INDC reporting - Project Compilation of Nuclear Data Experiments for Radiation Characterisation (CoNDERC)

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Objectives

- To transfer into technology the experimental integral radiation information that can be used as part of the Validation and Verification processes of nuclear model and code systems
- To provide various schema, protocol to perform the V&V processes
- The aim is to construct several benchmarks databases based on extensive and thorough V&V activities for example, data evaluation processes, inventory calculations, source-term and reaction rates simulation, but also outreaching to engineering systems.

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Objectives

- The aim is to provide all experimental and calculational information in such computational ways that it can easily, seamlessly and rapidly be deployed in support of the many scientific systems that need them:
  - model, inventory, transport, material sciences code systems, etc..

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Key Elements

- Identify and compile a set of radiation characterization benchmarks (both computational and experimental) that includes spectral indices, reaction rates, decay heat, resonance integral, particle emissions (source terms), etc.
- Assess and review the data, including quantification of uncertainties, then compile the data into computer format for dissemination
- Perform simulations of each benchmark with a suitable code system and selected nuclear libraries and produce a database/repository of the necessary input files to repeat those simulations for other nuclear data libraries.

Benchmarks experiments

1. JAEA time dependent Fusion Neutron Source decay heat experiments (73 materials, 2/3 irradiation campaigns)
2. FZK 6764 (steel) – isotopic composition measurements
3. Li(p,n) (up to 150 MeV) angular neutron yields
4. Fission pulse decay heat experiments
5. Fission delayed neutron experiments
6. Selected criticality experiment with reaction rates (ICSBEP, IRPhEP, REAL-IAEA)
7. Experimental MACS from KADoNiS
8. Spectrum-averaged cross sections in reference spectra (e.g. ^{252}Cf, ^{235}U, ACRR, LR-0, BOR, HFR, etc.)

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Benchmarks experiments

9. Resonance integrals (based on the Atlas, other experiments, compilation)
10. Resonance integrals and thermal cross-section based on kayzero database for NAA
11. Time dependent gamma spectral measurements from PNNL (fission) and UK (fusion)
12. (gamma, n) experimental data (Laser-Compton scattering from TUNL and New Subaru)
13. Integro-differential benchmark (from EXFOR or otherwise)
14. Shielding and fusion leakage benchmarks from SINBAD and other sources (including models)
15. Reference spectra for computational analysis
16. ...

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Project

- The project has been managed and constructed through one Technical Contract (ending in 2021) a few experts small consultant agreements and generous contributions

- The WEB site, portal is been designed internally

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Portal entry

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CoNDERC

Home Documentation Contributors Datasets

Compilation of Nuclear Data Experiments for Radiation Characterisation (CoNDERC)

The purpose of the CoNDERC project is to transfer into technology the experimental integral radiation information that can be used as part of the Validation and Verification processes of nuclear model and code systems, and to provide various schema to perform the V&V. Under the auspices of the IAEA Nuclear Data Section, individuals and institutions are assembling several of databases and code infrastructures based on their own V&V activities mainly associated with inventory, activation-transmutation, source term and radiation shielding R&D.

Decay Heat

Fusion Events

Fission Events

Spectra

Spectra

Shielding

Aspis FNS NIST

Oktavian Pulsed Replica

Tiara

Beyond Keff

MCNP

TRIPOLI

Experiments

Thermal Resonance

Baghdad Atlas

CoNDERC — Home | Documentation | Contributors

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1. Reference Spectra

- The majority of neutron-application spectra stem from light-water assemblies, mock-ups, piles or reactors where the integral responses are strongly, if not solely, influenced by the energy ranges of the fission spectra, resonance range and thermal Maxwellian.
- Fusion spectra that have been obtained from magnetic confinement (MCF) or inertial confinement fusion (ICF) present typical D-D 2.5 MeV, or D-T 14 MeV peaks sometimes accompanied by a higher-energy tail, but also showing rather different slowing-down profiles.
- Accelerator-driven beam spectra are important in their role in nuclear data acquisition and materials research, but also for medical therapeutic and diagnostic applications.

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Reference Spectra

- 85 incident particle spectra are provided, mostly including neutron incident spectra but with some charged particle spectra.
- Note that these are provided in the original energy group structures as generated by the code(s) that calculated them. These are often not the same energy group structures as those provided for the nuclear data libraries and may require a flux conversion.
- Note that while the group conversion can easily be performed, this cannot add structure when moving from a coarse group structure to a more refined multi-group.

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Reference Spectra

- From all over the World, all types, style of piles, research reactors, NPPs, beams, etc..

#	Name	Group	Particle	arb_flux.txt	Figure.png	Description
1	ACRR-FF-CC-32Cl	640	n	ACRR-FF-CC-32Cl	ACRR-FF-CC-32Cl	SNL MCNP E8
2	ACRR-LB44	640	n	ACRR-LB44	ACRR-LB44	SNL MCNP E8
3	ACRR-PLG	640	n	ACRR-PLG	ACRR-PLG	SNL MCNP E8
4	FREC-II-FF	640	n	FREC-II-FF	FREC-II-FF	SNL MCNP E8
5	ACRR-CdPoly	640	n	ACRR-CdPoly	ACRR-CdPoly	SNL MCNP E8
6	SPR-III-CC	640	n	SPR-III-CC	SPR-III-CC	SNL MCNP E8
7	FBR-6in-leakage	640	n	FBR-6in-leakage	FBR-6in-leakage	SNL MCNP E8
8	LR-0-Void	640	n	LR-0-Void	LR-0-Void	Rez MCNP
9	LR-0-NaF	640	n	LR-0-NaF	LR-0-NaF	Rez MCNP
10	LR-0-As2O3	640	n	LR-0-As2O3	LR-0-As2O3	Rez MCNP
11	LR-0-Y2O3	640	n	LR-0-Y2O3	LR-0-Y2O3	Rez MCNP
12	LR-0-ZrO2	640	n	LR-0-ZrO2	LR-0-ZrO2	Rez MCNP
13	LR-0-MnO2	640	n	LR-0-MnO2	LR-0-MnO2	Rez MCNP
14	LR-0-NaI	640	n	LR-0-NaI	LR-0-NaI	Rez MCNP
15	MURR-G1	112	n	MURR-G1	MURR-G1	EXFOR xxxxx
16	TRIGA	79	n	TRIGA	TRIGA	EXFOR 31733
17	HBR-2-RPV	47	n	HBR-2-RPV	HBR-2-RPV	ORNL/TM-13204
18	LANL-OWR	69	n	LANL-OWR	LANL-OWR	LANL Omega West
19	SCK-BR2	621	n	SCK-BR2	SCK-BR2	SCK-CEN BR2 MCNP
20	EBR-2	29	n	EBR-2	EBR-2	ANL West
21	BOR-60c	42	n	BOR-60c	BOR-60c	Rosatom
22	BOR-60b	69	n	BOR-60b	BOR-60b	Rosatom
23	BOR-60a	176	n	BOR-60a	BOR-60a	Rosatom
24	BWR-RPV	198	n	BWR-RPV	BWR-RPV	EPRI NP-152
25	PWR-RPV	198	n	PWR-RPV	PWR-RPV	EPRI NP-152
26	Cf252	70	n	Cf252	Cf252	PTB
27	Bigten	407	n	Bigten	Bigten	CEA TRIPOLI
28	HFIR-lowres	100	n	HFIR-lowres	HFIR-lowres	ORNL
29	HFIR-highres	238	n	HFIR-highres	HFIR-highres	ORNL
30	HFIR-VXF3-AD	238	n	HFIR-VXF3-AD	HFIR-VXF3-AD	ORNL MCNP
31	HFR-high	616	n	HFR-high	HFR-high	NRG MCNP
32	HFR-low	616	n	HFR-low	HFR-low	NRG MCNP
33	HFR-C3	171	n	HFR-C3	HFR-C3	NRG MCNP
34	HFR-C7	171	n	HFR-C7	HFR-C7	NRG MCNP
35	IFMIF-DLi	211	n	IFMIF-DLi	IFMIF-DLi	KFK
36	Tokyo-90KeV	94	n	Tokyo-90KeV	Tokyo-90KeV	EXFOR 22850
37	Tokyo-190KeV	150	n	Tokyo-190KeV	Tokyo-190KeV	EXFOR 22850
38	Tokyo-330KeV	145	n	Tokyo-330KeV	Tokyo-330KeV	EXFOR 22850
39	Tokyo-540KeV	275	n	Tokyo-540KeV	Tokyo-540KeV	EXFOR 22850
40	Paluel	172	n	Paluel	Paluel	Framatome APOLLO2

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Reference Spectra

- NNP also: BWR and PWR in cycle at 600K not room temperature
- ESS, CERN, Maxwellian, Am-Be, Yayoi, Phenix, etc.

41	PWR-MOX-0	1102	n	PWR-MOX-0	PWR-MOX-0	NDS-139(2017)1-76
42	PWR-MOX-15	1102	n	PWR-MOX-15	PWR-MOX-15	NDS-139(2017)1-76
43	PWR-MOX-40	1102	n	PWR-MOX-40	PWR-MOX-40	NDS-139(2017)1-76
44	PWR-UO2-0	1102	n	PWR-UO2-0	PWR-UO2-0	NDS-139(2017)1-76
45	PWR-UO2-15	1102	n	PWR-UO2-15	PWR-UO2-15	NDS-139(2017)1-76
46	PWR-UO2-40	1102	n	PWR-UO2-40	PWR-UO2-40	NDS-139(2017)1-76
47	PWR-UO2-Gd-0	1102	n	PWR-UO2-Gd-0	PWR-UO2-Gd-0	NDS-139(2017)1-76
48	PWR-UO2-Gd-15	1102	n	PWR-UO2-Gd-15	PWR-UO2-Gd-15	NDS-139(2017)1-76
49	PWR-UO2-Gd-40	1102	n	PWR-UO2-Gd-40	PWR-UO2-Gd-40	NDS-139(2017)1-76
50	BWR-MOX-Gd-0	1102	n	BWR-MOX-Gd-0	BWR-MOX-Gd-0	NDS-139(2017)1-76
51	BWR-MOX-Gd-15	1102	n	BWR-MOX-Gd-15	BWR-MOX-Gd-15	NDS-139(2017)1-76
52	BWR-MOX-Gd-40	1102	n	BWR-MOX-Gd-40	BWR-MOX-Gd-40	NDS-139(2017)1-76
53	BWR-UO2-Gd-0	1102	n	BWR-UO2-Gd-0	BWR-UO2-Gd-0	NDS-139(2017)1-76
54	BWR-UO2-Gd-15	1102	n	BWR-UO2-Gd-15	BWR-UO2-Gd-15	NDS-139(2017)1-76
55	BWR-UO2-Gd-40	1102	n	BWR-UO2-Gd-40	BWR-UO2-Gd-40	NDS-139(2017)1-76
56	Phenix	172	n	Phenix	Phenix	CEA ERANOS
57	Superphenix	172	n	Superphenix	Superphenix	CEA ERANOS
58	Yayoi	107	n	Yayoi	Yayoi	EXFOR 23075
59	Frascati-NG	175	n	Frascati-NG	Frascati-NG	ENEA
60	TUD-NG	175	n	TUD-NG	TUD-NG	TUD
61	JAEA-FNS-pos3	175	n	JAEA-FNS-pos3	JAEA-FNS-pos3	JAEA MCNP
62	JAEA-FNS-pos1	175	n	JAEA-FNS-pos1	JAEA-FNS-pos1	JAEA MCNP
63	JAEA-FNS-pos2	175	n	JAEA-FNS-pos2	JAEA-FNS-pos2	JAEA MCNP
64	JAEA-FNS-pos7	175	n	JAEA-FNS-pos7	JAEA-FNS-pos7	JAEA MCNP
65	JET-FW	100	n	JET-FW	JET-FW	UKAEA McBend
66	ITER-DD	175	n	ITER-DD	ITER-DD	UKAEA
67	ITER-DT	175	n	ITER-DT	ITER-DT	UKAEA
68	NIF-ignition	150	n	NIF-ignition	NIF-ignition	MIT
69	LMJ-g	161	γ	LMJ-g	LMJ-g	CEA
70	DEMO-HCPB-FW	616	n	DEMO-HCPB-FW	DEMO-HCPB-FW	UKAEA
71	DEMO-HCPB-VV	616	n	DEMO-HCPB-VV	DEMO-HCPB-VV	UKAEA
72	DEMO-HCPB-BP	616	n	DEMO-HCPB-BP	DEMO-HCPB-BP	UKAEA
73	WCLL-FW	616	n	WCLL-FW	WCLL-FW	UKAEA
74	WCLL-VV	616	n	WCLL-VV	WCLL-VV	UKAEA
75	WCCB-FW	616	n	WCCB-FW	WCCB-FW	UKAEA
76	WCCB-VV	616	n	WCCB-VV	WCCB-VV	UKAEA
77	HCPB-FW	616	n	HCPB-FW	HCPB-FW	UKAEA
78	HCPB-VV	616	n	HCPB-VV	HCPB-VV	UKAEA
79	HCLL-FW	616	n	HCLL-FW	HCLL-FW	UKAEA
80	HCLL-VV	616	n	HCLL-VV	HCLL-VV	UKAEA
81	Maxwellian	709	n	1keV 10keV 30keV 5keV 80keV	Maxwellian	UKAEA
82	Maxwellian-25keV	30	n	Maxwellian-25keV	Maxwellian-25keV	EXFOR O1963
83	Am-Be	46	n	Am-Be	Am-Be	EXFOR 31724
84	ESS-2	117	n	ESS-2	ESS-2	ESS
85	CERN-H4IRRAD	288	n	CERN-H4IRRAD	CERN-H4IRRAD	CERN

