

USNDP Fiscal Year 2001 Final Report



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I. Introduction

This report summarizes the work of the U.S. Nuclear Data Program (USNDP) for the period of October 1, 2000 through September 30, 2001. In March 2000, the participants of the program prepared and published a work plan for the fiscal year 2001. A mid-year addendum was prepared and distributed in April 2001.

This report consists of activity summaries for the major components of the U.S. Nuclear Data Program that were prepared by the chairs of the USNDP Working Groups and Task Forces. The next section of this report is an updated staff level assignment table that reflects the final distribution of effort among the tasks carried out during FY2001. This is followed by the work plan for FY2001 as modified in the mid-year addendum. The plan has been annotated with on status of each commitment made by the program participants.

Total staff assigned to USNDP activities during the year was lower than anticipated by 2.35 FTE. This lower figure is largely due to a decline in inflation adjusted funding from the Department of Energy and the termination of the effort at San Jose State University (1.2 FTE). Support staff effort has been reduced by 0.25 FTE each at BNL and ORNL. The effort level at LANL has eroded by 0.4 FTE. Small reductions of about .1 FTE occurred at ANL, LBNL and ORNL. Further effort reductions are expected in the next fiscal year due to the flat dollar budget for DOE Nuclear Physics. Regrettably, the effort at San Jose State has been terminated. Thus the common ENSDF web-interface project has been terminated. The overall data dissemination improvement activity has been significantly reduced.

This has been the second year during which the Nuclear Data Program has operated under a work plan developed by the program participants and reviewed externally. As the following sections clearly illustrate, the nuclear data program is successfully carrying out important work in direct support of DOE missions. The work is a balance of continuing tasks of collecting, analyzing, and archiving nuclear physics information critical to basic nuclear research and to the development and improvement of nuclear technologies and electronic distribution of this information to users in a timely and convenient manner.

II. National Nuclear Data Center Operations and Network Coordination

The NNDC continues to serve as the core facility of the U.S. Nuclear Data Program (USNDP). While serving as the secretariat for the program, the NNDC has prepared the program work plan for fiscal year 2002 in conjunction with the members of the Coordinating Committee. The NNDC Head continues as chair of the program Coordinating Committee, which consists of the Principal Investigators from each of the participating groups, and chaired the annual meeting of the program held at Brookhaven National Laboratory in April 2001. NNDC continues to chair the Cross Section Evaluation Working Group, which produces the ENDF/B evaluated nuclear data library for applied nuclear technology use and hosted its annual meeting which was held at BNL in November 2000.

Staff members from the Idaho group, Los Alamos National Laboratory, and Lawrence Berkeley National Laboratory chair the three working groups of the USNDP, which are responsible for coordinating the technical activities of the program. These three chairs organized the technical discussions held during the USNDP annual meeting.

The NNDC serves as the focal point for U.S. collaboration in international nuclear data activities. Staff members from each of the nuclear structure and decay data evaluation centers attended the biennial meeting of the NSDD Network sponsored by the IAEA in Vienna in December 2000. The NSDD Network coordinates the evaluation of data for the ENSDF file. One staff member from NNDC participated in the IAEA-sponsored Nuclear Reaction Data Center (NRDC) technical meeting in Vienna in May 2001. The NRDC coordinates the compilation of nuclear reaction data and the dissemination of nuclear data worldwide. Four NNDC staff served as consultants to the IAEA Nuclear Data Section during the past fiscal year. An NNDC staff member chaired the annual meeting of the Nuclear Energy Agency's Working Party on Evaluation Cooperation which was held in Santa Fe in April 2001 and hosted by LANL. Adjacent to this meeting, a workshop on nuclear model codes was organized by LANL, BNL and LLNL staff members.

The NNDC operates a Compaq ALPHA 4100 computer, which archives and serves the nuclear data produced by the U.S. Nuclear Data Program and the data obtained by other national and international collaborations. This facility operates 24 hours a day, 7 days a week, to provide electronic access to the data.

The NNDC maintains seven nuclear physics databases for the USNDP. These databases have been updated continuously in FY2001 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. Release 8 of the ENDF/B-VI library was distributed on schedule. Retrievals from the network databases located at NNDC increased 10% as compared to the prior fiscal year.

The nuclear data base migration effort continues. Sybase ASE database software has been purchased and installed on a server running Linux. The Apache web server in conjunction

with the Tomcat Java servlet engine will be used for database access. Initial database schema designs have been completed in cooperation with the IAEA Nuclear Data Section.

III. Dissemination Summary

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. LBNL continues to chair the U.S. Nuclear Data Program's Data Dissemination Working Group, and helps to coordinate data dissemination work at different labs to advance USNDP goals. This year there have been a number of activities that have enhanced the capabilities of the USNDP to disseminate data.

The NNDC added to its WWW service a flexible data display module for experimental reaction data, ZVView, and an interface for the Q-value calculator, QCALC. An improved tabular representation for nuclear structure data was implemented. Links from the nuclear databases to the APS Link Manager were extended to cover journals from 1913 to the present. Updated ENSDF and ENDF format manuals were made available on the site.

As part of an IAEA-sponsored Coordinated Research Project, LBNL helped to develop a searchable database for capture gamma ray data. An update of REACLIB data for astrophysics reactions was performed. A new Nuclear Structure Systematics home page was also developed.

ORNL updated reaction rate information on their Nuclear Astrophysics Data WWW site. Major improvements were also made to their FTP site providing a RADWARE interface to ENSDF and XUNDL information

TUNL provided on their WWW site additional information about nuclides in the $A = 3 - 20$ mass region. Modified versions of $A=5-10$, $A=11-12$, $A=13-15$, $A=16-17$, $A=18-20$, and an $A=9$ preliminary report were posted, along with documents for over 165 nuclides. Scanned versions of earlier Energy Level Diagrams in PDF and GIF formats were also posted.

A number of developments and improvements were made to LANL's T16's WWW site for retrieving and viewing nuclear data evaluations and measurements, including access to new photo-atomic and fluorescence data. This data was included in ENDF/B-VI, Release 8. Numerous links to other relevant sites were also added.

ANL continues to maintain and add content to two Web sites of interest to the USNDP. One provides access to all of the ANL/NDM Report Series dealing with nuclear data issues. A second site provides information on experimental resources available in the United States for nuclear data measurements.

IV. Nuclear Structure and Decay Data Evaluation Summary

The main activity of the evaluators during the past year has involved the evaluation of the nuclear structure and decay data for mass chains and the entry of these results into the Evaluated Nuclear Structure Data File (ENSDF) with subsequent publication in the Nuclear Data Sheets. In addition, evaluations have been carried out for priority nuclides and newly published data on superdeformed bands for ENSDF, and the data in recent publications have been compiled and entered into the XUNDL file.

Evaluations for ENSDF

The USNDP nuclear structure and decay data evaluation groups have submitted 21 mass chains and 22 nuclides for inclusion in ENSDF evaluations. The evaluators have also reviewed evaluations for 13 mass chains in addition to checks done at NNDC for all published evaluations. In addition, the data on superdeformed bands have been submitted for 23 nuclides, which maintain currency for the evaluation for these bands in ENSDF.

Compilations for XUNDL

The XUNDL file includes data sets from the compilation and evaluation of data from recent single papers. The McMaster group has submitted 216 new and 25 updated data sets, which are primarily, but not exclusively, for high-spin data. These data have been entered into XUNDL by BNL.

Horizontal Evaluation Contributions

The Decay Data Evaluation Project, DDEP, which includes non-ENSDF evaluators from France, Germany, Russia, Spain, and the United Kingdom, prepares evaluations for radionuclide decays. Evaluators from LBNL and Idaho provided ENSDF data sets to the NNDC, or the appropriate ENSDF evaluator, for these radionuclides. New evaluations have been completed for 7 nuclides by LBNL and the Idaho group and submitted to the DDEP project for review.

Nuclear Structure Reference File

The keyworded-references included in the NSR file have been expanded by 3300, including 170 prepared by foreign collaborators.

Administrative and Other Items

Evaluators have provided support for the International Atomic Energy Agency through participation in its Coordinated Research Projects on prompt gamma activation analysis and decay data for detector calibration.

The Wallet Cards were updated by BNL.

Administrative chores have been carried out related to this Working Group, the DDEP, the April 2001 meeting of the USNDP, and the December 2000 meeting of the international ENSDF network.

V. Nuclear Reaction Data Summary

Reaction Data Highlights

The NNDC has compiled 46 neutron data sets and 160 charged-particle data sets for the experimental nuclear reaction database, CSISRS. The evaluation of neutron reactions with 19 important fission product nuclei, a three-year joint project with the Korea Institute of Atomic Energy, has been completed. The thermal neutron capture cross sections for $Z=1-60$ have been evaluated as a part of an IAEA Coordinated Research Project.

ENDF/B-VI, Release 8 was issued by BNL. LANL assisted in the preparation for ENDF/B-VI release 8. LANL did extensive development and NJOY data-processing of photonuclear data; submitted a new Bi evaluation to 150 MeV (published), completed a new $p+Li$ evaluation for neutron source studies; completed a new $n+^{16}O$ evaluation which was included in Release 8 (published in Nuclear Science and Engineering).

