Nuclear data uncertainty propagation for a Sodium Fast Reactor

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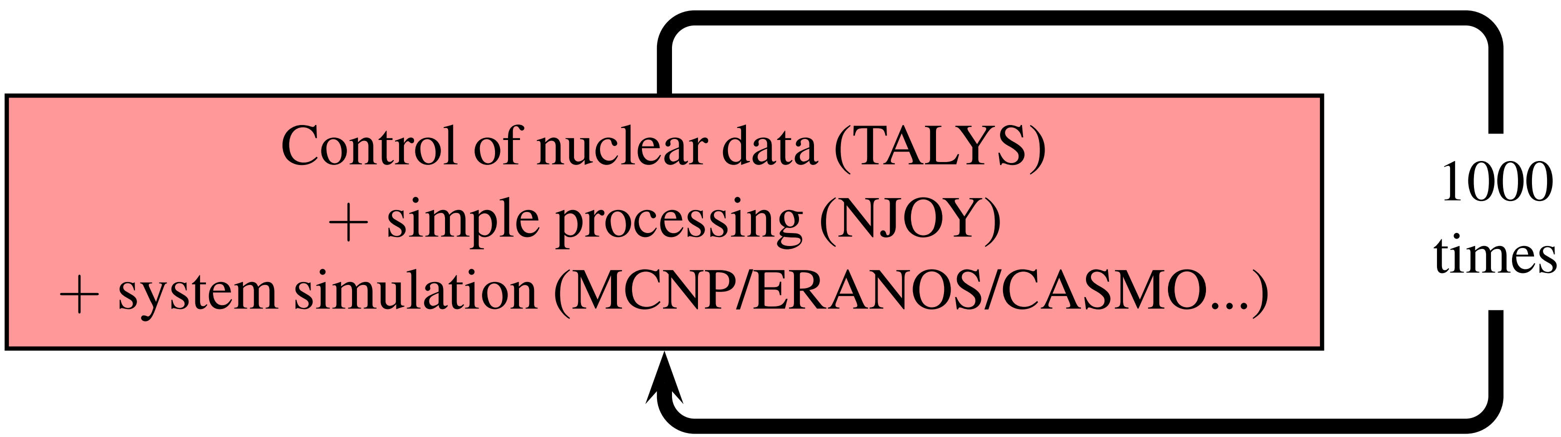
Goals:

① Obtain uncertainties on an SFR model due to nuclear data uncertainties

② Systematic approach, reliable and reproducable

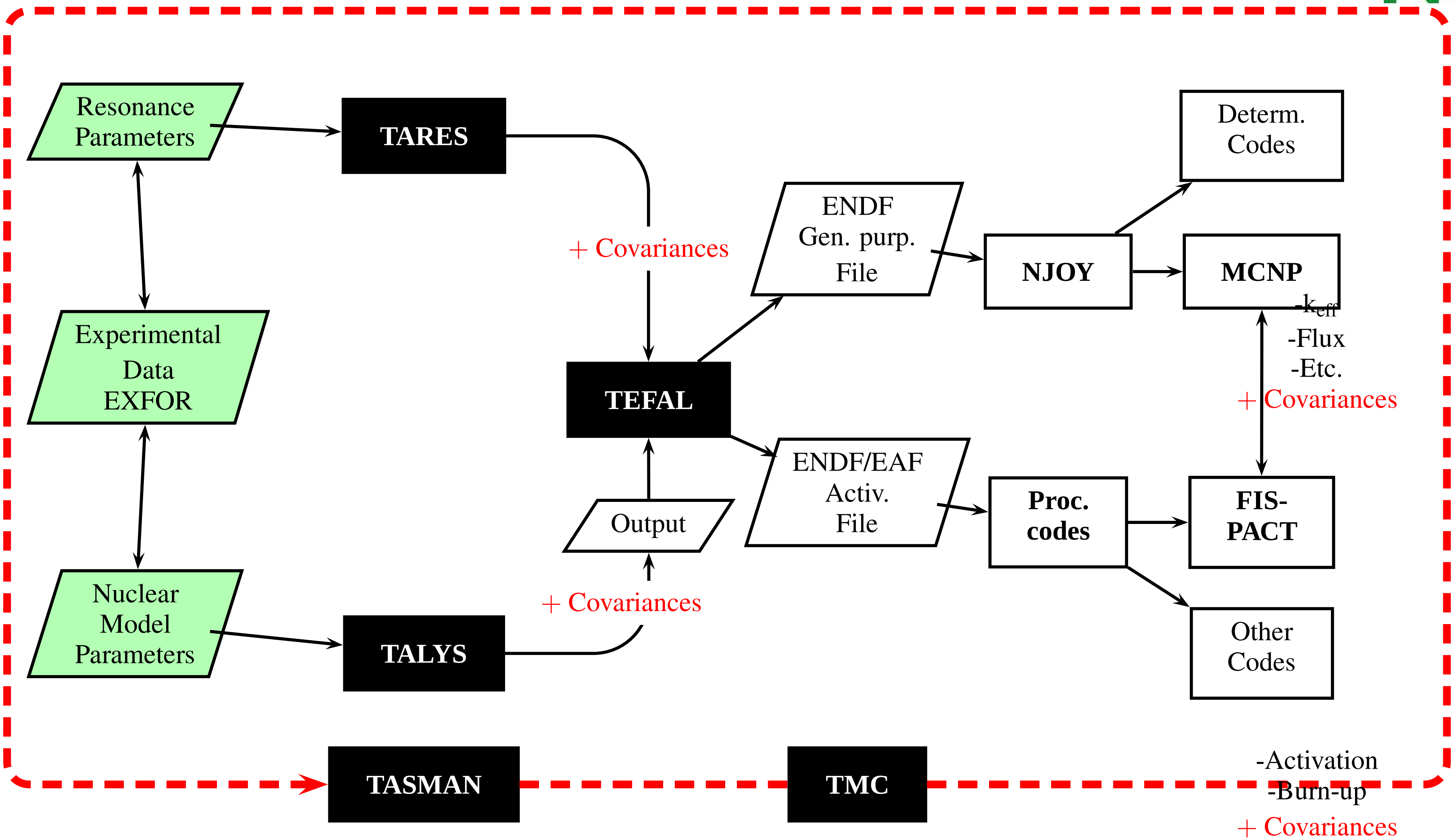
