Characterisation Methods in FiR1 Decommissioning Project

Nuclear Science and Technology Symposium SYP2019, Helsinki, 30.10.2019
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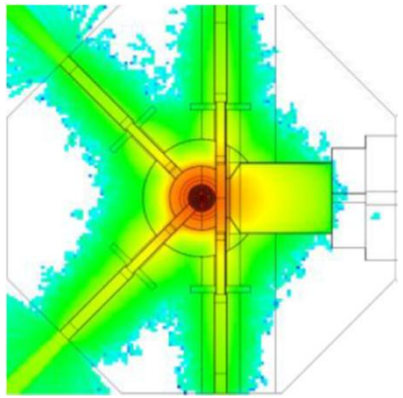
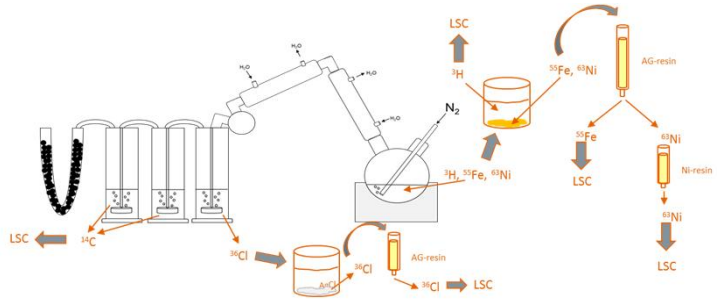


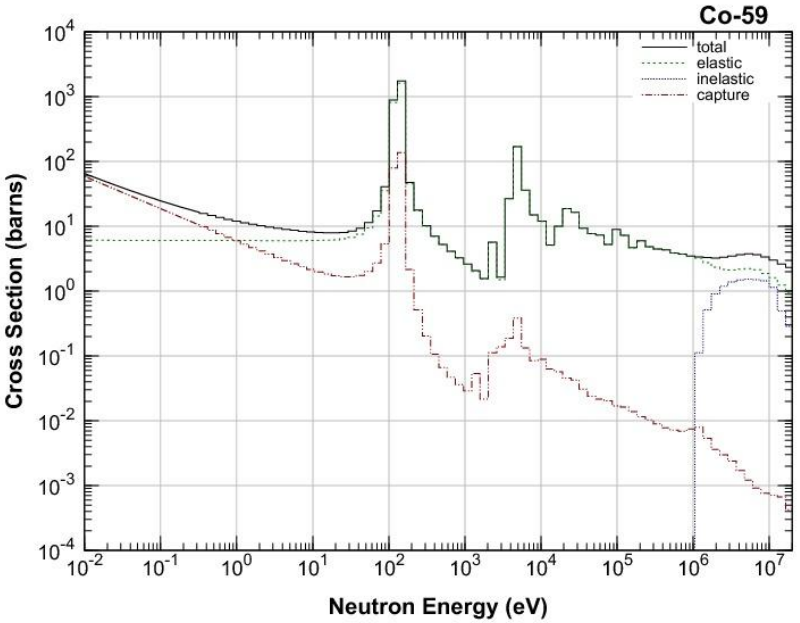


Neutron activation in the reactor structures

$$\frac{dN_i}{dt} = \underbrace{-N_i(\lambda_i + \sigma_i\phi)}_{\text{Loss}} + \underbrace{\sum_{j\neq i}(\lambda_{ji} + \sigma_{ji}\phi)}_{\text{Creation}}$$

Nuclear fission in the reactor core creates excess neutrons that are absorped into surrounding materials and cause activation via reactions

