



## USNDP Work Plan for Fiscal Year 2015

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# 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 2015 that begins on October 1, 2014. Previously, **15 work plans** have been prepared for the data program covering fiscal years 2000 - 2014. 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 meet one of the three program priorities:
  - a) Maintenance & update of information in the USNDP nuclear physics databases
  - b) Improvement in dissemination of the information contained in those databases to the user community
  - c) Modernization of data evaluation software used by the program participants
2. A task should be useful to at least one major user community
3. A task should not duplicate effort within or outside the program

The plan is divided into six major components. Specific tasks have been assigned to one of these components. 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 FY2015, 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 for the **2015 Guidance** scenarios.

**Table 1:** Summary of the USNDP funding and metrics for FY2001- FY2014, the last two years are projections under the **2013 CR** and **2014 Proposed** scenarios.

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*	-7.9%	4,925	282	3,447	29	84
2014 CR	\$7,020*	+12.3%	4,455	191	3,362	17	81
2015 Guidance	\$7,370*	+5.0%	4,445	246	3,464	22	70

\*:Includes an Early Career Award of \$500K to LANL.

With the current and planned funding situation we expect that:

- ANL will not be fully supported, and as a consequence, their productivity in terms of ENSDF evaluations and XUNDL compilations will be seriously compromised.
- BNL will need to suspend Nuclear Data Sheets editorial support, that is, the NNDC will not be able to a) check the Nuclear Data Sheets articles for format errors; a) check and fix the articles for spelling and grammar errors; c) optimize the tables and plots layout. Additionally, the NNDC will not be able to support postdocs and will need to terminate a scientific position.
- Compilation and dissemination activities will be fully supported.
- Evaluation effort will continue a moderate decline, mostly due to the temporary decrease of the reaction evaluations in favor of evaluation methodology development following recent release of ENDF/B-VII.1 and setting up international CIELO collaboration.
- Training and mentoring of new ENSDF evaluators will continue but will be limited.

- Development of nuclear reaction codes will continue focusing on evaluation methodology (covariances, fission, prompt fission neutron spectra, angular distributions).
- 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 while being moved to the new servers.

The FY2015 Guidance budget increases by \$350K (5.0%) compared to FY2014. The above mentioned consequences will be largely mitigated if the FY2015 is increased by an additional \$800K, which will allow ANL to maintain a postdoc and fully cover its scientific position, as well as to allow the NNDC to maintain its scientific workforce, keep one postdoc and maintain the Nuclear Data Sheets editorial support.

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. These include two database servers, two Web servers, the GForge server and the recently added ADVANCE system server for nuclear data Quality Assurance and automatic posting of the results on the NNDC Web site. 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
Ensure compliance with DOE cyber security rules and regulations through regular scanning of NNDC servers and desktops and prompt remediation of discovered vulnerabilities within the prescribed time. Noncompliance could result in a machine's total block from network (BNL internal network and the Internet) access.
Provide prompt and effective computer support to NNDC staff, its visitors and major end-users in their use of NNDC computing resources.
Upgrade the suite of software powering the GForge server, the ADVANCE server and the Linux cluster to meet NNDC's and the nuclear data community's computing requirements.
Upgrade the Windows-based central backup system to be able to handle the new filesystem format being used by NNDC servers running Red Hat Enterprise Linux version 6 and higher.

## 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: Chair the Covariance Committee the Cross Section Evaluation Working Group.

ANL Planned Activities
Organize and chair the CSEWG Covariance Committee

BNL: Chair USNDP Coordinating Committee, chair Cross Section Evaluation Working Group, develop USNDP work plan, and maintain its USNDP website.

BNL planned activities
Prepare FY2016 work plan for USNDP.
Organize and chair CSEWG Meeting at BNL in November 2014.
Organize and chair USNDP Meeting at BNL in November 2014.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.
Maintain CSEWG and USNDP websites
Aid LLNL to organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.

LANL planned activities
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2014.
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2014.

LBNL: Serve as a member of the USNDP Coordinating Committee and chair the USNDP Nuclear Structure and Decay Data Working Group in addition to overseeing, coordinating, and directing the work of members of the Isotopes Project. The latter effort includes working with LBNL management, with other members of the USNDP, and with the program officers of the DOE.

