# IAEA-Nuclear Data Section Status Report

NSDD Scientific Secretary:
Paraskevi (Vivian) Dimitriou: 2017 - present

# Nuclear Data Section

Section Head: **A.J. Koning**
Nuclear Physicist

Deputy Section Head: **R. Capote Noy**
Nuclear Physicist

Section Secretary & team assistant: **R. Rangel Alvarez**

| Nuclear Data Services Unit | Nuclear Data Development Unit | Atomic & Molecular Data Unit |
|---|---|---|
| **J.C Sublet**<br>Unit Head/Nuclear physicist | **R. Capote Noy**<br>Unit Head/Nuclear physicist | **C. Hill**<br>Unit Head/Atomic physicist |
| **V. Zerkin**<br>Software Engineer | **A. Trkov**<br>Nuclear Physicist | **K. Heinola**<br>Atomic Physicist |
| **N. Otsuka**<br>Nuclear Physicist | **P. Dimitriou**<br>Nuclear Physicist | **L. Marian (1 April 2019)**<br>IT Systems Engineer |
| **S. Okumura (Sep 1 2018)**<br>Nuclear Physicist | **K. Nathani**<br>Team Assistant | **M. Verpelli**<br>Nuclear Data Analyst/Programmer |
| **L. Vrapcenjak**<br>Nuclear Data Services Assistant | | **M. O'Connell** (25%)<br>Applications Programmer |
| **A. Oechs**<br>Team Assistant | | |

# Nuclear Data Section efforts

- Coordination – Europe, Japan, India
- Organisation of meetings (NSDD, TAGS, ENSDF Codes, Anti-neutrinos)
- Training (Joint IAEA-ICTP Workshop on NSDD, 15-26 Oct. 2018)
- Technical support: codes, editors, web tools
- Financial support
- Coordinated Research Projects (Medical isotopes, beta-delayed neutrons, photonuclear data, new FY data) and Data Development Projects (Nuclear Moments, Decay Data for Monitoring Applications)
- Dissemination tools (Live Chart, Medical Portal, Decay Data Portal)
- Bibliography access (NSR+EXFOR PDF database)

# Coordination: Data Centers

- INDIA (discussions on shift of DC) –Tuesday
- Japan:  JAEA (future), RIKEN
- *China – organize a meeting at ND2019?*
- *Europe – Collaboration with NuPECC (continue), NuPECC Long Range Plan (done)*

# Data for Decay Heat, Anti-neutrino spectra calculations

- CM on Updating data needs for TAGS measurements, 19-21 February 2018, IAEA
  - Update tables of high-priority nuclides for TAGS measurements (and HR-Ge) based on recent comprehensive inventory calculations (UKAEA reports) on a variety of fuel cycles and energies and irradiation times
    - U-233, 234, 235; Pu-238, 239, 240; Am-241, 242; Cm-243, 244, 245 etc;
    - Over 100 contributing fission fragments identified and assessed for the decay data
  - Assess impact of new TAGS measurements on decay heat calculations, anti-neutrino spectra and beta-delayed neutron yields (in progress)
  - *Publication in preparation*

Participants: Nichols, Algora, Kondev, Yoshida, Tain, Rykaczewski, Fallot, Sonzogni

# Assessment of Decay Data: over 100 fission product decay data assessed

**Table Y. Fission-product Decay Data: Assessment of Potential Pandemonium and Need for Further TAGS and γ-ray Studies.**

Relevant references in the literature are listed in NSR keynumber format (e.g., 2017Fi06 (real/exists), 2016ORNL (artificial)).
(a) Δ (keV) = (Q-value – energy of highest known relevant nuclear level); (b) $S_n$ (keV) neutron separation energy of daughter nucleus = – M(A,Z) + M(A–1,Z) + n; (c) d-n → delayed neutrons from ($\beta^-$n) decay;
(d) Request for specific measurements denoted by √; (e) Priorities defined as 1 → high priority, 2 → intermediate priority, 3 → low priority, – unassigned.

| Fission product | $J^\pi$ | Half-life 2017Au13 | Q($\beta^-$) (keV) 2017Wa10 | Δ (keV) | $S_n$ (keV) 2017Wa10 | Assessment of potential Pandemonium | γ singles + γ–γ coin. | TAGS | Priority |
|---|---|---|---|---|---|---|---|---|---|
| 35-Br-86 | (1–) | 55.1 (4) s | 7633 (3) | 865 (3) | 9856.7 (20) | $^{235}$U (100 s, 3.9%γ, 2.7%β, 3.3%) – issue of impact of d-n emissions at short cooling times; only 18 β-decay levels populated by β-decay when many higher-energy levels are known – potential for Pandemonium effect. Existing TAGS studies support existence of Pandemonium; need for more extensive γ and γ–γ coincidence measurements (2014Fi09, 2016Ka, 2017Fi06, 2017Ri08). | √ | – | 2 |
| 35-Br-87 | (5/2–) | 55.65 (12) s | 6818 (3) | 1025 (3) | 5515.17 (25) | $^{235}$U (100 s, 3.9%γ, 2.2%β, 3.1%) – issue of impact of d-n emissions at short cooling times; 139 levels populated by β-decay, plus evidence of numerous and relevant higher-energy levels from $^{86}$Kr(n,x) studies – potential for Pandemonium effect. Existing TAGS studies support existence of Pandemonium; significant need for more extensive and supportive γ and γ–γ coincidence measurements (2014VaZZ, 2015Ta17, 2016ORNL, 2017Va04). $^{87}$Br($\beta^-$n) = 0.0260 (4) | √ | – | 2 |
| 35-Br-88 | (1–) | 16.34 (8) s | 8975 (4) | 1976 (4) | 7053.1 (26) | $^{235}$U (10 s, 2.7%γ, 2.0%) – issue of impact of d-n emissions at short cooling times; 59 levels populated by β-decay with little evidence of higher-energy levels – potential for Pandemonium effect. Existing TAGS studies support existence of Pandemonium; significant need for more extensive and supportive γ and γ–γ coincidence measurements (2015Ta17, 2016Ag03, 2016ORNL, 2017Va04). $^{88}$Br($\beta^-$n) = 0.0658 (18) | √ | – | 2 |
| 36-Kr-87 | 5/2+ | 76.3 (5) min | 3888.27 (25) | 64 (8) | 9922.11 (20) | $^{235}$U (5011 s, 4.2%β, 2.7%), (10000 s, 2.0%γ, 4.9%β, 3.1%), $^{240}$Pu (10000 s, 2.3%β); 14 levels populated by β-decay, but also evidence for other appropriate levels – potential for some Pandemonium, although most likely to be of little to no direct impact (2016ORNL). | – | – | – |
| 36-Kr-88 | 0+ | 2.825 (19) h | 2917.7 (26) | 147 (3) | 6082.52 (16) | $^{235}$U (5011 s, 3.7%γ, 2.7%), (10000 s, 6.7%γ, 4.8%), $^{238}$Pu (10000 s, 2.6%γ), $^{240}$Pu (10000 s, 2.4%γ); 24 levels populated by β-decay, but also evidence for other appropriate levels – potential for some Pandemonium, although most likely to be of little to no direct impact (2016ORNL). | – | – | – |
| 36-Kr-89 | 3/2(+) | 3.15 (4) min | 5177 (6) | 491 (6) | 7175 (5) | $^{235}$U (100 s, 3.2%γ, 2.8%β, 3.0%) – issue of impact of d-n emissions at short cooling times; 57 levels populated by β-decay, with no evidence for the existence of other appropriate levels – while evidence for Pandemonium effect is sparse, TAGS has revealed an impact factor of over two decrease in β feeding to the $^{89}$Rb ground state from 23(4)% to 11(1)% (2014Fi11, 2017Fi06). | – | – | – |
| 36-Kr-90 | 0+ | 32.32 (9) s | 4405 (7) | 524 (7) | 5723 (8) | $^{235}$U (100 s, 2.4%γ, 2.8%β, 2.6%) – issue of impact of d-n emissions at short cooling times; 32 levels populated by β-decay, with no direct evidence for the existence of any other appropriate levels – while support for Pandemonium effect is extremely sparse, TAGS has revealed a significant impact factor of over four decrease in β feeding to the $^{90}$Rb ground state from 29(4)% to 7(1)% (2017Fi06). | – | – | – |

# ENSDF Codes

- CM on Improvement of Analysis Codes for NSDD Evaluations, 3-7 Dec. 2018, IAEA
  - Reviewed current status and progress in:
    ALPHAD_RAdD, RADLIST codes (WebRadlist, NS_Radlist), RULER codes (py-RULER, J-RULER, T-RULER), BETASHAPE, BrIccEmis, Ensdf± editor
  - New codes: J-RULER, ConsistencyCheck
  - Testing/validation of codes
  - Updated webpage, ENSDF Manual, policies on treatment of asymmetric uncertainties
  - List of actions: summary report INDC(NDS)-0745

# Technical Support

- ENSDF codes, editor, web tools
  - MyEnsdf Web tools: working version of codes
  - *Dissemination* from IAEA Webpage:
    all the codes sent to IAEA are tested to make sure they run; for Linux/Mac OS, source codes + Makefile are provided (no executables)
  - 'Under development': for codes that need to be tested first
  - 'PNPI codes': all codes developed by PNPI group

M. Verpelli, V. Zerkin

Links
Nuclear Data Services
Nuclear Data Section
NSDD Network
ENSDF manual
MyENSDF Web tools
Improvement of ENSDF codes
ENSDF web application
IAEA

# ENSDF Analysis and Utility Programs

The Brookhaven National Nuclear Data Center maintains and distributes various programs in support of the International Atomic Energy Agency sponsored Nuclear Structure and Decay Data Network. These programs generally use as input files in the Evaluated Nuclear Structure Data File (ENSDF) format.[1]
For further information about the status and revision history please visit the **NNDC dedicated web pages.**

The tab '**Under development**' contains new codes which are in beta versions or still under development and require further testing by the users. Bugs or other problems should be sent to the code developers at the email address indicated.

## List of modifications:

- 2019-03 **J-GAMUT** for testing/debugging:
  A new version of J-GAMUT that treats very large files and includes an option for matching very closely-spaced level energies. A test case (Pt-190) is provided in the folder. Feedback on bugs, suggestions and comments should be sent to B.Singh
  **Alphad** for testing/debugging:
  ALPHAD code has been updated for recent official symbols for super-heavy elements Z=112-118. 2. In this package, some additional sample input files (pertaining to super-heavy nuclei) have been added just to test validity of code for newly added systems.
  **Alphad_RaDd** for testing/debugging:
  an updated version of even-even radius parameter file is included and official symbols for super-heavy elements Z=112-118 included.
- 2019-01 **Ruler** January 2019 :
  the fundamental constants were updated with the most recent values. The subroutine to calculate the Weisskopf partial lifetimes was corrected. The logic of the error propagation of the individual gamma-ray branching ratios was modified to include the approach outlined by E. Browne (NIM A249 (1986) 461
- 2019-01 **Fmtchk** December 2018, bug fixes
- 2019-01 **JAVA-NDS** version 1.9_19 December 2018
- 2019-01 **ALPHAD** version V2d 29-12-2018
  1. alpha record with no intensity: the record is now ignored for calculation of Abundance, Half-life and Hindrance .
  2. bug fixing for radius parameter and Hindrance of unplaced alpha
- 2018-12 **Java-Ruler** Java version of Ruler code which has an improved treatment of uncertainties with respect to the old Ruler code. Comments and feedback should be sent to the code developer Jun Chen at: J.Chen
- 2018-12 **Consisteny Check - beta version** Comments and feedback should be sent to the code developer Jun Chen at: J.Chen

Analysis | Utility | **Under development** | PNPI Codes | NSDFLIB | SETMDC

**Programs in Beta version for testing**
New codes which are in beta versions or still under development and require further testing by the users.
Bugs or other problems should be sent to the code developers at the email address indicated.

