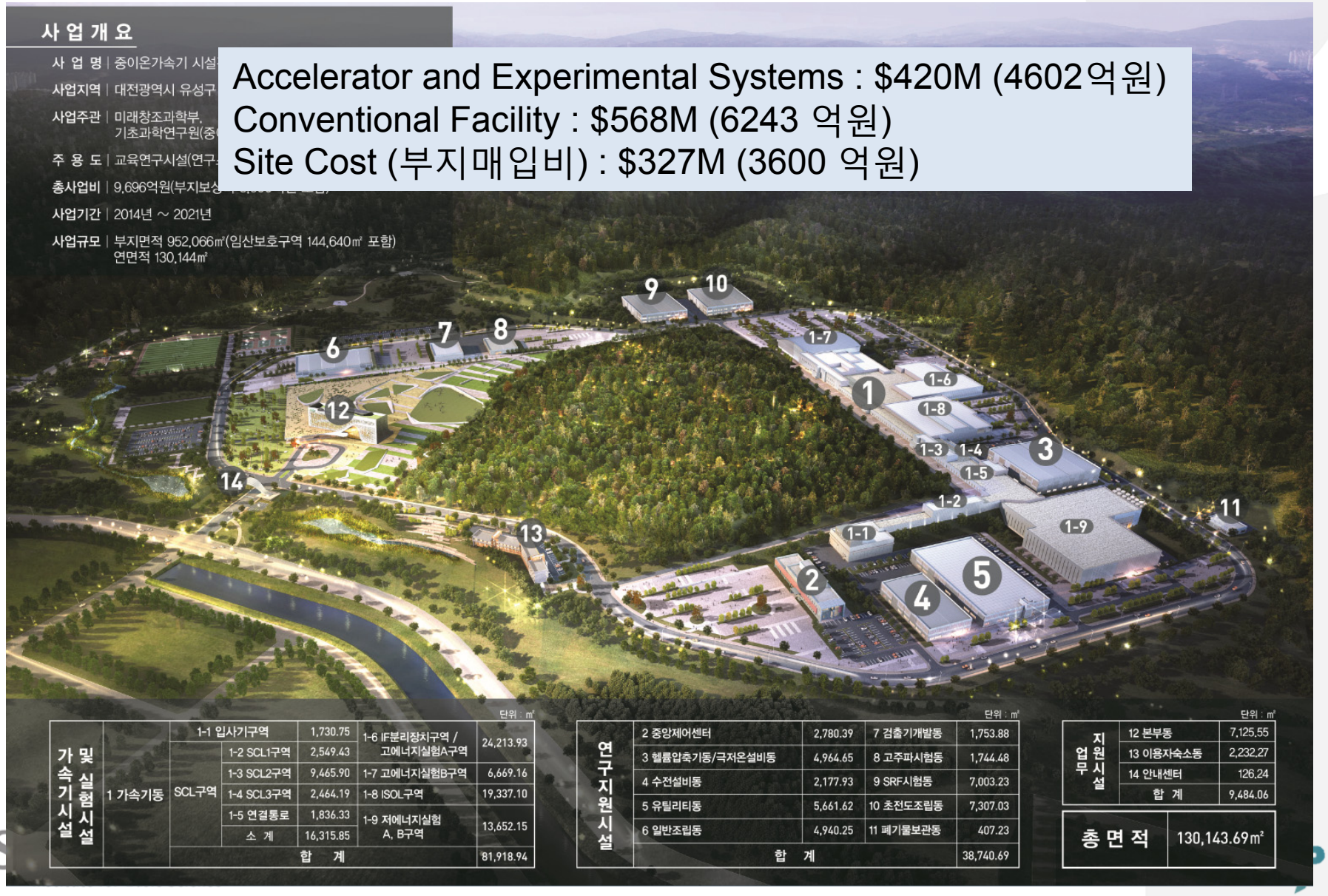
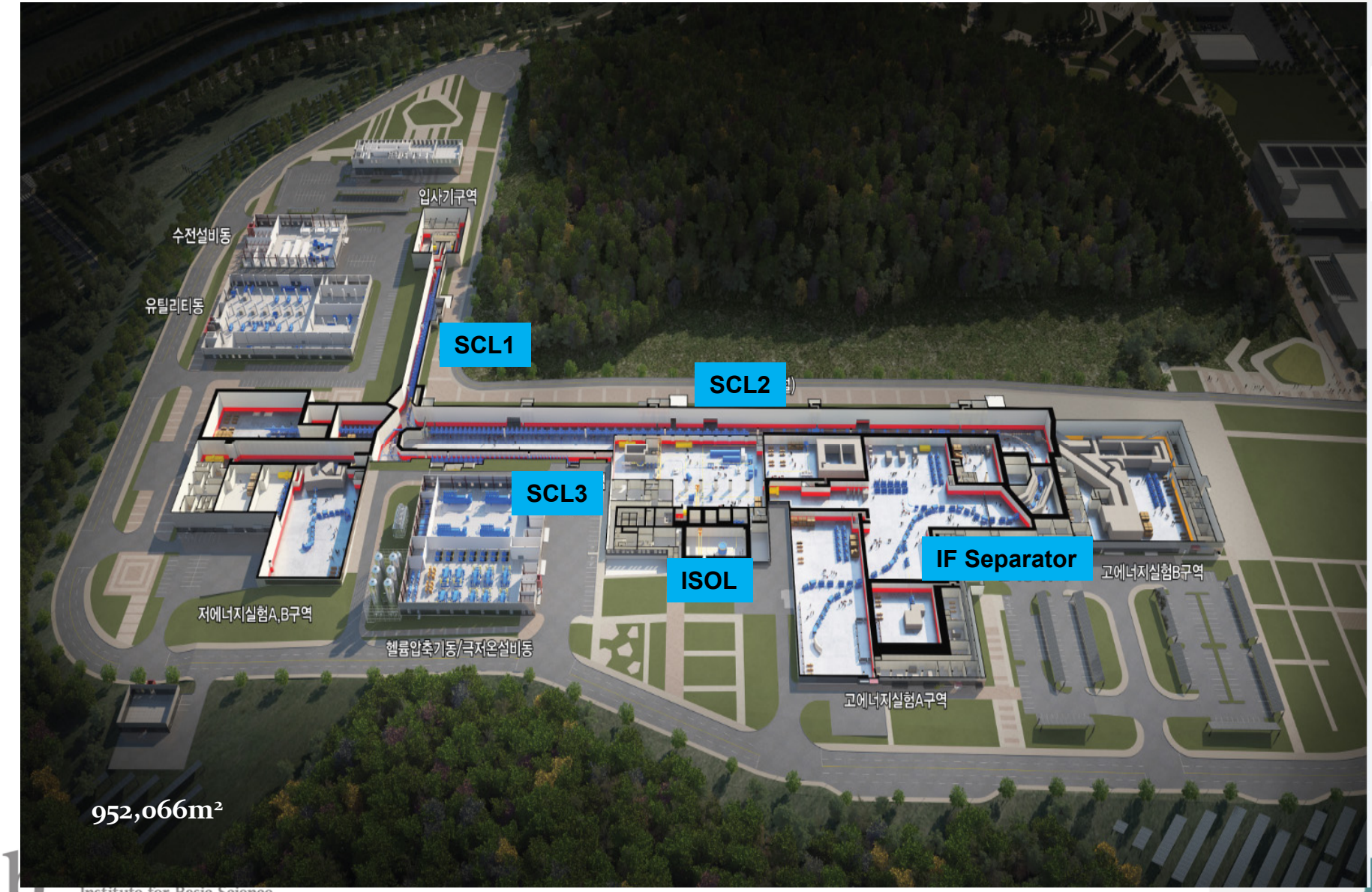
Progress of the RAON (RISP)

