500 random evaluations for ^{239}Pu

D. Rochman and A.J. Koning

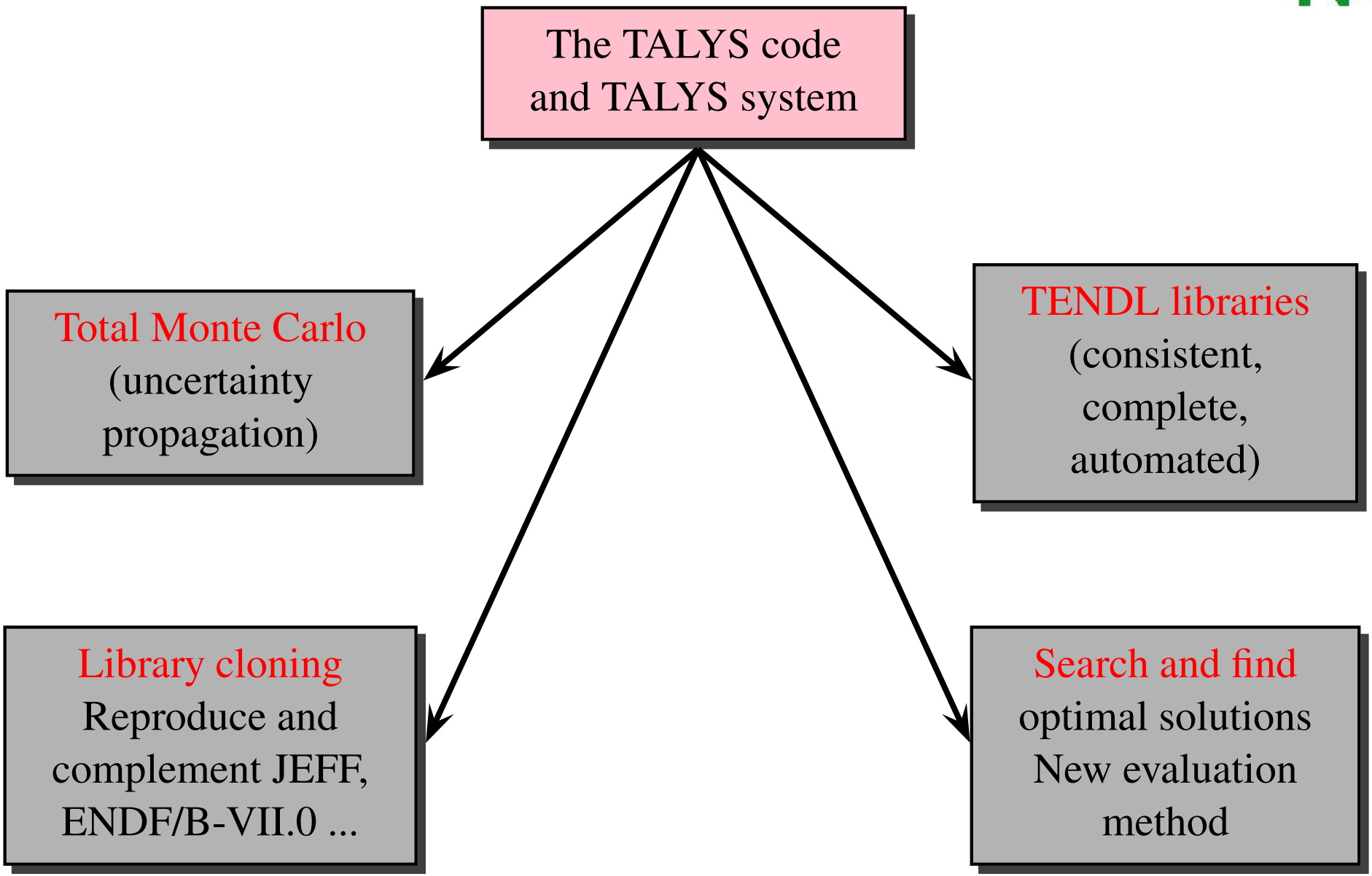
Nuclear Research and Consultancy Group,

NRG, Petten, The Netherlands

JEF/DOC-1327, JEFF Meeting, June 2010

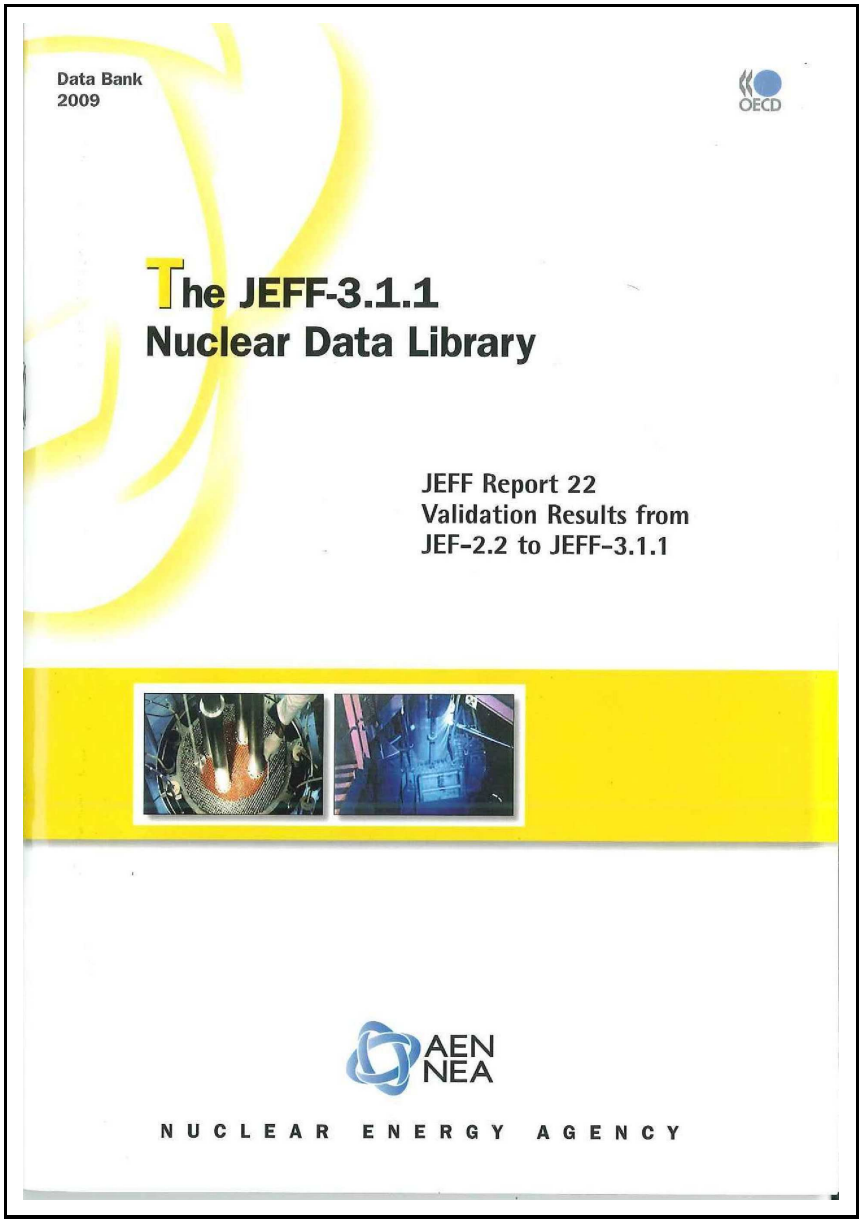
Contents

The TALYS system and outcomes



Goals: Create JEFF-4

In 2009, the JEFF-3.1.1 library was accepted by nuclear industry

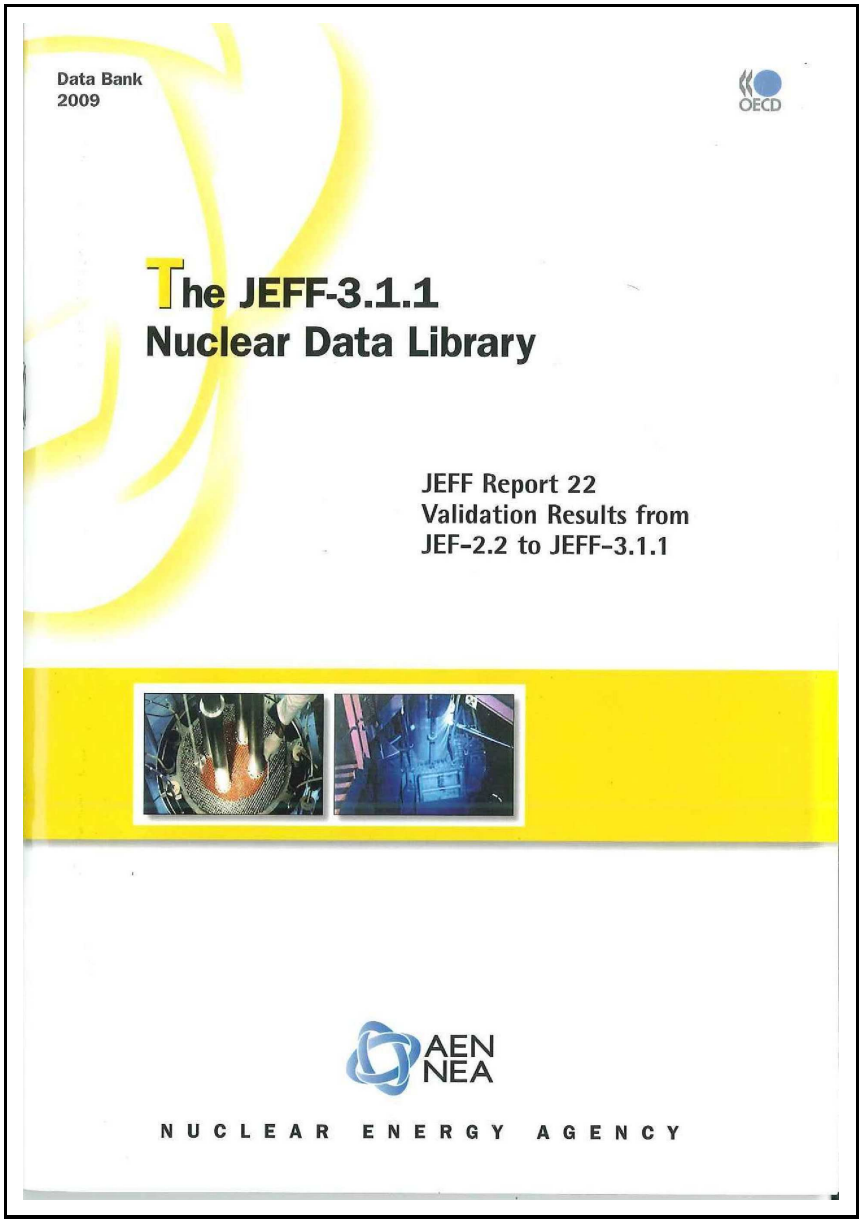


Goals: Create JEFF-4

In 2009, the JEFF-3.1.1 library was accepted by nuclear industry

$\Longrightarrow$ It gives freedom for the next 10 years to

1. Define a new way of working
   (Shall we continue as before
   or try modern and innovative methods ?)
2. Based on ”full nuclear data control” and
   ∞ reproducibility
3. Example of non-incremental approach
4. Test TMC & TENDL
5. Feed results into JEFF-4



