Nuclear data uncertainty propagation: Preliminary results

D. Rochman, S.C. van der Marck,

and A. Hogenbirk

Nuclear Research and Consultancy Group,

NRG, Petten, The Netherlands

SG-33, December 2010

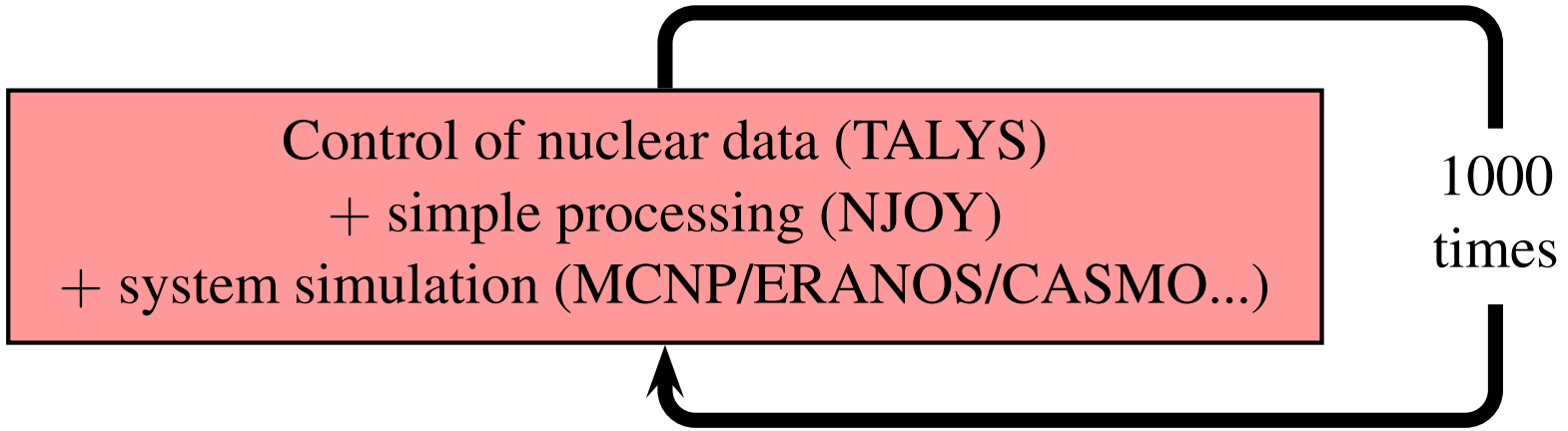
Contents

Goals:

① Obtain uncertainties for SG-33 due to nuclear data uncertainties

② Systematic approach, reliable and reproducable

Solution (1): Total Monte Carlo



Solution (2): Perturbation method

$\Longrightarrow$MCNP+ Perturbation cards+covariance files

Preliminary results: Summary table for k_{eff} calculations

Benchmark	^{239}Pu	^{240}Pu	^{241}Pu	^{235}U	^{238}U	^{56}Fe	^{52}Cr	^{58}Ni	^{23}Na	^{16}O	^{10}B
pmf1 (Jezebel-239)	/	/	/								
pmf2 (Jezebel-240)	X	X	/								
pmf6 (Flat-top)	/	/	/	/	/						
mcf1 (ZPR6-7)	/	/	/	/	/	/	/	/	/	/	
mcf2 (ZPR6-7 ^{240}Pu)	o	o	o	o	o	o	o	o	o	o	
ZPPR9	/	/	/	/	/	/	/	/	/	/	
JOYO	/	/	/	/	/	/	/	/	/	/	/
FBR	/	/	/		/	/	/	/	/	/	/
ABR	o	o	o	o	o	o	o	o	o	o	o

