Nuclear Data

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Contents

1. Nuclear Data

What are nuclear data

Nuclear data underpin all nuclear science and technology
Nuclear data = basic data for the numerical simulation of nuclear systems

- Basic data
  Cross sections, energy/angular distributions, multiplicities, fission yields, radioactive decay data, etc.

- Nuclear systems
  Nuclear reactors, criticality-safety, medical applications (radiotherapy), neutron sources, transport and storage of radioactive material, radioprotection, nuclear astrophysics (nucleosynthesis), design of nuclear physics experiments, etc.

What are nuclear data

For all these systems one needs to simulate,

- Interaction of particles/radiations with materials
- Particle/radiation transport (propagation/multiplication/absorption)
- Depletion/evolution with time of the nuclide concentration/radioactivity

Nuclear data = central values + uncertainties + uncertainty correlations

What are nuclear data

- Nuclear structure
  - Nucleus mass and excited levels spin, parity, half-life
  - Decay modes: α, β, γ, n, p, Spontaneous Fission (SF)
  - Branching ratio
  - Lines/spectra of emitted radiations
- Nuclear reaction (energy dependent)
  - Cross sections (or resonance parameters)
  - Angular/Energy distributions of emitted particles/radiation
  - Yields of residual nuclides
- For fissile nuclides (incl. SF)
  - Fission product yields (before emission of delayed neutrons)
  - Spectra and multiplicity of prompt and delayed neutrons (and gammas)

Why nuclear data measurements

- Despite progress, there is no Standard Model of the nucleus describing nuclear reactions from first principles (i.e., QCD and QED in a strongly correlated n-body quantum system)

- Nuclear reaction models have been developed thanks to nuclear data measurements (of cross sections, angular distributions, etc…)

- New measurements allow to improve further the nuclear data quality (i.e., accuracy, consistency, completeness),
  - Directly, by updating the evaluated nuclear data file
  - Indirectly, by improving the nuclear reaction models

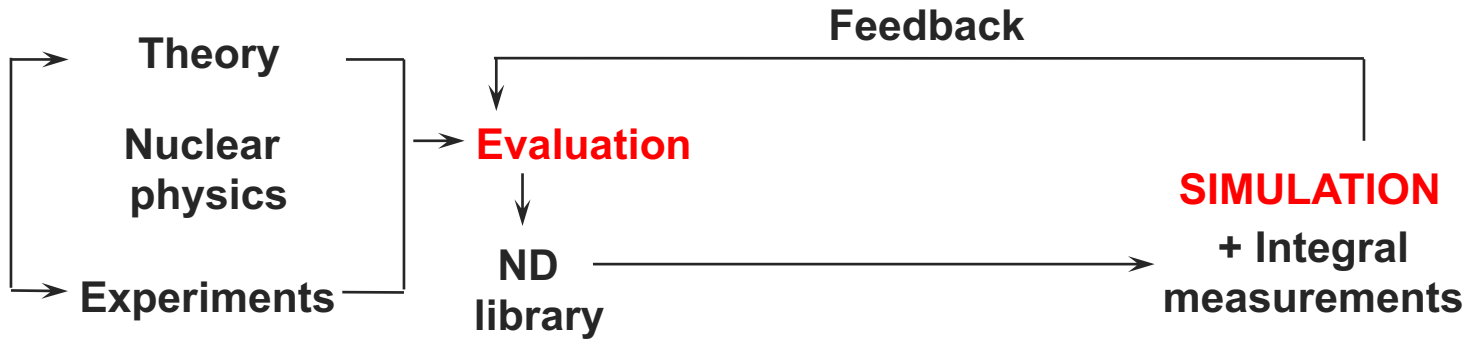
Why nuclear data modeling

- Phenomenological models may interpolate and (slightly) extrapolate when experimental data are available
- Microscopic and semi-ab initio models are required when there is no experimental data
- Truly ab initio models are a long-term goal for answering needs of many applications

Nuclear models are the basis for consistent nuclear data evaluations (e.g., TALYS-based Evaluated Nuclear Data Library, TENDL)

What is nuclear data evaluation

Properly weighted (e.g., by GLSQ fit) combination of information from measurements and theoretical models to provide recommended values and uncertainties



Nuclear data evaluation requires knowledge from two different but connected fields: nuclear physics and nuclear applications

The goal is to perform better simulations, which means more accurate, comprehensive and/or consistent nuclear data, depending on the application

What is nuclear data validation

Objectives of the validation process by the nuclear data users:

1. Determine whether the quality of the data is sufficient to meet the simulation requirements (e.g., accuracy)
2. Identify the data that need to be improved further
3. Provide feedback to evaluators and physicists (i.e., nuclear data producers)

- The validation is performed against various benchmark experiments at various scales (reaction channel, nuclide-evaluation, full library)
- Multi-scale validations against various types of benchmarks aim at minimizing error compensations

What is an evaluated library

Nuclear data are formatted according to the ENDF format and stored in evaluated libraries containing hundreds or thousands evaluations (isotopes)

- TENDL (IAEA, PSI) thousands of isotopes
- ENDF/B (USA) hundreds of isotopes
- JENDL (Japan) hundreds of isotopes
- JEFF-3.3 (Europe) hundreds of isotopes
- Sub-libraries are available for activation, decay data, fission yields, etc.
- Application libraries are also available: FENDL (fusion), IRDFF (dosimetry)

An evaluated library is not an archive (as EXFOR is for instance), the goal is not to store knowledge, but to make numerical simulations => a nuclear data evaluation must be complete

Why another yet evaluated library

To answer needs of different communities (application-wise or country-wise)

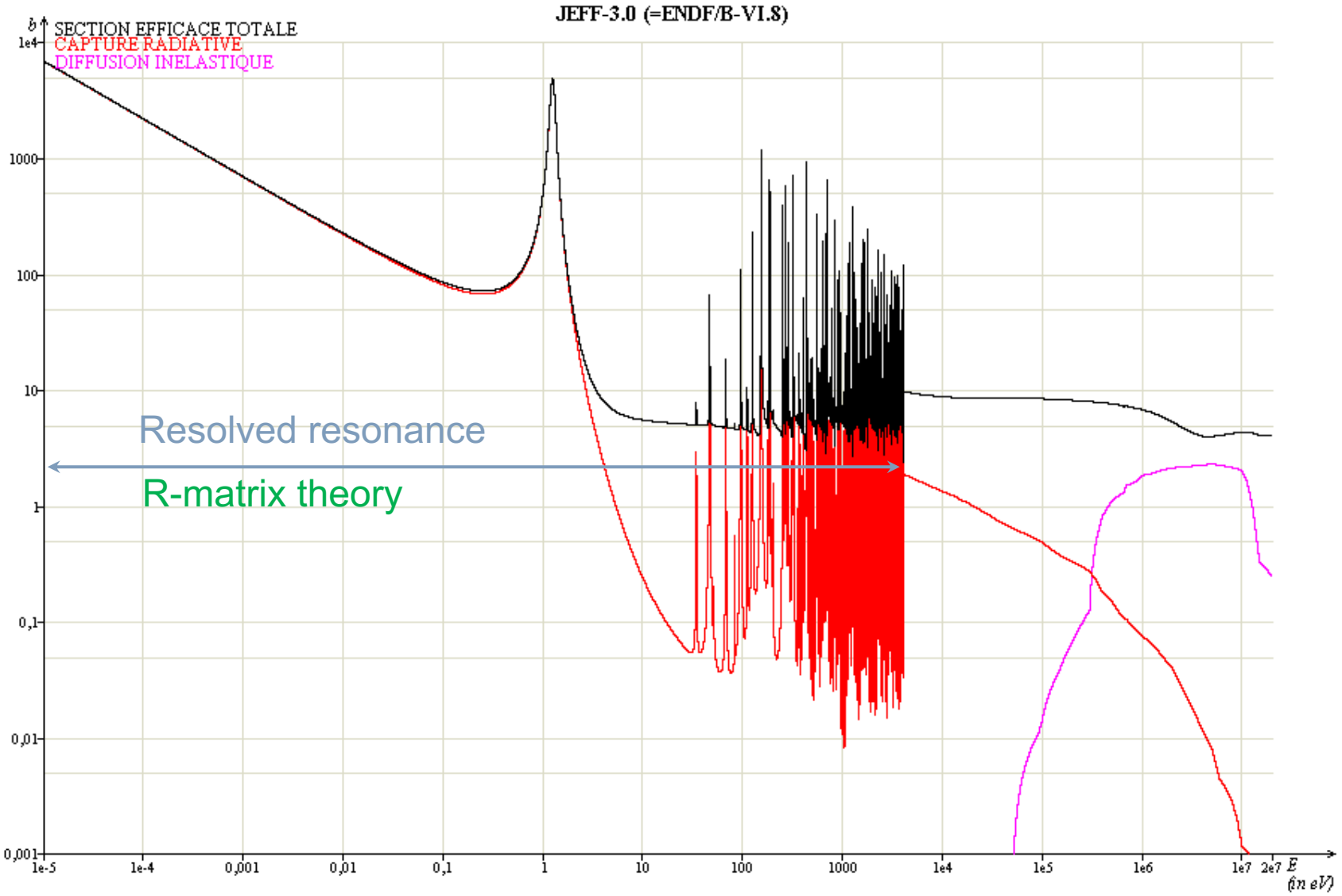
- Feedback from integral measurements
- New energy range to cover
  - up to 10 MeV for thermal reactors
  - up to 20 MeV for fast and fusion reactors
  - up to 200 MeV for accelerator-based systems
- New incident particles to consider
  - Deuton GANIL-SPIRAL2, IFMIF-DONES
  - Proton Accelerator Driven Systems (n_TOF, ESS, MYRRHA)
  - Photon Active screening of containers
- Missing isotopes
- Improvements in nuclear reaction models and new measurements

Modeling of nuclear (reaction) data

Different energy ranges in the evaluations correspond to different models

- Resolved resonance region: <D> >> <Γ> (E_n < ~10-100 keV)
  - R-matrix theory
  - Resonance parameters in evaluations => cross sections
- Unresolved resonance region: <D> ~ <Γ>
  - < R-matrix > (statistical model)
  - Average resonance parameters in evaluations => cross sections
- Statistical continuum region: <D> << <Γ> (E_n > ~100-1000 keV)
  - Optical model, direct/pre-equilibrium/statistical models, …
  - Tabulated cross sections in evaluations