Example of innovative approach on ^{239}Pu

To understand the ”Total Monte Carlo” approach, let’s go for the ”Monte Carlo” approach with ^{239}Pu

① Use TALYS to create a single ^{239}Pu evaluation close or equal to ENDF/B-VII.0 or JEFF-3.1.1

② Randomize all model parameters (resonances, nubar, fission neutron spectrum, TALYS parameters) to create 500 random ^{239}Pu evaluations

③ Benchmarks the 500 files with the same set of criticality benchmarks

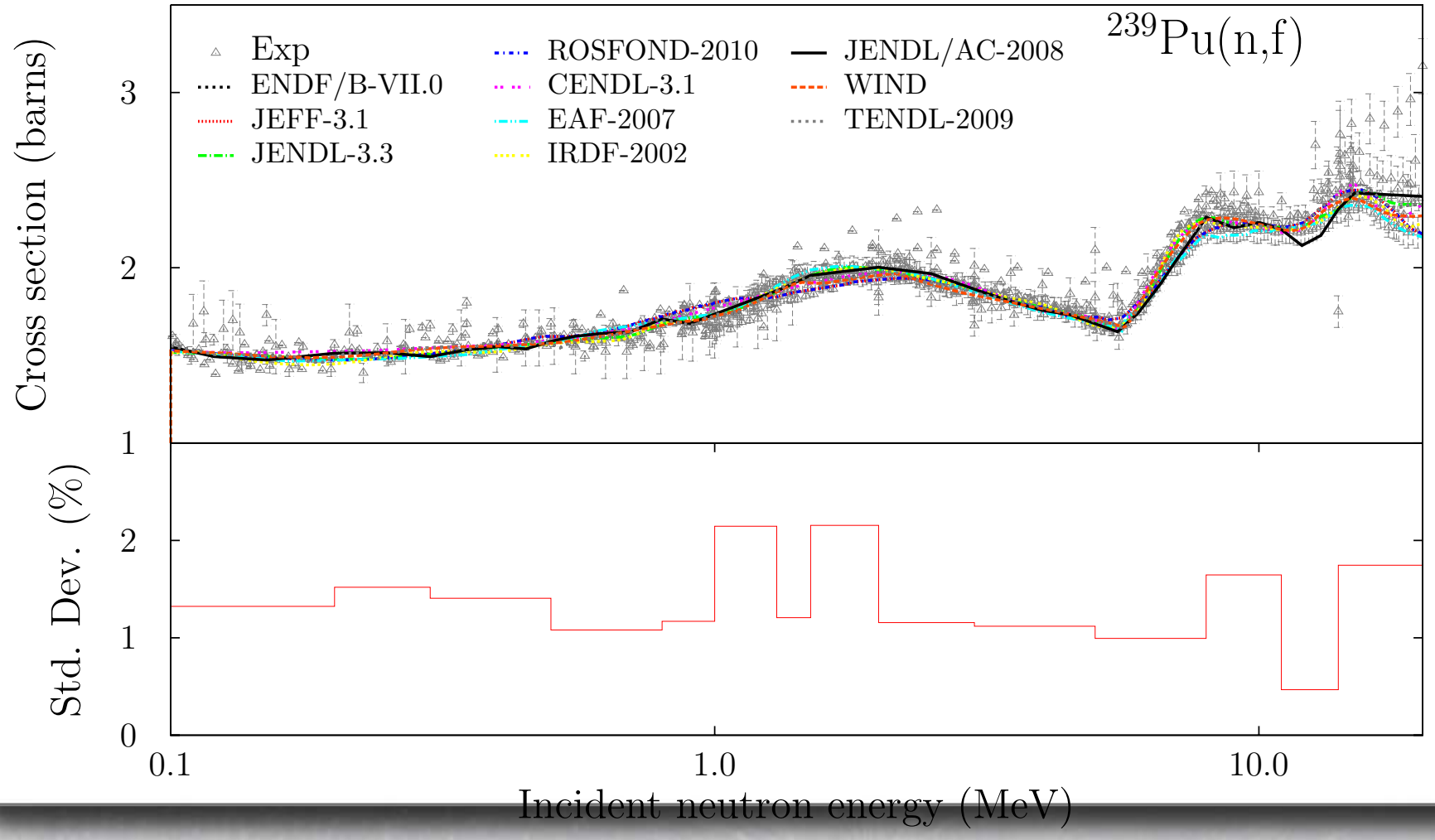
④ Select the best random file

⑤ Create JEFF-3.2β = JEFF-3.1.1 + new ^{239}Pu

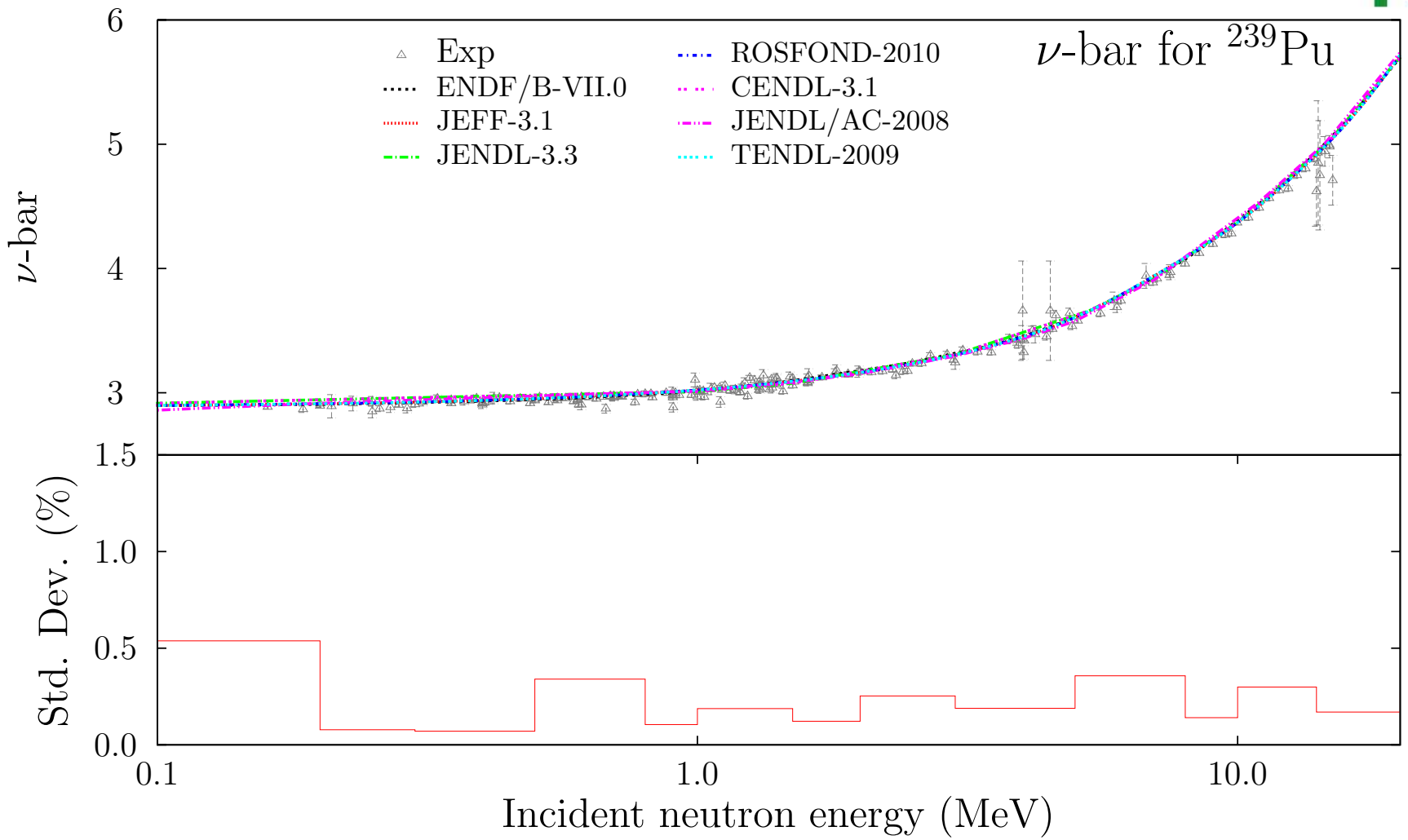
Is ^{239}Pu well known ?

① Many ^{239}Pu evaluations already exist, how can we improve the situation ?

