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Harwell Decommissioning - including the Materials Test Reactors, DIDO & PLUTO

Kozloduy NPP visit to Harwell, 4 November 2009

Dr Ed Abel

Harwell Reactors Manager

See slide 42 for Chernobyl Kiev'92 competition scheme – virtually as built in 2016/17. ....

Background to Harwell reactors decommissioning

- Harwell has a history of developing innovative reactor designs - since 1946, 14 reactors have been built and 11 have been decommissioned or moved off-Site
- Our experience of decommissioning and development of advanced remote handling equipment means that the three remaining reactors can be completely decommissioned, whenever funding is available.
- Until then, these reactors and their storage blocks
  - are defuelled and have undergone Initial Decommissioning
  - are sealed and are in safe Care and Maintenance

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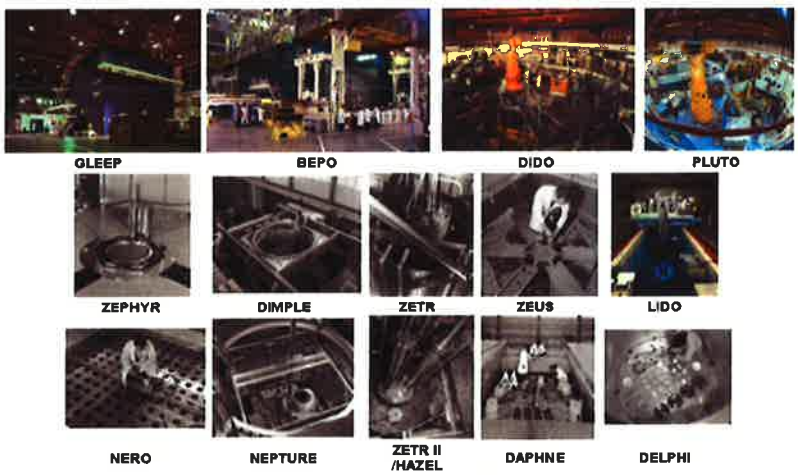
The Harwell Reactors



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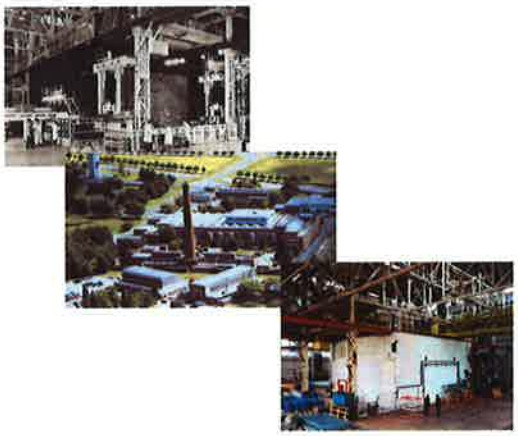
BEPO – British Experimental Pile Operation

- First large reactor built outside North America or USSR
- Used to improve design of the Windscale Piles
- Used for isotope production, fuel development and scientific studies
- Forerunner of all UK power reactors (PIPPA/Magnox/AGRs)
- Operated 3/7/48 – 13/12/68

- In Care & Maintenance, but Final Decommissioning possible now



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Materials Test Reactors, DIDO & PLUTO

- 26MW high flux heavy water moderated reactors
- Used for isotope production, neutron physics, radiation chemistry, nuclear reactor materials studies, neutron doping of silicon, neutron radiography
- Supported all UK reactor programmes
- Operated 1956/7 – 1990

- In Care & Surveillance, but Final Decommissioning possible now

PLUTO

DIDO

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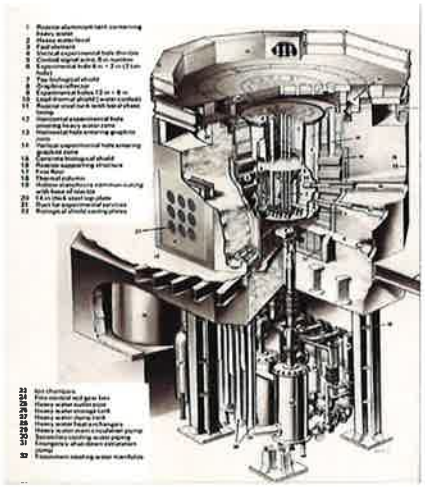
DIDO



