U.S. Nuclear Data Program

Work Plan for FY2010

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Introduction (Work Plan FY2010)

The work plan described in this document has been developed to cover work to be done by the United States Nuclear Data Program (USNDP) during fiscal year 2010 that begins on October 1, 2009. Previously, **10 work plans** have been prepared for the data program covering fiscal years 2000 - 2009. This plan has been prepared in consultation with the members of the Coordinating Committee who represent the organizations participating in the program. Each Coordinating Committee member prepared a draft plan for his/her organization. Each contribution was integrated into a unified work plan. The draft plan was then circulated to the Coordinating Committee for comments and corrections before the final document was submitted to the Department of Energy.

As was the case in the work plan for FY2009, the tasks proposed by the various organizations were reviewed internally according to the following criteria which were developed considering the mission and goals outlined in past review panel reports and oversight committee discussions, and in consultation with the DOE program manager.

1. A task should meet one of the three program priorities:
    a) Maintenance & update of information in the USNDP nuclear physics databases
    b) Improvement in dissemination of the information contained in those databases
        to the user community
    c) Modernization of data evaluation software used by the program participants
2. A task should be useful to at least one major user community
3. A task should not duplicate effort within or outside the program

The plan is divided into six major components. Specific tasks have been assigned to one of these components. They are as follows:

    I.   NNDC Facility Operation
    II.   Coordination
    III.   Nuclear Physics Databases
    IV.   Information Dissemination
    V.   Nuclear Structure Physics
    VI.   Nuclear Reaction Physics

The following section details the proposed work plan for FY2010, defining tasks, organizational responsibilities, and planned activities. It is envisioned that this document will serve as the basis for a performance review at the end of fiscal year 2010. Incorporated in the NNDC plan is a group of subcontracted external scientists, including nuclear structure evaluators and compilers.

The major challenge for the USNDP is the volatile funding situation. Thus, in FY06 we lost 6.6% of funding, followed by solid 14.6% increase in FY07 and by modest increase of 2.2% in FY2008. The numbers in FY2009 Presidential budget for DOE-SC nuclear data program are encouraging (+6.0%), yet, given an overall situation and in the light of the current DOE-SC projections we continue to be conservative and assume flat-flat budget in the current fiscal year. In this spirit also the **present Workplan was prepared for the flat-flat FY2010 scenario.**

The impact on the program is discussed below. Table 1 summarizes the US Nuclear Data Program budget and metrics for previous years and provides projections for the current year FY2009 and for FY2010.

Tab.1. Summary of the US Nuclear Data Program funding and metrics for FY 2001 – 2010, with metrics for FY2009 and FY2010 representing projections.

Fiscal Year	USNDP Funding	Change	Compi-lations	Evalu-ations	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	72	59	42
2006	$5,099K	-6.6%	4,936	318	1,863	47	60	48
2007	$5,841K	14.6%	5,355	366	2,239	40	56	51
2008	$5,967K	2.2%	5,104	385	2,996	48	72	68
2009*	$5,967K	0.0%	5,000	360	3,600	45	60	55
2010**	$5,967K	0.0%	5,000	340	4,000	40	55	50

*) Projections for the current Continuing Resolution and assumed overall flat-flat scenario; President's Budget for FY09 is $6,325K representing 6.0% increase.

**) Flat-flat scenario adopted in the present document. FY2010 DOE-SC Guidance assumes an increase to $6,601K plus $1,603K new money for Advanced Fuel Cycle, $8,204K in total.

A comment should be made on the nuclear data activities for Advanced Fuel Cycle (AFC). In response to the renewed interest in nuclear energy applications the President's Budget for both FY2007 and FY2008 included $1mil for AFC, but these funds were never approved. The President's Budget FY2009 continues in this trend and proposes $2,066K for AFC. In FY2010 the DOE-SC Guidance assumes $1,603K for AFC.

Fig.1. USNDP budget and scientific permanent FTE with projections prepared in February 2007.
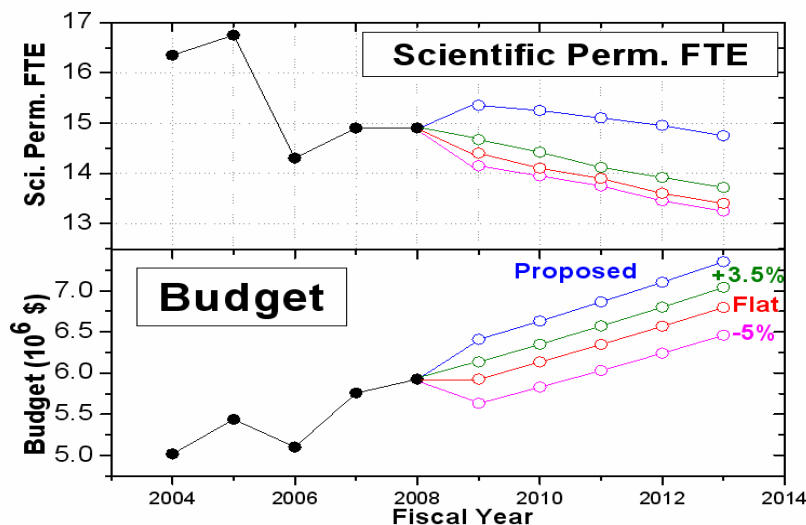
Our major challenge that we are facing is the trend of continuing decline in the scientific permanent staff. This has already been observed in the past as shown in Fig.1 and continues to be true today. We are making this point with a considerable urgency again.

