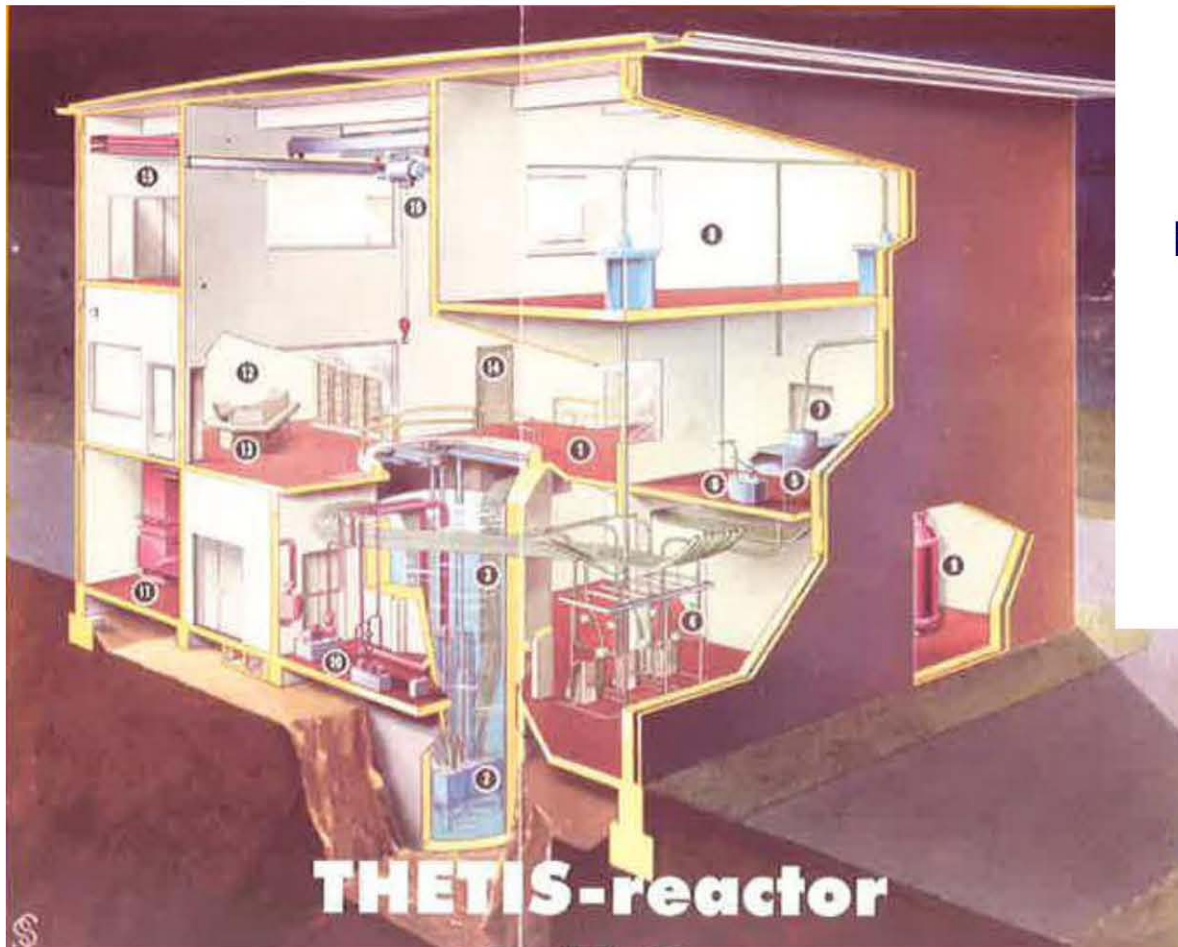


**Geert Cortenbosch¹, Chantal Mommaert¹, Hubert Thierens²,
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Karel Strijckmans³**

**ESTABLISHING DECOMMISSIONING PLANS,
MANAGING THE TRANSITION PERIOD BETWEEN
OPERATION AND DECOMMISSIONING, AND THE
DECOMMISSIONING OF THE POOL REACTOR THETIS
IN GHENT, BELGIUM**

Summary

- The Thetis Decommissioning Project (*U Ghent / Bel V presentation*)
 - History
 - Licensing procedure for decommissioning
 - Content of demand for license for decommissioning and dismantling
 - License to start decommissioning
 - Transition period (2004 – 2010)
 - The removal, transportation, final treatment and conditioning of the research reactor spent fuel of the University of Ghent achieved in 2010
 - The question for a solution for the spent fuel
 - On-site operations
 - Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 01/2013)
 - Final decommissioning phase (2013 - 2015)
 - Situation 2015



Thetis research reactor:

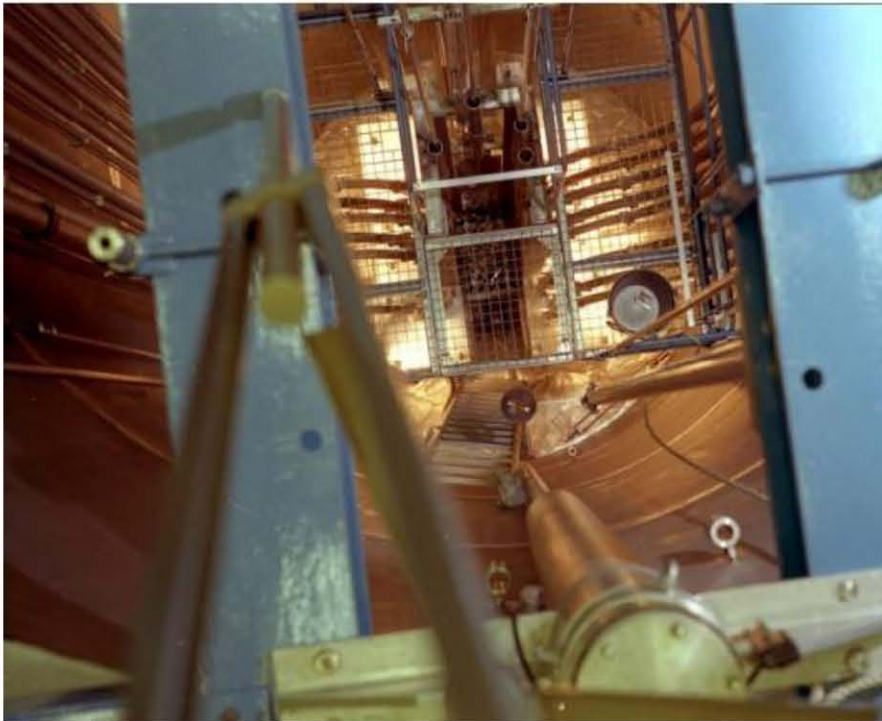
Type: Pool type.

Fuel: Low enriched Uranium.

Moderator: Light water.

Reflector: Graphite

Building Thetis reactor 1965-1967



ICEM 27/09/2011

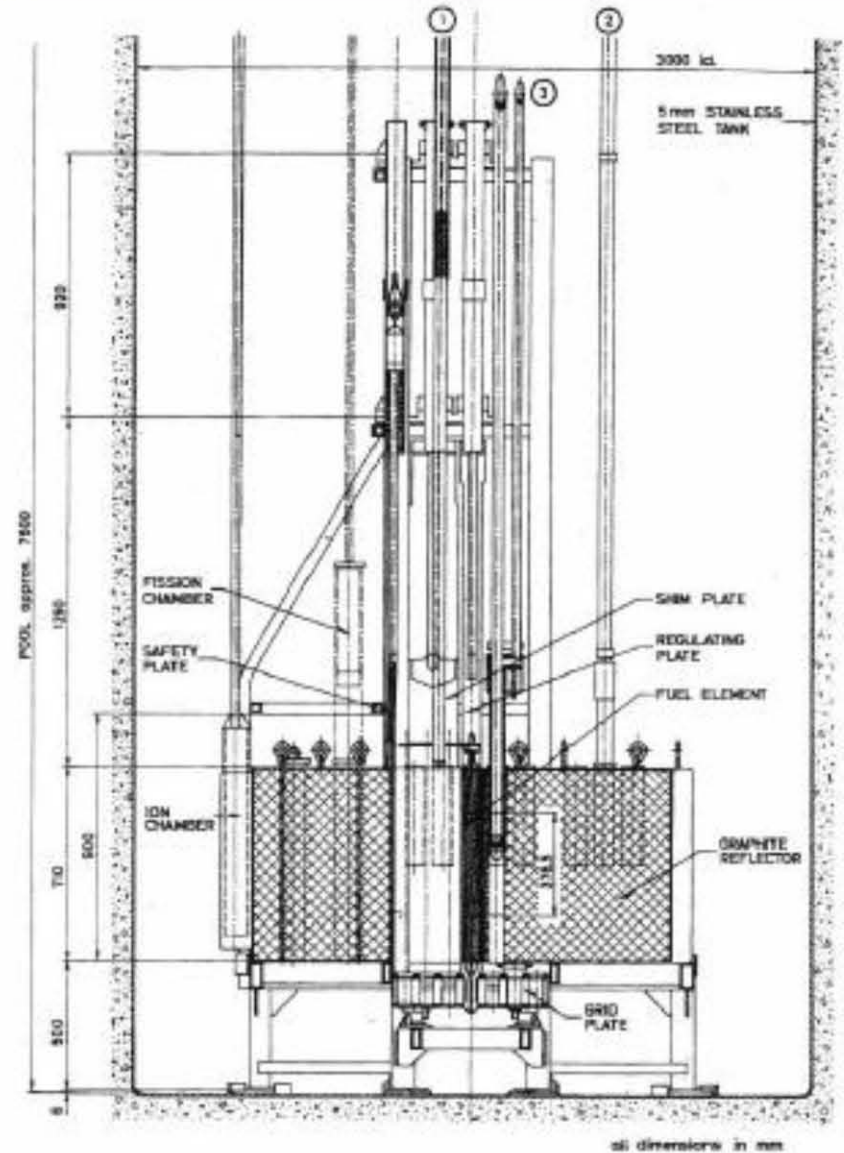


Fig. 1: Vertical cut of reactor pool and core



1967: Commissioned.

