Isotopes Project

LAWRENCE BERKELEY NATIONAL LABORATORY

E.B. Norman (Project Leader)
C.M. Baglin, E. Browne, S.Y. Chu (to 5/00), R.B. Firestone.

Report prepared for the December 2000 IAEA Advisory Group Meeting on Coordination of the International Network of Nuclear Structure and Decay Data Evaluators. This report covers the period from December 1998 to November 2000.

A. NUCLEAR STRUCTURE AND DECAY EVALUATION

Mass Chain Responsibility:
A = 59, 81, 83, 90-93, 166-187, 189, 191-193, 206, 210-212, 215, 219, 223, 227, >266

PERSONNEL

The group's data evaluation effort has ranged from 2.0 to 2.5 FTE during the period covered by this report.

In addition, two guests spent leave with the Isotopes Project: Professor Shiu-Chin (Alice) Wu (Taiwan) (to August '99 and Jul.–Sept. 2000) and Dr. Jean Blachot (October '99). Dr. Wu evaluated A=46 and A=83, and Dr. Blachot assisted with the preparation of ENSDF files for A=21-29 based on the 1998 update evaluation of A=21-44 by Peter Endt.

Ongoing international collaborations exist with Gabor Molnar (Hungary) and Zhou Chunmei (China) (preparation of evaluated (n,γ) data), and with French, German, British, US, Spanish and Russian scientists participating in a radioactive decay data evaluation project.

The group is indebted to Jean Zipkin (also a guest of LBNL) for data entry of many (n,γ) and A=21-39 datasets.

EVALUATION/COMPILATION ACCOMPLISHMENTS

- **Mass Chains**
  Submitted: 46, 83, 92, 167, 169, 174, 215, 219, 223, 227, 231, A>266
  Published: 91, 167, 174, 206, A=267-293

- **Complete Nuclide Evaluations**

  The nuclide evaluations (listed below) were undertaken because of their 'priority' status (those marked with *), the existence of significant, newly-published information which could be expeditiously included in ENSDF (thus improving the timeliness of the file), the need to revise α-decay parent or daughter information (for internal consistency of the file), or the absence of a published evaluation for the nuclide.

  - Published in Nuclear Data Sheets:
    ^{170}Pt, ^{181}Pt, ^{181}Au, ^{181}Hg, ^{186}W, ^{187}Tl*, ^{183}Hg*.
  - Unpublished; reviewed and added to ENSDF:
    ^{81}Zr, ^{166}W*, ^{168}Tb/Dy, ^{170}Os, ^{170}W, ^{170}Yb, ^{171}Os, ^{171}Ir, ^{171}Pt, ^{171}Au, ^{179}Ta, ^{183}Au, ^{186}Hf, ^{186}Ta, ^{187}Pb, ^{191}Po, ^{191}Bi.
  - Submitted: ^{91}Kr, ^{91}Sr, ^{91}Zr.

    * Priority nuclide

- **Decay Data Evaluation Project (DDEP) Participation**

  DDEP Nuclides Evaluated:
  ^{44}Sc, ^{60}Fe.

  DDEP Evaluator Training:
  LBNL organized (with INEEL) a special two-week training session at LBNL for non-US evaluators who had recently joined the Decay Data Evaluation Project.

  ENSDF-Coding of non-US DDEP Evaluations:
  "Decay" and "Adopted" datasets were prepared for inclusion in ENSDF for ^{68}Ge, ^{68}Ga, ^{125}I, ^{141}Ce.

- **Continuation of IAEA CRP to develop an (n,γ) Database:**

  This 3-year IAEA-sponsored Coordinated Research Project is to be completed in 2002. It aims to produce a database for use in neutron-induced prompt gamma-ray activation (PGAA) analysis. Thermal and cold neutron capture isotopic data are being evaluated in China and the US to obtain best values for gamma-ray yields per 100 neutron captures. CRP participants in Hungary and the US will then combine those data (in ENSDF format) with measured elemental data (from Hungary and elsewhere) to produce recommended values for prompt-gamma energies and intensities and other useful information. The database will be tested at several neutron facilities.
  Evaluated (thermal n,γ) data sets not already in ENSDF will be made available to NNDC for inclusion in ENSDF.

