IAEA-NDS and the CIELO Project
U-235

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International Atomic Energy Agency

The CIELO Project – U-235

Quote: “A new paradigm to facilitate evaluated nuclear reaction data advances” (ND2013)

Evaluated nuclear data for U-235

- P. Romain et al., Bruyere-le-Chatels (BRC) with L. Leal (ORNL) resonance data
- IAEA evaluation (including thermal PFNS) with L. Leal (ORNL) resonance data

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U-235 General Features – nu-bar

- IAEA adopts ENDF/B-VII.1
- BRC linear at low energies

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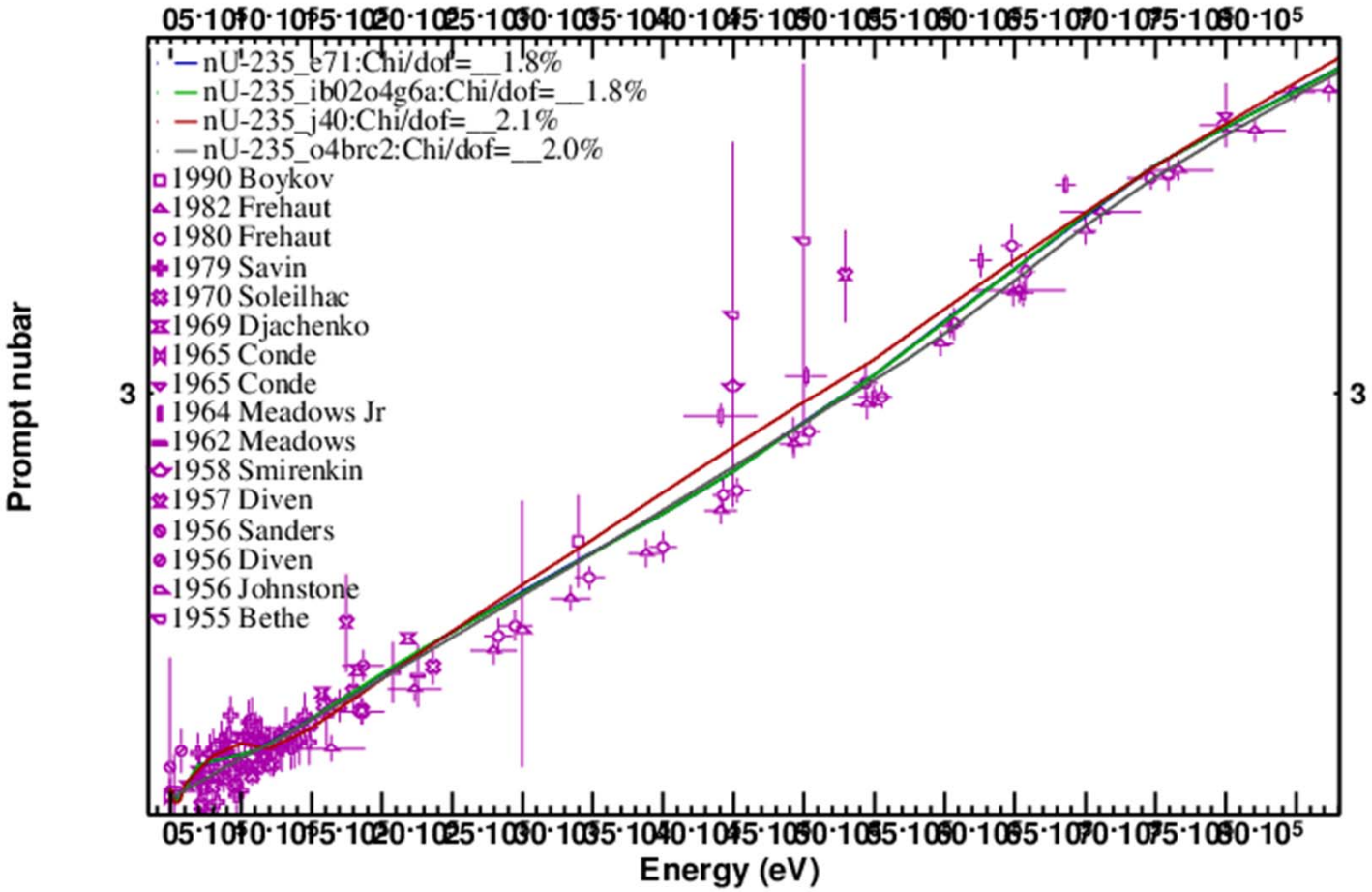
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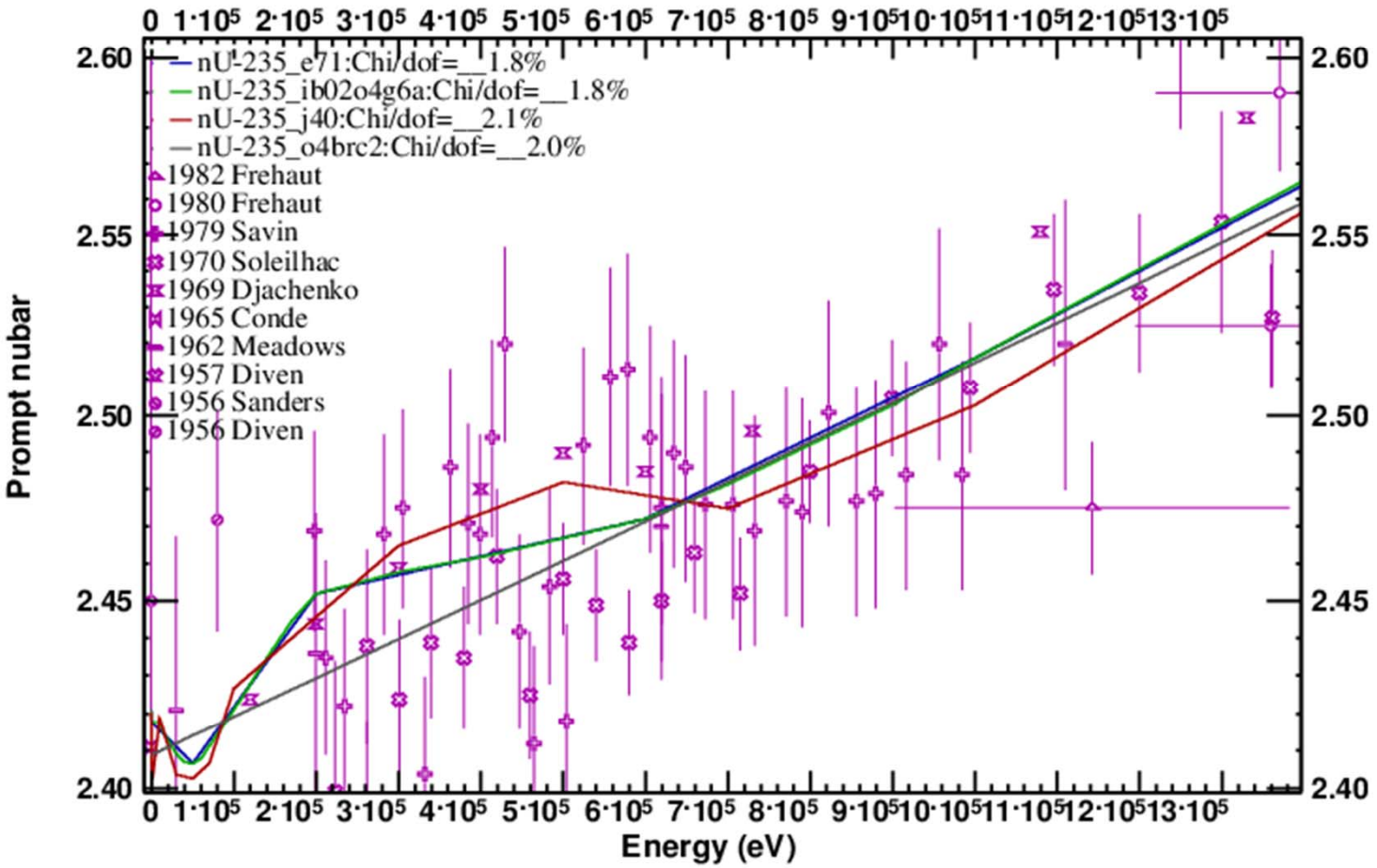
nU-235_j40:Chi/dof=__2.1%
nU-235_o4brc2:Chi/dof=__2.0%
1990 Boykov
1982 Frehaut
1980 Frehaut
1979 Savin
1970 Soleilhac
1969 Djachenko
1965 Conde
1965 Conde
1964 Meadows Jr
1962 Meadows
1958 Smirenkin
1957 Diven
1956 Sanders
1956 Diven
1956 Johnstone
1955 Bethe
Prompt nubar
Energy (eV)
3
3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nU-235_j40:Chi/dof=__2.1%
nU-235_o4brc2:Chi/dof=__2.0%
1982 Frehaut
1980 Frehaut
1979 Savin
1970 Soleilhac
1969 Djachenko
1965 Conde
1962 Meadows
1957 Diven
1956 Sanders
1956 Diven
Prompt nubar
Energy (eV)
2.60
2.55
2.50
2.45
2.40
0 1·10⁵ 2·10⁵ 3·10⁵ 4·10⁵ 5·10⁵ 6·10⁵ 7·10⁵ 8·10⁵ 9·10⁵ 10·10⁵ 11·10⁵ 12·10⁵ 13·10⁵

