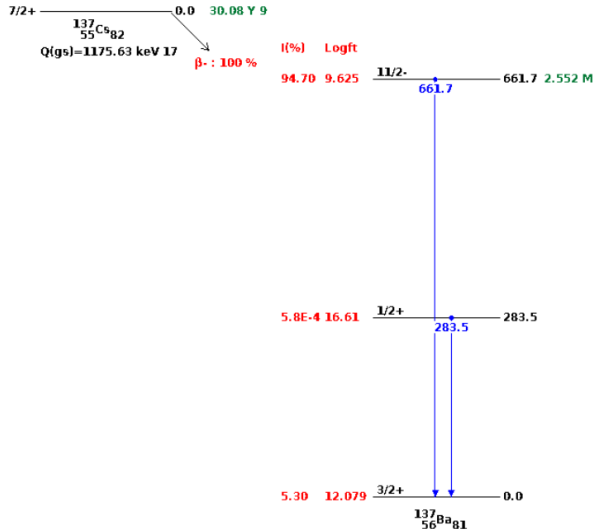


# Introduction & History of ENSDF

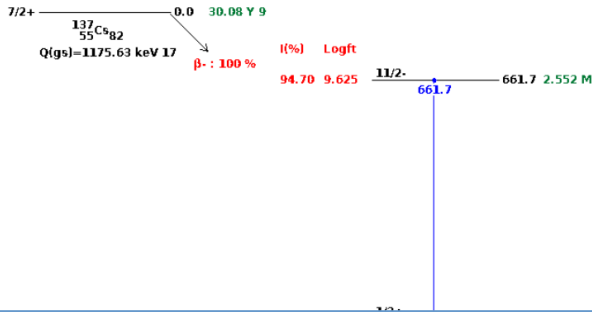
Paraskevi (Vivian) Dimitriou  
Nuclear Data Section,  
International Atomic Energy Agency,  
Vienna, Austria

# Evaluated Nuclear Structure Data File



- Half-lives, decay modes, branching ratios, decay radiation
- Levels, spins, parities, multipolarities, mixing ratios, conversion coefficients, moments, Q-values, transition strengths

# Evaluated Nuclear Structure Data File



- Half-lives, decay modes, branching ratios, decay radiation
- Levels, spins, parities, multipolarities, mixing ratios, conversion coefficients, moments, Q-

- Best recommended values
- Based on available experimental data

# Evaluation I

- **Compilation**

*“To compose out of materials from other documents”*

*(Marriam-Webster Dictionary)*

*serves as a convenient source of detailed information sorted, organised, and edited*

- **Evaluation**

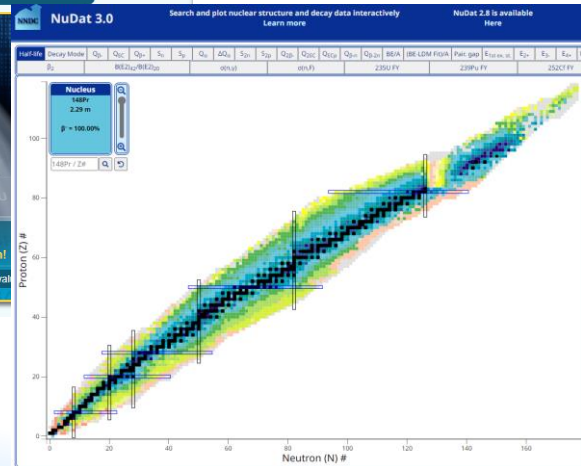
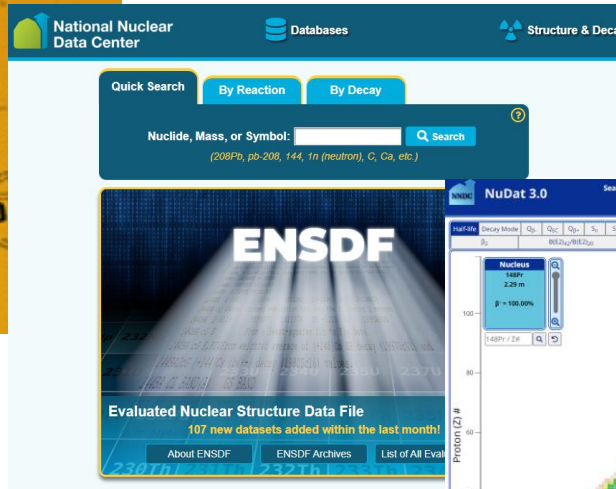
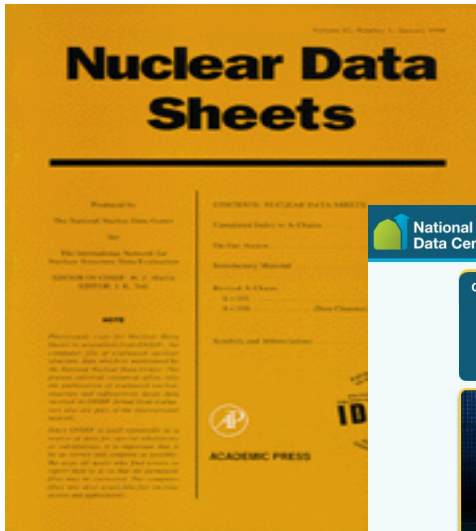
*“to determine the significance, worth, or condition of usually by careful appraisal; to assess”*

