



D. Rochman and A.J. Koning

Thermal capture cross sections for evaluated libraries: selection, validation and recommendation

Technical meeting on thermal capture and capture gammas, IAEA,
May 23-27, 2022

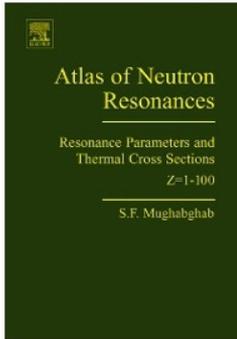
- Introduction/context
- (n_{th}, g) sources
- Rule(s)
- Implementation and validation
- Remarks
- Conclusion

Introduction/context

- Evaluated thermal capture cross sections are of prime importance for reactor applications:
 - Fission products, actinides, structural & light element activation
 - Incore, out of core
- Evaluated $(n_{th,g})$ are related to I_g
- Evaluated $(n_{th,g})$ are obtained from resonance parameters
- Evaluation of $(n_{th,g})$ is not based on resonance parameters
 - Using differential measurement (EXFOR)
 - Using integral information (reactor simulations): xs related to other quantities (e.g. FY)
- Some $(n_{th,g})$ are not measured but required for application (spent fuel, or astrophysics). What can be done ?

(n_{th},g) sources (not ordered)

1. EXFOR
2. Holden 1991-1993 (compilation) + RIPL
3. k_0 neutron activation
4. Atlas of Neutron resonances BNL-325, 2006, 2018
5. EAF-2010
6. JUKO Research reports 2000-2017
7. Sukhoruchkin 2009 and 2015
8. Standard
9. Systematics
10. ENDF/B
11. JEF(F)
12. JENDL
13. and more



Atlas of Neutron Resonances
Resonance Parameters and Thermal Cross Sections
Z=1-100
S.F. Mughabghab

Mughabghab Atlas 2018
Mughabghab Atlas 2006



LANDOLT-BÖRNSTEIN
Neutron Resonance Parameters
Supplement to Volume I/24

Sukhoruchkin 2015

Neutron Activation Analysis: <http://www.kayzero.com/k0naa>



ELSEVIER

Available online at www.sciencedirect.com



ScienceDirect

Nuclear Data Sheets 110 (2009) 3107-3214

Nuclear Data Sheets

www.elsevier.com/locate/nucds

RIPL – Reference Input Parameter Library for Calculation of Nuclear Reactions and Nuclear Data Evaluations

R. Capote,^{1*} M. Herman,^{1,2} P. Obložinský,^{1,2} P.G. Young,³ S. Goriely,⁴ T. Belgya,⁵ A.V. Ignatyuk,⁶ A.J. Koning,⁷ S. Hilaire,⁸ V.A. Plujko,⁹ M. Avrigeanu,¹⁰ O. Bersillon,⁸ M.B. Chadwick,³ T. Fukahori,¹¹ Zhigang Ge,¹² Yinlu Han,¹² S. Kailas,¹³ J. Kopecky,¹⁴ V.M. Maslov,¹⁵ G. Reffo,¹⁶ M. Sin,¹⁷ E.Sh. Soukhovitskii,¹⁸ P. Talou⁹

RIPL: Kopecky compilation
(Includes Holden tables)

