Experience from HANARO Reactor Management

2010. 4. 13

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KAERI
Korea Atomic Energy Research Institute

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Introduction to HANARO

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Dawning of Nuclear Age in Korea

The 1st Research Reactor in Korea, TRIGA Mark II (100 kW)

The 1st president of Korea in the ground breaking ceremony (1959.7.14)

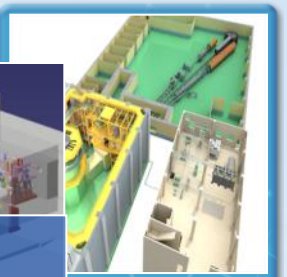
Milestones of Nuclear Program

1962.3.19
KRR-1

1972.3.10
KRR-2

1995.2.8
HANARO

2009.9
FTL

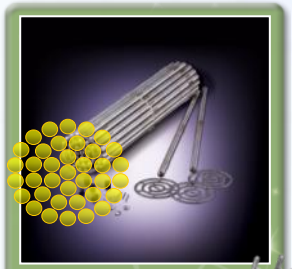


2010
CNS

1960 1980 2000 2020

1959.2.3
Establishment of KAERI

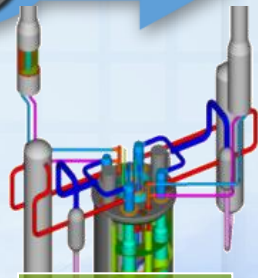
1978.7.20
NPP No.1 Operation



1987
CANDU-6 Fuel

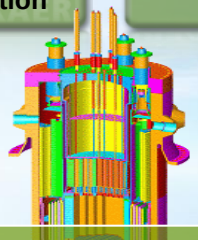
1995.4.19
KSNP Operation

2013
APR1400

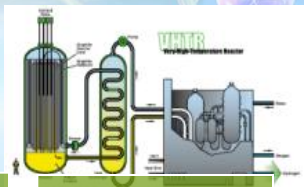


SFR

1989
PWR Fuel

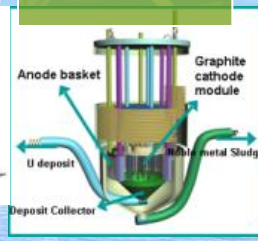


2012
SMART DC



Hydrogen Production

PYRO



HANARO Complex

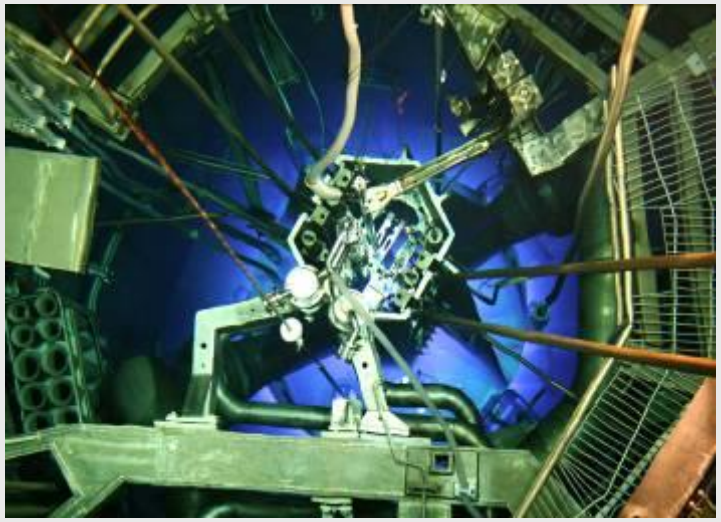
AE : Auxiliary Equipment Building for CNS
AU : Auxiliary Utility Building for CNS
CNL : Cold Neutron Laboratory
CT : Cooling Tower

IMEF : Irradiated Material Examination Facility
PH : Pump House for Secondary Cooling System
RX : Reactor Building
RIPF : Radio-Isotope Production Facility

HANARO Reactor

High-flux
Advanced
Neutron
Application
React**O**r

Multi-purpose Research Reactor



Radio-Isotope Production Facility

Bank II (11 Cells)

^{166}Ho,$^{32,33}P$, ^{99m}Tc,^{51}Cr, HDR ^{192}Ir

Bank III (6 Cells)

^{131}I, ^{125}I

Bank I [4 Cells]