Dong-O Jeon
representing the RAON
Institute for Basic Science

The RAON Overview

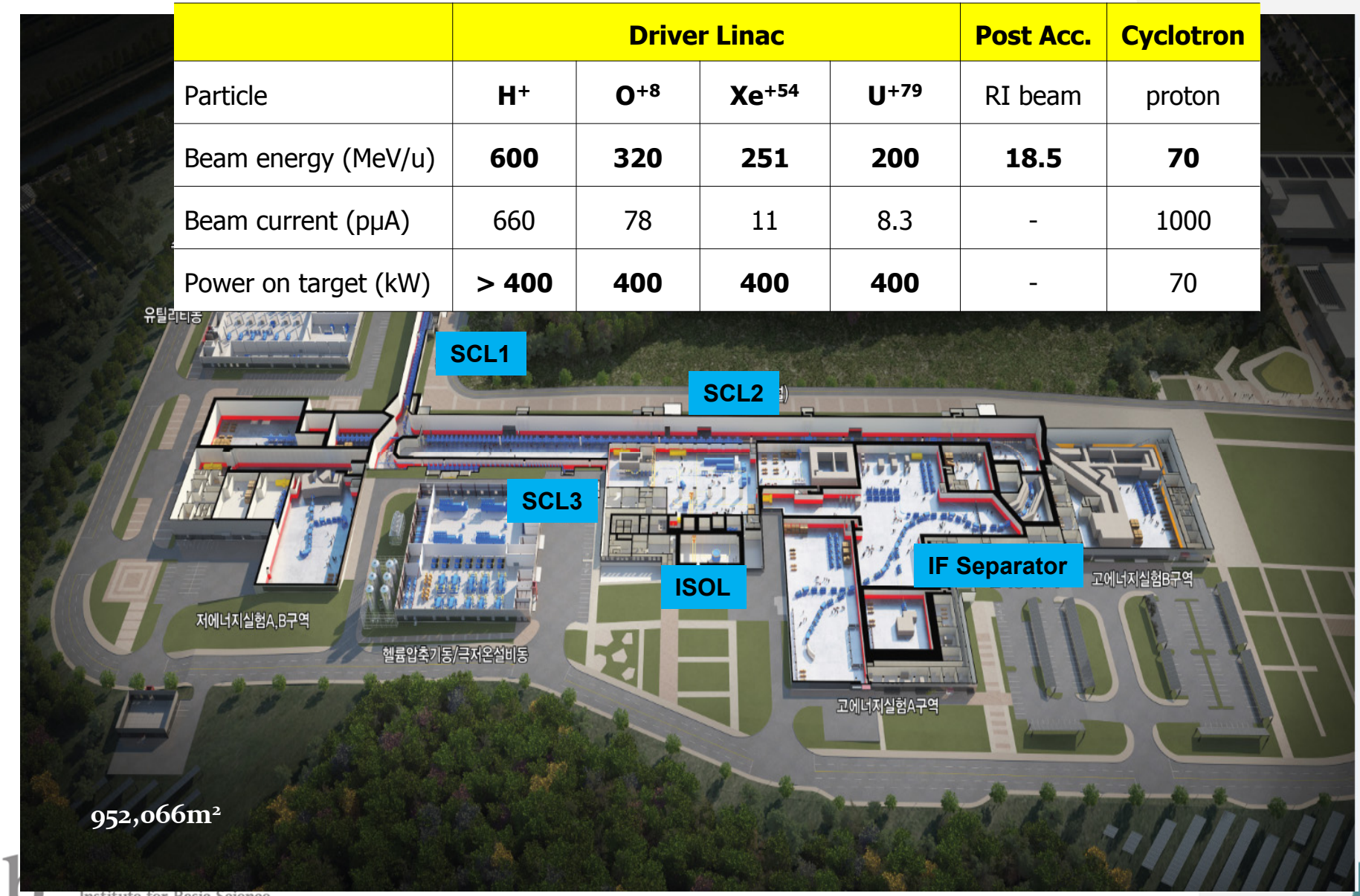


Bird's-eye View



Bird's-eye View

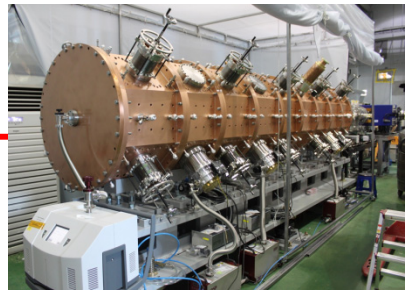
	Driver Linac				Post Acc.	Cyclotron
Particle	**H^{+}**	**O^{+8}**	**Xe^{+54}**	**U^{+79}**	RI beam	proton
Beam energy (MeV/u)	**600**	**320**	**251**	**200**	**18.5**	**70**
Beam current (pμA)	660	78	11	8.3	-	1000
Power on target (kW)	**> 400**	**400**	**400**	**400**	-	70