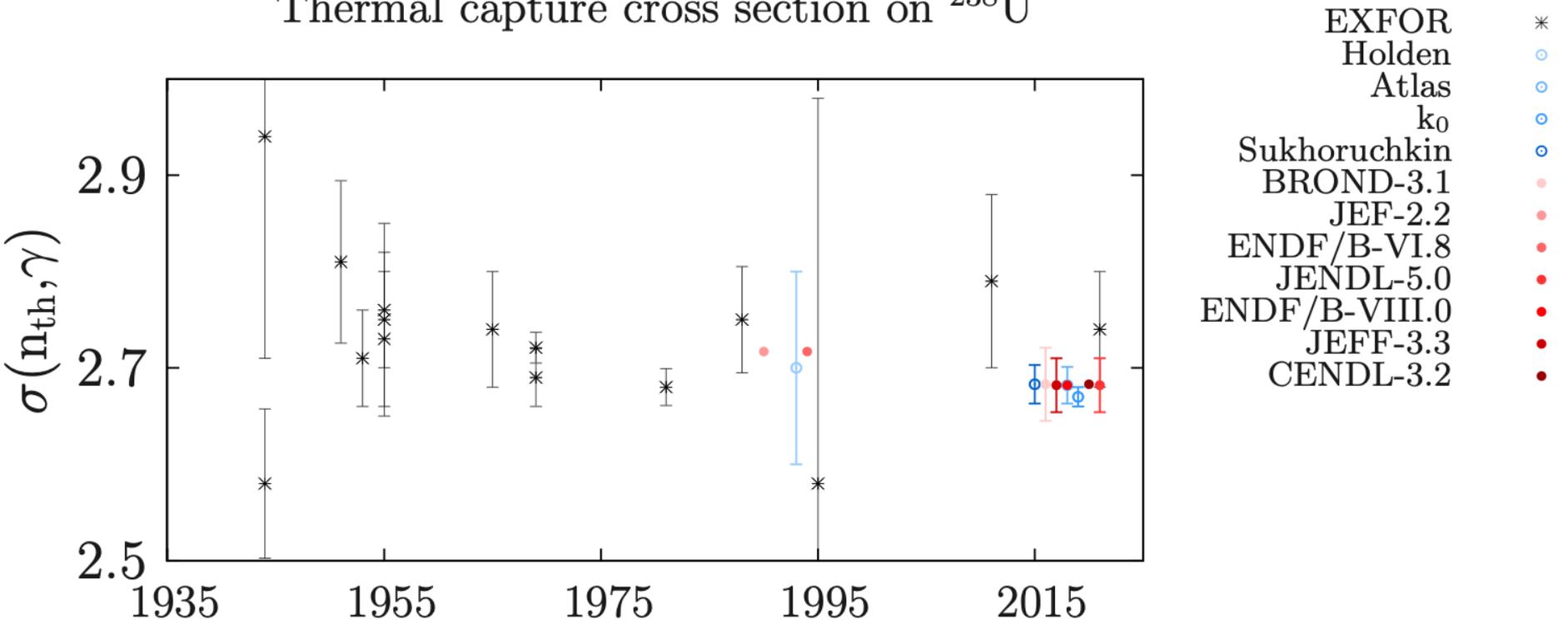
EXFOR

(n_{th,g}) sources: Example 1

- Evaluated values (red) and compilations (blue) do not come from EXFOR alone



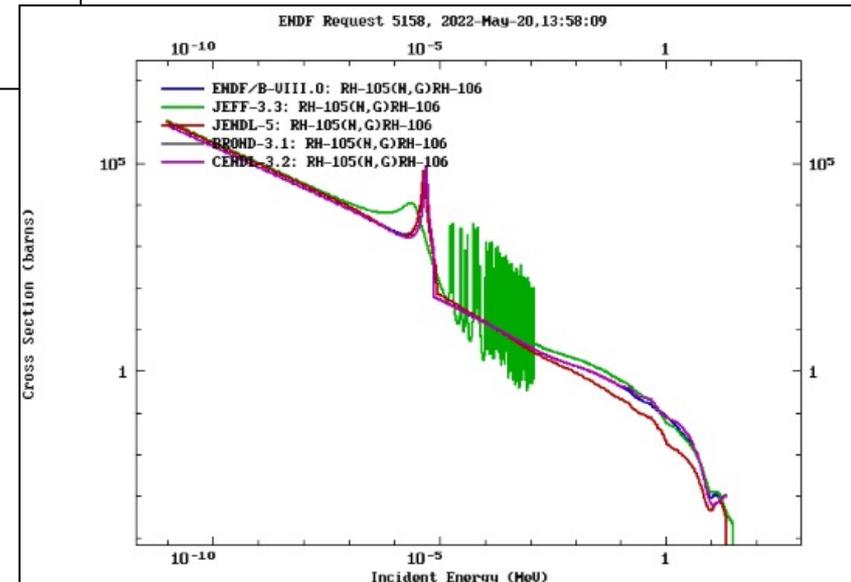
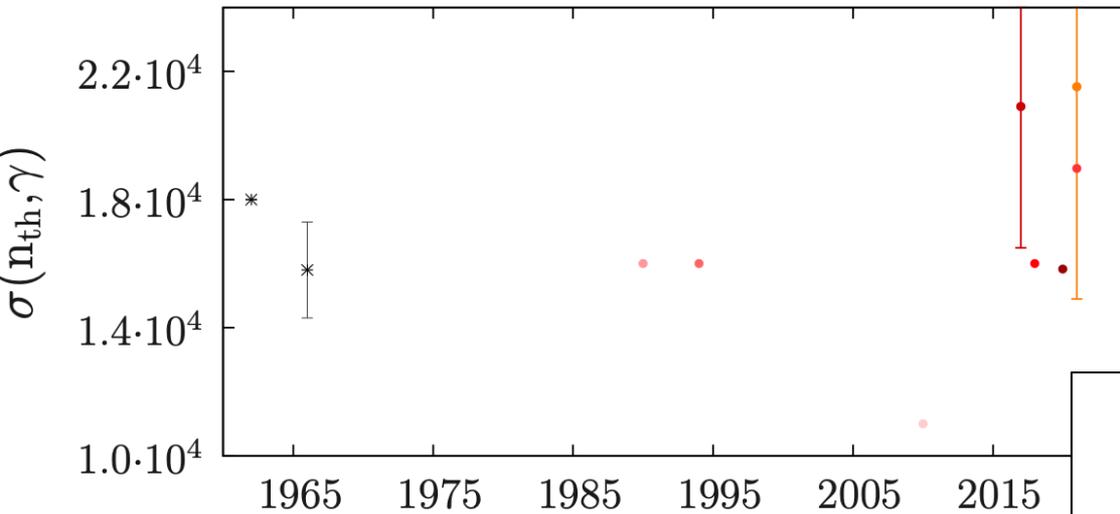
Thermal capture cross section on ²³⁸U



(n_{th,g}) sources: Example 2

- Evaluated values (red) do not come from EXFOR alone

Thermal capture cross section on ¹⁰⁵Rh



- Rules of selection applied for TENDL and some JEFF fission products
- Traceability
- Scripts based

New webpage under construction at IAEA

The screenshot shows a webpage titled 'TALYS-Related Software and Databases'. It features three main sections:

- TALYS**: Nuclear reaction model code. Authors: Arjan Koning, Stéphane Hilalre, Stéphane Goriely. Includes links for 'Download TALYS-1.95', 'Download previous versions', and 'Read Tutorial'.
- EXFORTABLES**: Experimental nuclear reaction database based on EXFOR. Author: Arjan Koning. Includes links for 'Download EXFORTABLES-1.0' and 'Read Tutorial'.
- RESONANCETABLES**: Database for thermal cross sections, MACS and average resonance parameters. Authors: Arjan Koning, Dimitri Rochman. Includes links for 'Download RESONANCETABLES-1.0' and 'Read Tutorial'.

