IAEA
International Atomic Energy Agency
Atoms for Peace and Development

Benchmark testing for nuclear data validation at the IAEA

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Scope

- The MCNP Monte Carlo code is used to run the benchmarks
- Benchmarks include cases from the ICSBEP Handbook, as well as shielding benchmarks from the SINBAD collection
- More than 2000 cases are available
- Features of the IAEA system:
  - A single input defines libraries to be tested and benchmarks to be included
  - Inputs are collected automatically to pass on to the computational machine
  - Outputs are distributed automatically to the appropriate directories
  - Plots are generated automatically for all relevant inputs and libraries

Nomenclature

- Benchmark directories are named as in ICSBEP, except that they are not subdivided into Volumes
- ICSBEP Benchmark Case names are generally consistent with DICE (exception: MIX-MISC-FAST labelled “mif” to maintain a 3-character name designation); examples:
  - Inputs: hmf001.i; hst009-004.i; mmi003.i; mif002-001.i …
  - Outputs: hmf001_e71.o; hst009-004_e80.o; …
- In the input material specifications the suffix is stripped – material selection is controlled via the xsdir file

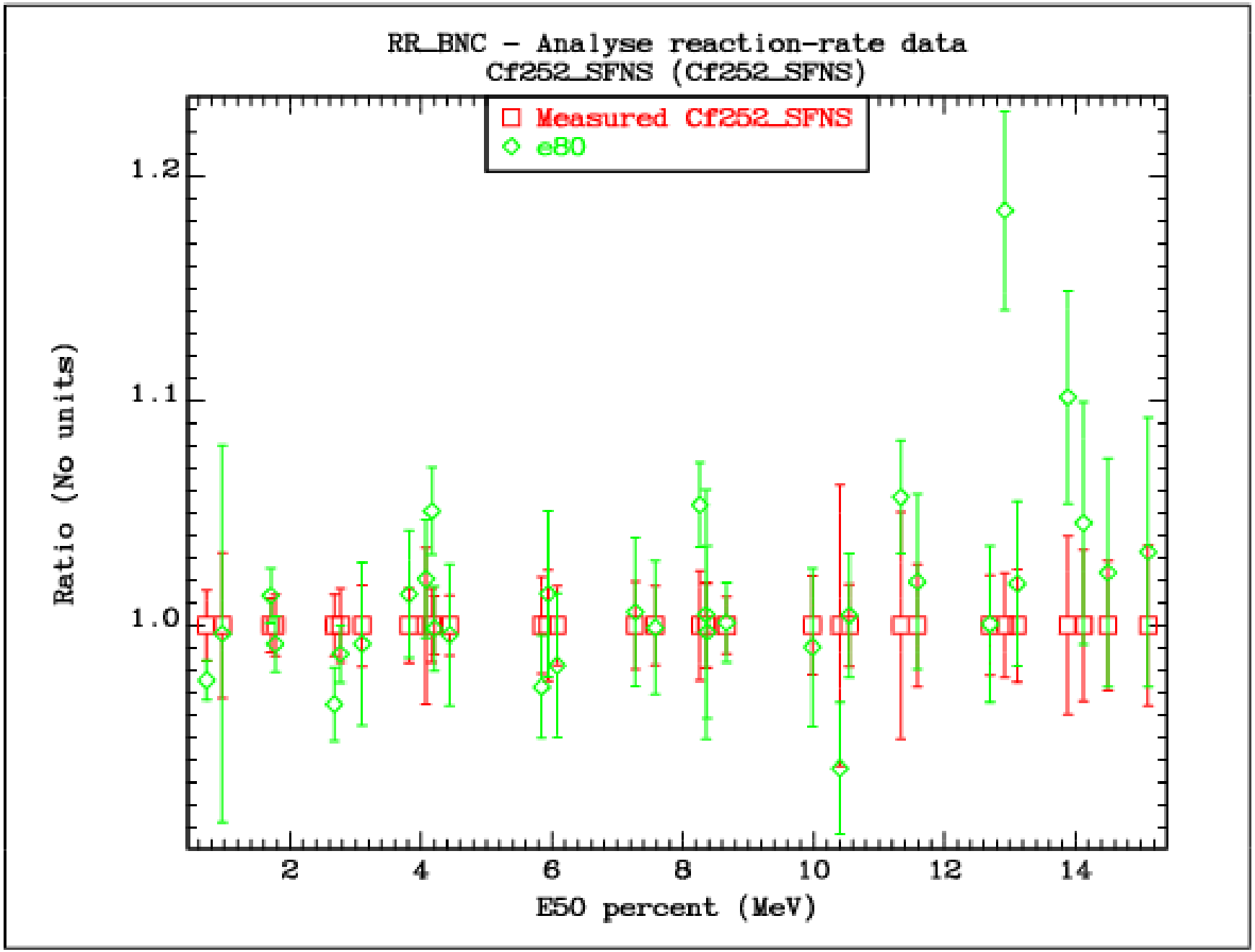
Hi-Fi ICSBEP cases with reaction rates

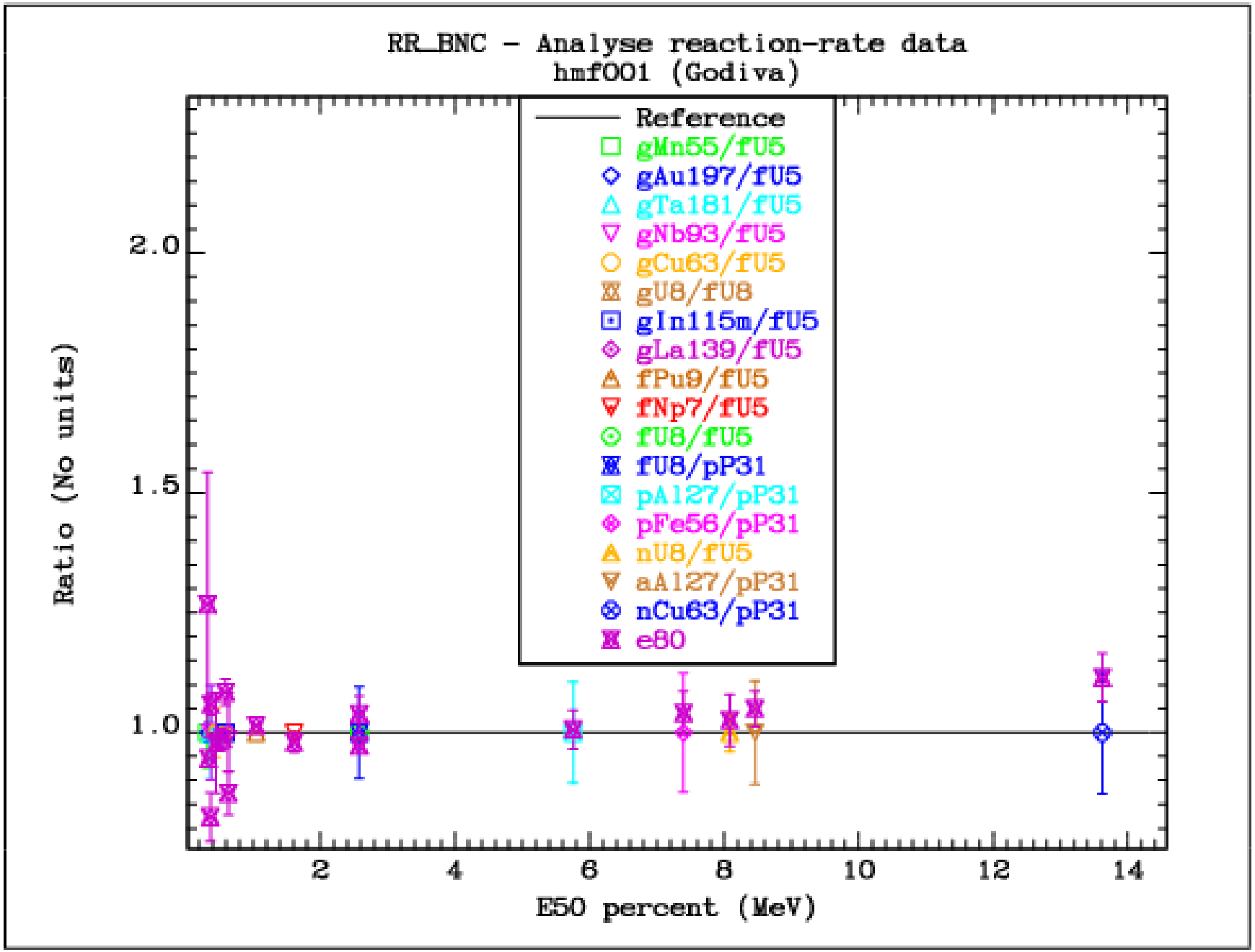
- Computational models (and MCNP outputs) were provided by A. Kahler. Our primary interest is in the spectra in 725-groups, which is used in the IRDFF dosimetry library.
- RR_UNC code can be used to calculate average reaction rates in the given spectrum, including:
  - uncertainties from the cross sections AND the spectrum (only statistical in the case of MC calculations).
  - Cross sections from a chosen library (e.g. new IRDFF-II dosimetry library – in preparation)

