USNDP

U.S. Nuclear Data Program
Work Plan for
Fiscal Year 2004

Prepared by:
Charles L. Dunford
National Nuclear Data Center
Brookhaven National Laboratory
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With Contributions from:
Coral Baglin, LBNL
Allan D. Carlson, NIST
Mark B. ChadwicK, LANL
Robert Haight, LANL
Richard Helmer, Idaho
John Kelley, TUNL
Filip G. Kondev, ANL
Dennis McNabb, LLNL
Pavel Oblozinsky, BNL
Balraj Singh, McMaster U.
Michael Smith, ORNL
Constance Walker, TUNL

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Introduction

The work plan described in this document has been developed to cover work to be done by the United States Nuclear Data Program (USNDP) during fiscal year 2004 that begins on October 1, 2003. Previously, four work plans have been prepared for the data program covering fiscal years 2000, 2001, 2002 and 2003. This plan has been prepared in consultation with the members of the Coordinating Committee who represent the organizations participating in the program. Each Coordinating Committee member prepared a draft plan for his or her organization. Each contribution was integrated into a unified work plan. The draft plan was then circulated to the Coordinating Committee for comments and corrections before the final document was submitted to the Department of Energy

As was the case in the work plan for FY2003, 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 FY2004, defining tasks, organizational responsibilities, and deliverables. It is envisioned that this document with mid-year updates will serve as the basis for a performance review at the end of fiscal year 2004.

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. The effort table shows essentially a constant level of effort as compared to the FY2003 plan with a slight reduction of about 0.2 FTE of scientific and professional effort. The 1.1 FTE staff reduction at LBNL is made up of a real reduction of 0.3 FTE and the transfer of 0.8 FTE from the nuclear data program category to "other" support category as the funding for that 0.8 FTE comes from the low energy nuclear physics program. This year, the effort table contains a complete reporting of the nuclear data effort supported by other organizations, largely NNSA, which amounts to about 56% of the total U.S. nuclear data effort.

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

US Nuclear Data Program Metrics

Fiscal Year	Compilations	Evaluations	Dissemination (retrievals in thousands)	Reports	Journal Papers	Invited Talks
2001*	7139	334	667	21	25	22
2002*	6159	300	799	23	40	22
2003**	6000	300	930	22	32	22
2004**	5800	300	1080	22	32	22

* Actual   ** Projected

All statistics refer only to those results that can be attributable to work performed under nuclear data program funding. If it is not possible to separate a statistic from the total for full funding, then the resulting number used in this table has been estimated using the ratio of DOE nuclear data program funding to total funding.

Compilations
The total number reported is the sum of the new entries added to the USNDP bibliographic and experimental databases.
- NSR, nuclear physics bibliography – number of new references entered.
- CINDA, neutron reaction physics bibliography – number of new experimentally measured reactions added.
- XUNDL, experimental nuclear structure measurements – number of experiments from which new data has been added.
- CSISRS, experimental nuclear reaction data – number of reactions for which new data has been added.

Evaluations
The total number reported is the sum of new evaluations submitted or accepted for inclusion in the USNDP evaluated nuclear databases.

- ENSDF, evaluated nuclear structure – number of nuclides for which new evaluated data have been submitted.
- ENDF, evaluated nuclear reactions – number of reactions for which new evaluated data have been submitted for inclusion in ENDF/B.

Dissemination

The number reported is the number of electronic retrievals made from USNDP maintained Web or Telnet sites. This number is defined as the number of times a user places a request for data from any of the databases and receives a result. Total pages, gifs, etc., accessed is not tallied here. Where only total "hits" are supplied, the number reported has been renormalized using the ratio derived from the BNL site. Non-electronic dissemination is not included as it is small compared to electronic publication. Likewise, it is impossible to estimate an equivalent value for a publication such as the "Wallet Cards".

Also not counted are regular transmissions of the 5 major databases (ENSDF, ENDF, NSR, CINDA and CSISRS) by BNL to cooperating national and international centers and organizations that further disseminate the data. Examples are ENDF to LANL and NSR to the IAEA.

Reports

All technical documents or papers except for journal publications and invited talks that are tabulated separately are reported here. No administrative documents such as meeting minutes are reported.

Papers

The number given for papers reports only articles published in refereed journals.

Invited talks

Presentations given at the invitation of the organizers of a conference, symposium, workshop, training course, etc. are given under this category.

Work Plan Tasks and Deliverables

I. NNDC Facility Operation

A. Management

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

B. Library

NNDC maintains an archival collection of low- and intermediate-energy nuclear physics publications. This library supports the NNDC compilation activities and the U.S. nuclear reaction and nuclear structure data evaluation and international nuclear structure evaluation.

C. Computer Operation

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

BNL Deliverables:
Keep downtime on the central database server to less than 3%.
Provide full computer support for database migration project.
Upgrade hardware and software of Windows-based desktop computers.

II. Coordination

A. <u>National Coordination</u>

ANL -- Chair the Measurement and Basic Physics Committee of the Cross Section Evaluation Working Group and represent U.S. measurement interests in the NEA Working Party for Evaluation Cooperation.

ANL Deliverables:
    Organize and Chair Measurement and Basic Physics Committee meeting at
        CSEWG meeting in FY2004.
    Provide Measurement and Basic Physics Committee report for CSEWG.

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

BNL Deliverables:
    Prepare FY2005 work plan for USNDP in time for spring 2004 FWP
        submittals.
    Organize and chair CSEWG Meeting at BNL in November 2003.
    Organize and chair USNDP Meeting at BNL in April 2004.
    Edit and publish summary reports of the CSEWG and USNDP meetings.
    Maintain CSEWG and USNDP Web sites.

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

LANL Deliverables:
    Organize and chair CSEWG Evaluation Committee meeting at BNL,
        November 2003.
    Organize and chair Nuclear Reaction Working Group meeting at USNDP
        meeting in April 2004.
    Help organize and help lead the CSEWG Homeland Security Task Force, and
        interact with LANL NA22 representative to provide feedback on user
        needs.

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

LBNL Deliverables:
>Organize and chair Nuclear Structure and Decay Data Working Group
>>meeting at USNDP meeting, April 2004.

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

ORNL Deliverables:
>Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP
>>Meeting in May 2004.
>Summarize USNDP efforts in nuclear data for nuclear astrophysics in FY03
>>for USNDP written reports.
>Communicate current efforts and future plans with researchers in nuclear
>>astrophysics data.
>Discuss future plans in nuclear astrophysics data with USNDP/NNDC and
>>DOE.

TUNL -- Chair task force on "The Impact of Nuclear Data on Society"

TUNL Deliverables:
>Coordinate discussion of Nuclear Data applications and prepare report.

B. International Coordination

BNL – – Represent the United States in IAEA-sponsored Nuclear Reaction Data Center Network (NRDC) and Nuclear Structure and Decay Data Network (NSDD). The NNDC center head is the U.S. member and vice-chair of the IAEA's International Nuclear Data Committee and the lead US member of the NEA Working Party on International Evaluation Cooperation in his position as chair of CSEWG. BNL frequently participates in IAEA sponsored activities such as Workshops, Technical Meetings and Coordinated Research Projects.

BNL Deliverables:
>Host and participate in the NRDC meeting at BNL in 2004.
>Participate in NEA WPEC annual meeting in 2004.
>Provide director and lecturers for the NSDD Workshop at Trieste in
>>November 2003.

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. LANL will host visits by foreign scientists with international reputations to benefit from the exchange of information and ideas.

LANL Deliverables:

Complete the organization of the next international nuclear data conference (ND2004) to be held in Santa Fe, September 26-October 1, 2004.

Participate in NEA June 2004 meeting.

Participate in relevant IAEA meetings, including Trieste Lectures in spring 2004.

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

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

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

LBNL Deliverable:

Provide lecturer(s) for structure and decay data evaluator-training sessions at Workshop at Trieste in November 2003.

III. Nuclear Physics Databases

A. <u>Nuclear Science References</u> (NSR)

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

BNL Deliverables:
Database distributed to collaborators monthly.

B. <u>Experimental Nuclear Structure Data</u> (XUNDL)

The NNDC is responsible for maintaining and providing access to the XUNDL database. This database contains compilations (in ENSDF format) of recently published or completed level-structure data. The emphasis is primarily on recent high-spin physics publications, but selected older papers and those for low-spin studies are also included. The compilation work is mainly carried out at McMaster University. The McMaster group also coordinates this work with that of other centers. The NNDC updates the database as new/revised data sets are received from McMaster.

C. <u>Evaluated Nuclear Structure Data File</u> (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. This task includes database updates and distribution to collaborators. Updates are done upon completion of reviews. Corrections are implemented on a continuing basis.

BNL Deliverables:
Database distributed to collaborators twice a year.

D. <u>Numerical Nuclear Data File</u> (NuDat)

The NNDC is responsible for NuDat, an all numeric database of nuclear data including level and γ-ray properties extracted from ENSDF, ground and metastable state properties (Wallet Cards), atomic and nuclear radiations derived from ENSDF and thermal neutron cross sections and resonance integrals. The database is also available in a stand-alone PC version.

BNL Deliverables:
Distribute NuDat database to collaborators twice a year.

E. <u>Neutron Reaction Data Bibliography</u> (CINDA)

The NNDC is responsible for the CINDA database that contains references to nuclear reaction data in the published and unpublished literature. Its contents are produced cooperatively by the four international neutron data centers with updates exchanged in an agreed computer format. The data are organized by data measured, not by reference. The database serves as an index to the neutron data contained in the experimental database, CSISRS. The database is updated as transmissions from the data centers are received and checked.

BNL Deliverables:
Update CINDA database with CINDA transmissions from cooperating centers
(12 expected).

F. <u>Experimental Reaction Data File</u> (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. The effort described here includes the quality control, file update and data exchange activities. The database is updated, as transmissions from the compiling centers are received and checked. The compilation activity is given under Nuclear Reaction Physics.