U-235 General Features - Inelastic

- BRC inelastic higher at low energies but lower near the plateau,
- IAEA inelastic similar to JENDL,
- All evaluations lower than ENDF/B-VII.1 near the plateau.

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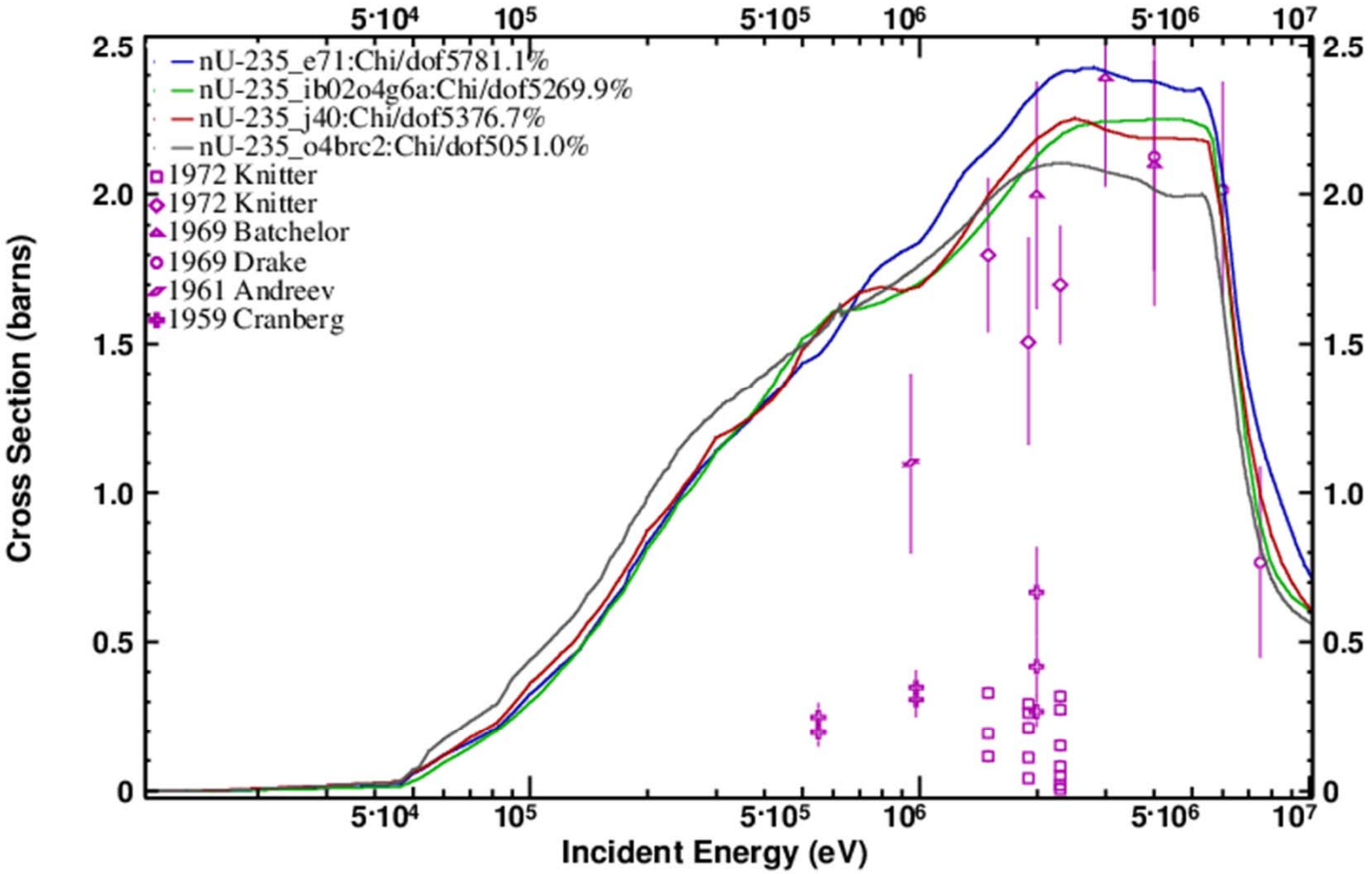
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nU-235_ib02o4g6a:Chi/dof5269.9%
nU-235_j40:Chi/dof5376.7%
nU-235_o4brc2:Chi/dof5051.0%
1972 Knitter
1972 Knitter
1969 Batchelor
1969 Drake
1961 Andreev
1959 Cranberg
Cross Section (barns)
Incident Energy (eV)
5·10⁴
10⁵
5·10⁵
10⁶
5·10⁶
10⁷
0
0.5
1.0
1.5
2.0
2.5

U-235 General Features – (n,2n)

- BRC higher at low energies, falls off earlier after the plateau
- All other evaluations look similar

