



# USNDP Work Plan for Fiscal Year 2011

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February 2010

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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 2011 that begins on October 1, 2010. Previously, **11 work plans** have been prepared for the data program covering fiscal years 2000 - 2010. This plan has been prepared in consultation with the members of the Coordinating Committee who represent the organizations participating in the program. Each Coordinating Committee member prepared a draft plan for his/her organization. Each contribution was integrated into a unified work plan. The draft plan was then circulated to the Coordinating Committee for comments and corrections before the final document was submitted to the Department of Energy.

As was the case in the work plan for FY2010, the tasks proposed by the various organizations were reviewed internally according to the following criteria which were developed considering the mission and goals outlined in past review panel reports and oversight committee discussions, and in consultation with the DOE program manager.

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

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

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

The following section details the proposed work plan for FY2011, defining tasks, organizational responsibilities, and planned activities. It is envisioned that this document will serve as the basis for a performance review at the end of fiscal year 2010. Incorporated in the NNDC plan is a group of subcontracted external scientists, including nuclear structure evaluators and compilers.

The present Workplan was prepared for the **2010 appropriations** and **2011 guidance** scenarios.

**Table 1:** Summary of the USNDP funding and metrics for FY2001- FY2011, the last two years are projections under the **2010 appropriations** and **2011 guidance** scenarios.

Fiscal Year	USNDP Funding	Change	Compilations	Evaluations	Dissemination (in thousands)	Reports	Papers	Invited Talks
2001			7,139	334	667	21	25	22
2002	\$4,890K		6,159	300	799	23	40	22
2003	\$4,932K	+0.9%	4,975	260	966	27	40	23
2004	\$5,015K	+1.7%	6,241	276	1,212	35	36	43
2005	\$5,437K	+8.4%	6,623	422	1,642	74	59	42
2006	\$5,099K	-6.6%	4,936	318	1,863	47	60	48
2007	\$5,841K	+14.6%	5,355	366	2,239	40	56	51
2008	\$5,967K	+2.2%	5,104	385	2,996	48	72	68
2009	\$6,267K	+5.0%	4,035	400	3,294	26	61	56
2010	\$6,472K	+3.27%	6,016	419	3,566	26	55	55
2011	\$6,708K	+3.65%	4,962	417	3,569	27	56	55

We expected that the budgets under the **2010 appropriations** and **2011 guidance** scenarios plus the stimulus funding will ensure a solid program for FY 2011. We expect to achieve:

- Compilation, evaluation and dissemination activities will be fully supported.
- Training and mentoring of new ENSDF evaluators will continue.
- A large amount of effort will be devoted to prepare the new VII.1 version of ENDF/B-VII.1
- Development of nuclear reaction codes will continue (covariances and fission).
- The new XENDL format will enter testing phase, ARRA funding being instrumental.

Several important staff issues will be dominant in 2011:

ANL will possibly have to convert an ARRA funded post-doc in staff in 2012.

BNL has had some difficulties filling vacancies due to the scarcity of suitable candidates and the high cost of living in Long Island. With the retirement of a senior ENDF PI looming, this issue will become crucial. The NNDC has a large number of highly-skilled external collaborators, about 13. This initiative should be maintained and strengthened.

LBL is expecting the retirement of two ENSDF evaluators by 2012. LBNL needs to hire a new evaluator with leadership skills to work with outgoing staff to rebuild the program if it is to continue.

ORNL needs to strengthen the funding for its junior staff as well as maintaining the support for their programming activities.

Additionally, BNL will be the main Web-dissemination center after LBNL shuts down its web activities in 2011.

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# 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 effort.

## C. Computer Operation

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

BNL planned activities
Conduct regular scanning and remediation of vulnerabilities on NNDC servers and clients to ensure compliance with DOE cyber security requirements. Noncompliance could result in a total block of a machine from network access.
Provide computer support to NNDC staff and its visitors in their use of NNDC computing resources.
Upgrade existing NNDC Windows servers from Windows Server 2000 to Windows Server 2008 RC2 to meet DOE cyber security requirements. Microsoft will no longer provide security patches beyond July 2010. Noncompliance could result in a total block of a machine from network access. Finally, migrate Windows Vista desktops to Windows 7.

# II. Coordination

## A. National Coordination

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

ANL: Chair the Covariance Committee of the Cross Section Evaluation Working Group

ANL Planned Activities
Organize and chair the CSEWG Covariance Committee

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

BNL planned activities
Prepare FY2011 work plan for USNDP in time for spring 2010 FWP submittals.
Organize and chair CSEWG Meeting at BNL in November 2009.
Organize and chair USNDP Meeting at BNL in November 2009.
Edit and publish summary reports and proceedings of the CSEWG and USNDP meetings.
Maintain CSEWG and USNDP websites

LANL planned activities
Organize and chair CSEWG Evaluation Committee meeting at BNL, November 2010.
Organize and chair Nuclear Reaction Working Group meeting at USNDP meeting in November 2010, and help coordinate Homeland Security and Astrophysics Task Forces.

