Annual Report for FY2016

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November 2016

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I. Introduction

The USNDP Annual Report for FY2016 summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2015 through September 30, 2016 with respect to the work plan for FY2016 that was prepared in February 2015. The work plan and final report for the U.S. Nuclear Data Program are prepared for the DOE Office of Science, Office of Nuclear Physics. The support for the nuclear data activity from sources outside the nuclear data program is described in the staffing table and in Appendix A. This leverage amounts to about 11.6 FTE scientific, mostly at NNSA laboratories, to be compared with 24.7 FTE scientific (permanent + postdocs + contractors) at USNDP laboratories funded by the DOE Office of Science, Office of Nuclear Physics. Since it is often difficult to separate accomplishments funded by various sources, some of the work reported in the present report was accomplished with nuclear data program support leveraged by other funding.

Fiscal year 2016 was the 17th year in which the Nuclear Data Program has operated under a work plan developed by the program participants. The program continued to carry out important work in support of the DOE mission. The work balances the ongoing collecting, analyzing, and archiving of nuclear physics information critical to basic nuclear research and to the development and improvement of nuclear technologies with the electronic distribution of this information to users in a timely and easily accessible manner. The present section of the report consists of activity summaries for the major components of the U.S. Nuclear Data Program. This is followed by an updated staff level assignment table that reflects the final distribution of effort among the tasks carried out during FY2016. Then, we continue with the detailed status of work done in FY2016. Total staff assigned to USNDP activities during the year represented 24.7 FTE.

The first meeting of the USNDP Nuclear Data Advisory Committee (NDAC) took place in November 2015 during Nuclear Data Week, resulting in a report issued a few weeks afterwards. Following recommendations from NDAC, a workshop on Nuclear Data Needs and Capabilities for Basic Science was organized by ANL and Michigan State University, which took place in conjunction with the Low Energy Community meeting at the University of Notre Dame, in August 2016. More information on this workshop is found later on in the report.

In terms of personnel changes, E.A. McCutchan became the XUNDL database manager on October 15, 2016, and on April 30 2016, the ENSDF database manager and Nuclear Data Sheets editor. On September 1st 2016, A.A. Sonzogni became the NNDC head and M.W. Herman became the deputy head. During FY2016, G. Gurdal from Millsaps College collaborated with the NNDC on XUNDL compilation. The LBNL Nuclear Data Group consists of staff from LBNL and UCB. In October, 2015, J.C. Batchelder joined the Nuclear Engineering Dept, UCB as a new nuclear data staff, while A. Hurst has moved from LBNL to UCB system in January 2016. In June 2016, L. Bernstein joined the Nuclear Data Group at LBNL and leading the data activities at LBNL and UCB. Sadly, Charles Dunford, who had been the NNDC head during 1991-2001, passed away on April 26 2016.

Table 1 summarizes the USNDP metrics since 2001. Table 2 shows the breakdown of the metrics by laboratory for the reported fiscal year and comparison with the previous fiscal year. The tables are followed by a definition of each metric.

Table 1: Summary of the USNDP metrics in FY2001- FY2016, the definitions of the various terms follow the table.

Fiscal Year	USNDP Funding	Change	Compilations	Evaluations	Dissemination (in thousands)	Reports	Papers	Invited Talks
2001			7,139	334	667	21	25	22
2002	$4,890K		6,159	300	799	23	40	22
2003	$4,932K	+0.9%	4,975	260	966	27	40	23
2004	$5,015K	+1.7%	6,241	276	1,212	35	36	43
2005	$5,437K	+8.4%	6,623	422	1,642	74	59	42
2006	$5,099K	-6.6%	4,936	318	1,863	47	60	48
2007	$5,841K	+14.6%	5,355	366	2,239	40	56	51
2008	$5,967K	+2.2%	5,104	385	2,996	48	72	68
2009	$6,267K	+5.0%	4,047	400	3,294	26	61	56
2010	$6,549K	+4.5%	4,662	395	2,843	27	83	51
2011	$6,534K	-0.2%	4,662	479	3,252	29	96	67
2012	$6,785K	+3.8%	5,221	209	3,013	22	90	48
2013	$6,249K*	-7.9%	4,925	282	3,447	29	84	79
2014	$7,031K*	+12.5%	3,738	166	3,411	7	107	81
2015	$7,381K*	+5.0%	4,849	271	4,246	12	98	50
2016	$7,597K*	+2.9%	3,936	375	4,655	7	82	72

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

In particular:

1. **Compilations**: Compilations efforts, including NSR, EXFOR and XUNDL databases, remain basically on the similar level.
2. **Evaluations**: Evaluations efforts, the number of ENDF evaluations is zero since no new releases of the library took place this year, however an important number of evaluation fixes were undertaken. The number of ENSDF evaluations has increased due to the inclusion of newly discovered nuclides. However, the number of nuclides evaluated is still below the critical number, around 330 per year, needed to make sure that every nucleus is evaluated at least every 10 years.
3. **Dissemination**: This year there has remained increased by 9.6%. At BNL, the most popular product continues to be NuDat that contributes nearly 70% of data retrievals.
4. **Papers**: The number of articles has remained relatively constant in the last few years. A selected list of articles published in FY2016is given in Appendix B.
5. **Invited Talks**: The number of invited talks has increased this year, mainly due to the presentations made in the ND2016 conference.

Table 2: USNDP metrics in FY2016, numbers for FY2015 are shown for comparison.

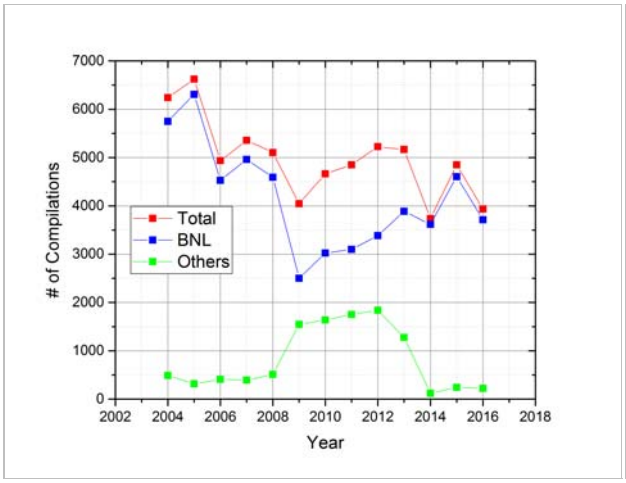
Laboratory	Compilations		Evaluations		Dissemination (in thousands)		Reports		Papers		Invited Talks	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
ANL	110	83	27	32	60	68	0	0	37	24	3	3
BNL[1]	4,605	3712	214	213.5	3,972	4364	3	3	16	13	15	25
LANL	-	-	0	90	-	-	2	1	22	14	17	20
LBNL	45	44	12	23	-	-	0	1	15	23	9	11
LLNL	-	-	-	-	0	0	2	0	0	0	0	7
ORNL	28	39	7	9.5	120	120	1	1	4	4	6	6
Universities	61	58	11	7	94	103	4	4	4	2	0	0
Total	4,849	3,936	271	375	4,246	4,655	12	7	98	82	50	68

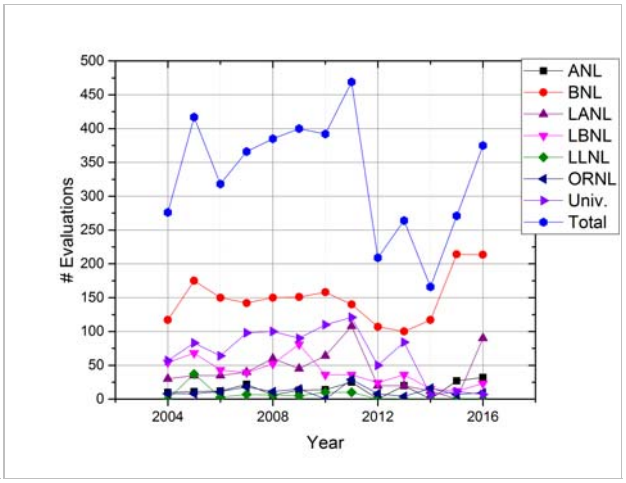
[1]: BNL compilations for FY2016 consist of a) 3,263 NSR articles, including key-words for 1856 of the; b) 126 EXFOR; c) 163 articles encompassing 323 XUNDL datasets. BNL evaluations for FY2016 consist of a) 136.5 nuclides for ENSDF; b) 25 materials for the decay data sub-library in ENDF/B; c) 4 materials for the neutron reactions sub-library in ENDF/B. Applying the prescription developed a number of years ago, this corresponds to an equivalent number of ENDF evaluations of 77. LANL ENDF/B evaluations focused on 6 materials, resulting in an equivalent number of 90 ENDF/B evaluations.

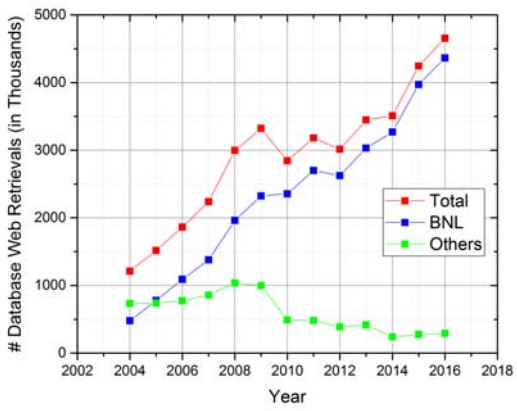
Definitions:

- *Compilations*: The sum of the new entries added to the USNDP bibliographic (NSR - articles) and experimental databases (EXFOR - reactions, XUNDL - structure data sets).
- *Evaluations*: The sum of new evaluations submitted or accepted for inclusion in the USNDP evaluated nuclear databases. For ENSDF, it is the number of evaluated nuclides, while for ENDF, it is the number of evaluated reactions/covariances.
- *Dissemination*: The number of electronic data retrievals made from USNDP maintained web sites. Data retrieval is defined as a request for data from any of the databases that receives a result. Total pages, gifs, etc. accessed is not tallied.
- *Reports*: The number of technical documents (includes papers in conference proceedings) or papers other than journal publications and invited talks. No administrative documents such as meeting minutes are reported.
- *Papers*: The number of articles published in refereed journals.
- *Invited talks*: The number of presentations given at the explicit invitation of the organizers of a conference, symposium, workshop, training course, etc.

The number of compilations, evaluations and database retrievals from 2004 to 2016 are shown in the plots below. As BNL is the main contributor to compilations and disseminations, the contributions of the other centers are shown as 'others'.







II. Network Coordination and Data Dissemination

The National Nuclear Data Center (NNDC) continues to serve as the core facility of the U.S. Nuclear Data Program (USNDP). It has the main responsibility for national and international coordination, database maintenance, and data dissemination. However, other program participants are also involved in coordination and dissemination activities.

National and International Coordination

The NNDC, while serving as the secretariat for the program, has prepared the work plan for FY2016 in cooperation with the members of the Coordinating Committee. The NNDC Head serves as a chair of the USNDP Coordinating Committee, which consists of the Principal Investigators from each of the participating groups, and chairs the annual meeting of the program held at the Brookhaven National Laboratory. LANL chairs the Nuclear Reaction Data Working Group, and LBNL the Nuclear Structure Working Group. ORNL chairs the Astrophysics Task Force and LLNL chairs the Homeland Security Task Force.

In February 2016, DOE Office of Nuclear Physics conducted its annual Budget Briefing. Michal Herman, Toshihiko Kawano, John Kelley, Filip Kondev, Alejandro Sonzogni, Michael Thoennessen and Ian Thompson represented USNDP and made the case for the 2018 funding.

The NNDC serves as the focal point for U.S. collaboration in international nuclear data activities. This collaboration continued both in nuclear structure and decay data (Network of Nuclear Structure and Decay Data Evaluators, NSDD) and reaction data (NEA Working Party on International Nuclear Data Evaluation, WPEC, and Network of Nuclear Reaction Data Centers, NRDC).

The NNDC continues to chair the Cross Section Evaluation Working Group, which produces the ENDF/B evaluated nuclear data library for nuclear science and applied nuclear technology use. As in the past, the 2015 CSEWG meeting was held at BNL. The major topic of the CSEWG meeting was the progress on the CIELO evaluations.

USNDP Databases

The NNDC operates six Dell servers running the Linux operating system to support its compilation, evaluation, database maintenance, and information dissemination functions. These computers archive and serve the nuclear data produced by the U.S. Nuclear Data Program and the data obtained by other national and international collaborations. In addition, the NNDC maintains the collaboration GForge server that facilitates data and codes development and employs Subversion to keep track of changes.

