Radiological Characterization and Decommissioning in Denmark

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- Radiological Characterisation, April 2012, Studsvik.

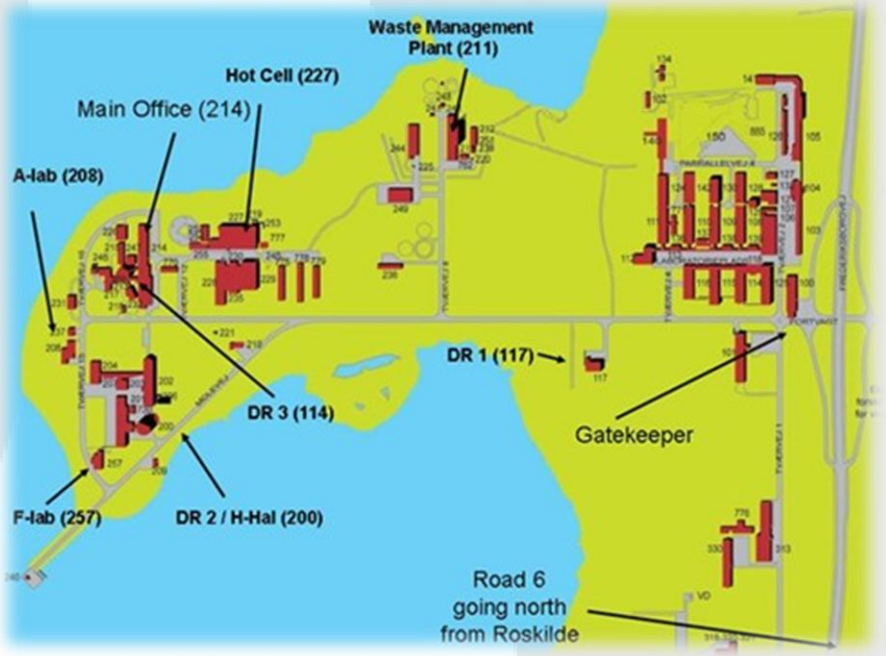
DANSK DEKOMMISSIONERING

- DD and Nuclear Facilities
- Sampling
- Inventory and Outlook

DANSK DEKOMMISSIONERING

Danish Decommissioning

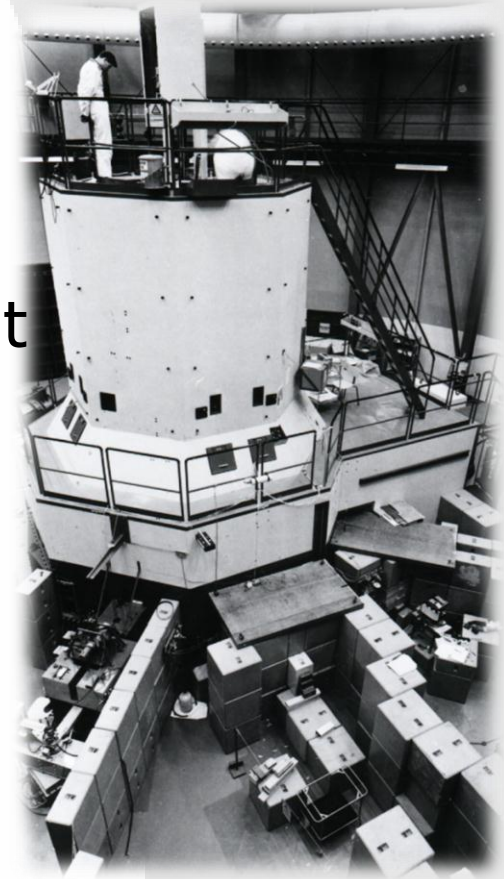
- Decommissioning
- Radioactive Waste
  - Receive
  - Handling
  - Storing
- Health Physics



DANSK DEKOMMISSIONERING

Danish Reactors

- DR1
  - 1957-2001 (2006), 2 kW
- DR2
  - 1957-1975 (2008), 5 MW, Light water
  - Research, Production
- DR3
  - 1960-2000, 10 MW, Heavy Water
  - 2012: Design, Tendering Equipment



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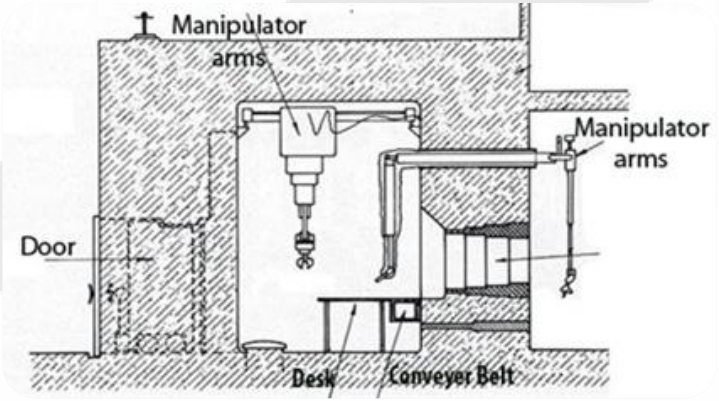
Hot Cell Decontamination

