



## Annual Report for FY2011

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## I. Introduction

The USNDP Annual Report for FY2011 summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2010 through September 30, 2011 with respect to the work plan for FY2011 that was prepared in February 2009. 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 30 FTE scientific, mostly at NNSA laboratories, to be compared with 17.5 FTE scientific (permanent + temporary) 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 2011 was the 12th 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 FY2011. Then, we continue with the detailed status of work done in FY2011. Total staff assigned to USNDP activities during the year represented 22.17 FTE. In recent years there has been continuing loss of permanent scientific staff in the USNDP activities. This year, the FTE slightly increased from 12.5 in FY2010 to 12.7 in FY2011. While the total FTE variation was very modest there was a considerable change in staff, especially at BNL where two permanent scientific staff left (one moved to ORNL, the other retired), two new permanent scientific staff were hired and two postdoc positions were filled up. With two new hires in FY2010 more than half of the NNDC scientific staff has been at the NNDC less than two years.

Tab. 1 summarizes the USNDP metrics for the last ten fiscal years. Tab. 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.

Tab. 1 shows that the FY2011 budget changed slightly by -0.2%. ARRA funding helped to maintain a solid program. Major difficulties were related to ensuring adequate manpower that turned out to be an issue due to retirements, losing staff to other Labs and difficulties to replace them with new qualified staff.

**Table 1:** Summary of the USNDP metrics in FY2001- FY2011, the definitions of the various terms follow the table.

Fiscal Year	USNDP Funding	Change	Compilations	Evaluations	Dissemination (in thousands)	Reports	Papers	Invited Talks
2001			7,139	334	667	21	25	22
2002	\$4,890K		6,159	300	799	23	40	22
2003	\$4,932K	+0.9%	4,975	260	966	27	40	23
2004	\$5,015K	+1.7%	6,241	276	1,212	35	36	43
2005	\$5,437K	+8.4%	6,623	422	1,642	74	59	42
2006	\$5,099K	-6.6%	4,936	318	1,863	47	60	48
2007	\$5,841K	+14.6%	5,355	366	2,239	40	56	51
2008	\$5,967K	+2.2%	5,104	385	2,996	48	72	68
2009	\$6,267K	+5.0%	4,047	400	3,294	26	61	56
2010	\$6,549K	+4.5%	4,662	395	2,843	27	83	51
2011	\$6,534	-0.2%	4,662	479	3,252	29	96	67

In particular:

1. **Compilations.** Compilations efforts, including NSR, CSISRS and XUNDL databases, remain on the similar level.
2. **Evaluations.** Evaluations efforts, including ENSDF and ENDF databases, remain on the similar level.
3. **Dissemination.** This year there has been an increase in the number of web retrievals, mainly nuclear decay data related to the Fukushima Daiichi accident (see the additional accomplishments section). At BNL, the most popular product continues to be NuDat that contributes almost 60% of data retrievals.
4. **Reports.** The number of published reports has been remained approximately constant over the last three years.
5. **Papers.** The number of articles published in the refereed journals reached a new high value this year.
6. **Invited Talks.** The number of invited talks decreased slightly compared to the last year but remains relatively constant.

These results must be considered satisfactory taking into account that the performance, essentially equivalent to the previous year, has been achieved in spite of the loss of more than two permanent scientific FTE. Increased workload resulted in the decrease of the number of published reports, which is the most immediate indicator (papers take longer to be published).

**Table 2:** USNDP metrics in FY2011, numbers for FY2009 are shown for comparison.

Laboratory	Compilations		Evaluations		Dissemination (in thousands)		Reports		Papers		Invited Talks	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
ANL	38	43	14	25	24	30	2	3	19	21	8	10
BNL <sup>1</sup>	3,023	2,911	158	150	2,355	2,771	7	6	13	26	8	10
LANL	-	-	64	108	300	300	2	2	12	9	14	18
LBNL	-	-	36	36	-	0	7	11	18	17	10	10
LLNL	-	-	10	10	8	8	2	0	3	1	4	0
ORNL	-	-	0	29	97	97	0	0	8	8	10	10
Universities <sup>2</sup>	1,601	1,708	113	121	59	46	7	7	10	14	7	9
<b>Total</b>	<b>4,662</b>	<b>4,662</b>	<b>395</b>	<b>479</b>	<b>2,843</b>	<b>3,252</b>	<b>27</b>	<b>29</b>	<b>83</b>	<b>96</b>	<b>61</b>	<b>67</b>

<sup>1</sup>: BNL compilations for FY2011 consist of 2161 NSR papers and 750 CSISRS reactions. BNL evaluations for FY2011 consist of 90 nuclides for ENSDF and 60 reactions for ENDF.

<sup>2</sup>: Universities compilations for FY2011 consist of 1,152 NSR papers (McMaster), 412 XUNDL datasets (McMaster), 23 Atomic mass articles (McMaster) and 62 XUNDL datasets (TUNL). Universities evaluations for FY2011 consist of 119 ENSDF evaluations (McMaster) and 2 astrophysical reaction rates datasets (McMaster).

#### Definitions

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

## 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, many of the other program participants are also involved in the coordination and dissemination activities.

### National and International Coordination

The NNDC, while serving as the secretariat for the program, has prepared the program work plan for FY2012 in conjunction with the members of the Coordinating Committee. The NNDC Head serves as a chair of the USNDP Coordinating Committee, which consists of the Principal Investigators from each of the participating groups, and chairs the annual meeting of the program held at the Brookhaven National Laboratory. LANL chairs the Nuclear Reaction Data Working Group, and LBNL the Nuclear Structure Working Group. ORNL chairs the Astrophysics Task Force and LLNL chairs the Homeland Security Task Force.

In February 2011, DOE Office of Nuclear Physics conducted its annual Budget Briefing. Michal Herman, Richard Firestone, Toshihiko Kawano, Filip Kondev, Michael Smith, and Alejandro Sonzogni represented the USNDP and made the case for the FY2013 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. The 2010 CSEWG meeting was, exceptionally, held at Santa Fe (NM) rather than at BNL. The venue was changed to allow interaction of the participants of the CSEWG and USNDP meetings with the participants of the annual meeting of the APS. All these meetings were held in November 2010. The major topic of the CSEWG meeting was the progress towards the VII.1 release of the ENDF/B library.

In June 2011, the NNDC organized the Summer Nuclear Data Week consisting of the mini-CSEWG meeting, and two accompanying meetings (the NDAG criticality safety and Nuclear Physics Working Group by the AFCI project).

### USNDP Databases

The NNDC operates five Dell servers running 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.

The NNDC maintains seven nuclear physics databases for USNDP. These databases have been updated continuously in FY2011 with new and revised

information from efforts of the NNDC, the USNDP and international collaborators. Distributions of all or parts of these databases have been made to national and international collaborators as scheduled.

### **Data Dissemination**

In FY2011, retrievals from the USNDP databases as offered by the USNDP laboratories reached 3,252 million database retrievals.

### **Major Publications**

The USNDP continues to publish monthly the refereed journal Nuclear Data Sheets. 11 issues were devoted to nuclear structure data and one issue to nuclear reaction data.

## **III. Nuclear Structure and Decay Data**

The Working Group's priorities emphasize the evaluation of nuclear structure and decay data, either for entire mass chains or for individual nuclides, and the entry of these results into the Evaluated Nuclear Structure Data File (ENSDF). ENSDF is of particular importance because it provides the source information for various other databases and applications such as NuDat, Nuclear Wallet Cards and MIRDB as well as contributing much valuable structure and decay data information needed for ENDF/B.VII. Most ENSDF evaluations will also appear as peer-reviewed publications in either Nuclear Data Sheets or Nuclear Physics A.

In addition, the USNDP leads the Decay Data Evaluation Project (DDEP) in collaboration with the Bureau International des Poids et Mesures (BIPM, France) and the Evaluated Gamma-ray Activation File (EGAF) effort in collaboration with the International Atomic Energy Agency (IAEA, Vienna). Nuclear structure and decay data provided by the USNDP are widely used in basic nuclear and astrophysics research and applications in fields including nuclear energy, nonproliferation, homeland security, nuclear medicine, geology, chemistry, and biology.

### **Evaluations for ENSDF III. Nuclear Structure and Decay Data**

ENSDF The Nuclear Structure and Decay Data Working Group's priorities emphasize the evaluation of nuclear structure, neutron capture, radioactive decay, and nuclear reaction data for entry of into the Evaluated Nuclear Structure Data File (ENSDF). ENSDF is of particular importance because it provides the source information for various other databases and applications including NuDat, Nuclear Wallet Cards, Medical Internal Radiation Dose (MIRD) file, Reaction Input Parameter Library (RIPL) and ENDF/B.VII.1. Nuclear structure and decay data provided by the USNDP are widely used in basic nuclear and astrophysics research and applications in fields including nuclear energy, nonproliferation, homeland security, nuclear medicine, geology, chemistry, and biology. ENSDF evaluations are peer-reviewed and published primarily in Nuclear Data Sheets and Nuclear Physics A. A total of 21 mass chain evaluations were published in 2011 in Nuclear Data Sheets

XUNDL The XUNDL compilation is led by the McMaster group with the assistance of evaluators at TUNL, ANL, LBNL, and BNL. Research published in all major nuclear science journals is continuously scanned into ENSDF format and provided on-line by the NNDC.

DDEP The USNDP leads the Decay Data Evaluation Project (DDEP) in collaboration with the Bureau International des Poids et Mesures (BIPM, France). DDEP evaluations are published in Applied Radiation and Isotopes and available in ENSDF format. Evaluations of decay data for 190 nuclides were published through 2011.

EGAF The Evaluated Gamma-ray Activation File (EGAF) effort is led by LBNL in collaboration with LLNL and the International Atomic Energy Agency (IAEA, Vienna). The EGAF collaboration is responsible for evaluating neutron capture gamma-ray data, primarily measured with guided neutron beams at the Budapest and Garching FRM II reactors. These data are evaluated for inclusion in the ENSDF and ENDF libraries and are published in Physical Review C.

Atomic Mass Data The Atomic Mass Data Center (AMDC, CSNSM Orsay, France) published the last atomic mass evaluation in 2003 and a new edition is due in 2012-13. Atomic mass data are updated continuously and interim evaluations are provided to ENSDF evaluators. The AMDC is scheduled to move from Orsay to Lanzhou China in 2013.

Nuclear Science References The NSR database and its content is managed by the NNDC in collaboration with evaluators at the IAEA, McMaster and Slovakia. NSR contains over 202,000 keyworded references and is the starting point for all USNDP evaluations. A total of 3802 new entries were added in FY2011.

The reaction and structure data communities held a joint measurements session at the 2011 CSWEG/USNDP nuclear data meetings where the research activities of both the CSWEG and USNDP communities were shared. New cross section measurements coming from USNDP members were discussed. The LLNL effort to modernize the ENDF file structure using Extensible Markup Language XML has been extended, in collaboration with LBNL and BNL, to also modernize ENSDF file structure. Nuclear Data Sheets is rapidly moving towards fully electronic publication which will mitigate the concern for the ever increasing page size of mass chain publications. A new proposal was brought forward by LBNL to streamline ENSDF evaluation by merging with XUNDL to replace supporting datasets, collaborating with the DDEP and EGAF collaborations to reduce duplication of effort.

