

Benchmarking ENDF/B-VII beta2

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CSEWG meeting
BNL, June 27, 2006

❖ Criticality safety benchmarks

- overview, Pb, Gd, F, W, H₂O, ...

❖ (Fusion) shielding

- Oktavian (Al, Co, Cr, Cu, LiF, Mo, Mn, Si, Ti, W, Zr)
- FNS (Be, C, N, O, Fe, Pb)
- LLNL (⁶Li, ⁷Li, Be, C, N, O, Mg, Al, Ti, Fe, Pb, H₂O, D₂O, CH₂, CF₂)
(Wim Haeck, SCK)
- NIST (Cd, H₂O)

❖ Delayed neutrons (β_{eff})

Processing ENDF/B-VII beta2

- By Alfred Hogenbirk & Marieke Duijvestijn
- NJOY-99.125
- For MCNP-4C3 (and MCNPX-2.5.0, MCNP-5)
- Problems:

Rh-103	MCNP-expung error
Pa-231, Pa-233, Th-232	Wrong TYR from NJOY
Am-242, Am-242m	Crash in HEATR
Es-253	Crash in PURR

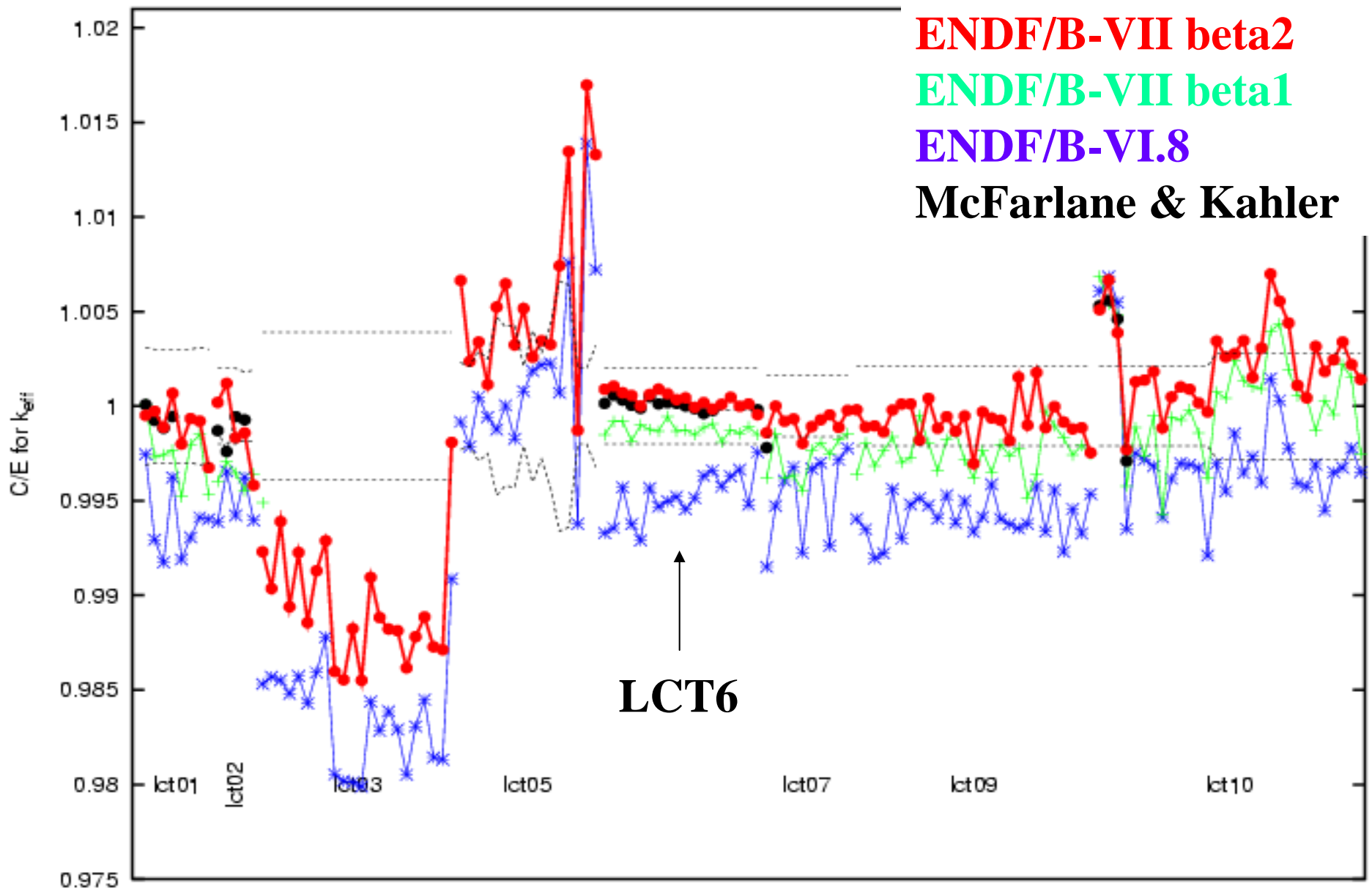
723 ICSBEP benchmarks



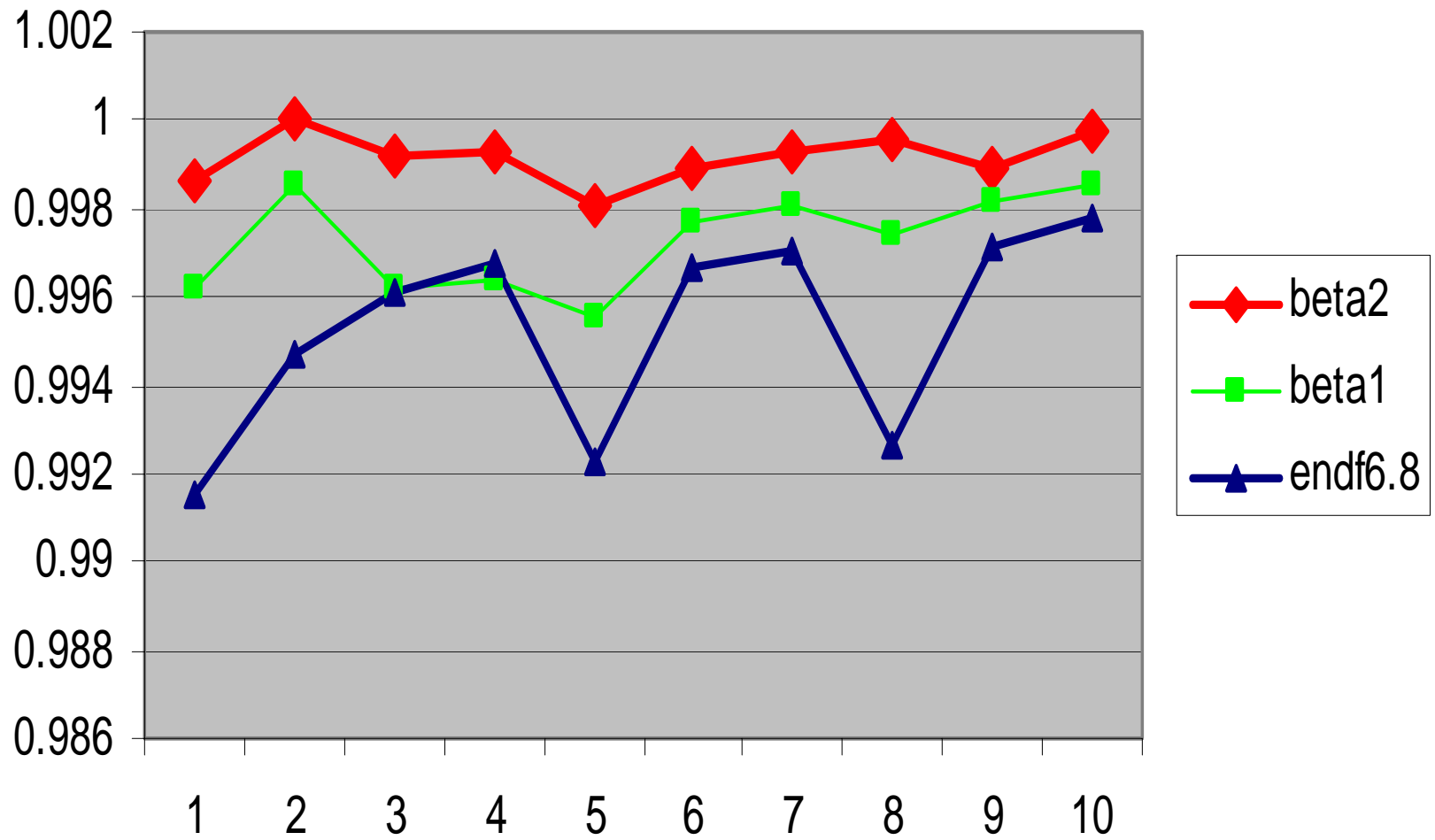
Thermal / intermediate / fast / mixed spectrum

	COMP	MET	SOL	total
LEU	257 / / /	1 / / /	49	307
IEU	6 / 4 / /	/ / 16 /		26
HEU	/ 6 / /	42 / 5 / 66 / 5	87	211
MIX	34 / / 1 /	/ / 4 /	3	42
PU	/ 1 / /	/ 1 / 7 / 6	105	120
U233	8 / / /	/ / 4 /	5	17

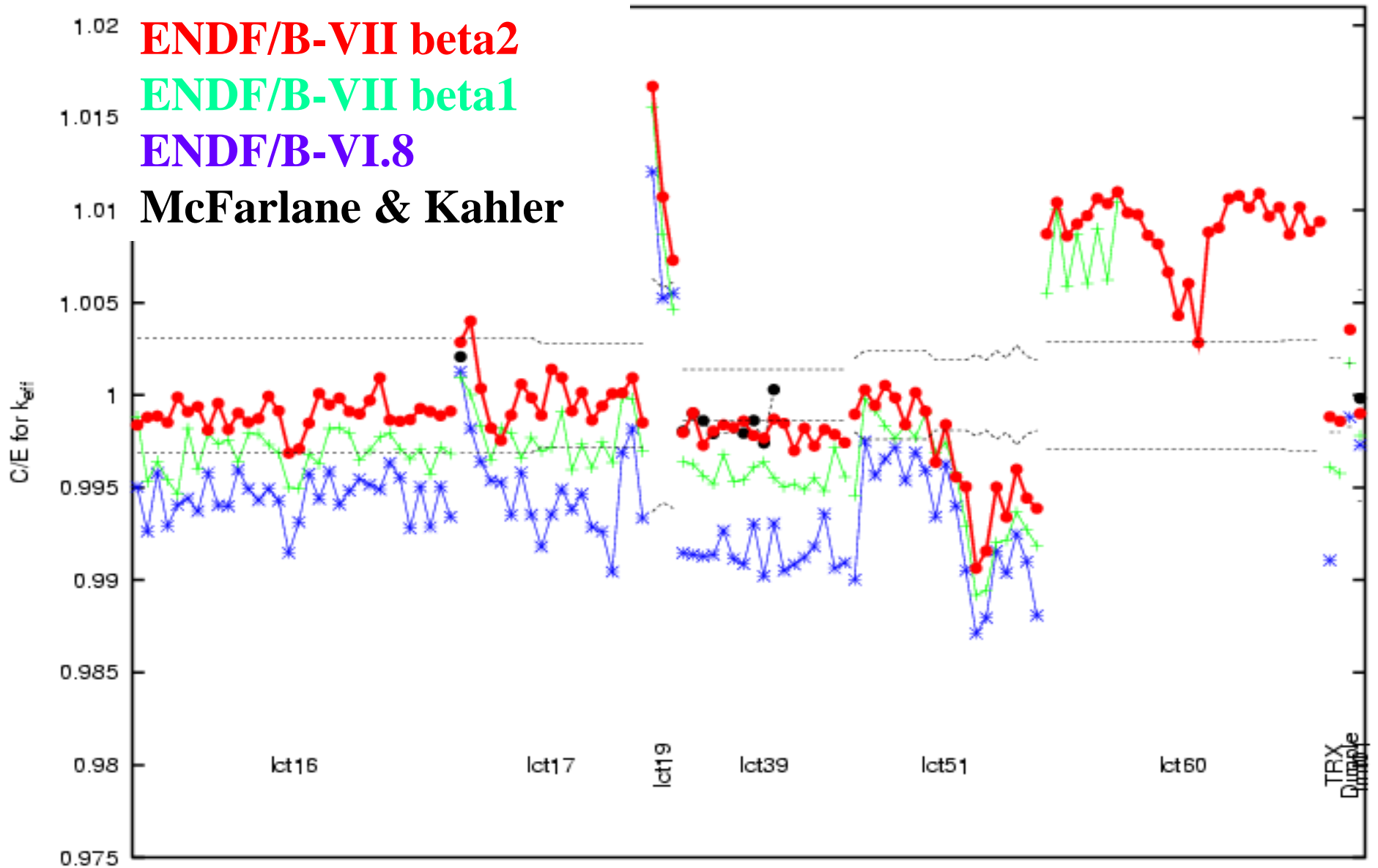
LEU-COMP-THERM (1)



