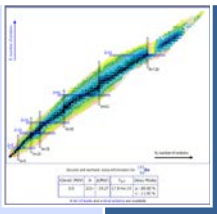
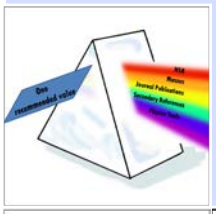
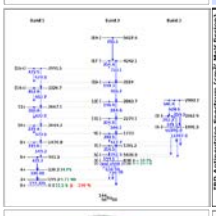
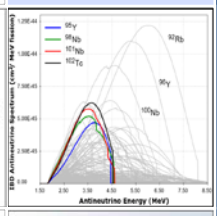
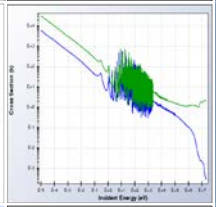
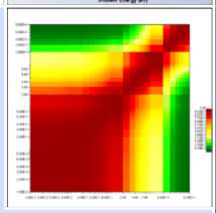












United States Nuclear Data Program

Annual Report for FY2018

This document describes the activities including related metrics performed by the US Nuclear Data program members during fiscal year 2018.

Prepared by

Alejandro Sonzogni
National Nuclear Data Center
Brookhaven National Laboratory

With contributions from

Lee Bernstein, LBNL
David Brown, BNL
Jun Chen, MSU
Toshihiko Kawano, LANL
John Kelley, TUNL
Filip G. Kondev, ANL
Libby McCutchan, BNL
Ninel Nica, TAMU
Michael Smith, ORNL
Ian Thompson, LLNL

www.nndc.bnl.gov/usndp

BNL

Acknowledgements

Work at Brookhaven National Laboratory was sponsored by the Office of Nuclear Physics, Office of Science of the U.S. Department of Energy under Contract No. DE-AC02-98CH10886.

I. Introduction

The USNDP Annual Report for FY2018 summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2017 through September 30, 2018 with respect to the work plan for FY2018 that was prepared in 2017. 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 0.8 FTE scientific to be compared with 25.7 FTEs 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 2018 was the 19th 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 FY2017. Then, we continue with the detailed status of work done in FY2017. Total staff assigned to USNDP activities during the year represented 25.7 FTE.

In terms of personnel changes, Dr. Michal Herman, former NNDC head and USNDP chair, retired from BNL in June 2018. Dr. Herman started employment in LANL in August 2018, which will give us the opportunity to continue interacting with this very talented professional and amazing individual.

Sadly, Said Mughabghab passed on July 6, 2018 following a short illness, and just a few months after the publication of the new edition of the Atlas of Neutron Resonances. A section describing Dr. Mughabghab's accomplishments and contributions to USNDP can be found later in this document.

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- FY2017, the definitions of the various terms follow the table.

Fiscal year	USNDP funding ($K)	Change (%)	Compilations	Evaluations	Disseminations	Articles	Invited talks
2001			7,139	334	667	25	22
2002	4,890		6,159	300	799	40	22
2003	4,932	+0.9	4,975	260	966	40	23
2004	5,015	+1.7	6,241	276	1,212	36	43
2005	5,437	+8.4	6,623	422	1,642	59	42
2006	5,099	-6.6	4,936	318	1,863	60	48
2007	5,841	+14.6	5,355	366	2,239	56	51
2008	5,967	+2.2	5,104	385	2,996	72	68
2009	6,267	+5.0	4,047	400	3,294	61	56
2010	6,549	+4.5	4,662	395	2,843	83	51
2011	6,534	-0.2	4,662	479	3,252	96	67
2012	6,785	+3.8	5,221	209	3,013	90	48
2013	6,249*	-7.9	4,925	282	3,447	84	79
2014	7,032*	+12.5	3,738	166	3,411	107	81
2015	7,381*	+5.0	4,949	271	4,246	98	50
2016	7,597*	+2.9	3,936	375	4,655	82	72
2017	6,953	-8.5	3,684	404	4,730	95	51
2018	8,496[a]	+22.2	4,097	231	4,722	79	58

*: It includes $500K of Early Career Award (LANL).
a: It includes the following (a) FIRE collaboration funding $100 (LLNL), (b) LAB17 call funding: $325K (ANL), $220K (LANL), (c) LAB18 call funding $26K (ANL), $282K (BNL), $120K (LANL), $75K (LBNL), $100K (LLNL), $372K (ORNL).

In particular:

1. **Compilations**: Includes compilations for the NSR, EXFOR and XUNDL databases. The compilation activities are on a healthy situation and these databases are updated regularly with newly published material.

2. **Evaluations**: There were 221 ENDF evaluations and 10 ENDF/B evaluations. The number of ENSDF evaluations remains well below the number needed, about 340, to evaluate each of the ENSDF nuclides on average every 10 years.

3. **Disseminations**: The number of database retrievals has not changed significantly from last year's value.

4. **Articles**: The number of articles has remained relatively constant in the last few years. A selected list of articles published is given in the Appendix B.

5. **Invited Talks**: The number of invited talks has slightly increased this year.

Table 2: USNDP metrics in FY2018, numbers from the previous fiscal year are shown for comparison.

Laboratory	Compilations		Evaluations		Disseminations (in thousands)		Articles		Invited Talks	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
ANL	13	15	60	14	-	-	31	31	5	5
BNL*	3,543.5	3,976	241	80	4,413	4,560	21	18	15	15
LANL	-	-	16	0	-	-	21	21	18	18
LBNL	18	17	15	23	-	-	13	16	8	9
LLNL	-	-	0	10	-	-	0	0	3	3
MSU	60	54	22	30	-	-	0	3	0	0
ORNL	11.5	3	0	25	200	82	3	1	2	4
TAMU	-	-	17	17	-	-	3	2	4	4
Universities	38	32	9	9	117	80	1	0	0	0
Total	3,684	4,097	404	231	4,730	4,722	98	79	55	58

*: BNL compilations for FY2018 consist of a) 3,714 NSR articles, including key-words for 1825 of them; b) 130 articles for EXFOR; c) 132 articles encompassing 366 XUNDL datasets. BNL evaluations for FY2018 consist of a) 80 nuclides for ENSDF and none for ENDF/B. For the remaining groups, all compilations are for XUNDL, while all evaluations are either ENSDF (ANL, LBNL, MSU, ORNL and TAMU), or ENDF/B (LANL, LLNL, NIST).

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.
- Articles: The number of articles published in refereed journals.
- Invited talks: The number of presentations given at the explicit invitation of the organizers of conferences, symposia, workshops and training courses.

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 this fiscal year 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 group and chairs the annual meeting of the program held at the Brookhaven National Laboratory. A representative from LANL chairs the Nuclear Reaction Data Working Group, and a representative from TUNL chairs the Nuclear Structure Working Group. ORNL chairs the Astrophysics Task Force.

In February 2019, DOE Office of Nuclear Physics conducted its annual Budget Briefing. Lee Bernstein, David Brown, Michael Carpenter, William Horak, Toshihiko Kawano, John Kelley, Hye Young Lee, Elizabeth McCutchan, Alejandro Sonzogni and Ian Thompson represented USNDP and made the case for the 2020 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 2017 CSEWG meeting was held at BNL. The major topic of the CSEWG meeting was validation on the ENDF/B-VIII.0 library,

USNDP Databases

The NNDC operates siven 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 employing Subversion to keep track of changes. The NNDC maintains seven nuclear physics databases for USNDP. These databases were updated continuously this fiscal year 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

There were 4,722 million database retrievals this fiscal year, about the same as 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.

Additionally, a new edition of the Atlas of Neutron Resonances by BNL scientist Said Mughabghab was published by Elsevier. More details about this accomplishment can be found in the 'additional highlights' section of this document.

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 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. The Nuclear Science Reference (NSR) and Experimental Unevaluated Nuclear Structure Data List (XUNDL) databases 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 2.1% over the past year, and at the end of FY18 there were 3356 nuclides in the database. A total of 221 evaluated nuclides were submitted this fiscal year, including nuclides from 15 mass chains and nuclides for ENSDF update. Evaluation articles from 11 mass chains, encompassing 141 nuclides, were published in the Nuclear Data Sheets this fiscal year.

The network works to revise all the mass chains within a time frame of 10 years, along with considerations of new data, age, importance, and request from users. One of the many indicators to measure the currency of the database is the average time of the nuclides since they were last evaluated, which was **6.9 years** at the end of FY2004 and **8.25 years** in November 2017. Here it should be noted that the size of the ENSDF database has increased from 148 MB to 230 MB an increase of about 55%, from FY2004 to FY2018, and every new evaluation, due to limitations of the ENSDF format, not only needs to include the new data but must also repeat some of the work of previous evaluators.

General usage statistics for ENSDF and products derived from ENSDF (Nuclear Data Sheets, NuDat, etc.) show a high usage and popularity on the NNDC website and the Elsevier site.

Status of XUNDL:

Based on regular scanning of nuclear physics journals, 585 datasets were compiled from 253 papers. Communications with the authors were made to resolve many data-related issues and obtain additional data in support of their findings.

Status of NSR:

In FY2019, 3714 new articles were added to the NSR database and the database contains a total number of 232,746 articles. USNDP contributions are from B. Pritychenko (manager), E. Betak, B. Singh, J. Totans, and V. Zerkin from the IAEA participates as a collaborator. The database is up-to-date and in good shape. The number of NSR web retrievals was 318,405.

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, Chen
- 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: Kondev,
- 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 r_0 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

Status of ENSDF codes:

In the last few years, significant development has been made in McMaster's JAVA-NDS code by Jun Chen, which is useful to prepare the print-ready documents for publication in the Nuclear Data Sheets and incorporated many recommended changes for the print-ready document. In this fiscal year, the code has been implemented both to produce print-ready documents for the Nuclear Data Sheets and web retrieval of ENSDF data sets at NNDC site.

IV Nuclear Reaction data

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

Reaction Data Highlights:

The Cross Section Evaluation Working Group (CSEWG) collaboration released the ENDF/B-VIII.0 library on February 2018. A 142-page article, written by 70 authors from 29 organizations, describing the library was published in Nuclear Data Sheets. The main features of ENDF/B-VIII.0 are:

- New IAEA standard cross sections,
- Improved thermal neutron thermal neutron scattering.
- CIELO project evaluations for the neutron sub-library on ^{1}H, ^{16}O, ^{56}Fe, ^{235}U, ^{238}U and ^{239}Pu.
- Updated decay data sub-library.