It should be noted that three laboratories, LBNL, LLNL and NIST, warn that their participation may cease in future if the budgetary situation does not improve. Individual laboratories foresee the following **impact** in FY2010 and beyond:

- **BNL.** The NNDC staffing situation continues to deteriorate. At the end of FY2005, the NNDC lost 1 FTE of scientific permanent staff due to budget cut in FY2006. In the FY2008, we lost another 1 FTE scientific permanent staff in the nuclear reactions activities. Under FY2010 flat-flat scenario this loss will become permanent. Such decline in permanent scientific staff already has negative impact on the ENDF evaluation effort and ENDF support activity. In an attempt to mitigate these recent losses, the nuclear reactions compilation work has been outsourced. In spite of all effort to maintain the quality of the nuclear databases and services, deterioration is inevitable. Another consequence is increased need for exceptionally flexible and skilled staff, with broad capabilities always concentrated in one person, spanning from compilation skills, evaluation expertise, database management and web application development capabilities. The painful truth is that such nuclear physics scientists, with very few exceptions, either do not exist or are not available to join gradually declining data program.

- **ANL**. The anticipated flat-flat FY2010 funding would allow maintaining 1 FTE staff effort at ANL.

- **LANL.** The proposed FY2010 budget would allow the LANL nuclear data evaluation group to hire a new Post-Doc, although the Post-Doc will be largely supported from funds other than the nuclear data program. This situation may cause a slight reduction in LANL scientific activities as well as other DOE programs that require high quality nuclear data in near future.

- **LBNL**. In FY2009, 1 FTE of evaluation effort was funded by LBNL from sources outside of the Data Program. This support will no longer be available in FY2010. In addition, the two remaining LBNL evaluators are expected to retire in the next three years. Support for the LBNL evaluation effort has fallen from ~5 FTE ten years ago to ~2 FTE currently. Without funding to support the third FTE evaluator in FY2010 we will be forced to consider ceasing LBNL participation in the USNDP after FY2012.

- **LLNL**. **LLNL**. The anticipated flat-flat budget scenario for FY2010 has caused us to postpone all non-evaluation tasks planned in our Field Work Proposal as the current funding level barely covers 0.36 FTE of effort. We view our evaluation effort as the core of our participation in the USNDP, however if the budget situation does not

improve, even this effort will be curtailed and LLNL will most likely not be able to participate in the USNDP further.

- **McMaster.** In the current grant from July 1, 2007 to June 30, 2010, total DOE personnel supported is 1.6 FTE (0.6 FTE permanent staff and 1.0 FTE temporary: post-doctoral fellow). Division of work is ~1.35 FTE for nuclear structure work and ~0.25 FTE for nuclear astrophysics work. In addition there is some partial support for undergraduate student. In December 2009, we plan to apply for renewal of grant for the next 3-year period (July 1, 2010 to June 30, 2013), thus beyond June 30, 2010, our work plan depends on the successful outcome of this application. In the scenario of flat-flat budget for FY2010, some of the compilation activity may be curtailed. It is anticipated that 0.4 FTE support from Canadian research agency (NSERC) for nuclear structure evaluation will continue in FY2010 and beyond.

- **NIST.** The NIST Neutron Cross Section Standards effort would have to be discontinued if DOE funding is stopped. Maintaining this work is important for future standards evaluations that are the basis for cross section libraries. NIST resources that provide leverage to the DOE funding for this work are contingent on DOE support.

- **ORNL.** The ORNL Nuclear Data Project recently transitioned a long-term postdoc into a permanent Staff position for A-chain evaluations and evaluations of reactions for astrophysics. This move was based on guidance from DOE and favorable budget projections for an increase in our program in FY2010 and beyond. In a flat budget scenario, ORNL will lose this position, and will also lose a full time programmer required to enable the Computational Infrastructure for Nuclear Astrophysics to keep serving nuclear data to the research community. Both of our core areas – astrophysics studies and A-chains – are at risk in flat budget scenarios.

- **TUNL.** The nuclear modeling effort (0.4FTE) at TUNL lost the funding in FY07. Expected recovery of the funding in FY2009 and FY2010, still below the FY2005 level, would allow increase in the ENSDF evaluation effort.

Work Plan Tasks and Planned Activities (Work Plan FY2010)

I. NNDC Facility Operation (Work Plan FY2010)

A. <u>Management</u>

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

> **BNL Planned Activities:**
> Manage the NNDC facility.

B. <u>Library</u>

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 data evaluation effort.

> **BNL Planned Activities:**
> Maintain the NNDC library.

C. <u>Computer Operations</u>

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

Over several years the NNDC has been developing and continues to develop new web applications for users of the NNDC web service. These applications often require considerable increase in demand for computer power. In view of this, regular upgrades of the NNDC computer system are necessary. After completion of major upgrade in April 2004, the NNDC is working on another upgrade that should be completed in the second half of FY2009.

> **BNL Planned Activities:**
> Scan and remediate regularly vulnerabilities on NNDC servers and clients to ensure compliance with DOE cyber security requirements
> Provide computer support to the NNDC staff and its visitors as necessary.
> Maintain the NNDC computer system, including database servers and web servers.

II.   Coordination (Work Plan FY2010)

A. <u>National Coordination</u>

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

ANL -- Chair the Covariance Committee of the Cross Section Evaluation Working Group.

> **ANL Planned Activities**:
> Organize and chair the CSEWG Covariance Committee.

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

> **BNL Planned Activities:**
> Prepare FY2011 work plan for USNDP in time for spring 2010 FWP submittals.
> Organize mini-CSEWG meeting, in spring 2010, devoted to preparations of ENDF/B-VII.1 library release.
> Organize and chair CSEWG Meeting at BNL in November 2009.
> Organize and chair USNDP Meeting at BNL in November 2009.
> Edit and publish electronic summary reports of the CSEWG and USNDP meetings.
> Edit and publish electronic USNDP Annual Report for FY2009.
> Maintain CSEWG and USNDP websites.

LANL -- Chair U.S. Nuclear Data Program's Nuclear Reaction Working Group and to 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 2009.
> Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2009, and help coordinate Homeland Security, and Astrophysics Task Forces.

LBNL – Coordinate the joint LBNL/LLNL Neutron Capture Gamma-ray Library project. Chair the USNDP Nuclear Structure and Decay Data Working Group.

