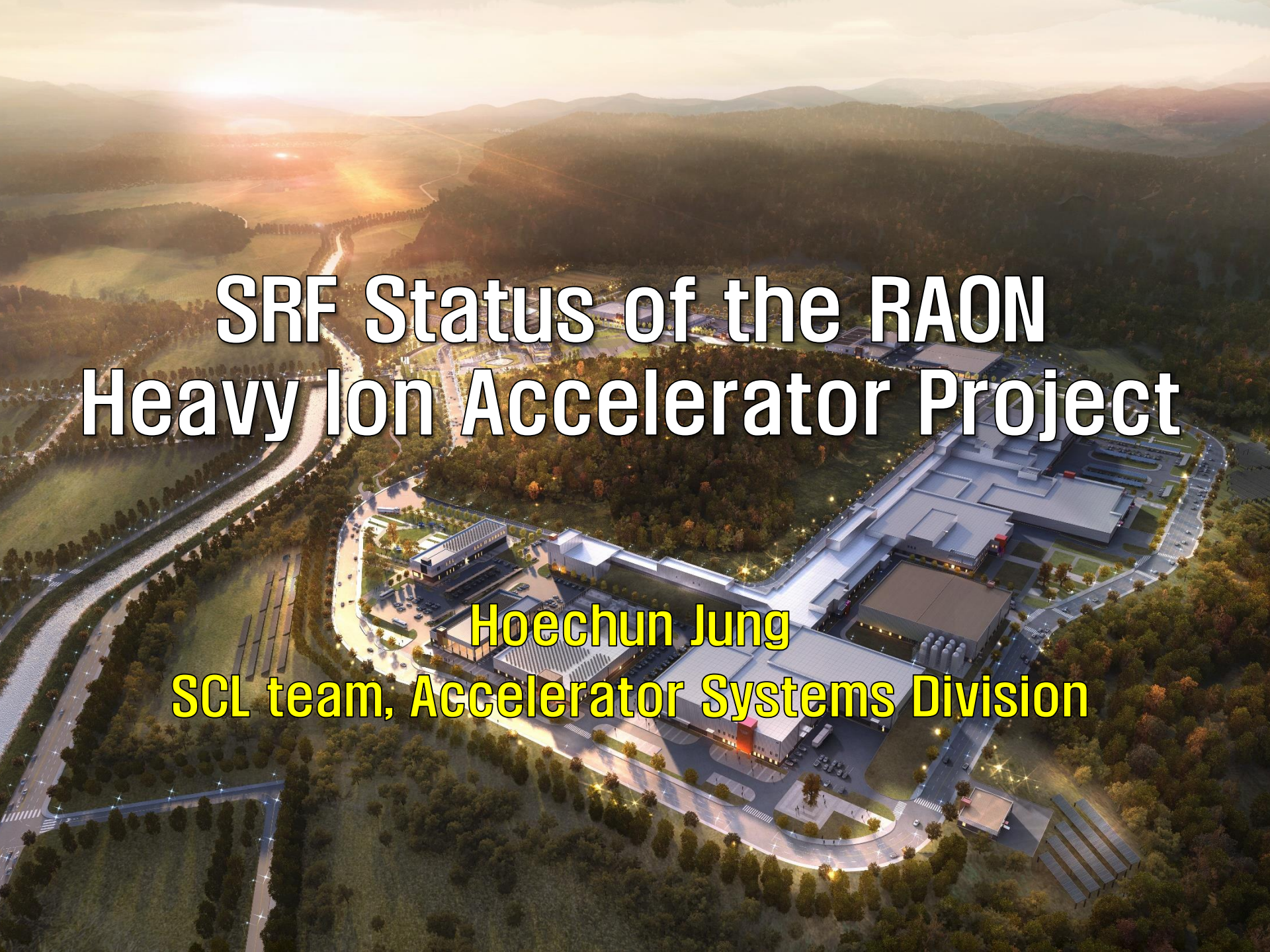


SRF Status of the RAON Heavy Ion Accelerator Project

Hoechun Jung
SCL team, Accelerator Systems Division

Overview

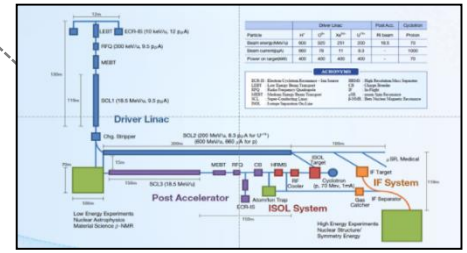
- **Goal:** To build **a heavy ion accelerator complex RAON,** for **rare isotope science** research in Korea.

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

- **Budget: KRW 1,432 billion (US$ 1.26 billion, 1$=1,135krw)**
  - accelerators and experimental apparatus : 460.2 billion won
  - civil engineering & conventional facilities : 972 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**

Milestone

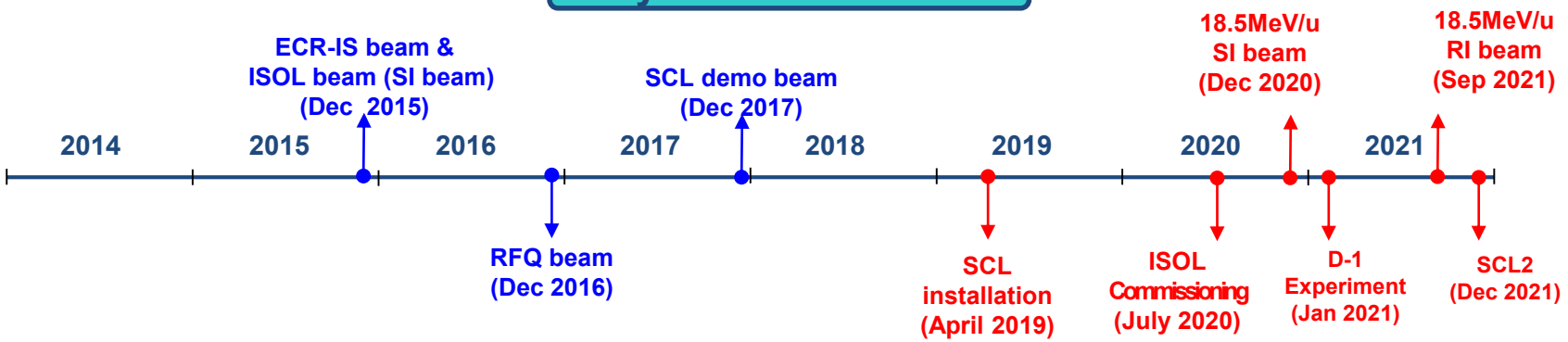
(2018)
SCL3 manufacturing
SCL2 Prototype

