INDEN Fe validation

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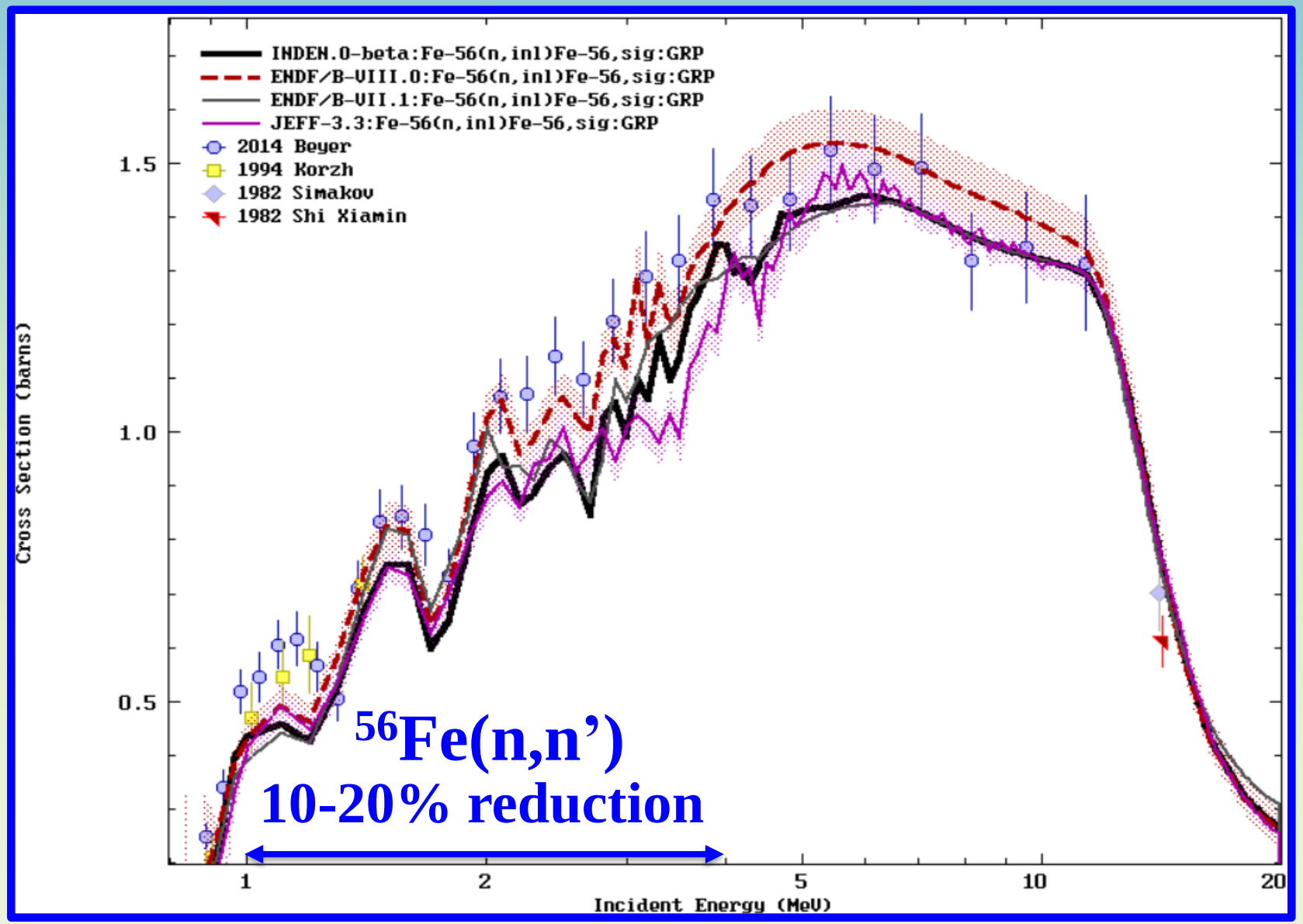
Nuclear Data Section, International Atomic Energy Agency

On behalf of the INDEN collaboration

INDEN Fe: major reduction in ^{56}Fe(n,n')



