Current Status of the HANARO Operation

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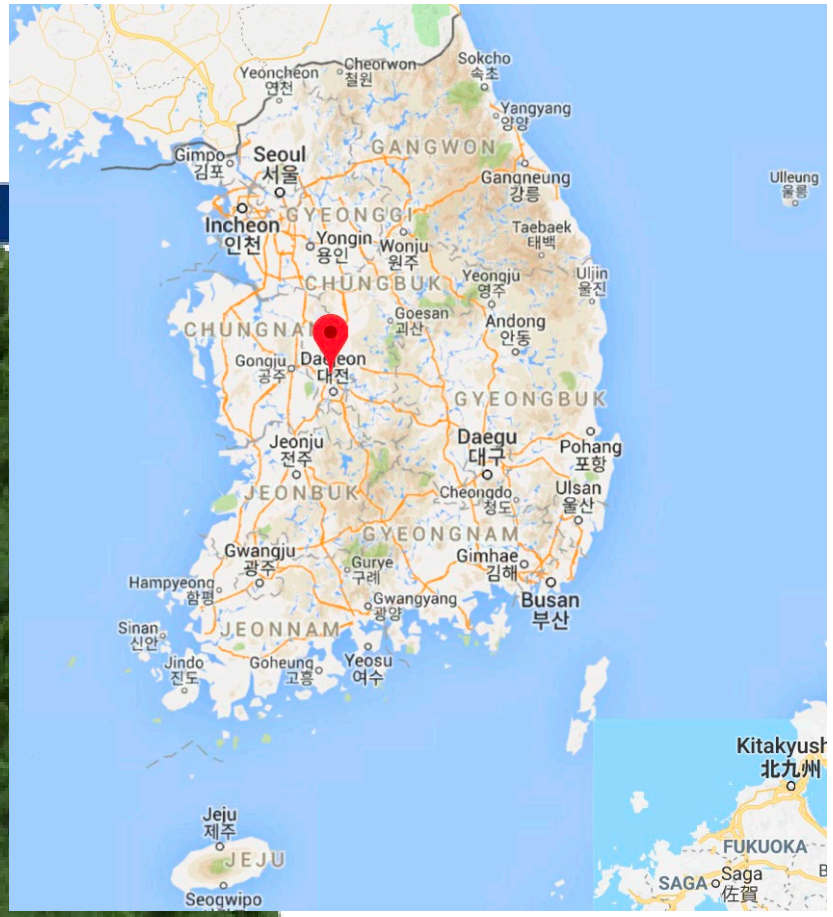
HANARO