Power: 15 kW

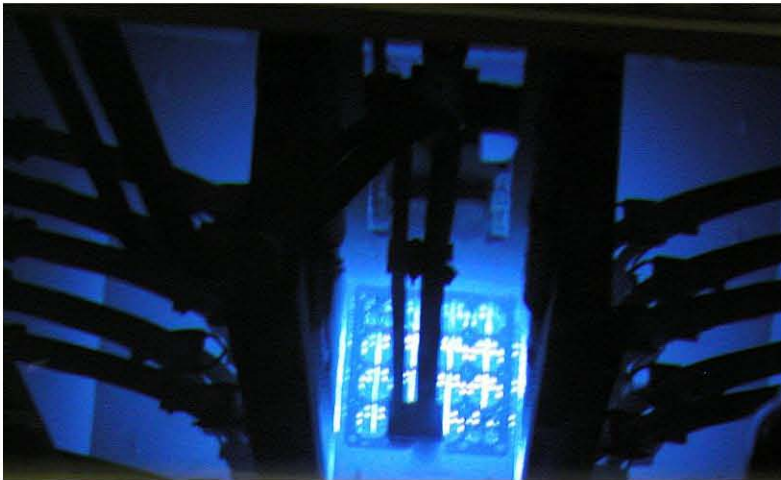




1972: core enlargement.

Power:

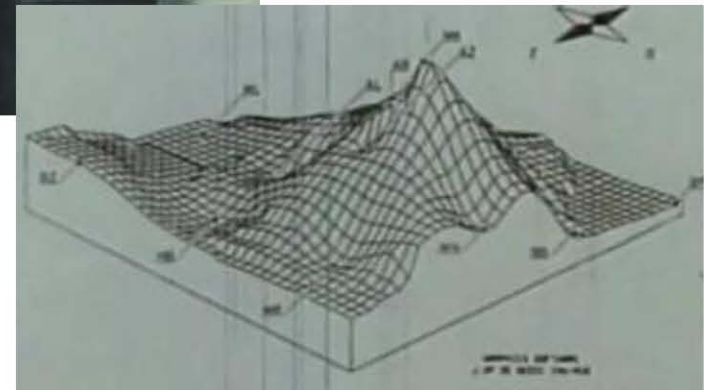
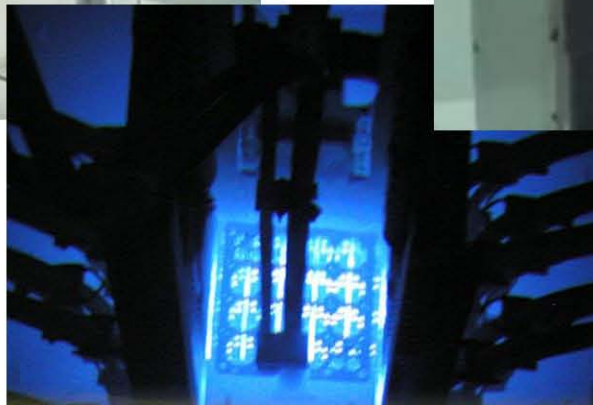
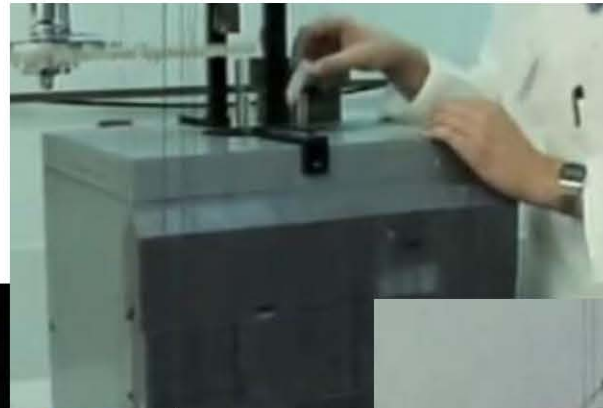
150 kW nominal,
250 kW maximum.





Mainly used as a neutron source for :

- Production of radionuclides for material analysis
- Activation analysis.



Licensing procedure for decommissioning

- Based on requirements of FANC
- Based on:
 - - IAEA Safety Requirements: Predisposal Management of Radioactive Waste, including Decommissioning (WS-R-2)
 - - IAEA Safety Guides:
 - - Decommissioning of Nuclear Power Plants and Research Reactors (WS-G-2.1)
 - - Decommissioning of Medical, Industrial and Research Facilities (WS-G-2.2)
 - - Decommissioning of Nuclear Fuel Cycle Facilities (WS-G-2.4)

Content of demand for license for decommissioning and dismantling

- Introduction
- Description of the installation
- Radiological and toxic inventory
- Dismantling strategy
- Purpose, dismantling alternatives, safety principals and criteria, destination of the site, ...
- Project Management
- Personnel, Documentation, Financing
- Quality System

Content of demand for decommissioning and dismantling

- Dismantling activities
 - Planning, decontamination and dismantling techniques, release, re-use of materials,...
 - Safety Analysis
 - ALARA study
 - Safety systems, Incident Analysis, Criticality, Industrial Safety, Emergency Planning, Security,...
 - Environmental Report

License to start decommissioning

- Safety document “Decommissioning of Thetis Reactor” needed
 - Approved by FANC and Bel V
 - All safety related modifications during decommissioning had to be approved

- Reporting to FANC and Bel V

Transition period (2004 – 2010)

- 3-monthly internal inspections during cooling period
 - ventilation, pneumatic pumps, demineralisation loop, reactor pool, control room, safety systems, radiation monitoring, underpressure, alarms, reactor water activity, reactor water temperature, water level.
- Monthly Bel V inspections during cooling period

The removal, transportation, final treatment and conditioning of the research reactor spent fuel of the University of Ghent achieved in 2010

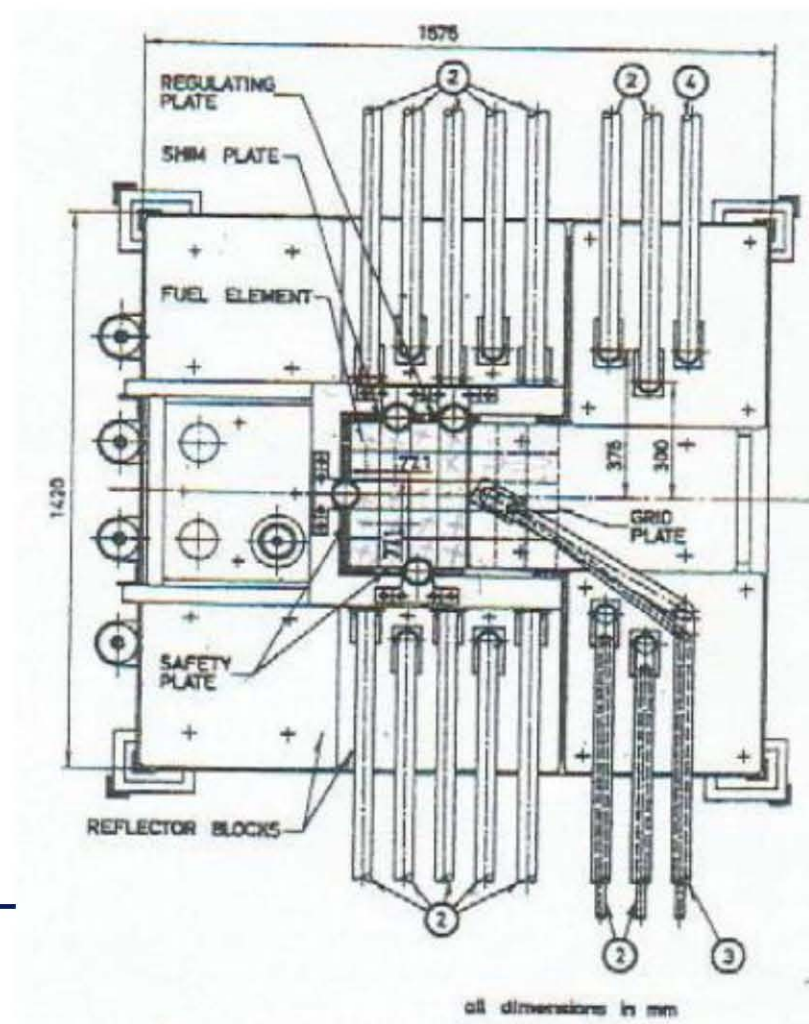
- *(under the existing license for operation of the reactor)*

The quest for a solution for the spent fuel.

