



Annual Report for FY2007

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USNDP Annual Report for FY2007

Summary of the U.S. Nuclear Data Program Activity for 2007

I. Introduction (Report FY07)

The USNDP Annual Report for FY2007 summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2006 through September 30, 2007 with respect to the work plan for FY2007 that was prepared in February 2006. The work plan and final report are prepared at the direction of the DOE Office of Science, Office of Nuclear Physics for the nuclear data program. 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 26.5 FTE scientific, mostly at NNSA laboratories, to be compared with 19.8 FTE scientific (permanent + temporary) at USNDP laboratories funded by the DOE Office of Science, Office of Nuclear Physics. Since it is often difficult to differentiate 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 FY2007. Then, we proceed with the detailed status of work done in FY2007.

Total staff assigned to USNDP activities during the year was 23.81 FTE, slightly more than in FY2006. Despite this there is gradual loss of permanent scientific staff in USNDP activities.

Fiscal year 2007 is the 9th year during which the Nuclear Data Program has operated under a work plan developed by the program participants. As the following sections illustrate, the nuclear data program is successfully carrying out important work in direct support of DOE missions. 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 convenient manner.

The program metrics requested by DOE are included below. Table 1 summarizes the USNDP metrics for the years that such metrics were reported. Table 2 shows the breakdown of the metrics for this fiscal year by laboratory and compares them with the previous fiscal year. The tables are followed by a description of the meaning of each metrics.

Table 1: Summary of the USNDP metrics in FY01- FY07, for definitions see next page.

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

Tab. 1 shows that the FY07 budget increased by a solid 14.6% compared to previous fiscal year, after substantial drop by -6.6% one year earlier. Thus, FY07 increase tends to compensate heavy loss in FY06. Near flat-flat budget for FY08 (+1.4% increase), already known to us at the moment of preparing the present report, continues an unfortunate record of volatile budgets in last several years.

Tab. 1 shows also the USNDP metrics. The metrics increased in two important categories, evaluations and dissemination, there is some increase in compilations and small decrease in remaining categories:

1. **Compilations.** Compilations include NSR, CSISRS and XUNDL databases, showing certain overall increase. Larger drop compared to FY05 is explained by the shift of three major European journals in NSR compilation to the IAEA Vienna.
2. **Evaluations.** There is solid increase in the evaluations, up by 15% compared to FY06. We note that FY05 was exceptional due to evaluation of large number of super-heavy nuclides (63 nuclides, A = 266-294).
3. **Dissemination.** This indicator continues a steady increase. In FY07 we exceeded the milestone of 2 million data retrievals from the USNDP databases. Most notable is sharp increase in the use of NucAstro web system maintained at ORNL. At BNL, the most popular product continues to be NuDat which contributes almost 60% data retrievals.
4. **Reports.** There is some drop in the number of published reports.
5. **Papers.** The number of papers published in refereed journals was somewhat reduced.
6. **Invited Talks.** The number of invited talks continues to grow over several last years.

Table 2: USNDP metrics in FY2007, numbers for FY2006 are shown for comparison.

Lab	Compilations		Evaluations		Dissemination ³		Reports		Papers		Invited Talks	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
BNL ¹	4528	4962	150	142	1089	1380	10	21	14	9	12	6
LANL	-	-	35	40	188	233	1	2	12	12	7	17
LBNL	-	-	43	39	376	376	4	2	5	5	6	3
ORNL	-	-	11	18	134	176	16	4	4	6	10	9
ANL	-	-	12	22	11	13	6	2	11	17	7	7
LLNL	-	-	3	7	13	8	6	6	6	3	6	6
University ²	408	393	64	98	52	53	4	3	8	2	-	3
Total	4936	5355	318	366	1863	2239	47	40	60	54	48	51

1) BNL evaluations in 2007 consist of 82 nuclides for ENSDF and 60 reactions for ENDF.

2) TUNL, NIST, McMaster. One half of McMaster funding comes from Canada.

3) Data retrievals in thousands. LBNL scaled in accord with retrievals/hits ratio observed at BNL.

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 (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 (Report FY07)

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 FY2008 in conjunction with the members of the Coordinating Committee. The NNDC Head serves as chair of the USNDP Coordinating Committee, which consists of the Principal Investigators from each of the participating groups, and he chairs the annual meeting of the program held at 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 March 2007, the DOE Office of Nuclear Physics conducted its annual Budget Briefing. Pavel Oblozinsky, Coral Baglin, Toshihiko Kawano and John Kelley represented the USNDP and made the case for the FY2009 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).

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 2006. The major topic of the meeting was the release of the ENDF/B-VII.0 library in December 2006.

Several USNDP participants attended the April 2007 meeting of the NEA-sponsored Working Party on International Evaluation Cooperation (WPEC) in Paris, France. The US has the lead responsibility for several projects sponsored by this activity.

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. This NNDC web system continues to operate without interruptions and provides stable service to US nuclear data users.

The NNDC maintains seven nuclear physics databases for the USNDP. These databases have been updated continuously in FY2007 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 FY2007, retrievals from the USNDP databases as offered by the USNDP laboratories reached a bit more than 2.2 million data retrievals. Thus, for the first time, we exceeded the benchmark of 2 million retrievals. The use of our services continues to grow, though there is some slowing down compared to sharp rise observed in previous 2-3 years.

Major Publications



The “big paper” on the new ENDF/B-VII.0 library was published in the special issue of Nuclear Data Sheets. The paper appeared simultaneously with the release of the library, in December 2006. It is expected that this paper will receive an exceptionally high number of citations.

III. Nuclear Structure and Decay Data (Report FY07)

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 publications in *Nuclear Data Sheets* or *Nuclear Physics A*. In addition, working group members participate in several international collaborations or coordinated research projects designed to provide nuclear data tailored to meet the specialized needs of various research and user communities. Frequently-accessed web sites maintained at several data centers continue to disseminate nuclear structure and decay data in a variety of user-friendly forms.

Evaluations for ENSDF

USNDP nuclear structure and decay data evaluation groups in the US and Canada were involved in 249 nuclide evaluations (or 74%) of a total of 336 nuclide evaluations that were submitted during FY2007 for inclusion in the ENSDF database. The USNDP evaluators have also provided peer review for 14 mass chain evaluations, and NNDC provided additional checks prior to publication. Additionally, super-deformed band data for 4 nuclides were updated in ENSDF. The eleven issues of the journal *Nuclear Data Sheets* (published by Elsevier) that were devoted to nuclear structure and decay data contained 19 individual mass chain evaluations; these publications also included work by evaluators from China, India, Japan and Russia.

Compilations for XUNDL

The XUNDL database facilitates prompt access to unevaluated structure information from the most recently published papers. The McMaster group submitted 368 new and 25 updated data sets during FY2007, and these were incorporated into the XUNDL database by BNL. Once again, private communications obtained from authors concerning some of the data entered into XUNDL during the year have been collected and forwarded to NNDC so that ENSDF evaluators also can benefit from the information they contain.

Revisions of NuDat

Two upgrades to NuDat were released during FY2007 by way of response to users' requests. The enhancements include direct access to ENSDF files, searches on transition probability information and a choice of notation for uncertainties. NuDat is a very popular, widely used structure and decay data dissemination tool and its use currently constitutes ~56% of NNDC's data retrievals.

Nuclear Science References Database (NSR)

This database has now grown to approximately 191,400 citations. Much of the work required to keep this database up to date is performed by NNDC staff members who regularly scan the majority of the journals, laboratory reports and conference proceedings that are monitored.

However, collaborators at the IAEA are now responsible for scanning three major European journals. “Recent References” summaries continue to be regularly made available to the scientific community *via* the web.

USNDP Contribution to Decay Data Evaluation Project (DDEP)

The international DDEP collaboration includes several USNDP evaluators as well as non-ENSDF evaluators from France, Germany, Romania, Russia, South Korea, Spain, and the United Kingdom. It prepares evaluations for radionuclide decays of importance in applied research, and LBNL continues to coordinate this project and provide general editorial oversight without cost to the US data program. Also, during FY 2007, USNDP participants in this program reviewed eight radionuclide evaluations and evaluated one radionuclide decay.

USNDP Evaluator Participation in IAEA CRPs

The participation of USNDP nuclear structure evaluators in two IAEA Coordinated Research Projects (CRP) continues. One project is the “Updated Decay Data Library for Actinides”, and it involves both data evaluations and measurements that will ultimately benefit the ENSDF database. The other is titled “Reference Database for Neutron Activation Analysis”; its purpose is to provide evaluated k_0 /cross section data for use by the neutron activation community and those data will ultimately benefit the existing database (EGAF) which contains evaluated discrete-line photon data from thermal neutron capture.

Assessment of Internal Conversion Coefficient Calculations

The US-Australian-Russian collaboration that developed the software package routinely used by ENSDF evaluators to calculate internal conversion coefficients has recently engaged in a thorough, systematic comparison between the most precise experimental conversion coefficient and sub-shell ratio data available and the values calculated using three different relativistic Dirac-Fock methods.

New Evaluator Mentoring and Training

During FY2007, Postdoctoral positions for structure and decay data evaluators were filled at ANL, TUNL and McMaster, adding much-needed manpower to the USNDP effort. Experienced evaluators at their institutions are overseeing their training and mentoring, and evaluators at BNL, ANL and McMaster have also served as mentors for several non-US evaluators who recently began evaluation work.

Modernization of Drawings in Nuclear Data Sheets Publications

Recognizing the need to improve the quality and legibility of level scheme drawings in *Nuclear Data Sheets* mass-chain publications, NNDC contracted in December 2006 for new drawing preparation software to address this problem. The project is far from complete, but prototype band drawings already show considerable promise.

Outreach

Interactions between data evaluators and those who generate or use nuclear data are essential, both to inform users of the products available and to generate a better understanding of users' needs. The Working Group's approach to this in FY2007 has been multi-faceted. A user forum at the November 2006 USNDP meeting facilitated interaction with researchers from GANIL (G. de France), Michigan State University (B. Tsang), IAEA (A. Mengoni) and Oak Ridge National Laboratory (C. Baktash). USNDP structure data evaluators were prominently represented at the International Conference on Nuclear Data for Science and Technology in Nice, France in April 2007. A well-received invited talk was presented at the Eurisol/Eurons Joint Town Meeting in Helsinki in September 2007 to inform about and encourage participation in the international structure and decay data program. An 'awareness' article was prepared for inclusion in the NuPECC journal *Nuclear Physics News*. NNDC and others engaged in various forms of both direct and indirect outreach at both local and international meetings *via* booths, talks, posters, handouts or informal interactions with attendees and by presenting data-related talks in lab seminar series.

IV. Nuclear Reaction Data (Report FY07)

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

The NNDC has compiled 136 papers (36 neutron and 100 charged-particle papers with 565 reactions) for the experimental nuclear reaction database, CSISRS. The NNDC assembled the ENDF/B-VII.0 library and performed its phase 1 testing. The Cross Section Evaluation Working Group (CSEWG), which is partly supported by the US Nuclear Data Program, released this library in December 2006 - the first major release since 1990.

