



IAEA

60 Years

Atoms for Peace and Development

Other activities for 2021-2023

A.J. Koning

**33rd Meeting of International Nuclear Data Committee,
March 29 – April 1 2021, IAEA, Vienna**

Other developments

- New NDS homepage
- Multiple accessibility of nuclear data: current GUI's but also command-line API's
- Contributions to NEA WPEC
- Release of all TALYS and TENDL related software
- Develop other attractive GUI for end products
- Medical isotope nuclear data library and Medical Isotope Browser

Towards a new NDS homepage

More modern look

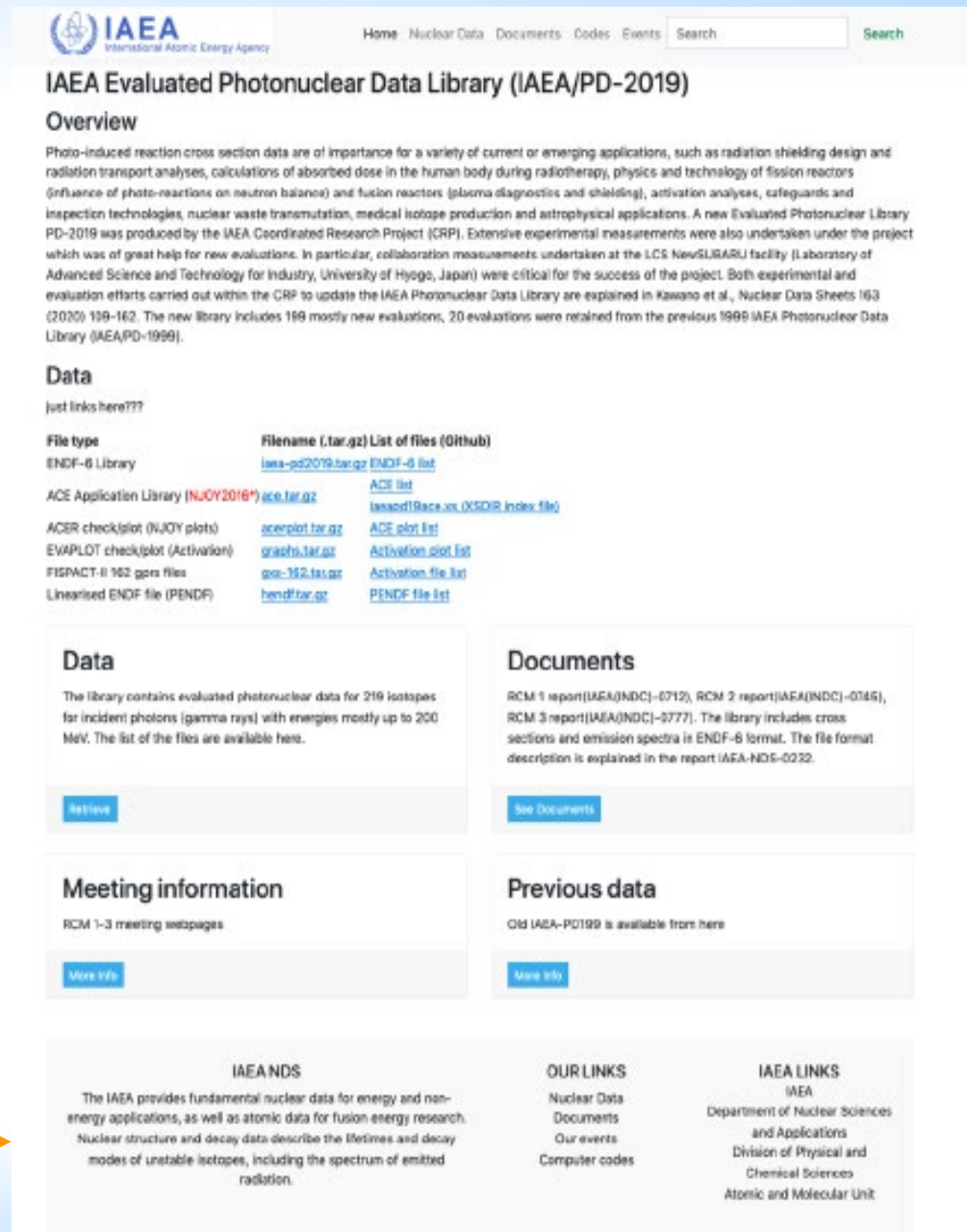
Requires detailed inventory of everything that exists: historical meetings, data libraries, etc