BNL Deliverables:
Update CSISRS with EXFOR exchange tapes from cooperating centers (20
expected).

G. <u>Evaluated Nuclear Data File</u> (ENDF)

The NNDC is responsible for ENDF, a database of evaluated nuclear data required for many nuclear applications. The work is organized under the Cross Section Evaluation Working Group (CSEWG), coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident charged particles and photons are also included. The data are stored in the ENDF format developed at NNDC about 35 years ago–and adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia, and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. A new version of the library, ENDF/B-VII, is being prepared by the members of the Cross Section Evaluation Working Group. There will be no more releases of ENDF/B-VI; the work will focus on ENDF/B-VII.

BNL Deliverables:
Maintain CSEWG Web site; keep information current.
Make ENDF/B-VII evaluations available on the CSEWG Web site after
reviews are completed.

H. Database Software Maintenance

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

I. Future Database Systems

   In the 1980's, the NNDC migrated most of its databases to run under the Digital Equipment Corporation (DEC) CODASYL database management system (DBMS) on the VMS operating system (this DBMS has since been bought by Oracle). Retrieval programs written in FORTRAN allowed dial-up, DECNET, and telnet-based online retrieval well before the advent of the World-Wide Web. In the 1990's, Web interfaces were developed using the very same DBMS system.

   In recent years, relational database management systems (RDBMSs) using Structured Query Language (SQL) have become standard in business and academia. There are many ways in which the nuclear data program could benefit from an increased use of relational database technology. Because it is a widely used technology, a large variety of auxiliary tools and interfaces exist for the administration and dissemination of data. These tools include replication and synchronization capabilities that would improve the efficiency and reliability of data exchange between centers. Because commercial RDBMSs software is available on a wide variety of platforms, and in a wide variety of price ranges, their use provides an opportunity to explore new options for dissemination to end-users of the data. The use of common standards in data storage will allow data centers to choose the software that best meets their needs, without being tied to a particular vendor.

   Migration to this new database format represents a generational shift in the way data are stored. This is a major project that requires substantial effort stretched over a period of several years. Among the tasks that need to be undertaken for each database are:

   • Database design: The design of relational schema should be compatible with the current system and allow flexible and efficient access to the data.
   • Data migration: Current data will be loaded into the Sybase RDBMS system. The software written to do this will also be used to add new data as it comes in. Until the migration project is complete, parallel instances of the data will be kept in both the old and new database formats.
   • Code migration: To the extent that it is feasible, the legacy programs for database administration, written mostly in FORTRAN, will be modified to work with the new RDBMS.
   • Code development: For many tasks, and in particular for Web-based data dissemination, new software will be developed. Because of its portability, the Java programming language is being used for new software development.

   As discussed in last year's plan, the NNDC is involved in a multi-year project to migrate its databases to a relational format. In FY2003 the Linux/Sybase computing environment was established using existing and newly purchased Dell hardware. The migration of the software

supporting the nuclear structure data activities and databases (NSR, ENSDF and NuDat) was completed and extensive testing started. Migration of the software supporting the nuclear reaction data activities and databases (CINDA, CSISRS and ENDF) will be completed in FY 2004. Testing of the migrated nuclear reaction data software will be completed in the first quarter of FY2005 and full implementation of the NNDC activity in the new computing environment will be completed in the second quarter of FY2005.

BNL Deliverables:

Complete testing of the migrated software, which supports the nuclear structure activities and databases (NSR, ENSDF and NuDat) in the new computing environment.

Complete testing of the migrated software, which supports the nuclear reaction data activities and databases (CINDA, CSISRS and ENDF) to the new computing environment.

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 Web.

BNL Deliverables:
> Only maintenance work will be performed on the existing Web interfaces to
> the data in the existing VMS computing environment.

B. Customer Services

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

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.

ANL Deliverables:
> Maintain electronic access to the ANL Nuclear Data Measurements
> (ANL/NDM) report series web site.
> Maintain and upgrade Experimental Resources for Nuclear Data Web site.
> Maintain and upgrade ANL Nuclear Data Information Web site.

BNL Deliverables:
> Effort required to maintain the currency of the CSEWG, USNDP and the
> NNDC Web sites.

LANL Deliverables:
> Include access to new reaction and structure data evaluations, supported by
> DOE/Nuclear Physics, via the T-16 Web site.
> Continue coordination of T-16 site with other USNDP sites.

LBNL Deliverables:

Maintain and update the home pages for neutron-capture gammas, nuclear astrophysics, nuclear structure and decay systematics, nuclear science education, atomic masses, and other.

ORNL Deliverables:

Maintain, update, and improve the Web FTP site providing the RadWare interface to ENSDF and XUNDL information.

Improve the automatic graphical layout routines for ENSDF-to-RadWare conversion.

Improve and update web pages devoted to nuclear astrophysics data.

TUNL Deliverables:

Continue to prepare new PDF and HTML documents of the most recent TUNL reviews $A = 11$ and 12 (publication version) and $A = 13$ (preliminary version). PDF and HTML documents are currently available for TUNL and FAS publications for the years 1975-present.

Continue to provide PDF and HTML documents for older FAS reviews for the $A = 3 - 20$ series; provide new PDF and HTML documents for earlier Fay Ajzenberg-Selove evaluations based on $A = 5 - 10$ (74AJ01), $A = 18 - 20$ (72AJ02), $A = 16 - 17$ (71AJ02), and $A = 13 - 15$ (70AJ04).

Continue to provide General Tables to accompany the most recent TUNL reviews of the $A = 3 - 20$ series; General Tables for $A = 13$ to be completed to correspond to preliminary report; update $A = 11$ and 12 General Tables to correspond to the review published in *Nuclear Physics A*.

Continue to provide Energy Level Diagrams (in GIF, PDF and EPS/PS formats) to accompany the PDF and HTML documents for the most recent TUNL reviews and preliminary reports, and for the earlier FAS reviews.

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, but receives some assistance from Russia and Japan.

BNL Deliverables:
Prepare entries for 4100 new references with keyword abstracts for 3100.

B. Compilation of Experimental Structure Data

This activity involves compilation of recently published or completed experimental nuclear structure data (primarily high-spin) for inclusion in XUNDL.

McMaster Deliverables:
Compile data sets (in ENSDF format) of current publications, primarily in high-spin physics. Selected low-spin publications will also be compiled.
Compile, on a time available basis, high-spin data from older publications not yet incorporated in outdated (older than about 7 years) ENSDF evaluations
Review compiled data sets submitted by other data centers prior to inclusion in the XUNDL database.

ORNL Deliverables:
Improve software for converting tabular/graphic published level-scheme data in journals as well as unpublished data supplied by researchers to RadWare database into ENSDF format.
Finish debugging code that was recently ported from Fortran to C.

C. Data Evaluation for ENSDF

The USNDP evaluates nuclide and mass chain nuclear structure and decay data for inclusion in the ENSDF database. This effort now includes the A=21-44 mass region previously evaluated by the Utrecht group; LBNL is responsible for A=21-30, Canada for A=31-44.

ANL Deliverables:
One and one-half equivalent mass chains will be evaluated.
At least one mass chain will be reviewed.

BNL Deliverables:
Three and one-half equivalent mass chains will be evaluated.
At least four mass chains will be reviewed.

Idaho Deliverables:
One equivalent mass chain will be evaluated.

Two mass chains will be reviewed.

LBNL Deliverables:
5 mass chain equivalents chosen from regions for which LBNL is responsible (including at least one from the A=21-30 region) will be evaluated.
Mass chains will be reviewed as requested.

McMaster Deliverables:
1.5 equivalent mass chains (including some in the A=31-44 region) will be evaluated. Mass chains will be reviewed as requested.
Update superdeformed-band data in ENSDF. All nuclides will be covered that do not require a complete reevaluation.

ORNL Deliverables:
Evaluate A=217 and A=247 nuclei.
Begin to evaluate A=243 nuclei which are connected to A=247 and 239 nuclei via alpha decay.

TUNL Deliverables:
Begin to prepare the ENSDF files for $A = 11 - 12$ to correspond with the *Nuclear Physics A* publication.

D. Ground and Metastable State Properties

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

BNL Deliverables:
NNDC will include data revisions in the NuDat 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 United States, LBNL coordinates this project.

ANL Deliverables:
Decay data for one nuclide will be evaluated.

LBNL Deliverables:
Coordinate and plan activities of this international collaboration.
Review the evaluations of about five radionuclides.
Submit decay datasets for two radionuclides.

Idaho Deliverables:
Decay data for 3 nuclides will be evaluated.

F. Thermal Capture Gamma Data Evaluation

As new measurements from the Budapest Reactor become available, they will be evaluated and added to the "Prompt Gamma Activation Analysis" database that resulted from a recent IAEA CRP in which LBNL was involved. Total capture cross sections will also be extracted from those data when possible.

LBNL Deliverables:
Evaluate new (n,γ) data as they become available from the Budapest reactor
and add them to the Prompt Gamma Activation Analysis database.

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

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

TUNL Deliverables:
Distribute and mail out $A = 12$ preliminary review for comments.
Publish *"Energy Levels of Light Nuclei, A = 11 - 12"* in *Nuclear Physics A*.
Evaluate and distribute for comment $A = 13$ preliminary review.

H. Nuclear Structure Data Measurement

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

LANL Deliverables:
Examine prompt gamma-ray emission data on ^{191}Ir and ^{193}Ir to search for
previously unobserved transitions.
Interact with mass chain evaluators on the nuclear structure of these nuclei.

I. ENSDF Physics and Checking Codes

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

BNL Deliverables:
Upgrade RADLST and LOGFT to properly treat higher-order (≥ 3) unique
forbidden $\beta^{\pm}$ transitions and to use the Schoenfield electron-capture
probabilities.

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.

Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data. Hence, there is a larger staff commitment to compiling this type of data.

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

BNL Deliverables:
Compile data from 100 charged-particle and neutron reaction publications.