The library takes advantage from recent experimental work and improvements in theory and modelling, which resulted in updated values of fission energy release, prompt fission neutron and gamma fission spectra and charged particle reactions. A considerable improvement in integral validation testing is observed when compared to the previous ENDF/B-VII.1 library.

As a result of the 2018 NDREW meeting, a project to produce a new evaluation of fission yields, a collaboration between LANL and BNL, will start in FY19, funded by NA22. A full evaluation of fission yields has not taken place since the early 1990s, and due to funds shortages, most of the fission yield data published has not been incorporated in EXFOR.

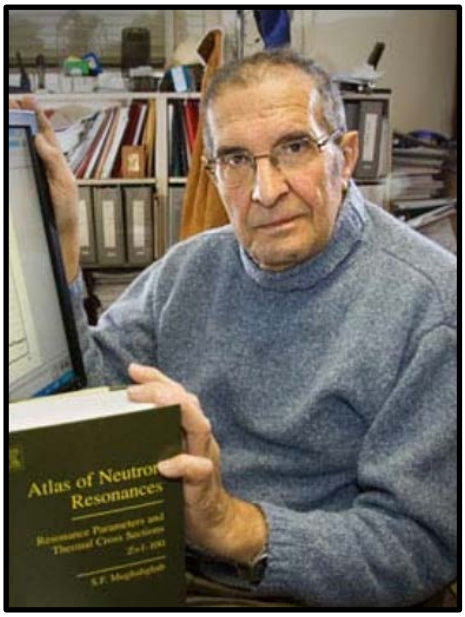
The 6th International Workshop on Compound-Nuclear Reactions and Related Topics took place on 24-28 September 2018 in LBNL. It was organized BNL, LANL, LBNL and LLNL scientists and was attended by 79 people. This conference's topics overlap greatly with the research interests of USNDP members responsible for the nuclear reaction modelling that powers ENDF/B evaluations.

Additional Highlights

Atlas of Neutron Resonances

Said Mughabghab passed on July 6, 2018 following a brief disease. During the previous 5 years, Said had been quite busy working on a new edition of the Atlas of Neutron Resonances, and we actually last saw Said by the end of April as he signed a few copies of the just arrived Atlas from Elsevier. Until early May, Said had shown no signs of an impending sickness, if anything, we were delighted by the abundance of energy displayed as the new Atlas was being finalized.

We will remember Said as the gentleman with an encyclopedic knowledge of low-energy neutron-induced reactions, and in particular, neutron resonances. Said could remember all data relevant for these thousands of resonances as well as which laboratories had studied them and when the results were published. Precise knowledge of neutron resonances is crucial for the design and operation of nuclear reactors, as well as to understand the origin of heavy elements in stars produced in the s-process. Plenty of our knowledge about the physics governing neutron resonances was garnered at BNL's Graphite Research Reactor, where Said would start working in 1963.



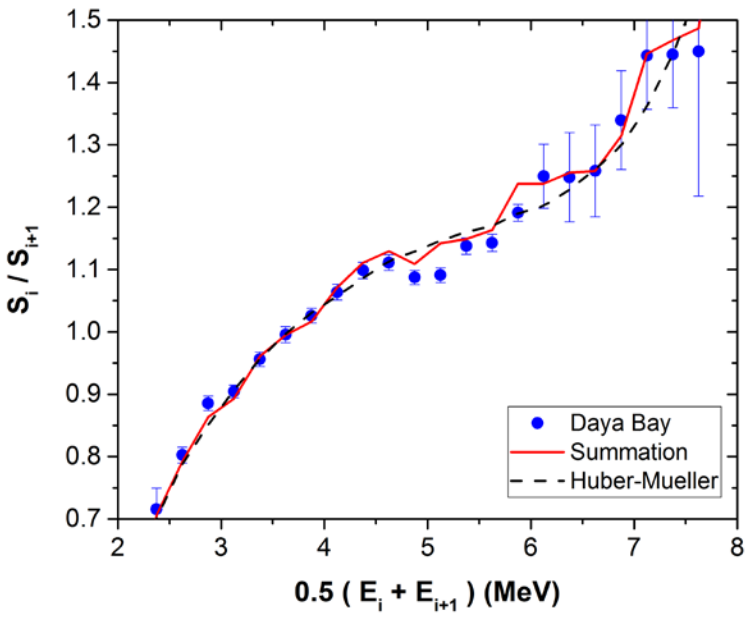
Said was born in Lebanon, obtaining his B.S. and M.S. in physics from the American University in Beirut. Said attended the University of Pennsylvania for graduate studies, obtaining his Ph.D. in 1964. Said retired in 2000 from BNL and became Senior Physicist Emeritus in 2008.

The need to count with a recommended set of neutron resonance parameters, derived following a critical review of all available published data, arose from the early days of nuclear physics. BNL published the first work containing such data in 1955. Said finished the 6th edition, which unknown to us was going to become his swan song, in late 2018, achieving publication in early 2019. Said's work will posthumously reach many professionals and influence their work, as with early editions, the new Atlas will become a great resource in nuclear science and technology and will undoubtedly achieve a high number of citations.

Revealing fine structure in the antineutrino spectra from a nuclear reactor

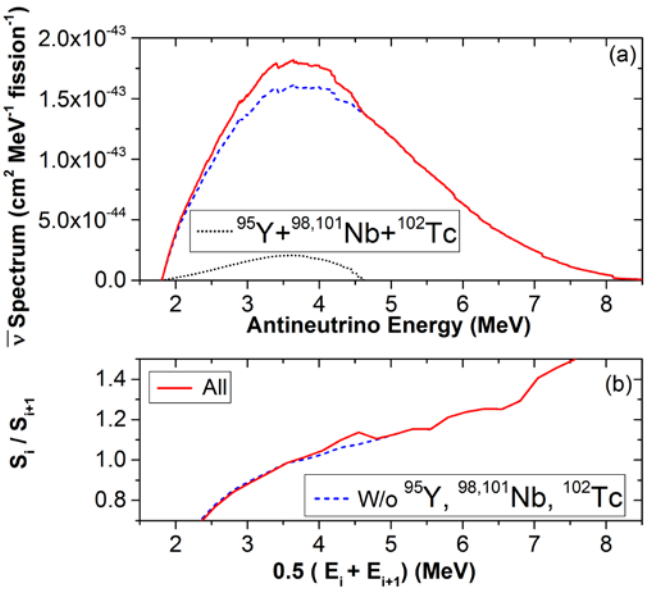
Nuclear reactors are prolific sources of electron antineutrinos, producing about 10^{21} of them per second for a typical power reactor. These electron antineutrinos are produced by the beta-minus decay of the more than 800 neutron-rich fission fragments, which are the debris from the main source of energy generation in a reactor, the neutron induced fission of actinide nuclides. These antineutrinos are also the only radiation escaping from a safely operating reactor.

Nuclear reactors have been an essential tool to study the weak interaction. Their large antineutrino flux was capitalized by Cowan and Reines to discover antineutrinos in 1956, more than 25 years after they were first hypothesized by Pauli in 1930 to explain the continuum electron spectra observed following beta-minus decay. In the last few years, the transformation of electron antineutrinos into the other two flavors was beautifully measured by three large-scale experimental efforts, Daya Bay, Double Chooz and RENO. These experiments also confirmed a deficit of antineutrinos of about 5% at short distances that had been revealed in a 2011 re-analysis of the conversion procedure to obtain antineutrino spectra from the measured electron spectra.



Electrons and antineutrinos produced in beta-minus decay, unlike their sharp-peaked counterpart gamma rays, have broad energy distributions. And there are more than 5000 of these transitions in a reactor antineutrino spectrum! By using the highest-fidelity USNDP nuclear databases to date a team from the National Nuclear Data Center (A.A. Sonzogni, M. Nino and E.A. McCutchan) showed that the signature from individual fission products could be disentangled from the total spectrum, in a process analogous to singling out a few trees in a dense forest. To achieve that, the novel yet simple numerical procedure shown on the figure was developed. Basically, by taking the ratio of adjacent spectrum points, a concave down feature in the Daya Bay data is observed, which is not reproduced by the most precise model available (Huber-Mueller), but in agreement with the summation calculations using nuclear databases.

A query to those databases also revealed that only four nuclides are responsible for this effect: ^{95}Y, ^{98,102}Nb and ^{102}Tc. A similar analysis performed on the ^{235}U electron spectrum revealed also the presence of ^{96}Y and ^{92}Rb. The reason beyond this ability to identify individual products is that the emission of antineutrinos in a nuclear reactor is not a purely statistical process. Out of the 800 fission products, a smaller number will be significantly produced due to quantum effects, and for each one of those lucky fission products, the number of substantial beta transitions is reduced to just a few. This work was published on July 20, 2018 in the Physical Review C Journal.



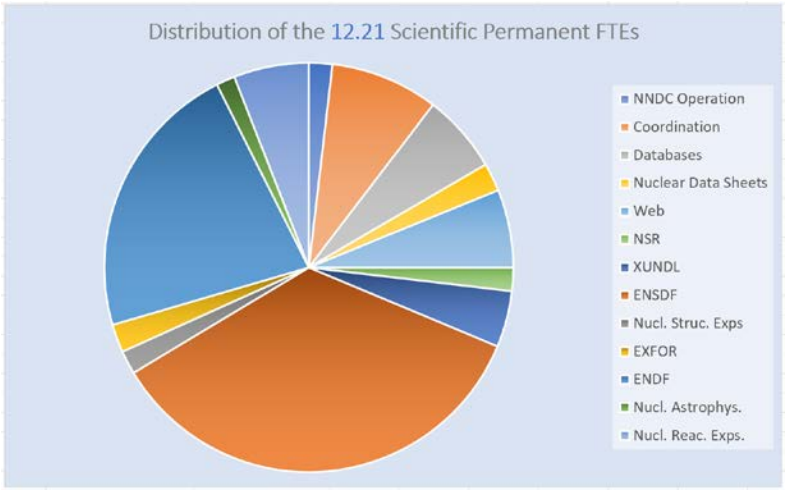
USNDP Staffing Table FY 2018

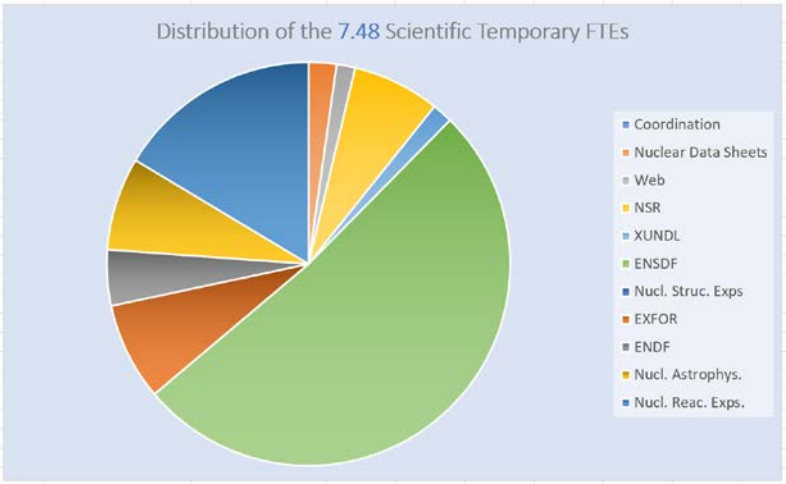
The table below gives the FTE distribution for each USNDP group according to activity. The values in this table and following plots are for the based funding only. In this table PhD P means PhD Permanent; PhD T means PhD Temporary, which includes post-docs and scientists working under contract; T/A means Technical and administrative; and GS means graduate student.

