

Nuclear data for β_{eff} sensitivity- uncertainty analysis

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Ivo Kodeli

Jožef Stefan Institute, Slovenia

ivan.kodeli@ijs.si

Benchmark	Isotope	k_{eff} uncertainty (pcm)			β_{eff} uncertainty (pcm)		
		Two-block	JENDL-4.0	SCALE-6.0	Two-block	JENDL-4.0	SCALE-6.0
SNEAK 7A	²³⁵ U	22	27	20	53	50	36
	²³⁸ U	71	99	78	49	25	17
	²³⁹ Pu	261	288	264	572	523	414
	Total	271	305	276	577	526	416
SNEAK 7B	²³⁵ U	41	49	37	78	71	51
	²³⁸ U	109	150	119	36	46	18
	²³⁹ Pu	335	377	343	551	489	377
	Total	354	409	364	557	496	381
Jezebel	²³⁹ Pu	292	367	343	637	820	774
Skidoo Jez-23	²³³ U	106	121	97	212	106	91
Popsy Flat-Pu	²³⁵ U	6	8	6	28	30	22
	²³⁸ U	47	68	54	105	94	79
	²³⁹ Pu	302	371	348	100	172	45
	Total	306	377	352	147	199	93
Topsy Flat-25	²³⁵ U	220	290	229	195	374	289
	²³⁸ U	44	64	50	47	92	70
	Total	224	279	234	201	385	297
Flattop 23	²³³ U	167	180	156	218	304	227
	²³⁵ U	5	7	5	16	17	13
	²³⁸ U	41	58	46	53	45	36
	Total	171	189	163	225	308	231
Big-ten	²³⁵ U	456	575	441	43	200	132
	²³⁸ U	189	273	217	218	400	307
	Total	493	637	491	218	448	334
ZPPR-9	²³⁵ U	6	7	5	14	13	9
	²³⁸ U	76	103	81	45	16	11
	²³⁹ Pu	331	371	332	706	639	520
	Total	340	385	342	708	639	521

Delayed fission spectra uncertainty

I. Kodeli, Nucl. Instr. & Meth. A **715** (2013) 70-78

SNEAK-7A: Uncertainty in β_{eff} (TOTAL~3 %)

SNEAK-7A			Uncertainty (%)						
MAT.	elastic	inelast.	(n,f)	(n, γ)	v_{del}	v_{pmt}	χ_{p}	χ_{d}	TOTAL
JENDL 4.0m									
U-235	~0	0.017	0.074	0.004	0.218	0.006	0.050	0.044	0.23
U-238	0.051	1.425	0.101	0.066	1.610	0.138	0.025	0.279	2.18
Pu-239	0.008	0.120	0.074	0.018	1.528	0.122	0.523	0.091	1.63
SUM	0.13	1.44	0.19	0.07	2.23	0.18	0.53	0.30	2.7
COMMARA-2									
U-235	0.008	0.008	0.025	0.017	N/A	0.002	0.036	/	0.05
U-238	2.515	2.595	0.144	0.045	N/A	0.270	0.017	/	2.62
Pu-239	0.169	0.216	0.126	0.055	N/A	0.051	0.341	/	0.43
SUM	2.52	2.60	0.19	0.07	N/A	0.28	0.35	/	2.6

SNEAK-7B: Uncertainty in β_{eff} (TOTAL~3 %)

SNEAK-7B		Sensitivity (%/%)					
MAT	elastic	inelastic	(n,f)	(n, γ)	v _{del}	v _{pmt}	v
U-235	-2·10 ⁻⁴	-0.002	0.060	-0.001	0.111	-0.052	0.059
U-238	-0.018	-0.160	0.261	0.011	0.550	-0.326	0.224
Pu-239	-0.001	-0.008	-0.228	-0.001	0.292	-0.565	-0.273

