D. Rochman, A. Vasiliev, H. Ferroukhi

PSI approach to the decay heat blind test exercise

Decay heat blind test benchmark meeting,
April 6, 2018, NEA, Paris, France

Summary

- Tools and database to be used

- Methods
  - No modeling (simple approach): pick and choose
  - New modeling: traditional approach

- Examples for the “no modeling” approach

All slides can be found here: https://tendl.web.psi.ch/bib_rochman/presentation.html

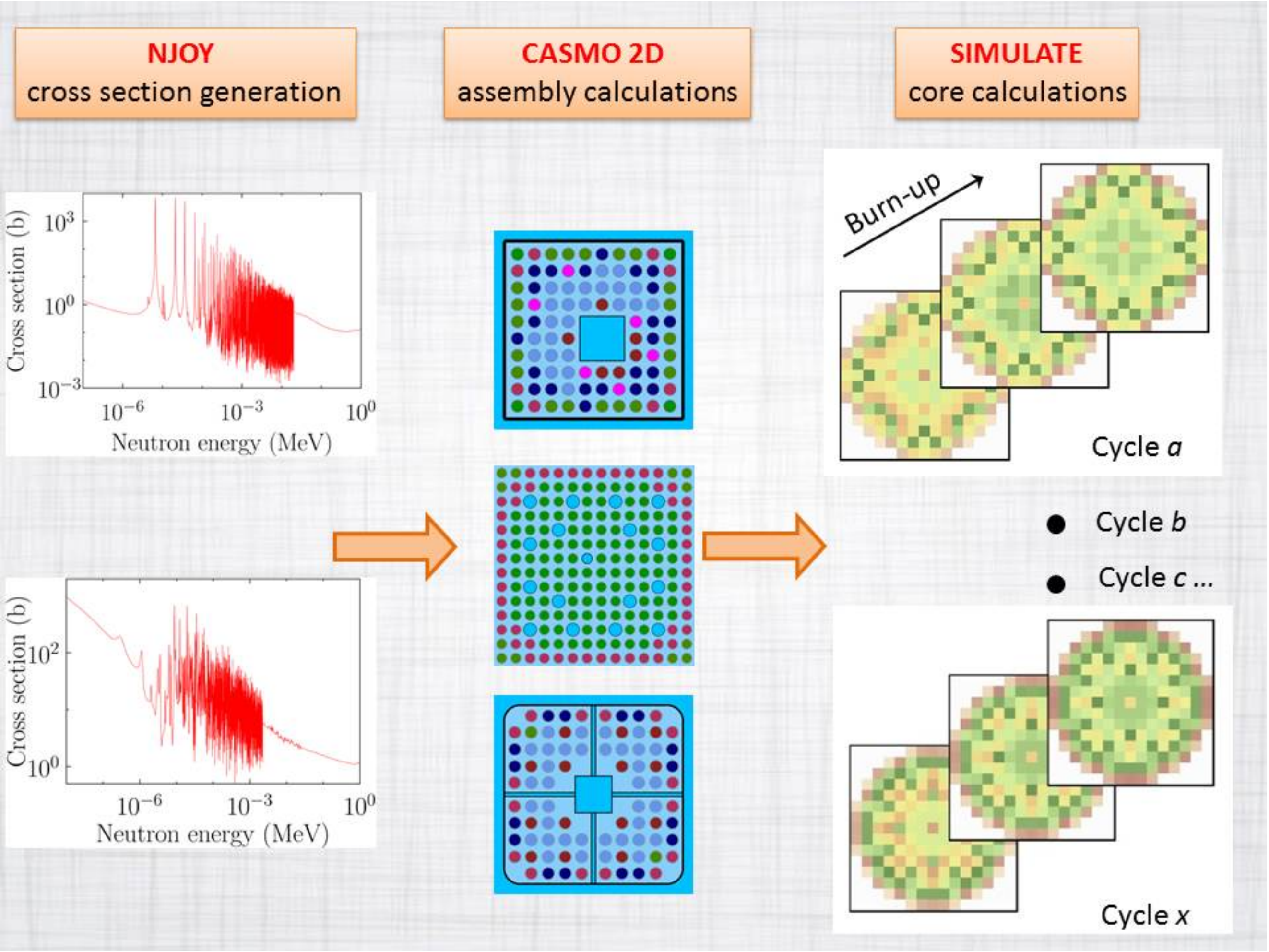
Tools and database to be used

- Our group performs core licensing for the 5 Swiss reactors (3 PWR and 2 BWR)
- We have access to all cycle histories from the operators and the experimental data (e.g. boron concentration, reaction rates, TIPS…)
- Over the years, we have validated built-up models based on this information
- The simulation tools are CASMO5 + SIMULATE3/SIMULATE5 + SNF from Studsvik Scandpower (CMSYS database).
- Example for a PWR relevant for this work:

Core label	Type	Fuel	Enrichment %	Cycles	Assembly-cycles	Burn-up MWd/kgU
PWR-1	PWR	UO_2	2.9-4.7	17-42	2542	4-60
PWR-1	PWR	MOX	2.2-5.8	17-42	297	4-50
PWR-2	PWR	UO_2	1.9-3.5	1-16	2647	7-55
BWR-1	BWR	UO_2	0.7-4.5	19-44	3746	10-45

