USNDP

U.S. Nuclear Data Program
Work Plan for
Fiscal Year 2001

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Introduction

Previously, a work plan for the U.S. Nuclear Data Program for fiscal year 2000 was prepared and presented for review to the DOE at a meeting held in Washington, D.C. on November 1 and 2, 1999. The work plan described in this document has been developed to cover work to be done by the data program during fiscal year 2001 that begins on October 1, 2000. The Chair of the U.S. Nuclear Data Coordinating Committee has prepared this plan 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 or her organization. The Coordinating Committee Chair prepared a unified work plan based on these submissions. The draft plan was then circulated to the Coordinating Committee for comments and corrections.

As was the case in the work plan for FY2000, the tasks proposed by the different 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 meets one of the three program priorities:

    a) The maintenance and update of the USNDP nuclear physics databases;
    b) The improvement of dissemination of the information contained in those databases to the user community;
    c) The modernization of data evaluation software used by the program participants.

2. A task is useful to more than a single user community.

3. A task does 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:

- NNDC Facility Operation
- Coordination
- Nuclear Physics Databases
- Information Dissemination
- Nuclear Structure Physics
- Nuclear Reaction Physics

The following section details the proposed work plan for FY2001, defining tasks, organizational responsibilities, and deliverables. One must understand that a plan is just a plan. To be successful, the planning process must be flexible enough to be able to respond to unforeseen circumstances. It is envisioned that this document will serve as the basis for a performance review at the end of fiscal year 2001.

An effort table follows the detailed work plan. The effort table provides a summary of the total effort devoted to the defined tasks and the distribution of this effort by organization.

Finally, the detailed plan submissions by each organization are attached as appendices to allow for more detailed explanation of their plans.

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Work Plan Tasks and Deliverables

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 DEC Alpha 4100 computer to support our compilation, evaluation, database maintenance, and information dissemination functions. Task includes software upgrades, hardware and software procurements, machine operations and internal user support.

Deliverables:

Keep downtime to less than 3%.

D. NT Server Operation

The NNDC operates a DELL Work Station running WINDOWS-NT and WINCENTER software as a multi-user PC software server with output to staff X-window terminals. Task includes software upgrades and internal user support.

II. Coordination

A. National Coordination

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

Deliverables:

Prepare FY2002 work plan for USNDP in time for spring 2001 FWP submittals.
Participate in USNDP Steering Committee Meetings.
Chair USNDP Meeting in April 2001.
Organize and chair CSEWG Meeting at BNL, November 2000.
Maintain USNDP WWW-site.

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.

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.

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, member of USNDP Steering Committee, chair of Evaluation Committee of the Cross Section Evaluation Working Group.

Deliverables:

Prepare FY2002 Reaction Working Group Work Plan with BNL.
Participate in USNDP Steering Committee meetings.
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2000.
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in 2001.

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. LBNL staff member serves as an advisor to USNDP Steering Committee. Included here is also the Isotopes project management responsibilities of interacting with LBNL management and the DOE program manager.

Deliverables:

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

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.

Deliverables:

Participate in technical meeting of NRDC in Vienna, June 2000.
Chair NEA Working Party in the United States in 2001.
Provide one consultancy to IAEA Nuclear Data Section, December 2000.
Participate in the biennial Nuclear Structure and Decay Data Meeting in Vienna, December 2000.
Provide a lecturer for the Nuclear Structure Workshop in Trieste in 2001.

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

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.

Deliverables:

Participate in NEA evaluation meeting in 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.

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.

Deliverables:
Database distributed to collaborators monthly.

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.

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.

Deliverables:
Database distributed to collaborators monthly.

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. Database is also available in a PC version. The database is updated twice a year.

Deliverables:
Database distributed to collaborators twice in the year.

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 is 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.

Deliverables:

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

Deliverables:

Database retrieval codes will be completed.

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

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.

Deliverables:

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

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.

Deliverables:

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

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.

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.

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 electronic access to the nuclear physics databases that it maintains. This access is supported in two forms, remote login (TELNET) and via the WWW.

Deliverables:

No enhancements are planned for the remote login (TELNET) access software.
Add WWW interface to the Q-value calculator (QCALC).

B. Customer Services

This task accounts for the non-electronic services which the USNDP renders to customers. At the scientific staff level, we mean 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.

Deliverables:

NNDC -- Effort required keeping the USNDP and the NNDC site current.

LANL -- 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.

LBNL -- Develop website for compiled capture gamma data as part of IAEA CRP.
Update Table of Superdeformed Bands and Fission Isomers with revised information prepared by McMaster.
Update nuclear astrophysics reaction rates on the nuclear astrophysics page.

TUNL -- 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.

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.

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.

Deliverable:
Prototype system in operation.

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.

Deliverables:

NNDC -- Keyword abstracts for 3200 references will be prepared in FY2001.

B. Compilation of Experimental Structure Data

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

Deliverables:

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

ORNL -- Improve software for converting tabular/graphic published level-scheme data in journals and unpublished data supplied by researchers to Radware database, into ENSDF format. Examples used in the development of these procedures will be submitted to BNL as XUNDL data sets**.**

C. Data Evaluation

The USNDP evaluates nuclide and mass chain nuclear structure and decay data for inclusion in the ENSDF database.

Deliverables:

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

Idaho -- Evaluate two equivalent mass chains.
Mass chains will be reviewed as requested.

LBNL -- Five equivalent mass chains and six nuclides will be evaluated.
Mass chains will be reviewed as requested.
Update evaluations for A>266.
Add data for newly discovered nuclides as they occur (joint with Audi/Blachot)

McMaster -- 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.

ORNL – Evaluate A=225 and 229.
Mass chains will be reviewed as requested.

TUNL -- Evaluate masses 10 and 11.
Prepare publication for A = 8, 9 and 10 for submission to Nuclear Physics A..
Prepare ENSDF files for A = 5, 6, 7, 14 and 15.

D. Ground and Metastable State Properties

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

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

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 in the U.S. Idaho coordinates this project.

Deliverables:
LBNL -- 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.

Idaho -- Decay data for 5 nuclides will be evaluated.

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.

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

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.

Deliverables:

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

Update LOGFT to calculate higher orders of forbiddances.

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. NNDC is compiling new charged-particle measurements. However, because of emerging needs such as astrophysics, the NNDC is attempting to compile older data. 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.

Deliverables:

NNDC -- Compile data from 120 charged-particle reaction publications.
Compile data from 15 neutron reaction publications.

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 coming 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.

Deliverables:

Host a workshop to determine guidelines for compilation of RHIC data.
Make a decision on the future of this activity based on the workshop outcome.

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.

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.

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.

Deliverables:

LANL -- 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 $n+^{16}O$ evaluation covering energies up to 150 MeV, incorporating new LANSCE/WNR from 6 to 30 MeV.

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.

Deliverables:

NIST -- 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; start the 14 MeV measurements.

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.

Deliverables:

Experimental data will be submitted to NNDC for inclusion in CSISRS.
Complete evaluations for these reactions and submit for inclusion in ENDF.
Participate in a study of nuclear model parameters in the region A = 30 to 60 with collaborators at IRMM, Belgium.
Publish the experimental results and the model parameter study.

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.

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, preequilbrium 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}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.

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

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.

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).

Deliverables:

Database augmented with additional (N,xN) spectra from the literature at energies of 40 to 1000 MeV.

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 $^{31}P(p,\gamma)$ reactions. Evaluate resonance parameters for $^{31}P(p,\gamma)$ and $^{31}P(p,\alpha)$ 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. This work is done in collaboration with Hiram College.

Deliverables:

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

Compiled data for the sulfur isotopes will be sent to NNDC for inclusion in CSISRS.

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

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.

Deliverables:

Training of a new evaluator will be completed.

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

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.

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 7Be(p,γ)8B 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.

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.

Deliverables:

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

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.

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.

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. Participate in a third SBIR awarded to Scientific Digital Visions.

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.

