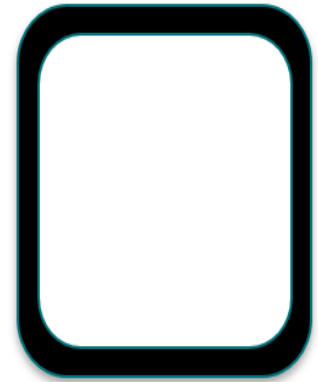# Testing ENDF/B-VIII.1_beta1 files using fast ICSBEP benchmarks

Mark Cornock and Tim Gaines

AWE.plc

Validation Session

Mini CSEWG

April 2023

First Do No Harm

Data and Processing

- 2 Datasets

  - beta1 tag, commit 9611a574

  - ENDF/B-VIII.0 taken from NNDC website.

- Both processed with NJOY2016.67, commit1cb7237

  - Reprocessed ENDF/B-VIII.0 from scratch to eliminate differences in processing.

  - Groupwise, GROUPR, 460 groups.

  - Pointwise, ACER

- Cr54 processing failure, Tracker 471 (fix 06/04), Issues in MF32.

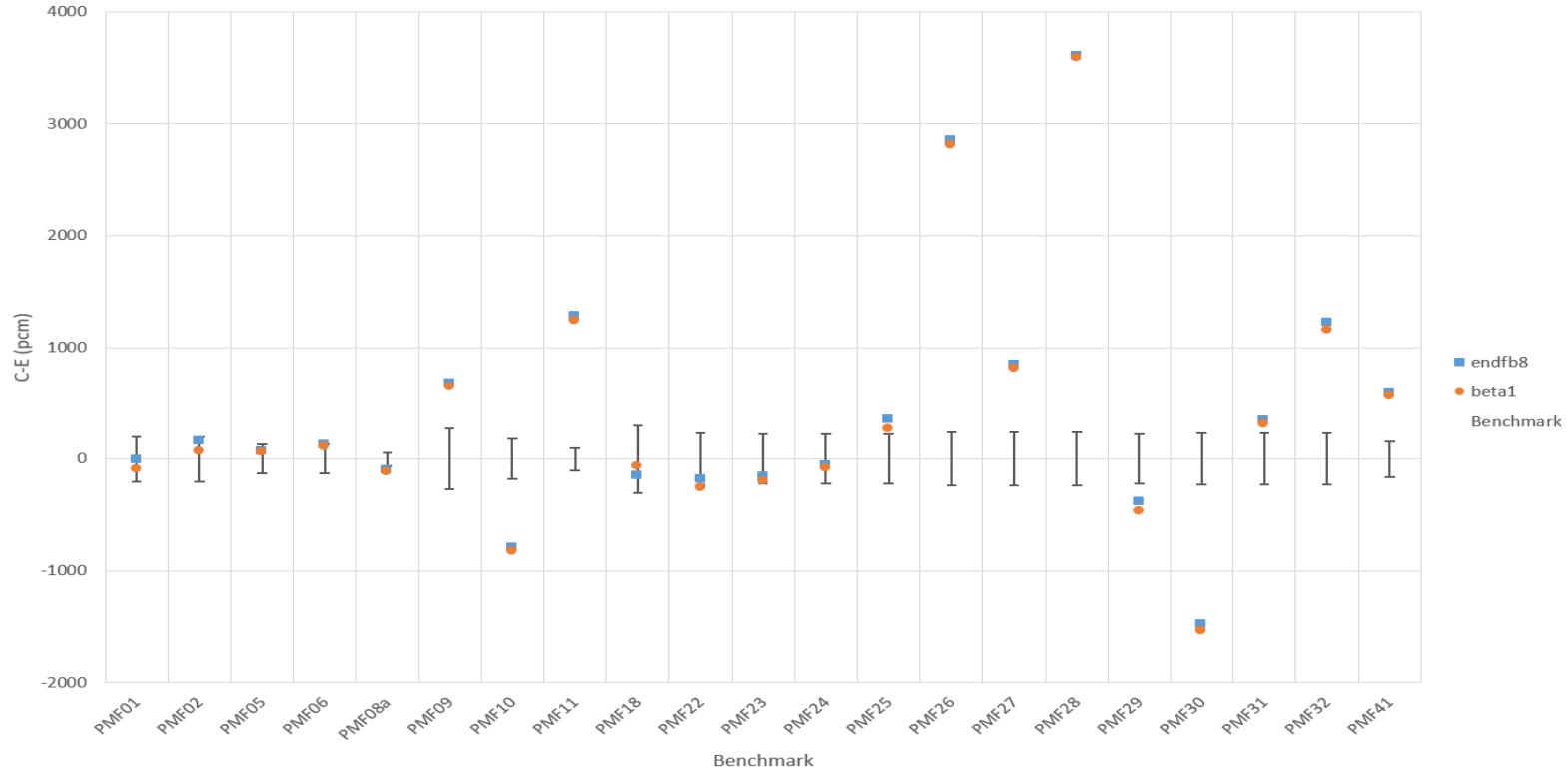 - Fixed file passes through NJOY without issue.

Tests

- 90 ICSBEP cases. Fast Metal systems

  - Pu, HEU, Mixed and U233 cores.

  - 16 different reflectors.