Modeling of nuclear (reaction) data

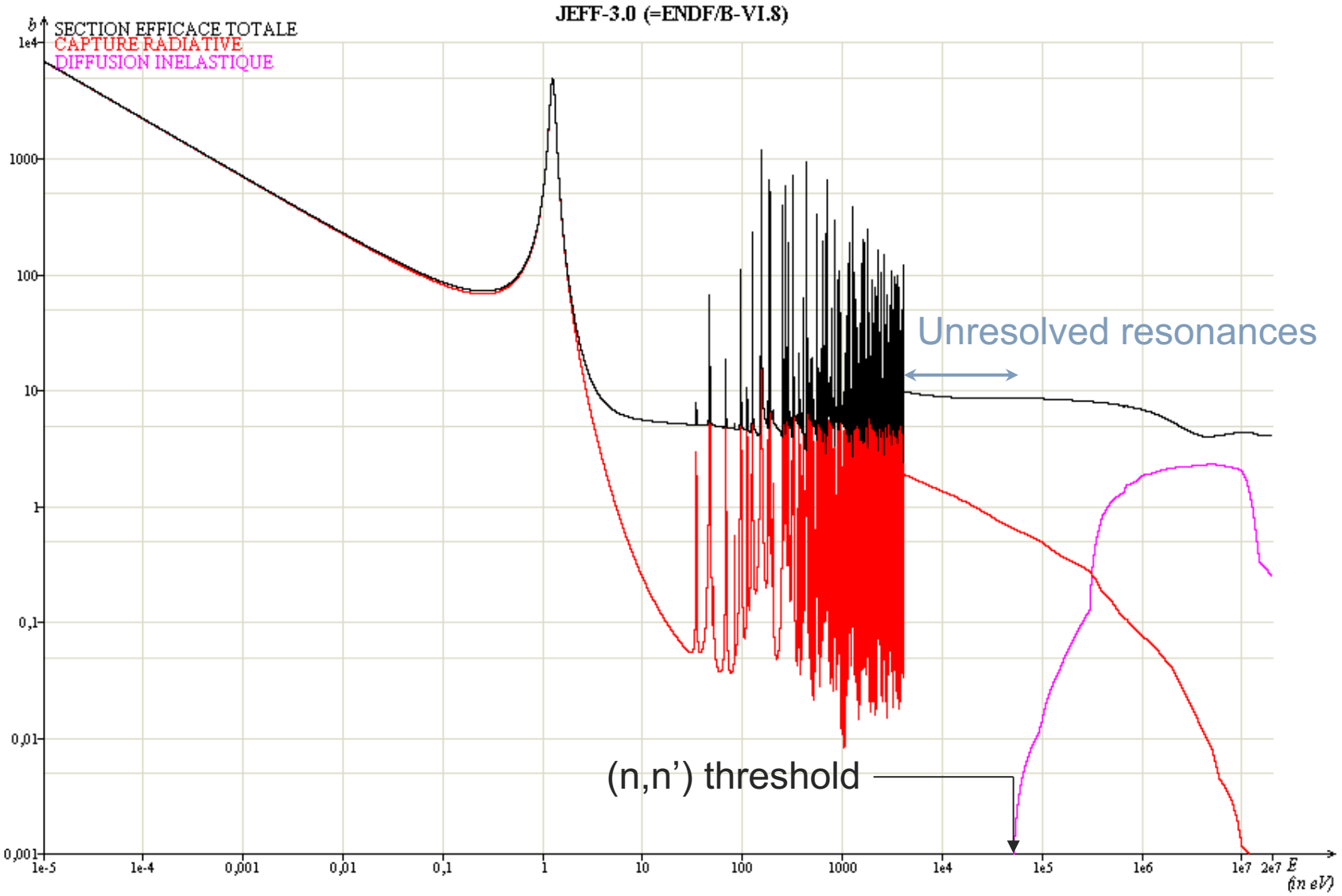


Modeling of nuclear (reaction) data

The R-matrix theory is not predictive

- Resonance parameters are fitted on (n,tot), (n,γ), (n,f) cross section measurements.
  - Position (E_r)
  - Spin and parity (J^π)
  - Partial width (Γ_n, Γ_γ, Γ_f)
  - Nuclear radius
- Typically, parameters of hundreds of resonances are adjusted (using analysis codes such as REFIT, SAMMY or CONRAD)
  - Input for Atlas of neutron resonances, ENSDF, and evaluated files

Modeling of nuclear (reaction) data



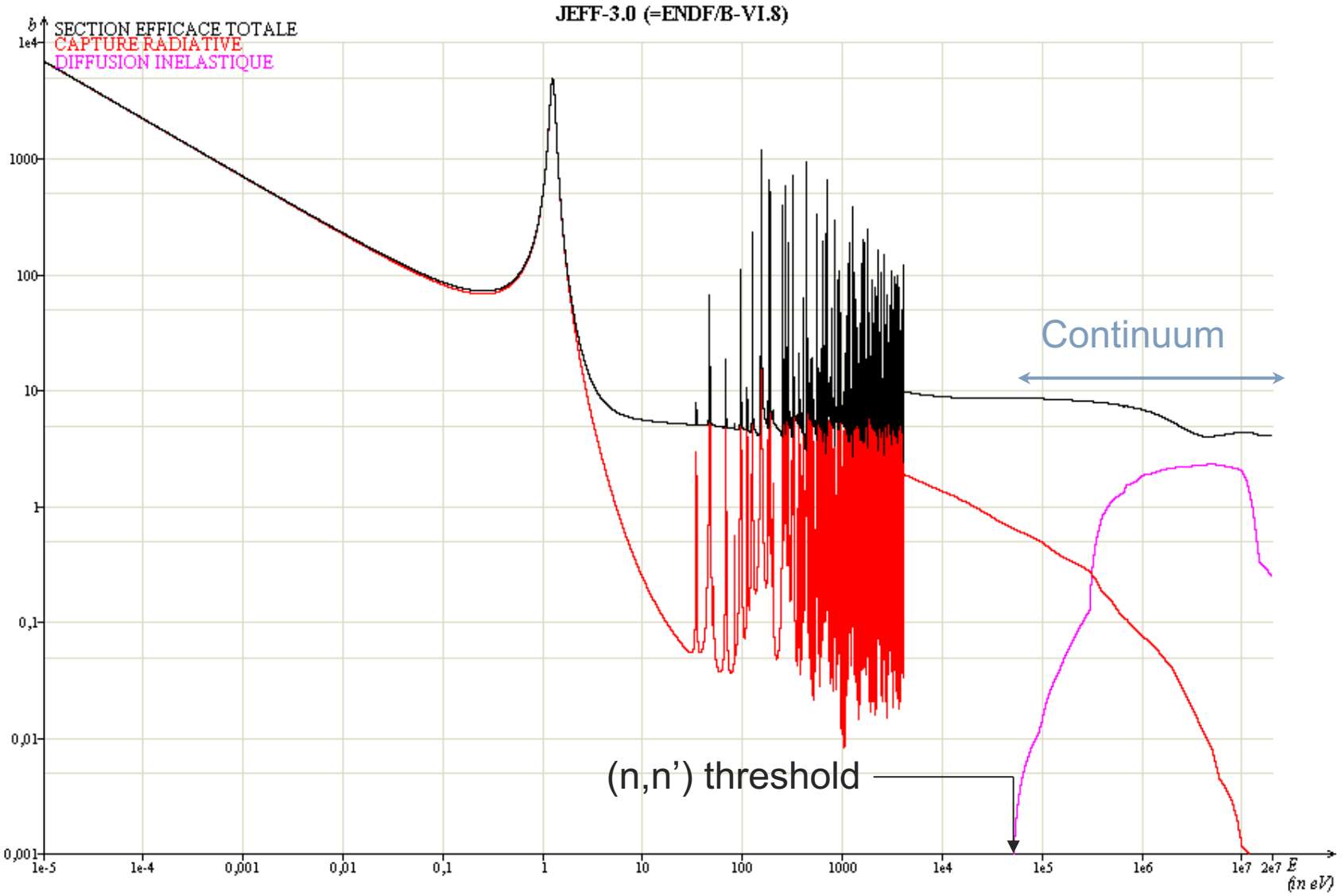
Modeling of nuclear (reaction) data

Hauser-Feshbach formalism for partial cross sections

$$<\sigma_{cc'}> = 2\pi^2 \lambda\!\!\!^{-2} g_c \rho_c \frac{<\Gamma_c><\Gamma_{c'}>}{<\Gamma>} W_{cc'}$$

- The s-wave parameters are extracted from the resolved resonance analysis
  - Scattering radius R’
  - L=0 (s-wave) S_0 $<\Gamma_{\gamma 0}>$
  - Average spacing D_0
- Other parameters may be fitted on measured data or calculated
  - L=1 (p-wave) S_1 $<\Gamma_{\gamma 1}>$
  - L=2 (d-wave) S_2 $<\Gamma_{\gamma 0}>$
  - Normalization
- These average parameters are directly used in evaluated files