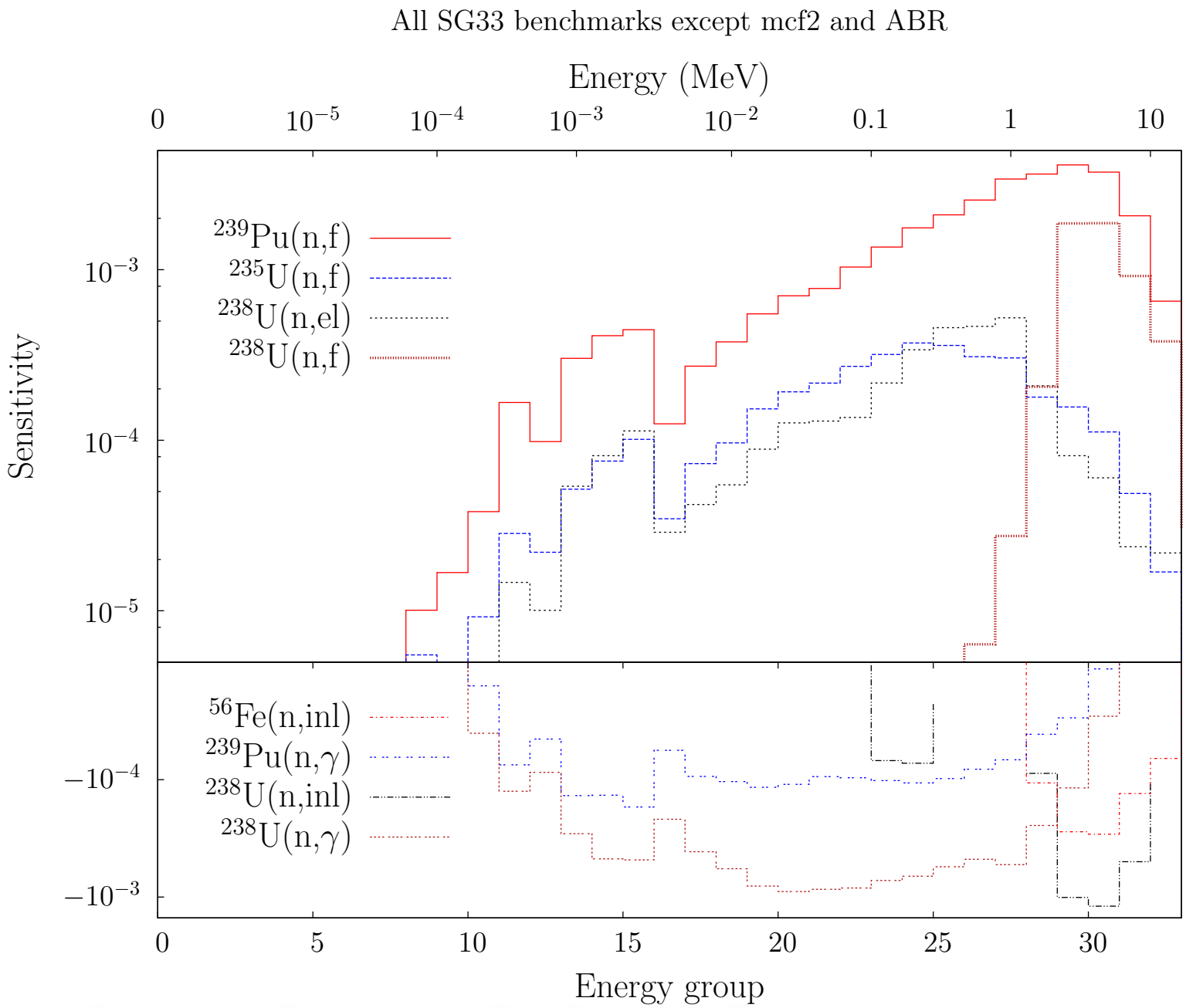
Legend:

X: calculations finished

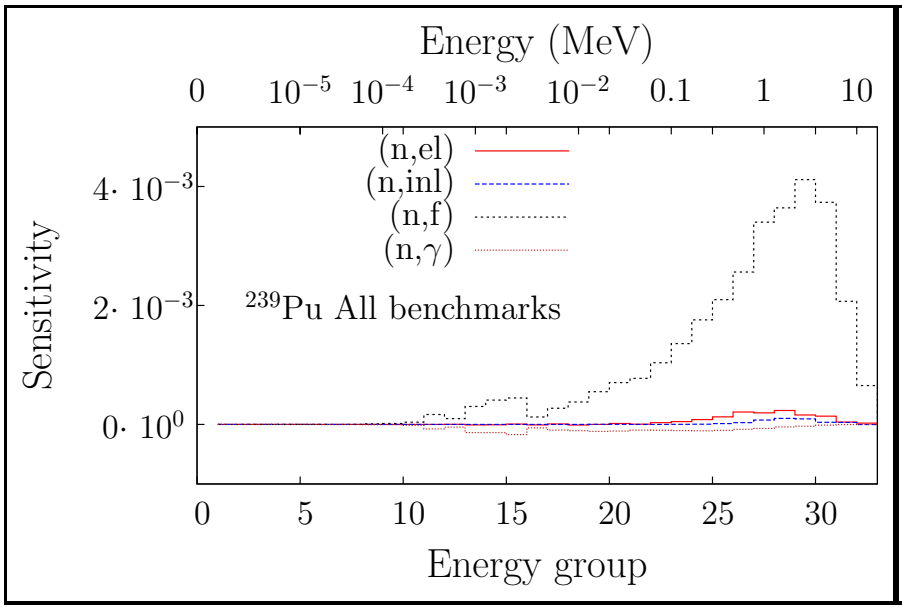
/: ongoing calculations

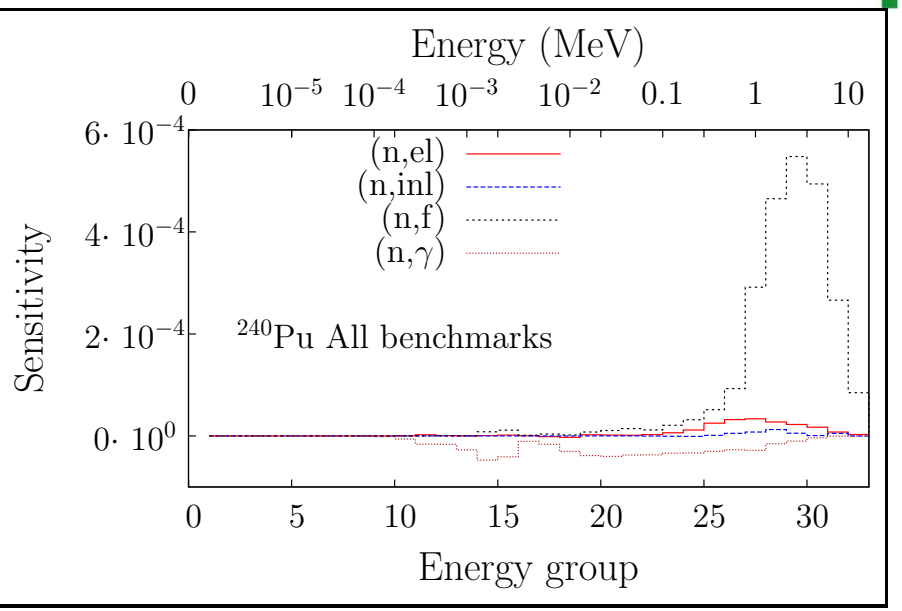
o: calculations not started

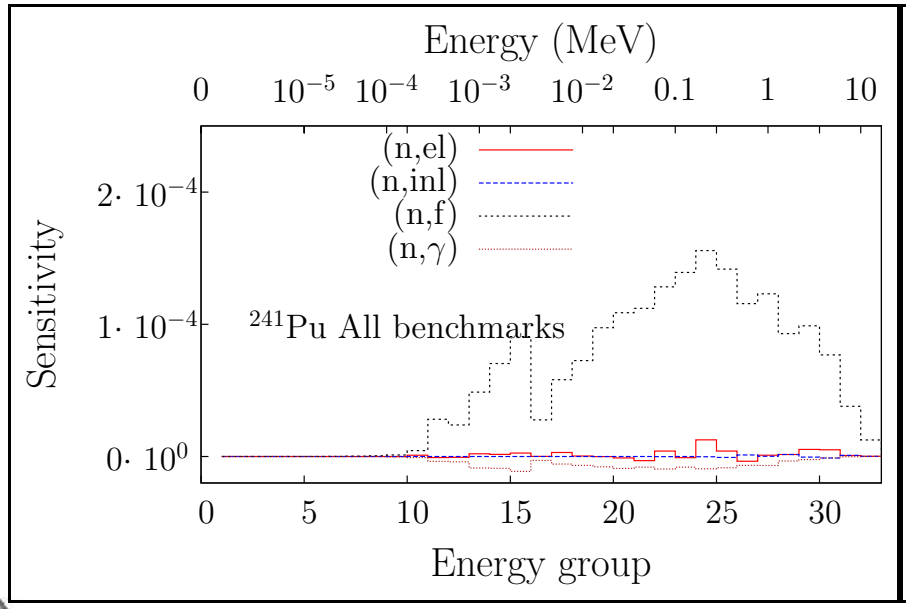
k_{eff} Sensitivities to 8 most important cross sections

