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Nuclear Validation Efforts at Livermore

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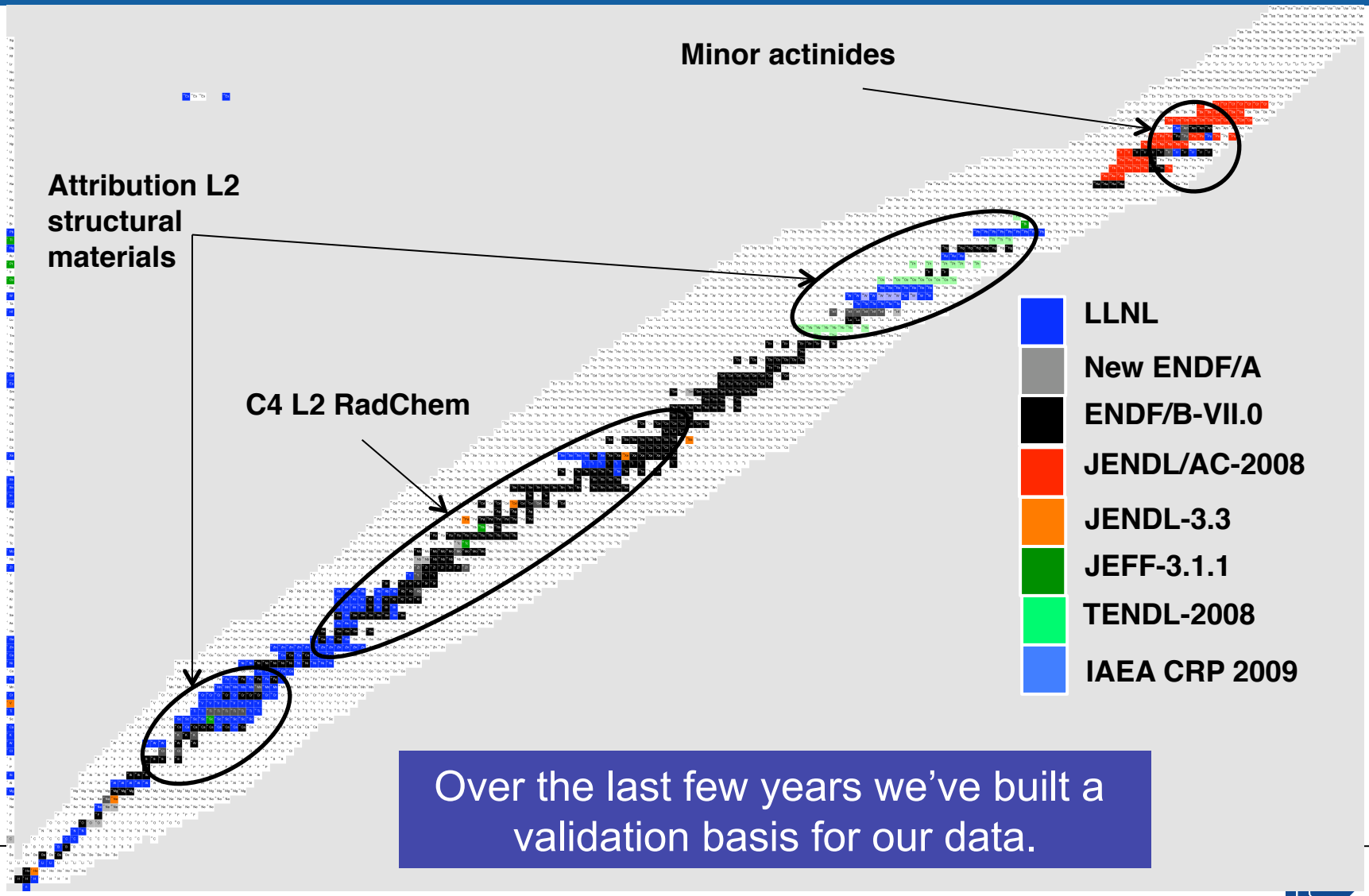
We are releasing ENDL2009; we use the best available evaluations ~ 50% from ENDF/B-VII.0



Over the last few years we've built a validation basis for our data.

Our test suite relies on different types of tests

- We developed models of benchmark experiments for two codes
  - Amtran, deterministic transport, and ndf library
  - Mercury, Monte Carlo transport, and mcf library

- Several types of tests
  - Simple sanity checks to ensure the libraries are running
  - Criticality benchmarks
  - Time-of-flight experiments: LLNL pulsed spheres & oktavian spheres
  - Fission and activation ratios

New evaluations in ENDL2009 that are being considered for ENDF/B-VII.1 & .2

No tests available In our test suite

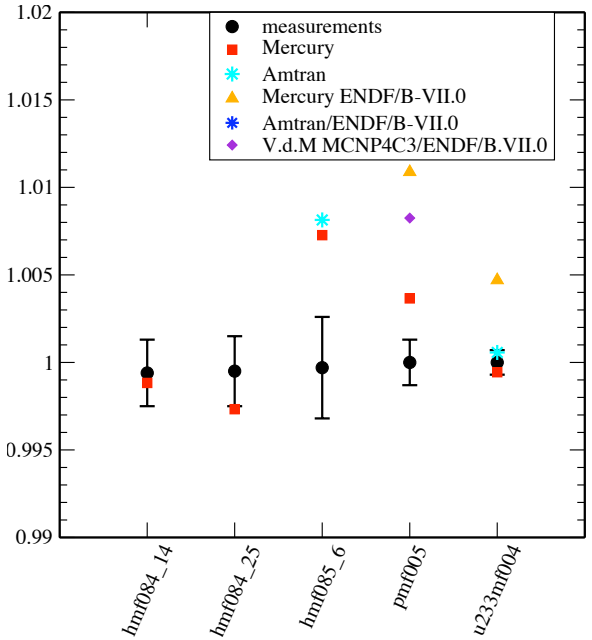
ENDF-B.VII.1
64, 66, 67, 68, 70 Zn
^{78}Kr
^{240}Am
^{239}U

