IAEA 60 Years
Atoms for Peace and Development

IAEA report 2020 and some comments on NSDD

Roberto Capote
Deputy Head, Nuclear Data Section
International Atomic Energy Agency
Department for Nuclear Sciences and Applications

Outlook

- ❑ Good and bad news
- ❑ IAEA CRP on FY of Actinides
- ❑ Updates of IAEA dissemination activities and ENDF retrieval
    - ➢ Medical applications
    - ➢ IRDFF-II
    - ➢ Photonuclear Library
- ❑ Unrecognized Sources of Uncertainties (USU) in CS and NSDD
- ❑ Summary and conclusions

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

Decay data issues in activation experiments: Different DD values to deal with - DDEP vs ENSDF = f(t)

TABLE 8: IRDFF-II recommended nuclear decay data content for gamma emitters. (DD eval.) refers to the latest Chechev compilation at https://www-nds.iaea.org/IRDFFtest/RCM3/Chechev-RCM3.pdf. (*) indicates data taken from ENSDF. New DDEP evaluations undertaken within this project are highlighted in blue. Numbers in parentheses indicate the absolute uncertainties, *e.g.*, 109.734(14) ≡ 109.734 ± 0.014.

Reaction Product	Half-life (recomm.)	Half-life (DD eval.)	Time unit	Gamma/X-ray Energy[keV]	Gamma/Xray Emiss.Prob. [%] (recomm.)	Emiss.Prob. [%] (DD eval.)	Source Document
^{18}F	109.77(5)	109.734(14)	m	511.	193.72(38)		BIPM
				0.525 $XK_\alpha 1$	0.013(4)		
				0.525 $XK_\alpha 2$	0.007(2)		
^{22}Na	2.6018(22)	2.6020	a	1274.537(7)	99.94(13)	99.940(14)	BIPM
				511.	180.7(2)	180.76(4)	
^{24}Na	14.997(12)	14.958(2)	h	1368.630(5)	99.9934(5)	99.9936(15)	BIPM
				2754.049(13)	99.862(3)	99.855(5)	
^{27}Mg	9.458(12)		m	843.76(10)	71.800(20)	71.8(4)	ENSDF
				1014.52(10)	28.200(20)	28.0(4)	

$T_{1/2}$=14.997 (12) h –R. Firestone et al, Nucl. Data Sheets 108 (2007) 2317

$T_{1/2}$=14.958 (2) h – V.P. Chechev, N.K. Kuzminov, 06/2014,

IAEA IRDFF evaluation adopted for DDEP.

✓ **~~From users: A long standing issue, we need time stamp and archive~~ !**

A. Trkov et al, IRDFF-II: A new neutron metrology library
Nuclear Data Sheets 163, 1-111 (2020); arXiv 1909.03336 (2019)

Problems identified in inelastic/capture gammas of many ENDF/B-VIII.0 evaluations

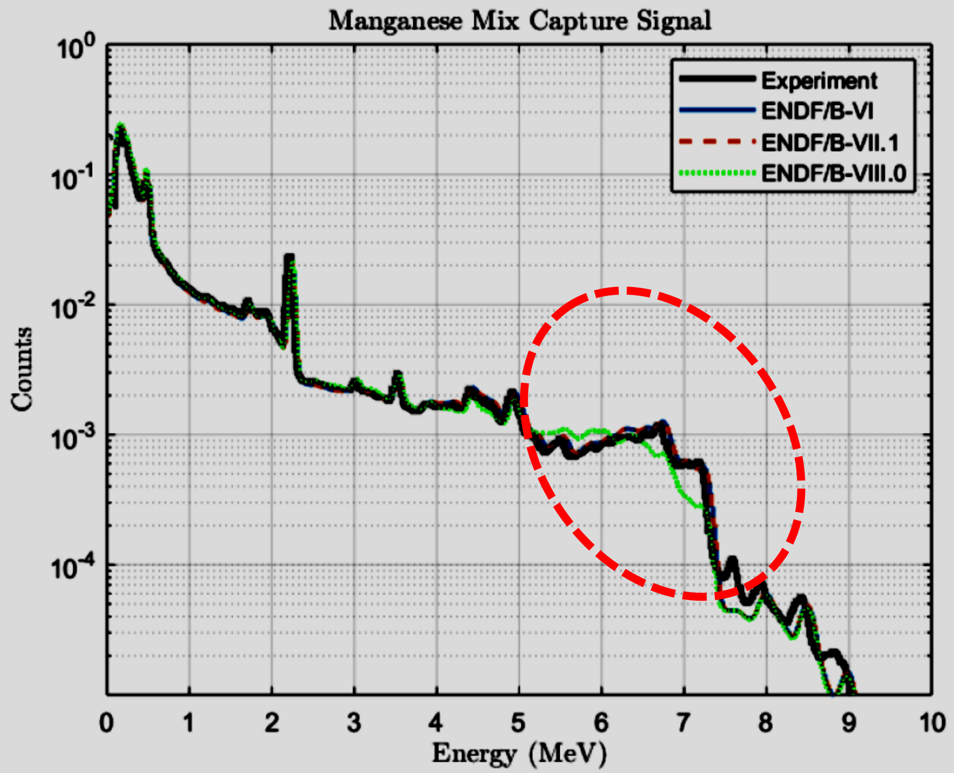


Fig. 9: Comparison of capture γ-ray spectra from the manganese mix from experiment and modeled with various libraries

Similar problems:
Si(n,n'**γ**),
Fe(n,**γ**), Fe(n,n'**γ**),
Mg(n,**γ**), Mg(n,n'**γ**),
Ti(n,**γ**), Ti(n,n'**γ**)

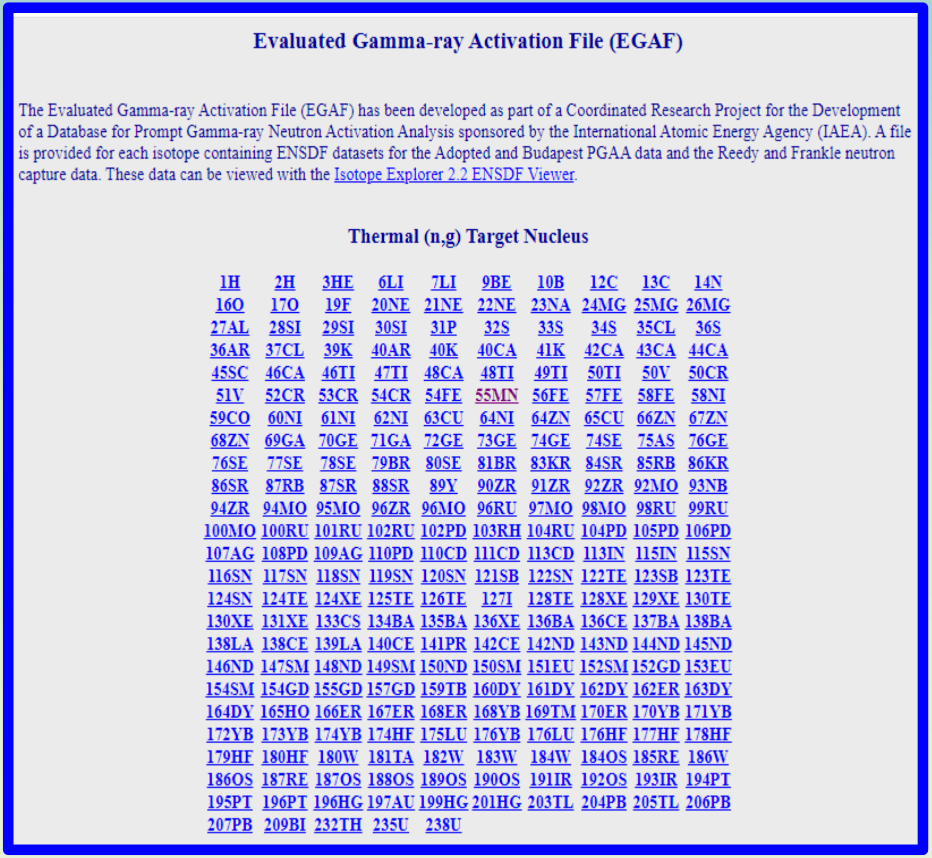
Hint:
ENDF/B-VI.8
was better for gammas

Marie-Laure Mauborgne et al, CSWEG 2019 & EPJ WoC **239** (2020) 20007 (ND2019)

IAEA EGAF vs CapGam

Reviewed measured data vs ENSDF

https://www-nds.iaea.org/pgaa/egaf.html https://www.nndc.bnl.gov/capgam/indexbyn.html

