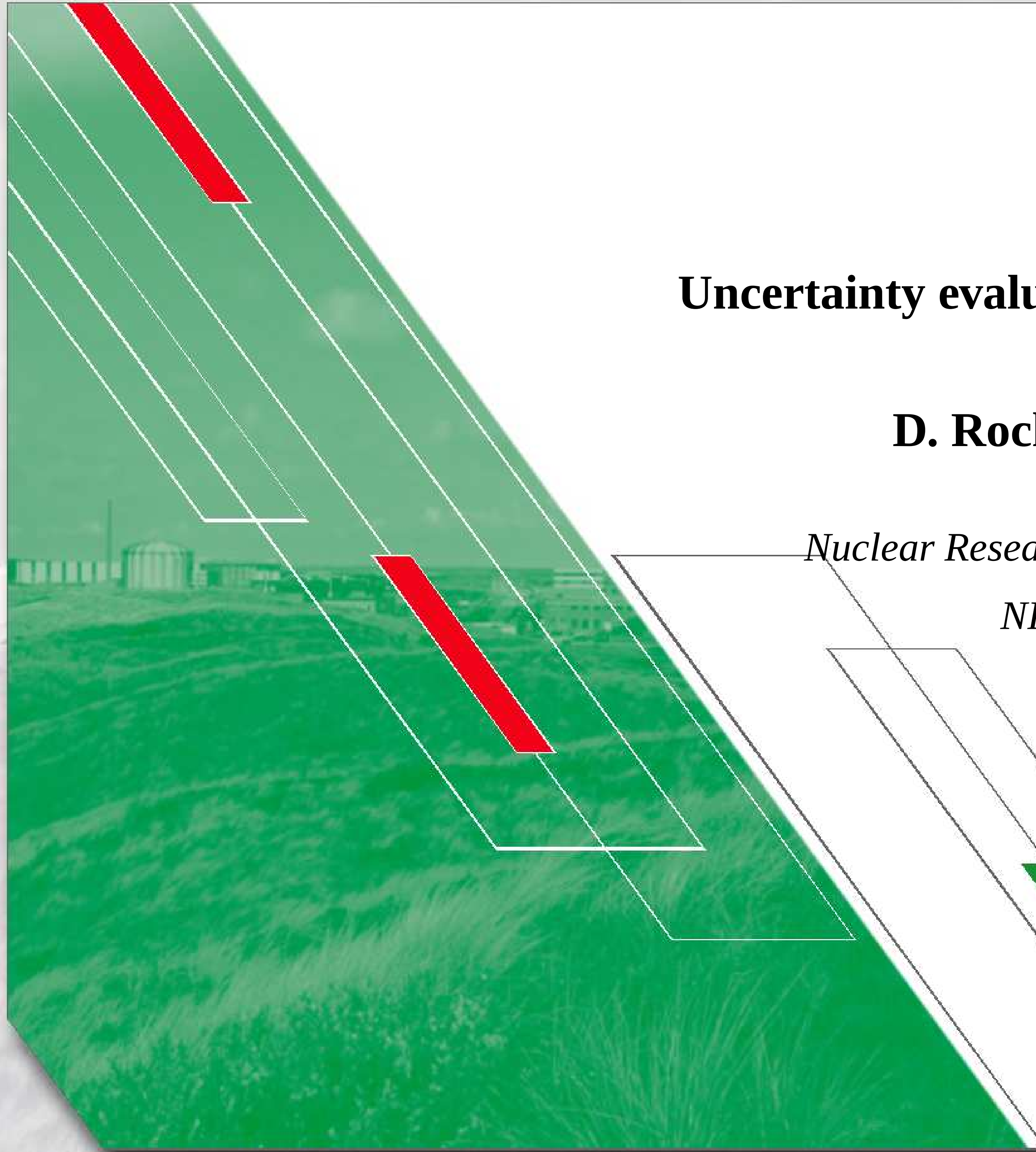

Uncertainty evaluations and validations

D. Rochman and A.J. Koning

Nuclear Research and Consultancy Group,
NRG, Petten, The Netherlands

May 22, 2008

Contents

① Motivations for a change:

⟹ *a roadmap to ban covariance files*

② Concept:

⟹ *Monte Carlo from nuclear data to large-scale systems*

③ Where can we apply it ?

⟹ *(needed tools & knowledge)*

④ How does it work ?

⑤ Examples with Pb isotopes:

⟹ *k_{eff} benchmarks and reactors*

⑥ Examples on global scale:

⟹ *k_{eff} benchmarks, fusion shielding, reactivity swing*

⑦ Pros, Cons and Conclusions

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- ☞ and so on. . .

➼ Most of these routines were developed decades ago when the support for nuclear data and nuclear reactor physics research was sufficient to allow them to be produced !

After all, not a new idea

Here is the mantra in which we believe and motivates us:

> *“Researchers should cease trying to be clever in devising refinements to old methods that were developed when computational resources were limited.*

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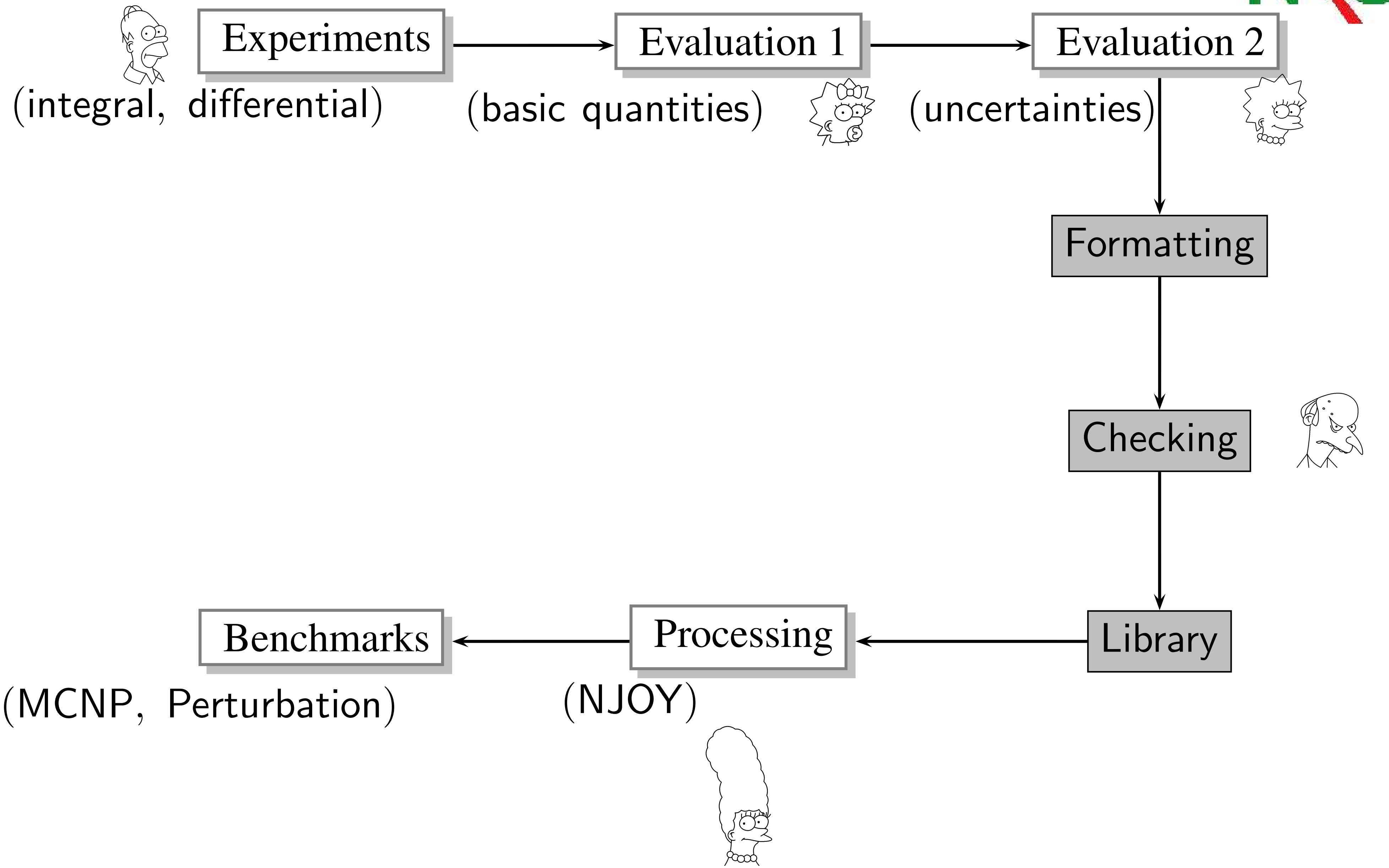
> *Instead, their creative instincts should be redirected to unleashing the full potential of computers for* **brute** *force analysis"*

D. Smith, Santa Fe 2004

We are proposing a conceptual revolution



Experiments → Evaluation 1 → Evaluation 2

(integral, differential)

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Library

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Benchmarks

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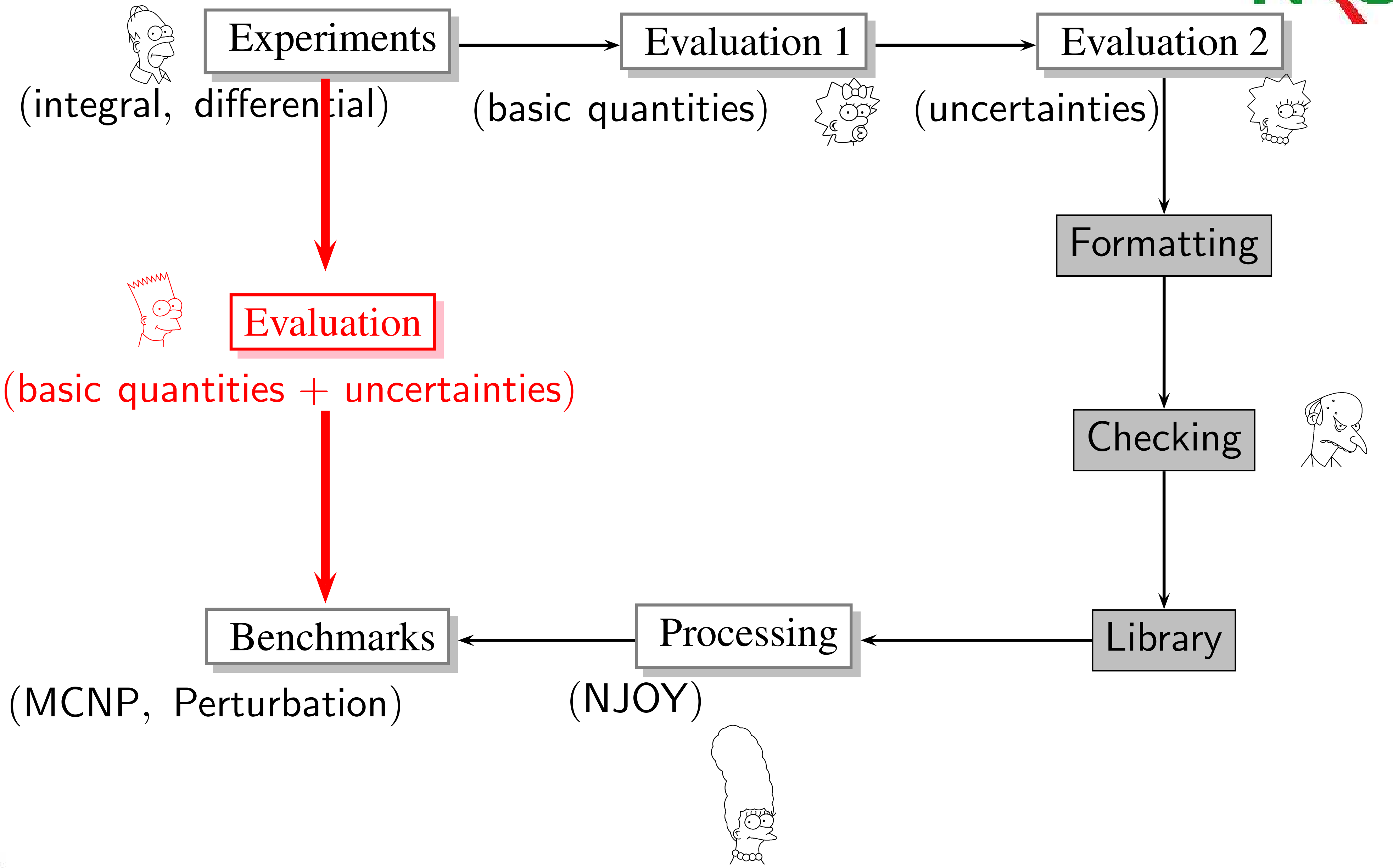

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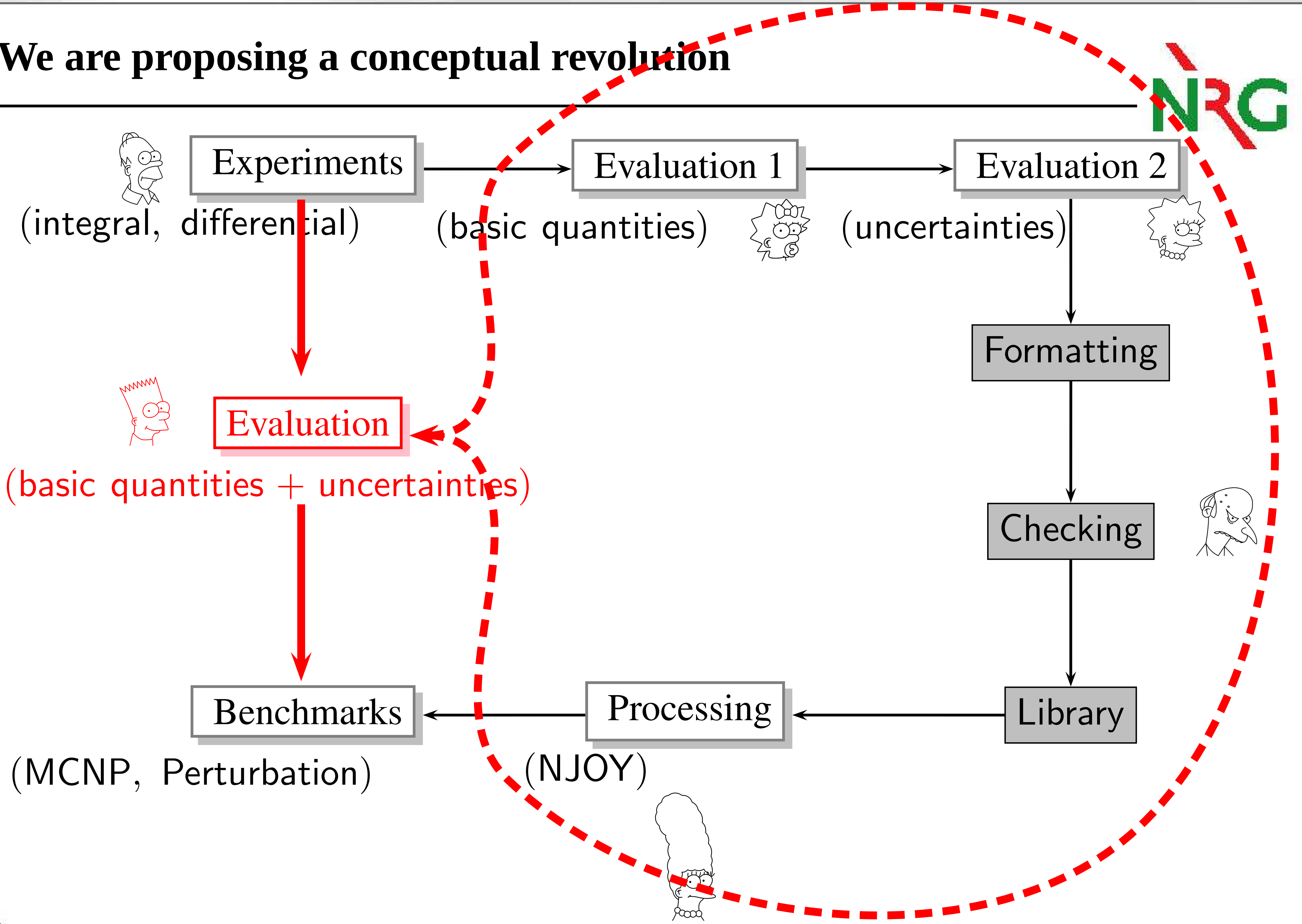

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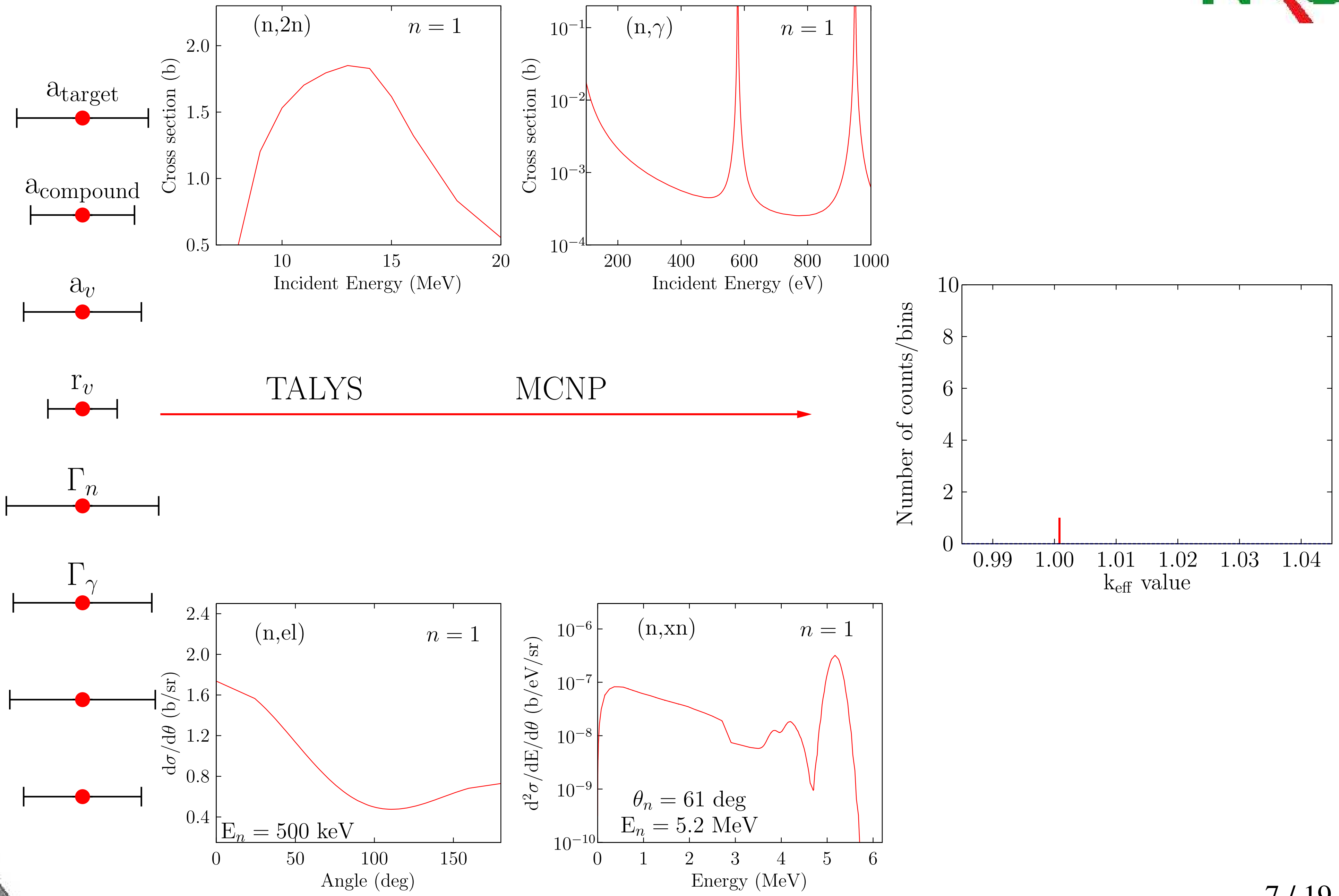

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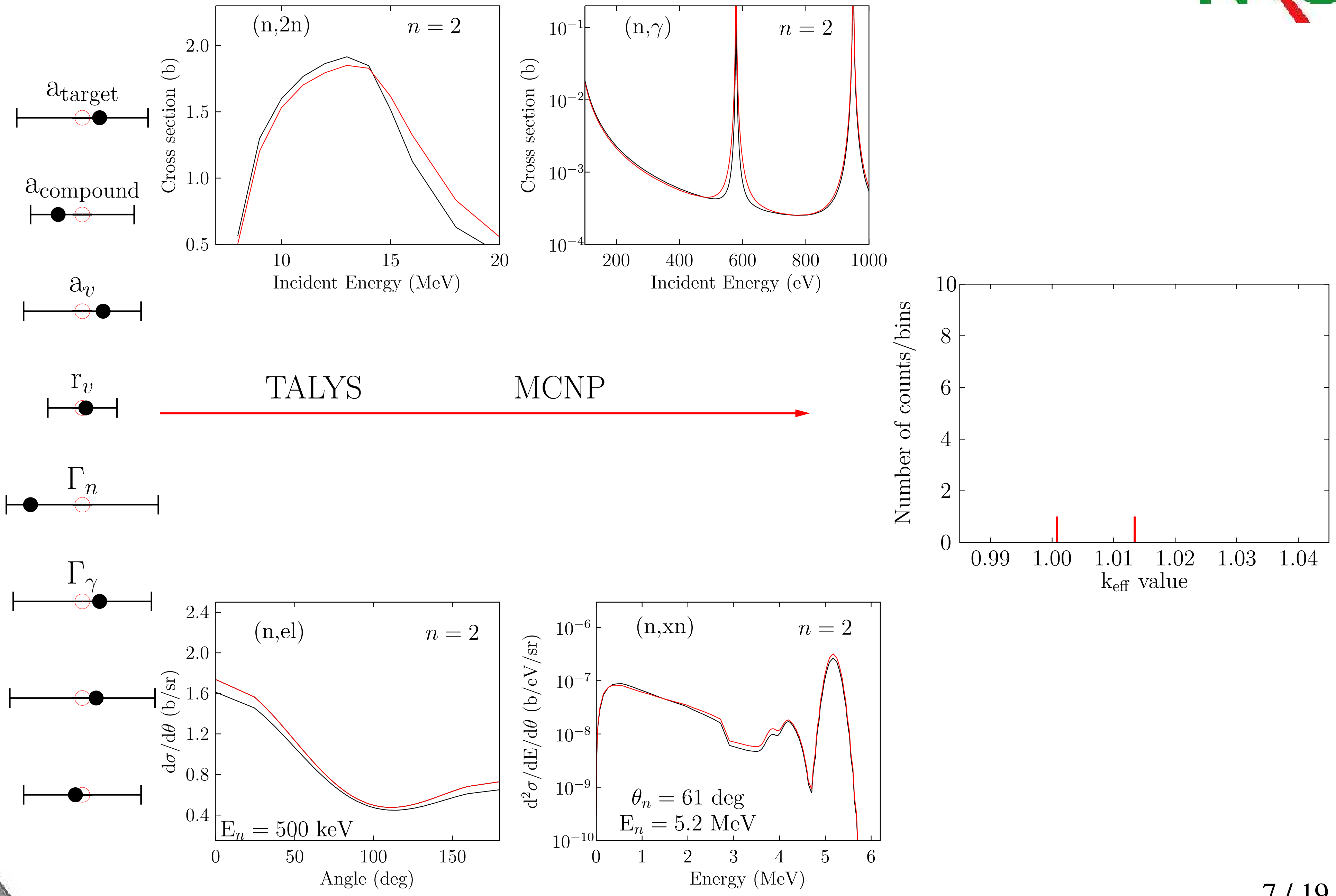