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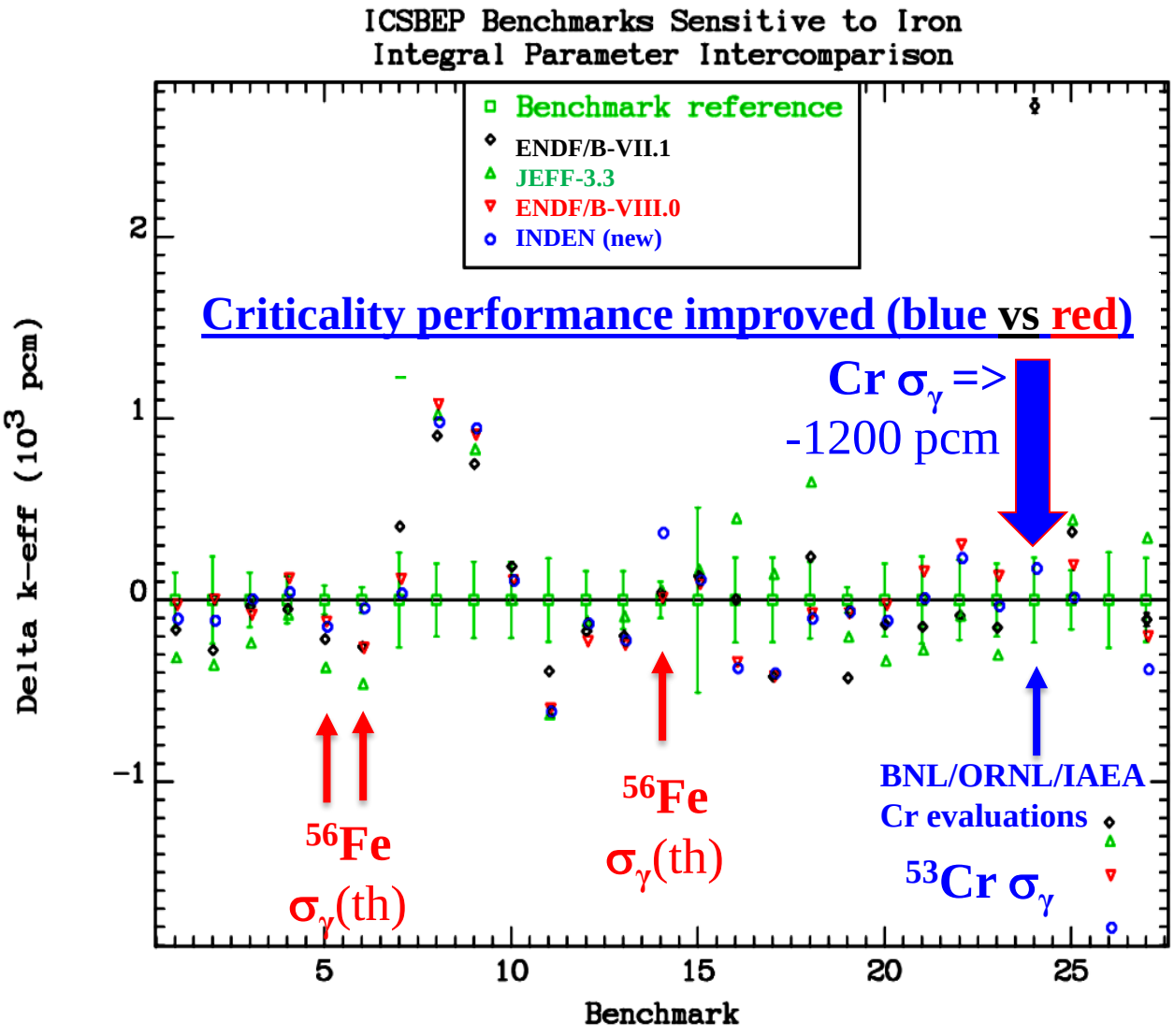
Criticality impact of Fe/ ^{53}Cr – St.Steel



1	hmf013	VNIITF-CTF-SS-13
2	hmf021	VNIITF-CTF-SS-21
3	hmf024	VNIITF-CTF-SS-24
4	hmf087	VNIITF-CTF-Fe
5	hmf088-001	FKBN-2/SS-PE-1
6	hmf088-002	FKBN-2/SS-PE-2
7	hmi001	ZPR-9/34
8	hmt013-002	Planet_Fe-PE-2
9	hmt015	Planet_HEU/Fe/PE
10	imf005	VNIIEF-CTF-5
11	imf006	VNIIEF-CTF-6/Al
12	lct042-001	PNL_1.68p-1
13	lct042-002	PNL_1.68p-2
14	lct043-002	IPEN/MB-01
15	lmt015-001	RB-Vinca-01
16	mcf001	ZPR-6/7(s)
17	mcf005s	ZPR-9/31(s)
18	mcf006s	ZPPR-2
19	pmf015	BR-1-3
20	pmf025	VNIIEF Pu/SS 1.55
21	pmf026	VNIIEF Pu/SS-11.9
22	pmf028	VNIIEF Pu/SS 19.6
23	pmf032	VNIIEF Pu(88%)/SS
24	pmi002	ZPR-6/10
25	pmi003-001s	ZPR-3/58(U)
26	pmi004-001s	ZPR-3/59(Pb)
27	ici005	ZPR-6/6A

