

ICALEPCS 2015, Oct. 17-23, 2015, Melbourne, Australia

Machine Protection System (MPS) for KOMAC 100-MeV Proton Linac

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**October 20, 2015
KOMAC, KAERI**



KOMAC
Korea Multi-Purpose Accelerator Complex
양성자속기연구센터

KOrea Multi-purpose Accelerator Complex

- About KOMAC
- Operation Status
- Interlock System
- Summary

KOMAC Site : Gyeongju

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

KTX Station
To Seoul ~2 Hour



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

Access Road 1-100m(L) x 20m(W)

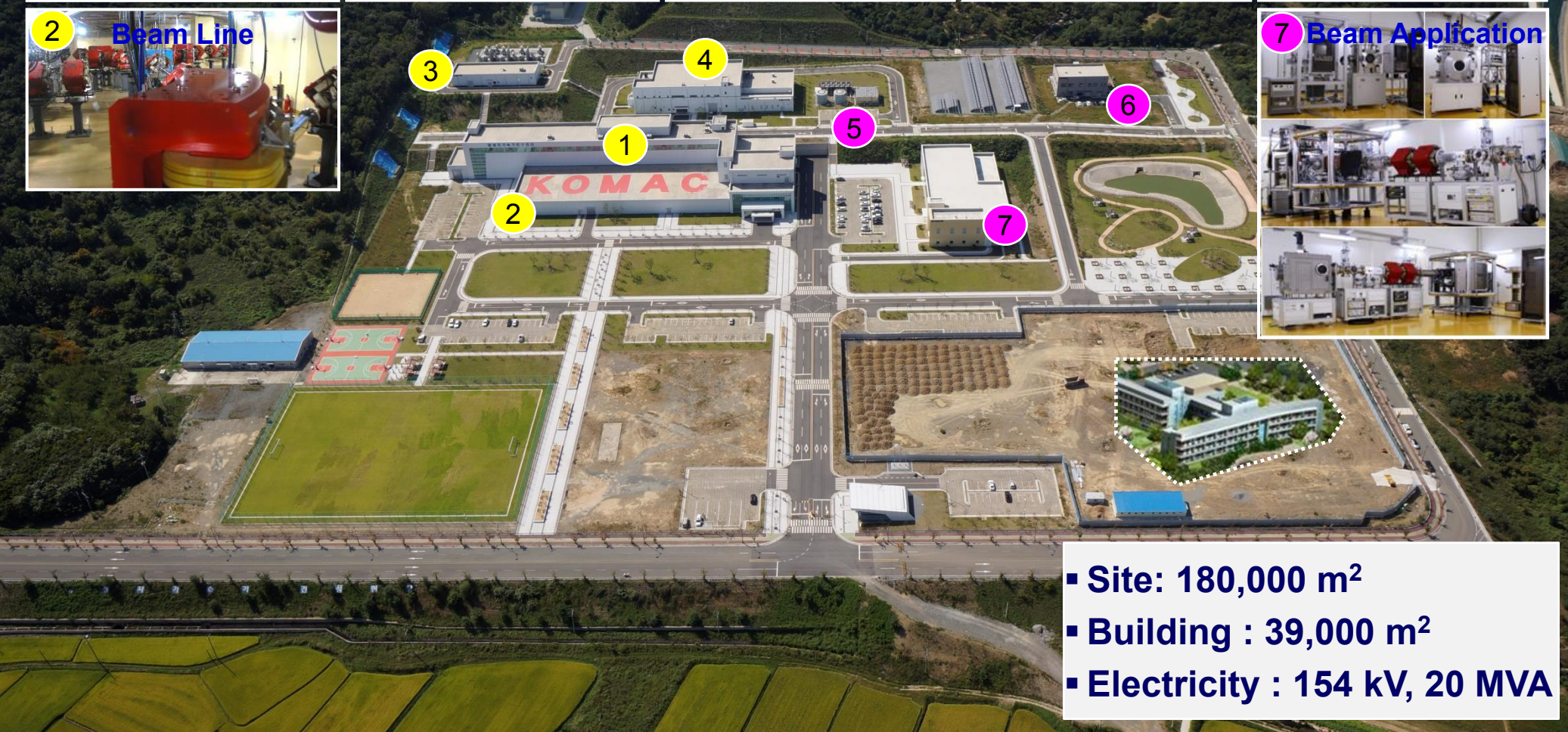
KOMAC site
450 m(L) X 400 m(W)

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

Seoul-Busan
Expressway

Main Facility of KOMAC

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



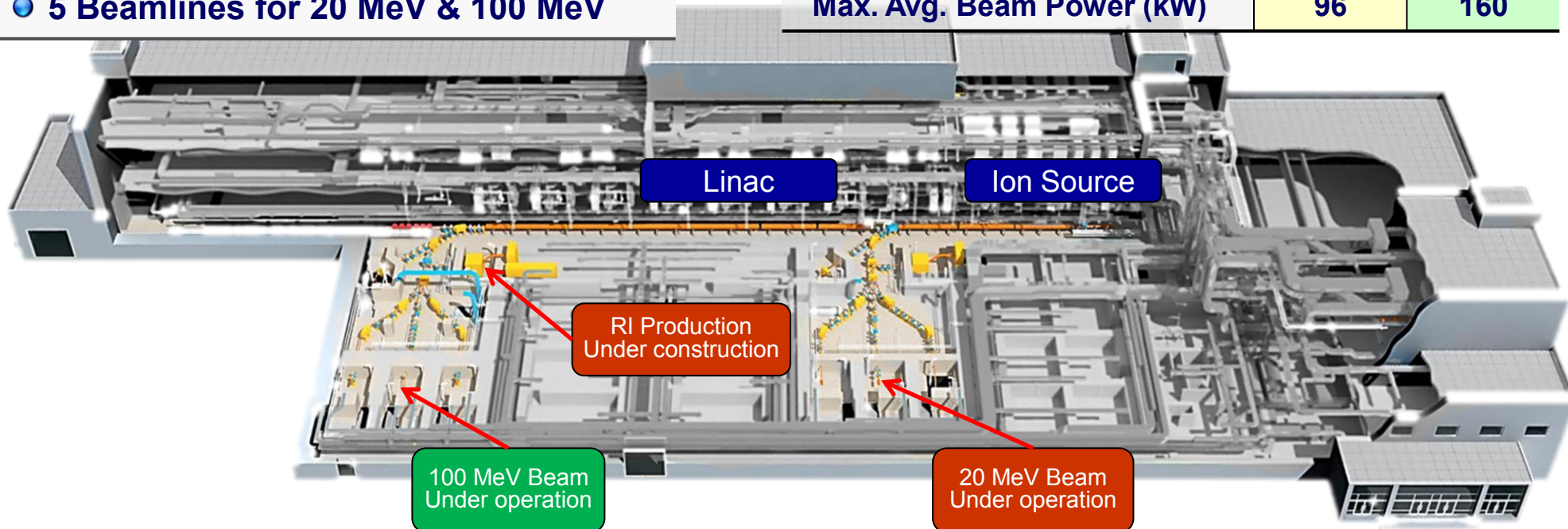
- Site: 180,000 m²
- Building : 39,000 m²
- Electricity : 154 kV, 20 MVA