  - 1D Deterministic Sn transport and MCNP Monte Carlo Transport calculations.
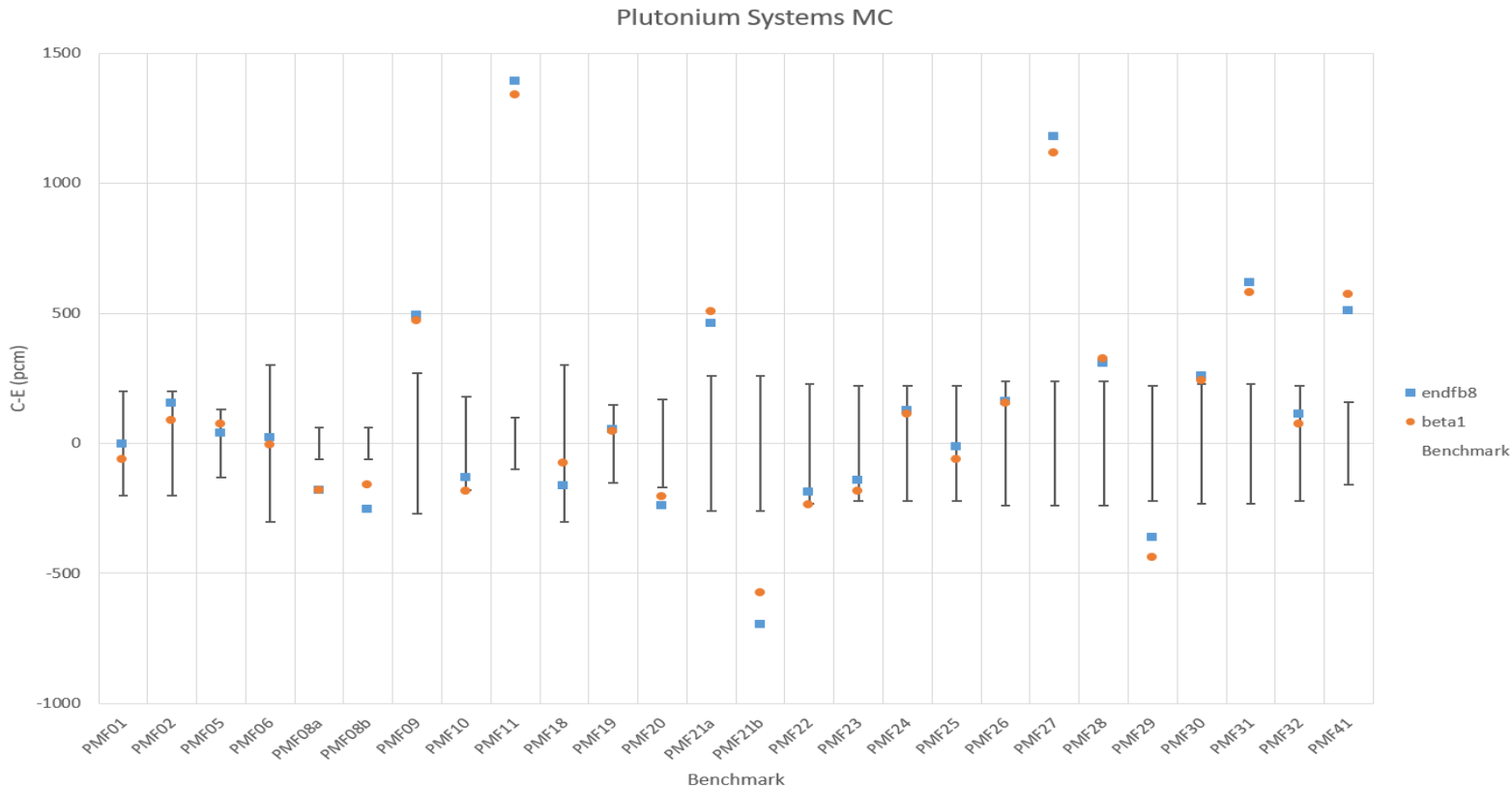
PMF Benchmarks