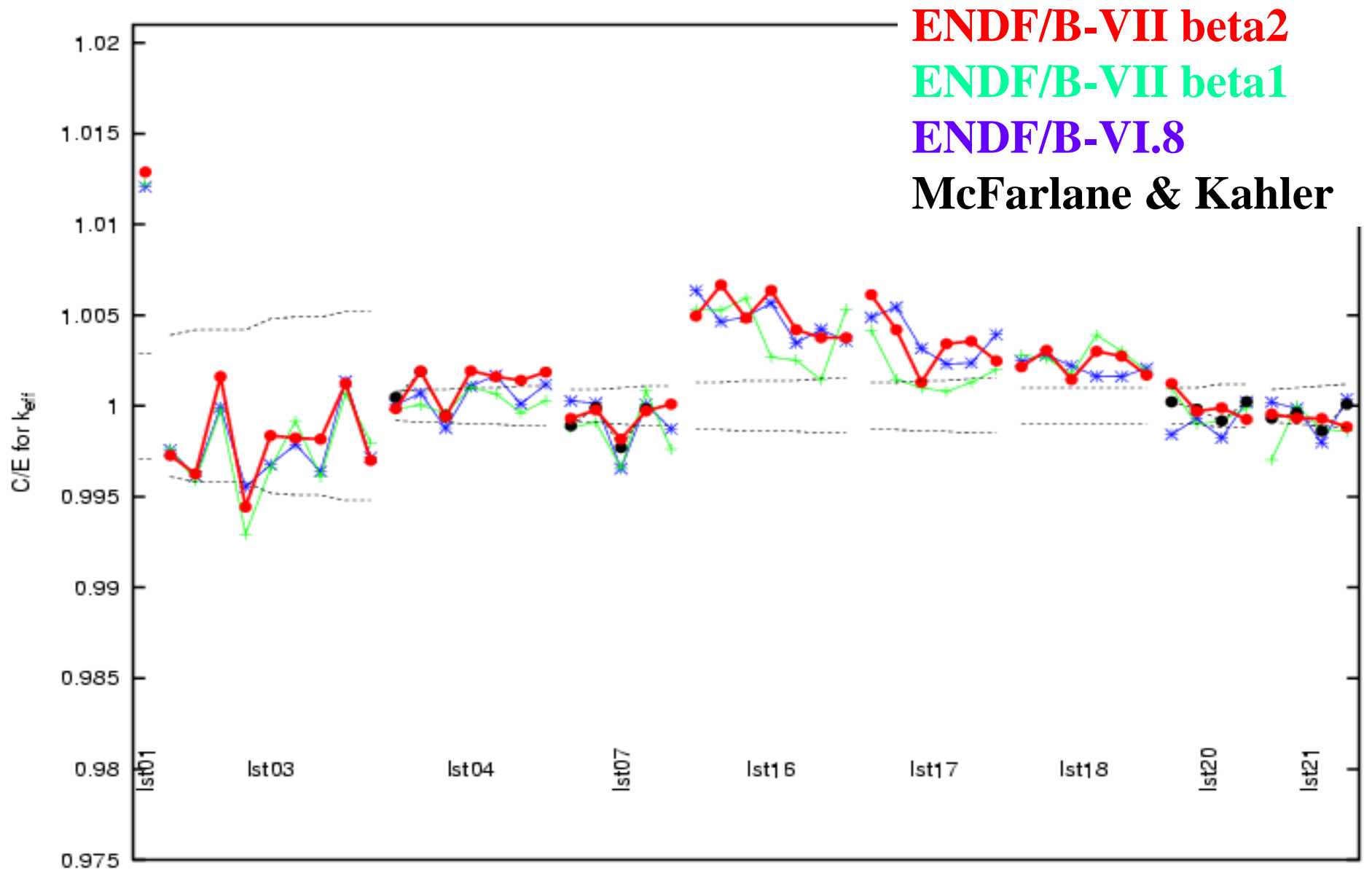
LCT7 (Valduc)



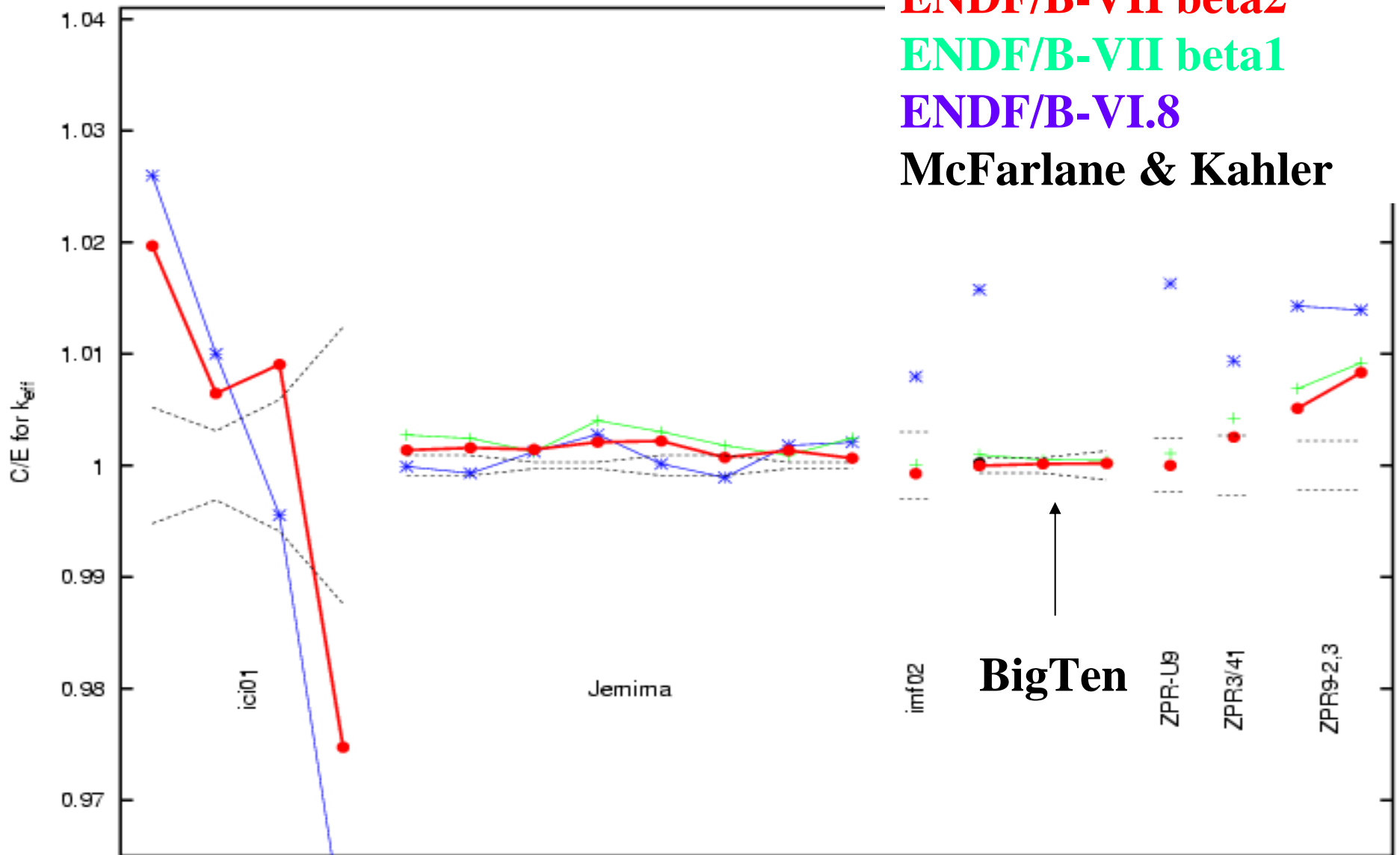
LEU-COMP-THERM (2)