Solution (1): Total Monte Carlo



Solution (2): Perturbation method

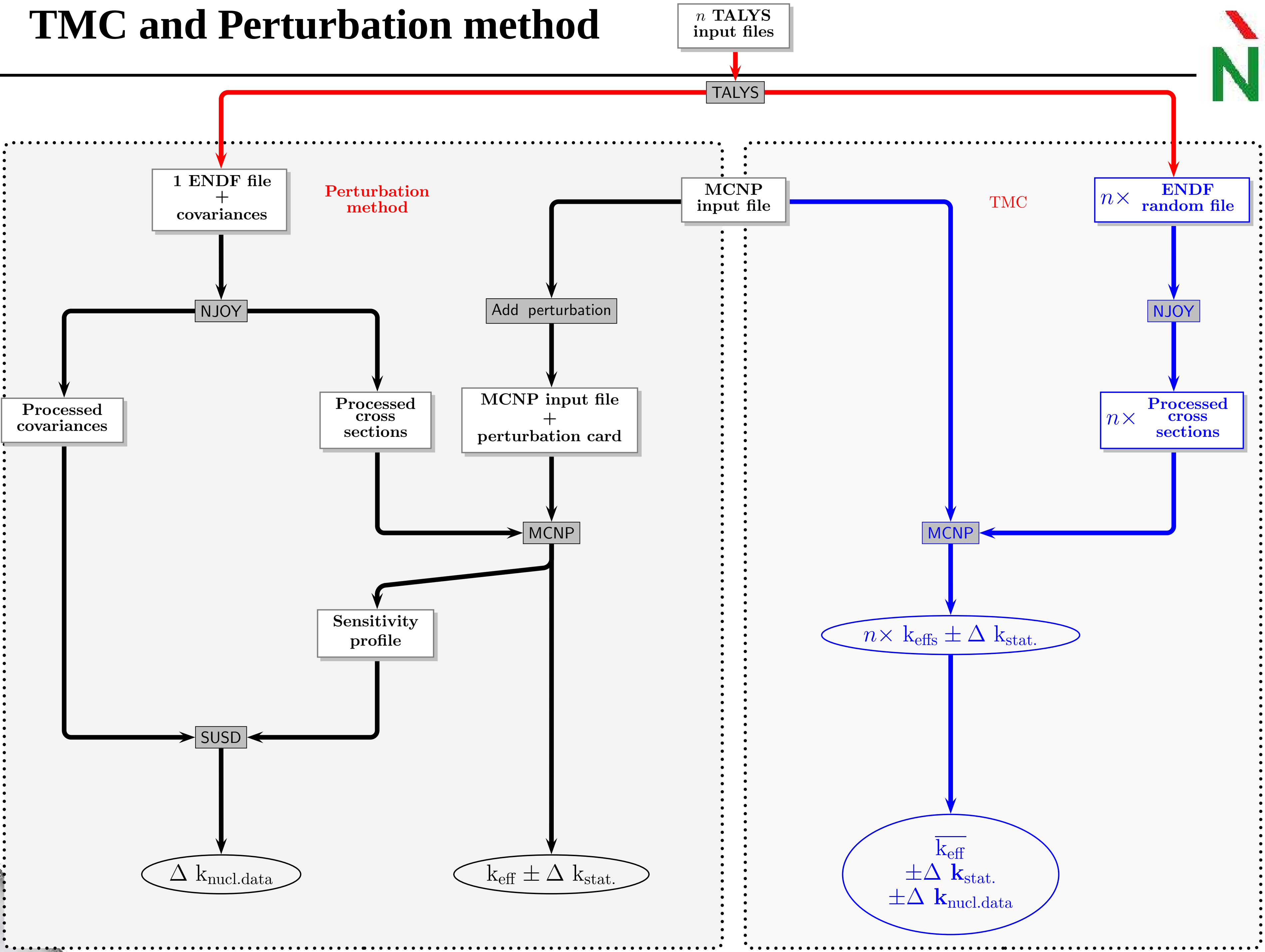
$\Longrightarrow$MCNP+ Perturbation cards