Thetis core: 20 elements, typically containing 25 fuel rods.

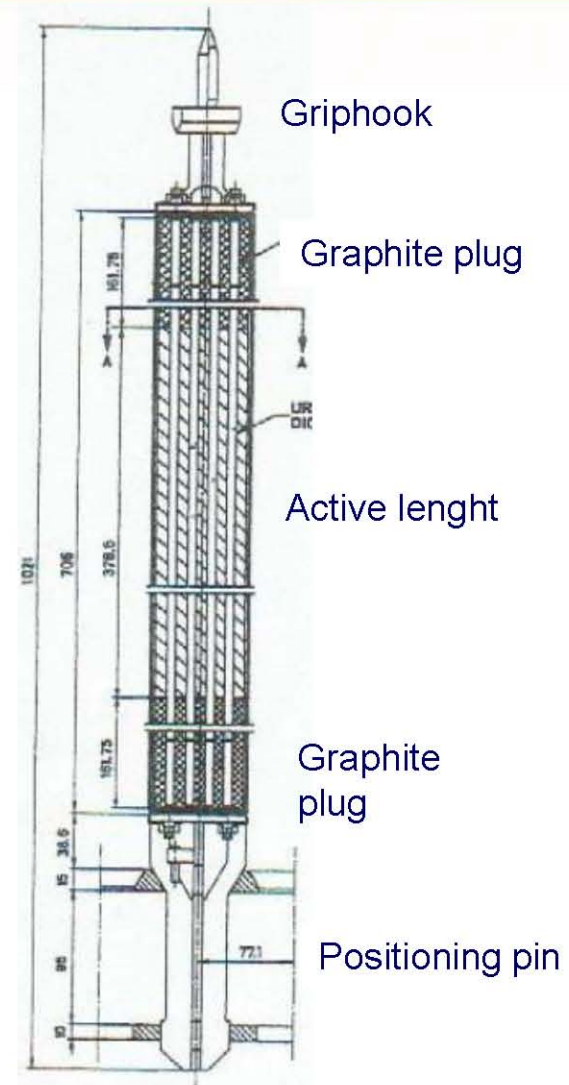
Total number of :

- elements irradiated: 25,
- elements present: 26,
- rods: 583,
- ^{235}U : 3758g



Fuel rod:

- Active pin height: 376 mm
- Containing 5 % enriched Uraniumoxide,
- Graphite plugs 162 mm at both ends.
- Cladded with 200 μm AISI304L stainless steel
- Average burn-up: 3.15 GWd/tIHM,
- Maximum burn-up: 5.15 GWd/tIHM



1) Reprocessing.

2) Intermediate storage
awaiting final disposal

Criteria for evaluation:
available techniques, safety, waste production, total cost

Fuel = exotic (no end user).

Acceptance criteria not met due to
graphite plugs.

Technical issues: cutting, repackaging,
reprocessing, final storage.

Total cost = high.

Option abandoned

New technique:

- Direct cementation in 400 l drum
with inner basket.
- Interim storage.

Technically feasible.

Total cost = lower.

Option adopted

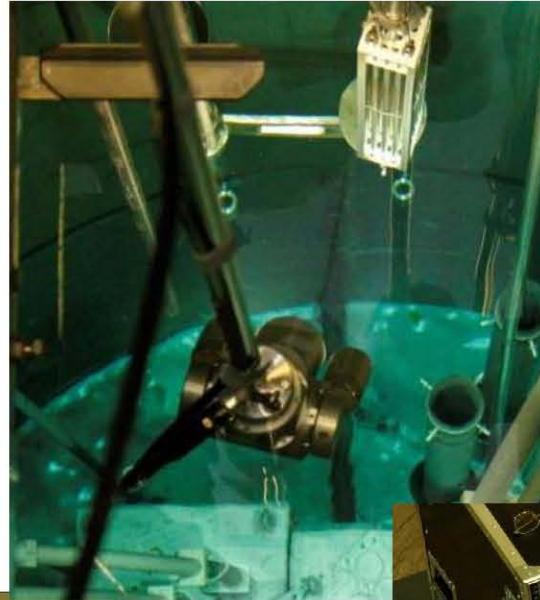
On-site operations.

Unloading of reactor Thetis in 2010





Original
manual
manipulators



Under water
camera
and
sipping tubes

Health Physics
equipment

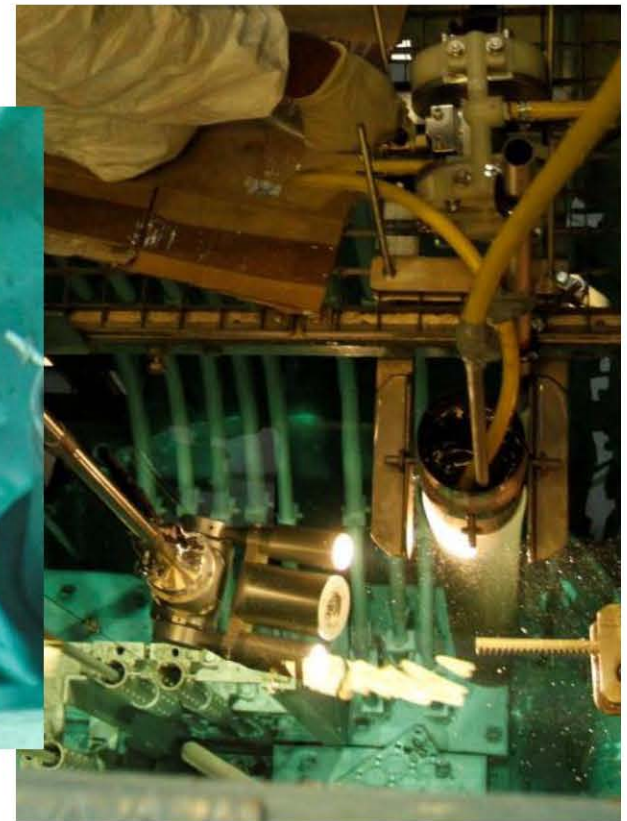
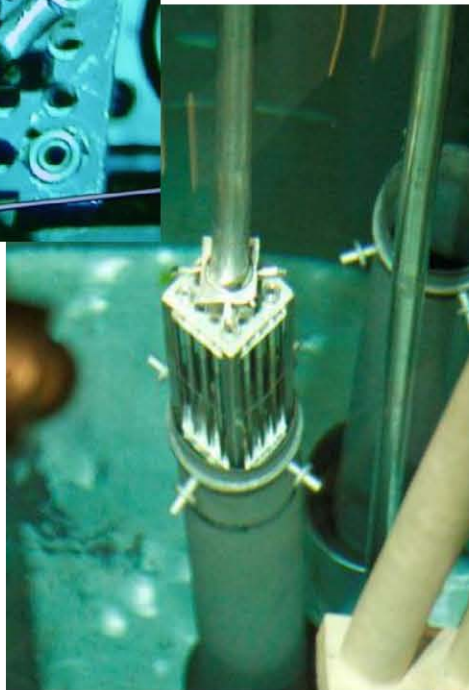
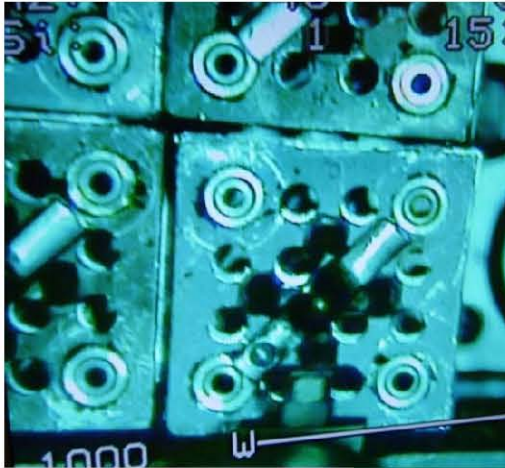




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Sipping test

Element placed in sipping tube,
Tube hoisted to the surface,
2h delay (sipping),
Water pumped in tube (15 min).