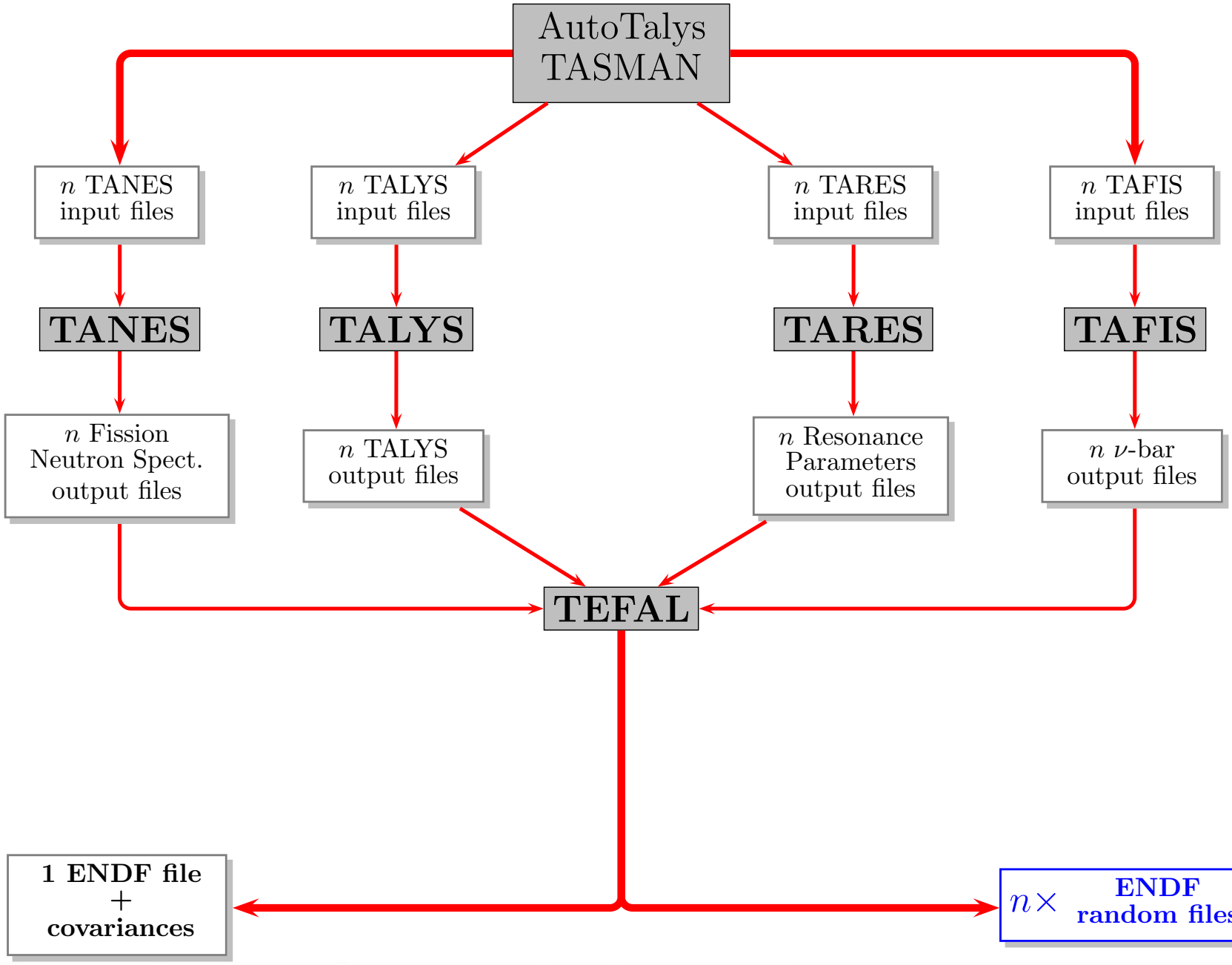
② Random search for the best file (TENDL-2010)



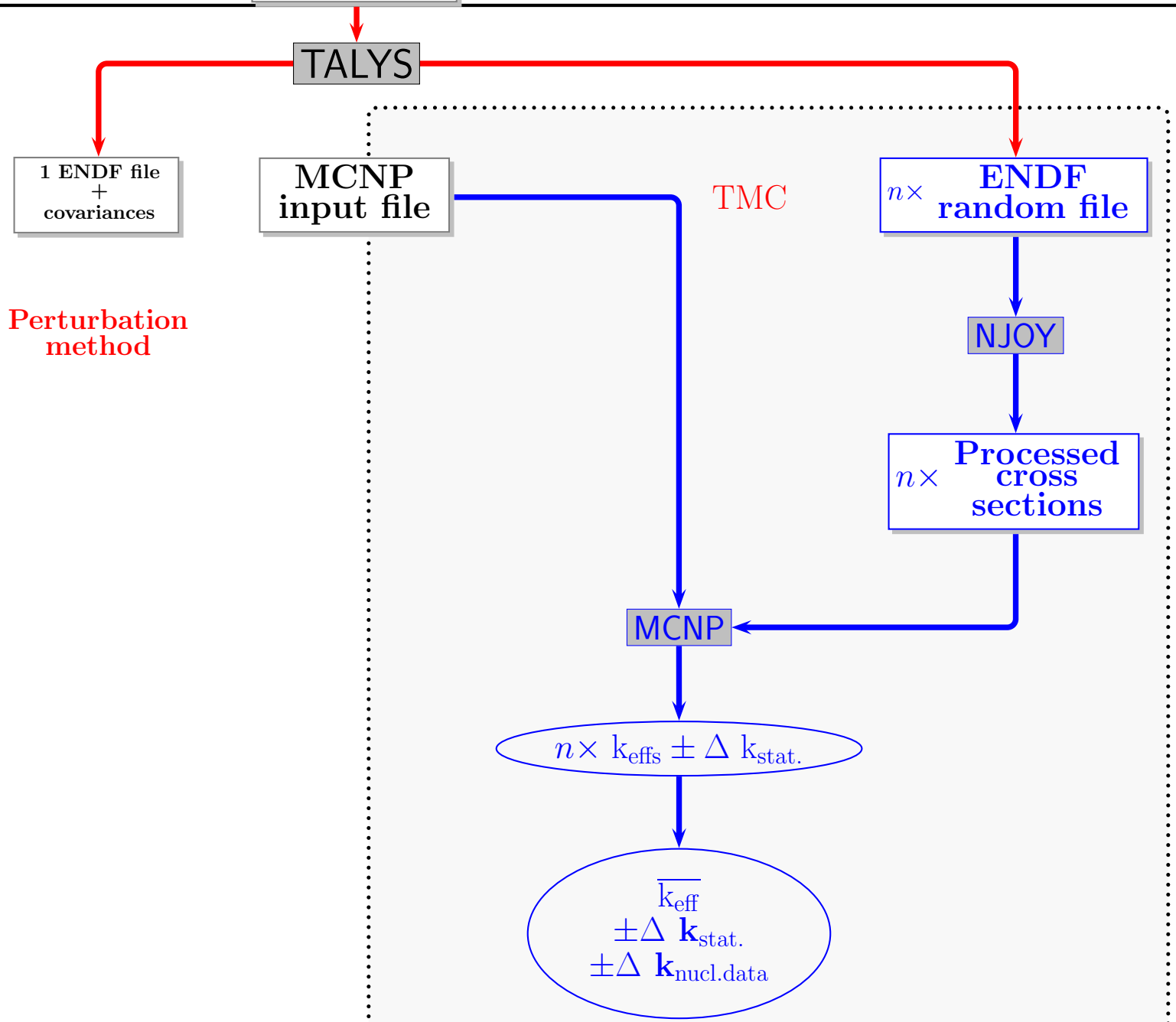
Is ^{239}Pu well known ? It seems so.



The TALYS system



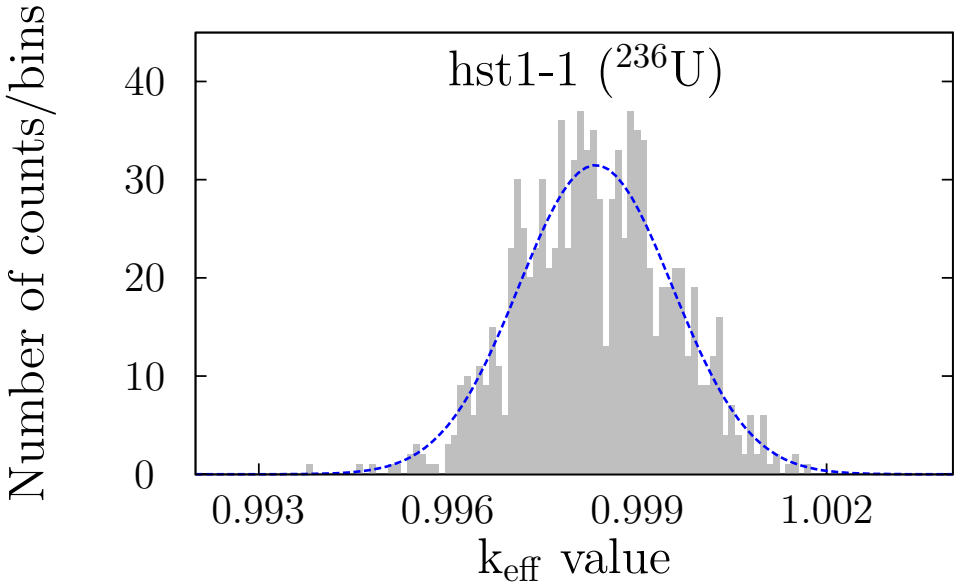
Idea: TALYS +(n TALYS input files) Monte Carlo = Total Monte Carlo



Total Monte Carlo: examples

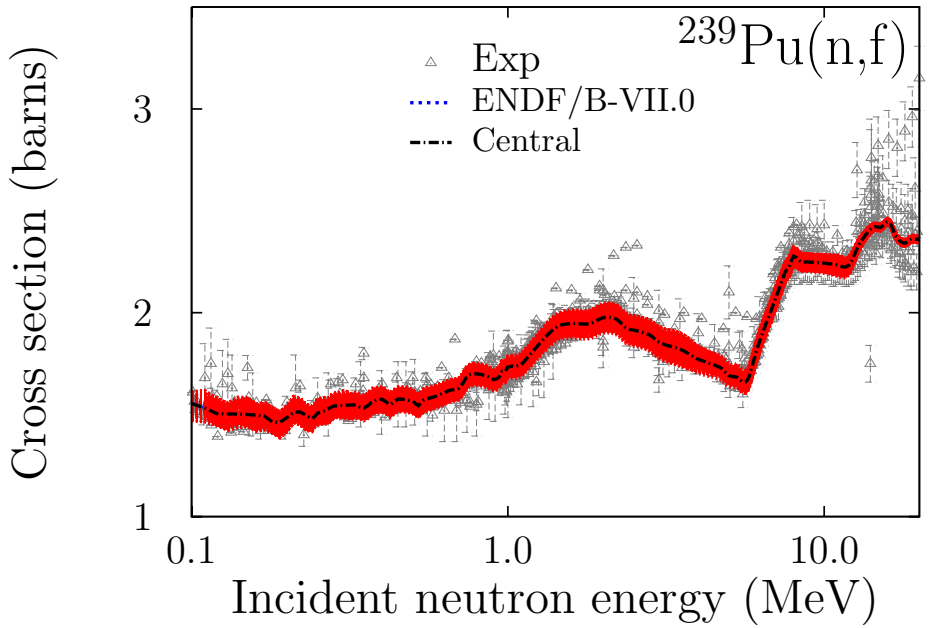
For each random ENDF file, the benchmark calculation is performed with MCNP. At the end of the *n* calculations, *n* different k_{eff} values are obtained. In the obtained probability distribution of k_{eff}, the standard deviation σ_{total} reflects two different effects:

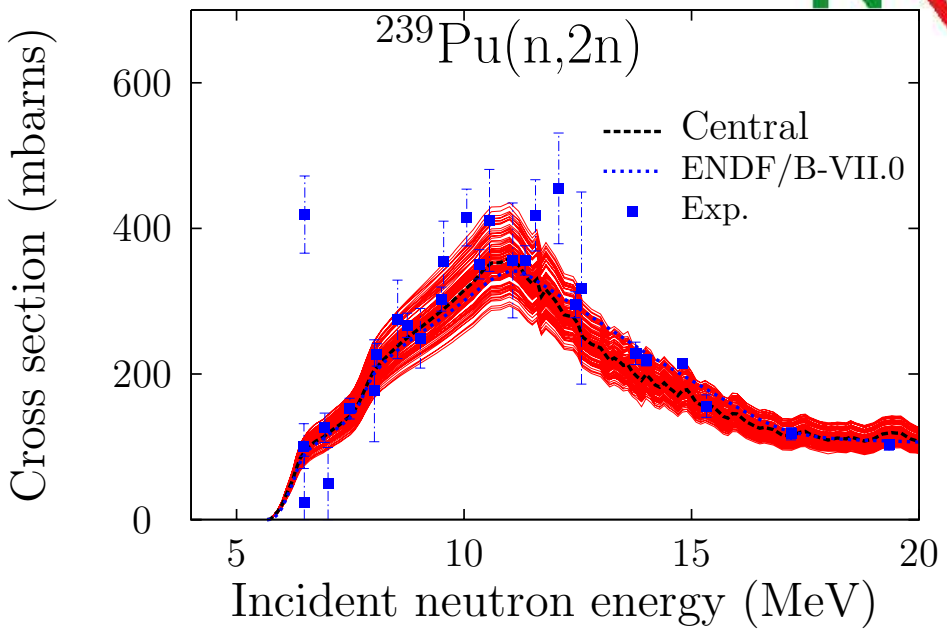
$$\sigma^2_{total} = \sigma^2_{statistics} + \sigma^2_{nuclear\ data}. \quad (1)$$

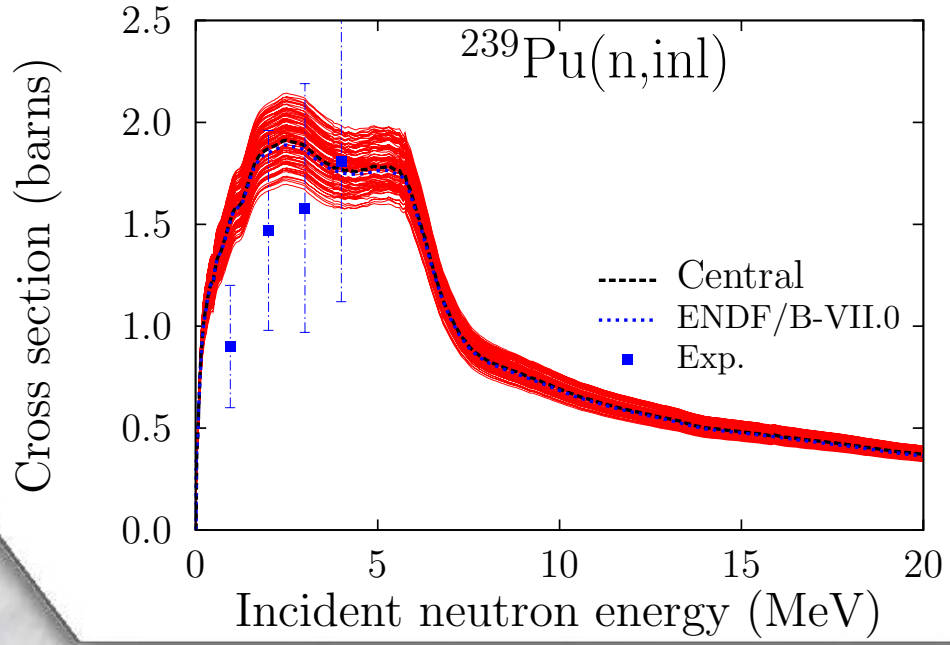


Each random file is completely different from another one: nu-bar ("*MF1*"), resonance parameters ("*MF2*"), cross sections ("*MF3*"), also *MF4*, *MF5*, *MF6*, etc.

Nuclear data: random ^{239}Pu in the thermal and fast range





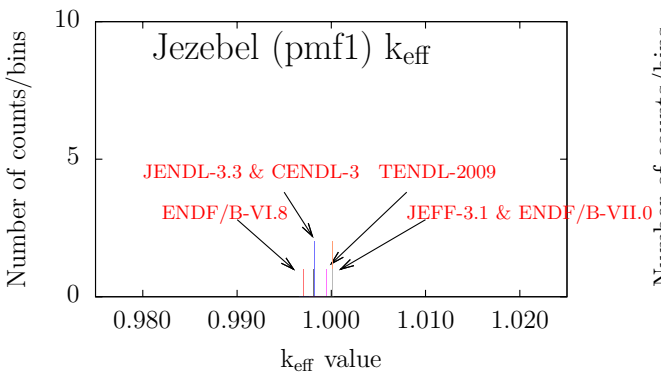


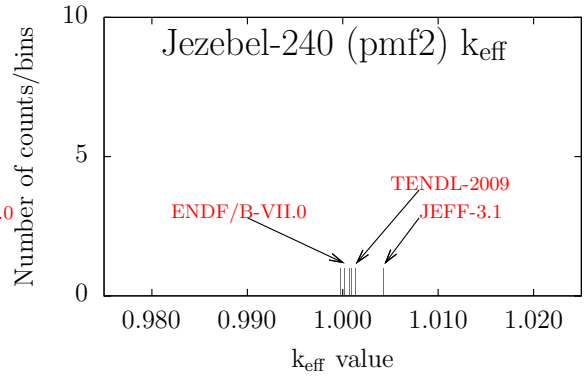
(1) Central cross sections *almost* equal to ENDF/B-VII.0 or JEFF-3.1

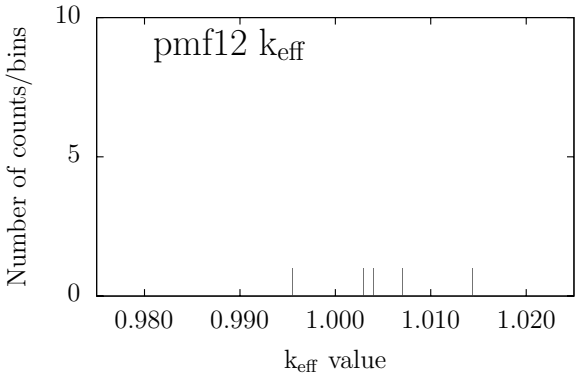
(2) Random cross sections obtained from random model parameters

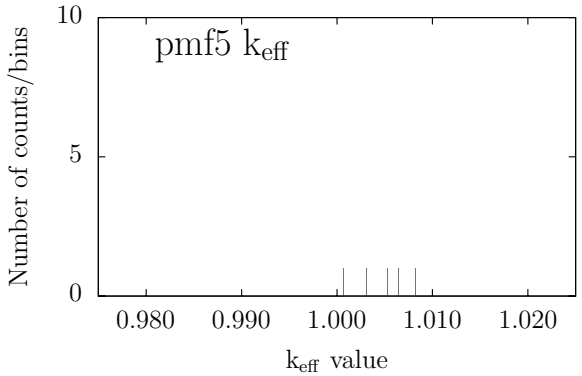
(3) Similar results in MF1, 2, 4, 5 and 6

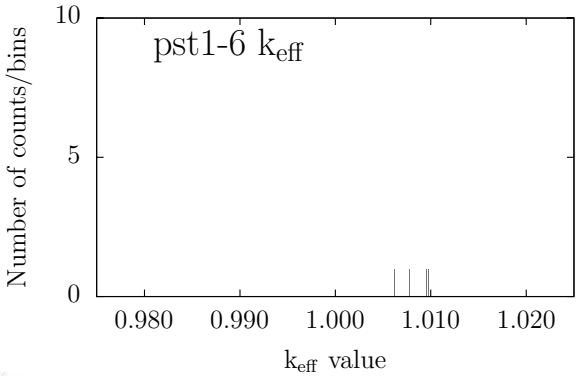
Benchmarking: simple example with 6 k_{eff} benchmarks

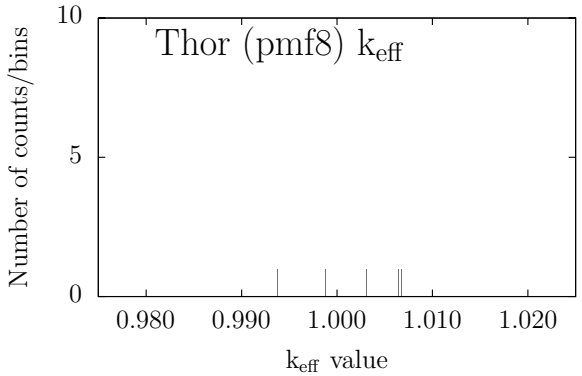












χ^2

JEFF-3.1.1:	$1.14e^{-4}$
JENDL-3.3:	$1.71e^{-4}$
TENDL-2009:	$3.66e^{-4}$
ENDF/B-VI.8:	$1.72e^{-4}$
ENDF/B-VII.0:	$1.69e^{-4}$

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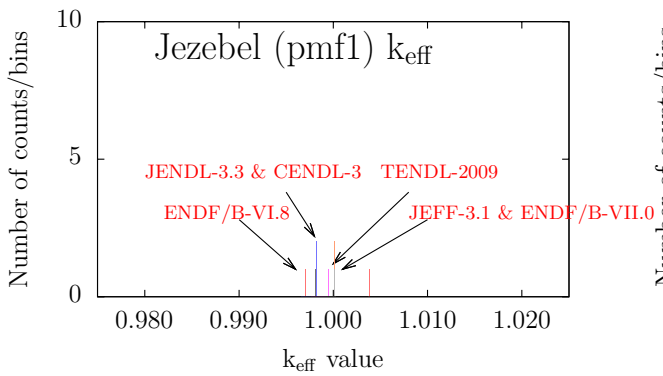