> **LBNL Planned Activities:**
> Plan coordinated LBNL/LLNL efforts to develop a Capture Gamma-ray library for ENDF.
> Serve on the USNDP Coordinating Committee and chair the NSDD Working Group Meeting at the FY2010 USNDP Meeting in November 2009.

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

> **LLNL Planned Activities**:
> Organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.

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 2009.
> Communicate current efforts and future plans with researchers in nuclear astrophysics data.
> Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data.
> Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.
> Discuss future plans in nuclear astrophysics data with DOE, with USNDP/NNDC, with JUSTIPEN (for collaborations with Japan), and with other agencies and organizations.

B. <u>International Coordination</u>

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

> **ANL Planned Activities**:
> Participate in the 2010 DDEP meeting.
> Provide a lecturer at the IAEA/ICTP organized nuclear structure data workshop.

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 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/ICTP-sponsored activities such as Workshops and Technical Meetings.

   BNL Planned Activities:
   Participate in the IAEA-sponsored NRDC meeting in 2010.
   Participate in NEA WPEC annual meeting in 2010.
   Attend major ND2010 conference in April 2010, in Korea.
   Provide lecturer(s) to the IAEA/ICTP workshops on nuclear structure and nuclear reaction data (if organized).
   Coordinate development of the EMPIRE nuclear reaction model code and make it available to the international community.

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

   LANL Planned Activities:
   Participate in NEA-WPEC 2010 meeting.
   Participate in relevant IAEA CRP meetings (FENDL).
   Participate in the International Conference on Nuclear Data for Science and Technology (ND2010) - April 26-30, 2010 in Jeju, Korea.
   Participate in the International Advisory Committee to help organizing Second International Workshop on Compound Nuclear Reaction and Related Topics (CNR*09), October 5-8 2009 in Bordeaux, France.
   Make latest version of NJOY data processing code available to the international community.
   Host a couple of international visitors to LANL to collaborate on the evaluation of reaction data.

LBNL – Lead the IAEA Coordinated Research Project on a Database for Neutron Activation Analysis. Maintain and develop the LBNL/IAEA Evaluated Gamma-ray Activation File (EGAF). Lead neutron cross section measurement efforts at the Budapest Reactor. Edit and coordinate efforts of the Decay Data Evaluation Project (DDEP).

   LBNL Planned Activities:
   Coordinate the final report of the IAEA CRP on a Database for Neutron Activation Analysis.

Manage the EGAF database.

Lead new σ_0 and σ_γ measurements at the Budapest Reactor.

Edit new DDEP evaluations.

McMaster – Represent the Canadian effort in nuclear structure and decay data evaluation at the International network NSDD operating under the auspices of the IAEA.

McMaster Planned Activities:

Participate in the evaluation policy matters related to the NSDD network.

Participate in training/mentoring of new ENSDF evaluators through collaborative work, especially with the new emphasis on the participation of prospective ENSDF evaluators from Europe.

III. Nuclear Physics Databases (Work Plan FY2010)

The National Nuclear Data Center archives and maintains number of nuclear physics databases. Archival is of critical importance, the NNDC having sole responsibility for preserving these databases in the United States. Maintenance includes regular activities such as updating of databases, processing of new evaluations including QA activities and distribution to collaborators and other data centers as applicable. The NNDC is devoting effort to database software maintenance as well as to database development to ensure that use is make of recent advances in the area of database management.

The NNDC database portfolio includes several major databases (NSR, XUNDL, ENSDF, NuDat, CSISRS, ENDF as well as the recently developed SIGMA) and a few smaller ones (such as MIRD and CINDA).

A. <u>Nuclear Science References</u> (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 falls under Nuclear Structure Physics.

> **BNL Planned Activities:**
> Database distributed to collaborators monthly.

B. <u>Experimental Nuclear Structure Data</u> (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 maintains, updates, and distributes the database as new/revised data sets are received from McMaster.

> **BNL Planned Activities:**
> Update database as input is received from McMaster.

C. <u>Evaluated Nuclear Structure Data File</u> (ENSDF)

The NNDC is responsible for the ENSDF, a database of evaluated experimental nuclear structure and decay data. The NNDC is responsible for format and content checking, preparation of manuscript, and the 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.

D. Numerical Nuclear Data File (NuDat)

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

> **BNL Planned Activities:**
> Update NuDat database as necessary, about 10 times a year.

E. Experimental Reaction Data File (CSISRS)

The NNDC is responsible for maintaining the CSISRS database at BNL. This database contains experimental nuclear reaction data for incident energies below 1 GeV, including neutron-induced reactions and reactions with incident charged particles of mass $A \leq 12$. Many groups worldwide compile experimental data and send it to the central database in Vienna in the EXFOR format. Then, each is responsible to update its own database. The effort described here includes quality control, file update and data transfer activities. The NNDC database is updated, as compilations are exchanged and checked from the compiling centers. The compilation activity is given under Nuclear Reaction Physics.

> **BNL Planned Activities:**
> Update CSISRS with EXFOR compilations from cooperating centers (500 entries expected). The NNDC compilation work can be found under Nuclear Reaction Physics, chapter V of the present document.

F. Evaluated Nuclear Data File (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The work is organized under the Cross Section Evaluation Working Group (CSEWG), coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident charged particles and photons are also included. The data are stored in the ENDF format developed at NNDC in early 1970-ties, and adopted as an international standard. In addition to

the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally.

New evaluations for the next release of the library, ENDF/B-VII.1, will be assembled, tested and made available to users through a preliminary ENDF/A web interface.

> **BNL Planned Activities:**
> Maintain ENDF discussion list to facilitate validation of the new ENDF/B-VII.0 library.
> Establish and maintain cooperative development site (GForge) for collecting and maintaining new evaluations submitted for future release of the ENDF/B-VII.1 library.
> Perform phase1 testing of all new evaluations for the ENDF/B-VII.1 library.