Linac and Beam Lines

Features of KOMAC 100MeV linac

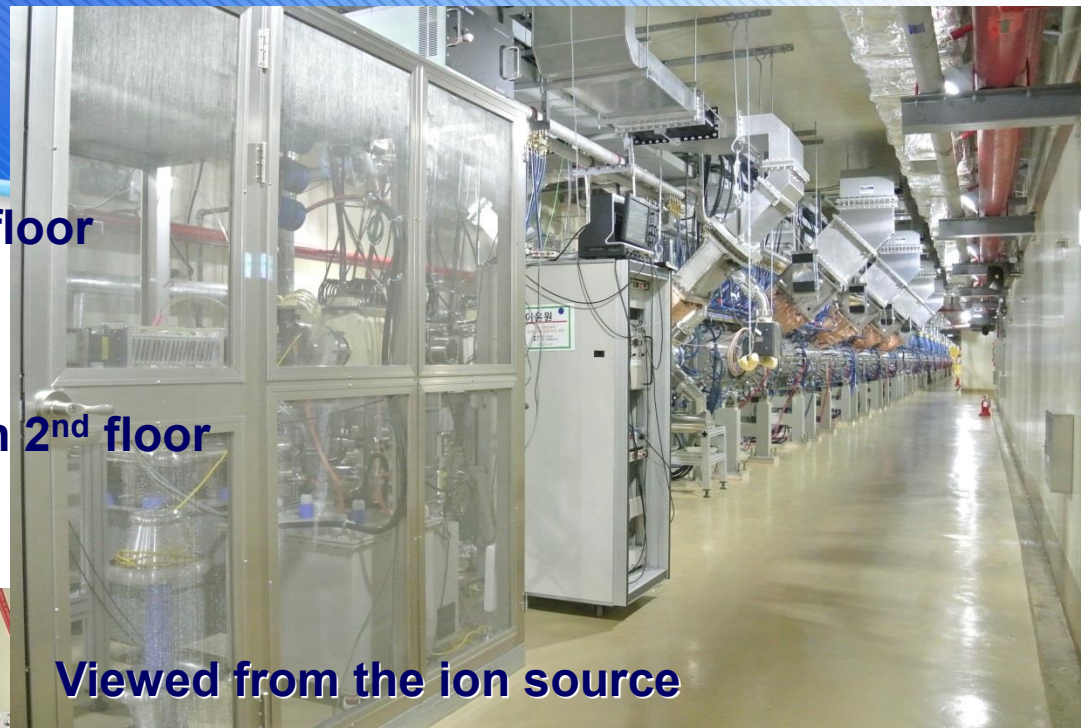
- 50-keV Injector (Ion source + LEBT)
- 3-MeV RFQ (4-vane type)
- 20 & 100-MeV DTL
- RF Frequency : 350 MHz
- Beam Extractions at 20 or 100 MeV
- 5 Beamlines for 20 MeV & 100 MeV