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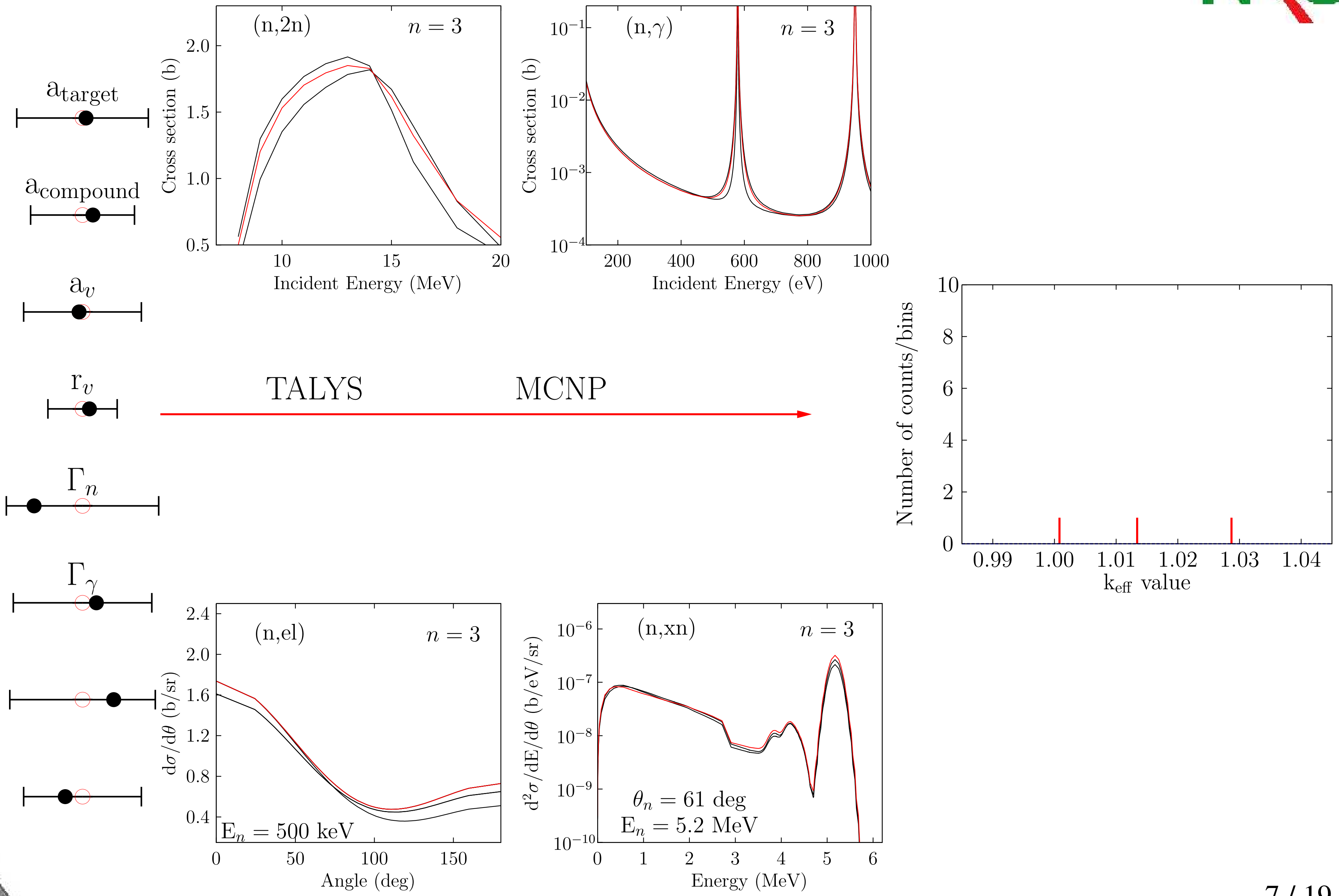

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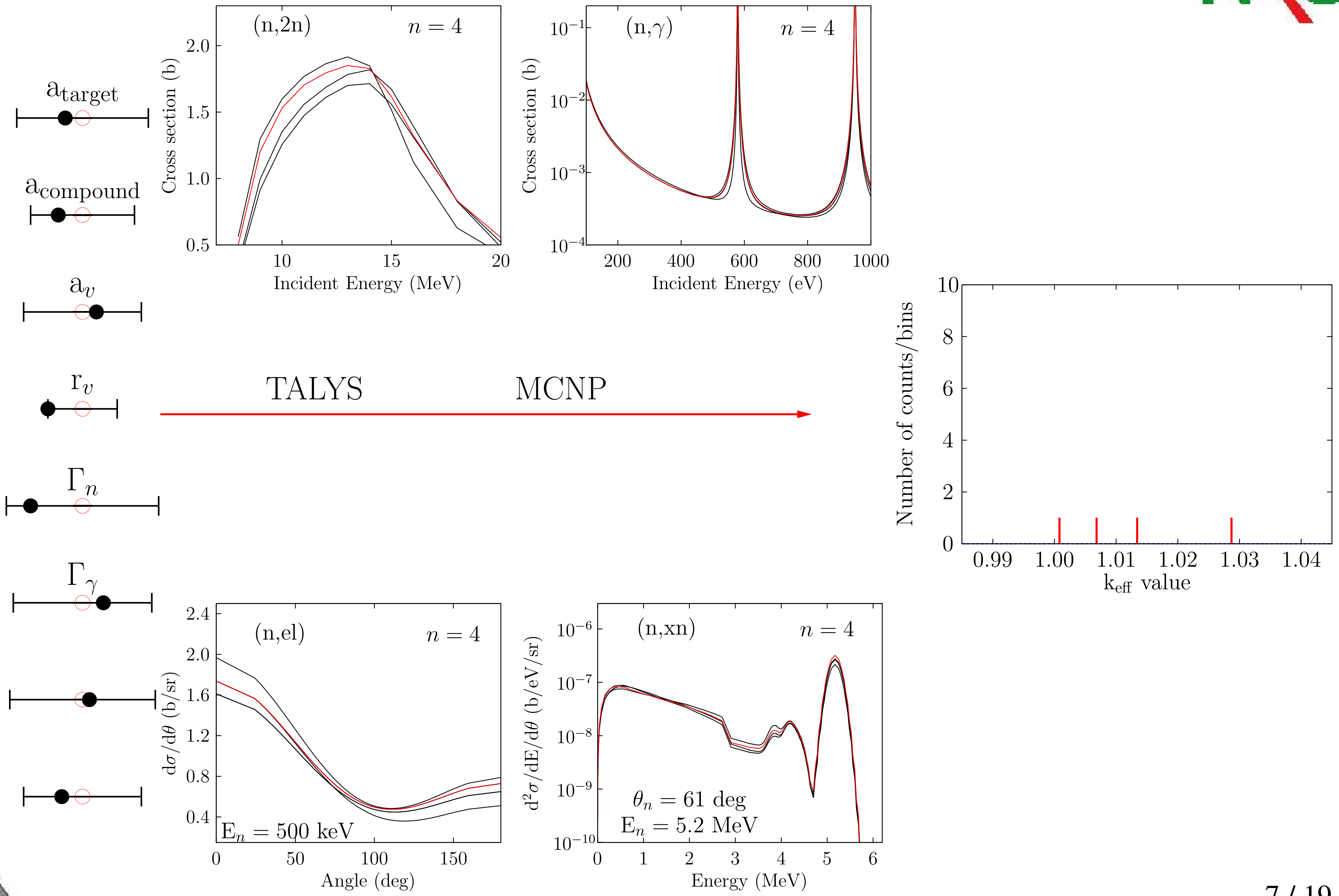

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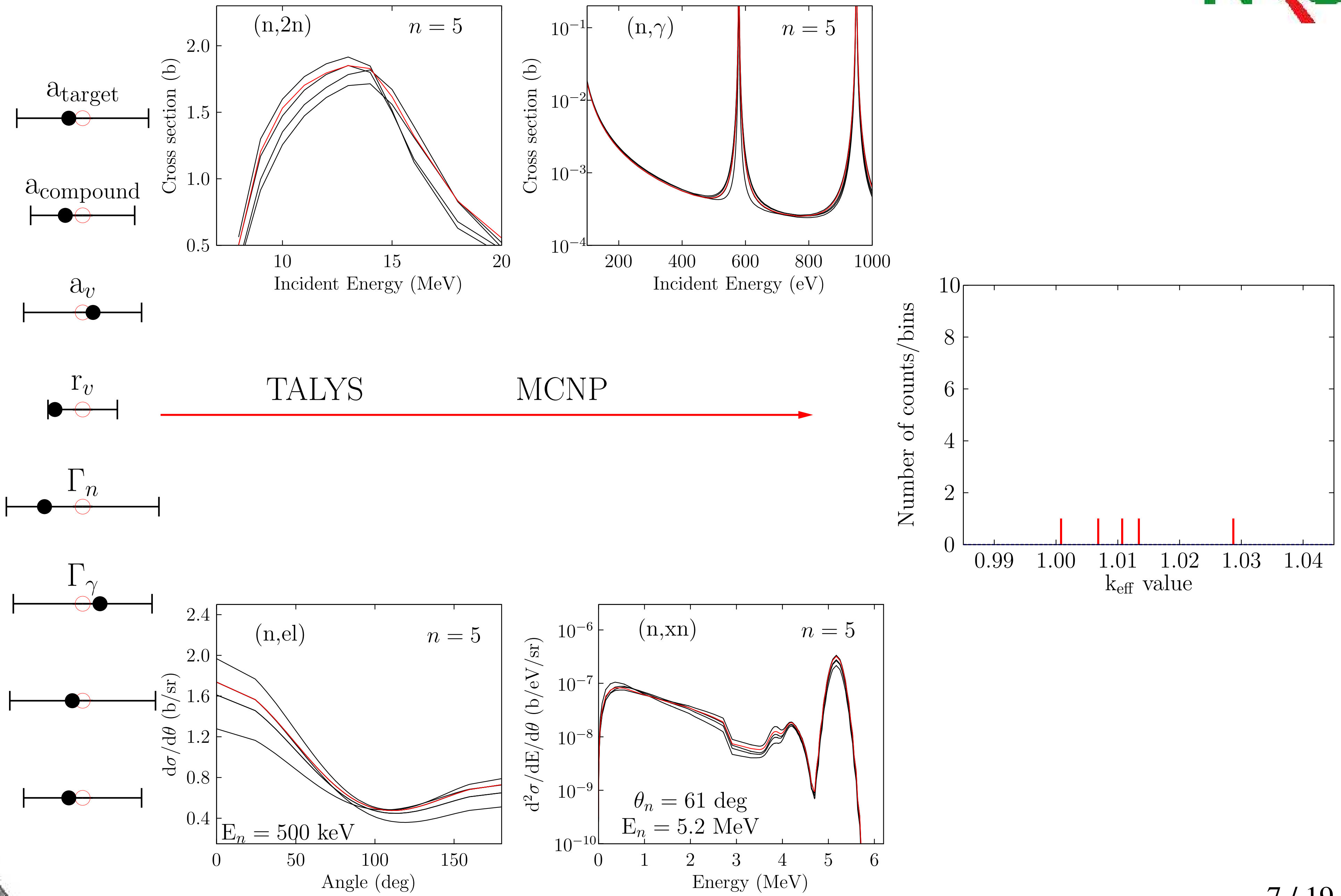

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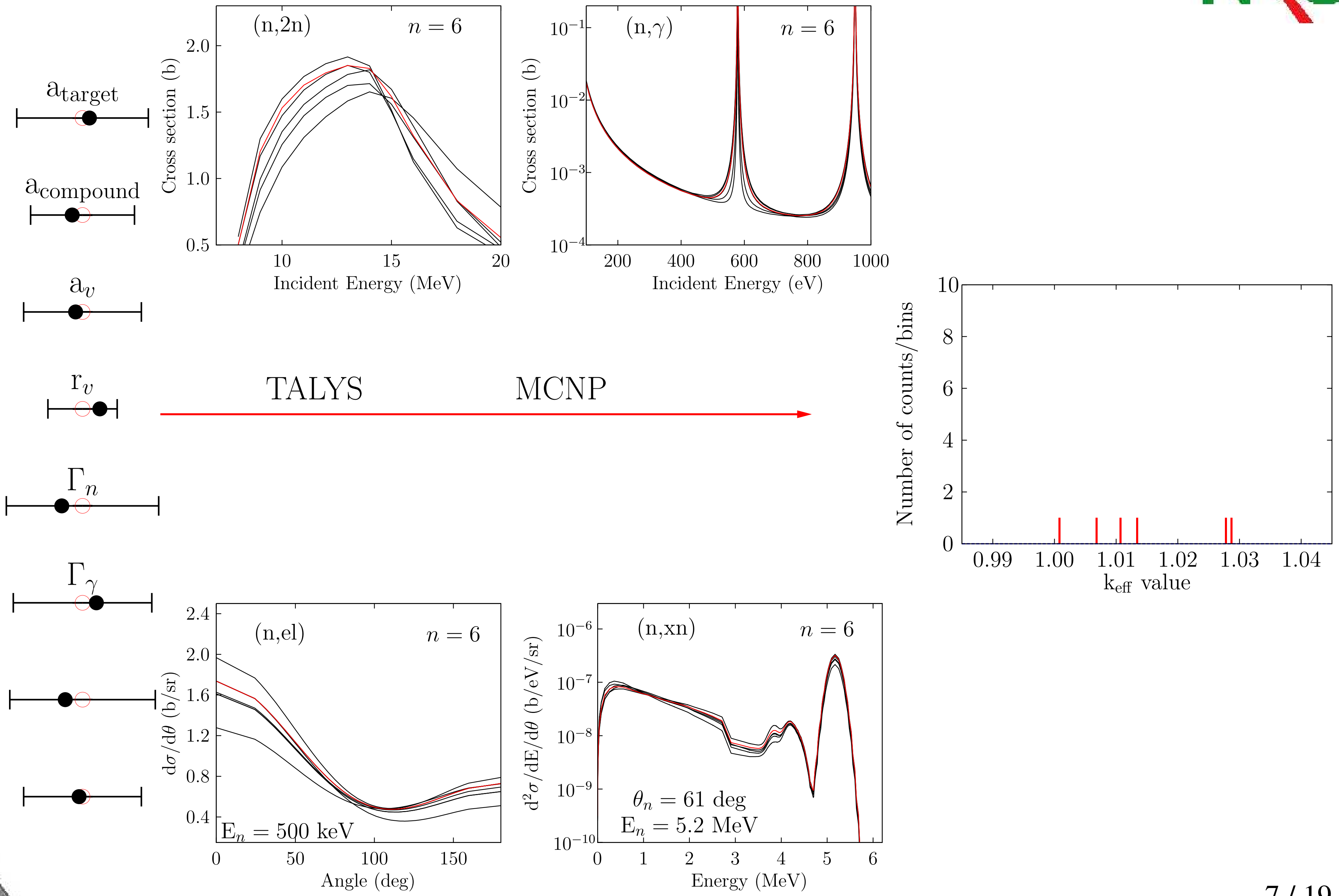

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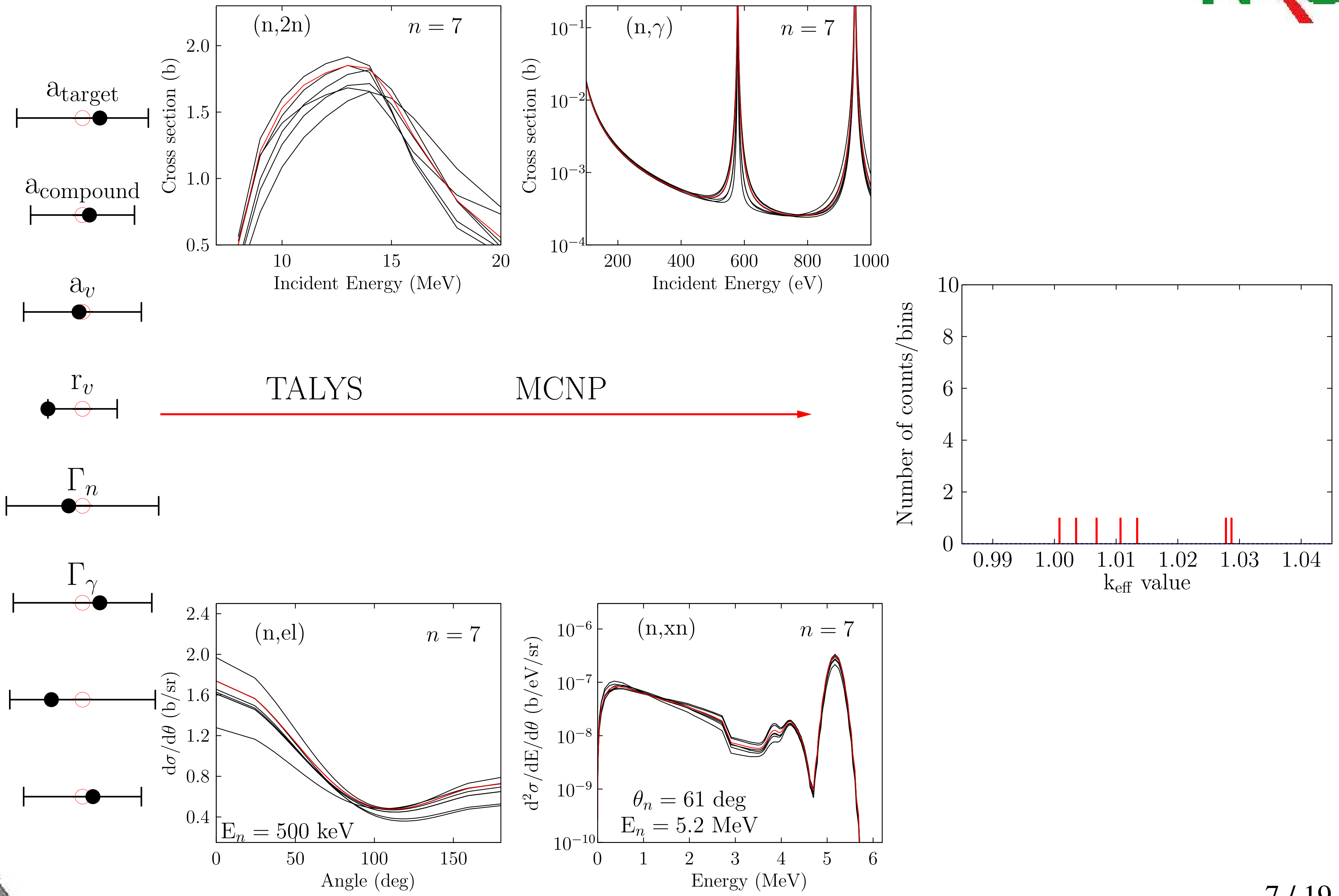

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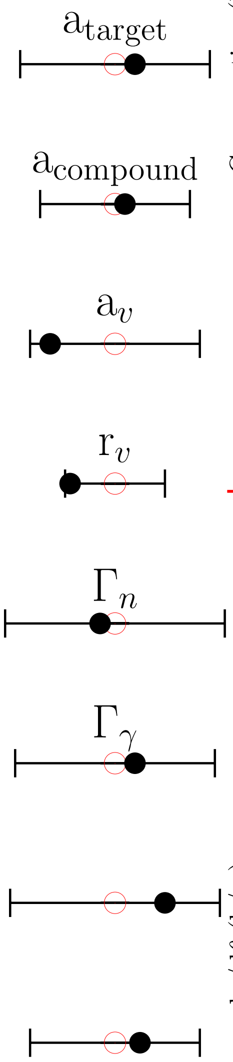

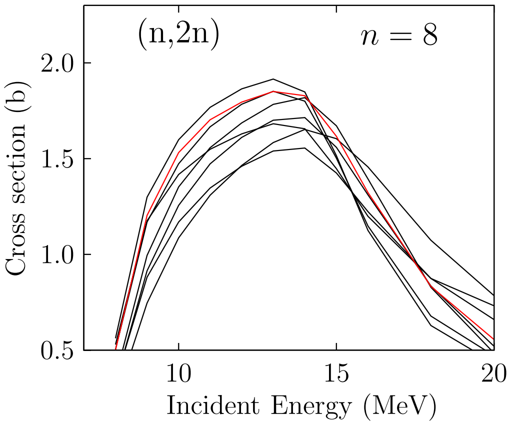

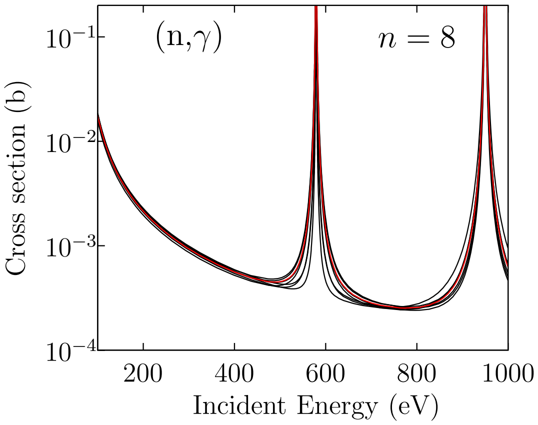

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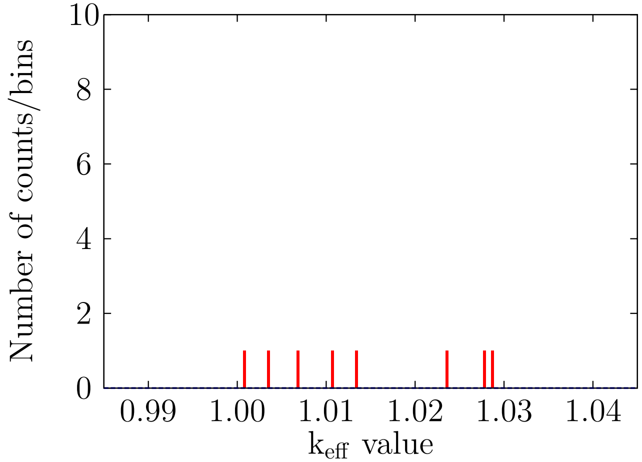