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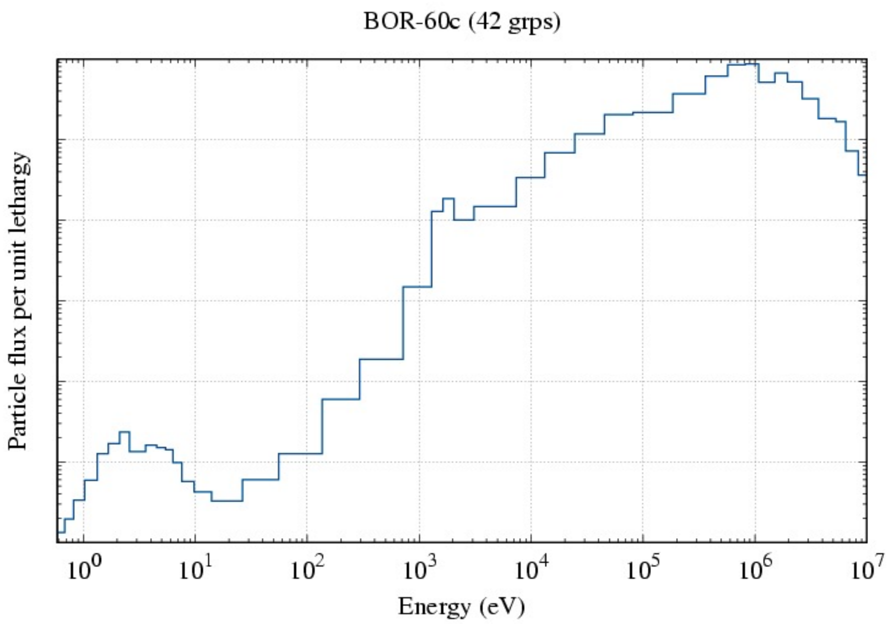
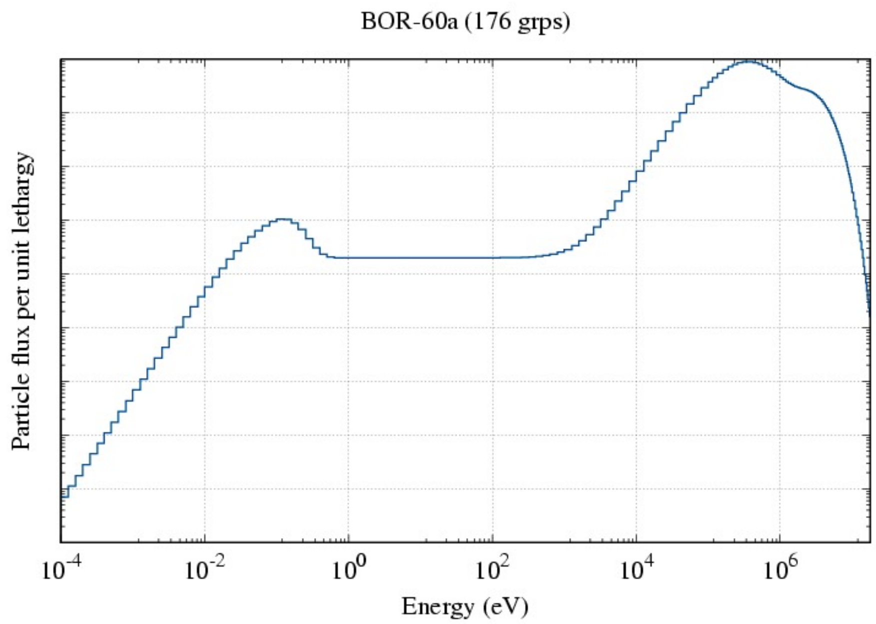
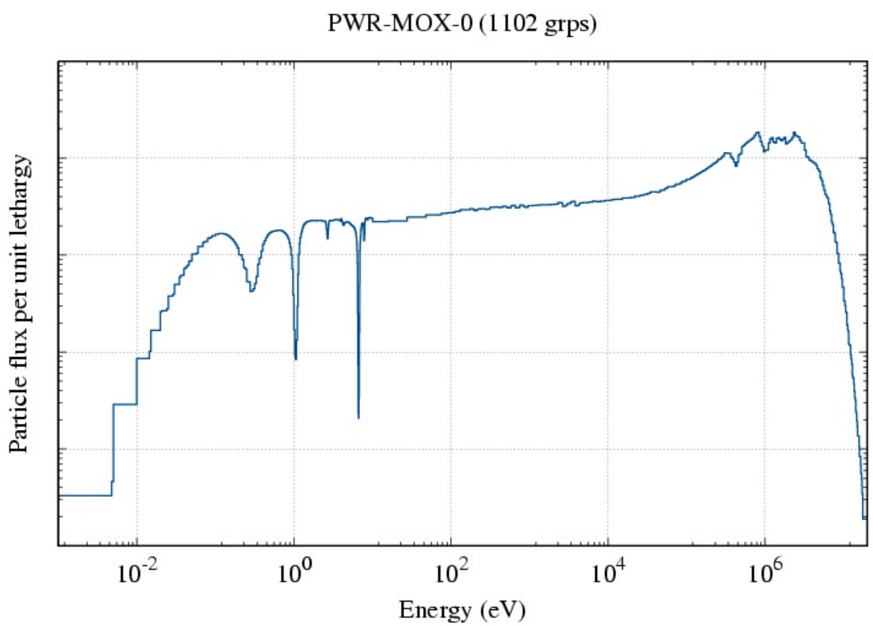
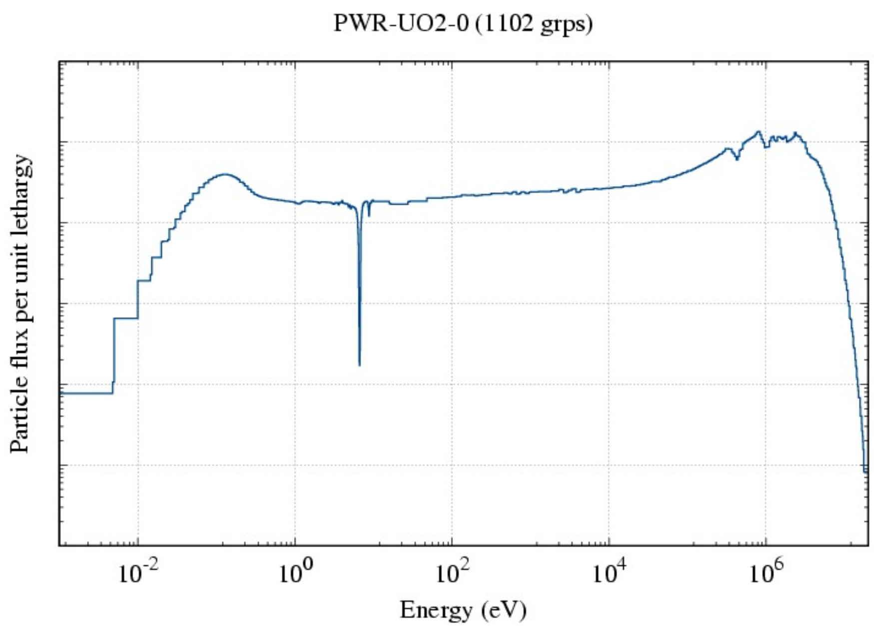
Reference Spectra



