ANALYSIS OF ICSBEP U233-SOL BENCHMARKS

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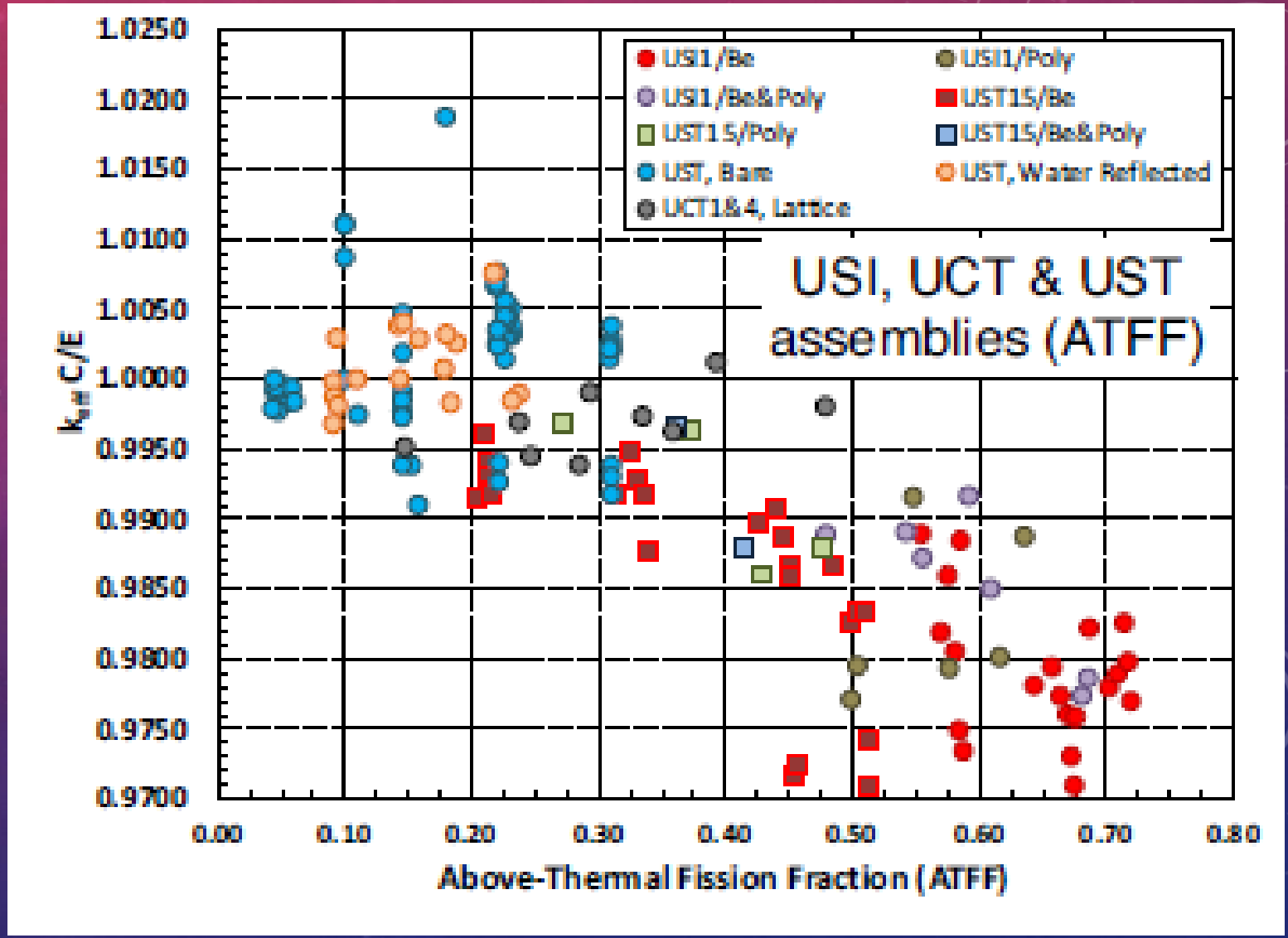
RATIONALE

- ENDF/B-VIII.0 paper (NDS 148 2018, p83) was showing strong trend in reactivity with ATFF (=FEPIT)
- The impact of different U-233 data on the trend was investigated, particularly:
  - **PFNS of U-233**
  - **Thermal constants of U-233**



SCOPE

Data libraries being tested

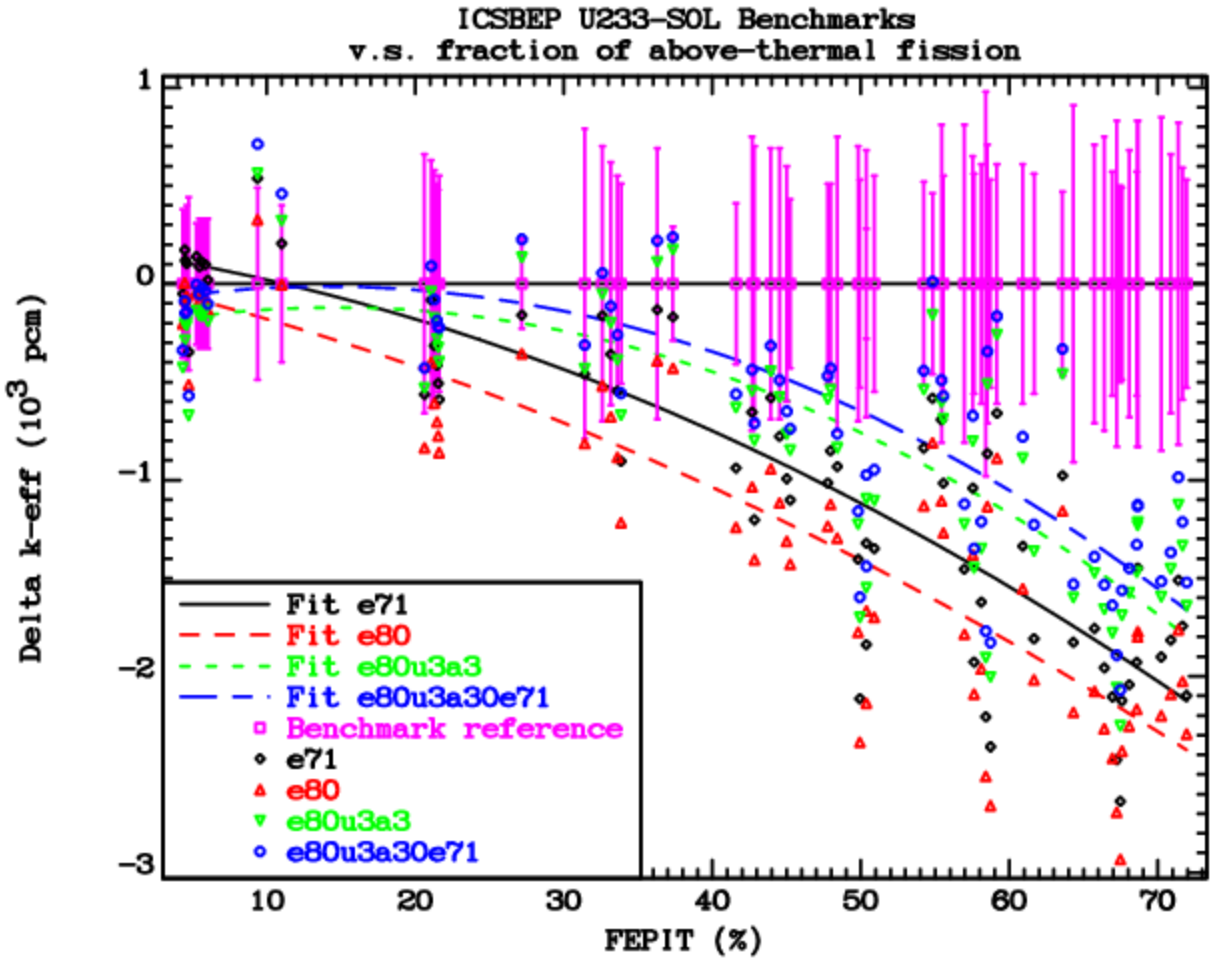
- “e71” = ENDF/B-VII.1
- “jeff33” = JEFF=3.3
- “e80”= ENDF/B-VIII.0
- “e80u3a2” = PFNS of U-233 in “e80” updated
- “e80u3a3” = PFNS and thermal constants adjusted to match Standards-2017
- “e80u3a3Oe71 = same as above, O-16 substituted from ENDF/B-VII.1

U-233 SOLUTION BENCHMARK CHARACTERISTICS

The following sets of benchmarks were excluded:

- UST002,003,004 old ORNL paraffin-reflected nitrate/fluoride benchmarks, large uncertainties, large scatter
- UST006 – no input available - only KENO input is provided in ICSBEP
- UST007 Purnima-II (MCNP input given in ICSBEP Handbook for Case-1 only)
- UST010 benchmark is rejected by ICSBEP
- UST-011 is included in USI001
- UST012,013 ORNL reflected and unreflected spheres, large uncertainties, large scatter
- UST014 PNL “array of bottles” – perhaps not representative
- UST015 (Cases 6, 8, 9, 18, 19 seem to be outliers) – Falstaff Programme (see IAEA(SLO)-004)
- UST016,017 ORNL cylinders, large uncertainties, large scatter, might be biased to positive reactivity

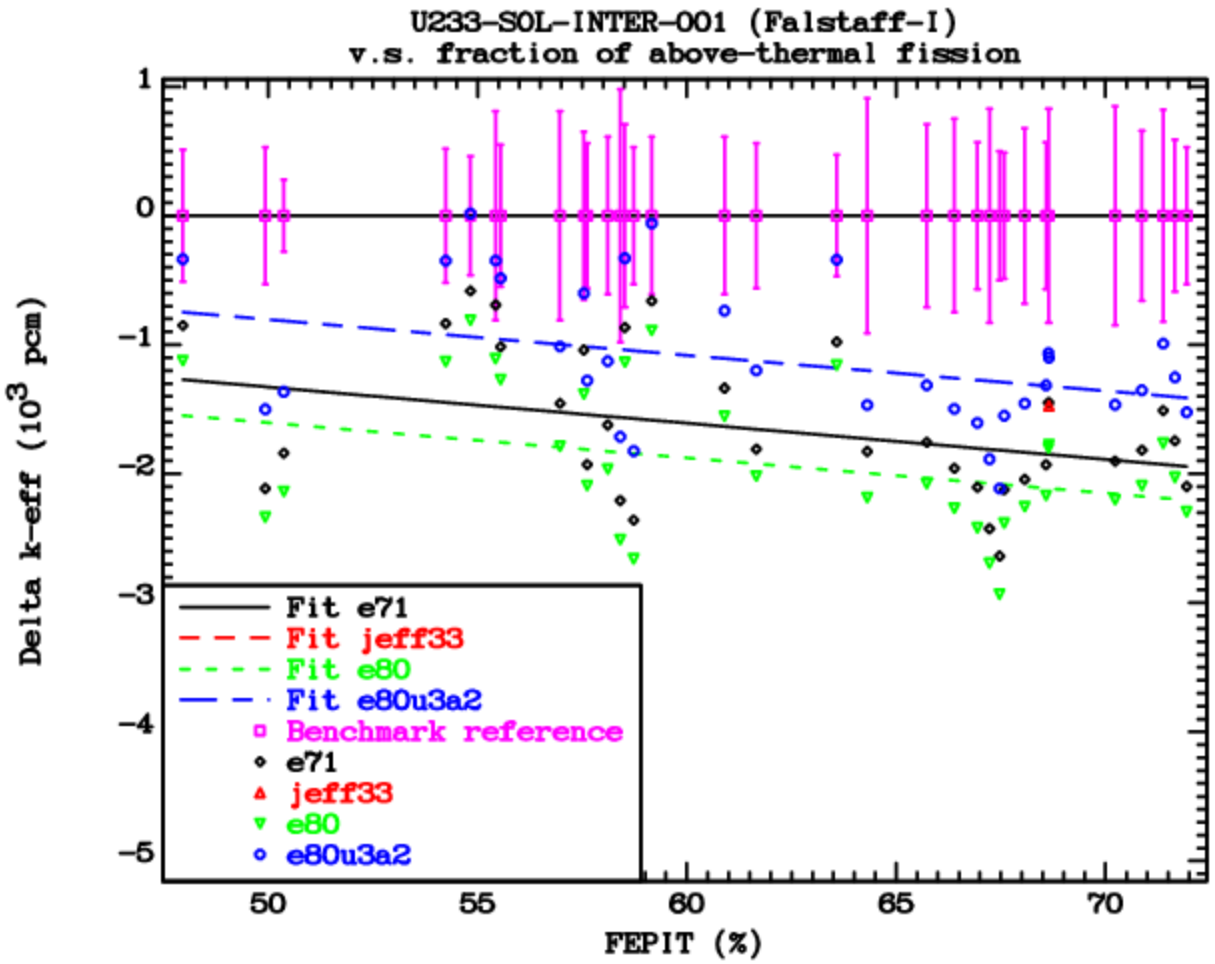
The remainder includes USI001, UST001, UST005, UST008 UST009, UST015, and are shown on the next plot as a function of the fraction of epithermal fissions (FEPIT)

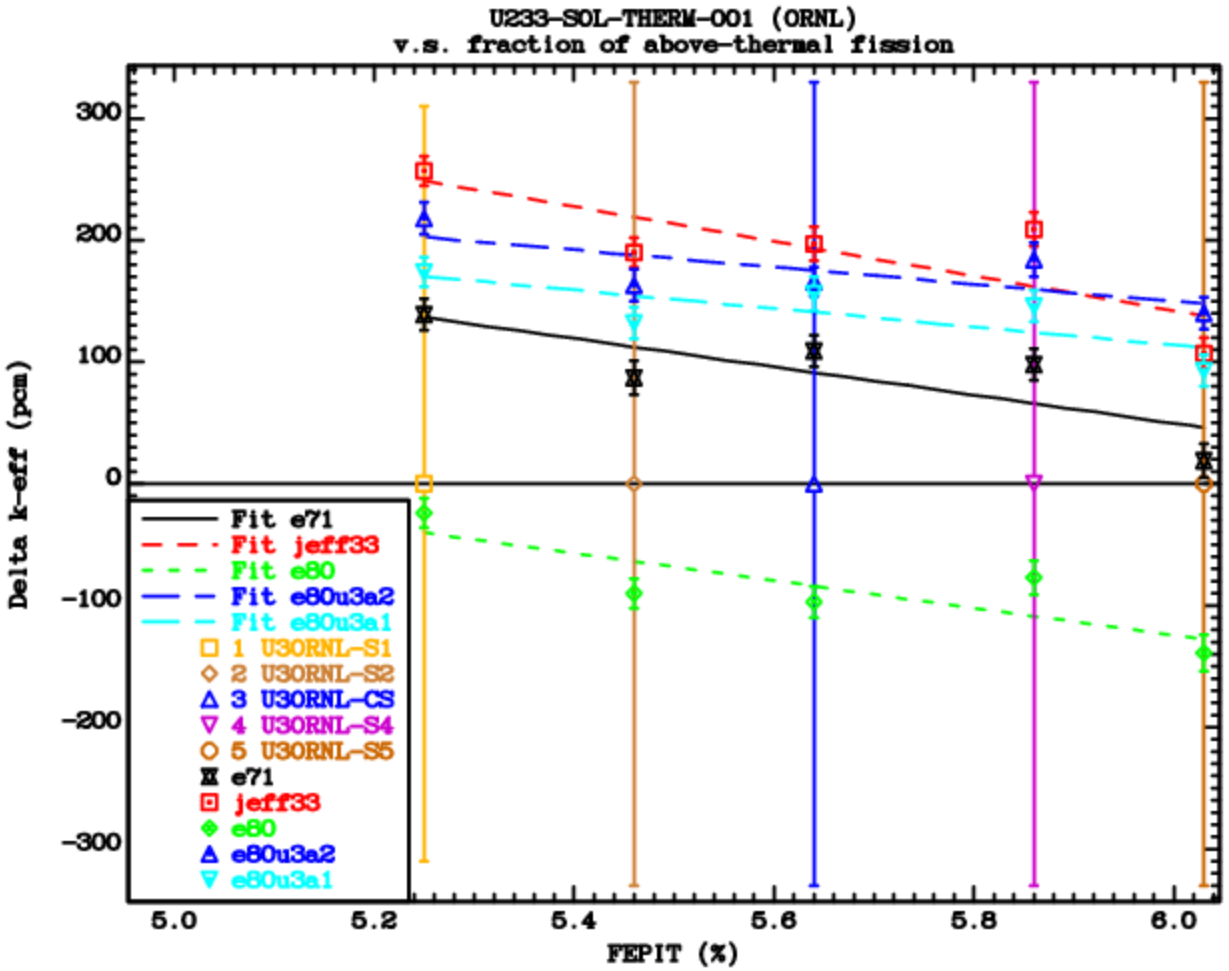

ICSBEP U233-SOL Benchmarks
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
FEPIT (%)
1
0
-1
-2
-3
10
20
30
40
50
60
70
Fit e71
Fit e80
Fit e80u3a3
Fit e80u3a30e71
Benchmark reference
e71
e80
e80u3a3
e80u3a30e71

