



## Annual Report for FY2010

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## I. Introduction

The USNDP Annual Report for FY2010 summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2009 through September 30, 2010 with respect to the work plan for FY2010 that was prepared in February 2008. 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 16.9 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.

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 FY2010. Then, we proceed with the detailed status of work done in FY2010.

Total staff assigned to USNDP activities during the year represented 21.35 FTE. In recent years there has been continuing loss of permanent scientific staff in the USNDP activities. This year, the FTE slightly decreased from 12.6 in 2009 to 12.5 in 2010. While the total FTE change was modest there was a considerable rearranging of the personnel accompanied by the reduction of the temporary scientific staff. The major factor limiting a consistent recovery of the program was lack of qualified candidates, especially in the reaction branch of nuclear data activities.

Fiscal year 2010 was the 11th 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.

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 FY2010 budget increased by 4.5%. On the average, during the last two years there has been an increase of the budget on the level slightly higher than inflation. In addition, 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. The metrics show that there was a recovery in the number of compilations, evaluations were essentially stable, although lower than in 2009, total number of publications was practically stable, and for the first time there was a decline in the number of Web retrievals, mostly due to the discontinuing of the LBNL Web site.

**Table 1:** Summary of the USNDP metrics in FY2001- FY2010, 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

In particular:

- 1. Compilations.** Compilations efforts, including NSR, CSISRS and XUNDL databases, remain on the similar level, a decrease in BNL's number of NSR compilations is due to staff change and training, it is expected that BNL's output in FY2010 will match traditional values. The coverage of the major journals was complete but there has been some delay in the compilation of conference proceedings in NSR.
- 2. Evaluations.** There is a modest 3% increase in the evaluations, compared to FY2008. We note that the top performance in evaluations, reached in FY05, was exceptional due to preparation of the ENDF/B-VII.0 library and evaluation of large number of super-heavy nuclides (63 nuclides, A = 266-294) for ENSDF.
- 3. Dissemination.** This indicator continues to increase also at a slower pace of about 10%. In FY2009 USNDP reached 3.3 million (3,294,000) data retrievals. At BNL, the most popular product continues to be NuDat that contributes almost 60% of data retrievals.
- 4. Reports.** Number of published reports, which has been approximately constant over the last three years, suffered a sharp drop: nearly by a factor of 2.
- 5. Papers.** Number of papers published in the refereed journals remained high, close to the record level of FY2008.
- 6. Invited Talks.** The number of invited talks decreased slightly compared to the FY2008 but remains the second best result ever.

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 FY2010, numbers for FY2009 are shown for comparison.

Laboratory	Compilations		Evaluations		Dissemination (in thousands)		Reports		Papers		Invited Talks	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
ANL	39	38	13	14	20	24	3	2	19	19	9	8
BNL <sup>1</sup>	2,500	3,023	151	158	2,325	2,355	4	7	8	13	6	8
LANL	-	-	45	64	300	300	3	2	13	12	14	14
LBNL	-	-	81	36	306	0	8	7	7	18	7	10
LLNL	-	-	5	10	8	8	2	2	3	3	4	4
ORNL	-	-	15	0	285	97	0	0	6	8	13	10
Universities <sup>2</sup>	1,508	1,601	90	113	50	59	6	7	5	10	3	7
<b>Total</b>	<b>4,047</b>	<b>4,662</b>	<b>400</b>	<b>395</b>	<b>3,294</b>	<b>2,843</b>	<b>26</b>	<b>27</b>	<b>61</b>	<b>83</b>	<b>56</b>	<b>61</b>

<sup>1</sup>: BNL compilations for FY2010 consist of 2185 NSR papers and 838 CSISRS reactions. BNL evaluations for FY2010 consist of 92 nuclides for ENSDF and 66 reactions for ENDF.

<sup>2</sup>: Universities compilations for FY2010 consist of 1,100 NSR papers (McMaster), 412 XUNDL datasets (McMaster), 24 Atomic mass articles (McMaster) and 65 XUNDL datasets (TUNL). Universities evaluations for FY2010 consist of 111 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 FY2010 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 2010 the DOE Office of Nuclear Physics conducted its annual Budget Briefing. Mike Herman, Richard Firestone, Toshihiko Kawano, F. Kondev, Balraj Singh, Alejandro Sonzogni and Neil Summers represented the USNDP and made the case for the FY2012 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 NNDC hosted the CSEWG annual meeting in November 2010. The major topic of the meeting was the performance of the ENDF/B-VII.0 library and outlining plans for the next ENDF/B-VII.1 release.

In June 2010 the NNDC organized the Summer Nuclear Data Week consisting of the mini-CSEWG meeting, covariance workshop.

### 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 FY2010 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 FY2010, retrievals from the USNDP databases as offered by the USNDP laboratories reached 2.843 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 MIRD 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** A total of 15 mass chain evaluations were published in Nuclear Data Sheets and one mass chain was published in Nuclear Physics. 30 additional mass chain evaluations are in various stages of review.

**XUNDL and Atomic Mass Compilations** XUNDL includes 3805 datasets for 1860 nuclides from 2543 journal articles published from 1995-2010. In FY2010 515 datasets from 260 publications were added to XUNDL. 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 Database (NSR)** The NSR database and its content is managed by B. Pritychenko, J. Totans, E. Betak (BNL), M.A. Kellett (IAEA) and B. Singh (McMaster University). The total number of new entries in FY10 was 3,920 compared to 2,714 in FY09. FY10 entries include 2,185 BNL entries, 635 IAEA entries and 1,100 McMaster entries. Recent accomplishments include the Web integration of NSR and EXFOR databases, as well as work with XSB, Inc. on Semantic Analysis of Nuclear Physics Publications and Automatic NSR Keyword Generation. The last project, which is still in its pilot stage, shows great promise for automation of NSR operations and reducing manual effort for PRC and NPA keyworded abstracts preparation.

### Other Activities:

- USNDP evaluators led in the IAEA Coordinated Research Project (CRP) "Reference Database for Neutron Activation Analysis" which was completed in 2010. An intercomparison of IUPAC Neutron Activation Analysis (NAA)  $k_0$  values and thermal neutron cross sections was performed with the intent of improving data for both the NAA and nuclear data communities.
- USNDP evaluators participated in the DDEP Workshop, CIEMAT, Madrid, Spain, June 2010.
- USNDP evaluators participated in the International Conference on Nuclear Data for Science and Technology, April 26-30, 2010, Jeju Island, Korea.
- USNDP evaluator-led environmental research discovered evidence of an extraterrestrial impact event, 12,900 years ago, that caused the extinction of the mammoths and triggered the Younger Dryas era of global cooling. The paper published in the Proceedings of the National Academy has received over 100 citations in recent literature and led to numerous documentaries and extensive media coverage.

## 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

LANSCE continued measurements of prompt fission neutron spectra with the Chi-Nu detectors. A parallel-plate avalanche counter (PPAC) developed at Lawrence Livermore National Laboratory demonstrated significantly better performance in timing and reduced neutron scattering. An array of  $^6\text{Li}$ -glass detectors measures fission neutrons below 1 MeV while liquid scintillators detect neutrons from 0.6 to above 12 MeV. These developments aim at providing essential information for resolving long-standing problems in the theories of fission neutron emissions. Neutron-induced  $\gamma$ -ray production cross sections were measured with GEANIE in the  $^{103}\text{Rh}(n,\gamma)$  reaction. For neutron capture measurement with DANCE, data analysis for  $^{89}\text{Y}$ , Gd and Mo isotopes was completed. Preliminary data for  $^{238}\text{U}$ ,  $^{242\text{m},243}\text{Am}(n,\gamma)$  were presented at the international nuclear data conference in 2010.

### Model Code Highlights

Several new features were added to the nuclear reaction calculation code EMPIRE. The updates include the Double Differential Hybrid Monte Carlo Simulation (DDHMS) preequilibrium model with exclusive spectra, KERCEN code for estimating covariances in the resonance region, modifications to accommodate primary gamma-rays from EGAF, and new fission parameterizations.

LLNL and LANL continue developing prompt fission neutron spectrum modeling codes for better prediction and uncertainty quantification of evaluated spectra. The FREYA simulation of  $^{239}\text{Pu}(n,f)$  at LLNL was extended into the higher energy region, where multi-chance fission and preequilibrium emission need to be included. A statistical method was applied to obtain fit parameters needed for the evaluation of the prompt fission neutron spectrum, also yielding covariances between the outgoing neutron energies.

Recent fission modeling development at LANL is based on the R-matrix approach, including nuclear structure studies of the potential energy surface calculations at LANL and/or more microscopic theories. The coupling between class-I and class-II states is explicitly taken into account. A code written in Fortran95, which is an updated version of AVXSF, applied to Pu isotopes.