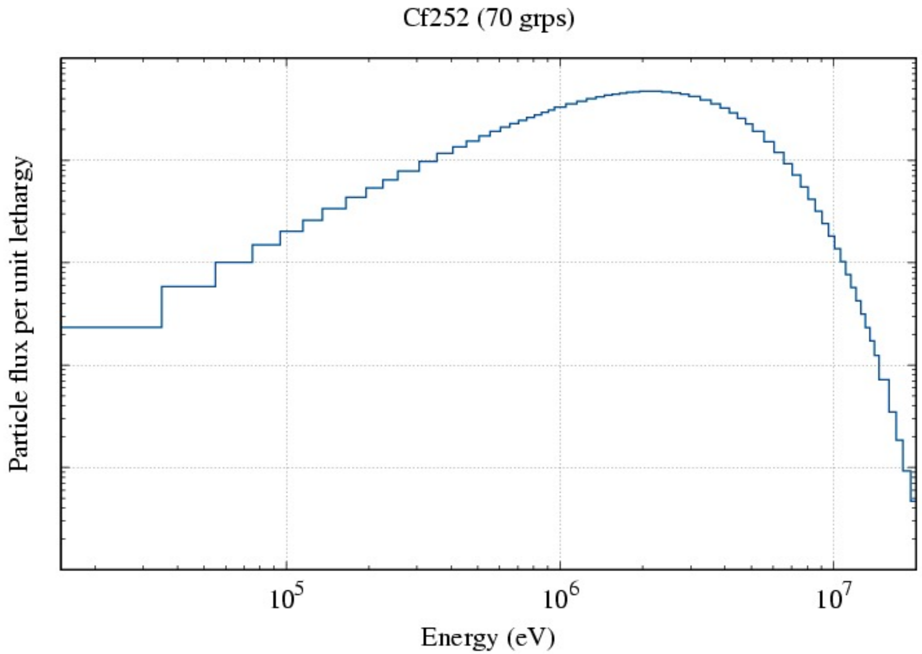




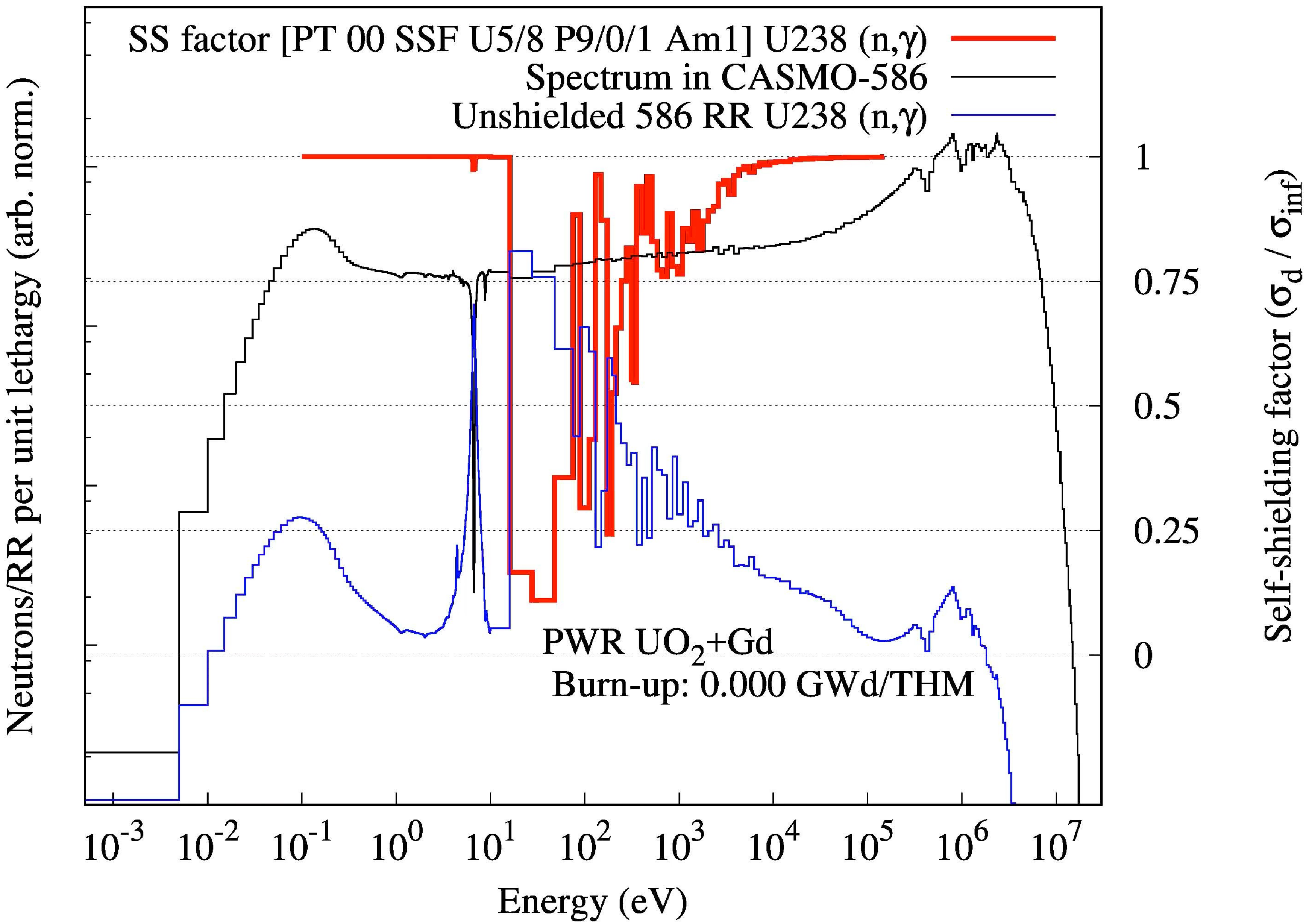


Reference Spectra: numerical data and plots

GROUP	UPPER	LOWER	LETHARGY	DATA	DATA/LETHARGY
1	2.0000E+07	1.9100E+07	4.6044E-02	2.1455E-06	4.6597E-05
2	1.9100E+07	1.7900E+07	6.4888E-02	6.0124E-06	9.2659E-05
3	1.7900E+07	1.6900E+07	5.7487E-02	1.0638E-05	1.8505E-04
4	1.6900E+07	1.5900E+07	6.0995E-02	2.1185E-05	3.4733E-04
5	1.5900E+07	1.4600E+07	8.5298E-02	6.1493E-05	
6	1.4600E+07	1.4050E+07	3.8399E-02	4.7771E-05	
7	1.4050E+07	1.3550E+07	3.6236E-02	6.2139E-05	
8	1.3550E+07	1.3050E+07	3.7598E-02	8.7463E-05	
9	1.3050E+07	1.2550E+07	3.9067E-02	1.2292E-04	
10	1.2550E+07	1.2050E+07	4.0656E-02	1.7245E-04	
********					
60	3.0500E+05	2.5500E+05	1.7905E-01	1.4090E-02	
61	2.5500E+05	2.2500E+05	1.2516E-01	8.0411E-03	
62	2.2500E+05	1.9500E+05	1.4310E-01	7.6730E-03	
63	1.9500E+05	1.6500E+05	1.6705E-01	7.2473E-03	
64	1.6500E+05	1.3500E+05	2.0067E-01	6.7495E-03	
65	1.3500E+05	1.1500E+05	1.6034E-01	4.1777E-03	
66	1.1500E+05	9.5000E+04	1.9106E-01	3.8803E-03	
67	9.5000E+04	7.5000E+04	2.3639E-01	3.5380E-03	1.4967E-02
68	7.5000E+04	5.5000E+04	3.1015E-01	3.1338E-03	1.0104E-02
69	5.5000E+04	3.5000E+04	4.5199E-01	2.6389E-03	5.8385E-03
70	3.5000E+04	1.5000E+04	8.4730E-01	1.9806E-03	2.3375E-03
TOTAL			1.0000E+00		



Time evolution: flux, ssf and rr



2. Resonance integrals and thermal values

- THERMAL - RESONANCE RANGES INFORMATION TABLE – May 2021

  - Recent publications
  - Data table compiled from EXFOR (May 2021)
  - S.F. Mughabghab in Atlas of Resonances (sixth Edition)
  - N.E. Holden in Handbook of Chemistry and Physics 99Th Edition
  - I. Dillmann, R. Plag, F. Kappeler and T. Rauscher in KADoNiS v1.0 +
  - J. Kopecky in UKAEA-R(15)30

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Resonance integrals and thermal values

Headers is 10 lines; 502 entries

Format : ascii columns

- no uncertainty means upper value
- D/D0/D1 level spacing (mean, s-, p-wave)
- I resonance integral, c=capture radiative a=alpha, p=proton, f=fission, abs=absorption
- Macs30 averaged over a Maxwellian spectrum peaking at 30 KeV

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296 columns width – Audi Wapstra mass table style

T H E R M A L - R E S O N A N C E R A N G E S I N F O R M A T I O N T A B L E

D A T E May 2019

Data table compiled from EXFOR (May 2019); S.F. Mughabghab in Atlas of Resonances (sixth Edition); N.E. Holden in Handbook of Chemistry and Physics 99Th Edition; I. Dillmann, R. Plag, F. Kappeler and T. Rauscher in KADoNiS v0.3; J. Kopecky in UKAEA-R(15)30.

Headers is 10 lines; 502 entries

Format : ascii columns

Remarks, no uncertainty means upper value; D/D0/D1 level spacing (mean,s-,p-wave): I resonance integral, c=capture radiative; a=aplha, p=proton; f=fission, abs=absorption; Macs30 averaged over a maxwellian spectrum peaking at 30 KeV

