

# **NuPECC LRP 2024**

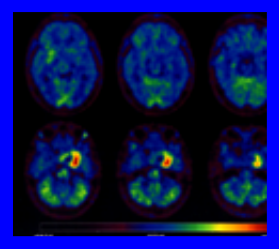
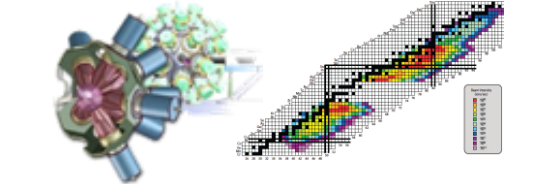
## **TWG 9.5: Nuclear Data (Databases) and Evaluation**

**Paraskevi (Vivian) Dimitriou**  
**Nuclear Data Section**  
**International Atomic Energy Agency**

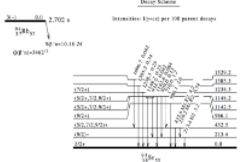
# Nuclear Science



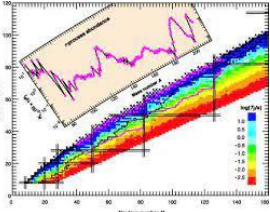
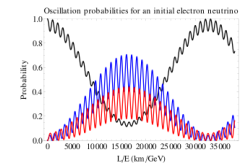
Radiation Safety



Medicine



Cultural Heritage



Energy

Basic Research

Applications

# Link between nuclear research and applications



Publications



organised

formatted-  
numerical

open/  
findable/  
retrievable

**Nuclear  
Databases-  
Libraries**

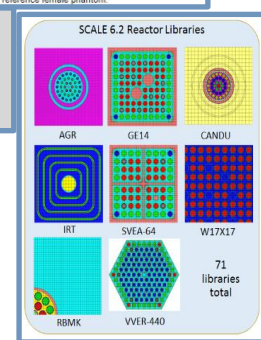
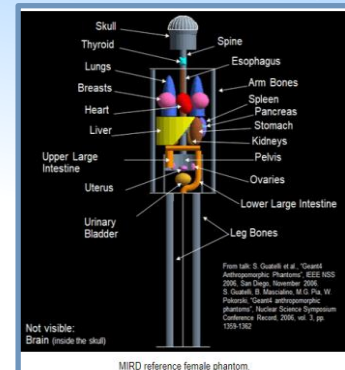
documented

traceable

Basic Research



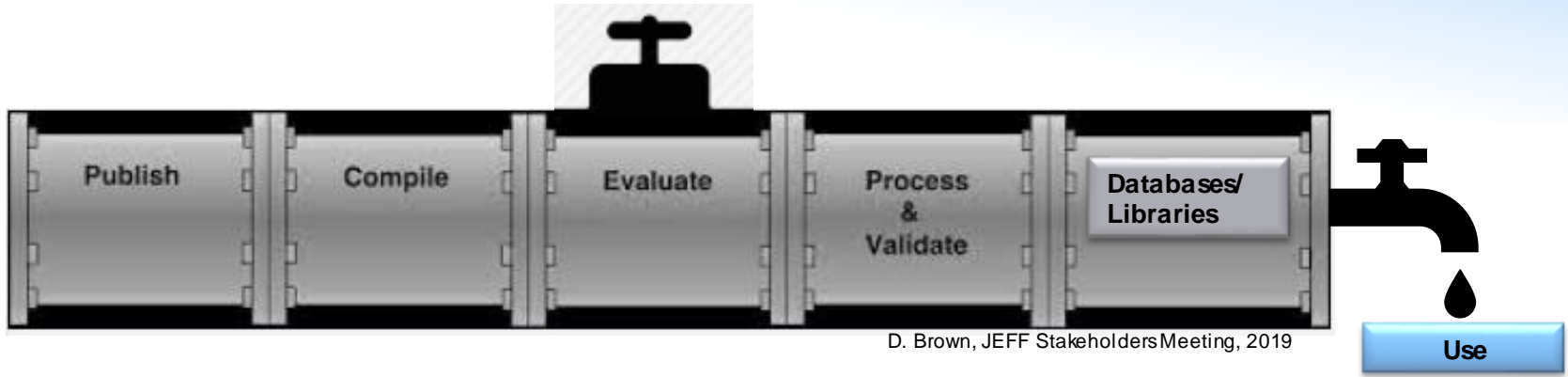
Applications



**SIMRA**

Computer simulation of RBS, ERDA, NRA, MEIS and PIGE.