The NNDC maintains seven nuclear physics databases for USNDP. These databases were updated continuously in FY2016 with new and revised information from efforts of the NNDC, USNDP and international collaborators. Distributions of all or parts of these databases have been made to national and international collaborators as scheduled.

Data Dissemination

In FY2016, there were 4,655 million database retrievals, about 9.6% higher than the number of retrieval in the previous year. Most of these retrievals, 95%, were from the NNDC web site, with NuDat as the most popular product.

Major Publications

USNDP continues to publish the refereed journal Nuclear Data Sheet, 8 issues were published this fiscal year, 7 dedicated to ENSDF evaluations and one issue devoted to nuclear reactions.

Workshop on Nuclear Data Needs and Capabilities for Basic Science
University of Notre Dame, August 10-11, 2016

Following on a recommendation by the Nuclear Data Advisory Committee, the US Nuclear Data Program organized a Workshop on Nuclear Data Needs and Capabilities for Basic Science that took place on August 10-11, 2016 at the University of Notre Dame. The purpose of this targeted workshop was to assemble and prioritize the needs of the nuclear physics research community for data sets and capabilities in areas including Nuclear Structure, Nuclear Reactions, Nuclear Astrophysics, Fundamental Interactions, Neutrino Physics and Nuclear Theory. More than 87 participants from 33 different institutions attended the workshop. The workshop program is available at http://meetings.nscl.msu.edu/2016ND_workshop/html/program.html, together with copies of the presentations. The nuclear data needs and capabilities presented at this meeting are being summarized into a whitepaper document. It will contain specific recommendations that will be used by the DOE Office of Science/Nuclear Physics office to guide future nuclear data activities in those areas that directly benefit the broader nuclear physics research community.

III. Nuclear Structure and Decay Data

The nuclear structure working group emphasizes the evaluation of measured nuclear structure and decay properties for all isotopes. These data are maintained at the National Nuclear Data Center (NNDC) in the Evaluated Nuclear Structure Data File (ENSDF). Production of ENSDF is an international effort operating under the auspices of the IAEA Nuclear Structure & Decay Data (NSDD) network. ENSDF is an important source of information for derivative databases and applications including NuDat, Nuclear Wallet Cards, RIPL, MIRD and ENDF/B. Evaluations are published as peer-reviewed articles in Nuclear Data Sheets for A>20 and in Nuclear Physics A for A = 20. Nuclear Science Reference (NSR) and Experimental Unevaluated Nuclear Structure Data List (XUNDL) have been kept up-to-date. The combination of ENSDF and XUNDL database represents nearly a complete experimental nuclear structure data of the literature, which is a salient feature of these databases.

Status of ENSDF & Nuclear Data Sheets: The ENSDF database has increased in size by roughly ~1.5% over the past year. Presently there are 3312 nuclides in the database, compared to 3296 of FY2015. The total number of datasets is 18752. In this fiscal year, 15 mass chain evaluation articles were published in the Nuclear Data Sheets, while 12 mass chains were submitted for review and publication. A total of ~219 evaluated nuclides were submitted, which includes nuclides both from 12 mass chains (~157 (US) + 12 (non-US)) and individual (~50) evaluation for ENSDF update. The number of mass chains in the review/publishing process is listed as 23. An additional 26 mass chains and A260-266 group are listed as currently being evaluated. General usage statistics for ENSDF and products derived from ENSDF (Nuclear Data Sheets, NuDat, etc.) shows a high usage and popularity on the NNDC website and the Elsevier site.

The network works for an ideal target to revise all the mass chains within a time frame of 10 years, which would yield an average life between 5 to 5.5 years for each mass chain. In reality, the average life of a mass chain was 6.8 years at the end of FY2004, which has now increased to 8.7 years in FY2016. Here it should be noted that the size of the ENSDF database has increased from 148 MB to ~212 MB, an increase of about 43%, from FY2004 to FY2016. The total effort for ENSDF database remained nearly the same in the US, combining permanent and temporary (postdoc/contracts) staff, however, the non-US effort has been dropped in recent years.

Since April 30, 2016, E.A. McCutchan at NNDC, BNL has taken the responsibility of ENSDF database, its maintenance, and processing of new and existing evaluations. Also she has been appointed as the editor of Nuclear Data Sheets.

Status of XUNDL: Based on regular scanning of nuclear physics journals, 550 datasets were compiled from 289 papers. Communications with the authors were being made to resolve many data-related issues and obtain additional data in support of their findings. As of Oct 31, 2016, XUNDL contains compiled experimental nuclear structure data from more than 3500 papers. Since October 1, 2015, E.A. McCutchan at NNDC, BNL has taken up the responsibility of coordination of XUNDL effort.

Status of NSR: In FY16, 3263 new articles were added to the NSR database and the database contains a total number of 222684 articles. USNDP contributions are from B. Pritychenko (manager), E. Betak, B. Singh, and J. Totans. The database is up-to-date and in good shape. The database now contains a total of 6415 nuclides and 7904 reactions, of which new entry of 408 nuclides and 225 reactions were made in this fiscal year. The number of NSR web retrievals was 442175.

Horizontal Evaluations and Other Data Related Activities: A summary list of "Horizontal Evaluations and Other Data Related Activities" involving USNDP structure evaluators includes the following.

- IAEA technical meetings on ENSDF evaluation and analysis codes: Kondev, Singh, Tuli
- IAEA-CRP on Delayed Neutron Emission Probabilities: Singh, Sonzogni, McCutchan, Johnson.
- IAEA-CRP on Nuclear Data for Charged-Particle Monitor Reactions and Medical Isotope Production: F. Kondev,
- IAEA-CRP on Updating Photonuclear Data Library and Generating a Reference Database for Photon Strength functions: Firestone
- IAEA consultant's work on evaluation of fission yields, which may turn into a CRP: Sonzogni
- The Atomic Mass Evaluation effort (AME) and NuBase: Kondev
- Atlas of Nuclear Isomers: Singh
- B(E2) evaluation for first 2+ states in all the e-e nuclei: Pritychenko, Singh
- Horizontal evaluation of beta-delayed proton emitting nuclei: Batchelder
- Update of 1998Ak04 table of r0 radius parameter: Singh, Dhindsa
- nucastrodata.org and the Computational Infrastructure for Nuclear Astrophysics (CINA): M. Smith,
- Compilation of current papers on mass measurements on a yearly basis and make data file available on nuclearmasses.org: Singh

Other contributions: In recent years due to shrinking resources and retirement of supporting staff at NNDC, the ENSDF evaluators are expected to play a greater role in preparation of the print-ready manuscripts for review and publication in the Nuclear Data Sheets. In this fiscal year, motivated by IAEA technical meetings, significant development has been made in McMaster's JAVA-NDS code by Jun Chen, which is not only useful to prepare the print-ready documents for Nuclear Data Sheets, but also incorporates many recommended changes for the print-ready document. A two and a half-day workshop was organized at TUNL (May 9-11, 2016) by Prof. John Kelly to discuss various issues for this code by evaluators. The code is being used on test for the print-ready document and passing through debugging phases.

Status of ENSDF Analysis codes: In recent years there has been extended discussion on the present state of ENSDF analysis codes. Some codes has been either rewritten/developed, like JGAMUT, V_Ave, GABS, etc. RULER code is known to have bugs and is being rewritten and repaired. The IAEA has sponsored technical meeting on ENSDF evaluation codes.

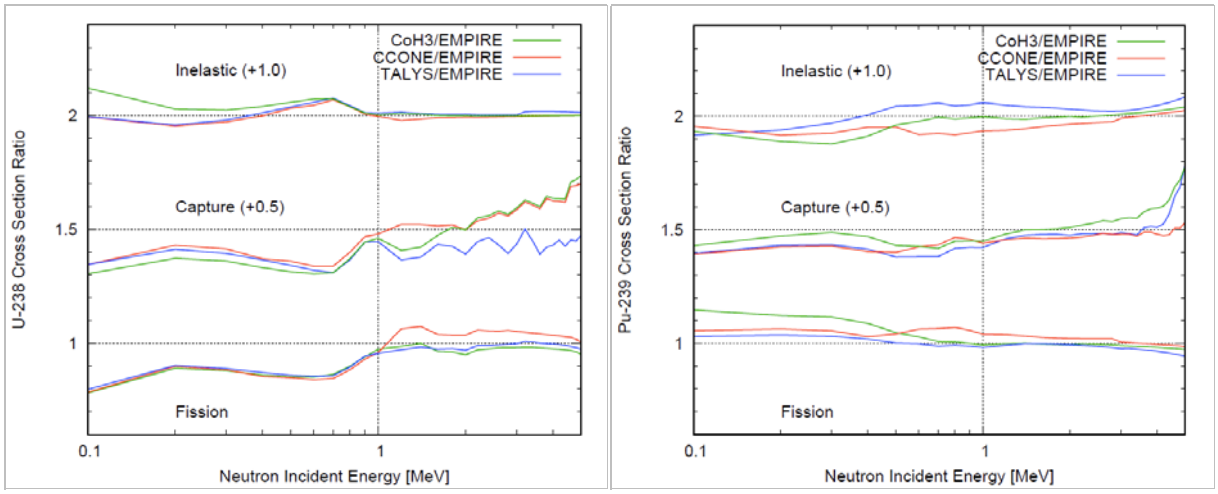
IV. Nuclear Reaction Data

The nuclear reaction data effort focuses on evaluation of nuclear reaction data and the related measurement and compilation activities. The USNDP also makes important contributions to nuclear reaction model code development and improvement of reaction cross-section standards.

Reaction Data Highlights

Two major progresses in the statistical Hauser-Feshbach theory have been made at LANL. The width fluctuation model was extensively studied with the Monte Carlo approach to the Gaussian Orthogonal Ensemble (GOE), and this technique was extended to the case where strongly coupled channels exist. A new model for the statistical theory was developed in collaboration with CEA and IAEA, and the model has been implemented in the Hauser-Feshbach code, CoH3 at LANL, TALYS at CEA. The same model is to be implemented in EMPIRE at BNL/IAEA.

We performed, first time, a detailed inter-comparison of the Hauser-Feshbach codes, CoH3, EMPIRE, TALYS, and CCONE. It was reported at ND2016 that the discrepancy among these codes is less than 10% when well-defined and consistent input parameters are employed. The comparison for 238U and 239Pu can be seen in the plots below.



The worldwide collaborative effort to modernize the ENDF nuclear data format was profiled in the Sep. 2016 issue of Science and Technology Review (https://str.llnl.gov/september-2016/beck). In response to the long-recognized need for modernization, a far more capable and flexible format called Generalized Nuclear Data (GND) has been developed, originally at LLNL. Later an international collaboration Subgroup 38, led by LLNL and BNL, was formed under the auspices of OECD/NEA Working Party on Evaluation Cooperation. BNL has produced a detailed document (BNL Report BNL-112394-2016-IR) through the corporation of international nuclear data community under Subgroup 38.

The GND format was significantly utilized in two major projects at LLNL. The first project was to translate the Evaluated Charged Particle Library (ECPL) developed at LLNL into the ENDF-6 format that is widely adopted in the nuclear data communities in the world. The second area was to use GND as an exchange medium to translate the R-matrix parameters between the different data format files formats as well as R-matrix codes.

Standards for the next version of a number of cross section libraries, including ENDF/B-VIII, have been produced with important contributions by both LANL and NIST staff. In addition to the traditional neutron data standards, evaluations performed include very high energy fission reference cross sections, gamma-ray production reference cross sections, the capture cross section of gold at energies below 200 keV, as well as neutron spectrum results for the spontaneous fissioning of 252Cf and the fissioning of 235U with thermal neutrons.

Nuclear Astrophysics highlights

At ORNL, two new reaction rate collections were converted into the REACLIB database format using a customized processing code. This required fitting a set of ordered pairs of (temperature, rate) where the rate varies over 30 orders of magnitude. We were able to perform this fitting to 2% over the entire relevant temperature range. A paper on this effort will be submitted soon. A second ORNL effort is an assessment of the cross section of the 19F(alpha,n) reaction which plays an important role in the creation of the long-lived radioisotope 22Na, a target of gamma-ray astronomy. At LANL, global calculations of beta-delayed neutrons yields performed, and a PRC paper was submitted. The photon strength functions for M1 scissors mode were estimated from a large number of deformed nuclei, and showed the impact on the neutron capture rate calculations at the 2016 Nuclei in the Cosmos symposium in Niigata, Japan. At BNL, neutron cross sections in the TENDL-2015 library were converted into Maxwellian-averaged cross sections (MACS) and reaction rates for 2809 materials. This is the first such rate library from the nuclear data community that covers the entire slow neutron capture process (s-process).