*(Marriam-Webster Dictionary)*

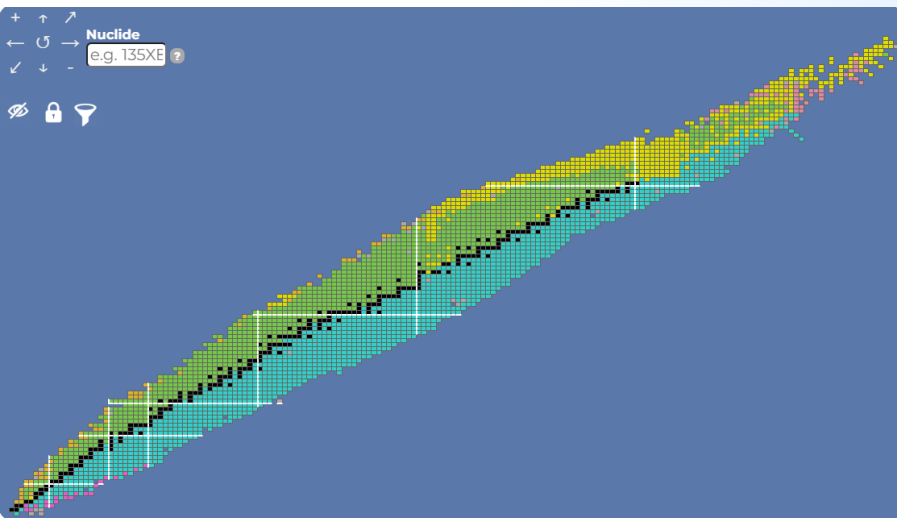
# Evaluation II

- A pre-requisite for an “evaluation” is to have an exhaustive “compilation”
- A good “compilation” usually involves an “evaluation”

# Where do we find ENSDF?



# Where else?



## Live Chart of Nuclides

nuclear structure and decay data ms: \*249\*  
email: nds contact point guide & sources

### Color zones by ?

☐ value ☒ quantile

### Main Decay Mode

- alpha
- EC+ beta+
- beta-
- p
- n
- EC
- SF
- Stable



### Mass chains

β and ec decays plotting



### Neutron Cross Sections

Resonance Integrals



### List of updates

From Nov 2021 to Apr 2022

- Click on a nuclide to fill the data tabs.
- Double click to bring it to the centre.
- Mouse: to move the chart drag  
Use the wheel to zoom
- Numeric keypad: zoom with 3 and 7  
Use 8, 6, 2, 4, 9, 1 to move and 5 to reset

## Isotope Browser for mobile



Live Chart of Nuclides  
for mobile phones

# ENSDF is also part of:

- Reference Input Parameter Library (RIPL)



## Reference Input Parameter Library (RIPL-3)

R. Capote, M. Herman, P. Oblozinsky, P.G. Young, S. Goriely, T. Belgya, A.V. Ignatyuk, A.J. Koning, S. Hilaire, V.A. Plujko, M. Avrigeanu, O. Bersillon, M.B. Chadwick, T. Fukahori, Zhigang Ge, Yinlu Han, S. Kailas, J. Kopecky, V.M. Maslov, G. Reffo, M. Sin, E.Sh. Soukhovitskii and P. Talou

*Nuclear Data Sheets - Volume 110, Issue 12, December 2009, Pages 3107-3214*

RIPL discrete levels database updated in **September 2020** - it contains the correction for +X,... levels

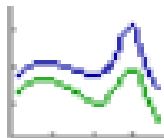


[Introduction](#) [MASSES](#) [LEVELS](#) [RESONANCES](#) [OPTICAL](#) [DENSITIES](#) [GAMMA](#) [FISSION](#) [CODES](#) [Contacts](#)

Discrete levels: energies, spin-parities, decay modes, branching ratios are taken from ENSDF