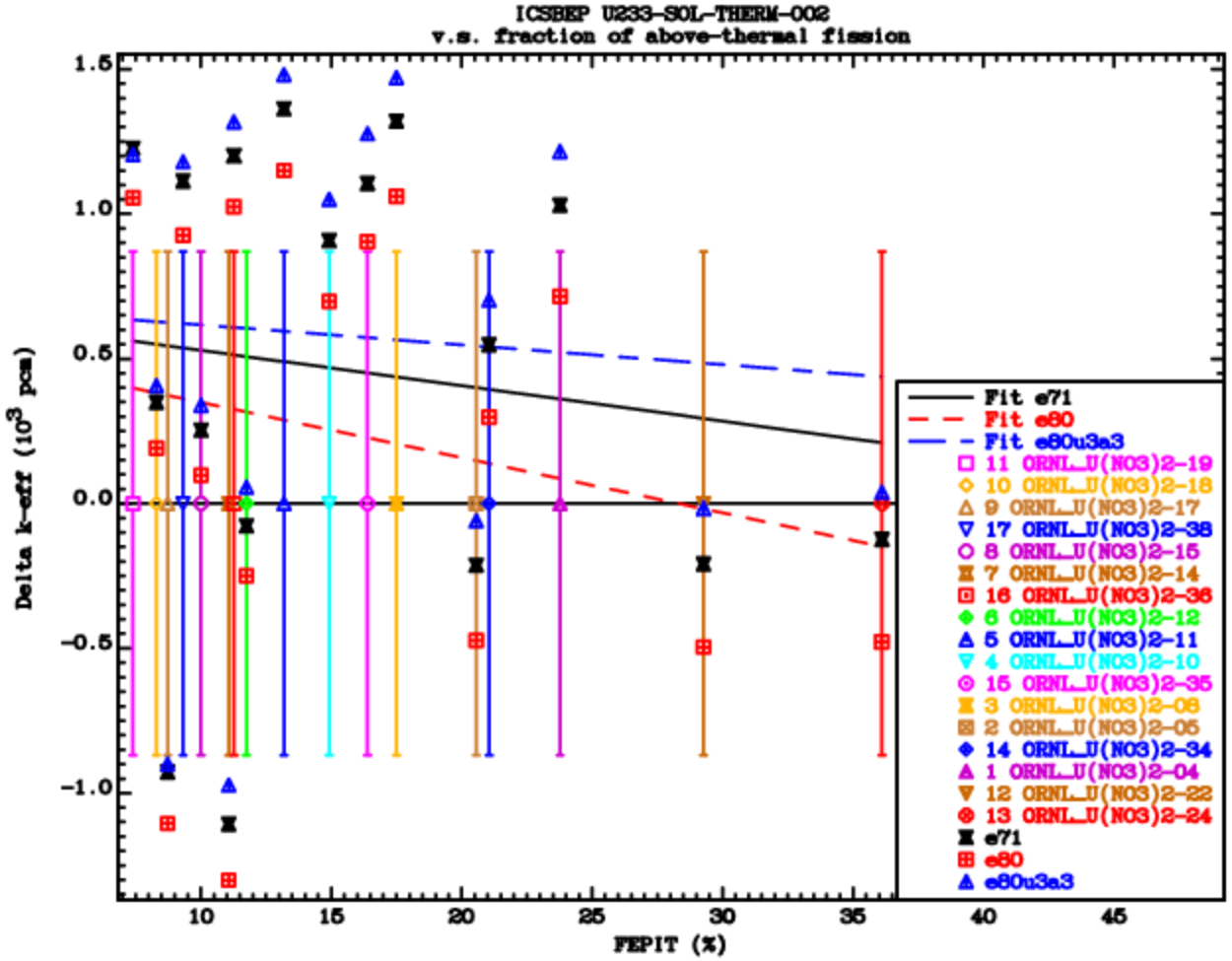
CONCLUSIONS

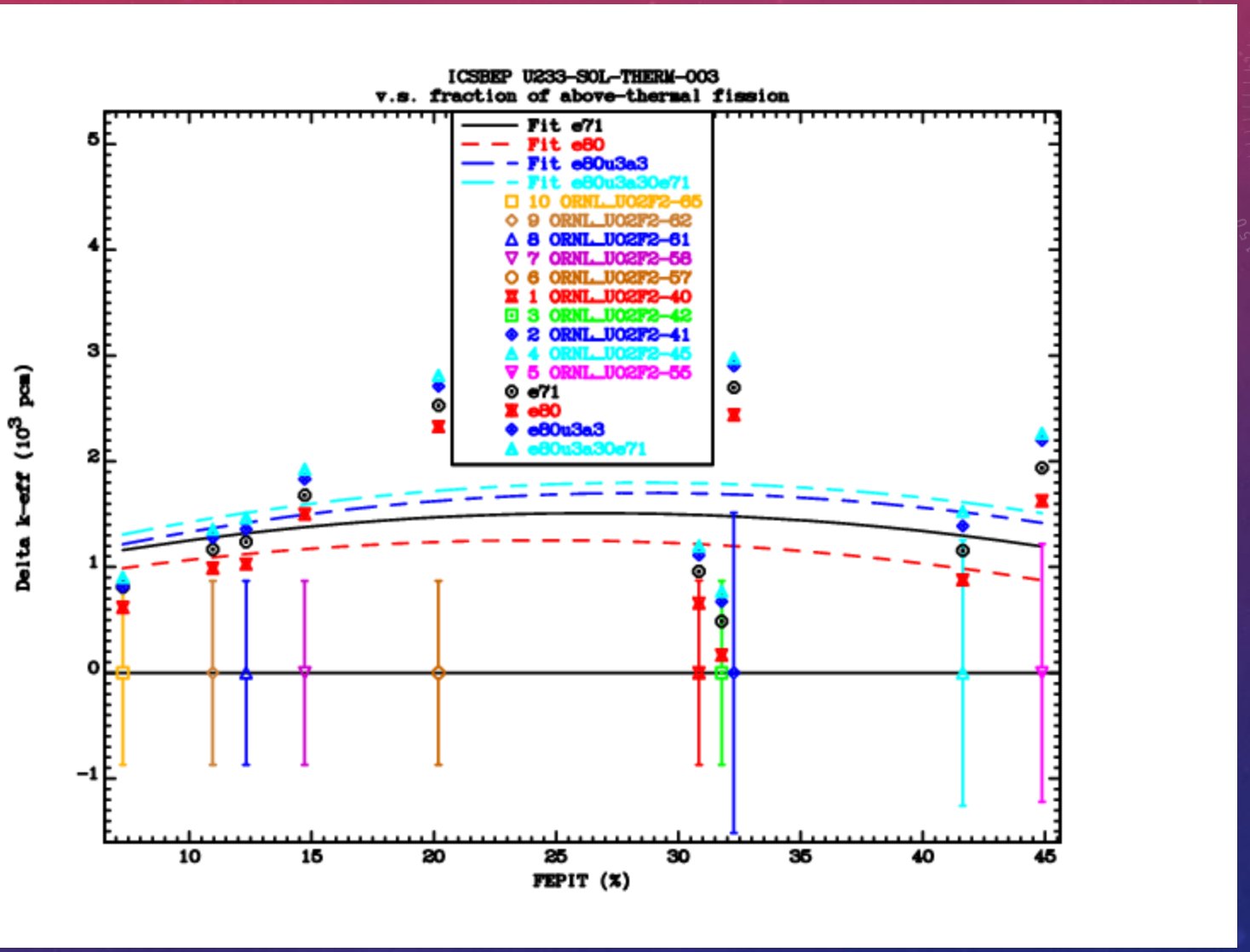
- Selection of USI001, UST001, UST005, UST008, UST009, UST015 might be subjective. A more detailed study of benchmark selection is warranted.
- With “e80u3a3” the parabolic trend-line v.s. FEPIT is flat up to FEPIT<40%, then begins to decline, based mainly on benchmarks from the Falstaff Programme (USI001, UST015).
- Substituting O-16 from “e71” into “e80u3a3” increases reactivity to a non-negligible extent.