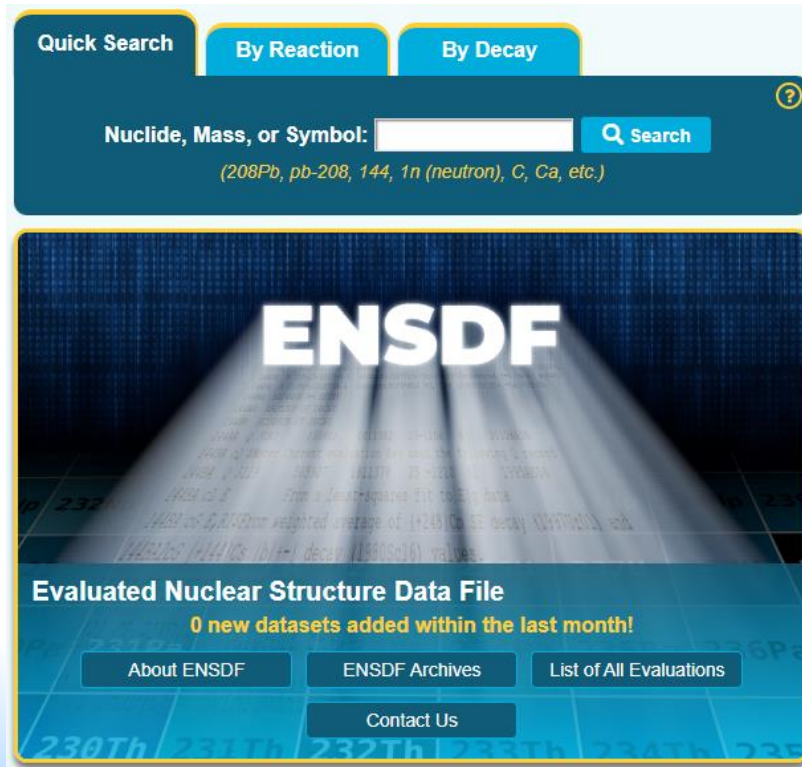
# Nuclear Data Pipeline



D. Brown, JEFF Stakeholders Meeting, 2019

Unless measurements go through the nuclear data pipeline and are incorporated in the nuclear databases they ARE NOT USED in applications

# Nuclear databases: nuclear structure and decay



The screenshot shows the ENSDF website interface. At the top, there are three tabs: "Quick Search", "By Reaction", and "By Decay". Below these is a search bar with the placeholder text "Nuclide, Mass, or Symbol:" and a "Search" button. Below the search bar, there is a small text snippet: "(208Pb, pb-208, 144, 1n (neutron), C, Ca, etc.)". The main content area features a large "ENSDF" logo in the center, with a background of a grid and some faint text. Below the logo, there is a section titled "Evaluated Nuclear Structure Data File" with a sub-header "0 new datasets added within the last month!". At the bottom, there are four buttons: "About ENSDF", "ENSDF Archives", "List of All Evaluations", and "Contact Us".

Evaluated Nuclear Structure Data File (ENSDF)

Hosted at National Nuclear Data Center,  
Brookhaven National Laboratory

**International effort:** international network of nuclear structure and decay data evaluators (NSDD)

Network is coordinated by the Nuclear Data Section of the IAEA

European effort: <10%, recently funded by SANDA

# Nuclear reactions: compilation of experiments



## Experimental Nuclear Reaction Data (EXFOR) Database Version of 2023-05-15

Software Version of 2023-05-08

The EXFOR library contains an extensive compilation of experimental nuclear reaction data. Neutron reactions have been compiled systematically since the discovery of the neutron, while charged particle and photon reactions have been covered less extensively. [EXFOR Reference Paper: Nucl. Data Sheets 120\(2014\)272, \[arxiv\]](#).

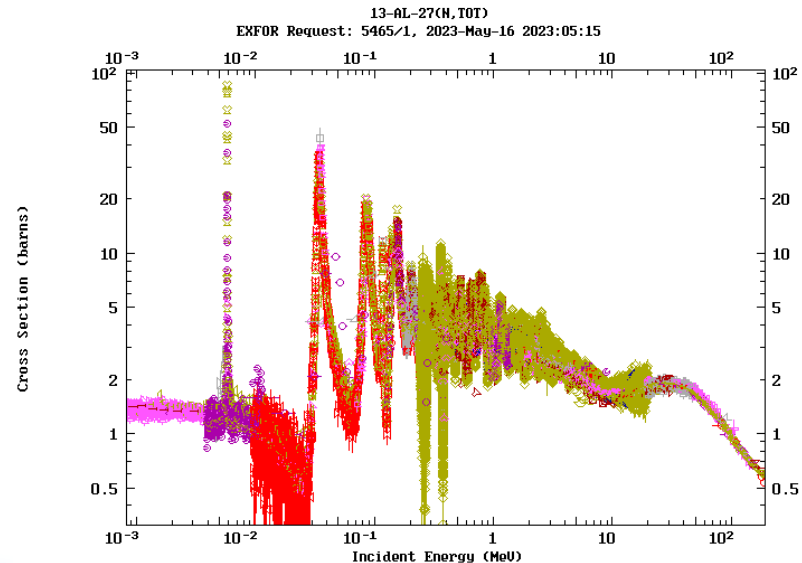
EXFOR Web database retrieval system provides: data search, output to various formats (incl.XML), plotting and comparison to ENDF, re-normalization old data to new standards, calculating data for inverse reactions and kinematics, constructing correlation matrices from partial uncertainties, etc. [EXFOR Web Database & Tools Paper: NIM A 888 \(2018\) 31, \[arxiv\]](#).