(2019)
SCL3 Installation
SCL2 manufacturing

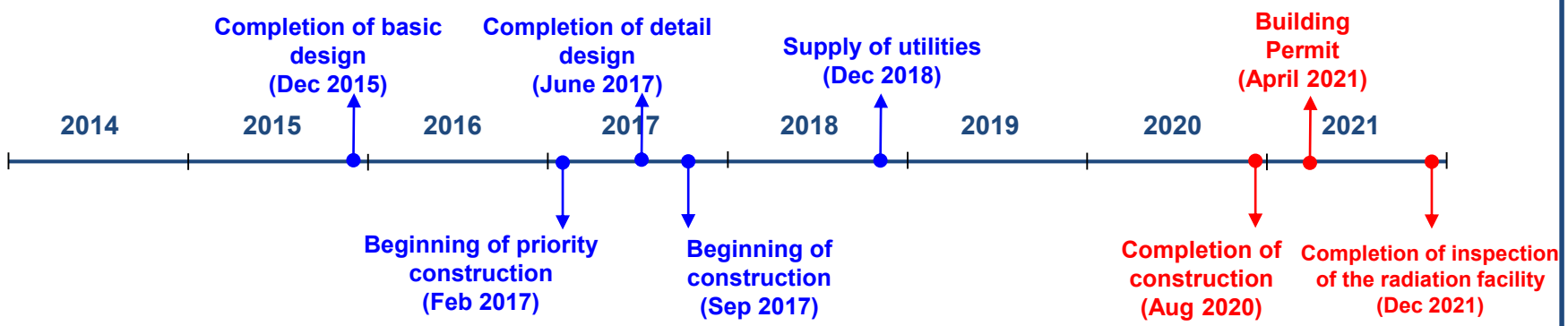
(2020)
SCL3 Beam Commissioning/
Const. Completion

(2021)
SCL3 Beam Commissioning/
Project Completion

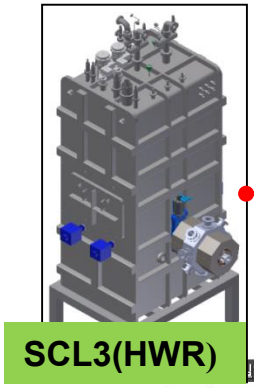
System Installation



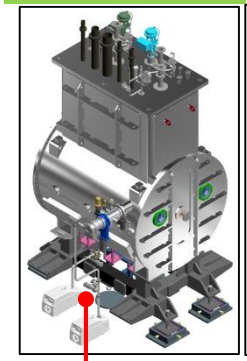
Facility Construction



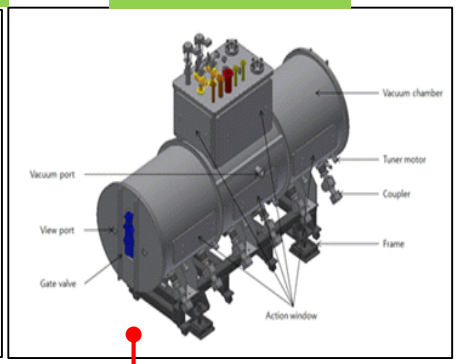
Superconducting Linear Accelerators



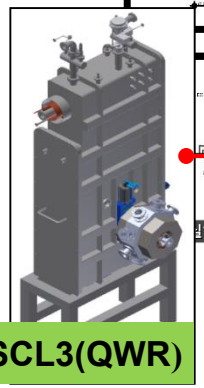
SCL3(HWR)



SCL2(SSR1)



SCL2(SSR2)



SCL3(QWR)

Linac	Frequency (MHz)	Cavity type	# of cavity	# of Module	Cav. Op. T (K)
Low energy SRF linac (SCL3)	81.25	QWR	1	22	4
	162.5	HWR	2	13+2	2
			4	19	2
High energy SRF linac (SCL2)	325	SSR1	3	23	2
	325	SSR2	6	23+2	2

104 cryomodules, 341 cavities

Production of Cryomodules for Low Energy SRF Linear Accelerator

- **Designed performance was achieved with prototypes**
  - 1st QWR cryomodule (2017.05): <20 Watts at 6.1 MV/m, 4K
  - 1st HWR type A cryomodule (2017. 10): <14.1 Watts at 6.6 MV/m(average), 2K
- **Oxygen beam was accelerated with a RFQ and the QWR cryomodule (2017.10)**
  - 500 keV/u → ~700 keV/u after the QWR Cryomodule
  - RF stabilities were matched the requirements (<±1%, <±1°)
- **The contract for mass production of cryomodules with VITZRO tech(Korea)**
  - 22 QWR cryomodules(2017.12~), 34 HWR cryomodules(2018. 05~)
- **6 QWR cavities and 3 QWR modules are fabricated/tested (Present)**
- **1st QWR Cryomodule will be installed in the tunnel (2019. 09)**
  - 22 QWR cryomodules and 32 HWR cryomodules will be installed until 2020.6