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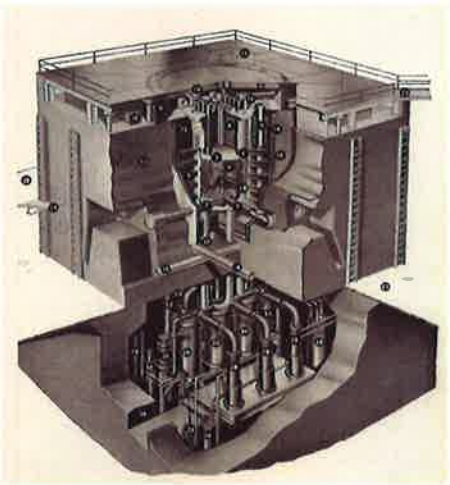
PLUTO



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Initial Decommissioning of the MTRs

- MTRs closed for economic, not technical reasons
- Majority of work between shutdown in March 1990 to September 1995
- Office blocks and associated facilities demolished in 1998 – 2002
- Originally the first two of the DIDO fleet of 5 reactors, worldwide, to close
- Now probably will be the last to complete Final Decommissioning as Denmark, Germany and Australia have adequately funded decommissioning programmes

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The three Stages of decommissioning (& sub-phases…)

Stage 1	Phase 1	•Defuel & remove D_2O
		•Remove samples, except cobalt, from rigs
		•Obtain approval for Safety Justification for Phase 2
	Phase 2	•Remove less hazardous secondary systems external to block
		•Obtain approval for Safety Justification for Phase 3
	Phase 3	•Remove remaining Secondary System
		•Unload cobalt from rigs
		•Obtain approval for Safety Justification for Stage 2, Phase 1
Stage 2	Phase 1	•Complete Interim decommissioning & decontamination
		•Decommissioning old ventilation systems and install new ones
		•Obtain approval for Safety Justification for Stage 2, Phase 2
		•Modify Safety Case, reduce category to Safety Category 3
	Phase 2	**•Extended Surveillance & Maintenance**
Stage 3		•Reduction of reactors' legacy to a delicensed (no harm) state

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Key events in initial decommissioning

EVENT	DATE ACHIEVED	
	DIDO	PLUTO
Decision to shut down	February 1990	October 1989
Reactor shut down	31 March 1990	
Fuel unloaded	April 1990	
Fuel transferred to B466	June 1990	
D2O drained into drums	May 1990	
Completion of fuel dispatch for reprocessing	Sep 1990	
D2O dispatched to Winfrith	July 1991	
DIDO and PLUTO projects combined	November 1991	
Stage I complete	January 1993	
DIDO/PLUTO Stage 2 Phase 1 Safety Justification issued	December 1994	
Stage 2 Phase 1 complete	June 1995	
Rigs in final storage positions	January 1993	February 1994
Rig disposal programme complete	July 1994	
Cobalt pencils disposal programme complete	NA	February 1995
New ventilation system installed	March 1995	
HAHC demolished	31 August 1994	NA
Cranes and VALs disabled	November 1994	September 1995

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Removing the Cooling Towers

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Demolishing the Flight Tube & Block House



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Clearing away internal structures, services & equipment



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Air Heater removal and clearance & monitoring

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Closing up the reactor tops

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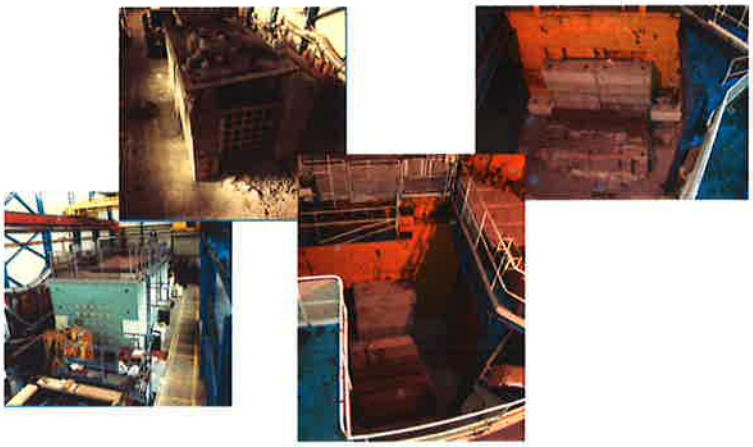
External Storage Block – the substantial steel tube plates are contaminated and are retained in PLUTO



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Demolishing the DIDO AHB

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Demolishing the DIDO Office Block

