Consistent uncertainties in criticality benchmarks

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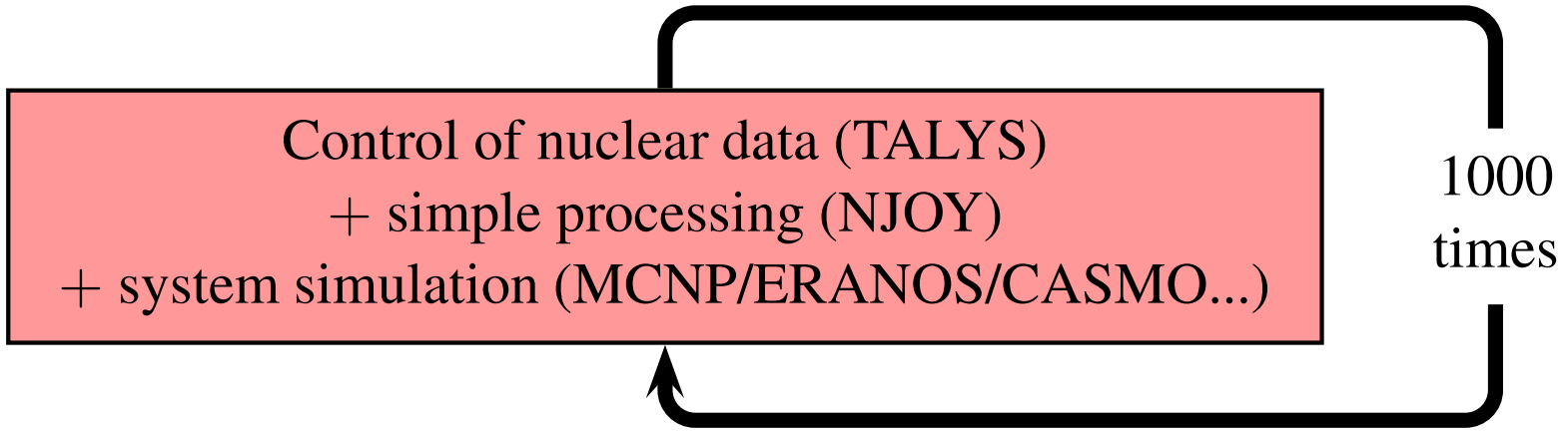
Contents

Goals:

① Obtain uncertainties for ANDES due to nuclear data uncertainties

② Systematic approach, reliable and reproducable

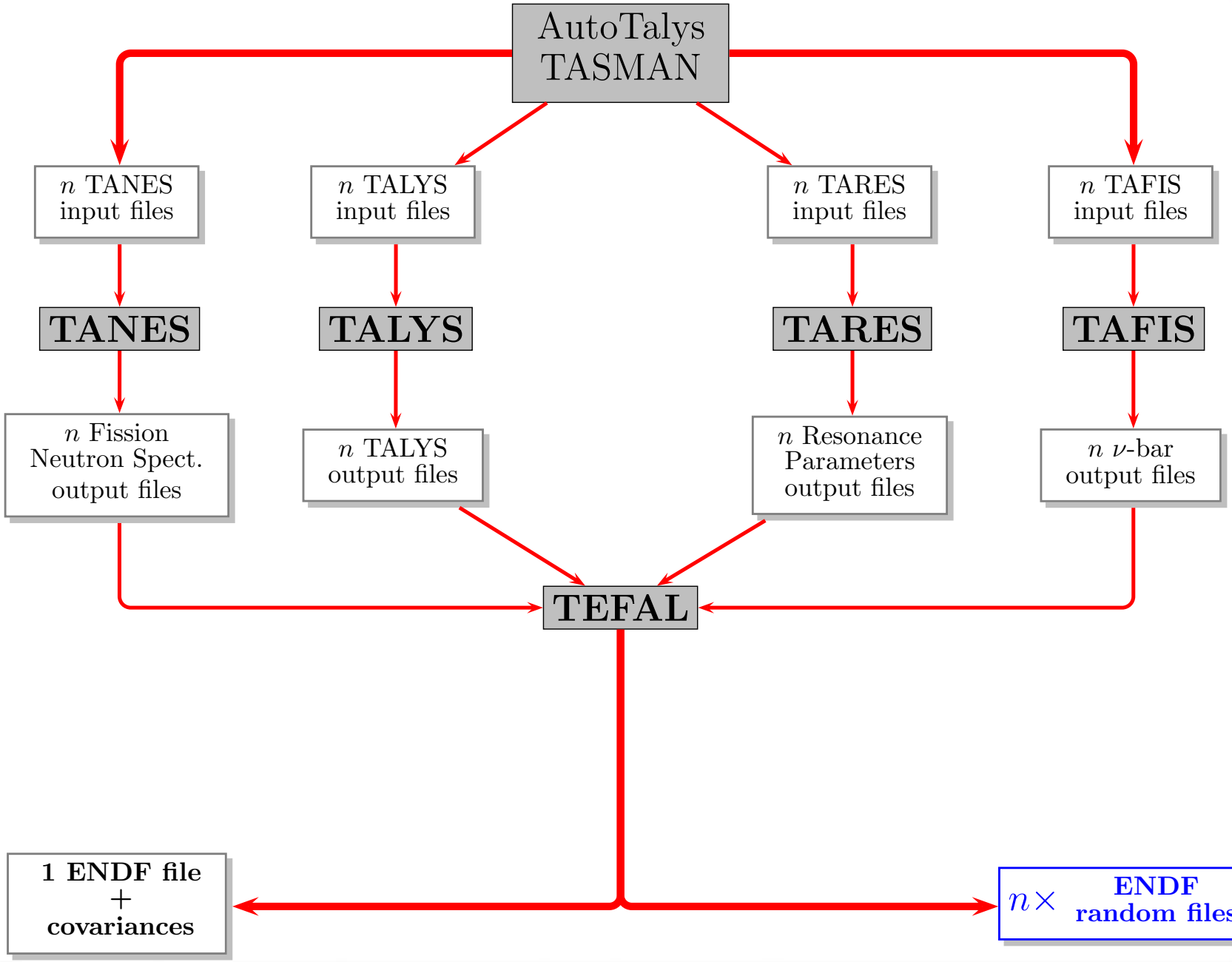
Solution (1): Total Monte Carlo



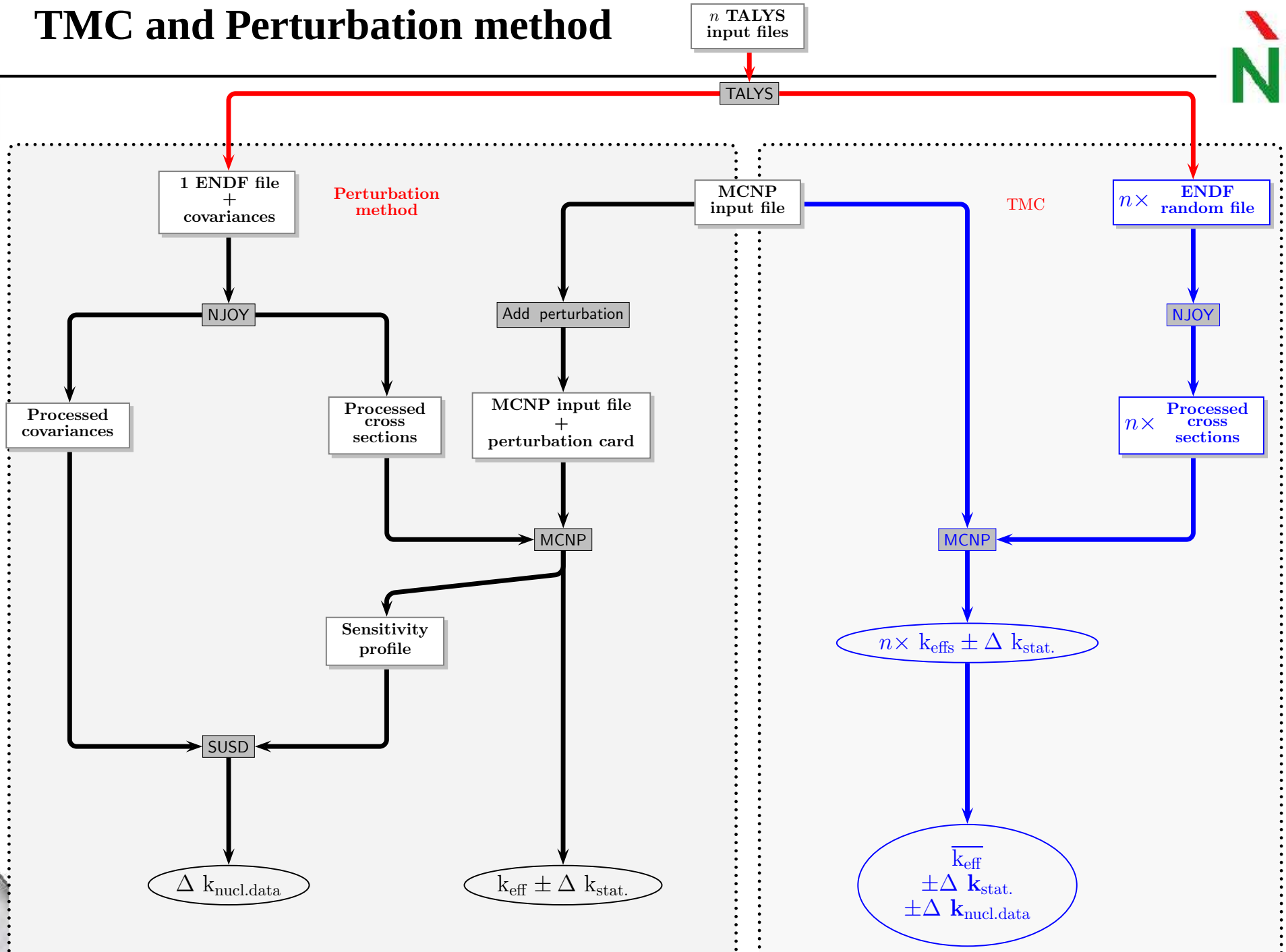
Solution (2): Perturbation method

$\Longrightarrow$MCNP+ Perturbation cards+covariance files

TMC and Perturbation method: File production



TMC and Perturbation method



Necessary software

Common to TMC and Perturbation methods:

- TALYS
- NJOY (ACE)
- MCNP

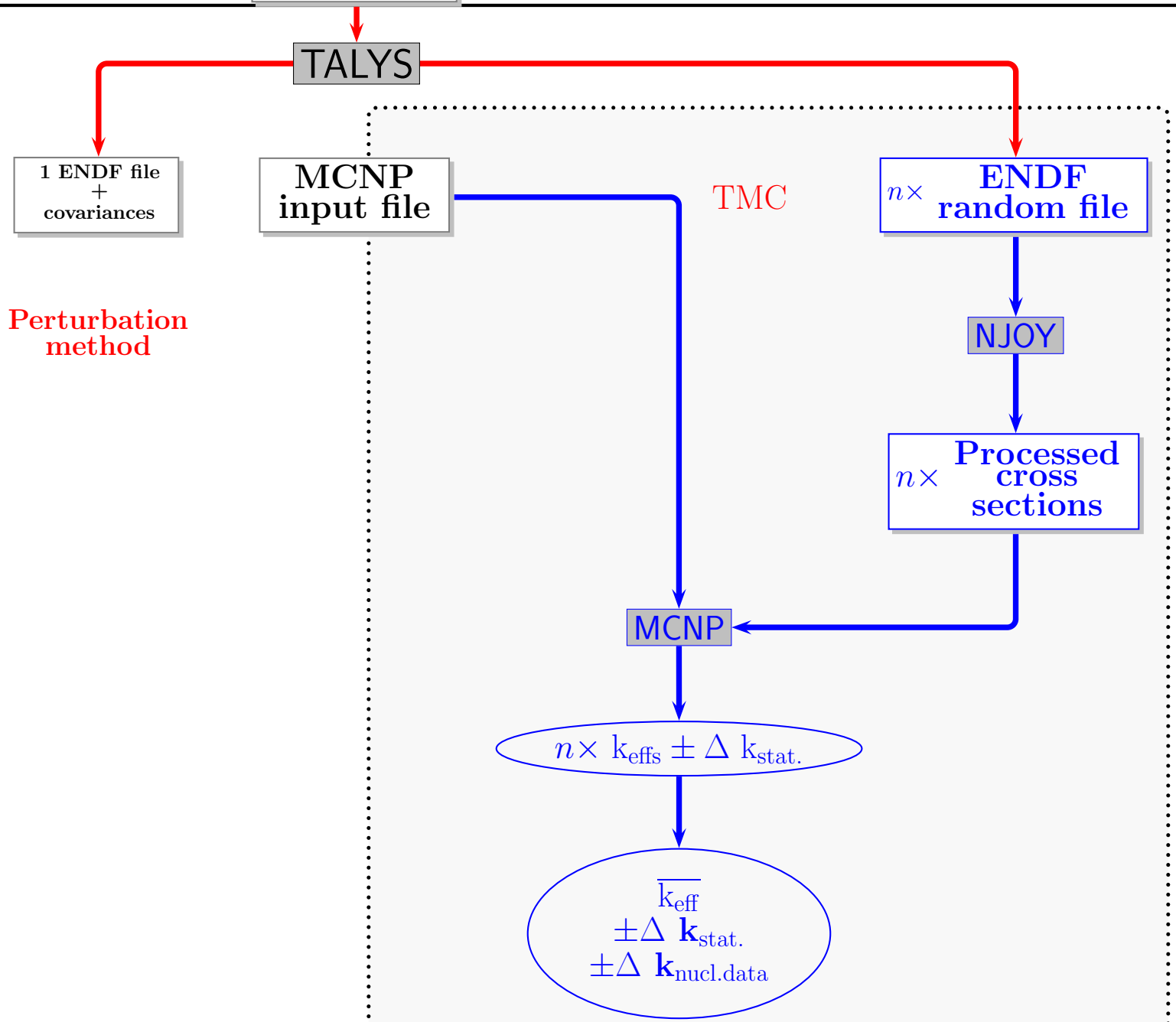
For the TMC method only:

- ∅

For the Perturbation method only:

- NJOY (ERRORR)/PUFF
- Add perturbation
- SUSD

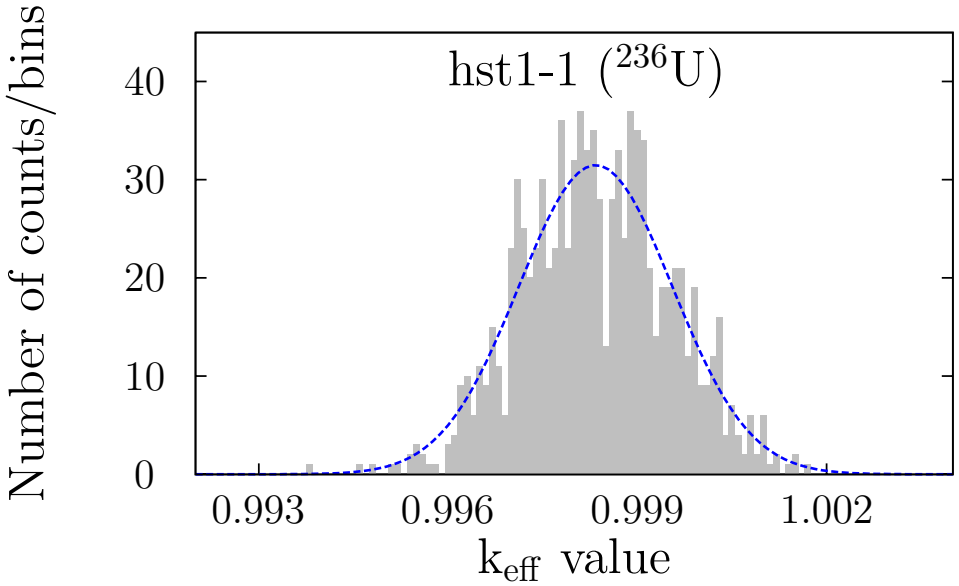
Idea: TALYS +(n TALYS input files) Monte Carlo = Total Monte Carlo