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USNDP Staffing Table for October 2000 through September 2004

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
I. NNDC Facility Operation	**0.00**	**1.60**	**1.35**	**0.00**	**0.00**	**0.00**	**0.00**
Management		0.50					
Secretarial/Administrative Support			1.00				
Library			0.35				
Computer Operation		0.75					
NT Server Operation		0.35					
II. Coordination	**0.00**	**0.65**	**0.00**	**0.10**	**0.30**	**0.30**	**0.00**
National Coordination		0.35		0.05	0.1	0.3	
International Coordination		0.30		0.05	0.2		
III. Nuclear Physics Databases	**0.00**	**2.75**	**1.50**	**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	0.60				
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)		0.20					
Database Software Maintenance		0.65					
Future Database Systems		0.90					
IV. Information Dissemination	**0.00**	**1.05**	**0.50**	**0.00**	**0.00**	**0.60**	**0.00**
Maintenance of Remote Access to USNDP Data	0.00	0.40					
Telnet Service		*0.05*					
WWW Service		*0.35*					
Customer Services		0.15	0.45				
Web Site Maintenance		0.15	0.05			0.30	
Common ENSDF Web Interface Project	0.00	0.10				0.30	0.00
APS Link to NNDC Experimental databases		0.25					

USNDP Staffing Table for October 2000 through September 2004

	McM	NIST	ORNL		SJSU	TUNL	Program Total	
			Sci/Pro	Support			Sci/Pro	Support
I. NNDC Facility Operation	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.60**	**1.35**
Management							0.50	0.00
Secretarial/Administrative Support							0.00	1.00
Library							0.00	0.35
Computer Operation							0.75	0.00
NT Server Operation							0.35	0.00
II. Coordination	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**1.35**	**0.00**
National Coordination							0.80	0.00
International Coordination							0.55	0.00
III. Nuclear Physics Databases	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**2.75**	**1.50**
Nuclear Science References (NSR)							0.15	0.75
Experimental Nuclear Structure Data (XUNDL)							0.05	0.00
Evaluated Nuclear Structure Data (ENSDF)							0.45	0.60
Numerical Nuclear Data (NuDat)							0.05	0.00
Reaction Data Bibliography (CINDA)							0.25	0.05
Experimental Reaction Data (CSISRS)							0.05	0.10
Evaluated Nuclear Data File (ENDF)							0.20	0.00
Database Software Maintenance							0.65	0.00
Future Database Systems							0.90	0.00
IV. Information Dissemination	**0.00**	**0.00**	**0.10**	**0.00**	**1.20**	**1.50**	**4.45**	**0.50**
Maintenance of Remote Access to USNDP Data							0.40	0.00
Telnet Service							*0.05*	*0.00*
WWW Service							*0.35*	*0.00*
Customer Services							0.15	0.45
Web Site Maintenance			0.00			1.50	1.95	0.05
Common ENSDF Web Interface Project	0.00	0.00	0.10	0.00	1.20	0.00	1.70	0.00
APS Link to NNDC Experimental databases							0.25	0.00

USNDP Staffing Table for October 2000 through September 2004

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
V. Nuclear Structure Physics	**0.00**	**2.60**	**0.00**	**0.30**	**0.00**	**2.80**	**0.00**
NSR Abstract Preparation		0.55	0.00				
Compilation of Experimental Structure Data							
Evaluation of data for ENSDF		1.65		0.30		2.80	
Masses and Nuclides		*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						*0.40*	
ENSDF Physics and Checking Codes		0.40					
VI. Nuclear Reaction Physics	**0.85**	**1.65**	**0.25**	**0.00**	**1.10**	**0.00**	**0.40**
Experimental Data Compilation		0.60	0.25				
Neutron Data		*0.10*	*0.25*				
Charged Particle Data		*0.45*					
EXFOR Manuals		*0.05*					
Compilation of RHIC and TJNAF Data		0.05	0.00				
ENDF Manuals and Documentation		0.05	0.00				
ENDF Evaluations					0.10		
Nuclear Reaction Standards							
Nuclear Model Development	0.20				0.40		0.40
Evaluation of Data Needed for Astrophysics	0.65	0.95	0.00		0.40		
Reaction Data for RIA Target Design					0.20		
DOE/Science Nuclear Data Funded Staff	**0.85**	**10.30**	**3.60**	**0.40**	**1.40**	**3.70**	**0.40**
Staff Supported by Other Funding		**0.50**	**0.40**				
TOTAL STAFF	**0.85**	**10.80**	**4.00**	**0.40**	**1.40**	**3.70**	**0.40**

USNDP Staffing Table for October 2000 through September 2004

	McM	NIST	ORNL		SJSU	TUNL	Program Total	
			Sci/Pro	Support			Sci/Pro	Support
V. Nuclear Structure Physics	**0.50**	**0.00**	**0.60**	**0.25**	**0.00**	**1.15**	**7.95**	**0.25**
NSR Abstract Preparation							0.55	0.00
Compilation of Experimental Structure Data	0.05		0.10				0.15	0.00
Evaluation of data for ENSDF	0.45		0.50	0.25		1.15	6.85	0.25
Masses and Nuclides	*0.45*		*0.50*	*0.25*		*1.15*	*6.05*	*0.25*
Ground and Metastable State Properties							*0.10*	*0.00*
Radioactive Decay Data Evaluation							*0.30*	*0.00*
Thermal Capture Gamma Data Evaluation							*0.40*	*0.00*
ENSDF Physics and Checking Codes							0.40	0.00
VI. Nuclear Reaction Physics	**0.00**	**0.20**	**0.50**	**0.00**	**0.00**	**0.40**	**5.10**	**0.25**
Experimental Data Compilation							0.60	0.25
Neutron Data							*0.10*	*0.25*
Charged Particle Data							*0.45*	*0.00*
EXFOR Manuals							*0.05*	*0.00*
Compilation of RHIC and TJNAF Data							0.05	0.00
ENDF Manuals and Documentation							0.05	0.00
ENDF Evaluations							0.10	0.00
Nuclear Reaction Standards		0.20					0.20	0.00
Nuclear Model Development						0.40	1.40	0.00
Evaluation of Data Needed for Astrophysics			0.50				2.50	0.00
Reaction Data for RIA Target Design							0.20	0.00
DOE/Science Funded Staff	**0.50**	**0.20**	**1.20**	**0.25**	**1.20**	**3.05**	**23.20**	**3.85**
Staff Supported by Other Funding	**0.50**	**0.80**	**0.00**	**0.00**	**0.00**	**0.00**	**1.80**	**0.40**
TOTAL STAFF	**1.00**	**1.00**	**1.20**	**0.25**	**1.20**	**3.05**	**25.00**	**4.25**

Work Plan for FY2001

Argonne National Laboratory

The format of the present work plan is based on the similar document prepared in 1999 for FY2000. The structure and components of the Argonne contributions are very much like those presented in last year's document. Only those items that pertain to the Argonne activities are shown in each section below:

Work Plan Tasks and Deliverables

VI. *Nuclear Reaction Physics*

F. Nuclear Model Development

ANL – Analysis of experimental data obtained from neutron activation measurements in the energy range 16 to 21 MeV performed during FY2000 - in collaboration with IRMM, Geel, Belgium - will be completed and the cross-section results will be interpreted in terms of the statistical, pre-compound model using code STAPRE, mainly by scientists at IRMM. The experimental results will be submitted in EXFOR format to NNDC for inclusion in the CSISRS database. The results of this work will also be published. Specific evaluations for these reactions will be prepared and submitted to NNDC in ENDF format to be included in ENDF-A. The program that began during FY2000 - of detailed nuclear model calculations and parameter sensitivity studies for all neutron reaction channels in the mass range A = 30 to 60 that are open at neutron energies up to 20 MeV, and lead to radioactive by-products - will be continued. Some reactions for higher-mass targets (A > 60) may also be examined during this year, depending on the status of the work for the lower mass region and time available. This nuclear modeling project will involve comparison of theoretical cross-section excitation curves with all pertinent measured data collected from the literature as well as with available experimental results from the ANL/IRMM collaborative measurement program.

Deliverables:
i) Experimental results transmitted to NNDC in EXFOR format for inclusion in the CSISRS database; ii) evaluated reaction cross sections transmitted to NNDC in ENDF format to be included in ENDF-A; iii) a journal article communicating the results from those aspects of the model parameter sensitivity study completed during the time period FY2000-2001; iv) a journal publication that reports the results from the ANL/IRMM collaborative experiment performed during FY2000.