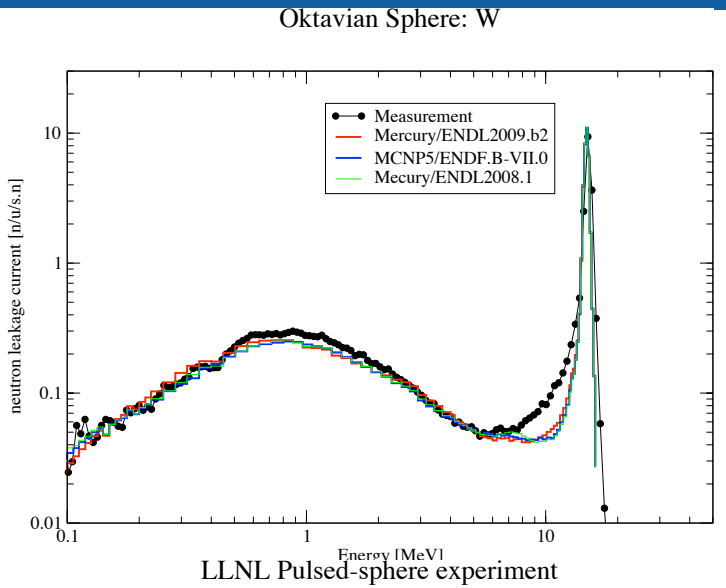
ENDF/B.VII.2
^{36}Ar
$^{74, 75}$ As
^{87}Rb
$^{90, 96}$Zr
^{103}Rh
^{113}Cd
$^{123, 124}$Xe
$^{174, 176-180}$ Hf
Os
Pt
$^{203-205}$Tl
Yb

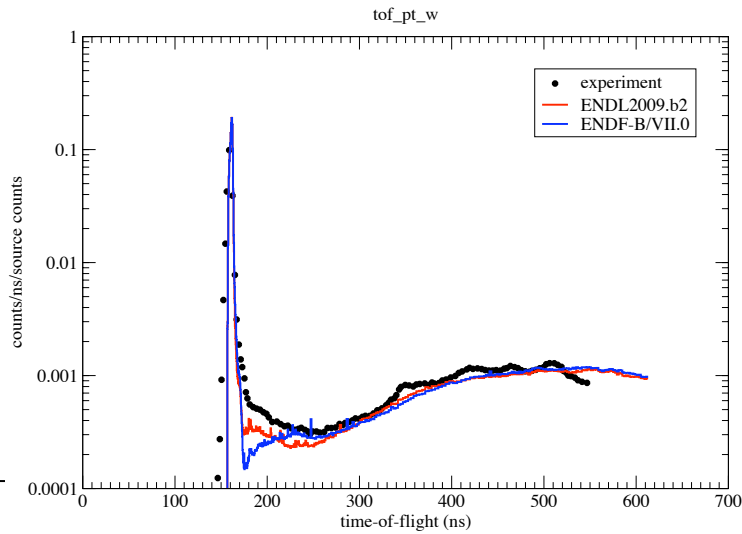
We have tests for about half of these evaluations

ENDF/B.VII.2	Crit	TOF	x ratio	source
$^{46, 47,48,49, 50}$Ti	x	x		ENDF/A (7/2009)
^{55}Mn			x	ENDF/A (7/2009)
^{57}Fe	x	x		^{57}Fe LLNL-2009
^{59}Co	x		x	LLNL-2009
^{75} As			x	LLNL-2009
^{89}Y			x	ENDF/A (7/2009)
^{97}Mo	x			ENDF/A (7/2009)
^{169}Tm			x	TENDL-2008
^{180} , ^{181}Ta		x		LLNL-2009
$^{180, 182-184, 186}$W	x	x	x	IAEA-W-CRP-2009
$^{185, 187}$Re			x	LLNL-2009
$^{204, 206, 207, 208}$Pb	x			LLNL-2009
^{209}Bi			x	JEFF-3.1
^{237}Np			x	JENDL-AC-2008
^{237}U			x	LLNL-2009
$^{240, 241, 242}$Pu	x			ENDF/A –(9-2009)

W (IAEA-W-CRP-2009)

