

Beam Commissioning of 100-MeV KOMAC Linac

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for KOMAC accelerator team**

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KOMAC, KAERI**



KOMAC
Korea Multi-Purpose Accelerator Complex
양성자속기연구센터

KOrea Multi-purpose Accelerator Complex

- Facility Introduction
- 100-MeV Linac
- Operation Status
- Beam Service Status
- Plan for Beam Power Increase
- Summary

KOMAC Site : Gyeong-ju

K O M A C
Korea Multi-purpose Accelerator Complex
양성자가속기연구센터

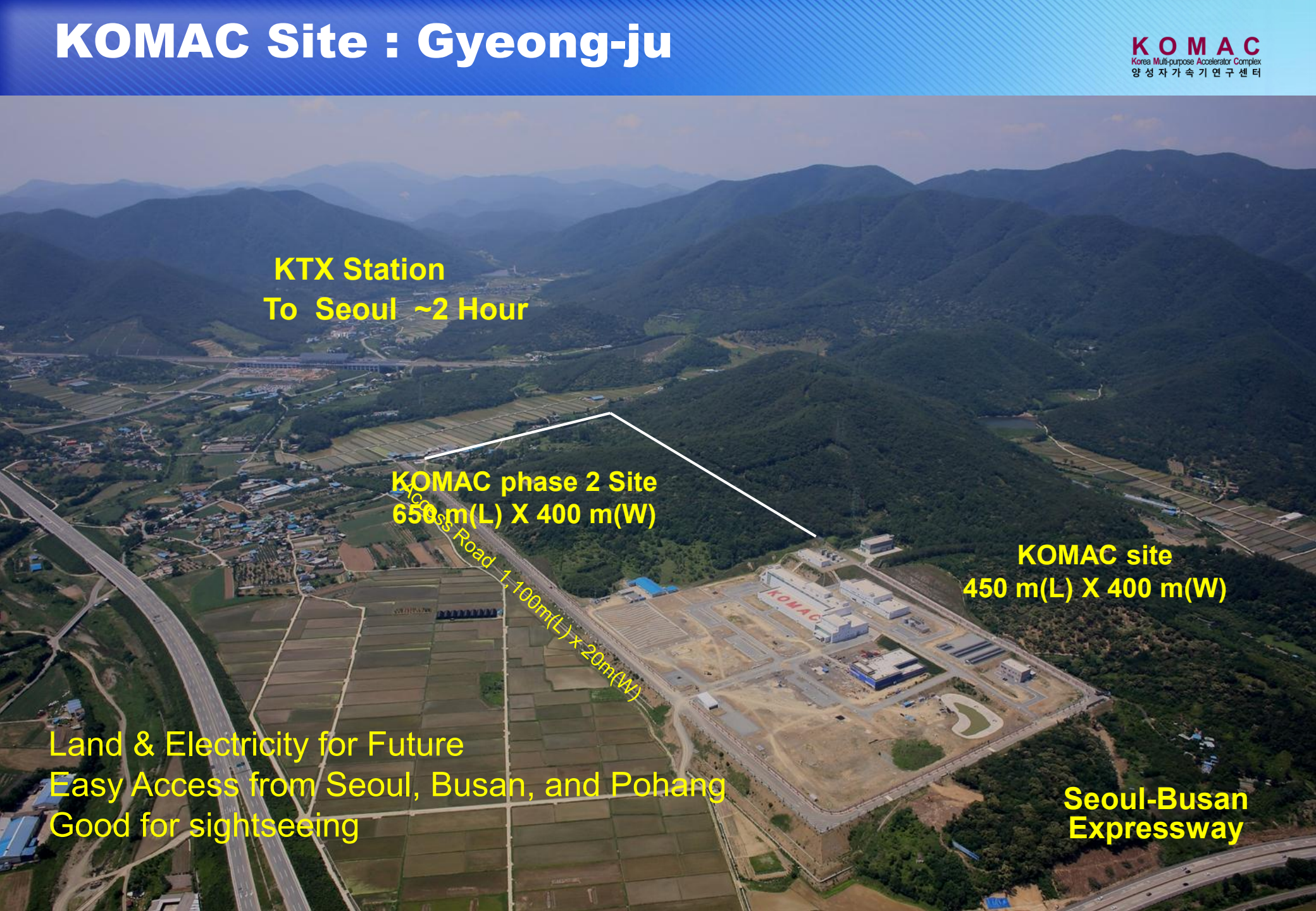
KTJ Station
To Seoul ~2 Hour

KOMAC phase 2 Site
650 m(L) X 400 m(W)

KOMAC site
450 m(L) X 400 m(W)

Land & Electricity for Future
Easy Access from Seoul, Busan, and Pohang
Good for sightseeing

Seoul-Busan
Expressway



Main Facility

K O M A C
Korea Multi-purpose Accelerator Complex
양성자가속기연구센터



▪ Beam application building :
Construction to be completed
in December 2014

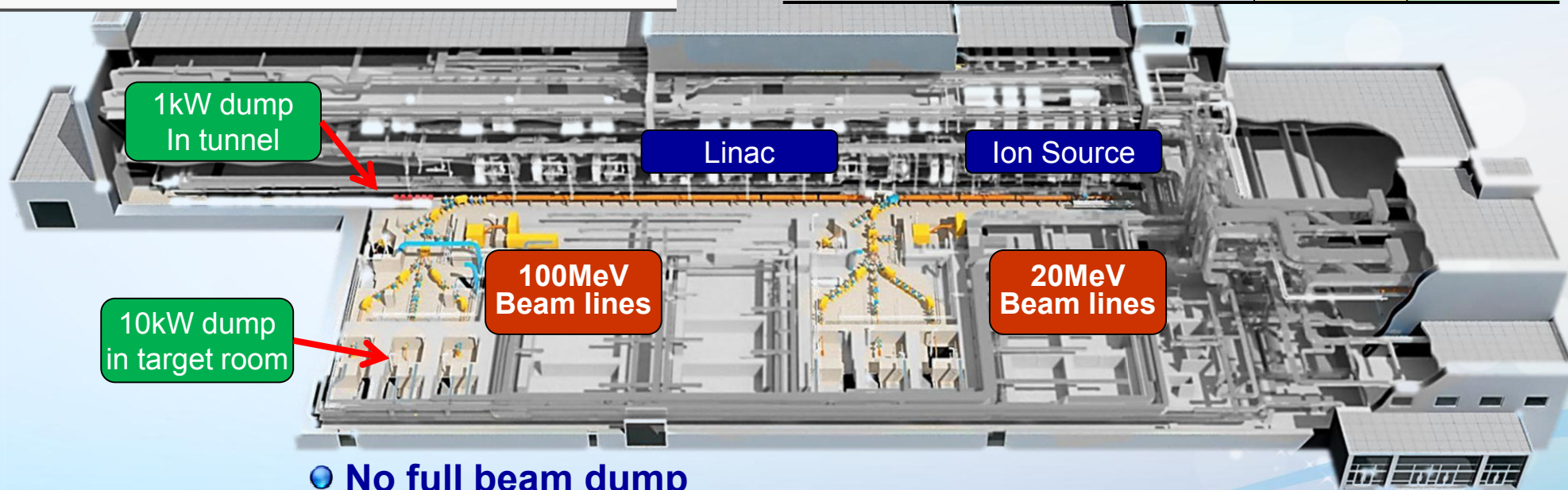
- Site: 180,000 m²
- Building : 39,000 m²
- Electricity : 154 kV, 20 MVA

Linac and Beam Lines

Features of KOMAC 100MeV linac

- 50-keV Injector (Ion source + LEBT)
- 3-MeV RFQ (4-vane type)
- 20 & 100-MeV DTL
- RF Frequency : 350 MHz
- Beam Extractions at 20 or 100 MeV
- 5 Beamlines for 20 MeV & 100 MeV

