

# Development of Fission Mo-99 Production System and Facility for the KJRR of Korea



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**KAERI**

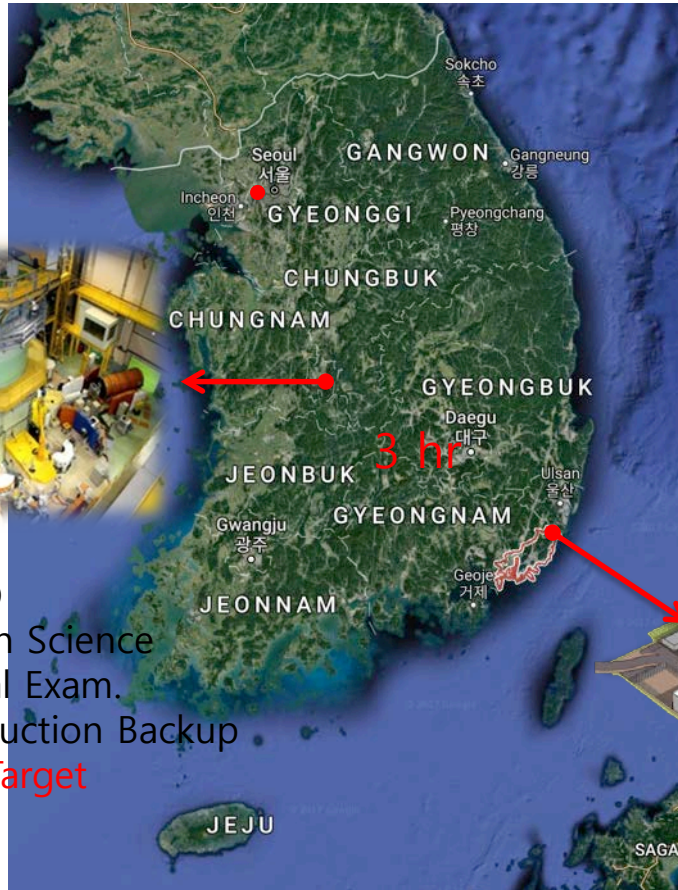
1. KJRR Introduction
2. KJRR Updates
3. Fission  $^{99}\text{Mo}$  Production Facility Development
4. Fission  $^{99}\text{Mo}$  Production Target / Process Development
5. Summary

## Project Initiated to Solve Insecurity of Medical Radioisotopes (Mo-99) Supply in Korea

- Project Launched in 2012.
- Location: Gijang, Busan.
- Mo-99 Production Capacity: 2,000Ci/w.
- NTD, Ir-192, I-125, Lu-177 etc.

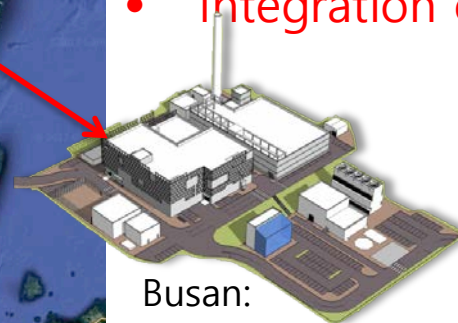
### Beauty:

- Dedicated Rx & Facilities
- Fuel/Target Self-supplied by KAERI
- Integration of Rx/Processing/Generator



Daejeon:  
HANARO

- Neutron Science
- Material Exam.
- RI Production Backup
- Fuel / Target



Busan:  
KJRR

- FM/RI Production
- NTD





Kori NPP

KJRR Site

East Sea (Pacific)