B. ENDF Evaluations

Evaluated nuclear reaction data, for applications and for basic science needs, are stored in the ENDF database, which is maintained by BNL. As chair of the CSEWG evaluation committee, LANL staff works with BNL to insure quality control, particularly for new evaluations. New evaluations funded primarily from other sources are prepared for archival in the ENDF library. BNL, LANL, LLNL and ORNL will provide neutron, proton and photonuclear reaction data evaluations for ENDF/B-VII planned for release in FY2005.

BNL Deliverables:
Lead international effort (WPEC Subgroup 21) to review the bulk of fission
    products.
Recommend the best available fission product neutron reaction evaluations for
    ENDF/B-VII.
Submit new evaluations for Germanium isotopes with photon production data
    for use in homeland security applications.

LANL Deliverables: (work mostly supported from other sources)
Work with BNL to coordinate upgraded evaluations for new version of
    ENDF: ENDF/B-VII
Submit new improved evaluations that will eventually be available in
    ENDF/B-VII (^{232,233,234,235,236,238,239,241}U isotopes, ^{239}Pu, ^{237}Np, ^{241}Am)
Complete and submit to CSEWG high energy LA150 actinide evaluations for
    ^{239}Pu and ^{238}U

Complete and submit to CSEWG new photonuclear actinide evaluations for U, Pu isotopes that include delayed neutron information, for Homeland Security detection of SNM

Provide ENDF evaluated data files for charged-particle reactions having A≤10.

LLNL Deliverables:

An exhaustive search of the literature on fusion reactions for compound systems of A<12 will be completed. The experimental CSISRS database will be updated where appropriate.

A recommended set of evaluations will be submitted to CSEWG in ENDF format.

C. <u>ENDF Manuals and Documentation</u>

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

BNL Deliverables:

Maintain ENDF-7 formats manual that is available on the Web.

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

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 that can be accomplished only through international cooperation. A new international evaluation of the neutron cross section standards was initiated to provide the improved standards that are needed. This evaluation, which is nearly complete, has been largely performed by an IAEA Coordinated Research Project (CRP) with support, largely experimental in nature, through the Working Party on International Evaluation Cooperation (WPEC) of the Nuclear Energy Agency and CSEWG.

LANL Deliverables:

Participate in the international effort to reevaluate the light-element standard cross sections.

Participate in test problems designed to investigate the nature of output covariance data from R-matrix analyses of systems containing the light-element standard cross sections.

Participate in a standards measurement of the angular distribution of n-p scattering near 14 MeV with Ohio University and NIST. This quantity is the primary standard in all neutron cross section measurements.

NIST Deliverables:

Coordinate the international standards activity (Subgroup 7 of the NEA Working Party on International Evaluation Cooperation) and chair the IAEA CRP on the Improvement of the Standard Cross Sections.

Complete the review of new experimental data for use in the standards evaluation.

Complete the examination of older experiments with an emphasis on discrepant data that will have the highest impact on the evaluation.

Establish the methodology for performing a comprehensive standards evaluation.

Provide interim standards for the ENDF/B-VII library.

Continue work on understanding the uncertainties obtained from the standards evaluation.

Continue to recommend new measurements and perform examinations of the data from them for use in future evaluations of the standards.

Continue the collaboration with Ohio University and LANL on the measurement of hydrogen elastic scattering angular distributions with the completion of the measurements and analysis of data measured at a neutron energy of 15 MeV.

E. Nuclear Model Development

This task covers activities such as development and validation of nuclear reaction models used for prediction of nuclear reaction cross sections. The LANL code development work will be coordinated with the proposed LLNL work. The collaboration will include intercomparison of results, validation of the models with experimental data, and development of new physics modules. The TUNL preequilibrium code will be incorporated into the LANL code. Measurements made by ANL and LANL along with other measurements made with DOE low-energy physics funds (e.g., Grimes, Becker and others) will play a crucial role in the validation of the models in these computer codes.

ANL – Analysis of neutron activation cross section data measured at IRMM, Geel, Belgium, will continue in collaboration with scientists from IRMM. Results will be archived in the EXFOR system and special evaluations will be prepared for inclusion in ENDF, where possible.

ANL Deliverables:
Compile experimental data into EXFOR format for selected neutron activation reactions.

Assist in evaluations for some of these reactions by coding data into ENDF format and submit the results to the NNDC for inclusion in ENDF.

BNL – We will enter actively into the nuclear reaction model development arena with the BNL code EMPIRE. The work will focus on further extensions and improvements of its graphic user interface, including merging capability (resonance and fast energy) and extended plotting features. The work on validation and improvements of the code will be actively pursued, in particular in relation to emerging requirements of homeland security applications. Close collaboration with LANL will continue on validation of the preequilibrium code HMS. Development of a new module of EMPIRE will be initiated that would allow interactive search for optical model parameters.

BNL Deliverables:
  Release updated version of the code EMPIRE with extended GUI capabilities.
  Study the gamma production from Ge+n reactions for homeland security applications.
  Study the performance of the LANL preequilibrium code HMS.
  Preliminary version of the new module of the code EMPIRE that would allow an interactive search for optical model parameters.

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

LANL Deliverables:
  Calculate and interpret gamma-ray reactions measured with GEANIE/DANCE at LANSCE, including ^{171}Tm(n,γ) reactions producing unstable products and isomers; finalize the n+^{89}Y, n+^{193}Ir analysis.
  Work with LANSCE on the interpretation of new ^{28}Si(n,n') data obtained with the new FIGARO detector, in terms of compound, preequilibrium, and direct, reaction mechanism theory.
  Collaborate with LANSCE experimentalists on the interpretation of new FIGARO measurements of prompt neutron spectra.
  For Homeland Security attribution users, model and evaluate ^{236}U(n,γ) reactions, based in part on new DANCE measurements, and make these data available to CSEWG.
  Provide data on neutron emission spectra following inelastic scattering (n,n′) at FIGARO to provide "exclusive" data gated by specific gamma rays. These data will test the LANL code McGNASH now in development. Test cases will include ^{28}Si and ^{56}Fe and molybdenum isotopes.
  Continue work with Ohio University on neutron-induced charged particle emission cross sections and spectra to study effect of isospin. This degree of freedom is just now being included in GNASH and McGNASH. Test data will come from nuclei near N=Z.
  Obtain information on nuclear level densities on some fission product nuclei through (n,n′γ) reactions.
  Measure the fission neutron spectrum from neutron-induced fission of 235U and 238U with the FIGARO array for neutron energies from 1 to 100 MeV. Collaborators include scientists from CEA (France.) The data will test the Los Alamos Model of fission neutron emission.

Analyze particle emission spectra (neutrons, protons, alpha particles) from neutron reactions on iron to see if a consistent interpretation of pre-equilibrium emission can be obtained.

LLNL --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. A new Hauser-Feshbach code using object-oriented programming techniques is being developed. These techniques 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 is being written in ANSI/ISO standard C++.

TUNL – Ongoing work involves the development of preequilibrium nuclear reaction models, as well as the improvement and benchmarking the computer code PRECO. Work will continue on extending model verification—and, where necessary, modification—as well as code benchmarking for (N,N) reactions at higher incident energies. This involves studying the incident energy dependence of the matrix elements for the residual interactions causing nuclear energy equilibration. Other tasks (possibly related to interfacing with Hauser-Feshbach codes or to expanding stand-alone code functionality) may be substituted based on user input.

TUNL Deliverables:
An expanded dataset of spectra for (N,N) reactions at incident energies of 40 to 100 MeV.
Possible revisions to the models and/or global input set and thus to the code.

F. Nuclear Reaction Data Measurements

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

LANL Deliverables:
Complete the experiment and analysis of prompt gamma-ray emission following interactions of fast neutrons with 99Tc.
Measure prompt gamma rays from neutron interaction with at least one other fission product with the goal of deducing partial reaction cross sections.
Consult with evaluators on neutron interactions with fission products.

G. Evaluation of Data Needed for Astrophysics

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

ANL – The compilation of charged-particle data of the type (p,α) and (p,γ) for mass A = 30-50 nuclides will continue. The main focus during this period will be on completing the

evaluation for the (p,γ) reactions on stable sulfur isotopes. The objective is the preparation of evaluated data files that can be used for computation of astrophysical nuclear reaction rates. A report on this activity will be issued in the ANL/NDM series.

ANL Deliverables:
Data will be compiled, evaluated and documented for the ^{33,34,36}S(p,γ) reactions.

BNL – In support of the increasingly sophisticated nuclear data needs for astrophysics, NNDC is involved in a joint project with VNIIEF, Sarov, Russia, and ORNL to compile and evaluate alpha-induced nuclear reaction cross sections for astrophysics. The work is expected to be partially funded by the U.S. Civilian Research and Development Foundation, and will focus on nuclei with $8 < Z < 32$ and alpha particles with an incident energy below 20 MeV. These reactions, which are important in the helium burning stage of stars, novae, and supernovae events, include (α,α), (α,n), (α,p) and (α,γ) reaction channels. Based upon thorough compilation of data, including reactions and structural information, a critical analysis of the data will be done, and related cross sections and reaction rates will be evaluated.

BNL Deliverables:
Compile all available (α,α), (α,n), (α,p) and (α,γ) data for $8 < Z < 32$.
Install the statistical model code MOST at NNDC.
Develop preliminary module for Empire that would allow interactive search for alpha optical model parameters.
Perform preliminary calculations of (α,n), (α,p) and (α,γ) cross sections for target nuclei $8 < Z < 32$.

LANL -- Participate in the USNDP effort to develop high-quality data for astrophysics calculations of nucleosynthesis. Make new calculated and evaluated results available to the wider astrophysics research community *via* the USNDP Dissemination Working Group.