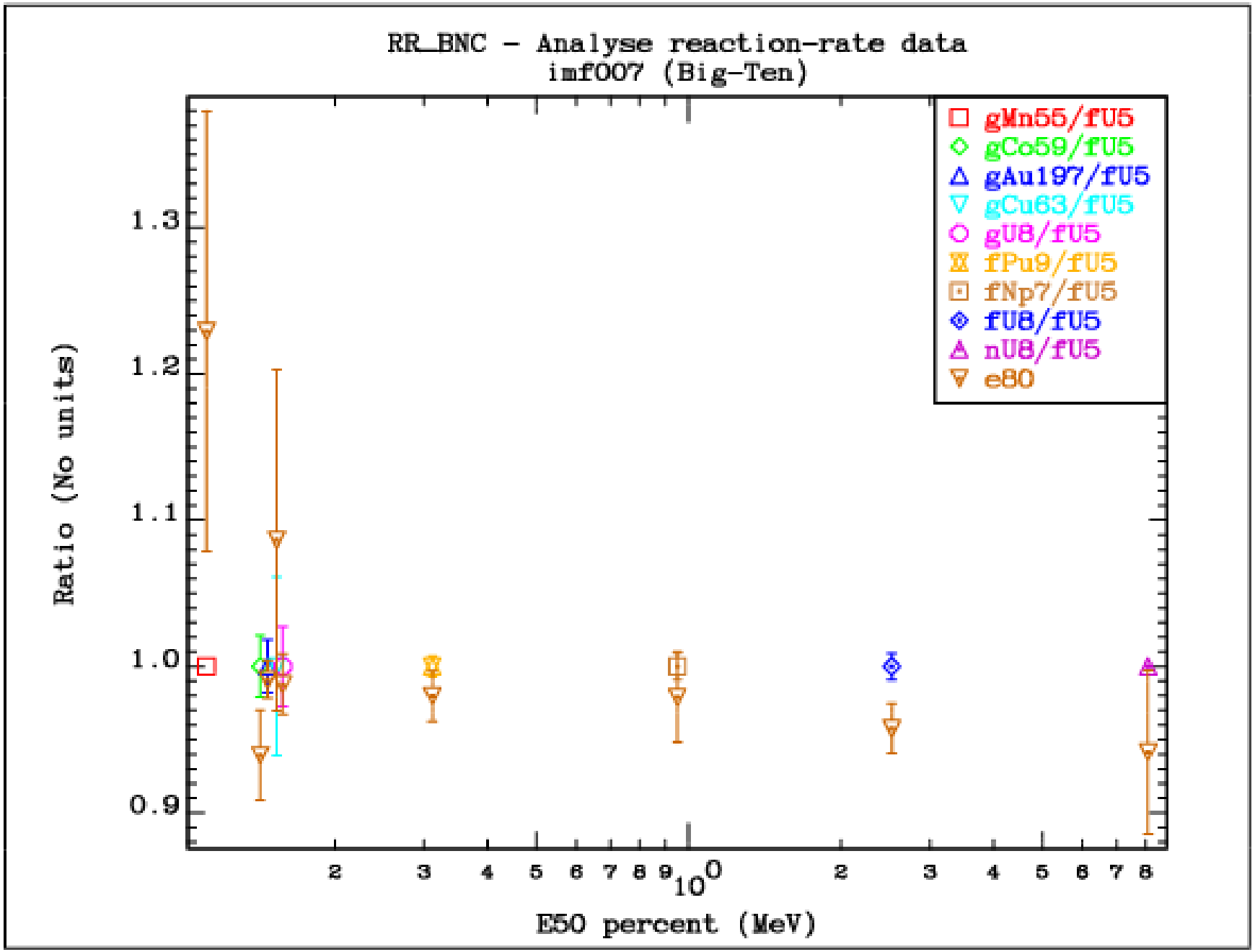
Hi-Fi ICSBEP cases with reaction rates (Cont.)