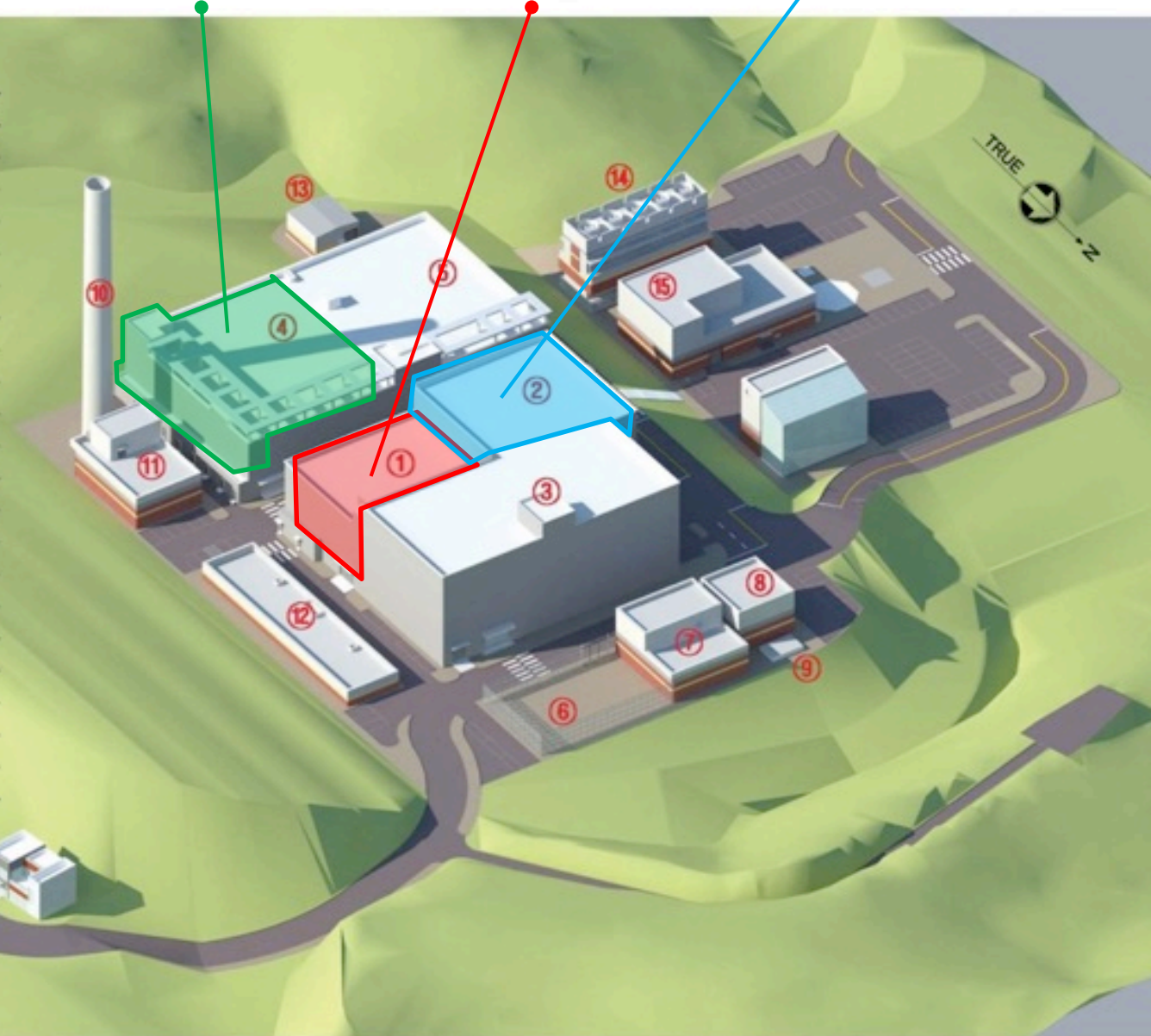
Medical Center

# BIRD'S EYE VIEW

**RIPF** (Radioisotope Production Facility) **FMPF** (Fission Molybdenum Production Facility) **Reactor**

## LEGEND

BUILDING AND STRUCTURE LIST	
MARK	DESCRIPTION
1	FISSION MOLYBDENUM PRODUCTION FACILITY BUILDING (FM 생산 건물)
2	REACTOR BUILDING (동자로 건물)
3	UTILITY BUILDING (유체처리 건물)
4	RADIOISOTOPE PRODUCTION FACILITY BUILDING (라디오이소 건물)
5	RADIOACTIVE WASTE TREATMENT FACILITY BUILDING (방사성폐기물 처리 건물)
6	154KV GIS & TRANSFORMER (154KV 배전 변전소)
7	ELECTRIC BUILDING (전기 설비 건물)
8	DG BUILDING (디젤 발전기 건물)
9	FUEL OIL TANK (공유 저장 탱크)
10	STACK (굴뚝)
11	HVAC FACILITY (공조 시설)
12	FIRE WATER TANK AND FACILITY (소방탱크 및 시설)
13	RWTF WAREHOUSE (방사성폐기물 처리 시설 창고)
14	COOLING TOWER / BASIN (냉각탑 / 수조)
15	DEMI. SYSTEM & PUMP BUILDING (순환수처리 및 펌프 건물)
16	PH ADJUSTMENT BASIN & DISCHARGE POND (PH 조정조)
17	RAW WATER STORAGE TANK (원수 저장 탱크)
18	SEWAGE LIFTING STATION (하수 리프트 시설)
19	NATURAL EVAPORATION BUILDING (자연 증발조)
20	GUARD HOUSE (경비실)