G. Evaluation of Data Needed for Astrophysics

ANL – All aspects of the data evaluation activity associated with the reactions $^{31}P(p,\gamma)$ and $^{31}P(p,\alpha)$ reactions that were not completed during FY2000 will be finished during FY2001. This mainly would involve finishing the evaluations, transmitting the results to NNDC, and publishing a journal article on this investigation and the astrophysical implications of the results obtained. Attention will then be turned for the remainder of FY2001 to a similar data compilation and evaluation activity for (p,γ) and (p,α) reactions on the stable sulfur isotopes, namely, $^{32,33,34,36}S$. Since $^{33,34,36}S$ are minor isotopes (comprising < 5% of natural sulfur in total), it is anticipated that the experimental database will be sparse for these processes and it will be necessary to rely heavily on statistical model calculations in performing the evaluations.

Deliverables:
i) Compiled results from the literature for the sulfur reactions transmitted to NNDC in EXFOR format for inclusion in CSISRS database; ii) evaluated reaction cross sections for the phosphorus reactions transmitted to NNDC in ENDF format to be included in ENDF-A; iii) a journal article communicating the results from the phosphorus reaction evaluation activity and investigation of related astrophysical issues.

USNDP Level of Effort for October 2000 through September 2001

Information for inclusion in the EXCEL spreadsheet is given below – only the ANL components are indicated here:

VI. Nuclear Reaction Physics – 0.85 professional FTE (total effort for this category)
Nuclear Model Development - 0.20 professional FTE
Evaluation of Data Needed for Astrophysics - 0.65 professional FTE

Zero effort for all other categories in the EXCEL spreadsheet.

Note: These are the same numbers as appear in the FY2000 Work Plan.

Tasks for Consideration if Data Program Funding is Increased

The assumption made here is that the increase would be 10% above "Flat" funding. The exact level of increased effort that could be allocated to work on this project would depend on the actual final funding authorization for FY2000, on DOE/SC-DNP interpretation of "Flat" funding, and on the applicable professional effort costs at ANL during FY2001. All of these factors are undetermined at the time that this FY2001 Work Plan is being prepared (early March 2000).

Argonne National Laboratory

Professional effort devoted to evaluation of the sulfur (p,γ) and (p,α) reactions for astrophysics could be increased by approximately 0.25 FTE, thereby speeding up the process significantly.

Impact of a Ten Percent Reduction in Funding

Argonne National Laboratory

Professional effort devoted to evaluation of sulfur (p,γ) and (p,α) reactions for astrophysics would decreased by about 0.20 – 0.25 FTE, leading to considerable delay in completing some aspects of this project. Such a delay in this part of the ANL program would be unavoidable since pre-existing commitments to an international collaborative project would prevent a corresponding reduction in effort allocated to the Nuclear Model Development work. Furthermore, it would be very difficult to justify support for a post doc appointee who is working part time in the ANL Nuclear Data Program.

APPENDIX

Argonne National Laboratory

Program Administration

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Program Technical Overview

The program consists of two major projects; each of these falls under the Nuclear Reaction component of the DOE/SC-DNP nuclear data activity: i) compilation and evaluation of nuclear reaction data for astrophysics; ii) nuclear reaction data studies that contribute to improvement of pre-compound nuclear models used in obtaining cross-sections needed for such contemporary applications as RIB production. This work involves collaborations with Hiram College, Ohio, and the Institute for Reference Materials and Measurements, Geel, Belgium.

Detailed Program Technical Description

Task #1: *Nuclear Data for Astrophysics*

The objective of this project is ultimately to generate greatly improved evaluations of reaction cross sections and stellar reaction rates for hydrogen-induced reactions on stable nuclei in the mass range A = 30-50. This work complements ongoing studies of nuclear data for astrophysics off the line of stability (using RIB techniques) in progress at ORNL (funded by DOE/SC-DNP) and elsewhere. The ANL activity is conducted in collaboration with Prof. Laura Van Wormer at Hiram College (also funded by DOE/SC-DNP). Proton reactions in this mass range - in particular (p,γ) and (p,α) - are considered by nuclear astrophysicists to be essential for understanding explosive (high temperature) nucleo-synthesis in Novae, Super-novae, and X-ray Bursters. The energy region of interest is from zero to about 5 MeV. Existing libraries of reaction rates used in contemporary stellar evolution calculations are largely based on Hauser-Feshbach (H-F) calculations which - in many cases - are seriously deficient due to the limiting assumptions, e.g., the continuum level-density assumption. In order to obtain improved evaluations it is necessary to: i) compile information on discrete-resonance energies, strengths, and quantum numbers; ii) seek for "missing" resonances through indirect means such as transfer reactions, properties of isobaric analogue nuclei, etc.; iii) estimate the direct (non-resonant) proton-capture strength; iv) estimate possible reaction yields at very low proton energies due to existing bound-states near the proton binding energy; and, v) perform the best possible H-F calculations at incident proton energies above 2 MeV - a region where levels tend to overlap strongly and a discrete-level approach no longer works. The approach being used in the ANL/Hiram College collaboration is to first compile the available information on the discrete resonances - since they tend to dominate the reaction rates in this mass range - and then address the issue of providing corrections due to missing resonances, direct capture, and H-F contributions (at the higher proton energies). In addition, this evaluation project addresses the issue of cross section uncertainties in the individual evaluations since such information is beginning to be included in contemporary astrophysics network calculations (e.g., by the astrophysics group at ORNL).

Task #2: *Nuclear Data for Nuclear Modeling*

Nuclear models are needed to calculate reaction cross sections in situations where experimental data are difficult to acquire. The pre-compound model for nuclear reactions has proved to be very useful - in the range from several MeV up to several hundred MeV - for this purpose in a number of applied areas, e.g., ATP, ATW, medical (proton and neutron radio-therapy), and fusion. In basic science this model is proving useful for computing the yields of RIB species from spallation targets. However, the pre-compound model requires accurate knowledge of parameters for each open reaction channel. Often this information is missing and blind inter-comparison exercises of nuclear modeling without prior agreement on the choice of parameters can lead to widely discrepant results. The goal of this work is to contribute to development of a set of systematics for this parameterization that can be applied to nuclear reaction cross section calculations.

However, this can be accomplished only through extensive comparisons with experimental data when the latter can be measured. The ANL Nuclear Data Program is collaborating with the Institute for Reference Materials and Measurements (IRMM) of the European Commission, Geel, Belgium, in a project of measuring a large number of neutron activation reactions at energies well into the region where the pre-compound model is important (above 15 MeV). Experiments and corresponding data analysis are being carried out at ANL in collaboration with IRMM staff, graduate students, and post docs. Results from this work have been published in Physical Review (1998), Radiochimica Acta (1999), and Nuclear Science and Engineering (2000). The advantage to DOE/SC-DNP of this project is a significant leveraging of resources. Experiments can be carried out at a well-equipped accelerator facility in Belgium at no direct cost to DOE beyond professional effort and some travel expenses. Furthermore, staff and student personnel at the Belgian laboratory are contributing to the acquisition of data and its analysis in these experiments.

Work Plan for FY2001

The following tasks and component sub-tasks - and corresponding anticipated deliverables - are scheduled for the period in question:

Task #1: *Nuclear Data for Astrophysics*

Sub-task 1.a --- Finish all uncompleted aspects of the data evaluation work for the $^{31}P(p,\gamma)$ and $^{31}P(p,\alpha)$ reactions.

Deliverables: Evaluated files in ENDF format transmitted to NNDC for inclusion in ENDF-A and a journal article on the data compilation and evaluation activity and its implications for astrophysics. [This work will be done in collaboration with Hiram College, Ohio.]

Sub-task 1.b --- Work on compilation of the available information from the literature for the $^{33,34,36}S(p,\gamma)$ and $^{32,33,34,36}S(p,\alpha)$ reactions. This work will complement a similar already completed and documented compilation activity for the $^{32}S(p,\gamma)$ reaction (Report ANL/NDM-143).

Deliverable: Documentation appearing in one or more ANL/NDM series reports and compiled data files for the CSISRS database transmitted in EXFOR format to the NNDC.

Sub-task 1.c --- Begin work on evaluation of the resonance parameters and other essential parameters associated with generating cross sections for the $^{32,33,34,36}S(p,\gamma)$ and (p,α) reactions. [This work will be done in collaboration with Hiram College, Ohio.]