G. Evaluated Neutron Reaction Data (SIGMA)

This is new database introduced in 2007 with the idea to support development of the new NDC interface of the identical name. Sigma should facilitate quick and transparent retrieval and visualization of evaluated neutron data including cross sections and covariances.

> **BNL Planned Activities:**
> Maintain the database by including new evaluations such as the new RUSFOND library.

H. Other Databases (MIRD, CINDA)

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

> **BNL Planned Activities:**
> Maintain MIRD database as necessary.
> Contribute to CINDA by compiling experimental cross section data to the CSISRS database (100 compiled papers expected).

I. Database Software Maintenance

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

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

J. 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 to be performed.

A new database along with web interface called Sigma has been developed to facilitate the retrieval of evaluated reaction data from ENDF libraries along with experimental data from the CSISRS library by non-ENDF users, such as nuclear astrophysicists. This database focuses on the class of users who do not posses specialized knowledge of complex ENDF-6 format. Sigma-1.0 version released in 2007 allowed for basic retrieval and plotting of cross sections. The subsequent SIGMA-2.0 version, released in April 2008, provided for plotting angular distributions and spectra of emitted neutrons, as well as photon spectra, and mathematical operations on cross sections. New features will be added step-by-step, including plots of correlated energy-angle distributions, visualization of covariance data and calculation of thermal constants.

BNL Planned Activities:
  Effort needed to maintain Linux/Sybase database system.
  Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).

IV.   Information Dissemination (Work Plan FY2010)

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. <u>Web Site Maintenance</u>

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 the Linux operating system and using the Apache Tomcat and Sybase server software. This solution was made public in April 2004 and has proven to be secure, fast and to have minimum downtime. Most of the databases were redeveloped to take advantage of the new hardware possibilities as well as new programming technologies, such as the use of the Java and Java scripts languages. In FY 2005 this system was upgraded from a single web server to dual web server system. This upgrade significantly increases reliability of the system. The NNDC also maintains the Atomic Mass Data Center website. Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

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

BNL Planned Activities:
Improve NSR and ENSDF web interfaces by modernizing their visual appearances.
Maintain web interface to the ENDF database.
Implement and maintain GForge web cooperative development server for collecting, storing, versioning and distributing ENDF/B-VII.1 candidate evaluations.
Improve Sigma web interface by adding new and extended features following user's requests.
Maintain web interface for double-beta decay.
Improve reliability and cyber security of the NNDC web services by installing the latest version of Apache/Tomcat servers and mod-jk connector software for a new dual web server system.
Maintain currency of the CSEWG, USNDP and the NNDC web sites.

LANL Planned Activities:

Include access to new reaction and structure data evaluations, supported by DOE/Nuclear Physics, via the T-2web site.

Provide actinide ENDF/B-VII data via LANL web site for criticality data testing, together with other LANL evaluations (e.g., light nuclei reactions).

LBNL Planned Activities:

Maintain Isotopes Project existing web pages and begin search for a new site in anticipation of shut down of LBNL web services by FY2012.

LLNL Planned Activities:

Maintain LLNL's Nuclear and Atomic Data Viewer.

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

Maintain and upgrade LLNL's Computational Nuclear Physics web pages.

ORNL Planned Activities:

Continued development and maintenance of our online software suite to convert nuclear data to astrophysical reaction rates and plot, manipulate, and share results online; this activity, utilized by researchers in over 70 institutions in 20 countries, is at risk of termination.

TUNL Planned Activities:

Continue to improve the TUNL website 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.

Develop web page to provide compiled and evaluated data on particle decay of unstable ground states.

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 required to provide technical support to users as necessary.
Maintain Comments/Questions option for all reaction databases, for the NNDC web service and for 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.
Prepare special issue of Nuclear Data Sheets on neutron reaction data, with two extensive papers, on the Reference Input Parameter Library and on Neutron Cross Section Standards.
Prepare publication of the new version of Nuclear Wallet Cards.

V. Nuclear Structure Physics (Work Plan FY2010)

A. <u>NSR Abstract Preparation</u>

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

BNL Planned Activities:
Prepare entries for about 3,500 new references, and keyword abstracts for 1,800 of them.
Perform QA including checking and editing of approximately 300 key-worded abstracts for three European journals prepared at the IAEA Nuclear Data Section.
Perform QA including checking and editing of key-worded abstracts from other collaborators as applicable and necessary.

McMaster Planned Activities:
Prepare key-wording of publications in Phys. Rev. C, approximately 1,000 references a year. Draft versions will be prepared by undergraduate students working under supervision of B. Singh.

B. <u>Compilation of Experimental Structure Data</u>

This activity involves compilation of recently published or completed experimental nuclear structure data for inclusion in XUNDL. The compilation is done by McMaster, while the NNDC is maintaining the database. In FY2009, ANL plans to start contributing to compilation effort.

ANL Planned Activities:
Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database.

BNL Planned Activities:
Compile new BE(2) experimental data.
Compile new $\beta\beta$-decay experimental data.
Maintain, update and distribute XUNDL.

McMaster Planned Activities:
Compile data sets (in ENSDF format) for current experimental nuclear structure publication. The websites of prominent journals in nuclear physics will be scanned regularly for new papers.
Compile recent papers on measurement of atomic masses and send compilation to online service at `www.nuclearmasses.org`.

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 for XUNDL compilation work.

C. Data Evaluation for ENSDF

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

ANL Planned Activities:
Evaluate 1 mass chain.
Review mass chain evaluations, as requested.
Collaborate with scientists from other NSDD network centers on data evaluation projects.

BNL Planned Activities:
At least 6 equivalent mass chains will be evaluated.
At least 6 mass chains will be reviewed.
Continue mentoring new ENSDF evaluators.