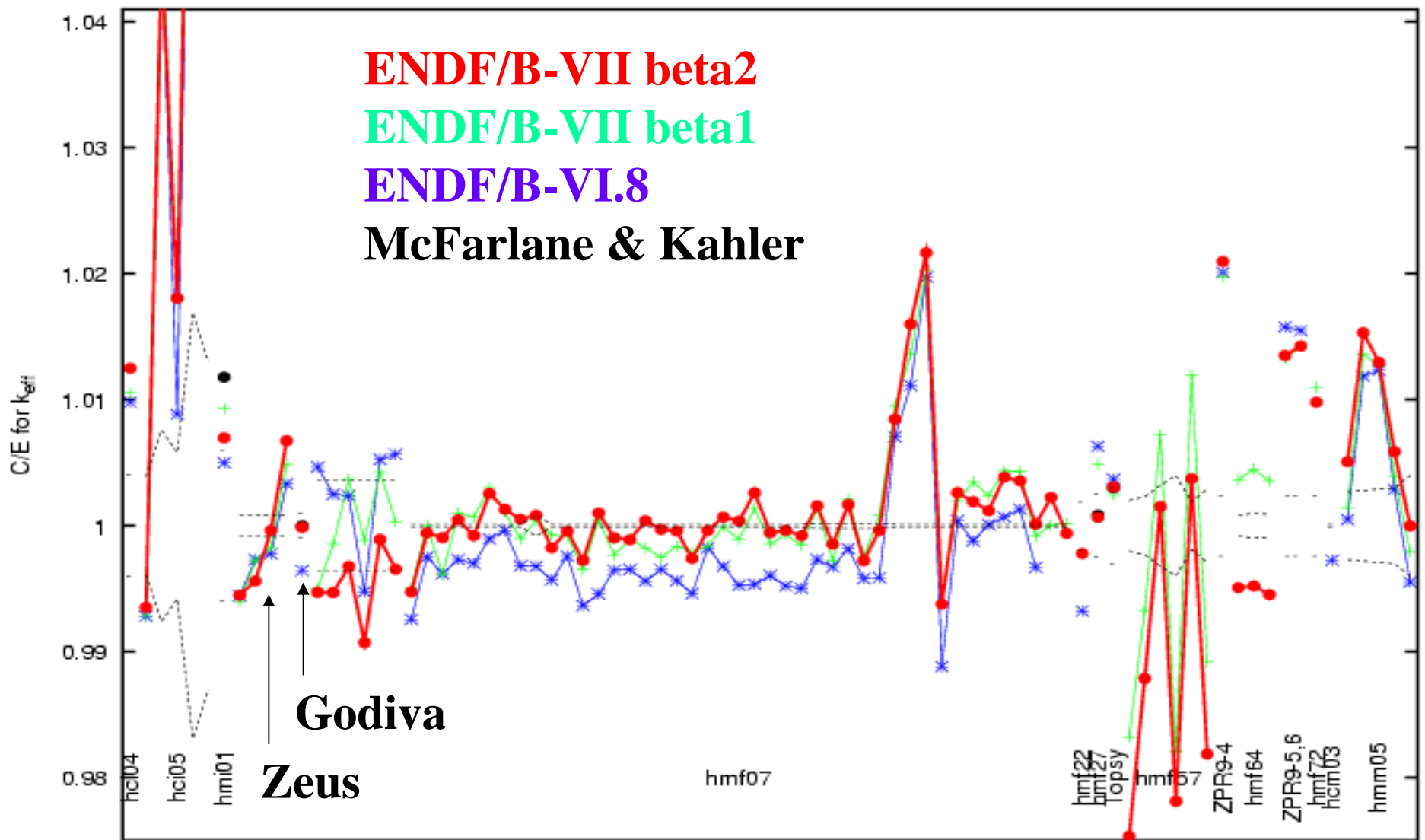
LEU-SOL-THERM



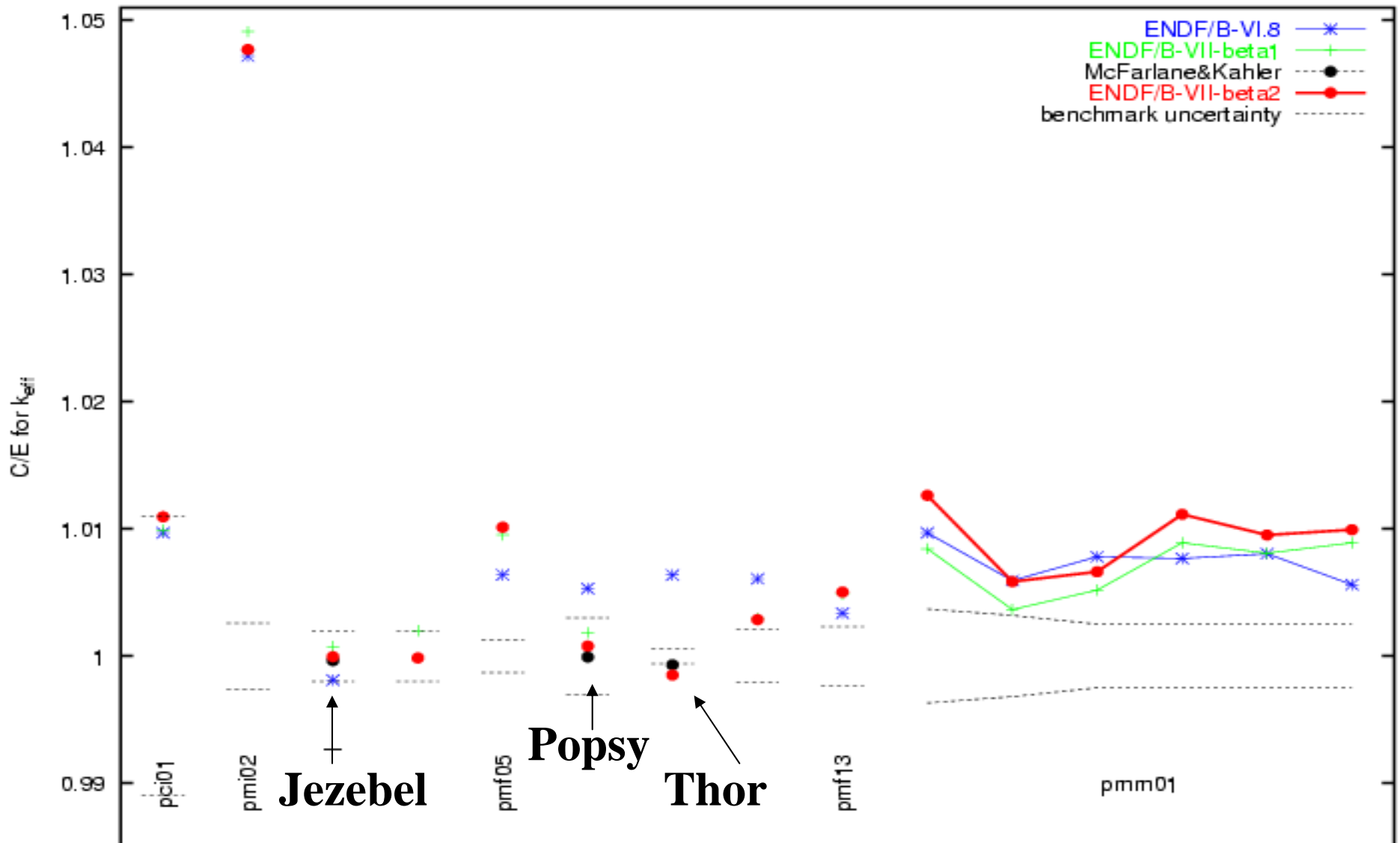
IEU-COMP-INTER, IEU-MET-FAST



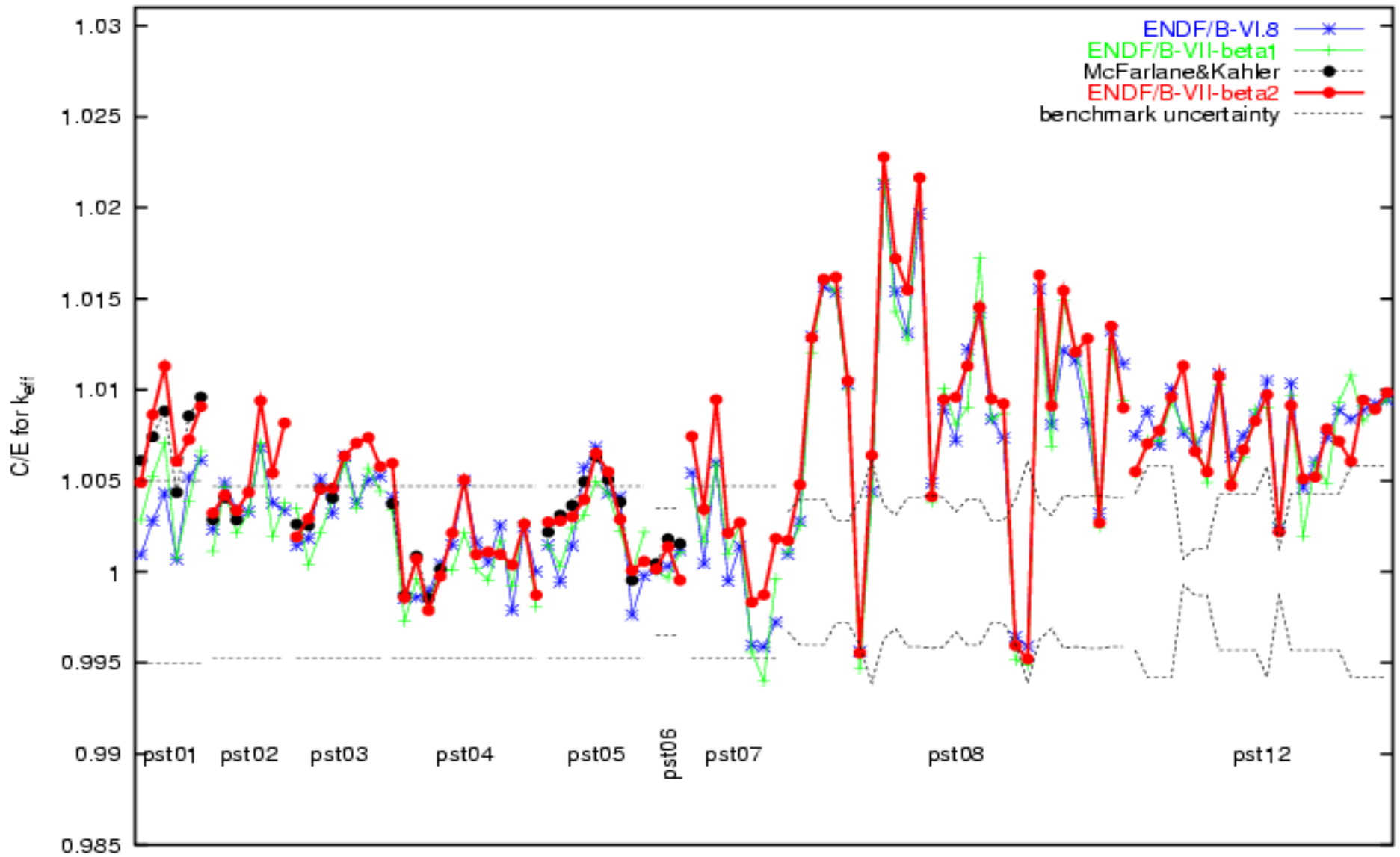
HEU-MET-FAST



PU-MET-FAST



PU-SOL-THERM



C/E-1 (in pcm)

	COMP	MET	SOL
LEU	20 / / /	-99 / / /	137
IEU	55 / 254 / /	/ / 167 /	
HEU	/1791 / /	55 / 69 / -15 / 785	122
MIX	448 / /73 /	/ / 194 /	178
PU	/1095 / /	/4707 / 244 / 927	618
U233	156 / / /	/ / -348 /	311

Pu: systematically higher?

beta2-beta1 [pcm]

	COMP	MET	SOL
LEU	191/ / /	119/ / /	73
IEU	207/ /-94/	/ / /	
HEU	/ 37/ /	270/ -4/-122/195	108
MIX	/ / 54/	/ / -9/	
PU	/ 103/ /	/ / -67/209	110
U233	432/ / /	/ /-255/	

beta2-endf6.8 [pcm]

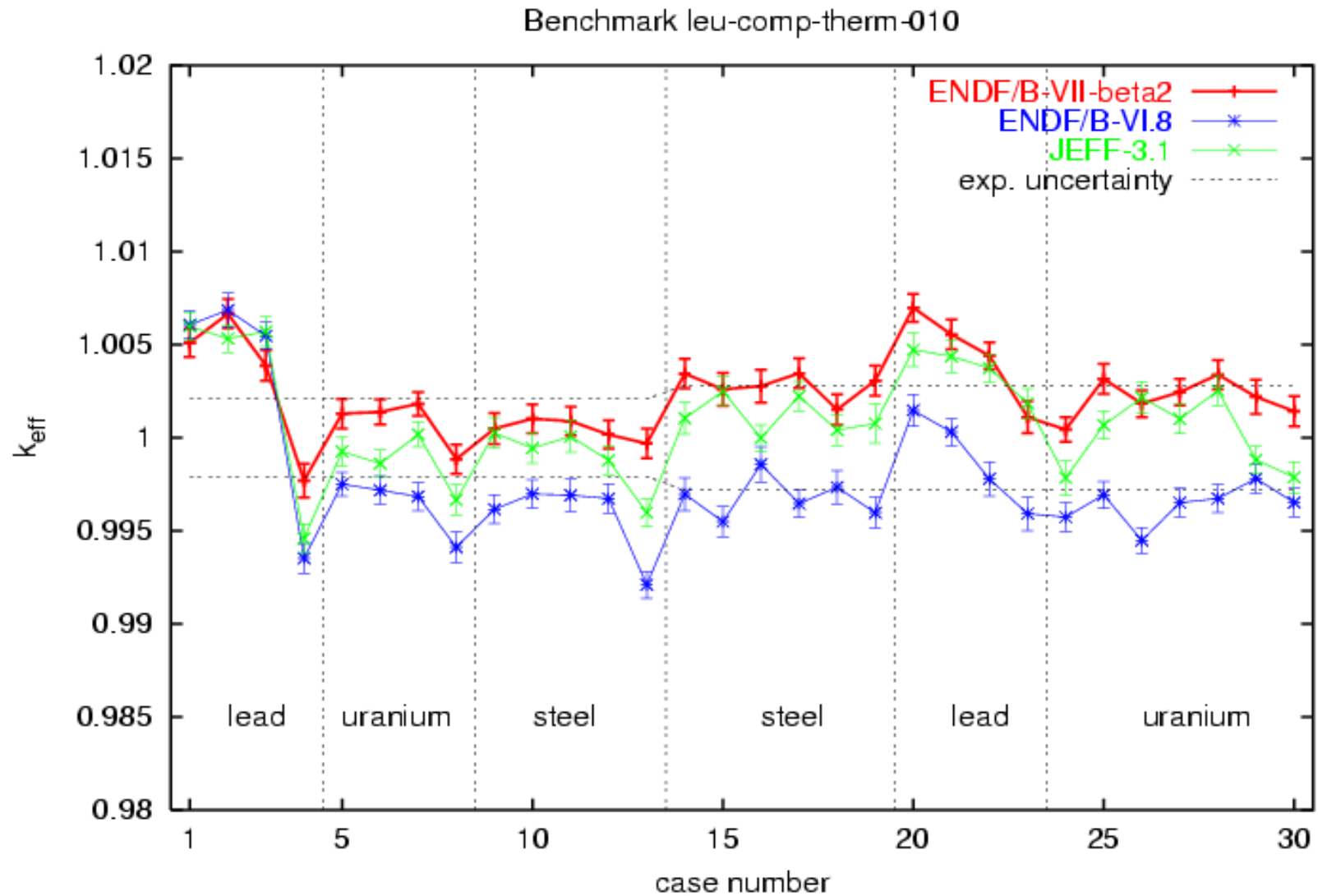
	COMP	MET	SOL
LEU	488/ / /	171/ / /	30
IEU	355/ / -407/	/ / /	
HEU	/ 349/ /	382/ 112/ 164/323	-19
MIX	72/ /-1409/	/ / 124/	277
PU	/ 127/ /	/ /-112/182	87
U233	538/ / /	/ / -10/	604

Correlation with spectrum?

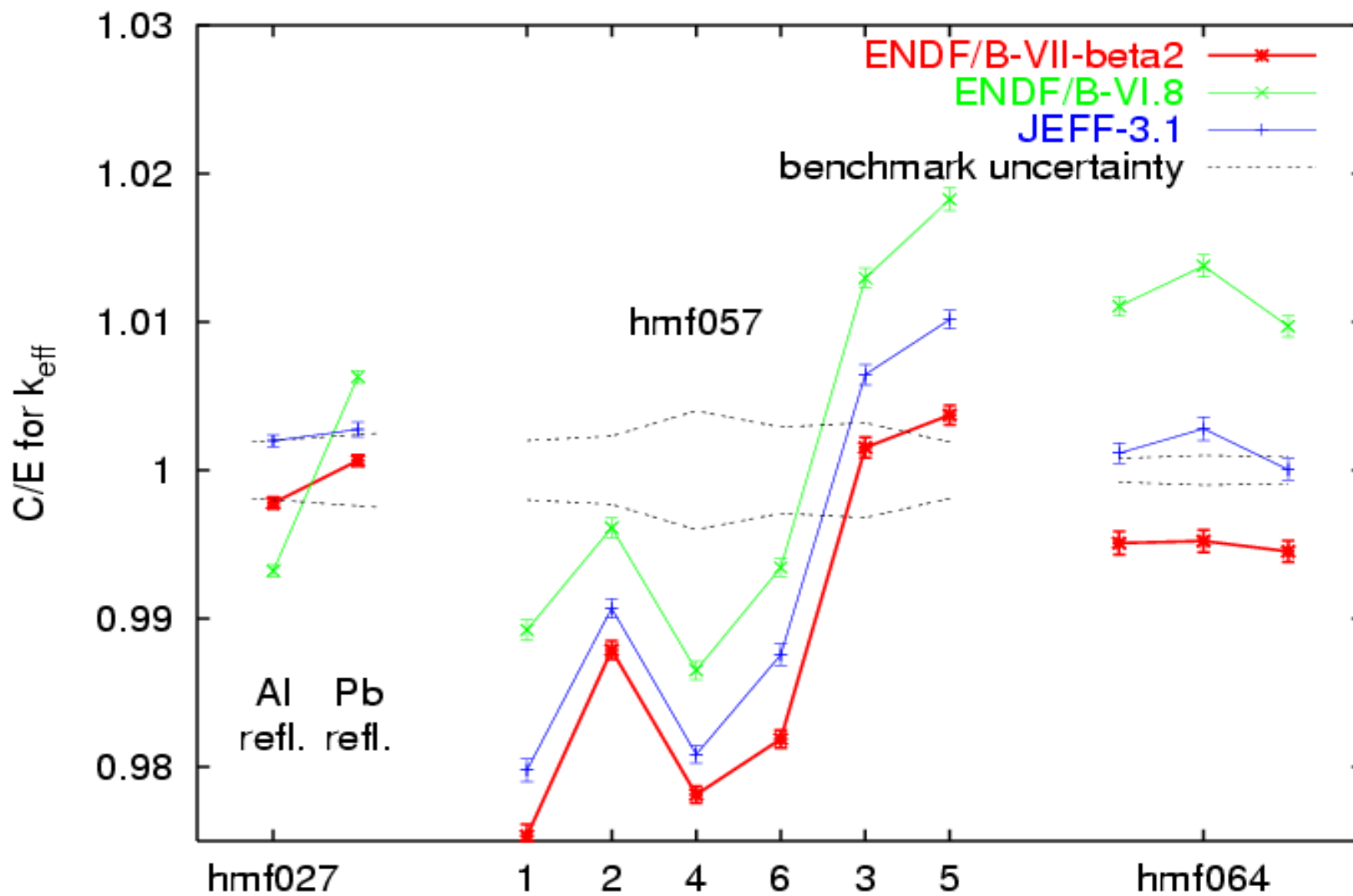
- Beta2: $1.000 - 38e-5 \times E_f$
- VI.8: $0.997 - 53e-5 \times E_f$
- Jeff-3.1: $0.998 - 54e-5 \times E_f$