LBLN: Serve as a member of the USNDP Coordinating Committee and chair the USNDP Nuclear Structure and Decay Data Working Group in addition to overseeing, coordinating, and directing the work of members of the Isotopes Project. The latter effort includes

working with LBNL management, with other members of the USNDP, and with the program officers of the DOE.

#### LBNL planned activities

Organize and chair Nuclear Structure and Decay Data Working Group meeting at USNDP meeting, November 2011. Work with the NNDC to improve the efficiency of nuclear structure data evaluation and better integrate US efforts with other nuclear data activities.

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

#### LLNL planned activities

Organize and chair the CSEWG Task Force on Nuclear Data Needs for Homeland Security.

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

#### ORNL planned activities

Summarize USNDP efforts in nuclear data for nuclear astrophysics at USNDP Meeting in November 2008.

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

Represent USNDP nuclear astrophysics efforts at international collaboration meetings on nuclear astrophysics data.

Initiate collaborative research projects to raise the visibility of nuclear data projects directed at astrophysics applications.

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

## B. International Coordination

ANL: Represent ANL in the Nuclear Structure and Decay Data Network (NSDD), Decay Data Evaluation Project and other international nuclear data collaborations. Participate in IAEA-sponsored coordinated research programs (CRP) and training workshops.

#### ANL planned activities

Participate in the 2011 NSDD meeting.

As a member of the organizing committee, participate in a nuclear physics workshop at ANL that is aimed at improving decay data for neutron-rich fission products.

Host several international visitors to ANL to collaborate on nuclear structure and nuclear astrophysics data evaluation projects.

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 of the IAEA's International Nuclear Data Committee (INDC), the lead US member and chair of the NEA Working Party on International Evaluation Cooperation (WPEC) in his position as chair of CSEWG. Many of the NNDC staff participates in IAEA sponsored activities such as Workshops and Technical Meetings.

#### BNL planned activities

Participate in the IAEA-sponsored NRDC meeting in 2011.

Participate in NEA WPEC annual meeting in 2011.

Participate in the IAEA-sponsored NSDD meeting in 2011.

Conduct and lecture at likely IAEA-sponsored workshop at Trieste in 2011.

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

#### LANL planned activities

Participate in NEA-WPEC 2011 meeting

Participate in relevant IAEA CRP meetings (FENDL and prompt fission neutron spectrum data).

Participate and give a talk at the Joint International Conference of the 7th Supercomputing in Nuclear Application and the 3rd Monte Carlo (SNA + MC2010), will be held in Tokyo, Japan, Oct. 17-20, 2010.

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, planning meetings and coordinated research programs on nuclear structure and decay data.

#### BNL planned activities

Coordinate the evaluation of a new k0/cross section database with International k0 users committee.

Participate in the IAEA/NSDD meeting in 2011.

Edit the IAEA/LBNL Evaluated Gamma-ray Activation File.

McMaster: Continue participation in new evaluators training program.

#### McMasters planned activities

Participate in the matters related policies, ENSDF formats and procedures for the NSDD network.

Continue to participate in training/mentoring of new ENSDF evaluators through collaborative work.

Participate in IAEA-NSDD 2011 meeting.

TUNL: Represent TUNL at IAEA-sponsored at Nuclear Structure and Decay Data network (NSDD).

#### TUNL planned activities

Participate in the policy matters related to the NSDD network.

Participate in NSDD/IAEA meetings

## 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 planned activities

Database distributed to collaborators monthly.

Provide international coordination of NSR compilations and activities.

### B. Experimental Nuclear Structure Data (XUNDL)

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

#### BNL planned activities

Weekly update of the database using input received from McMasterUniversity.

Distributed twice a year to the NSDD network.

### C. Evaluated Nuclear Structure Data File (ENSDF)

The NNDC is responsible for ENSDF, a database of evaluated experimental nuclear structure and decay data. The NNDC is responsible for format and content checking, preparation of manuscript, and quality control (review) of evaluations submitted for inclusion. The NNDC maintains the database, which includes database updates and distribution to collaborators. Corrections are implemented on a continuing basis.

#### BNL planned activities

Database distributed to collaborators twice a year.

Process evaluations received from NSDD evaluators.

### D. Numerical Nuclear Data File (NuDat)

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

Nuclides and interactive level schemes.

BNL planned activities

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

## E. Neutron Reaction Data Bibliography (CINDA)

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

BNL planned activities

Contribute to CINDA by compiling experimental cross-section data to the CSISRS database (120 compiled papers expected).