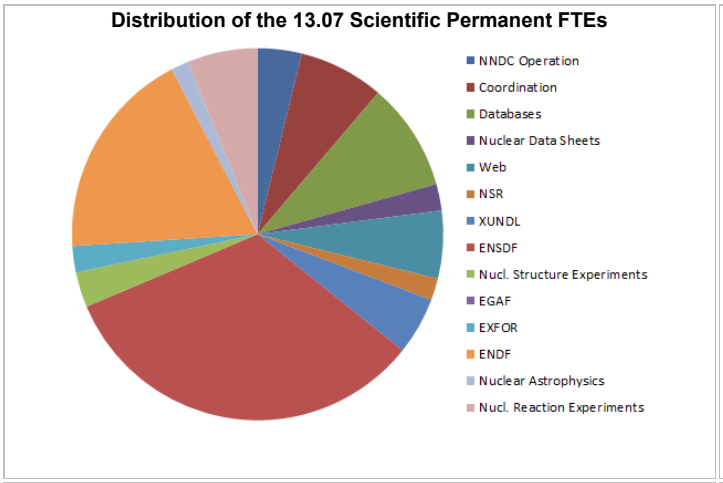
USNDP Staffing table FY2016

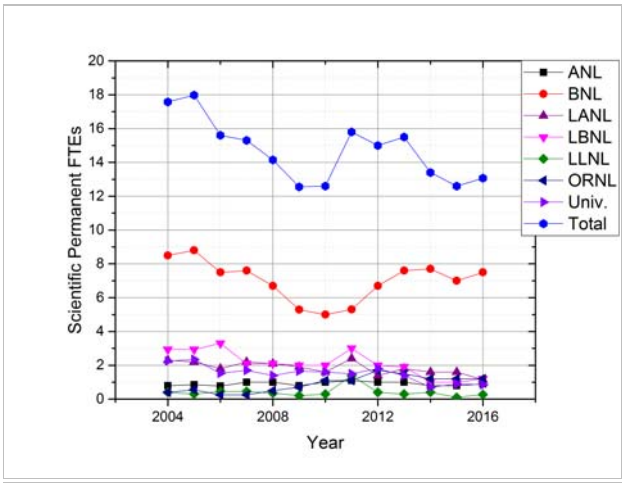
	ANL		BNL			LANL		LBNL		LLNL		NIST		ORNL			TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	PhD P	PhD T	PhD P	PhD T/A	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	T/A	
I. NNDC Facility Operation	0.00	0.00	0.50	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30
Management	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Secretarial/Administrative Support	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.00
Library	0.00	0.00	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Computer Operations	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50
II. Coordination	0.10	0.00	0.45	0.00	0.00	0.15	0.00	0.10	0.60	0.07	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.00	1.57
National Coordination	0.05	0.00	0.24	0.00	0.00	0.05	0.00	0.10	0.50	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.05	0.00	0.00	1.09
International Coordination	0.05	0.00	0.21	0.00	0.00	0.10	0.00	0.00	0.10	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.48
III. Nuclear Physics Databases	0.00	0.00	1.13	0.00	0.70	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.93
Nuclear Science References, NSR	0.00	0.00	0.25	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85
Exper. Nucl. Structure Data, XUNDL	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Eval. Nucl. Structure Data, ENSDF	0.00	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30
Numerical Nuclear Data, NuDat	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Experimental Reaction Data, CSISRS	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Evaluated Nuclear Data File, ENDF	0.00	0.00	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18
Database Software Maintenance	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Future Database System Develop.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
IV. Information Dissemination	0.00	0.00	1.02	0.15	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.55	2.07
Nuclear Data Sheets	0.00	0.00	0.30	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.65
Customer Services	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
Web Maintenance & Development	0.00	0.00	0.72	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.10	0.00	0.00	0.35	1.32
V. Nuclear Structure Physics	0.80	1.00	2.20	2.05	0.00	0.00	0.00	0.90	1.60	0.00	0.00	0.00	0.00	1.00	0.15	0.25	0.70	0.60	0.20	11.45
NSR Abstract Preparation	0.00	0.00	0.25	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65
Compilation of Exper. Structure Data	0.05	0.10	0.20	0.30	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.20	0.00	0.25	0.10	0.00	0.00	1.40
Eval. of Masses & Nuclides for ENSDF	0.40	0.50	1.35	1.35	0.00	0.00	0.00	0.80	0.60	0.00	0.00	0.00	0.00	0.80	0.15	0.00	0.30	0.40	0.10	6.75
Ground & Metastable State Properties	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.75
Radioactive Decay Data Evaluation	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Thermal Capture Gamma Data Eval.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
Light Mass Eval. for Nucl. Physics A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.20	0.10	0.60
Nuclear Structure Data Measurement	0.10	0.00	0.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.40
ENSDF Evaluation Support Codes	0.00	0.40	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.50

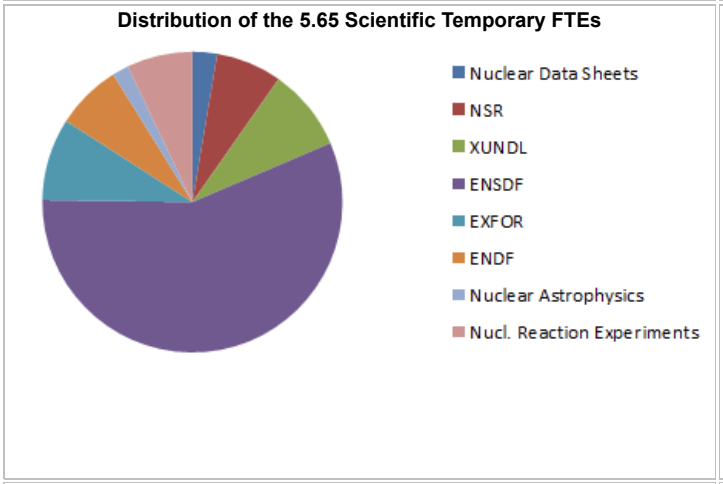
	ANL		BNL			LANL		LBNL		LLNL		NIST		ORNL			TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	PhD P	PhD T	PhD P	PhD T/A	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	T/A	
VI. Nuclear Reaction Physics	0.00	0.00	2.20	0.50	0.30	1.00	0.40	0.20	0.40	0.10	0.00	0.10	0.10	0.10	0.00	0.05	0.00	0.00	0.00	5.45
Experimental Data Compilation	0.00	0.00	0.30	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.80
ENDF Manuals and Documentation	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.10
ENDF Evaluations	0.00	0.00	0.90	0.00	0.00	0.20	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14
Nuclear Reaction Standards	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Nuclear Model Development	0.00	0.00	0.30	0.00	0.00	0.10	0.30	0.00	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.73
Nucl. Reaction Data Measurements	0.00	0.00	0.00	0.00	0.00	0.60	0.00	0.20	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.20
Astrophysics Nuclear Data Needs	0.00	0.00	0.05	0.00	0.00	0.05	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10	0.00	0.05	0.00	0.00	0.00	0.35
Covariances development	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11
Reactor anti-neutrino & decay heat calculations	0.00	0.00	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Verification and Validation	0.00	0.00	0.20	0.00	0.30	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.52
DOE-SC Nucl. Data Funded Staff	0.90	1.00	7.50	2.70	3.00	1.15	0.40	1.20	2.60	0.27	0.00	0.10	0.10	1.20	0.15	0.40	0.75	0.60	0.75	24.77
Staff Supported by Other Funds	0.10	0.00	0.30	0.00	0.00	7.85	0.60	0.00	0.00	1.30	0.00	0.10	1.30	0.00	0.00	0.00	0.00	0.00	0.00	11.55
TOTAL STAFF	1.00	1.00	7.80	2.70	3.00	9.00	1.00	1.20	2.60	1.57	0.00	0.20	1.40	1.20	0.15	0.40	0.75	0.60	0.75	36.32

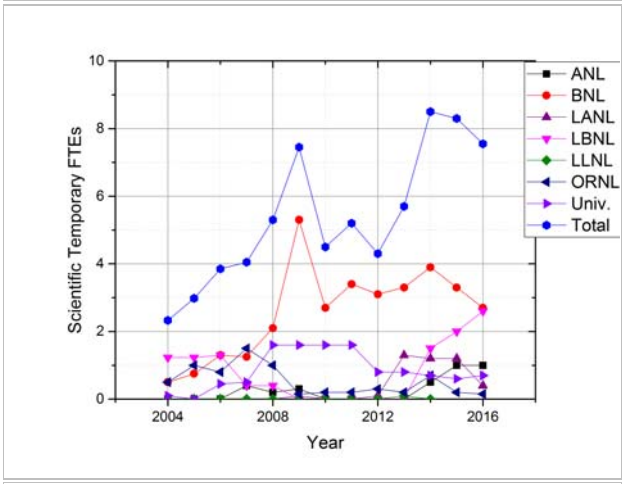
PhD P: PhD Permanent,
PhD T: PhD Temporary, includes post-docs and scientists working under contract,
T/A: Technical and administrative,
GS: Graduate student.

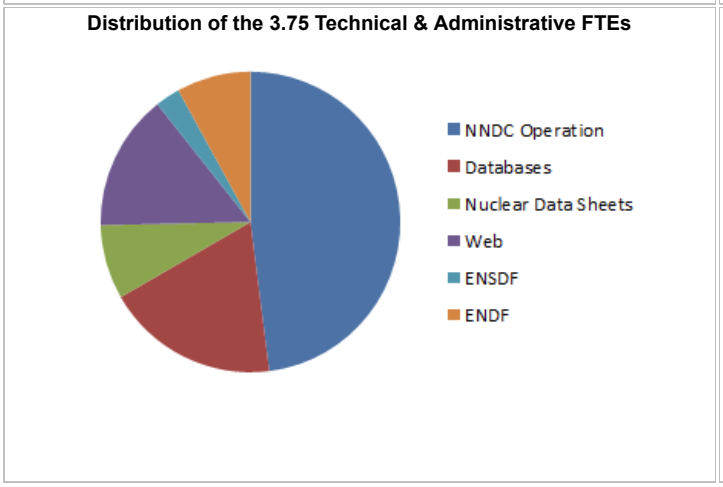
USNDP FTE plots

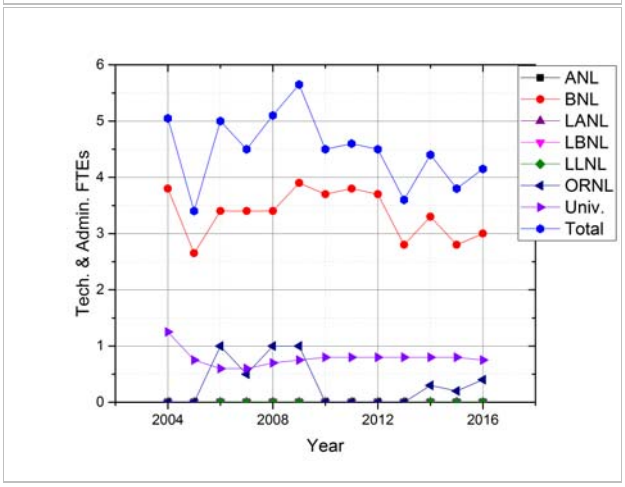












Detailed Status of the Work Plan
Fiscal Year 2016 Report

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	Status
Ensure full compliance of NNDC computers with DOE cyber security requirements through regular scanning and prompt remediation of discovered vulnerabilities to prevent suspension of its network access. Full compliance guarantees continuous availability of mission-critical NNDC services.	NNDC servers passed two security audits conducted by the DOE Inspector General in May and September 2016. This ensured continuous availability of NNDC Web Services, the USNDP community collaboration server (GForge) and the nuclear data continuous quality assurance server (ADVANCE).
Provide prompt and effective technical computer support to NNDC staff, visitors and external collaborators in their use of NNDC computing resources.	Installed and configured a new Linux server, 3 Linux workstations and a Windows PC for use in the DOE Summer Science Undergraduate Laboratory Internship and the Visiting Faculty Program (VFP). Provided technical computer support thereafter.
Upgrade the suite of software running on the development/working server, the GForge server, the NNDC internal Web server, the ADVANCE server and the Linux cluster to meet NNDC's and the nuclear data community's growing computing requirements.	Installed software updates and security patches on GForge server, development server, ADVANCE server and the Linux cluster. The updates included bug fixes and new functionalities essential to NNDC's application development activities.