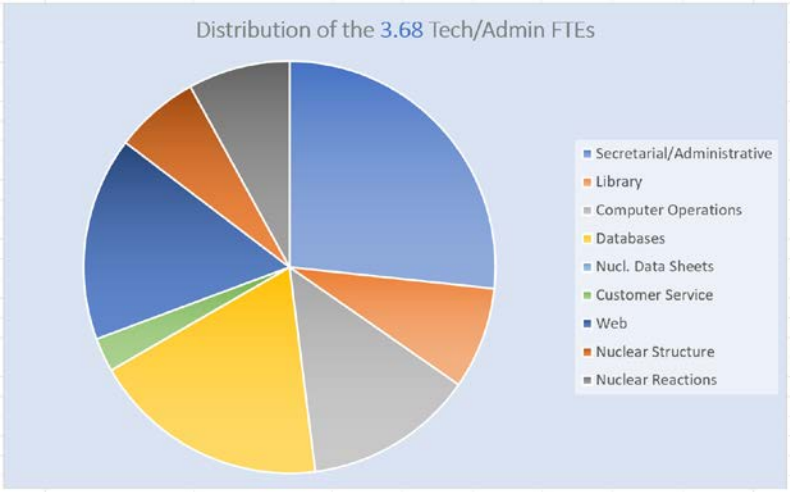
	ANL	BNL			LANL		LBNL		LLNL			MSU	NIST		ORNL			TAMU	TUNL			
Activity	PhD P	PhD P	PhD T	T/A	PhD P	PhD T	PhD P	PhD T	PhD P	PhD T	GS	PhD P	PhD P	PhD T	PhD P	PhD T	GS	PhD P	PhD P	PhD T	T/A	Totals
I. NNDC Facility Operation	0.00	0.25	0.00	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.05
Management		0.25																				0.25
Secretarial/Admin. Support				1.00																		1.00
Library				0.30																		0.30
Computer Operations				0.50																		0.50
II. Coordination	0.20	0.35	0.00	0.00	0.10	0.00	0.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.00	1.15
National Coordination	0.15	0.19			0.05		0.40								0.05				0.05			0.89
International Coordination	0.05	0.16			0.05																	0.26
III. Nuclear Physics Databases	0.00	0.84	0.00	0.70	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	1.54
Nuclear Science References, NSR		0.25		0.60																		0.85
Expr. Nucl. Struct. Data, XUNDL		0.20																				0.20
Eval. Nucl. Structure Data, ENSDF		0.20																				0.20
Numerical Nuclear Data, NuDat		0.05																				0.05
Exp. Reaction Data, EXFOR		0.10																				0.10
Evaluated Nuclear Data File, ENDF		0.04																				0.04
Database Software Maintenance				0.10																		0.10
Future Database System Develop.																						0.00
IV. Information Dissemination	0.00	1.08	0.15	0.20	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.50	2.08
Nuclear Data Sheets		0.30	0.15																			0.45
Customer Services				0.10																		0.10
Web Maintenance & Develop.		0.78		0.10											0.05						0.50	1.43
V. Nuclear Structure Physics	0.75	1.10	0.97	0.00	0.00	0.00	0.90	2.31	0.00	0.00	0.00	1.00	0.00	0.00	1.00	0.15	0.00	0.63	0.45	0.60	0.25	10.11
NSR Abstract Preparation		0.25	0.47																			0.72
Compilation of Exper. Struct.Data	0.10	0.15	0.11				0.10					0.15							0.10		0.05	0.76
A-chains & Nuc. Evals for ENSDF	0.40	0.40	0.39				0.80	0.89				0.65			1.00	0.15		0.63	0.35	0.60	0.20	6.46
Ground & Metastable State Prop.	0.20																					0.20
Non-ENSDF Decay Data Eval.								0.40														0.40
N-induced γ's Data Evals.								0.78														0.78
Nuclear Structure Data Meas.	0.05	0.20																				0.25
ENSDF Phys. & Checking Codes		0.10						0.25				0.20										0.55
VI. Nuclear Reaction Physics	0.05	2.58	0.50	0.30	0.75	0.95	0.45	0.38	0.25	0.50	1.00	0.00	0.10	0.10	0.10	0.00	0.20	0.00	0.00	0.00	0.00	8.21
Experimental Data Compilation		0.30	0.50					0.03														0.83
ENDF Manuals & Documentation		0.05																				0.05
ENDF Evaluations		1.33			0.20				0.08													1.61
Nuclear Reaction Standards													0.10	0.10								0.20
Nuclear Model Development		0.25			0.20	0.10			0.14													0.69
Nucl. Reac. Data Measurements					0.35	0.75	0.45	0.35														1.90
Astrophysics Nuclear Data Needs	0.05									0.50	1.00				0.10		0.20					1.85
Covariances development		0.15				0.10																0.25
Reactor Antineutrino & Dec. Heat		0.20																				0.20
Verification and Validation		0.25		0.30					0.03													0.58
DOE-SC Nucl. Data Funded Staff	1.00	6.20	1.62	3.00	0.85	0.95	1.75	2.79	0.25	0.50	1.00	1.00	0.10	0.10	1.20	0.15	0.20	0.63	0.50	0.60	0.75	25.14
Staff Supported by Other Funds	0.00	0.55	0.00	0.00	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	0.80
TOTAL STAFF	1.00	6.75	1.62	3.00	0.85	0.95	2.00	2.79	0.25	0.50	1.00	1.00	0.10	0.10	1.20	0.15	0.20	0.63	0.50	0.60	0.75	25.94

USNDP FTE plots FY 2018

The plots below give the FTE distribution for Scientific permanent, Scientific temporary and Tech. / admin. FTEs, in pie charts according to activity.







Detailed Status of the Work Plan

Fiscal Year 2018 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
In collaboration with ITD, ensure continuous availability of mission-critical Web services through full compliance of NNDC's computers with DOE cyber security requirements.	Completed. All servers up to date with security requirements.
Provide technical computer support to NNDC staff, visitors and external collaborators to enable them to effectively and securely use NNDC computing resources, as well as procure computer hardware, software and support services to meet NNDC's computing requirements.	Completed. A significant number of ageing units were replaced.
Manage NNDC/NE cluster.	A new server, with specifications defined following consultations with ITD, was bought and has been tested. Results are very positive, and three more servers, a disk unit and a new data switch will be bought in FY 19 to fully upgrade the cluster.

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).

BNL Planned Activities	Status
Prepare FY2019 work plan for USNDP.	Completed.
Organize and chair CSEWG Meeting at BNL in November 2017.	Completed.
Organize and chair USNDP Meeting at BNL in November 2017.	Completed.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.	Completed.
Maintain CSEWG and USNDP websites.	Ongoing and completed.
Organize mini-CSEWG meeting in the summer if needed	Not performed as there was no mini-CSEWG meeting
Host and help organize NDAC meeting	Completed, NDAC met on April 2018.

LANL Planned Activities	Status
Organize and chair CSEWG Evaluation Committee meeting at BNL.	CSEWG evaluation committee meeting organized
Organize and chair CSEWG Covariance Committee meeting at BNL.	CSEWG covariance committee meeting organized
Organize and chair Nuclear Reaction Working Group.	Chair of Nuclear reaction working group served and gave a talk at CSEWG.

LBNL Planned Activities	Status
Organize the Nuclear Structure High Priority List together with A. Negret from Bucharest.	Completed.
Unplanned activity: Organize NDREW meeting	NDREW meeting took place in February 2018 in Washington DC.

ORNL Planned Activities	Status
Coordinate and outreach USNDP Nuclear Astrophysics activities.	Discussions with MSU regarding the future of the REACLIB database. Submitted an abstract to present several USNDP data activities at ND2019.

TUNL Planned Activities	Status
Organize and chair USNDP Nuclear Structure Committee.	Continuing.

A. International Coordination

ANL Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	a) participated in the IAEA-led Coordinated Research Project on "Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production". Contributed to comprehensive nuclear data evaluations and measurements for selected radionuclides. Co-authored three journal articles that were published in the journals Nuclear Data Sheets and Journal of Radioanalytical and Nuclear Chemistry. b) organized and chaired the Nuclear Data Working Group session at the 2nd China-US-RIB meeting, Beijing, China (October 2017) c) participated in the IAEA technical meeting on "Total Absorption Gamma-ray Spectroscopy" (February 2018).

BNL Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	Completed. NNDC members attended the INDEN and NRDC meetings.
Participate in NEA WPEC annual meeting.	D. Brown and A. Sonzogni attended the 2018 WPEC meeting and attended several sub-groups.
Participate in IAEA CRP and technical meetings.	E. McCutchan and A. Sonzogni participated on the beta-delayed neutrons CRP.
Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work.	E. McCutchan helped setup a training workshop in Trieste.