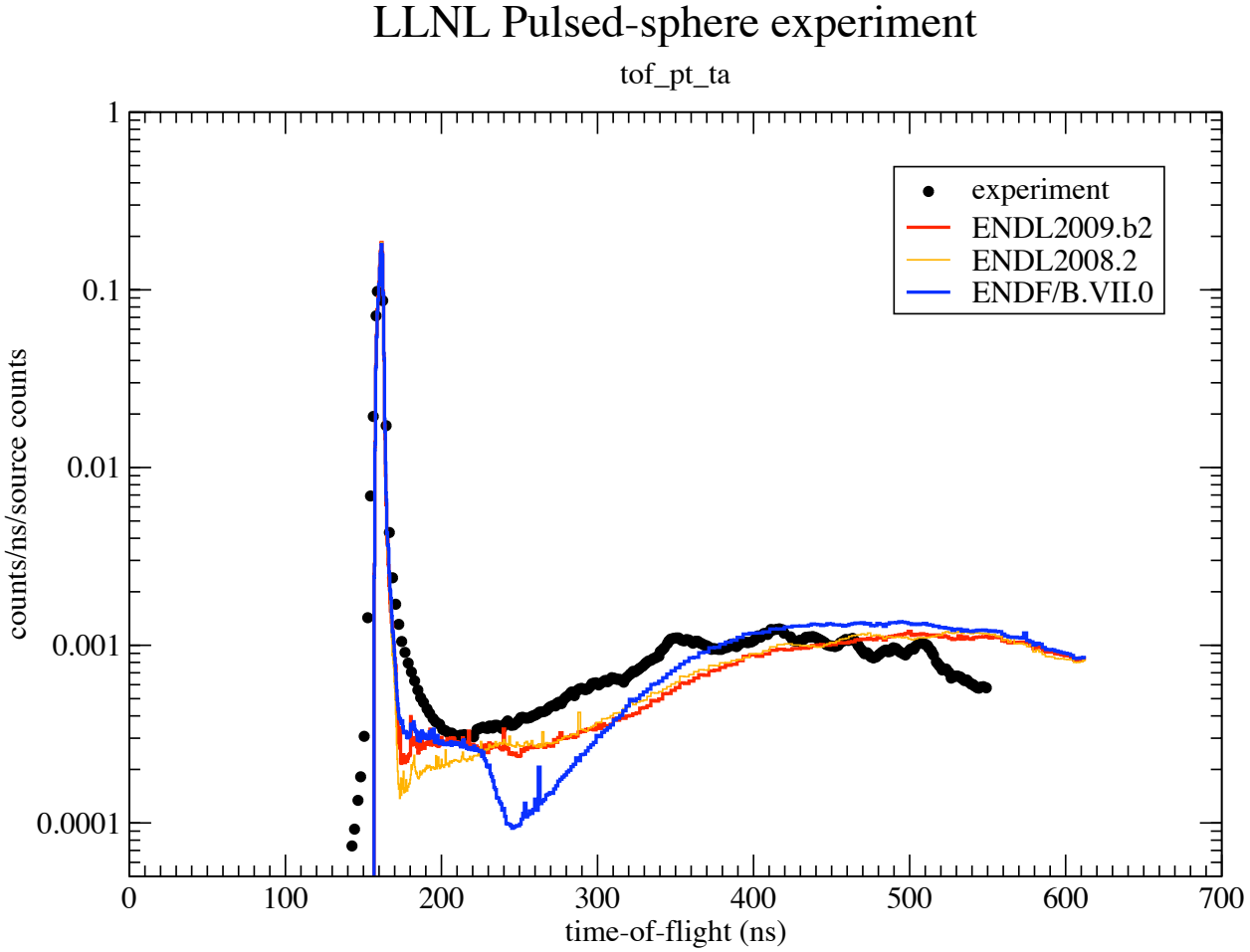






With the IAEA evaluation, the criticality simulations are within 3 sigmas of the measurements, and the pulsed sphere spectrum shows a significant improvement.

Ta (LLNL-2009)

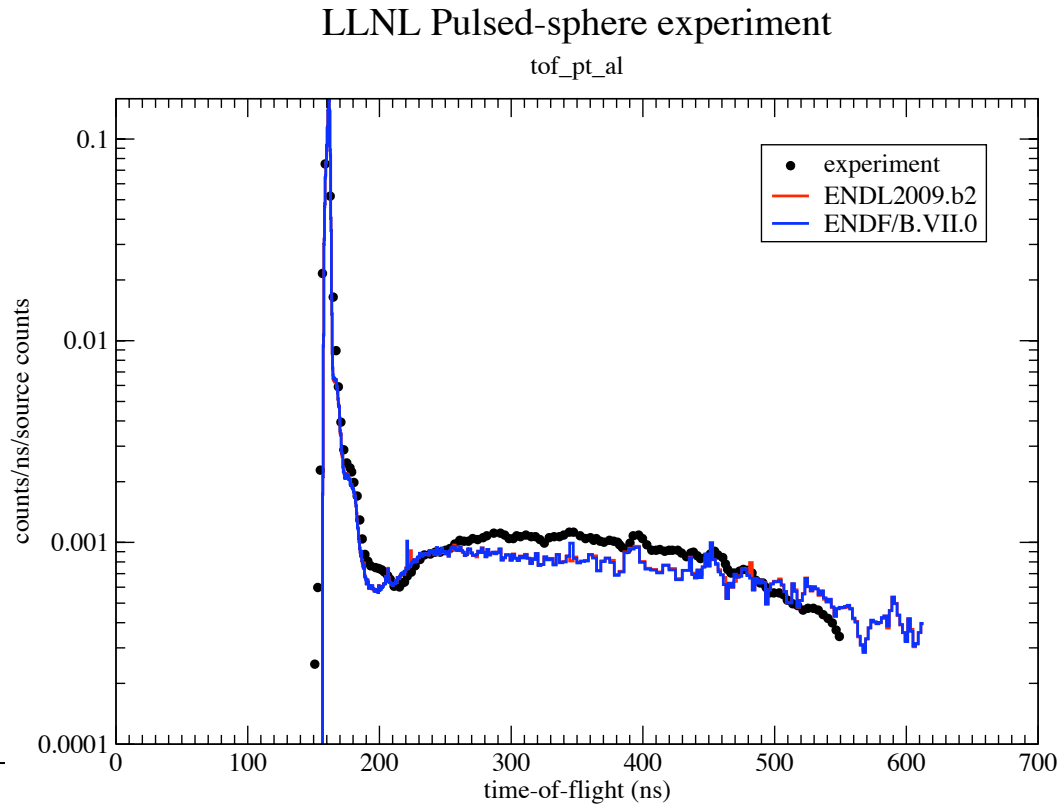


Our modeling of Ta can use improvements (esp. to pre-equilibrium) but it performs significantly better than ENDF/B-VII.0

Al (LLNL-2009)