 Logos for NRG, ORNL, IAEA, and PSI are visible at the bottom of the sections. The footer of the page reads '© 2020 IAEA | Contact'.

TASMAN, TEFAL, Libraries, ENDFTABLES, ISOTOPIA and Tools for TALYS (“T6”) to follow

RESONANCETABLES-1.0

Database for thermal cross sections, MACS and average resonance parameters

Arjan Koning and Dimitri Rochman

Draft version

Available on new website soon, together with other TALYS-related software

<https://www-nds.iaea.org/talys/>

Example: Table with all possible options for thermal capture cross sections



IAEA Atoms for Peace and Development

| 62 151 0 | 1.51400E+04 | 3.00000E+02 | Mugh18 | Sm151 |
|--------------|-------------|-------------|-----------------------------|-------|
| ripl | 1.52000E+04 | 3.00000E+02 | JUKO | |
| mugh06 | 1.51700E+04 | 3.00000E+02 | Mugh06 | |
| mugh18 | 1.51400E+04 | 3.00000E+02 | Mugh18 | |
| sukhoruchkin | 1.51700E+04 | 2.99000E+02 | Sukhoruchkin | |
| exfor | 1.20000E+04 | 0.00000E+00 | Melaika_1955_12086003 | |
| exfor | 1.51700E+04 | 3.00000E+02 | Mughabghab_2006_V10022001 | |
| exfor | 1.50200E+04 | 5.25000E+02 | Marrone_2006_22893007 | |
| cendl3.1 | 1.51239E+04 | CE= | 9.98937E-01 | |
| endfb8.0 | 1.51379E+04 | CE= | 9.99861E-01 | |
| jeff3.3 | 1.51294E+04 | CE= | 9.99300E-01 | |
| jendl4.0 | 1.51598E+04 | CE= | 1.00131E+00 | |
| tendl.2019 | 1.51334E+04 | CE= | 9.99564E-01 | |
| 62 152 0 | 2.06000E+02 | 3.00000E+00 | Mugh18 | Sm152 |
| ripl | 2.06000E+02 | 1.50000E+01 | JUKO | |
| mugh06 | 2.06000E+02 | 6.00000E+00 | Mugh06 | |
| mugh18 | 2.06000E+02 | 3.00000E+00 | Mugh18 | |
| sukhoruchkin | 2.06000E+02 | 6.00000E+00 | Sukhoruchkin | |
| exfor | 1.38000E+02 | 2.76000E+01 | Seren_1947_11447096 | |
| exfor | 2.00000E+02 | 6.00000E+00 | Pattenden_1958_21325012 | |
| exfor | 2.24000E+02 | 7.00000E+00 | Tattersall_1960_20638048 | |
| exfor | 2.15000E+02 | 1.00000E+01 | Fehr_1960_12023006 | |
| exfor | 2.09000E+02 | 9.00000E+00 | Cabell_1962_20627002 | |
| exfor | 2.09100E+02 | 2.07000E+01 | Bernabei_1962_12099002 | |
| exfor | 2.06000E+02 | 6.00000E+00 | Mughabghab_2006_V10022041 | |
| exfor | 2.04800E+02 | 6.32832E+00 | Karadag_2007_22964002 | |
| exfor | 2.38930E+02 | 1.91100E+01 | Nyarko_2010_31698006 | |
| exfor | 2.07300E+02 | 9.40000E+00 | Agbemava_2011_31717003 | |
| exfor | 2.07000E+02 | 1.00000E+00 | FarinaArbocco_2013_23266134 | |
| exfor | 2.12000E+02 | 8.00000E+00 | Nguyen_2017_30843002 | |
| cendl3.1 | 2.06640E+02 | CE= | 1.00311E+00 | |
| endfb8.0 | 2.05946E+02 | CE= | 9.99738E-01 | |
| jeff3.3 | 2.05974E+02 | CE= | 9.99874E-01 | |
| jendl4.0 | 2.05842E+02 | CE= | 9.99233E-01 | |
| tendl.2019 | 2.05971E+02 | CE= | 9.99859E-01 | |

Library values obtained
from point wise files
(PREPRO's RECENT module)

Order of adoption for thermal cross sections, resonance integrals and MACS



1. Kayzero database
2. Mughabghab 2018 Atlas
3. Sukhoruchkin 2015 Atlas
4. Mughabghab 2006 Atlas
5. RIPL or Kopecky database
6. EXFOR (the most recent value)

For MACS, the order of adoption is

1. Mughabghab 2018 Atlas
2. Sukhoruchkin 2015 Atlas
3. KADONIS database
4. EXFOR (the most recent value)

Final database: if 1 doesn't exist, we take 2, if it doesn't exist, we take 3, etc.

Implementation and validation

- Different tools were developed, followed by (extensive) testing

TALYS-based evaluated nuclear data library

Home Reference & us Citations Feedback TALYS

How to...
Sub-li...

We believe that our great goal can be achieved with systematism and reproducibility. We are so outside the box, that the box is a point!³⁷

New webpage under construction at IAEA

TALYS

TALYS-Related Software and Databases

TALYS and the TALYS-related packages are open source software and datasets (OSF License) for the simulation of nuclear reactions.

TALYS
Arjan Koning, Stéphane Hilborn, Stéphane Gorjode

NEA
NUCLEAR ENERGY AGENCY

Related sites

JEFF-3.3

The Joint Evaluated Fission and Fusion File (JEFF) is an evaluated library produced via an international collaboration of NEA Data Bank participating countries.