LBNL Planned Activities:
Evaluate the equivalent of at least 3 mass chains and several additional isotopes of particular interest to current research.
Evaluate ENSDF format neutron capture gamma-ray datasets as part of the EGAF effort.
Work towards incorporating DDEP decay datasets into the ENSDF file.
Mentor new efforts in nuclear structure evaluation proposed at LLNL.
Review Nuclear Data Sheets publications.

McMaster Planned Activities:
3.5 equivalent mass chains (including the A=31-44 region and the data for new nuclides as mentioned below) will be evaluated.
Mass chains will be reviewed as requested.
Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides.

Train a new evaluator at McMaster for ENSDF evaluations, who will join as post-doctoral fellow in summer 2009.
Collaboration with a new center/evaluator as part of mentoring process, as needed.

ORNL Planned Activities:
Complete evaluation of structure information for one mass in A=241-249 region.
Review one mass chain evaluation.

TUNL Planned Activities:
Prepare the ENSDF files corresponding to new publications in the "Energy Levels of Light Nuclei" series.

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.

E. Radioactive Decay Data Evaluation

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

ANL Planned Activities:
Evaluate two radionuclides for the DDEP collaboration.
Review of selected nuclides for the DDEP collaboration, as requested.

McMaster Planned Activities:
Evaluate or review decay datasets for one or two radionuclides.

LBNL Planned Activities:
Coordinate and edit DDEP decay evaluations.
Evaluate the EGAF activation data files.

F. Neutron-Induced γ-Ray Data Evaluation

The Evaluated Gamma-ray Activation File (EGAF) database was developed by LBNL as part of an IAEA Coordinated Research Project. It continues to be maintained by LBNL and is disseminated by both the IAEA and LBNL. EGAF contains discrete-line γ-ray cross sections

(σ_γ) from prompt and delayed (n,γ) reactions and total radiative thermal neutron cross sections (σ_0). It is available in both ENSDF and tabular formats that satisfy the needs of many nuclear applications. EGAF datasets are comparable to ENSDF (n,γ) datasets with the critical difference that the data are given as absolute cross sections, based mainly on new measurements at the Budapest Reactor, rather than relative gamma ray intensities. The first version of EGAF was published in *Database of Prompt Gamma Rays from Slow Neutron Capture for Elemental Analysis*, IAEA STI/PUB/1263, 251 pp (2007).

LBNL has joined with LLNL to prepare EGAF-based ENDF format capture gamma-ray datasets. These datasets require the addition of continuum gamma ray data which can be derived from statistical model calculations and benchmarked by comparison with the EGAF experimental cross section feedings determined to low-lying levels. This evaluation procedure has been validated for the Palladium isotopes and was published in Physical Review C77, 054615 (2008). LLNL is developing automated procedures to optimize the input parameters to the statistical model calculations and accelerate the evaluation process. Byproducts of these calculations include new insights into ENSDF nuclear structure properties which are constrained by the statistical model calculations and a new generation of σ_0 values that will be included in EGAF and published in the literature as they become available. The LBNL/LLNL collaboration capitalizes on the long history of nuclear structure evaluation at LBNL, a long history of reaction evaluation and application at LLNL, and the close proximity of the two institutions that allows us to work together efficiently. The collaboration began as the thesis project of LLNL PI Brad Sleaford performed under the supervision of LBNL PI Richard Firestone and demonstrates the efficacy of joint projects between the nuclear structure and reaction communities. Colleagues at the Budapest Reactor collaborate with the LBNL/LLNL collaboration to measure new prompt and delayed neutron capture σ_γ data with their neutron beam and NAA facilities. This collaboration provides an experimental capability to resolve data discrepancies and determine missing information.

LBNL Planned Activities:
Maintain and develop the Evaluated Gamma-ray Activation File (EGAF).
Continue to evaluate data for the EGAF activation file.
Complete the IAEA/LBNL comparison of σ_0 values derived from k_0 measurements of the NAA community, σ_γ measurements at the Budapest Reactor, and s0 values compiled in the CSISRS database and evaluated by S. Mughabghab in the Atlas of Neutron Resonances (Elsevier, 2006). Recommended σ_0 values will be included in EGAF.
Continue LBNL/LLNL development of methods to use statistical model calculations in conjunction with EGAF experimental data to produce "complete" ENDF format capture gamma-ray data sets and derived σ_0 values. New ENDF capture gamma-ray datasets will be evaluated and σ_0 results will be published in refereed journals.
Extend the EGAF file to include experimental σ_γ data for fast and high-energy neutrons.
Develop procedures to include continuum gamma ray data in EGAF.
Measure σ_γ cross sections at the Budapest Reactor.

LLNL Planned Activities (supported from other sources):
> Continue LBNL/LLNL collaboration developing EGAF: Continue to develop toolset to automate the evaluation of EGAF experimental data using statistical model calculations. Working with LBNL, develop rigorous methods to evaluate the data and build them into toolset.

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

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

> **TUNL Planned Activities:**
>> Prepare *"Energy Levels of Light Nuclei, A = 13 - 15"* manuscript for publication in *Nuclear Physics A*.

H. Nuclear Structure Data Measurement

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

> **ANL Planned Activities:**
>> Participate in nuclear structure research activities at ANL with main emphasis on decay studies of neutron-rich fission products of relevance to reactor decay heat and astrophysics applications, and spectroscopy of heavy actinide nuclei.
>> Complete analyses of 243Cm and 237Np decay data and publish the results.

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

> **LANL Planned Activities:**
>> Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on Iridium isotopes to search for previously unobserved transitions in these nuclides
>> Interact with mass chain evaluators on the nuclear structure of these nuclei.

LBNL – Gamma-ray cross sections σ_γ will be measured in collaboration with scientists at the Budapest Reactor. These data are included in the EGAF database and made available to ENSDF evaluators for the normalization of (n,γ) datasets. This research has been funded by the IAEA and US-Hungarian joint research support. LBNL continues to participate in other research important to the nuclear physics community as opportunities arise.

