China Institute of Atomic Energy

R2D2P Workshop on Safety Assessment

STATUS OF HWRR DECOMMISSIONING

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China Institute of Atomic Energy (CIAE)
October 18, 2010, Roskilde, Denmark

Map of Beijing City

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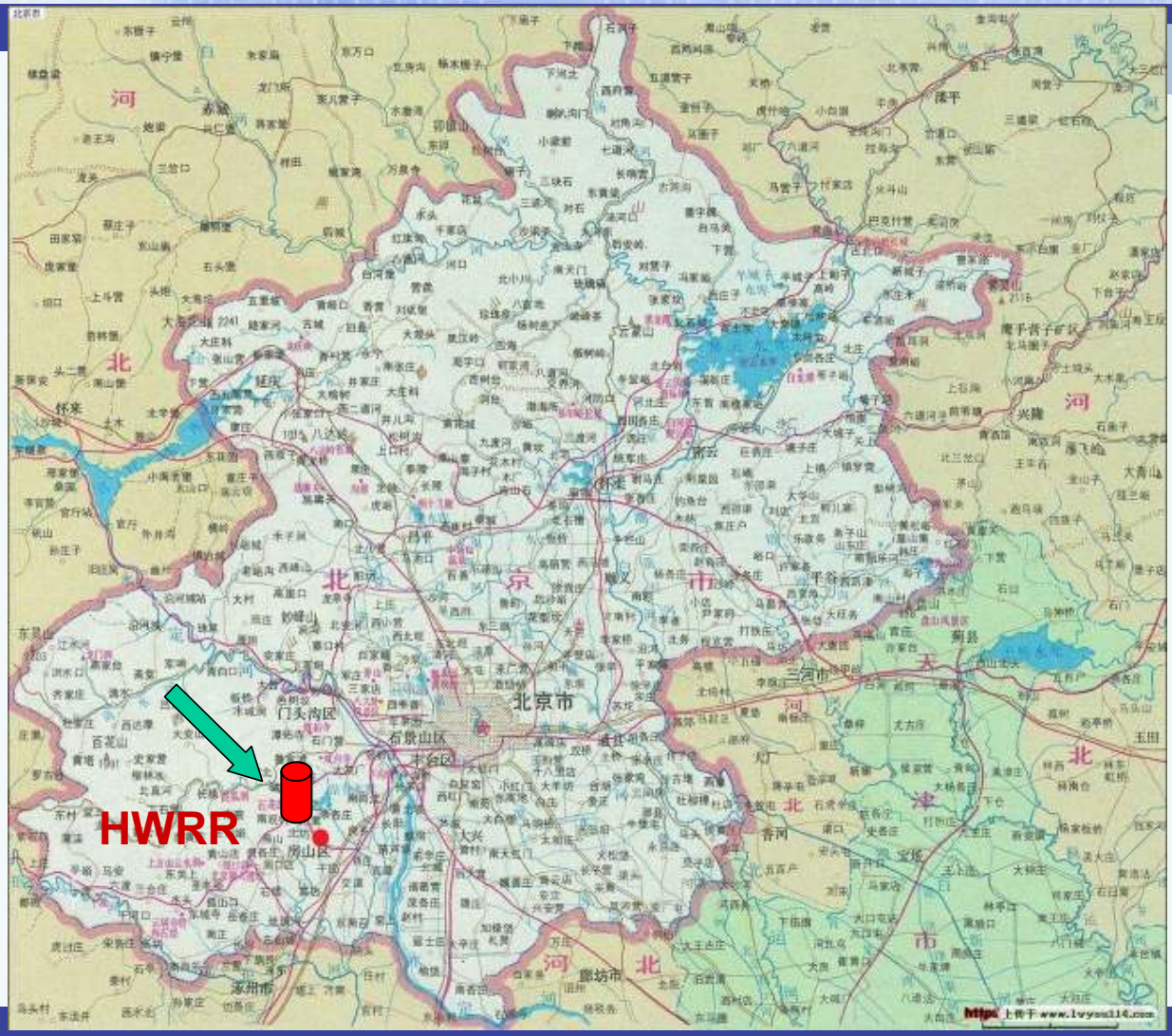