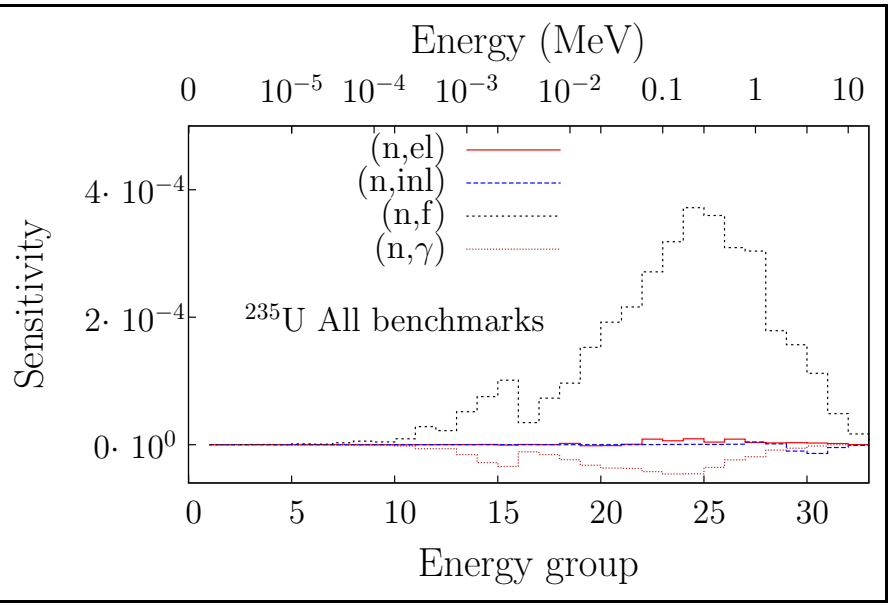


k_{eff} Sensitivities (%/%) to ^{239,240,241}Pu and ^{235}U

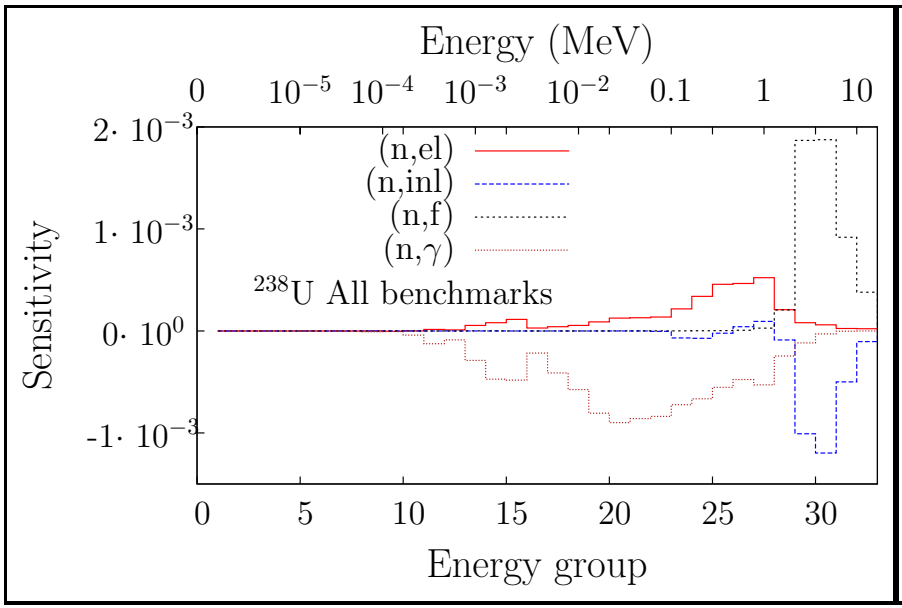


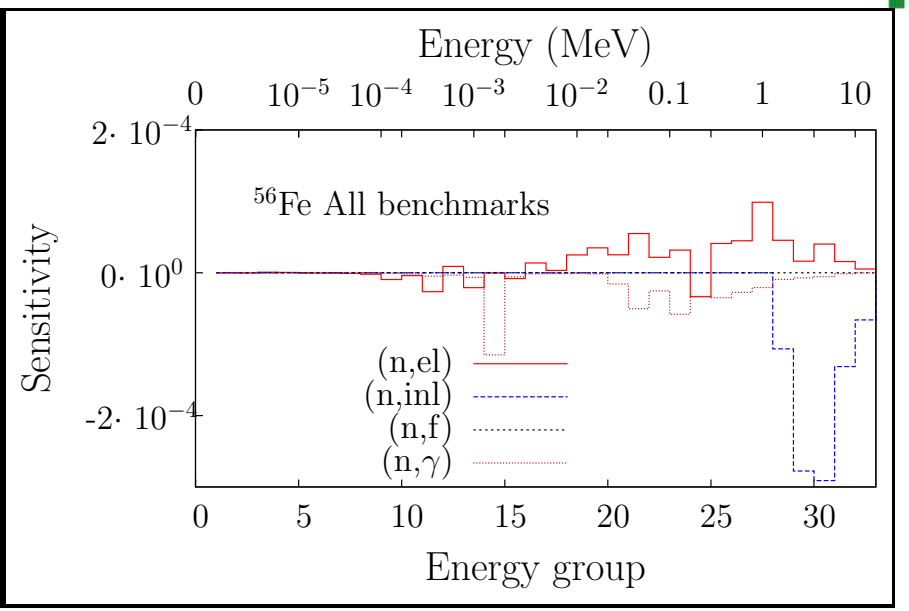