LANL Deliverables:
In FY03 we developed the folded Yukawa macroscopic-microscopic code to include an axial-asymmetry shape-degree of freedom; in FY04 we will use this new capability to calculate and analyze barriers for nuclides important in "termination of r-process".
Continue N-N analysis to higher energies and provide evaluated n-p data; compare evaluation with new microscopic high-precision calculations.
Perform analyses of other processes important to Big Bang nucleosynthesis and provide S-factors and reaction rates. We will begin new work on the t+α capture in FY04.
Reanalyze the important ^{12}C(n,γ)^{16}O reaction using our R-matrix tools that include an improved photon channel in order to determine the extrapolated cross section at astrophysically-relevant energies.
Continue to contribute to the TUNL Energy Levels of Light Nuclei project.
Continue analyses of reactions involving radioactive light isotopes, including ^{17}F+p, and possibly other reactions being measured at ORNL.

McMaster University – Evaluate hydrogen and helium capture reactions on unstable proton-rich nuclei that are important for energy generation and element synthesis in stellar explosions, with a focus on reactions to be studied at radioactive beam facilities (e.g., TRIUMF-ISAC).

McMaster Deliverables:
Evaluate the reaction rate of radiative proton capture on ^{21}Na.
Evaluate the ^{18}Ne(α,p)^{21}Na reaction rate.

ORNL – Evaluation work will be carried out for capture reactions on radioactive proton-rich nuclei that are important for element synthesis and energy generation in stellar explosions as well as for capture reactions important for understanding Red Giant Stars and reactions important for nuclear burning in the interior of the sun.

ORNL Deliverables:
Complete evaluations of proton capture on ^{18}F and ^{17}O.
Continue assessments of capture reactions on proton-rich radioactive nuclei.
Provide technical support for BNL in the compilation and evaluation of α-induced nuclear reaction cross sections (8<Z<32) for astrophysics.

H. Reaction Data for RIA Target Design

Rare Isotope Accelerator facility design needs high-quality nuclear reaction data for target design. LANL will collaborate in order to provide key reaction cross-sections using theory calculations and measurements to evaluate the data.

LANL Deliverables:
Work closely with Nuclear Physics RIA community to determine nuclear data needs for RIA target design, and support these needs.
Develop spallation and fission models in intra-nuclear cascade models and codes (CEM), including reaction products from light ions on heavy target.
Provide spallation and fission predictions of radionuclides to guide the design of the two-stage experiment being planned for TRIUMF.
Study performance of new LANL isospin-dependent global relativistic Schrödinger optical model.

Nuclear Data Activities Funded from Sources Outside the Nuclear Data Program

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

1. Academic Press supports the production of computer-generated photo-ready copy of manuscripts for the Nuclear Data Sheets.
2. Consultant services to the DOE Nuclear Criticality Safety program.

Georgia Tech – There are no additional sources of funding for nuclear data work in this group.

Idaho – The group has one subcontract with Idaho State University to compute efficiencies for Ge semiconductor gamma-ray detectors using Monte Carlo methods.

LANL – Most of the nuclear data work is supported from funds other than the nuclear data program. The effort is in support of the ENDF related work of nuclear model development, nuclear reaction evaluation and ENDF processing.

1. **Nuclear weapons (ASCI program).** This work supports the development of more accurate ENDF cross section databases for actinide fission fuels, light-nucleus thermonuclear fuels, and for reactions important on materials used for diagnostics (radiochemical reactions). Nuclear model code development, for both statistical and preequilibrium models, and for light R-matrix codes, is supported by this program, as is the development of the NJOY data processing code for providing data usable by Monte Carlo and deterministic transport codes in applications. The funding also supports physics research developments in nuclear reaction and structure theory (with a recent emphasis on nuclei and isomers away from stability), and fission theory. Data testing using integral benchmarks such as fast critical assemblies are used to validate the ENDF data.

2. **AFCI(Advanced Fuel Cycle Initiative).** This supports the development of improved nuclear data important for transmutation in the fast neutron energy region, as well as high-energy spallation models important for describing processes in the spallation target. Recent focuses have been improved ENDF data on minor actinides (ATW fuel), and lead and bismuth (target/coolant), as well as better intra-nuclear cascade codes for modeling neutron production and radionuclide production in the spallation target. This program also supports experimental nuclear reaction measurements at WNR.

3. **Nuclear criticality safety.** This funding supports improved nuclear data important in criticality safety studies, such as uranium isotopes, as well as data on chlorine, aluminum,

etc. Data testing using critical assemblies, and NJOY processing code development, is also funded by the program.

4. **RIA R&D.** The RIA R&D program funds LANL participation in the national program at a modest level. The funding supports improved intra-nuclear cascade code development (CEM and LAQGSM) for modeling radionuclide production in both ISOL and target-fragmentation mechanisms, including validation and optimization through comparisons with recently-measured data at GSI and other facilities.

5. **LANL LDRD.** There are 3 LANL LDRD projects that support nuclear reaction data measurements.

LBNL – Members of the Isotopes Project have always been encouraged to spend a portion of their time working on experiments in the area of low energy nuclear physics. This year, we plan to increase our activities in the area of experiments related to needs of nuclear data and nuclear astrophysics. We anticipate that a newly hired post doc will spend 50% of his or her time working on experiments at the 88" cyclotron. A measurement of the half-life of ^{108m}Ag is planned. Other experimental activities include total (n,γ) cross section measurements in collaboration with the Budapest group at the Budapest reactor, and a Prompt Gamma Activation Analysis feasibility study and the continuation of other neutron activation analysis experiments using a neutron generator at LBNL. . Support for these activities is drawn from the DOE low-energy nuclear physics component of our budget.

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

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

NIST – A variety of sources support nuclear data activities.

1. The Nuclear Data Verification and Standardization program has funding through the Commerce Department (NIST). This provides 44% of the total support for the program.

2. NIST provides 1 FTE for interferometry work, which has yielded coherent scattering lengths (which provide scattering data) needed for neutron cross section evaluations.

3. NSF provided 1 FTE for a graduate student to work on the interferometry experiments cited above.

4. DOE NE (Office of Nuclear Energy, Science and Technology) provided NERI funding of 0.75 FTE for iron transmission studies that will have an impact on evaluations of the iron cross sections.

5. NIST provided 1 FTE (75% experimental, 25% evaluation) for nuclear structure and decay data work. Much of this work also has applications in radioactivity standards and radio-pharmaceutical studies.

ORNL – The nuclear data work is partly funded by the Low Energy Nuclear Physics program.

TUNL – The nuclear data work is partly funded by the Low Energy Nuclear Physics program through a TUNL/NCSU grant.

USNDP Staffing Table for October 2003 through September 2004

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
I. NNDC Facility Operation	**0.00**	**1.15**	**1.25**	**0.00**	**0.00**	**0.00**	**0.00**
Management		0.35					
Secretarial/Administrative Support			1.00				
Library			0.25				
Computer Operation		0.80					
II. Coordination	**0.02**	**0.55**	**0.00**	**0.00**	**0.40**	**0.20**	**0.00**
National Coordination	0.02	0.35			0.1	0.2	
International Coordination		0.20			0.3		
III. Nuclear Physics Databases	**0.00**	**3.85**	**1.05**	**0.00**	**0.00**	**0.00**	**0.00**
Nuclear Science References (NSR)		0.10	0.75				
Experimental Nuclear Structure Data (XUNDL)		0.05					
Evaluated Nuclear Structure Data (ENSDF)		0.45	0.30				
Numerical Nuclear Data (NuDat)		0.05					
Reaction Data Bibliography (CINDA)		0.10					
Experimental Reaction Data (CSISRS)		0.10					
Evaluated Nuclear Data File (ENDF)		0.25					
Database Software Maintenance		0.10					
Future Database Systems		2.65					
IV. Information Dissemination	**0.02**	**0.65**	**0.50**	**0.00**	**0.10**	**0.25**	**0.00**
Maintenance of Remote Access to USNDP Data		0.30					
Customer Services		0.15	0.45				
Web Site Maintenance	0.02	0.20	0.05		0.10	0.25	

USNDP Staffing Table for October 2003 through September 2004

	McMaster	NIST	ORNL	TUNL	Program Total	
			O		Sci/Pro	Support
I. NNDC Facility Operation	**0.00**	**0.00**	**0.00**	**0.00**	**1.15**	**1.25**
Management					0.35	0.00
Secretarial/Administrative Support					0.00	1.00
Library					0.00	0.25
Computer Operation					0.80	0.00
II. Coordination	**0.00**	**0.00**	**0.05**	**0.05**	**1.17**	**0.00**
National Coordination			0.05	0.05	0.67	0.00
International Coordination					0.50	0.00
III. Nuclear Physics Databases	**0.00**	**0.00**	**0.00**	**0.00**	**3.85**	**1.05**
Nuclear Science References (NSR)					0.10	0.75
Experimental Nuclear Structure Data (XUNDL)					0.05	0.00
Evaluated Nuclear Structure Data (ENSDF)					0.45	0.30
Numerical Nuclear Data (NuDat)					0.05	0.00
Reaction Data Bibliography (CINDA)					0.10	0.00
Experimental Reaction Data (CSISRS)					0.10	0.00
Evaluated Nuclear Data File (ENDF)					0.25	0.00
Database Software Maintenance					0.10	0.00
Future Database Systems					2.65	0.00
IV. Information Dissemination	**0.00**	**0.00**	**0.05**	**1.20**	**1.02**	**0.50**
Maintenance of Remote Access to USNDP Data					0.30	0.00
Customer Services					0.15	0.45
Web Site Maintenance			0.05	1.20	0.57	0.05

