

# IAEA status report 2021-2022

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Energy Agency

# Status



- IAEA NSDD website – [continuously updated](#)
- Nuclear structure and decay databases –
  - Nuclear moments
  - Beta-delayed neutrons
  - Decay data portal
  - LiveChart/Nubase interactive chart (M. Verpelli)
  - [MyEnsdf Webtools](#), [X4-NSR pdf database](#) (V. Zerkin)
- Financial support
- Decay Data for Monitoring
- Training / meetings
- International contribution

# Nuclear Data Section



- Major overhaul of Nuclear Data web services
- New: web platform, back-end organization, structure and programming
- New front-end design
- Major databases shall not be touched (EXFOR, ENDF-interface, Live Chart, beta-delayed neutron, etc)
- Coming soon....

# Nuclear Structure & Decay Database



IAEA.org | NDS MI

Search

International Atomic Energy Agency

## Nuclear Data Services

Секция Ядерных Данных МАГАТЭ

Hot Topics » IAEA-CIELO » TENDL-2019 » JENDL-5 » ENDF/B-VIII.0 News » Pointwise2020/TENDL-2019

### Download

Download data

### Quick Links

ADS-Lib

Atomic Mass Data

Centre

Beta-delayed neutrons

CINDA

Charged particle reference cross section

CoNDERC

DICEBOX

DR05G-2000

DXS

Decay Data Library for Actinides

EMPIRE-3.2

EMPIRE-3.2

ENDF Archive

ENDF Retrieval

ENDF-6 Codes

ENDF-6 Format

ENDVER

ENSDF

ENSDF ASCII Files

ENSDF programs

EPICS Electron & photon interaction data

NEW

**JENDL-5** Japanese evaluated nuclear data library, 2021: [page] [download] [list] [retrieve]  
**GRUCON-2021** ENDF data processing code package (includes source code): [page] [download]  
**Empire-3.2.2/2021.11** - nuclear reaction model code system for data evaluation [page]  
 **$\beta$ -delayed neutrons** reference database for beta-delayed neutron emission [page]  
**TALYS** nuclear reaction model code; TALYS-related software and databases [page]

Main | All | Reaction Data | **Structure & Decay** | by Applications | Doc & Codes | Index | Events | Links | News



### EXFOR

Experimental nuclear reaction data



### LiveChart of Nuclides

Interactive Chart of Nuclides



### ENDF

Evaluated nuclear reaction libraries



### ENSDF

evaluated nuclear structure and decay data (+XUNDL) \*\*



### CINDA

Nuclear reaction bibliography



### NSR

Nuclear Science References \*

### NuDat-2

selected evaluated nuclear structure data \*\*

### RIPL

reference parameters for nuclear model calculations

### IBANDL

Ion Beam Analysis Nuclear Data Library

### Charged particle reference cross section

Beam monitor reactions

### PGAA

Prompt gamma rays from neutron capture

### FENDL

Fusion Evaluated Nuclear Data Library

### Photonuclear

- IAEA Photonuclear Data Library, 2019  
- EPICS Electron & Photon Interaction Data, 2017

### IRDF-11

International Reactor Dosimetry and Fusion File

### NAA

Neutron Activation Analysis Portal

### Safeguards Data

Last updated: May 2021

### Medical Portal

- Medical Radiotopes Production, 2015  
- Medical isotope browser, 2019

### Standards

- Neutron cross-sections, 2017  
- Decay data, 2005

\*Database at the IAEA, Vienna

\*\*Database at the US NNDCC

### IAEA Nuclear Data Section



IAEA-NDS Mission



A-M Atomic and Molecular Data



Meetings and Workshops



Newsletters



Coordinated Research Projects



Nuclear Reaction Data Center Network



Nuclear Structure & Decay Data Network



International Network of Nuclear Data Evaluators



Technical Documents INDC Reports Publications



Computer Codes



IAEA-NA Department of Nuclear Sciences and Applications

# Nuclear Moments Database

<http://www-nds.iaea.org/nuclearmoments>



Main All Reaction Data **Structure & Decay** by Applications Doc & Codes Index Events Links News

## Structure and Decay Data



**NSR**  
Nuclear Science References \*



**ENSDF**  
evaluated nuclear structure and decay data (+XUNDL) \*\*



**NuDat-2**  
selected evaluated nuclear structure data \*\*



**LiveChart of Nuclides**  
Interactive Chart of Nuclides



**Decay Data Library for Actinides**  
Evaluated data with detailed comments and decay schemes



**Nuclear Electromagnetic Moments**  
Experimental and recommended nuclear moments



**MIB**  
Medical isotope browser



**Beta-delayed neutrons**  
Reference Database for Beta-Delayed Neutron Emission

## Miscellaneous

[ENSDF and NSR Manuals](#) - ENSDF Feb. 2001 version & NSR Aug. '96 version

[ENSDF programs](#) - ENSDF Analysis and Utility programs (ALPHAD, LOGFT, etc.)