# ENSDF is also part of:

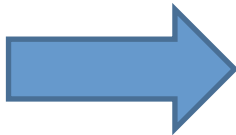


**ENDF**

Evaluated nuclear reaction libraries

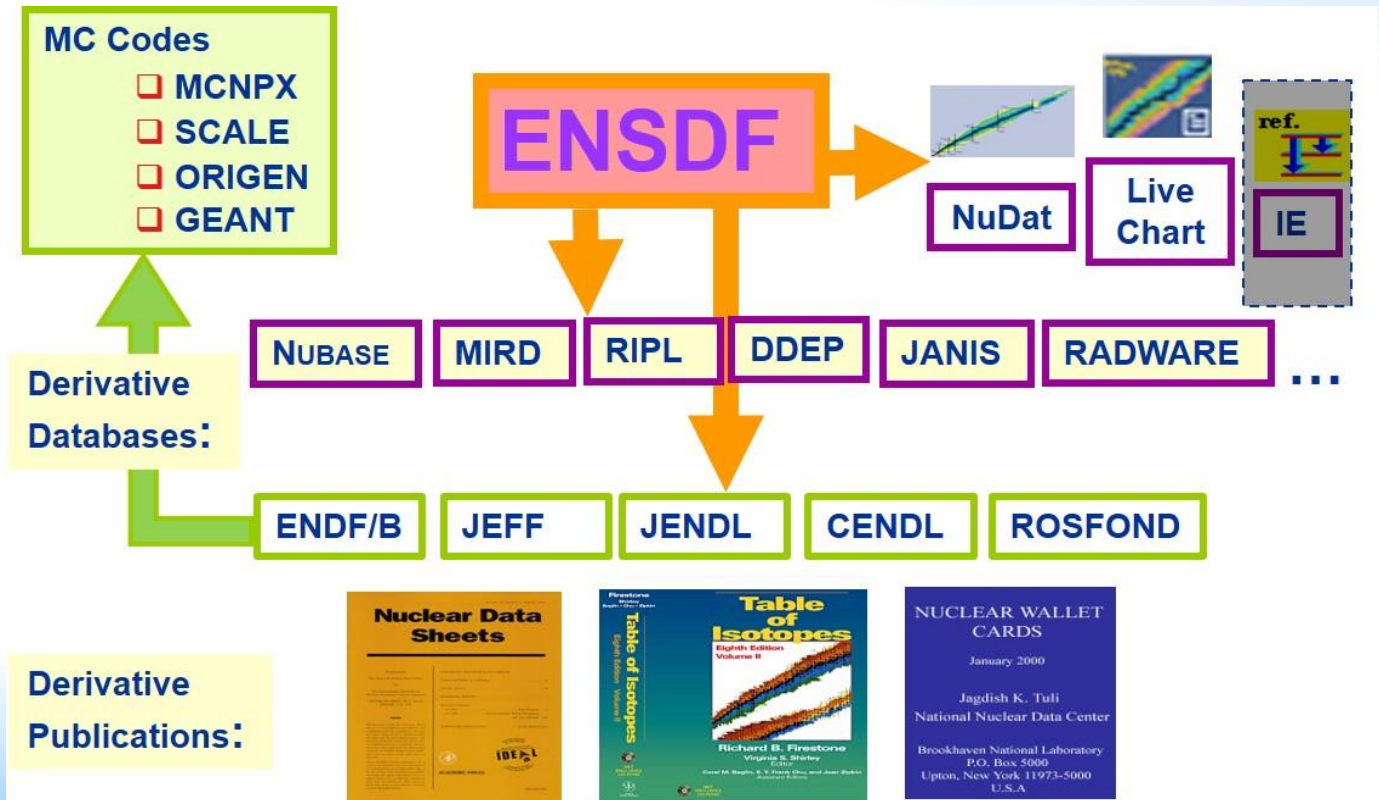
## Major Libraries

- 1) ENDF/B-VIII.0 (USA,2018)
- 2) JEFF-3.3 (Europe,2017)
- 3) JENDL-5 (Japan,2021)
- 4) JENDL-4.0u2 (Japan,2012)
- 5) CENDL-3.2 (China,2020)
- 6) BROND-3.1 (Russia,2016)
- 7) TENDL-2019 (TALYS, 2019)



Decay data sub-libraries  
containing decay radiation  
data for over 2000  
radionuclides

# ENSDF: Major Source for other Derivative Products



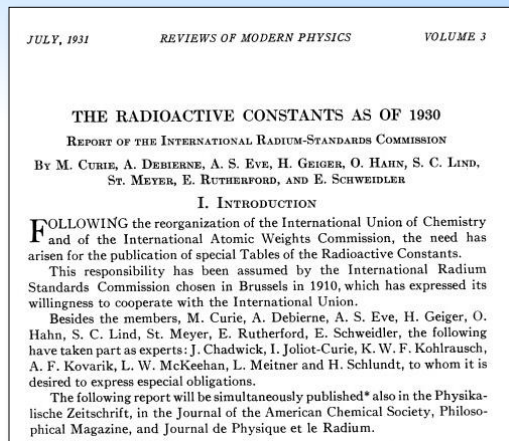


# History of Evaluation

## The Radioactive Constants as of 1930, Reviews of Modern Physics, 3, 427 (1931)

by M. Curie, A. Debierne, A.S. Eve, H. Geiger, O. Hahn,  
S.c. Lind, St. Meyer, E. Rutherford, and E. Schweidler

*Decay Half-lives, lifetimes, decay constants*

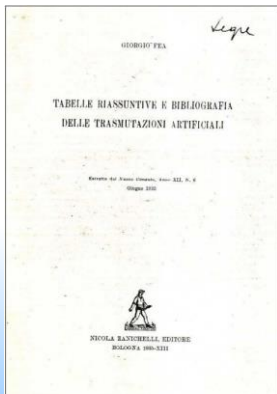


First Compilation of known nuclides:

## Tabelle Riassuntive E Bibliografia delle Transmutazioni Artificiali

Nuovo Cimento 6, 1 (1935)

by Giorgio Fea

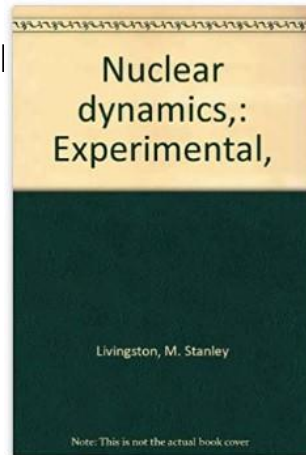


## Nuclear Dynamics, Experimental

Rev. of Modern Physics, 9, 359 (1937)

M. Stanley Livingston and H.A. Bethe

*Nuclide decay modes, half-life,  
decay energy, production*



# Table of Isotopes



- First evaluation as *Table of Isotopes* published by J.J. Livingwood and G. T. Seaborg  
Rev Mod Phys 12, 30 (1940)  
Evaluation was limited to Artificially Produced Nuclear Species – for use in identification of radionuclides and radiotracers
- Subsequent editions:
  - G.T. Seaborg, Rev Mod Physics 16, 1 (1944)
  - G.T. Seaborg, I. Perlman, *ibid.* 20, 585 (1948)
  - J. M. Hollander, I. Perlman, and G. T. Seaborg, *ibid.*, 25, 469 (1953)
  - D. Strominger, J.M. Hollander, G.T. Seaborg, *ibid.*, 30, 585 (1958)
- Subsequent editions of Table of Isotopes Published by John Wiley:
  - 6<sup>th</sup> Edition: C. M. Lederer, J. M. Hollander, and I. Perlman
  - 7<sup>th</sup> Edition: Editors: C. M. Lederer, V. S. Shirley;  
Principal Authors: E. Browne, J.M. Dairiki, R.E. Doebler;  
Authors: A.A. Shihab-Eldin, L.J. Jardine, J.K. Tuli, and A.B. Buyrn

