Benchmarking of the CIELO ^{238}U Evaluated Data File

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Background

The Working Party on Evaluation Cooperation of the OECD set up a subgroup WPEC-SG40 (alias CIELO) to focus on the evaluated nuclear data of the major nuclides in reactor technology, namely ^{1}H, ^{16}O, ^{56}Fe, ^{235}U, ^{238}U and ^{239}Pu. Different research groups in various parts of the world are working on improved evaluated nuclear data and their uncertainties for these nuclides; the ultimate test of improvement is the performance of the data in simulating integral experiments.

Evaluated data file "ib36" is the most recent version of the fast energy range evaluation from the IAEA. In addition, an updated unresolved resonance range evaluation was provided by I. Sirakov through the IRMM collaboration for the JEFF project and the CIELO project.

File description

Sirakov provided several versions of the ENDF files with unresolved resonance range starting at 10 keV or 20 keV, and the options of the capture and inelastic cross sections extracted from the resonance data, or forced to match the Standards or the IAEA version "ib33" evaluation, respectively. The inelastic cross sections in "ib36" differ insignificantly from "ib33" in this energy range. Since our interest lies in the impact of new capture data, we considered the IRMM evaluation labelled "G20-3" in the energy range between 20 keV and 149 keV with capture cross sections fitted to the resonance data and inelastic cross sections fitted to the "ib33" evaluation. The comparison of the cross sections is shown in Figures 1 and 2. The resolved resonance re-evaluation is said to be incomplete, although the present version differs slightly from the ENDF/B-VII.1 evaluation. The resolved resonance evaluation was not considered at present.

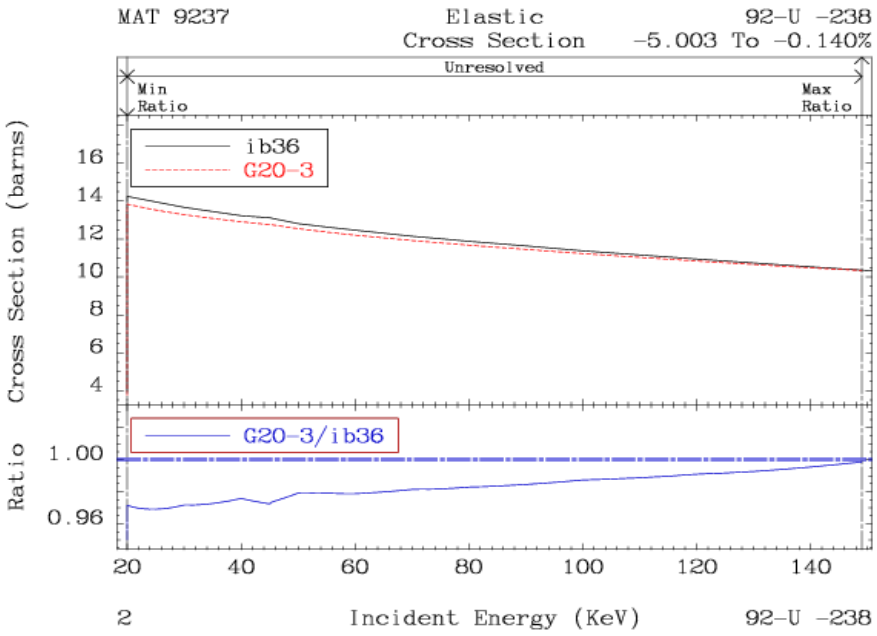

Figure 1: Comparison of the elastic cross sections of ^{238}U from the ENDF/B-VII.1 and the IRMM evaluations.