LBNL planned activities
Coordinate EGAF Capture Gamma-ray Library evaluations with LLNL for preparation of ENDF format datasets and improved RIPL files.
Coordinate the West Coast collaboration to measure and evaluate neutron cross section measurements at the LBNL Cyclotron and UC Berkeley Department of Nuclear Engineering.

LLNL: Chair the Task Force on Nuclear Data Needs for Homeland Security of the Cross Section Evaluation Working Group.

LLNL planned activities
Organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.

ORNL: Chair the Astrophysics Task Force, and help facilitate and coordinate nuclear astrophysics data work at different labs to advance USNDP goals; provide leadership in planning future activities in nuclear data for nuclear astrophysics

ORNL planned activities
Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting.
Communicate current efforts and future plans with researchers in nuclear astrophysics and nuclear astrophysics data.
Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data and in "town meetings", community meetings, and summer schools.
Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.
Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, and with other funding agencies.

## B. International Coordination

ANL: Represent the ANL in IAEA-sponsored Nuclear Structure and Decay Data Network (NSDD) and Decay Data Evaluation Project and IAEA-sponsored coordinated research programs (CRP) and training workshops.

ANL planned activities
Participate in the IAEA Coordinated Research Project on "Nuclear data for charged-particle monitor reactions and medical isotope production".
Participate in an IAEA-organized project aimed at improving the existing ensdf analysis codes.
Participate in the NSDD meeting in FY2015.

BNL: Represent the United States in IAEA-sponsored Nuclear Reaction Data Center Network (NRDC) and Nuclear Structure and Decay Data Network (NSDD). The NNDC center head is the U.S. member and chairman of the IAEA's International Nuclear Data Committee (INDC), the lead US member of the NEA Working Party on International Evaluation Cooperation (WPEC) in his position as chair of CSEWG. Many of the NNDC staff participates in IAEA and NEA sponsored activities such as Workshops and Technical Meetings and Subgroups.

BNL planned activities
Participate in the IAEA-sponsored NRDC meeting in FY2015.
Participate in NEA WPEC annual meeting in FY2015.
Conduct and lecture at likely IAEA-sponsored workshop at Trieste in FY2015.
Participate in IAEA organized network coordination meetings (NRDC, NSDD)

Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work (McMaster).
Participate in NSDD and DDEP meetings, as well as IAEA CRP meeting on Beta-delayed Neutrons.

LANL: Participate in and chair international nuclear reaction data collaborations. This insures that the U.S. benefits from breakthroughs around the world, and plays a leadership role in new developments. LANL staff members participate in NEA/WPEC committees on covariance data and international model code development cooperation. LANL will host visits by foreign scientists with international reputations to benefit from the exchange of information and ideas.

LANL planned activities
Participate in NEA-WPEC 2015 meeting
Participate in relevant IAEA CRP meetings (fission model parameters and nuclear cross section standards).
Organize International Nuclear Reaction Mechanisms, Varenna, Italy, 2015.
Make latest version of NJOY data processing code available to the international community.
Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.
Organize a technical meeting on the international cooperative nuclear data library

LBNL: Participate in IAEA-sponsored training workshops, planning meetings and coordinated research programs on nuclear structure and decay data.

LBNL planned activities
Participate in NSDD/IAEA meetings.
Host visitors/students to continue and improve existing EGAF database.

ORNL: Represent ORNL at IAEA-sponsored meetings.

ORNL planned activities	Status
Participate in the policy matters related to the NSDD network.	C. Nesaraja participated in the 2013 NSDD meeting in Kuwait

TUNL: Represent TUNL at IAEA-sponsored at Nuclear Structure and Decay Data network (NSDD).

TUNL planned activities
Participate in the policy matters related to the NSDD network.
Participate in NSDD/IAEA meetings

### 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.
Provide international coordination of NSR compilations and activities.
Database updates and maintenance.
Explore the possibility of cooperation with OSTI on nuclear data storage and dissemination.
Explore the possibility of cooperation with NRDC network on the transfer of selected EXFOR 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 updates the database as new/revised data sets are received from participating centers.

BNL planned activities
Weekly update of the database using input received from McMaster University.
Distributed twice a year to the NSDD network.

#### 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 twice a year.

## 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  $\gamma$ -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 (CSISRS) 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 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. 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 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 six 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 periodically the Linux/MySQL system software to fix bugs, provide new functionalities and improve the system's performance, security and availability.
Implement and maintain automatic replication of updates from the internal MySQL database server to the external.