Concept: TALYS + Monte Carlo = Total Monte Carlo



Monte Carlo: 1000 runs of all codes

TMC and Perturbation method

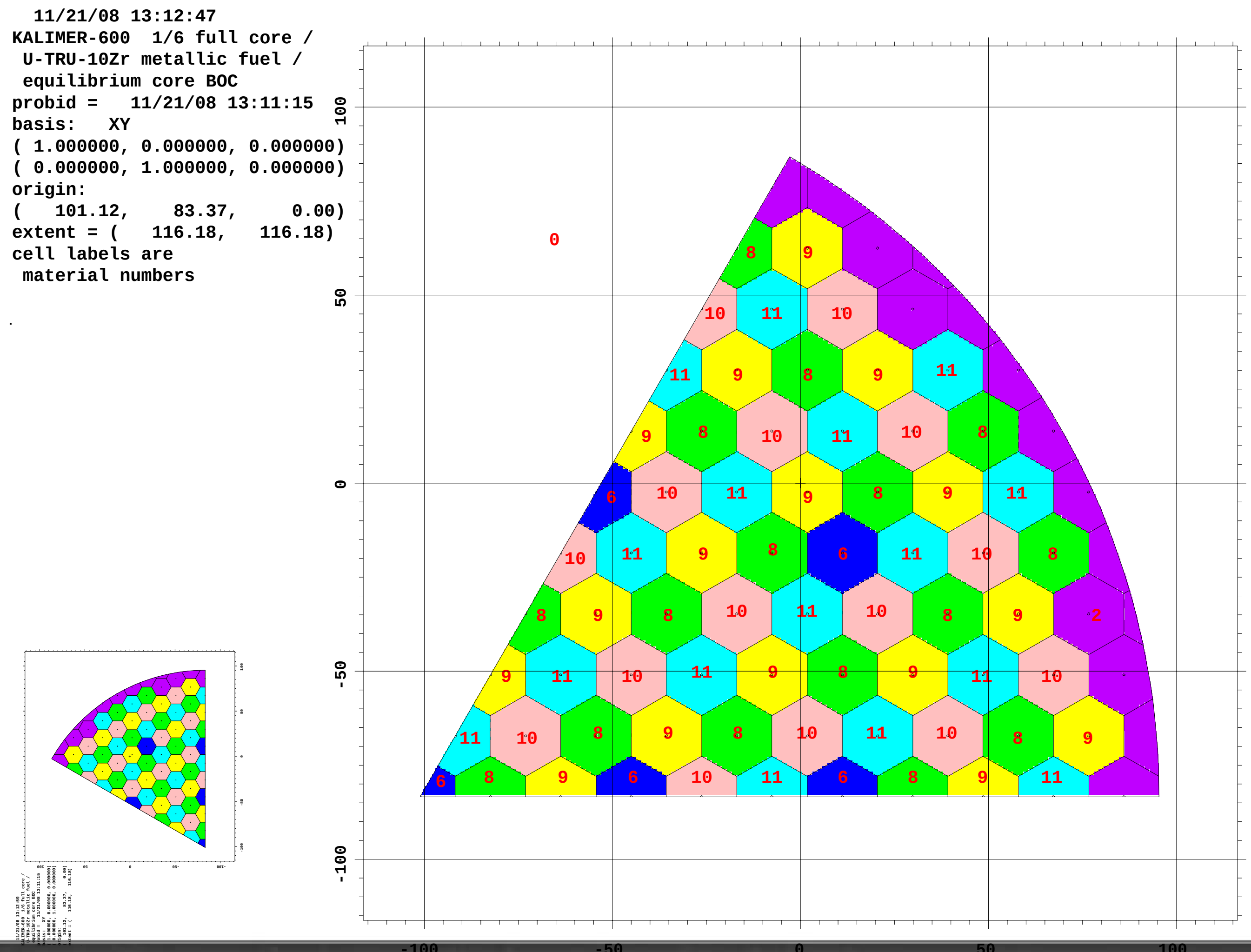


Kalimer model and MCNP

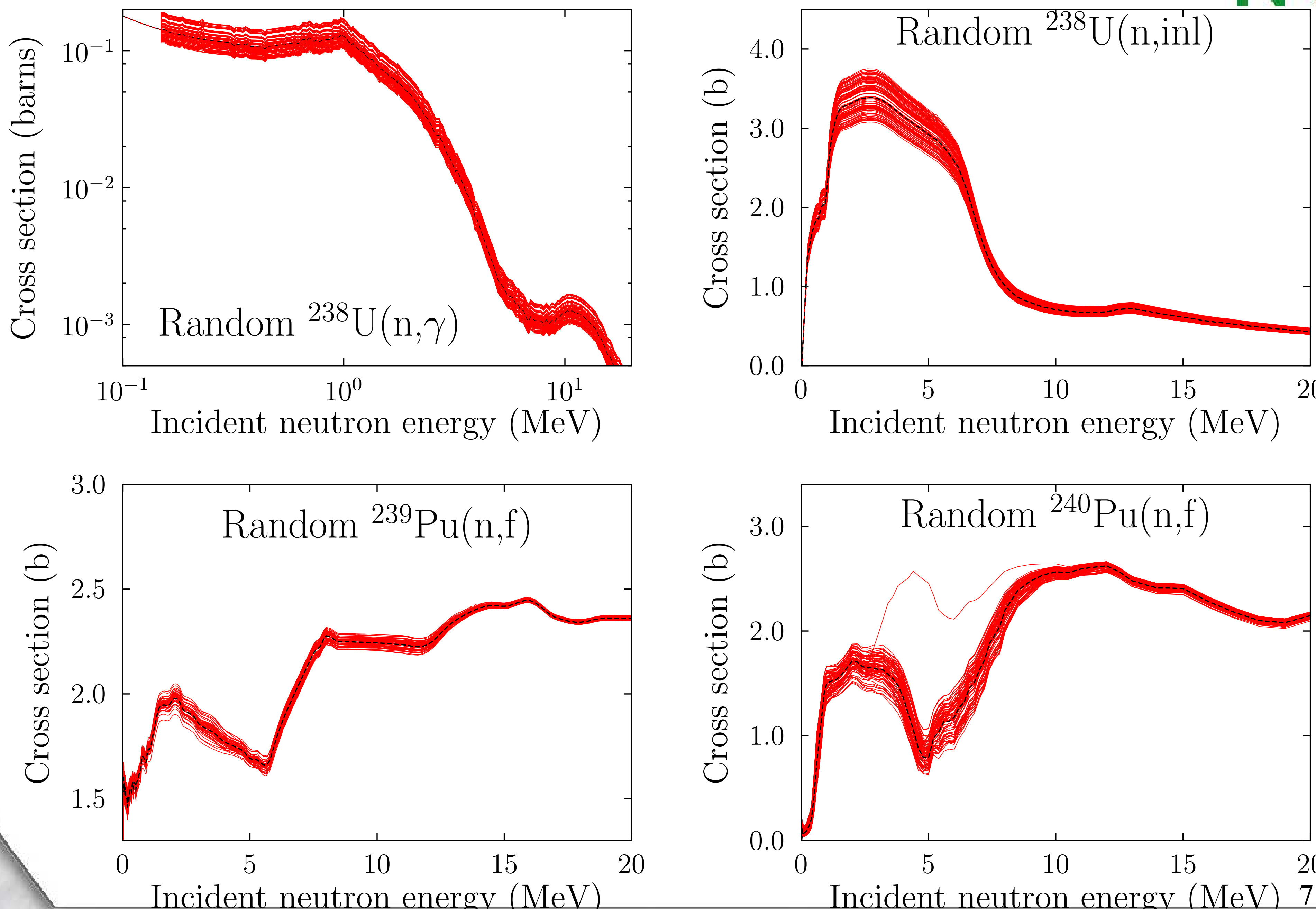