| # | Program | Version/Last Changed | Notes | ANSI | Linux | Windows | MacOS |
|---|---|---|---|---|---|---|---|
| 1 | **ALPHAD** | 2019-03-11 Updated version | | | Compressed file with source, NSDFLIB95, and makefile | Compressed file with executable, source, NSDFLIB95, and makefile | Compressed file with source, NSDFLIB95, and makefile |
| 2 | **ALPHAD-RadD** | 2019-03-11 Updated version | | | Compressed file with source, NSDFLIB95, and makefile | Compressed file with executable, source, NSDFLIB95, and makefile | Compressed file with source, NSDFLIB95, and makefile |
| 3 | **Consistency Check** | | Java for all platforms | | | | |
| 4 | **JGAMUT** Produces an Adopted Levels, Gammas (ALG) dataset from all other input data sets | 2019-03 Updated version | Java for all platforms<br>Sample files | | | | |

Analysis | Utility | Under development | **PNPI Codes** | NSDFLIB | SETMDC

## PNPI Codes

| # | Program | Version/Last Changed | Purpose | Download |
|---|---|---|---|---|
| 1 | **PNPI-checkers** | 2019-04-03 | | Compressed file with executable, source, makefile, test files |
| 2 | **NEWGTOL** | 2019-04-03 | | Compressed file with executable, source, makefile, test files |
| 3 | **NSRManager** | 2019-04-03 | | Windows only |

# Financial support

- Mass chain evaluation:
  - Pascu (ROM): 2017-
- Horizontal evaluation:
  - Stone (2017-): Tables of Evaluated Nuclear Moments
- Assessment:
  - Nichols (2018): Assessment of Decay Data of Fission Fragments for Decay Heat calculations (94 nuclides)
  - Yoshida (2018): Assessment of decay data for decay heat calculations

# Evaluation of Nuclear Moments

- New publication of recommended Q (Pykko, 2018) – to be uploaded in NM database in 2019
- Spins/parities and T1/2 in NM database to be adopted from ENSDF - in 2019
- Tables of evaluated NMs: ongoing
  - Corrections for long-lived states finalized (publication in preparation)
  - Hyperfine corrections insignificant
  - Transient Field methods: require a lot of re-analysis, work in progress

Contributors: Stone, Stuchbery, Jakowski, Persson

# Coordinated Research Projects (2017-2019)

- Charged-particle Monitor reactions and Medical Isotope production (2012-2016)
  - Four publications:
    - Nucl. Data Sheets 148 (2018) 338-382
    - J. Radioanal. Nucl. Chem. 2018
    - Nuclear Data Sheets, Jan. 2019
    - J. Radioanal. Nucl. Chem. 2019
  - Paper on Decay Data Evaluation, in preparation
  - New decay data evaluations for: under review
    Fe-52, Mn-52m, Zn-63, Ga-66, Cu-67, Se-73, Br-76, Zr-89, Tc-94, I-120,125, Th-226, U-230

# Medical Portal

International Atomic Energy Agency
**Nuclear Data Services**
Sección Datos Nucleares, OIEA

IAEA.org | NDS Mission | About Us | Mirrors: Ind

Search

**Handbooks**
- IAEA TRS 473
- IAEA TECDOC 1211

**Reference Data**
- Monitor Reactions
- MIRD

**Therapeutic RN**
- Emerging
- Established

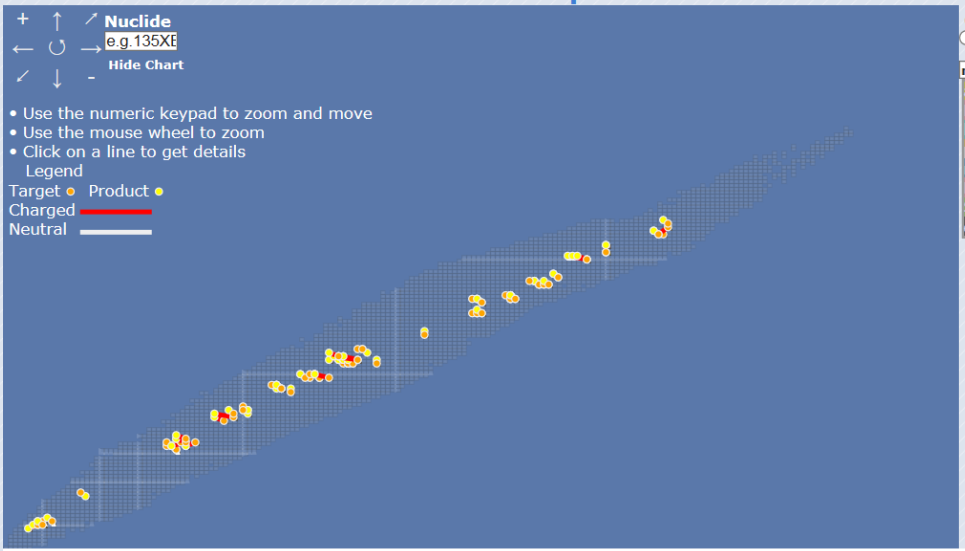
**Production Data**
- Therapeutic
- Emerging
- Established
- Diagnostic
- Gamma emitters
- Positron emitters

**Related Reports**
- INDC(NDS)-0638
- INDC(NDS)-0535
- INDC(NDS)-0560
- INDC(NDS)-0523

**On-going Project**
- INDC(NDS)-0675
- INDC(NDS)-0630
- INDC(NDS)-0591

**Links**
- NAHU
- DMRP Section
- Previous version

## Medical Radioisotopes Production




Color zones by ?
value quantile

main decay mode ...
- alpha
- EC+ beta+
- beta-
- p
- n
- EC
- SF
- other

**Decay data of nuclides denoted by green band were evaluated within IAEA CRPs.**

| Nuclide | Half-life | Decay % | Emission | Target | Reaction | Product | Mird |
|---|---|---|---|---|---|---|---|
| $^{11}_{6}C_5$ | 20.364 min *14* | ec β+ 100 *(β+ ≈ 99.8)* | $e^+$ | $^{14}_{7}N_7$ | $^{14}N(p,a)^{11}C$ | $^{11}_{6}C_5$ | mird |
| $^{13}_{7}N_6$ | 9.965 min *4* | ec β+ 100 *(β+ ≈ 99.8)* | $e^+$ | $^{16}_{8}O_8$ | $^{16}O(p,a)^{13}N$ | $^{13}_{7}N_6$ | mird |

# Coordinated Research Projects cont'd

- Reference database for Beta-delayed neutrons (2013-2018)
  - Evaluation of Z<29, Birch et al, NDS 133, 2015
  - Evaluation of Z>28, Liang et al, submitted to NDS, 2018:

**Compilation and Evaluation of Beta-Delayed Neutron Emission Probabilities and Half-Lives for Z > 28 Precursors**

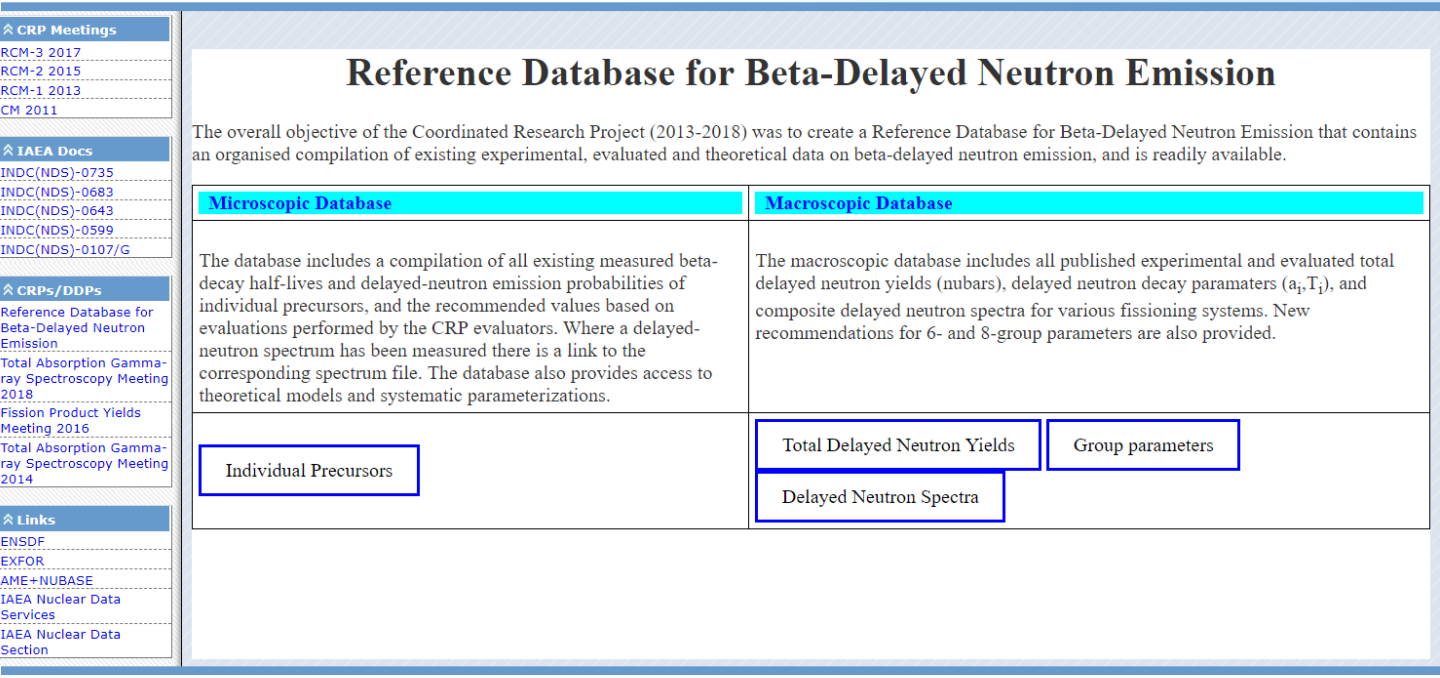
J. Liang,[1] B. Singh,[1] E.A. McCutchan,[2] I. Dillmann,[3] M. Birch,[1] A.A. Sonzogni,[2] X. Huang,[4] M. Kang,[4] J. Wang,[4] G. Mukherjee,[5] K. Banerjee,[5] D. Abriola,[6] A. Algora,[7,8] A.A. Chen,[1] T.D. Johnson,[2] and K. Miernik[9]

  - Final CRP report: Dimitriou et al, submitted to NDS, 2019

**Development of a Reference Database for Beta-Delayed Neutron Emission**

P. Dimitriou,[1,*] I. Dillmann,[2,3] B. Singh,[4] V. Piksaikin,[5] K.P. Rykaczewski,[6] J.L. Tain,[7] A. Algora,[7] K. Banerjee,[8] I.N. Borzov,[9,10] D. Cano-Ott,[11] S. Chiba,[12] M. Fallot,[13] D. Foligno,[14] R. Grzywacz,[15,6] X. Huang,[16] T. Marketin,[17] F. Minato,[18] G. Mukherjee,[8] B.C. Rasco,[19,6,15,20] A. Sonzogni,[21] M. Verpelli,[1] A. Egorov,[5] M. Estienne,[13] L. Giot,[13] D. Gremyachkin,[5] M. Madurga,[15] E.A. McCutchan,[21] E. Mendoza,[11] K.V. Mitrofanov,[5] M. Narbonne,[13] P. Romojaro,[11] A. Sanchez-Caballero,[11] and N. Scielzo[22]

# New database



**CRP Meetings**
- RCM-3 2017
- RCM-2 2015
- RCM-1 2013
- CM 2011

**IAEA Docs**
- INDC(NDS)-0735
- INDC(NDS)-0683
- INDC(NDS)-0643
- INDC(NDS)-0599
- INDC(NDS)-0107/G

**CRPs/DDPs**
- Reference Database for Beta-Delayed Neutron Emission
- Total Absorption Gamma-ray Spectroscopy Meeting 2018
- Fission Product Yields Meeting 2016
- Total Absorption Gamma-ray Spectroscopy Meeting 2014