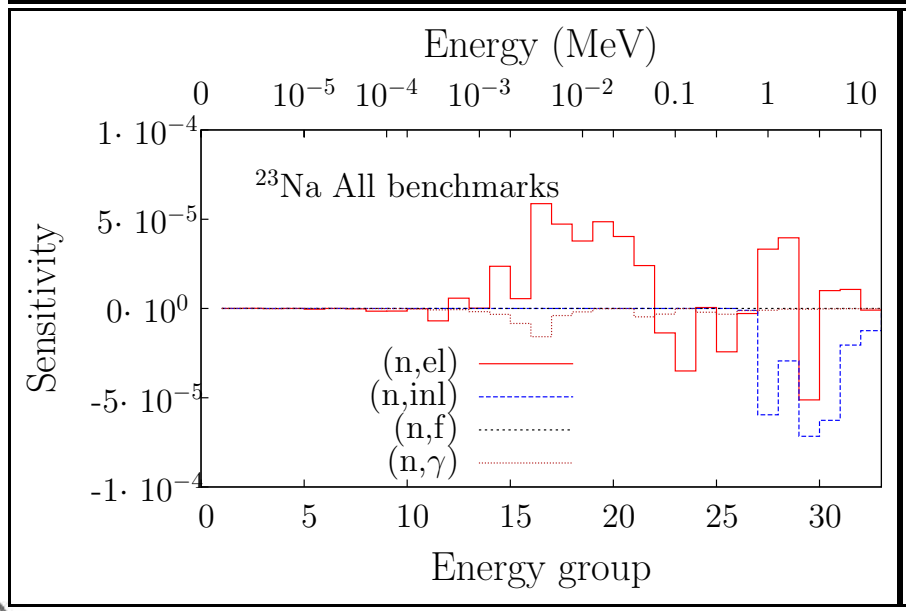


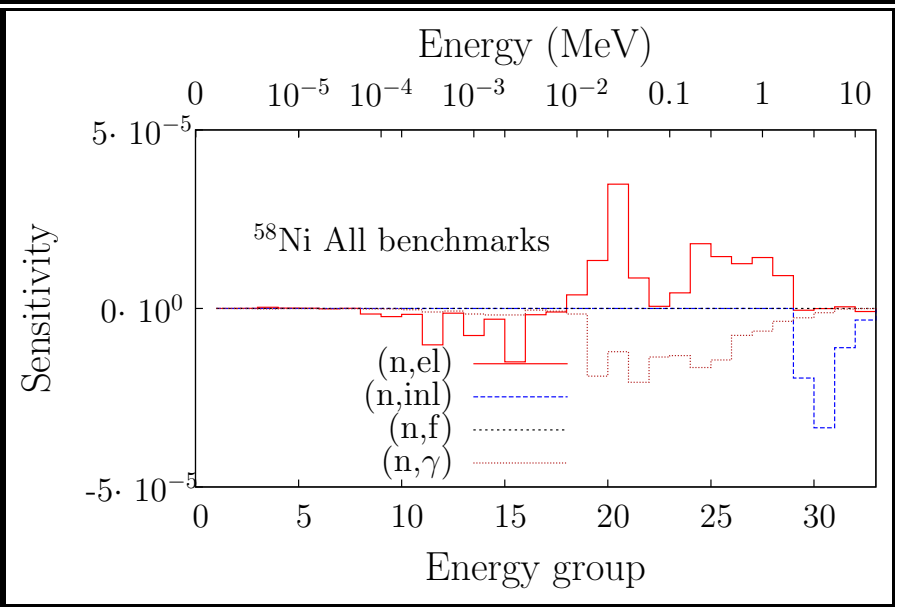


k_{eff} Sensitivities (%/%) to ^{238}U, ^{56}Fe, ^{23}Na and ^{58}Ni

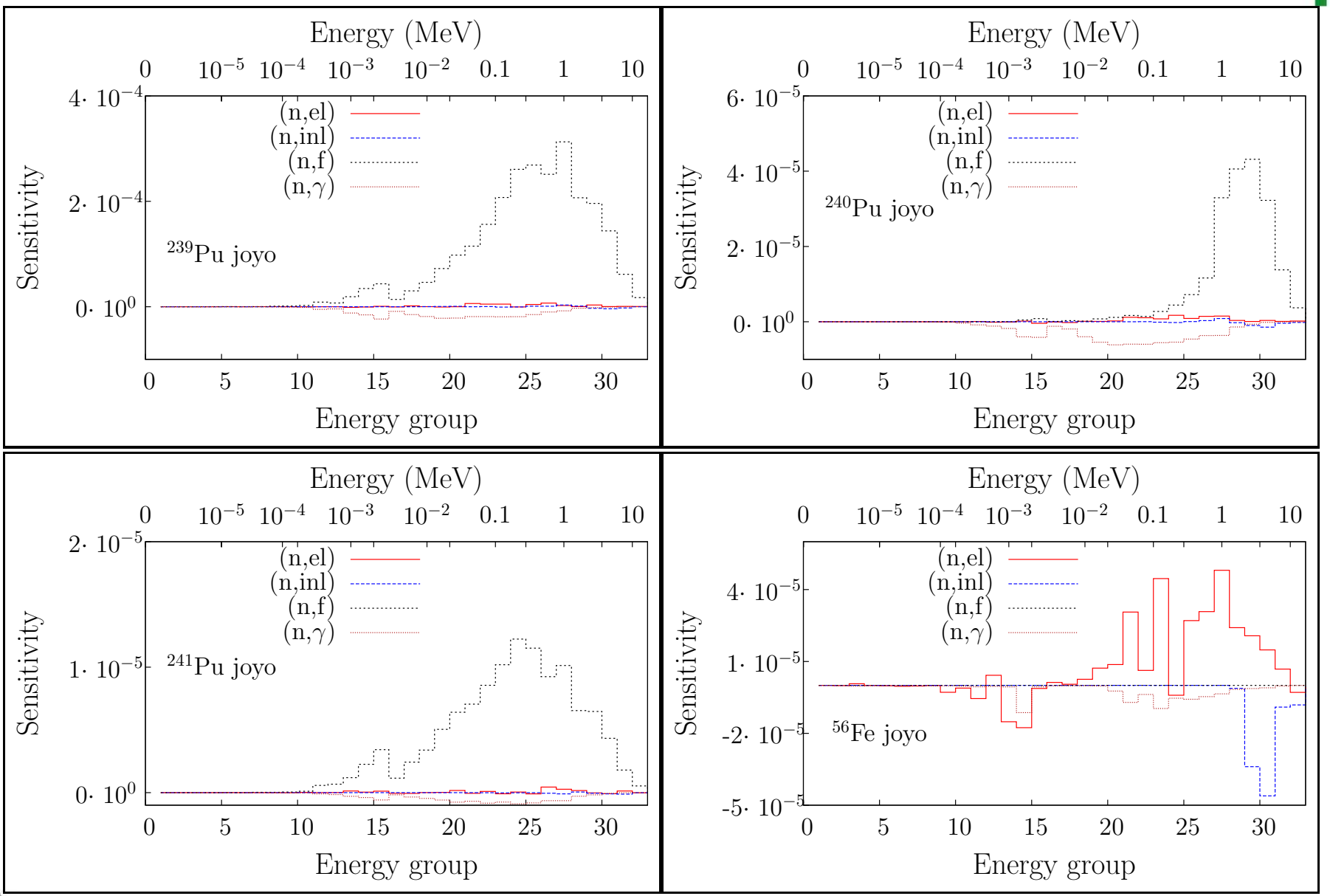






