RAON Rare isotope Accelerator complex for ON-line experiments

Overview of RAON Beam Instrumentation System and Construction Status of the Low-Energy Linac

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ibs 기초과학연구원 Institute for Basic Science

RISP 중이온가속기건설구축사업단 Rare Isotope Science Project

Contents

Rare Isotope Science Project (RISP)

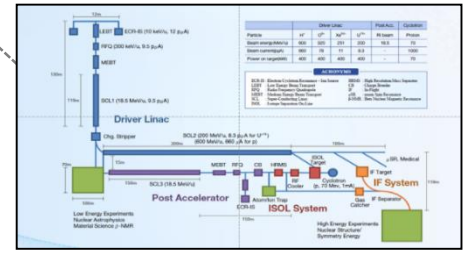
- **Goal:** To build **a heavy ion accelerator complex RAON,** for **rare isotope science** research in Korea.

  * RAON - Rare isotope Accelerator complex for ON-line experiments

- **Budget: KRW 1,518 billion (US$ 1.32 billion, 1$=1,146krw)**
  - accelerators and experimental apparatus : 522.8 billion won
  - civil engineering & conventional facilities : 996 billion won (incl. site 357 billion won)
- **Period: 2011.12 ~ 2021.12**

System Installation Project

Development, installation, and commissioning of the accelerator systems that provides high-energy (200MeV/u) and high-power (400kW) heavy-ion beam



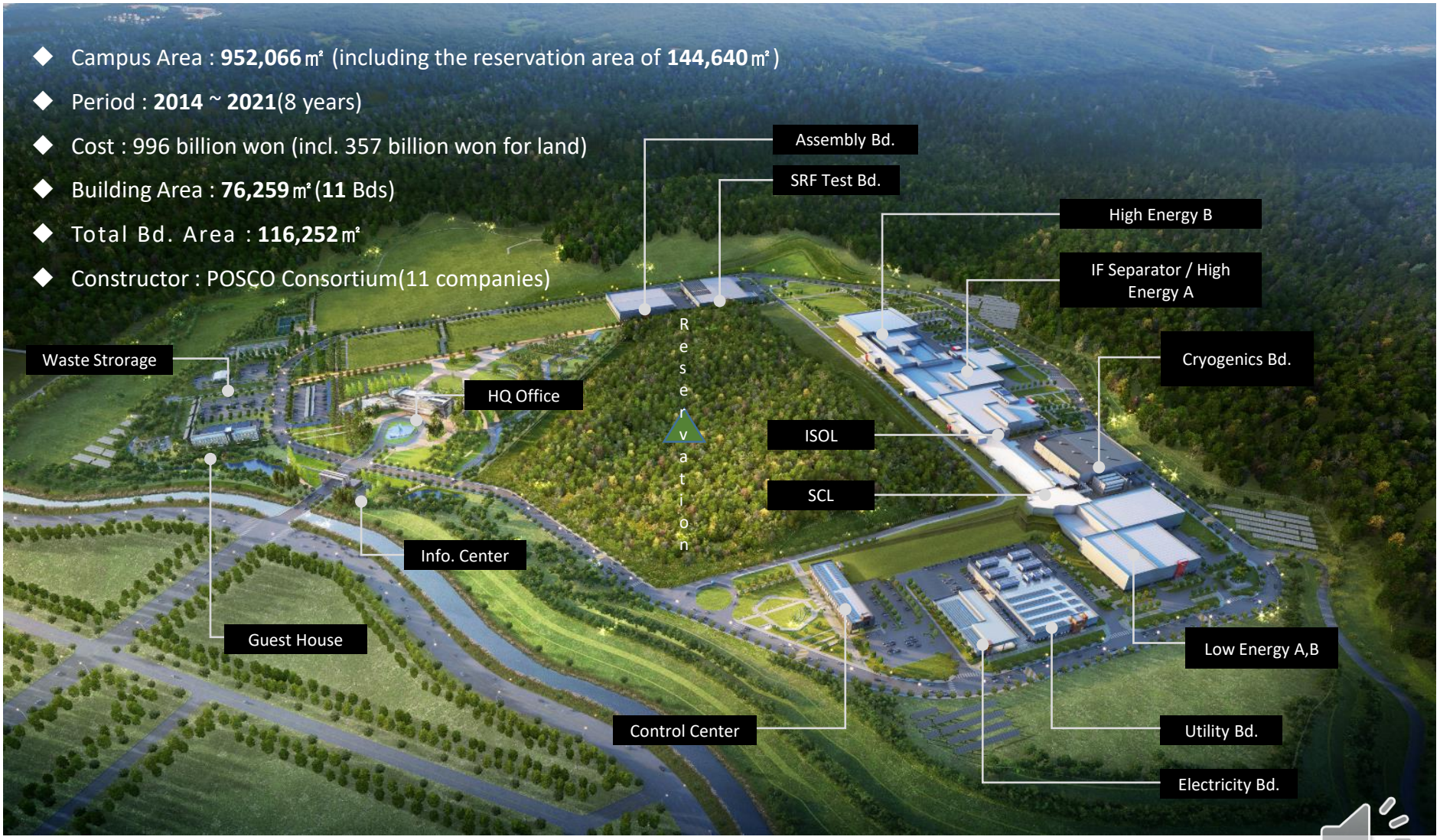
Facility Construction Project

Construction of research and support facility to ensure the stable operation of the heavy-ion accelerator, experiment systems, and to establish a comfortable research environment

