Isotopes Project

LAWRENCE BERKELEY NATIONAL LABORATORY

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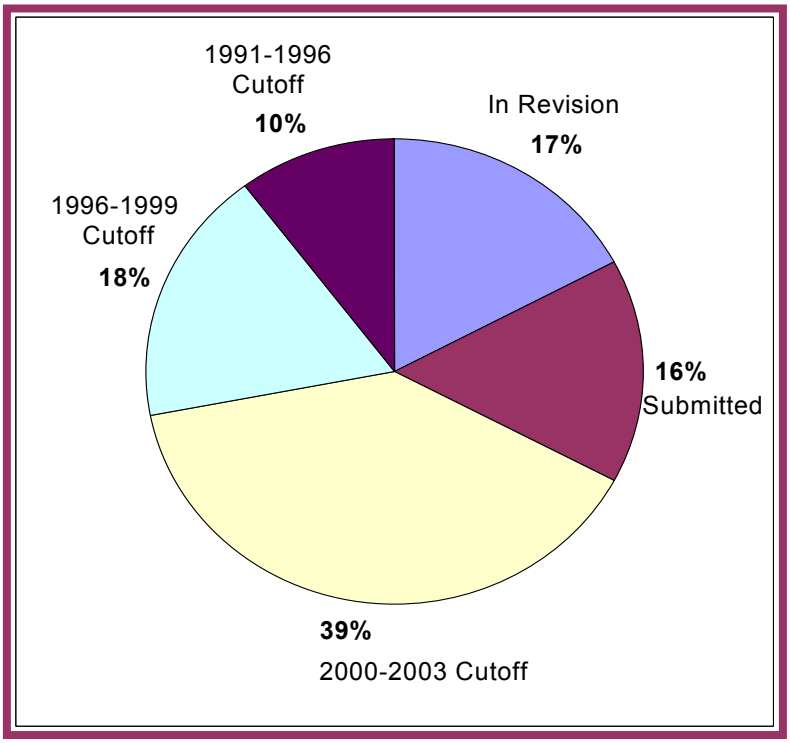
Report prepared for the USNDP Annual Meeting, November 6-7, 2003 at Brookhaven National Lab.

A. NUCLEAR DATA EVALUATION ACTIVITIES
April 2002 through September 2003

MASS CHAIN RESPONSIBILITY, STATUS (~550 nuclides)

Permanent: A = 21-30, 59, 81, 83, 90-93, 166-193 (except 188, 190), 210-212, 215, 219, 223, 227, 231.
Temporary: A = 235, 239.

The literature cutoff dates for the ~550 permanently-assigned nuclides are summarized below.
(Both temporarily-assigned chains have been evaluated and were published in Spring 2003.)



PERSONNEL (EVALUATION)

Isotopes Project personnel currently involved in data evaluation/compilation are as follows:

C. Baglin	0.70 FTE	E. Browne	0.43 FTE
S. Basunia	0.50 FTE (since April '03)	R. Firestone	0.55 FTE

In addition, one guest routinely spends her leave with the Isotopes Project: Professor Shiu Chin (Alice) Wu (Tsing-Hua Univ., Taiwan) evaluated A=180 during this time.

International collaborations continued with Gabor Molnár (Hungary) and Zhou Chunmei (China) (preparation of evaluated (n,γ) data), and with French, German, British, US, Spanish, Brazilian and Russian scientists participating in the radioactive Decay Data Evaluation Project (DDEP). Short-term visitors to the Isotopes Project include V. Vanin (Brazil, collaboration on A=193), Z. Révay and L. Szentmiklosi (Hungary, (n,γ) data), T. Kibédi (Australia, collaboration on A=172).

EVALUATION ACCOMPLISHMENTS (since April 2002 Meeting)

- **Mass Chain Evaluations:**
  - Submitted: 21, 168, 179, 180, 186, 210, 211 (81 nuclides, including 8 priority nuclides).
  - Published: 170, 171, 186, 189, 210, 235, 239.

- **Complete Nuclide Evaluations:**
  The nuclide evaluations (listed below) were undertaken because of their 'priority' status (those marked with *), because of the existence of significant newly-published information that could be expeditiously included in ENSDF (thus improving the timeliness of the file), because of the need to revise α-decay parent or daughter information (for internal consistency of the file), or because of the absence of a published evaluation for the nuclide.
  - Unpublished (reviewed and added to ENSDF): ^{59}Zn, ^{92}Sr, ^{173}Au, ^{173}Hg, ^{183}Pb, ^{184}Au*, ^{184}Pb (7 nuclides).

