PAUL SCHERRER INSTITUT

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ICSBEP benchmarking…reaction rates

Consultancy Meeting on International Radiation Characterization Benchmark Experiment Project (IRCBEP), Vienna, IAEA, 6-8 August 2018

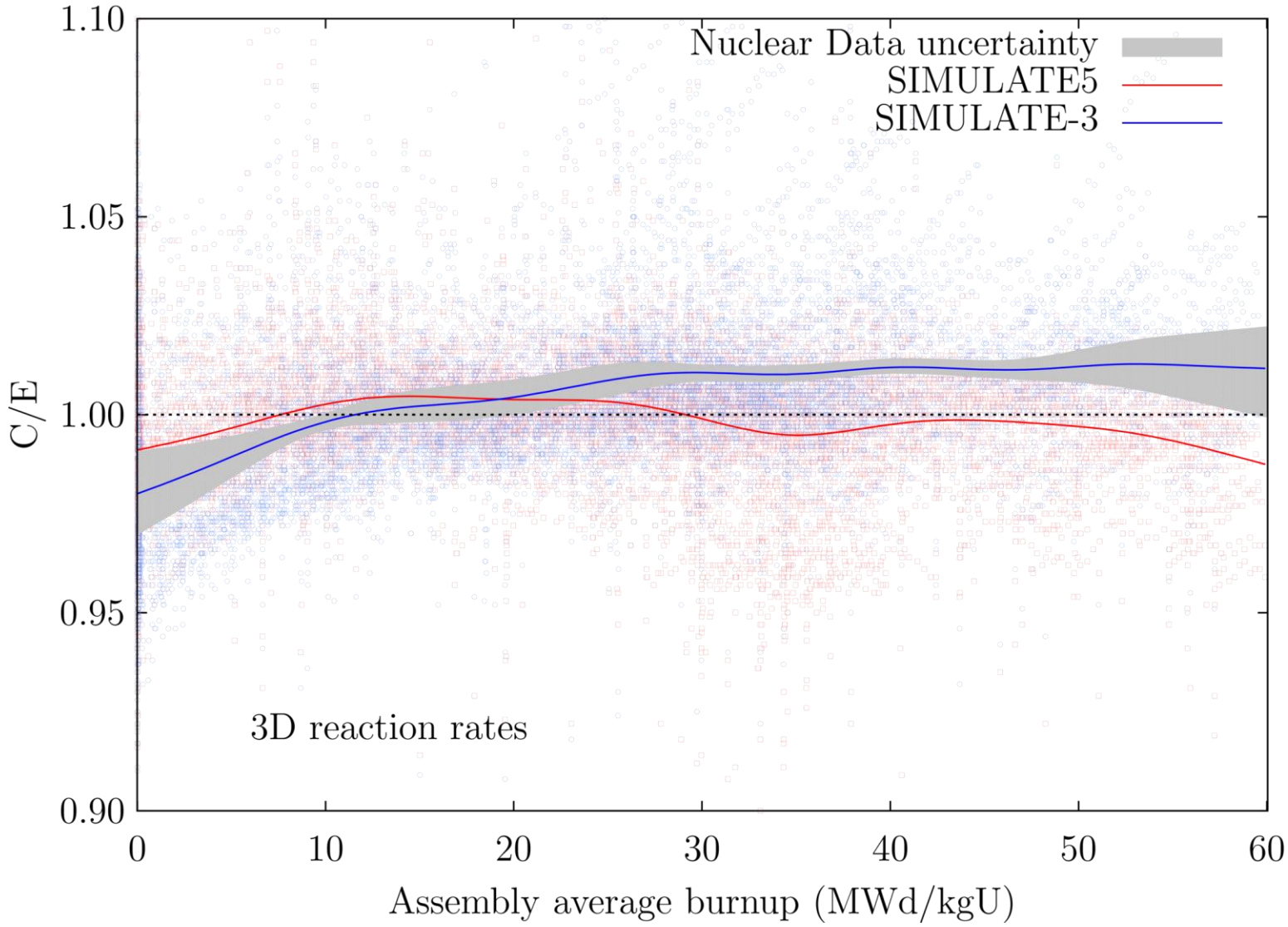
Zertifiziertes Managementsystem STARS ISO 9001

Summary

- Some observations and needs from reactor and spent fuel simulations
- ICSBEP & reaction rates
- Conclusion