The CGM code at LANL, which calculates the  $\gamma$ -ray cascade in compound nucleus decay, was extended to include multiple-neutron emission competition. CGM code was utilized for evaluating  $\beta$ -delayed neutron and  $\gamma$  emission spectra. The calculated energy spectra were applied to the decay heat calculations, and preliminary results were presented at two international conferences in 2010.

## **Nuclear Standards Highlights**

A comprehensive paper was published in Nuclear Data Sheets that documents in detail the activities that led to the international evaluation of the neutron cross section standards.

The Ohio U., NIST, LANL and the U. of Guelma collaboration produced two Phys. Rev. publications on measurements of the H(n,n)H angular distribution. These included measurements of the angular distribution at 14.9 MeV and improvements to previous work at 10 MeV. A new experiment has been initiated that will allow smaller CMS angles to be measured. The hydrogen standard is considered a primary cross section standard since so many standards are measured relative to it.

LANL provided an important addition to the hydrogen standard with covariance data for the hydrogen elastic cross section that will be included in ENDF/B-VII.1.

Improvements to the standards database were provided with measurements of the  $^{239}\text{Pu}(n,f)$  and  $^{238}\text{U}(n,\gamma)$  cross sections at LANL. Though these cross sections are not standards, they are used in the standards evaluation since ratio data of them to the standards are in the database.

## **Nuclear Astrophysics Highlights**

In FY10, there were a number of interesting nuclear data projects that have direct relevance for astrophysics. At ANL, C. Nair and F. Kondev measured the electron capture - delayed fission of  $^{180}\text{Tl}$ . The motivation was to improve our understanding of beta-delayed fission of heavy neutron-rich nuclei that play a role in the rapid neutron capture process (r-process) that occurs in supernovae. They used an available heavy proton-rich nucleus to develop their technique of recoil-decay tagging with Gammasphere and the FMA. Data analysis for this work is still in progress, and it is hoped that this technique can be applied at radioactive beam facilities to directly measure the beta-delayed fission yields in r-process nuclei. At LANL, P. Moeller combined potential energy surfaces from a 2001 study with a new 5-dimensional dynamical model from J. Randrup to get new potential surfaces for heavy nuclei; they will use these to calculate new sets of theoretical fission yields for thousands of heavy nuclei from the line of beta stability to the r-process nuclei.

At BNL, B. Pritychenko made the first global determination of uncertainties for neutron capture reaction rates in the slow neutron capture process (s-process). This work, important for red giant stars, utilized low-fidelity covariances that have been calculated by USNDP members to get the capture reaction uncertainties. These uncertainties can be used in future Monte Carlo studies of heavy element creation in red giant stars.

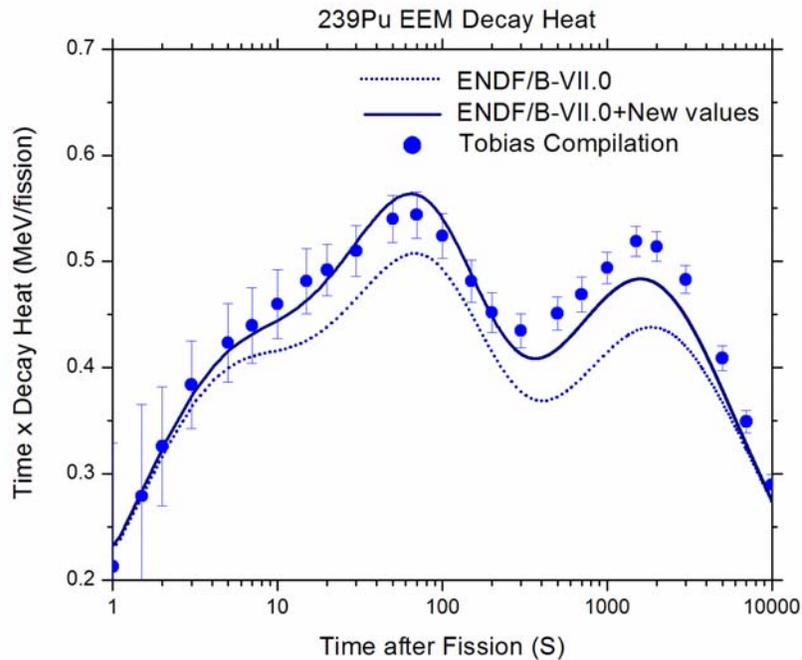
At ORNL's Holifield Radioactive Ion Beam Facility, a measurement of the  $^{132}\text{Sn}(d,p)^{133}\text{Sn}$  by K. Jones et al. with radioactive  $^{132}\text{Sn}$  beam was made to examine the nature of low-lying levels in  $^{133}\text{Sn}$ . Through data analysis and subsequent evaluation, it was found that these levels have a "pure" single particle nature, confirming the magicity of the unstable  $^{132}\text{Sn}$  nucleus. This shows that the shell model, built in the 1950s with stable nuclei as a guide, is still valid for a heavy unstable nucleus, and shows that  $^{132}\text{Sn}$  is one of only 10 doubly - magic nuclei known. It also shows that the hypothesized suppression of shell gaps in unstable nuclei does not occur in this case. The result, published in Nature, will furthermore be used for new neutron capture calculations -- important for the r-process in supernovae - and as basis to extrapolate nuclear structure models to nuclei farther from stability. Also at HRIBF, the structure of levels in  $^{26}\text{Si}$  above the  $^{25}\text{Al} + p$  threshold was evaluated after a new measurement by K. Chipps et al. of  $^{28}\text{Si}(p,t)^{26}\text{Si}^*$  and the subsequent detection of the proton decay of  $^{26}\text{Si}^*$  into  $^{25}\text{Al} + p$ . This was the first such proton-decay measurement, giving direct determination of one  $^{26}\text{Si}$  level that is a zero angular momentum transfer in  $^{25}\text{Al} + p$  - which, therefore, likely dominates the thermonuclear  $^{25}\text{Al} + p$  capture reaction rate in nova explosions.

The  $^{25}\text{Al}+p$  reaction was also examined at McMaster Univ. by K. Setoodehnia, A. Chen, and J. Chen, along with the  $^{23}\text{Mg} + p$  and  $^{29}\text{P} + p$  capture reactions. These three reactions, each with significant uncertainties and few if any direct measurements, were examined via combining the results from numerous indirect rate determinations made at different labs. Specifically, indirect studies at Tsukuba, RIKEN, and NSCL [for  $^{25}\text{Al}(p,\gamma)^{26}\text{Si}$ ] were examined, along with a direct measurement at TRIUMF ISAC of  $^{23}\text{Mg}(p,\gamma)^{24}\text{Al}$  and indirect studies at Yale [for  $^{29}\text{P}(p,\gamma)^{30}\text{S}$ ]. Further updates expected for  $^{29}\text{P}(p,\gamma)^{30}\text{S}$  based on finalizing ( $^3\text{He},n\gamma$ ) experiment at Tsukuba. 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 100 institutions in 26 countries] to process their nuclear data into astrophysical simulations, run the simulations, and visualize and analyze the results. New features include an automation of reaction rate sensitivity studies, a new file manager system for managing simulation files, and a tool [Data Harvester] to automatically collect information on a nucleus from a number of international databases with just a few clicks.

## V. Additional Accomplishments

An article by Algora *et al.* was recently published in Physical Review Letters. This work reports newly measured values of average gamma and beta energies for seven neutron rich nuclides. The measurements were performed in CERN and Jyväskylä (Finland), funded by European nations. When used in **decay heat calculations**, these values of average energy improve considerably the agreement with data for  $^{239}\text{Pu}$ , as can be seen in the figure below.



The input for these calculations are fission fragment yields (from ENDF-6 formatted libraries), as well as half-lives, branching ratios and average energy values (often obtained from ENSDF). This is a very exciting field where USNDP members have and will make a considerable contribution.