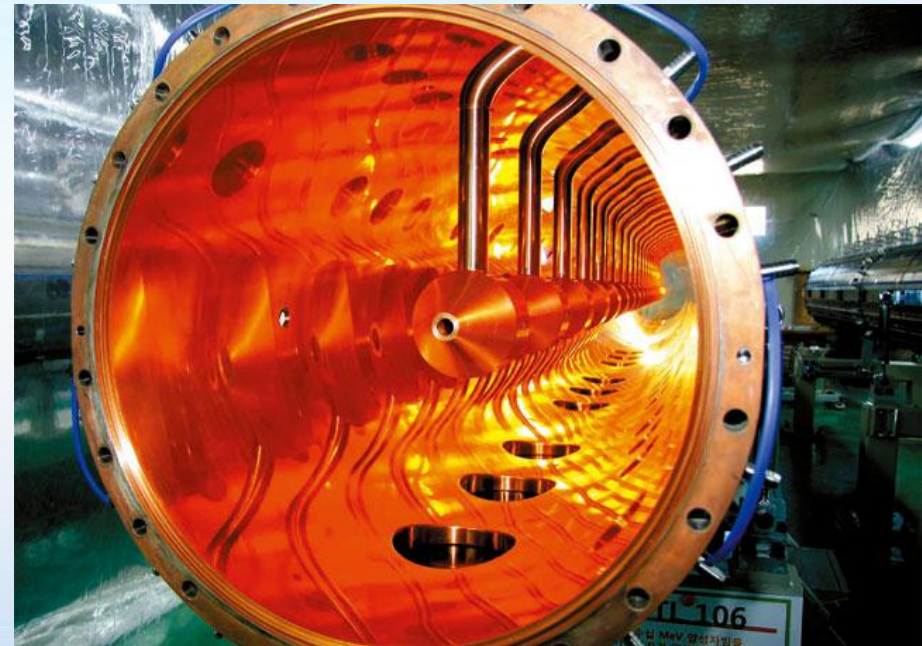
Output Energy (MeV)	20	100
Max. Peak Beam Current (mA)	1 ~ 20	1 ~ 20
Max. Beam Duty (%)	24	8
Avg. Beam Current (mA)	0.1 ~ 4.8	0.1 ~ 1.6
Pulse Length (ms)	0.1 ~ 2	0.1 ~ 1.33
Max. Repetition Rate (Hz)	120	60
Max. Avg. Beam Power (kW)	96	160



- No full beam dump
- Beam power increase goes with target room preparation

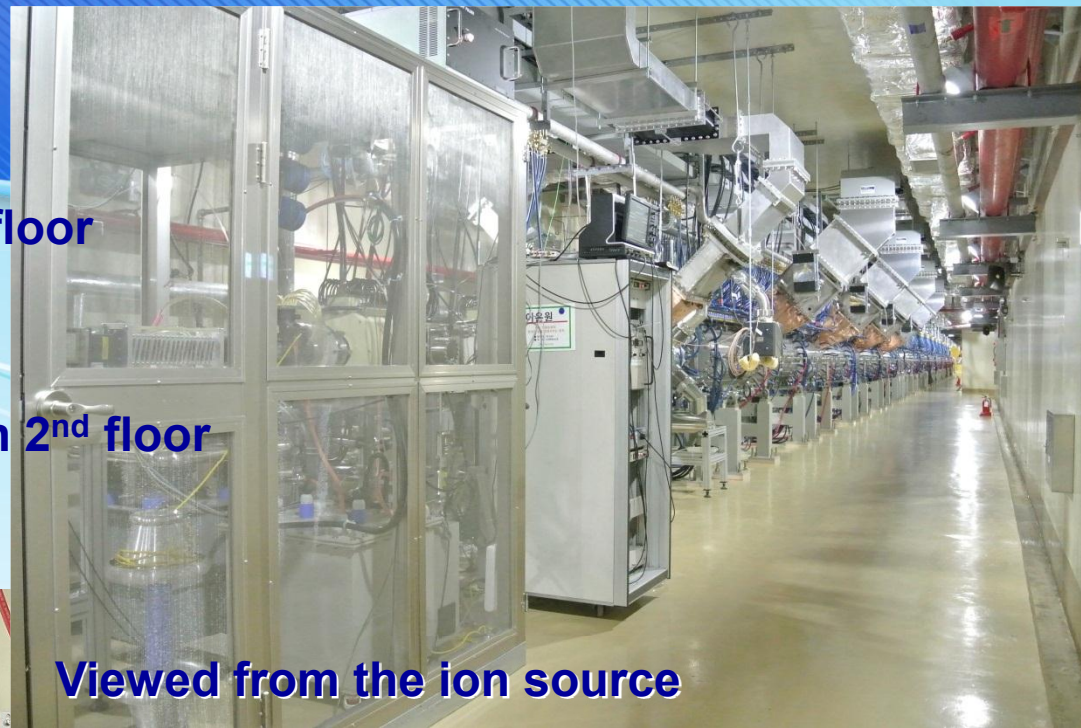
- Developed proton linac technologies over the past 10 years
 - Microwave ion source
 - RFQ
 - DTL
 - Elliptical SC cavity
 - LLRF and EPICS control system
- Built KOMAC 100-MeV proton linac of our own design with the technologies

KOMAC DTL

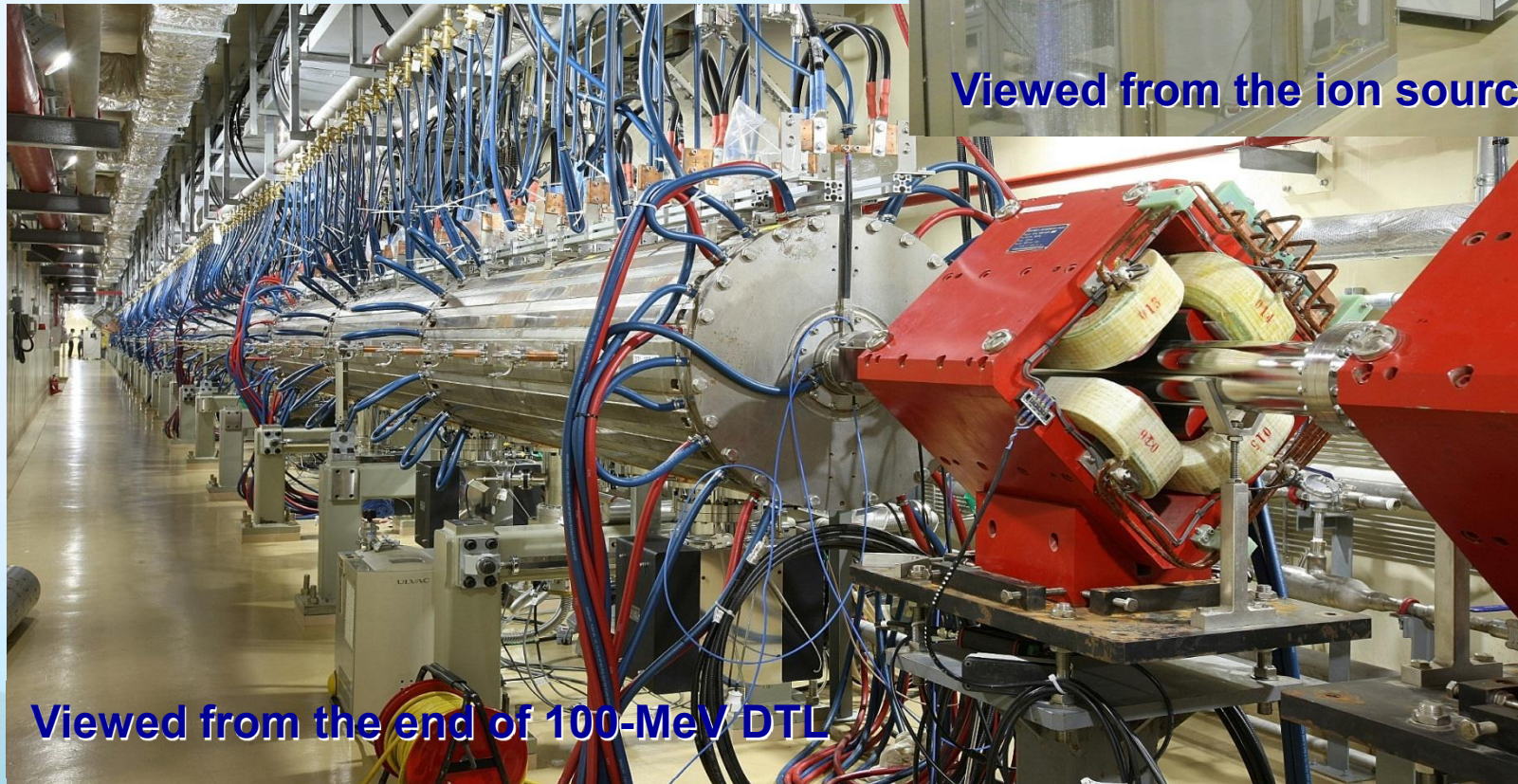


100-MeV Linac

- Linac and beam lines : installed in 1st floor
- Tunnel : 100 m
- 100-MeV linac : 75 m
- HPRF and cooling system : installed in 2nd floor