- **DDEP Evaluation:**
  - Coordinated DDEP international collaboration.
  - Evaluated ^{227}Th, ^{66}Ga
  - Reviewed ^{123m}Te, ^{140}Ba, ^{140}La, ^{85}Kr, ^{66}Ga, ^{33}P, ^{18}F, ^{11}C (8 radionuclides).

- **Evaluated Gamma-ray Activation File (EGAF)**
  Evaluation of thermal neutron capture gamma-ray data for 262 isotopes has been completed as part of an IAEA-sponsored Coordinated Research Project begun in November 1999 to develop a Database of Prompt Gamma-rays from Slow Neutron Capture for Elemental Analysis. A new database, the Evaluated Gamma-ray Activation File (EGAF), has been produced containing ≈35,000 prompt and decay gamma-ray energies and thermal neutron cross sections for isotopes of all stable elements from hydrogen to uranium. These adopted data are derived from isotopic capture gamma-ray energy and intensity data in ENSDF, which were updated from the current literature, and combined with elemental energy and absolute cross section measurements from the Budapest Reactor. In addition, total radiative neutron capture cross sections have been deduced for most isotopes from the intensity balance through the level scheme. Also, new precise neutron separation energies have been determined by least-squares fits of the primary gamma-ray energies to the level schemes. These data will be published as an IAEA TECDOC with CD-ROM (in press) and in the *Handbook of Prompt Gamma-ray Activation Analysis* (Kluwer). The

EGAF database will be disseminated by the IAEA on the WWW in tabular and ENSDF formats. An IAEA-PGAA Database Viewer has also been provided for interactive searching of the database. The ENSDF format version of EGAF will be sent to the NNDC following its official release by the IAEA. EGAF neutron separation energy data have also been provided to the Atomic Mass Data Center (ORSAY) for inclusion in the next mass evaluation.

In conjunction with this evaluation effort, Isotopes Project personnel collaborated in measurements of radiative thermal neutron cross-sections, performed using the cold neutron beam at the Budapest Reactor. The cross sections for two isotopes important for applications, ^{6}Li and ^{12}C, were found to differ by several standard deviations from previously accepted values, the first precise measurement of the ^{11}B cross section (11.5(3) mb) has been accomplished, and measurements of the tellurium isotopic cross sections have been submitted for publication.

- **Reviews of Evaluations:**
  Mass Chains: A= 177, 190, 244.

B. NUCLEAR DATA DISSEMINATION ACTIVITIES
April 2002 through September 2003

DISSEMINATION RESPONSIBILITY, STATUS

- **IAEA-PGAA Database Viewer**

As part of the IAEA CRP for the *Development of a Database for Prompt Gamma-ray Neutron Activation Analysis* we have developed a PGAA Database Viewer. The viewer supports the retrieval of thermal neutron capture gamma-ray data by element or isotope. The database may also be searched by A, Z, energy, cross section, or k_0 value. Histograms of gamma-ray energies and cross sections for elements or isotopes are also provided. The PGAA Database Viewer will be disseminated from the IAEA website in 2004.

- **LBNL Nuclear Data Server**

The Isotopes Project developed and supports Isotope Explorer 2 (C++, Windows), Isotope Explorer 3 (Java, HTML), and the WWW Table of Radioactive Isotopes. The group also supports WWW dissemination home pages for Neutron Capture, Spontaneous Fission, Radioactive Decay, Nuclear Structure, Atomic Masses, Education, Nuclear Structure Systematics and other topics. The home page for Nuclear Astrophysics data is no longer updated, and support for this effort is now the responsibility of R. Hoffman, T. Rauscher, A. Heger, and S. Woosley at LLNL who maintain a *Reaction Rates for Stellar Nucleosynthesis* home page at http://www-pat.llnl.gov/Research/RRSN/.

The demand for these services has increased substantially each year. In 2002, the Isotopes Project served over 154,735 distinct hosts who downloaded nearly 338 GB of data, up dramatically from 117,755 distinct hosts who downloaded 84 Gb in 2001. A comparison of 2001 through September 2003 usage is given in Figure 1. ENSDF file usage (.ENS file extensions) has risen dramatically from 272,739 in 2001 to 4,187,095 in the first nine months of 2003. Most ENSDF usage is by Isotope Explorer 2 users who download ENSDF data directly from our server without accessing any WebPages. About 3500-4000 people download Isotope Explorer 2 software annually.