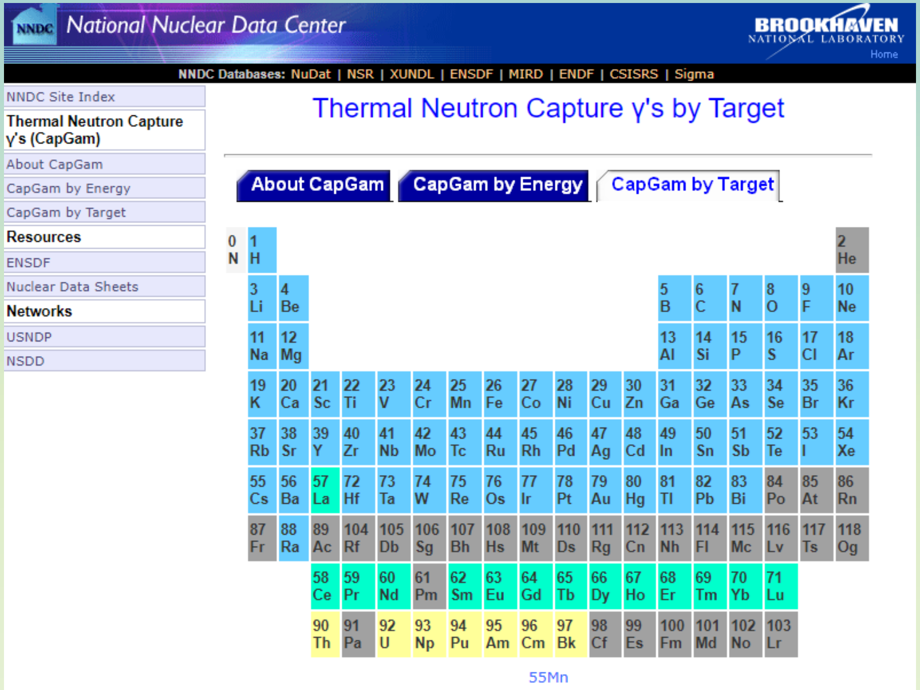


Evaluated Gamma-ray Activation File (EGAF)

The Evaluated Gamma-ray Activation File (EGAF) has been developed as part of a Coordinated Research Project for the Development of a Database for Prompt Gamma-ray Neutron Activation Analysis sponsored by the International Atomic Energy Agency (IAEA). A file is provided for each isotope containing ENSDF datasets for the Adopted and Budapest PGAA data and the Reedy and Frankle neutron capture data. These data can be viewed with the Isotope Explorer 2.2 ENSDF Viewer.

Thermal (n,g) Target Nucleus

1H	2H	3HE	6LI	7LI	9BE	10B	12C	13C	14N
16O	17O	19F	20NE	21NE	22NE	23NA	24MG	25MG	26MG
27AL	28SI	29SI	30SI	31P	32S	33S	34S	35CL	36S
36AR	37CL	39K	40AR	40K	40CA	41K	42CA	43CA	44CA
45SC	46CA	46TI	47TI	48CA	48TI	49TI	50TI	50V	50CR
51V	52CR	53CR	54CR	54FE	55MN	56FE	57FE	58FE	58NI
59CO	60NI	61NI	62NI	63CU	64NI	64ZN	65CU	66ZN	67ZN
68ZN	69GA	70GE	71GA	72GE	73GE	74GE	74SE	75AS	76GE
76SE	77SE	78SE	79BR	80SE	81BR	83KR	84SR	85RB	86KR
86SR	87RB	87SR	88SR	89Y	90ZR	91ZR	92ZR	92MO	93NB
94ZR	94MO	95MO	96ZR	96MO	96RU	97MO	98MO	98RU	99RU
100MO	100RU	101RU	102RU	102PD	103RH	104RU	104PD	105PD	106PD
107AG	108PD	109AG	110PD	110CD	111CD	113CD	113IN	115IN	115SN
116SN	117SN	118SN	119SN	120SN	121SB	122SN	122TE	123SB	123TE
124SN	124TE	124XE	125TE	126TE	127I	128TE	128XE	129XE	130TE
130XE	131XE	133CS	134BA	135BA	136XE	136BA	136CE	137BA	138BA
138LA	138CE	139LA	140CE	141PR	142CE	142ND	143ND	144ND	145ND
146ND	147SM	148ND	149SM	150ND	150SM	151EU	152SM	152GD	153EU
154SM	154GD	155GD	157GD	159TB	160DY	161DY	162DY	162ER	163DY
164DY	165HO	166ER	167ER	168ER	168YB	169TM	170ER	170YB	171YB
172YB	173YB	174YB	174HF	175LU	176YB	176LU	176HF	177HF	178HF
179HF	180HF	180W	181TA	182W	183W	184W	184OS	185RE	186W
186OS	187RE	187OS	188OS	189OS	190OS	191IR	192OS	193IR	194PT
195PT	196PT	196HG	197AU	199HG	201HG	203TL	204PB	205TL	206PB
207PB	209BI	232TH	235U	238U					



Many applications need reliable thermal capture gammas (see previous slide !!)

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

IAEA Coordinated Research Project on Fission Yields of Actinides (2020-2025)

FOCUS: Many of the evaluated libraries are rather old and date back to the beginning of the 1990s, therefore there is an urgent need to update both the fission yield libraries and the decay data libraries, and to include covariances, consistently.

Ambition: re-evaluate major actinides at several energy points from thermal up to 14 MeV

- ❑ Planned 3 Research Coordination Meetings (RCM)
  September 2020, Spring 2022, Winter 2024
- ❑ First RCM held by video conference
  31 August – 4 September 2020 (2-5pm, GMT+1)
- ❑ More than 60 participants from 16 countries (17 US–27%)
- ❑ The meeting presentations are available at:
  https://nds.iaea.org/index-meeting-crp/FissionYields2020/

Nuclear Data week 2020, USNDP (video conference), November 30 – December 3, 2020
Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

NEW

CoNDERC Compilation of Nuclear Data Experiments for Radiation Characterisation [page]
CENDL-3.2 Chinese evaluated neutron data library, issued in 2020: [introduction] [download] [list] [retrieve]
TENDL-2019 TALYS-based Evaluated Nuclear Data Library, 2019: [page] [retrieve]

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

EXFOR
Experimental nuclear reaction data

LiveChart of Nuclides
Interactive Chart of Nuclides

CINDA
Nuclear reaction bibliography

ENDF
Evaluated nuclear reaction libraries

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

NSR
Nuclear Science References *

NuDat-2
selected evaluated nuclear structure data **

RIPL
reference parameters for nuclear model calculations

IBANDL
Ion Beam Analysis Nuclear Data Library

Charged particle reference cross section
Beam monitor reactions

PGAA
Prompt gamma rays from neutron capture

FENDL
Fusion Evaluated Nuclear Data Library

Photonuclear
- IAEA Photonuclear Data Library, 1999
- EPICS Electron & Photon Interaction Data, 2017

IRDFF-II
International Reactor Dosimetry and Fusion File

NAA
Neutron Activation Analysis Portal

Safeguards Data
recommendations, August 2008

Medical Portal
- Medical Radioisotopes Production, 2015
- Medical isotope browser, 2019

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

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

IAEA Nuclear Data Section

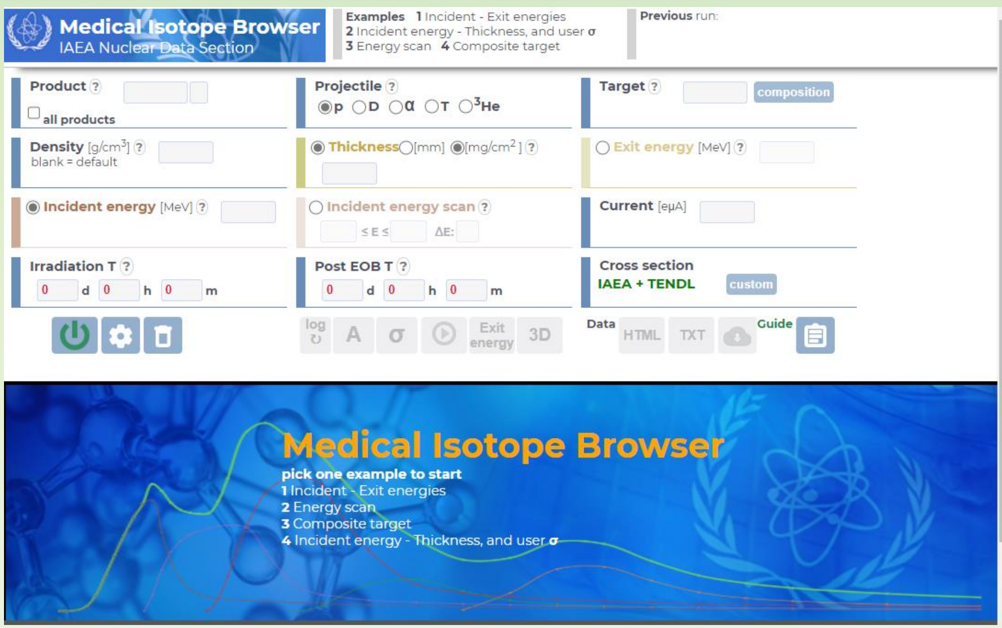
IAEA-NDS Mission | A+M Atomic and Molecular Data | Meetings Workshops | Newsletters | Coordinated Research Projects | NRDC Nuclear Reaction Data Center Network | NSDD Nuclear Structure & Decay Data Network | INDEN International Network of Nuclear Data Evaluators | Technical Documents INDC Reports Publications | Computer Codes | IAEA-NA Department of Nuclear Sciences and Applications