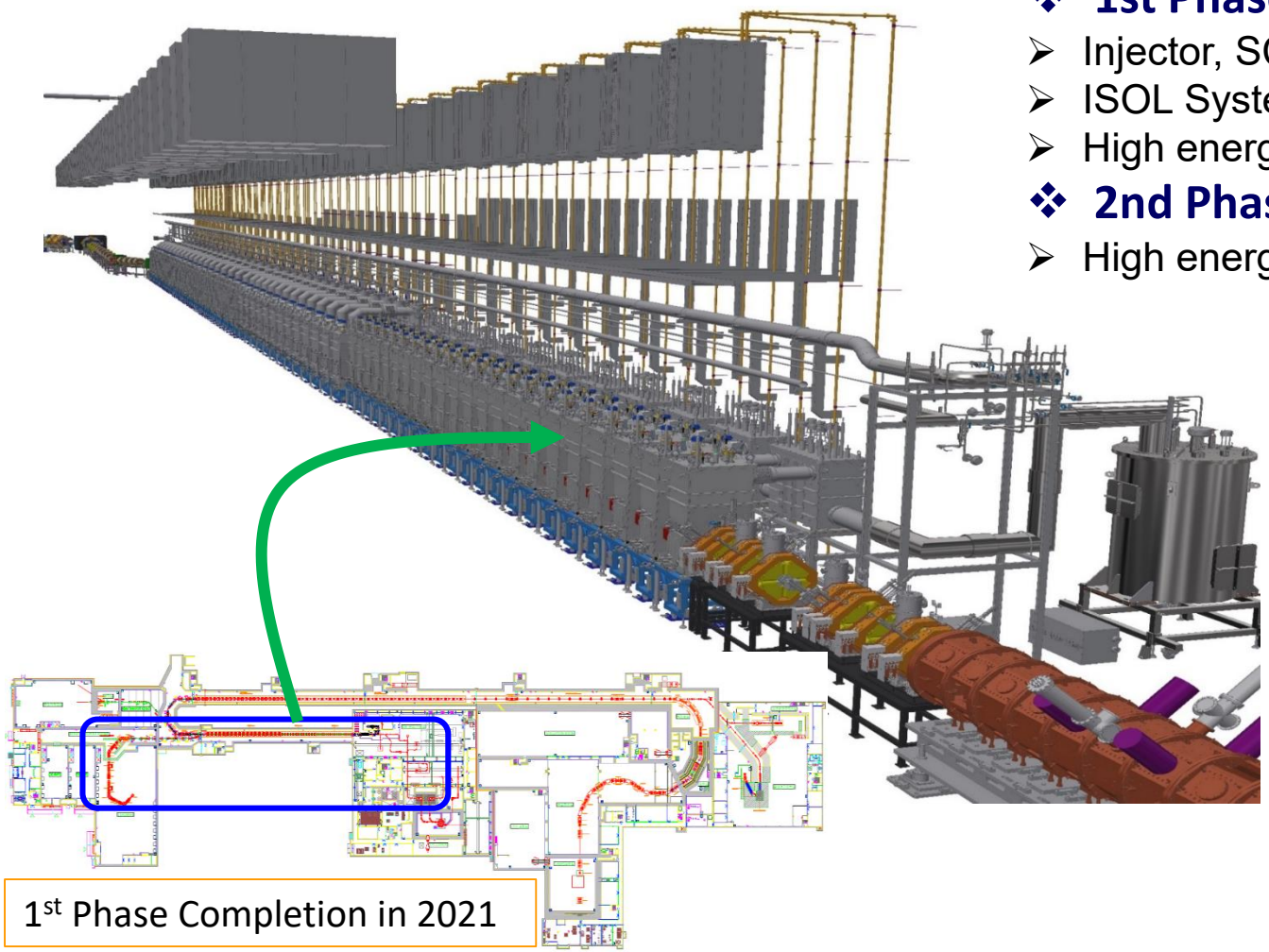
※ Accelerator and experiment buildings, support facility, administrative buildings, and guest house, etc.

- **Providing high intensity RI beams by ISOL and IF**
  ISOL: direct fission of ^{238}U by 70 MeV proton
  IF: 200 MeV/u ^{238}U (intensity: 8.3 pμA)
- **Providing high quality neutron-rich beams**
  e.g., ^{132}Sn with up to 250 MeV/u,
  up to 10^9 particles per second
- **Providing More exotic RI beam production by combination of ISOL and IF**

Campus Layout



RAON Construction Status/Plan



❖ **1st Phase (~2021)**

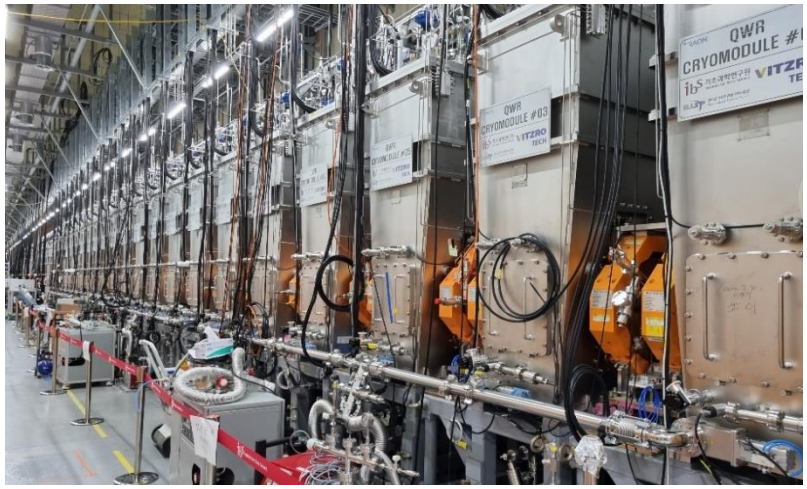
- Injector, SCL3, Low energy exp.
- ISOL System
- High energy exp.