- Pu only:
- Beta2: $1.002 - 84e-5 \times E_f$
- VI.8: $1.009 + 42e-5 \times E_f$
- Jeff-3.1: $1.002 - 77e-5 \times E_f$

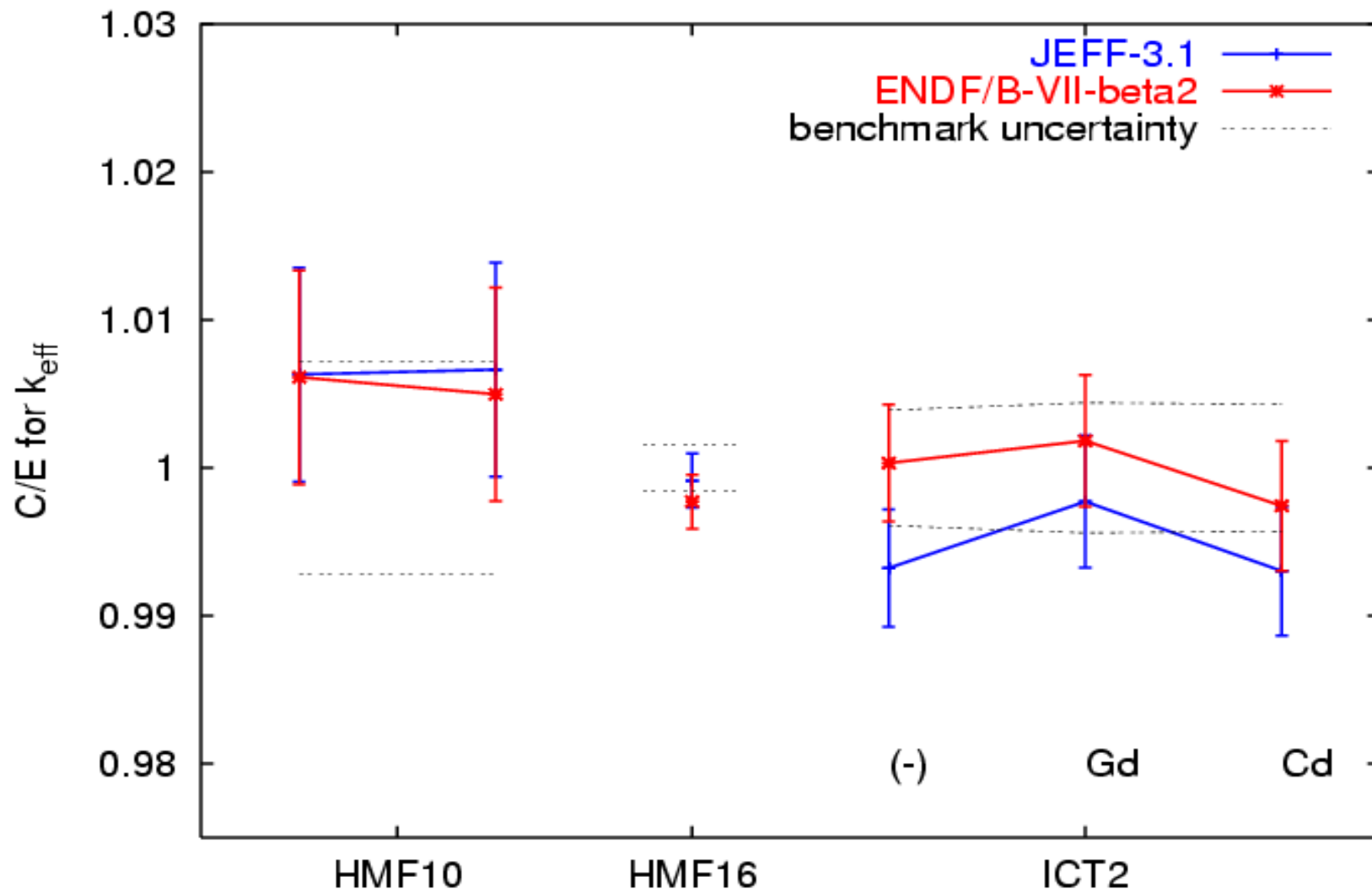
Pb: leu-comp-therm-010



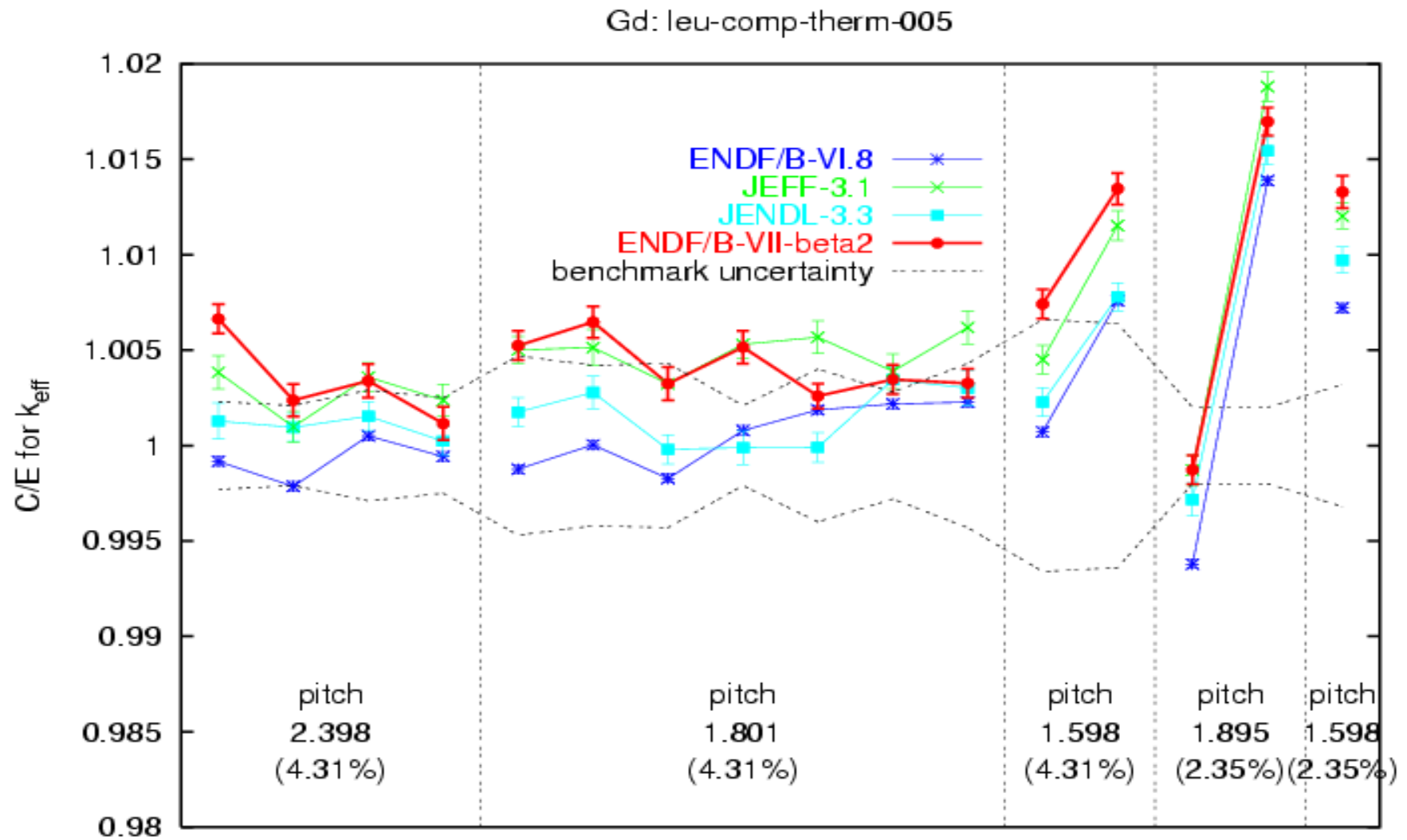
Pb: heu-met-fast