HANARO – 30 MW Multipurpose Research Reactor in KAERI



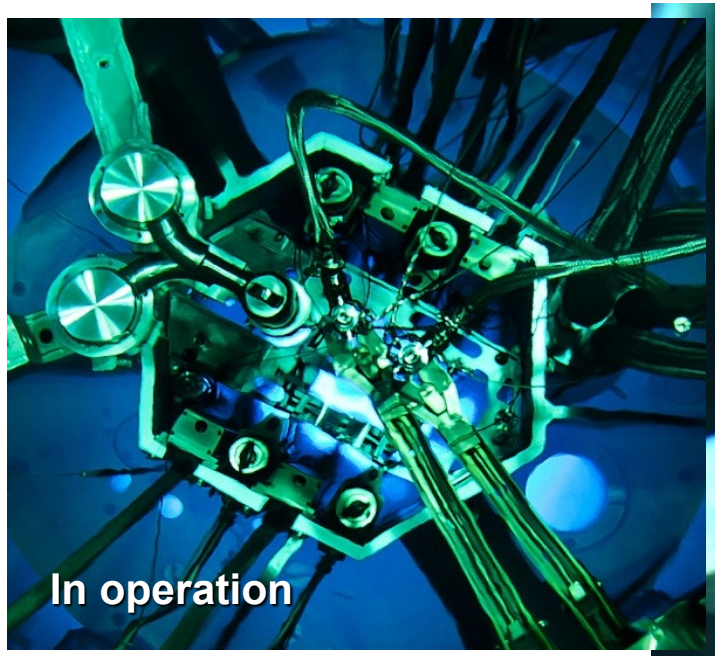
Design Feature & Fuel

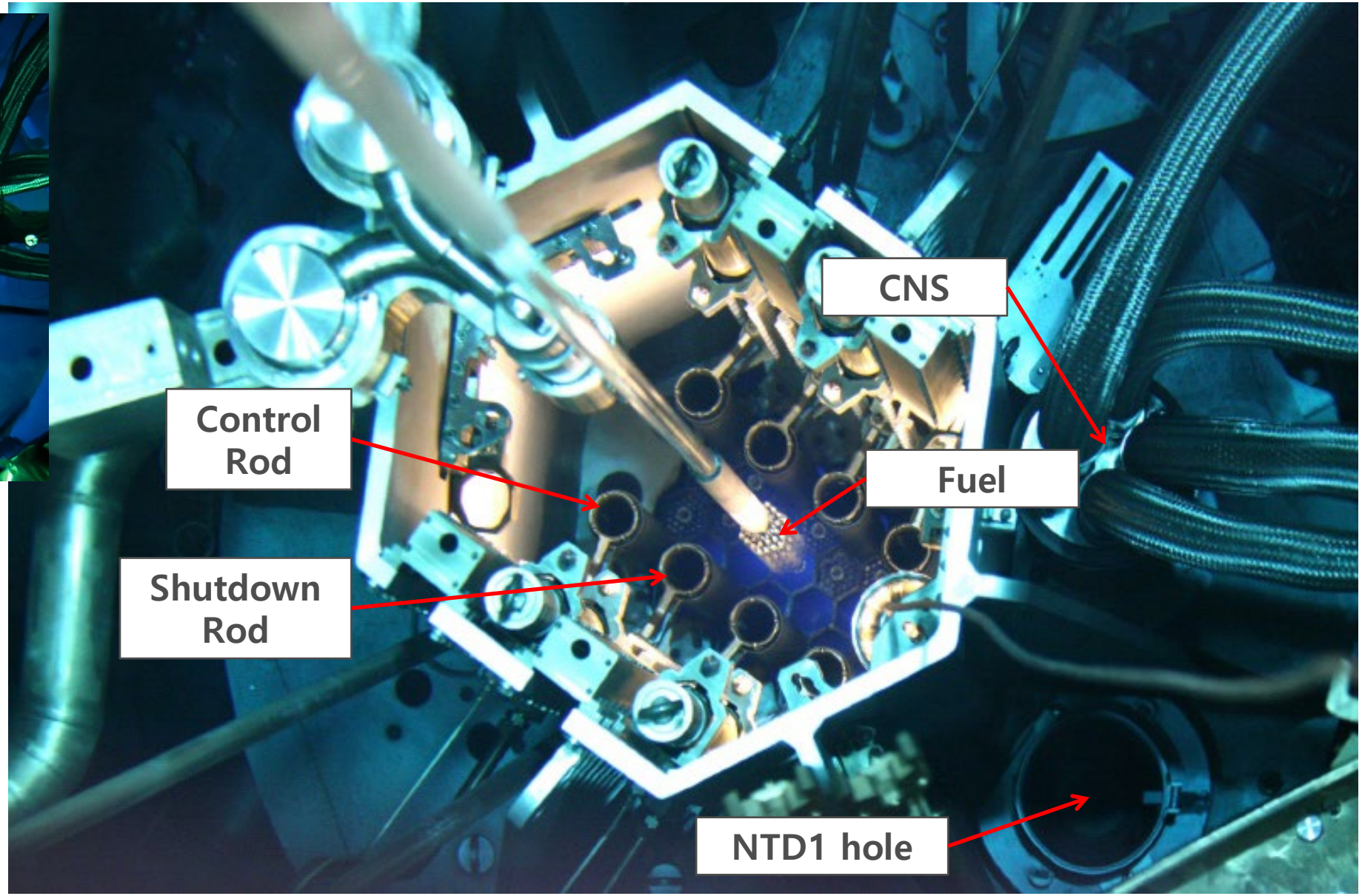
HANARO uses nuclear fuel manufactured domestically, and its fuel manufacturing technology has been continuously developed.

Currently, HANARO possesses the manufacturing technology for **4.8 gU/cc commercial-grade U_3Si_2 plate fuel, 5.3 gU/cc high-density U_3Si_2 plate fuel, and 8.0 gU/cc high-density U-Mo plate fuel** as well as HANARO fuel(3.15 gU/cc).

