# Aging Management Activities at HANARO Research Reactor

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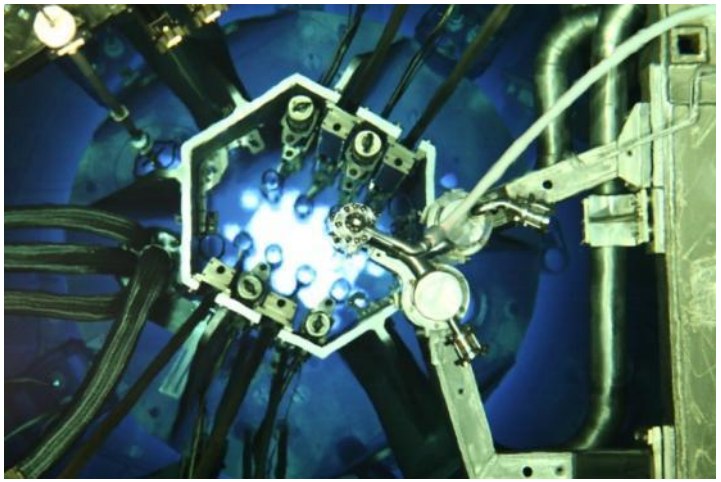
# Overview of HANARO

# HANARO Research Reactor

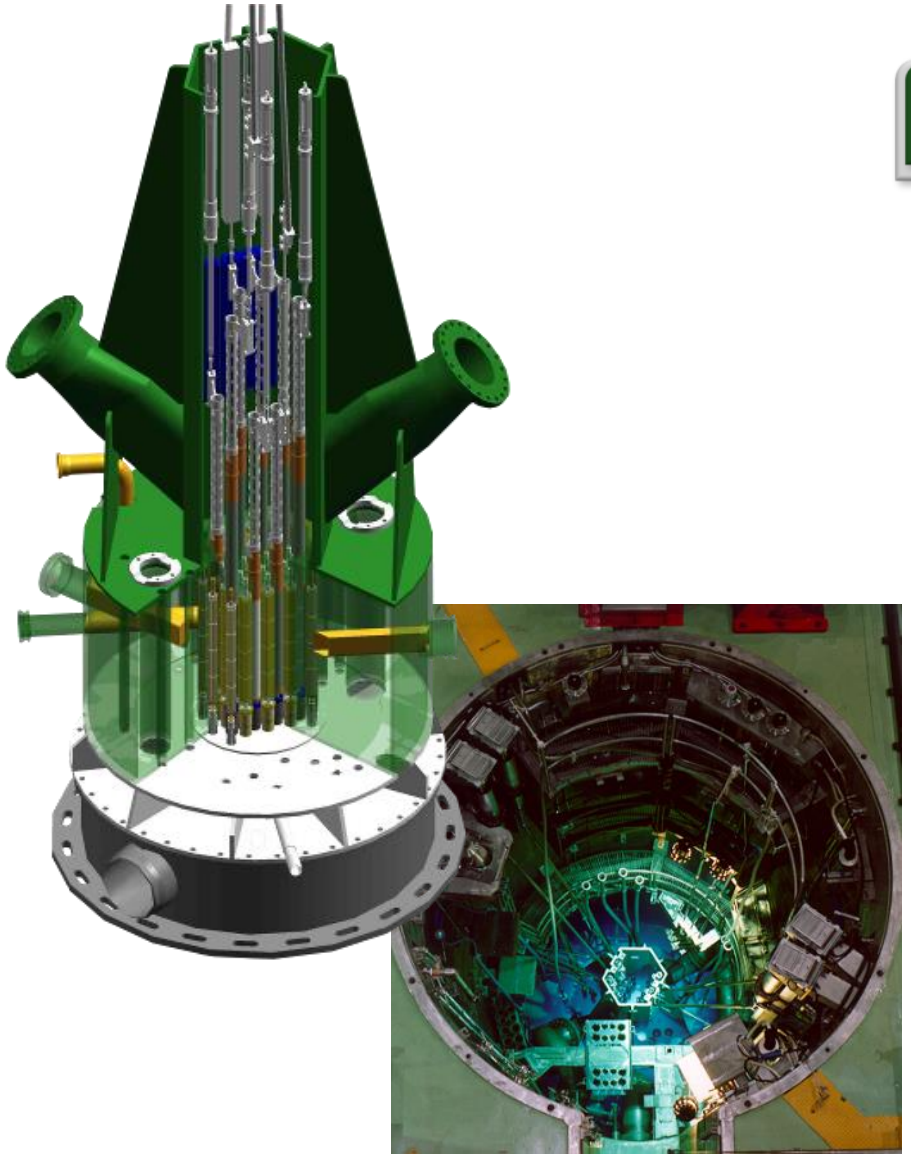
**H**igh-flux
**A**dvanced
**N**eutron
**A**pplication
React**O**r