LANL generated uncertainty (covariance) data for actinides, including ^{233}U , which are required by many nuclear applications, especially for the criticality safety study. We have also assessed covariance evaluation methodology by comparing two different approaches, a Kalman-filter technique and Backward-Forward Monte Carlo method developed at CEA. These activities aim at quality assurance of the ENDF/B-VII database. In addition, numerous new covariance evaluations were performed by BNL for non-fissile materials.

The activity to supply nuclear data for Homeland Security continues in the framework of the Task Force that holds a special session during each annual USNDP meeting. LANL and LLNL developed a new method to calculate the prompt-neutron fission spectra based on the Monte Carlo technique, which allows us to obtain more microscopic information in the chain of fission fragments decay. LANL also completed a new evaluation of delayed neutron spectra based on the microscopic/macrosopic nuclear structure theory and the Hauser-Feshbach statistical model calculations.

LANSCE produced a set of fission and capture experimental data for actinides. The neutron capture data for $^{239,240}\text{Pu}$ and ^{241}Am were obtained at DANCE. The fission cross section measurements were performed for plutonium isotopes and ^{233}U . The analysis of those preliminary data are underway at T-16 by using the Hauser-Feshbach statistical model combined with the direct reaction theory.

Model Code Highlights

Several new features were added to the nuclear reaction calculation code EMPIRE. The newly added features include formatting of isomeric cross sections, generation of fake resonances using unresolved resonance parameters, use of parity dependent level densities based on the Hartree-Fock-BCS, deformed MSD calculations with the Cassini potential, and further refinements of the fission channel. The deformed MSD model calculations were applied to demonstrate the impact of the Cassini potential on neutron spectra from ^{232}Th .

The TUNL program on pre-equilibrium phenomenology is no longer funded through the DOE USNDP program. Work continues at a very-much-reduced pace and this year led to the release

of the new code version PRECO-2006.

At LANL, two important theories were developed for the ENDF data evaluation. The Kawai-Kerman-MacVoy theory was first implemented into the Hauser-Feshbach model to test the impact of the direct reaction on the cross section calculations. The microscopic quantum mechanical MSD theory for deformed nuclei was also developed to calculate the inelastic scattering process on the actinides.

Nuclear Standards Highlights

A new evaluation of the neutron cross section standards was recently completed. The evaluation, which was led by NIST, was largely performed by an IAEA Coordinated Research Project (CRP) with support, primarily experimental in nature, through the NEA Working Party on International Evaluation Cooperation (WPEC) of the Nuclear Energy Agency and CSEWG. The evaluations were produced by combining R-matrix calculations with experimental data using the GMA code. Within this effort, LANL provided one of the sets of R-matrix evaluations for the ${}^6\text{Li}(n,t)$, ${}^{10}\text{B}(n,\alpha)$ and ${}^{10}\text{B}(n,\alpha_1\gamma)$ standards. LANL also did an R-matrix evaluation of the H(n,n) standard that was used to renormalize data that were relative to the hydrogen standard. As a result of these efforts, the standards were provided for the ENDF/B-VII.0 library. For the first time, the ENDF/B-VII.0 standards sublibrary was created that contains the cross sections and also the covariances for most of the standards.

Additional R-matrix work is planned at LANL on the ${}^3\text{He}(n,p)$ and H(n,n) standards. New measurements for several standards, including H(n,n), ${}^6\text{Li}(n,t)$, ${}^{10}\text{B}(n,\alpha)$, ${}^{10}\text{B}(n,\alpha_1\gamma)$ and ${}^{238}\text{U}(n,f)$ are being made that will be useful for future standards evaluations. An IAEA data development project on maintenance of the standards has begun its activities that should allow continual improvements to the standards.

Nuclear Astrophysics Highlights

Work continued on the evaluation of several nuclear reactions important for astrophysics modeling at ORNL [${}^{18}\text{F}(p,\alpha)$, ${}^{18}\text{F}(p,\gamma)$, ${}^{17}\text{O}(p,\alpha)$, ${}^{17}\text{O}(p,\gamma)$, ${}^{30}\text{P}(p,\gamma)$, ${}^{82}\text{Ge}(n,\gamma)$, ${}^{84}\text{Se}(n,\gamma)$, ${}^{132}\text{Sn}(n,\gamma)$, ${}^{130}\text{Sn}(n,\gamma)$, ${}^{134}\text{Te}(n,\gamma)$] and at McMaster [${}^{25}\text{Al}(p,\gamma)$, ${}^{40}\text{Ca}(\alpha,\gamma)$]. LANL continued on the theoretical development of the direct/semi-direct nucleon capture in the case of odd-mass target. A preliminary calculation was made for a proton capture on ${}^{176}\text{Yb}$.

Neutron capture experiments of importance to understanding s-process nucleosynthesis are underway at LANL using the DANCE highly segmented 4- π calorimeter at the Los Alamos Neutron Science Center (LANSCE). The following reactions are being studied: ${}^{62}\text{Ni}(n,\gamma)$ (with Colorado School of Mines – published), ${}^{102}\text{Pd}(n,\gamma)$ (with Colorado School of Mines – completed), ${}^{152}\text{Eu}(n,\gamma)$, and ${}^{203,205}\text{Tl}$. This facility is capable of making neutron capture measurements on samples of 1 mg or less.

V. Accomplishments (Report FY07)

This chapter was prepared for the second time, in response to a request by DOE-SC, Office of Nuclear Physics. Following this request, in this chapter we summarize our most significant accomplishments in FY2007/FY2008 (anticipated).

In the present document we report two accomplishments.

The first accomplishment is 2.2 million data retrievals from the USNDP databases served by the USNDP laboratories. This achievement reflects the collective work of USNDP in maintaining and improving the databases as well as its web services.

The second accomplishment is the release of the new evaluated nuclear data library ENDF/B-VII.0 for nuclear science and technology in December 2006. This is the common result of considerable importance achieved together by the Cross Section Evaluation Working Group (CSEWG) and USNDP. Although the CSEWG contribution to the final product was dominant, USNDP made significant contributions that are highlighted in the following page. We note that this accomplishment has already been reported as *anticipated* in the Annual Report FY06.

Two Million Retrievals from the USNDP Databases

In FY2007, retrievals from the USNDP databases as offered by the USNDP laboratories reached almost 2.2 million data retrievals. Thus, for the first time, we exceeded the benchmark of 2 million retrievals, which followed shortly after 1 million retrievals were reached by the NNDC in FY2006. This achievement reflects the collective work of USNDP in maintaining and improving the databases as well as its web services.

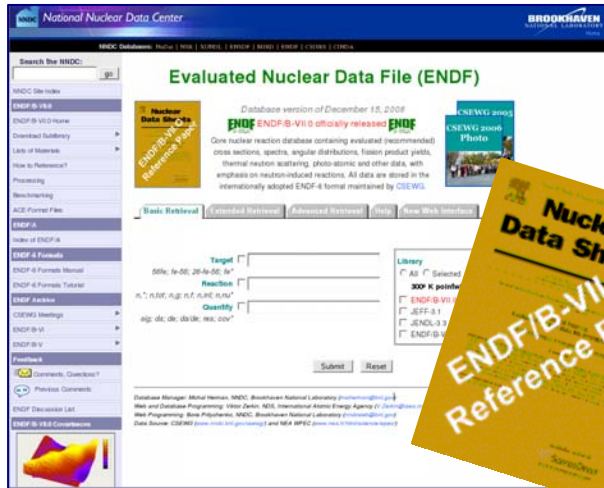
Tab. 3 illustrates the rapid growth in the use of nuclear data produced and offered by the US Nuclear Data Program. We show years 2001-2007, the period of time this statistic has been systematically maintained. One can see that in last four years the use more than doubled. The contribution from the NNDC increased sharply after major database migration and web service upgrade was completed in 2004. There is a relative slow down in several USNDP laboratories caused by limited funding in last several years. In 2006 and 2007, the new NucAstro web system at ORNL started to make significant contributions.

Table 3: Data retrievals in thousands from the USNDP databases, shown is the sum of all USNDP laboratories and the NNDC contribution.

	2001	2002	2003	2004	2005	2006	2007
USNDP	667	799	966	1,212	1,642	1,863	2,239
NNDC	257	281	330	478	778	1,089	1,380

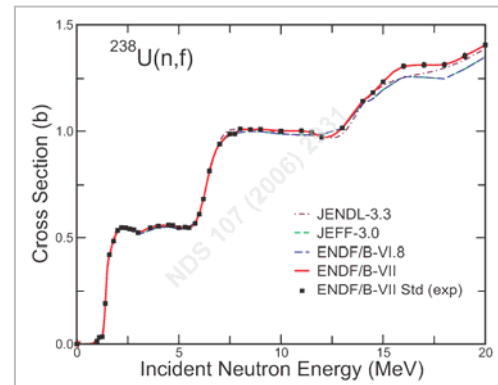
Release of the ENDF/B-VII.0 Library (The first major release since 1990)

In December 2006, the NNDC released the next generation evaluated nuclear data library for nuclear science and technology, ENDF/B-VII.0 - the major US library dedicated to nuclear reactions. This remarkable event coincides with the renewed interest in the nuclear energy option (AFC, GNEP, Gen-IV). The ENDF/B-VII.0 has been developed by CSEWG with a significant contribution from the **USNDP** laboratories (LANL, BNL, NIST, LLNL).

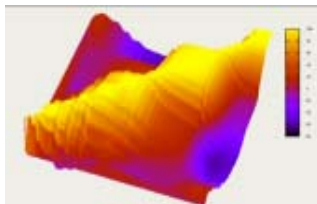


The principal advances over the previous ENDF/B-VI library:

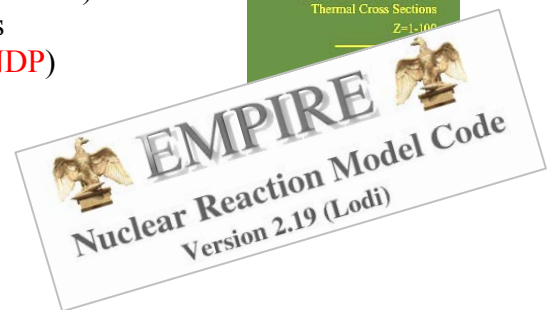
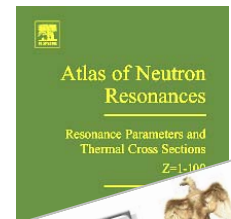
1. New cross sections for U, Pu, Th, Np and Am, with improved performance in benchmark tests (**USNDP**)



2. More precise standard cross sections for neutron reactions on H, ^6Li , ^{10}B , Au and for $^{235,238}\text{U}$ fission (**USNDP**)
3. Improved thermal neutron scattering
4. Large suite of photonuclear reactions
5. Extensive set of neutron cross sections on fission products (**USNDP**, 70 BNL evaluations with EMPIRE-Atlas method)
6. Many new light nucleus neutron and proton reactions
7. Post-fission beta-delayed photon decay spectra (**USNDP**)
8. New radioactive decay data (**USNDP**)



9. New methods for uncertainties and covariances (**USNDP**)



10. New actinide fission energy deposition.

Validation carried out in US and Europe (hundreds of integral experiments) proved absolute superiority of the ENDF/B-VII.0 over earlier libraries.