## F. Experimental Reaction Data File (CSISRS)

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

BNL planned activities

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

## 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. New evaluations for the next release of the library, ENDF/B-VII.1, are assembled, tested and made available to users through the GForge web interface.

BNL planned activities

Maintain Linux/MySQL database system.

Maintain GForge/Subversion system for tracking development of the ENDF/B-VII.1 library.

Maintain and improve Sigma database and web interface for users without specialized knowledge of ENDF-6 format. (See also information dissemination, chapter IV).

## H. Database Software Maintenance

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

BNL planned activities

Fix bugs and develop enhancements for the six nuclear physics databases maintained by NNDC.

## I. Database Systems Development

The multi-year effort to migrate the USNDP databases to a LINUX/MySQL environment was completed in FY2009. Several follow-up tasks will need to be performed.

BNL planned activities

Effort needed to maintain Linux/MySQL database system and improve its performance.



Implement and maintain automatic replication of updates from the internal MySQL database server to the external.

## 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. Web Site Maintenance

The NNDC provides electronic access to the nuclear physics databases that it maintains on behalf of the USNDP as well as access to other nuclear physics information through its web site. The NNDC web services are powered by four quad-processor Dell servers running on the Linux operating system and using the Apache Tomcat and Sybase server software. This type of solution was made public in April 2004. Most of the databases were redeveloped to take advantage of the new hardware possibilities as well as new programming technologies, such as the use of the Java and Java scripts languages. In FY 2009 all the servers were replaced and the software was upgraded, migrating from Sybase to MySQL. The NNDC also maintains the Atomic Mass Data Center website. Other USNDP members also offer nuclear physics information through their websites. These services require resources to maintain currency and improve performance.

#### ANL Planned Activities

Maintain and upgrade the ANL/NDM report series web site.

Maintain and upgrade Experimental Resources for Nuclear Data web site.

Maintain and upgrade ANL Nuclear Data Information web site.

#### BNL Planned Activities

Improve ENSDF and NSR web interfaces.

Maintain web interfaces for ENDF and EXFOR databases.

Improve Sigma web interface by adding new and extended features following user's requests.

Maintain web interface for double-beta decay, B(E2) and Maxwellian-averaged cross sections and reaction rates.

Maintain currency of the CSEWG, USNDP and the NNDC web sites, proactively respond to the users requests.

Improve reliability of its web services by installing the latest version of Apache/Tomcat servers and mod-jk connector software for a new dual web server system. Maintain the NNDC Web Services readiness above the 99% level.

Strictly follow all BNL and DOE cybersecurity rules and regulations during the Web application design, development and implementation.

Maintain GForge Web site.

#### LANL Planned Activities

Maintain LANL web site and provide actinide ENDF/B-VII data for criticality data testing, together with other LANL evaluations.

#### LLNL Planned Activities

Maintain LLNL's Nuclear and Atomic Data Viewer.

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

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

#### LBNL planned activities

The Isotopes Project web site will be shut down in FY2011.

#### ORNL Planned Activities

Continued development and maintenance of our online software suite to convert nuclear data to astrophysical reaction rates and plot, manipulate, and share results online; this activity is at risk of termination.

#### TUNL Planned Activities

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

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

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

Continue to provide 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.

## B. Customer Services

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

### BNL Planned Activities

Provide technical support to users as necessary.

Maintain Comments/Questions option for all reaction databases, for the NNDC web services, ENDF, EXFOR and for Nuclear Wallet Cards.

## C. Publications

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

### BNL Planned Activities

Prepare twelve issues of Nuclear Data Sheets for publication.

Prepare special issue of Nuclear Data Sheets on neutron reaction data.

## V. Nuclear Structure Physics

### A. NSR Abstract Preparation

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

### BNL Planned Activities

Prepare entries for about 3,100 new references, and keyword abstracts for 2,000 of them.

Check and edit approximately 700 key-worded abstracts for three European journals prepared at the IAEA Nuclear Data Section.

Check and edit key-worded abstracts from other collaborators as applicable and necessary.

Provide training and knowledge sharing for external NSR collaborators.

### McMaster Planned Activities

NSR keywording for Physical Review C journal

### B. Compilation of Experimental Structure Data

This activity involves compilation of recently published or completed experimental nuclear structure data for inclusion in XUNDL. The compilation is done by McMaster, while the NNDC is maintaining the database. In FY09, ANL plans to start contributing to compilation effort.

### ANL Planned Activities

Compile and review datasets for recently published experimental nuclear structure data for inclusion in the XUNDL database. Interact with the authors for requesting additional experimental data or for further clarification of the published results.

### BNL Planned Activities

Compile new B(E2) experimental data, start work on a B(E2) evaluation project (in collaboration with McMaster).

Compile new double-beta decay experimental data.

Maintain, update and distribute XUNDL.