- **ENSDF Coding of non-US Evaluation:**
  (1998 Update for A=21-44 by P. Endt)
  All chains from A=21 to A=39 have been submitted for inclusion in ENSDF and are currently in review. For each chain:
  - The updated information from Endt (1998) was added to the "Adopted Levels, Gammas" datasets.

- The existing decay datasets in ENSDF were updated from the literature and new datasets were created as needed.
- Reaction datasets were created from material given in Endt's evaluation (this information had not been in ENSDF).
- Evaluated (n,γ) datasets (from the IAEA CRP activity) were added.

- **Reviews of Evaluations**
  Mass Chains: A=52, 107, 109, 121
  DDEP Nuclides: ^{85}Sr, ^{166}Ho, ^{166m}Ho, ^{241}Am.

- **Compilation**

Approximately 7 datasets were prepared and included in the XUNDL database.

B. NUCLEAR DATA DISSEMINATION

PERSONNEL

The group's data dissemination effort has ranged from 1.5 to 0.5 FTE during the period covered by this report.
Approximately 1.0 FTE additional effort has been provided by students visiting from EVITech, Finland and Lund University, Sweden.

DISSEMINATION ACTIVITIES

1. Isotope Explorer

Isotope Explorer 3.0 was released for Internet use in 1999 and can be accessed at http://ie.lbl.gov/ensdf/. This platform-independent version of the program can download ENSDF data from the Isotopes Project Server. The ENSDF format data can be displayed as level scheme drawings and Nuclear Data Sheet style tables. The data can be selected by level properties (E, JPI, half-life), gamma-ray coincidence relationships, or nuclear structure and band assignments. Tables can be displayed with comments included. Isotope Explorer 3.0 can also retrieve the keyword abstracts for the references from the WWW.

Most ENSDF retrieval is still done using the more versatile Isotope Explorer 2.0. A tour of its capabilities, and the user manual can be downloaded from the WWW at http://ie.lbl.gov/isoexpl/isoexpl.htm. In addition, it is available on the *Table of Isotopes* CD-ROM complete with the ENSDF and NSR databases. There are over 3200 registered users, and about 1600 users express interest in this program each month. Isotope Explorer users downloaded ENSDF datasets for about 450,000 isotopes during the past year. Month-to-month usage fluctuates substantially, possibly coinciding with preparation for major meetings. Usage since 1996 is summarized in Figure 1.

