Nuclear Data Group Report
LBNL+UCB

November 2022 – March 2024

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Berkeley, CA 94720

NSDD Technical Meeting, Vienna, Austria, April 15-19, 2024

Nuclear Data Group Members (LBNL+UCB)

Staff:

- **Lee Bernstein (UCB + LBNL) (Group Leader)**
- **Shamsuzzoha Basunia (LBNL)**
- **Mathis Wiedeking (LBNL) – since January, 2024**
- **Bethany Goldblum (UCB+LBNL)**

- **Aaron Hurst (UCB)**
- **Jon Batchelder (UCB)**
- **Andrew Voyles (UCB)**
- **Josh Brown (UCB)**
- **Thibault Laplace (UCB) (Honorary Member)**

Postdoc and Graduate students:

- **2 postdocs and 8 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
  - One third of these are over 12-years (since cut-off):
    - 25, 27, 29, 30, 81, 93, 166, 168, 169, 184, 187
- **Databases:**
  - BEApR: Global database/evaluation of beta-delayed and direct heavy charged particle (p, a, cluster, fission) emitters (Batchelder)
  - 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=24, Basunia, Chakraborty, NDS 186, 3, 2022
  - A=191, Basunia, NDS 195, 368, 2024
  - A=222, Singh, *et. al.* (ICTP, IAEA workshop), NSD 192, 315, 2023
  - A=231, Singh, Tuli, Browne, NSD 185, 560, 2022
- **Submitted (Oct, 2022 – Mar, 2024):**
  - A=81 (Basunia – 15 nuclides) – received rev. com.
  - A=25 (Basunia – 8 nuclides, Chakraborty - 1 from India)
- **Pipeline:**
  - A=30 (Basunia, Chakraborty) – addressed reviewer's comments
- **Reviewed:**
  - Two mass chains

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

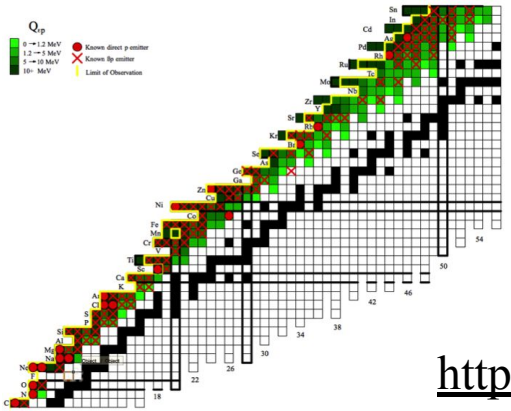
Jon Batchelder

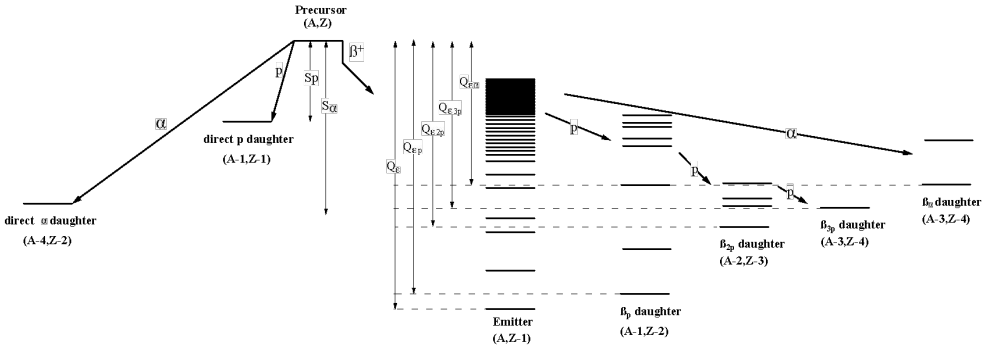
- Provides an overview of spontaneous, charged particle decay for exploration of systematics, relationships between Energy and Branching Ratio (BR), and competition between decay modes
  - Many nuclei have only been observed via heavy charged particle emission
- Recommended values will be updated monthly
- 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)
Nuclear Level Density (NLD) databases

Mathis Wiedeking

BERKELEY LAB
Lawrence Berkeley National Laboratory

PSF database:

- Update of database to be released first half of 2024
- Update includes a new interface (Application Programming Interface (API) web application) which was developed.