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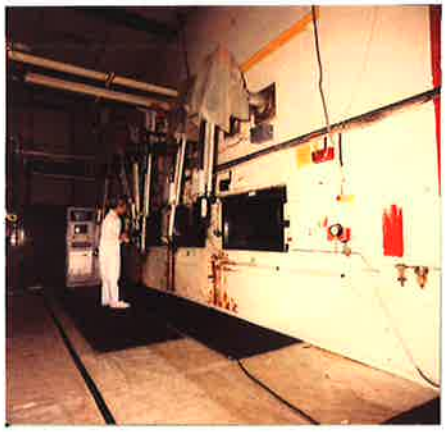
The DIDO High Activity Handling Cell (HAHC)



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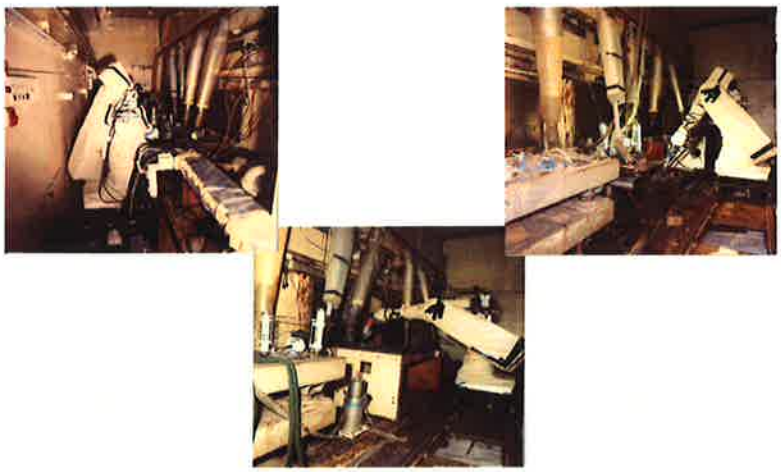
The DIDO High Activity Handling Cell (HAHC)

- Highly contaminated support cell line (>5Gy) with additional unknown debris under benches and equipment
- during initial decommissioning, a power manipulator hose burst, spreading oil through cell
- Preferred plasma arc cutting for size-reduction stopped
- NEATER and TV^3 system installed to carry out cell strip-out, cleaning and waste removal to man-entry levels
- New systems saved >80man-mSv, £1.1M and reduced clean-out time by 2 years

NEATER size-reduces in-cell furniture



NEATER cleans up

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HAHC demolition – sand and flame cutting

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Final decommissioning of the MTRs

- No technology issues with immediate decommissioning
- Dose levels prevent hands-on dismantling
- Lessons learnt from UKAEA , BNFL as well as DOE experiences confirm the approaches are valid
- Use of COTS equipment with some tailoring and radiation tolerant designs required
- Immediate decommissioning will generate RH- & CHILW

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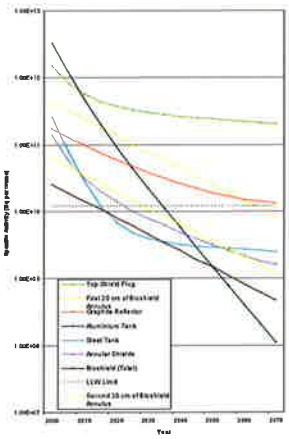
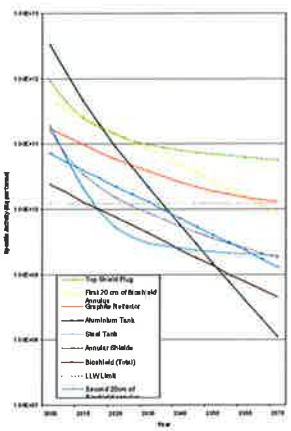
Accelerated Decommissioning vs half life? -

DECAY OF MAJOR COMPONENTS - DIDO



DECAY OF MAJOR COMPONENTS - PLUTO



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No space to move in a 2m RAT through 250mm holes – another approach is preferred

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BNFL uses Brokks for small reactor decommissioning

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ANL's Chicago Pile – 5, the idea behind DIDO

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Brokks at ANL, CP-5, & radiation tolerant version

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Tracked Brokk & multi-tool dispensing!