Total Monte Carlo: examples

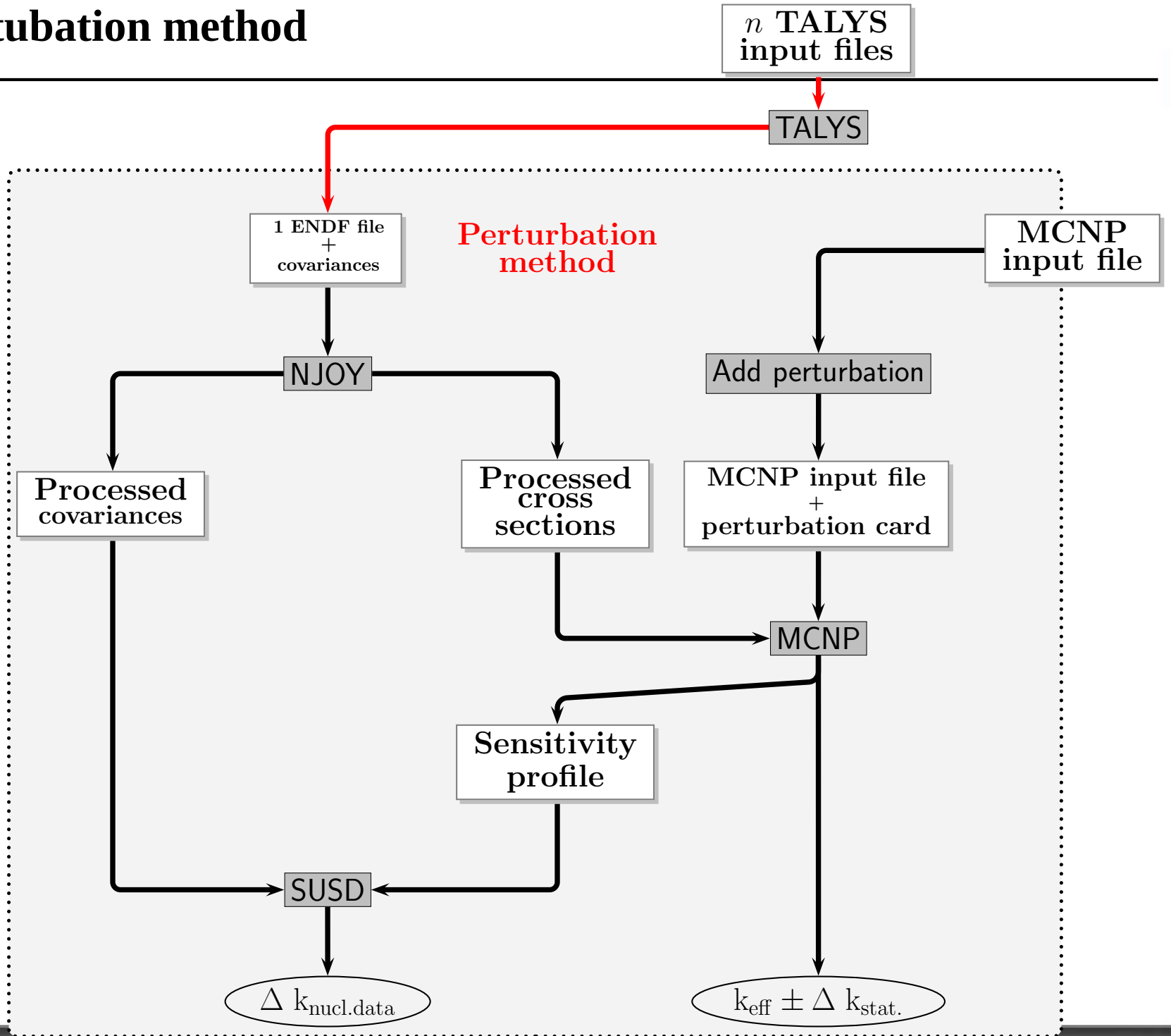
For each random ENDF file, the benchmark calculation is performed with MCNP. At the end of the *n* calculations, *n* different k_{eff} values are obtained. In the obtained probability distribution of k_{eff}, the standard deviation σ_{total} reflects two different effects:

$$\sigma^2_{total} = \sigma^2_{statistics} + \sigma^2_{nuclear\ data}. \quad (1)$$