NLD database:

- NLD CRP recommendation (from 2023 consultant's meeting) sent to Internal research projects committee for approval.
- If approved anticipated start date October 2024

Experimental: SM: ^{60}Ni(p,γ), SM: ^{50}Cr(p,γ), OM: ^{193,194}Ir, NIF - NLD on ^{133}Xe, SM (^{63}Ni,^{106}Cd), Radiation Protection Basis of Design for SAIF.

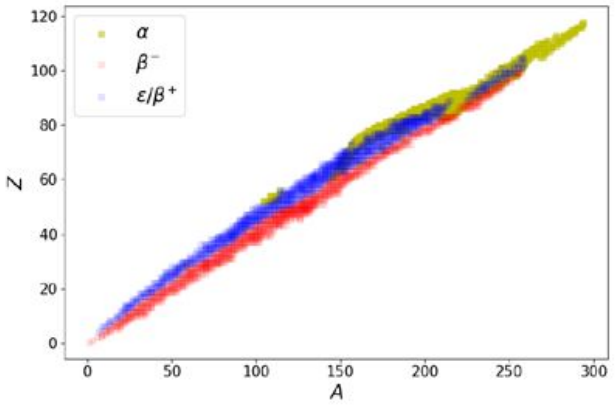
Open-source Python library paceENSDF on PyPI

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

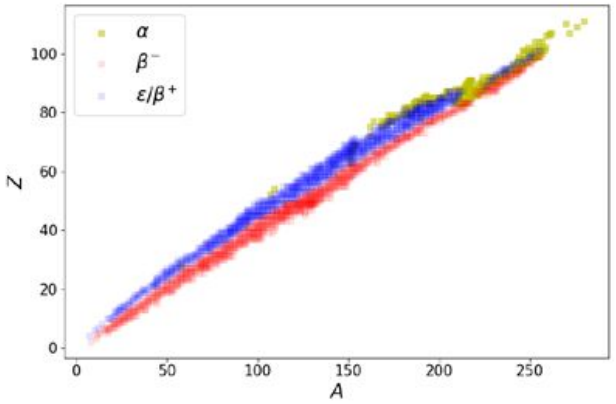
Aaron Hurst

- 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 2500 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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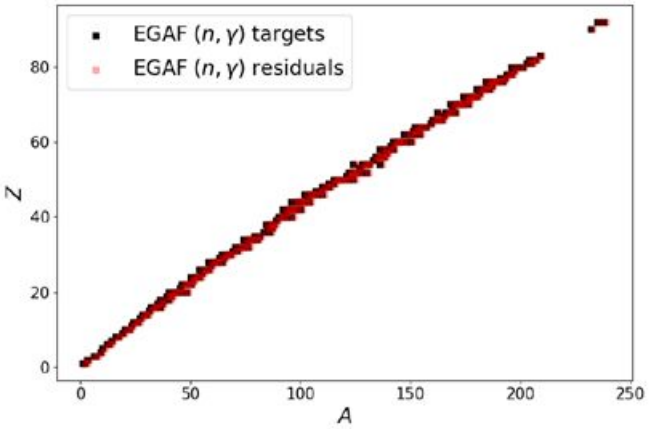
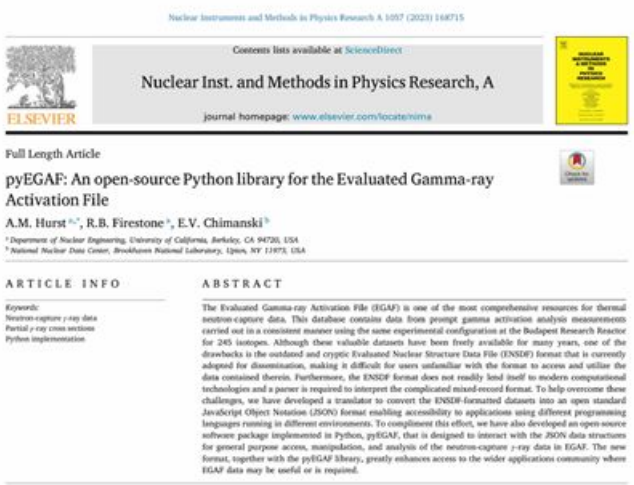
- Translated all 245 ENSDF-formatted EGAF datasets to a new `JSON` format.
- Generated RIPL-format EGAF for reaction calculations.
- Developed suite of Python modules enabling interaction, analysis, and visualization of the EGAF (n, γ) data.
- Docstrings provided for all methods.
- JSON schema keys documented 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 800 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