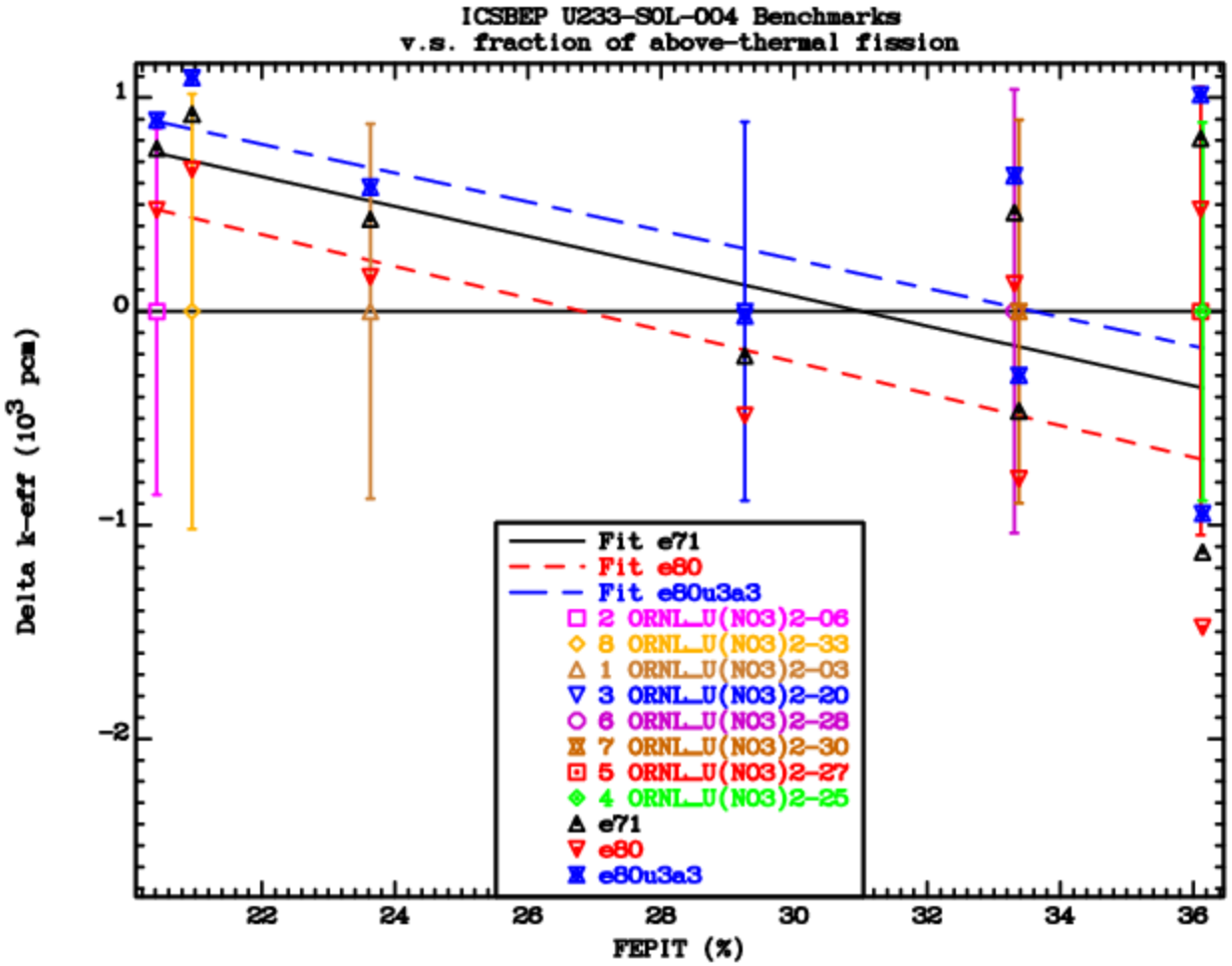
Details of each benchmark group follow below.

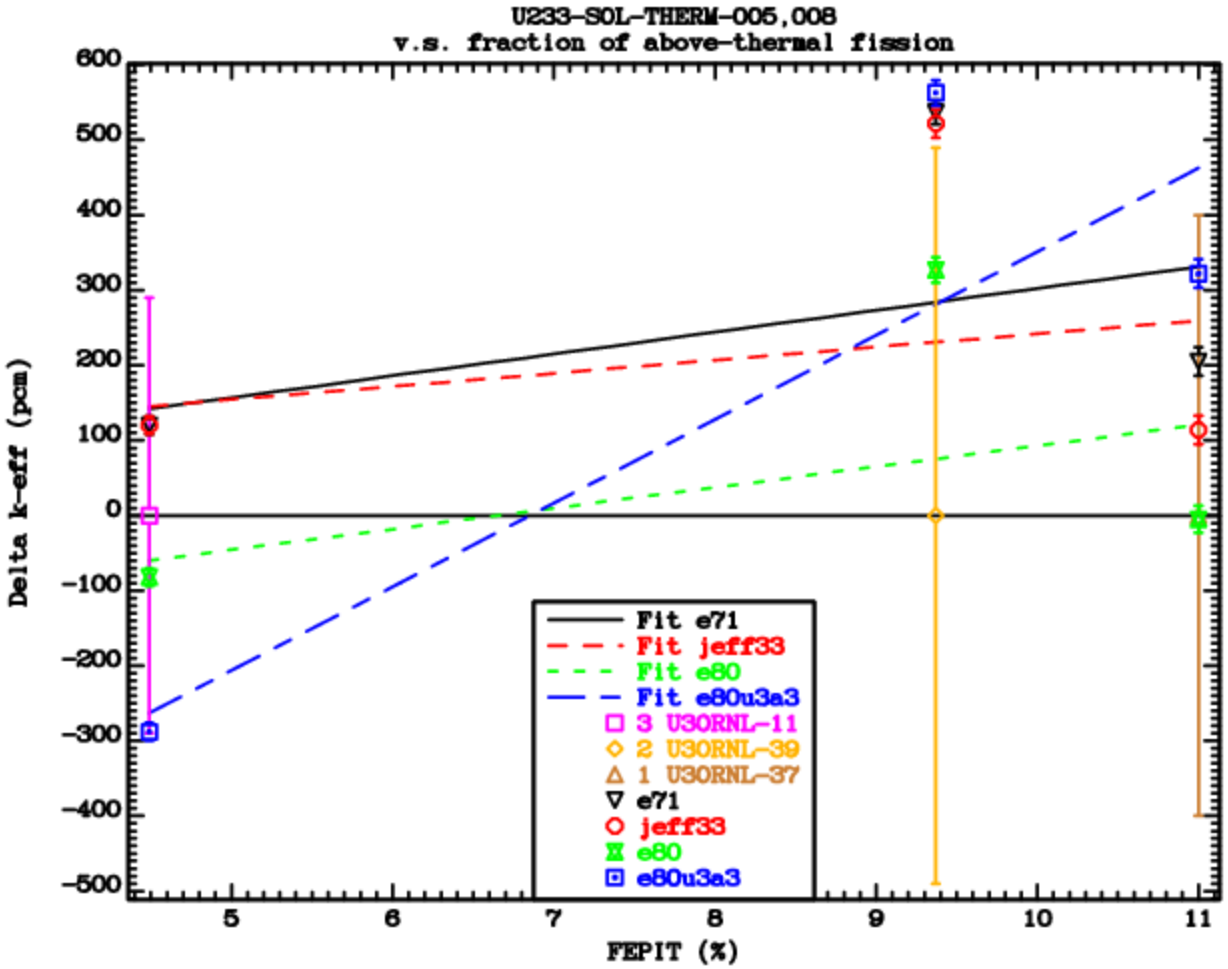

U233-SOL-INTER-001 (Falstaff-I)
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
FEPIT (%)
1
0
-1
-2
-3
-4
-5
50
55
60
65
70
Fit e71
Fit jeff33
Fit e80
Fit e80u3a2
Benchmark reference
e71
jeff33
e80
e80u3a2