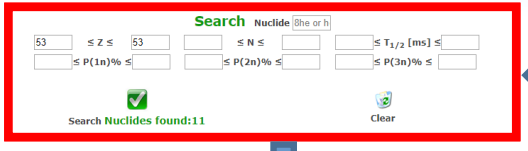
**Links**
- ENSDF
- EXFOR
- AME+NUBASE
- IAEA Nuclear Data Services
- IAEA Nuclear Data Section

## Reference Database for Beta-Delayed Neutron Emission

The overall objective of the Coordinated Research Project (2013-2018) was to create a Reference Database for Beta-Delayed Neutron Emission that contains an organised compilation of existing experimental, evaluated and theoretical data on beta-delayed neutron emission, and is readily available.

| Microscopic Database | Macroscopic Database |
|---|---|
| The database includes a compilation of all existing measured beta-decay half-lives and delayed-neutron emission probabilities of individual precursors, and the recommended values based on evaluations performed by the CRP evaluators. Where a delayed-neutron spectrum has been measured there is a link to the corresponding spectrum file. The database also provides access to theoretical models and systematic parameterizations. | The macroscopic database includes all published experimental and evaluated total delayed neutron yields (nubars), delayed neutron decay paramaters ($a_i$,$T_i$), and composite delayed neutron spectra for various fissioning systems. New recommendations for 6- and 8-group parameters are also provided. |
| Individual Precursors | Total Delayed Neutron Yields<br>Group parameters<br>Delayed Neutron Spectra |

# Reference Database for beta-delayed neutron emission I



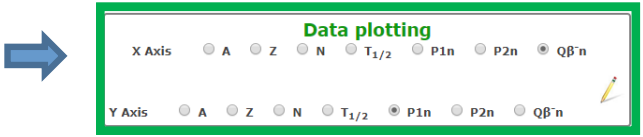


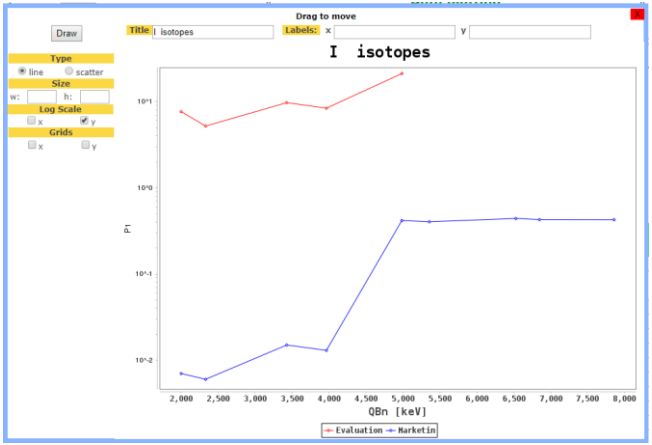

Click a label to show/hide table columns  Legend & References

Compilations Comments Qvalues | Systematics Miernik 14 | Theory Moeller et al. 03 | Marketin et al. 16

**Recommended** and compiled values - in red the ones used in the evaluation

| Nuclide | Isomer | $T_{1/2}$ | %P(1n) | %P(2n) | %P(3n) | # of neutrons per decay | Reference | Spectra |
|---|---|---|---|---|---|---|---|---|
| $^{137}_{53}I_{84}$ | | 24.59(10) s | 7.65 (14) | | | 0.0765 | | 2 |
| | | 19.3(5) | | | | | 1949Su14 | |
| | | 24.4(4) | | | | | 1959Pe28 | |
| | | 24 | 3.0 (5) | | | 0.03 | 1964Ar24 | |
| | | | 5.2 (5) | | | 0.052 | 1969ScZY | |
| | | | 6 | | | 0.06 | 1969WaZS | |
| | | 24.5(2) | | | | | 1970OsZZ | |
| | | 24.6(2) | | | | | 1970OsZZ | |
| | | 24.7(1) | 8.6 (12) | | | 0.086 | 1971De35 | |
| | | 24.5(2) | | | | | 1974Gr29 | |
| | | 24.3(8) | 6.6 (8) | | | 0.066 | 1974Kr21 | |
| | | 24.5(3) | | | | | 1974Ru08 | |
| | | 24.8(2) | 6.1 (8) | | | 0.061 | 1975As04 | |
| | | 24.2(5) | | | | | 1975Kr17 | |
| | | 24.25(12) | | | | | 1976Lu02 | |
| | | 23.7(24) | | | | | 1976KiZK | |
| | | 25.2(12) | | | | | 1976OtZW | |
| | | | 7.8 (12) | | | 0.078 | 1976ReZN | |
| | | | 8.5 (9) | | | 0.085 | 1977Re05 | |
| | | | 6.1 (5) | | | 0.061 | 1978Kr15 | |
| | | | 6.7 (4) | | | 0.067 | 1980Lu04 | |
| | | | 7.6 (11) | | | 0.076 | 1980ReZQ | |
| | | | 7.2 (16) | | | 0.072 | 1981Ho07 | |
| | | 24.13(12) | 7.46 (30) | | | 0.0746 | 1993Ru01 | |
| | | | ~6.9 | | | | 2010MaZS | |
| | | | 6.88 (76) | | | 0.0688 | 2013Ye02 | |
| | | | 6.35 (32) | | | 0.0635 | 2015CaZM | |
| | | | 7.76 (14) | | | 0.0776 | 2016Ag03 | |
| | | | 7.51 (86) | | | 0.0751 | 2016CzZZ | |
| | | | 7.9 (5) | | | 0.079 | 2017Ra10 | |
| | | | | | | | 1989BRZI | fig34 adjusted |
| | | | | | | | 1989BRZI | fig34 raw |



# Reference Database for beta-delayed neutron emission II

**Search** Target: 235U | Energy: thermal | Reaction inducing fission: Neutron

☐ Only recommended values
☑ Evaluated Libraries

**Legend** Compilation by V. Piksaikin, A.S. Egorov, D.E. Gremyachkin, K.V. Mitrofanov

**Downloads**
Numerical data | Original

235U

| ENSDF/B-VII.1 | | JEFF-3.1.2 | | JENDL-4.0 | |
|---|---|---|---|---|---|
| **Energy [eV]** | **TDN [1/eV]** | **Energy [eV]** | **TDN [1/eV]** | **Energy [eV]** | **TDN [1/eV]** |
| 1.00E-05 | 0.01585 | 1.00E-05 | 0.0162 | 1.00E-05 | 0.01585 |
| 0.0253 | 0.01585 | 200000 | 0.0163 | 0.0253 | 0.01585 |
| 50000 | 0.0167 | 1000000 | 0.0164 | 50000 | 0.01623 |
| 4.00E+06 | 0.0167 | 3.90E+06 | 0.0167 | 3.43E+06 | 0.01704 |
| 7.00E+06 | 0.009 | 5.70E+06 | 0.0132 | 6.70E+06 | 0.01013 |
| 2.00E+07 | 0.009 | 6.00E+06 | 0.0124 | 1.12E+07 | 0.01013 |
| | | 7.00E+06 | 0.011 | 1.41E+07 | 0.0094 |
| | | 1.00E+07 | 0.011 | 1.49E+07 | 0.0092 |
| | | 1.20E+07 | 0.0089 | 2.00E+07 | 0.00792 |
| | | 2.00E+07 | 0.0071 | | |

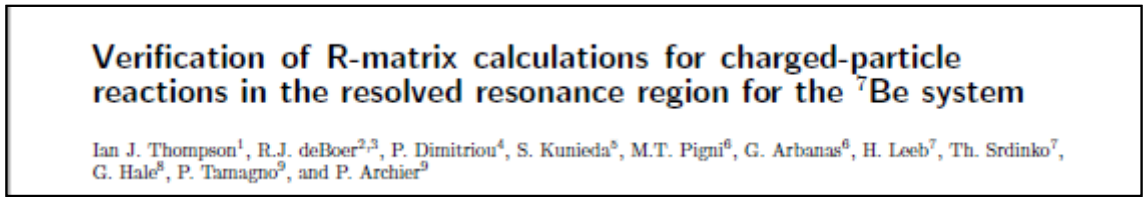
| # | Target | Energy [MeV] | Total delayed neutron yield | | |
|---|---|---|---|---|---|
| | | | Reported | Adjusted | |
| | 235-U | Neutron induced fission | | | |
| 156 | 235-U | Thermal | β = 0.010 ± 0.002 | 0.0176 ± 0.0054 | |
| 157 | 235-U | Thermal | β = 0.00755 ± 0.00050 | 0.0183 ± 0.0026 | |
| 158 | 235-U | thermal | 0.0183 ± 0.0014 | | |
| 159 | 235-U | Thermal | | 0.0175 ± 0.0028 | Brunson G.S. et al. Nucl. Sci. Eng., 1956, v.1, p.174. |
| 161 | 235-U | thermal | 0.0168 ± 0.0018 | | Zamyatnin 1976 |
| 163 | 235-U | Thermal | 0.0158 ± 0.0005 | 0.0158 ± 0.0016 | G. R. Keepin, T. F. Wimett, and R. K. Zeigler, J. Nucl. Energy, 6, 1 (1957); |
| 165 | 235-U | thermal | 0.0158 ± 0.0007 | | Keepin G. R., Wimett T. F., and Zeigler R. K. - Phys. Rev., 1957, v. 107, p. 1044. |
| 167 | 235-U | thermal | 0.0158 ± 0.0007 | | Keepin G.R., Wimett T.F., Zeigler R.K., J. Nucl. Energy, 6, 1, (1957), and Phys. Rev., 107, 1044 (1957). |
| 169 | 235-U | Thermal | (reference data) | 0.0173 ± 0.0012 | B.P.Maksyutenko, Soviet At.Energ.,vol.7,943 (1961) translated from Atom.Energ. Vol.7,474 (1959). |
| 174 | 235-U | Thermal | | 0.0221 ± 0.0031 | G. Herrmann, Delayed Fission Neutrons, Proc. Panel, International Atomic Energy Agency, Vienna (1968). |
| 183 | 235-U | Thermal | | 0.0254 ± 0.0081 | Notea A. Israel Atomic Energy Comm. Rep. IA-1190, 1969, p.95. |
| 184 | 235-U | thermal | 0.0205 ± 0.0061 | | Zamyatnin 1976 |
| 185 | 235-U | Thermal | | 0.0217 ± 0.0039 | |
| 192 | 235-U | Thermal | β = 0.0065 ± 0.0003 | 0.0157 ± 0.0010 | (R.J. Tuttle, 1979) |
| 193 | 235-U | thermal | 0.0158 ± 0.0007 | | Conant J.F., Palmedo P.F. Nucl. Sci. Eng., 1971, v.44, p. 173. |
| 194 | 235-U | thermal | 0.0158 ± 0.0010 | | Conant J.F., Palmeda P.F. Nucl. Sci. Eng., 1971, v.44, p. 173. |
| 236 | 235-U | Thermal | 0.0156 ± 0.0010 | 0.0156 ± 0.0010 | |
| 253 | 235-U | thermal | 0.0167 ± 0.0007 | | R.W. Waldo, R.A. Karam, R.A. Meyer. Delayed neutron yields: Time dependent measurements and a predictive model. Phys. Rev., C, V. 23, No. 3, 1981. |
| 254 | 235-U | thermal | 0.0162 | | A. D'Angelo, J.L. Rowlands. Conclusions concerning the delayed neutron data for the major actinides. Progress in Nuclear Energy, Vol. 41. No. 1-4, pp. 391-412, 2002. |
| 259 | 235-U | thermal | 0.01621 ± 0.00050 | | R.J. Tuttle. Delayed-neutron yields in nuclear fission. Procedings of the consultants' meeting on delayed neutron properties, Vienna, 26-30 March 1979. INDC(NDS)-107/G+Special. pp. 29-67, 1979 |
| 261 | 235-U | thermal | 0.0165 ± 0.0002 | | "Y. KANEKO, F. AKINO, T. YAMANE. Evaluation of Delayed Neutron Data for Thermal Fission of U-235 Based on Integral Experiments at Semi-Homogeneous Experiment. Journal of NUCLEAR SCIENCE and TECHNOLOGY, 25[9], pp. 673-681 (September 1988). |
| 262 | 235-U | thermal | 0.0162 | | A. D'Angelo, J.L. Rowlands. Conclusions concerning the delayed neutron data for the major actinides. Progress in Nuclear Energy, Vol. 41. No. 1-4, pp. 391-412, 2002. |