> **LBNL Planned Activities:**
> Publication of new σ_0 values for isotopes with Z<20 and selected heavier isotopes.
> Investigation of systematic half-life discrepancies.

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:**
> Maintain and upgrade ENSDF checking and physics programs for format changes as required.

VI. Nuclear Reaction Physics (Work Plan FY2010)

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 experimental data from 100 charged particle and neutron reaction
> publications.

B. ENDF Evaluations

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

> **ANL Planned Activities**:
> No work planned for FY2009.

> **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 on upgraded evaluations for future release of the ENDF/B
> library (version VII.1).
> Improve methodology for providing covariance data, in the resonance and the
> fast neutron regions, to the next release of ENDF.

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

Upgrade the LANL ENDF evaluations for actinides that perform well in criticality benchmarks, considering new LANSCE experimental data.

Provide upgraded ENDF evaluated data files for light elements, including covariance data. Nuclear reaction data on ^{16}O will be studied to understand discrepant feedback from thermal nuclear reactor community.

Finalize V data including covariances, for which problems in the criticality benchmarks are reported.

Submit the updated covariance data for light elements (this is supported by many projects including criticality safety, AFC, and also a WPEC collaboration).

Perform new evaluations of prompt fission neutron spectrum data for several actinides.

LBNL Planned Activities:

Collaborate with LLNL to provide EGAF data and evaluate nuclear structure data for the generation of a new ENDF capture gamma ray library.

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

Perform new evaluations as per LLNL customer requests and submit these and other LLNL generated evaluations into ENDF.

Continue to develop toolset to build ENDF library from DICEBOX/CASINO statistical model calculations. Collaborate with surrogate LLNL/LBNL surrogate reactions group to validate models for continuum gammas and higher incident energy neutrons. Collaborate with LBNL to supplement EGAF capture gamma ray experimental data with statistical model calculations to provide complete ENDF sections, and combine with latest ENDF evaluations and submit them to NNDC.

Continue collaborating with LBNL to develop the event-by-event fission spectrum simulation tool FREYA: add 2nd and 3rd chance fission, extent parameter tuning for 239Pu(n,f) above the 2nd chance threshold, produce new 235U(n,f) and 238U(n,f) fission neutron spectrum.

Continue development of structure-rich (XML) data representation for deterministic and Monte-Carlo processed data and extend format to encompass ENDF unprocessed data formats.

C. ENDF Manuals and Documentation

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

BNL Planned Activities:

Maintain ENDF-6 formats manual that is available on the web. This format is used for the ENDF/B-VII (as well as the future ENDF/B-VII.1) library.

D. <u>Nuclear Reaction Standards</u>

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, which was initiated by the CSEWG, was recently completed. The work was performed largely by an IAEA Coordinated Research Project (CRP) with support from the NEA Working Party on International Evaluation Cooperation (WPEC) of the Nuclear Energy Agency and the CSEWG. It is important to improve the standards database and procedures for evaluations in preparation for new evaluations of the standards.

ANL Planned Activities:
   No work planned for FY2010.

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.
   Complete report on the measured cross sections for the standards reaction ^{6}Li(n,α) in the MeV region together with an R-matrix analysis of these and literature data.
   Study covariance data evaluation for the standards in a different technique when the R-matrix analysis gives extremely small uncertainties.
   Complete report on H(n,p) angular distribution standards measurements at 15 MeV with Ohio University and NIST. Begin experiment on H(n,n) angular distribution for improving the standard at several neutron energies.
   Complete the analysis and evaluation of the ^{56}Fe(n,xγ=847 keV) cross section and angular distribution as a reference cross section for (n,xγ) measurements.

NIST Planned Activities:
   Complete work on a journal publication of the International Evaluation of the Neutron Cross Section Standards.
   Work on action items from an IAEA Consultant's Meeting on the data development project Maintenance of the Neutron Cross Section Standards. This includes updating of the standards database, investigation an inelastic scattering cross section standard and other items listed in INDC(NDS)-0540.
   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 and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.

Continue an experiment using neutron detection (instead of proton detection) to measure the H(n,n) angular distribution in collaboration with Ohio University and LANL. Investigate use of a time projection chamber for angular distribution measurements.

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.

Complete fluence determinations and obtain initial measurements of the ^{6}Li(n,t) standard cross section at ~ 4 meV neutron energy using an improved fluence determination based on α-γ coincidences with the ^{10}B(n,α$_1$γ) reaction.

Submit cross section standards for inclusion in the WPEC High Priority Request List.

E. <u>Nuclear Model Development</u>

This task covers activities such as development and validation of nuclear reaction models used for prediction of nuclear reaction cross sections. The two major codes are GNASH (LANL) and EMPIRE (BNL). Measurements made by ANL and LANL along with other measurements made with DOE low-energy physics funds will play a crucial role in the validation of the models in these computer codes. BNL and LANL will also participate in the IAEA Coordinated Research Project RIPL-3 to improve accuracy and reliability of input parameters used in nuclear reaction calculations

BNL – We are active in nuclear reaction model development focusing on the BNL code EMPIRE. The work in this fiscal year will concentrate on further extensions and improvements of its capabilities, including a new version of the Monte-Carlo pre-equilibrium model with extended capabilities. The work on validation of the code will be actively pursued, in particular in relation to emerging requirements of homeland security applications. Close collaboration with LANL will continue focusing on validation of the fission models in EMPIRE and GNASH and developing default inputs for actinides. Major effort is dedicated to the development of capabilities for estimating covariance data for resonance region and fast-neutron cross sections, in response to the needs from many user groups (such as Gen-IV reactors, criticality safety, Advanced Fuel Cycle Initiative).

BNL Planned Activities:
Release new version of the code EMPIRE with above-mentioned improvements.

Employ the improved version of the covariance module in EMPIRE for fast neutrons in ENDF/B-VII.1 evaluations.