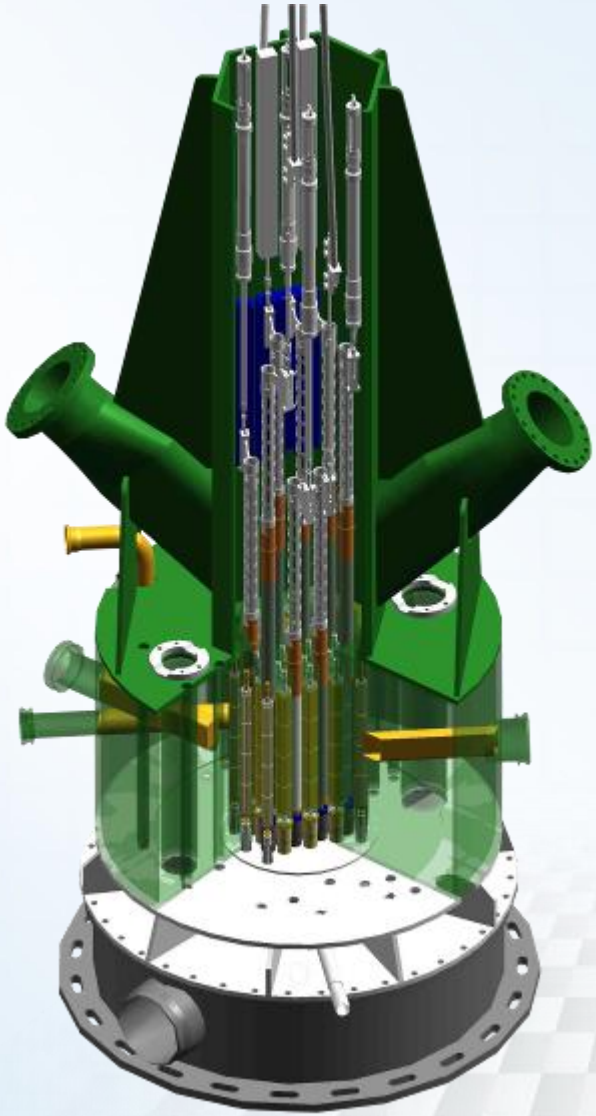
^{60}Co, ^{192}Ir, ^{169}Yb

Bank IV (4 Cells)

$^{99}Mo/^{99m}Tc$ Generator

Preparation Room for Cold Kits

Reactor Structure and Characteristics



Features

- Type — Open-tank-in-pool
- Power — 30 MW_{th}
- Coolant — Light water
- Reflector — Heavy water
- Fuel materials — U_3Si, 19.75% enriched
- 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
- Vertical hole for cold neutron source
- Operation cycle — 24 days@5 weeks

