Impact of CIELO Evaluation on C/E of a Large Integral Experiments Data Base

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Introduction

- **Because covariances were not available for the CIELO isotopes, it was decided to skip, for the moment, the adjustment and look at the impact of the use of the five CIELO isotopes, ^{16}O, ^{56}Fe, ^{235}U, ^{238}U, and ^{239}Pu, on the C/E of a large experiment data base (158 experiments used for previous adjustments).**
- **The linearity hypothesis was used and the calculated values related to the CIELO isotopes was derived by using sensitivity coefficients: $C'=C(1+S*\Delta\sigma/\sigma)$**
- **CIELO isotopes were downloaded from NNDC as ENDF/B-VIIIβ4.**
- **Reference values in the following are the corresponding isotopes of ENDF/B-VII.0. This file was the one used for calculating with the most accurate tool (i. e. Monte Carlo) the reference C.**
- **Both set of files were processed in exactly the same way infinite dilution cross sections using the latest (.84) version of NJOY2012.**
- **In the following blue colors indicated large values differences, while yellow points out compensations.**

LANL Criticals C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
JEZEBEL K_{eff}	0.99986	1.00013	0.027
JEZEBEL F28/F25	0.97700	0.96545	-1.181
GODIVA K_{eff}	0.99983	1.00653	0.670
GODIVA F28/F25	0.95500	0.94505	-1.042
FLATTOP K_{eff}	1.00097	1.00339	0.242
FLATTOP F28/F25	0.98220	0.97124	-1.115
BIGTEN K_{eff}	1.00002	1.00017	0.015
BIGTEN F28/F25	0.94700	0.94857	0.166
BIGTEN F37/F25	0.96700	0.99483	2.878

LANL Criticals Breakdown

JEZEBEL F28/F25 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{238}U	-	-	-	-	-1.045	-	-	-1.045
^{239}Pu	-0.007	-	-0.009	0.005	-0.043	0.001	-0.242	-0.295
Total	-0.007	-	-0.009	0.005	-0.930	0.001	-0.242	-1.181

GODIVA K_{eff} (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{235}U	-0.365	0.422	0.003	0.547	-0.107	0.088	0.076	0.670

GODIVA F28/F25 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{235}U	0.213	-2.667	-0.004	0.206	0.125	0.001	2.202	0.075
^{238}U	-0.008	0.006	0.001	0.005	-1.123	-	0.002	-1.118
Total	0.206	-2.661	-0.003	0.211	-0.998	0.001	2.204	-1.042

LANL Criticals Breakdown

FLATTOP K_{eff} Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{238}U	0.103	-0.158	-0.038	0.353	-0.073	0.042	0.003	0.224
^{239}Pu	0.004	-	0.030	-0.006	-0.088	0.086	-0014	0.010
Total	0.105	-0.155	-0.008	0.352	-0.163	0.128	-0.017	-0.242

BIGTEN K_{eff} Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{235}U	-0.017	-0.080	-0.068	0.022	-0.126	0.047	0.363	0.278
^{238}U	0.041	-0.081	-0.243	0.114	-0.213	0.138	-0.019	-0.263
Total	0.025	-0.161	-0.008	0.135	-0.339	0.185	0.344	0.015

BIGTEN F37/F25 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{235}U	0.016	-0.187	-0.115	-0.005	0.191	-	0.707	0.608
^{238}U	0.043	1.807	0.257	0.020	0.018	-0.001	-0.125	2.270
Total	0.059	1.620	0.143	0.016	0.210	-0.001	0.832	2.878

ZPPRs C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
ZPPR-9 K_{eff}	0.99922	0.99984	0.062
ZPPR-9 F28/F25	0.97100	0.96877	-0.230
ZPPR-9 C28/F25	1.00930	1.02228	1.286
ZPPR-9 STEP 3	1.01920	0.98789	-3.072
ZPPR-9 STEP 5	0.97320	0.93333	-4.096
ZPPR-10 K_{eff}	1.00015	1.00106	0.091
ZPPR-10 STEP 2	1.15898	1.12024	-3.342
ZPPR-10 STEP 3	1.05639	1.02001	-3.444
ZPPR-10 STEP 6	1.03665	0.99598	-3.923
ZPPR-10 STEP 9	1.00826	0.96308	-4.481
ZPPR-10 Central Control Rod	1.06700	1.06772	0.068