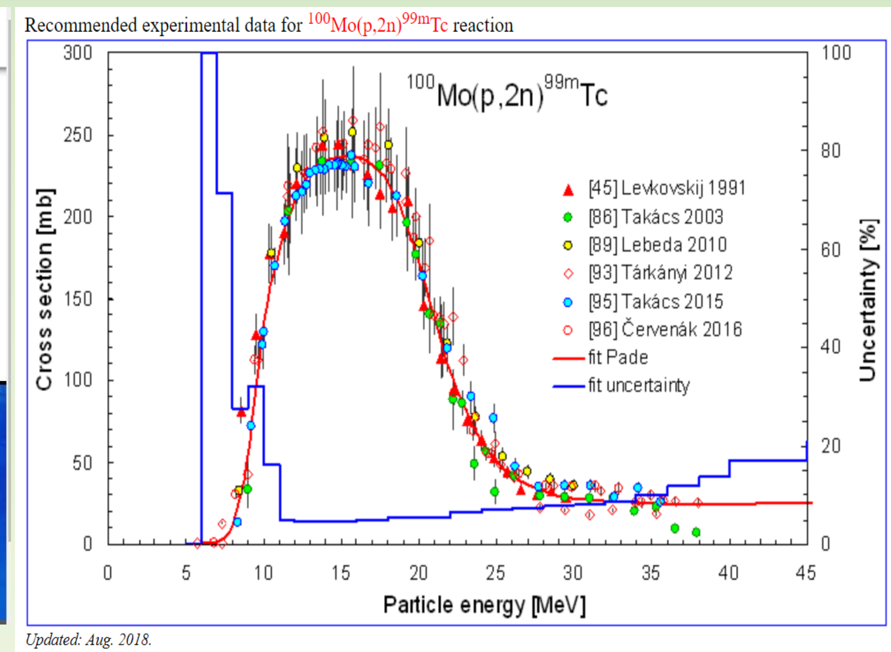
IAEA Medical Isotope Browser

https://www-nds.iaea.org/mib

- ❑ Aims to bring fundamental nuclear data directly to straightforward use in radiopharmaceutical research and industry
- ❑ Gives a direct first guess whether a production route is viable

www-nds.iaea.org/medical/

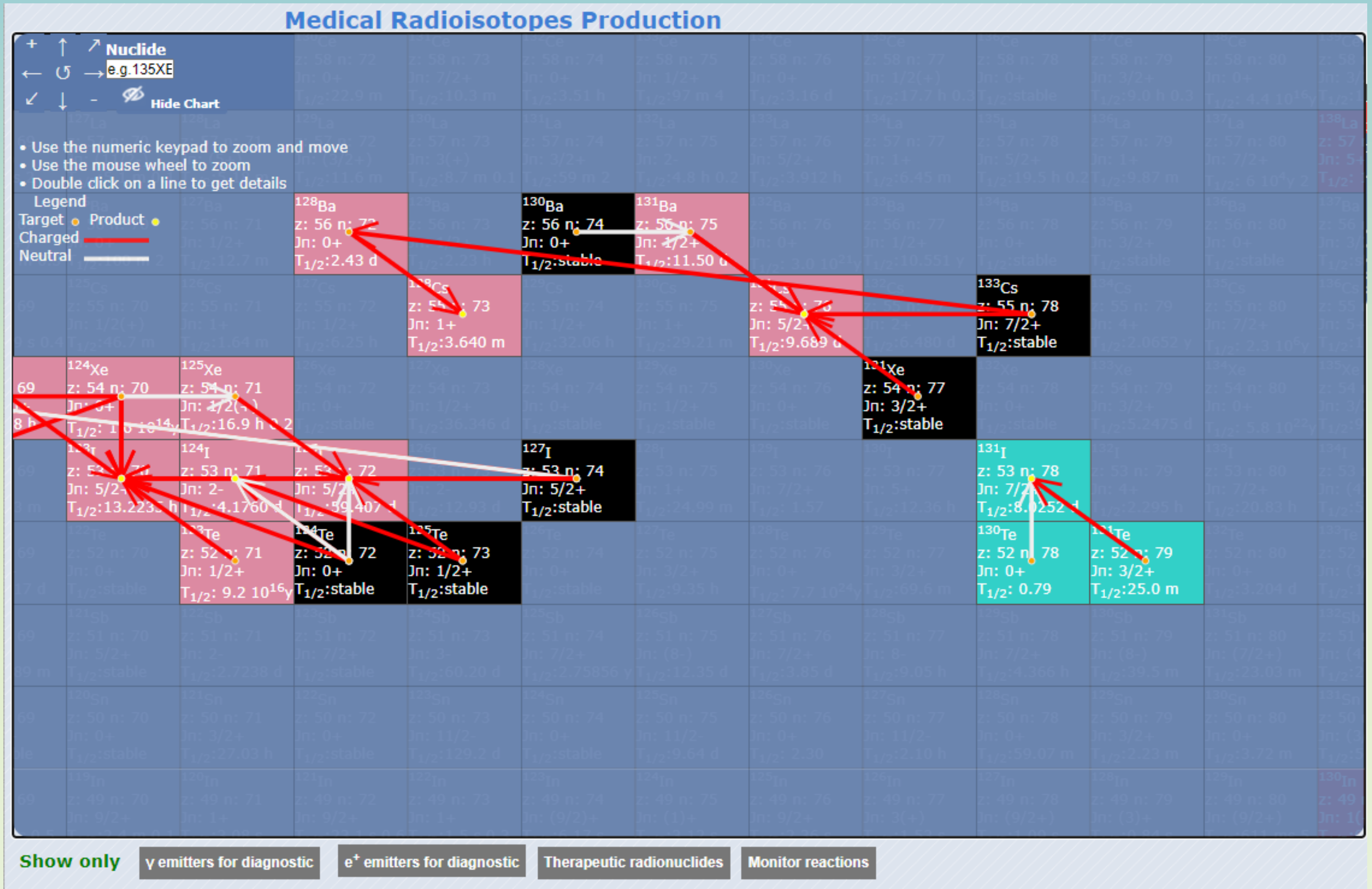




Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

IAEA Medical Portal

https://www-nds.iaea.org/medportal



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^+	$^{14}_{7}N_{7}$	$^{14}N(p,\alpha)^{11}C$	$^{11}_{6}C_{5}$	mird
$^{13}_{7}N_{6}$	9.965 min *4*	ec β+ 100 (*β+ ≈ 99.8*)	e^+	$^{16}_{8}O_{8}$	$^{16}O(p,\alpha)^{13}N$	$^{13}_{7}N_{6}$	mird

IAEA Evaluated Photonuclear Data Library (IAEA/PD-2019)

IAEA Coordinator: Paraskevi (Vivian) Dimitriou **Library released on August 14, 2020** **(Last updated on August 14, 2020).**

CRP participants:
P. Oblozinsky (chair), P. Dimitriou, S. Goriely, Xu Ruirui, Tian Yuan, M. Krticka, R. Schwengner, T. Belgya, N. Iwamoto, H. Utsunomiya, Y.S. Cho, J. Kopecky, S. Siem, R. B. Firestone, T. Kawano, D. M. Filipescu, V.V. Varlamov, V. Plujko

IAEA/PD-2019 REFERENCE:
*T. Kawano, Y.S. Cho, P. Dimitriou, D. Filipescu, N. Iwamoto, V. Plujko, X. Tao, H. Utsunomiya, V. Varlamov, R. Xu, R. Capote, I. Gheorghe, O. Gorbachenko, Y.L. Jin, T. Renstrm, M. Sin, K. Stopani, Y. Tian, G.M. Tveten, J.M. Wang, T. Belgya, R. Firestone, S. Goriely, J. Kopecky, M. Krticka, R. Schwengner, S. Siem and M. Wiedeking, Nuclear Data Sheets **163** (2020) 109-162. Also available as a preliminary version at arXiv 1908.00471 (2019).*

https://www-nds.iaea.org/photonuclear/

Contents

The library contains evaluated photonuclear data for 219 isotopes for incident photons (gamma rays) with energies mostly up to 200 MeV. The list of the files are available here. The library includes cross sections and emission spectra in ENDF-6 format. The file format description is explained in the report IAEA-NDS-0232. The ENDF-6 formatted individual evaluations are available at IAEA Github site. The complete ENDF-6 library can also be downloaded as a compressed (tgz) archive. To untar the files, use the command `tar -zxvf filename.tar.gz` on Unix or MacOS.