Viewed from the ion source



Viewed from the end of 100-MeV DTL

Target Room

- 2 beam lines and 2 target rooms are installed and in services
 - 1 for 20 MeV, 1 for 100 MeV
- Irradiation: in air through 0.5-mm Al-Be alloy window

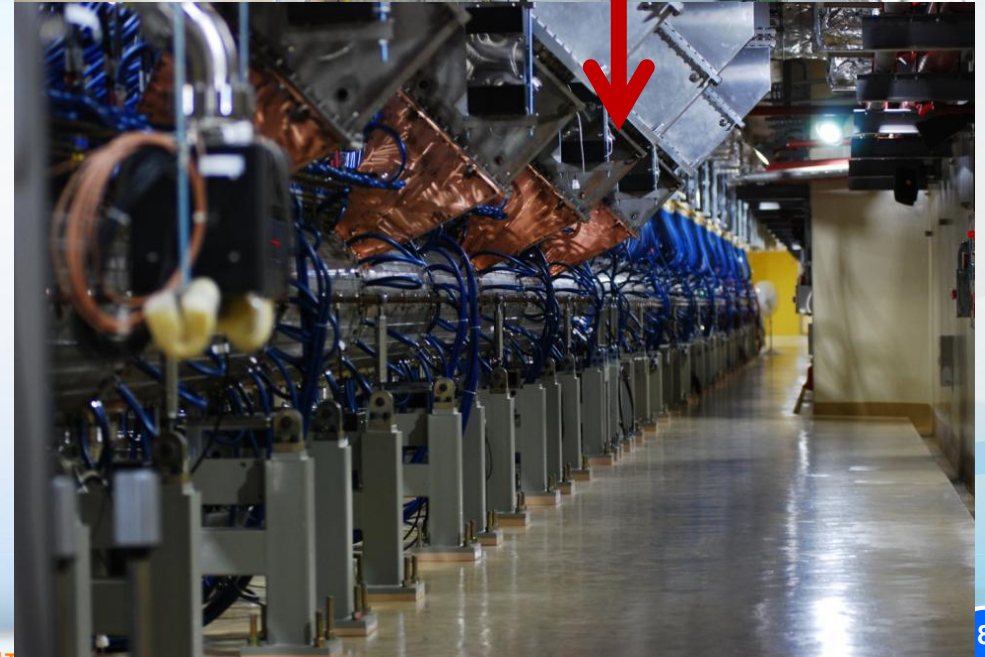
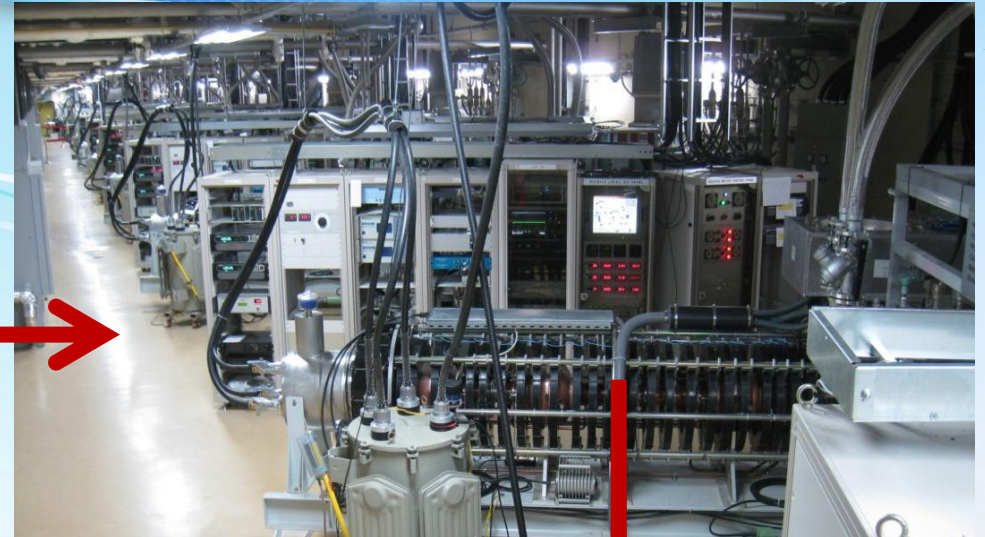


