An Example of Cross Section Adjustment – A Broader Discussion of Covariance Needs

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Introduction

- This short presentation is intended to broaden the dialog on Covariance Data needs
- Applications of nuclear data covariances
  - Sensitivity / Uncertainty Analysis or Error Propagation
  - Data Assimilation or Data Adjustment
- Very brief review of the current WPEC SG33 Data Adjustment Exercise
- Discussion of covariance needs

WPEC SG33 Data Adjustment Exercise

Assembly	Integral Experiments
FLATTOP Pu239	k_{eff}, f^{28}/f^{25} and f^{37}/f^{25}
JEZEBEL Pu239	k_{eff}, f^{28}/f^{25}, f^{37}/f^{25} and f^{49}/f^{25}
JEZEBEL Pu240	k_{eff}
ZPR-6/7	k_{eff}, f^{49}/f^{25}, f^{28}/f^{25} and c^{28}/f^{25}
ZPR-6/7 High Pu240	k_{eff}
JOYO	k_{eff}
ZPPR-9	k_{eff}, f^{49}/f^{25}, f^{28}/f^{25} and c^{28}/f^{25}, Na Void "Step 3" and Na Void "Step 5"
ZPR-9/34	k_{eff}
Target Systems	**Integral Experiments**
FBR	k_{eff}
ABR Oxide w/ Startup Core Compositions	k_{eff}
ABR Oxide w/ Recycled Core Compositions	k_{eff}
ABR Metal Core	k_{eff}

20 Integral Experiments

4 Target Systems

4 optional "stress" tests:
- **ZPR-9/34**
- **ZPR-3/53**
- **ZPR-3/54**
- **ZPR-6/10**

Participants

ANL	JAEA
CEA	KAERI
CIAE	NRG
INL	ORNL
IRSN	PSI

ANL Computational Methods and Data

- Generalized least square fitting code GMADJ
- Cross section data: ENDF/B-VII.0
- Covariance data: 33-group COMMARA-2.0
  - χ_p only for ^{239}Pu and ^{240}Pu
  - μ-bar only for ^{23}Na and ^{56}Fe
- 33-group sensitivity coefficients calculated with ERANOS (transport theory) based on ENDF/B-VII.0 data
- 1266 group constants considered
  - Isotopes: ^{235}U, ^{238}U, ^{239}Pu, ^{240}Pu, ^{241}Pu, ^{56}Fe, ^{52}Cr, ^{58}Ni, ^{16}O, ^{23}Na, ^{10}B
  - Reactions: capture ((n,α) for ^{10}B), fission, prompt fission spectrum, total nu, elastic scattering, inelastic scattering and mu-bar

Calculated, Experimental and C/E Values

Assembly	Parameters	Reference Detailed Monte Carlo	Experiment	C/E	
JEZEBEL Pu239	k_{eff}	0.99986±9pcm	1.00000±200pcm	0.9999	-0.05
	f^{28}/f^{25}	0.2084±0.0009	0.2133±1.1%	0.9770	-1.99
	f^{37}/f^{25}	0.9707±0.0013	0.9835±1.4%	0.9870	-0.94
	f^{49}/f^{25}	1.4248±0.0018	1.4609±0.9%	0.9753	-2.79
JEZEBEL Pu240	k_{eff}	0.99981±9pcm	1.00000±200pcm	0.9998	-0.10
FLATTOP Pu239	k_{eff}	1.00097±18pcm	1.00000±300pcm	1.0010	0.33
	f^{28}/f^{25}	0.1767±0.0013	0.1799±1.1%	0.9822	-1.37
	f^{37}/f^{25}	0.8523±0.0013	0.8561±1.4%	0.9956	-0.31
ZPR-6/7	k_{eff}	1.00094±7pcm	1.00051±230pcm	1.0004	0.17
	f^{49}/f^{25}	0.9093±0.0065	0.9435±2.1%	0.9638	-1.69
	f^{28}/f^{25}	0.0224±0.0002	0.0223±3.0%	1.0045	0.14
	c^{28}/f^{25}	0.1336±0.0008	0.1323±2.4%	1.0098	0.39
ZPR-6/7 Pu240	k_{eff}	1.00017±11pcm	1.00080±220pcm	0.9994	-0.27
JOYO	k_{eff}	0.99851±9pcm	1.00105±180pcm	0.9975	-1.39
ZPPR-9	k_{eff}	1.00028±3pcm	1.00106±117pcm	0.9992	-0.68
	f^{28}/f^{25}	0.0201±0.55%	0.0207±2.7%	0.9710	-1.08
	f^{49}/f^{25}	0.9048±0.37%	0.9225±2.0%	0.9808	-0.96
	c^{28}/f^{25}	0.1308±0.33%	0.1296±1.9%	1.0093	0.48
	Void Step3	106±4pcm	104pcm ±1.9%	1.0192	0.45
	Void Step5	109±4pcm	112pcm ±1.9%	0.9732	-0.67
ZPR-9/34	k_{eff}	1.00943±4pcm	1.00060±110pcm	1.0088	7.93