Reactor Type	**Open-tank-in-Pool**
Power	**30 MW_{th}**
Fuel	**LEU(19.75 w/o 235 U, U_3Si-Al Meat, Al clad)**
Coolant	**H_2O**
Moderator	**H_2O / D_2O**
Reflector	**D_2O**
Absorber	**Hafnium**
Core Cooling	**Upward Forced Convection Flow + Bypass Flow**
Reactor Building	**Confinement**
Max. Thermal Flux	**$3\sim4\times10^{14}$ n/cm^2s**
Holes & tubes	**7 horizontal ports & 36 vertical holes**
Normal Operation Cycle	**28 days operation in one fuel cycle** **8 cycles/yr (~200 days/yr)**

Reactor Core





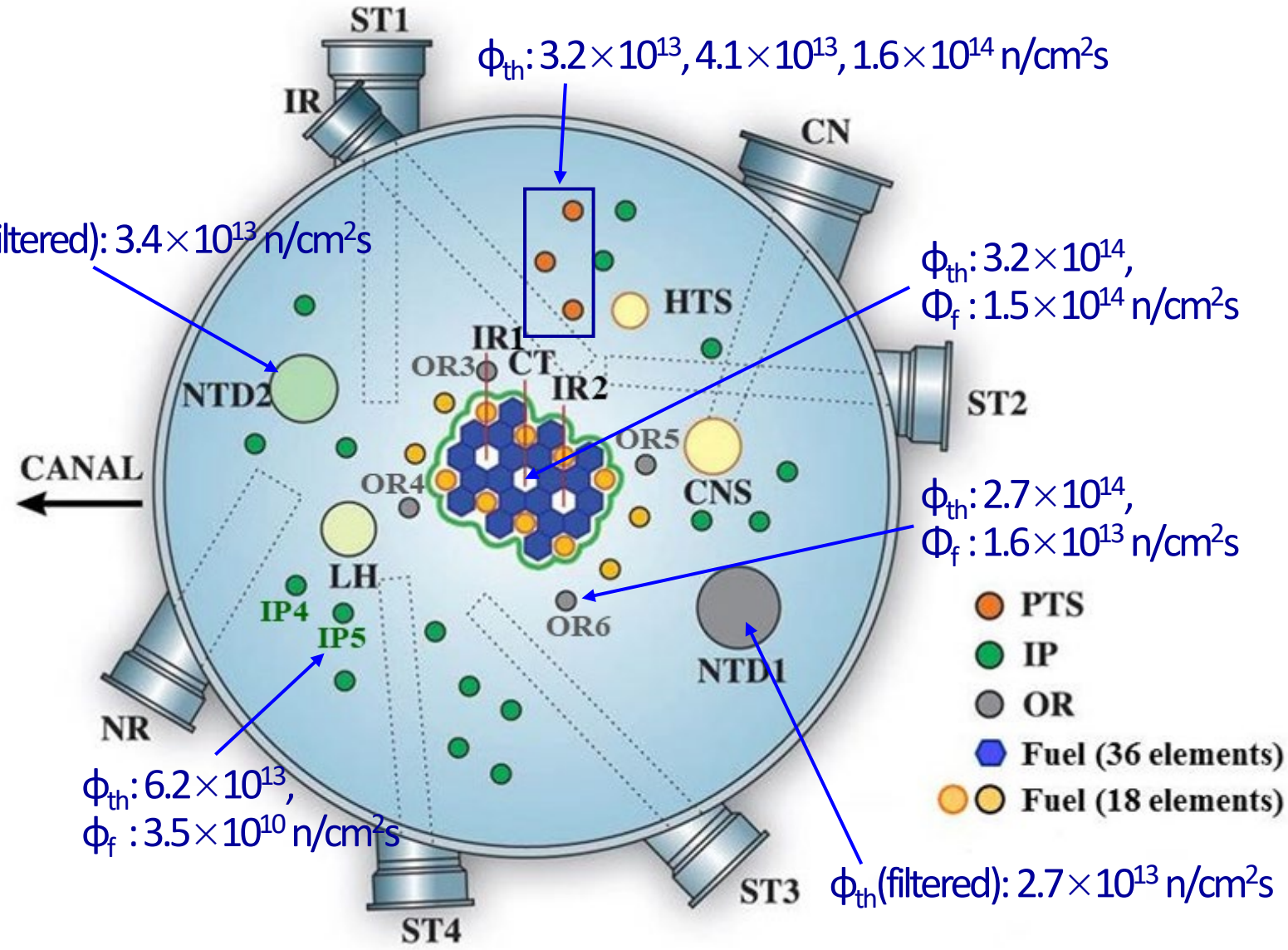
Utilization Holes and Tubes

Vertical Holes

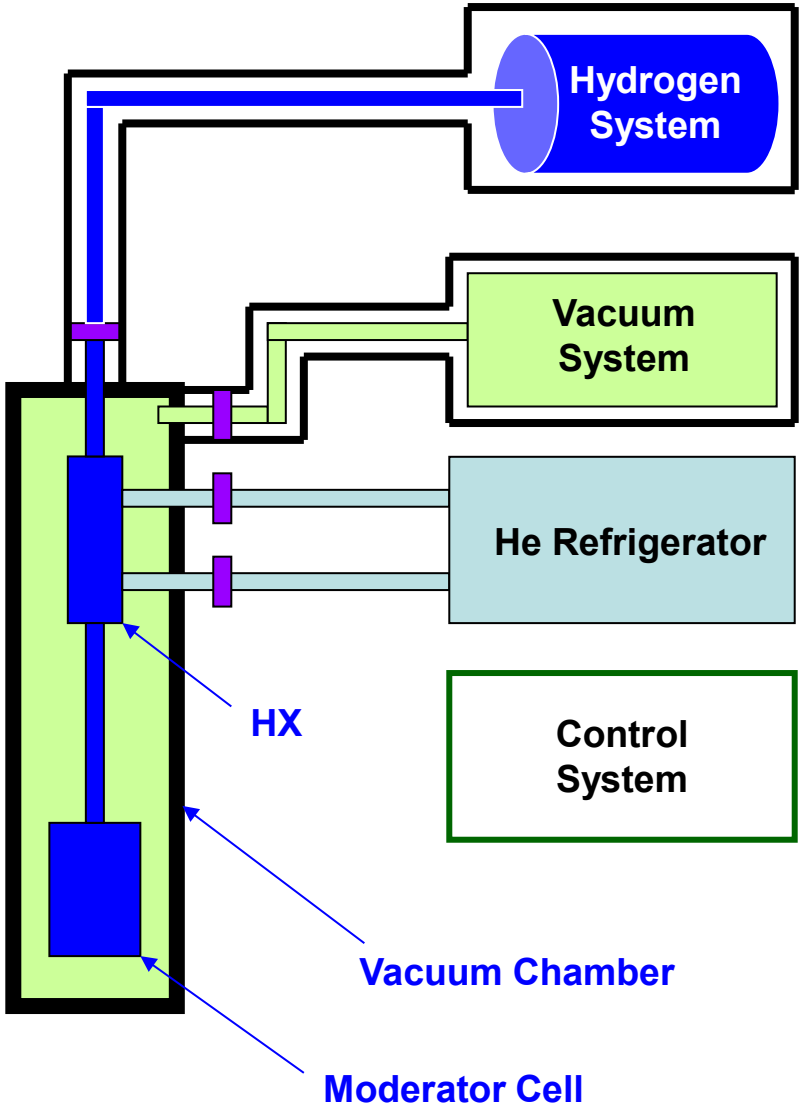
CT, IR2 : Material Irradiation & RI Production
IR1 : Fuel Test & Material Irradiation
OR : Material Irradiation & RI Production
IP : RI Production
HTS : Hydraulic Transfer System for RI Production
PTS : Pneumatic Transfer System for Neutron activation Analysis
NTD : Neutron Transmutation Doping of Silicon
CNS : Cold Neutron Source Installation