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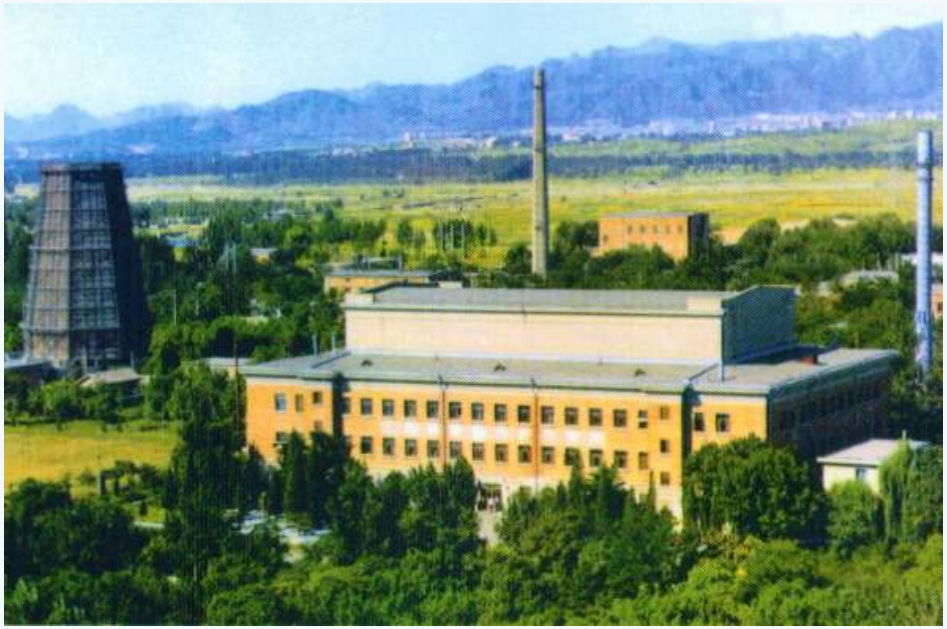
Heavy Water Research Reactor (HWRR)



Reactor Building
& Cooling Tower

