Optimal Decommissioning Planning of NPPs Using Validated Neutron Fluence Calculations

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Introduction & Motivation

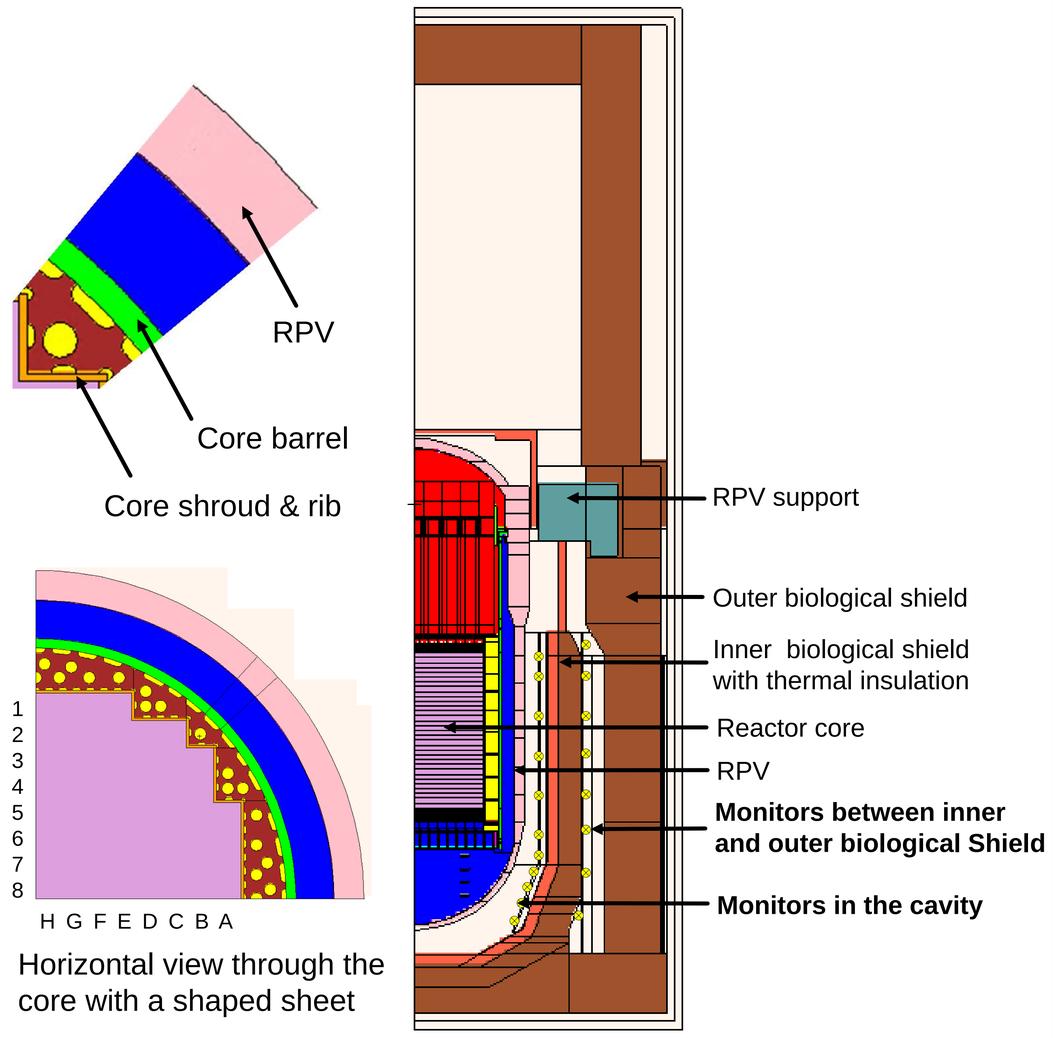
- April 2023, the last German NPPs were shut down
- **Challenge**: decommissioning of the NPPs in a safe, economical, and timely manner
- **Important task**: estimation of the neutron activation distribution within the NPP components which have emerged during its lifetime operation
- Improved knowledge of the activation distribution within the NPP components can:
  - significantly minimize the radioactive waste
  - contribute to the safety of the operating personnel and the general public

Objectives

- To develop a method based on the combined use of two Monte Carlo codes, MCNP and FLUKA, to serve as a non-destructive tool for evaluating the activation in an NPP
- To demonstrate the methodology through the activation calculations of selected components of a German PWR