✓ 5), 6) hmf088 (1&2)

✓ 24) pmi002 (-1.2%)

X 14) lct043.002

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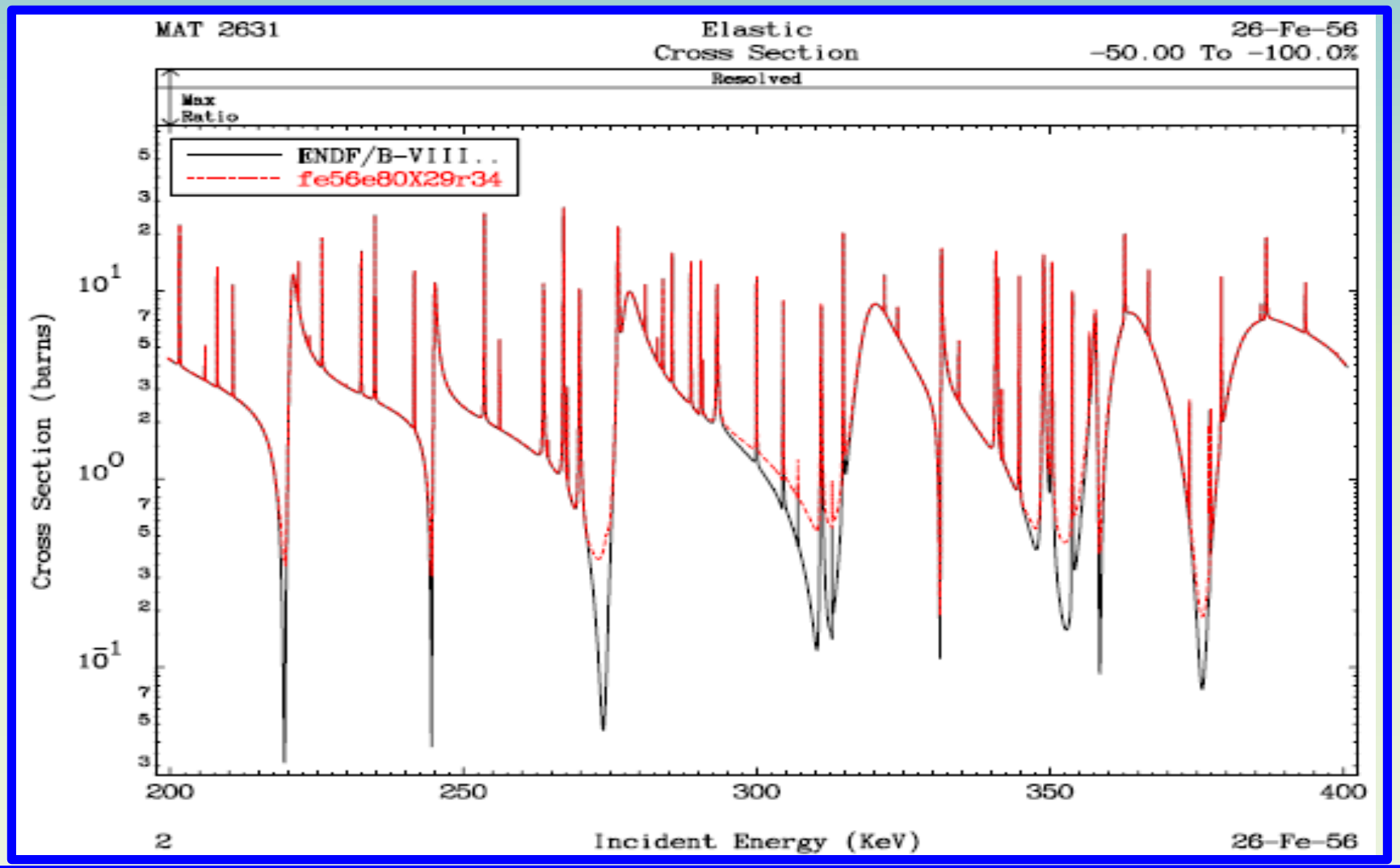
INDEN Fe: Filling the elastic cross-section minima

(relevant for deep penetration problems only)