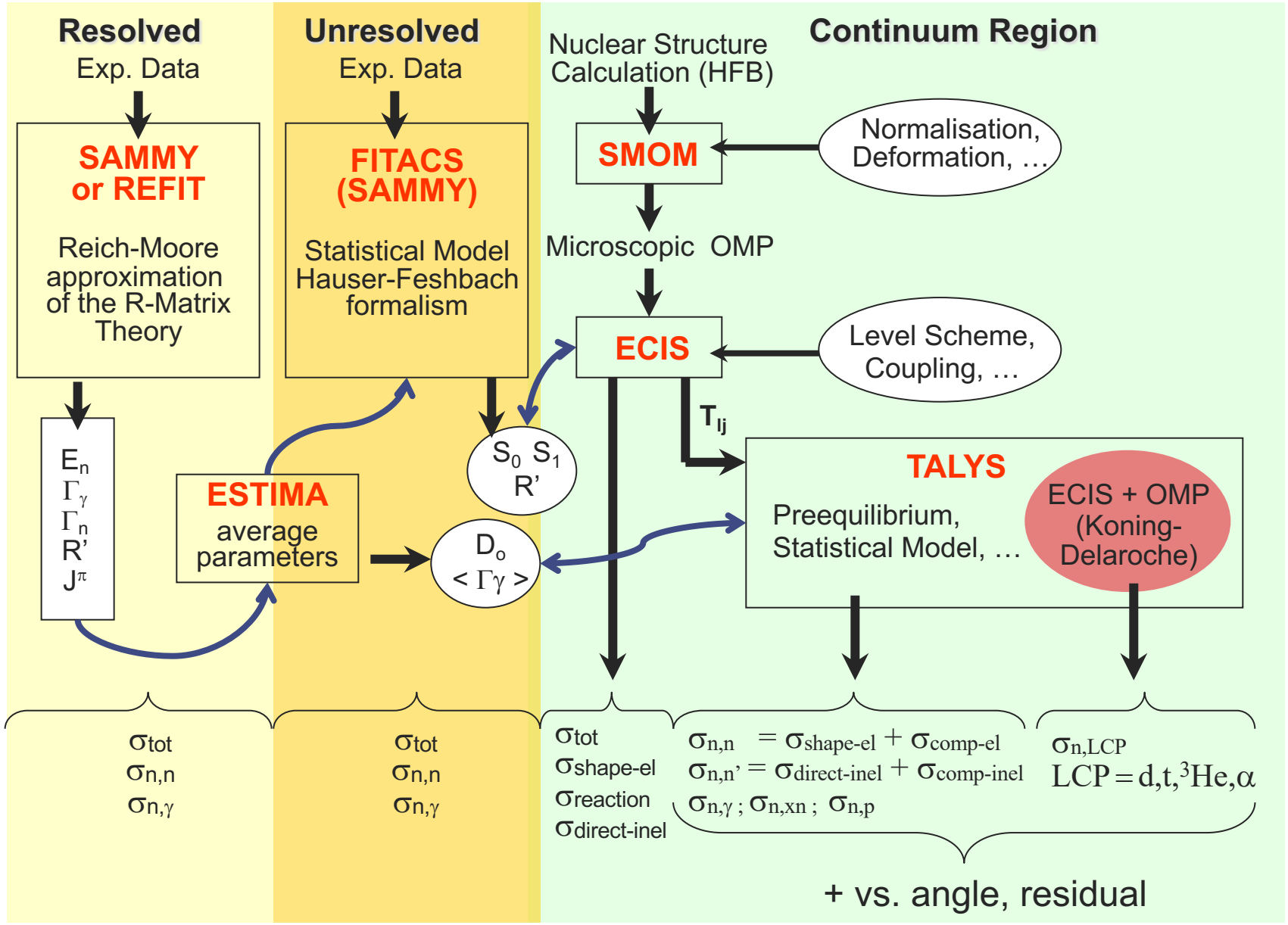
Modeling of nuclear (reaction) data



Modeling of nuclear (reaction) data

- Models in the statistical continuum region
  - Scattering/Absorption: Optical model (ECIS)
  - Nucleus deexcitation: Pre-equilibrium, statistical model (TALYS)
- Parameters of these models may be adjusted or calculated from (semi-)ab initio models
- In this energy range, the evaluated files contain the calculated cross sections (not the model parameters)

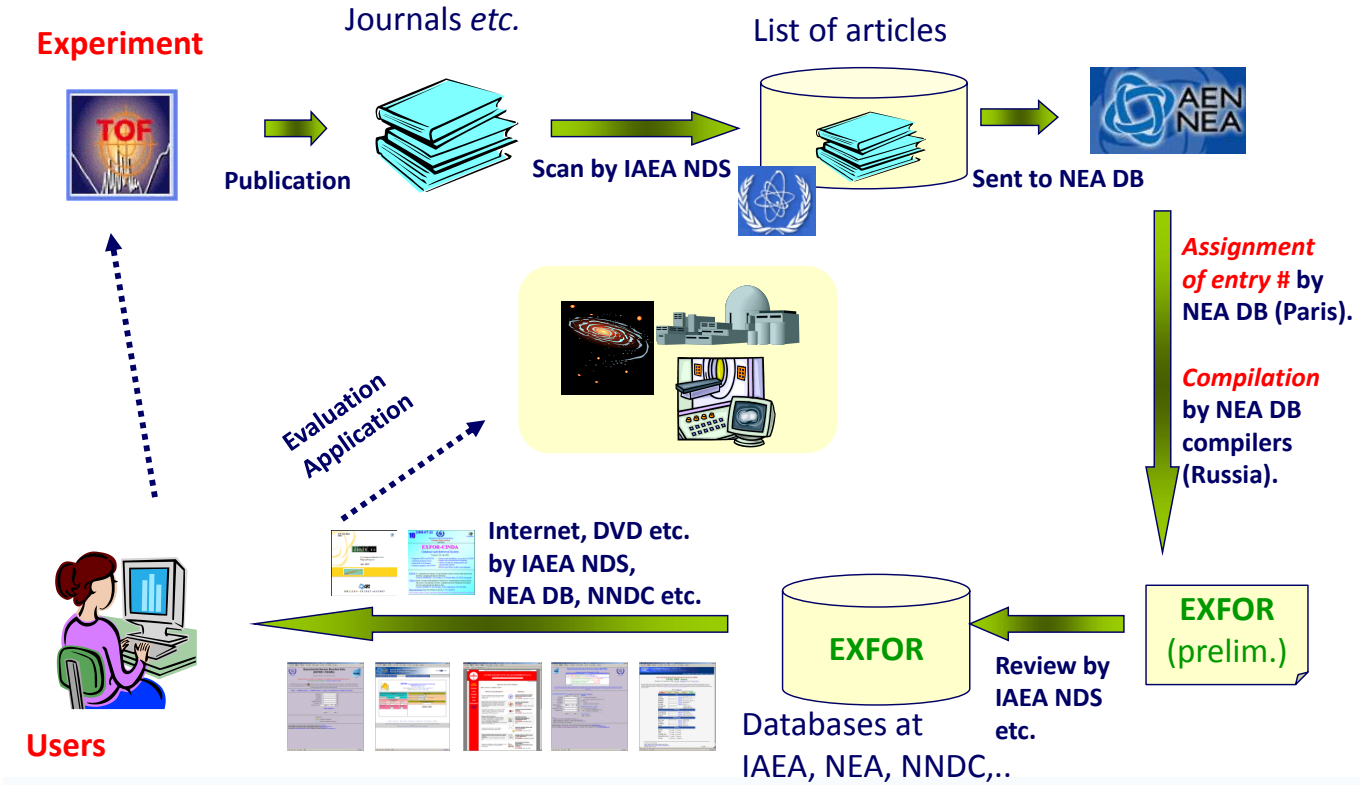
Consistency of nuclear data modeling



2. Nuclear Databases

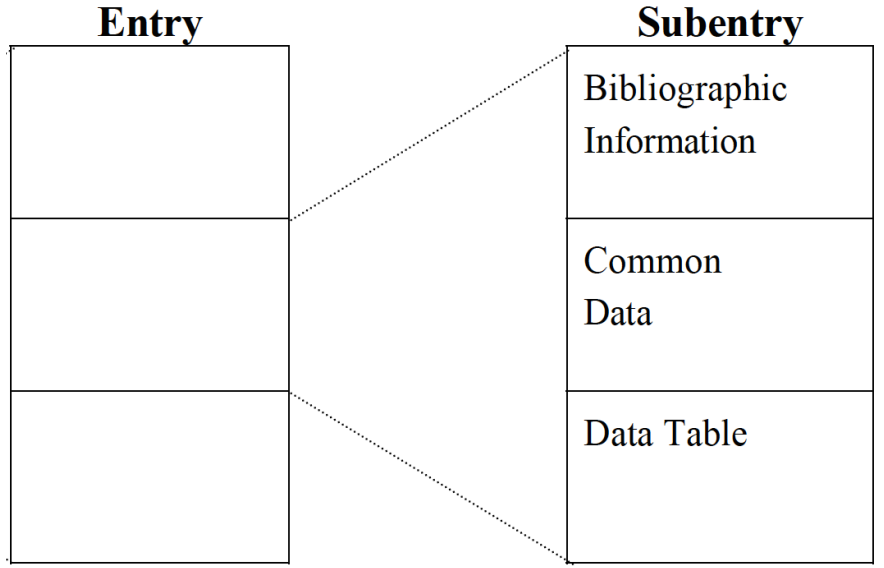
Nuclear reaction data (EXFOR)

- What is the EXFOR library
  - http://www-nds.iaea.org/nrdc/about/about-exfor.html (screenshot)
  - Archive of experimental nuclear reaction data
  - Maintained by the Nuclear Reaction Data Centres (IAEA, NNDC, NEA, etc.)