SNEAK-7B		Uncertainty (%)							
MAT.	elastic	inelast.	(n,f)	(n, γ)	v _{del}	v _{pmt}	χ_p	χ_d	TOTAL
JENDL 4.0m									
U-235	~0	0.023	0.079	0.005	0.329	0.011	0.071	0.086	0.35
U-238	0.051	1.701	0.112	0.067	1.848	0.196	0.046	0.469	2.57
Pu-239	0.003	0.086	0.055	0.012	1.162	0.099	0.489	0.195	1.29
SUM	0.17	1.72	0.18	0.07	2.21	0.22	0.50	0.52	2.9
COMMARA-2									
U-235	0.009	0.010	0.028	0.011	N/A	0.005	0.051	/	0.06
U-238	2.863	2.991	0.139	0.046	N/A	0.385	0.018	/	3.01
Pu-239	0.105	0.148	0.108	0.070	N/A	0.044	0.323	/	0.38
SUM	2.87	2.99	0.18	0.06	N/A	0.39	0.33	/	3.0

FLATTOP-23: Total uncertainty in β -eff: **5.5/6.9 %**

($\beta_{\text{exp}} = 395 \text{ pcm}$)

β (pcm):

^{233}U : **260**

^{235}U : **650**

$^{238}\text{U}_f$: **1480**

MAT	Sensitivity (%/%)						
	elastic	inelastic	(n, f)	(n, γ)	$\bar{\nu}_d$	$\bar{\nu}_p$	$\bar{\nu}_t$
^{233}U	-0.005	-0.034	-0.230	-0.016	0.697	-0.882	-0.184
^{234}U	$2 \cdot 10^{-5}$	-0.001	-0.001	$-2 \cdot 10^{-4}$	0.007	-0.009	-0.002
^{235}U	0.001	-0.001	0.015	-0.001	0.015	0.002	0.017
^{238}U	0.074	-0.129	0.166	-0.033	0.273	-0.104	0.170