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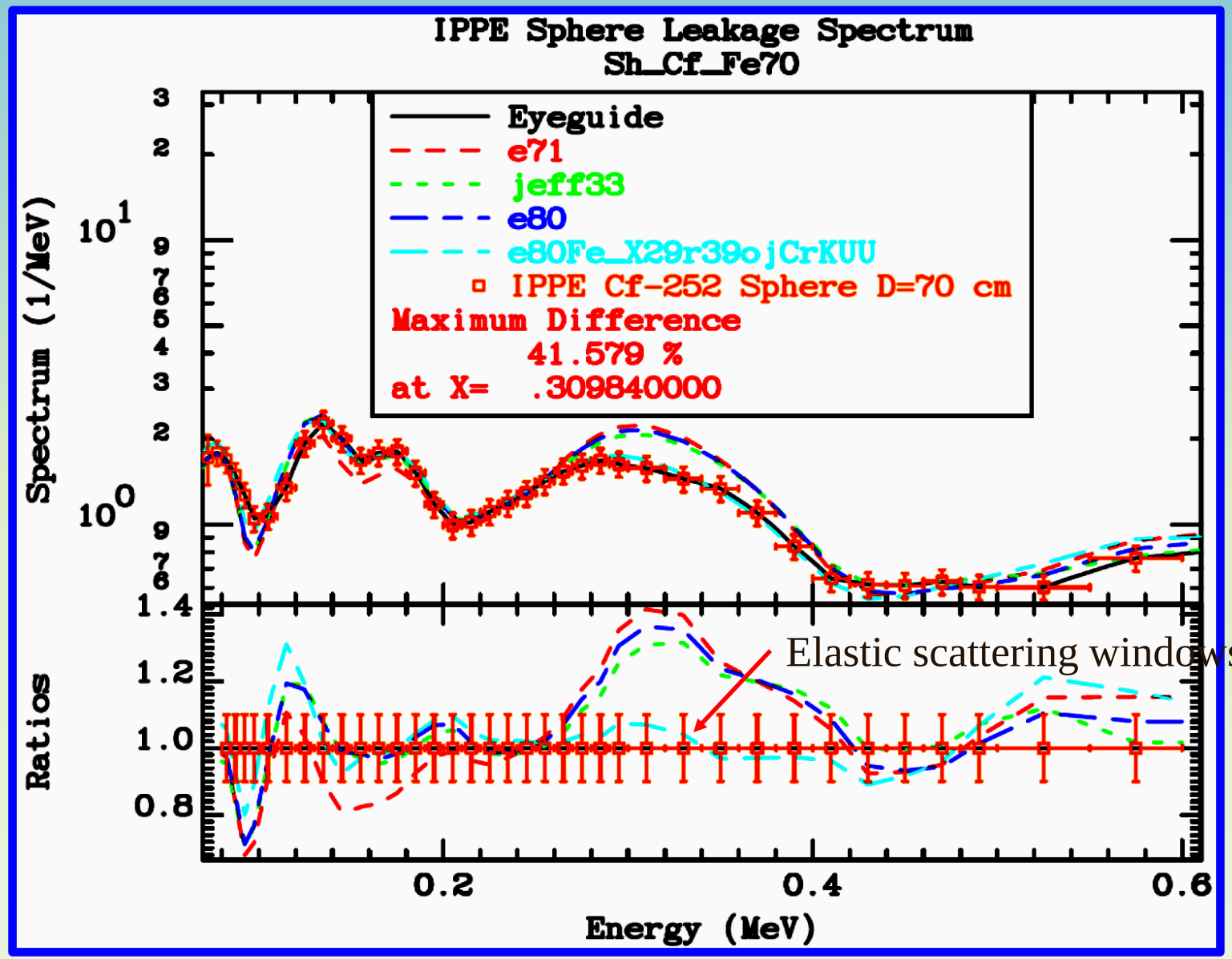
^{252}Cf(sf) neutron leakage: 70 cm sphere