#### McMaster Planned Activities

Compile data sets (in ENSDF format) for current experimental nuclear structure publication. Scan the webpages of prominent journals in nuclear physics for new papers.

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

Communicate with the authors of the original papers for data-related problems and to request additional details of unpublished data.

Train a new undergraduate student in 2011 for XUNDL and other compilation work.

#### TUNL Planned Activities

Compile XUNDL data for A=2-20

## C. Data Evaluation for ENSDF

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

#### ANL Planned Activities

Evaluate at least 1 mass chain from the ANL region of responsibility.

Review mass chain evaluations, as requested.

Collaborate with scientists from other NSDD network centers on data evaluation projects.

#### BNL Planned Activities

At least 6 mass chains, or their equivalent nuclides, will be evaluated.

At least 6 mass chains, or their equivalent nuclides, will be reviewed.

Continue mentoring new ENSDF evaluators.

#### LBNL Planned Activities

Evaluate the equivalent of at least 3 mass chains, including a minimum of one from the A=21-30 region. Emphasis will be placed on evaluating data of current interest to the nuclear structure and nuclear application communities.

Review mass-chain evaluations, as requested.

Work with the NNDC to include DDEP decay data and EGAF capture gamma-ray data in the ENSDF file and published in Nuclear Data Sheets.

Train new evaluators to replace retiring 2.0 FTE expected in FY2011.

#### McMaster Planned Activities

3.5 equivalent mass chains and the data for new nuclides as mentioned below) will be evaluated.

Mass chains will be reviewed as requested.

Update ENSDF for the identification of new nuclides and for the first publications on the findings of the excited states of nuclides.

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

#### ORNL Planned Activities

Complete evaluation of structure information for one nucleus in A=241-249 region.

Review one mass chain evaluation.

#### TUNL Planned Activities

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

## D. Ground and Metastable State Properties

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

#### BNL Planned Activities

Update database as new information becomes available.

## E. Radioactive Decay Data Evaluation

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

#### ANL Planned Activities

Evaluate at least one radionuclide for the DDEP collaboration.

Review of selected nuclides for the DDEP collaboration, as requested.

#### McMaster Planned Activities

Evaluate or review decay datasets for one or two radionuclides, as needed.

## F. Neutron-Induced $\gamma$ -Ray Data Evaluation

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

#### LBNL Planned Activities

Continue to maintain and develop the EGAF database:

- Collaborate with LLNL to perform statistical-model calculations of quasi-continuum  $\gamma$ -ray cascade information and generate ENDF-format capture  $\gamma$ -ray datasets for use with MCNP and other transport-code calculations.
- Prepare ENDF capture gamma-ray datasets in collaboration with LLNL
- Include improved nuclear structure data for the RIPL library in EGAF datasets.
- Add activation data to the EGAF file.
- Update EGAF prompt gamma-ray cross sections from new measurements.

#### LLNL Planned Activities

Evaluation of EGAF data in collaboration with LBNL

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

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

#### TUNL Planned Activities

Finalize publications in the A=11, 12 and 13 region.

Continue to evaluate A=14 & 15 nuclei.

## H. Nuclear Structure Data Measurement

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

#### ANL Planned Activities

Participate in nuclear physics research activities at ANL with main emphasis on decay studies of neutron-rich fission products of relevance to reactor decay heat and astrophysics applications (Co-PI of a DOE/ONP ARRA funded project), spectroscopy of heavy actinide nuclei and nuclei far from stability line.

Complete analyses of <sup>233</sup>Pa and <sup>243</sup>Cm decay data and publish the results.

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

#### LANL Planned Activities

Examine prompt gamma-ray emission data and gamma-gamma coincidence data from neutron reactions on nickel isotopes to search for previously unobserved transitions in these nuclides.

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

LBNL – to promote a closer working relationship with the nuclear structure community, LBNL will devote a small effort (~0.1 FTE) to participation in local nuclear structure experimental work.

#### LBNL Planned Activities

- Participate in LBNL 88" Cyclotron experiments with an emphasis on topical issues and data needs such as AFC-related measurements or nuclear structure experiments on nuclei far from stability.
- Continue capture gamma-ray cross section measurements with neutron beams at the Budapest Reactor.
- Perform DICEBOX statistical model calculations to determine total radiative cross sections and nuclear level spins and parities.
- Continue applied nuclear applications relevant to climate and environment.

## I. ENSDF Physics and Checking Codes

The NNDC maintains ENSDF checking and physics programs on behalf of the national and international evaluator networks

#### BNL Planned Activities

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

## VI Nuclear Reaction Physics

### A. Experimental Data Compilation

The NNDC, as part of a larger international cooperation, has responsibility for compiling experimental nuclear reaction data that have been produced in the U.S. and Canada. Incident neutron reactions have been well covered historically. NNDC thus concentrates on new measurements, but continues compilations of earlier publications that have not been included in the CSISRS database. Since incident charged particle data have not been completely compiled in the past, NNDC is compiling new charged-particle measurements. In addition, because of emerging needs such as astrophysics, the NNDC is compiling older data. Hence, there is a larger staff commitment to compiling this type of data.