Extensive paper, already known as the "big paper", on ENDF/B-VII.0 appeared in the special issue of Nuclear Data Sheets in December 2006.

Table 4: USNDP Staffing Table for FY 2007

Annual Report FY 2007	ANL		BNL			LA NL	LBNL		LL NL	McMaster		NI ST	OR NL		TUNL		Program Total			
	Sci Per	Sci Tem	Sci Per	Sci Tem	Tec Adm		Sci Per	Sci Tem		Sci Per	Sci Tem		Sci Per	Sci Tem	Sci Per	Sci Tem	Sci Per	Sci Tem	Tec Adm	Total
I. NNDC Facility Operation	0.00	0.00	0.35	0.00	1.65	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.35	0.00	1.65	2.00
Management			0.35														0.35	0.00	0.00	0.35
Secretarial/Administrative Support					0.55												0.00	0.00	0.55	0.55
Library					0.25												0.00	0.00	0.25	0.25
Computer Operations					0.85												0.00	0.00	0.85	0.85
II. Coordination	0.05	0.00	0.65	0.00	0.00	0.40	0.30	0.00	0.05	0.00	0.00	0.00	0.05	0.00	0.00	0.00	1.50	0.00	0.00	1.50
National Coordination			0.35			0.10	0.30		0.05				0.05				0.85	0.00	0.00	0.85
International Coordination	0.05		0.30			0.30											0.65	0.00	0.00	0.65
III. Nuclear Physics Databases	0.00	0.00	1.05	0.00	1.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.05	0.00	1.50	2.55
Nuclear Science References, NSR			0.10		0.70												0.10	0.00	0.70	0.80
Exper. Nucl. Structure Data, XUNDL			0.05														0.05	0.00	0.00	0.05
Eval. Nucl. Structure Data, ENSDF			0.20		0.65												0.20	0.00	0.65	0.85
Numerical Nuclear Data, NuDat			0.15														0.15	0.00	0.00	0.15
Reaction Data Bibliography, CINDA			0.05														0.05	0.00	0.00	0.05
Experimental Reaction Data, CSIRS			0.10														0.10	0.00	0.00	0.10
Evaluated Nuclear Data File, ENDF			0.30														0.30	0.00	0.00	0.30
Database Software Maintenance					0.15												0.00	0.00	0.15	0.15
Future Database System Develop.			0.10														0.10	0.00	0.00	0.10
IV. Information Dissemination	0.00	0.00	0.95	0.00	0.25	0.10	0.10	0.00	0.00	0.00	0.00	0.00	0.00	1.50	0.60	0.00	1.75	1.50	0.25	3.50
Nuclear Data Sheets			0.10		0.15												0.10	0.00	0.15	0.25
Customer Services			0.15		0.10												0.15	0.00	0.10	0.25
Web Maintenance & Development			0.70			0.10	0.10							1.50	0.60		1.50	1.50	0.00	3.00

Table 4: USNDP Staffing Table for FY 2007

Annual Report FY 2007	ANL		BNL			LA NL	LBNL		LL NL	McMaster		NI ST	OR NL	TUNL			Program Total			
	Sci Per	Sci Tem	Sci Per	Sci Tem	Tec Adm		Sci Per	Sci Tem						Sci Per	Sci Tem	Sci Per	Sci Tem	Tec Adm	Total	
V. Nuclear Structure Physics	0.90	0.40	2.90	1.20	0.00	0.10	1.70	0.40	0.20	0.61	0.00	0.00	0.00	0.30	0.85	0.50	7.26	2.80	0.00	10.06
NSR Abstract Preparation			0.70														0.70	0.00	0.00	0.70
Compilation of Exper. Structure Data										0.15							0.15	0.00	0.00	0.15
Eval. of Masses & Nuclides for ENSDF	0.60	0.40	1.75	1.20			1.25	0.4		0.44				0.30	0.45	0.25	4.49	2.55	0.00	7.04
Ground & Metastable State Properties			0.15														0.15	0.00	0.00	0.15
Radioactive Decay Data Evaluation	0.20		0.05							0.02							0.27	0.00	0.00	0.27
Thermal Capture Gamma Data Eval.							0.35	0.00	0.20								0.55	0.00	0.00	0.55
Light Mass Eval. for Nucl. Physics A														0.40	0.25		0.40	0.25	0.00	0.65
Nuclear Structure Data Measurement	0.10					0.10	0.10										0.30	0.00	0.00	0.30
ENSDF Evaluation Support Codes			0.25														0.25	0.00	0.00	0.25
VI. Nuclear Reaction Physics	0.05	0.00	1.70	0.05	0.00	1.60	0.00	0.00	0.20	0.00	0.00	0.20	0.20	0.20	0.00	0.00	3.95	0.25	0.00	4.20
Experimental Data Compilation			0.50														0.50	0.00	0.00	0.50
<i>Neutron Data</i>			0.15																	
<i>Charged Particle Data</i>			0.30																	
<i>Photonuclear Data</i>			0.05																	
ENDF Manuals and Documentation			0.15														0.15	0.00	0.00	0.15
ENDF Evaluations			0.55	0.05		0.30			0.20								1.05	0.05	0.00	1.10
Nuclear Reaction Standards						0.10						0.20					0.30	0.00	0.00	0.30
Nuclear Model Development			0.30			0.60											0.90	0.00	0.00	0.90
Nucl. Reaction Data Measurements			0.10			0.20											0.30	0.00	0.00	0.30
Astrophysics Nuclear Data Needs	0.05		0.10			0.40							0.20	0.20			0.75	0.20	0.00	0.95
Reaction Data for RIA Target Design						0.00											0.00	0.00	0.00	0.00
	ANL		BNL			LANL	LBNL	LLNL	McMaster	NIST	ORNL	TUNL	Program Total							
DOE-SC Nucl. Data Funded Staff	1.00	0.40	7.60	1.25	3.40	2.20	2.10	0.40	0.45	0.61	0.00	0.20	0.25	2.00	1.45	0.50	14.86	4.55	4.40	23.81
Staff Supported by Other Funds			0.40	0.70	0.20	14.40	0.15	0.80	7.50	0.48		2.80					25.73	1.50	0.20	27.43
TOTAL STAFF	1.00	0.40	8.00	1.95	3.60	16.60	2.25	1.20	7.95	1.09	0.00	3.00	0.25	2.00	1.45	0.50	40.59	6.05	4.60	51.24

Detailed Status of the Work Plan (Report FY07)

I. NNDC Facility Operation (Report FY07)

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

BNL Planned Activities:

Scan and remediate regularly vulnerabilities on NNDC servers and clients to ensure compliance with DOE cyber security requirements.

Purchase and install a new and powerful EMPIRE server for time-consuming cross section covariance calculations using Empire-Kalman code system, to be developed by BNL-LANL collaboration.

Provide computer support to the NNDC staff and its visitors as necessary.

Status:

- Cyber security vulnerabilities were regularly addressed and resolved.
- Dell Linux cluster, purchased in spring 2006 for ENDF/B-VII.0 phase 1 testing, was upgraded from 32 – to 64-bit precision to allow more precise covariance data processing and sensitivity matrix calculations.
- Computer support to the NNDC staff and to about a dozen of the NNDC visitors was provided.
- Automatic replication of NSR/ENSDF/XUNDL from the primary to the secondary database server was implemented.
- The Linux OS, Sybase RDBMS and disk storage capacity on NNDC database servers were upgraded to handle increased load from the new Sigma retrieval and plotting system.

- The primary database server was relocated to ITD building, while secondary database server remained located at the NNDC. This arrangement should improve data safety in the case of natural disaster or other major failure.

II. Coordination (Report FY07)

A. National Coordination

ANL -- Chair the Measurement and Basic Physics Committee of the Cross Section Evaluation Working Group.

ANL Planned Activities:

Organize and chair the CSEWG Measurement and Basic Physics Committee.

Status:

- ANL organized and chaired the Measurement and Basic Physics Committee at the November 2006 CSEWG Meeting

BNL -- Chair USNDP Coordinating Committee, chair Cross Section Evaluation Working Group, develop USNDP work plan, and maintain its USNDP web site.

BNL Planned Activities:

Prepare FY2008 work plan for USNDP in time for spring 2007 FWP submittals.

Organize and chair CSEWG Meeting at BNL in November 2006.

Organize and chair USNDP Meeting at BNL in November 2006.

Edit and publish summary reports of the CSEWG and USNDP meetings.

Edit and publish USNDP Annual Report for FY 2006.

Maintain CSEWG and USNDP web sites.

Status:

- FY2008 work plan for USNDP was prepared in February 2007.
- CSEWG Meeting was held at BNL in November 2006.
- USNDP Meeting was held adjacent to CSEWG Meeting in November 2006.
- Summary report of CSEWG-USNDP 2006 meeting was published in December 2006.
- USNDP Annual Report for FY 2006 was published in February 2007.
- CSEWG and USNDP web sites were regularly maintained, with major focus on the web site related to the new ENDF/B-VII.0 library.

LANL -- Chair U.S. Nuclear Data Program's Nuclear Reaction Working Group and help coordinate nuclear reaction data work at different labs to advance USNDP; chair Evaluation Committee of the Cross Section Evaluation Working Group.

LANL Planned Activities:

Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2006.

Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2006.

Help to organize and assist to lead the CSEWG Homeland Security Task Force, and interact with LANL NA22 representative to provide feedback on user needs.

Status:

- Organized and chaired the Evaluation Committee at the November 2006 CSEWG meeting.
- Organized and chaired Nuclear Reaction Working Group meeting at USNDP meeting in November 2006.
- Homeland Security and Astrophysics data needs were investigated. New theoretical developments for Homeland Security and Astrophysics data were made.

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

LBL Planned Activities:

Organize and chair Nuclear Structure and Decay Data Working Group meeting at USNDP meeting, November 2006.

Status:

- Served on USNDP Coordinating Committee.
- Organized and chaired USNDP Nuclear Structure and Decay Data Working Group meeting in November 2006.

LLNL -- Chair the Task Force on Nuclear Data Needs for Homeland Security and serve on the Cross Section Evaluation Working Group and USNDP executive committees.

LLNL Planned Activities:

Attend the annual CSEWG meeting in November 2006.

Provide Task Force on Nuclear Data Needs for Homeland Security report for CSEWG.

Status:

- Five LLNL participants attended the FY07 CSEWG meeting.
- LLNL prepared the Task Force on Nuclear Data Needs for Homeland Security report for CSEWG.

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

ORNL Planned Activities:

Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting in November 2006.

Communicate current efforts and future plans with researchers in nuclear astrophysics data.

Discuss future plans in nuclear astrophysics data with USNDP/NNDC and DOE.

Status:

- USNDP efforts in nuclear data for nuclear astrophysics summarized in an oral presentation for USNDP meeting in November 2006.
- Represented nuclear astrophysics data efforts of USNDP members at Workshop on Nuclear Astrophysics Data in Trento, Italy, and gave invited presentation on status and future of international nuclear astrophysics data efforts.
- Explored prospects for joint research / data projects in nuclear astrophysics involving multiple USNDP sites and international collaborators.

