

Design of Beam Diagnostics System for Heavy Ion Accelerator Facility, RAON

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on behalf of Beam Diagnostic Group, RISP, IBS

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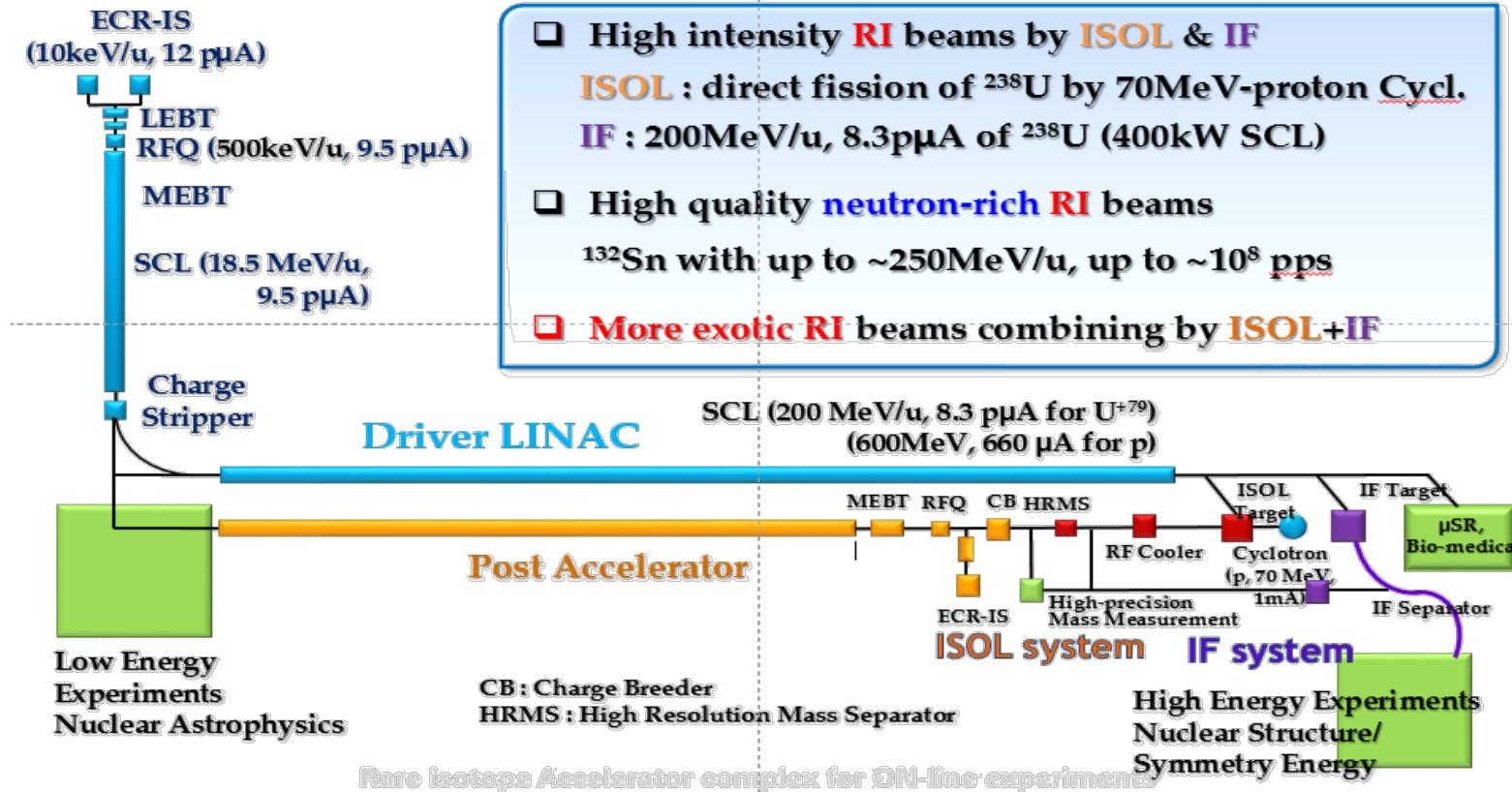
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RISP (Rare Isotope Science Project)



- Goal : To build a heavy ion accelerator complex, RAON, for rare isotope science researches
 - * RAON - Rare Isotope Accelerator Complex for ON-line Experiments
- Project period : 2011.12 - 2021.12
- Total budget : ~1.43 B\$ (Facilities ~0.46 B\$, Bldgs & Utilities ~0.97 B\$)