Test the new resonance module allowing generating covariances utilizing information from the Atlas of Neutron Resonances and employ it for ENDF/B-VII.1 evaluations.

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

LANL Planned Activities:
Perform neutron inelastic scattering and fission-neutron spectrum measurements with the FIGARO array. Correlate new ^{56}Fe(n,$x\gamma$) data from GEANIE with ^{56}Fe(n,xn) data from FIGARO.

Improve the techniques to measure the fission-neutron spectrum for fission induced by neutrons of 0.4 to 200 MeV on ^{235}U and ^{239}Pu. The shape of the major part of the emission spectrum between 0.3 and 10 MeV will be determined in this experiment, performed in collaboration with CEA and LLNL researchers, and will be compared with the Los Alamos model prediction. The modeling includes the Monte Carlo prompt neutron emission technique and the microscopic quantum mechanical pre-equilibrium calculations.

Perform radiative capture calculations on Gd and Tm isotopes, and investigate the enhancement factor of neutron capture rate on the excited nuclei, which supports s-process nucleo-synthesis and DANCE detector capture measurements.

Perform (n,xn) calculations for fission products with several nuclear reaction codes (GNASH, TALYS, and EMPIRE), in collaboration with CEA (France).

Develop a new code to simulate the decay of compound nucleus using the Monte Carlo technique to identify correlations between neutron and gamma.

Modern nuclear structure models, such as Hartree-Fock, will be applied to calculate nuclear reaction cross sections to reduce phenomenological model parameters.

Study neutron-induced fission of ^{239}Pu at low-excitation energies when the target is in its excited state. Because the half-life of the state is extremely short, theoretical prediction is crucial.

LLNL/LBNL – Development and automation of the DICEBOX statistical model code in collaboration with Milan Krticka (Charles University, Prague). DICEBOX produces a simulated neutron capture decay scheme based on user selected level density and gamma ray strength models. Capture gamma ray spectra are generated by the Monte Carlo method with DICEBOX which can be normalized to experimental cross sections from the EGAF file. Multiple DICEBOX simulations can be performed to determine a statistical uncertainty in the calculation based on fluctuations in the decay scheme. DICEBOX is a powerful tool in determining the continuum contribution to the ENDF capture gamma ray datasets.

> **LBNL Planned Activities**:
> No activities planned under USNDP in FY2010.

> **LLNL Planned Activities**:
> No activities planned under USNDP in FY2010.

TUNL – Ongoing work involves the development of preequilibrium nuclear reaction models, as well as the improvement and benchmarking of the computer code PRECO. The unique strengths of this program are its ability to describe reactions with complex particles in the exit and/or entrance channel, and the comprehensive nature of the state densities, which contain the effects of shell structure, the pairing interaction and isospin conservation.

> **TUNL Planned Activities:**
> DOE funding for this activity has been discontinued.

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 the compilers to maintain 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 an understanding of data uncertainties. This goal could be best achieved by taking part in nuclear data measurements, such as LANSCE at LANL.

> **BNL Planned Activities:**
> No activities planned for FY2010.

LANL Planned Activities:

Measure and analyze prompt neutron emission following interactions of fast neutrons with fission products such as strontium. These measurements are gated on gamma rays from (n,n'γ) reactions.

Complete data analysis for gamma-ray output from neutron-induced fission of ^{235}U, ^{238}U, and ^{239}Pu for neutron energies from 1 to 100 MeV. Collaborators include scientists from CEA (France).

Design an experiment to measure that part of the fission neutron spectrum that lies below 1 MeV.

Complete analysis of gamma-ray production for neutrons on krypton isotopes that are fission products with the goal of deducing partial reaction cross sections.

Measure the neutron capture cross-section of ^{242m}Am at DANCE for neutron energies less than 200 keV.

Measure the neutron capture and fission cross sections of ^{239}Pu at DANCE for energies less than 200 keV.

Measure the neutron capture cross-section at DANCE for at least one radioactive isotope of importance to nuclear astrophysics.

LBNL – The Isotopes Project has an ongoing program to measure neutron capture gamma ray cross sections σ_γ at the Budapest Reactor. These measurements provide a direct determination of the total neutron cross sections σ_0 for light nuclei and an indirect determination of s0 when combined with DICEBOX statistical model calculations of missing continuum decay. These results are included in the EGAF database and published in the refereed literature. This research has been funded by the IAEA and US-Hungarian joint research support. The Isotopes Project also collaborates on LBNL/LLNL surrogate reaction cross section measurements at the 88" Cyclotron's Liberace facility.

LBNL Planned Activities:

Publication of new σ_0 values for isotopes with Z<20 and selected heavier isotopes.

Participation in surrogate reaction cross section measurements at the LBNL Cyclotron Liberace facility.

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.

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:
Complete work on ^{186m}Re, which is of relevance to the ^{187}Re/^{187}Os cosmo-chronometer, including measurements and modeling of the production and destruction cross-sections of the ^{186m}Re isomer (in collaboration with TUNL).
Compile and evaluate nuclear structure and decay data for neutron-rich fission fragments, produced at the CARIBU facility (ANL), that are of relevance to r-process modeling.

BNL Planned Activities (largely done by guest scientist not funded by USNDP):
Perform systematic evaluations of neutron capture cross sections in the energy region of interest for nuclear astrophysics (neutron unresolved resonance region). Produce Maxwellian averages of these data.
USNDP support of this work will be limited to including the evaluations in appropriate databases and to providing data dissemination.

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.
Improve neutron capture models to provide neutron capture rates off-stability to s-process hydro-dynamics simulations.
Provide fission decay widths of actinides off-stability based on the microscopic/macroscopic model at LANL for r-process network calculations.
Study neutron capture rate for the exited state by using the Hauser-Feshbach statistical theory.

McMaster -- The evaluation of reaction rates relevant to nuclear astrophysics data will continue to complement our on-going experimental program of measurements of radiative capture cross sections and particle-transfer experiments using radioactive ion beam facilities at TRIUMF, NSCL, RIKEN, Yale and ANL.