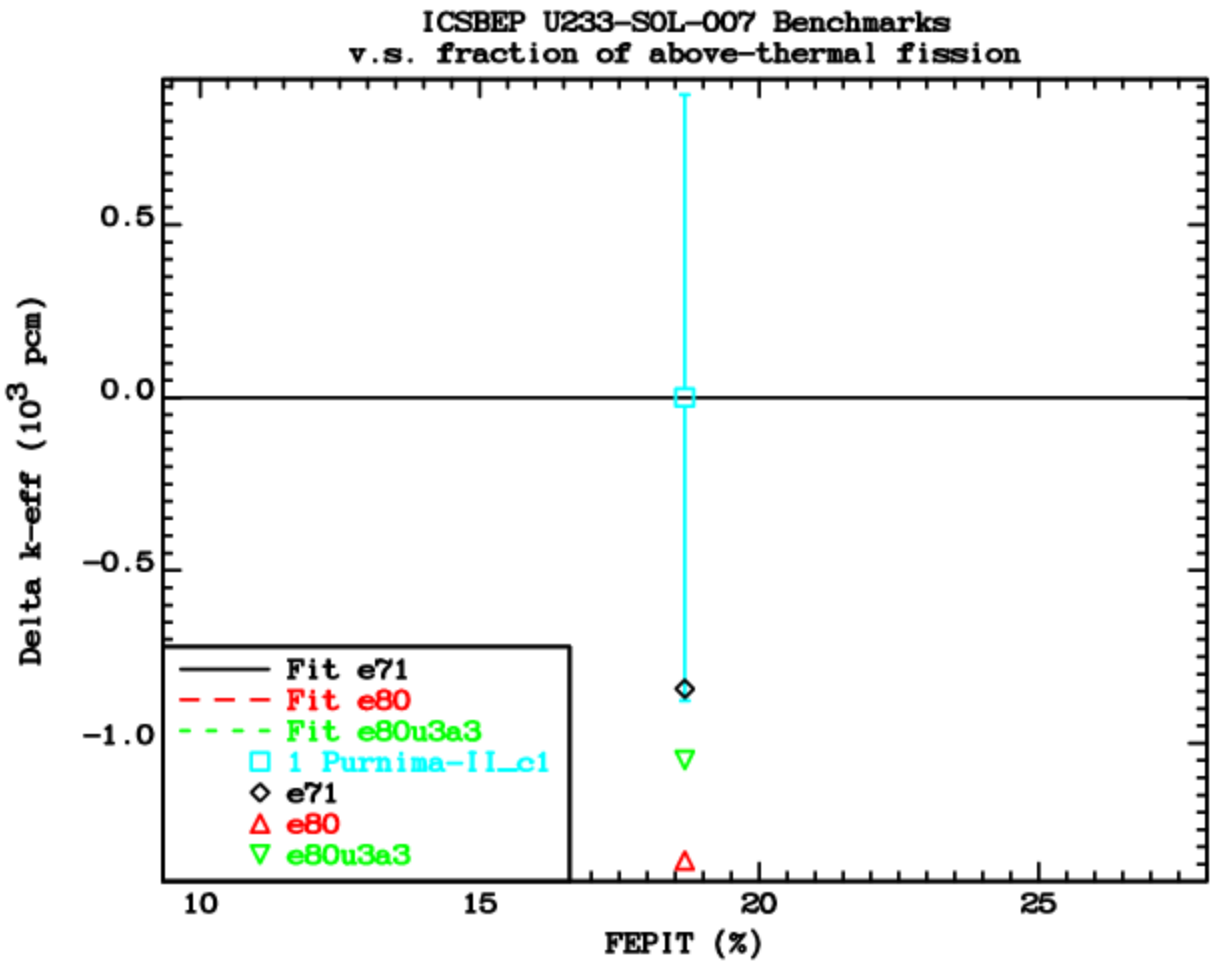

U233-SOL-THERM-001 (ORNL)
v.s. fraction of above-thermal fission
Delta k-eff (pcm)
FEPIT (%)
300
200
100
0
-100
-200
-300
5.0
5.2
5.4
5.6
5.8
6.0
Fit e71
Fit jeff33
Fit e80
Fit e80u3a2
Fit e80u3a1
1 U30RNL-S1
2 U30RNL-S2
3 U30RNL-CS
4 U30RNL-S4
5 U30RNL-S5
e71
jeff33
e80
e80u3a2
e80u3a1

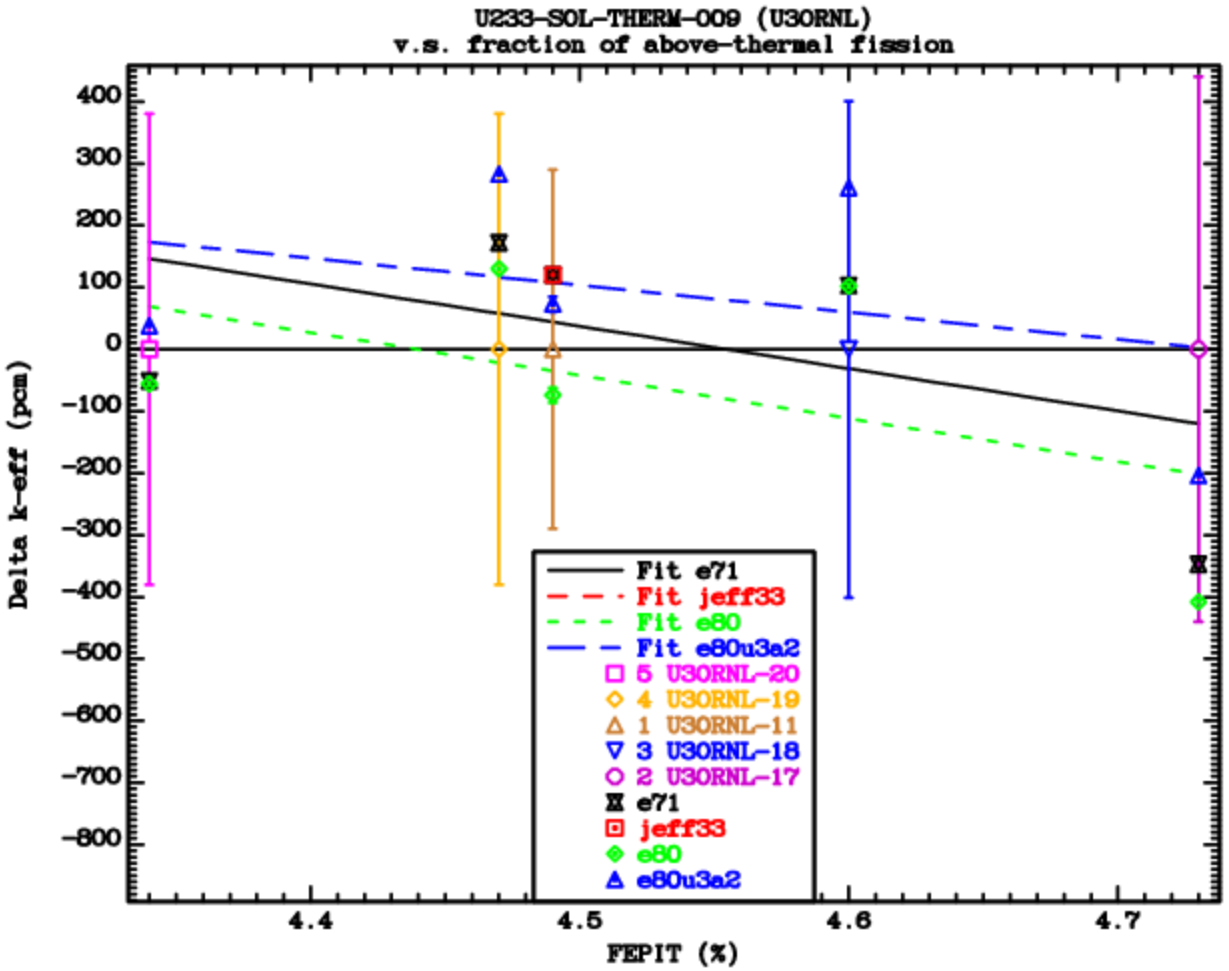

ICSBEP U233-SOL-THERM-002
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
FEPIT (%)
1.5
1.0
0.5
0.0
-0.5
-1.0
10
15
20
25
30
35
40
45
Fit e71
Fit e80
Fit e80u3a3
11 ORNL_U(NO3)2-19
10 ORNL_U(NO3)2-18
9 ORNL_U(NO3)2-17
17 ORNL_U(NO3)2-38
8 ORNL_U(NO3)2-15
7 ORNL_U(NO3)2-14
16 ORNL_U(NO3)2-36
6 ORNL_U(NO3)2-12
5 ORNL_U(NO3)2-11
4 ORNL_U(NO3)2-10
15 ORNL_U(NO3)2-35
3 ORNL_U(NO3)2-08
2 ORNL_U(NO3)2-05
14 ORNL_U(NO3)2-34
1 ORNL_U(NO3)2-04
12 ORNL_U(NO3)2-22
13 ORNL_U(NO3)2-24
e71
e80
e80u3a3