Deliverable: None since the work will not have been completed during FY2001.

Task #2: *Nuclear Data for Nuclear Modeling*

Sub-task 2.a --- Experimental data acquired during FY2000 will be analyzed and interpreted using the statistical, pre-compound model. Most of the modeling activity will be carried out at IRMM. Final results will be prepared for journal publication and the experimental data files will be transmitted to NNDC in EXFOR format for inclusion in the CSISRS database.

Deliverables: Experimental data files transmitted to NNDC in EXFOR format for inclusion in the CSISRS database and a journal article will be prepared to report on these measurements.

Sub-task 2-b --- Neutron reactions on targets in the mass range A = 30 – 60 and leading to radioactive by-products will be analyzed using the statistical, pre-compound code STAPRE. Most of this work will be performed at IRMM with guidance and some input from ANL. Comparisons will be made with experimental data from the ANL/IRMM collaboration as well as other results available from the literature. Detailed model-parameter sensitivity studies will then be performed and a manuscript reporting on the results of this investigation will be prepared.

Deliverable: A manuscript on the nuclear-model parameter sensitivity studies - described above and completed during FY2000/2001 – and corresponding evaluated reaction cross-section files in ENDF format transmitted to NNDC.

Travel and Miscellaneous Expenses

Travel is a necessity for the pursuit of this research program. Some foreign travel – mainly to Belgium – may be required to participate in existing fruitful research collaborations. The Principal Investigator has been invited to participate - as a U.S. representative - in the activities of the recently re-organized Nuclear Energy Agency Working Party for Evaluation Cooperation. This committee coordinates international nuclear data activities and holds an annual meeting that may take place in either the U.S., Europe, or Japan. Domestic travel is essential to fulfill obligations to the U.S. Nuclear Data Program. The Principal Investigator is a member of the USNDP Coordinating Committee. Miscellaneous expenses include such items as personal computer hardware and software, publication costs, etc.

Impact of FY2001 Budget

The major long-term tasks and corresponding objectives of the Argonne nuclear data program will not be altered significantly by the proposed budget scenarios for FY2001 (-10%, Flat, +10%). However, the pace at which work can be accomplished on the various sub-tasks involved in this program will obviously be affected because the level of available effort that can be allocated to this work is budget sensitive. For the near term, the main impact of budget reductions will be in the Task #1 area since commitments to an international collaboration make it difficult to reduce the effort on Task #2. The program described above basically assumes the “Flat” scenario. More

specifically, the following table shows the proposed allocation of effort and dollar-cost budget items for each of the three scenarios:

Table: Budget Scenarios for the Argonne Nuclear Data Program

		Budget Scenario		
Task	Topic	-10%	Flat	+10%
Task #1	Astrophysics	0.60	0.65	0.70
Task #2	Nuclear Models	0.15	0.20	0.25
Total	Effort	0.75	0.85	0.95
Travel & Misc. Expenses		$10K	$10K	$10K

Notes:

1. Task # 1 (Evaluation of Data Needed for Astrophysics); Task # 2 (Nuclear Model Development).
2. Effort given in FTE units and dollar-cost budget items are in units of $10,000.

From a programmatic point of view, it is evident that increased or reduced funding will impact mainly on the work activity for the Astrophysics related topics because they represent the major portion of the program. This is a near-term issue because it is anticipated that the Astrophysics related projects will continue to grow in the future on a relative basis. However, a major reduction of effort for the Nuclear Model Development topics at the present time seems unwise since the leverage achieved by preserving an existing carefully cultivated collaboration with IRMM in Belgium would be lost before the tangible benefits are fully realized.

14 January 2000

Idaho Evaluators

Work for U. S. Nuclear Data Program

Responsibilities and Activities for FY2001

R. G. Helmer and C. W. Reich

	FTE
Evaluation responsibilities: masses 87, 153-163	
FY2001 evaluations: all of the data for A=87 and 156	0.23
Coordinate Working Group of Nuclear Structure and Decay Data	
Coordinate US contribution to international network meeting in December 2000	0.02
Plan program and chair Working Group session at the US NDP meeting in 2001	0.02
International Subcommittees	
Participate in topical subcommittee as requested by international network chair	0.02
Review evaluations from other groups	
Review two mass chain evaluations when requested	0.04
Decay Data Evaluation Project	
Coordinate the work of the Project	0.02
Evaluate data for the decay of five radio-nuclides	0.05
TOTAL	0.40

LANL Group T-2 FY2001 Work Plan for US Nuclear Data Program (USNDP)

	Description	Effort (FTEs)
1	USNDP Reaction Working Group Organization	0.1
2	Nuclear Physics ENDF Database	0.1
3	Astrophysics Reaction Data	0.4
4	Reaction data for RIA Target Design	0.2
5	Model code development, and reaction theory studies at LANSCE and GEANIE	0.4
6	WWW Dissemination of nuclear data	0.1
7	International nuclear data cooperation	0.2
8	Publications	
		Total=1.5

1. USNDP Reaction Working Group Organization (0.1 FTE)

Chair US Nuclear Data Program's Reaction Working Group, and help coordinate reaction data work at different labs to advance USNDP goals. Member of USNDP Steering Committee. Chair of Evaluation Committee of the Cross Section Evaluation Working Group.

Deliverables:

Participate in USNDP Steering Committee meetings
Organize and chair CSEWG Evaluation Committee meeting at BNL, Nov 2000
Organize and chair Reaction Working Group meeting at USNDP meeting, April 2001.

2. Nuclear Physics ENDF Database (0.1 FTE)

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, work with BNL to insure quality control, particularly for new evaluations. We will also submit new evaluations listed below (funded primarily from other sources) for archival in ENDF/B-VI.

Deliverables:

Work with BNL to issue Release VIII of ENDF/B-VI
Submit suite of new photonuclear ENDF evaluations to CSEWG – this will be the first time that photonuclear data are available in the ENDF/B Library
Submit new p+Li evaluations for ENDF, important for design of quasimonoenergetic neutron sources for reaction cross section measurements
Complete and submit new n+16O evaluation up to 150 MeV, including major improvements in the 6-30 MeV region through use of LANSCE/WNR gamma-ray data.

3. Astrophysics Reaction Data (0.4 FTE)

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.

Deliverables:

Provide evaluated cross sections, S-factors, and Maxwellian rates for n-p capture; continue analysis of other processes important in Big-Bang nucleosynthesis
Continue analysis to predict the $^{7}Be(p,\gamma)^{8}B$ cross section, for the solar neutrino problem
Continue to contribute to the TUNL Energy Levels of Light Nuclei (A=5-10) effort

Study effects of electronic screening on Maxwellian rates under astrophysical conditions, using a fully quantum-mechanical description

Continue a project initiated in FY00 to use Hauser-Feshbach methods to calculate photonuclear data important in nucleosynthesis

4. Reaction Data for RIA target design (0.2 FTE)

A Rare Isotope Accelerator (RIA) facility design needs high-quality nuclear reaction data for target design, and facility design. We have worked with ORNL and ANL researchers to provide key reaction cross sections, using theory calculations and measurements to evaluate the data, and will continue to address their needs in the future.

Deliverables:

Work closely with Nuclear Physics RIA community to determine nuclear data needs for RIA target design, and support these needs.

Develop nuclear reaction model code tools for improved predictions of RIA cross sections (see 5 below), 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, into the use of the Los Alamos CINDER/LAHET code for predictions of radioactive products in RIB facilities.

5. Model code development, and reaction theory studies at LANSCE and GEANIE (0.4 FTE)

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, McGANSH, to provide a state-of-the-art capability to predict reaction cross sections. This also involves a close collaboration with experimentalist at LANSCE (R.C. Haight, J.A. Becker, S.M. Grimes) to interpret new measurements using the GEANIE gamma-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.

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, preequilbrium reactions, transmission coefficients, and gamma-ray strength functions. Include a Monte-Carlo option. (Note, this is highly-leveraged with support from DOE/DP). Collaborate With LLNL, and with NEA working party group, on benchmark validation tests.

Calculate and interpret gamma-ray reactions measured with GEANIE at LANSCE, including n+^{92}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 and Grimes at LANSCE.