Simplified full core model of the Kalimer-600 (one single fuel zone for fresh fuel) & Equilibrium reactor core with 4-batches,

Fuel type: metal alloy U-TRU-10 %Zr, isotopic vector provided by KAERI.

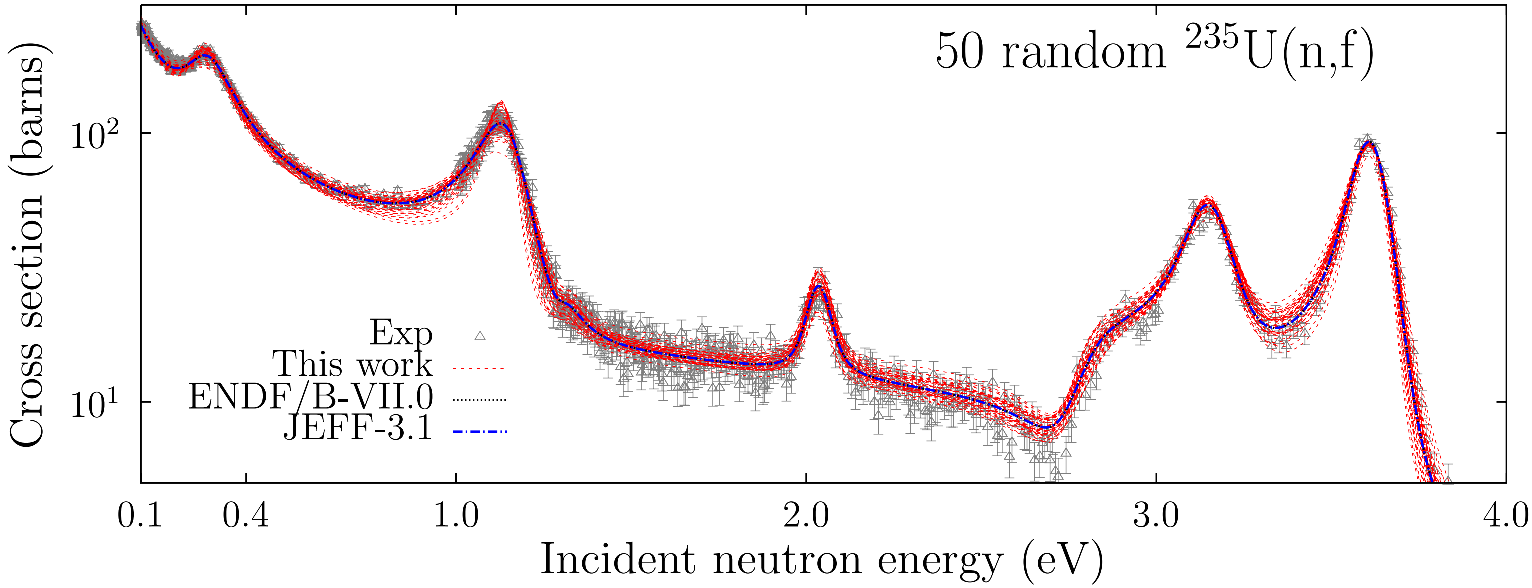
^{238}U: 83 %, ^{239}Pu: 10 %, ^{240}Pu: 5 %, ^{241}Pu: 1 %

