Nuclear Data Group Report
LBNL+UCB

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Berkeley, CA 94720

USNDP Meeting, TUNL, October 1-4, 2024

Nuclear Data Group Members (LBNL+UCB)

Staff:

- Lee Bernstein (UCB + LBNL) (Group Leader) – 0.375 FTE
- Shamsuzzoha Basunia (LBNL) – 0.8 FTE
- Mathis Wiedeking (LBNL) – since January 2024 ≈1.0 FTE
- Bethany Goldblum (UCB+LBNL) – 0.10 FTE

New

- Aaron Hurst (UCB) – 0.10 FTE
- Jon Batchelder (UCB) – 0.75 FTE
- Andrew Voyles (UCB) – 0.2 FTE
- Josh Brown (UCB) – 0.0 FTE
- Thibault Laplace (UCB) 0.0 FTE (Honorary Member)

Postdoc and Graduate students:

- Charles (Joe) Henderson (UCB) – Student partially supported by "Berkeley Atlas" NDIAWG FOA (≈0.25 FTE)
- 2 postdocs and graduate students from other supports

Activities:

- **ENSDF:**
  - Responsibility: 33 mass chains: 21-30, 81, 83, 90-93, 166-171, 184, 186, 187, 191-193, 210, 211, 212, 213, 214
  - About 10 of these are over 12-years (since cut-off):
    - 25, 27, 29, 81, 93, 166, 168, 169, 184, 187
- **Databases:**
  - BEApR: Global database/evaluation of beta-delayed and direct heavy charged particle (p, α, cluster, fission) emitters (Batchelder, Hurst)
  - Photon Strength Functions, Nuclear Level Densities (Wiedeking)
  - pyEGAF, (n,n'γ) Baghdad Atlas, γ-X- coin (and decay), paceENSDF (Hurst)
  - Library of Scintillator Properties and their Response to Recoil Nuclei (Goldblum, Laplace)
- **Measurements:**
  - High-energy (n,x), (p,x) reactions for Isotope Production (Voyles)
  - GENESIS (Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering) (n,n'γ) (Brown)
  - SM: ^{60}Ni(p,γ), SM: ^{50}Cr(p,γ), OM: ^{193,194}Ir, etc. (Wiedeking)
  - Nuclear Data for Microcalorimetry (Voyles, Hurst, Basunia, Bernstein)

Mass chain evaluation and related activities

- **Nuclear Data Sheets:**
  - A=30, Basunia, Chakraborty, NDS 197, 1, 2024
  - A=191, Basunia, NDS 195, 368, 2024
  - A=222, Singh, *et. al.* (ICTP, IAEA workshop), NSD 192, 315, 2023
- **Submitted:**
  - A=25 (Basunia – 8 nuclides, Chakraborty - 1 from India)
  - A=169 (Basunia)
- **Pipeline:**
  - A=81 (Basunia) – received reviewer's comments
- **Reviewed:**
  - One mass chain

Berkeley Evaluated Alpha & proton Radioactivity (BEApR) database, Horizontal Evaluation