USNDP Staffing Table for October 2003 through September 2004

	ANL	BNL		Idaho	LANL	LBNL	LLNL
		Sci/Pro	Support				
V. Nuclear Structure Physics	**0.73**	**2.05**	**0.00**	**0.50**	**0.10**	**2.48**	**0.00**
NSR Abstract Preparation		0.45					
Compilation of Experimental Structure Data							
Evaluation of Masses and Nuclides for ENSDF	0.68	1.40		0.40		2.05	
Ground and Metastable State Properties		0.10					
Radioactive Decay Data Evaluation	0.05			0.10		0.28	
Thermal Capture Gamma Data Evaluation						0.15	
Light Mass Evaluations for Nuclear Physics A.							
Nuclear Structure Data Measurement					0.10		
ENSDF Physics and Checking Codes		0.10					
VI. Nuclear Reaction Physics	**0.13**	**1.25**	**0.00**	**0.00**	**1.70**	**0.00**	**0.40**
Experimental Data Compilation	0.00	0.30					
Neutron Data		*0.05*					
Charged Particle Data		*0.20*					
EXFOR Manuals		*0.05*					
ENDF Manuals and Documentation		0.05					
ENDF Evaluations		0.35			0.10		0.20
Nuclear Reaction Standards					0.20		
Nuclear Model Development	0.08	0.20			0.60		0.20
Nuclear Reaction Data Measurements					0.30		
Astrophysics Nuclear Data Needs	0.05	0.35			0.30		
Reaction Data for RIA Target Design					0.20		
DOE/Science Nuclear Data Funded Staff	**0.90**	**9.50**	**2.80**	**0.50**	**2.30**	**2.93**	**0.40**
Staff Supported by Other Funding	**0.00**	**0.25**	**0.20**	**0.20**	**14.40**	**0.80**	**7.50**
TOTAL STAFF	**0.90**	**9.75**	**3.00**	**0.70**	**16.70**	**3.73**	**7.90**

USNDP Staffing Table for October 2003 through September 2004

	McMaster	NIST	ORNL	TUNL	Program Total Sci/Pro	Program Total Support
V. Nuclear Structure Physics	**0.50**	**0.00**	**0.55**	**1.00**	**6.36**	**0.00**
NSR Abstract Preparation					0.45	0.00
Compilation of Experimental Structure Data	0.15		0.05		0.15	0.00
Evaluation of Masses and Nuclides for ENSDF	0.35		0.50	0.55	4.88	0.00
Ground and Metastable State Properties					0.10	0.00
Radioactive Decay Data Evaluation					0.43	0.00
Thermal Capture Gamma Data Evaluation					0.15	0.00
Light Mass Evaluations for Nuclear Physics A.				0.45	0.00	0.00
Nuclear Structure Data Measurement					0.10	0.00
ENSDF Physics and Checking Codes					0.10	0.00
VI. Nuclear Reaction Physics	**0.50**	**0.20**	**0.40**	**0.40**	**4.38**	**0.00**
Experimental Data Compilation					0.30	0.00
Neutron Data					*0.05*	*0.00*
Charged Particle Data					*0.20*	*0.00*
EXFOR Manuals					*0.05*	*0.00*
ENDF Manuals and Documentation					0.05	0.00
ENDF Evaluations					0.85	0.00
Nuclear Reaction Standards		0.20			0.20	0.00
Nuclear Model Development				0.40	1.28	0.00
Nuclear Reaction Data Measurements					0.30	0.00
Astrophysics Nuclear Data Needs	0.50		0.40		1.20	0.00
Reaction Data for RIA Target Design					0.20	0.00
DOE/Science Funded Staff	**1.00**	**0.20**	**1.05**	**2.65**	**17.93**	**2.80**
Staff Supported by Other Funding	**0.50**	**2.80**	**0.00**	**0.00**	**31.15**	**0.20**
TOTAL STAFF	**1.50**	**3.00**	**1.05**	**2.65**	**49.08**	**3.00**

Argonne National Laboratory

US Nuclear Data Program
FY2004 Work Plan

Program Administration

Principal Investigator: Filip G. Kondev
Consultant: Donald L. Smith

       Contact: Filip G. Kondev
                 Nuclear Engineering Division
                 Argonne National Laboratory
                 Argonne, IL 60439
       Phone: (630) 252 4484
       Fax: (630) 252 5287
       E-mail: kondev@anl.gov

I. Program Technical Overview

The Argonne Nuclear Data Program includes a variety of scientific activities carried out within the broader framework of the Coordinated Work Plan of U.S. Nuclear Data Program (USNDP). Among these are the compilation and evaluation of nuclear structure and nuclear reaction data, and the development of new methodologies for nuclear data measurement, analysis, and applications. The experimental measurements are carried out at the U.S. Department of Energy national nuclear physics facilities and at leading nuclear laboratories overseas through collaborative arrangements. Attention is paid to collaborative and cooperative opportunities that serve to enhance the effectiveness of the U.S. nuclear physics and nuclear data research activities at minimal cost to the USNDP. The Program emphasizes nuclear structure and decay data, neutron activation data for nuclear model development, and charged particle reaction data for astrophysical applications. Contributions are also made to various specialized nuclear databases serving specific needs in the fields of nuclear structure, nuclear astrophysics, and applied nuclear physics.

II. FY2004 Commitments

1. National Coordination Activities (0.02 FTE)

ANL will Chair the Measurements and Basic Physics Committee of the Cross Section Evaluation Working Group.

2. Information Dissemination Activities (0.02 FTE)

ANL will continue to develop, update, and maintain the ANL Nuclear Data Measurement Report Series Web site, the ANL Nuclear Data Information Web site and the Experimental Resources for Nuclear Data Web site.

3. Evaluation of Nuclear Structure and Decay Data (0.73 FTE)

The ANL will continue to contribute to the activities of the International Nuclear Structure and Decay Data Network by compiling and evaluating data for selected mass chains and individual nuclides. Since the last USNDP meeting, Argonne has been assigned the responsibility for evaluating the A=199-209 mass chains. Our ultimate goal is to make these evaluations current in the next 3-4 years. During FY2004 we plan to complete evaluations for one and one half equivalent mass chains, including some nuclides that are on the NNDC priority list. Reviews of selected evaluations, submitted by members of NSDD network for publication, will be also performed, as requested. Contributions to the Decay Data Evaluation Project (DDEP) activities will continue. It is planned to submit one decay dataset to the DDEP Chairman. A special (horizontal) evaluation of properties of nuclear K-isomers will continue in collaboration with scientists from the Australian National University, Australia, and the University of Surrey, U.K. It is envisioned to continue activities in the area of experimental nuclear physics related to the need of nuclear data, particularly in the areas of nuclear structure and decay, and RIA issues. The experimental activities will be carried out at the ANL Physics Division, as well as at other national low-energy nuclear physics facilities, at little or no cost to the Argonne nuclear data participant. The results of this work will be documented in journal articles and laboratory reports. These will be also made available to the members of the NSDD network for inclusion in ENSDF.

4. Nuclear Model Development (0.08 FTE)

Argonne has participated in a fruitful collaboration with IRMM, Geel, Belgium for several years in the area of neutron activation cross sections. Argonne was instrumental in designing and developing new measurement capabilities at IRMM including the construction of pneumatic transport systems for use in measuring neutron activation cross sections with short half lives. This program has also included a sub-project to better characterize spectra from neutron-producing reactions in order to be able to determine corrections for the effects of secondary neutrons more accurately. This activity has been conducted in part under the auspices of a WPEC project (Subgroup 19) involving participation from the Belgium, Holland, France, Japan, Bulgaria, Hungary, Germany, among others. The thrust of this effort was to develop a database of new experimental reaction information and also to employ these results to investigate the systematic behavior of fundamental nuclear model parameters such as nuclear level densities. The approach of sensitivity analysis is being followed and a methodology developed by Argonne National Laboratory is being implemented for this purpose. Work in this area will continue in 2004. Argonne will participate mainly by preparing files of archived experimental data in the EXFOR format for inclusion in the experimental databases of the NNDC and other nuclear data centers around the world. Similarly, results from special evaluations of reaction cross sections will be coded into the ENDF format for archiving at these data centers.

5. Evaluation of Data Needed for Astrophysics (0.05 FTE)

A program to compile data on charged particle reaction information of interest for nuclear astrophysical applications will continue at a modest level with a main focus on (p,γ) and (p,α) reactions for mass A=30-50 nuclei. During FY2004 the main emphasis will be on data for the minor stable sulfur isotopes. Argonne has also been a leader in developing techniques for handling nuclear data with large uncertainties in nuclear astrophysics calculations. During FY2004 the issue of handling error correlations in astrophysical Monte Carlo analyses will be explored if time is available.

Brookhaven National Laboratory
National Nuclear Data Center

US Nuclear Data Program
FY2004 Work Plan

I. NNDC Facility Operation

A. Management

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

B. Library

NNDC maintains an archival collection of low- and intermediate-energy nuclear physics publications. This library supports the NNDC compilation activities and the U.S. nuclear reaction and nuclear structure data evaluation and international nuclear structure evaluation.

C. Computer Operation

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

BNL Deliverables:
Keep downtime on the central database server to less than 3%.
Provide full computer support for database migration project.
Upgrade hardware and software of Windows-based desktop computers.

Staff: 1.15 Scientific/Professional and 1.25 Support

II. Coordination

A. National Coordination

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

BNL Deliverables:
    Prepare FY2005 work plan for USNDP in time for spring 2004 FWP submittals.
    Organize and chair CSEWG Meeting at BNL in November 2003.
    Organize and chair USNDP Meeting at BNL in April 2004.
    Edit and publish summary reports of the CSEWG and USNDP meetings.
    Maintain CSEWG and USNDP Web sites.

B. International Coordination

BNL – Represent the United States in IAEA-sponsored Nuclear Reaction Data Center Network (NRDC) and Nuclear Structure and Decay Data Network (NSDD). The NNDC center head is the U.S. member and vice-chair of the IAEA's International Nuclear Data Committee and lead US member of NEA Working Party on International Evaluation Cooperation in his position as chair of CSEWG. BNL frequently participates in IAEA sponsored activities such as Workshops, Technical Meetings and Coordinated Research Projects.

BNL Deliverables:
    Host and participate in the NRDC meeting at BNL in 2004.
    Participate in NEA WPEC annual meeting in 2004.
    Provide director and lecturers for the NSDD Workshop at Trieste in November 2003.