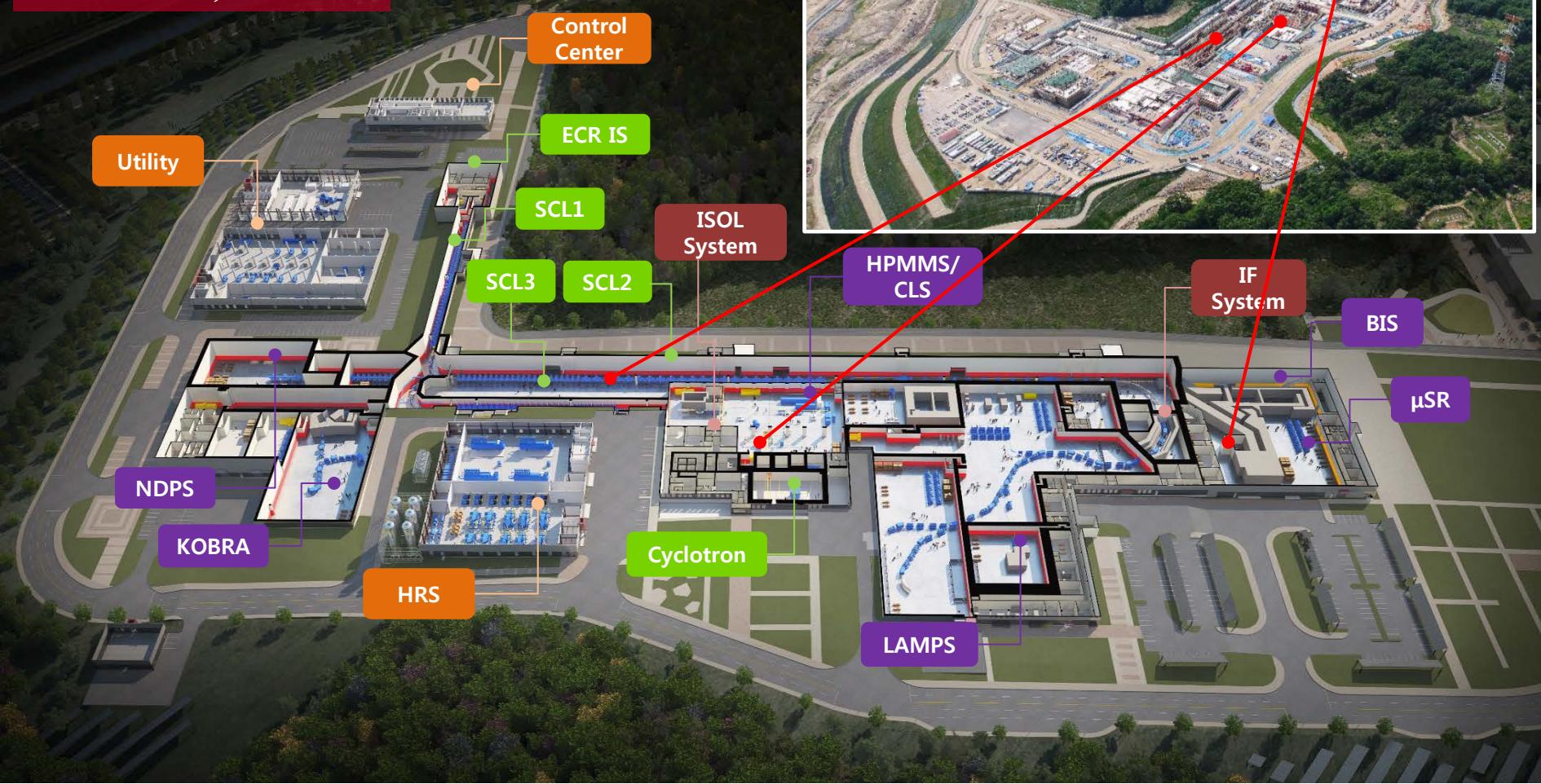
RAON Site : Sindong in Daejeon



RAON Layout

RISIP

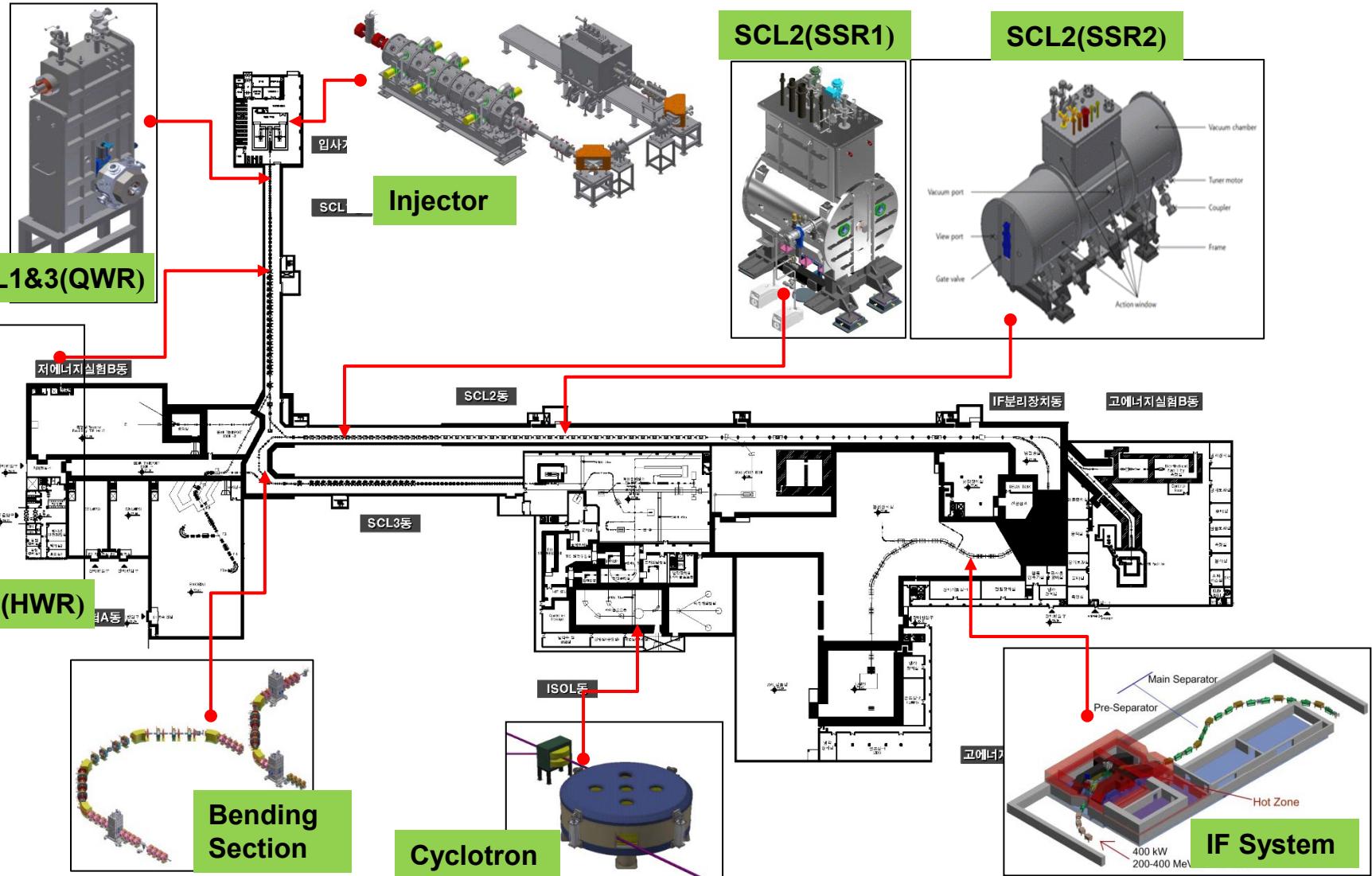
<Area 952,000 m²>



< RAON site (2018.5) >

RAON Layout : Accelerator System

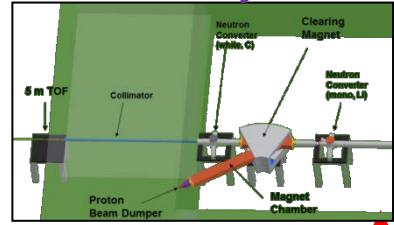
RISP



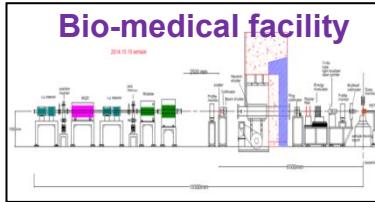
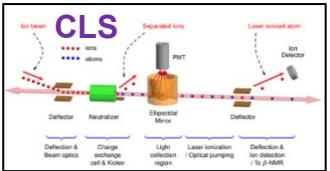
RAON Layout : RI & Experimental System

RISP

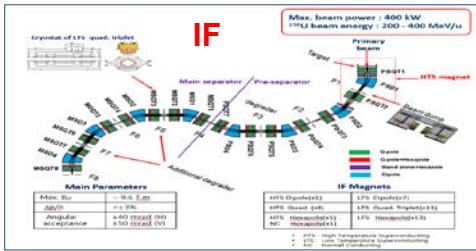
Neutron Facility



Low Energy Exp. Bldg

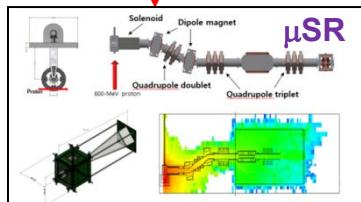


Ultra-low Exp. Bldg

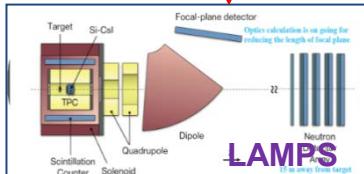
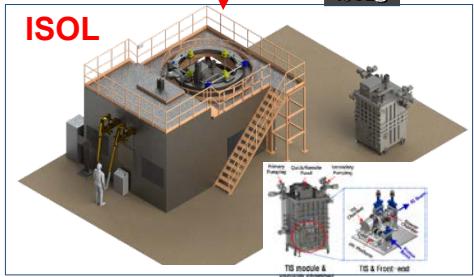
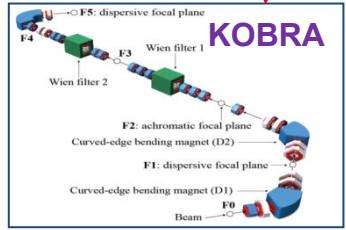


IF

High Energy Exp. Bldg



ISOL동

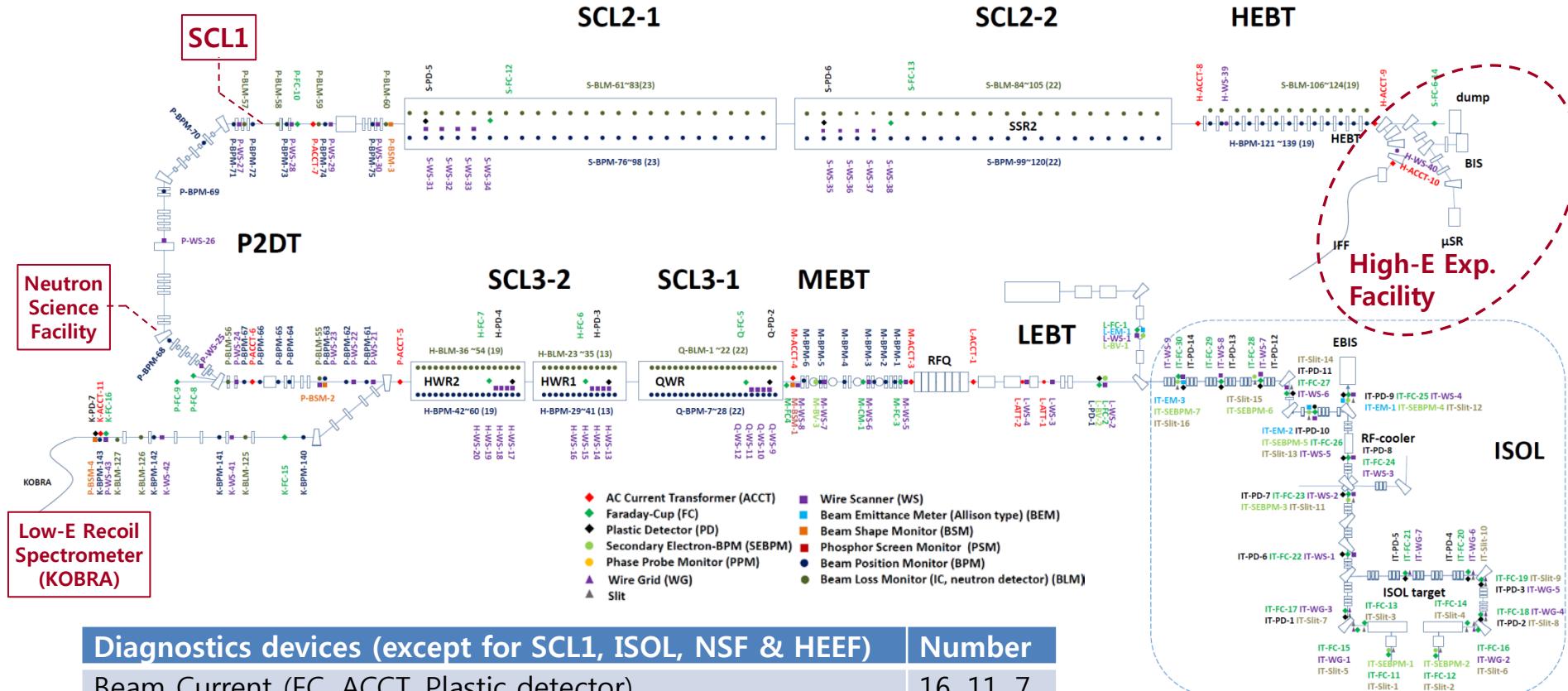


LAMPS

Beam Diagnostic System at RAON

The logo for RISP (Rheumatoid Inflammation Suppression Project) features the acronym "RISP" in a large, bold, white font. The letters are partially submerged in a thick, green, textured band that has a diamond pattern. Below this green band is a solid dark blue horizontal bar.