6. WWW Dissemination of nuclear data (0.1 FTE)

Continue to develop our T-2 Online Nuclear Information Service, for convenient and wide access to our nuclear modeling research, data evaluations, and publications. Develop this WWW site in coordination with the USNDP Dissemination working Group.

Deliverables:

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

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

Include WWW access to ENDF/B-VI Release 7, when available

7. International nuclear data cooperation (0.2 FTE)

Participate in, and chair, international nuclear reaction data collaborations. This ensures that the US benefits from breakthroughs around the world, and plays a leadership role in new developments. We 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. Host a couple of high-quality foreign scientist to visit LANL to undertake USNDP work, to benefit from collaborative exchanges of information and ideas.

Deliverables:

Participate in NEA June 2001 meeting
Participate in relevant IAEA meetings, including Trieste Lectures
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

8. Publications

We will document our work in refereed journal articles and laboratory reports.

ISOTOPES PROJECT NUCLEAR STRUCTURE AND DECAY EVALUATION/COMPILATION PLANS FOR FY2001

The Isotopes Project's plans for FY2001 include a mix of individual nuclide and entire mass chain evaluations chosen from those for which LBNL has been assigned responsibility. The former are particularly effective in enabling the prompt inclusion in ENSDF of major new data for nuclides on which current research activities are centered. The latter, however, provide a comprehensive view of the nuclear systematics of isobars. In addition, participation in two international collaborations will continue; these are concerned with evaluation of radioactive decay data (with emphasis on decays having specific astrophysical interest), and a systematic evaluation of nuclear structure aspects of (thermal/cold n,γ) data; each was undertaken in response to current research community needs. Also, Isotopes Project personnel will continue to participate in the coding of special non-US evaluations for inclusion in ENSDF and in the review of other data evaluations submitted to NNDC. The anticipated level of effort for the above activities is 2.5 FTE from LBNL employees plus 0.3 FTE from visiting evaluators.

- **Mass Chain Evaluation:**
  5 Mass Chains.

- **Individual Nuclide Evaluation:**
  - Approximately 6 nuclides from LBNL-responsibility chains, to be chosen as new literature adds significant information.
  - Update of A>266 nuclides as new data become available.
  - Newly discovered isotopes, in collaboration with NUBASE evaluators.

- **Mass Chain Reviews:**
  Provide reviews of mass chains as needed by the ENSDF editor.

Effort for above items: 2.15 FTE (which includes 0.3 FTE from visitors)

- **Continuation of (thermal/cold n,γ) Horizontal Evaluation:**
  Three-year IAEA CRP for Prompt Gamma Activation Analysis:
  This program covers the evaluation of isotopic and elemental (thermal/cold n,γ) data to develop an adopted capture γ ray database. A draft version of this database will be completed (in collaboration with Zhou Chunmei, China), and we will coordinate the CRP evaluation and research efforts.

Effort: 0.4 FTE

- **Continuation of Decay Data Evaluation Project (DDEP): Nuclear and Atomic Radiations**

  Submit decay datasets for two radionuclides.

  Code Decay and Adopted data sets for non-US evaluations of radionuclides as needed for inclusion in the ENSDF database.

Effort: 0.25 FTE

- **Compilation of XUNDL Datasets:**

  Some datasets may be prepared in collaboration with LBNL by a student compiler from Westmont College, CA, and provided for XUNDL during FY2001.

  Some additional datasets from evaluations that we are planning will be prepared and submitted for inclusion in the XUNDL database.

Effort: unknown at this time

ISOTOPES PROJECT ELECTRONIC DISSEMINATION FY2001 PLANS

We are planning to continue nuclear data dissemination efforts with a view to providing scientists and engineers throughout the world with user-friendly means to access the wide variety of evaluated and compiled nuclear data. This work will be done with 0.6 FTE LBNL staff in collaboration with Lund University and EVITech**.**

- **USNDP Web Interface to Nuclear Data**

  As a part of the recently started USNDP Dissemination collaboration (BNL, LBNL, ORNL, SJSU), we will continue our participation in the effort to produce a single web interface to the ENSDF, XUNDL, NSR, and other databases.

Effort: 0.3 FTE

- **WWW Table of Radioactive Isotopes**

  Databases will be updated and additional utilities will be added in collaboration with Lund University.

Effort: 0.1 FTE

- **Capture Gamma-Ray Data**

  Maintenance and development of a website for the IAEA Coordinated Research Program (CRP) for Prompt Capture Gamma-Ray Activation Analysis will continue.

Effort: 0.1 FTE

- **WWW Home Pages**

  Home pages for nuclear astrophysics, superdeformation, atomic masses, and other topics will be updated and maintained as needed.

Effort: 0.1 FTE

ISOTOPES PROJECT MANAGEMENT

The group leader of the Isotopes Project works 30% of his time on USNDP activities. He is the leader of the USNDP Working Group on Data Dissemination, and serves as an ex-officio member of the USNDP Steering Committee. He oversees, coordinates, and directs the work of members of the Isotopes Project. This effort includes working with LBNL management, with other members of the USNDP, and with the program officers of the DOE.

Effort: 0.3 FTE

Work Plan for FY2001
Lawrence Livermore National Laboratory

Title: Advanced shell-model treatment of level densities in the mass-90 region

Description: We will initiate a project to calculate nuclear level densities using a combination of shell-model Monte Carlo and Lanczos techniques. These techniques, which include the effect of residual interactions, have shown promise in the Fe-Ni region. The goal is an improved treatment of level densities in nuclei near A=90 off the valley of stability that are relevant to nuclear astrophysics.

FTE: 0.2

Leverage: These calculations will require significant time on the Livermore ASCI computers. This time will be provided by internal support, since reactions near A=90 are relevant to Laboratory programs.

FY00 Deliverables: Development of an effective interaction in the mass-90 region suitable for shell-model Monte Carlo calculations, and generation of preliminary results suitable for evaluating the effectiveness of this technique.

Title: Development of techniques for nuclear reaction calculations

Description: We are developing a suite of reaction modeling codes that will be suitable for investigating processes involving reactions on unstable targets, such as encountered in astrophysics, radioactive ion beam physics, and other applications. The first step will be development of a new Hauser-Feshbach code using object-oriented programming techniques. These techniques will eliminate the need for fixed dimensions within the program and will facilitate incorporation of special features, such as isospin conservation and nonstandard forms for level densities. The code will be written in ANSI/ISO standard C++ so that it can be released for use on a wide variety of platforms.

FTE: 0.2

Leverage: USNDC support will be used to design the structure of the Hauser-Feshbach code and implement it. Support from Laboratory programs will be used to develop or adapt specific models and libraries required by this code, such as spherical and coupled-channel optical models, fission models, level density prescriptions, mass and structure tables, and preequilibrium models.

FY01 Deliverables: The Hauser-Feshbach code, designed and tested in its initial form in FY00 for simple nucleon-induced reactions such as (n,n'), will be augmented with width-fluctuation corrections and gamma strength functions. With these developments the code will be suitable for astrophysical calculations. We will also add a fission model.

Work Plan for FY2001 (October 1, 2000 to September 30, 2001)

McMaster University, Nuclear Data group

The following work plan for FY2001 corresponds to the work directly connected with **0.5 FTE** support by the Nuclear Data Program of U.S. DOE.

Our work will be related, primarily, to Nuclear Structure and decay data evaluation for ENSDF.

1. Evaluation of **1.5 full-length mass chains** or its equivalent in terms of full Nuclide updates. The mass chains or the nuclides selected will be based on the priority list prepared by BNL: ~0.35 FTE..

2. Continuous update of ENSDF for currently (from 2000- onwards) published data on superdeformed structures: ~0.05 FTE.

3. Review of one full-length mass chain or its equivalent of individual nuclides (submitted for ENSDF by other network evaluators) : ~0.05 FTE.

4. Compilation (in ENSDF format) of currently (from 2000- onwards) published or completed nuclear level-structure data for XUNDL database: ~0.05 FTE.