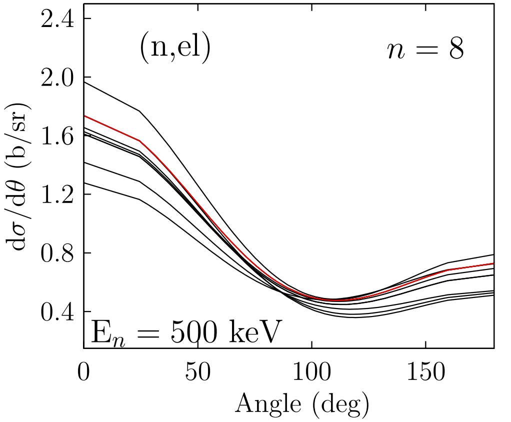

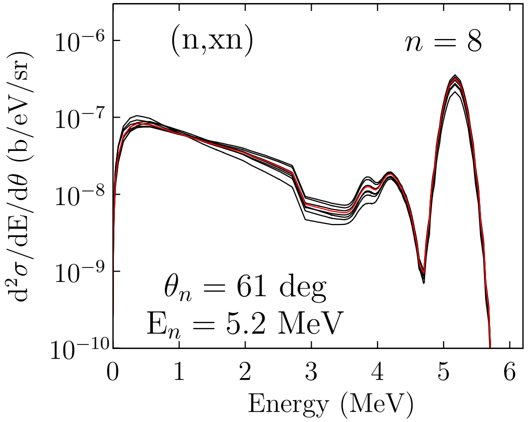

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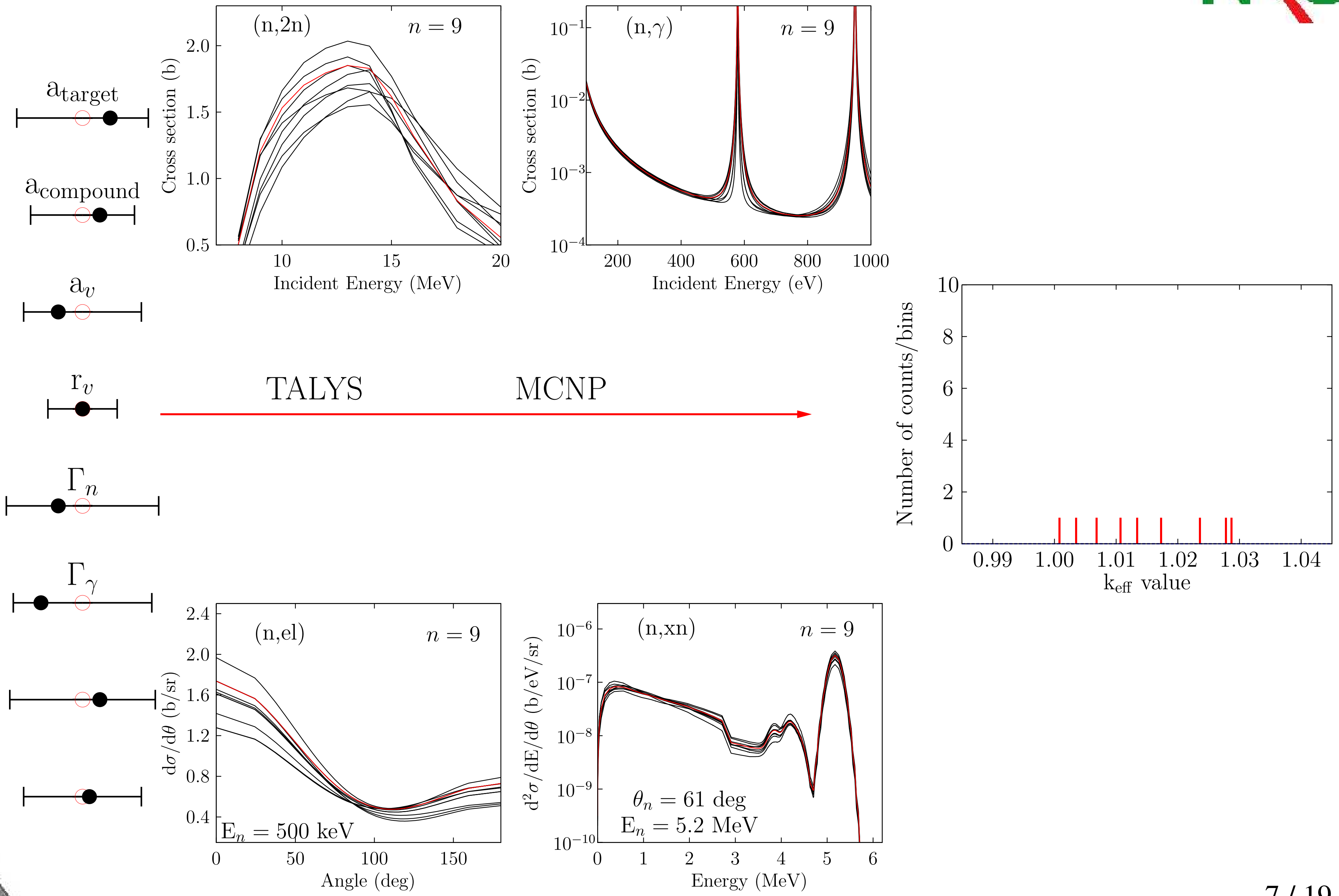

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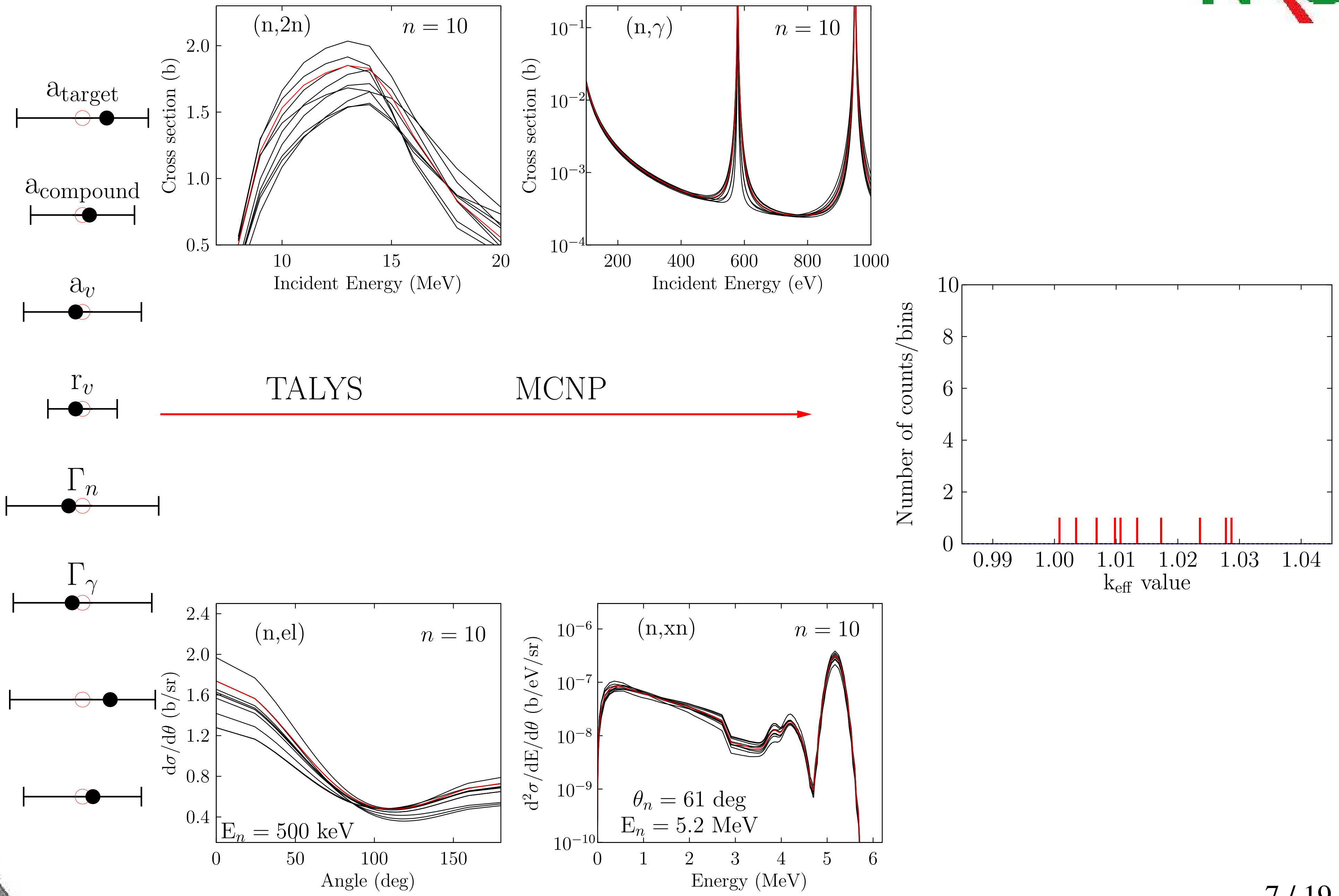

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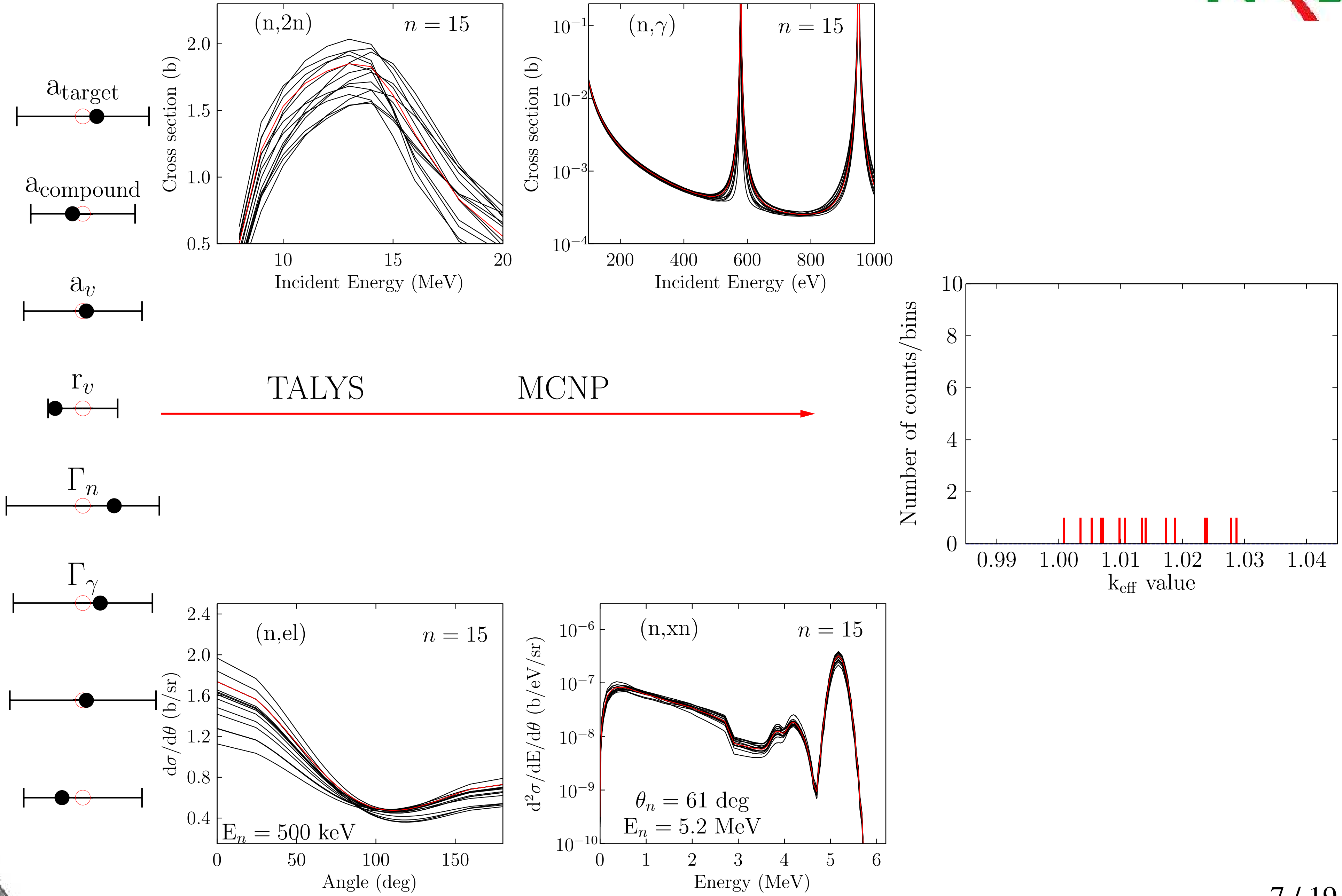

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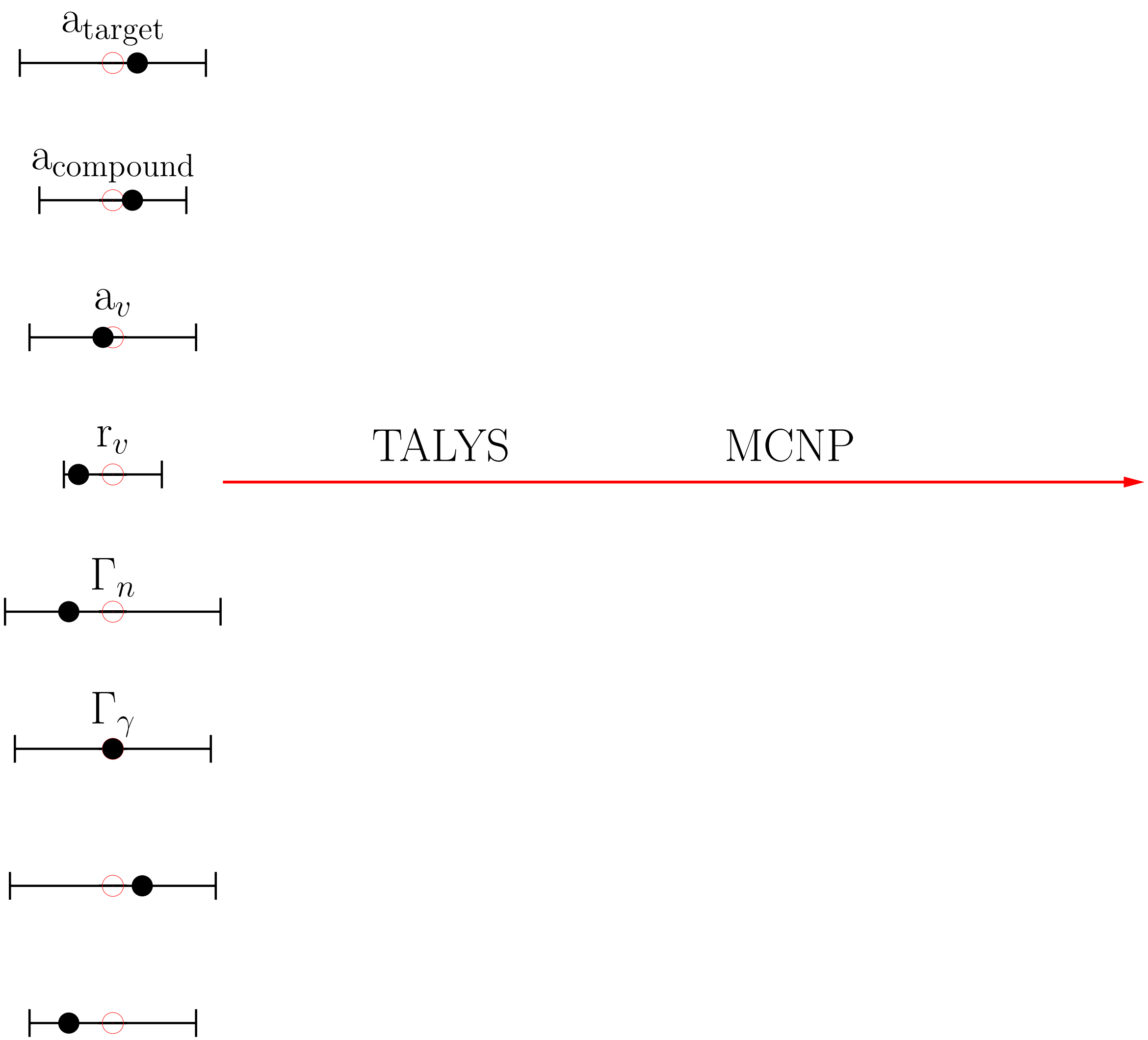
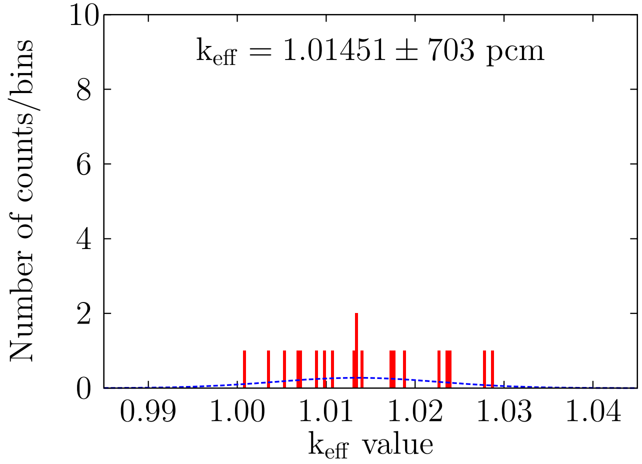


$n = 20$



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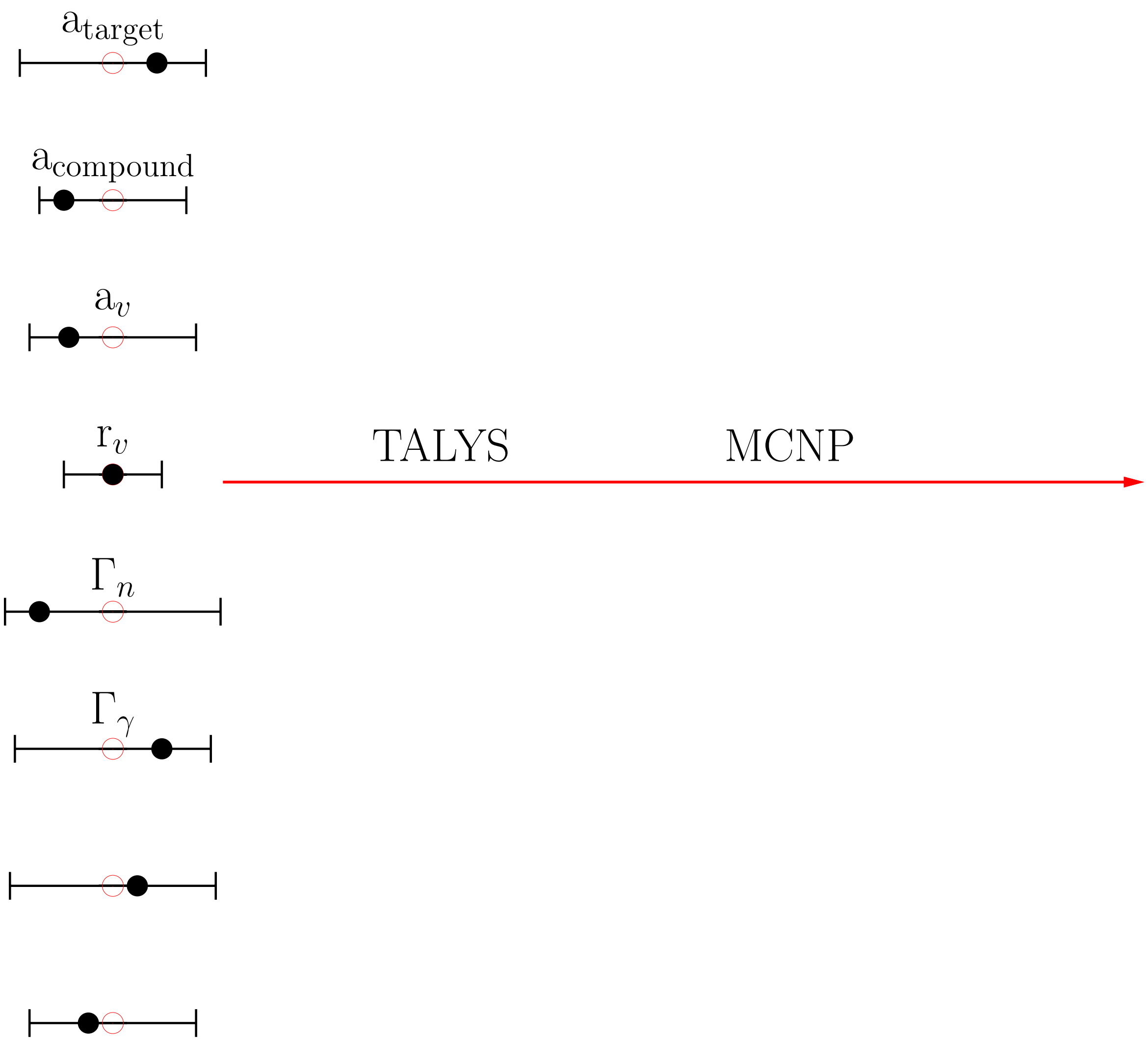