Beam line



Target room

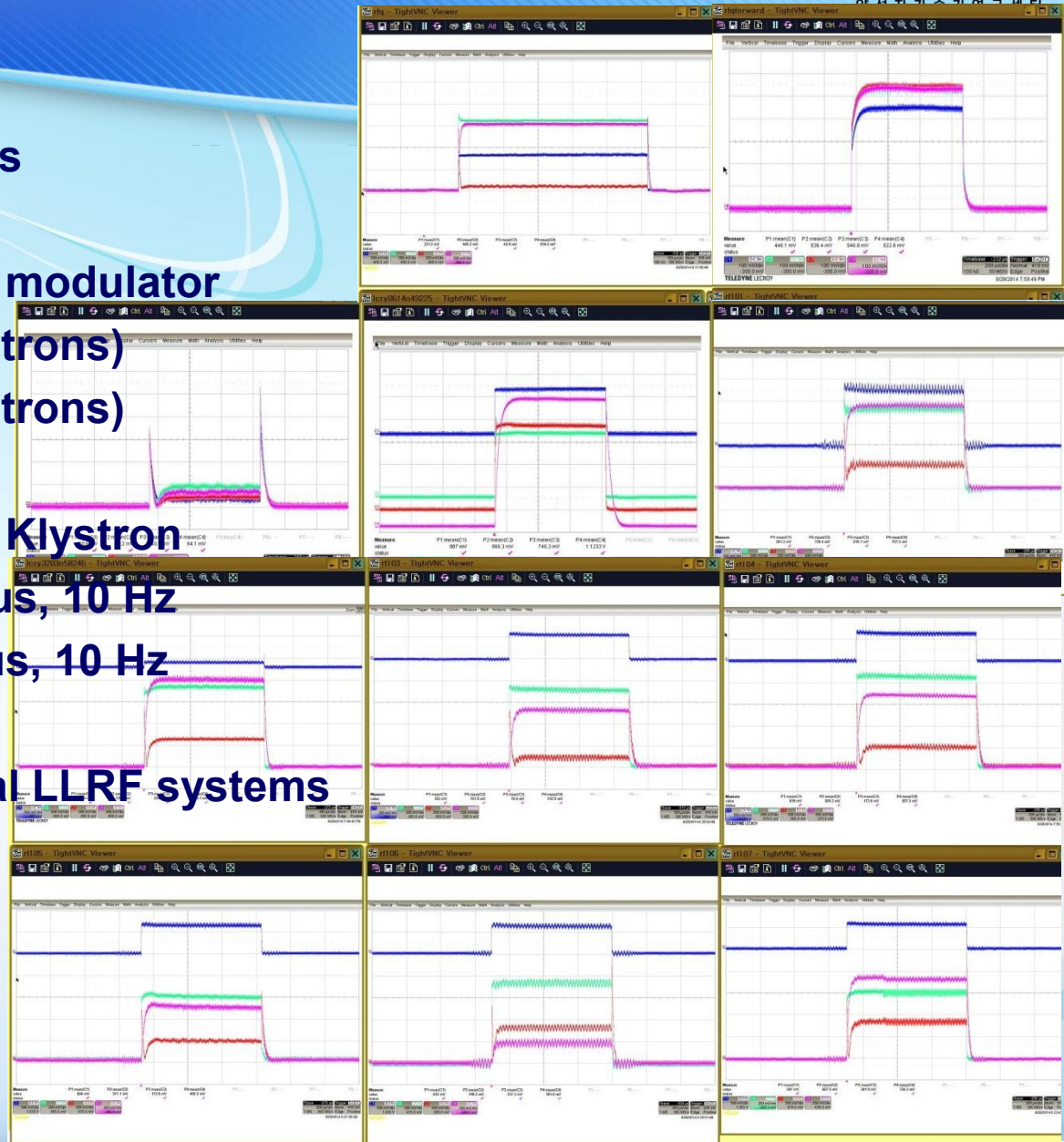
RF Power Conditioning



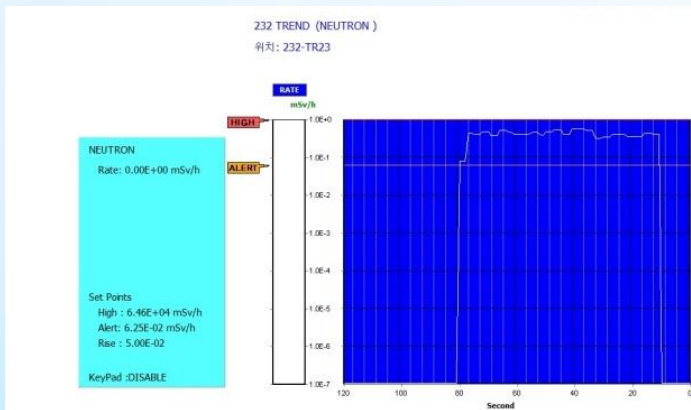
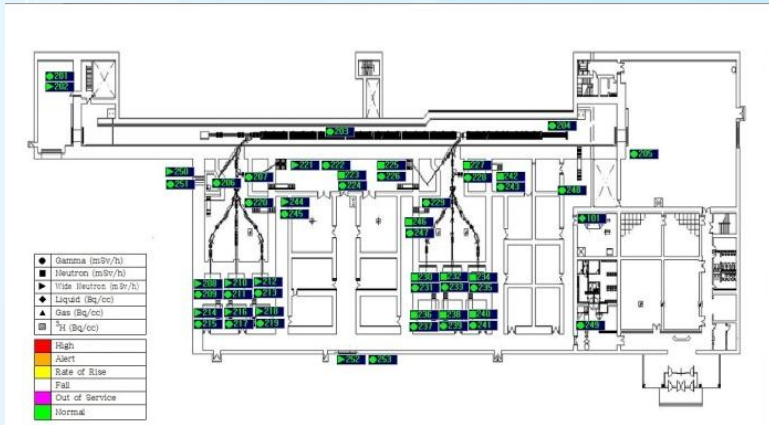
- Performed high-power conditioning with installation of the components

RF Power Conditioning

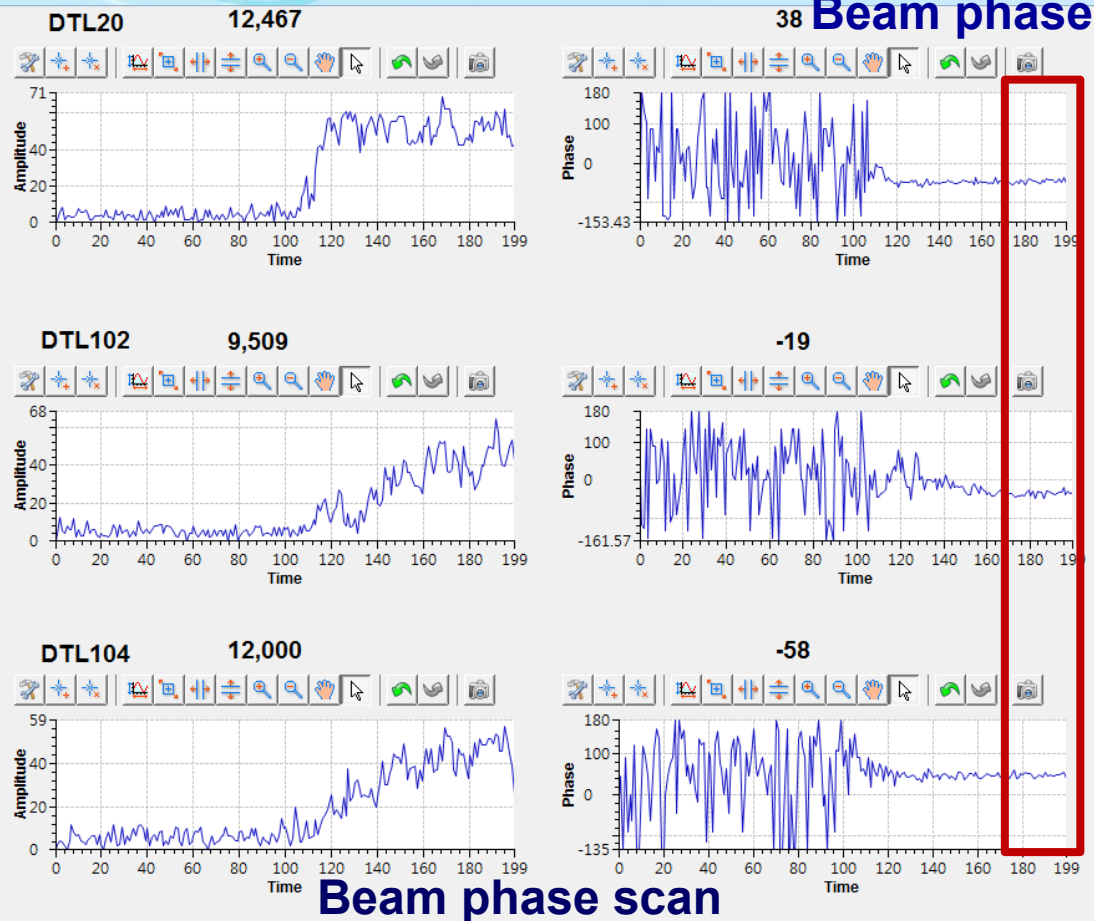
- Number of HPRF systems : 9 sets
- Nominal operation conditions of modulator
 - 5 MW @ 1 ms, 10 Hz (for 2 klystrons)
 - 7 MW @ 1 ms, 10 Hz (for 3 klystrons)
- Nominal operation conditions of Klystron
 - RFQ Klystron : 500 kW @ 550 μ s, 10 Hz
 - DTL Klystron : 1.2 MW @ 700 μ s, 10 Hz
- RF system is controlled by digital LLRF systems



- RF set point tuning was performed by
 - Monitoring radiation along the linac and in the target room
 - Scanning beam phase by BPM