**Multi-purpose Research Reactor**



# HANARO Complex

# Reactor Structure & Feature



## Features

- Type: Open-tank-in-pool
- Power: 30MWth
- Coolant: Light Water
- Fuel Materials: $U_3Si$, 19.75%
- Reflector: Heavy water
- Absorber: Hafnium
- Reactor Building: Confinement
- Max Thermal Flux: $5x10^{14}$ $n/cm^2s$
- Typical flux at port nose: $2x10^{14}$ $n/cm^2s$
- 7 horizontal ports & 36 vertical holes
- Fuel test loop & Cold neutron source
- Operation Cycle: 28 days@6 weeks

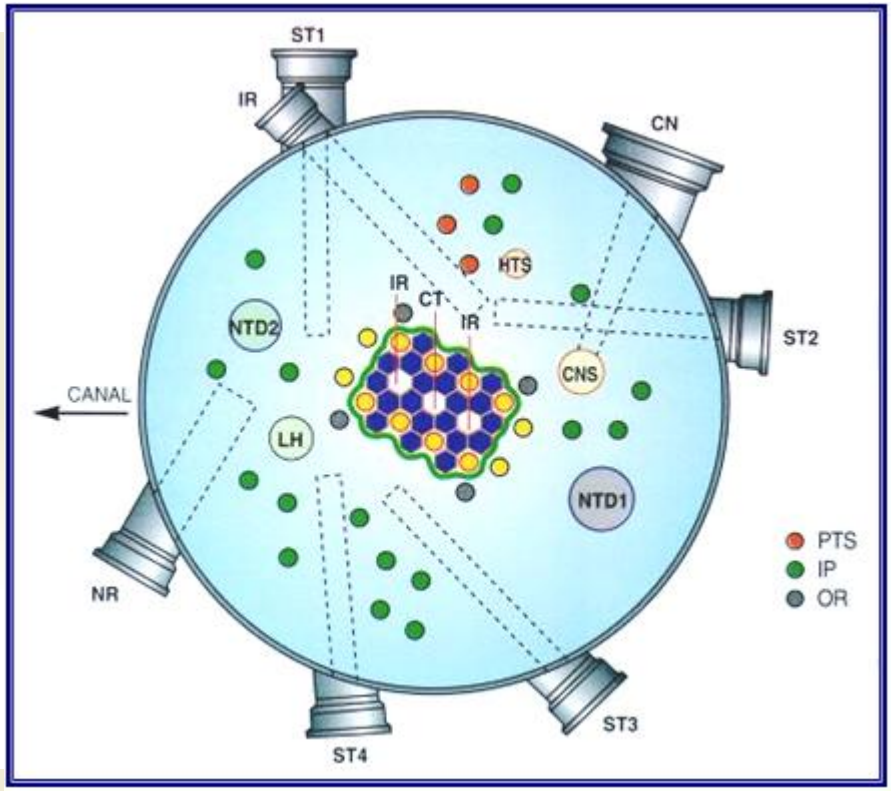
# Chronology of HANARO

- 1985 JAN Start of HANARO Project
- 1985 JAN Start of HANARO Project
- 1989 JAN Start of HANARO Construction
- 1993 AUG Installation of HANARO Reactor Structure
- 1995 FEB Fuel Loading and Achievement of Initial Criticality
- 1996 JAN 15MW Power Operation
- 1999 DEC 22MW Power Operation
- 2004 NOV 30MW (Design Power) Power Operation started
- 2005 MAR First Loading of HANARO Fuel Made by KAERI
- 2006 APR Start of Cold Neutron Laboratory Construction
  (Completed in May 2008)
- 2008 MAY Start of Cold Neutron Source System Installation
- 2009 SEP 3 First Generation of Cold Neutron
- 2010 NOV 1 Inauguration of Cold Neutron Research Facility
- 2014 FEB 10 Reach to 3000 day operation
- 2014 JUL 10 Reactor shutdown for seismic re-enforcement of reactor building
- 2017 NOV Completion of seismic re-enforcement of reactor building
- 2017 DEC Resume operation