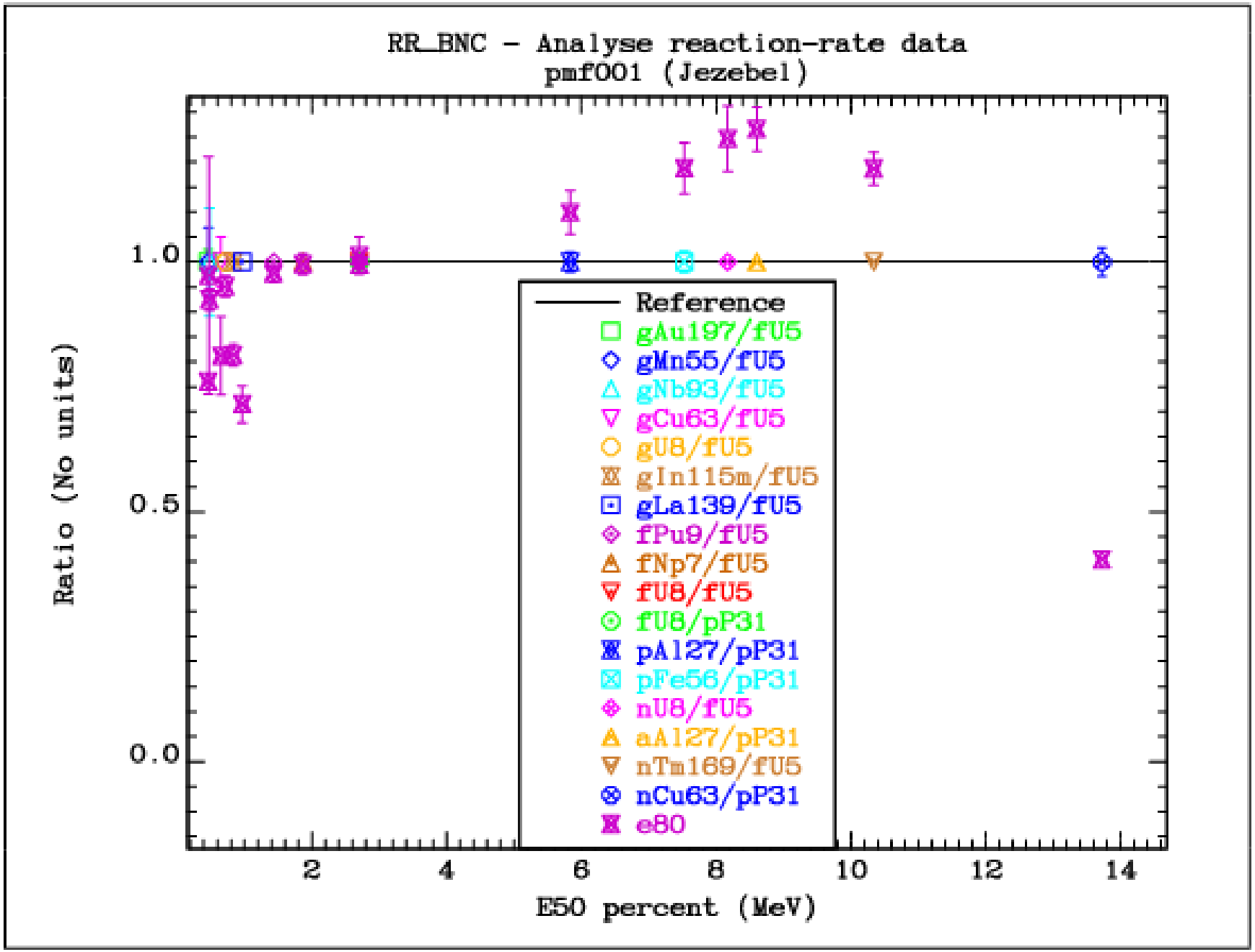
Examples (only reactions in IRDFF-II are considered):

- Cf-252 SFNS is a Standard (validation of cross sections, good consistency)
- U-235 PFNS is also a standard (Standards-2017) (validation of cross sections, good consistency)
- Godiva (good consistency)
- Big-Ten (good consistency)
- Jezebel (something wrong with PFNS of Pu-239 ?)