Plutonium Systems

PMF Benchmarks

Plutonium Systems MC

HMF Benchmarks

Uranium Systems
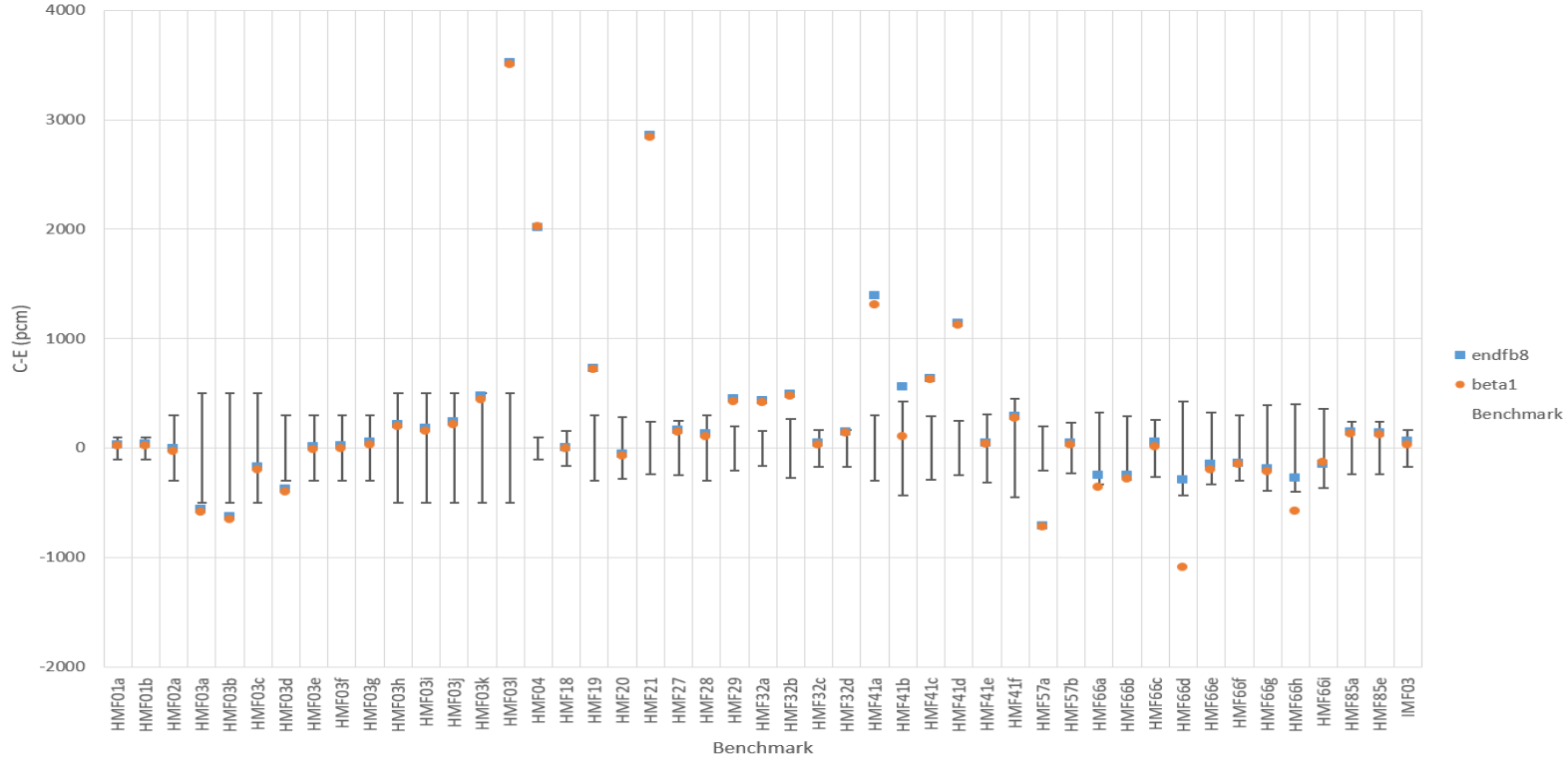
HMF Benchmarks
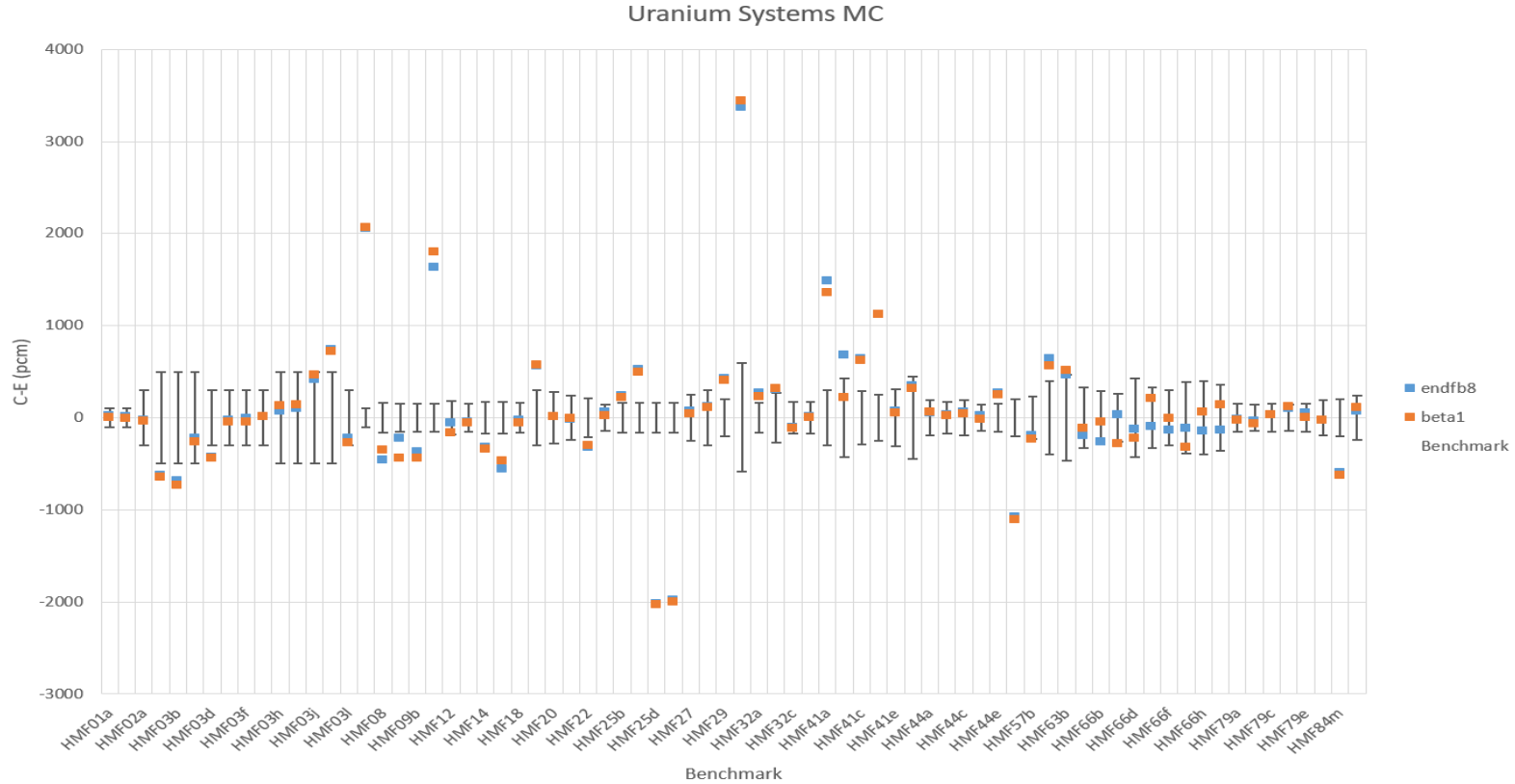
Uranium Systems MC