Other Activities:

- The USNDP organized a Workshop and mini-Symposium on the Emerging Needs of Nuclear Data at the Fall, 2011 American Physical Society, Division of Nuclear Physics meeting. This brought together members of the nuclear research and nuclear data communities to discuss ways to better work together towards the future needs of basic and applied research.
- USNDP evaluators led in the IAEA Technical Meeting "Intermediate-term Nuclear Data Needs for Medical Applications: Cross Sections and Decay Data" August 22-26, 2011 in Vienna.
- USNDP evaluators led an IAEA exploratory meeting to investigate the possibility of a Coordinated Research Project on "Beta-delayed Neutron Emitters".
- USNDP evaluators played a pivotal role in the 19th Nuclear Structure and Decay Data (NSDD) Evaluators Meeting at the IAEA, April 4-8, 2011. The

NSDD provides International leadership to the nuclear data community and is pivotal towards providing human resources for the ENSDF, XUNDL, EGAF, DDEP, Atomic Masses, NSR and other efforts.

## IV. Nuclear Reaction Data

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

### Reaction Data Highlights

BNL activities focused on generation of covariances for the ENDF/B-VII.1 library, their testing through the newly developed Web-based QA procedure and preparing the release of the library. In addition resonance region in several structural and fission product nuclei were revised to remove deficiencies reported in the validation of the ENDF/B-VII.0 library. New evaluations of Zr isotopes were developed and, after proving their performance to be superior to VII.0, accepted for VII.1. Five beta versions of the new library release were assembled and made available to the testers in FY2011. All of them were subject to verification and phase I testing at BNL including running suite of over 100 integral experiments.

LANSCe continued the development of techniques to measure prompt fission neutron spectra with two types of neutron detectors, liquid scintillators to detect and identify neutrons above 0.6 MeV and  $^6\text{Li}$ -glass detectors for neutrons below 1 MeV. A new beam line is under construction at WNR/LANSCe to make these measurements with much reduced neutron scattering. Neutron-induced gamma-ray production at GEANIE elucidated nuclear structure in tin isotopes and the regularity of excited states built on J- $\pi$ =10+ isomeric states. Measurements of gamma-ray production that could be backgrounds in proposed neutrino-less double beta-decay experiments continue with several materials having been reported (e.g. Cu and Kr), and others in progress. Neutron capture measurements at DANCE extended from five gadolinium isotopes through actinides where new data were obtained on  $^{238}\text{U}$  and  $^{239}\text{Pu}$ . Gamma-ray spectra and multiplicities are providing insights into radiative strength functions and nuclear level densities. In fission cross section measurements, the U-236 fission cross section was measured from threshold to 200 MeV, and, with the lead slowing-down spectrometer, that for  $^{237}\text{U}$  (6.75 day half-life) was measured below 5 keV.

### Model Code Highlights

Several new features were added to the nuclear reaction calculation code EMPIRE. The major changes are inclusion of OPTMAN, KERCEN, and upgraded checking codes, direct access to C4 files with experimental data. For better reproduction of the measured cross sections, parameters in the EGSM level density were updated, and the level density has become possible to be shifted manually. The EMPIRE code has been used for ENDF/B-VII.1 evaluations.

LLNL and LANL continue developing prompt fission neutron spectrum modeling codes for better prediction and uncertainty quantification of evaluated spectra. At LLNL, three parameters, which are related to TKE, level densities, and relative excitation of both fragments, are selected as the model parameters of FREYA, and they were estimated to reproduce the average number of neutrons per fission in the energy range thermal to 20 MeV with the Bayesian method. At LANL the fission decay calculation was combined with the Monte Carlo Hauser-Feshbach code, CGM, to calculate prompt neutrons and gamma-rays from fission fragments. Impacts of initial conditions for the fragments were examined.

LANL extended the clustering pre-equilibrium model by Iwamoto and Harada for better reproduction of the experimental alpha-particle production data above 20 MeV from LANSCe. The improved clustering model gives good agreements with both the production cross sections and the secondary particle energy spectra. The updated alpha-production cross sections for some structural materials were included in ENDF/B-VII.1.

### Nuclear Standards Highlights

A comprehensive contribution on "Cross Section Standards - Their History, How They Are Measured, Evaluated and Used" was written by NIST for a publication on "Neutron Metrology" in a special issue of the journal Metrologia. The Ohio U., NIST, LANL and the U. of Guelma collaboration continues work that will allow smaller CMS angles to be measured for the hydrogen scattering angular distribution. The focus of the recent work has been on methods to improve the determination of detector efficiency. The hydrogen standard is considered a primary cross section standard since so many standards are measured relative to it. For the 14th International Symposium on Reactor Dosimetry, NIST worked on the Program Committee, organized a session "Nuclear Data for Dosimetry" and gave a paper on an update of the standards. LANL worked on the light element standards using R-matrix techniques and provided uncertainty data for the hydrogen elastic cross section that was included in ENDF/B-VII.1. Also LANL published an article on the PPP problem. LANL and NIST continue to work on the IAEA data development project on maintenance of the neutron cross section standards.

### Nuclear Astrophysics Highlights

In FY11, there were a number of interesting nuclear data projects that have direct relevance for astrophysics. They ranged from projects relevant to heavy element creation in Asymptotic Giant Branch (red giant) stars to nova explosions to supernovae.

At ANL, C. Nair and F. Kondev collaborated on a measurement of the decay of  $^{179-180}\text{Tl}$  at the ATLAS facility at ANL. The motivation was to improve our understanding of fission barriers of heavy neutron-rich nuclei that play a role in the rapid neutron capture process (r-process) in supernovae. The fission of heavy nuclei can terminate the r-process, and a process of "fission cycling" whereby the heaviest elements are created by neutron capture, fission, then are re-synthesized by additional neutron captures can significantly change the predicted abundances produced in the r-process. Any information that can be obtained on the fission of n-rich nuclei can be valuable to understand this effect. They measured alpha decays, alpha-gamma coincidences, and EC decays of  $^{179-180}\text{Tl}$  at ANL ATLAS as a precursor to studies with neutron rich nuclei near the r-process path.

At BNL, B. Pritychenko's work to calculate Maxwellian Averaged Cross Sections (MACS) with cross sections from ENDF is now an integral part of the ENDF library development effort and is actively supported at NNDC and LANL. For example, MACS and their uncertainties, from low fidelity covariances, were included in the ENDF/B-VII.1 paper. Comparisons of MACS from ENDF and KADONIS, a library from the nuclear astrophysics community, has helped with quality assurance of ENDF and has triggered evaluation updates of a number of nuclei including  $^3\text{He}$ ,  $^9\text{Be}$ ,  $^{10}\text{C}$ ,  $^{16}\text{O}$ , and

$^{58}\text{Co}$ . Also, the MACS derived from ENDF now verifies the famous " $\sigma * N$ " curve (cross section \* abundance) -- with errors -- for heavy elements synthesized in the slow neutron capture process in red giants.

At ORNL's Holifield Radioactive Ion Beam Facility, a measurement of the  $^{80}\text{Ge}(d,p)^{81}\text{Ge}$  reaction with a radioactive  $^{80}\text{Ge}$  beam was made to examine the nature of low-lying levels in  $^{81}\text{Ge}$ . This is to mimic  $^{80}\text{Ge}+n$  reaction that is in the r-process path in supernovae. Simultaneously, ORNL is collaborating on sensitivity studies of r-process burning that focusses on the N=50 closed shell nuclei [near  $^{82}\text{Ge}$ ]. Level information will be extracted on  $^{81}\text{Ge}$  and an assessment of the  $^{81}\text{Ge}$  structure will be made as part of a Ph.D. thesis.

The  $^{29}\text{P} + p$  and  $^{30}\text{P} + p$  capture reactions were assessed at McMaster Univ. by K. Setoodehnia, A. Chen, and J. Chen. These reactions are crucial for nova nucleosynthesis simulations, and have significant uncertainties caused by uncertain level in formation in  $^{30,31}\text{S}$ . They used reactions including (p,t), (d,t), and ( $^3\text{He},n\gamma$ ), at facilities including Yale and Tsukuba, to populate levels of astrophysical interest above the proton thresholds. They made assessments of the properties of these levels, calculated new rates, and submitted them for publication as well as to the Computational Infrastructure for Nuclear Astrophysics. The new rates from these evaluations will help improve estimates of the synthesis of nuclei in nova outbursts.

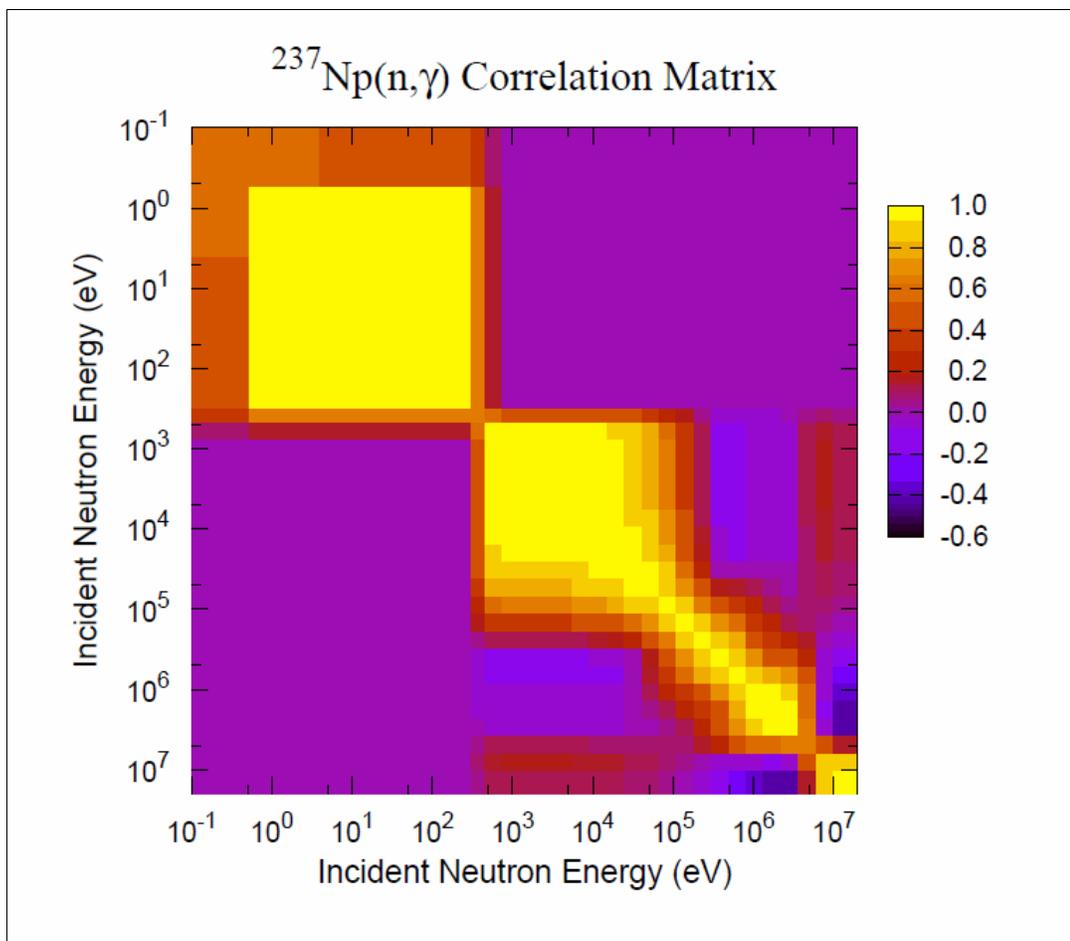
Finally, at ORNL there have been a number of significant improvements in the Computational Infrastructure for Nuclear Astrophysics, an online computational suite that enables users from around the world [over 115 institutions in 29 countries] to process their nuclear data into astrophysical simulations, run the simulations, and visualize and analyze the results. New features include a further streamlining of automated reaction rate sensitivity studies, updated simulation libraries, and additional libraries of reaction rates. A code to calculate reaction rates from resonance information is in the final stages of preparation.