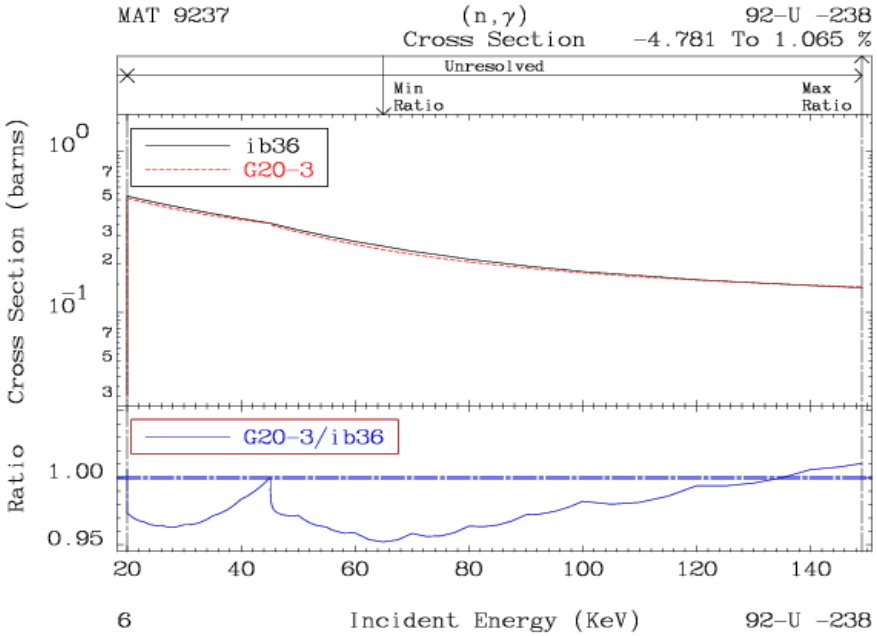

Figure 2: Comparison of the capture cross sections of ^{238}U from the ENDF/B-VII.1 and the IRMM evaluations.

The resonance file from the ENDF/B-VII.1 evaluation of the ^{238}U was inserted into the ib36 version of the IAEA evaluation. A PENDF file was created from the IRMM evaluation labelled “G20-3”. The total, elastic and capture cross sections between 2.5 keV and 20 keV were extracted and inserted into the new file labelled “u238ib36ur”. The unresolved resonance parameters were also replaced by the IRMM data, but changing the LSSF flag to zero, since the cross sections were entered in pointwise form into the ENDF File 3.

The following files have been considered:

e71	Original ^{238}U evaluation from ENDF/B-VII.1.
u238ib33	IAEA “ib33” evaluation with resonance data from ENDF/B-VII.1, which was the original starter file for CIELO.
u238ib36	Improved IAEA “ib36” evaluation with resonance data from ENDF/B-VII.1. The improvements include more coupled levels to describe the inelastic cross sections and a slight increase of the (n,2n) cross section, as indicated by the experiments on MINERVE (G. Noguere, provate communication, July 2014).
u238ib36ur	“u238ib36” evaluation with unresolved resonance data from the IRMM evaluation “G20-3”. The comparison of the cross sections is shown in Figure 1.

Results

The evaluated data files described above were processed with NJOY2012 to prepare ACE libraries with which the selected benchmark assemblies wire modelled. The list of benchmarks that were included in the analysis is given in Table 1. The impact of the new IRMM evaluation in the unresolved resonance region is shown in Figures 3-5; the Big Ten, the VNIIEF-CFT-4 and the ZPR -6/9(U9) assemblies shows a strong increase of reactivity. The results of the combined effect of all changes in the ^{238}U, ^{235}U and ^{16}O are shown in Figures 6-8. The results for the major benchmarks like Flattop-25 and Big Ten show improvement. The Jemima-3 and -4 are slightly underpredicted. The strong impact on the Comet-UH3.1, 4, 6, 7 needs a more detailed investigation. The underprediction of reactivity of the BW-XI series of benchmarks and VNIIEF-CTF-6 also requires attention, but overall, the results are encouraging.