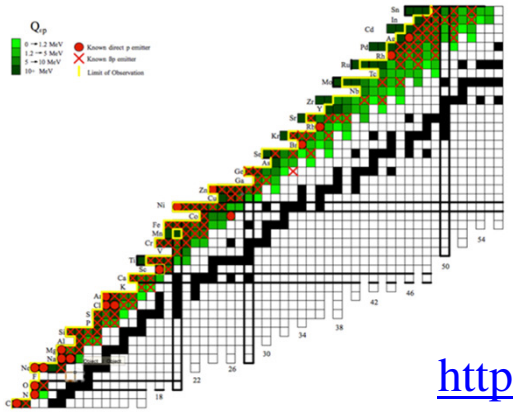
Batchelder, Hurst

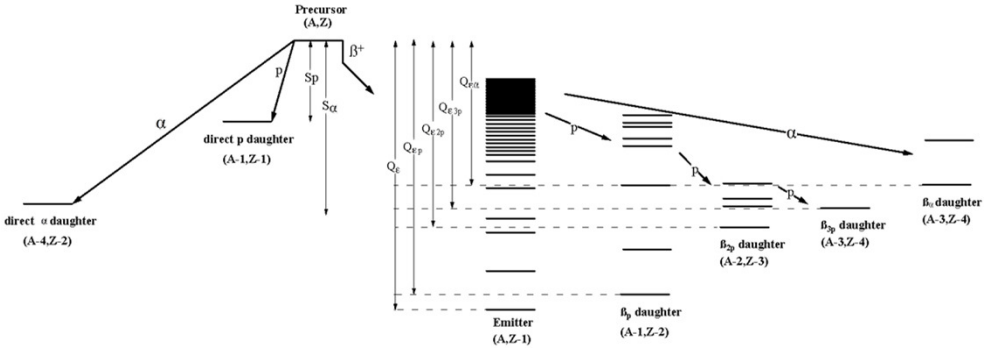
- Provides an overview of spontaneous, charged particle decay for exploration of systematics, relationships between Energy and Branching Ratio (BR), and competition between decay modes
  - Many nuclei have only been observed via heavy charged particle emission
- Recommended values will be updated monthly
- All references, including proceedings, reports etc. provided (unlike NSR).
- Explicit organization by Energy, BR, $T_{1/2}$ etc.
- Organized by T_z / α-chain

Spontaneous comments from the research community regarding BEApR

"Thanks for this great compilation" - Alex Brown, FRIB

Received comments/suggestions from
Futoshi Minato, Kyushu University, Japan
John Hardy (Texas A&M)
Rykaczewski Krzysztof (ORNL), and
Sean Liddick (MSU)





https://nucleardata.berkeley.edu/research/betap.html

Photon Strength Function (PSF) Database

Mathis Wiedeking

IAEA Coordinated Research Project on Photonuclear Data and Photon Strength Functions F41032, 2016-2019.

Eur. Phys. J. A (2019) **55**: 172
DOI 10.1140/epja/i2019-12840-1

THE EUROPEAN PHYSICAL JOURNAL A

Review

Reference database for photon strength functions

S. Goriely[1], P. Dimitriou[2,a], M. Wiedeking[3], T. Belgya[4], R. Firestone[5], J. Kopecky[6], M. Krtička[7], V. Plujko[8], R. Schwengner[9], S. Siem[10], H. Utsunomiya[11], S. Hilaire[12], S. Péru[12], Y.S. Cho[13], D.M. Filipescu[14], N. Iwamoto[15], T. Kawano[16], V. Varlamov[17], and R. Xu[18]

Experimental data:

- NRF for 29 nuclei, 47 data files
- Oslo method for 103 nuclei, 194 data files
- ARC/DRC for 88 nuclei, 221 data files
- (p,γ) for 22 nuclei, 37 data files
- Shape/Ratio method for 10 nuclei, 28 data files
- (p,p_0) measurements for 8 nuclei, 26 data files
- E1 photodata for 159 nuclei, 452 data files
- TC incl EGAF for 55 nuclei, 137 data files

Theoretical data:

- D1M-QRPA data files
- SMLO data file

https://www-nds.iaea.org/PSFdatabase/

2024 Data Updated Imminent: New user interface

Nuclear Level Density IAEA CRP (2025-2029)

Mathis Wiedeking

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- Lastest update 2008: important developments & information since.

- CRP start January 2025 with objectives:
  - Compilation of available experimental information
  - Evaluation of experimental data with uncertainty analysis
  - Theoretical developments
  - Global models
  - Validation of global models
  - Creation of repository and publications

- Traineeship funded by US Nuclear Data Program
  - ~$1.2m funding (over 4 years)
  - includes 50% for post-doc and 25% Research Engineer