# Irradiation Holes and Beams

## Vertical Holes

- IR1 : Fuel Test Loop
- CT, IR2 : Capsule Irradiation& RI Production
- OR : Capsule Irradiation & RI Production
- IP : RI Production
- HTS : Hydraulic Transfer System for RI Production
- PTS : Pneumatic Transfer System for NAA
- NTD : Neutron Transmutation Doping of Silicon
- CNS : Cold Neutron Source




## Horizontal Tubes

- NR : Neutron Radiography Facility
- IR : Ex-core Neutron-irradiation Facility for BNCT & Dynamic Neutron Radiography
- ST1 : Prompt Gamma Activation Analysis, RSI
- ST2 : High Resolution Powder Diffractometer, Four Circle Diffractometer
- ST3 : Bio Diffractometer, High Intensity Powder Diffractometer
- ST4 : Triple Axis Spectrometer
- CN : Cold Neutron Guide

# Aging management Activities in HANARO

# Aging Management

- What is aging?
  - A process of obsolescence
  - A process in which items like components, systems and structures suffer degradation of its physical properties due to operational conditions leading to wear, tear, corrosion and general deterioration
- Aging management objectives
  - To maintain at an adequate safety level the operational research reactor
  - To extend lifetime
- The actual reactor life time will be much more than the design lifetime
  - By a safety reassessment based on realistic data, preventive maintenance, predictive maintenance and an appropriate in-service inspection (ISI) plan
- Aging management activities are
  - Inspection and examination, monitoring, Testing, and performance test as surveillance
  - Preventive maintenance and corrective maintenance

# Overview of AM activities in HANARO

- Preventive and corrective maintenance has been conducted to mitigate the effects of ageing.
- The upgrade of the instrumentation and control system has been carried out gradually since 2001 to overcome ageing and obsolescence problem.
- Aging matrix was developed on the basis of maintenance history and recommendation of manufacturer
- New systematic aging program is being developed
  - To be completed by 2023

# AM activities in HANARO

- AM Activities before seismic reinforcement of reactor building in 2014
  - Overhauled primary cooling pump 1 and 2
    - Balancing the pump shafts and impellers
    - Welding the bearing housings and covers
    - Replacement of bearing and mechanical seal
    - Performance test before/after repair
  - Replacement of neutron detectors
    - Two of the worst neutron detectors in 2008
    - Three detectors in 2010
    - One detector in 2012
  - Safety diagnosis for building structure
    - Conducted visual inspection, endurance evaluation every 5 years
    - Effective life management and insurance of safety by evaluation of the structural safety of building structure