RR_BNC - Analyse reaction-rate data
Cf252_SFNS (Cf252_SFNS)
Measured Cf252_SFNS
e80
Ratio (No units)
1.2
1.1
1.0
2
4
6
8
10
12
14
E50 percent (MeV)

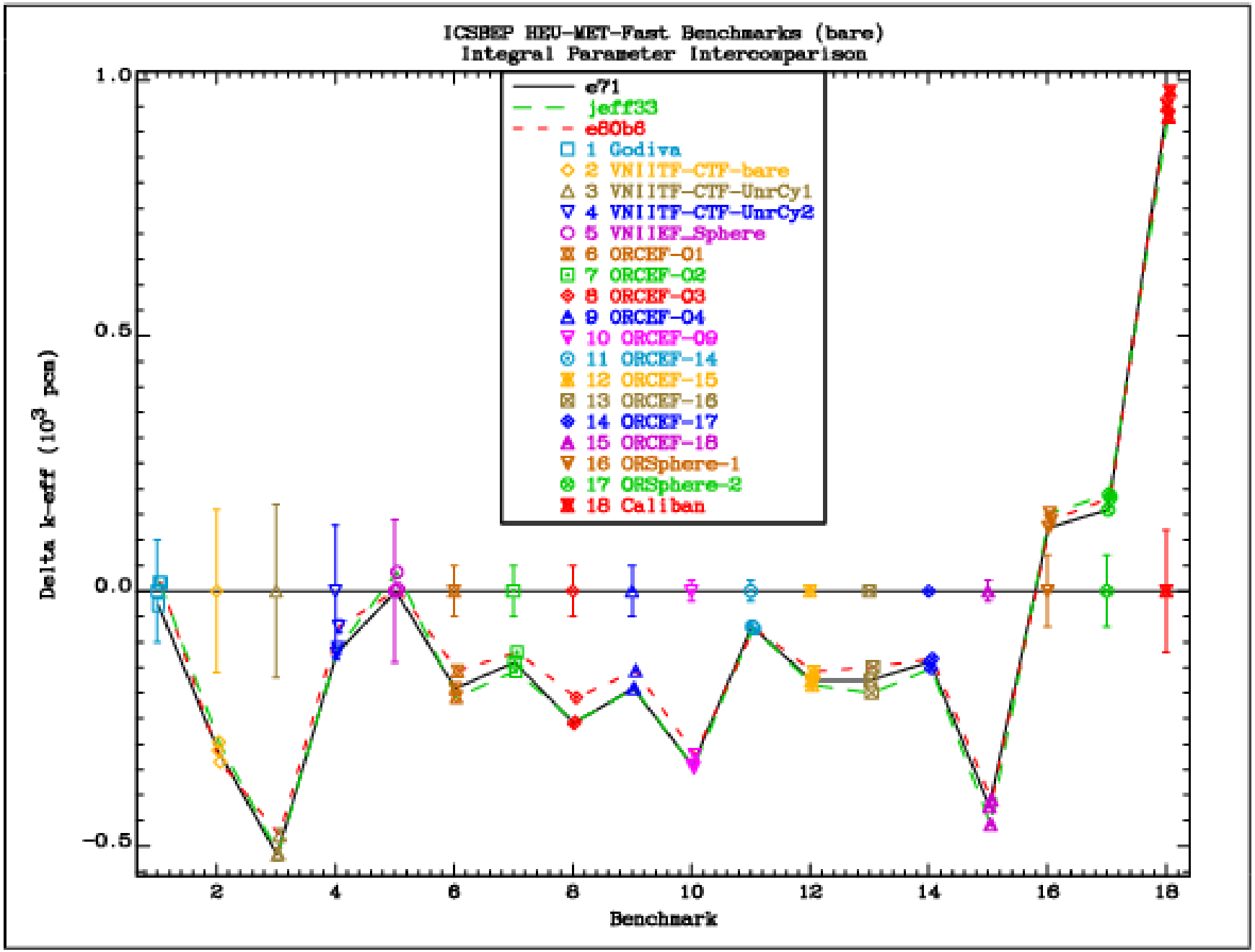

RR_BNC - Analyse reaction-rate data
hmf001 (Godiva)
Reference
gMn55/fU5
gAu197/fU5
gTa181/fU5
gNb93/fU5
gCu63/fU5
gU8/fU8
gIn115m/fU5
gLa139/fU5
fPu9/fU5
fNp7/fU5
fU8/fU5
fU8/pP31
pAl27/pP31
pFe56/pP31
nU8/fU5
aAl27/pP31
nCu63/pP31
e80
Ratio (No units)
2.0
1.5
1.0
2
4
6
8
10
12
14
E50 percent (MeV)