1) Neutrons capture
2) Transmutation
3) Fission

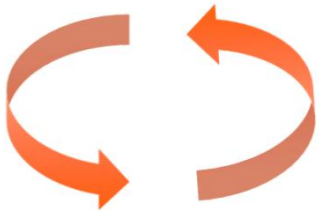


$E.g.\ {}^{59}_{27}Co + {}^{1}_{0}n \rightarrow {}^{60}_{27}Co$

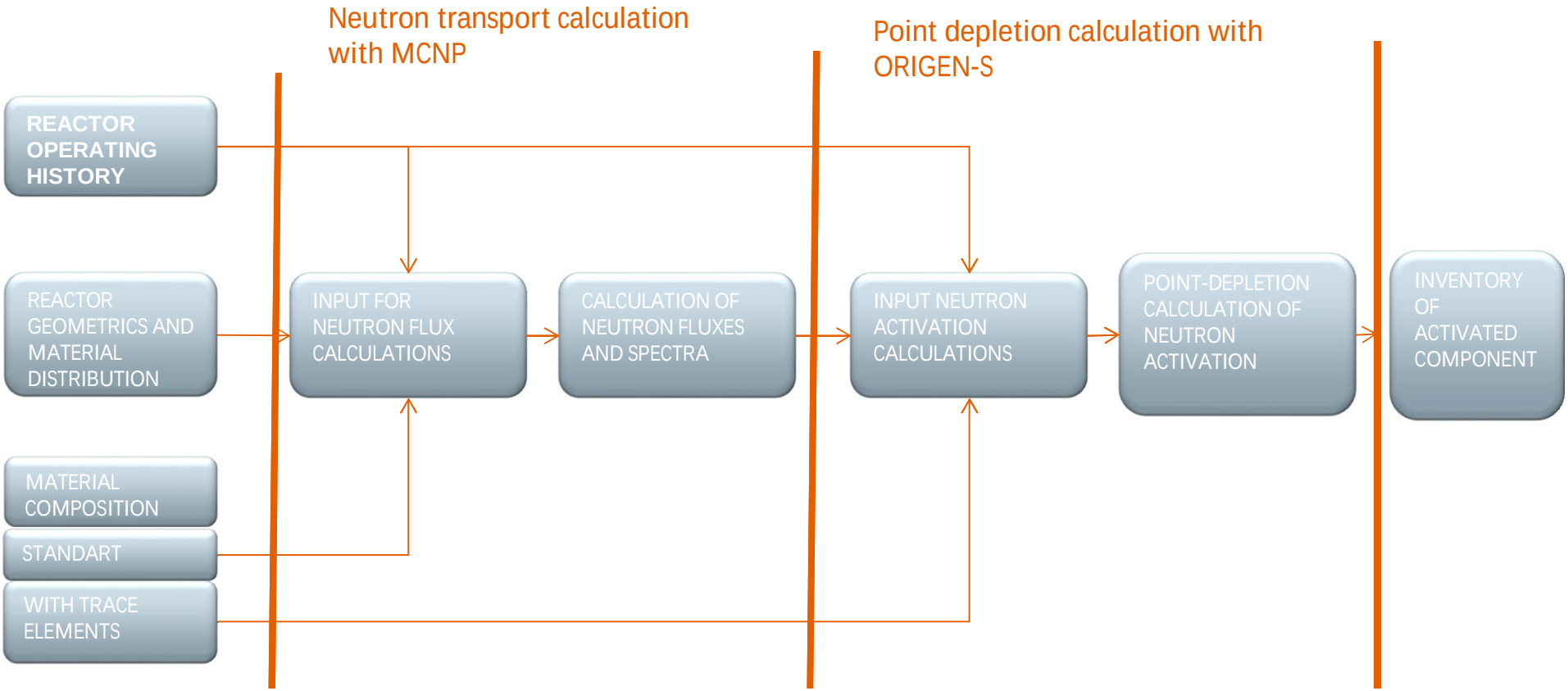
Characterisation in a decommissioning project

Aims for characterisation

- **Legal requirement for each waste package:**
  - total activity
  - nuclide vector
  - external dose rate
- **Characterisation provides data for various parts of a decom project**
  - methods for dismantling, radiation safety
  - waste packaging, transportation and waste final disposal etc.
- **Aim is ensure SAFETY (minimize radiation doses) and COST-EFFICIENCY (optimise the amount of waste and choosing correct packages).**
- **Characterisation is a combination of calculations and measurements.**