# Coordinated Research Projects cont'd

- Photonuclear Data and Photon Strength Functions (2016-2020)
  - 3rd RCM on 17-21 Dec. 2018, Summary report: INDC(NDS)-0777
  - 1st paper: Reference Database for Photon Strength Functions: Goriely, Dimitriou et al, to be submitted to European Physical Journal A
  - 2nd paper: New IAEA Photonuclear Data Library: Kawano et al., in preparation –special issues of NDS
  - Reference Database for Photon Strength Functions – in preparation

# R-matrix codes project: ongoing

- 4th CM on R-matrix codes, 13-14 May 2019, IAEA
  - Verification of R-matrix codes through a series of joint exercises: European Physical Journal A, in press



Verification of R-matrix calculations for charged-particle reactions in the resolved resonance region for the $^{7}$Be system

Ian J. Thompson[1], R.J. deBoer[2,3], P. Dimitriou[4], S. Kunieda[5], M.T. Pigni[6], G. Arbanas[6], H. Leeb[7], Th. Srdinko[7], G. Hale[8], P. Tamagno[9], and P. Archier[9]

  - Next step is to perform an evaluation (7Be) to compare R-matrix fits, uncertainties and covariances
  - Final goal: perform evaluations for dissemination in ENDF libraries + develop capability to process charged-particle differential data

# International Network of Nuclear Data Evaluators (INDEN)

- Follow-up project of CIELO
- Kick-off meeting Dec. 2017;
- Purpose to enhance international collaboration on nuclear reaction data evaluation
- Lead to improvements in physics models, statistical analysis and treatment of uncertainties, new measurements and finally new improved evaluations
- Three sub-groups:
  - Actinides
  - Structural material
  - *Light elements (Hale, Thompson, Pigni, Kunieda, Zh. Chen, DeBoer, Leeb, Tamagno, Archier)*

# International Network of Nuclear Data Evaluators (INDEN) on light elements: 2nd CM on 15-17 May 2019

– *Light elements (up to 20 MeV):*

| | | |
|---|---|---|
| Be-9 → n+$^{9}$Be | : | extend RRR to break-up threshold |
| N-14; 15 → n+$^{14}$N, n+$^{15}$N | : | RRR and high-energies |
| Na-23 → n+$^{23}$Na | : | RRR, URR and high-energies |
| O-16 → n+ $^{16}$O | : | RRR and high energies |

Nuclear structure data:

$^{10}$Be: ENSDF (2007): cut-off 2004
new XUNDL: 18 datasets (2007-2018)

$^{15}$N: ENSDF (2002): cut-off 1990
new XUNDL: 8 datasets (2008-2017)

$^{16}$N: ENSDF (1999): cut-off 1992
new XUNDL: 9 datasets (2008-2018)

$^{24}$Na: ENSDF (2007): cut-off 2006
new XUNDL: 2002, 2014

17O: ENSDF (199): cut-off 1992
new XUNDL: 14 (2007-2017)

# New CRP (2019-): Updating Fission Yield Data for Applications

- Objective: improve existing evaluated Fission Product Yields (FPY)
- Scope:
  - Compilation of all new FFY and FPY experimental data
  - Improve systematics and models
  - Incorporate new knowledge in FPY evaluations: correct errors and inconsistencies, update evaluations, provide reliable estimate of uncertainties
  - Agree on treatment of covariances, provide FPY covariance data and propose suitable format for inclusion in ENDF-6
  - Validation of new evaluations

- Participant countries: Belgium, China, Finland, France, Germany, India, Japan, Russia, Sweden, UK, USA

# Upcoming Meeting

- Technical Meeting on Nuclear Data for Anti-neutrino Spectra and Applications, 23-26 April 2019, IAEA

-neutrino anomalies and the sterile neutrino hypothesis
-existing measurements of integral beta spectra
-recent Daya Bay, Double Chooz and Reno results on spectra measurements
-results from short baseline experiments Prospect, SoLid, Neutrino-4/DANSS, NEOS
-conversion method and uncertainties, corrections
-summation method and impact of nuclear data (beta decay data; fission yield data; uncertainties and correlations)
-nuclear data libraries (ENDF/B; JEFF; JENDL)

# TM on Anti-neutrinos cont'd

- Goals of the meeting:

(a) assess the sensitivity of the observations to uncertainties affecting large and short-baseline anti-neutrino measurements,

(b) address the limitations and uncertainties of the theoretical methods (conversion vs summation),

(c) estimate their dependence on the available data (beta spectra, decay data, fission yields),

(d) make recommendations for the existing measurements, theories and evaluations and

(e) new proposals for the future where needed.

# Meeting Webpage

## Technical Meeting on Nuclear Data for Anti-neutrino Spectra and Their Applications

**23-26 April 2019, IAEA Headquarters, Vienna, Austria**

**Participants**

- Leendert Hayen
- Jun Cao
- Liangjian Wen
- Yufeng Li
- Zeyuan Yu
- Fengpeng An
- Liang Zhan
- Cecile Jollet
- Muriel Fallot
- Madalina Wittel
- Karl-Heinz Schmidt
- Tadashi Yoshida
- Soo-Bong Kim
- Sunny Seo
- Marek Karny
- Marzena Wolinska
- Dmitry Svirida
- Alejandro Algora
- Jose Tain
- Antonin Vacheret
- Alejandro Sonzogni
- Toshihiko Kawano
- Filip Kondev
- Krzysztof Rykaczewski
- B.S. Rasco
- Anna Hayes-Sterbenz
- Jonathan Link
- Bryce Littlejohn
- Yuri Efremenko
- Patric Huber
- Karsten Heeger
- Nathaniel Bowden
- Frederik Tovesson
- Patric Huber
- Karsten Heeger
- Nathaniel Bowden

**Abstracts**

| # | Author | Title | Link |
|---|---|---|---|
| 1 | P. Huber | Antineutrino spectrum prediction and nuclear data | DOC |
| 2 | B.S. Rasco | The Impact of Beta-Neutron Measurements on the Reactor Antineutrino Anomaly | DOC |
| 3 | K.P. Rykaczewski | Determination of anti-neutrino energy spectra in fission products | DOC |
| 4 | K.H. Schmidt | Extensive study of the quality of fission yields from experiment, evaluation and GEF for anti-neutrino studies and applications | PDF |
| 5 | J. Cao | Measuring High Resolution Reactor Neutrino Spectrum with JUNO-TAO | DOC |
| 6 | J. Link | The CHANDLER Project | DOC |
| 7 | Y. Efremenko | Results from the COHERENT collaboration | DOC |
| 8 | Yufeng Li | Diagnosing the Reactor Antineutrino Anomaly with Global Antineutrino Flux Data | DOC |
| 9 | B. Littlejohn | Reactor Antineutrino Flux Measurements at Daya Bay | PDF |
| 10 | F.G. Kondev | Decay data measurements aimed at improving nuclear data for antineutrino spectra predictions | PDF |
| 11 | M. Wolinska | Modular Total Absorption Spectrometer and anti-neutrino properties in fission products | PDF |
| 12 | Liang Zhan | Measurement of Reactor Antineutrino Spectrum at Daya Bay | PDF |
| 13 | T. Yoshida | Reactor Antineutrino as a New Frontier of FP Summation Calculations | DOC |
| 14 | K.E. Heeger | Measurement of Antineutrinos from 235U with PROSPECT at the High Flux Isotope Reactor | PDF |
| 15 | S. Seo | NEOS Results and Status | DOC |
| 16 | S.B. Kim | Precise Measurement of Reactor Antineutrino Yield and Spectrum at RENO | DOC |
| 17 | M. Wittel | Prospects for Spent Nuclear Fuel Safeguarding with Antineutrinos | DOC |
| 18 | N.S. Bowden | Implications of the PROSPECT Aboveground Reactor Antineutrino Detection | PDF |
| 19 | C. Jollet | The Double Chooz experiment | PDF |
| 20 | A. Vacheret | Measuring antineutrinos from the BR2 reactor core with the SoLid detector | PDF |
| 21 | T. Kawano | Upgrading the Fission Product Yield Database | PDF |
| 22 | A. Hayes | Inadequacies of Current Antineutrino Spectra and New data Needs | PDF |
| 23 | L. Hayen | Forbidden transitions in reactor beta spectra | PDF |
| 24 | A. Algora | Pandemonium free beta decay data for antineutrino summation calculations | PDF |
| 25 | D. Svirida | Using DANSS Antineutrino Detector for Industrial Reactor Power Monitoring | PDF |

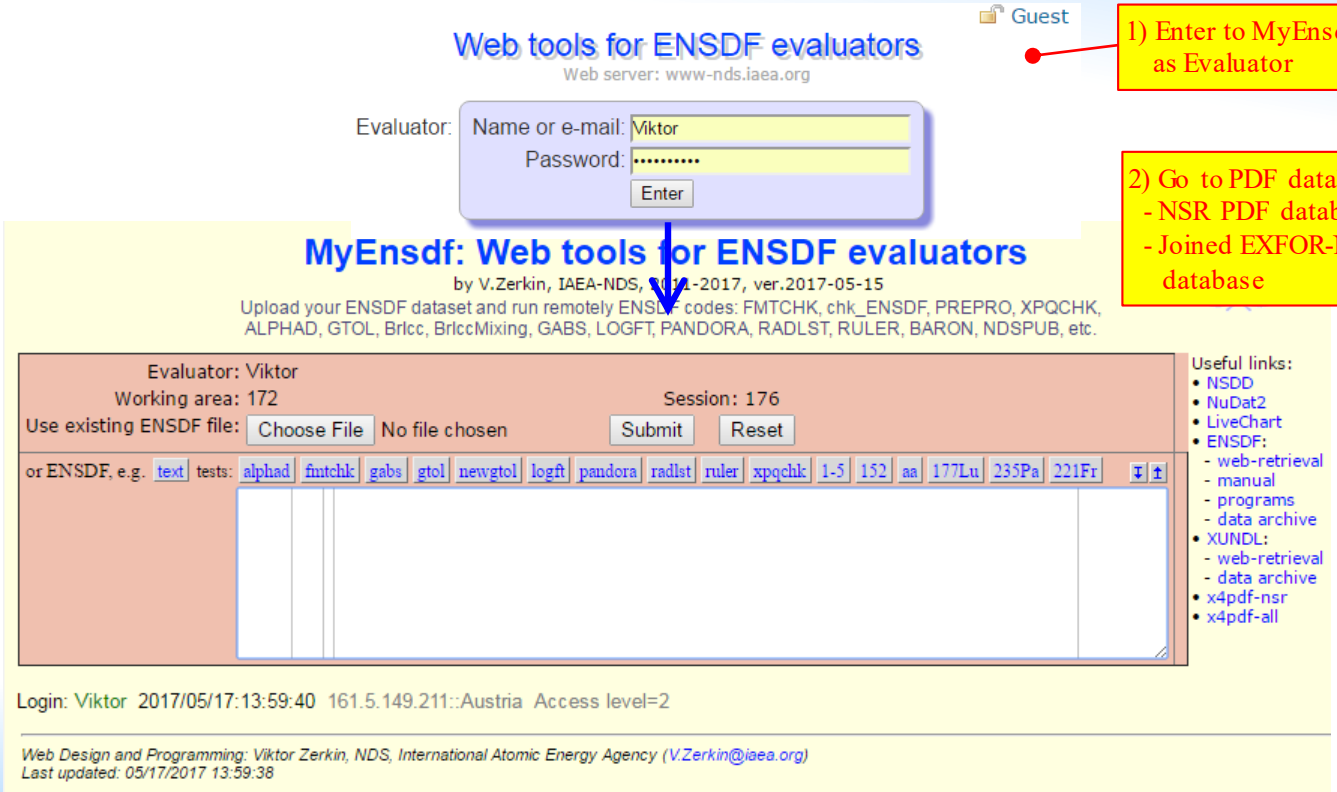
# ND2019, 19-24 May 2019, Beijing, China

## 4 Talks:

- NSDD network [on behalf of the network]
- Invited talk on beta-delayed neutrons (based on CRP)
- Talk on decay data for Decay heat and Anti-neutrino spectra calculations (based on the assessment work)
- Talk on Photonuclear Data Library and Photon Strength Functions (based on CRP)

# Access to full EXFOR-NSR PDF Database

http://www-nds.iaea.org/exfor/myensdf.htm




1) Enter to MyEnsdf as Evaluator

2) Go to PDF database:
- NSR PDF database
- Joined EXFOR-NSR database

# X4-NSR PDF collection.

Database updated: 2017-10-25. Files: 121796 from 2000-04-19 to 2017-10-23.