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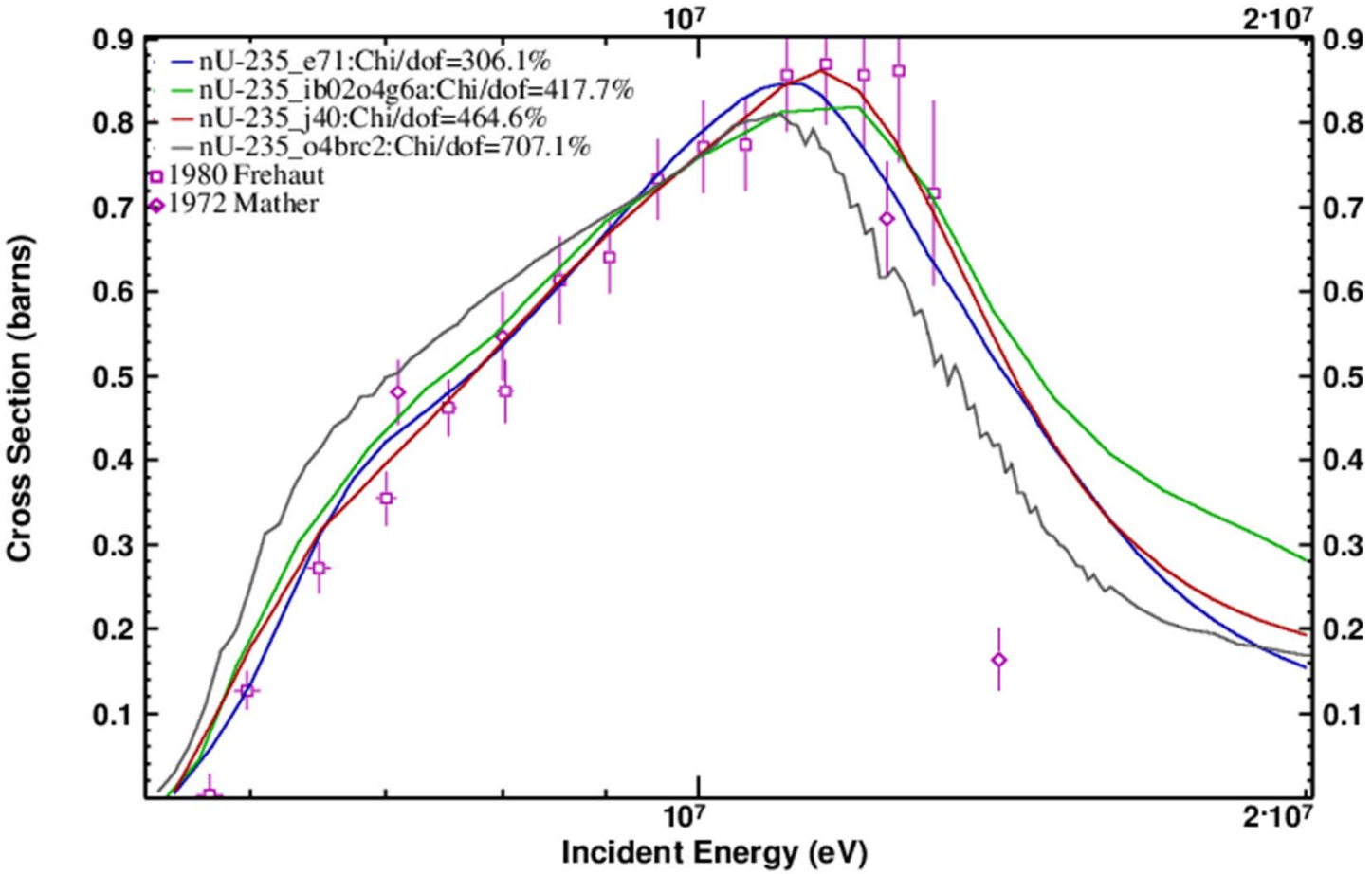
nU-235_e71:Chi/dof=306.1%
nU-235_ib02o4g6a:Chi/dof=417.7%
nU-235_j40:Chi/dof=464.6%
nU-235_o4brc2:Chi/dof=707.1%
1980 Frehaut
1972 Mather
Cross Section (barns)
Incident Energy (eV)
10^7
2·10^7
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

U-235 General Features - Capture

- BRC capture above the resonance range is distinctly higher
- IAEA evaluation adopts JENDL-4

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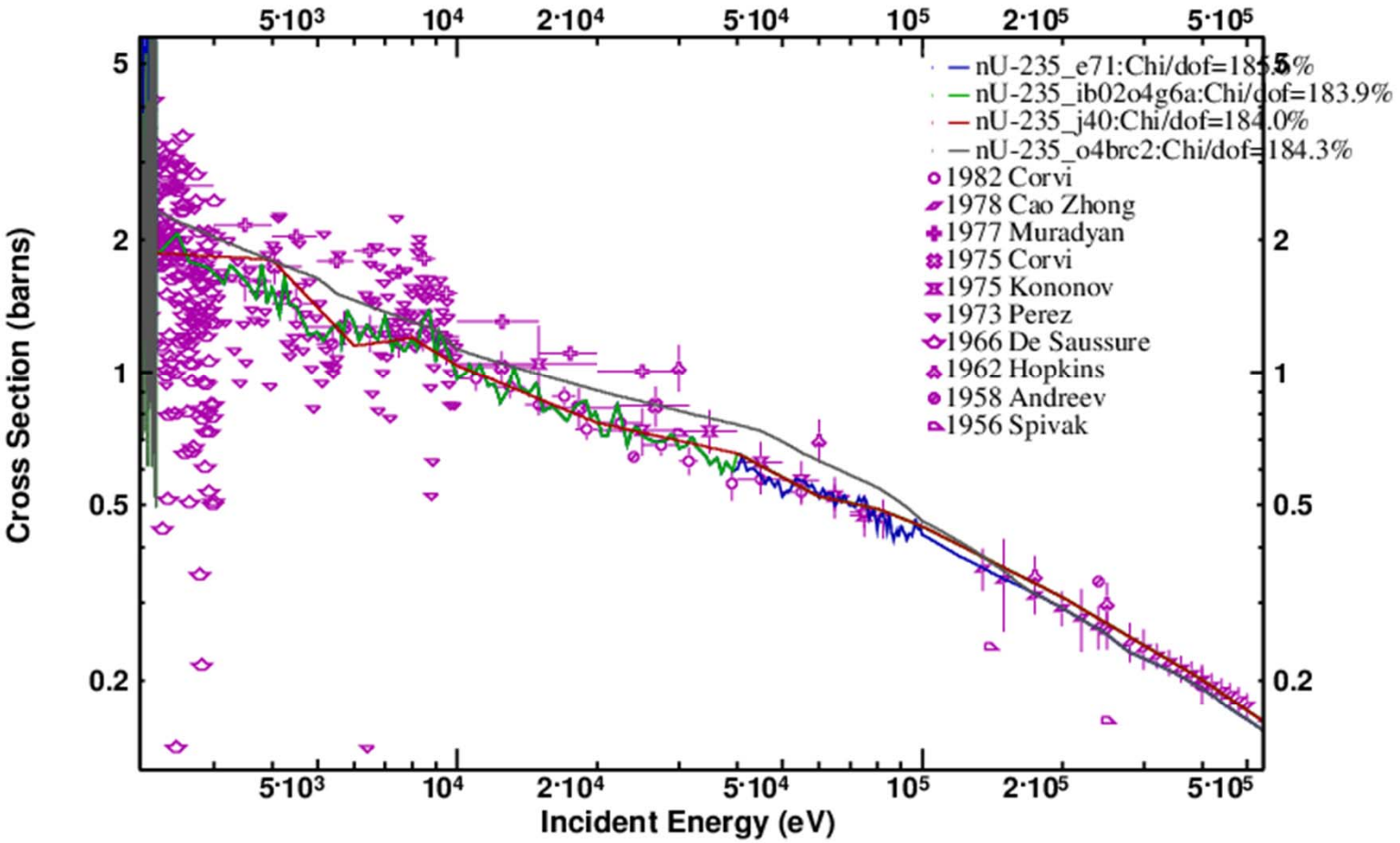
Cross Section (barns)
Incident Energy (eV)
5·10³
10⁴
2·10⁴
5·10⁴
10⁵
2·10⁵
5·10⁵
5
2
1
0.5
0.2
nU-235_e71:Chi/dof=185.5%
nU-235_ib02o4g6a:Chi/dof=183.9%
nU-235_j40:Chi/dof=184.0%
nU-235_o4brc2:Chi/dof=184.3%
1982 Corvi
1978 Cao Zhong
1977 Muradyan
1975 Corvi
1975 Kononov
1973 Perez
1966 De Saussure
1962 Hopkins
1958 Andreev
1956 Spivak

U-235 General Features – (n,p)