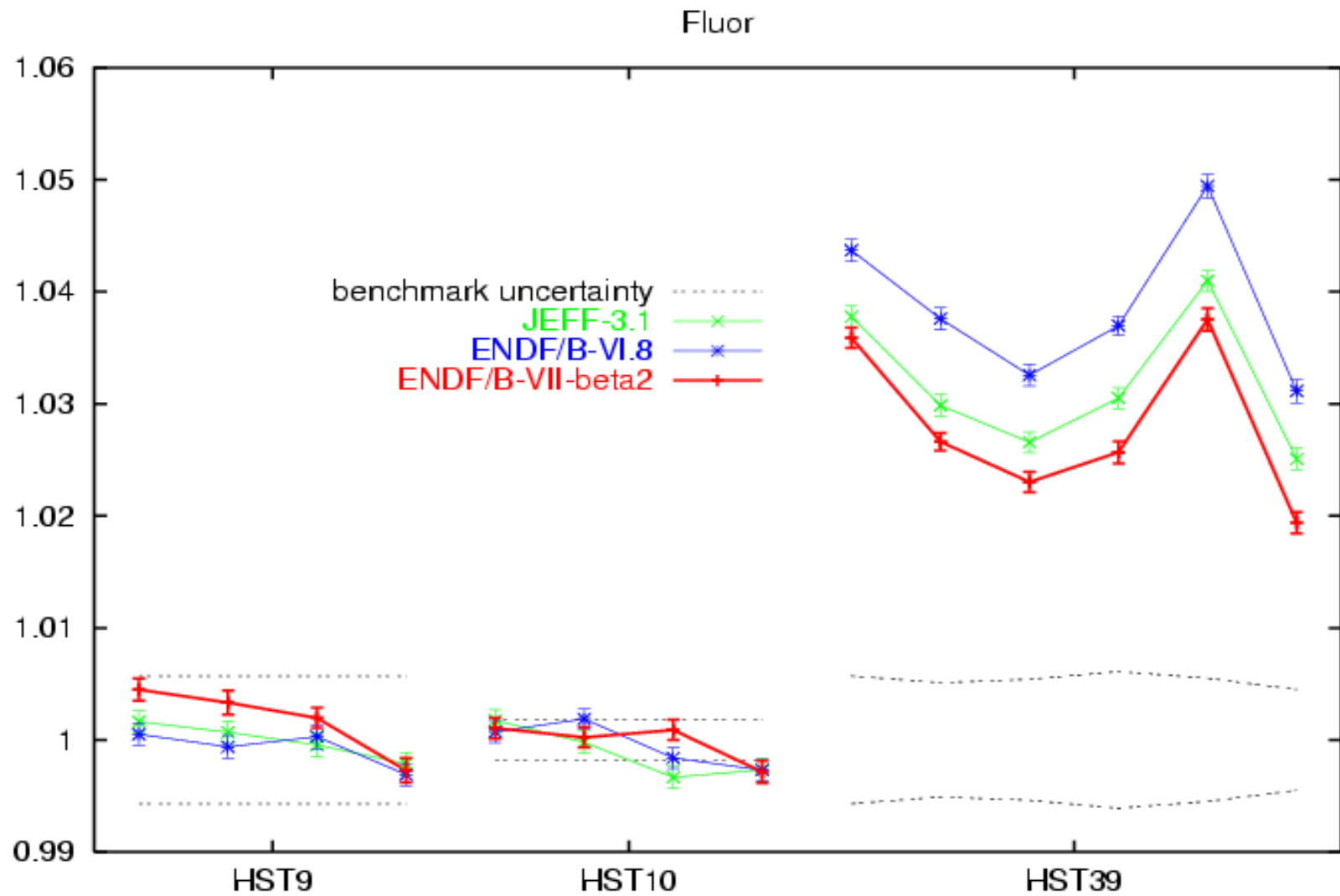
Gd



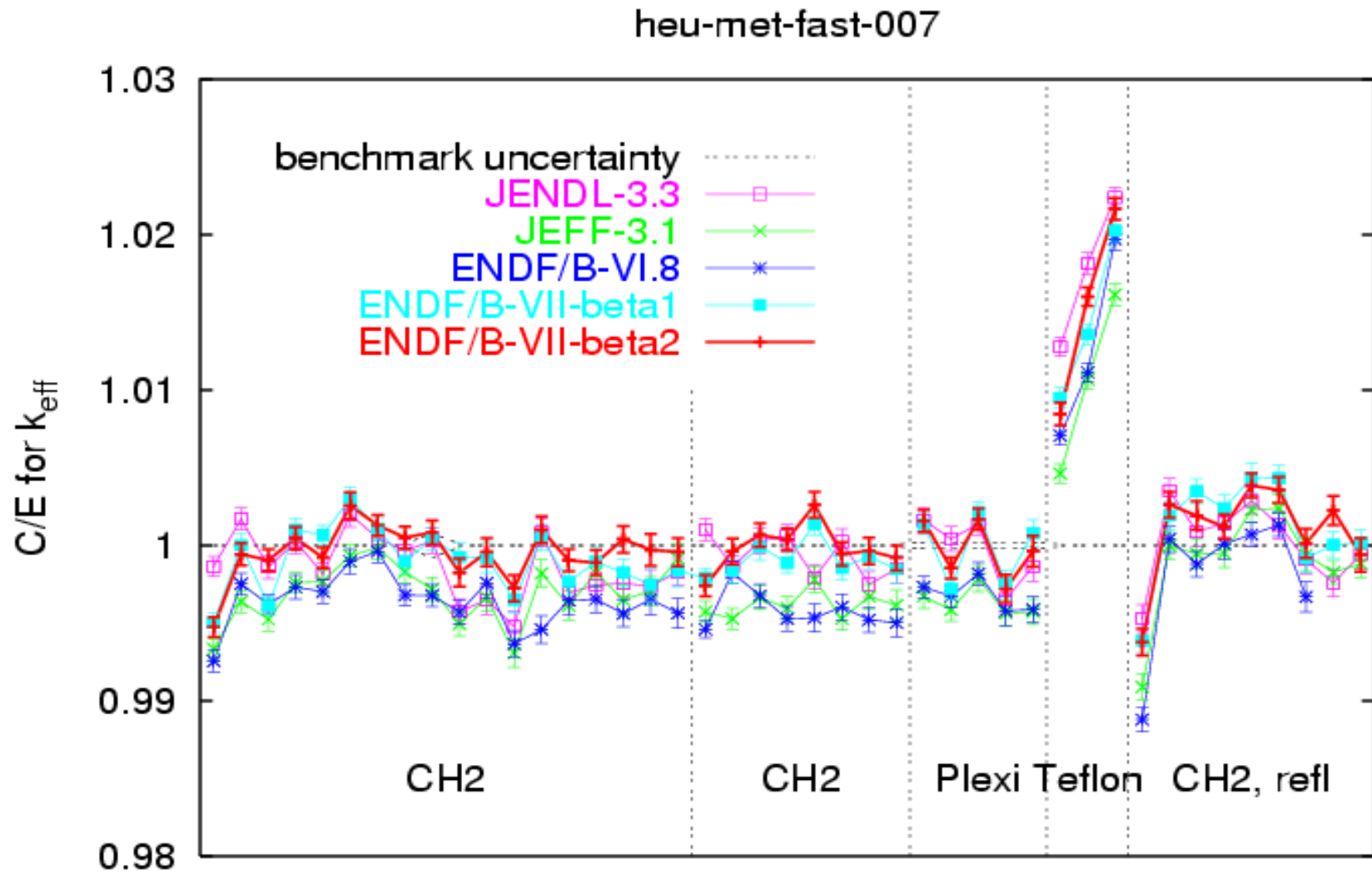
Gd: leu-comp-therm-005



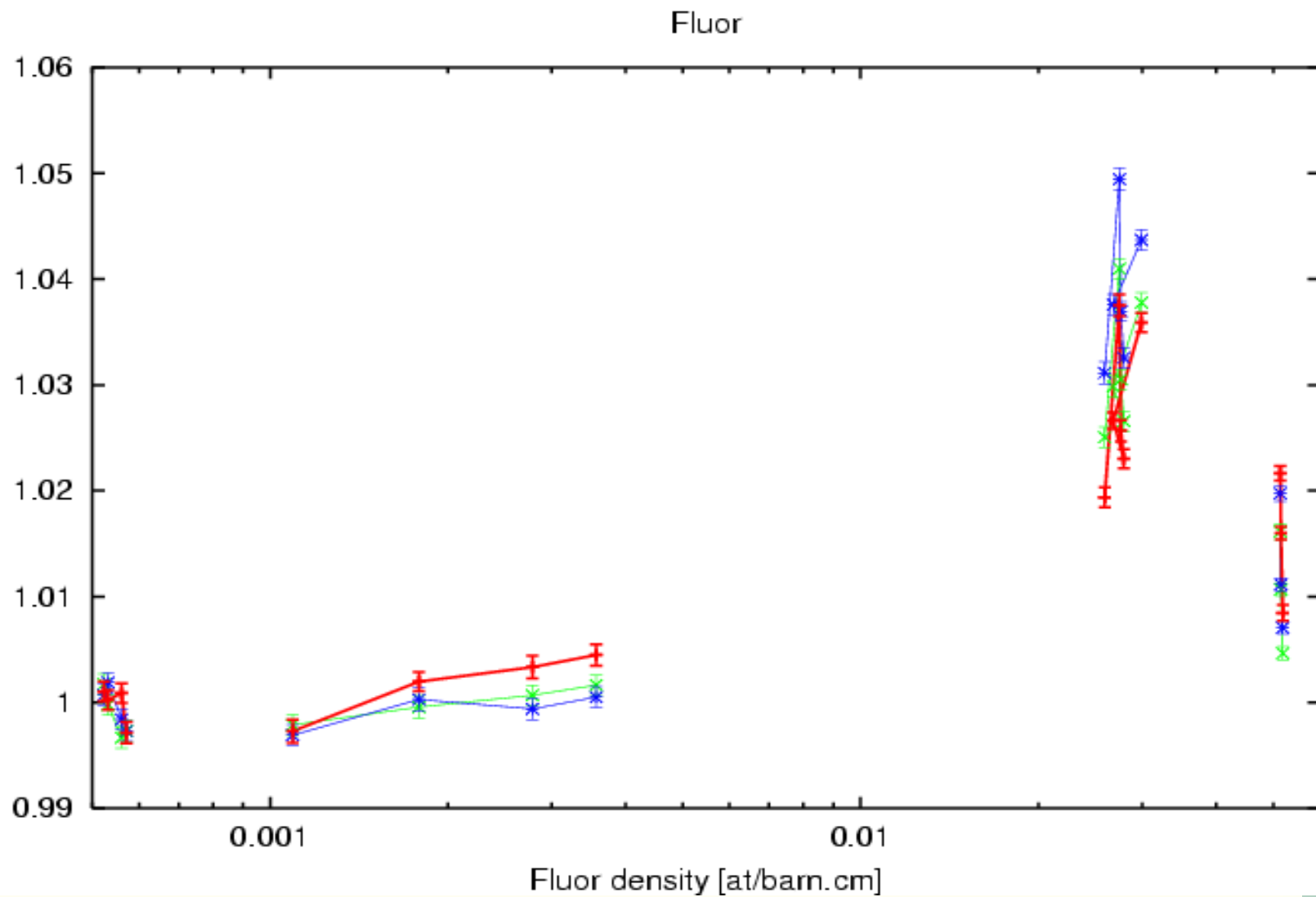
Fluor: heu-sol-therm



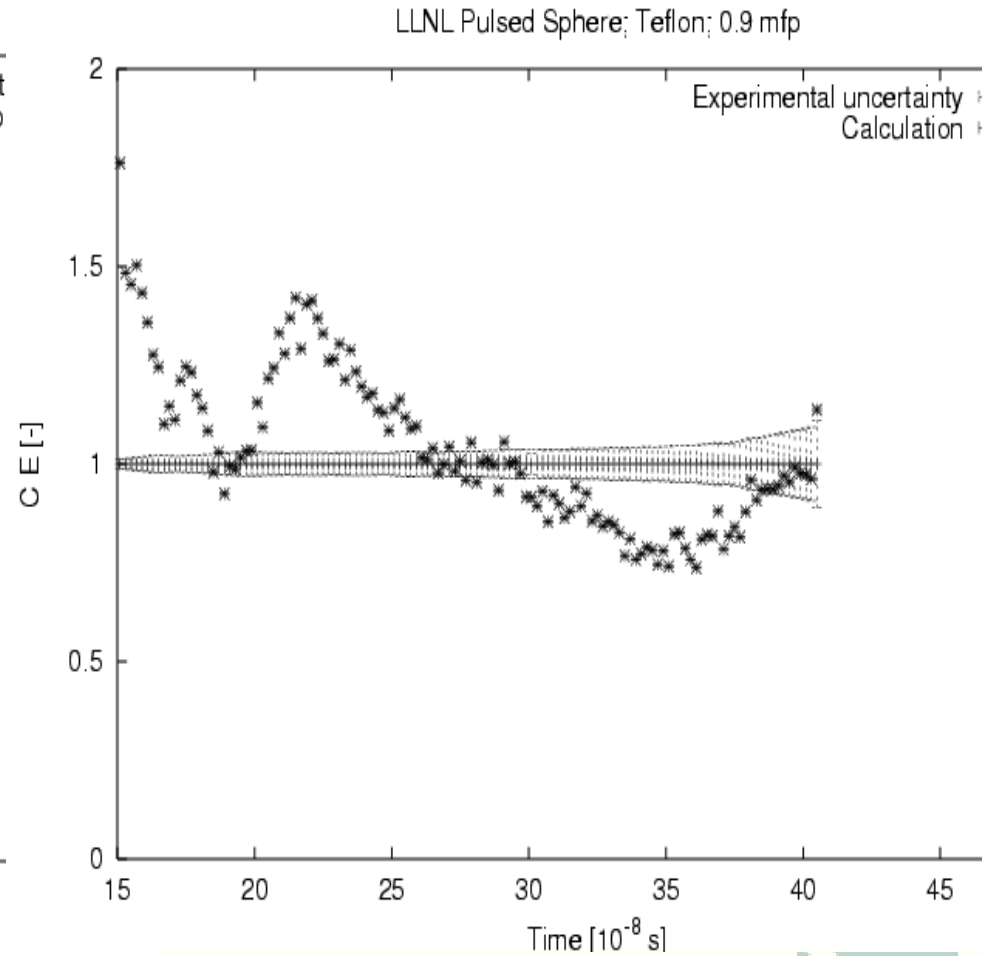
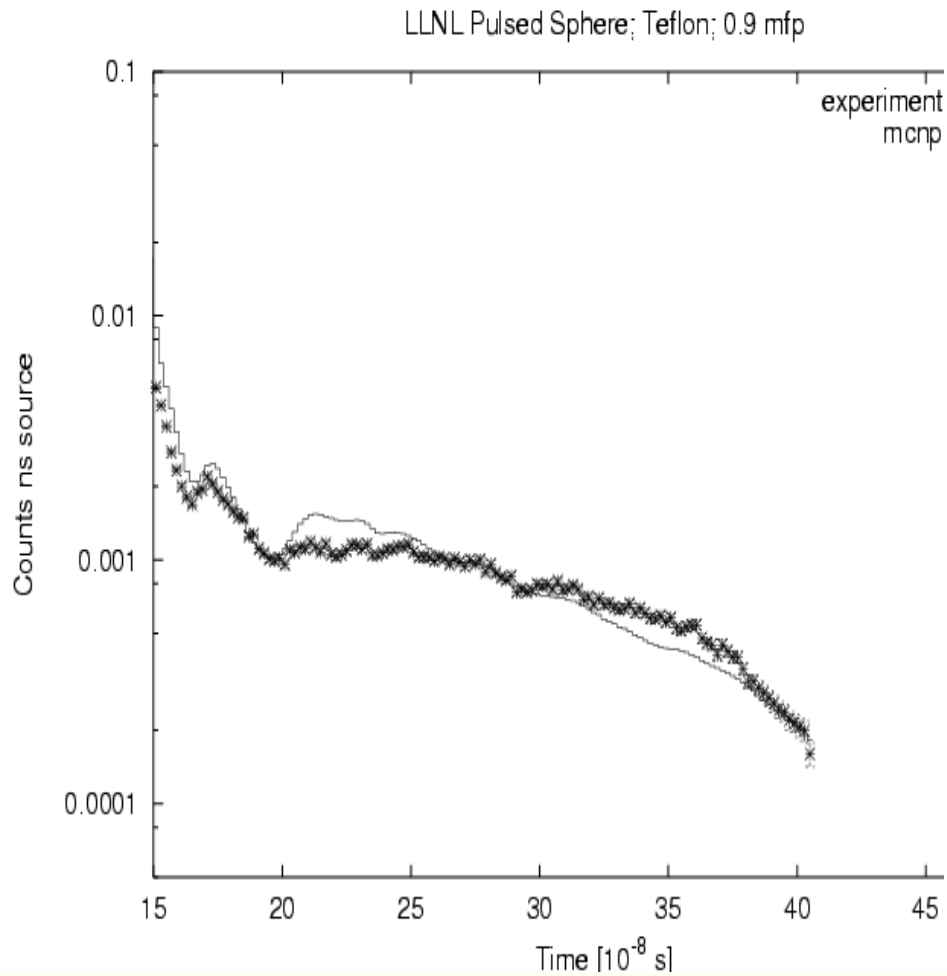
Fluor: heu-met-fast-007