The December 2009 issue of Nuclear Data Sheets contains two nuclear reaction articles:

1) **RIPL – Reference Input Parameter Library for Calculation of Nuclear Reactions and Nuclear Data Evaluations**

*R. Capote, M. Herman, P. Oblozinsky, P.G. Young, S. Goriely, T. Belgia, A.V. Ignatyuk, A.J. Koning, S. Hilaire, V.A. Plujko, M. Avrigeanu, O. Bersillon, M.B. Chadwick, T. Fukahori, Zhigang Ge, Yinlu Han, S. Kailas, J. Kopecky, V.M. Maslov, G. Reffo, M. Sin, E.Sh. Soukhovitskii and P. Talou.*

2) **International Evaluation of Neutron Cross Section Standards** *A.D. Carlson, V.G. Pronyaev, D.L. Smith, N.M. Larson, Zhenpeng Chen, G.M. Hale, F.-J. Hamsch, E.V. Gai, Soo-Youl Oh, S.A. Badikov, T. Kawano, H.M. Hofmann, H. Vonach, S. Tagesen.*

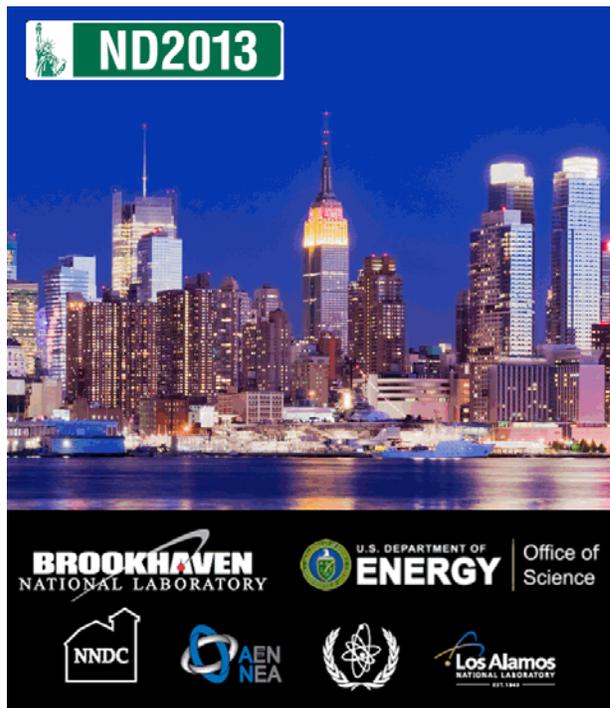
Both articles report on multiyear efforts that received considerable USNDP input. RIPL is of great relevance in cross section calculations, while the cross sections standards are crucial in cross section measurements.

Finally, the NNDC will organize **2013 International Conference on Nuclear Data for Science and Technology** which will take place in New York City on March 4-8 2013.

The purpose of ND2013 is to bring together scientists and engineers involved in the production and use of nuclear data for various applications. About 400 to 500 people are expected to attend this conference. The proceedings are likely to be published in Nuclear Data Sheets.

The topics will include:

- Nuclear reaction, structure and decay data,
- Experimental facilities and detection techniques,
- Nuclear data measurements and analysis,
- Nuclear theories, models and data evaluation,
- Uncertainty quantification and covariances,
- Evaluated nuclear data libraries,
- Nuclear data processing,
- Nuclear data adjustment,
- Validation of evaluated data,
- Integral experiments,
- Cross section and decay standards,
- Data dissemination and international collaboration,
- Nuclear Fission (75th anniversary),
- Nuclear data for reactors,
- Nuclear decay heat,
- Dosimetry and shielding,
- Safeguards and security,
- Criticality safety,
- Homeland security and safety,
- Accelerator related applications,
- Fusion technology,
- Space, cosmic-rays, radiation effects on electronics,
- Astrophysics and cosmology,
- Medical and environmental applications,
- Nuclear physics education.



## USNDP Staffing table FY2010

	ANL			BNL			LANL	LBL	LLNL	MCMAS	NIST			ORNL			TUNL			Sum			
	PhD P	PhD T	GS	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	GS	PhD P	PhD T		T/A		
<b>I. NNDC Facility Operation</b>	0.00	0.00	0.00	0.60	0.00	1.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.85
Management				0.60																			0.60
Secretarial																							
Administrative Support						0.75																	0.75
Library						0.10																	0.10
Computer Operations						0.40																	0.40
<b>II. Coordination</b>	0.10	0.00	0.00	0.20	0.00	0.00	0.40	0.25	0.21	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.21
National Coordination				0.15			0.10	0.15	0.21					0.05									0.66
International Coordination	0.10			0.05			0.30	0.10															0.55
<b>III. Nuclear Physics Databases</b>	0.00	0.00	0.00	1.30	0.20	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.55
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				0.15																			0.15
Database Software Maintenance				0.30		0.30																	0.60
Future Database System Develop.				0.15	0.20																		0.35
<b>IV. Information Dissemination</b>	0.00	0.00	0.00	0.70	0.00	1.20	0.05	0.05	0.00	0.00	0.00	0.00	0.00	0.00	0.70	0.00	0.00	0.00	0.00	0.00	0.00	0.60	3.30
Nuclear Data Sheets				0.25		0.90																	1.15
Customer Services				0.15		0.30																	0.45
Web Maintenance & Development				0.30			0.05	0.05						0.70								0.60	1.70
	ANL			BNL			LANL	LBL	LLNL	MCMAS	NIST			ORNL			TUNL						
	PhD P	PhD T	GS	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	GS	PhD P	PhD T	T/A	Sum		
<b>V. Nuclear Structure Physics</b>	0.85	0.00	0.00	1.40	1.60	0.00	0.10	1.50	0.00	0.60	0.80	0.00	0.00	0.00	0.20	0.15	0.00	0.86	0.48	0.15		8.69	
NSR Abstract Preparation				0.10	0.20					0.10												0.40	
Compilation of Exper. Structure Data	0.10									0.20									0.10			0.40	
Eval. of Masses & Nuclides for ENSDF	0.50			1.05	1.40			0.80		0.30	0.80			0.20	0.15			0.33	0.19	0.15		5.87	
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							0.10											0.43	0.29			0.82	
Nuclear Structure Data Measurement	0.10							0.20														0.30	
ENSDF Evaluation Support Codes				0.15																		0.15	
<b>VI. Nuclear Reaction Physics</b>	0.05	0.00	0.00	0.75	0.85	0.20	1.05	0.20	0.10	0.00	0.20	0.10	0.10	0.00	0.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.75
Experimental Data Compilation				0.40																		0.40	
Neutron Data																						0.00	
Charged Particle Data																						0.00	
Photonuclear Data																						0.00	
ENDF Manuals and Documentation				0.05	0.05																	0.10	
ENDF Evaluations				0.55	0.20	0.20	0.25		0.10													1.30	
Nuclear Reaction Standards							0.10					0.10	0.10									0.30	
Nuclear Model Development				0.05	0.20		0.40															0.65	
Nucl. Reaction Data Measurements							0.10	0.20														0.30	
Astrophysics Nuclear Data Needs	0.05			0.10			0.20				0.20			0.15								0.70	
DOE-SC Nucl. Data Funded Staff	1.00	0.00	0.00	4.95	2.65	3.70	1.60	2.00	0.31	0.60	1.00	0.10	0.10	0.00	1.10	0.15	0.00	0.86	0.48	0.75		21.35	
Staff Supported by Other Funds	0.00	2.00	0.50	2.68	0.70	0.00	12.00	1.30	5.00	0.40	0.00	2.50	0.00	1.00	0.60	0.00	1.00	0.00	0.00	0.00	0.00	29.68	
<b>TOTAL STAFF</b>	1.00	2.00	0.50	7.63	3.35	3.70	13.60	3.30	5.31	1.00	1.00	2.60	0.10	1.00	1.70	0.15	1.00	0.86	0.48	0.75		51.03	

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

# Detailed Status of the Work Plan Fiscal Year 2010 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 their 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
Regularly scan and remediate vulnerabilities on NNDC servers and clients to ensure compliance with DOE cyber security requirements	Continuing.
Provide computer support to the NNDC staff and its visitors as necessary.	Continuing. This year, the NNDC Conference Room was renovated, and a new projector and a new presentation workstation were installed.
Maintain the NNDC computer system, including database servers and web servers.	Continuing. This year, computer systems running on MS Windows 2000, namely the aging Windows print/file server and the Windows backup server, were decommissioned and replaced with new hardware and new MS Windows operating system. This is to comply with DOE cyber security requirements, and to significantly improve NNDC's printing, file serving and system recovery capabilities.

## II. Coordination

### A. National Coordination

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

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

ANL Planned Activities	Status
Organize and chair the CSEWG Covariance Committee.	Completed

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 FY2011 work plan for USNDP in time for spring 2010 FWP submittals.	FY2011 work plan for USNDP was prepared in February 2010.
Organize mini-CSEWG meeting, in spring 2010, devoted to preparations of ENDF/B-VII.1 library release.	A mini CSEWG meeting took place in Port Jefferson, NY, in June 2010.
Organize and chair CSEWG Meeting at BNL in November 2009.	Continuing. CSEWG meeting took place in BNL in November 2009.
Organize and chair USNDP Meeting at BNL in November 2009.	Continuing. USNDP Meeting was held adjacent to CSEWG Meeting
Edit and publish electronic summary reports of the CSEWG and USNDP meetings.	Continuing
Edit and publish electronic USNDP Annual Report for FY2009.	Continuing. This year, a software package was developed to performed this task remotely.

Maintain CSEWG and USNDP websites.	Continuing
<b>LANL planned activities</b>	<b>Status</b>
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2009.	Organized and chaired Evaluation Committee meeting at the November 2009 CSEWG meeting.
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2009, and help coordinate Homeland Security, and Astrophysics Task Forces.	Organized and chaired Nuclear Reaction Working Group meeting at the November 2009 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>LBNL planned activities</b>	<b>Status</b>
Plan coordinated LBNL/LLNL efforts to develop a Capture Gamma-ray library for ENDF.	Continuing
Serve on the USNDP Coordinating Committee and chair the NSDD Working Group Meeting at the FY2010 USNDP Meeting in November 2009.	Completed

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.	Continuing.