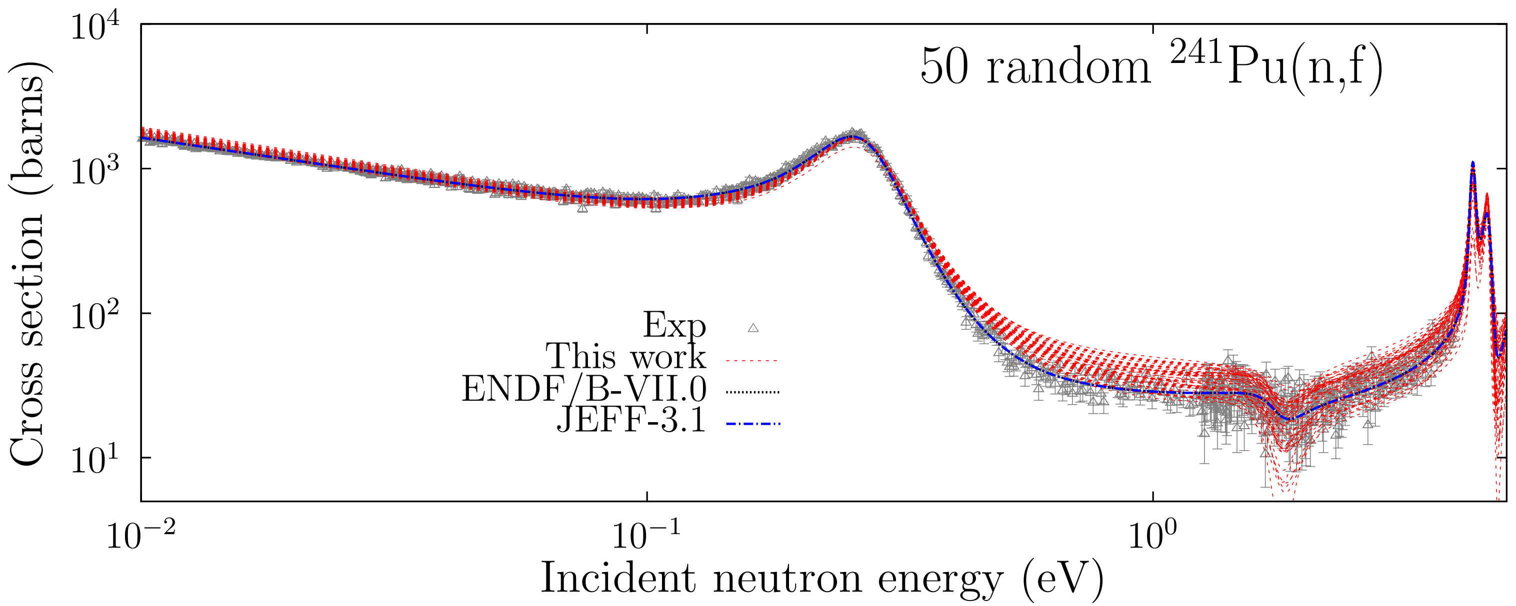


Nuclear data: ^{239}Pu and ^{238}U

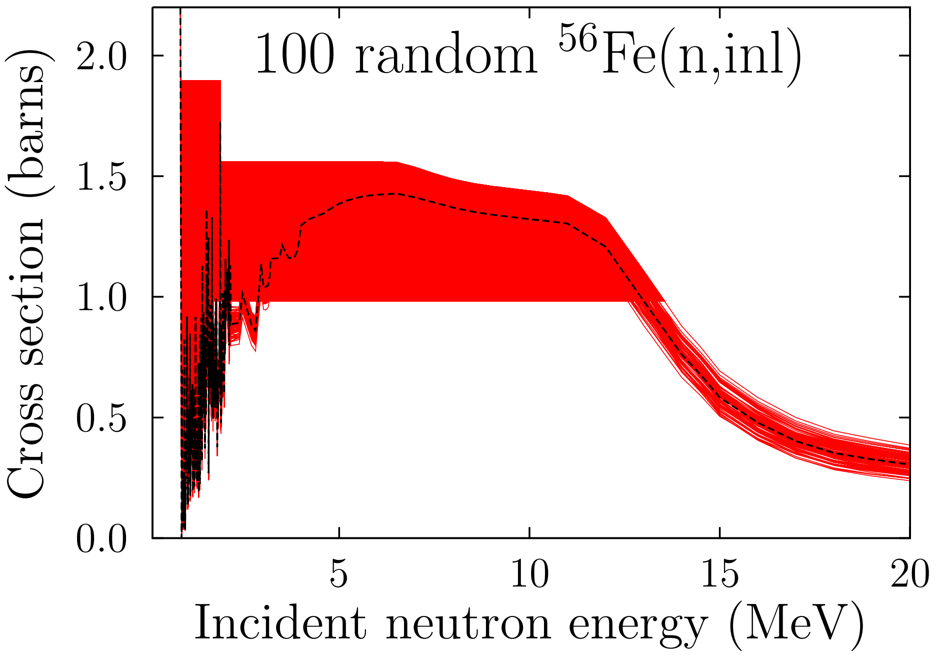


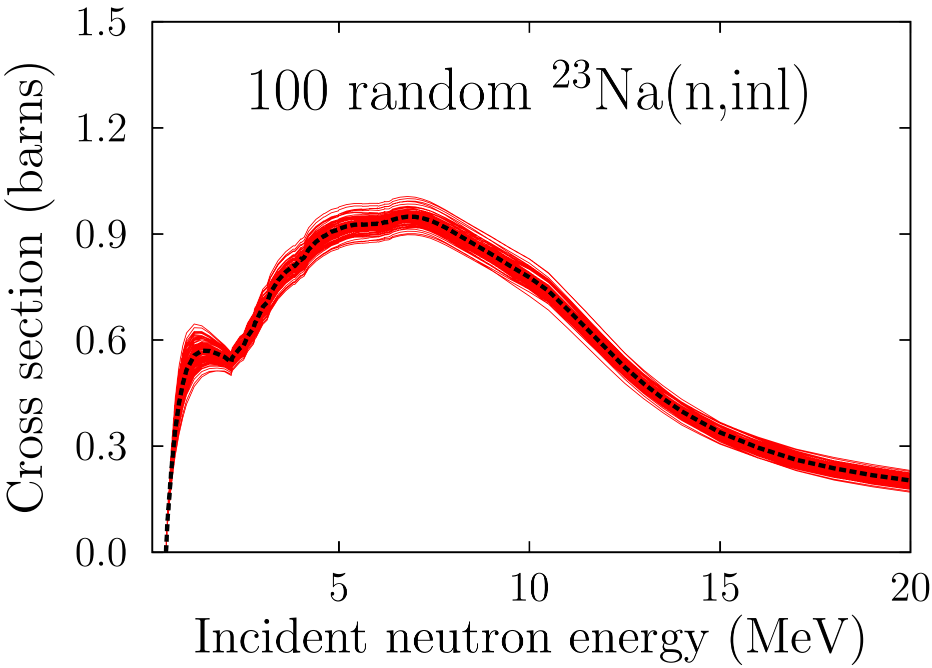
Nuclear data: examples in the resonance region