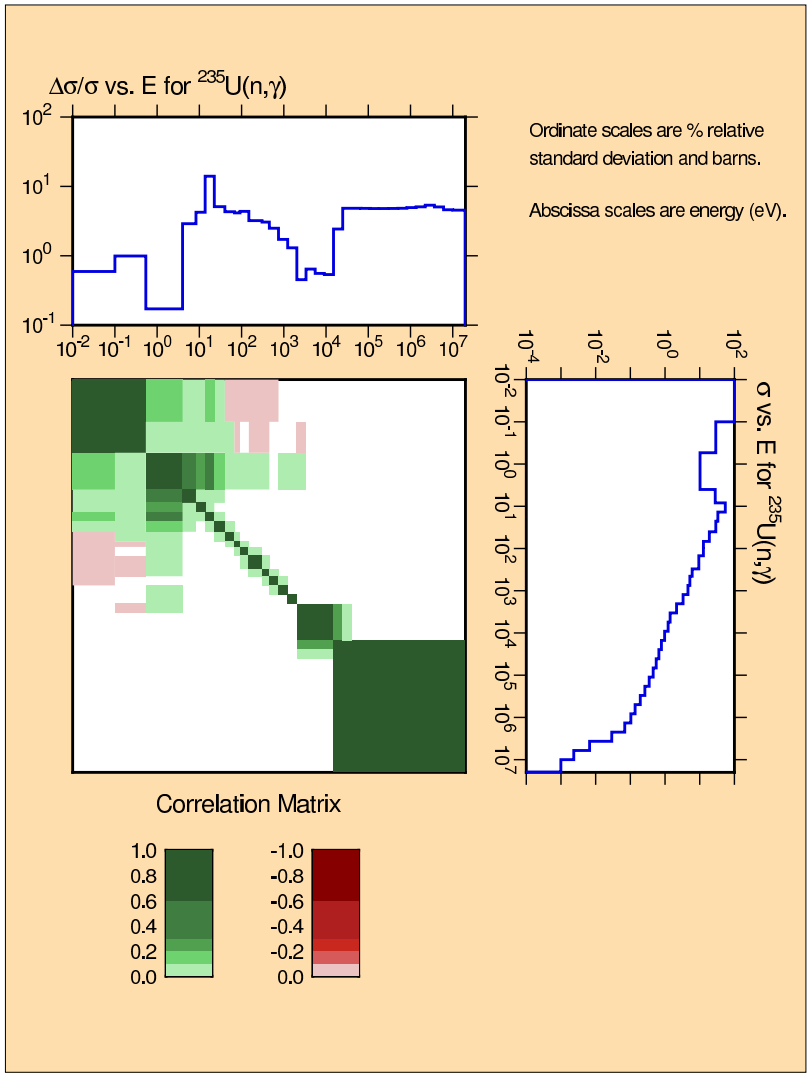


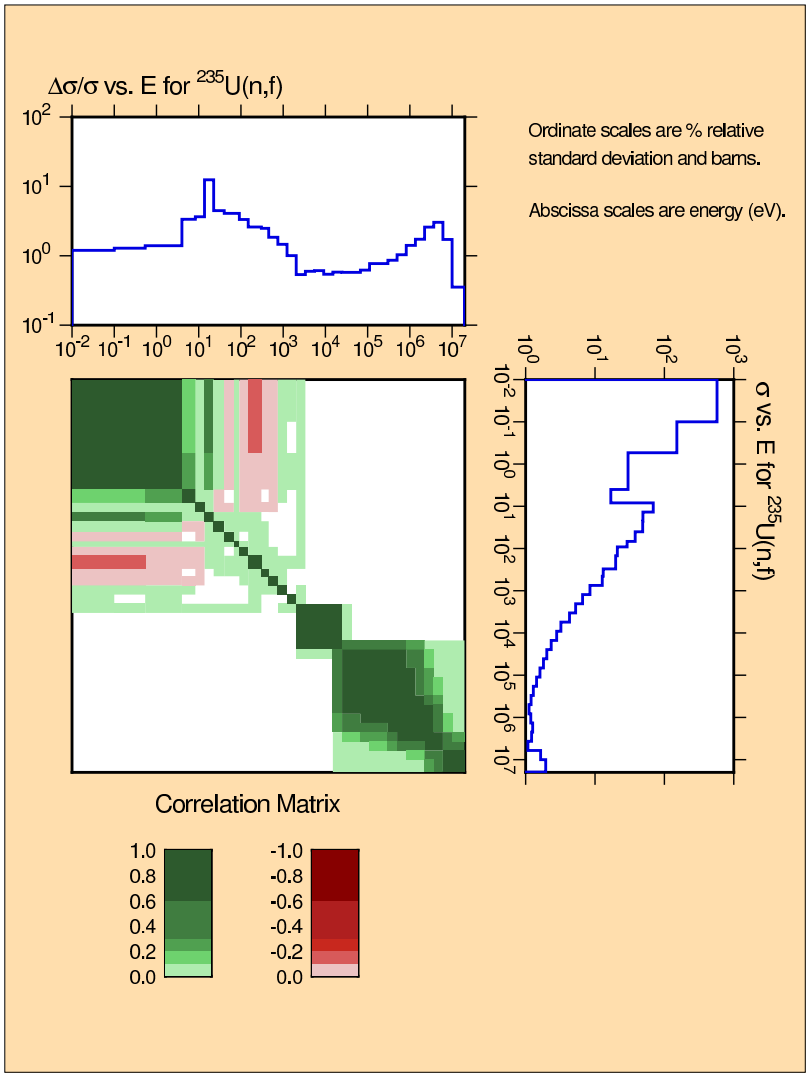
Details of k_{eff} sensitivities (%/%) for JOYO to ^{239,240,241}Pu and ^{56}Fe