Table 1: List of benchmarks considered in the analysis

ICSBEP name	Short name	Common name
HEU-MET-FAST-001	hmf001	Godiva
HEU-MET-FAST-028	hmf028	Flattop-25
IEU-MET-FAST-007	imf007	Big_Ten
IEU-MET-FAST-007	imf007d	Big_Ten(detaile)
PU-MET-FAST-006	pmf006	Flattop-Pu
U233-MET-FAST-006	umf006	Flattop-23
HEU-MET-FAST-002	hmf002-1	Topsy-1
HEU-MET-FAST-002	hmf002-2	Topsy-2
HEU-MET-FAST-002	hmf002-3	Topsy-3
HEU-MET-FAST-002	hmf002-4	Topsy-4
HEU-MET-FAST-002	hmf002-5	Topsy-5
HEU-MET-FAST-002	hmf002-6	Topsy-6
IEU-MET-FAST-001	imf001-1	Jemima-1
IEU-MET-FAST-001	imf001-2	Jemima-2
IEU-MET-FAST-001	imf001-3	Jemima-3
IEU-MET-FAST-001	imf001-4	Jemima-4
PU-MET-FAST-010	pmf010	pmf010
PU-MET-FAST-012	pmf012	pmf012
PU-MET-FAST-020	pmf020	pmf020
PU-MET-FAST-029	pmf029	pmf029
PU-MET-FAST-041	pmf041	pmf041
MIX-MET-INTER-004	mmi004	ZPR-3/53
HEU-COMP-INTER-003	hci003-1	COMET-UH3-1
HEU-COMP-INTER-003	hci003-4	COMET-UH3-4
HEU-COMP-INTER-003	hci003-6	COMET-UH3-6
HEU-COMP-INTER-003	hci003-7	COMET-UH3-7
HEU-MET-FAST-003	hmf003-01	Topsy-U_2.0in
HEU-MET-FAST-003	hmf003-02	Topsy-U_3.0in
HEU-MET-FAST-003	hmf003-03	Topsy-U_4.0in
HEU-MET-FAST-003	hmf003-04	Topsy-U_5.0in
HEU-MET-FAST-003	hmf003-05	Topsy-U_6.0in
HEU-MET-FAST-003	hmf003-06	Topsy-U_8.0in
HEU-MET-FAST-003	hmf003-07	Topsy-U_11.in
HEU-MET-FAST-008	hmf008	VNIIEF-CTF-bare
HEU-MET-FAST-014	hmf014	VNIIEF-CTF-DU
HEU-MET-FAST-032	hmf032-1	COMET-TU1_3.93i
HEU-MET-FAST-032	hmf032-2	COMET-TU2_3.52i
HEU-MET-FAST-032	hmf032-3	COMET-TU3_1.742
HEU-MET-FAST-032	hmf032-4	COMET-TU4_0.683
IEU-MET-FAST-003	imf003-2	VNIIEF-CTF-3
IEU-MET-FAST-004	imf004-2	VNIIEF-CTF-4
IEU-MET-FAST-005	imf005	VNIIEF-CTF-5
IEU-MET-FAST-006	imf006	VNIIEF-CTF-6
IEU-MET-FAST-010	imf010	ZPR-6/9(U9)
LEU-COMP-THERM-008	lct008-01	BW-XI-1

LEU-COMP-THERM-008	lct008-02	BW-XI-2
LEU-COMP-THERM-008	lct008-05	BW-XI-5
LEU-COMP-THERM-008	lct008-07	BW-XI-7
LEU-COMP-THERM-008	lct008-08	BW-XI-8
LEU-COMP-THERM-008	lct008-11	BW-XI-11
LEU-SOL-THERM-002	lst002-1	ORNL-UO2F2
LEU-SOL-THERM-002	lst002-2	ORNL-UO2F2
LEU-SOL-THERM-007	lst007-14	STACY-14
LEU-SOL-THERM-007	lst007-30	STACY-30
LEU-SOL-THERM-007	lst007-32	STACY-32
LEU-SOL-THERM-007	lst007-36	STACY-36
LEU-SOL-THERM-007	lst007-49	STACY-49
PU-MET-FAST-015	pmf015	BR-1-3
PU-MET-FAST-025	pmf025	pmf025
PU-MET-FAST-026	pmf026	pmf026
PU-MET-FAST-028	pmf028	pmf028
PU-MET-FAST-032	pmf032	pmf032
HEU-MET-FAST-013	hmf013	VNIITF-CTF-SS-13
HEU-MET-FAST-021	hmf021	VNIITF-CTF-SS-21
HEU-MET-FAST-024	hmf024	VNIITF-CTF-SS-24
HEU-MET-FAST-087	hmf087	VNIITF-CTF-Fe
HEU-MET-FAST-088	hmf088-1	hmf088-1
HEU-MET-FAST-088	hmf088-2	hmf088-2
HEU-MET-INTER-001	hmi001	ZPR-9/34
PU-MET-INTER-002	pmi002	ZPR-6/10
MIX-COMP-FAST-001	mcf001	ZPR-6/7
MIX-COMP-FAST-005	mcf005	ZPR-9/31
MIX-COMP-FAST-006	mcf006	ZPPR-2
LEU-COMP-THERM-042	lct042-1	lct042-1
LEU-COMP-THERM-042	lct042-2	lct042-2
LEU-COMP-THERM-043	lct043	IPEN/MB-01
LEU-MET-THERM-015	lmt015	lmt015
HEU-MET-THERM-013	hmt013-2	hmt013-2
HEU-MET-THERM-015	hmt015	hmt015