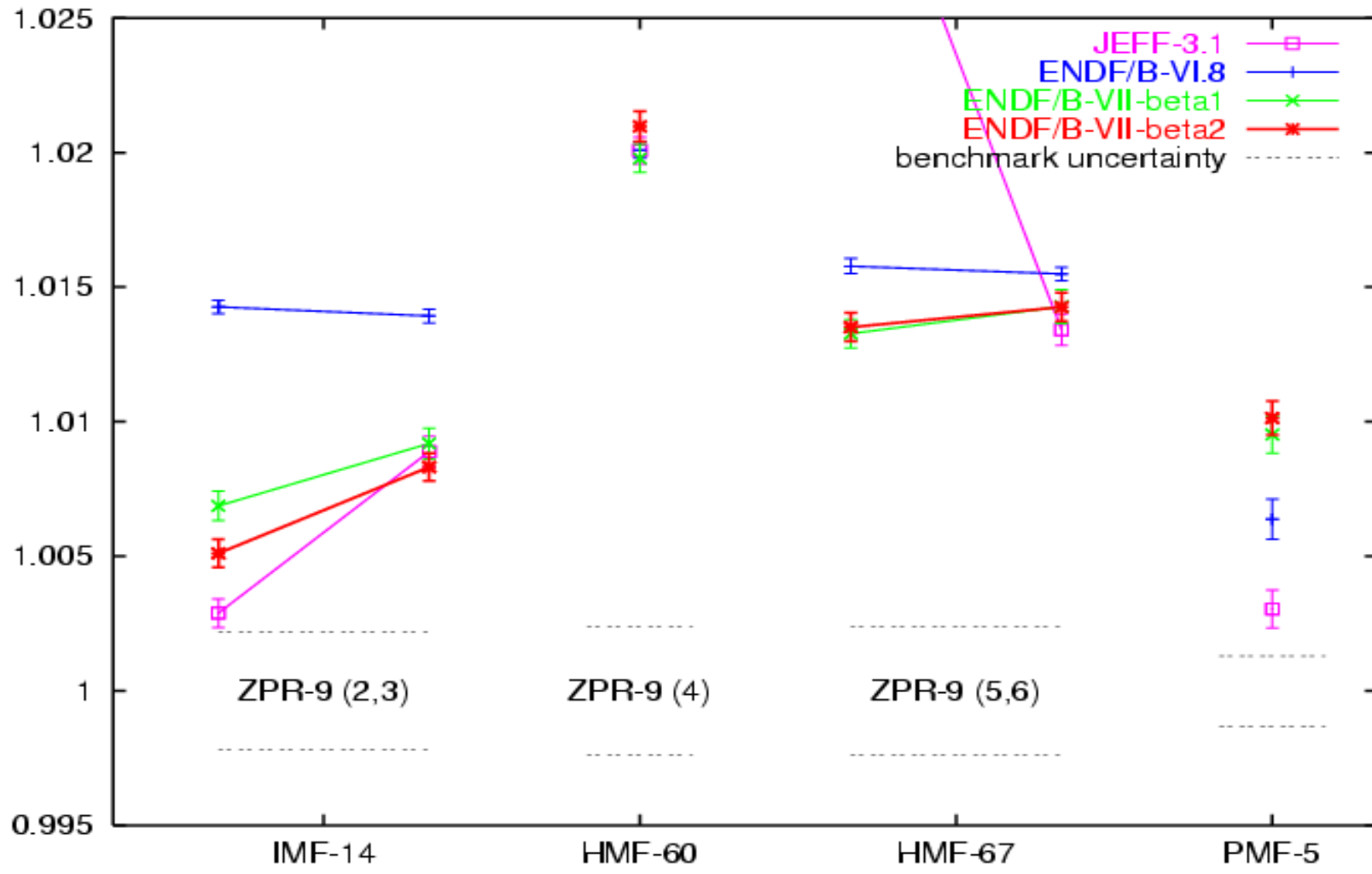
C/E vs density of Fluor



LLNL Pulsed Sphere: Teflon (CF₂)