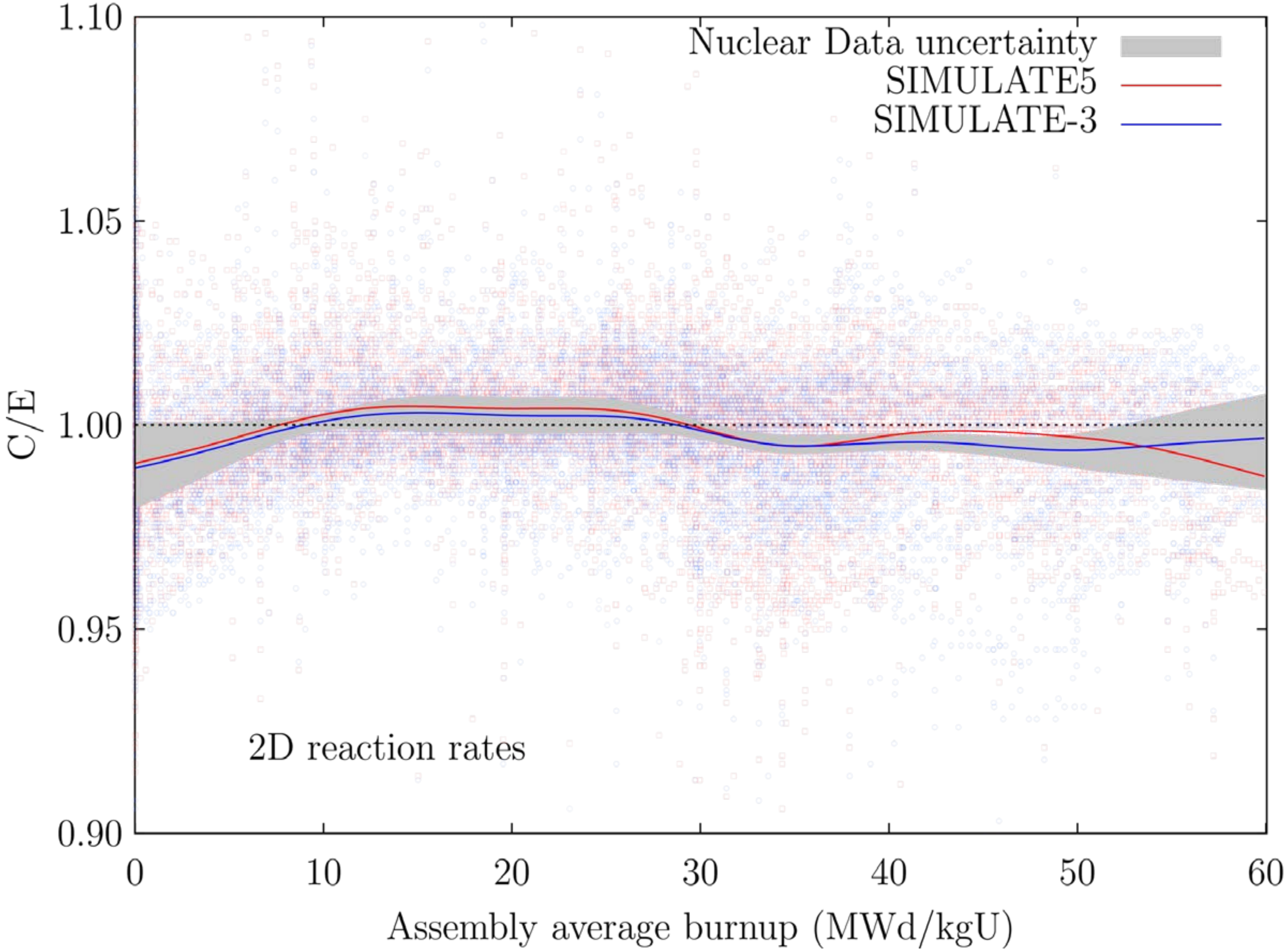
Tools and database to be used

- Example of the complete process line from cross sections to reactor quantities, including validation based on core measurements.



Tools and database to be used

- Example of validation for a specific PWR, over 26 cycles.



Tools and database to be used

- Available cases: almost 10 000 assembly-cycles,
- Example for one PWR:

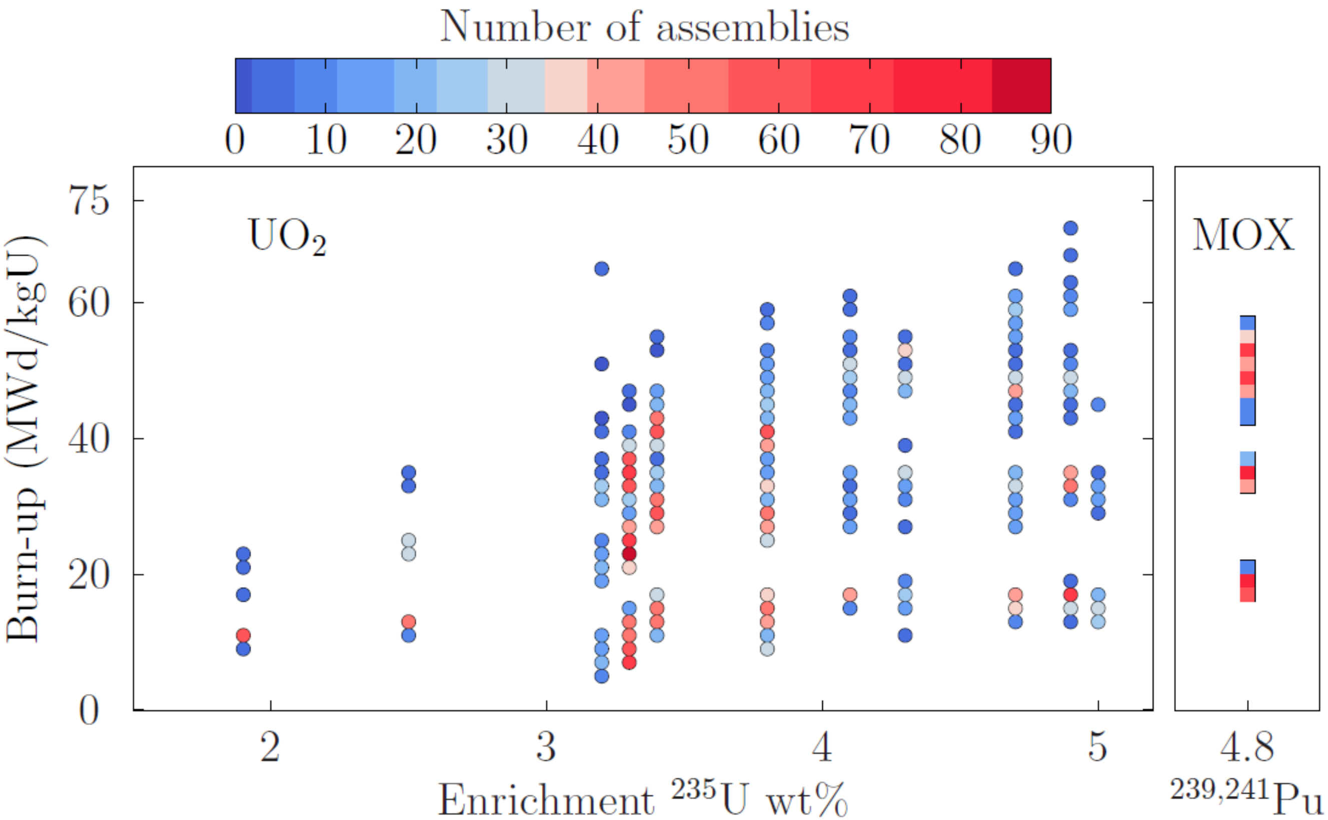
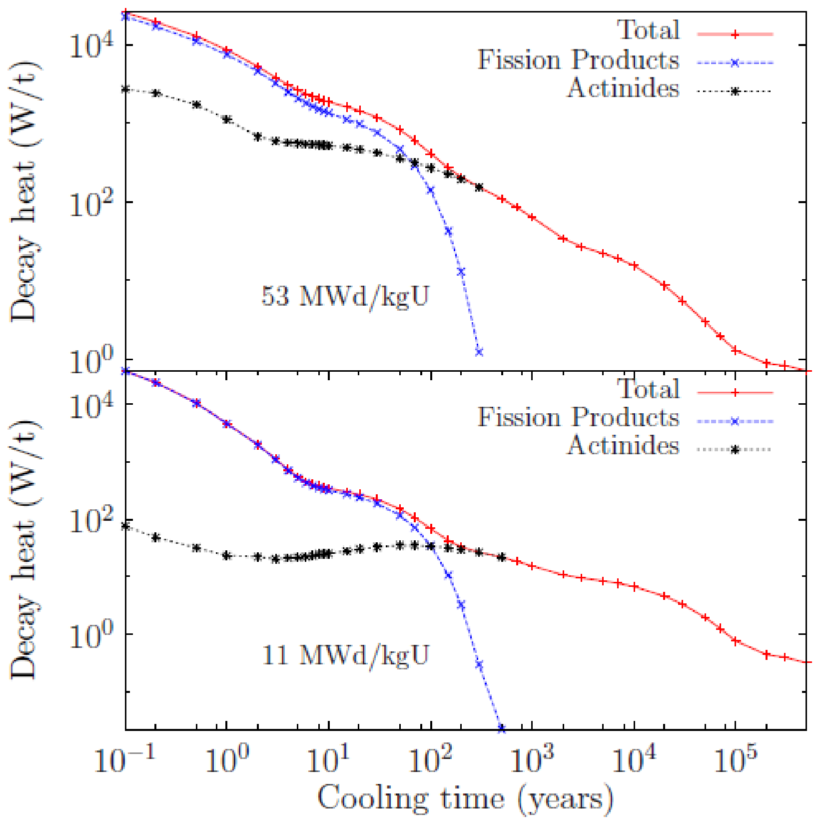