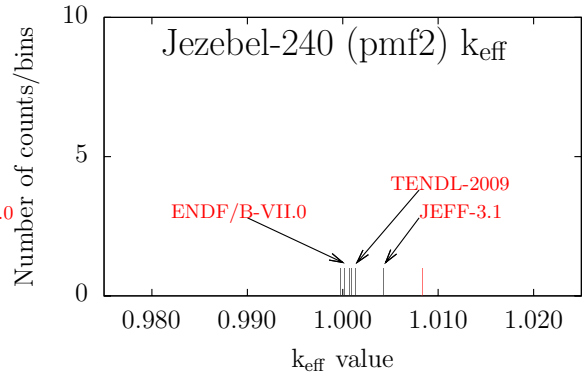

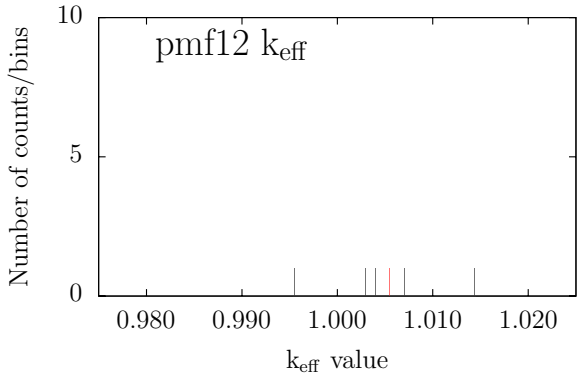

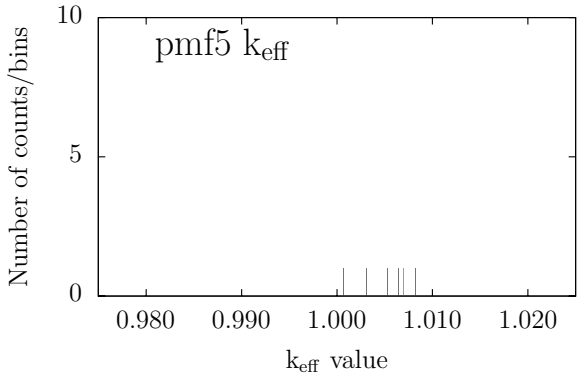

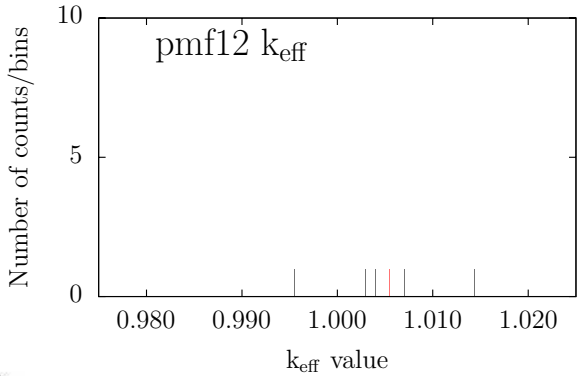

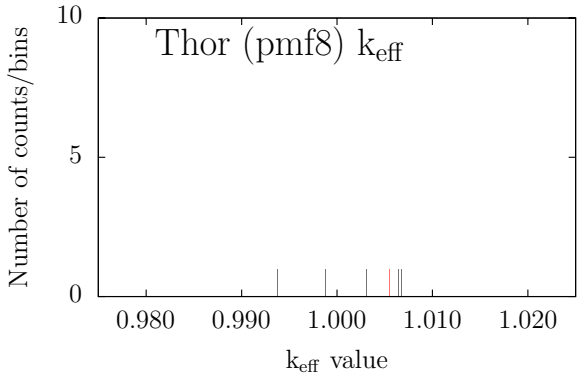

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random 0:	$2.29e^{-4}$

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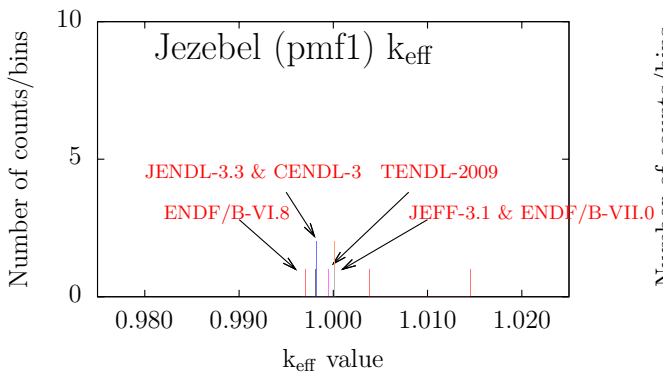

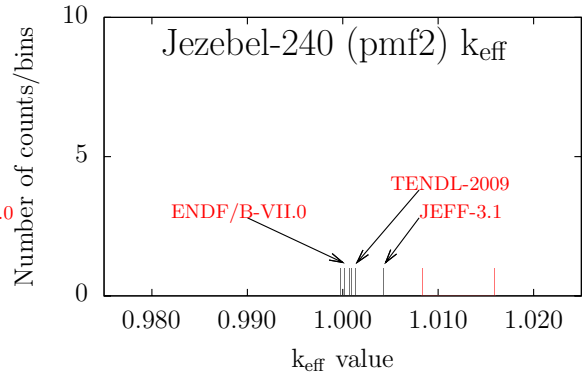

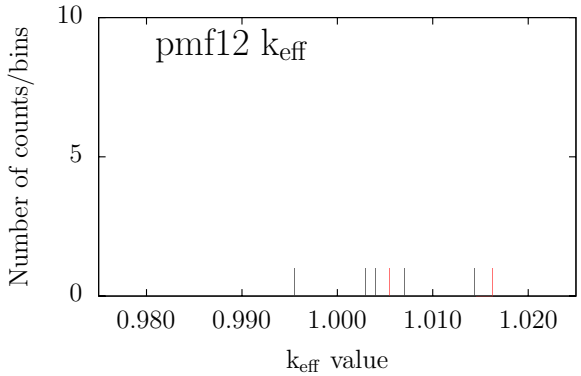

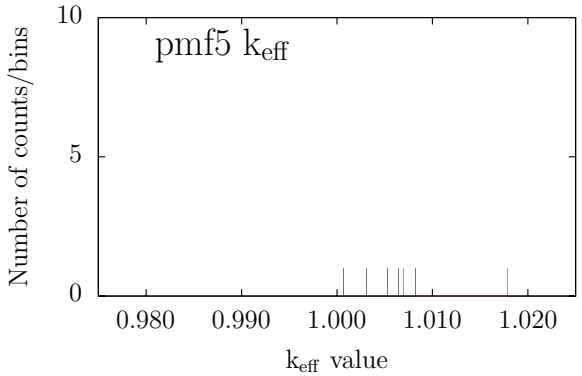

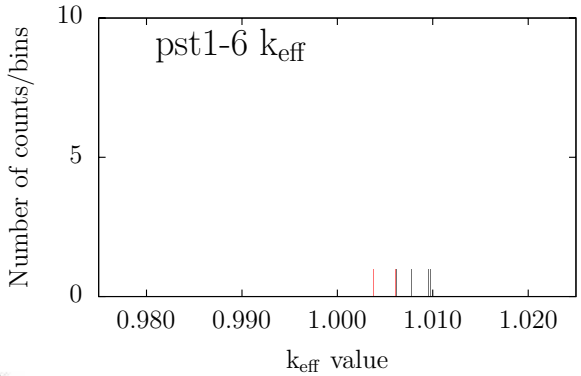

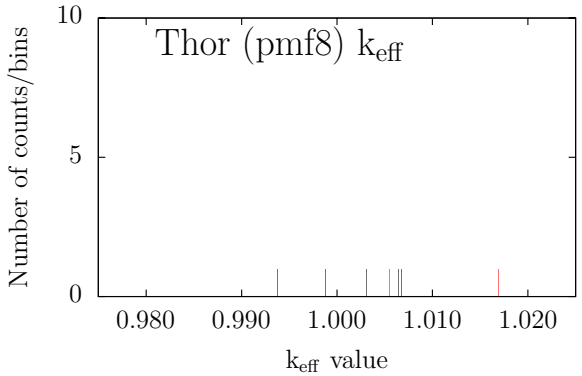

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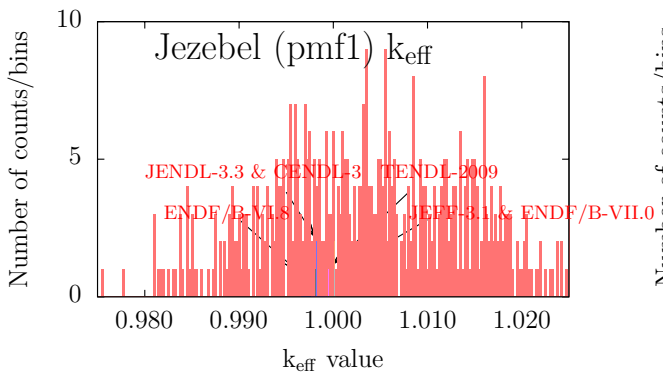
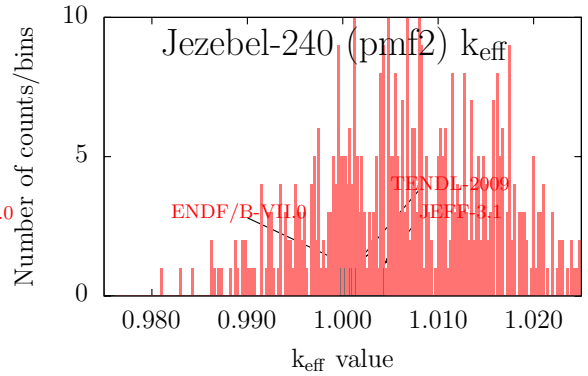
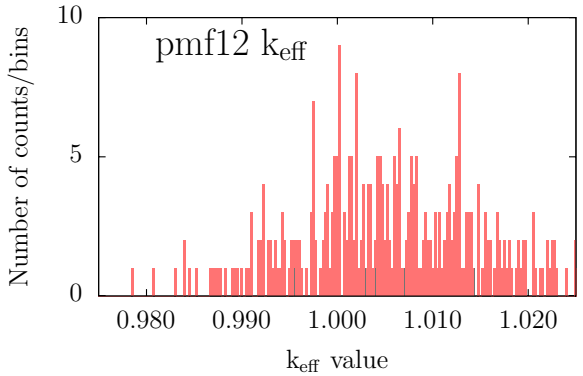
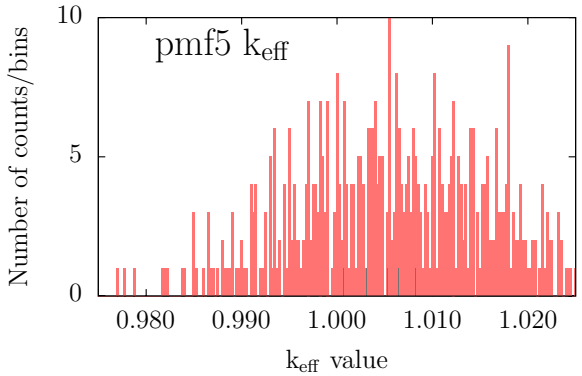
random 0:	$2.29e^{-4}$
random 1:	$13.4e^{-4}$