McMaster Planned Activities:

Specifically, we will evaluate the ^{19}Ne(p,γ)^{20}Na and ^{29}P(p, γ)^{30}S reaction rates. The former plays an important role in breakout from the hot-CNO cycle in x-ray bursts, while the latter is a key reaction in nova nucleosynthesis.

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

ORNL Planned Activities:

Continue assessments of capture reactions on p-rich unstable nuclides that are important for novae and X-ray bursts. The nuclei to be studied are those planned for measurements at ORNL's Holifield Radioactive Ion Beam Facility.

Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANCs) on nuclei near the N=82 closed shell from transfer reaction measurements on radioactive neutron-rich unstable nuclei. This information is important for modeling the r-process in supernovae.

I. Reaction Data for RIA Target Design

The Facility for Rare Isotope Beam (FRIB) 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 connections with the FRIB community because of its importance in nuclear science, but effort is limited because of budget restrictions. However, we will continue to maintain a presence in the FRIB planning community via participation in FRIB meetings and workshops.

Table 2: USNDP Staffing Table in FY2010

Workplan FY 2010	ANL Sci Per	ANL Sci Tem	BNL Sci Per	BNL Sci Tem	BNL Tec Adm	LANL	LBNL Sci Per	LBNL Sci Tem	LLNL	McMaster Sci Per	McMaster Sci Tem	NIST	ORNL Sci Per	ORNL Sci Tem	TUNL Sci Per	TUNL Sci Tem	Program Total Sci Per	Program Total Sci Tem	Program Total Tec Adm	Total
I. NNDC Facility Operation	**0.00**	**0.00**	**0.35**	**0.00**	**1.55**	**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**	**1.55**	**1.90**
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					0.15												0.00	0.00	0.15	0.15
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**	**0.20**	**0.00**	**0.05**	**0.00**	**0.00**	**0.00**	**0.05**	**0.00**	**0.00**	**0.00**	**1.40**	**0.00**	**0.00**	**1.40**
National Coordination			0.35			0.10	0.10		0.05				0.05				0.65	0.00	0.00	0.65
International Coordination	0.05		0.30			0.30	0.10										0.75	0.00	0.00	0.75
III. Nuclear Physics Databases	**0.00**	**0.00**	**1.05**	**0.00**	**1.40**	**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**	**1.40**	**2.45**
Nuclear Science References, NSR			0.10		0.60												0.10	0.00	0.70	0.70
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, CSISRS			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**	**0.05**	**1.00**	**0.60**	**0.00**	**1.80**	**1.00**	**0.25**	**3.05**
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						0.05	1.00	0.60		1.55	1.00	0.00	2.55

Table 2: USNDP Staffing Table in FY2010, cnt'nd

Workplan FY 2010	ANL Sci Per	ANL Sci Tem	BNL Sci Per	BNL Sci Tem	BNL Tec Adm	LANL	LBNL Sci Per	LBNL Sci Tem	LLNL	McMaster		NIST	ORNL Sci Per	ORNL Sci Tem	TUNL Sci Per	TUNL Sci Tem	Total Sci Per	Total Sci Tem	Total Tec Adm	Total
V. Nuclear Structure Physics	**0.90**	**0.00**	**2.90**	**1.20**	**0.00**	**0.10**	**1.60**	**0.00**	**0.00**	**0.60**	**0.80**	**0.00**	**0.30**	**0.15**	**0.85**	**0.50**	**6.25**	**2.65**	**1.00**	**9.90**
NSR Abstract Preparation			0.70							0.05							0.75	0.00	0.00	0.75
Compilation of Exper. Structure Data	0.05									0.15							0.20	0.00	0.00	0.20
Eval. of Masses & Nuclides for ENSDF	0.55		1.75	1.20			1.00			0.38	0.80		0.30	0.15	0.45	0.25	4.43	2.40	0.00	6.83
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.							0.50										0.50	0.00	0.00	0.50
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**	**0.75**	**0.80**	**0.00**	**1.40**	**0.10**	**0.00**	**0.31**	**0.00**	**0.20**	**0.20**	**0.20**	**0.00**	**0.00**	**0.00**	**3.10**	**1.00**	**0.00**	**4.10**
Experimental Data Compilation				0.35													0.00	0.35	0.00	0.35
Neutron Data				0.10																
Charged Particle Data				0.20																
Photonuclear Data				0.05																
ENDF Manuals and Documentation			0.10														0.10	0.00	0.00	0.10
ENDF Evaluations			0.40	0.35		0.20			0.31								1.00	0.35	0.00	1.35
Nuclear Reaction Standards						0.10						0.20					0.30	0.00	0.00	0.30
Nuclear Model Development			0.20	0.10		0.50											0.70	0.10	0.00	0.80
Nucl. Reaction Data Measurements						0.30	0.10										0.40	0.00	0.00	0.40
Astrophysics Nuclear Data Needs	0.05		0.05			0.30						0.20	0.20				0.60	0.20	0.00	0.80
Reaction Data for RIA Target Design																	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**	**0.00**	**6.65**	**2.00**	**3.20**	**2.00**	**2.00**	**0.00**	**0.36**	**0.60**	**1.00**	**0.20**	**0.60**	**1.15**	**1.45**	**0.50**	**13.95**	**4.65**	**4.20**	**22.80**
Staff Supported by Other Funds			0.35	0.70	0.20	14.60			7.50	0.40		2.80	0.60	1.00			**26.05**	**1.70**	**0.20**	**27.95**
TOTAL STAFF	**1.00**	**0.00**	**7.00**	**2.70**	**3.40**	**16.60**	**2.00**	**0.00**	**7.86**	**1.00**	**1.00**	**3.00**	**1.20**	**2.15**	**1.45**	**0.50**	**40.00**	**6.35**	**4.40**	**50.75**