## V. Additional Accomplishments

### COMMARA-2.0

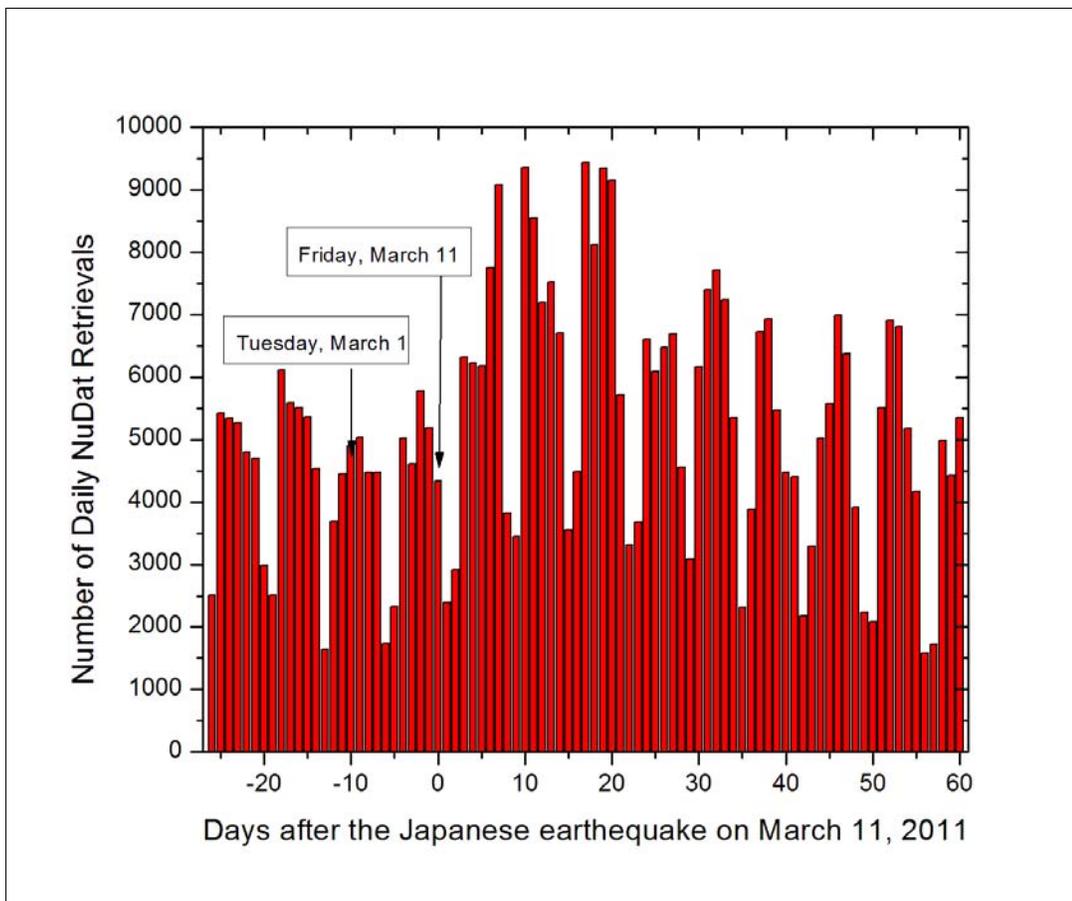
In March, 2011 the COMMARA-2.0 covariance library was released. The library was developed through a collaboration between Brookhaven and Los Alamos National Labs for Advanced Fuel Cycle Initiative (AFCI) applications. It contains cross-section covariances for 110 materials tabulated on a 33-group energy grid suitable for use with fast reactor R&D, from  $10^{-5}$  to 19.6 MeV, obtained by processing with the LANL code NJOY using 1/E flux. The library contains covariances for 12 light nuclei, 78 structural materials, and 20 actinides and are to be used with cross sections in the ENDF/B-VII.0 release of the US files of evaluated neutron cross sections. Covariances are provided for total, elastic, inelastic, (n,2n), and capture cross sections. In addition, covariances for average neutron multiplicities are provided for the 20 actinides, for prompt fission neutron spectra for 3 materials and for the average scattering cosines (mubar) for 2 materials.

As an example, the covariance matrix, cross section and uncertainties for the elastic neutron scattering cross section on  $^{237}\text{Np}$  are shown in the figure below.



**Web retrieval statistics following the Japanese earthquake.**

The plot below shows the number of daily retrievals from NuDat, which contains nuclear structure and decay data, before and after the March 11th 2011 Japanese earthquake. The resulting tsunami crippled several of the Fukushima Daiichi nuclear reactors.



Typically, the number of retrieval is low during weekends (valleys) and peaks during the working days of the week. It was observed that soon after the earthquake, the number of retrievals went up by about 50%. In particular, there was a strong demand on decay properties of fission fragments, such as  $^{137}\text{Cs}$  and  $^{131}\text{I}$ .

The data in NuDat are from ENSDF while the application itself was developed at the NNDC. This plot clearly demonstrates the usefulness of ENSDF data during an emergency, in particular data that can be accessed remotely through the Internet.

## USNDP Staffing table FY2011

	ANL		BNL			LANL	LBNL	LLNL	MCMMASTER		NIST			ORNL		TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD P	PhD P	PhD P	PhD T	PhD P	PhD T	GS	PhD P	PhD T	PhD P	PhD T	T/A	
<b>I. NNDC Facility Operation</b>			0.60		1.25														1.85
Management			0.60																0.60
Secretarial/Administrative Support					0.85														0.85
Library					0.10														0.10
Computer Operations					0.30														0.30
<b>II. Coordination</b>	0.10		0.20			0.25	0.10							0.05					0.70
National Coordination			0.15			0.05	0.05							0.05					0.30
International Coordination	0.10		0.05			0.20	0.05												0.40
<b>III. Nuclear Physics Databases</b>			1.04	0.10	0.95														2.09
Nuclear Science References, NSR			0.15		0.75														0.90
Exper. Nucl. Structure Data, XUNDL			0.05																0.05
Eval. Nucl. Structure Data, ENSDF			0.20																0.20
Numerical Nuclear Data, NuDat			0.30																0.30
Reaction Data Bibliography, CINDA																			0.00
Experimental Reaction Data, CSISRS																			0.00
Evaluated Nuclear Data File, ENDF			0.09																0.09
Database Software Maintenance			0.10		0.20														0.30
Future Database System Develop.			0.15	0.10															0.25
<b>IV. Information Dissemination</b>			0.60	0.20	1.30									0.70				0.60	3.40
Nuclear Data Sheets			0.25	0.20	0.90														1.35
Customer Services			0.15		0.30														0.45
Web Maintenance & Development			0.20		0.10									0.70				0.60	1.60
	ANL		BNL			LANL	LBNL	LLNL	MCMMASTER		NIST			ORNL		TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD P	PhD P	PhD P	PhD T	PhD P	PhD T	GS	PhD P	PhD T	PhD P	PhD T	T/A	
<b>V. Nuclear Structure Physics</b>	0.95		1.49	1.80		0.10	1.70		0.60	0.80				0.20	0.15	0.76	0.10	0.15	8.80
NSR Abstract Preparation			0.10	0.20					0.10										0.40
Compilation of Exper. Structure Data	0.10			0.20					0.20							0.10			0.60
Eval. of Masses & Nuclides for ENSDF	0.60		1.04	1.40			1.00		0.30	0.80				0.20	0.15	0.33		0.15	5.97
Ground & Metastable State Properties			0.10																0.10
Radioactive Decay Data Evaluation	0.15																		0.15
Thermal Capture Gamma Data Eval.							0.50												0.50
Light Mass Eval. for Nucl. Physics A																0.33	0.10		0.43
Nuclear Structure Data Measurement	0.10					0.10	0.20												0.40
ENSDF Evaluation Support Codes			0.25																0.25
<b>VI. Nuclear Reaction Physics</b>	0.05		1.36	1.45	0.30	1.05	0.20	0.37		0.20	0.10	0.10		0.15					5.33
Experimental Data Compilation				0.50															0.50
Neutron Data																			0.00
Charged Particle Data																			0.00
Photonuclear Data																			0.00
ENDF Manuals and Documentation				0.20															0.20
ENDF Evaluations			1.26	0.55	0.30	0.40		0.37											2.88
Nuclear Reaction Standards						0.10						0.10	0.10						0.30
Nuclear Model Development				0.20		0.15													0.35
Nucl. Reaction Data Measurements						0.30	0.20												0.50
Astrophysics Nuclear Data Needs	0.05		0.10			0.10				0.20				0.15					0.60
DOE-SC Nucl. Data Funded Staff	1.10		5.29	3.55	3.80	1.40	2.00	0.37	0.60	1.00	0.10	0.10		1.10	0.15	0.76	0.10	0.75	22.17
Staff Supported by Other Funds	0.10	2.00	2.76	0.20		9.70	1.30	7.20	0.40		2.50		1.00	0.60					27.76
<b>TOTAL STAFF</b>	<b>1.20</b>	<b>2.00</b>	<b>8.05</b>	<b>3.75</b>	<b>3.80</b>	<b>11.10</b>	<b>3.30</b>	<b>7.57</b>	<b>1.00</b>	<b>1.00</b>	<b>2.60</b>	<b>0.10</b>	<b>1.00</b>	<b>1.70</b>	<b>0.15</b>	<b>0.76</b>	<b>0.10</b>	<b>0.75</b>	<b>49.93</b>

PhD P: PhD Permanent,  
 PhD T: PhD Temporary,  
 T/A: Technical and administrative,  
 GS: Graduate student.

# Detailed Status of the Work Plan Fiscal Year 2011 Report

## I. NNDC Facility Operation

### A. Management

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

### B. Library

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

### C. Computer Operation

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

BNL planned activities	Status
Ensure compliance with DOE cyber security requirements through regular network scanning and vulnerabilities remediation on NNDC servers and clients. Noncompliance could result in a total block of a machine from network access.	Continuing.
Provide computer support to NNDC staff and visitors in their use of NNDC computing resources. Also provide remote assistance to external NNDC collaborators in their use of BNL's Web-accessible scientific publications.	Continuing.
Upgrade NNDC's Linux cluster to handle CPU-intensive calculations due to ENDF/B-VII.1 pre-release data verification and validation, and COMARRA-related covariance processing.	Continuing.
Conduct regular backup of mission-critical servers to minimize loss of data and staff productivity during system failures.	Continuing.