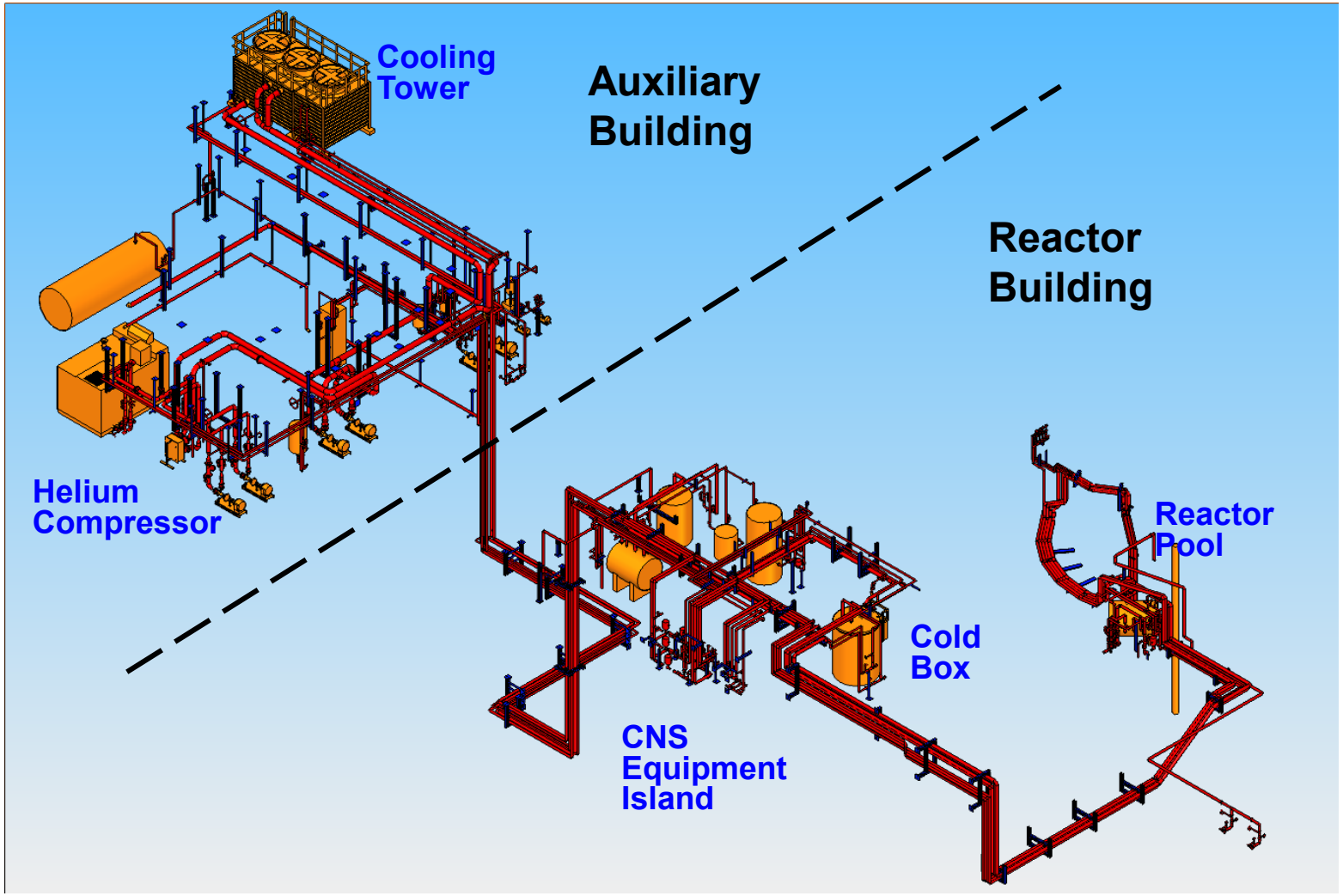
Horizontal Tubes

ST1 : PGAA and RSI
ST2 : High Resolution Powder Diffractometer, Four Circle Diffractometer
ST3 : Bio-C,D
NR : Neutron Radiography Facility
CN : Cold Neutron Guide
IR : Ex-core Neutron-irradiation Facility for BNCT & DNR
ST4 : Triple Axis Spectrometer