a_{target}

a_{compound}

a_v

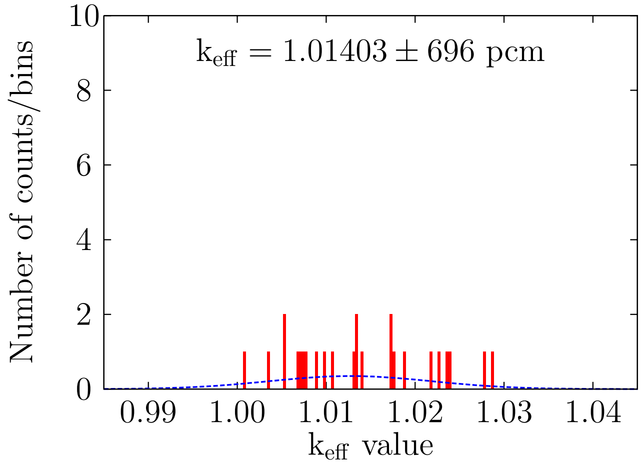
r_v

Γ_n

Γ_γ

TALYS MCNP

$n = 25$



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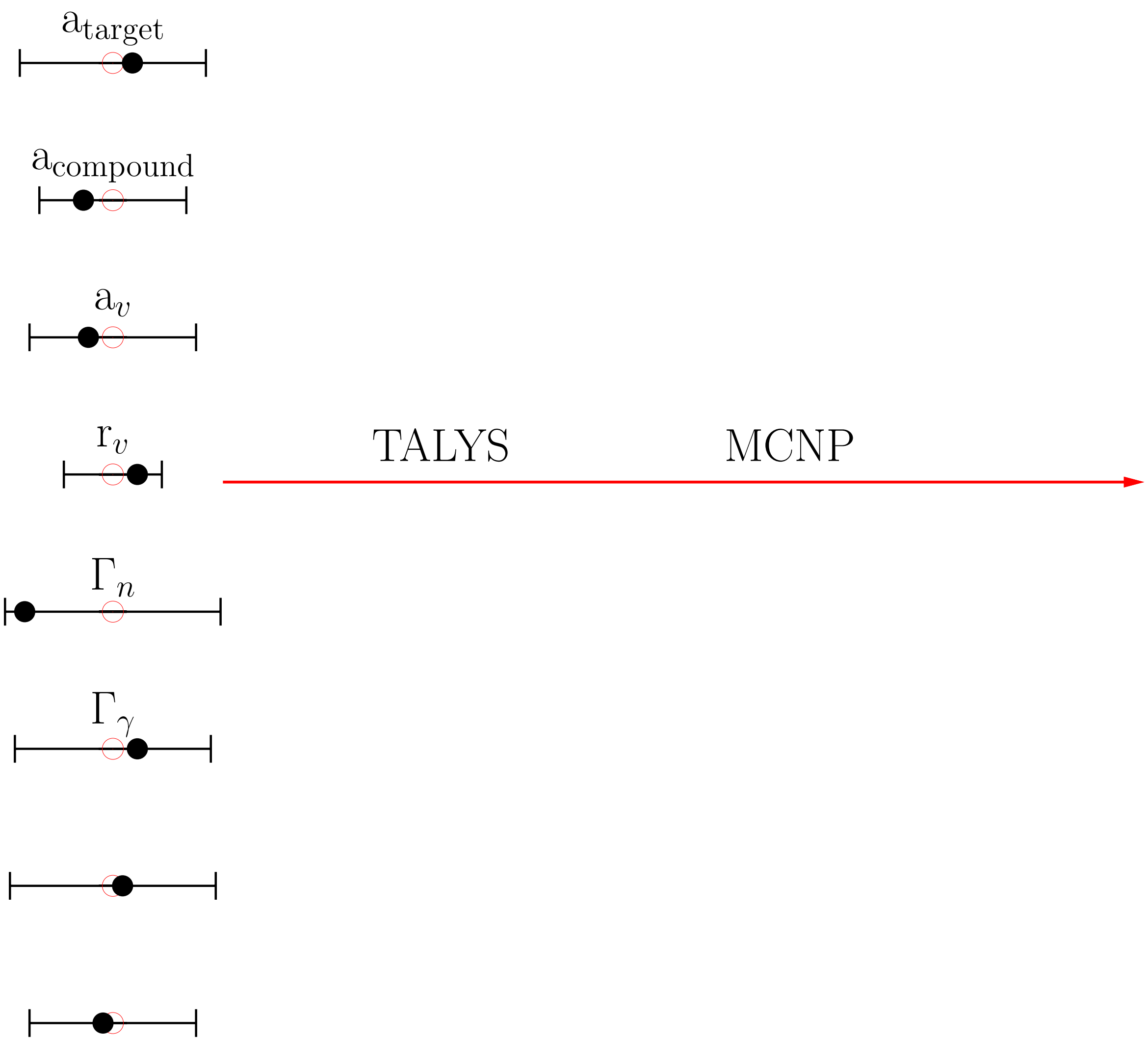
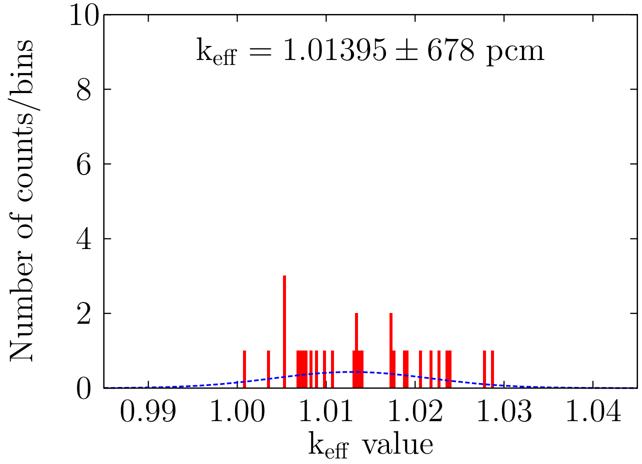


$n = 30$



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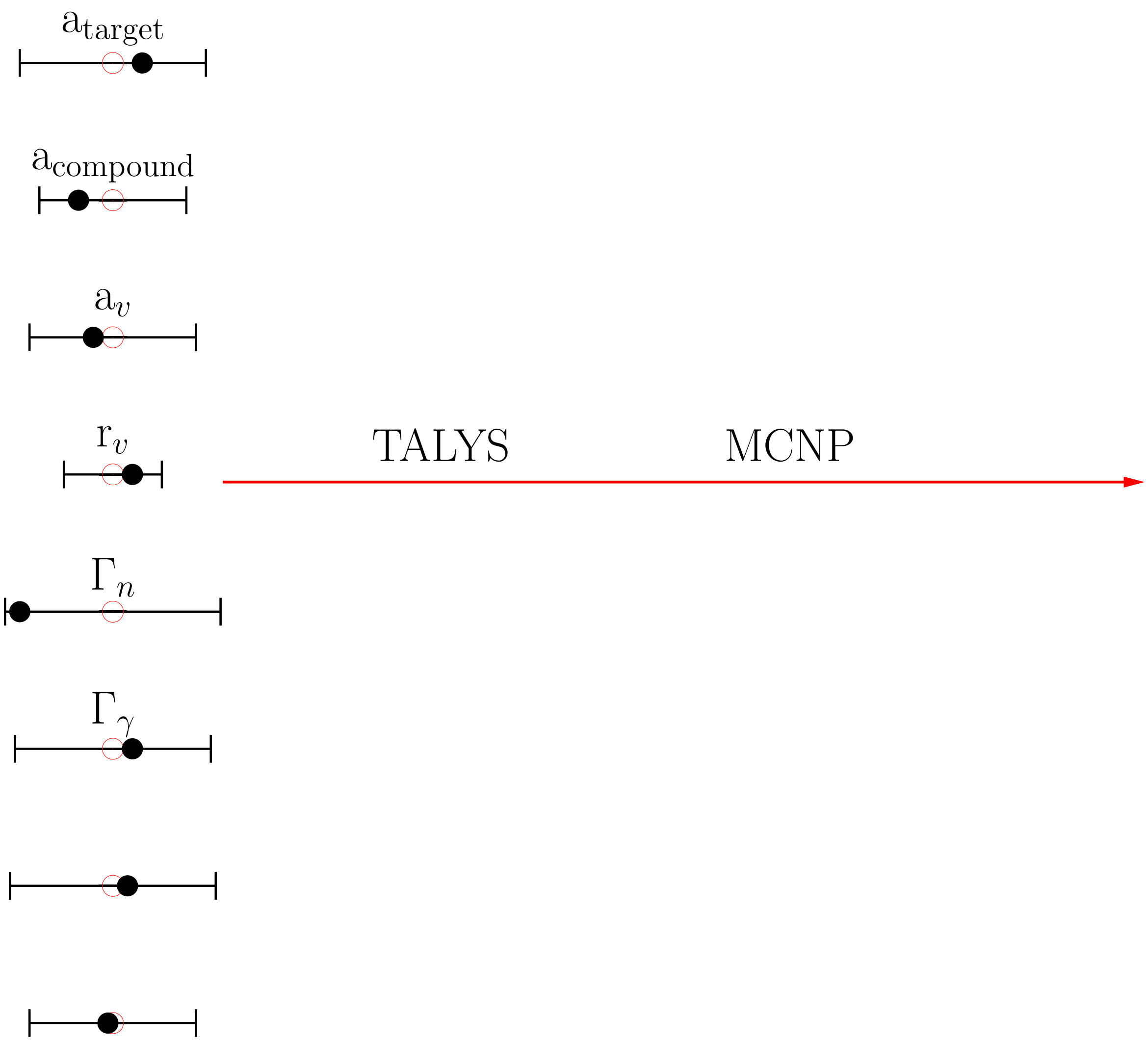
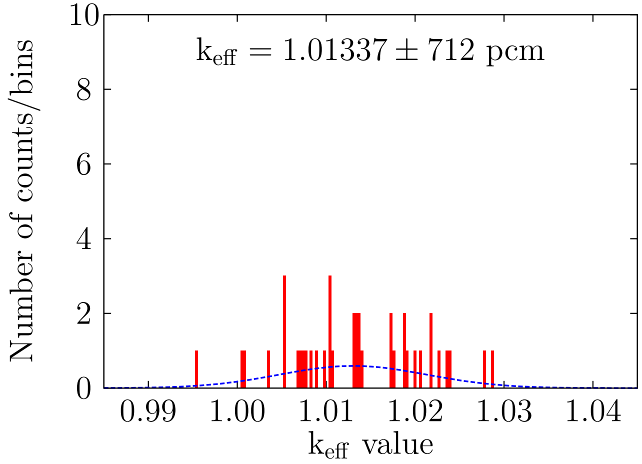


$n = 40$



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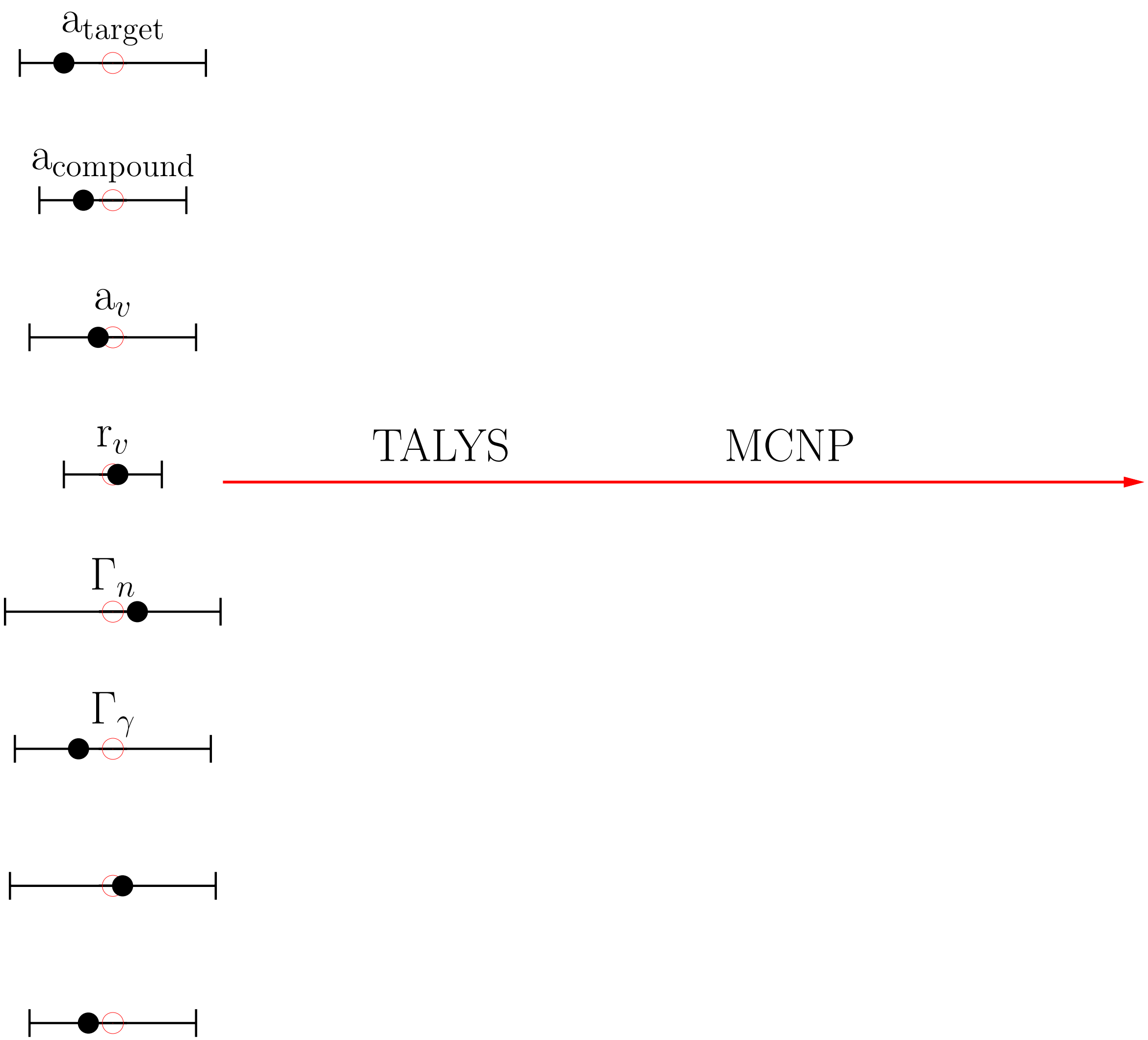
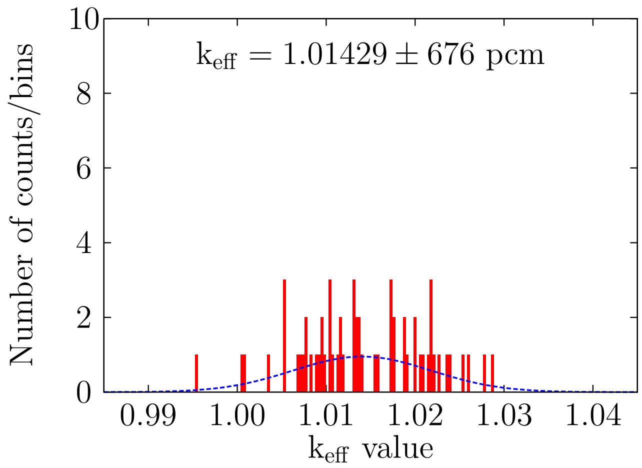


TALYS MCNP

$n = 60$



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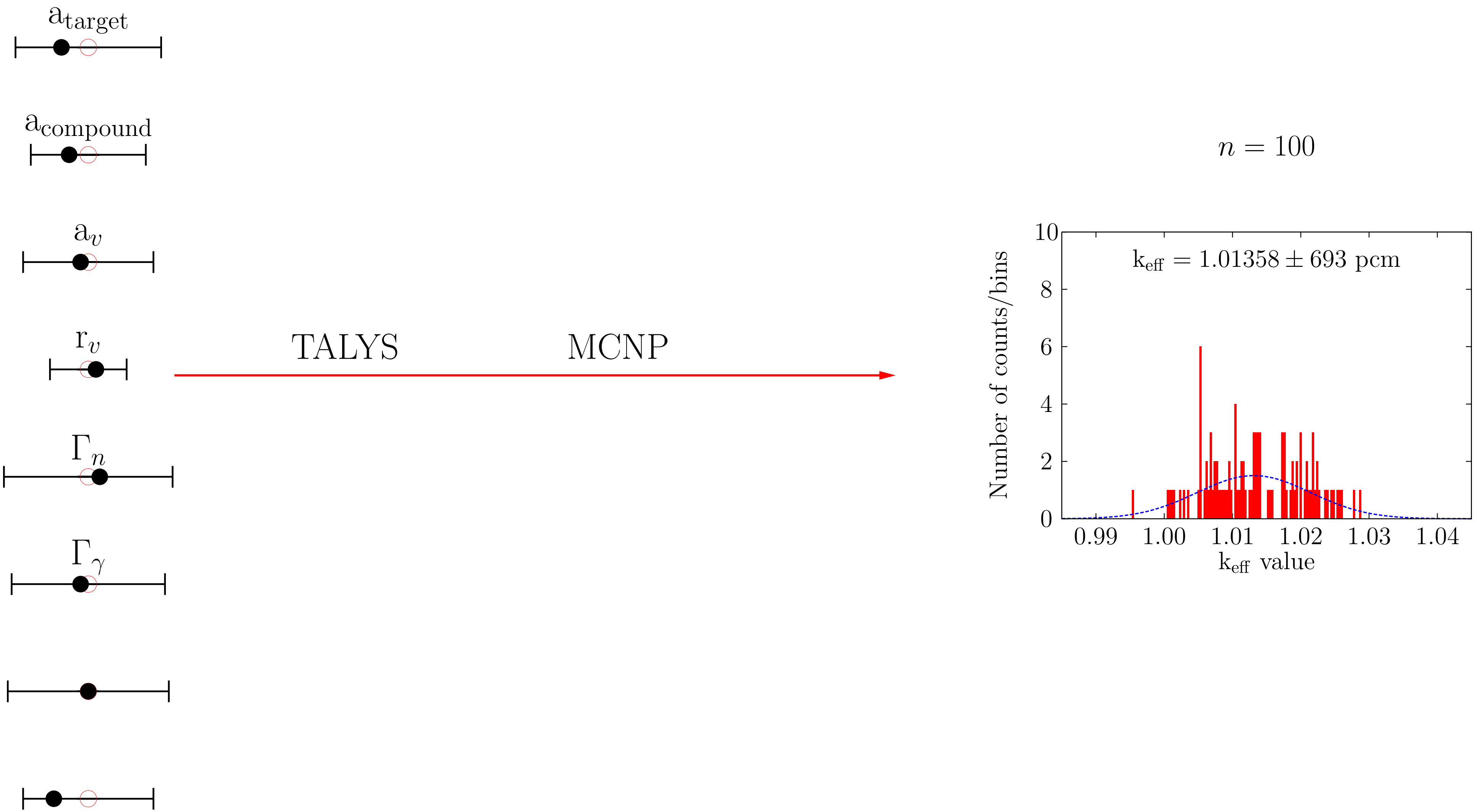

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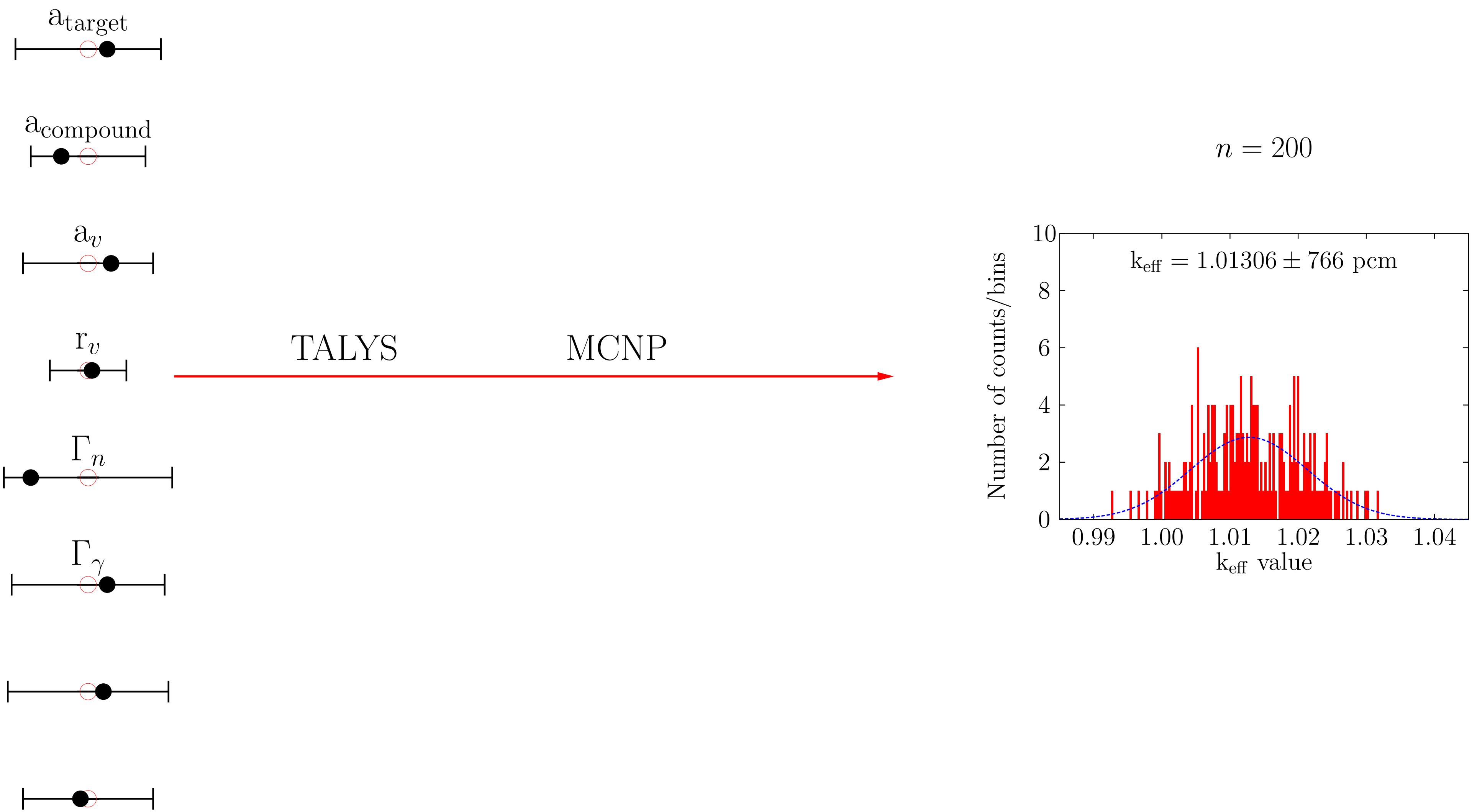

