Uncertainties for fusion shielding benchmarks using Total Monte Carlo

D. Rochman, A.J. Koning and S.C. van der Marck

Nuclear Research and Consultancy Group,

NRG, Petten, The Netherlands

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① Motivations for a change:

$\Longrightarrow$ *a roadmap to consistent and state-of-the-art evaluations*

② Concept:

$\Longrightarrow$ *Monte Carlo from nuclear data evaluations to large-scale systems*

③ How does it work ?

$\Longrightarrow$ *TALYS + Monte Carlo*

④ Examples with Oktavian, FNS and LLNL benchmarks:

$\Longrightarrow$ *Neutron and gamma leakage for Al, Cu, Si, Ti, Cr, Mn, Co, Mo, Zr, Fe, W, and Mg*

⑤ Conclusions

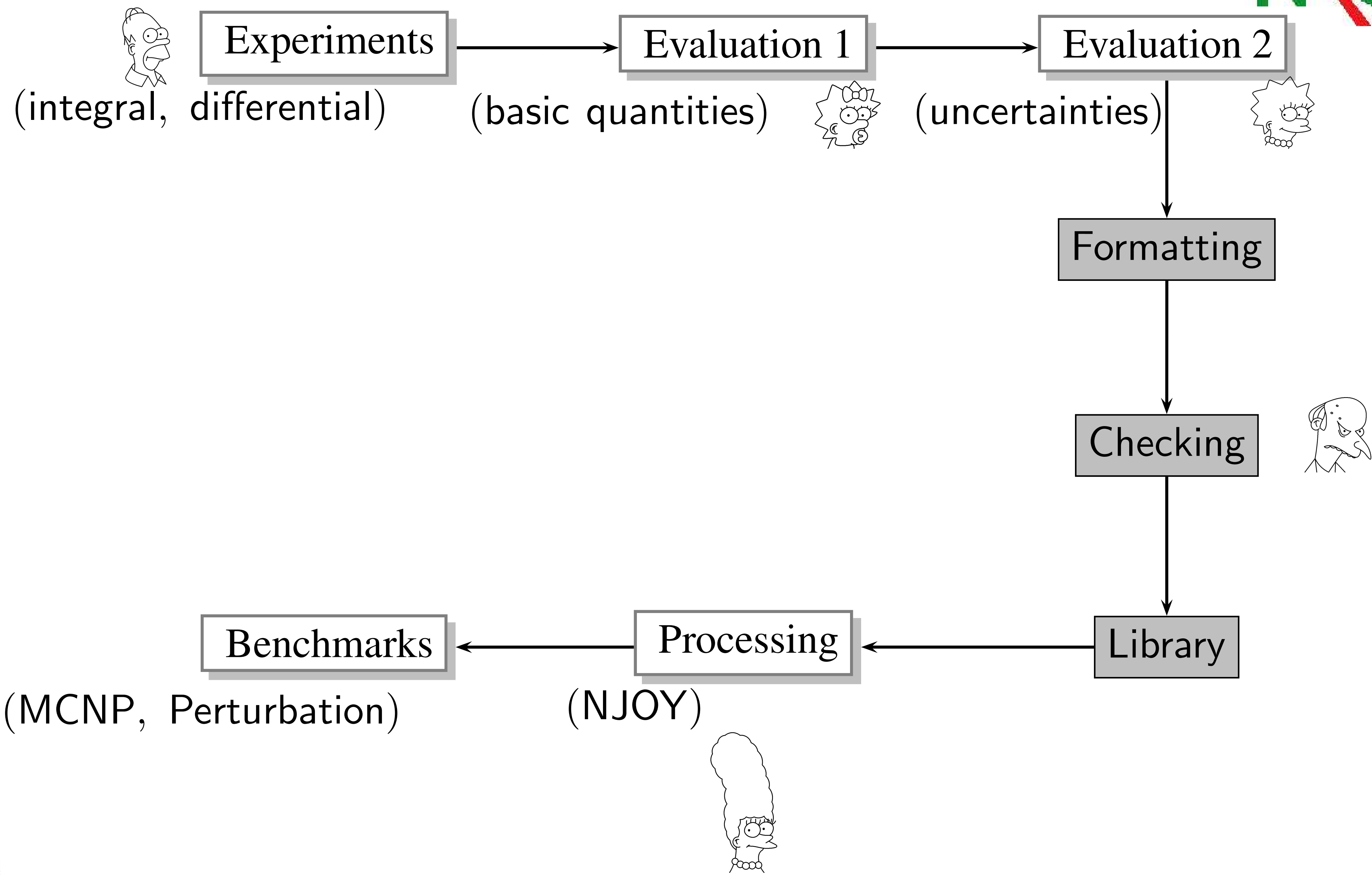
Motivations: How to propagate nuclear data uncertainties through fusion benchmarks ?

Usual procedures in evaluations imply

- ☞ First, there were measurements,
- ☞ Then nuclear reaction codes (TALYS, GNASH, EMPIRE...),
- ☞ Format the output semi-manually to ENDF file,
- ☞ Compare with experimental cross sections,
- ☞ Modify manually the ENDF file,
- ☞ Compare with integral tests,
- ☞ Modify manually the ENDF file, ENDF file ready,
- ☞ At last, ”Evaluations are available to users”, but...

➸ How to include propagation of nuclear data uncertainties with a minimum number of approximations ?

Concept: No more delocalization



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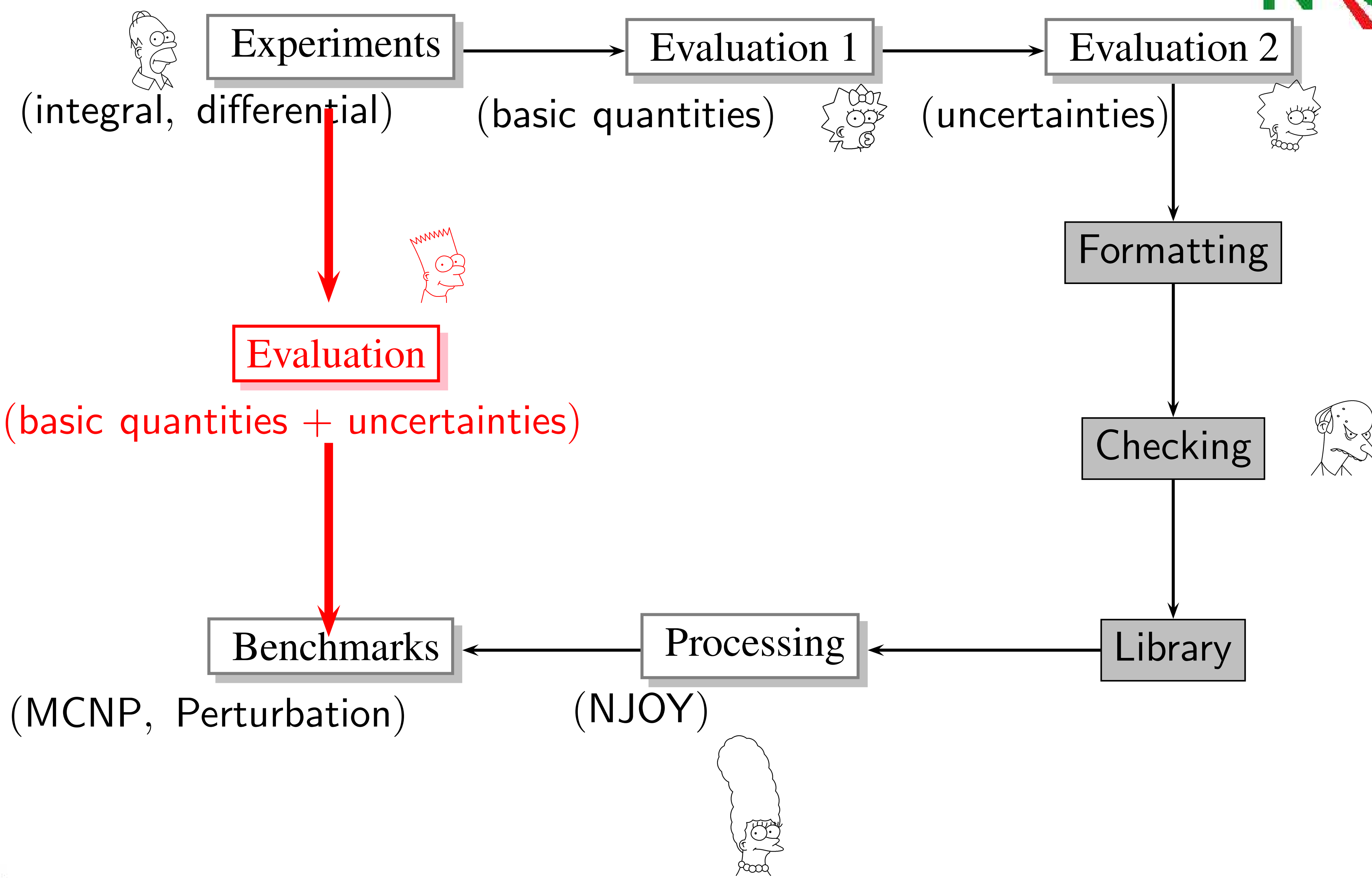