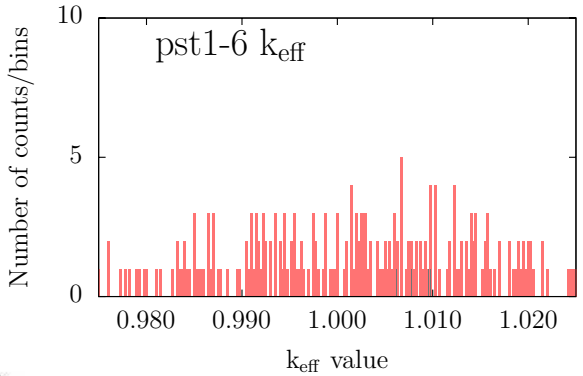
Benchmarking: 6 k_{eff} benchmarks with random ^{239}Pu

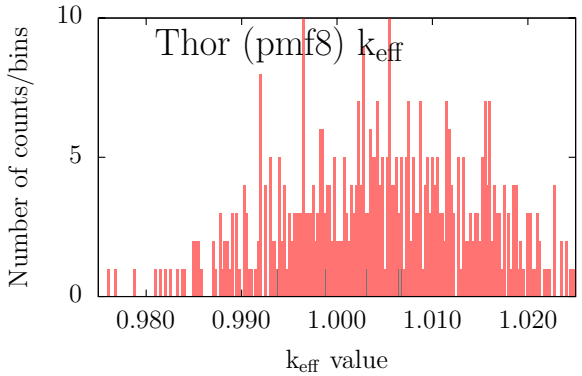












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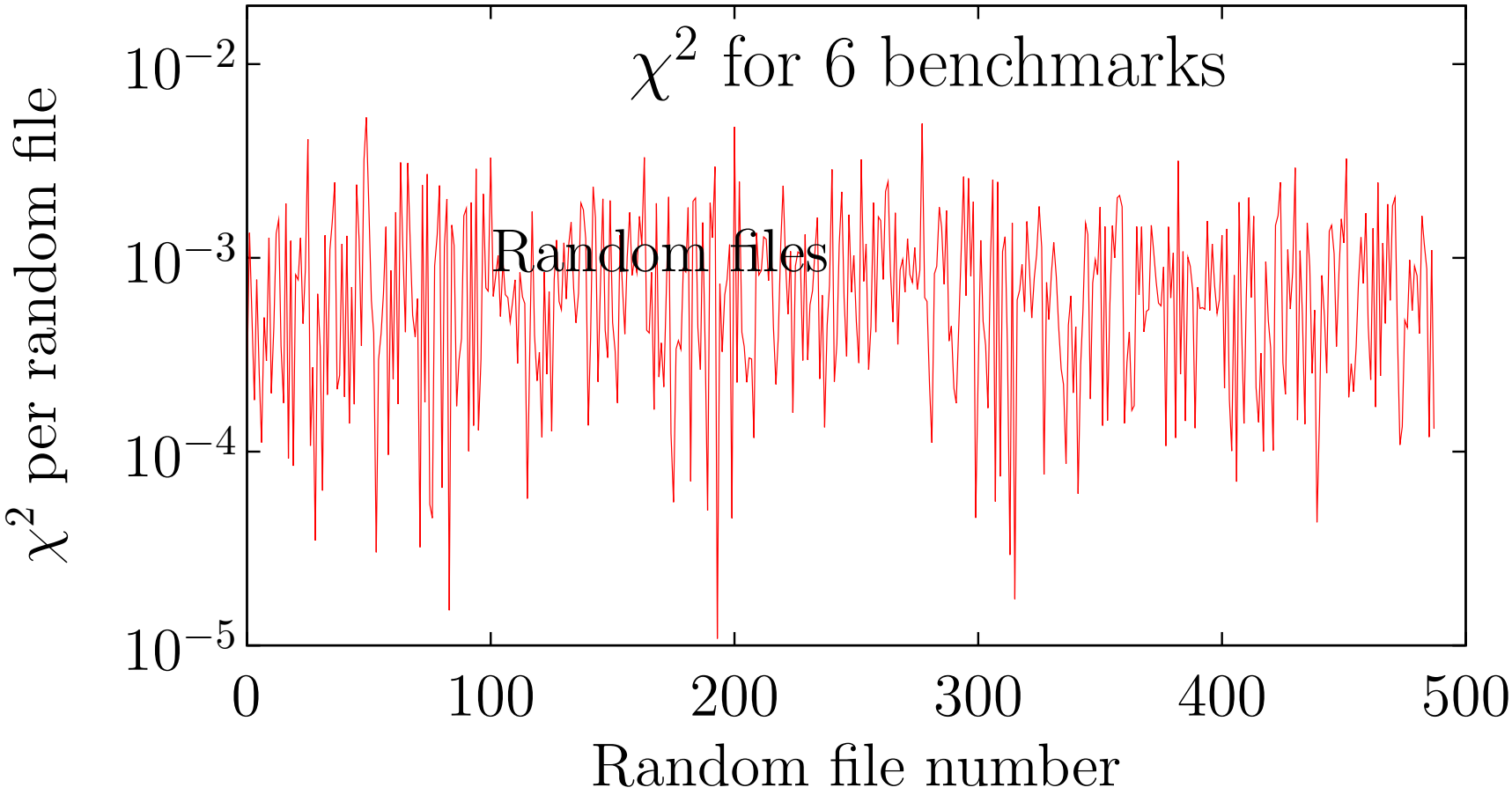
Benchmarking: 6 k_{eff} benchmarks with random ^{239}Pu



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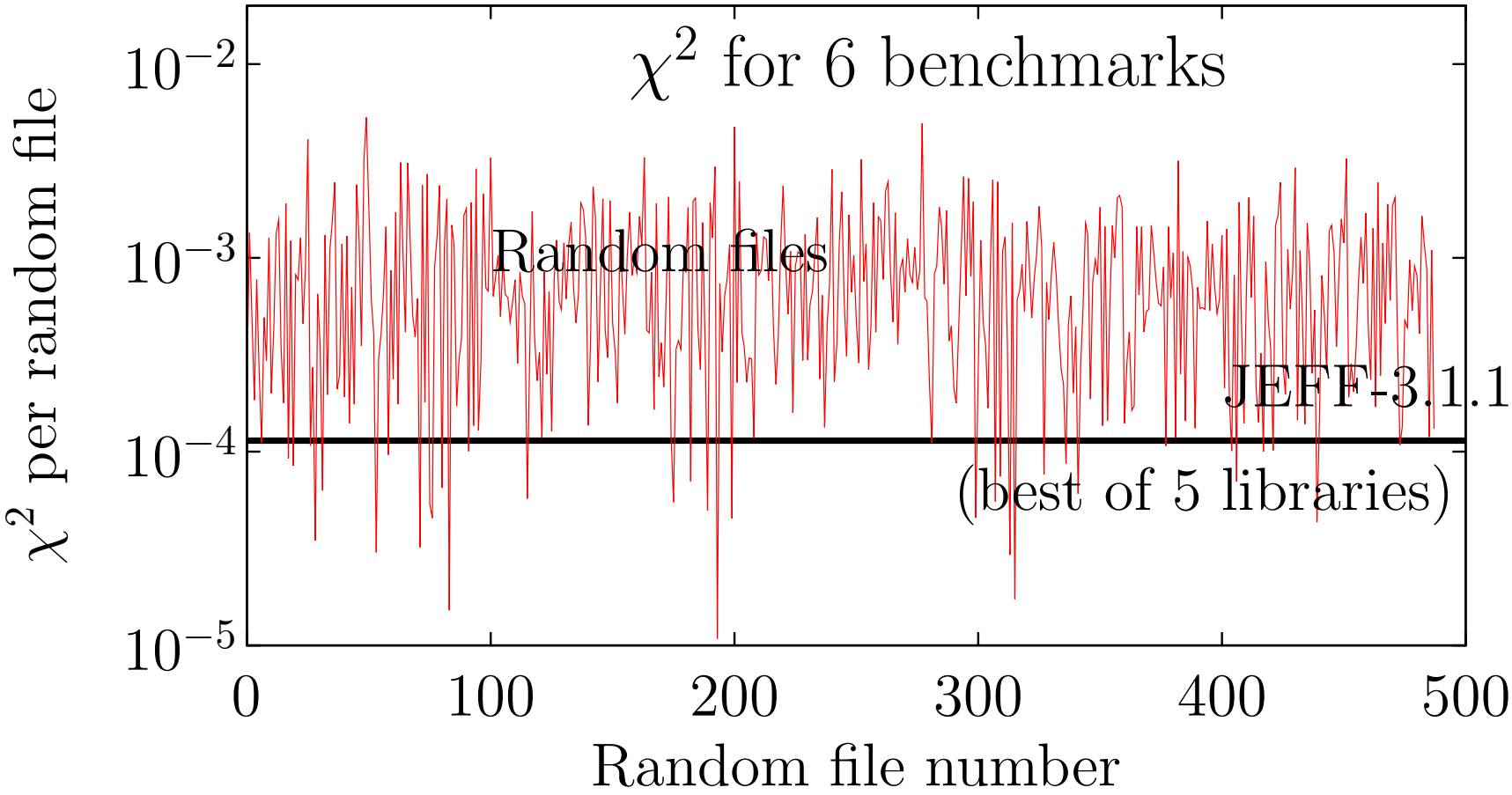