Open-source Python library paceENSDF on PyPI

https://pypi.org/project/paceENSDF/

Aaron Hurst

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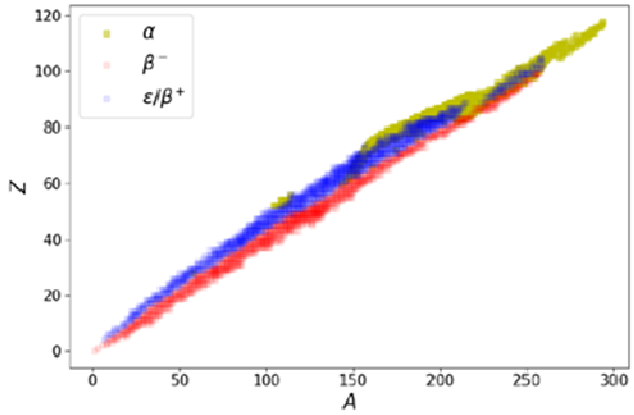
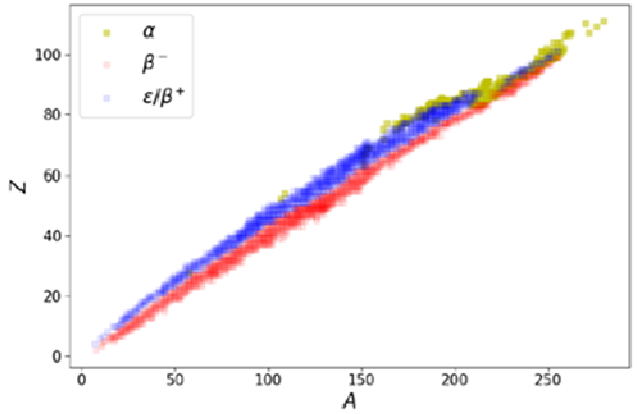
- paceENSDF: Python Archive of Coincident Emissions from ENSDF.
- Translated 3254 ENSDF-decay datasets to JSON format.
- Converted each ENSDF-decay dataset into RIPL format.
- Generated 2394 JSON-formatted coincidence datasets, i.e., only those containing γ rays.
- Developed suite of Python modules enabling interaction, analysis, and visualization of the **ENSDF-decay data** and derived **coincidence** $\gamma - \gamma$ and $\gamma - X$-ray data.
- JSON schema keys documented extensively in README.
- 283 unit tests (multiple virtual Python3 environments).
- Installation, testing scripts, and Jupyter Notebooks.
- JSON and RIPL files bundled with software.
- Open-source (FreeBSD License) library maintained on PyPI and GitHub.
- Over 4200 downloads.

ENSDF decay (all)



ENSDF decay (with γ data)




```
pip install paceENSDF
```

Open-source Python library pyEGAF on PyPI

https://pypi.org/project/pyEGAF/

Aaron Hurst

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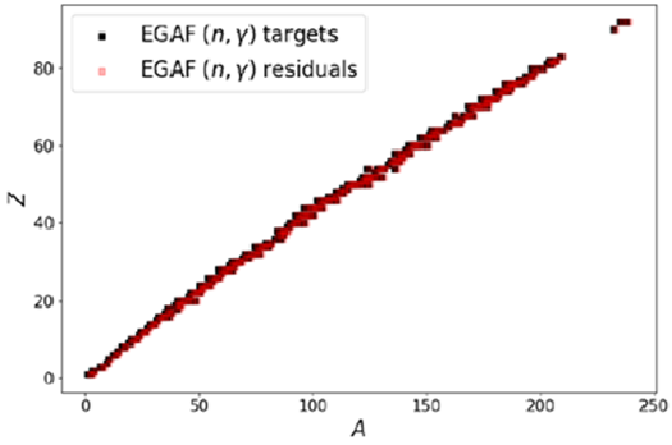
Lawrence Berkeley National Laboratory

- Translated all 245 ENSDF-formatted EGAF datasets to a new `JSON` format.
- Generated RIPL-format EGAF for reaction calculations.
- Developed suite of Python modules enabling interaction, analysis, and visualization of the EGAF (n, γ) data.
- Docstrings provided for all methods.
- JSON schema keys documented extensively in `README`.
- 224 unit tests (multiple virtual `Python3` environments).
- Installation, testing scripts, and `Jupyter Notebooks` provided.
- `ENSDF`, `RIPL`, and `JSON` files bundled with software.
- Open-source (FreeBSD License) library maintained on PyPI and GitHub.
- Over 1100 downloads.




Nuclear Instruments and Methods in Physics Research A 1057 (2023) 168715

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima

Full Length Article

pyEGAF: An open-source Python library for the Evaluated Gamma-ray Activation File