# AM activities in HANARO

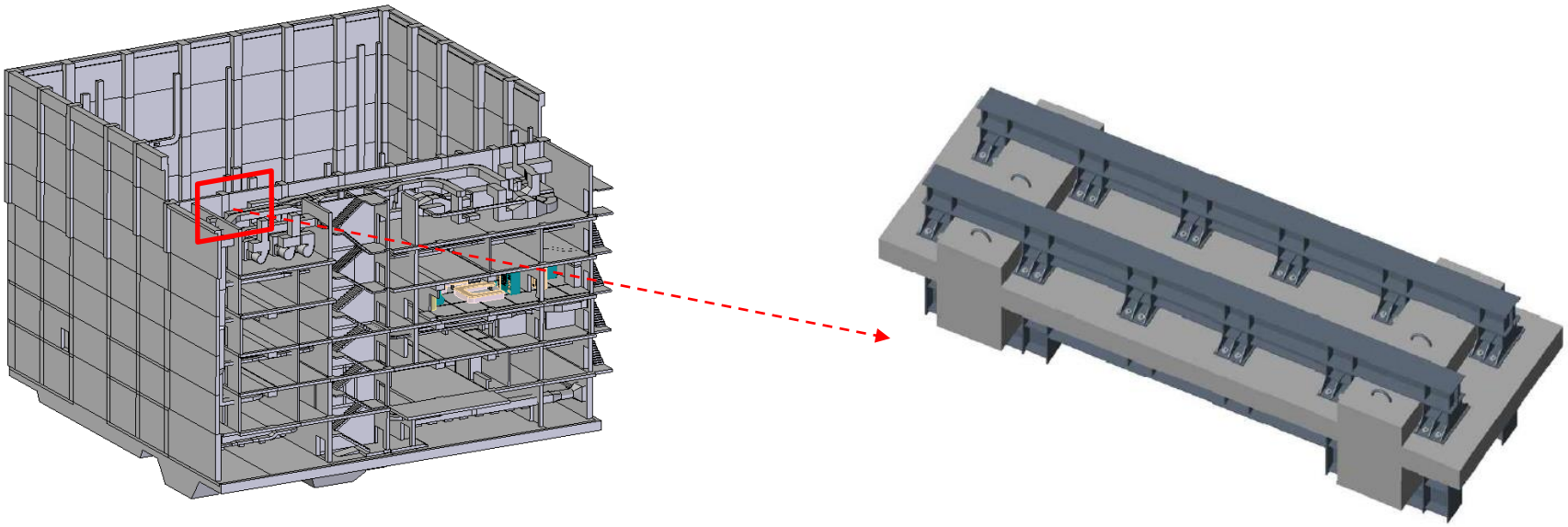
- AM Activities before seismic reinforcement of reactor building in 2014
  - I&C upgrade and modernization
    - Ageing and obsolescence
    - Increasing need to improve reliability of reactor I&C systems
    - Enhancement of the functions for the operator
    - Replacement of HANARO control computers was started in 2011 and completed in 2015

# AM activities in HANARO

- AM Activities after seismic reinforcement of reactor building in 2014
  - Right after the Fukushima accident in 2011, the Nuclear Safety and Security Commission (NSSC) of the Korean government formed a special nuclear safety inspection team with the participation of civilian experts.
  - Review and reevaluation of the design basis earthquake
    - Reassessment of the seismic capability reflecting modification and design change during operation
      - Identifying vulnerable point and planning remediation action
    - Evaluation of margin
      - Seismic margin assessment
      - range of earthquake severity the plant can withstand with losing confinement integrity
      - Provisions to prevent the cliff edge effect and to increase robustness of the plant