Nuclear reaction data (EXFOR)

- EXFOR is an EXchange (text) FORmat and a repository
- Each entry contains subentries
  - Bibliographic information
  - Tabulated data
- EXFOR entry is a five-digit number
- 1st character is a digit for neutron-induced data
  - 1 = NNDC area (USA and Canada)
  - 2 = NEA Data Bank area (other OECD countries)
  - 3 = IAEA NDS area (~rest of the world)
  - 4 = CJD Obninsk area (Russia)
- 1st character is a letter for cp- and γ-induced data



Why sending data to EXFOR

- EXFOR is sometimes called the “Mother of all libraries”
  - It is the ground for the development of all evaluated nuclear reaction libraries (particle transport, activation, dosimetry, standards, etc.)
- EXFOR is a long standing standard
  - It has been successfully developed, maintained and updated for 50+ years by NRDC
  - No local databases survived as long as EXFOR until now
- EXFOR is old-fashioned, but the best for data dissemination and long-term preservation

How to browse EXFOR library

- JANIS App & JANIS Web directly available from www
  - http://www.oecd-nea.org/janis
- Browsing EXFOR with JANIS Web
  - Home: http://www.oecd-nea.org/janisweb (screenshot)
  - Content: http://www.oecd-nea.org/janisweb/tree (screenshot)
  - Search: http://www.oecd-nea.org/janisweb/search/exfor (screenshot)
  - Book: http://www.oecd-nea.org/janisweb/book/neutrons (screenshot)
- Direct links to EXFOR
  - http://www.oecd-nea.org/janisweb/exfor (screenshot)
  - http://www.oecd-nea.org/janisweb/exfor/22965 (screenshot)

Nuclear structure data (ENSDF)

What is the ENSDF library

- Evaluated Nuclear Structure Data File
- https://www.nndc.bnl.gov/ensdf (screenshot)
- Recommended nuclear structure and decay data for all known nuclides
  - Nuclear level properties (energy, half-life, decay modes, spin and parity)
  - Gamma-ray energies, intensities, multipolarities, mixing ratios and conversion coefficients
  - Nuclear radiation energy and intensity for other radiation types (α, β, n)

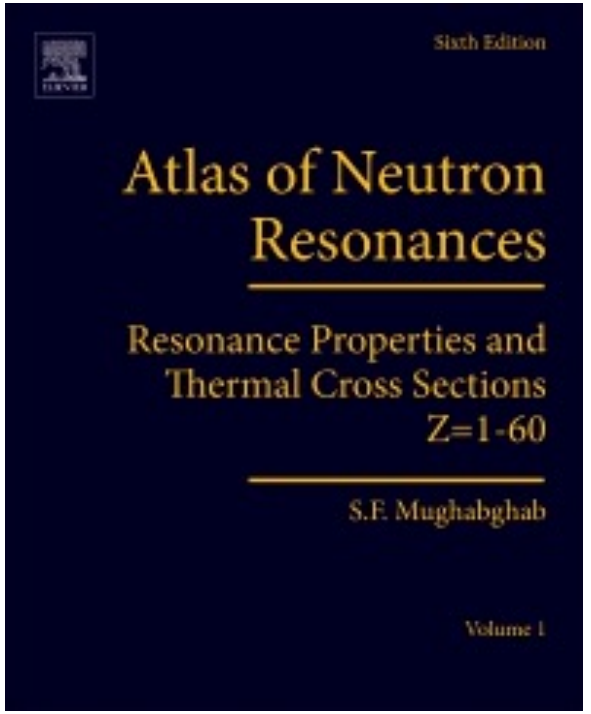
How to browse ENSDF library

- With NuDat available from www
  - https://www.nndc.bnl.gov/nudat3 (screenshot)
- Browsing ENSDF with NuDat
  - e.g., level scheme of ^{56}Fe (screenshot)
  - e.g., decay radiations from ^{137}Cs (screenshot)
- Direct access to ENSDF is also possible to get the most up-to-date data

Other useful compilations: Atlas

What is the Atlas of Neutron Resonances

- Compilation of resonances properties (and more) for all measured nuclides
  - Individual resonance parameters
  - Thermal cross sections
  - Maxwellian Average Capture CS (MACS)
  - Average resonance parameters
- Several editions from the 50's (known as BNL-325 report) until the last one in 2018 by Mughabghab
- https://www.nndc.bnl.gov/atlas



Other useful compilations: NACRE

What is NACRE

- NACRE
  - Charged-Particle-Induced Thermonuclear Reaction Rate Library (1999)
- NACRE II update and extension (2013)
  - Reaction rates in the range $10^6 < T\ (K) < 10^{10}$
  - Astrophysical S-factor for capture and transfer reactions
  - 34 reactions on nuclides with mass A < 16
- http://www.astro.ulb.ac.be/nacreii

Other useful compilations: KADoNiS

What is KADoNiS

- Karlsruhe Astrophysical Database of Nucleosynthesis in Stars
  - Data relevant to the s process (and p process)
  - MACS, Stellar Enhancement Factor (SEF), Reaction Rates
- https://www.kadonis.org
  updated test version at https://exp-astro.de/kadonis1.0

Evaluated libraries

- Traditional evaluated libraries leverage 50+ years of nuclear data development
  - From ENDF/B-I (1968) to ENDF/B-VIII.0 (2018) (ENDF/B-VIII.1 in 2024)
  - From JENDL-1 (1977) to JENDL-5 (2021)
  - From JEF-1 (1985) to JEFF-3.3 (2017) (JEFF-4.0 in 2024-2025)
- Decrease of resources and increase of requirements (for accuracy, but also completeness and consistency) makes more and more difficult to improve further the evaluated libraries (but this is still done for important nuclides)

Evaluated libraries

- TENDL-2008 opened the path to a new approach based on TALYS (and other satellite codes) to produce complete, consistent and reproducible libraries
- TENDL-2023 is the latest version:
  - Complete evaluations of all reaction channels, including resonances and covariances
  - Consistent evaluations up to 200 MeV for 2850 isotopes and seven incident particles (n, p, d, t, ^{3}He, α, γ)
  - However, the most application-sensitive files are taken from ENDF/B-VIII.0 (^{1,2,3}H, ^{3,4}He, ^{6,7}Li, ^{10,11}B, ^{7,9}Be, ^{12,13}C, ^{14,15}N, ^{16,17,18}O, ^{19}F, ^{232}Th, ^{233,235,238}U, ^{239}Pu)

ENDF format and processing

- ENDF-6 is the standardized format of evaluated libraries
  - Well documented (400+ pages, manual available at https://www.nndc.bnl.gov/csewg)
  - Text files in fixed-width format over 80 columns
  - Old-fashioned but do the job handling all nuclear (and photo-atomic) data, plus supported by all processing codes worldwide
  - Format adopted by all evaluation projects since the early days to facilitate exchange
- Modern XML-based structure (GNDS) is also available, but not as widely supported yet

ENDF format and processing

- First ENDF-6 learning steps are cumbersome…
  - MAT is the material number (e.g., MAT=5325 for ^{127}I)
  - MF is the quantity number (e.g., MF=3 for cross sections)
  - MT is the reaction channel number (e.g., MT=18 for fission)
- The ENDF format requires complete information wrt energy range, reaction channels, quantities (i.e., some of the MF/MT are mandatory)

ENDF format and processing

- MF (main) quantities
  see Table 4 of the ENDF format manual at https://www.nndc.bnl.gov/csewg
  - MF=1 General information, nu-bar, fission energies
  - MF=2 Resonance parameters (resolved and unresolved)
  - MF=3 Cross sections
  - MF=4 Angular distributions of emitted particles
  - MF=5 Energy distributions of emitted particles
  - MF=6 Energy-angle distributions of emitted particles
  - MF=7 Thermal neutron scattering law data
  - MF=12 Multiplicities for photon production
  - MF=13 Cross sections for photon production
  - MF=14 Angular distributions for photon production
  - MF=15 Energy distributions for photon production
  - MF=30-40 Covariances for the main quantities

ENDF format and processing

- MT (main) neutron-induced reactions
  see Appendix B of the ENDF format manual at https://www.nndc.bnl.gov/csewg
  - MT=1 (n,tot)
  - MT=2 (n,n)
  - MT=4 (n,n')
  - MT=16 (n,2n)
  - MT=17 (n,3n)
  - MT=18 (n,f)
  - MT=102 (n,γ)
  - MT=103 (n,p)
  - MT=104 (n,d)
  - MT=105 (n,t)
  - MT=106 (n,^{3}He)
  - MT=107 (n,α)
  - MT=151 resonance parameters
  - MT=452 total nu-bar
  - MT=455 delayed nu-bar
  - MT=456 prompt nu-bar
  - MT=458 energy release in fission
  - MT=454 independent FY
  - MT=459 cumulative FY
  - MT=460 delayed γ from fission
  - etc.

ENDF format and processing

- No processing for special sub-libraries such as Fission Yields, Decay Data
- However, most evaluated libraries needs further processing
  - Reconstruction of cross sections (from resonance parameters and thermal scattering law)
  - Doppler broadening at the desired temperature (application-dependent)
  - Reconstruction of emission spectra
  - Calculation of derived quantities (e.g., gas production, DPA, KERMA)
  - Multi-group cross sections and covariances (application-dependent)
- Processing codes: Pre-Pro, NJOY, FUDGE (for XML-based GNDS)
- Additional processing is required for deterministic codes (WIMS, ERANOS…)

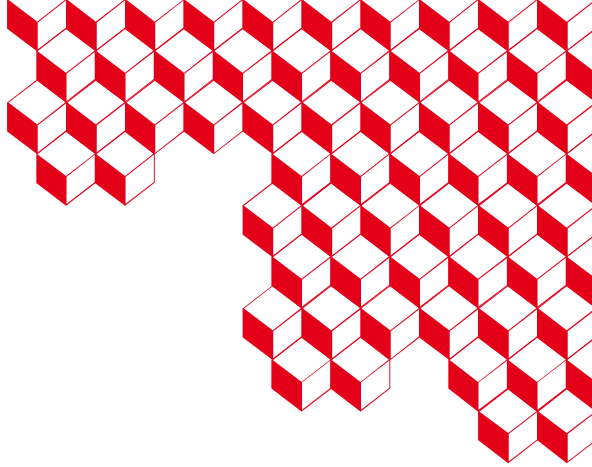
3. Summary

Summary

- Nuclear data relies on nuclear physics (for measurements, modeling and consistency) but is strongly constrained by application requirements (for accuracy and completeness)
- Nuclear data evaluation is a compromise between what
  - Experimentalists can measure
  - Theoreticians can model
  - Users actually need: format, accuracy, consistency, completeness (application-dependent)
- Nuclear data validation, as well as iterations between physicists, evaluators and end-users, are key for the improvement of nuclear data (and for answering actual needs)

Summary

- Initially for simulations, nuclear databases are more and more used as knowledge repository
  - Plenty of nuclear data for free (which were not cost-free to produce…)
  - Little information on the application domain (e.g., evaluated libraries made for power reactors will give poor results in astrophysics simulations and reciprocally)
- Nuclear data is essential to link nuclear physics and applications

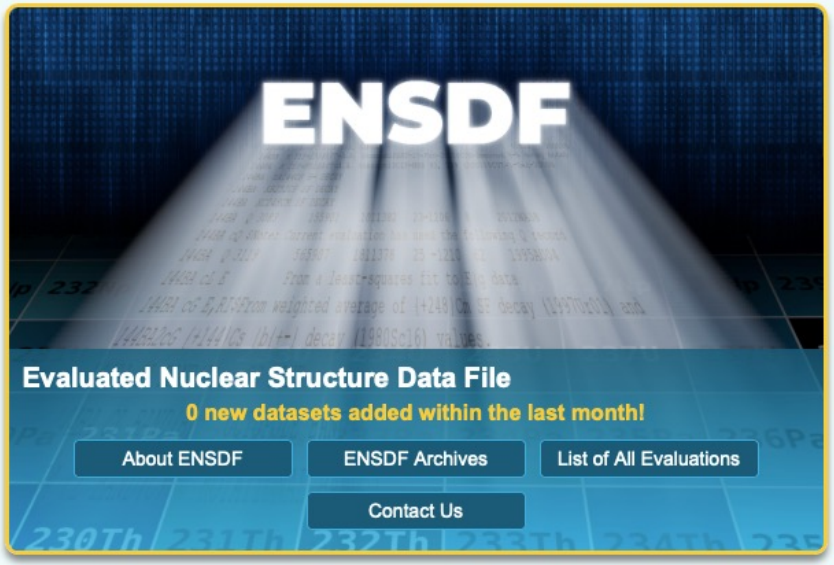


Thank you for your attention

Quick Search | By Reaction | By Decay

Nuclide, Mass, or Symbol: Search

(208Pb, pb-208, 144, 1n (neutron), C, Ca, etc.)