Chronology of HANARO

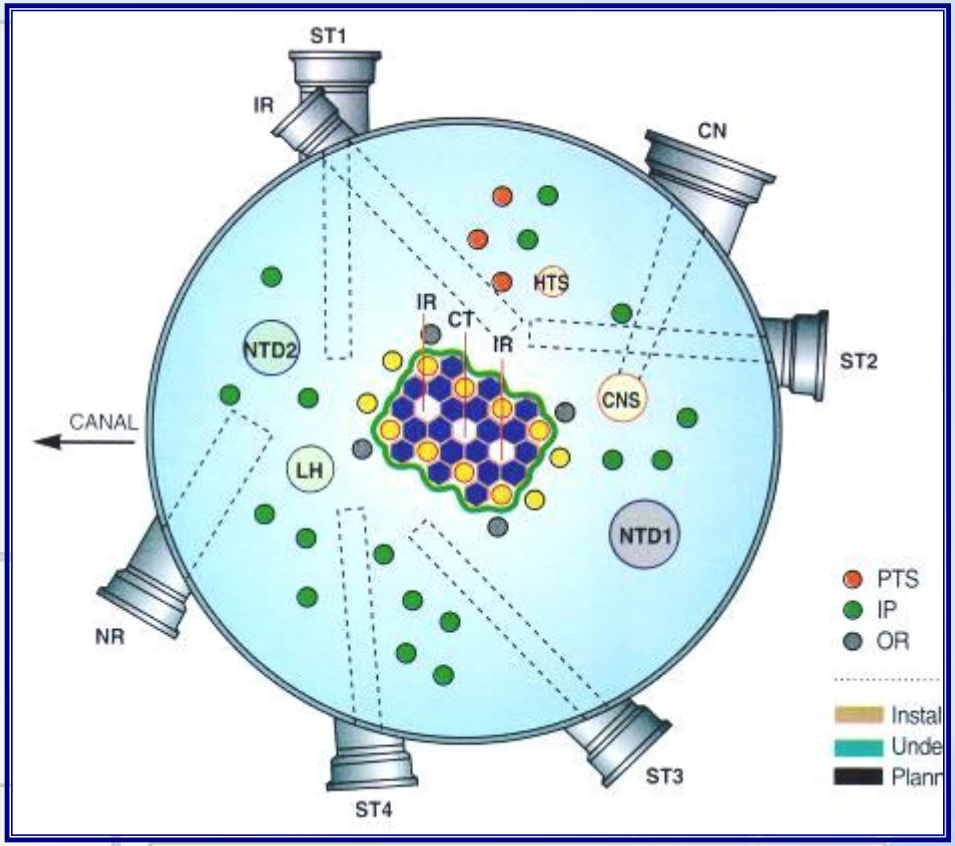
- 1985 JAN Start of HANARO Project
- 1989 JAN Start of HANARO Construction
- 1993 AUG Installation of HANARO Reactor Structure
- 1995 FEB Fuel Loading and Achievement of Initial Criticality
- 1996 JAN 15MW Power Operation
- 1999 DEC 22MW Power Operation
- 2004 NOV 30MW (Design Power) Power Operation started
- 2005 MAR First Loading of HANARO Fuel made by KAERI
- 2006 APR Start of Cold Neutron Laboratory Construction (Completed in May 2008)
- 2006 JUL Start of Fuel Test Loop Installation (Completed in Feb. 2008)
- 2008 MAY Start of Cold Neutron Source System Installation
- 2009 SEP 3 First Generation of Cold Neutron
- 2009 SEP 28 Completion of FTL Commissioning Test
- 2009 DEC 4 Selected as the most favorable bidder for JNRR project

Status of Experimental Facilities

Vertical Holes

Installed

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 neutron activation analysis
NTD : Neutron Transmutation Doping of Silicon
CNS : Cold Source Installation



Horizontal Tubes

Installed

ST2 : High Resolution Powder Diffractometer, Four Circle Diffractometer
NR : Neutron Radiography Facility
CN : Cold Neutron Guide
IR : Ex-core Neutron-irradiation Facility for BNCT & DNR
ST1 : PGAA and RSI
ST3 : Vertical Reflectometer