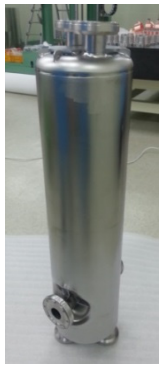
Status of Prototyping

28GHz ECR Ion Source

81.25MHz RFQ



HTS (High Tc Superconducting) Magnet



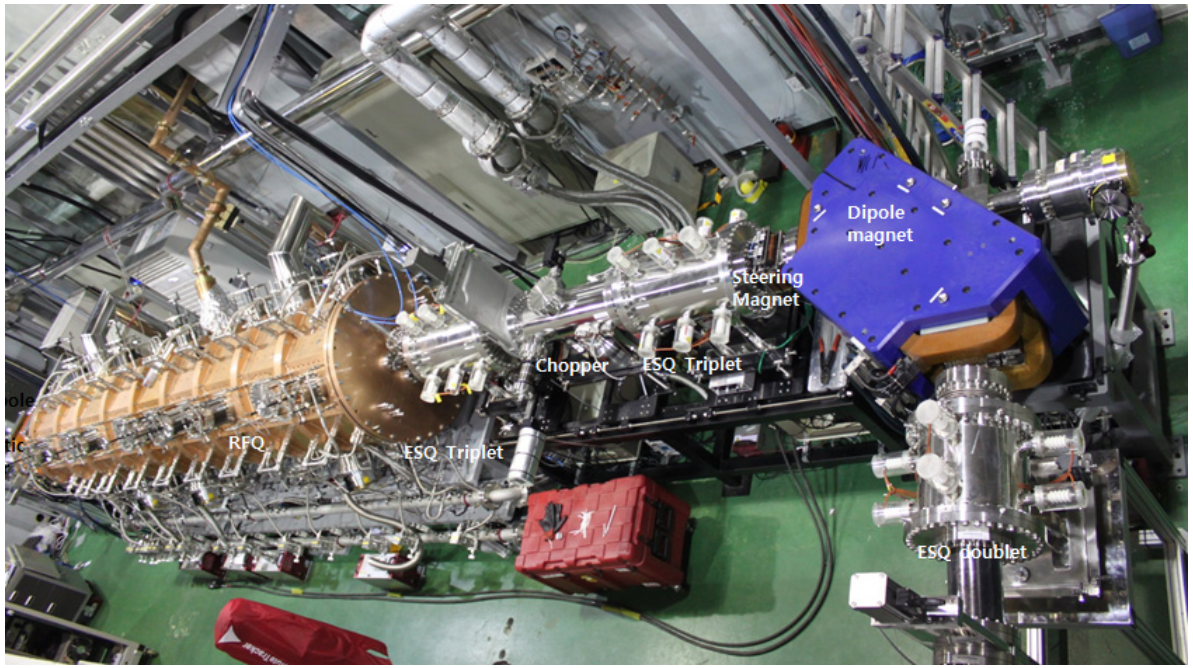
QWR & Cryomodule

HWR & Cryomodule

SSR2 & Cryomodule

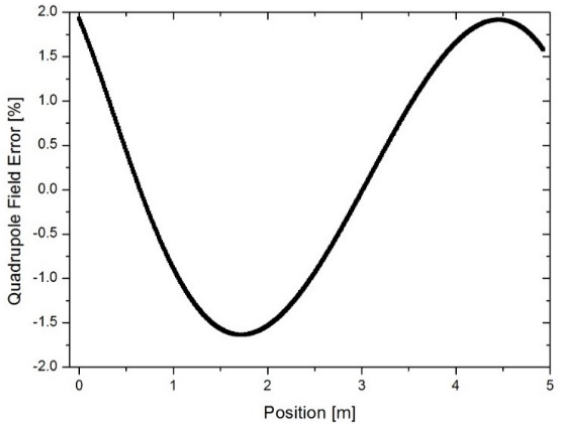
RFQ

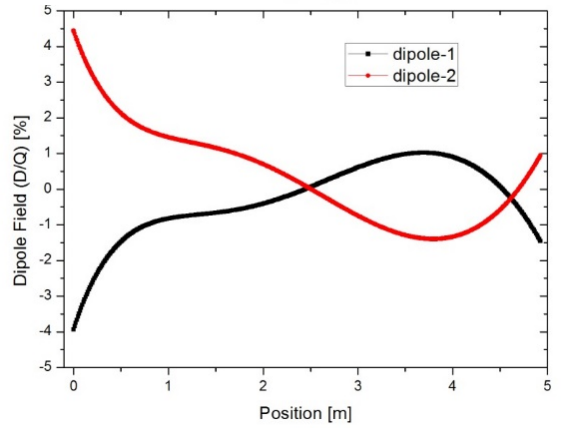
- 4 vane-type RFQ: 0.01 ~ 0.5 MeV/u
  - Frequency 81.25 MHz, Transmission 98%, RF power 94 kW total
  - Fabricated by a domestic company
- Initial beam test was conducted in November 2016.



RFQ delivered and tuned
(October 2016)