Evaluated Nuclear Structure Data File

0 new datasets added within the last month!

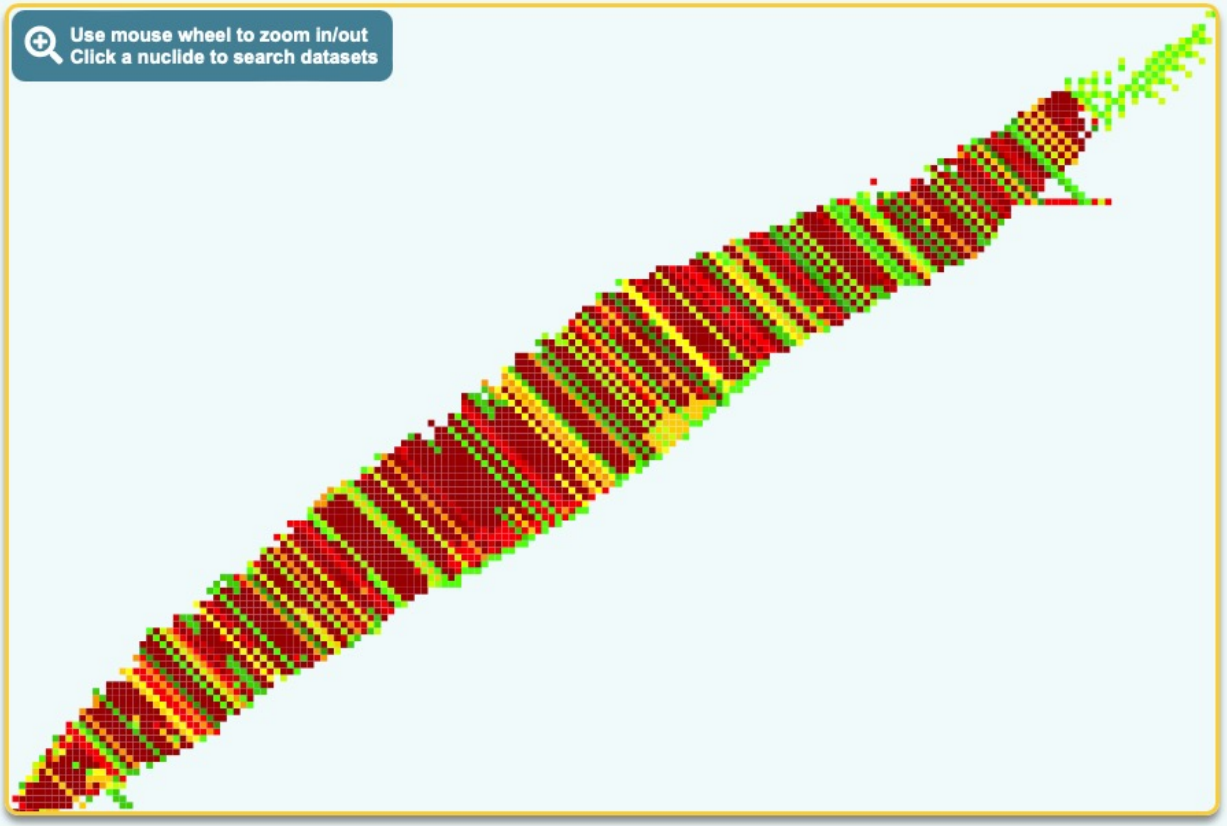
About ENSDF | ENSDF Archives | List of All Evaluations | Contact Us

Color Code

Time Since Cutoff Date

Years Since Cutoff

≤1	2	3	4	5	6	7	8	9	10	≥11



Tools

CapGam | Thermal Neutron Capture γ-rays

The energy and photon intensity with uncertainties of gamma rays as seen in thermal-neutron capture are presented in two tables, one in ascending order of gamma energy and a second organized by Z, A of the target

QCalc | Q-Value Calculator

Calculate the Q-values for nuclear reactions or decay using mass values from the 2020 Atomic Mass Evaluation by M. Wang et al

LOGFT | Analysis Program

Calculate the log ft values for beta and electron-capture decay, average beta energies, and capture fractions

Bricc | Band-Raman Internal Conversion Coefficents

Calculate the conversion electron (αIC), elec… conversion coefficients (απ) and the E0 elect… (σIC,π(E0))

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www.nndc.bnl.gov/nudat3/

NuDat 3.0

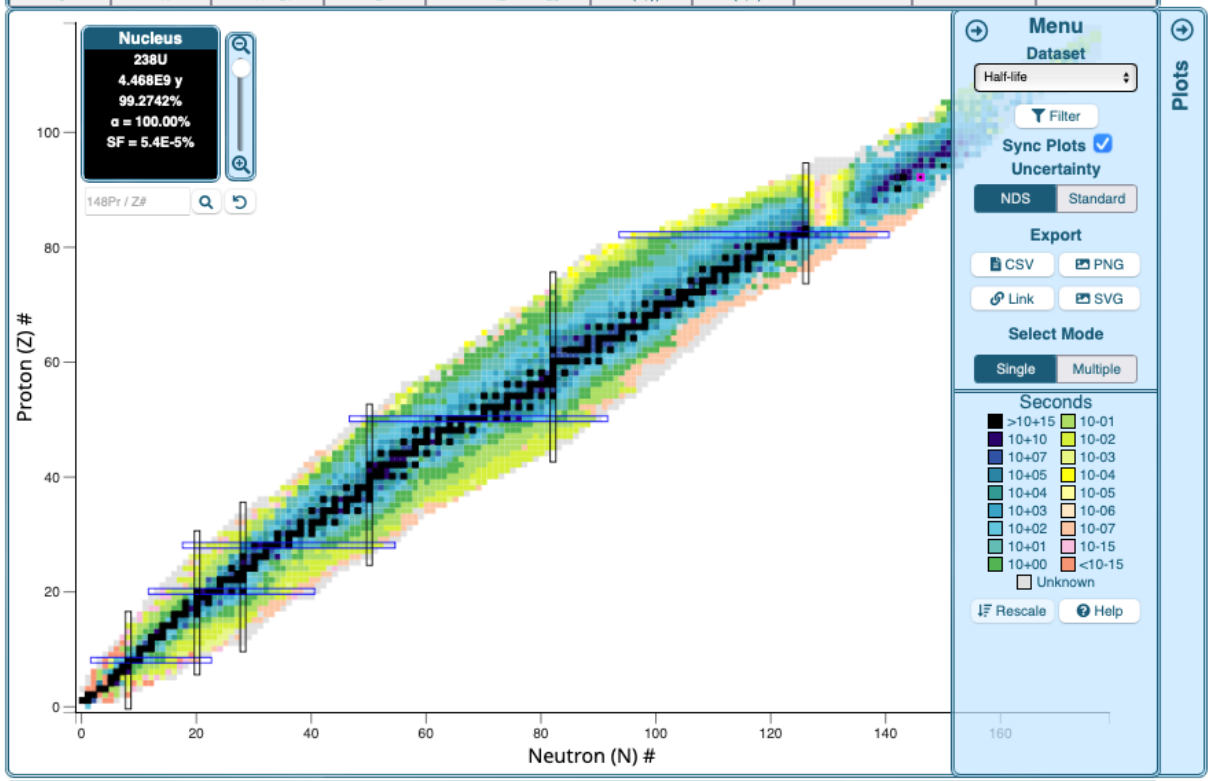
Search and plot nuclear structure and decay data interactively
Learn more

NNDC Databases: NuDat | NSR | XUNDL | ENSDF | MIRD | ENDF | EXFOR | Sigma

Levels & Gammas Search | Nuclear Wallet Cards Search | Decay Radiation Search | Advanced Cross-Variable Plot

Half-life | Decay Mode | $Q_{\beta-}$ | Q_{EC} | $Q_{\beta+}$ | S_n | S_p | Q_α | ΔQ_α | S_{2n} | S_{2p} | $Q_{2\beta-}$ | Q_{2EC} | Q_{ECp} | $Q_{\beta-n}$ | $Q_{\beta-2n}$ | BE/A | (BE-LDM Fit)/A | Pair. gap | $E_{1st\ ex.\ st.}$ | E_{2+}

E_{3-} | E_{4+} | E_{4+}/E_{2+} | β_2 | $B(E2)_{42}/B(E2)_{20}$ | σ(n,γ) | σ(n,F) | 235U FY | 239Pu FY | 252Cf FY



Ground and isomeric state information for $^{238}_{92}U$

E(level) (MeV)	Jπ	Mass Excess (keV)	$T_{1/2}$	Abundance	Decay Modes
0.0	0+	47307.7 *15*	4.468E9 y *6*	99.2742% *10*	α = 100.00% SF = 5.4E-5%
2.5579	0+	49865.6 *15*	280 ns *6*		IT = 97.40% SF = 2.60%