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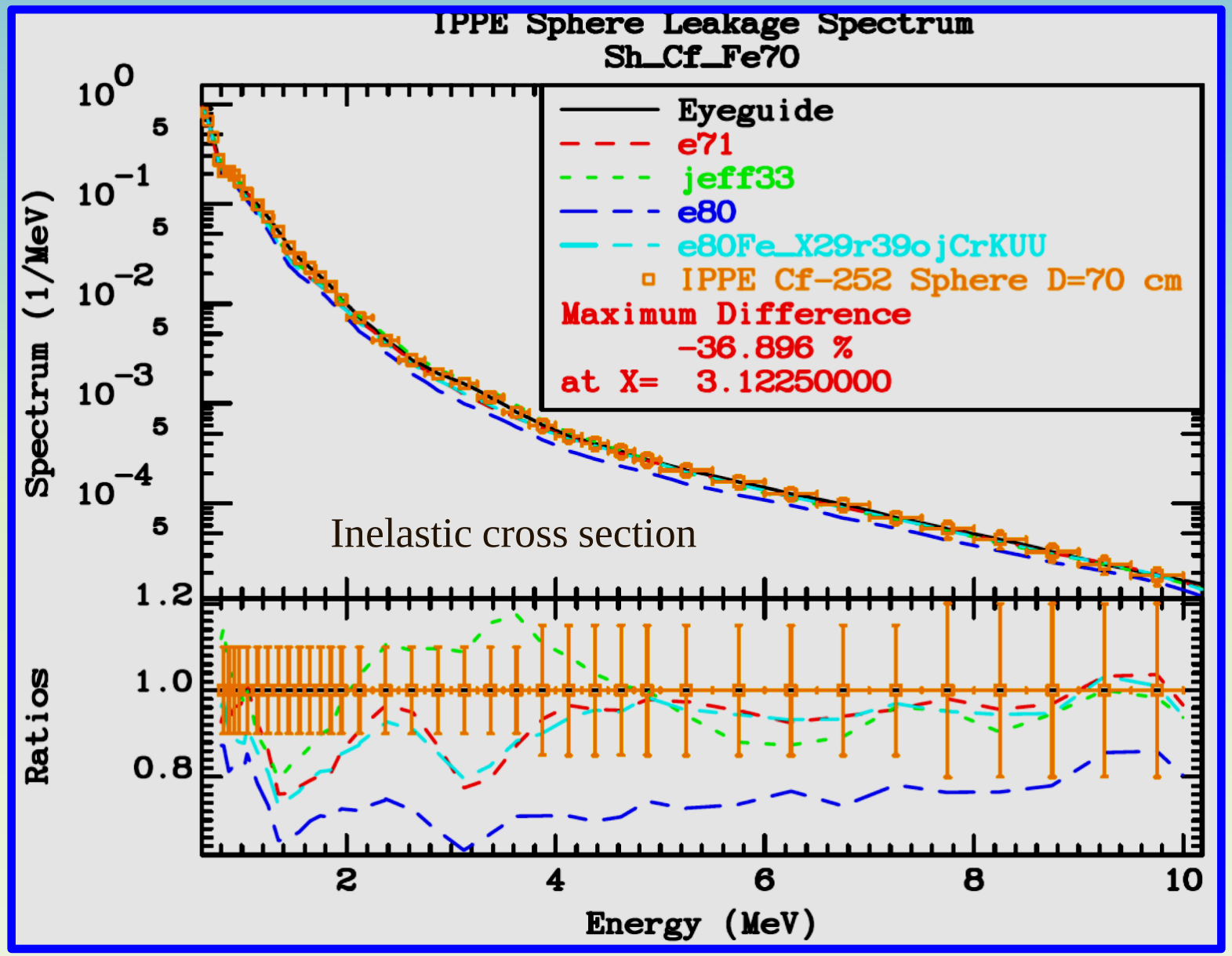
^{252}Cf(sf) neutron leakage: 70 cm sphere