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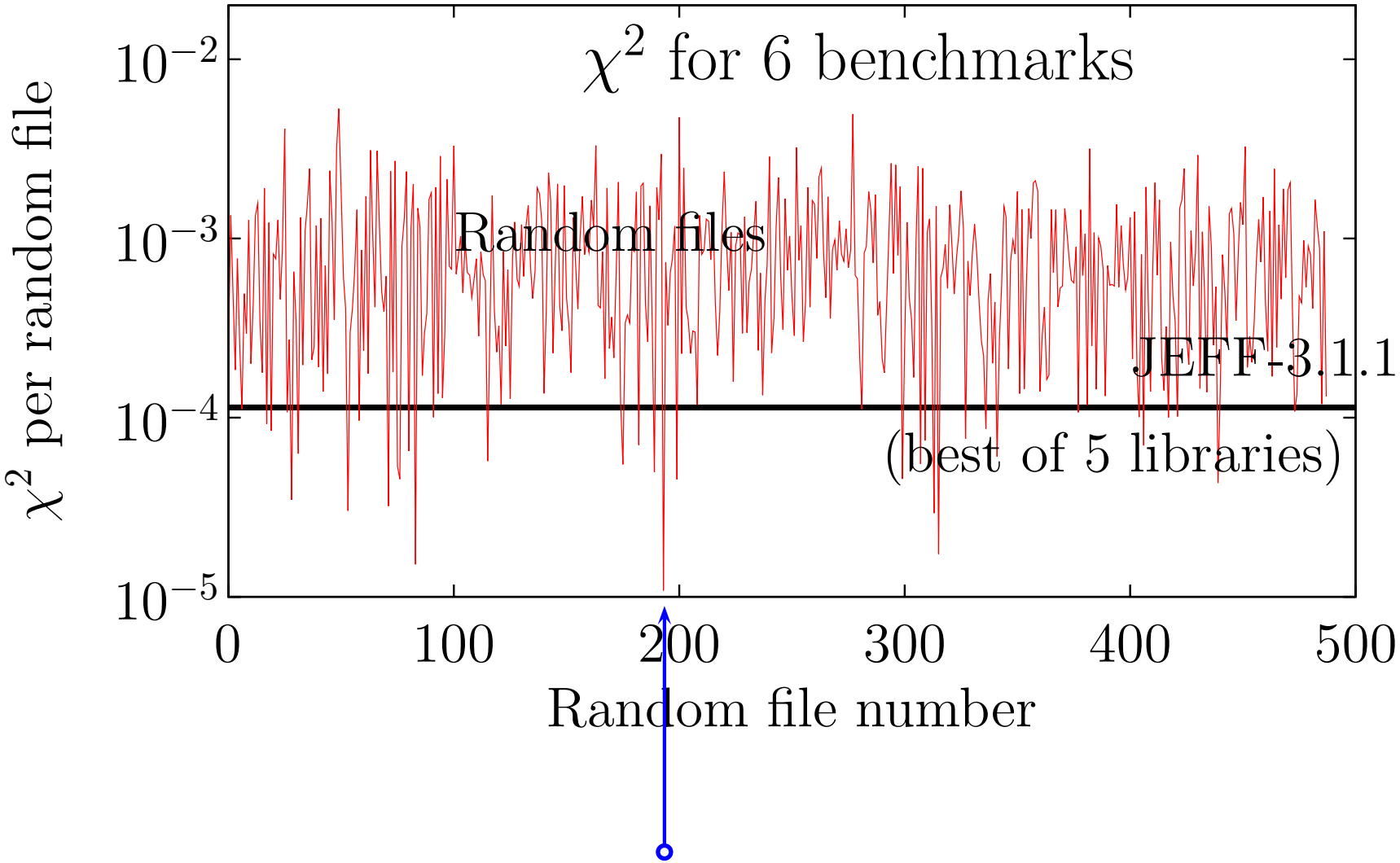
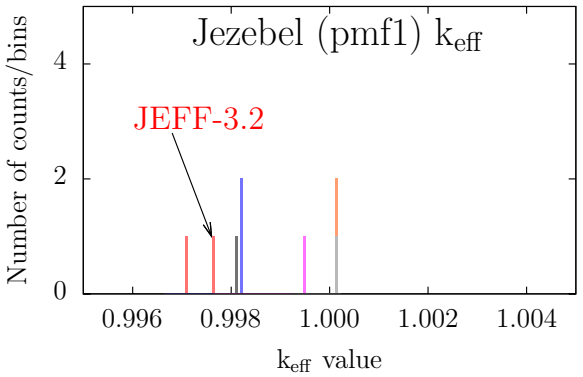
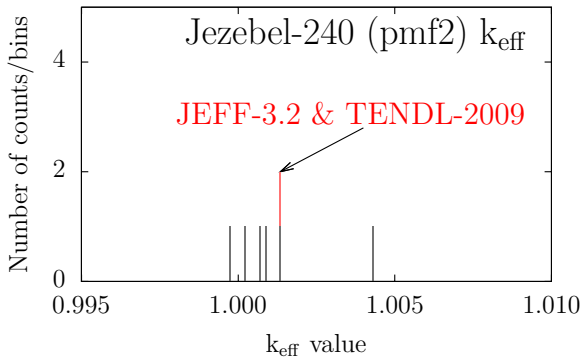
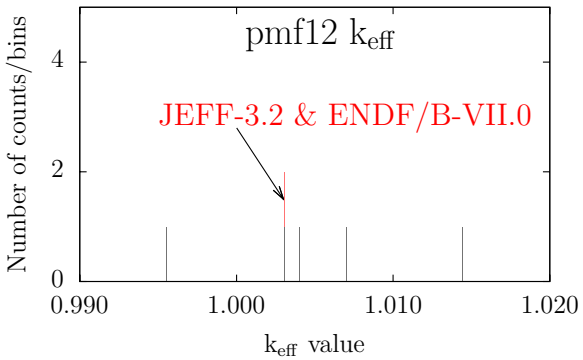


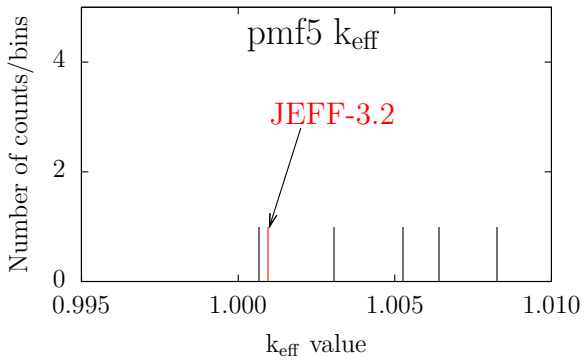
Best χ^2 for random file 193 ($\chi^2 = 1.08e^{-5}$, 10 $\times$ smaller than JEFF-3.1.1, 17 $\times$ smaller than ENDF/B-VII.0)

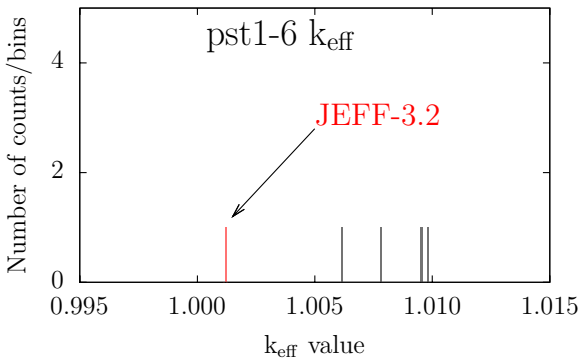
Benchmarking: 6 k_{eff} benchmarks with random ^{239}Pu

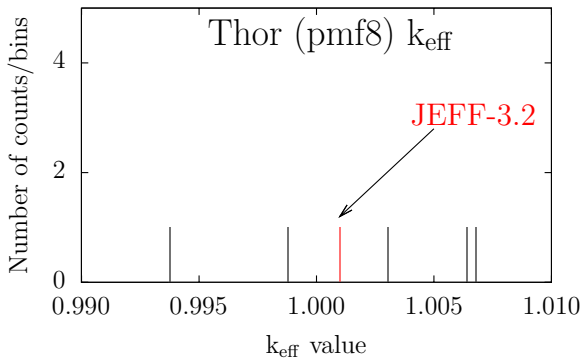












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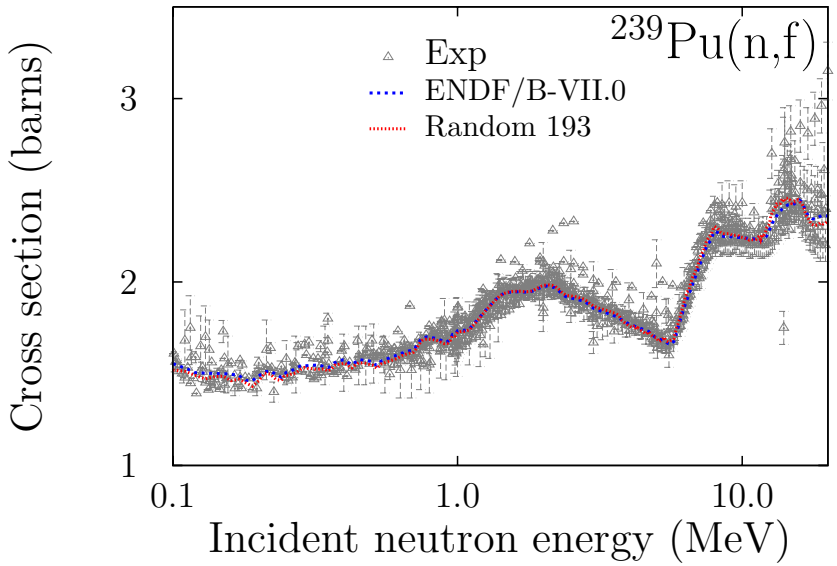
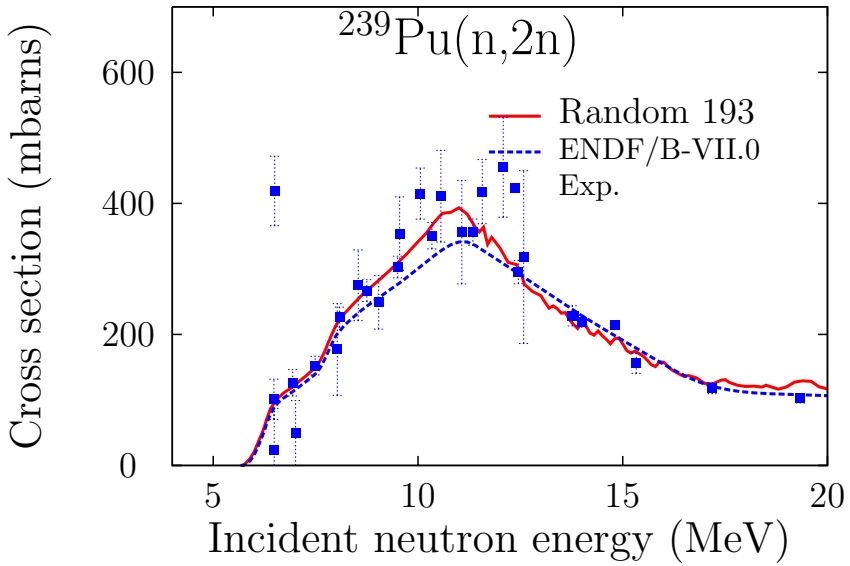
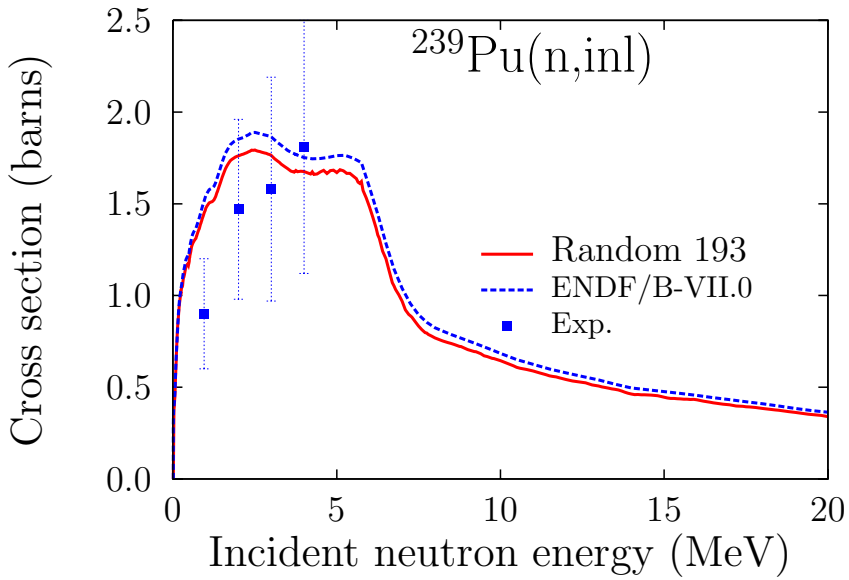
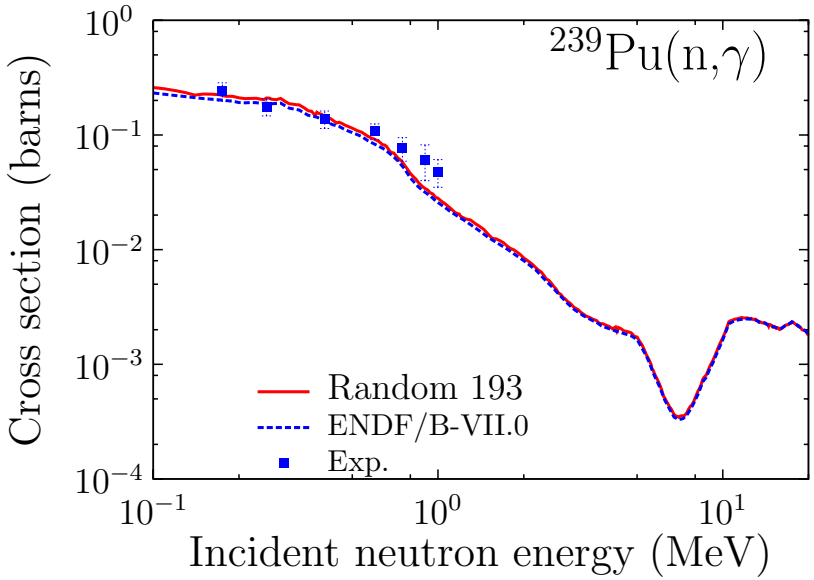
JEFF-3.2β:	$1.08e^{-5}$