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	Status
Organize and chair the CSEWG Covariance Committee	Completed
Unplanned: Organize a workshop on Nuclear Data Needs and Capabilities for Basic Science	Completed. The workshop took place on August 10-11, 2016 at the University of Notre Dame

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

BNL planned activities	Status
Prepare FY2017 work plan for USNDP.	Completed. Work plan finished after budget briefing and published online.
Organize and chair CSEWG Meeting at BNL in November 2015.	Completed, CSEWG took place during November 2-4, 2015.
Organize and chair USNDP Meeting at BNL in November 2015.	Completed, USNDP took place during November 4-6, 2015.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.	Completed. All documents available online.
Maintain CSEWG and USNDP websites.	Continuing task. Web sites are up to date.

Organize mini-CSEWG meeting in the summer if needed.	This year mini-CSEWG was organized by LANL.

LANL: Chair Evaluation and Validations Committees of the Cross Section Evaluation Working Group.

LANL planned activities	Status
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2015.	Completed
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2015.	There was no nuclear reaction working group meeting at USNDP in 2015 due to change in the agenda.

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	Status
Work with the NNDC to improve the efficiency of nuclear structure data evaluation and better integrate US efforts with other nuclear data activities.	Continuing
Coordinate EGAF Capture Gamma-ray Library evaluations with LLNL for preparation of ENDF format datasets and improved RIPL files.	EGAF - continuing - but preparation of ENDF and RIPL files were not done for budget issues.
Coordinate the West Coast collaboration to measure and evaluate neutron cross section measurements at the LBNL Cyclotron, UC Berkeley Department of Nuclear Engineering, and National Ignition Facility neutron facilities.	Continuing
Unplanned activity: Serve as a USNDP representative in the Nuclear Data Working Group (NDWG) that was formed following the NDNCA workshop at LBNL. Author the Conversion Electron and Neutron Spectroscopy for Understanding Scattering Proposal (CENSUS) and present it at the first Nuclear Data Exchange Meeting at DNDO headquarters in Washington on 4/14/16. The proposals and presentations can be found online here.	Continuing

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

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

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	Status
Communicate current efforts and future plans with researchers in nuclear astrophysics and nuclear astrophysics data.	Organized session on nuclear astrophysics at the Nuclear Data for Basic Research workshop, and initiated lengthy discussions on future nuclear astrophysics data activities within the USNDP with US-based nuclear astrophysics researchers
Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data and in "town meetings", community meetings, and summer schools.	Gave invited presentation on US efforts in nuclear astrophysics data in Korea, and initiated discussions with colleagues in Korea and China on future collaborative efforts; represented USNDP efforts in nuclear astrophysics data in draft of White Paper section on nuclear astrophysics data for the Nuclear Data for Basic Research workshop
Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.	Discussed the synergy of nuclear astrophysics data efforts and NNSA research interests with NNSA funding officers
Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, and with other funding agencies.	recommended future USNDP efforts in nuclear astrophysics data in draft of White Paper section on nuclear astrophysics data for the Nuclear Data for Basic Research workshop

B. International Coordination

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

ANL planned activities	Status
Participate in the IAEA Coordinated Research Project on "Nuclear data for charged-particle monitor reactions and medical isotope production"	Completed. Presented a talk at the meeting.
Host several international visitors to ANL to collaborate on nuclear data research projects	None were hosted, due to lack of funding.

Unplanned: Lecturer at the Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Experiment, Theory and Evaluation, 22 August - 2 September 2016, Trieste	Two lectures were prepared and presented at the workshop. Participated in the workshop hands-on activities.
Unplanned: Participated in the IAEA-organized technical meeting on “Fission Yield: current status and perspectives in measurements, theory and evaluation”	Completed. Presented a talk at the meeting.

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 vice-chair 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 sponsored activities such as Workshops and Technical Meetings.

BNL planned activities	Status
Participate in the IAEA-sponsored NRDC meeting in FY2016.	Two NNDC representatives attended the NRDC 2016 meeting and presented three talks. M. Herman chaired the meeting.
Participate in NEA WPEC annual meeting in FY2016.	Two NNDC representatives attended the May 2016 WPEC meeting in Paris and presented several talks in the Subgroup 40 (CIELO) session and co-organized the Subgroup 38 sessions and presented several talks. M. Herman chaired the WPEC meeting.
Participate in IAEA organized network coordination meeting NSDD.	n/a (NSDD hasn't been held this year)
Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work (McMaster).	Mentoring of Dr. S. Pascu in Bucharest is continuing with B. Singh with work on the evaluation of A=130 nuclei. If the local funds in Bucharest permit, Dr. Pascu may visit McMaster for 2 weeks in summer 2017
Unplanned activity: Draft new format requirements as part of Subgroup 38 activities. The new format will serve as a modern replacement for the ENDF format.	The complete top high level hierarchy requirements for the new format was finalized in June 2016 as BNL Report number BNL-112394-2016-IR.
Complete the 56Fe evaluation within the NEA-WPEC Subgroup 40 project.	Two beta versions have been submitted to ENDF and CIELO in FY2016. Further revisions will continue in FY17.
Unplanned activity: Participate in IAEA organized INDC meeting	M. Herman attended and chaired the INDC meeting in Vienna in June 2016.
Unplanned activity: IAEA-ENSDF codes meeting, October 2015	B. Singh and M. Birch from McMaster gave two formal presentations: 1. McMaster-MSU JAVA-NDS code. 2. JAVA-GAMUT and enhanced V-AVELIB code.
Unplanned activity: IAEA-ICTP ENSDF workshop Aug 22-Sept 2, 2016	E.A. McCutchan acted as Co-director of workshop, participating in organization of program and coordination of hands-on exercises. E.A. McCutchan gave three lectures and tutored in ENSDF exercises. B. Singh gave two lectures. Tutored for both weeks in XUNDL and ENSDF exercises. J.K. Tuli gave two lectures and tutored for one week in XUNDL exercises. Completion of these exercises for submission to the respective databases is continuing.

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	Status
Participate in NEA-WPEC 2016 meeting	Several LANL scientists participated in WPEC meeting in 2016.
Participate in relevant IAEA coordinated meetings, such as reference input parameter library and nuclear cross section standards.	LANL scientists participated in two IAEA meetings, the nuclear cross section standards, and the photo-reaction data library.
Co-organize and participate in the workshop on compound nucleus and related topics, CNR15, Oct 19-23, 2015, Tokyo	LANL co-organized CNR15 in Tokyo, and there were 4 LANL participants.
Make latest version of NJOY data processing code available to the international community.	The latest NJOY made available to the user community.
Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.	We hosted two international scientists, one JAEA in Japan and one from CEA in France. Our collaboration was on the reaction theory development, particularly on the R-matrix theory and the Hauser-Feshbach theory.
Serve International Committee members of International Conference of Nuclear Data for Science and Technology, Belgium, Sept. 2016	We served the international committee members for ND2016.

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

LBNL planned activities	Status
Coordinate EGAF and RIPL evaluations with the IAEA.	Continuing

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.	Continuing - IAEA CRP initiated.
Coordinate LBNL/Budapest/FRM-II/Julich TransActinide Nuclear Data Evaluation and Measurement (TANDEM) collaboration to measure actinide neutron cross sections.	Not continued due to other projects.

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

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

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	Status
Distribute database to collaborators.	NSR database is distributed to the IAEA on a monthly basis.
Provide international coordination of NSR compilations and activities.	NSR compilations were coordinated internationally.
Database updates and maintenance.	The database was maintained regularly.
Continue work on NNDC library publications digitization and Web access projects.	In collaboration with the IAEA NNDC has provided Web access to NSR documents. The scanning work at the NNDC is in progress.
Continue cooperation with NRDC network on the transfer of 6,000 EXFOR nuclear reaction references to NSR.	Approximately 1200 major journal publications were added to NSR.

B. Experimental Nuclear Structure Data (XUNDL)

The NNDC is responsible for maintaining, disseminating and coordinating the XUNDL database. This database contains compilations (in ENSDF format) of recently published or completed nuclear structure and decay data.

BNL planned activities	Status
Weekly update of the database using input received from compilers.	The database was regularly updated
Distributed twice a year to the NSDD network.	The database was distributed to the network.
Take over management of the XUNDL library.	BNL assumed the responsibility of XUNDL coordination on October 3, 2016

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	Status
Maintain ENSDF database, includes continuous updating.	The database was regularly updated.
Process evaluations received from NSDD evaluators.	All evaluations received from NSDD network were processed.
Distribute ENSDF database to collaborators twice a year.	Database was distributed via email and made available on NNDC website.

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	Status
Update NuDat database as necessary, about 10 times a year.	Continuing, NuDat was updated regularly.

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, CSISRS. The database is maintained by the Nuclear Data Section, IAEA Vienna.

BNL planned activities	Status
Contribute to CINDA by compiling experimental cross-section data to the EXFOR and NSR databases.	CINDA database was maintained using EXFOR and NSR database contents.

F. Experimental Reaction Data File (CSISRS)

The NNDC is responsible for maintaining the 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 ≤ 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	Status
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.	The NRDC network has added 479 new article compilations. 737 existing compilations were modified.

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-VII.1, are assembled, tested and made available to users through NNDC's Web servers and GForge collaboration server.

BNL planned activities	Status
Maintain Linux/MySQL database system.	Continuing.
Maintain GForge/Subversion system for tracking development of the ENDF/B library.	Continuing.
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).	Continuing.
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.	Continuing.

H. Database Software Maintenance

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

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

I. Database Systems Development

This acivity includes updating database schema, maintanace of the existing content and addition of new data.

BNL planned activities	Status
Upgrade the Linux/MySQL server software to fix bugs, provide new functionalities and improve the system's performance, security and reliability.	Installed MySQL Server software updates and security patches to fix bugs, provide new capabilities and remain compliant with DOE cyber security requirements.
Maintain the software for automatic replication of updates from the internal MySQL database server to the external to continuously comply with DOE cyber security requirements.	Deployed high-priority updates for the MySQL automatic replication software.

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 five Dell servers, each one has dual 2.9-GHz 8-core processors, 128-GB RAM and 15k-RPM disk drives Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

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

BNL Planned Activities	Status
Continued improvement to the ENSDF, NSR, NuDat and Sigma web interfaces.	Enhancements were added to the ENSDF/XUNDL web application, based on user requests, and included some changes in look and feel. There were also 5 webtrend.pl fixes/enhancements, and 50 web application checkins.
Maintain web interfaces for ENDF and EXFOR databases.	Continuing.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users requests.	These sites have been kept current. There were 161 checkins (svn tag copies excluded).
Continue to maintain the NNDC Web Services availability on the 99% and higher level.	This was achieved, partially using the heartbeat script and investigating issues as they arise.
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.	This was done, without about 100 vulnerabilities investigated, and several which were not false positive, have been addressed.
Maintain GForge server powering NNDC collaboration services.	Continuing.
Begin modernization of the web site, following industry best practices.	Designed and implemented the web search application, utilizing industry standard tools. Work continues on other modernization aspects.

ORNL Planned Activities	Status
Expansion of features of our online software suite that supports the new mass evaluation effort, including new evaluation tools and dissemination capabilities; this activity is at risk of termination.	Due to lack of funding for this work, only minor upgrades of the content of our online software systems were possible in FY16

TUNL Planned Activities	Status
Continue to improve the TUNL website and provide access to new information on A = 3 - 20 nuclei.	Continuing
Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.	Continuing
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.	We have completed FAS reviews from year 1970 to 1975.
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.	Continuing
Provide compiled and evaluated data on the decay of unstable ground states and on structure data from thermal neutron capture.	Continuing
Provide compiled data related to the level parameters for A = 3 - 20 nuclei populated in proton- and alpha-particle-induced reactions.	Continuing
Provide online access of TUNL dissertations collection.	Essentially completed and includes all presently available documents.

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	Status
Provide technical support to nuclear data end-users as necessary.	Continuing. About 200 emails were answered.
Maintain Comments/Questions for all databases and web products.	Continuing.

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	Status
Prepare issues of Nuclear Data Sheets for publication.	7 issues of Nuclear Data Sheets were prepared and submitted to Elsevier for publication.
Work on new version of Nuclear Wallet Cards.	Incorporated new evaluation information from beta-n evaluation, and recent evaluations into updated Wallet Card file.
Develop software for Nuclear Data Sheets publication (McMaster)	Throughout 2015-16, participated in checking of .pdf journal quality outputs of JAVA-NDS computer code. Proposed several changes which have been incorporated by Dr. J. Chen at MSU. Participated in TUNL meeting in May 2016, where McMaster-MSU JAVA-NDS code was approved for publication of NDS starting in 2017.