❖ **2nd Phase (2022~)**

- High energy Linac, SCL2

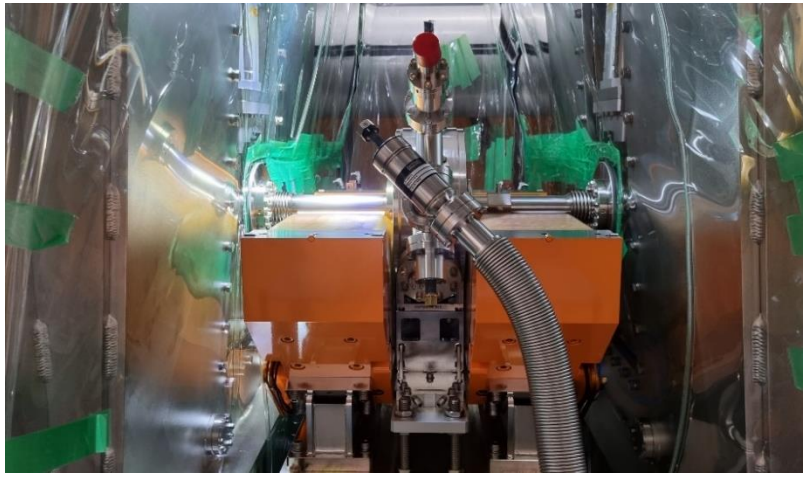
1st Phase Completion in 2021

Superconducting Linac, SCL3 Tunnel and Gallery



QWR & HWR Cryomodule

Cryogenic Distribution to Cryomodule



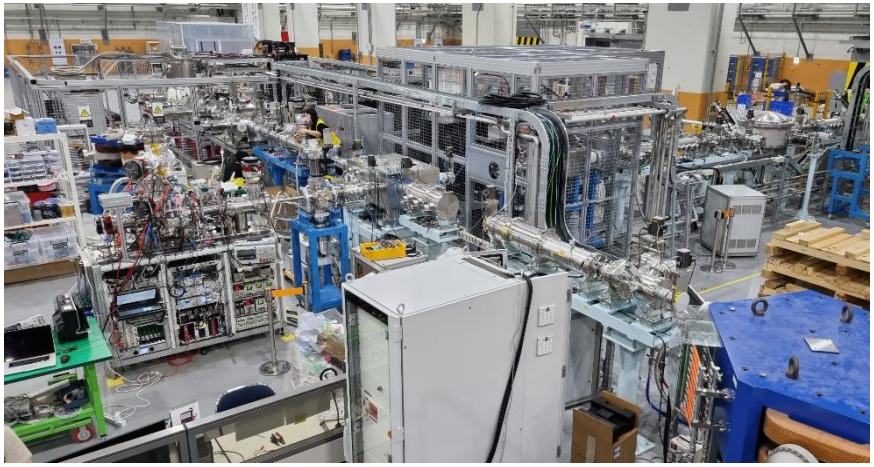
Clean beam line assembly

CM/Cryogenic Control Rack and SSPA

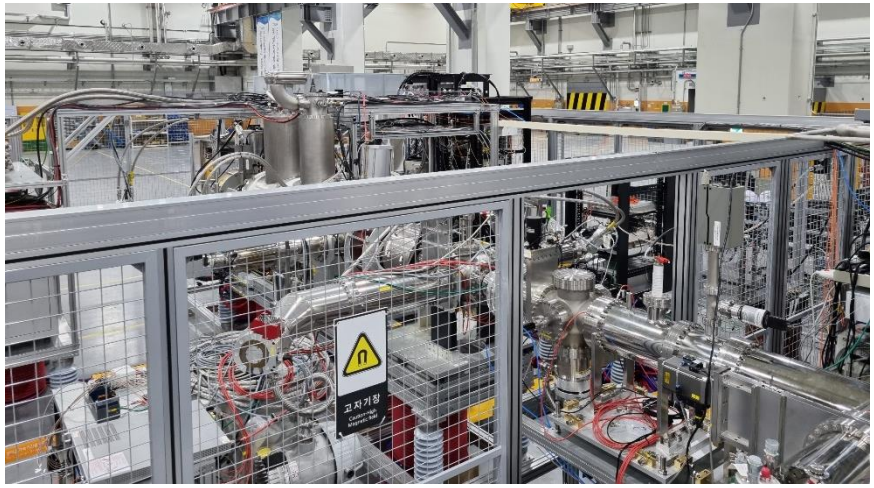
Installation completion and ready for beam commissioning in 2021

ISOL System

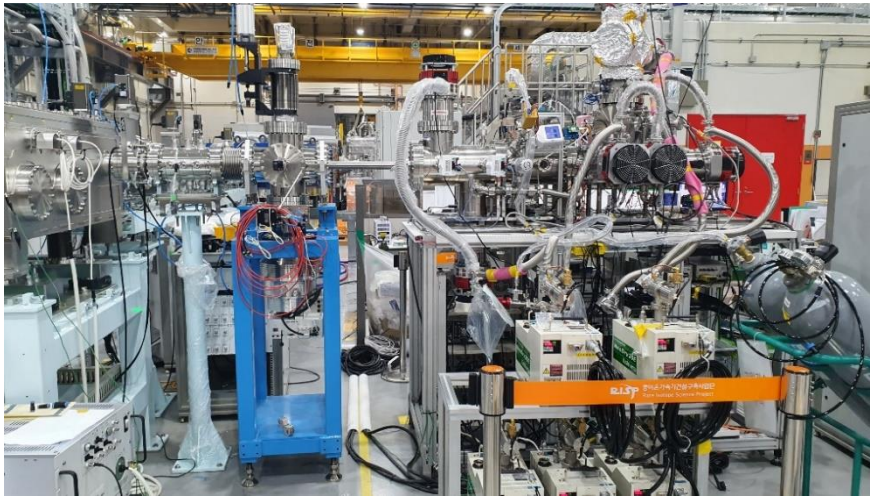
ISOL Target Room



ISOL Beam Line



EBIS Charge Breeder



MMS/MR-TOF

TIS, EBIS, RFQ-CB, beam line is being tested with SI(Cs) beam, completed in 2021

Beam Diagnostics Functions

➢ Initial commissioning & Component tuning

- FC, WS, BV, ACCT, BPMs(position, phase, TOF)

❖ Beam specification : Ar(9+), ~30eμA, 100μs, 1Hz

➢ During operation(On-line)

- Monitor beam transport and acceleration function

✓ BPM : Beam position and phase

✓ BCM : Beam current and transmission(RFQ, SCL3, P2DT, SCL2)

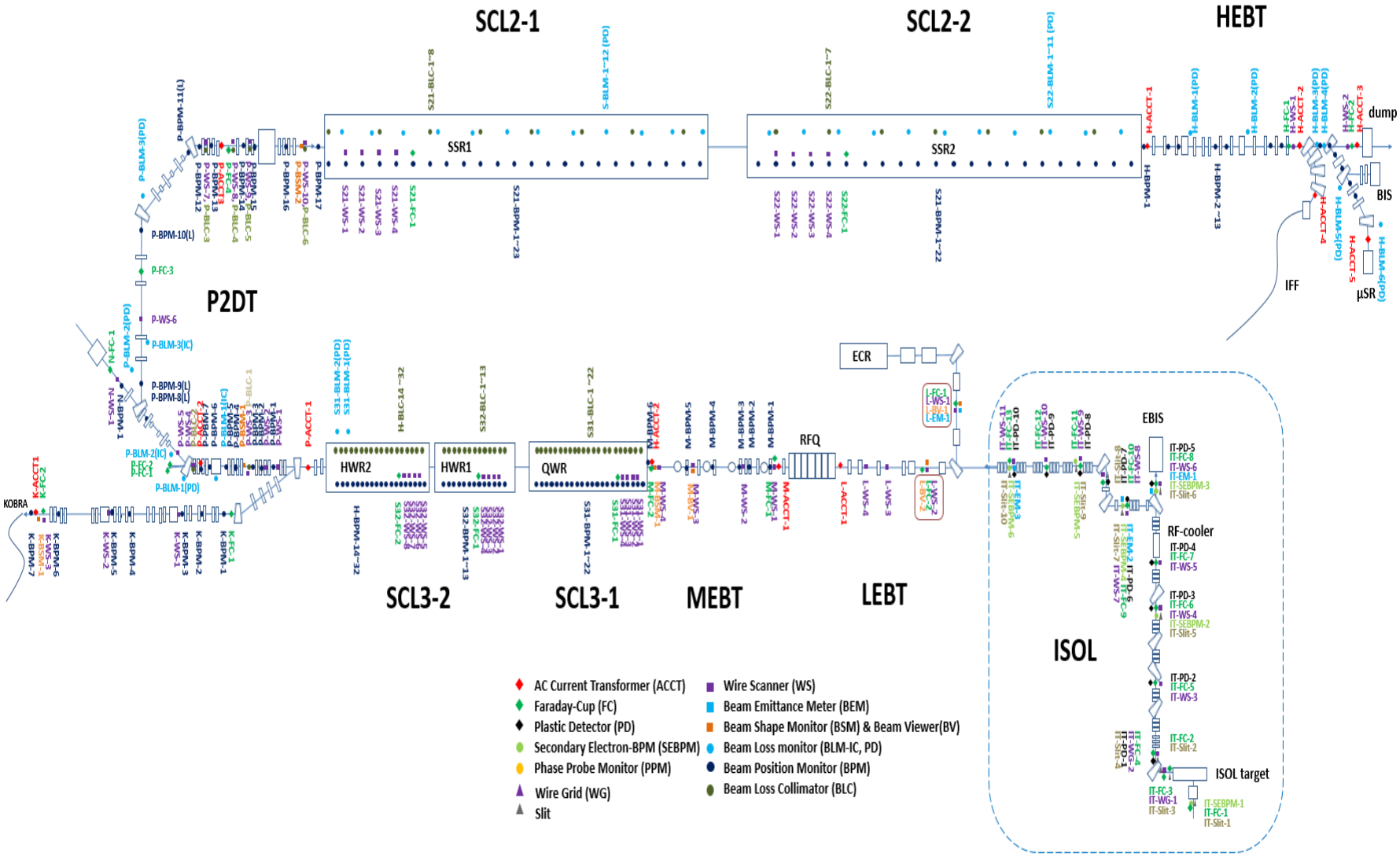
✓ BLM : Beam Loss and link to Machine Protection