The EXFOR database contains data from **24560** experiments (see [statistics](#) and recent database updates). Mirror-sites 

Maintained and hosted at the  
Nuclear Data Section of the IAEA

**International effort:** network of  
Nuclear Reaction Data Centers  
coordinated by the Nuclear Data  
Section

European journals: NEA data Bank  
via out-sourcing



# Evaluated nuclear data libraries

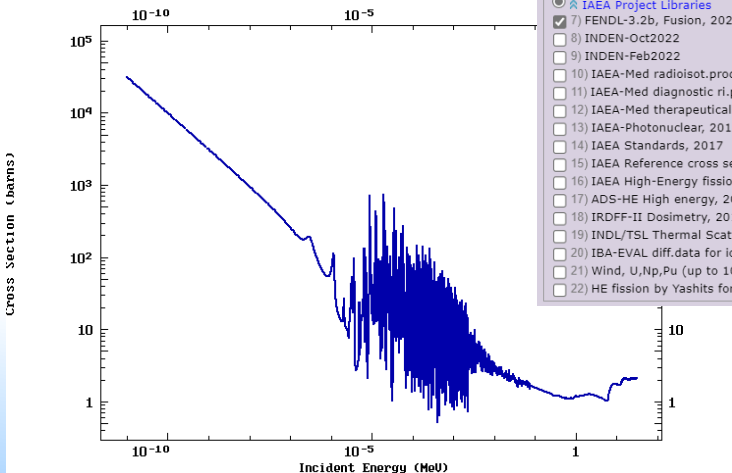
## Evaluated Nuclear Data File (ENDF) Database Version of 2022-10-07

Software Version of 2023-05-08

### News & History

2023/03 New software feature: plotting covariances of the average number of neutrons per fission MF31 [example]  
2023/02 New software tool: EE-View - fast experimental-evaluated data viewer [about] → go to SIG:[eeview][eeview1]; DA:[eeview1]  
2022/10 New software feature: plotting covariances for angular distributions of secondary particles MF34 [example]  
2022/10 New library: **INDEN-Oct2022** evaluations produced by International Nuclear Data Evaluators Network (coord. by the IAEA) [page]  
2022/09 New library: **TENDL-2021** TALYS-based Evaluated Nuclear Data Library, 2021 [page]  
2022/03 Undated libraries:

- Major Libraries
  - 1) ENDF/B-VIII.0 (USA,2018)
  - 2) JEFF-3.3 (Europe,2017)
  - 3) JENDL-5 (Japan,2021)
  - 4) CENDL-3.2 (China,2020)
  - 5) BROND-3.1 (Russia,2016)
  - 6) TENDL-2021 (TALYS, 2021)
- Special Libraries
  - Archival
  - Derived
- IAEA Project Libraries
  - 7) FENDL-3.2b, Fusion, 2022
  - 8) INDEN-Oct2022
  - 9) INDEN-Feb2022
  - 10) IAEA-Med radioisot.prod.2019
  - 11) IAEA-Med diagnostic ri.prod.2001
  - 12) IAEA-Med therapeutical ri.prod.2009
  - 13) IAEA-Photonuclear, 2019
  - 14) IAEA Standards, 2017
  - 15) IAEA Reference cross sections, 2017
  - 16) IAEA High-Energy fission ref., 2015
  - 17) ADS-HE High energy, 2013
  - 18) IRDFF-II Dosimetry, 2019
  - 19) INDL/TSL Thermal Scattering Law, 2006
  - 20) IBA-EVAL diff.data for ion beam analysis, 2013
  - 21) Wind, U,Np,Pu (up to 100 MeV), 1996
  - 22) HE fission by Yashits for Pb-Pu, 2000



National and international effort:  
ENDF/B, JEFF, JENDL, CENDL

European effort: Joint Evaluated Fission  
and Fusion File – coordination by  
OECD/NEA

International Nuclear Data Evaluation  
Network (INDEN) – coordinated by IAEA

# Workforce behind the databases



- Nuclear Reaction Data Centers (NRDC) – since 1975:  
13 data centers maintaining EXFOR
  - USA/BNL, **NEA Data Bank**, IAEA, Russia (3), China, **Hungary**, Japan (2), Korea, India, Ukraine



Experimental Nuclear Reaction Data (EXFOR)