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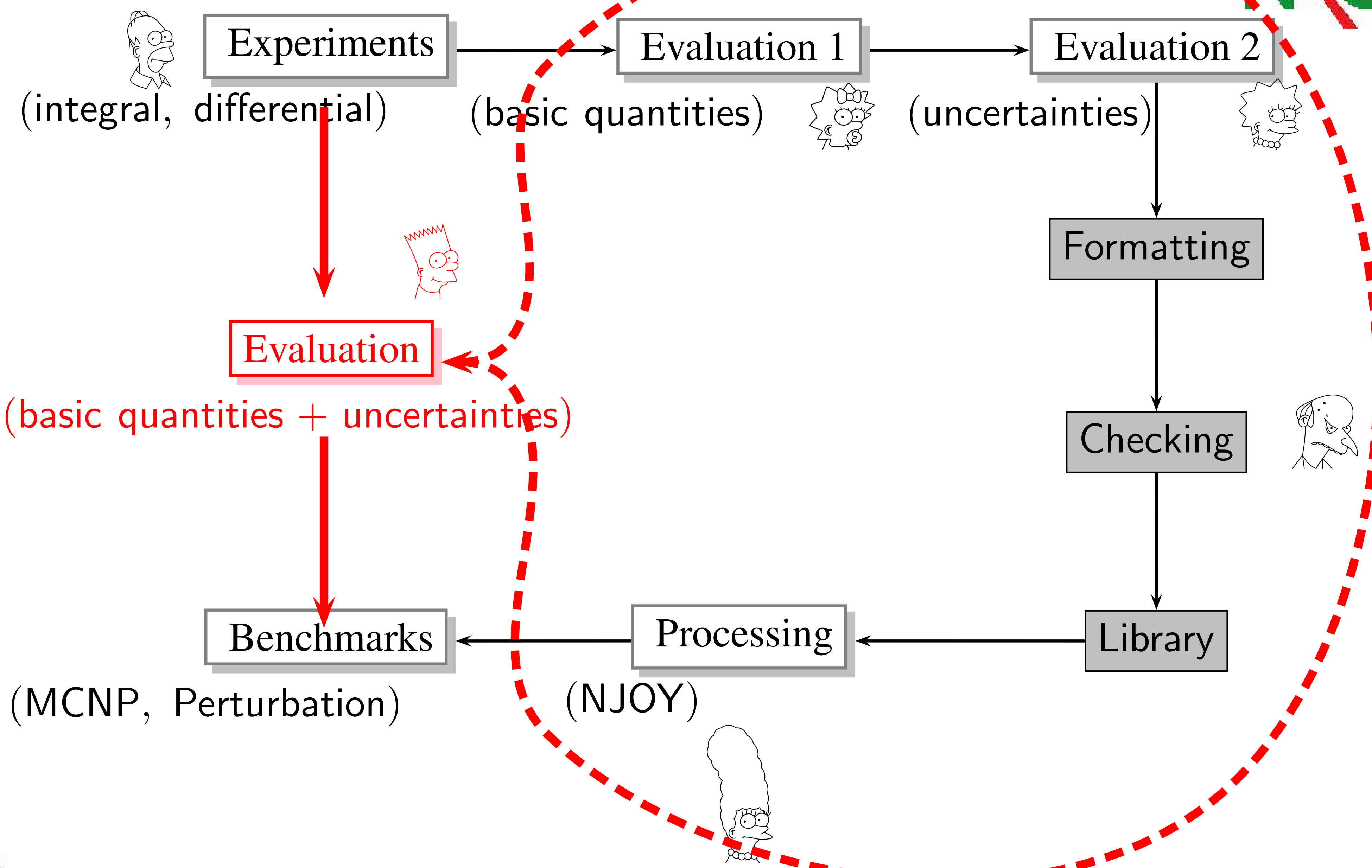

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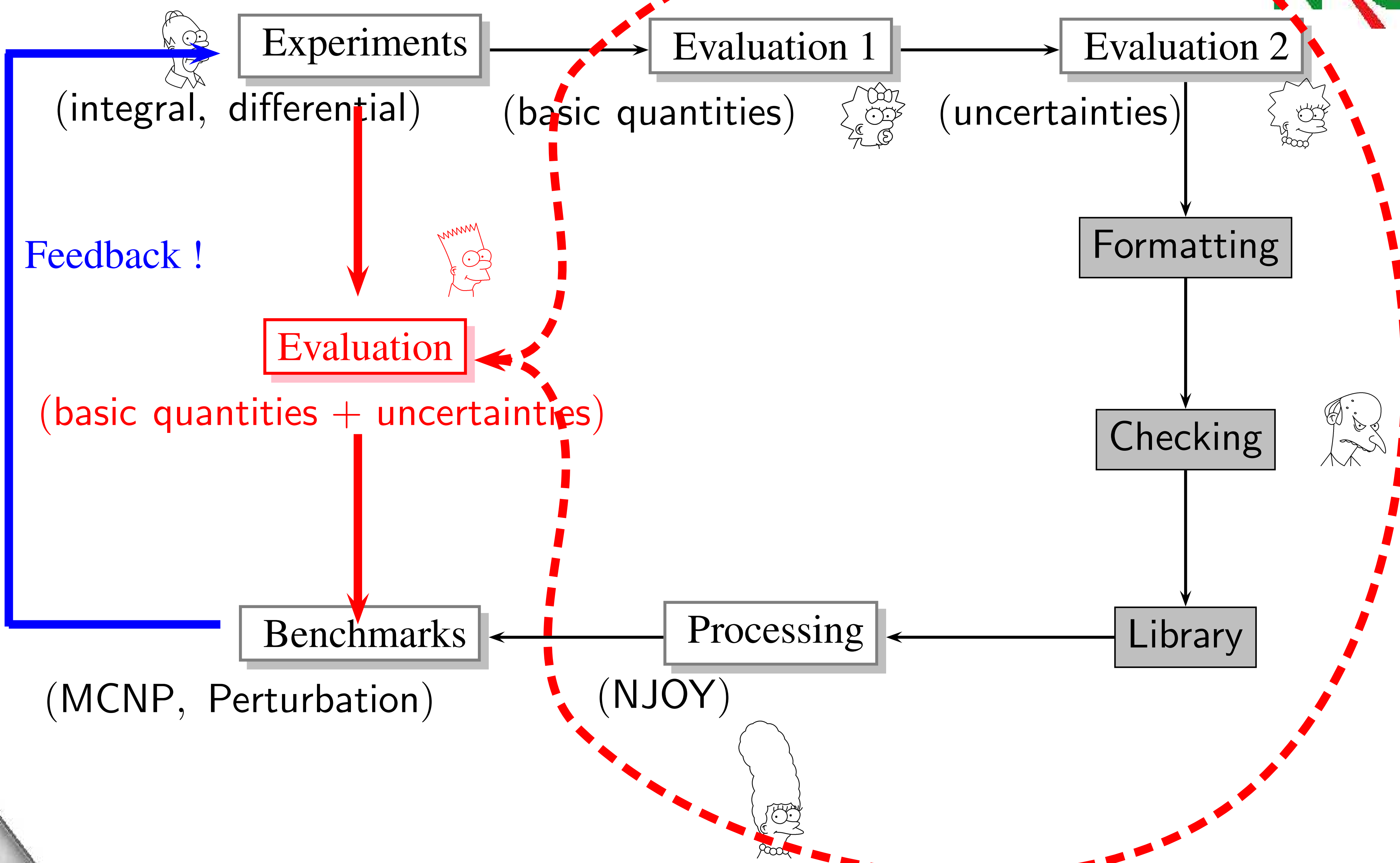
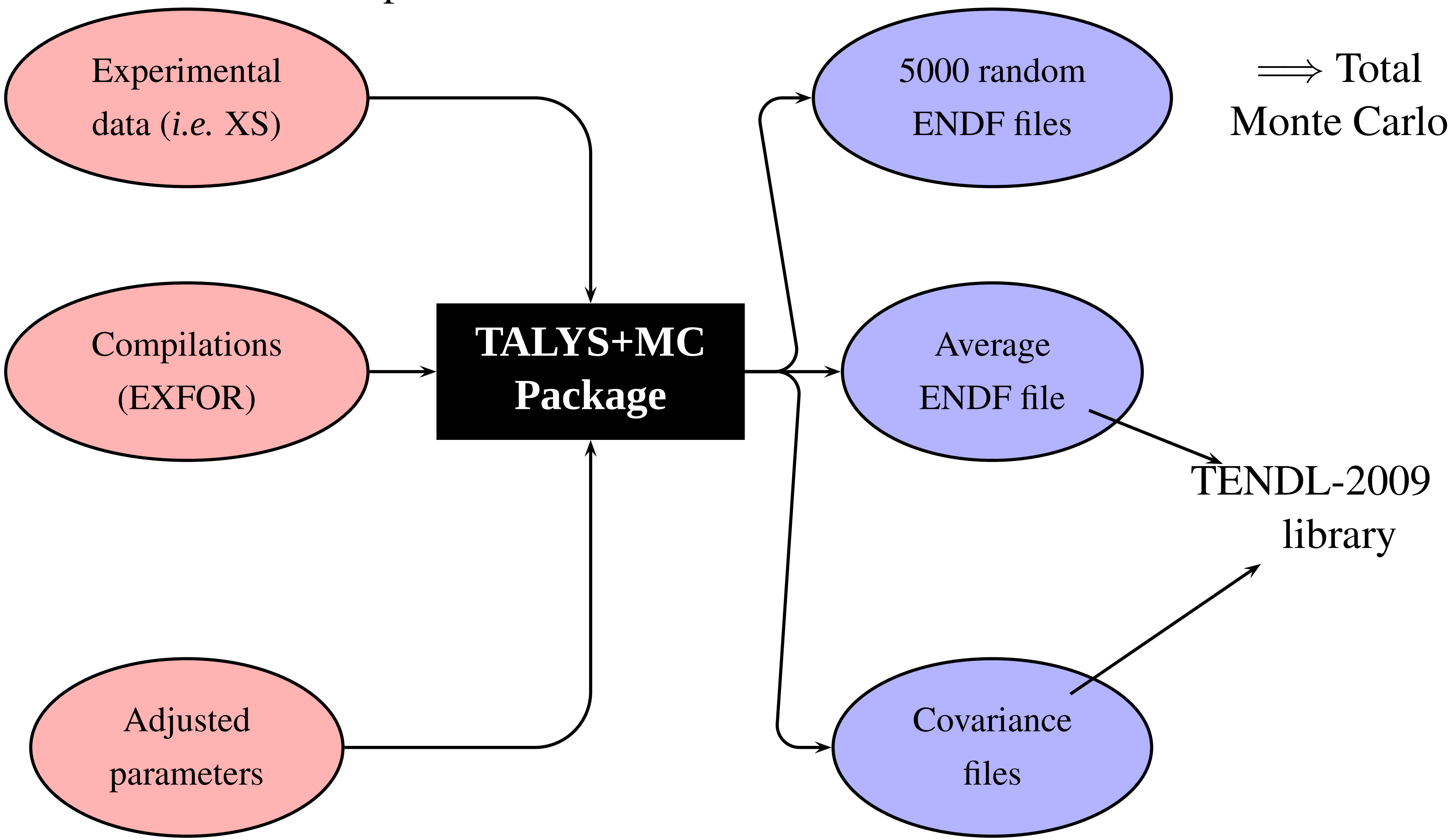
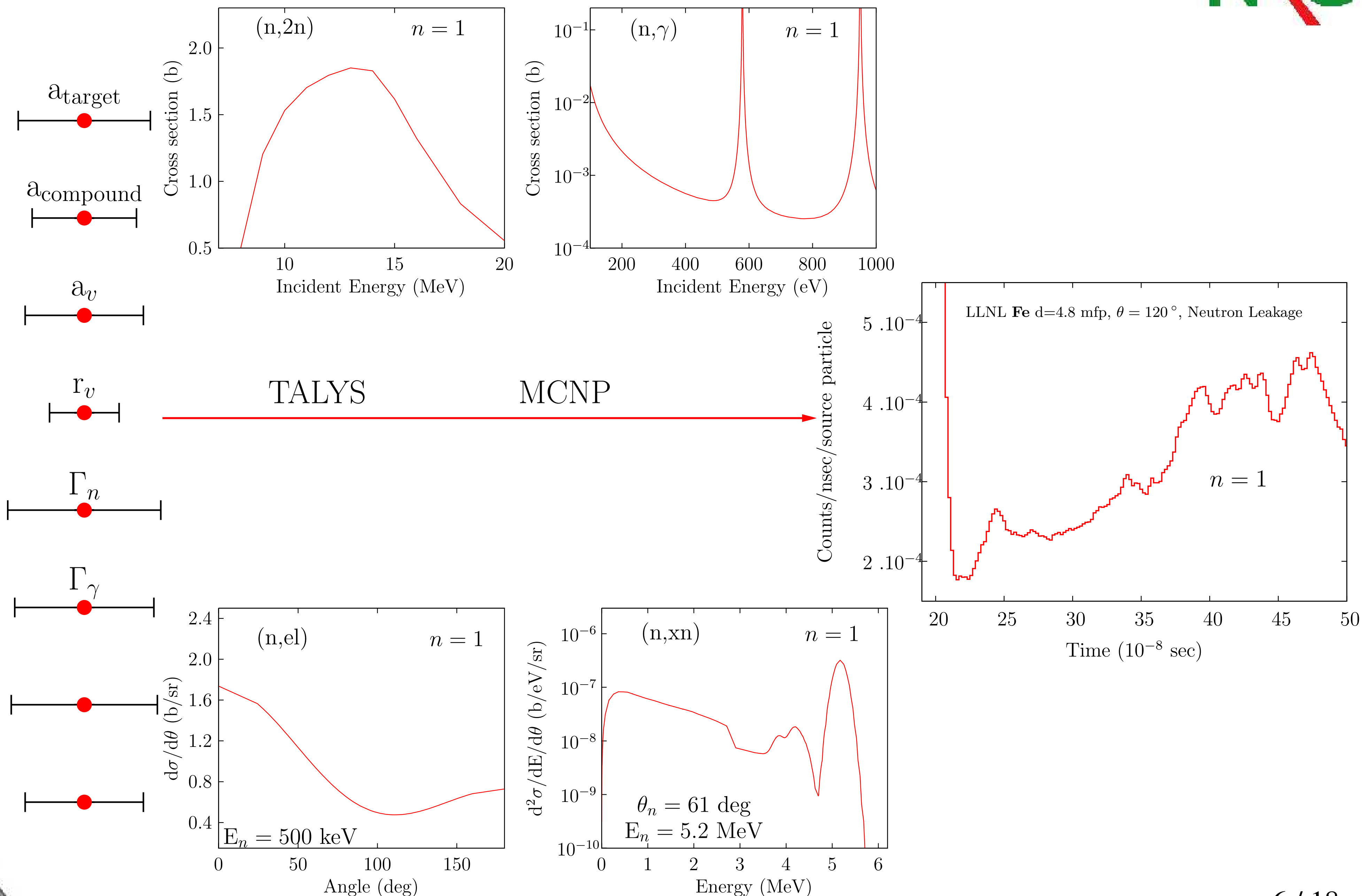