❖ Beam current is 1mA ~ 1μA

➢ Commissioning and during operation(On-demand)

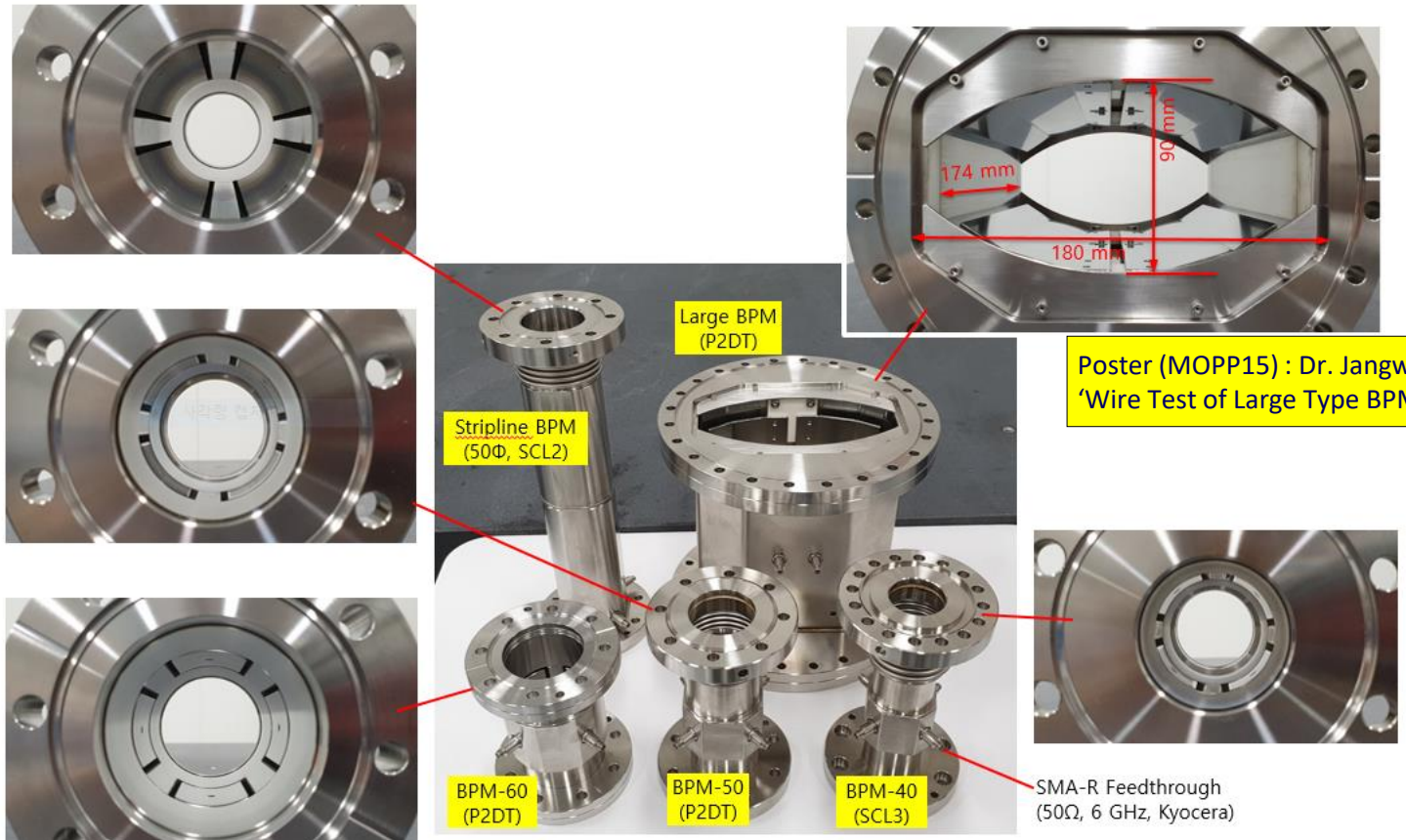
- 1-D, 2-D profile distribution (WS, EM)
- Bunch length (Stripline FFC)
- Beam Attenuator @LEBT

Layout of RAON Beam Diagnostics



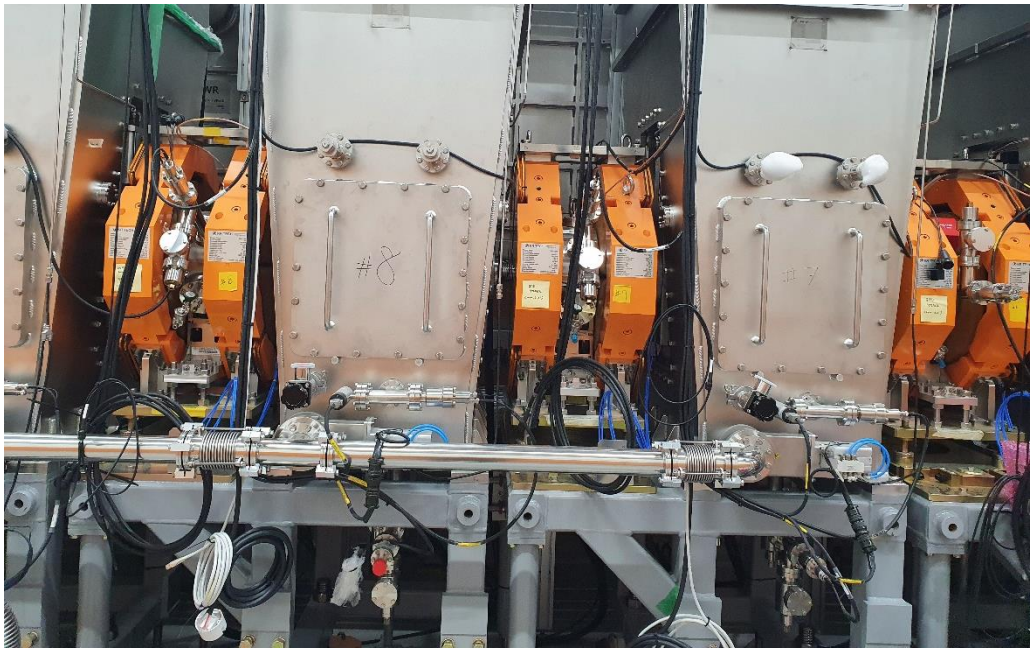
Beam Position Monitor(BPM)

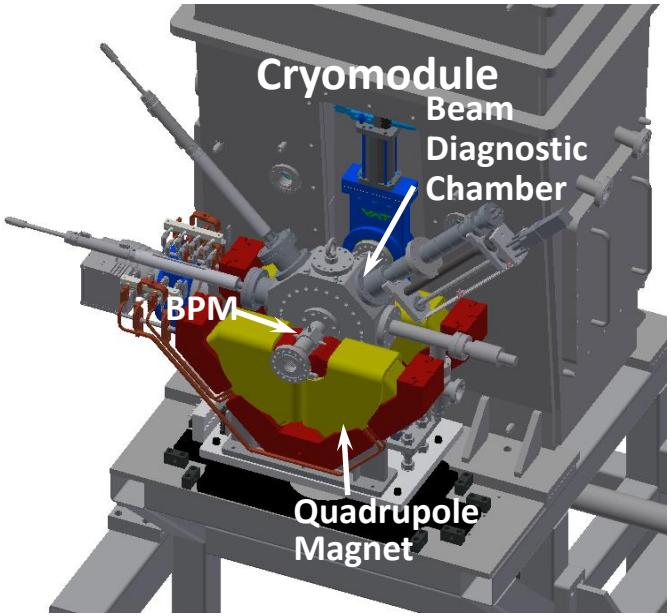
- Measurements : Beam Position, Phase, relative Intensity
- SCL3(Installed) : Button-type BPM, Curved type 20mmx30mm
- P2DT(Fabricated) : Large button-type BPM(Bending section), Button-type BPM
- SCL2(Fabricated) : Stripline BPM, Curved type 25mmx150mm