TUNL Planned Activities	Status
Assist with preparation of print-ready manuscripts for review and publication in Nuclear Data Sheets.	We hosted a meeting in May 2016, where McMaster-MSU JAVA-NDS code was approved for publication of NDS starting in 2017.

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	Status
Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them.	3263 NSR abstracts were prepared and 1856 were keyworded. 859 existing entries were modified. 1750 new authors, 7 new journals, 225 new reactions, and 408 new nuclides were added to NSR dictionaries.
Strengthen cooperation between NSR and EXFOR database compilation activities.	The compilation activities between NSR and EXFOR were well coordinated.
Analyze NSR database content for nuclear science development and authorship trends. Coordinate this effort with EXFOR database if necessary.	NSR database contents were analyzed for authorship trends. The results have been published in Journals of Scientometrics.

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, BNL, ORNL, and TUNL, while the NNDC is managing and maintaining the database.

ANL Planned Activities	Status
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.	84 compilations for the XUNDL database were completed

BNL Planned Activities	Status
Compile new B(E2) experimental data. Continue work on a B(E2) evaluation project (in collaboration with McMaster and Central Michigan Universities). Publish a new evaluation for even-even nuclei, analysis of experimental data and Grodzin's fits.	28 new B(E2) values were compiled. The complete B(E2) evaluation and analysis of experimental results have been published in ADNDT and NPA, respectively. Grodzins systematics analysis is in progress.
Compile new double-beta decay experimental data. Evaluate precision of double-beta decay experimental half-lives and nuclear matrix elements.	17 new double-beta decay nuclei and 53 decay modes were compiled. The precision of experimental half lives and nuclear matrix elements has been analyzed and results are published in Journal of Physics G.
Maintain, update and distribute XUNDL.	Continuing.
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)	189 datasets from 84 current papers were compiled for XUNDL at McMaster. As usual, communications with the original authors have continued throughout 2015-16, and quite a lot additional data received from the authors in support of their publications. Additionally, 17 papers published in 2014-2015 on mass measurements were compiled and data file for 90 nuclides was made available on nuclearmasses.org webpage maintained by M.S. Smith at ORNL. 79 datasets from 39 papers were compiled at BNL.

LBNL Planned Activities	Status
Compile nuclear structure data for the XUNDL database.	Compiled 44 XUNDL datasets from 19 published articles.

ORNL Planned Activities	Status
Compile XUNDL datasets as required.	40 XUNDL datasets were compiled in FY16

TUNL Planned Activities	Status
Compile datasets for current experimental nuclear structure data publications on A=2-20 nuclei for inclusion in the XUNDL database.	58 XUNDL datasets were compiled in FY16

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	Status
Evaluate at least 1 mass chain from the ANL region of responsibility.	Evaluation of A=138 and 188 mass chains were completed and submitted to NNDC for subsequent review and publication in Nuclear Data Sheets
Review mass chain evaluations, as requested.	One mass chain was reviewed.
Collaborate with scientists from other NSDD network centers on data evaluation projects.	Collaborated with scientist from University of Jyvaskyla and US Naval Academy on the A=188 mass chain evaluation

BNL Planned Activities	Status
Continue mentoring new ENSDF evaluators.	Participated in IAEA-sponsored ICTP workshop.
3.0 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).	A=227 (ICTP workshop), 189 (with Tim Johnson) and 172 (with Tibor Kibedi) were submitted; McMaster group's share is 7 nuclides for A=227 + coordination; 61/2 nuclides for a=189, and all the 16 nuclides for a=172. In addition 54 individual nuclides were updated at McMaster for ENSDF for either as new nuclides or where excited-state data first became available. Collaboration with a new evaluator Dr. S. Pascu at Bucharest with work on A=130 is continuing at McMaster. A=158 mass chain was reviewed at McMaster. BNL submitted A=136 and A=99. BNL reviewed A=140 and A=26.
All evaluations submitted for publications are edited including checking for their format and physics content. Extensive changes are often made by NNDC staff.	Continuing.

LBNL Planned Activities	Status
Evaluate the equivalent of at least 3 mass chains (30 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.	Evaluated A=26 (9 nuclides) and published in Nuclear Data Sheets and submitted A=193 (14 nuclides) for review and publication.
Review mass-chain evaluations, as requested.	Reviewed one mass chain
Train new compilers/evaluators.	Continuing
Coordinate XUNDL evaluation efforts with UC Berkeley/LBNl/LLNL Nuclear Data Collaboration.	Continuing
Unplanned activity: Developed an ENSDF2XML parser and new XML data format that is compatible with the GND format. ENSDF2XML accommodates all of the ENSDF inputs except for continuation records.	ENSDF2XML is functioning and A.M. Hurst will coordinate future efforts on this with the LLNL group working on GND.

ORNL Planned Activities	Status
3.0 equivalent mass chains and the data for new nuclides (as mentioned below) will be evaluated. Mass chains will be reviewed as requested.	evaluated A=244 with 9 nuclides, 215 adopted levels; publication of A=133 evaluation in FY16.

TUNL Planned Activities	Status
Evaluate about 1-2 A-chains per year for publication in Nuclear Data Sheets and inclusion in the ENSDF database.	A=12 ENSDF file is in progress.
Evaluate and update ENSDF for A=2-20 near drip-line nuclides, especially for first observations or when ENSDF has no previous data set.	We have submitted 7 nuclide evaluations.
Update various reaction data sets in ENSDF, such as for beta-decay and beta-delayed particle emission.	Continuing

D. Ground and Metastable State Properties

ANL Planned Activities	Status
Contribute to the development of the Atomic Mass Evaluation and NUBASE databases in collaboration with CSNSM, Orsay, IMP, Lanzhou and RIKEN, Japan	Continuing. The new AME2016 and NUBASE2016 evaluations are near completion and will be published in February 2017.
Unplanned: Publish a review article of metastable states in heavy nuclei.	Following the completion of the horizontal evaluation on properties of K isomers in deformed nuclei, a review article entitled "Review of Metastable States in Heavy Nuclei" was published in the journal Reports on Progress in Physics.

BNL Planned Activities	Status
Update database as new information becomes available.	Continuing.

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	Status
Evaluate at least one radionuclide in support of the IAEA-CRP on “Nuclear data for charged-particle monitor reactions and medical isotope production”	No new evaluations were requested. A preparation of a journal article is continuing.
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 applications of medical radioisotopes	Continuing.

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	Status
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.	Continuing - three PRC publications in FY16.
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.	Continuing.
Collaborate with the University of Oslo to measure low-energy photon strength functions and level densities.	Continuing.
Unplanned activity: Compile (n,n'gamma) data from the Baghdad Atlas and similar papers from Demidov et al., into a database for use in applications and for comparison to reaction model calculations.	Continuing.

LLNL Planned Activities
Evaluation of EGAF data in collaboration with LBNL

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	Status
With serious reflection that considers both the great value of the breadth of information provided in the “Energy Levels of Light Nuclei” publications and the NSDD/ENSDF network expected 7-10 year periodicity for reviews of a given nuclear mass-chain, the only feasible direction for future evaluations is to focus solely on ENSDF reviews to be published in the Nuclear Data Sheets. This follows a similar shift away from publications in Nuclear Physics A that has been made regarding the	Our evaluation of A=12 nuclides is essentially completed.

A=21-44 nuclear mass region that had previously been maintained by P. Endt and C. Van Der Leun.	

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	Status
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	Participated in several collaborative experiments at ATLAS and CARIBU (ANL). Analysis of data collected during previous campaigns is continuing.
Participate in research activities using the GRETINA spectrometer and in dissemination of produced data from those activities	Not completed.

BNL Planned Activities	Status
In collaboration with the Brookhaven Linear Isotope Producer (BLIP), precisely determine decay schemes of key medical isotopes using state-of-the-art gamma-ray spectroscopy.	Measured 86Y, 76Br, 77Br, 61Cu, 62Cu decay using Gammasphere at Argonne National Laboratory.
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.	Experiment on 92Rb measured using CARIBU and the X-array, relating to antineutrino spectra is currently underway.
Perform precision measurements of electromagnetic transition strengths in light nuclei as a guide for improved formulations of ab-initio theories	Experiment completed at TRIUMF in May 2016 to precisely measure M1 transition strengths in 7Li,8Li and 9Li.
Analyze the deep inelastic data that would be measured at ANL.	Publication on 209Tl has been submitted to PRC. Analysis of 202Hg and 203Tl completed and results presented as poster at APS DNP meeting.

LANL Planned Activities	Status
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. We will study neutron reactions on ^{136}Xe (with Indiana Univ) to learn more about the level structure and transitions. This nucleus is important in the search for neutrino-less double beta-decay experiments at Enriched Xenon Observatory (EXO). In addition we will study ^{186}Re and look for transitions that feed the long-lived isomer.	The measurement using the DANCE array at En < 0.5 MeV has been published in PRC and the measurement using the GENIE with fast neutrons is being analyzed.
Interact with mass chain evaluators on the nuclear structure of these nuclei.	Unfortunately the interaction with mass chain evaluators was very limited in this fiscal year.

LBNL Planned Activities	Status
Perform DICEBOX statistical model calculations to determine total radiative cross sections and elucidate nuclear level spins and parities.	Continuing - student mentoring in there research using DICEBOX statistical model calculations.
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.	Completed - published papers.
Investigate primary gamma ray photon strength functions and the contribution of the M1+E2 mixing ratio to nuclear statistical model calculations.	Continued - submitted for publication related to 57Fe.

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	Status
Maintain and upgrade ENSDF checking and physics programs for format changes as required.	Several enhancements made for fmtchk and pandora.
Move codes off the Lahey compiler and make compatible with gfortran.	Done for fmtchk, pandora, and logft.

VI. Nuclear Reaction Physics

A. Experimental Data Compilation

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. NNDC concentrates on new measurements, and 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	Status
Compile experimental data for neutron, charged particle, and photon induced reactions from 120 publications.	126 new publications were compiled, 122 existing compilations were modified.
Explore possibilities of recovering missing reaction data at Oak Ridge National Laboratory.	The Oak Ridge National Laboratory data sets were recovered and compiled.

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 commited 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.

BNL Planned Activities	Status
Respond to user needs for evaluated nuclear reaction data.	Continuing.
Collect and address users feedback related to the ENDF library.	The NNDC maintains the GForge repository which includes detailed bug-tracking for the ENDF library. Many of the issues will be dealt with early in FY17 in the preparation for BNL's Nuclear Data Week in Nov. 2016.
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.	We have created two beta versions of the full 56Fe evaluation and have generated evaluations for 54Fe, 57Fe and 58Fe.
Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.	Continuing.
In collaboration with LLNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.	The requirements document for the top level hierarchy was completed and released over the summer as BNL Report BNL-112394-2016-IR. We are currently coordinating the drafting of the detailed format specifications.
Provide production cross sections for medical isotopes.	Continuing.

LANL Planned Activities	Status
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.	Continued. We produce several interim ENDF files for data testing purpose. These evaluations include a new technique to calculate the scattering cross sections when strongly coupled channels exist. We maintain close collaborations with nuclear data group outside the US, with particular focus on the CIELO project.
Provide upgraded ENDF evaluated data files for light and medium mass elements, including covariance data. Perform criticality benchmarks.	New evaluations of carbon isotopes, Co59, Cu63,65, As isotopes, were produced. Benchmark testing performed when integral experimental data available.
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.	New evaluations of prompt fission neutron spectra, based on both the Monte Carlo and deterministic methods, performed. The deterministic calculation includes a pre-fission neutron emission.
Improve photon production data for neutron capture and inelastic scattering, which will be used in prompt gamma-ray spectroscopy.	We calculated photon-production cross sections for tungsten isotopes, and the results were compared with new experimental data at IPHC/CNRS, France.

LLNL Planned Activities	Status
Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.	Evaluations for reactions of light charged particles amongst themselves will be ready to submit to BNL for ENDF/B-VIII in October 2016
In collaboration with BNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.	The requirements document for the top level hierarchy was completed and released over the summer as BNL Report BNL-112394-2016-IR. We are currently coordinating the drafting of the detailed format specifications.

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	Status

Maintain GForge version of the ENDF-6 formats manual up-to-date with CSEWG endorsed format changes. Issue official release of the manual.	The manual was updated in accordance with CSEWG endorsed format changes. These changes included correcting 5/6 errors submitted in FY15, updating the Appendix H of the manual and implementing 2 format changes.
Automate the generation and posting of the latest unofficial version of the ENDF-6 formats manual.	ADVANCE continues to process the ENDF manual as the latest unofficial version of the manual.

D. Nuclear Reaction Standards

Maintaining accurate current values for the standard cross sections is the primary objective of this task. It is efficiently accomplished through international cooperation under auspices of the IAEA.

