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Spent fuel inventory calculations in the SPIRE project: Current limits and expected improvements

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Summary

- Goal
- Current conservative approach
- Possible improvements with uncertainty calculations
- Conclusion

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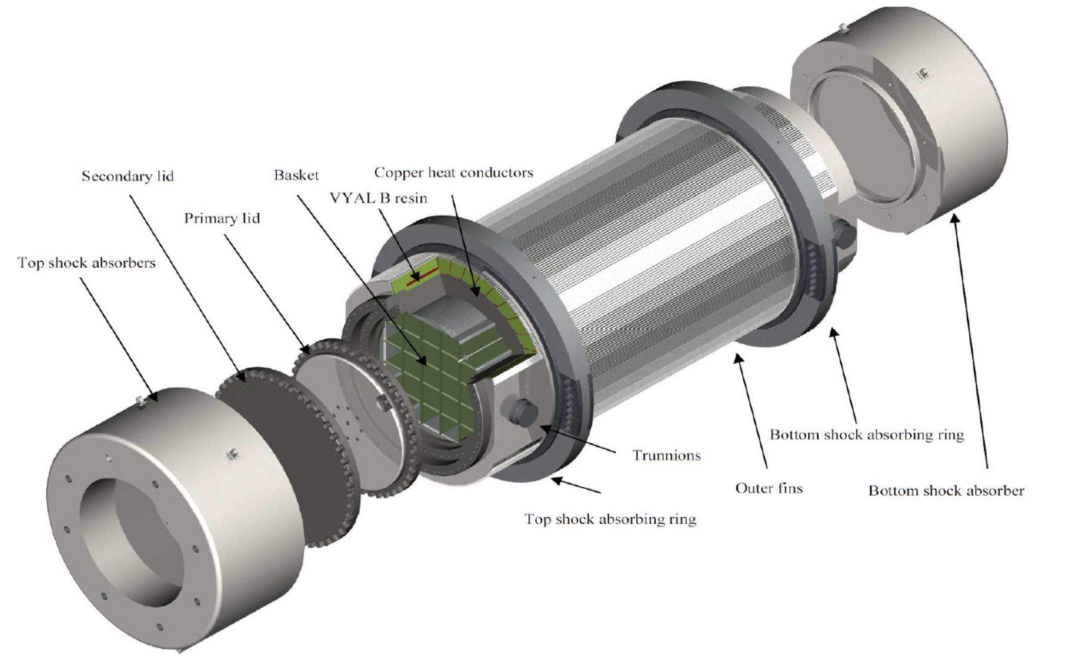
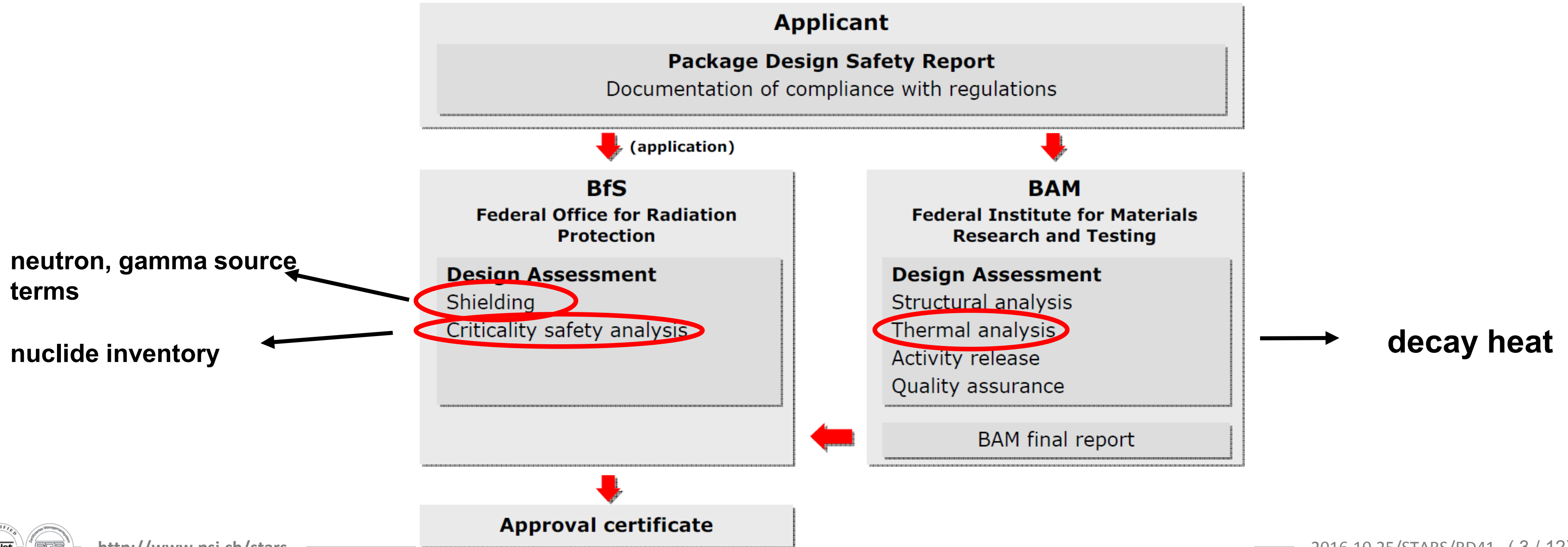


