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, May 2011

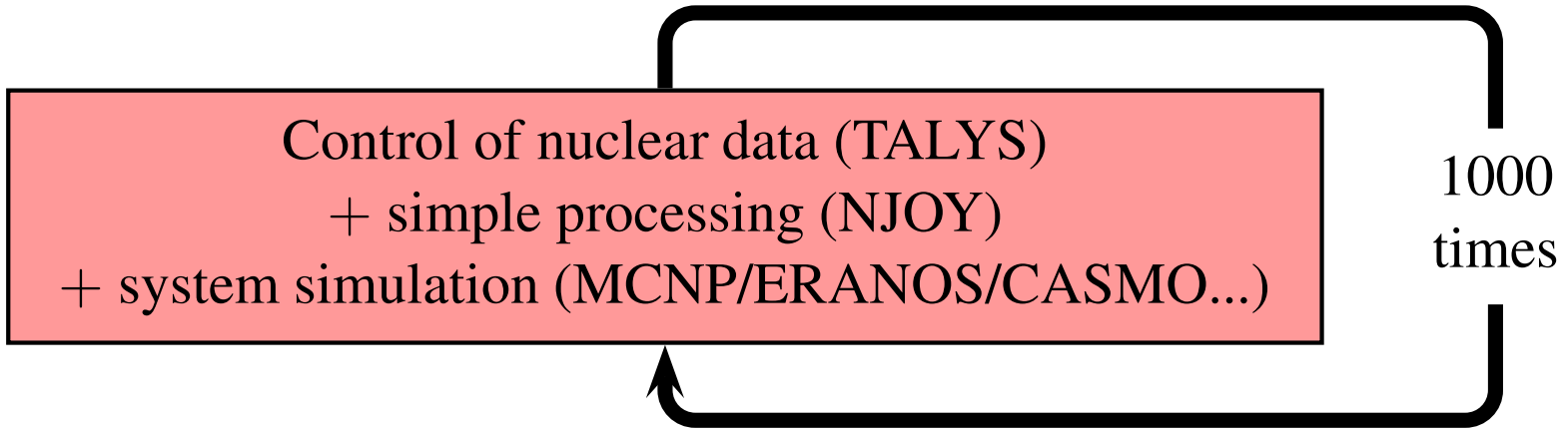
Contents

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 (in red are the new results compared to last meeting).

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)	X	X	X								
pmf2 (Jezebel-240)	X	X	X								
pmf6 (Flat-top)	X	X	X	/	X						
mcf1 (ZPR6-7)	X	X	X	/	X	X	/	X	X	/	
mcf2 (ZPR6-7 ^{240}Pu)	o	o	o	o	o	o	o	o	o	o	
ZPPR9	X	X	X	/	X	/	/	X	/	/	
JOYO	X	X	X	/	X	/	/	X	X	/	/
FBR	X	X	X		X	X	X	/	X	/	/
ABR	o	o	o	o	o	o	o	o	o	o	o