ST3 : Horizontal Reflectometer
ST3 : High Intensity Powder Diffractometer

Under-development

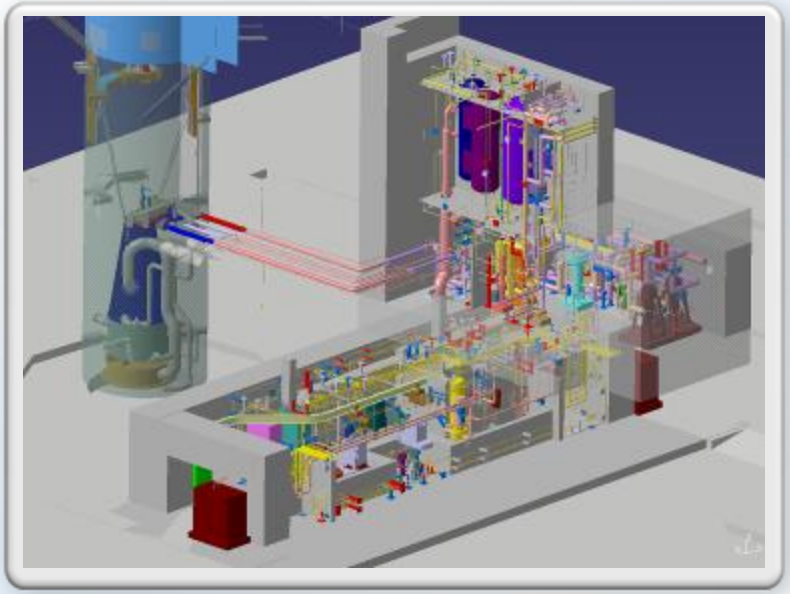
ST4 : Triple Axis Spectrometer

Fuel Test Loop Facility

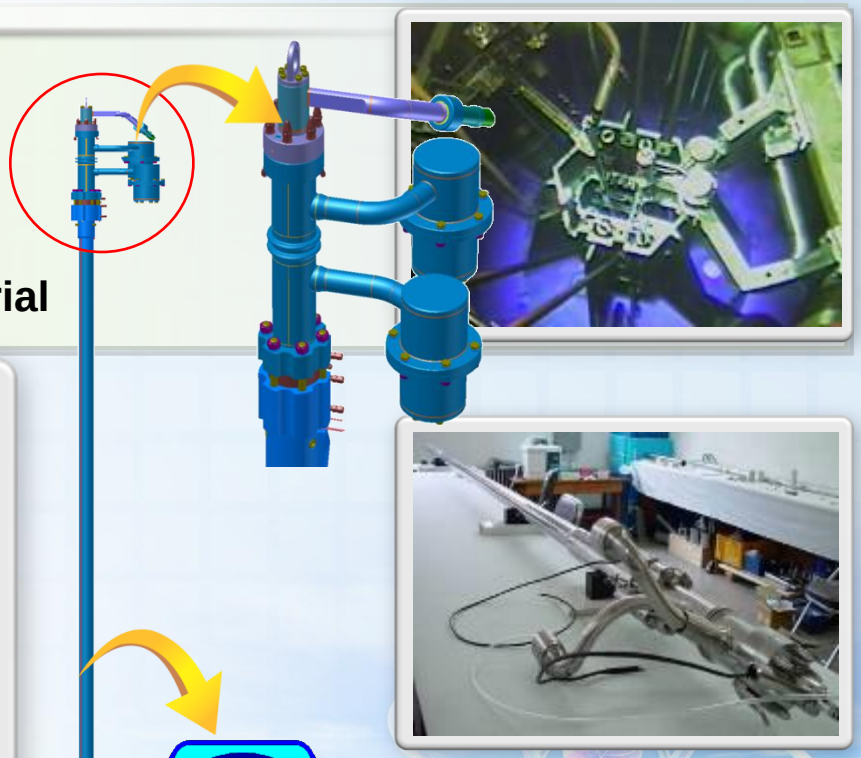
Commissioning test : ~ Sept. 2009

Applications

- Integral Fuel Irradiation Tests
- Fuel Qualification Tests
- High Burn-up Fuel Tests
- Water Chemistry and Corrosion Tests
- Non-fissile Tests of Pressure Tube Material