- Operation 1964-1989
- ”Cleaned” and Sealed 1993
- High Doses and Offices Nearby



DANSK DEKOMMISSIONERING

- DD and Nuclear Facilities
- **Sampling**
- Inventory and Outlook

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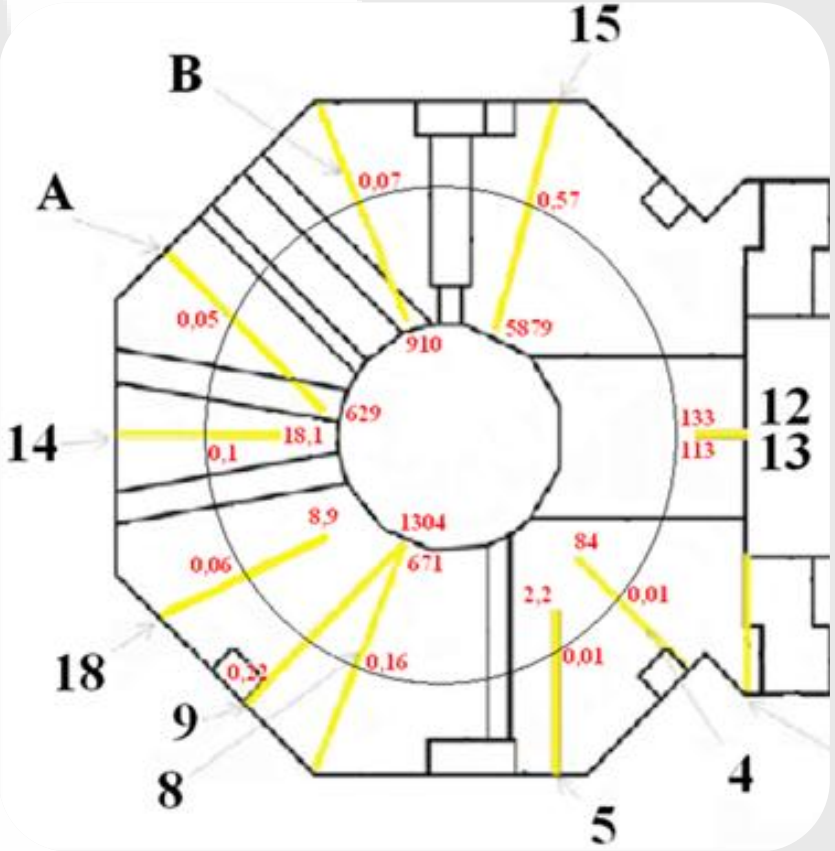
Sampling or Modelling?

- Modelling not as precise or fast as Sampling
- Complex systems, Variable Waste - Hard to Model
- Both Sampling and Modelling?



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Sampling Process

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Sampling in Danish Decommissioning

- Cradle-to-Grave Work Planning
- Samples Representing Sorted Waste
- Ad Hoc Procedures for Dismantling

- DD and Nuclear Facilities
- Sampling
- **Inventory and Outlook**

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Calculation of Inventory - Scaling

Induced activity can be calculated by this equation:

$$q(\mathrm{tirr}, \mathrm{tdecay}) = \frac{N}{A} \cdot \frac{a}{100} \sigma \cdot \phi \cdot \left(1 - \exp\left(\frac{-\ln(2)}{\mathrm{thalf}} \cdot \mathrm{tirr} \right) \right) \cdot \exp\left(\frac{-\ln(2)}{\mathrm{thalf}} \cdot \mathrm{tdecay} \right)$$

Scale factors can be defined as:

$$SF(\mathrm{tirr}) = \frac{a}{A} \cdot \sigma \cdot \left(1 - \exp\left(\frac{-\ln(2)}{\mathrm{thalf}} \cdot \mathrm{tirr} \right) \right) \cdot \exp\left(\frac{-\ln(2)}{\mathrm{thalf}} \cdot \mathrm{tdecay} \right)$$

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Examples of Scaling Factors

- Normalisation to a key nuclide
- Contamination scaling factors based on Sampling and measurements

Activation - Isotopes	DR3 Steel: Co-60 Scaling factors
Ni-63	12,01
Fe-55	6,067
Eu-152	2,792
Ba-133	0,4873
Cl-36	0,3814
Eu-154	0,1497
Ni-59	0,1270