## II. Coordination

### A. National Coordination

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

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

ANL Planned Activities	Status
Organize and chair the CSEWG Covariance Committee	Continuing

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

BNL planned activities	Status
Prepare FY2012 work plan for USNDP in time for spring 2011 FWP submittals.	Continuing. Work plan have been posted on the CSEWG Web site, FWP has been prepared and submitted.
Organize and chair CSEWG Meeting at BNL in November 2011.	Continuing. Meeting took place at BNL November 15-17, 2011.
Organize and chair USNDP Meeting at BNL in November 2011.	Continuing. Meeting took place at BNL November 16-18, 2011.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.	Continuing. Presentation and minutes of both meetings have been posted on the NNDC Web site.

Maintain CSEWG and USNDP websites	Continuing.
Unplanned activity: Work on ND2013 planning.	The poster, web site, committees and contracts for ND2013 were setup.
<b>LANL planned activities</b>	<b>Status</b>
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2010.	Organized and chaired Evaluation Committee meeting at the November 2010 CSEWG meeting.
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2010, and help coordinate Homeland Security and Astrophysics Task Forces.	Organized and chaired Nuclear Reaction Working Group meeting at the November 2010 USNDP meeting, and help coordinate Homeland Security and Astrophysics Task Forces.

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

<b>LANL planned activities</b>	<b>Status</b>
Organize and chair Nuclear Structure and Decay Data Working Group meeting at USNDP meeting, November 2010. Work with the NNDC to improve the efficiency of nuclear structure data evaluation and better integrate US efforts with other nuclear data activities.	Continuing.
Coordinate the LLNL/LBNL ENDF Gamma-ray Library project to use EGAF data to improve capture gamma ray data in ENDF.	Continuing.

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

<b>LLNL planned activities</b>	<b>Status</b>
Organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.	The previous chair (D. Brown) has moved to BNL and is continuing this role until a new chair is named. The 2011 task force report was delivered at the Nov. 2011 USNDP meeting. The task force is drafting a new Nuclear Data Needs for Homeland Security document.

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

<b>ORNL planned activities</b>	<b>Status</b>
Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting in November 2011.	A presentation on USNDP nuclear astrophysics data efforts was given at the 2011 USNDP meeting at BNL in November 2011
Communicate current efforts and future plans with researchers in nuclear astrophysics data.	At a Nuclear Data Workshop at the Fall 2011 DNP meeting, there were numerous discussions on future work in nuclear astrophysics data involving ORNL, McMaster Univ., BNL, and Michigan State Univ.
Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data.	Efforts in USNDP nuclear astrophysics data were discussed at the First International Symposium on Science with KoRIA in Sejong City, South Korea in Fall 2011, and at the Origins of Matter and Evolution of Galaxies 2011 [OMEG11] in Wako, Japan in Fall 2011.
Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.	A paper between ORNL, ANL, and JAEA on nuclear mass models for astrophysics was submitted to the OMEG11 meeting in Japan, and the work was presented at OMEG11 and presented at the Fall 2011 DNP meeting
Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, and with other agencies.	Future plans in nuclear astrophysics data were discussed at two separate budget briefings [for NNDC/USNDP and for ORNL] in Feb. 2011

## B. International Coordination

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

<b>ANL planned activities</b>	<b>Status</b>
Participate in the 2011 NSDD meeting.	Participated in the activities of the NSDD meeting at IAEA, April 2011
As a member of the organizing committee, participate in a nuclear physics workshop at ANL that is aimed at improving decay data for neutron-rich fission products.	Co-chaired the workshop on "Decay Spectroscopy at CARIBU: Advanced Fuel Cycle Applications, Nuclear Structure and Astrophysics"
Host several international visitors to ANL to collaborate on nuclear structure and nuclear astrophysics data evaluation projects.	Hosted several visitors to ANL who contributed to collaborative nuclear structure data activities, including evaluation of nuclear data for ENSDF database and for the DDEP network

Coordinate the International DDEP network activities	Provided coordination and overseen the review process for the DDEP collaboration
Unplanned activity: participate in the IAEA Technical meeting on "Intermediate-term Nuclear Data Needs for Medical Applications: Cross Sections and Decay Data"	Participated in the IAEA Technical meeting on "Intermediate-term Nuclear Data Needs for Medical Applications: Cross Sections and Decay Data", August 2011

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

BNL planned activities	Status
Participate in the IAEA-sponsored NRDC meeting in 2011.	S. Hlavac, compiling EXFOR data under contract with BNL participated in the meeting.
Participate in NEA WPEC annual meeting in 2011.	Mike Herman participated in the WPEC meeting on May 11-12, 2011
Participate in the IAEA-sponsored NSDD meeting in 2011.	Mike Herman, Alejandro Sonzogni and Jag Tuli attended the NSDD meeting in April, 2011.
Conduct and lecture at likely IAEA-sponsored workshop at Trieste in 2011.	The IAEA has not organized the Trieste workshop this year.
Unplanned activity: Work on ND2013 planning.	The poster, web site, committees and contracts for ND2013 were setup.

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

LANL planned activities	Status
Participate in NEA-WPEC 2011 meeting	Three LANL participants participated in the WPEC meeting in Paris.
Participate in relevant IAEA CRP meetings (FENDL and prompt fission neutron spectrum data).	Two LANL participants participated in the IAEA meetings (FENDL and fission neutron spectrum).
Participate and give a talk at the Joint International Conference of the 7th Supercomputing in Nuclear Application and the 3rd Monte Carlo (SNA + MC2010), will be held in Tokyo, Japan, Oct. 17-20, 2010.	One LANL participant gave an oral presentation and served a session chair at the Joint International Conference of the 7th Supercomputing in Nuclear Application and the 3rd Monte Carlo (SNA + MC2010).
Make latest version of NJOY data processing code available to the international community.	Upgrades to NJOY were released to international NJOY nuclear data processing community.
Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.	Hosted scientists from IAEA and JAEA to collaborate on the nuclear reaction data evaluation.

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

LBNL planned activities	Status
Coordinate the evaluation of a new k0/cross section database with International k0 users committee.	Continuing.
Evaluate the IAEA/LBNL Evaluated Gamma-ray Activation File.	Continuing.

McMaster: Continue participation in new evaluators training program.

McMasters planned activities	Status
Participate in the matters related policies, ENSDF formats and procedures for the NSDD network.	At the April 2011 NSDD meeting, B. Singh presented several items regarding evaluation procedures, the main one dealing with evaluation of half-life data.
Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work.	B. Singh visited several collaborating centers in Europe in the month of June. McMaster hosted visits of A.L. Nichols (Surrey) and A. Negret (Bucharest) for 2 weeks each, to work on ENSDF evaluations of A=62 and 75, respectively. B. Singh participated in IAEA-ICTP Trieste ENSDF workshop in October 2010; co-ordinated evaluation of 10 nuclides for ENSDF database. This work continued for several months after the workshop, until completion and inclusion of the data for these nuclides in ENSDF database.
Participate in IAEA-NSDD 2011 meeting.	B. Singh participated in IAEA-NSDD April 2011 meeting; made several presentations about the evaluation policies and status reports.

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

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

### III. Nuclear Physics Databases

#### A. Nuclear Science References (NSR)

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

BNL planned activities	Status
Database distributed to collaborators monthly.	Continuing.
Provide international coordination of NSR compilations and activities.	Continuing.

#### 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 compilation work is mainly carried out at McMaster University. The McMaster group also coordinates this work with that of other centers. The NNDC updates the database as new/revised data sets are received from McMaster.

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

#### 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
Database distributed to collaborators twice a year.	Continuing.
Process evaluations received from NSDD evaluators.	Continuing.

#### D. Numerical Nuclear Data File (NuDat)

The NNDC is responsible for NuDat, which consists of a database and a suite of codes that access it, allowing web users to search for level and  $\gamma$ -ray properties extracted from ENSDF, ground and meta-stable state properties (Wallet Cards), atomic and nuclear radiations derived from ENSDF, and thermal neutron cross sections and resonance integrals. Additionally, NuDat contains an interactive Chart of Nuclides and interactive level schemes.

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

#### E. Neutron Reaction Data Bibliography (CINDA)

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

BNL planned activities	Status
Contribute to CINDA by compiling experimental cross-section data to the CSISRS database (120 compiled papers expected).	Continuing. 104 articles were compiled.

#### F. Experimental Reaction Data File (CSISRS)

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

described here includes quality control, file update and data transfer activities. The NNDC database is updated, as compilations are exchanged and checked from the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

BNL planned activities	Status
Update CSISRS with EXFOR compilations from cooperating centers (500 entries expected). The NNDC compilation work can be found under Nuclear Reaction Physics, chapter V of the present document.	Continuing.

## G. Evaluated Nuclear Data File (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The work is organized under the Cross Section Evaluation Working Group (CSEWG), coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident charged particles and photons are also included. The data are stored in the ENDF format developed at NNDC about 35 years ago, and adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. New evaluations for the next release of the library, ENDF/B-VII.1, are assembled, tested and made available to users through NNDC's Web servers and GForge collaboration server.

BNL planned activities	Status
Maintain Linux/MySQL database system.	Continuing.
Start upgrading GForge/Subversion system for tracking development of the ENDF/B-VII.1 library.	The new GForge server installation, configuration and testing has been started.
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).	Continuing.
Perform data verification and data validation on the beta versions of ENDF/B-VII.1 library. Present results of these activities in pre-release CSEWG meetings.	Continuing.
Provide ENDF/B-VII.1 beta ACE libraries at 300K, 900K and 1500K to INL to be used in TRAPU/PHENIX experiment calculations.	Data have been provided to INL for several beta versions of the library.

## H. Database Software Maintenance

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

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

## I. Database Systems Development

The multi-year effort to migrate the USNDP databases to a LINUX/MySQL environment was completed in FY2009. After wards, 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 CSISRS 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
Effort needed to maintain Linux/MySQL database system and improve its performance.	Continuing.
Implement and maintain automatic replication of updates from the internal MySQL database server to the external.	Continuing.

# IV. Information Dissemination

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

## A. Web Site Maintenance

The NNDC provides electronic access to the nuclear physics databases that it maintains on behalf of the USNDP as well as access to other nuclear physics information through its Web site. The NNDC Web services are powered by four Dell servers each with two 3.3-GHz, quad-core processors running on the Linux operating system and using the Apache, Tomcat and MySQL database server software. The migration from Sybase was completed in July 2009 and has proven to be secure, fast and to have minimum downtime. On the overall, the migration significantly improved the reliability and cost-effectiveness of the NNDC Web services. The NNDC also maintains the Atomic Mass Data Center website. Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

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

BNL Planned Activities	Status
Improve ENSDF and NSR web interfaces.	NSR Web Interface was upgraded to make it more user friendly to nuclear reaction physicists.
Maintain web interfaces for ENDF and EXFOR databases.	Continuing.
Improve Sigma web interface by adding new and enhanced features following user's requests.	Continuing.
Maintain web interface for double-beta decay, B(E2) and Maxwellian-averaged cross sections and reaction rates.	Continuing.
Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users requests.	Continuing.
Improve reliability of its web services by installing the latest version of Apache/Tomcat servers and mod-jk connector software for a new dual web server system. Maintain the NNDC Web Services readiness above the 99% level.	Web Services reliability was maintained, readiness was slightly affected by hurricane Irene.
Strictly follow all BNL and DOE cybersecurity rules and regulations during the Web application design, development and implementation.	Continuing.
Maintain GForge Web site.	Continuing.