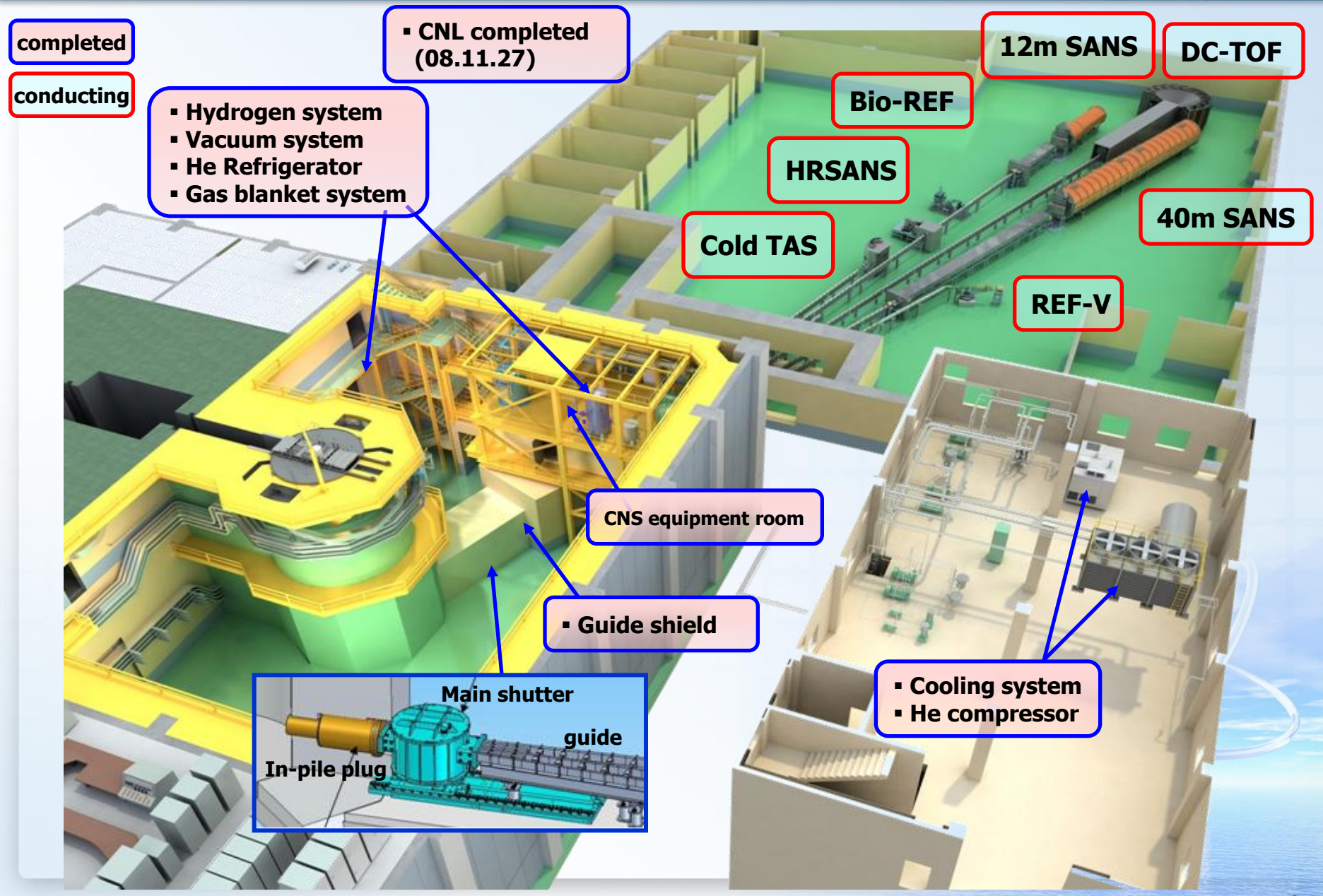
Out-Pile System



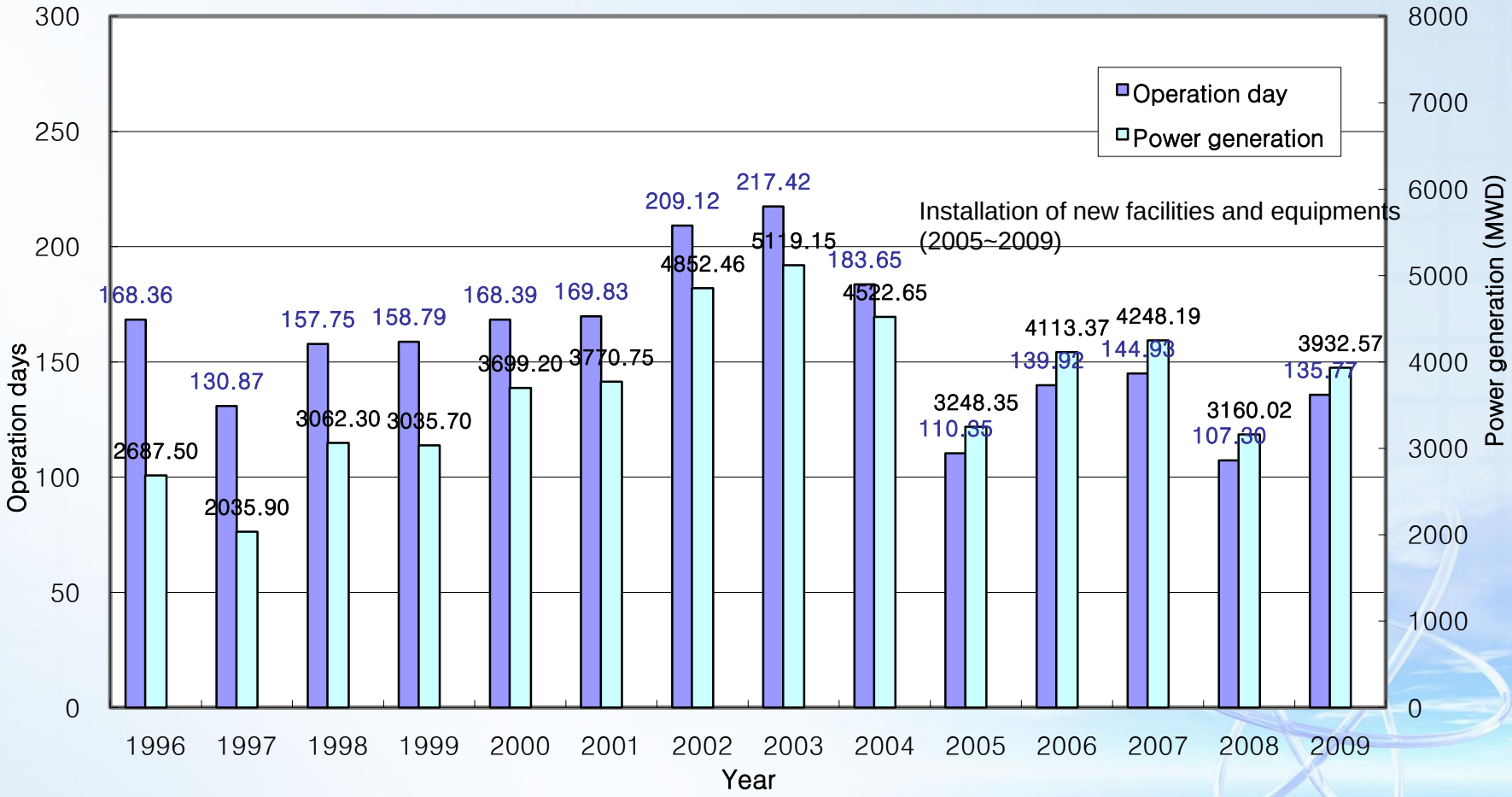
In-Pile Section

- ► Design Pressure : 17.5 MPa
- ► Design Temperature : 350 ℃