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

<b>ORNL planned activities</b>	<b>Status</b>
Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting in November 2009.	USNDP efforts in nuclear data for nuclear astrophysics summarized in an oral presentation at the USNDP meeting in November 2009
Communicate current efforts and future plans with researchers in nuclear astrophysics data.	Current efforts and future work in nuclear astrophysics data were communicated to researchers in the field, and to those who may join our field, via invited presentations at CIAE [CHINA], OMEG2010 / RCNP Osaka Univ. [Japan], ND2010 [Korea], Ewha Univ. [Korea], Seoul National University [Korea], Liaoning Normal Univ. [CHINA], and Beihang Univ. [CHINA], and via numerous contributed talks and scientific discussions at institutions in the US and abroad
Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data.	Discussed ongoing USNDP efforts in nuclear astrophysics with researchers at RIKEN [Japan], Liaoning Normal University [PR China], and Beihang Univ. [PR China]
Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.	Met with researchers at RIKEN concerning a proposal to improve determinations of beta decays of nuclei far from stability needed for nuclear astrophysics simulations [a possible ORNL / ANL / RIKEN collaboration], and with researchers at Liaoning Normal University [PR China] and Beihang Univ. [PR China] about possible future collaborations in nuclear astrophysics data
Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, with JUSTIPEN (for collaborations with Japan), and with other agencies and organizations.	Introduced the concept of "Cloud Computing in Nuclear Data" at the ND2010 conference

## 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 2010 DDEP meeting.	Completed
Provide a lecturer at the IAEA/ICTP organized nuclear structure data workshop.	A lecturer from ANL was not requested

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.

<b>BNL planned activities</b>	<b>Status</b>
Participate in the IAEA-sponsored NRDC meeting in 2010.	Completed.
Participate in NEA WPEC annual meeting in 2010.	Completed

Attend major ND2010 conference in April 2010, in Korea.	Completed, four staff members attended the meeting, presenting xx oral presentations and yy posters. Additionally, NNDC members were part of the reviewing committee.
Provide lecturer to the IAEA/ICTP workshop on nuclear reaction data (if organized).	The workshop has been organized but, this time, it was TALYS code rather than EMPIRE oriented, therefore participation of the NNDC lecturer was not needed.
Coordinate development of the EMPIRE nuclear reaction model code and make it available to the international community.	
<b>Unplanned activity</b> Attend DDEP meeting	Two NNDC personnel attended the DDEP meeting in Madrid, Spain, May 2010.
<b>Unplanned activity</b> Organization of ND2013 meeting	The NNDC will organize the ND2013 meeting. Venues were searched for, budgets were generated. Conference received BNL and DoE approval. Contract with the venue was signed.

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 2010 meeting.	One LANL participant participated in the WPEC meeting in Paris.
Participate in relevant IAEA CRP meetings (FENDL).	Two LANL participants participated in the IAEA meetings (FENDL and fission neutron spectrum).
Participate in the International Conference on Nuclear Data for Science and Technology (ND2010) - April 26-30, 2010 in Jeju, Korea.	There were 8 scientists from LANL at the ND2010 conference. Note that not everybody supported by USNDP.
Participate in the International Advisory Committee to help organizing Second International Workshop on Compound Nuclear Reaction and Related Topics (CNR*09), October 5-8 2009 in Bordeaux, France.	Four scientists from LANL participated in the CNR*09 conference. Three of them served the international advisory committee members.
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.	Due to several international conferences in this FY, we have made cooperative meetings outside the laboratory. This year we hosted one visitor, a professor from Bordeaux university.

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 final report of the IAEA CRP on a Database for Neutron Activation Analysis.	Completed and submitted to Mark Kellett, IAEA for final processing.
Manage the EGAF database.	Continuing activity.
Lead new $\sigma_0$ and $\sigma_\gamma$ measurements at the Budapest Reactor.	New measurements were performed on Na, K, Eu, Gd, and W isotopes.
Edit new DDEP evaluations.	Continuing activity.

McMaster: Continue participation in new evaluators training program.

McMasters planned activities	Status
Participate in the evaluation policy matters related to the NSDD network.	Policy on inclusion of charged-particle resonance data and neutron resonance data formulated. Final version presented at USNDP-10 meeting, will also be presented at NSDD-11 meeting for approval by the ENSDF network.
Participate in training/mentoring of new ENSDF evaluators through collaborative work, especially with the new emphasis on the participation of prospective ENSDF evaluators from Europe.	Visits of following scientists were hosted: Alan Nichols(Surrey,UK); K. Zuber (Krakow,Poland); J. Timar (Debrecen, Hungary), K. Abu Saleem (Jordan), P.K. Joshi (TIFR, India). Locally Dr. Jun Chen, working as post-doctoral fellow received the training

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

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

### III. Nuclear Physics Databases

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

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

## Structure Physics.

BNL planned activities	Status
Database distributed to collaborators monthly.	NSR database and its content is managed by B. Pritychenko, J. Totans, E. Betak (BNL), M.A. Kellett (IAEA) and B. Singh (McMaster University). The total number of new entries in FY10 was 3,818 compare to 2,714 in FY09. FY10 entries include 2,185 BNL entries, 635 IAEA entries and 998 McMaster entries. Recent accomplishments include Web integration of NSR and EXFOR databases and work with XSB, Inc. on Semantic Analysis of Nuclear Physics Publications and Automatic NSR Keyword Generation. This project shows a great promise for automation of NSR operations and reducing manual effort. Completed, updates were distributed to NDS,IAEA and LBNL.

## 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
Update database as input is received from McMaster.	Updates done as received, about once a week. Database distributed twice during the FY.

## 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.	Completed
Process evaluations received from NSDD evaluators.	Completed

## 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 (150 compiled papers expected).	All reaction data compiled by the NNDC and introduced into the CSISRS database are automatically included in CINDA.

## 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.	The CSISRS database was regularly updated.

## 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 the ENDF/A web interface.

BNL planned activities	Status
Maintain ENDF discussion list to facilitate validation of the new ENDF/B-VII.0 library.	The ENDF discussion list was migrated to the GForge collaboration environment. Nuclear data community members subscribed to the list automatically received e-mails on every new posting in the list.
Establish and maintain cooperative development site (GForge) for collecting and maintaining new evaluations submitted for future release of the ENDF/B-VII.1 library.	Began hosting the ENDF/B-VII.1 library on the newly installed and operated GForge server. New evaluations have been collected and maintained using Subversion versioning system under GForge.
Perform phase1 testing of all new evaluations for the ENDF/B-VII.1 library.	Performed phase1 testing on ENDF/B-VII.1 Beta0 by processing it using the NNDC Utility Codes (CHECKR, FIZCON, PSYCHE) and NJOY99.347. Presented results in CSEWG Annual Meeting, Santa Fe, NM, Nov. 1-5, 2010.

## 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/SYBASE environment was completed in FY2004. 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 astrophysics. 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/Sybase database system.	Completed.
Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).	Completed. See sections III.g and IV.a.

## 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 2.8 GHz dual-processor Dell servers running on the Linux operating system and using the Apache Tomcat and Sybase server software. This solution was made public in April 2004 and has proved to be secure, fast and to have minimum downtime. Most of the databases were redeveloped to take advantage of the new hardware possibilities as well as new programming technologies, such as the use of the Java and Java scripts languages. In FY 2005 this system was upgraded from a single web server to dual web server system. This upgrade significantly increases reliability of the system. 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.	The web site was maintained and periodically upgraded
Maintain and upgrade Experimental Resources for Nuclear Data web site.	The web site was maintained and periodically upgraded
Maintain and upgrade ANL Nuclear Data Information web site.	The web site was maintained and periodically upgraded

BNL Planned Activities	Status
Improve NSR and ENSDF web interfaces.	NSR Web interface upgrades addressed FRIB user requests.
Maintain web interface to the ENDF database.	ENDF Web interface was improved.

Implement and maintain GForge Web-based collaborative development server for collecting, storing, versioning and distributing ENDF/B-VII.1 candidate evaluations.	Installed and operated GForge server for collaboration work on: 1) development of the ENDF/B-VII.1 library and the ENDF-6 manual, 2) development of the AFCI covariance library, 3) ENSDF mass chain evaluations, 4) development of ENSDF analysis codes and NSR Web-based applications, and 5) the development of the EMPIRE nuclear data processing system.
Improve Sigma web interface by adding new and extended features following user's requests.	JENDL 4 and CENDL 3.1 were added to Sigma, mathematical operations were upgraded, and a QA system for AFCI covariances was developed.
Maintain web interface for double-beta decay.	Completed.
Improve reliability and cyber security of the NNDC web services by installing the latest version of Apache/Tomcat servers and mod-jk connector software for a new dual web server system.	Completed.
Maintain currency of the CSEWG, USNDP and the NNDC web sites.	Completed.