# KJRR Specification

Power	15 MW
Type	Open Tank in Pool type
Max. thermal neutron flux (n/cm <sup>2</sup> s)	> 3.0x10 <sup>14</sup> (Central Trap)
Operation day	~300/year
Design Life Time	50 year
LEU Fuel	U-7Mo plate type (U loading : 6.5, 8.0 g/cc)
LEU FM Target	UAix plate type (2.6 gU/cc)
Reflector	Be and Gr
Coolant and flow direction in operation	H <sub>2</sub> O, downward forced convection flow
Reactor building	Confinement
Decay heat removal	Safety Residual Heat Removal System

Robust Design, Aircraft Crash, 0.3g SSE, Digital I&C, Cyber Security, etc.





- **2012. 4 Project Initiation**
- **2013. 3 Land purchase (Gijang-Local Gov.)**
- **2013. 4 Reactor Conceptual Design.**
  - Initiating Basic Design for RR, FMPF, RIFP etc.
- **2014. 11 PSAR Submit (NSSC, KINS)**
- **2015. 5 Reactor Assembly Fabrication (Doosan Eng.)**
- **2016. 9. 12 Gyeongju Earth Quake**
- **2016. 10 Project Re-planning Initiated (Re-evaluation): 150M USD**
  - ↑
- **2016. 11 Progress Report (NSSC)**
- **2017. 9 PSAR Review Complete (KINS): 500 action item → 2 items**
- **2017. 12 Construction Permit (NSSC)**
- **2018. 1 Construction Start (34 months for construction)**
- **2019. 9 FSAR Submit for Operation License**

1 year  
Delay





# Project Schedule (KJRR)

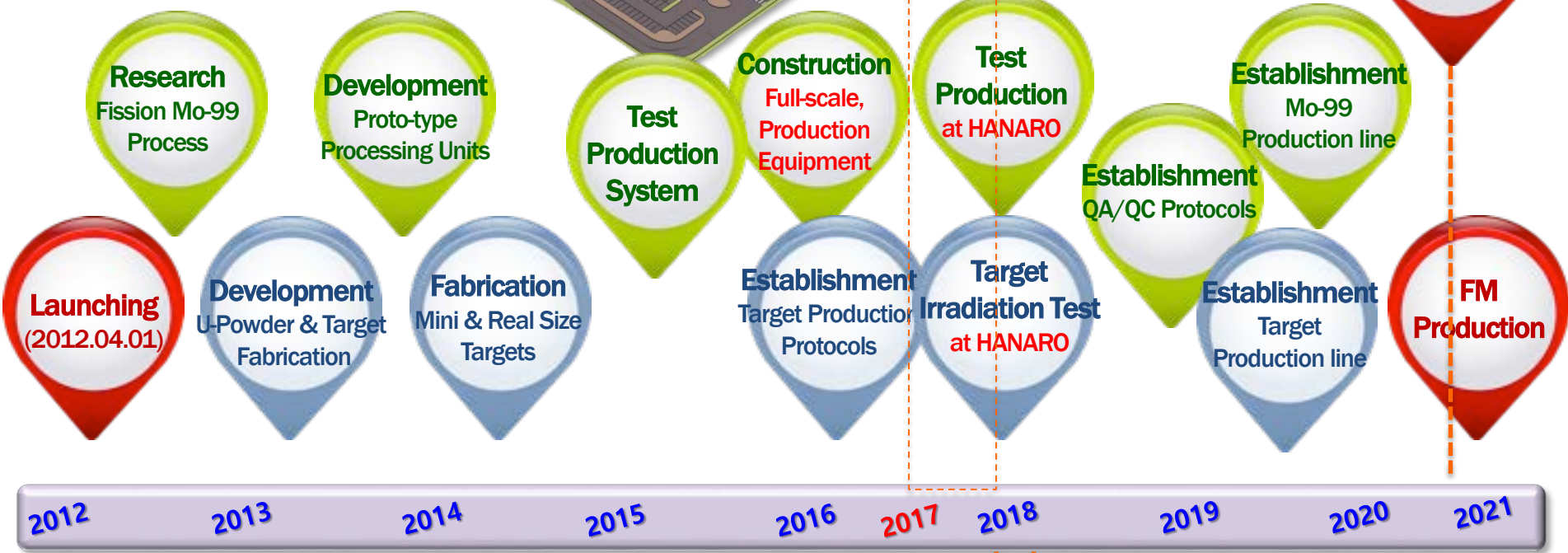
	2011	2012	2013	2014	2015	2016	2017	2018	2019
Feasibility Study Report (2011.02)	◆								
Project Launching (2012.04)		◆							
Contract with A/E (2013.04)			◆						
Apply Construction Permit (2014.11)				◆					
Construction start (2018.1)								◆	
Reactor Critical					60% progress as of June 2017				
Reactor Full Power									
Fission Moly Production									