Water sample

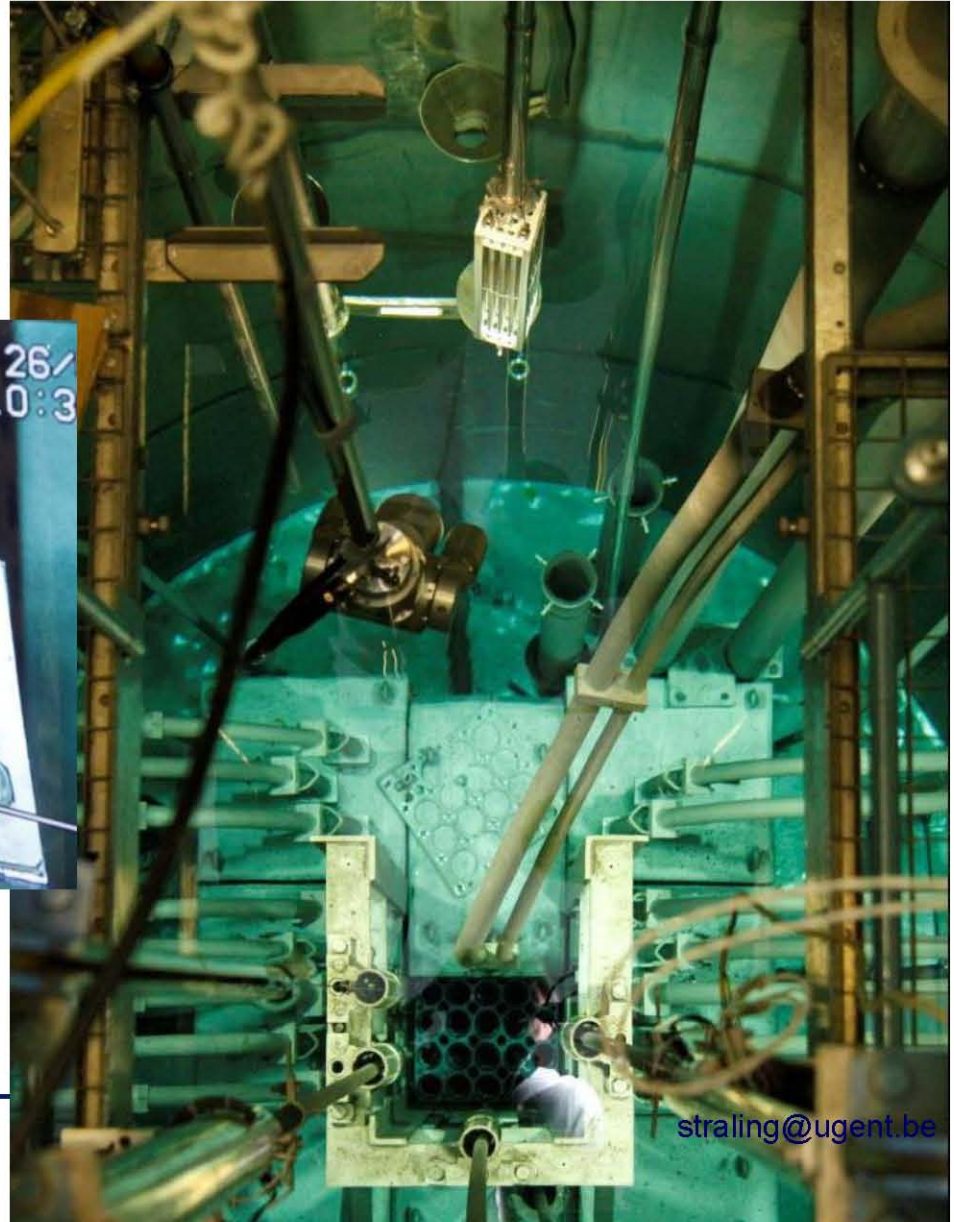
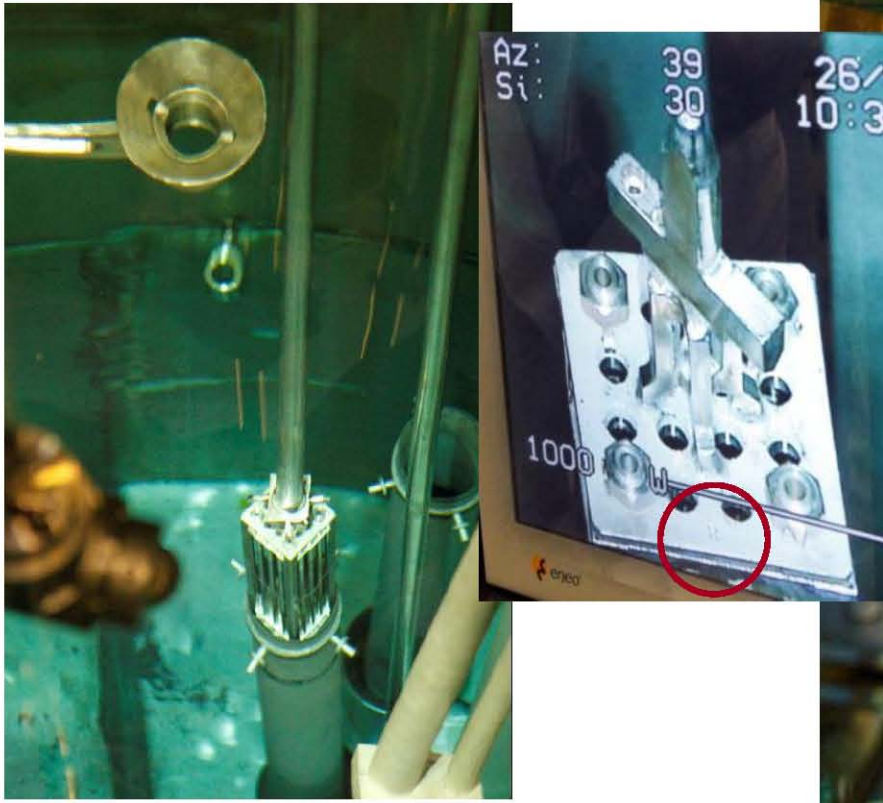


Gamma spectrometry
using Germanium detector



Moving element to
presentation position :

- Visual inspection
- Identification





IAEA inspection

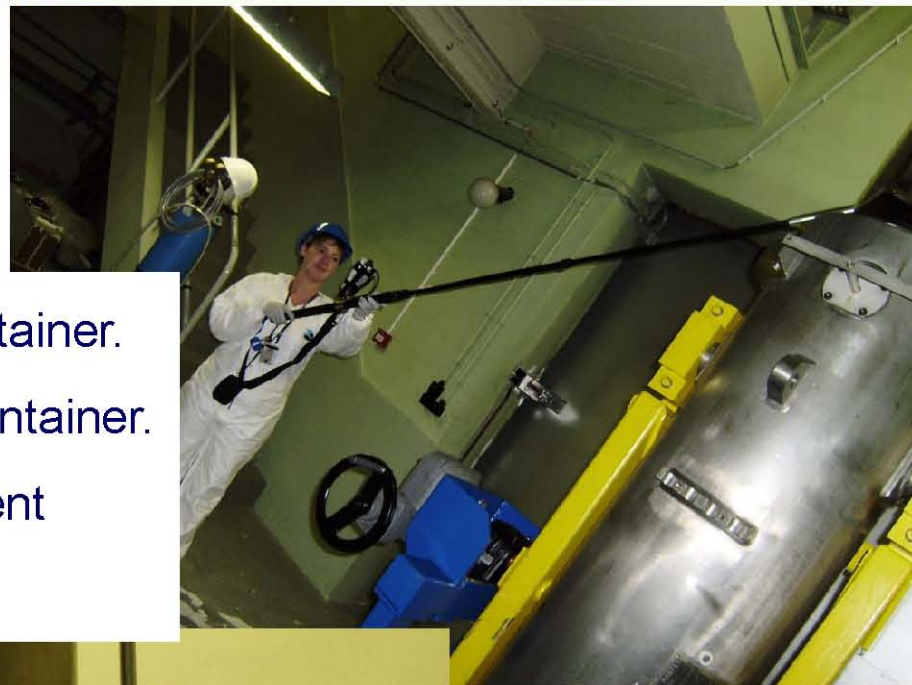


Positioning transfer container to pick up
element from presentation position





Loading transportcontainer.
Docking of transfercontainer.
Doserate measurement
during element shift.





Sealing transportcontainer.

Drying container.

Leaktest.