Cold Neutron Source

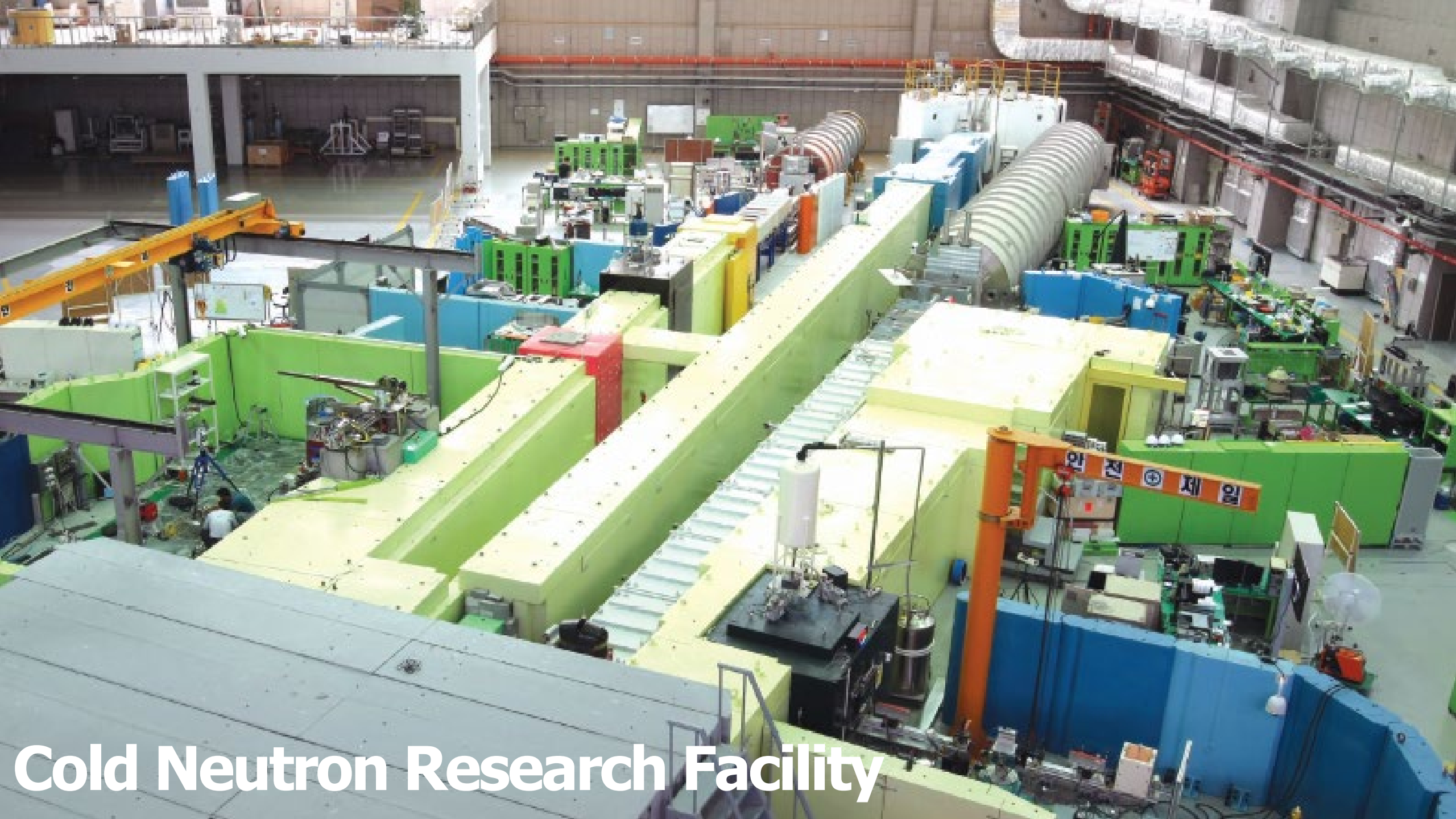




HANARO Reactor Hall

Feb. 1995


Now



Cold Neutron Research Facility

HANARO Applications

- ✓ Neutron Beam Application Research
- ✓ Nuclear Fuel & Material Test
- ✓ Neutron Transmutation Doping
- ✓ RI Production
- ✓ Neutron Activation Analysis
- ✓ Medical Applications
- ✓ Nuclear Data Generation
- ✓ Education & Training
- ✓ Intense Positron Source (planned)
- ✓ Etc.

