ON THE ESTIMATION OF NUCLIDE INVENTORY AND DECAY HEAT:

A review from the eurad WP8 SFC

March 16th, 2023 • D. Rochman on behalf of the WP8

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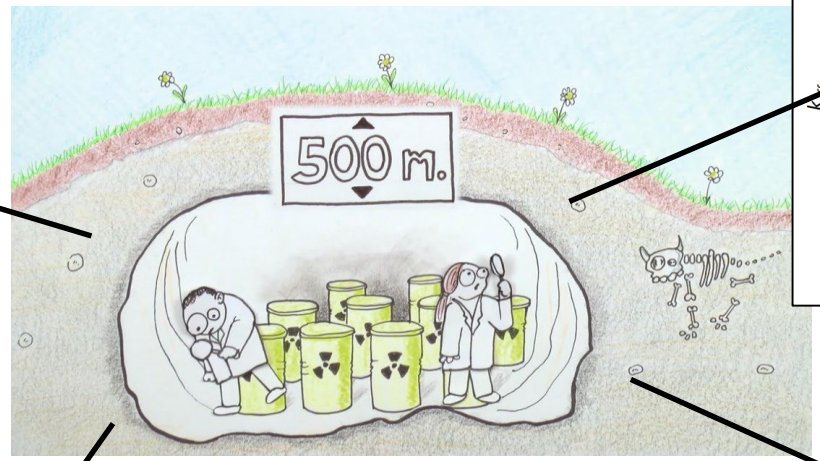
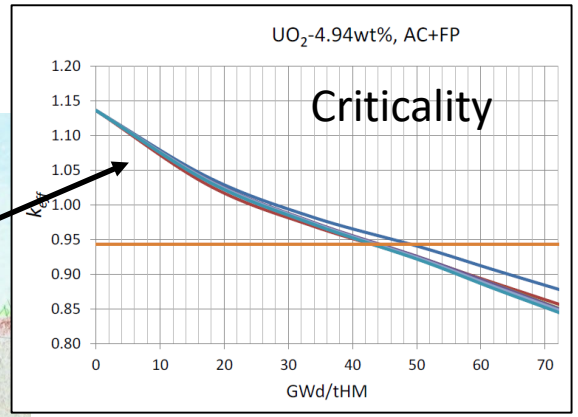
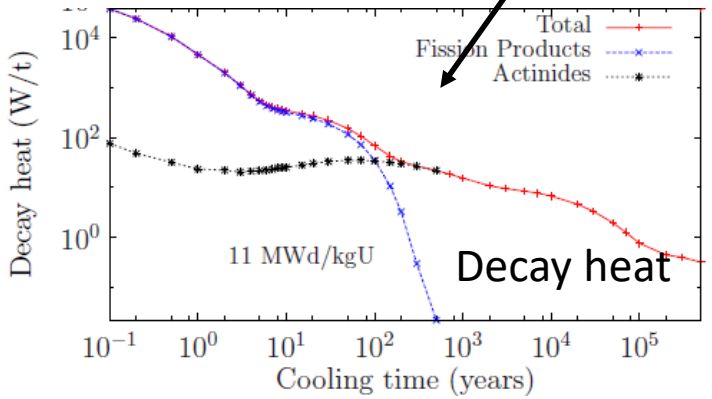
SUMMARY

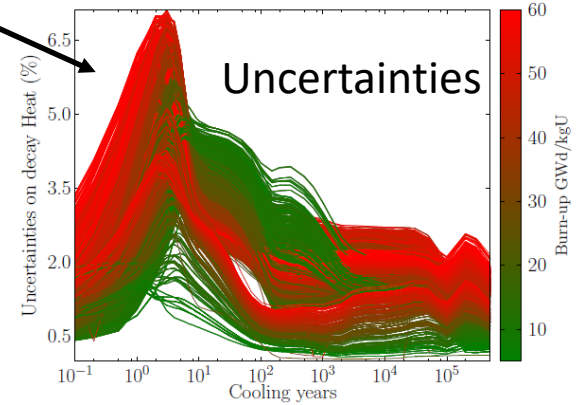
- What, why ?
- Tasks in EURAD
- Achievements
- Future