LANL Planned Activities	Status
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.	LANL scientist participate in the IAEA CRP meeting. We also collaborate with JAEA to produce new evaluations of oxygen cross sections.
Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.	The IAEA standards of fission cross sections have not yet been finalized in this fiscal year. We continue this effort.
We will continue the search for suitable (n,xgamma) reactions as possible reference cross sections to complement or replace the ^{56}Fe(n, xgamma = 847 keV) reaction, which has several experimental limitations. Targets of Fe, Cr, Ti, and Li will be studied. We work with the Institute of Reference Materials and Measurements (IRMM Belgium) in comparing their measurements with ours.	The inelastic gamma-ray standard still under investigation in collaboration with the IAEA standards project.

NIST Planned Activities	Status
Standards for the next version of a number of cross section libraries will be made available for data testing and review. These data are largely a result of work on the IAEA data development project on maintenance of the neutron cross section standards. In addition to the traditional neutron cross section standards, this includes results for the capture cross section of gold at energies below 200 keV, as well as neutron spectrum results for the spontaneous fissioning of ^{252}Cf and the fissioning of ^{235}U with thermal neutrons.	Standards for the next version of a number of cross section libraries will be made available for data testing and review. These data are largely a result of work done through an IAEA data development project on maintenance of the neutron cross section standards. In addition to the traditional neutron data standards, this work includes very high energy fission reference cross sections, gamma production reference cross sections, the capture cross section of gold at energies below 200 keV, as well as neutron spectrum results for the spontaneous fissioning of ^{252}Cf and the fissioning of ^{235}U with thermal neutrons. All data except the boron standards were reported on at the ND2016 conference. The boron data should be ready by the end of the year.
Drafts of the work done on the standards evaluation prepared through the IAEA data development project will be prepared in electronic form.	Efforts will begin on drafts of the work done on the standards evaluation prepared through the IAEA data development project. This work will be prepared in electronic form.
In an effort to continually improve the standards, we continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.	In an effort to continually improve the standards, we continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.
Diagnostic measurements with the new deuterium gas target will be made. This work is a step in the process of detecting neutrons to measure the H(n,n) angular distribution. The measurement will lead to improved determinations at small center-of-mass angles. This work is on an experiment at 10 MeV. Data will also be obtained at 14.9 MeV in the future. This work is done in collaboration with Ohio University, LANL and the U. of Guelma.	A measurement of the H(n,n) angular distribution at 14.9 MeV was completed using a ^{252}Cf source for determination of the neutron fluence. The work was reported at the ND2016 conference. Some diagnostic work was done related to a process involving symmetry of angular distributions to relate the fluence of lower energy neutrons to the fluence of higher energy neutrons. This work could lead to improved angular distribution determinations at small center-of-mass angles. The initial work is on an experiment at 10 MeV. This work is done in collaboration with Ohio University, LANL and the U. of Guelma.
Data will be obtained on an experiment based on ^{252}Cf nu-bar leading to an improved calibration of NBS-I, the U.S. national primary standard neutron source and determination of our manganese bath efficiency.	Work has been done on experiments that should lead to an improved calibration of NBS-I, the U.S. national primary standard neutron source. Initial work was done based on neutrons from a ^{252}Cf source using its very well-known nu-bar. Further investigation determined that the best way to carry out the experiment was to directly compare a neutron source, BIPM-1, with the absolute neutron beam on the NG-6M beam line at NIST using a mini-bath. Plans have been made to install and run the mini-bath experiment on the NG-6M beam line by the end of the year. In parallel, studies of certain systematic effects in the mini-bath using neutron sources will be done. Intercomparison of BIPM-1 and NBS-I will follow this work.
Submit for publication a measurement of the ^{6}Li(n,t) standard cross section at ~ 4 meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the ^{10}B(n,alpha)	The work on the measurement and analysis of the ^{6}Li(n,t) standard cross section at ~ 4 meV neutron energy has been completed. This experiment used an improved neutron fluence determination based on alpha-gamma

reaction. Continue a study of the stability of ^{10}B deposits for ^{10}B(n,alpha)cross section measurements. If suitable targets can be made, cross section measurements will be initiated.	coincidences with the ^{10}B(n,alpha) reaction. The initial cross section determination obtained was in excellent agreement with the ENDF/B-VII standards evaluation. It was recently found that the ^{6}Li mass reported by IRMM was in error. Using the new mass value produces a cross section value with an uncertainty of 0.3% that is 1% lower than the ENDF/B-VII value. Efforts are underway to determine the mass very accurately using Isotope Dilution Mass Spectrometry, if support can be found.
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.	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 and CGM (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	Status
Continue to improve reaction modeling in the EMPIRE code, maintain code's numerical integrity and enhance user friendly GUI.	311 updates improving reaction modeling and numerical integrity of the EMPIRE code were committed to the GForge server in FY2016.
Improve EMPIRE covariance capabilities for fast neutrons.	This task has been postponed to FY2017 when covariances for CIELO iron evaluation will be produced.
Maintain GForge site with the current version of the EMPIRE code.	The GForge site was maintained and used for EMPIRE code distribution.
Maintain continuous integration system ADVANCE for checking and validation of new EMPIRE versions.	The Advance server has been used to validate each EMPIRE version committed to the GForge Subversion.
Began development of new approach to calculation of cross section probability distributions in the URR.	Task not complete but preliminary report delivered as contributed talk at ND2016.

LANL Planned Activities	Status
Continue to develop a microscopic description of fission process in the fast energy range, which includes Class-I and Class-II coupling. Implement the theory into the Hauser-Feshbach code to facilitate actinide evaluations.	A new fission modeling, in which the fission penetration is calculated through a realistic potential shape, continues. Preliminary calculations were compared with a similar model at CEA.
Apply a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets to study M1 strength function, in support of DANCE and GEANIE measurements, and fission cycle in r-process nucleo-synthesis studies.	The coupled-channels Hauser-Feshbach technique was applied to more than 100 deformed nuclei, and the M1 strength was estimated as a function of nuclear deformation. The derived M1 strength was employed in the r-process nucleo-synthesis calculations.
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.	The neutron inelastic scattering off deformed nuclei extensively studied, and a PRC paper published with scientists in CEA 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.	The model development for the prompt fission neutron and gamma-ray spectrum continued. The preequilibrium model was added to the fission spectrum model, which allows to calculate higher incident neutron energy cases.
Extend the new width fluctuation correction calculation in the fast energy range to the deformed systems, based on the Gaussian Orthogonal Ensemble and the Monte Carlo technique.	The Gaussian Orthogonal Ensemble technique was applied to the width fluctuation correction calculation for deformed nuclei, and a fast calculation method was developed. This was implemented in the Hauser-Feshbach code.
Continue to develop Monte-Carlo Hauser-Feshbach code, CGM, that can be used as an event generator in radiation transport codes.	The CGMF code development continued, and the next MCNP will include this code as an event generator.

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. BNL is involved in a collaboration with BLIP to measure cross sections of relevance to the production of medical radioisotopes. LANL is traditionaly 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,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.

ANL Planned Activities	Status
Participate in nuclear data activities at ANL using the Accelerator Mass Spectrometry technique and recently irradiated actinide samples at INL	No experimental AMS activities took place during FY16

BNL planned activities	Status
We are planning possible measurements of proton cross sections in support of isotope production at BLIP.	Measurements of production cross sections for high energy protons on platinum were presented at ND2016 conference and results are being drafted for publication.

LANL Planned Activities	Status
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}U and ^{239}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 FY16, we will conduct measurements on the portion of the fission neutron spectrum above 0.5 MeV for spontaneous fission of ^{252}Cf and neutron-induced fission of either ^{235}U or ^{239}Pu.	The preliminary low-energy (10 keV - 2 MeV) PFNS on ^{235}U at the incoming neutron energy of 1-20 MeV has been presented. Currently working on the higher energy PFNS on ^{235}U and the production data for low-energy PFNS on ^{239}Pu is being measured by the Chi Nu collaboration at LANSCE. MCNP framework has been used for a double-ratio method and for a forward propagation analysis to obtain PFNSs from measured yields.
Study radiative strength functions in neutron capture on ^{167}Er and ^{195}Pt. The residual nuclei in their low-lying states are those characterized as a strongly deformed rotator (^{168}Er) and a transitional, gamma-soft nucleus (^{196}Pt). The gamma-ray cascades differ markedly for neutron capture in these two nuclear systems. (with Yale University and Charles University - Prague).	The new neutron-capture measurement on ^{166}Er has been performed at DANCE for further study on photon strength functions.
Complete analysis of neutron capture-to-fission cross section ratio for ^{239}Pu for neutron energies between 1 and 200 keV.	Final capture-to-fission cross section ratio for ^{239}Pu for neutron energies between 1 and 1000 keV is completed. The paper is under preparation.
Measure the neutron capture cross-section at DANCE for at least one radioactive isotope of importance to nuclear astrophysics, probably isotopes of zinc (collaboration with Louisiana State University)	The neutron capture measurement on zinc isotopes has been completed and the analysis is ongoing. In addition, there are two DANCE measurement on ^{57}Fe and ^{96}Zr in order to compare with inverse kinematics beam measurement at ANL using HELIOS and Apollo instruments. This is a new effort to validate the method to improve nuclear input parameters for Hauser-Feshbach formalism.
Characterize the new scintillator, CLYC, which contains Lithium, Chlorine, Cesium and Yttrium (with University of Masachusetts at Lowell). One possible use is as a neutron detector with the ^{6}Li(n,alpha) reaction and, at higher energies, reactions on chlorine. Another is to measure the cross section of the ^{6}Li(n,alpha) reaction.	The second production measurement using CLYC by the UMass-Lowell group has been completed at the fast neutron beam line.

LBNL Planned activities	Status
Measure thermal (n,γ) cross sections using guided neutron beams in collaboration with the Budapest Research Centre and at the Munich Reactor.	Continuing - published papers
Established and measure (n,n'g) measurement capabilities at the LBNL 88" cyclotron, and the UC Berkeley neutron generator laboratory. Measure gamma ray partial cross sections.	Not done due to other priority work.
Unplanned activity: Perform medical isotope production cross section measurements at the High Flux Neutron Generator at UC Berkeley and the LBNL 88-Inch cyclotron	Continuing. A manuscript has been prepared for publication reporting the results of the 64Zn(n,p)64Cu and 47Ti(n,p)47Sc cross section measurements.

LLNL Planned Activities	Status
Perform surrogate (n,n'), (n,2n), (n,γ) and (n, f) measurements on several nuclei with programmatic and/or astrophysical importance. (funded from other sources)	Many of these are now ready for evaluators to examine, model, and decide whether standard evaluation data sets should be modified
Perform neutron capture measurements with DANCE array at LANSCE in collaboration with LANL. (funded from other sources)	

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	Status
Compile and evaluate nuclear structure and decay data for neutron-rich nuclei in the fission fragments region, produced at the CARIBU facility (ANL), that are of relevance to modeling of the r-process nucleosynthesis.	Continuing
Develop new computational tools aimed at studying the sensitivity of atomic masses and other nuclear ground state properties on the astrophysical r-process	Not completed due to lack of funding

BNL Planned Activities	Status
Continue work neutron capture and fission integral values and their uncertainties in the energy region of interest for nuclear astrophysics.	The comparative analysis of ENDF/B-VII.1 and TENDL-2015 Maxwellian-averaged cross sections is in progress.
Unplanned activity: Evaluate n+86Kr for astrophysical applications and in support of NIF	Summer student activity that did not complete in FY16.

LANL Planned Activities	Status
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 utilizing nuclear mean-fields theories in the nuclear reaction calculations.	The neutron capture model for the s and r-processes improved by including the M1 scissors mode for deformed nuclei. The nuclear deformation is predicted by the mean-field model.
Develop a method to calculate simultaneous beta-delayed neutron and fission, and provide the reaction rates for the fission cycle study in the r-process nucleo-synthesis.	The beta-delayed neutron and fission model development continues, and preliminary calculations performed for the r-process nucleo-synthesis. A paper is under preparation.

ORNL Planned Activities	Status
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.	Assessment made of the 19F(alpha,n) reaction that is crucial for producing the long-lived radioisotope 22Na, a target of gamma ray astronomy and indicator of recent nucleosynthesis activity in the Galaxy. Project to determine precision fits in a community standard format to recent calculations of reaction rates crucial for stellar explosions is nearing completion. Work is in danger of termination due to funding cuts.
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.	Work suspended due to funding cuts.

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	Status
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.	Not completed due to lack of funding.