B. Goldblum and T. Laplace

Intended for two main uses:

- A web-accessible reference to useful scintillation detector materials
- An aid in developing fundamental theories or empirical relations between basic material properties and scintillation performance.

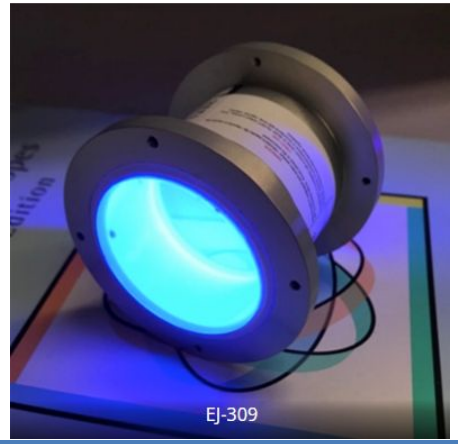
https://scintillator.lbl.gov/

Inorganic scintillators:

- Initially developed under a DHS project focused on the discovery and development of new inorganic scintillating materials

Organic scintillators:

- New addition focused on scintillator response to neutrons and charged particles
- Important for modeling detector response for nuclear physics and applications

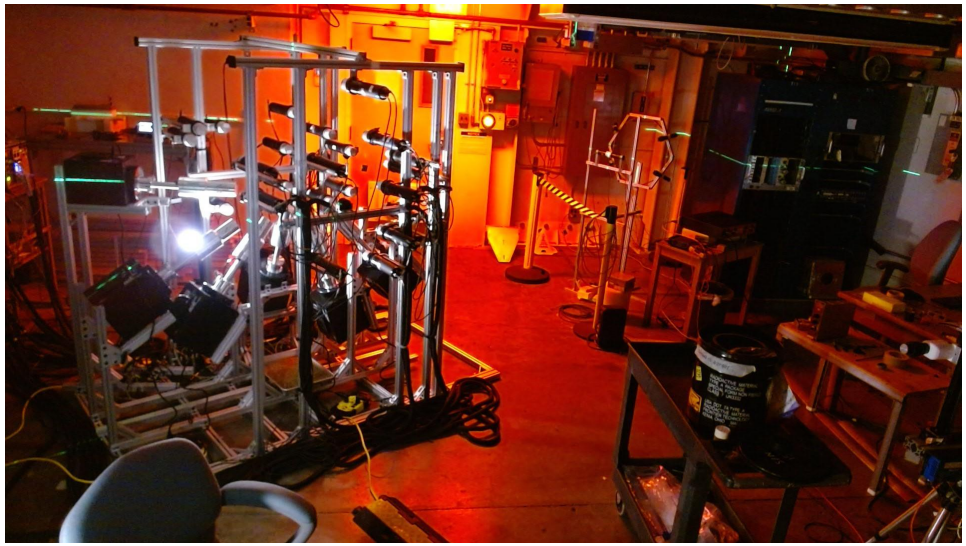


GENESIS (Gamma Energy Neutron Energy Spectrometer for Inelastic Scattering)