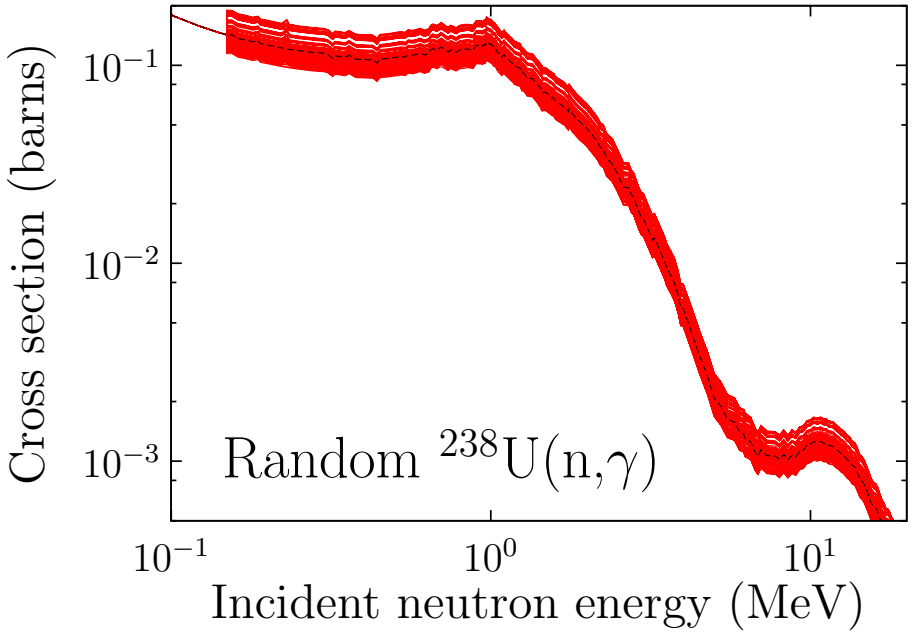


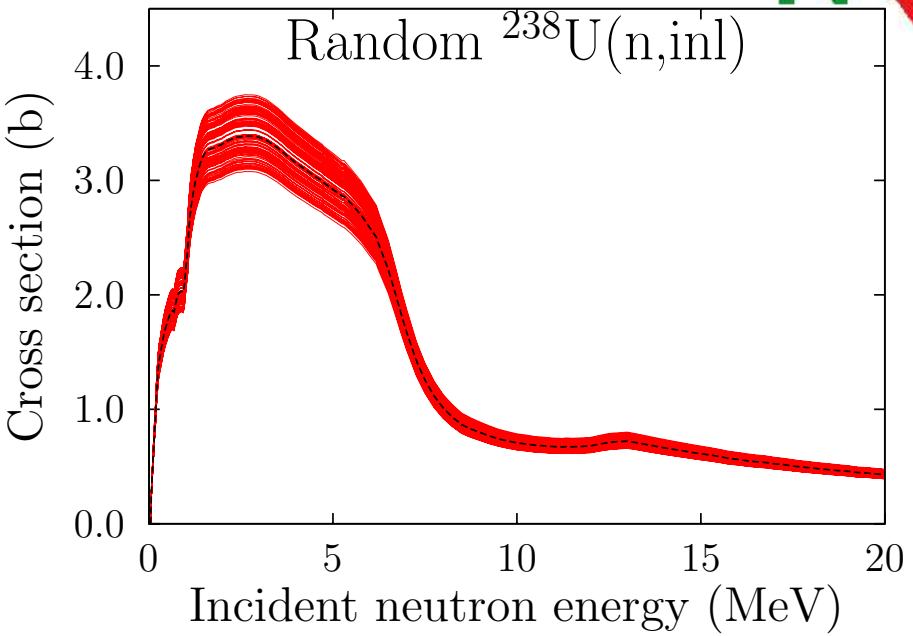
Each random file is completely different than another one: nu-bar ("*MF1*"), resonance parameters ("*MF2*"), cross sections ("*MF3*"), but also *MF4*, *MF5* and *MF6*.