Optimal cross sections (random file 193)

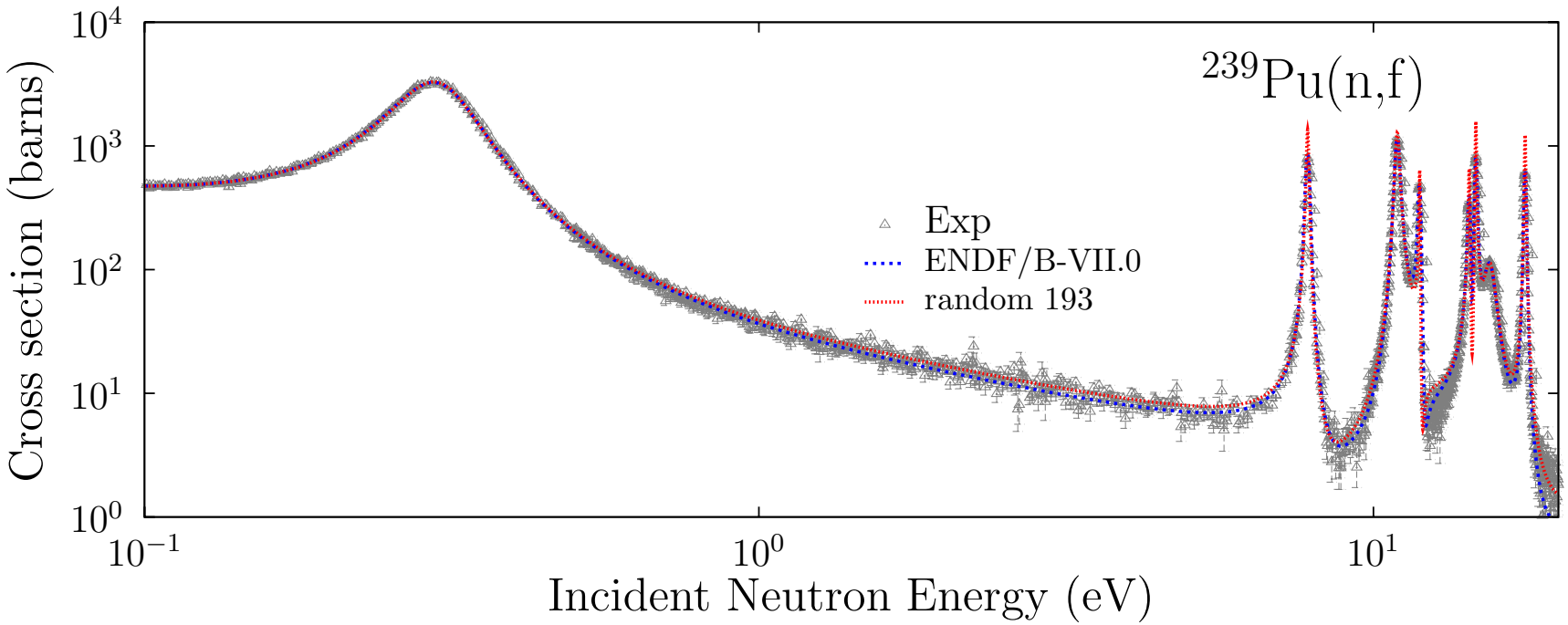




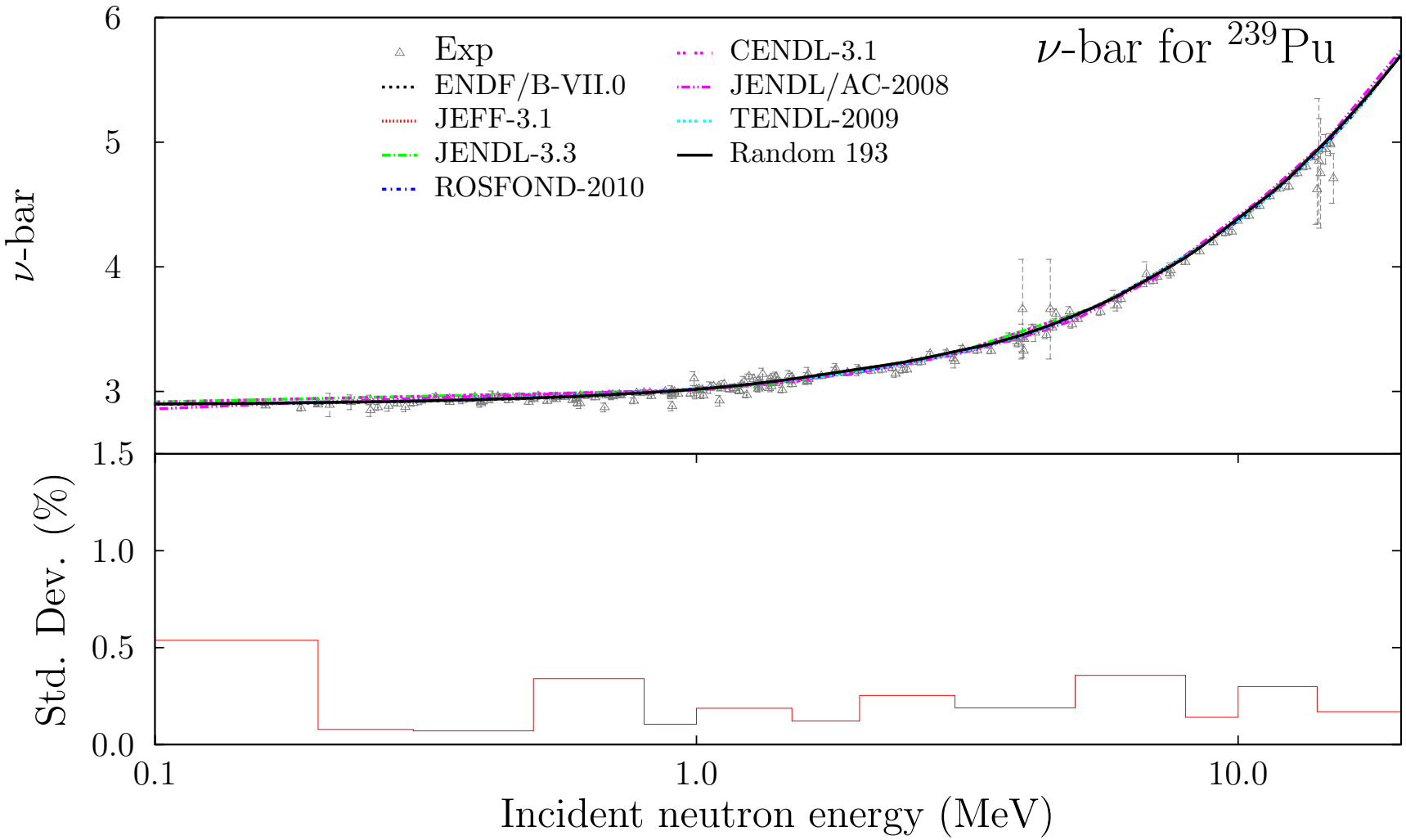




Optimal cross section (random file 193)



Optimal nu-bar (random file 193)



Generalization

Based on this simple example:

- More random files can be used
- More benchmarks can be included $\Longrightarrow$ JEFF-3.2β = JEFF-3.1.1 + New ^{239}Pu
- Add other actinides (such as ^{235}U) $\Longrightarrow$ JEFF-3.n = JEFF-3.2β + *n* new isotopes
- Apply this method to many (virtually all) isotopes, while improving the agreement with differential data (TALYS) : JEFF-4

We believe that this approach is condemned to succeed !

Generalization and (no longer) secret plan

For the next Nuclear Data conference (ND2013) in Manhattan, we want to apply this methodology to produce the first 21st century library (which is different from the first library of the 21st century),

competing (at least) with any existing library !

Generalization and (no longer) secret plan

For the next Nuclear Data conference (ND2013) in Manhattan, we want to apply this methodology to produce the first 21st century library (which is different from the first library of the 21st century),
competing (at least) with any existing library !

2010-2013, New library $\Longrightarrow$ A Manhattan Project

Conclusions

- First attempt to randomly search for optimal nuclear data
- What is presented is not about ^{239}Pu
- It is about using current knowledge applied for library optimization without incremental approach
- While TALYS-based, results are tuned to reproduce successful aspects of libraries such as ENDF/B-VII.0 and JEFF-3.1.1
- We need to take the opportunity offered by the success of JEFF-3.1.1 and move ahead