Database Version of 2022-11-08

Software Version of 2022-10-20

- Nuclear Structure and Decay Data (NSDD) – since 1976:  
17 data centers contributing to ENSDF database
  - USA (ANL, BNL, FRIB/MSU, LBNL, ORNL, TAMU, TUNL), Australia, **Bulgaria**, Canada, China (2), **Hungary**, India, Japan, **Romania**, Russia

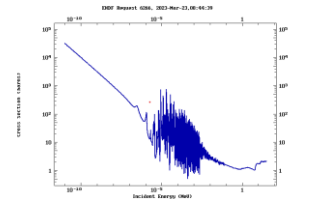


LiveChart of Nuclides

Interactive Chart of Nuclides  
Mobile App: Isotope Browser



- International Nuclear Data Evaluation Network (INDEN) – since 2018: international cooperation on nuclear reaction data evaluation
  - USA (BNL, LANL, LLNL, Notre-Dame, ORNL, RPI), IAEA, **JRC/EU**, Austria, Czech Rep., China, France, Germany, Greece, Japan, Slovenia, Spain, Switzerland, Romania, Russia



# International networks & databases



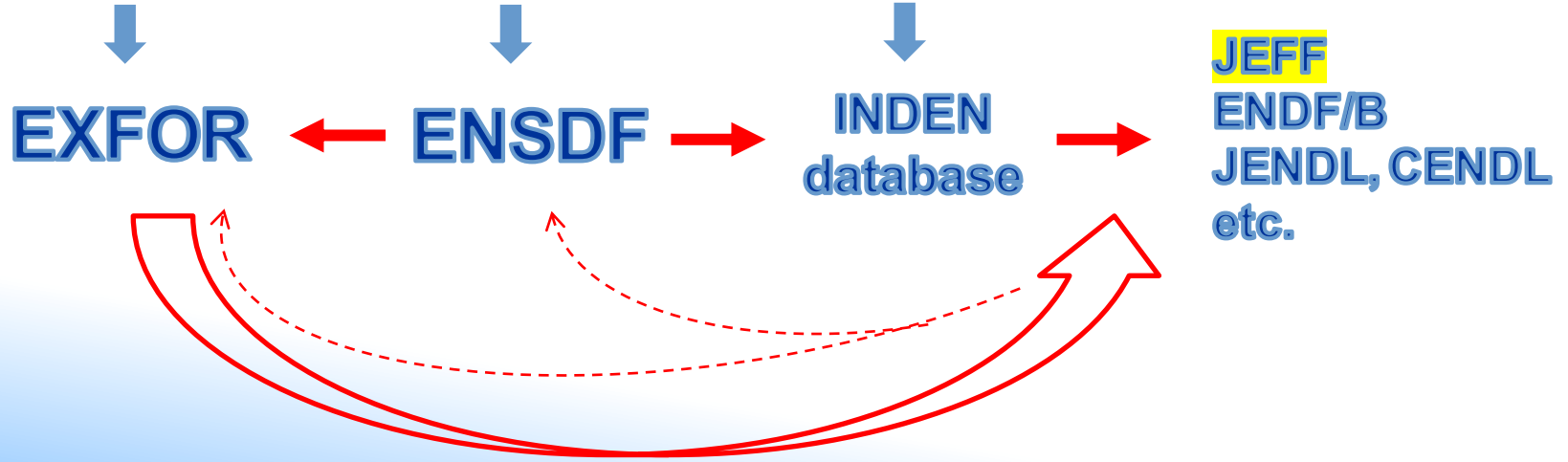
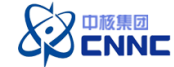
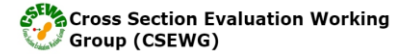
Nuclear Reaction  
Data Center  
Network