Derived transport and activation libraries

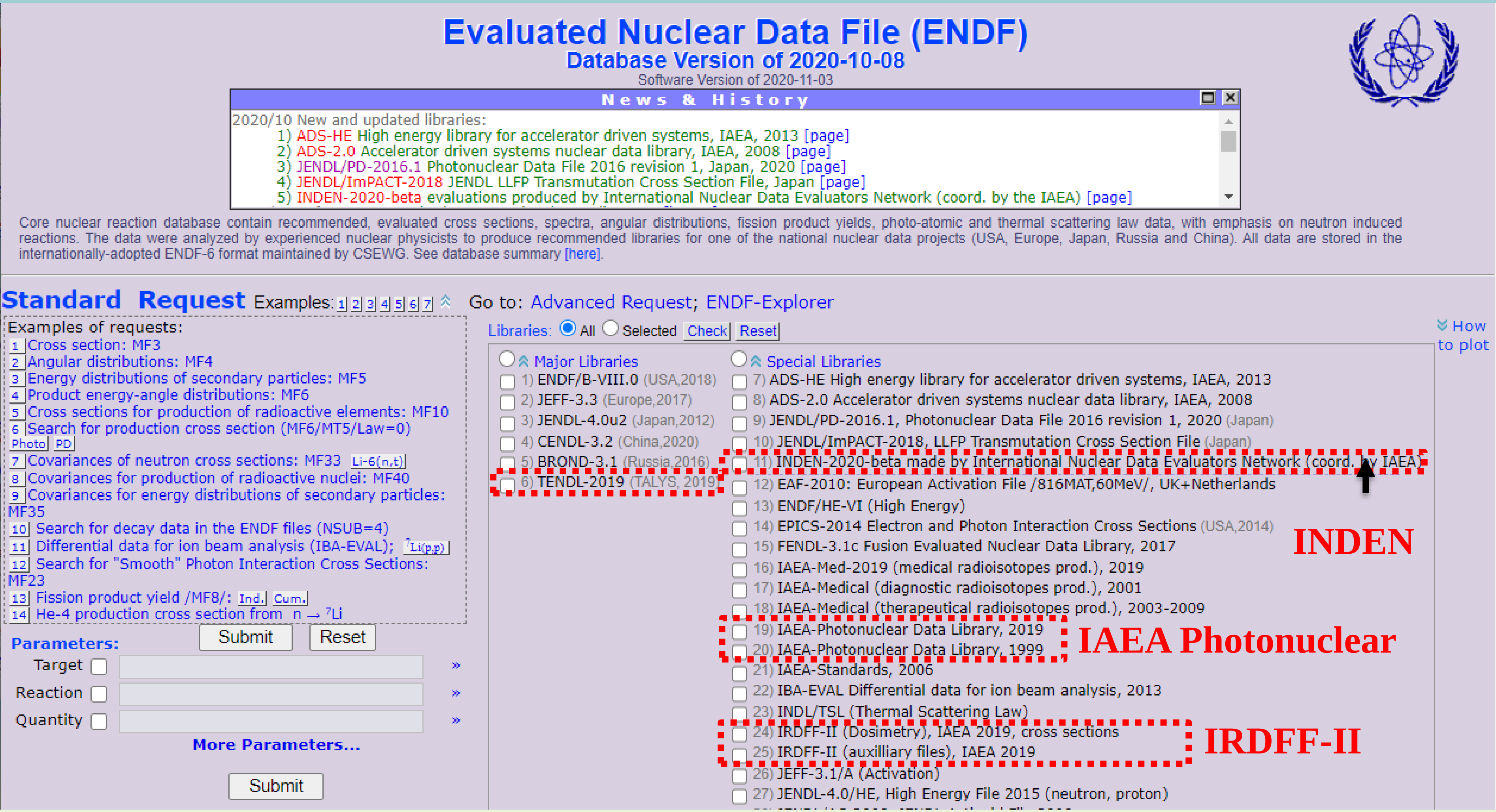
The production of application libraries from the ENDF-6 formatted files was undertaken at the IAEA Nuclear Data Section by H. Kawada (Tokyo Institute of Technology, Japan), J.-Ch. Sublet and S. Okumura (IAEA), and T. Kawano (LANL, USA), and is described in the report on "Processing of the Evaluated Photonuclear Data Library (IAEA-PD2019)" available as IAEA-NDS-0232. The processed IAEA/PD-2019 transport libraries and the processed activation libraries can be also retrieved from the IAEA Github as individual files (*.endf, *.pdf, etc) and tar compressed file (*.tar.gz) as follows.

File type	Filename (.tar.gz)	List of files (Github)
ENDF-6 Library	iaea-pd2019.tar.gz	ENDF-6 list
ACE Application Library (NJOY2016*)	ace.tar.gz	ACE list iaeapd19ace.xs (XSDIR index file)
ACER check/plot (NJOY plots)	acerplot.tar.gz	ACE plot list
EVAPLOT check/plot (Activation)	graphs.tar.gz	Activation plot list
FISPACT-II 162 gprs files	gxs-162.tar.gz	Activation file list
Linearised ENDF file (PENDF)	hendf.tar.gz	PENDF file list

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

IAEA ENDF retrieval system

https://www-nds.iaea.org/exfor/endf.htm

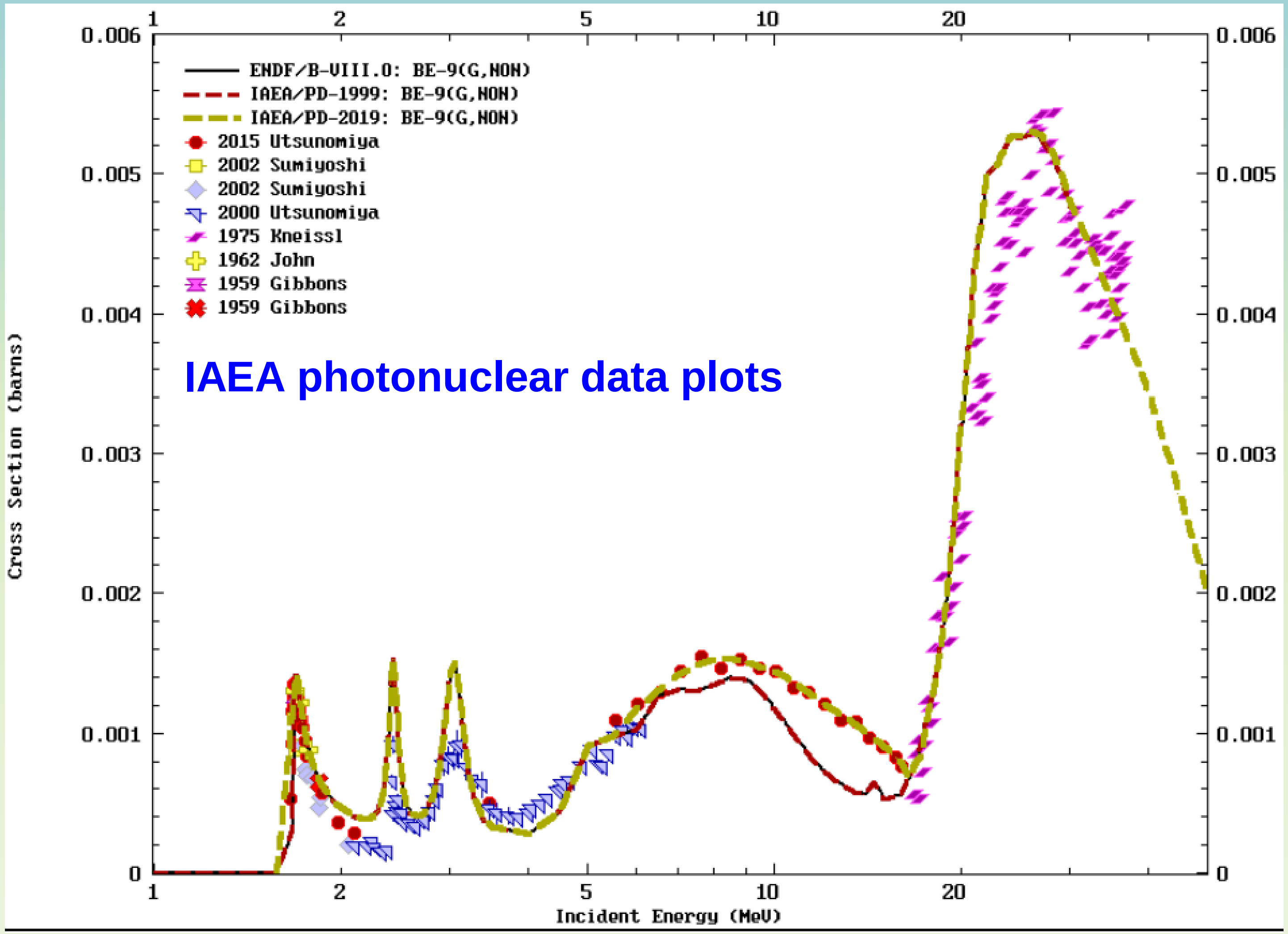


New evaluated libraries (ENDF-6) added to the ENDF retrieval/plotting (V. Zerkin)