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

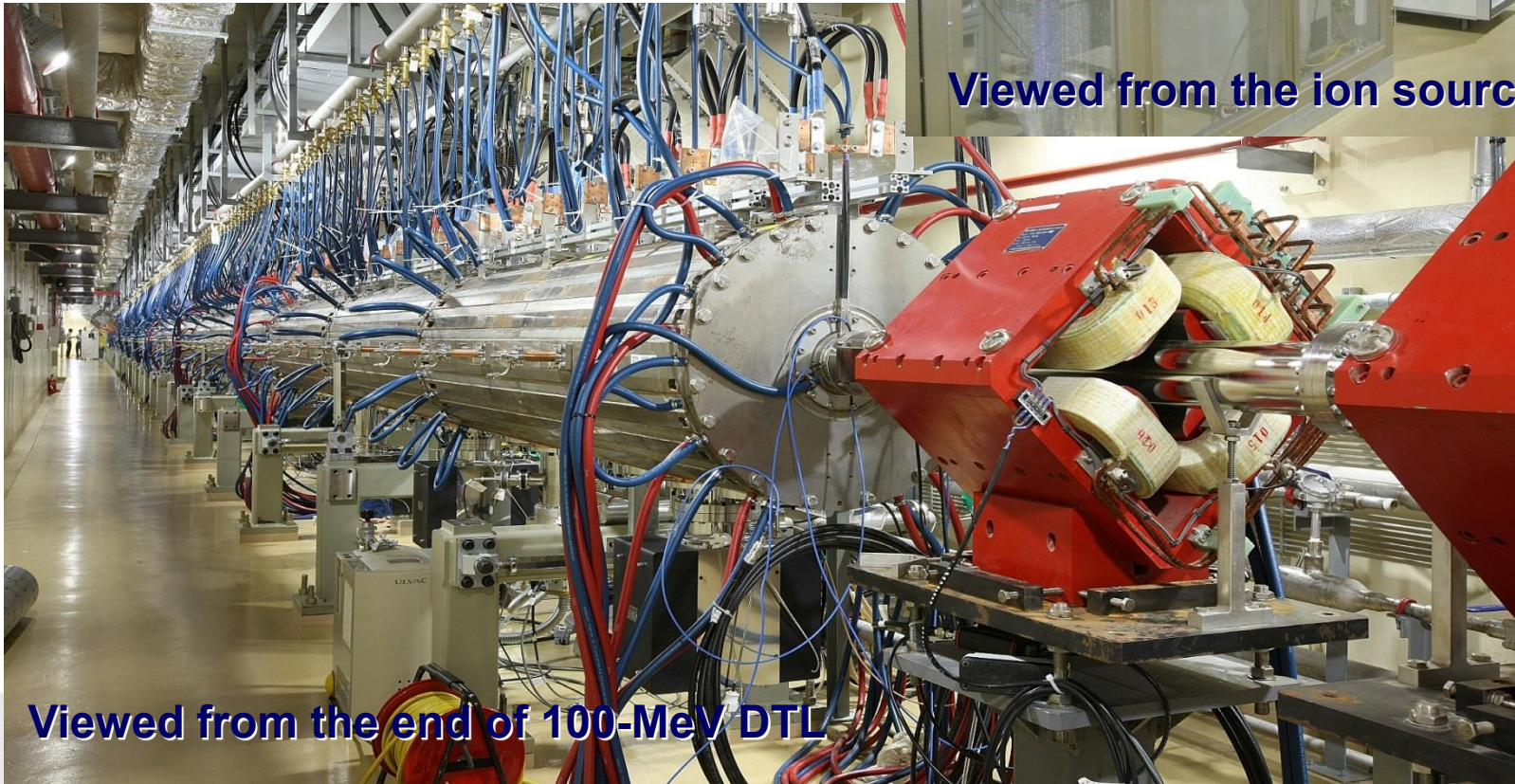


100-MeV Linac

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



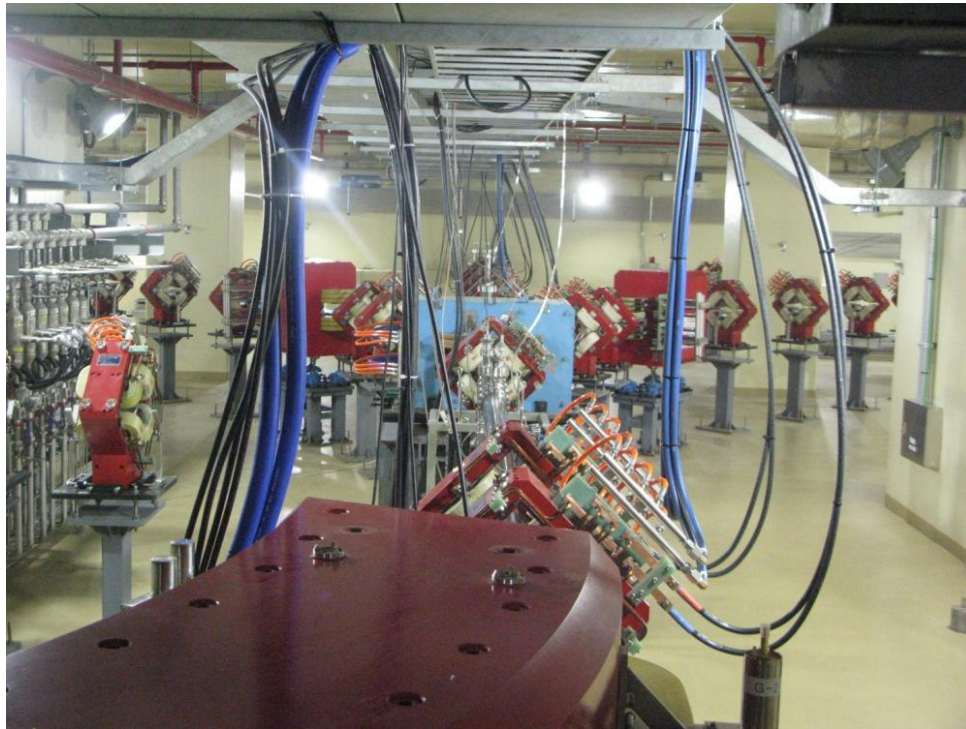
Viewed from the ion source



Viewed from the end of 100-MeV DTL

Target Room

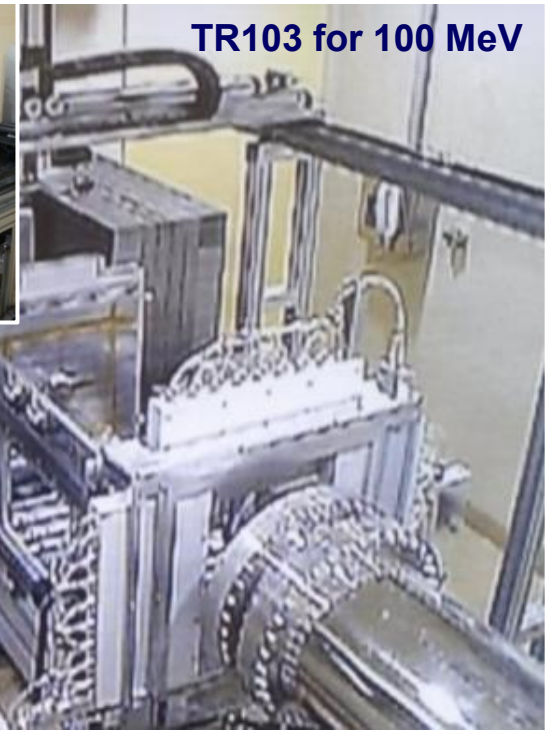
- 2 beam lines and 2 target rooms are installed and in services
 - 1 for 20 MeV, 1 for 100 MeV
- Irradiation: in air through 0.5-mm Al-Be alloy window



Beam line



TR23 for 20 MeV



TR103 for 100 MeV

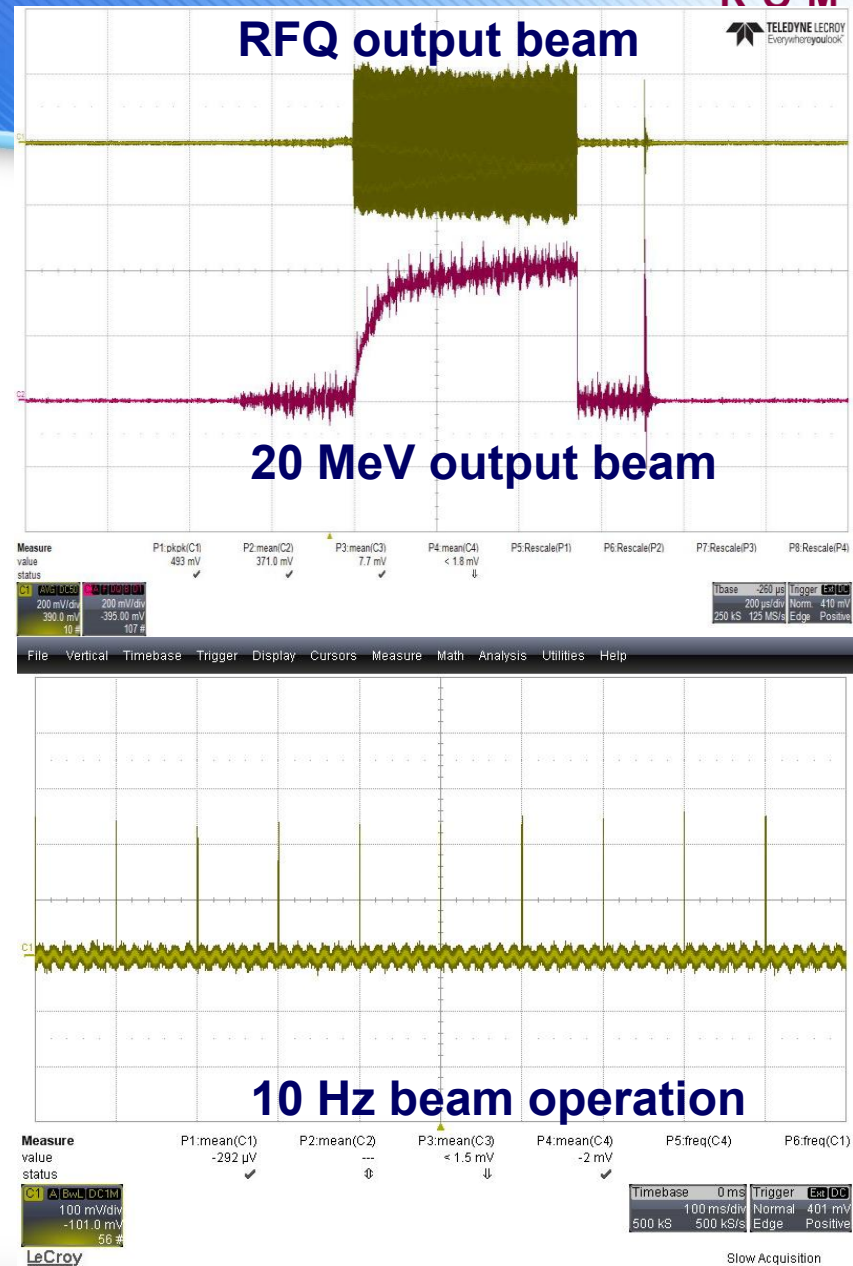
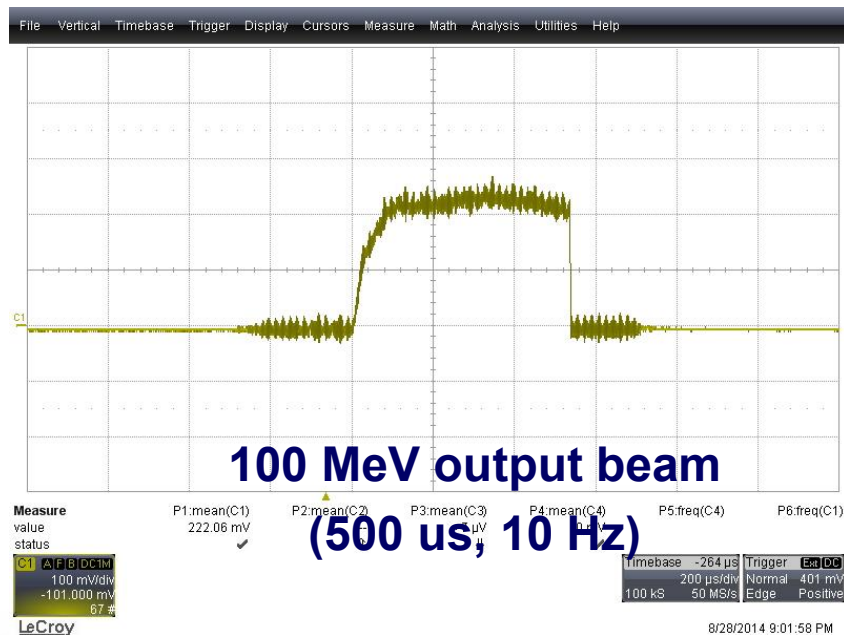
Target room