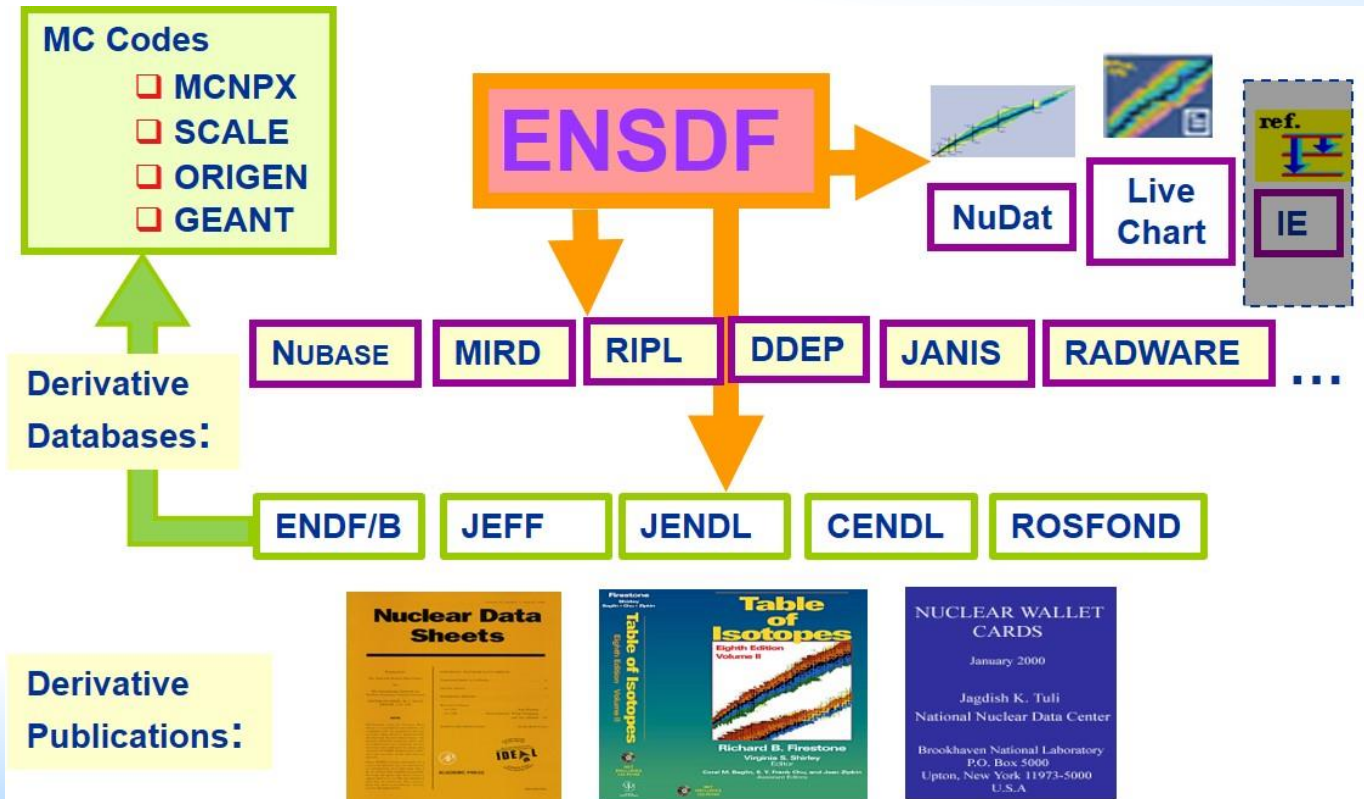
Nuclear Structure  
& Decay Data  
Network



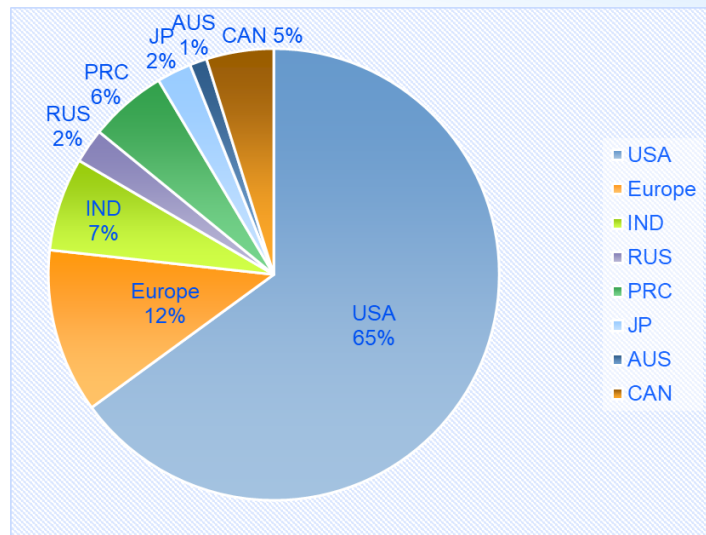
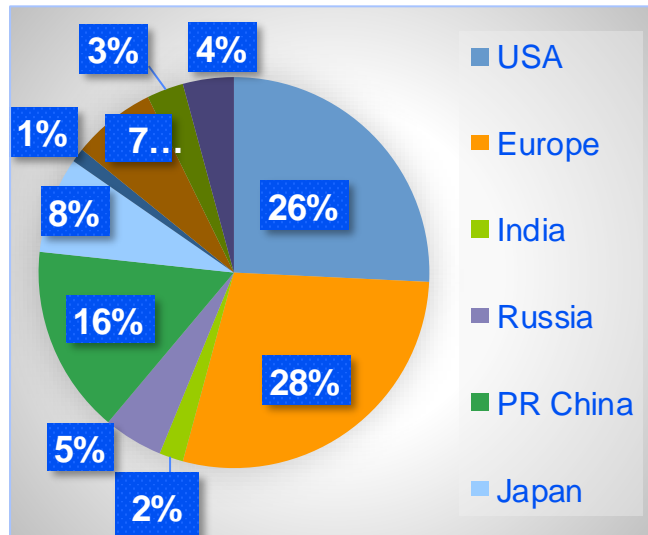
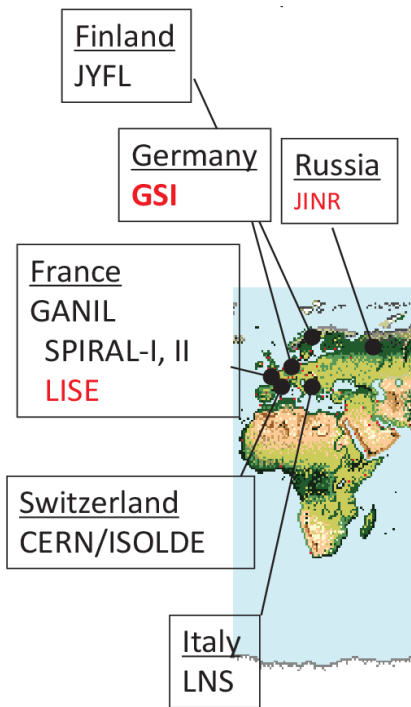
International  
Network of Nuclear  
Data Evaluators