# Project Schedule (FM)



HANARO Resume operation  
In Oct. 2017 ?



HANARO stopped operation  
In July. 2014

Reactor assembly PSAR  
(Dec. 2017)

Construction Start  
(Jan. 2018)

# Gyeongju Earthquake

## 경주 인근 주요 시설 현황

(2016년 9월 현재)

12일 규모 5.8

19일 규모 4.5



자료: 한국지질자원연구원, USGS 등 종합 인포그래픽 현역진

KBS

- Date: Sept. 12, 2016
- Magnitude: 5.8 (5.4 USGS)
- Location: 35.77N, 129.18E
- Depth: 15 km
- Distance from KJRR: 50 km

## Influence of the Earthquake on the Project

- New NPP construction near KJRR stopped (NSSC)
- KJRR review delayed (NSSC-KINS)
- Study on the regional fault lines
- 1<sup>st</sup> Report: Sept. 2017: OK
- In-depth Report: 2020



# FM Safety Analysis and HANARO Status

## ISA of FM Process/Facility

- Implementation of Research Reactor Reg. Guide for FM Process (from PWR)
- 2016. 12 NSSC/KINS – Implementation of **Fuel Cycle Reg. Guide** for FM Process
- 2017. 5 Integrated Safety Review on the FM Process and Facility
- 2016. 7 KINS – Implementation of Nuclear Codes (made for NPPs) for FM Process  
(KEPIC code for PWR: ASME Sec. III, Safety Class, Seismic Category,

etc.)

## HANARO Status

- 2017. 9 PSAR Review Complete (KINS) (by Accepting the Suggestion)
- 2014. 7 NSSC – HANARO Stop Operation
- 2014. 7 ~2015 Design, Regulatory Works, Contract
- 2016.2 Construction: Reinforcement of HANARO Outer Wall (~5%)
- 2017. 1 Construction Completed
- 2017. 5 Tri-lateral Agreement : KAERI – Local Community – Local Government
- 2017. mid-Oct. Approval by NSSC after KINS inspection