EXFORTABLES
Experimental nuclear reactions

Download EXFORTABLES-1.0
Read Tutorial

TASMAN, TEFAL, Libraries, ENDF/TABLES, ISOTOPIA

JEFF-3.3

The Joint Evaluated Fission and Fusion File (JEFF) is an evaluated library produced via an international collaboration of NEA Data Bank participating countries.

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Data Sheets

Nuclear Data Sheets 163 (2020) 163–190

www.elsevier.com/locate/nds

ELSEVIER

Check for updates

A Statistical Analysis of Evaluated Neutron Resonances with TARES for JEFF-3.3, JENDL-4.0, ENDF/B-VIII.0 and TENDL-2019

Implementation and validation

- Different tools were developed, followed by (extensive) testing

TABLE I. (Color online) Average $\overline{C/E}$ and standard deviation (Std) for each library and different quantities. In the case of the fission cross section, ^{238}U is excluded from the JEFF-3.3 library as thermal fission cross section is zero. Both contributions from MF2 and MF3 are considered. In this table as in the following ones, the term E refers to Ref. [30].

| Thermal capture cross section | | | | |
|-------------------------------|----------|------------------|-------|---------|
| Library | Isotopes | $\overline{C/E}$ | Std | Outlier |
| TARES&TENDL-2019 | 374 | 1.000 | 0.050 | 3 |
| JEFF-3.3 | 308 | 1.045 | 0.454 | 4 |
| JENDL-4.0 | 244 | 1.021 | 0.194 | 12 |
| ENDF/B-VIII.0 | 282 | 1.216 | 3.871 | 1 |
| Thermal elastic cross section | | | | |
| TARES&TENDL-2019 | 226 | 0.991 | 0.075 | 15 |
| JEFF-3.3 | 208 | 1.056 | 1.398 | 2 |
| JENDL-4.0 | 193 | 1.087 | 1.398 | 1 |
| ENDF/B-VIII.0 | 199 | 1.138 | 1.421 | 1 |
| Thermal fission cross section | | | | |
| TARES&TENDL-2019 | 45 | 1.003 | 0.521 | 2 |
| JEFF-3.3 | 34 | 2.310 | 7.923 | 0 |
| JENDL-4.0 | 33 | 0.971 | 0.371 | 4 |
| ENDF/B-VIII.0 | 33 | 2.057 | 6.142 | 0 |

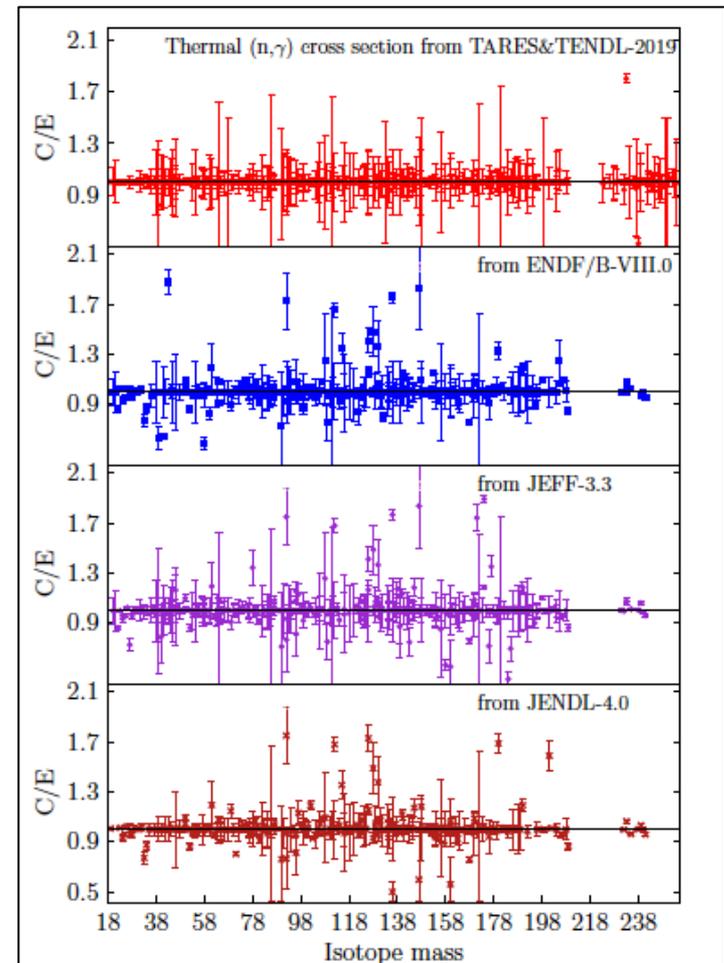
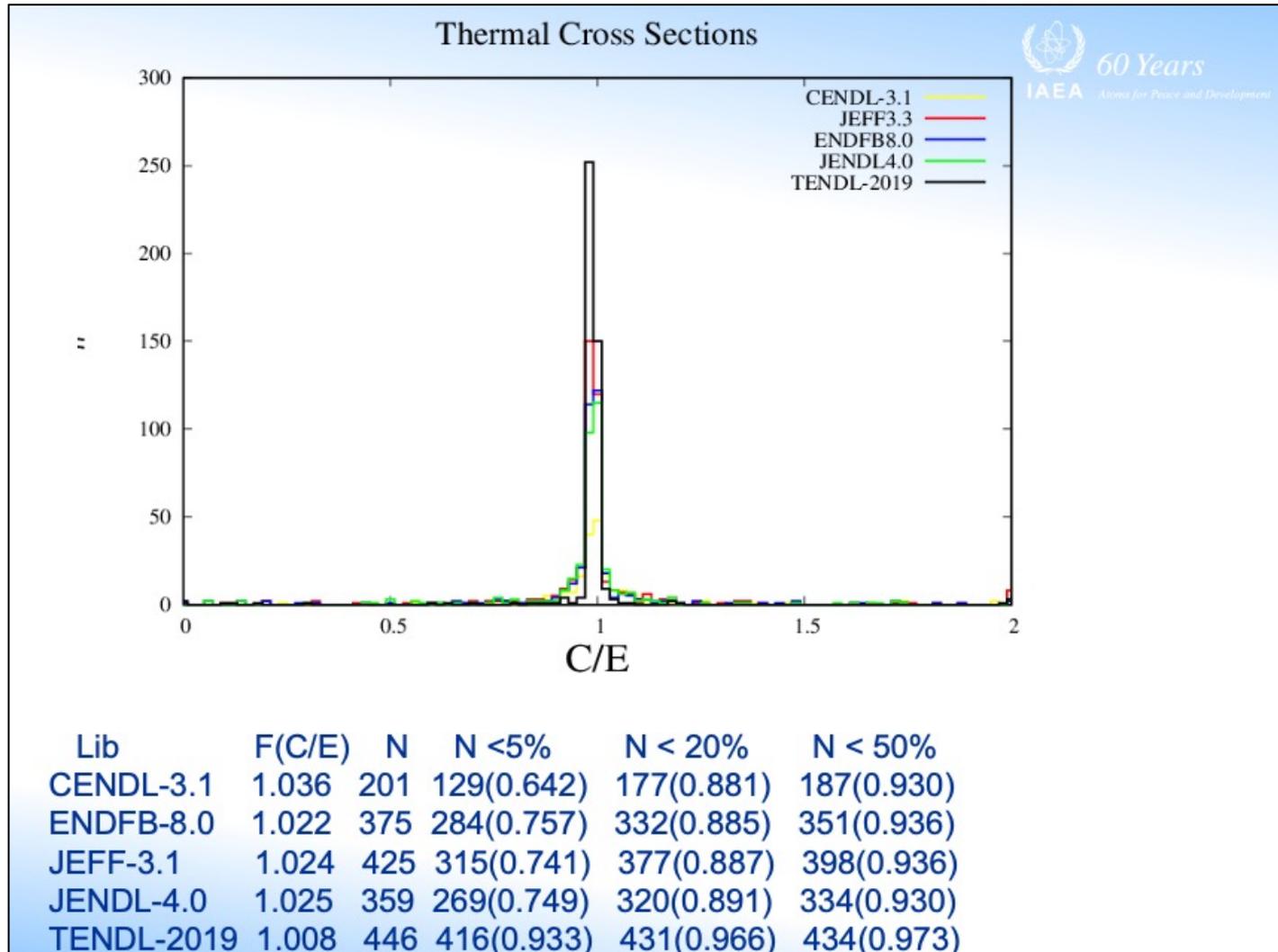