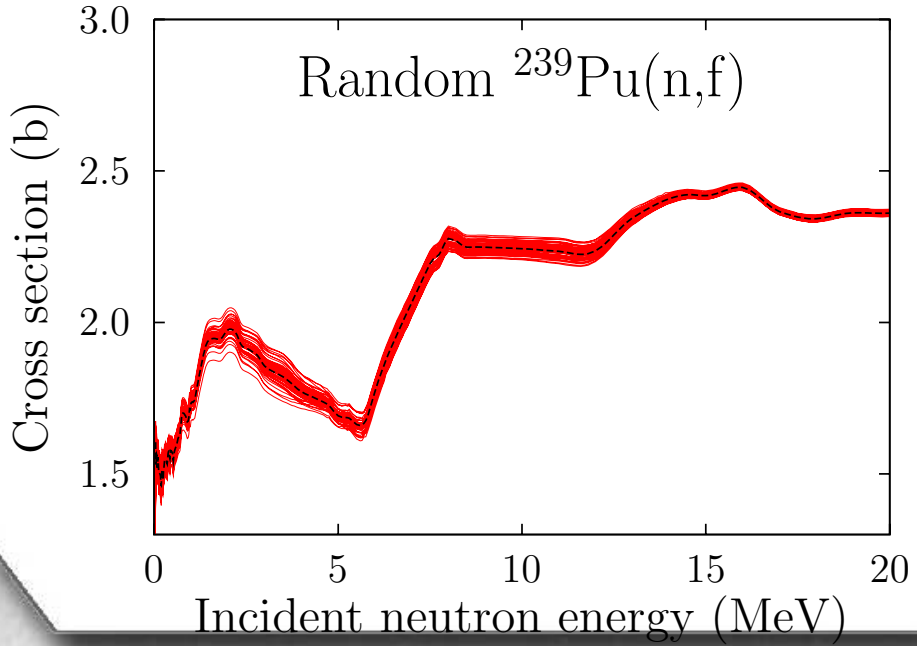
Pertubation method

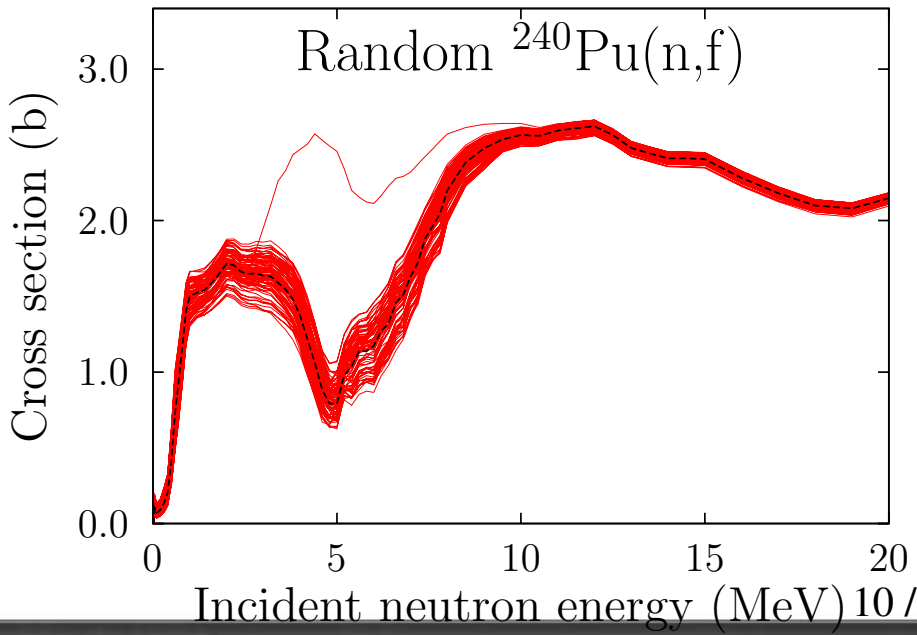


Nuclear data: ^{239}Pu and ^{238}U

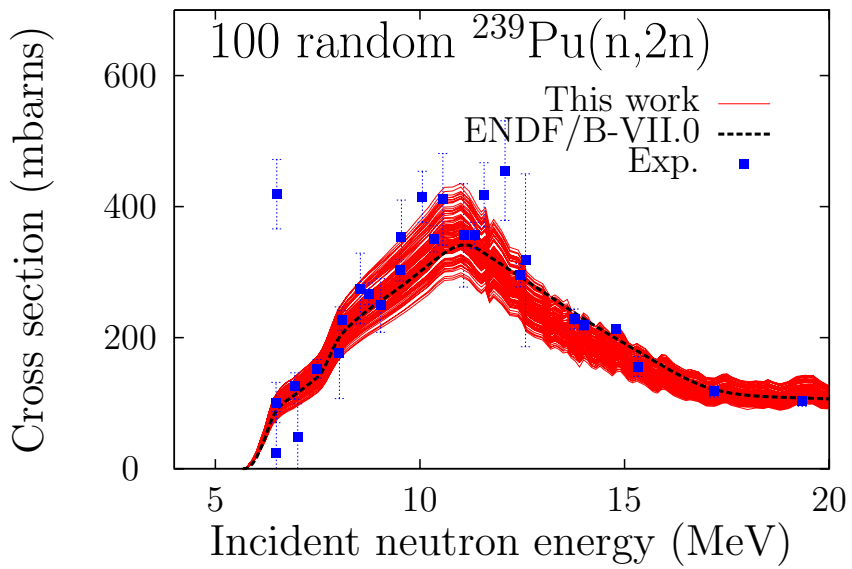


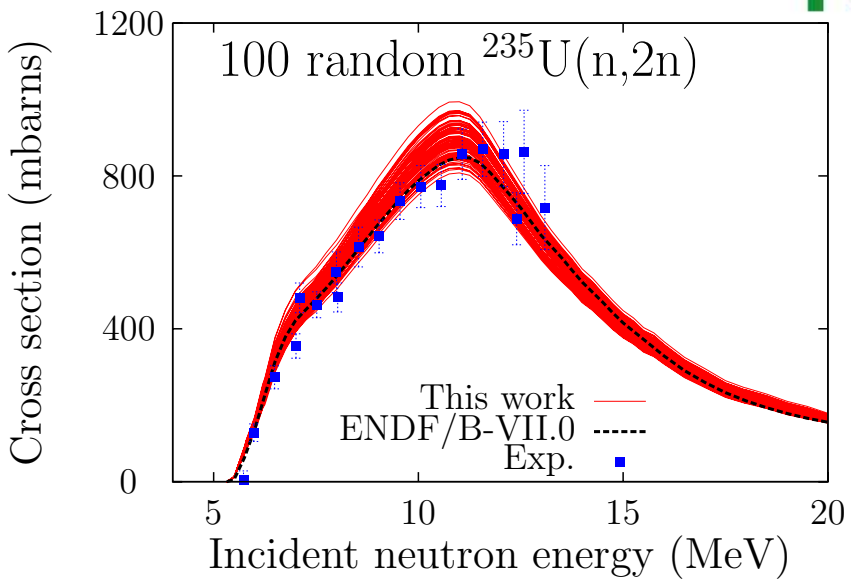


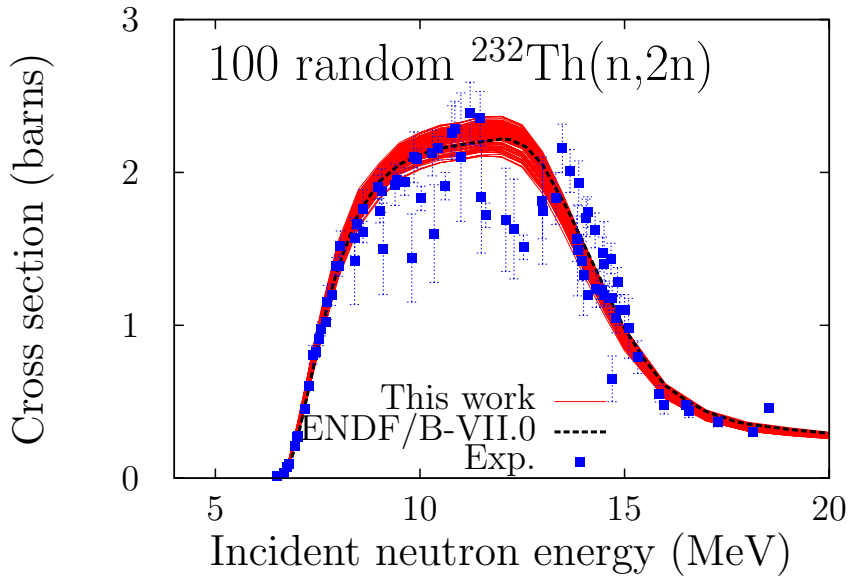


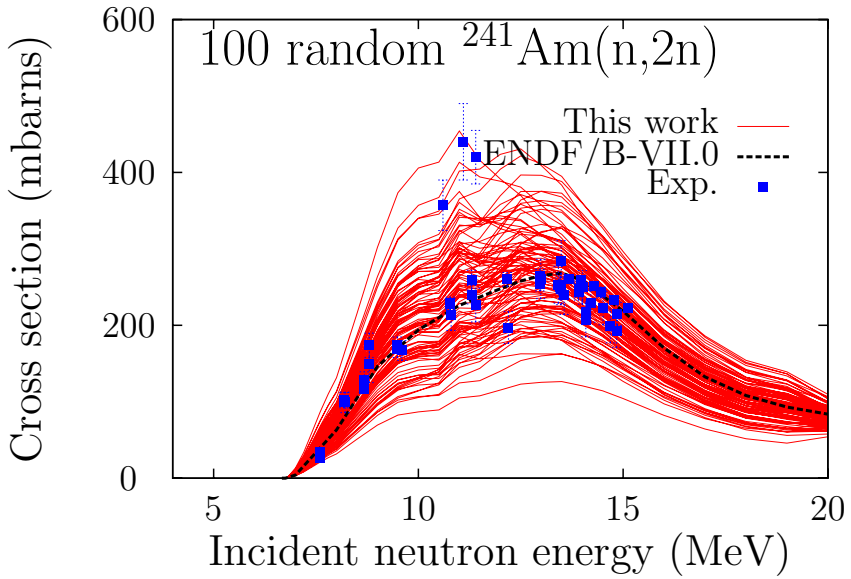


Nuclear data: examples on (n,2n) cross sections

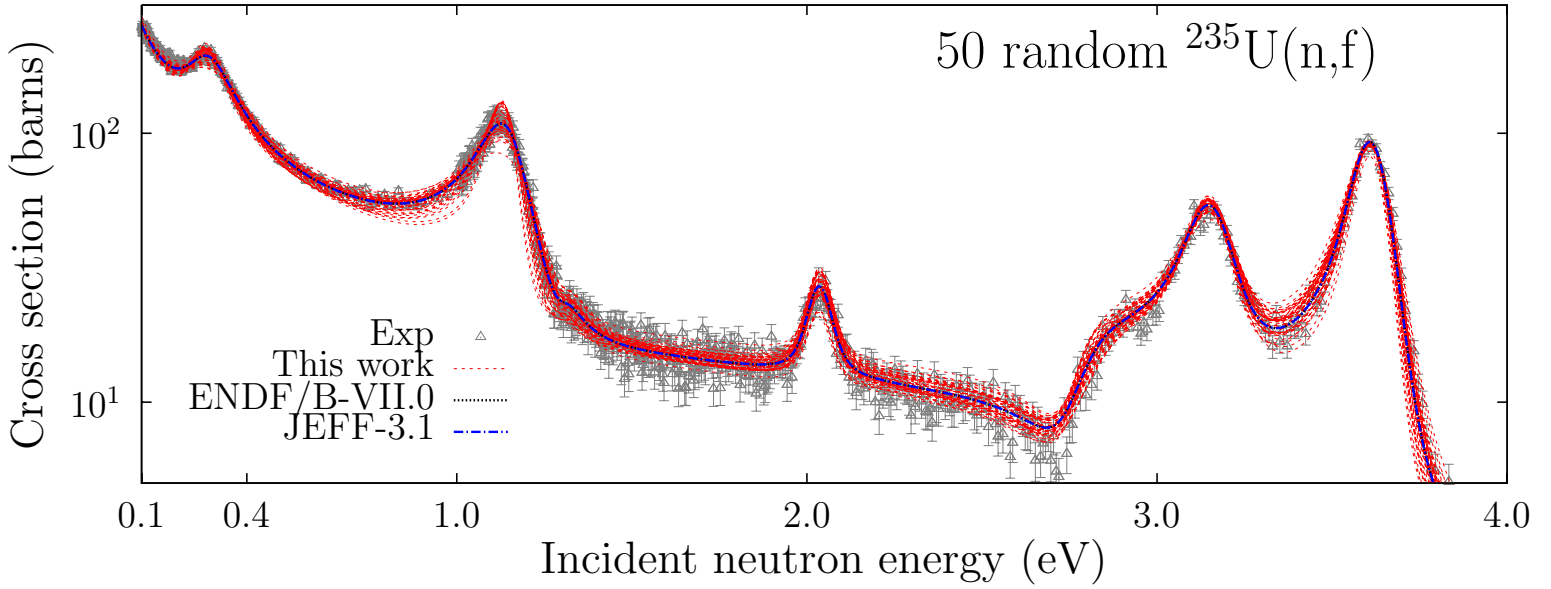


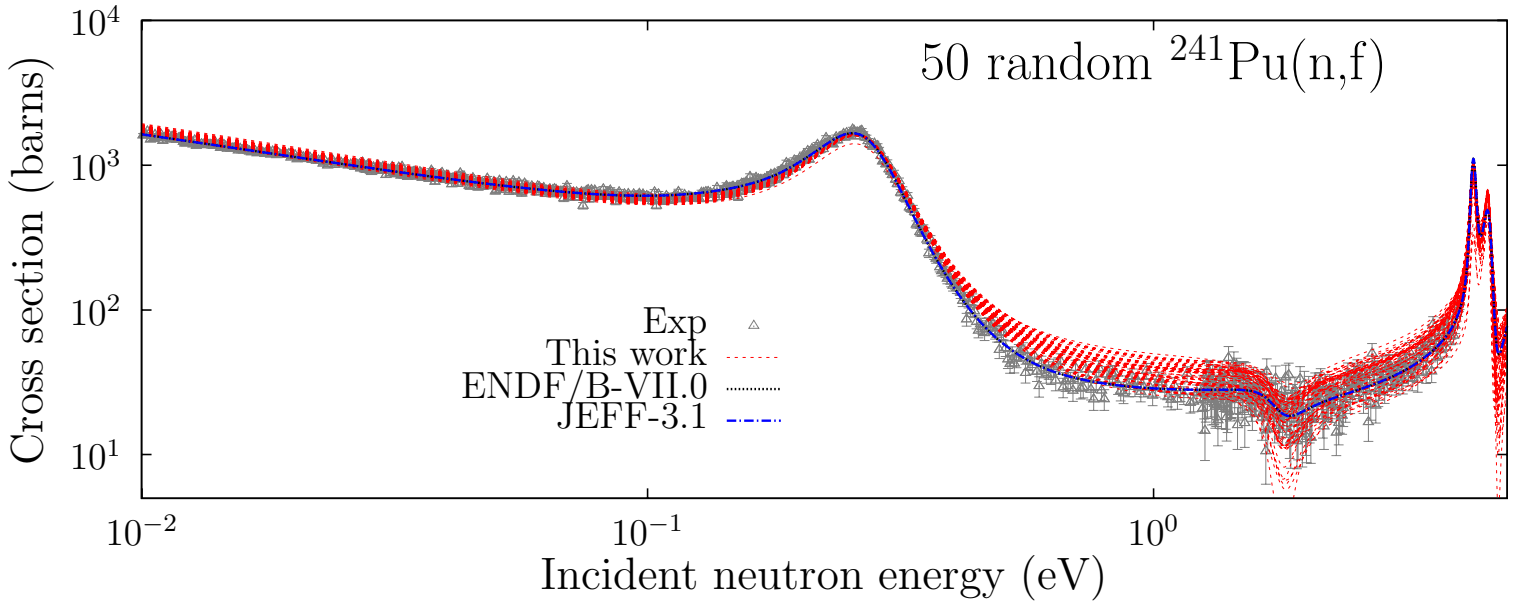




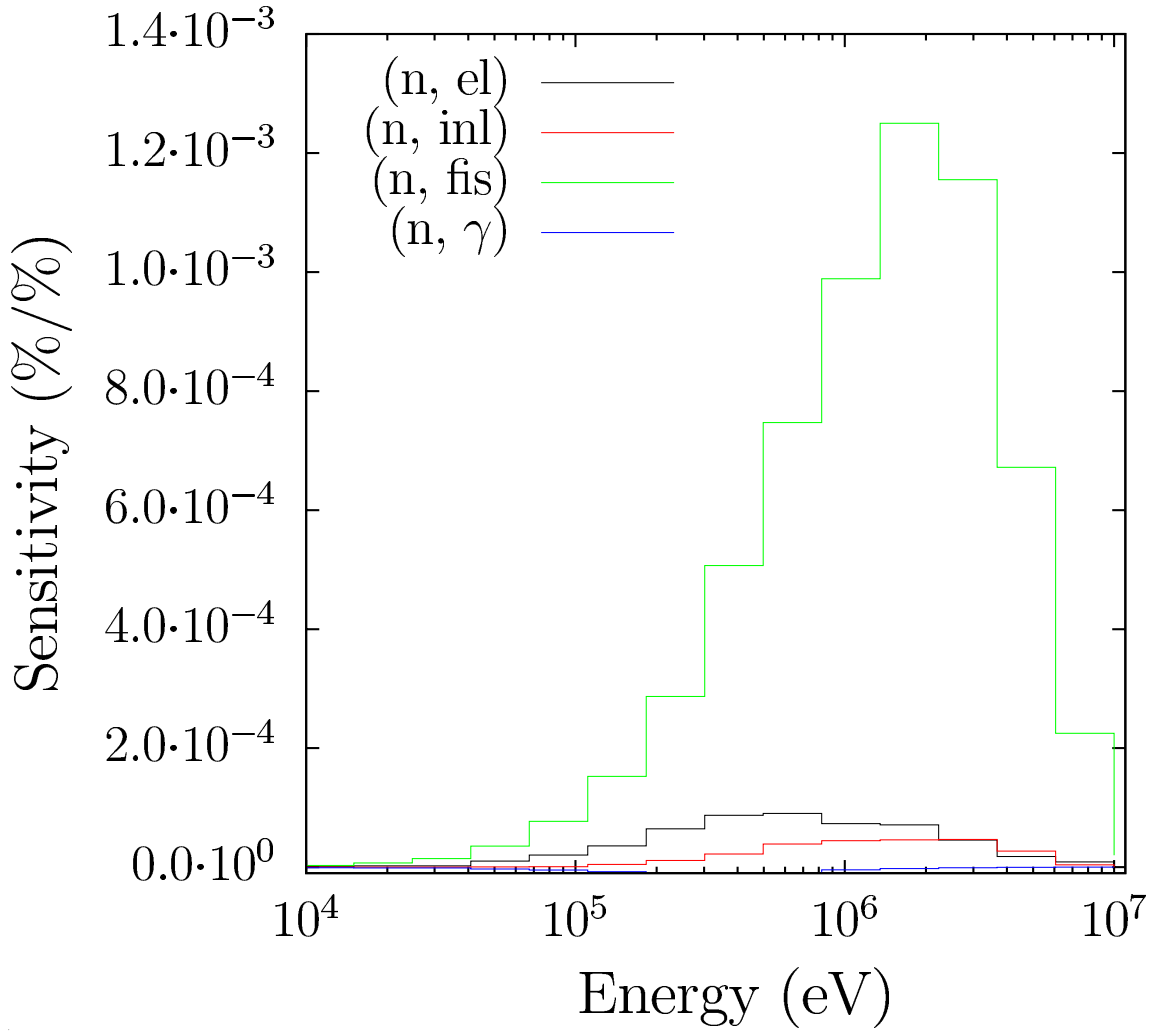


Nuclear data: examples in the resonance region