B. International Coordination

ANL – Represent ANL in the International Nuclear Structure and Decay Data Network that is under auspices of IAEA. Participate in IAEA-sponsored coordinated research programs and training workshops.

ANL Planned Activities:

Participate in IAEA CRP on “Updated Data Library for Actinides”.

Participate in the 2007 NSDD meeting

Status:

- ANL staff continues participating in the IAEA-CRP on “Updated Decay Data Library for Actinides” and chaired the second IAEA-CRP meeting that was held in March 2007 at the IAEA Headquarter in Vienna.
- As a member of the US delegation, ANL staff participated in the activities of the 2007 international NSDD network meeting that was held in June 2007 in St. Petersburg, Russia.

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 participate in IAEA sponsored activities such as Workshops and Technical Meetings.

BNL Planned Activities:

Participate in IAEA-sponsored NRDC meeting in 2007.

Participate in NEA WPEC annual meeting in 2007.

Serve as coordinator of the WPEC Subgroup 23 on fission product neutron cross-section library.

Serve as coordinator of the WPEC Subgroup 24 on fast neutron cross-section covariances.

Status:

- The NNDC head participated in the meeting of the Network of the Nuclear Reaction Data Centers (NRDC) organized by the IAEA, Vienna in October 2007. He presented status report on the NNDC activities in reaction data (compilation, evaluation, dissemination).
- The NNDC head led the US team at the NEA Working Party on International Evaluation Cooperation (WPEC) meeting at Paris, France in April 2007. He presented a talk on the status of the ENDF/B library.
- P. Oblozinsky served as the coordinator of the WPEC Subgroup 23 that completed its work. The resulting neutron cross-section evaluations for 219 fission products were incorporated into the new ENDF/B-VII.0 library.
- M. Herman served as the coordinator of the WPEC Subgroup 24. The subgroup continues to study and compare different approaches to produce covariances in the fast neutron region.
- M. Herman continued to serve as the chairman of the IAEA Coordinated Research Program on the advanced version of the Reference Input Parameter Library, RIPL-3.

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 chair NEA/WPEC committees in covariance data, and international model code development cooperation. LANL will host visits by foreign scientists with international reputations to benefit from the exchange of information and ideas.

LANL Planned Activities:

Participate in NEA WPEC May 2007 meeting.

Participate in the International Program Committee to plan the next International nuclear data conference (ND2007), to be held in Nice, France, April 23-26, 2007.

Participate in relevant IAEA meetings.

Make latest version of NJOY data processing code available to the international community.

Status:

- LANL staff members participated in WPEC meeting in Paris, France in April 2007.
- Planned and participated in the International Conference on Nuclear Data for Science and Technology, Nice France

- Participated in IAEA Technical Meeting Nuclear Data for Advanced Systems –Fusion
- Upgrades to NJOY were released to the international NJOY data processing community.
- Collaborate with JAEA researchers to upgrade a covariance processing module, ERRORJ, as a part of the NJOY code system. The module was tested and merged into NJOY.
- Hosted key researchers and professors from IRMM Belgium, University of Milano Italy, CEA France, and JAEA Japan.

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

LBNL Planned Activities:

Participate in IAEA-NSDD 2007 meeting.

Participate in IAEA CRP on “Reference Database for Neutron Activation Analysis”.

Participate in new non-US evaluator training and mentoring as needed.

Status:

- Participated in IAEA-NSDD 2007 meeting in St. Petersburg, Russia.
- Participation in IAEA CRP on “Reference Database for Neutron Activation Analysis” continued.
- No training or mentoring of non-US evaluators was called for in FY2007.

McMaster – Continue participation in new evaluators training program.

McMaster Planned Activities:

Collaborate with new evaluators for ENSDF work.

Status:

- One evaluator from Oak Ridge center spent about 3 weeks at McMaster in May 2007 for collaborative work on ENSDF evaluation of A=58. This mass chain has been submitted. Work has also started on a preliminary level with a physicist at Panjab University in India, with evaluation of A=71 chain.
- Participated in the IAEA-NSDD 2007 meeting at St. Petersburg, Russia.

Nuclear Physics Databases (Report FY07)

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:

Database distributed to collaborators monthly.

Status:

- Database was updated on a weekly basis with newly published references.
- IAEA/NDS contributors were trained and a significant backlog was eliminated.
- Database updates were distributed monthly to external contributors. The NSR compiler and database manager left the NNDC, he was replaced by a new staff member and the activity continued smoothly without interruption.

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:

Update database as new data sets are received from McMaster University.

Status:

- Database updated as required, 368 new and 25 updated files were included.
- Database was distributed to the NSDD network once.

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:

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

Status:

- The ENSDF database was distributed in October 2006 and March 2007.
- 25 mass-chains, an additional 63 nuclides, and 2 data sets were received, processed and added to ENSDF in FY2007. Processing includes file checking, review and post-review checking.

D. Numerical Nuclear Data File (NuDat)

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

BNL Planned Activities:

Update NuDat database as necessary, about 10 times a year.

Status:

- The NuDat database was updated regularly.

E. Neutron Reaction Data Bibliography (CINDA)

The NNDC is responsible for 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 updated regularly.

BNL Planned Activities:

Update CINDA database with reference from cooperating centers (500 expected), to be done automatically from the CSISRS database.

Status:

- 555 new references were added following the new entries compiled to the CSISRS (EXFOR) database of experimental nuclear reaction data.

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, the file update and data exchange activities. The NNDC database is updated, after compilations are exchanged and checked by the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

BNL Planned Activities:

Update CSISRS with EXFOR with compilation from cooperating centers (500 expected).

Status:

- The CSISRS database was regularly updated using input from the cooperating data centers (555 new compilations/entries, corresponding to 3,108 reactions/subentries).

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. A new version of the library, ENDF/B-VII, will be assembled, tested and made available to users through a web interface linked to the relational database.

BNL Planned Activities:

Maintain ENDF discussion list to facilitate validation of the new ENDF/B-VII library.

Complete phase 1 testing of the ENDF/B-VII library.

Complete assembly and release of the ENDF/B-VII library.

Status:

- The ENDF discussion list, endf@lists.bnl.gov, was regularly maintained.
- Complete phase 1 testing of the ENDF/B-VII.0 library was performed. This was done for the beta3 (October 2006) testing version of the library that became the new ENDF/B-VII.0 library in December 2006.
- The new ENDF/B-VII.0 library was assembled and prepared for release and validation. The library contains a complete set of 14 sub-libraries, including the neutron sub-library with 393 evaluations and the photonuclear sub-library with 163 evaluations. The official release

of ENDF/B-VII.0 occurred on December 15, 2006. This is the first major release since 1990.

- Validation of the new ENDF/B-VII.0 library continued and the results are being collected on the NNDC web site.

H. Database Software Maintenance

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

BNL Planned Activities:

Re-write the selector generation program for NSR.

Status:

- Completion of this task has already been reported in the Annual Report FY06.

I. Database Systems Development

The multi-year effort to migrate the USNDP databases to a LINUX/SYBASE environment was completed in FY2004. Afterwards, several follow-up tasks needed 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:

Continue development of journal tracking database in support of NSR compilation

Continue development of java-based publication codes for ENSDF.

Develop new CSISRS web interface for users without specialized knowledge of ENDF.

Develop new ENDF web interface for users without specialized knowledge of ENDF format.

Status:

- The NSR journal tracking system was extended to cover additional journals.
- Development of java-base publication software for ENSDF was pursued under external contract. Preliminary results were obtained, but further work is needed to complete the project.

- No new development was made; the existing CSISRS web interface was extended and further modified to better serve non-ENDF users.
- The new ENDF retrieval and plotting interface, Sigma-1.0, was completed and released in April 2007. This interface offers ENDF data in a transparent way and its use does not require any prior knowledge of the ENDF-6 format.

IV. Information Dissemination (Report FY07)

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 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 web site. Other USNDP members also offer nuclear physics information through their web sites. These services require resources to maintain currency and improve performance.

ANL Planned Activities:

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

Status:

- The three web sites were maintained and periodically upgraded.

BNL Planned Activities:

- Improve NSR and ENSDF web interfaces.
- Maintain web interface to the ENDF database.
- Improve web interface for B(E2) and develop interface for double-beta decay.
- Replace Perl-based programs with Java versions.
- Improve reliability and cyber security of its web services by installing the latest version of the Apache/Tomcat servers and mod-jk2 connector software for a new dual web server system.
- Maintain currency of the CSEWG, USNDP and the NNDC web sites.

Status:

- Improved versions of the NuDat web interface (NuDat-2.3 and 2.4) were produced. NuDat continues to be by far the most popular product of the NNDC web service. In FY07, NuDat was responsible for as much as 57% data retrievals out of total of 1,380K retrievals served by the entire NNDC web service system.

- An improved version of the NSR database (NSR2) was developed and the interface was updated; the ENSDF interface was updated.
- The existing web interface for the ENDF database was maintained. The new ENDF retrieval and plotting system, Sigma-1.0, was developed and launched in April 2007.
- The web interface for B(E2) was maintained; the interface for double-beta decay was completed already in April 2006.
- Perl-based programs were largely replaced with Java programs.
- Reliability and cyber security of the NNDC web service was improved by adding a new public server.
- The currency of the CSEWG, USNDP and the NNDC web sites was maintained.

LANL Planned Activities:

Include access to new reaction and structure data evaluations supported by DOE/Nuclear Physics, via the T-16 web site.

Provide actinide ENDF/B-VII data via LANL web site for criticality data testing.

Status:

- The server was renewed to provide faster and more secure services to the users.
- The latest LANL evaluations were made available via our web site. This has been particularly important for the integral data testing community that is validating the preliminary ENDF/B-VII evaluations.

LBLN Planned Activities:

Maintain and update Active Server Pages enabling interactive searches of nuclear structure data, radioactive-decay data, neutron capture γ -ray data, x-ray data, atomic-mass data and Nuclear Science References as needed. Maintain web pages for fission data, nuclear systematics and nuclear science education.

Support the Isotope Explorer 2 and 3 software previously developed by LBNL.

Status:

- Maintained and updated existing web pages as needed and supported Isotope Explorer 2 and 3 and NSR search software.
- Worked with computer support personnel to enhance server security

LLNL Planned Activities:

Maintain LLNL Nuclear Data and Atomic Data Viewer.

Add search capability to the Nuclear and Atomic Data Viewer.

Extend the Nuclear and Atomic Data Viewer as per user requests.

Maintain and upgrade LLNL Computational Nuclear Physics web pages.

Status:

- Nuclear and Atomic Data System was maintained.
- A lack of manpower prevented the development of a search capability for the Nuclear and Atomic Data System.
- Computational Nuclear Physics web pages were reorganized and a new set of pages describing Physics Simulations tools were added.