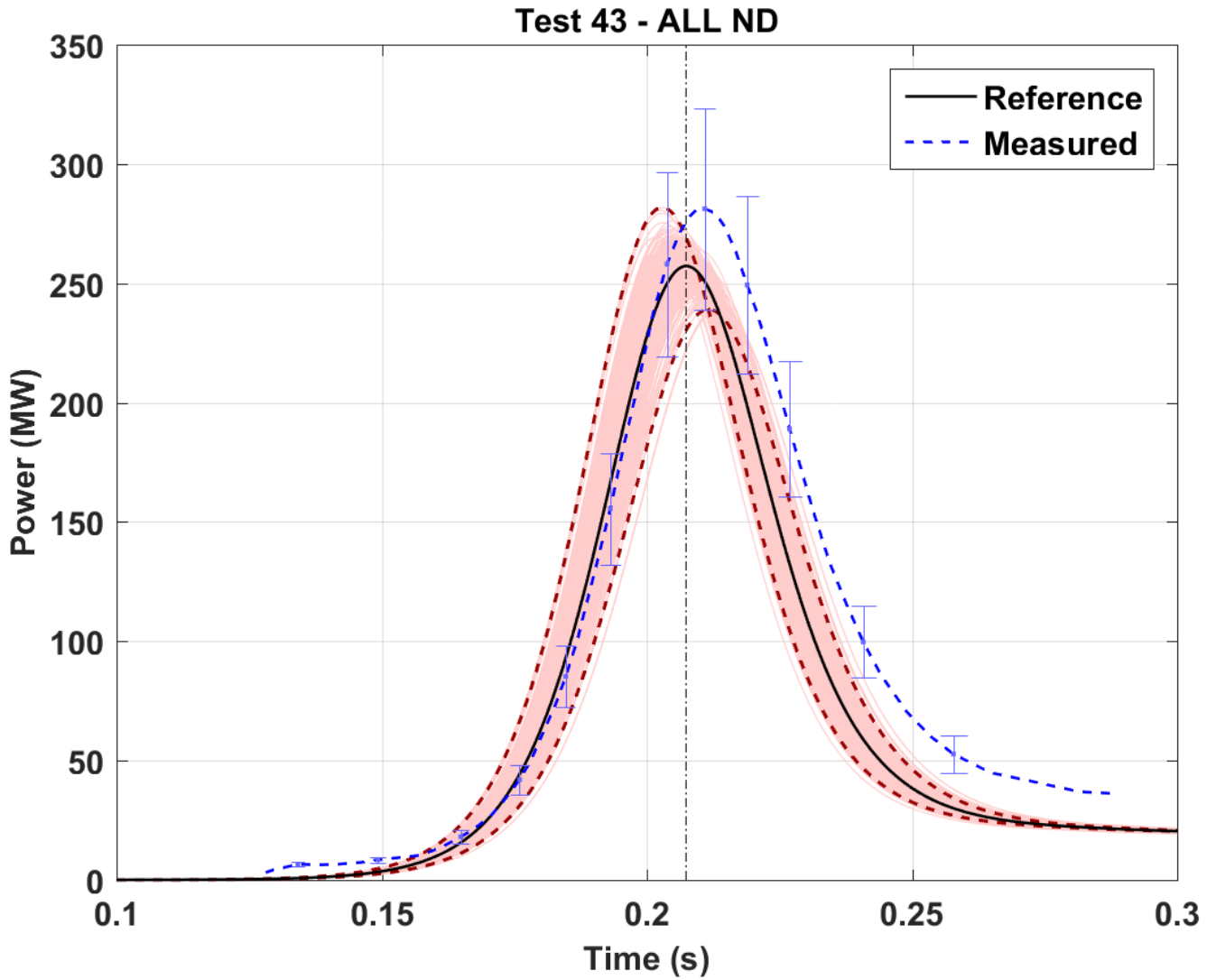
Reactor and Spent fuel simulations

- What are the needs from the LWR normal operation for nuclear data ?