Concept: TALYS + Monte Carlo

Possible answer to this problem: Maximization of automation



Hands on “1000 ×(Talys + ENDF + NJOY + MCNP) calculations”



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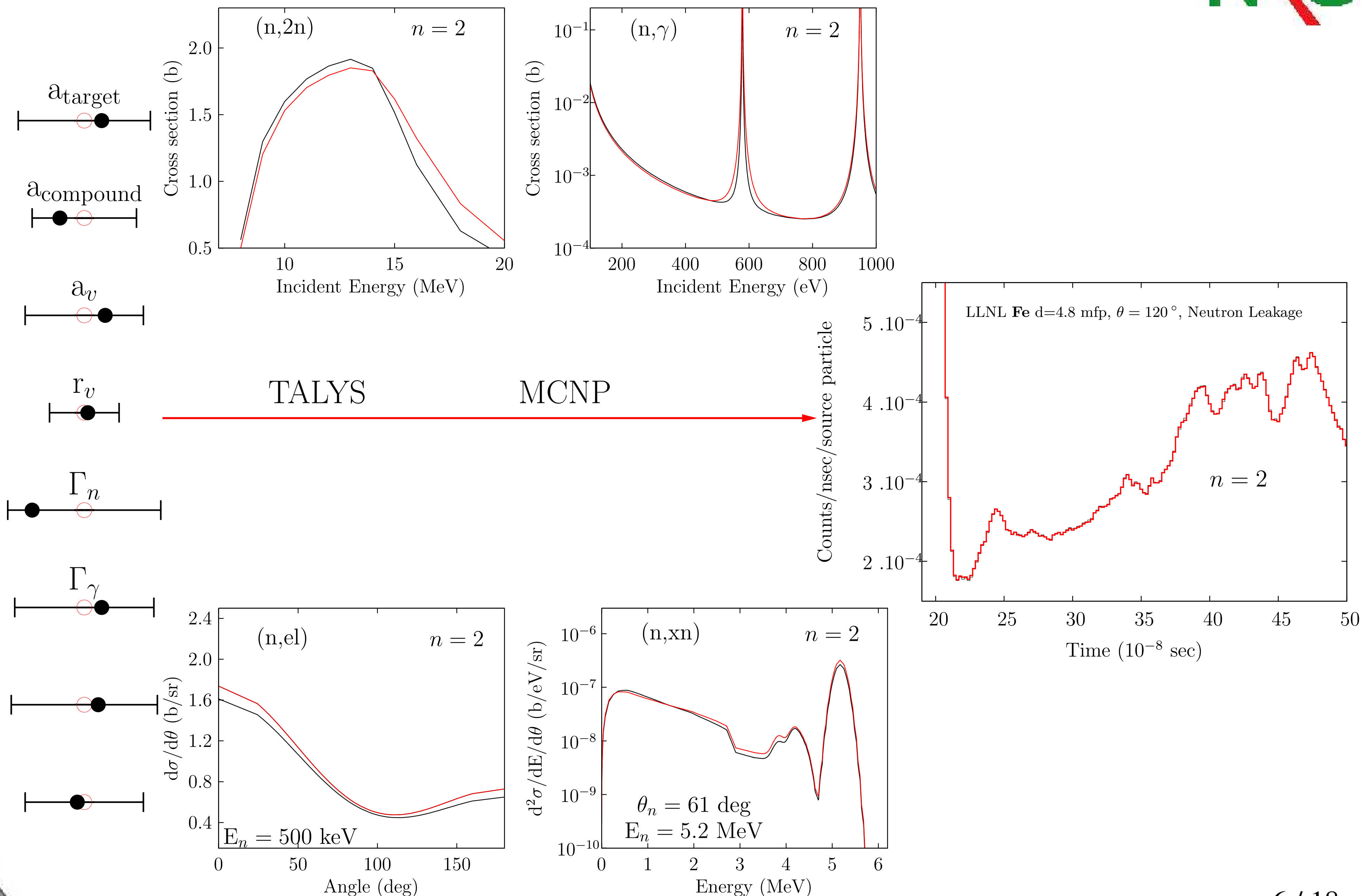

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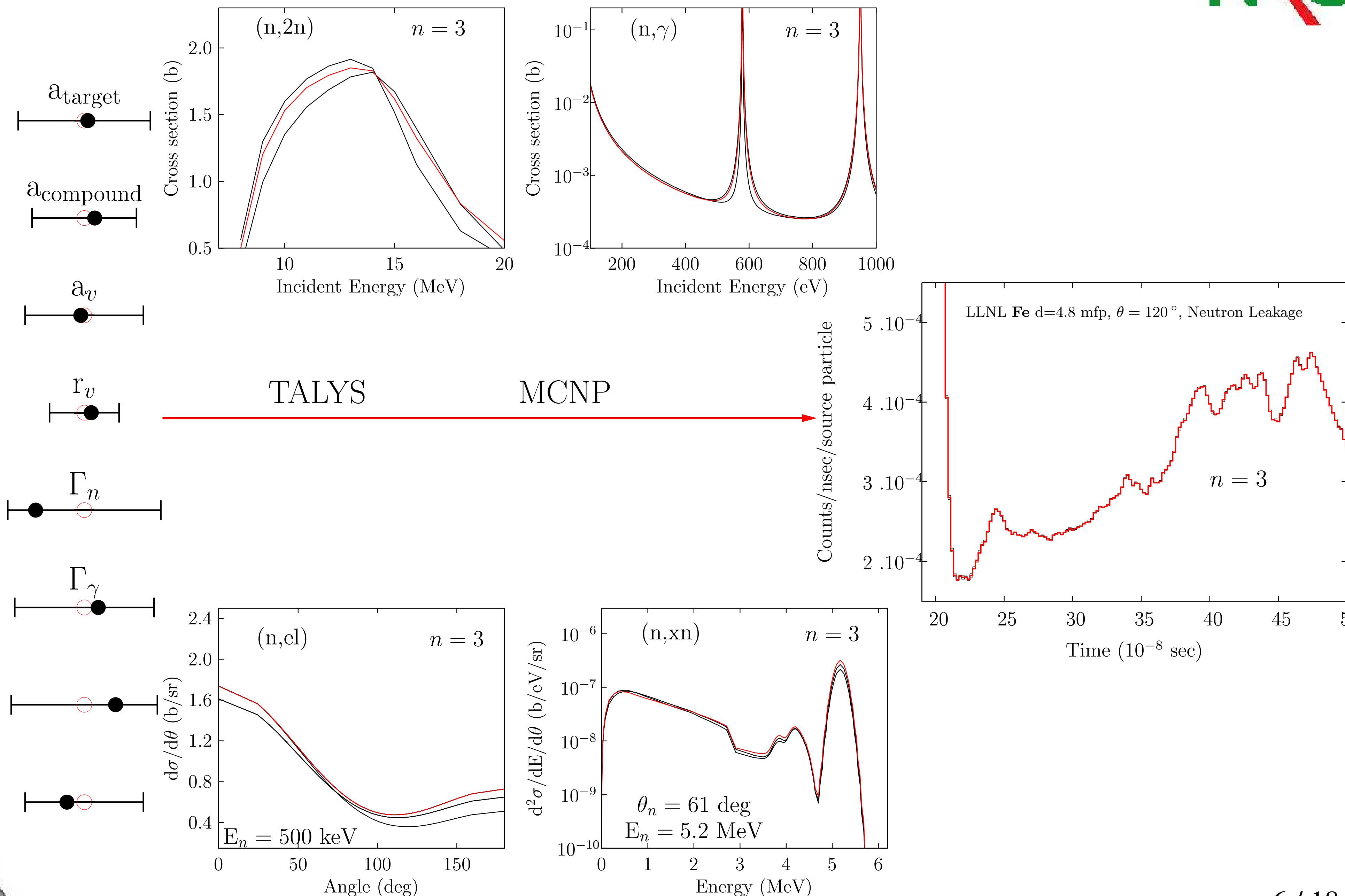