[ICTP Workshops](#) - workshop material, codes, programme, etc.

[International network of Nuclear Structure and Decay Data evaluators](#) - the NSDD network

[ENSDF ASCII Files](#) - Evaluated Nuclear Structure Data File in raw (ASCII) format

## Medical Portal

- Medical Radioisotopes Production, 2015

- Medical isotope browser, 2019

IAEA CRP

IAEA CRP

IAEA CRP

# Nuclear Moments Database

<http://www-nds.iaea.org/nuclearmoments>



## NUCLEAR ELECTROMAGNETIC MOMENTS

The present compilation includes experimental information on nuclear magnetic dipole and electric quadrupole moments found in print compilations (such as INDC(NDS)-0650, INDC(NDS)-0658 etc), the ENSDF nuclear database, peer-reviewed journals, international conferences and other resources. The online interface was created by Theo J. Mertzimekis under the IAEA auspices.

**New:** Recommended magnetic dipole moments for long-lived states (INDC(NDS)-0794) and short-lived states (INDC(NDS)-0816), and recommended electric quadrupole moments (INDC(NDS)-0833) are available on the database. The recommended tables have been produced by N.J. Stone. Detailed discussion with Karel Jackowski (diamagnetism), Pekka Pyykko (electric field gradient computation data) and Andrew Stuchbery (transient field calibration) is gratefully acknowledged.



Periodic Table

Z-Helix

Elementary Particles

CSV file with recommended nuclear dipole moments

CSV file with compiled nuclear moments

DISCLAIMER

Help

Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	1 H																	2 He
Period 1	H																	He
	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne
2	Li	Be											Al	Si	P	S	Cl	Ar
	11 Na	12 Mg																
3	Na	Mg																
	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr
4	K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe
5	Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
	55 Cs	56 Ba	* 71 Lu	72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
6	Cs	Ba	* Lu	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
	87 Fr	88 Ra	** 103 Lr	104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og
7	Fr	Ra	** Lr	Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Nh	Fl	Mc	Lv	Ts	Og

Z:  Search

A:  Reset

*Lanthanides	* 57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb
**Actinides	** 89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No

# Nuclear Moments Database

<http://www-nds.iaea.org/nuclearmoments>



Periodic Table

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CSV file with recommended nuclear dipole moments

CSV file with compiled nuclear moments

DISCLAIMER

Help

## Chromium (Z=24)

[49Cr](#) [50Cr](#) [51Cr](#) [52Cr](#) [53Cr](#) [54Cr](#)

### Recommended<sup>†</sup> magnetic dipole moments

Isotope	Energy [keV]	$t_{1/2}$	Spin/Parity	$\mu$ [nm]	Method	Recommended Tables
<sup>52</sup> Cr	1434	0.783 ps	2+	+2.4(4)	TF	<a href="#">INDC(NDS)-0816</a>

### Recommended<sup>†</sup> electric quadrupole moments

Isotope	Energy [keV]	$t_{1/2}$	Spin/Parity	Q [b]	Method	Recommended Tables
<sup>52</sup> Cr	1434	0.783 ps	2+	-0.08(2)	ES	<a href="#">INDC(NDS)-0833</a>

Currently: compiled tables are being updated  
More from Nick Stone

### Compiled<sup>†</sup> magnetic dipole and electric quadrupole moments from published articles

Isotope	Energy [keV]	$t_{1/2}$	Spin/Parity	$\mu$ [nm]	Q [b]	Ref. Std	Method	NSR keyword	doi
<sup>52</sup> Cr	1434.	0.707 ps	2 <sup>+</sup>	+2.41(13)			TF	<a href="#">2000ER06</a>	<a href="#">10.1103/PhysRevC.62.024305</a>
				+3.0(5)		[ <sup>56</sup> Fe 847.]	TF	<a href="#">1987ST07</a>	<a href="#">10.1007/BF02396850</a>
				+3.2(22)			TF	<a href="#">1987PA28</a>	<a href="#">10.1103/PhysRevC.36.2088</a>
					-0.08(2)		ES	<a href="#">1989RA17</a>	<a href="#">10.1016/0092-640X(89)90008-9</a>
								<a href="#">2013STZZ</a>	

<sup>†</sup> Recommended magnetic moments are for the bare nucleus with published results corrected consistently for diamagnetism (including error estimate). Where appropriate published results are also adjusted to the most recent adopted half-life for the state. Recommended quadrupole moments are adjusted using the best electric field gradient calculation for the system concerned. For details see the Reports referenced.