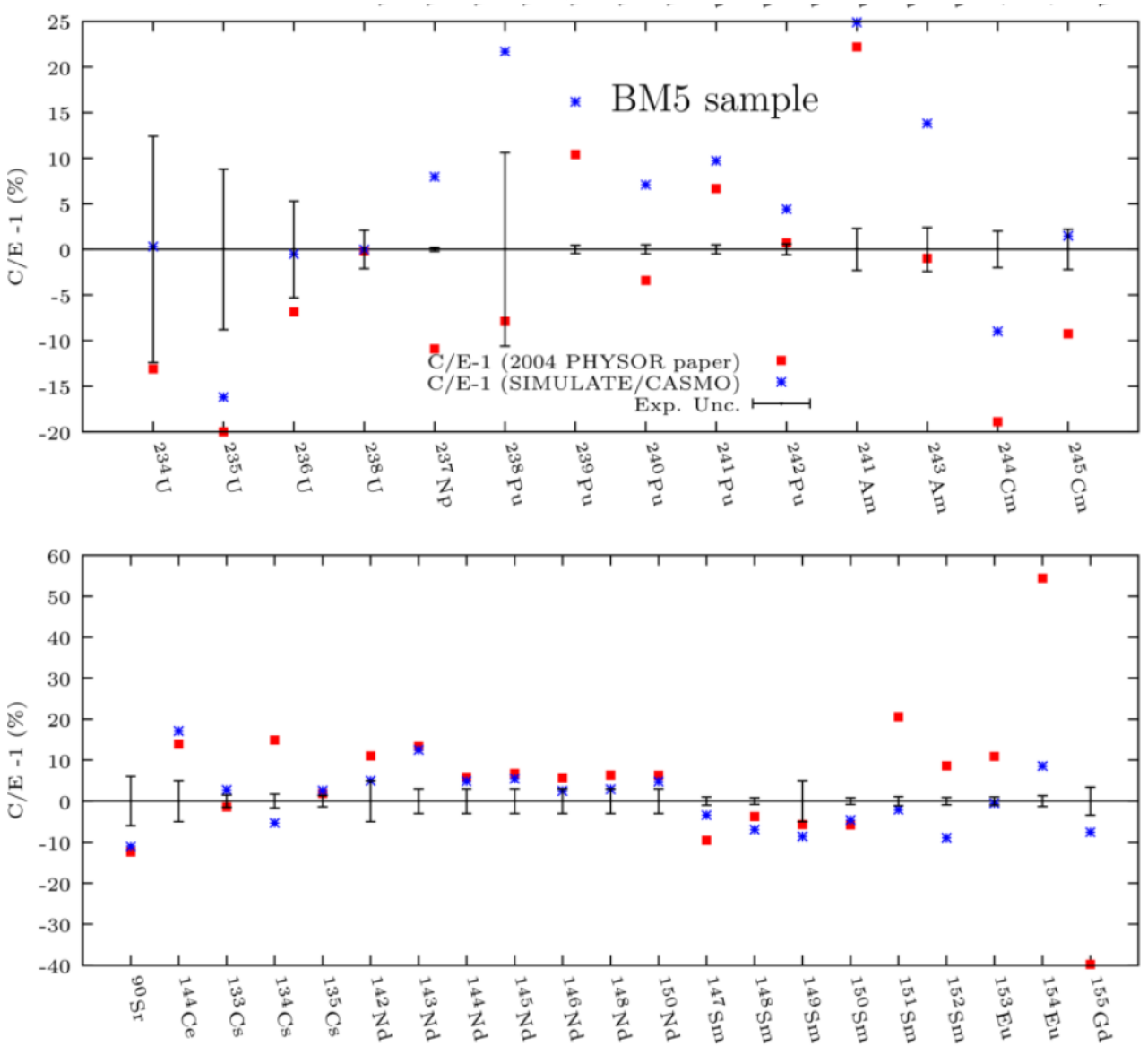
Reactor and Spent fuel simulations

- What are the needs from the LWR transient for nuclear data ?
- Example of RIA experiment:

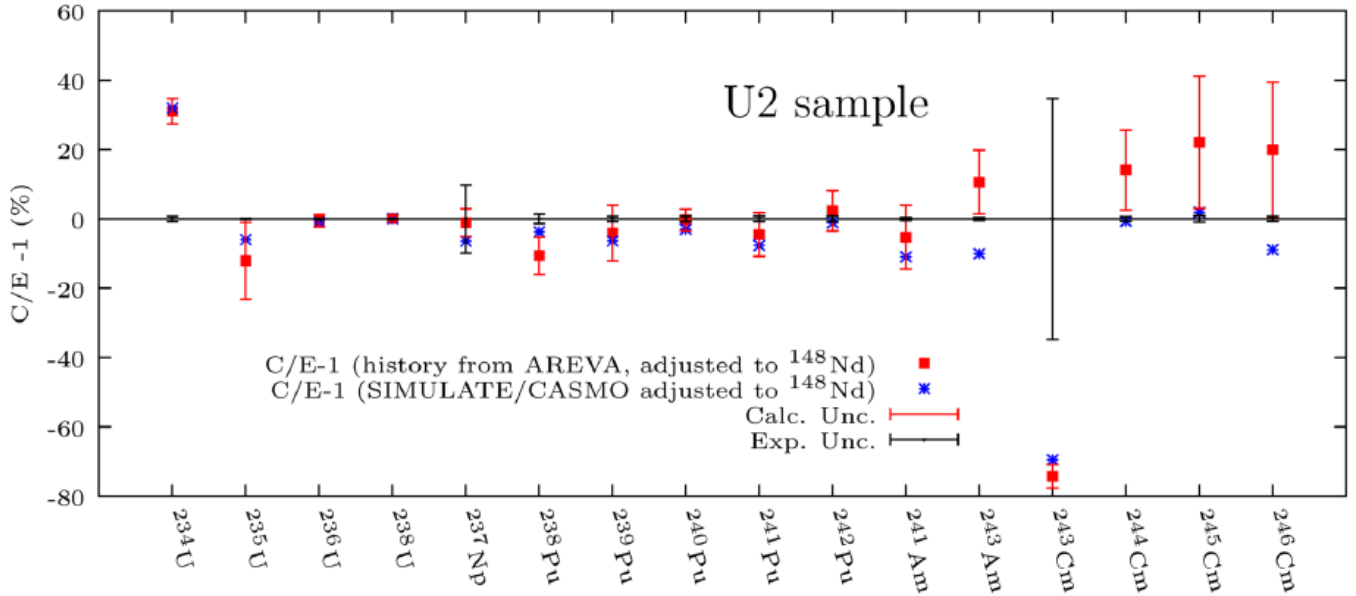


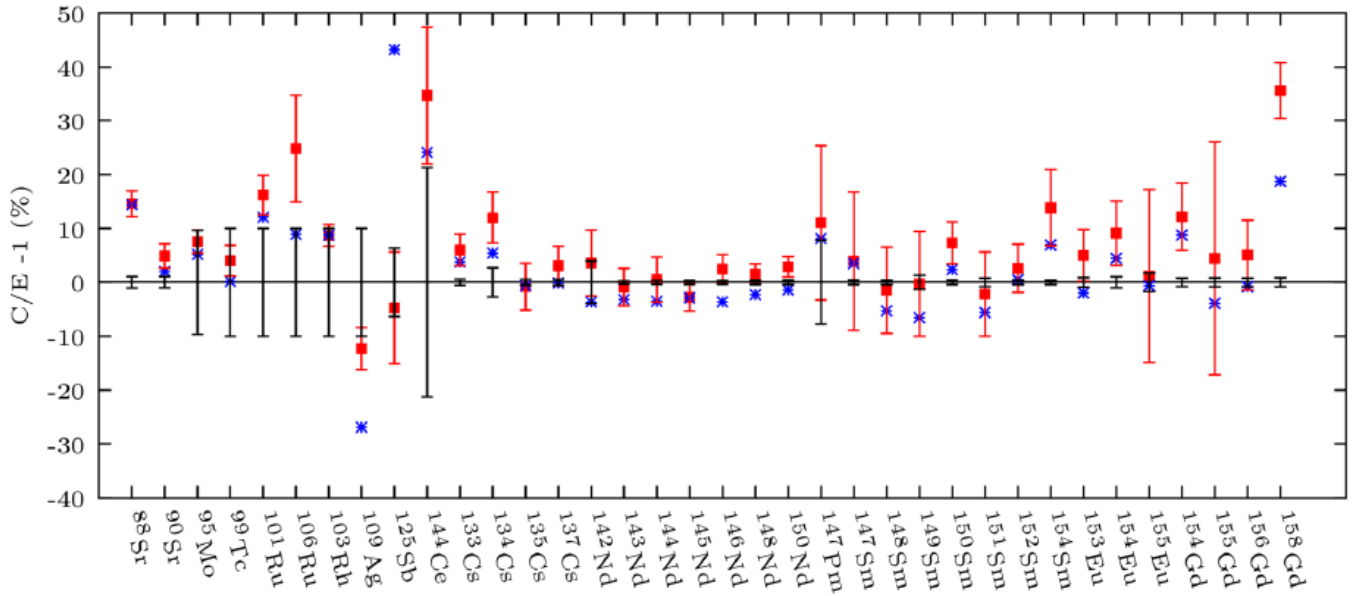
Reactor and Spent fuel simulations

- What are the needs from the LWR spent fuel for nuclear data ?