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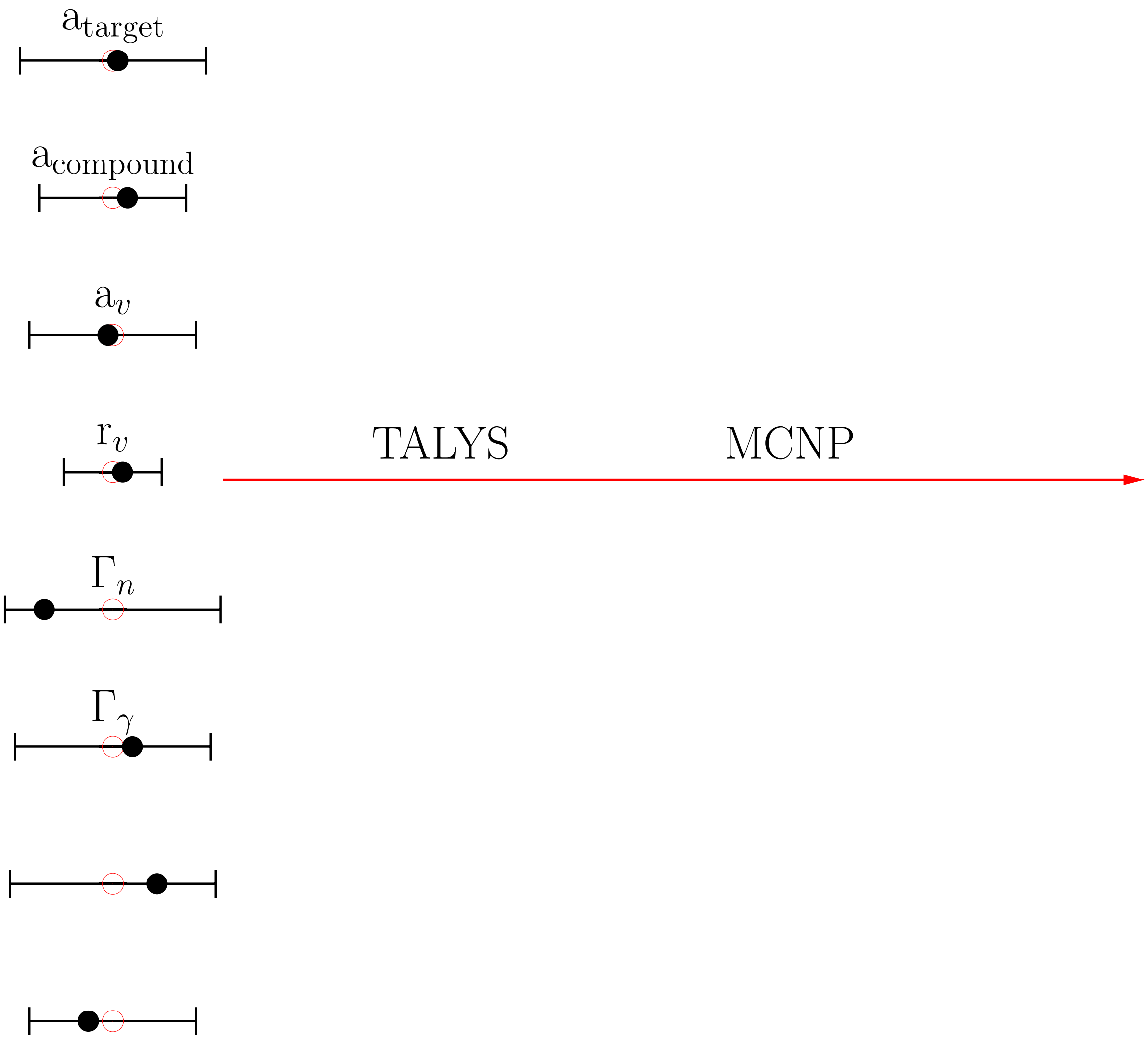
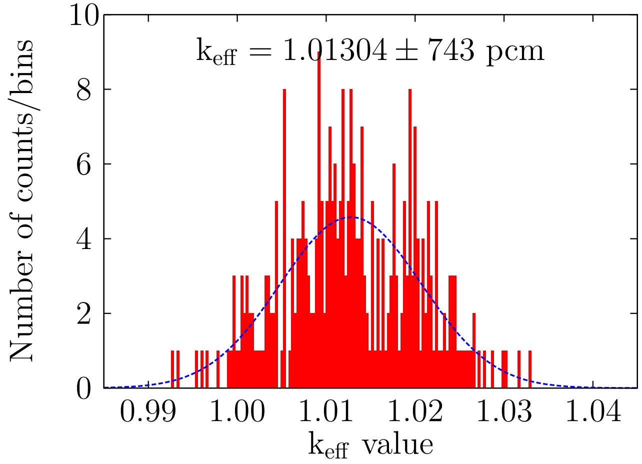


$n = 300$



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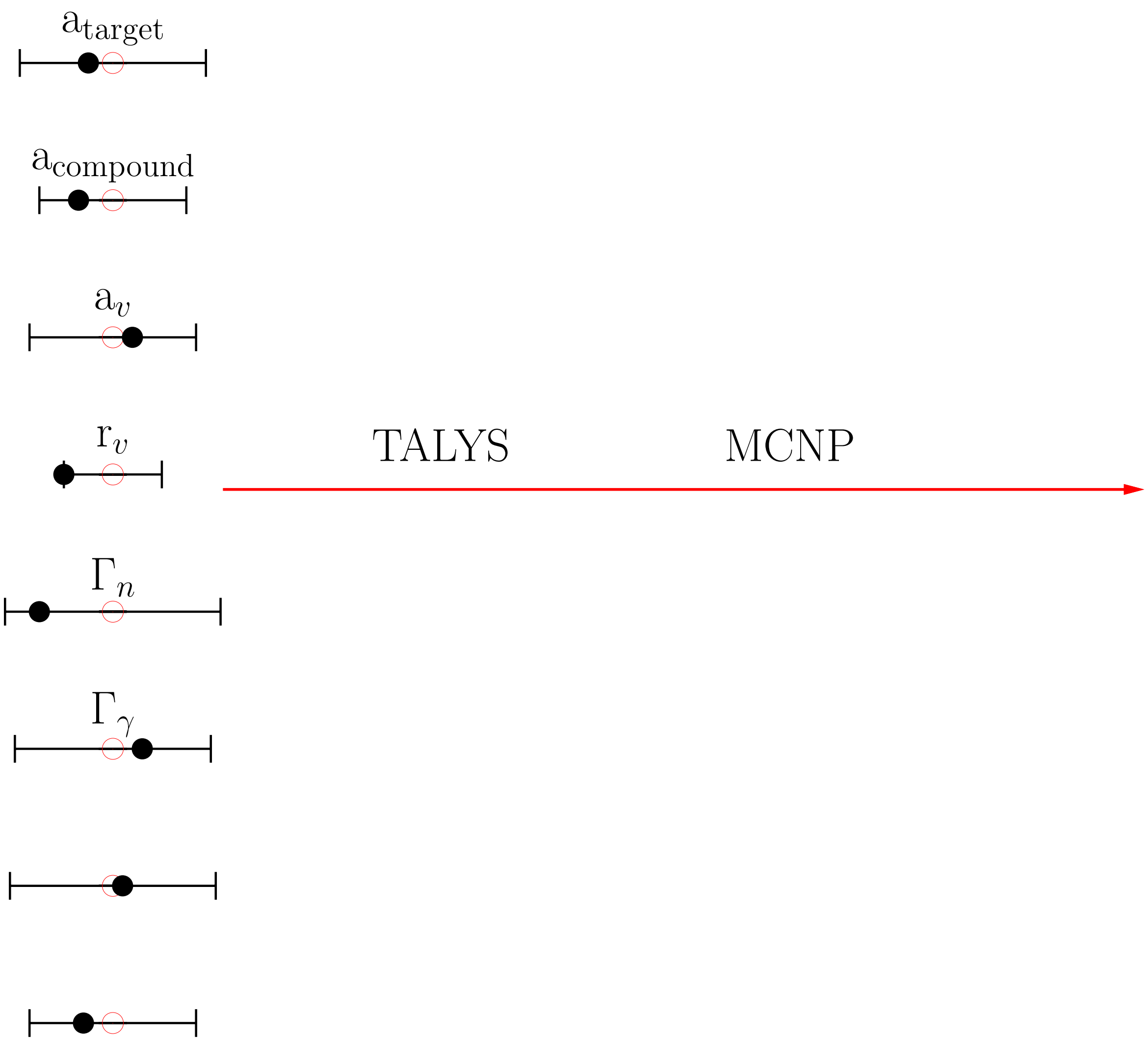

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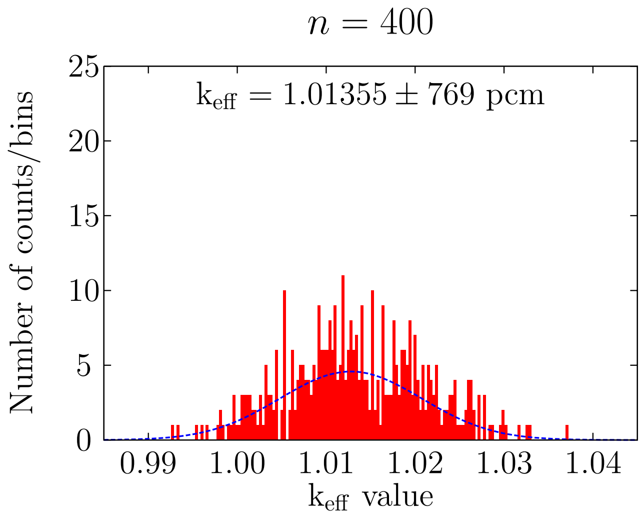

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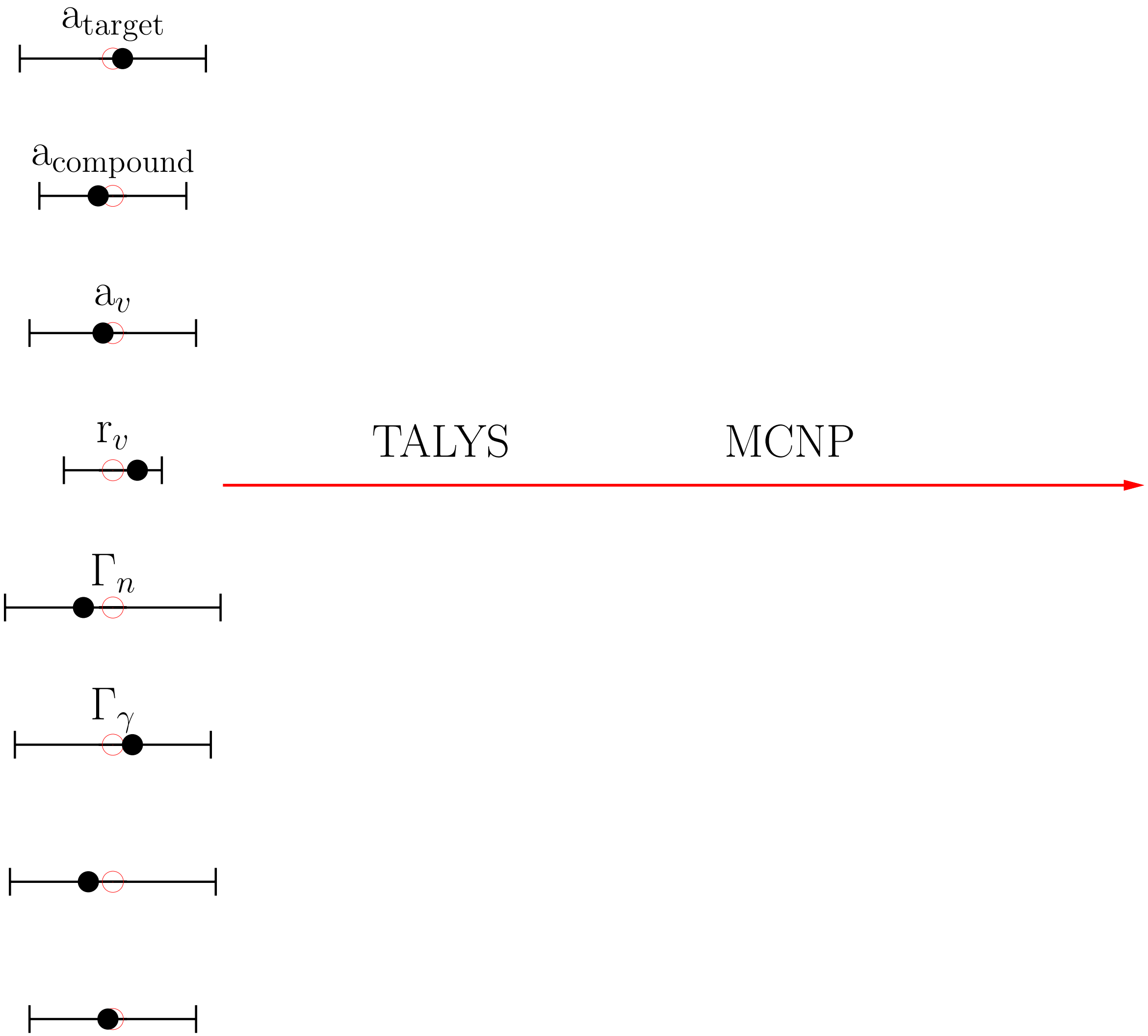

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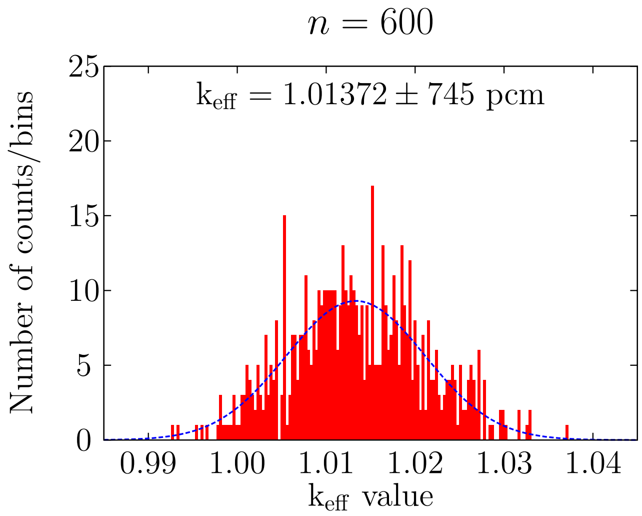

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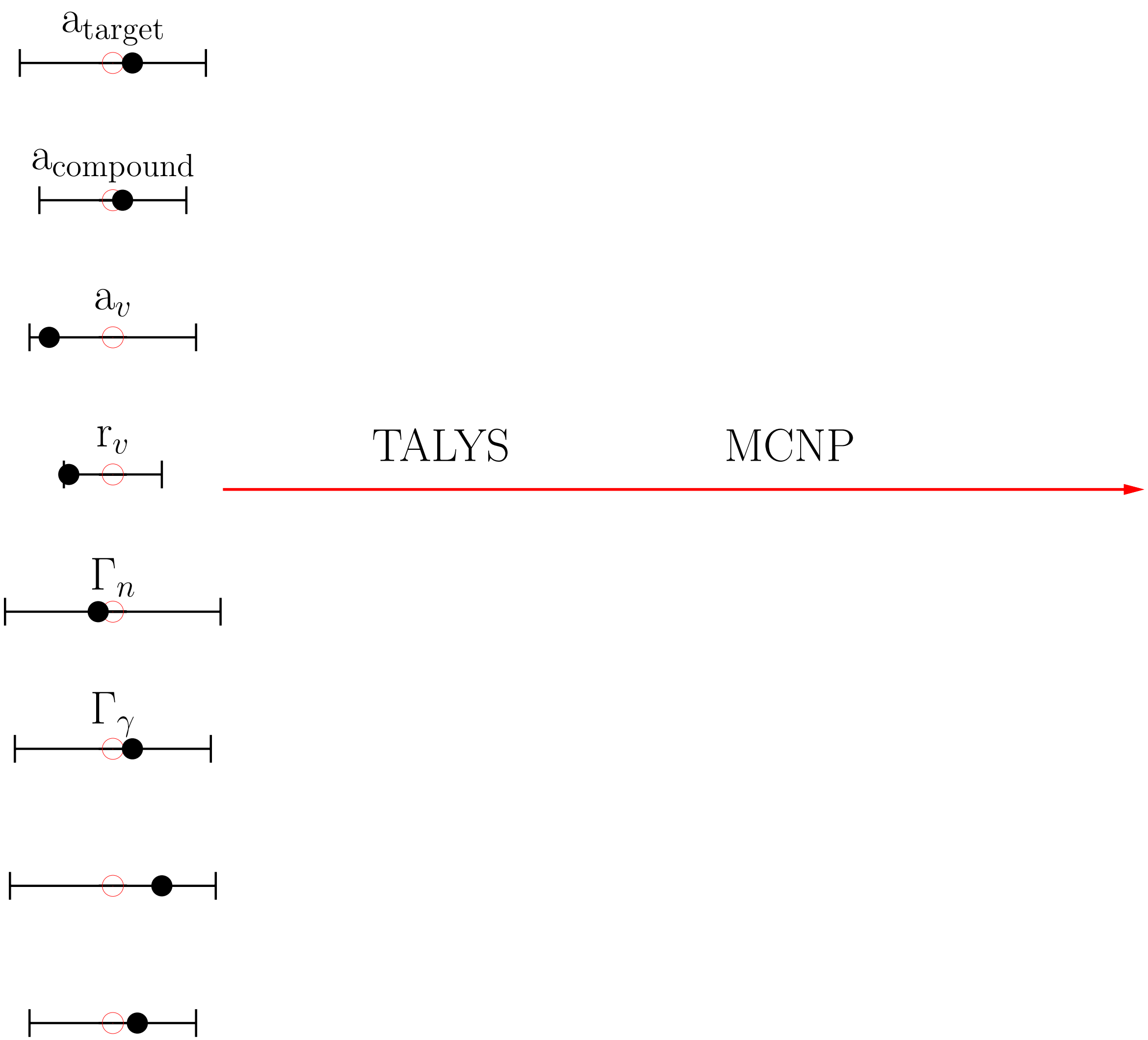

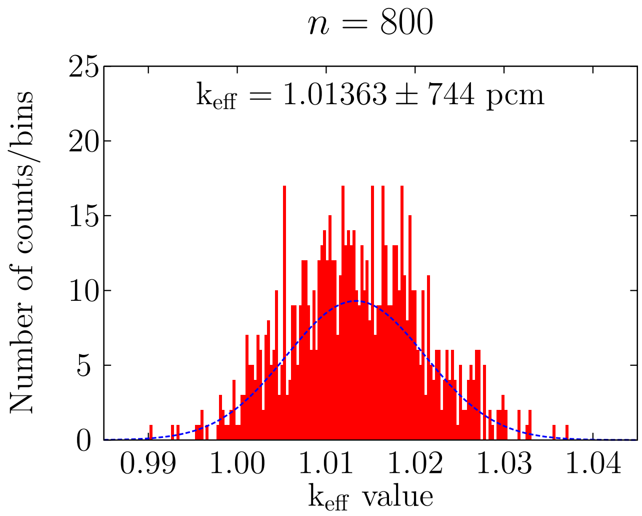

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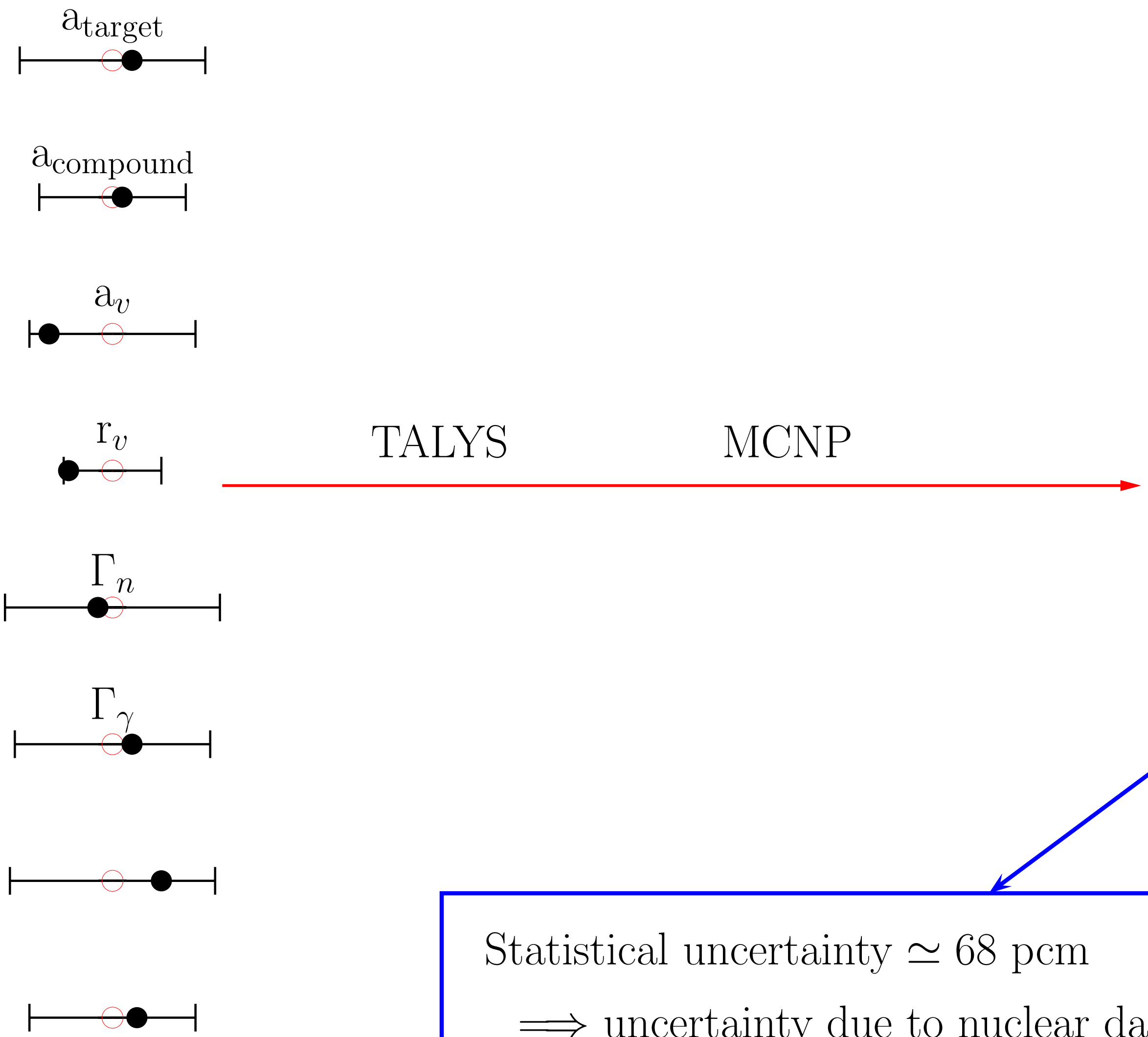