* SCL1 configuration is the same as the SCL3.



Diagnostics devices (except for SCL1, ISOL, NSF & HEEF)	Number
Beam Current (FC, ACCT, Plastic detector)	16, 11, 7
Beam Position Monitor (BPM)	143
Beam Loss Monitor (BLM)	127
Beam Profile (Wire Scanner, Phosphor Screen)	43, 3
Beam Shape Monitor (Beam Bunch Shape)	4
Emittance Scanner	2

Beam Parameters & BD Functions



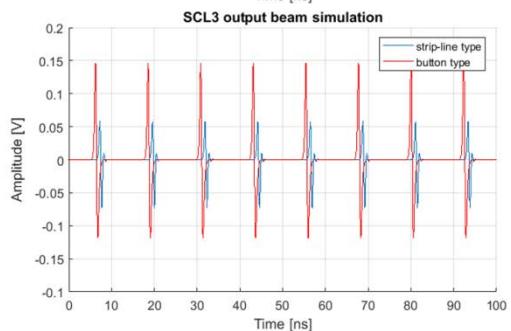
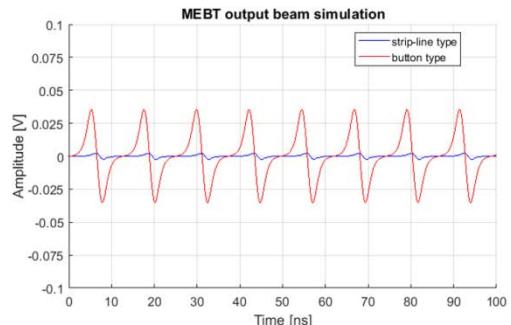
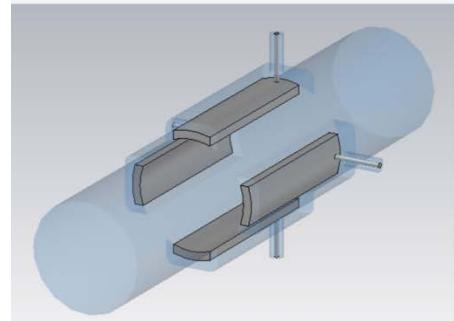
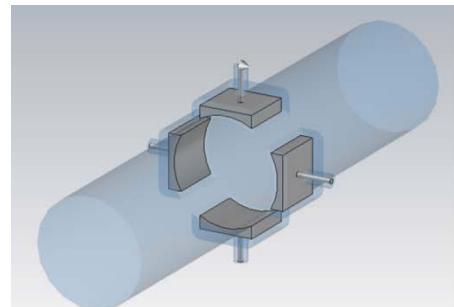
	Driver Linac				Post Acc.	Cyclotron
Particle	H ⁺	O ⁺⁸	Xe ⁺⁵⁴	U ⁺⁷⁹	RI beam	proton
Beam energy (MeV/u)	600	320	251	200	18.5	70
Beta (v/c)	0.79	0.67	0.62	0.57	-	0.37
Particle current (pμA)	660	78	11	8.3	-	1000
Power on target (kW)	400	400	400	400	-	70

Functions of Beam Diagnostics

- Initial commissioning & component tuning
 - FC, WS, BV, CT, BPMs (position, phase, TOF), etc
 - commissioning beam : ex. Ar(9+), 30 eμA, 50 μs, 1 Hz, ...
- During operation (on-line)
 - monitoring beam transport and acceleration function
 - BPM : beam position and phase
 - BCM : beam current and transmission(RFQ, SCL3(1), P2DT, SCL2, etc.)
 - BLM : beam Loss and link to machine protection
- Commissioning and during operation (on-demand)
 - 1-D, 2-D beam profiles (WS, EM)
 - Bunch length (FFC)

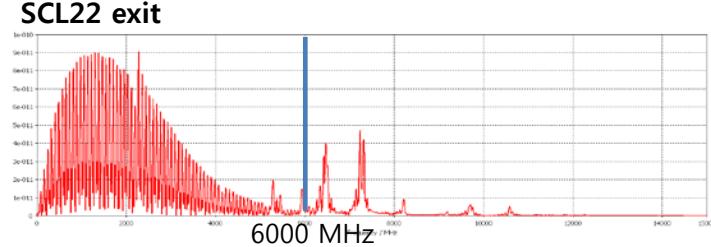
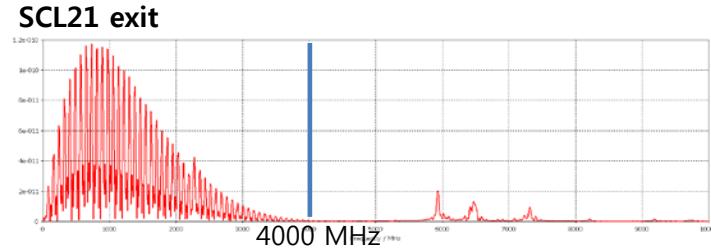
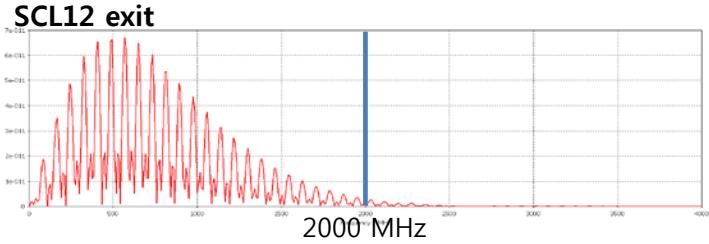
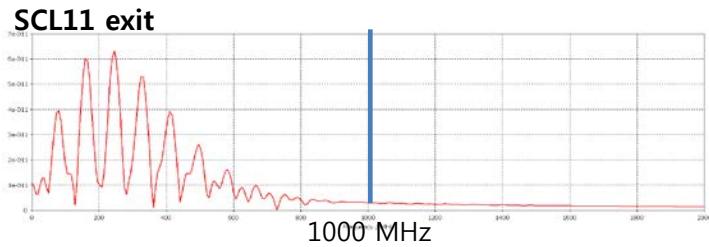
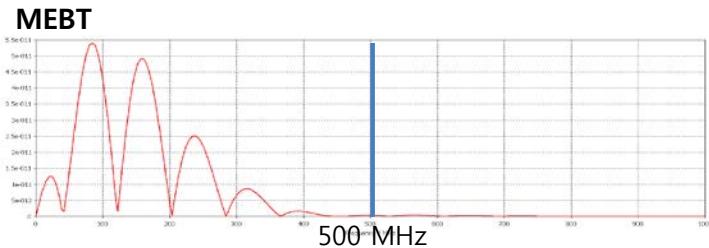
Beam Position Monitor

- Measurements : beam position, phase & relative intensity
- Type of BPM : considering signal strength and space limitation, button-type BPMs were selected instead of stripline BPM.
- 4 sizes of BPM : BPM-40, 50, 60 & Large BPM at folding segment.
- Inspection of fabricated BPMs : vacuum, TDR and calibration (wire test).



* Please refer to the Poster (TUPC06) : 'Beam Position Monitor for SCL3 of RAON'

BPM Signals in Frequency domain

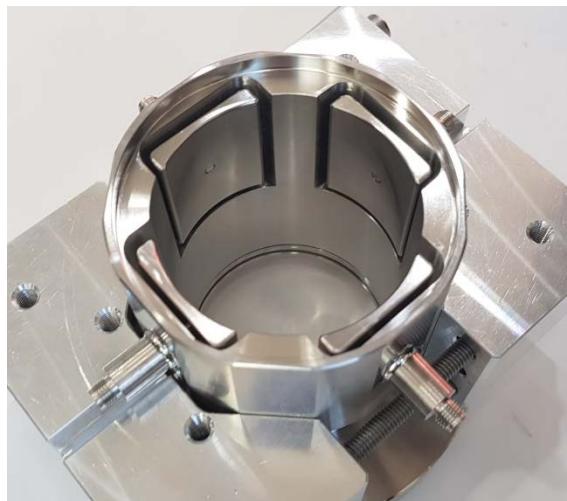
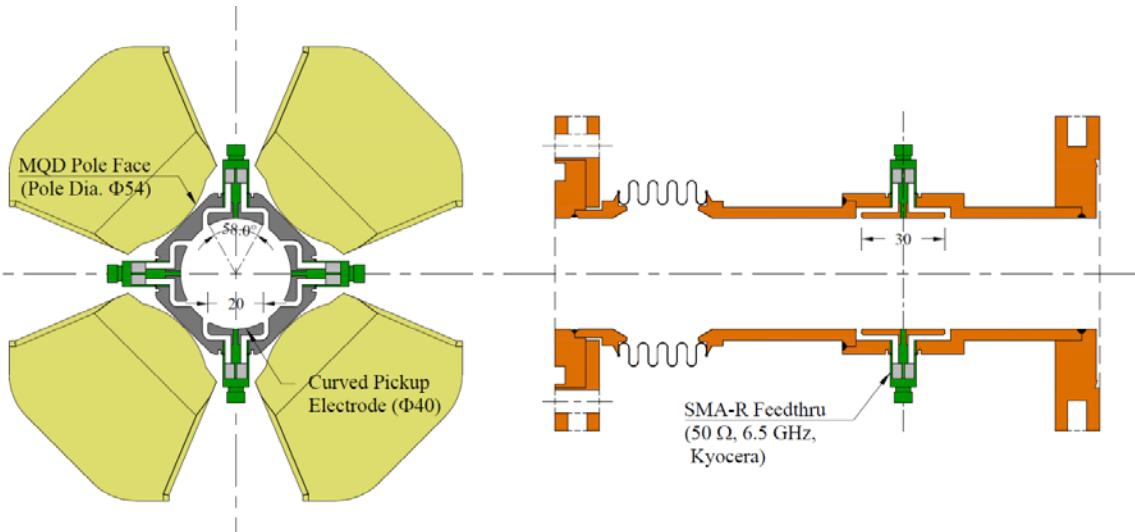