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....+...10....+...20....+...30....+...40....+...50....+...60....+...70....+...80....+...90....+..100....+..110....+..120....+..130....+..140....+..150....+..160....+..170....+..180....+..190....+..200....+..210....+..220....+..230....+..240....+..250....+..260....+..270....+..280....+..290....+
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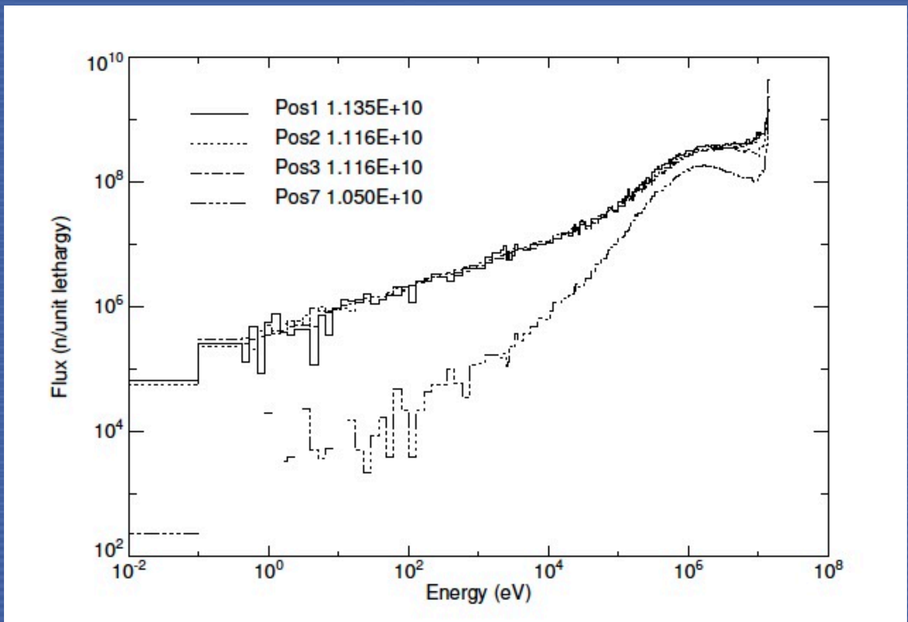
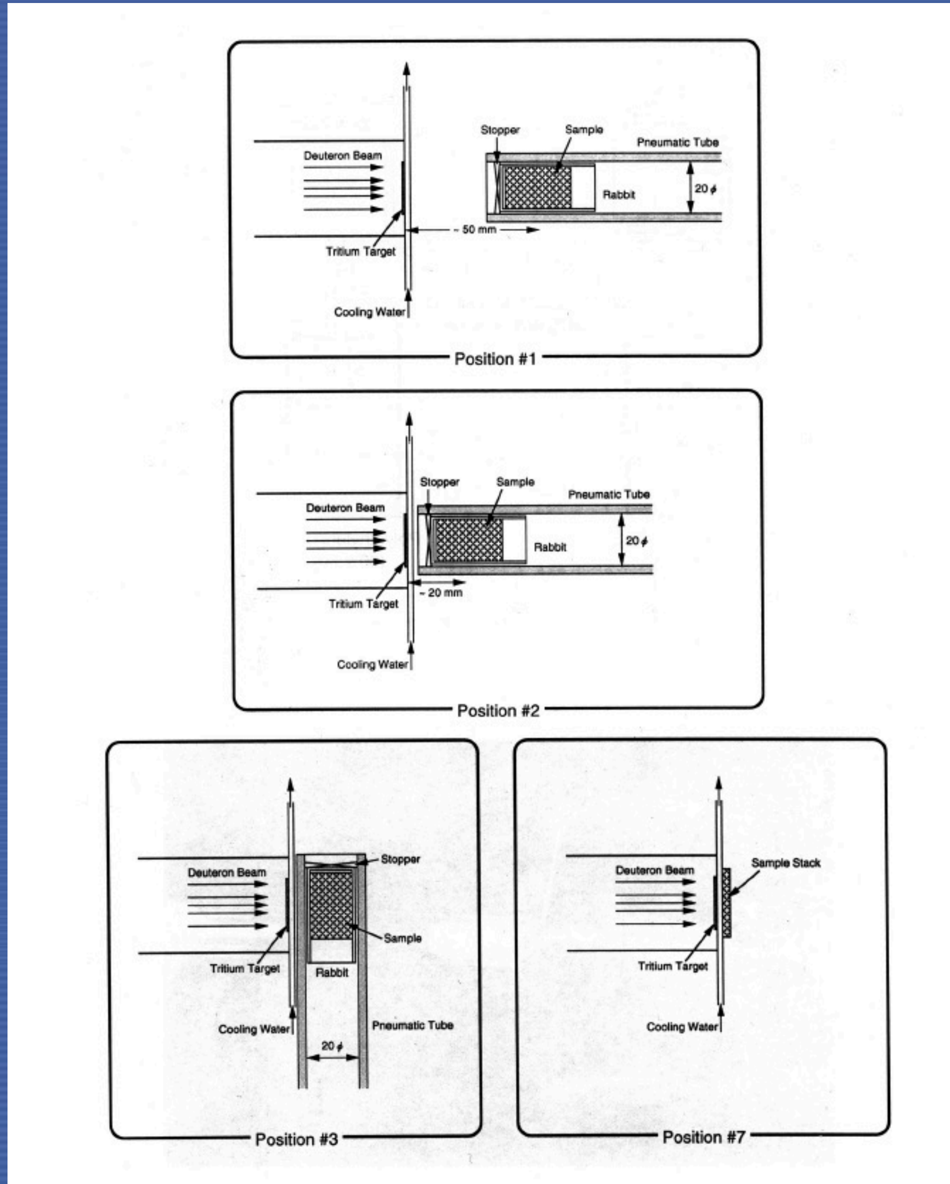
El	A	Z	Iso	Spin	Maxw. (n, g)		(n, g)		(n, el)		(n, a)		(n, p)		(n, f)		Iso	R		D/D0/D1		Ic		Ia		Ip		If		Iabs		Macs30		Sym
Unit:					b		b		b		b		b		b			fm		KeV		b		b		b		b		b		mb		
H	1	1	0				0.3326	0.0007	20.491	0.014							H001	2.0	.006													2.54e-1	2.00e-2	H001
H	2	1	0		5.08e-4	1.5e-5			3.390	0.012							H002															3.00e-3	2.00e-4	H002
H	3	1	0	1/2+	6e-6				1.70	0.03							H003																	H003
He	3	2	0	1/2+	5.5e-5	3e-6			3.10	0.13			5333	8			He003	3.0	0.2							2400	7					7.60e-3	6.00e-4	He003
He	4	2	0	0+					0.79	0.02							He004	3.3	0.1															He004
Li	6	3	0	1+	0.0393	0.0007			0.75	0.02	940	4					Li006	3.8	0.2			1.77e-2	1.4e-3							425	4			Li006
Li	7	3	0	3/2-	0.0442	0.0005			0.97	0.04							Li007	3.49	0.03			2e-2	2e-3									4.20e-2	3.00e-3	Li007
Be	7	4	0	3/2-							0.1		38820	809			Be007									17500	500							Be007
Be	9	4	0	3/2-	8.27e-3	1.3e-4			6.151	0.005							Be009	4.37	0.4			3.7e-3	2e-4									1.02e-2	1.60e-3	Be009
Be	10	4	0		1.0e-3												Be010																	Be010
B	10	5	0		0.394	0.015			2.23	0.06	3837	9					B010	4.33	0.4					1722	5					1722	5			B010
B	11	5	0	3/2-	9.0e-3	0.2e-3			4.83	0.04							B011	4.93	0.2			4.3e-3	2e-4											B011
C	12	6	0	0+			3.87e-3	0.3e-4	4.746	0.002							C012	5.1	0.2			1.83e-3	5e-5			37e-3	3e-3					1.54e-2	1.00e-3	C012
C	13	6	0	1/2-	1.50e-3	2e-5			4.19	0.12							C013	4.69	0.15			1.1e-3	2e-4									2.10e-2	4.00e-3	C013
C	14	6	0	0+	1e-6												C014															8.48e-3	5.70e-4	C014
N	14	7	0	1+	80.1e-3	0.6e-3			10.02	0.12	^		1.86	0.03			N014	5.5	0.3			3.6e-2	1e-3			0.87	3e-2					4.10e-2	6.00e-2	N014
N	15	7	0	1/2-	2.4e-5	8e-6			4.59	0.05							N015	5.58	0.1			1.1e-4										5.80e-3	6.00e-4	N015
O	16	8	0	0+	1.90e-4	1.9e-5			3.761	0.006							O016	4.94	0.1	450	63	2.7e-4	3e-5									3.80e-2	4.00e-3	O016
O	17	8	0	5/2+	5.38e-4	6.5e-5			3.61	0.06	0.235	0.01					O017	4.63	0.2			4.1e-4	6e-5							0.11	0.01			O017
O	18	8	0	0+	1.6e-4	1e-5											O018	4.80	0.11			8.1e-4	4e-5									8.90e-3	8.00e-4	O018
F	19	9	0	1/2+	9.51e-3	9e-5			3.641	0.01							F019	5.47	0.2	60	10	1.8e-2	3e-3									3.20e+0	1.00e-1	F019
Ne	20	10	0	0+	37e-3	4e-3			2.47	0.03							Ne020	5.0	0.2	250	0.04	1.65e-2	3e-3									1.19e-1	1.10e-2	Ne020
Ne	21	10	0	3/2+	0.666	0.11			5.22	0.30	1.8e-4	7e-5					Ne021	5.10	0.3			0.296	0.05									1.50e+0	9.00e-1	Ne021
Ne	22	10	0	0+	5.27e-2	7.0e-3			1.705	0.009							Ne022	5.15	0.1			6e-4										5.80e-2	4.00e-3	Ne022
Na	22	11	0	3+			462				262	50	27840	2400			Na022							2e+5	5e+4	1.37e5	1.2e4							Na022
Na	23	11	0	3/2+	0.501	0.030	0.525	0.005	3.038	0.007							Na023	4.90	0.2	122	30	0.312	0.01									2.10e+0	2.00e-1	Na023
Mg	24	12	0	0+			0.0538	0.0013	3.74	0.04							Mg024	5.4	0.1	158	24	0.030	0.004									3.30e+0	4.00e-1	Mg024
Mg	25	12	0	5/2+	0.199	0.003			1.73	0.13							Mg025	5.07	0.2	24.9	4.4	0.104	0.015									6.40e+0	4.00e-1	Mg025
Mg	26	12	0	0+			0.0374	0.0004	2.83	0.17							Mg026	5.15	0.15			0.020	0.001									1.26e-1	9.00e-3	Mg026
Mg	27	12	0		0.07	0.02											Mg027																	Mg027
Al	26	13	0	5+							0.335	0.014	1.97	0.01			Al026															3.70e+0	0.00e+0	Al026
Al	27	13	0	5/2+			0.231	0.003	1.4134	0.001							Al027	5.09	0.1	53	7	0.136	0.01									3.74e+0	3.00e-1	Al027
Si	28	14	0	0+	0.177	0.004			1.992	0.006							Si028	4.8	0.2	332	35	0.080	0.015									1.42e+0	1.30e-1	Si028
Si	29	14	0	1/2+	0.119	0.003			2.66	0.13							Si029	4.34	0.2	52.4	5.4	0.081	0.015									6.58e+0	6.60e-1	Si029
Si	30	14	0	0+	0.107	0.002			2.49	0.04							Si030	4.21	0.2	70.8	7.9	0.098	0.007									1.82e+0	3.30e-1	Si030
Si	31	14	0	3/2	0.073	0.006											Si031																	Si031
Si	32	14	0		0.50												Si032																	Si032
P	31	15	0	1/2+			0.166	0.003	3.134	0.01							P031	4.4	0.2	54.9	10.4	0.079	0.002									1.74e+0	9.00e-2	P031
S	32	16	0	0+	0.518	0.014			0.9432	0.0021	7e-3	4e-3					S032	3.93	0.2	179	29	246	10									4.10e+0	2.00e-1	S032
S	33	16	0	3/2+	0.454	0.025			2.73	0.25	115	10	2	1			S033	3.85	0.1	9.35	0.89	221	15									7.40e+0	1.50e+0	S033
S	34	16	0	0+	2.56e-1	9e-3			1.46	0.03							S034	3.5	0.1	111	40	105	5									2.26e-1	1.00e-2	S034
S	36	16	0		0.236	0.006											S036					170	4									1.71e-1	1.40e-2	S036
Cl	35	17	0	3/2+	43.6	0.4			20.6	0.3	0.8e-4	0.4e-4	0.489	0.014			Cl035	3.9	0.3	22.3	2.5	17.9	0.3			0.554	0.023					9.70e+0	2.10e-1	Cl035
Cl	36	17	0	2+	10						5.9e-4	7e-5	4.62e-2	4e-4			Cl036					3.8				0.42						1.20e+1	1.00e+0	Cl036
Cl	37	17	0	3/2+	0.433	0.006			1.15	0.05							Cl037	3.48	0.1	6.6	0.7	0.3	0.04									2.12e+0	7.00e-2	Cl037
Ar	36	18	0	0+	5.2	0.5			73.7	0.4	5.5e-3	1e-4					Ar036	2.84	0.1													9.00e+0	1.50e+0	Ar036
Ar	37	18	0	3/2+							1070	80	37	4			Ar037																	Ar037
Ar	38	18	0	0+	0.8	0.2			1.5	1.5							Ar038															3.00e+0	3.00e-1	Ar038
Ar	39	18	0		600	300					0.29						Ar039															8.00e+0	2.00e+0	Ar039
Ar	40	18	0	0+	0.660	0.010			0.413	0.004							Ar040	2.43	0.05	51.9	2.3	0.41	0.03									2.55e+0	1.00e-1	Ar040
Ar	41	18	0		0.5	0.1											Ar041																	Ar041
K	39	19	0	3/2+	2.1	0.2			1.99	0.17	4.3e-3	5e-4					K039	2.65	0.3	8.0	0.8	1.1	0.1									1.18e+1	4.00e-1	K039
K	40	19	0	4-	38	8					0.39	0.03	4.4	0.3			K040			0.84	0.09	13	4			2.0	0.2					3.10e+1	7.00e+0	K040
Cm	243	96	0	5/2+			139	10			794	23			655	20	Cm243			1.11e-3	0.7e-4	184	20					1492	100	2345	470			Cm243
Cm	244	96	0	0+			15.3	1.2	8.39	1.86					1.04	0.2	Cm244			12.1e-3	0.9e-3	655	30					6.2	0.2	605	40			Cm244
Cm	245	96	0	7/2+			369	17			2387	41			2018	37	Cm245	9.7	0.3	0.69e-3	0.5e-4	102	8					772	40	897	180			Cm245
Cm	246	96	0	0+			1.22	0.16	11.1	0.2					0.14	0.05	Cm246	9.3	0.2	27e-3	4e-3	121	7					10.2	0.4	260	75			Cm246
Cm	247	96	0	9/2-			57	10							83.4	4.4	Cm247			1.0e-3	1.5e-4	530	30					760	50					Cm247
Cm	248	96	0	0+			2.63	0.26	7.65	0.40					0.37	0.05	Cm248	9.65	0.3	27.9e-3	2.4e-3	270	15					13.2	0.8					Cm248
Cm	249	96	0		1.6	0.8											Cm249																	Cm249
Bk	249	97	0	7/2+			746	40							2.5		Bk249			1.22e-3	0.9e-4	1114	100					3.9	1.2	1240	75			Bk249
Bk	250	97	0	2	350										960	150	Bk250																	Bk250
Cf	249	98	0	5/2-	497	21									1642	33	Cf249			0.76e-3	0.3e-4	765	35					2380	85					Cf249
Cf	250	98	0	0+	2034	200									112	99	Cf250			12.9e-3	3.9e-3	11900	500					161	39	5300	75			Cf250
Cf	251	98	0	1/2+	2850	150					7745	290			4895	250	Cf251			8.9e-3		1600	30					748	100	900	75			Cf251
Cf	252	98	0	0+	20.3	1.5									32	4	Cf252			24e-3	3e-3	43.5	3					110	30	42	75			Cf252
Cf	253	98	0		17.6	1.8									1300	240	Cf253					13	3					2000	400					Cf253
Cf	254	98	0		4.5	1.5									2		Cf254																	Cf254
Es	253	99	0		184	15											Es253					3864	200							3600	75			Es253
Es	254	99	0	7.0	28.3	2.5					1777	110			1749	110	Es254					18.2	1.5					1010	80	1200				Es254
Es	254	99	1												1826	80	Es254m					1000												Es254m
Es	255	99	0		55	10											Es255																	Es255
Fm	254	100	0		76												Fm254																	Fm254
Fm	255	100	0		26	3					3386	170			3360	170	Fm255																	Fm255
Fm	256	100	0		45												Fm256																	Fm256
Fm	257	100	0												2950	160	Fm257													5000				Fm257

3. FNS decay heat: fusion events

14 MeV neutrons are generated by a 2 mA deuteron beam impinging on a stationary tritium-bearing titanium target.





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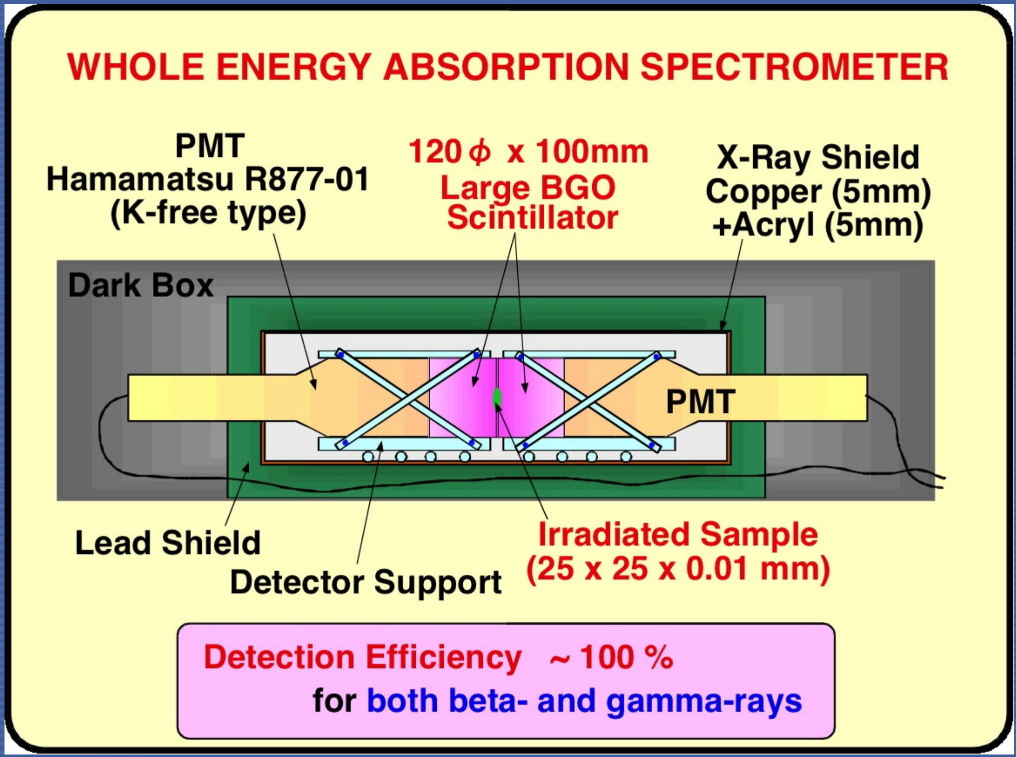
FNS decay heat: fusion events