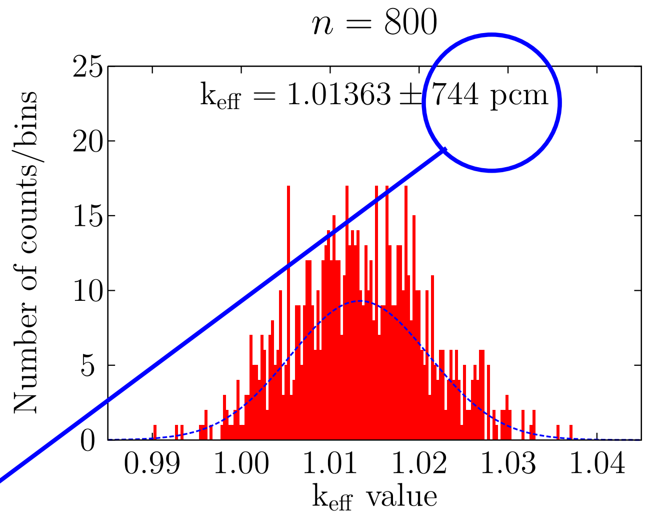

Statistical uncertainty $\simeq$ 68 pcm

$\Longrightarrow$ uncertainty due to nuclear data $\simeq$ 740 pcm

Examples with Pb isotopes

- Full evaluations for $^{204-208}$Pb (see NIM A589 (2008) 85 for evaluation)

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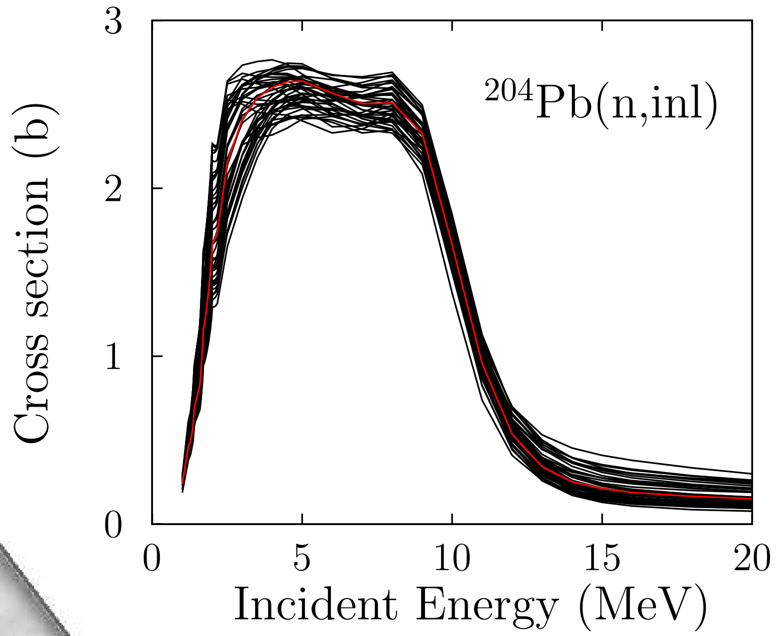

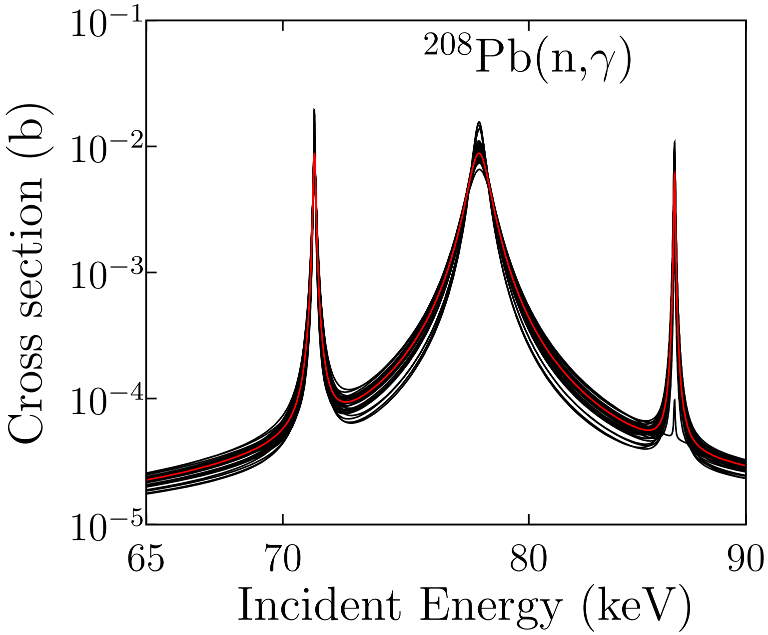

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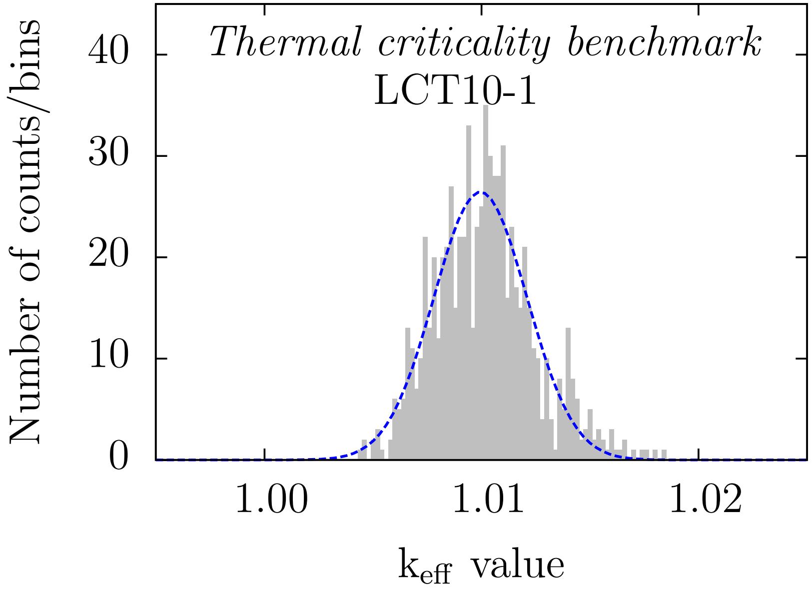

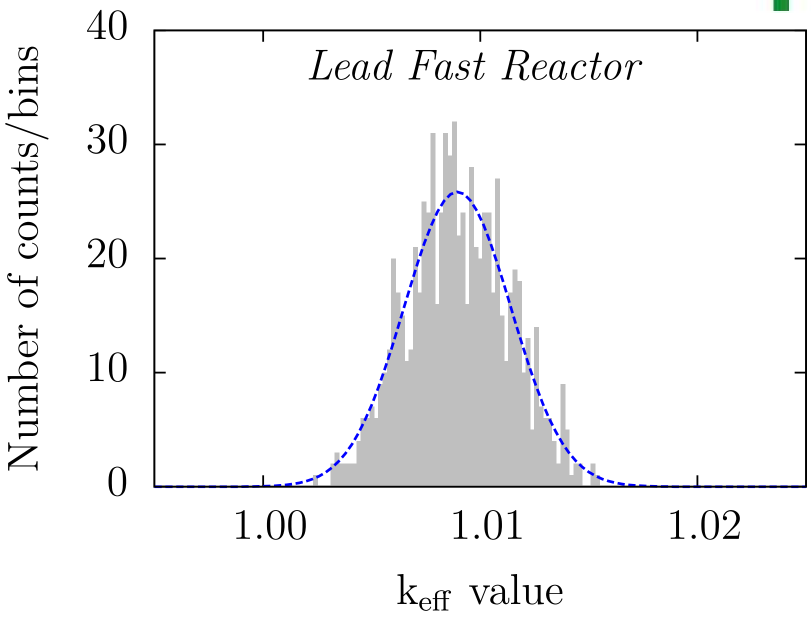

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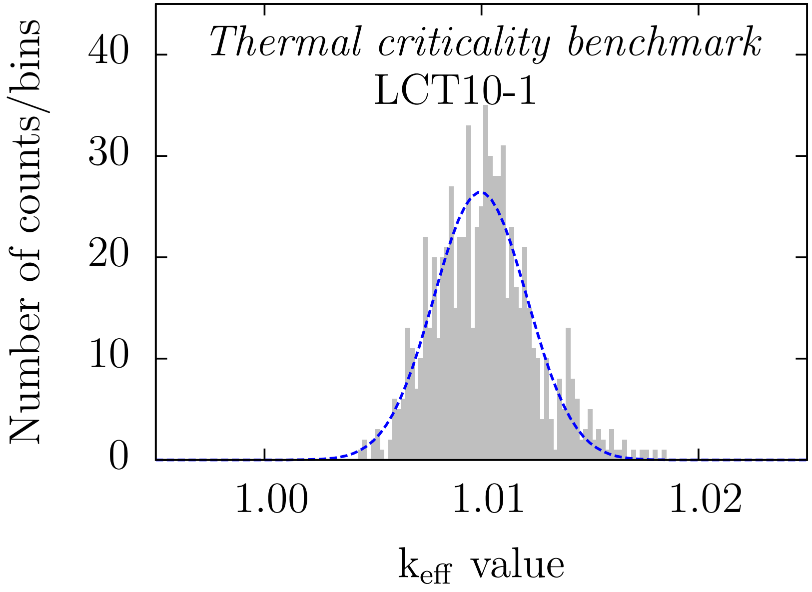
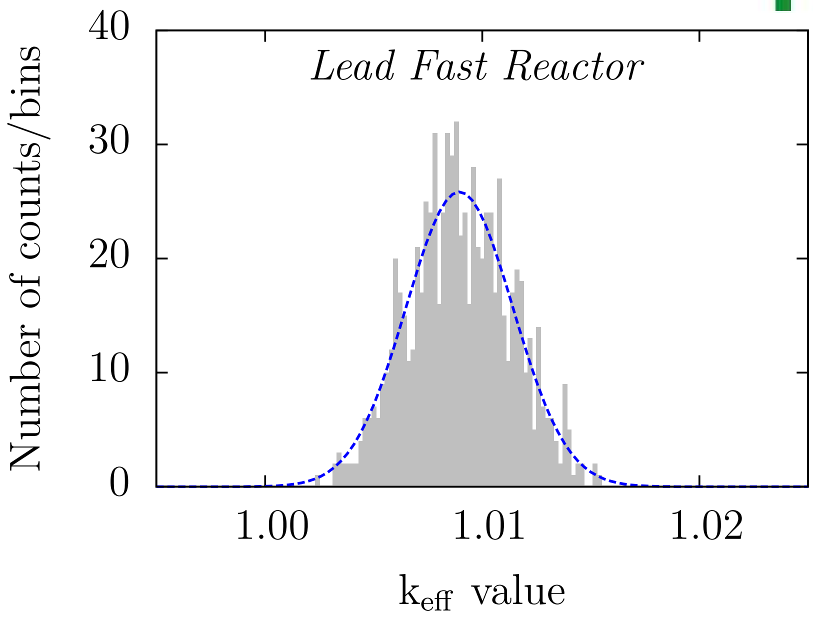
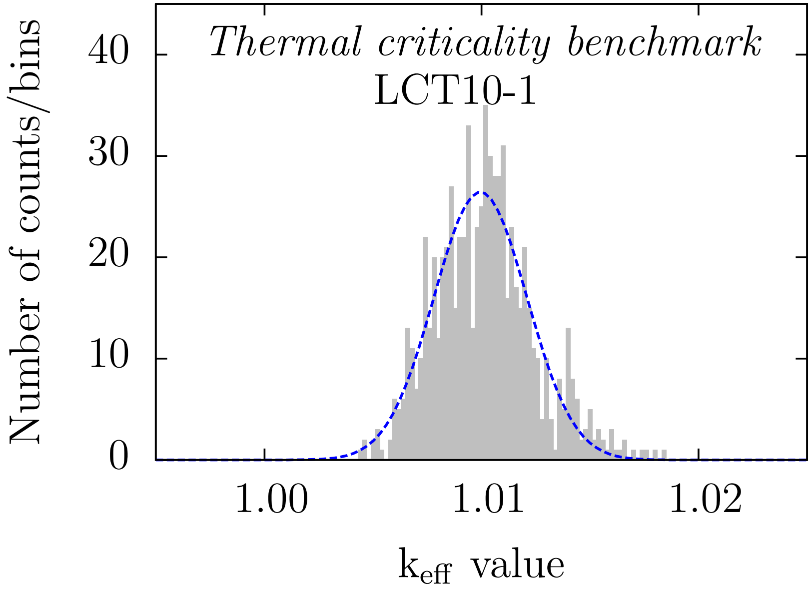
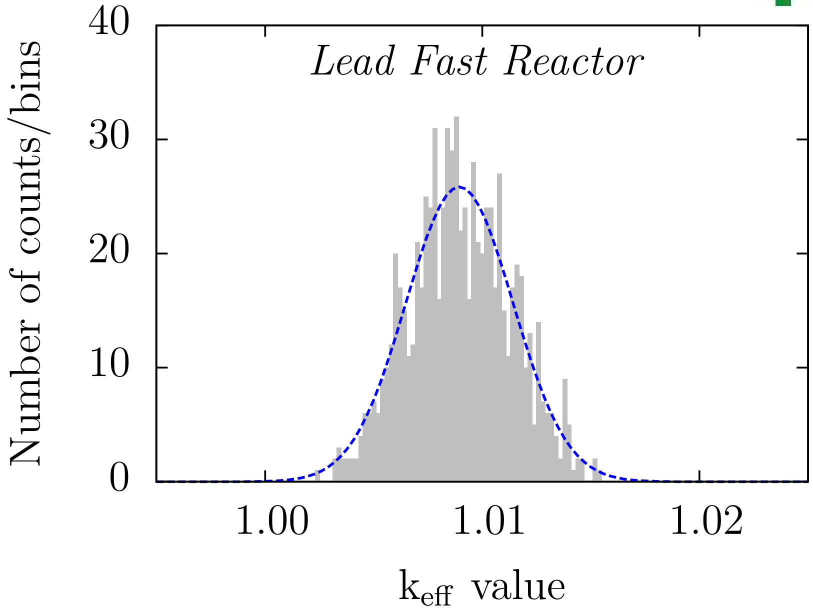




$k_{eff} = 1.01028 \pm$(60 pcm and 212 pcm) $k_{eff} = 1.00894 \pm$(60 pcm and 240 pcm)

Examples with Pb isotopes





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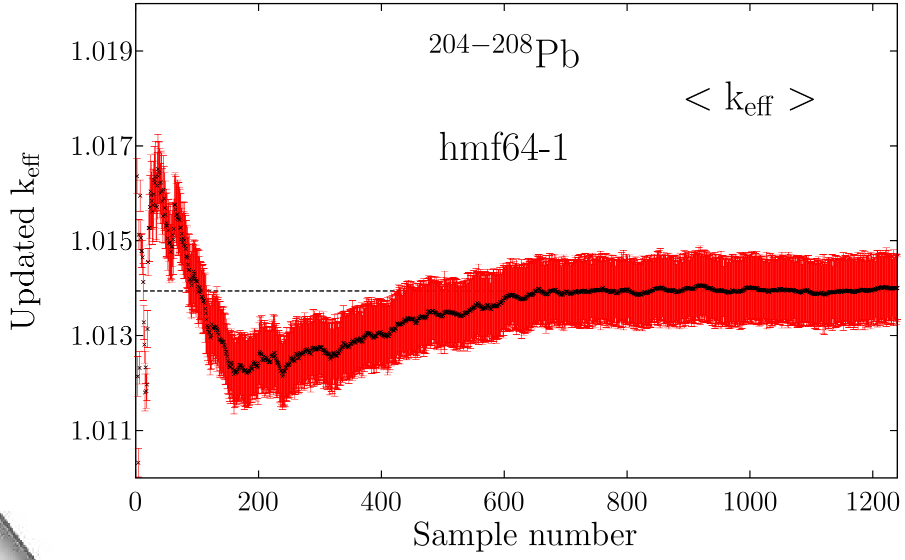

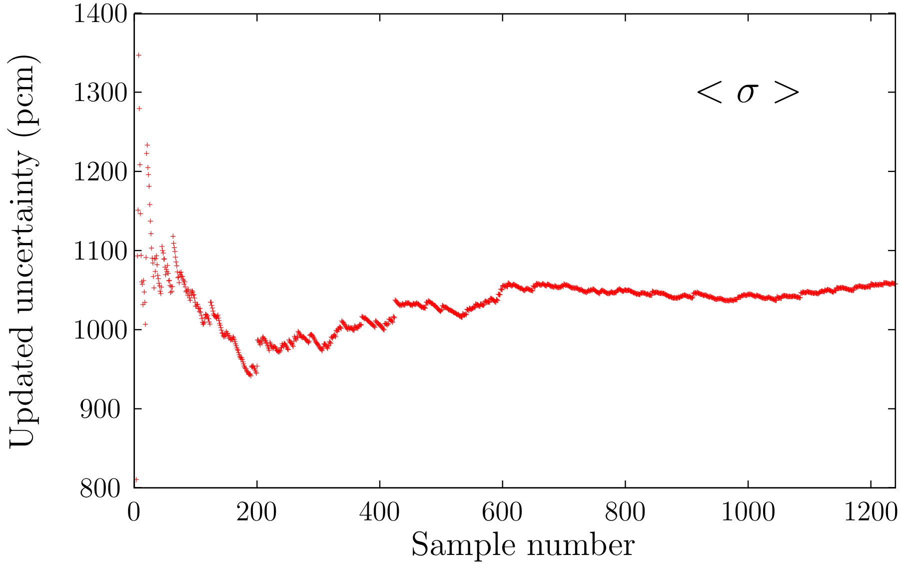

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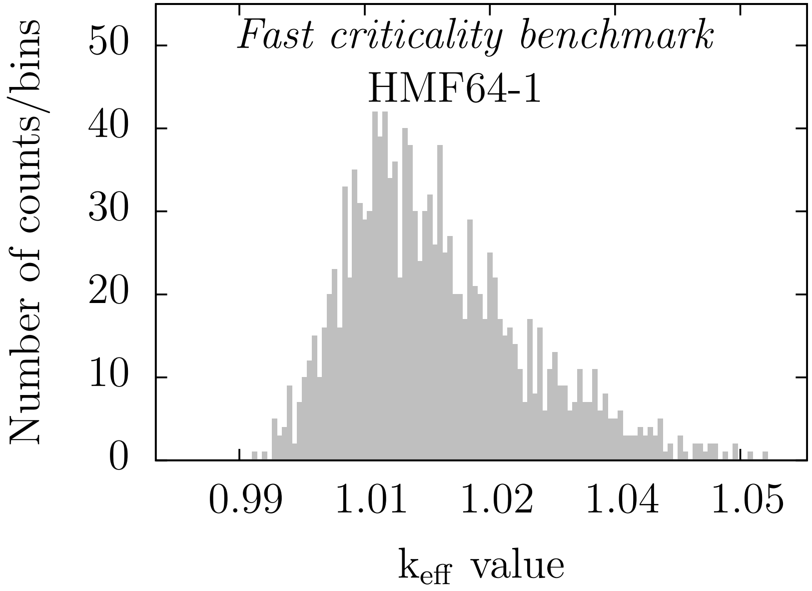

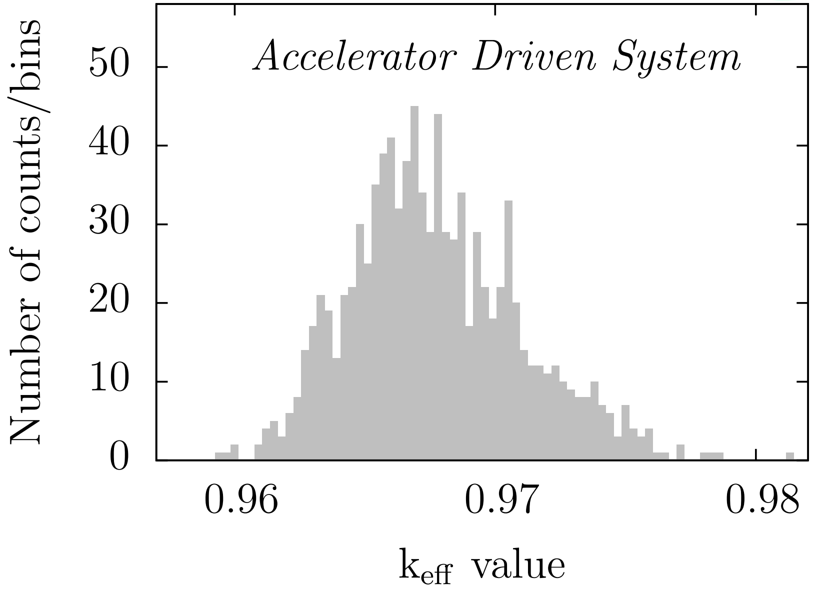

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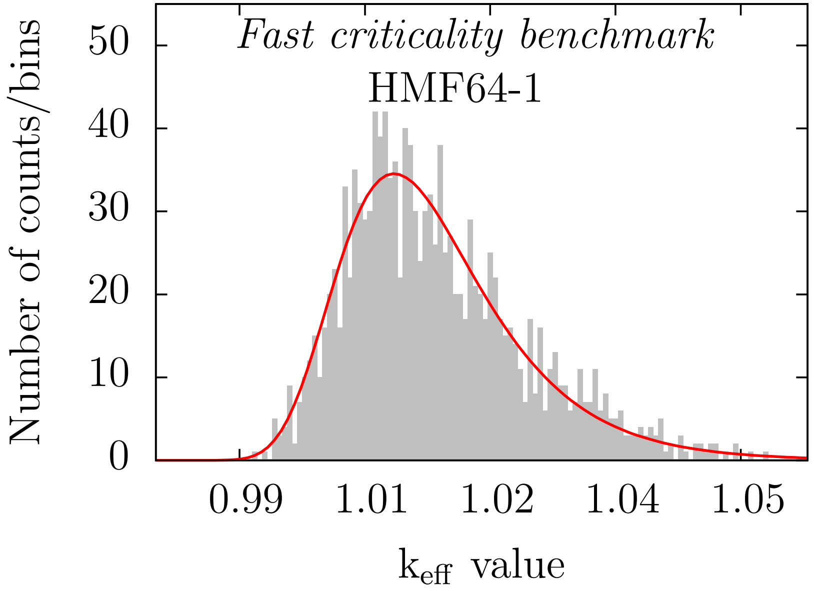