Analysis of experimental measurements is being used to improve nuclear model code predictions. GEANIE ($n,x\gamma$) data are being analyzed by a collaboration of LANL, LANSCE/WNR and LLNL researchers. The results are being published in Physical Review C. Don Smith (ANL) spent two months at IRMM (Belgium) performing neutron activation cross-section measurements, as a participant in an international NEA-WPEC project to generate nuclear reaction cross section data for nuclear model testing. Electronic experimental data files (EXFOR) were prepared for 3 reactions involving technetium and 3 reactions involving vanadium, as part of this overall program. Work is also in progress to prepare evaluations for these reactions that will be included in ENDF/A. A journal paper was prepared and accepted for publication in Annals of Nuclear Energy concerning a new approach to assessing the sensitivity of calculated nuclear reaction cross sections to specific nuclear model parameters. A review paper on this work was prepared for the International Conference on Nuclear Data for Science and Technology (Tsukuba, Japan, October 2001).

LANL worked with ANL and ORNL on reaction physics important for Rare Isotope Accelerator target design, particularly improvements in intra-nuclear cascade theory and codes, and isospin-dependent global optical models.

Model Code Highlights

LANL improved the McGNASH nuclear reaction code to better model width fluctuation physics (with Bruyeres-le-Chatel). In collaboration with BNL and Marshall Blann, a model for preequilibrium spin distribution was added to the hybrid model Monte Carlo module of McGnash. Mark Chadwick, Pavel Oblozinsky and Frank Dietrich organized a nuclear models workshop in Santa Fe, April 2001.

BNL, in collaboration with the IAEA, has added an exciton model module to the EMPIRE nuclear model code system to improve the calculation of neutron-capture and particle-emission cross sections.

Connie Kalbach Walker (TUNL) is working on a major revision of the phenomenological description of complex particle reaction channels for the exciton model computer code PRECO. Initial work, done using an existing database, was included in PRECO-2000. A broader database, extending to higher incident energies is now being used. The PRECO-2000 users manual was completed, and the code and manual were released to code distribution centers at BNL and at ORNL (RSICC).

Initial results at LLNL indicate that statistical methods for calculating level densities have significant advantages over MC shell model in terms of speed, physical insight, and applicability to reaction models. C++ infrastructure and interface for width-fluctuation corrections, gamma-ray strength functions, and transmission coefficients have been completed.

Nuclear Standards Highlights

Nearly all nuclear reaction data measurements are made relative to some reaction standard such as the hydrogen elastic cross section. Maintaining accurate current values for the standard cross sections is the objective of this task. The task can be accomplished only through international cooperation. The Nuclear Energy Agency is the umbrella organization for completing the project to update these recommended data. The IAEA is planning to initiate a Coordinated Research Program in support of this activity. Allan Carlson (NIST) is leading this activity and coordinating the worldwide effort through the Nuclear Energy Agency and the International Atomic Energy Agency.

Allan Carlson (NIST) and Gerry Hale (LANL) planned the agenda and program for the IAEA Consultants' Meeting on improving the neutron cross section standards. Carlson chaired the meeting in Vienna. The meeting developed a detailed program for improving the standards, which will be organized under an IAEA Coordinated Research Project.

A special session in conjunction with the ND2001 conference in Tsukuba, Japan was organized to discuss the progress being made on the experimental and evaluation efforts on the standards. Carlson has identified more than 50 experiments that are being reviewed or have been reviewed for inclusion in the standards database. Recommended new measurements of the ^{10}B branching ratio and new $^{235}\text{U}(n,f)$ and $^{238}\text{U}(n,f)$ measurements above 20 MeV neutron energy are being made. Preliminary results from these measurements were reported at the ND2001 conference. A paper by the NIST-Ohio University-LANL collaboration on the measurements of the np elastic scattering angular distribution at 10 MeV neutron energy has been accepted for publication in Phys. Rev. Plans for a measurement collaborative at 15 MeV are nearly complete. It is anticipated that the experiment will begin in March 2002.

VI. Nuclear Astrophysics Data Summary

A number of efforts within the U.S. Nuclear Data Program (USNDP) either directly or indirectly help improve our understanding of a wide range of exciting astrophysical phenomena such as stellar explosions, the interior of our sun, Red Giant stars, and the early Universe. This work includes evaluations of particular nuclear reactions or the properties of certain nuclei, development of nuclear models to calculate unmeasured properties, data dissemination in formats requested by astrophysicists as well as in standard NNDC formats, and assistance in the design of next-generation experimental facilities. The work done by members of the Nuclear Astrophysics Data Task Force spans the activities done within the USNDP Nuclear Reaction, Nuclear Structure, and Dissemination Working Groups. More detailed descriptions of these projects can be found elsewhere in this report.

Nuclear Reaction Data

At ANL, work was almost completed on evaluations of the $^{31}\text{P}(p,\gamma)^{32}\text{S}$ and $^{31}\text{P}(p,\alpha)^{28}\text{Si}$ reactions in collaboration with Hiram College. Considerable effort was devoted during FY01 to the issue of handling the very large uncertainties often encountered in nuclear astrophysics reaction data sets; this was done in collaboration with Hiram College and in consultation with ORNL. A collaboration led by ORNL is utilizing this new large-uncertainty formalism in simulations of the synthesis of nuclei in nova explosions.

At BNL, a project to compile and evaluate alpha-induced nuclear reaction cross sections has begun, focusing on light to medium light nuclei up to $Z = 32$ and alpha particles with energies up to about 20 MeV. A number of these reactions are of interest in astrophysics. Preliminary results were obtained for reactions on ^{40}Ca and ^{44}Ti . The NNDC also compiled 160 charged particle cross section data sets, some of which are important for astrophysics, for entry into CSISRS.

At LANL, the n-p capture reaction – crucial for the early Universe – is being investigated with R-matrix theory. The analysis includes cross sections, S-factors, and reaction rates. Other reactions important for the Big Bang have been evaluated: $d(d,n)$, $d(d,p)$, $^3\text{He}(d,p)$, $^7\text{Li}(p,\alpha)$, and $^7\text{Be}(n,p)$. Work is also continuing on predictions of the $^7\text{Be}(p,\gamma)^8\text{B}$ cross section, which contributes the largest nuclear physics uncertainty to the neutrino oscillation “solutions” of the Solar Neutrino Problem. Calculations are also being made for the TUNL Energy Levels of Light Nuclei ($A=5-10$) effort; the $A=5-7$ evaluation will soon be published. The effects of electron screening potentials are being explored, and preliminary screened reaction rates were produced for some of the hydrogen-isotope reactions. LANL is also collaborating with ANL and ORNL on the design for the radioactive beam production target at the Rare Isotope Accelerator (RIA). Because of the importance of radioactive beams to studies of the cosmos, this work is of vital importance for astrophysics. The focus this year was on developing intranuclear cascade models to optimize radionuclide production, using new GSI data to guide and test theory development.

At ORNL, evaluations of the $^{18}\text{F}(p,\gamma)$ and $^{18}\text{F}(p,\alpha)$ reactions, important for understanding stellar explosions, and $^{17}\text{O}(p,\gamma)$ and $^{17}\text{O}(p,\alpha)$ reactions, important for understanding the evolution of Red Giant Stars, are nearing completion. The reactions on ^{18}F are incorporating the latest exciting new experimental results with ^{18}F beams from ORNL's Holifield Radioactive Ion Beam Facility, as well as new Thomas-Ehrman level shift calculations and an improved non-resonant reaction rate calculation. The new reaction rates will be put into formats requested by astrophysicists and distributed over the WWW. Also in progress is a project examining evaluated cross sections for the 19 reactions important for the Solar Neutrino Problem. These cross sections are being converted into reaction rates, parameterized, and compared to analytical approximations (e.g., the NACRE collection or rates). ORNL is also leading a novel effort to gauge the influence of nuclear reaction rate uncertainties (such as those determined from detailed cross section evaluations) on nucleosynthesis predictions in novae. Additionally, assessments of level structure of Ar isotopes for hydrogen burning on Cl have been made, to initiate evaluations relevant for nuclear burning in stellar explosions.

Nuclear Structure Data

TUNL completed $A = 9$ evaluations, and will soon finish $A = 8$. An evaluation of $A = 10$ is in progress, and final revisions have been made on the evaluations of $A = 5 - 7$. When finished, these will be added to their extremely valuable collection of online evaluations, submitted to ENSDF, and published. This work is important to astrophysics research because many reactions induced on light ions are dominated by individual resonances detailed in these evaluations.

Dissemination

At LBNL, an update of the REACLIB collection of reaction rates for astrophysics was performed on their Nuclear Astrophysics Data WWW site based on data released by Thielemann et al. At TUNL, work has continued on disseminating important evaluations of nuclei with $A \leq 20$. This includes level schemes, tables, and PDF and HTML versions of complete evaluations. ORNL has updated reaction rate information on their Nuclear Astrophysics Data WWW site.