LANL Planned Activities	Status
Participate in NEA WPEC annual meeting.	LANL scientists participated in WPEC meeting
Participate in relevant IAEA coordinated meetings, such as reference input parameter library, nuclear cross section standards, and photo-nuclear data.	LANL scientists participated in these IAEA coordinated meetings
Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.	Hosted one scientist from IAEA, and plan to invite another scientist from IAEA.
Host a couple of international visitors to collaborate on reaction experiments at LANSCE.	Hosted a long-term visitor from KAERI, and one scientist from Charles University, Prague.

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	Continuing.

IAEA.	
Coordinate LBNL/Budapest/FRM-II/Julich Trans Actinide Nuclear Data Evaluation and Measurement (TANDEM) collaboration to measure actinide neutron cross sections.	Continuing.

MSU Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	No relevant meetings at available dates took place.

ORNL Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	Continuing.

TAMU Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	Continuing.

TUNL Planned Activities	Status
Participate in IAEA-sponsored nuclear data activities.	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 was distributed to the IAEA on a monthly basis.
Perform Database updates and maintenance.	NSR was updated 135 times, and cybersecurity updates were implemented.
Continue joint project with the NRDC network to transfer missing nuclear reaction references to NSR.	Paper and electronic versions of the P.M. Endt library was acquired from McMaster University and stored at NNDC. Conferences proceedings EXFOR entries were added to NSR, work continues.

B. Experimental Nuclear Structure Data (XUNDL)

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

BNL Planned Activities	Status
Perform Weekly update of the database using input received from compilers.	Completed.
Distribute database twice a year to the NSDD network	Completed.
Distribute ENSDF database to collaborators on a monthly basis.	Completed.

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.	Completed.
Process evaluations received from NSDD evaluators.	Completed.
Distribute ENSDF database to collaborators on a monthly basis.	Completed. ENSDF is archived on a monthly basis and made available through the NNDC website.

E. Neutron Reaction Data Bibliography (CINDA)

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

BNL Planned Activities	Status
Contribute to CINDA by compiling experimental cross-section data to the CSISRS and NSR databases.	Completed.

F. Experimental Reaction Data File (EXFOR)

The NNDC is responsible for maintaining the EXFOR database at BNL. This database contains experimental nuclear reaction data for incident energies below 1 GeV, including neutron-induced reactions and reactions with incident charged particles of mass A ≤ 12. Many groups worldwide compile experimental data and send it to the central database in Vienna in the EXFOR format. Then, each is responsible to update its own database. The effort described here includes quality control, file update

and data transfer activities. The NNDC database is updated, as compilations are exchanged and checked from the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

BNL Planned Activities	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.	Completed. EXFOR database was updated 24 times.

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 in the 1960s and adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. New evaluations for the next release of the library, ENDF/B-VIII.0, are assembled, tested and made available to users through NNDC's Web servers and GForge collaboration server.

BNL Planned Activities	Status
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV)	Not performed due to personnel shortage.
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.	Completed. A new server to be integrated into an upgraded cluster was bought to be the new ADVANCE server.

H. Database Software Maintenance

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

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

I. Database Systems Development

The multi-year effort to migrate the USNDP databases to a LINUX/MySQL environment was completed in FY2009. Afterwards, several follow-up tasks needed to be performed. A new web interface,

complementary to the existing one, should be developed to facilitate the retrieval of experimental data in EXFOR by non-ENDF users, such as nuclear astrophysicists. This interface should focus on the relevant experimental data, such as a full reference to the publication, a comprehensive reaction description and the experimental data. The existing interface, giving access to the complete compilation (with more details than the reference, reaction and data) will be retained and will still be accessible to users who need it. Also, a new ENDF interface should be developed for users who do not possess specialized knowledge of ENDF-6 format.

BNL Planned Activities	Status
Upgrade the Linux/MySQL server software to fix bugs, provide new functionalities and improve the system's performance, security and reliability.	With the deployment of new database servers running on a new operating system, the MySQL database system software was replaced with MariaDB to comply with BNL/ITD's operational requirements. This required the migration of all nuclear databases and their associated application software from MySQL to MariaDB.
Maintain MySQL database system software for automated replication of updates from the internal database server to the external for continuing compliance with DOE cyber security requirements.	As part of the migration from MySQL to MariaDB, the automated replication software was rewritten, tested and deployed while ensuring full compliance with DOE cyber security requirements.

IV. Information Dissemination

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

A. Nuclear Data Sheets

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

BNL Planned Activities	Status
Prepare issues of Nuclear Data Sheets for publication.	8 issues of Nuclear Data Sheets, including a Special Issue devoted to the release of ENDF/B-VIII.0, were prepared.
Work on new version of Nuclear Wallet Cards.	New code was developed to generate print and mobile versions of Nuclear Wallet Cards.

MSU Planned Activities	Status
Continue development of software for Nuclear Data Sheets publication.	Continuing activity. JAVA NDS code was modernized through the year.

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.	About 300 requests for articles were received by our librarian. Additionally, a large number of emails, about 150, were answer with different type of data requests.
Maintain Comments/Questions for all databases and web products	No longer maintained as users communicate only through e-mail.

C. Web site maintenance

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

BNL Planned Activities	Status
Solicit user suggestions on enhancements to the ENSDF, NSR, NuDat and Sigma web interfaces and be responsive to those needs. Expand search capabilities of ENSDF.	Limited work performed due to personnel shortages.
Maintain web interfaces for ENDF and EXFOR databases.	ENDF and EXFOR database Web interfaces were updated in collaboration with the IAEA.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users' requests.	Completed.
Maintain the NNDC Web Services availability on the 99% and higher level.	Successfully kept NNDC Web Services downtime at a maximum of eight hours only for the whole year (~99.9% uptime).
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	Completed.
Upgrade GForge server software to provide more powerful and advanced functionalities in the NNDC collaboration services.	Successfully upgrade the GForge collaboration software from version 6.4.2 to 6.4.3. This fixed most of the reported bugs and made available useful functionalities to end-users.
Make progress with modernization of the web site, enhancing capabilities and follow industry best practices.	Very limited activity performed due to personnel shortages.

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.	No funding was available for the planned expansion of this activity. A new set of compiled masses from McMaster Univ. were uploaded to the system.

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.	Continuing.
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.	Continuing. The collection is essentially complete and includes all presently available documents.

V. Nuclear Structure Physics

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. NSR Abstract Preparation

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

BNL Planned Activities	Status
Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them. Provide coverage for 80 major journals, including complete	Completed. 3,714 new references were added, and 2,206 references were keyworded.

coverage of Physical Review C and Nuclear Physics A.	

B. Compilation of Nuclear Structure Data

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

ANL Planned Activities	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.	Completed 51 datasets (15 papers) for XUNDL, mentored a scientist from the RIKEN facility to compile data for XUNDL.

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 an experimental methods analysis and start on Grodzin's formula fits.	28 new B(E2) values were compiled.
Compile new double-beta decay experimental data. Start working on a data project with Kiev Institute for Nuclear Research.	36 new double-beta decay values were compiled. Started paperwork on Dr. V. Tretyak (KINR) visit to NNDC.
Maintain, update and distribute XUNDL.	Completed.
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.	132 papers were compiled for inclusion into the XUNDL database. 585 datasets were reviewed prior to their inclusion into the database.
Compile new mass measurements and submit data file to nuclearmasses.org webpage at ORNL. (McMaster).	Continuing.
Unplanned activity: Prepublication compilation of Physical Review C articles.	In March 2018, a project started with Physical Review C journal to check and compile papers prior to their publication. This has become an on-going effort.

LBNL Planned Activities	Status
Perform XUNDL compilation.	17 articles including 22 datasets were compiled.

MSU Planned Activities	Status
Compile datasets for at least 50 journal papers.	54 papers (101 datasets) were compiled and submitted to XUNDL.

ORNL Planned Activities	Status
Compile XUNDL datasets as required.	No XUNDL compilations requested in FY2019.

TUNL Planned Activities	Status
Compile datasets for current experimental nuclear structure data publications on A=2-20 nuclei for inclusion in the XUNDL database.	Compiled 42 XUNDL reaction data sets from 32 articles

C. Compilation of Nuclear Structure Data

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	1 mass chain was evaluated (A=177 - 15 nuclides).
Review mass chain evaluations, as requested.	No request for a review of mass chain was made by NNDC during FY18.

BNL Planned Activities	Status
At least 4 mass chains, or their equivalent nuclides, will be evaluated.	5.5 Mass chains were evaluated.
At least 4 mass chains, or their equivalent nuclides, will be reviewed.	4 mass chains were reviewed.
Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides. Collaborate with anew center/evaluator as part of mentoring process, as needed (McMaster).	Completed.
All evaluations submitted for publications will be edited including checking for their format and physics content. Extensive changes are often made by NNDC staff.	All mass chains were carefully reviewed and edited prior to their inclusion into the database in order to enhance the quality of ENSDF evaluations.
Continue mentoring new ENSDF evaluators.	

LBNL Planned Activities	Status
Evaluate the equivalent of at least 3 mass chains	23 nuclides were evaluated for ENSDF.

(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.	
Review mass-chain evaluations, as requested.	1 mass chain was reviewed.
Train new compilers/evaluators.	
Coordinate XUNDL evaluation efforts with UC Berkeley/LBNl/LLNL Nuclear Data Collaboration.	Continuing.

MSU Planned Activities	**Status**
Evaluate the equivalent of at least 1 mass chain.	4 mass chains (56 nuclides) were evaluated and submitted to ENSDF (shared effort with NNDC).
Review mass-chain evaluations, as requested.	1 mass chain (17 nuclides) was reviewed.

ORNL Planned Activities	**Status**
1 equivalent mass chains and the data for new nuclides will be evaluated. Mass chains will be reviewed as requested.	A=137 was submitted. Additionally, A=66 evaluation in progress (Nesaraja), A=98 review in progress (Nesaraja), A=218 evaluation completed (Martin co-Author), Radius parameters for alpha decay of even-even nuclides - review in progress (Martin), Making Corrections on A=242 evaluation based on referee comments (Martin).

TAMU Planned Activities	**Status**
At least 1 mass chain, or their equivalent nuclides, will be evaluated.	Completed full evaluation and submitted A=153 of 17 nuclei to NNDC. Resubmitted delayed A=160 of 17 nuclei after pre-review corrections to NNDC.