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| - | - | - | - | - | - | 1896:3 | - | 1898:4 | 1899:1 | [1890-1899]:8 |
| 1910:4 | 1911:2 | 1912:1 | - | - | - | - | - | 1918:2 | 1919:1 | [1910-1919]:10 |
| 1920:2 | 1921:2 | - | - | 1924:1 | - | - | - | 1928:4 | 1929:4 | [1920-1929]:13 |
| 1930:2 | 1931:3 | 1932:5 | 1933:2 | 1934:4 | 1935:20 | 1936:18 | 1937:31 | 1938:29 | 1939:58 | [1930-1939]:172 |
| 1940:52 | 1941:40 | 1942:18 | 1943:14 | 1944:19 | 1945:24 | 1946:78 | 1947:152 | 1948:161 | 1949:287 | [1940-1949]:845 |
| 1950:397 | 1951:428 | 1952:387 | 1953:493 | 1954:561 | 1955:621 | 1956:681 | 1957:699 | 1958:958 | 1959:917 | [1950-1959]:6142 |
| 1960:1034 | 1961:1046 | 1962:1251 | 1963:1576 | 1964:1424 | 1965:1647 | 1966:1787 | 1967:1366 | 1968:1447 | 1969:2314 | [1960-1969]:14892 |
| 1970:2714 | 1971:2865 | 1972:3257 | 1973:3323 | 1974:2898 | 1975:2541 | 1976:2533 | 1977:2446 | 1978:2414 | 1979:2167 | [1970-1979]:27158 |
| 1980:1973 | 1981:1986 | 1982:1993 | 1983:2039 | 1984:2119 | 1985:1943 | 1986:1871 | 1987:1965 | 1988:1509 | 1989:1669 | [1980-1989]:19067 |
| 1990:1531 | 1991:1257 | 1992:1326 | 1993:1640 | 1994:1549 | 1995:2157 | 1996:2057 | 1997:2140 | 1998:2210 | 1999:2406 | [1990-1999]:18273 |
| 2000:2565 | 2001:1818 | 2002:1949 | 2003:1857 | 2004:2339 | 2005:2423 | 2006:2518 | 2007:3040 | 2008:2152 | 2009:1943 | [2000-2009]:22604 |
| 2010:1917 | 2011:2142 | 2012:2086 | 2013:1927 | 2014:1758 | 2015:1725 | 2016:792 | 2017:265 | | | [2010-2017]:12612 |

Years: 101 Publications: 121796

Full volumes: [conferences and books] [theses] [reports]

Contributions:

1) 201200_Totans /3610/
2) 201300_Totans /991/
3) 201400_Totans /549/
4) 201500_Totans /622/
5) 201510_Balraj /260/
6) 201510_Rodionov /2470/
7) 201512_Audi /2609/
8) 201600_Totans /2050/
9) 201603_Rodionov /295/
10) 201603_Shulyak /13425/
11) 201604_Kondev /1098/
12) 201611_PNPI /31657/
13) 201701_Totans /275/
14) 201702_Totans /176/
15) 201703_PNPI /11151/
16) 201703_Shulyak /303/
17) 201703_Totans /370/
18) 201704_Totans /116/
19) 201704_Zerkin /132/
20) 201705_Kondev /44/
21) 201705_Totans /820/
22) 201705_Zerkin /31/
23) 201706_Totans /1/
24) 201708_Totans /175/
25) 201709_Pritychenko /1208/
26) 201710_PNPI /18736/
27) 201710_Totans /175/
28) 201710_Zerkin /74/

Sum: /93423/

Contributors:

| | | | |
|---|---|---|---|
| 1 | PNPI | 61544 | 65.9% |
| 2 | Shulyak | 13728 | 14.7% |
| 3 | Totans | 9930 | 10.7% |
| 4 | Rodionov | 2765 | 2.96% |
| 5 | Audi | 2609 | 2.8% |
| 6 | Pritychenko | 1208 | 1.3% |
| 7 | Kondev | 1142 | 1.23% |
| 8 | Balraj | 260 | 0.28% |
| 9 | Zerkin | 237 | 0.26% |
| | Total | 93423 | |

PDF Statistics:

| *DB* | *#PDF/References* | *#PDF+* | *Total #PDF* |
|---|---|---|---|
| NSR: | 93379/225841 ~42% | +7419 from EXFOR | 100798 |
| EXFOR: | 21913/30804 ~72% | +689 from NSR | 22602 |

# Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Experiment, Theory and Evaluation, 15 -26 Oct. 2018, Trieste

- Lectures on experimental techniques, nuclear models, shell model practical (code)
- Hands-on exercises: XUNDL datasets, evaluation of mass chain A=218

*Lecturers:*

P. Regan (Surrey)
P. Van Isacker (GANIL)
S. Lenzi (LNL)

E. McCutchan (BNL) (DIR)M. Martin (ORNL)
F. Kondev (ANL)
B. Singh (McMaster)
T. Kibedi (ANU)
S. Basunia (LBL)

IAEA:

M. Verpelli
V. Zerkin
P. Dimitriou (DIR)


Joint ICTP-IAEA Workshop on Nuclear Structure and Decay Data: Theory, Experiment and Evaluation

ICTP

15 - 26 October 2018
Trieste, Italy

The workshop introduces young and established nuclear scientists to the evaluation of nuclear structure and decay data, by providing an overview of experimental and theoretical nuclear techniques and basic training in the evaluation procedures and formats involved in the production of the Evaluated Nuclear Structure Data File (ENSDF).

Description:

Topics:

Call for Papers:

How to apply:

Grants:

Directors:

Local Organizer:

Speakers:

Deadline:
30 June 2018

# Participants of ICTP-IAEA Workshop on NSDD, 15-26 Oct. 2018

| | | | | |
|---|---|---|---|---|
| 1 | Africa | Algeria | Algeria | KAIM Samra |
| 2 | Africa | Tunisia | Tunisia | DERBALI Ezzeddine |
| 3 | Asia | Bangladesh | Bangladesh | KOBRA Monira |
| 4 | Asia | India | India | BALA Indu |
| 5 | Asia | India | India | BONDYOPADHAYA Debasmita |
| 6 | Asia | India | India | CHAKRABARTI Ritwika |
| 7 | Asia | India | India | NANDI Soumen |
| 8 | Asia | India | France | SINGH Abhilasha |
| 9 | Asia | India | India | SINGH Papinder |
| 10 | Asia | Japan | Japan | KOURA Hiroyuki |
| 11 | Asia | Malaysia | Australia | TEE Bryan |
| 13 | Europe | Romania | Romania | OLACEL Adina-Adriana |
| 14 | Europe | Spain | Canada | CABALLERO FOLCH Roger |
| 15 | Europe | Ukraine | Ukraine | CHEKHOVSKA Anastasiia |
| 16 | Europe | Ukraine | Ukraine | KASPEROVYCH Dmytro |
| 17 | Europe | United Kingdom | United Kingdom | CANAVAN Rhiann |
| 18 | North America | USA | USA | GRINDER Mara |

# Participants of ICTP-IAEA Workshop on NSDD, 15-26 Oct. 2018

| | | | | |
|---|---|---|---|---|
| 1 | Africa | | | M Samra |
| 2 | Africa | | | BALI Ezzeddine |
| 3 | Asia | | | RA Monira |
| 4 | Asia | | | A Indu |
| 5 | Asia | India | India | NDYOPADHAYA asmita |
| 6 | Asia | | | KRABARTI Ritwika |
| 7 | Asia | | | DI Soumen |
| 8 | Asia | | | H Abhilasha |
| 9 | Asia | | | GH Papinder |
| 10 | Asia | | | URA Hiroyuki |
| 11 | Asia | | | Bryan |
| 13 | Europ | | | CEL Adina-Adriana |
| 14 | Europ | | | ALLERO FOLCH er |
| 15 | Europe | Ukraine | Ukraine | CHEKHOVSKA Anastasiia |
| 16 | Europ | | | PEROVYCH Dmytro |
| 17 | Europ | | | AVAN Rhiann |
| 18 | North A | | | NDER Mara |

6 participants from developed countries: Australia, Canada, France, Japan, UK, USA

Majority: female (59%)

Age: early PhD to young research scientists (22 to 20 years old)

Good background in nuclear physics (structure & reactions): no prior knowledge of XUNDL/ENSDF

# Week 1: XUNDL

- Split in groups of 2: 9 groups
- Compilation of 1 article per group in XUNDL dataset
- Group supervisors: Filip Kondev (coordinator), Murray Martin, Tibor Kibedi

# Week 2: ENSDF Exercise
# Evaluation of nuclides of A=218 for ENSDF database

Experimentally 11 nuclides of A=218 are known (Z=82-92, N=136-126).
Current data in ENSDF/ NDS: January 2006 update (~13 years old).
Tasks: addition of new papers, update for decay Q values in AME-2016, revision of internal conversion coefficients from BrIcc code, log *ft,* HF, etc.
Pb-218, Bi-218, At-218, Pa-218, U-218: nuclear data available for only the ground states, and a high-spin isomer in U-218: already updated by Balraj Singh

Po-218, Rn-218: Libby McCutchan.
Ra-218 Murray Martin.
Ac-218: Shamsu Basunia
Fr-218, Th-218: Balraj Singh.