## 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. The NNDC Web services are powered by several multi-core servers running the Linux operating system and using the Apache, Tomcat and MySQL software. The NNDC also maintains the Atomic Mass Data Center website. Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

ANL Planned Activities
Maintain and upgrade the ANL/NDM report series web site.
Maintain and upgrade Experimental Resources for Nuclear Data web site.
Maintain and upgrade ANL Nuclear Data Information web site.

BNL Planned Activities
Continued improvement to the NuDat, ENSDF and NSR web interfaces.
Maintain web interfaces for ENDF and EXFOR databases.
Improve Sigma web interface by adding new and extended features following user's requests.
Maintain web interface for double-beta decay, B(E2) and Maxwellian-averaged cross sections and reaction rates.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users requests.
Maintain the NNDC Web Services availability level at the 99% level or higher.
Strictly follow all BNL and DOE cybersecurity rules and regulations during the Web application design, development and implementation.
Maintain GForge server powering collaboration platform for the U.S. nuclear data community and its international collaborators.
Begin work on redesign of web interface for NNDC pages, utilizing modern technologies.
Rewrite the web HTML format presentation of ENSDF (currently known as webtrend).

ORNL Planned Activities
Expansion of features of our online software suite to convert nuclear data to astrophysical reaction rates and plot, manipulate, combine, and share results online.
Expansion of host website nucastrodata.org to hyperlink in more relevant nuclear data sets for astrophysics research.

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 reaction databases, for the NNDC web services, NuDat, ENSDF, XUNDL, ENDF, EXFOR and Nuclear Wallet Cards.

## 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.

Develop software for Nuclear Data Sheets publication (McMaster)

## 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 and since July 2013 is the only provider of the new entries to the NSR database.

BNL Planned Activities

Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them.

Check and edit key-worded abstracts from other collaborators as applicable and necessary.

Provide database updates with the missing and historic references.

NSR keywording for all articles in Physical Review C journal (McMaster)

### B. Compilation of Experimental Structure Data

This activity involves compilation of recently published or completed experimental nuclear structure data for inclusion in XUNDL and other, more specific, databases. The XUNDL compilation is done by ANL, ORNL, and TUNL, while the NNDC is maintaining the database.

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). Produce a new evaluation for even-even nuclei that will include evaluated, calculated and experimental B(E2) values.

Compile new double-beta decay experimental data. Produce evaluated half-lives and nuclear matrix elements.

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. Train a new undergraduate student in 2014 for XUNDL and other compilation work. Compile new mass measurements and submit data file to nuclearmasses.org webpage at ORNL. (McMaster)

ORNL 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.

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 0.5 equivalent mass chains from the ANL region of responsibility.

Review mass chain evaluations, as requested.

BNL Planned Activities
At least 6 mass chains, or their equivalent nuclides, will be evaluated.
At least 6 mass chains, or their equivalent nuclides, will be reviewed.
Continue mentoring new ENSDF evaluators.
2 equivalent mass chains and the data for new nuclides (as mentioned below) will be evaluated. Mass chains will be reviewed as requested. 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 are edited including checking for their format and physics content. Extensive changes are often made by NNDC staff.

LBNL Planned Activities
Evaluate the equivalent of at least 2 mass chains. 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 evaluators/compiler for ENSDF/XUNDL.
Train students for XUNDL compilation.

ORNL Planned Activities
Complete evaluation of structure information for two nuclei in A=241-249 region, or others assigned by NNDC.
Review one mass chain evaluation.

TUNL Planned Activities
Prepare the ENSDF files corresponding to new publications in the "Energy Levels of Light Nuclei" series.
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
Contribute to the development of the Atomic Mass Evaluation and NUBASE databases in collaboration with CSNSM and INP, Orsay and IMP, Lanzhou.

BNL Planned Activities
Update the Nuclear Wallet Cards as new information becomes available.

## 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 at least one radionuclide in support of the IAEA-CRP on "Nuclear data for charged-particle monitor reactions and medical isotope production".
In collaboration with scientists from the Australian National University and under auspices of IAEA, develop new computational tools for improving data on Auger-electron emissions following radioactive decay, which are relevant to medical radioisotopes applications.
Evaluate radioactive decay data produced at the CARIBU facility.

## F. Neutron-Induced $\gamma$ -Ray Data Evaluation

The EGAF (Evaluated Gamma-ray Activation File) database, disseminated by the IAEA and maintained by LBNL, currently provides discrete-line prompt  $\gamma$ -ray information from thermal ( $n,\gamma$ ) 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.