I. Reactor antineutrino spectra and decay heat calculations

Decay heat and anti-neutrino spectra can be calculated using the fission yields and decay data sublibrary from the ENDF-6 formatted libraries.

BNL Planned Activities	Status

Improve our methods and databases to calculate anti-neutrino spectra for major actinides.	We studied the effects of fission yields, publishing the following article: A.A. Sonzogni, E.A. McCutchan, T.D. Johnson and P. Dimitriou, Phys. Rev. Lett. **116**, 132502 (2016).
Perform decay heat calculations in collaboration with experimental groups.	Continue working with groups in Valencia and ORNL on decay heat calculations.
Possibly organize a workshop on the modeling of nuclear reactors antineutrino spectra.	Not done, since there was a similar workshop in the Nuclear Structure conference in Knoxville.

LANL Planned Activities	Status
Continue assessments of continuous electron and neutrino energy spectra calculated with the Gamow-Teller strength function.	This plan continued. The beta-strength function assessed by comparing evaluated one-neutron emission probabilities. A PRC paper was submitted.

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	Status
Establish automatic, real time verification and validation of new/modified ENDF evaluations submitted to the NNDC GForge server.	Not completed, there was no time to work on this planned task this FY.

Detailed Status of the Work Plan
Fiscal Year 2016 Report

Appendix A
Fiscal Year 2016 Additional Funding Sources

BNL

Additional support for the nuclear data work at the National Nuclear Data Center comes from the following sources:

1. The US Nuclear Criticality Safety Program (NCSP), funded by DOE NNSA, supports the NNDC services in maintaining NCSP data submitted to ENDF/B-VII library as well as data development work on estimates/ evaluations of neutron cross section covariances for criticality safety applications.

LANL

Most of the nuclear data work is supported from funds other than the nuclear data program. The effort is in support of the ENDF-related work of nuclear model development, nuclear reaction evaluation and ENDF processing.

1. Advanced Simulation and Computing (ASC program). This work supports the development of more accurate ENDF cross section databases for actinide fission fuels, light-nucleus thermonuclear fuels, and for reactions on important materials used for diagnostics (radiochemical reactions). Nuclear model code development, for both statistical and preequilibrium models, and for light R-matrix codes, is supported by this program, as is the development of the NJOY data processing code for providing data usable by Monte Carlo and deterministic transport codes in applications. The funding also supports physics research developments in nuclear reaction and structure theory (with a recent emphasis on nuclei and isomers away from stability), and fission theory. Data testing using integral benchmarks such as fast critical assemblies is used to validate the ENDF data.

2. Nuclear criticality safety. This funding supports improved nuclear data important in criticality safety studies, such as uranium isotopes, as well as data on structural materials. Data testing using critical assemblies and NJOY processing code development is also funded by the program.

3. LANL LDRD. There are two LANL LDRD projects; nuclear reaction data measurements and nuclear reaction modeling for isomeric states, and to study the cosmogenic origins of 60Fe.

4. Nuclear Weapons supports LANSCE measurements of fission output (neutrons and gamma rays), neutron capture on actinides and radchem isotopes, and neutron reactions relevant to radchem.

5. DOE/NNSA Correlated Data in Fission Events (NA22), supports Monte Carlo Hauser-Feshbach modeling for fission neutron and gamma-ray emissions, and relevant code development.

LBNL

Nuclear data group staff at LBNL/UCB are partially supported by external funds:

1. Na-22 for capture gamma-ray library evaluations in collaboration with LLNL - A.M. Hurst (LBNL/UCB).

2. UCB (Teaching) - L.A. Bernstein (LBNL/LLNL/UCB).

3. UCOP - Neutron Generator - J.C. Batchelder (UCB).

4. LDRD - Radiative Strength Functions - L.A. Bernstein (LLNL).

LLNL

NNSA Defense Programs, the Department of Homeland Security, and branches of the Office of Science outside the USNDP support most of the nuclear efforts at LLNL. Funding from USNDP is used to coordinate these efforts and process data for use by the larger community. Much of the Livermore experimental work is made possible by beam time and collaborations at TUNL, TRIUMF, Texas A&M University Cyclotron Institute, LANSCE and LBNL. Sponsorship for different nuclear efforts includes:

1. NNSA/ASC funds data evaluation, validation and verification efforts, development of theory supporting the surrogate measurement campaign for unstable actinides, and optical potentials. Also funds part of the nuclear data formats and the processing of nuclear data.

2. NNSA/DP/SC funds experimental campaigns for unstable actinides, including development of the Time Projection Chamber at LLNL for new 239Pu fission cross section measurements.

3. NNSA/NA-22 funds the event by event fission modeling and the capture-gamma-ray evaluations.

4. OS/ARRA funds in part the generalized nuclear data efforts in tandem with ASC/IC.

5. NNSA/NA-22 is now funding full cross section evaluations

6. NNSA/NA-22 funds experimental efforts in surrogate measurements of nuclear cross sections

NIST

A variety of sources support nuclear data activities:

1. The NIST-DOE Neutron Cross Section and Fluence Standards program has funding through the Commerce Department. This provides about half of the total support for the program.

2.NIST provides 1 FTE for standard cross section work using ~4 meV neutrons and also for interferometry work, which has yielded coherent scattering lengths (which provide scattering data) needed for neutron cross-section evaluations.

4.NIST provided 1 FTE (75% experimental, 25% evaluation) for nuclear structure and decay data work. Much of this work also has applications in radioactivity standards and radiopharmaceutical studies.

ORNL

The nuclear data work is partly funded by the DOE-SC Low Energy Nuclear Physics program.

TUNL

The nuclear data work is partly funded by the DOE-SC Low Energy Nuclear Physics program through a TUNL/NCSU grant.

Appendix B
Fiscal Year 2016 Selected Articles

1. **2016AL18** Phys.Rev. C 94, 034301 (2016)
   M.Albers, S.Zhu, A.D.Ayangeakaa, R.V.F.Janssens, J.Gellanki, I.Ragnarsson, M.Alcorta, T.Baugher, P.F.Bertone, M.P.Carpenter, C.J.Chiara, P.Chowdhury, H.M.David, A.N.Deacon, B.DiGiovine, A.Gade, C.R.Hoffman, F.G.Kondev, T.Lauritsen, C.J.Lister, E.A.McCutchan, C.Nair, A.M.Rogers, D.Seweryniak
   Single-particle and collective excitations in ^{62}Ni

2. **2016AY04** Phys.Rev. C 93, 054317 (2016)
   A.D.Ayangeakaa, U.Garg, C.M.Petrache, S.Guo, P.W.Zhao, J.T.Matta, B.K.Nayak, D.Patel, R.V.F.Janssens, M.P.Carpenter, C.J.Chiara, F.G.Kondev, T.Lauritsen, D.Seweryniak, S.Zhu, S.S.Ghugre, R.Palit
   In-beam spectroscopy of medium- and high-spin states in ^{133}Ce

3. **2016BA04** Phys.Rev. C 93, 014313 (2016)
   T.Baugher, A.Gade, R.V.F.Janssens, S.M.Lenzi, D.Bazin, M.P.Carpenter, C.J.Chiara, A.N.Deacon, S.J.Freeman, G.F.Grinyer, C.R.Hoffman, B.P.Kay, F.G.Kondev, T.Lauritsen, E.M.Lunderberg, S.McDaniel, K.C.Meierbachtol, A.Ratkiewicz, S.R.Stroberg, K.A.Walsh, D.Weisshaar, S.Zhu
   In-beam spectroscopy of ^{63}Mn

4. **2016BA41** Phys.Rev. C 94, 024317 (2016)
   J.C.Batchelder, N.T.Brewer, C.J.Gross, R.Grzywacz, J.H.Hamilton, M.Karny, A.Fijalkowska, S.H.Liu, K.Miernik, S.W.Padgett, S.V.Paulauskas, K.P.Rykaczewski, A.V.Ramayya, D.W.Stracener, M.Wolinska-Cichocka
   ^{124}In levels populated in the β decay of ^{124}Cd

5. **2016BA18** Nucl.Data Sheets 134, 1 (2016)
   M.S.Basunia, A.M.Hurst
   Nuclear Data Sheets for A = 26

6. **2016BA19** Nucl.Data Sheets 134, 149 (2016)
   C.M.Baglin
   Nuclear Data Sheets for A = 183

7. **2016BE24** Phys.Rev. C 94, 034303 (2016)
   N.Benczer-Koller, G.J.Kumbartzki, K.H.Speidel, D.A.Torres, S.J.Q.Robinson, Y.Y.Sharon, J.M.Allmond, P.Fallon, I.Abramovic, L.A.Bernstein, J.E.Bevins, H.L.Crawford, Z.E.Guevara, A.M.Hurst, L.Kirsch,T.A.Laplace, A.Lo, E.F.Matthews, I.Mayers, L.W.Phair, F.Ramirez, A.Wiens
   Magnetic moment and lifetime measurements of Coulomb-excited states in ^{106}Cd

8. **2016BI09** Nucl.Phys. A955, 145 (2016)
   M.Birch, B.Pritychenko, B.Singh
   On the equivalence of experimental B(E2) values determined by various techniques.

9. **2016BU02** Phys.Rev.Lett. 116, 112503 (2016)
   B.Bucher, S.Zhu, C.Y.Wu, R.V.F.Janssens, D.Cline, A.B.Hayes, M.Albers, A.D.Ayangeakaa, P.A.Butler, C.M.Campbell, M.P.Carpenter, C.J.Chiara, J.A.Clark, H.L.Crawford, M.Cromaz, H.M.David, C.Dickerson, E.T.Gregor, J.Harker, C.R.Hoffman, B.P.Kay, F.G.Kondev, A.Korichi, T.Lauritsen, A.O.Macchiavelli, R.C.Pardo, A.Richard, M.A.Riley, G.Savard, M.Scheck, D.Seweryniak, M.K.Smith, R.Vondrasek, A.Wiens
   Direct Evidence of Octupole Deformation in Neutron-Rich ^{144}Ba

10. **2016BU09** Phys.Rev. C 93, 044613 (2016)
    M.Q.Buckner, C.Y.Wu, R.A.Henderson, B.Bucher, A.Chyzh, T.A.Bredeweg, B.Baramsai, A.Couture, M.Jandel, S.Mosby, J.M.O'Donnell, J.L.Ullmann
    Absolute measurement of the ^{242}Pu neutron-capture cross section

11. **2016CH23** Nucl.Data Sheets 135, 1 (2016)
    J.Chen, B.Singh
    Nuclear Data Sheets for A = 42

12. **2015CH57** Phys.Rev. C 92, 044330 (2015)
    J.Chen, F.G.Kondev, I.Ahmad, M.P.Carpenter, J.P.Greene, R.V.F.Janssens, S.Zhu, D.Ehst, V.Makarashvili, D.Rotsch, N.A.Smith
    Precise absolute γ-ray and β-decay branching intensities in the decay of $^{67}_{29}$Cu

13. **2016DR08** Rep.Prog.Phys. 79, 076301 (2016)
    G.D.Dracoulis, P.M.Walker, F.G.Kondev
    Review of metastable states in heavy nuclei

14. **2016FI04** Phys.Rev. C 93, 044311 (2016)
    R.B.Firestone, Zs.Revay
    Thermal neutron capture cross sections for ^{16,17,18}O and ^{2}H

15. **2016FI06** Phys.Rev. C 93, 054306 (2016)
    R.B.Firestone, Zs.Revay
    Thermal neutron radiative cross sections for ^{6,7}Li, ^{9}Be, ^{10,11}B, ^{12,13}C, and ^{14,15}N

16. **2016GU11** Nucl.Data Sheets 136, 1 (2016)
    G.Gurdal, E.A.McCutchan

Nuclear Data Sheets for A = 70

17. **2016HI01** Nucl.Data Sheets 131, 377 (2016)
J.A.Hirdt, D.A.Brown
Identifying Understudied Nuclear Reactions by Text-mining the EXFOR Experimental Nuclear Reaction Library

18. **2016HO13** Phys.Rev. C 94, 021303 (2016)
S.S.Hota, S.K.Tandel, P.Chowdhury, I.Ahmad, M.P.Carpenter, C.J.Chiara, J.P.Greene, C.R.Hoffman, E.G.Jackson, R.V.F.Janssens, B.P.Kay, T.L.Khoo, F.G.Kondev, S.Lakshmi, S.Lalkovski, T.Lauritsen, C.J.Lister, E.A.McCutchan, K.Moran, D.Peterson, U.Shirwadkar, D.Seweryniak, I.Stefanescu, Y.Toh, S.Zhu
Population and decay of a Kp = 8- two-quasineutron isomer in ^{244}Pu