HWRR Reactor Hall
& Reactor Block

Schematic of Facility

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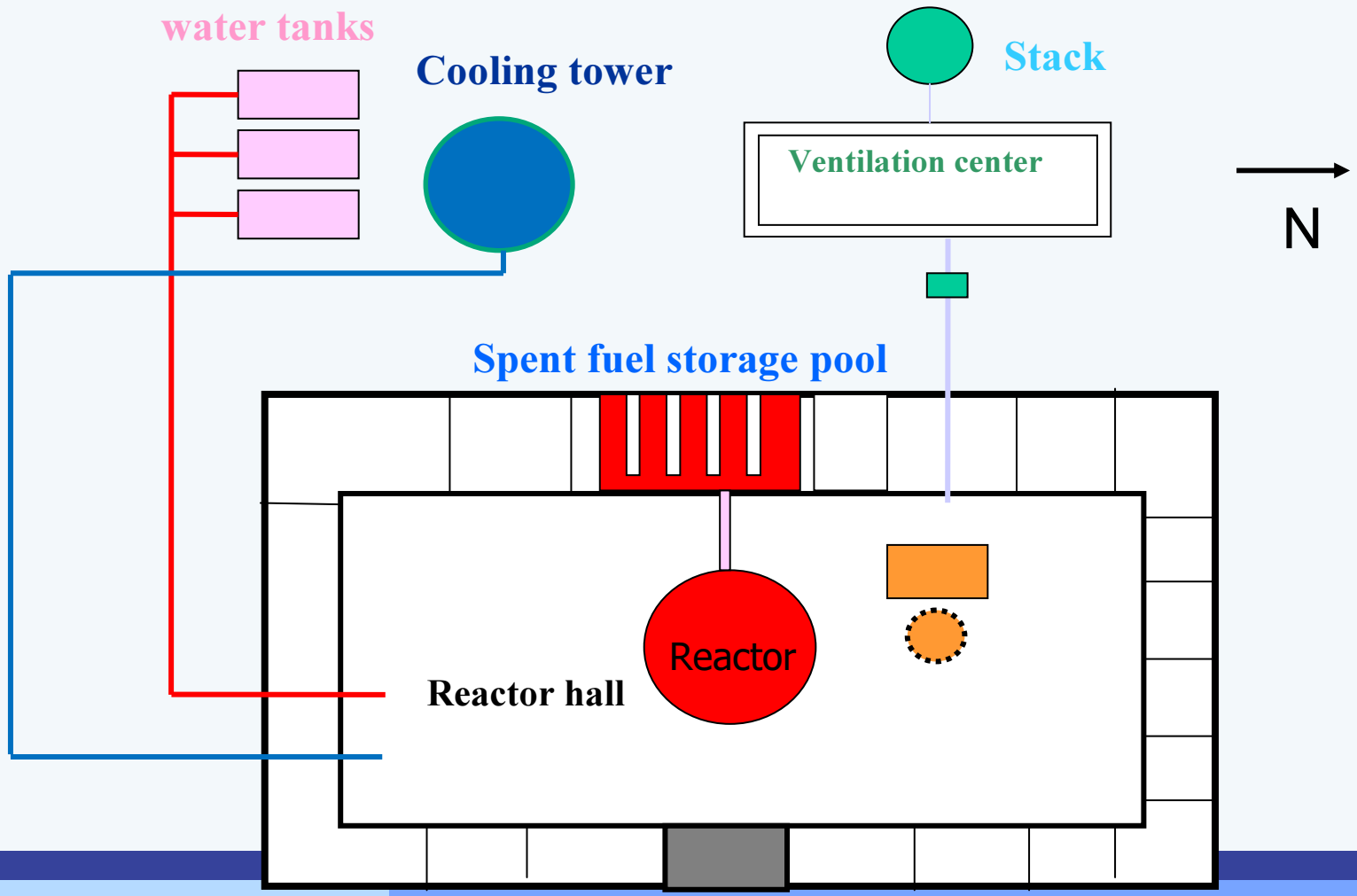

