophysicists. This interface should focus on the relevant experimental data, such as a full reference to the publication, a comprehensive reaction description and the experimental data. The existing interface, giving access to the complete compilation (with more details than the reference, reaction and data) will be retained and will still be accessible to users who need it. Also, a new ENDF interface should be developed for users who do not possess specialized knowledge of ENDF-6 format.

BNL planned activities
Upgrade the Linux/MySQL server software to fix bugs, provide new functionalities and improve the system's performance, security and reliability.
Maintain MySQL database system software for automated replication of updates from the internal database server to the external for continuing compliance with DOE cyber security requirements.

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. 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 Web site. 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 capabilities of ENSDF.
Maintain web interfaces for ENDF and EXFOR databases.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the 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 GForge server software to provide more powerful and advanced functionalities in the NNDC collaboration services.
Make progress with modernization of the web site, enhancing capabilities and follow industry best practices.

ORNL Planned Activities
Expansion of features of our online software suite that supports the new mass evaluation effort, including new evaluation tools and dissemination capabilities.

TUNL Planned Activities
Continue to improve the TUNL website and provide access to new information on A = 3 - 20 nuclei.
Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.
Continue to provide PDF and HTML documents for FAS reviews for the A = 3 - 20 series with the most current NNDC reference keys and with the direct hyperlink of reference with TUNL keys.
Continue to provide Energy Level Diagrams (in GIF, PDF and EPS/PS formats) to accompany the PDF and HTML documents for the most recent TUNL reviews and preliminary reports, and for the earlier FAS reviews.
Provide compiled and evaluated data on the decay of unstable ground states and on structure data from thermal neutron capture.
Provide compiled data related to the level parameters for A = 3 - 20 nuclei populated in proton- and alpha-particle-induced reactions.
Provide online access of TUNL dissertations collection.

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" and for administrative/clerical support of its customer services.

BNL Planned Activities
Provide technical support to nuclear data end-users as necessary.
Maintain Comments/Questions for all databases and web products.

C. Publications

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 published by Elsevier and various versions of the Nuclear Wallet Cards.

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

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

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. The IAEA is expected to provide more than 20% of the keywords. 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 about 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 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 and Central Michigan Universities). Publish an experimental methods analysis and start on Grodzin's formula fits.
Compile new double-beta decay experimental data. Start working on a data project with Kiev Institute for Nuclear Research.
Maintain, update and distribute XUNDL.
Compile data sets (in ENSDF format) for current experimental nuclear structure publication. Scan the webpages of prominent journals in nuclear physics for new papers. Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database. Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data.
Compile new mass measurements and submit data file to nuclearmasses.org webpage at ORNL. (McMaster)

LBNL Planned Activities
Perform XUNDL compilation.

MSU Planned Activities
Compile datasets for at least 50 journal papers.

ORNL Planned Activities
Compile XUNDL datasets as required.

TUNL Planned Activities
Compile datasets for current experimental nuclear structure data publications on A=2-20 nuclei for inclusion in the XUNDL database.

C. Data Evaluation for ENSDF

The 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. The US effort is supplemented by foreign contributions prepared under the auspices of the IAEA-sponsored international Nuclear Structure and Decay Data network.

ANL Planned Activities
Evaluate at least 1 mass chain from the ANL region of responsibility.
Review mass chain evaluations, as requested.

BNL Planned Activities
At least 4 mass chains, or their equivanent nuclides, will be evaluated.

At least 4 mass chains, or their equivanent nuclides, will be reviewed.
Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides. Collaborate with a new center/evaluator as part of mentoring process, as needed (McMaster).
All evaluations submitted for publications will be edited including checking for their format and physics content. Extensive changes are often made by NNDC staff.
Continue mentoring new ENSDF evaluators.

LBNL Planned Activities
Evaluate the equivalent of at least 2 mass chains (22 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.
Train new compilers/evaluators.

MSU Planned Activities
Evaluate the equivalent of at least 2 mass chains.
Review mass-chain evaluations, as requested.

ORNL Planned Activities
1 equivalent mass chains and the data for new nuclides will be evaluated. Mass chains will be reviewed as requested.