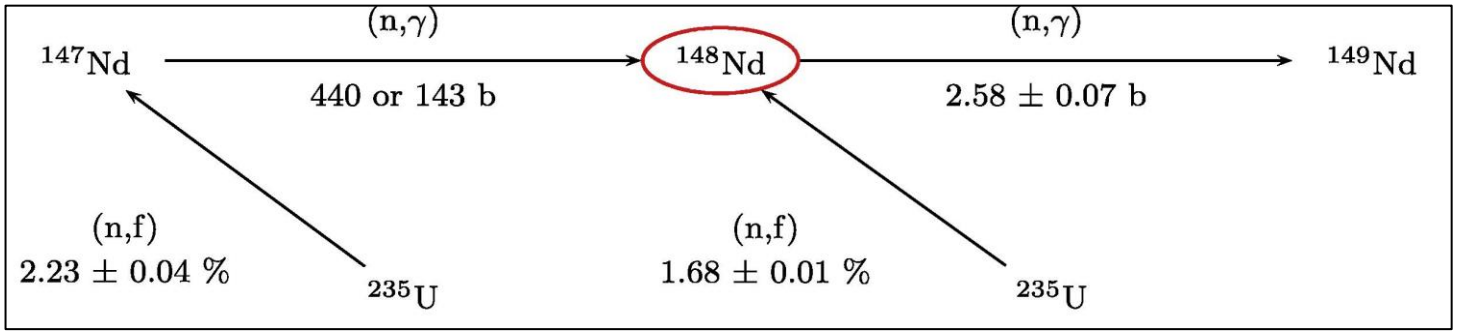
Uncertainty and biases for PIE C/E

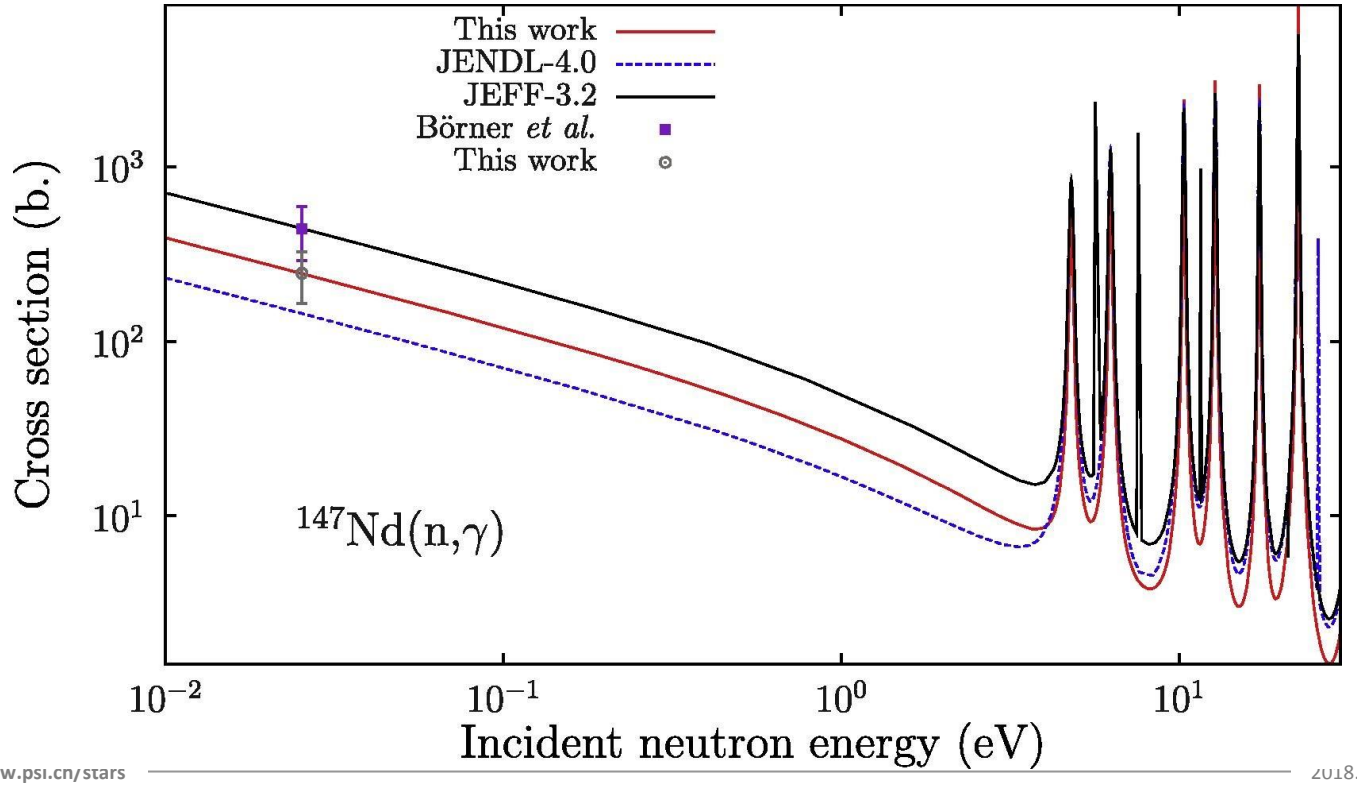




Reactor and Spent fuel simulations

- What are the needs from the LWR spent fuel for nuclear data ?
- Example for Nd147(n,g)