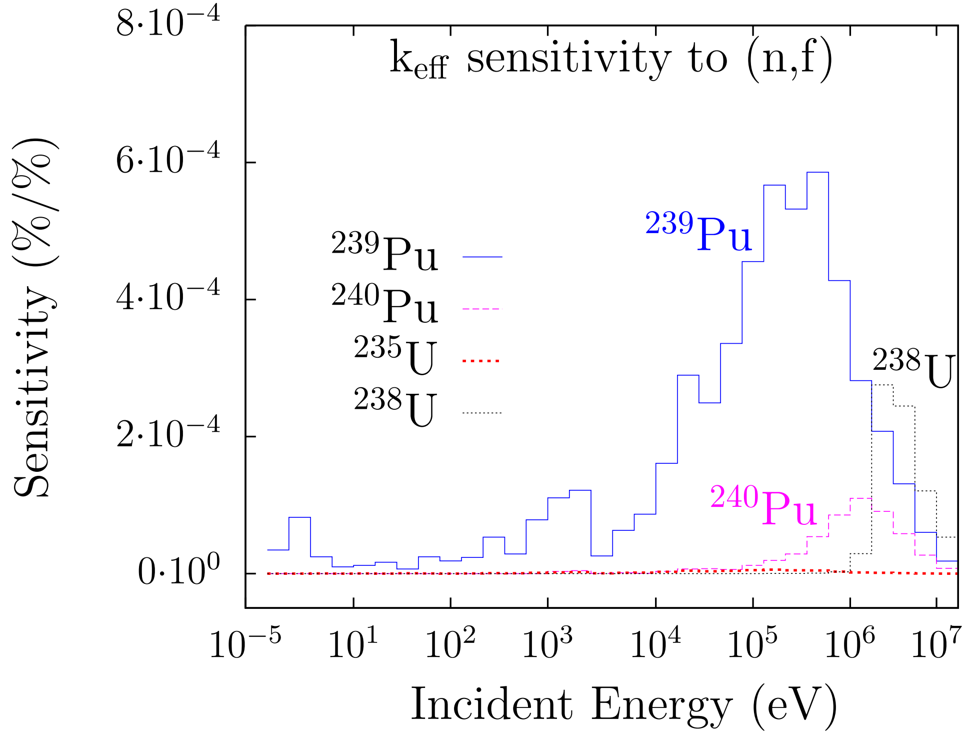
Nuclear data: ^{56}Fe and ^{23}Na

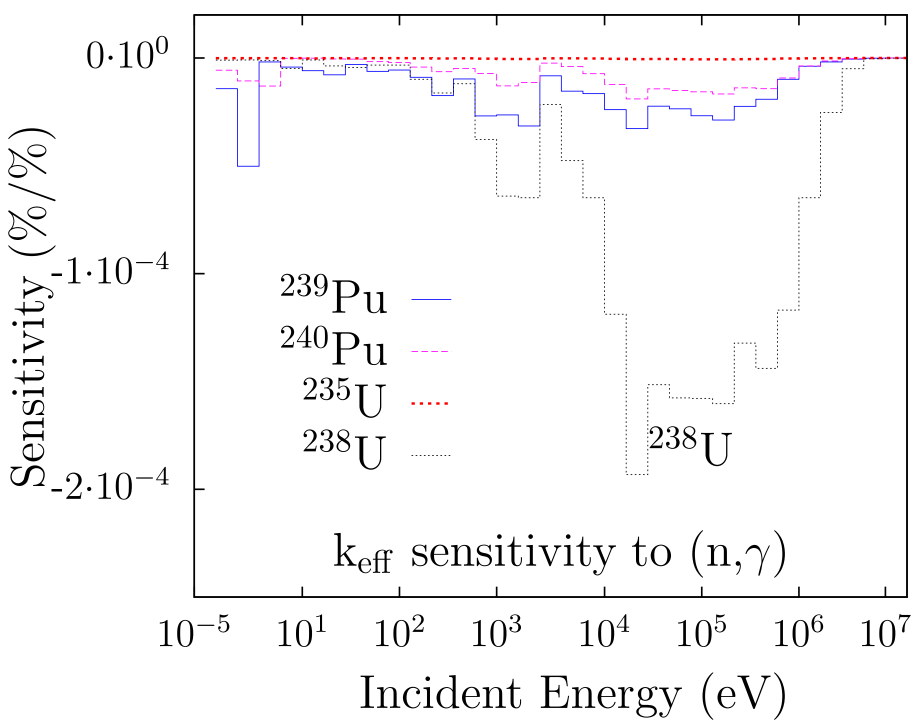




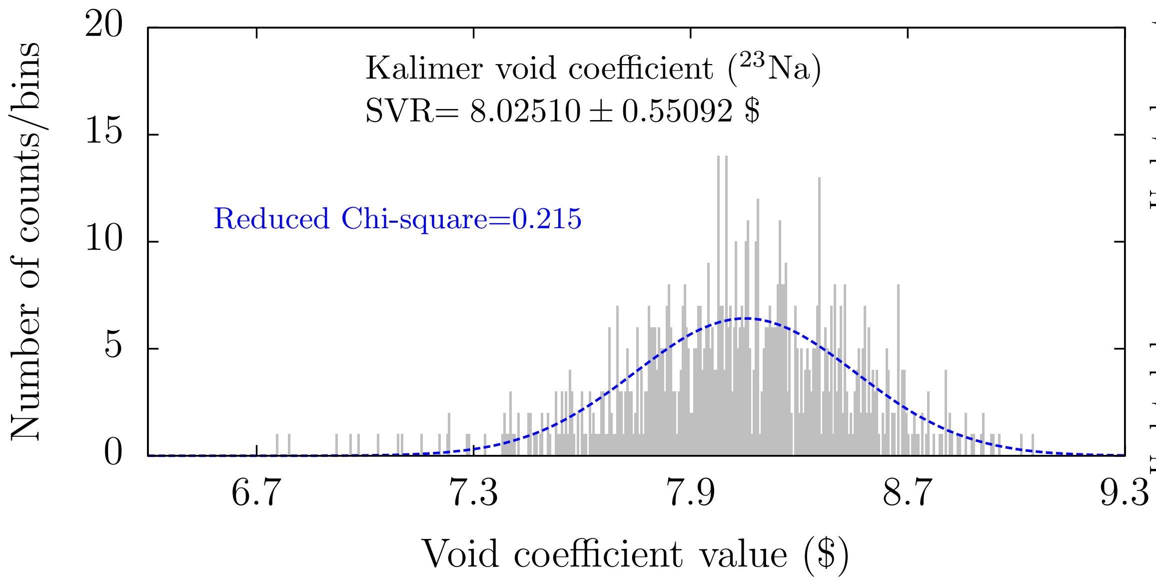
Sensitivities to k_{eff}

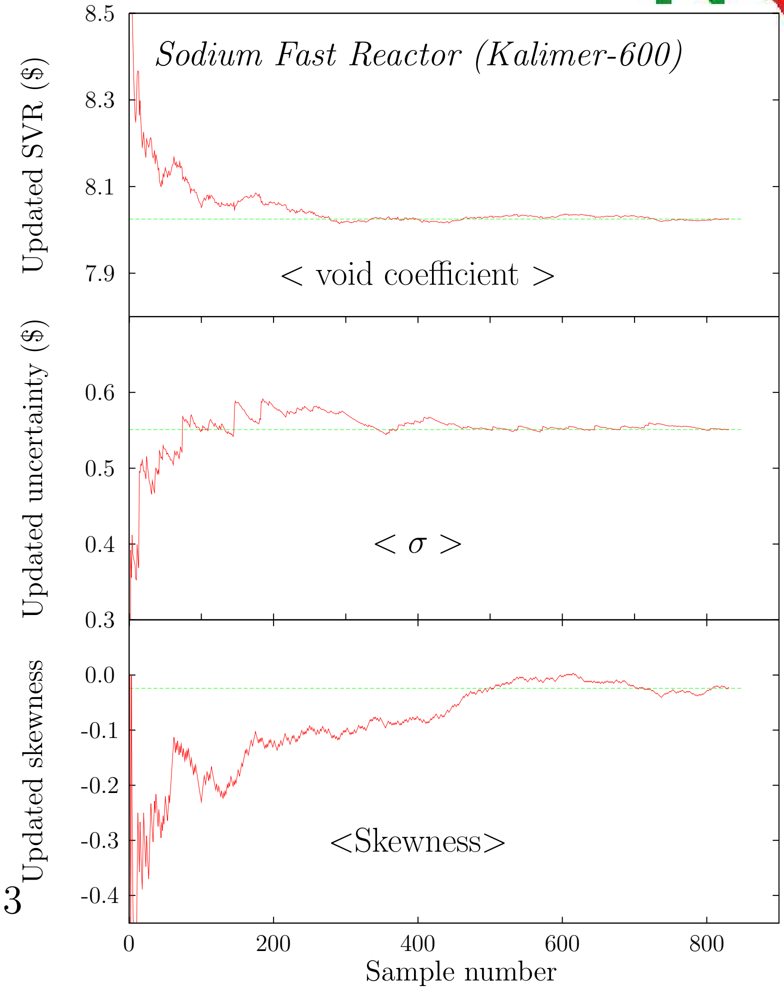
Main components: ^{23}Na, ^{56}Fe, Zr, ^{238}U, ^{239,240}Pu
Most sensitive reactions: ^{239}Pu(n,f) and ^{238}U(n,γ)





Results on void coefficient $\mathrm{SVR} = \frac{k_2 - k_1}{k_1 k_2} \frac{1}{\beta_{eff}}$





Uncertainty on the void coefficient due to nuclear data using the TMC and perturbation methods

Isotope	Varied Nuclear data	Uncertainty on SVR	Method
^{23}Na	all	$\simeq 6$ %	TMC
^{238}U	(n,inl)+(n,γ)	$\simeq 2$ %	Pert.
^{239}Pu	(n,f) +(n,γ)	$\simeq 2$ %	Pert.
^{239}Pu	all	$\simeq 2.5$ %	TMC
^{240}Pu	(n,f) +(n,γ)	$\simeq 0.1$ %	Pert.
^{56}Fe	(n,inl)	$\simeq 0.1$ %	Pert.
^{90}Zr	(n,inl)+(n,γ)	< 0.1 %	Pert.

Uncertainty on k_{eff} due to nuclear data using the TMC and perturbation methods

Isotope	Varied Nucl. data.	Uncertainty on k_{eff} (pcm)	Method
^{238}U	(n,γ)	1000	Pert.
^{239}Pu	all	800	TMC
^{239}Pu	(n,f)	700	Pert.
^{240}Pu	(n,f)	600	Pert.
^{238}U	(n,inl)	300	Pert
^{239}Pu	(n,γ)	260	Pert.
^{23}Na	all	130	TMC
^{241}Pu	(n,f)	120	Pert.
^{56}Fe	(n,inl)	100	Pert.

Conclusions and Future improvements

- Two methods were applied to propagate nuclear data uncertainties for a Kalimer model
- Main isotopes were considered (^{239,240}Pu, ^{235,238}U, ^{23}Na, ^{56}Fe, ^{90}Zr)
- Results in agreement with previous studies (SG-26) for *initial target accuracies*
- Better evaluation work is necessary to meet *final target accuracies*
- Consider all nuclear data with the TMC method
- Obtain uncertainty on burn-up (isotope content at the end of cycle)