❖ CST Particle Studio
Repetition: 81.25 MHz, ~ 12.3 ns

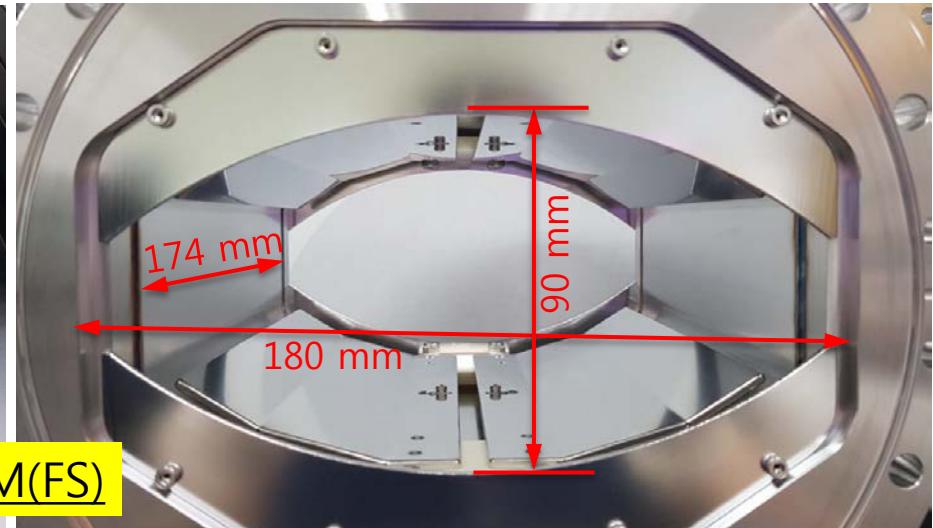
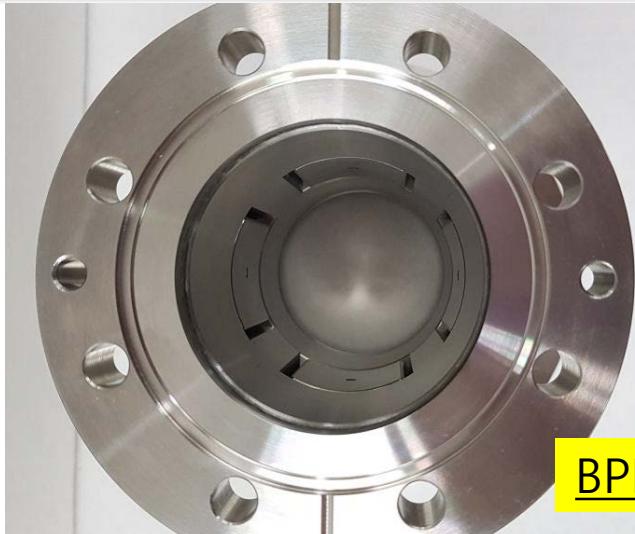
- Higher harmonic ($\geq 2^{\text{nd}}$) signals are dominant after SCL11 (SCL31).
- Signal Processing with,
 - 1st, 2nd harmonics for MEBT & SCL11 (SCL31)
 - 1st, 3rd harmonics for SCL12(SCL32)
- 60 BPM modules in fabrication by a domestic company (Mobiis).



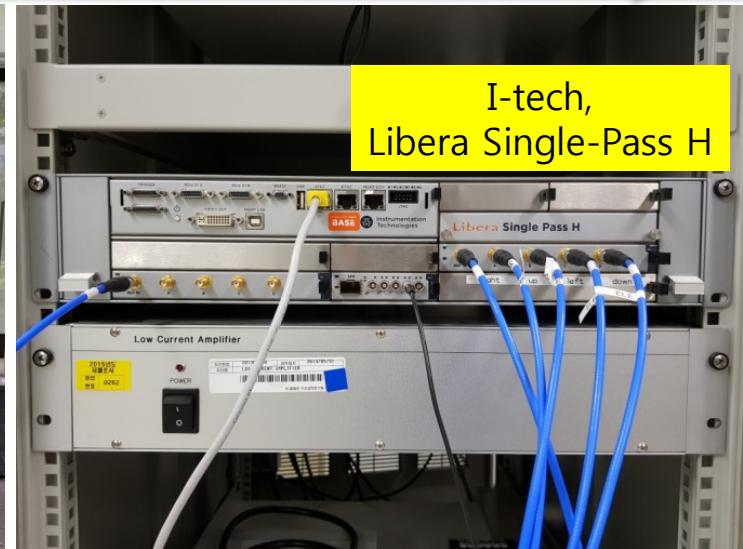
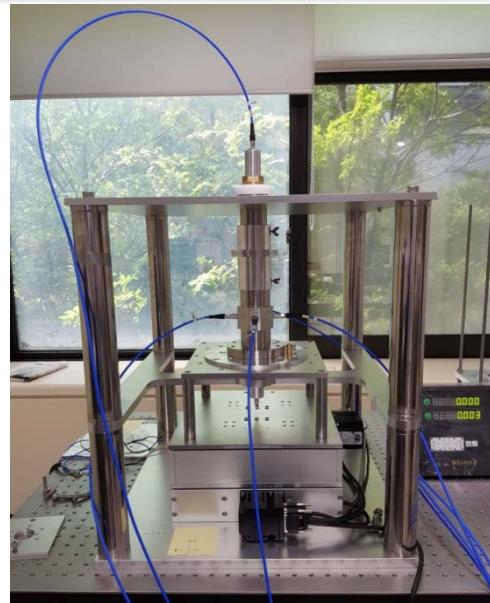
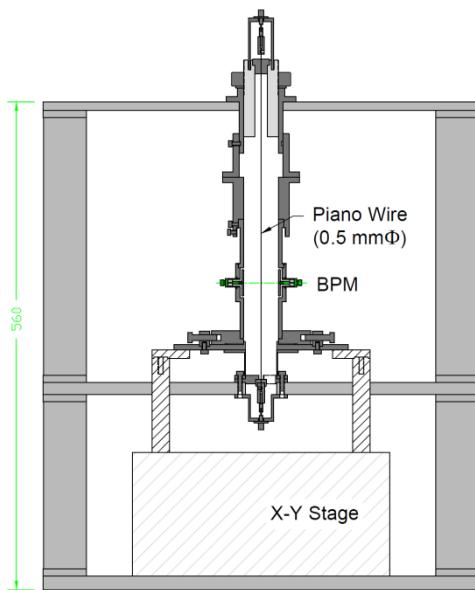
BPM-40