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 structure data for the RIPL library in EGAF datasets.

## G. Evaluation of Light Nuclei for Nuclear Physics A.

TUNL evaluates additional data not included in ENSDF for publication in Nuclear Physics A and on its web site.

TUNL Planned Activities
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Finalize any loose ends for publication of "Energy Levels of Light Nuclei A=12," and continue in preparation of the "Energy Levels of Light Nuclei A=13" manuscript.

## H. Nuclear Structure Data Measurement

ANL, BNL, LANL and LBNL will devote a relatively small effort (a fraction of FTE each) to participate, through collaborative agreements, in nuclear physics research activities related to nuclear data needs. The emphasis will be on measurements aimed at providing answers to specific questions that arise from recent nuclear data evaluations and at improving quality of existing databases in the specific areas. These activities maintain important collaborative connections with local and national research communities.

### 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 fission products of relevance to reactor decay heat and astrophysics applications, spectroscopy of heavy actinide nuclei and nuclei far from the line of stability.

Participate in research activities using the GRETINA spectrometer and in dissemination of produced data from those activities.

### BNL Planned Activities

Participate in beta-decay measurements at Argonne's CARIBU facility with an emphasis on beta-delayed neutron emitters.

Complete analyses of  $^{152}\text{Eu}$  and  $^{154}\text{Eu}$  decay data and publish results.

Perform precision measurements of electromagnetic transition strengths in light nuclei as a guide for improved formulations of ab-initio theories.

Participate in Deep Inelastic experiment to obtain nuclear structure data on neutron rich nuclide south of  $^{208}\text{Pb}$ .

### LANL Planned Activities

Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on fission-product nuclei to search for previously unobserved transitions in these nuclides.

Interact with mass chain evaluators on the nuclear structure of these nuclei.

### LBNL Planned Activities

Perform DICEBOX statistical model calculations to determine total radiative cross sections and elucidate nuclear level spins and parities.

Measure gamma ray cross sections at the Garching FRM-II and Budapest Reactors and produce improved (n,g) decay schemes and total radiative capture cross sections.

Investigate primary gamma ray photon strength functions and the contribution of the M1+E2 mixing ratio to nuclear statistical model calculations.

## I. ENSDF Physics and Checking Codes

### ANL Planned Activities

Under the auspices of IAEA, develop an improved decay data evaluation code.

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.

Develop the Java based production code from McMaster to get it in working shape for use and distribution.

## VI. Nuclear Reaction Physics

### A. Experimental Data Compilation for EXFOR

The NNDC, as part of a larger international cooperation (NRDC), 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.

### BNL Planned Activities

Compile experimental data for neutron, charged particle, and photon induced reactions from 120 publications.

Explore and update the missing and unobtainable data in EXFOR.

### B. ENDF Evaluations

Evaluated nuclear reaction data, for applications and for basic science needs, are stored under version control software on the GForge server, which is maintained by BNL. New evaluations funded primarily from other sources are committed by LANL, LLNL and ORNL, while BNL contribution is

supported by the USNDP funding. LLNL is leading international collaboration developing a new XML based data structure intended as a modern replacement for the current ENDF-6 format.

<b>BNL Planned Activities</b>
Respond to user needs for evaluated nuclear reaction data.
Collect and address users feedback related to the ENDF library.
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.
Use the BNL-INL collaboration efforts on the assimilation of integral experiments to provide modifications to ENDF evaluations and cross-reaction covariances.
Depending on funding, we plan to develop a program to provide recommended production cross sections for medical isotopes.

<b>LANL Planned Activities</b>
Upgrade the LANL ENDF evaluations for U and Pu isotopes that perform well in criticality benchmarks, considering new LANSCE experimental data.
Provide upgraded ENDF evaluated data files for light and medium mass elements, including covariance data. Perform criticality benchmarks.
Provide new evaluations and covariances of the prompt fission neutron spectra for major actinides, which include pre-fission neutrons based on the statistical model.
Provide evaluated prompt fission neutron and gamma-ray spectra of $^{235}\text{U}$ , $^{239}\text{Pu}$ , and $^{252}\text{Cf}$ to the user community, which are based on the Monte Carlo Hauser-Feshbach method.

<b>LLNL Planned Activities</b>
In collaboration with BNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.