MMF Benchmarks

Mixed Metal Systems
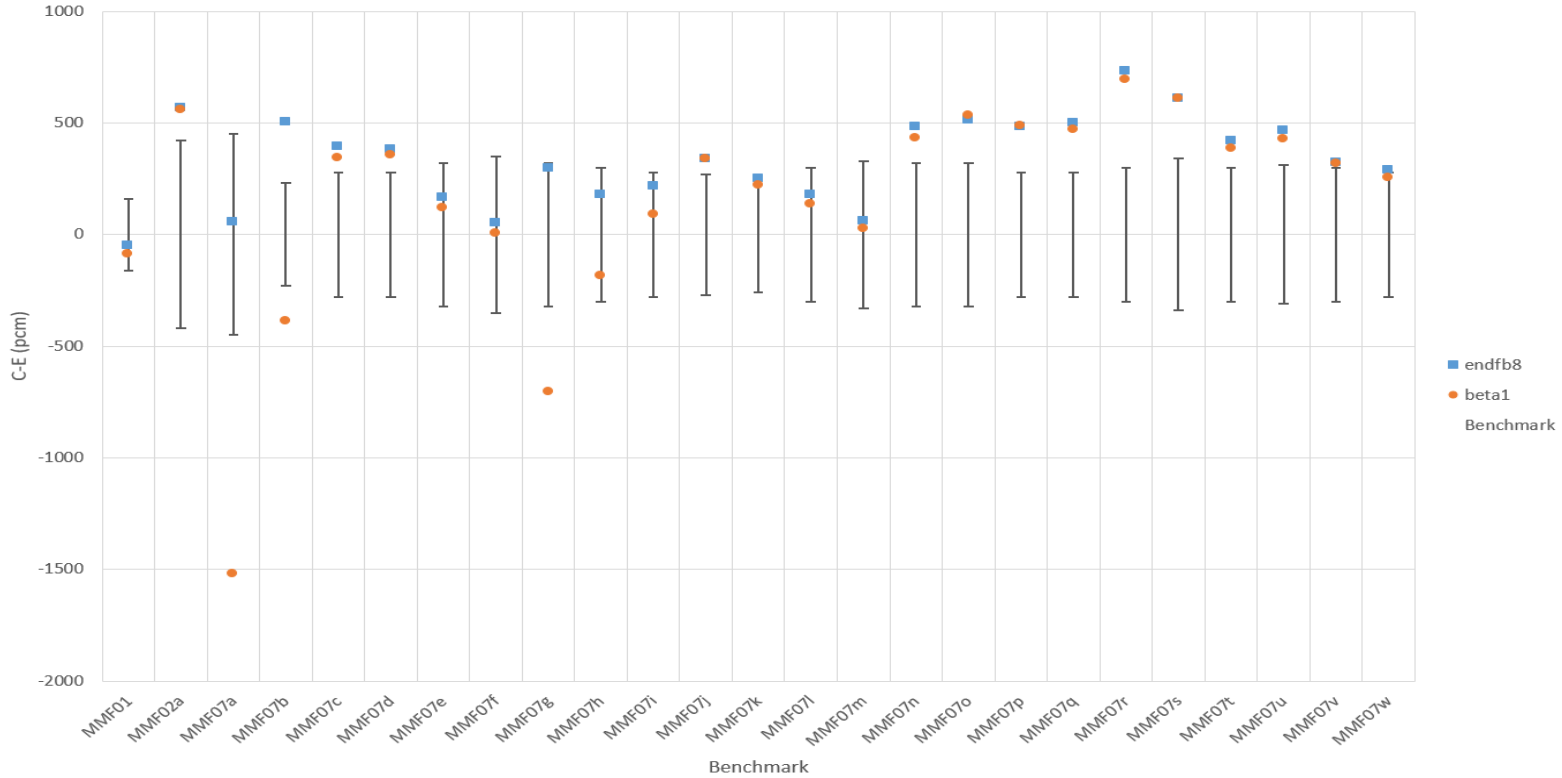
MMF Benchmarks

Mixed Metal Systems MC

U3MF Benchmarks

Uranium 233 Systems
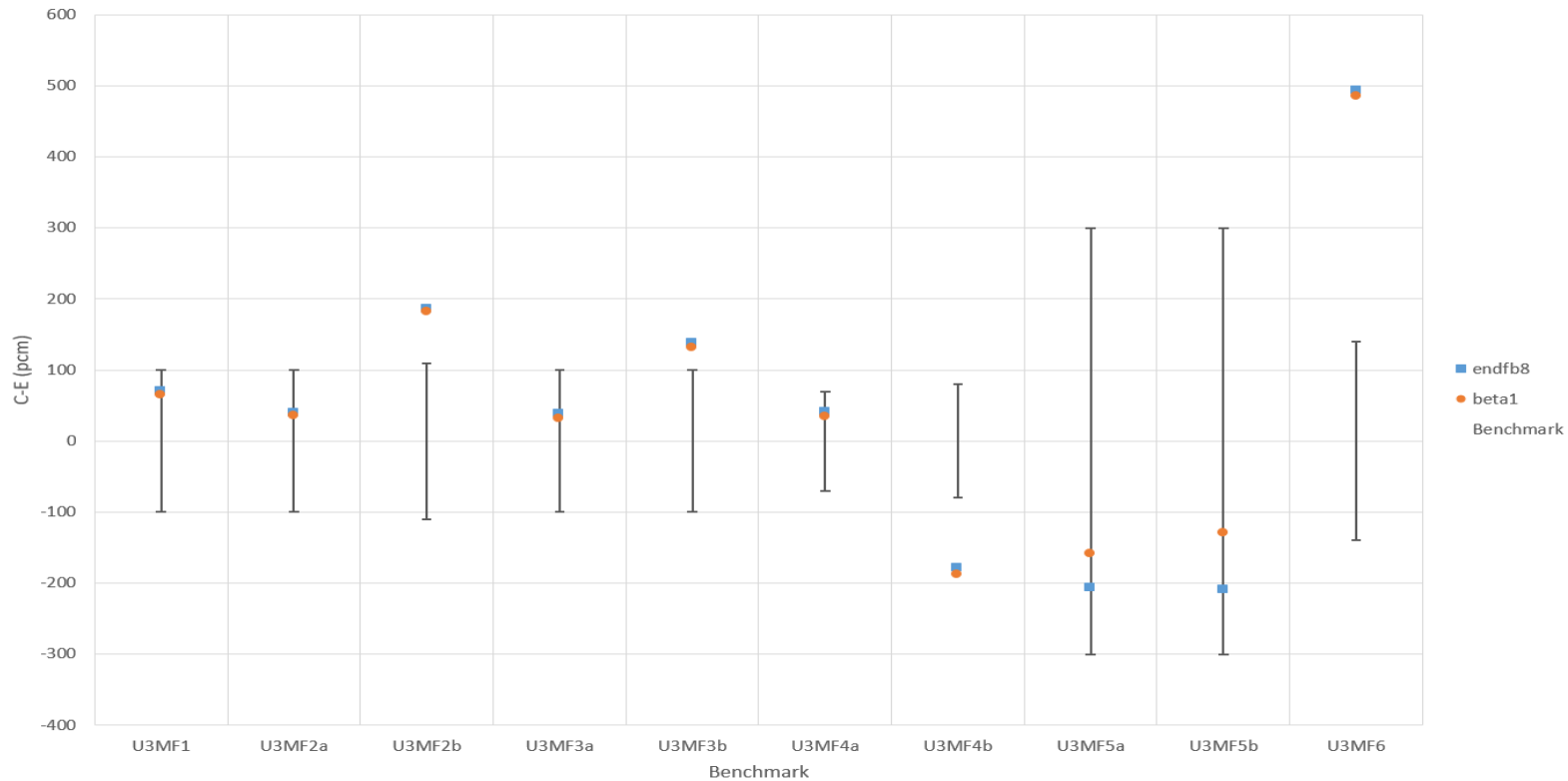
U3MF Benchmarks

Uranium 233 Systems MC