Balraj Singh
Jim Waddington

Submitted to BNL: January 28, 2000

National Institute of Standards and Technology

Nuclear Data Verification and Standardization Program
(total of 0.2 FTE of support from the DoE)

STRUCTURE ACTIVITIES:
NONE

REACTION ACTIVITIES:
Perform the duties required for an international evaluation of the neutron cross section standards. Coordinate, as chairperson, the activities of NEANSC Working Party on International Evaluation Cooperation Subgroup which promotes international cooperation on measurements and evaluations of the nuclear data standards. Continue efforts to establish an IAEA Coordinated Research Program focused on studying the uncertainties obtained from the evaluation process. Investigate procedures for doing the comprehensive evaluation. Continue the testing of some of the programs which could be used for this effort. Continue examining the experimental database. Involvement in this project now includes Austria, France, Germany, Japan and the USA. This activity is done under the auspices of the U.S. CSEWG, the NEANSC, and the IAEA. (0.15 FTE)

Suggest, motivate and monitor measurements for use in standards evaluations, largely through the NEANSC Working Party on International Evaluation Cooperation. Continue the NIST-Ohio University-LANL collaboration on the measurements and analysis of hydrogen angular distribution measurements by completing the 10 MeV analysis and beginning measurements at 14 MeV. Investigate methods to improve the $^{10}B(n,\forall)$ standard. Coordinate CSEWG standards activities. Participate in CSEWG meetings. Participate in USNDP Coordinating Committee meetings. Maintain National Repository for Fissionable Isotope Mass Standards. In order to effectively motivate and monitor standards experiments, which are needed for the standards evaluation, NIST has become an active participant in a number of experiments including measurements of the angular distribution of neutrons scattering from hydrogen which is one of the most important standards. (0.04 FTE)

DISSEMINATION ACTIVITIES:
Update the NIST contribution to the unified USNDP website. Make presentations at meetings on the NIST standards activities. (0.01 FTE)

OTHER:
NIST provides approximately a 0.8 FTE of support for these standards activities. Also independent of the verification and standards program, there is a modest NIST effort in nuclear structure and decay studies which receives no funding from DoE.

National Nuclear Data Center
Work Plan for FY2001

The NNDC is responsible for data compilation, evaluation and information services for neutron, charged particle, and photonuclear reactions, radioactivity, and nuclear structure physics. The NNDC maintains bibliographic, experimental, and evaluated data files for these areas of physics and provides data services to basic and applied scientists in the United States and Canada. The NNDC is the focal point for data exchange with other countries and international organizations. In particular, the Center is responsible for the development, maintenance, and distribution of the Nuclear Science References (NSR) database, the Evaluated Nuclear Data File/B (ENDF/B) and the Evaluated Nuclear Structure Data File (ENSDF).

The NNDC assists applied and basic research scientists by coordinating inter-laboratory groups of experts to provide recommended values for nuclear data. The Center coordinates the Cross Section Evaluation Working Group (CSEWG) consisting of representatives from over 20 U.S. laboratories, meeting annually to develop an internationally recognized database for nuclear energy applications, coordinates the U.S. Nuclear Data Network which provides data support for basic research, and provides support services for the U.S. Nuclear Data Network, consisting of low energy nuclear physics evaluation centers. These coordinated efforts unite and integrate data compilation and evaluation efforts to achieve maximum utilization of manpower.

I. NNDC Facility Operation

The National Nuclear Data Center operates a facility dedicated to the collection, analysis and dissemination of nuclear data. The staff consists of 8 scientific, 3 professional and 4 supporting staff members. The operation of this facility requires a manager to perform the tasks of planning, budgeting, personnel management, and interaction with BNL management and with funding authorities.

The NNDC operates a library in order to fulfill its mission to maintain 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.

The NNDC operates a DEC Alpha 4100 computer to support our compilation, evaluation, and database maintenance and information dissemination missions. The NNDC also operates a DELL workstation running WINDOWS-NT and WINCENTER software as a multi-user PC software server with output to staff X-window terminals. This activity includes software upgrades, hardware and software procurements, machine operations and internal user support.

Staff: 1.6 Scientific/Professional and 1.35 Support

II. Coordination

The NNDC serves as the focal point of the US nuclear data program and the point of contact for international cooperation in nuclear data. In this role, NNDC serves as the secretariat for the US nuclear data program (USNDP) and the Cross Section Evaluating Working Group (CSEWG), producers of the ENDF/B evaluated data file. An NNDC staff member chairs the Coordinating Committee of the USNDP and CSEWG.

The chair of the USNDP Coordinating Committee is responsible for establishing technical policy for the US data program with the assistance of the Coordinating Committee, for organizing the annual meetings of the program participants, for preparing the annual work plan for the data program, and for maintaining the official USNDP web site. In its secretariat role, the NNDC assembles and publishes the minutes of the annual meetings of the program participants and maintains the official program web site. An NNDC staff member participates in meetings of the USNDP Steering Committee. The NNDC performs similar functions for CSEWG.

International collaborations provide an important mechanism for augmenting the nuclear data information made available to US researchers from non-US sources. As the international focal point for the US nuclear data program, the NNDC represents the US program in two IAEA-sponsored networks, the Nuclear Reaction Data Center Network and the Nuclear Structure and Decay Data Network. The NNDC represents the US CSEWG on the Nuclear Energy Agency (NEA) Working Party on Evaluation Cooperation and currently holds the chair of that organization. In addition, the NNDC contributes to IAEA sponsored training courses and participates in staff exchanges with the IAEA Nuclear Data Section.

Staff FTE: 0.65 Scientific/Professional

III. Nuclear Physics Databases

The NNDC maintains seven nuclear physics databases on behalf of the US nuclear data program. These are the

- Nuclear Science References (NSR) database containing keyword abstracts of publications in low- and intermediate-energy nuclear physics;
- Experimental Unevaluated Nuclear Data List (XUNDL) database containing experimentally measured nuclear structure and radioactivity data;
- Evaluated Nuclear Structure Data File (ENSDF) database containing evaluated nuclear structure and radioactivity data;
- Nuclear Data (NuDat) database containing searchable numeric nuclear data;
- Computerized Index to Nuclear Data (CINDA) database containing bibliographic information from publications on nuclear reaction data indexed by reaction;

- Cross Section Information Storage and Retrieval System (CSISRS) database contains experimentally measured nuclear reaction data;
- Evaluated Nuclear Data File (ENDF) contains evaluated nuclear data required for large-scale calculations needed in the nuclear design of research, energy and non-energy applications.

The contents of these databases are generated largely through national and international collaborations. The NNDC contributes to the contents of these databases as described below. Data for inclusion in each database are prepared in internationally accepted computer format. There data exchanged among cooperating partners worldwide.

NNDC responsibilities include both the development and maintenance of the software for update of and retrieval from each database and quality control and distribution of the contents of each database to collaborators on a regular basis.

NSR --- The NNDC maintains the master copy of the NSR database. It is responsible for quality control and for updating the database with information generated by NNDC and by international collaborators.

XUNDL --- The NNDC maintains the master copy of the XUNDL database. Input data is supplied solely by collaborators.

ENSDF --- The NNDC maintains the master copy of the ENSDF database. The NNDC is responsible for maintaining the database and organizing the quality control (review) of evaluations submitted for inclusion. Many ENSDF evaluations are published in the **Nuclear Data Sheets**. The cost of preparing the manuscripts from the ENSDF database is borne by the publishers, Academic Press.

NuDat --- This data base contains numeric nuclear data in searchable form from ENSDF, from the Nuclear Wallet Cards, radiations derived from ENSDF using the RADLIST computer code and thermal neutron cross sections and resonance parameters. The database is updated as new information is received.

CINDA --- The NNDC maintains its own copy of the CINDA database. Additional copies are maintained at the Nuclear Energy Agency Data Bank, the International Atomic Energy Agency and the Russian Nuclear Data Center. These organizations exchange updates prepared by them in accord with well-defined responsibilities.

CSISRS --- The NNDC role in this database is identical to that for CINDA. Database copies exist at the three other centers mentioned under CINDA. Approximately 10 non-US centers compile data that we receive and enter into our database.

ENDF --- The NNDC maintains the master database for the US evaluated nuclear data file. New releases of this library are prepared and distributed annually. The database also contains the four evaluated data libraries prepared in Western Europe, Japan, Russia and China.

Much of the database systems and software presently used at NNDC were developed more than 15 years ago. In FY2000, the NNDC undertook an investigation of state-of-the art software that is platform independent and could be used for the next generation of database system. In this fiscal year, we will develop an implementation plan after hosting a workshop on the subject at BNL. In conjunction with this project, the NNDC operates a Windows-NT server and a LINUX workstation.