# Table of Isotopes, last edition

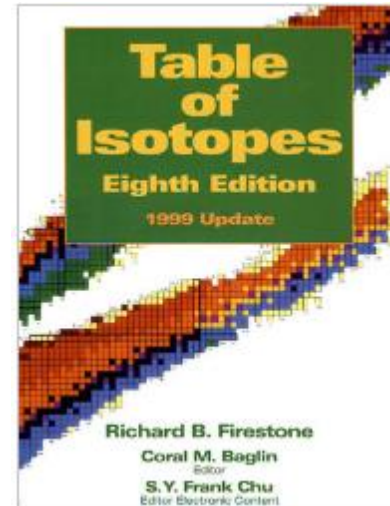
- 8<sup>th</sup> edition of Table of Isotopes  
published by John Wiley in two volumes, ~3000 pages+  
CD ROM

Editors: R.B. Firestone, V.S. Shirley

Assistant Editors: C.M. Baglin, S.Y. Frank Chu, J. Zipkin

Not an independent evaluation

Last update 1999



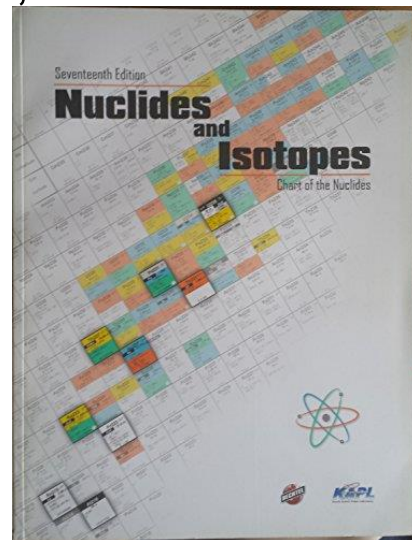
# Efforts around the world



- USA: light masses ( $A=2-20$ )  
T. Lauritsen (and later F. Ajzenberg-Selove) (1948-on)
- USSR:  
B.S. Dzhelepov (and later with L. Peker and others) (1950-on)
- Europe: mass  $A=20-40$   
P. M. Endt (and later with C. van der Leun) (1954 – on)
- Decay data for metrology - international  
**Decay Data Evaluation Project (DDEP)**

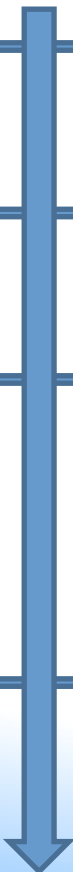
# Wall Charts

- First wall chart introduced by Emilio Segre, with Z along X axis and N along Y axis (published in LANL report, 1945)
- GE Wall Chart: first published in 1948 (G. Friedlander and M. Perlman) at GE Research Lab, with Z and N reversed.
- Knolls Atomic Power Lab published 17 editions since 1948 (17<sup>th</sup> in 2010)



# Nuclear Data Project – Nuclear Data Sheets



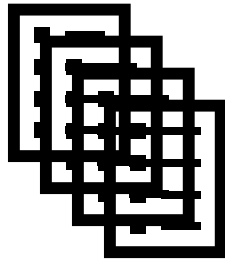
- 
- A large blue arrow pointing downwards, serving as a timeline axis. It has horizontal tick marks corresponding to the years 1940, 1948, 1950, and 1953.
- 1940 → • Manhattan project
    - Katherine Way starts collecting nuclear data at Clinton Lab (later ORNL)
  - 1948 → • Nuclear Data Project
    - Katherine Way, US National Bureau of Standards (later NIST)
  - 1950 → – **Nuclear Data report:**
    - Measured values (isotopic abundances; methods of production; neutron cross sections; half-lives; decay modes; energies and intensities of radiations; conversion coefficients; reaction data; decay schemes
    - No uncertainties or recommended values
  - 1953 → • Nuclear Data Project
    - US National Academy of Sciences-National Research Council, Washington, DC



# Nuclear Data Sheets

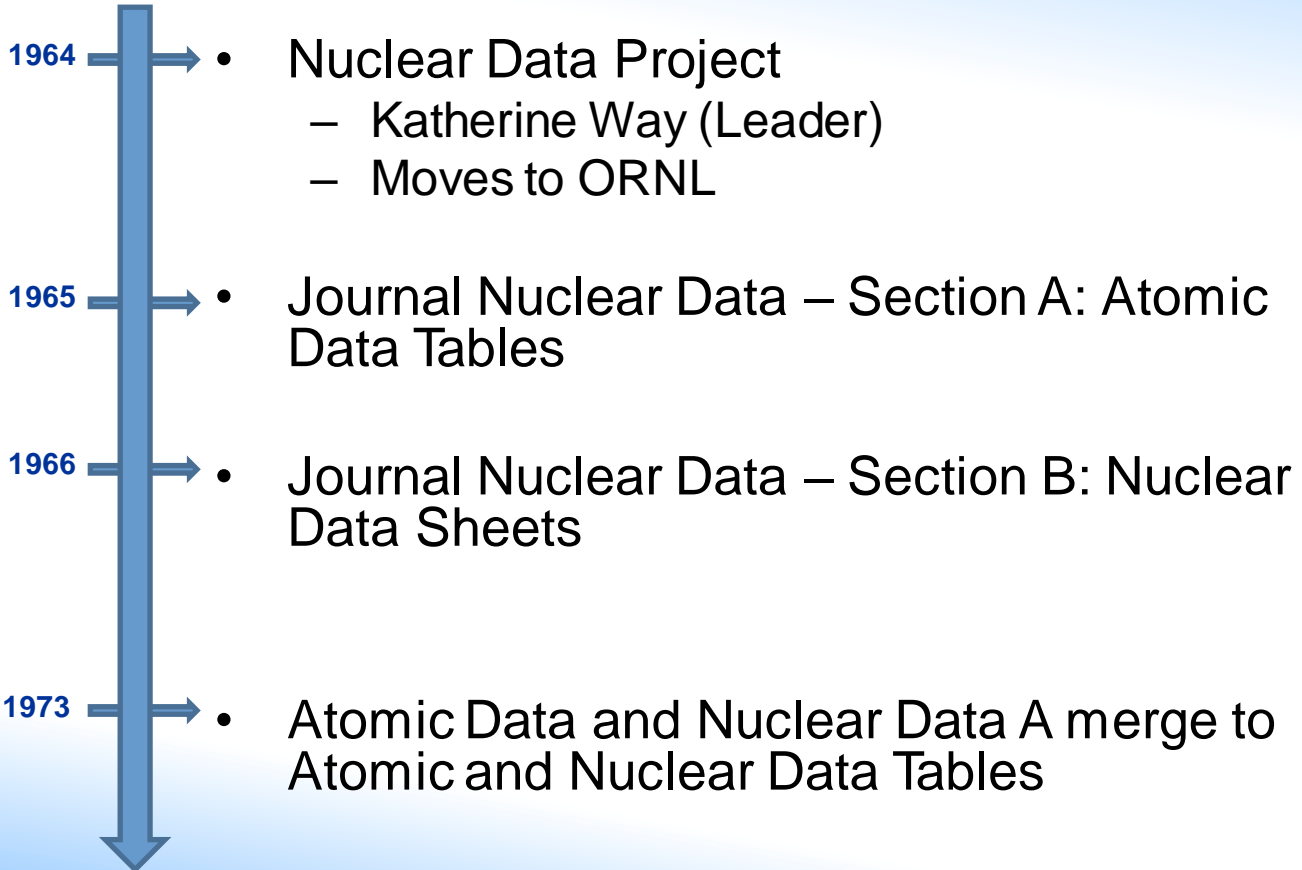
- AEC reports:

- coin, mass assignments, n-, p- separation energies, total disintegration energies, spins, magnetic and electric moments.
- Uncertainties were given.
- A single decay scheme for all isobars for given A.



The data were in form of loose-leaf  
pages called the  
“NUCLEAR DATASHEETS”

# Nuclear Data Sheets cont'



# US Nuclear Data Project → international cooperation

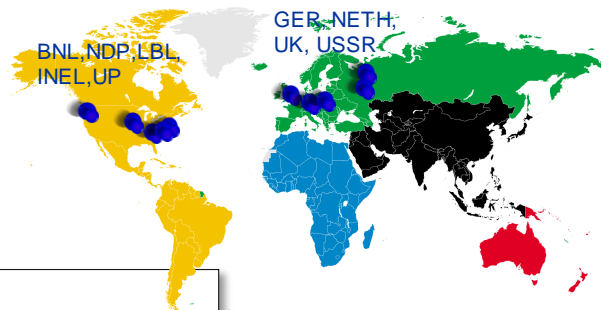


- Demands for nuclear data growing in 1970s'
- NSF/NAS created a 3-year program to train young PhD scientists (1971-1974)
- Several stayed in the evaluation business after the end of the program
- International cooperation proposed in 1974, under the auspices of the IAEA, Nuclear Data Section
- Adoption of internationally accepted rules of evaluation, processing codes, and formats for producing and disseminating NSDD recommended data

# International network: NSDD



- Creation of international network of Nuclear Structure and Decay Data evaluators (NSDD) in 1974 -1976
- Evaluation responsibility divided amongst various data centers within the US and internationally
- Common evaluation rules
- NNDC/BNL coordinates US effort  
and NDP/ORNL has leading role in editing and processing of evaluation
- IAEA/NDS coordinate the international effort



IAEA/NDS coordination

## POTENTIAL

- JAP
- SWE
- KUW
- IND
- GER

### IAEA Advisory Group Meeting

on

Nuclear Structure and Decay Data for Applications

Vienna, Austria, 3-7 May 1976

### SUMMARY REPORT

### Abstract

The IAEA Nuclear Data Section convened this Advisory Group Meeting on Nuclear Structure and Decay Data for Applications at IAEA Headquarters from 3 to 7 May 1976. The meeting was attended by 26 representatives from 13 countries and 2 international organizations.

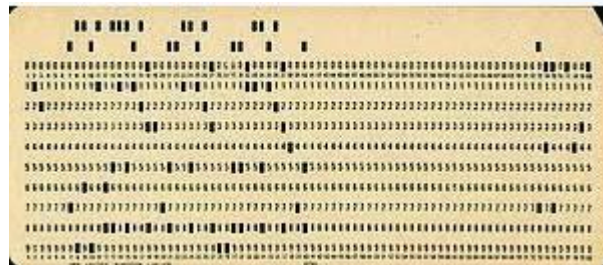
The objective of this meeting was the development of an internationally coordinated system for the compilation, evaluation and dissemination of nuclear structure and decay data. The meeting succeeded in agreeing on common formats for the exchange of bibliographic and numerical nuclear structure and decay data, in establishing an international file of evaluated nuclear structure and decay data to serve as a single source of these data for the benefit of the scientific community, and in setting up a world-wide network of data centres and groups for the systematic compilation and evaluation of mass-chain data.