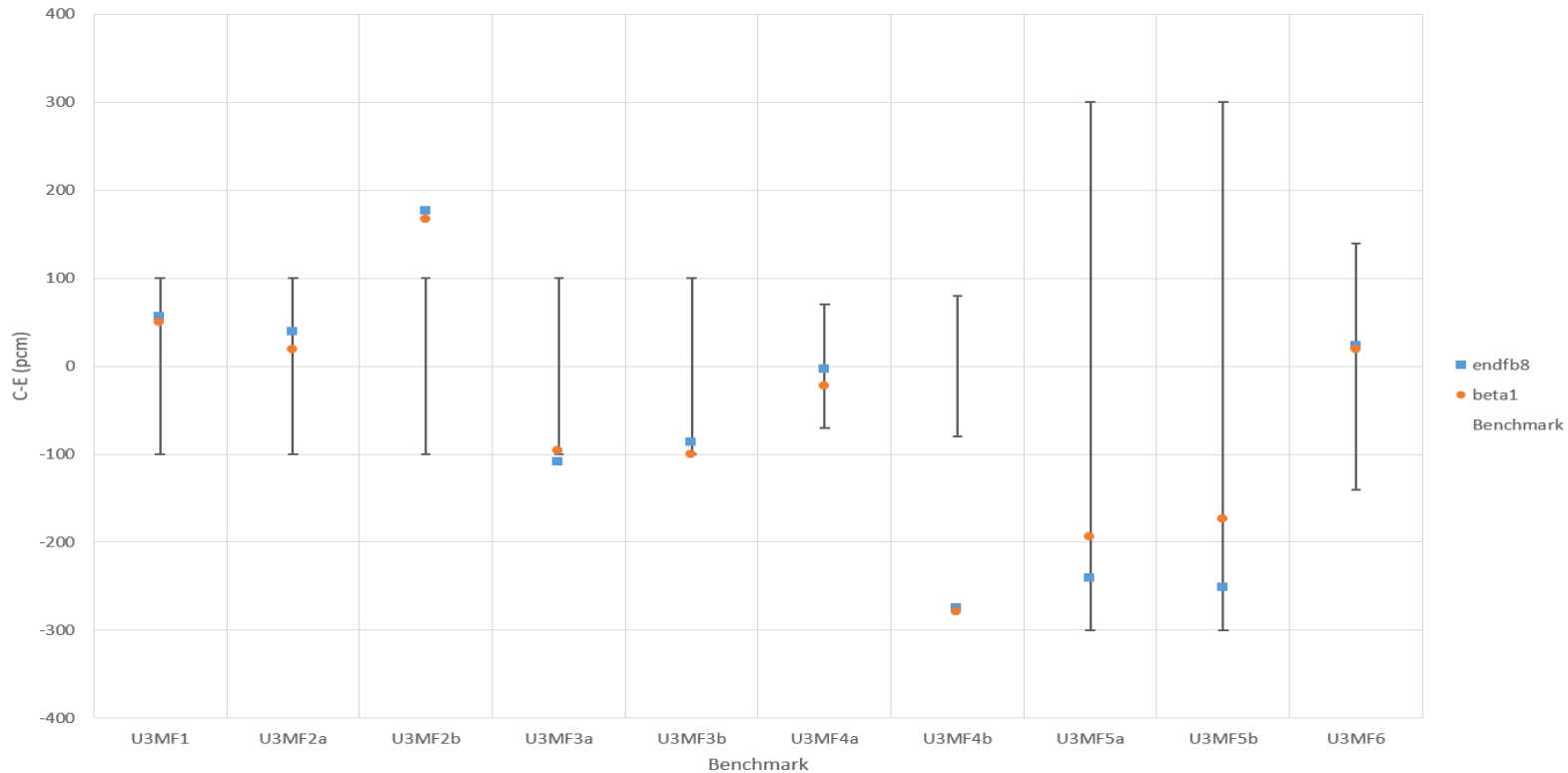
Goodness of Fit Metrics

- Chi Squared like parameter

$$\chi^2 = \sum \frac{\left(\left(k_{calc} - k_{exp}\right)/\delta k_{exp}\right)^2}{n}$$

- Average difference between calculation and benchmark values.