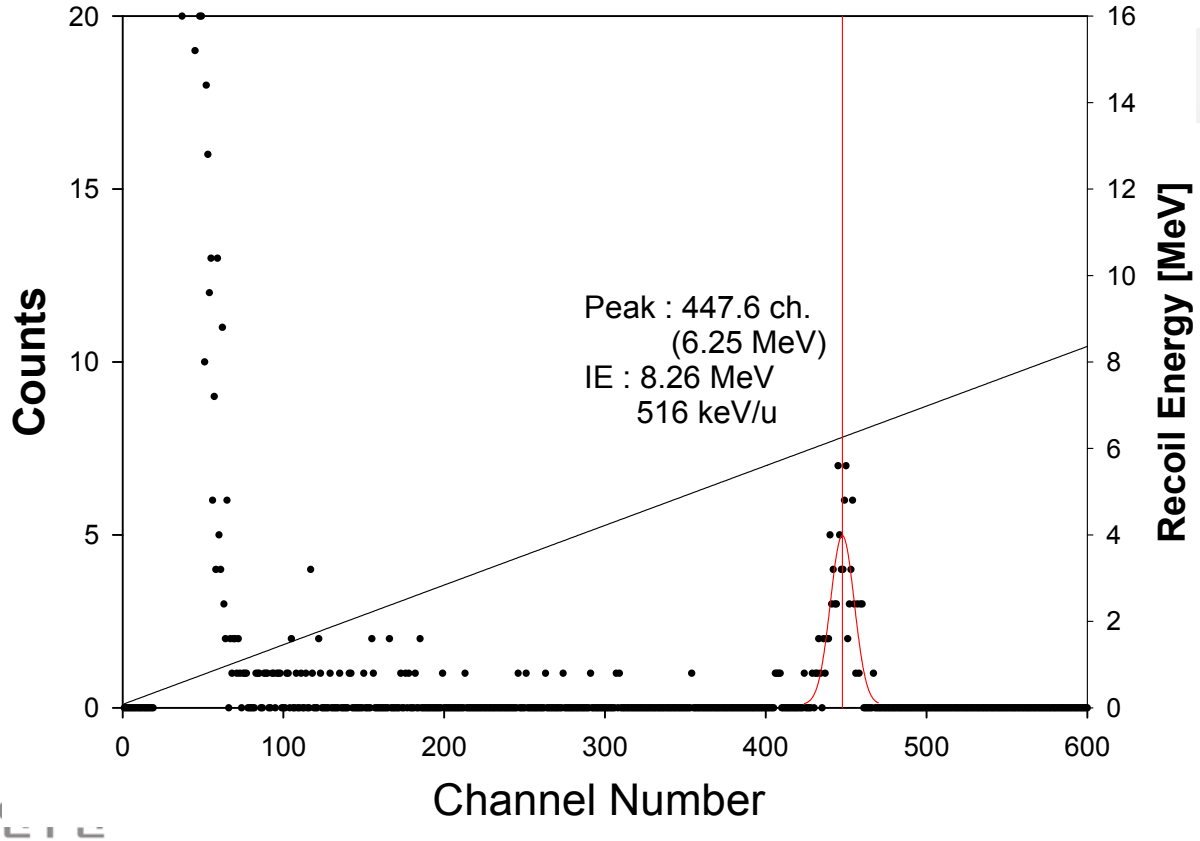
Quad field error < ±2%
Dipole/Quad field < ±5%





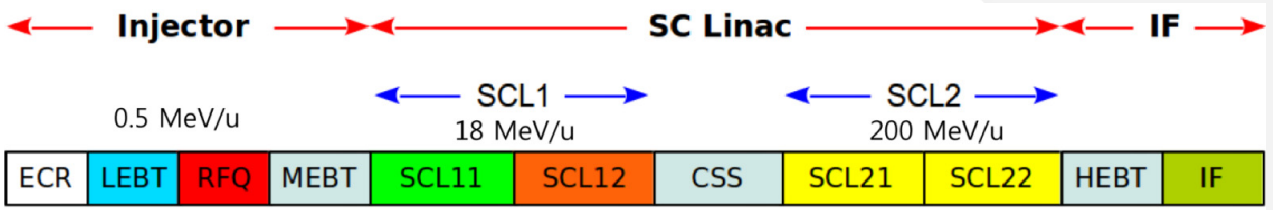
RFQ Beam Test

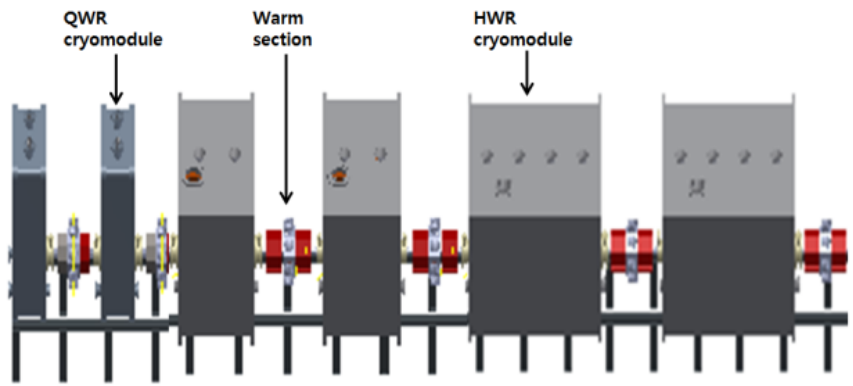
- RFQ energy measurement
  - $^{16}O^{7+}$ beam energy was accelerated.
  - Beam energy was measured to be 516 keV/u (using RBS method)
  - PARMTEQ simulation result: 508.5 ± 4.0 keV/u

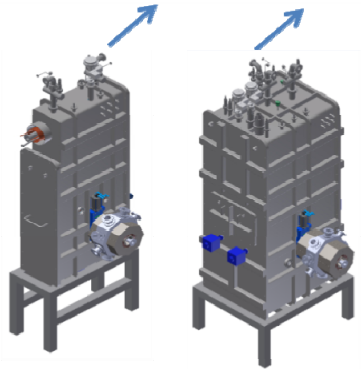


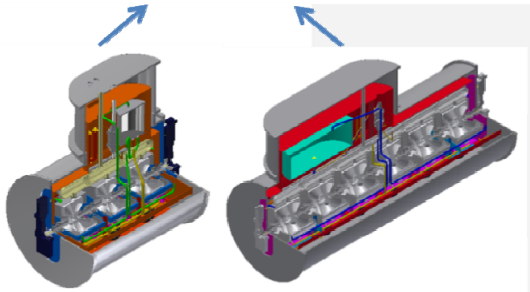
Superconducting Linac (SCL)

- Employs short-cryomodule and NC quadrupole design.
- Employs large aperture SC cavities to reduce beam loss on cavities (40 mm and 50 mm aperture).
- Lattice design enables flexible and straightforward operation.
  - Beam operation is possible without one or two cryomodules.
  - Alignment and turn-on procedure are straightforward.