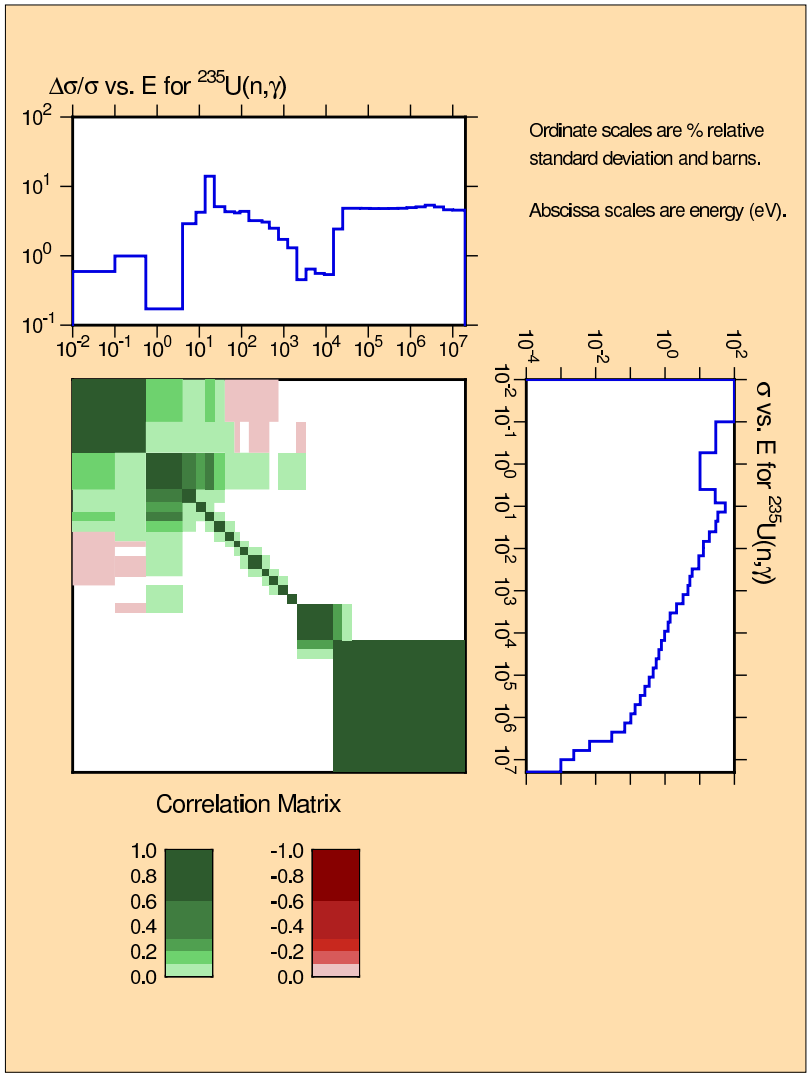
Legend:

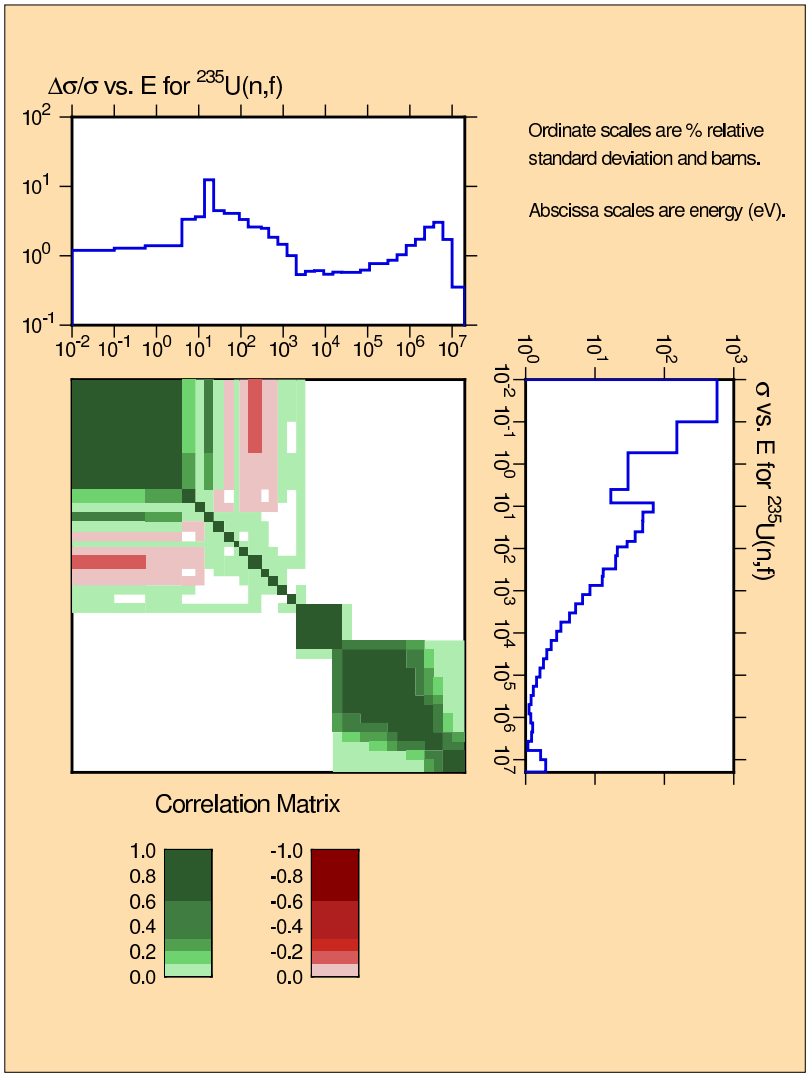
X: calculations finished

/: ongoing calculations

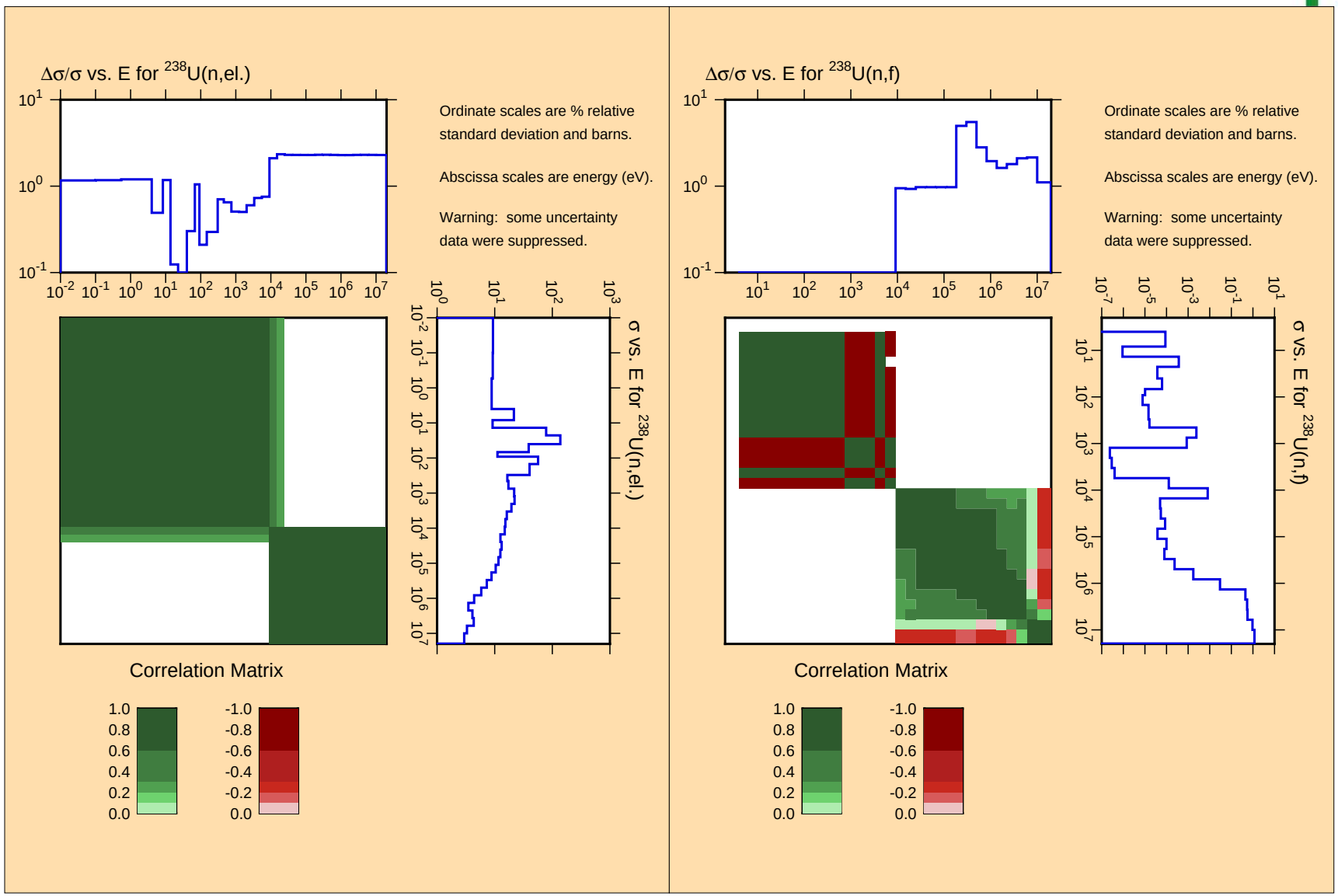
o: calculations not started (mcf2 model is being included)