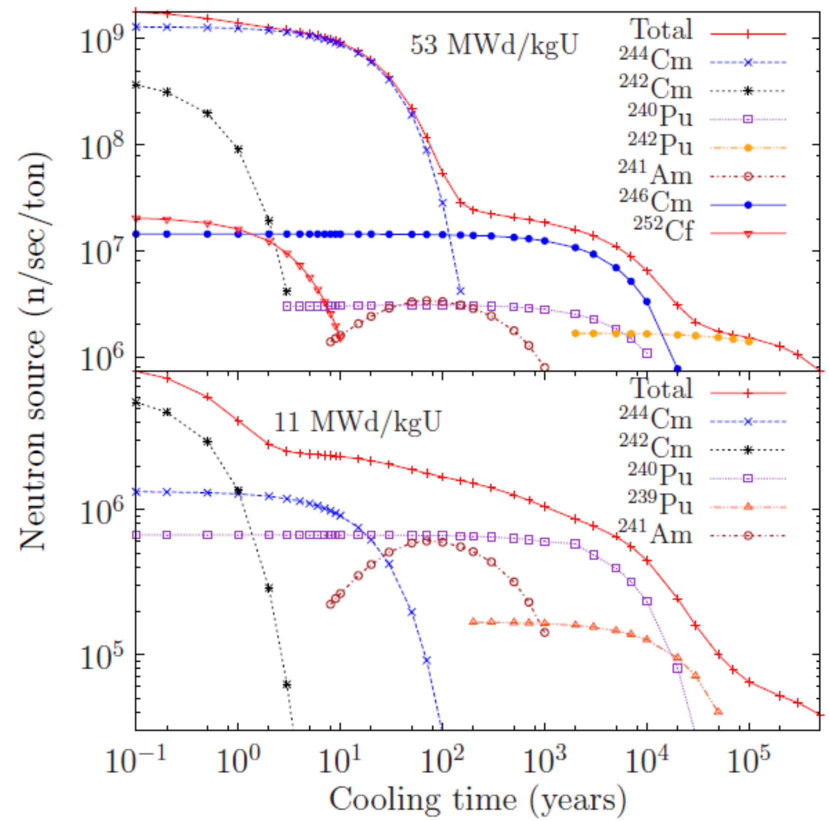