TAMU Planned Activities
At least 1 mass chain, or their equivanent nuclides, will be evaluated.

TUNL Planned Activities
Evaluate about 1-2 A-chains per year for publication in Nuclear Data Sheets and inclusion in the ENSDF database.
Evaluate and update ENSDF for A=2-20 near drip-line nuclides, especially for first observations or when ENSDF has no previous data set.
Update various reaction data sets in ENSDF, such as for beta-decay and beta-delayed particle emission.

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
Update Nuclear Wallet Cards database as new information becomes available.

E. Non-ENSDF Decay Data Evaluations

ANL: compile and evaluate radioactive decay data for selected nuclei that are of relevance to nuclear structure physics and astrophysics, as well as to energy and non-energy (medical radioisotopes) related applications.

ANL Planned Activities
Evaluate and publish nuclear structure and decay data evaluations for selected radionuclides of relevance to medical and energy-related applications.

BNL Planned Activities
Contribute to the beta-delayed neutron emitters CRP.

LBNL Planned Activities
Produce a horizontal evaluation of beta-delayed proton emitters.

F. Neutron-Induced γ-Ray Data Evaluation

The EGAF (Evaluated Gamma-ray Activation File) database, disseminated by the IAEA and maintained by LBNL, currently provides discrete-line prompt γ-ray information from thermal (n,γ) reactions in a format tailored to suit the needs of the neutron activation analysis community. However, it requires ongoing maintenance and development to make it more useful to the applied communities it serves. Statistical-model calculations can generate quasi-continuum photon cascade data to complement these experimental discrete-line data. Together, the experimental and calculated data could constitute a valuable resource required for updating the ENDF database. Additionally, delayed photon data need to be added to EGAF. The k0-value database currently used by the neutron activation analysis community needs to be assessed and compared with the corresponding decay information in ENSDF, and the resulting evaluated k0 values then need to be integrated into EGAF and, ultimately, made available to ENSDF evaluators.

LBNL Planned Activities
Continue to maintain and develop the EGAF database. Update EGAF prompt gamma-ray cross sections from new measurements. Add activation data to the EGAF file. Include improved nuclear stucture data for the RIPL library in EGAF datasets. Develop a Nuclear Data Sheet publication format for EGAF data.

Collaborate with Charles University (Prague) to perform statistical-model calculations of quasi-continuum γ-ray cascade information and generate ENDF-format capture γ-ray datasets for use with MCNP and other transport-code calculations.
Collaborate with the University of Oslo to measure low-energy photon strength functions and level densities.
Work to develop a database of (n, n'gamma), starting with the compilation and release of the Atlas of Inelastic Scattering of Reactor Fast Neutrons. The data is now available on the web at http://nucleardata.berkley.edu and is being integrated with modern structure data from ENSDF.
Continue to update the Inelastic Scattering of Reactor Fast Neutrons Database (e.g., the “Baghdad Atlas”) with modern ENSDF data. (http://nucleardata.berkeley.edu).

H. Nuclear Structure Data Measurement

ANL will devote a relatively small effort (0.1 FTE) to participate through collaborative agreements in nuclear physics research activities related to nuclear data needs. The emphasis will be on data measurements aimed at providing answers to specific questions that arise from recent nuclear data evaluations and at improving the quality of existing databases in specific areas, such as (but not limited to) decay data of minor actinides and neutron-rich fission products. Maintain important collaborative connections with RIA and GRETINA research communities, because of their vital importance to the nuclear science in US.

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

BNL has spent a modest amount of time to participate in experiments relevant to isotope production and nuclear structure.

BNL Planned Activities
Precisely determine decay schemes of relevant medical isotopes using state-of-the-art gamma-ray spectroscopy.
Participate in 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.
Driven by deficiencies in nuclear data on the neutron-rich side of 208Pb, complete and analyze deep-inelastic reaction experiments performed at Argonne.

LANL/LANSCE continues to maintain a small program to measure nuclear decay data information.

LANL Planned Activities
Analyze and publish the prompt gamma-ray data taken on fission products of mass range ~100, using the GEANIE array.
Publish the gamma-ray production cross section on Xe-124, which was measured using the GEANIE array.