Performances: 6 QWR Cavities

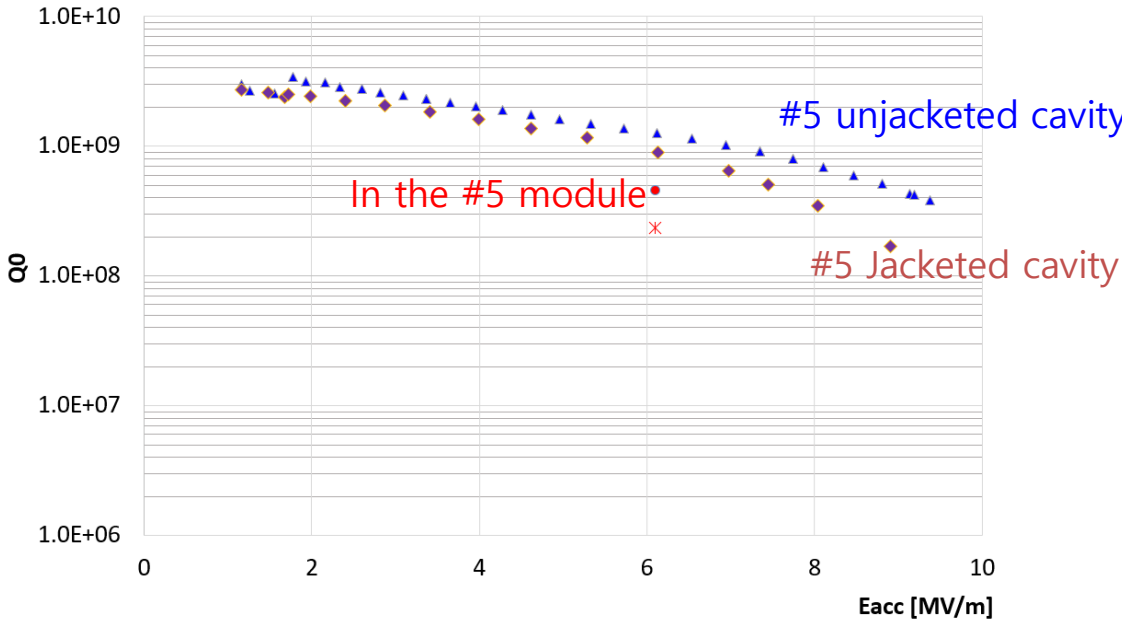
6/6 QWR cavities are passed the qualification test

Target Q_0 : >2.4e+8@6.1MV/m, 4.2 K

Performances: 3 QWR Modules

Qualification:

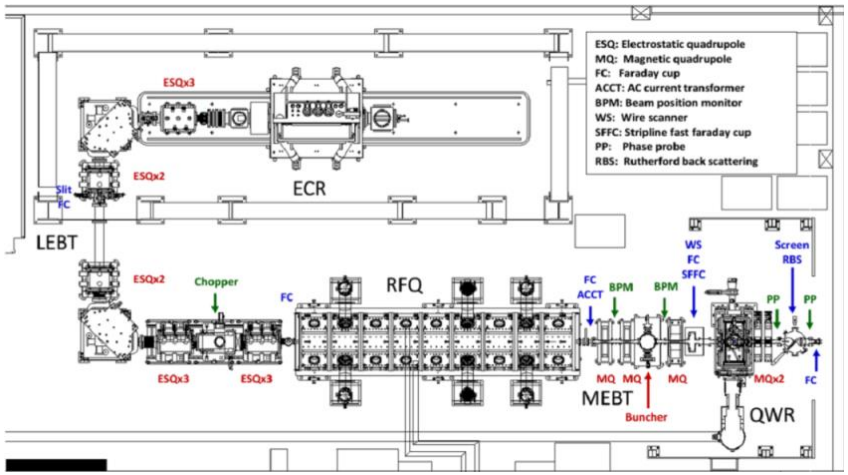
Heat load is less than 20Watt @ 6.1MV/m, 4.2K

