eurad 2
European Partnership
on Radioactive Waste Management

EURAD-2 Spotlight on Cutting Edge Science

Post-Closure Criticality Safety: Studying and Modelling Aspects of the DGR Long-Term Evolution

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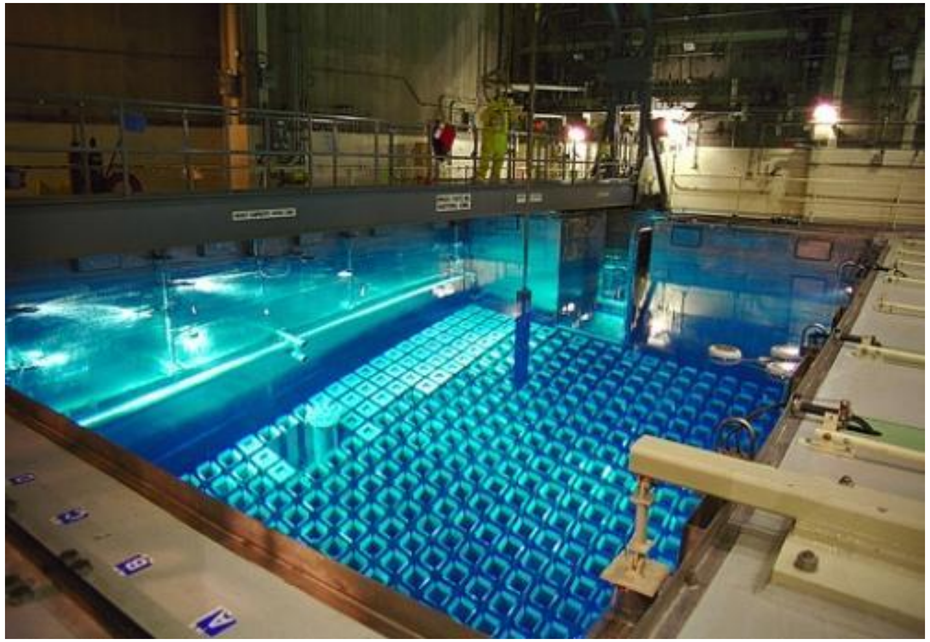
INTRODUCTION

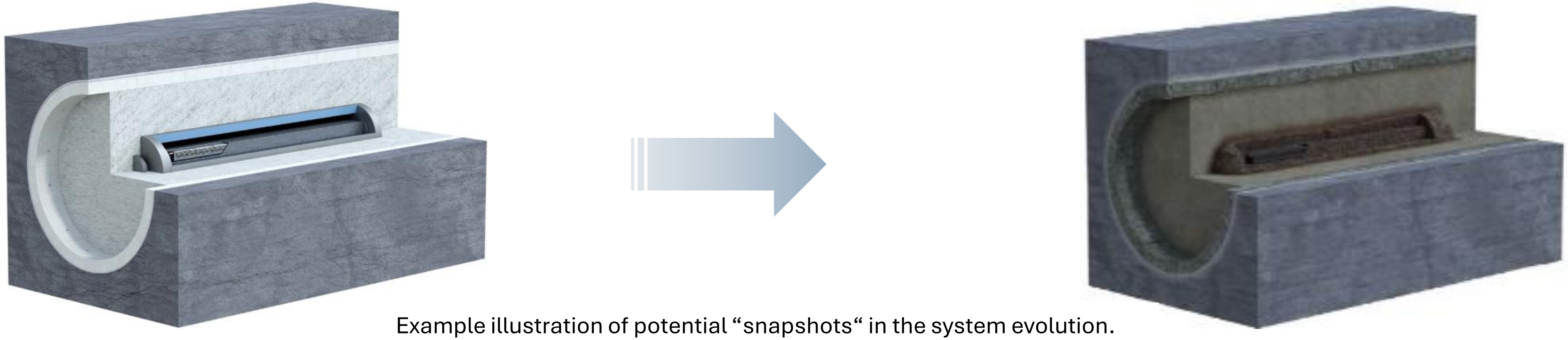
- **Deep geological repositories (DGR) are designed and built to ensure the safe disposal of radioactive waste for very long timescales.**
    - High-level radioactive waste such as spent nuclear fuel still contains certain amounts of fissile material.
    - Under very specific circumstances, this could theoretically lead to new fission chain reactions (criticality) ocurring in the DGR.
    - ➢ **Criticality safety is a safety requirement in all national programmes that must dispose of high-level waste.**



- **WP-17 "CSFD" addresses the unique challenges posed by the very long time frames by**:
    - Identifying & exploring the optimisation potential of **measures for ensuring** post-closure criticality safety.
    - Developing & improving **methods to demonstrate** post-closure criticality safety.