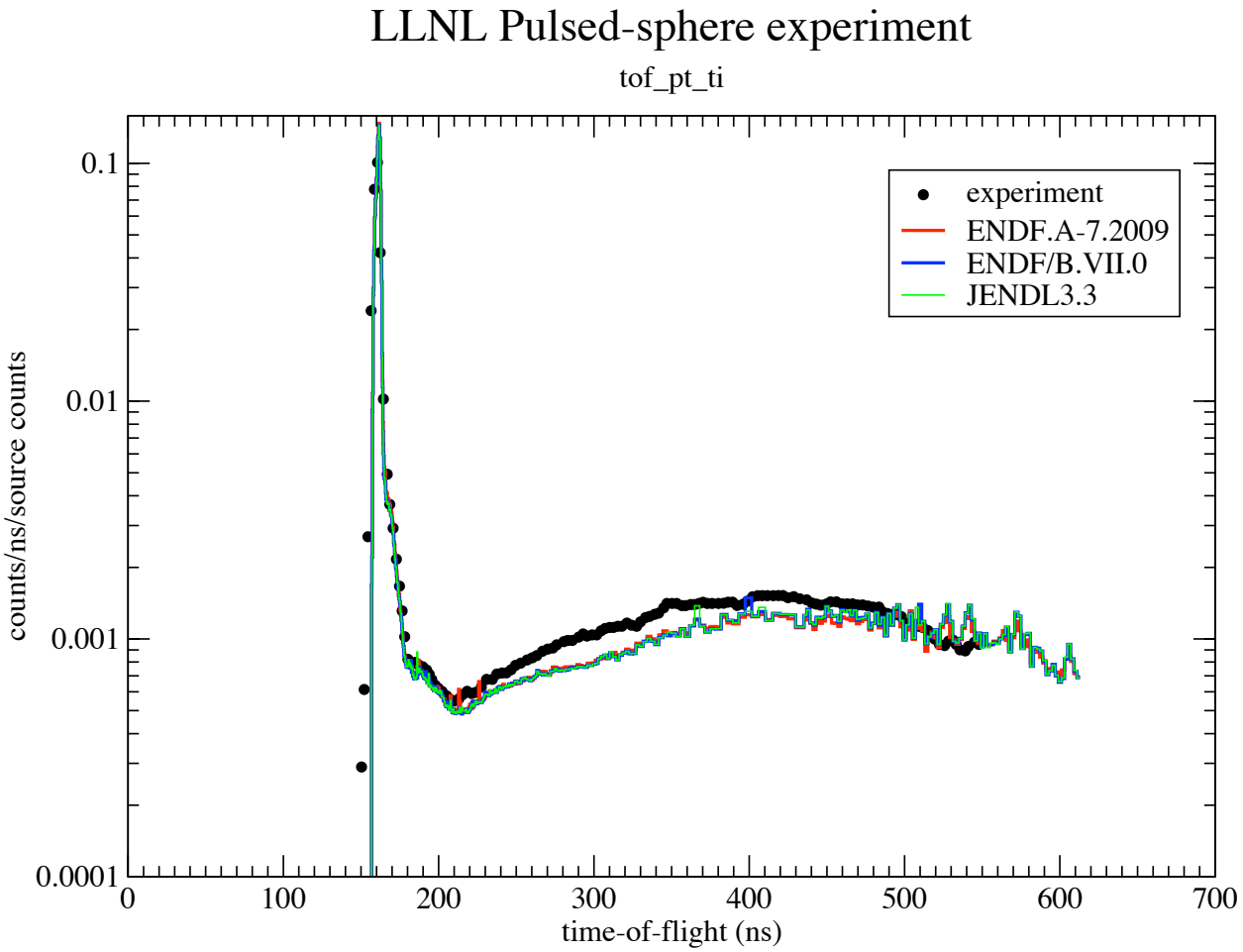
Case	reflector	benchmark keff	benchmark dkeff	Mercury keff	dkeff
Hmf084_1	Al	0.9994	0.0019	0.9994	0.0001
hmf084_2	Al2O3	0.9994	0.0021	0.9997	0.0001
hmf084_15	Al2O3	0.9995	0.0021	0.9982	0.0001
pmf_009	Al	1.0000	0.0027	1.0066	0.0001

ENDL2009 & ENDF/B-VII.0 evaluations are so similar that it is no surprise that they perform identically



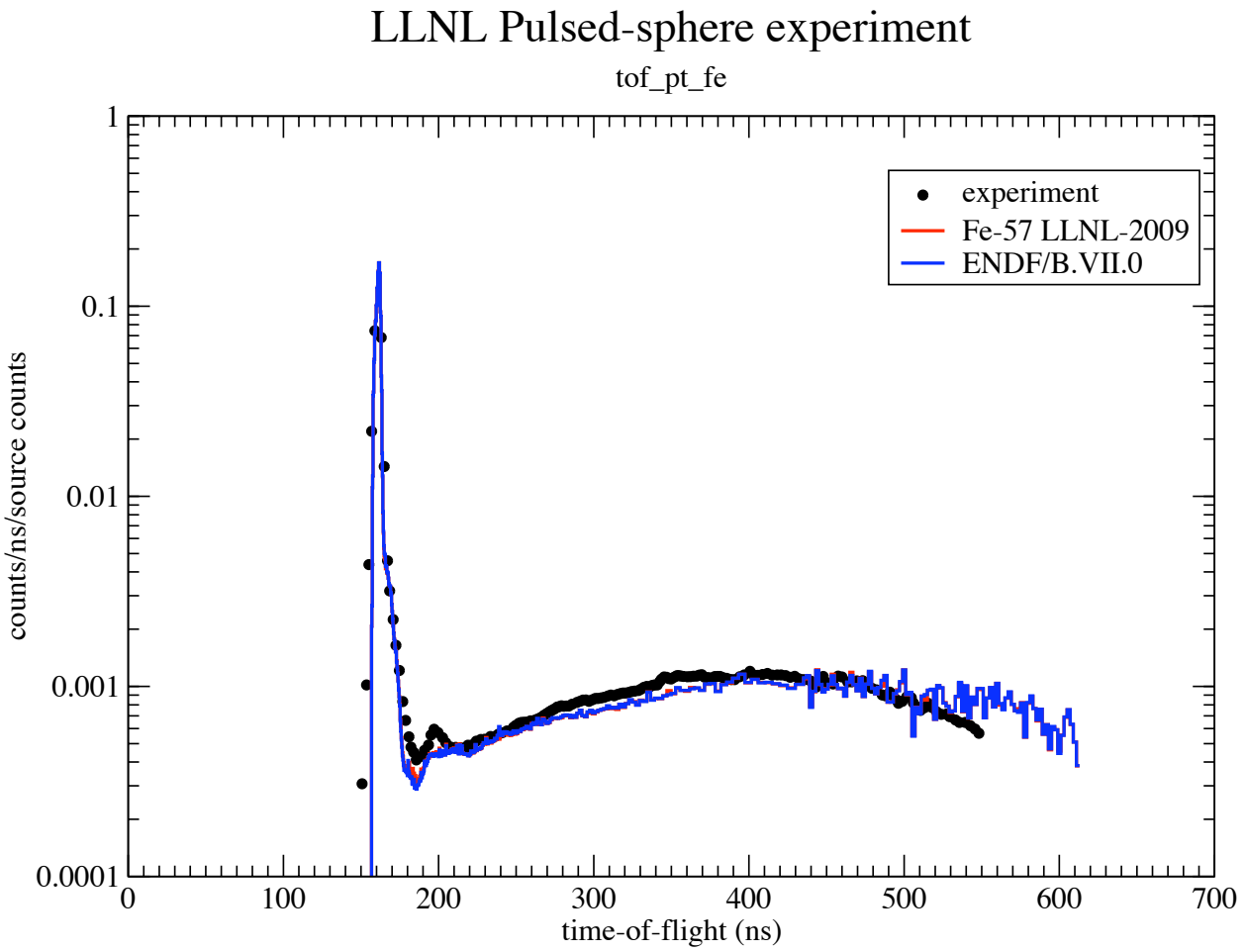
Ti (ENDF/A 7/2009)