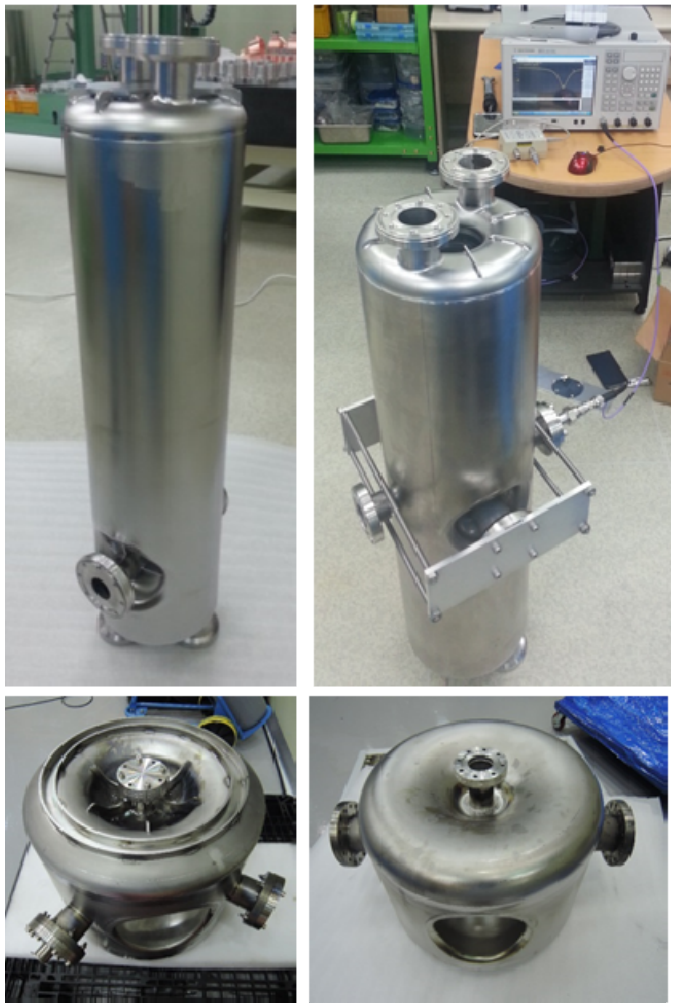








Superconducting Cavity

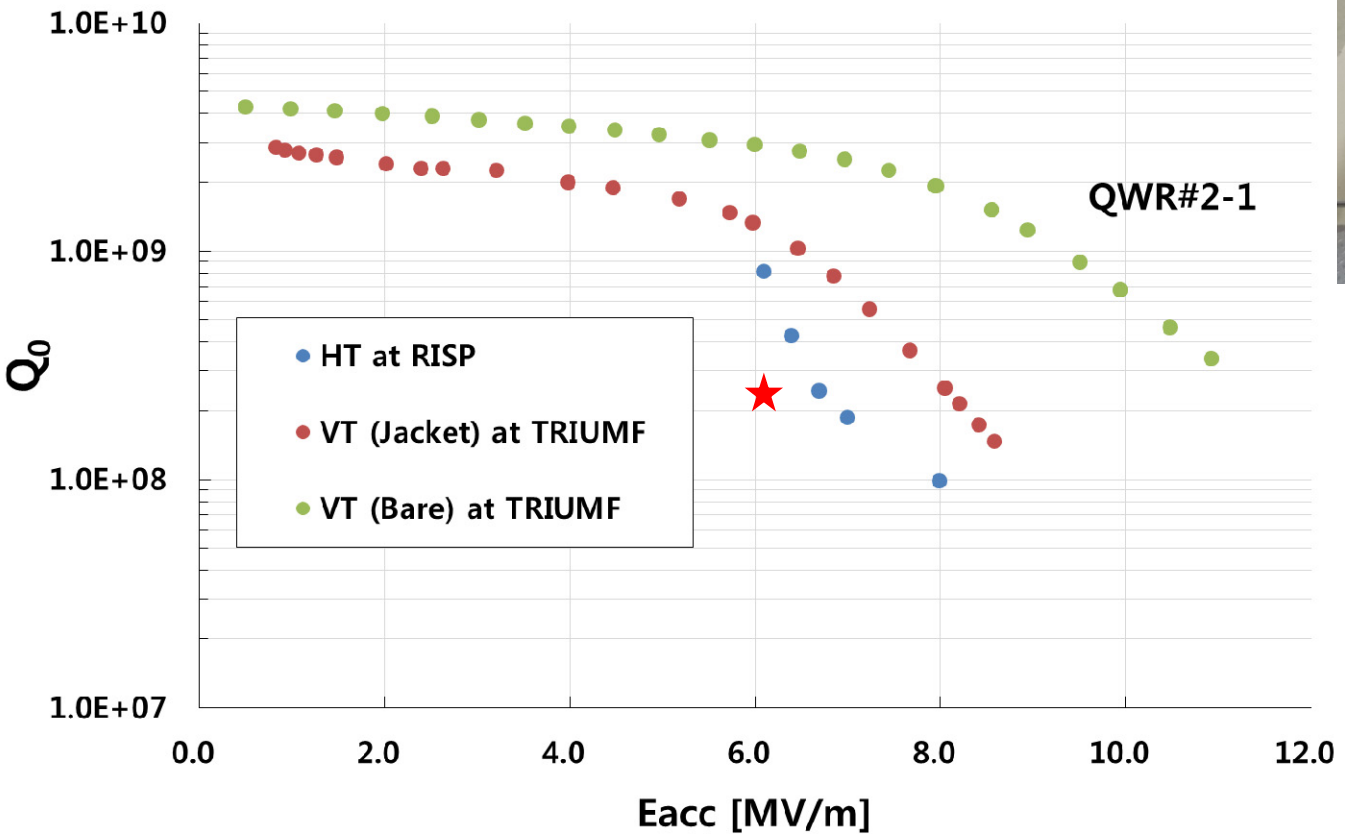


Parameters	Unit	QWR	HWR	SSR1	SSR2
β_g	-	0.047	0.12	0.30	0.51
F	MHz	81.25	162.5	325	325
Aperture	mm	40	40	50	50
QR_s	Ohm	22	42	94	112
R/Q	Ohm	468	310	246	296
V_{acc}	MV	1.1	1.5	2.4	4.1
E_{peak}	MV/m	35	35	35	35
B_{peak}	mT	57	55	58	64
$Q_{calc}/10^9$	-	2.1	4.2	9.0	10.5
Temp.	K	4.5	2	2	2

(E_{peak} = 35MV/m)