Build on consistent metadata for data libraries, meetings, documents and. Restructure data files for future development (data portals etc)

Important engines, e.g. EXFOR-ENDF retrieval will remain intact

Feedback from you expected before and at INDC June 2022

An example from last week which has already changed in the meantime



The screenshot shows the IAEA website header with the logo and navigation links (Home, Nuclear Data, Documents, Codes, Events, Search). The main heading is "IAEA Evaluated Photonuclear Data Library (IAEA/PD-2019)". Below this is an "Overview" section with a paragraph of text. A "Data" section follows, with a table listing file types and their corresponding file names and lists. The table has two columns: "File type" and "Filename (.tar.gz) List of files (Github)". The rows include ENDF-6 Library, ACE Application Library (NUJOY2018), ACER check/plot (NUJOY plots), EVAPLOT check/plot (Activation), FISRACT-II 162 gpcr files, and Linearised ENDF file (PENDF). Below the table are four boxes: "Data" (with a "Retrieve" button), "Documents" (with a "See Documents" button), "Meeting information" (with a "More info" button), and "Previous data" (with a "More info" button). At the bottom, there are three columns: "IAEA NDS" (describing the agency's role), "OUR LINKS" (listing Nuclear Data, Documents, Events, and Codes), and "IAEA LINKS" (listing the Department of Nuclear Sciences and Applications, Division of Physical and Chemical Sciences, and Atomic and Molecular Unit).

EXFOR and/or ENDF GUI's and API's



Request #2269 www.nds.iaea.org 2021-03-24,11:46:09
 Access-Level=2 /pdf/ /db/ [11]
 Results: Reactions: 7 Datasets: 41

Data Selection

Retrieve Selected Unselected All

Output: X4+ EXFOR Bibliography TAB C4 PlotC4

Plot: Quick-plot (cross-sections) Ungroup /product: Advanced plot [how-to] using C5 and convert ratios to

Narrow incident energy (optional), eV: Min: Max:

Apply Data re-normalization (for advanced users, results in: C4, TAB and Plots)

n	Display	Year	Author-1	Energy range,eV	Points	Reference	Subentry#P	NSR-Key	Info+
1	41-NB-93 (N,EL) 41-NB-93,,DA C4: MF4 MT2								
Quantity: [DA] Differential c/s with respect to angle									
1	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1999	E.G.Christodoulou+	1.40e7	16	[pdf]+ J,NSE,132,273,1999	13804008 [4]	R33/0	1999CH27 An[16]=16:161
2	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1992	A.Takahashi+	1.41e7	16	[pdf]+ R,OKTAV-A-92-01,1992	22136016 [2]	R33/0	An[16]=15:160
3	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1991	R.S.Pedroni+	7.95e6	148	[pdf]+ J,PR/C,43,2336,9105	12995002 [4]	R33/0	1991PE02 An[140]=18:162
4	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1991	R.Finlay+	2.00e7	15	+ W,FINLAY,9111	13532002 [4]	R33/0	An[15]=15:154
5	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1991	Wan Dairong+	1.47e7	6	+ W,WANDAIRONG,199101	32523003 [8]	R33/0	An[6]=3:14
6	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1988	Cao Jianhua+	1.47e7	28	+ R,INDC(CPR)-011,125,198803	32521003 [8]	R33/0	An[28]=6:151
7	<input type="checkbox"/> <input type="checkbox"/> <input checked="" type="checkbox"/> X4 <input checked="" type="checkbox"/> X4+ <input checked="" type="checkbox"/> X4± <input type="checkbox"/> T4	1987	X.Wang+	7.00e6	9	[pdf]+ J,NP/A,465,483,8704	12892003 [4]	R33/0	1987WA08 An[9]=30:140

Web interface very complete and detailed

But also API's under development for automated use

Goal: release command-line API's (also for use in WPEC SG50)