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

IAEA ENDF retrieval/plotting system

https://www-nds.iaea.org/exfor/endf.htm



Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

International Reactor Dosimetry and Fusion File, IRDFF-II, January, 2020

(Nuclear data supersede **IRDFF-v1.05** and all previous versions of IRDFF and IRDF-2002)

IAEA Coordinators: Andrej Trkov and Roberto Capote; **LAST WEBPAGE UPDATE:** June 19, 2020

IRDFF-II PRIMARY REFERENCE:

A. Trkov, P.J. Griffin, S.P. Simakov, L.R. Greenwood, K.I. Zolotarev, R. Capote, D.L. Aldama, V. Chechev, C. Destouches, A.C. Kahler, C. Konno, M. Kostal, M. Majerle, E. Malambu, M. Ohta, V.G. Pronyaev, V. Radulovic, S. Sato, M. Schulc, E. Simeckova, I. Vavtar, J. Wagemans, M. White, and H. Yashima, IRDFF-II: A New Neutron Metrology Library. *Special issue of Nuclear Data Sheets, Vol. 163, pp. 1-108 (2020)*. *Also available as arXiv 1909.03336 (2019).*

Metrology (dosimetry) metrics: Damage cross sections (updated on June 19,2020)

A dosimetry metric is the result of folding a calculated dosimetry-related energy-dependent response function with the incident neutron energy-dependent fluence. Only dosimetry metrics that have been endorsed by a national nuclear regulator and/or by an international standards organization have been included. Table I lists the six dosimetry metrics included in the IRDFF-II library (note the two metrics listed for JEFF-3.3):
Metrology metrics can be downloaded from the links below:

- **natSi(n,1-MeV)** ASTM E722-14 1-MeV(Si)-equivalent response function, ENDF-6 format (tabulated file=ASTM E722-14 standard, 1.E-10 to 20 MeV, README).
- **natFe(n,X)dpa** ASTM E693-17 displacement cross sections, NRT model, ENDF-6 format (tabulated file= ASTM E693-17 standard = IRDF-2002 MT900, 1.E-10 to 20 MeV, README).
- **natFe(n,X)dpa** EURATOM displacement cross sections NRT model, ENDF-6 format (tabulated file= IRDF-2002 library MT901, 1.E-10 to 20 MeV).
- **natFe(n,X)dpa** JEFF-3.3 damage cross sections, NRT model, ENDF-6 format (tabulated file = JEFF-3.3, 2017, ENDF-6 file, MT901, 1.E-10 to 200 MeV).
- **natFe(n,X)dpa** JEFF-3.3 damage cross sections, Arc model, ENDF-6 format (tabulated file = JEFF-3.3, 2017, ENDF-6 file, MT900; 1.E-10 to 200 MeV).
- **GaAs(n,1-MeV)** ASTM E722-14 1-MeV(GaAs)-equivalent response function, ENDF-6 format (tabulated file = ASTM E722-14 standard, 1.E-10 to 20 MeV, README).

Fission product yield data

The recommended set of cumulative fission product yield data are taken from the JEFF-33 and ENDF/B-VIII.0 libraries. Since the yields are given for selected isotopes only, no ENDF-formatted data are given.

TABLE 2. IRDFF-II thermal-neutron-induced fission yields (neutron energy $E_n = 0.0253$ eV).

Target	Fission Product	Cumulative Fission Yield
^{235}U	^{95}Zr	6.5042E-02 ± 1.00 %
	^{99}Mo	6.1399E-02 ± 1.30 %
	^{103}Ru	3.1118E-02 ± 2.10 %
	^{106}Ru	4.0958E-03 ± 2.30 %
	^{137}Cs	6.0897E-02 ± 1.04 %
	^{140}Ba	6.3444E-02 ± 1.00 %
	^{144}Ce	5.4781E-02 ± 0.90 %

TABLE 3. IRDFF-II fast-neutron-induced fission yields (neutron energy $E_n \approx 400 - 500$ keV).

Target	Fission Product	Cumulative Fission Yield
^{232}Th	^{95}Zr	5.4494E-02 ± 2.90 %
	^{99}Mo	2.8740E-02 ± 2.80 %
	^{103}Ru	1.5179E-03 ± 6.30 %
	^{106}Ru	5.3236E-04 ± 5.70 %
	^{137}Cs	6.1790E-02 ± 5.12 %
	^{140}Ba	7.6222E-02 ± 3.19 %
	^{144}Ce	7.6334E-02 ± 6.12 %

The typical cooling times that are necessary are listed below:

^{95}Zr	The longest lived member of the chain is ^{95}Y at 10.3 minutes. All the others are less than 1 minute. If we wait for 6 half-lives that would be 1 hour.
^{99}Mo	Longest half-life has ^{99m}Nb at 2.6 m, requiring cooling time of about 15 minutes.
^{103}Ru - ^{103}Tc	Half-life 54 s, ^{103}Mo half life 1.13 m, requiring cooling time of about 13 minutes.
^{106}Ru - ^{106}Tc	Half-life 36 s, requiring cooling time of about 3.6 minutes.
^{137}Cs - ^{137}Xe	Half-life 3.82 m, requiring cooling time of about 23 minutes.
^{140}Ba - ^{140}Cs	Half-life 1.06 m, requiring cooling time of about 6 minutes.
^{144}Ce - ^{144}La	Half-life 40.7 s, requiring cooling time of about 4.1 minutes.

International Reactor Dosimetry and Fusion File, IRDFF-II, January, 2020

(Nuclear data supersede IRDFF-v1.05 and all previous versions of IRDFF and IRDF-2002)

IAEA Coordinators: Andrej Trkov and Roberto Capote; **LAST WEBPAGE UPDATE:** June 19, 2020

IRDFF-II PRIMARY REFERENCE:

A. Trkov, P.J. Griffin, S.P. Simakov, L.R. Greenwood, K.I. Zolotarev, R. Capote, D.L. Aldama, V. Chechev, C. Destouches, A.C. Kahler, C. Konno, M. Kostal, M. Majerle, E. Malambu, M. Ohta, V.G. Pronyaev, V. Radulovic, S. Sato, M. Schulc, E. Simeckova, I. Vavtar, J. Wagemans, M. White, and H. Yashima, IRDFF-II: A New Neutron Metrology Library. Special issue of Nuclear Data Sheets, Vol. 163, pp. 1-108 (2020). Also available as arXiv 1909.03336 (2019).