- Not present in ENDF/B-VII.1 and JENDL-4

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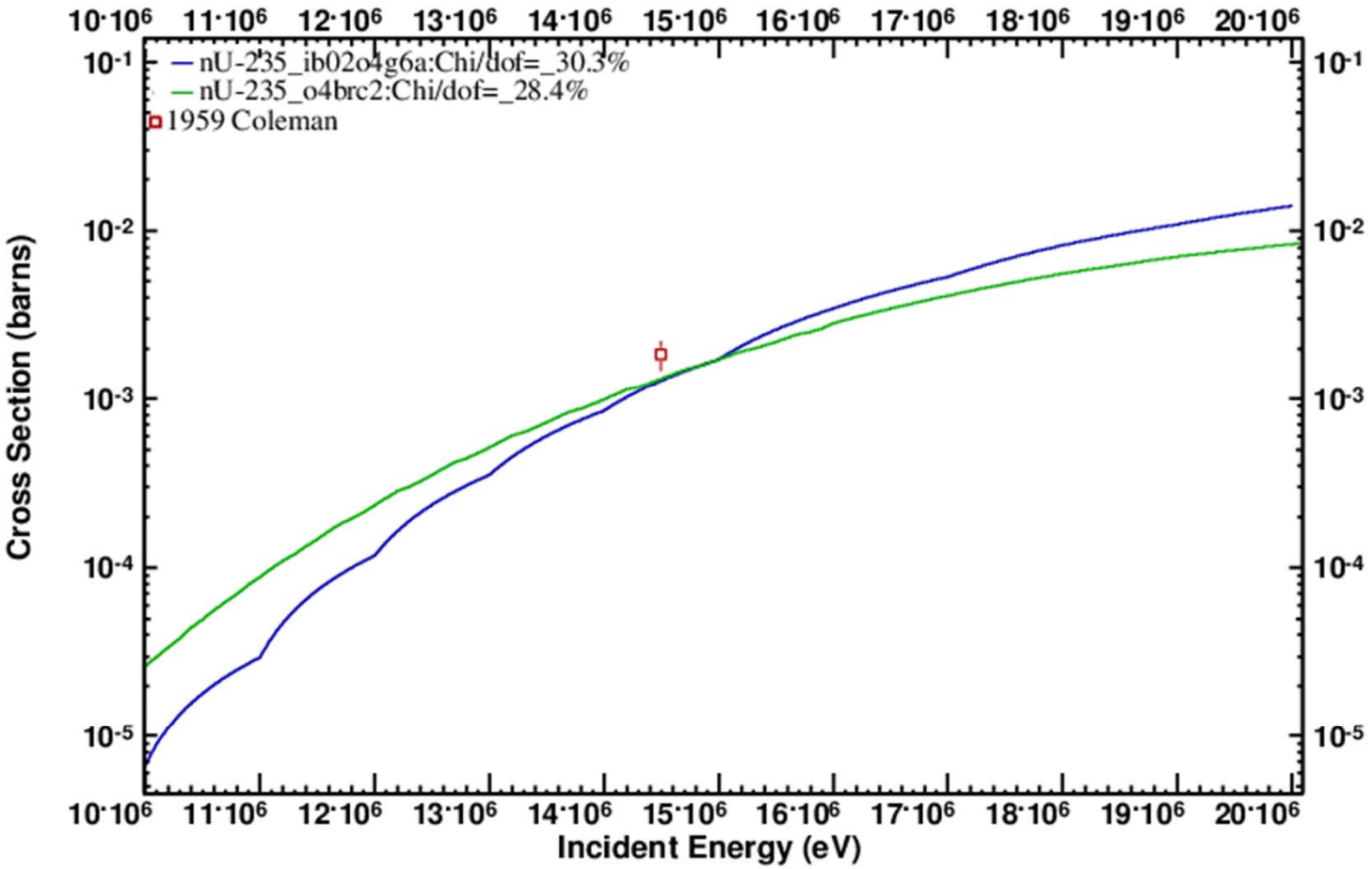
nU-235_ib02o4g6a:Chi/dof=_30.3%
nU-235_o4brc2:Chi/dof=_28.4%
1959 Coleman
Cross Section (barns)
Incident Energy (eV)
10·10⁶ 11·10⁶ 12·10⁶ 13·10⁶ 14·10⁶ 15·10⁶ 16·10⁶ 17·10⁶ 18·10⁶ 19·10⁶ 20·10⁶
10⁻¹ 10⁻² 10⁻³ 10⁻⁴ 10⁻⁵

U-235 General Features – mu-bar

- Differences…

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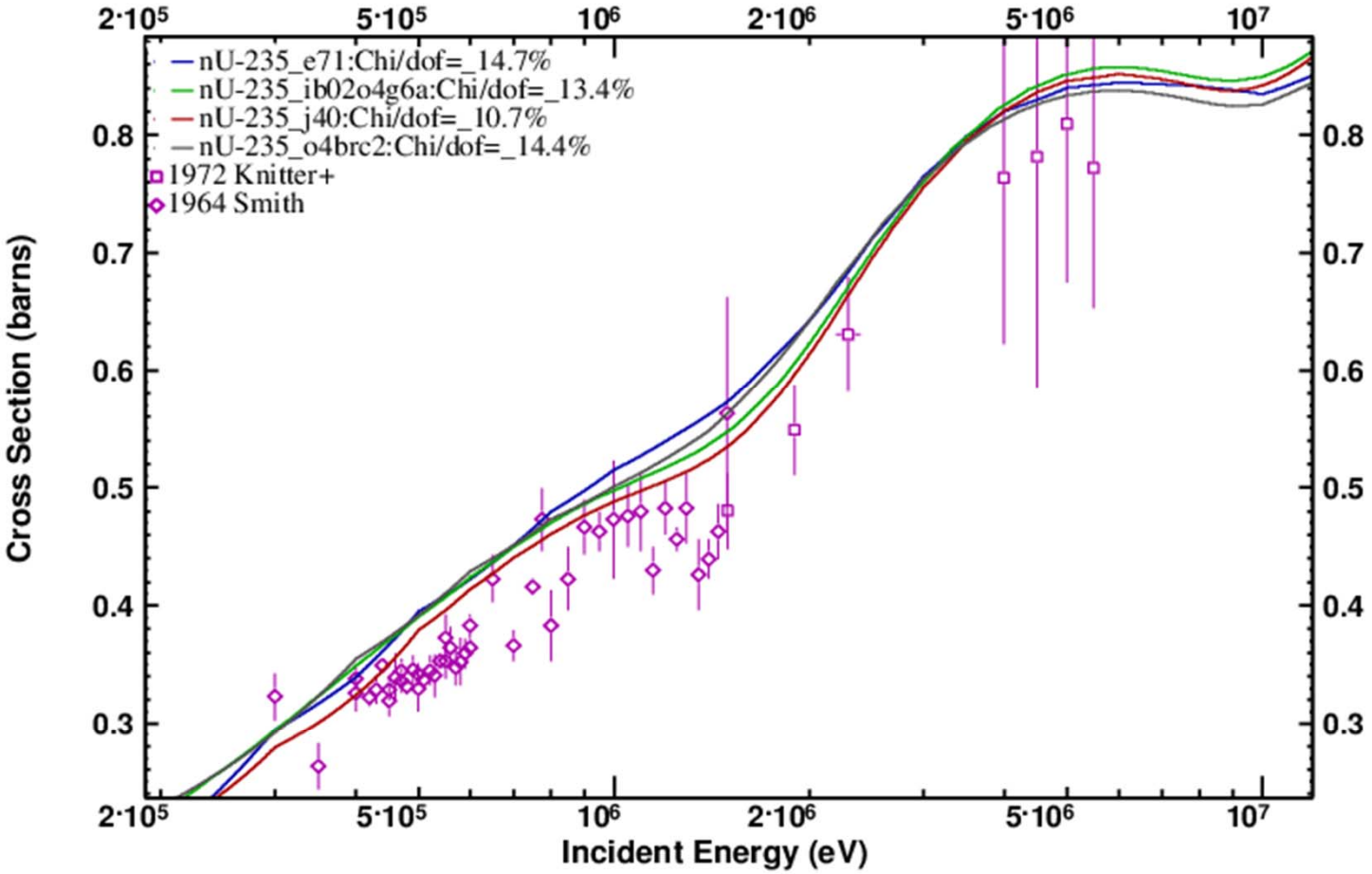
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nU-235_ib02o4g6a:Chi/dof=_13.4%
nU-235_j40:Chi/dof=_10.7%
nU-235_o4brc2:Chi/dof=_14.4%
1972 Knitter+
1964 Smith
Cross Section (barns)
Incident Energy (eV)
2·10^5
5·10^5
10^6
2·10^6
5·10^6
10^7
0.3
0.4
0.5
0.6
0.7
0.8