Of initial 20 C/E values:
14 within 1σ
additional 5 within 2σ
additional 1 within 3σ

Correlation of Experimental Errors

Assembly	Parameter	#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
JEZEBEL Pu239	k_{eff}	1	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	2	0	1000	230	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{37}/f^{25}	3	0	230	1000	320	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{49}/f^{25}	4	0	230	320	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JEZEBEL Pu240	k_{eff}	5	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLATTOP Pu239	k_{eff}	6	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	7	0	0	0	0	0	0	1000	230	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{37}/f^{25}	8	0	0	0	0	0	0	230	1000	0	0	0	0	0	0	0	0	0	0	0	0	0
ZPR-6/7	k_{eff}	9	0	0	0	0	0	0	0	0	1000	0	0	0	130	0	310	0	0	0	0	0	0
	f^{49}/f^{25}	10	0	0	0	0	0	0	0	0	0	1000	230	320	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	11	0	0	0	0	0	0	0	0	0	230	1000	230	0	0	0	0	0	0	0	0	0
	c^{28}/f^{25}	12	0	0	0	0	0	0	0	0	0	320	230	1000	0	0	0	0	0	0	0	0	0
ZPR-6/7 Pu240	k_{eff}	13	0	0	0	0	0	0	0	0	130	0	0	0	1000	0	300	0	0	0	0	0	0
JOYO	k_{eff}	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0
ZPPR-9	k_{eff}	15	0	0	0	0	0	0	0	0	310	0	0	0	300	0	1000	0	0	0	0	0	0
	f^{28}/f^{25}	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	230	230	0	0	0
	f^{49}/f^{25}	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230	1000	320	0	0	0
	c^{28}/f^{25}	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	230	320	1000	0	0	0
	Void Step3	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	410	0
	Void Step5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	410	1000	0
ZPR-9/34	k_{eff}	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000

Correlation of Calculation Errors

Assembly	Parameter	#	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
JEZEBEL Pu239	k_{eff}	1	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	2	0	1000	500	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{37}/f^{25}	3	0	500	1000	500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{49}/f^{25}	4	0	500	500	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
JEZEBEL Pu240	k_{eff}	5	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
FLATTOP Pu239	k_{eff}	6	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	7	0	0	0	0	0	0	1000	500	0	0	0	0	0	0	0	0	0	0	0	0	0
	f^{37}/f^{25}	8	0	0	0	0	0	0	500	1000	0	0	0	0	0	0	0	0	0	0	0	0	0
ZPR-6/7	k_{eff}	9	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	0	0
	f^{49}/f^{25}	10	0	0	0	0	0	0	0	0	0	1000	500	500	0	0	0	0	0	0	0	0	0
	f^{28}/f^{25}	11	0	0	0	0	0	0	0	0	0	500	1000	500	0	0	0	0	0	0	0	0	0
	c^{28}/f^{25}	12	0	0	0	0	0	0	0	0	0	500	500	1000	0	0	0	0	0	0	0	0	0
ZPR-6/7 Pu240	k_{eff}	13	0	0	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0	0
JOYO	k_{eff}	14	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0
ZPPR-9	k_{eff}	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0
	f^{28}/f^{25}	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	500	500	0	0	0
	f^{49}/f^{25}	17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	1000	500	0	0	0
	c^{28}/f^{25}	18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	500	1000	0	0	0
	Void Step3	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000	500	0
	Void Step5	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	500	1000	0
ZPR-9/34	k_{eff}	21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1000