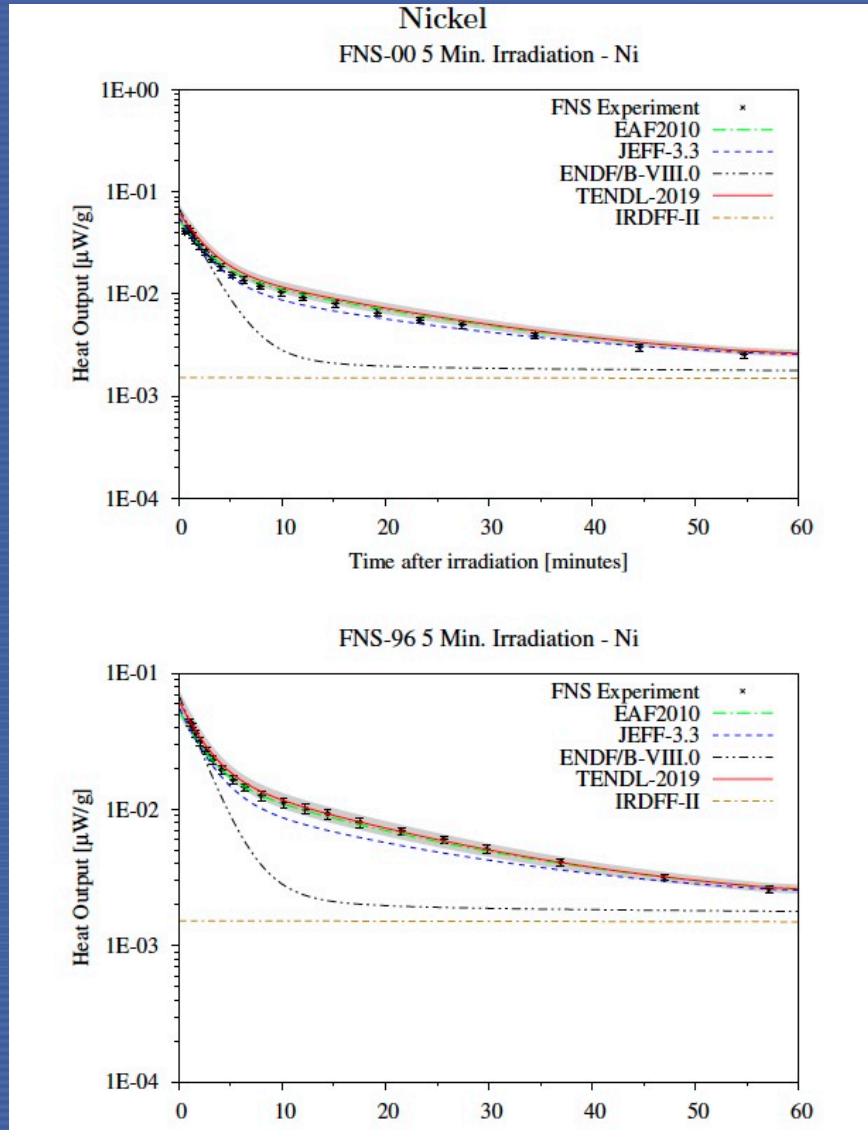
- 83 samples, two campaigns
- 5 min and 7 hrs irradiations
- Seconds to a year coolings measurements

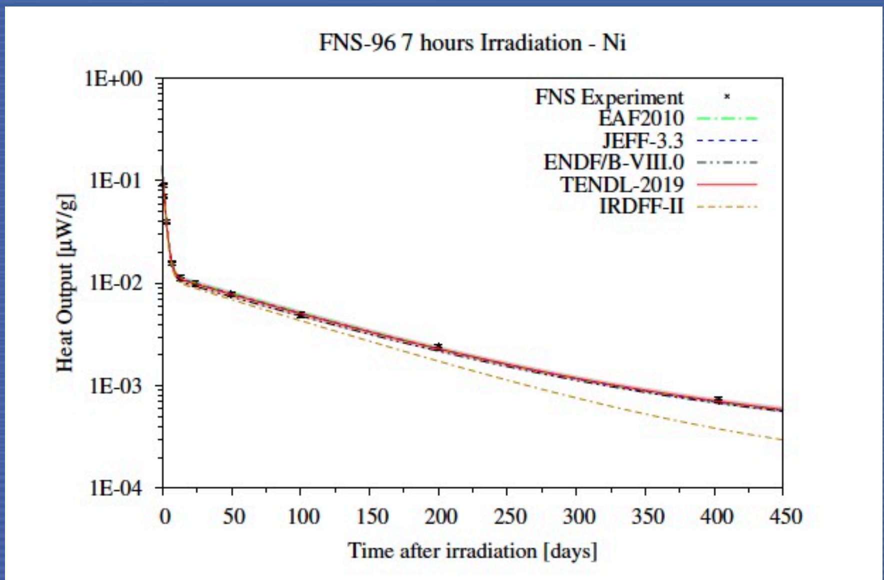


Z	Material	Form	Z	Material	Form
9	Fluorine*§	CF_2	46	Palladium§	Metallic Foil
11	Sodium*§	Na_2CO_3	47	Silver§	Metallic Foil
12	Magnesium*§	MgO	48	Cadmium§	Metallic Foil
13	Aluminium*§	Metallic Foil	49	Indium*§	Metallic Foil
14	Silicon*	Metallic Powder	50	Tin	SnO_2
15	Phosphorus*§	P_3N_5	51	Antimony§	Metallic Powder
16	Sulphur§	Powder	52	Tellurium§	TeO_2
17	Chlorine§	$C_2H_2Cl_2$	53	Iodine*§	IC_6H_4OH
19	Potassium§	K_2CO_3	55	Caesium§	Cs_2O_3
20	Calcium	CaO	56	Barium	$BaCO_3$
21	Scandium§	Sc_2O_3	57	Lanthanum*§	La_2O_3
22	Titanium*§	Metallic Foil	58	Cerium§	CeO_2
23	Vanadium*§	Metallic Foil	59	Praseodymium*§	Pr_6O_{11}
24	Chromium	Metallic Powder	60	Neodymium§	Nd_2O_3
25	Manganese*§	Metallic Powder	62	Samarium§	Sm_2O_3
26	Iron*§	Metallic Foil	63	Europium§	Eu_2O_3
Alloy	SS304*§	Metallic Foil	64	Gadolinium§	Gd_2O_3
Alloy	SS316*§	Metallic Foil	65	Terbium§	Tb_4O_7
27	Cobalt*§	Metallic Foil	66	Dysprosium§	Dy_2O_3
Alloy	Inconel-600*§	Metallic Foil	67	Holmium§	Ho_2O_3
28	Nickel*§	Metallic Foil	68	Erbium§	Er_2O_3
Alloy	Nickel-chrome*§	Metallic Foil	69	Thulium*§	Tm_2O_3
29	Copper*§	Metallic Foil	70	Ytterbium§	Yb_2O_3
30	Zinc§	Metallic Foil	71	Lutetium§	Lu_2O_3
31	Gallium§	Ga_2O_3	72	Hafnium§	Metallic Powder
32	Germanium§	GeO_2	73	Tantalum§	Metallic Foil
33	Arsenic§	As_2O_3	74	Tungsten*	Metallic Foil
34	Selenium§	Metallic Powder	75	Rhenium	Metallic Powder
35	Bromine§	BrC_6H_4COOH	76	Osmium§	Metallic Powder
37	Rubidium§	Rb_2CO_3	77	Iridium§	Metallic Powder
38	Strontium	$SrCO_3$	78	Platinum§	Metallic Foil
39	Yttrium*§	Y_2O_3	79	Gold*§	Metallic Foil
40	Zirconium*	Metallic Foil	80	Mercury*§	HgO
41	Niobium*§	Metallic Foil	81	Thallium§	Tl_2O
42	Molybdenum	Metallic Foil	82	Lead*	Metallic Foil
44	Ruthenium§	Metallic Powder	83	Bismuth	Metallic Powder
45	Rhodium*§	Metallic Powder			

FNS decay heat: fusion events

- Nickel
- Two campaigns
- Irradiations 5 min & 7 Hrs
- 1 hours, 450 days coolings





Decay Heat Validation: timeline

- From 2009 to 2020 in 5 majors steps

CCFE
CULHAM CENTRE FUSION ENERGY

CCFE-R(14)21
February 2014

Jean-Christophe Sublet
Mark R. Gilbert

Decay heat validation, FISPACT-II & TENDL-2013,-2012 and EAF-2010 nuclear data libraries

www.ccfe.ac.uk

CCFE
CULHAM CENTRE FUSION ENERGY

CCFE-R(15)25
January 2015

Jean-Christophe Sublet
Mark R. Gilbert

Decay heat validation, FISPACT-II & TENDL-2014, JEFF-3.2, ENDF/B-VII.1 and JENDL-4.0 nuclear data libraries

www.ccfe.ac.uk

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CCFE-R(18)002
September 2018

Mark R. Gilbert
Jean-Christophe Sublet

Fusion decay heat validation, FISPACT-II & TENDL-2017, EAF2010, ENDF/B-VIII.0, JEFF-3.3, and IRDFF-1.05 nuclear data libraries

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UKAEA-CCFE-RE(20)04
April 2020

Mark R. Gilbert
Olga Vilkhivskaya
Jean-Christophe Sublet

Fusion decay heat validation, FISPACT-II & TENDL-2019, ENDF/B-VIII.0, JEFF-3.3, EAF2010, and IRDFF-II nuclear data libraries

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CEA-R-6213

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ISSN 0429 - 3460

COMMISSARIAT À L'ÉNERGIE ATOMIQUE

DECAY POWER : A COMPREHENSIVE EXPERIMENTAL VALIDATION

par
Jean-Christophe SUBLET, Fujio MAEKAWA

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DIRECTION DE L'ÉNERGIE NUCLÉAIRE
DÉPARTEMENT D'ÉTUDES DES RÉACTEURS
SERVICE DE PHYSIQUE DES RÉACTEURS ET DU CYCLE
LABORATOIRE D'ÉTUDES DE PHYSIQUE

DIRECTION DE L'ÉNERGIE NUCLÉAIRES

DIRECTION DES SYSTÈMES D'INFORMATION

CEA / SACLAY 91191 GIF-SUR-YVETTE CEDEX FRANCE

RAPPORT
CEA-R-6213

2009

At every steps interpretation and validation processesses were improved

FNS decay heat: CoNDERC

Dataset of FNS decay-heat benchmark

The dataset contains all of the necessary input data and information from which to perform a validation of a nuclear data library with an inventory code against the JAEA-generated decay-heat benchmark from the FNS (fusion-neutron-source) facility. As well as the experimental data for each material, the data set also contains example simulation input files for the FISPACT-II inventory code, which includes information about the material specification, irradiation schedule, neutron spectrum and experimental measurement times. These simulation files can be sued directly with FISPACT-II or can be modified for use with a user's own personal choice of simulation tool. More details and understanding of the benchmark can be found in:

- M.R. Gilbert and J.-Ch. Sublet 2019 "Experimental decay-heat simulation-benchmark for 14 MeV neutrons & complex inventory analysis with FISPACT-II" Nuclear Fusion 59 086045 (resource)
- M.R. Gilbert and J.-Ch. Sublet 2018 "Fusion decay heat validation, FISPACT-II & TENDL-2017, EAF2010, ENDF/B-VIII.0, JEFF-3.3, and IRDFF-1.05 nuclear data libraries" CCFE-R(18)002, UKAEA (resource)

Download entire data set (14 MB)

or

Access individual material data sets

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Ds	Rg	Cn	Uut	Fl	Uup	Lv	Uus	Uuo
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