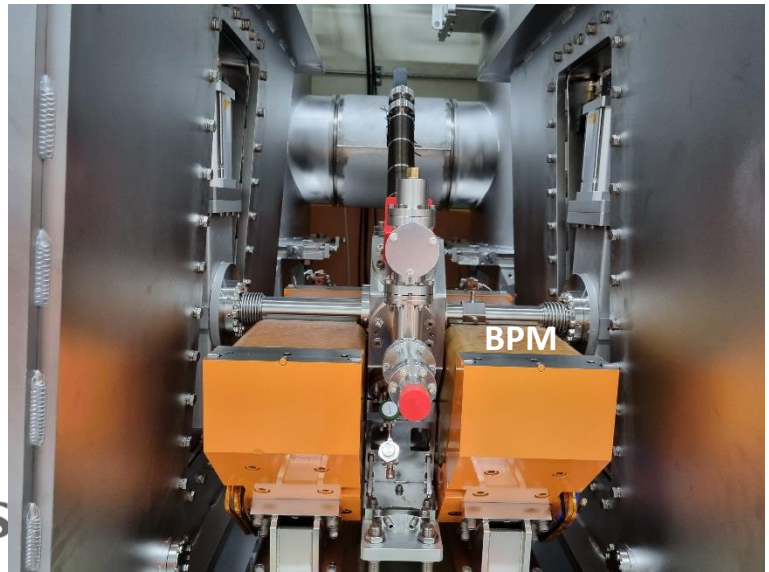


Poster (MOPP15) : Dr. Jangwon Kwon
'Wire Test of Large Type BPM for P2DT in RAON'

Beam Diagnostics at SCL3-Warm Section

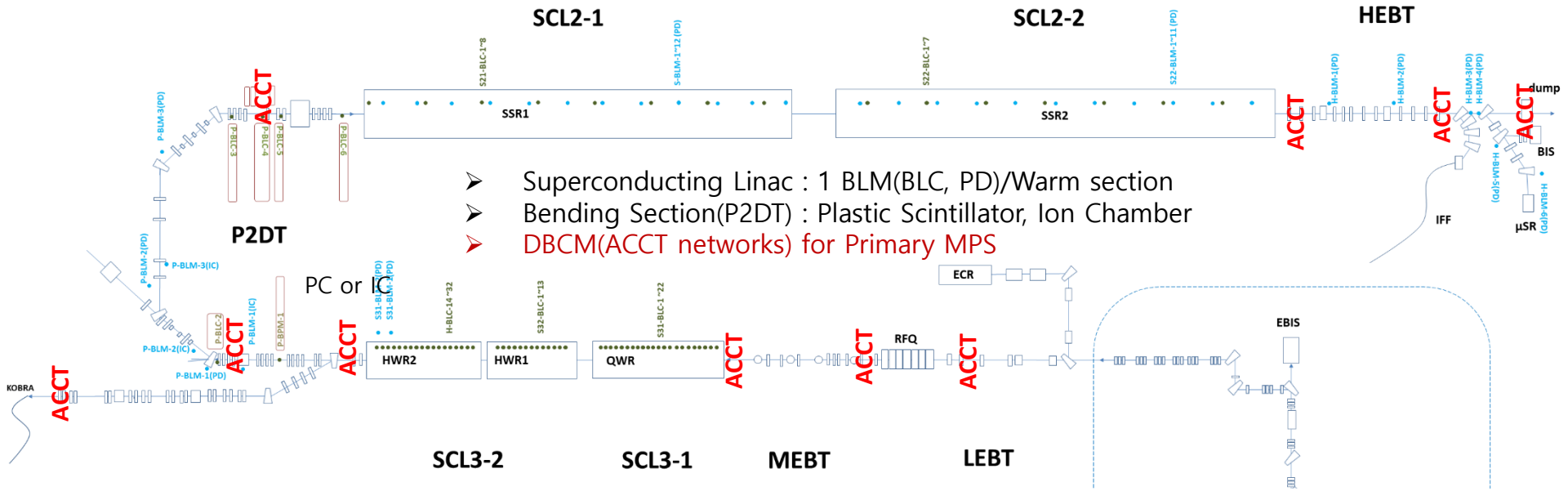






- BPM and BDC inside of Magnetic Quadrupole Doublet
- Installation (& alignment) procedure of BDC/BPM/Beam Pipe assembly (particle-free with pure N_2 purging) in between two cryomodules is well defined & followed
- Ring Type(ID=36 mm, Nb) BLC inside BDC
  - Directly collect halo/stray beam

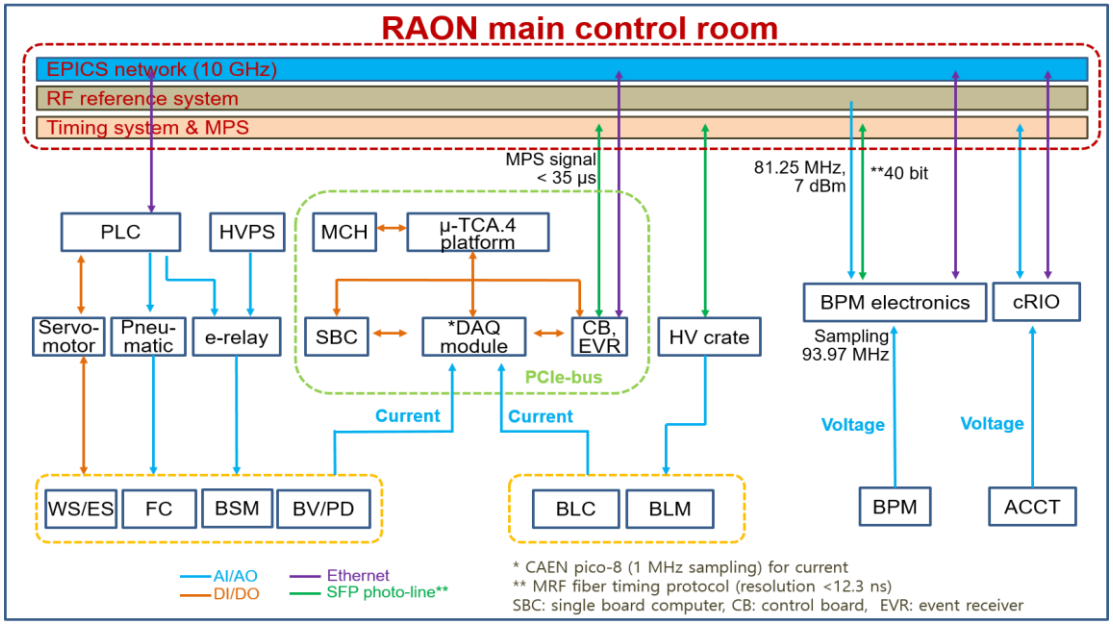
Beam Loss Monitor(BLM)