FIG. 8. (Color online) C/E values for the thermal capture cross sections for the various considered libraries. The “E” is from Ref. [30], see Table I for details. The uncertainties are experimental. For other reactions, see Appendix B.

Implementation and validation

- Different tools were developed, followed by (extensive) testing



- K_0 generally good, with some exceptions

Table 3.1: List of isotopes presenting the largest differences between the recommended values and the k_0 neutron activation. For ^{70}Zn , ^{76}Se and ^{190}Os the uncertainty on the resonance integral for the k_0 database is assigned to 10 %, as no value is originally provided.

| Isotope | cross section | | resonance integral | |
|-------------------|---------------------|------------------------|--------------------|----------------------|
| | This work | Refs. [7, 29] | This work | Refs. [7, 29] |
| ^{110}Pd | 0.30 ± 0.03 b. | 0.0137 ± 0.0012 b. | 2.18 ± 0.04 b. | 0.163 ± 0.023 b. |
| ^{68}Zn | 1.07 ± 0.19 b. | 0.0701 ± 0.0020 b. | 3.06 ± 0.55 b. | 0.224 ± 0.007 b. |
| ^{70}Zn | 92.3 ± 18.8 mb. | 21 ± 1 mb. | 0.94 ± 0.16 b. | 0.166 ± 0.017 b. |
| ^{76}Se | 85.0 ± 8.7 b. | 18.9 ± 0.6 b. | 39.0 ± 3.4 b. | 14.6 ± 1.5 b. |
| ^{190}Os | 10.95 ± 1.12 b. | 3.48 ± 0.25 b. | 39.5 ± 1.9 b. | 7.06 ± 0.8 b. |

[7] Frans de Corte. “The k_0 -standardization method: a move to the optimization of neutron activation analysis”. PhD thesis. University of Gent, Belgium, 1987 (cited on page 17).

[29] A. Trkov and V. Radulovic. “Nuclear reactions and physical models for neutron activation analysis”. In: *Jour. of Radioanal. Nucl. Chem.* 304 (2015), pages 763–778 (cited on pages 17, 18).