<sup>‡</sup> In this listing published results are given without adjustment or correction.



# Reference Database for Beta-Delayed Neutron Emission

Produced by IAEA Coordinated Research Project (2013-2018): CRP Publication

## Microscopic Database

Contains compiled experimental beta-decay half-lives, beta-delayed neutron emission probabilities and beta-delayed neutron emission spectra for individual precursors. Provides recommended values, and results from systematics and global models.

Individual Precursors

Publication on  $Z \leq 28$

Publication on  $Z > 28$

## Macroscopic Database

Contains compiled and evaluated total delayed neutron yields (nubar), composite delayed neutron spectra, compiled and recommended 6- and 8-group parameters.

Total Delayed Neutron Yields

Group Spectra

Delayed Neutron Spectra

Group Parameters

Publication on integral delayed neutron spectra

Publication on new total delayed-neutron yields

## Documents and Links

INDC reports

CRPs/DDPs webpages

INDC(NDS)-0735

Reference Database for Beta-Delayed Neutron Emission (2013-2018)

INDC(NDS)-0683

Total Absorption Gamma-ray Spectroscopy Meeting 2018

INDC(NDS)-0643

Fission Product Yields Meeting 2016

INDC(NDS)-0599

Total Absorption Gamma-ray Spectroscopy Meeting 2014

INDC(NDS)-0107/G

CRP on Updating the fission yield data for applications (Ongoing)



# Beta-delayed neutron microscopic database: update Feb. 2022



- $Z > 28$  data from Liang et al. 2020 (2020Li32)
  - $Z > 28$  new published data in period Aug. 2020 – Jan. 2022 (B. Singh):
    - PRL, PRC, PL-B, EPJ-A, NP-A, JP-G, ARI
    - Revised  $T_{1/2}$ ,  $P_n$  values for **56** bDN emitters
1. 2021Ha19: O. Hall et al., Phys. Lett. B **816**, 136266 (2021): B-RIKEN: 115,116Tc, 116-121Ru, 118-124Rh, 121-128Pd, 124-129Ag, 127-130Cd: 33 nuclides: half-lives and  $P_n$ .
  2. 2021Su01: T. Sumikama et al., Phys. Rev. C **103**, 014614 (2021): RIKEN: 101Br, 102Kr, 105,106Rb, 108Sr, 110,111Y, 114Zr, 117Nb: nine new neutron-rich nuclides identified, no half-lives available, expected to be B-n emitters.
  3. 2021Mi07: A.J. Mitchell et al, Phys. Rev. C **103**, 024323 (2021): CARIBU-ANL: 106Nb:  $T_{1/2}$ .
  4. 2021Mo10: B. Moon et al., Phys. Rev. C **103**, 034320 (2021): RIKEN: 137,138Sb: half-lives,  $P_n$  and  $P_{2n}$ .
  5. 2021Ga10: F.H. Garcia et al., Phys. Rev. C **103**, 024310 (2021): TRIUMF: 129In: g.s. and three isomers: half-lives of all the four activities; B-n decay mode seen but no  $P_n$  value extracted
  6. 2021Pi11: M. Piersa-Silkowska et al., Phys. Rev. C **104**, 044328 (2021): ISOLDE-CERN: 134,135In: half-lives,  $P_n$ ,  $P_{2n}$ , possible observation of B-3n for 135In decay.
  7. 2021Ba34: J.C. Batchelder et al., Phys. Rev. C **104**, 024308 (2021): ORNL: 125,125mAg: half-life,  $P_n$ .
  8. 2021Wa49: H. Watanabe et al., Phys. Lett. B **823**, 136766 (2021): RIKEN: 127mAg: half-life.
  9. 2021Te02: D.A. Testov et al., Eur. Phys. Jour. A **57**, 59 (2021): TETRA-ALTO: 123Ag: half-life,  $P_n$ .
  10. 2020Ju02: A. Jungclaus et al., Phys. Rev. C **102**, 034324 (2020): RIKEN: 136,137,138Sn: half-lives,  $P_n$ .
  11. 2020Wh02: K. Whitmore et al., Phys. Rev. C **102**, 024327 (2020): TRIUMF: 132In: half-life,  $P_n$ .