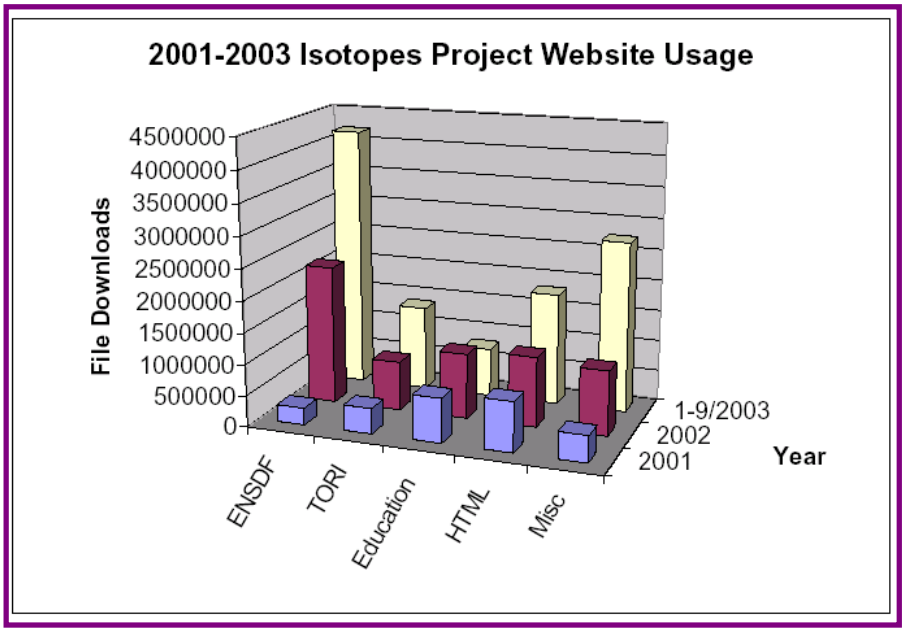


Figure 1. Distribution of Isotopes Project server data retrievals in 2001-9/2003. This information was compiled using Analog 5.22 log file analyzer software. The statistics for usage of NSR, PS, PDF, TXT, Java applets and other data files are combined under the miscellaneous column.

PERSONNEL

Isotopes Project personnel involved in data dissemination are as follows:
R. Firestone 0.25 FTE.

C. PUBLICATIONS (since April '02 Meeting)

- **Nuclear Data Evaluations**

Nuclear Data Sheets for A=171, Coral M. Baglin, Nuclear Data Sheets **96**, 399-610 (2002).

Nuclear Data Sheets for A=170, Coral M. Baglin, Nuclear Data Sheets **96**, 611-873 (2002)

Table of Superdeformed Nuclear Bands and Fission Isomers, B. Singh, R. Zywina, R.B. Firestone, Nuclear Data Sheets **97**, 241 (2002).

Nuclear Data Sheets for A=235, 239, E. Browne, Nuclear Data Sheets **98**, 665 (2003).

Nuclear Data Sheets for A=186, Coral M. Baglin, Nuclear Data Sheets **99**, 1 (2003).

Nuclear Data Sheets for A=210, E Browne, Nuclear Data Sheets **99**, 649 (2003).

Nuclear Data Sheets for A=189, S.-C. Wu and H. Niu, Nuclear Data Sheets **100**, 1 (2003).

- **Other research Activities:**

a) Journal Publications & Reports

Prompt Gamma Activation Analysis: An Old Technique Made New, J. English, R. Firestone, D. Perry, K-N. Leung, J. Reijonen, G. Garabedian, B. Bandong, G. Molnár, and Zs. Révay, Accelerator Radiation Safety Newsletter 11 (2002).

Response to the Comments by J.R. Southon and R.E. Taylor on Terrestrial Evidence of a Nuclear Catastrophe in Paleoindian Times, R.B. Firestone, Mammoth Trumpet **17**, 14 (2002).

Thermal Neutron Capture for A=36-44, Z. Chunmei and R.B. Firestone, IAEA Report INDC(CPR)-057 (2003).

Development of a Database for Prompt Gamma-ray Neutron Activation Analysis, R.B. Firestone *et al,* INDC(NDS)-443, March 2003.

Development of a Database for Prompt Gamma-ray Neutron Activation Analysis, H.D. Choi, R.B. Firestone, R.M. Lindstrom, G.L. Molnár, A.V.R. Reddy, V.H. Tan, C.M. Zhou, R. Paviotti-Corcuera, and A. Trkov, Proceedings of the International Conference on Nuclear Data for Science and Technology, 7-12 October 2001, Tsukuba, Ibaraki, Japan. Journal of Nuclear Science and Technology, Supplement 2, 1372-1375 (2002).