Remarks on (n_{th},g) not measured

- Short-lived fission products, or isotopes for astrophysics.
- What to do ?
 - Rely on systematics (HFR) for resonance parameters,

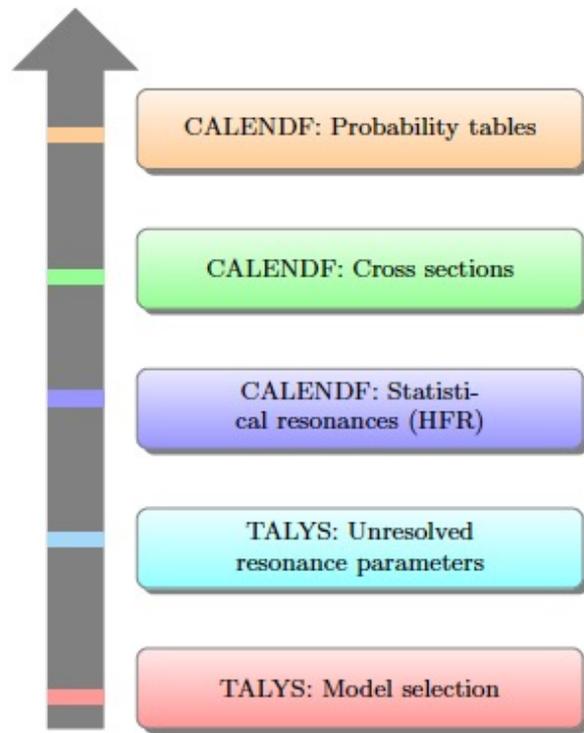
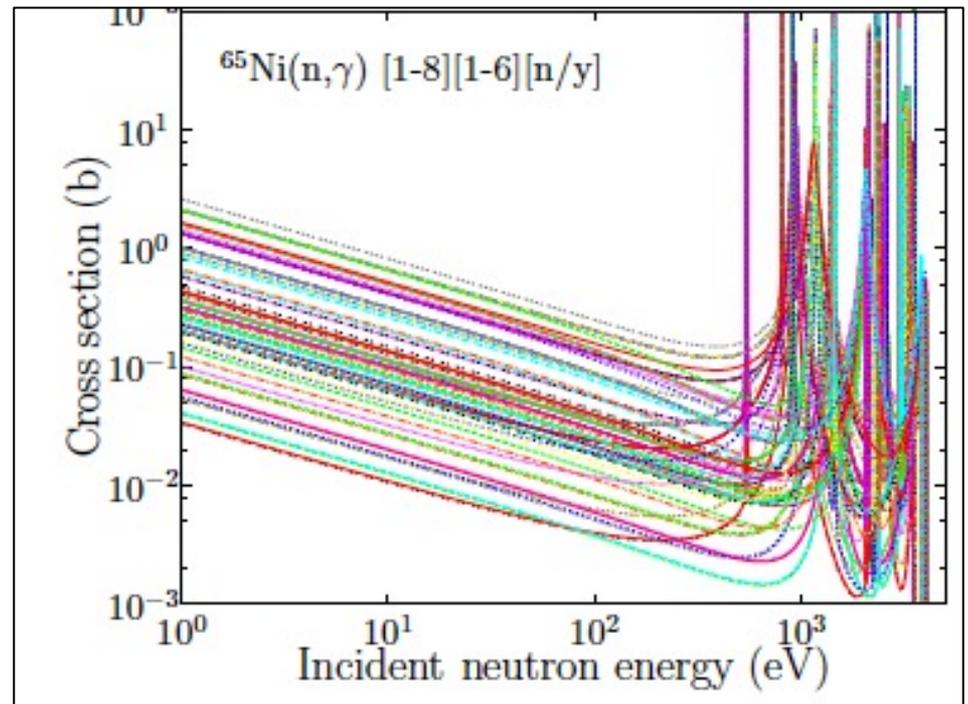


FIG. 18. (Color online) Flow chart for the production of the statistical resonances (HFR) using TALYS and TARES/CALENDF.



Remarks on (n_{th},g) not measured

- Short-lived fission products, or isotopes for astrophysics.
- What to do ?
 - or simply on model variations for average values (thermal, MACS)
 - (work performed with A. Koning, S. Goriely and D. Rochman)

TALYS-based evaluated nuclear data library

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TALYS



TENDL-2021

“ We believe that our great goal can be achieved with systematism and reproducibility. We are so outside the box, that the box is a point”

How to reference

Sub-library files

1. Neutron
2. Proton
3. Deuteron (updated)
4. Triton
5. He3
6. Alpha
7. Gamma
8. Fission yields
9. Thermal scattering
10. For astrophysics

TENDL-2021: (release date: December 30, 2021)

Last update: February 23, 2022

TENDL is a nuclear data library which provides the output of the TALYS nuclear model code system for direct use in both basic physics and applications. The 11th version is **TENDL-2021**, which is based on both default and adjusted TALYS calculations and data from other sources (previous releases can be found here: [2008](#), [2009](#), [2010](#), [2011](#), [2012](#), [2013](#), [2014](#), [2015](#), [2017](#) and [2019](#)).

Up to 2014, TENDL was produced at NRG Petten. Since 2015, TENDL is mainly developed at PSI and the IAEA (Nuclear Data Section). Still, many people contribute to TENDL with the testing and processing of the files.

TENDL contains evaluations for seven types of incident particles, for all isotopes living longer than 1 second: Z=1 ¹H to Z=115 ²⁹¹Mc (about 2800 isotopes), up to 200 MeV, with

TENDL-stars 2021

(n,g) cross sections, reaction rates and MACS for astrophysics

Description

Below are various links to 8892 isotopes for astrophysics applications (capture cross sections, capture rates and MACS).