U-235 - Benchmarking

At present, limited to criticality benchmarks:

a) General, commonly used benchmarks

b) Additional uranium benchmarks

c) Highly-enriched uranium solutions

d) Benchmarks containing thorium

e) Benchmarks containing tungsten and nickel

f) Benchmarks containing zirconium

g) Benchmarks containing iron

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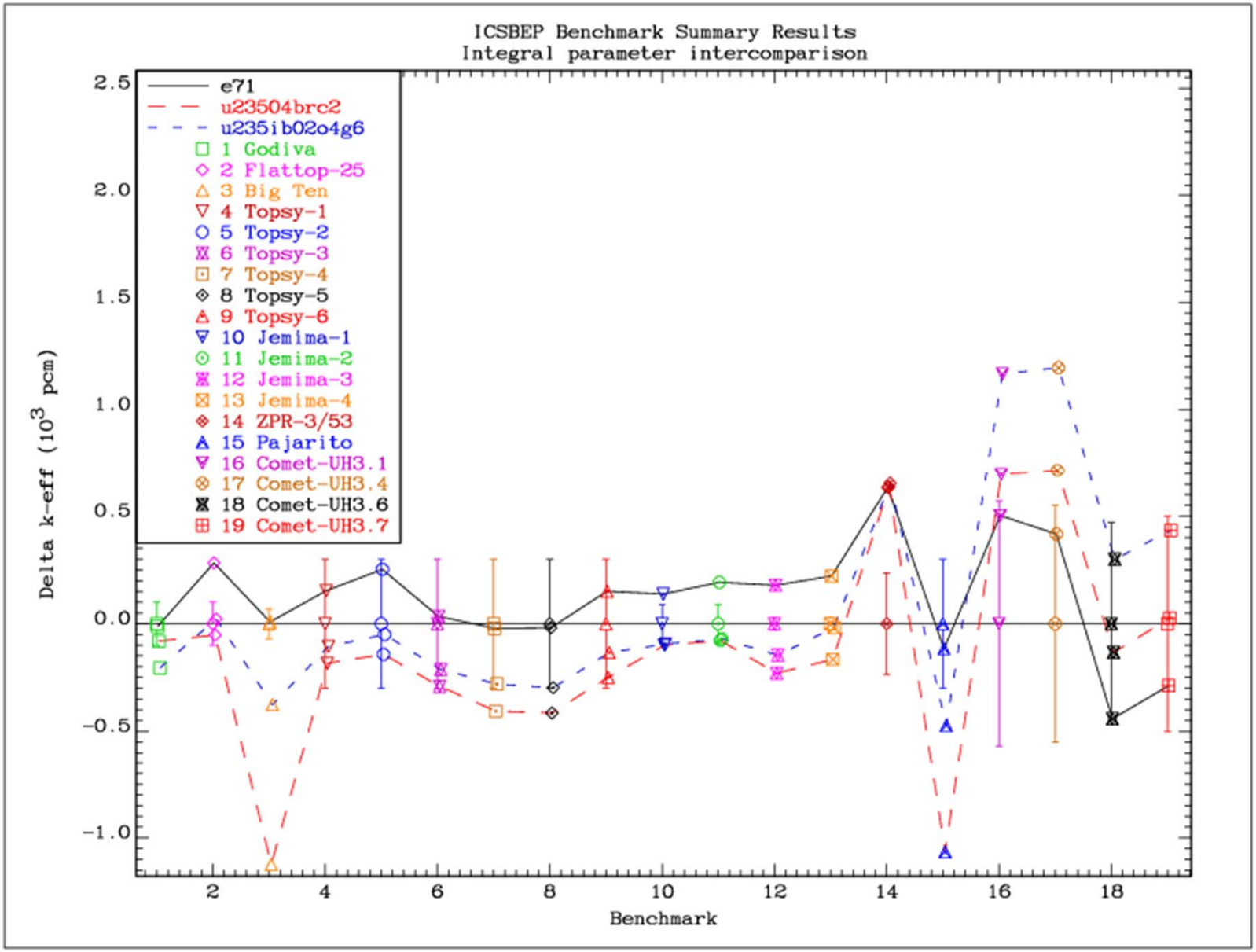