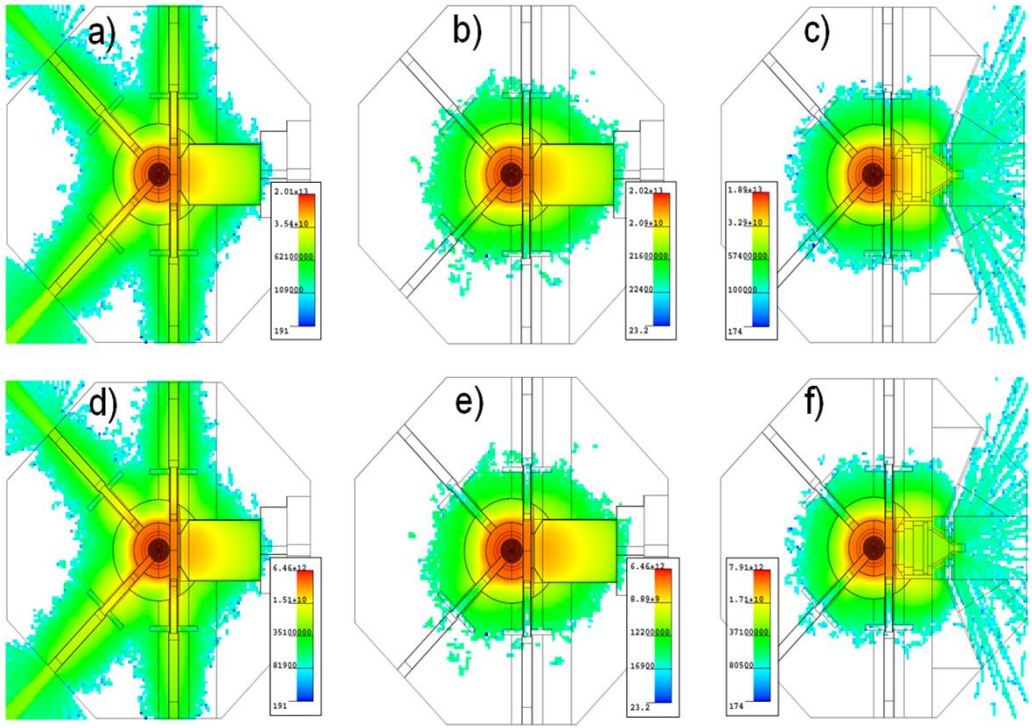
Modeling  Measurements

Calculation is a two-step process



Important points in the calculation

- Different models for different parts in the operating history.
  - Structural changes
  - Significant changes in core configuration
- Activating nuclides are typically very small impurities.
  - Sometimes they are not taken into account in construction spesifications
  - use measured composition instead
- What is the suitable way to divide the components and structures?
- If some data is missing, use conservative assumptions.
  - Underestimate neutron shielding structures and material shielding properties
  - Overestimate activating impurities
  - Overestimate operating hours or underestimate cooling time.