USNDP Level of Effort for October 2000 through September 2001

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
I. NNDC Facility Operation	0.00	1.45	1.25	0.00	0.00	0.00	0.00
Management		0.45					
Secretarial/Administrative Support			1.00				
Library			0.25				
Computer Operation		1.00					
NT Server Operation							
II. Coordination	0.00	0.70	0.00	0.10	0.20	0.30	0.00
National Coordination		0.35		0.05	0.1	0.3	
International Coordination		0.35		0.05	0.1		
III. Nuclear Physics Databases	0.00	3.60	1.45	0.00	0.00	0.00	0.00
Nuclear Science References (NSR)		0.15	0.75				
Experimental Nuclear Structure Data (XUNDL)		0.05					
Evaluated Nuclear Structure Data (ENSDF)		0.45	0.55				
Numerical Nuclear Data (NuDat)		0.05					
Reaction Data Bibliography (CINDA)		0.25	0.05				
Experimental Reaction Data (CSISRS)		0.05	0.10				
Evaluated Nuclear Data File (ENDF)		0.50					
Database Software Maintenance		0.75					
Future Database Systems		1.35					
IV. Information Dissemination	0.00	1.05	0.50	0.00	0.05	0.30	0.00
Maintenance of Remote Access to USNDP Data	0.00	0.55	0.00	0.00	0.00	0.00	0.00
Telnet Service		0.05					
WWW Service		0.50					
Customer Services		0.15	0.45				
Web Site Maintenance		0.25	0.05		0.05	0.30	
Common ENSDF Web Interface Project							
APS Link to NNDC Experimental databases		0.10					

USNDP Level of Effort for October 2000 through September 2001

	McMaster	NIST	ORNL	TUNL	Program Total	
					Sci/Pro	Support
I. NNDC Facility Operation	0.00	0.00	0.00	0.00	1.45	1.25
Management					0.45	0.00
Secretarial/Administrative Support					0.00	1.00
Library					0.00	0.25
Computer Operation					1.00	0.00
NT Server Operation					0.00	0.00
II. Coordination	0.00	0.00	0.00	0.00	1.30	0.00
National Coordination					0.80	0.00
International Coordination					0.50	0.00
III. Nuclear Physics Databases	0.00	0.00	0.00	0.00	3.60	1.45
Nuclear Science References (NSR)					0.15	0.75
Experimental Nuclear Structure Data (XUNDL)					0.05	0.00
Evaluated Nuclear Structure Data (ENSDF)					0.45	0.55
Numerical Nuclear Data (NuDat)					0.05	0.00
Reaction Data Bibliography (CINDA)					0.25	0.05
Experimental Reaction Data (CSIRS)					0.05	0.10
Evaluated Nuclear Data File (ENDF)					0.50	0.00
Database Software Maintenance					0.75	0.00
Future Database Systems					1.35	0.00
IV. Information Dissemination	0.00	0.00	0.10	1.50	3.00	0.50
Maintenance of Remote Access to USNDP Data	0.00	0.00	0.00	0.00	0.55	0.00
Telnet Service					0.05	0.00
WWW Service					0.50	0.00
Customer Services					0.15	0.45
Web Site Maintenance			0.10	1.50	2.20	0.05
Common ENSDF Web Interface Project					0.00	0.00
APS Link to NNDC Experimental databases					0.10	0.00

USNDP Level of Effort for October 2000 through September 2001

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
V. Nuclear Structure Physics							
NSR Abstract Preparation	0.30	2.40	0.00	0.30	0.00	3.00	0.00
Compilation of Experimental Structure Data		0.55					
Evaluation of data for ENSDF	0.30	1.65		0.30	0.00	3.00	0.00
Masses and Nuclides	0.30	1.55		0.25		2.15	
Ground and Metastable State Properties		0.10					
Radioactive Decay Data Evaluation				0.05		0.25	
Thermal Capture Gamma Data Evaluation						0.60	
ENSDF Physics and Checking Codes		0.20					
VI. Nuclear Reaction Physics							
Experimental Data Compilation	0.65	1.35	0.15	0.00	0.85	0.00	0.40
Neutron Data	0.00	0.60	0.15	0.00	0.00	0.00	0.00
Charged Particle Data		0.10	0.15				
EXFOR Manuals		0.45					
Compilation of RHIC and TJNAF Data		0.05					
ENDF Manuals and Documentation		0.15					
ENDF Evaluations					0.10		
Nuclear Reaction Standards							
Nuclear Model Development	0.30	0.20			0.30		0.40
Evaluation of Data Needed for Astrophysics	0.35	0.40			0.30		
Reaction Data for RIA Target Design					0.15		
DOE/Science Nuclear Data Funded Staff	0.95	10.55	3.35	0.40	1.10	3.60	0.40
Staff Supported by Other Funding		0.45	0.40				
TOTAL STAFF	0.95	11.00	3.75	0.40	1.10	3.60	0.40

USNDP Level of Effort for October 2000 through September 2001

	McMaster	NIST	ORNL	TUNL	Program Total	
					Sci/Pro	Support
V. Nuclear Structure Physics						
NSR Abstract Preparation	0.50	0.00	0.60	1.15	8.25	0.00
Compilation of Experimental Structure Data	0.05		0.10		0.55	0.00
Evaluation of data for ENSDF	0.45	0.00	0.50	1.15	0.15	0.00
Masses and Nuclides	0.45		0.50	1.15	6.35	0.00
Ground and Metastable State Properties					0.10	0.00
Radioactive Decay Data Evaluation					0.30	0.00
Thermal Capture Gamma Data Evaluation					0.60	0.00
ENSDF Physics and Checking Codes					0.20	0.00
VI. Nuclear Reaction Physics	0.00	0.20	0.40	0.40	4.25	0.15
Experimental Data Compilation	0.00	0.00	0.00	0.00	0.60	0.15
Neutron Data					0.10	0.15
Charged Particle Data					0.45	0.00
EXFOR Manuals					0.05	0.00
Compilation of RHIC and TJNAF Data					0.00	0.00
ENDF Manuals and Documentation					0.15	0.00
ENDF Evaluations					0.10	0.00
Nuclear Reaction Standards		0.20			0.20	0.00
Nuclear Model Development				0.40	1.60	0.00
Evaluation of Data Needed for Astrophysics			0.40		1.45	0.00
Reaction Data for RIA Target Design					0.15	0.00
DOE/Science Funded Staff	0.50	0.20	1.10	3.05	21.85	3.35
Staff Supported by Other Funding	0.50	0.80	0.00	0.00	1.75	0.40
TOTAL STAFF	1.00	1.00	1.10	3.05	23.60	3.75

Detailed Status of Work Plan

I. NNDC Facility Operation

A. Management

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 data evaluation and international nuclear structure evaluation.

C. Computer Operation

The NNDC operates a Compaq Alpha 4100 server using the OpenVMS operating system to support our compilation, evaluation, database maintenance, and information dissemination functions. In addition to the primary production server, the NNDC operates WINDOWS-NT and LINUX servers in support of its database migration project. Task includes software upgrades, hardware and software procurements, machine operations and internal user support.

BNL Deliverables:

Keep downtime to less than 3%.

Status:

- NNDC's Alpha server has been very stable, and downtime was less than 3%.
- The Sybase ASE database software and Tomcat Java servlet engine have been installed on Linux servers. Web based database access using Java servlet and Java Server Pages have been investigated.
- The NNDC staff's desktop computer hardware was enhanced and their operating systems have been upgraded to Windows 2000.

II. Coordination

A. National Coordination

BNL -- Chair USNDP Coordinating Committee, Chair Cross Section Evaluation Working Group, USNDP specific tasks.

BNL Deliverables:

Prepare FY2002 work plan for USNDP in time for spring 2001 FWP submittals.

Chair USNDP Meeting in April 2001.

Organize and chair CSEWG Meeting at BNL, November 2000.

Maintain USNDP WWW-site.

Status:

- The FY2002 work plan was completed by March 1, 2001.
- C. Dunford chaired the 2001 USNDP Meeting.
- P. Oblozinsky organized and chaired the 2000 CSEWG Meeting.
- USNDP site updated as information was received from the program members.
- The NNDC organized and conducted an ENSDF evaluators' workshop at the April USNDP meeting.

Idaho -- Chair U.S. Nuclear Data Program's Nuclear Structure Working Group, and help coordinate nuclear structure data work at different labs to advance USNDP goals.

Idaho Deliverables:

Coordinate U.S. contribution to the NSDD meeting in Vienna in December 2000.

Organize and chair Nuclear Structure Working Group meeting at USNDP meeting in 2001.

Status:

- U. S. contribution to NSDD meeting coordinated.
- Nuclear Structure Working Group session at USNDP meeting organized and chaired.

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 goals, chair Evaluation Committee of the Cross Section Evaluation Working Group.

LANL Deliverables:

Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2000.

Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in 2001.