LANL Planned Activities	Status
Include access to new reaction and structure data evaluations, supported by DOE/Nuclear Physics, via the T-2web site.	T-2 web site provided access to new reaction and structure data evaluations.
Provide actinide ENDF/B-VII data via LANL web site for criticality data testing, together with other LANL evaluations (e.g., light nuclei reactions).	Although the new actinide and light element evaluations are available inside the LANL, we migrated the updated evaluations to BNL web service for better communication with other nuclear data communities.

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 extensions performed.
Maintain and upgrade LLNL's Computational Nuclear Physics web pages.	Web pages maintained.

LBNL planned activities	Status
Maintain Isotopes Project existing web pages and begin search for a new site in anticipation of shut down of LBNL web services by FY2012.	In response to numerous user complaints the Isotopes Project will continue to maintain its websites but updating has been suspended due to lack of manpower.

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, utilized by researchers in over 70 institutions in 20 countries, is at risk of termination.	The Computational Infrastructure for Nuclear Astrophysics, online at nucasrodata.org, is serving nuclear data for astrophysics research to users in 100 institutions in 26 countries. New features this year include a Data Harvester, when information can be obtained from a number of major international databases with just one click. Also new are tools to enable investigations of the importance of nuclear data in astrophysics simulation predictions, by automating sensitivity studies

TUNL Planned Activities	Status
Continue to improve the TUNL website and provide access to new information on A = 3 - 20 nuclei.	Continuing.
Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.	"Energy Levels of Light Nuclei, A = 3" was published on Nuclear Physics A 848 (2010) 1 on December, 2010. The links of PDF and HTML documents corresponding to this publication have been added on the TUNL web page
Continue to provide PDF and HTML documents for FAS reviews for the A = 3 - 20 series.	PDF and HTML files are online for Fay Ajzenberg-Selove and TUNL reviews for 1959-present. We continue to correct typographical errors found in the text of the original publications, and we continue to update references to the NSR keynumbers.
Continue to provide General Tables to accompany the most recent TUNL reviews of the A = 3 - 20 series.	This activity is not continuing. The NNDC/NSR search abilities are more than adequate for users to find references of interest.
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.	Energy Level Diagrams are online for Fay Ajzenberg-Selove and TUNL reviews for 1959-present.
Develop web page to provide compiled and evaluated data on particle decay of unstable ground states.	The interface is present on the TUNL pages, and the pages are updated at least once a year.

## B. Customer Services

This task accounts for the non-electronic services which the USNDP renders to customers. At the scientific staff level, this means direct assistance to users needing advice from nuclear data experts or advice on solving complex queries via electronic access to the database. The NNDC staff allocation at the support level is for maintaining a "help desk" and for administrative/clerical support of its customer services.

BNL Planned Activities	Status
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Effort required to provide technical support to users as necessary.	All reasonable user queries were addressed and adequate support was provided.
Maintain Comments/Questions option for all reaction databases, for the NNDC web service 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.	Completed
Prepare special issue of Nuclear Data Sheets on neutron reaction data, with two extensive papers, on the Reference Input Parameter Library and on Neutron Cross Section Standards.	The December 2009 special issue was published which included the RIPL and Standards article.

McMaster Planned Activities	Status
Develop software for Nuclear Data Sheets publication	Ongoing effort.

## 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 3,500 new references, and keyword abstracts for 1,800 of them.	3,818 new references were added to NSR and 2,331 keyworded. NNDC contribution was: 2,185 new entries, 1,511 keywords and 101 modifications.
Perform QA including checking and editing of approximately 300 key-worded abstracts for three European journals prepared at the IAEA Nuclear Data Section.	Completed.
Perform QA including checking and editing of key-worded abstracts from other collaborators as applicable and necessary.	Completed.

McMaster Planned Activities	Status
Prepare key-wording of publications in Phys. Rev. C, approximately 1,000 references a year. Draft versions will be prepared by undergraduate students working under supervision of B. Singh.	1100 articles in PRC were processed for NSR; keywords were supplied for 650 articles.

### 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.	Compiled and reviewed 38 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 BE(2) experimental data.	24 nuclei were compiled. New evaluation of Cr, Fe, Ni and Zn isotopes, in collaboration with McMaster and Central Michigan Universities, that includes 14 new B(E2) values has been produced.
Compile new 2b-decay experimental data.	12 nuclei and 30 decay modes were compiled.
Maintain, update and distribute XUNDL.	Completed

McMaster Planned Activities	Status
Compile data sets (in ENSDF format) for current experimental nuclear structure publication. The websites of prominent journals in nuclear physics will be scanned regularly for new papers.	372 new datasets were compiled. 40 datasets were updated for new papers and/or new data.
Compile recent papers on measurement of atomic masses and send compilation to online service at <a href="http://www.nuclearmasses.org">www.nuclearmasses.org</a> .	140 data points compiled from 24 papers and submitted to <a href="http://nuclearmasses.org">nuclearmasses.org</a> webpage at ORNL

Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database.	111 datasets from other centers were reviewed.
Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data. On a timely basis send a copy of all such private communications to NNDC for archival and distribution purposes.	About 40 communications with the authors of the original authors. In two cases, data details were submitted by the authors for inclusion in XUNDL database.
Train a new undergraduate student for XUNDL compilation work.	Jeremie Choquette joined in March 2010, is receiving training in XUNDL, NSR and mass compilations.
BE2 for first 2+ states in even-even nuclides of Cr, Fe, Ni and Zn isotopes.	The data for 24 nuclides were compiled, evaluation procedure established, and a master table prepared for all these nuclides.

TUNL Planned Activities	Status
Compile XUNDL data for A=2-20	Sixty-five data sets were compile in FY2010.

### 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 1 mass chain.	Evaluation of A=207 mass chain was completed and submitted to NNDC for a review
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 and 207), University of Jyvaskyla, Finland (A=188), China Nuclear Data Center, China (A=174), VECC, India (A=209), St. Petersburg, Russia (A=133) and Australian National University, Australia (A=174)

BNL Planned Activities	Status
At least 6 equivalent mass chains will be evaluated.	92 nuclides in 8 mass chains evaluated.
At least 6 mass chains will be reviewed.	8 mass chains reviewed
Continue mentoring new ENSDF evaluators.	Continued mentoring.

LBNL Planned Activities	Status
Evaluate the equivalent of at least 3 mass chains and several additional isotopes of particular interest to current research.	3 mass chains, A=30, A=168, and A=-184 were published in FY2010.
Evaluate ENSDF format neutron capture gamma-ray datasets as part of the EGAF effort.	Data for Z=1-19, Eu, Gd, and W isotopes were evaluated.
Mentor new efforts in nuclear structure evaluation proposed at LLNL.	The Isotopes Project continues to mentor LLNL efforts to evaluate capture gamma ray data. Renewed funding was received by LLNL from NNSA for this effort.
Review Nuclear Data Sheets publications.	Two mass chains were reviewed in FY2010.

McMaster Planned Activities	Status
3.5 equivalent mass chains (including the A=31-44 region and the data for new nuclides as mentioned below) will be evaluated.	A=33, 35, 36, 37, 61, 129 (total of 58 nuclides; note that A=36 and 37 were shared with Ninel Nica, thus only half the number of nuclides is counted).
Mass chains will be reviewed as requested.	One full length mass chain was reviewed
Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides.	53 nuclides in this category were evaluated and included in ENSDF database.
Train a new evaluator at McMaster for ENSDF evaluations, who will join as post-doctoral fellow in summer 2009.	Dr. Jun Chen, who started in July 2009 received training during the 2009-2010 year.

ORNL Planned Activities	Status
Complete evaluation of structure information for one mass in A=241-249 region.	A=152 evaluation in progress, A=69 evaluation in progress, A=121 follow up on review
Review one mass chain evaluation.	A=125 mass chain reviewed

TUNL Planned Activities	Status
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Prepare the ENSDF files corresponding to new publications in the “Energy Levels of Light Nuclei” series.	We are now updating the ENSDF files in tandem with the Nuclear Physics A articles in order to provide a clear description of the data sources and procedure for deducing best values. The ENSDF file corresponding to the published A=3 review will be added to the data base in early 2011, and the ENSDF file for a review of A=11 nuclei is essentially complete and will be added to the data base after submission of the manuscript for publication in Nuclear Physics in early spring.
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## D. Ground and Metastable State Properties

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

BNL Planned Activities	Status
Update database as new information becomes available.	Continued updating Nuclear Wallet Cards file.