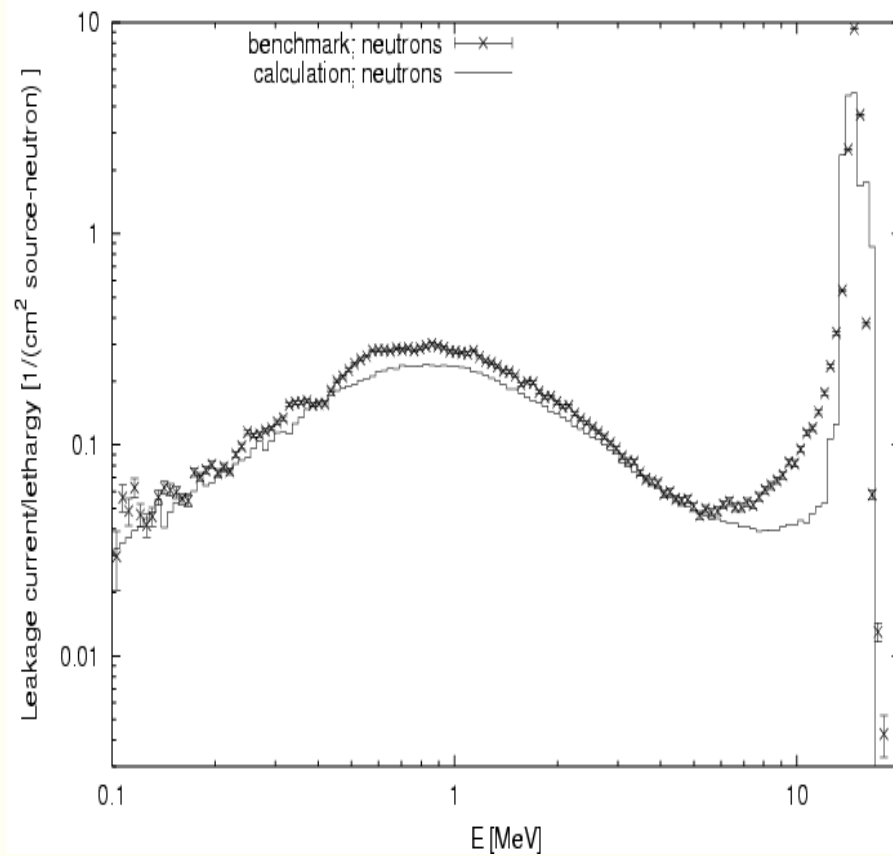


W

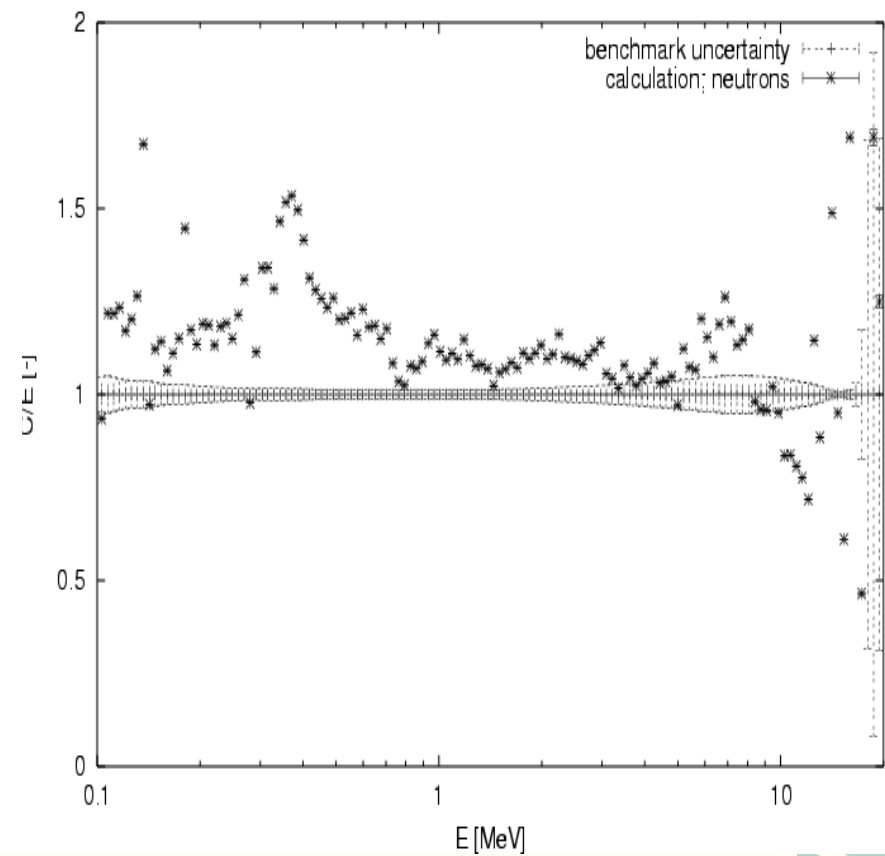


W: Oktavian

Benchmark Oktavian, W

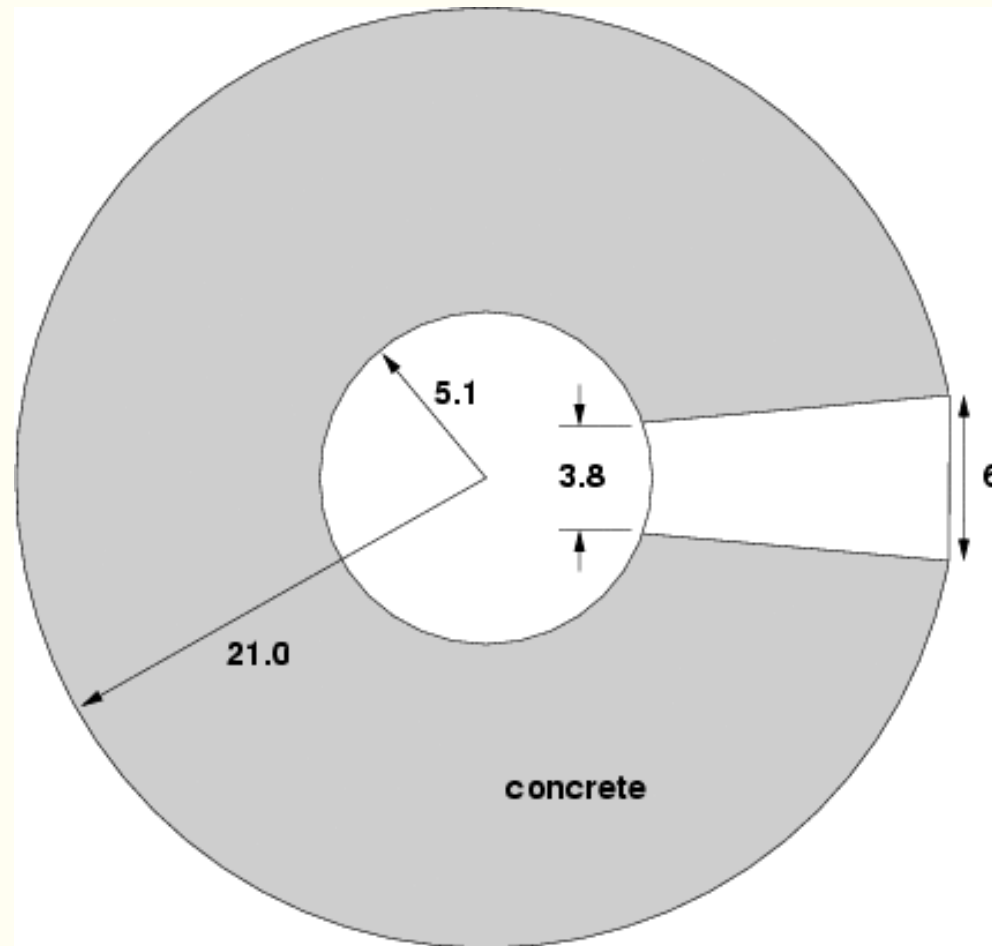


Benchmark Oktavian, Zr: C/E

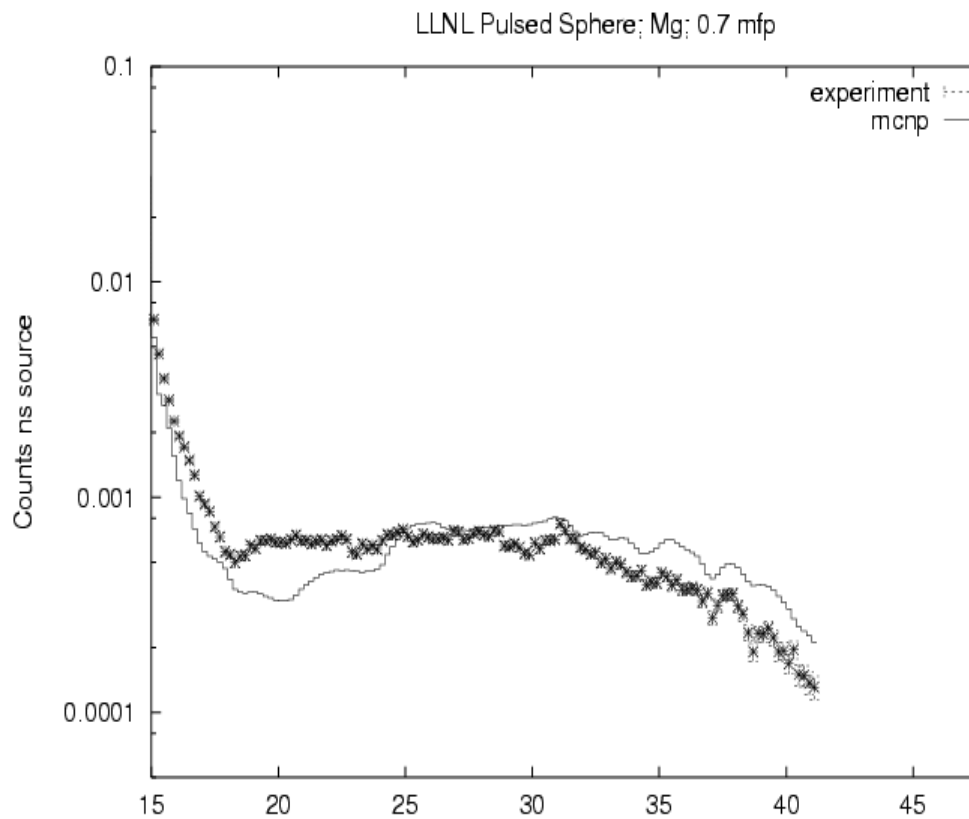


Shielding: LLNL Pulsed Spheres

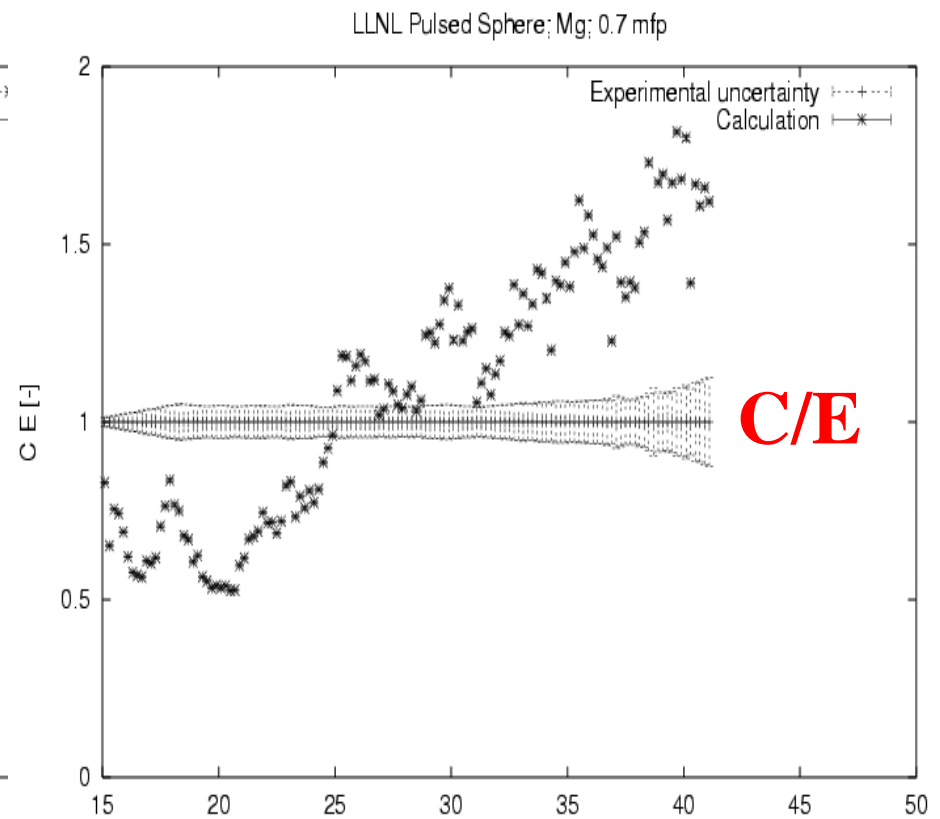
Time of Flight measurement



Shielding: LLNL Pulsed sphere: Mg



Time [10^{-8} s]

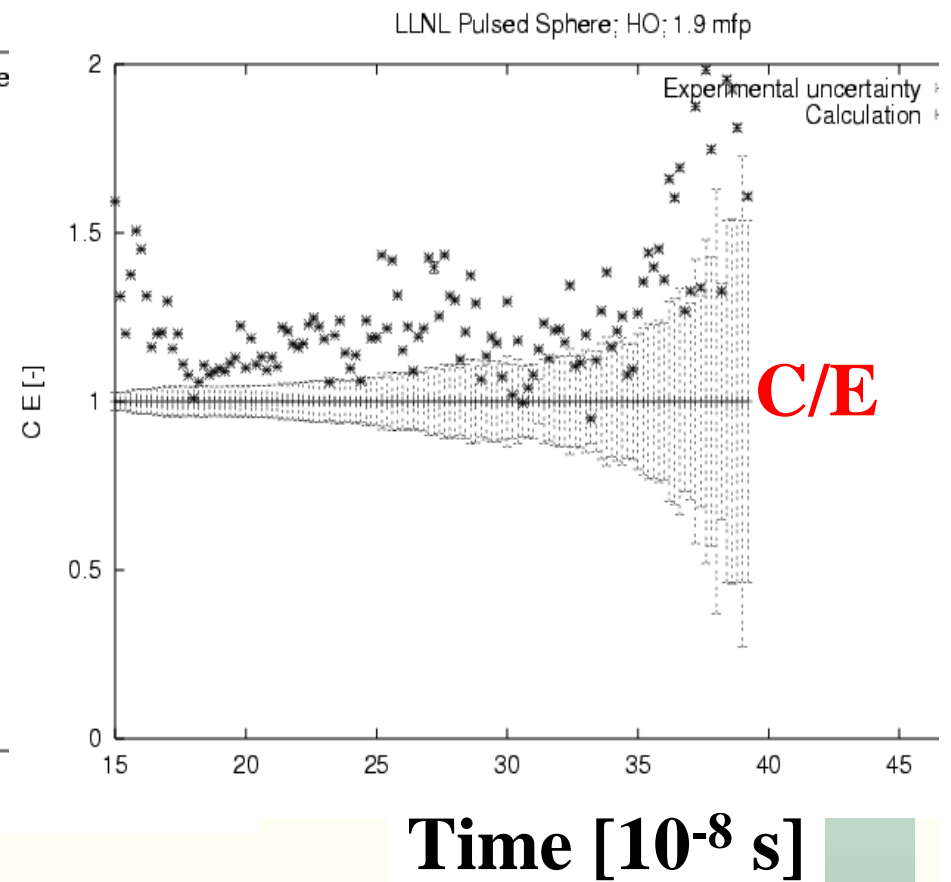
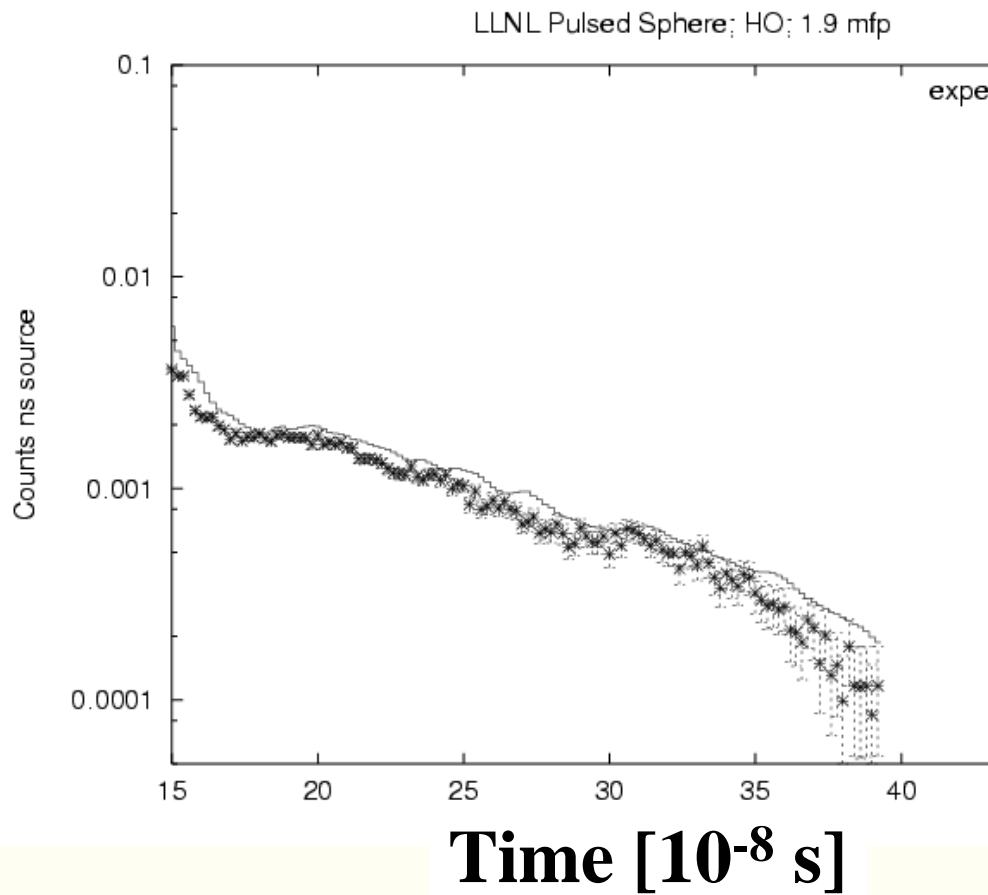


Time [10^{-8} s]

See Wim Haeck, JEFDOC-1141 (2006) for ‘suggestions’

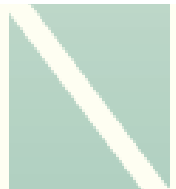
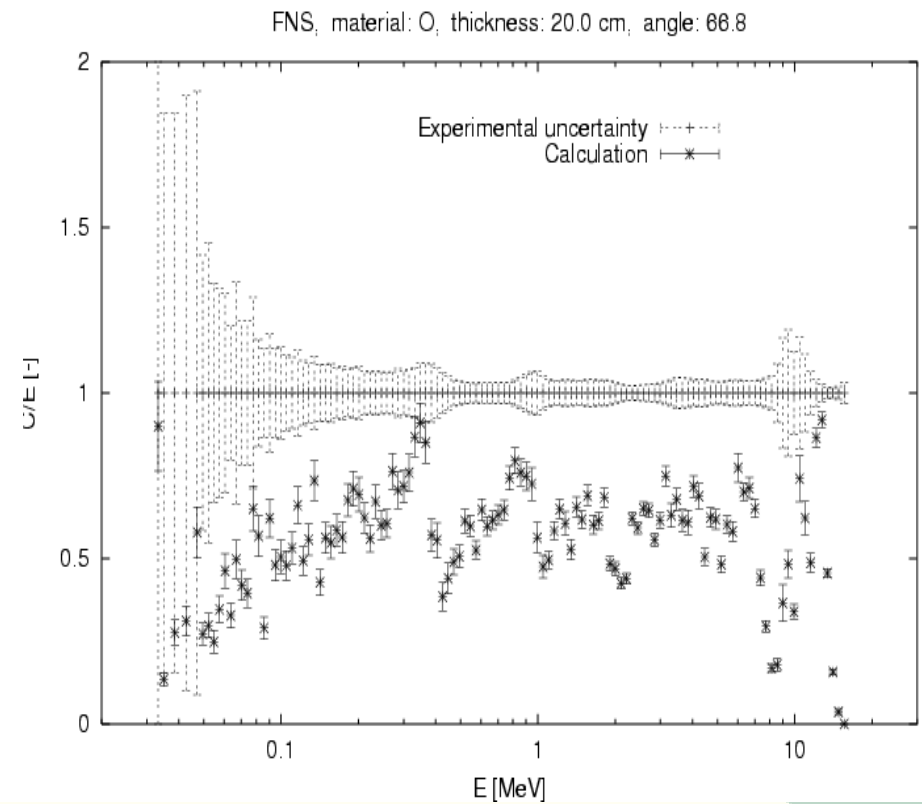
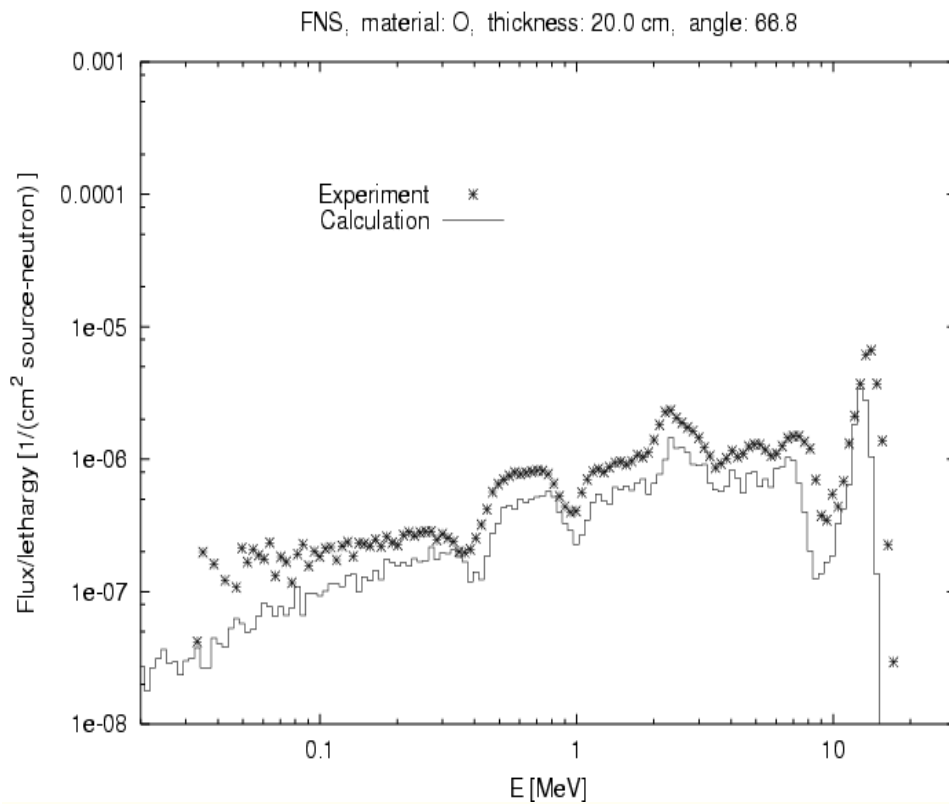