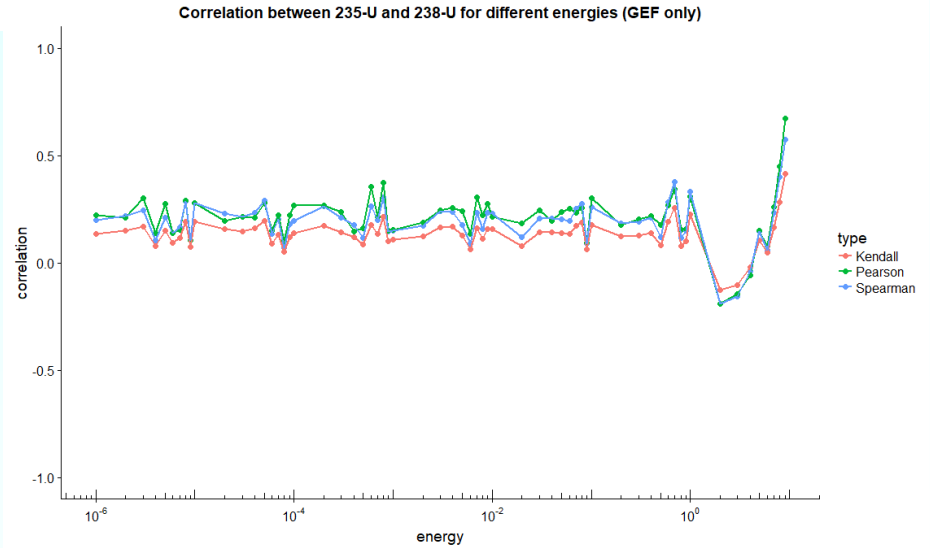
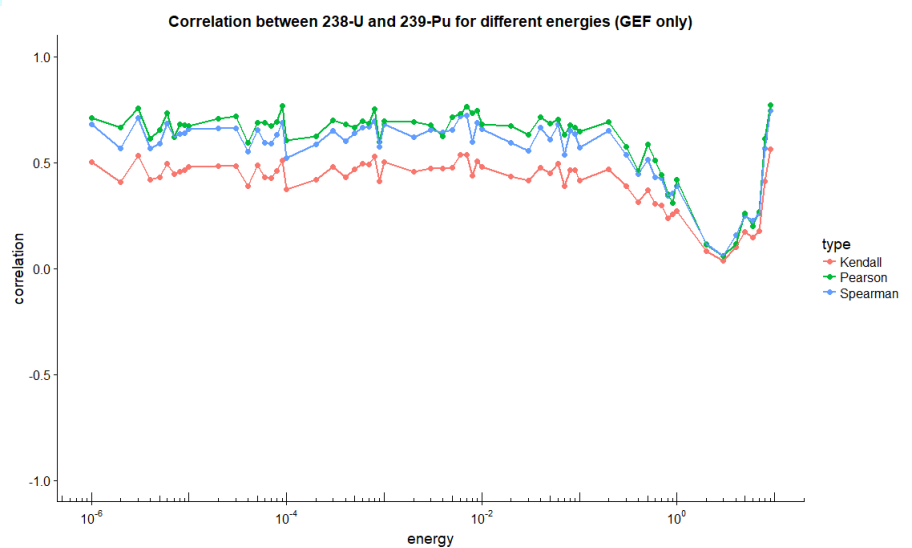
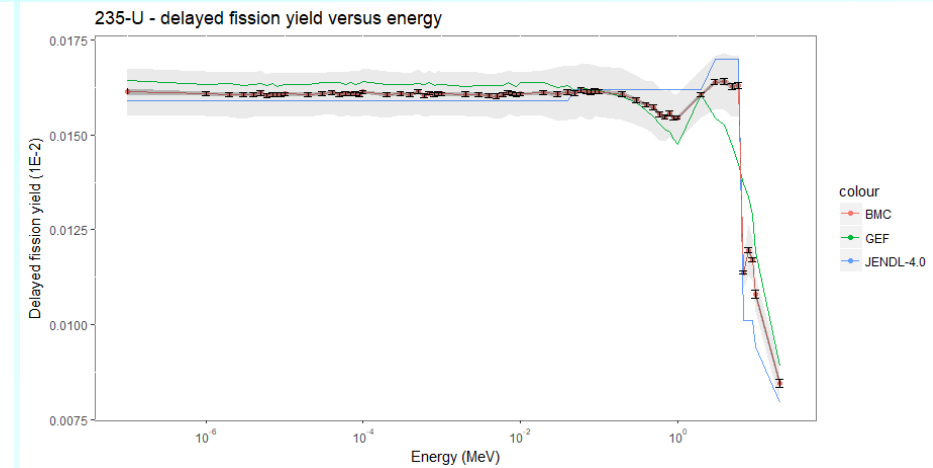
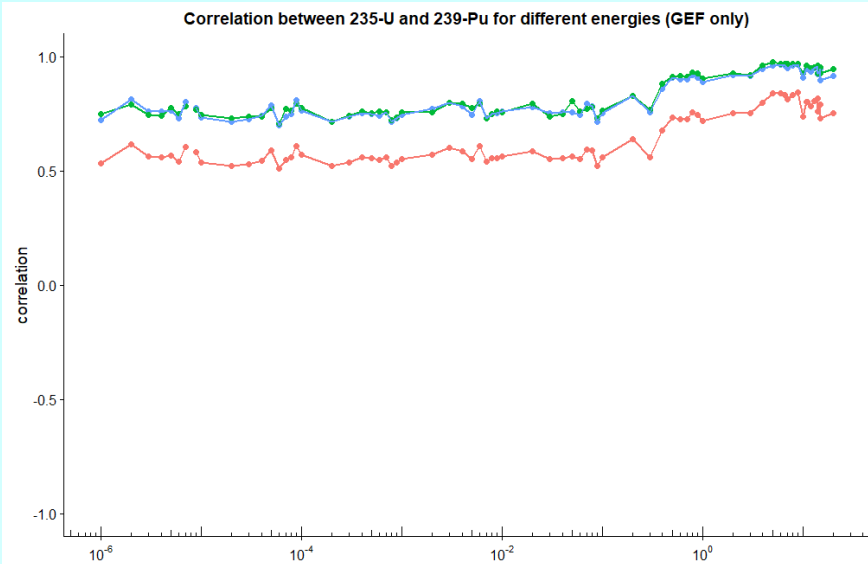
MAT	Uncertainty (%)								
	elastic	inelastic	(n, f)	(n, γ)	$\bar{\nu}_d$	$\bar{\nu}_p$	χ_p	χ_d	Total
JENDL-4.0m									
^{233}U	0.089	0.584	0.209	0.217	5.097	0.657	0.304	0.762	5.27
^{235}U	0.004	0.009	0.063	0.001	0.048	0.002	0.017	0.001	0.06
^{238}U	0.318	1.293	0.103	0.073	0.916	0.061	0.045	0.110	1.63
Sum	0.33	1.42	0.24	0.23	5.18	0.81	0.31	0.77	5.5
COMMARA-2									
^{233}U	0.298	0.432	0.195	0.227	6.444	0.197	0.227	N/A	6.47
^{235}U	0.003	0.004	0.006	0.010	N/A	0.001	0.013	N/A	0.01
^{238}U	1.770	2.430	0.088	0.046	N/A	0.122	0.036	N/A	2.44
Sum	1.77	2.47	0.21	0.23	6.44	0.23	0.23	N/A	6.9