MAT	ENDF	GENDF	RR_UNC	Spectrum	Description
9004	--	705 group	ISNF	ISNF	ISNF Reactor Spectrum 705-group
9005	--	460 group	CFRMF	CFRMF	CFRMF Reactor Spectrum from IRDF-2002
9007	--	431 group	Sigma-Sigma	Sigma-Sigma	Sigma-Sigma Reactor Spectrum from IRDF-2002
9010	--	641 group	ACRR-FF-32	ACRR-FF-32	ACRR-FF-32 Reactor Spectrum 640-group
9011	--	641 group	ACRR-CdPoly	ACRR-CdPoly	ACRR-CdPoly Reactor Spectrum 640-group
9012	--	641 group	ACRR-PLG	ACRR-PLG	ACRR-PLG Reactor Spectrum 640-group
9013	--	641 group	ACRR-LB44	ACRR-LB44	ACRR-LB44 Reactor Spectrum 640-group
9014	--	641 group	SPR-III	SPR-III	SPR-III Reactor Spectrum 640-group
9015	--	640 group	FREC-II	FREC-II	ACRR-FREC-II external cavity 640-group
9020	--	640 group	Mol-BR1-MkIII	Mol-BR1-MkIII	RB1_MarkIII Reactor Spectrum 640-group
9032	--	641 group	Rez-LR0	Rez-LR0	Rez-LR0 Central void 641-group
9041	--	641 group	TRIGA-JSI-PT	TRIGA-JSI-PT	TRIGA-JSI-PT channel 641-group
9042	--	641 group	TRIGA-JSI-BN	TRIGA-JSI-BN	TRIGA-JSI-BN cover 641-group
9043	--	641 group	TRIGA-JSI-B4C	TRIGA-JSI-B4C	TRIGA-JSI-B4C cover 641-group
9044	--	641 group	TRIGA-JSI-10B4C	TRIGA-JSI-10B4C	TRIGA-JSI-10B4C enriched boron cover
9101	--	725 group	Godiva	Godiva	HMF001 (Godiva) 725-group
9102	--	725 group	Flattop	Flattop	HMF028 (Flattop) 725-group
9103	--	725 group	Big-Ten	Big-Ten	IMF007 (Big_Ten) 725-group
9104	--	725 group	Jezebel (**)	Jezebel	PMF001 (Jezebel) 725-group (**)
9105	--	725 group	Jezebel-240 (**)	Jezebel-240	PMF002 (Jezebel-240) 725-group (**)
9106	--	725 group	Flattop-Pu (**)	Flattop-Pu	PMF006 (Flattop-Pu) 725-group (**)
9107	--	725 group	Thor (**)	Thor	PMF008 (Thor) 725-group (**)
9110	--	725 group	IPPE-BR1	IPPE-BR1	FMR001 (IPPE-BR1) 725-group
9201	--	725 group	FNS-Grph-096mm	FNS-Grph-096mm	FNS-Graphite 096mm
9202	--	725 group	FNS-Grph-293mm	FNS-Grph-293mm	FNS-Graphite 293mm
9228	E.le.30MeV	725 group	U235_e80	U235_e80	U-235 thermal PFNS from ENDF/B-VIII.0
9408	E.le.60MeV	235 group	Bedn16	Bedn16	Be(d,n) E_d=16 MeV
9409	E.le.60MeV	220 group	Bedn40	Bedn40	Be(d,n) E_d=40 MeV
9437	E.le.30MeV	725 group	Pu239_IAEA	Pu239_IAEA	Pu-239 PFNS (IAEA)
9861	E.le.30MeV	725 group	Cf252_In	Cf252_In	Cf-252 spontaneous fission neutron spectrum
9900	E.le.60MeV	725 group	Constant	Constant	Constant spectrum Phi=1
9901	E.le.60MeV	725 group	MxwThrml	MxwThrml	Thermal Maxwellian at 293.6 K
9902	E.le.60MeV	513 group	1oE2MeV	1oE2MeV	Pure 1/E between Ecd and E2 (0.55 eV < E < 2 MeV)
9904	E.le.60MeV	515 group	1oE20MeV	1oE20MeV	Pure 1/E between Ecd and E2 (0.5 eV < E < 20 MeV)
9905	E.le.60MeV	725 group	MxwFiss	MxwFiss	Maxwellian fission spectrum (T-2.03MeV)
9910	E.le.60MeV	725 group	Linear	Linear	Linear spectrum Phi=E (1.E-5 eV < E < 20 MeV)
9920	--	640 group	ThrmlPnt	ThrmlPnt	Thermal Point
9925	E.le.60MeV	725 group	Mxw25keV	Mxw25keV	Maxwellian spectrum at 25 keV
9930	E.le.60MeV	725 group	Mxw30keV	Mxw30keV	Maxwellian spectrum at 30 keV
9932	E.le.60MeV	725 group	Mxw32keV	Mxw32keV	Maxwellian spectrum at 32 keV
9935	E.le.60MeV	725 group	Mxw35keV	Mxw35keV	Maxwellian spectrum at 35 keV
9940	E.le.60MeV	725 group	Mxw40keV	Mxw40keV	Maxwellian spectrum at 40 keV
9945	E.le.60MeV	725 group	Mxw45keV	Mxw45keV	Maxwellian spectrum at 45 keV
9950	E.le.60MeV	725 group	Mxw50keV	Mxw50keV	Maxwellian spectrum at 50 keV
9960	E.le.60MeV	725 group	Mxw60keV	Mxw60keV	Maxwellian spectrum at 60 keV

IRDFF-II neutron benchmark spectra

https://www-nds.iaea.org/IRDFF/spectra.html

International Reactor Dosimetry and Fusion File, IRDFF-II, January, 2020

(Nuclear data supersede IRDFF-v1.05 and all previous versions of IRDFF and IRDF-2002)

IAEA Coordinators: Andrej Trkov and Roberto Capote; **LAST WEBPAGE UPDATE:** June 19, 2020

IRDFF-II PRIMARY REFERENCE:

A. Trkov, P.J. Griffin, S.P. Simakov, L.R. Greenwood, K.I. Zolotarev, R. Capote, D.L. Aldama, V. Chechev, C. Destouches, A.C. Kahler, C. Konno, M. Kostal, M. Majerle, E. Malambu, M. Ohta, V.G. Pronyaev, V. Radulovic, S. Sato, M. Schulc, E. Simeckova, I. Vavtar, J. Wagemans, M. White, and H. Yashima, IRDFF-II: A New Neutron Metrology Library. Special issue of Nuclear Data Sheets, Vol. 163, pp. 1-108 (2020). Also available as arXiv 1909.03336 (2019).

IRDFF-II cross-section and decay data files:

The cross-section data for individual monitor and cover materials and corresponding decay data files can be accessed from the ENDF interface of the IAEA-NDS web page under the "Special Libraries" tab as **11) IRDFF-II (Dosimetry), IAEA 2019, cross sections**. All individual reactions used in the IRDFF-II evaluations of reactions on natural targets are also available as **12)) IRDFF-II (auxiliary files), IAEA 2019**.
Complete cross-section library in various forms can be downloaded from the links below:

- IRDFF-II dosimetry cross sections in 3-column format (Energy in eV, cross section in barn, absolute uncertainty in barn, compressed).
- IRDFF-II dosimetry cross sections in pointwise ENDF-6 format (compressed).
- IRDFF-II dosimetry group cross sections in ENDF-6 format, 640-groups (compressed).
- IRDFF-II dosimetry group cross sections in ENDF-6 format, extending from 1.E-5 eV up to 60 MeV, 725-groups (compressed).
- IRDFF-II dosimetry cross sections in ACE format (compressed). A summary of contents is given in the LIST file. Activation cross sections for the excitation of isomeric states are identified by ACE reaction numbers MT*=(10+LFS)*1000+MT, where LFS is the final state (LFS=0 is the ground state, LFS=1 is the first isomeric state, etc.). Cross sections for the production of radionuclides are identified by ACE reaction numbers MT*=(50+LFS)*1000000+ZA where ZA identifies the product (ZA=1000*Z+A). (The ACE files affected by the new convention for radionuclide production cross section reaction numbers were updated on 9 January 2020.)
- Recommended decay data are listed in Tables 7 and 8; these data are consistent with the cross-section evaluations. Latest decay data evaluations in ENDF-6 format are also available; these evaluations are consistent with recommended decay data for all nuclides but the half-life of Na-22. For more details please refer to the full IRDFF-II library documentation.

- ❑ All evaluations are non-model evaluations based on careful selection/renormalization of measured data
- ❑ All evaluations include validated covariance matrices
- ❑ Note: TENDL-2019 reaction channels have been fitted/replaced to IRDFF-II (but covariances are different)

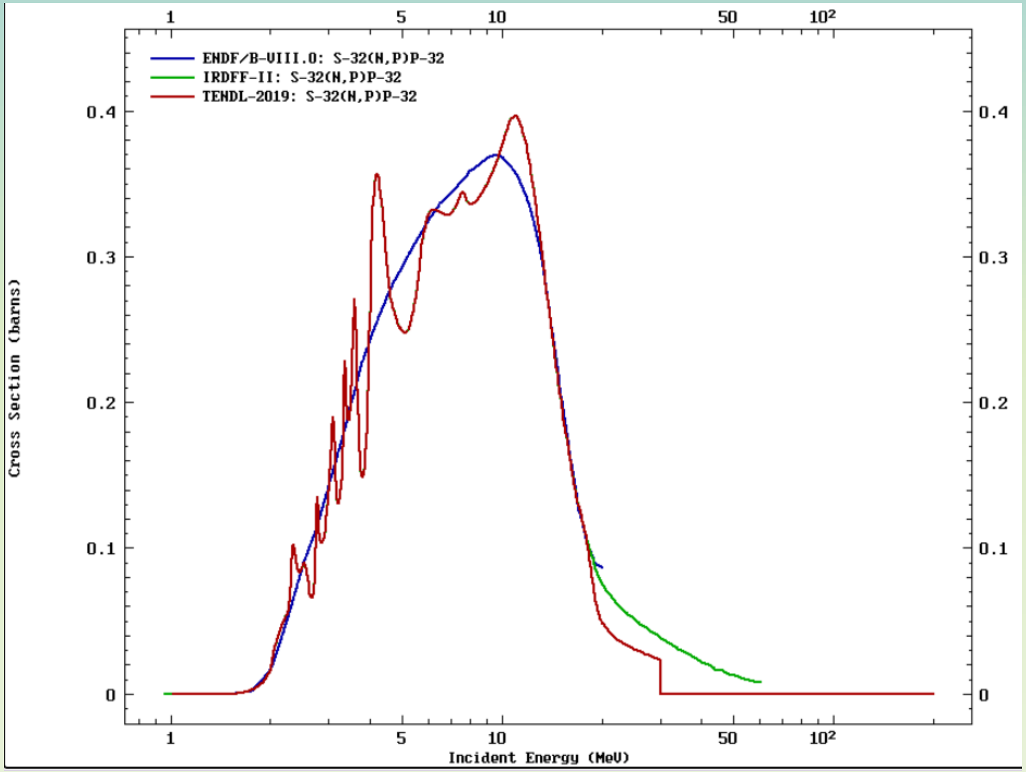
International Reactor Dosimetry and Fusion File, IRDFF-II, January, 2020

(Nuclear data supersede **IRDFF-v1.05** and all previous versions of IRDFF and IRDF-2002)

IAEA Coordinators: Andrej Trkov and Roberto Capote; **LAST WEBPAGE UPDATE:** June 19, 2020

IRDFF-II PRIMARY REFERENCE:

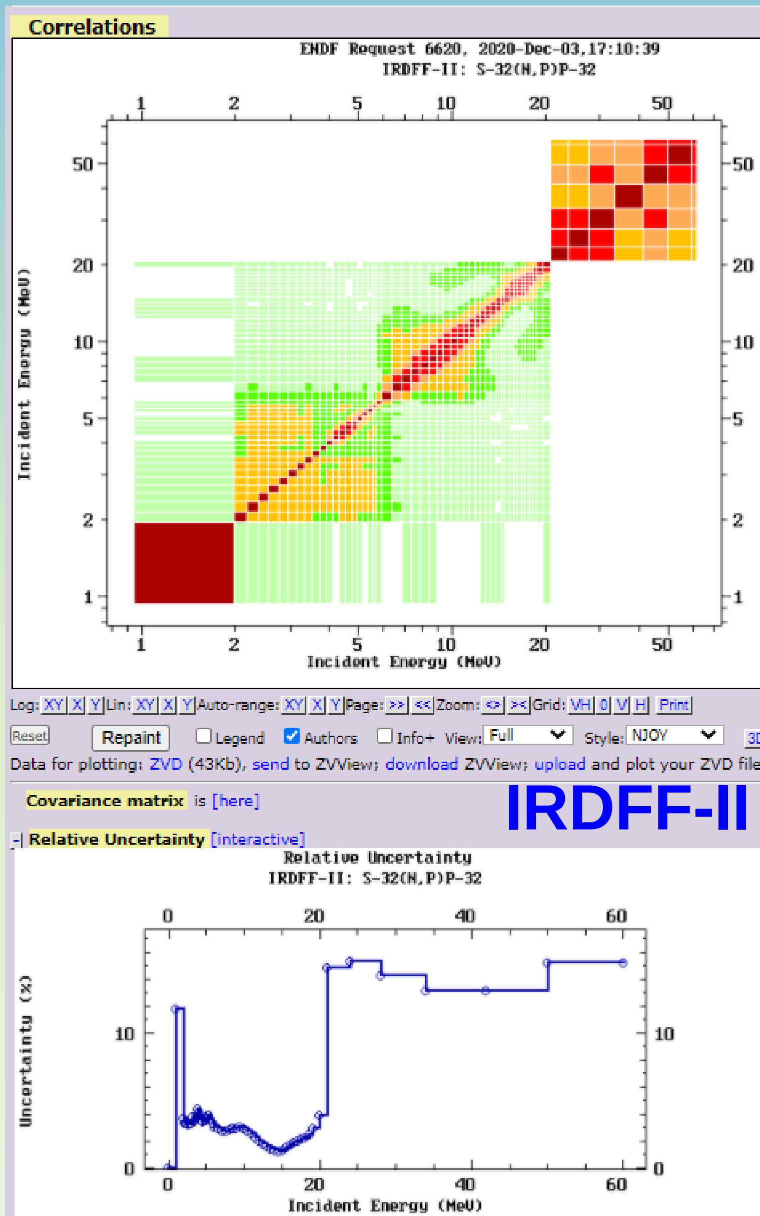
A. Trkov, P.J. Griffin, S.P. Simakov, L.R. Greenwood, K.I. Zolotarev, R. Capote, D.L. Aldama, V. Chechev, C. Destouches, A.C. Kahler, C. Konno, M. Kostal, M. Majerle, E. Malambu, M. Ohta, V.G. Pronyaev, V. Radulovic, S. Sato, M. Schulc, E. Simeckova, I. Vavtar, J. Wagemans, M. White, and H. Yashima, IRDFF-II: A New Neutron Metrology Library. Special issue of Nuclear Data Sheets, Vol. 163, pp. 1-108 (2020). Also available as arXiv 1909.03336 (2019).

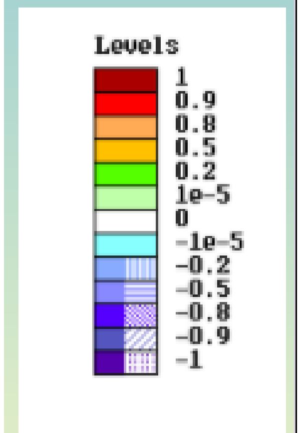


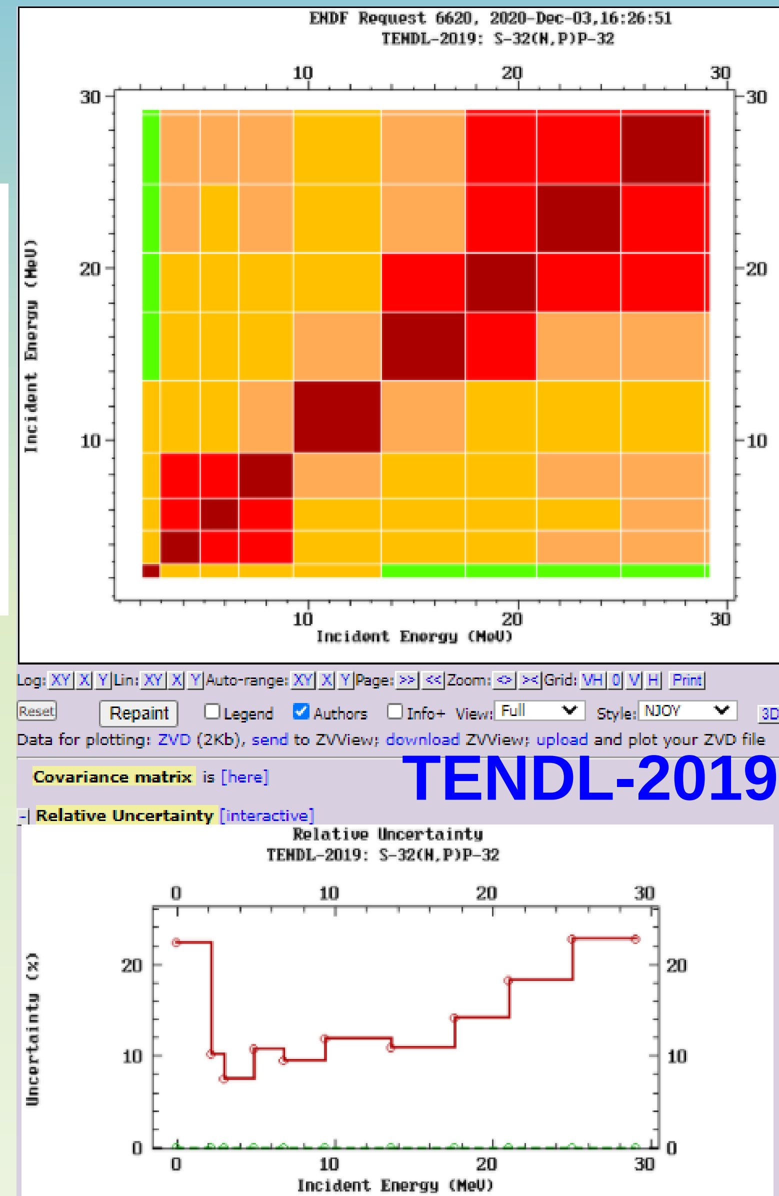
IRDFF-II vs TENDL-2019: evaluations

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

IRDFF-II vs TENDL-2019: covariances







Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

USU: Nucl. Data Sheets 163 (2020) 191

Available online at www.sciencedirect.com

ScienceDirect

Nuclear Data Sheets

Nuclear Data Sheets 163 (2020) 191–227

www.elsevier.com/locate/nds

Unrecognized Sources of Uncertainties (*USU*) in Experimental Nuclear Data

R. Capote,[1,*] S. Badikov,[2] A.D. Carlson,[3] I. Duran,[4] F. Gunsing,[5] D. Neudecker,[6] V.G. Pronyaev,[7] P. Schillebeeckx,[8] G. Schnabel,[9] D.L. Smith,[10] and A. Wallner[11]

[1] *NAPC–Nuclear Data Section, International Atomic Energy Agency, A-1400 Vienna, Austria*
[2] *Atomstandard, Rosatom State Corporation, Moscow, Russia*
[3] *National Institute of Standards and Technology, Gaithersburg, MD 20899, USA*
[4] *Universidade de Santiago de Compostella, 15782 Santiago de Compostela, La Coruna, Spain*
[5] *CEA Irfu, University Paris-Saclay, F-91191 Gif-sur-Yvette, France*
[6] *Los Alamos National Laboratory, Los Alamos, NM 87545, USA*
[7] *Contractor, NAPC–Nuclear Data Section, International Atomic Energy Agency, A-1400 Vienna, Austria*
[8] *Joint Research Centre - Geel, 2440 Geel, Belgium*
[9] *Uppsala University, Lagerhyddsvagen, 75120 Uppsala, Sweden*
[10] *Argonne National Laboratory, 1710 Avenida del Mundo, No. 1506, Coronado, CA 92118, USA*
[11] *Australian National University, Canberra ACT, Australia*

(Received 9 August 2019; revised received 14 November 2019; accepted 25 November 2019)