Uncertainty Propagation Using COMMARA-2.0 Data

Parameter		Calculated value	Uncertainties							
			Elastic	Inelastic	Capture	Mu-bar	Fission	Nu	χ_p	Total
JEZEBEL Pu239	k_{eff}	1.00538	-0.42	0.64	0.08	0.00	0.35	0.11	0.16	0.64
	f^{28}/f^{25}	0.2010	-0.90	3.19	0.10	0.00	0.67	0.00	2.00	3.71
	f^{37}/f^{25}	0.9582	-0.59	2.23	0.08	0.00	0.41	0.00	0.90	2.37
	f^{49}/f^{25}	1.4207	-0.13	0.51	0.02	0.00	0.63	0.00	0.19	0.83
JEZEBEL Pu240	k_{eff}	1.00460	-0.32	0.47	0.11	0.00	0.35	0.37	0.21	0.66
FLATTOP Pu239	k_{eff}	1.00093	-0.44	0.79	0.13	0.00	0.29	0.14	0.16	0.76
	f^{28}/f^{25}	0.1698	-0.51	2.40	0.17	0.00	0.66	0.06	1.93	3.11
	f^{37}/f^{25}	0.8411	-0.21	1.82	0.15	0.00	0.42	0.04	0.85	2.04
ZPR-6/7	k_{eff}	0.98875	0.26	0.71	0.49	0.07	0.24	0.18	0.19	0.96
	f^{49}/f^{25}	0.9358	0.24	0.46	0.16	0.01	0.59	0.00	0.08	0.81
	f^{28}/f^{25}	0.0218	-0.24	6.10	0.75	0.04	0.67	0.01	1.70	6.40
	c^{28}/f^{25}	0.1387	0.76	0.56	1.21	0.02	0.43	0.00	0.10	1.59
ZPR-6/7 Pu240	k_{eff}	0.98762	0.27	0.71	0.48	0.07	0.23	0.19	0.18	0.97
JOYO	k_{eff}	0.99859	0.36	0.01	0.76	0.19	0.17	0.15	0.05	0.89
ZPPR-9	k_{eff}	0.98701	0.23	0.98	0.49	0.06	0.24	0.20	0.22	1.18
	f^{28}/f^{25}	0.01982	-0.54	7.62	0.79	0.05	0.67	0.01	1.64	7.85
	f^{49}/f^{25}	0.9264	0.20	0.54	0.17	0.00	0.59	0.00	0.07	0.84
	c^{28}/f^{25}	0.1371	0.65	0.66	1.15	0.00	0.43	0.00	0.09	1.54
	Void Step3	106 pcm	2.40	6.62	2.37	0.69	1.47	0.54	0.26	7.63
	Void Step5	141pcm	2.59	8.57	3.15	1.53	1.99	0.78	0.41	9.86
ZPR-9/34	k_{eff}	1.01192	1.39	0.17	2.00	0.22	0.23	0.11	0.00	2.47

Mu-bar data only for ^{23}Na and ^{56}Fe; χ_p data only for ^{238}Pu, ^{239}Pu and ^{240}Pu.

Case Studies provided to SG33

Case 1.

Cross section adjustment for the initial twenty selected experiments including experimental and calculation uncertainties without correlations, i.e., including diagonal uncertainties but neglecting off-diagonal elements of these covariance matrices.

Case 2.

Cross section adjustment for the initial twenty selected experiments including experimental correlations and omitting the calculation error correlations.

Case 3.

Cross section adjustment for the initial twenty selected experiments including both experimental and calculation error correlations.

Case 4.

Cross section adjustment for the initial twenty selected experiments plus the multiplication factor of ZPR-9 Assembly 34, including both experimental and calculation error correlations.