History of HWRR

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Operation History

- 1956: decree of construction
- 13 Jun 1958: first criticality
- 1958-1978: operation
- 1978-1981: modification
- 1981-2007: operation
- end of 2007: shut down

Introduction

- It is the first nuclear reactor in China
- UO_2 — fuel, U235 enrichment 3%
- D_2O — coolant and moderator
- Graphite — reflector
- Inner vessel — aluminum alloy
- Outer vessel — stainless steel
- Maximum thermal neutron flux: $2.6 \times 10^{14}/cm^2.s$
- Maximum power: 15MW
- Irradiation tube:
  - Vertical: 24 inside core, 33 outside core.
  - Horizontal: 6 neutron beams and 1 thermal column.

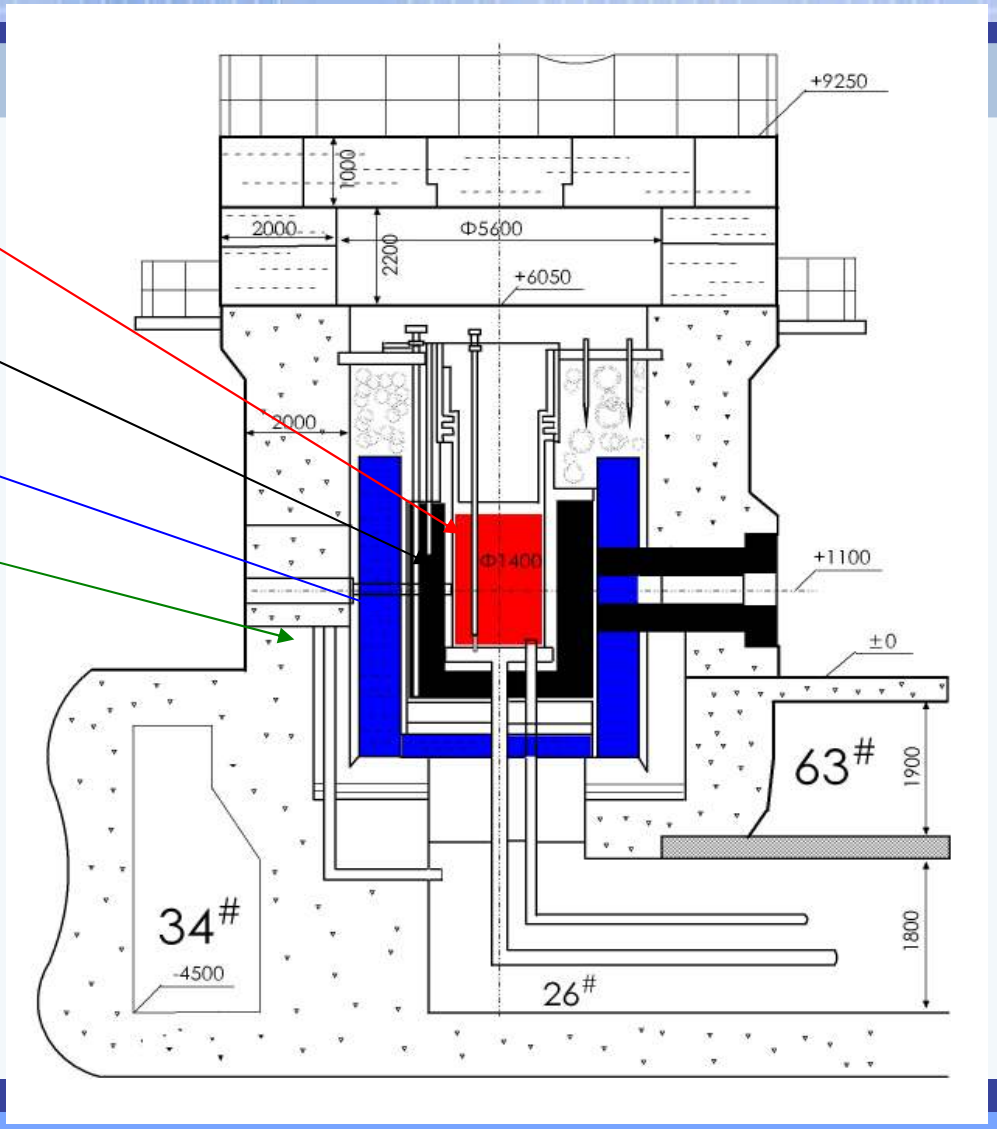
Structure of the Reactor

Active zone

Graphite shielding

Shielding tank

Concrete shielding



Decommissioning Timescale

- 2008-2011 : Transition Period
- 2012-2015 : Stage 1 decommissioning
- 2016-2020 : Stage 2 decommissioning

Current Status

- Reactor was defueled in December 2008
- Primary and secondary coolant system were drained in July 2009
- 290 spent fuel assemblies are stored in the pool

Decommissioning Goal

Decommissioning strategy

Immediate dismantling

Definition of final state

Limited opening to the public as an museum!