T. Kawano's corrections to the JENDL-3.3 evaluation did not noticeably impact performance



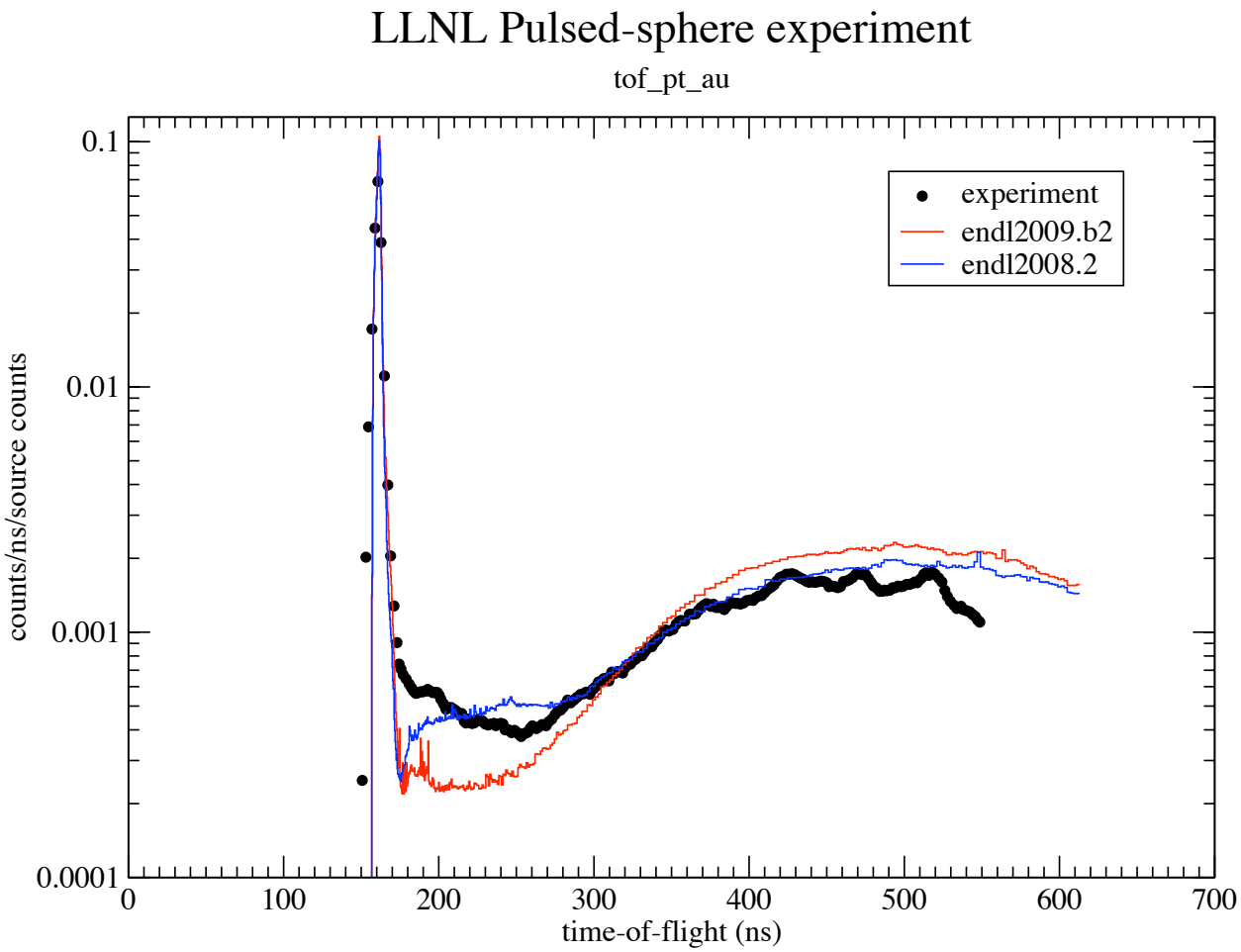
^{57}Fe (LLNL-2009)

ENDL2009 & ENDF/B-VII.0 evaluations are so similar that it is no surprise that they perform identically