WHERE CUTTING-EDGE SCIENCE IS KEY

- Demonstrating post-closure criticality safety is a unique challenge: we are **assessing a system that is evolving continuously over** timeframes of **thousands of years**.
  - Over such large timescales, the system changes through a multitude of processes such as material degradation (e.g. corrosion), geometrical deformation, radioactive decay, etc.



Example illustration of potential “snapshots“ in the system evolution.
Graphics: courtesy of Nagra.

- WP-17 “CSFD” is carrying out innovative R&D work to develop a holistic framework to address these challenges and contribute to demonstrating post-closure criticality safety.

THE INNOVATIVE R&D WORK IN WP-17 “CSFD” [SELECTION]

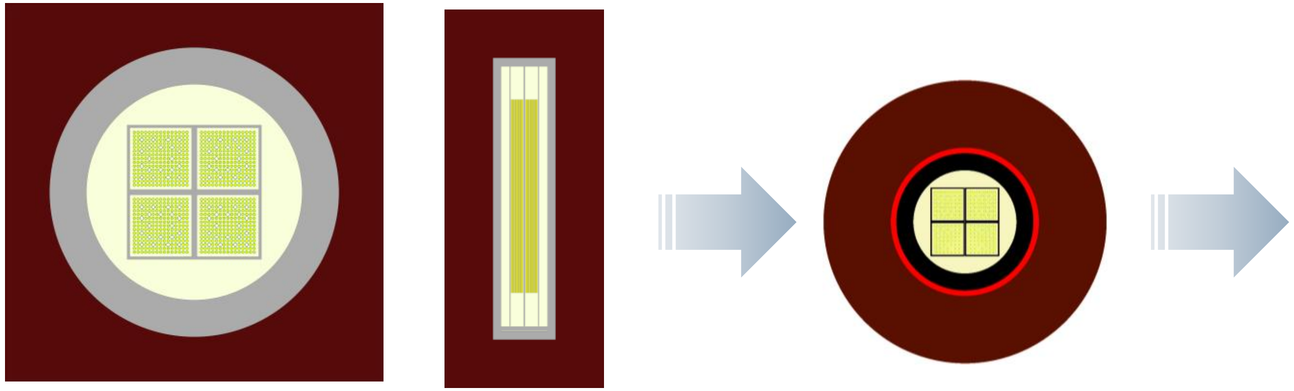
- WP-17 is developing & consolidating the scientific basis to bring the understanding of the post-closure system evolution to a new level of detail and **for the first time with a specific focus on criticality safety:**
  - **Task 3** is developing a catalogue of post-closure features, events and processes that are specifically relevant for post-closure criticality
- WP-17 is investigating modelling approaches for post-closure criticality safety assessments that address both the need for detailed computational models and the extremely large parameter space
  - **Task 4** is creating a detailed understanding of various modelling methods and aims at producing, for the first time, a systematic evaluation of the impact of unavoidable model assumptions and simplifications.
- WP-17 is exploring the potential of assessing the effects of potential post-closure criticality events with a view to improving the system understanding and demonstrating the robustness of the disposal concept
  - **Task 7**: is investigating various approaches to modelling and assessing the effects of potential post-closure criticality events.