Josh Brown

BERKELEY LAB
Lawrence Berkeley National Laboratory

- 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



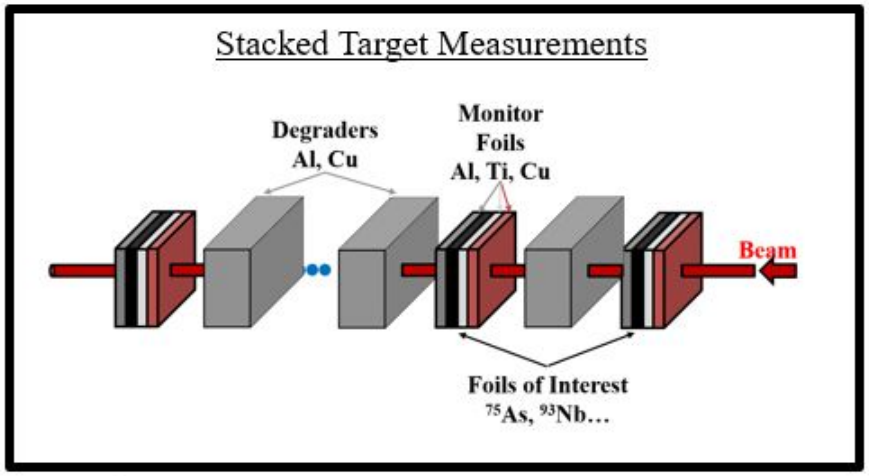
Priority	Elements
First	C, N, O, Na, Al, Si, Fe, Cu, Pb, W, U, Pu
Follow-up	He, Li, Be, B, Cl, Cr, Mn, Ni, Ge, Br, Cd, I, Cs, La
Remaining	F, Mg, P, S, Ar, K, Ca, Ti, As, Kr, Mo, Sn, Sb, Xe, Gd, Bi, Np, Am

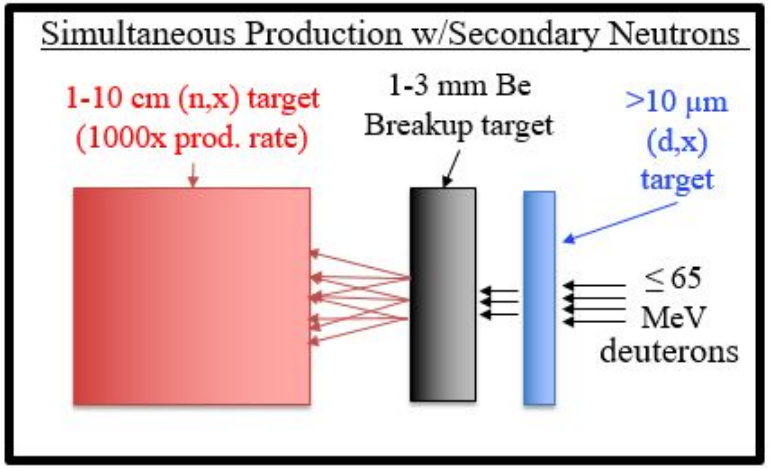
- GENESIS includes HPGe detectors and organic scintillators to enable measurement of double-differential neutron and gamma emission spectra.
- Recently commissioned 7 mechanically cooled HPGe detectors as part of the ^{23}Na(n,n'g) cross section studies

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

Medical isotope production cross section measurements since 2016

Andrew Voyles





We perform R&D for emerging isotopes, and develop novel paradigms to improve existing production efforts

Radionuclide (Purpose)	Reaction(s)	Radionuclide (Purpose)	Reaction(s)
^{134}Ce (^{225}Ac PET analog)	^{nat}La(p,6n), ^{127}I(^{11}B,4n)	^{51,52m}Mn (PET imaging)	Fe(p,x)
^{236m}Np/^{236}Pu (Mass Spec. Cal.)	^{235,238}U(p/d,x)	^{202}Pb (Chronology, Mass Spec.)	^{nat}Tl(p,x) (w/BNL, LANL)
^{225}Ac (α-therapy)	***^{226}Ra(n,2n)^{225}Ra → ^{225}Ac****	^{117m}Sn, ^{119m}Te (Auger Therapy)	^{nat}Sb(p,x) (w/BNL, LANL)
^{64,67}Cu (Theranostic)	^{nat}Zn(n,p)	^{211}At (α-therapy)	^{209}Bi(a,x)
^{193m}Pt (Auger Therapy)	^{nat}Ir(d,x)	^{149,152,155,161}Tb (Theranostics)	Gd(p,x)
^{86}Y (Imaging)	^{86}Sr(p/d,x) (w/Jülich)	^{86}Y (Imaging)	Zr(d,x) (w/Jülich)
^{72}As and ^{68}Ge/Ga (Imaging)	***^{75}As(p,x) (w/BNL, LANL)***	^{209}Po (RTGs)	^{209}Bi(d,2n)
^{229}Th / ^{229}Pa (^{225}Ac generator)	^{230,232}Th(n,2n),(p,2n),(d,xn)	^{90}Mo (Beam Monitor)	^{93}Nb(p,x)