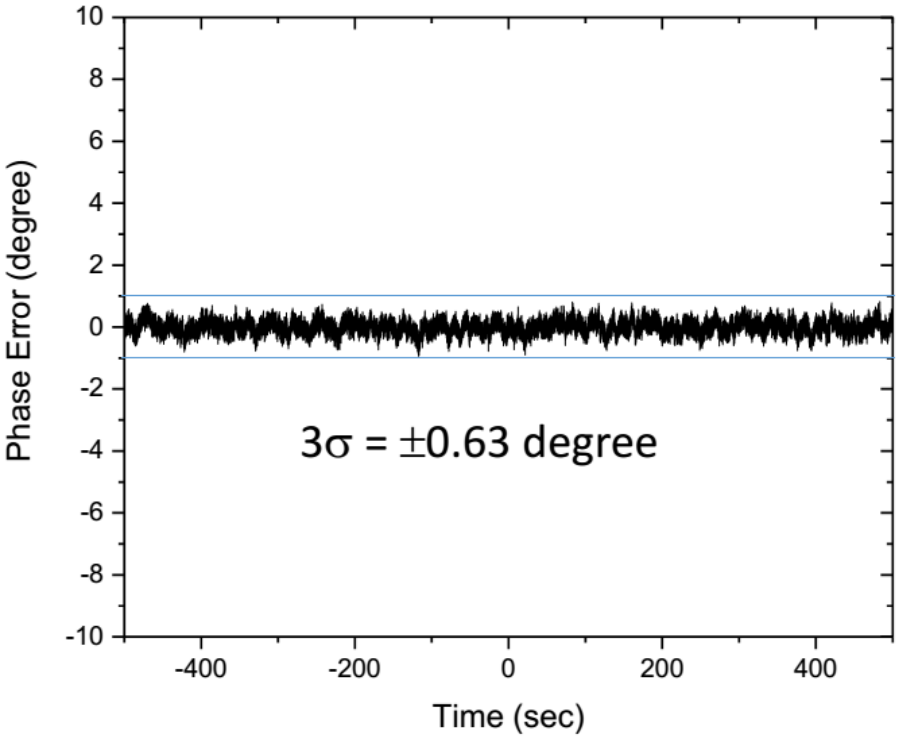


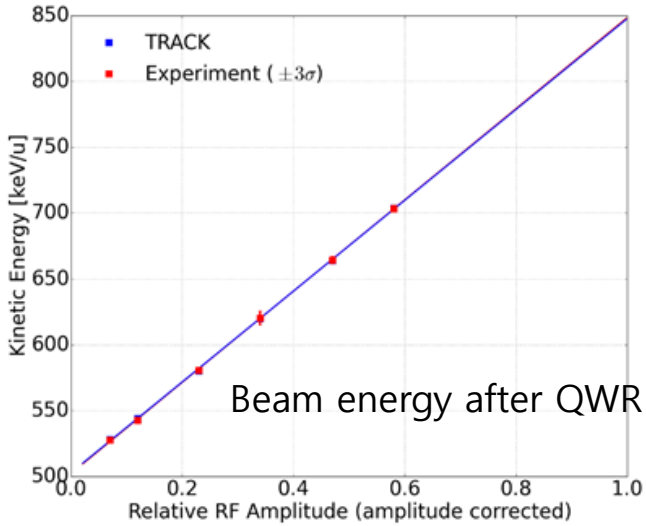
	Total (W)	Static (W)	Dynamic (W)
QWR-CM-#1	**11.7**	7.7	4.0
QWR-CM-#3	**13.1**	8.4	4.7
QWR-CM-#5	**15.8**	9.5	6.3

Beam Accelerating test using one QWR

- Oxygen ion is successfully accelerated (~3 MV/m)





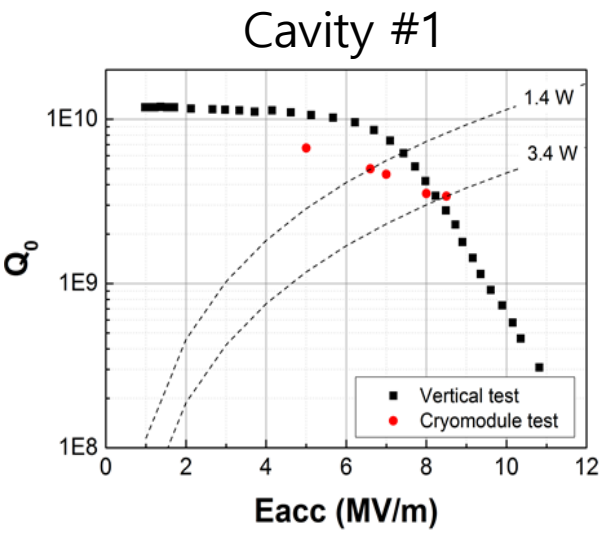


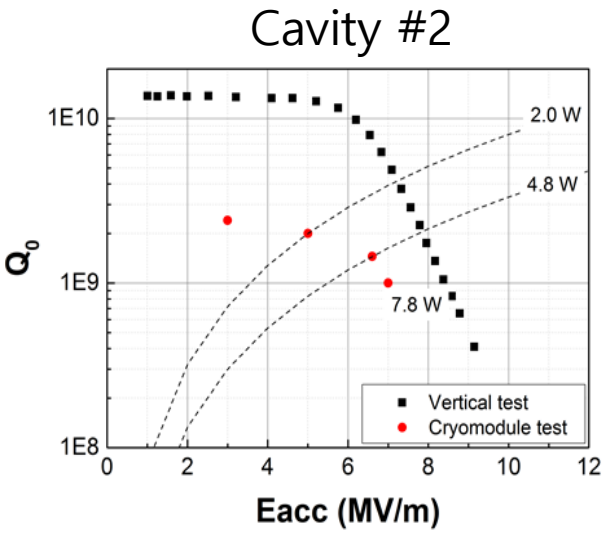
Beam energy after QWR CM

Phase stability, measured for 1000 sec
(requirement: < ±1°)

Performances: HWR Prototype

- **HWR cryomodule A**



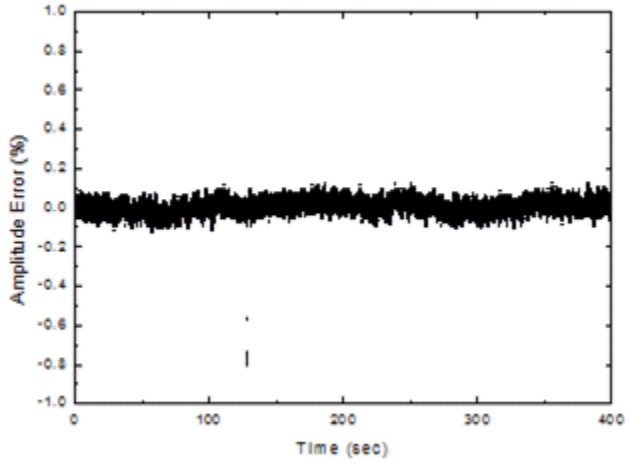


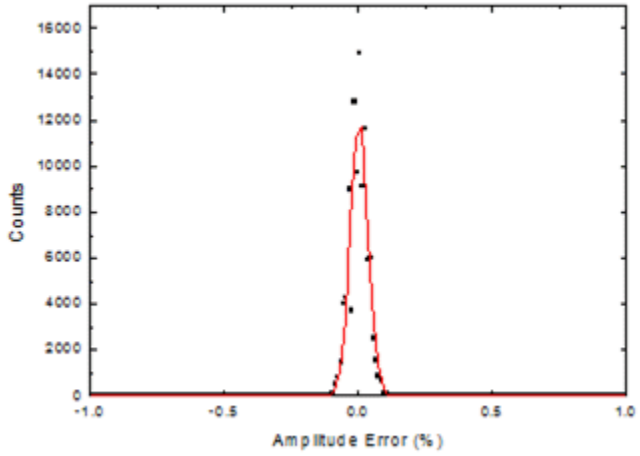
Static thermal load	Dynamic thermal load	Total thermal load
6.6 W	1.4 W (cavity#1)	**12.8 W**
	4.8 W (cavity#2)	