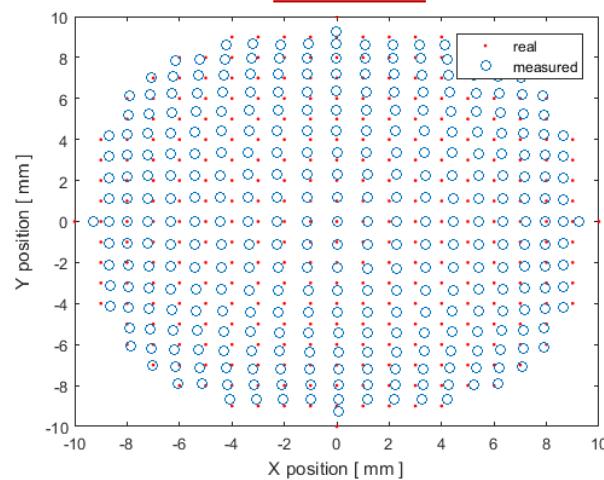
Beam Position Monitor



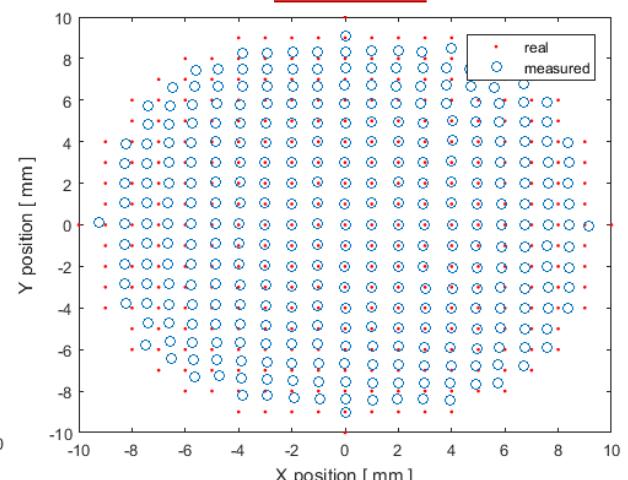
Wire Test Bench



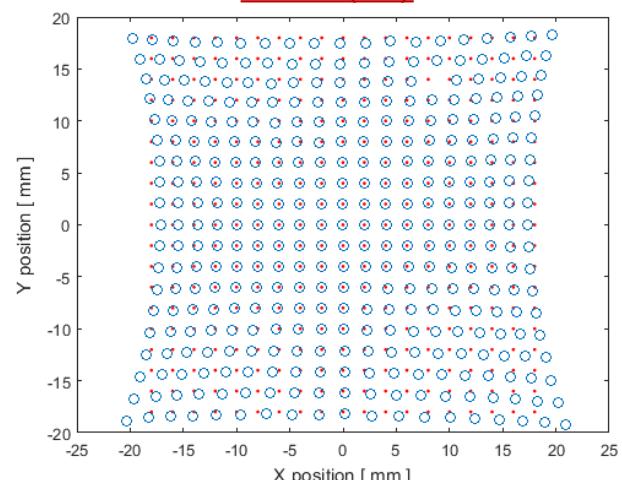
BPM-40



BPM-60



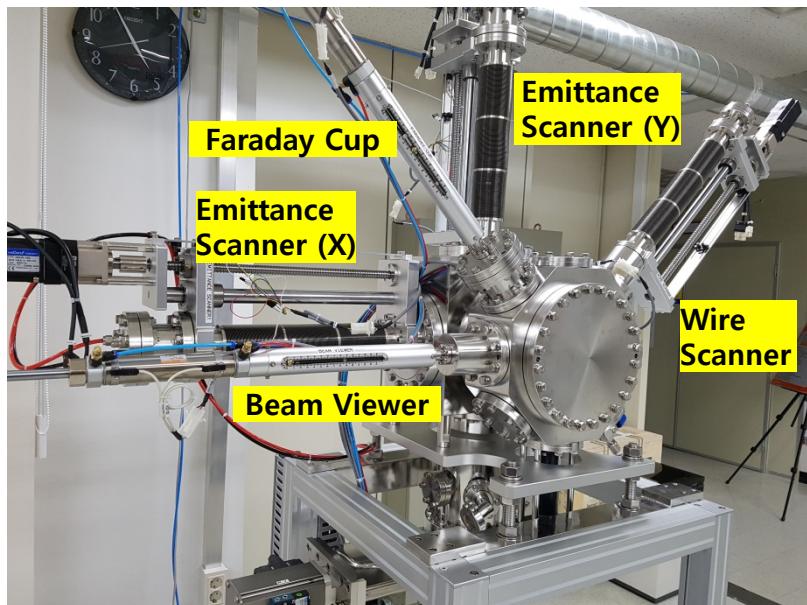
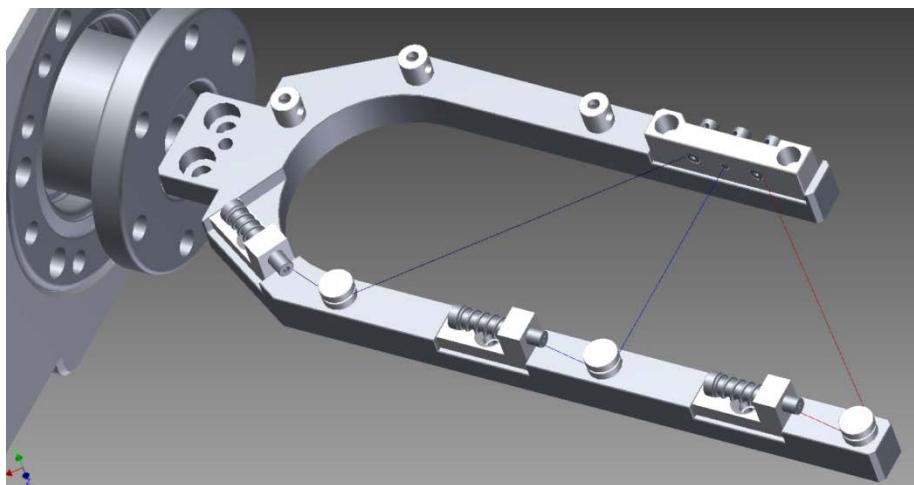
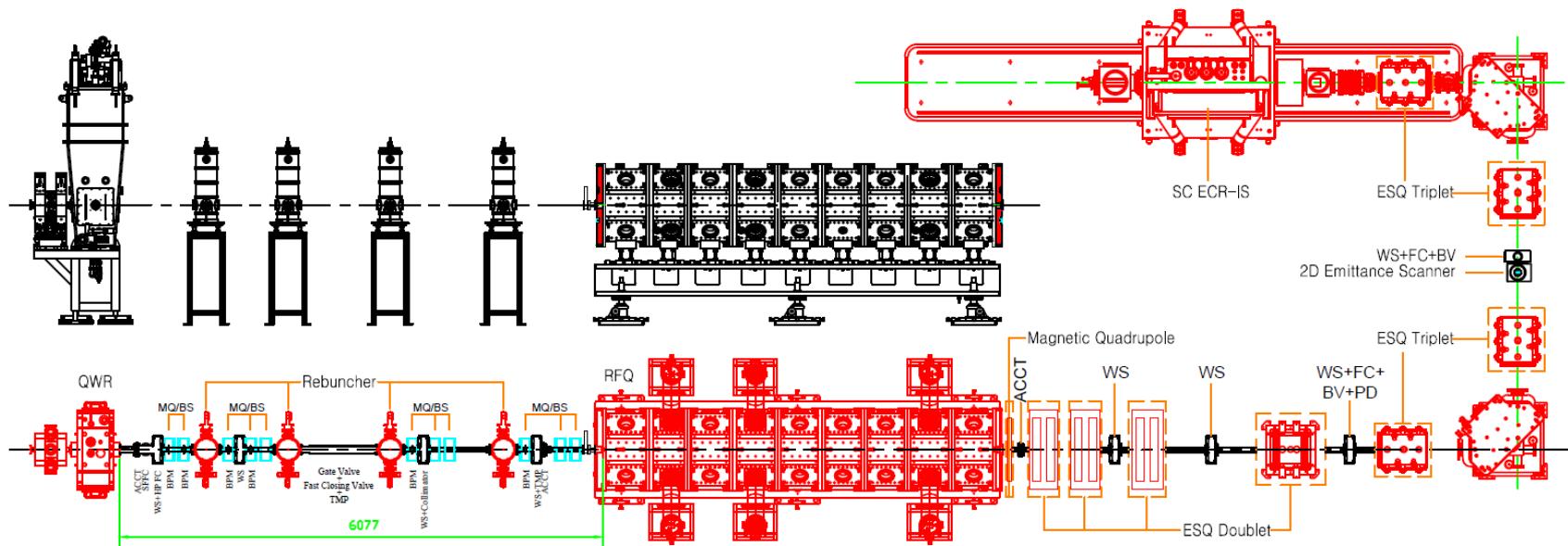
BPM (FS)



Precision @ ± 5 mm : <50 μ m

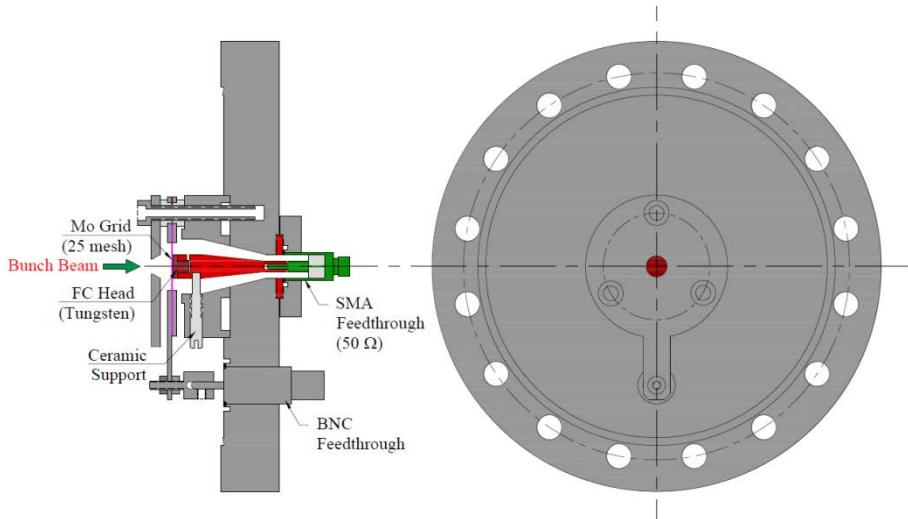
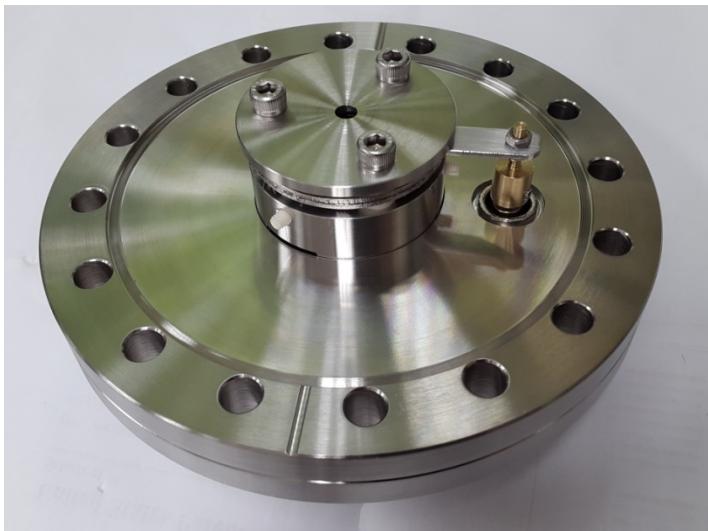
Injector Beamline