## KJRR Project Re-planning (re-evaluation, feasibility)

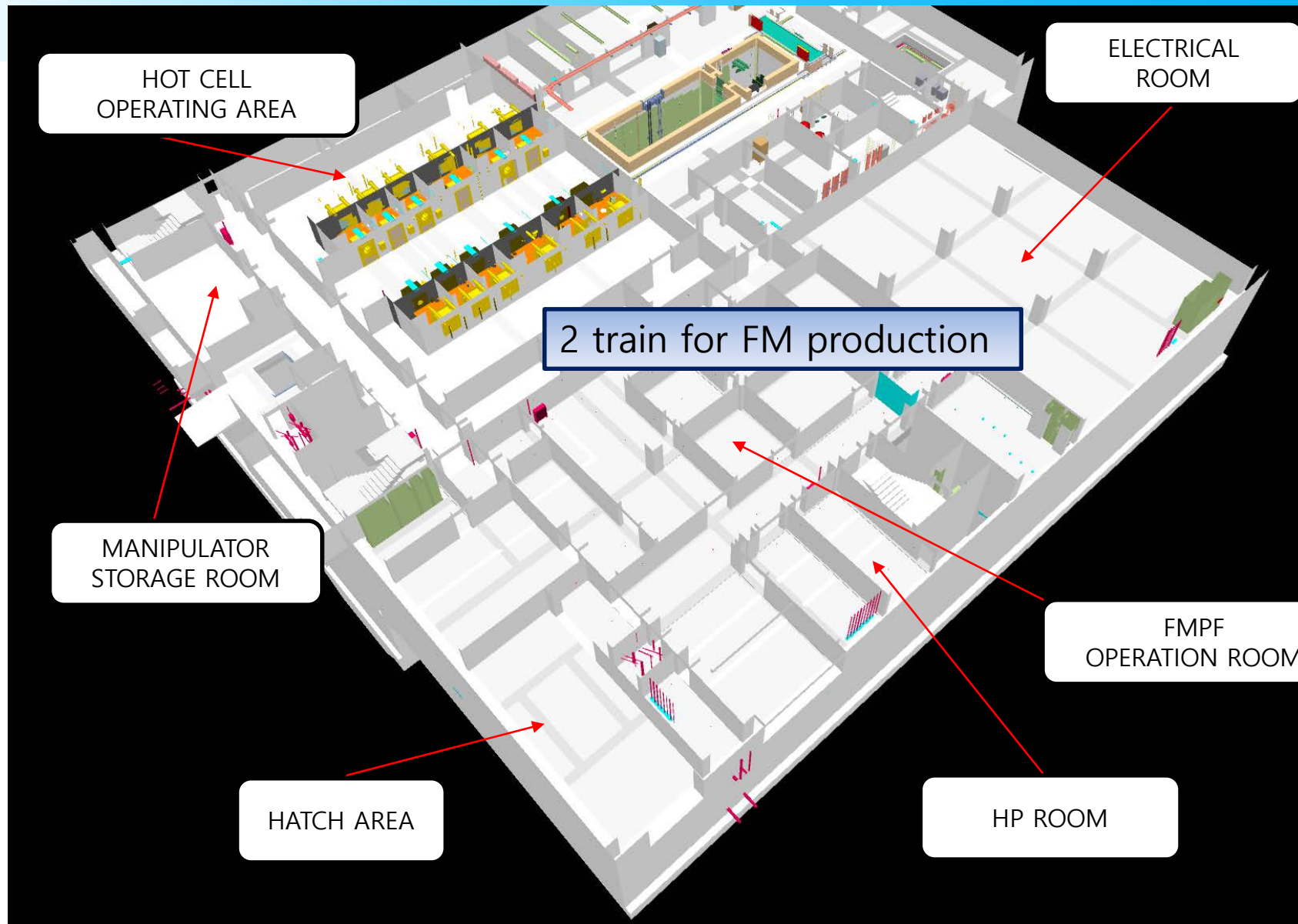
	Previous	Present
Project Budget	221M USD	369M USD+ $\alpha$
Period	'12~'16 (5Y)	'12~'20 (9Y)
Building Area	15,000m <sup>2</sup>	33,082m <sup>2</sup>
Thermal Power	20MW	15 MW

\* Not included: 35.5M USD for Land (Local Gov.)

Final re-planning report will be appeared in **Sept. 2017**

(KISTEP, Ministry of Strategy and Finance): **Green Light**

Decision of Deliberation on the Budget by National Assembly (Dec. 2017)