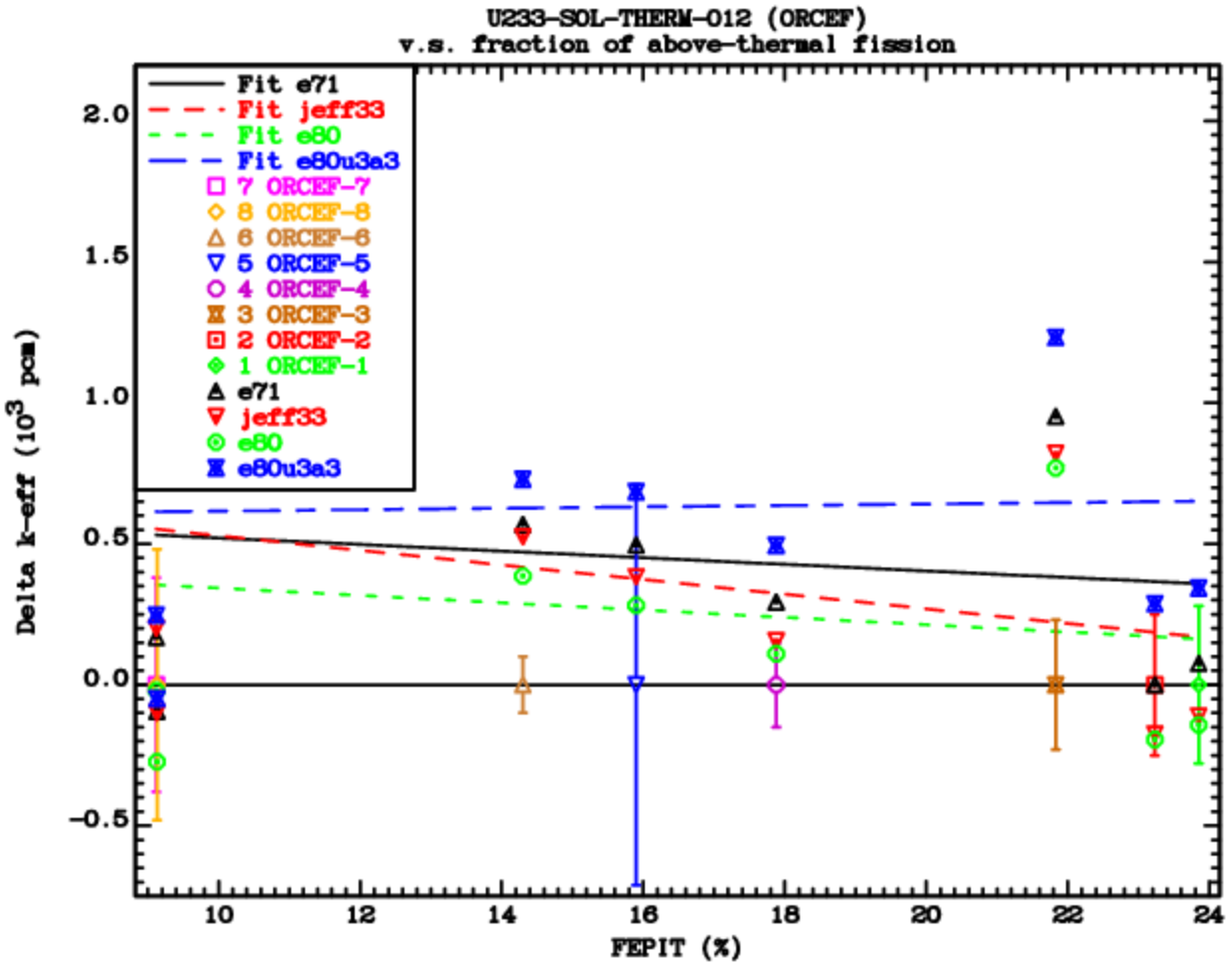

ICSBEP U233-SOL-THERM-003
v.s. fraction of above-thermal fission
Fit e71
Fit e80
Fit e80u3a3
Fit e80u3a30e71
10 ORNL_U02F2-65
9 ORNL_U02F2-62
8 ORNL_U02F2-61
7 ORNL_U02F2-58
6 ORNL_U02F2-57
1 ORNL_U02F2-40
3 ORNL_U02F2-42
2 ORNL_U02F2-41
4 ORNL_U02F2-45
5 ORNL_U02F2-55
e71
e80
e80u3a3
e80u3a30e71
Delta k-eff (10^3 pcm)
FEPIT (%)
5
4
3
2
1
0
-1
10
15
20
25
30
35
40
45

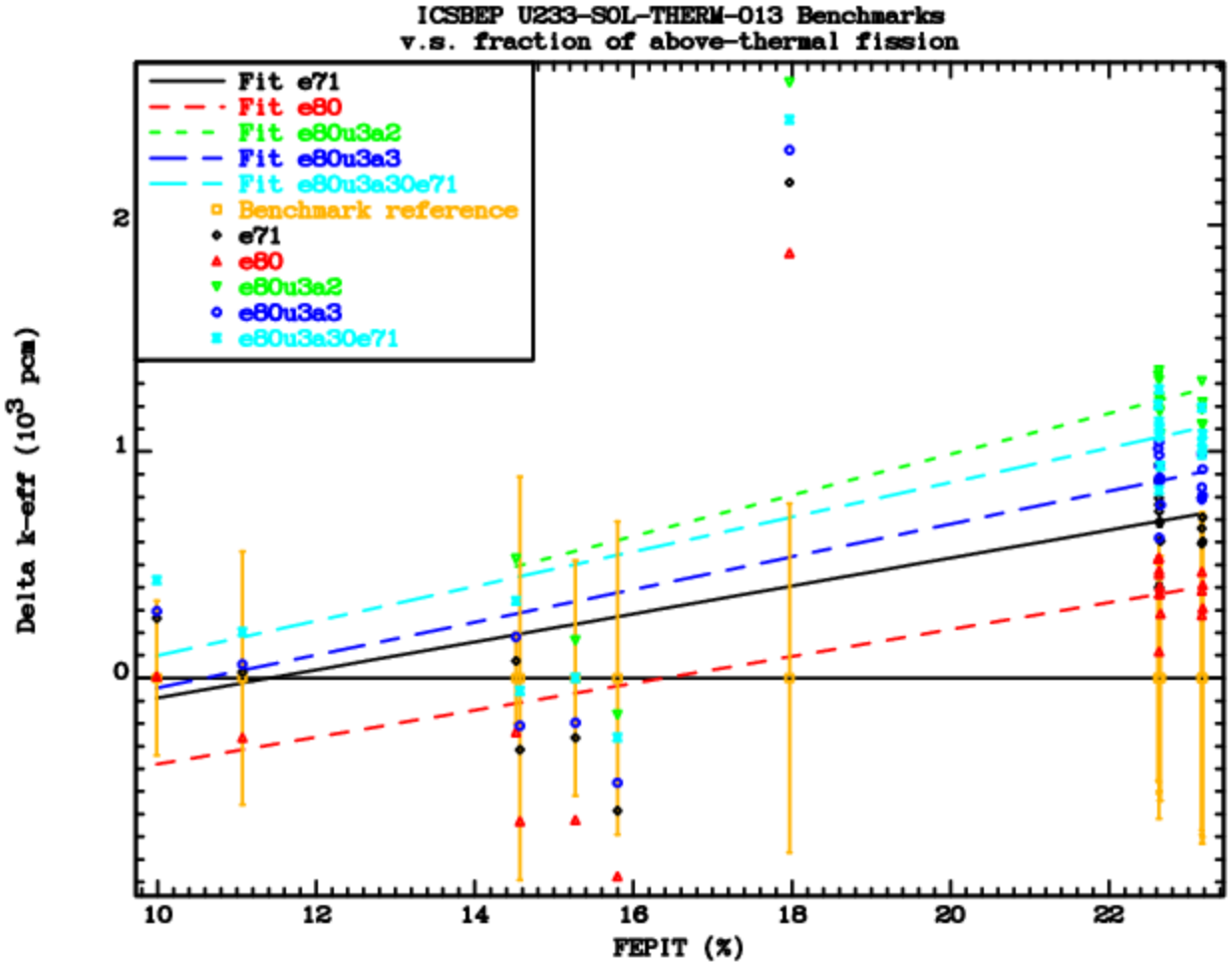

ICSBEP U233-SOL-004 Benchmarks
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
FEPIT (%)
1
0
-1
-2
22
24
26
28
30
32
34
36
Fit e71
Fit e80
Fit e80u3a3
2 ORNL_U(NO3)2-06
8 ORNL_U(NO3)2-33
1 ORNL_U(NO3)2-03
3 ORNL_U(NO3)2-20
6 ORNL_U(NO3)2-28
7 ORNL_U(NO3)2-30
5 ORNL_U(NO3)2-27
4 ORNL_U(NO3)2-25
e71
e80
e80u3a3