Figure: TN 24E dual purpose cask: transport and storage for 40 years

Details on the SPIRE project were given in the 3 previous presentations

SNF characterizations

- <u>Goal</u>:
  - Prediction of the SNF (Spent Nuclear Fuel) isotopic contents,
  - Precise calculation of the neutron/gamma source emission,
  - Precise calculation of the decay heat for short and long term,
- <u>Reasons</u>:
  - Safe transport and storage, Radiation control,
  - Cost optimization,
- <u>Example of approval procedures</u> (German type of container):



SNF: need for calculated uncertainties

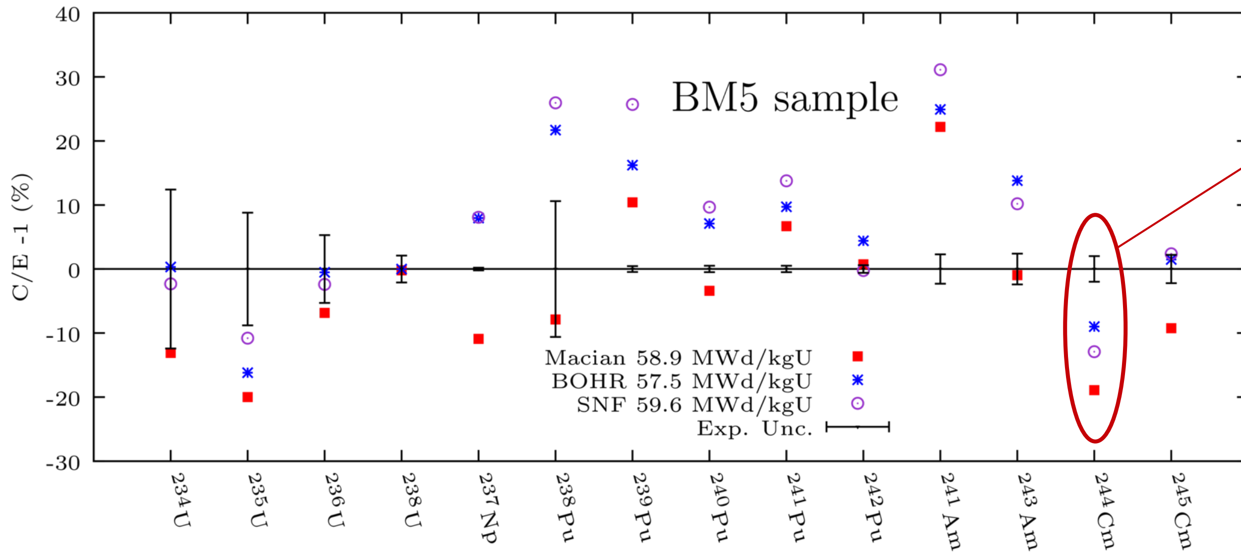
<u>Example of the procedure for source term licensing and approval</u>:

- Cask vendors:
  - Demonstration for the source term that for an envelope of fuel assembly properties safety criteria are fulfilled,
  - Approval for a set of simplified shielding, heat and criticality safety checks to be performed for each individual cask loading.