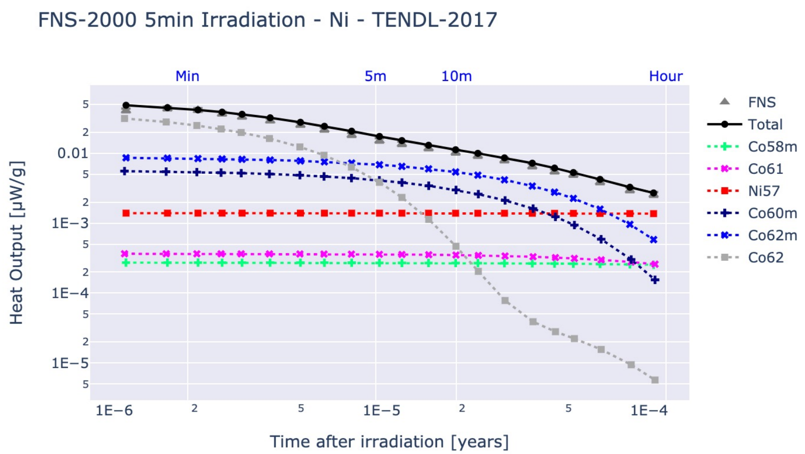
SS304 SS316 Inc600 NiCr

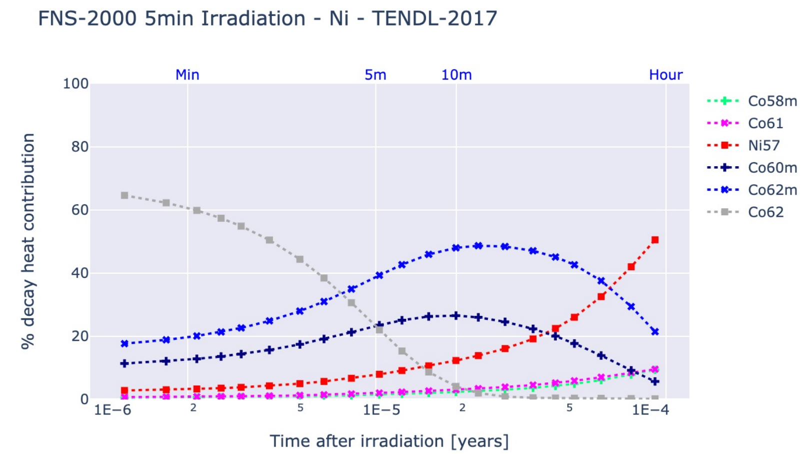
FNS decay heat: CoNDERC

Nickel (Ni)

Z = 28 | Form: Metallic Foil

Year 2000, 5min Irradiation | Year 1996, 7hour Irradiation | Year 1996, 5min Irradiation





Files 28

Experimental data 6

- 1996exp_5min.exp
- 1996exp_5min_fluxes
- 1996exp_7hour.exp
- 1996exp_7hour_fluxes
- 2000exp_5min.exp
- 2000exp_5min_fluxes

FISPACT I/O 15

- TENDL-2017_1996exp_5min.gra
- TENDL-2017_1996exp_5min.i
- TENDL-2017_1996exp_5min.nuclides
- TENDL-2017_1996exp_5min.out
- TENDL-2017_1996exp_5min_files
- TENDL-2017_1996exp_7hour.gra
- TENDL-2017_1996exp_7hour.i
- TENDL-2017_1996exp_7hour.nuclides
- TENDL-2017_1996exp_7hour.out
- TENDL-2017_1996exp_7hour_files
- TENDL-2017_2000exp_5min.gra
- TENDL-2017_2000exp_5min.i
- TENDL-2017_2000exp_5min.nuclides
- TENDL-2017_2000exp_5min.out
- TENDL-2017_2000exp_5min_files

FISPACT Plots 7

- TENDL-2017_1996exp_7hour.pdf
- TENDL-2017_1996exp_7hour_fractions.pdf
- TENDL-2017_2000exp_5min.pdf
- TENDL-2017_2000exp_5min_fractions.pdf
- total_1996exp_5min.pdf
- total_1996exp_7hour.pdf
- total_2000exp_5min.pdf

Last updated: 2020-04-30 15:58:08

*The files highlighted are used to generate the plots on this page.

All data

- experimental
- code input
- code outputs
- plots input

&

live graphs

pdf graphs

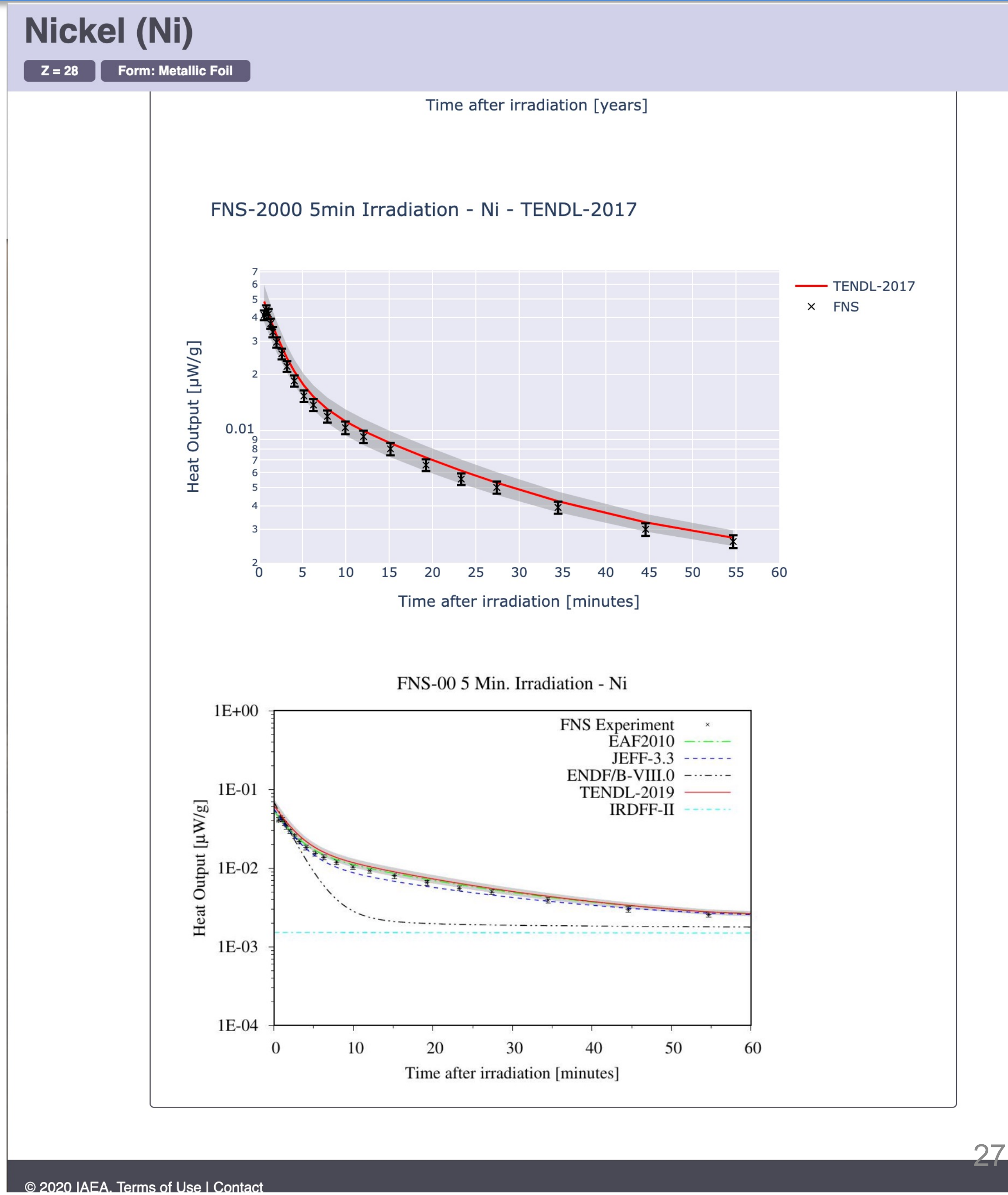
&

All one needs to repeat the V&V protocols

FNS decay heat: CoNDERC

- Experimental uncertainty
- Calculational uncertainty

- Many libraries results and TENDL uncertainty



FNS decay heat: CoNDERC

- One final portal
  - https://www-nds.iaea.org/Conderc/
- 24 hours a day every day of the year
- Live plots, mouse numerics
- Static download, also github
- Open access

IAEA

4. Fission pulse heat: fission events

- The importance, treatment of the fission processes differs depending on the applications, but the physic principles underlying them do not, should not
  - fission cross-sections, energy dependence, fission chances, ternary fission
  - prompt, delayed neutron multiplicities
  - prompt, delayed emitted neutron spectra
  - **fission products yields metrics for typical reactor applications @ thermal @fast**
  - fragment, independent and cumulative fragment yields
  - prompt, delayed gamma radiations
- For reactor physics fission is a must (to bank 200 MeV per event) but it faces stiff competition (fortunately) from another usually open channel in the same energy range: radiative capture
- In the NPP's fuel MOx, UOx, fission is on ^{235}U, while capture is on ^{238}U

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Fission pulse heat: fission events

The importance, treatment of the fission processes differs depending on the applications, what is missing:

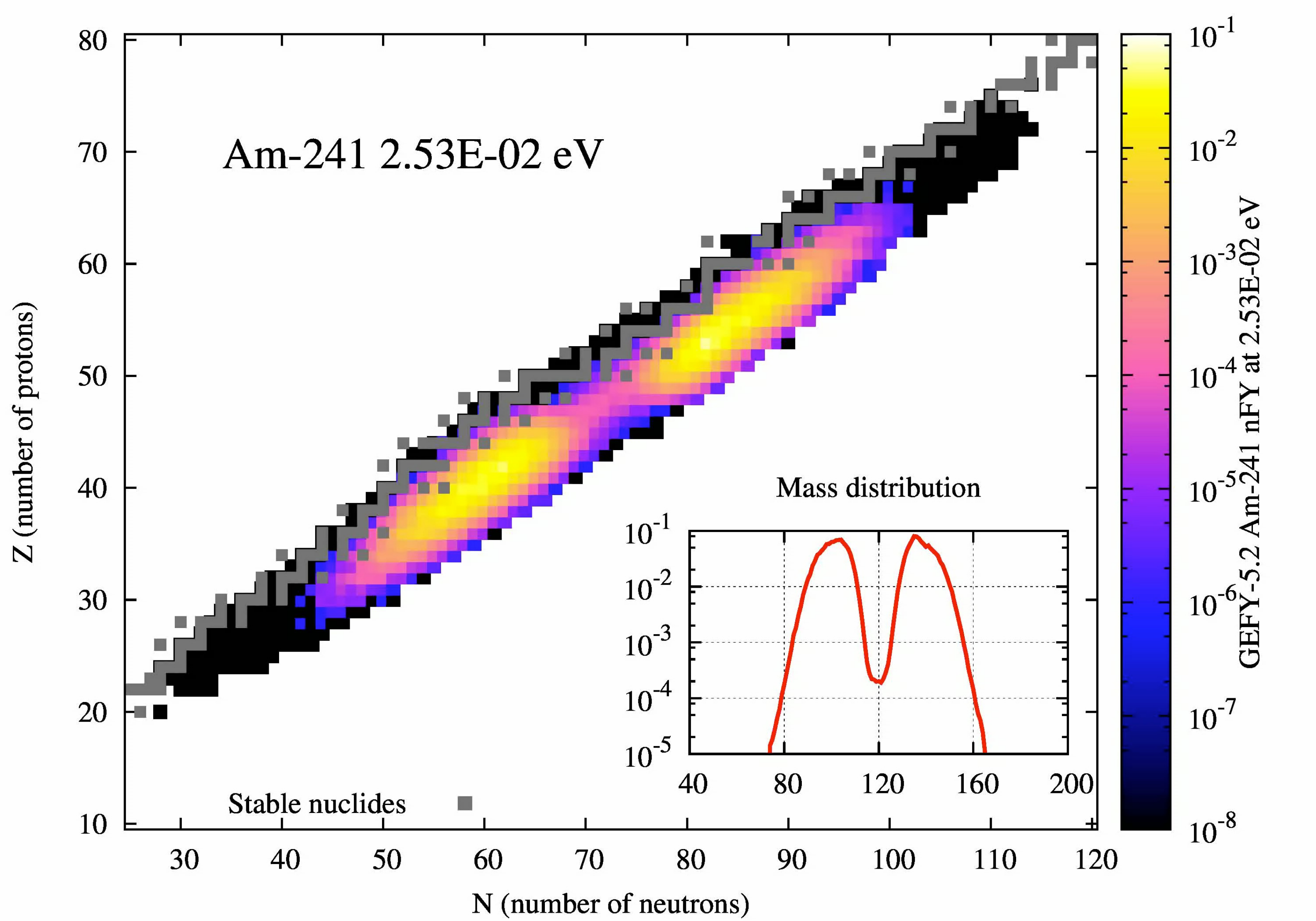
- isotropic, really all events !!
- fission fragments angular/energy distributions
- P(nu) dependence in energy and fragments mass
- time dependent energy release rates
- multi-chance fission (n,n'f), (n,2n'f),….
- fission on non-actinides, the lesser fissile
- correlations