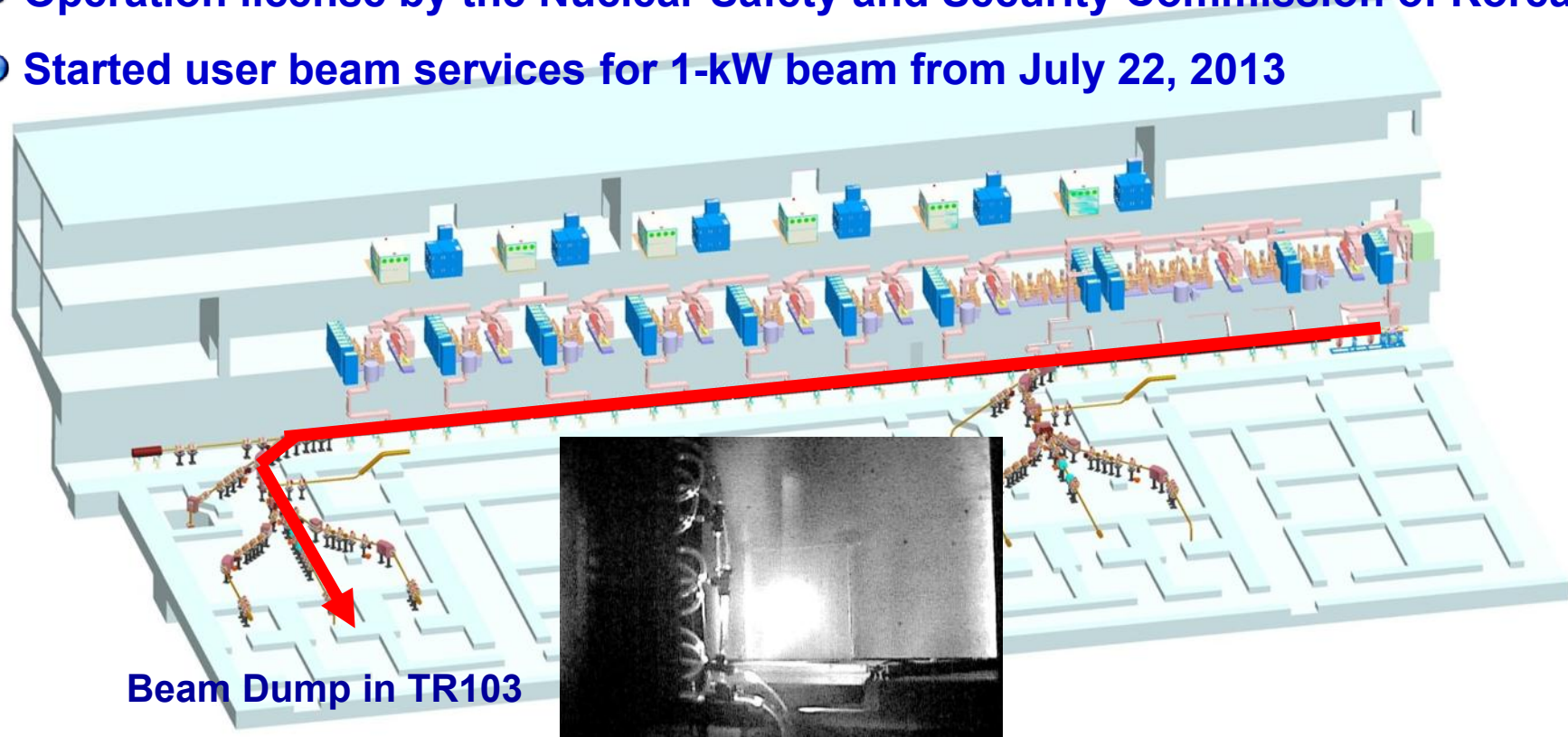
Radiation monitoring



Beam phase scan

Commissioning in 2013

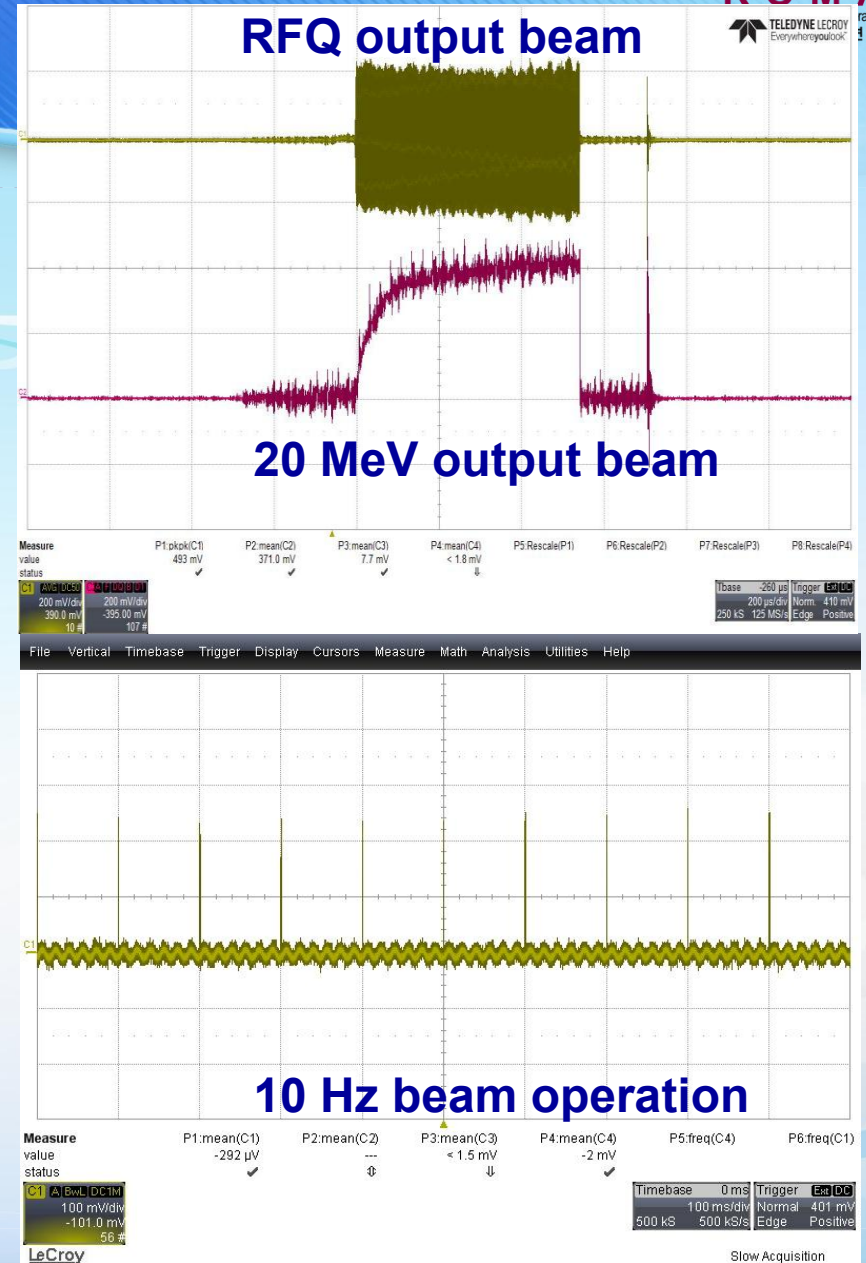
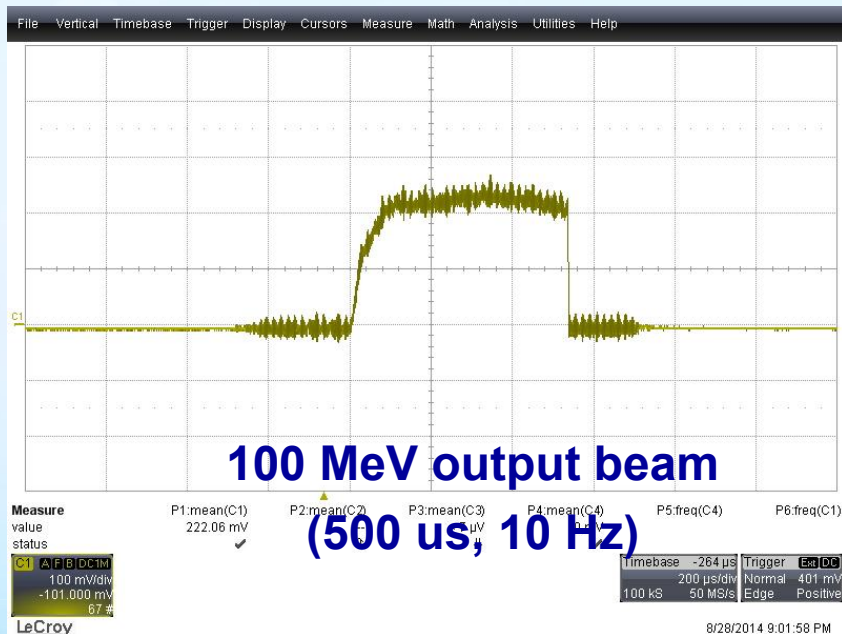
- Commissioning goal in 2013 : 1-kW proton beam into TR103
 - Delivered 1-kW beam into TR103 in July, 2013
 - Checked beam energy change by turning off 7 DTL tanks one-by-one
- Operation license by the Nuclear Safety and Security Commission of Korea
- Started user beam services for 1-kW beam from July 22, 2013