#### BNL Planned Activities

Compile experimental data for neutron, charged particle, and photon induced reactions from 120 publications.

### B. ENDF Evaluations

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

#### BNL Planned Activities

Respond to user needs for evaluated nuclear reaction data.

Collect and address users feedback related to the ENDF library.

Work with LANL on upgraded evaluations for future release of the ENDF/B library (version VII.1).

Improve methodology for providing covariance data in the resonance region and in the fast neutron region to the next release of ENDF.

#### LANL Planned Activities

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

Provide upgraded ENDF evaluated data files for light elements, including covariance data. Finalize new evaluations of  $^9\text{Be}$  and  $^{16}\text{O}$ .

Finalize new evaluations for gas production cross-sections on structural materials, considering LANSCE experimental data.

Re-evaluate V and Mn data, for which problems in the criticality benchmarks are reported.

Upgrade new delayed gamma-ray data, by combining ENSDF beta-decay data.

Fix energy grid problem in the prompt fission neutron spectra for major actinides.

#### LLNL Planned Activities

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

## C. ENDF Manuals and Documentation

The NNDC is responsible for maintaining the format and procedures manual for the ENDF system, which recently has been updated and migrated to LaTeX. We also produce the documentation supporting the contents of the ENDF/B library.

#### BNL Planned Activities

Maintain ENDF-6 formats manual up-to-date with CSEWG endorsed format changes. This format is used for the ENDF/B-VII library.

## D. Nuclear Reaction Standards

Nearly all neutron cross section measurements are made relative to a neutron cross section standard such as the hydrogen elastic cross section. Maintaining accurate current values for the standard cross sections is the objective of this task that can be most efficiently accomplished through international cooperation. A new international evaluation of the neutron cross-section standards, which was initiated by the CSEWG, was recently completed. The work was performed largely by an IAEA Coordinated Research Project (CRP) with support from the NEA Working Party on International Evaluation Cooperation (WPEC) of the Nuclear Energy Agency and the CSEWG. It is important to improve the standards database and procedures for evaluations in preparation for new evaluations of the standards.

#### LANL Planned Activities

Participate in the international effort to reevaluate the light-element standard cross sections with LANL leadership for H, Li and B, and investigate the nature of output covariance data from R-matrix analyses of systems containing the light-element standard cross sections.

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

Study covariance data evaluation for the standards in a different technique when the R-matrix analysis gives extremely small uncertainties.

Complete report on the measured cross sections for the standards reaction  $^6\text{Li}(n,\alpha)$  in the MeV region together with an R-matrix analysis of these and literature data. The measured data have already been given to the NNDC.

Begin experiment on H(n,n) angular distribution for improving the standard at several neutron energies for forward neutron scattering angles in the center-of-mass. This measurement follows the H(n,p) measurements that improved the data base at backward angles. We collaborate with researchers at Ohio University and NIST.

Continue the search for suitable (n,x  $\gamma$ ) reactions as possible reference cross sections to complement or replace the  $^{56}\text{Fe}(n,x \gamma = 847 \text{ keV})$  reaction, which has several experimental limitations.

#### NIST Planned Activities

Continue work on the IAEA data development project on maintenance of the neutron cross section standards. Prepare a conference paper on the update of the standards from the work of this project. Prepare for the next IAEA Consultants' Meeting on this project and provide results on the updating of the standards database and its impact on the standards.

Prepare a paper for publication in the journal Metrologia on neutron cross section standards - their history, how they are measured, evaluated and used.

Work on the Program Committee for the 14th International Symposium on Reactor Dosimetry to be held in 2011. We will organize the topic "nuclear data for dosimetry" to be used in a session at this Symposium.

Submit for publication the finalized measurements on the angular distribution of neutrons scattered by hydrogen at 14.9 MeV based on proton recoil work. Work done in collaboration with Ohio University and LANL.
Continue work on an experiment using neutron detection (instead of proton detection) to measure the H(n,n) angular distribution in collaboration with Ohio University and LANL. Study the possible use of a time projection chamber for angular distribution measurements.
Continue work based on $^{252}\text{Cf}$ nu-bar leading to an improved calibration of NBS-I, the U.S. national primary standard neutron source and determination of our bath efficiency.
Complete a measurement of the $^6\text{Li}(n,t)$ standard cross section at $\sim 4$ meV neutron energy using an improved fluence determination based on alpha-gamma coincidences with the $^{10}\text{B}(n,\alpha)$ reaction. Continue work to finalize the design for the $^3\text{H}$ target for the n- $^3\text{H}$ coherent scattering length measurement including safety review, detailed design, prototype fabrication, and element testing. This work complements work on the $^3\text{He}(n,p)$ standard cross section
Continue the documentation of changes to EXFOR files based on the corrections obtained from the files of Poenitz and new information obtained from the CRP investigations.
Continue to recommend and encourage new measurements and perform examinations of the data from them for use in future evaluations of the standards.
Continue to acquire and monitor samples in the National Repository for Fissionable Isotope Mass Standards. Also make these samples available for loan in physics experiments.