INDC(NDS)-0079

# Computerized ENSDF – INTERNATIONALLY adopted file



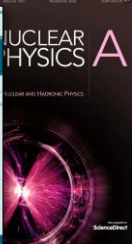
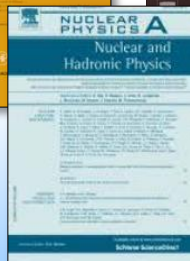
- Bruce Ewbank (NDP/ORNL) in 1970s:
  - Computerized references (Nuclear Structure References)
  - Computerized drawings
  - Evaluated Nuclear Structure Data File was born (80-column format)
  - Publication in Nuclear Data Sheets
  - Computer programs



```

148CE  ADOPTED LEVELS, GAMMAS                                14NDS  201404
148CE  H TYP=FULSAUT=N. NICA$CIT=NDS 117, 1 (2014)$CUT=1-Oct-2013$
148CE  Q 2137      13 6456  14 11009 15 -1056 13      2012WA38
148CE  DG CC$ FROM BrIcc v2.2b (20-Jan-2009) 2008Ki07, "Frozen Orbitals" appr.
148CE  CG E$FROM 148LA B- DECAY FOR TRANSITIONS NOT RELATED TO BAND STRUCTURES,
148CE2CG WHILE FOR IN-BAND AND INTER-BAND TRANSITIONS EG'S ARE
148CE2CG FROM 252CF SF DECAY; FOR LEVELS COMMON TO BOTH DATASETS, EG'S ARE FROM
148CE2CG 148LA B- DECAY
148CE CG RI          Relative photon branching from each level
148CE CL E          From a least-squares fit to EG data
148CE CL J$FROM 2006CH24 BASED ON PRESUMED ROTATIONAL-BAND STRUCTURE AND
148CE2CL SYSTEMATICS, UNLESS NOTED OTHERWISE
148CE CL J(G)$E2 G TO 0+ BAND MEMBER AND REGULAR BAND SEQUENCE
148CE CL J(G)        Gammas to 0+ and 2+
148CE CL BAND(A)$ K|p=0+ band, |a=+1.
148CE CL BAND(B)$ K|p=7- band, |a=+1.
148CE CL BAND(C)$ K|p=3+ band, |a=-1.
148CE CL BAND(D)$ K|p=4- band, |a=-1.
148CE CL BAND(E)$ Band based on 7.
148CE  XA148LA B- DECAY
148CE  XD149LA B-N DECAY (1.05 S)
148CE  XB252CF SF DECAY
148CE  XC235U(N,F) E=THERMAL
148CE  PN
148CE  L 0.0      0+      56.8 S      3
148CEX L XREF=ABC
148CE2 L %B=100
148CE CL T$WEIGHTED AVERAGE OF: 56 S 1 (1983AR15) AND 56.9 S 3 (2004K005).
148CE2CL Others: 48 S 1 (1974AR25), 45.1 S 5 (1986BU2V)
148CE CL $MEASURED |d<r(+2)> =1.089 FM(+2) |12| RELATIVE TO 144CE (2003CH60);
148CE2CL <r(+2)>(+1/2)=4.9911 FM 35 (2004AH14)
148CE L 158.467 5 2+      1.01 NS      6
148CEX L XREF=ABC
    
```

## Nuclear Data Sheets



## NUCLEAR WALLET

### CARDS

APRIL 2006

## NUCLEAR WALLET CARDS

October 2011

Jagdish K. Tuli

National Nuclear  
Data Center

[www.nndc.bnl.gov](http://www.nndc.bnl.gov)

Brookhaven National Laboratory

P.O. Box 500

Upton, New York 11973-5000

U.S.A.

# Workshops/meetings

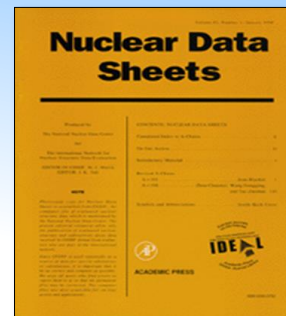


ENSDF-format Workshop, Oak Ridge 1978



ENSDF Workshop, JAEA, 1979

# Nuclear Data Sheets



1966 – 1968

Editor: K. Way

Asstt: A. Artna, N.B. Gove,  
W.B. Ewbank

1969 – 1976

Editor: D. Horen

Asstt. Editor: W.B. Ewbank

1976 – 1980

Editor: W.B. Ewbank

1981 – 1998

Editor-in-Chief: M. J. Martin

Editor: J.K. Tuli

1999 – 2016

Editor: J.K. Tuli

2016 –

Editor: E.A. Ricard-McCutchan

# Since 1980

- Production of Nuclear Data Sheets and complete computerized ENSDF evaluation process transferred over to NNDC/BNL in 1980-81
- NSDD network of evaluation groups has grown and changed over the decades
- IAEA coordination meetings organized biennially
- Developments in policies, formats, computer codes, and dissemination
- Establishment of training workshops



NSDD meeting, Utrecht, 1982



NSDD meeting, Karlsruhe, 1984



NSDD meeting, Ghent, 1988



# Joint IAEA-ICTP Workshops



2003



Since 2005, nearly all active ENSDF evaluators have been to an IAEA-ICTP Workshop