## C. ENDF Manuals and Documentation

The NNDC is responsible for maintaining manual of formats and procedures for the ENDF system.

<b>BNL Planned Activities</b>
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. A new international evaluation of the neutron cross-section standards, which was initiated by the CSEWG, was completed before release of ENDF/B-VII.0. Maintaining accurate current values for the standard cross sections is the primary objective of this task. It can be most efficiently accomplished through international cooperation. To assist in this, an IAEA data development project was initiated to ensure that we are prepared for the next evaluations of the neutron cross section standards.

<b>LANL Planned Activities</b>
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.
Continue the search for suitable $(n,\gamma)$ reactions as possible reference cross sections to complement or replace the $^{56}\text{Fe}(n,\gamma) = 847$ keV reaction, which has several experimental limitations.
Continue to assess the feasibility of very high accuracy experiments on the $\text{H}(n,n)$ angular distribution for improving this standard at several neutron energies for forward neutron scattering angles in the center-of-mass. This measurement follows the $\text{H}(n,p)$ measurements that improved the data base at backward angles. We collaborate with researchers at Ohio University and NIST.

<b>NIST Planned Activities</b>
Continue work on the IAEA data development project on maintenance of the neutron cross section standards. Prepare for the next IAEA Consultants' Meeting on this project and provide results on the updating of the standards database and its impact on the standards.
Prepare a publication on standards activities.
Continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.
Continue work on an experiment using neutron detection to measure the $\text{H}(n,n)$ angular distribution. This work will lead to improved determinations at small center-of-mass angles. The focus will be on an experiment at 10 MeV. Work will also be done at 14.9 MeV. This work is done in collaboration with Ohio University, LANL and the U. of Guelma.
Work on an experiment based on $^{252}\text{Cf}$ nu-bar leading to an improved calibration of NBS-1, the U.S. national primary standard neutron source and determination of our bath efficiency.

Complete a measurement of the  ${}^6\text{Li}(n,t)$  standard cross section at  $\sim 4$  meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the  ${}^{10}\text{B}(n,\alpha)$  reaction. Study stability of  ${}^{10}\text{B}$  deposits for  ${}^{10}\text{B}(n,\alpha)$  cross section measurements. If suitable targets can be made, cross section measurements will be initiated.

Continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. Also make these samples available for loan in physics experiments.

## E. Nuclear Model Development

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. USNDP develops advanced model codes to provide a state-of-the-art capability to predict reaction cross sections and to explore nuclear reaction physics in details. This task covers development and validation of nuclear reaction model codes, such as CoH, CGM and GNASH (LANL), EMPIRE (BNL) and FREYA (LLNL) used for prediction of nuclear reaction observables. These codes, with parameters calibrated to reproduce available experimental data, are used to produce reaction evaluations by providing complete and consistent set of cross sections, spectra and angular distributions.

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.

### 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.

Maintain GForge site with the current version of the EMPIRE code.

Implementing continuous integration system ADVANCE for checking and validation of new EMPIRE versions.

### LANL Planned Activities

Apply a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets to study gamma-ray cascading, in support of DANCE and GEANIE measurements, and s-process nucleo-synthesis studies.

Study neutron elastic and inelastic scattering angular distributions for some structural materials in the fast energy range, which have high sensitivities to the simulation for critical assemblies.

Continue neutron inelastic scattering study for actinides in the fast energy range, to which theoretical calculations are essential, in collaboration with CEA, France.

Extend the Gaussian Orthogonal Ensemble and the Monte Carlo technique to calculate the width fluctuation correction factor for the deformed systems.

Continue to develop Monte-Carlo Hauser-Feshbach code, CGMF, that can be used as an event generator in radiation transport codes.

## F. Nuclear Reaction Data Measurements

Experimental results are primary source of information in evaluation of nuclear data. They are also used to calibrate nuclear reaction theory calculations to interpolate or extrapolate to the regions for which no experimental data are available in order to provide complete nuclear data file. This activity is also essential to support and verify nuclear model development and application.

ANL is collaborating with INL on Measurement of Actinide Neutronic Transmutation Rates with Accelerator mass spectroscopy (MANTRA) aimed at obtaining valuable integral information about neutron cross sections on high mass actinides that are of importance to advanced nuclear fuel cycles. LANL is traditionally involved in extensive measurement campaigns carried out at several LANL facilities at WNR such as GEANIE, FIGARO, Chi-Nu, and DANCE. Most of these activities are funded from other sources. LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal  $(n,\gamma)$  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.