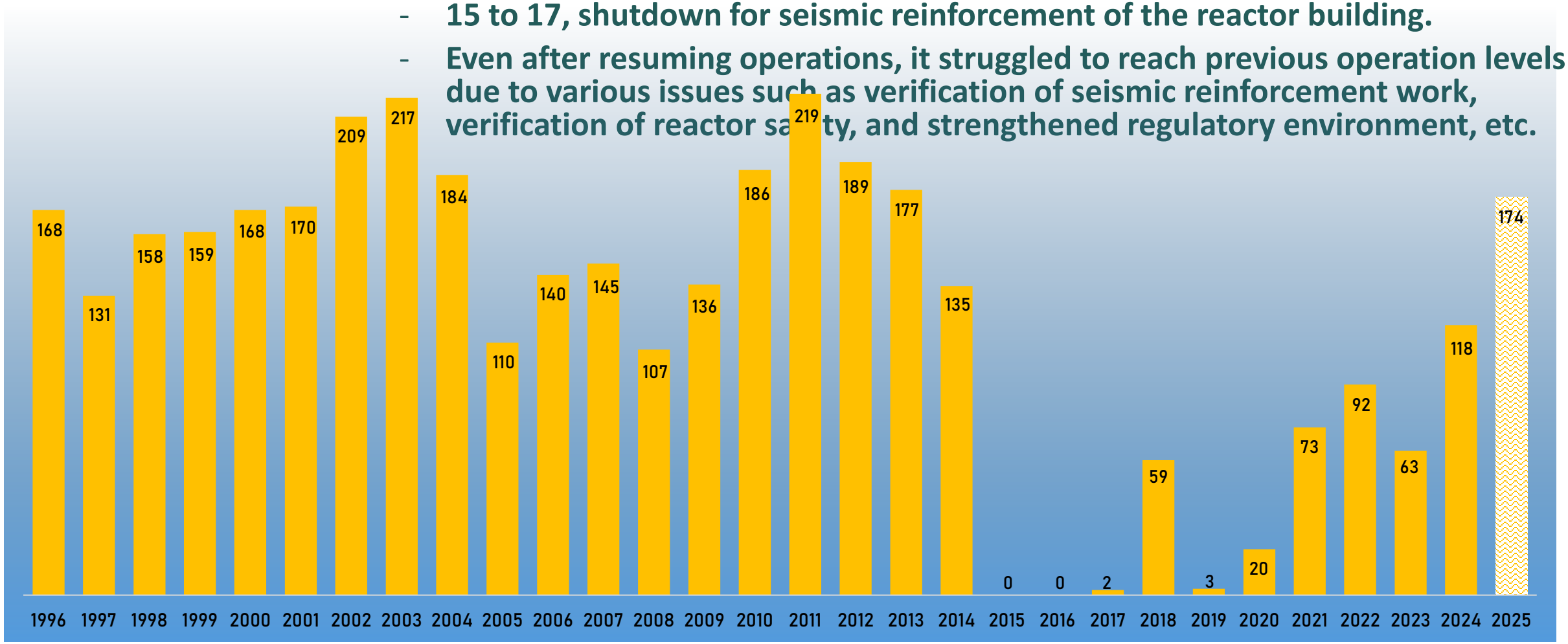
Reinforcement of HANARO Wall

- After Fukushima accident (March 2011), a special safety inspection - Seismic Margin Assessment (SMA)
- 2015.3 - 2017.4, Design and Construction work for reinforcement of HANARO wall