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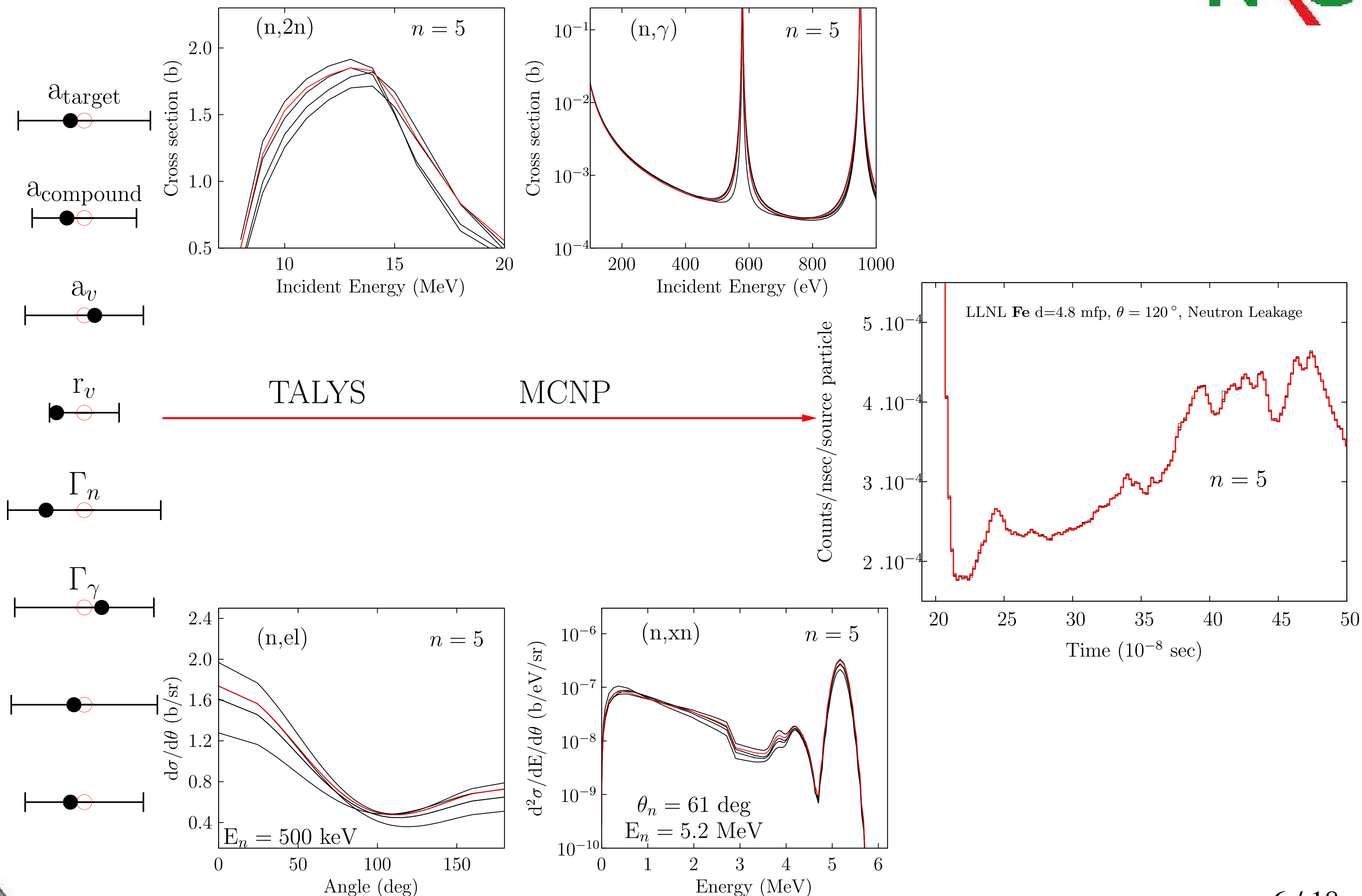

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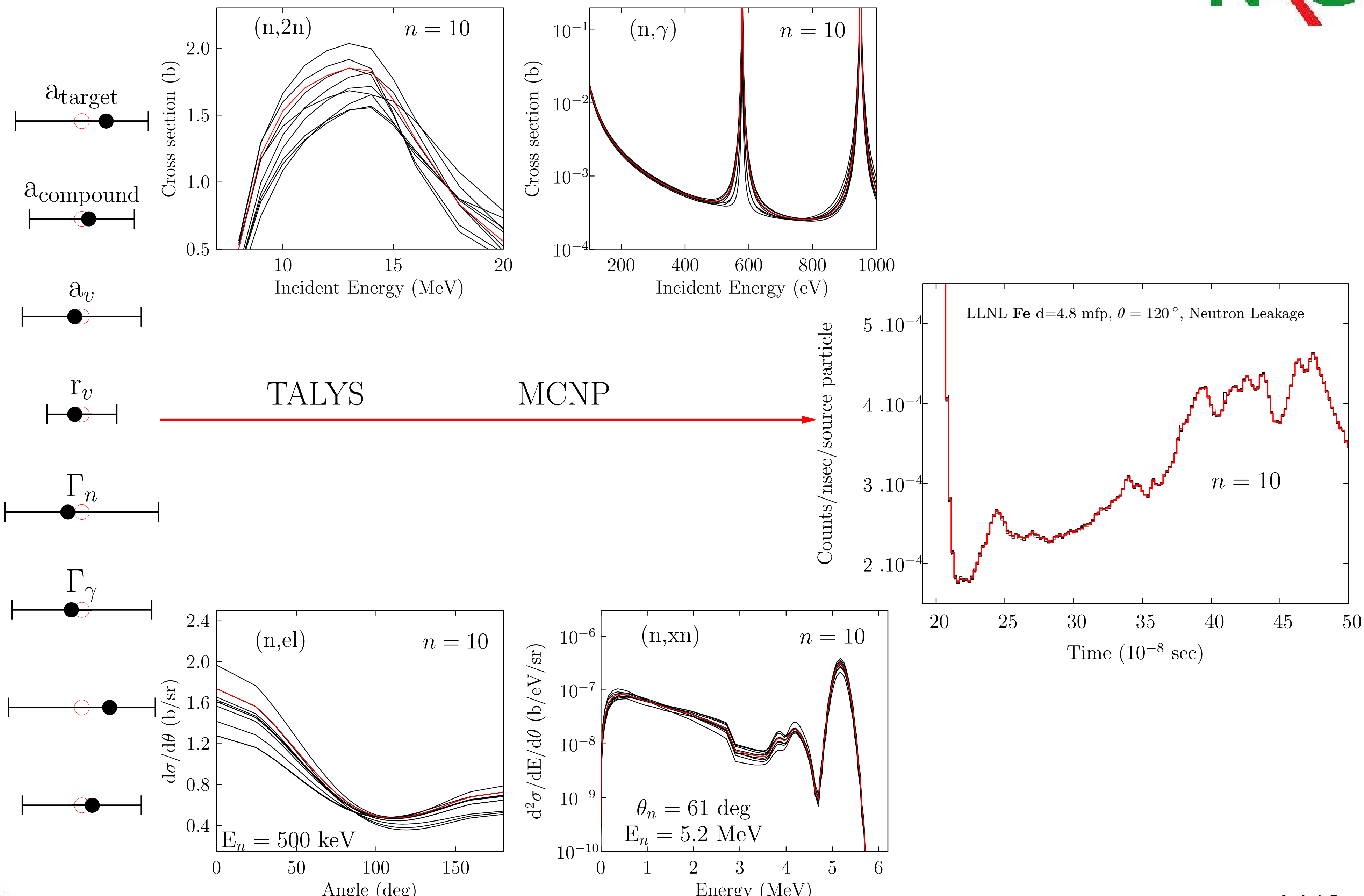

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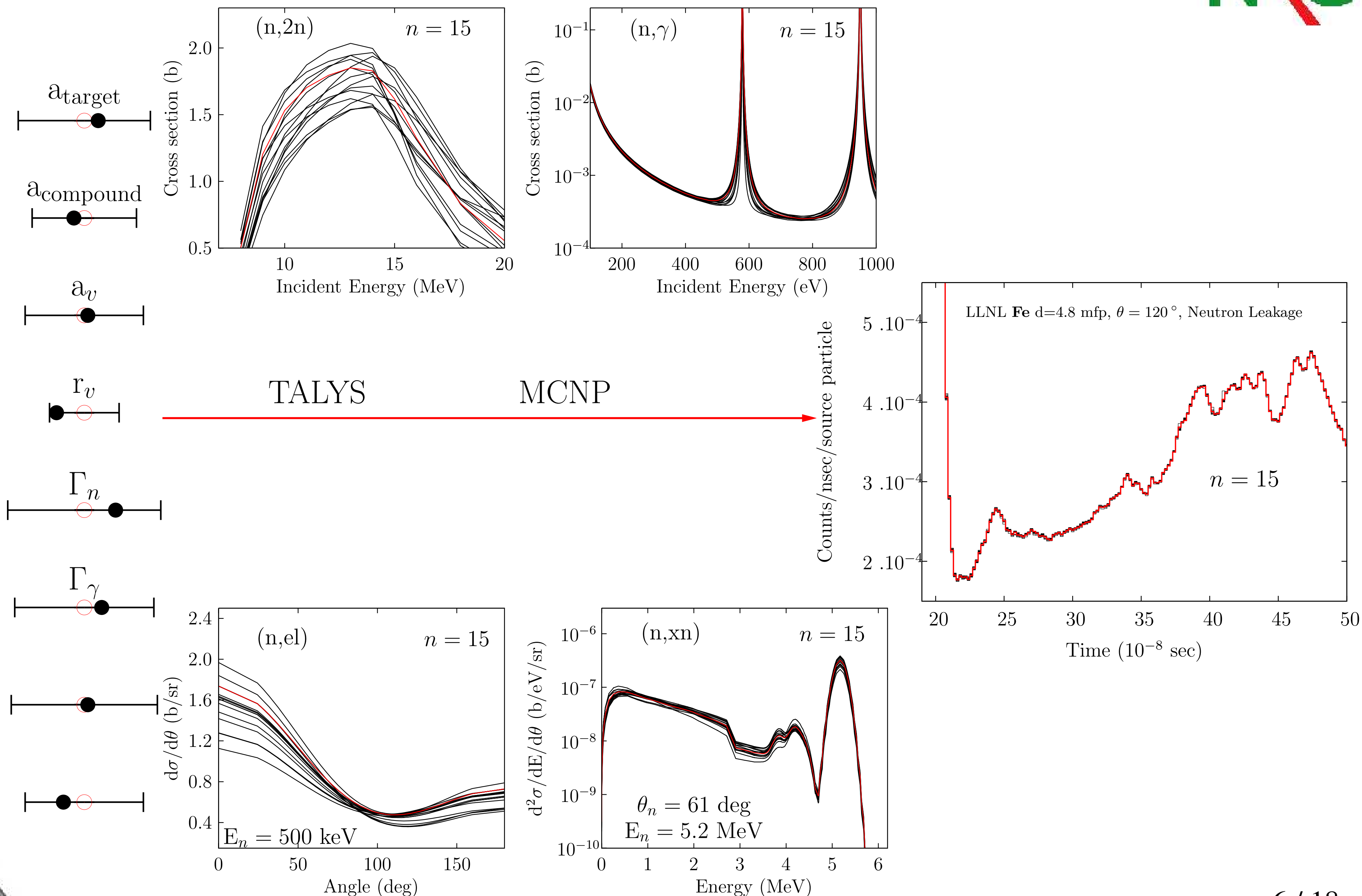