ZPPRs Breakdown

ZPPR-9 K_{eff} Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-	0.108	0.047	0.024	-	-	-	0.133
^{238}U	0.010	0.024	-0.252	-0.026	-0.115	0.081	0.001	-0.224
^{239}Pu	-	-	0.050	-	0.015	0.075	-0.023	0.117
Total	-0.013	0.132	-0.093	-0.002	-0.104	0.157	-0.016	0.062

ZPPR-9 F28/F25 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-	0.819	-0.099	0.004	-	-	-	0.724
^{238}U	-0.014	-0.174	0.389	-0.003	-1.287	0.003	0.009	-1.077
^{239}Pu	-	-	-0.067	-	0.072	-	-0.205	-0.199
Total	-0.150	0.639	0.309	0.005	-0.872	0.003	-0.164	-0.230

ZPPR-9 C28/F25 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{235}U	-	-	0.003	-	0.344	-	-0.002	0.345
^{238}U	0.002	-0.012	0.903	-	-	-	-0.006	0.887
^{239}Pu	-	-	-0.007	-	0.064	-	0.009	0.079
Total	0.021	-0.060	0.919	-	0.408	-	-0.001	1.286

ZPPRs Breakdown

ZPPR-9 STEP3 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{16}O	-0.841	-	0.323	-0.007	-	-	-	-0.526
^{56}Fe	0.033	0.716	-0.453	0.030	-	-	-	0.327
^{238}U	-0.008	0.402	1.255	0.005	-0.119	0.111	-0.026	1.672
^{239}Pu	-0.003	-	-0.340	-	-3.996	-0.300	-0.022	-4.662
Total	-0.819	1.114	0.866	0.027	-4.074	--0.190	0.003	-3.072

ZPPR-10 STEP9 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{16}O	-0.723	-	0.373	-0.007	-	-	-	-0.526
^{56}Fe	0.057	0.824	-0.701	-0.098	-	-	-	0.082
^{238}U	0.078	0.353	1.737	0.225	-0.248	0.186	0.028	2.360
^{239}Pu	-0.004	-	-0.477	-0.001	-5.786	-0.381	-0.035	-6.685
Total	-0.593	1.173	1.040	0.086	-5.984	--0.195	0.008	-4.481

ZPPR-10 Step9 Major Contributions:

^{239}Pu fission: 2.03 kev to 1.23 kev (-5.239%) ^{238}U capture: 1.23 kev to 0.749 kev (1.288%)

ZPRs C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
ZPR6/7 K_{eff}	1.00043	1.00174	0.131
ZPR6/7 F28/F25	1.00450	1.00256	-0.193
ZPR6/7 C28/F25	1.00980	1.02288	1.295
ZPR6/6A K_{eff}	0.99876	0.99700	-0.176
ZPR9-34 Keff	1.00882	1.00938	0.055
ZPR3-53 Keff	1.00923	1.01058	0.134
ZPR3-54 Keff	1.01202	1.01311	0.107

ZPRs Breakdown

ZPR6/7 K_{eff} Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-0.001	0.103	0.059	-0.030	-	-	-	0.132
^{238}U	0.016	0.006	-0.234	0.036	-0.103	0.071	-	-0.207
^{239}Pu	-	-	0.055	-	0.036	0.078	-0.019	0.150
Total	0.011	0.110	-0.057	0.002	-0.070	0.149	-0.014	0.131

ZPR9-34 K_{eff} (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-0.010	-0.181	0.442	0.141	-	-	-	0.392
^{235}U	-0.014	-0.004	-0.270-	0.011	-0.146	0.088	0.007	-0.329
Total	0.011	0.110	-0.057	0.002	-0.070	0.149	-0.014	0.055