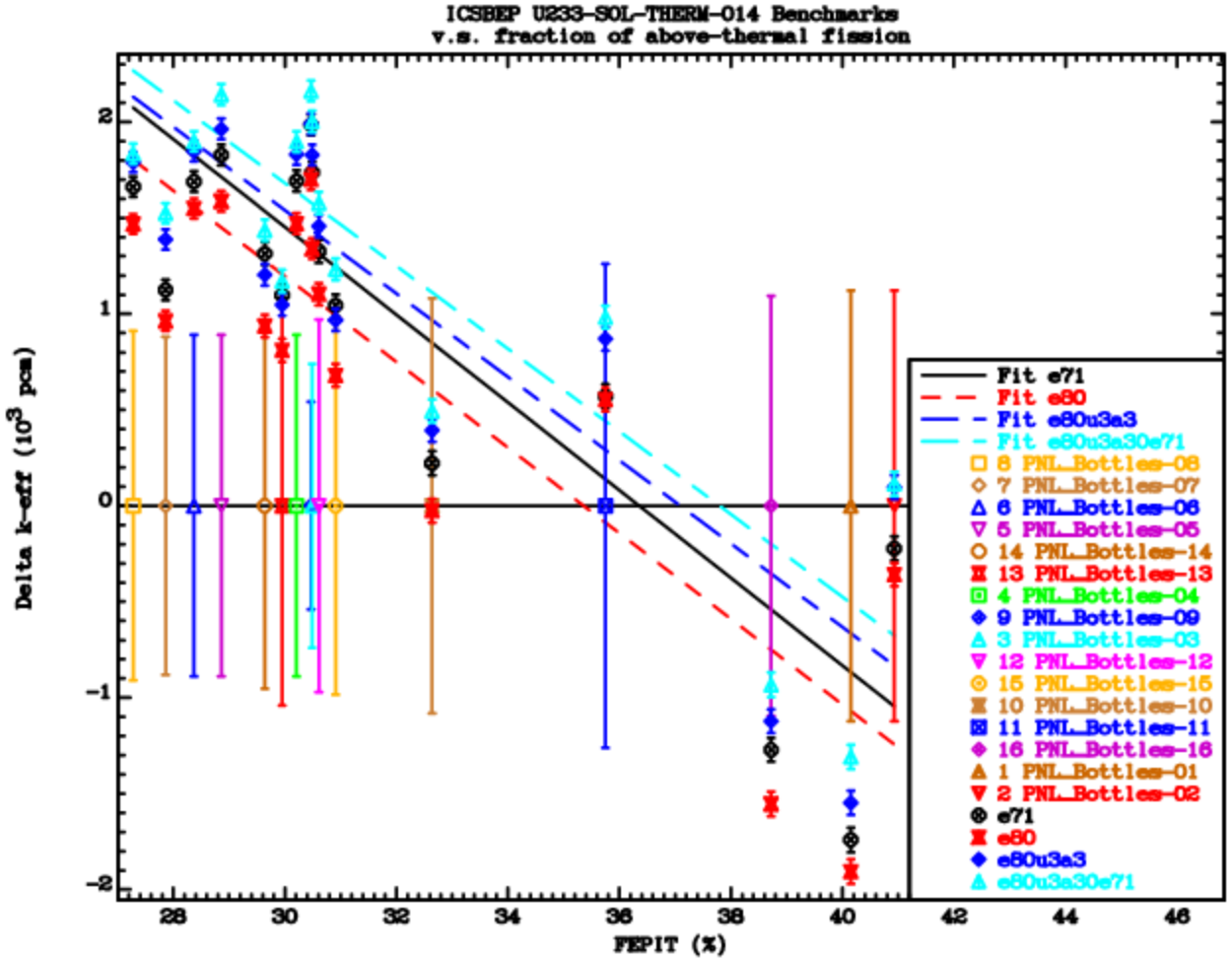

U233-SOL-THERM-005,008
v.s. fraction of above-thermal fission
Delta k-eff (pcm)
FEPIT (%)
600
500
400
300
200
100
0
-100
-200
-300
-400
-500
5
6
7
8
9
10
11
Fit e71
Fit jeff33
Fit e80
Fit e80u3a3
3 U30RNL-11
2 U30RNL-39
1 U30RNL-37
e71
jeff33
e80
e80u3a3

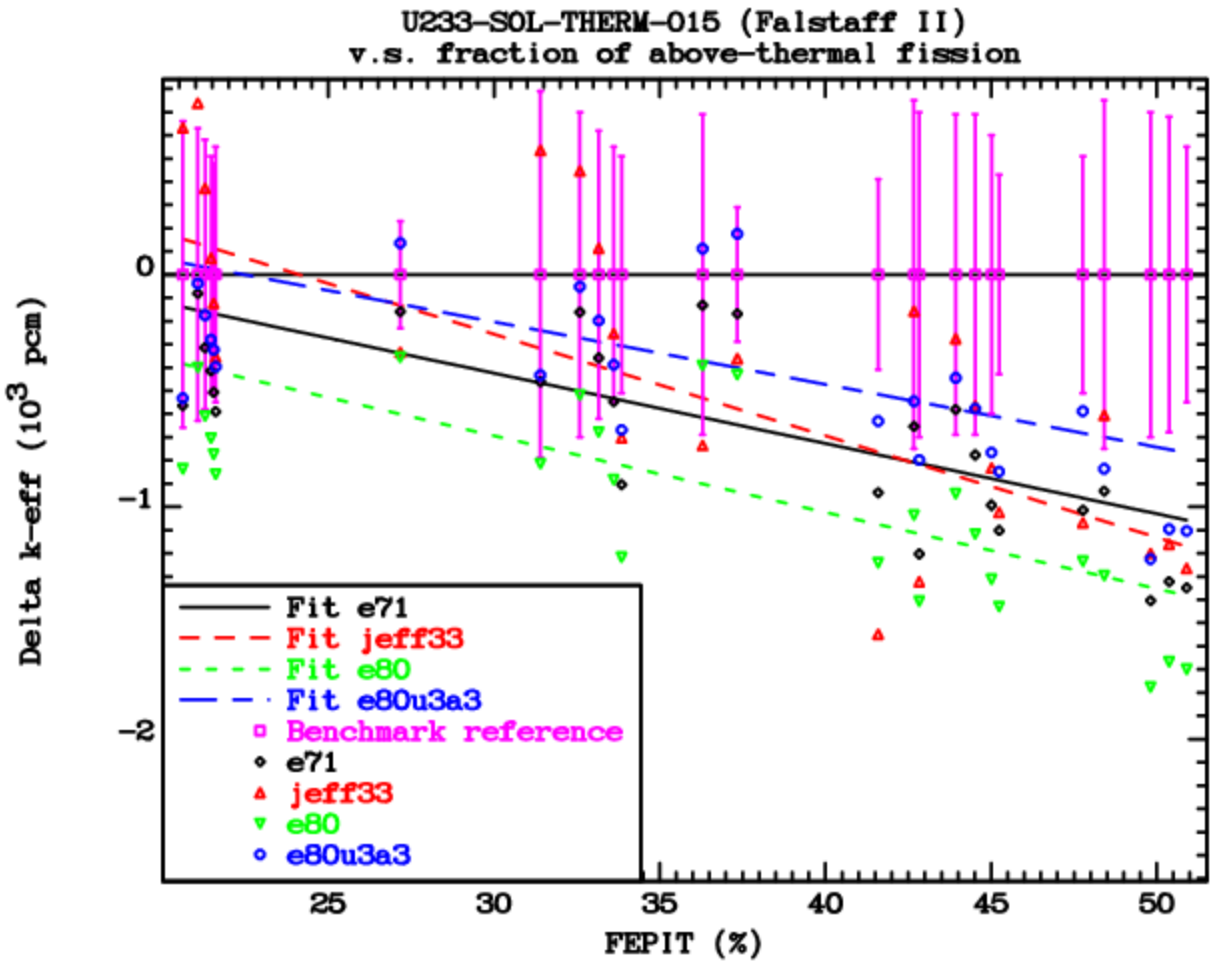

ICSBEP U233-SOL-007 Benchmarks
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
0.5
0.0
-0.5
-1.0
10
15
20
25
FEPIT (%)
Fit e71
Fit e80
Fit e80u3a3
1 Purnima-II_c1
e71
e80
e80u3a3