$$\langle|\Delta|\rangle = \sum \frac{\left|k_{calc} - k_{exp}\right|}{n}$$

Goodness of Fit Metrics

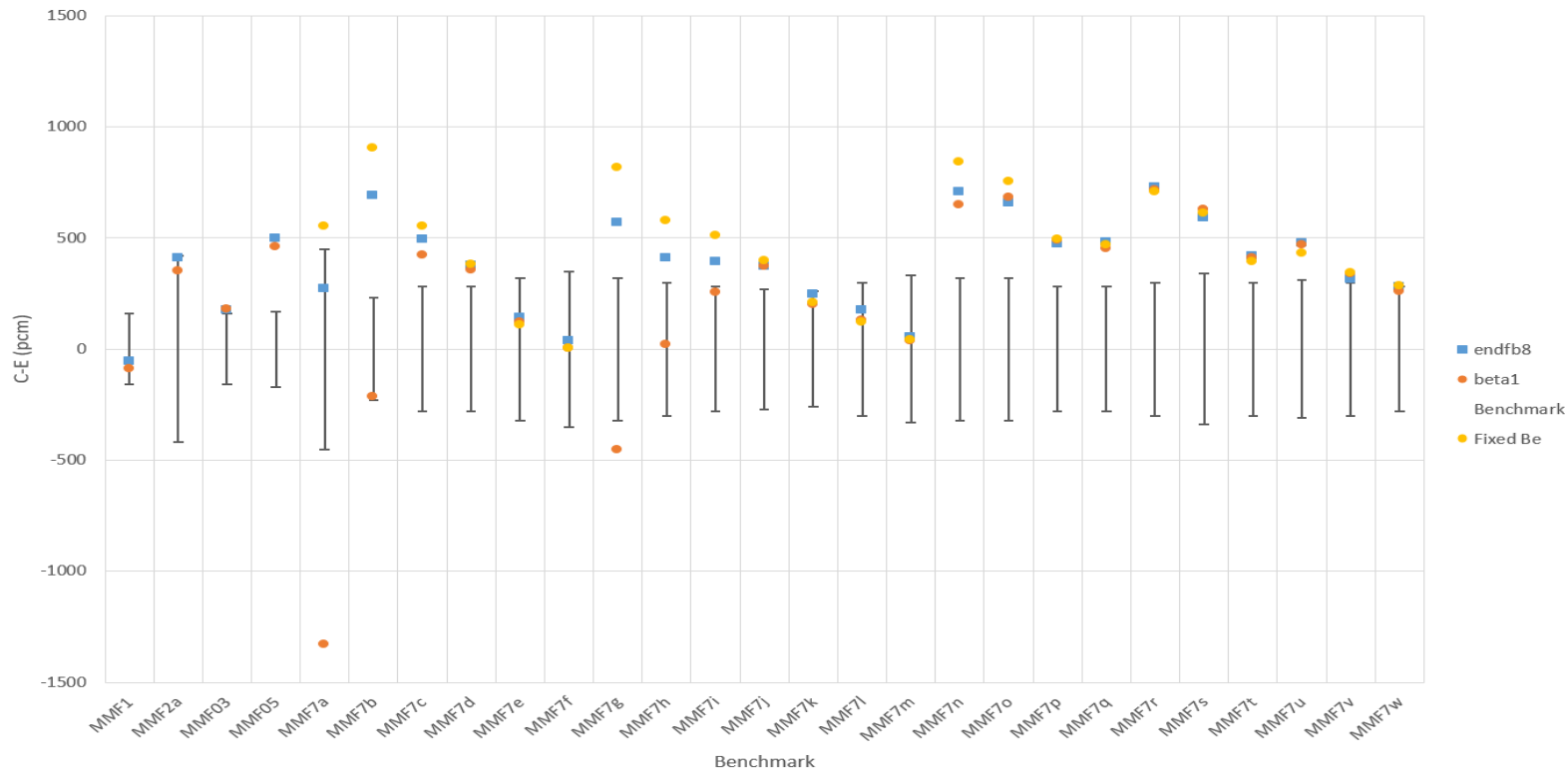| | "Chi Squared" | | | | | Average Difference | | | |
| | Groupwise | | Pointwise | | | Groupwise | | Pointwise | |
	ENDF8.0	beta1	ENDF8.0	beta1		ENDF8.0	beta1	ENDF8.0	beta1
ALL	13.81	13.79	10.29	10.27		451.16	463.66	358.47	355.09
HEU	15.01	15.12	14.26	14.70		453.68	463.52	393.16	397.20
MIX	1.69	2.08	2.43	2.17		340.47	387.88	388.41	373.41
PU	31.69	30.91	11.05	10.01		734.57	727.01	317.73	310.08
U233	2.43	2.33	1.87	1.81		160.14	144.08	126.20	112.20
Bare	0.56	0.72	2.20	1.79		102.84	113.28	211.54	204.00
Beryllium	1.80	2.16	2.27	2.15		326.72	373.28	354.30	335.70
Steel	107.63	105.52	0.41	0.43		2175.32	2132.89	111.00	113.67
HEU	1.03	1.05	1.12	1.05		92.04	101.74	90.00	92.33
Nat U	3.39	3.31	0.72	0.74		298.65	295.04	191.21	197.74

JEZEBEL Revisions

	Benchmark	error	k-effective		bias (pcm)	
			VIII.0	VIII.1	VIII.0	VIII.1
R2 simple	1	0.002	0.99998	0.99939	-2	-61
R4 simple	1	0.0011	1.00076	1.00024	76	24
R4 detailed A	0.99999	0.0011	1.00031	0.99977	32	-22
R4 detailed B	1.00016	0.0011	1.00077	1.00021	61	5
R4 detailed C	1.0002	0.0011	1.0005	0.99997	30	-23
R4 detailed D	1.00128	0.0011	1.00151	1.00095	23	-33

Conclusions/Observations

- Noticeable yet small decrease in Criticality.