TUNL Planned Activities	**Status**
Evaluate about 1-2 A-chains per year for publication in Nuclear Data Sheets and inclusion in the ENSDF database.	Submitted ENSDF file for A=12, 12He, 12Li, 12Be, 12B, 12C, 12N, 12O.
Evaluate and update ENSDF for A=2-20 near drip-line nuclides, especially for first observations or when ENSDF has no previous data set.	Submitted ENSDF files for 5Be,17Ne
Update various reaction data sets in ENSDF, such as for beta-decay and beta-delayed particle emission.	Continuing.

C. Ground and Metastable State Properties

ANL Planned Activities	**Status**
Complete and publish the new Atomic Mass Evaluation and NUBASE evaluation of nuclear properties in collaboration with scientists from	Continued compilation and evaluation activities related to the next Atomic Mass Evaluation and NUBASE evaluation of nuclear properties.

CSNSM, Orsay, IMP, Lanzhou and RIKEN, Japan	

BNL Planned Activities	Status
Update Nuclear Wallet Cards database as new information becomes available.	A few updates on the nuclear wallet cards file were performed, as well as migrating the file to MariaDB.

E. Non-ENSDF Decay Data Evaluations

ANL Planned Activities	Status
Evaluate and publish decay data evaluations for selected nuclides within the auspices of the IAEA-CRP on "Nuclear data for charged-particle monitor reactions and medical isotope production.	participated in the IAEA-led Coordinated Research Project on "Nuclear Data for Charged-particle Monitor Reactions and Medical Isotope Production". Contributed to comprehensive nuclear data evaluations and measurements for selected radionuclides. Co-authored three journal articles that were published in the journals Nuclear Data Sheets and Journal of Radioanalytical and Nuclear Chemistry.

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

E. Neutron-induced γ-Ray Data Evaluation

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 structure data for the RIPL library in EGAF datasets. Develop a Nuclear Data Sheet publication format for EGAF data.	Continuing.
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.	This activity has been discontinued.
Collaborate with the University of Oslo to measure low-energy photon strength functions and level densities.	Continuing.
Work to develop a database of (n, n'gamma), starting with the compilation and release of the Atlas of Inelastic Scattering of Reactor Fast	Continuing.

Neutrons. The data is now available on the web at http://nucleardata.berkley.edu and is being integrated with modern structure data from ENSDF.	

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

H. Nuclear Structure Data Measurements

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 nuclei, spectroscopy of heavy actinide nuclei and nuclei far from the line of stability.	a) completed the analysis of decay data for the 160Eu and 162Eu nuclei in the light rare-earth region that resolved discrepancies with recent measurements at the RIKEN facility. Beta-decaying isomers were discovered in both nuclei and evidences were presented for the existence of a large subshell gap at N=98 and large deformation. The results were published in the journal Physical Review Letters. b) completed the analysis of the 243Bk and 244Bk decay data and published the results in the journal Physical Review C. c) continued nuclear structure research activities at the ATLAS and CARIBU facilities. The main emphasis was on decay studies of neutron-rich nuclei in the A~160 deformed, rare-earth region and on heavy actinide nuclei.

BNL Planned Activities	Status
Precisely determine decay schemes of relevant medical isotopes using state-of-the-art gamma-ray spectroscopy.	Experiment was performed at Argonne National Laboratory in May 2018 to study the decay of Arsenic isotopes with potential for use in medical imaging. Data form the senior thesis for two students.
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.	The analysis on the decay of 92Rb, relevant to reactor antineutrino calculations was finalized.
Driven by deficiencies in nuclear data on the neutron-rich side of 208Pb, complete and analyze deep-inelastic reaction experiments performed at Argonne.	Data analysis is on-going.

LANL Planned Activities	Status
Analyze and publish the prompt gamma-ray data taken on fission products of mass range ~100, using the GEANIE array.	Completed and Published in PRC 99, 024606 (2019).
Publish the gamma-ray production cross section on Xe-126, which was measured using the GEANIE array.	Completed and Published in PRC 98, 064606 (2018).

LBNL Planned Activities	Status
Perform DICEBOX statistical model calculations to determine total radiative cross sections and elucidate nuclear level spins and parities.	Continuing.
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.	Continuing.
Investigate primary gamma ray photon strength functions and the contribution of the M1+E2 mixing ratio to nuclear statistical model calculations.	Continuing.

H. ENSDF Physics and Checking Codes

BNL Planned Activities	Status
Maintain and upgrade ENSDF checking and physics programs for format changes as required.	Updates were performed.
Move codes off the Lahey compiler and make compatible with GFORTRAN.	All codes were moved.

MSU Planned Activities	Status
Work on NDS java code.	Continued to maintain and improve existing codes developed at MSU, e.g., Java-NDS. Modernized legacy FORTRAN codes using Java: Java-RULER. Developed new codes in Java: ConsistencyCheck, KeynumberCheck, Excel2ENSDF.

V. Nuclear Reaction Physics

A. Experimental Data Compilation

The NNDC, as part of a larger international cooperation, has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada. Incident neutron reactions have been well covered historically. NNDC thus concentrates on new measurements but continues compilations of earlier publications that have not been included in the EXFOR database. Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-

particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data. Hence, there is a larger staff commitment to compiling this type of data.

BNL Planned Activities	Status
Compile experimental data for neutron, charged particle, and photon induced reactions from 120 publications.	43 + 87 (BNL) = 130 new EXFOR entries were compiled. Corrected entries: 158 + 53 (BNL) = 211.
Explore possibilities of recovering previously unobtainable reaction data and proactively respond to users needs.	The completeness of EXFOR fission yield compilations was thoroughly investigated. Total number of missing publications: 134 spontaneous fission, 88 photo fission, and 234 neutron-induced fission yields.

B. ENDF Evaluations

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

BNL Planned Activities	Status
Respond to user needs for evaluated nuclear reaction data.	On 2 Feb. 2018, the Cross Section Evaluation Working Group (CSEWG) released its latest revision of the ENDF/B library, ENDF/B-VIII.0, incorporating work from across the US and the international nuclear science community over the last six years. ENDF/B is arguably the most important library for neutronics and shielding calculations in the United States. ENDF/B-VIII.0 includes major improvements to the neutron, thermal scattering and atomic reaction data as well as important, but smaller in scope, improvements to charged particle and decay data. The library is detailed in the Feb. 2019 issue of Nuclear Data Sheets, see the list of publications at the end of this document.
Collect and address users feedback related to the ENDF library.	Participated in 7 separate conferences, presenting the ENDF/B-VIII.0 release and soliciting feedback pertaining to the library performance. An errata page has been generated for ENDF/B-VIII.0 collecting smaller corrections. Larger corrections are being addressed through the normal CSEWG process and the newly established Nuclear Data FOA process.
Complete evaluation of 56Fe in the frame of the CIELO project. Work with CSEWG on upgraded	Nearly new evaluations for 56Fe and other minor Fe isotopes were generated as part of BNL's

evaluations for future release of the ENDF/B library.	participation in the CIELO project. This work is detailed in the Nuclear Data Sheets special issue.
Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.	All of the new CIELO evaluations were generated with extensive covariance data. See above.
In collaboration with LLNL, coordinate the development of the Generalized Nuclear Data (GND) format as a proposed successor format for ENDF.	FUDGE-4.2.3 with support for GNDS-1.9 was released on 20 Mar. 2018 through LLNL. As part of the WPEC Expert Group on GNDS, the drafting the formal specifications for the GNDS-1.9 format has begun. ENDF/B-VIII.0 was released simultaneously in the legacy ENDF-6 format an in GNDS-1.9.
Provide production cross sections for medical isotopes.	Not completed due to lack of funding.
Improve methodology for generating unresolved resonance region cross section probability distributions.	Two extensive studies of the unresolved resonance region were published in FY18. The first describes an attempt to connect the fast region and the resolved and unresolved resonance regions by studying the properties of neutron transmission coefficients [D. A. Brown, G. P. A. Nobre, M. W. Herman, Phys. Rev. C 98, 024616 (2018)]. The second details the application of cross section correlation functions to the fluctuations in the 235U(n,f) cross section [G. Bertsch, D. Brown, E.D. David, Phys. Rev. C 98, 014611 (2018)]

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.	Two new evaluations of uranium isotopes produced, which is based on the new statistical model for deformed nuclei. Prompt gamma-ray production from U-238 investigated by including the Engelbrecht-Weidenmueller transformation under CIELO collaboration.
Provide upgraded ENDF evaluated data files for light and medium mass elements, and perform criticality benchmarks.	Oxygen evaluation on-going. The benchmark test for copper isotopes performed and some issues reported.
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.	U235 prompt fission neutron spectrum calculated with the deterministic model and compared with experimental data. Pu239 spectrum that includes the FKK pre-fission neutron emission calculated and compared with new LANSCE ChiNu data. PRL paper published.
Improve photon production data for neutron capture and inelastic scattering, which will be used in prompt gamma-ray spectroscopy.	Prompt gamma-ray production improved by including the quantum mechanical pre-equilibrium model. Work performed with CEA, CNRS, and IAEA.

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

C. ENDF Manuals and Documentation

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

BNL Planned Activities	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 ENDF-6 manual is dutifully maintained by the NNDC and the latest release, coinciding with ENDF/B-VIII.0, was released on 2 Feb. 2018. The manual report number is BNL-203218-2018-INRE.
Automate the generation and posting of the latest unofficial version of the ENDF-6 formats manual.	The generation of the in-development version of the ENDF-6 manual is fully automated. Deployment of the in-development manual will be re-enabled in FY19 after a review of our release procedures in lieu of the difficulties with the distribution of the EMPIRE software package.

D. Nuclear Reaction Standards

Nearly all neutron cross section measurements are made relative to a neutron cross section standard such as the hydrogen elastic cross section. Maintaining accurate current values for the standard cross sections is the primary objective of this task that can be most efficiently accomplished through international cooperation. A new international evaluation of the neutron cross-section standards is now underway. It is important to improve the standards database and procedures for evaluations in preparation for new evaluations of the standards. To assist in this, an IAEA data development project "maintenance of the neutron cross section standards" was initiated to ensure that we are prepared for the next evaluations of the neutron cross section standards. Historically the standards evaluation

activity has included data other than the cross section standards, i.e. the thermal constants and the 252Cf spontaneous fission neutron spectrum. Recently the scope has been broadened, largely through the data development project, to include an investigation of possible inelastic scattering cross section reference standards; considering adding additional standards energy ranges for the Au(n,γ) cross section; and proposing updates for the evaluations of the 252Cf spontaneous fission neutron spectrum and the 235U thermal neutron-induced fission neutron spectrum.