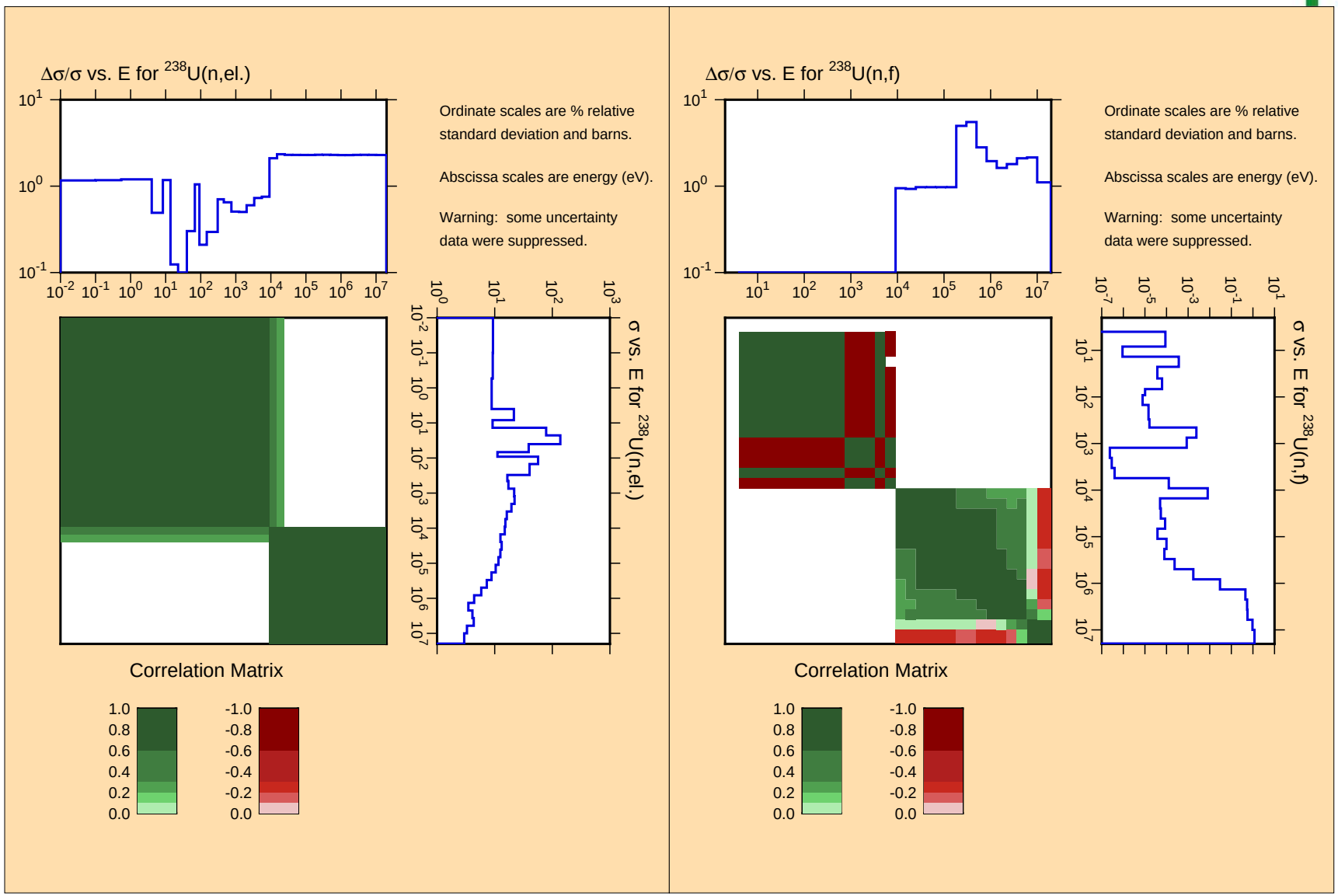
Other sensitivities are included in the report.

Examples of covariance files





Examples of covariance files



Other covariances are included in the report.

k_{eff} uncertainties from perturbation methods and TMC

Table 1: Details of the comparison TMC-Perturbation method for pmf1 k_{eff} benchmarks.

	pmf1 ^{239}Pu		pmf1 ^{240}Pu		pmf1 ^{241}Pu	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Perturbation	TMC	Perturbation	TMC	Perturbation
Total	940	860		130		10
MF1	440	-		-		-
(n,inl)	240	170		15		0
(n,el)	230	270		10		0
(n,γ)		140		5		1
(n,f)		780		130		10
MF4		-		-		-
MF5		-		-		-
MF6		-		-		-

k_{eff} uncertainties from perturbation methods and TMC

Table 2: Details of the comparison TMC-Perturbation method for pmf2 k_{eff} benchmarks.