Organization

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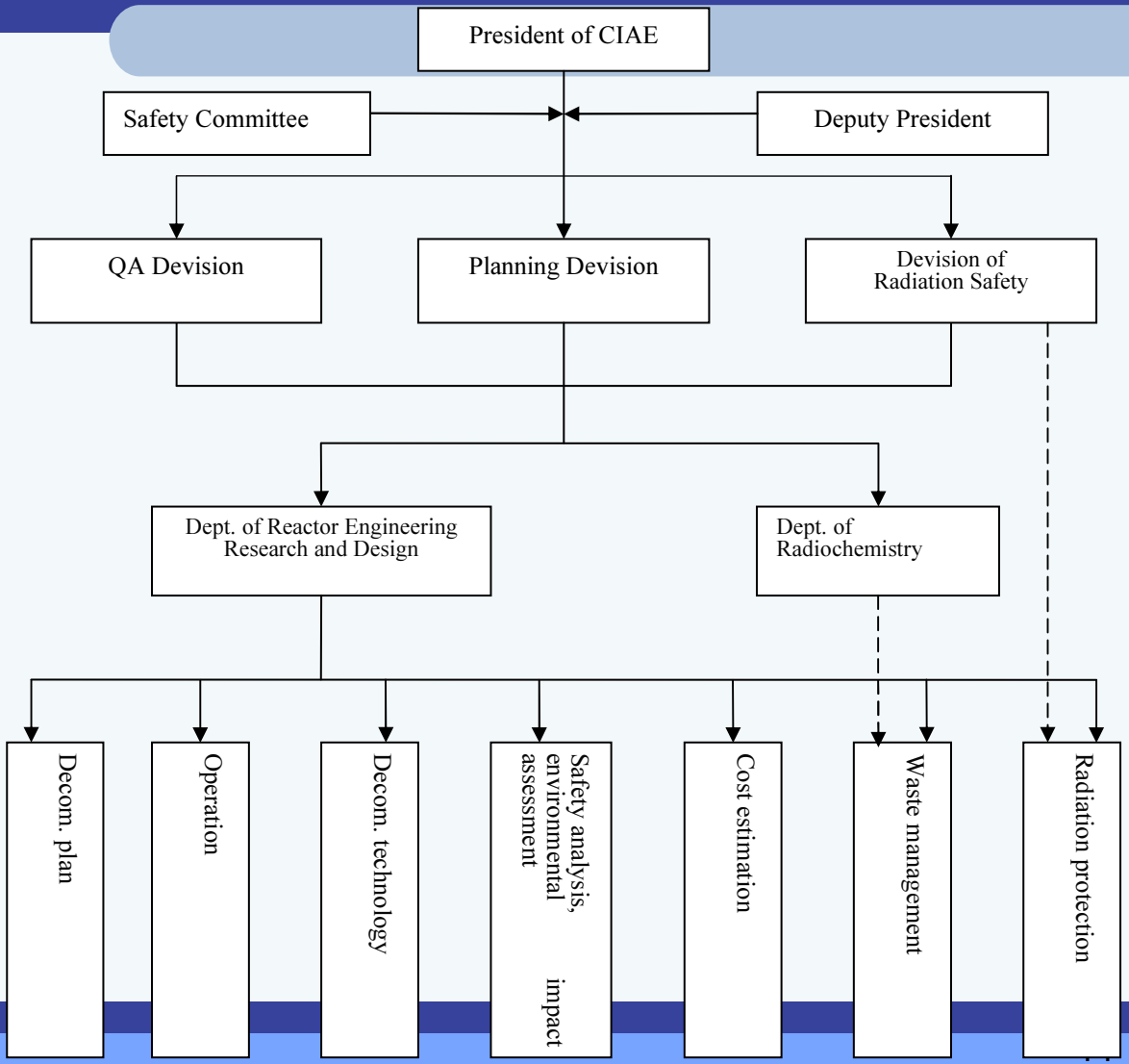
Organization for transition phase is established.



Regulation

- NNSA (National Nuclear Safety Administration) is responsible for safety regulation.
- NNSA is making effort to develop regulation system for decommissioning and waste management.
- A number of documents are in the process of development, review, revision or approval.
- Work with regulatory bodies to support them in the development of regulatory actions and rules.

National Support

- HWRR decommissioning has been included in the governmental plans for the period of **2006 –2010** and **20-year long-term plan**.
- Spent fuel transport project with budget of **US$5m** was approved **in October 2007**.
- HWRR transition phase project with budget of **US$3.5m** was approved **in September 2008**.

Decommissioning Planning

- **Scenarios**
  - **Step 1: worksite preparation**
  - **Step 2: peripheral systems decontamination & dismantling**
  - **Step 3: spent fuel storage pool decontamination & dismantling**
  - **Step 4: reactor block dismantling**
  - **Step 5: hot cells, waste water tanks decontamination & removal**
  - **Step 6: radiation protection, ventilation circuit, etc. decontamination & removal**
  - **Step 7: worksite clean up**
  - **Step 8: restoration of the facility**
  - **Step 9: open to the public**