## E. Nuclear Model Development

This task covers activities such as development and validation of nuclear reaction models used for prediction of nuclear reaction cross sections. The two major codes are GNASH (LANL) and EMPIRE (BNL). Measurements made by ANL and LANL along with other measurements made with DOE low-energy physics funds will play a crucial role in the validation of the models in these computer codes.

BNL – We are active in nuclear reaction model development focusing on the BNL code EMPIRE. The work in this fiscal year will concentrate on further extensions and improvements of its capabilities. The work on validation of the code will be actively pursued, in particular in relation to emerging requirements of homeland security applications. Close collaboration with LANL will continue focusing on validation of the fission models in EMPIRE and GNASH. Major effort is dedicated to the development of capabilities for estimating covariance data for fast-neutron reaction cross sections. In response to the needs from many user groups (such as Gen-IV reactors, criticality safety, Advanced Fuel Cycle Initiative), BNL will collaborate with LANL and ANL on a methodology for nuclear data covariances. To this end, a covariance module in EMPIRE for fast neutron energies should be extended and tested.

### BNL Planned Activities

Release new version of the code EMPIRE with above-mentioned improvements.
Develop the improved version of the covariance module in EMPIRE for fast neutrons.
Implement and test the new resonance module allowing to generate covariances utilizing information from Atlas of Neutron Resonances.
Maintain GForge site with the current version of the EMPIRE code.
Attempt parallelization of EMPIRE on the NNDC cluster.

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

### LANL Planned Activities

Perform radiative capture calculations on Gd and Tm isotopes, and investigate the enhancement factor of neutron capture rate on the excited nuclei, in support of DANCE detector capture measurements and s-process nucleosynthesis studies.
Perform neutron emission cross section calculations for fission products, in collaboration with CEA (France).
Develop a code to calculate the delayed gamma spectrum from fission products, using the Monte Carlo technique for the Hauser-Feshbach statistical decay, and extend the code to handle a neutron competition channel.
Apply a coupled-channels Hauser-Feshbach method to neutron capture process for deformed targets to study gamma-ray cascading, in support of DANCE and GEANIE measurements.

Modern nuclear structure models, such as Hartree-Fock, will be applied to calculate proton capture process for odd-target cases, with reasonable approximations.

Study  $^{238}\text{U}$  and  $^{232}\text{Th}$  neutron inelastic scattering at low-excitation energies where theoretical calculation underestimates experimental data.

Apply beta-delayed gamma calculations to fission product decay heat to benchmark beta-decay modelling at LANL.

#### LLNL Activities

Event by event fission modeling

Reaction theory for surrogate reactions

## F. Nuclear Reaction Data Measurements

The measurement of nuclear data is essential to provide data, which either cannot be calculated or cannot be calculated with sufficient accuracy for user applications. This activity is also essential to support and verify nuclear model development and application.

ANL: ANL has recently initiated a new program in collaboration with INL (Measurement of Actinide Neutronic Transmutation Rates with Accelerator mass spectroscopy - MANTRA), supported through ARRA funding from ONP/DOE, aimed at obtaining valuable integral information about practically all high mass actinides neutron cross sections that are of importance to advanced nuclear fuel cycles and to USNDP.

#### ANL Planned Activities

Coordinate research activities between INL and ANL and participate in nuclear data measurements, equipment development, cross section modeling and sensitivity studies.

#### LANL Planned Activities

Analyze neutron inelastic scattering made with the GEANIE and FIGARO arrays. Correlate new data from GEANIE with data from FIGARO on targets of  $^{56}\text{Fe}$  and  $^{58}\text{Ni}$ . New measurements at GEANIE will include  $^{60}\text{Ni}$ .

Continue to improve the techniques to measure the fission-neutron spectrum for fission induced by neutrons of 0.4 to 200 MeV on  $^{235}\text{U}$  and  $^{239}\text{Pu}$ . The shape of the major part of the emission spectrum between 0.1 and 10 MeV will be determined in this experiment, performed in collaboration with CEA and LLNL researchers, and will be compared with the Los Alamos model prediction. The modeling includes the Monte Carlo prompt neutron emission technique and the microscopic quantum mechanical pre-equilibrium calculations. In FY11, we will complete measurements on the portion of the fission neutron spectrum below 1 MeV for  $^{235}\text{U}$ .