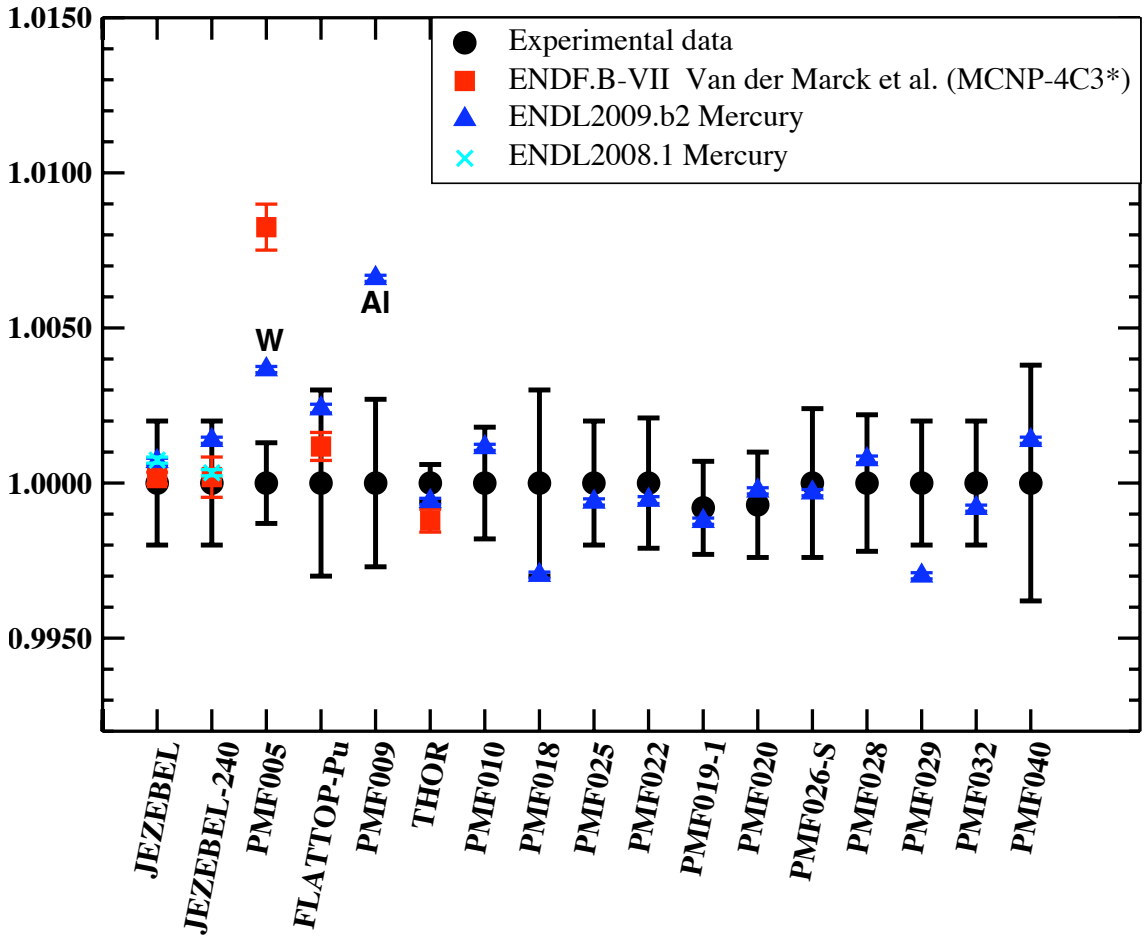


^{197}Au (LLNL-2009)

The current ENDL2009 evaluation is not ready



^{240}Pu(ENDF-A), $^{241\text{-}242}$Pu(JENDL-AC)

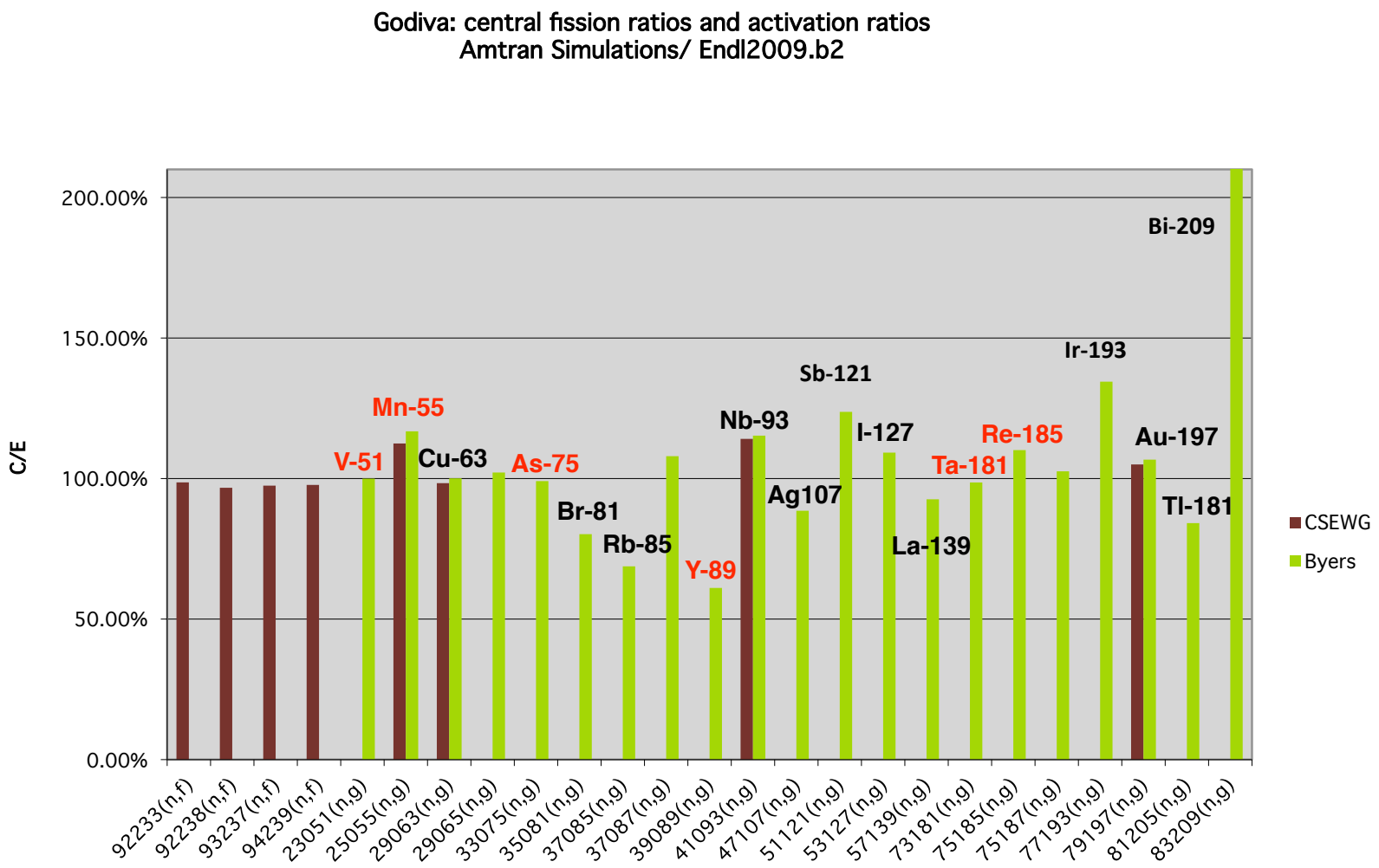


- Results for bare Pu assemblies are very good
- ^{240}Pu evaluation from ENDF/A (endl2009.b2) leads to a slight increase in k_{eff} compared to the JENDL-Actinoid library (endl2008.1) as shown by Jezebel240 = PMF002