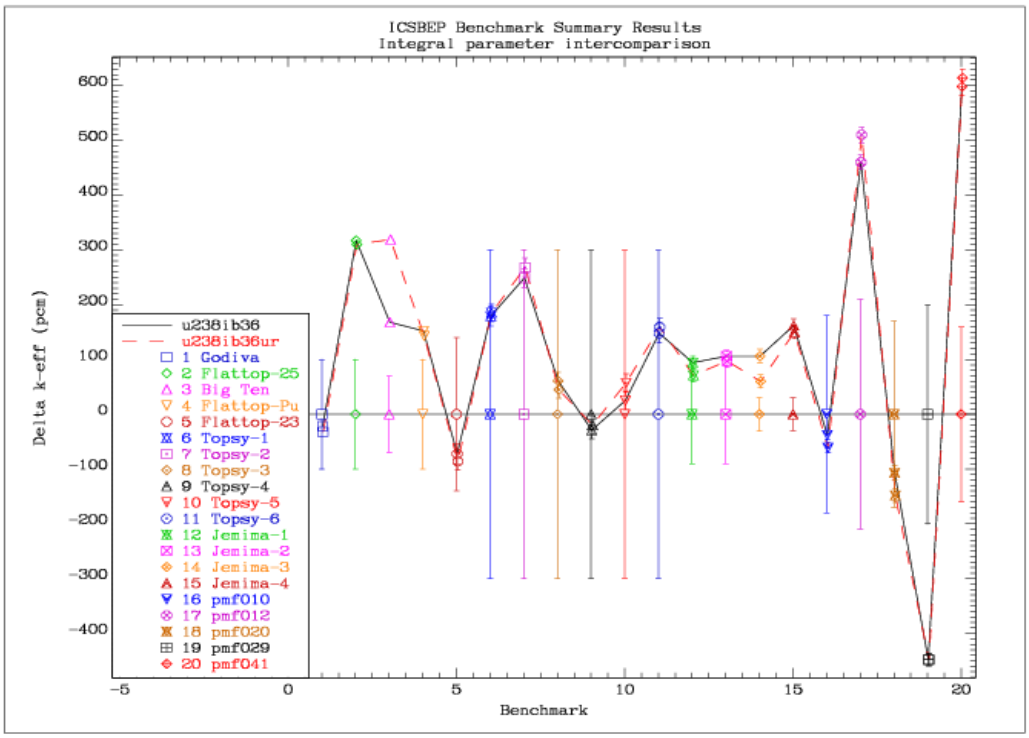

Figure 3: Results of the sensitivity study on the impact of the IRMM cross sections in the unresolved resonance range of ^{238}U data on the k_{eff}.