Staff: 0.55 Scientific/Professional

III. Nuclear Physics Databases

A. Nuclear Science References (NSR)

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

BNL Deliverables:
    Database distributed to collaborators monthly.

B.   Experimental Nuclear Structure Data (XUNDL)

   The NNDC is responsible for maintaining and providing access to XUNDL database. This database contains compilations (in ENSDF format) of recently published or completed level-structure data. The emphasis is primarily on recent high-spin physics publications, but selected older papers and those for low-spin studies are also included. The compilation work is mainly carried out at McMaster University. The McMaster group also coordinates this work with that of other centers. The NNDC updates the database as new/revised data sets are received from McMaster.

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. This task includes database updates and distribution to collaborators. Updates are done upon completion of reviews. Corrections are implemented on a continuing basis.

   BNL Deliverables:
        Database distributed to collaborators twice a year.

D.   Numerical Nuclear Data File (NuDat)

   The NNDC is responsible for NuDat, an all numeric database of nuclear data including level and γ-ray properties extracted from ENSDF, ground and metastable state properties (Wallet Cards), atomic and nuclear radiations derived from ENSDF and thermal neutron cross sections and resonance integrals. The database is also available in a stand-alone PC version.

   BNL Deliverables:
        Distribute NuDat database to collaborators twice a year.

E.   Neutron Reaction Data Bibliography (CINDA)

   The NNDC is responsible for the CINDA database that contains references to nuclear reaction data in the published and unpublished literature. Its contents are produced cooperatively by the four international neutron data centers with updates exchanged in an agreed computer format. The data are organized by data measured, not by reference. The database serves as an index to the neutron data contained in the experimental database, CSISRS. The database is updated as transmissions from the data centers are received and checked.

   BNL Deliverables:

Update CINDA database with CINDA transmissions from cooperating centers (12 expected).

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. The effort described here includes the quality control, file update and data exchange activities. The database is updated, as transmissions from the compiling centers are received and checked. The compilation activity is given under Nuclear Reaction Physics.

BNL Deliverables:
Update CSISRS with EXFOR exchange tapes from cooperating centers (20 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 work is organized under the Cross Section Evaluation Working Group (CSEWG), coordinated by the NNDC. The ENDF file contains complete descriptions of nuclear reactions of neutrons with many nuclides and elements for energies up to 20 MeV and radiations from radioactive decay. A number of evaluations for energies up to 150 MeV and for incident charged particles and photons are also included. The data are stored in the ENDF format developed at NNDC about 35 years ago and adopted as an international standard. In addition to the U.S. library, ENDF/B, the database contains evaluated data libraries from the European Union, Japan, Russia and China. This activity includes the processing and quality control for the U.S. ENDF/B library, the distribution of this database in the United States and the exchange of libraries internationally. A new version of the library, ENDF/B-VII, is being prepared by the members of the Cross Section Evaluation Working Group. There will be no more releases of ENDF/B-VI, the work will focus on ENDF/B-VII.

BNL Deliverables:
Maintain CSEWG Web site; keep information current.
Make ENDF/B-VII evaluations available on the CSEWG Web site after reviews are completed.

H. Database Software Maintenance

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

I. Future Database Systems

In the 1980's, the NNDC migrated most of its databases to run under the Digital Equipment Corporation (DEC) CODASYL database management system (DBMS) on the VMS operating system (this DBMS has since been bought by Oracle). Retrieval programs written in FORTRAN allowed dial-up, DECNET, and telnet-based online retrieval well before the advent of the World-Wide Web. In the 1990's, Web interfaces were developed using the very same DBMS system.

In recent years, relational database management systems (RDBMSs) using Structured Query Language (SQL) have become standard in business and academia. There are many ways in which the nuclear data program could benefit from an increased use of relational database technology. Because it is a widely used technology, a large variety of auxiliary tools and interfaces exist for the administration and dissemination of data. These tools include replication and synchronization capabilities that would improve the efficiency and reliability of data exchange between centers. Because commercial RDBMSs software is available on a wide variety of platforms, and in a wide variety of price ranges, their use provides an opportunity to explore new options for dissemination to end-users of the data. The use of common standards in data storage will allow data centers to choose the software that best meets their needs, without being tied to a particular vendor.

Migration to this new database format represents a generational shift in the way data are stored. This is a major project that requires substantial amount of effort stretched over a period of several years. Among the tasks that need to be undertaken for each database are:

- Database design: The design of relational schema should be compatible with the current system, and allow flexible and efficient access to the data.
- Data migration: Current data will be loaded into the Sybase RDBMS system. The software written to do this will also be used to add new data as it comes in. Until the migration project is complete, parallel instances of the data will be kept in both the old and new database formats.
- Code migration: To the extent that it is feasible, the legacy programs for database administration, written mostly in FORTRAN, will be modified to work with the new RDBMS.
- Code development: For many tasks, and in particular for Web-based data dissemination, new software will be developed. Because of its portability, the Java programming language is being used for new software development.

As discussed in last year's plan, the NNDC is involved in a multi-year project to migrate its databases to a relational format. In FY2003 the Linux/Sybase computing environment was established using existing and newly purchased Dell hardware. The migration of the software supporting the nuclear structure data activities and databases (NSR, ENSDF and NuDat) was completed and extensive testing started. Migration of the software supporting the nuclear reaction data activities and databases (CINDA, CSISRS and ENDF) will be completed in FY 2004. Testing of the migrated nuclear reaction data software will be completed in the first quarter

of FY2005 and full implementation of the NNDC activity in the new computing environment will be completed in the second quarter of FY2005.

> BNL Deliverables:
>> Complete testing of the migrated software, which supports the nuclear structure activities and databases (NSR, ENSDF and NuDat) in the new computing environment.
>> Complete testing of the migrated software, which supports the nuclear reaction data activities and databases (CINDA, CSISRS and ENDF) to the new computing environment.

Staff: 3.85 Scientific/Professional and 1.05 Support

IV. Information Dissemination

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 Web.

> BNL Deliverables:
>> Only maintenance work will be performed on the existing Web interfaces to the data in the existing VMS computing environment.

B. Customer Services

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

C. Web Site Maintenance

> BNL Deliverables:
>> Effort required to keep the CSEWG, the USNDP and the NNDC sites current.

Staff: 0.65 Scientific/Professional and 0.5 Support

V. Nuclear Structure Physics

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

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 assistance from Russia and Japan.

BNL Deliverables:
Prepare entries for 4100 new references with keyword abstracts for 3100.

C. <u>ENSDF Data Evaluation</u>

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

BNL Deliverables:
Three and one-half equivalent mass chains will be evaluated.
At least four mass chains will be reviewed.

D. <u>Ground and Metastable State Properties</u>

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

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

I. <u>ENSDF Physics and Checking Codes</u>

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

BNL Deliverables:
Upgrade RADLST and LOGFT to properly treat higher-order (≥ 3) unique forbidden $\beta^{\pm}$ transitions and to use the Schoenfield electron-capture probabilities.

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.

Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data. Hence, there is a larger staff commitment to compiling this type of data.

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

> BNL Deliverables:
> Compile data from 100 charged-particle and neutron reaction publications.

B. ENDF Evaluations

Evaluated nuclear reaction data, for applications and for basic science needs, are stored in the ENDF database, which is maintained by BNL. As chair of the CSEWG evaluation committee, LANL staff works with BNL to insure quality control, particularly for new evaluations. New evaluations funded primarily from other sources are prepared for archival in the ENDF library. BNL, LANL, LLNL and ORNL will provide neutron, proton and photonuclear reaction data evaluations for ENDF/B-VII planned for release in FY2005.

> BNL Deliverables:
> Lead international effort (WPEC Subgroup 21) to review the bulk of fission products.
> Recommend the best available fission product neutron reaction evaluations for ENDF/B-VII.
> Submit new evaluations for Ge isotopes with photon production data for use in homeland security applications.

C. ENDF Manuals and Documentation

BNL Deliverables:

Maintain ENDF-7 formats manual that is available on Web.

E. Nuclear Model Development

BNL – We will enter actively into nuclear reaction model development arena with the BNL code EMPIRE. The work will focus on further extensions and improvements of its graphic user interface, including merging capability (resonance and fast energy) and extended plotting features. The work on validation and improvements of the code will be actively pursued, in particular in relation to emerging requirements of homeland security applications. Close collaboration with LANL will continue on validation of the pre-equilibrium code HMS. Development of new module of EMPIRE will be initiated that would allow interactive search for optical model parameters.

BNL Deliverables:
Release updated version of the code EMPIRE with extended GUI capabilities.
Study on gamma production from Ge+n reactions for homeland security applications.
Study on the performance of the LANL pre-equilibrium code HMS.
Preliminary version of new module of the code EMPIRE that would allow interactive search for optical model parameters.

G. Evaluation of Data Needed for Astrophysics

BNL – In support of the increasingly sophisticated nuclear data needs for astrophysics, NNDC is involved in a joint project with VNIIEF, Sarov, Russia, and ORNL to compile and evaluate alpha-induced nuclear reaction cross sections for astrophysics. The work is expected to be partially funded by the U.S. Civilian Research and Development Foundation[1], and will focus on nuclei $8 < Z < 32$ and alpha particles with the incident energy below 20 MeV. These reactions, important in the helium burning stage of stars, novae, and supernovae events, include (α,α), (α,n), (α,p) and (α,γ) reaction channels. Based upon thorough compilation of data including reactions and structural information, critical analysis of the data will be done, and related cross sections and reaction rates will be evaluated.

BNL Deliverables:
Compile all available (α,α), (α,n), (α,p) and (α,γ) data for $8 < Z < 32$. Install the statistical model code MOST at NNDC. Develop preliminary module for Empire that would allow interactive search for alpha optical model parameters. Perform preliminary calculations of (α,n), (α,p) and (α,γ) cross sections for target nuclei $8 < Z < 32$.