# ICTP-IAEA Workshop on NSDD, 15-26 Oct. 2018


# ICTP-IAEA Workshop on NSDD, 15-26 Oct. 2012

Feedback:

VERY VERY POSITIVE

- Useful webtools
- Excellent lectures on theory and experiment
- Better understanding of their own research work
- Learned to be CRITICAL of published work
- Appreciated the networking with their peers from all over the world

# ICTP-IAEA Workshop on NSDD, 15-26 Oct. 2012

SOME USEFUL SUGGESTIONS TOO:

- All XUNDL/ENSDF lectures should be HANDS-ON
- Always more effective to give exercises even on retrieving data
- Analysis/checking codes could be run from Myensdf

# ICTP Workshops: perspectives

- No proper new evaluator recruited since 2010 from the workshop alone
- Very demanding for both lecturers/group leaders and trainees (XUNDL compilation and ENSDF evaluation in 2 weeks)
- Should we continue with such a format?
- Should we consider a lighter version: outreach

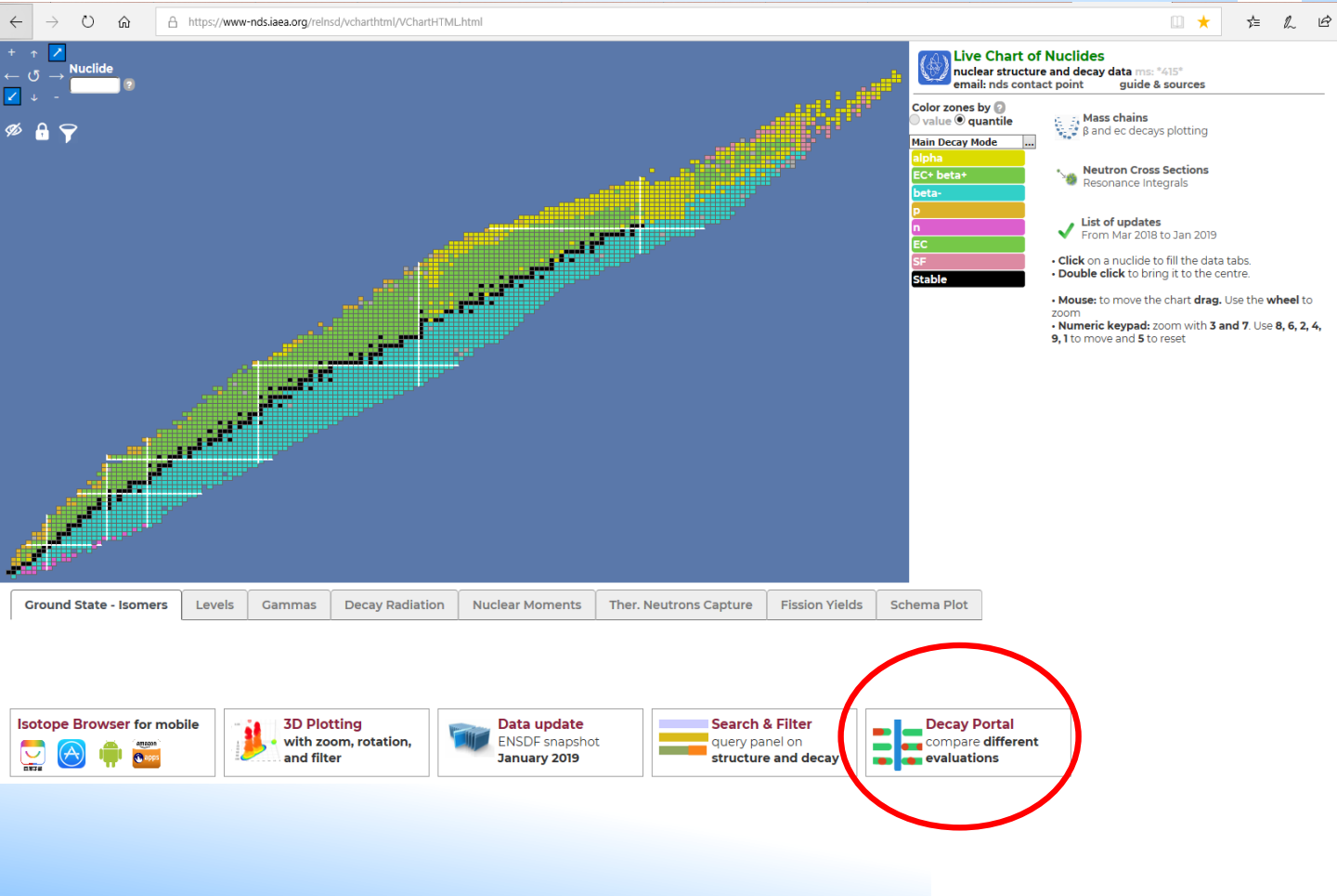
one week introduction to nuclear data in applications, databases, retrieval systems, evaluation process + hands-on exercises on selected items: half-life evaluation, retrieving information and data, BrIcc?

# Dissemination tools

- Live Chart (M. Verpelli)
  - New 2016 masses correctly inserted with proper treatment/calculation of uncertainties
  - New code to calculate atomic radiation data (using EADL database): currently in test mode

- Isotope Browser (M. Verpelli)
  - Translated in 5 UN official languages (french, spanish, chinese, arabic, russian) + italian, slovenian, traditional chinese

# Live Chart


https://www-nds.iaea.org/relnsd/vcharthtml/VChartHTML.html
Nuclide
Live Chart of Nuclides
nuclear structure and decay data ms: "415"
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 Mar 2018 to Jan 2019
• 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
Ground State - Isomers
Levels
Gammas
Decay Radiation
Nuclear Moments
Ther. Neutrons Capture
Fission Yields
Schema Plot
Isotope Browser for mobile
3D Plotting
with zoom, rotation, and filter
Data update
ENSDF snapshot
January 2019
Search & Filter
query panel on
structure and decay
Decay Portal
compare different
evaluations

# Statistics

## Overall IAEA web statistics on Google-Analytics (running since 2013)

May 1, 2018 - May 31, 2018

| | Custom Variable | Pageviews |
|---|---|---|
| 1. | NAPC/NDS | 231,595 (75.36%) |
| 2. | MTCD | 61,264 (19.94%) |
| 3. | NSNI | 8,967 (2.92%) |
| 4. | MTIT | 4,900 (1.59%) |
| 5. | NAEL/MESL | 556 (0.18%) |

Inspecting usage of features of our web systems.
Examples:

| # | Product | Function | Page views | Users |
|---|---|---|---|---|
| 1. | ENDF | Search | 23,225(18.42%) | 1,754(10.51%) |
| 2. | EXFOR | Search | 19,110(15.15%) | 1,491(8.94%) |
| 4. | ENDF | Retrieve | 12,422(9.85%) | 1,268(7.60%) |
| 5. | ENDF | Plot | 10,093(8.00%) | 1,160(6.95%) |
| 7. | EXFOR | Retrieve | 5,459(4.33%) | 697(4.18%) |
| 9. | EXFOR | Plot | 3,388(2.69%) | 529(3.17%) |
| 19. | IBANDL | Plot | 793(0.63%) | 110(0.66%) |
| 23. | EXFOR | goto:Web-Publisher | 614(0.49%) | 174(1.04%) |
| 28. | EXFOR | download:x4pdf | 440(0.35%) | 38(0.23%) |
| 29. | CINDA | Search | 418(0.33%) | 177(1.06%) |
| 42. | EXFOR | X4Construct-Covar | 110(0.09%) | 72(0.43%) |
| 58. | ENDF | download:Mat2gnd | 45(0.04%) | 31(0.19%) |
| 62. | EXFOR | x4corr | 42(0.03%) | 9(0.05%) |

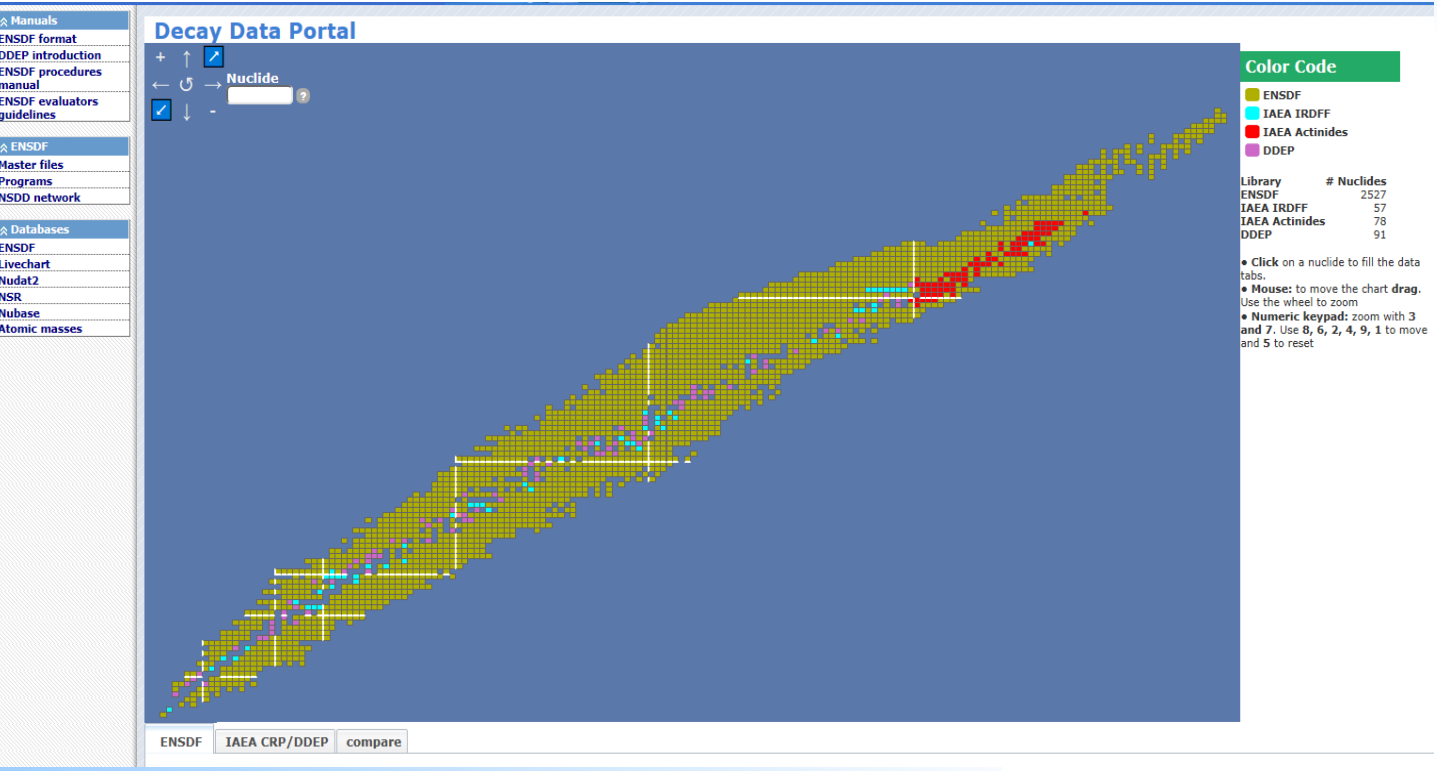
| | Custom Variable (Value 01) | Custom Variable (Value 02) | Pageviews | Users |
|---|---|---|---|---|
| 1. | NAPC/NDS | NDS/x4service | 99,984 (32.54%) | 3,280 (13.84%) |
| 2. | NAPC/NDS | NDS/livechart | 81,423 (26.50%) | 6,771 (28.58%) |
| 3. | MTCD | Indico | 61,264 (19.94%) | 2,794 (11.79%) |
| 4. | NAPC/NDS | US/x4service | 25,303 (8.23%) | 1,090 (4.60%) |
| 5. | NSNI | IRS | 7,443 (2.42%) | 299 (1.26%) |
| 6. | NAPC/NDS | NDS/ | 6,715 (2.19%) | 2,680 (11.31%) |
| 7. | MTIT | NUCLEUS | 4,900 (1.59%) | 597 (2.52%) |
| 8. | NAPC/NDS | NDS/AMDIS | 2,779 (0.90%) | 884 (3.73%) |
| 9. | NAPC/NDS | NDS/nrdc/ | 2,022 (0.66%) | 314 (1.33%) |
| 10. | NAPC/NDS | NDS/stopping/ | 1,835 (0.60%) | 235 (0.99%) |
| 13. | NAPC/NDS | NDS/safeguards/ | 1,007 (0.33%) | 470 (1.98%) |
| 14. | NAPC/NDS | NDS/amdc/ | 782 (0.25%) | 496 (2.09%) |
| 15. | NAPC/NDS | NDS/AMDIS/ALADDIN | 753 (0.25%) | 138 (0.58%) |
| 16. | NAPC/NDS | NDS/public/download-endf/ | 706 (0.23%) | 150 (0.63%) |
| 19. | NAPC/NDS | CN/x4service | 474 (0.15%) | 18 (0.08%) |
| 23. | NAPC/NDS | IN/x4service | 277 (0.09%) | 130 (0.55%) |
| 60. | NAPC/NDS | RU/x4service | 25 (0.01%) | 7 (0.03%) |