Cold Neutron Research Facility



Reactor Operation Record



Unique Experiences

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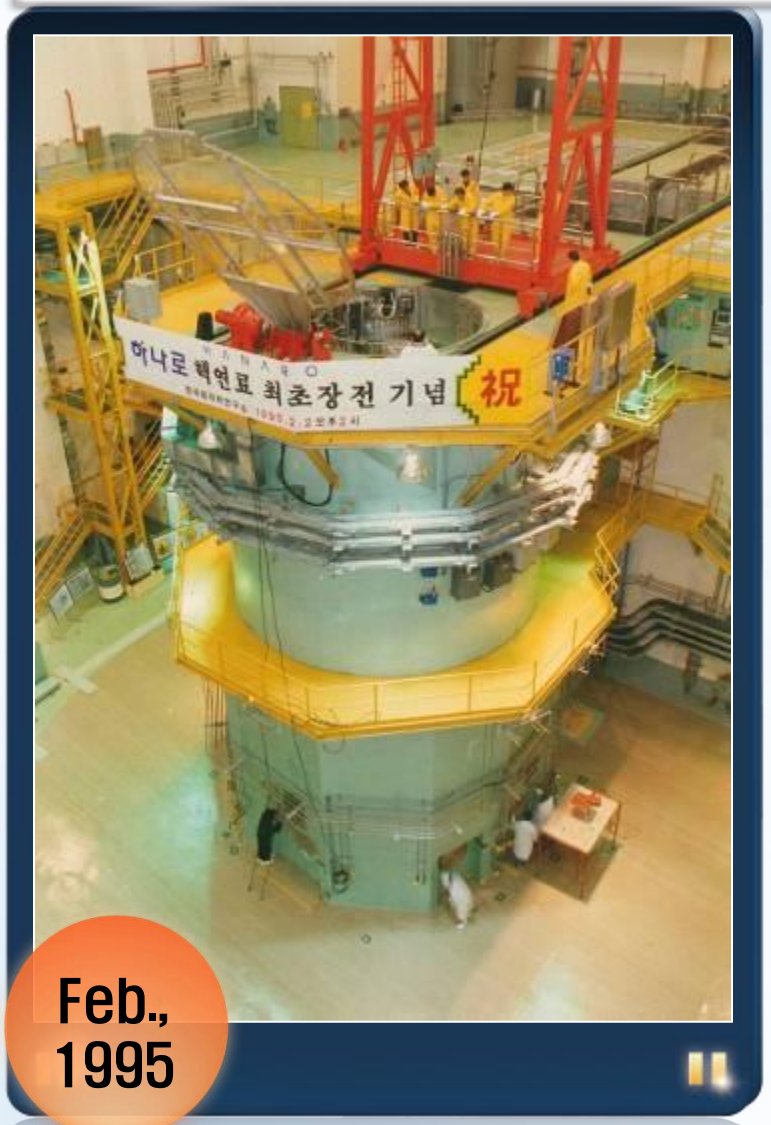
Dynamic change