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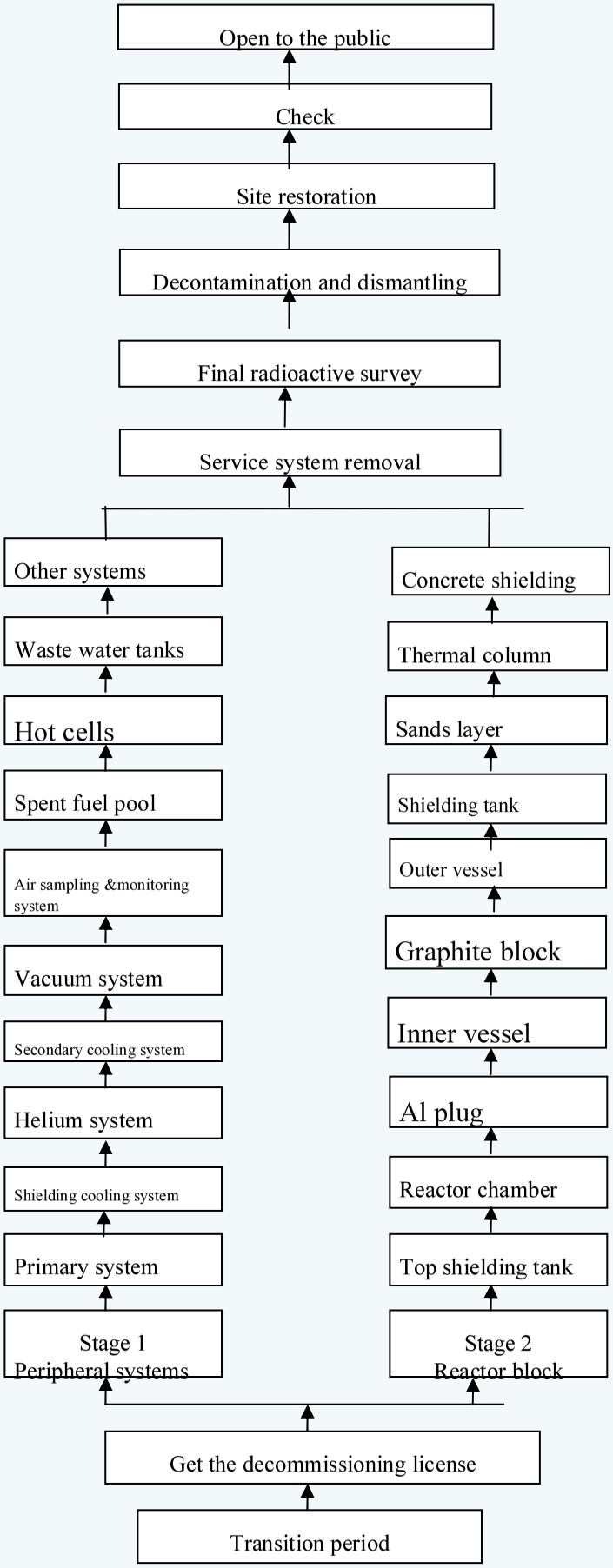
Flow Chart of Decommissioning Plan



Stage 1 Decommissioning

- Removal of most of systems and components (except of the reactor block, hot cells, 3 waste water tanks, old reactor vessel and reactor components, etc.)
- Disposal of water in spent fuel pool & low-level waste water containing tritium
- Disassembly/packaging/transport of radwastes
- Cleaning & surface decontamination of wall/floor

Stage 2 Decommissioning

- Disassembly/packaging/transport of internal components of reactor, graphite reflector, sand layers, etc.
- Decontamination and partially dismantling of reactor concrete shielding
- Decontamination and disassembly of used reactor vessel and Al plug.
- Decontamination and dismantling of 3 hot cells
- Decontamination and dismantling of 3 waste water tanks
- Decontamination and dismantling/demolishing of supporting equipment, ventilation system, etc
- Restoration of the site
- Final radiological survey

Transition Period

- Domestic project proposal for transition phase (2009-2011) was approved.
- Preliminary Decommissioning Plan (Draft) was developed
- Relevant operation documents were reviewed.
- Related projects on waste conditioning/treatment are ongoing at CIAE, e.g.
  - Low-level waste cutting facility
  - Low-level /mediate-level waste conditioning facility
  - Liquid waste treatment facility
  - Super compaction facility
  - Waste interim storage.

Transition Period

- Reactor cooling and defueling (finished)
- Transport of spent fuels (partially finished)
- Clean-up operational radioactive waste and site preparation (ongoing)
- Drainage of heavy water and chemical decontamination of primary coolant system and reactor vessel (partially finished)
- Reconstruction of supporting decommissioning facilities (e.g., ventilation, radiation protection, workshop) (ongoing)
- Development of software & documents (ongoing)
- Research on the key techniques (ongoing)
- Personnel training (partially finished)
- International cooperation (ongoing)
- Development and approval of decommissioning plan and issuance of decommissioning license

Other Development

- Modification of ventilation system (ongoing)
- Modification of radiation protection and monitoring system (ongoing)
- Modification of entrance to reactor hall and shower room (ongoing)
- Treatment of shielding water containing chromium (ongoing)
- Purification of spent fuel storage pool (ongoing)

Reactor Defueling

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System Drainage



- Primary and secondary coolant system were drained in July, 2009.
- About 5.7 m^3 D_2O is stored in the tank in the basement.
- D_2O will be transported and reused in the near future.