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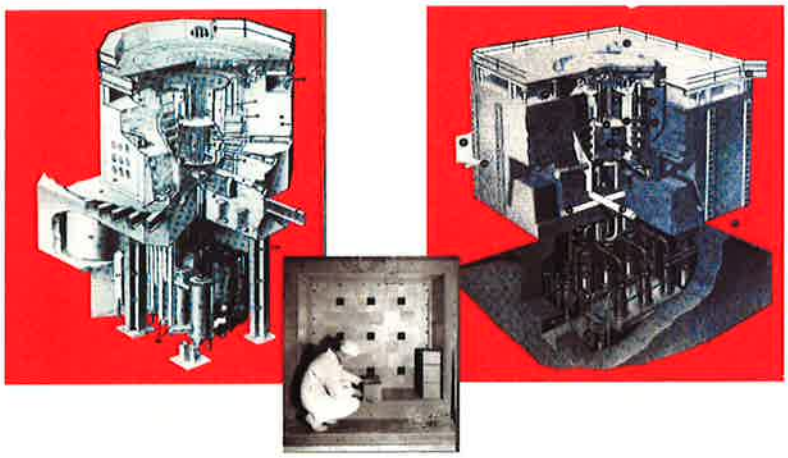
Horizontal access for decommissioning



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Present Day Care and Surveillance

- Objective is to keep the MTRs in a stable and prepared state until Final Decommissioning begins
- Prevent unauthorised access
- Ensure corrosion is prevented inside the reactor and D_2O Plant Rooms to minimise particulate discharges
- Keep the Containment Shells in a secure state
- Keep support facilities in Care & Maintenance
- Maintain records important to decommissioning in an accessible Nuclear Knowledge Management system

Surveillance & Maintenance



DIDO today

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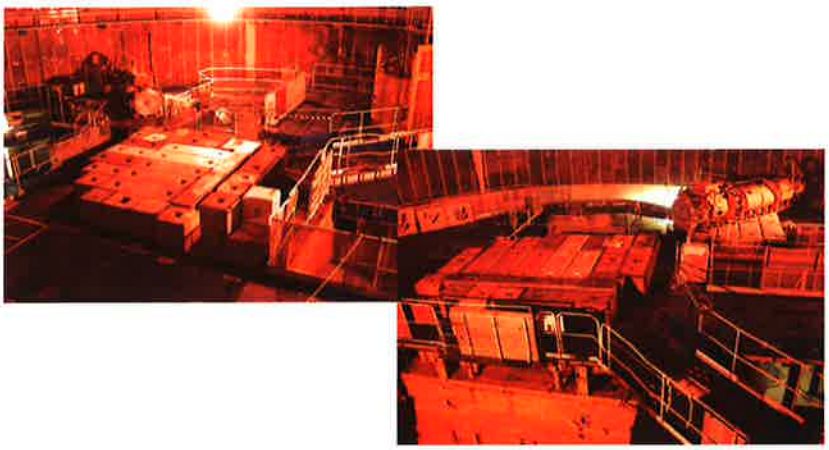
PLUTO today



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Innovation and decommissioning experience

- Harwell experiences in remote handling, advanced robotics and decommissioning complex contaminated, radioactive facilities have paralled reactor operation and decommissioning

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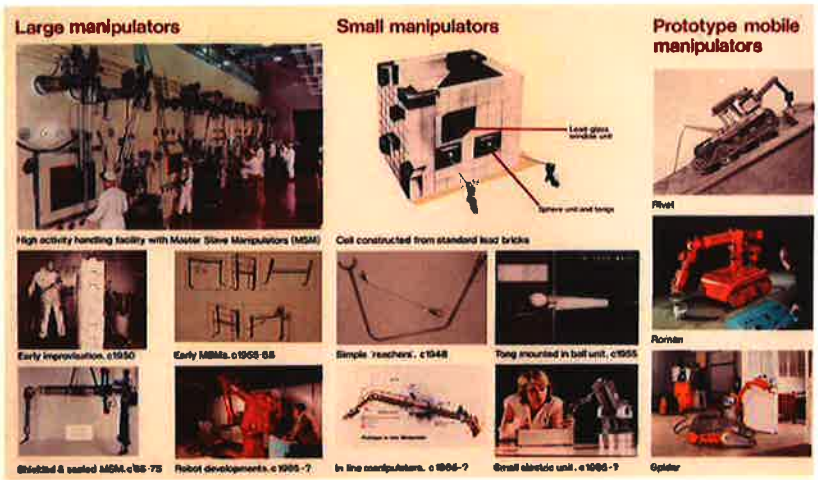
Innovation – Remote Handling 1946 - 1986



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Innovation – Remote Handling 1981+
Advanced Robotics as a new approach

- Existing systems too expensive and complicated
- Modified and improved COTS equipment for use in the nuclear industry up to 10^6 Gy as commercial products
- Nuclear Engineered Advanced Telerobot (NEATER) – a autonomous or man-in-the-loop manipulator, based on industrial robotics, with force feedback, at 10% cost of contemporary specialist machines
- stereoscopic tv systems (TV^3), precisely designed for continuous periods of use without discomfort
- tools for all decommissioning tasks
- proven capabilities in nuclear and sub-sea environments