Staff: 2.75 Scientific/Professional and 1.5 Support

IV. Information Dissemination

A mission of NNDC is to provide scientists and engineers with nuclear data from the USNDP nuclear databases that it maintains in a variety of user-friendly formats and media. This mission is accomplished by providing electronic access to the nuclear physics databases and by answering mail, email and telephone queries. Electronic access is supported in two forms, by remote login (TELNET) and via the WWW. In the past year more than 150,000 electronic data retrievals were made from the NNDC computer facility with approximately two thirds coming from the WWW service.

In FY2001, the NNDC does not plan to make any significant enhancements to the remote login (TELNET) access software. We plan to develop a WWW interface for the Q-value calculator currently available via the TELNET access only.

While most data disseminated from NNDC is retrieved electronically by the users, our scientific staff is available to give advice on solving complex queries via electronic access to the database. Our support staff is used to offer a "help desk" for NNDC customers, for administrative/clerical support of our customer services and for producing a Newsletter.

Common ENSDF Web Interface

During FY2000, BNL, LBNL, ORNL, and SJSU jointly began to develop a common web interface to the ENSDF, XUNDL and NSR databases. At the time that this work plan was developed, the responsibilities for each participant had not been agreed. The NNDC envisions its role to be to provide the necessary interface to the NNDC nuclear physics databases.

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, NY), we are developing the capability to go from the Phys. Rev. abstract/article to the NNDC database where data mentioned in the publication will be archived. We expect to have the prototype system operational in FY2001.

Staff: 1.05 Scientific/Professional and 0.5 Support

V. Nuclear Structure Physics

The NNDC contributes to the contents of the nuclear structure and radioactive decay databases.

Nuclear Science References

NNDC staff performs the literature search to identify publications that are appropriate for inclusion in the NSR database. NNDC maintains a WWW site with links to all of the journals covered that are available electronically. Keyword abstracts are prepared for references that are found to be appropriate. Approximately 4000 new entries are added to NSR per year. While most of the entries are created by NNDC staff, some NSR entries for Russian and Japanese reports and conferences are prepared in Russia and Japan, respectively.

Nuclear Structure and Decay Data Evaluation

NNDC staff evaluates nuclear structure and decay data for the ENSDF database. One senior evaluator retired in 2000. Two new evaluators are being trained to carry on this work. The NNDC evaluators produce about three and one-half mass chain evaluations a year. Data to be selected for evaluation are chosen on the basis of priorities set by the USNDP ENSDF file manager. In addition, NNDC will review four mass chains or their equivalent as part of the ENSDF quality control activity.

Data for the ground and metastable state properties of all known nuclei are evaluated for inclusion in the NuDat database and for the Nuclear Wallet Cards which are published about every five years. The last published edition of the booklet was made in 2000.

ENSDF Physics and Checking Codes

The NNDC maintains ENSDF checking and physics programs on behalf of the national and international evaluator networks. For most of the programs, only maintenance and upgrades for format changes are planned. However, we plan to upgrade RadList, the program which derives atomic and nuclear radiations from ENSDF data sets, by providing improved energy grids for calculated continuum particle spectra. We also plan to update Logft to calculate higher orders of forbiddenness.

Staff: 2.6 Scientific/Professional

VI. Nuclear Reaction Physics

Experimental Data Compilation

The NNDC as part of a larger international cooperation has responsibility for compiling experimental nuclear reaction data that has been produced in the U.S. and Canada. Experimental nuclear reaction data is compiled in an internationally agreed format called EXFOR. Approximately 11 nuclear data centers throughout the world participate in this compilation activity. Responsibilities are clearly defined and duplication avoided. Compilation results are exchanged on a regular basis.

The NNDC compiles all available new data for incident neutrons and charged particles. Coverage of incident neutron reaction data is essentially complete since 1936. However, charged particle data have been only selectively compiled in the past. NNDC is compiling new charged-particle measurements. However, because of emerging needs such as astrophysics, the NNDC is attempting to compile older data, hence, there is a larger staff commitment to compiling this type of data. In FY2001, NNDC expects to compile 120 charged particle and 15 neutron reaction experimental data sets.

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

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. We are planning to hold a workshop for this purpose.

ENDF Manuals and Documentation

The ENDF format for storing evaluated nuclear data which can be used as input for large scale application calculations was developed at Brookhaven National Laboratory about 35 years ago. It has become the international standard for storage and exchange of such data. 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. The official format manual is posted on the NNDC www site.

G. Evaluation of Nuclear Data Needed for Astrophysics

The objective of this work 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.

The NNDC has staff members experienced in evaluating nuclear reaction data in the thermal, resonance and fast energy regions. In addition, NNDC has hired a Post Doc, one half of whose effort will be devoted to evaluation of nuclear data for astrophysics. The selection of data to be evaluated will be made in consultation with the Nuclear Astrophysics Steering Committee.

Staff: 1.65 Scientific/Professional and 0.25 Support

VII. Funding sources outside the Nuclear Data program

The NNDC receives a subsidy from Academic Press to prepare computer-generated photoready copy for the "Nuclear Data Sheets".

The NNDC participates in some SBIRs awarded to Scientific Digital Visions. In this fiscal year we will finish work on one SBIR and expect to participate in one or two additional phase 2 awards to SDV.

Work Plan for the Nuclear Data Project for FY2001

(With the assumption that FY2001 budget for the Nuclear Data Project will support 1.18 scientific FTE and 0.25 technical support FTE)

The Nuclear Data Project's program for nuclear structure evaluation, reaction data evaluation for nuclear astrophysics, and experimental nuclear structure data compilation meets the present needs and interests of the nuclear research community. Our work plan for FY2001 which is in accordance with the guidelines set by the International Nuclear Data Network and the USNDP advisors is outlined below.

I. Nuclear Structure Evaluation (0.5 FTE)

A study of the systematic behavior of nuclear states and other nuclear properties in the heavy-mass region provides needed systematics of evaluated data to use for searches for superheavy elements, a field of high current interest in the community. This survey should serve as the basis for expectations of the properties of nuclei in this region, and should help the exploration of new mass regions. Such studies will also be valuable for experiments using in the development of neutron-rich radioactive beams and in plans to study new nuclei with the use of radioactive beams, as well as stable beams. To be most useful, this systematic study requires the information given to be complete and up-to-date. The evaluations of most of the nuclei in the $248 \leq A \leq 265$ region have been recently completed. The remaining nuclear-structure data evaluations (evaluations of nuclei with mass 250, 254, 258, 262 and 266) are expected to be completed this year, bringing the structure information for the heavy elements in the $A \geq 248$ region up-to-date which is one of the high priorities set by USNDP.

The structure information in ENSDF for nuclei with mass numbers 242 and 244 which are assigned by the Network as the responsibility of the Center for Nuclear Structure and Reaction Data of Kurchatov Institute in Moscow, have not been updated since 1985 and 1986, respectively. There are new important experimental data published for these nuclei, and the Center for Nuclear Structure and Reaction Data of Kurchatov Institute has agreed to transfer their responsibility for those nuclei to the Nuclear Data Project on a temporary base. We plan to evaluate the available data for nuclei with mass number 242. The A=238 nuclei, daughter of 242 nuclei, are being evaluated by the evaluators in Moscow. Consistency of recommended nuclear properties for parent - daughter nuclei will be ensured by collaborating efforts with the Russian colleagues. We plan also to review the evaluations of nuclear data for nuclei with mass numbers 215, 219, 223 which are being evaluated at LBNL.

II. Nuclear Reaction Evaluations for Astrophysics (0.48 FTE)

We plan to continue our evaluations of nuclear reactions of vital importance for studies in nuclear astrophysics. These reactions address some of the most fundamental questions in

nature: what are the origins of the elements that make up our bodies and our world? How did the solar system, the sun, the stars, and the galaxy form, and how do they evolve? Progress in many such fundamental problems in nuclear astrophysics can be significantly aided by improvements in nuclear data. Our evaluation work in FY2001 will focus on(1) capture reactions on radioactive isotopes on the proton-rich side of stability such as ^{33}Cl, ^{25}Al, and ^{26}Si - reactions that are important for understanding the element synthesis and energy generation in stellar explosions; and (2) reactions important for understanding the nuclear burning in the interior of our sun.
These reactions will be studied over a variety of energy ranges as required for applications in astrophysics. All cross sections that are evaluated will be provided in an ENDF-style format. All reaction rates determined will be disseminated on the WWW. Since many reactions are dominated by resonances, all recommended resonance parameters will be provided in ENSDF-style formats.