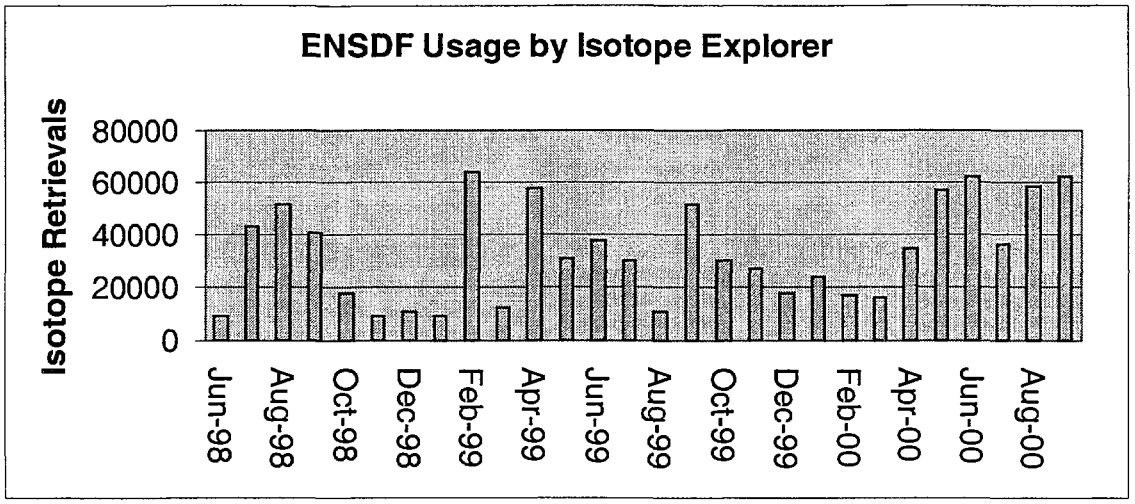

Figure 1. Usage of Isotope Explorer 6/98 – 9/00

2. LBNL/Lund WWW Table of Radioactive Isotopes

The LBNL/Lund Table of Radioactive Isotopes on the WWW may be accessed at http://nucleardata.nuclear.lu.se/Database/toi. Gamma-ray and alpha-particle data from ENSDF and the *Table of Isotopes* can be searched by combination of energy and nuclide range. Additional information, including x-ray, Auger, and continuous radiations, was added in 1999. This service has been provided for about 6 months with usage rising rapidly. Nearly 220,000 data requests were received by the Table of Radioactive Isotopes web site in 1999.

3. LBNL/Lund Isotope Explorer NSR Server

The LBNL/Lund Isotope Explorer NSR Server on the WWW supersedes the 1996 Nuclear Data and References CD-ROM. This information can be accessed from the LBNL server at http://128.3.5.61:6023/welcome.htm. References from the Nuclear Science Reference file can be selected using any combination of author, nuclide, keynumber, publication date, reaction, keyword, and data type. The Isotopes Project or Lund server selects references satisfying the selection criteria and the keyword abstracts are returned to the user and displayed. Currently about 3000 reference requests are processed each month.

4. World Wide Web

The Isotopes Project has continued to update and improve its WWW home pages. Linked home pages for access to data from the *Table of Isotopes*, nuclear astrophysics, high-spin nuclear structure, radioactive decay, atomic masses, neutron capture gammas, fission, and other topics have been developed. These home pages can be accessed from the WWW at http://ie.lbl.gov/toi.html. Data are provided in text, Postscript, and Portable Document Format. About 10,000 separate users per month submitted over 2.5 million data requests last year. The usage since 1998 is summarized in Figure 2.