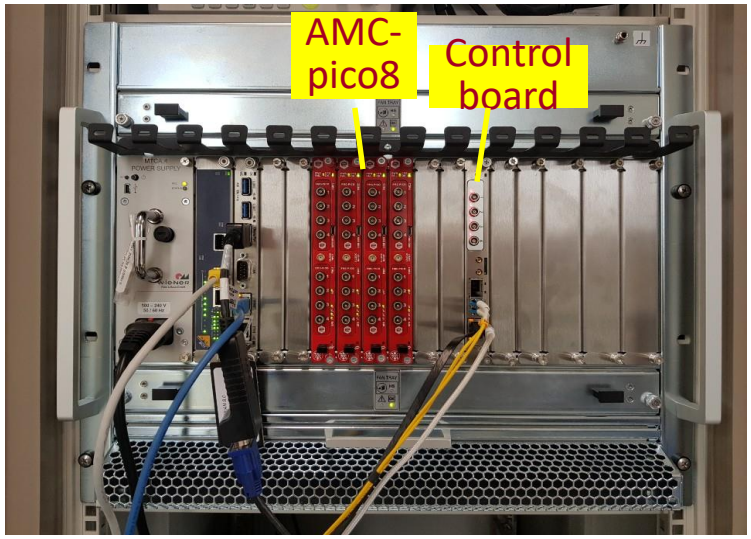


- Superconducting Linac : 1 BLM(BLC, PD)/Warm section
- Bending Section(P2DT) : Plastic Scintillator, Ion Chamber
- DBCM(ACCT networks) for Primary MPS

	PC(IC)	PD	BLC	DBCM(ACCT)
QWR	-	-	ongoing	ongoing
HWR1	-		ongoing	ongoing
HWR2	-		ongoing	ongoing
P2DT	X	X	X	X
SSR1		X	X	X
SSR2		X	X	X

Diagnostics DAQ System



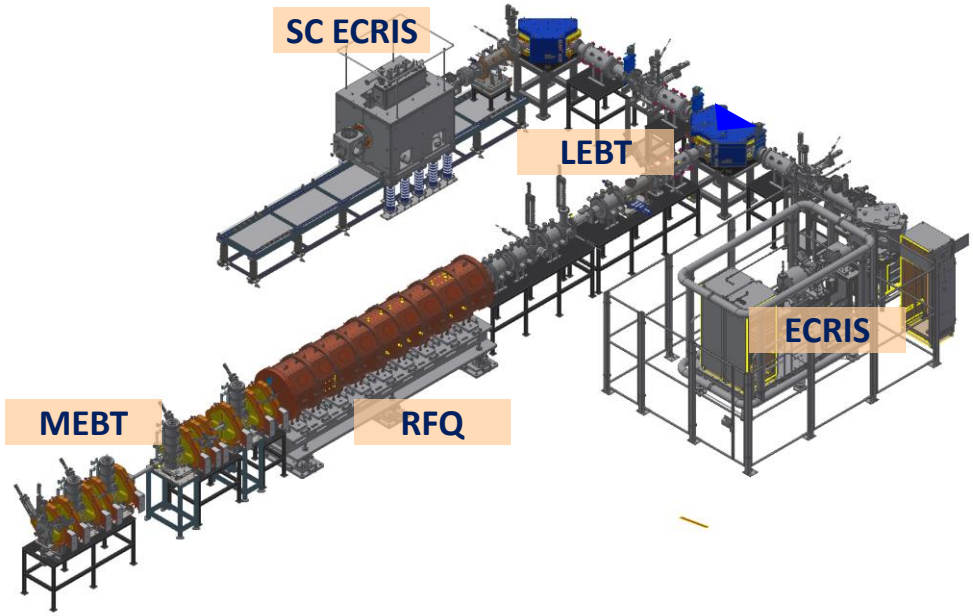


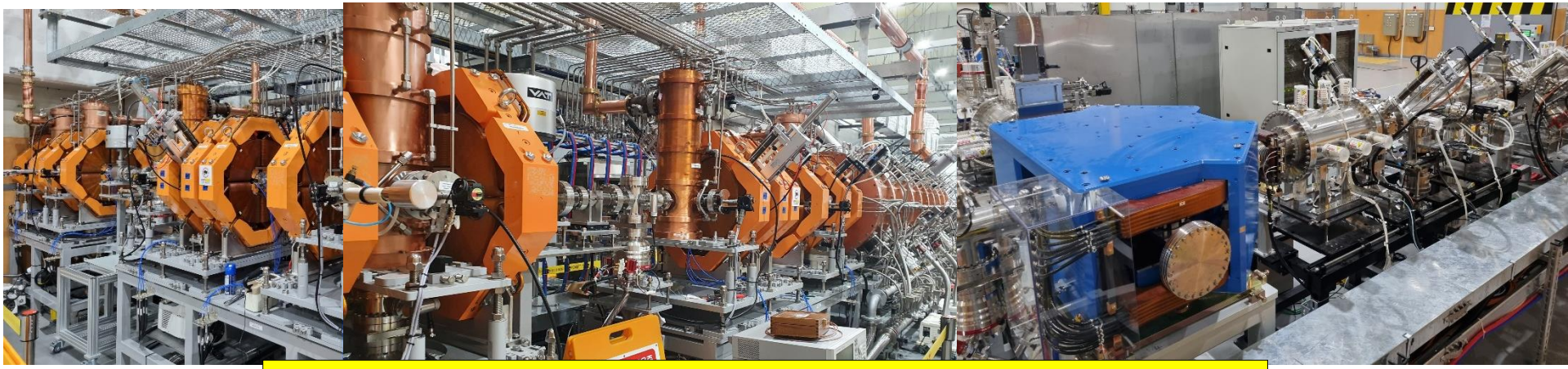
- **BPM**
  - 153 modules fabricated; SCL3(60), P2DT(28), SCL2(65)
  - supports timing, trigger, interlock, postmortem, EPICS of RAON
- **Current (WS, FC, BLM, BLC) - μTCA system**
  - CAENels AMC-pico: 42 boards, 8 ch/20 bit/pA range
  - Modified firmware for RAON trigger, interlock and EPICS
- **ACCT – Standalone 1u chassis**
  - 100 MS/sec, 14-bit 4 ADC channels
  - Upgrade from cRIO System(1MS/sec)
  - supports timing, trigger, interlock, postmortem, EPICS of RAON