  - A couple of HMF models have small increases (no groupwise models for these).
  - U233 Good, improvement for U3MF5

- Bug in beta1 tagged Be9 file causes big changes in models with thick Be reflectors

  - New file fixes problem but we still don't do well for Be Mixed metal (MMF7).
  - How does everyone else do with Be9 generally.

- No Major issues with Fast Critical systems in Groupwise or Pointwise calculations

- Changes in Criticality seem consistent with expectations of PFNS changes.

First Do No Harm

Thank you for your attention

Questions

Left table:

Reflector	System	k-exp	error	Groupwise C-E (pcm) ENDF8	Beta1	Pointwise C-E (pcm) ENDF8	Beta1
None	HMF01a	1	0.001	30.58	18.61	22	3
None	HMF01b	1	0.001	31.51	19.47	14	-10
Nat U	HMF02a	1	0.003	-7.75	-33.53	-27	-37
Nat U	HMF03a	1	0.005	-564.9	-585.46	-631	-649
Nat U	HMF03b	1	0.005	-632.95	-655.45	-685	-736
Nat U	HMF03c	1	0.005	-173.77	-197.76	-223	-265
Nat U	HMF03d	1	0.003	-374.21	-399.13	-437	-444
Nat U	HMF03e	1	0.003	13.03	-13.3	-27	-54
Nat U	HMF03f	1	0.003	20.49	-5.83	-6	-46
Nat U	HMF03g	1	0.003	50.84	24.23	14	11
WC	HMF03h	1	0.005	213.74	194.48	65	128
WC	HMF03i	1	0.005	175.12	151.18	97	138
WC	HMF03j	1	0.005	241.11	212.47	409	461
WC	HMF03k	1	0.005	473.48	443.28	739	721
Nickel	HMF03l	1	0.005	3521.19	3502.33	-223	-272
Light wate	HMF04	0.9985	0.001	2013.35	2024.8	2051	2058
None	HMF08	0.9989	0.0016			-461	-359
Beryllium	HMF09a	0.9992	0.0015			-228	-446
BeO	HMF09b	0.9992	0.0015			-371	-443
Polythene	HMF11	0.9989	0.0015			1634	1794
Aluminiur	HMF12	0.9992	0.0018			-59	-172
Steel	HMF13	0.999	0.0015			-47	-57
DU	HMF14	0.9989	0.0017			-328	-348
None	HMF15	0.9996	0.0017			-561	-470
None	HMF18	1	0.0016	5.09	-8.71	-28	-57
Graphite	HMF19	1	0.003	721.76	717.98	559	572
Polythene	HMF20	1	0.0028	-58.06	-70.05	9	13
Steel	HMF21	1	0.0024	2851.44	2834.2	-25	-11
Aluminiur	HMF22	1	0.0021			-324	-309
Vanadium	HMF25a	0.9987	0.0014			60	23
Vanadium	HMF25b	0.999	0.0016			234	216
Vanadium	HMF25c	0.9991	0.0016			517	493
Vanadium	HMF25d	0.9995	0.0016			-2020	-2034
Vanadium	HMF25e	0.9991	0.0016			-1989	-2004
Lead	HMF27	1	0.0025	164.19	147.64	66	42
Nat U	HMF28	1	0.003	128.88	102.5	121	103
DU	HMF29	1	0.002	444.04	421.79	418	402
Polythene	HMF31	1	0.0059			3366	3437

Right table:

Reflector	System	k-exp	error	Groupwise C-E (pcm) ENDF8	Beta1	Pointwise C-E (pcm) ENDF8	Beta1
Nat U	HMF32a	1	0.0016	431.05	416.35	261	230
Nat U	HMF32b	1	0.0027	489.3	475	301	309
Nat U	HMF32c	1	0.0017	42.82	31.09	-110	-114
Nat U	HMF32d	1	0.0017	148.99	139.17	8	-1
Beryllium	HMF41a	1.0013	0.003	1393.12	1306.57	1486	1356
Beryllium	HMF41b	1.0022	0.0043	557.47	107.14	678	218
Graphite	HMF41c	1.0006	0.0029	633.74	622.61	642	621
Graphite	HMF41d	1.0006	0.0025	1135.85	1120.48	1121	1124
Graphite	HMF41e	1.0006	0.0031	46.5	32.04	64	51
Graphite	HMF41f	1.0006	0.0045	284.78	271.46	346	312
Aluminiur	HMF44a	0.9995	0.0019			45	62
Aluminiur	HMF44b	0.9995	0.0017			25	16
Aluminiur	HMF44c	0.9995	0.0019			60	39
Aluminiur	HMF44d	0.9995	0.0014			19	-22
Aluminiur	HMF44e	0.9995	0.0015			262	247
Lead	HMF57a	1	0.002	-709.24	-725.59	-1081	-1107
Lead	HMF57b	1	0.0023	43.07	27.66	-194	-235
LiD	HMF63a	0.9993	0.004			639	563
LiD	HMF63b	0.9988	0.0047			459	506
Beryllium	HMF66a	1.003	0.0033	-251.1	-356.81	-196	-119
Beryllium	HMF66b	1.0023	0.0029	-250.08	-285.44	-264	-49
Beryllium	HMF66c	1.0023	0.0026	54.23	11.92	30	-282
Beryllium	HMF66d	1.0043	0.0043	-293.36	-1087.37	-133	-229
Beryllium	HMF66e	1.003	0.0033	-153.21	-196.59	-94	207
Beryllium	HMF66f	1.0028	0.003	-140.66	-151.49	-134	-8
Beryllium	HMF66g	1.0048	0.0039	-189.05	-214.92	-120	-324
Beryllium	HMF66h	1.0039	0.004	-278.02	-575.89	-149	58
Beryllium	HMF66i	1.0027	0.0036	-150.19	-131.42	-140	137
Titanium	HMF79a	0.9996	0.0015			-18	-27
Titanium	HMF79b	0.9996	0.0014			-39	-67
Titanium	HMF79c	0.9996	0.0015			28	24
Titanium	HMF79d	0.9996	0.0014			101	119
Titanium	HMF79e	0.9996	0.0015			52	3
Aluminiur	HMF84a	0.9994	0.0019			-29	-34
Titanium	HMF84m	0.9994	0.002			-600	-628
	HMF85a	0.9995	0.0024	147.04	131.26		
Thorium	HMF85e	0.9995	0.0024	135.08	119.25	71	107
None	IMF03	1	0.0017	60.34	29.84	73	78