Organizational Efforts:

Nuclear Science Advisory Committee:

- NSAC - Nuclear Data Subcommittee Chair: L.A. Bernstein – **Second Report of the Nuclear Data Subcommittee of the Nuclear Science Advisory Committee**. https://www.osti.gov/servlets/purl/1959550 LLNL-TR-845408 (2023).

Nuclear Data for Fusion Energy Systems:

- Fusion energy has received an increasing amount of attention from the Biden Administration and due to the achievement of Lawson's criterion in August 2021 (Abu-Shawareb *et al* PRL) - L.A. Bernstein (organizer)

Fusion Nuclear Data Roundtable @White House

Office of Science & Technology Policy, May 4, 2023

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

- **Published about 15 articles (FY 2023): (Selected ones)**
  - 2023Mo19: J.T.Morrell, A.S.Voyles, J.C.Batchelder, J.A.Brown, L.A.Bernstein; Secondary neutron production from thick target deuteron breakup; **Phys.Rev. C 108, 024616 (2023). doi**: 10.1103/PhysRevC.108.024616
  - Complete β-Decay Patterns of ^{142}Cs, ^{142}Ba, and ^{142}La Determined Using Total Absorption Spectroscopy; M. Wolin´ska-Cichocka, et al. **Phys.Rev. C 107, 034303 (2023)**. doi: 10.1103/PhysRevC.107.034303
  - 2023UdZZ: M.S.Uddin, M.S.Basunia, L.A.Bernstein, I.Spahn, B.Scholten, B.Neumaier, and S.M.Qaim,; Determination of positron emission intensity in the decay of ^{86g}Y; **EPJ Web of Conferences 284, 09003, (2023)**. **doi**: 10.1051/epjconf/202328409003.
  - A.M. Hurst, B.D. Pierson, B.C. Archambault, L.A. Bernstein, S.M. Tannous, *"A decay datababase of coincident γ-γ and γ-X-ray branching ratios for in-field spectroscopy applications"*, **Eur. Phys. J. (Web of Conf.) 284, 18002 (2023)**. https://doi.org/10.1051/epjconf/202328418002
  - J.A. Brown, T.A. Laplace, B.L. Goldblum, J.J. Manfredi, T.S. Johnson, F. Moretti, and A. Venkatraman, "*Absolute light yield of the EJ-204 plastic scintillator,*" **Nucl. Instrum. Meth. A, 1054, 168397 (2023),** doi:10.1016/j.nima.2023.168397.
- **Invited and contribution talks - 13: (Selected ones)**
  - L.A. Bernstein, Nuclear Data for Fusion Workshop, Nuclear Data for Fusion. Office of Science and Technology Policy. Washington DC. May 4, 2023.
  - J. C. Batchelder, International Conference on Proton-Emitting Nuclei (PROCON2023), Warsaw, Poland, June 25 - 30, 2023
  - L.A. Bernstein, 11th International Conference on Isotopes, Investigating High-Energy Proton-Induced Reactions: Implications for Level Densities and the Pre-equilibrium Exciton Model. Saskatoon, SK Canada. July 24, 2023.
  - A.M. Hurst, invited participation at the IAEA "Consultants Meeting on Thermal Capture and Gamma Emission", October 23-25, 2023