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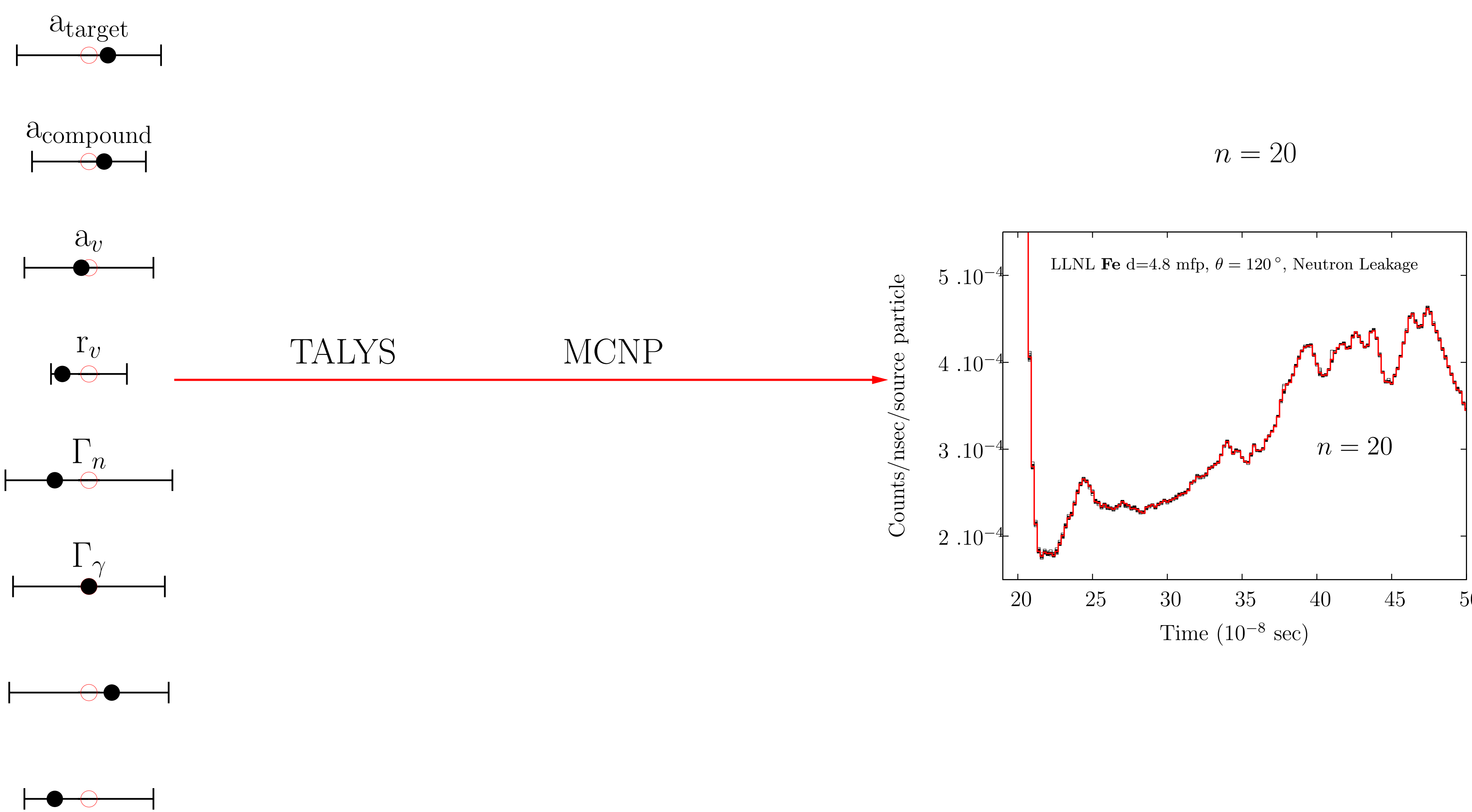

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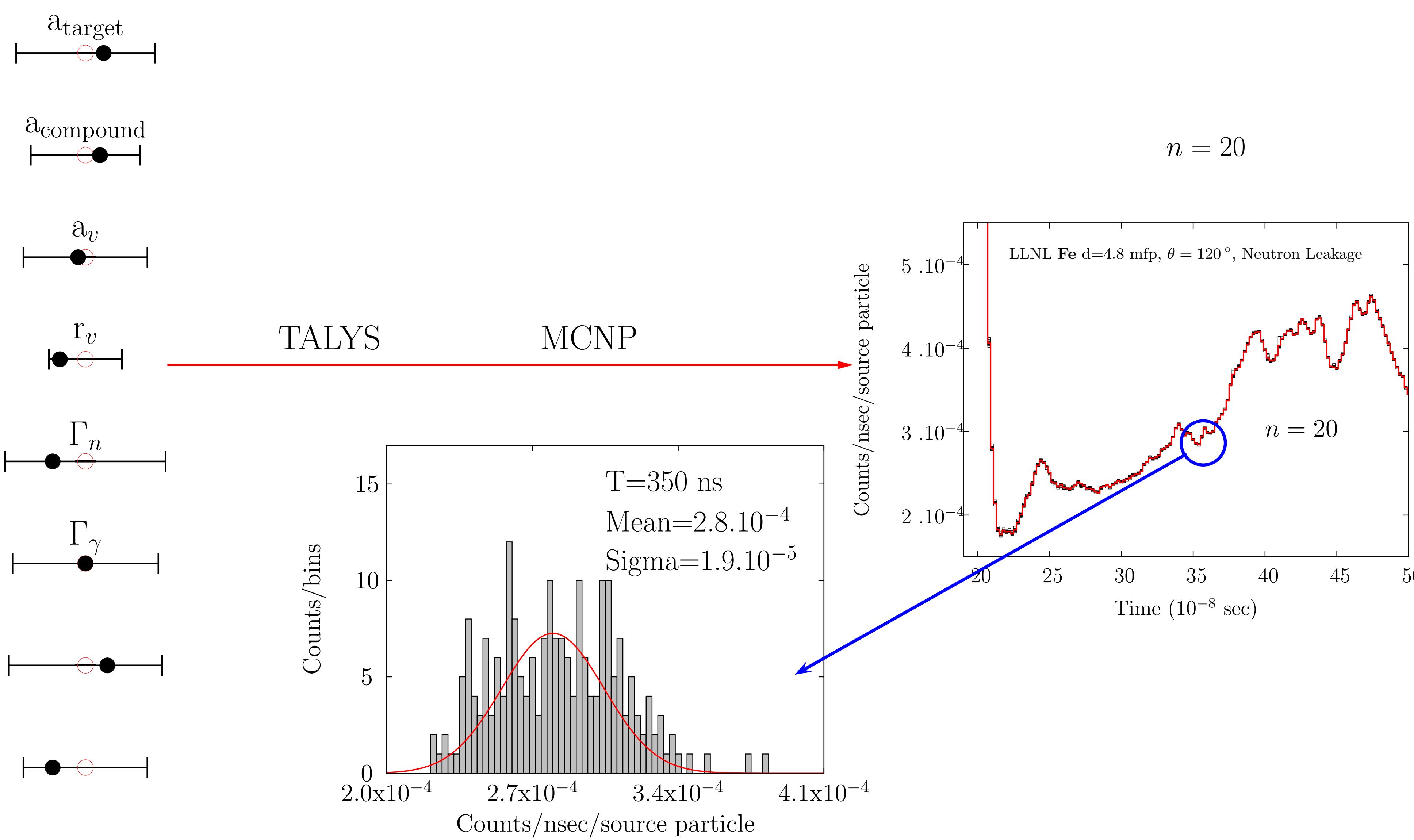
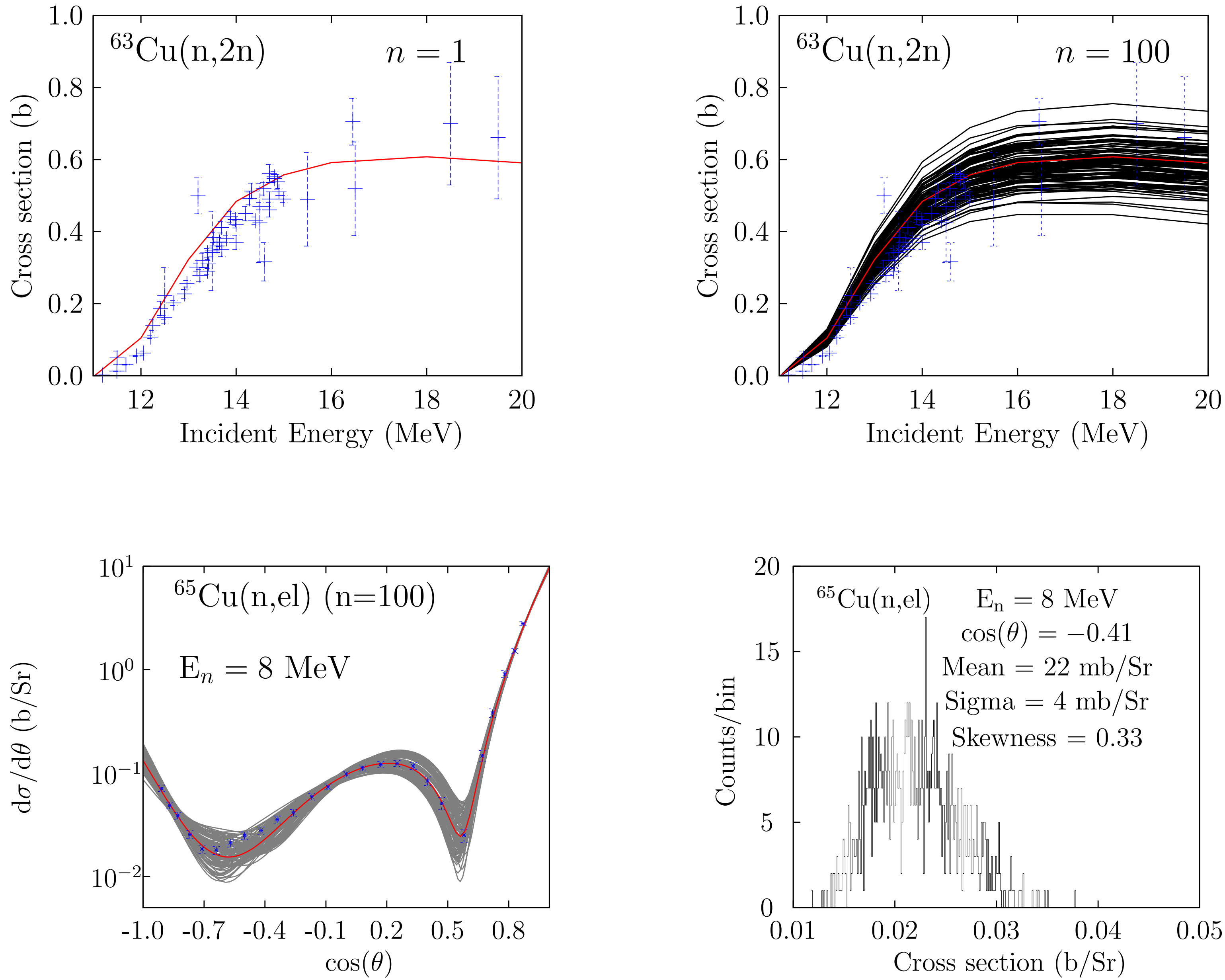