C/E's Before and After Cross Section Adjustment

Assembly	Parameter	Experiment Uncertainty (%)	C/E's				
			before Adjustment	After Adjustment			
				Case 1	Case 2	Case 3	Case 4
JEZEBEL Pu239	k_{eff}	0.20	0.9999	0.9998	0.9999	0.9999	0.9998
	f^{28}/f^{25}	1.10	0.9770	0.9964	0.9935	0.9909	0.9910
	f^{37}/f^{25}	1.40	0.9870	1.0011	0.9988	0.9977	0.9977
	f^{49}/f^{25}	0.90	0.9753	0.9841	0.9836	0.9832	0.9832
JEZEBEL Pu240	k_{eff}	0.20	0.9998	1.0000	1.0000	1.0000	1.0001
FLATTOP Pu239	k_{eff}	0.30	1.0010	1.0009	1.0009	1.0009	1.0012
	f^{28}/f^{25}	1.10	0.9822	0.9993	0.9969	0.9945	0.9940
	f^{37}/f^{25}	1.40	0.9956	1.0087	1.0067	1.0058	1.0053
ZPR-6/7	k_{eff}	0.23	1.0004	1.0007	1.0007	1.0008	1.0008
	f^{49}/f^{25}	2.10	0.9638	0.9699	0.9700	0.9696	0.9694
	f^{28}/f^{25}	3.00	1.0045	1.0196	1.0182	1.0152	1.0143
	c^{28}/f^{25}	2.40	1.0098	1.0079	1.0056	1.0055	1.0048
ZPR-6/7 Pu240	k_{eff}	0.22	0.9994	0.9997	0.9997	0.9997	0.9998
JOYO	k_{eff}	0.18	0.9975	0.9997	0.9997	0.9997	0.9991
ZPPR-9	k_{eff}	0.12	0.9992	1.0001	1.0002	1.0001	1.0002
	f^{28}/f^{25}	2.70	0.9710	0.9867	0.9852	0.9820	0.9803
	f^{49}/f^{25}	2.00	0.9808	0.9869	0.9870	0.9866	0.9863
	c^{28}/f^{25}	1.90	1.0093	1.0077	1.0055	1.0054	1.0050
	Void Step3	1.90	1.0192	1.0274	1.0261	1.0208	1.0283
	Void Step5	1.90	0.9732	0.9843	0.9827	0.9767	0.9769
ZPR-9/34	k_{eff}		1.0088				1.0001

Nuclear Data Induced Uncertainties (%) Before and After Cross Section Adjustment

Assembly	Parameter	before adjustment	After adjustment			
			Case 1	Case 2	Case 3	Case 4
JEZEBEL Pu239	k_{eff}	0.64	0.17	0.17	0.17	0.17
	f^{28}/f^{25}	3.71	1.04	1.08	1.06	1.06
	f^{37}/f^{25}	2.37	0.72	0.78	0.78	0.78
	f^{49}/f^{25}	0.83	0.48	0.50	0.50	0.50
JEZEBEL Pu240	k_{eff}	0.66	0.18	0.18	0.18	0.18
FLATTOP Pu239	k_{eff}	0.76	0.22	0.22	0.22	0.22
	f^{28}/f^{25}	3.11	0.91	0.93	0.91	0.91
	f^{37}/f^{25}	2.04	0.69	0.73	0.74	0.73
ZPR-6/7	k_{eff}	0.97	0.11	0.12	0.12	0.12
	f^{49}/f^{25}	0.81	0.56	0.56	0.57	0.57
	f^{28}/f^{25}	6.40	1.66	1.65	1.64	1.64
	c^{28}/f^{25}	1.59	1.02	1.01	1.01	1.01
ZPR-6/7 Pu240	k_{eff}	0.97	0.11	0.12	0.12	0.12
JOYO	k_{eff}	0.89	0.18	0.18	0.18	0.17
ZPPR-9	k_{eff}	1.18	0.10	0.11	0.12	0.11
	f^{28}/f^{25}	7.85	1.86	1.85	1.84	1.84
	f^{49}/f^{25}	0.84	0.55	0.56	0.57	0.57
	c^{28}/f^{25}	1.54	0.96	0.95	0.95	0.95
	Void Step3	7.67	3.66	3.69	3.68	3.63
	Void Step5	9.92	4.60	4.63	4.63	4.63
ZPR-9/34	k_{eff}	2.46				0.11

Contributions of the Adjusted Cross Section to the Variation (%) of the Calculated Integral Parameters