Dynamic Change



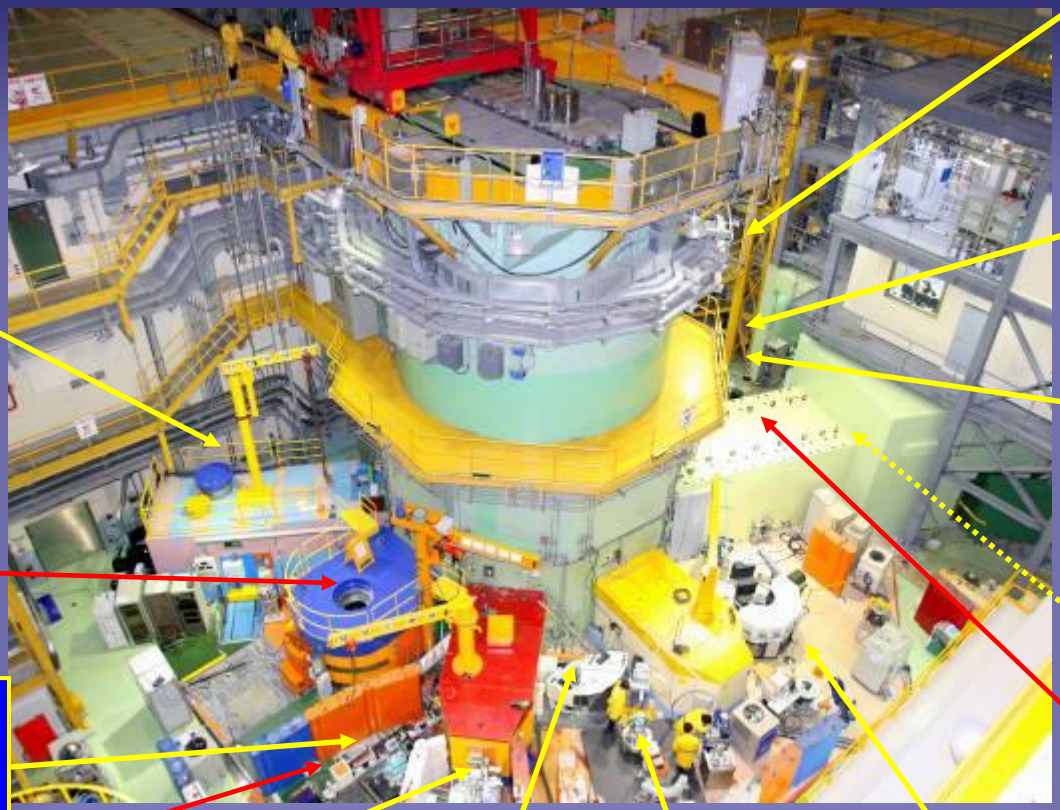
Feb., 1995

- Continuous support from government

Oct., 2009

Reactor Hall, 2010

In-service
Under way



IR Port

Ex-Core Neutron Irradiation Facility (ENF), 2005

ST1 Port

Prompt Gamma Neutron Activation Analysis(PGAA), 2003

Residual Stress Instrument(RSI), 2003

NR Port

Neutron Radiography Facility (NRF),1997 Upgrade

ST4 Port

Triple Axis Spectrometer (TAS), 2010

CN Port

Small Angle Neutron Scattering (SANS),2001 Currently dismantled

Cold Neutron Guide, 2009

Neutron Reflectometer (REF-V), 2006 Currently dismantled

Bio-Diffractometer (Bio-D), 2010

ST3 Port

Neutron Reflectometer, (REF-H), 2008 Currently dismantled

High Intensity Powder Diff. (HIPD), 2008

ST2 Port

High Resolution Powder Diff. (HRPD),1998

Four Circle Diffractometer (FCD),1999 Upgrade '05-'06

Experienced and devoted people

Engineers

- Experiences in design/construction/commissioning/operation
- Combination of experiences from industries and new ideas

Contribution of TRIGA experiences

- Nuclear commissioning
- Establishment operation technology
- Beam instrument development
- RI technology development