 Nuclear Data Section International Atomic Energy Agency Wagramer Strasse 5, P.O.Box 100, A-1400 Vienna, Austria Tel:(+43 1) 2600-21714; Fax:(+43 1) 26007		2020-04-07 International Atomic Energy Agency Nuclear Data Services 2004-2020 for Windows, Linux, Mac SQLite	
<h2>EXFOR for Applications</h2> EXFOR-CINDA databases, retrieval systems, Endver/GUI package for Linux, Windows and MacOSX using SQLite Run software packages:			
Preparation. Install JDK "1.7" or higher, + on MacOSX: install XQuartz Download: https://www.nds.iaea.org/cdroms/#x4app2 ==> x4app-2020-04-07.tar.gz Un-compress:			
Windows: → Run → cmd.exe	Linux: → Terminal		
> cd c:\x4app	MacOSX: → Finder → Applications		
>"c:\program files\7-zip\7z.exe" x x4app-2020-04-07.tar.gz	→ Utilities → Terminal		
>"c:\program files\7-zip\7z.exe" x -r x4app-2020-04-07.tar	\$ tar xvfz x4app-2020-04-75.tar.gz		
> cd x4app-2020-04-07	\$ cd x4app-2020-04-07		
Run:	Windows	Linux	MacOSX
1 Interactive EXFOR retrieval system	run_x4cd.bat	./run_x4cd.sh	./run_x4cd-mac.sh
2 EndVer/GUI	run_endver.bat	./run_endver.sh	./run_endver-mac.sh
3 Non-interactive retrieval utility	cd app_example runme.bat	cd app_example ./runme.sh	cd app_example ./runme-mac.sh
4 EXFOR retrieval and converters	cd app_example2020 ./runme.sh	cd app_example2020 ./runme.sh	cd app_example2020 ./runme.sh
General description: readme.txt How to use and setup: setup.txt IAEA Nuclear Data Services: http://www.nds.iaea.org/			
<h2>EXFOR for Applications</h2> EXFOR-CINDA databases and retrieval systems, ENDVER/GUI integrated tools for ENDF-Evaluators (Windows, Linux, MacOSX) Version 2.1.1. April 2020			
<ul style="list-style-type: none"> ✓ Does not need installation ✓ Integrated CINDA and EXFOR. ✓ Advanced interactive search ✓ Help based on Dictionaries ✓ Interactive graphics with ZVView 		<ul style="list-style-type: none"> ✓ Can work with local and remote databases ✓ Non-interactive EXFOR retrievals ✓ Converter from EXFOR to C4, C5, X4+, JSON, XML ✓ Examples of retrieval and converter scripts ✓ Real application: ENDVER/GUI package + EXFOR 	
EXFOR is a comprehensive library of experimental nuclear reaction data induced by neutrons, charged particles and photons. Contents (2020-03-05): 23038 Entries, 33092 publications, 158739 data tables CINDA library contains bibliographical references to experimental nuclear reaction data and to calculations, reviews, compilations and evaluations of neutron, charged particle reactions and spontaneous fission data. Includes import from EXFOR. Contents (2020-03-09): 497717 lines, 68261 publications, 209927 blocks Retrieval Systems on Java2: v1=2.1.1 (2020-04-02) © The data on this CD are a product of the Network of Nuclear Reaction Data Centers.			

TALYS-Related Software and Databases

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

Coming soon, still available [here](#)

TALYS

Arjan Koning, Stephane Hilaire, Stephane Goriely

Nuclear reaction model code.

- Download TALYS-1.95
- Download previous versions
- Read Tutorial

Created at    UNIVERSITE LIBRE DE BRUXELLES 

nds.iaea.org/talys

TASMAN, TEFAL, and Tools for TALYS (“T6”, TENDL) soon to follow

Contribution to WPEC: SG49 on reproducibility of nuclear data Evaluation

SG50 on curated computer-readable experimental database (based on EXFOR)

Direct-access plotting tool under development

EXFORTABLES

Arjan Koning

Experimental nuclear reaction database based on EXFOR.



- Download EXFORTABLES-1.0
- Read Tutorial

RESONANCETABLES

Arjan Koning, Dimitri Rochman

Database for thermal cross sections, MACS and average resonance parameters.

- Download RESONANCETABLES-1.0
- Read Tutorial

Created at  

ENDFTABLES

Arjan Koning

Code to translate ENDF nuclear data libraries into tabular format.