Dose



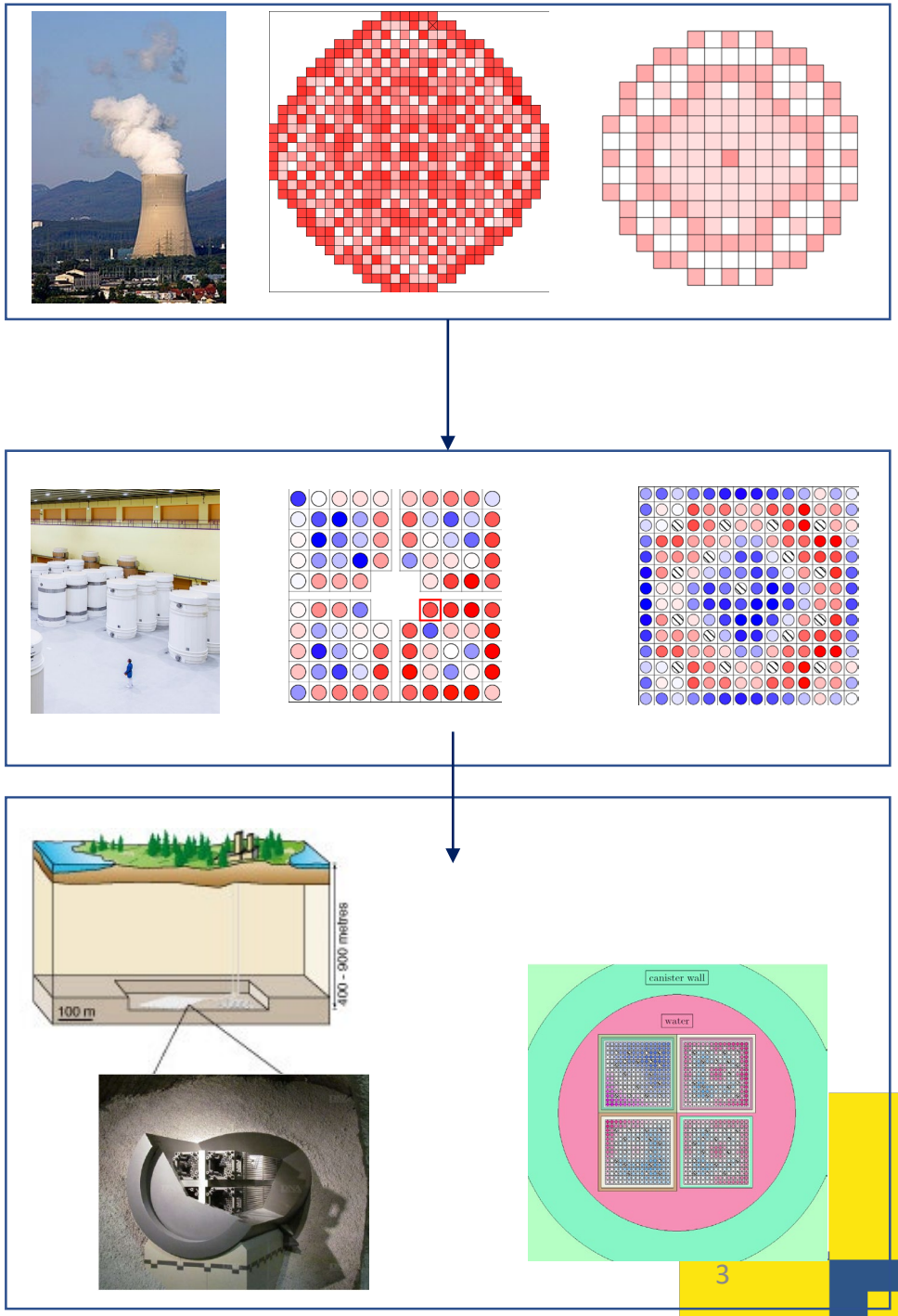






WHY, WHAT ?