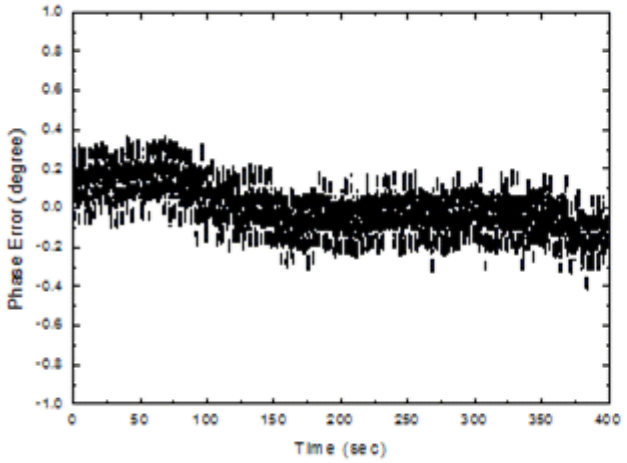
Target total thermal load @ 2.92 MV, 2K: <14.1 W

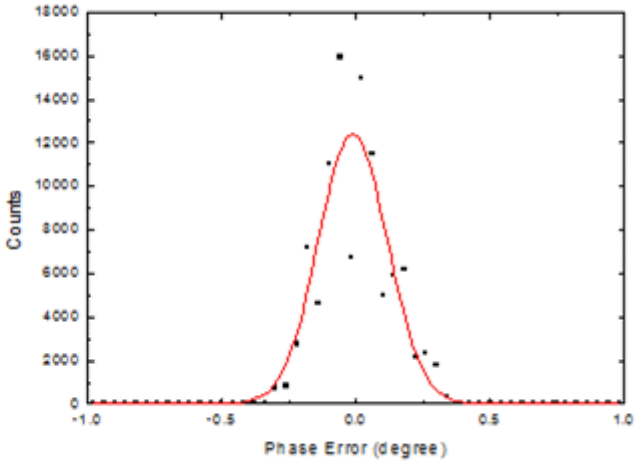
RF Stabilities of HWR prototype

- **RF stability test**
  - Amplitude stability: 0.93% (requirement: ±1%, peak-to-peak)
  - Phase stability: 0.784° (requirement: ±1°, peak-to-peak)









Microphonics in SRF test facility

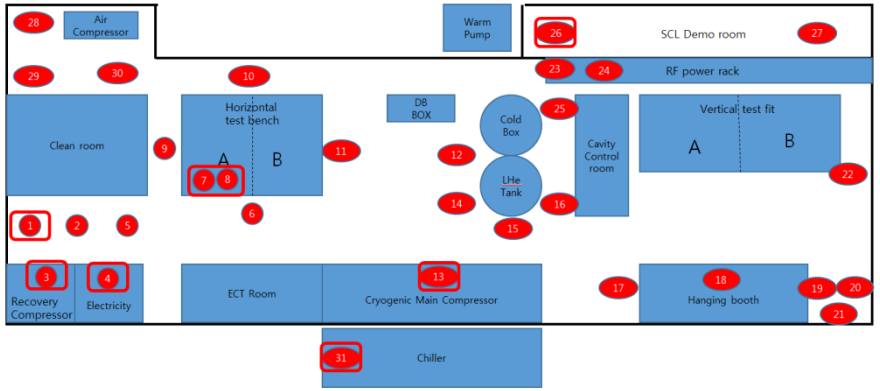
Sensor for Vibration

PCB Piezotronics accelerometer : 393B05

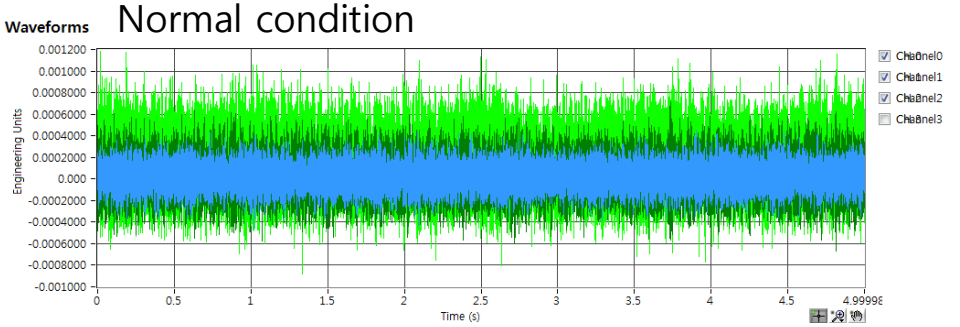
- Ceramic fiexural ICP accelerometer
- 10 V/g
- 0.7~450 Hz
- Range: 4e-6g ~ 0.5g