Status:

- LANL organized and chaired Nov 2000 CSEWG Evaluation Committee meeting, which resulted in determining ENDF/B-VI Release 8 files.
- LANL organized and chaired Nuclear Reaction Working Group meeting at USNDP meeting in 2001 at Brookhaven.

LBNL -- Chair U.S. Nuclear Data Program's Data Dissemination Working Group, and help coordinate data dissemination work at different labs to advance USNDP goals. Included here is also the Isotopes project management responsibility of interacting with LBNL management and the DOE program manager.

LBNL Deliverables:

Organize and chair Data Dissemination Working Group meeting at USNDP meeting, April 2001.

Status:

- LANL organized and chaired Dissemination Working Group at the April Meeting.

B. International Coordination

BNL -- Member of Nuclear Reaction Data Center Network, Member Nuclear Structure and Decay Data Network, Advisor to U.S. Member of the International Nuclear Data Committee, incoming Chair of NEA Working Party on Evaluation Cooperation, participation in IAEA sponsored activities.

BNL Deliverables:

Participate in technical meeting of NRDC in Vienna, May 2001.

Chair NEA Working Party Meeting in the United States in 2001.

Provide three consultancies to IAEA Nuclear Data Section in FY2001.

Participate in the biennial Nuclear Structure and Decay Data Meeting in Vienna, December 2000.

Participate in IAEA Consultants Meeting to plan for the Nuclear Structure Workshop in Trieste in 2003.

Participate in IAEA Advisory Group Meeting on Long Term Needs in Nuclear Data Development in Vienna, November 2000.

Status:

- V. McLane attended NRDC meeting in May 2001.
- C. Dunford chaired the NEA Working Party on Evaluation Cooperation meeting that was held in Santa Fe and hosted by LANL.
- D. Winchell, T. Burrows, P. Oblozinsky and V. McLane served as consultants to the IAEA Nuclear Data Section.

- Tom Burrows presented an invited paper at the IAEA Advisory Group Meeting on Long Term Needs in Nuclear Data Development in Vienna.
- Four staff members participated in the Nuclear Structure and Decay Data Meeting in Vienna.
- Trieste workshop planning meeting was postponed to the first quarter of FY 2002.

Idaho -- Chair USNDP Nuclear Structure Working Group and interact with international Nuclear Structure and Decay Data network on behalf of USNDP on technical matters.

Idaho Deliverables:

Transfer chairmanship of the International Radioactive Decay Data Evaluation project to E. Browne, LBNL.

Status:

- Chairmanship of DDEP transferred to E. Browne.

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 committees in fission spectra, and international model code development cooperation; and chair IAEA coordinated research programs on photonuclear reactions, and on reference input model parameters. LANL will host visits by foreign scientists with international reputations to benefit from the exchange of information and ideas.

LANL Deliverables:

Host and participate in NEA evaluation meeting in April 2001.

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

Host a couple of international visitors to collaborate on the evaluation of nuclear data.

Status:

- LANL hosted and organized the April 2001 NEA Working Party on Evaluation Cooperation meeting in Santa Fe, 2001, comprised of over 25 participants from Europe, Japan, USA, together with IAEA representatives from Russia and China.
- NJOY 2001 was completed and documented in FY01 by Bob MacFarlane and has been made available to the international user community.
- We hosted a number of international visitors specializing in nuclear reaction and structure data, including K.L. Kratz (Mainz), S. Hilaire (Bruyeres-le-Chatel), M. Herman (IAEA), M. Blann (LLNL, retired).

LBL -- Participate in, and chair, international nuclear structure data collaborations to insure that the U.S. benefits from international collaborations.

LBL Deliverables:

Participate in the biennial meeting of the international Nuclear Structure and Decay Data Network and chair the International Radioactive Decay Data Evaluation Project.

Status:

- Participated in the biennial Nuclear Structure and Decay Data Meeting in Vienna, December 2000.
- E. Browne, LBNL, assumed chairmanship of the International Radioactive Decay Data Evaluation Project (DDEP) and chaired the meeting of the DDEP in Braunschweig in May 2001.

III. Nuclear Physics Databases

A. Nuclear Science References (NSR)

The NNDC is responsible for NSR, the bibliographic database for nuclear physics research. Task includes quality control, file update and maintenance, and file distribution to collaborators. Entry preparation not included. Updates are done on a continuing basis.

BNL Deliverables:

Database distributed to collaborators monthly.

Status:

- Twelve monthly distributions done.

B. Experimental Nuclear Structure Data File (XUNDL)

The NNDC is responsible for XUNDL, the database of unevaluated experimental nuclear structure data. Recent additions contain mostly "high-spin" data sets. NNDC responsibility is limited to maintaining database and access to it. Data set compilation coordinated through McMaster University. Updates are done as data sets are received.

BNL Deliverables:

Update XUNDL as data sets are submitted.

Status:

- All data sets received from McMaster have been added to the database.

C. Evaluated Nuclear Structure Data File (ENSDF)

The NNDC is responsible for the ENSDF database that contains evaluated experimental nuclear structure and decay data. The NNDC is responsible for maintaining the database and organizing the quality control (review) of evaluations submitted for inclusion. Task includes database updates and distribution to collaborators. Updates are done upon completion of reviews. Corrections implemented on a continuing basis.

BNL Deliverables:

Database distributed to collaborators every six months.

Status:

- Two biannual distributions done.
- The ENSDF manual has been revised and distributed.

D. Numerical Nuclear Data File (NuDat)

The NNDC is responsible for NuDat, an all numeric database of nuclear data including 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. The database is also available in a PC version. The database is updated twice a year.

BNL Deliverables:

Database distributed to collaborators every six months.

Status:

- Two biannual distributions done.

E. 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. Its contents are produced cooperatively by the four international neutron data centers with updates exchanged in an agreed computer format. The data are organized by data measured, not by reference. The database serves as an index to the neutron data contained in the experimental database, CSISRS. The database is updated as transmissions from the data centers are received and checked.

BNL Deliverables:

20 CINDA exchange files from cooperating centers will be added to the database.

Status:

- 5 CINDA exchange files produced and distributed to cooperating centers.
- 8 CINDA exchange files from cooperating centers received and added to database.

A project CINDA2001 has been initiated to modernize the database and expand it to cover charged particle and photonuclear data references presently stored elsewhere.

BNL Deliverables:

Database retrieval codes will be completed.

Old database will be converted to the new format. The new database will replace the current one.

Status:

- Relational database designed and initial database created.

F. Experimental Reaction Data File (CSISRS)

The NNDC is responsible for maintaining the CSISRS database. This database contains experimentally measured nuclear reaction data covering low- and intermediate-energy regions. Many groups worldwide compile and exchange experimental data in an agreed format, EXFOR. In support of the reaction data compilation effort, we maintain a database of validated coded information (thesaurus) called the EXFOR dictionary system. The effort described here includes the quality control, file update and data exchange activities. The database is updated, as transmissions from the compiling centers are received and checked. The compilation activity is given under Nuclear Reaction Physics.

BNL Deliverables:

Update CSISRS with EXFOR exchange tapes from cooperating centers (18 expected).

Status:

- 20 exchange tapes created and distributed to cooperating centers.
- 20 exchange tapes from cooperating centers received and added to database.

G. Evaluated Nuclear Data File (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The 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. Some evaluations cover energies up to 150 MeV. A limited number of evaluations for incident charged particles are also included. The data are stored in the ENDF format developed at NNDC about 35 years ago. This format has been adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from Western Europe, 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.

BNL Deliverables:

Release 8 of the ENDF/B-VI evaluated data library will be issued.

Status:

- Eight release 8 tapes completed and added to library. Distribution awaiting one input file.

H. Database Software Maintenance

Includes software bug fixes and enhancements for the six nuclear physics databases maintained by NNDC.

I. Future Database Systems

The NNDC is assessing new database software and computer platforms in order to determine the future directions that our database and computer activities should take. Effort includes the operation of two "experimental" computing systems (an NT server and a Red Hat Linux server) and development of prototype databases for various available database software packages. Recommendations in the report on the investigations completed in the prior fiscal year will be reviewed and a database and application programs migration plan proposed.

BNL Deliverables:

Host a workshop with our international partner data centers to review the report recommendations.

Conclusions of workshop reviewed and migration plan adopted, February 2001.

Begin implementation of the plan in cooperation with our international partners, April 2001.

Status:

- The workshop conclusions and recommendations have been published.
- Work has started on the migration of the nuclear databases to the Sybase Adaptive Server Anywhere on Linux.
- Initial schemas for the databases have been designed such that they can be ported to any compliant relational database software in cooperation with IAEA staff.
- Web-based retrieval programs in initial test phase for NSR (NNDC) and CSISRS (IAEA)

IV. Information Dissemination

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

A. Maintenance of Remote Access to USNDP Databases

The NNDC provides access to the nuclear physics databases that it maintains. This access is supported in three forms, remote login (TELNET), via the WWW and computer programs for use locally.

BNL Deliverables:

No enhancements are planned for the remote login (TELNET) access software.
Add WWW interface to the Q-value calculator (QCALC).
Maintain the ENSDAT and NUDAT codes for use on OPENVMS and Windows platforms.