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 Scientists participated in IAEA meetings on the standards evaluation as well as R-matrix code.
Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.	New uranium evaluations include the standards, and validation tests still under plan. ChiNu project has incorporated the 6Li(n,a) cross sections from the new ENDF and performed validation tests as a part of detector response function studies in the Li-glass detector array.
Perform the precision measurements on ^{6}Li(n,α)t and ^{6}Li(n,α)dn using CLYC detectors, in order to improve uncertainties En > 1 MeV due to the triton breakup ambiguity shown in previous measurements.	Measurements were completed and analyses are ongoing, and preliminary results have been presented in various meetings.

NIST Planned Activities	**Status**
Initial values of the standards for use in the next version of a number of cross section libraries will have been determined at a July meeting. Additional data are expected that can be included in the evaluation shortly after the end of FY16. The final values will be obtained by the end of calendar year 2016 and 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.	Work continued on improving the database for the new standards evaluation. The major accomplishment was the finishing of that work and publishing the results. It led to the completion of a comprehensive paper on the neutron standards published in Nuclear Data Sheets in January 2018. It contains a discussion on the evaluation process, details of the database used and listings of the results obtained from the process. These data were accepted as the standards for ENDF/B-VIII. These standards are not changed for different versions of ENDF/B-VIII. In this paper unrecognized systematic uncertainties (USU) in nuclear data were studied to arrive at uncertainties that are more reasonable.
Drafts of the work done on the standards evaluation prepared through the IAEA data development project will be prepared in electronic	Work on the analysis of the hydrogen scattering cross section measurement at Ohio University continued with important corrections to the data

form. This becomes the documentation for this new evaluation of the standards.	and a draft of a publication.
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.	A paper on the standards work noting their use as dosimetry data was finished. It was presented at the International Symposium on Reactor Dosimetry meeting (ISRD 16).
Diagnostic work will continue leading to measurements with the new deuterium gas target. 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.	To perform work leading to improvements in the neutron cross section standards and related standards. The work shall include work on measurements of a hydrogen standard cross section; investigation of improved methods to obtain high accuracy neutron standard cross section measurements; review of experiments which may be candidates for use in standards evaluations, including examination of uncertainties and possible changes needed in the data and preparation of the data for use in evaluations; suggestions for new experiments to improve the standards database; studies of unrecognized systematic uncertainties and uncertainty quantification.
Work will continue 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 new determination of our manganese bath efficiency. Another approach is also underway in which the neutron fluence is based on alpha-gamma coincidences with the ^{10}B(n,alpha) reaction. It will be done with a small bath and inter-compared with NBS-I indirectly.	Continuing.
The measurement and initial analysis of the ^{6}Li(n,t) standard cross section determination at ~ 4 meV neutron energy has been completed. It uses an improved fluence determination based on alpha-gamma coincidences with the ^{10}B(n,alpha) reaction. A significant effort has gone into an investigation of the uncertainty of this result resulting mainly from uncertainty in the ^{6}Li mass. The initial value obtained was in excellent agreement with the ENDF/B-VII standards evaluation. It was found that the mass reported by IRMM was in error. Using the new mass value produces a cross section value with an uncertainty of 0.3% lower by 1% compared with the ENDF/B-VII value. Publication of the result of this work is delayed due to interactions with IRMM on their new mass value. Work continues on a study of the	Continuing.

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.	
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.	Continuing.

E. Nuclear Model Development

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

BNL Planned Activities	Status
Continue to improve reaction modeling in the EMPIRE code, maintain code's numerical integrity and enhance user friendly GUI.	Work improving EMPIRE continued throughout this year. A GUI was not developed.
Improve EMPIRE covariance capabilities for fast neutrons.	Work improving EMPIRE continued throughout this year.
Maintain GForge site with the current version of the EMPIRE code.	EMPIRE distribution was halted in the GForge server and the project was removed due to technical reasons.
Maintain continuous integration system ADVANCE for checking and validation of new EMPIRE versions.	Continuous checking of EMPIRE with ADVANCE was suspended when EMPIRE was no longer distributed through BNL's GForge.

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, as well as penetrability calculations through arbitrary fission barrier shapes. Implement the theory into the Hauser-Feshbach code to facilitate actinide evaluations.	Model to calculate penetration through arbitrary fission barrier shapes developed, and incorporated into the Hauser-Feshbach code. This capability is still optional in the code.
Continue to develop a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets including M1 scissors mode, in support of DANCE and GEANIE measurements, and fission cycle in r-process nucleo-synthesis studies.	Results of the systematic study of M1 scissors mode implemented into the Hauser-Feshbach code. The M1 strength is automatically calculated according to the nuclear deformation. The calculated reaction rates were used in the r-process calculations.
Study neutron inelastic scattering from deformed nuclei in the fast energy range, to which	The inelastic scattering process calculated by including both the Engelbrecht-Weidenmueller

theoretical calculations are essential, in collaboration with CEA, France and IAEA.	transformation and the FKK theory. Results were compared with those from CEA and IAEA. A paper is under preparation.
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.	Study on the Monte Carlo approach to the prompt fission neutron and gamma continued. The high energy extension completed, and combined with the Monte Carlo radiation transport calculations.
Develop new width fluctuation correction calculation for the deformed systems, based on the Gaussian Orthogonal Ensemble and the Monte Carlo technique, which includes both the coupled and uncoupled channels in a consistent way.	The S-matrix diagonalization method for the deformed system, which also includes uncoupled channels, implemented into the Hauser-Feshbach code. A channel degree-of-freedom parameter estimated by the Monte Carlo technique.
Continue to develop Monte-Carlo Hauser-Feshbach code, CGM, that can be used as an event generator in radiation transport codes.	CGM and CGMF developments continued. They are used as the event generator in the MCNP code.
Develop a semi-microscopic level density model based on the Gaussian Orthogonal Ensemble.	The random matrix level density model applied to 208Pb and showed an enhancement due to the residual interaction. The method also applied to iron isotopes.

C. Nuclear Reaction Data Measurements

ANL Planned Activities	**Status**
Continue participating at MANTRA research activities at ANL	Completed.

LANL Planned Activities	**Status**
Perform the precision measurement on the prompt fission-neutron spectrum for fission induced by neutrons of 0.5 to 200 MeV on ^{235}U and ^{239}Pu. With the high energy neutron detector array, the measurement will be extended to the outgoing neutrons up to 12 MeV.	Results were presented in various meetings and the work on preequilibrium asymmetries in the 239Pu(n,f) prompt fission neutron spectrum was published in PRL 122, 072503 (2019).
Analyze and publish radiative strength functions in neutron capture on ^{234,236,238}U in collaboration with Theory Division at LANL.	Continuing.
Transmission experiments on oxygen or neon isotopes at neutron energies from 1 MeV to 200 MeV for the interest of Dispersive Optical Model potential investigation and some level information near particle thresholds.	Measurements were completed and analyses are ongoing
Perform the measurements of the Pu-239 fission cross section relative to H(n,n) using the TPC.	Continuing.
Perform the precision measurement on the ^{16}O(n,α) reaction cross section at LANSCE	Preliminary cross sections have been presented in meetings and the result with uncertainties is being finalized.

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.
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.	Continuing.

G. Evaluation of Data Needed for Astrophysics

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

BNL Planned Activities	Status
Work on neutron capture and fission integral values and their uncertainties in the energy region of interest for nuclear astrophysics.	Maxwellian-averaged cross sections and uncertainties for ENDF/B-VIII.0 library have been calculated and published in Nuclear Data Sheets.
Evaluate nuclear astrophysics potential of EXFOR library.	Work is in progress on evaluation of astrophysical potential of the EXFOR library.

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 a semi-microscopic level density modeling including spin and parity distributions, which is based on nuclear mean-fields theories.	Development of the semi-microscopic level density model based on the finite-range droplet model continuing. The spin and parity dependence obtained.
Continue development of simultaneous beta-delayed neutron and fission calculations, and provide the reaction rates for the fission cycle study in the r-process nucleo-synthesis.	A large scale beta-delayed neutron and fission calculation performed and data used in the r-process calculations.
Perform measurements on (n,p) and (n,α) cross sections on the isotopes of interest for better understanding of p-process nucleosynthesis, in conjunction with the improvement on Hauser-Feshbach calculations	Measurement on 75As(n,p) (n,a) is planned for the impact on p-process nucleosynthesis and improved Hauser-Feshbach calculations have been applied for NZ data analyses.

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	Assessing levels in 16O+p and 17F+p capture for future measurement at FRIB. Assessments of the rate uncertainties of proton capture on light nuclei for nova explosions in

beam facilities.	progress.
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 completed on level information and direct/semi-direct capture cross sections on 80Ge and published in Phys. Rev. C. Work continues on implications of these levels for nuclear structure models. Calculations of direct neutron capture on these nuclei using complementary (RMF-based) approach is in progress.

H. Covariances Development

BNL Planned Activities	Status
COMMARA-3, a library of covariance matrices including cross-reaction correlations will be produced for the iron evaluations (54,56,57,58Fe) developed within the international CIELO project.	Although the COMMARA-3 project stalled with the passing of S. Hoblit, the NNDC did release cross-reaction correlations for the iron evaluations (54,56,57,58Fe) as part of its participation in the international CIELO project.

I. Reactor Antineutrino Spectra and Decay Heat Calculations

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

BNL Planned Activities	Status
Improve our methods and databases to calculate anti-neutrino spectra for major actinides.	An article on the observation of fine structure in nuclear reactors antineutrino spectra was published in PRC, detailing all our progress during the year. NNDC staff also attended the Neutrino 2018 conference in Heidelberg.
Perform decay heat calculations in collaboration with experimental groups.	Decay heat calculations were performed in collaboration with the Valencia and Nantes groups.
Possibly participate in relevant experiments.	No opportunities for experimental activities appeared.

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.	Progress on this task continues. A new server was bought to replace the previous one, which will be incorporated in the new NNDC cluster.

Appendix A

Fiscal Year 2018 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) supports the NNDC services in maintaining NCSP data submitted to the ENDF/B library as well as data development work on evaluations of neutron cross section covariances for criticality safety applications. 2. The Fission in Rapid Process Elements (FIRE) collaboration.