- 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



Beam Test

- 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

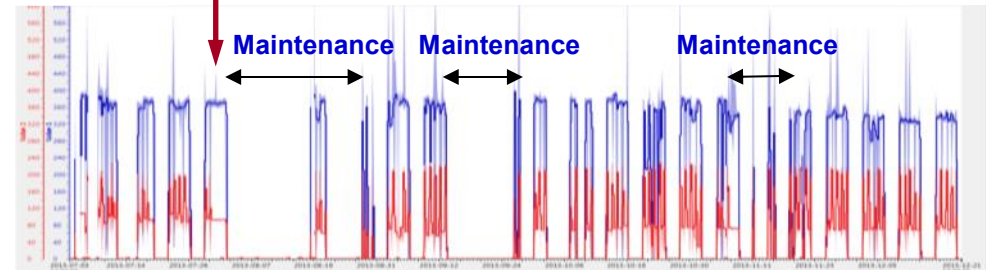


Summary of Operation History

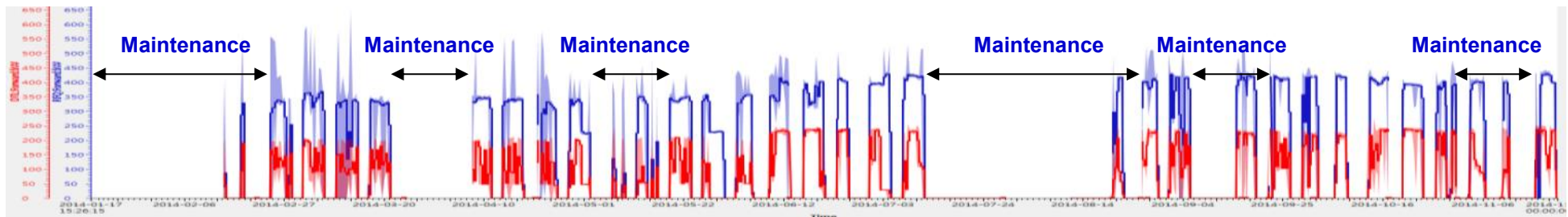
❖ 2013 : Commissioning

- Operation plan : Weekly based
- Beam service : Monday ~ Friday

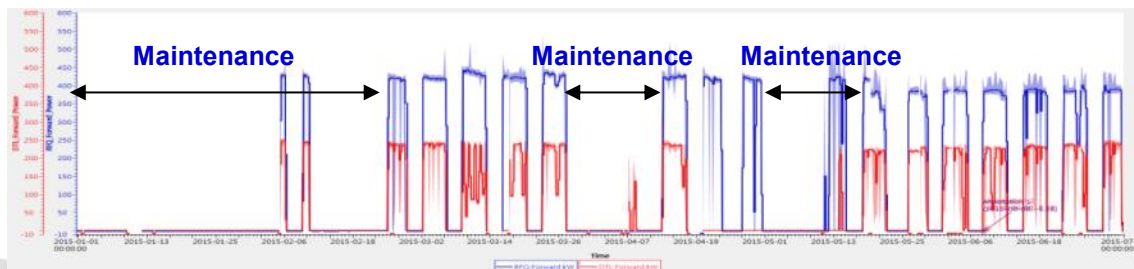
Beam Service (7/22)



❖ 2014 : Normal operation



❖ 2015 first half period

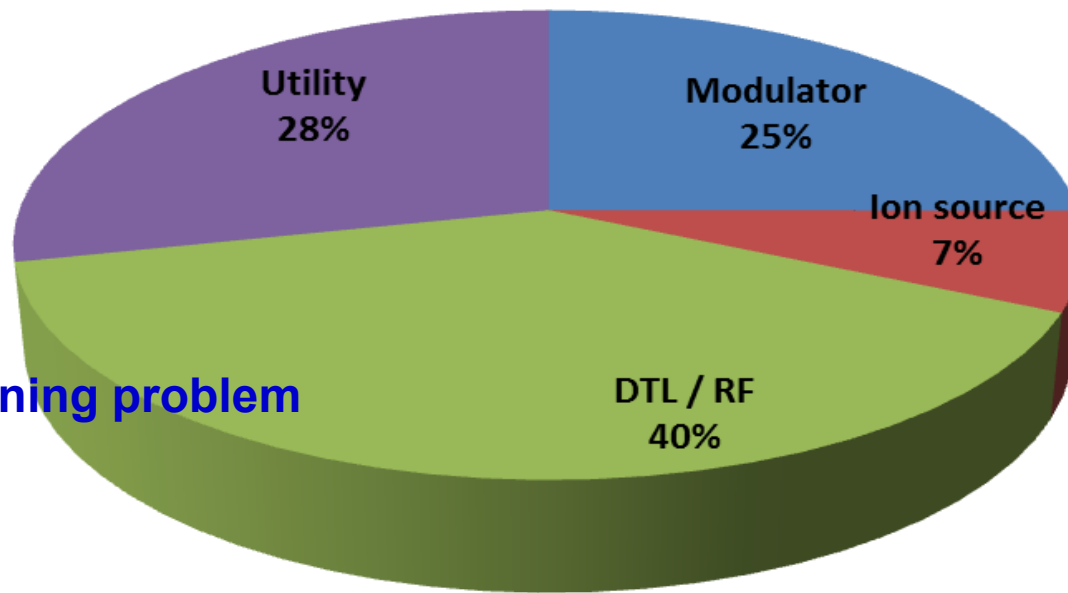


● RF Operation time and Availability

Year	Goal	Achieved
2013	2000 hr / -	2290 hr / 82%
2014	2500 hr / 85%	2863 hr / 86.3%
2015	2800 hr / 88%	1368 hr / 88.4 %

● Down time in beam service : 94.7 hours

- DTL / RF : arcing at the power coupler
- Modulator : IGBT blast, controller malfunction
- Utility : radiation shielding door failure
 - : water leakage from fire extinguishing system
 - : cooling system shut down from electrical power failure



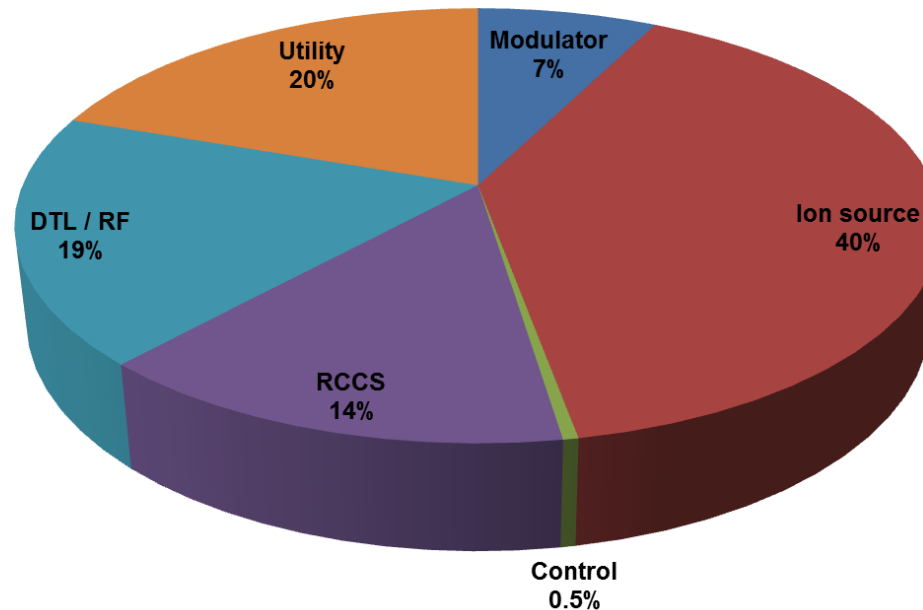
Initial RF conditioning problem

Downtime statistics

● Down time in beam service : 111.2 hours

- Ion source : magnetron fault, HV switch fault, solenoid power supply fault
- DTL / RF : DTL vacuum (RF arc at slug tuner)
- RCCS : Flow rate of QMP, 3-way valve fault
- Utility : Shielding door failure
: Sample transfer device fault at target room

Downtime in 2014 [%]