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Rigging and sealing

Getting ready for transport



Documents per element:

- Quality assurance check list for manipulations
- Leak test and identification
- Dose rate measurements.
- Container certificates
- Transport documents (ADR adherence)





Security

Transport under “special arrangement”

Enhanced security on site and during transport

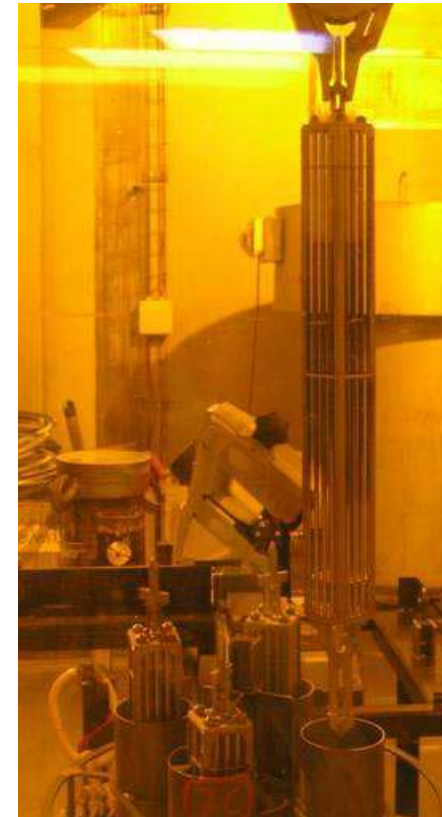
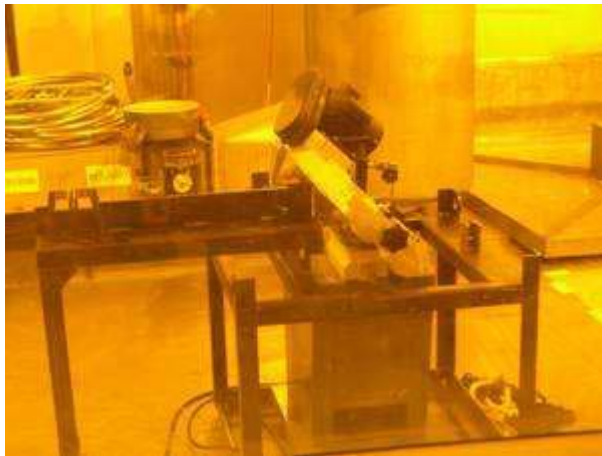


Conditioning of the spent fuel:

- Cut top and bottom plugs from each element.
- Conditioning in 400 l drum.
- Internal basket containing 4 concentric cylinders for fuel elements.
- Additional central cylinder for cut plugs.
- Use of special cement mixture containing LiNO_3 due to presence of Aluminium.
- Criticality.



Cutting at Belgoprocess



- The unloading of the Thetis fuel was completed during the summer of 2010.
- The cumulative dose for the team at Thetis was only 404 μSv .
- 7 400 l drums of conditioned fuel were produced and stored at Belgoprocess.

Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 17/03/2013)

- 3-monthly internal inspections during transition period
 - ventilation, radiation monitoring, underpressure, alarms, water level, reactor water activity, reactor water temperature.
- 3-monthly Bel V inspections during transition period
(Bel V organised 3 thematic inspections on Fire Safety between 2011 and 2013)

Transition period between removal of spent fuel and start of decommissioning phase (09/2010 – 17/03/2013)

- Decommissioning license (15/05/2012)
 - License conditions
 - Specific procedures needed (release of waste, dismantling techniques, ...)
 - Safety evaluation report / Decommissioning plan / Technical report
 - QS system
 - Working procedures and instructions / ALARA study
 - Inventory of radioactive waste
 - Inspection program of safety systems (3-monthly)
 - Risk analysis (for new dismantling techniques)
 - Dose registration
 - Operational experience feedback system
 - Methodology and results of final characterisation

Final decommissioning phase (2013-2015)

- Started on March 18, 2013
- Different phases
 - Primary mapping (ended)
 - Asbestos removal (part 1) (ended)
 - Dismantling of instrumentation / rabbitsystem / internal reactorparts (graphite, grid, core plate) (ended)
 - Dismantling of watercircuits and ventilation system, stripping of contaminated installations (ended)
 - Decontamination of infrastructure (ended)
 - Asbestos removal (part 2) (ended)
 - Removal of activated bottom plate of reactor pool (ended)
 - Final radiological survey (ended in 2015)
 - **Declassification to Class II (or III)** (foreseen before the end of 2015)
- Bel V inspections (monthly)
- UGhent / SCK / Belgoprocess / Bel V meetings during decommissioning phase (2 weekly)

Final decommissioning phase (2013)

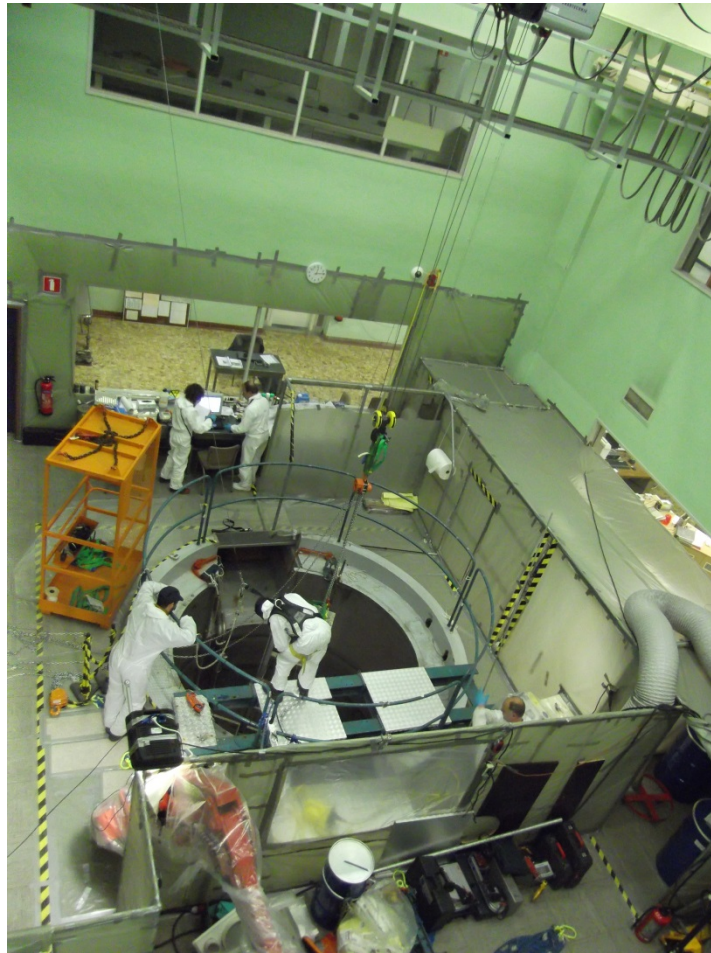
- Approval by Bel V of all reports and procedures in February 2013
- Received doses from 18/03/2013 (start of decommissioning phase) till 06/08/2013 (after removal of most of the radioactive waste)
 - 1561 man.μSv in total (61 persons)
 - 232 μSv (max. individual dose)

Final decommissioning phase (2013)

- 1 **incident** rated INES 1 in April 2013: no underpressure in controlled areas due to power outage. No radiological consequences.
- **Unforeseen activation** of the bottom plate of the reactor pool (detected during decommissioning phase → removal of liner in May 2014 and characterisation of activated bottom plate (Co-60 and Eu-152) in June 2014

Approval of Procedures & Methodology by Bel V was needed.