## 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.

ANL Planned Activities	Status
Evaluation of two radionuclides will be carried out as a part of the ANL contribution to the IAEA CRP on “Updated Decay Data Library for Actinides” and the DDEP collaboration.	Completed evaluation of $^{207}\text{Tl}$ and $^{215}\text{Bi}$ radionuclides
Reviews of selected nuclides will be carried out, if requested.	Since June 2010, ANL coordinates the DDEP evaluations review process, with 25 radionuclides currently into the system

McMaster Planned Activities	Status
Evaluate or review decay datasets for one or two radionuclides.	One nuclide (decay of $^{182}\text{Ta}$ ) was reviewed in two stages.

## 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.

LBNL Planned Activities	Status
Maintain and develop the Evaluated Gamma-ray Activation File (EGAF).	Evaluation efforts continue with completion of activation data and improved evaluations of data for Z=1-19, Eu, Gd, and W.
Complete the IAEA/LBNL comparison of $\sigma_0$ values derived from k0 measurements of the NAA community, $\sigma_a$ measurements at the Budapest Reactor, and s0 values compiled in the CSISRS database and evaluated by S. Mughabghab in the Atlas of Neutron Resonances (Elsevier, 2006). Recommended $\sigma_0$ values will be included in EGAF.	Comparison completed and submitted to the IAEA.
Extend the EGAF file to include experimental $\sigma_a$ data for fast and high-energy neutrons.	Development of methods of analysis continuing in collaboration with LLNL.
Develop procedures to include continuum gamma ray data in EGAF.	Development of methods of analysis continuing in collaboration with LLNL.
Measure $\sigma_a$ cross sections at the Budapest Reactor.	Measurements done for Na, K, Eu, Gd, and W isotopic targets.

LLNL Planned Activities	Status
Continue LBNL/LLNL collaboration developing EGAF: Continue to develop toolset to automate the evaluation of EGAF experimental data using statistical model calculations. Working with LBNL, develop rigorous methods to evaluate the data and build them into toolset.	Continued to develop toolset for evaluating EGAF data in collaboration with LBNL.

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

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

TUNL Planned Activities	Status
Prepare “Energy Levels of Light Nuclei, A = 11 - 13” manuscript for publication in <i>Nuclear Physics A</i> .	The preliminary draft of the A=11 review is essentially completed; it is expected to be ready for submission to Nuclear Physics in Early Spring 2011. The review of literature for A=12 and A=13 nuclei is continuing; manuscripts for each of these mass chains will be published separately.

## 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.

ANL Planned Activities	Status
Participate in nuclear structure research activities at ANL with main emphasis on decay studies of neutron-rich fission products of relevance to reactor decay heat and astrophysics applications, and spectroscopy of heavy actinide nuclei.	Participated in nuclear structure research activities at ANL with main contributions in studying decay properties of $^{177}\text{Lu}$ , $^{180}\text{Tl}$ and $^{175}\text{Pt}$ , and in spectroscopy investigations of heavy actinide nuclides
Complete analyses of $^{243}\text{Cm}$ and $^{237}\text{Np}$ decay data and publish the results.	Analysis of $^{237}\text{Np}$ data is complete, and an article was submitted for publication in Nuclear Instruments and Methods. The analysis of $^{243}\text{Cm}$ data is continuing

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

LANL Planned Activities	Status
Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on Iridium isotopes to search for previously unobserved transitions in these nuclides	Data taken at GEANIE have been analyzed for spectroscopy of iridium isotopes populated by (n,n') and (n,2n) reactions. The data are being analyzed further for cross sections.
Interact with mass chain evaluators on the nuclear structure of these nuclei.	Interaction with the evaluators for these nuclei continues.

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

LBNL Planned Activities	Status
Publication of new $\sigma_{0}$ values for isotopes with $Z < 20$ and selected heavier isotopes.	Papers are in preparation for publication of these data. Preliminary data presented at APSORC09 Conference in Napa, CA are accepted for publication in Radiochimica Acta. (in press).
Investigation of systematic half-life discrepancies.	Proposal for support of this research has been submitted to FQXi Foundation.

## 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.	Continued maintenance of ENSDF analysis codes.

## 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 from 150 charged particle and neutron reaction publications.	Compiled were experimental reaction data from 126 articles, published mainly in regular journals and conference proceedings. Included in EXFOR database were 131 entries (55 neutrons, 81 charged particles, 5 photons), containing 838 sub-entries.

### 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.	Aid was provided to users who requested assistance with retrieving nuclear reaction data.
Collect and address users' feedback related to the ENDF library.	GForge, a collaboration software system, has served as the platform on which ENDF deficiencies were posted; the designated evaluators performed updates, and the nuclear data community monitored their status.
Work with LANL on upgraded evaluations for future release of the ENDF/B library (version VII.1).	New and upgraded evaluations were collected in the Subversion repository under the GForge collaboration system.  Feedback was provided to LANL on performance of the NJOY code in processing covariance data.  Ongoing collaborative BNL-LANL effort focuses on producing extensive set of covariances for ENDF/B-VII.1 library. In FY10 BNL developed new method for covariance evaluation in the resonance region based on kernel approximation. This method was applied to evaluate covariances for 9 structural materials, $^{50,52,53}\text{Cr}$ , $^{54,56,57}\text{Fe}$ and $^{58,60}\text{Ni}$ .
Improve methodology for providing covariance data, in the fast neutron energy region, to the next release of ENDF.	Tendency of the statistical methods to provide too optimistic error estimates has been addressed. Several reasons have been identified and their effects are being tested.
LANL Planned Activities	Status
Upgrade the LANL ENDF evaluations for actinides that perform well in criticality benchmarks, considering new LANSCE experimental data.	A new $^{240}\text{Pu}$ evaluation, which considers new LANSCE fission cross section data, completed. The evaluation of Am241 now includes complete covariance data. A new $^{238}\text{Pu}$ evaluation was made, which includes the covariance data too.
Provide upgraded ENDF evaluated data files for light elements, including covariance data. Nuclear reaction data on $^{16}\text{O}$ will be studied to understand discrepant feedback from thermal nuclear reactor community.	New evaluations of $^4\text{He}$ , $^9\text{Be}$ , and $^{16}\text{O}$ submitted to ENDF/B-VII.
Finalize V data including covariances, for which problems in the criticality benchmarks are reported.	A new evaluation of V data submitted to ENDF/B-VII. There is an issue of criticality benchmark reported. We will fix this problem soon. The covariance data have not been completed yet.
Submit the updated covariance data for light elements (this is supported by many projects including criticality safety, AFC, and also a WPEC collaboration).	Complete covariance files were generated for $^1\text{H}$ , $^4\text{He}$ , $^6\text{Li}$ , and $^{16}\text{O}$ . Earlier, we had produced coarse-grid versions of these covariances that included also $^{10}\text{B}$ . The later versions, especially that for $^{16}\text{O}$ , were made on a much finer energy grid.
Perform new evaluations of prompt fission neutron spectrum data for several actinides.	A new evaluation of prompt fission neutron spectrum at the fast neutron energy performed by using the Monte Carlo method.
LLNL Planned Activities	Status
Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.	Submitted evaluations for U-239, Re-185, Re-187, Xe-123, Xe-124, Kr-78. Worked on evaluations for As-74, As-75, but need to coordinate with LANL to provide best evaluations for ENDF/B-VII.1.
Continue to develop toolset to build ENDF library from DICEBOX/CASINO statistical model calculations. Collaborate with surrogate LLNL/LBNL surrogate reactions group to validate models for continuum gammas and higher incident energy neutrons. Collaborate with LBNL to supplement EGAF capture gamma ray experimental data with statistical model calculations to provide complete ENDF sections, and combine with latest ENDF evaluations and submit them to NNDC.	Worked on W isotopes evaluation in collaboration with LBNL. Worked on fixing level schemes from the thermal neutron capture data in EGAF. Started coordinating with EMPIRE/TALYS developers on how to include primary gammas in ENDF.
Continue collaborating with LBNL to develop the event-by-event fission spectrum simulation tool FREYA: add 2nd and 3rd chance fission, extent parameter tuning for $^{239}\text{Pu}(n,f)$ above the 2nd chance threshold, produce new $^{235}\text{U}(n,f)$ and $^{238}\text{U}(n,f)$ fission neutron spectrum.	We continued collaborating with LBNL to develop the event-by-event fission spectrum simulation tool FREYA. We added 2nd and 3rd chance fission and pre-equilibrium neutron emission to complete the evaluation of the $^{239}\text{Pu}(n,f)$ prompt fission neutron spectrum.
Continue development of structure-rich (XML) data representation for deterministic and Monte-Carlo processed data and extend format to encompass ENDF unprocessed data formats.	The first beta release of the Generalized Nuclear Data (GND) format and infrastructure and the first release of the General Interaction Data Interface (GIDI) was announced at the annual USNDP/CSEWG meeting. Source code for both projects is available on the NNDC's GForge project server. This version of GND includes the GND-to-ENDF translation code and code to serialize GND data into both XML and HDF (standard binary format). Roughly 70% of the ENDF format is fully supported in this release.