Variance penalty:

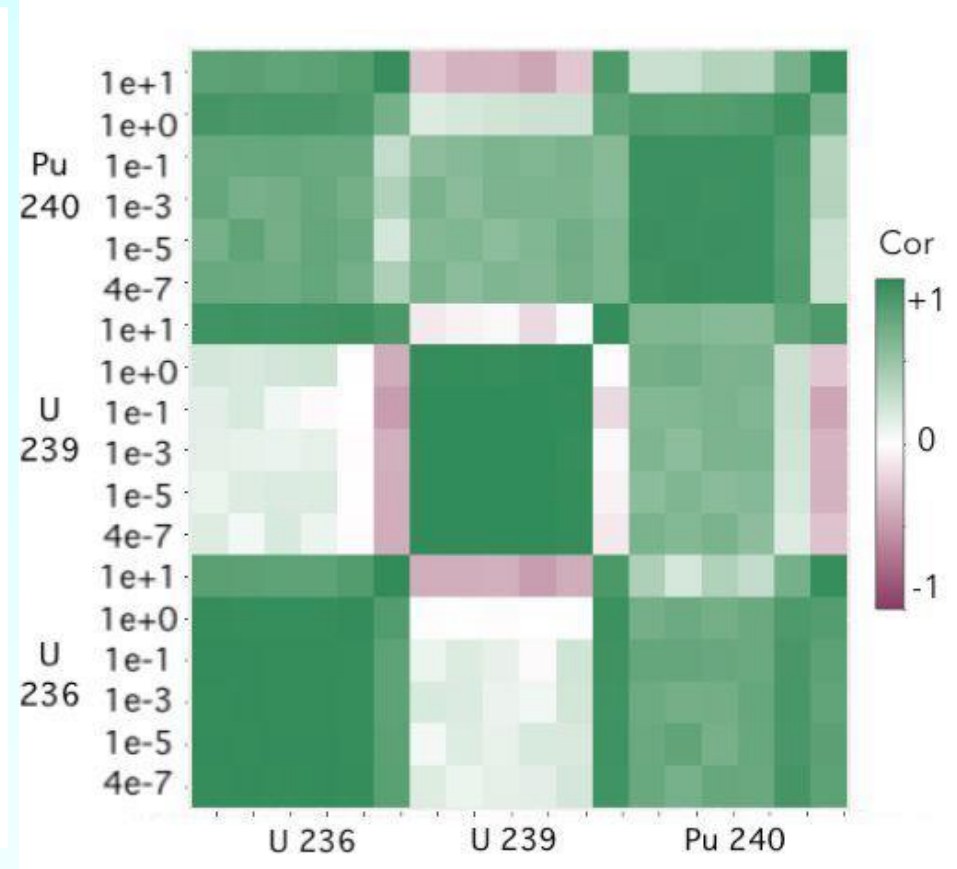
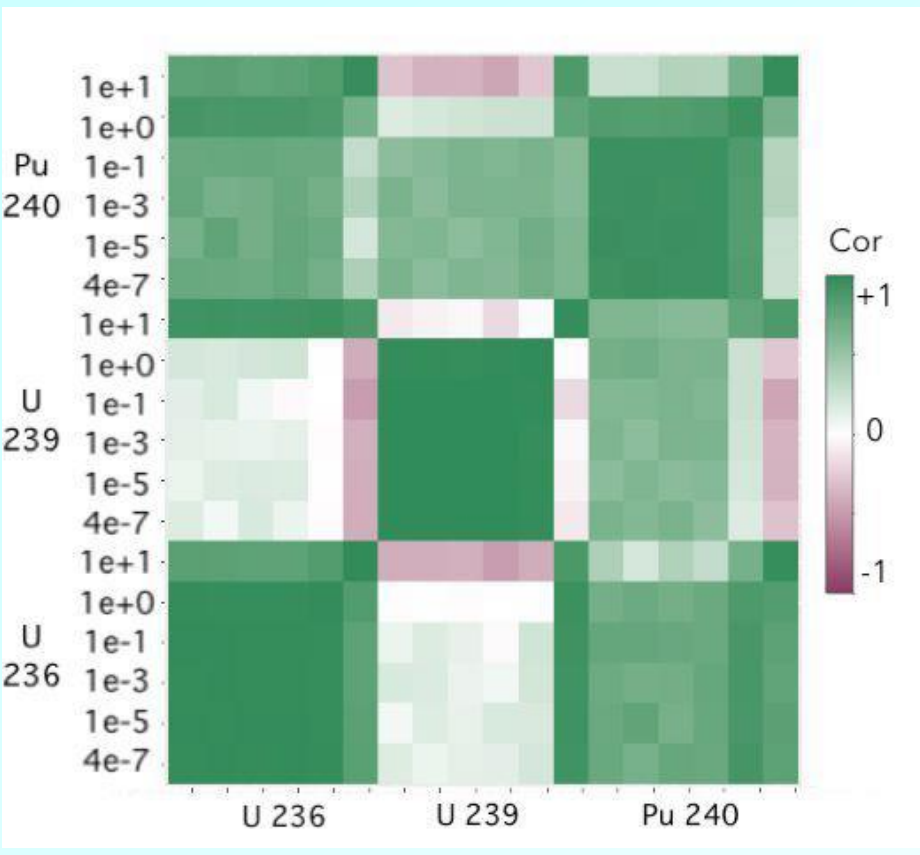
D.W.Muir, NIM-A