### ANL Planned Activities

Participate in nuclear data activities at ANL using the Accelerator Mass Spectrometry technique and recently irradiated actinide samples at INL.

### LANL Planned Activities

Analyze neutron inelastic scattering and reaction cross sections made with the GEANIE array for nuclides near mass 60.

Continue to improve the techniques to measure the prompt fission-neutron spectrum for fission induced by neutrons of 0.5 to 200 MeV on  ${}^{235}\text{U}$  and  ${}^{239}\text{Pu}$ . The shape of the major part of the emission spectrum between 0.1 and 10 MeV will be determined in this experiment, performed in collaboration with LLNL researchers, and will be compared with the Los Alamos model prediction. The modeling includes the Monte Carlo prompt neutron emission technique and the microscopic quantum mechanical pre-equilibrium calculations. In FY15, we will conduct measurements on the portion of the fission neutron spectrum below 1 MeV for spontaneous fission of  ${}^{252}\text{Cf}$  and neutron-induced fission of either  ${}^{235}\text{U}$  or  ${}^{239}\text{Pu}$ .

Conduct proof-of-principle measurements of neutron inelastic scattering at the Chi-Nu facility at WNR with neutron emission below 1 MeV.

Complete the study of radiative strength functions in neutron capture on  ${}^{167}\text{Er}$  and  ${}^{195}\text{Pt}$ . The residual nuclei in their low-lying states are those characterized as a strongly deformed rotator ( ${}^{168}\text{Er}$ ) and a transitional, soft-gamma nucleus ( ${}^{196}\text{Pt}$ ). The gamma-ray cascades differ markedly for neutron capture in these two nuclear systems. (with Yale University).

Complete analysis of neutron capture-to-fission cross section ratio for  ${}^{239}\text{Pu}$  for neutron energies between 1 and 200 keV.

Measure the neutron capture cross-section at DANCE for at least one isotope of importance to nuclear astrophysics.

LBNL Planned activities
Measure thermal (n, $\gamma$ ) cross sections using guided neutron beams in collaboration with the Budapest Research Centre and at the Munich Reactor.
Investigate nuclear level densities and gamma ray strengths at the Budapest and Munich Reactors and the LBNL 88" cyclotron, and the UC Berkeley neutron generator laboratory. Develop improved statistical model calculations in collaboration with Charles University, Prague.

## 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. ORNL chairs the Astrophysics Task Force of the USNDP, which serves to improve communication and coordination of nuclear data evaluation activities relevant for studies in astrophysics. ORNL also evaluates capture reactions on radioactive, proton-rich nuclei which are important for element synthesis and energy generation in stellar explosions. LANL participates in the USNDP effort by developing high-quality data for calculation of nucleosynthesis and makes these results available to astrophysics research community.

ANL Planned Activities
Continue working on issues related to ground- and isomeric-state data (masses and decay properties) and their uncertainties of relevance to astrophysics applications, and r-process modeling in particular.

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

LANL Planned Activities
Incorporate nuclear structure models into the neutron capture models to provide neutron capture rates off-stability to s and r-process hydro-dynamics simulations.
Continue working on beta-delayed neutron emission rates in the astrophysical stellar environment, including explicit neutron and gamma-ray competition.
Develop beta-delayed fission model for the r-process simulation.

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 stable and 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. This information is important for modeling the r-process in supernovae.

## 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
COMMARA-3, a library of covariances for the major reaction channels processed on a 33-energy grid, is to be based the reaction cross sections in ENDF/B-VII.1. Currently there is no funding for this project. Should funding be restored, the library will be reviewed and additional covariances included for the 1st Legendre moment for elastic scattering (mubar), average number of neutrons produced/fission (nubar), prompt fission neutron spectra (PFNS), and cross-material, cross-reaction covariances, where applicable. A preliminary beta version of this library was produced in FY2013 based entirely on covariance data in ENDF/B-VII.1. As time permits, additional beta releases may be possible by including processed covariances that result from integral data assimilation studies at the NNDC.

## I. Reactor antineutrino spectra and decay heat calculations

The NNDC has been setting up methods 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 methods and databases to calculate anti-neutrino spectra for major actinides.

## 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 the new/modified ENDF evaluations submitted to the NNDC GForge server.