Example for sensitivity to ^{239}Pu cross section for pmf1 (Jezebel)



Results

Comparison TMC-Perturbation methods for a few k_{eff} benchmarks. The ratio in the last column is "TMC over Perturbation".

		Total Monte Carlo	Perturbation	Ratio
Benchmark	Isotopes	Uncertainty due to nuclear data (pcm)	Uncertainty due to nuclear data (pcm)	
pmf1	^{239}Pu	1000	860	1.16
pmf2	^{239}Pu	840	720	1.16
pmf2	^{240}Pu	790	650	1.21

Results: Details of the TMC-Perturbation methods for ^{239,240}Pu k_{eff} benchmarks

	pmf2 ^{239}Pu			pmf2 ^{240}Pu	
	Δk_{eff} (pcm)			Δk_{eff} (pcm)	
	TMC	Perturbation		TMC	Perturbation
Total	840	720		790	650
MF1	400	-		370	-
(n,inl)	170	140		70	50
(n,el)	250	240		30	40
(n,γ)	100	100		30	30
(n,f)	720	660		730	640
MF4	20	-		20	-
MF5	50	-		30	-
MF6	50	-		30	-

Plans for ANDES WP 3

- Uncertainty and sensitivity analysis on a large set of criticality benchmarks
  - Thermal and fast benchmarks
  - Monte Carlo and perturbation methods
  - Use libraries from WP2
- Investigate the impact of improved uncertainty methods from WP2 (UMC)