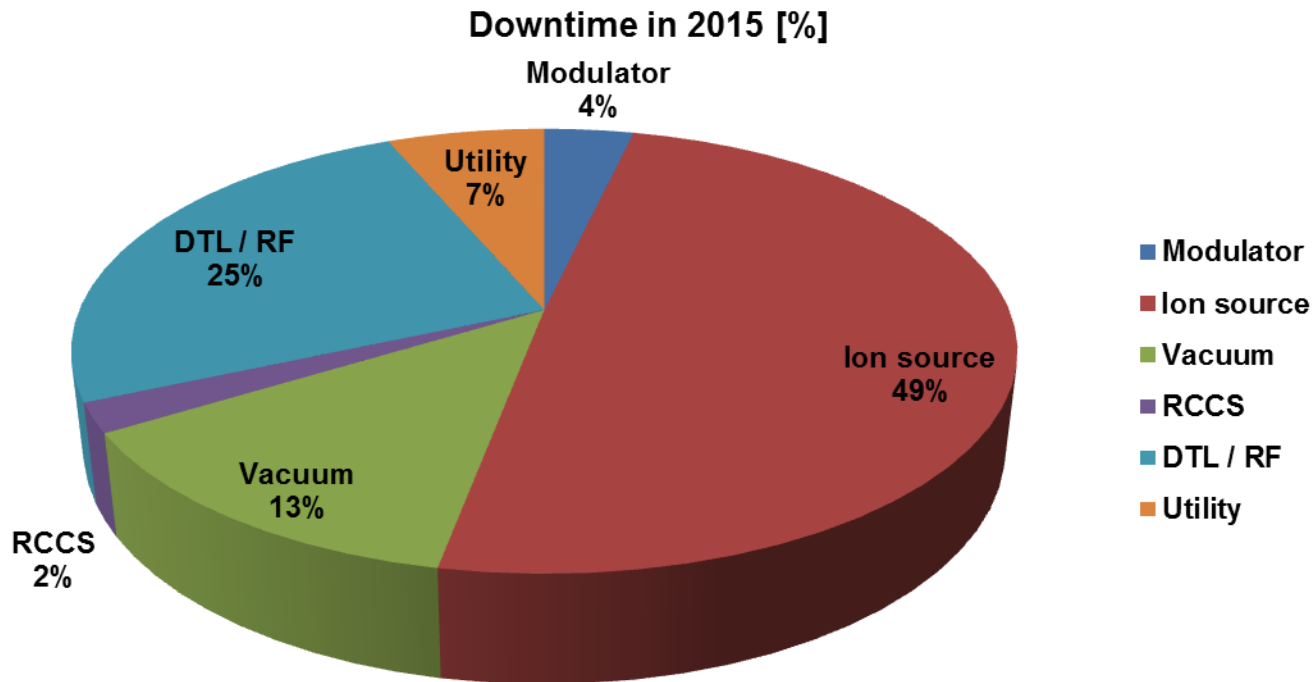
Downtime statistics

풍부한 에너지 깨끗한 환경 건강한 삶

Downtime Distributions in 2015

● Down time in beam service : 46.6 hours (Accumulation : 252.5 hours)

- Ion source : magnetron fault, beam current instability
- DTL / RF : 20MeV DTL QM failure
- Modulator : IGBT blast
- Utility : Shielding door failure



Downtime statistics

Accelerator Downtime

Utility

- Equipment wet at klystron gallery
- Cooling pump shut down
- Radiation shielding door failure

Modulator

- IGBT blasting
- Controller failure
- SCR firing circuit failure
- Oil pump failure

DTL / RF

- RF arcing at a power coupler
- RF arcing at a slug tuner of DTL tank
- Dividing resistor failure for klystron

Ion source

- Solenoid failure
- High voltage switch failure
- Electro-magnetic power supply failure



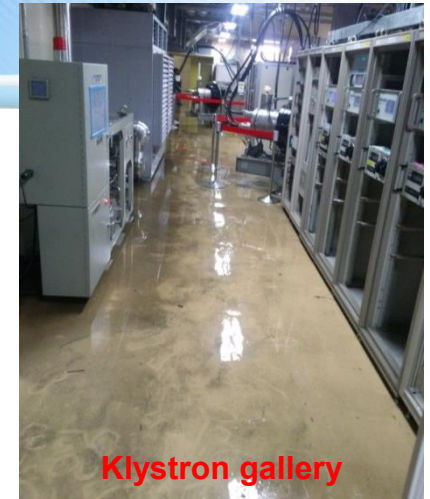
Iris plate after arcing



Blasted IGBT



Burned O-ring



Klystron gallery



Strainer

Waste including the metal piece

Cooling unit of 1st modulator

● MPS (Machine Protection System)

- Preparing a reliable MPS
 - Monitor machine operations
 - Protects machine from beam damages
- Minimize machine downtime

● Management Tools

- Management of items and spare parts
 - Reduction of repair time
- Communication Messenger between operators and beam users
 - Deliver accurate information

- Reduce downtime and increase availability
- Save time and money
- Protection for the entire machine against failures
 - Safely switch off or reduce beam and RF in case of failures
- Interface to RF interlock systems and injectors
 - Combination with the beam loss and position monitors
- Microsecond response times
 - Very fast response is required
- Monitor and control beam and subsystems

● List of interlock sensor

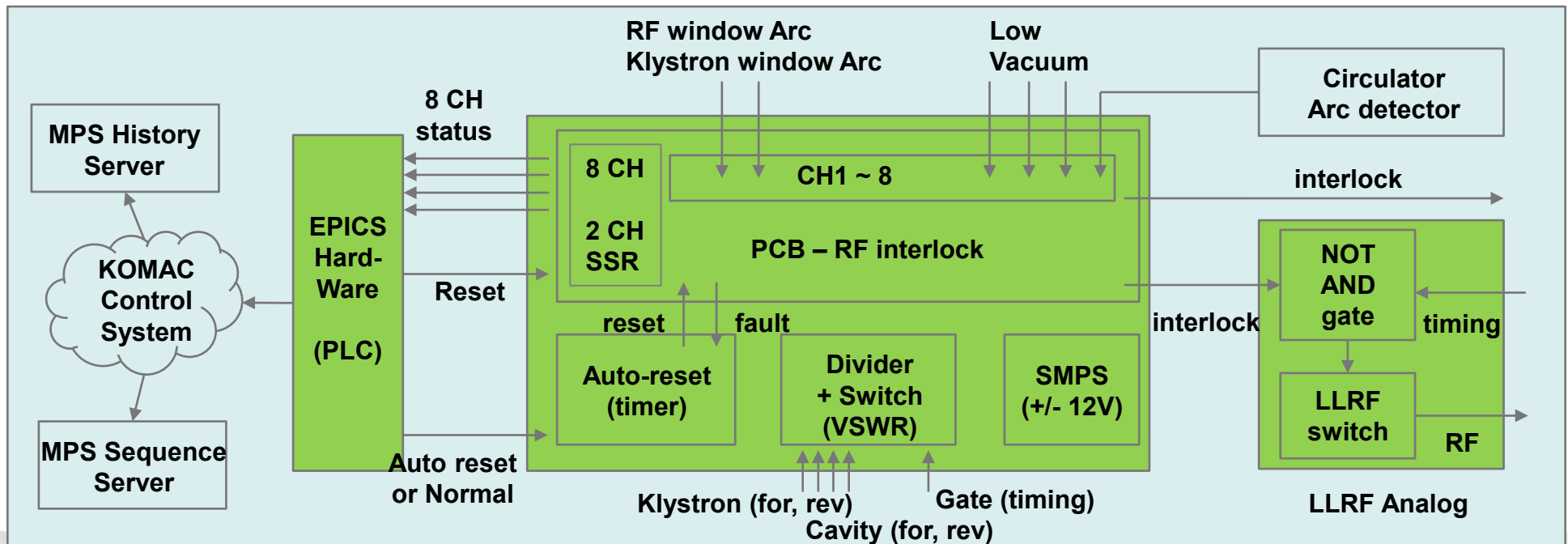
High-power RF source	Klystron (heater, magnet, ion pump) Low level RF Waveguide (circulator, RF window arc)
RF cavity	Cavity (vacuum, RF arc) Cooling water (flow rate, temperature, RCCS, wall cooling)
High-voltage power supply	Equipment fault Personnel fault
Beam	Beam loss, position
Beam line	Fast closing valve Safety block