Different reaction "model sets" were used: "a model set" represents a combination of 7 TALYS models:

1. Gamma strength function (values 8 or 9): either Gogny D1M HFB+QRPA, or SMLO
2. Level density (values 1, 2 or 5): Constant temperature + Fermi gas model, or Back-shifted Fermi gas model, or Microscopic level densities (Skyrme force) from Hilaire's combinatorial tables
3. JLM microscopic optical model potential or KD optical model (values y or n)
4. Gamma strength function for M1 (values 3 or 8): Hartree-Fock BCS tables or Gogny D1M HFB+QRPA
5. Collective enhancement (values y or n): yes or no
6. Width fluctuation (values 0, 1 or 2): Moldauer model, or Hofmann-Richert-Tepel-Weidenmueller model
7. Mass model (values 0, 1, 2 or 3): Duflo-Zuker formula, Moeller table, Goriely HFB-Skyrme table, or HFB-Gogny D1M table (except for known masses, where the experimental value is used)

Each of the set models is named with 7 values, such as "91n3n12" (default TALYS model), or 81n8n12. These values correspond to the ones in the TALYS manual. Quantities are defined such as:

- 1) XS (n,g) cross sections: capture cross sections from 0.01 eV to 20 MeV (from the TALYS file xs000000.tot)
- 2) $\langle \sigma_{v} \rangle$: reaction rates for all temperatures taking into account the thermal population of the target (from the TALYS file astrorate.g)
- 3) G(T): normalized partition function (from the TALYS file astrorate.tot)
- 4) MACS: Maxwellian Averaged (n,g) Cross Sections

Available files

| | XS (n,g) cross sections with | $\langle \sigma_{v} \rangle$ rates with | G(T) with | MACS 30 keV |
|----------------------------------|--|--|--|--|
| 1. 270 stable isotopes: | 12 or 288 model sets |
| 2. 3256 isotopes with known mass | 12 or 288 model sets | 12 or 288 model sets | 12 model sets | 12 model sets |
| 3. 5366 other isotopes | 12 or 288 model sets | 12 or 288 model sets | 12 model sets | 12 model sets |