- Download ENDFTABLES-1.0
- Read Tutorial (Chapter 2)

Libraries-2020

Arjan Koning

Evaluated nuclear data libraries and EXFOR in tabular format.

- Libraries-2020 [15GB]
- Read Tutorial (Chapter 3)

Alternative plotting tools



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LIBRARIES-2020 Data Explorer

File Download

Cross Section (Experiment vs Library)

Multiple Reaction Channels Cross Section

Residual Production Cross Section

Fission Yield

Cross Sections in ENDFTABLES and EXFORTABLES

Element

sr

e.g., C, c, Pd, pd

Mass

87

e.g., 0: natural, 242m: metastable state

Reaction

n,g

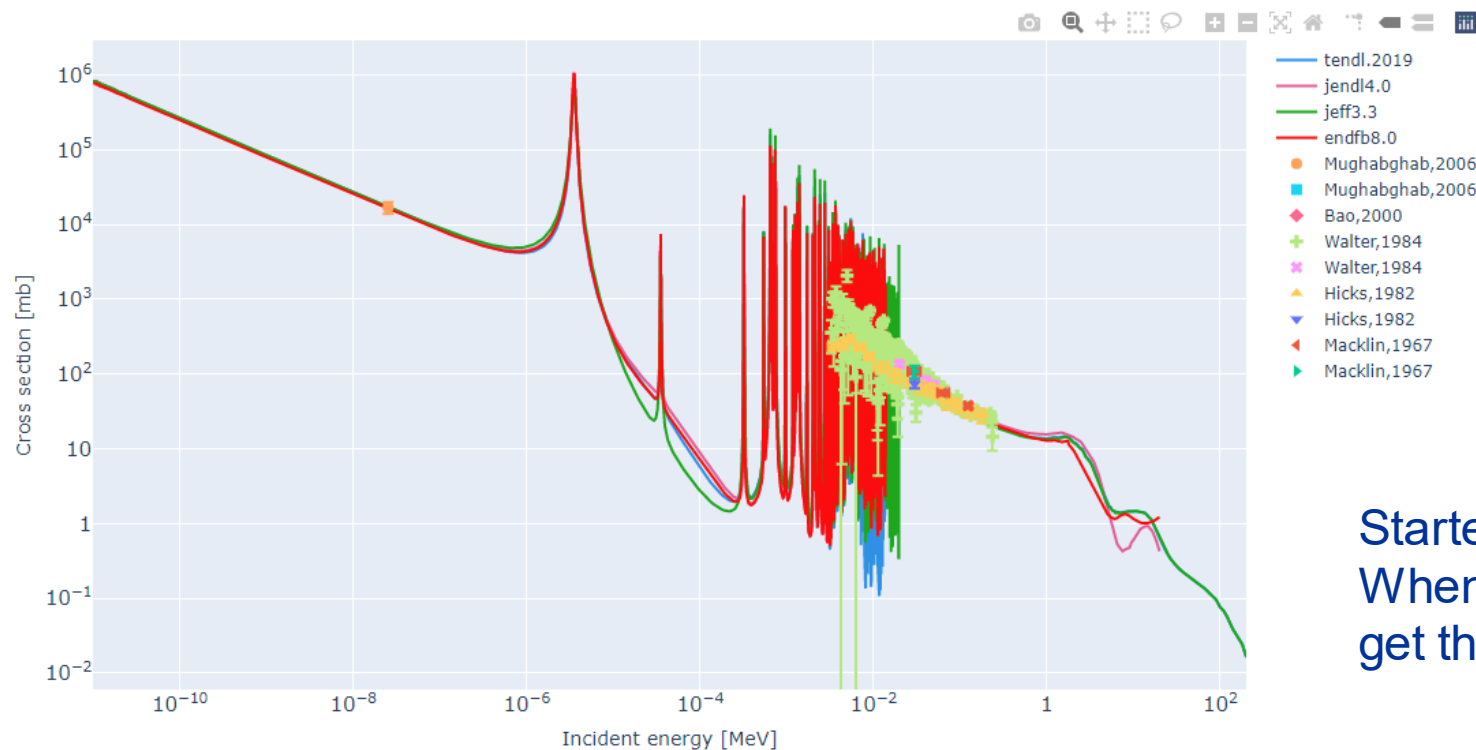
Chart

Data Table

Download

Plot for: Sr087(n,g) MF:3 MT:102, found 9 experimental data set(s).