Status:

- WWW interface to the Q-value calculator (QCALC) added.
- Improved HTML tabular representation of data retrieved from ENSDF, MIRD, and XUNDL.
- Option added to CSISRS to allow ZVView to be used as a helper application.
- ENSDAT and NUDAT updated for latest ENSDF formats.
- LINUX versions of ENSDAT and NUDAT are being tested.

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 of 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.

C. Web Site Maintenance

USNDP members who offer information through a web site require resources to maintain currency and improve performance. All sites will coordinate their effort and implement a "USNDP approved site" program with an appropriate identifier.

BNL Deliverables:

Effort required keeping the USNDP and the NNDC site current.

Status:

- NNDC site updated as follows:

- Linux distribution added for the ENDF utility codes and the ENSDF analysis and utility codes.
- Nuclear Model Code site added including the programs ABEREX (R.D. Lawson & A.B. Smith) and PRECO-2000 (C.K. Walker).
- Added Table of Magnetic Dipole Rotational Bands (B. Singh, *et al.*) and EXFOR Basics Manual.
- CINDA, CSISRS, and NSR links to the APS Link Manager extended back to cover journals from 1913 to present ($\approx 39,000$ links from NSR to APS, EDPS, and NPE link managers as of Oct. 7, 2001).
- ENSDF format manual, ENDF-102 manual, and Table of Nuclear Moments (N. Stone) updated.
- CSEWG site added.

LANL Deliverables:

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

Add access to ENDF/B-VI, Release 8.

Continue coordination of T-2 site with other USNDP sites.

Status:

- A number of developments and improvements have been made to T16's WWW site for retrieving and viewing nuclear data evaluations and measurements, including access to new photoatomic and fluorescence data.
- Since ENDF/B-VI, Release 8 was released it has been made available on our WWW site.
- Coordination is an ongoing effort, and we have added numerous links to other relevant sites.

LBNL Deliverables:

Develop website for compiled capture gamma data as part of IAEA CRP.

Update nuclear astrophysics reaction rates on the nuclear astrophysics page.

Status:

- Preliminary, Java enabled, searchable database for capture gamma ray data developed in collaboration with EVITech, Finland and Lund, Sweden. Continued collaboration with Viktor Zerkin, IAEA Nuclear Data Section.
- Full REACLIB data for astrophysics reactions rates not yet available so only partial update was performed based on data released by Thielemann et al.
- Developed new Nuclear Structure systematics home page for NSAC Long-Range Plan Berkeley Town Meeting.

ORNL Deliverables:

Maintain, update, and improve FTP site providing

RADWARE interface to ENSDF and XUNDL information

Status:

- Added directory for site using cgi scripts for rapid access to data.
- Added functionality to create customized plots in jpg and pdf formats.
- Added ability to zoom in on plots.
- Updated code to C computer language.
- Regularly updated Radware files on FTP site from latest ENSDF and XUNDL databases.

TUNL Deliverables:

Continue to provide most recent reviews for $A = 3$ through 20 in PDF format.
Complete all Reference Update lists for $A = 3$ through 20 and keep them current.
Continue project with publishers of Nuclear Physics A to provide online versions of all prior publications in the Energy Levels of Light Nuclei for 1959 through 1991.

Status:

- Completed PDF documents with hyperlinks for: $A = 5-7$ (prepublication version, Jan. 2001); $A = 9$ (preprint version, June 2001); $A = 5-10$ (1984), $A = 11-12$ (1985), $A = 13-15$ (1986), $A = 16-17$ (1986), $A = 18-20$ (1987).
- Elsevier (Nuclear Physics A) has provided on their website scanned PDF documents [documents do not have hyperlinks and are scanned versions only] of Fay Ajzenberg-Selove's Energy Levels of Light Nuclei $A = 5-20$ series from 1966 – 1991.
- HTML documents have been completed for 135 nuclides found within the $A = 3-18$ series [HTML includes hyperlinks and PDF/PS tables].
- Update Lists for $A = 13, 14$ and 15 have been completed.
- General Tables [that correspond to publications in Nuclear Physics A] have been completed for $A = 5, 6, 7$ and 9.
- Scanned versions of earlier FAS Energy Level Diagrams have been completed for $A = 5-10$ (1984), $A = 11-12$ (1985), $A = 13-15$ (1986) $A = 16-17$ (1986), and $A = 18-20$ (1987).

Common ENSDF Web Interface

During FY2000, BNL, LBNL, ORNL, and SJSU began the development of the common web interface to the ENSDF, XUNDL and NSR databases. The development of an agreed plan outlining responsibilities and commitments for each of the four organizations has been delayed until April 2000. Therefore, no details are available for this section of the plan. Suggested tasks and contributions to the project are contained in the individual laboratory work plans included as appendices. (This project has been terminated since the essential SJSU effort is no longer funded by the nuclear data program. Effort at other laboratories has been redirected.)

D. APS Link to NNDC Experimental Data Bases

Presently NNDC provides a link from our bibliographic databases to paper abstracts for journals which support this access. For those with subscriptions, the user can then access the complete paper. In cooperation with APS (Ridge), we will provide the ability to go from the Phys. Rev. abstract/article to the NNDC database where data mentioned in the publication will be archived.

BNL Deliverable:

Prototype system in operation.

Status:

- Prototype system tested. Still to be completed is a Web-based author submittal form and database for the Data Link Manager.

V. Nuclear Structure Physics

A. NSR Abstract Preparation

The literature search and preparation of KEYWORD abstracts for publications included in NSR require scientific expertise. NNDC staff creates most of the entries with some help from Russia and Japan.

BNL Deliverables:

Keyword abstracts for 3200 references will be prepared in FY2001.

Status:

- Keyword abstracts for 3301 references were prepared

B. Compilation of Experimental Structure Data

Compilation of currently published or completed experimental nuclear structure data (primarily high-spin) for inclusion in XUNDL.

McMaster Deliverables:

Compile experimental data sets (in ENSDF format) of current publications, primarily in high-spin physics.

Status:

- A total of **216 new data sets** (in ENSDF format) compiled from current publications were prepared at McMaster and submitted to NNDC, BNL for inclusion in XUNDL database. Three of these data sets were prepared in collaboration with Grenoble data group. Additional **25 data sets**, previously in XUNDL, were updated for more current publications on these nuclides.

ORNL Deliverables:

Improve software for converting tabular/graphic published level-scheme data in journals and unpublished data supplied by researchers to Radware database, into ENSDF format. Continue supplying converted XUNDL data sets to BNL.

Status:

- Ported code from Fortran to C, for compatibility with required subroutine libraries.

C. Data Evaluation

The USNDP evaluates nuclide and mass chain nuclear structure and decay data for inclusion in the ENSDF database. Responsibility for $A > 266$ has been permanently reassigned and responsibility for $A = 242$ and 244 has been temporarily assigned to ORNL. Temporary responsibility for $A = 235$ and $A = 239$ has been given to LBNL. A nuclear structure evaluator joined ANL nuclear data program in February 2001 and has been assigned responsibility for evaluation of the $A = 177$ chain.

ANL Deliverables:

None promised.

Status:

- Reviewed one mass chain ($A = 103$).
- Evaluation of one mass chain ($A = 177$) is 25% completed. This mass chain includes 14 nuclei. There are many new data to be considered for each isotope.

BNL Deliverables:

Three and one-half equivalent mass chains will be evaluated.
Mass chains will be reviewed as requested.

Status:

- Four and one-half equivalent mass-chains were evaluated.
- One mass chain, several nuclides, one journal paper reviewed.

Idaho Deliverables:

Complete evaluation for one equivalent mass chain and start another.
Mass chains will be reviewed as requested.

Status:

- Evaluation of data for $A = 87$ completed and submitted.
- The revision to the "Rules for JPI Assignments," in which we played a major role, were presented for adoption by the International NSDD Network at its meeting in Vienna in December 2000.

LBNL Deliverables:

Five equivalent mass chains and eleven nuclides will be evaluated.
Three mass chains will be reviewed.

Status:

- Evaluations of four mass chains ($A = 59, 170, 171, 235$) submitted.

- Evaluations of six nuclides (^{91}Kr , ^{91}Sr , ^{91}Zr , $^{93}(\text{Kr},\text{Br})$, $^{93}(\text{Rh},\text{Pd})$, ^{179}Tl) submitted and now included in ENSDF.
- Evaluation of five nuclides from the A=189 mass chain completed but not submitted, pending completion of mass chain in FY2002.
- Reviewed seven mass chains (A=141, 144, 198, 250, 254, 258, 262).
- Completed post-submission corrections to ENSDF-coded datasets for A=27-39.

McMaster Deliverables:

1.5 equivalent mass chains (including some in the A=40-44 region) will be evaluated.

Mass chains will be reviewed as requested.

Update super-deformed data in ENSDF.