# Beta-delayed neutron microscopic database cont'd



- Future updates:
  - $Z > 28$ :
    - Update the numerical file
    - Incorporate new global RHF+QRPA – Hauser-Feshbach calculations: F. Minato et al., PRC 104, 044321 (2021)
  - $Z < 28$
- Plans to engage new evaluator for future updates – first training with Balraj

# Beta-delayed neutron macroscopic database



- Recommended constants with correlations:

*Nucl. Data Sheets 173 (2021) 144*

*INDC(NDS)-0784 (reference DN data)*

*Piksaikin et al., EPJ Nuclear Sci. Technol. 6,54  
(2020)*

- Include uncertainties in composite DN spectra:

*INDC(NDS)-0849*

- Derive DN group spectra from composite spectra:

*INDC(NDS)-0849*

# Financial support



- Contracts for mass chain evaluations:
  - Sorin Pascu (ROM): mass chain  $A=130$  (post-review), 118 renewed 2019,2020; ended in 2021
  - *Anagha Chakraborty (IND): in preparation*
- Contracts for horizontal evaluations:
  - Nick Stone (2018-2022):
    - Evaluation of Magnetic Dipole Moments for Long-lived states: INDC(NDS)-0794 (2019)
    - Evaluation of Magnetic Dipole Moments for Short-Lived states: INDC(NDS)-0816 (2020)
    - Tables of recommended Electric Quadrupole Moments: INDC(NDS)-0833 (2021)
    - *Updated Compilation Tables of Nuclear Moments: ongoing*
  - Balraj Singh (2022): Updates of beta-delayed-neutron data ( $Z>28$ )
    - Uploaded onto database

# Meetings

- 24<sup>th</sup> TM: Canberra, Australia, 2022 (ANU)
  - Host Government agreement; website; nominations-invitations (30 participants; 15 in person); agenda
- Joint IAEA-ICTP NSDD Workshop 2022
  - 2 weeks: 3 – 14 October 2022; student selection; lecturers; program; lecture & exercises supervision; management
- Meeting on Decay Data for Monitoring Applications
  - 18 – 22 July 2022; reports, deadlines
  - Presentation at ND2022

# Decay Data for Monitoring Applications, 18 – 22 July 2022



- 3 in-person (Kibedi, Kondev, Tuli, Verpelli); 5 remote (Chen, Negret, Nichols, Singh)
- Report in preparation
- Deadlines for submitting evaluations
- Deadlines for reviews
- Project deadline for evaluations: Dec. 2023
- Publication: 2024
- For 28 priority 1 fission product radionuclides

# Decay Data for Monitoring Applications



- Continuous project:
  - CTBTO priority nuclides: 42 fission products + 42 activation products
  - Aim to continue and produce adopted decay data sets for all these radionuclides
  - Revise other decay data files produced by IAEA CRPs (medical, dosimetry)
  - Create IAEA Adopted decay Data Library
  - Data files will be publicly available on GitHub and via interface and APIs
  - Effort will be partially funded

# International effort



- Japan support letter sent to Director of Division of Nuclear Fuel Safety
- To do (2023):
  - Webinar on nuclear structure and decay data in
    - Japan
    - Europe
- European Nuclear Structure Long Range Plan
  - Contact made to present nuclear data case



# Meetings/workshops 2023



- Technical Meeting on Nuclear Data for Antineutrino Spectra Calculations
  - 16-20 January 2023
- IAEA Advanced Workshop for ENSDF Evaluators
  - Dates to be determined - Doodle

# Coordinated Research Projects (ongoing)



- CRP on RIPL Fission Cross Sections
  - Improve input parameters for fission cross-section calculations (masses, fission barriers, saddle-point level densities)
  - 4 meetings; ending in 2024
- CRP on Updating Fission Yield Data for Applications
  - Started: 2020
  - Compilation of all available FY data; modelling of FYs; new evaluations of FYs of major actinides; validation of new evaluated FY files
  - 2<sup>nd</sup> meeting 19-23 December 2022



**IAEA**

International Atomic Energy Agency  
*Atoms for Peace and Development*

*Thank you!*