	pmf2 ^{239}Pu		pmf2 ^{240}Pu		pmf2 ^{241}Pu	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Perturbation	TMC	Perturbation	TMC	Perturbation
Total	844	722	790	650		113
MF1	400	-	370	-		-
(n,inl)	170	140	70	50		10
(n,el)	250	240	30	40		16
(n,γ)	100	100	30	30		10
(n,f)	720	660	730	640		110
MF4	20	-	20	-		-
MF5	50	-	30	-		-
MF6	50	-	30	-		-

k_{eff} uncertainties from perturbation methods and TMC

Table 3: Details of the comparison TMC-Perturbation method for pmf6 k_{eff} benchmarks.

	pmf6 ^{239}Pu		pmf6 ^{240}Pu		pmf6 ^{241}Pu		pmf6 ^{238}U	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.
Total	990	570		80		6		950
MF1	460	-		-		-		-
(n,inl)	70	20		3		0		420
(n,el)	85	80		2		0		320
(n,γ)		180		6		0		730
(n,f)		530		80		6		280
MF4		-		-		-		-
MF5		-		-		-		-
MF6		-		-		-		-

k_{eff} uncertainties from perturbation methods and TMC

Table 4: Details of the comparison TMC-Perturbation method for mcf1 k_{eff} benchmarks.

	mcf1 ^{239}Pu		mcf1 ^{240}Pu		mcf1 ^{241}Pu		mcf1 ^{238}U		mcf1 ^{235}U	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.
Total	860	530		220		30		1800		5
MF1	480	-		-		-		-		-
(n,inl)	30	16		1		0		280		0
(n,el)	15	7		0		2		60		0
(n,γ)		240		8		10		1700		2
(n,f)		530		210		30		100		5

	mcf1 ^{56}Fe		mcf1 ^{52}Cr		mcf1 ^{58}Ni		mcf1 ^{23}Na		mcf1 ^{16}O	
Total		85		160		6		23		40
(n,inl)		70		10		2		10		0
(n,el)		25		160		1		21		40
(n,γ)		40		20		5		1		0

k_{eff} uncertainties from perturbation methods and TMC

Table 5: Details of the comparison TMC-Perturbation method for zppr9 k_{eff} benchmarks.

	zppr9 ^{239}Pu		zppr9 ^{240}Pu		zppr9 ^{241}Pu		zppr9 ^{238}U		zppr9 ^{235}U	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.
Total	680	480		115		25		1700		3
MF1	480	-		-		-		-		-
(n,inl)	<20	15		5		0		310		0
(n,el)	<20	3		1		0		320		0
(n,γ)		200		35		10		1680		2
(n,f)		440		110		25		140		2

	zppr9 ^{56}Fe		zppr9 ^{52}Cr		zppr9 ^{58}Ni		zppr9 ^{23}Na		zppr9 ^{16}O	
Total		70		45		10		45		85
(n,inl)		55		5		3		25		2
(n,el)		30		40		5		35		85
(n,γ)		30		15		5		3		0

k_{eff} uncertainties from perturbation methods and TMC

Table 6: Details of the comparison TMC-Perturbation method for Joyo k_{eff} benchmarks.

	Joyo ^{239}Pu		Joyo ^{240}Pu		Joyo ^{241}Pu		Joyo ^{238}U		Joyo ^{235}U		
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{ef}
	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC
Total	230	350		170		35		970		220	
MF1	280	-		-		-		-		-	
(n,inl)	15	2		2		0		70		10	
(n,el)	<30	15		2		1		85		15	
(n,γ)		170		30		10		960		125	
(n,f)		300		160		30		85		170	

	Joyo ^{56}Fe		Joyo ^{52}Cr		Joyo ^{58}Ni		Joyo ^{23}Na		Joyo ^{16}O		Joy
Total		55		220		14		75		100	
(n,inl)		25		5		2		3		0	
(n,el)		45		220		12		75		100	
(n,γ)		20		10		10		3		0	

k_{eff} uncertainties from perturbation methods and TMC

Table 7: Details of the comparison TMC-Perturbation method for FBR k_{eff} benchmarks.

	fbr ^{239}Pu		fbr ^{240}Pu		fbr ^{241}Pu		fbr ^{238}U		fbr ^{10}B	
	Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)		Δk_{eff} (pcm)	
	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.	TMC	Pert.
Total	760	360		295		230		1400		0
MF1	420	-		-		-		-		
(n,inl)	35	10		12		12		230		0
(n,el)	15	20		2		5		25		0
(n,γ)	195	160		90		190		1350		0
(n,f)		320		280		130		70		

	fbr ^{56}Fe		fbr ^{52}Cr		fbr ^{58}Ni		fbr ^{23}Na		fbr ^{16}O	
Total		50		30		15		35		70
(n,inl)		40		5		5		20		0
(n,el)		10		25		10		25		70
(n,γ)		20		15		10		3		0

Conclusions

- ☺ First results for k_{eff} uncertainties for 7 benchmarks (out of 9)
- ☺ All sensitivities from MCNP for these 7 benchmarks
- ☺ Partial comparison between TMC and perturbation methods
- ☺ All covariances in 33 groups (cover files with BOXER format)

➪ See the report for all results

- ☹ Need MCNP models for ZPR6-7 ^{240}Pu and the ABR
- ☺ Spectral indexes will be done soon with the TMC method