Reactor building



Entering Top Tec cutting device

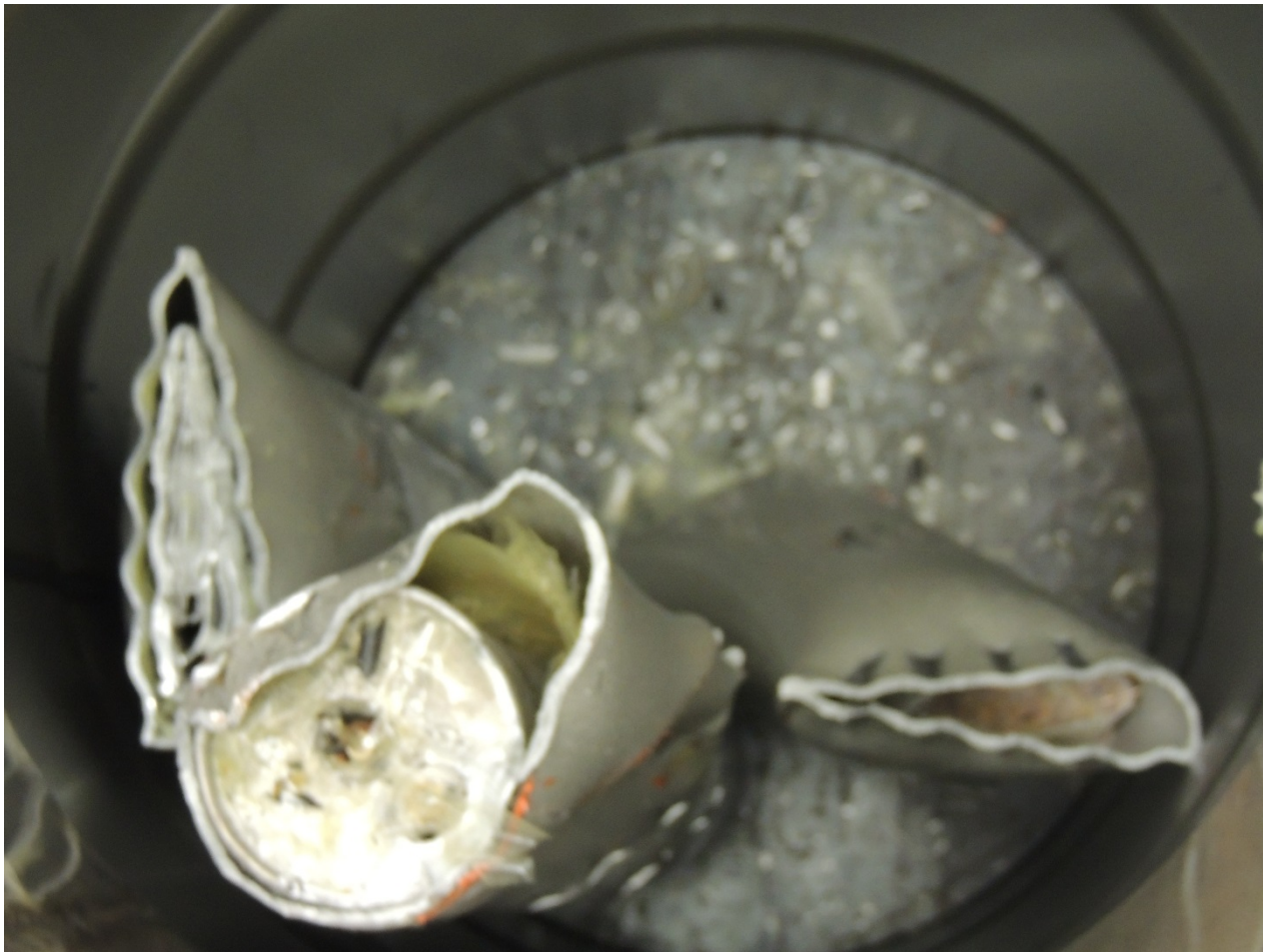


Waste Management

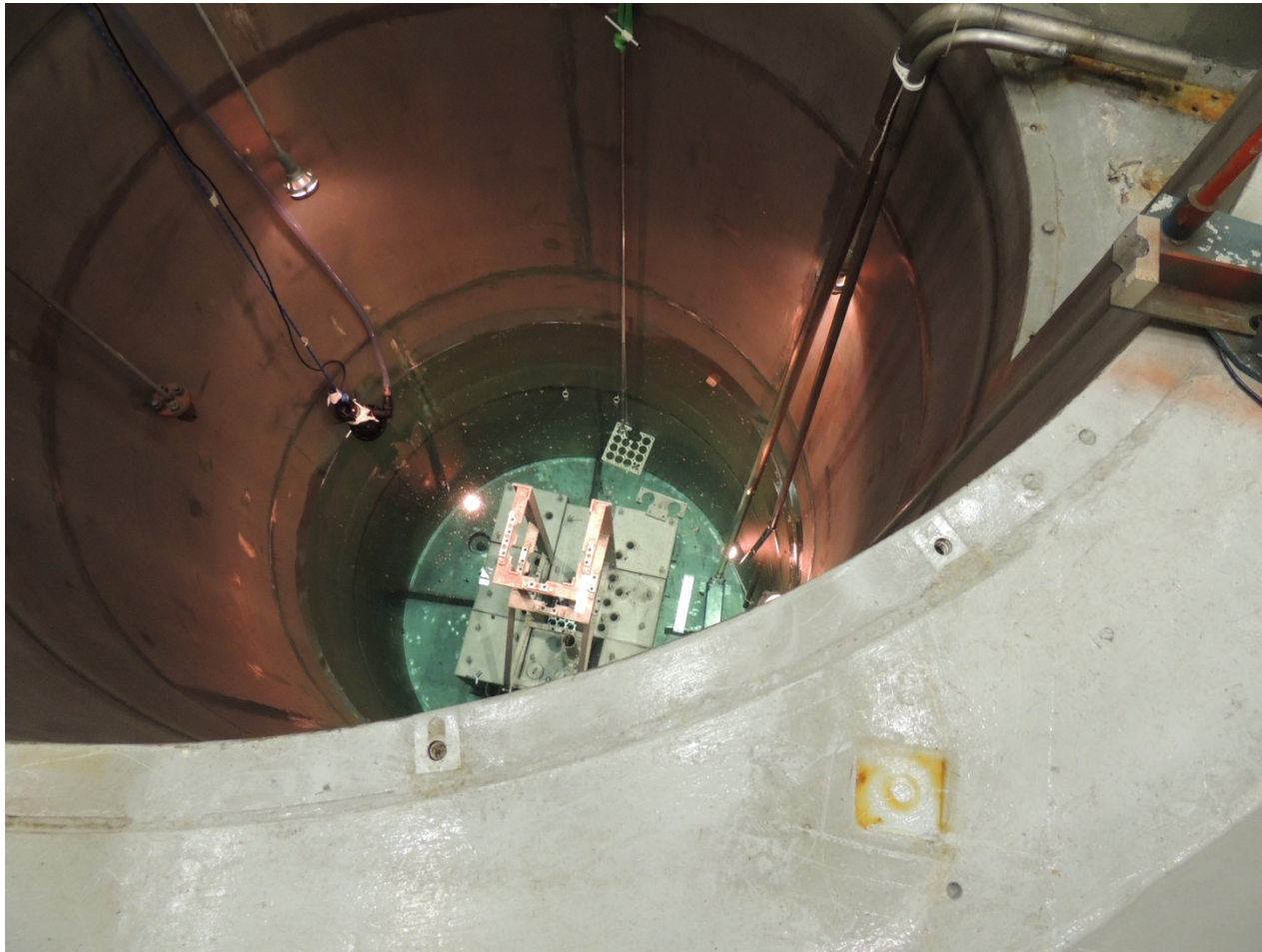


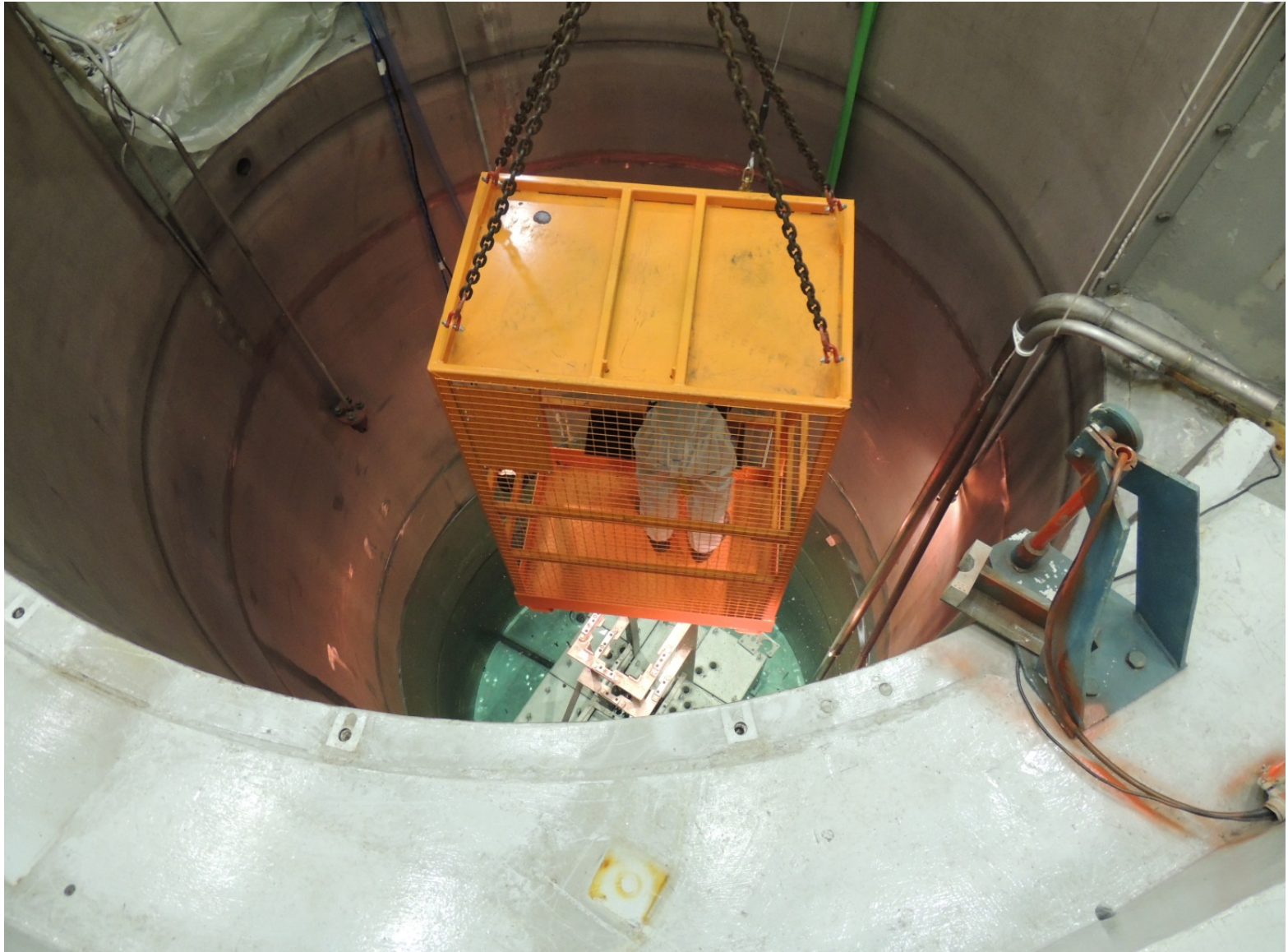
Cutting of instrumentation tubes



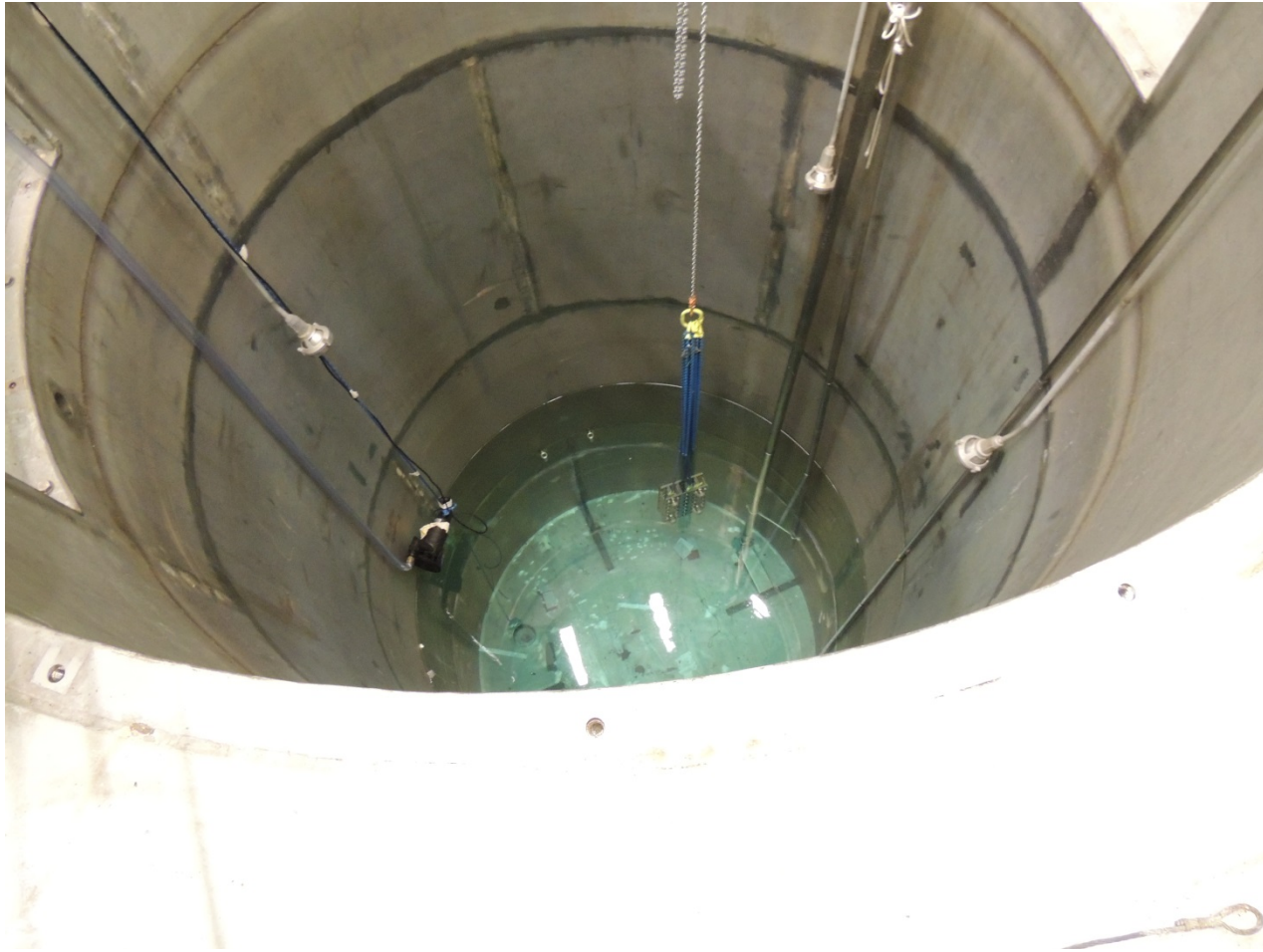


Removal of the grids



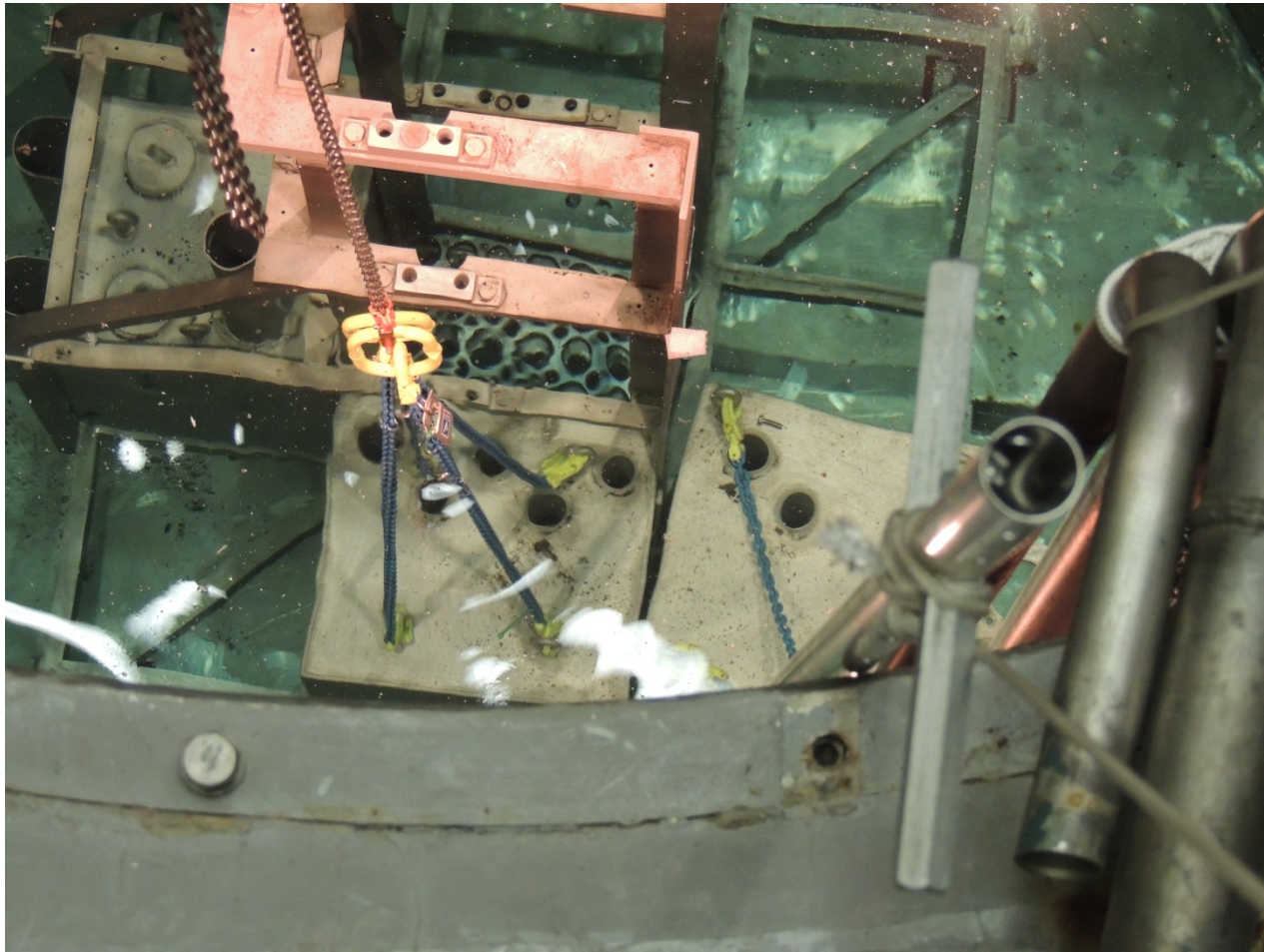








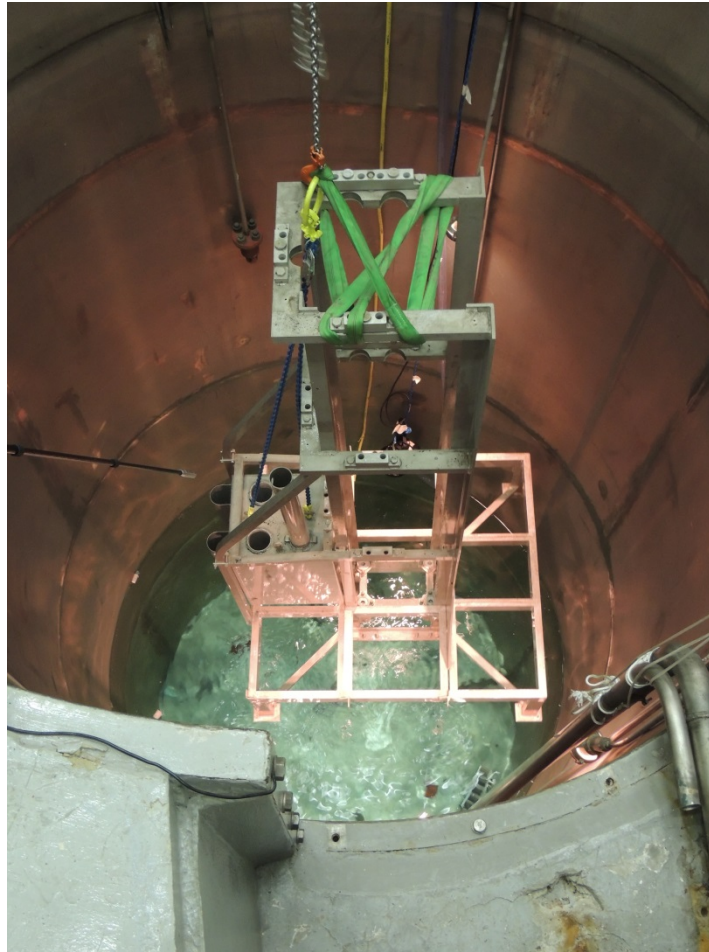
Removal of the graphite blocks



Storage of graphite blocks in 1m³ containers



Removal of supporting structure



Cutting of supporting structure



Sawing



Local ventilation



Ventilation unit



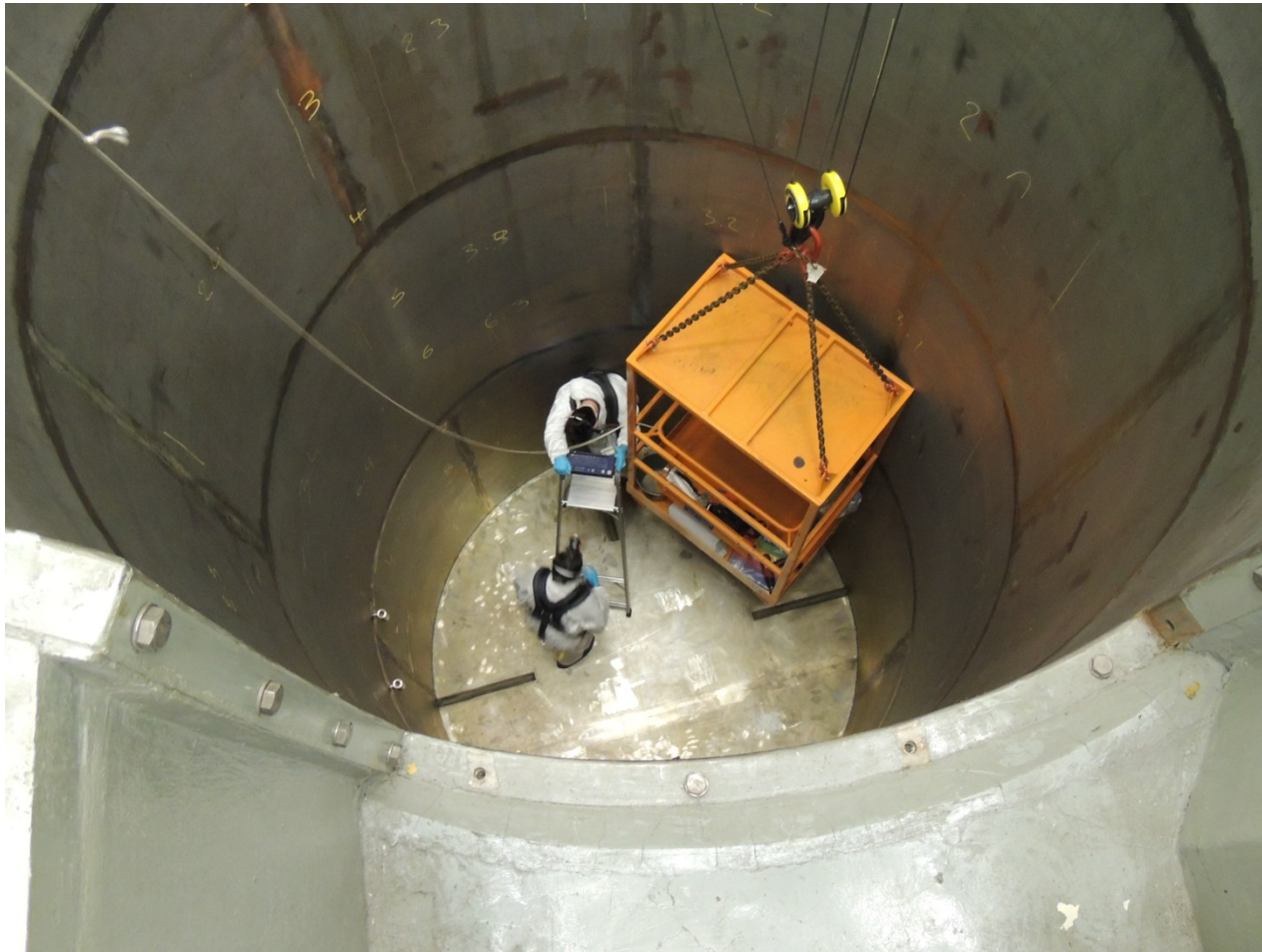
Pumping of the reactor pool water







Mapping and decontamination of the pool



Rabbit station (1)



Rabbit station (2)



Laboratory



Transportation