USU in Nuclear Data evaluation

OPEN ACCESS
IOP Publishing | Bureau International des Poids et Mesures Metrologia
Metrologia 53 (2016) S55–S64 doi:10.1088/0026-1394/53/2/S55

When the model doesn't cover reality: examples from radionuclide metrology

S Pommé

European Commission, Joint Research Centre, Institute for Re
Retieseweg 111, B-2440 Geel, Belgium

E-mail: stefaan.pomme@ec.europa.eu

1. Introduction

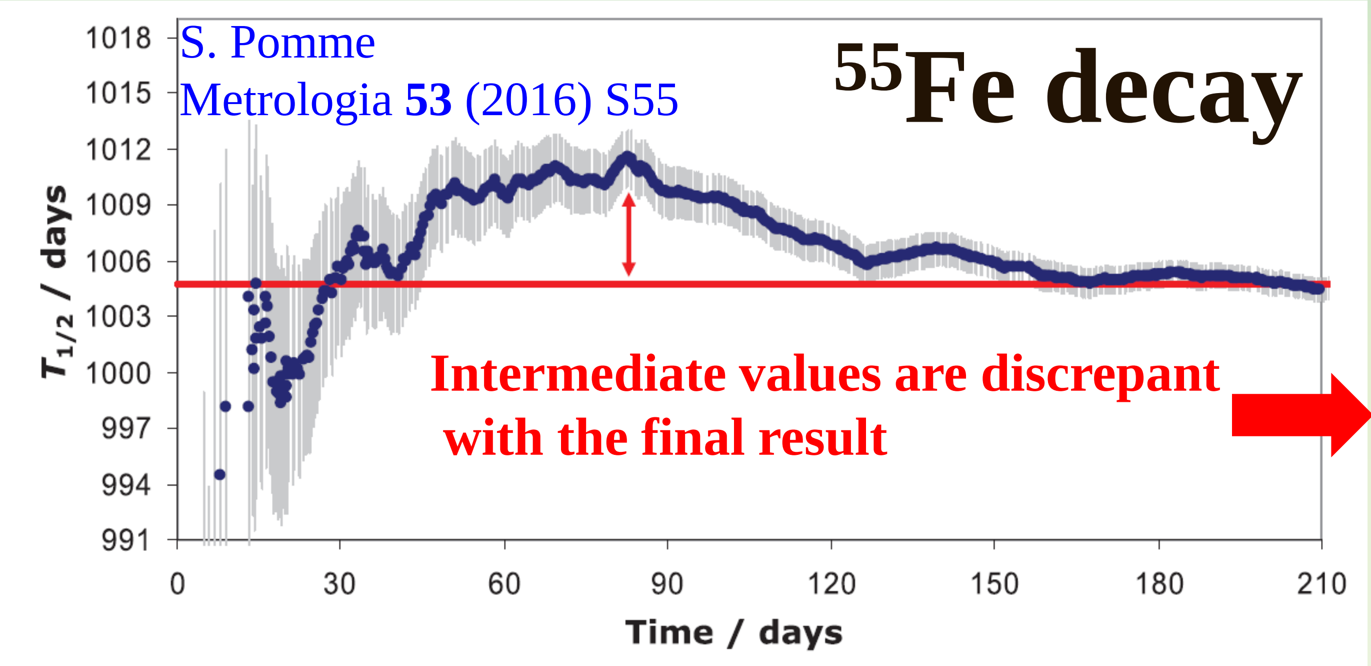
'[…] as we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know.'

—Donald Rumsfeld

Don Smith, April 04/2020 … reading this (Pomme) paper
I found a source of validation to the effort our group
expended on the USU project (2 CM in Vienna, LOTS of talks)

USU in Decay Data measurements: $T_{1/2}$

"The least-squares method is not robust to violation of implicit assumptions, such as e.g. the presence of outlier data and errors on independent variables. It is tempting to be uncritical about the physical meaning of the parameter values obtained from curve fitting: there can be unexpected reasons why there is a mismatch between the model and the physical reality which it is meant to represent.", S. Pomme



$T_{1/2}$ = 2.744(9) y
= 1002(3) d

GLSQ uncertainties unrealistically low for correlated residuals !!

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

USU in Decay Data measurements: P_α

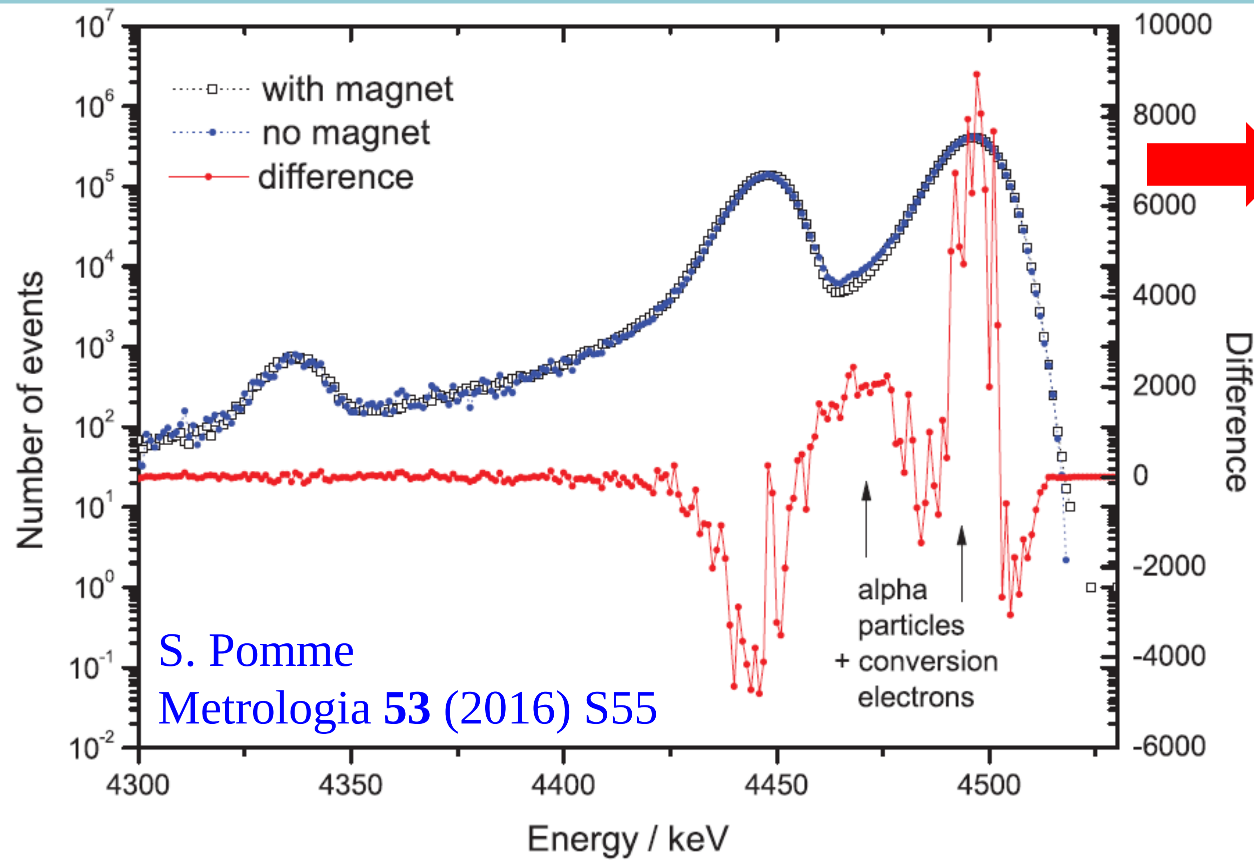


Figure 8. Difference between ^{236}U alpha spectrum taken without and with magnet system (using a 150 mm^2 PIPS detector), showing how coincidences with conversion electrons depopulates the second peak and broadens the highest peak.

P_α -alpha emission prob. derived from measur. without magnet are significantly WRONG !!

Recommendation to experimentalists

S. Pomme, metrologist, EC JRC Geel, priv. comm. 04/29/2020

… as a collective, we know which type of errors may occur in our measurements, but as individual experimentalists we tend to turn a blind eye to the factors that we don't control so well. I have heard many colleagues saying that they ignore some sources of error in the uncertainty budget because they don't know much about it… whereas **this is exactly the reason why we should provide an estimate of uncertainty to everything that we don't fully understand.**

RC: Lesson learned -- often USU is needed as UQ is not comprehensive nor complete

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org

Summary and conclusions

- A new IAEA CRP started to study "Fission Yields of Actinides"
- IAEA Photonuclear library released
- Medical isotopes production data widely disseminated
- INDEN work is on-going
- INDEN evaluations, TENDL-2019, Neutron Standards, IRDFF-II, and IAEA Photonuclear data added to the ENDF retrieval/plotting
- USU paper published in Nuclear Data Sheets
- USU introduction in Neutron Standards has been largely justified

Roberto Capote, IAEA Nuclear Data Section
e-mail: R.CapoteNoy@iaea.org; Web: www-nds.iaea.org