Staff: 1.25 Scientific/Professional

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[1] Funding is awaiting the issuance of a formal Project Agreement. The U.S. participants will receive $8,775 for travel and materials from the CRDF [Project RP2-2403-SR-02].

Idaho Evaluators

US Nuclear Data Program
FY2004 Work Plan

R.G. Helmer and C.W. Reich

	FTE
Evaluation responsibilities: masses 87, 1530163	
One equivalent mass chain will be evaluated.	0.35
Two mass chains will be reviewed.	0.05
Decay Data Evaluation Project	
Decay data for 3 nuclides will be evaluated.	0.10
Total	0.50

Los Alamos National Laboratory

US Nuclear Data Program
FY2004 Work Plan

Group T-16

	Description	Effort (FTEs)
1	USNDP Reaction Working Group Organization	0.1
2	Nuclear Physics ENDF Database	0.1
3	Astrophysics Reaction Data	0.3
4	Reaction data for RIA Target Design	0.2
5	Model code development, and reaction theory studies at LANSCE and GEANIE	0.3
6	WWW Dissemination of nuclear data	0.1
7	International nuclear data cooperation	0.1
8	Publications	
		Total=1.2

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. Chair of Evaluation Committee of the Cross Section Evaluation Working Group.

Deliverables:
    Organize and chair CSEWG Evaluation Committee meeting at BNL, Nov 2003
    Organize and chair Reaction Working Group meeting at USNDP meeting, April 2004.
    Help organize and help lead the CSEWG Homeland Security Task Force, and interact with LANL NA22 representative to provide feedback on user needs

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 ensure quality control, particularly for new evaluations. We will also submit new evaluations listed below (funded primarily from other sources) for archival in ENDF/B. We will coordinate the evaluation effort to upgrade reaction cross section evaluations for ENDF/B-VII, a major new release anticipated in 2004-5.

Deliverables:

Organize/Participate in international effort to reevaluate the light-element standard cross sections, &Participate in test problems designed to investigate the nature of output covariances from R-matrix analyses of systems containing the light-element standard cross sections.

Work with BNL to coordinate upgraded evaluations for new version of ENDF: ENDF/B-VII

Submit new improved evaluations that will be eventually available in ENDF/B-VII (^{232,233,234,235,236,238,239,241}U isotopes, ^{239}Pu, ^{237}Np, ^{241}Am)

Complete and submit to CSEWG high energy LA150 actinide evaluations for ^{239}Pu,^{238}U

Complete and submit to CSEWG new photonuclear actinide evaluations for U, Pu isotopes that include delayed neutron information, for Homeland Secuity detection of SNM

Provide ENDF evaluated data files for charged-particle reactions having A<=10.

3. Astrophysics Reaction Data (0.3 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:

In FY03 we developed folded Yukawa macroscopic-microscopic code to include axial-asymmetry shape-degree of freedom; in FY04 we will use this new capability to calculate and analyze barriers for nuclides important in "termination of r-process"

Continue N-N analysis to higher energies and provide evaluated n-p data, and compare evaluation with new microscopic high-precision calculations

Perform analyses of other processes important to BBN, and provide S-factors and reaction rates. We will begin new work on the t+alpha capture (for Big Bang nucleosynthesis) in FY04.

Reanalyze the important 12C(n,g)16O reaction using our R-matrix tools that include an improved photon channel, to determine the extrapolated cross section at astrophysically-relevant energies.

Continue to contribute to the TUNL Energy Levels of Light Nuclei project.

Continue analyses of reactions involving radioactive light isotopes, including 17F+p, and possibly other reactions being measured at ORNL.

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

The RIA R&D committee has recently endorsed official LANL collaboration. A Rare Isotope Accelerator 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 spallation and fission models in intranuclear cascade models and codes (CEM), including reactions products from light ions on heavy target.

Provide spallation and fission predictions of radionuclides to Will Talbert (who has an SBIR grant) to guide the design of the two-stage experiment being planned for TRIUMF,

Study performance of new LANL isospin-dependent global relativistic Schrodinger optical model

5. Model code development, and reaction theory studies at LANSCE and GEANIE (0.3 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, M. Devlin, 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. Also, largely under DOE/DP support, we will continue modernization of our R-matrix EDA code (used for light nucleus calculations and data evaluations) and explore implementation of exact particle-exchange formalism.

Deliverables:

Calculate and interpret gamma-ray reactions measured with GEANIE/DANCE at LANSCE, including $Tm^{171}(n,\gamma)$(and finalize $n+^{89}Y$, $n+^{193}Ir$ analysis) reactions producing unstable products and isomers

Work with LANSCE on the interpretation of new 28Si(n,n') data using the new FIGARO detector, in terms of compound, preequilibrium, and direct, reaction mechanism theory.

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

For Homeland Security attribution users, model and evaluate 236U(n,g) reactions, based in part on new DANCE measurements, and make these data available to CSEWG

6. WWW Dissemination of nuclear data (0.1 FTE)

Continue to develop our T-16 Online Nuclear Information Service, for convenient and wide access to our nuclear modeling research, data evaluations, and publications.
Deliverables:
Include access to new reaction and structure data evaluations, supported by DOE/ Nuclear Physics, via the T-16 WWW site
Continue coordination of T-16 WWW site with other USNDP sites

7. International nuclear data cooperation (0.1 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.. 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:
Continue organization of the major international nuclear data conference (ND2004), to be held in Santa Fe, September 2004.
Participate in NEA June 2004 meeting
Participate in relevant IAEA meetings, including Trieste Lectures in spring'04
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.

Experimental Nuclear Data Activities

Deliverables for FY2004:

II. Coordination
B. International Cooperation:

1. Complete organization of the major international nuclear data conference (ND2004) to be held in Santa Fe, September 26-October 1, 2004

2. Participate in INDC meeting if requested by the US representative.

V. Nuclear Structure Physics
1. Examine prompt gamma-ray emission data on 191Ir and 193Ir to search for previously unobserved transitions
2. Interact with mass chain evaluators on the nuclear structure of these nuclei.

VI. Nuclear Reaction Physics
D. Nuclear Reaction Standards

1. Participate in a standards measurement of the angular distribution of n-p scattering near 14 MeV with Ohio University and NIST. This quantity is the primary standard in all neutron cross section measurements.

E. Nuclear model development

1. Provide data on neutron emission spectra following inelastic scattering (n,n') at FIGARO to provide "exclusive" data gated by specific gamma rays. These data will test the LANL code McGNASH now in development.   Test cases will include 28Si and 56Fe and molybdenum isotopes.
2. Continue work with S. Grimes (Ohio University) and colleagues on neutron-induced charged particle emission cross sections and spectra to study effect of isospin. This degree of freedom is just now being included in GNASH and McGNASH. Test data will come from nuclei near N=Z.
3. Obtain information on nuclear level densities on some fission product nuclei through (n,n'gamma) reactions.
4. Measure the fission neutron spectrum from neutron-induced fission of 235U and 238U with the FIGARO array for neutron energies from 1 to 100 MeV. Collaborators include scientists from CEA (France.) The data will test the Los Alamos Model of fission neutron emission.
5. Analyze particle emission spectra (neutrons, protons, alpha particles) from neutron reactions on iron to see if a consistent interpretation of pre-equilibrium emission can be obtained.

Lawrence Berkeley National Laboratory
ISOTOPES PROJECT

US Nuclear Data Program
FY2004 Work Plan

<u>NUCLEAR STRUCTURE AND DECAY DATA EVALUATION</u>

The Isotopes Project's plans for FY2004 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. Also, Isotopes Project personnel will participate in the review of other data evaluations submitted to NNDC. Once again, Isotopes Project personnel will play a leadership role in the Decay Data Evaluation Project (DDEP), an international collaboration addressing current applied and research community needs.

The anticipated level of effort for data evaluation activities is 2.18 FTE from LBNL employees (which includes 0.5 FTE from the post-doc we wish to hire in FY'03/04) plus 0.3 FTE from visiting evaluators.

- **Mass Chain and Nuclide Evaluation:**
  5 mass chain equivalents chosen from regions for which LBNL is responsible (including at least one from the A=21-30 region).

- **Mass Chain Reviews:**
  Provide reviews of mass chains as requested.

Effort for above items: 2.05 FTE (which includes 0.3 FTE from visitors)

- **Decay Data Evaluation Project (DDEP): Nuclear and Atomic Radiations:**
  Coordinate and plan activities of this international collaboration
  Review evaluations of ~5 radionuclides.
  Submit decay datasets for two radionuclides.

Effort: 0.28 FTE

- **(n,γ) data evaluation**
  As new measurements from the Budapest Reactor become available, they will be evaluated and added to the "Prompt Gamma Activation Analysis" database that resulted from a recent IAEA CPR in which LBNL was involved. Total capture cross sections will also be extracted from those data when possible.

Effort: 0.15 FTE

NUCLEAR DATA DISSEMINATION

We will continue our 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 an LBNL staff effort of 0.25 FTE**.**

- **WWW Home Pages**
    Home pages for neutron-capture gamma rays, nuclear astrophysics, nuclear structure and decay systematics, nuclear science education, atomic masses, and other topics will be updated and maintained as needed.

Effort: 0.25 FTE

EXPERIMENTAL ACTIVITIES

Members of the Isotopes Project have always been encouraged to spend a portion of their time working on experiments in the area of low energy nuclear physics. In the coming year, we plan to increase our activities in the area of experiments related to needs of nuclear data and nuclear astrophysics. We anticipate that a newly-hired post doc will spend 50% of his or her time working on experiments at the 88" cyclotron. We also plan a measurement of the half-life of ^{108m}Ag, total (n,γ) cross section measurements in collaboration with the Budapest group at the Budapest reactor, and a Prompt Gamma Activation Analysis feasibility study and a continuation of other neutron activation analysis experiments using a neutron generator at LBNL. These activities are supported from the DOE Low-energy Nuclear Physics component of our budget.