Reactions	JEZEBEL Pu239				FLATTOP Pu239		
	k_{eff}	f^{28}/f^{25}	f^{37}/f^{25}	f^{49}/f^{25}	k_{eff}	f^{28}/f^{25}	f^{37}/f^{25}
U235 Fission	-	0.24	0.24	0.24	-	0.24	0.24
U238 Elastic	-	-	-	-	0.01	-0.01	-
U238 Inelastic	-	-	-	-	-0.07	0.06	0.05
U238 Fission	-	0.04	-	-	-	0.04	-
U238 Nu	-	-	-	-	-0.01	0.01	-
Pu239 Elastic	0.13	-0.10	-0.04	-0.01	0.06	-0.02	0.01
Pu239 Inelastic	-0.36	1.42	0.94	0.21	-0.13	0.99	0.68
Pu239 Capture	-0.02	0.02	0.02	0.01	-0.03	0.04	0.03
Pu239 Fission	0.27	0.01	0.01	0.37	0.22	0.06	0.04
Pu239 Nu	-0.01	-	-	-	-0.01	-	-
Pu239 χ_p	-0.02	-0.22	-0.08	-0.01	-0.02	-0.21	-0.07
Pu240 Inelastic	-	0.01	0.01	-	-	0.01	-
Total Adjustment	-	1.43	1.08	0.81	0.02	1.20	0.98

- indicates values null or less than 0.005%

Contributions of the Adjusted Cross Section to the Variation (%) of the Calculated Integral Parameters

Reactions	JEZEBEL Pu240	ZPR-6/7				ZPR-6/7 Pu240	JOYO
	k_{eff}	k_{eff}	f^{49}/f^{25}	f^{28}/f^{25}	c^{28}/f^{25}	k_{eff}	k_{eff}
O16 Elastic	-	-	-0.03	-0.07	0.08	-	0.03
O16 Capture	-	0.01	-	0.01	-	0.01	0.01
Na23 Elastic	-	-	-0.01	-0.06	0.02	-	0.02
Na23 Inelastic	-	-	-	-0.01	-	-	-
Na23 Mu-bar	-	0.02	-	-0.01	-0.01	0.02	0.07
Fe56 Elastic	-	-0.07	0.09	0.20	-0.27	-0.07	-0.16
Fe56 Inelastic	-	-	-	0.01	-	-	-
Fe56 Capture	-	-0.06	0.01	0.08	-0.04	-0.06	-0.03
U235 Capture	-	0.01	-	-0.01	-	0.01	0.26
U235 Fission	-	-	0.19	0.19	0.19	-	-0.06
U238 Inelastic	-	0.05	0.04	0.44	-0.05	0.05	-
U238 Capture	-	0.07	-0.02	-0.11	-0.27	0.07	0.03
U238 Fission	-	-	-	0.04	-	-	-
U238 Nu	-	-0.02	-	-	-	-0.02	-0.01
Pu239 Elastic	0.11	-	-	-	-	-	-
Pu239 Inelastic	-0.26	0.02	0.04	0.20	-0.06	0.02	-0.01
Pu239 Capture	-0.01	-0.12	0.04	0.19	-0.10	-0.11	-0.05
Pu239 Fission	0.23	0.14	0.25	0.06	-0.02	0.14	0.08
Pu239 Nu	-0.01	-0.01	-	-	-	-0.01	-
Pu239 χ_p	-0.02	-0.02	-0.01	-0.19	0.01	-0.02	-0.01
Pu240 Elastic	0.01	-	-	-	-	-	-
Pu240 Inelastic	-0.01	-	-	0.01	-	-	-
Total Adjustment	0.03	0.04	0.59	0.97	-0.50	0.04	0.16

- indicates values null or less than 0.005%

Contributions of the Adjusted Cross Section to the Variation (%) of the Calculated Integral Parameters