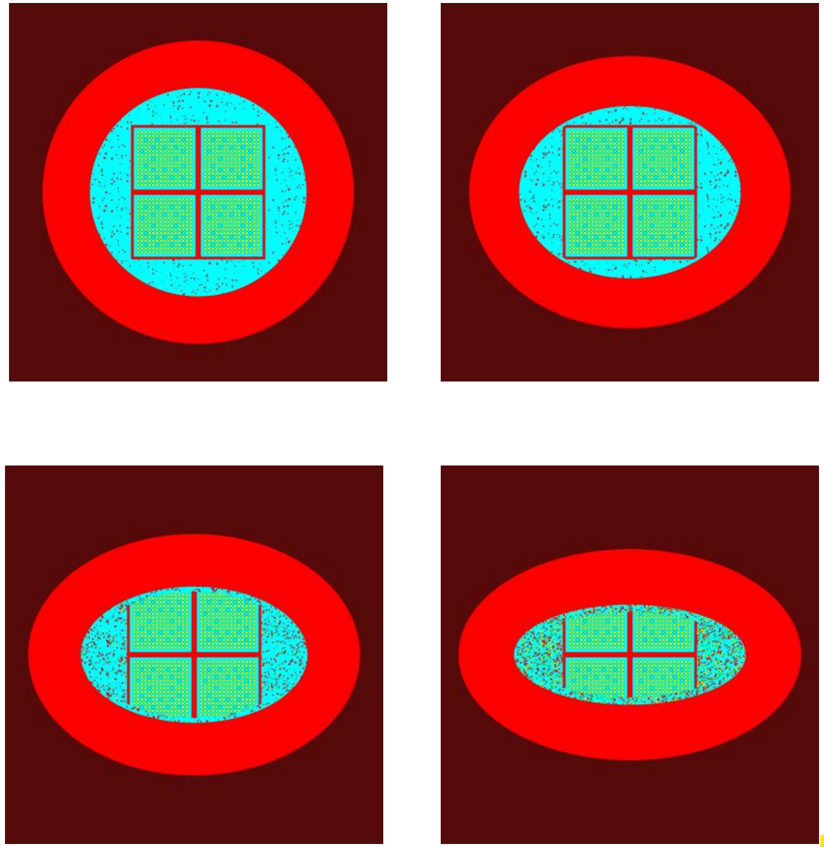
WP-17 SPOTLIGHT ON CUTTING EDGE R&D WORK

- **Example illustration of the innovative R&D work carried out in WP-17**
  - Research carried out in a joint **EPFL – Nagra PhD thesis project**
  - Defined at the interface of **WP-17 Tasks 3,4 and 7**
  - Aims at addressing **key questions** such as:
    (example focused on the Swiss DGR concept)
    - What are the post-closure processes that matter most for post-closure criticality safety?
    - Developing & implementing new modelling techniques to reach unprecedented level of realism
    - What is the impact of modelling decisions, assumptions and simplifications?
      How can this be quantified?
    - How can neutronics aspects be coupled with the nearfield modelling?
    - What are the relevant feedback mechanisms?
    - Etc.

WP-17 SPOTLIGHT ON CUTTING EDGE R&D WORK II

- No individual process determines post-closure criticality safety: This R&D work contributes to improving the understanding of the impact that the coupled evolution of material composition and geometrical changes has on the system reactivity:





A container filled with 4 PWR UO_2 fuel assemblies was modelled surrounded by a layer of bentonite.
Assumptions: corrosion rate of 0.3 μm/yr & Pilling-Bedworth ratio of 2.

- A **completely new approach** was developed to model the evolution & assumed degradation of the spent fuel elements and internal support structures.