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Activities in the Transition Period

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Activities in the Transition Period

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Activities in the Transition Period






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Preliminary Characterization Survey

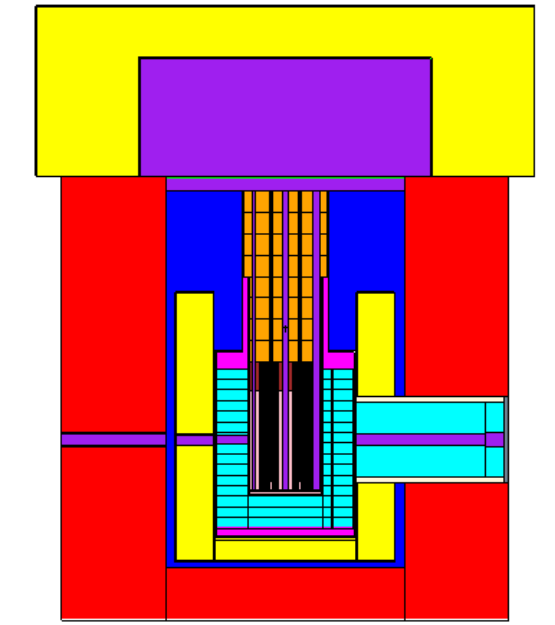
1. Planning — Finished
2. Review existing information — Ongoing
3. Calculating — Ongoing
4. Measurement & Sampling — Ongoing
5. Data Analyzing
6. Reporting

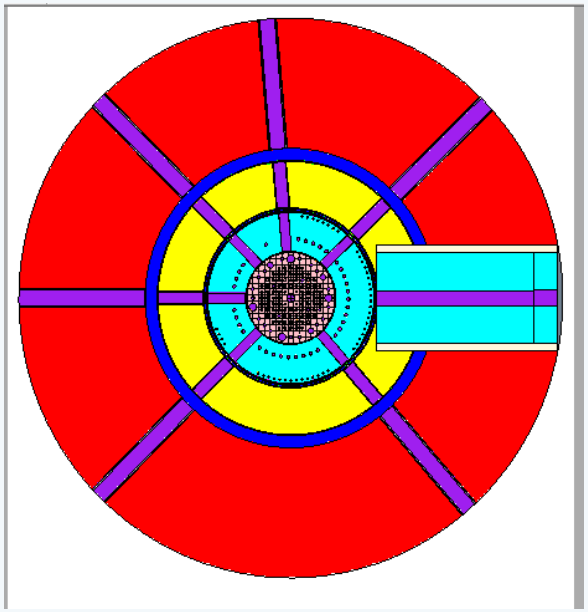
Characterization Process

- Review existing data and information
- Perform calculations
- Take in situ measurements
- Obtain samples and analyze them
- Interpret the data from the calculations, measurements and sample analysis
- Provides information for subsequent decommissioning activities

Calculating

- **Software application**
  - Activation study tools — MCNP & ORIGEN2





Measurement

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Instruments

In situ:

- γ Portable Spectrometer - ORTEC, with NaI detector.
- EBERLINE E-600 Monitor used for alpha, beta and gamma measurements.
- X、 γ dose rate instrument (FJ-347A and SG-102).

In laboratory:

- Gamma Spectrometer Object Counting System with large hyper pure germanium (HPGe) detector, EG&G ORTEC (CPR laboratory).
- WPC-9550 α、 β counters used for contamination measurement.