Electronics for SCL3 are fully tested/calibrated

RAON Injector System

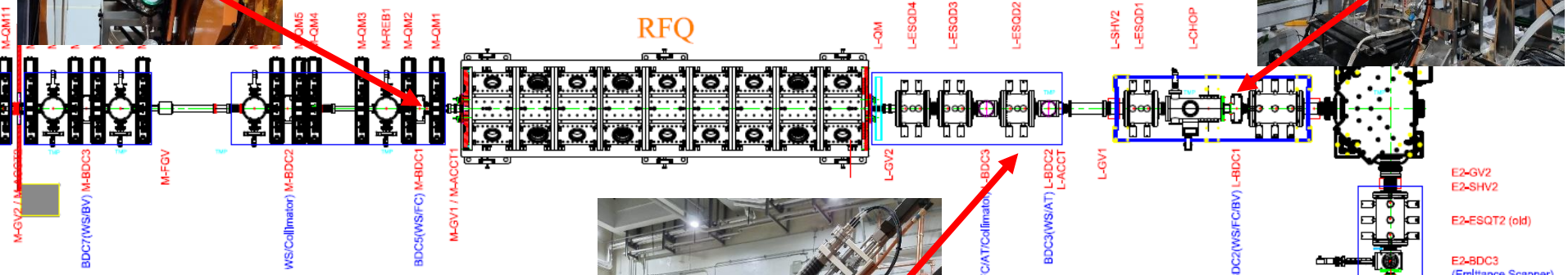
- **Two ECR-IS on high voltage platforms**
  - 14.5 GHz ECR ion source
  - 28 GHz superconducting ECR ion source
- **LEBT (E = 10 keV/u)**
  - 10 keV/u, Dual bending magnet
  - Chopper & Electrostatic quads, Instrumentation
- **RFQ (E = 500 keV/u)**
  - 81.25 MHz, Transmission Eff. ~98%
  - CW RF Power 94 kW (SSPA: 150 kW)
- **MEBT (E = 500 keV/u)**
  - Four RF bunchers (SSPA: 20, 15, 4×2 kW)
  - Simple quadrupole magnets, Instrumentation

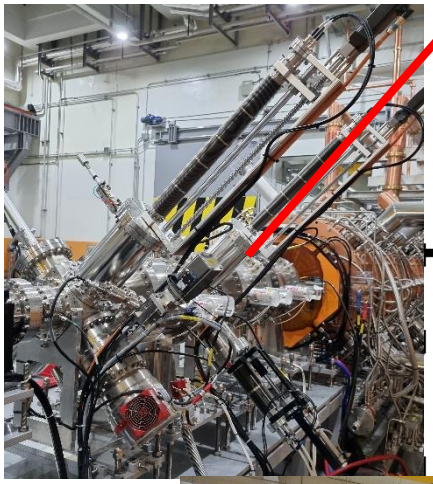




Installation completed and beam commissioning from October, 2020

RAON Injector Instrumentation





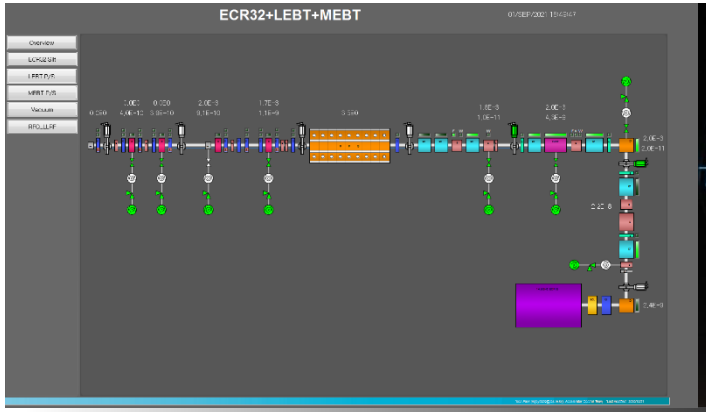
- **LEBT**
  - Wire scanner - 5 sets (4 installed)
  - Beam Viewer – 3 sets (2 installed)
  - Bergoz ACCT – 1 set
  - Faraday Cup – 5 sets (4 installed)
  - beam Attenuator – 2 sets
  - 2-D Allison Scanner – 2sets (1 installed)
- **MEBT (Installed)**
  - Wire scanner - 4 sets
  - Beam Viewer – 1 set
  - Bergoz ACCT – 2 sets
  - Faraday Cup – 2 sets
  - Stripline FFC – 1 set
  - BPM – 6 sets

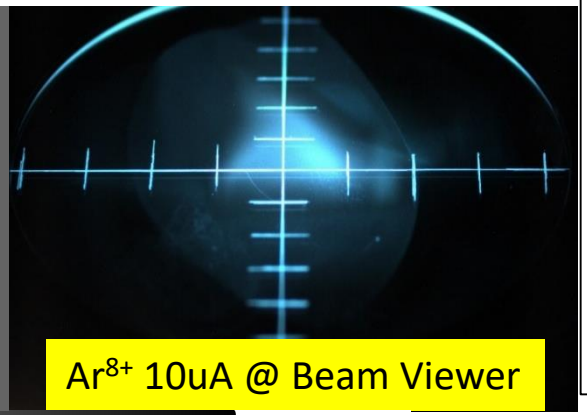
Injector Beam Commissioning

◈ Injector beam commissioning

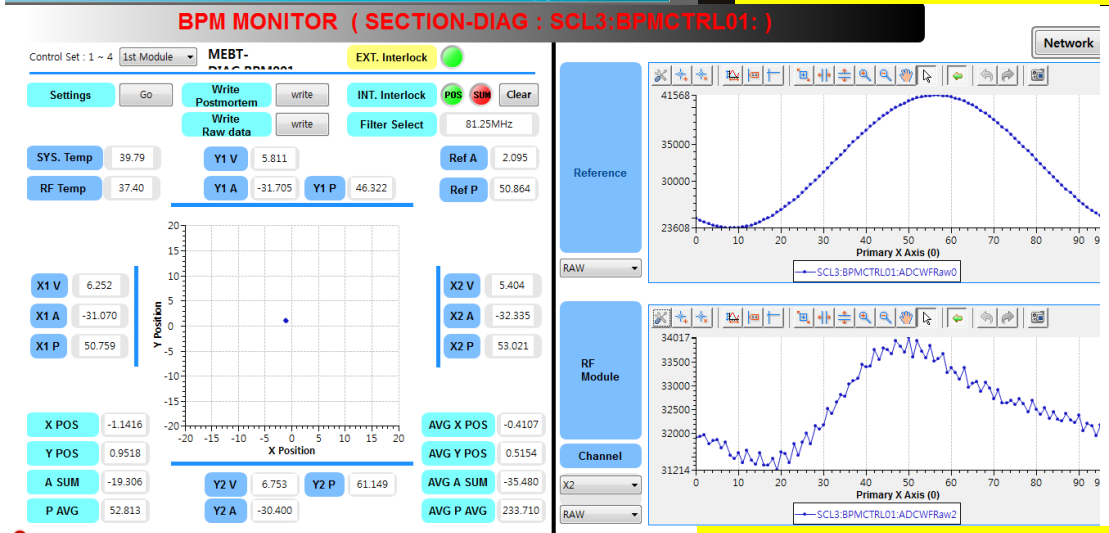
- ✓ Started on 10.19(2020), and 1~2 times/week
- ✓ 14.5 GHz ECR-IS → LEBT → RFQ → MEBT
- ✓ Reference beam: $^{16}O^{6+}$, $^{40}Ar^{8+}$, $^{40}Ar^{9+}$ (100 μs pulse, 1Hz)

- **LEBT**
  - Charge selection
  - Emittance measurement
  - Transverse beam size measurement
  - Orbit correction, etc
- **RFQ**
  - Beam transmission
  - Beam energy measurement, etc.
- **MEBT**
  - Rebuncher amplitude & phase scan
  - Transverse beam matching
  - Longitudinal beam matching
  - Orbit correction, etc.