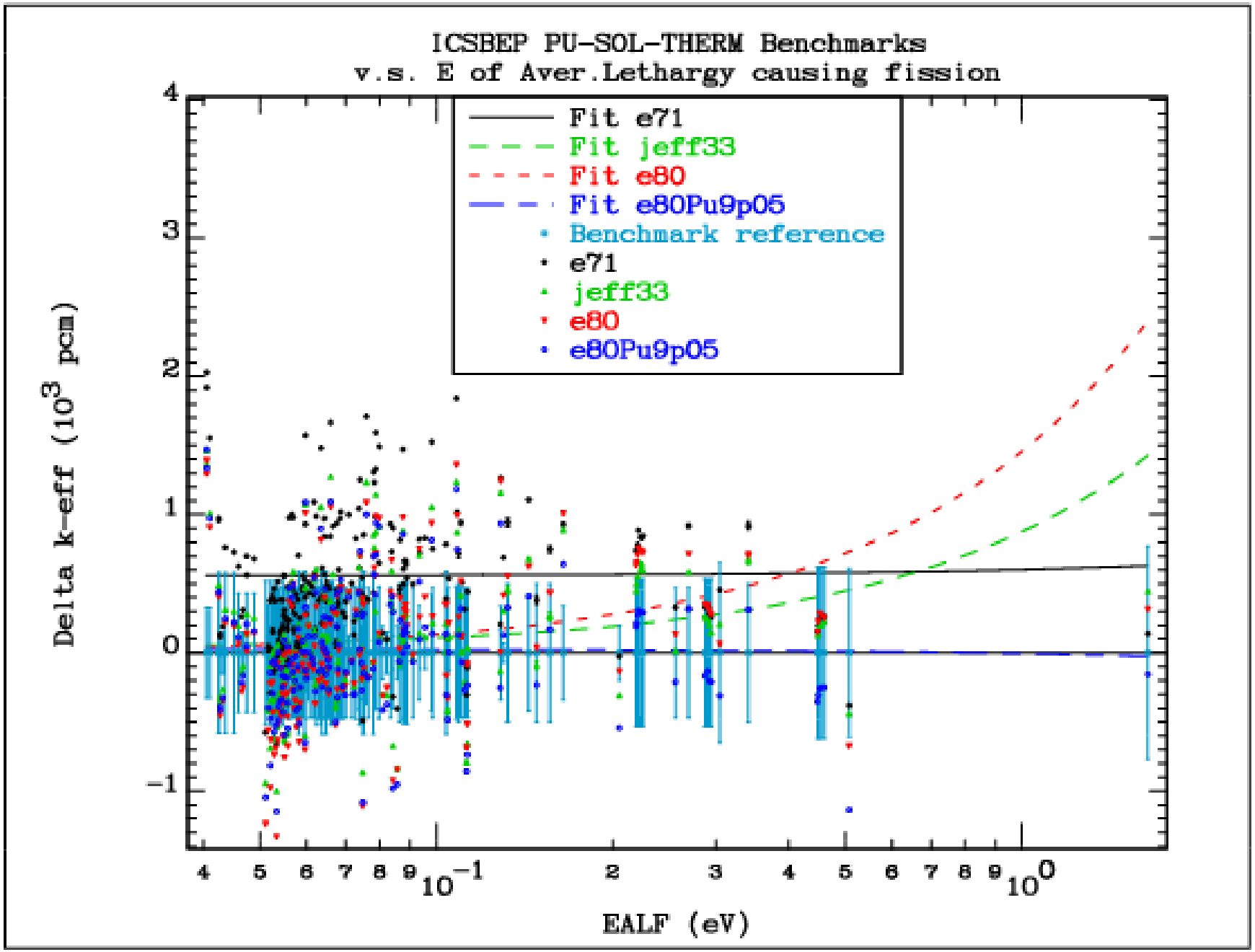

RR_BNC - Analyse reaction-rate data
imf007 (Big-Ten)
gMn55/fU5
gCo59/fU5
gAu197/fU5
gCu63/fU5
gU8/fU5
fPu9/fU5
fNp7/fU5
fU8/fU5
nU8/fU5
e80
Ratio (No units)
1.3
1.2
1.1
1.0
0.9
2
3
4
5
6
7
8
9
10^0
2
3
4
5
6
7
8
E50 percent (MeV)