- We are dealing with nuclear materials: Spent Nuclear Fuel
- 1st main question: What is in the spent Fuel ?
- Safety first for transport, storage, and long-term repository
  - Over 100 000s years
  - Criticality-safety, dose, decay heat
  - Risk, uncertainties, consequences
- All SFC start from the knowledge of source terms: nuclide concentrations
  - Knowledge: experimental or theoretical
  - Includes safeguard needs
- 2nd main question: What is the required degree of knowledge ?
  - 5 %, 10 %, 50 % ?
- Need for measurements, calculations, uncertainties & validations, prior to any other studies



TASKS IN EURAD WP 8

- For representative SNF assemblies:
  - Calculate nuclide concentrations, decay heat, γ/n emission
  - Cooling up to 10^5 years
  - Compare code predictions (and possible measurements), uncertainties
  - Identify relevant parameters, gaps

- Validations (C/E) for decay heat, nuclide concentrations
- PSI, JSI, SCK-CEN, JRC, KIT, Nagra, VTT, CIEMAT, ENRESA/ENUSA
- More than 10 peer reviewed publications
- Strong links with NEA WNCS, WPEC and IAEA (NDS and Nuclear Fuel)

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REGULAR ARTICLE

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On the estimation of nuclide inventory and decay heat: a review from the EURAD European project

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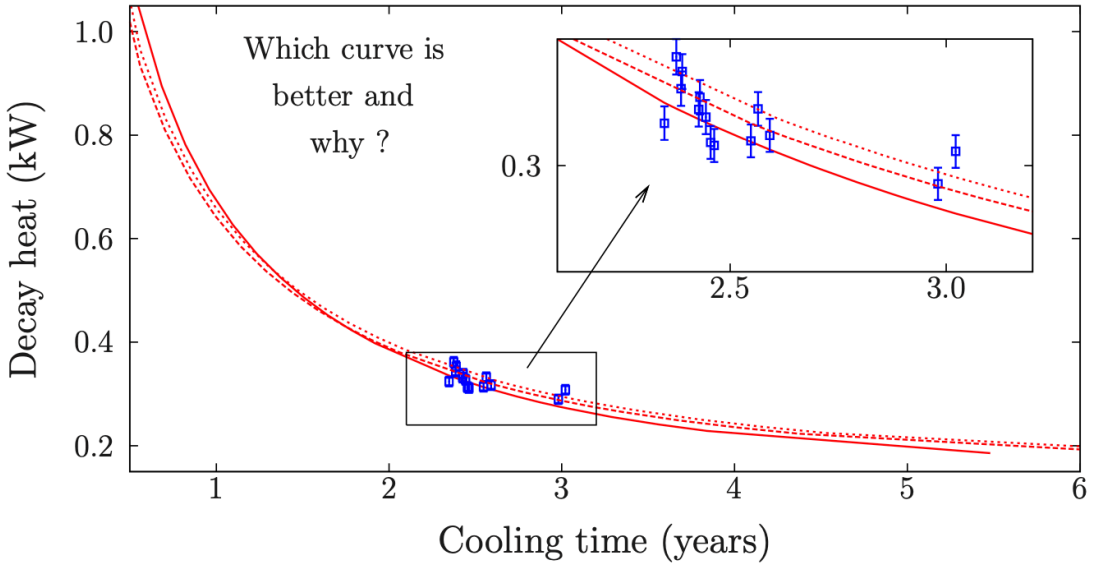


1 % difference in decay heat
⇒1 % difference in canister number
(1 canister ≈ 0.5-1 M€)