● Hardwired interlock system for the 100 MeV Machine

- Will shut off the beam at the ion source and RF power

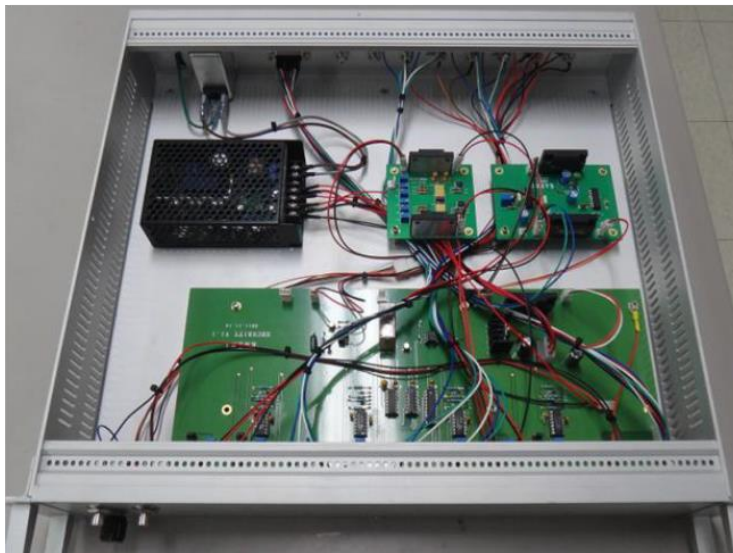
● Connected to EPICS control system to monitor the MPS status

- Interlock box (8 CH, 10V DC) 16 sets (RF 12 sets, Beam 3 sets, IS 1 set)
- Monitoring and Control (remote reset / auto or normal reset)

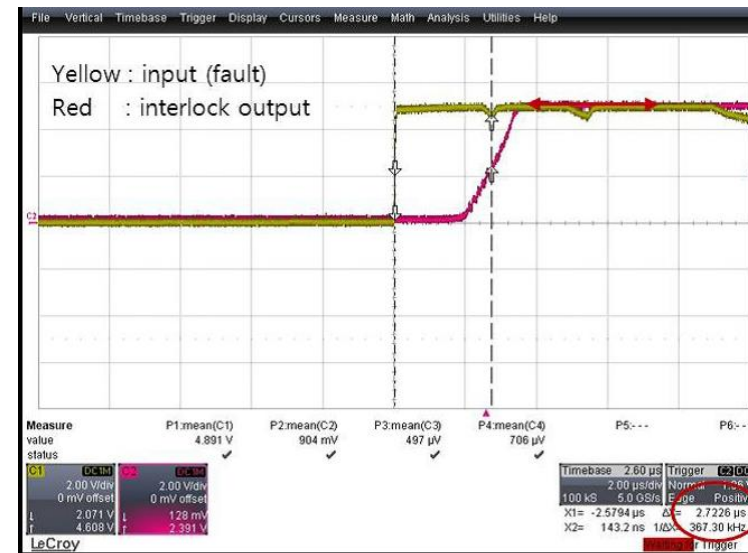


Local interlock system

- Analog modules like comparators and latches, an auto-reset module, a voltage standing wave ratio (VSWR) module for only the RF interlock unit, and a power supply