Contamination - Isotopes	Hot Cell: Cs-137 Scaling factors
Pu-241	1,574
Sr-90	0,535
Pu-238	0,114
Am-241	0,093
Pu-239	0,054
Pu-240	0,041
Cm-243 Cm-244	0,035

Summary & Outlook
DD Practice

- Decommissioning yield Variable Waste
- Sampling over Modelling when Possible
- Cradle-to-Grave Planning
- Ad Hoc Procedures as Needed

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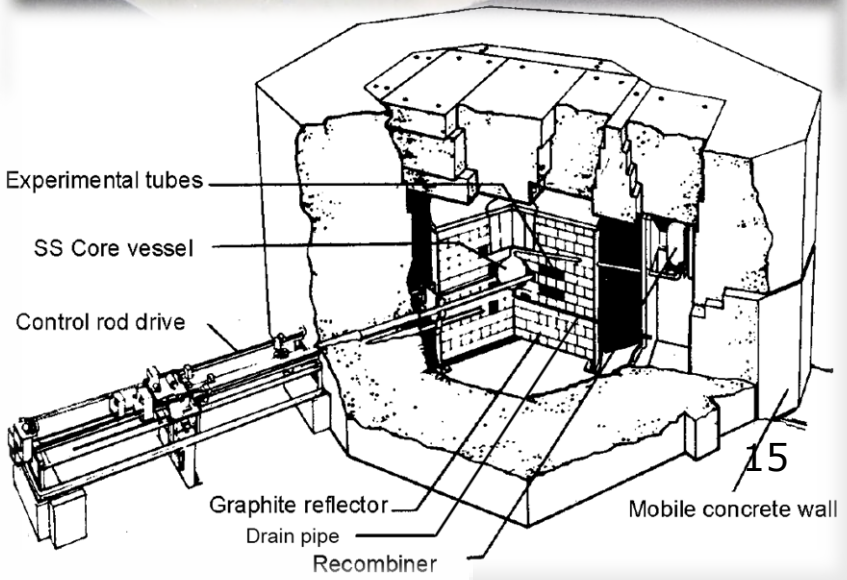
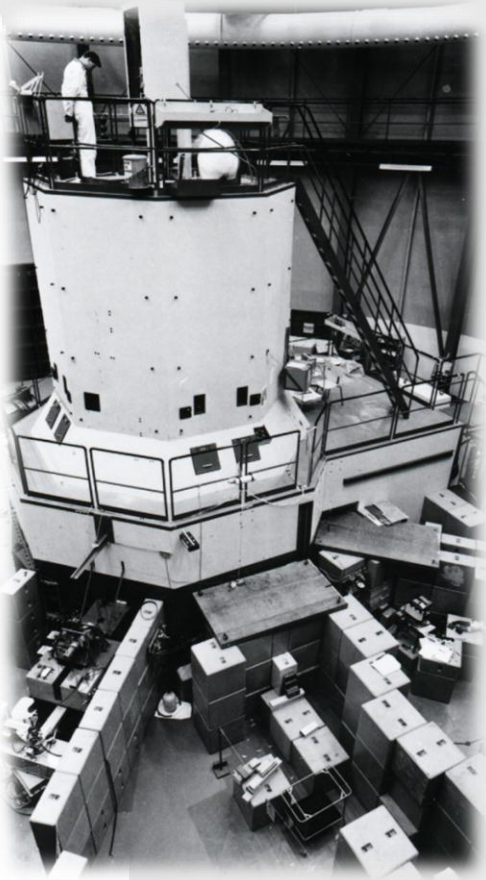
DR1

- Operated 1957-2001 – 2 kW
- Decommission completed in 2006



DR2

- Operation: 1957-1975
- 5 MW Light Water Reactor
- Research and Production of Isotopes
- Decommis-sioned 2005-2008