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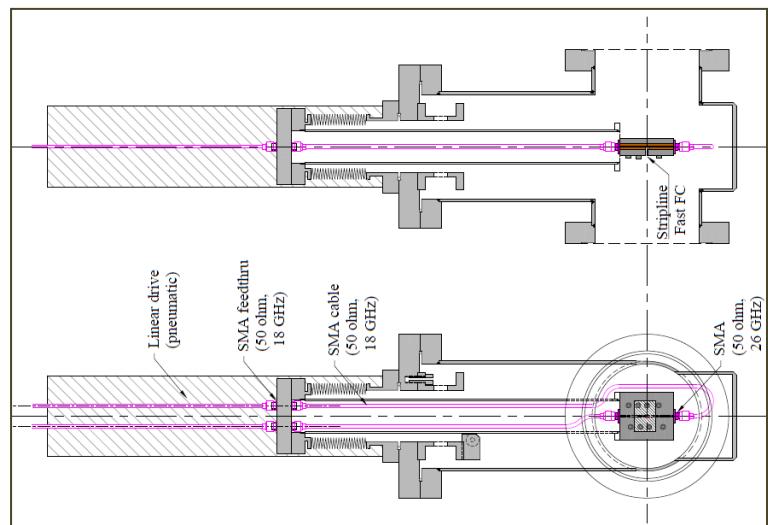


Fast Faraday Cup (FFC)

- Coaxial Fast Faraday Cup (for SCL demo-facility)

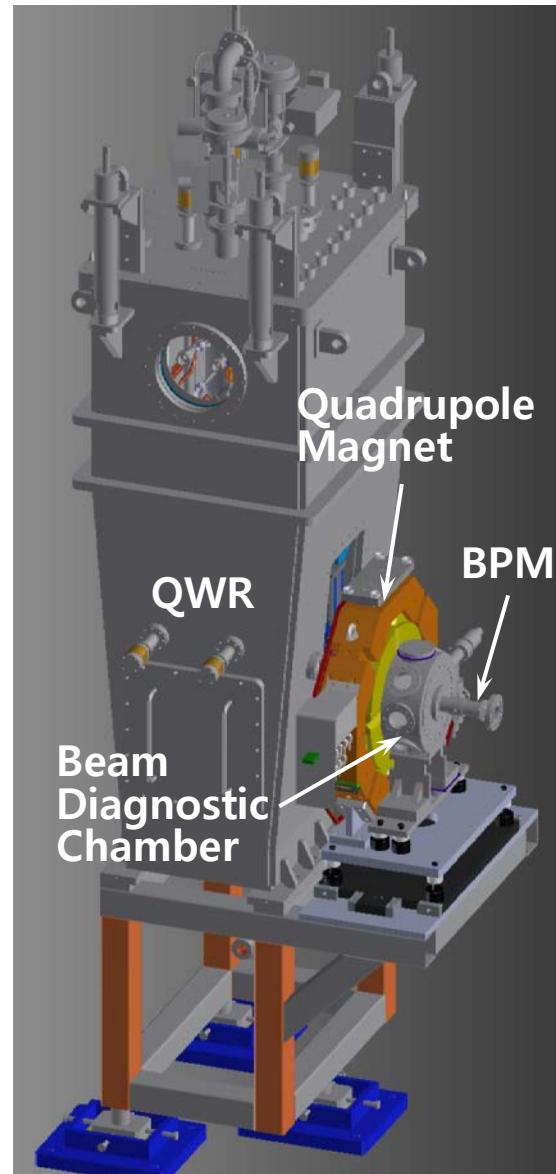
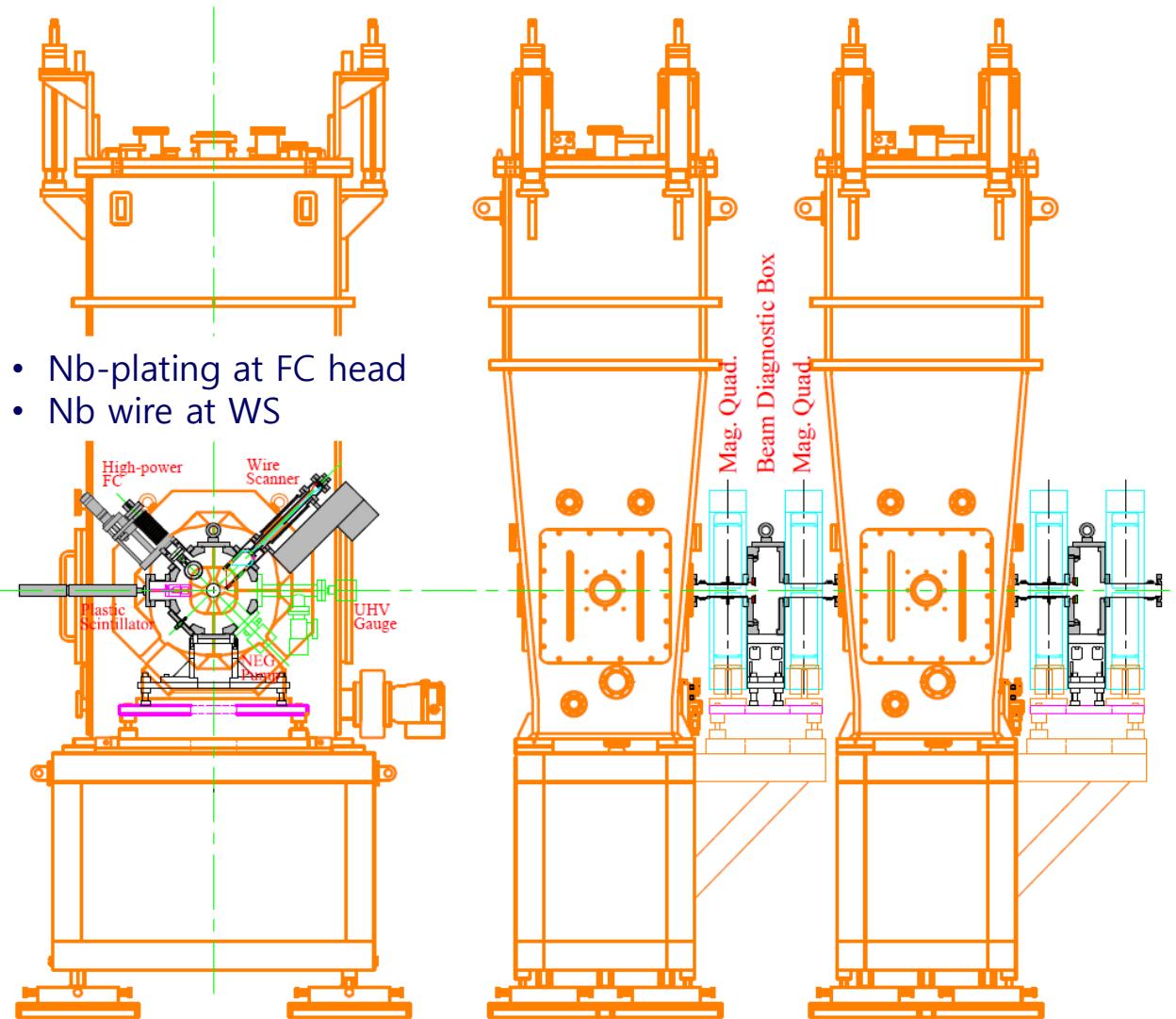


- Stripline Fast Faraday Cup (SFFC)