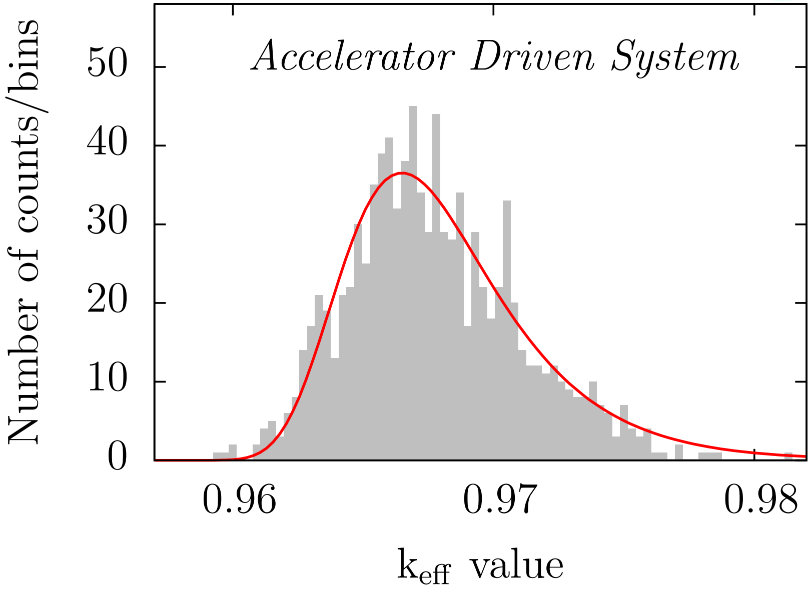

Better fit with the "*Extreme Value Theory*", or EVT:

$F(z) = e^{-z-e^{-z}}$ with $z = \frac{X-\mu}{\sigma}$

Mean $\mu' = \mu + \gamma\sigma$

Standard Deviation $\sigma' = \sigma\frac{\pi}{\sqrt{6}}$

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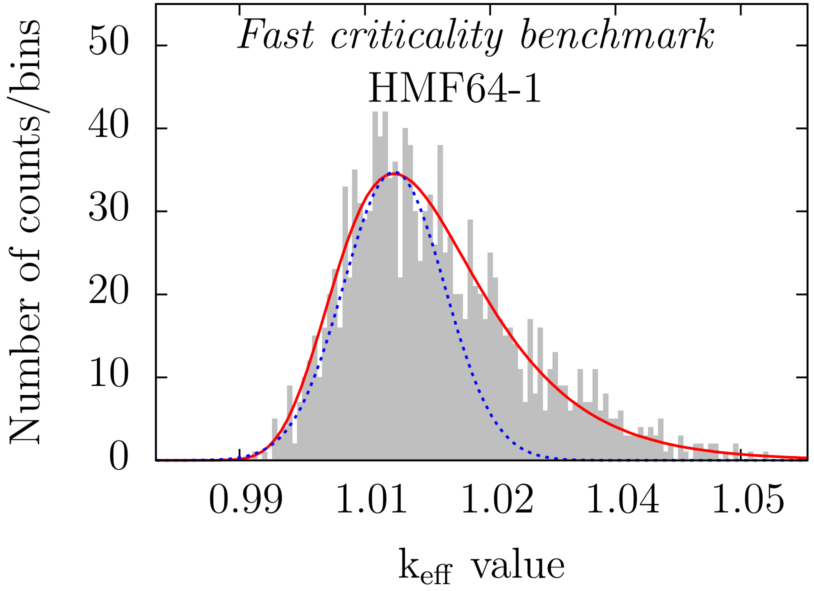

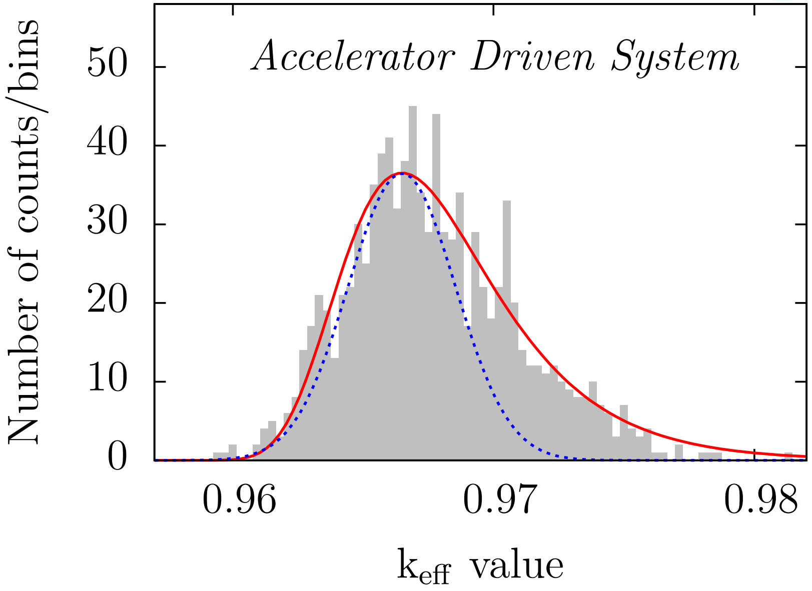

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	HMF-64.1	ADS
k$_{\text{eff}}$	1.00848 μ'=1.01394	0.96648 μ'=0.96785
$\sigma_k \times 10^5$	**855** **σ'=1097**	**291** **σ'=345**

Why not a Normal distribution for k_{eff} ?

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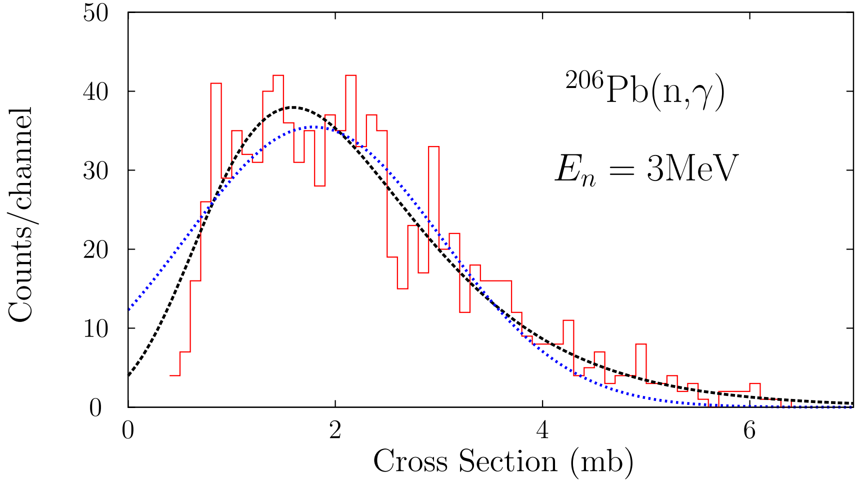
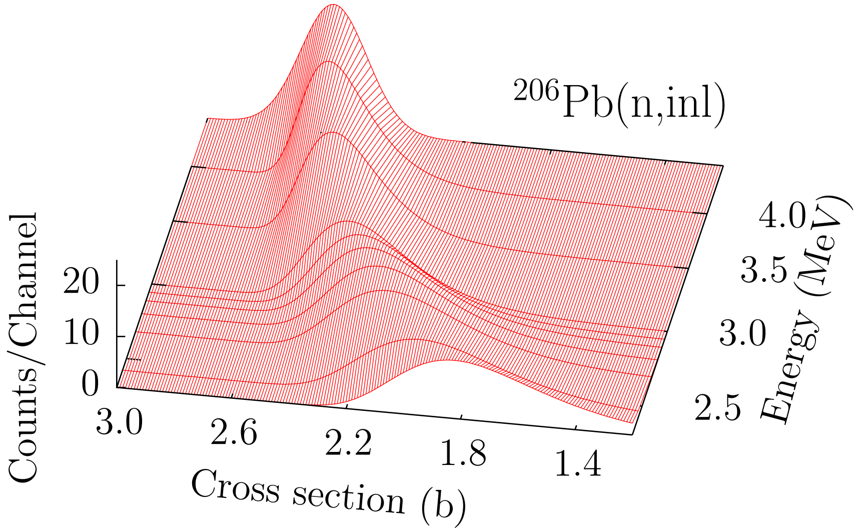
(2) Cross sections do not follow a Gaussian distribution:





Any safety related issue regarding high k_{eff} tail ?

Global calculations: from ^{19}F to ^{208}Pb

“In general, this paper will or will not be a breakthrough in methodology if the [practicality and robustness] can or can not be demonstrated.”,

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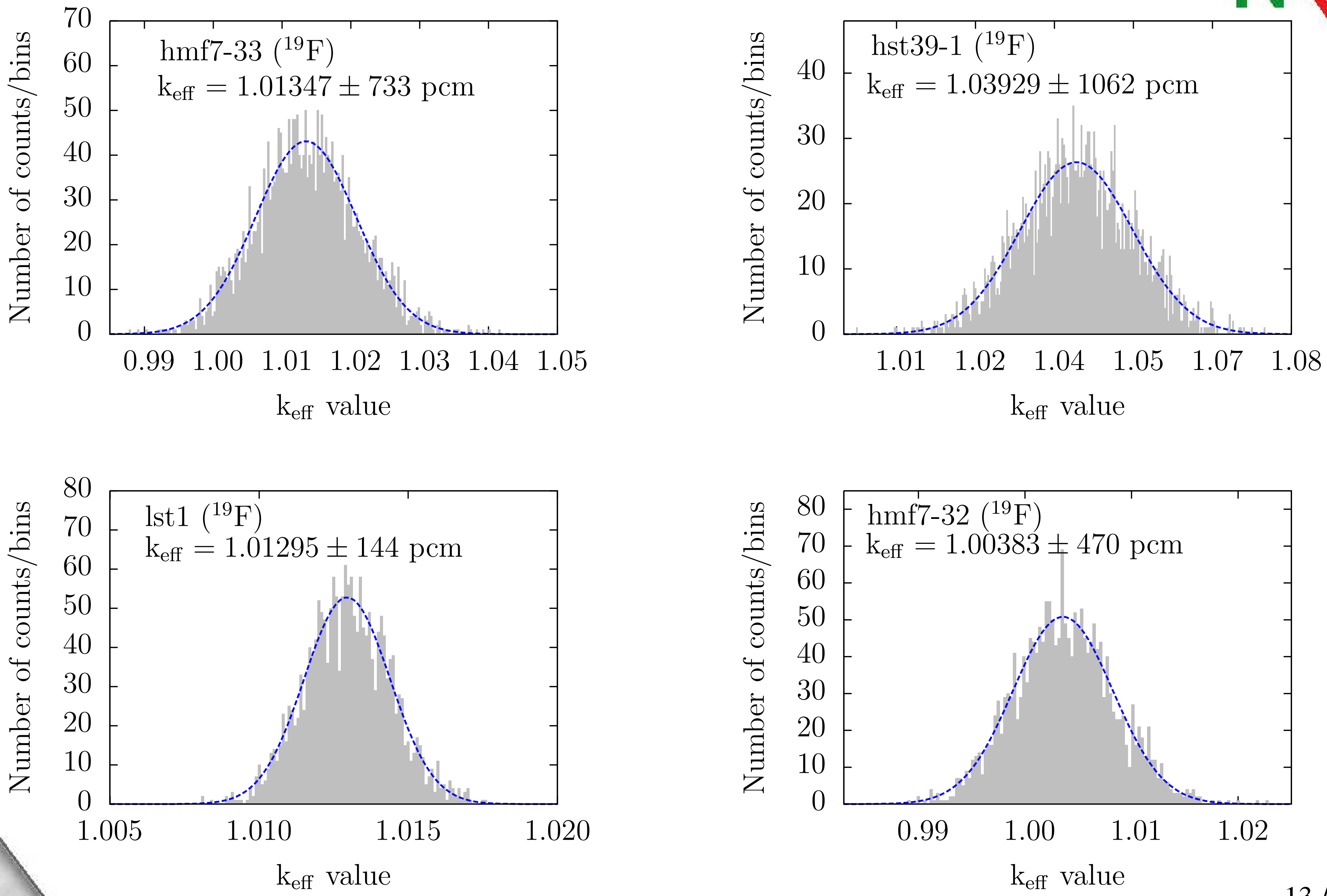
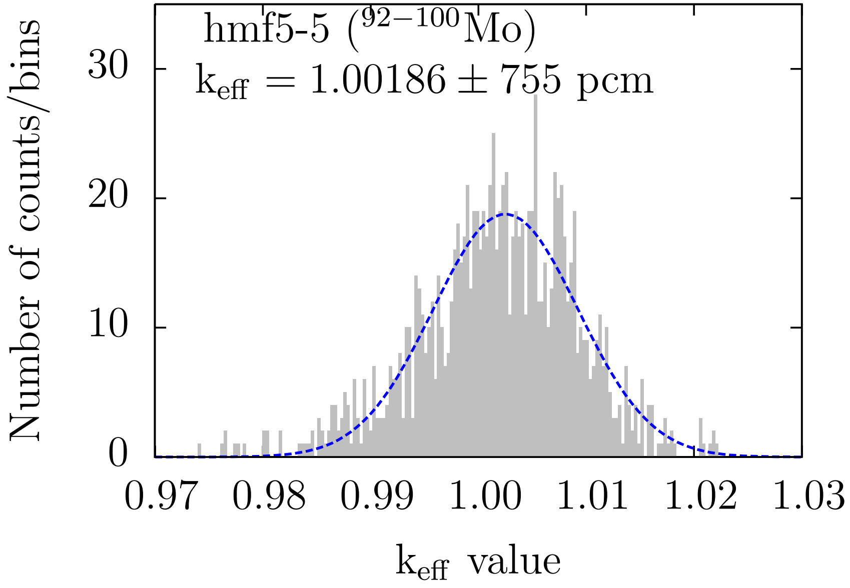
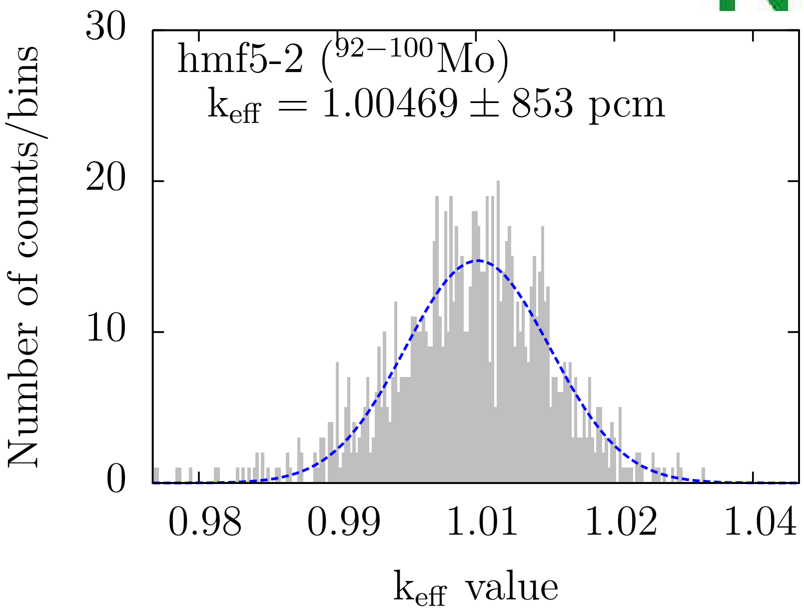
- Reactivity swing for a LWR using an "Inert Matrix Fuel" (Pu and Mo), Westinghouse 3 loops type reactor

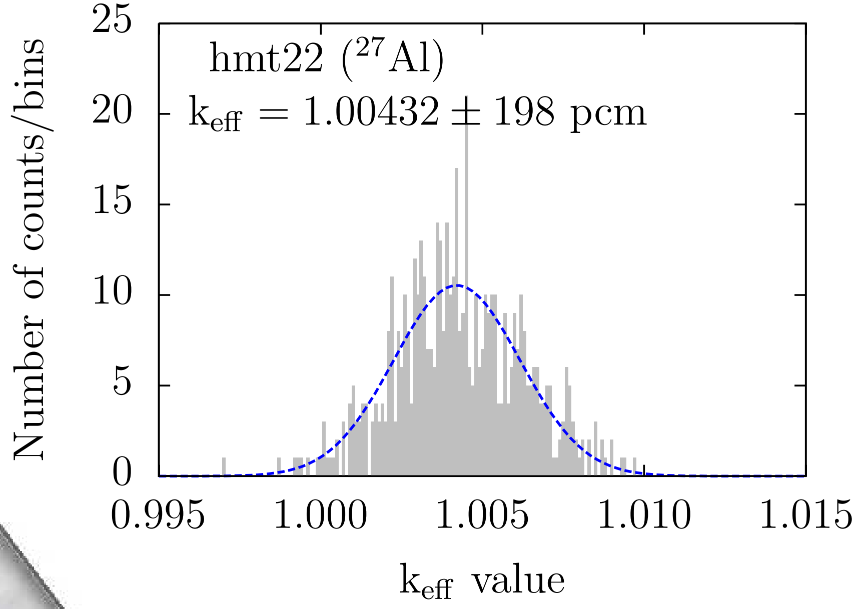
Examples of k_{eff} benchmarks for ^{19}F