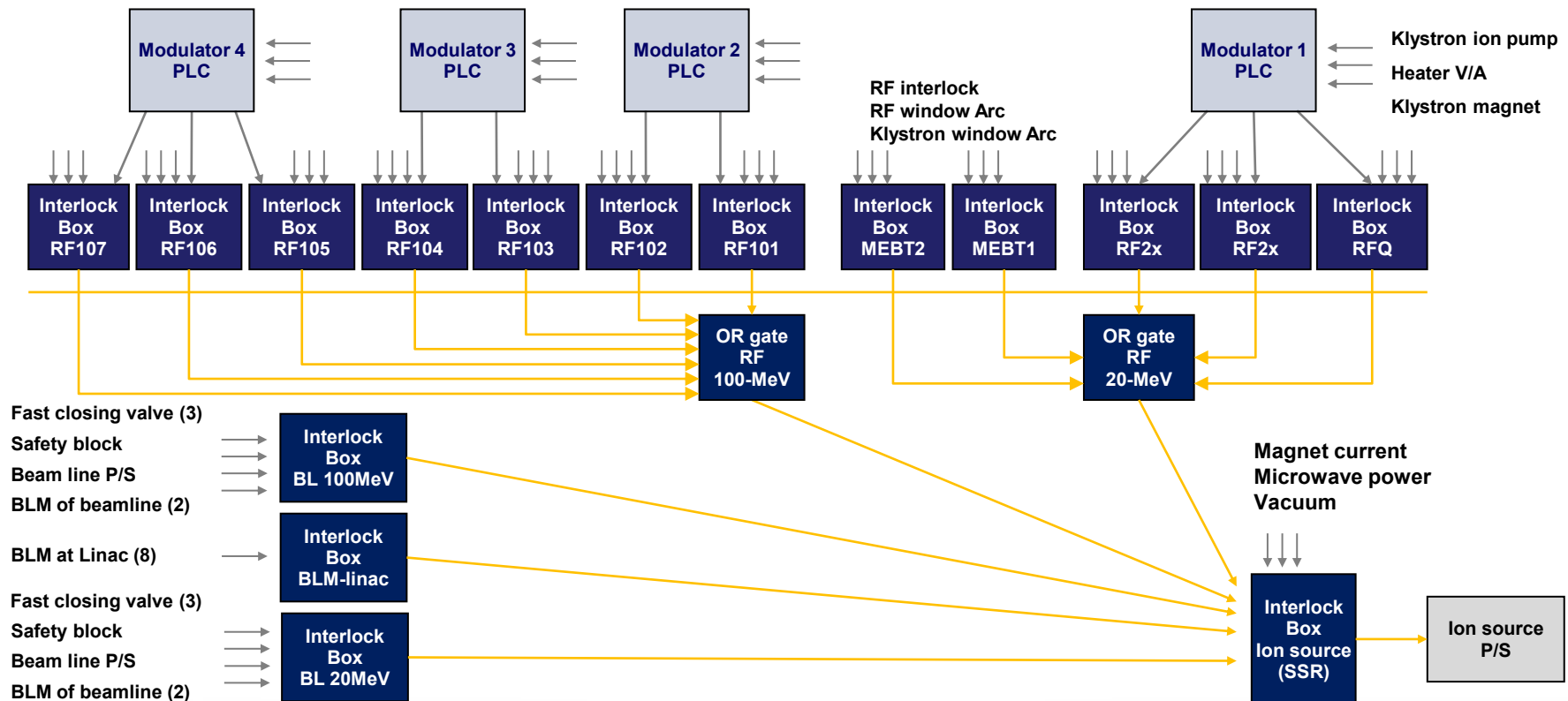
Local Interlock system



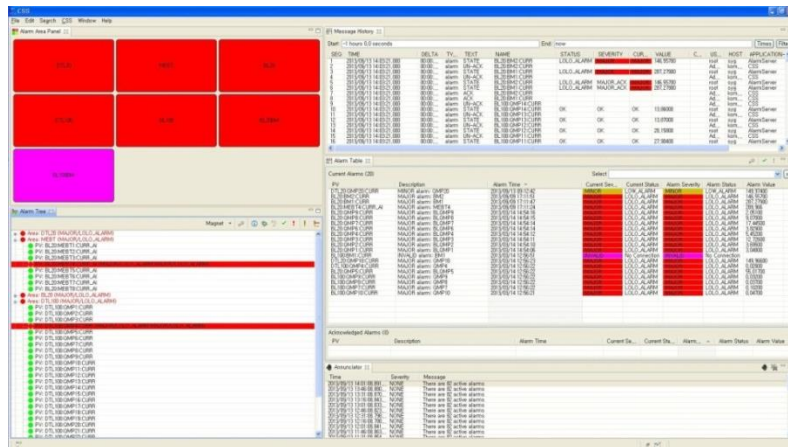
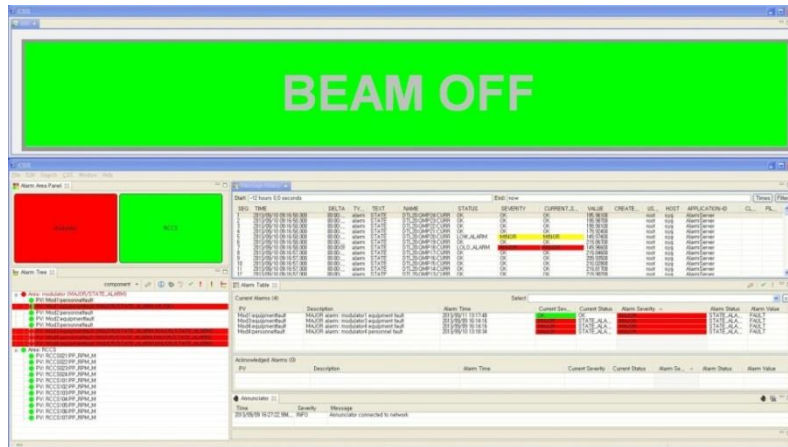
Response time : within 3 μ s

MPS Configuration

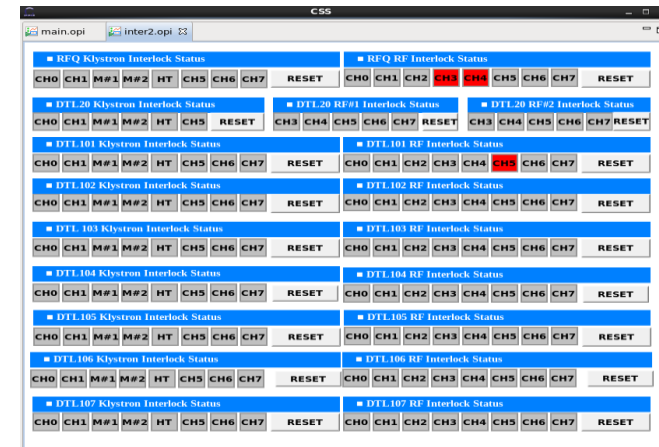
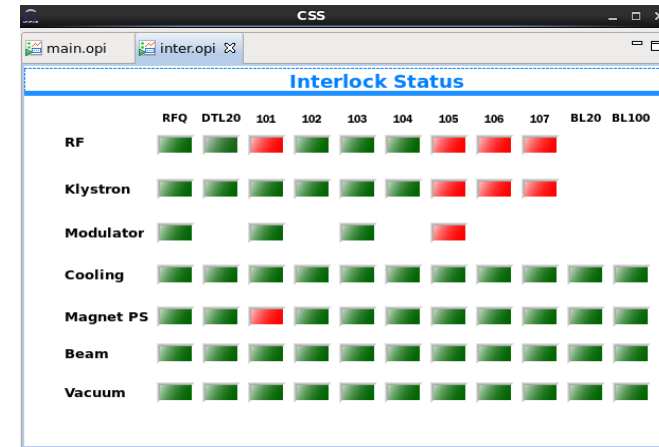
- Local interlock boxes are installed into each klystron and RF rack of klystron galley
- Local MPSs collect signals from various fault sensors and report to a I/S MPS
 - To prevent a beam when a device failure is activated



Alarm and interlock screen



CSS Alarm and history system



Interlock monitoring screen

● MPS (Machine Protection System)

- Preparing a reliable MPS
 - Monitor machine operations
 - Protects machine from beam damages
- Minimize machine downtime

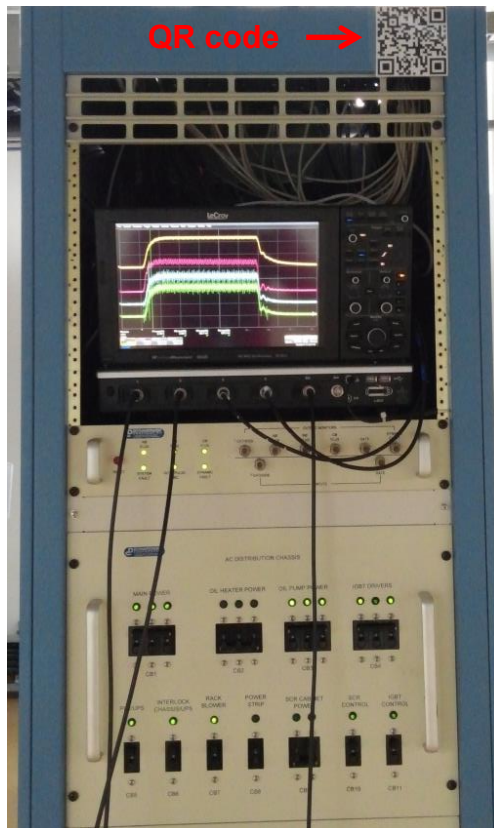
● Management Tools

- Management of items and spare parts
 - Reduction of repair time
- Communication Messenger between operators and beam users
 - Deliver accurate information

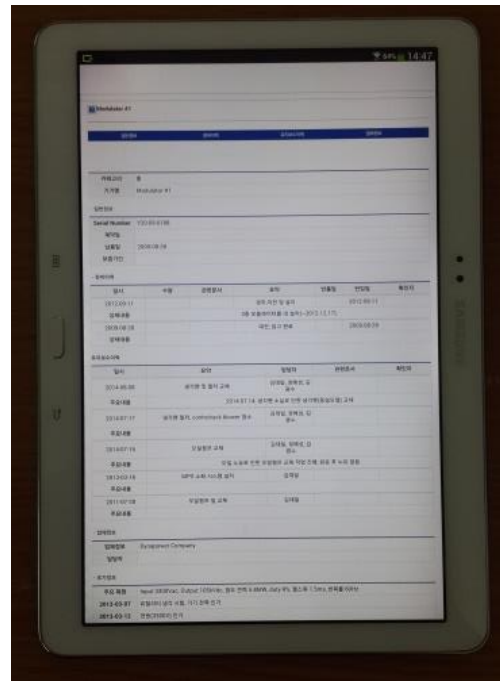
Reduction of Downtime (1)

Management of items and spare parts

- set up MIS (Management Information System) which can be known the details of item as check the QR code on machine



Control rack of modulator



Tablet PC

65% 10:45

Modulator #1

일시	수량	관련문서	요약	반출일	반입일
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카테고리 종

기종명 Modulator #1

일반정보

Serial Number Y20-09-0188

제작일

납품일 2009-08-28

보증기간

장비이력

일시	수량	관련문서	요약	반출일	반입일	확인자
2012-09-11					2012-09-11	
상세내용			2012.09.11, 냉각팬 소실로 인한 냉각팬(동일모델) 교체			
2009-08-28			대선, 입고 완료		2009-08-28	
상세내용						

유지보수이력

일시	요약	발달자	관련문서	확인자
2014-08-08	냉각팬 및 필터 교체	김대일, 정복현, 김광수		
주요내용	2014.07.14, 냉각팬 소실로 인한 냉각팬(동일모델) 교체			
2014-07-17	냉각팬 필터, controlrack blower 청소	김대일, 정복현, 김광수		
주요내용				
2014-07-16	오일펌프 교체	김대일, 정복현, 김광수		
주요내용	오일 누유로 인한 오일펌프 교체 작업 진행, 완료 후 누유 없음			
2013-03-18	MPS 소화 시스템 설치	김대일		
주요내용				
2011-07-28	오일펌프 및 교체	김대일		
주요내용				