X: Linear Log Y: Linear Log



Started in March 2021.
When we are ready you
get the URL

Add more data to the chart by selecting entries from following table. Use filter function, e.g. >2000 in Year field

Computational steering

TALYSview int-nds.iaea.org/relnsd/tests/talys.html

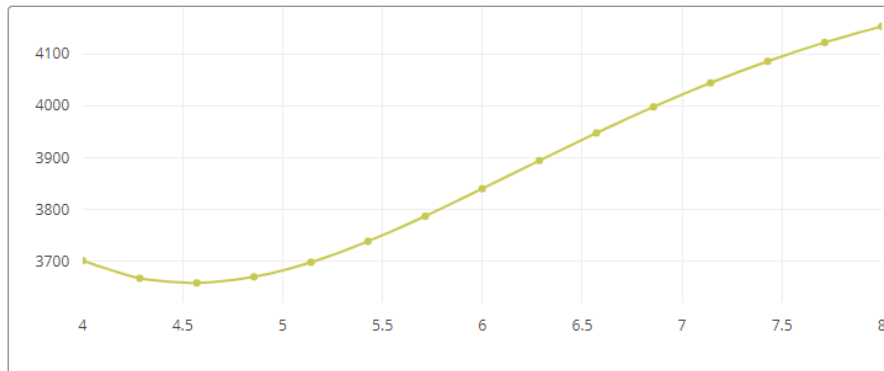
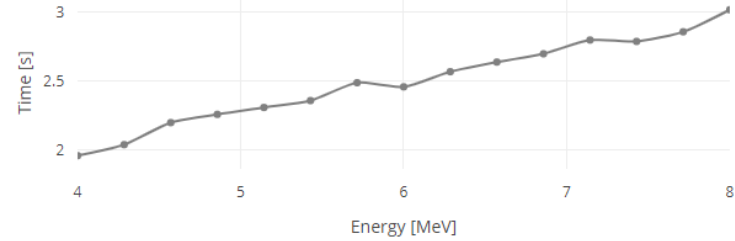
Computational steering: TALYSview

Projectile Element Mass
n **nb** **93**

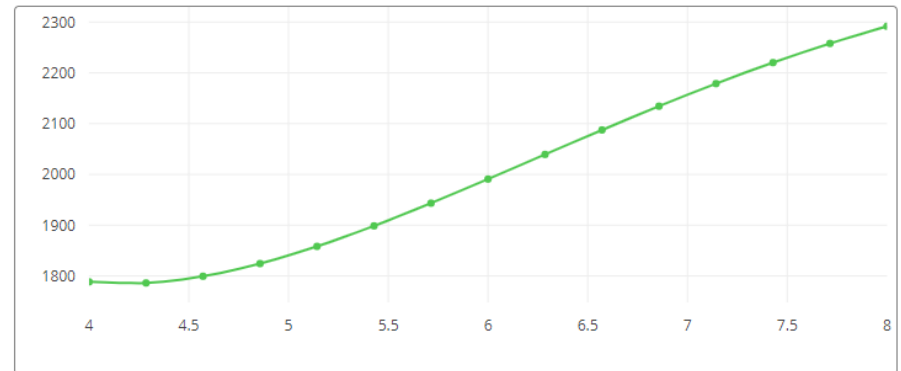
Energy [MeV]
from to points
4 **8** **15**



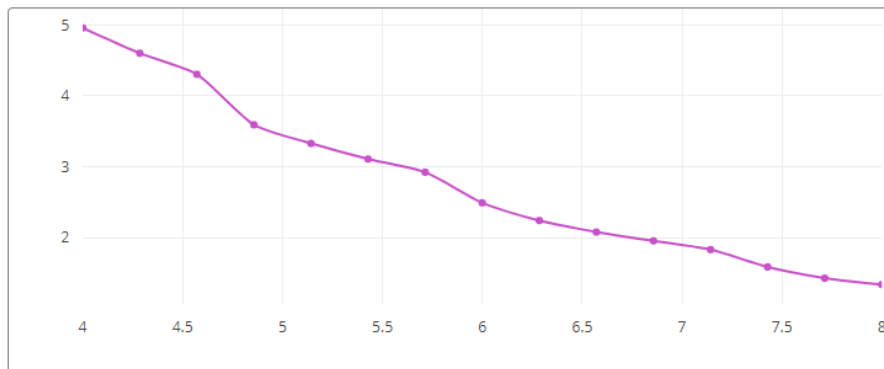
done in 37.5 s



Total



Total elastic



(n,g)