Effort: 0.8 FTE (which includes 0.5 FTE from post-doc yet to be hired)

MANAGEMENT AND NATIONAL COORDINATION

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

Effort: 0.2 FTE

McMaster University

FY 2004 WORK PLAN FOR DATA EVALUATION

Nuclear Structure Physics: (Submitted by B. Singh, January 31, 2003)

Compilation of Experimental Structure Data:

Compilation of currently published or completed experimental nuclear structure data for inclusion in the XUNDL database.
       (0.15 FTE)

McMaster Deliverables:

   Compile data sets (in ENSDF format) of current publications, primarily in high-spin physics. Selected low-spin publications will also be compiled.

   Compile high-spin publications for outdated (older than about 7 years) ENSDF evaluations on a time available basis.

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

Data Evaluation for ENSDF database:
       (0.35 FTE)

McMaster Deliverables:

   Evaluate mass chains or nuclides to an equivalent of 1.5 full-length A-chains.

   Update ENSDF for new data on super-deformed structures as these become available. All nuclides will be covered that do not require an extensive re-evaluation of other data.

   Review mass chain evaluations as requested by NNDC.

Nuclear Reaction Physics: (submitted by A. Chen on February 10, 2004)

Evaluation of Data Needed for Astrophysics: The goal of this program is to evaluate reactions of importance in stellar explosions, focusing on ones that will be measured at radioactive beam facilities. The McMaster group is heavily involved with the research program at TRIUMF-ISAC, where some of these reactions will be studied. The data project involves complete evaluations of radiative proton capture on ^{21}Na, ^{13}N, ^{25}Al, ^{26}Al$_g$, and ^{19}Ne.

(0.5 FTE)

McMaster Deliverables (FY04):

Evaluate the reaction rate of radiative proton capture on ^{21}Na.
Evaluate the ^{18}Ne(α,p) ^{21}Na reaction rate.

FUNDING:

DOE supported staff: 0.5 FTE for structure data evaluation; and
                          0.5 FTE for astrophysics data evaluation.
Other funding: 0.5 FTE for structure data evaluation (from Canadian research agency).

National Institute of Standards and Technology
Nuclear Data Verification and Standardization Program

US Nuclear Data Program
FY2004 Work Plan

(total of 0.2 FTE of support from the DOE)

STRUCTURE ACTIVITIES: NONE

REACTION ACTIVITIES: Perform the duties, which will lead to an international evaluation of the neutron cross section standards. Chair the activities of the IAEA Coordinated Research Program (CRP) on the Improvement of the Standard Cross Sections. Complete the work with the CRP on code comparisons for both R-matrix and least-squares codes which will lead to a better understanding of the cross section uncertainties. Establish with the CRP the procedures for doing a comprehensive standards evaluation. Examine inconsistent (discrepant) data in the experimental database; focusing maximum attention on those experiments having the greatest weight. Complete the preparation of the data from experiments for use in the evaluation process. Act as Coordinator of the activities of the NEANSC's Working Party on International Evaluation Cooperation (WPEC) Subgroup, which promotes international cooperation on measurements and evaluations of the nuclear data standards. This Subgroup has been most helpful in providing experimental work to improve the database for the standards evaluation.   This standards evaluation activity is done under the auspices of the U.S. CSEWG, the NEANSC, and the IAEA, and includes participants from Austria, Belgium, China, France, Germany, Japan, Korea, Russia and the USA.

Suggest, motivate and monitor measurements, with an emphasis on measurements related to the $^{10}B(n,\alpha)$ cross section, for use in future standards evaluations, largely through the NEANSC's WPEC. Such activities will continue to be encouraged however they cannot be used for the present international evaluation of the standards. Continue the NIST-Ohio University-LANL collaboration with plans to improve the hydrogen scattering angular distribution. 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.   The renormalization of all measurements in the database which are relative to the H(n,n) standard should be completed during this year. An interim partial set of neutron cross-section standards for use in the ENDF/B-VII library will be produced. Coordinate CSEWG standards activities. Participate in CSEWG meetings. Participate in USNDP Coordinating Committee meetings. Maintain the National Repository for Fissionable Isotope Mass Standards.

DISSEMINATION ACTIVITIES: Make presentations at informal meetings on standards activities.

OTHER: NIST and the Contractor Carlson provide approximately a 0.8 FTE of support for these standards activities.   Independent of the verification and standards program, there is approximately 1 FTE of NIST support for nuclear structure and decay studies, and also

approximately 1 FTE of NIST support for interferometry and low energy cross section work related to the standards.

Oak Ridge National Laboratory
Nuclear Data Project

US Nuclear Data Program
FY2004 Work Plan

II. Coordination

A. National Coordination

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

ORNL Deliverables:
- Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting in May 2003
- Summarize USNDP efforts in nuclear data for nuclear astrophysics in FY02 and FY03 for USNDP written reports
- Communicate current efforts and future plans with researchers in nuclear astrophysics data
- Discuss future plans in nuclear astrophysics data with USNDP/NNDC and DOE

IV. Information Dissemination

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.

ORNL Deliverables:
- Maintain and update the Web FTP site providing the RadWare interface to ENSDF and XUNDL information.
- Improve the automatic graphical layout routines for ENSDF-to-Radware conversion.
- Improve and update web pages devoted to nuclear astrophysics data

V. Nuclear Structure Physics

C. Data Evaluation

The USNDP evaluates nuclide and mass chain nuclear structure and decay data for inclusion in the ENSDF database. TUNL has expressed interest in taking responsibility for A=21-30 but funding has not yet been obtained. This would complement the agreement of Canada to assume responsibility for A=31-44 and thereby cover the region formerly evaluated by the Utrecht group. LBNL intends to hire a post doc who will spend 50% of his or her time working on evaluation and 50% on reaction experiments for astrophysics.

ORNL Deliverables:
Evaluate A=217 and 247 nuclei
Begin evaluations of A=243 nuclei which are connected to A=247 and 239 nuclei via
alpha decays (time permitting)

VI. Nuclear Reaction Physics

G. Evaluation of Data Needed for Astrophysics

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

ORNL Deliverables:
Complete evaluations of proton capture on 18F and 17O.
Continue assessments of capture reactions on proton-rich radioactive nuclei.
Provide technical support for BNL in compilation and evaluation of alpha-induced
nuclear reaction cross sections (8<Z<32) for astrophysics.

TRIANGLE UNIVERSITIES NUCLEAR LABORATORY
NUCLEAR DATA PROGRAM

US Nuclear Data Program
FY2004 Work Plan

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NUCLEAR DATA EVALUATION PROJECT

A = 3 – 20

J.H. Kelley, J. L. Godwin, J.E. Purcell, G. Sheu, H.R. Weller

<u>COORDINATION</u>   Total FTE: 0.05

Report preparation and coordination for ad-hoc task force on "The Impact of
Nuclear Data on Society"

<u>NUCLEAR STRUCTURE</u>   Total FTE: 1.0

EVALUATIONS: (0.55 FTE evaluation of levels for ENSDF)
                           (0.45 FTE evaluation for other published literature: including
                            nuclear reaction information published in Energy Levels of Light
                            Nuclei manuscripts, and information published on our website.)

Distribute and mail out $A = 12$ preliminary review for comments.
Publish _"Energy Levels of Light Nuclei, A = 11 - 12"_ in _Nuclear Physics A_.
Evaluate and distribute for comment $A = 13$ preliminary review.

ENSDF:

Begin to prepare the ENSDF files for $A = 11 - 12$ to correspond with the _Nuclear Physics
A_ publication.

<u>DISSEMINATION</u>   Total FTE 1.2

TUNL Nuclear Data Evaluation Project Website:

Continue to prepare new PDF and HTML documents of the most recent TUNL reviews:
$A = 11$ and 12 (publication version) and $A = 13$ (preliminary version).

Continue to provide PDF and HTML documents for older FAS reviews for the $A = 3 - 20$ series; provide new PDF and HTML documents for earlier Fay Ajzenberg-Selove evaluations based on $A = 5 - 10$ (74AJ01), $A = 18 - 20$ (72AJ02), $A = 16 - 17$ (71AJ02), and $A = 13 - 15$ (70AJ04).

Continue to provide General Tables to accompany the most recent TUNL reviews of the $A = 3 - 20$ series; General Tables for $A = 13$ to be completed to correspond to preliminary report; update $A = 11$ and 12 General Tables to correspond to the review published in *Nuclear Physics A*.

Continue to provide scanned versions (in GIF, PDF and PS formats) of earlier Energy Level Diagrams to accompany the PDF and HTML documents for those nuclides.

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PROGRAM ON PREEQUILIBRIUM PHENOMENOLOGY

Constance Kalbach Walker

<u>NUCLEAR REACTIONS</u>   Total FTE 0.4

MODEL AND CODE DEVELOPMENT:

Program Overview:
Development of preequilibrium nuclear reaction models with a global input parameter set; improvement and benchmarking of the computer code PRECO which embodies these models. Once released, the code modules are used alone or in Hauser-Feshbach codes such as GNASH. The goal is to achieve a predictive tool for continuum reactions at 14 to 200 MeV.

Recent Accomplishments:
Release of PRECO-2000 and its users manual through the BNL and ORNL code distribution centers (June 2001)
New insights into reactions involving complex projectiles and/or ejectiles and into conditions for isospin conservation during preequilibrium processes.
Progress on describing surface localization of initial interactions by incident neutrons at energies above 25 MeV using newly available data.

FY2004 Plans:
Work on extending model verification (and, where necessary, modification) and code benchmarking for (N,N) reactions to higher incident energies. An important part of this involves studying the incident energy dependence of the matrix elements for the residual interactions causing nuclear energy equilibration.
Other tasks (related to interfacing with Hauser-Feshbach codes or to expanding stand-alone code functionality) may be substituted based on user input.

FY2004 Deliverables:

An expanded dataset of spectra for (N,N) reactions at incident energies of 40 to 100 MeV.

Possible revisions to the models and/or global input set and thus to the code.