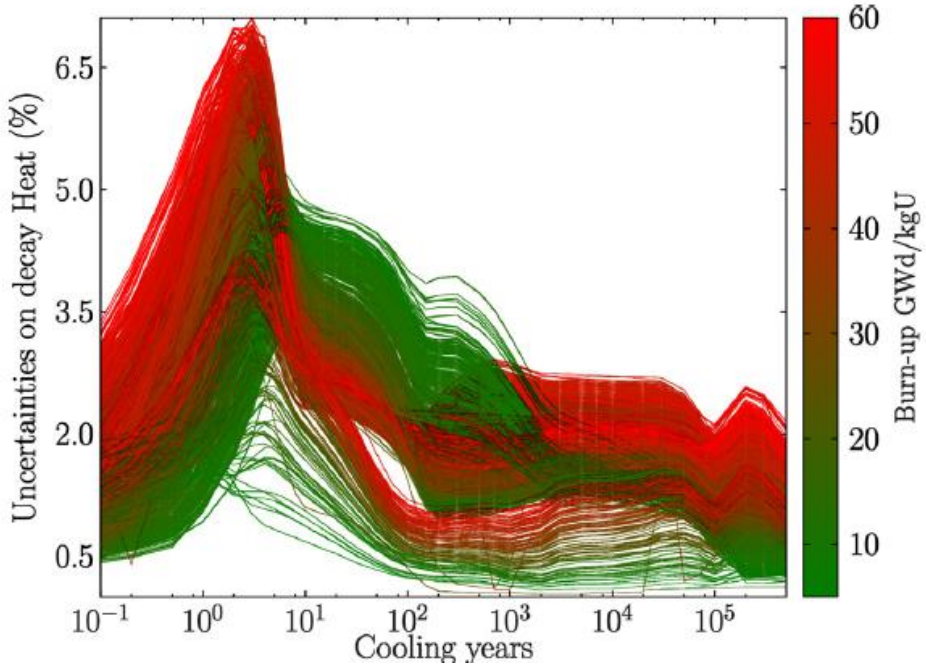


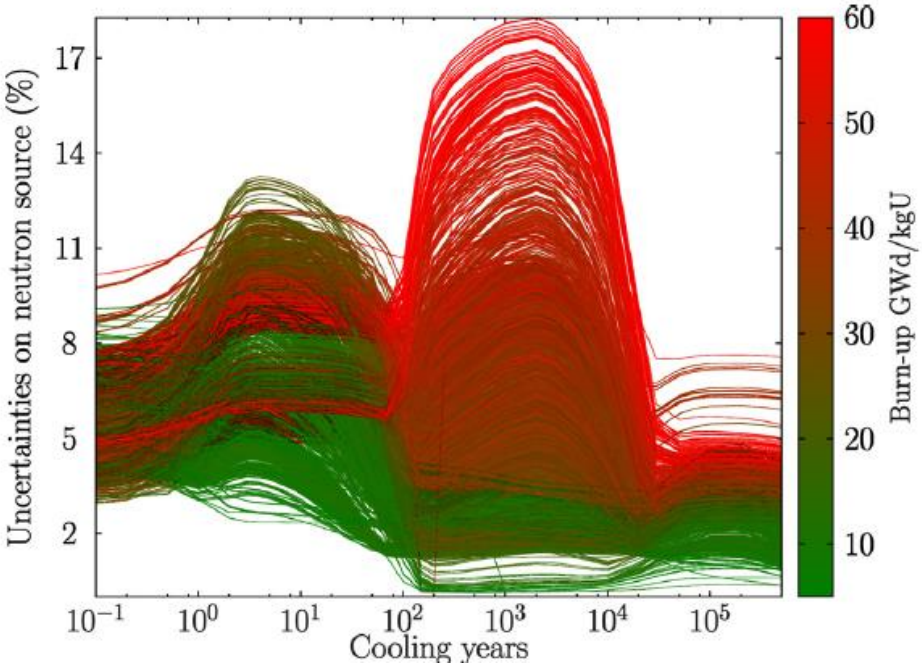


Reactor and Spent fuel simulations

- What are the needs from the LWR spent fuel for nuclear data ?

- Example for uncertainties for spent nuclear fuel for realistic irradiation history

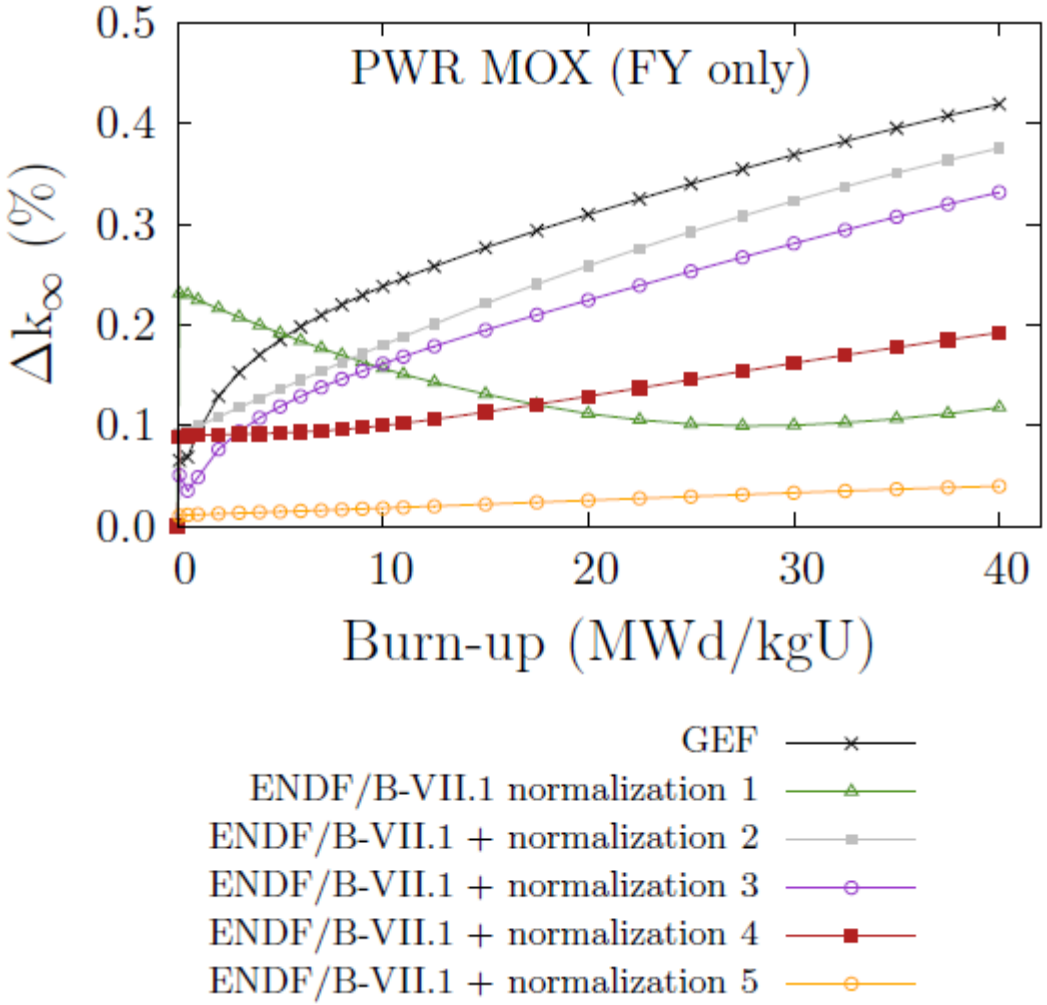




Reactor and Spent fuel simulations

- What are the needs from the LWR spent fuel for nuclear data ?