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NEATER and TV^3

NEATER

Bringing the power of VAL II within the reach of Nuclear Technologists

- NEATER – radiation tolerant version of commercial Industrial robot
- TV3 – radiation tolerant stereo camera with simple display, designed for in-reactor, in-cell applications
- Both systems integrated to solve nuclear remote handling problems at a fraction of the cost of conventional hardware
- Supported by extensive testing, Human Factors trials, simulated and real-environment applications

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NEATER Applications

Windscale Vitrification Plant

Harwell Glovebox Decommissioning

Harwell DIDO High Active Handling Cell Decomissioning

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British entry to Kiev '92 Chernobyl Competition

- British Consortium, including Ukrainian Partner, submitted design for moveable containment, remotely located
- Technical solutions for
  - remote handling equipment to immobilise and make safe the materials inside Unit 4
  - dismantling or stablising the UKRITIYE encasement
  - waste processing and disposal

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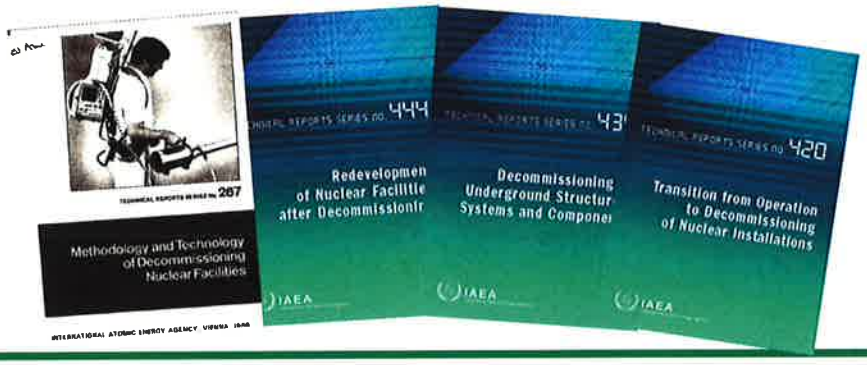
shelter design is virtually as built at Chernobyl !

IAEA Consultancy

- Harwell have been employed by IAEA as Technical Consultants in decommissioning for over 20 years



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Practical decommissioning – Building 351, the Chemical Engineering Building

- A seven storey, unlicensable radiochemical building

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B351

< Seven Years >




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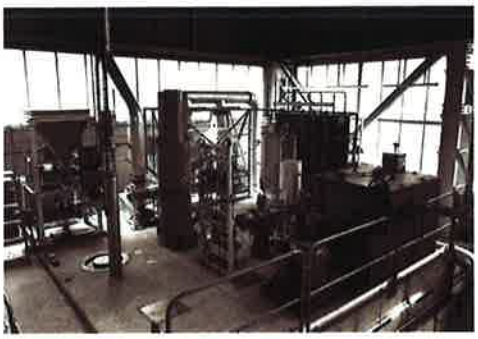
Abandoned vitrification cell – one of >200 RDAs FINGAL (i)

- Early 1960s plant
- Used active liquors from Windscale (10^{15}Bq)
- Built into Storage Pit with shielded roof blocks
- Incidents led to cell and roof contamination
- Abandoned in mid-60s in favour of Harvest and rotary calciners



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FINGAL (ii)

- FINGAL Flask, active block and γ gate removed
- Several controlled in-cell inspections + surveys
- Unproductive search of records for as-built details
- Intrusive survey from roof with cctv and tele-scopic β/γ probe
- Planned approach to tackle decommissioning

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FINGAL (iii)

- Cell contained Pb wall >2.5m high with ~800 150kg blocks
- Modular Containment built to give extra space
- Access limited to narrow corridor and 0.75m door
- Ventilation system contaminated and decrepit
- No way to deal with large quantities of LLW

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FINGAL (iv)

- Mobile Filtration Unit (4000 cfm) fitted to RDP
- HISO facility built in Pit using 50 ton crane
- Modified stacker truck and folding cranes used to aid manual handling
- Improved tooling, audio & cctv communications



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FINGAL (v) & Pit Concrete

- Cell decontamination attempted and concrete sampled (hollow drill)
- Roof blocks removed, cored & decontaminated
- Support walls broken down and disposed of
- Wall bulk removal trials
- Remaining areas cleaned and scabbled/scarified

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