Shielding: LLNL Pulsed sphere: H₂O

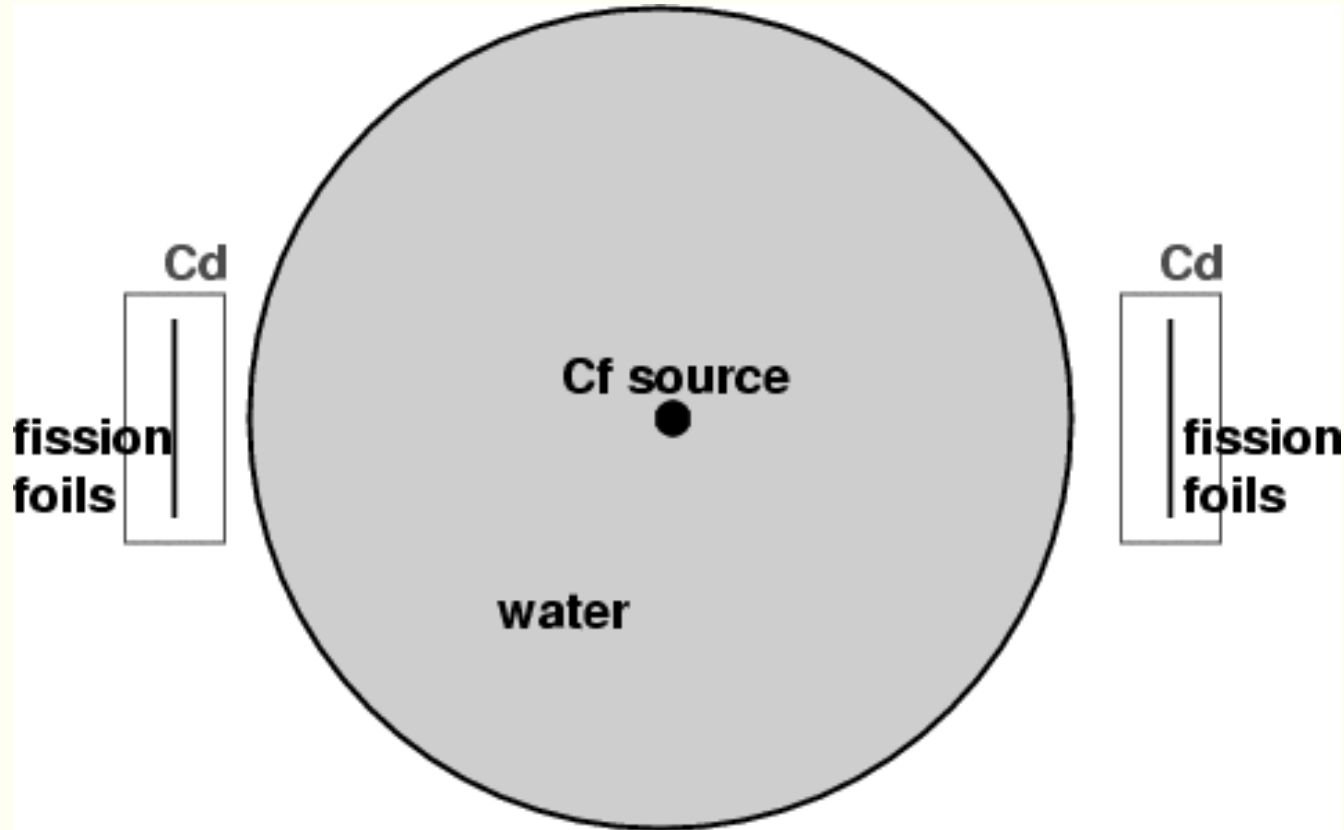


Shielding: FNS, 20cm “O”

Angle: 66.8°

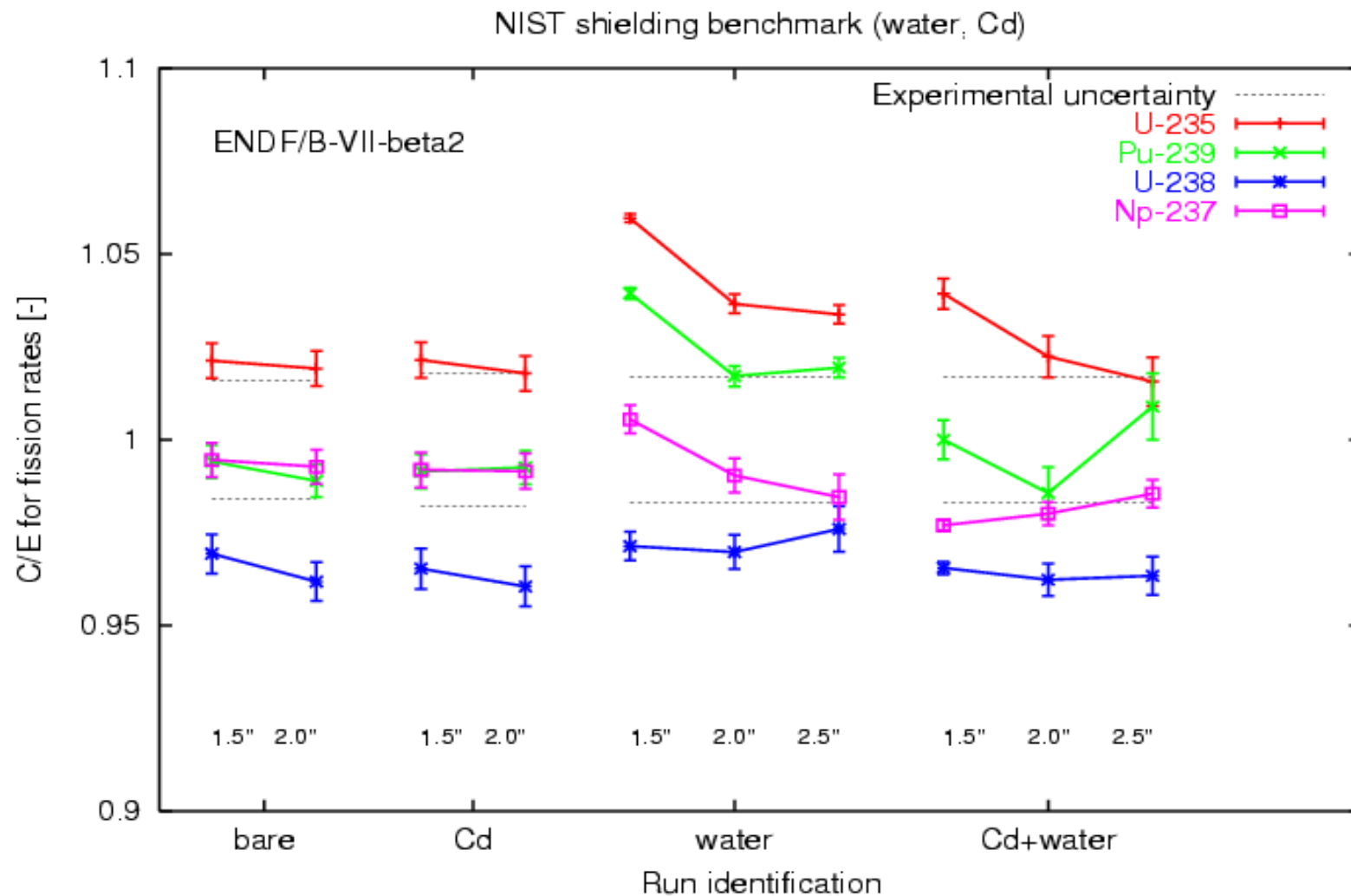


Shielding: NIST water spheres



- Diameter of water sphere varied
- Cd or 'no Cd'

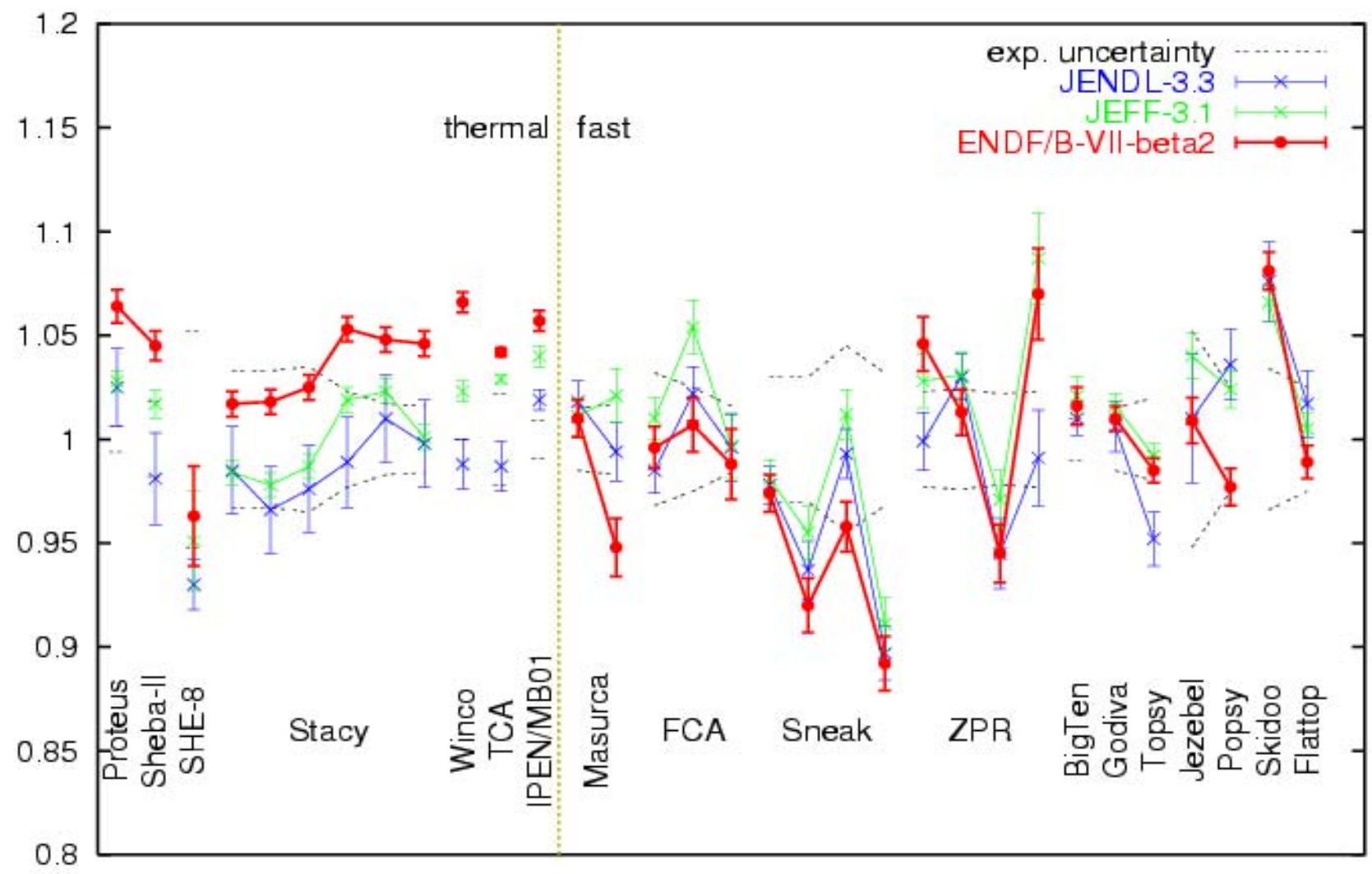
Shielding: NIST water spheres



β_{eff} calculations

- Monte Carlo method, implemented in MCNP
Robin Klein Meulekamp & SvdM
NSE 152 (2006) 142–148
- Set of reference calculations
Fast: **Masurca, FCA**, ZPR, SNEAK, Godiva, ...
Thermal: **TCA, IPEN**, Proteus, Stacy, Sheba, ...
- Only two thermal β_{eff} measurements
(the others are $\alpha = \beta_{\text{eff}}/l$ measurements)
- Some cases involve interpretation by SvdM;
Independent verification calculations needed

β_{eff} calculations



Conclusions for ENDF/B-VII beta2

- ❖ Almost all evaluations can be processed
- ❖ LEU-COMP-THERM results spot-on
- ❖ No clear trend with spectrum or enrichment for LEU / IEU / HEU
- ❖ PU cases: C/E on average slightly above 1
- ❖ Results ‘sorted’ by element: Pb, Gd, F, W, H₂O, ...
- ❖ Information on shielding in 0.1–1 MeV for many elements
- ❖ β_{eff} for thermal systems somewhat high