# ENSDF: Major Source for other Derivative Products & Data Libraries



# European contribution to ENSDF



Major producer of nuclear structure and decay data

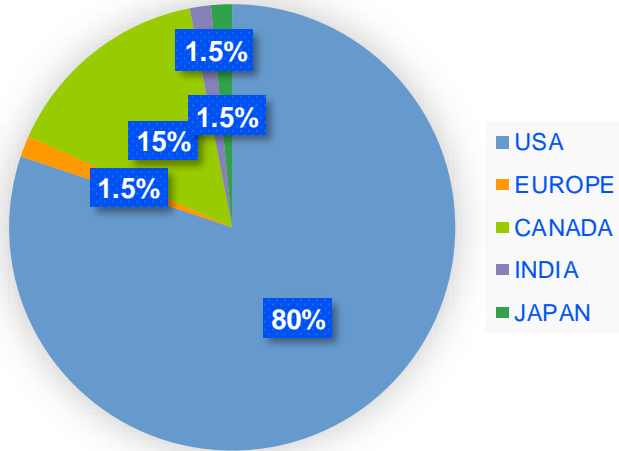
Major user of nuclear structure and decay data (Nuclear Data Sheets)

Minor contributor to evaluated nuclear structure and decay data

# Data Center *real* contribution

*real*: based on mass chain production in 2018-2022

European funding



Data Center	FTE
USA	5.25
EUROPE	0.1(0.95)
CANADA	1.0(0.39)
CHINA	0.25(0.45)
INDIA	0.1(0.54)
JAPAN	0.1(0.2)

**Total** 6.80

## SANDA project:

Wp4. Evaluation of nuclear structure and decay data

20kEuro per Data Center or 5 PM/Data Center

Data Centers: Sofia Univ., ATOMKI, IFIN-HH

To preserve 10-year recycling of mass chains: need FTE=12 (12 full-time evaluators)