Beam Dump in TR103

Commissioning in 2014

- Goal : 10-kW beam @ 100 MeV
- Achieved 10-kW beam in August 2014:
550us, 10Hz
- Normal operation with 10-kW is to start with revision of operation license

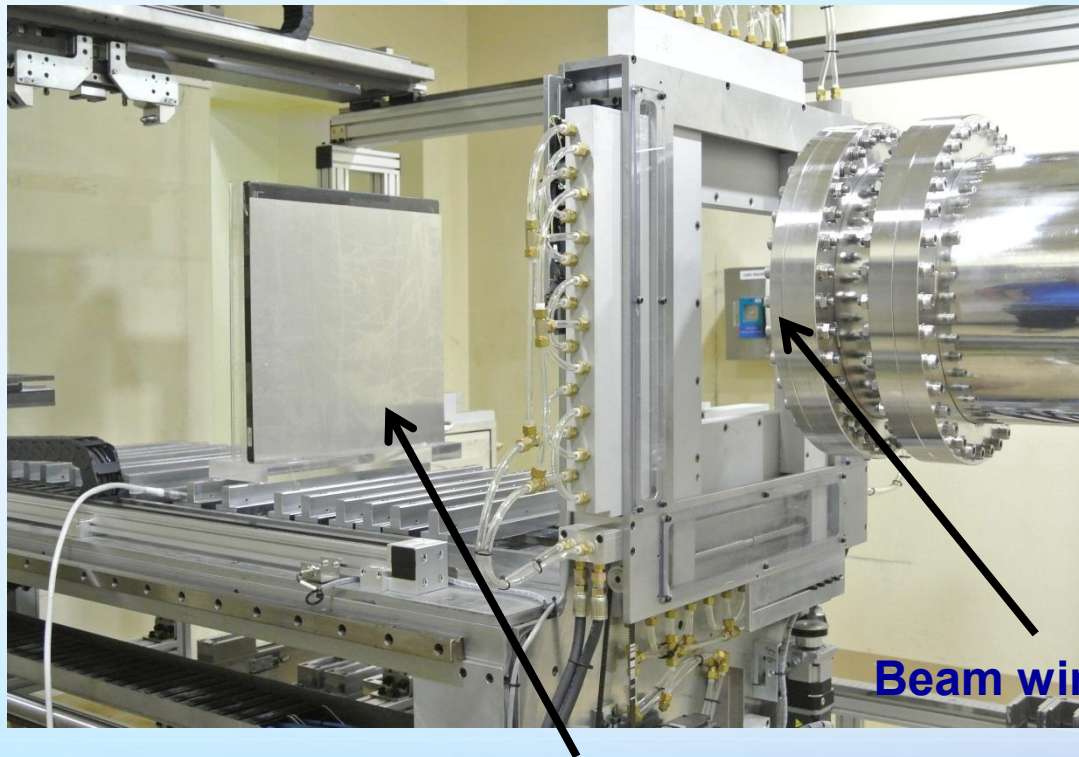


Beam Profile at Target Room

- User requirement for beam size: max. 300-mm diameter
- Monitoring beam profile
 - Flat panel detector with CsI scintillator
 - Panel size 430 mm × 430 mm, pixel size 139 μm