Criticality benchmarks

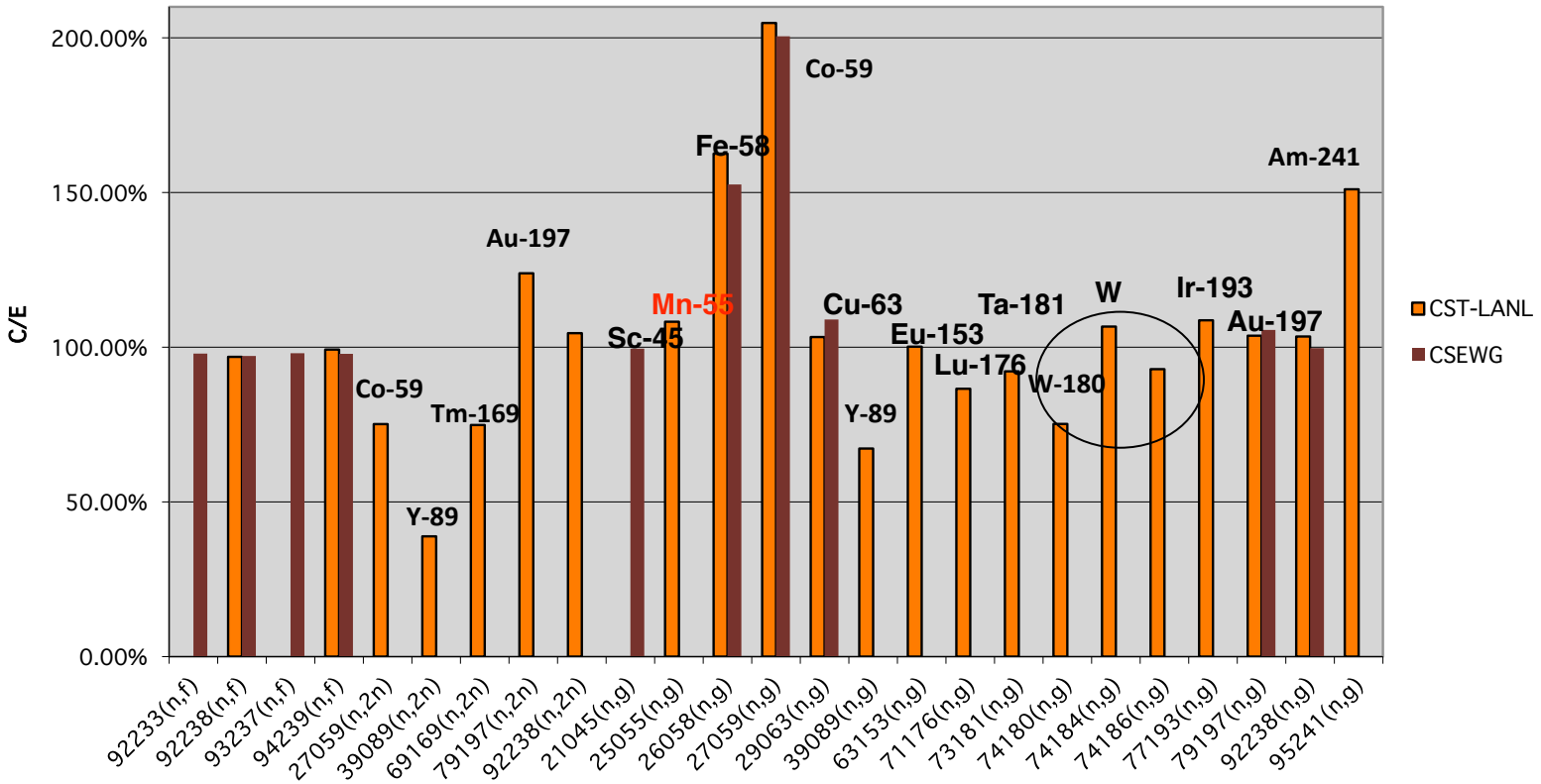
Case	reflector	benchmark keff	benchmark dkeff	Mercury keff	dkeff	1 sigma	2 sigma	3 sigma
hmf084_1	Al	0.9994	0.0019	0.99936	0.00010			
PMF09	Al	1.0000	0.0027	1.00660	0.00010	fail	fail	
hmf084_15	Al2O3	0.9995	0.0021	0.99816	0.00010			
hmf084_20	Al2O3	0.9994	0.0021	0.99975	0.00010			
hmf084_16	Be	0.9994	0.002	0.99757	0.00010			
hmf084_3	Be	0.9993	0.0021	0.99707	0.00010	fail		
PMF019_1	Be	0.9992	0.0015	0.99877	0.00010			
PMF018	Be	1.0000	0.0030	0.99703	0.00010			
hmf084_26	Be inner reflec	0.9993	0.0022	0.99887	0.00010			
hmf084_27	Be inner reflec	0.9994	0.002	0.98258	0.00010	fail	fail	fail
hmf084_17	Co	0.9995	0.0019	1.02744	0.00010	fail	fail	fail
hmf084_5	Co	0.9993	0.0021	1.05147	0.00010	fail	fail	fail
HMF073	Cu	1.0082	0.0003	1.01229	0.00013	fail	fail	fail
hmf084_18	Cu	0.9995	0.0022	0.99779	0.00010			
hmf084_6	Cu	0.9994	0.0024	0.99879	0.00010			
PMF040	Cu	1.0000	0.0038	1.00138	0.00010			
hmf085_4	Cu-Ni-Zn alloy	0.9996	0.0029	1.01182	0.00010	fail	fail	fail
hmf085_1	Cu(outer)	0.9998	0.0029	1.00028	0.00010			
hmf085_2	Cu(outer)	0.9997	0.0031	1.00441	0.00010	fail		
hmf085_3	Fe (outer)	0.9995	0.0046	0.99824	0.00010			
hmf084_20	Mo	0.9995	0.0025	1.00343	0.00010	fail		
hmf084_8	Mo	0.9994	0.0034	1.00913	0.00010	fail	fail	
hmf084_21	MoC2	0.9995	0.0045	1.00167	0.00010			
hmf084_9	MoC2	0.9993	0.0054	1.00532	0.00010	fail		
HMF03	Ni	1.0000	0.0030	1.00837	0.00010	fail	fail	
hmf084_10	Ni	0.9993	0.0022	1.00131	0.00010			
hmf084_22	Ni	0.9994	0.002	0.99850	0.00010			
hmf064_1	Pb	0.9996	0.0008	1.01636	0.00010	fail	fail	fail
PMF035	Pb	1.0000	0.0016	1.00798	0.00010	fail	fail	fail