진동 측정 위치

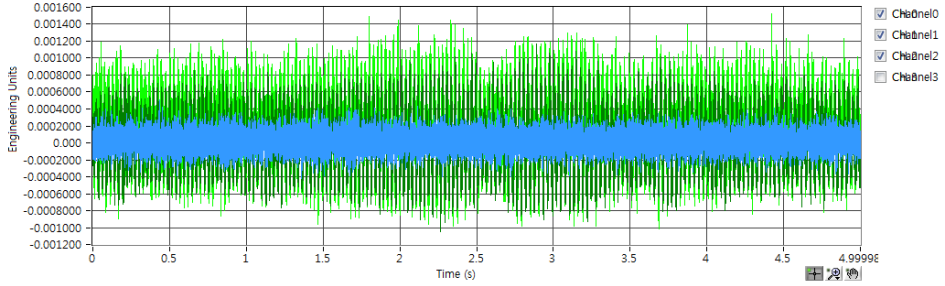
Vibration Survey in SRF test facility



Normal condition



A heavy vehicle (ex, Bus) around SRF test facility



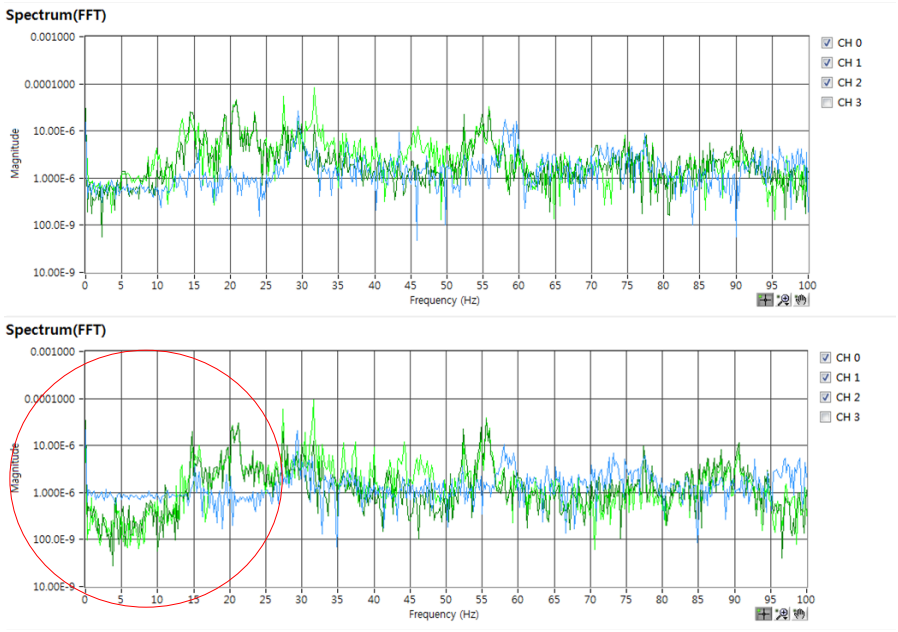
uppper

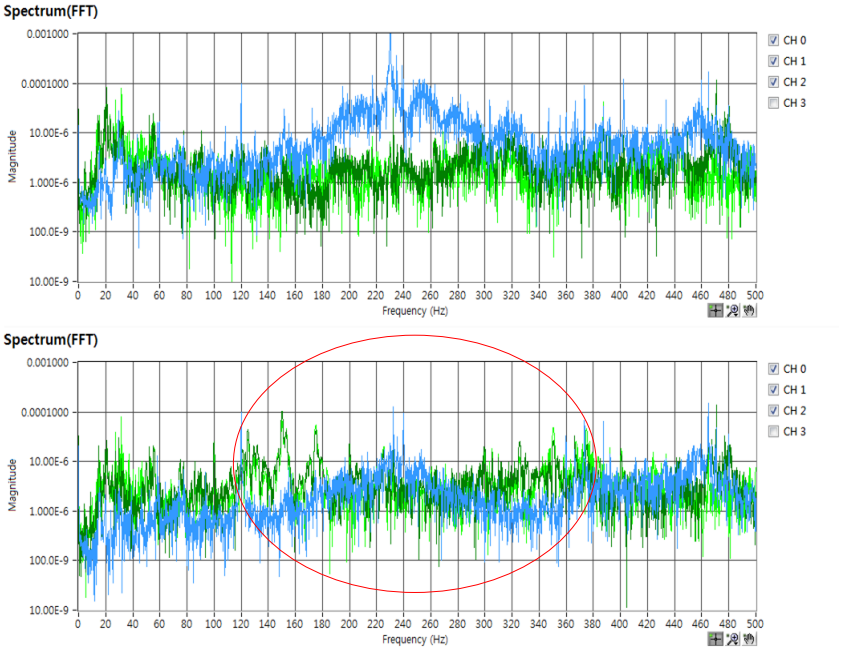
Support

Floor

Vibration Sources(turn off one by one)

Reference: TUP032



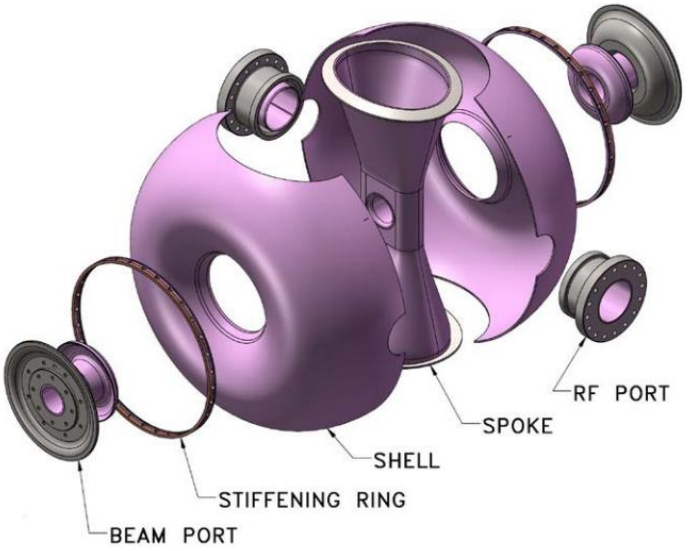


Vibration decrease around 20 Hz
After Cryogenic system is turn off

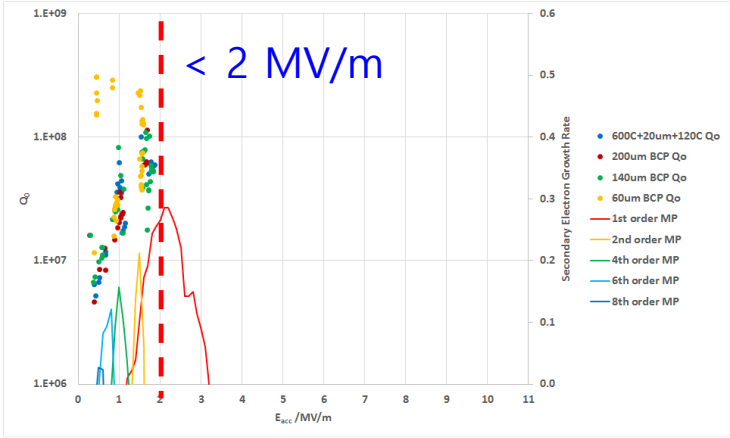
Vibration decrease around 160~300 Hz
After Water circulation is turn off