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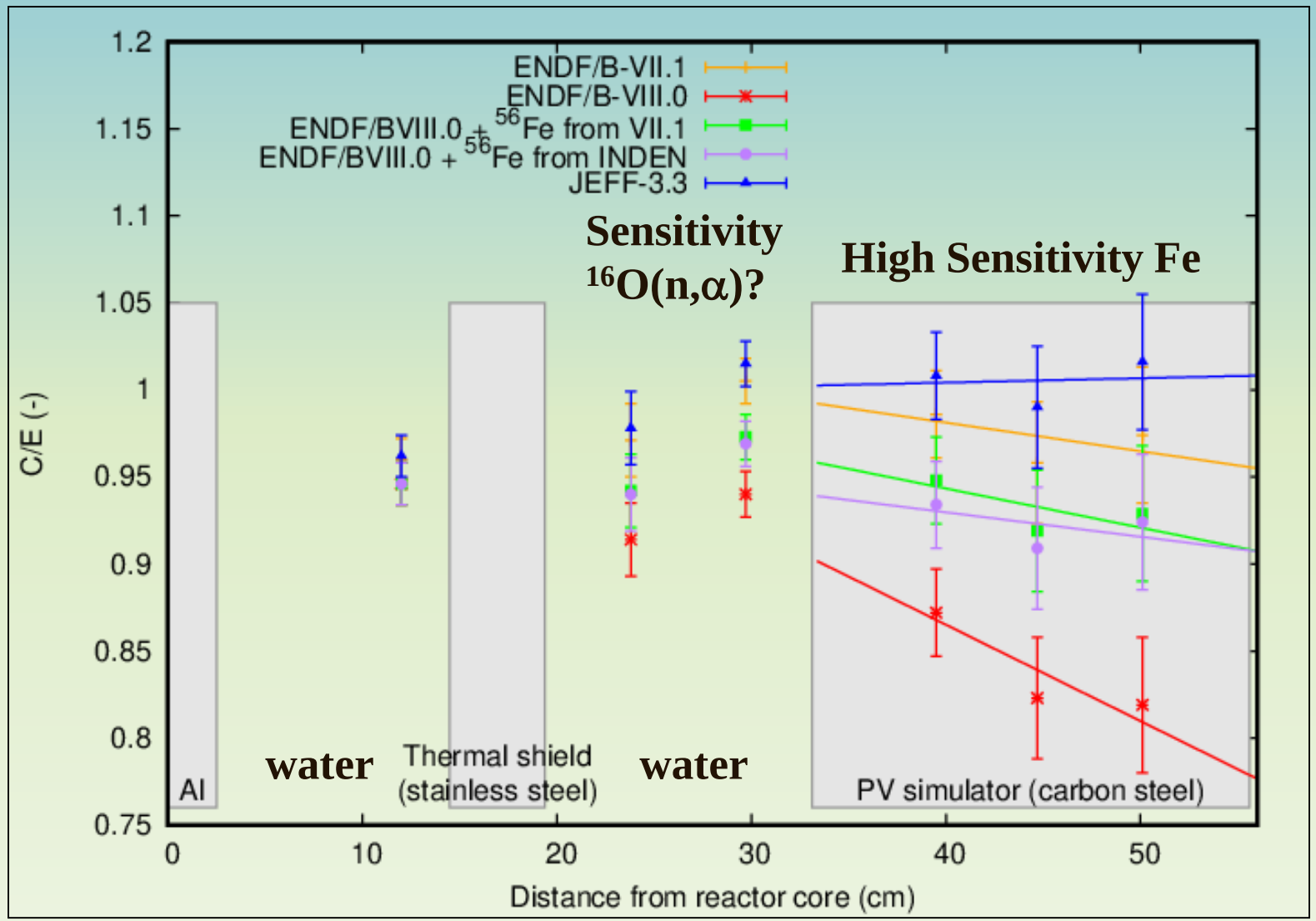
PCA reactor benchmark

Courtesy of Steven van der Marck (priv. comm.)



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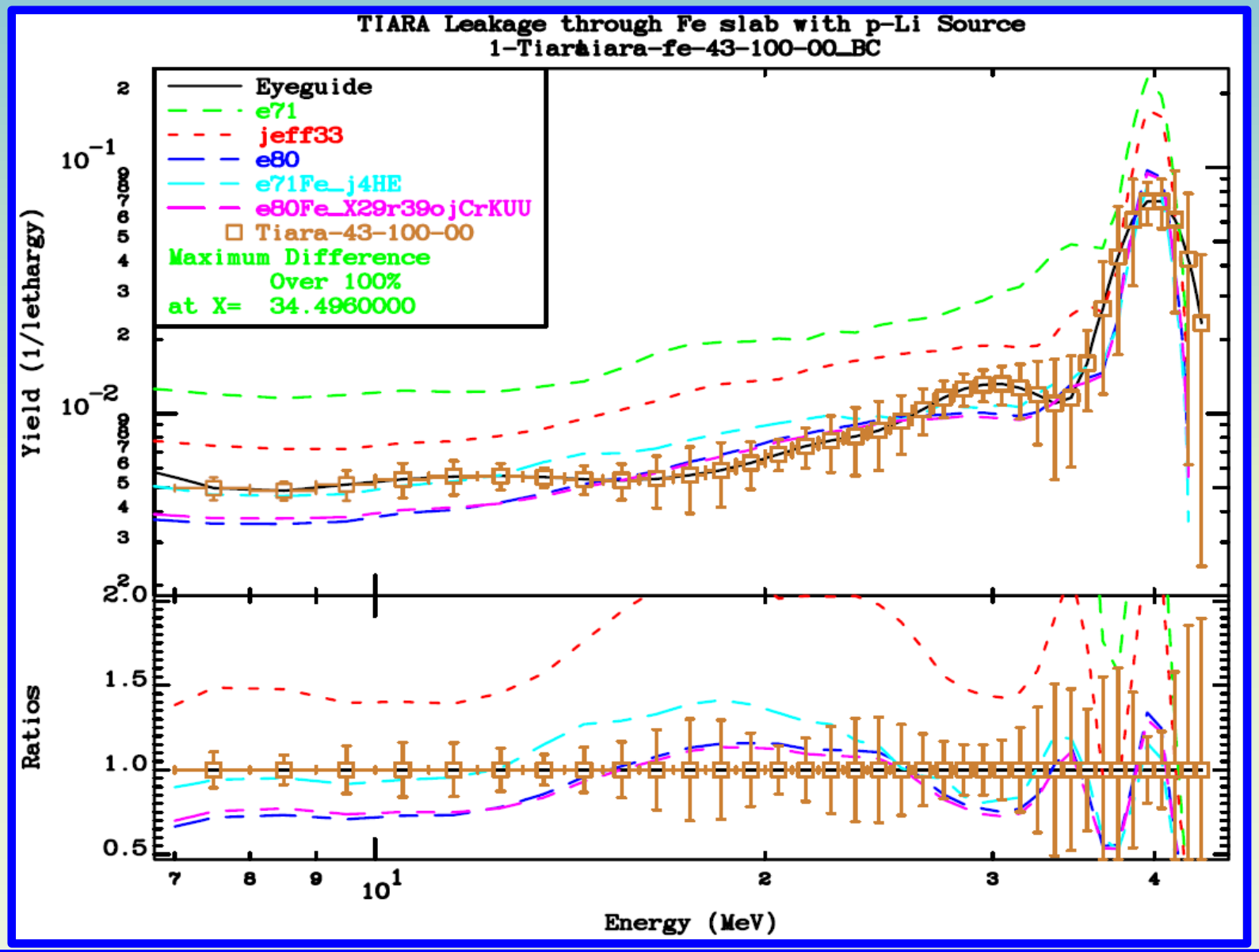
TIARA Leakage through 1m slab