ZPR3-54 K_{eff} (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-0.006	-0.097	0.091	-0.079	-	-	-	-0.091
^{238}U	0.007	0.029-	-0.105-	0.015	-0.043	0.029	-0.004	-0.129
^{239}Pu	0.001	-	0.113	-0.001	0.107	0.110	-	0.330
Total	0.001	-0.125	0.097	-0.065	-0.063	0.139	-0.003	0.107

Irradiation Experiments C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
PROFIL-1 ^{235}U Sample	0.94900	0.96988	2.200
PROFIL-1 ^{238}U Sample	0.97200	0.98571	1.410
PROFIL-1 ^{239}Pu Sample	0.90600	0.89952	-0.715
TRAPU-2 ^{235}U Sample	0.99500	1.00633	1.138
TRAPU-2 ^{238}U Sample	1.01200	1.01520	0.316
TRAPU-2 ^{239}Pu Sample	0.98400	0.98079	-0.327
MANTRA Cd Filter ^{235}U Sample	0.97000	0.95856	-1.180
MANTRA Cd Filter ^{238}U Sample	1.03000	1.03288	0.280
MANTRA Cd Filter ^{239}Pu Sample	1.04000	1.04066	0.063

FCA-IX C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
FCA-IX-1 F42/F49	1.04700	1.05930	1.175
FCA-IX-1 F51/F49	0.94800	0.96014	1.281
FCA-IX-1 F53/F49	0.92000	0.93237	1.345
FCA-IX-6 F42/F49	1.03700	1.04654	0.920
FCA-IX-6 F51/F49	0.92900	0.93784	0.952
FCA-IX-6 F53/F49	0.90700	0.91571	0.960
FCA-IX-7 F42/F49	1.04700	1.07104	2.296
FCA-IX-7 F51/F49	0.93400	0.95474	2.220
FCA-IX-7 F53/F49	0.93700	0.95841	2.285

FCA-IX Breakdown

FCA-IX-1 F53/F49 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	0.014	0.312	-0.029	-0.025	-	-	-	0.272
^{235}U	0.006	-0.588	0.617	0.022	-0.451	0.005	1.692	1.304
^{239}Pu	-	-	-	-	-0.268	-	--	-0.268
Total	-0.008	-0.240	0.641	-0.037	-0.696	-0.009	1.693	1.345

FCA-IX-6 F53/F49 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	0.028	0.485	0.006	-0.158	-	-	-	0.361
^{235}U	-0.065	-1.165	-0.035	0.114	-0.051	0.005	1.323	0.127
^{238}U	-0.023	0.231	0.055	-0.034	0.039	-0.023	0.009	0.255
^{239}Pu	-	-	-	-	0.219	-	--	0.219
Total	-0.061	-0.450	0.027	0.207	-0.696	-0.018	1.332	0.960

FCA-IX-7 F53/F49 Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	0.004	0.109	0.002	-0.014	-	-	-	0.100
^{235}U	0.017	-0.689	-0.049	0.014	-0.054	0.001	1.121	0.361
^{238}U	-0.007	1.357	0.136	-0.028	0.024	-0.005	0.009	1.563
^{239}Pu	-	-	-	-	0.262	-	--	0.262
Total	0.013	0.777	0.090	-0.029	0.232	-0.004	1.206	2.285

PROTEUS Breakdown

PROTEUS C7 K_{eff} (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{16}O	-0.037	-	0.135	0.001	-	-	-	0.099
^{238}U	-0.005	0.009	-0.191	0.009	-0.069	0.057	-0.004	-0.195
^{239}Pu	0.001	-	0.070	-	-0.094	0.122	-0.017	0.083
Total	-0.040	0.041	0.029	0.012	-0.203	0.205	-0.005	0.039

PROTEUS C8 F28/F49 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{16}O	-0.003	-	0.142	0.042	-	-	-	0.180
^{238}U	-0.025	-0.381	0.286	-0.003	-1.243	-0.005	-0.001	-1.374
^{239}Pu	0.001	-	-0.047	-	0.240	0.001	-0.146	-0.049
Total	-0.022	-0.018	0.356	0.081	-0.101	-0.005	-0.040	-0.658