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	150	130	15	10
MF1	440	-	30	-	< 20	-
(n,inl)	240	170	20	15	< 20	0
(n,el)	230	270	20	10	< 20	0
(n,γ)	120	140	20	5	< 20	1
(n,f)	840	780	155	130	10	10
MF4	30	-	20	-	< 20	-
MF5	50	-	20	-	< 20	-
MF6	20	-	20	-	< 20	-

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	140	113
MF1	400	-	370	-	10	-
(n,inl)	170	140	70	50	< 20	10
(n,el)	250	240	30	40	< 20	16
(n,γ)	100	100	30	30	10	10
(n,f)	720	660	730	640	140	110
MF4	20	-	20	-	10	-
MF5	50	-	30	-	< 20	-
MF6	50	-	30	-	10	-

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	140	80	30	6	380	660
MF1	460	-	20	-	10	-	260	-
(n,inl)	70	20	10	3	10	0	170	400
(n,el)	85	80	10	2	15	0	270	320
(n,γ)	190	180	15	6	10	0	235	290
(n,f)	680	530	130	80	15	6		260
MF4	25	-	10	-	10	-	$<$20	-
MF5	75	-	10	-	10	-	30	-
MF6	25	-	15	-	15	-	$<$20	-

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	240	220	50	30	760	1010		5
MF1	480	-	<20	-	<20	-	380	-		-
(n,inl)	30	16	<20	1	<20	0	150	380		0
(n,el)	15	7	<20	0	<20	2	70	100		0
(n,γ)	220	240	30	8	<20	10	720	830		2
(n,f)	600	530	210	210	50	30	100	140		5

	mcf1 ^{56}Fe		mcf1 ^{52}Cr		mcf1 ^{58}Ni		mcf1 ^{23}Na		mcf1 ^{16}O	
Total	40	85	40	160	50	6	55	23		40
MF1		-		-				-		-
(n,inl)		70		10		2		10		0
(n,el)		25		160		1		21		40

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	170	115	40	25	770	1000		3
MF1	480	-	30	-	35	-	430	-		-
(n,inl)	<20	15	15	5	25	0	220	380		0
(n,el)	<20	3	<20	1	20	0	75	180		0
(n,γ)	200	200	30	35	20	10	700	830		2
(n,f)	530	440	150	110	40	25	100	140		2

	zppr9 ^{56}Fe		zppr9 ^{52}Cr		zppr9 ^{58}Ni		zppr9 ^{23}Na		zppr9 ^{16}O	
Total	80	70	50	45	30	10	50	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	200	170	50	35	510	550		220	
MF1	280	-	30	-	25	-	350	-		-	
(n,inl)	15	2	30	2	30	0	30	100		10	
(n,el)	<30	15	5	2	35	1	120	130		15	
(n,γ)	170	170	50	30	<20	10	490	430		125	
(n,f)	330	300	190	160	50	30	100	110		170	

	Joyo ^{56}Fe		Joyo ^{52}Cr		Joyo ^{58}Ni		Joyo ^{23}Na		Joyo ^{16}O		Joy
Total	180	55	300	220	65	14	55	75		100	
(n,inl)		25		5		2	-	3		0	
(n,el)		45		220		12	55	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	480	295	280	230	810	840		0
MF1	420	-	40	-	60	-	430	-		
(n,inl)	35	10	40	12	35	12	160	300		0
(n,el)	15	20	5	2	25	5	30	30		0
(n,γ)	195	160	90	90	80	190	780	660		0
(n,f)	520	320	450	280	250	130	100	90		

	fbr ^{56}Fe		fbr ^{52}Cr		fbr ^{58}Ni		fbr ^{23}Na		fbr ^{16}O	
Total	75	50	45	30	105	15	60	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 preliminary 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 the ABR
- ☺ Spectral indexes will be done soon with the TMC method