Application to shielding benchmarks:

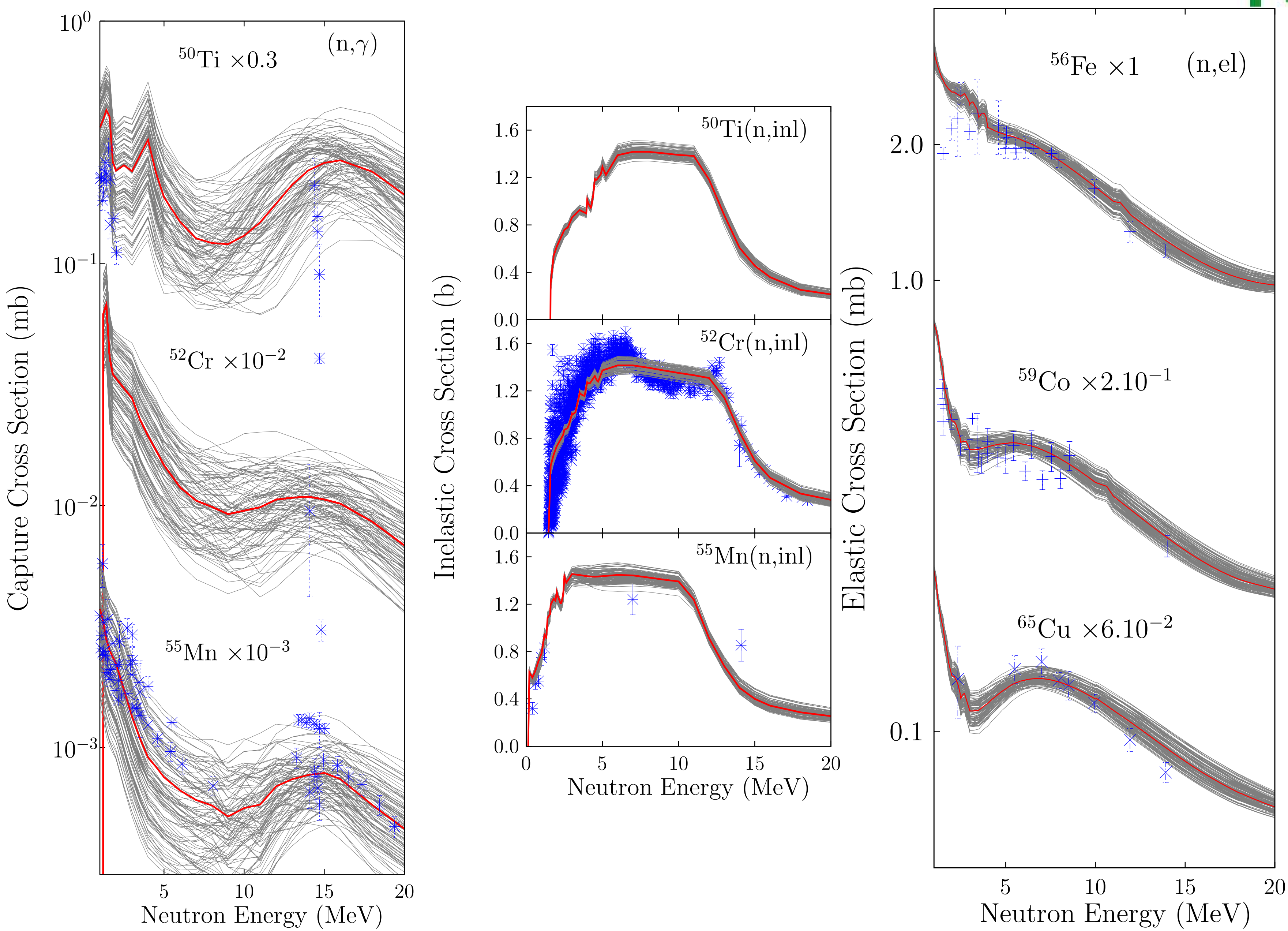
Benchmark	Mat.	Outer ∅	Benchmark	Mat.	Outer ∅ or slab thickness	Angle
Oktavian	Al	40 cm	Oktavian	Mo	61 cm	-
Oktavian	Cu	61 cm	Oktavian	Zr	61 cm	-
Oktavian	Si	60 cm	FNS	Fe	20-40 cm	22.8-42.8°
Oktavian	Ti	40 cm	FNS	W	5 cm	22.8-38.0°
Oktavian	Cr	40 cm	LLNL	Al	1.6-2.6 mfp	39°
Oktavian	Mn	61 cm	LLNL	Mg	1.2-1.9 mfp	39°
Oktavian	Co	40 cm	LLNL	Fe	0.9-4.8 mfp	39°

- Oktavian: Leakage current spectrum from the outer surface of a spherical pile of material, 14 MeV D-T neutron source at the center of the pile.
- FNS: Slabs of material of varying thickness, at five different angles, 20 cm from a 14 MeV D-T neutron source.
- LLNL Pulsed Spheres: Time-of-Flight measurements through spherical shells of varying thickness, 14 MeV D-T neutron source.

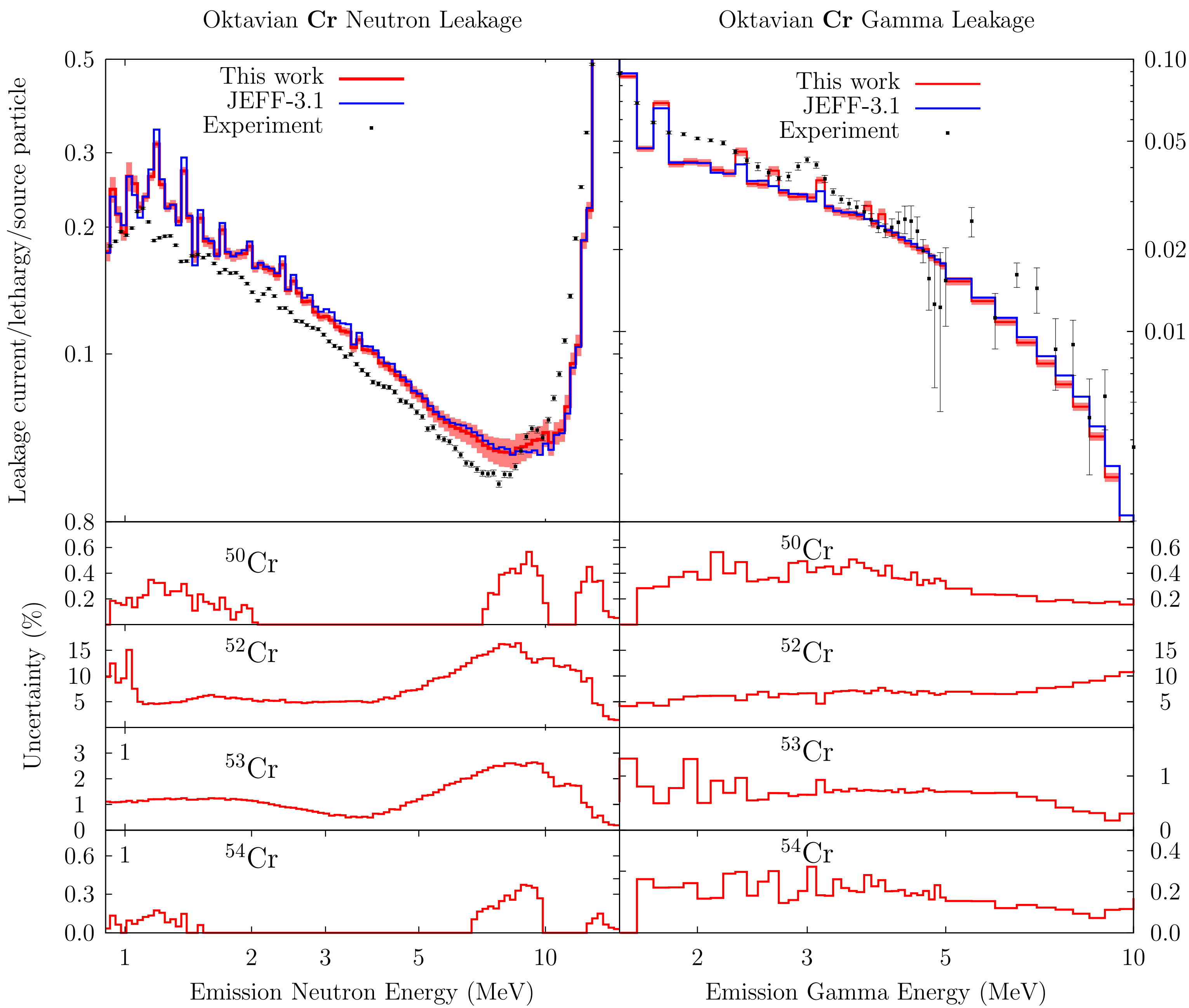
Examples with ^{63}Cu(n,2n) and ^{65}Cu(n,el)