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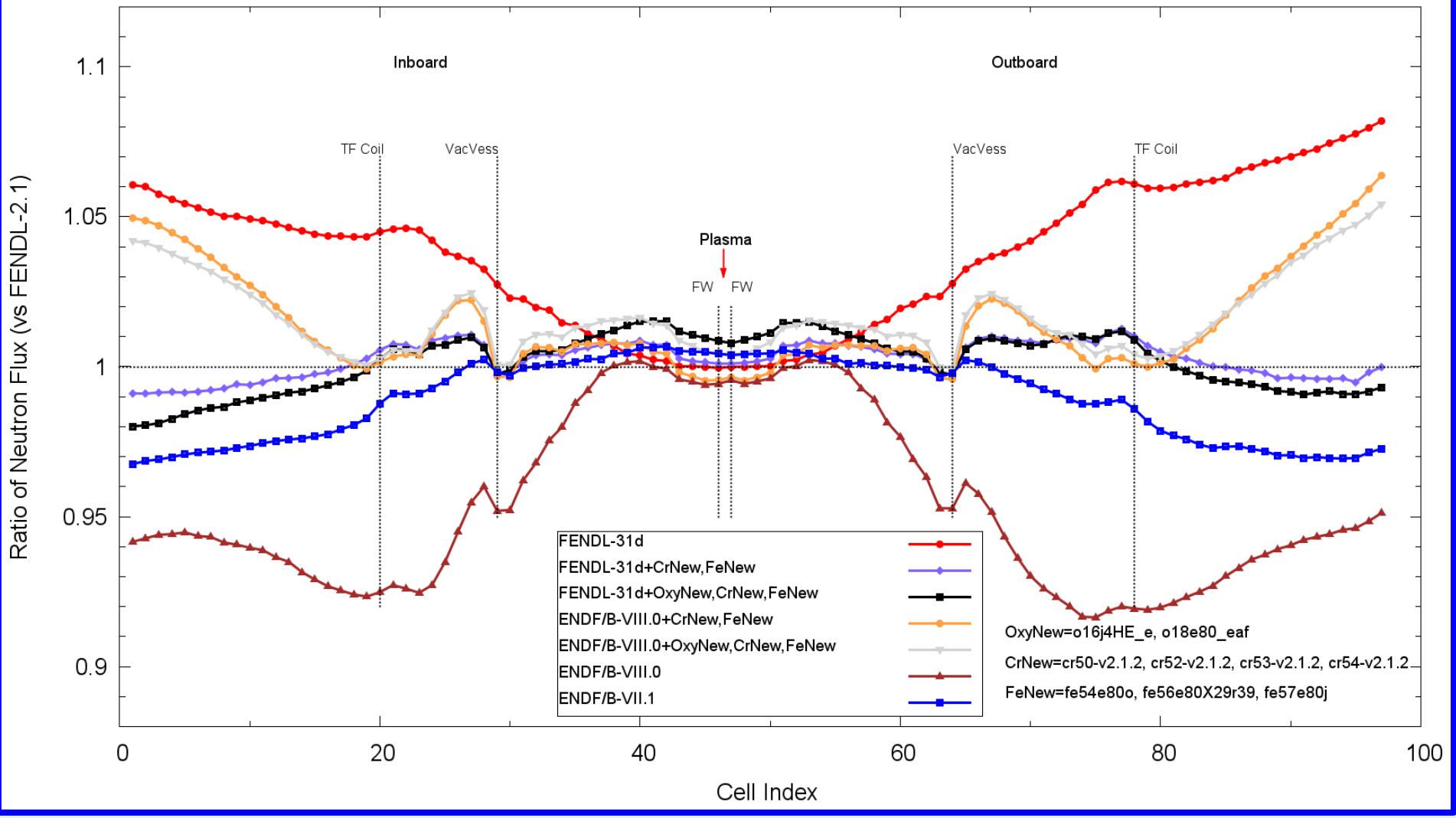
ITER 1-D Cylindrical Benchmark
Note, this is relative to FENDL-2.1 data !