644(2011) 55-58

Correlation between delayed nu-bars of ^{235}U , ^{238}U , ^{239}Pu



Correlation between delayed nu-bars of ^{235}U , ^{238}U , ^{239}Pu



T. Cordier, I. Kodeli, K.-H. Schmidt, P. Dossantos-Uzarralde, Estimation of Delayed Fission Yield Covariance Information and Corresponding Uncertainty to Improve Nuclear Data of ^{235}U , ^{238}U , ^{239}Pu and ^{241}Am , proc. NENE-2018 conference, Portorož, Sept. 2019

Sensitivity & uncertainty in β -eff

1) k-ratio derivation sensitivity method

$$\frac{\sigma}{\beta_{eff}} \frac{\partial \beta_{eff}}{\partial \sigma} = \frac{k_p}{k \beta_{eff}} (S_k - S_{kp})$$

2) Second order derivative of k-eff to delayed nu-bar

I. Kodeli, Sensitivity and uncertainty in the effective delayed neutron fraction (β_{eff}), Nucl. Instr. & Meth. in Phys. Research A 715 (2013) 70–78

I. Kodeli, Beta-Effective Sensitivity and Uncertainty Analysis of MYRRHA Reactor for Possible Use in Nuclear Data Validation and Improvement, Annals of Nuclear Energy 113 (2018) 425 - 435.

I. Kodeli, M. Aufiero, W. Zwermann, Comparison Of Deterministic and Monte Carlo Codes SUS3D, Serpent and XSUSA for Beta-Effective Sensitivity Calculations, Proc. PHYSOR-2016: Unifying Theory and Experiments in the 21st Century, May 1-5, 2016, Sun Valley, Idaho, USA