Reactions	ZPPR-9						ZPR-9/34
	k_{eff}	f^{28}/f^{25}	f^{49}/f^{25}	c^{28}/f^{25}	Void Step3	Void Step5	k_{eff}
O16 Elastic	-0.01	-0.06	-0.03	0.08	-0.23	-0.25	-
O16 Capture	0.01	0.01	-	-	0.03	0.05	-
Na23 Elastic	-	-0.05	-0.01	0.02	0.29	0.26	-
Na23 Inelastic	-	-0.01	-	-	0.06	0.08	-
Na23 Capture	-	-	-	-	-0.04	-0.06	-
Na23 Mu-bar	0.02	-0.02	-	-	-0.06	-0.52	-
Cr52 Elastic	-	-	-	-	-	-	-0.01
Fe56 Elastic	-0.04	0.13	0.07	-0.22	0.51	0.38	-1.02
Fe56 Inelastic	-	0.01	-	-	-0.01	-0.01	-
Fe56 Capture	-0.05	0.07	0.01	-0.03	0.11	0.14	-0.38
Fe56 Mu-bar	-	-	-	-	0.03	0.03	-0.02
Ni58 Capture	-	-	-	-	-	0.01	-
U235 Capture	0.01	-0.01	-	-	0.01	0.01	0.67
U235 Fission	-	0.19	0.19	0.19	-	-0.01	-0.11
U238 Inelastic	0.07	0.56	0.04	-0.06	0.48	0.61	-
U238 Capture	0.08	-0.13	-0.03	-0.25	-0.47	-0.62	-
U238 Fission	-	0.04	-	-	-	0.01	-
U238 Nu	-0.02	-	-	-	-0.03	-0.05	-
Pu239 Inelastic	0.03	0.17	0.03	-0.05	0.25	0.31	-
Pu239 Capture	-0.11	0.18	0.04	-0.09	0.05	0.06	-
Pu239 Fission	0.14	0.05	0.24	-0.02	-0.08	-0.04	-
Pu239 Nu	-0.01	-	-	-	-	-	-
Pu239 χ_p	-0.02	-0.18	-0.01	0.01	-0.03	-0.05	-
Pu240 Inelastic	-	-	-	-	-	0.01	-
Pu240 Capture	-	-	-	-	-	0.01	-
Total Adjustment	0.10	0.96	0.56	-0.42	0.89	0.38	-0.86

- indicates values null or less than 0.005%

Summary

- In addition to Nuclear Data Covariance Data, applications such as data adjustment or assimilation also require Covariance Data for:
  - Integral Experiments
  - Calculational Methods

- Status of these data is similar to status of Nuclear Data Covariances, i.e., even those these data have been estimated and used for many decades, the theory and method of evaluation for these data are still evolving.

- Importance of these data are also still evolving.

Backup Slides

Changes in Cross Section Value and Standard Deviation of the Most Important Contributors to the Adjustment

Energy Group	[MeV]	Pu239 Inelastic			U238 Inelastic			Pu239 Capture		
		change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%
1	1.964E+1	-0.30	24.02	24.07	0.37	31.48	31.62	0.35	36.18	36.25
2	1.000E+1	-3.73	26.30	27.59	-1.26	26.95	30.30	1.02	39.75	39.85
3	6.065E+0	-8.26	19.52	25.62	-1.65	8.15	20.14	1.83	41.81	41.95
4	3.679E+0	-7.64	11.51	19.46	-1.50	5.55	19.42	2.55	34.03	34.23
5	2.231E+0	-7.85	9.02	19.00	-1.21	8.43	20.58	2.47	26.33	26.56
6	1.353E+0	-9.80	14.53	27.04	-1.29	7.37	16.94	2.35	20.20	20.48
7	8.209E-1	-10.53	19.97	32.61	-0.23	5.15	5.59	2.58	15.04	15.51
8	4.979E-1	-9.32	22.18	32.73	-0.14	4.13	4.27	2.02	11.60	12.07
9	3.020E-1	-9.55	25.73	36.23	-0.19	3.95	4.10	1.62	10.94	11.33
10	1.832E-1	-11.47	31.19	43.73	-0.34	5.78	6.00	1.59	9.16	9.60
11	1.111E-1	-13.23	35.54	49.97	-1.11	18.46	19.18	1.85	10.26	10.83
12	6.738E-2	-13.20	29.70	45.14	-1.34	17.15	17.86	1.84	10.86	11.41
13	4.087E-2	-11.47	15.14	31.91				1.90	8.23	8.86
14	2.479E-2	-11.71	10.81	30.07				2.40	6.15	7.25
15	1.503E-2	-10.64	6.86	26.65				2.81	6.45	7.79
16	9.119E-3	-0.07	17.07	17.07				5.00	14.70	16.54
17	5.531E-3							5.04	14.70	16.54
18	3.355E-3							3.42	9.58	10.73
19	2.035E-3							0.10	1.50	1.50
20	1.234E-3							0.10	1.52	1.53
21	7.485E-4							0.10	1.58	1.59
22	4.540E-4							0.08	1.58	1.58
23	3.043E-4							0.09	1.58	1.58
24	1.486E-4							0.09	1.94	1.94
25	9.166E-5							0.17	5.50	5.50
26	6.790E-5							0.13	3.18	3.19
27	4.017E-5							0.06	2.12	2.12
28	2.260E-5							0.03	1.32	1.32
29	1.371E-5							0.02	0.68	0.68
30	8.315E-6							0.02	1.05	1.05
31	4.000E-6							0.03	1.54	1.54
32	5.400E-7							0.02	1.30	1.30
33	1.000E-8							0.03	1.49	1.50