Methodology

- **MCNP calculations**:
  - Development of a detailed 3D geometrical model of a German PWR
    - based on original technical drawings
  - Specification of the neutron source
    - based on real operating conditions
    - defined as a pin-by-pin distribution (each pin divided into 32 axial layers)
  - Estimation of neutron fluence rate within the reactor components
    - for the ensuing activation calculations
- **FLUKA calculations**:
  - Development of a detailed 3D geometrical model of the studied components
  - Evaluation of the activation distribution within the components
    - using the neutron fluence rate parameters calculated by the MCNP code



Validation of the MCNP Model

Several activation monitors were placed at two positions in an active German PWR:

- Radial position No. 1: positioned in the cavity between the RPV and the inner biological shielding
- Radial position No. 2: outside the inner biological shield in different angular positions

Activation monitor: an aluminum box with 8-9 metal foils

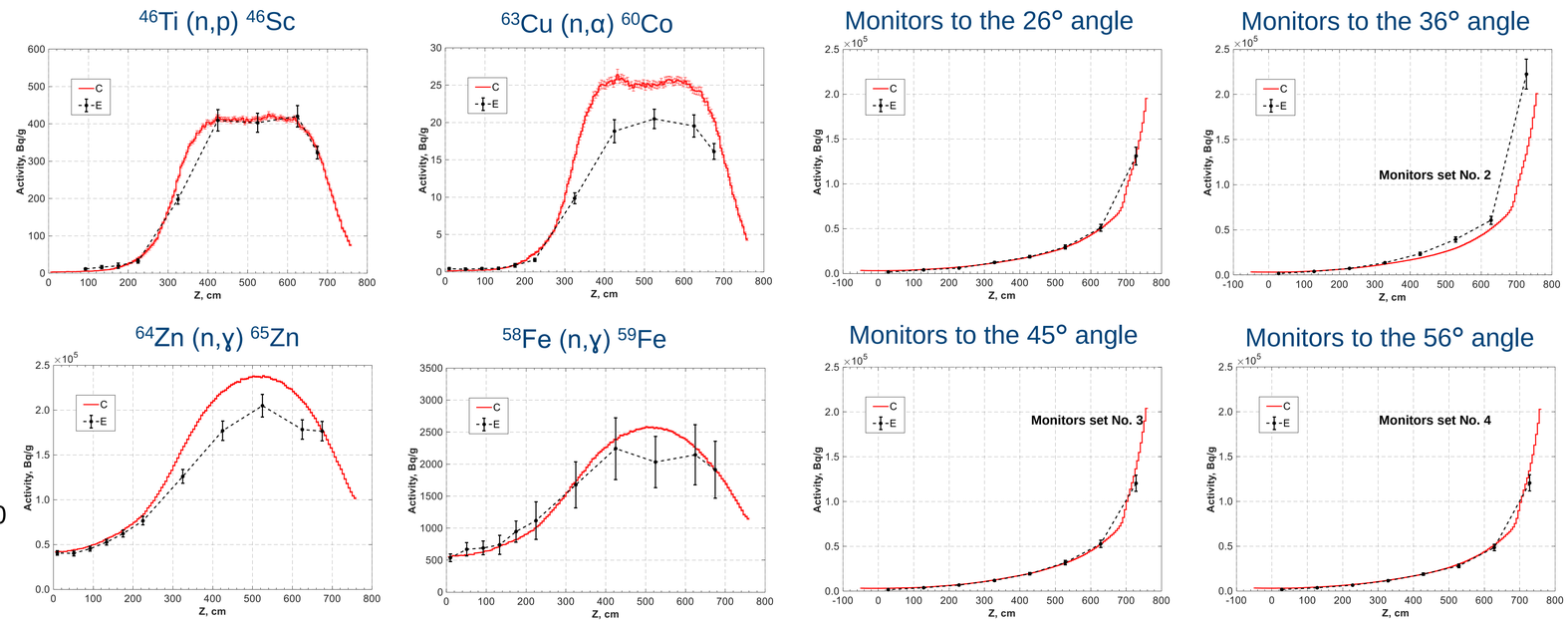
Metal foils characteristics:

- thickness: 0.1 mm
- size: 5 x 5 mm to 10 x 10 mm or 10 mm Ø
- materials: Ti, Fe, Ni, Cu, Zn, Nb, In, Sn, Ta

MCNP results vs. experimental measurements results

Angle position to 85° on radial position No. 1

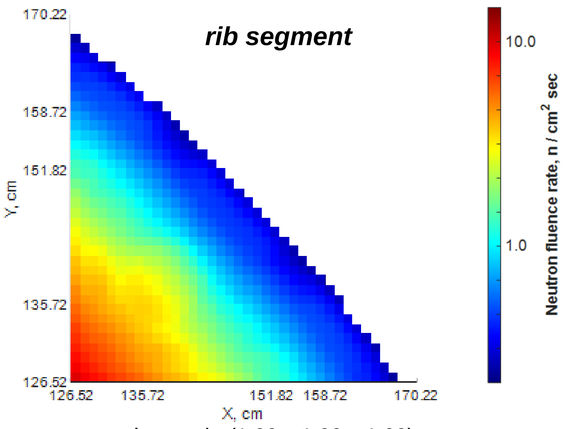
Reaktion ^{113}In (n,γ) ^{114m}In on radial position No. 2



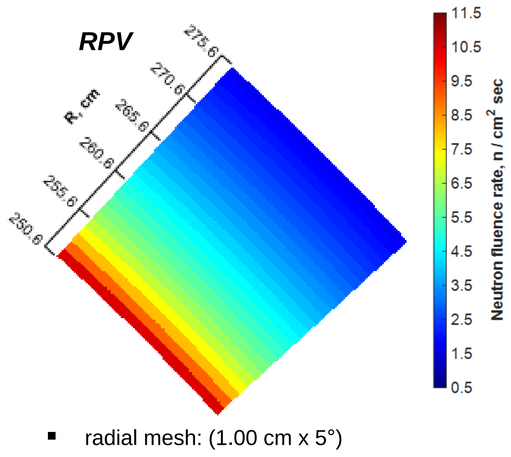
➢ **Good agreement was obtained between the calculated and measured activities**

Neutron Fluence Rate Distribution (MCNP Results)

Neutron fluence rate in a rib segment and RPV (at the coremiddle plane and 45°)



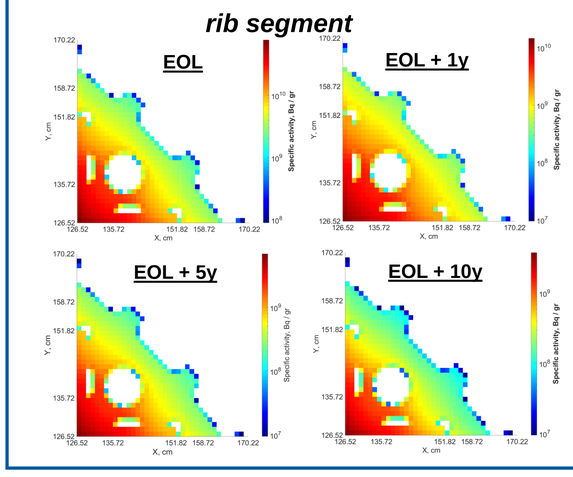
- rectangular mesh: (1.00 x 1.00 x 1.00) cm

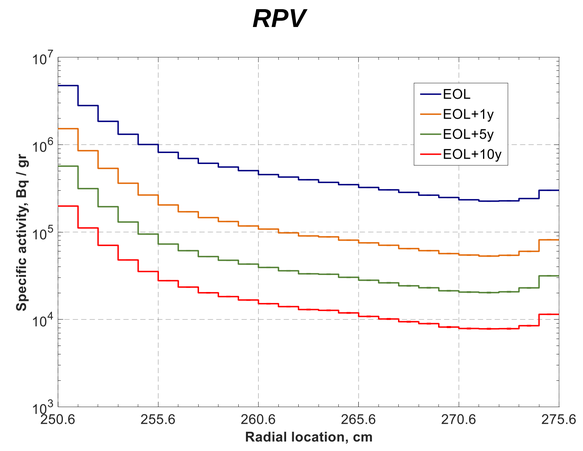


- radial mesh: (1.00 cm x 5°)

Activation Distribution (FLUKA Results)

Activation in a rib segment and RPV (core middle plane, at 45°) after shut down (EOL)





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