HOT CELL  
OPERATING AREA

ELECTRICAL  
ROOM

2 train for FM production

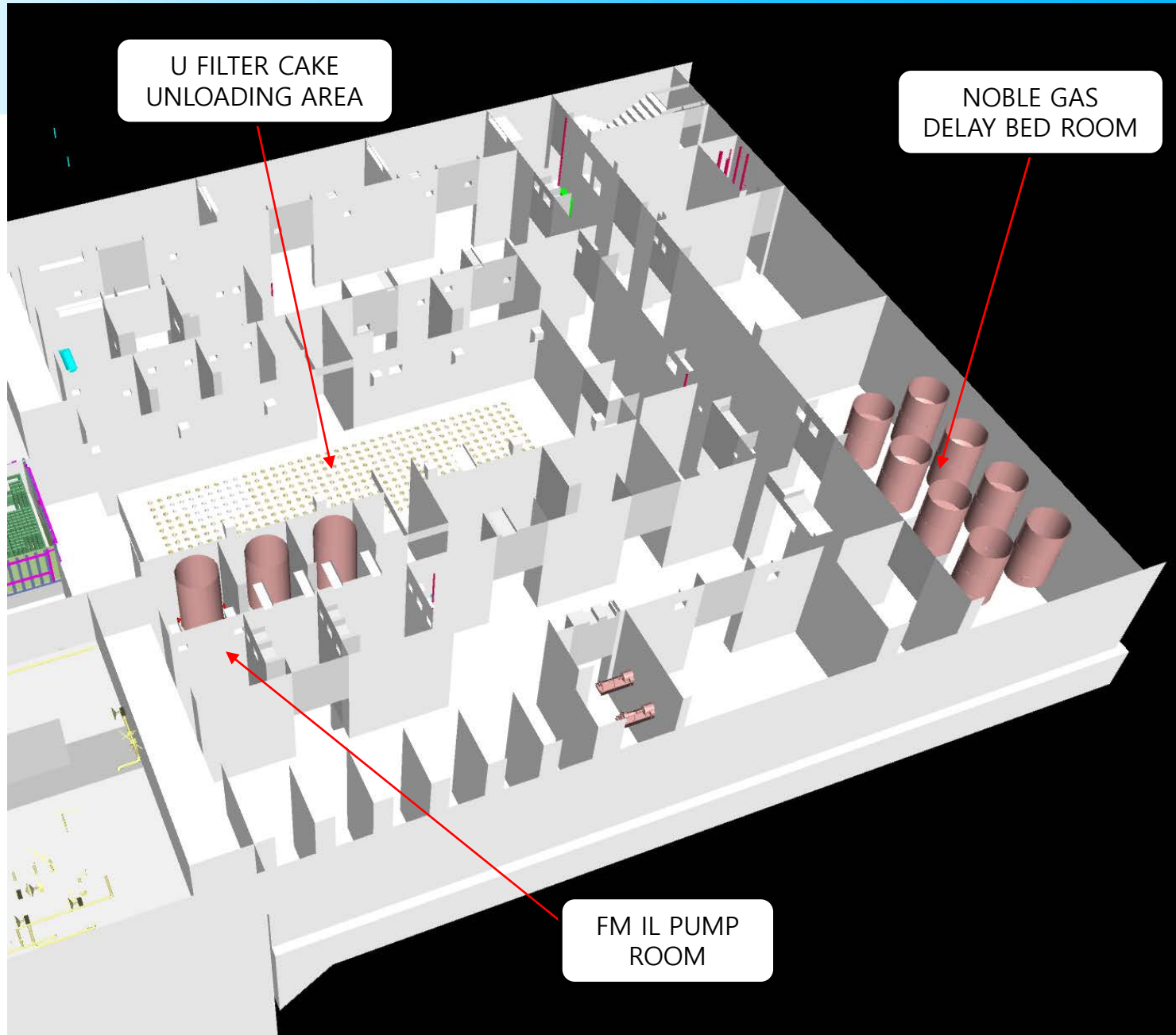
MANIPULATOR  
STORAGE ROOM

HATCH AREA

FMPF  
OPERATION ROOM

HP ROOM

FMPF & UTILITY Building ( FL. +1)