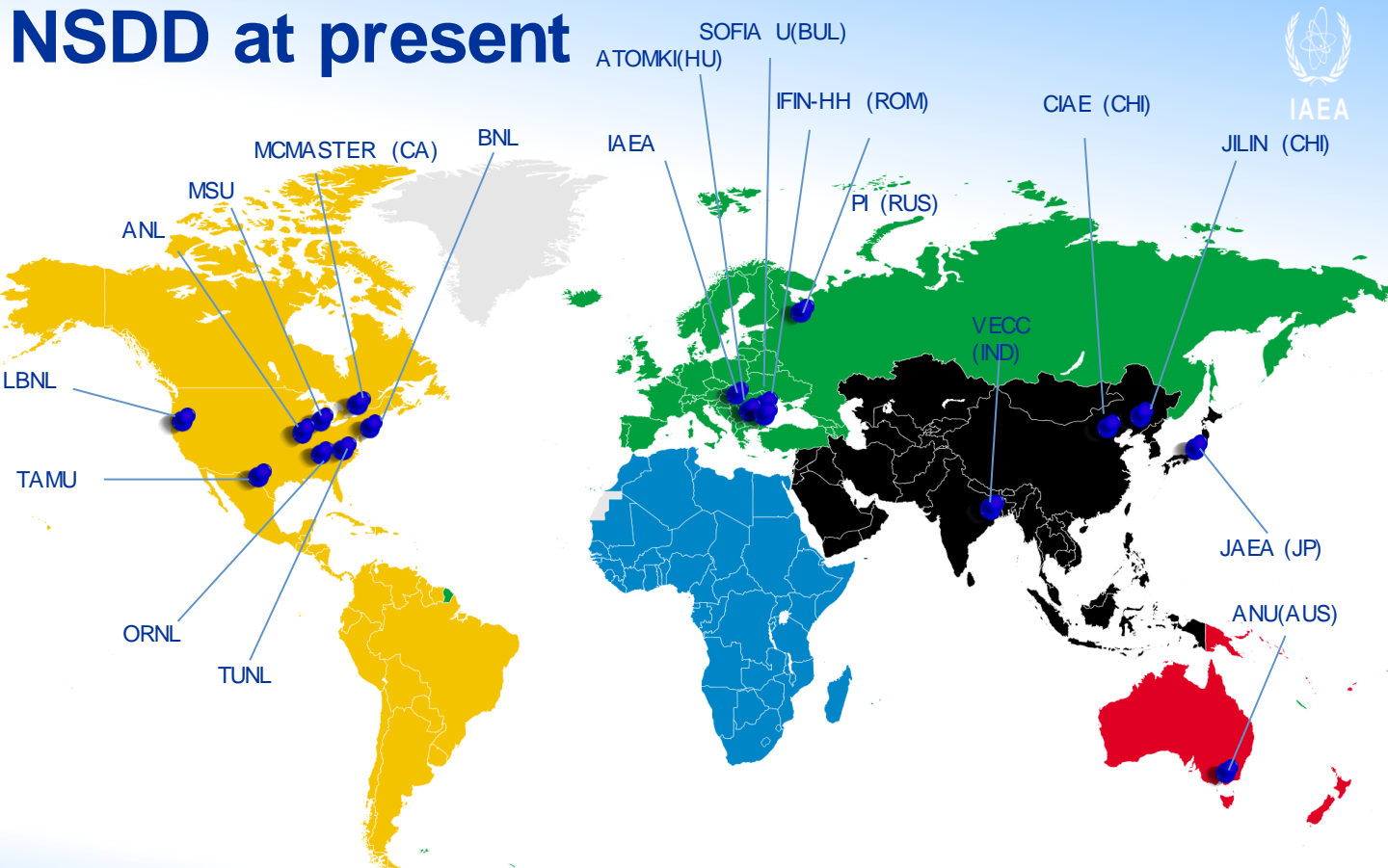
2007



2018

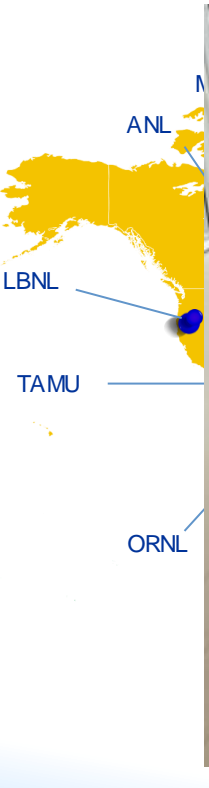


# NSDD at present



17 DATA CENTRES

# At present



ATOMKI(HU)

SOFIA U(BUL)

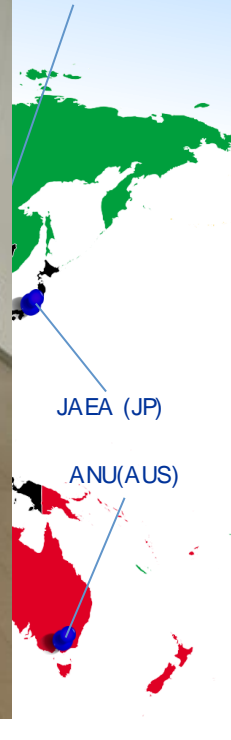
IFIN-HH (ROM)

CIAE (CHI)



IAEA

JILIN (CHI)



NSDD meeting, IAEA 2019

• 17 DATA CENTRES

# NSDD evaluation

- Vertical Mass chain A (ENSDF)  
<https://www.nndc.bnl.gov/ensdf/>

- mass chains A = 1 – 294 with available experimental data
- Updated: 10-year cycle
- Policies: January issue of Nuclear Data Sheets
- Computer codes: analysis and checking codes developed and maintained by NSDD Data Centers (ANU, MSU, NNDC, India, Canada) [https://www-nds.iaea.org/public/ensdf\\_pgm/](https://www-nds.iaea.org/public/ensdf_pgm/)

152Er	153Er	154Er	155Er	156Er	157Er	158Er
151Ho	152Ho	153Ho	154Ho	155Ho	156Ho	157Ho
150Dy	151Dy	152Dy	153Dy	154Dy	155Dy	156Dy
149Tb	150Tb	151Tb	152Tb	153Tb	154Tb	155Tb

- XUNDL – Experimental Unevaluated Nuclear Data Listing  
<https://www.nndc.bnl.gov/ensdf/xundl>

- Compilation of published experimental nuclear structure and decay data
- Use ENSDF format and ENSDF processing and checking codes

- NSR – Nuclear Science References <https://www.nndc.bnl.gov/nsr/>

- Bibliography of references on nuclear physics publications. Available online

- Horizontal evaluation:  
<https://www.nndc.bnl.gov/ensdf/evalcorner/horizonta/.html>

- Masses, Q-moments, charged-radii, log ft, B(E2), isomers, etc.
- Other projects: Nuclear Wallet Cards, AME/NUBASE, DDEP

# NSDD website



International Atomic Energy Agency

**Nuclear Data Services**

Секция Ядерных Данных МАГАТЭ

IAEA.org | NDS Mission | Mirrors: India | China | Russia

Go

Databases » ENSDF | XUNDL | NuDat | LiveChart | NSR | Nuclear Wallet Cards

Related » ENSDF Manuals | Codes | Nuclear Data Sheets | EXFOR

## Scientific Secretary

Paraskevi (Vivian)  
Dimitriou (IAEA)