Status:

- Evaluation of four full-length mass chains (A=41, 79, 86, 188) was completed and submitted to NNDC, BNL for inclusion in ENSDF and publication in NDS. Two of these are at post-review stage while the other two are under review.
- Evaluation of the following 16 nuclides was completed and submitted to BNL for inclusion in ENSDF. Some of these were also published in NDS.

^{58}Cu , ^{99}Tc (*), ^{126}Pr , ^{132}Pr , ^{133}Sm , ^{136}Nd , ^{143}Ho , ^{143}Tb , ^{143}Dy , ^{145}Gd ,
 ^{149}Gd , ^{163}Lu , ^{168}Hf , ^{199}Ir , ^{199}Fr , ^{199}Pb

(*): This nuclide was update in collaboration with BNL.

- Data on superdeformed bands were continuously updated as these appeared in literature during 2000-2001. SD band data for the following 23 nuclides have been updated and submitted to BNL for inclusion in ENSDF:

^{36}Ar , ^{58}Ni , ^{59}Cu , ^{68}Ge , ^{80}Sr , ^{81}Sr , ^{82}Sr , ^{83}Sr , ^{83}Y , ^{84}Zr , ^{88}Mo , ^{89}Tc ,
 ^{91}Tc , ^{143}Eu , ^{154}Er , ^{190}Hg , ^{191}Hg , ^{192}Hg , ^{193}Pb , ^{196}Pb , ^{197}Pb , ^{198}Pb , ^{240}Pu

ORNL Deliverables:

Evaluate A=225 and 229.

Update evaluations for A>266 as required.

Mass chains will be reviewed as requested.

Status:

- Evaluations of A=250, 254, 257, 260, 262 and 266 nuclei have been completed; manuscripts have been reviewed; final copies are submitted for publication. The evaluation for A=242 has been completed and submitted to BNL. It has not yet been reviewed.
- Ground-state properties of alpha decaying A=270 nuclei are updated.

- A=215, 219, 223, 227 and 231 mass chains are reviewed

Explanation:

- During the IAEA meeting in December 2000, ORNL was requested to evaluate A=242 which was last revised in 1985 by the Kurchatov group. ORNL agree to do this evaluation instead of A=225 and A=229.

TUNL Deliverables:

Evaluate masses 8 and 9; begin evaluation of A = 10.

Prepare publication for A = 5, 6 and 7 for submission to Nuclear Physics A.

Prepare ENSDF files for A = 5, 6, 7, 14 and 15.

Status:

- Completed and mailed out for review the preprint version of A = 9 (June 2001).
- Expect to finish review of A = 8 and mail preprint by year's end.
- Evaluation of A = 10 in progress.
- Completed final revisions of A = 5-7 review in preparation for submission to Nuclear Physics A.
- Submitted ENSDF file for A = 14; continue preparation of A = 15; submit A = 5,6,7 ENSDF files after review is published.

D. Ground and Metastable State Properties

This is the evaluation of data for the Nuclear Wallet Cards.

BNL Deliverables:

NNDC will include the data revisions in the NuDat and ENSDF databases.

Status:

- Wallet Cards database updated to last ENSDF distribution.

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 and merged into the ENSDF database. LBNL coordinates this international project.

LBNL Deliverables:

Decay data for two nuclides of astrophysical interest will be evaluated.

Adopted and decay data sets from non-U.S. evaluators will be coded into ENSDF format.

Status:

- Evaluation of ^{152}Eu completed.
- Reviewed evaluations of ^{46}Sc , ^{51}Cr , ^{54}Mn , ^{153}Sm , ^{153}Gd .

Idaho Deliverables:

Decay data for 5 nuclides will be evaluated.

Status:

- Evaluations completed for the decay of 6 nuclides.

F. Thermal Capture Gamma Data Evaluation

This work is being performed by LBNL as part of an IAEA Coordinated Research Project entitled, "Prompt Gamma Activation Analysis." The specific task assigned to LBNL is to evaluate thermal and cold (n, γ) data sets for stable nuclei. The results of this evaluation will be placed into a database.

LBNL Deliverables:

A preliminary version of this database will be completed in collaboration with the Chinese Nuclear Data Center.

Status:

- Preliminary version of database completed for Z=1-83.
- Final draft database completed for Z=1-21.

G. ENSDF Physics and Checking Codes

The NNDC maintains ENSDF checking and physics programs on behalf of the national and international evaluator networks. Only maintenance and upgrades for format changes are planned.

BNL Deliverables:

Complete a partial upgrade to RadList to provide improved energy grids for continuum spectra.

Update LOGFT to calculate higher orders of forbiddances.

Status:

- Some work on the upgrades done but project not completed in FY2001.

VI. Nuclear Reaction Physics

A. Experimental Data Compilation

The NNDC as part of a larger international cooperation has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada.

Incident neutron reactions have been well covered historically. NNDC thus concentrates on new measurements only.

Incident charged particle data have not been completely compiled in the past. Therefore, NNDC is not only compiling new charged-particle measurements, but is also attempting to compile older data to help meet emerging needs such as those of the astrophysics community. Hence, there is a larger staff commitment to compiling this type of data.

NNDC is responsible for maintaining the manuals describing the EXFOR format and the methods for compiling different kinds of data.

BNL Deliverables:

Compile data from 120 charged-particle reaction publications.

Compile data from 15 neutron reaction publications.

Status:

- Compiled 46 neutron data sets, 160 charged-particle data sets.

B. Compilation of RHIC and TJNAF Data

For several years, the NNDC has maintained a small pilot project to investigate the compilation of high-energy data measured on the BNL AGS. With the start up of the RHIC facility in FY2000, it is timely to determine whether there is enough support in the RHIC community to begin a long-term compilation activity and to determine what physical quantities measured experimentally need to be archived. (No action planned)

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 Deliverables:

The ENDF format manual will be updated as necessary and placed on the WWW.

The ENDF summary documentation will be updated as necessary and placed on the WWW.

Status:

- The ENDF-102 Manual was updated and placed on the WWW.
- The ENDF-201 Summary Documentation history was updated through release 8 (not yet on Web).

D. 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.

LANL Deliverables:

- Work with BNL to issue Release 8 of ENDF/B-VI.
- Submit new photonuclear evaluations for ENDF.
- Submit additional evaluations up to 150 MeV (e.g. bismuth) for ENDF.
- Submit new p+Li evaluations for ENDF/B that are important for the design of quasi-monoenergetic neutron sources.
- Complete a new n+¹⁶O evaluation covering energies up to 150 MeV, incorporating new LANSCE/WNR from 6 to 30 MeV.

Status:

- Assisted in preparation of release 8 of ENDF/B-VI was issued earlier this year.
- Bob MacFarlane at LANL has undertaken extensive work in data testing and NJOY processing of photonuclear data evaluations. This led to MacFarlane fixing numerous format errors, mainly in files from Japan, Russia, and China; the LANL and KAERI evaluations were correctly formatted. The new suite of evaluations is being provided to the NNDC for possible inclusion in ENDF/B-VII, and will be discussed at the 2001 CSEWG meeting.
- Bismuth for neutrons and protons to 150 MeV is now available in ENDF/B-VI. This work was documented in a paper: "Nuclear data for accelerator-driven systems", Chadwick MB, Hughes HG, Little RC, Pitcher EJ, Young PG, PROGRESS IN NUCLEAR ENERGY, v. 38(#1-2/SISI) pp. 179-219 2001.
- The p+Li evaluation has been submitted to the NNDC, and was described in a paper at the recent Japan ND2001 conference.
- A new n+¹⁶O evaluation has been completed and was included in ENDF/B-VI release 8. It was published in "High-resolution measurements and calculations of photon-production cross sections for O-16(n,xγ) reactions induced by neutrons with energies between 4 and 200 MeV", Nelson RO, Chadwick MB, Michaudon A, Young PG, NUCLEAR SCIENCE AND ENGINEERING , v. 138(#2) pp. 105-144 JUN 2001.

E. Nuclear Reaction Standards

Nearly all nuclear reaction data measurements are made relative to some reaction standard such as the hydrogen elastic cross section. Maintaining accurate current values for the standard cross sections is the objective of this task. The task can be accomplished only through international cooperation. The Nuclear Energy Agency is the umbrella organization for completing the project to update these recommended data. The IAEA is planning to initiate a Coordinated Research Program in support of this activity.

NIST Deliverables:

Coordinate the international standards activity.

Determine the methodology for producing the new standards evaluation.

Review existing experimental data and recommend new measurements as needed.

Collaborate with Ohio University and LANL in the measurement of hydrogen elastic angular distributions; design experiments for measurement at 15 MeV.