19. **2016IS03** Phys.Rev. C 93, 014303 (2016)
L.W.Iskra, R.Broda, R.V.F.Janssens, C.J.Chiara, M.P.Carpenter, B.Fornal, N.Hoteling, F.G.Kondev, W.Krolas, T.Lauritsen, T.Pawlat, D.Seweryniak, I.Stefanescu, W.B.Walters, J.Wrzesinski, S.Zhu
Shell-model states with seniority v = 3, 5, and 7 in odd-A neutron-rich Sn isotopes

20. **2016JU03** Phys.Rev. C 94, 024303 (2016)
A.Jungclaus, H.Grawe, S.Nishimura, P.Doornenbal, G.Lorusso, G.S.Simpson, P.-A.Soderstrom, T.Sumikama, J.Taprogge, Z.Y.Xu, H.Baba, F.Browne, N.Fukuda, R.Gernhauser, G.Gey, N.Inabe, T.Isobe, H.S.Jung, D.Kameda, G.D.Kim, Y.-K.Kim, I.Kojouharov, T.Kubo, N.Kurz, Y.K.Kwon, Z.Li, H.Sakurai, H.Schaffner, Y.Shimizu, K.Steiger, H.Suzuki, H.Takeda, Zs.Vajta, H.Watanabe, J.Wu, A.Yagi, K.Yoshinaga, G.Benzoni, S.Bonig, K.Y.Chae, L.Coraggio, J.-M.Daugas, F.Drouet, A.Gadea, A.Gargano, S.Ilieva, N.Itaco, F.G.Kondev, T.Kroll, G.J.Lane, A.Montaner-Piza, K.Moschner, D.Mucher, F.Naqvi, M.Niikura, H.Nishibata, A.Odahara, R.Orlandi, Z.Patel, Zs.Podolyak, A.Wendt
decay of semi-magic ^{130}Cd: Revision and extension of the level scheme of ^{130}In

21. **2016Ka29** Phys.Rev. C 94, 014612 (2016)
T.Kawano, R.Capote, S.Hilaire, P.Chau Huu-Tai
Statistical Hauser-Feshbach theory with width-fluctuation correction including direct reaction channels for neutron-induced reactions at low energies

22. **2016KO07** Nucl.Data Sheets 132, 257 (2016)
F.Kondev, E.McCutchan, B.Singh, J.Tuli
Nuclear Data Sheets for A = 227

23. **2016KU05** Phys.Rev. C 93, 044316 (2016)
G.J.Kumbartzki, N.Benczer-Koller, K.-H.Speidel, D.A.Torres, J.M.Allmond, P.Fallon, I.Abramovic, L.A.Bernstein, J.E.Bevins, H.L.Crawford, Z.E.Guevara, G.Gurdal, A.M.Hurst, L.Kirsch, T.A.Laplace, A.Lo,E.F.Matthews, I.Mayers, L.W.Phair, F.Ramirez, S.J.Q.Robinson, Y.Y.Sharon, A.Wiens
Z = 50 core stability in ^{110}Sn from magnetic-moment and lifetime measurements

24. **2016LA02** Phys.Rev. C 93, 014323 (2016)
T.A.Laplace, F.Zeiser, M.Guttormsen, A.C.Larsen, D.L.Bleuel, L.A.Bernstein, B.L.Goldblum, S.Siem, F.L.Bello Garotte, J.A.Brown, L.C.Campo, T.K.Eriksen, F.Giacoppo, A.Gorgen, K.Hadynska-Klek,R.A.Henderson, M.Klintefjord, M.Lebois, T.Renstrom, S.J.Rose, E.Sahin, T.G.Tornyi, G.M.Tveten, A.Voinov, M.Wiedeking, J.N.Wilson, W.Younes
Statistical properties of ^{243}Pu, and ^{242}Pu(n, γ) cross section calculation

25. **2016MA31** Nucl.Phys. A952, 62 (2016)
B.Maheshwari, A.K.Jain, B.Singh
Asymmetric behavior of the B(E2; 0+ to 2+) values in $^{104\text{-}130}$Sn and generalized seniority

26. **2016MA35** Phys.Rev. C 93, 054319 (2016)
D.A.Matters, A.G.Lerch, A.M.Hurst, L.Szentmiklosi, J.J.Carroll, B.Detwiler, Zs.Revay, J.W.McClory, S.R.McHale, R.B.Firestone, B.W.Sleaford, M.Krticka, T.Belgya *Investigation of ^{186}Re via radiative thermal-neutron capture on ^{185}Re*

27. **2016MI02** Phys.Rev. C 93, 014306 (2016)
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ψ-soft 146Ba and the role of nonaxial shapes at N ≈ 90

28. **2016NA29** Phys.Rev. C 94, 034307 (2016)
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O*bservation of high-spin bands with large moments of inertia in ^{124}Xe*

29. **2016NE02** Nucl.Data Sheets 131, 289 (2016)
D.Neudecker, T.N.Taddeucci, R.C.Haight, H.Y.Lee, M.C.White, M.E.Rising
The Need for Precise and Well-documented Experimental Data on Prompt Fission Neutron Spectra from Neutron-induced Fission of ^{239}Pu

30. **2016NE07** Nucl.Data Sheets 133, 1 (2016)
C.D.Nesaraja, E.A.McCutchan
Nuclear Data Sheets for A = 41

31. **2016NE08** Phys.Rev. C 94, 024332 (2016)
D.Negi, M.Wiedeking, E.G.Lanza, E.Litvinova, A.Vitturi, R.A.Bark, L.A.Bernstein, D.L.Bleuel, S.Bvumbi, T.D.Bucher, B.H.Daub, T.S.Dinoko, J.L.Easton, A.Gorgen, M.Guttormsen, P.Jones, B.V.Kheswa,N.A.Khumalo, A.C.Larsen, E.A.Lawrie, J.J.Lawrie, S.N.T.Majola, L.P.Masiteng,

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Nature of low-lying electric dipole resonance excitations in ^{74}Ge

32. **2016NI02** Nucl.Data Sheets 132, 1 (2016)
N.Nica
Nuclear Data Sheets for A = 157

33. **2016NI03** Phys.Rev. C 93, 024301 (2016)
M.N.Nino, E.A.McCutchan, S.V.Smith, C.J.Lister, J.P.Greene, M.P.Carpenter, L.Muench, A.A.Sonzogni, S.Zhu
High-precision γ-ray spectroscopy of the cardiac PET imaging isotope ^{82}Rb and its impact on dosimetry

34. **2016NI05** Phys.Rev. C 93, 034305 (2016)
N.Nica, J.C.Hardy, V.E.Iacob, T.A.Werke, C.M.Folden, L.Pineda, M.B.Trzhaskovskaya
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Triaxiality and exotic rotations at high spins in ^{134}Ce

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B.Pritychenko, M.Birch, B.Singh, M.Horoi
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37. **2016RA25** Phys.Rev.Lett. 117, 092501 (2016)
B.C.Rasco, M.Wolinska-Cichocka, A.Fijalkowska, K.P.Rykaczewski, M.Karny, R.K.Grzywacz, K.C.Goetz, C.J.Gross, D.W.Stracener, E.F.Zganjar, J.C.Batchelder, J.C.Blackmon, N.T.Brewer, S.Go, B.Heffron,T.King, J.T.Matta, K.Miernik, C.D.Nesaraja, S.V.Paulauskas, M.M.Rajabali, E.H.Wang, J.A.Winger, Y.Xiao, C.J.Zachary
Decays of the Three Top Contributors to the Reactor v(bar)e High-Energy Spectrum, ^{92}Rb, ^{96gs}Y, and ^{142}Cs, Studied with Total Absorption Spectroscopy

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M.W.Reed, G.J.Lane, G.D.Dracoulis, F.G.Kondev, M.P.Carpenter, P.Chowdhury, S.S.Hota, R.O.Hughes, R.V.F.Janssens, T.Lauritsen, C.J.Lister, N.Palalani, D.Seweryniak, H.Watanabe, S.Zhu, W.G.Jiang, F.R.Xu
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M.Sin, R.Capote, M.W.Herman, A.Trkov
Extended optical model for fission

42. **2016SI14** Nucl.Data Sheets 135, 193 (2016)
B.Singh
Nuclear Data Sheets for A = 79

43. **2016SO03** Phys.Rev.Lett. 116, 132502 (2016)
A.A.Sonzogni, E.A.McCutchan, T.D.Johnson, P.Dimitriou
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G.M.Tveten, A.Spyrou, R.Schwengner, F.Naqvi, A.C.Larsen, T.K.Eriksen, F.L.Bello Garrote, L.A.Bernstein, D.L.Bleuel, L.Crespo Campo, M.Guttormsen, F.Giacoppo, A.Gorgen, T.W.Hagen, K.Hadynska-Klek, M.Klintefjord, B.S.Meyer, H.T.Nyhus, T.Renstrom, S.J.Rose, E.Sahin, S.Siem, T.G.Tornyi
Completing the nuclear reaction puzzle of the nucleosynthesis of ^{92}Mo

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H.Watanabe, G.X.Zhang, K.Yoshida, P.M.Walker, J.J.Liu, J.Wu, P.H.Regan, P.-A.Soderstrom, H.Kanaoka, Z.Korkulu, P.S.Lee, S.Nishimura, A.Yagi, D.S.Ahn, T.Alharbi, H.Baba, F.Browne, A.M.Bruce, R.J.Carroll, K.Y.Chae, Zs.Dombradi, P.Doornenbal, A.Estrade, N.Fukuda, C.Griffin, E.Ideguchi, N.Inabe, T.Isobe, S.Kanaya, I.Kojouharov, F.G.Kondev, T.Kubo, S.Kubono, N.Kurz, I.Kuti, S.Lalkovski, G.J.Lane, C.S.Lee, E.J.Lee, G.Lorusso, G.Lotay, C.-B.Moon, I.Nishizuka, C.R.Nita, A.Odahara, Z.Patel, V.H.Phong, Zs.Podolyak, O.J.Roberts, H.Sakurai, H.Schaffner, C.M.Shand, Y.Shimizu, T.Sumikama, H.Suzuki, H.Takeda, S.Terashima, Zs.Vajta, J.J.Valiente-Dobon, Z.Y.Xu
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γ-ray decay from neutron-bound and unbound states in ^{95}Mo and a novel technique for spin determination

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J.M.Allmond, A.E.Stuchbery, A.Galindo-Uribarri, E.Padilla-Rodal, D.C.Radford, J.C.Batchelder, C.R.Bingham, M.E.Howard, J.F.Liang, B.Manning, S.D.Pain, N.J.Stone, R.L.Varner, C.-H.Yu
Investigation into the semimagic nature of the tin isotopes through electromagnetic moments

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F.Giacoppo, F.L.Bello Garrote, L.A.Bernstein, D.L.Bleuel, R.B.Firestone, A.Gorgen, M.Guttormsen, T.W.Hagen, M.Klintefjord, P.E.Koehler, A.C.Larsen, H.T.Nyhus, T.Renstrom, E.Sahin, S.Siem, T.Tornyi
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M.Guttormsen, M.Aiche, F.L.Bello Garrote, L.A.Bernstein, D.L.Bleuel, Y.Byun, Q.Ducasse, T.K.Eriksen, F.Giacoppo, A.Gorgen, F.Gunsing, T.W.Hagen, B.Jurado, M.Klintefjord, A.C.Larsen, L.Lebois,B.Leniau, H.T.Nyhus, T.Renstrom, S.J.Rose, E.Sahin, S.Siem, T.G.Tornyi, G.M.Tveten, A.Voinov, M.Wiedeking, J.Wilson
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Capture and fission with DANCE and NEUANCE

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T.Kawano, P.Talou, H.A.Weidenmuller
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R.Massarczyk, R.Schwengner, L.A.Bernstein, M.Anders, D.Bemmerer, R.Beyer, Z.Elekes, R.Hannaske, A.R.Junghans, T.Kogler, M.Roder, K.Schmidt, A.Wagner, L.Wagner
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C.Mazzocchi, K.P.Rykaczewski, R.Grzywacz, P.Baczyk, C.R.Bingham, N.T.Brewer, C.J.Gross, C.Jost, M.Karny, A.Korgul, M.Madurga, A.J.Mendez, K.Miernik, D.Miller, S.Padgett, S.V.Paulauskas, A.A.Sonzogni, D.W.Stracener, M.Wolinska-Cichocka
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B.Singh
Nuclear Data Sheets for A = 182

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S.Singh, B.Singh
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Rotation-aligned isomer and oblate collectivity in ^{196}Pt