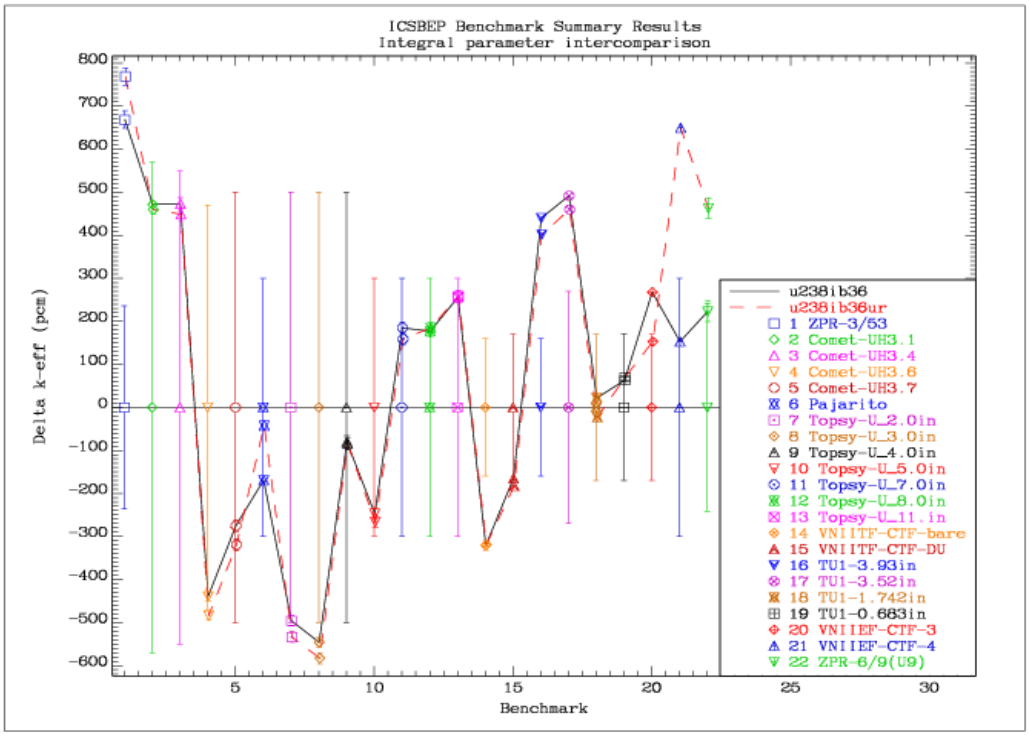

Figure 4: Results of the sensitivity study on the impact of the IRMM cross sections in the unresolved resonance range of ^{238}U data on the k_{eff}.

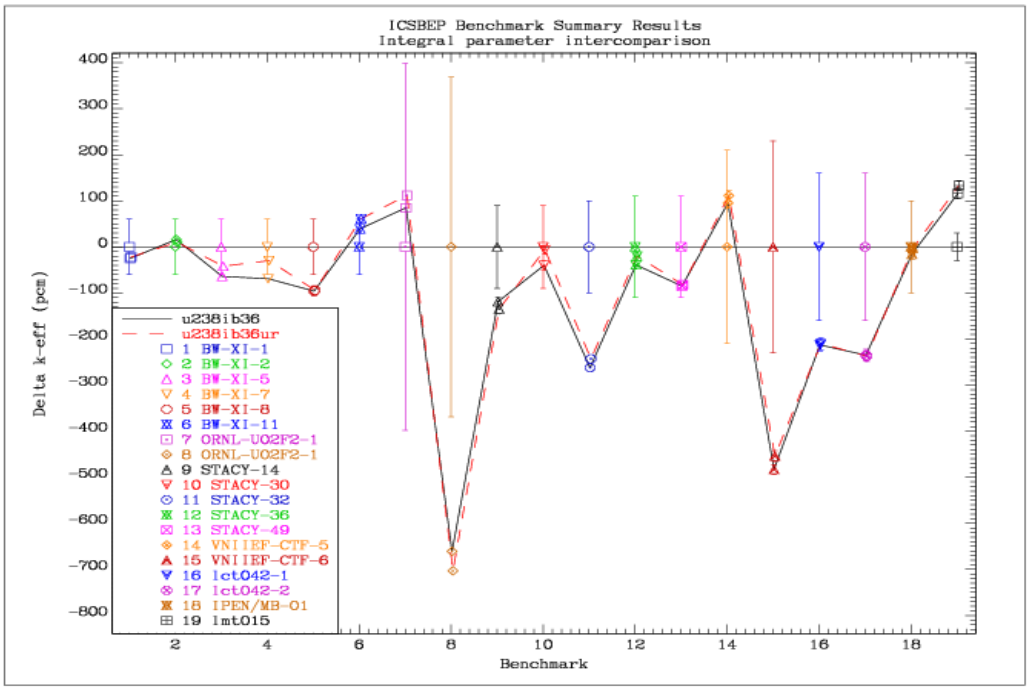

Figure 5: Results of the sensitivity study on the impact of the IRMM cross sections in the unresolved resonance range of ^{238}U data on the k_{eff}.