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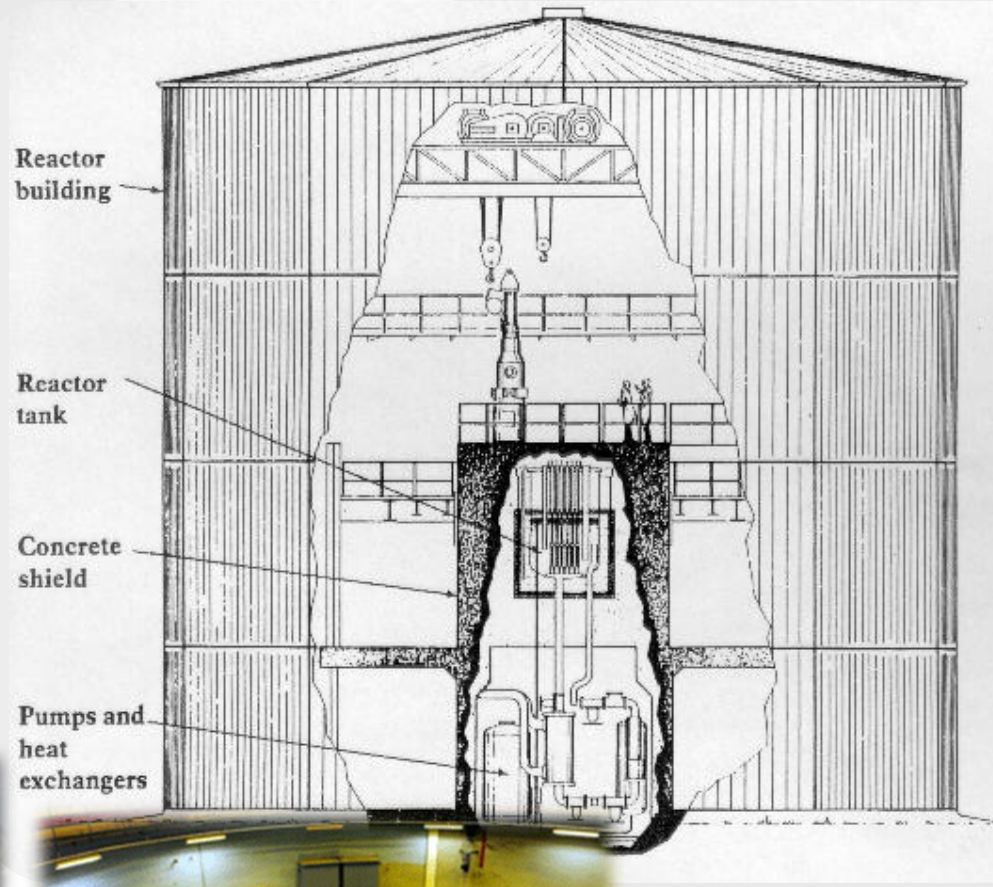
DR3

- Operation: 1960-1999
- 10 MW Heavy Water Reactor
- 2012: Design, Tendering Equipment, External Parts



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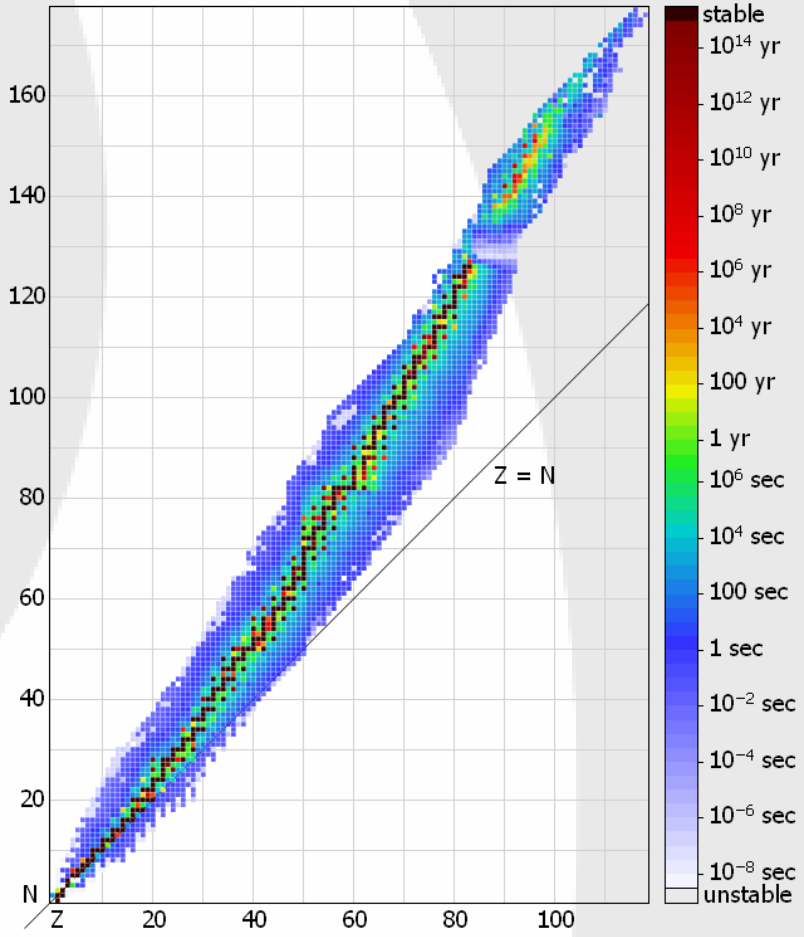

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