The following are available

List of levels | Interactive Level Scheme (Beta) | Level Scheme | J vs. E* plot | J vs. E(γ) plot | E(γ)/J plot | Band parameters

Decay radiation information

NuDat 3 is actively maintained and updated by the National Nuclear Data Center (NNDC) at Brookhaven National Laboratory
Please direct questions, comments and suggestions to Donnie Mason at the NNDC: dmason@bnl.gov

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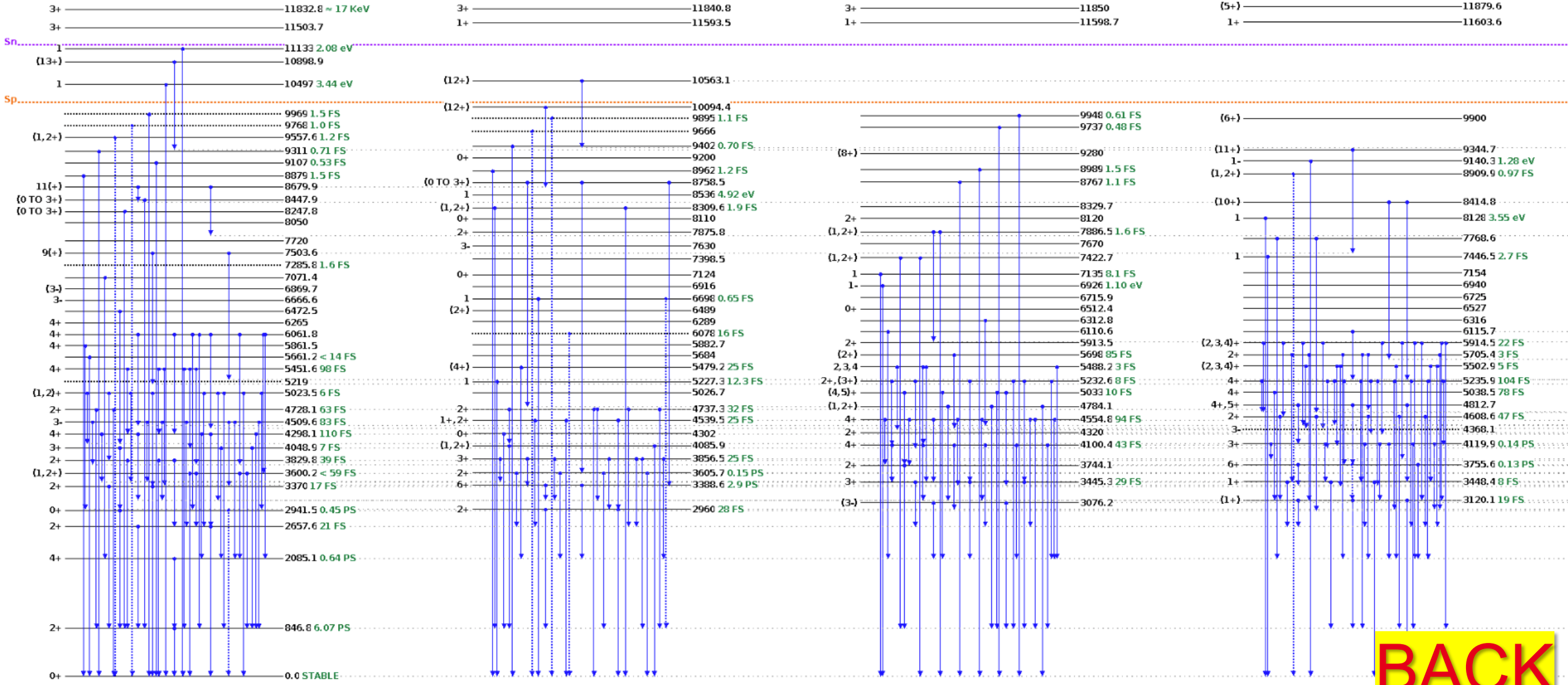
^{56}Fe Level Scheme



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Results:

Dataset #1:

Authors: E. Browne, J. K. Tuli Citation:Nuclear Data Sheets 108,2173 (2007)

Parent Nucleus	Parent E(level)	Parent Jπ	Parent $T_{1/2}$	Decay Mode	GS-GS Q-value (keV)	Daughter Nucleus	Decay Scheme	ENSDF file
$^{137}_{55}$Cs	0.0	7/2+	30.08 y *9*	β^-: 100 %	1175.63 *17*	$^{137}_{56}$Ba		

Beta-:

Energy (keV)	End-point energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
174.32 *6*	513.97 *17*	94.70 % *20*	0.1651 *4*
334.65 *8*	892.13 *20*	5.8E-4 % *8*	1.9E-6 *3*
416.26 *8*	1175.63 *17*	5.30 % *20*	0.0221 *8*

Mean beta- energy: 187.1 keV *10*, total beta- intensity: 100.0 % *3*, mean beta- dose: 0.1871 MeV/Bq-s *12*

Electrons:

	Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
Auger L	3.67	7.40 % *10*	2.72E-4 *4*
Auger K	26.4	0.78 % *3*	2.06E-4 *9*
CE K	624.216 *3*	7.79 % *11*	0.0486 *7*
CE L	655.668 *3*	1.402 % *20*	0.00920 *13*
CE M	660.364 *3*	0.300 % *4*	0.00198 *3*
CE N	661.404 *3*	0.0646 % *9*	4.27E-4 *6*
CE O	661.637 *3*	0.00965 % *14*	6.39E-5 *9*

Gamma and X-ray radiation:

	Energy (keV)	Intensity (%)	Dose (MeV/Bq-s)
XR l	4.47	0.91 % *4*	4.09E-5 *19*
XR kα2	31.817	1.99 % *5*	6.34E-4 *17*
XR kα1	32.194	3.64 % *10*	0.00117 *3*
XR kβ3	36.304	0.348 % *9*	1.26E-4 *3*
XR kβ1	36.378	0.672 % *18*	2.44E-4 *6*
XR kβ2	37.255	0.213 % *6*	7.92E-5 *21*
	283.5 *1*	5.8E-4 % *8*	1.64E-6 *23*
	661.657 *3*	85.10 % *20*	0.5631 *13*

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Databases
EXFOR
- What is EXFOR?
- EXFOR Citation
- EXFOR News
- Articles for compilation
- Entries for corrections
- Scanned journals
CINDA
- What is CINDA?
ENDF
- What is ENDF?
- ENDF Citation

NRDC Centres
ATOMKI (Hungary)
CDFE (Russia)
CJD (Russia)
CNDC (China)
CNPD (Russia)
JAEA (Japan)
JCPRG (Japan)
KNDC (Korea)
NDPCI (India)
NDS (IAEA)
NEADB (OECD)
NNDC (USA)
UkrNDC (Ukraine)

Contacts
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Links
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NRDC Asia

EXFOR

The experimental nuclear reaction database, known as EXFOR stores nuclear reaction data and its' bibliographic information, as well as experimental information about the data. The status (e.g., the source of the data), and history (e.g., date of last update) of the data set is also included.

The data presently included in the EXFOR databases include:

- a "complete" compilation of experimental neutron-induced reaction data,
- a selected compilation of charged-particle-induced reaction data,
- a selected compilation of photon-induced reaction data.

The data is compiled in the EXFOR format, which was originally conceived for the exchange of neutron data, and was further developed and adapted to cover all nuclear reaction data. The format is designed for flexibility in order to meet the diverse needs of the nuclear reaction data centres, and allows a large variety of numerical data tables with explanatory and bibliographic information to be transmitted in a format:

- that is machine-readable (for checking and indicating possible errors),
- that can be read by personnel (for passing judgement on and correcting e rrors).

In addition to the EXFOR format, users may obtain data from the centres in other centre-to-user formats that have been developed to meet the needs of users within each centre's own sphere of responsibility.

Links to EXFOR Services

Centre	URL
CDFE (Russia)	http://cdfe.sinp.msu.ru/exfor/
JCPRG (Japan)	https://www.jcprg.org/exfor/
NDS (IAEA)	http://nds.iaea.org/exfor/
NEADB (OECD)	http://www.oecd-nea.org/janisweb/search/exfor/
NNDC (USA)	http://www.nndc.bnl.gov/exfor/