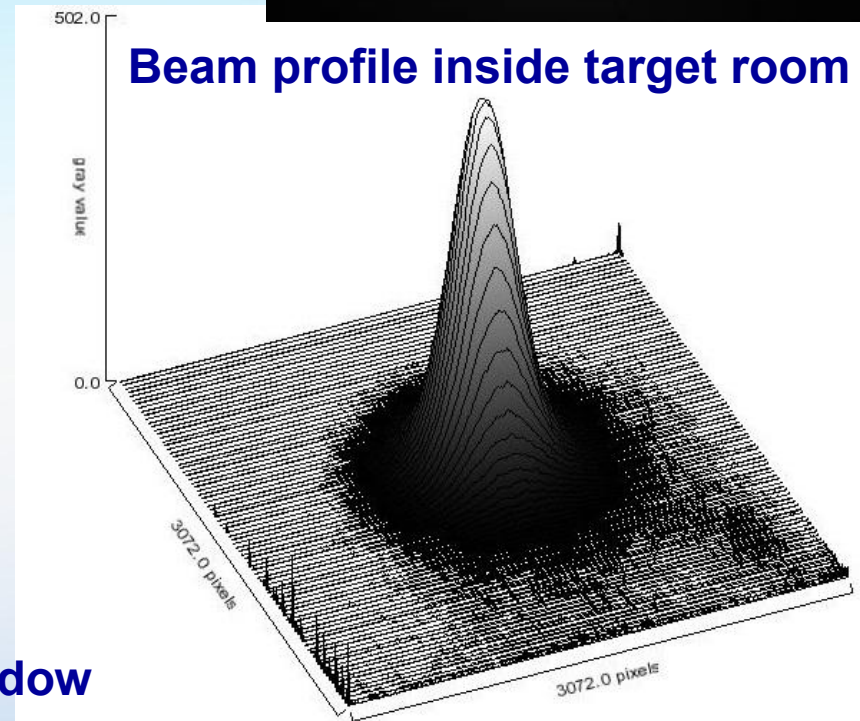


Beam profile inside target room



Beam window

Flat panel detector



Beam rms radius : 25 mm

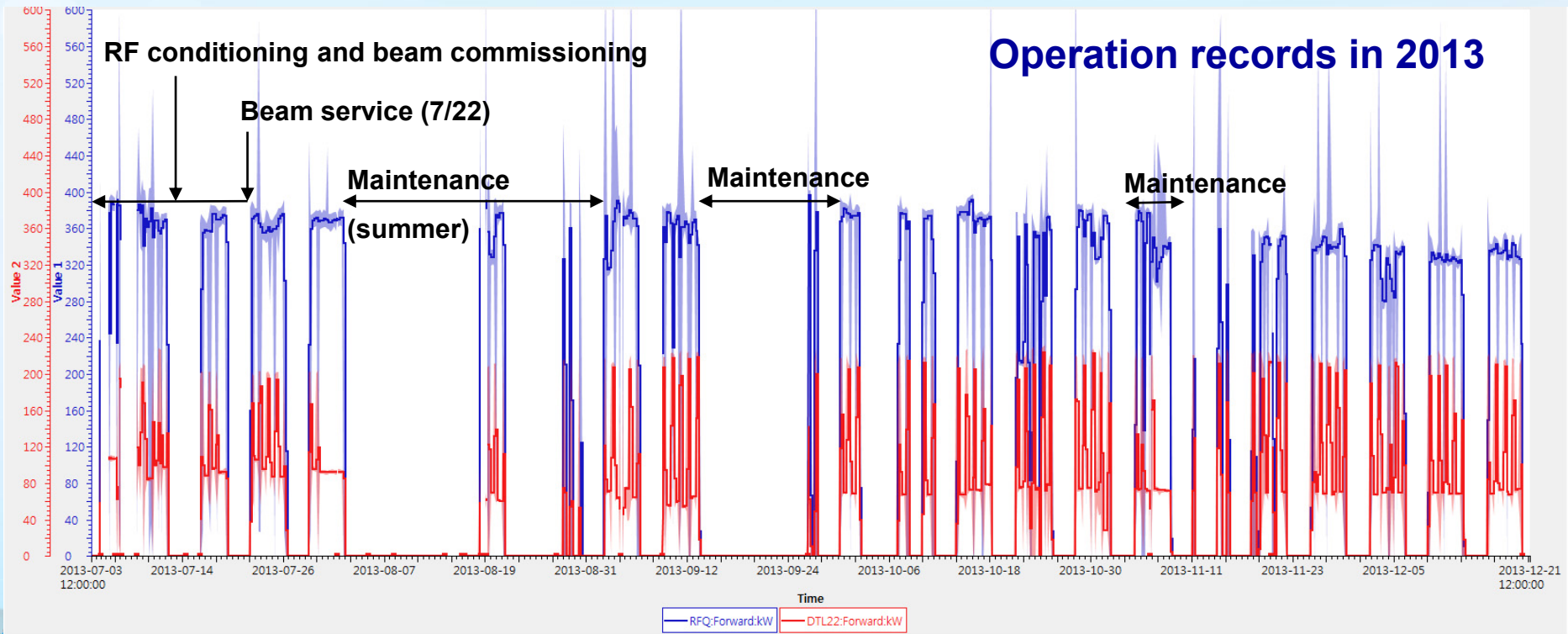
Control Room & Operator

- **EPICS based control system**
 - Accelerator / Utilities / PSIS / RMS are controlled in the main control room
- **Operators : 2 for accelerator, 2 for beam service in target room**



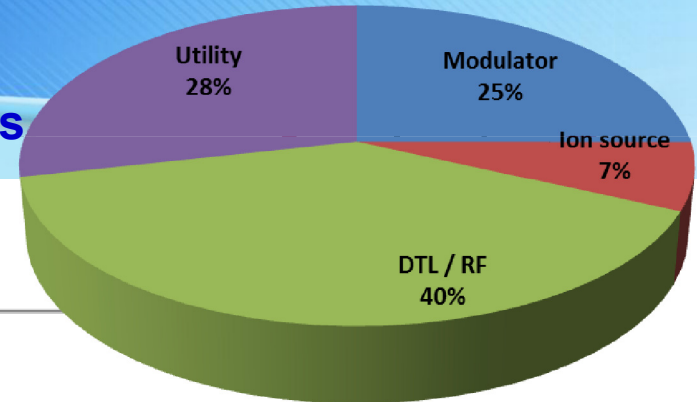
One Year Operation (July 2013 ~ June 2014)

- Operation plan : Weekly based
- Beam service : Monday ~ Friday
- Operation statistics (accumulated)
 - Operation : 3,772 hours (FY 2013 : 2,290 hours / FY 2014 : 1,482 hours)
 - Beam service : 798.4 hours (FY 2013 : 432.7 hours / FY 2014 : 365.7 hours)
 - Availability : FY 2013 : 82.0% , FY 2014 : 91.5 %