Devoted technicians

- New staff, TRIGA staff, staff from fuel conversion facilities
- Participation from the end of construction phase
- Many of them having shift work experience for more than 20 years

Technology share

Research Reactor Operator Training

- 2000 Training of Taiwan RR project commissioning team
- 2004 Training of CARR(China) operators

Fuel Technology

- Export of U-Mo powders
- Export of U foil

Reactor System Technology

- 2009 Upgrade of GRR(5MW, Greece) primary cooling system
- 2009 Consultation on the upgrade of I&C for TRR-1(2MW, Thailand)
- 2009 Selected to supply JRTR (5MW, Jordan)

Utilization Technology

- PSD(Neutron detector) for JRR-3M(20 MW, Japan)
- Tc-99m abstraction system using solvent
- I-131 distillation system, I-131 distribution system(capsule, solution)
- Ir-192 irradiator assembling equipment
- Neutron transmutation doping service

Establishment of user community

HANARO Steering Committee

- Major function : To recommend the main stream of the utilization and facility operation
- Members from user group, government, experts and KAERI
- Two meetings every year

Committee of User Representatives

- Major function : discussion on the user interest and recommendations to be discussed at the steering committee
- Members : representatives from neutron beam, RI research, irradiation research and NAA

User Groups

- Groups for the exchange of experience and idea

HANARO Symposium

- Forum for users, operators and engineers held every year

For Better Return

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Importance of Strategic Plan

- Contents of Strategic Plan
  - Identification of national demand
  - Investment plan for the facilities
  - Utilization plan

- The preparation of strategic plan should start from the stage of feasibility study on the introduction of a new research facility

- HANARO
  - -1990 : A Utilization of the KMRR
  - -1998 : Review and recommendation for the maximum utilization and reasonable management of the HANARO reactor
  - -2008 : Strategic plan for BNS&T department of KAERI

For Better Return

Value Chain of a Research Reactor

Strong demand

Strong Support

Further Support

Value Creation

or

Vague Demand

Hesitation in Continuous Support

Value Reduction

Low Utilization

Facility Life Reduction

For Better Return

International Cooperation

- **Mutual visits**
  (CARR, JRR3-M, JMTR, OPAL, HFIR, RRs in CEA, ….)
- **Invitation of experts**
- **Regional Cooperation (FNCA, RCA)**
- **Sabbatical stay in other RR Institute**
- **HANARO Symposium**
  - Official international symposium for 2005 and 2010

For Better Return

The Asia-Oceania Neutron Scattering Association was officially formed on August 28th, 2008

Members

- Korean Neutron Beam Users Association
- Japanese Society of Neutron Science
- Australian Neutron Beam Users Group
- Indian Neutron Scattering Society
- Taiwan Neutron Science Society

Observers

- China
- India
- Indonesia
- Malaysia
- Singapore

Turn-over of responsibility and documentation

- Turn-over may occur between the following activities
  - Planning
  - Construction
  - Commissioning
  - Operation and Utilization
- Preparation of turn-over documentation
  - The turn-over should be conducted by following a established document.
- Commissioning
  - The procedures, findings and field changes should be well-documented.

Ageing Management

- Establishment ageing management plan for facilities
  - Upgrade, overhaul and replacement
  - The potential impact on the safety and reliability should be identified.
  - Experienced in-house engineers should be secured.
- Man Ageing
  - Stimulate the staff to establish their vision in carrier
  - Make the experienced people be harmonized with the new comers
- Users
  - Request the improvement in proposal and outcome

Others

- Establishment of safety management system
  - The facility manager should respect the messages from the safety officer.
  - Integrated safety management : Radiation safety, environmental safety, quality management and health
  - Safety culture : Establishment of safety policy, procedures, share of good/bad experiences
- Fostering of local manufactures
  - Help the establishment of component design capability and QA
- Public Acceptance
  - Single contact
  - Adoption of IT techniques for flexible exhibition system

For Better Return

Others

- Adoption of electronic procedures
  - On-line guide for operation
  - Management of spare parts
  - Expert system may be adopted later.
- Adoption of IT based management system
  - Management of documents, operation and maintenance
  - Knowledge management tool
- Adoption of user home page
  - Upload of beam time proposal, project proposal
  - Notice of beam time allocation
  - Upload of user achievement

Thank You!

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