SUMMARY

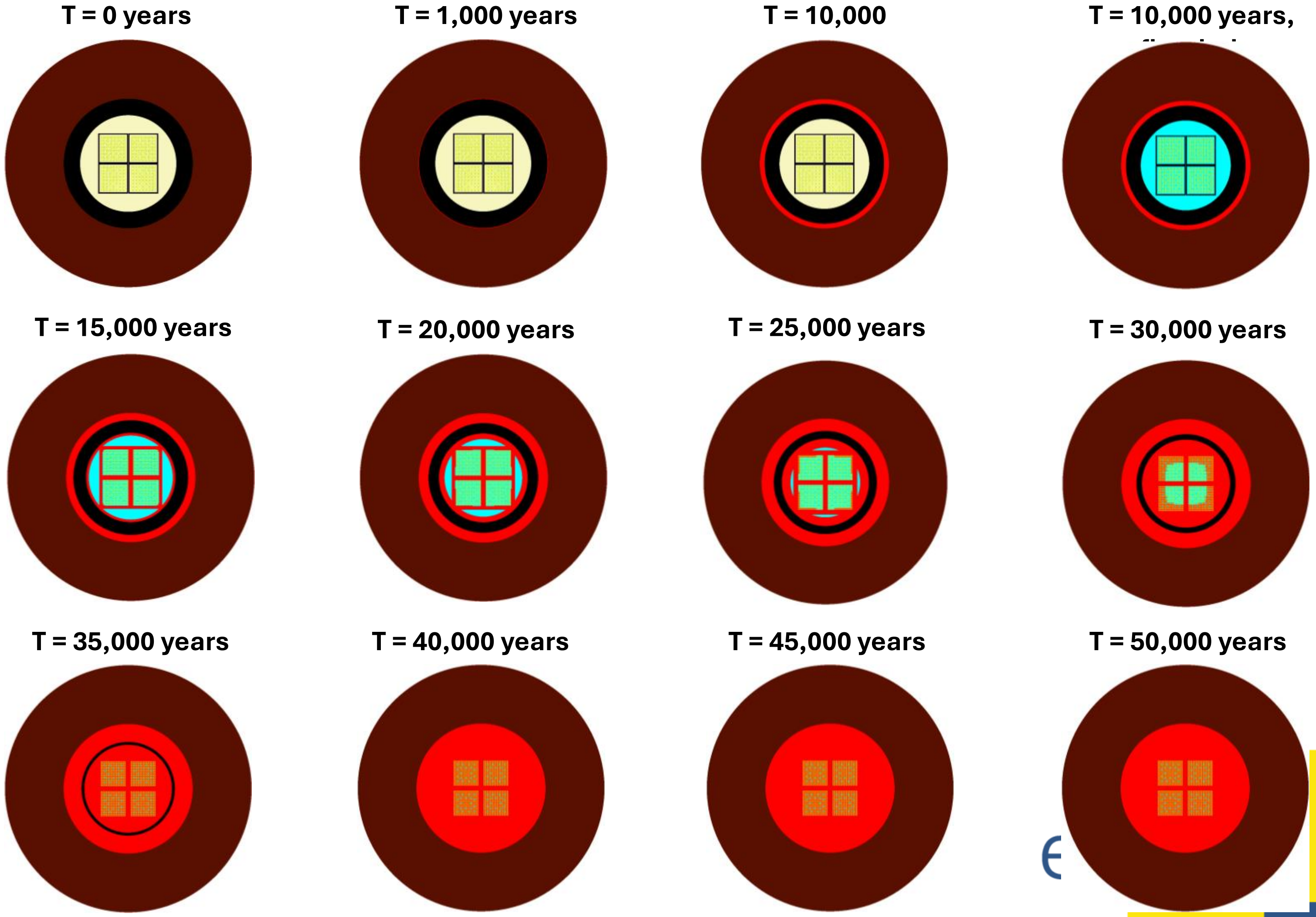
- **Demonstrating post-closure criticality safety is a unique challenge due to the very long timeframes required for assessment.**
- **WP-17 is addressing the challenges by developing & improving methods to demonstrate post-closure criticality safety, e.g. by:**
  - Identifying the post-closure processes relevant specifically for criticality safety
  - Investigating new approaches to modelling the long-term evolution considering both the need for detailed computational models and the large variations due to an almost infinite parameter space.
  - Developing new methods to assess the impact of modeling assumptions and sytem uncertainties.
  - etc.
- **The deepened understanding achieved will support and strengthen the confidence in DGR as a robust and safe solution for final disposal.**
- **This represents only a "spotlight" selection of the innovative work carried out in WP-17.**