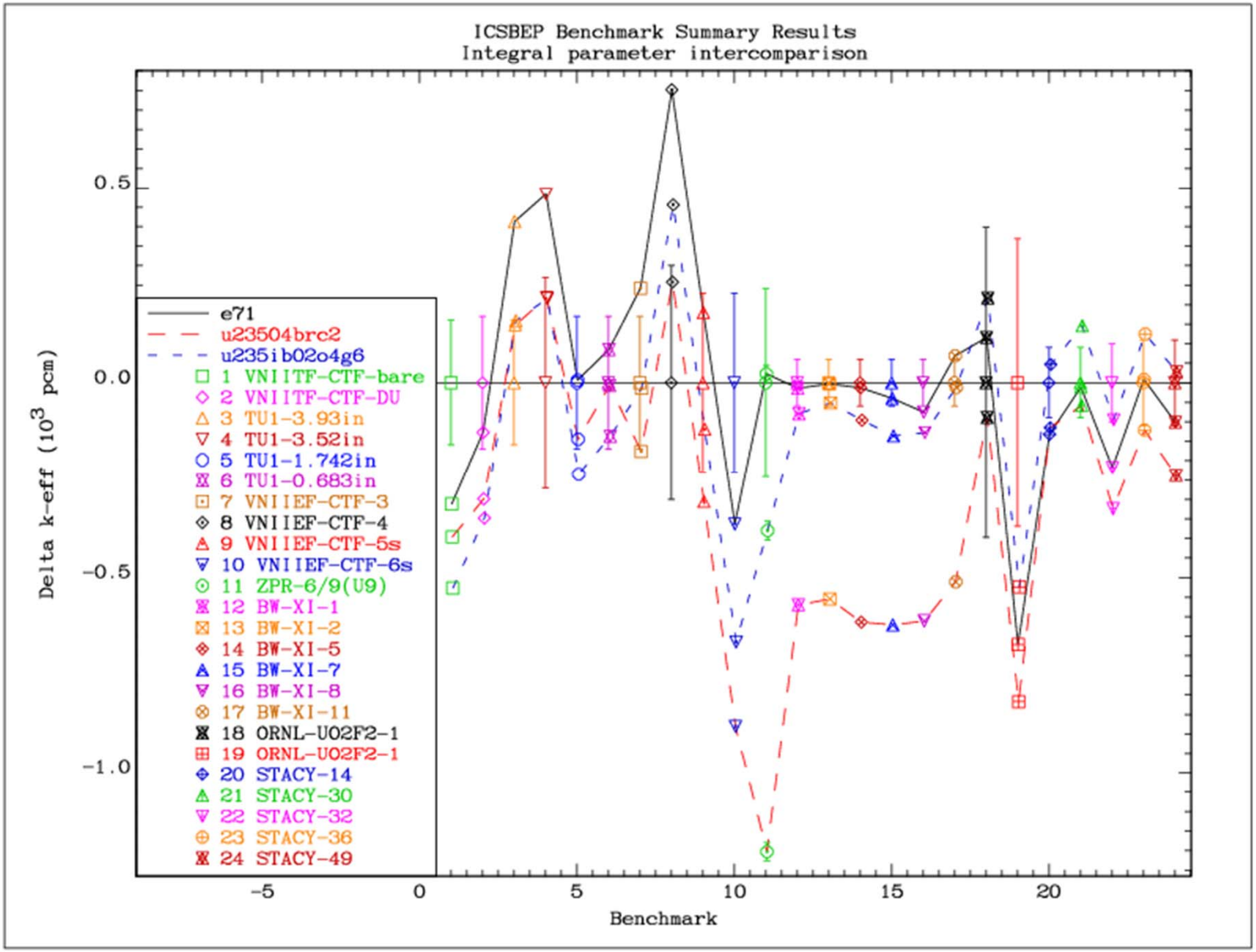
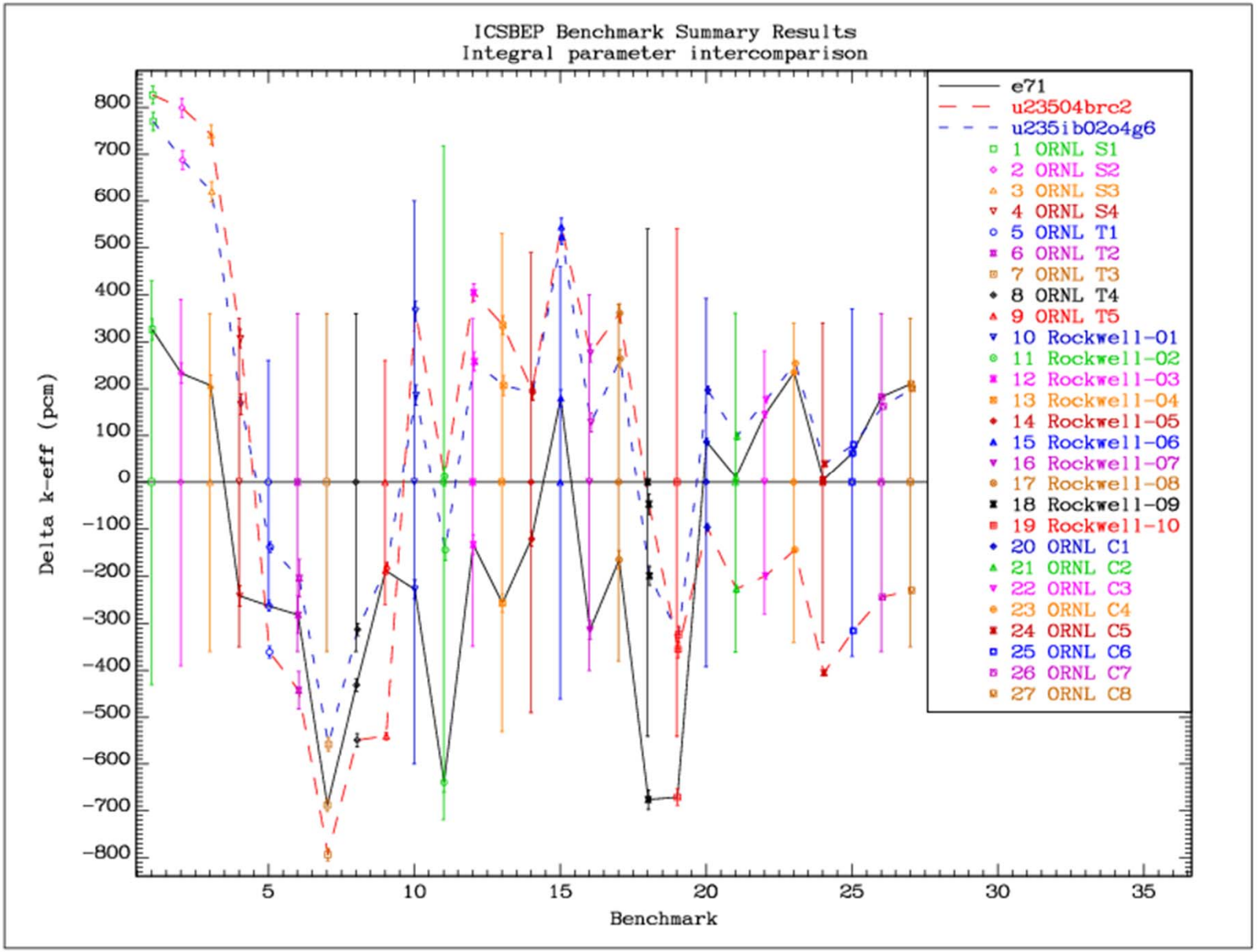
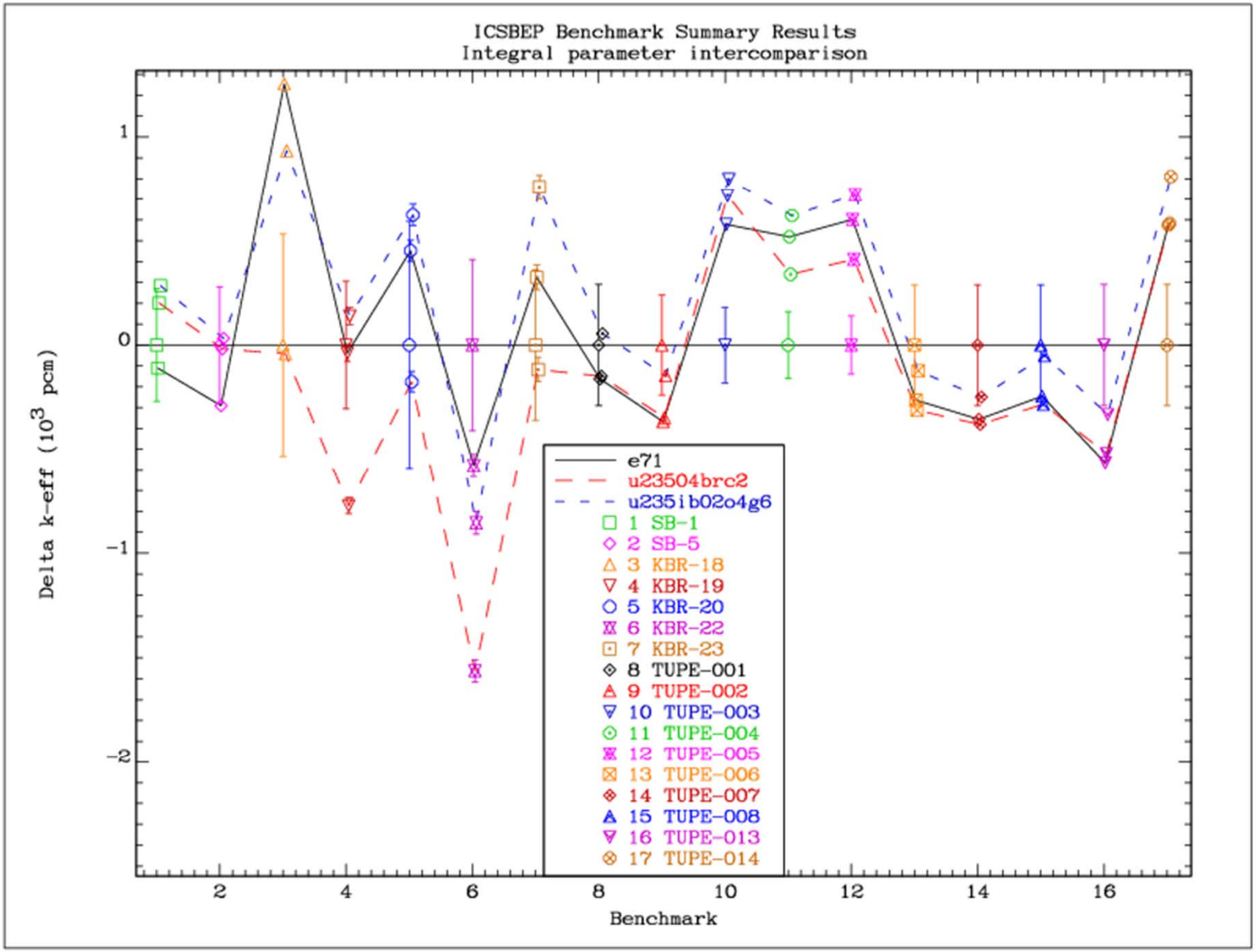
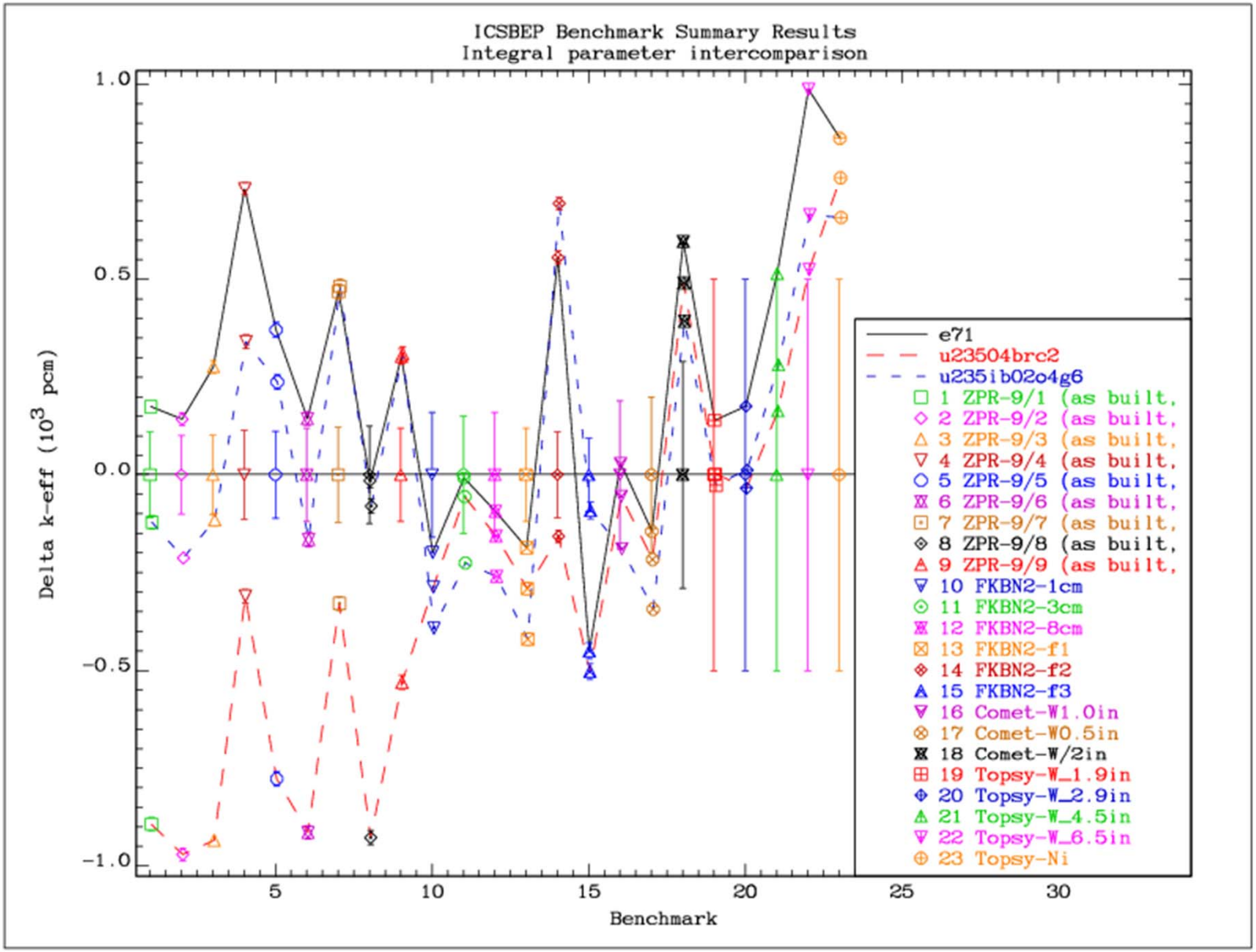
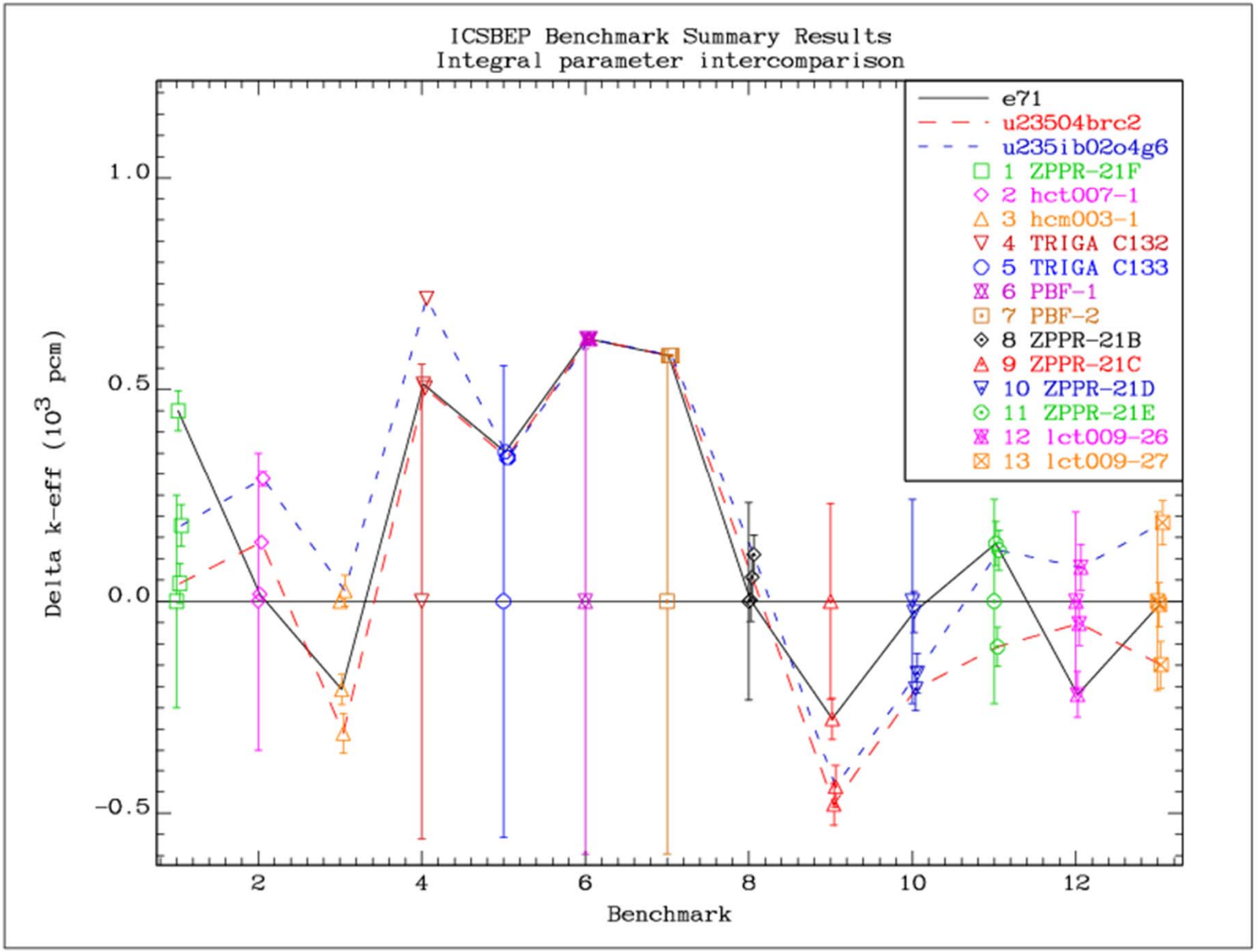