Changes in Cross Section Value and Standard Deviation of the Most Important Contributors to the Adjustment

Energy Group	[MeV]	U238 Capture			Pu239 Fission			Pu239 Fission Spectrum		
		change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%
1	1.964E+1	0.36	24.91	25.00	0.15	0.74	0.75	-2.32	15.96	18.98
2	1.000E+1	0.17	24.98	25.00	0.23	0.84	0.87	-0.81	4.79	6.23
3	6.065E+0	0.03	19.91	19.91	0.28	0.76	0.81	-0.38	2.84	4.00
4	3.679E+0	-0.03	5.89	5.89	0.43	0.82	0.91	-0.14	1.40	1.93
5	2.231E+0	-0.08	6.03	6.05	0.48	0.79	0.89	0.05	1.14	1.24
6	1.353E+0	-0.04	3.08	3.10	0.39	0.72	0.79	0.16	1.71	2.17
7	8.209E-1	-0.02	1.65	1.67	0.32	0.77	0.82	0.23	1.66	2.45
8	4.979E-1	-0.03	1.43	1.47	0.28	0.85	0.89	0.32	2.54	3.49
9	3.020E-1	-0.06	1.36	1.46	0.24	0.73	0.77	0.37	4.02	4.90
10	1.832E-1	-0.07	1.54	1.65	0.27	0.98	1.02	0.39	4.96	5.81
11	1.111E-1	-0.08	1.61	1.72	0.24	0.81	0.85	0.42	5.59	6.45
12	6.738E-2	-0.08	1.57	1.67	0.21	0.72	0.75	0.42	5.93	6.77
13	4.087E-2	-0.07	1.49	1.58	0.19	0.89	0.91	0.43	6.08	6.92
14	2.479E-2	-0.38	2.81	3.15	0.17	0.85	0.87	0.42	6.12	6.95
15	1.503E-2	-0.61	3.36	3.89	0.14	1.20	1.21	0.42	6.13	6.95
16	9.119E-3	-0.55	2.84	3.28	0.09	0.76	0.76	0.43	6.33	7.17
17	5.531E-3	-0.51	2.38	2.81	0.07	0.77	0.78	0.43	6.32	7.15
18	3.355E-3	-0.49	2.55	2.91	0.09	0.73	0.74	0.43	6.29	7.12
19	2.035E-3	-0.54	2.51	2.91	0.14	1.12	1.15	0.42	6.23	7.05
20	1.234E-3	-0.52	2.47	2.83	0.15	1.21	1.25	0.42	6.26	7.09
21	7.485E-4	-0.44	2.37	2.65	0.15	1.30	1.33	0.43	6.36	7.20
22	4.540E-4	-0.36	3.30	3.44	0.16	1.45	1.48	0.43	6.33	7.16
23	3.043E-4	-0.46	2.64	2.88	0.14	1.29	1.32	0.42	6.28	7.10
24	1.486E-4	-0.52	3.96	4.13	0.15	1.55	1.57	0.42	6.22	7.03
25	9.166E-5	-0.40	4.94	5.06	0.11	1.80	1.82	0.43	6.39	7.23
26	6.790E-5	-0.34	3.48	3.60	0.13	1.58	1.60	0.43	6.37	7.21
27	4.017E-5	-0.28	3.52	3.60	0.14	2.59	2.60	0.43	6.33	7.16
28	2.260E-5	-0.24	3.58	3.64	0.07	1.72	1.72	0.42	6.26	7.08
29	1.371E-5	-0.22	2.62	2.70	0.05	0.98	0.99	0.30	4.46	5.05
30	8.315E-6	-0.08	1.00	1.02	0.07	1.50	1.51			
31	4.000E-6	-0.20	2.78	2.84	0.07	1.82	1.83			
32	5.400E-7	-0.18	1.88	1.95	0.03	0.84	0.84			
33	1.000E-8	-0.16	1.78	1.83	0.04	1.12	1.12			