Complete the measurement and analysis of prompt neutron emission following interactions of fast neutrons with fission products such as strontium and barium. These measurements are gated on gamma rays from  $(n,n'\gamma)$  reactions.

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

Measure neutron capture cross sections  $^{239}\text{Pu}$  and  $^{241}\text{Pu}$  for neutron energies less than 200 keV, contingent on obtaining the targets.

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

LBNL – LBNL has recently initiated a new program to use surrogate reactions to deduce reaction cross sections which are of importance to Advanced Fuel Cycle (AFC) programmatic needs (a national priority). This is collaboration between the nuclear structure and nuclear reaction groups at LBNL and outside groups at LLNL and the University of Richmond that is currently funded from outside of the DOE Data Program. The LBNL group is leading a series of benchmarking experiments to test the applicability and accuracy of these new techniques for deducing cross sections of importance to AFC and the s-process. It is anticipated that this activity will provide nuclear reaction data measurements of importance to the Data Program. LBNL is collaborating with the Budapest Reactor Centre in the measurement, using isotopically-enriched targets, of selected thermal  $(n,\gamma)$  cross section data to supplement earlier elemental target measurements from which important information was either lacking (e.g., data from low-abundance isotopes) or discrepant.

#### LBNL planned activities

Measure thermal  $(n,\gamma)$  cross sections using guided neutron beam in collaboration with the Budapest Research Centre.

Lead series of surrogate-reaction benchmarking measurements at the LBNL 88" cyclotron.

#### LLNL Planned Activities

Neutron induced reaction measurements on one or more isomer targets.

Perform surrogate  $(n,n')$ ,  $(n,2n)$ ,  $(n,\gamma)$  and  $(n,f)$  measurements on several nuclei with programmatic and/or astrophysical importance. (funded from other sources)

Perform neutron capture measurements with DANCE array at LANSCE in collaboration with LANL. (funded from other sources)



Perform fission cross-section measurements with the lead slowing down spectrometer at LANSCE in collaboration with LANL. (funded from other sources)

## G. Evaluation of Data Needed for Astrophysics

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

### ANL Planned Activities

ANL will continue working in the area of data needs for nuclear astrophysics. The main emphasis will be on improving the data for cosmo-chronometers in the rare-earth region -  $^{176}\text{Lu}$ ,  $^{180}\text{Ta}$  and  $^{186}\text{Re}$ .

Compile and evaluate nuclear structure and decay data for neutron-rich fission fragments, produced at the CARIBU facility (ANL), that are of relevance to r-process modeling.

### BNL Planned Activities

Produce uncertainties for Maxwellian averages of neutron capture cross sections in the energy region of interest for nuclear astrophysics.

LANL: Participate in the USNDP effort to develop high-quality data for astrophysics calculations of nucleosynthesis. Make new calculated and evaluated results available to the wider astrophysics research community via the USNDP Astrophysics Task Force.

### LANL Planned Activities

Improve neutron capture models to provide neutron capture rates off-stability to s and r-process hydro-dynamics simulations.

Provide beta-delayed fission rates in the astrophysical stellar environment, based on the macroscopic-microscopic nuclear mass model.

McMaster: The evaluation of nuclear astrophysics data is expected to complement the on-going experimental program of measurements of radiative capture cross sections and particle-transfer experiments using radioactive ion beam facilities at TRIUMF, NSCL, RIKEN and ANL.

### McMaster Planned Activities

Specific reactions planned for evaluation in FY11:  $^{29}\text{P}(p,\gamma)^{30}\text{S}$  and  $^{30}\text{P}(p,\gamma)^{31}\text{S}$ .

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

### ORNL Planned Activities

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

Extract spectroscopic information (excitation energies, spectroscopic factors, spins, parities, ANCs) on nuclei near the N=82 closed shell –  $^{131}\text{Sn}$ ,  $^{133}\text{Sn}$ ,  $^{135}\text{Te}$  - from transfer reaction measurements on radioactive Sn and Te nuclei. This information is important for modeling the r-process in supernovae.

## H. Reaction Data for FRIB Target Design

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

### LANL Planned Activities

We aim to maintain important collaboration connections with the FRIB community because of its importance in nuclear science, but effort is limited because of budget restrictions. However, we will continue to maintain a presence in the FRIB planning community via participation in FRIB meetings and workshops.