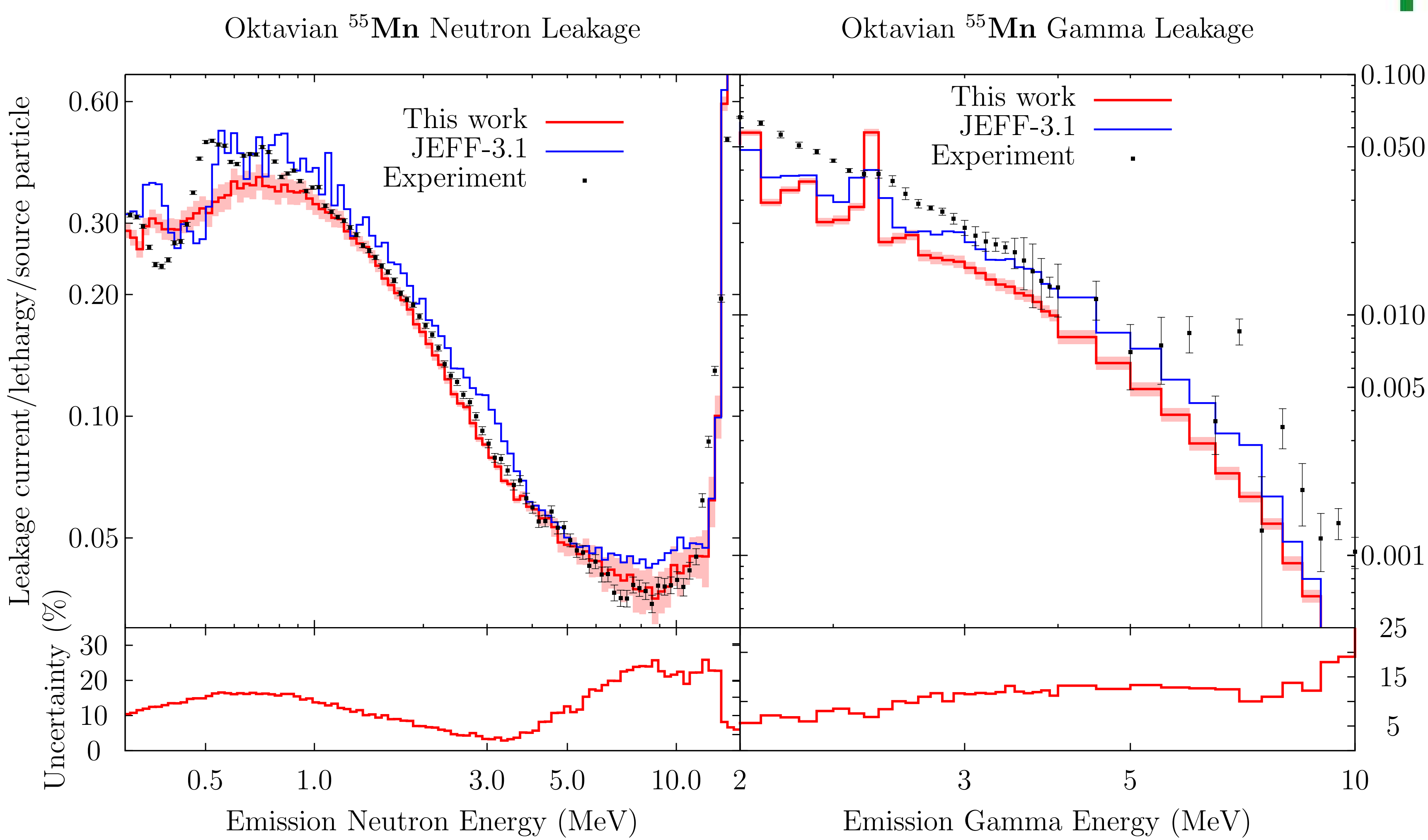
Examples with (n,γ), (n,inl) and (n,el)