LBNL:– to promote a closer working relationship with the nuclear structure community, LBNL will devote a small effort (~0.1 FTE) to participation in local nuclear structure experimental work.

LBNL Planned Activities
Continue to update the Inelastic Scattering of Reactor Fast Neutrons Database (e.g., the “Baghdad Atlas”) with modern ENSDF data. (http://nucleardata.berkeley.edu).
Perform statistical model calculations using the DICEBOX, RAINIER and CoH gamma-cascade codes to determine total radiative cross sections and elucidate nuclear level spins and parities.

I. ENSDF Physics and Checking Codes

The NNDC maintains ENSDF checking and physics programs on behalf of the national and international evaluator networks

BNL Planned Activities
Maintain and upgrade ENSDF checking and physics programs for format changes as required.
Move codes off the Lahey compiler and make compatible with gfortran.

MSU Planned Activities
Maintain and improve the JAVA-NDS code, and the xls2ens and ens2xls Python codes.
Maintain and improve the new Java code-ConsistencyCheck-for checking physics and consistency among ENSDF datasets.
Develop new utility and analysis codes used by evaluators, as requested. An example is a Java code for calculating angular distribution or correlation coefficients for a given Jpi sequence and for searching for possible Jpi sequences for given coefficients.

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. Incident neutron reactions have been well covered historically. NNDC thus concentrates on new measurements, but continues compilations of earlier publications that have not been included in the EXFOR database. Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data. Hence, there is a larger staff commitment to compiling this type of data.

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 Evaluations

Evaluated nuclear reaction data, for applications and for 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 insure 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 for ENDF/B-VII released in FY2007. LLNL develops a computer code that translates LLNL evaluations in the internal ENDL format into ENDF-6 formatted data so that LLNL evaluations can flow back into the nuclear data community.

BNL Planned Activities
Respond to user needs for evaluated nuclear reaction data.
Collect and address users feedback related to the ENDF library.
Complete evaluation of 56Fe in the frame of the CIELO project. Work with CSEWG on upgraded evaluations for future release of the ENDF/B library.
Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.
In collaboration with LLNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.
Provide production cross sections for medical isotopes.
Improve methodology for generating unresolved resonance region cross section probability distributions.

LANL Planned Activities
Upgrade the LANL ENDF evaluations for U and Pu isotopes that perform well in criticality benchmarks, including new theoretical development of statistical model for deformed systems. Close collaboration with international nuclear data library activities, CIELO coordinated under OECD/NEA.
Provide upgraded ENDF evaluated data files for light and medium mass elements, and perform criticality benchmarks.
Provide new evaluations of the prompt fission neutron spectra for major actinides, based on the Monte Carlo 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.

LLNL Planned Activities
Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.
In collaboration with BNL, coordinate the development of the Generalized Nuclear Data Structure (GNDS) format as a proposed successor format for ENDF.
Finish converting LLNL's 'Charged Particle Library' to ENDF format for targets up to A=7, to make candidates for inclusion in ENDF/B-VIII when/if they are improvements on existing evaluations.
Perform R-matrix fits for proton and alpha particles incident on selected medium-mass nuclei ($4 < A < 50$), to accurately describe low-energy resonances and make candidates for future ENDF/B-VIII evaluations. Translate R-matrix evaluation parameters between those of fitting codes to and from GNDS and ENDF libraries.

C. ENDF Manuals and Documentation

The NNDC is responsible for maintaining the format and procedures manual for the ENDF system. We also produce the documentation supporting the contents of the ENDF/B library.

BNL Planned Activities
Maintain GForge version of the ENDF-6 formats manual up-to-date 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.

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. Maintaining accurate current values for the standard cross sections is the primary objective of this task that can be most efficiently accomplished through international cooperation. A new international evaluation of the neutron cross-section standards is now underway. It is important to improve the standards database and procedures for evaluations in preparation for new evaluations of the standards. To assist in this, an IAEA data development project "maintenance of the neutron cross section standards" was initiated to ensure that we are prepared for the next evaluations of the neutron cross section standards. Historically the standards evaluation activity has included data 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 Au(n,γ) 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.