Waste Management Program

- All materials are selectively collected in waste categories
- Specific waste drums are used to collect the waste
- All drums are radiologically characterised
- The results of the characterisation determine the removal paths of the material
- All information of each drum is saved in a data management system

Measuring methods for ^{60}Co activity

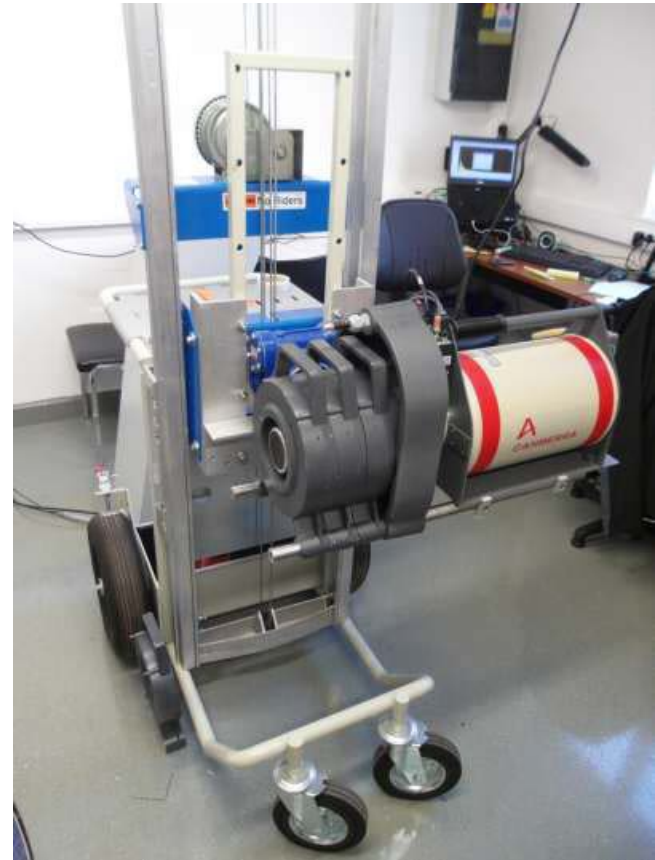
- Low Level Radioactive Waste System (LLRWS)

a fixed laboratory setup manufactured by Canberra and VUB (lead shielding) High-Purity Ge detector (relative efficiency of 25%)



Measuring methods for ^{60}Co activity

- **ISOCS** (In Situ Object Counting System)
- **mobile system**
- used in a fixed setup
- used for measurement of walls & floors of the reactor-building
- manufactured by Canberra
- **Genie-2000 software** (Canberra)
- **High-Purity Ge-detector**
(relative efficiency of 25%)



Measurement Zone



Measurement Zone



Waste storage



Situation 2015

- Activated bottom plate
 - Approximately 3,1 MBq Eu-152
 - Approximately 0,34 MBq Co-60
- Declassification to Class II (or III) foreseen before the end of 2015
- Measurements for free release of reactorbuilding performed in 2015 (1 contamination detected by Bel V in a former lab → was removed in June 2015)
- Removal of waste drums still ongoing (free release, NIRAS and melting at Studsvik)

Activated bottom plate



Inspection hole



Cover



Detected contamination in former lab



THANKS to

- University of Ghent
- SCK
- Belgoprocess

THANK YOU
for your attention !

ANY QUESTIONS ?