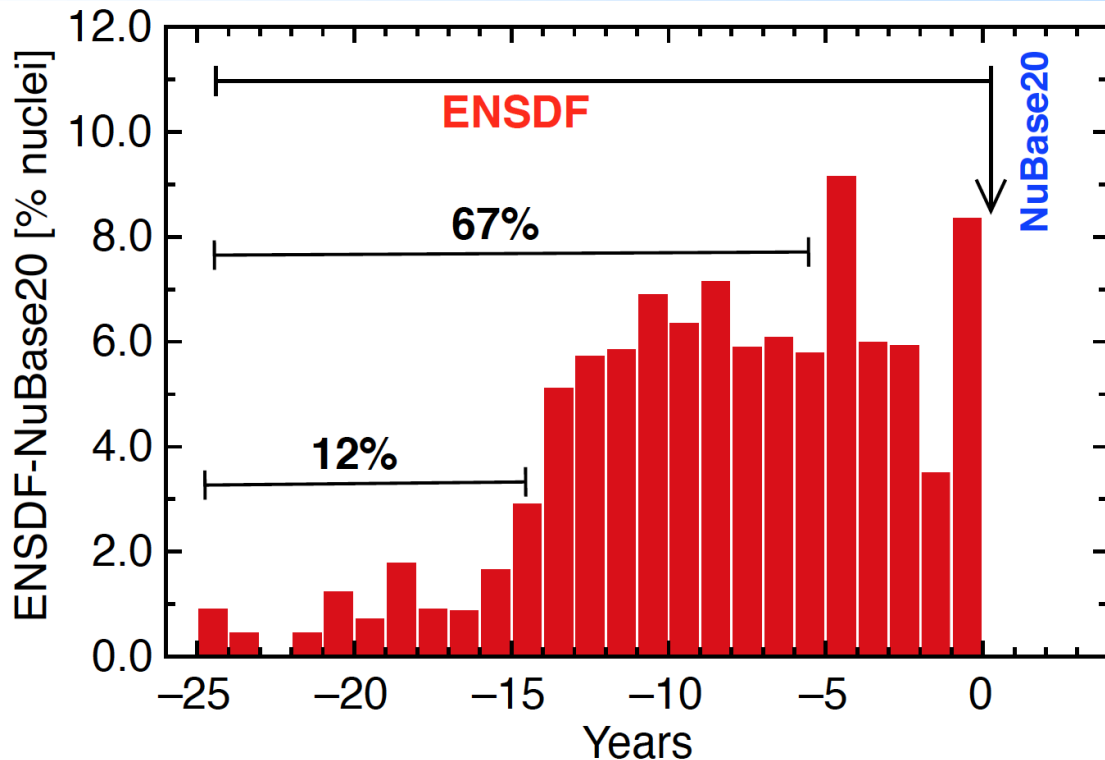
# Present status of ENSDF

ENSDF is invaluable to the nuclear physics community but it is

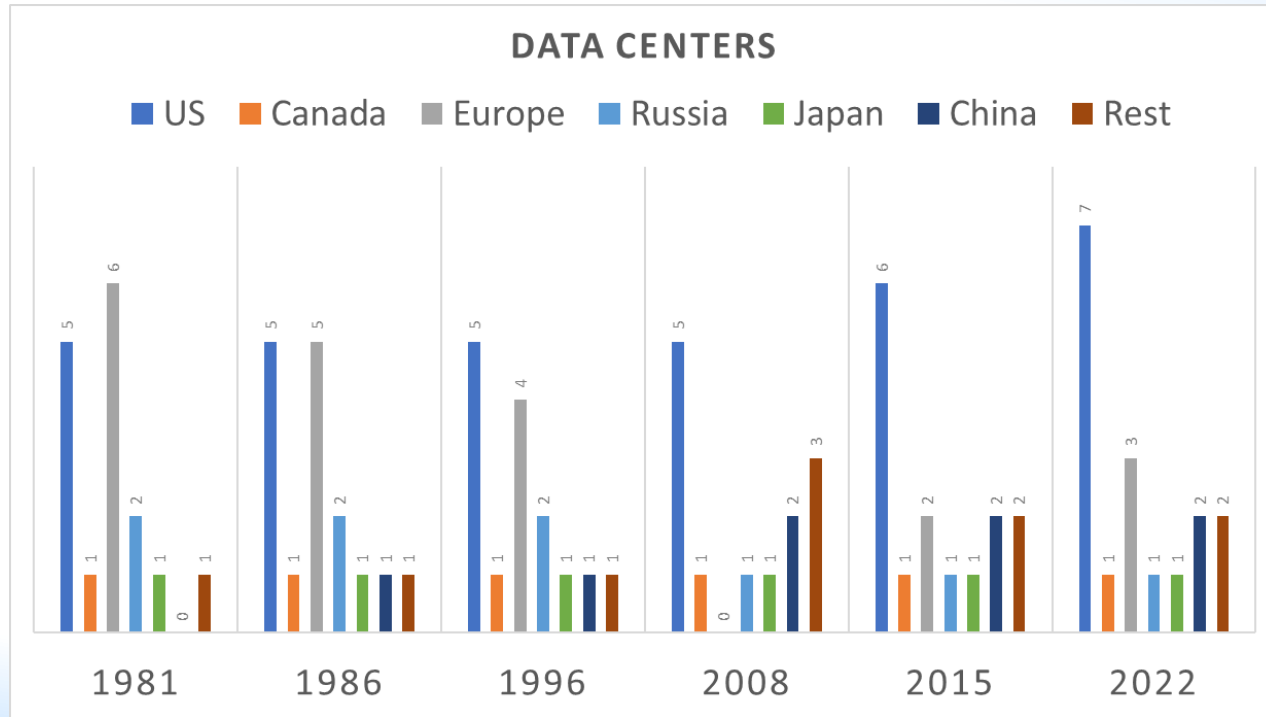
- becoming increasingly outdated
- non-uniform in coverage & subjectivity

**3558** ground states: 256 not in ENSDF

**1983** isomers: 241 not in ENSDF



# Evolution of European contribution to ENSDF



# Nuclear Data Evaluation in LRP 2024



- NuPECC Meeting, 2 Dec. 2022, Vienna
- IAEA Consultant's Meeting on Comprehensive European Plan to acquire and curate nuclear data, 25-27 April 2023  
(<https://conferences.iaea.org/event/347/>)
  - NuPECC (M. Lewitowicz, E. Widmann, S. Koerner); EURATOM (R. Garbil); CEA (S. Leray); ChETEC-INFRA (A. Boeltzig); V. Dimitriou, A. Koning, D. Ridikas (IAEA)
  - Report in preparation

The short and long-term nuclear data needs of the growing and diverse European user community require a comprehensive European plan involving all contributing and benefiting scientific communities, to ensure that they are met satisfactorily.