- Example for the impact of the methods



Reactor and Spent fuel simulations

- What are the needs from the LWR spent fuel for nuclear data ?
- Example for the impact of the methods/sources of covariances

Table 3. Comparisons with the uncertainties presented in reference [26] for a PWR case, 4.1 wt.% enrichment, UO fuel, exposure of 40 MWd/tHM without cooling (case 1), and with reference [11] for a PWR case, 3.4% enrichment, UO fuel, exposure of 54 MWd/kgU, with 10 years cooling (case 2).

Isotope	Uncertainty (%)			
	Case 1		Case 2	
	[26]	This work	[11]	This work
^{234}U	–	1.8	2.4	2.1
^{235}U	1.0	1.4	3.3	2.7
^{236}U	1.5	1.6	1.5	1.6
^{239}Pu	2.0	2.3	2.9	2.6
^{240}Pu	1.9	2.3	2.5	2.2
^{241}Pu	2.7	1.7	2.7	2.1
^{242}Cm	2.2	2.7	–	3.6
^{244}Cm	8.5	9.7	9.6	9.1

Isotope	Uncertainty (%)			
	Case 1		Case 2	
	[26]	This work	[11]	This work
^{90}Sr	5.0	0.7	1.5	0.7
^{99}Tc	9.5	1.3	10	1.5
^{129}I	13	2.5	–	2.9
^{137}Cs	1.7	7	4.0	6.2
^{148}Nd	14	0.4	0.4	0.4

Reactor and Spent fuel simulations

Intermediate conclusions:

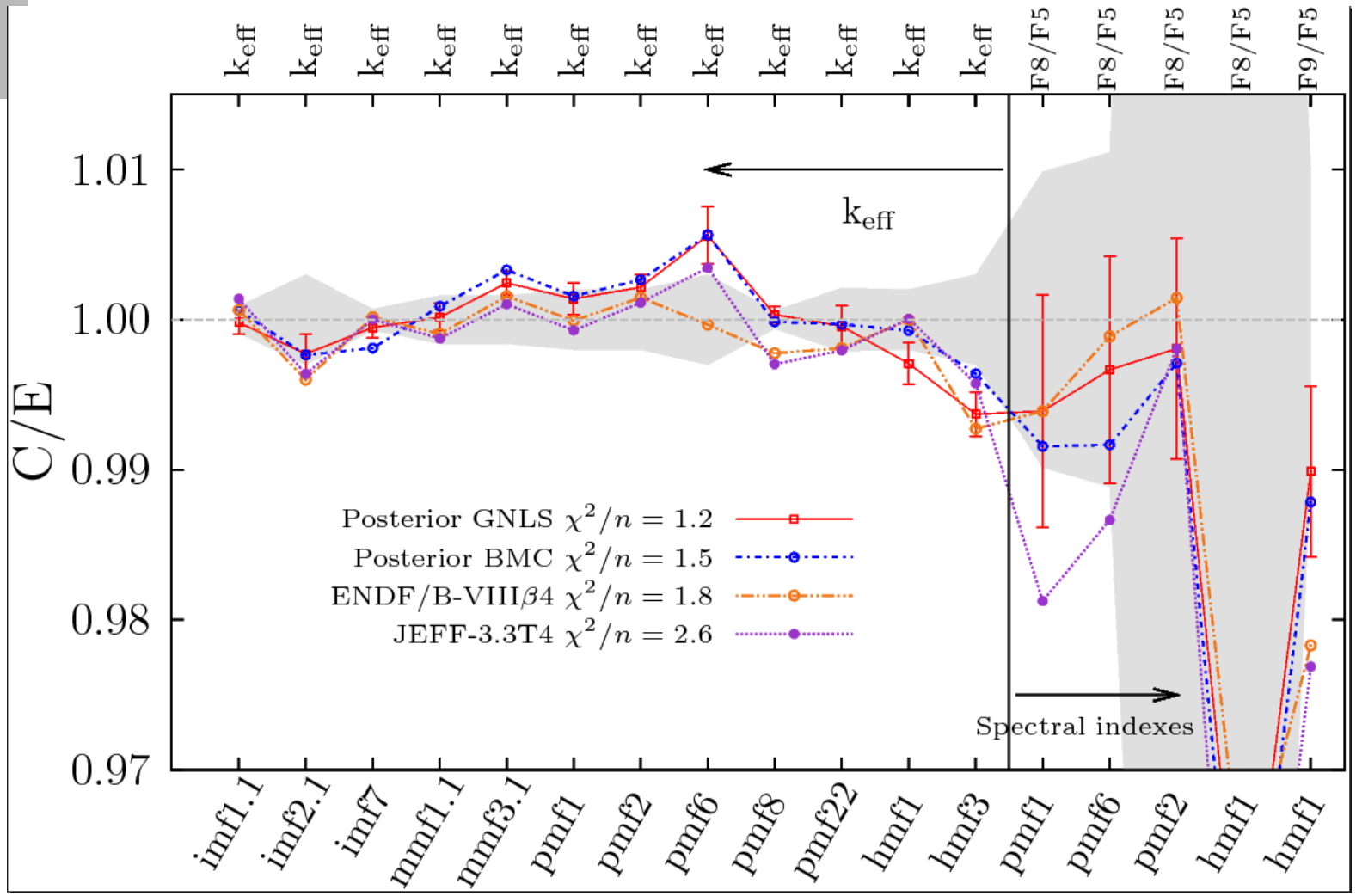
- Reaction rates are of prime importance for reactor applications
- Nuclear data are important for transient and spent nuclear fuel assessments (SNF)
- Different methods lead to differences as large or larger than the nuclear data impact for SNF (see for instance the “blind benchmark” from SKB)