Changes in Cross Section Value and Standard Deviation of the Most Important Contributors to the Adjustment

Energy Group	[MeV]	Na23 Elastic			U238 Nu			Pu239 Elastic		
		change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%	change,%	posterior std,%	prior std,%
1	1.964E+1	0.49	8.28	8.31	-0.07	1.40	1.42	-0.03	5.56	5.58
2	1.000E+1	1.10	9.47	9.62	-0.11	1.40	1.44	1.04	8.34	8.66
3	6.065E+0	1.47	10.18	10.42	-0.12	1.28	1.33	3.13	8.62	10.83
4	3.679E+0	1.41	9.72	9.95	-0.13	1.25	1.34	3.09	6.12	9.35
5	2.231E+0	1.32	9.09	9.31	-0.13	1.25	1.34	3.63	5.95	10.67
6	1.353E+0	1.00	6.21	6.44	-0.09	1.07	1.11	3.46	7.04	11.72
7	8.209E-1	0.34	4.15	4.36	-0.01	2.00	2.00	2.26	6.09	9.17
8	4.979E-1	0.27	6.03	6.51	-0.01	2.00	2.00	1.44	4.67	6.40
9	3.020E-1	0.26	4.61	5.06	-0.01	2.00	2.00	1.11	3.92	5.15
10	1.832E-1	0.37	6.72	7.34	-0.01	2.00	2.00	0.93	3.44	4.47
11	1.111E-1	0.32	6.76	7.36	-0.01	2.00	2.00	0.68	2.77	3.60
12	6.738E-2	0.21	4.56	4.93	-0.01	2.00	2.00	0.53	1.98	2.63
13	4.087E-2	0.29	6.67	7.21	-0.01	2.00	2.00	0.50	1.43	2.13
14	2.479E-2	0.29	6.54	7.07	-0.01	2.00	2.00	0.44	1.28	2.13
15	1.503E-2	0.26	6.21	6.71	-0.01	2.00	2.00	0.43	1.25	2.26
16	9.119E-3	0.20	5.42	5.84	-0.01	2.00	2.00	-0.72	3.61	3.74
17	5.531E-3	0.04	3.63	3.82	-0.01	2.00	2.00	-0.81	4.10	4.25
18	3.355E-3	-0.05	1.55	1.56	-0.01	2.00	2.00	-0.50	3.12	3.25
19	2.035E-3	-0.12	3.81	3.83	-0.01	2.00	2.00	0.04	0.53	0.53
20	1.234E-3	0.05	4.15	4.32	-0.01	2.00	2.00	0.05	0.66	0.67
21	7.485E-4	0.13	5.05	5.33	-0.01	2.00	2.00	0.07	1.20	1.21
22	4.540E-4	0.17	5.52	5.86	-0.01	2.00	2.00	0.07	0.92	0.93
23	3.043E-4	0.20	5.80	6.17	-0.01	2.00	2.00	0.11	1.55	1.57
24	1.486E-4	0.22	5.98	6.36	-0.01	2.00	2.00	0.07	1.14	1.15
25	9.166E-5	0.22	6.04	6.43	-0.01	2.00	2.00	0.10	2.30	2.31
26	6.790E-5	0.22	6.08	6.48	-0.01	2.00	2.00	0.04	0.77	0.77
27	4.017E-5	0.23	6.11	6.51	-0.01	2.00	2.00	0.01	0.32	0.32
28	2.260E-5	0.23	6.13	6.53	-0.01	2.00	2.00	0.01	0.27	0.27
29	1.371E-5	0.23	6.14	6.55	-0.01	2.00	2.00	0.01	0.26	0.26
30	8.315E-6	0.23	6.15	6.55	-0.01	2.00	2.00	0.01	0.28	0.28
31	4.000E-6	0.23	6.15	6.56	-0.01	2.00	2.00	0.01	0.29	0.29
32	5.400E-7	0.23	6.15	6.56	-0.01	2.00	2.00	0.01	0.43	0.43
33	1.000E-8	-0.02	1.12	1.13	-0.01	2.00	2.00	0.02	0.68	0.68