LANL Planned Activities
Participate in the international effort to reevaluate the light-element standard cross sections with LANL leadership, and investigate the nature of output covariance data from R-matrix analyses of systems containing the light-element standard cross sections.
Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.
Perform the precision measurements on ^{6}Li(n,α)t and ^{6}Li(n,α)dn using CLYC detectors, in order to improve uncertainties En > 1 MeV due to the triton breakup ambiguity shown in previous measurements.

NIST Planned Activities
Continue work for the next generation of reaction standards.

E. Nuclear Model Development

This task covers activities such as 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 and LANL 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. BNL and LANL will also participate in the IAEA Coordinated Research Project RIPL to improve accuracy and reliability of input parameters used in nuclear reaction calculations

BNL - We are active in nuclear reaction model development focusing on the BNL code EMPIRE. The work iwill concentrate on further extensions and improvements of its capabilities. Work on validation of the code will be actively pursued. Close collaboration with LANL will continue focusing on validation of the fission models in EMPIRE and CoH3. Major effort is dedicated to the development of capabilities for estimating covariance data for fast-neutron reaction cross sections.

BNL Planned Activities
Continue to improve reaction modeling in the EMPIRE code, maintain code's numerical integrity and enhance user friendly GUI. Improve EMPIRE covariance capabilities for fast neutrons.

LBNL Planned Activities
Work with the LANL group to update and improve gamma-ray data for neutron-induced reactions using the CoH reaction modeling code.
Work with LLNL to benchmark the newly-published RAINIER (Randomizer of Assorted Initial Nuclear Intensities and Emissions of Radiation) statistical model code against gamma-cascade calculations performed using TALYS and CoH.
The LBNL group will use the newly-published FIER (Fission Induced Electromagnetic Response) delayed fission gamma-decay code to address deficiencies in fission product yields and decay data.

LANL - Nuclear reaction theory calculations have played a crucial role in the evaluation of nuclear data, and will continue to play an important part in future evaluations. The LANL CoH3 code has proved to be an important tool, and we will continue development of advanced model codes to provide a state-of-the-art capability to predict reaction cross sections and to explore nuclear reaction physics in detail. This also involves a close collaboration with experimentalists at LANSCE to interpret new measurements using the GEANIE, DANCE, and CHI-NU detectors. These data will result in advances in our understanding of nuclear reaction mechanisms, and improvements in our modeling codes.

LANL Planned Activities
Continue to develop a microscopic description of fission process in the fast energy range, which includes Class-I and Class-II coupling, 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 to neutron capture process for deformed targets including M1 scissors mode, in support of DANCE and GEANIE measurements, and fission cycle in r-process nucleo-synthesis studies.
Study neutron inelastic scattering from deformed nuclei in the fast energy range, to which theoretical calculations are essential, in collaboration with CEA, France and IAEA.
Continue prompt fission neutron and gamma-ray spectrum calculations with the Monte Carlo method to ^{235}U, ^{239}Pu, and ^{252}Cf, and compare available experimental information. Extend the neutron incident range to cover applications.
Develop new width fluctuation correction calculation for the deformed systems, based on the Gaussian Orthogonal Ensemble and the Monte Carlo technique, which includes both the coupled and uncoupled channels in a consistent way.
Continue to develop Monte-Carlo Hauser-Feshbach code, CGM, that can be used as an event generator in radiation transport codes.
Develop a semi-microscopic level density model based on the Gaussian Orthogonal Ensemble.

F. Nuclear Reaction Data Measurements

The measurement of nuclear data is essential to provide data, which either cannot be calculated or cannot be calculated with sufficient accuracy for user applications. This activity is also essential to support and verify nuclear model development and application.

ANL Planned Activities
Continue participating at MANTRA research activities at ANL

LANL Planned Activities
Perform the precision measurement on the prompt fission-neutron spectrum for fission induced by neutrons of 0.5 to 200 MeV on ^{235}U and ^{239}Pu. With the high energy neutron detector array, the measurement will be extended to the outgoing neutrons up to 12 MeV.
Analyze and publish radiative strength functions in neutron capture on ^{234,236,238}U in collaboration with Theory Division at LANL.
Transmission experiments on oxygen or neon isotopes at neutron energies from 1 MeV to 200 MeV for the interest of Dispersive Optical Model potential investigation and some level information near particle thresholds.
Perform the measurements of the Pu-239 fission cross section relative to H(n,n), using the TPC.
Perform the precision measurement on the ^{16}O(n,α) reaction cross section at LANSCE

LBNL: LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal (n,γ) cross section data to supplement earlier elemental target measurements from which important information was either lacking (e.g., data from low-abundance isotopes) or discrepant.