A.M. Hurst, R.B. Firestone, E.V. Chimanski

ARTICLE INFO

ABSTRACT

The Evaluated Gamma-ray Activation File (EGAF) is one of the most comprehensive resources for thermal neutron-capture data. This database contains data from prompt gamma activation analysis measurements carried out in a consistent manner using the same experimental configuration at the Budapest Research Reactor for 245 isotopes. Although these valuable datasets have been freely available for many years, one of the drawbacks is the outdated and cryptic Evaluated Nuclear Structure Data File (ENSDF) format that is currently adopted for dissemination, making it difficult for users unfamiliar with the format to access and utilize the data contained therein. Furthermore, the ENSDF format does not readily lend itself to modern computational technologies and a parser is required to interpret the complicated mixed-record format. To help overcome these challenges, we have developed a translator to convert the ENSDF-formatted datasets into an open standard JavaScript Object Notation (JSON) format enabling accessibility to applications using different programming languages running in different environments. To compliment this effort, we have also developed an open-source software package implemented in Python, pyEGAF, that is designed to interact with the JSON data structures for general purpose access, manipulation, and analysis of the neutron-capture γ-ray data in EGAF. The new format, together with the pyEGAF library, greatly enhances access to the wider applications community where EGAF data may be useful or is required.

```
pip install pyEGAF
```

Nuclear Data Library for Scintillators

Goldblum, Laplace

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- Provides data on inorganic and organic scintillating materials

➔ equivalent of EXFOR for scintillating materials

- Web-based reference of scintillator properties, including:
  - Luminosity
  - temporal response
  - energy resolution
  - etc.
- Enables accurate modeling of scintillator-based detector response

Aid in developing fundamental theories, linking material properties and scintillation performance

https://scintillator.lbl.gov/

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Material	Type	Quenching Data	Light Output % Anthracene	Wavelength of Max Emission (nm)	Decay Constant (ns)	Attenuation Length (cm)	Refractive Index
Pilot U EJ-228 BC-418	Plastic	Protons Stevanato2011ApplRadIso69	67	391	1.4		1.58
NE-120 EJ-290 BC-490	Resin	Protons Nattress2016IEEETNS63	58	423	3		1.58
NE-111A EJ-232 BC-422	Plastic	Protons Manfredi2020IEEETNS67	55	370	1.6	8	1.58
EJ-232Q (0.5%) BC-422Q	Plastic	Protons Manfredi2020IEEETNS67	11	370	0.7	<8	1.58
Pilot U2 EJ-230 BC-420	Plastic	Protons Manfredi2020IEEETNS67	64	391	1.5	120	1.58

Recently expanded to include organic scintillators!

GENESIS (Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering)

Josh Brown

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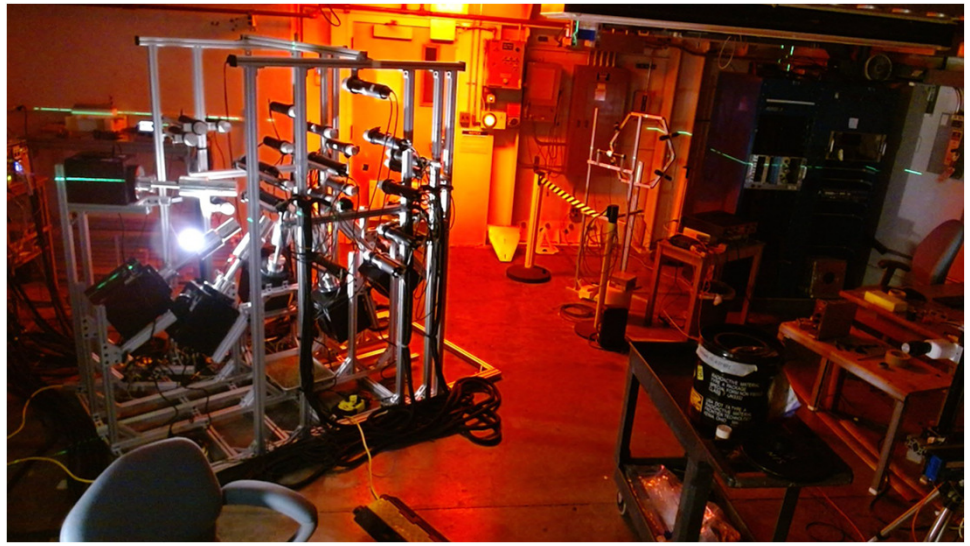
- New neutron-induced γ/neutron emission spectra are required
  - Advanced reactor systems
  - Neutron active interrogation
- Measurement observables coupled with reaction model calculations in forward modeling approach to extract (n,n'γ) cross sections