→ Vibration Survey will be done in the tunnel
To eliminate or isolate sources during the installation of SRF Linacs

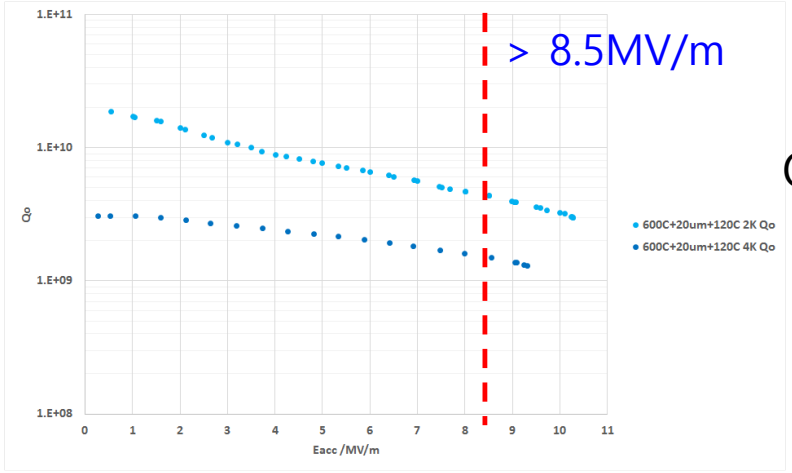
1st Prototyping of SSR type 1(opt. beta ~0.3) for High Energy SRF Linac



- Designed/fabricated/tested by TRIUMF(Canada)
- Accelerating gradient is higher than 8.5 MV/m
- Spinning method is used for two Shells
- Multipacting barrier is lower than 2 MV/m



Multipating

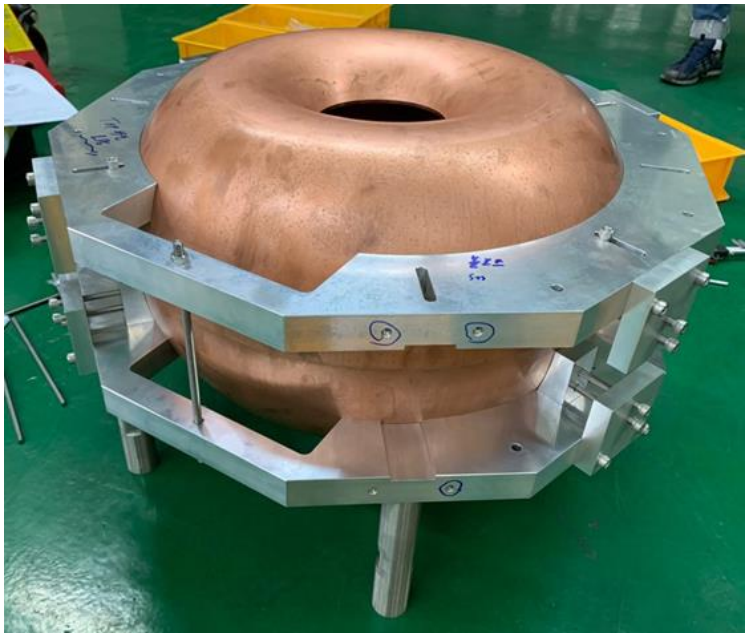


Q vs. Eacc

2nd Prototyping of SSR1

Nb Shell after Deep drawing

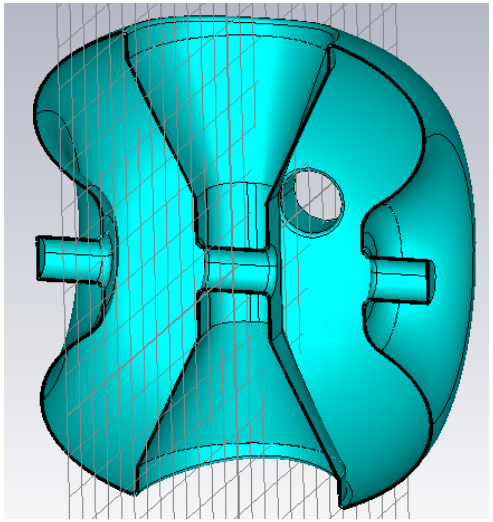
- Fabrication is on-going by VITZRO tech(Korea)
- Deep drawing(depth ~ 220 mm) is used for two Shells
- 1st cavity will be tested within this August
- 1st Cryomodule(3 cavities) will be tested in this year