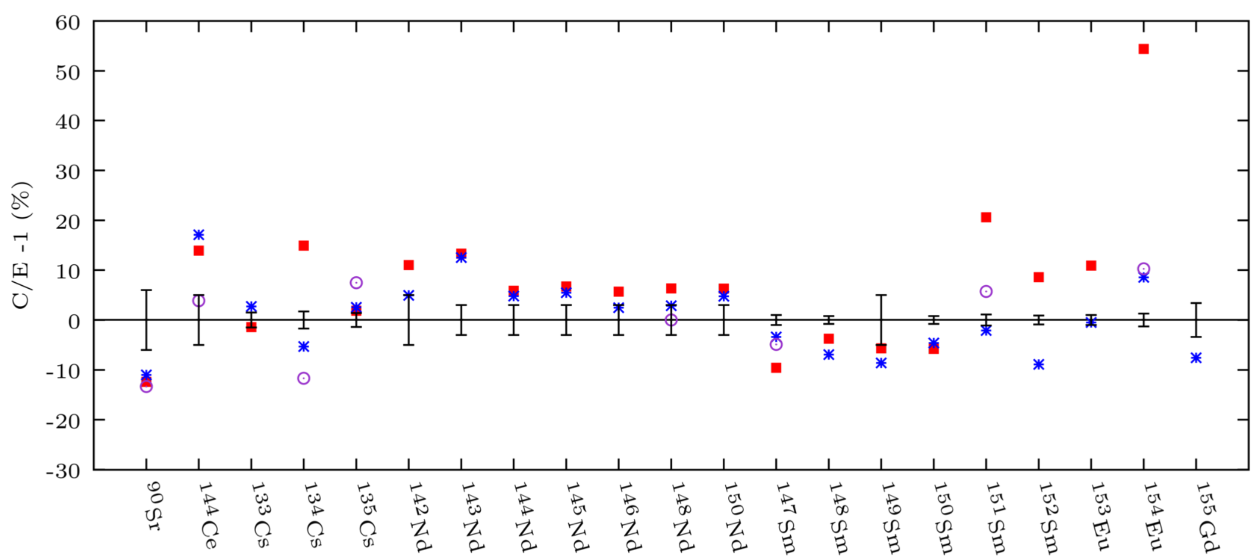
- Cask vendors and utilities:
  - Demonstration that their source term calculation tools are conservative. In practice this has meant that a benchmark against data provided for example from PROTEUS/ARIANE/MALIBU has to be performed and **correction factors** for a number of nuclides are determined.

SNF: need for calculated uncertainties

<u>Example with a specific ARIANE sample</u>:



Underprediction can lead to high correction factors



SNF: need for calculated uncertainties

Example of the source term determination for individual cask loading:

1. NPPs provide power histories for fuel assemblies from core monitoring data,
2. Utilities provide source term data with tools like CASMO5 and/or SNF,
3. Utilities multiply **correction factors** to selected nuclides,
4. Utilities perform simplified shielding, criticality and heat source calculations and checks as prescribed by cask vendors with corrected nuclide inventory from 3.