ORNL Planned Activities:

Development and maintenance of our online software suite to convert nuclear data to astrophysical reaction rates and plot, manipulate, and share results online is at severe risk of termination

Efforts to regularly update nucastrodata.org html web pages is at risk of termination

Status:

- The **Computational Infrastructure for Nuclear Astrophysics**, online at **nucastrodata.org**, will serve as the software backbone for data processing and dissemination of a new international collaboration in nuclear astrophysics data. New workflow management tools are being developed for this effort. Additionally, new astrophysics simulations have been added to our online suite, and improved data handling has speeded up data access.

TUNL Planned Activities:

Continue to improve the TUNL web site and provide access to new information on $A = 3 - 20$ nuclei.

Continue to prepare new PDF and HTML documents of the most recent TUNL reviews.

Continue to provide PDF and HTML documents for FAS reviews for the $A = 3 - 20$ series.

Continue to provide General Tables to accompany the most recent TUNL reviews of the $A = 3 - 20$ series.

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.

Status:

- PDF and HTML files are online for *Fay Ajzenberg-Selove and TUNL reviews* for 1959-present. This year we added $A = 18 - 20$ (1959Aj76).
- Re-creation of PDF files for *Fay Ajzenberg-Selove and TUNL reviews* to provide the most current NNDC reference keys and to correct all errors found since the articles went to press is in progress. This year we re-created $A = 3 - 20$ (1981-present).
- Energy Level Diagrams are online for *Fay Ajzenberg-Selove and TUNL reviews* for 1959-present.

- Compiled information on Thermal Neutron Capture data for $A = 2 - 20$ nuclei is online.
- An effort to provide compiled information on beta-decay data for $A = 3 - 20$ nuclei is essentially completed.

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:

Effort is required to provide technical support to users as necessary.
Extend Comments/Questions option for all reaction databases.

Status:

- The use of the NNDC web service continued to grow. In FY07, the growth was 26% compared to previous year and the service provided total of 1,380K data retrievals.
- The NNDC staff responded to user inquiries by phone, email and web.
- Comments/Questions option was maintained for the reaction databases, CSISRS and ENDF, also for the whole NNDC web service as well as Nuclear Wallet Cards.

C. Publications

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

BNL Planned Activities:

Prepare twelve issues of Nuclear Data Sheets for publication
Investigate a publication of adopted levels and gammas of all nuclides in ENSDF in electronic form (web and CD-ROM).

Status:

- Twelve issues of Nuclear Data Sheets were published. Eleven issues were dedicated to ENSDF mass-chain evaluations and one issue was dedicated to the new ENDF/B-VII.0 library.
- The project to publish all adopted levels and gammas in ENSDF was discontinued in 2006.

V. Nuclear Structure Physics (Report FY07)

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 approximately 30% of the keywords. These will be checked and edited by BNL as necessary before being added to the database.

BNL Planned Activities:

Prepare entries for 4,100 new references with keyword abstracts for 2,200 of them.

Check and edit approximately 1,000 key-worded abstracts (Nucl. Phys. A, Eur. Phys. J. A, and Phys. Lett. B) prepared at the IAEA Nuclear Data Section.

Status:

- 4396 references, 2870 of them with keyword abstracts, from approximately 80 journals and several conference proceedings were added to the NSR database.
- IAEA/NDS staff members were trained to efficiently prepare keyword abstracts and were helped to eliminate a considerable backlog of approximately 600 references.

B. Compilation of Experimental Structure Data

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

BNL Planned Activities:

Compile BE(2) experimental data

Status:

- 23 new entries for 20 different nuclides were added to the BE(2) database.

McMaster Planned Activities:

Compile data sets (in ENSDF format) for current experimental nuclear structure publications on high-spin and low-spin physics.

Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database.

Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data. On a timely basis send a copy of all such private communications to NNDC for archival and distribution purposes.

Train a new undergraduate student in early 2007 for XUNDL compilation work.

Status:

- 368 new data sets from current journal publications in experimental nuclear structure (high-spin and low-spin) were compiled and sent to NNDC. Another 25 data sets were updated based on new papers from the same groups or authors as in data sets from earlier papers.
- One compiled data set was received this year from another data center.
- Throughout the year there were active communications with the original authors of the papers to resolve data-related problems and to obtain additional details of data that are useful to include in XUNDL and/or ENSDF databases.
- A new undergraduate student Scott Geraedts was trained in March-April 2007 to work during the year on XUNDL compilations. He will continue part-time work until about April 2009.

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 nucleus or group of related nuclei to deduce recommended values from the measured data and prepare a file in ENSDF format that will be the basis for a publication “*Nuclear Data Sheets*” and will be 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:

1.5 equivalent mass chains will be evaluated and published.

At least one mass chain will be reviewed.

Complete the horizontal evaluation on nuclear K-isomers and initiate drafting of a final publication.

Collaborate with evaluators from new evaluation centers.

Status:

- Two mass chains ($A=202$ and 206) were evaluated and submitted to NNDC for further processing.
- Two mass chains ($A=200$ and 201) were revised and published in *Nuclear Data Sheets*
- One mass chain ($A=208$) was reviewed.
- Work on the horizontal evaluation on K-isomers is continuing in collaboration with scientists from Australia. A talk on the subject was presented at the ND2007 conference in Nice, France and corresponding article was submitted for publication in the proceedings.

- Collaborations with evaluators from data centers in India, Bulgaria/UK and Australia continue.

BNL Planned Activities:

At least 5 equivalent mass chains will be evaluated.

At least 6 mass chains will be reviewed.

Continue mentoring of 3 new ENSDF evaluators.

Status:

- Includes three subcontracted part-time evaluators: C. Reich – Idaho, N. Nica - Texas A&M and E. Browne – LBNL
- 7 mass chains and 4 individual nuclides were evaluated and submitted, the NNDC share being 82 evaluated nuclides:
 - A = 45 (12 nuclides by Burrows)
 - A = 49 (13 nuclides by Burrows)
 - A = 96 (7 nuclides by Sonzogni, collaboration with D. Abriola)
 - A = 137 (16 nuclides by Browne and Tuli)
 - A = 162 (16 nuclides by Reich)
 - A= 221 (5 nuclides by Tuli, collaboration with A. Jain)
 - A = 230 (9 nuclides by Browne and Tuli)
 - ^{251}No , ^{255}Rf , ^{155}Ta , ^{159}Re (4 nuclides by Tuli and Reich)
- 6 mass chains were published in Nuclear Data Sheets:
 - A = 47 (Burrows)
 - A = 140 (Nica)
 - A = 162 (Reich)
 - A = 221 (Tuli, collaboration with A. Jain)
 - A = 234 (Browne & Tuli)
 - A= 236 (Browne)
- 7 mass chains were reviewed:
 - A = 55 and 104 (Tuli); 135 (Sonzogni); 140 (Burrows)
 - A = 106 and 200 (Reich); 196 (Browne)
- Mentoring of new evaluators continued (M. Gupta, N. Nica, D. Abriola, and S. Basu).

LBNL Planned Activities:

Evaluate the equivalent of at least 4 mass chains, including a minimum of one from the A=21-30 region.

Review mass-chain evaluations, as requested.

Participate in training and/or mentoring of new nuclear structure data evaluators, as needed.

Status:

- Submitted evaluations for 4 mass chains and one nuclide (a total of 45 nuclides, including 6 evaluated without Data Program support):
 - A=24 (Firestone; 8 nuclides)
 - A=81 (Baglin; 12 nuclides)

- A=169 (Baglin; 13 nuclides)
- A=187 (Basunia; 11 nuclides)
- ^{172}Hg (Baglin)
- Reviewed two mass chain evaluations (A=38 and 191)

McMaster Planned Activities:

1.5 equivalent mass chains (including one in the A=31-44 region) will be evaluated.

Mass chains will be reviewed as requested.

Update superdeformed-band data in ENSDF for new publications. All nuclides will be covered that do not require extensive updating and reevaluation for data sets involving low-spin or non-SD structures.

Collaboration with a new center/evaluator as part of mentoring process as needed.

Status:

- Three full-length mass chains (A=58, 151, 182) and 56 individual nuclides were evaluated and sent to NNDC for inclusion in ENSDF and mass-chain publication in Nuclear Data Sheets. A=58 was done in collaboration with the group in Oak Ridge, also as part of the training and mentoring process.
- A=24 from Berkeley center and 124 from the Japanese data center were reviewed.
- Two nuclides were updated for new super-deformed band data and revised data sets were sent to BNL for inclusion in ENSDF. We are current on the coverage of known superdeformed structures (SD bands) in the ENSDF database.
- One evaluator from Oak Ridge spent about 3 weeks at McMaster for collaborative work on ENSDF evaluation of A=58. This mass chain has been submitted. A new evaluator at McMaster for ENSDF work is undergoing training through collaborative work on A=31 mass chain. Preliminary work started on A=71 with a prospective new evaluator in India, a physics faculty member at Panjab University.

ORNL Planned Activities:

Complete evaluation of structure information for nuclei with A=248 and 246. Start evaluations of A=242 and 247 nuclei.

Status:

- A=208 evaluation completed and published
- A=201 and A = 202 evaluations were reviewed
- A=58 evaluation completed [collaboration with McMaster]
- Evaluation of levels in ^{19}Ne , ^{31}S completed
- Murray Martin has continued his training of post-doc Caroline Nesaraja in A-chain evaluations.

TUNL Planned Activities:

Prepare the ENSDF files corresponding to new publications in the “Energy Levels of Light Nuclei” series.

Status:

- The data file for A = 10 was accepted in ENSDF in early 2007.
- Work on A = 11, 12 ENSDF files is underway.
- TUNL's new post-doc is evaluating A=13 nuclei and preparing the ENSDF file.

D. Ground and Metastable State Properties

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

BNL Planned Activities:

Update database as new information becomes available.

Status:

- The database was updated twice during FY 2007.

E. Radioactive Decay Data Evaluation

Decay data for nuclides of importance for metrology are evaluated in an international collaboration. When complete, these evaluations are entered into the ENSDF format, merged 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:

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”. The data will be made available to ENSDF and DDEP databases. Reviews for selected isotopes will be performed, as requested.

Status:

- Evaluation of ^{246}Cm was completed and work on ^{206}Hg is near completion.
- Two nuclides (^{242}Am and ^{244}Am) were reviewed.

LBNL Planned Activities:

Coordinate and plan activities of this international collaboration.

Review the evaluations of about five radionuclides.

Status:

- Coordination and planning of the activities of this collaboration continued, but that work no longer receives any financial support from the Data Program.

McMaster Planned Activities:

Evaluate decay datasets for one or two radionuclides.

Status:

- Decays of six nuclides in ^{226}Ra chain were reviewed for DDEP.

F. Neutron-Induced γ -Ray Data Evaluation

The EGAF (Evaluated Gamma-ray Activation File) database, disseminated by the IAEA and maintained by LBNL, currently provides discrete-line prompt γ -ray information from thermal (n, γ) reactions in a format tailored to suit the needs of the neutron activation analysis community. However, it requires ongoing maintenance and development to make it more useful to the applied communities it serves. Statistical-model calculations can generate quasi-continuum photon cascade data to complement these experimental discrete-line data. Together, the experimental and calculated data will constitute a valuable resource required for updating the ENDF database. Additionally, delayed photon data need to be added to EGAF. The k_0 -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 k_0 values then need to be integrated into EGAF and, ultimately, made available to ENSDF evaluators.