## 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 that is available on the web and prepare major update of the manual. This format is used for the ENDF/B-VII library.	The ENDF-6 Formats manual was migrated to the GForge collaboration environment and has been kept up to date with the format changes endorsed by CSEWG. Updates were loaded as needed to the GForge server and subscribed members of the nuclear data community are automatically alerted (through e-mail) on the latest updates.

## 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  $^{252}\text{Cf}$  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  $\text{Au}(n,\gamma)$  cross section; and proposing updates for the evaluations of the  $^{252}\text{Cf}$  spontaneous fission neutron spectrum and the  $^{235}\text{U}$  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. Fine-grid covariances were produced for n-p scattering, and for the $n+^6\text{Li}$ reactions. The data will be made available through the new ENDF release.
Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.	$^{236}\text{U}$ fission cross sections were reevaluated by using the cross section standards, and integral tests were performed.
Complete report on the measured cross sections for the standards reaction $^6\text{Li}(n,\alpha)$ in the MeV region together with an R-matrix analysis of these and literature data.	The measurements were finalized in 2008, and the R-matrix analysis including them was completed last year. A new evaluation was submitted for ENDF/B-VII that includes covariances. A publication is in preparation, but the results have been communicated in several reports and talks.
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 submitted to a peer-review journal.
Complete report on $\text{H}(n,p)$ angular distribution standards measurements at 15 MeV with Ohio University and NIST. Begin experiment on $\text{H}(n,n)$ angular distribution for improving the standard at several neutron energies.	report on the $\text{H}(n,p)$ measurements was published: N. Boukharouba, F.B. Bateman, A.D. Carlson, C.E. Brient, S.M. Grimes, T.N. Massey, R.C. Haight, and D.E. Carter, "Measurement of the n - p Elastic Scattering Angular Distribution at $E_n = 14.9$ MeV," Phys. Rev. C 82, 014001 (2010). An experiment to measure the differential $\text{H}(n,n)$ at forward angles is being designed with preliminary tests on the accuracy to which the neutron detector efficiency can be known.
Complete the analysis and evaluation of the $^{56}\text{Fe}(n,x\gamma = 847 \text{ keV})$ cross section and angular distribution as a reference cross section for $(n,xy)$ measurements.	Final data agree quite well with measurements made at IRMM (Belgium) and with evaluations in ENDF/B-VII and JEFF. A presentation was made at the Workshop on (In)Elastic Neutron Scattering, WINS2010, in Strasbourg, France, in December, 2010.

NIST Planned Activities	Status
Complete work on a journal publication of the International Evaluation of the Neutron Cross Section Standards.	A major effort for the year was the writing of an extensive journal contribution on the evaluation process for the recently completed neutron cross section standards. It was published in Nuclear Data Sheets.
Work on action items from an IAEA Consultant's Meeting on the data development project Maintenance of the Neutron Cross Section Standards. This includes updating of the standards database, investigation an inelastic scattering cross section standard and other items listed in INDC(NDS)-0540.	We have continued working on the items listed for the IAEA data development project "maintenance of the neutron cross section standards" to ensure that we are prepared for the next evaluations of the neutron cross section standards. We gave an invited talk at ND2010 on this work.
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.	We continue the documentation of changes to files based on the corrections obtained from the work of Poenitz and new information obtained from the CRP investigations.
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. Several new measurements are now underway.
Continue an experiment using neutron detection (instead of proton detection) to measure the $\text{H}(n,n)$ angular distribution in collaboration with Ohio University and LANL. Investigate use of a time projection chamber (TPC) for angular distribution measurements.	A paper was published in Phys. Rev. on our measurement of the n - p Elastic Scattering Angular Distribution at 14.9 MeV. Also changes to our earlier work at 10 MeV were published in a Phys. Rev. article. Preliminary work on the new experiment to measure the differential $\text{H}(n,n)$ at smaller CMS angles using neutron detection has been done. This is a collaboration of NIST with Ohio U., LANL and the U. of Guelma. TPC studies continue.

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 that are in the National Repository for Fissionable Isotope Mass standards. These samples have been used by several laboratories and they continue to be available for loan in physics experiments.
Complete fluence determinations and obtain initial measurements of the $6\text{Li}(n,t)$ standard cross section at $\sim 4$ meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the $10\text{B}(n,\alpha\text{p}\gamma)$ reaction.	The work on this experiment strives for fraction of percent accuracy. The fluence determinations continue so that possible systematic uncertainties can be reduced. Diagnostic work has been done on the $6\text{Li}(n,t)$ standard cross section at $\sim 4$ meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the $10\text{B}(n,\alpha\text{p}\gamma)$ reaction.
Submit cross section standards for inclusion in the WPEC High Priority Request List.	We have worked with the WPEC High Priority Request List subgroup to get approval for putting the neutron cross section standards on this List. When the standards are on this list, the prospects improve for experimental work being done on them.

## 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.	EMPIRE is under continued development and the current version is available on-line through the Subversion versioning system hosted under the GForge collaboration environment. Recent improvements include: <ul style="list-style-type: none"> <li>■ DDHMS preequilibrium model extended to produce exclusive spectra</li> <li>■ Disentangling overlapping reactions using exclusive spectra</li> <li>■ New parametrization of the fission channel</li> <li>■ Better support for Mac's</li> </ul>
Employ the improved version of the covariance module in EMPIRE for fast neutrons in ENDF/B-VII.1 evaluations.	New covariance evaluations for the priority structural materials as well those for $^{237}\text{Np}$ and $^{242}\text{Pu}$ in the fast neutron region were obtained using covariance module of EMPIRE.
Test the new resonance module allowing generating covariances utilizing information from the Atlas of Neutron Resonances and employ it for ENDF/B-VII.1 evaluations.	The resonance module has been tested intensively - as the result a new kernel method was developed and implemented in the KERCCEN code being part of the EMPIRE system.

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 due to the decrease in operating experimental facilities throughout the world. The LANL GNASH code has proved to be an important tool, and we will continue development of a new version of this code, McGNASH, to provide a state-of-the-art capability to predict reaction cross sections. This also involves a close collaboration with experimentalists at LANSCE to interpret new measurements using the GEANIE and DANCE gamma-ray detectors, and FIGARO detectors for neutron emission as well as (n,charged-particle) data. These data will result in advances in our understanding of nuclear reaction mechanisms, and improvements in our modeling codes. Also, largely under DOE/DP support, we will continue modernization of our R-matrix EDA code (used for light nucleus calculations and data evaluations) and explore implementation of exact particle-exchange formalism.

LANL Planned Activities	Status
Perform neutron inelastic scattering and fission-neutron spectrum measurements with the FIGARO array. Correlate $^{56}\text{Fe}(n,\gamma)$ data from GEANIE with $^{56}\text{Fe}(n,n)$ data from FIGARO.	Data were taken both at GEANIE and at FIGARO. Neutron emission at low energies was measured with $^6\text{Li}$ -glass detectors. The GEANIE analysis is complete and the FIGARO analysis is underway.
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 0.3 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.	A manuscript was submitted for publication. S. Noda, R. C. Haight, R. O. Nelson, M. Devlin, J. M. O'Donnell, A. Chatillon, T. Granier, G. Belier, J. Taieb, T. Kawano and P. Talou, "Measurement and analysis of prompt fission neutron spectra from 1 to 8 MeV in neutron-induced fission of $^{235}\text{U}$ and $^{239}\text{Pu}$ using the double time-of-flight technique," submitted to Phys. Rev. C (2010).
Perform radiative capture calculations on Gd and Tm isotopes, and investigate the enhancement factor of neutron capture rate on the excited nuclei, which supports s-process nucleo-synthesis and DANCE detector capture measurements.	Radiative capture calculations on Tm and Pu performed, and we investigated if the reaction cross sections differ when the target is in its ground or excited states.

Perform (n,xn) calculations for fission products with several nuclear reaction codes (GNASH, TALYS, and EMPIRE), in collaboration with CEA (France).	Prompt fission product average cross sections were calculated with GNASH, TALYS, and EMPIRE. The cross sections include (n,2n), (n,3), and neutron radiative capture. A paper was published, in collaboration with CEA.
Develop a new code to simulate the decay of compound nucleus using the Monte Carlo technique to identify correlations between neutron and gamma.	A new Monte Carlo simulation code for calculating the neutron and gamma-ray correlations was developed. A paper was published in J. Nucl. Sci. Technol.
Modern nuclear structure models, such as Hartree-Fock, will be applied to calculate nuclear reaction cross sections to reduce phenomenological model parameters.	The Hartree-Fock nuclear structure model was applied in two reaction mechanisms. A nucleon direct / semidirect capture process at low energies, and a neutron inelastic scattering process at higher energies. A Phys. Rev. C paper was accepted for publication.
Study neutron-induced fission of $^{239}\text{Pu}$ at low-excitation energies when the target is in its excited state. Because the half-life of the state is extremely short, theoretical prediction is crucial.	We studied the calculated fission cross section of $^{239}\text{Pu}$ at low energies within two different theoretical frameworks, the compound reaction, and the intermediate class coupling. The results were published in Phys. Rev. C.