Our experience:

- The European industry is interested in better characterization of the SNF, and a quantification of the impact of key parameters (including nuclear data)
- The current knowledge of nuclear data, **combined** with a variety of calculation methods, need to be improved for better understanding and cost reduction

ICSBEP, k_{eff} and reaction rates

- The ICSBEP or IRPhe databases are mostly used for k_{eff} calculations,
- Nuclear data are (too) often validated primarily on k_{eff}



Reaction rates (fission and activation ratios)

- Not many benchmarks include reaction rates
- Large experience in NEA subgroups for data adjustments (SG-26,33,39,46):

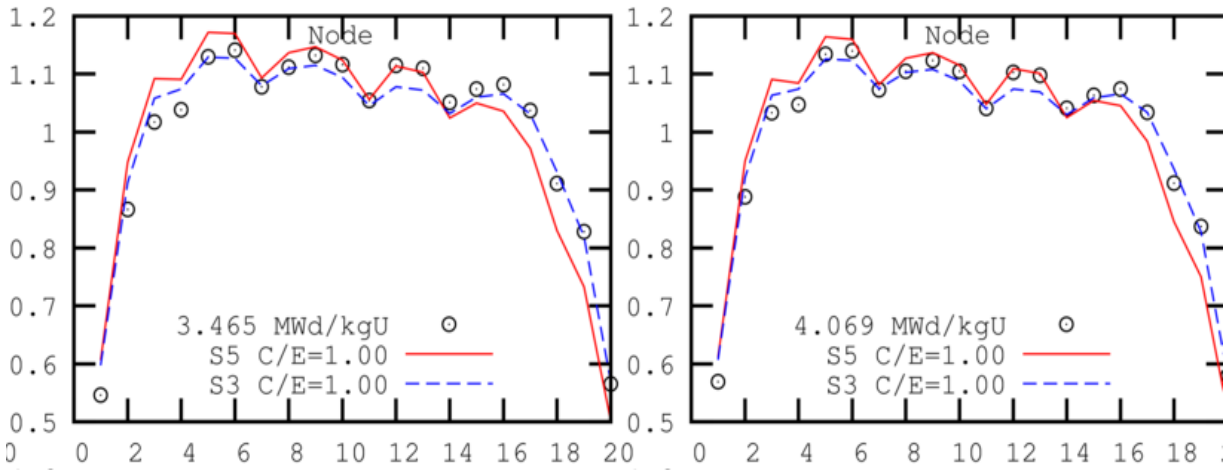
– pmf1	(Jezebel)	F28/F25, F49/F25, F37/F25
– pmf2	(Jezebel-240)	F28/F25, F37/F25
– pmf6	(Flattop Pu)	F28/F25, F37/F25
– pmf8		
– hmf1	(Godiva)	F28/F25, F49/F25, F37/F25
– hmf28	(Flattop)	F28/F25, F49/F25, F37/F25
– imf7	(Bigten)	F28/F25, F49/F25, F37/F25, C28/F25
– zpr6-7		F28/F25, F49/F25, C28/F25
– zppr9		F28/F25, F49/F25, C28/F25
– sneak 7A		F28/F25, F49/F25, C28/F25
– sneak 7B		F28/F25, F49/F25, C28/F25

- Additionally, many activation measurements are also provided

Reaction rates (fission and activation ratios)

- Uncertainties for the reaction rates are often larger than for $k_{eff,}$ therefore an adjustment procedure will be driven mainly by k_{eff}
- Some questions arise due to poor descriptions (type of fission chambers, fissile contents and impurities, possible calibration)

- For reactor applications, fission chamber and aerobal measurements ($^{51}V(n,g)$+beta decay) are of prime importance (local and possible tilts)
- Many corrections are necessary (deadtime, geometry, photons…)
- "How far" better nuclear data are needed ?



Conclusions

- From the nuclear data point of view, k_{eff} validation is not enough,
- From the application side, many important cross sections and uncertainties do not depend on k_{eff},

- There is a need for a common compiled database for integral quantities other than keff
  - thermal cross sections,
  - resonance integral,
  - reaction rates (fission and activation),
  - MACS…
  - Spectra averaged cross sections,
  - Integral measurements from shutdown (to be) NPP ?

- Such database needs to include covariance information (not only recommended, but also all experimental details),

- There is also a need to quantify the impact of other parameters and of the methods of validation.

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