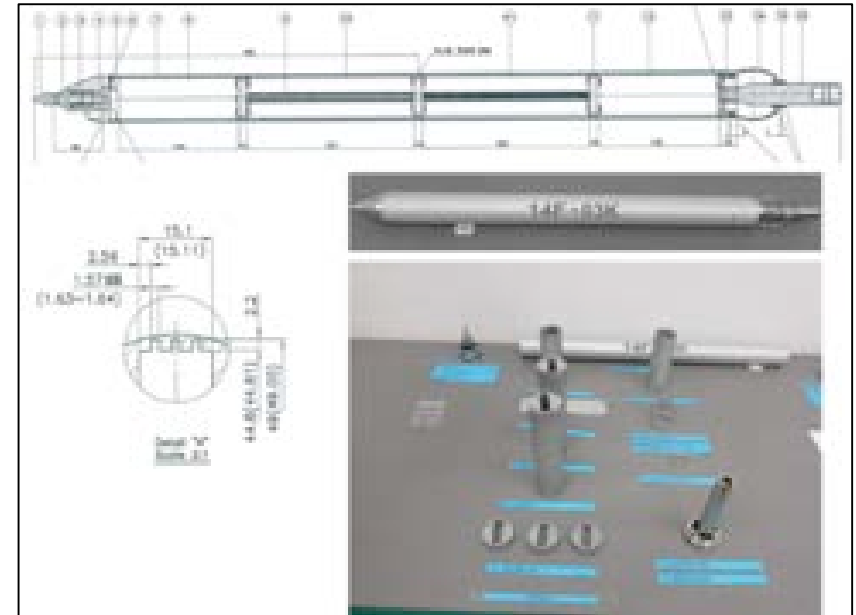
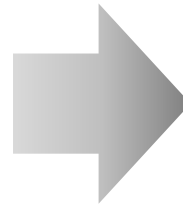
U FILTER CAKE UNLOADING AREA

NOBLE GAS DELAY BED ROOM

FM IL PUMP ROOM



## Fission Mo Target Assembly

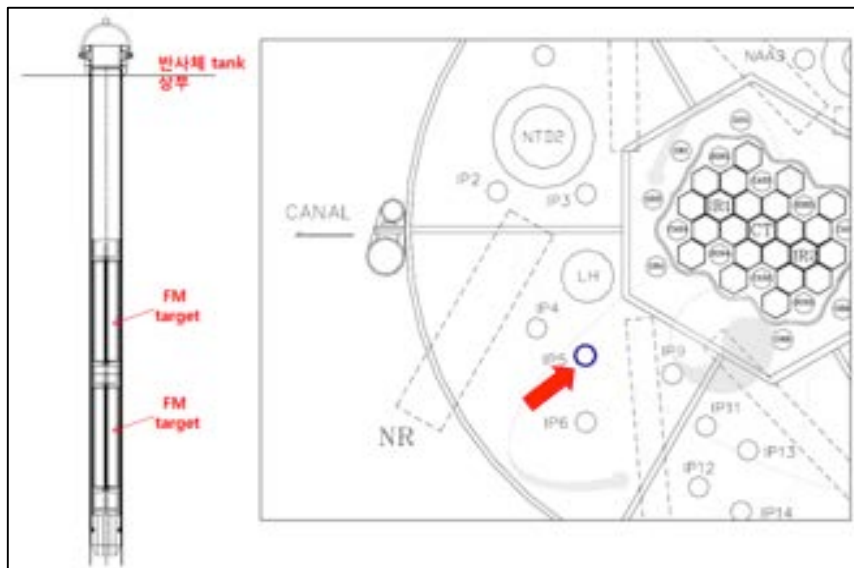


- **60-days ex-core test completed**
  - Flow rate & pressure drop: **satisfied**
  - Vibration test: **satisfied**
- **Waiting resume of HANARO**
- **Establishing target / fuel production line: Dec. 2017**



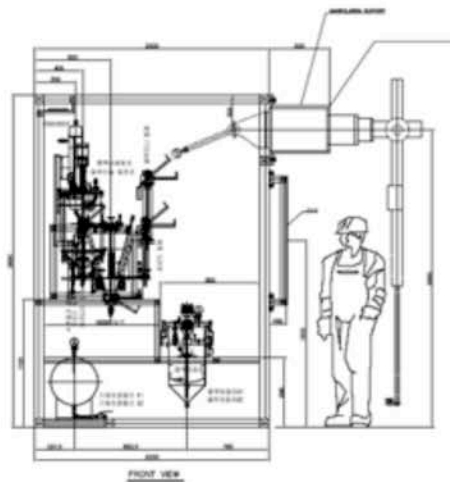
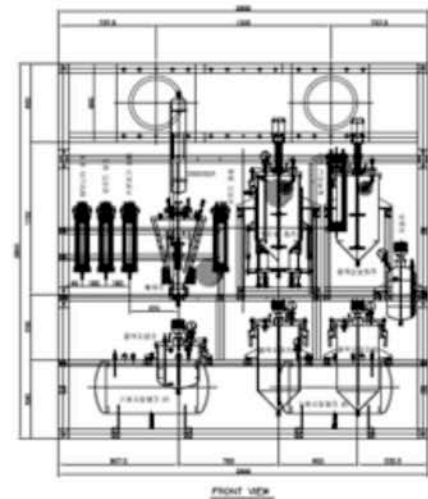