LANL Planned Activities	Status
Maintain LANL web site and provide actinide ENDF/B-VII data for criticality data testing, together with other LANL evaluations.	We maintain the T-2 web site to make the new actinide and light element evaluations available inside the LANL.

LLNL Planned Activities	Status
Maintain LLNL's Nuclear and Atomic Data Viewer.	Continuing
Extend the Nuclear and Atomic Data Viewer as per user requests.	No modifications made.
Maintain and upgrade LLNL's Computational Nuclear Physics web pages.	Web page maintained. Planned upgrade postponed due to task coordinator (D. Brown) moving to BNL.

LBNL planned activities	Status
The Isotopes Project web site continues to operate and will be upgraded in collaboration with the UC Berkeley Nuclear Engineering Department.	Discontinued activity.

ORNL Planned Activities	Status
Continued development and maintenance of our online software suite to convert nuclear data to astrophysical reaction rates and plot, manipulate, and share results online; this activity is at risk of termination.	streamlined procedure to do studies of the sensitivity of element creation code predictions on input nuclear physics information; updated databases; maintained system and implemented substantial new ORNL cyber security features

TUNL Planned Activities	Status
Continue to improve the TUNL website and provide access to new information on A = 3 - 20 nuclei.	Added new activity compiling excitation functions for (p,X) and (alpha,X) reactions on A=3-20 nuclei. When possible we provide a link to the NNDC X4 cross section library.
Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.	Added preprint manuscript for "Energy Levels of Light Nuclei A=11".
Continue to provide PDF and HTML documents for FAS reviews for the A = 3 - 20 series.	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 information for thermal neutron capture reactions on A=3-20 nuclei.	A website focusing on compiled structure data derived from relevant neutron capture reactions is maintained and updated annually.
Provide information for beta-decay reactions and ground-state particle-decay reactions relevant to A=3-20 nuclei.	A website focusing on compiled structure data derived from beta-decay reactions and ground-state particle-decay reactions is maintained and updated annually.

## 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 users as necessary.	Continuing. A large number of e-mails were answered as well as material was mailed.
Maintain Comments/Questions option for all reaction databases, for the NNDC web services, ENDF, EXFOR and for Nuclear Wallet Cards.	Continuing.

## C. Publications

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

BNL Planned Activities	Status
Prepare twelve issues of Nuclear Data Sheets for publication.	Continuing. All 12 issues were sent for publication.
Prepare special issue of Nuclear Data Sheets on neutron reaction data.	Special issue was published containing an extensive article on the NJOY code and three articles on fission product yields.

McMaster Planned Activities	Status
Develop software for NDS publication	JAVA version of a new code for NDS was completed and sample versions of complete mass chains were sent for comments. The code has been submitted to NNDC for further checking and modifications.

## V. Nuclear Structure Physics

### A. NSR Abstract Preparation

The literature search and preparation of KEYWORD abstracts for publications included in NSR require scientific expertise. BNL continues to have the overall responsibility for this database. The IAEA is expected to provide more than 20% of the keywords. Similar contributions from other external collaborators are expected. These will be checked and edited by BNL as necessary before being added to the database.

BNL Planned Activities	Status
Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them.	2,161 new references and 1,384 keyworded abstracts were added.
Check and edit approximately 700 key-worded abstracts for three European journals prepared at the IAEA Nuclear Data Section.	USNDP-IAEA collaboration on NSR keywording was finished in FY 2011.
Check and edit key-worded abstracts from other collaborators as applicable and necessary.	Continuing.
Provide training and knowledge sharing for external NSR collaborators.	Continuing.

McMaster Planned Activities	Status
NSR keywording for Physical Review C journal	1100 articles from PRC were scanned, NSR keywords were written for 650. Training was also provided to a new undergraduate student Michael Birch.

### B. Compilation of Experimental Structure Data

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

by McMaster, while the NNDC is maintaining the database. In FY09, ANL plans to start contributing to compilation effort.

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.	Compiled and reviewed 43 datasets from recently published experimental nuclear structure data in journals Physics Letters B, Journal of Physics G and Nuclear Instruments and Methods that were included in the XUNDL database. Interacted with the authors for requesting additional experimental data or for further clarification of the published results

BNL Planned Activities	Status
Compile new B(E2) experimental data, start work on a B(E2) evaluation project (in collaboration with McMaster).	25 new nuclei were compiled, B(E2) evaluation for Cr, Fe, Ni and Zn isotopes was accepted to Atomic Data & Nuclear Data Tables.
Compile new double-beta decay experimental data.	21 new nuclei and 45 decay modes were compiled.
Maintain, update and distribute XUNDL.	Continuing.

McMaster Planned Activities	Status
Compile data sets (in ENSDF format) for current experimental nuclear structure publication. Scan the webpages of prominent journals in nuclear physics for new papers.	493 datasets were compiled and included in XUNDL database. All major nuclear physics journals were scanned regularly and papers picked up for compilation, generally before they were entered in NSR database. 23 new papers on mass measurements were compiled separately and data for 130 nuclides were included in the ORNL's www.nuclearmasses.org database.
Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database.	101 datasets prepared at other centers were reviewed and edited if needed. 30 datasets were updated for new papers from the same experimental groups.
Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data.	Continuing. About 50 emails were sent to resolve discrepancies and obtain additional data details.
Train a new undergraduate student in 2011 for XUNDL and other compilation work.	Michael Birch, undergraduate physics honors student at McMaster was trained in the XUNDL, and NSR compilations.

TUNL Planned Activities	Status
Compile XUNDL data for A=2-20	Compiled 62 data sets.

### C. Data Evaluation for ENSDF

The USNDP evaluates nuclear structure and decay data for inclusion in the ENSDF database. This effort includes the critical analysis of all available experimental nuclear structure and radioactive decay data for a nuclide or a group of related nuclei to deduce recommended values from the measured data and prepare a file in ENSDF format that is the basis for publications in "Nuclear Data Sheets" and is used to update the contents of the USNDP nuclear structure and decay database, ENSDF. The US effort is supplemented by foreign contributions prepared under the auspices of the IAEA-sponsored international Nuclear Structure and Decay Data network.

ANL Planned Activities	Status
Evaluate at least 1 mass chain from the ANL region of responsibility.	Evaluation of A=110 and 133 mass chains were completed and submitted to NNDC for a review. The latter was published in Nuclear Data Sheets
Review mass chain evaluations, as requested.	Mass chain evaluation reviews were not requested
Collaborate with scientists from other NSDD network centers on data evaluation projects.	As a part of ENSDF mentoring activities, the ANL program collaborated on various mass-chain evaluations with scientists from University of Sofia, Bulgaria (A=112), University of Jyväskylä, Finland and US Naval Academy (A=188), China Nuclear Data Center, China and Australian National University, Australia (A=174), VECC, India (A=209)

BNL Planned Activities	Status
At least 6 mass chains, or their equivalent nuclides, will be evaluated.	Continuing.
At least 6 mass chains, or their equivalent nuclides, will be reviewed.	Continuing.
Continue mentoring new ENSDF evaluators.	Continuing.

LBNL Planned Activities	Status
Evaluate the equivalent of at least 3 mass chains, 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.	Continuing
Review mass-chain evaluations, as requested.	Continuing

Work with the NNDC to include DDEP decay data and EGAF capture gamma-ray data in the ENSDF file and published in Nuclear Data Sheets.	Continuing
Hire new evaluators to replace retiring 2.0 FTE expected in FY2013.	Continuing
<b>McMaster Planned Activities</b>	<b>Status</b>
3.5 equivalent mass chains and the data for new nuclides as mentioned below) will be evaluated.	A=43, 44, 62, 75 full mass chain updates (total of 46 nuclides) were submitted for NDS/ENSDF.
Mass chains will be reviewed as requested.	Two full mass chains were reviewed. ENSDF updates for 12 nuclide were reviewed
Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides.	75 nuclides were updated in ENSDF, these were either new nuclides or for which excited state data became available for the first time.
Collaborate with a new center/evaluator as part of mentoring process, as needed.	Collaboration with A.L. Nichols on A=62 evaluation started this year. It has since been submitted for publication. Collaboration on several other mass chains is continuing.

<b>ORNL Planned Activities</b>	<b>Status</b>
Complete evaluation of structure information for one nucleus in A=241-249 region.	A = 152 submitted; A=69 submitted
Review one mass chain evaluation.	none requested in this FY by NNDC

<b>TUNL Planned Activities</b>	<b>Status</b>
Prepare the ENSDF files corresponding to new publications in the "Energy Levels of Light Nuclei" series.	Energy Levels of Light Nuclei A=11 was accepted Jan 19 2011, corresponding ENSDF file will be delivered to NNDC.

## D. Ground and Metastable State Properties

The NNDC maintains a database of nuclide properties for the Nuclear Wallet Cards.

<b>BNL Planned Activities</b>	<b>Status</b>
Update database as new information becomes available.	Continuing.

## E. Radioactive Decay Data Evaluation

Decay data for nuclides of importance for metrology are evaluated in an international collaboration. When complete, these evaluations will be entered into the ENSDF format, included into the ENSDF database and made available to ENSDF evaluators. In the United States, E. Browne (LBNL) coordinates this project at no cost to the US Nuclear Data Program.

<b>ANL Planned Activities</b>	<b>Status</b>
Evaluate at least one radionuclide for the DDEP collaboration.	Completed decay data evaluations for <sup>209</sup> Tl and <sup>211</sup> Pb radionuclides
Review of selected nuclides for the DDEP collaboration, as requested.	Continuing

<b>McMaster Planned Activities</b>	<b>Status</b>
Evaluate or review decay datasets for one or two radionuclides, as needed.	DDEP evaluation of 2 nuclides was reviewed.

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

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

<b>LBNL Planned Activities</b>	<b>Status</b>
Continue to maintain and update the EGAF database	Continuing
Collaborate with LLNL to perform statistical-model calculations of quasi-continuum gamma-ray cascade information and generate ENDF-format capture gamma-ray datasets for use with MCNP and other transport-code calculations.	Continuing

Prepare ENDF capture gamma-ray datasets in collaboration with LLNL	Continuing
Include improved nuclear structure data for the RIPL library in EGAF datasets	Continuing
<b>LLNL Planned Activities</b>	<b>Status</b>
Evaluation of EGAF data in collaboration with LBNL	Continuing

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

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

<b>TUNL Planned Activities</b>	<b>Status</b>
Finalize publications in the A=11, 12 and 13 region.	Energy Levels of Light Nuclei A=11 was submitted to Nuclear Physics A; Accepted Jan 2011. Continuing evaluations of A=12 & 13.