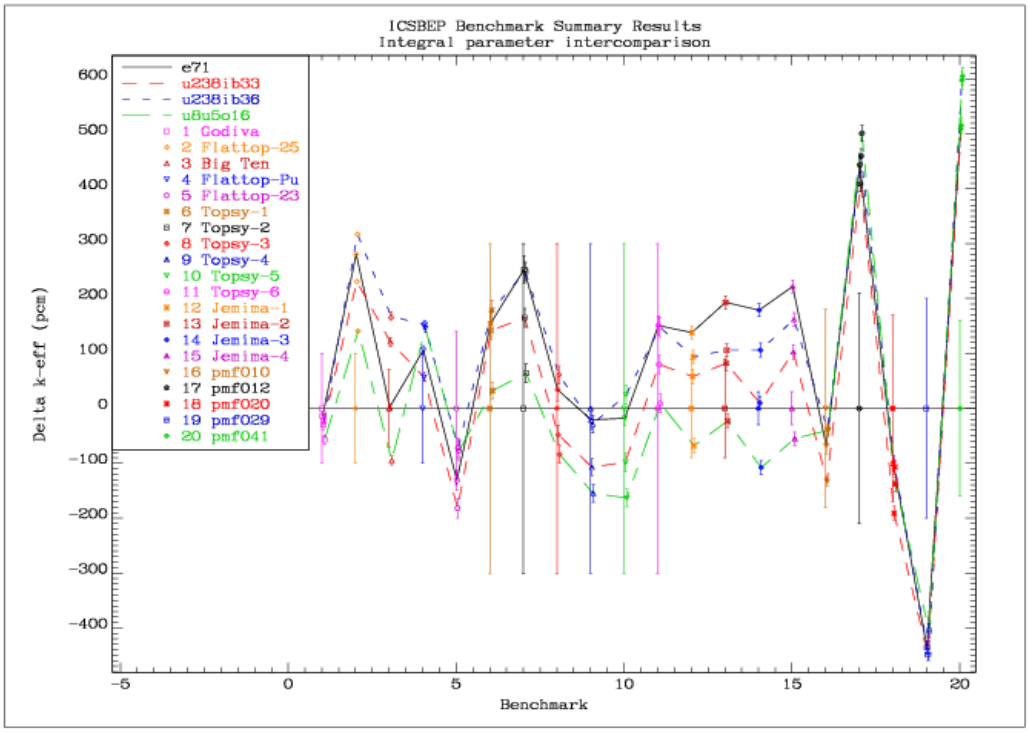

Figure 6: Results of the combined effect of the changes in the cross section data of ^{238}U, ^{235}U and ^{16}O on the k_{eff}.