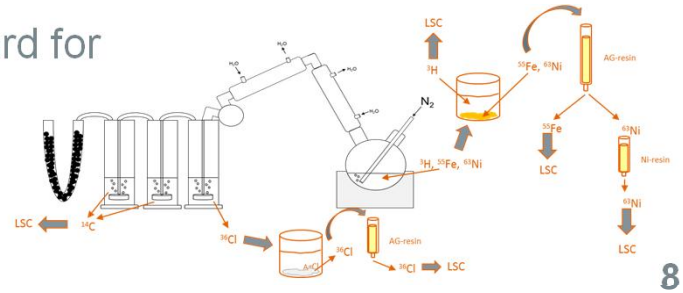


Characterisation with measurements

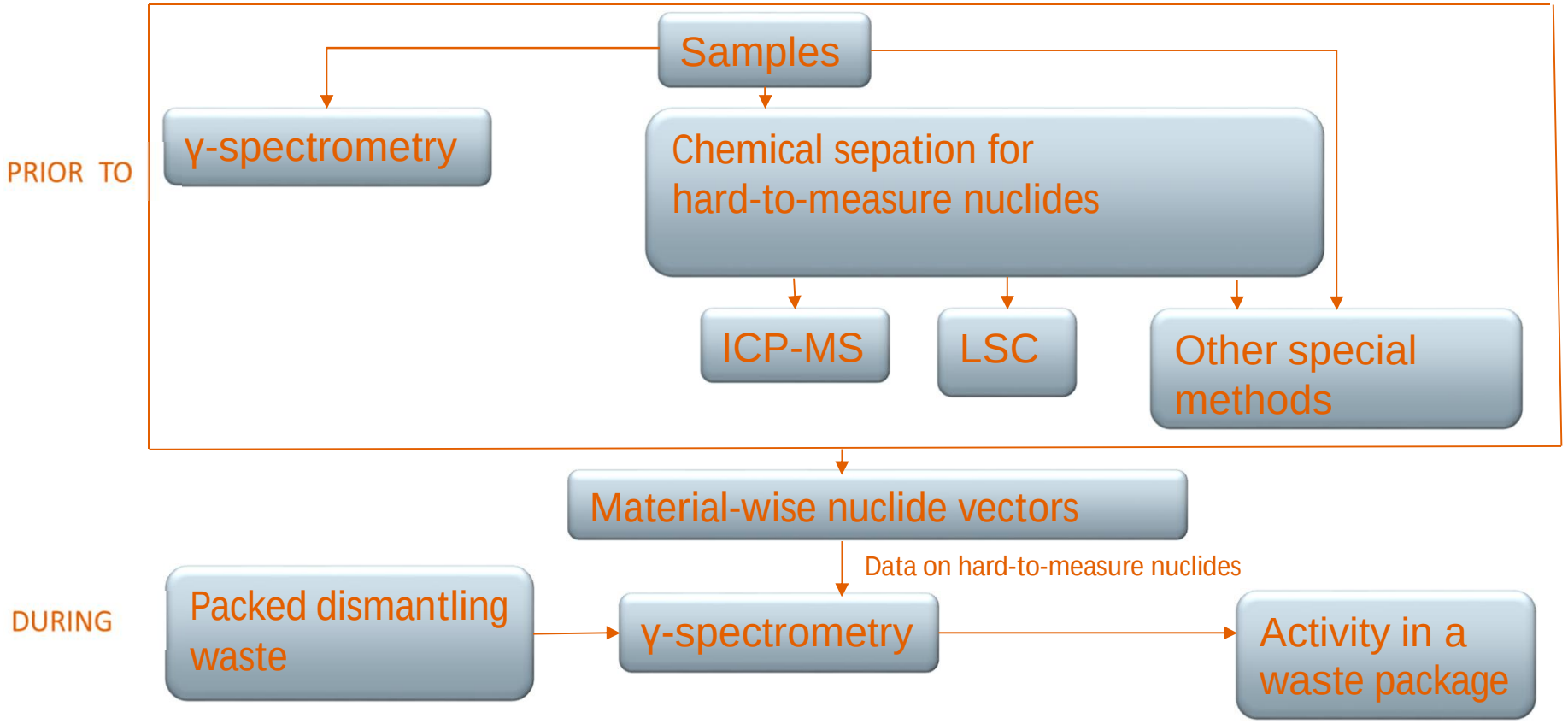
- **Aims for measurements**
  - Chemical composition of original materials
  - Radionuclide inventory in each material
    - Gamma spectrometry
    - Radiochemical analysis for difficult to measure radionuclides
  - Formation of scaling factors - material and reactor specific
- **Challenges in FiR 1 project**
  - Access to samples (constrains caused by the SNF)
  - Heterogeneity of materials (statistical uncertainty vs. Justification for waste production and use of resources)
  - Correct sampling technique (e.g. volatility of radionuclides)
  - No reference materials → validation via intercalibrations