ACHIEVEMENTS: NUCLIDE CONCENTRATIONS IN SNF

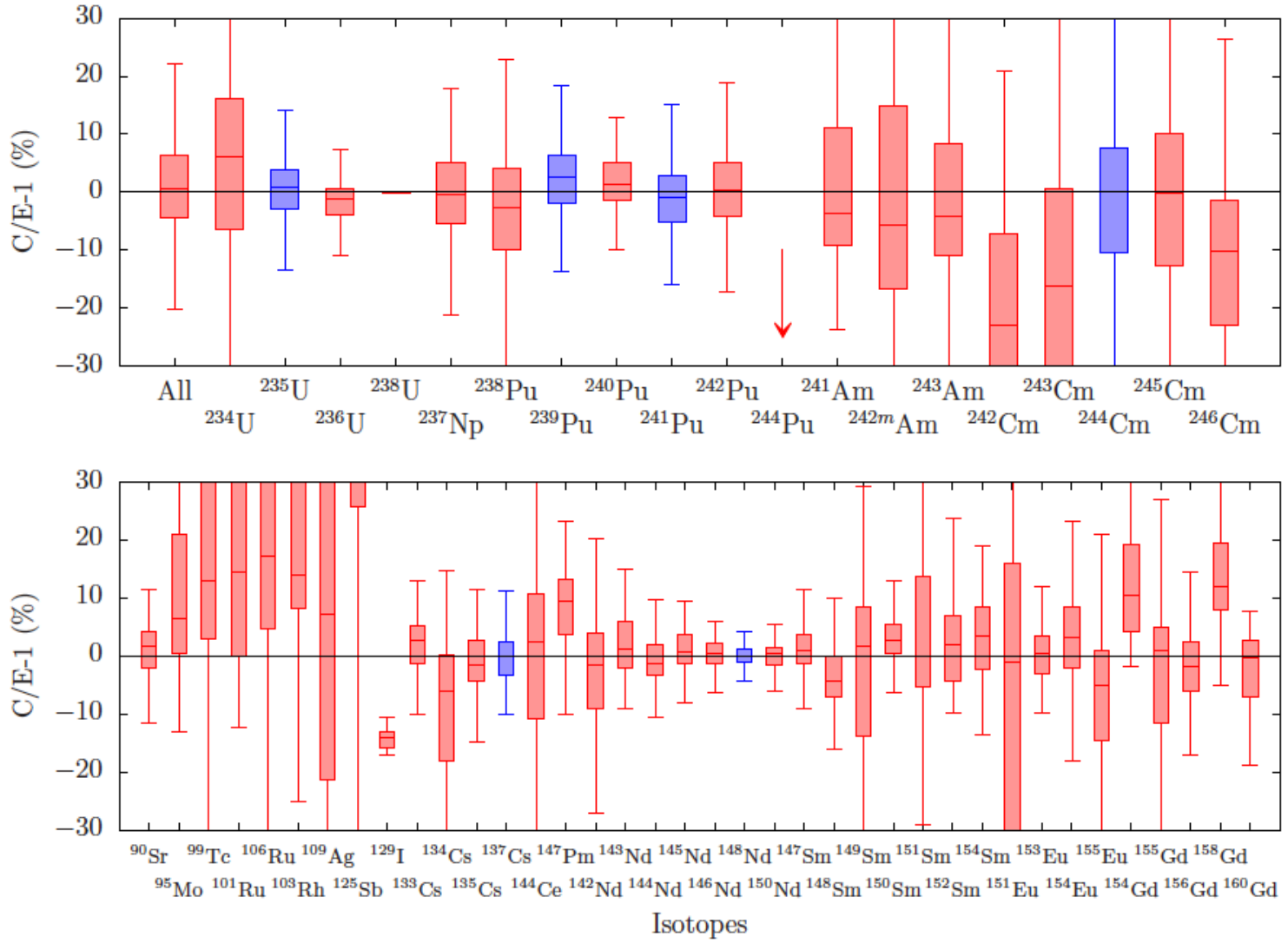
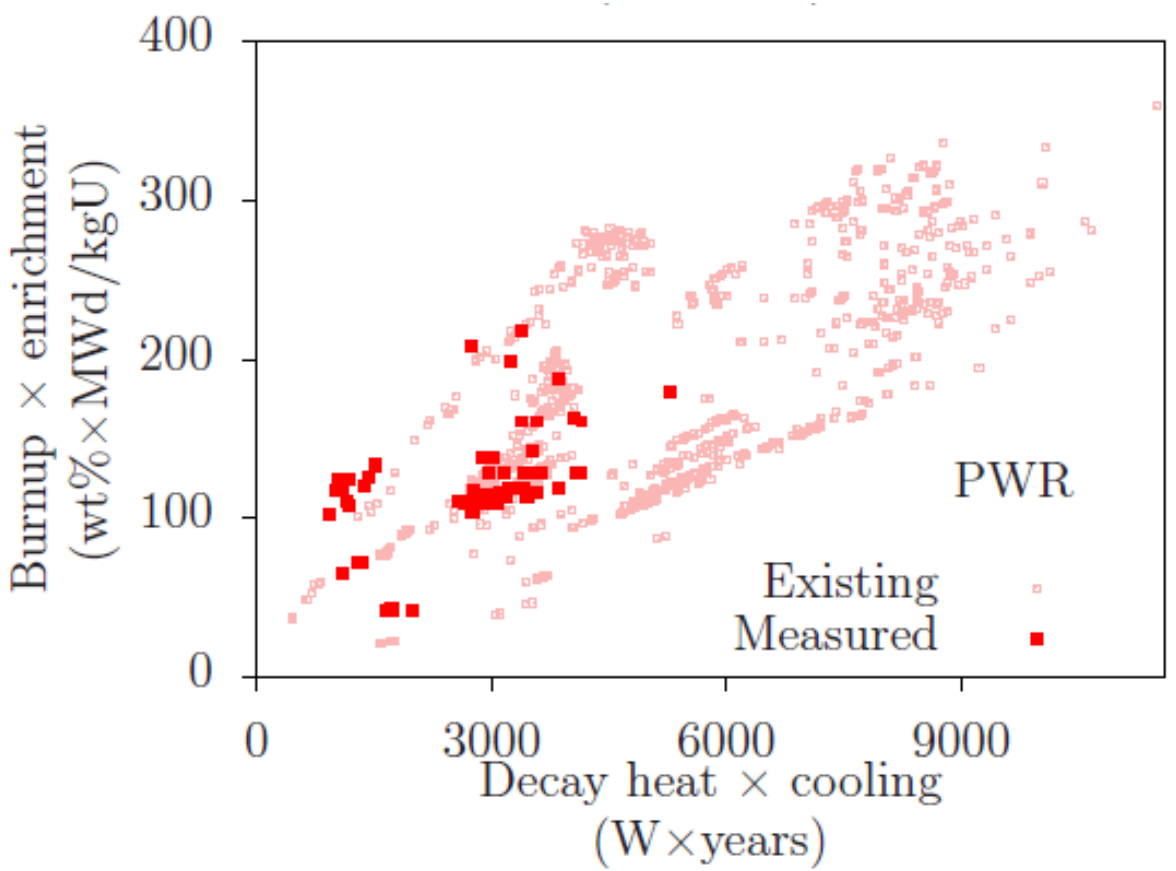