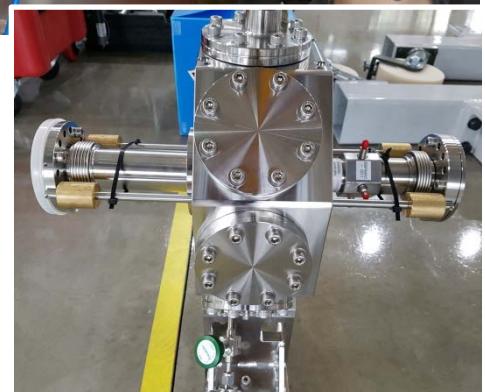
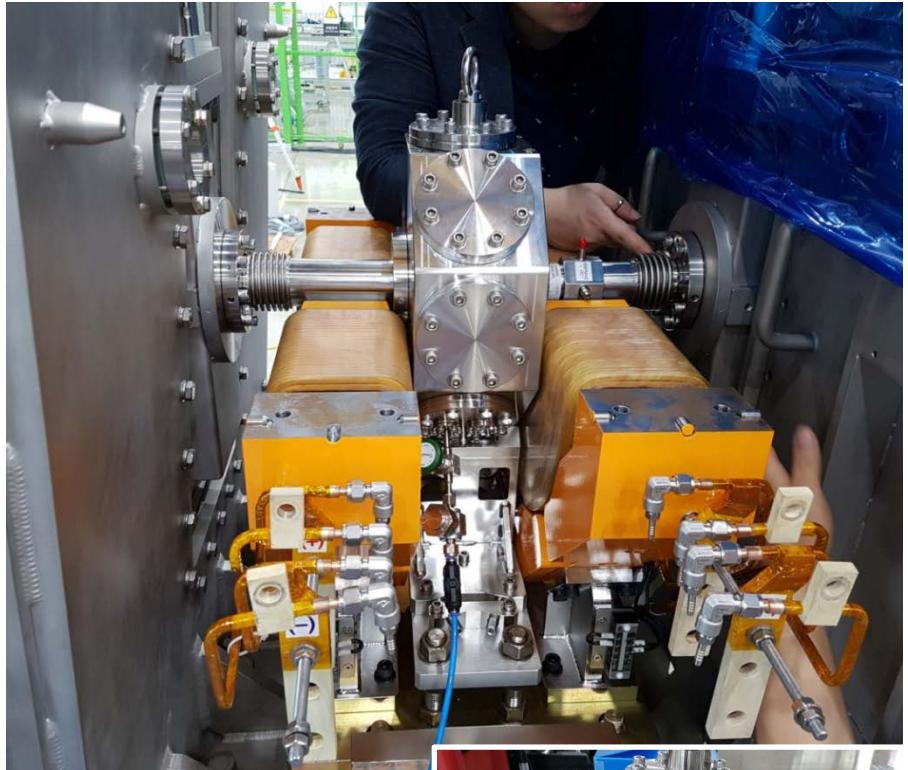


SCL QWR Section

RISIP



SCL3 Warm Section



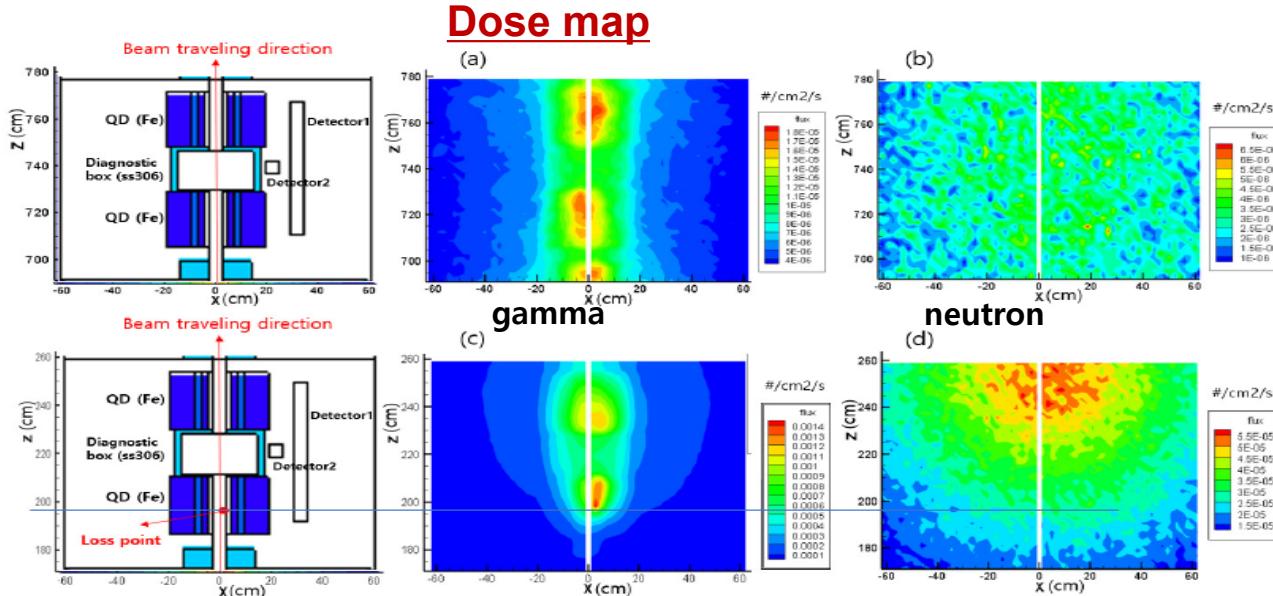
- BPM inside of Magnetic Quadrupole
- Installation (& align) procedure of BDC/BPM/Beam Pipe assembly (with pure N₂ purging) in between two cryo-modules was prepared.

Beam Loss Monitor (BLM)

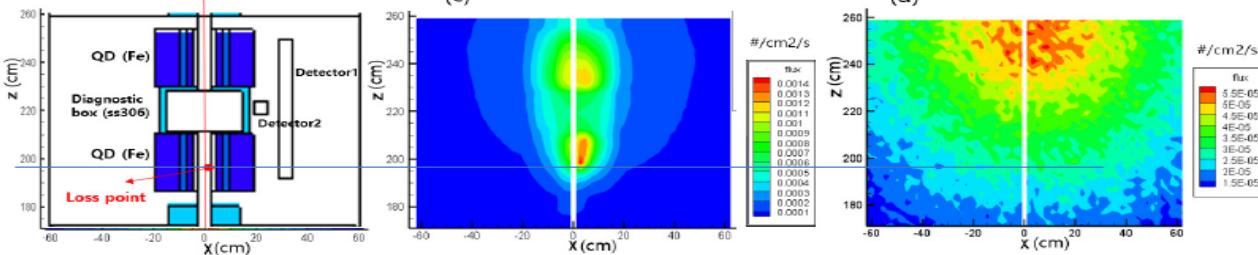
- Monitor regular (slow) and irregular (fast) losses
 - Radiation Sources
 - Radiation : neutron, proton, gamma, electron, ion for $>\sim 7$ MeV/u
gamma, electron $<\sim 7$ MeV/u
 - outside of Vacuum Chamber (secondary) : gamma, neutron
 - at low energy region (SCL31/SCL11) : very low radiation level expected
 - X-rays from SC Cavity & RF source is background source to BLM
 - Source term simulation (MCNPX) has been done throughout Linac Tunnel
 - MPS (Machine Protection System) requirements are checked
 - DBCM (Differential Beam Current Monitor) with ACCT networks is considered for primary fast loss detection.
 - CT networks : ACCT1 – RFQ – ACCT2 – MEBT- ACCT3 – SCL3 – ACCT4
 - Beam Loss Collector, Plastic Scintillator and Proportional Counter are considered as BLM sensors.
- ❖ Please refer to the Poster (TUPA11) : 'Design Study of the Beam Loss and Halo Monitoring for the RAON Heavy Ion Accelerator'