업체정보

업체명 Dynapower Company

담당자

추가정보

주요 제원 Input 3300Vac, Output 105kVdc, 출력 전력 5.8kW, duty 99%, 절속 1.5mm, 전속률 60%

2013-03-07 유류러터 냉각 시험, 기기 전력 인가

2013-03-12 전원(3300V) 인가

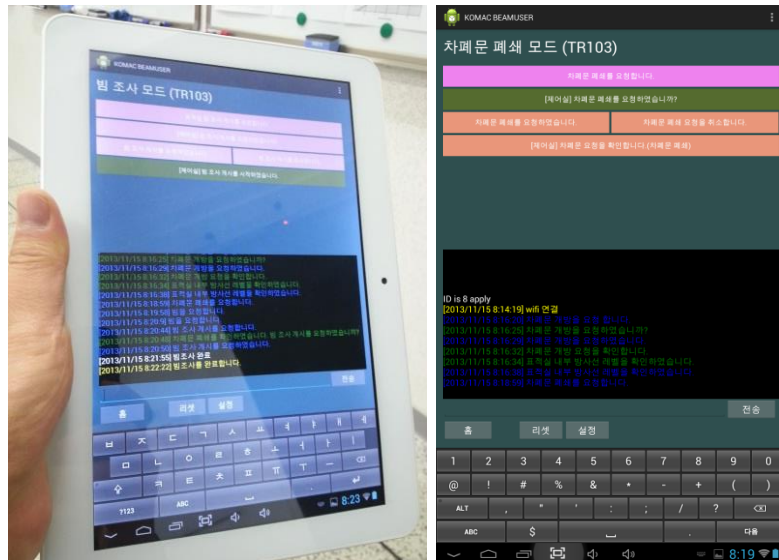
Tablet screen

Reduction of Downtime (2)

Communication between operators and beam users

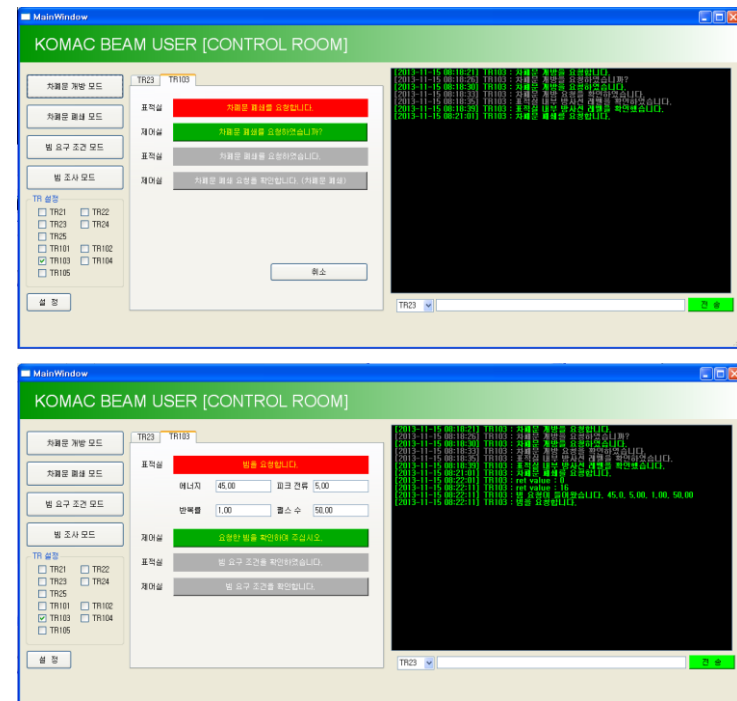
- Wireless tablet PC for beam users, deliver accurate information, user convenience

Beam User (Target Room)



Wireless Tablet PC

Operator (Control Room)

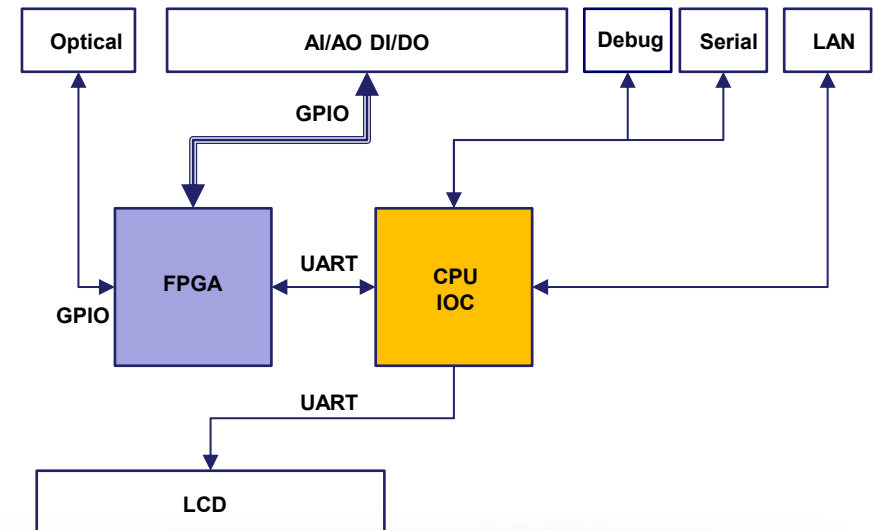
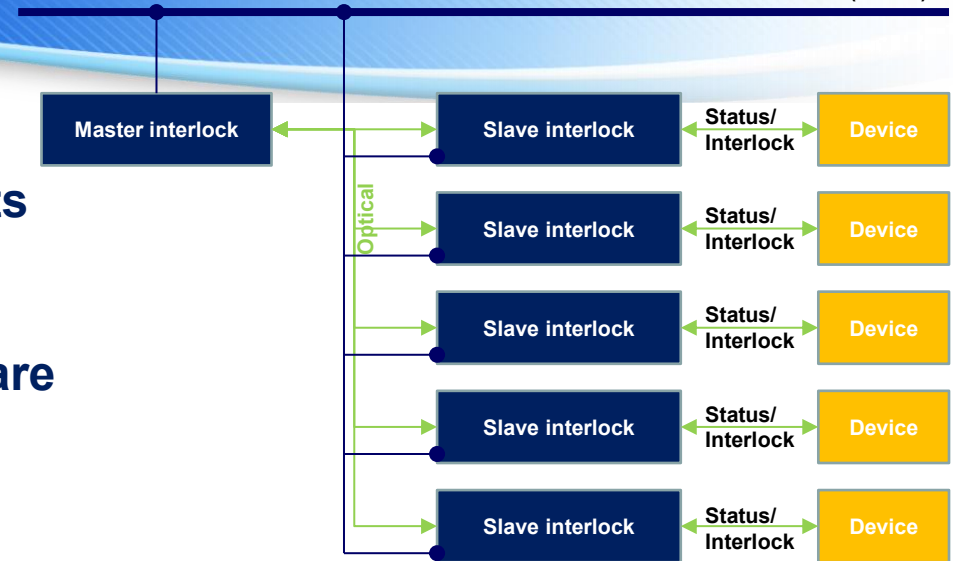


Desktop PC

MPS Upgrade Plan

- Fully programmable system
- One module type for all measurements
- Sensor interface that's totally flexible
- Utilizes individual processors which are independent from other hardware
- Master and slave model (embedded processor)

- FPGA Xilinx XC6SLX16-2CSG225C
- BCM2835 SoC Core ARM11
- Nodes interconnected with optical links



Interlock system

- Interlock system designed and installed
- Protection for the entire machine against failures
- Reduced downtime
- Increased availability
- Continued user beam service with interlock systems
- MPS will be developed based on experience

Thank you.