New Catalog of Neutron Capture Gamma Rays for Prompt Gamma Activation Analysis, G.L. Molnár, Zs. Révay, T. Belgya, R.B. Firestone, Proceedings of the International Conference on Nuclear Data for Science and Technology, 7-12 October 2001, Tsukuba, Ibaraki, Japan. Journal of Nuclear Science And Technology, Supplement 2, 1338-1343 (2002).

Searching for X(5) behavior in nuclei , R. M. Clark, M. Cromaz, M. A. Deleplanque, M. Descovich, R. M. Diamond, P. Fallon, R. B. Firestone, I. Y. Lee, A. O. Macchiavelli, H. Mahmud, E. Rodriguez-Vieitez, F. S. Stephens, and D. Ward , Phys. Rev. C 68, 037301 (2003)

Prompt Gamma Activation Analysis (PGAA) and Short-Lived Neutron Activation Analysis (NAA) Applied to the Characterization of Legacy Materials, Gerald A. English, Richard B. Firestone, Dale L. Perry, Jani P. Reijonen, Bernhard A. Ludewigt, Ka-Ngo Leung, Glenn F. Garabedian and Bryan B. Bandong, Gabor L. Molnár and Zsolt Révay, Sixth international conference on Methods and Applications of Radioanalytical Chemistry, MARC VI Kailua-Kona, Hawaii, April 7-11 2003, J. Nucl. Radioanal. Chem, in press (2003).

The Characterization of Legacy Radioactive Materials by Gamma Spectroscopy and Prompt Gamma Activation Analysis (PGAA), G.A. English, D.L. Perry, J. Reijonen, B. Ludewigt, K-N. Leung, R.B. Firestone, G. Garabedian, G. Molnár, and Zs. Révay, Proceedings of the 5th International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRRMA-V), Bologna, Italy, 9-14 June 2002, Nucl. Instrum. Meth. B, in press (2003).

The Use of Prompt Gamma Activation Analysis (PGAA) for the Analysis and Characterization of Materials: Photochromic materials, D.L. Perry, G.A. English, R.B. Firestone, K-N. Leung, G. Garabedian, G.L. Molnár and Zs. Révay, Proceedings of the 5th International Topical Meeting on Industrial Radiation and Radioisotope Measurement Applications (IRRMA-V), Bologna, Italy, 9-14 June 2002, Nucl. Instrum. Meth. B, in press (2003).

New Capture Gamma-Ray Library and Atlas of Spectra for All Elements, R. B. Firestone, Zs. Révay, and G. L. Molnár, Proceedings of the Eleventh International Symposium on Capture Gamma-Ray

Spectroscopy and Related Topics, Pruhonice near Prague, Czech Republic, September 2 - 6, 2002, World Scientific, in press.

PGAA/NAA Analysis with the Lawrence Berkeley National Laboratory (LBNL) D+D Neutron Generator, R.B. Firestone, G.A. English , D.L. Perry, J.P. Reijonen, F. M. Gicquel, S. Basunia, K.N. Leung, G.F. Garabedian, B.B. Bandong, G.L. Molnár, L. Szentmiklosi and Zs. Révay, Proceedings of the American Nuclear Society Embedded Topical Meeting on Accelerator Applications in a Nuclear Renaissance (AccApp'03), June 1-5 2003, San Diego CA, in press (2003).

Compact Neutron Generator Development at LBNL, J. Reijonen, G. English, R. Firestone, F. Giquel, M. King, K-N. Leung and M. Sun, Proceedings of the American Nuclear Society Embedded Topical Meeting on Accelerator Applications in a Nuclear Renaissance (AccApp'03), June 1-5 2003, San Diego CA, in press (2003).

b) Invited Talks

New Capture Gamma-Ray Library and Atlas of Spectra for All Elements, R. B. Firestone, Zs. Révay, and G. L. Molnár, Eleventh International Symposium on Capture Gamma-Ray Spectroscopy and Related Topics, Pruhonice near Prague, Czech Republic, September 2 - 6, 2002.

Analysis of Unknown Materials With prompt Gamma-Ray Activation Analysis, R.B. Firestone and J. English, Russian-American WSSX Workshop on High Explosives Aging, July 25, 2002, Monterey.

Overview of Nuclear Data, R.B. Firestone, Lecture given at the Workshop on Nuclear Data for Science and Technology: Materials Analysis, Abdus Salam International Centre for Theoretical Physics, Trieste, 19-30 May 2003.