Status:

- Planned with G. Hale (LANL) the agenda and program for the IAEA Consultants' Meeting on improving the neutron cross section standards.
- Chaired the IAEA Consultants' Meeting on improving the neutron cross section standards. Wrote (with V. Pronyaev and D. Muir) the summary report of the meeting.
- Organized a special session in conjunction with the ND2001 conference to discuss the progress being made on the experimental and evaluation efforts on the standards.
- Wrote the proposal (with V. Pronyaev) for the IAEA Coordinated Research Program on improving the cross section standards. This proposal was fully accepted for IAEA funding. This proposal was a result of the Consultants' Meeting at which a detailed program for improving the standards was developed.
- Coordinated the standards Subgroup of the WPEC.
- Identified more than 50 experiments, which are being or have been reviewed for inclusion in the standards database.
- Recommended additional work on the ^{10}B total cross section which is being done.
- Recommended new measurements of the ^{10}B branching ratio. Results were reported at the ND2001 conference.
- Recommended new $^{235}\text{U}(n,f)$ and $^{238}\text{U}(n,f)$ measurements above 20 MeV neutron energy. Preliminary data were reported at the ND2001 conference.
- The measurements at 10 MeV neutron energy of the np elastic scattering angular distribution have been accepted for publication in Phys. Rev.

- Several meetings and conference calls have been held to discuss the 15 MeV experiment. Some preliminary work needs to be done to finalize the design. It is anticipated that the experiment will begin in March 2002.

F. 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 LANL code development work will be coordinated with the proposed LLNL work. The collaboration will include intercomparison of results, validation of model with experimental data and development of new physics modules. The TUNL pre-compound code will be incorporated into the LANL code. Measurements made by ANL and other measurements made with DOE low-energy physics funds (e.g., Grimes, Haight, Becker and others) will play a crucial role in the validation of the models in these computer codes.

ANL -- Perform analysis of neutron activation measurements in the energy range from 16 to 21 MeV completed in FY2000 to provide an extensive database for use in validating pre-compound nucleus modeling. This work is done in collaboration with IRRM, Geel, and Belgium at no cost to DOE, other than salary and travel. Collaboration with IRMM as well as scientists from Eastern Europe is carried out within the framework of a NEA WPEC subgroup.

ANL Deliverables:

The available experimental results will be submitted in EXFOR format to the NNDC. Evaluations for some of these reactions will be performed and the results submitted for inclusion in ENDF/A.

A study of nuclear model parameter sensitivities will be initiated under the auspices of the Nuclear Energy Agency Working Party for Evaluation Cooperation (WPEC) in collaboration with scientists in Belgium, Hungary, and Romania.

A paper describing the nuclear model parameter sensitivity method to be used in the above-mentioned investigation will be prepared and submitted for publication.

Status:

- Worked on the analysis of data acquired during FY2000 (and earlier) during a 2-month visit to IRMM, Geel, Belgium in January – February 2001. This visit was partially financed by the European Commission.
- Prepared EXFOR files for 3 Technetium and 3 Vanadium neutron reactions. They will be submitted to the NEA Data Bank (since the experimental work was done in Europe) following approval by the collaborators.
- The preparation of horizontal evaluations for these 6 reactions is nearly finished and files will be prepared for inclusion in ENDF/A early in FY2002.
- A review paper has been prepared for presentation at the International Conference on Nuclear Data for Science and Technology (Japan, October 2001). This paper includes results from experiments, nuclear modeling, and

nuclear-model-parameter sensitivity studies for several neutron activation reactions examined in collaboration with IRMM.

- Participated in experiments carried out at IRMM, Geel, Belgium, during the January – February 2001 visit in order to obtain additional neutron activation data for use in nuclear-model development and nuclear-energy applications.
- A paper describing the nuclear-model-parameter sensitivity method has been prepared, submitted, and accepted for publication in *Annals of Nuclear Energy*.

BNL – As part of the BNL effort to reestablish a nuclear reaction evaluation capability, the EMPIRE code system developed and maintained by Mike Herman (IAEA) has been installed and tested. BNL has entered into collaboration with the author to make improvements to this code system. The NNDC will participate in the USNDP and NEA nuclear model development activities.

BNL Deliverables:

An improved fast neutron capture module will be completed.

Complete an improved hybrid-Monte Carlo module for calculating particle emission in collaboration with LANL.

Collaborate with IAEA to improve Empire mode code system

Status:

- Co-organized with LANL, a Nuclear Model Workshop sponsored by the Nuclear Energy Agency WPEC.
- Improved fast neutron capture module has been completed and incorporated into the code system EMPIRE. The module is based on the exciton model code DEGAS that was shown to perform well compared to much more involved direct-semidirect capture model. In addition, DEGAS represents a considerable improvement for modeling of (n,p) cross sections in EMPIRE.
- Improvement of the hybrid model Monte Carlo module was achieved by completing, through LANL-BNL collaboration, a model for pre-equilibrium spin distribution. This improves modeling of particle emission and it is important for a proper coupling of the hybrid pre-equilibrium Monte Carlo module to subsequent Hauser-Feshbach calculations.
- Completed evaluation of 19 important fission product nuclei, a joint KAERI-BNL project begun in 1999.
- Neutron thermal capture cross sections were updated for 237 stable isotopes and elements with $Z=1-60$ as part of an IAEA CRP.

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 develop a new version of this code to provide a state-of-the-art capability to predict reaction cross sections. This task also involves a close collaboration with experimentalists at LANSCE (R.C. Haight, J.A. Becker, S.M. Grimes)

to interpret new measurements using the GEANIE γ -ray detector, as well as (n,charged-particle) data, resulting in advances in our understanding of nuclear reaction mechanisms, as well as improvements in our modeling codes.

LANL Deliverables:

Continue development of McGNASH, our improved version of the GNASH Hauser-Feshbach code, using Fortran90 and modern coding practices, with numerous improved physics packages, particularly: level densities, preequilibrium reactions, transmission coefficients, and γ -ray strength functions. Include a Monte-Carlo option. (Note, this is highly leveraged with support from DOE/DP).

Calculate and interpret γ -ray reactions measured with GEANIE at LANSCE, including $n+^{92}\text{Mo}$ reactions producing far-from-stability products, and reactions in competition with fission.

Study level densities, a crucial input in nuclear model calculations, using Ca(n,z) measurements by Haight at LANSCE.

Status:

- Significant progress has been made on the development of McGNASH. A recent focus has been on width fluctuation physics, where we wrote and tested new modules in collaboration with Bruyeres-le-Chatel scientists (Hilaire) for modeling compound nucleus reactions. We also worked on improved Monte Carlo pre-equilibrium modules for spin transfer with Blann and Oblozinsky (BNL). Some of this work was documented in “Pre-compound Monte-Carlo model for cluster induced reactions” art. no. 034604, Blann M, Chadwick MB, PHYSICAL REVIEW C , v. 6203(#3) pp. 4604-& 2000.
- The calculation and interpretation of γ -ray reactions measured with GEANIE at LANSCE, was completed and published in a Phys Rev article: “Mo-92(Mo-92(n,xn yp $z\alpha$ γ) reactions for neutron energies up to 250 MeV” art. no. 054608, Garrett PE, Chadwick MB et al., PHYSICAL REVIEW C , v. 6205(#5) pp. 4608-& NOV 2000.
- We have continued to collaborate with Steve Grimes on isospin physics in the context of Haight’s (n,z) LANSCE data. Work on calcium was presented at the LANSCE Users Group Meeting.
- Co-organized and hosted a Nuclear Model Workshop sponsored by the Nuclear Energy Agency WPEC.

LLNL -- Develop an advanced shell-model treatment of level densities in the A=90 mass region. Develop a platform-independent Hauser-Feshbach code.

LLNL Deliverables:

Develop an effective interaction for shell model Monte Carlo calculations in the A=90 mass region.

Begin testing of level density predictions from this model.

Augment Hauser-Feshbach code developed in FY2000 with width-fluctuation corrections, gamma-ray strength functions and a fission model.

Status:

- “Statistical Models of Nuclear Levels,” C. W. Johnson, J. Nabi, W. E. Ormand, submitted to Phys. Rev. Lett. (UCRL-JC-143941). Initial results indicate that statistical methods for calculating level densities have significant advantages over Monte Carlo Shell model in terms of speed, physical insight, and applicability to reaction models.
- C++ infrastructure and interface for width-fluctuation corrections, gamma-ray strength functions and fission have been completed. Gamma-ray strength functions and transmission coefficients from J. A. Holmes et al., At. Dat. Nucl. Tables **18** 305 (1976) are available.

TUNL -- Development of pre-compound nuclear reaction models. Improvement and benchmarking of the computer code PRECO, extending code validity to higher incident energies for (N,xN) reactions. Issues are isospin conservation, energy dependence of the collective state model, and residual nn, np and pp interactions (energy dependence and relative size).

TUNL Deliverables:

The description of complex particle channels will be revised.
Formal release of PRECO-2000 to code distribution centers.
Database augmented with additional (N,xN) spectra from the literature at energies of 40 to 100 MeV, including working graphs of all spectra.
Begin testing of exciton model in the 40 to 100 MeV energy range.

Status:

- Revised description of complex particle channels included in PRECO-2000; extensions in incident energy and projectile are continuing.
- PRECO-2000 released to BNL and ORNL (RSICC) code distribution centers; debugging for compiler/platform portability carried out in collaboration with RSICC.
- Database additions for (N,xN) reactions delayed because of extra work on complex particle channels.
- Some work on (N,xN) reactions at higher energies started.