## Members

Dave Brown (BNL)  
Elizabeth McCutchan  
(BNL)  
Filip Kondov (ANL)  
Jun Chen (FRIB/MSU)  
Lee Bernstein (LBNL)  
Michael Smith (ORNL)  
Ninel Nica (Texas A&M)  
John Kelley (TUNL)  
Tibor Kibedi (ANU)  
Stefan Lalkovski (Univ.  
Sofia)  
Bairaj Singh (McMaster)  
Ge Zhigang (CNCDC)  
Dong Yang (Univ. Jilin)  
Janos Timar (ATOMKI)  
Gopal Mukherjee (VCC)  
Hideki Timura (JAEA)  
Alexandru Negret (IFIN-  
HH)  
Ivan Mitropolsky (PNP)

## Evaluators / Advisors

Shamsuzzoha Basunia  
Caroline D. Nesaraja  
Alexander Rodionov  
Zsoltan Elekes  
Huang Xiaolong  
Sorin Pascu  
Jagdish K. Tuli  
Andrea Mattered  
Chris Morse  
Donnie Mason  
Benjamin Shu  
Boris Pritychenko  
Aaron M. Hurst  
Jon Batchelder  
Sukhjeet Singh Dhindsa  
Mohini Gupta



## INTERNATIONAL NETWORK OF NUCLEAR STRUCTURE AND DECAY DATA EVALUATORS (NSDD)

### 24th Technical Meeting of the NSDD network: 24-28 October 2022, Canberra, Australia

The 24th meeting of the NSDD network is being hosted by the Australian National University in Canberra, Australia, from 24 to 28 October 2022. Representatives of the data centers and affiliated evaluators will gather to discuss the current status of mass chain evaluations, evaluation responsibilities, and analysis and checking code needs, as well as ENSDF formats and policies. Priority activities for the subsequent two years will also be agreed.

The meeting is hosted by the Australian National University (Tibor Kibedi, Andrew Stuchbery). It is an in-person meeting with a virtual component. More information is available on the meeting website.

### NSDD Spring meeting: ENSDF Evaluations, Policies and Procedures, Codes and Dissemination Tools

A preparatory meeting for the upcoming 24th Technical Meeting of the NSDD network was held on 4-7 April 2022. The purpose was to discuss policy proposals, evaluation issues, codes and dissemination tools in view of taking final decisions at the 24th Technical Meeting in October 2022.

The meeting (virtual) was attended by 50 participants, members of the network and collaborating evaluators, from 13 Member States. The meeting presentations are available from the meeting website. The summary report is published in INDC(NDS)-0850.

### Updated Guidelines 2021

Updated guidelines for nuclear structure and decay data evaluators are available ORNL/TM-2022/1835. The revision of the guidelines started in 2015 at the [IAEA Specialized Workshop on Nuclear Structure and Decay Data Evaluations](#) and was completed and edited by Murray Martin (ORNL) in April 2021.

### New recommended electric quadrupole moments

Updated tables of recommended electric quadrupole moments have been published by N.J. Stone in [INDC\(NDS\)-0833](#). The data are available on the IAEA Nuclear Moments database.

### Status Reports of NSDD Data Centres May 2021

#	Author	Title	Link
1	D. Dimitriou	NDS/IAEA	PDF

## NSDD Network

About

Status of NSDD network  
List of NSDD network  
institutes and contacts

## Evaluation Tools

Online Webtools

(V. Zerkin)

Revised Guidelines for  
Evaluators, 2021

ENSDF Manual

ENSDF Procedures

Guidelines for ENSDF  
half-life evaluations

Specialized Workshop for  
NSDD Evaluators

ENSDF Codes

Improvement of ENSDF  
Codes

## NSDD Meetings

23rd Meeting 2019

22nd Meeting 2017

21st Meeting 2015

20th Meeting 2013

19th Meeting 2011

18th Meeting 2009

17th Meeting 2007

16th Meeting 2005

15th Meeting 2003

14th Meeting 2000

## Workshops on NSDD: Theory and Evaluation

IAEA-ICTP 2018

IAEA-ICTP 2016

IAEA-ICTP 2014

IAEA-ICTP 2012

IAEA-ICTP 2010

IAEA-ICTP 2008

IAEA-ICTP 2006

IAEA-ICTP 2005

Workshop 2003-part 2

Workshop 2003-part 1

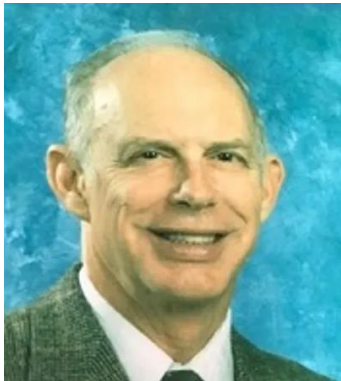
# ENSDF modernization

- Project to modernize ENSDF format and database (NNDC, BNL; PI: E.A. McCutchan): 2021 - 2023
  - New format (JSON)
  - New database structure – retrieval via APIs
  - Online Editor
  - AI/ML techniques to translate text to into data format

Almost 50 years since the introduction of the 80-column punch cards...Dawn of a new era?!



# Losses in 2022



**Murray Martin**

Passed away on 15 March 2022

One of the first ENSDF evaluators

Leader of NDP at ORNL

Editor of NDS

Author of the Guidelines for  
Evaluators

Log ft Tables (Gove and Martin)



**Edgardo Browne**

Passed away in May 2022

One of the widely acknowledged  
experts on decay data evaluation

Teacher and mentor

Table of Isotopes

# Sources

- Jagdish Tuli, Lectures at ICTP-IAEA Workshop 2012
- Richard Firestone, Lecture at ICTP Workshop 2003



*Thank you!*