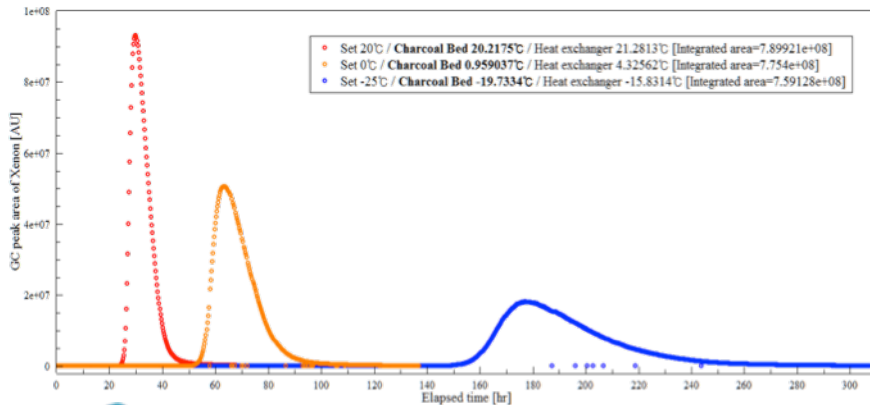
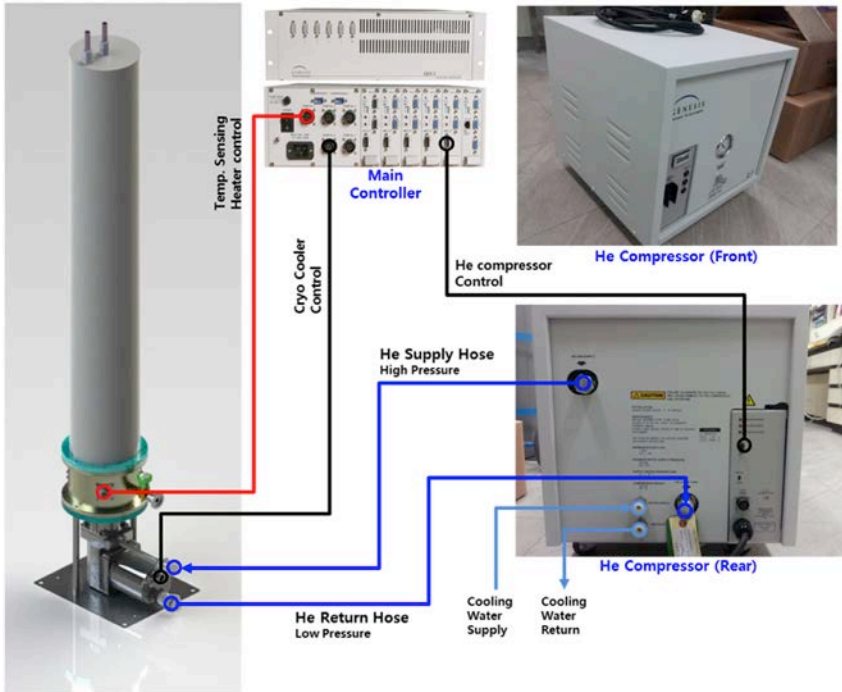
# Fission Mo Production: Hot Test Module (1/8 scale)





# Full-scale Prototype (cold test)





- Retention for 80-days (6 /week)
  - Need 8.484 kg of charcoal (@ about -18°C)
  - Replaceable with the huge conventional xenon treatment facilities (72 Tanks, 200 Liter)
- Related to the national security, CTBT
- International cooperation: IAEA (CRP), CTBTO, PNNL

- Re-planning of the project for additional funding: OK (Sept. 2017)
- Earthquake effect: OK (Sept. 2017)
- Safety analysis of FM process and facility: OK (Sept. 2017)
- Resume of HANARO and FM target / process hot evaluation:  
Technically OK (mid-Oct. 2017)
- **Conclusion: Green Light for the Construction**





# National Radioisotope Program



Sept. 27, 2016 in Seoul

*Thank You !!!*