ICSBEP Benchmark Summary Results
Integral parameter intercomparison
e71
u23504brc2
u235ib02o4g6
1 Godiva
2 Flattop-25
3 Big Ten
4 Topsy-1
5 Topsy-2
6 Topsy-3
7 Topsy-4
8 Topsy-5
9 Topsy-6
10 Jemima-1
11 Jemima-2
12 Jemima-3
13 Jemima-4
14 ZPR-3/53
15 Pajarito
16 Comet-UH3.1
17 Comet-UH3.4
18 Comet-UH3.6
19 Comet-UH3.7
Delta k-eff (10^3 pcm)
2.5
2.0
1.5
1.0
0.5
0.0
−0.5
−1.0
2
4
6
8
10
12
14
16
18
Benchmark

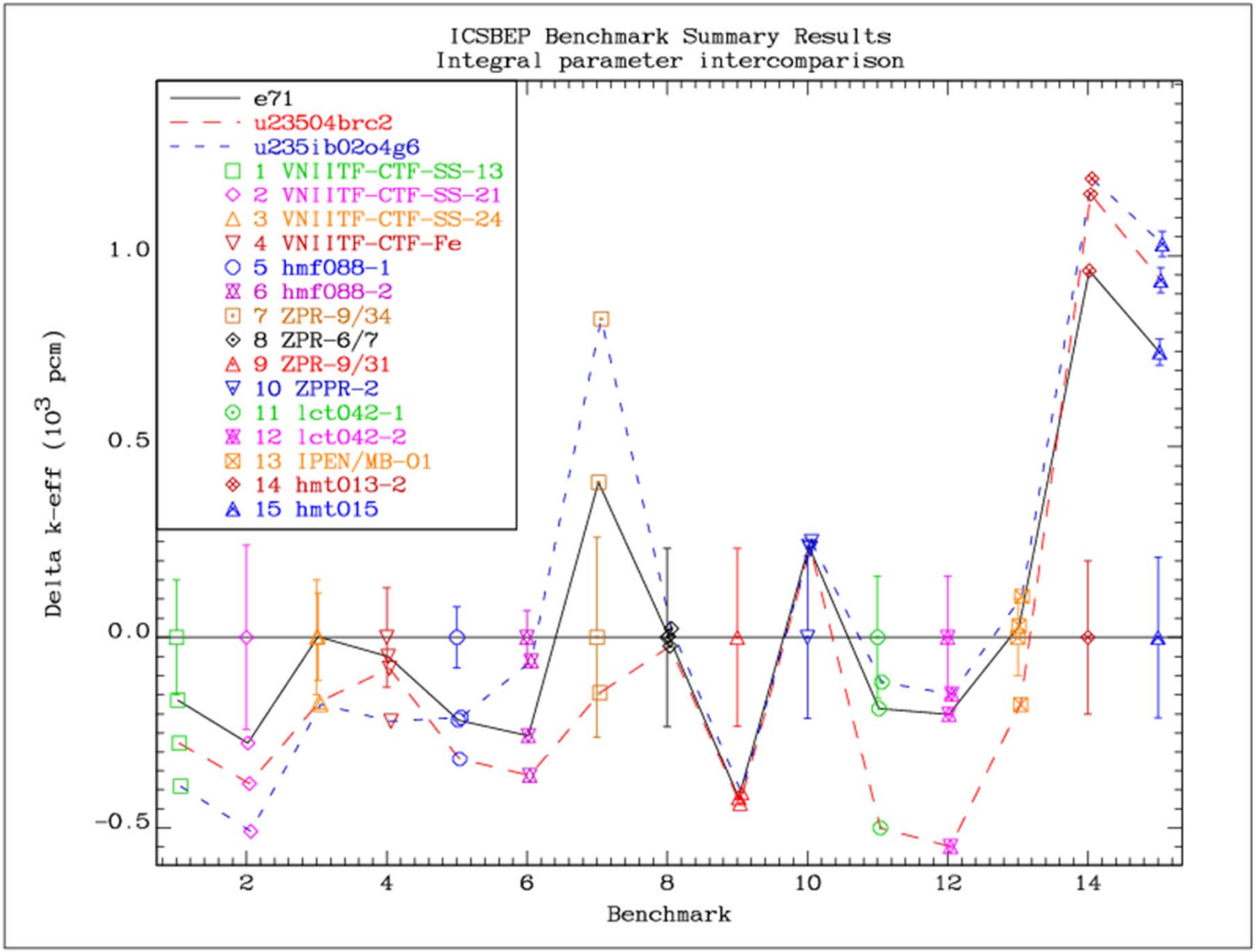

ICSBEP Benchmark Summary Results
Integral parameter intercomparison
Delta k-eff (10^3 pcm)
0.5
0.0
-0.5
-1.0
-5
0
5
10
15
20
Benchmark
e71
u23504brc2
u235ib02o4g6
1 VNIITF-CTF-bare
2 VNIITF-CTF-DU
3 TU1-3.93in
4 TU1-3.52in
5 TU1-1.742in
6 TU1-0.683in
7 VNIIEF-CTF-3
8 VNIIEF-CTF-4
9 VNIIEF-CTF-5s
10 VNIIEF-CTF-6s
11 ZPR-6/9(U9)
12 BW-XI-1
13 BW-XI-2
14 BW-XI-5
15 BW-XI-7
16 BW-XI-8
17 BW-XI-11
18 ORNL-U02F2-1
19 ORNL-U02F2-1
20 STACY-14
21 STACY-30
22 STACY-32
23 STACY-36
24 STACY-49


ICSBEP Benchmark Summary Results
Integral parameter intercomparison
Delta k-eff (pcm)
Benchmark
800
700
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
5
10
15
20
25
30
35
e71
u23504brc2
u235ib02o4g6
1 ORNL S1
2 ORNL S2
3 ORNL S3
4 ORNL S4
5 ORNL T1
6 ORNL T2
7 ORNL T3
8 ORNL T4
9 ORNL T5
10 Rockwell-01
11 Rockwell-02
12 Rockwell-03
13 Rockwell-04
14 Rockwell-05
15 Rockwell-06
16 Rockwell-07
17 Rockwell-08
18 Rockwell-09
19 Rockwell-10
20 ORNL C1
21 ORNL C2
22 ORNL C3
23 ORNL C4
24 ORNL C5
25 ORNL C6
26 ORNL C7
27 ORNL C8


ICSBEP Benchmark Summary Results
Integral parameter intercomparison
Delta k-eff (10^3 pcm)
Benchmark
1
0
-1
-2
2
4
6
8
10
12
14
16
e71
u23504brc2
u235ib02o4g6
1 SB-1
2 SB-5
3 KBR-18
4 KBR-19
5 KBR-20
6 KBR-22
7 KBR-23
8 TUPE-001
9 TUPE-002
10 TUPE-003
11 TUPE-004
12 TUPE-005
13 TUPE-006
14 TUPE-007
15 TUPE-008
16 TUPE-013
17 TUPE-014


ICSBEP Benchmark Summary Results
Integral parameter intercomparison
Delta k-eff (10^3 pcm)
1.0
0.5
0.0
-0.5
-1.0
5
10
15
20
25
30
Benchmark
e71
u23504brc2
u235ib02o4g6
1 ZPR-9/1 (as built,
2 ZPR-9/2 (as built,
3 ZPR-9/3 (as built,
4 ZPR-9/4 (as built,
5 ZPR-9/5 (as built,
6 ZPR-9/6 (as built,
7 ZPR-9/7 (as built,
8 ZPR-9/8 (as built,
9 ZPR-9/9 (as built,
10 FKBN2-1cm
11 FKBN2-3cm
12 FKBN2-8cm
13 FKBN2-f1
14 FKBN2-f2
15 FKBN2-f3
16 Comet-W1.0in
17 Comet-W0.5in
18 Comet-W/2in
19 Topsy-W_1.9in
20 Topsy-W_2.9in
21 Topsy-W_4.5in
22 Topsy-W_6.5in
23 Topsy-Ni


ICSBEP Benchmark Summary Results
Integral parameter intercomparison
e71
u23504brc2
u235ib02o4g6
1 ZPPR-21F
2 hct007-1
3 hcm003-1
4 TRIGA C132
5 TRIGA C133
6 PBF-1
7 PBF-2
8 ZPPR-21B
9 ZPPR-21C
10 ZPPR-21D
11 ZPPR-21E
12 lct009-26
13 lct009-27
Delta k-eff (10^3 pcm)
1.0
0.5
0.0
-0.5
2
4
6
8
10
12
Benchmark


ICSBEP Benchmark Summary Results
Integral parameter intercomparison
e71
u23504brc2
u235ib02o4g6
1 VNIITF-CTF-SS-13
2 VNIITF-CTF-SS-21
3 VNIITF-CTF-SS-24
4 VNIITF-CTF-Fe
5 hmf088-1
6 hmf088-2
7 ZPR-9/34
8 ZPR-6/7
9 ZPR-9/31
10 ZPPR-2
11 lct042-1
12 lct042-2
13 IPEN/MB-01
14 hmt013-2
15 hmt015
Delta k-eff (10^3 pcm)
1.0
0.5
0.0
-0.5
2
4
6
8
10
12
14
Benchmark

Conclusion

- Premature to draw definite conclusions, but:
- Current results are encouraging
- Broad scoping study identified some of potential problem areas
- Study of trends (tbd) might give additional information, but beware of compensating effects…

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