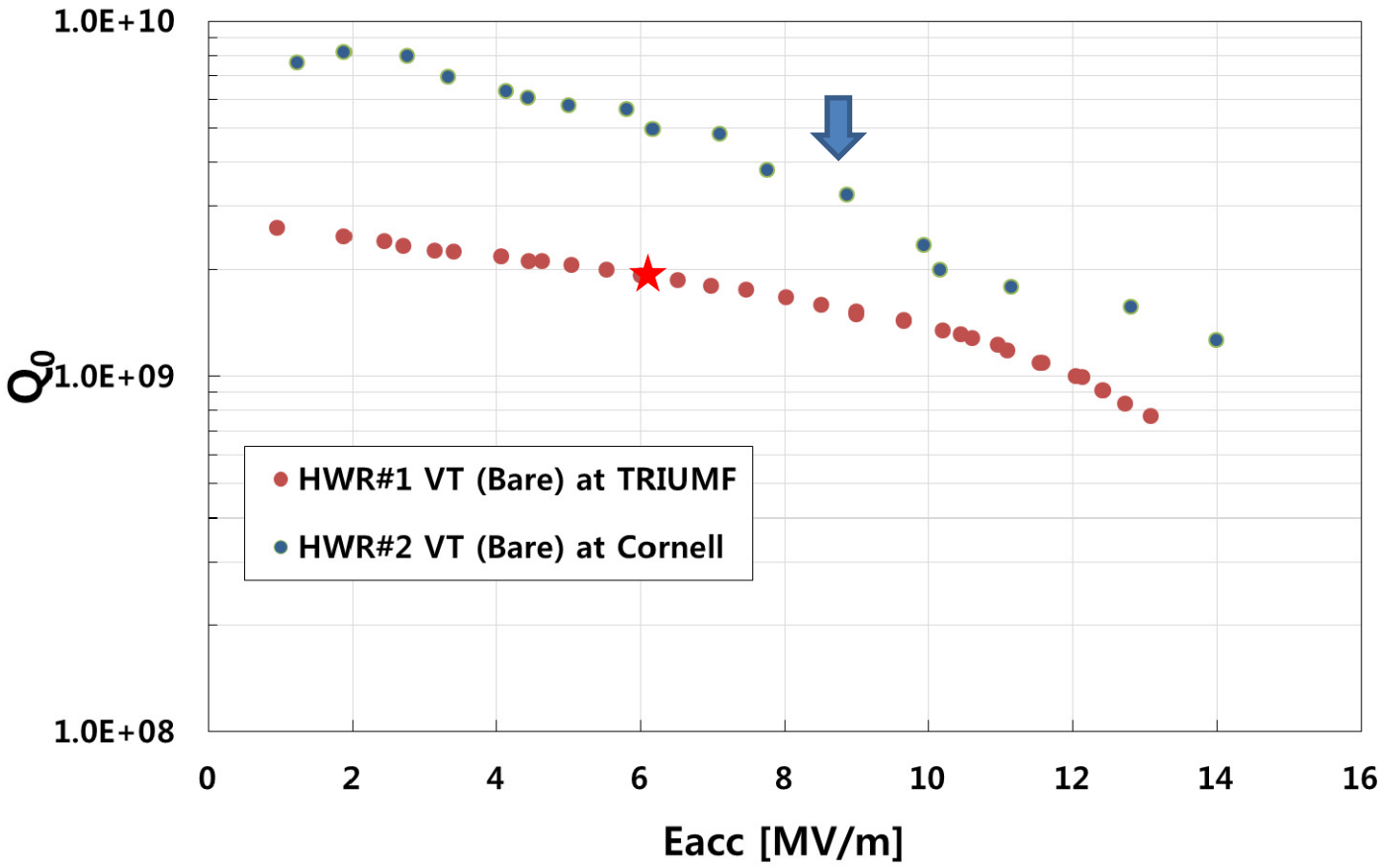
Prototype cavities fabricated through domestic vendors

QWR Horizontal Test at 4K



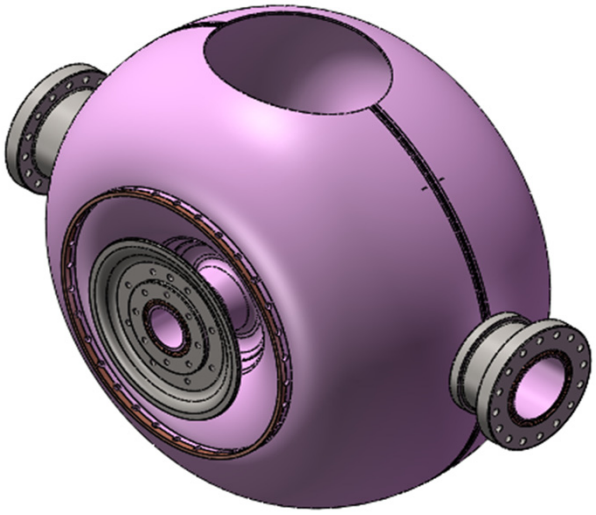
- QWR horizontal test in cryomodule was conducted.

HWR Vertical Test at 2K

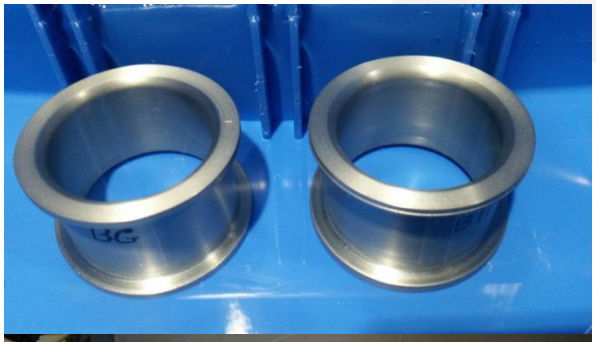


- Vertical test of the 1st cavity was conducted in collaboration with TRIUMF.
- Vertical test of the 2nd cavity was conducted in collaboration with Cornell Univ.
- Q values improved for the 2nd HWR cavity after design improvement.

SSR1 Prototyping



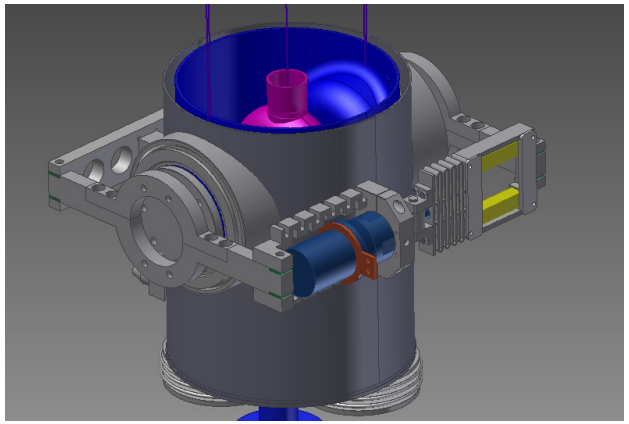
- Developed in collaboration with TRIUMF
- To reduce the multipacting band, balloon-like SSR is chosen
- Bare cavity will be tested in Aug/2017