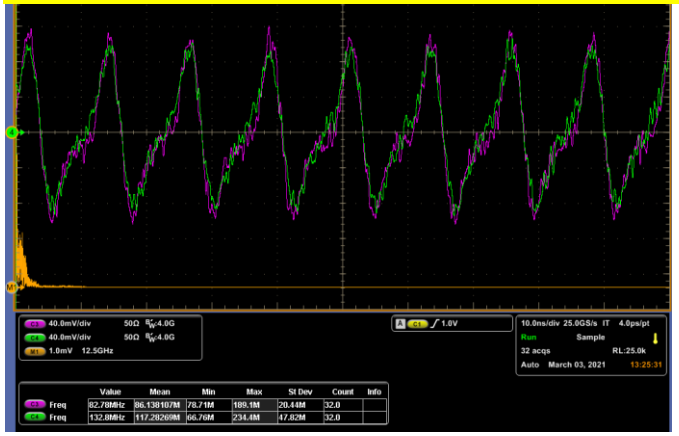


Ar^{8+} 10uA @ Beam Viewer



BPM@MEBT; O^{6+} 500 keV/u

~40 dB Amplifier - Oscilloscope

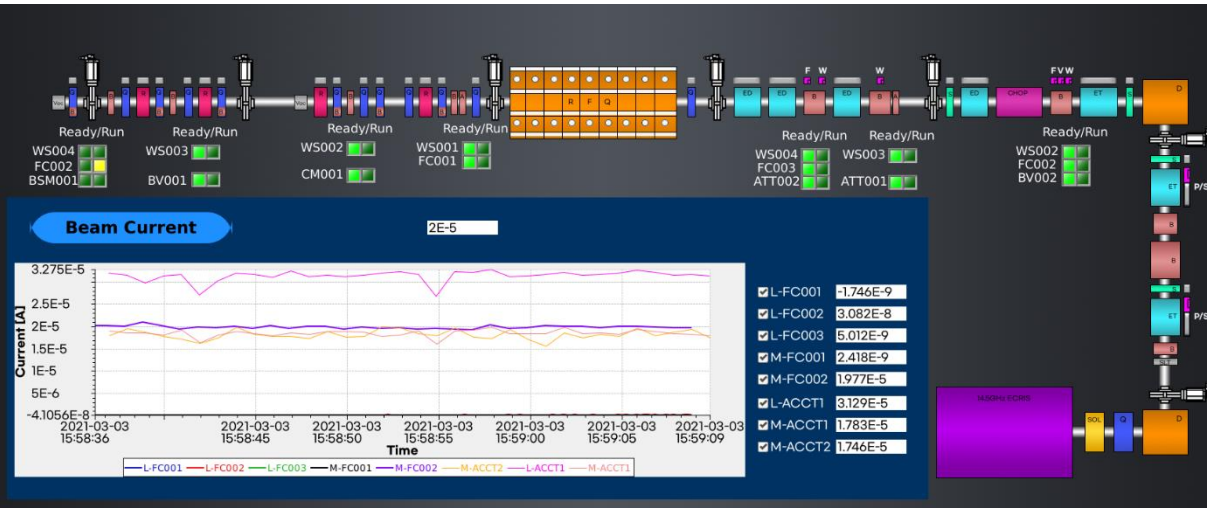


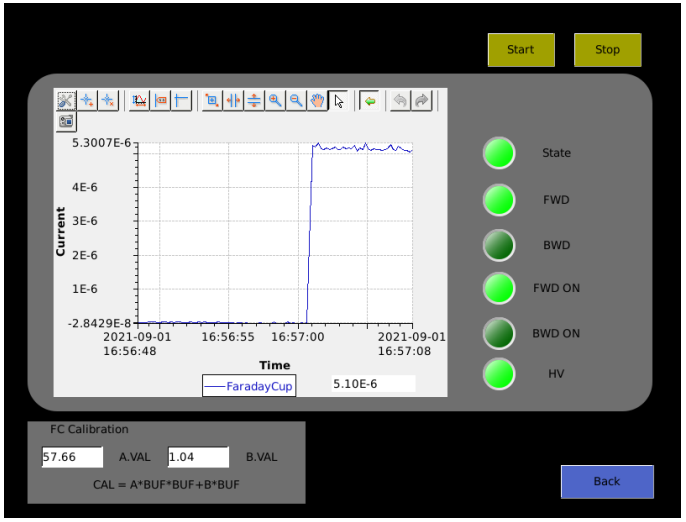
Injector Beam Commissioning –Diagnostics Control

◈ Injector beam commissioning

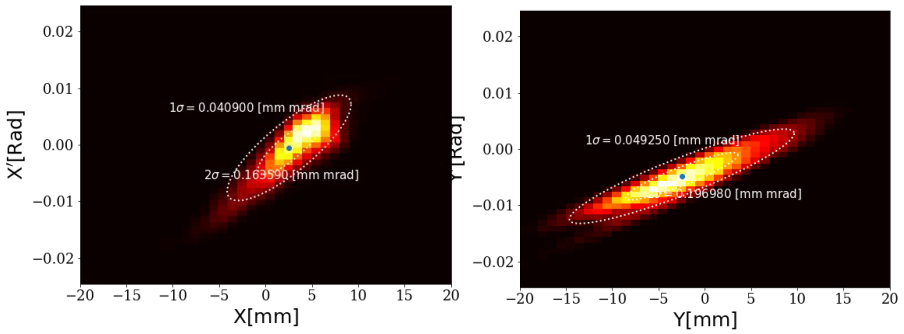
Poster (WEPP35) : EunHun. Lim
'EPICS Control System for RAON Diagnostics'

- ✓ EPICS basis control system
- ✓ Reference beam: $^{40}Ar^{9+}$ (100 μs pulse beam, 1Hz repetition rate)





- WS/FC/BV operation GUI(Sequence, Interlock)
- WS/FC – DAQ calibration and auto setting/saving
- Analysis(fitting) WS measurements using py-epics
- Energy measurements with BPM pairs(TOF)



Summary & Outlook

❖ Status of RAON Accelerator

- Injector system is in the beam commissioning stage since October 2020
- Low-energy linac, SCL3 will be completed in 2021, followed by beam commissioning.
- High-energy superconducting linac is pushed to the phase 2 project
- ISOL beam line components(TIS, RF-CB, EBIS, etc.) is being successfully tested with SI(Cs) beam

❖ Beam Instrumentations

- Button-type BPM and electronics for SCL3 are fully calibrated
- Large(P2DT section) BPM, Stripline BPM, and electronics for SCL2 are fabricated/tested
- Bergoz ACCT; 3 in the injector/2 in the P2DT installed
- BLM(Beam Loss Monitor); BLC(36 mm Ring) in the SCL3 warm section is installed
- Plastic Scintillator+PMT, Proportional Counter in the P2DT will be installed
- Current/voltage modules based on μTCA and BPM electronics are being tested.
- DBCM(ACCT networks) is being established/demonstrated for primary MPS(FPS)
- WS, FC, 2D-EM, BV, BPM, ACCT support beam tuning during injector beam commissioning
- EPICS based control systems/software are being updated

감사합니다.
Thank you