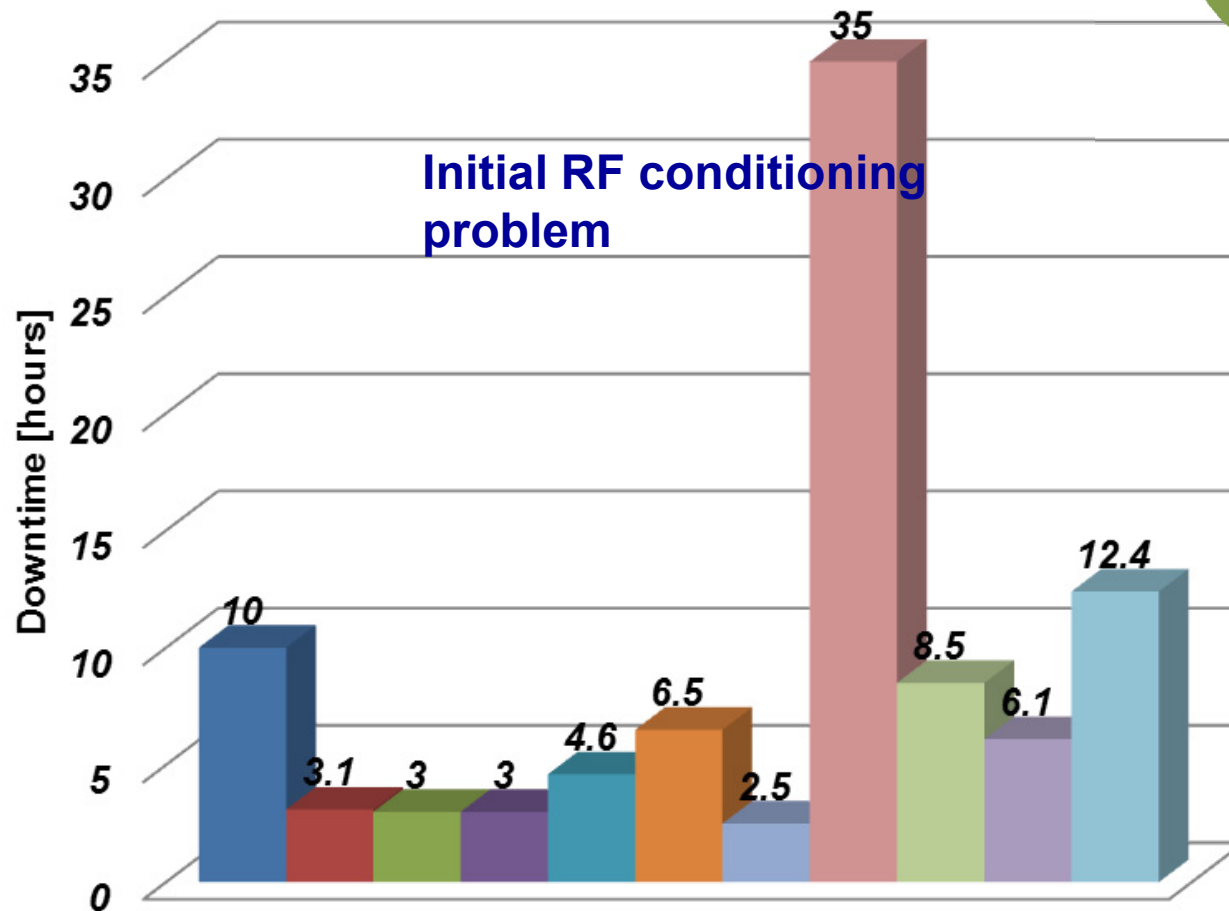


Downtime Statistics at 2013

● Accumulated down time in beam service : 94.7 hours

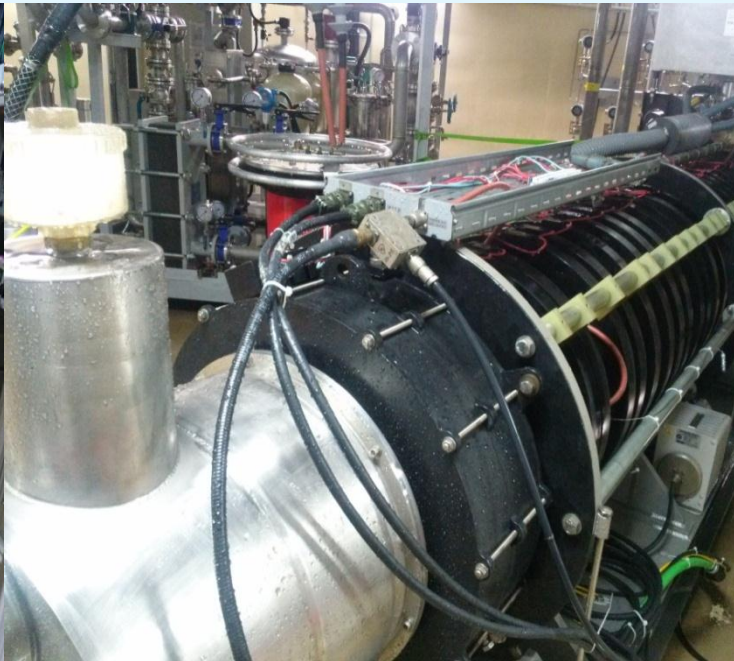
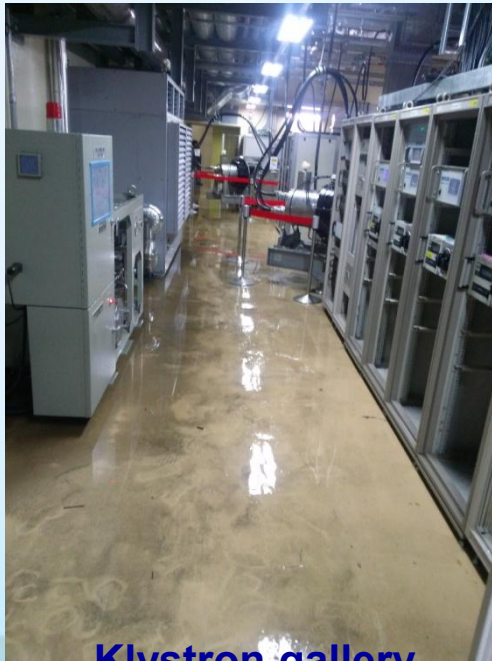


Downtime in 2013



- Moulator IGBT blast
- MPS interlock
- Moulator controller malfunction
- Klystron magnet fault
- Moulator Oil pump failure
- HV fault at Ion source
- LLRF controller fault
- RF arcing at Power coupler
- Electrical failure
- Shielding door failure
- PSIS PLC fault

- Although completed commissioning of the utility, several troubles
- Examples
 - Watered electronics in klystron gallery due to unexpected triggering the fire extinguisher (Shut down vacuum, RF and control system)
 - Abnormal stopping cooling pump caused by momentary electrical power failure
 - Tripped off vacuum system due to improper grounding



Issue : Modulator

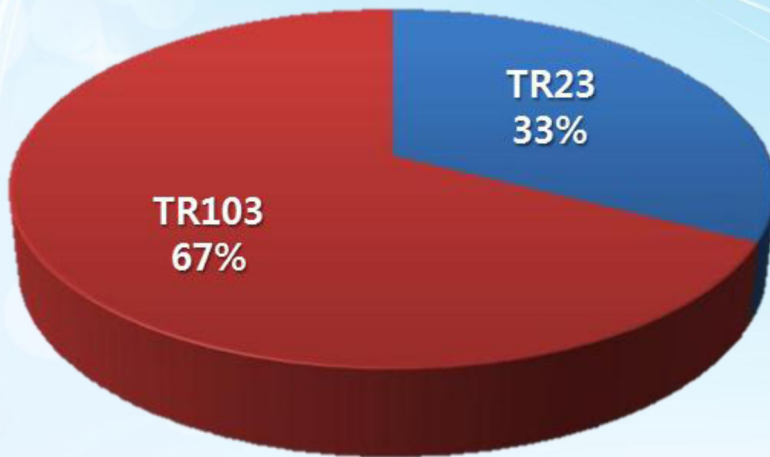
- Major issues
 - IGBT blasting at low duty 500 us, 2 Hz
 - Controller failure
 - SCR firing circuit failure
- Minor issues
 - PLC logic
 - IGBT over-current set value
 - SCR control circuit jumper
 - Oil pump hose and so on
- In our case, insufficient spare parts lead to long downtime



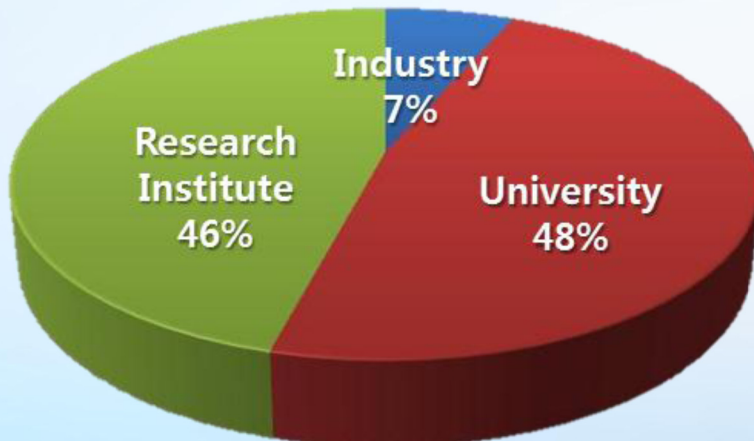
M02 A phase IGBT blasting

Beam Service Statistics (2013~2014)

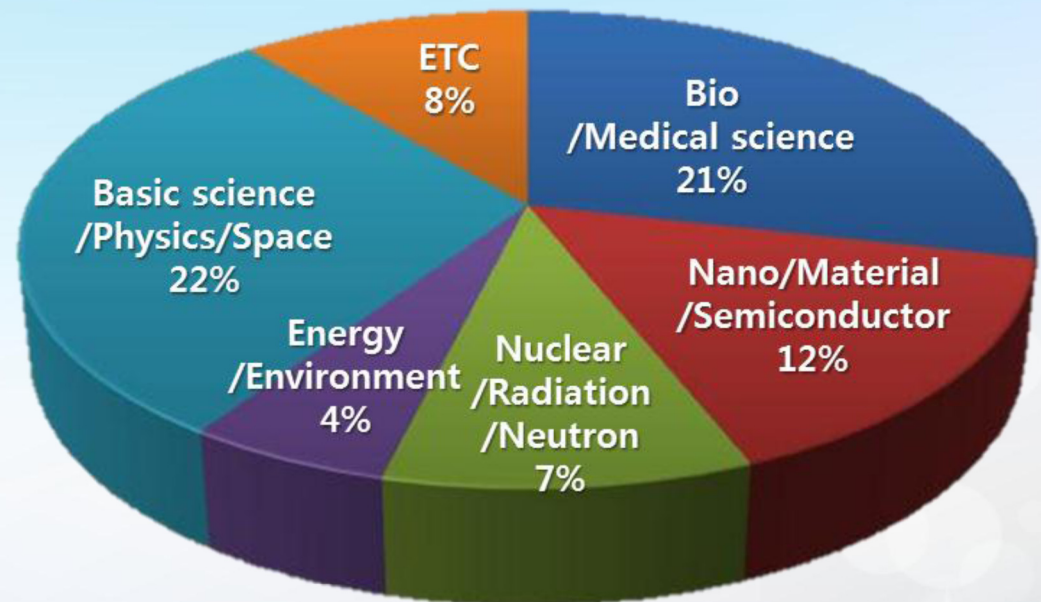
- Total number of charges : 1,641 (2013 : 937 charges / 2014 : 704 charges)



100MeV / 20MeV users



Users in institutions



Users in R&D fields

Plan for beam power increase

- **Plan for RI production at KOMAC**
 - Major RI: Sr-82, Cu-67, etc.
 - Beam requirements
 - Sr-82 : 100 MeV, 60 kW, 4 weeks on Rb target
 - Cu-67 : 100MeV, 60 kW, 2 days on Zn target
 - To start RI production target room construction in 2015
- **100 kW beam commissioning**
 - In 2016, using RI target room and dummy target
- **Operation**
 - Day-time for user beam experiments
 - Night-time for RI production

- **Operation in 2013**
 - Successfully commissioned 100-MeV linac with 1 kW
 - Licensed normal operation (Nuclear Safety and Security Commission of Korea)
 - Started user beam service in July.
- **Operation in 2014**
 - Increased beam power to 10-kW
 - Continued user beam service with improved beam conditions
- **Near-term plan**
 - Installation of beam line and target room for RI production
 - 100-kW beam test
- **Long-term plan**
 - Linac upgrade to 1GeV for spallation neutron source

Thank you