Fig. 4. Interquartile ranges for the $C/E-1$ isotopic concentrations, considering a total of more than 12 000 measured concentrations. The blue color is given to important isotopes. See Tables 3 and 4 for numerical values.

FUTURE: TOWARDS NEXT DEVELOPMENT

- Only a small part of the SNF characteristics were explored: mainly UO_2, 2-5 % enrichment, <60 MWd/kgU
- Nowadays in Europe:
  - high enrichment (HALEU),
  - high BU (>60 MWd/kgU),
  - long-cooling time,
  - ATF, VVER, MOX, CANDU
- Tomorrow in Europe:
  - SMR, GEN-III, GEN-IV
- 1 exp. facility worldwide for decay heat
- Knowledge management/transfer over many generations/civilizations



CONCLUSION

- **Spent Fuel Characterization is a must for any Nuclear Fuel activity**
- **WP8 has achieved tremendous results on SFC (UO_2, source terms, decay heat, validation, knowledge sharing, uncertainties, biases**
- **New challenges were discovered for the EU landscape:**
  - Changes in the industry (high-"everything"), energy politics
  - New systems (ATF, various SMR designs, GEN-IV)
  - New "old fuel": MOX, VVER
  - Design and optimization of cask, canister, repository
- **One unique measurement facility: Clab. Need for diversification**
- **Finally: any study on SNF over 1 million years must start with its characterization: (1) content and (2) criticality. Then can come the rest.**