LANL
Additional supports for the nuclear data project at LANL are as follows: 1. Advanced Simulation and Computing under NNSA. 2. The US Nuclear Criticality Safety Program (NCSP). 3. Fission in R-Process Elements (FIRE) collaboration. 4. Two LDRDs at LANL. 5. Science Campaign support under Office of Experimental Sciences by NNSA.

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

TAMU
Data and experimental activities supported by U.S. Department of Energy, Office of Science, Office of Nuclear Physics, under Grant No. DE-FG03-93ER40773.

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 2018 Selected Articles

2018AH01 Phys. Rev. C 97, 014324 (2018)
I.Ahmad, F.G.Kondev, J.P.Greene, S.Zhu
Decay properties of 24397BK and 24497BK

2018Ba32 Nucl. Data Sheets 151, 1 (2018)
M.S. Basunia
Nuclear Data Sheets for A=59

2018BA33 Nucl. Data Sheets 151, 334 (2018)
C.M. Baglin, E.A. McCutchan
Nuclear Data Sheets for A=171

2018BA41 Nucl. Data Sheets 153, 1 (2018)
C.M. Baglin, E.A. McCutchan, S. Basunia, E. Browne
Nuclear Data Sheets for A=170

2018BE14 Phys.Rev. C 98, 014611 (2018)
G.F.Bertsch, D.Brown, E.D.Davis
Fluctuations in the 235U (n, f) cross section

2018BR05 Nucl.Data Sheets 148, 1 (2018)
D.A.Brown, M.B.Chadwick, R.Capote, A.C.Kahler, A.Trkov, M.W.Herman, A.A.Sonzogni, Y.Danon, A.D.Carlson, M.Dunn, D.L.Smith, G.M.Hale, G.Arbanas, R.Arcilla, C.R.Bates, B.Beck, B.Becker, F.Brown, R.J.Casperson, J.Conlin, D.E.Cullen, M.-A.Descalle, R.Firestone, T.Gaines, K.H.Guber, A.I.Hawari, J.Holmes, T.D.Johnson, T.Kawano, B.C.Kiedrowski, A.J.Koning, S.Kopecky, L.Leal, J.P.Lestone, C.Lubitz, J.I.Marquez Damian, C.M.Mattoon, E.A.McCutchan, S.Mughabghab, P.Navratil, D.Neudecker, G.P.A.Nobre, G.Noguere, M.Paris, M.T.Pigni, A.J.Plompen, B.Pritychenko, V.G.Pronyaev, D.Roubtsov, D.Rochman, P.Romano, P.Schillebeeckx, S.Simakov, M.Sin, I.Sirakov, B.Sleaford, V.Sobes, E.S.Soukhovitskii, I.Stetcu, P.Talou, I.Thompson, S.van der Marck, L.Welser-Sherrill, D.Wiarda, M.White, J.L.Wormald, R.Q.Wright, M.Zerkle, G.Zerovnik, Y.Zhu
ENDF/B-VIII.0: The 8th Major Release of the Nuclear Reaction Data Library with CIELO-project Cross Sections, New Standards and Thermal Scattering Data

2018BR14 Phys. Rev. C 98, 024616 (2018)
D.A.Brown, G.P.A.Nobre, M.W.Herman
Impact of alternative transmission coefficient parametrizations on Hauser-Feshbach theory

2018BR15 Phys. Rev. C 98, 024324 (2018)
R.Broda, L.W.Iskra, R.V.F.Janssens, B.A.Brown, B.Fornal, J.Wrzesinski, N.Cieplicka-Orynczak, M.P.Carpenter, C.J.Chiara, C.R.Hoffman, F.G.Kondev, G.J.Lane, T.Lauritsen, Zs.Podolyak, D.Seweryniak, W.B.Walters, S.Zhu

Two-neutron and core-excited states in 210Pb: Tracing E collectivity and evidence for a new β-decaying isomer in 210Tl

2018CH12 Nucl. Data Sheets 148, 189 (2018)
M.B.Chadwick, R.Capote, A.Trkov, M.W.Herman, D.A.Brown, G.M.Hale, A.C.Kahler, P.Talou, A.J.Plompen, P.Schillebeeckx, M.T.Pigni, L.Leal, Y.Danon, A.D.Carlson, P.Romain, B.Morillon, E.Bauge, F.-J.Hambsch, S.Kopecky, G.Giorginis, T.Kawano, J.Lestone, D.Neudecker, M.Rising, M.Paris, G.P.A.Nobre, R.Arcilla, O.Cabellos, I.Hill, E.Dupont, A.J.Koning, D.Cano-Ott, E.Mendoza, J.Balibrea, C.Paradela, I.Duran, J.Qian, Z.Ge, T.Liu, L.Hanlin, X.Ruan, W.Haicheng, M.Sin, G.Noguere, D.Bernard, R.Jacqmin, O.Bouland, C.De Saint Jean, V.G.Pronyaev, A.V.Ignatyuk, K.Yokoyama, M.Ishikawa, T.Fukahori, N.Iwamoto, O.Iwamoto, S.Kunieda, C.R.Lubitz, M.Salvatores, G.Palmiotti, I.Kodeli, B.Kiedrowski, D.Roubtsov, I.Thompson, S.Quaglioni, H.I.Kim, Y.O.Lee, U.Fischer, S.Simakov, M.Dunn, K.Guber, J.I.Marquez Damian, F.Cantargi, I.Sirakov, N.Otuka, A.Daskalakis, B.J.McDermott, S.C.van der Marck
CIELO Collaboration Summary Results: International Evaluations of Neutron Reactions on Uranium, Plutonium, Iron, Oxygen and Hydrogen

2018CH17 Nucl. Data Sheets 149, 1 (2018)
J. Chen
Nuclear Data Sheets for A=39

2018FO11 Phys.Rev.Lett. 120, 212501 (2018)
A.M.Forney, W.B.Walters, C.J.Chiara, R.V.F.Janssens, A.D.Ayangeakaa, J.Sethi, J.Harker, M.Alcorta, M.P.Carpenter, G.Gurdal, C.R.Hoffman, B.P.Kay, F.G.Kondev, T.Lauritsen, C.J.Lister, E.A.McCutchan, A.M.Rogers, D.Seweryniak, I.Stefanescu, S.Zhu
Novel $\Delta J = 1$ Sequence in 78Ge: Possible Evidence for Triaxiality

2018GA09 Phys.Rev. C 97, 034629 (2018)
L.R.Gasques, A.S.Freitas, L.C.Chamon, J.R.B.Oliveira, N.H.Medina, V.Scarduelli, E.S.Rossi, M.A.G.Alvarez, V.A.B.Zagatto, J.Lubian, G.P.A.Nobre, I.Padron, B.V.Carlson
Elastic, inelastic, and 1n transfer cross sections for the 10B+ 120Sn reaction

2018GA23 Acta Phys. Pol. B49, 555 (2018)
E.R.Gamba, A.M.Bruce, M.Rudigier, S.Lalkovski, S.Bottoni, M.P.Carpenter, S.Zhu, A.D.Ayangeakaa, J.T.Anderson, T.A.Berry, I.Burrows, R.J.Carrol, P.Copp, M.Carmona-Gallardo, D.M.Cullen, T.Daniel, G.Fernandez-Mart inez, J.P.Greene, L.A.Gurgi, D.J.Hartley, R.Ilieva, S.Ilieva, R.V.F.Janssens, F.G.Kondev, T.Kroll, G.J.Lane, T.Lauritsen, I.Lazarus, G.Lotay, C.R.Nita, Zs.Podolyak, V.Pucknell, M.Reed, P.H.Regan, J.Rohrer, J.Sethi, D.Seweryniak, C.M.Shand, J.Simpson, M.Smolen, V.Vedia, E.A.Stefanova, O.Yordanov
Fast-timing Measurements in 100Zr Using LaBr3(Ce) Detectors Coupled with Gammasphere

2018HA01 Phys. Rev. Lett. 120, 022503 (2018)
A.C. Hayes, G. Jungman, E.A. McCutchan, A.A. Sonzogni, G.T. Garvey, X.B. Wang
Analysis of the Daya Bay Reactor Antineutrino Flux Changes with Fuel Burnup

2018HA07 Appl.Radiat.Isot. 134, 406 (2018)
J.C.Hardy, N.Nica, V.E.Iacob, M.B.Trzhaskovskaya

Precise test of internal-conversion theory: αK measurements for transitions in nine nuclei spanning 45 ≤ Z ≤ 78

2018HA19 Phys. Rev. Lett. 120, 182502 (2018)
D.J.Hartley, F.G.Kondev, R.Orford, J.A.Clark, G.Savard, A.D.Ayangeakaa, S.Bottoni, F.Buchinger, M.T.Burkey, M.P.Carpenter, P.Copp, D.A.Gorelov, K.Hicks, C.R.Hoffman, C.Hu, R.V.F.Janssens, J.W.Klimes, T.Lauritsen, J.Sethi, D.Seweryniak, K.S.Sharma, H.Zhang, S.Zhu, Y.Zhu
Masses and β-Decay Spectroscopy of Neutron-Rich Odd-Odd 160, 162Eu Nuclei: Evidence for a Subshell Gap with Large Deformation at N=98

2018HE06 Nucl. Data Sheets 148, 214 (2018)
M.Herman, A.Trkov, R.Capote, G.P.A.Nobre, D.A.Brown, R.Arcilla, Y.Danon, A.Plompen, S.F.Mughabghab, Q.Jing, G.Zhigang, L.Tingjin, L.Hanlin, R.Xichao, L.Leal, B.V.Carlson, T.Kawano, M.Sin, S.P.Simakov, K.Guber
Evaluation of Neutron Reactions on Iron Isotopes for CIELO and ENDF/B-VIII.0

2018HE07 Nucl. Data Sheets 148, 338 (2018)
A.Hermanne, A.V.Ignatyuk, R.Capote, B.V.Carlson, J.W.Engle, M.A.Kellett, T.Kibedi, G.Kim, F.G.Kondev, M.Hussain, O.Lebeda, A.Luca, Y.Nagai, H.Naik, A.L.Nichols, F.M.Nortier, S.V.Suryanarayana, S.Takacs, F.T.Tarkanyi, M.Verpelli
Reference Cross Sections for Charged-particle Monitor Reactions

2018IA01 Phys. Rev. C 97, 035501 (2018)
V.E.Iacob, J.C.Hardy, L.Chen, V.Horvat, M.Bencomo, N.Nica, H.I.Park, B.T.Roeder, A.Saastamoinen
Precise half-life measurement of the superallowed emitter 30S