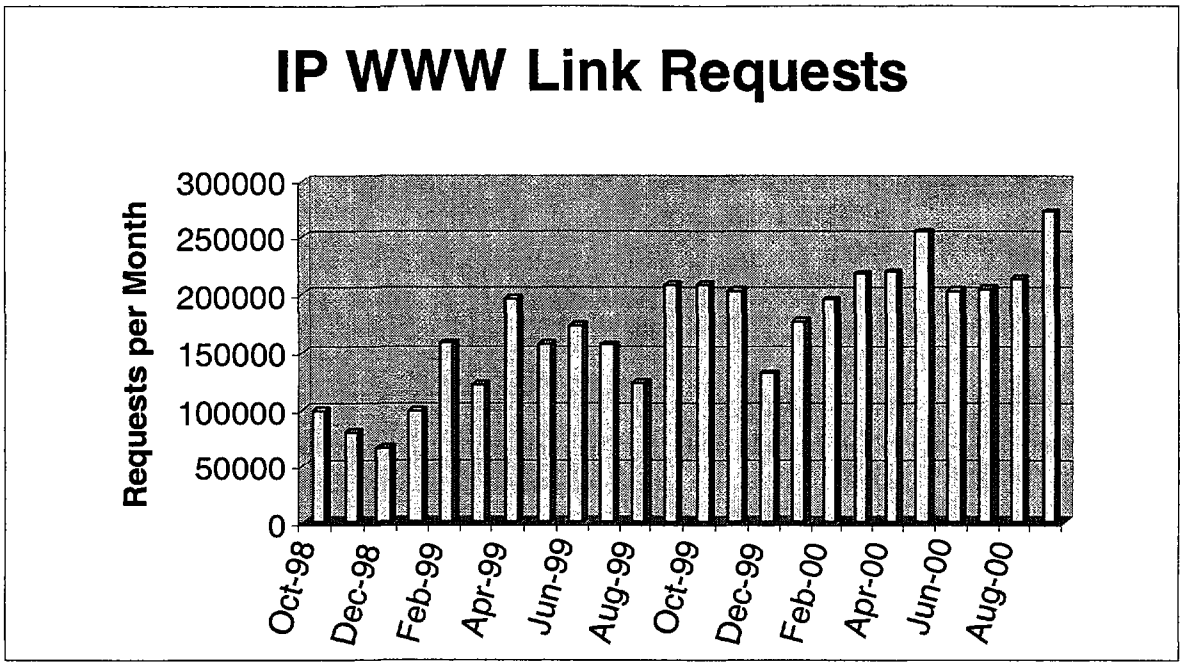

Figure 2. Usage of Isotopes Project WWW sites 10/98 – 9/00

- **Nuclear Astrophysics Home Page** (~750 users/mo.)

The Nuclear Astrophysics home page at http://ie.lbl.gov/astro.html includes a comprehensive bibliography of interest to researchers in the nuclear astrophysics community. Links are provided to those references or data that are available in electronic form. Stellar nucleosynthesis data from Hoffman and Woosley, Thielemann *et al.*, and others, are made available from this home page in both text and Postscript format.

- **High-Spin and Nuclear Structure Home Page** (~500 users/mo.)

An electronic edition of the *Table of Superdeformed Nuclear Bands and Fission Isomers* is available from the High-Spin and Nuclear Structure home page at http://ie.lbl.gov/hspin.html. This home page also provides reference lists and links to information of interest to nuclear structure researchers.

- **Decay Data Home Page** (~800 users/mo.)

The decay data home page at http://ie.lbl.gov/decay.html provides summary mass-chain decay schemes and nuclear charts from the *Table of Isotopes*; energy-ordered tables of gamma rays from radioactive decay; alpha and gamma energy and intensity standards; data from the 1986 edition of the *Table of Radioactive Isotopes*; and links to information of interest to users of decay data.

- **Atomic Masses Home Page** (~1100 users/mo.)

The atomic mass home page at http://ie.lbl.gov/toimass.html provides access to the experimental atomic mass tables of Audi et al and 14 calculated mass tables.

- **Thermal Neutron Capture Home Page** (~700 users/mo.)

The Thermal Neutron Capture home page at http://ie.lbl.gov/ng.html was developed jointly by the Isotopes Project and the Institute for Isotope and Surface Chemistry, Hungary. Lone *et al.* gamma-ray yield data, ENSDF (n,γ) E=thermal data for A>44, LBNL/Hungary (n,γ) compilation for A<45, isotopic abundances, and thermal neutron cross sections are available from this site.

- **Fission Home Page** (~700 users/mo.)

The Fission home page at http://ie.lbl.gov/fission.html contains fission yields compiled by England and Rider and spontaneous fission data from ENSDF.

- **Education Home Page** (~3600 users/mo.)

The Education home page at http://ie.lbl.gov/education/isotopes.htm serves students of all ages from around the world with information on isotopes and an animated glossary of nuclear and astrophysical terms. This page is incorporated into the science curriculum of many schools and we receive considerable feedback from young people.

- **Other Data Pages** (~2600 users/mo.)

Additional home pages for atomic data, elemental data, education, nuclear moments, interaction of radiation with matter and other topics are available.

5. Other Dissemination Activities

The Isotopes Project is a participant in the USNDP Dissemination Collaboration effort to produce a single web interface to the ENSDF, XUNDL, NSR, and other databases. The group is also developing the web interface to the Prompt Gamma-ray Activation Analysis database in collaboration with the IAEA Coordinated Research Project for the Development of a Database for Prompt Gamma-ray Activation Analysis.

C. PUBLICATIONS and INVITED TALKS

Mass Chain or Nuclide Evaluations

Nuclear Data Sheets for ^{170}Lu, Coral M. Baglin, Nuclear Data Sheets **85**, 575 (1998).

Nuclear Data Sheets for ^{179}Ir, Coral M. Baglin, Nuclear Data Sheets **85**, 595 (1998).

Nuclear Data Sheets for A=91, Coral M. Baglin, Nuclear Data Sheets **86**, 1 (1999).

Nuclear Data Sheets for ^{170}Pt, Coral M. Baglin, Nuclear Data Sheets **86**, 449 (1999).