III. Database and Web Interface Development; Experimental Nuclear Structure Data Compilation (XUNDF) (0.2 FTE)

We will continue to participate in the NNDC Common Web Interface working group. This initiative aims to improve the consistency of the data dissemination web interface at different NNDC sites, to provide more modern, efficient and consistent user access to the nuclear data. The work to be performed under this initiative is not yet well-defined; the common interface is still in the conceptual design stage.

Other software, already developed at ORNL, will continue to be maintained and perhaps further developed, as the need becomes apparent. These programs include software for semi-automatic extraction of tabular level-scheme data contained in PDF manuscripts (and possibly other formats of published and unpublished data) into ENSDF-format data sets, for the XUNDL database, and for conversion of ENSDF datasetsto RadWare format, a high-quality graphical level scheme interface.

The compilation and electronic dissemination of most recent data on reaction gammas will be done continuously throughout FY2001 as data become available. Upkeep of the RadWare database which is very much in accordance with the Steering Committee's recommendation for addressing the immediate needs of the main stream research community, will be continued. This program requires only minimal effort, at the level of a few days per year.

San Jose State University
FY2001 Work Plan

During the next year San Jose State University will continue to develop cross platform technologies. Our goal is to produce software technologies that directly support the U.S. Nuclear Data program, and that specifically support the goals of the joint dissemination project headed by Tom Burrows of the NNDC. The software development efforts focus on three basic goals: (1) Adapt our current Java software to more general applications within custom software or on web pages. (2) Develop new technologies that extend the database services of the NNDC in web pages or in custom software. (3) Use our existing software technologies to meet specific needs within the nuclear data community.

Much of our effort will focus on componentizing software objects that make up our Java nuclear data software. This effort involves producing small software packages that perform well-defined, discrete operations. Properly developed, the components can be easily inserted into other applications, thereby extending their functionality. An early example of a software component is the nuclide chart applet that can be found on the web at www.digitalcreativity.com/NSRstats. We produced the chart applet on this web page as a test of the concept. It is used here to display the number of recent references as a function of nuclide. Clearly it was a successful test. We are nearing completion on a more general nuclide chart applet that will provide the nuclear data network a method of displaying information, and an intuitive method of retrieving information from a server.

The concept for a new nuclear data application programmers interface (API) will be explored using our Java nuclear data software as a model. An API will provide an interface between low-level nuclear data services and high-level software applications. With this interface, users should be able to drop a component onto the nuclear data application, adding new services to the application or changing the type of service. Level scheme components are one example. Several formats exist and each format may be appropriate in different circumstances. The API should allow the user to adapt the nuclear data environment to their specific needs and style. Furthermore, the API model will allow users to easily update their application when new versions of the components are released.

Three other activities are planned for the upcoming year. The first is to extend remote database services, improving the link between the NNDC and the desktop application. A related activity is to develop a sort of NNDC status page for nuclides. Our early thoughts are that the user should be able to view the current status of nuclear data for a nuclide and to have a simple method of retrieving the information. A final activity we have undertaken is to develop an applet or application to produce animated nuclide charts. We implemented a crude version some years ago in a daughter decay chain feature, but this focused on displaying Boolean information: is the nuclide present or absent from a nuclide list. Dr. Smith needs to display an intensity or probability as a function of nuclide and show changes over time. The concept is simple to implement. We will need to change our painting routines to accept a range of colors rather than the fixed eight colors currently used and we will need to define a color mapping algorithm. We

will also need to define a method for storing the time-dependent images in an appropriate format such as Quicktime.

Table of Tasks and Deliverables

1. Component development
   - Effort: 0.4 FTE
   - Deliverable: demonstrations of prototyped components;
     adoption of relevant completed components;
     distribution of relevant completed components.
2. API model for nuclear data applications
   - Effort: 0.2 FTE
   - Deliverable: summary of API model;
     prototype of key technologies.
3. Remote database services
   - Effort: 0.2 FTE
   - Deliverable: adoption of services as new software features.
4. Interactive nuclide status/properties page
   - Effort: 0.1 FTE
   - Deliverable: demonstrations of software prototype;
     development schedule if future work is necessary.
5. Animated nuclide charts
   - Effort: 0.1 FTE
   - Deliverable: software to produce time-dependent animations.

TRIANGLE UNIVERSITIES NUCLEAR LABORATORY
NUCLEAR DATA PROGRAM

Work Plan for FY 2001

NUCLEAR DATA EVALUATION PROJECT

A = 3 – 20

J. L. Godwin, J.H. Kelley, C.D. Nesaraja, J.E. Purcell, G. Sheu, D.R. Tilley, H.R. Weller

NUCLEAR STRUCTURE FTE 1.15

- EVALUATIONS:

Evaluate A = 10 nuclides.

Issue preliminary versions of A = 9, 10.

Prepare "*Energy Levels of Light Nuclei A* = 8, 9, 10" for publication in *Nuclear Physics A.*

Evaluate A = 11 nuclides and prepare a preliminary version for A = 11.

- ENSDF

Finalize and submit ENSDF Files for A = 5, 6, 7 in conjunction with publication of the evaluation in *Nuclear Physics A.*

Update existing A = 14, 15 files (based on most recent Ajzenberg-Selove review). This will complete the A = 3 – 20 set with all files including reaction information. Future ENSDF files will be issued simultaneously with *Nuclear Physics A* evaluations.

Prepare ENSDF files for A = 10.

DISSEMINATION FTE 1.5

• TUNL Nuclear Data Evaluation Project Website:

Continue to provide PDF documents based on most recent review (TUNL or Fay Ajzenberg-Selove) for $A = 3 – 20$. Documents for $A = 4, 11, 12, 14, 15$ planned for completion in FY 2000 were completed in January 2000.

Continue to explore web-based browsing options (such as HTML) in order to provide more expansive information on each individual nuclide, for example, dynamic links for discussions, NSR references, tables and figures.

Continue the project begun in the year 2000 in collaboration with the publishers of *Nuclear Physics A* to provide online versions of all of Fay Ajzenberg-Selove's "*Energy Levels of Light Nuclei A* = 5 – 20" publications from 1959 to 1991. The documents will be accessible through links from the TUNL website or directly from the *Nuclear Physics A* website.

Provide Update Lists for $A = 16, 17, 18, 19, 20$ experimental and theoretical level information, making the set of update lists on the TUNL website complete for $A = 3 – 20$. Begin adding new references to all $A = 3 – 20$ Update Lists on a continuing basis.

TUNL PROGRAM ON PREEQUILIBRIUM PHENOMENOLOGY

Work Plan for FY 2001
(Nuclear Reactions)

Constance Kalbach Walker

PROGRAM

Develop Models / Code PRECO / Global Input for Preequilibrium Rxns.

Achieve a predictive tool for continuum rxns at 14 to 200 MeV.

Use alone or in Hauser-Feshbach codes (e.g. GNASH).

RECENT ACCOMPLISHMENT

Robust Description of (N,N) Rxns up to 30 MeV.

Simultaneously reproduce (n,n'), (n,p), (p,n) and (p,p') spectra.

(Preliminary checks up to 100 MeV encouraging).

FY 2000 PLANS AND DELIVERABLES

Include giant resonance excitations in model calculations (Added item).

Submit recent results on surface effects and collective states to journal for publication.

Issue new formal release of code PRECO.

FY 2001 PLANS

Augment project data base with additional (N, xN) spectra at 40 to 100 MeV from literature.

Begin testing exciton model and code PRECO against data base in this energy domain.

Investigate isospin conservation during preequilibrium phase. If needed, modify energy dependence of collective state excitation model in code.

Revise global model input set as required. Change relative mean square matrix elements for nn, np, and pp residual interactions?

FY 2001 DELIVERABLES

Augmented data base with working graphs of all spectra.

Revised collective state excitation model?

Revised global model input set?

LEVEL OF EFFORT

0.4 FTE (Senior Research Scientist).