Priority	Elements
First	C, N, O, Na, Al, Si, Fe, Cu, Pb, W, U, Pu
Follow-up	He, Li, Be, B, Cl, Cr, Mn, Ni, Ge, Br, Cd, I, Cs, La
Remaining	F, Mg, P, S, Ar, K, Ca, Ti, As, Kr, Mo, Sn, Sb, Xe, Gd, Bi, Np, Am

- GENESIS includes HPGe detectors and organic scintillators to enable measurement of double-differential neutron and gamma emission spectra.
- Recently commissioned 7 mechanically cooled HPGe detectors as part of the ^{23}Na(n,n'g) cross section studies

Publication on Array Characterization: Gordon, *et al*; NIM A 1061, April 2024, 169120

Other Efforts:

Dissertations (Principal Advisor): Lee Bernstein

Four PhD Graduates:

- Catherine Apgar
- Christopher Brand
- Tyler Nagel
- J. M. Gordon: Co-Chaired by Goldblum.

One masters thesis :

- Elise Malmer Martinsen, "*Nuclear excitation functions for natZr(d,x) reactions with focus on the PET/ theranostic candidate* ^{86}Y",. Department of Physics, University of Oslo (Spring 2024). Chaired by Voyles.

In the process of hiring an undergraduate:

- For sorting, scanning, and sending articles to upload in the x4-pdf database

Publications/Invited talks (https://nucleardata.berkeley.edu/)

- **Published about 16 articles (FY 2024): (Selected ones)**
  - **2024NaAA**: T.S. Nagel, J.A. Brown, J.C. Batchelder, D. Bleuel, C.A. Brand, A. Georgiadou, B.L. Goldblum, M. Fratoni, J. Gordon, T.A. Laplace, L.A. Bernstein, "Measurement of the energy-differential $^{35}Cl(n,p_0)^{35}S$ cross section via ratio with $^{6}Li(n,\alpha)^{3}H$," Phys. Rev. C 110, 034612, 2024. https://doi.org/10.1103/PhysRevC.110.034612
  - **2024Go02**: J.M. Gordon, J.C. Batchelder, L.A. Bernstein, D.L. Bleuel, C.A. Brand, J.A. Brown, B.L. Goldblum, B.G. Frandsen, T.A. Laplace, T. Nagel, "*GENESIS: Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering,*" Nucl. Instrum. Meth. A, 1061, 169120, 2024. doi:10.1016/j.nima.2024.169120.
  - **2024Hu12**: A.M. Hurst, R.B. Firestone, and E.V. Chimanski, "*pyEGAF: Modernization of the EGAF database,*" J. Radioanal. Nucl. Chem. 333, 3669, 2024. doi:10.1007/s10967-023-09316-2.
  - **2024Sw01**: A. Sweet, D. L. Bleuel, N. D. Scielzo, L. A. Bernstein, A. C. Dombos, B. L. Goldblum, C. M. Harris, T. A. Laplace, A. C. Larsen, R. Lewis, S. N. Liddick, S. M. Lyons, F. Naqvi, A. Palmisano-Kyle, A. L. Richard, M. K. Smith, A. Spyrou, J. Vujic, and M. Wiedeking, "*Nuclear level density and γ-decay strength of ^{93}Sr,*" Phys. Rev. C, **109**, 054305, 2024. doi:10.1103/PhysRevC.109.054305.
  - **2024Ud01**: Md. Shuza Uddin, Sándor Sudár, M. Shamsuzzoha Basunia, Bernhard Scholten, Stefan Spellerberg, Andrew S. Voyles, Jonathan T Morrell, Ingo Spahn, Alex Hermanne, Lee A. Bernstein, Bernd Neumaier, and Syed. M. Qaim, "*Excitation functions and isomeric cross-section ratios of (d,xn) reactions on ^{86}Sr,*" Eur. Phys. J. A, **60**, 128, 2024. doi:10.1140/epja/s10050-024-01330-6.
- **Invited and contribution talks - 9: (Selected ones)**
  - M. Wiedeking, "Constraints on Nucleosynthesis Processes through Measurements in the Nuclear Quasi-Continuum", 11th Nuclear Physics in Astrophysics Conference (NPA2024), Technical University of Dresden, Dresden, Germany, September 15-20, 2024
  - A.M. Hurst, "Complete decay of the neutron-capture state", Nuclear Data for Space Applications, Waikoloa, The Big Island, Hawaii, USA, December 2, 2023.