PROTEUS Water Void Difference (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{16}O	-10.267	-	0.819	-2.010	-	-	-	-11.459
^{56}Fe	0.057	4.045	0.073	-0.104	-	-	-	4.934
^{235}U	0.077	-0.272	-0.485	0.035	2.569	-1.718	0.936	1.137
^{238}U	0.180	8.834	-4.883	-0.775	-3.626	2.726	0.087	3.327
^{239}Pu	-0.034	-	-1.535	-0.013	-2.573	-6.022	-0.581	-10.732
Total	-9.993	12.606	-5.356	-2.634	-3.630	-5.014	1.227	-12.793

ASPIS C/E

EXPERIMENT	ENDF/B-VII.0	CIELO	Differ. %
ASPIS FE-88 Al (n,α) A7	1.35100	1.62860	20.548
ASPIS FE-88 S (n,p) A7	0.97900	1.21506	24.112
ASPIS FE-88 S (n,p) A12	0.93900	1.33214	41.868
ASPIS FE-88 S (n,p) A14	0.91600	1.35829	48.284
ASPIS FE-88 In (n,inel) A7	0.97400	1.07091	9.950
ASPIS FE-88 In (n,inel) A11	0.96800	1.07100	10.651
ASPIS FE-88 Rh (n,inel) A7	1.05400	1.10418	4.761
ASPIS FE-88 Rh (n,inel) A14	1.09900	1.14366	4.063
ASPIS FE-88 Au (n,γ) A7	1.00700	1.03634	2.914
ASPIS FE-88 Au (n,γ) A11	1.02400	1.06569	4.071
ASPIS FE-88 Au (n,γ) A14	1.05100	1.10140	4.796

ASPIS Breakdown

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ASPIS FE-88 Al (n,α) A7 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-3.485	15.825	-5.264	9.948	-	-	-	17.025
^{235}U	-	-	--	-	-	-	3.532	3.532
Total	-3.485	15.825	-5.264	9.948	-	-	3.532	20.548

ASPIS FE-88 S (n,p) A14 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-5.671	37.620	-0.740	14.801	-	-	-	46.073
^{235}U	-	-	--	-	-	-	2.236	2.236
Total	-5.671	37.620	-0.740	14.801	-	-	2.236	48.204

ASPIS FE-88 In (n,inel) A11 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-0.081	10.019	-0.414	-	-	-	-	9.523
^{235}U	-	-	--	-	-	-	1.148	1.148
Total	-0.081	10.019	-0.414	-	-	-	1.148	10.651

ASPIS FE-88 Rh (n,inel) A7 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-0.030	4.119	-0.263	-	-	-	-	3.887
^{235}U	-	-	--	-	-	-	0.887	0.887
Total	-0.030	4.119	-0.263	-	-	-	0.887	4.761

ASPIS FE-88 Au (n,γ) A14 (%)								
Isotope/Reaction	Elast.	Inel.	Capt.	P_1 Elas	Fiss.	Nubar	χ	Sum
^{56}Fe	-	-	4.659	-	-	-	-	4.659
Total	-	-	4.659	-	-	-	-	4.659

Summary

- **Regarding experiments, this exercise has shown that the experiments other than critical masses (e. g. spectral indices, irradiation experiments, reactivity coefficients, and neutron propagation) provide extremely useful information.**
- **Many compensations have been observed among reactions and also energy range (not shown in viewgraphs).**
- **Regarding the 5 isotopes, the major impacts are related to:**
  - **^{16}O: elastic, (n,α), P_1 elastic. Only few experiments are sensitive.**
  - **^{56}Fe: elastic, inelastic, capture, P_1 elastic. Propagation experiments are the most sensitive.**
  - **^{235}U: inelastic, capture, fission, fission spectrum**
  - **^{238}U: inelastic, capture, P_1 elastic, fission, nubar**
  - **^{239}Pu: capture, fission, nubar, fission spectrum (in general lesser impact than the other isotopes)**
- **When covariances will be available for CIELO isotopes, more relevant feedback could be provided through data assimilation using PIA strategy (avoiding compensations) and careful choice among available experiments.**