LLNL Activities	Status
(Unplanned activity) Develop hybrid R-Matrix Approach, aimed at combining the strengths of ab initio NCSM/RGM and traditional R-matrix analysis.	The Hybrid R-Matrix Approach consists in using parameters calculated within the ab initio NCSM/RGM as starting values in a traditional R-Matrix analysis (at least for a subset of reaction channels). In other words, the predictions of the ab initio theory are fed into the data fitting procedure to supply information when data are unavailable or conflicting and guide the convergence of the fit. As part of this project we have been writing a modern R-matrix Analysis code in Fortran90 for particle-particle reactions using the Hybrid R-matrix Approach. The code, called HyRMa, can be used for both Hybrid R-matrix and traditional R-matrix analysis. It is complete (photon channels have yet to be included) and has past first consistency checks, but a benchmark with an existing established R-matrix code is in order before this new tool can be released.

## 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.

LANL Planned Activities	Status
Measure and analyze prompt neutron emission following interactions of fast neutrons with fission products such as strontium. These measurements are gated on gamma rays from (n,n'gamma) reactions.	Analysis is underway on MeV neutrons emitted from neutron inelastic scattering on barium and strontium. Data were taken for neutrons emitted below 1 MeV on targets of iron and molybdenum.
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).	Gamma-ray data taken previously with the CEA fission chamber still needs to be analyzed. New data were taken for gamma rays from neutron-induced fission of $^{235}\text{U}$ with an improved fission chamber, a parallel-plate avalanche counter, PPAC) from LLNL. Detector response functions for gamma rays are now being measured in order to analyze the new data.
Design an experiment to measure that part of the fission neutron spectrum that lies below 1 MeV.	Data were taken and are now being analyzed for neutron emission below 1 MeV from neutron-induced fission of $^{235}\text{U}$ as detected with a small array of $^6\text{Li}$ -glass detectors. The new PPAC fission counter was used in this work.
Complete analysis of gamma-ray production for neutrons on krypton isotopes that are fission products with the goal of deducing partial reaction cross sections.	New data were taken on $^{86}\text{Kr}$ with colleagues from the CEA (France). Excitation functions have been measured for about 40 transitions. Absorption corrections are in progress to convert these excitation functions into cross sections.
Measure the neutron capture cross-section of $^{242\text{m}}\text{Am}$ at DANCE for neutron energies less than 200 keV.	Analysis of the data taken so far indicates that the quality of the data is poor. For the present, this project has been superseded by other experiments.
Measure the neutron capture and fission cross sections of $^{239}\text{Pu}$ at DANCE for energies less than 200 keV.	Full data taking has been completed and the data are being analyzed.
Measure the neutron capture cross-section at DANCE for at least one radioactive isotope of importance to nuclear astrophysics.	New data were taken on $^{63}\text{Ni}$ in order to correct problems experienced in the first experiment. The data are being analyzed as part of a PhD thesis research by a student at the University of Frankfurt, Germany.

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.

LBLN planned activities	Status
Publication of new $\sigma_{n0}$ values for isotopes with $Z < 20$ and selected heavier isotopes.	Preliminary results have been accepted for publication in <i>Radiochimica Acta</i> and presented at various conferences.
Participation in surrogate reaction cross section measurements at the LBNL Cyclotron Liberace facility.	The Isotopes Project has been asked to take a leadership role in the LBNL LiBeRACE experimental program. The group is responsible for detector maintenance. New experiments relevant to nuclear data have been proposed. An experiment to measure collective nuclear structure contributions to the statistical model has been approved but postponed due to Cyclotron problems and experimental difficulties.

LLNL Planned Activities	Status
Neutron induced reaction measurements on one or more isomer targets.	Continuing.
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)	Continuing.
Perform neutron capture measurements with DANCE array at LANSCE in collaboration with LANL. (funded from other sources)	Continuing.
Perform fission cross-section measurements with the lead slowing down spectrometer at LANSCE in collaboration with LANL. (funded from other sources)	Continuing.

## G. Evaluation of Data Needed for Astrophysics

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

ANL Planned Activities	Status
Complete work on $^{186m}\text{Re}$ , which is of relevance to the $^{187}\text{Re}/^{187}\text{Os}$ cosmo-chronometer, including measurements and modeling of the production and destruction cross-sections of the $^{186m}\text{Re}$ isomer (in collaboration with TUNL).	Work of $^{186m}\text{Re}$ is 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.	This activity has not started yet due to delays with the CARIBU project

BNL Planned Activities	Status
Perform systematic evaluations of neutron capture cross sections in the energy region of interest for nuclear astrophysics (neutron unresolved resonance region). Produce Maxwellian averages of these data.	Results for ENDF nuclei have been published, work on complete coverage of s-process nuclei is in progress.

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
Continue N-N analysis to energies above 50 MeV and provide evaluated n-p capture cross-sections, rates, and covariance data.	No new R-matrix work on the N-N system above 50 MeV was done this year. We are considering in the interim a match to a higher-energy analysis above 20 MeV to extend the energy range of the n-p evaluation to 250 MeV.
Improve neutron capture models to provide neutron capture rates off-stability to s-process hydro-dynamics simulations.	Hartree-Fock BCS model calculations were performed for proton induced reactions on odd targets. A Phys. Rev. paper was submitted.
Provide fission decay widths of actinides off-stability based on the microscopic/macrosopic model at LANL for r-process network calculations.	Fission barrier data calculated with the microscopic/macrosopic model were provided.
Perform fission cross-section measurements with the lead slowing down spectrometer at LANSCE in collaboration with LANL.	In collaboration with a graduate student from Rensselaer Polytechnic Institute, preliminary measurements were conducted on $(n,p)$ and $(n,\alpha)$ reactions on $^{50}\text{V}$ and $^{147}\text{Sm}$ . Compensated diamond detectors were used to detect the light charged particles. The data are being analyzed.

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
Specifically, we will evaluate the $^{19}\text{Ne}(p,\gamma)^{20}\text{Na}$ and $^{29}\text{P}(p,\gamma)^{30}\text{S}$ reaction rates. The former plays an important role in breakout from the hot-CNO cycle in x-ray bursts, while the latter is a key reaction in nova nucleosynthesis.	Following reactions were evaluated and sent to ORNL website <a href="http://nucastro.org">nucastro.org</a> for evaluated reaction rates: $^{23}\text{Mg}(p,\gamma)^{24}\text{Al}$ and $^{29}\text{P}(p,\gamma)^{30}\text{S}$

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.	Assessments of levels in a number of nuclei were made and published as a result of measurements at ORNL HRIBF: in $^{27}\text{Si}$ via $^{26}\text{Al}(p,p)$ and $^{26}\text{Al}(d,p)$ measurements [in progress]; in $^{26}\text{Si}$ via a $^{28}\text{Si}(p,t)^{26}\text{Si}$ measurement [Phys. Rev. C]; in $^{19}\text{Ne}$ via a $^{18}\text{F}(d,n)^{19}\text{Ne}$ measurement [in review at PRL]; in $^{22}\text{Na}$ via a $^{24}\text{Mg}(p,^3\text{He})^{22}\text{Na}$ measurement; in $^{18}\text{Ne}$ via a $^{17}\text{F}(p,p')$ measurement [Phys. Rev. C].
Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANCs) on nuclei near the $N=82$ closed shell from transfer reaction measurements on radioactive neutron-rich unstable nuclei. This information is important for modeling the r-process in supernovae.	Paper published in Nature on level structure of $^{133}\text{Sn}$ and first experimental determination of double magicity of $^{132}\text{Sn}$ ; this work won two prestigious awards at ORNL; level assessments in progress for $^{131}\text{Sn}$ and $^{135}\text{Te}$ .

## 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.

## Appendix A

### Nuclear Data Activities Funded from Sources outside the Nuclear Data Program (Report FY2010)

#### 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  $^{30}\text{F}$ ,  $^{30}\text{Al}$ ,  $^{30}\text{Si}$  were completed. Capture gamma-ray data from the EGAF database for all elements with  $Z < 20$ ,  $^{151}\text{Eu}$ ,  $^{153}\text{Eu}$ ,  $^{152}\text{Gd}$ ,  $^{154}\text{Gd}$ ,  $^{155}\text{Gd}$ ,  $^{156}\text{Gd}$ ,  $^{157}\text{Gd}$ ,  $^{158}\text{Gd}$ ,  $^{160}\text{Gd}$ ,  $^{182}\text{W}$ ,  $^{183}\text{W}$ ,  $^{184}\text{W}$  and  $^{186}\text{W}$  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  $^{239}\text{Pu}$  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.