SNF: need for calculated uncertainties

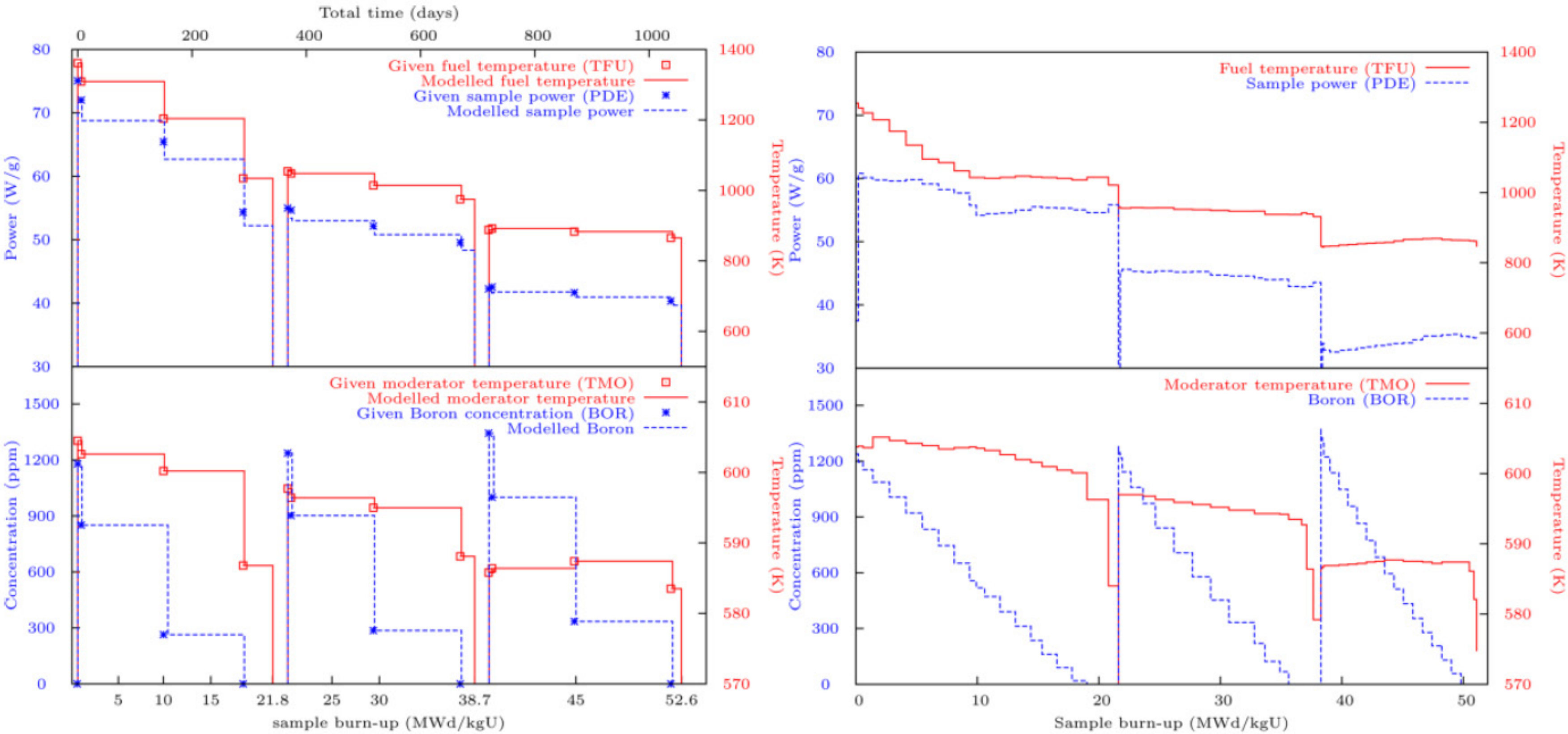
1. These correction factors are unnecessarily conservative and are based on a comparatively small database. On-site measurements over many years on loaded casks have shown that neutron and gamma dose lie well below predicted values.

2. Correction factors do not give an indication where uncertainties come from and how they could be improved: microscopic data uncertainty, irradiation boundary conditions of the reference samples, calculation methods ?