Nuclear Data Sheets for ^{186}W, Coral M. Baglin, Nuclear Data Sheets **86**, 455 (1999).

Nuclear Data Sheets for ^{187}Tl, Coral M. Baglin, Nuclear Data Sheets **86**, 487 (1999).

"Table de Radionucléides", M.-M. Bé, N. Coursol, B. Duchemin, J. Lamé, C. Morillon, F. Piton, E. Browne, V. Chechev, R. Helmer and E. Schönfeld, Document CEA-ISBN 2 7272 0200 8 (1999); CD-ROM "Nucléide", the computerized form of "Table de Radionucléides", version: 1-98, 19/12/98, CEA Laboratoire Primaire des Rayonnements Ionisants.

"Table of Radionuclides: Comments on Evaluations", M.-M. Bé, B. Duchemin, E. Browne, S.-C. Wu, V. Chechev, R. Helmer and E. Schönfeld, Document CEA-ISBN 2 7272 0211 3 (1999).

Nuclear Data Sheets for A=174, E. Browne and J. Huo, Nuclear Data Sheets **87**, 15 (1999).

Nuclear Data Sheets for ^{181}Pt, Coral M. Baglin, Nuclear Data Sheets **87**, 197 (1999).

Nuclear Data Sheets for ^{181}Au, Coral M. Baglin, Nuclear Data Sheets **87**, 225 (1999).

Nuclear Data Sheets for ^{181}Hg, Coral M. Baglin, Nuclear Data Sheets **87**, 239 (1999).

Nuclear Data Sheets for A=206, E. Browne, Nuclear Data Sheets **88**, 29 (1999).

Nuclear Data Sheets for A=267-293, R.B. Firestone and J. Gilat, Nuclear Data Sheets **90**, 293 (2000).

Nuclear Data Sheets for A=167, Coral M. Baglin, Nuclear Data Sheets **90**, 431 (2000).

Nuclear Data Sheets for ^{183}Hg, Coral M. Baglin, Nuclear Data Sheets **91**, 117 (2000).

Outreach Talks on Nuclear Data

"Data Dissemination Activities of the U.S. Nuclear Data Program", Richard B. Firestone, Bull. Am. Phys. Soc. **44**, 263, FB11.3 (Atlanta, 1999).

"The Decay Data Evaluation Project", E. Browne, Bull. Am. Phys. Soc. **44,** Paper CE.14 (Asilomar, 1999).

"WWW Table of Radioactive Isotopes", R.B. Firestone, L.P. Ekstrom, S.Y.F. Chu, Bull. Am. Phys. Soc. **44**, Paper CE.13 (Asilomar, 1999).

"Update on the U.S. Nuclear Structure and Decay Data Evaluation Program", Coral M. Baglin, Bull. Am. Phys. Soc. **45**, No. 2, 30, B14.7 (Long Beach, 2000).

Other Talks/Publications Related to Nuclear Data

"A New Gamma-Ray Spectrum Catalog for PGAA", Z. Rezavy, G.L. Molnar, T. Belgya and R.B. Firestone, Proc. 10th International Conference on Modern Trends in Activation Analysis (MTAA-10), 19-23 April 1999, Bethesda MD (invited paper).

Table of Isotopes, 8th Edition, 1999 CD-ROM Update, John Wiley & Sons, Inc., NY, R.B. Firestone, Coral M. Baglin, S.Y. Frank Chu (July 1999).

"IAEA Coordinated Research Project on the Development of a Database for Prompt Gamma-Ray Neutron Activation Analysis: Progress Report", Richard B. Firestone in **INDC(NDS)-411**, 45 (2000).

"The New Prompt Gamma-ray Catalog for PGAA", G.L. Molnar, Zs. Revay, T. Belgya and R. B. Firestone, Proc. 4th Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRMMA'99), 3-7 October 1999, Raleigh NC; Appl. Radiat. Isot. **53**, 527 (2000)

"Nuclear Structure and Decay Data in the Electronic Age", R.B. Firestone, J. Radioanal. Nucl. Chem. **243**, 77 (2000).