LBNL Planned activities

Complete publication of the results of their 139La(p,xn) cross section measurements as a part of the La/Ce project led by PIs Rebecca Abergel and Jon Engle.
Collaborate with the LANL-IPF team to perform measurements of the 238U(p,3n) and 235U(d,n) cross sections for the production of 237Np as a part of the newly-funded NDIWG grant.
Perform targeted measurements of (p,x) and (d,x) and (n,x) reactions for isotope production and to determine spin distributions via observation of isomer-to-ground state ratios using the LBNL 88-Inch cyclotron and the High Flux Neutron Generator on the UC Berkeley campus.
Collaborate with the NUSTEM group to publish results of the 35Cl(n,p) cross section measurement made using the HFNG. This cross section is important for the design of molten salt reactors.
Work with researchers from LANL and Wisconsin will work towards developing the 93Nb(p,4n) reactions as a new high-energy proton monitor.

G. Evaluation of Data Needed for Astrophysics

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.

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

LANL Planned Activities
Continue improvement of neutron capture modelling for calculating neutron capture rates off-stability to s and r-process hydro-dynamics simulations. Our focus is on a semi-microscopic level density modeling including spin and parity distributions, which is based on nuclear mean-fields theories.
Continue development of simultaneous beta-delayed neutron and fission calculations, and provide the reaction rates for the fission cycle study in the r-process nucleo-synthesis.
Perform measurements on (n,p) and (n,α) cross sections on the isotopes of interest for better understanding of p-process nucleosynthesis, in conjuction with the improvement on Hauser-Feshbach calculations

LLNL Planned Activities
The FIssion in R-process Elements (FIRE) collaboration was jointly funded in FY17. Its goal is to determine the astrophysical conditions of the rapid neutron capture process (r-process), which is responsible for the formation of heavy elements. This will be achieved by including in r-process simulations the most advanced models of fission (spontaneous, neutron-induced, β-delayed) that have been developed at LLNL and LANL. The collaboration is composed of LLNL (lead) and LANL for work on nuclear data (ground-state properties, fission, β-decay), BNL for nuclear data management, and the university of Notre Dame and North Carolina State University for r-process simulations. Under DOE/NNSA agreement, universities receive funds from the DOE Office of Science, while national laboratories receive funds directly from NA221.

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.
Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANCs) on nuclei near the N=82 closed shell – 81Ge, 127,129Sn, 135Te - from transfer reaction measurements on radioactive Ge, Sn, and Te nuclei. Use this information to calculate direct capture cross sections needed to model the r-process in supernovae. Develop techniques to quickly provide the nuclear structure information needed for these cross section calculations.

H. Covariances Development

Quantification of uncertainties and their correlations, mathematically represented as covariance matrices, became recently a focal point of the ENDF evaluation effort world-wide. A strong motivation for this revival is the role of covariances in guiding adjustment of the evaluations to the integral experiments to improve reliability and performance of the new libraries. Work in this field includes improvement of the methodology as well as development of actual covariance data. Major covariance activities are carried out at BNL, LANL and ORNL (the latter in the resonance region).

BNL Planned Activities
New covariance matrices, including cross-reaction correlations, will be produced for the structural materials.

I. Reactor antineutrino spectra and decay heat calculations

The NNDC has been setting up methos to calculate antineutrino spectra decay heat from fissioning systems using the fission yield and decay data sub-libraries from ENDF-6 formatted libraries.

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 participate in 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 National Nuclear Data Center. Furthermore, checking performance of the library against the integral experiments, known as validation, is an important step ensuring 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
Establish automatic, real time verification and validation of new/modified ENDF evaluations submitted to the NNDC GForge server.