Measurement tools

- **Elemental analysis from solids and liquids**
  - Ultrawave sample digestion
  - ICP-SF-MS
  - ICP-OES
- **Gamma measurements**
  - ISOCS (In Situ Object Counting System) gammaspectromery with HP Ge detector
- **Beta and alpha activities**
  - Radiochemical separations – a crucial point!
  - Hidex 300 SL ***liquid scintillation counter*** with a TDCR technology, a Guard and Eu-152 external standard for beta measurements and 2D alpha/beta plots
  - Ortec Alpha-Ensemble-4 ***alpha spectrometer***, 4 input benchtop spectrometer



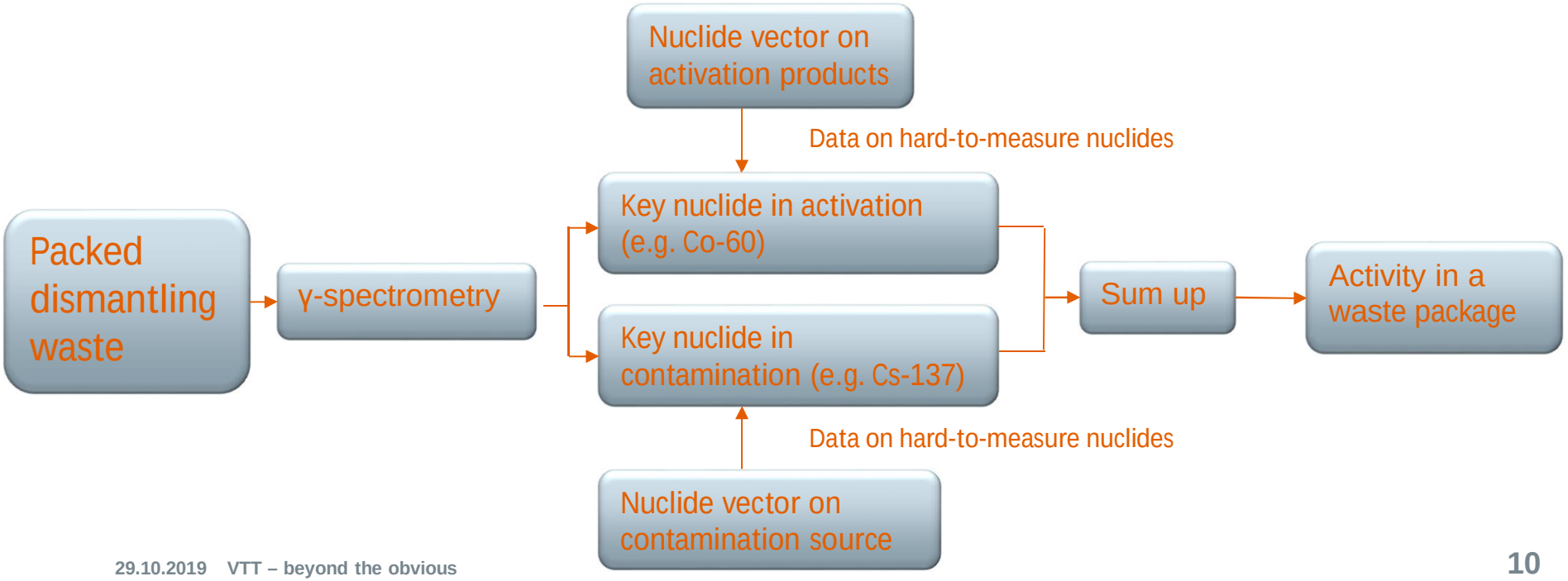
Utilizing the results: Scaling matrix approach



Contamination

§ **Activity in a component = activation + contamination.**

- Neutron activation calculation estimates only the reactions inside the material.
- Surface contamination cannot be taken into account directly.



Summary

- **Proper characterisation provides input for dismantling planning, radiation safety, waste management, etc.**
  - Enables safety and cost-efficiency.
- **Characterisation is a process using modeling and measurements.**
  - Calculation is a combination of neutron transport and point-depletion methods.
  - Measurements both provide input data for calculations and validate the results.
  - Methods at VTT Centre of Nuclear Safety enable forming a full nuclide vector for decommissioning waste.
- **Waste management utilizes the results with scaling matrix approach**

beyond

the obvious

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29/10/2019