- For reactor physics fission, all the above are of little interest, what is in fact important are
  - the energy release(s) and fission neutron maps during operation and shortly thereafter (accidental scenarios also)
  - the fuel burnup rate, the poisonous fission fragments that capture the neutron that should induce another fission

Fission pulse heat: fission events

- Measurements of fission product energy release rates (decay heat power) following fast and thermal neutron irradiation of ^{233}U, ^{235}U, ^{238}U, ^{239}Pu, ^{241}Pu, ^{237}Np, and ^{232}Th have been reported for decay times up to 48 hours
- Compilation of all the World experiments has been thoroughly scouted, assembled with proper references

Fission yield GEFY Am241



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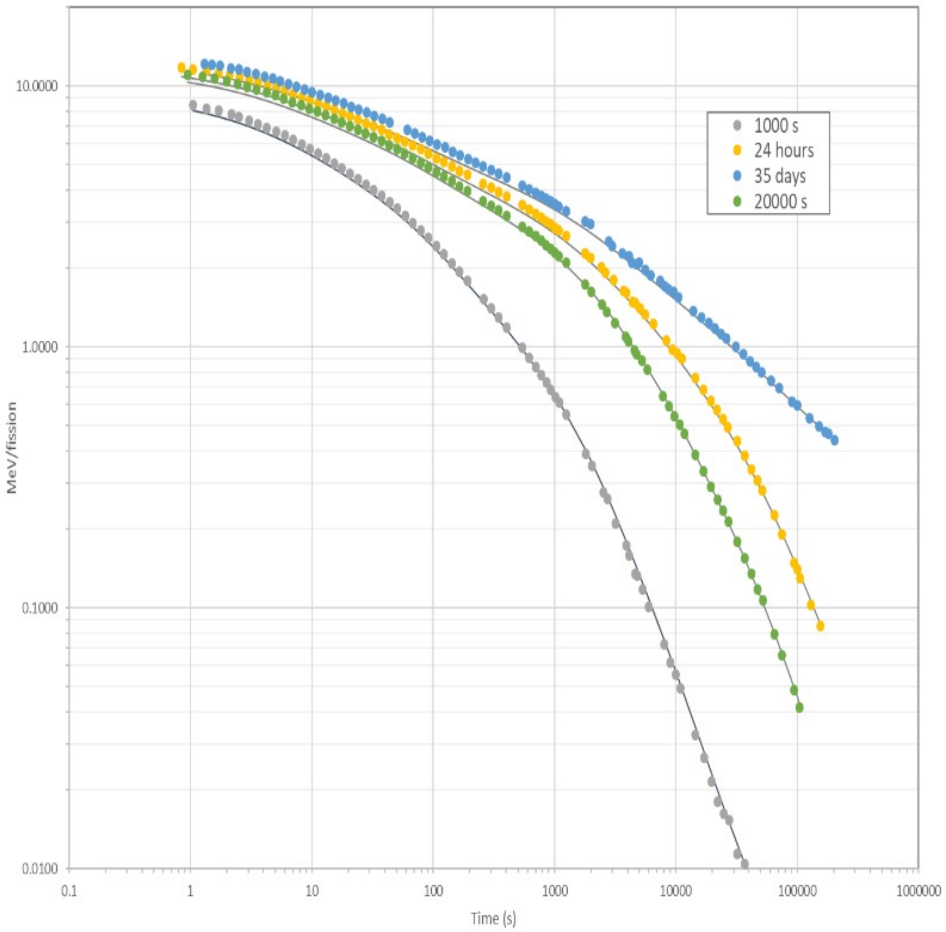
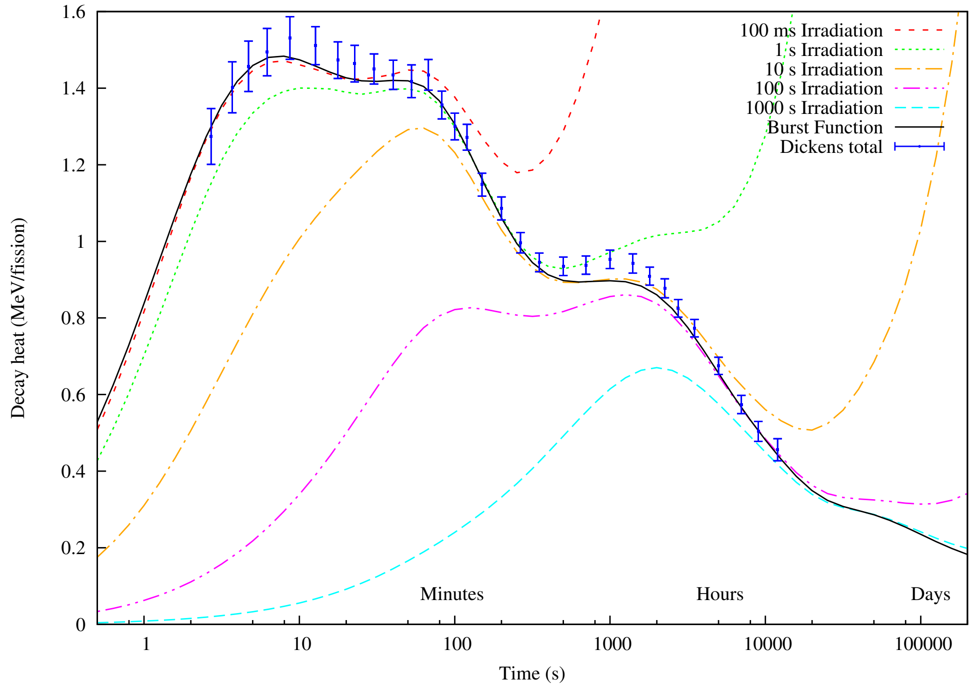
Fission pulse heat: fission events

- Comparison of measurements (points) and calculations (lines) of decay heat power (MeV/fission) for ^{235}U thermal fission for different irradiation times Measurements are those by Friesenhahn et al. in 1979

- Comparison of ^{241}Pu irradiations against the burst function and Dickens experimental results





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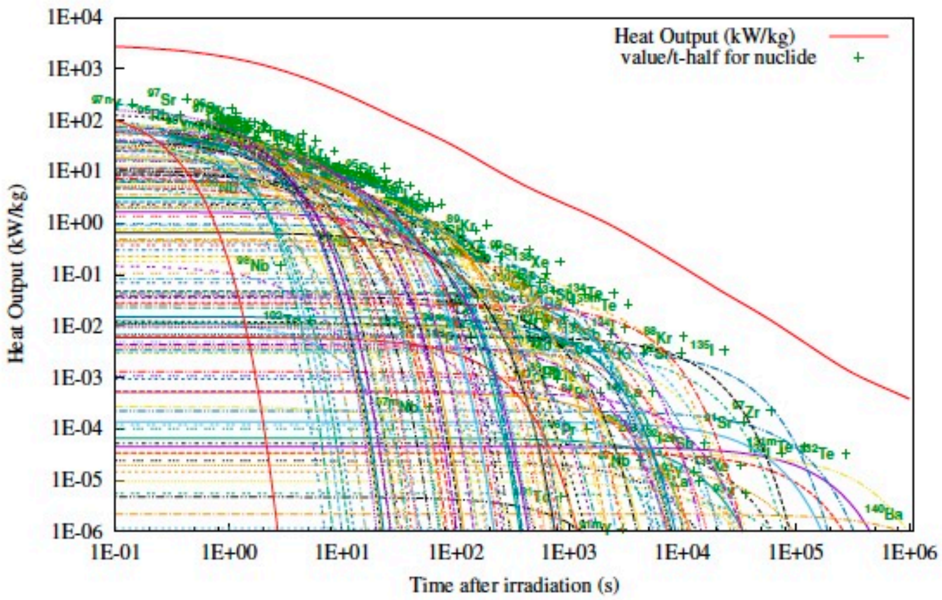
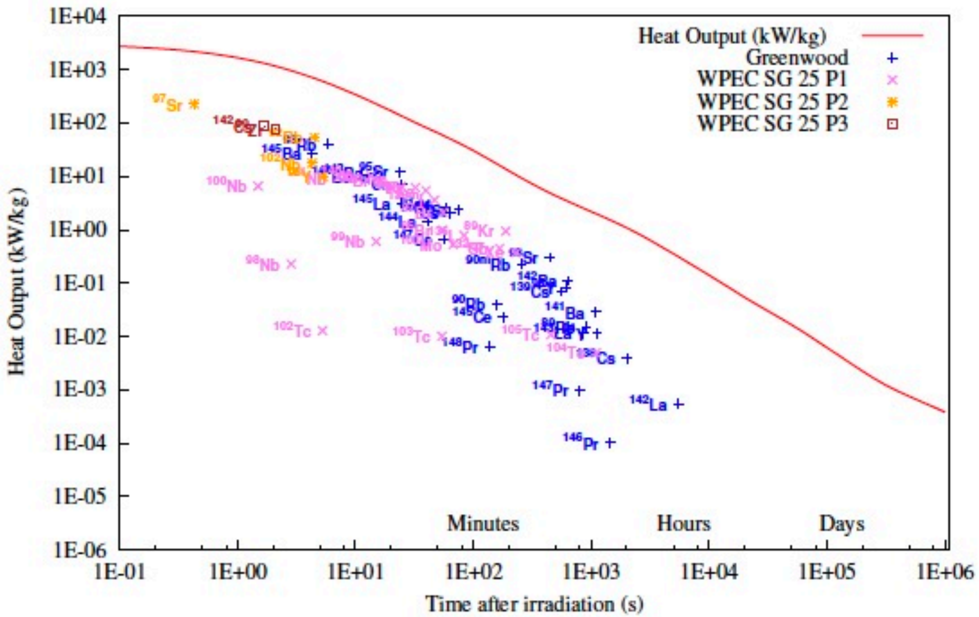
Fission pulse heat: fission events

Total decay heat from $^{235}U_{th}$ pulse with radionuclide labels at = $(t_{1/2}$,heat(EOI))



Total decay heat from $^{235}U_{th}$ pulse with TAGS radionuclide labels at (x,y) = $t_{1/2}$,heat(EOI)

WPEC subgroup 25 nuclides are labelled as PX = priority X.