Reflector	System	k-exp	error	Groupwise C-E (pcm) ENDF8	Beta1	Pointwise C-E (pcm) ENDF8	Beta1
HEU	MMF01	1	0.0016	-51.11	-87.96	-55	-91
Nat U	MMF02a	1	0.0042	569.43	558.55	411	352
None	MMF03	0.9993	0.0016			176	179
Aluminium	MMF05	0.999	0.0017			498	461
Beryllium	MMF07a	1	0.0045	56.17	-1518.85	272	-1329
Beryllium	MMF07b	1	0.0023	503.16	-389.37	690	-216
Beryllium	MMF07c	1	0.0028	395.9	345.43	495	424
Beryllium	MMF07d	1	0.0028	380.77	354.57	377	356
Beryllium	MMF07e	1	0.0032	166.1	118.2	143	119
Beryllium	MMF07f	1	0.0035	50.61	6.85	38	3
Beryllium	MMF07g	1	0.0032	296.63	-703.58	569	-455
Beryllium	MMF07h	1	0.003	179.87	-186.11	409	18
Beryllium	MMF07i	1	0.0028	215.67	91.42	392	254
Beryllium	MMF07j	1	0.0027	339.2	337.77	370	372
Beryllium	MMF07k	1	0.0026	250.15	222.16	244	199
Beryllium	MMF07l	1	0.003	179.29	135.81	175	127
Beryllium	MMF07m	1	0.0033	61.94	27.4	53	36
Beryllium	MMF07n	1	0.0032	482.25	433.53	705	647
Beryllium	MMF07o	1	0.0032	511.59	534.94	656	683
Beryllium	MMF07p	1	0.0028	484.24	485.72	473	491
Beryllium	MMF07q	1	0.0028	498.91	470.09	480	450
Beryllium	MMF07r	1	0.003	733.51	692.58	729	714
Beryllium	MMF07s	1	0.0034	608.55	608.7	591	627
Beryllium	MMF07t	1	0.003	418.79	387.83	417	410
Beryllium	MMF07u	1	0.0031	467.44	428.07	475	470
Beryllium	MMF07v	1	0.003	321.98	317.32	313	339
Beryllium	MMF07w	1	0.0028	288.47	254.23	281	260

Reflector	System	k-exp	error	Groupwise C-E (pcm) ENDF8	Beta1	Pointwise C-E (pcm) ENDF8	Beta1
None	PMF01	1	0.002	-9.07	-88.32	-2	-61
None	PMF02	1	0.002	156.89	72.27	153	87
Tungsten	PMF05	1	0.0013	70.18	63.96	37	73
Nat U	PMF06	1	0.0013	131.37	108.91	20	-6
Thorium	PMF08a	1	0.0006	-95.77	-113.61	-181	-182
Thorium	PMF08b	1	0.0006			-253	-159
Aluminium	PMF09	1	0.0027	679.29	647.32	493	469
Nat U	PMF10	1	0.0018	-789.86	-821.57	-132	-184
Light Water	PMF11	1	0.001	1282.89	1235.97	1392	1337
Beryllium	PMF18	1	0.003	-146.17	-62.94	-165	-77
Beryllium	PMF19	0.9992	0.0015			53	46
DU	PMF20	0.9993	0.0017			-241	-206
Beryllium	PMF21a	1	0.0026			462	505
BeO	PMF21b	1	0.0026			-697	-575
None	PMF22	1	0.0023	-181.22	-253.69	-189	-238
Graphite	PMF23	1	0.0022	-160.5	-201.54	-143	-184
Polythene	PMF24	1	0.0022	-59.67	-84.41	126	110
Steel	PMF25	1	0.0022	348.94	271.18	-14	-63
Steel	PMF26	1	0.0024	2848.55	2814.68	160	153
Polythene	PMF27	1	0.0024	842.02	810.42	1178	1116
Steel	PMF28	1	0.0024	3601.16	3591.89	307	323
None	PMF29	1	0.0022	-381	-463.24	-364	-440
Carbon	PMF30	1	0.0023	-1479.86	-1536.45	259	242
Polythene	PMF31	1	0.0023	347.62	314.08	617	580
Steel	PMF32	1	0.0023	1226.5	1152.51	113	75
DU	PMF41	1	0.0016	587.52	558.15	510	571
None	SMF08	1.0026	0.0034			-651	-620

Reflector	System	k-exp	error	Groupwise C-E (pcm)		Pointwise C-E (pcm)	
				ENDF8	Beta1	ENDF8	Beta1
None	U3MF1	1	0.001	69.85	65.39	56	50
HEU	U3MF2a	1	0.001	39.73	35.73	39	19
HEU	U3MF2b	1	0.0011	185.29	181.53	176	167
Nat U	U3MF3a	1	0.001	38.1	31.79	-109	-96
Nat U	U3MF3b	1	0.001	138.58	131.41	-87	-101
Tungsten	U3MF4a	1	0.0007	40.78	33.9	-4	-23
Tungsten	U3MF4b	1	0.0008	-178.99	-187.29	-275	-279
Beryllium	U3MF5a	1	0.003	-207.13	-159.22	-241	-194
Beryllium	U3MF5b	1	0.003	-209.19	-129.61	-252	-174
Nat U	U3MF6	1	0.0014	493.81	484.91	23	19