Godiva: (n,f) and (n,g)

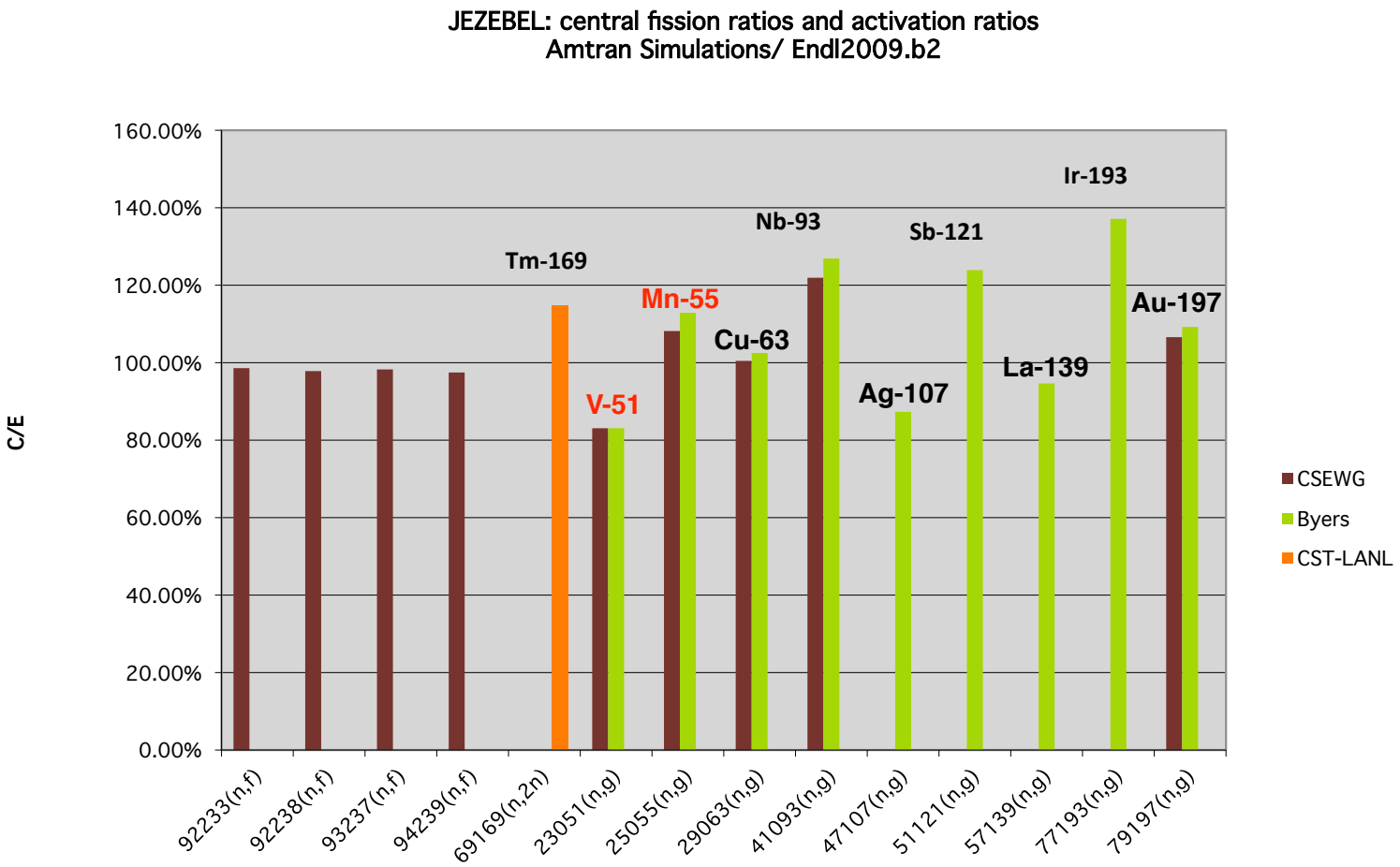


BigTen: (n,f), (n,2n) and (n,g)

Big ten: central fission ratios and activation ratios
Amtran Simulations/ Endl2009.b2



Jezebel: (n,f), (n,2n) for Tm169 and (n,g)



Testing has revealed several data problems; these are our recommendations for tackling them

- ENDL2009:
  - Poor $S_{\alpha\beta}$ support means poor performance for thermal assemblies (PST11, HMF19, PMF11, PMF23, PMF24)
  - URR treatment in data, but not fully tested in production code

- Criticality – TOF - Fission and Activation ratios
  - Pu: use evaluation from JENDL/AC-2008
  - W: the IAEA evaluation gives the best results so far;
  - Ta: improved TOF spectrum in the 10-12 MeV range.
  - ^{27}Al, Ti, ^{57}Fe: results are similar to ENDF/B-VII.0
  - Pb may be a problem
  - ^{59}Co needs work
  - ^{89}Y gives low estimates for (n,g) and (n,2n)

Quite a few tests were added this year… more to come

- We added tests for structural materials
  - Criticality, based on Red Cullen's TART test suite
  - Central Fission ratios and Activation ratios (S_n code)
  - Fusion Shielding Benchmarks
    - Oktavian spheres: Ni, Si, W; and Al (in progress)
    - FNS: V (in progress)

- For FY10 we plan to develop models of:
  - Bethe and Wyman spheres
  - Central Fission ratios and Activation ratios (Monte Carlo code)
  - LANL Traverse measurements