Fission product energy release experiments evaluated by the CoNDERC project

Author (first)	Institute	Year	Publication	Measured nuclide(s)
Gunst	Bettis Atomic Power Laboratory	1975	NSE 56 241	^{233}U, ^{235}U, ^{239}Pu, ^{232}Th
Shure	Bettis Atomic Power Laboratory	1979	NSE 71 327	^{235}U, ^{239}Pu
Fiche	Atomic Energy Commission CEA	1976	NEACRP-L-212	^{239}Pu, ^{233}U
Lott	Atomic Energy Commission CEN	1973	Nucl. En. 27	^{235}U
Friesenhahn	IRT Corporation (EPRI)	1976	EPRI NP-180	^{235}U
Friesenhahn	IRT Corporation (EPRI)	1979	EPRI NP-998	^{235}U, ^{239}Pu
Schrock	UC Berkeley (EPRI)	1978	EPRI NP-616	^{235}U
Baumung	Karlsruhe	1981	KfK 3262	^{235}U
Yarnell	Los Alamos National Laboratory	1978	LA-7452-MS	^{239}Pu, ^{233}U, ^{235}U
Yarnell	Los Alamos National Laboratory	1977	LA-NUREG-6713	^{235}U
Dickens	Oak Ridge National Laboratory	1978	ORNL/NUREG-39	^{235}U
Dickens	Oak Ridge National Laboratory	1978	ORNL/NUREG-34	^{239}Pu
Dickens	Oak Ridge National Laboratory	1978	ORNL/NUREG-47	^{241}Pu
Johansson	Uppsala University	1987	NEACRP-L-302	^{235}U, ^{239}Pu, ^{238}U
Johnston	UK Atomic Weapons Res. Est.	1965	Nucl. En. 19	^{239}Pu
Schier	University of Massachusetts Lowell	1993	DOE/ER/40723-1	^{235}U, ^{239}Pu, ^{238}U
Schier	University of Massachusetts Lowell	1993	DOE/ER/40723-2	^{235}U, ^{239}Pu, ^{238}U
Schier	University of Massachusetts Lowell	1994	DOE/ER/40723-3	^{235}U, ^{239}Pu, ^{238}U
Schier	University of Massachusetts Lowell	1996	DOE/ER/40723-4	^{235}U, ^{239}Pu, ^{238}U
Akiyama	University of Tokyo	1982	AESJ 24(9) (10)	^{235}U, ^{239}Pu, ^{233}U
Akiyama	University of Tokyo	1988	JAERI-M 88-252	^{232}Th, ^{233}U, ^{235}U, ^{238}U, ^{239}Pu
Ohkawachi	Japan Nuclear Cycle Devel. Inst.	2001	ND 2001	^{235}U, ^{237}Np
Fisher	Los Alamos National Laboratory	1964	Phys Rev B, 1959	^{232}Th, ^{233}U, ^{235}U, ^{238}U, ^{239}Pu
McNair	UK Atomic Weapons Res. Est.	1969	J Nucl En 23	^{235}U, ^{239}Pu
MacMahon	Scottish Research Centre	1970	J Nucl En 24	^{235}U
Jurney	Los Alamos National Laboratory	1979	LA-7620-MS	^{239}Pu, ^{233}U, ^{235}U
Murphy	UK Atomic Weapons Res. Est.	1979	AEEW-R 1212	^{235}U, ^{239}Pu
Scobie	Scottish Research Centre	1971	J Nucl En 25	^{235}U

Fission pulse heat: fission events

- All experimental data gathered, compiled and properly referenced
- FISPACT-II and ORIGEN code systems have been used to Verify the processes and Validate parts of the data
- The web site is still evolving

5. ICSBEP & RR : beyond K_{eff}

- A review of the ICSBEP and IRPhEP handbooks as well as other sources such as IAEA TRS No 480 (Research Reactor Benchmarking Database: Facility Specification and Experimental Data) has allowed to determine a variety of critical experiments with reaction rates, spectral index
- Thirteen identified so far, more to come, now available as MCNP6, TRIPOLI-4 input decks, outputs results simulated with ENDF-VIII.0 and TENDL-2019

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On-going activity

Progress: spectral indices, reaction rates

- A partial list of ICSBEP and IRPhEP Benchmarks with Reaction Rate Data

More to come !

ICSBEP or IRPhEP Identifier	Comment
HEU-MET-FAST-001	Godiva. CAUTION: The ICSBEP Handbook description is for the original (spherical, or Godiva-I) assembly which ceased operation in 1954, but the experimental data are said to come from a 1959 measurement. The 1959 "Godiva" assembly, Godiva-II, was a cylindrical assembly with a dome top. Further research is needed to determine the applicable model for these data.
HEU-MET-FAST-028	Flattop-25. A spherical HEU core surrounded by a spherical ^{nat}U reflector. Most of the experimental reaction rate data come from measurements near the core center.
IEU-MET-FAST-007	Big-10. A large cylindrical assembly consisting of uranium metal plates of various enrichments. Measurements were made in the center of a large 10% enriched region.
Pu-MET-FAST-001	Jezebel. A bare spherical mostly ^{239}Pu (~5 atom % ^{240}Pu) core. Reaction rate measurements were made near the core center.
Pu-MET-FAST-002	"dirty" Jezebel. A bare spherical, mostly ^{239}Pu core (^{240}Pu content is ~ 20 atom %). Reaction rate measurements were made near the core center.
Pu-MET-FAST-006	Flattop-Pu. A spherical ^{239}Pu core surrounded by a spherical ^{nat}U reflector. Most of the experimental reaction rate data come from measurements near the core center.
Pu-MET-FAST-008	THOR. A spherical mostly ^{239}Pu core (~5 atom % ^{240}Pu) surrounded by a cylindrical thorium reflector.

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Progress: spectral indices, reaction rates

- MCNP6® & TRIPOLI4® input decks have been developed using the recommended information provided by the respective evaluators in Section 3 of the various ICSBEP and IRPhEP reports

ICSBEP or IRPhEP Identifier	Comment
LEU-COMP-THERM-008	Mid-plane pin power distribution measurements were made in the central 15x15 region of a large (~4400 rods) Babcock & Wilcox reactor lattice. This evaluation includes 17 critical configurations with varying water hole and poison rod alignments. Twelve configurations included pin power measurements. These data are provided in Appendix B to the evaluation.
DIMPLE-LWR-EXP-002 (LEU-COMP-THERM-055)	Mid-plane pin power distributions. Data are provided for two configurations, designated as S06A and S06B. Although a full 3D description of these configurations is provided in the ICSBEP Handbook, when analyzing pin power data the IRPhEP evaluator recommends using a 2D model employing octant symmetry.
U233-MET-FAST-001	Jezebel-23. A spherical, bare, ^{233}U critical assembly. Reaction rate measurements were made near the core center.
U233-MET-FAST-006	Flattop-23. A spherical ^{233}U core surrounded by a spherical ^{nat}U reflector. Reaction rate measurements were made near the core center.
FUND-IPPE-FR-MULT-RRR-001	Cross section ratio data for a variety of foils irradiated near the center mid-plane of IPPE's Pu metal BR-1 core.

Progress: spectral indices, reaction rates

- Converging reaction rates is much more demanding than traditional Keff's simulation:
  - 50M, 250M, histories for Keff @ 10 pcm
  - 1B and 5B histories needed for RR @ 2%
- Deeper review, scouting for gems is continuing
- OpenMC & SERPENT inputs in the pipeline

ICSBEP & RR : beyond K_{eff}

- Many experimental data gathered, compiled and properly referenced
- MCNP6® and TRIPOLI4® code systems have been used to Verify the processes and Validate ENDF/B-VIII.0 and TENDL-2019 application data forms
- The web site is still evolving

6. Gamma transport: Verification

- Photonuclear (# photoatomic) evaluation are more commonly available
- Pure gamma transport (# coupled neutron-gamma) are more in demand
- Prior to its release near the end of 2019, a testing effort was undertaken for the next generation suite of Talys Evaluated Nuclear Data Library photonuclear files g-TENDL-2019 s0 form (#s30 explicit)

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Gamma transport: Verification

- This was not an effort to validate the physics accuracy of these files, rather to simply verify that the ACE files produced by NJOY from the underlying TENDL-2019 evaluations were structurally correct and that physically sounds MCNP6® jobs utilizing these files would run to completion
- A “mode e p n” MCNP6® input deck and ACE files generated at the Agency

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Gamma transport: Verification

- “Création d'une bibliothèque d'activation photonucléaire et mesures de spectres d'émission de neutrons retardés”

  2005 - M.L. Giacri-Mauborgne
- “Development and Implementation of Photonuclear Cross-Section Data for Mutually Coupled Neutron-Photon Transport Calculations in the Monte Carlo N-Particle (MCNP) Radiation Transport Code”

  2000 - Morgan C. White

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Gamma transport: Verification

- Input files were suitably modified to test the ACE photonuclear nuclear data files for all stable elements/isotopes from Z=3 through Z=83 as well as ^{232}Th and ^{234,235,238}U
- Values on the "cut:p" and "cut:e" were varied by element as appropriate, or set to minimum of 100 keV.
- The "nps" card value was set to 250 million or 50 million histories.

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Gamma transport: Verification

- Inputs for 82 elements, # cut values and nps

```
Example photonuclear simulation: find the n spectrum from a disc
c
c Zr
    1   11   -6.49    -11 21 -22
    2    0           ( 11 :-21: 22 ) -91
    9    0                             91

   11    cz      5.0
   21    pz      0.0
   22    pz      2.5
   91    so    150.0

 mode e p n
 sdef pos=0 0 0 sur=21 vec=0 0 1 dir=1 par=3 erg=20
c
c
   m11 plib=14p elib=01e nlib=00c pnlib=19u
       40090 0.5145
       40091 0.1122
       40092 0.1715
       40094 0.1738
       40096 0.0280
 mpn11
       40090
       40091
       40092
       40094
       40096
c
 fcl:p  1 0 0
 phys:p 3j 1
 cut:p j    2.957
 cut:e j    2.957
c
 wwp:e,p,n 5 3 5 0 0
 wwe:e,p,n 20
 wwn1:e,p  0.2    0.2     -1
 wwn1:n    0.0001 0.0001  -1
c
  e15      0.01 0.05 0.1 0.4 0.6 0.8 1
           1.25 1.5 1.75 2 2.5 3 3.5 4 5 6 7 8 9 10 12.3858
  f15:n    0.0 100.0 1.25 0.0
c
  e22      0.01 0.05 0.1 0.4 0.6 0.8 1
           1.25 1.5 1.75 2 2.5 3 3.5 4 5 6 7 8 9 10 12.3858
  f22:n    11 21 22 (11 21 22)
c
  nps 250000000
c nps 2500000
c
  print
```

```
Example photonuclear simulation: find the n spectrum from a disc
c
c U
    1   11   -18.95    -11 21 -22
    2    0            ( 11 :-21: 22 ) -91
    9    0                              91

   11    cz      5.0
   21    pz      0.0
   22    pz      2.5
   91    so    150.0

 mode e p n
 sdef pos=0 0 0 sur=21 vec=0 0 1 dir=1 par=3 erg=20
c
c
   m11 plib=14p elib=01e nlib=00c pnlib=19u
       92234 0.000055
       92235 0.007200
       92238 0.992745
 mpn11
       92234
       92235
       92238
c
 fcl:p  1 0 0
 phys:p 3j 1
 cut:p j    0.1   $replace zero threshold with 100 keV
 cut:e j    0.5   $replace zero threshold with 500 keV
c
 wwp:e,p,n 5 3 5 0 0
 wwe:e,p,n 20
 wwn1:e,p  0.2    0.2     -1
 wwn1:n    0.0001 0.0001  -1
c
  e15      0.01 0.05 0.1 0.4 0.6 0.8 1
           1.25 1.5 1.75 2 2.5 3 3.5 4 5 6 7 8 9 10 12.3858
  f15:n    0.0 100.0 1.25 0.0
c
  e22      0.01 0.05 0.1 0.4 0.6 0.8 1
           1.25 1.5 1.75 2 2.5 3 3.5 4 5 6 7 8 9 10 12.3858
  f22:n    11 21 22 (11 21 22)
c
  nps 50000000
c nps 2500000
c
  print
```

7. Transport – shielding

- Upon specific request of members state, radiation shielding benchmark are now also considered in CoNDERC
- Building from the existant: IAEA consultancy achievements, generous contributors and moving forward
- MCNP6® and TRIPOLI-4® input decks have been developed for:

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Shielding; e.g. Oktavian

Download all data
[2.0 MB, 161 files]

or

Access individual data sets

- oktavian_exp
  - oktavian_Co_tal21.exp
  - oktavian_Cr_tal41.exp
  - oktavian_W_tal41.exp
  - oktavian_Pb_tal41.exp
  - oktavian_LiF_tal21.exp
  - oktavian_Mn_tal21.exp
  - oktavian_LiF_tal41.exp
  - oktavian_Si_tal21.exp
  - oktavian_Si_tal41.exp
  - oktavian_Co_tal41.exp
  - oktavian_Cu_tal41.exp
  - oktavian_Mn_tal41.exp
  - oktavian_Al_tal41.exp
  - oktavian_Mo_tal21.exp
  - oktavian_Ti_tal21.exp
  - oktavian_Cr_tal21.exp
  - oktavian_Zr_tal21.exp
  - oktavian_Cu_tal21.exp
  - oktavian_Mo_tal41.exp
  - oktavian_Al_tal21.exp
  - oktavian_W_tal21.exp
  - oktavian_Ti_tal41.exp
- MCNP

Shielding

Aspis	FNS	NIST
Oktavian	Pulsed	Replica
Tiara		

Transport – shielding – SINBAD

- Expert crafted, verified input decks are openly available, retriveable
- Validation outputs results available for
  - JEFF-3.3
  - ENDF/B-VIII.0
  - JENDL-4.0
  - TENDL-2019
- Relevant documentations

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Conclusions: a way forward

- Live web portal, explicit with graphics, tables
- Deployable data streams, full download
- V&V codes inputs & outputs
- Experimental information in computer forms
- Computer accessible through github

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