# USNDP Staffing table FY2011

	ANL		BNL			LANL		LBNL	LLNL	MCMMASTER		NIST		ORNL				TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	PhD P	PhD P	PhD P	PhD T	PhD P	GS	PhD P	PhD T	T/A	GS	PhD P	PhD T	T/A	
<b>I. NNDC Facility Operation</b>	0.00	0.00	0.85	0.00	1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.00
Management			0.85																		0.85
Secretarial Admin.Support					0.75																0.75
Library																					0.00
Computer Operations					0.40																0.40
<b>II. Coordination</b>	0.05	0.00	0.40	0.00	0.00	0.40	0.00	0.20	0.01	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00	1.11
National Coordination			0.30			0.10		0.10	0.01					0.05							0.56
International Coordination	0.05		0.10			0.30		0.10													0.55
<b>III. Nuclear Physics Databases</b>	0.00	0.00	1.35	0.50	1.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.90
Nucl. Science References, NSR			0.15		0.75																0.90
Exper. Nucl. Structure Data, XUNDL			0.05																		0.05
Eval. Nucl. Structure Data, ENSDF			0.20																		0.20
Numerical Nucl. Data, NuDat			0.30																		0.30
Reaction Data Bibliography, CINDA																					0.00
Experimental Reaction Data, CSISRS																					0.00
Evaluated Nuclear Data File, ENDF			0.10	0.40																	0.50
Database Software Maintenance			0.30	0.10	0.30																0.70
Future Database System Develop.			0.25																		0.25
<b>IV. Information Dissemination</b>	0.00	0.00	0.70	0.05	1.30	0.05	0.00	0.10	0.00	0.00	0.00	0.00	0.00	0.15	0.00	0.00	1.00	0.00	0.00	0.59	3.94
Nuclear Data Sheets			0.35	0.05	0.90																1.30
Customer Services			0.15		0.40																0.55
Web Development & Maintenance			0.20			0.05		0.10						0.15			1.00			0.59	2.09
	ANL		BNL			LANL		LBNL	LLNL	MCMMASTER		NIST		ORNL				TUNL			Sum
	PhD P	PhD T	PhD P	PhD T	T/A	PhD P	PhD T	PhD P	PhD P	PhD P	PhD T	PhD P	GS	PhD P	PhD T	T/A	GS	PhD P	PhD T	T/A	
<b>V. Nuclear Structure Physics</b>	0.90	0.00	2.20	2.25	0.00	0.10	0.00	1.50	0.00	0.60	0.80	0.00	0.00	0.40	0.00	0.00	0.00	0.83	0.59	0.15	10.32
NSR Abstract Preparation			0.79	0.20						0.10											1.09
Compilation of Exper. Structure Data	0.05									0.20								0.10			0.35
Eval. of Masses & Nuclides for ENSDF	0.65		1.26	2.05				1.00		0.30	0.80			0.40				0.33	0.25	0.15	7.19
Ground & Metastable State Properties			0.10																		0.10
Radioactive Decay Data Evaluation	0.10																				0.10
Thermal Capture Gamma Data Eval.								0.30													0.30
Light Mass Eval. for Nucl. Physics A						0.10												0.40	0.34		0.84
Nuclear Structure Data Measurement	0.10							0.20													0.30

ENSDF Evaluation Support Codes			0.05																		0.05
VI. Nuclear Reaction Physics	0.05	0.00	1.10	2.10	0.20	1.35	0.10	0.20	0.29	0.00	0.20	0.20	0.49	0.60	0.00	0.00	0.00	0.00	0.00	0.00	6.88
Experimental Data Compilation				0.40																	0.40
ENDF Manuals and Documentation				0.15																	0.15
ENDF Evaluations			1.00	0.95	0.20	0.25			0.29												2.69
Nuclear Reaction Standards						0.10					0.20	0.49									0.79
Nuclear Model Development				0.60		0.40	0.10														1.10
Nucl. Reaction Data Measurements						0.30		0.20													0.50
Astrophysics Nucl. Data	0.05		0.10			0.30				0.20			0.60								1.25
DOE-SC Nucl. Data Funded Staff	1.00	0.00	6.60	4.90	3.70	1.90	0.10	2.00	0.30	0.60	1.00	0.20	0.49	1.20	0.00	0.00	1.00	0.83	0.59	0.74	27.15
Staff Supported by Other Funds	0.00	2.30	0.90	0.00	0.00	12.00	0.00	0.50	7.90	0.40	0.00	2.80	0.00	0.35	0.00	0.50	1.00	0.00	0.00	0.00	28.65
<b>TOTAL STAFF</b>	<b>1.00</b>	<b>2.30</b>	<b>7.50</b>	<b>4.90</b>	<b>3.70</b>	<b>13.90</b>	<b>0.10</b>	<b>2.50</b>	<b>8.20</b>	<b>1.00</b>	<b>1.00</b>	<b>3.00</b>	<b>0.49</b>	<b>1.55</b>	<b>0.00</b>	<b>0.50</b>	<b>2.00</b>	<b>0.83</b>	<b>0.59</b>	<b>0.74</b>	<b>55.80</b>

PhD P: PhD Permanent,  
 PhD T: PhD Temporary,  
 T/A: Technical and administrative,  
 GS: Graduate student.