"Application of Prompt Gamma Activation Analysis (PGAA) to Inorganic Photochromic Host Materials", D.L. Perry, R. Gatti, R.B. Firestone, G.L. Molnar, Z. Rezavy and Z. Kasztovszky, Am. Chem. Soc. National Meeting, 26-30 March 2000, San Francisco CA, Paper INOR590.

"Application of Prompt Gamma Activation Analysis (PGAA) to Ocean Floor Geothermal Vent-Produced Metal Sulphides", D.L. Perry, R. Gatti, R.B. Firestone, P. Wilde, G.L. Molnar, Z. Rezavy and Z. Kasztovszky, Am. Chem. Soc. National Meeting, 26-30 March 2000, San Francisco CA, Paper GEOC83.

"The Nuclear Science Database: 60 Years of Community Experience", keynote address to the HUGO Mutation Database Initiative Meeting, 9 April 2000, Vancouver, Canada.

"Databases: Science's Neglected Legacy", S.M. Maurer, R.B. Firestone and C.R. Scriver, Nature **405**, 116 (2000).

Other Nuclear Science Publications Involving Isotopes Project Personnel:

Collective Band Structures in Neutron-Rich ^{107,109}Ru Nuclei, S.-Z. Zhu, C.-Y. Gan, ..., S.Y. Chu, *et al.*, Chin. Phys. Lett. **15**, 793 (1998).

Octupole Correlations in Neutron-Rich ^{145,147}La Nuclei: Coriolis-limit-coupling bands with aligned h11/2 Proton, S.Z. Zhu, J.H. Hamilton, ..., J. Gilat, ..., S.Y. Chu, *et al.*, Phys. Rev. **C59**, 1316 (1999).

Octupole Deformation Bands of $\pi h_{11/2}$ in Neutron-Rich ^{145,147}La Nuclei, ... , S.Y. Chu, *et al.*, Chin. Phys. Lett. **16**, 169 (1999).

Cosmic Ray Half-Life of ^{56}Ni, K. Zaerpoor, Y.D. Chan, M.R. Dragowsky, M.C.P. Isaac, K.S. Krane, R.-M, Larimer, A.O. Macchiavelli, R.W. MacLeod and E.B. Norman, Phys. Rev. **C59**, 3393 (1999).

Octupole Correlations in Neutron-Rich ^{143,145}Ba and a Type of Superdeformed Band in ^{145}Ba, S.J. Zhu, ..., S.Y. Chu, *et al.*, Phys. Rev. **C60**, 051304 (1999).

Octupole Deformation and Signature Inversion in ^{145}Ba, S.J. Zhu, ..., S.Y. Chu, Chin. Phys. Lett. **16**, 715 (1999).

Systematic Investigation of Hexadecapole Collectivity in Even-even Nuclei, R.K. Sheline, B. Singh, P.C. Sood, S.Y. Chu, Czech. J. Phys. **49**, 1047 (1999).

Identification of Levels in Neutron-Rich ^{145,147}Ce Nuclei, M. Sakhaee, ..., S.Y. Chu, *et al.*, Phys. Rev. **C60**, 067303 (1999).

High-Spin States in Neutron-Rich Even-Even Pd Isotopes, K. Butler-Moore, ..., S.Y. Chu, *et al.*, J. Phys. (London) **G25**, 2253 (1999).

Quadrupole-Octupole Coupled States in ^{144}Nd, S.J. Robinson, M.M. Hindi ...E.B. Norman, *et al.*, Phys. Lett. **465B**, 61 (1999).

Internal Bremsstrahlung Endpoint of ^{54}Mn, M.M. Hindi, R.-M. Larimer, E.B. Norman and G.R. Rech, Phys. Rev. **C61**, 55501 (2000).

Measurement of Excitation Functions in the Reaction ^{197}Au(^{11}C,xn)$^{208-x}$At Using a Radioactive ^{11}C Beam, R. Joosten, J. Powell, F.Q. Guo, P.E. Haustein, R.-M. Larimer, M.A. McMahon, E.B. Norman, et al., Phys. Rev. Lett. **84**, 5066 (2000).