THANK YOU

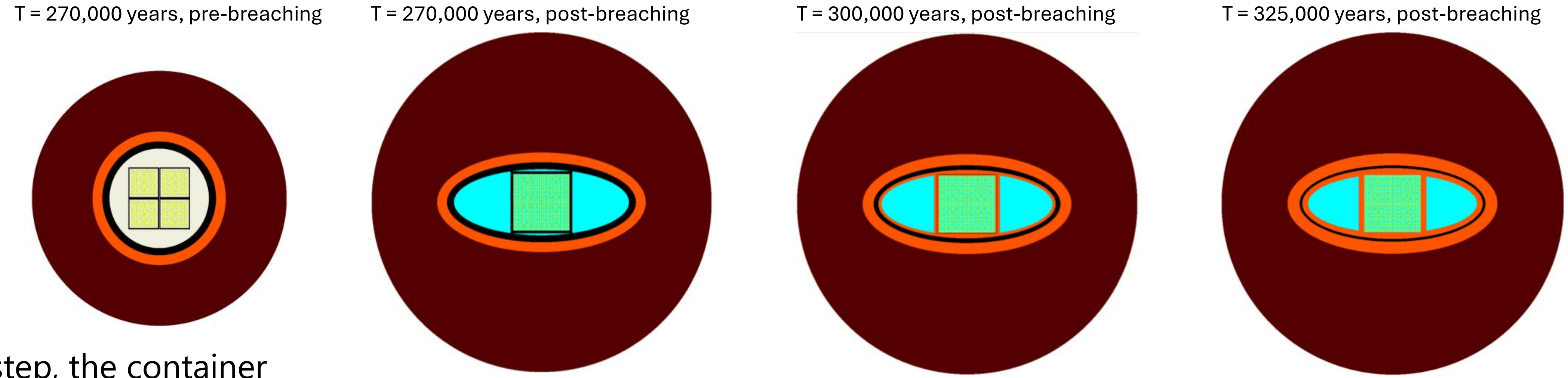
Back-up

WP-17 SPOTLIGHT ON CUTTING EDGE R&D WORK II

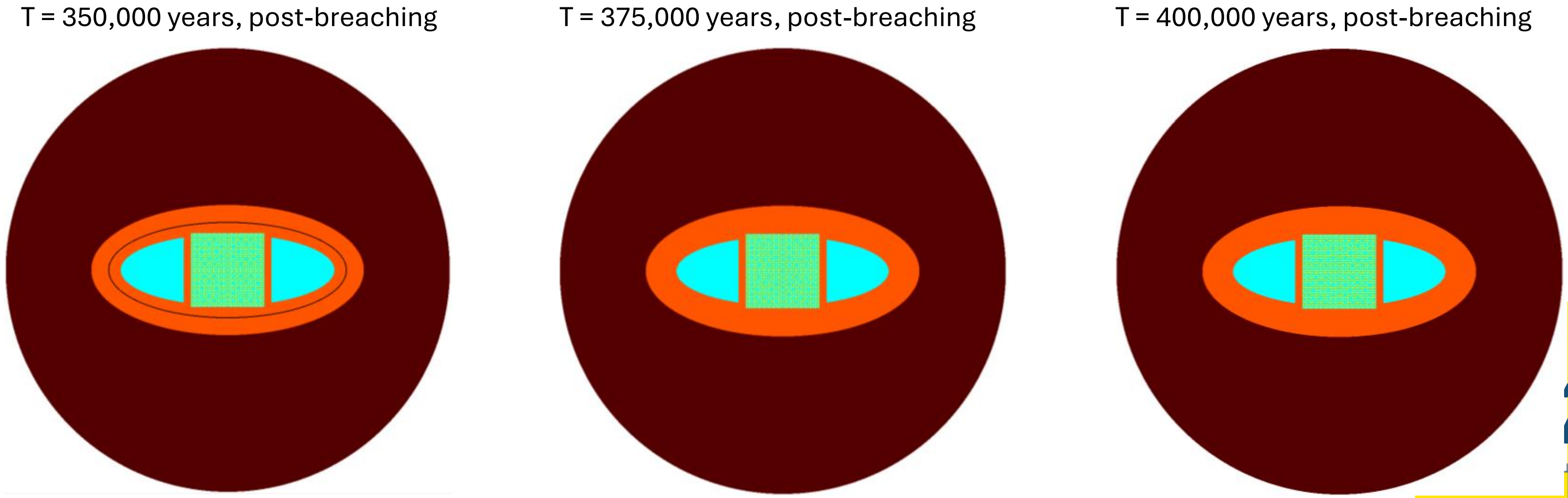
- Long-term criticality safety is
- An example storyboard depicting a potential long-term evolution of the system was defined:
  - A container filled with 4 PWR UO_2 fuel assemblies was modelled surrounded by a layer of bentonite.
  - The corrosion of the container was modelled assuming a corrosion rate of xy and a Pilling-Bedworth ratio of 2
- Criticality (keff) calculations were carried out for each step.



HIGHLIGHT: MODELLING POST-CLOSURE SYSTEM EVOLUTION II



- In a next step, the container corrosion followed by postulated plastic deformation was modelled
    - In this case, it was assumed that the main corrosion product is magnetite, which fully reprecipitates in situ.
- Criticality (keff) calculations were carried out for each step.



HIGHLIGHT: MODELLING POST-CLOSURE SYSTEM EVOLUTION III

- Hypothetical full degradation was modelled in a preliminary, simplified manner.
- Criticality (keff) calculations were carried out for each step.