Medical Isotope Browser
IAEA Nuclear Data Section

Examples 1 Incident - Exit energies
2 Incident energy - Thickness, and user σ
3 Energy scan 4 Composite target

Previous run: • 1 • 2

Product TC99 M
 show all products

Projectile
 p D α T ^3He

Target MO100 composition

Density [g/cm³] 0 < 10.3 < 100

Thickness [mm] [mg/cm²]
0 < []

Exit energy [MeV]
0 < 15.0 < 200

Incident energy [MeV]
0 < 22 < 200

Incident energy scan [MeV]
[] ≤ E ≤ [] ΔE: []

Current [μA] 0 < 100 < 10 000

Irradiation time 1d
1 d 0 h 0 m 0 s

Post EOB time 1d
1 d 0 h 0 m 0 s

Cross section
IAEA + TENDL User defined

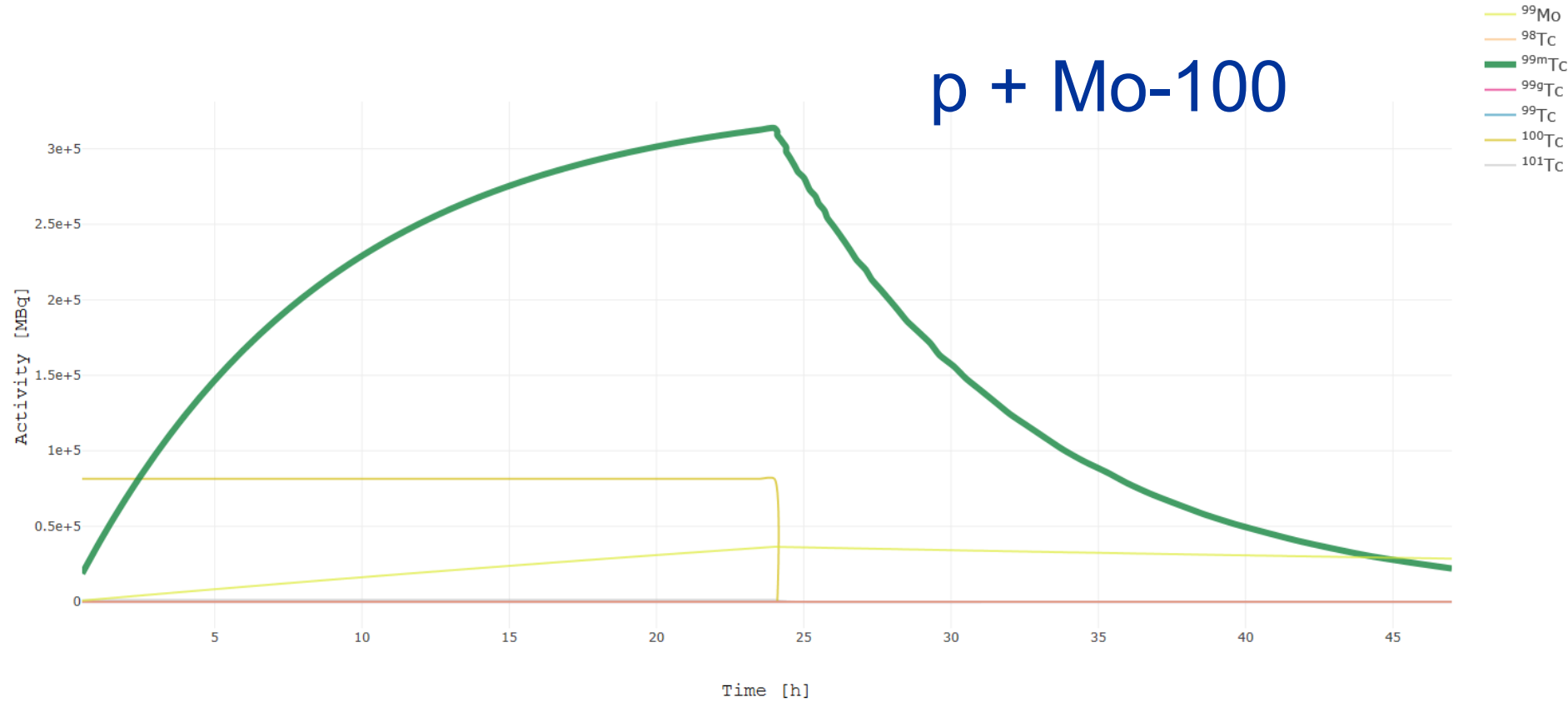


Plots Exit energy 3D

Data

• Effective target thickness : 0.045 cm • # incident particles: 6.24151E+14 [s⁻¹] • Produced heat in target : 0.700 kW • Activities less than 1.0E-6 MBq are not displayed

p + Mo-100



Medical isotope data library 1: High-quality cross section data



1. E. Betak, A.D. Caldeira, R. Capote, B.V. Carlson, H.D. Choi, F.B. Guimaraes, A.V. Ignatyuk, S.K. Kim, B. Kiraly, S.F. Kovalev, E. Menapace, A.L. Nichols, M. Nortier, P. Pompeia, S.M. Qaim, B. Scholten, Yu. N. Shubin, J-Ch. Sublet, F. Tarkany et al, **Nuclear data for the production of therapeutic radionuclides**. In: S.M. Qaim, F. Tarkanyi, R. Capote (Technical editors), IAEA Technical Reports Series no. 473, IAEA, scientific and technical report STI/DOC/010/473, IAEA Vienna, Austria (2011)