LBNL Planned Activities:

Continue to maintain and develop EGAF database:

Continue collaboration with LLNL (see also Section VI.B) to perform statistical-model calculations of quasi-continuum γ -ray cascade information; in FY07, these calculations will be extended to the heavier elements. This project also includes supervision of a doctoral student at LLNL who is generating ENDF-format capture γ -ray datasets for use with MCNP and other transport-code calculations.

Add to EGAF the neutron-capture decay data produced in the course of participating in the IAEA CRP on "Reference Database for Neutron Activation Analysis"; in FY07, the evaluation of k_0 values should be finalized.

Add any new thermal (n, γ) data that become available, along with any total radiative-capture cross-sections derived from them.

Status:

- A paper was written and submitted to Phys. Rev. C describing statistical model calculations performed in FY05 for the Pd isotopes.
- A comparison of k_0 data from three sources was drafted and presented at the May 2007 meeting for the IAEA-CRP on "Reference Database for Neutron Activation Analysis".
- No updates of the EGAF database are publicly available yet.

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

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

TUNL Planned Activities:

Prepare “Energy Levels of Light Nuclei A=11 – 12” manuscript for publication in Nuclear Physics A.

Evaluate nuclei in the A=13-15 mass region in preparation for a future “Energy Levels of Light Nuclei, A=13-15” publication

Status:

- Evaluation of A = 12 nuclei is underway
- Evaluation of A = 11 nuclides is complete, updates are being carried out as work on A=12 continues; preprints for A=11 and 12 will be released simultaneously.
- Evaluation of A = 3 nuclides is essentially complete and the manuscript is in preparation.
- The TUNL post-doc is making progress in the evaluation of A=13 nuclides.

H. Nuclear Structure Data Measurement

ANL - ANL will devote a relatively small effort (0.1 FTE) to participate through collaborative agreements in experimental nuclear physics activities related to nuclear data. The emphasis will be on 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. This small effort will complement the main ANL evaluation activities and it will allow maintaining contacts with a broad range of nuclear data user communities.

ANL Planned Activities:

Complete decay data measurements on $^{244,245,246}\text{Cm}$ as a part of the ANL contribution to the IAEA CRP on “Updated Decay Data Library for Actinides”.

Status:

- Decay data measurements of ^{240}Pu and ^{246}Cm were completed, data were analyzed and results published in journals *Nuclear Instruments and Methods* and *Applied Radiation and Isotopes*. Data were also incorporated into IAEA-CRP formatted evaluations. A poster was presented at the ND2007 conference in Nice, France and corresponding article was submitted for publication in the proceedings.
- Experimental work on $^{243,245}\text{Cm}$ is essentially completed and the data analysis is in progress.
- Participated in collaborative nuclear structure and decay data activities at the Argonne ATLAS facility with notable contributions to studies of K-isomers in heavy nuclei (^{244}Pu , ^{248}Cm , $^{252,254}\text{No}$ and ^{256}Rf) and in deformed nuclei in the A~180 region. This work complements the evaluation activities of K-isomers that are carried out by the ANL nuclear data staff. Maintained important collaborative connections with RIA and GRETINA research communities, because of their vital importance to nuclear science in US.

LANL - LANL/LANSCE maintains a small program to measure nuclear decay information.

LANL Planned Activities:

Examine prompt gamma-ray emission data from neutron reactions on ^{130}Te and ^{100}Mo to search for previously unobserved transitions in these and other, nearby residual nuclei.

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

Status:

- Data have been taken for both ^{130}Te and ^{100}Mo .
- Isomer states of $^{203,205}\text{Tl}$, and high-spin states of ^{135}Xe were studied.
- The experimental results on gold were accepted by Phys. Rev. C for publication.
- Interaction with the evaluators for these nuclei continues.

LBNL - LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal (n, γ) data to supplement earlier elemental target measurements from which important information was either lacking (*e.g.*, data from low-abundance isotopes) or discrepant.

LBNL Planned Activities:

Investigate feasibility of (n, γ) measurements at thermal energies for ^{17}O and/or ^{18}O targets and initiate isotopic measurements for the noble gases.

Continue collaboration on study of ^{100}Tb decay; this is of interest because of the importance in reactor physics of the $^{99}\text{Tc}(n,\gamma)$ reaction.

Status:

- Several cross section measurements for separated-isotope targets of Li, B, C and N were completed during the prior FY at the Budapest reactor.
- The ^{100}Tc measurements were not pursued.
- Feasibility studies were performed to ascertain whether the LBNL neutron generator could be used effectively for 2.5 MeV neutron capture and/or scattering cross section measurements.

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:

Maintenance and upgrades for format changes as required.

Continuing development of ENSDF editor as well as Java versions of LOGFT, BrIcc, ALPHAD and FMTCHK

Status:

- Maintenance and upgrades were done on regular basis.

- The ENSDF editor was improved; version 2.0b of BrIcc was released; upgrades to ALPHAD, ENSDAT, FMTCHK, GTOL, PANDORA, and RULER were made.

VI. Nuclear Reaction Physics (Report FY07)

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:

Compile data from 200 charged particle and neutron reaction publications.

Status:

- Experimental cross-section data from 136 publications were compiled (100 charged-particle reaction papers and 36 neutron-induced reaction papers). This translates into 566 compiled individual reactions. In August 2007, the compiler left the NNDC causing reduced compilation productivity.

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 FY2006. 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.

ANL Planned Activities:

No work planned for FY2007.

BNL Planned Activities:

Respond to user needs for evaluated nuclear reaction data.

Collect and address users' feedback related to the ENDF library.

Work with LANL to complete upgraded evaluations for ENDF/B-VII, to be released in December 2005.

Develop methodology for providing covariance data, in the fast neutron region, to the next release of ENDF.

Status:

- The NNDC responded to user needs for evaluated neutron reaction data by supplying 70 new evaluations included in the new ENDF/B-VII.0 library.
- Users' feedback on the ENDF library continues to be collected and stored under the Validation section of the ENDF/B-VII.0 web page.
- NNDC worked closely with LANL, all evaluations were upgraded as necessary and included into the testing versions of ENDF/B-VII. The official release of the new ENDF/B-VII.0 library, initially planned for December 2005, was delayed by one year in order to allow more time for testing. The release occurred on December 15, 2006.
- The development of the covariance methodology continued, focusing on the method for theory-based estimates of massive amount of data. The method was used to produce estimates of neutron cross section covariances for 219 fission products in the fast neutron region (5 keV – 20 MeV) for nuclear criticality safety applications.

LANL Planned Activities: (Work mostly supported from other sources)

Upgrade the LANL ENDF evaluations for U, Pu, Am, Np isotopes that perform well in criticality benchmarks, considering new LANSCE experimental data.

Provide upgraded ENDF evaluated data files for charged-particle reactions having $A \leq 10$, including covariance data. Also study a problem on oxygen, which is reported by criticality benchmarks.

Assess ENDF evaluated data files for Ti and V, and upgrade the data if needed.

Submit the covariance data for important actinides (this is supported by many projects including AFCI, criticality safety, and also a WPEC collaboration).

Provide new delayed neutron data that include neutron spectra, yields, and delayed gamma-ray data.

Status:

- It was reported that the data for major actinides perform well in the critical assemblies. The new experimental data for the neutron capture on ^{237}Np were analyzed with the Hauser-Feshbach model calculations.
- The covariance data of light element standards were converted into the ENDF-6 format. The covariance data for the other elements are still under development.
- Covariance data for important actinides, including ^{233}U , ^{235}U , ^{238}U , and ^{239}Pu in the fast neutron region were produced and provided to GNEP, criticality safety, and WPEC collaborations.
- New delayed neutron energy spectra were provided for homeland security studies. A delayed-gamma simulation code was newly developed, which will be combined with transport simulation codes.

- Benchmark tests that include Ti data were investigated, and some problems in the resonance parameters were identified. Studies on V data are still underway.

LLNL Planned Activities: (work mostly supported from other sources)

- Produce new evaluations of Pu isotopes based on study of systematics in this mass range.
- First release of structure based data representation specification to nuclear data community.
- Develop predictive model for fission energy distributions. Compute fission fragment energies, gamma energy and multiplicity distributions both versus incident neutron energy.
- First principles calculations for $d(t,n)^4\text{He}$ and $^6\text{Li}(n,t)^4\text{He}$.
- Re-evaluate $d(n,2n)$.
- Produce ENDF files with the discrete and quasi-continuum gamma-ray spectra in collaboration with LBNL using data in the EGAF database.

Status:

- LLNL programmatic customers reprioritized the evaluation activities and requested that the Uranium isotopes be reviewed and improved rather than perform the Plutonium evaluations. So, the ENDF/B-VII.0 ^{236}U and ^{238}U evaluations were peer reviewed and ^{237}U was re-evaluated based on surrogate measurements.
- A structure based (XML) data representation for deterministic and Monte-Carlo processed data and the processing codes and access routines to generate and use this data are being developed at LLNL. The access routines are being tested currently by the GEANT collaboration in the GEANT4 transport code and by us in LLNL transport codes. The format specifications and the access routines will be released in FY08.
- The FREYA code for simulating fission fragment formation and decay is being developed in an LLNL/LBNL collaboration. This model is discussed in Section VI.E below.
- A combined *ab initio*/potential-model was used for the $d(t,n)^4\text{He}$ and $^6\text{Li}(n,t)^4\text{He}$ reactions. This approach is discussed in Section VI.E. While the calculation is predictive, the quality of the predictions do not match that available within the current evaluations based on R-matrix fits.
- The evaluation of the $d(n,2n)$ reaction is being postponed until the *ab initio* reaction code (discussed in Section VI.E) is extended to handle three-particle final states.
- In collaboration with LBNL, discrete and quasi-continuum gamma-ray spectra from the EGAF database has been added to the ^{19}F , ^{182}W , ^{183}W , ^{184}W , ^{186}W and ^{207}Pb ENDF evaluations. A Phys. Rev. C article on Pd is in press. One student (B. Sleaford) has received a Ph.D. based on this work.

C. ENDF Manuals and Documentation

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:

Maintain ENDF-6 format manual that is available on the web. This format is used for the ENDF/B-VII release.

Status:

- ENDF-6 format manual has been updated in accordance with the decisions of CSEWG. This format was used for the ENDF/B-VII.0 release.
- Modernization of the ENDF-6 format manual was initiated (translation from Word to LaTeX, introducing color and many modern features for browsing and navigation). New version of the manual is available in the draft form and is being reviewed.

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 objective of this task that can be most efficiently accomplished through international cooperation. A new international evaluation of the neutron cross-section standards was initiated by the CSEWG to provide the improved standards that are needed. This evaluation, which was recently completed, was performed largely by an IAEA Coordinated Research Project (CRP) with support, largely experimental in nature, through the NEA Working Party on International Evaluation Cooperation (WPEC) of the Nuclear Energy Agency and the CSEWG.