## H. Nuclear Structure Data Measurement

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

<b>ANL Planned Activities</b>	<b>Status</b>
Participate in nuclear physics research activities at ANL with main emphasis on decay studies of neutron-rich fission products of relevance to reactor decay heat and astrophysics applications (Co-PI of a DOE/ONP ARRA funded project), spectroscopy of heavy actinide nuclei and nuclei far from stability line.	Participated in nuclear structure research activities at the ATLAS facility at ANL with emphasis on structure of heavy nuclei and properties of nuclei far the line of stability
Complete analyses of $^{233}\text{Pa}$ and $^{243}\text{Cm}$ decay data and publish the results.	Completed the analysis of the $^{233}\text{Pa}$ data. The results were published in the journal Nuclear Instruments and methods

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

<b>LANL Planned Activities</b>	<b>Status</b>
Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on nickel isotopes to search for previously unobserved transitions in this nuclides.	The data have been taken for $^{58,60}\text{Ni}$ and the data analysis is underway.
Interact with mass chain evaluators on the nuclear structure of these nuclei.	Continuing.

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

<b>LBNL Planned Activities</b>	<b>Status</b>
Participate in LBNL 88" Cyclotron experiments with an emphasis on topical issues and data needs such as AFC-related measurements or nuclear structure experiments on nuclei far from stability.	Continuing
Continue capture gamma-ray cross section measurements with neutron beams at the Budapest and Garching FRM II Reactors.	Continuing
Perform DICEBOX statistical model calculations to determine total radiative cross sections and nuclear level spins and parities.	Continuing
Develop a intensified neutron facility on the UC Berkeley campus in collaboration with the Department of Nuclear Engineering, LLNL NIF scientists, and the Berkeley Geochronology Center.	Continuing
Publish new research on the Younger Dryas impact event, discovered by the LBNL Isotopes Project, that caused 1300 years of global cooling and the extinction of the Mammoths and megafauna.	Continuing
Publish the discovery of 22 supernovae that exploded <250 pc from Earth during the past 300 kyr. This analysis based on the radiocarbon record is the first complete observation of cosmic rays emitted from an SNR.	Continuing

## I. ENSDF Physics and Checking Codes

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

BNL Planned Activities	Status
Maintain and upgrade ENSDF checking and physics programs for format changes as required.	Continuing

## VI. Nuclear Reaction Physics

### A. Experimental Data Compilation

The NNDC, as part of a larger international cooperation, has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada. Incident neutron reactions have been well covered historically. NNDC thus concentrates on new measurements, but continues compilations of earlier publications that have not been included in the CSISRS 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.	Continuing. A total of 750 EXFOR entries were added.

### B. ENDF Evaluations

Evaluated nuclear reaction data, for applications and for basic science needs, are stored in the ENDF database, which is maintained by BNL. As chair of the CSEWG evaluation committee, LANL staff works with BNL to insure quality control, particularly for new evaluations. New evaluations funded primarily from other sources are prepared for archival in the ENDF library. BNL, LANL, LLNL and ORNL provided neutron, proton and photonuclear reaction data evaluations for ENDF/B-VII released in FY2007. LLNL develops a computer code that translates LLNL evaluations in the internal ENDL format into ENDF-6 formatted data so that LLNL evaluations can flow back into the nuclear data community.

BNL Planned Activities	Status
Respond to user needs for evaluated nuclear reaction data.	The NNDC provides the Gforge website where the major releases as well as the currently updated versions of the evaluated nuclear data files (ENDF) are made available. Members on the working group on nuclear data evaluations are able to update or "commit" new changes for others to see and provide feedback.
Collect and address users feedback related to the ENDF library.	The first beta release of the ENDF/B-VII.1 library was released on Oct 22, 2010 with 5 additional beta versions in 2011. Feedback from these test versions provided valuable feedback to the community to help improve the library. The final release was on Dec 22, 2011.
Work with LANL on upgraded evaluations for future release of the ENDF/B library (version VII.1).	Version VII.1 of the ENDF/B library was released in Dec 2011. This was the culmination of work from many laboratories, both in the US and abroad. The NNDC provided new and updated evaluations for many materials and was also responsible for hosting the library and quality assurance.
Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.	The NNDC added new covariance data in the resonance region for many materials in 2011 at BNL using the kernel approximation method, where the uncertainties in the resonance parameters from the Atlas of Neutron Resonances are used as input. The updated materials include Cr-50,52,53, Ni-58, Si, Fe, Pb and Bi isotopes, among many others.

LANL Planned Activities	Status
Upgrade the LANL ENDF evaluations for actinides that perform well in criticality benchmarks, considering new LANSCE experimental data.	The evaluation of $^{233}\text{U}$ upgraded. $^{238}\text{Pu}$ and $^{240}\text{Pu}$ evaluations finalized. Some adjustments were made to $^{241}\text{Am}$ evaluation. All the results were included in ENDF/B-VII.1, which was released in 2011.
Provide upgraded ENDF evaluated data files for light elements, including covariance data. Finalize new evaluations of $^9\text{Be}$ and $^{16}\text{O}$ .	New evaluation of $^9\text{Be}$ capture cross section performed. $^{16}\text{O}$ capture cross section was also upgraded. Both evaluations include covariance data.
Finalize new evaluations for gas production cross-sections on structural materials, considering LANSCE experimental data.	Alpha-particle production cross sections on structural materials re-evaluated based on LANSCE experimental data. The results were included in ENDF/B-VII.1.

Re-evaluate V and Mn data, for which problems in the criticality benchmarks are reported.	New vanadium data evaluated, and submitted to ENDF/B-VII.1. Mn data evaluated at IAEA reviewed, and included in ENDF/B-VII.1. For V, Ti, and As isotopes, new particle spectra evaluations performed, which solved energy balance problem reported.
Upgrade new delayed gamma-ray data, by combining ENSDF beta-decay data.	New calculations performed for delayed gamma-ray data for more than 1000 nuclei, by combining available ENSDF data. A new decay data library was made.
Fix energy grid problem in the prompt fission neutron spectra for major actinides.	Energy grid problem fixed by adding finer energy points.

LLNL Planned Activities	Status
Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.	<sup>239</sup> U evaluation finalized, with improvements to resonance region.

## C. ENDF Manuals and Documentation

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

BNL Planned Activities	Status
Maintain ENDF-6 formats manual up-to-date with CSEWG endorsed format changes. This format is used for the ENDF/B-VII library. Updates are now being managed using a Subversion repository on NNDC's GForge server.	The ENDF format manual was updated and released with the ENDF/B-VII.1 library on Dec. 22, 2011.

## 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, which was initiated by the CSEWG, was recently completed. 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 <sup>252</sup>Cf spontaneous fission neutron spectrum. Recently the scope has been broadened, largely through the data development project, to include an investigation of possible inelastic scattering cross section reference standards; considering adding additional standards energy ranges for the Au(n,γ) cross section; and proposing updates for the evaluations of the <sup>252</sup>Cf spontaneous fission neutron spectrum and the <sup>235</sup>U 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 for H, Li and B, and investigate the nature of output covariance data from R-matrix analyses of systems containing the light-element standard cross sections.	Participated in the international effort to reevaluate the standards. Available R-matrix covariance matrices, together with other evaluated light element covariance data were made available through ENDF/B-VII.1 release.
Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.	<sup>241</sup> Am fission cross sections were reevaluated by using the cross section standards, and integral tests were performed.
Study covariance data evaluation for the standards in a different technique when the R-matrix analysis gives extremely small uncertainties.	A so-called PPP problem in covariance evaluation with the least-squares data fitting method was investigated by using a Monte Carlo technique. A paper was published in a peer-review journal.
Complete report on the measured cross sections for the standards reaction <sup>6</sup> Li(n,α) in the MeV region together with an R-matrix analysis of these and literature data. The measured data have already been given to the NNDC.	The data were taken and analyzed and transmitted to NNDC. A paper with R-Matrix calculations is in preparation.
Begin experiment on H(n,n) angular distribution for improving the standard at several neutron energies for forward neutron scattering angles in the center-of-mass. This measurement follows the H(n,p) measurements that improved the data base at backward angles. We collaborate with researchers at Ohio University and NIST.	The neutron detector efficiency calibration is the defining issue here. We are working with Ohio and NIST on several methods for improving the determination of the efficiency. The "neutron tagging" approach at WNR/LANSCE is effective from 1 MeV to 20 MeV and thereby extends the range above about 8 MeV where the "standard" <sup>252</sup> Cf spontaneous fission spectrum drops to low levels.
Continue the search for suitable (n,x γ) reactions as possible reference cross sections to complement or replace the <sup>56</sup> Fe(n,x γ) = 847 keV reaction, which has several experimental limitations.	The <sup>56</sup> Fe(n,x γ = 847 keV) is being measured relative to <sup>52</sup> Cr(n,x γ = 1434 keV) and reactions on titanium and vanadium. We continue to participate in the IAEA Standards work, for example in the Consultants' Meeting on International Neutron Cross-Sections Standards: Extending and Updating (October, 2010).

NIST Planned Activities	Status
Continue work on the IAEA data development project on maintenance of the neutron cross section standards. Prepare a conference paper on the update of the standards from the work of this project. Prepare for the next IAEA Consultants' Meeting on this project and provide results on the updating of the standards database and its impact on the standards.	Work was done on the IAEA data development project on maintenance of the neutron cross section standards. A paper was given at the International Symposium on Reactor Dosimetry on New Work on Updating and Extending the Nuclear Data Standards that resulted from this work. Work is underway in preparation for the next IAEA Consultants' Meeting.
Prepare a paper for publication in the journal Metrologia on neutron cross section standards - their history, how they are measured, evaluated and used.	A comprehensive paper was published in the journal Metrologia on Neutron Cross Section Standards - Their History, How They are Measured, Evaluated and Used.
Work on the Program Committee for the 14th International Symposium on Reactor Dosimetry to be held in 2011. We will organize the topic "nuclear data for dosimetry" to be used in a session at this Symposium.	We worked on the Program Committee for the 14th International Symposium on Reactor Dosimetry and organized a session on "Nuclear Data for Dosimetry". The meeting was held in May of 2011
Submit for publication the finalized measurements on the angular distribution of neutrons scattered by hydrogen at 14.9 MeV based on proton recoil work. Work done in collaboration with Ohio University and LANL.	Measurements on the angular distribution of neutrons scattered by hydrogen at 14.9 MeV based on proton recoil work were published in Phys. Rev. This work is a collaboration including Ohio University and LANL.
Continue work on an experiment using neutron detection (instead of proton detection) to measure the H(n,n) angular distribution in collaboration with Ohio University and LANL. Study the possible use of a time projection chamber for angular distribution measurements.	Work continues on an experiment using neutron detection (instead of proton detection) to measure the H(n,n) angular distribution in collaboration with Ohio University and LANL. The focus of the work is on methods to improve neutron detector efficiency. The possibility of using a TPC for hydrogen angular distribution measurements is under investigation.
Continue work based on $^{252}\text{Cf}$ nu-bar leading to an improved calibration of NBS-I, the U.S. national primary standard neutron source and determination of our bath efficiency.	Work continues based on $^{252}\text{Cf}$ nu-bar that could lead to an improved calibration of NBS-I, the U.S. national primary standard neutron source and improved determination of our bath efficiency.
Complete a measurement of the $^6\text{Li}(n,t)$ standard cross section at ~ 4 meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the $^{10}\text{B}(n,\alpha)$ reaction. Continue work to finalize the design for the $^3\text{H}$ target for the n- $^3\text{H}$ coherent scattering length measurement including safety review, detailed design, prototype fabrication, and element testing. This work complements work on the $^3\text{He}(n,p)$ standard cross section	The measurement of the $^6\text{Li}(n,t)$ standard cross section at ~ 4 meV neutron energy has been completed. This measurement used an improved fluence determination based on alpha-gamma coincidences with the $^{10}\text{B}(n,\alpha)$ reaction. Work continues to finalize the design for the $^3\text{H}$ target for the n- $^3\text{H}$ coherent scattering length measurement including safety review, detailed design, prototype fabrication, and element testing. This work complements work on the $^3\text{He}(n,p)$ standard cross section
Continue the documentation of changes to EXFOR files based on the corrections obtained from the files of Poenitz and new information obtained from the CRP investigations.	The documentation of changes to EXFOR files based on the corrections obtained from the files of Poenitz and new information obtained from the CRP investigations continues at a reduced pace due to other standards activities.
Continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.	We continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.
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.	We continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. We make these samples available for loan in physics experiments.