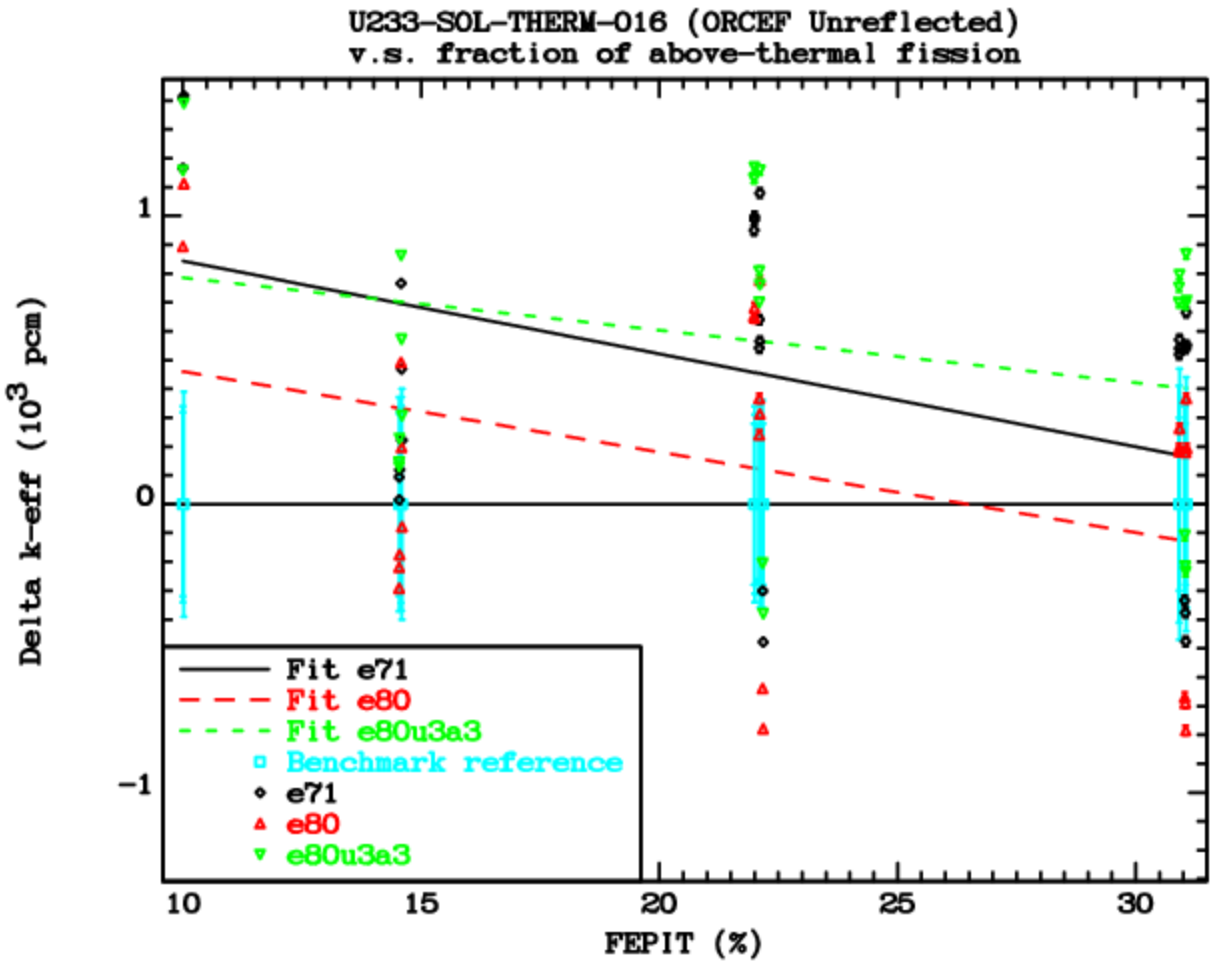

U233-SOL-THERM-009 (U3ORNL)
v.s. fraction of above-thermal fission
Delta k-eff (pcm)
FEPIT (%)
400
300
200
100
0
-100
-200
-300
-400
-500
-600
-700
-800
4.4
4.5
4.6
4.7
Fit e71
Fit jeff33
Fit e80
Fit e80u3a2
5 U3ORNL-20
4 U3ORNL-19
1 U3ORNL-11
3 U3ORNL-18
2 U3ORNL-17
e71
jeff33
e80
e80u3a2

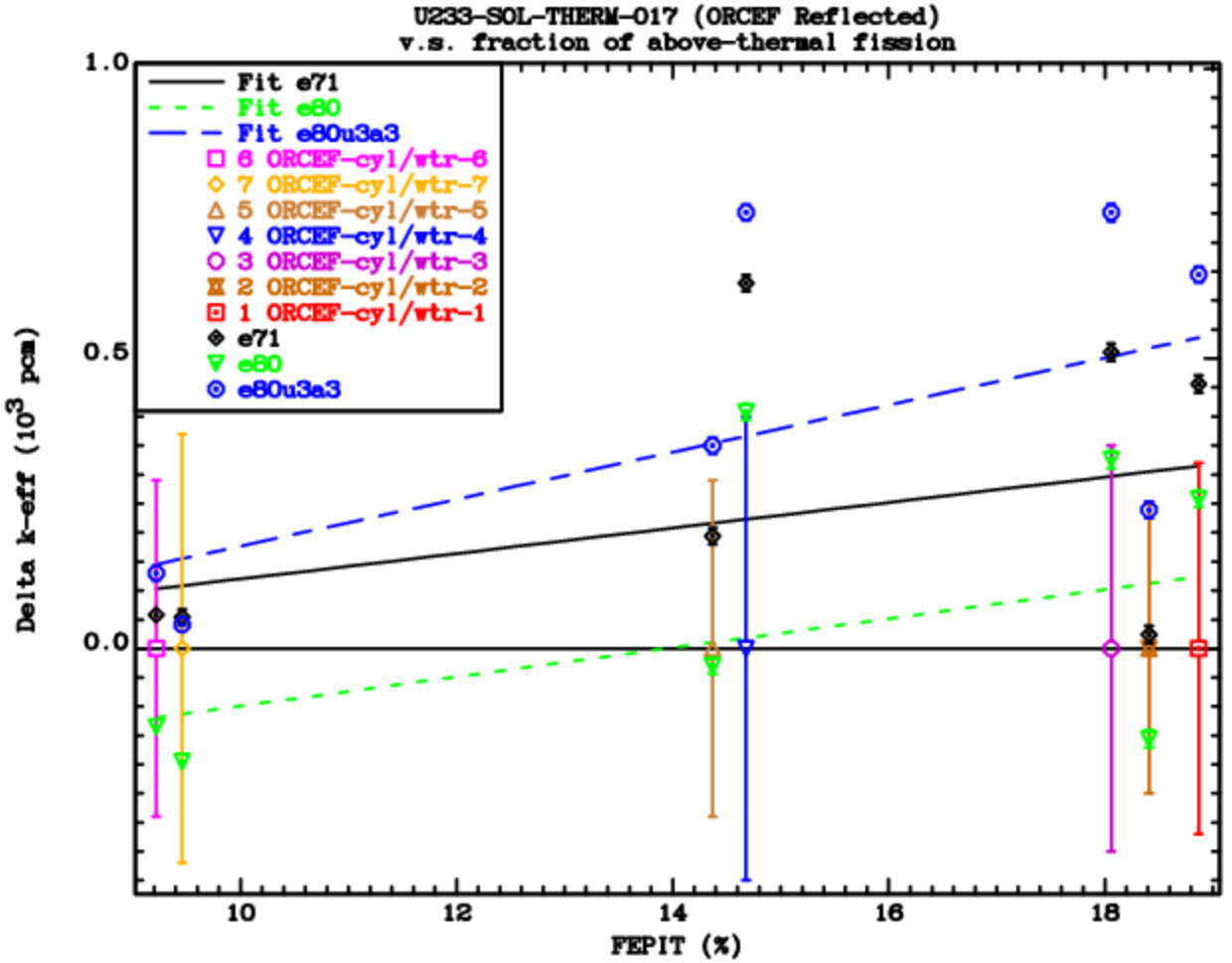

U233-SOL-THERM-012 (ORCEF)
v.s. fraction of above-thermal fission
Fit e71
Fit jeff33
Fit e80
Fit e80u3a3
7 ORCEF-7
8 ORCEF-8
6 ORCEF-6
5 ORCEF-5
4 ORCEF-4
3 ORCEF-3
2 ORCEF-2
1 ORCEF-1
e71
jeff33
e80
e80u3a3
Delta k-eff (10^3 pcm)
2.0
1.5
1.0
0.5
0.0
-0.5
10
12
14
16
18
20
22
24
FEPIT (%)


ICSBEP U233-SOL-THERM-013 Benchmarks
v.s. fraction of above-thermal fission
Fit e71
Fit e80
Fit e80u3a2
Fit e80u3a3
Fit e80u3a30e71
Benchmark reference
e71
e80
e80u3a2
e80u3a3
e80u3a30e71
Delta k-eff (10^3 pcm)
2
1
0
10
12
14
16
18
20
22
FEPIT (%)


ICSBEP U233-SOL-THERM-014 Benchmarks
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
FEPIT (%)
Fit e71
Fit e80
Fit e80u3a3
Fit e80u3a30e71
8 PNL_Bottles-08
7 PNL_Bottles-07
6 PNL_Bottles-06
5 PNL_Bottles-05
14 PNL_Bottles-14
13 PNL_Bottles-13
4 PNL_Bottles-04
9 PNL_Bottles-09
3 PNL_Bottles-03
12 PNL_Bottles-12
15 PNL_Bottles-15
10 PNL_Bottles-10
11 PNL_Bottles-11
16 PNL_Bottles-16
1 PNL_Bottles-01
2 PNL_Bottles-02
e71
e80
e80u3a3
e80u3a30e71


U233-SOL-THERM-015 (Falstaff II)
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
0
−1
−2
25
30
35
40
45
50
FEPIT (%)
Fit e71
Fit jeff33
Fit e80
Fit e80u3a3
Benchmark reference
e71
jeff33
e80
e80u3a3


U233-SOL-THERM-016 (ORCEF Unreflected)
v.s. fraction of above-thermal fission
Delta k-eff (10^3 pcm)
1
0
−1
10
15
20
25
30
FEPIT (%)
Fit e71
Fit e80
Fit e80u3a3
Benchmark reference
e71
e80
e80u3a3


U233-SOL-THERM-017 (ORCEF Reflected)
v.s. fraction of above-thermal fission
Fit e71
Fit e80
Fit e80u3a3
6 ORCEF-cyl/wtr-6
7 ORCEF-cyl/wtr-7
5 ORCEF-cyl/wtr-5
4 ORCEF-cyl/wtr-4
3 ORCEF-cyl/wtr-3
2 ORCEF-cyl/wtr-2
1 ORCEF-cyl/wtr-1
e71
e80
e80u3a3
Delta k-eff (10^3 pcm)
1.0
0.5
0.0
10
12
14
16
18
FEPIT (%)

THANK YOU!

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