Fig. 1. Total number of fuel assemblies considered in this work from a specific Swiss PWR power plant, over 34 cycles (5378 UO_2 and 640 MOX assemblies). All assemblies are considered at the end of each cycle, being discharged or not.

Tools and database to be used

- Available quantities for each assembly (average, pin and segment):
  – Decay heat,
  – Neutron and Gamma sources,
  – Isotopic vectors,
  – Uncertainties due to nuclear data.





Methods

- No modeling (simple approach): pick and choose
  - Using existing models,
  - And choosing assemblies which are the closest to the specifications.
  - Advantages:
    - provide a range of results (average and uncertainties ?)
    - less efforts
  - Drawback: no specific modeling, can provide a wide range of results

- New modeling (traditional approach):
  1. Develop specific CASMO5 model from the specifications,
     - New assemblies to be inserted in existing/adjusted SIMULATE models + SNF.
  2. Develop specific CASMO5 model from the specifications,
     - Use CASMO5 only (+ SNF Lite)
  3. Eventually use Monte Carlo modeling

- Best solution: both ?

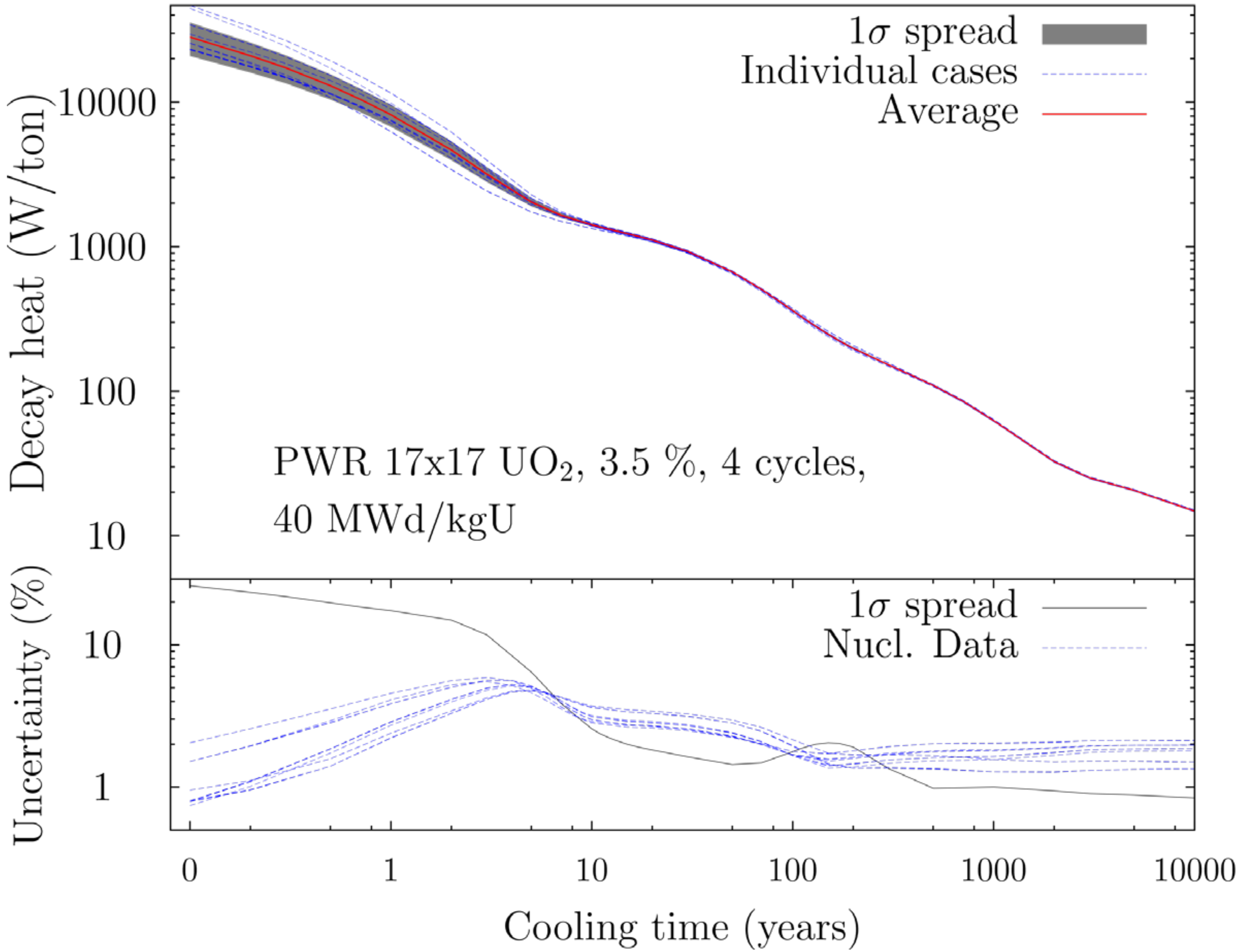
Example 1

- Hypothetic data:
  - 17x17 assembly PWR
  - UO_2 fuel, 3.5 % ^{235}U, no Gd
  - Used in 4 cycles (possibly with gaps ?), final average burnup: 40 MWd/kgU

- Results:

– 17x17 assembly PWR:	> 6000 cases
– UO_2 fuel:	> 5000 cases
– 3.5 % ^{235}U (+/- 3%), no Gd:	> 1400 cases
– 4 cycles and out	> 142 cases
– 40 MWd/kgU +/- 3%	= 29 cases
– 4 cycles and one later	> 20 cases
– 40 MWd/kgU +/- 3%	= 20 cases