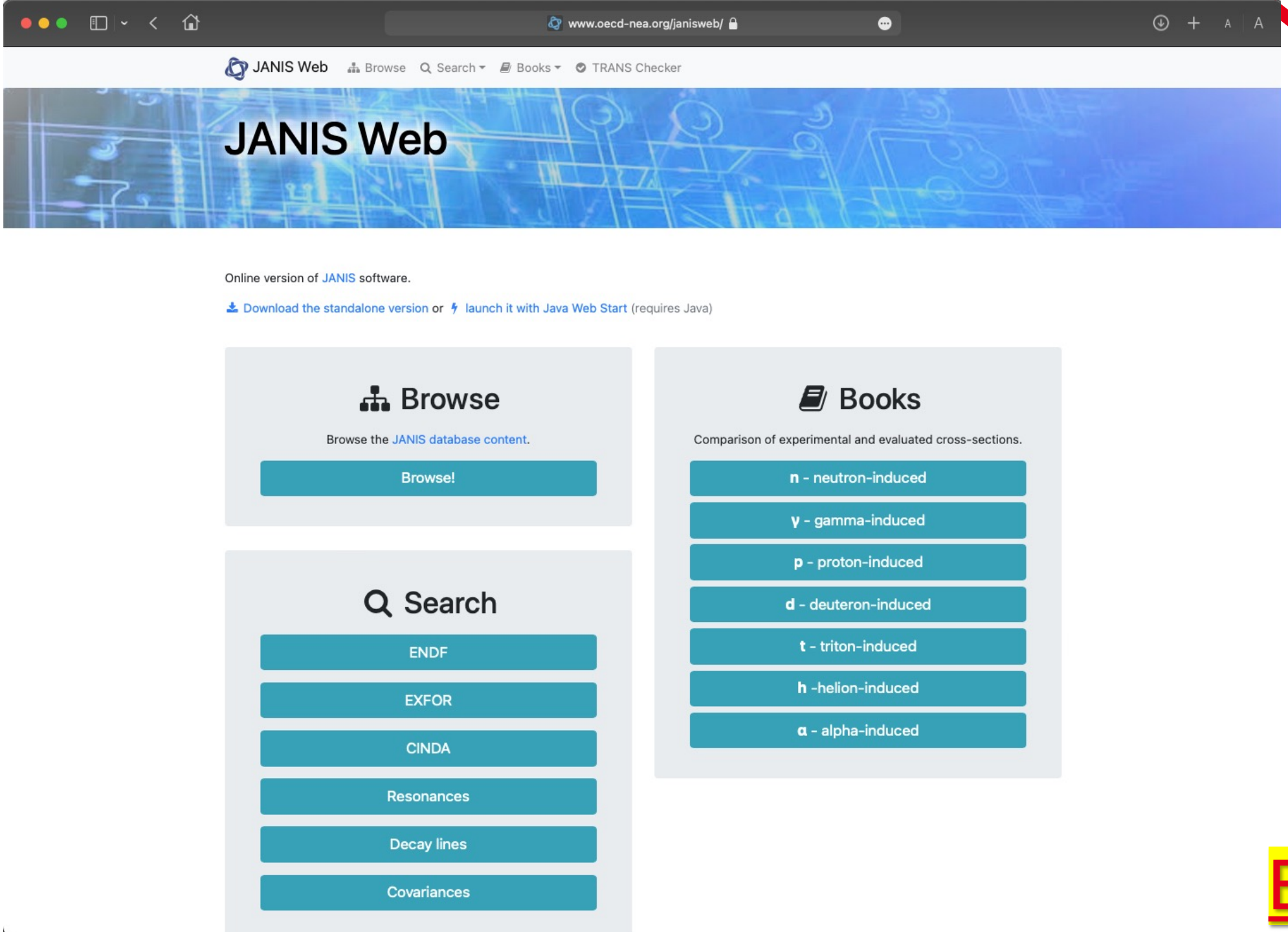
Documents
Network Document
EXFOR Basics (pdf)
EXFOR Basics (html)
EXFOR Formats
LEXFOR
NRDC Protocol
Dictionary Manual
EXFOR Leaflet
Marina's Short Guide
ENDF-6 Formats
Reports to ND Conf.
More Documents

Files
EXFOR Master File
JSON Dictionary
Area H EXFOR Entries

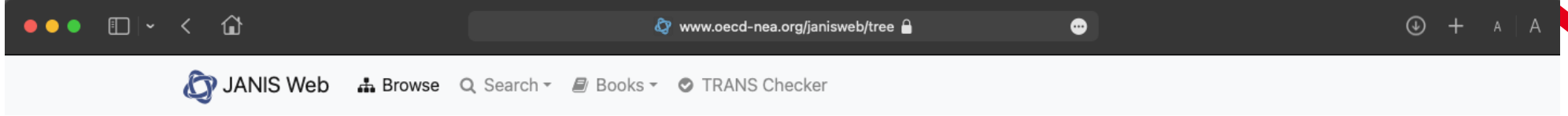
Codes
Codes
Comments on ZCHEX
Digitization Procedure

NRDC Meetings
2024 (Vienna)
2023 (Vienna)
2022 (Vienna)
2021 (Virtual)
2019 (Vienna)
2018 (Bahadurgarh)
2017 (Vienna)
2016 (Beijing)

BACK


www.oecd-nea.org/janisweb/
JANIS Web
Browse
Search
Books
TRANS Checker
JANIS Web
Online version of JANIS software.
Download the standalone version or launch it with Java Web Start (requires Java)
Browse
Browse the JANIS database content.
Browse!
Search
ENDF
EXFOR
CINDA
Resonances
Decay lines
Covariances
Books
Comparison of experimental and evaluated cross-sections.
n - neutron-induced
γ - gamma-induced
p - proton-induced
d - deuteron-induced
t - triton-induced
h -helion-induced
α - alpha-induced

BACK

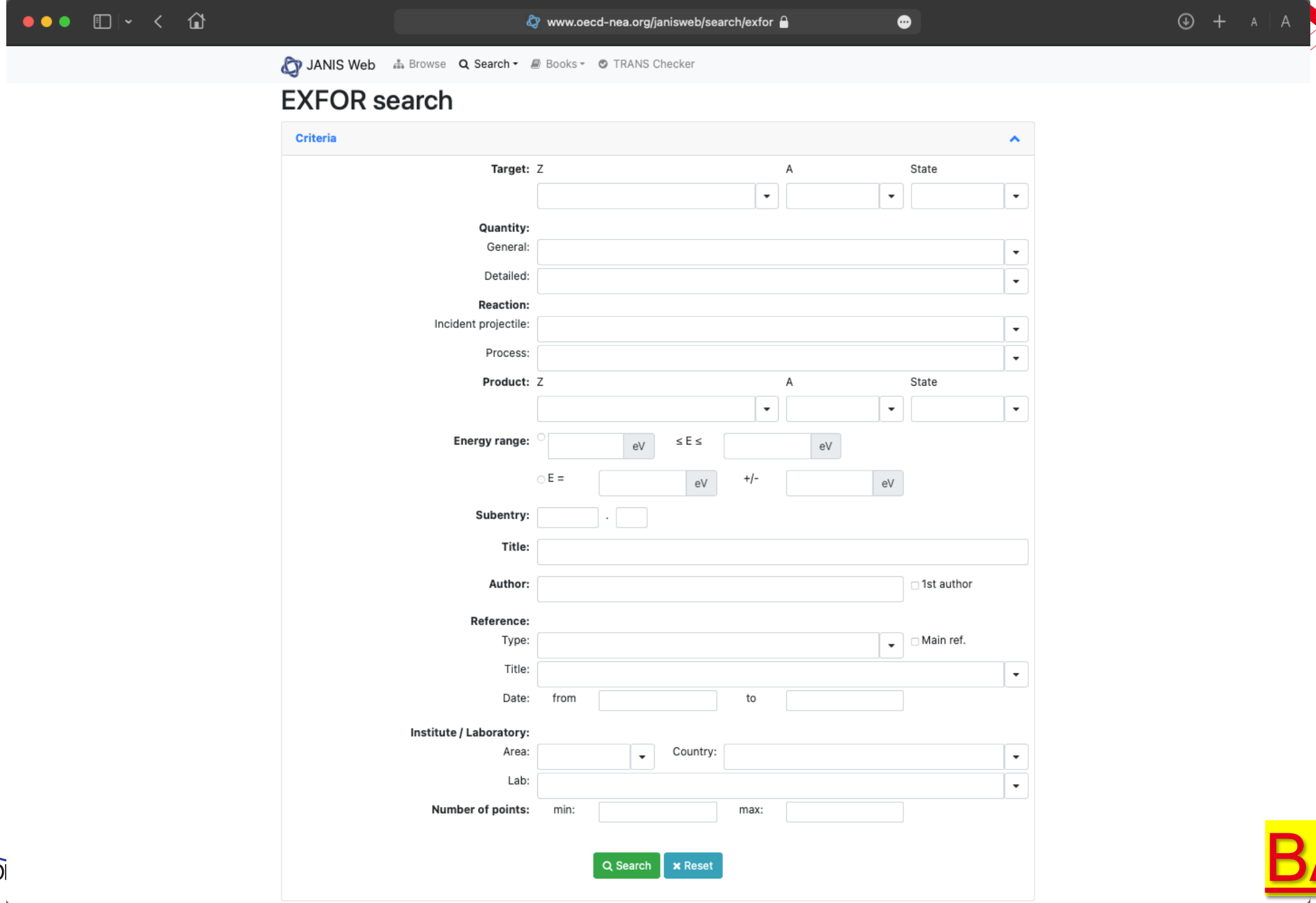


Browse database

Base

- Nuclear properties
- Radioactive data
- Incident neutron data
- Incident gamma data
- Incident proton data
- Incident deuteron data
- Incident triton data
- Incident He3 data
- Incident alpha data
- Heavy particles data
- Incident electron data
- Incident antiprotons
- Incident kaons,negative
- Incident kaons,positive
- Incident pions,negative
- Incident pions,positive

BACK


www.oecd-nea.org/janisweb/search/exfor
JANIS Web
Browse
Search
Books
TRANS Checker
EXFOR search
Criteria
Target: Z A State
Quantity:
General:
Detailed:
Reaction:
Incident projectile:
Process:
Product: Z A State
Energy range:
eV
≤ E ≤
eV
E =
eV
+/-
eV
Subentry:
Title:
Author:
1st author
Reference:
Type:
Main ref.
Title:
Date: from to
Institute / Laboratory:
Area:
Country:
Lab:
Number of points: min: max:
Search
Reset