ANL Planned Activities:

No work planned for FY2007.

LANL Planned Activities:

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.

Incorporate the cross section standards into the new ENDF evaluations, and perform validation tests with integral measurements.

Develop a plan with LLNL for measurements of fission cross sections with very high precision and accuracy.

Continue the collaboration with NIST and Ohio University on the measurement of hydrogen elastic scattering angular distributions. This project should be brought to completion in FY07.

Status:

- Covariance data evaluation continues. Covariance data of light element standards were compiled into the ENDF-6 format to test the data processing with NJOY.
- Cross sections reported as a ratio to the standards were modified by using the final standards evaluations. Those results were included in the ENDF/B-VII evaluations.
- Absolute fission cross section measurement in design stage with LLNL and others.
- New measurements of hydrogen elastic scattering were performed at the neutron incident energy of 14.9 MeV.
- ${}^6\text{Li}(n,\alpha)$ measurements at LANSCE completed for neutron energies from 1 to 5 MeV Data given to evaluators

NIST Planned Activities:

- Participate in the IAEA data development project on maintenance of the neutron cross section standards so that standards will be available for future cross section libraries.
- Provide detailed documentation for the standards evaluation process.
- 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.
- Continue to recommend new measurements and perform examinations of the data from them for use in future evaluations of the standards.
- Complete the collaborative measurements with Ohio University and LANL on the measurement of hydrogen elastic scattering angular distributions.
- Continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. Also make these samples available for loan in physics experiments.
- Continue work on a measurement of the ${}^6\text{Li}(n,t)$ standard cross section standard at $\sim 4\text{meV}$ neutron energy using improved fluence determinations based on calorimetry, nu-bar of ${}^{252}\text{Cf}$ and α - γ coincidences with the ${}^{10}\text{B}(n,\alpha)\gamma$ reaction.
- Continue efforts to improve the ${}^3\text{He}(n,p)$ standard cross section using spin-dependent n- ${}^3\text{He}$ coherent scattering length work.

Status:

- Work has begun on the IAEA data development project on the following topics: updating of the standards database; investigating the prospect of an inelastic scattering cross section standard; considering adding additional standards energy ranges for the $\text{Au}(n,\gamma)$ cross section; 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; developing a procedure for improving the smoothing process for the $\text{Au}(n,\gamma)$ cross section. An IAEA Consultants meeting is planned for October 2008 to report on the progress made on these topics.
- A detailed IAEA Technical Report that describes the standards evaluation process was finished. This provides a complete source of documentation for the standards evaluation. An invited talk on this work was given at the ND-2007 conference.

- Work has continued on the documentation of changes to data files made by Wolfgang Poenitz. Efforts have been made to obtain more of Poenitz's files of corrections which were made to datasets used in the evaluation process.
- We continue to recommend new measurements and monitor the progress being made on standards experiments. New work has been done on the ${}^6\text{Li}(n,t)$ cross section at LANL and NIST; ${}^{10}\text{B}(n,\alpha)$ cross section work continues at IRMM; new measurements have been made by two separate groups at n-TOF of the ${}^{238}\text{U}(n,f)/{}^{235}\text{U}(n,f)$ cross section ratio.
- The collaborative work with Ohio University and LANL on the measurements of the hydrogen elastic scattering angular distribution at 14.9 MeV has been completed. Analysis of these data is now underway. A paper on this work was given at the ND-2007 conference.
- The National Repository for Fissionable Isotope Mass Standards continues to monitor samples and make them available for loan in physics experiments.
- Work continues at NIST on a measurement of the ${}^6\text{Li}(n,t)$ cross section standard at $\sim 4\text{meV}$ neutron energy. A paper on this work using neutron fluence determination based on α - γ coincidences with the ${}^{10}\text{B}(n,\alpha_1\gamma)$ reaction will be given at the ISRD-13 meeting in May 2008.
- Measurements are nearing completion of the spin-dependent n - ${}^3\text{He}$ coherent scattering length that will improve the ${}^3\text{He}(n,p)$ standard cross section.

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.

ANL Planned Activities:

No work planned for FY2007.

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 for homeland security applications. Close collaboration with LANL will continue focusing on validation of the fission models in EMPIRE and GNASH. Major effort will be 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 developed and tested.

BNL Planned Activities:

Release new version of the code EMPIRE with above-mentioned improvements.

Develop the first version of covariance module in EMPIRE for fast neutrons.

Status:

- The EMPIRE-2.19 version (originally released in March 2005) was continuously updated in the CVS repository. This version gradually became EMPIRE-3.0 that has not yet been officially released. An extensive paper on EMPIRE was written and accepted for publication in Nuclear Data Sheets
- The first version of the covariance module in EMPIRE for fast neutrons was extended to allow for theory-based estimates of covariance data for large amount of materials.

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, 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:

Calculate and interpret gamma-ray reactions measured with GEANIE at LANSCE. A FY07 area of research centers on neutron reactions on fission products including the noble gasses, xenon and krypton.

Collaborate with LANSCE experimentalists on the interpretation of new FIGARO measurements of prompt neutron spectra.

Measure the fission neutron spectrum from neutron-induced fission of ^{235}U and ^{238}U with the FIGARO array for incident neutron energies from 1 to 100 MeV.

Measure neutron radiative capture cross sections on radioactive nuclei at DANCE with the goal of deriving nuclear level densities for nuclei off stability from neutron capture resonances.

- Perform radiative capture calculations on Gd in support of DANCE detector capture measurements, and provide the Maxwellian averaged cross section to s-process study.
- Obtain information on nuclear level densities on more fission product nuclei through (n,x γ) and (n,n') reactions. Nuclides in the mass-90 and mass-140 regions will be studied.
- Extend the measurements of the fission neutron spectrum and $\bar{\nu}$ from neutron-induced fission of actinides with the FIGARO array for neutron energies from 1 to 100 MeV. We expect to study the target nucleus ^{239}Pu in collaboration with the CEA (France).
- Measure neutron-capture cross sections on radioactive nuclei at DANCE with the goal of deriving nuclear level densities for nuclei off stability from neutron capture resonances.
- Extend the Monte Carlo method to calculate the fission neutron spectrum to the other actinides, taking account of sequential neutron evaporation from fission fragments. The calculation will be compared with the Los Alamos model that is widely used for the prompt fission neutron spectrum evaluations.
- Develop a code to calculate the delayed neutron spectrum, including Los Alamos micro-macroscopic nuclear mass model.

Status:

- The calculation and interpretation of the $^{150}\text{Sm}(n,n')$ reaction have been completed. A soft-rotator model was employed to calculate the neutron transmission coefficients. A quantum mechanical calculation for the pre-equilibrium process improved an agreement with the GEANIE data.
- Measured fission neutron spectrum and multiplicity for incident neutrons from 1 to 200 MeV on ^{235}U , ^{238}U and ^{237}Np to test models including the Los Alamos Model.
- Measured neutron capture cross sections on ^{147}Sm (with ORNL - published) and ^{152}Eu (data analysis in progress).
- Radiative capture data of DANCE for ^{237}Np in the unresolved resonance region were analyzed by using deformed Hauser-Feshbach model calculations, and a Phys. Rev. C paper was submitted. Data analysis of Gd is also prepared.
- We have developed a new technique to calculate the width fluctuation correction for deformed nuclei based on the Kawai-Kerman-McVoy theory, which combines the coupled-channels model with the Hauser-Feshbach theory.
- Hartree-Fock-BCS model was applied to calculate the inelastic scattering process on fissile materials. The model developed is a fully quantum-mechanical one, without any adjustable parameters. This new model will be applied to analyze FIGARO experimental data.
- A new code to calculate the delayed neutron spectra was developed.

LLNL – The following description of LLNL activities was added for completeness during the preparation of the present Annual Report.

LLNL's nuclear reaction modeling efforts are focused on modeling fission, techniques suitable for the study of unstable targets, and on *ab initio* methods to study light ion fusion. Much of this work is used to perform data evaluations at LLNL.

LLNL Planned Activities:

No activities planned for FY 2007.

Status:

- A tool for the statistical event-by-event simulation of induced fission is being developed in collaboration with J. Randrup of the LBNL Nuclear Theory Group. This tool is named Fission Reaction Event Yield Algorithm (FREYA). FREYA makes it possible to study correlations in fission observables in some detail. This model is currently being tuned to match experimental data and should be integrated into transport codes in the next year or two.
- In order to be able to extract cross sections for neutron-induced reactions on unstable targets from Surrogate experiments, LLNL is developing the theory relevant to the planning and interpretation of such experiments. The primary focus is on taking into account the spin mismatch between the Surrogate and desired reactions and on testing approximations to the full Surrogate approach.
- The Nuclear Theory & Modeling Group has been developing an *ab initio* framework to describe both the low-lying structure of light nuclei as well as their reactions. This effort has the promise to provide a truly microscopic theory for reactions involving light nuclei with broader capability than other competitive methods. Current efforts are based on a groundbreaking effort to couple the *ab initio* no-core shell model (NCSM) to the resonating-group method (RGM) technique to arrive at a completely new *ab initio* approach that is capable of describing simultaneously deeply and weakly bound states, clustering effects, resonance states, and reactions on light nuclei. A powerful feature of this formalism is that it based on the fundamental interactions between nucleons using effective interaction theory and, being *ab initio*, is parameter free. Recently, the first phase shift results for neutron scattering off ^3H , ^4He and ^7Li and proton scattering off $^3,4\text{He}$ and ^7Be using realistic nucleon-nucleon potentials have been obtained.
- As a predecessor to the above fully *ab initio* reaction theory, a combined *ab initio*/potential-model approach with microscopic bound-state wave functions and potential-model scattering wave functions was developed. This approach was used to calculate the S-factors of the d-t reaction and of the capture reactions important for astrophysics.

TUNL – USNDP funding for the development of preequilibrium nuclear reaction models, as well as the improvement and benchmarking the computer code PRECO was discontinued several years ago. Work continues at a much-reduced pace based on the priorities and time availability of the investigator.

TUNL Planned Activities:

No activities planned for FY 2007.

Status:

- DOE funding for this activity was discontinued. PRECO-2006 was released to the public.

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.

BNL – We are responsible for compilation of nuclear reaction data within the USNDP. It is very important for compilers to maintain an active contact with data producers so that they have up-to-date knowledge of measurement procedures and techniques including their advantages and drawbacks along with understanding of data uncertainties. This goal can be best achieved by taking part in nuclear data measurements. BNL will do so by devoting a relatively small effort, 0.1 FTE, to collaboration primarily with the LANSCE data measurement program at LANL.

BNL Planned Activities:

Participate in (n,n'γ) and fission neutron spectrum measurements at FIGARO at LANSCE.

Participate in the Lead-Slowing Down Spectrometer measurements on ultra-small targets, such as ^{235m}U(n,f), at LANSCE.

Status:

- This activity was cancelled as the NNDC staff left BNL.

LANL -- Nuclear data for fission products are important for a number of applications. This task is related to the evaluation activity described in Section VI.B.