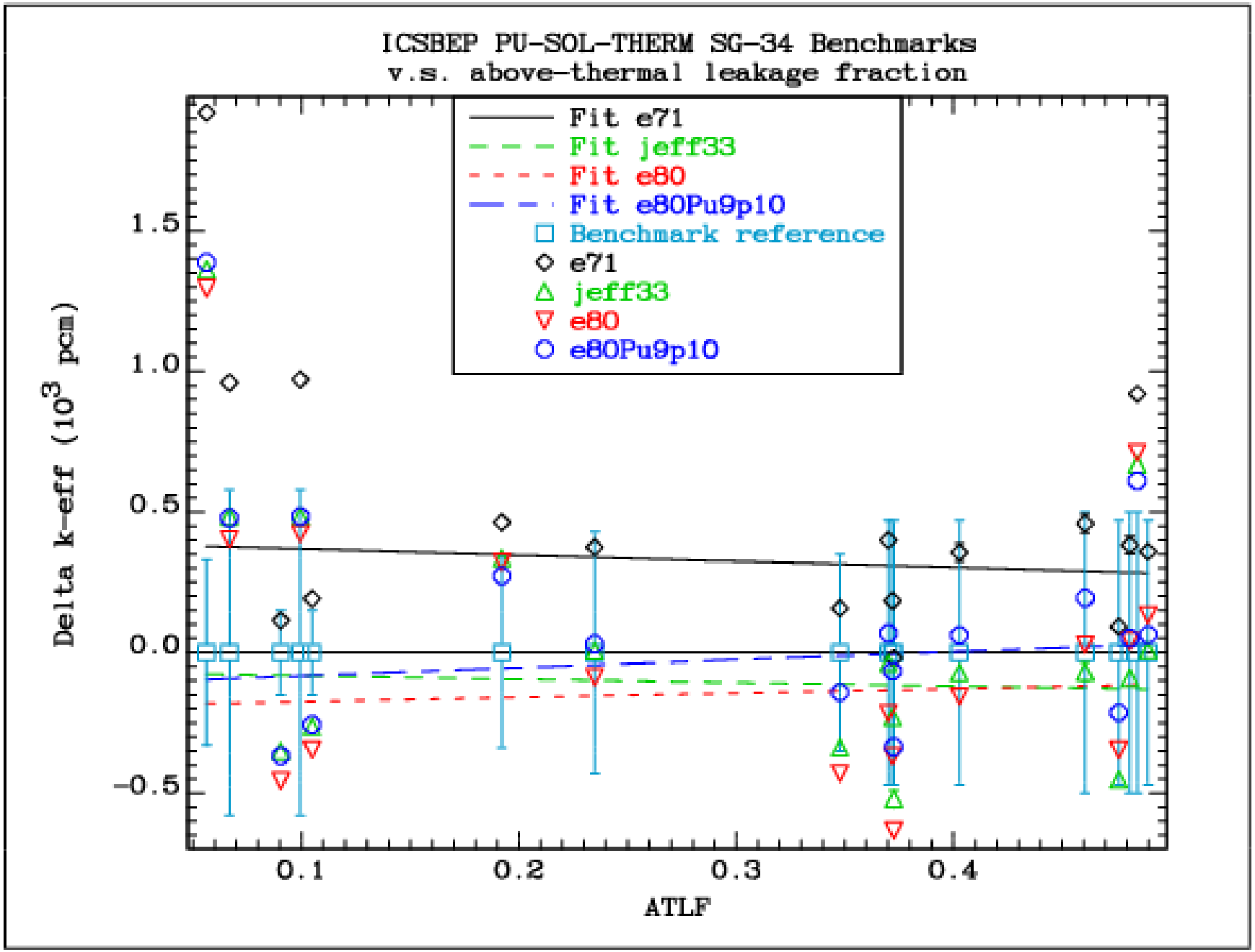

RR_BNC - Analyse reaction-rate data
pmf001 (Jezebel)
Ratio (No units)
1.0
0.5
0.0
2
4
6
8
10
12
14
E50 percent (MeV)
Reference
gAu197/fU5
gMn55/fU5
gNb93/fU5
gCu63/fU5
gU8/fU5
gIn115m/fU5
gLa139/fU5
fPu9/fU5
fNp7/fU5
fU8/fU5
fU8/pP31
pAl27/pP31
pFe56/pP31
nU8/fU5
aAl27/pP31
nTm169/fU5
nCu63/pP31
e80

Quality of ICSBEP for data validation

- ICSBEP primary intention is criticality safety, BUT
- If the quoted uncertainties are relative, this should be stated and an estimate of the systematic uncertainty given
- We are not a liberty to arbitrarily “add” uncertainty even when it is obvious that the quoted value is incomplete
- Examples:
  - HMF bare
  - PST


ICSBEP HEU-MET-Fast Benchmarks (bare)
Integral Parameter Intercomparison
e71
jeff33
e80b8
1 Godiva
2 VNIITF-CTF-bare
3 VNIITF-CTF-UnrCy1
4 VNIITF-CTF-UnrCy2
5 VNIIEF_Sphere
6 ORCEF-01
7 ORCEF-02
8 ORCEF-03
9 ORCEF-04
10 ORCEF-09
11 ORCEF-14
12 ORCEF-15
13 ORCEF-16
14 ORCEF-17
15 ORCEF-18
16 ORSphere-1
17 ORSphere-2
18 Caliban
Delta k-eff (10^3 pcm)
1.0
0.5
0.0
-0.5
2
4
6
8
10
12
14
16
18
Benchmark


ICSBEP PU-SOL-THERM Benchmarks
v.s. E of Aver.Lethargy causing fission
Fit e71
Fit jeff33
Fit e80
Fit e80Pu9p05