Courtesy of Tim Bohm, University of Wisconsin-Madison

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Conclusions

- Deficiencies of the ENDF/B-VIII.0 (CIELO) iron isotope evaluations were corrected:
  - Inelastic cross section of Fe-56
  - Elastic cross section minima in RRR
  - Inelastic cross section of Fe-57
- In combination with other INDEN evaluations:
  - Performance in criticality problems at least as good or better.
  - Solved problems of flux under-estimation in leakage from thick iron spheres (Cf-252 and D-T sources) and flux overestimation around 300 keV.
  - Good performance in deep penetration problems at higher energies (43 MeV TIARA benchmark).

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^{252}Cf(sf) neutron leakage: 100 cm sphere

E_n [MeV]		C/E ratio		
From	To	CIELO	JEFF-3.2T2	IND-R34
0.013	**1.290**	**1.0450**	**1.0520**	**1.0290**
0.013	0.033	0.9138	0.9958	1.0560
0.033	0.060	0.9005	1.0190	1.0940
0.060	0.090	0.9702	0.9894	1.1290
0.090	0.150	0.9934	1.0070	1.0130
0.150	0.200	1.0370	1.0070	1.0900
0.200	0.250	1.0280	1.0130	1.0390
0.250	0.289	1.0360	1.0050	0.9561
0.289	0.333	1.3330	1.2290	0.9150
0.333	0.367	1.3050	1.2680	0.9819
0.367	0.410	1.1910	1.1710	1.0450
0.410	0.520	1.0330	1.0810	1.0070
0.520	0.780	1.0890	1.0620	1.0440
0.780	1.060	0.7834	1.0490	0.9984
1.060	1.290	0.7584	0.8654	1.0530

D abs<5% | D=5-10% | D>10% | D=-(5-10%) | D<-10%

H-proportional detector (HPD)

Figure 4. Comparison of calculated and measured spectra - assembly FE100R53," HPD region", E: HPD, C: CIELO, JEFF, IND-R22 and IND-R34.

E_n [MeV]		C/E ratio		
From	To	CIELO	JEFF-3.2T2	IND-R34
1.0	**10.0**	**0.859**	**0.992**	**1.015**
0.8	0.9	0.921	1.120	0.979
0.9	1.0	0.957	1.080	1.038
1.0	1.2	0.874	0.941	0.967
1.2	1.4	0.868	0.971	1.034
1.4	1.6	0.773	0.901	0.971
1.6	1.8	0.893	1.032	1.083
1.8	2.0	0.913	1.095	1.116
2.0	3.0	0.852	1.114	1.044
3.0	4.0	0.817	1.193	1.089
4.0	5.0	0.843	1.120	1.064
5.0	6.0	0.857	1.022	1.035
6.0	7.0	0.874	1.029	1.020
7.0	8.0	0.878	1.040	1.013
8.0	9.0	0.940	1.110	1.083
9.0	10.0	0.912	1.058	1.041
10.0	12.0	0.895	0.975	0.983
12.0	14.0	0.799	0.803	0.824
14.0	16.0	0.672	0.638	0.673

D abs<5% | D=5-10% | D>10% | D=-(5-10%) | D<-10%

stilbene detector

Figure 6. Comparison of calculated and measured spectra - assembly FE50R100,"stilbene region", E: averaged from 4 measurement, C: CIELO, JEFF-3.2T2, IND-R22, IND-R34.

Note that ENDF/B-VIII.0 Fe = CIELO

✓ B. Jansky et al., CVR, Rez, Czechia,EPJ WoC **239** (2020) 18005 (ND2019)

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