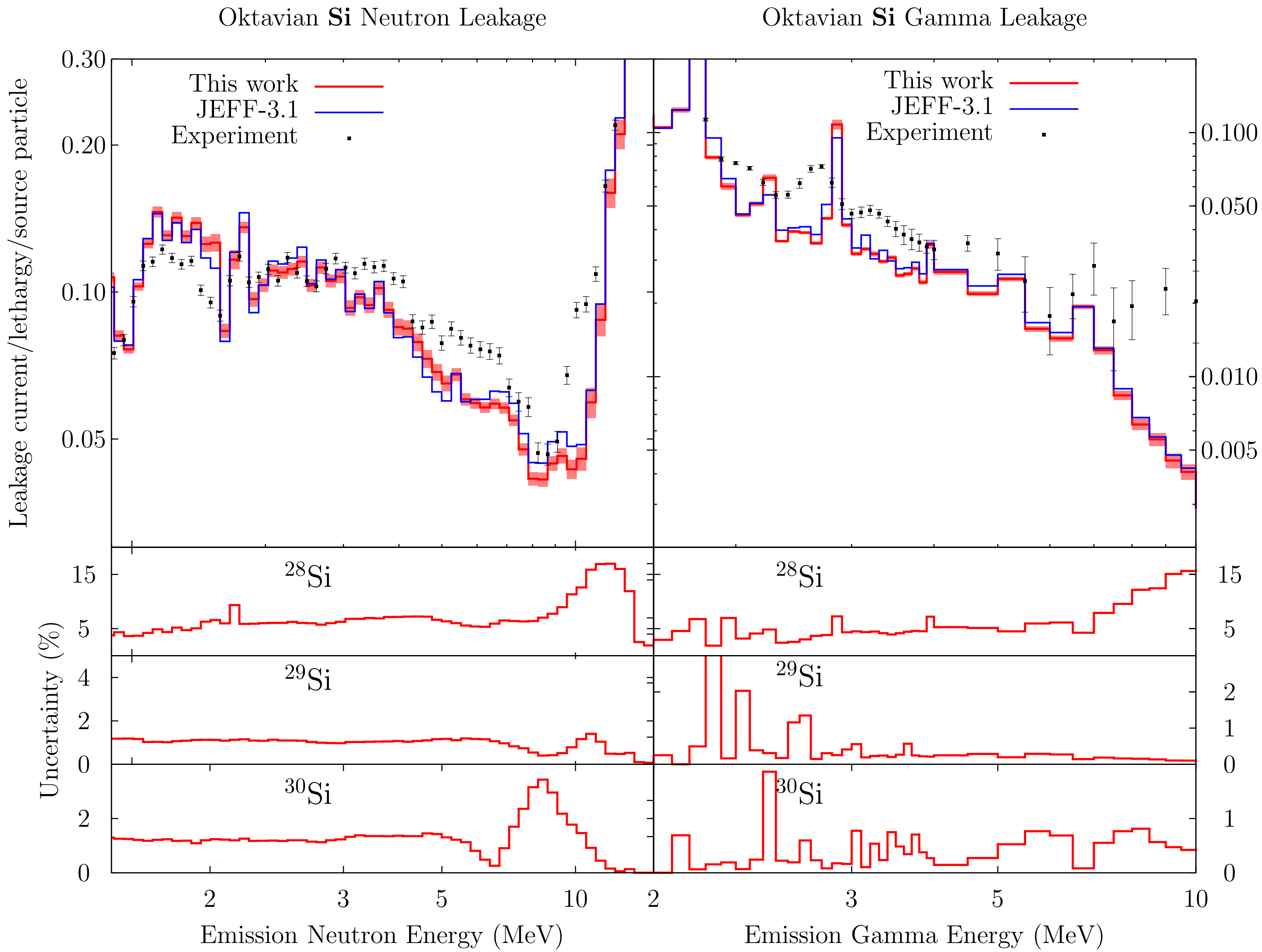
Application for Cr Oktavian benchmark



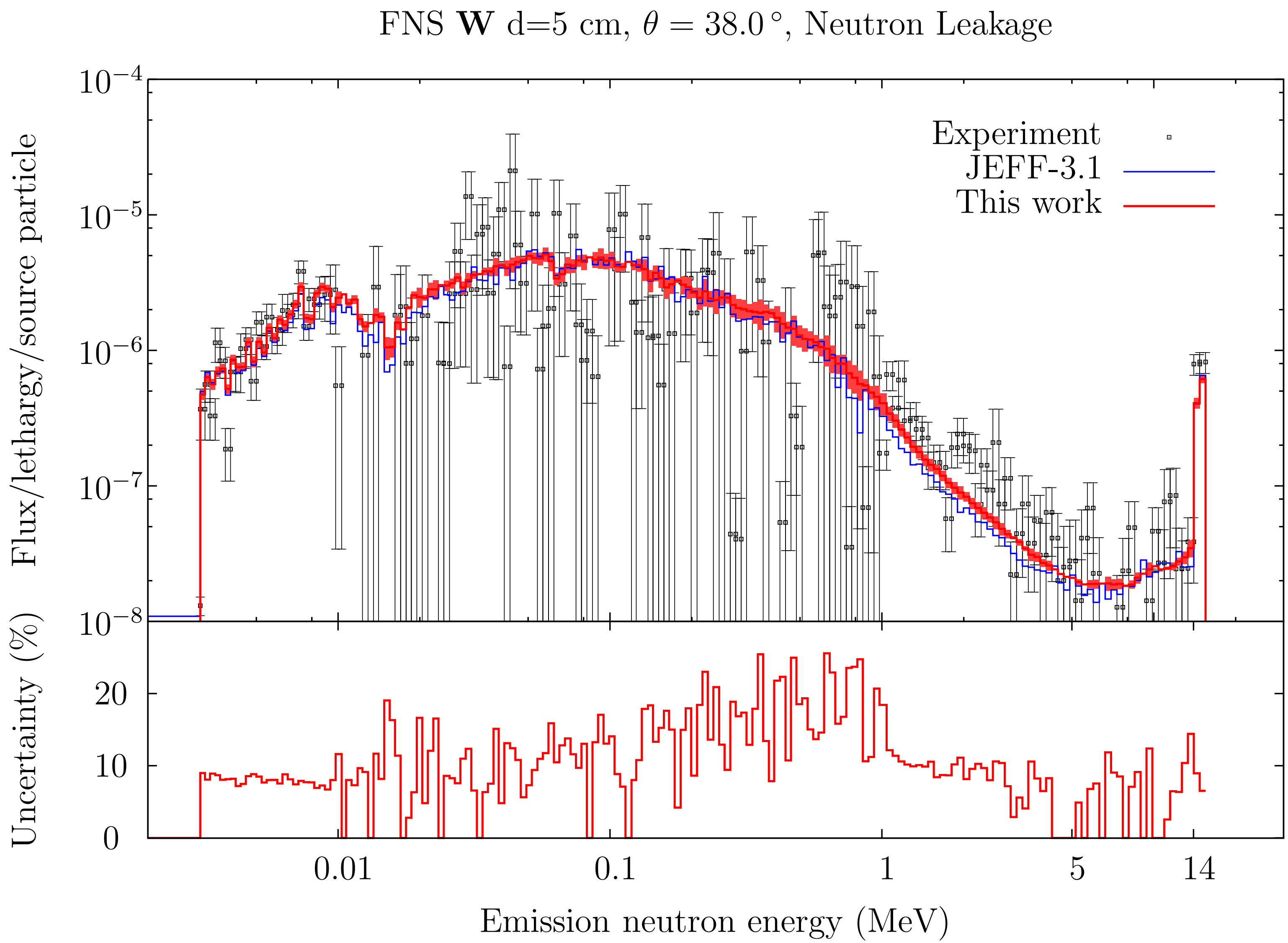
Application for Mn Oktavian benchmark



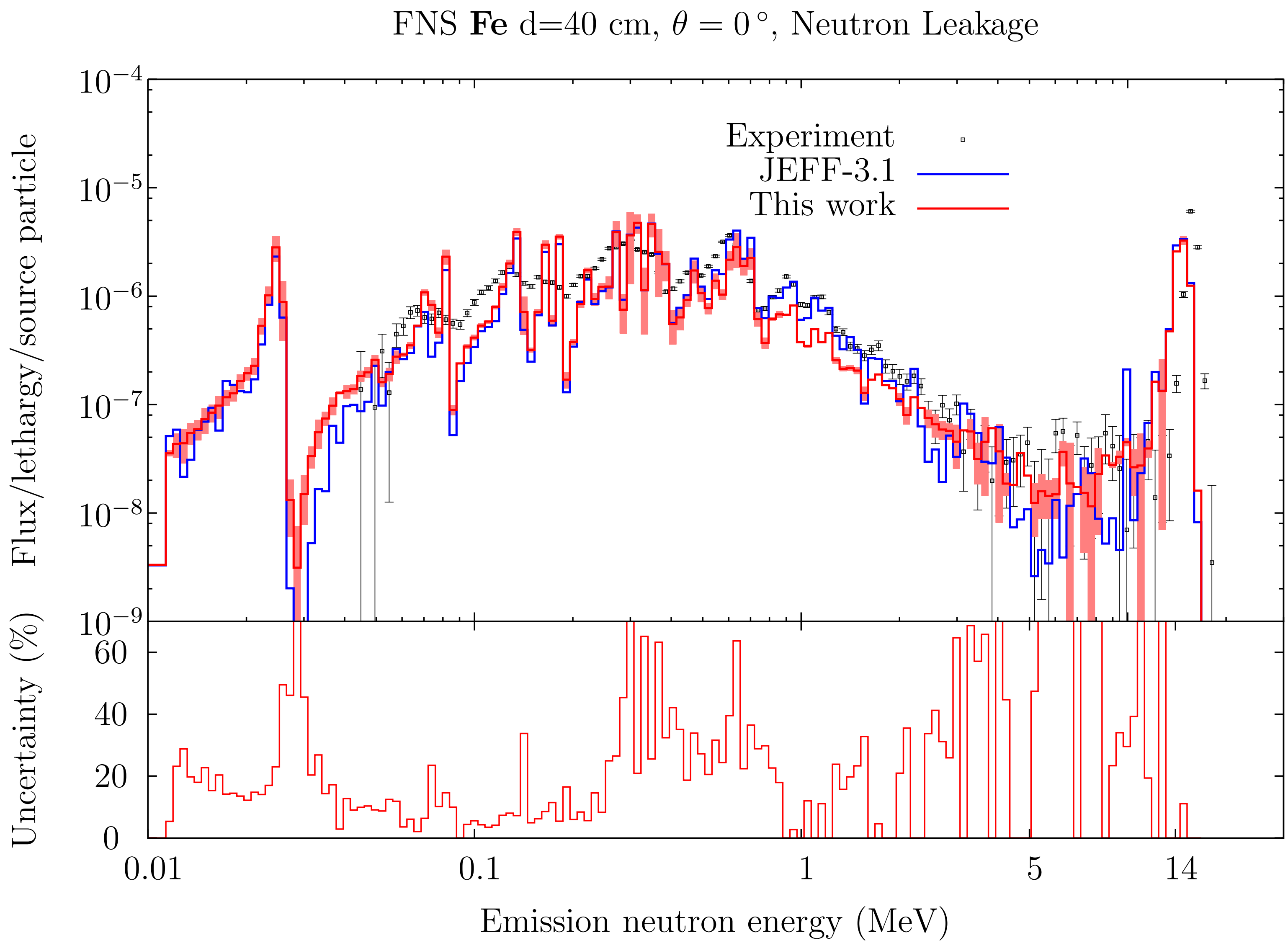
Application for Si Oktavian benchmark



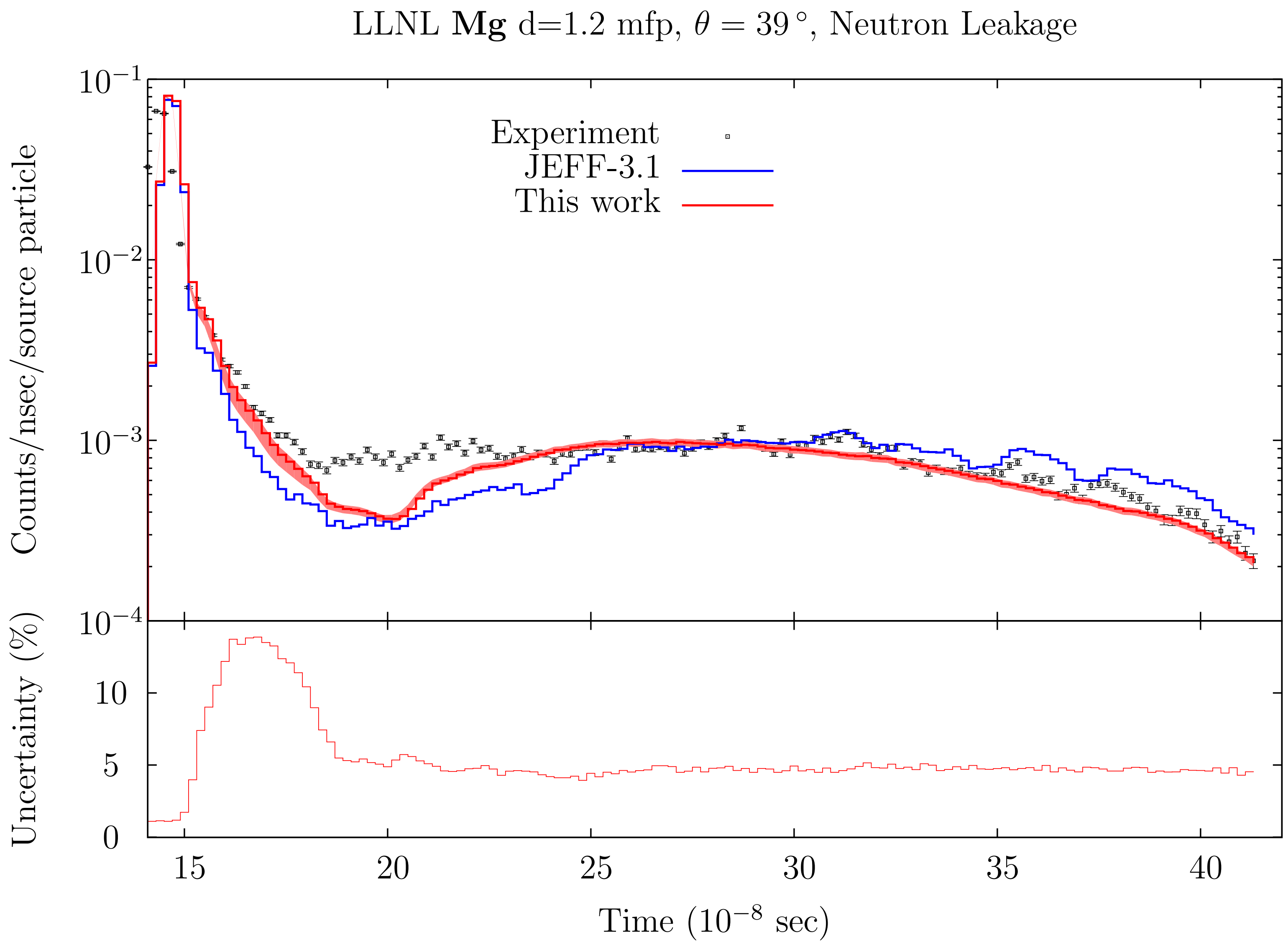
Application for W FNS benchmarks



Application for Fe FNS benchmarks



Application for Mg LLNL benchmarks



Pros and Cons

- ☺ + No MF 32-35 (no 2 Gb files) but every possible cross correlation included
- ☺ + No approximation but true probability distribution
- ☺ + Only essential info for an evaluation is stored
- ☺ + No perturbation code necessary, only “essential” codes
- ☺ + Feedback to model parameters
- ☺ + QA
- ☹ - Needs discipline to reproduce
- ☹ - Memory and computer time

Conclusions and future improvements

- ✗ New methodology to propagate nuclear data uncertainty to integral quantities (k_{eff} benchmarks, shielding benchmarks, reactivity swing, neutron flux for commercial reactor) via Monte Carlo
- ✗ Blending differential measurements, evaluations, and validation in one approach
- ✗ Proof of principle with some shielding benchmarks

Conclusions and future improvements

- ✗ New methodology to propagate nuclear data uncertainty to integral quantities (k_{eff} benchmarks, shielding benchmarks, reactivity swing, neutron flux for commercial reactor) via Monte Carlo
- ✗ Blending differential measurements, evaluations, and validation in one approach
- ✗ Proof of principle with some shielding benchmarks
- ☐ New calculations based on TENDL-2009 (see the JEFF meeting)
- ☐ Needs to develop best central-value evaluations ?
- ☐ Comparison with Hogenbirk method for MCNP
- ☐ Compare with more benchmarks
- ☐ Obtain sensitivity for reaction channels
- ☐ Need more clever sampling

And finally

If we can do a calculation once, we can also do it a 1000 times, each time with a varying data library.