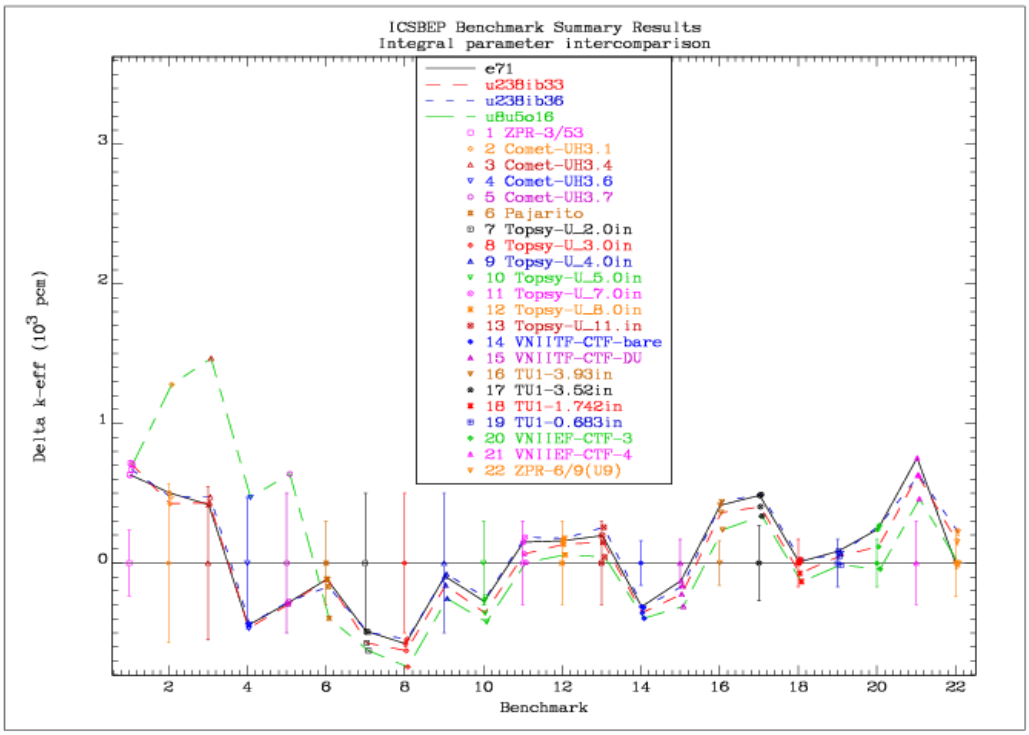

Figure 7: Results of the combined effect of the changes in the cross section data of ^{238}U, ^{235}U and ^{16}O on the k_{eff}.

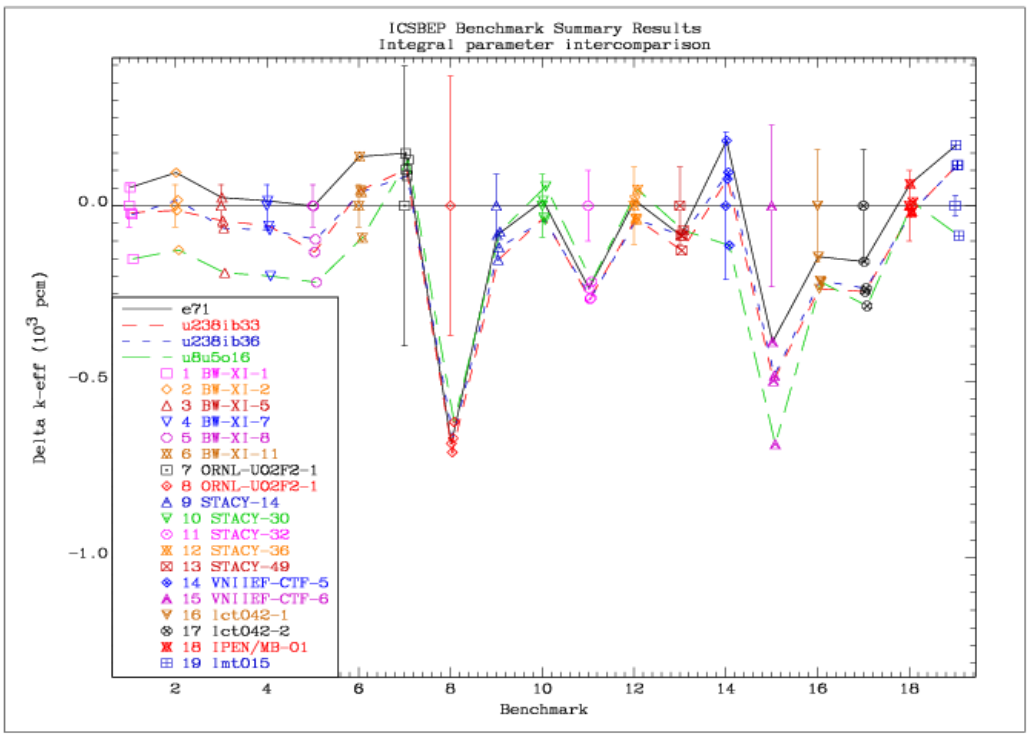

Figure 8: Results of the combined effect of the changes in the cross section data of ^{238}U, ^{235}U and ^{16}O on the k_{eff}.

Conclusions

The present analysis complements the study of the impact of the changes in the ^{235}U PFNS and inelastic cross sections on integral benchmarks [2]. The impact of the IAEA "ib36" evaluation of ^{238}U in comparison with version "ib33" was made. A separate study of the impact of the IRMM evaluation in the unresolved resonance range was produced. The cumulative results include also the LANL evaluation of ^{16}O.

None of the evaluations in this work are considered final, but the results are encouraging. They show the sensitivities to the nuclear data and indicate on which reactions the evaluation efforts should be focused.

References

[1] A. Trkov: On the Selection of the Differential ^{235}U PFNS Data, International Atomic Energy Agency, Vienna, Austria, December 2014 (unpublished).

[2] A. Trkov: The Impact of the "u235g6" Family of Evaluated Data Files, International Atomic Energy Agency, Vienna, Austria, December 2014 (unpublished).