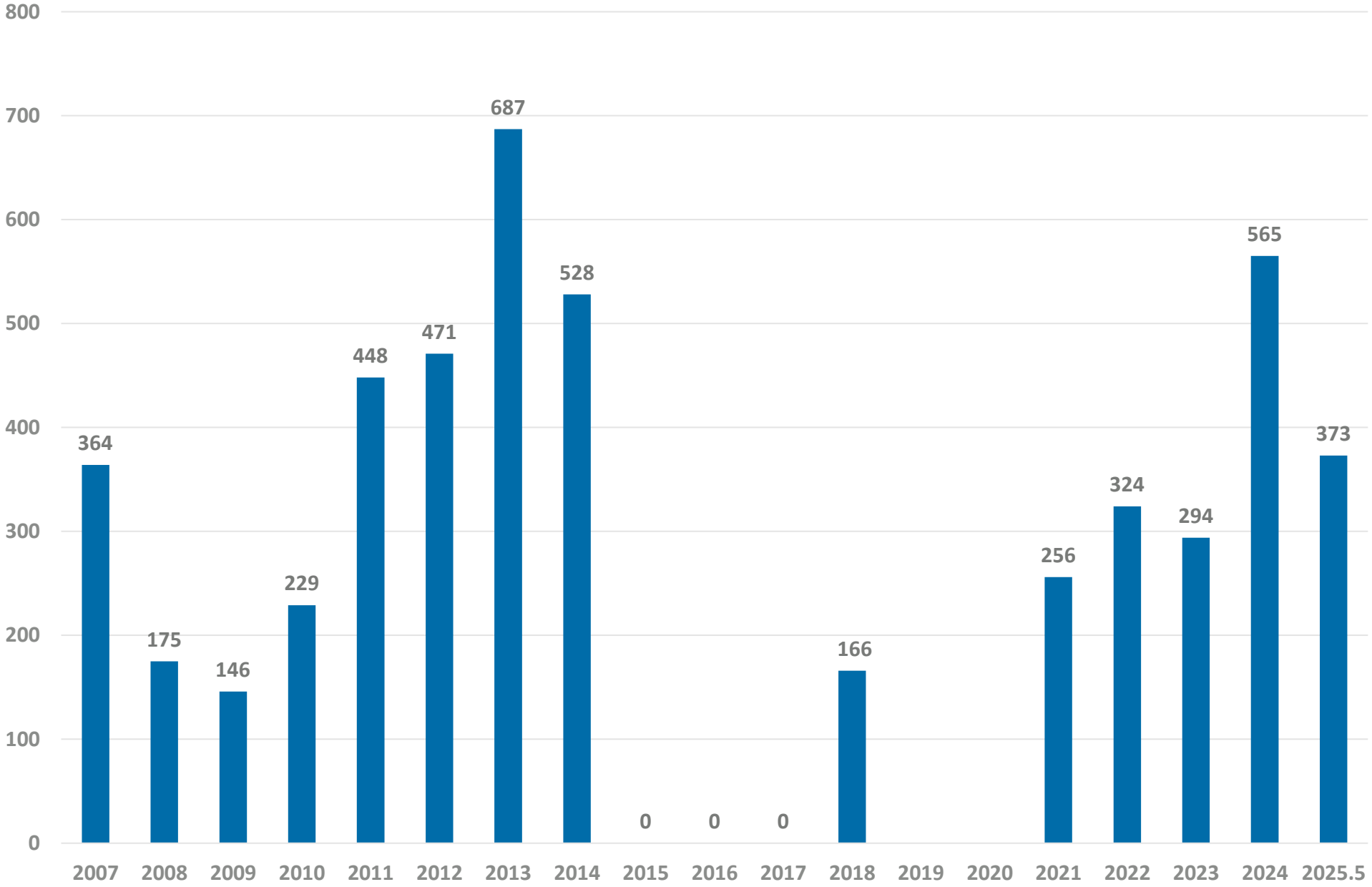
HANARO Operation

Operation Days

- Stable 4-week operation and 2-week maintenance cycle until 2014
- 05 to 09, installation works of experimental facilities like cold neutron source.
- In 2011, HANARO reached a maximum of 219 operation days
- 15 to 17, shutdown for seismic reinforcement of the reactor building.
- Even after resuming operations, it struggled to reach previous operation levels due to various issues such as verification of seismic reinforcement work, verification of reactor safety, and strengthened regulatory environment, etc.



Annual Number of HANARO Neutron Beam Facility Users



Regulatory Improvements Affecting Operational Stability-1

- In 2018, Korea's regulatory authority revised reporting and disclosure regulations for incidents and malfunctions in nuclear facilities.
  - → report all reactor shutdowns to the regulatory authority and obtain approval for re-operation.
- Before 2018, only shutdowns related to reactor safety had to be reported and approved for re-operation. Shutdowns unrelated to reactor safety, such as those to protect experimental systems, did not require regulatory reporting or operation approval.
- Due to this regulatory change, the re-operation period after a shutdown significantly increased (from an average of 9.3 days before to over two months).
- The primary cause of HANARO shutdowns has been to protect cold neutron source facility, with several shutdowns occurring annually for this purpose
  - → HANARO operation became highly unstable

Regulatory Improvements Affecting Operational Stability-2

- Implementation of two comprehensive measures:,
  - ✓ Proving HANARO's inherent safety based on its design characteristics
  - ✓ Developing a comprehensive plan to minimize unplanned shutdowns
    - The cold neutron source (CNS) operation was precisely analyzed and the facility and the operation technique of CNS were improved.
    - Various parts and equipment of HANARO were replaced for preventive maintenance.
- Through these efforts, understanding was gained from the regulatory authority.
- In September 2024, the reporting and re-operation regulations were significantly improved.
  - → Reporting and re-operation approval are limited to only shutdowns related to reactor safety and control rod malfunction.

⇒ This regulatory improvement is expected to enhance HANARO’s operational stability considerably, allowing annual operating days to be maintained at over 150.

HANARO Future Operation Plan

- Target: 200 operation days per year
- Expected: More than 160 days per year (assuming 2 or 3 unplanned shutdowns)
- Minimum: 100 days per year (This would only occur in the case of major maintenance work, such as replacing the Cold Neutron Source (CNS) or switching the type of nuclear fuel used in HANARO from U_3Si to UMo.)
- HANARO plans to operate on a continuous cycle of 28 days of operation followed by 14 days of maintenance.
- Major maintenance work is mainly carried out during the summer months, from June to September. Therefore, operations are generally suspended from late June to mid-September.
- The regular inspection of nuclear facilities conducted by the regulatory authority takes about one month and is carried out once every two years.

Expected Key Maintenance Items

- Replacement or enhancement of large-scale user facilities, such as the Cold Neutron Source (CNS).
- Failure of critical equipment or preventive replacement — such as pumps, valves, instrumentation, etc.
- Introduction of new equipment or technology as required by the regulatory authority.

Conclusion

- HANARO is a research platform available to numerous users who wish to utilize neutrons.
- Since the start of seismic reinforcement work in 2014, HANARO has not been able to operate normally and stably for a considerable period.
- As a result, many users faced difficulties in their research, leading to a significant loss for the scientific and technological community.
- Fortunately, in 2024, regulations that greatly hindered the stable operation of HANARO were improved.

⇒ **Consequently, HANARO operation was fully normalized from the second half of 2024. In 2024, HANARO operated for 118 days, and in 2025, it is expected to operate for 174 days, restoring its stable operation levels before 2014.**

Thank you!