→ The SPIRE project will help to answer the above questions

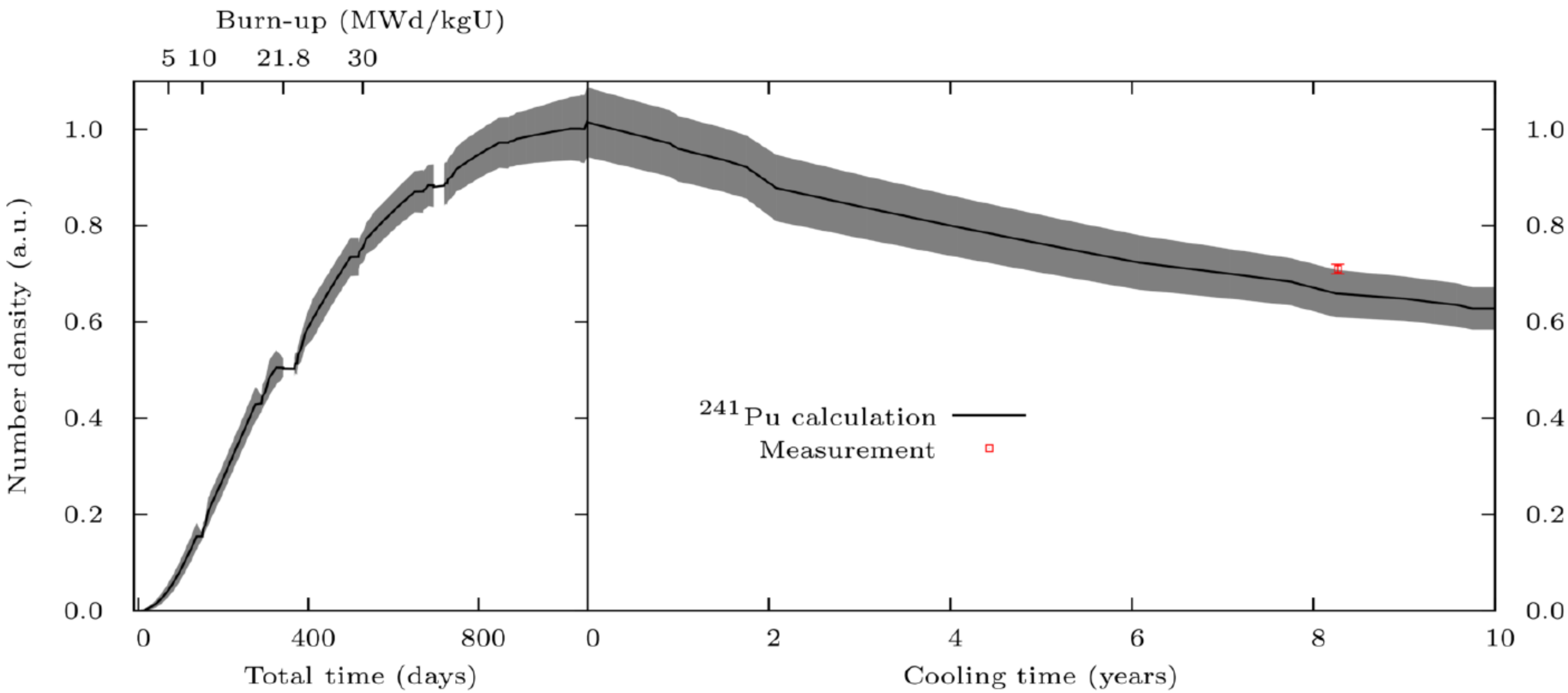
1. Analysis of the SNF database for different burn-up values,
2. understanding of the sources of uncertainties,
3. rank and quantify them,
4. Provide SNF calculations with calculated uncertainties
5. Improve the calculation methods (models, parameters and uncertainties)