Sampling Tools

Characterization Tasks

- **From calculations determine**
  - Potential quantity and distribution of radionuclides
  - Estimate health and safety significance
- **From measurements**
  - Confirm distribution and hazards
  - Consider type, energy, and mobility
- **From samples and analyses**
  - Identify surrogates
  - Develop scaling factors

Characterization Survey

- **Type of surveys that will be required**
  - Radiation, contamination, material, water, air
  - Alpha, beta, gamma, neutron
- **Support facilities**
  - Office space, sample preparation, sample analysis, storage
  - Available services – electricity, water, sanitary facilities, telephone, trash pickup
  - Security of site and equipment
- **Type of equipment needed**
  - Sample and analytical

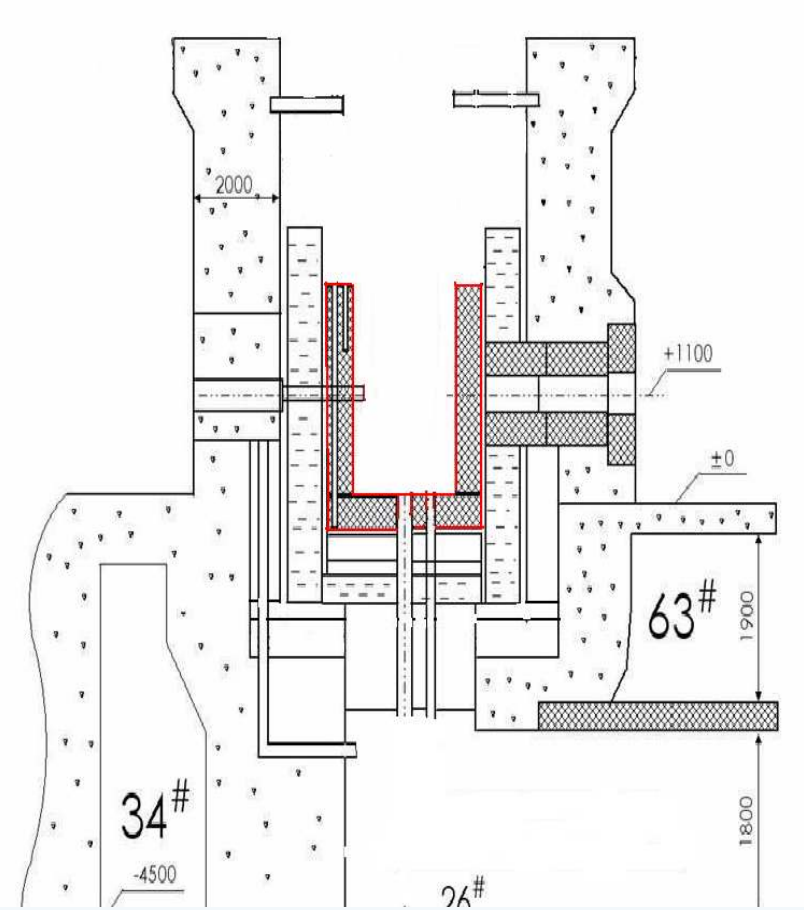
Characterization Survey Data

- Calculated data
  - Reviewed and verified
- In situ measurements
  - Manual or remote measurements of dose rates and/or contamination levels
  - Present in database or graphical format
- Sampling and analysis data
  - Quantitative information on isotopes
- Information needs to be retrievable!

Technologies - Robot

Dismantling graphite:

- The bottom : three layers, 600mm height;
  The radial : 15 layers, 3000mm height;
- 26 tons weight , 18 kinds of different configuration graphite block.
- Put the special robot in reactor chamber, and take out the graphite block, then put in container and transport to disposal area, then conditioning, encasement, reserve.



Technologies - Mechanical Cutting

- Heat exchanger of Shielding cooling system
- Heat exchanger of high temperature and high pressure loop
- Condenser of helium system

→ **Diamond Line Saw**

Safety Issues 1

- During the operation of HWRR, the concentration of tritium in the heavy water moderator continued to increase over the life of the reactor.
- Following shutdown, this water (about 9000 litres) containing an inventory of 1406TBq was transferred to tanks and drums for storage.
- The possibility that some of this water might have been spilled during transfer and to have soaked into a porous surface is a situation that one could expect to encounter during decommissioning and should be taken into consideration when planning the decommissioning.

Safety Issues 2

- There are 40 tons graphite block in HWRR reactor block. They have high radioactivity and wigner energy stored in the life of the reactor.
- When dismantling these graphite block, there will be possibly graphite dust explosibility and radiation harm to workers.
- We should learn about physical and mechanical properties of them and take into account all kinds of harm and difficulties when planning the decommissioning in order to avoid these situations occurred.

Thank you for your attention.