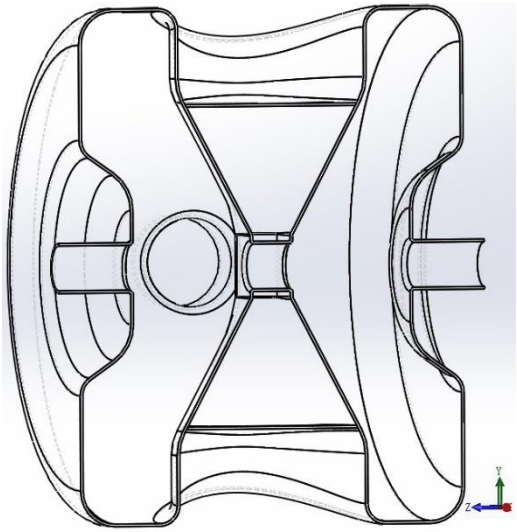
Clamp up Jig

Prototyping of SSR type 2(opt. beta ~0.51) for High Energy SRF Linac

- Fabrication is on-going by VITZRO tech(Korea)
- Deep drawing(depth ~ 280 mm) is used for two Shells
- 1st cavity will be fabricated within this October
- 1st Cryomodule(6 cavities) will be tested in early next year



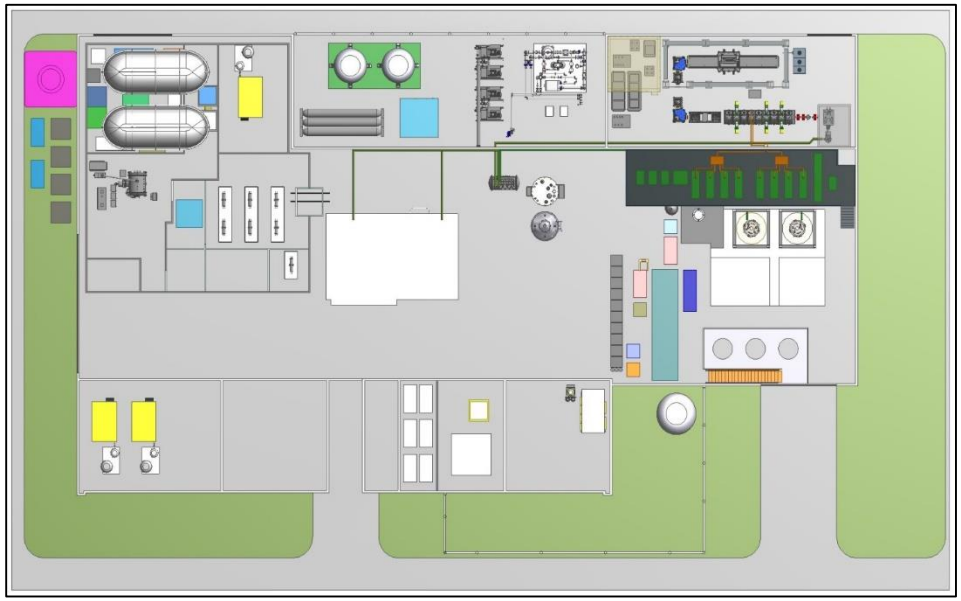
Parameters	Value
β	0.51
$f\ [MHz]$	325
$L_{eff}(=\beta_o\lambda)[mm]$	~470
Beam tube diameter [mm]	50
$E_{acc}\ [MV/m]$	8.7
$V_{acc}\ [MV]$	4.1



- SSR2 with different design is developed by IHEP(China)
- 1st cavity will be fabricated within this November
- 1st Cryomodule(6 cavities) will be tested in early next year

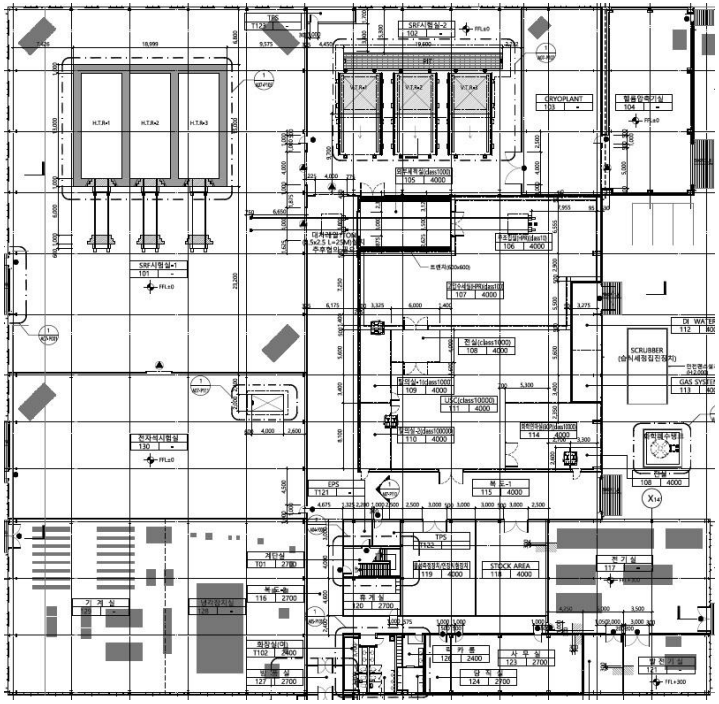
SRF test Facilities for Mass production

Munji SRF test facility



- Two bunkers, two pits
- Clean room (Class 10)
- BCP cabinet, Baking furnace(>800 ℃), USC, HPR, etc.

Sindong SRF test facility



- Three bunkers, Three pits
- Clean room (Class 10)
- USC, HPR, etc.

→ Two SRF test facilities are ready for testing ~300 cavities and 100 modules

Low Energy SRF Linac Tunnel

Outside of Tunnel

inside of Tunnel

→ Tunnel for Low energy SRF linac is ready to install

Summary

- **Mass production of cryomodules for Low energy SRF Linac is in progress**
  - 22 QWR cryomodules(2017.12~), 34 HWR cryomodules(2018. 05~)
  - 6 QWR cavities and 3 QWR modules are tested
- **5 bunkers and 5 pits are ready for SRF test**
- **Construction of Low energy SRF linac tunnel is done**
- **Cryomodules will be installed in the Low energy SRF linac tunnel until the middle of next year**
- **1st Prototyping for SSR type 1 is successfully completed**
- **2nd prototyping for SSR type 1 and 1st prototyping for SSR type 2 are ongoing**