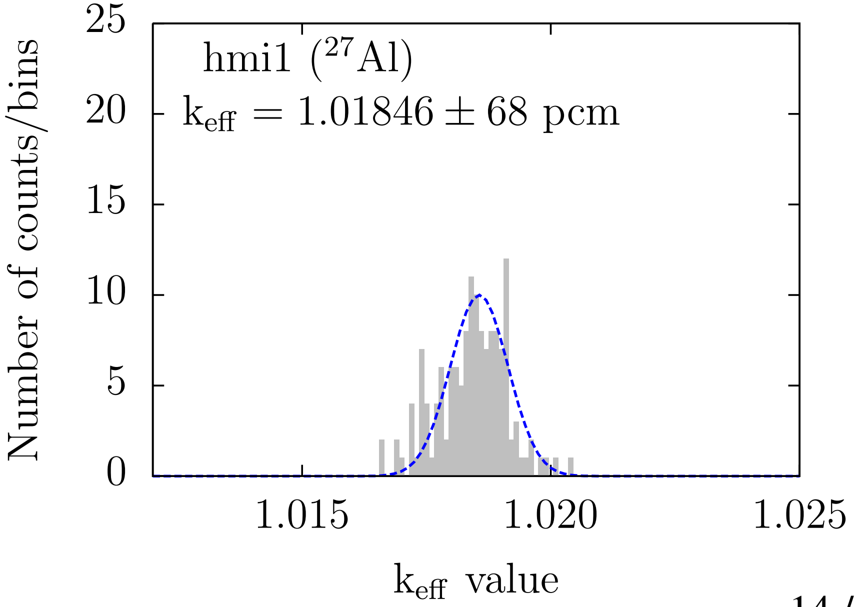


Examples of k_{eff} benchmarks for ^{27}Al and $^{92-100}$Mo

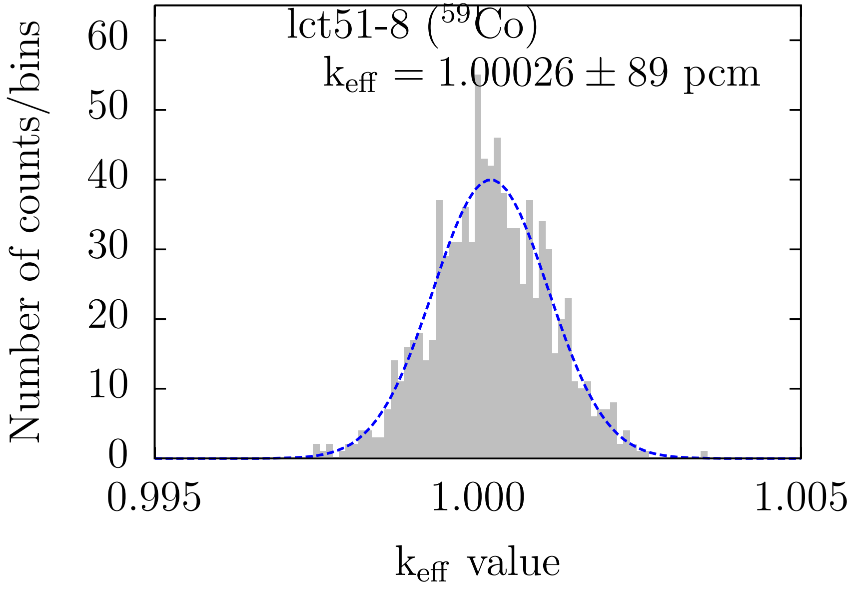


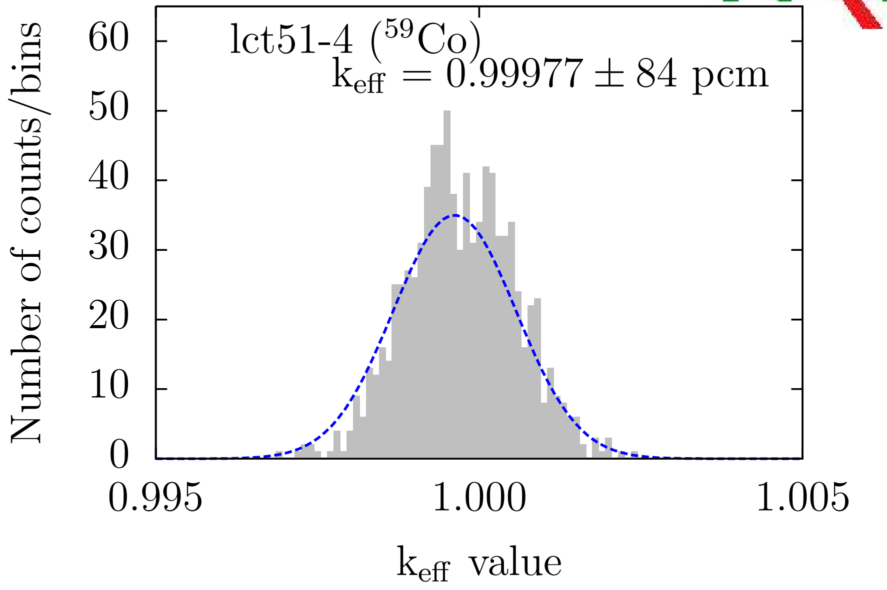


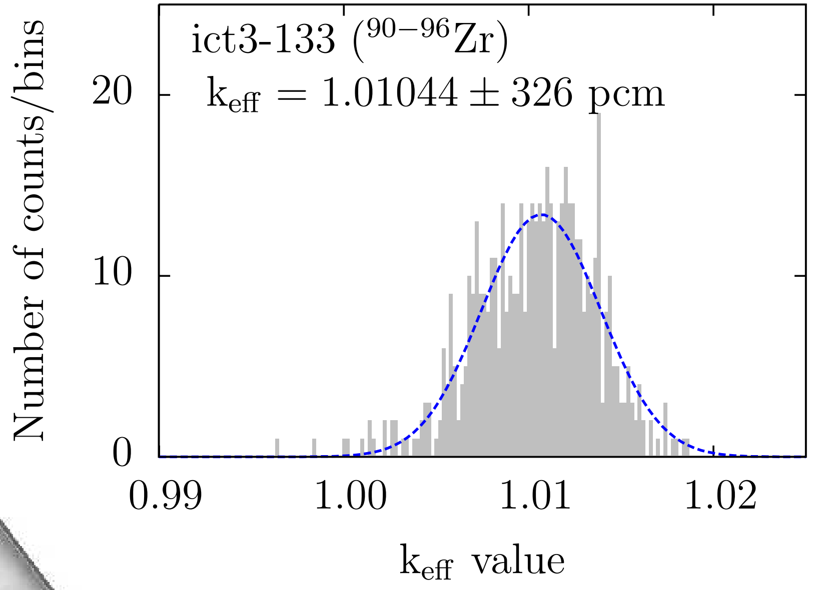


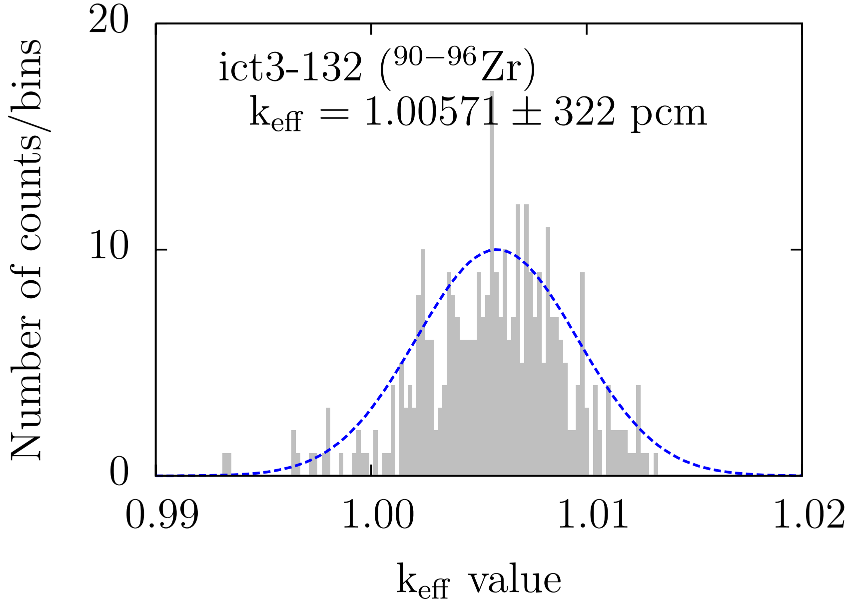


Examples of k_{eff} benchmarks for ^{59}Co and $^{90-96}$Zr

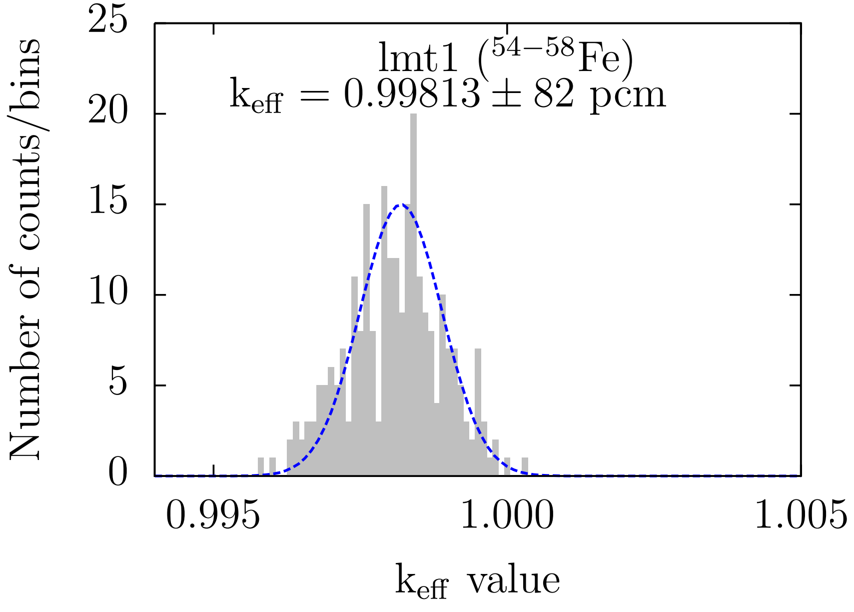


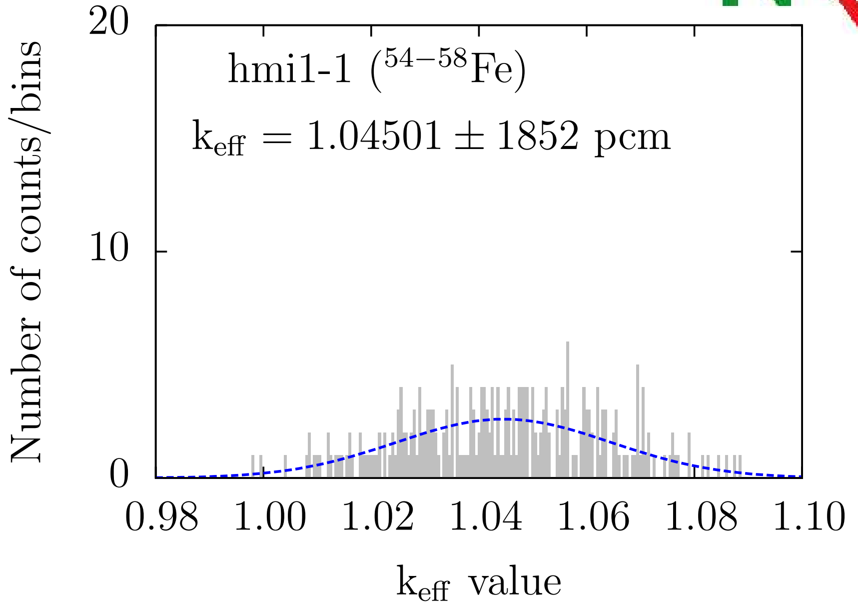


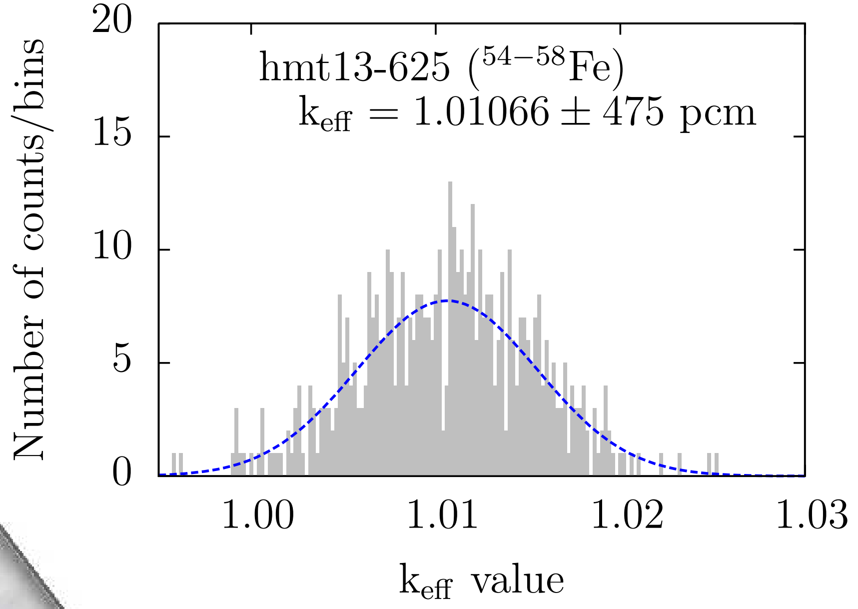


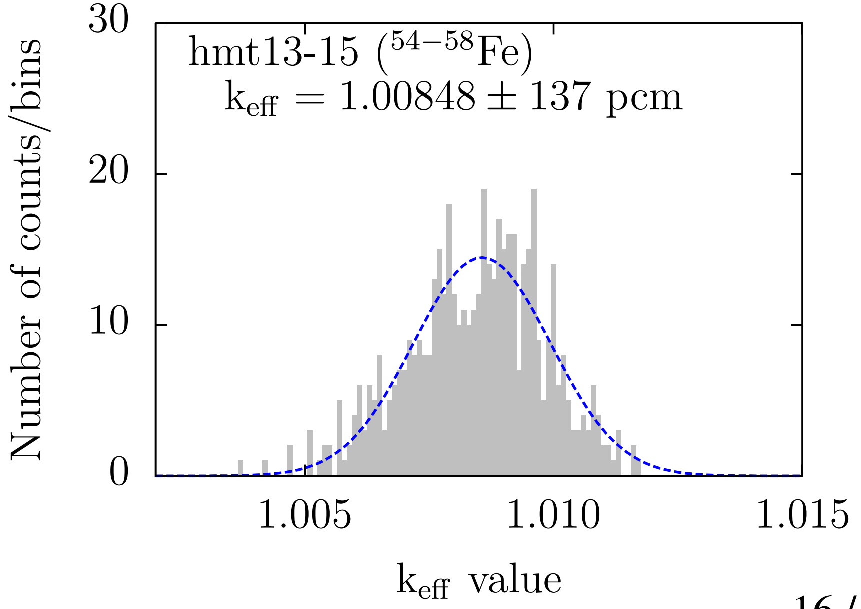


Examples of k_{eff} benchmarks for $^{54-58}$Fe

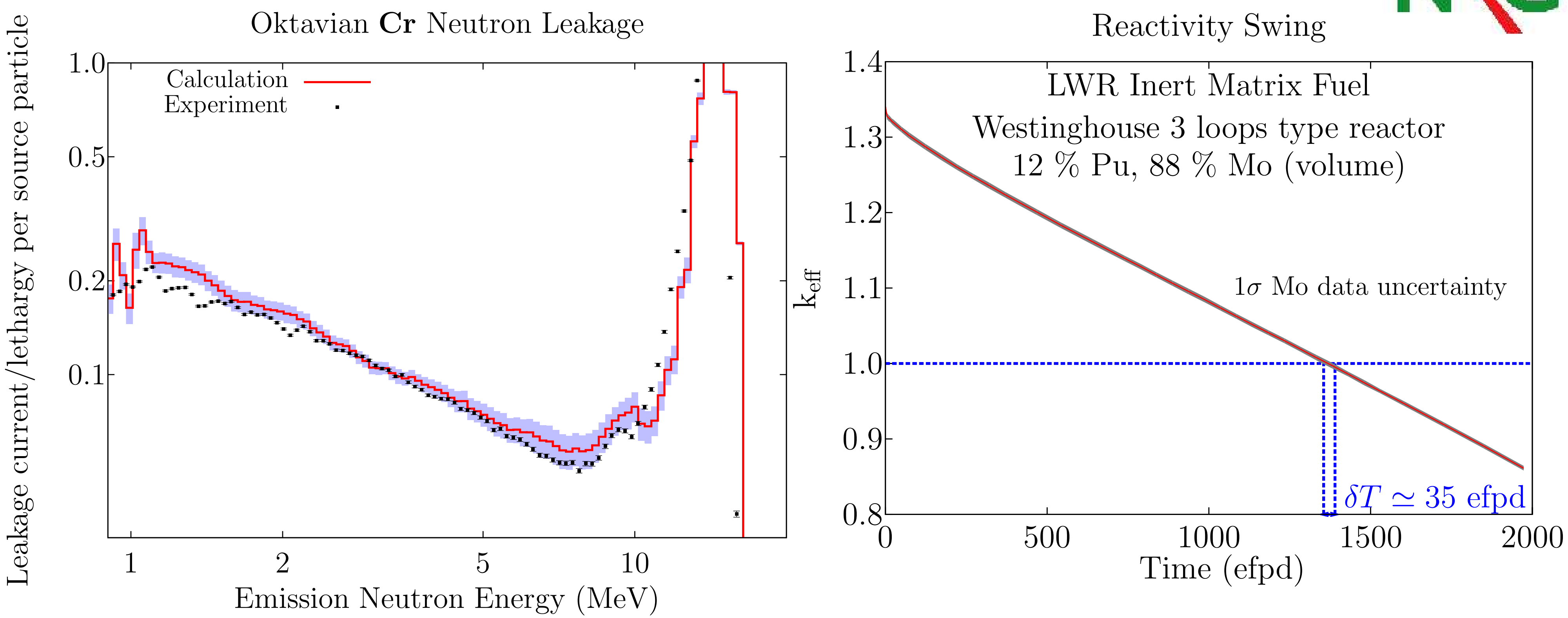








Examples of shielding benchmarks and reactivity swing



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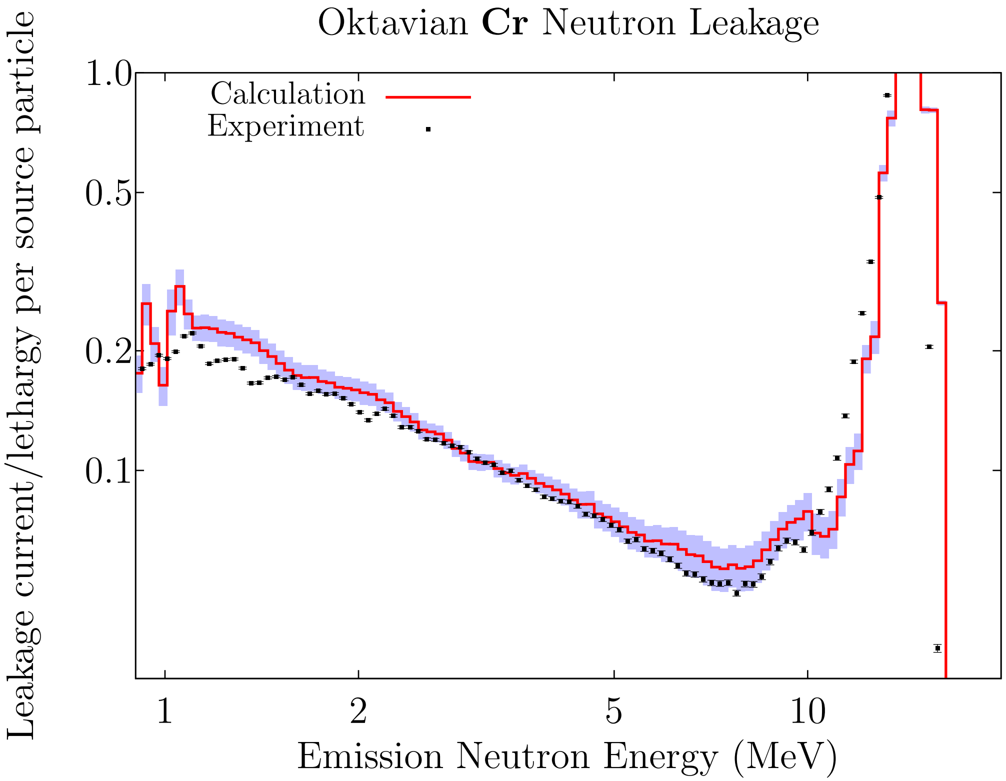

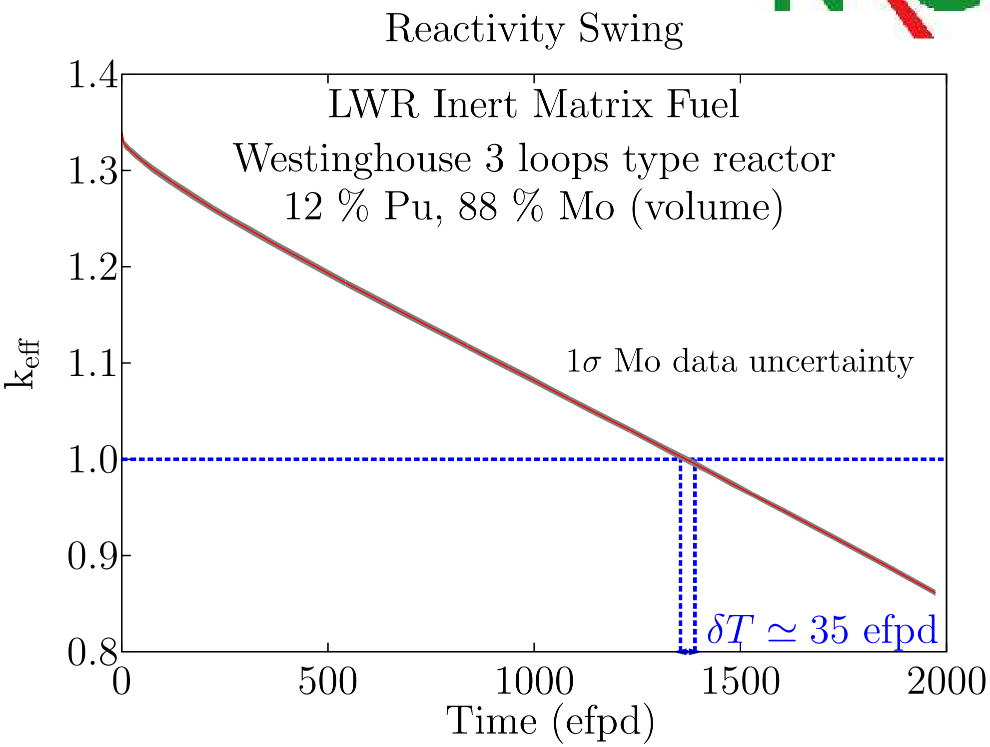

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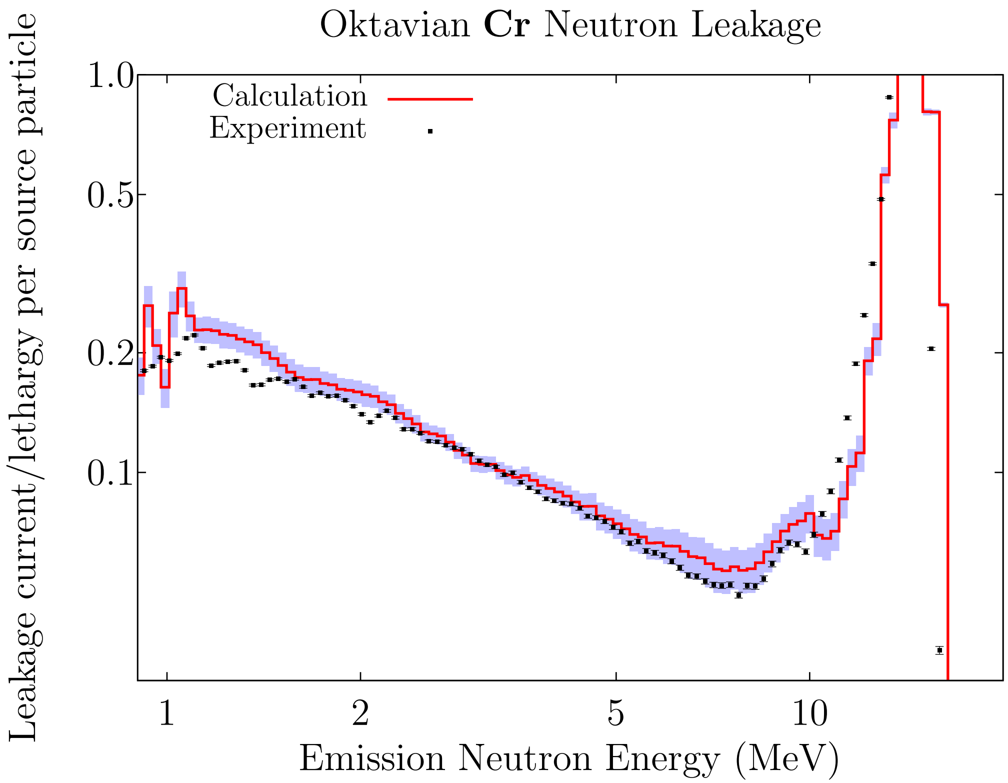

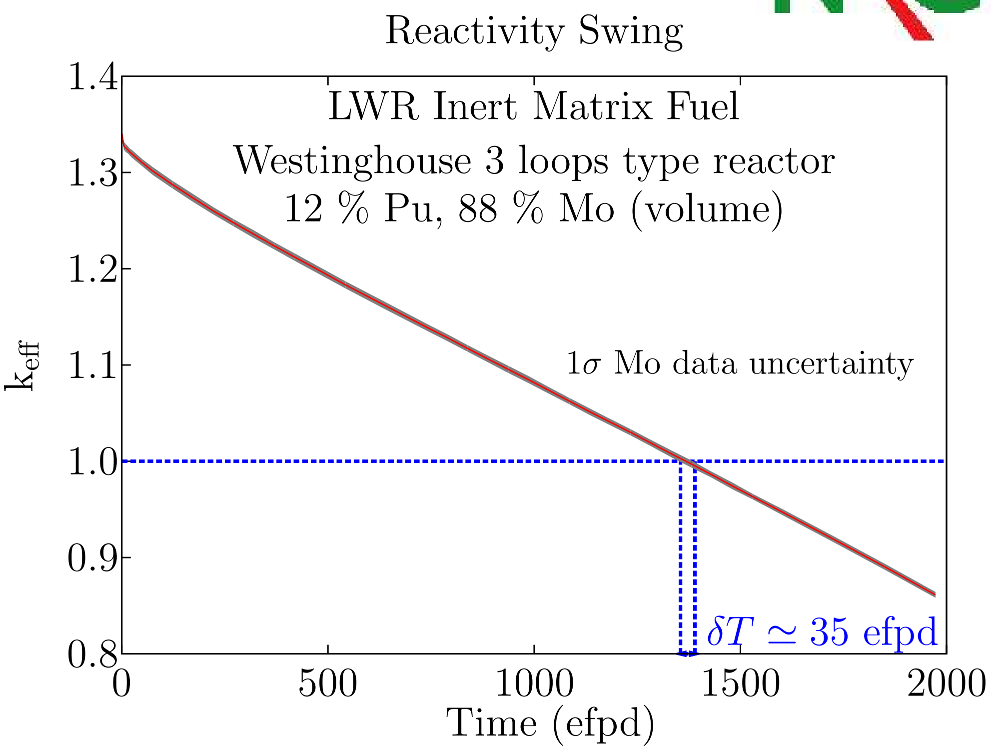

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- and industrial PWR reactor for life-time extension (uncertainty on the reactor pressure vessel damage)

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