Last update: Wed May 19, 2022

Remarks on (n_{th},g) not measured

```

1 # File for Tc079 reaction (n,g) PSI, Switzerland, 03-30-2022 11:27:59 PM
2 # Reaction calculated with TALYS 1.96
3 #
4 #
5 #
6 # name of model sets with 7 digits, such as 85y8n01
7 #
8 # |||||massmodel (0,1,2, or 3) (0: Duflo-Zuker formula, 1: Moeller table, 2: Goriely HFB-Skyrme table,
9 # |||||widthmode (0,1 or 2) (0: no width fluctuation, 1: Moldauer model, 2: Hofmann-Richert-Tepel-Weidenmueller mo
10 # |||colenhance (y, n) (y: (yes) explicit collective enhancement of the level density)
11 # |||strengthM1 (3, 8) (3: Hartree-Fock BCS tables, 8:Gogny D1M HFB+QRPA
12 # ||jlmomp (y, n) (y: (yes) JLM microscopic optical model potential)
13 # |ldmodel (1, 2, 5) (1: Constant temperature + Fermi gas model, 2: Back-shifted Fermi gas model,
14 # |strength (8, 9) (8: Gogny D1M HFB+QRPA, 9: SML0
15 #
16 # Default TALYS model: 91n3n12
17 #
18 # Number of model sets: 288
19 #
20 # energy (MeV) Mean Std Median MAD min max 91n3n12 ( 1) 85y8n00 ( 2) 85y8n01 ( 3) 85y8n02 ( 4) 85y8n03 ( 5)
21 1.00000E-11 6.008e+06 5.170e+06 4.512e+06 3.538e+06 8.238e+05 1.640e+07 8.739e+06 1.177e+07 9.226e+06 8.739e+06 1.640e+07
22 2.53000E-08 1.194e+05 1.028e+05 8.972e+04 7.036e+04 1.638e+04 3.261e+05 1.737e+05 2.340e+05 1.834e+05 1.737e+05 3.261e+05
23 2.00000E-07 4.249e+04 3.657e+04 3.190e+04 2.501e+04 5.825e+03 1.160e+05 6.180e+04 8.323e+04 6.524e+04 6.180e+04 1.160e+05
24 1.00000E-06 3.440e-05 5.947e-05 5.766e-06 3.917e-06 5.283e-07 1.946e-04 3.102e-06 3.223e-06 8.354e-06 5.108e-06 1.798e-04
25 1.00000E-05 1.108e-05 1.871e-05 2.186e-06 1.520e-06 2.085e-07 6.152e-05 1.102e-06 1.373e-06 3.322e-06 2.033e-06 5.684e-05
26 1.00000E-04 4.138e-06 5.661e-06 1.574e-06 1.069e-06 1.973e-07 1.942e-05 7.319e-07 1.554e-06 3.204e-06 1.965e-06 1.795e-05
27 2.00000E-04 3.427e-06 3.867e-06 1.889e-06 1.249e-06 2.427e-07 1.372e-05 8.189e-07 1.979e-06 3.958e-06 2.428e-06 1.268e-05
28 5.00000E-04 3.119e-06 2.469e-06 2.248e-06 1.328e-06 3.493e-07 8.662e-06 1.090e-06 2.921e-06 5.713e-06 3.507e-06 8.003e-06
29 1.00000E-03 3.327e-06 2.331e-06 2.881e-06 1.670e-06 4.763e-07 9.227e-06 1.444e-06 4.033e-06 7.822e-06 4.802e-06 5.646e-06
30 2.00000E-03 3.939e-06 3.064e-06 3.645e-06 1.932e-06 6.532e-07 1.265e-05 1.973e-06 5.631e-06 1.088e-05 6.677e-06 3.980e-06
31 5.00000E-03 5.492e-06 5.034e-06 3.070e-06 2.046e-06 4.329e-07 1.957e-05 3.047e-06 8.818e-06 1.699e-05 1.043e-05 2.500e-06
32 1.00000E-02 7.396e-06 7.274e-06 4.288e-06 3.258e-06 3.033e-07 2.737e-05 1.239e-05 2.385e-05 1.465e-05 1.754e-06
33 2.00000E-02 1.012e-05 1.033e-05 5.971e-06 5.104e-06 2.114e-07 3.813e-05 5.932e-06 1.733e-05 3.336e-05 2.051e-05 1.226e-06
34 3.00000E-02 1.215e-05 1.257e-05 7.205e-06 6.290e-06 1.706e-07 4.604e-05 7.161e-06 2.098e-05 4.039e-05 2.486e-05 9.924e-07
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37 2.00000E-01 2.251e-05 2.375e-05 1.317e-05 1.289e-05 6.040e-08 8.412e-05 1.313e-05 3.968e-05 7.684e-05 4.801e-05 3.690e-07
38 5.00000E-01 1.712e-05 1.805e-05 9.936e-06 9.789e-06 3.800e-08 6.499e-05 9.578e-06 3.054e-05 5.982e-05 3.862e-05 2.506e-07
39 8.00000E-01 1.096e-05 1.152e-05 6.237e-06 6.124e-06 3.030e-08 4.218e-05 5.873e-06 1.960e-05 3.892e-05 2.611e-05 2.134e-07
40 1.00000E+00 5.994e-02 1.364e-02 5.690e-02 9.890e-03 3.770e-02 9.118e-02 5.021e-02 9.111e-02 6.864e-02 5.678e-02 6.722e-02
41 1.20000E+00 1.150e-02 7.182e-03 1.427e-02 3.070e-03 8.911e-08 2.149e-02 2.148e-02 2.148e-02 5.344e-07 1.733e-02 1.548e-02
42 1.60000E+00 3.778e-02 1.439e-02 4.065e-02 1.021e-02 1.245e-02 6.052e-02 4.459e-02 6.049e-02 2.111e-02 5.532e-02 4.428e-02
43 1.80000E+00 2.457e-02 2.761e-02 1.413e-02 9.925e-03 2.194e-08 8.462e-02 2.937e-08 1.984e-02 8.462e-02 9.715e-08 1.460e-02
44 2.00000E+00 5.281e-02 1.102e-02 5.307e-02 9.235e-03 3.444e-02 7.549e-02 4.456e-02 7.548e-02 6.301e-02 5.870e-02 5.623e-02
45 2.50000E+00 5.049e-02 9.442e-03 5.141e-02 8.050e-03 3.438e-02 6.872e-02 4.375e-02 6.872e-02 5.951e-02 5.848e-02 5.146e-02
46 3.00000E+00 4.650e-02 7.474e-03 4.529e-02 6.570e-03 3.349e-02 6.010e-02 4.211e-02 6.010e-02 5.326e-02 5.458e-02 4.529e-02
47 3.50000E+00 4.155e-02 5.647e-03 4.038e-02 4.680e-03 3.185e-02 5.114e-02 3.973e-02 5.114e-02 4.586e-02 4.826e-02 3.875e-02
48 4.00000E+00 3.659e-02 4.282e-03 3.611e-02 3.275e-03 2.932e-02 4.516e-02 3.707e-02 4.311e-02 3.878e-02 4.148e-02 3.288e-02
49 5.00000E+00 3.129e-02 5.311e-03 3.113e-02 3.985e-03 2.267e-02 4.206e-02 4.202e-02 3.117e-02 3.133e-02 4.007e-02 2.404e-02
50 6.00000E+00 2.477e-02 4.381e-03 2.363e-02 3.145e-03 1.747e-02 3.518e-02 3.518e-02 2.365e-02 2.327e-02 2.985e-02 1.851e-02
51 7.00000E+00 2.006e-02 3.688e-03 1.945e-02 2.550e-03 1.403e-02 2.905e-02 2.899e-02 1.878e-02 1.795e-02 2.295e-02 1.483e-02
52 8.00000E+00 1.649e-02 3.154e-03 1.634e-02 2.205e-03 1.149e-02 2.413e-02 2.404e-02 1.523e-02 1.414e-02 1.816e-02 1.217e-02
53 1.00000E+01 6.177e-03 6.431e-03 4.397e-03 4.397e-03 2.713e-10 1.759e-02 1.722e-02 5.266e-08 9.482e-03 1.225e-02 8.625e-10
54 1.20000E+01 5.312e-03 5.483e-03 4.161e-03 4.161e-03 2.465e-10 1.384e-02 1.314e-02 3.649e-08 9.213e-03 8.959e-03 6.727e-10
55 1.40000E+01 2.127e-03 3.779e-03 0.000e+00 1.375e-08 1.251e-10 1.103e-02 1.468e-08 2.660e-08 7.121e-03 2.864e-08 3.336e-10
56 1.60000E+01 6.749e-03 1.458e-03 6.202e-03 1.329e-03 4.472e-03 9.422e-03 9.039e-03 5.762e-03 6.016e-03 5.888e-03 4.731e-03
57 1.80000E+01 6.063e-03 1.314e-03 5.557e-03 1.188e-03 4.001e-03 8.454e-03 8.131e-03 5.171e-03 5.399e-03 5.296e-03 4.228e-03
58 2.00000E+01 5.418e-03 1.178e-03 4.960e-03 1.057e-03 3.576e-03 7.534e-03 7.344e-03 4.596e-03 4.811e-03 4.783e-03 3.762e-03

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Conclusion

- There is a need for international recommendations on $(n_{th,g})$, RIPL-like,
- Need of clear rules, traceability,
- Need of accessibility in a computer format (and eventually reports/papers)
- $(n_{th,el})$, I_g , RP are also important,
- $(n_{th,g})$ for 8892 isotopes can be needed.

Wir schaffen Wissen – heute für morgen