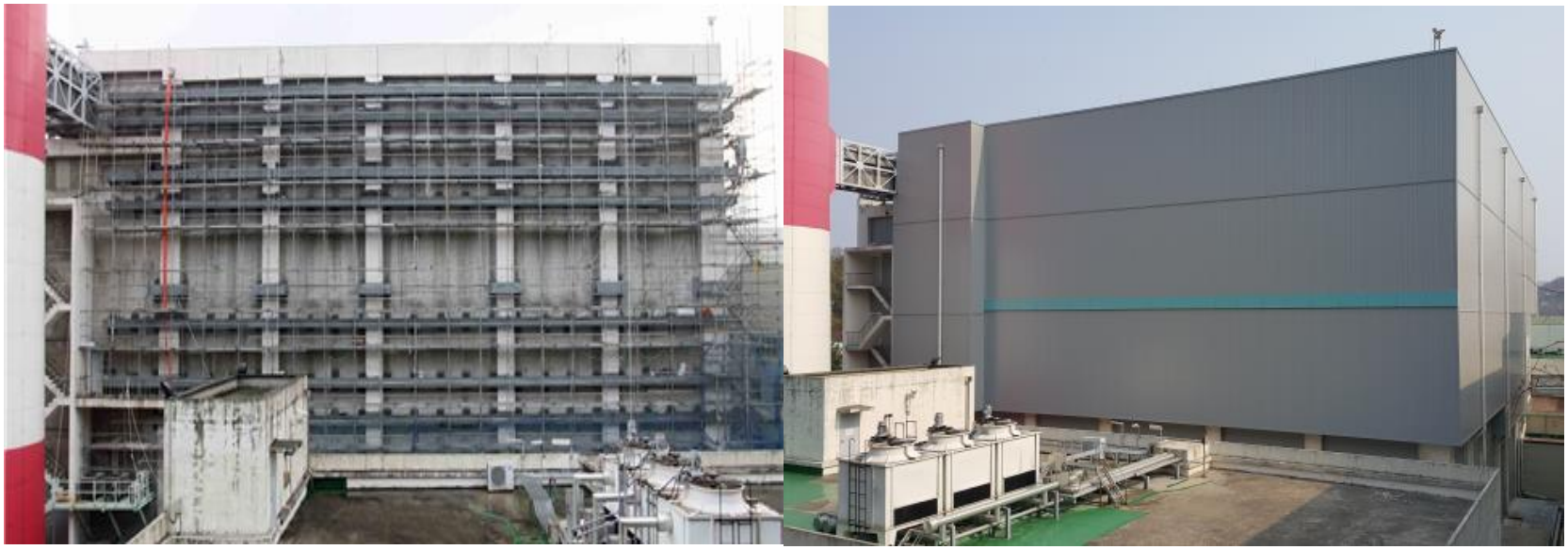
# AM activities in HANARO

- In approval process, a structural performance verification test was requested by regulatory body.
  - To confirm the reinforcing effect of a built-up section in a outer wall
  - To compare a built-up section with original condition making test specimens of same size as it is.



# AM activities in HANARO

- HANARO has resumed operation with the regulatory authority's approval.
  - An extensive leak test was successfully conducted for the whole reactor building and the result was satisfied with the design criteria.
  - KAERI had also welcome additional verification by a citizen's verification team organized by the local government



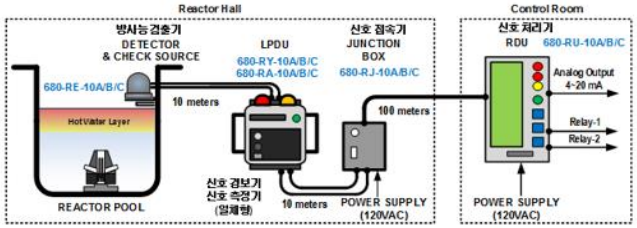
Rehabilitation project finished (Left : on installing procedure, Right : finishing with insulation panel)

# AM activities in HANARO

- Replacement of Pool Radiation Monitoring System
  - Jan 2018 regulatory body issued the permission of replacement of PRMS
  - Mar 2018 replacement of PRMA was completed

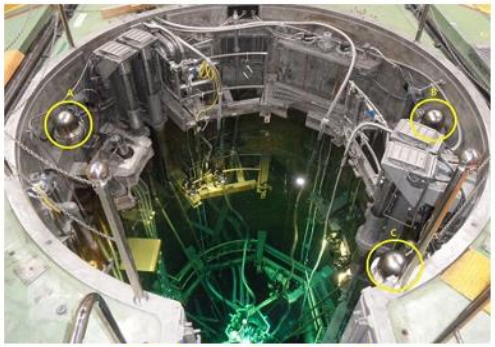
**수조 방사선 감시기(PRMS) 교체 완료**

- 수조표면방사선 감시기 노후화 교체
- 규제기관 인허가 취득 완료 : 2018년 1월
- 기기 설치완료일 : 2018년 3월




교체 후 구성도

현장 경보기



수조상부 검출기 (A/B/C)


제어실 판넬

# AM activities in HANARO

- Replacement of Electric Switchgear
  - High voltage switch gear and low voltage load center
  - Introduced electric quality monitoring system

임시배전반 시공

하나로 전력감시시스템 구축

Switch gear 시공

Load Center 시공

# Summaries

- The long term ISI program for HANARO has been performed for the purpose of safe operation and lifetime extension of the reactor.
- We've confirmed the structural integrity and performance of the in-pool components and safety related piping.
- The corrective and preventive maintenance for the primary cooling system was fulfilled and the predictive maintenance is going on by the monitoring system.
- The safety diagnosis of reactor building was done.
- HANARO control computer and electric power supply system was replaced
- **AMPs of HANARO will enhance its safety and raise its efficiency.**

# THANK YOU for Your ATTENTION !