Mirror-sites

c/o: V. Zerkin

# Dissemination tools cont'd.

- Decay Data Portal: collect and compare available decay data (ENSDF, IAEA CRPs, DDEP)



# ENSDF data

**Evaluation**: F.G. KONDEV **Publication cut-off**: 31-Jan-2008 **ENSDF insertion**: 2008-05 **Publication**: Nuclear Data Sheets 109, 1527 (2008)

| Parent | T1/2 | Ex [keV] | Jp order | Decay | Q (keV) note on Q value | Daughter | Comments | Total energy by radiation type, per 100 decays of the parent [keV] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | Alpha | Beta | CE & Auger | γ & X | Unplaced γ | Recoil | Neutrino | Absorbed | Total | Q * BR | Delta |
| $^{210}_{84}Po_{126}$ | 138.376 d 2 | 0.0 | 0+ | α 100 % | 5407.53 7 | $^{206}_{82}Pb_{124}$ | | 5304.377 0.070 | 0.000 0.000 | 0.000 0.000 | 0.008 0.000 | 0.000 0.000 | 101.738 0.009 | 0.000 0.000 | 5406.123 0.071 | 5406.123 0.071 | 5407.53 | 1.407 |

see the ENSDF source

**Note:** Q-value used in ENSDF to determine displayed decay data is: 5407.45 7 keV - see **note on Q value**

## Alpha

| Eα [keV] | Iα(abs) [%] | Daughter level [keV] | Jπ | HF | Comments |
|---|---|---|---|---|---|
| 4516.58 10 | 0.00104 6 | 803.049 25 | 2+ | 1.46 9 | |
| 5304.33 7 | **100** | 0.0 | 0+ | 1.000 | |

## Gamma

| Eγ [keV] | Iγ(abs) [%] | Initial level [keV] | Jπ | Final level [keV] | Jπ | Mult. | δ | αT | Comments |
|---|---|---|---|---|---|---|---|---|---|
| 803.06 3 | **0.00103 6** | 803.049 25 | 2+ | 0.0 | 0+ | E2 | | 0.01033 | |

- **Show Atomic data for Lead**
- **Siegbahn** notation **legend**
- **Atomic shell transition yields** : see **E.Schönfeld, H.Janßen** and its references.
- **Atomic shell energies** from **Evaluated Atomic Data Library**

## X-rays

| E [keV] | I(abs) [%] | Line |
|---|---|---|
| 9.184 - 15.860 | 0.00000323 20 | L |
| 72.805 | 0.00000233 14 | K-$L_2$ |
| 74.970 | 0.00000391 24 | K-$L_3$ |
| 84.451 - 85.521 | 0.00000134 8 | K-$M_{2,3,4}$ |
| 84.451 - 87.592 | 0.00000174 11 | K-MN |
| 87.242 - 87.360 | 0.00000040 3 | K-$N_{2,3,4,5}O_{2,3}$ |

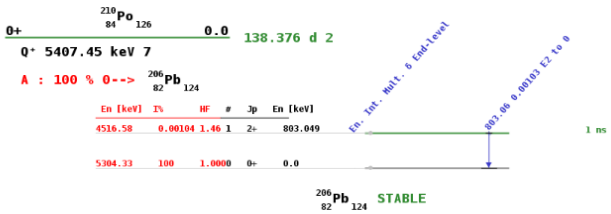
## Electrons

| E [keV] | I(abs) [%] | Origin | γ En. [keV] | αtotal |
|---|---|---|---|---|
| 5.327 - 15.817 | **0.0000053 3** | AU L | | |
| 0.000 - 68.287 | 0.000000105 13 | AU KLX | | |
| 0.000 - 87.896 | 0.00000031 4 | AU K | | |
| 56.277 - 61.929 | 0.000000187 23 | AU KLL | | |
| 80.297 - 87.896 | 0.0000000146 19 | AU KXY | | |
| 715.06 | 0.0000083 5 | CE K | 803.06 | 0.00804 12 |
| 787.58 | 0.00000180 11 | CE L | 803.06 | 0.001745 25 |
| 799.36 | 0.00000043 3 | CE M | 803.06 | 0.000420 6 |
| 802.22 | 0.000000110 7 | CE N | 803.06 | 0.0001065 15 |
| 802.93 | 0.0000000212 13 | CE O | 803.06 | 2.06E-5 3 |

## X-rays from each γ transition

| E [keV] | I(abs) [%] | Line | γ Energy [keV] | αtotal |
|---|---|---|---|---|
| 9.18 | 0.000000061 4 | L3-M1 | 803.06 | |
| 10.45 | 0.000000118 7 | L3-M4 | 803.06 | |
| 10.55 | 0.000000118 7 | L3-M5 | 803.06 | |
| 9.18 - 13.03 | 0.00000150 9 | $L_3$ | 803.06 | 0.0001317 19 |
| 11.35 | 0.0000000256 14 | L2-M1 | 803.06 | |
| 12.14 | 0.00000104 6 | L3-N1 | 803.06 | |
| 12.31 | 0.000000046 3 | L1-M2 | 803.06 | |
| 9.18 - 15.86 | 0.00000323 20 | L | 803.06 | 0.001745 25 |
| 12.60 - 12.62 | 0.0000000153 18 | L3-N45 | 803.06 | |
| 12.61 | 0.000000093 5 | L2-M4 | 803.06 | |
| 12.79 | 0.000000051 3 | L1-M3 | 803.06 | |
| 12.89 | 0.000000234 14 | L3-O1 | 803.06 | |
| 13.01 - 13.02 | 0.0000000033 2 | L3-O45 | 803.06 | |
| 13.03 | 0.0000000307 19 | L3-P1 | 803.06 | |
| 11.35 - 15.20 | 0.00000119 7 | $L_2$ | 803.06 | 0.000442 7 |
| 12.31 - 15.86 | 0.000000129 7 | $L_1$ | 803.06 | 0.001168 17 |
| 14.31 | 0.0000000066 4 | L2-N1 | 803.06 | |
| 14.76 | 0.000000199 11 | L2-N4 | 803.06 | |
| 15.05 | 0.000000199 11 | L2-O1 | 803.06 | |
| 15.10 | 0.000000121 7 | L1-N2 | 803.06 | |
| 15.18 | 0.0000000269 15 | L2-O4 | 803.06 | |
| 15.19 | 0.00000000024 12 | L2-P1 | 803.06 | |
| 15.22 | 0.0000000147 9 | L1-N3 | 803.06 | |
| 15.76 - 15.78 | 0.0000000053 3 | L1-O23 | 803.06 | |
| 15.86 | 0.00000000180 17 | L1-P23 | 803.06 | |
| 72.80 | 0.00000233 14 | K-$L_2$ | 803.06 | 0.00804 12 |

pop out Highlight: (keV) level Image Height: Image Width: Replot



# IAEA CRP data

ENSDF | IAEA CRP/DDEP | compare

**Evaluation made within an IAEA Coordinated Reserch Project — For atomic radiation data, please refer to the pdf files linked below**

| Parent | Energy [keV] | Half-life | $J^{\pi}$ | Decay | Q [keV] | Daughter |
|---|---|---|---|---|---|---|
| $^{210}_{84}Po_{126}$ | 0.0 | 138.3763 d *17* | 0+ | α | 5407.45 *7* | $^{206}_{82}Pb_{124}$ |

**Evaluation:** M.A.Kellett, V.Chist **Publication cut-off:** 28-FEB-2008

ENSDF Summary Comments

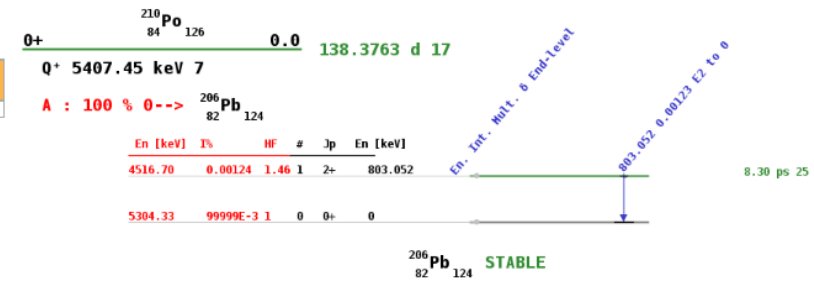
## Alpha

| $E_\alpha$ [keV] | $I_\alpha$(abs) [%] | Daughter level [keV] | $J^{\pi}$ | HF |
|---|---|---|---|---|
| 4516.70 9 | 0.00124 *4* | 803.052 *24* | 2+ | 1.46 |
| 5304.33 *7* | 99999E-3 *4* | 0 | 0+ | 1 |

## Gamma

| $E_\gamma$ [keV] | $I_\gamma$(abs) [%] | Initial level [keV] | $J^{\pi}$ | Final level [keV] | $J^{\pi}$ | Mult. | δ | $\alpha_T$ |
|---|---|---|---|---|---|---|---|---|
| 803.052 *24* | 0.00123 *4* | 803.052 *24* | 2+ | 0 | | E2 | | 0.01032 *15* |

pop out Highlight: (keV) level Image Height: Image Width: Replot



# Dissemination tools cont'd.

ENSDF | IAEA CRP/DDEP | compare

**Automated comparison** of the main evaluated quantities

- $^{210}$Po α decay to $^{206}$Pb

| Half-life | | Level energy | | Branching ratio | | Q value | | Authors | | Cut-off date | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA |
| 138.376 *2* d | 138.3763 *17* d | 0.0 | 0.0 | 1 *0* | 1 *0* | 5407.45 *7* | 5407.45 *7* | F.G. KONDEV | M.A.Kellett, V.Chist | 31-Jan-2008 | 28-FEB-2008 |

γ

| $E_\gamma$ | | $I_\gamma$(abs) | | δ | | $\alpha_T$ | |
|---|---|---|---|---|---|---|---|
| ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA |
| 803.06 *3* | 803.052 *24* | 0.00103 *6* | 0.00123 *4* | | | 0.01033 | 0.01032 *15* |

α

| $E_\alpha$ | | $I_\alpha$(abs) | | HF | |
|---|---|---|---|---|---|
| ENSDF | IAEA | ENSDF | IAEA | ENSDF | IAEA |
| 4516.58 *10* | 4516.70 *9* | 0.00104 *6* | 0.00124 *4* | 1.46 *9* | 1.46 |
| 5304.33 *7* | 5304.33 *7* | 100 | 99999E-3 *4* | 1.000 | 1 |

Next: include ENDF/B-VIII, JEFF-3.3, JENDL-4

Download
Download data, codes, packages

Quick Links
ADS-Lib
Atomic Mass Data Centre
CINDA
Charged particle reference cross section
DICEBOX
DROSG-2000
DXS
Decay Data Library for Actinides
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
EXFOR
FENDL

**NEW**
**GRUCON-2018** ENDF Data Processing Package (release incl. source code): [page]
**TENDL-2017** TALYS-based Evaluated Nuclear Data Library, 2017: [page] [list] [retrieve]
**ENDF/B-VIII.0** U.S. Evaluated Nuclear Data Library, issued in 2018: [page] [list] [retrieve]