2018JO01 Phys. Rev. C 97, 024327 (2018)
M.D. Jones, A.O. Macchiavelli, M. Wiedeking, L.A. Bernstein, et al.,
Examination of the low-energy enhancement of the gamma-ray strength function of 56Fe

2018KO01 Nucl. Data Sheets 147, 382 (2018)
F.G.Kondev, E.A.McCutchan, B.Singh, K.Banerjee, S.Bhattacharya, A.Chakraborty, S.Garg, N.Jovancevic, S.Kumar, S.K.Rathi, T.Roy, J.Lee, R.Shearman
Nuclear Data Sheets for A=217

2018KO15 Nucl. Data Sheets 150, 1 (2018)
F.G.Kondev, S.Juutinen, D.J.Hartley
Nuclear Data Sheets for A=188

2017KU24 Phys. Rev. C 96, 041301 (2017)
S.A.Kuvin, A.H.Wuosmaa, C.J.Lister, M.L.Avila, C.R.Hoffman, B.P.Kay, D.G.McNeel, C.Morse, E.A.McCutchan, D.Santiago-Gonzalez, J.R.Winkelbauer
Alpha decay of the T = 1, 2+ state in 10B and isospin symmetry breaking in the A = 10 triplet

2018LU08 Phys. Rev. C 97, 044312 (2018)

R.S.Lubna, V.Tripathi, S.L.Tabor, P.-L.Tai, K.Kravvaris, P.C.Bender, A.Volya, M.Bouhelal, C.J.Chiara, M.P.Carpenter, R.V.F.Janssens, T.Lauritsen, E.A.McCutchan, S.Zhu, R.M.Clark, P.Fallon, A.O.Macchiavelli, S.Paschalis, M.Petri, W.Reviol, D.G.Sarantites
Intruder configurations of excited states in the neutron-rich isotopes 33P and 34P

2018MC07 Nucl. Data Sheets 152, 331 (2018)
E.A. Mccutchan
Nuclear Data Sheets for A = 136

2018Mi03 Phys. Rev. C 97, 054317 (2018)
K.Miernik, K.P.Rykaczewski, R.Grzywacz, C.J.Gross, M.Madurga, D.Miller, D.W.Stracener, J.C.Batchelder, N.T.Brewer, A.Korgul, C.Mazzocchi, A.J.Mendez, Y.Liu, S.V.Paulauskas, J.A.Winger, M.Wolinska-Cichocka, E.F.Zganjar
beta-delayed neutron emission from 85Ga.

2018MO12 Phys. Lett. B 780, 227 (2018)
C.Morse, E.A.McCutchan, H.Iwasaki, C.J.Lister, V.M.Bader, D.Bazin, S.Beceiro Novo, P.Chowdhury, A.Gade, T.D.Johnson, C.Loelius, E.Lunderberg, E.Merchan, V.S.Prasher, F.Recchia, A.A.Sonzogni, D.Weisshaar, K.Whitmore
Enhanced collectivity in 12Be

2018SI01 Nucl.Data Sheets 147, 1 (2018)
B.Singh, J.Chen
Nuclear Data Sheets for A=164

2018SI28 Phys. Rev. C 98, 054307 (2018)
K.Siegl, K.Kolos, N.D.Scielzo, A.Aprahamian, G.Savard, M.T.Burkey, M.P.Carpenter, P.Chowdhury, J.A.Clark, P.Copp, G.J.Lane, C.J.Lister, S.T.Marley, E.A.McCutchan, A.J.Mitchell, J.Rohrer, M.L.Smith, S.Zhu
B-decay half-lives of 134, 134mSb and their isomeric yield ratio produced by the spontaneous fission of 252Cf

2018SO13 Phys. Rev. C 98, 014323 (2018)
A.A. Sonzogni, M. Nino, E.A. McCutchan
Revealing fine structure in the antineutrino spectra from a nuclear reactor

2018Tr07 Phys. Rev. C 98, 034309 (2018)
J.L.Tracy, J.A.Winger, B.C.Rasco, U.Silwal, D.P.Siwakoti, K.P.Rykaczewski, R.Grzywacz, J.C.Batchelder, C.R.Bingham, N.T.Brewer, L.Cartegni, A.A.Ciemny, A.Fijalkowska, C.J.Gross, C.Jost, M.Karny, K.Kolos, A.Korgul, W.Krolas, Y.Liu, M.Madurga, C.Mazzocchi, A.J.Mendez, K.Miernik, D.Miller, S.Padgett, S.V.Paulauskas, D.W.Stracener, M.Wolinska-Cichocka, M.M.Rajabali, E.F.Zganjar
Updated beta-decay measurement of neutron-rich 74Cu

2018VO05 Nucl. Instrum.Methods Phys.Res. B429, 53 (2018)
A.S. Voyles, L.A. Bernstein, E.R. Birnbaum, J.W. Engle, S.A. Graves, T. Kawano, A.M. Lewis, F.M. Nortier
Excitation functions for (p,x) reactions of niobium in the energy range of Ep=40-90 MeV

2018WI09 Phys. Rev. C98 (2018) 041302(R)
W. Witt, V. Werner, N. Pietralla, M. Albers, A. D. Ayangeakaa, B. Bucher, M. P. Carpenter, D. Cline, H. M. David, A. Hayes, C. Hoffman, R. V. F. Janssens, B. P. Kay, F. G. Kondev, W. Korten, T. Lauritsen, O. Möller, G. Rainovski, G. Savard, D. Seweryniak, J. Smith, R. Stegmann, S. Zhu, and C. Y. Wu
Sub-shell closure and shape coexistence in the transitional nucleus 98Zr

2018ZE01 Nucl. Instrum.Methods Phys.Res. A888, 31 (2018)
V.V. Zerkin, B. Pritychenko
The experimental nuclear reaction data (EXFOR): Extended computer database and Web retrieval system

2017CH47 Nucl. Data Sheets 146, 1 (2017)
J. Chen
Nuclear Data Sheets for A=138

Measurement, Vol. 127, 580, (2018)
M.Kireeff-Covo, R.A.Albright, B.F.Ninemire, M.B.Johnson, A.Hodgkinson, T.Loew, J.Y.Benitez, D.S.Todd, D.Z.Xie, T.Perry, L.Phair, L.A.Bernstein, J.Bevins, J.A.Brown, B.L.Goldblum, M.Harasty, K.P.Harrig, T.A.Laplace, S.B.Cronin.
The 88-Inch Cyclotron: A one-stop facility for electronics radiation and detector testing

J. Applied Physics 124, 045101 (2018)
J. A. Brown, B. L. Goldblum, T. A. Laplace, K. P. Harrig, L. A. Bernstein, D. L. Bleuel, W. Younes, D. Reyna, E. Brubaker, and P. Marleau.
Proton light yield in organic scintillators using a double time-of-flight technique

M. Ayllon, P.A. Adams, J.D. Bauer, J.C. Batchelder, T.A. Becker, L.A. Bernstein, Su-Ann Chong, Jay James, Leo E. Kirsch, Ka-Ngo Leung, Eric F. Matthews, Jonathan T. Morrell, Paul R. Renne, Andrew M. Rogers, Daniel Rutte, Andrew S. Voyles, Karl Van Bibber, Cory S. Waltz.
Nucl. Instrum. Methods in Physics Research A 903, 192 (2018)
Design, construction, and characterization of a compact DD neutron generator designed for 40Ar/39Ar geochronology

Nucl. Instrum. Methods A 892, 30 (2018)
L.E. Kirsch, L.A. Bernstein.
RAINIER: A Simulation Tool for Distributions of Excited Nuclear States and Cascade Fluctuations

Nucl. Instrum. Methods A891, 111 (2018).
E.F.Matthews, B.L.Goldblum, L.A.Bernstein, B..J. Quiter, J.A.Brown, W.Younes, J.T.Burke, S.W.Padgett, J.J.Ressler, A.P.Tonchev.
FIER: Software for analytical modeling of delayed gamma-ray spectra

Nuclear Inst. and Methods in Physics, A 877, 359, (2018).
K.P. Harrig, B.L. Goldblum, J.A. Brown, D.L. Bleuel, L.A. Bernstein, J. Bevins, M. Harasty, T.A. Laplace, E.F.Matthews.
Neutron Spectroscopy for pulsed beams with frame overlap using a double time-of-flight technique.

J. Phys. G: Nucl. Part. Phys. 45 033003 (111pp) (2018)
C. Cerjan, L. Bernstein, et al.,.
Dynamic high energy density plasma environments at the National Ignition Facility for nuclear science research

J.of Geology 126, 165 (2018)
W.S. Wolbach, J.P. Ballard, P.A. Mayewski, V. Adedeji, T.E. Bunch, R.B. Firestone, et al.,
Extraordinary Biomass-Burning Episode and Impact Winter Triggered by the Younger Dryas Cosmic Impact ~12,800 Years Ago. 1. Ice Cores and Glaciers

Scientific Reports 7, 16620 (2018).
J.T. Hagstrum, R.B. Firestone, A. West, J.C. Weaver and T.E. Bunch,
Impact-related microspherules in Late Pleistocene Alaskan and Yukon "muck" deposits signify recurrent episodes of catastrophic emplacement

Journal of Radioanalytical and Nuclear Chemistry
A.Hermanne, A.V.Ignatyuk, R.Capote, B.V.Carlson, J.W.Engle, M.A.Kellett, T.Kibedi, G.Kim, F.G.Kondev, M.Hussain, O.Lebeda, A.Luca, Y.Nagai, H.Naik, A.L.Nichols, F.M.Nortier, S.V.Suryanarayana, S.Takacs, F.T.Tarkanyi, M.Verpelli
Recommended nuclear data for medical radioisotope production: diagnostic gamma emitters

EPJ Web of Conferences 178 (2018) 02023
G.X. Zhang, H. Watanabe, F.G. Kondev, G.J. Lane, P.H. Regan, P.-A. Söderström, P.M. Walker, H. Kanaoka, Z. Korkulu, P.S Lee, J.J Liu, S. Nishimura, J. Wu, 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, T. Kubo, S. Kubono, N. Kurz, I. Kuti, S. Lalkovski, 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. Podolyák, 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-Dóbon, and Z.Y. Xu
β-γ and isomeric decay spectroscopy of 168Dy