2. F. T. Tarkanyi, A. V. Ignatyuk, A. Hermanne, R. Capote, B. V. Carlson, J. W. Engle, M. A. Kellett, T. Kibedi, G. N. Kim, F. G. Kondev, M. Hussain, O. Lebeda, A. Luca, Y. Nagai, H. Naik, A. L. Nichols, F. M. Nortier, S. V. Suryanarayana, S. Takacs, and M. Verpelli: **Recommended nuclear data for medical radioisotope production: diagnostic positron emitters**, J. Rad.Nucl.Chem. 319 (2019) 487-531.
3. A. Hermanne, A. V. Ignatyuk, R. Capote, B. V. Carlson, J. W. Engle, M. A. Kellett, T. Kibedi, G. N. Kim, F. G. Kondev, M. Hussain, O. Lebeda, A. Luca, Y. Nagai, H. Naik, A. L. Nichols, F. M. Nortier, S. V. Suryanarayana, S. Takacs, F. T. Tarkanyi, and M. Verpelli: **Reference cross sections for charged-particle monitor reactions**, Nucl. Data Sheets 148 (2018) 338-382.
4. F. T. Tarkanyi, A. V. Ignatyuk, A. Hermanne, R. Capote, B. V. Carlson, J. W. Engle, M. A. Kellett, T. Kibedi, G. N. Kim, F. G. Kondev, M. Hussain, O. Lebeda, A. Luca, Y. Nagai, H. Naik, A. L. Nichols, F. M. Nortier, S. V. Suryanarayana, S. Takacs, and M. Verpelli: **Recommended nuclear data for medical radioisotope production: diagnostic gamma emitters**, J. Rad. Nucl. Chem. 319 (2019) 533-666;
5. J. W. Engle, A. V. Ignatyuk, R. Capote, B. V. Carlson, A. Hermanne, M. A. Kellett, T. Kibedi, G. N. Kim, F. G. Kondev, M. Hussain, O. Lebeda, A. Luca, Y. Nagai, H. Naik, A. L. Nichols, F. M. Nortier, S. V. Suryanarayana, S. Takacs, F. T. Tarkanyi, and M. Verpelli: **Recommended Nuclear Data for the Production of Selected Therapeutic Radionuclides**, Nucl. Data Sheets 155 (2019) 56-74.