Beam tubes

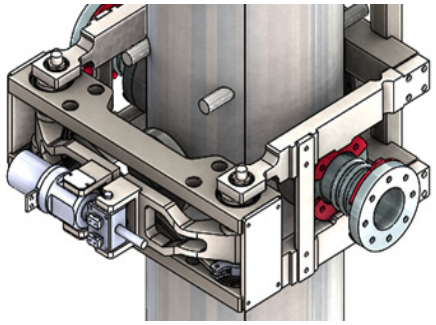
Half shell
(by spinning)

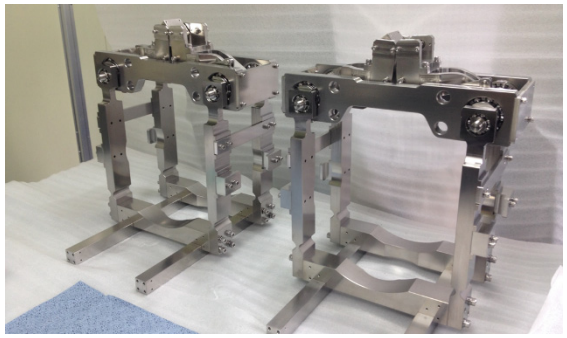
Tuners



Prototype QWR tuner

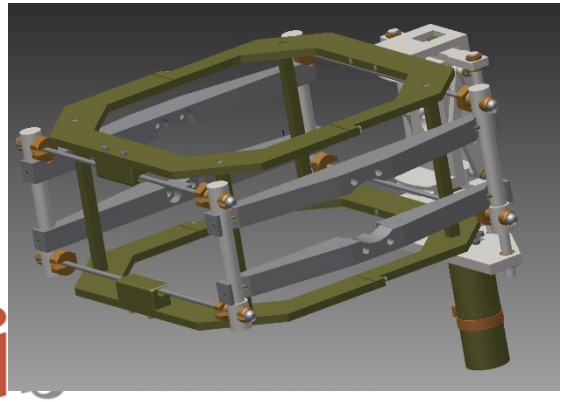
- Low temperature test conducted
- Cryomodule test conducted
- 50 kHz tuning range





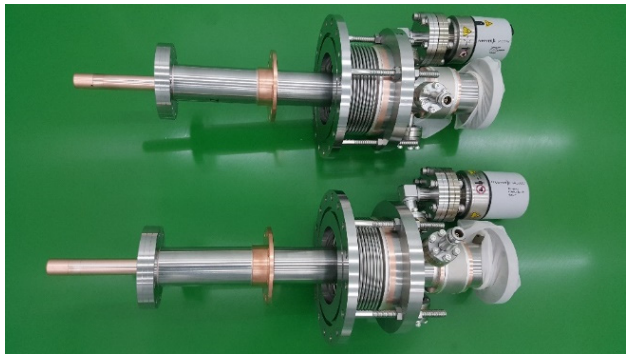
Prototype HWR tuner

- Room temperature test conducted
- Cryomodule test in preparation



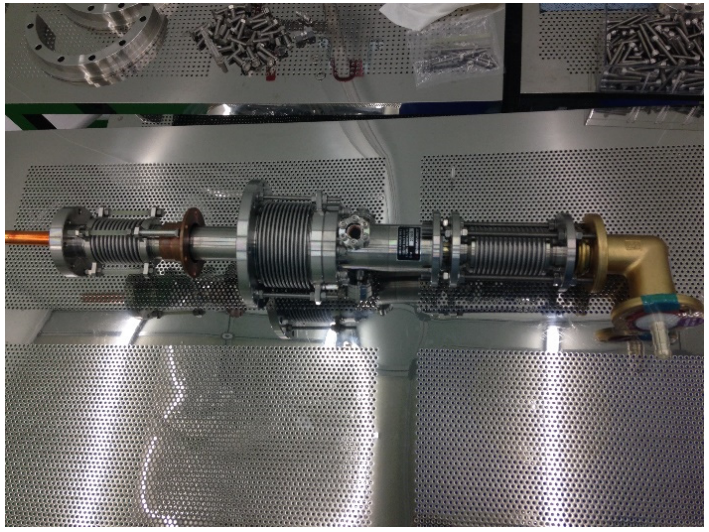
- Under fabrication & test
- 80 kHz tuning range

Couplers



Prototype coupler for QWR (TOSHIBA)

- Ready for RF conditioning



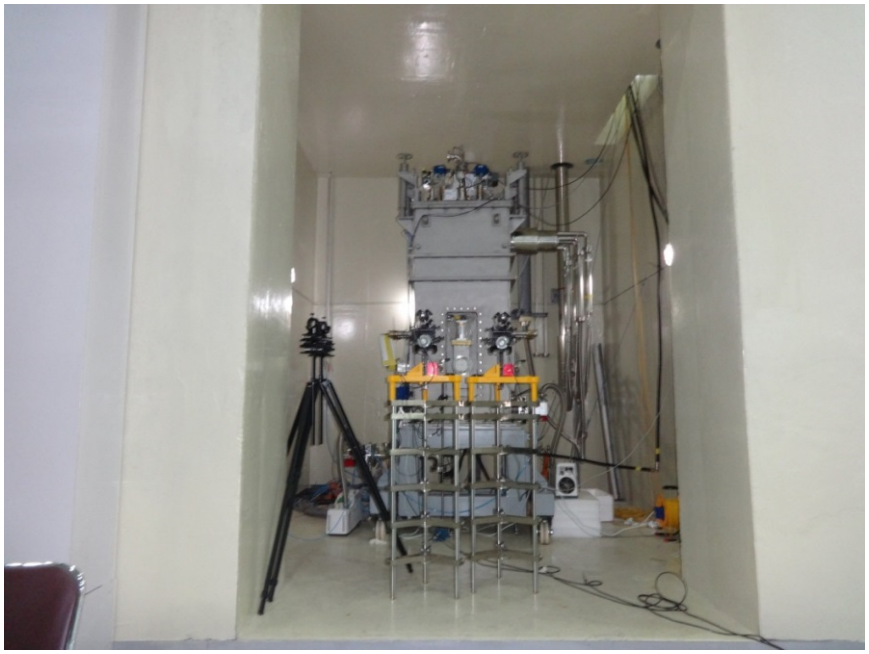
Prototype coupler for QWR (MHI)