G. Evaluation of Data Needed for Astrophysics

The objective of this activity is to support the nuclear data needs of the increasingly sophisticated nuclear astrophysics universe modeling. The Astrophysics Task Force of the USNDP, presently chaired by Michael Smith (ORNL), plans, initiates and implements cooperative nuclear data evaluation activities which involve the nuclear data and the nuclear astrophysics communities.

ANL -- Compile information on $^{31}\text{P}(p,\gamma)$ reactions. Evaluate resonance parameters for $^{31}\text{P}(p,\gamma)$ and $^{31}\text{P}(p,\alpha)$ reactions and determine their uncertainties. Search by indirect means for low-lying resonances for these reactions. Investigate direct reaction component and calculate Hauser-Feshbach contributions for proton energies above 2 MeV. Prepare an evaluation for these two reactions. Investigate procedures for handling large errors in astrophysical nuclear reaction rates. This work is done in collaboration with Hiram College and ORNL.

ANL Deliverables:

File of evaluated data for the two ^{31}P reactions will be submitted for inclusion in ENDF.

Publish a journal article describing a procedure for handling large errors in astrophysical nuclear reaction rates.

Publish a journal article on the phosphorous evaluation and related astrophysics issues.

Status:

- Completed an extensive study of procedures for handling large errors in physical quantities, not only for astrophysical reaction rates but also for other applications such as the decay of radioactivity and radiation shielding.
- Completed Argonne Report ANL/NDM-154 dealing with the large-error issue. This report has been submitted for clearance and will be available on the Internet shortly.
- A journal version of a paper dealing with the large-error work has been conditionally accepted by *Nuclear Instruments and Methods in Physics Research A*. A response to specific referee suggestions is in preparation.
- All technical details related to preparation of the $^{31}\text{P}(p,\gamma)$ and $^{31}\text{P}(p,\alpha)$ reaction evaluations have been dealt with and Report ANL/NDM-155 that documents this work is in preparation, in collaboration with Hiram College. It is anticipated that this report will be available for issue early in CY2002.

BNL – The NNDC will begin to evaluate nuclear reaction data with emphasis on incident energies above 10 MeV. The selection of data to be evaluated will be made in consultation with the Nuclear Task Force.

BNL Deliverables:

Training of a new evaluator will be completed.

Work will begin on the evaluation of selected reactions for nuclear astrophysics applications.

Status:

- A project to compile and evaluate α -induced nuclear reaction cross sections for astrophysics has started. Of interest are light to medium light nuclei up to

Z = 32 and alpha particles with energies up to about 20 MeV. Preliminary results were obtained for ^{40}Ca and ^{44}Ti .

- No new evaluator hired due to lack of funds.

LANL -- Participate in 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 Dissemination Working Group.

LANL Deliverables:

Provide evaluated cross sections, S-factors, and Maxwellian rates for n-p capture. Continue evaluation of other processes important in Big-Bang nucleosynthesis. Continue analysis to predict the $^7\text{Be}(p,\gamma)^8\text{B}$ cross section, for the solar neutrino problem.

Continue to contribute to the TUNL Energy Levels of Light Nuclei (A=5-10) effort.

Continue project to use Hauser-Feshbach methods to calculate photonuclear data important in nucleosynthesis.

Study effects of electronic screening on Maxwellian rates under astrophysical conditions.

Status:

- New cross sections and rates reported for this reaction at Nucleosynthesis 2000 are being made available on the T-16 (T-2) Web site, see "Evaluated cross sections for BBN and helium-burning reactions.", Hale GM, Johnson AS, ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY, v. 220(pt.2) pp. U12-U12 AUG 20, 2000; "Recent R-matrix Results for np-capture", Johnson AS, Hale GM, NUCLEAR PHYSICS A, v. 688(#1-2) pp. 566C-568C MAY 21, 2001.
- Continue evaluation of other processes important in Big-Bang nucleosynthesis.
- New evaluations were completed for the d-abundance reactions d(d,n) and d(d,p), and for the ^7Li -abundance reactions $^3\text{He}(d,p)$, $^7\text{Li}(p,\alpha)$, and $^7\text{Be}(n,p)$. Cross section files were produced in ENDF-6 format, and TN data ($\langle\sigma v\rangle$, etc.) were produced in the local Nuclear Data Interface (NDI) format.
- Some progress was made on the $^7\text{Be}(p,\gamma)^8\text{B}$ cross section, for the solar neutrino problem.
- The article for A=5-7 is in the final stages of preparation, and should be ready for publication by the end of the year. The recommended levels for A=5 and A=7 came from LANL R-matrix analyses of these systems.
- Since our work on γ +silicon reactions, important in nucleosynthesis, we have not undertaken other such Hauser-Feshbach photonuclear reaction calculations for astrophysics.
- Screening potentials are being explored, and preliminary screened rates were produced for some of the hydrogen-isotope reactions.

ORNL -- Evaluate capture reactions on radioactive proton-rich nuclei which are important for element synthesis and energy generation in stellar explosions. Evaluate capture reactions important for understanding Red Giant Stars. Evaluate reactions important for nuclear burning in the interior of the sun.

ORNL Deliverables:

Continue assessments of solar thermonuclear fusion reactions.

Complete analysis of $^{18}\text{F}(p,\alpha)$ and $^{18}\text{F}(p,\gamma)$ reactions.

Begin assessments of reactions on radioactive Cl isotopes.

Work will begin on the evaluation of reaction data for ^{33}Cl , ^{25}Al , and ^{26}Si .

Status:

- Analysis of solar thermonuclear fusion reactions extended to include NACRE evaluations - fits to NACRE rates in standardized format were made and rates compared to other evaluations.
- Draft of paper on solar thermonuclear fusion reactions completed - currently under revision.
- Analysis of $^{18}\text{F}(p,\alpha)$ and $^{18}\text{F}(p,\gamma)$ reactions extended to include latest experimental results from Belgium and from ORNL, and to include Thomas-Ehrman level shift calculations of unknown levels in ^{19}Ne and an improved non-resonant rate calculation using the TEDCA code.
- Draft of paper on $^{18}\text{F}(p,\alpha)$ and $^{18}\text{F}(p,\gamma)$ reactions completed - currently under revision.
- Assessments of level structure of Ar isotopes for hydrogen burning on Cl initiated.

H. Reaction Data for RIA Target Design

Rare Isotope Accelerator facility design needs high-quality nuclear reaction data for target design, and facility design. LANL works with ORNL and ANL researchers to provide key reaction cross sections using theory calculations and measurements to evaluate the data.

LANL Deliverables:

Work closely with RIA community to determine nuclear data needs for RIA target design.

Develop nuclear reaction model code tools for improved predictions of RIA cross sections including isospin dependence in optical models for nuclei with large isospin, and improvements in fission theory for predicting neutron-rich nuclides.

Guide/support RIA researchers at ORNL, ANL, and LBNL, in the use of the Los Alamos CINDER/LAHET code for predictions of radioactive products in RIA facilities.

Status:

- We are participating in the US RIA target design collaboration with Gerry Nolen (ANL) and Jim Beene (ORNL). This year we focused on developing intranuclear cascade models (S. Mashnik) to optimize radionuclide production, using new GSI data to guide and test theory development. The same code improvements led to improved neutron and gas production. We have supplied this code to Nolen, and it will be included in the new version of MCNPX for RIA target design. Publications: “How RIA measurements can advance R&D for technology applications”, Chadwick MB, ABSTRACTS OF PAPERS OF THE AMERICAN CHEMICAL SOCIETY , v. 221(pt.2) pp. U76-U76 APR 1, 2001; “A computer study of radionuclide production in high power accelerators for medical and industrial applications”, Van Riper KA, Mashnik SG, Wilson WB, NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH SECTION A-ACCELERATORS SPECTROMETERS DETECTORS AND ASSOCIATED EQUIPMENT , v. 463(#3) pp. 576-585 MAY 11, 2001.
- Work continues on our medium-energy relativistic Schrodinger global optical model. This is global in energy, and target and projectile N, Z (and therefore isospin). We have obtained good representations for scattering, reaction, and total cross section data for a limited set of nuclides spanning the periodic table; we hope to have a completed phenomenological global potential by the end of FY02. Publication: “Predicting total reaction cross sections for nucleon-nucleus scattering”, Deb PK, Amos K, Karataglidis S, Chadwick MB, Madland DG, PHYSICAL REVIEW LETTERS , v. 86(#15) pp. 3248-3251 APR 9, 2001.
- We provide codes such as MCNPX and LAHET/CINDER to the RIA design community and have provided guidance on their use.

Funding Sources Outside the Nuclear Data Program

The information here is not complete. The information is not required but is included here to show some examples of related external funding for those organizations that are mostly funded by the U.S. Nuclear Data program.

BNL -- Produce computer-generated photoready copy for the Nuclear Data Sheets.

McMaster – 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 experiments nuclear data for XUNDL.

NIST -- The Department of Commerce through NIST supports the standards activity.