20 years of IAEA CRP's and other projects led to ~150 high-quality nuclear reaction channels

TENDL: TALYS Evaluated Nuclear Data Library

- Produced by TALYS nuclear model code + other sources
- Complete in projectile (n, g, p, d, t, h, a), target (2813 nuclides) and energy range (0-200 MeV) + uncertainties
- ~1500 citations, current version TENDL-2019
- Globally reasonable predictive power

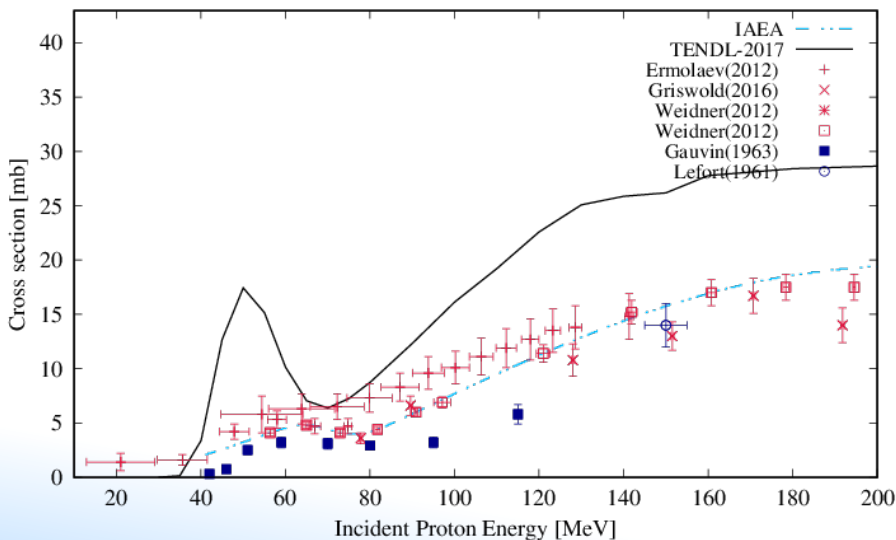
Medical isotope data library: combine the best with the most complete

IAEA high-quality evaluations (150 reaction channels)

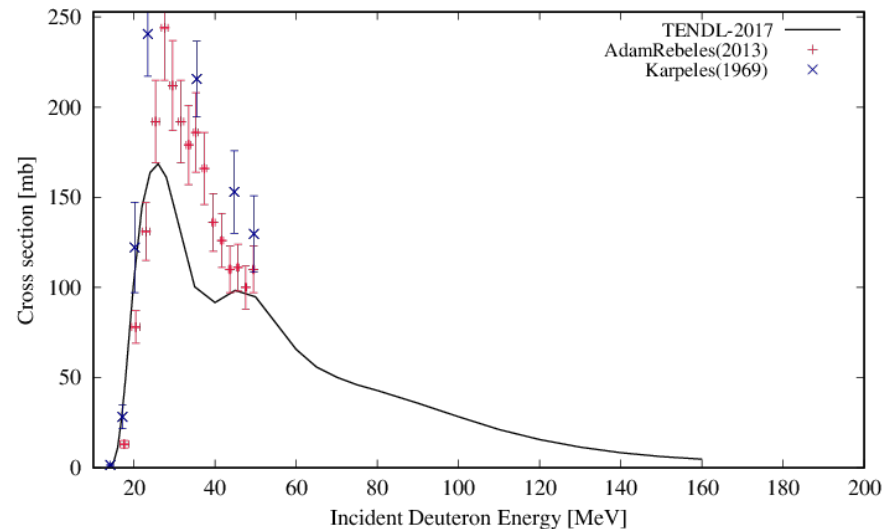
TENDL-2021

IAEA-201 Medical Isotope Data Library

$^{232}\text{Th}(p,x)^{225}\text{Ac}$



$^{\text{nat}}\text{Ga}(d,x)^{68}\text{Ge}$



Next: Add neutron reactions (for research reactors) and photonuclear route to Medical Isotope Browser

Summary

- Important to work on easy, attractive access of nuclear data, see the success of Livechart and Isotope Browser
- New NDS homepage under development
- Nuclear data can be and will remain to be accessible by GUI's, but complete libraries or command-line API's are needed for versatile use, see e.g. Medical Isotope Browser. This means work on a consistently formatted libraries.
- And a final question (also to us): where in nuclear data can Artificial Intelligence/Machine Learning be applied?



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Thank you!