LANL Planned Activities:

Measure and analyze prompt neutron emission following interactions of fast neutrons with fission products in the mass-90 and mass-140 regions. These measurements are gated on gamma rays from (n,n'γ) reactions.

Measure the fission neutron spectrum and $\bar{\nu}$ from neutron-induced fission of ²³⁹Pu with the FIGARO array for neutron energies from 1 to 100 MeV. Collaborators include scientists from CEA (France).

Measure prompt gamma rays from neutron interactions with stable noble-gas elements, xenon and krypton with the goal of deducing partial reaction cross-sections.

Measure the neutron capture cross-section of $^{241,243}\text{Am}$ at DANCE for neutron energies less than 200 keV.

Measure the neutron-induced fission cross-section of ^{240}Pu and ^{242}Pu up to $E_n = 200$ MeV.

Status:

- Neutron emission from natural barium and molybdenum measured at LANSCE/FIGARO in coincidence with gamma rays to deduce (n,n') emission spectra from isotopes. Data being analyzed.
- Measured fission neutron spectra for $^{239}\text{Pu}(n,f)$ with CEA (France) scientists at LANSCE/FIGARO. Incident neutron energy from 1 to 200 MeV. Measured $^{235}\text{U}(n,f)$ concurrently. First preliminary results now available.
- Measurements at LANSCE/GEANIE on ^{136}Xe completed and published; new transitions discovered
- Measured neutron capture cross sections of $^{241,243}\text{Am}$ for neutrons below 200 keV at LANSCE/DANCE. Data presented at workshop. Publication in preparation.
- Measured the neutron-induced fission cross-sections of ^{240}Pu and ^{242}Pu up to $E_n = 200$ MeV. Data given to evaluators. Results presented at international conference. Publication in preparation.
- Measured $^{152}\text{Eu}(n,\gamma)$ cross section for astrophysics at LANSCE/DANCE. Data being analyzed.
- Other measurements made include neutron capture on $^{94,95}\text{Mo}$ (with NC State, published), $^{151,153}\text{Eu}$ (with LLNL, report written), ^{151}Sm , $^{203,205}\text{Tl}$, $^{240,242}\text{Pu}$ (preliminary data presented at conference), and ^{242m}Am (preliminary data presented at workshop).

LLNL – N Division at LLNL performs measurements in support of various laboratory applications with NNSA and other funding. Most of this work is done in collaboration with other laboratories (e.g. LANL, LBNL and TUNL) and with university collaborators supported through the Stockpile Stewardship Academic Alliance program (e.g. Yale, Univ. Richmond, etc.). The evaluation activity discussed in Section VI.B is grounded in these measurements.

LLNL Planned Activities (work completely supported from other sources):

Neutron induced reaction measurements on one or more isomer targets.

Perform surrogate (n,n'), (n,2n), (n, γ) and (n,f) measurements on several nuclei with programmatic and/or astrophysical importance.

Perform neutron capture measurements with DANCE array at LANSCE in collaboration with LANL.

Perform fission cross-section measurements with the Lead Slowing Down Spectrometer at LANSCE in collaboration with LANL.

Status:

- Measurements of (n, γ) and (n,f) on the isomer target ^{242m}Am were performed at the DANCE array at LANSCE. This work will be reported in FY08.
- ^{237}U (n,f), (n,2n) and (n, γ) measurements using surrogate technique were produced. The (n,f) result was published in Phys. Rev. C and results from all three measurements were used in the ^{237}U evaluations from LANL and LLNL.
- The surrogate reaction method relies on an understanding of the spin matching of the desired compound state and the one actually encountered in the experiment. Using $^{235}\text{U}(^3\text{He},^4\text{He})$ and $^{238}\text{U}(^3\text{He},^4\text{He})$ as a surrogate for $^{233}\text{U}(n,f)$ and $^{236}\text{U}(n,f)$, this spin matching was investigated and found to be important and incompletely compensated for in the experimental analysis. Results were published in Phys. Rev. C.
- The ^{241}Am (n,2n) reaction was measured at TUNL and found to be in excellent agreement with the GNASH predictions used in ENDF/B-VII.0 evaluation.
- LLNL has led and participated in neutron capture cross section measurements using the DANCE array at LANSCE and the experiments were fielded for the stable Eu and several Gd isotopes. The data analysis for Eu is complete and for Gd in progress.

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:

No activities planned for FY2007.

Status:

- Studies of structure of states above the long-lived isomer in ^{186}Re that are of relevance to the $^{187}\text{Re}/^{187}\text{Os}$ cosmo-chronometer continued. Cross section measurements were initiated at the TUNL facility in collaboration with the local nuclear data group. Modeling of the isomer production and destruction cross sections is continuing.
- Participated at the joint JINA/CARINA collaboration meeting on nuclear data compilations for astrophysics modeling that was held in Trento, Italy. Chaired the atomic masses and decay data working group, and presented an assessment of the nuclear structure and decay data needs for astrophysics applications.

BNL Planned Activities:

No activity planned for FY2007.

Status:

- The NNDC used the opportunity offered by the fact that many new evaluations of neutron cross sections of interest to astrophysics were included in the new ENDF/B-VII.0 library. The NNDC calculated Maxwellian averaged cross sections (MACS) and astrophysics reaction rates for all reactions of interest. The related web interface that includes comparisons with other evaluated libraries is under completion.

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:

Continue N-N analysis to energies above 50 MeV and provide evaluated n-p capture cross sections, rates, and covariance data.

Complete the re-analysis of $^{10}\text{B}+n$ reaction, using a re-constructed set of experimental data including covariance.

Complete neutron-rich fission barrier calculations, using new and improved multidimensional macro-micro fission model.

Improve neutron capture models to provide capture cross sections for nucleosynthesis network calculations.

Provide neutron capture cross sections on important s-process branching point nuclei.

Status:

- Extension of the N-N analysis up to 200 MeV was not completed, but covariance data were prepared in the ENDF-6 format.
- Covariance data for $^{10}\text{B}+n$ was extracted from R-matrix calculation.
- Axial-asymmetry shape-degree of freedom was included in the macroscopic-microscopic code.
- Hartree-Fock BCS nucleon capture model was developed, and the sensitivity of the calculated results on the effective interaction was investigated. We applied the model to calculate the proton capture on the odd nuclei, and compared with experimental data. Neutron capture cross sections for tin isotopes were calculated with some different effective interactions.

McMaster University – Activities at McMaster will terminate on June 30, 2006.

McMaster Planned Activities:

No work was planned for FY2007 due to loss of funding for this effort. Work restarted in October 2007 with the increased renewal grant, the plan and status will be discussed in FY-08 report.

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

ORNL Planned Activities:

Complete evaluations of proton capture on ^{17}O and the $^{17}\text{O}(p,\alpha)^{14}\text{N}$ reaction for red giant stars.

Continue assessments of capture reactions on p-rich unstable nuclides.

Extract spectroscopic information on nuclei near the $N=82$ closed shell – ^{131}Sn and ^{133}Sn - from transfer reaction measurements on radioactive Sn nuclei.

Status:

- Paper published on evaluation of $^{17}\text{O}(p,\alpha)^{14}\text{N}$ and resonant levels in ^{18}F crucial for understanding element burning in red giant stars; this is part of a Ph.D. thesis for a graduate student.
- Paper published on evaluation of $^{18}\text{F}(p,\alpha)^{15}\text{O}$ and $^{18}\text{F}(p,\gamma)^{19}\text{Ne}$ reactions and 28 resonant levels in ^{19}Ne & ^{19}F crucial for understanding novae and X-ray bursts.
- Paper published on an evaluation of sixty-six ^{31}S levels in the $^{30}\text{P}(p,\gamma)^{31}\text{S}$ reaction relevant for novae; this work was part of a successful Ph.D. dissertation.
- Paper published on single-neutron excitations in ^{83}Ge , ^{85}Se , and the $^{82}\text{Ge}(n,\gamma)^{83}\text{Ge}$ and $^{84}\text{Se}(n,\gamma)^{85}\text{Se}$ reactions in the r-process in supernovae. Spectroscopic factors, ANCs, energies, and neutron widths were determined.

H. Reaction Data for RIA Target Design

Rare Isotope Accelerator facility design 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:

We aim to maintain important collaboration connecting with RIA 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 RIA planning community via participation in RIA meetings and workshops.

Status:

- Nucleon capture process was modeled based on a microscopic nuclear structure model, which allows us to predict nucleon-nucleus interactions on unstable nuclei.

Appendix A

Nuclear Data Activities Funded from Sources Outside the Nuclear Data Program (Report FY07)

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

1. Elsevier supports the production of computer-generated photo-ready copy of manuscripts for the Nuclear Data Sheets.
2. DOE Nuclear Criticality Safety program, funded by DOE NNSA, supports the NNDC consultant services and its data development work on estimates of neutron cross section covariances for large number of fission products.

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. Nuclear weapons (ASCI 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. AFCI (Advanced Fuel Cycle Initiative). 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 3 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. SciDAC (Scientific Discovery through Advanced Computing). This funding supports advanced nuclear reaction modeling based on microscopic nuclear structure theory (universal nuclear energy density functional).

LBL – LDRD funding for a project on the measurement of cross sections for advanced fuel cycles provided partial support for one of our structure evaluators, enabling retention of evaluation capability while addressing laboratory research priorities. Analysis of $^{238}\text{U}(^3\text{He},\text{tf})$ cross section data measured in collaboration with LLNL and University of Richmond was completed, and LBNL provided the lead author on the resulting paper submitted to Phys. Rev. C. This reaction serves as a surrogate for the $^{237}\text{Np}(n,\text{f})$ reaction which is of relevance to Advanced Fuel Cycle data needs. The work benchmarked the experimental procedures at LBNL using a previously-measured reaction, with a view to employing the surrogate reaction technique to obtain vital (n,f) cross section data for cases where direct experimental measurements are not feasible. USDOE Low-energy Nuclear Physics funds provided about 0.3 FTE support for ENSDF mass chain evaluation already mentioned in this report.

LLNL – NNSA supports most of the LLNL nuclear data activities. Slightly more than half of the support goes to nuclear data evaluation, nuclear data processing and nuclear data validation. The rest of the support is used for nuclear theory and modeling development.

McMaster – The nuclear data effort receives 0.5 FTE support from the Canadian research agency to evaluate A-chains/nuclides for ENSDF and to train/supervise summer students for compilation of experimental nuclear structure data for XUNDL

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 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.

Appendix B

USNDP Organization (Report FY07)

Coordinating Committee

1. P. Oblozinsky, BNL, chair
2. D. Brown, LLNL
3. A. Carlson, NIST
4. A. Chen (B. Singh), McMaster
5. R. Clark (C. Baglin), LBNL
6. T. Kawano, LANL
7. J. Kelley, TUNL
8. F.G. Kondev, ANL
9. M. Smith, ORNL

Working Groups

- Nuclear Structure and Decay Data (chair C. Baglin, LBNL)
- Nuclear Reaction Data (chair T. Kawano, LANL)

Task Forces

- Nuclear Data for Astrophysics (chair M. Smith, ORNL)
- Nuclear Data for Homeland Security (chair D. Brown, LLNL)