Example of calculated uncertainties



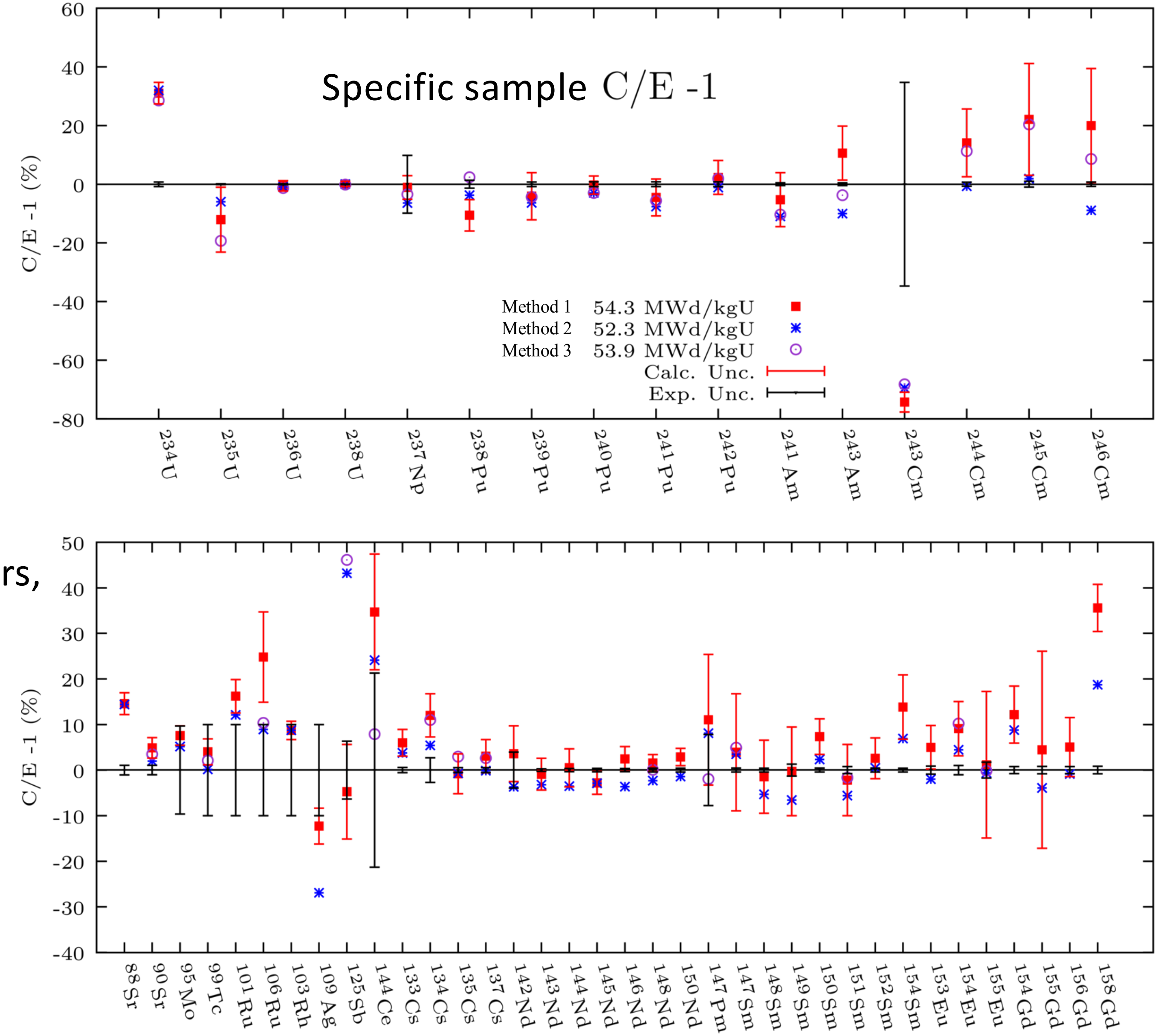
Possible source of uncertainties: irradiation history and the degree of details

Example of calculated uncertainties



Possible source of uncertainties for calculated isotopic content (1σ presented)

Example of calculated uncertainties



<u>Impact for PIE from</u>:

1. Methods,
2. Nuclear data,
3. Irradiation history,
4. Fuel uncertainties,
5. Engineering parameters,

Conclusion

- Current methods for cask licensing are based on conservative approach and limited comparison to SNF database,
- Such conservatism limits the possibilities for C/E improvements,
- Comparison with a limited SNF database also limits the understanding of C/E values,

In view of these existing shortcoming, the SPIRE project aims at

- increasing the experimental database for SNF,
- assessing the calculated uncertainties,
- providing better understanding of the C/E and biases for source terms and decay heat of SNF,
- and finally providing better methods for safer and more economical SNF storage.

Wir schaffen Wissen – heute für morgen