# Preserving the Nuclear Data Pipeline



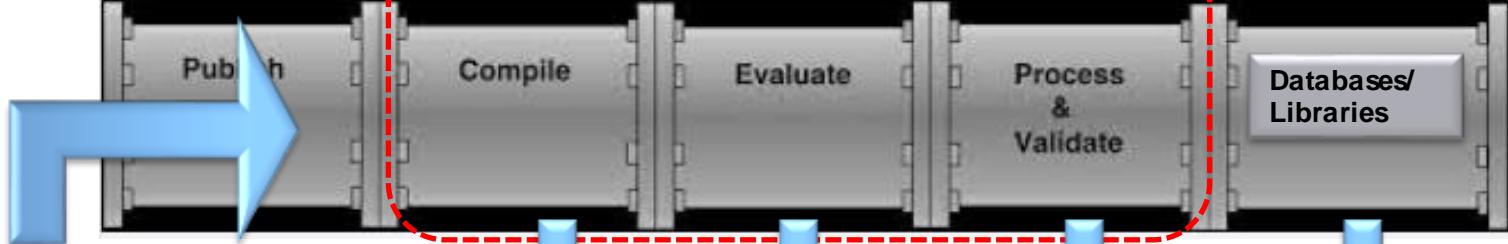
- Underfunded nuclear data evaluation & validation effort in Europe
- Shortfall in evaluators
- Loss of expertise

# Recommendations

- Establish a comprehensive European nuclear data program with priorities for nuclear data measurements and evaluations based on stakeholders needs
- Ensure a sustainable source of funding for measurements and data evaluation in Europe
- Maintain expertise in nuclear data in Europe by attracting and training the next generation of nuclear data experts
- Reinforce cooperation with international organisations (IAEA, NEA) for coordination, training, and outreach

# Future

## CHALLENGES



## NEW OPPORTUNITIES



Open and FAIR data as well as new AI/ML based approaches will pave the way for new formats, efficient data storage and evaluation/dissemination tools that will modernize and POTENTIALLY speed up and improve the nuclear data pipeline

# TWG9:



## Sub-group: Nuclear data (databases) and Evaluation

Vivian Dimitriou (IAEA)

Caterina Michelagnoli (ILL)

Antoine Lemasson (GANIL)- Convenor TWG 9

**TWG7:** Considerable overlap; liaising with Sub-group: Nuclear data (N. Patronis)

*Welcome feedback from other TWGs on nuclear data needs!*



**IAEA**

International Atomic Energy Agency  
*Atoms for Peace and Development*

*Thank you!*



## Applications and societal benefits – WG6

NuPECC Liaisons: Ioan Ursu, Jan Dobeš, Nicolas Alamanos ; Conveners: Marco Durante – Alain Letourneau

WG6 members : Eduardo Alves, Christoph Bert, Adrien Bidaud, Nicola Colonna, Daniel Cussol, Sergey Dmitrev, Xavier Doligez, Tobias Engert, Gilles de France, Carlos Granja, Ferid Haddad, Laura Harkness-Brennan, Sebastien Incerti, Jacek Jagielski, Maelle Kerveno, Ulli Koester, Franco Lucarelli, Ismael Martel, Christian Morel, Dénes Lajos Nagy, Dana Niculae, Alan Owens, Katia Parodi, Daniel Primetzhofer, Paddy Regan, Michael Scholz, Thomas Stöhlker, Zita Szikszai, Olof Tengblad, Vladimir Wagner

The compilation, evaluation and dissemination of nuclear data are laborious tasks that rely heavily on contributions from experts in both the basic and applied science research communities. Efforts carried out at national and international levels benefit from the coordination provided by international organisations such as the International Atomic Energy Agency (IAEA) in Vienna and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (NEA-OECD) in Paris. The development and maintenance of nuclear data libraries, and dissemination of nuclear data to various user communities constitute major goals of the international networks associated with these agencies: the Nuclear Reaction Data Centres Network (NRDC/IAEA), the Nuclear Structure and Decay Data evaluators (NSDD/IAEA), and NEA Data Bank. The challenge facing the nuclear research and applications communities is to ensure that the new measurements performed in the European facilities are

incorporated promptly into the available databases and are therefore used in both reaction modelling and evaluations that are important for energy and non-energy applications.

### 6. Summary and recommendations

- *Support activities related to the compilation, evaluation and dissemination of nuclear structure and decay data in Europe*
- *Maintain a high level of expertise in nuclear data evaluation to meet the requirements of a continuously developing European research and applied sciences landscape through targeted training and mentorship schemes*