BACK

www.oecd-nea.org/janisweb/book/neutrons/V51/MT1/renderer/3151

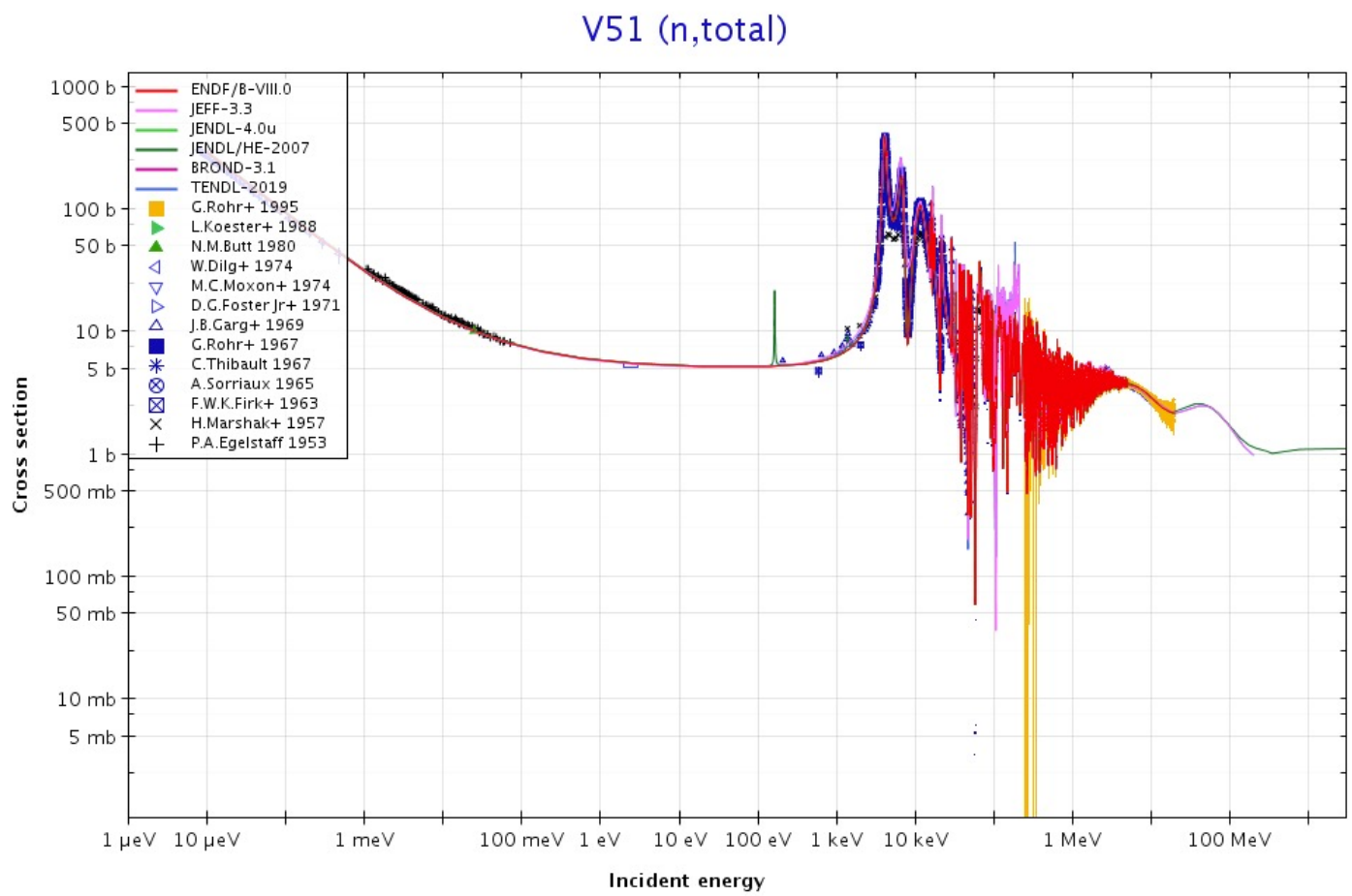
- By nuclide
  - 0-n
  - 1-H
  - 2-He
  - 3-Li
  - 4-Be
  - 5-B
  - 6-C
  - 7-N
  - 8-O
  - 9-F
  - 10-Ne
  - 11-Na
  - 12-Mg
  - 13-Al
  - 14-Si
  - 15-P
  - 16-S
  - 17-Cl
  - 18-Ar
  - 19-K
  - 20-Ca
  - 21-Sc
  - 22-Ti
  - 23-V
    - 23-V-Nat
    - 23-V-50
    - 23-V-51
      - MT1 (n,total)
      - MT2 (n,elastic)
      - MT22 (n,n+α)
      - MT24 (n,2n+α)
      - MT34 (n,n+³He)
      - MT37 (n,4n)
      - MT44 (n,n+2p)
      - MT102 (n,γ)
      - MT103 (n,p)
      - MT104 (n,d)
      - MT105 (n,t)
      - MT106 (n,³He)
      - MT107 (n,α)
      - MT111 (n,2p)
      - MT112 (n,p+α)
      - MT115 (n,p+d)
      - MT116 (n,p+t)
      - MT176 (n,2n+³He)
      - MT177 (n,3n+³He)
      - MT179 (n,3n+2p)
      - MT182 (n,d+t)
      - MT183 (n,n+p+d)
      - MT184 (n,n+p+t)
      - MT185 (n,n+d+t)
      - MT186 (n,n+p+³He)
      - MT190 (n,2n+2p)
      - MT192 (n,d+³He)
      - MT194 (n,4n+2p)
  - 24-Cr
  - 25-Mn
  - 26-Fe
  - 27-Co
  - 28-Ni
  - 29-Cu
  - 30-Zn
  - 31-Ga
  - 32-Ge
  - 33-As
  - 34-Se

<< 23-V-50 | << 23-V-50 MT107 (n,α)

23-V-51
MT1 (n,total)

24-Cr-50 >> | MT2 (n,elastic) >>

Home | 11640.005, 20965.003, 21176.004, 30579.002, 21278....



Node	Settings	Display
NEA / Incident neutron data		
EXFOR / Cross sections / V51 / (,TOT)		
10047.027		P T I
11640.005		P T I
14524.002		P T I
20152.002		P T I
20965.003		P T I
21176.004		P T I
21277.002		P T I

Plotter

X: Log Y: Log

X min:	1 μeV
X max:	3 GeV
Y min:	1.071266299 mb
Y max:	1292.243046755 b

APPLY

21176.004

points : 7

4 columns

Independent variables
- EN
- EN-RSL

Dependent variables
- DATA
- DATA-ERR

- Additional EXFOR
- Additional ENDF

BACK

EXFOR direct links

Syntax

/janisweb/exfor/ID1[,ID2,ID3,...]

IDn = EXFOR accession number or subaccession number

Examples

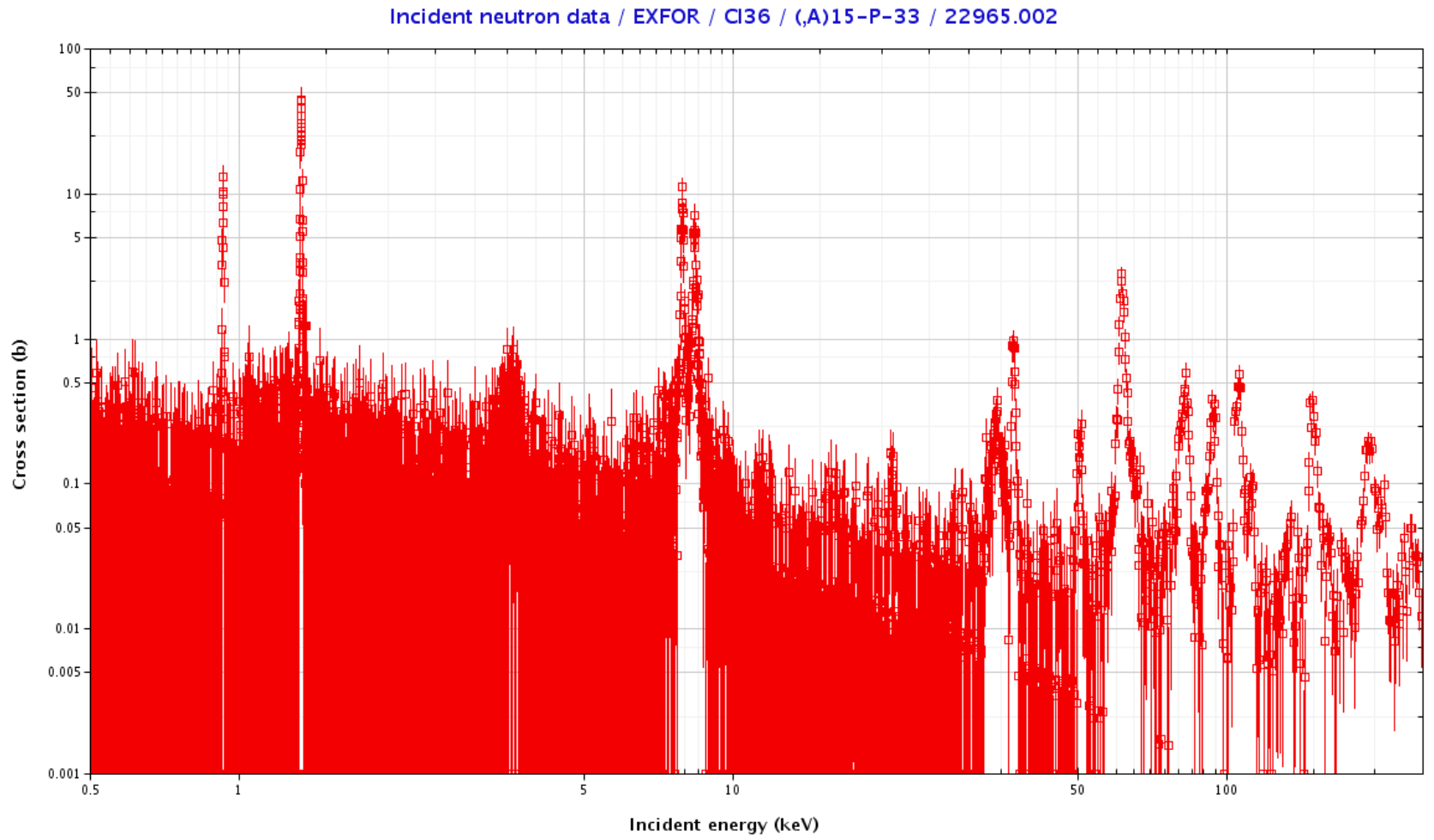
Open EXFOR entry 14233:
/janisweb/exfor/14233

Open EXFOR subentries 23126.002 and 23126.005:
/janisweb/exfor/23126.002,23126.005

Return to home

www.oecd-nea.org/janisweb/renderer/3876

Home | 22965.002



Plotter

X: Log Y: Log

Zero or negative values!

Change Y scale to Lin

X min:	500 eV
X max:	250 keV
Y min:	1.000 mb
Y max:	100 b

APPLY

22965.002

points : 4939

3 columns

Independent variables
EN
Dependent variables
DATA
ERR-T

- Additional EXFOR
- Additional ENDF

Node	Settings	Display
NEA / Incident neutron data / EXFOR		
Cross sections		
Cl36		
(,A)15-P-33		
22965.002		P T I
22965.004		P T I
22965.005		P T I
(,P)16-S-36		
Ca41 / (,A)18-AR-38 / 22965.006		I
Resonance parameters / Cl36		

BACK