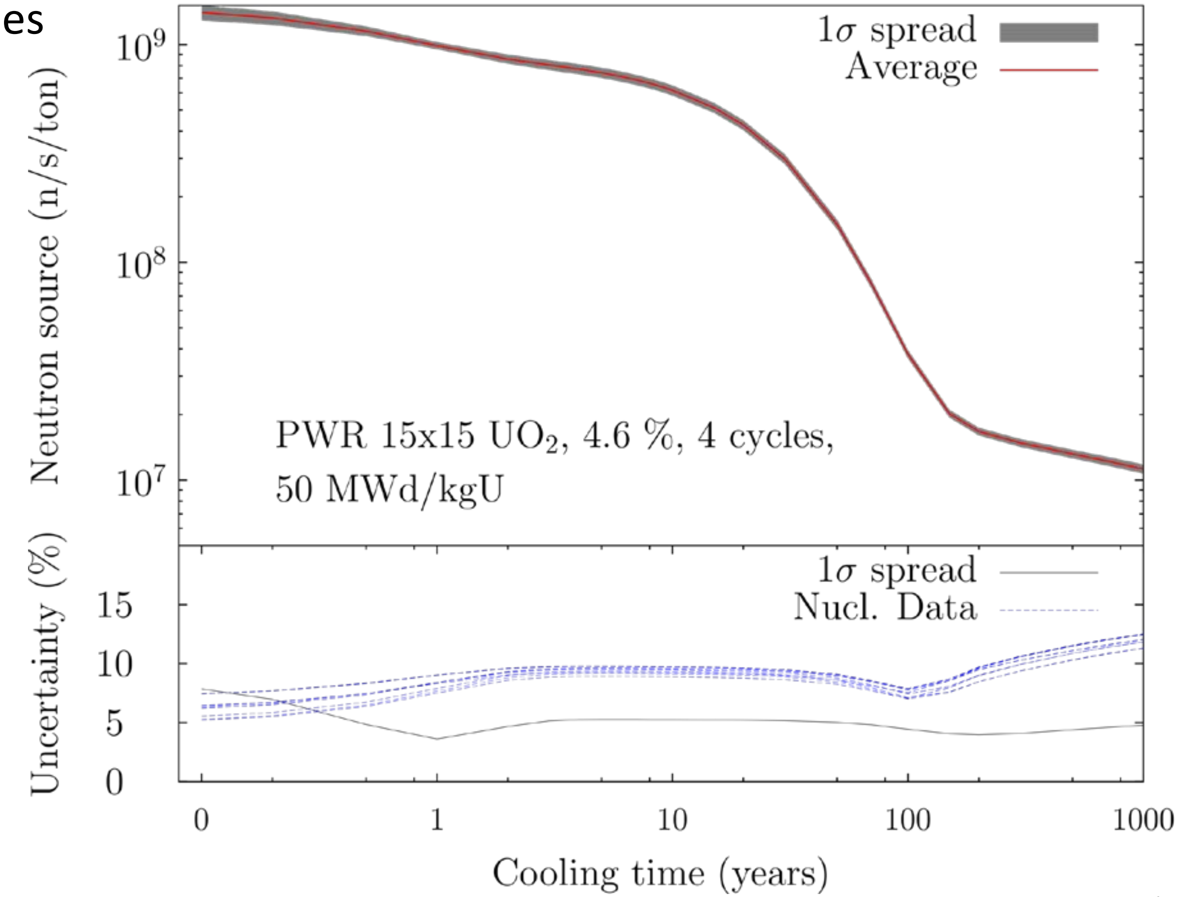
Example 1: decay heat



Example 2

- Hypothetic data:
  - 15x15 assembly PWR
  - UO_2 fuel, 4.6 % ^{235}U, no Gd
  - Used in 4 cycles (possibly with gaps ?), final average burnup: 50 MWd/kgU

- Results: 28 cases



Conclusion

- Our study will be based
  1. on existing CASMO/SIMULATE/SNF models,
  2. plus specific CASMO/SIMULATE/SNF models,
  3. Eventually Monte Carlo simulations.

- If possible, we will provide uncertainties due to the method and nuclear data,

- For more details on our CMSYS database and its application for spent fuel and uncertainties, see
  - "Uncertainties for Swiss LWR spent nuclear fuels due to nuclear data",
  - "Consistent criticality and radiation studies of Swiss spent nuclear fuel: the CS2M approach"

PAUL SCHERRER INSTITUT

Wir schaffen Wissen – heute für morgen