MCNPX simulation

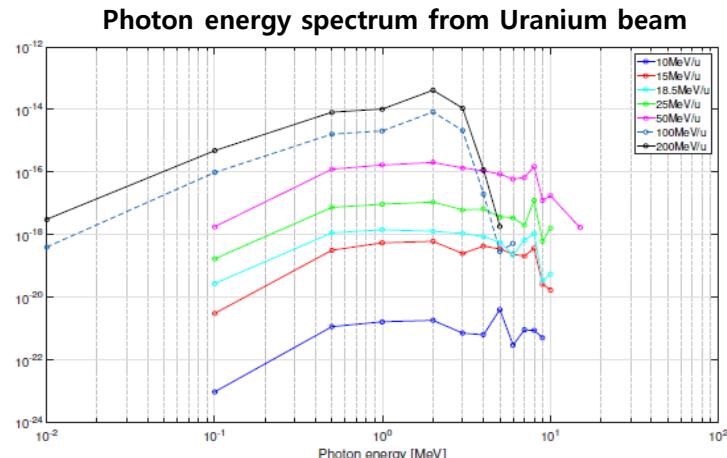
**Slow loss
(continuous, 1 W/m)**



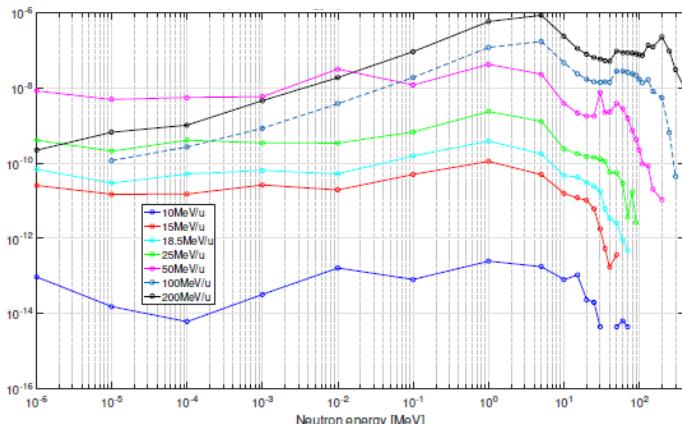
**Fast loss
(point Loss, 1 W)**



Energy spectrum

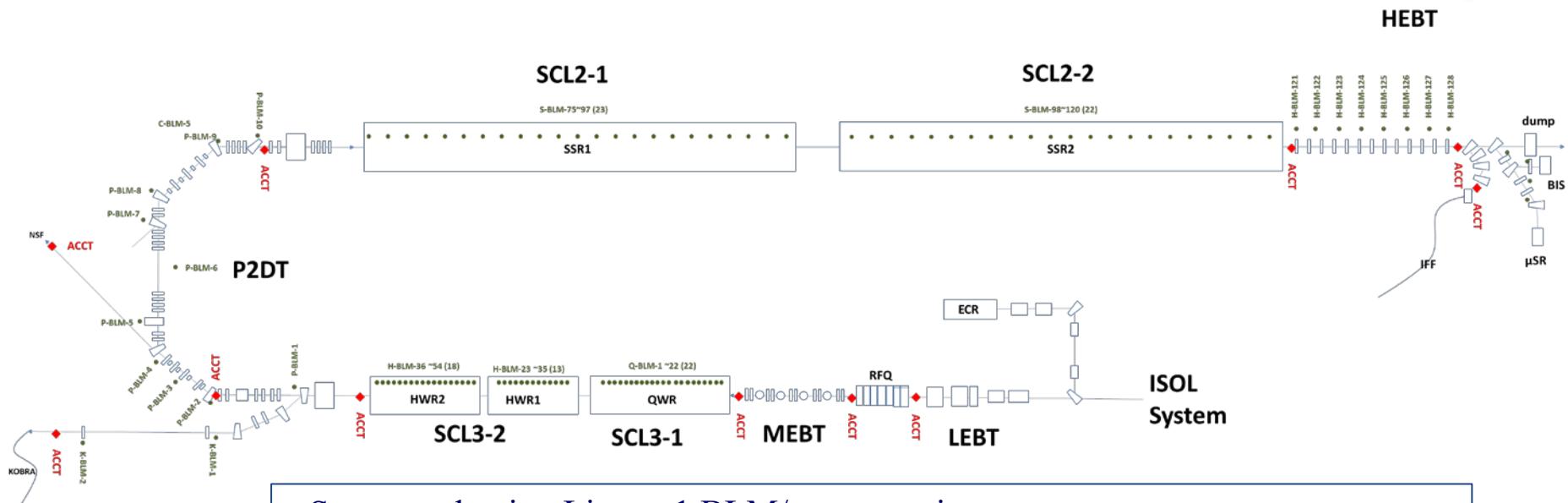


Neutron energy spectrum from Uranium beam



BLM Layout (preliminary)

RISIP



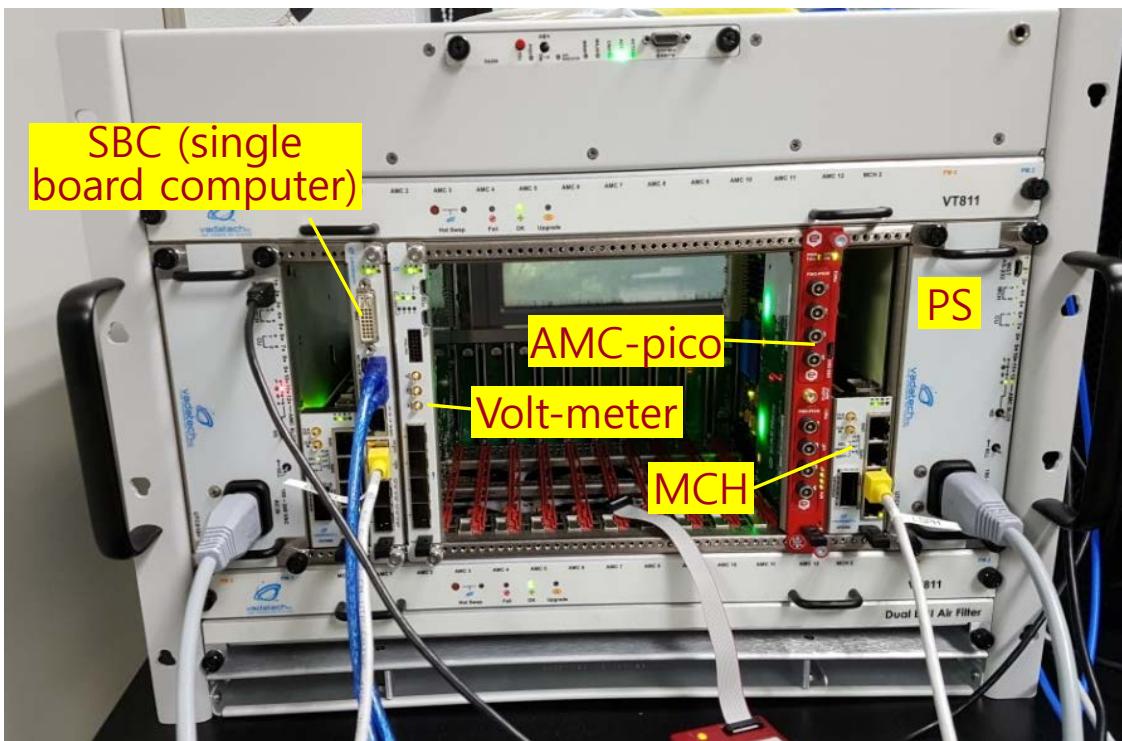
- Superconducting Linac : 1 BLM/warm section
- Bending Section (P2DT) : Beam Loss Points (charge selector, collimator, etc.)
- DBCM (ACCT networks) : Primary MPS input for fast loss

Section	BLM		
SCL31 (QWR)	DBCM	BLC	-
SCL32 (HWR-A)	DBCM	BLC	-
SCL32 (HWR-B)	DBCM	BLC	PD
P2DT	DBCM	PD	PC
SCL21 (SSR1)	DBCM	PD	BLC
SCL22 (SSR2)	DBCM	PD	BLC

*DBCM : Differential Beam Current Monitor
 BLC : Beam Loss Collector
 PD : Plastic Detector
 PC : Proportional Counter

DAQ System

- **BPM – standalone (with timing, trigger, interlock, etc.)**
 - Libera Single Pass H has been used at SCL demo-facility.
 - 60 modules (domestic) in fabrication (delivery in Jan. 2019).
- **Others (WS, FC, CT, BLM, etc.) with μTCA system**
 - CAENels AMC-pico: 8ch 20bit Pico-ammeter
 - Vadatech DAQ523: 12ch 16bit volt-meter (for ACCT only)
 - System design and test finished



Summary & Plan (I)

- **SCL-demo system**
 - Beam Diagnostic Chamber (BDC)-1 with RBS, Phosphor Screen, two Phase Probes, FFC was used for RFQ commissioning in November 2016.
 - BDC-2 with WS & FC, two BPM-50 and SFFC was used for QWR commissioning in October 2017.
- **Injector beamline**
 - BDC (LEBT) with 2D-ES, WS, FC and beam viewer was fabricated this year.
 - Beam Diagnostic System (for LEBT & MEBT) will be prepared this year.
- **SCL3 warm-section**
 - 60 Button-type BPMs were fabricated and tested, and 60 modules are under fabrication.
 - 15 BDCs in SCL3 warm section is under fabrication.
- **P2DT/KOBRA beamline**
 - Design of Beam Diagnostic System was finished, and ready to order.
 - Three Large BPMs (for P2DT) were fabricated and tested.

Summary & Plan (II)



■ **BCM (ACCT)**

- was tested at SCL Demo and showed good sensitivity to measure \sim few μA .
- 6 Bergoz ACCT are ready for installation

■ **BLM (Beam Loss Monitor)**

- Plastic Scintillator, Proportional Counter, BLC are under consideration.
- 3 PCs (Toshiba BLM) are under test.
- DBCM (ACCT networks) will be used for primary MPS.

■ **DAQ System**

- Readout and control systems with μTCA are being designed and tested.

■ **Schedule**

- 2018~ 2020 : Fabrication (Injector \rightarrow SCL3 \rightarrow P2DT \rightarrow SCL2 \rightarrow SCL1 in the order)
- 2019~ 2021 : Installation & commissioning

■ **Some difficult subjects**

- Optimization of BLM system
- Design of BD system for low-intensity rare isotope beams from ISOL system.



■ Acknowledgements

- Gi-Dong Kim, Yeonsei Chung (RISP/IBS)
- Jangwon Kwon (Korea Univ.)

*Thank you for
Your attention !*