Benchmark reference
e71
jeff33
e80
e80Pu9p05
Delta k-eff (10^3 pcm)
EALF (eV)
4
3
2
1
0
−1
10^{-1}
10^{0}


ICSBEP PU-SOL-THERM SG-34 Benchmarks
v.s. above-thermal leakage fraction
Fit e71
Fit jeff33
Fit e80
Fit e80Pu9p10
Benchmark reference
e71
jeff33
e80
e80Pu9p10
Delta k-eff (10^3 pcm)
1.5
1.0
0.5
0.0
-0.5
0.1
0.2
0.3
0.4
ATLF

No.	ICSBEP Label	Short name	Common name	Comment
1	PU-SOL-THERM-001	pst001-001	PNL(11.5)2210-1	pst_SG34
2	PU-SOL-THERM-001	pst001-004	PNL(11.5)2164-4	pst_SG34
3	PU-SOL-THERM-001	pst001-006	PNL(11.5)2218-6	pst_SG34
4	PU-SOL-THERM-004	pst004-001	P11(14)-01	
5	PU-SOL-THERM-004	pst004-005	P11(14)-05	pst_SG34
6	PU-SOL-THERM-005	pst005-001	P11(14)Pu0-1	pst_SG34
7	PU-SOL-THERM-005	pst005-007	P11(14)Pu0-7	pst_SG34
8	PU-SOL-THERM-006	pst006-002	P11(15)-2	pst_SG34
9	PU-SOL-THERM-007	pst007-003	PNL(11.5)p-03	pst_SG34
10	PU-SOL-THERM-007	pst007-010	PNL(11.5)p-10	pst_SG34
11	PU-SOL-THERM-009	pst009-003a	PNL-48R-3a	Mosteller119
12	PU-SOL-THERM-012	pst012-005	Valduc-05	pst_SG34
13	PU-SOL-THERM-012	pst012-010	Valduc-10	
14	PU-SOL-THERM-012	pst012-013	Valduc-13	pst_SG34
15	PU-SOL-THERM-018	pst018-006	PNL-11-6	
16	PU-SOL-THERM-038	pst038-003	Valduc_loPu-03	
17	PU-SOL-THERM-038	pst038-004	Valduc_loPu-04	