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

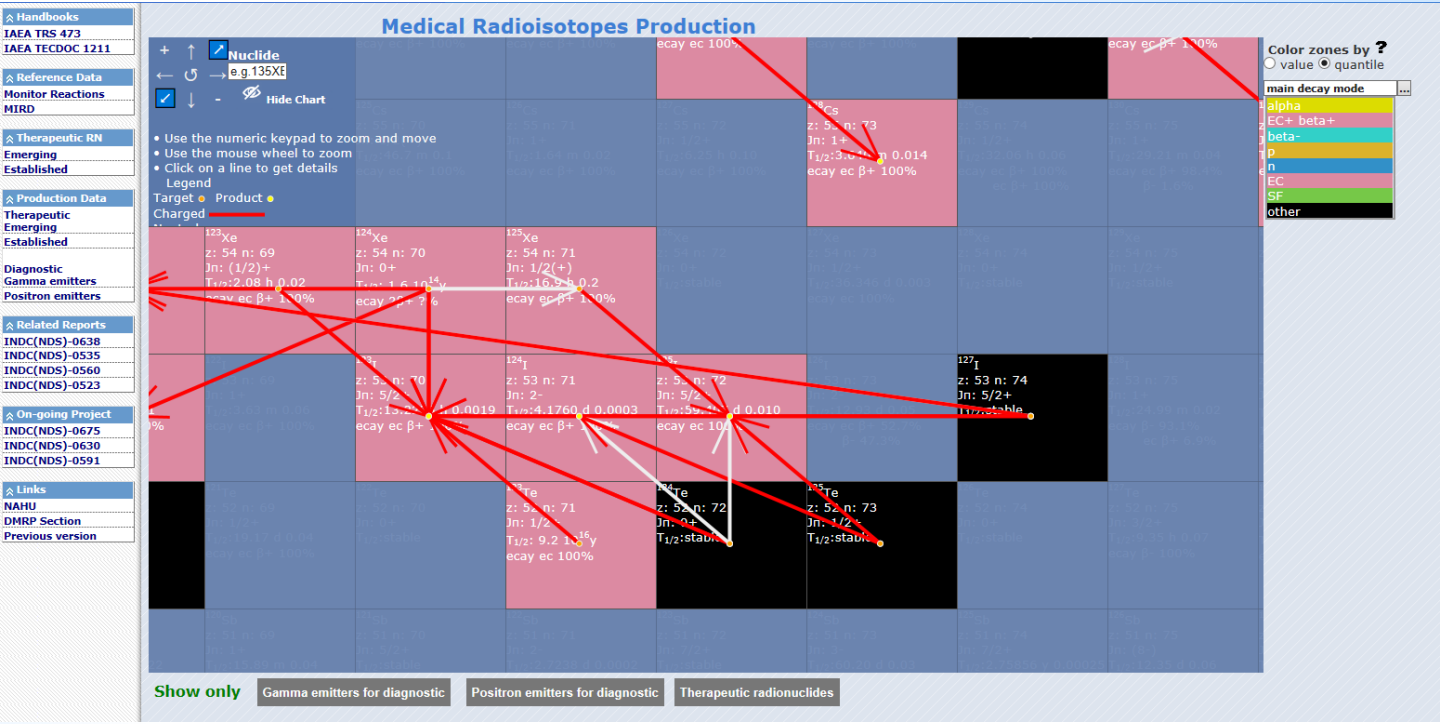
**Decay Portal**
compare **different**
**evaluations**

## 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
LOGFT - Analysis Program
Q-values, Thresholds - atomic masses, Q-values and threshold energies
Nuclear Charge Radii - Table of experimental nuclear charge radii for 909 isotopes

*Database at the IAEA, Vienna **Database at the US NNDC

# Medical Portal




New decay data to be uploaded soon!

# 3rd TM on Improvement of Analysis Codes for NSDD Evaluations 3-7 December 2018, IAEA

NSDD Scientific Secretary:
Paraskevi (Vivian) Dimitriou

# Goals for the meeting

- Follow-up on progress from TM Codes 2015 and NSDD 2017
- Discuss new codes (Java-Ruler, Consistency Check by Jun Chen)
- Validation procedure for codes (ready for release)
- Formats for atomic radiation data and continuous data
- Dissemination

# Reviewed tables of codes

| CODE | TASK | NAME | TIMELINE | PRESENT |
|---|---|---|---|---|
| JAVA NDS | FURTHER DEVELOPMENT AND TESTING | CHEN, SINGH | BETA-VERSION END OF NOVEMBER 2015 | OFFICIAL PUBLICATION CODE |
| JGAMUT | IMPROVEMENT AND TESTING | BIRCH, SINGH | BETA VERSION END OF NOVEMBER 2015 | DONE + RECOIL CORRECTIONS: VALIDATION: ISSUES WITH LEVEL ENERGY MATCHING MAINTENANCE |
| VISUAL AVERAGING LIBRARY | INCLUDE BARLOW METHOD AND PLOTTING | BIRCH, SINGH | END OF NOVEMBER 2015 | DONE: MAINTENANCE: (J. CHEN) |
| BETASHAPE | IMPROVED TREATMENT OF FORBIDDEN NON-UNIQUE +<br><br>EC | MOUGEOT | JANUARY 2016<br><br>NEXT CODES MEETING | DONE<br><br>VALIDATION OF LOGFT<br><br>ONGOING |
| EDITOR | EXPLORE DIFFERENT OPTIONS | ZERKIN | IN PROGRESS-ZERKIN TO START END OF SUMMER 2016 | ENSDF± AVAILABLE DEVELOPMENT ONGOING |

| CODE | TASK | NAME | TIMELINE | PRESENT |
|---|---|---|---|---|
| R0 (RADd) CODE | INCORPORATION IN ALPHAD | SINGH, SINGH | IN PROGRESS FEBRUARY 2016 | DONE:<br>NEW ALPHAD-RAdD CODE TO BE VALIDATED<br>NEW R0 TABLES – TO BE PUBLISHED |
| NEW R0 TABLES | UPDATE R0 TABLES FOR NEW Q-VALUES, BRANCHINGS AND NUCLIDES | SINGH, SINGH | | |
| ONLINE WEBTOOL | MAKE PNPI CHECKING CODES AVAILABLE | ZERKIN | MID-2016 | DONE |
| PANDORA | ENHANCE CODE | TULI-NSDD NETWORK | CONTINUOUS | BAND ASSIGNMENT (ZERKIN)<br>MAINTENANCE WTH NNDC |
| FMTCHK | ENHANCE FORMAT CHECKING | NNDC<br>INVOLVE PNPI GROUP | CONTINUOUS | NNDC (JOHNSON)<br>CONTINUOUS BUG FIXES DEVELOPMENT |

| CODE | TASK | NAME | TIMELINE | PRESENT |
|---|---|---|---|---|
| NS_RULER<br><br>PYRULER | DEVELOPMENT<br><br>DEVELOPMENT AND TESTING | T. KIBÉDI,<br><br>F. KONDEV, M. BIRCH | BETA VERSION BY JUNE 2016 | ONGOING – TREATMENT OF ASYMMETRIC UNCERTAINTIES WITH MONTE CARLO AVAILABLE |
| NS_LIB | DEVELOPMENT AND TESTING | T. KIBÉDI | NEXT CODES MEETING | DONE |
| BRICCEMIS/ NS_RADLIST | DEVELOPMENT | T. KIBÉDI | IN PROGRESS REPORT AT NEXT CODES MEETING | ONGOING – ASYMMETRIC UNCERTAINTIES WITH MONTE CARLO |
| LOGFT | WARNING MESSAGES FOR UNPHYSICAL INPUT DATA AND ASSIGNMENT OF UNCERTAINTIES | NNDC | PENDING | TO BE REPLACED BY IMPROVED CODE IN FUTURE (BETASHAPE AFTER VALIDATION) |

# Testing/validating codes

- First testing of codes from small group of evaluators then dissemination
- Submitted codes will be uploaded on IAEA Web page tab ‘Under development’
- *Evaluators who wish to test can send comments to code developer*
- A more dedicated smaller group will test codes for wide range of cases and after issues have been resolved the code will be moved to main tab for dissemination
- An email will be sent to inform evaluators

# List of Actions

| # | Person | Action | Deadline |
|---|---|---|---|
| 1 | IAEA<br>(V. Zerkin,<br>M. Verpelli) | Make available standalone versions of the codes NewGtol, Baron, and format checking codes developed at PNPI to the user community via the IAEA ENSDF Codes web page | January 2019 |
| 2 | IAEA<br>(M. Verpelli) | Create separate section for codes under development or testing on the IAEA ENSDF Codes Web page | December 2018 - done |
| 3 | T. Kibedi | Distribution of beta version of new GABS code | 1 March 2019 |
| 4 | IAEA<br>(V. Zerkin),<br>J. Chen | Make Java-NDS run on MyEnsdf Web too | After meeting - done |
| 5 | B. Singh<br>S. Singh | Distribution of 2nd beta version of ALPHAD-RaDd code | 1 March 2019 |
| 6 | NNDC (A. Sonzogni) | Distribution of corrected Web-Radlist code | 1 March 2019 |
| 7 | T. Kibedi | Include pair conversion and annihilation in atomic radiation records | 1st March 2019 |
| 8 | E. McCutchan<br>T. Kibedi | Check Atomic Radiation format against the ENSDF manual and dictionaries and present whatever changes are required at the NSDD meeting | NSDD meeting<br>(8-12 April 2019) |
| 9 | E. McCutchan, J. Chen,<br>T. Johsnon,<br>A. Sonzogni | Check new 'spectra' format against the ENSDF manual and dictionaries, FMTCHK and Java-NDS | NSDD meeting<br>(8-12 April 2019) |
| 10 | NNDC<br>(E. McCutchan, A. Sonzogni) | Update ENSDF Manual | 1 March 2019 |
| 11 | X. Mougeot | Beta version of BetaShape including EC | 1 June 2019 |
| 12 | IAEA<br>(P. Dimitriou) | Recommendation: Organize a short meeting with experimental uncertainties experts and ENSDF evaluators to discuss error propagation methods | tbd |

# IAEA Project on Improvement of Analysis and Checking Codes for NSDD Evaluations

Scientific Secretary: Paraskevi Demetriou

## Technical Meeting on Improving Analysis Codes for NSDD Evaluations, 3-7 December 2018, IAEA

The third meeting in the series of IAEA meetings dealing with ENSDF analysis and checking codes was held from 3 to 7 December 2018, at the IAEA Headquarters in Vienna.

Participants reviewed the status of the analysis and checking codes as well as the new editors since the previous meeting in 2015, discussed new codes that have emerged since then, and recommended actions to finalize and validate the codes before the upcoming NSDD meeting in 2019. Additional needs, such as an ENSDF editor and updating of the ENSDF Manual were also discussed.

Details on the discussions and recommendations are included in the summary report of the meeting which is in preparation.

The meeting was chaired by A. Sonzogni (BNL) and the minutes were kept by T. Kibedi (ANU).

- Summary report INDC(NDS)-0774
- Meeting agenda

**Presentations**

| # | Author | Title | Link |
|---|---|---|---|
| 1 | P. Dimitriou | Review of Actions from ENSDF Codes Meeting 2015 | PDF |
| 2 | V. Zerkin | MyEnsdf and ENSDF Editor | PDF |
| 3 | A. Rodionov | NSR_refs_manager package | PDF |
| 4 | J. Chen | Java-Ruler, ConsistencyCheck | PDF |
| 5 | V. Zerkin | Java-NDS on MyENSDF | PPT |
| 6 | B. Singh | ALPHAD-RAdD code | PDF |
| 7 | B. Singh | JGAMUT code | PDF |
| 8 | X. Mougeot | BetaShape code, beta shape factors and beta spectra in ENSDF | PDF |
| 9 | F. Kondev | RULER code | PDF |
| 10 | T. Kibedi | Uncertainty propagation tools | PDF |
| 11 | T. Kibedi | BrIcc - changes | PDF |
| 12 | T. Kibedi | Gabs v12 | PDF |
| 13 | T. Kibedi | BrIccEmis and NS_RadList | PDF |

*Thank you!*