## 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 GNASH (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-3 to improve accuracy and reliability of input parameters used in nuclear reaction calculations

BNL – We are active in nuclear reaction model development focusing on the BNL code EMPIRE. The work in this fiscal year will concentrate on further extensions and improvements of its capabilities, including a new version of the level densities with appropriate parameterization. The work on validation of the code will be actively pursued, in particular in relation to emerging requirements of homeland security applications. Close collaboration with LANL will continue focusing on validation of the fission models in EMPIRE and GNASH. Major effort is dedicated to the development of capabilities for estimating covariance data for fast-neutron reaction cross sections. In response to the needs from many user groups (such as Gen-IV reactors, criticality safety, Advanced Fuel Cycle Initiative), BNL will collaborate with LANL and ANL on a methodology for nuclear data covariances. To this end, a covariance module in EMPIRE for fast neutron energies should be extended and tested.

BNL Planned Activities	Status
Release new version of the code EMPIRE with above-mentioned improvements.	Working version of EMPIRE was periodically made available to the users on the GForge server.
Develop the improved version of the covariance module in EMPIRE for fast neutrons.	The covariance capabilities of EMPIRE were extended by including sensitivity calculations to basic parameters for fission barriers extending applicability of the code to estimate cross section uncertainties for

	actinides.
Implement and test the new resonance module allowing to generate covariances utilizing information from Atlas of Neutron Resonances.	The new Kerzen module based on the kernel approximation has been developed, implemented and applied to determination of covariances for ENDF/B-VII.1
Maintain GForge site with the current version of the EMPIRE code.	GForge server was maintained providing access to the most recent version of EMPIRE to the developers in US, Europe and Korea.
Attempt parallelization of EMPIRE on the NNDC cluster.	Dedicated scripts have been written to allow running EMPIRE in parallel on the NNDC cluster. This option turned out extremely useful in covariance determination that is particularly CPU intensive.

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

LANL Planned Activities	Status
Perform radiative capture calculations on Gd and Tm isotopes, and investigate the enhancement factor of neutron capture rate on the excited nuclei, in support of DANCE detector capture measurements and s-process nucleo-synthesis studies.	Radiative capture calculations on Tm and Pu performed with the coupled channels Hauser-Feshbach method. A coupling saturation problem identified in the coupled channels method, which was reported at the International workshop on compound nuclear reaction in Prague.
Perform neutron emission cross section calculations for fission products, in collaboration with CEA (France).	Fission product averaged cross sections for (n,n'), (n,2n), and (n,3n) calculated in collaboration with CEA. A peer review paper published.
Develop a code to calculate the delayed gamma spectrum from fission products, using the Monte Carlo technique for the Hauser-Feshbach statistical decay, and extend the code to handle a neutron competition channel.	A new Monte Carlo simulation code for calculating the neutron and gamma-ray correlations was developed. The code was applied to calculate the delayed neutron and gamma-ray energy spectra. The paper published in J. Nuclear Science and Technology received the best paper award in 2011.
Apply a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets to study gamma-ray cascading, in support of DANCE and GEANIE measurements.	M1 scissors mode considered in the Hauser-Feshbach statistical gamma-ray cascading calculation, in support of DANCE measurements for actinides.
Modern nuclear structure models, such as Hartree-Fock, will be applied to calculate proton capture process for odd-target cases, with reasonable approximations.	The Hartree-Fock nuclear structure model was applied to proton direct / semidirect capture process on odd mass targets. A Phys. Rev. C paper submitted.
Study <sup>238</sup> U and <sup>232</sup> Th neutron inelastic scattering at low-excitation energies where theoretical calculation underestimates experimental data.	Study on actinides continues. Study on microscopic neutron inelastic scattering from a spherical nucleus finalized, and a Phys. Rev. C paper was published.
Apply beta-delayed gamma calculations to fission product decay heat to benchmark beta-decay modelling at LANL.	New beta-delayed gamma calculations, including beta-decayed neutrons, applied to decay heat benchmark. Two talks were given at different international workshops.

LLNL Activities	Status
Event by event fission modeling	We added the capability for spontaneous fission to FREYA and increased the number of actinides available to include <sup>239</sup> Pu(n,f), <sup>240</sup> Pu(sf), <sup>235</sup> U(n,f), <sup>238</sup> U(sf), <sup>244</sup> Cm(sf) and <sup>252</sup> Cf(sf). We published a paper on this work with an emphasis on correlated observables, R. Vogt and J. Randrup, Phys. Rev. C 84, 044621 (2011). With funding from NA22, this version of FREYA, was incorporated into MCNP to make it accessible to the user community. We also improved the evaluation of <sup>239</sup> Pu(n,f) for incident neutron energies up to 20 MeV, incorporating multichance fission and pre-equilibrium emission. A paper on the evaluation was submitted to Phys. Rev. C.
Reaction theory for surrogate reactions	Work on extending surrogate reaction beyond Weisskopf-Ewing approximation continuing. Realistic spin/parity distributions compared to Gd surrogate data. Coherent treatment of compound nucleus formation and direct reaction channels using theory of Udagawa and Tamura.
Coupled-channels	Studies of coupled-channel optical potentials have revealed larger coupled channel sets than have previously used, need to be employed to gain convergence. Work on new optical potentials based on larger coupled-channels sets being initiated. Adiabatic approximation to coupled channels sets shows promise as a good approximation for a time efficient solution.
R-Matrix	Hybrid R-matrix/Ab-initio code being developed for light ion-reactions.

## F. Nuclear Reaction Data Measurements

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

ANL: ANL has recently initiated a new program in collaboration with INL (Measurement of Actinide Neutronic Transmutation Rates with Accelerator mass spectroscopy - MANTRA), supported through ARRA funding from ONP/DOE, aimed at obtaining valuable integral information about practically all high mass actinides neutron cross sections that are of importance to advanced nuclear fuel cycles and to USNDP.

ANL Planned Activities	Status
Coordinate research activities between INL and ANL and participate in nuclear data measurements, equipment development, cross section modeling and sensitivity studies.	Coordinated the research activities between ANL and INL. Participated in the first AMS test experiment and in the development of the laser ablation and sample changer capabilities at ATLAS. Organized the annual MANTRA collaboration meeting

LANL Planned Activities	Status
Analyze neutron inelastic scattering made with the GEANIE and FIGARO arrays. Correlate new data from GEANIE with data from FIGARO on targets of $^{56}\text{Fe}$ and $^{58}\text{Ni}$ . New measurements at GEANIE will include $^{60}\text{Ni}$ .	In progress. FIGARO data are being analyzed. Added target nucleus $^{60}\text{Ni}$ .
Continue to improve the techniques to measure the fission-neutron spectrum for fission induced by neutrons of 0.4 to 200 MeV on $^{235}\text{U}$ and $^{239}\text{Pu}$ . The shape of the major part of the emission spectrum between 0.1 and 10 MeV will be determined in this experiment, performed in collaboration with CEA and LLNL researchers, and will be compared with the Los Alamos model prediction. The modeling includes the Monte Carlo prompt neutron emission technique and the microscopic quantum mechanical pre-equilibrium calculations. In FY11, we will complete measurements on the portion of the fission neutron spectrum below 1 MeV for $^{235}\text{U}$ .	Published first results. Further measurements of prompt neutron emission from neutron-induced fission are planned with a new flight path at WNR, parallel-plate avalanche fission counters made at Lawrence Livermore National Laboratory, new detector arrays for high energy neutrons (> 0.6 MeV) and lower energy neutrons (50 keV - 1 MeV), and a new data acquisition system based on waveform digitizers. By the end of FY2012, this new system will have been commissioned and production measurements will begin shortly thereafter.
Complete the measurement and analysis of prompt neutron emission following interactions of fast neutrons with fission products such as strontium and barium. These measurements are gated on gamma rays from (n,n' $\gamma$ ) reactions.	Data have been taken. Analysis in progress.
Complete data analysis for gamma-ray output from neutron-induced fission of $^{235}\text{U}$ , $^{238}\text{U}$ , and $^{239}\text{Pu}$ for neutron energies from 1 to 100 MeV. Collaborators include scientists from CEA (France).	Data analyzed for $^{235}\text{U}$ and $^{252}\text{Cf}$ . Two articles, with first authors from LLNL, have been submitted for publication, a Physical Review C article on the $^{252}\text{Cf}$ investigated at DANCE and a Nuclear Instruments and Methods article on the technique for extracting gamma-ray spectra with liquid organic scintillators.
Measure neutron capture cross sections $^{239}\text{Pu}$ and $^{241}\text{Pu}$ for neutron energies less than 200 keV, contingent on obtaining the targets.	The data for $^{239}\text{Pu}$ capture cross section are being analyzed. For neutron capture on $^{63}\text{Ni}$ data are being analyzed at the University of Frankfurt, Germany, and good progress is reported. The sample had a contamination from the grow-in of $^{63}\text{Cu}$ . Data have been taken recently on that isotope to improve the background subtraction at LANL. Those for $^{241}\text{Pu}$ are being analyzed at LLNL.
Measure the neutron capture cross-section at DANCE for at least one radioactive isotope of importance to nuclear astrophysics.	Data for neutron capture on $^{63}\text{Ni}$ are being analyzed at the University of Frankfurt, Germany, and good progress is reported. The sample had a contamination from the grow-in of $^{63}\text{Cu}$ . Data have been taken recently on that isotope to improve the background subtraction.

LBNL: – LBNL has recently initiated a new program to use surrogate reactions to deduce reaction cross sections which are of importance to Advanced Fuel Cycle (AFC) programmatic needs (a national priority). This is collaboration between the nuclear structure and nuclear reaction groups at LBNL and outside groups at LLNL and the University of Richmond that is currently funded from outside of the DOE Data Program. The LBNL group is leading a series of benchmarking experiments to test the applicability and accuracy of these new techniques for deducing cross sections of importance to AFC and the s-process. It is anticipated that this activity will provide nuclear reaction data measurements of importance to the Data Program. LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal (n, $\gamma$ ) cross section data to supplement earlier elemental target measurements from which important information was either lacking (e.g., data from low-abundance isotopes) or discrepant.

LBNL planned activities	Status
Measure thermal (n,g) gamma ray and total radiative cross sections using guided neutron beam in collaboration with the Budapest Research Centre and the Garching FRM II reactor.	Continuing
Lead series of surrogate-reaction benchmarking measurements at the LBNL 88" cyclotron.	Continuing

LLNL Planned Activities	Status
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Perform neutron capture measurements with DANCE array and fission cross section measurements with the lead slowing down spectrometer at LANSCE in collaboration with LANL. (funded from other sources)	Experiments fielded using the DANCE array together with a newly designed fission counter for $^{239}\text{Pu}$ , $^{241}\text{Pu}$ , $^{235}\text{U}$ , and $^{238}\text{Pu}$ . Cross sections derived for $E_n$ from thermal to $\sim 100$ keV.
Perform surrogate (n,n'), (n,2n), (n, $\gamma$ ) and (n, f) measurements on several nuclei with programmatic and/or astrophysical importance. (funded from other sources)	$^{238}\text{Pu}(n,f)$ surrogate cross sections published. $^{239}\text{Np}(n,f)$ , $^{240}\text{Am}(n,f)$ , $^{241}\text{Am}(n,f)$ and $^{242}\text{Am}(n,f)$ cross sections measurements performed, analysis in progress. Experiments performed for $Y(n,2n)$ and $Y(n,\gamma)$ surrogate reactions. Analysis of spin distributions of Gd surrogate reactions published. Results being used to determine $^{153}\text{Gd}(n,\gamma)$ cross section.
$\beta$ -delayed neutron emission measurements for fission fragments	Applied precision ion trap approaches to $\beta$ -delayed neutron spectroscopy. Demonstrated technique offline by studying well-characterized $^{137}\text{I}$ decay.

## 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.

ANL Planned Activities	Status
ANL will continue working in the area of data needs for nuclear astrophysics. The main emphasis will be on improving the data for cosmochronometers in the rare-earth region - $^{176}\text{Lu}$ , $^{180}\text{Ta}$ and $^{186}\text{Re}$ .	Continuing
Compile and evaluate nuclear structure and decay data for neutron-rich fission fragments, produced at the CARIBU facility (ANL), that are of relevance to r-process modeling.	Due to delays with the availability of the CARIBU facility, such work will continue during FY2012

BNL Planned Activities	Status
Produce uncertainties for Maxwellian averages of neutron capture cross sections in the energy region of interest for nuclear astrophysics.	Uncertainties for ENDF/B-VII.1 Maxwellian-averaged cross sections were produced and published in Nuclear Data Sheets journal.

LANL: Participate in the USNDP effort to develop high-quality data for astrophysics calculations of nucleosynthesis. Make new calculated and evaluated results available to the wider astrophysics research community via the USNDP Astrophysics Task Force.

LANL Planned Activities	Status
Improve neutron capture models to provide neutron capture rates off-stability to s and r-process hydro-dynamics simulations.	Pygmy resonance and scissors mode in gamma-ray strength function included in Hauser-Feshbach model calculation. Sensitivity study on the gamma-ray strength function performed.
Provide beta-delayed fission rates in the astrophysical stellar environment, based on the macroscopic-microscopic nuclear mass model.	Beta-delayed fission modeling continues. The fission rates have not been provided.

McMaster: The evaluation of nuclear astrophysics data is expected to complement the on-going experimental program of measurements of radiative capture cross sections and particle-transfer experiments using radioactive ion beam facilities at TRIUMF, NSCL, RIKEN and ANL.

McMaster Planned Activities	Status
Specific reactions planned for evaluation in FY11: $^{29}\text{P}(p,\gamma)^{30}\text{S}$ and $^{30}\text{P}(p,\gamma)^{31}\text{S}$ .	$^{29}\text{P}(p,\gamma)^{30}\text{S}$ and $^{30}\text{P}(p,\gamma)^{31}\text{S}$ reactions were evaluated and results sent to M. Smith for inclusion in ORNL's nuclear astrophysics webpage.

ORNL: Evaluate capture reactions on radioactive proton-rich nuclei which are important for element synthesis and energy generation in stellar explosions.

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 ORNL's Holifield Radioactive Ion Beam Facility.	New level information on $^{18}\text{F}+p$ levels in $^{19}\text{Ne}$ was published in Phys. Rev. C. Rapid Comm -- "First proton-transfer study of $^{18}\text{F} + p$ resonances relevant for novae" . This was the result of a measurement of $^{18}\text{F}(d,n)$ at ORNL HRIBF and subsequent assessment of $^{19}\text{Ne}$ level information
Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANC's) on nuclei near the $N=82$ closed shell - $^{131}\text{Sn}$ , $^{133}\text{Sn}$ , $^{135}\text{Te}$ - from transfer reaction measurements on radioactive Sn and Te nuclei. This information is important for modeling the r-process in supernovae.	paper on levels of $^{131}\text{Sn}$ from the $^{130}\text{Sn}(d,p)$ reactions is in progress; calculation of direct capture cross sections and spectroscopic factors is included; analysis of $^{81}\text{Ge}$ levels from $^{80}\text{Ge}(d,p)$ is in progress; analysis of $^{130}\text{Te}(d,p)$ data is in progress and will lead to assessment of $^{131}\text{Te}$ levels

## H. Reaction Data for FRIB Target Design

The Facility for Rare Isotope Beams needs high-quality nuclear reaction data for target design. LANL will collaborate in order to provide key reaction cross-sections using theory calculations and measurements to evaluate the data.

LANL Planned Activities	Status
We aim to maintain important collaboration connections with the FRIB community because of its importance in nuclear science, but effort is limited because of budget restrictions. However, we will continue to maintain a presence in the FRIB planning community via participation in FRIB meetings and workshops.	Very limited activities. Theoretical modeling for neutron radiative capture reaction was investigated in collaboration with LANSCE experimentalists in support of FRIB.

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## Appendix A

### Nuclear Data Activities Funded from Sources outside the Nuclear Data Program (Report FY2011)

#### ANL

Additional support for the nuclear data work at Argonne comes from 3 ARRA projects funded by DOE-SC

#### BNL

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

1. Elsevier supports the production of computer-generated photo-ready copy of manuscripts for the Nuclear Data Sheets.
2. The US Nuclear Criticality Safety Program (NCSP), funded by DOE NNSA, supports the NNDC services in maintaining NCSP data submitted to ENDF/B-VII library as well as data development work on estimates/evaluations of neutron cross section covariances for criticality safety applications.
3. The AFCI Data Adjustment project, funded by DOE-NE, supports the NNDC work on development of neutron cross section covariances for fast advanced burner reactors.
4. Two ANST grants from DOE support development of neutron cross section covariances for selected materials to be included in ENDF/B-VII.1.

#### LANL

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

1. Advanced Simulation and Computing (ASC program). This work supports the development of more accurate ENDF cross section databases for actinide fission fuels, light-nucleus thermonuclear fuels, and for reactions on important materials used for diagnostics (radiochemical reactions). Nuclear model code development, for both statistical and preequilibrium models, and for light R-matrix codes, is supported by this program, as is the development of the NJOY data processing code for providing data usable by Monte Carlo and deterministic transport codes in applications. The funding also supports physics research developments in nuclear reaction and structure theory (with a recent emphasis on nuclei and isomers away from stability), and fission theory. Data testing using integral benchmarks such as fast critical assemblies is used to validate the ENDF data.
2. Advanced Fuel Cycle (AFC). This supports the development of improved nuclear data important for transmutation in the fast neutron energy region, as well as high-energy spallation models important for describing processes in the spallation target. Recent focuses have been improved ENDF data on minor actinides (ATW fuel), and lead and bismuth (target/coolant), as well as better intra-nuclear cascade codes for modeling neutron production and radionuclide production in the spallation target. This program also supports experimental nuclear reaction measurements at LANSCE for both fission and capture cross sections.
3. Nuclear criticality safety. This funding supports improved nuclear data important in criticality safety studies, such as uranium isotopes, as well as data on chlorine, aluminum, etc. Data testing using critical assemblies and NJOY processing code development is also funded by the program.
4. LANL LDRD. There are 2 LANL LDRD projects that support nuclear reaction data measurements.
5. Nuclear Weapons supports LANSCE measurements of fission output (neutrons and gamma rays), neutron capture on actinides and radchem isotopes, and neutron reactions relevant to radchem.
6. Two ARRA stimulus funds support development of neutron cross section covariances and nuclear reaction modelling for actinides.

#### LBNL

ARRA research stimulus funds received this year funded 1.0 FTE for ENSDF mass chain evaluation and capture gamma-ray library evaluations in collaboration with LLNL. The A=29 mass chain and isotope evaluations of <sup>30</sup>F, <sup>30</sup>Al, <sup>30</sup>Si were completed. Capture gamma-ray data from the EGAF database for all elements with Z<20, <sup>151</sup>Eu, <sup>153</sup>Eu, <sup>152</sup>Gd, <sup>154</sup>Gd, <sup>155</sup>Gd, <sup>156</sup>Gd, <sup>157</sup>Gd, <sup>158</sup>Gd, <sup>160</sup>Gd, <sup>182</sup>W, <sup>183</sup>W, <sup>184</sup>W and <sup>186</sup>W have been evaluated and presented at various nuclear physics conferences for comment. New experiments have been performed on separated isotope targets at the Budapest Reactor to resolving outstanding analysis questions. New FOA 09-13 Applications in Nuclear Science and Technology funding has been received from the DOE Office of Science to take the leadership role in LBNL LiBeRACE experiments at the 88" cyclotron. The Isotopes Project has taken responsibility for detector maintenance and will be doing surrogate reaction cross section measurements in collaboration with LLNL. This has led to coordinated efforts with NIC at LLNL and the submission of a joint multi-University/National Laboratory proposal to NNSA with the Isotopes Project as LBNL Principal Investigator.

#### LLNL

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

1. NNSA/DP/ASC funds data evaluation, validation and verification efforts, development of ab-initio structure and reaction methods and development of theory supporting the surrogate measurement campaign for unstable actinides.
2. NNSA/DP/SC funds experimental campaigns for unstable actinides, including development of the Time Projection Chamber at LLNL for new <sup>239</sup>Pu fission cross section measurements.

3. NNSA/NA-22 and DHS fund experimental work on the structure of Pu and U, including the recent discovery of strong electromagnetic resonances in these nuclei and the development of methods of improved calculations of neutron-capture spectra.
4. DHS funds fission-multiplicity experiments and theory development.
5. Two separate SciDAC grants support (i) reaction theory development and (ii) nuclear astrophysics.
6. LDRD supports ab-initio reaction theory.

#### **McMaster**

The nuclear data project at McMaster receives 0.4 FTE support from the Canadian research agency NSERC to evaluate A-chains/nuclides for ENSDF and to train/supervise undergraduate students for compilation of experimental nuclear structure data for XUNDL and NSR keywording

#### **NIST**

A variety of sources support nuclear data activities:

1. The Nuclear Data Verification and Standardization program has funding through the Commerce Department (NIST). This provides about half of the total support for the program.
2. NIST provides 1 FTE for standard cross section work using ~4 meV neutrons and also for interferometry work, which has yielded coherent scattering lengths (which provide scattering data) needed for neutron cross-section evaluations.
3. NSF provided 1 FTE for a graduate student to work on the interferometry experiments cited above.
4. NIST provided 1 FTE (75% experimental, 25% evaluation) for nuclear structure and decay data work. Much of this work also has applications in radioactivity standards and radiopharmaceutical studies.

#### **ORNL**

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

#### **TUNL**

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