- Completed RF conditioning (CW 2 kW during 8 hour)
- MP level: <120 W

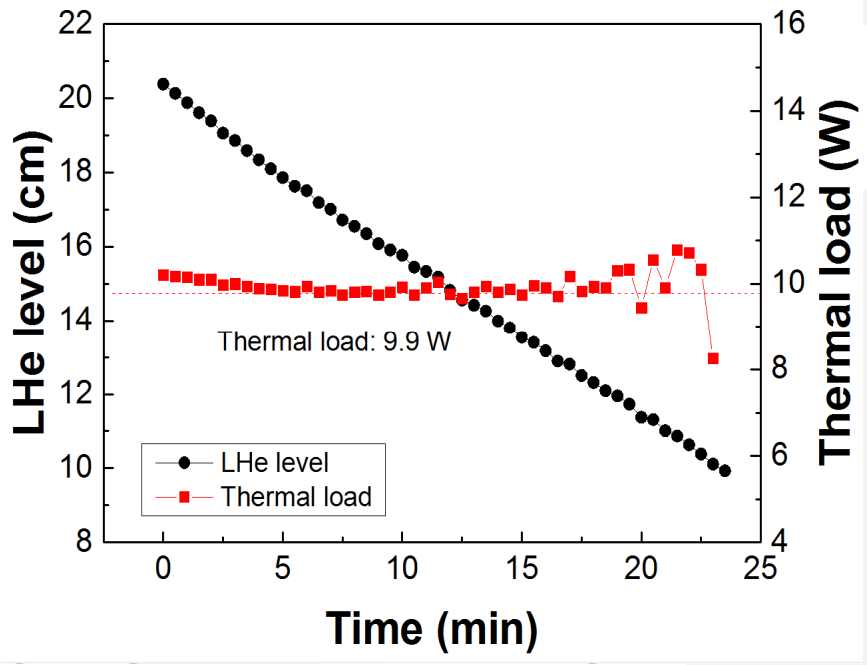
- Tested in QWR cryomodule

QWR Cryomodule

QWR cryomodule integrated test was conducted in May 2017



QWR Cryomodule (in test bunker)

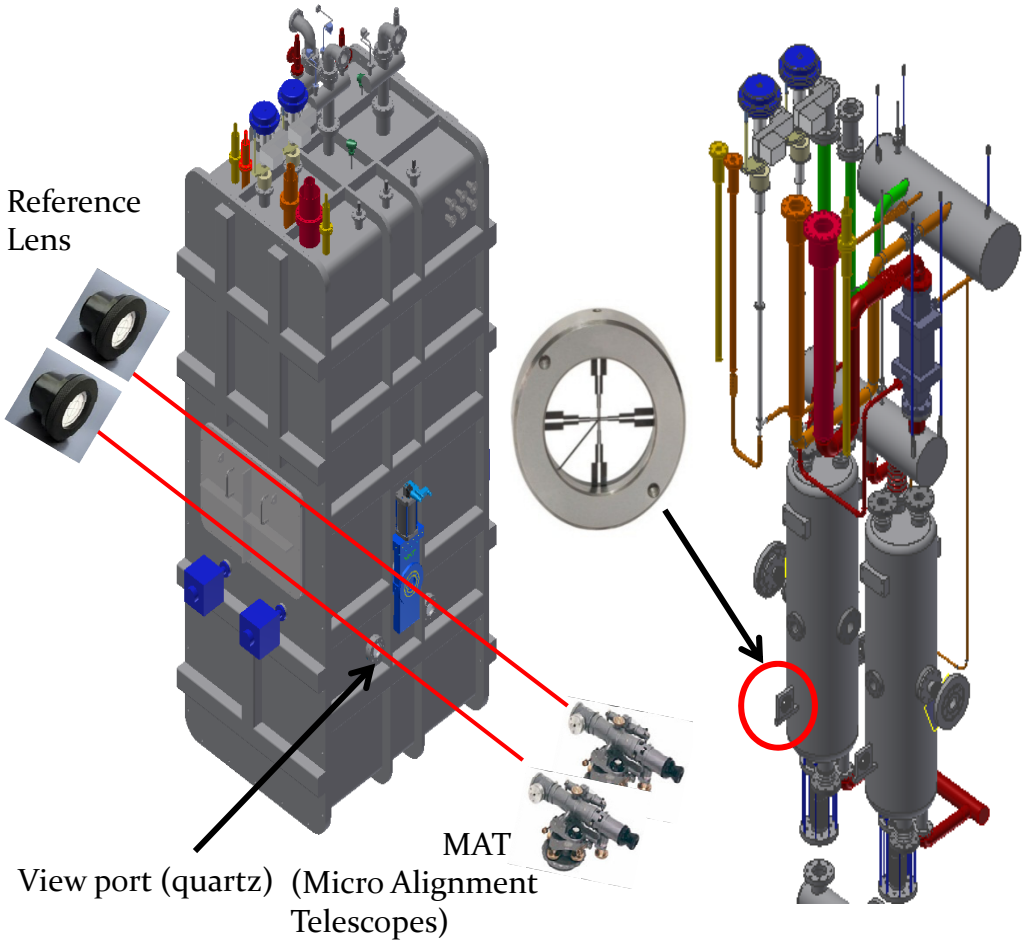


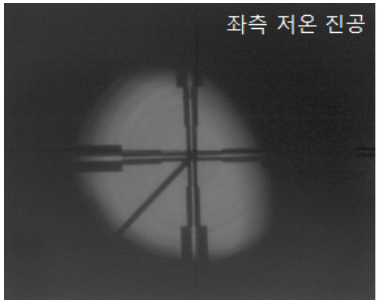
QWR cryomodule thermal load

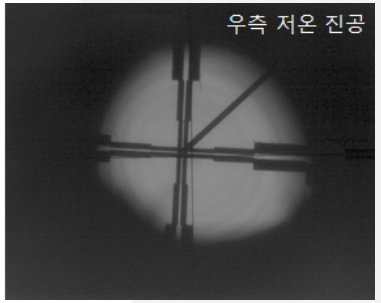
QWR cryomodule thermal load			
	Design	**Measurement**	
Thermal Load	< 25 W @ 4.2 K, 6MV/m	9.9 W @ 4.2 K, 6MV/m	

Cryomodule alignment

Cryomodule alignment was tested







Beam port alignment error

Vertical	Horizontal
0.71 mm	0.40 mm

Requirement of cavity alignment is met < ±1 mm

Beam Dynamics & Beam Loss

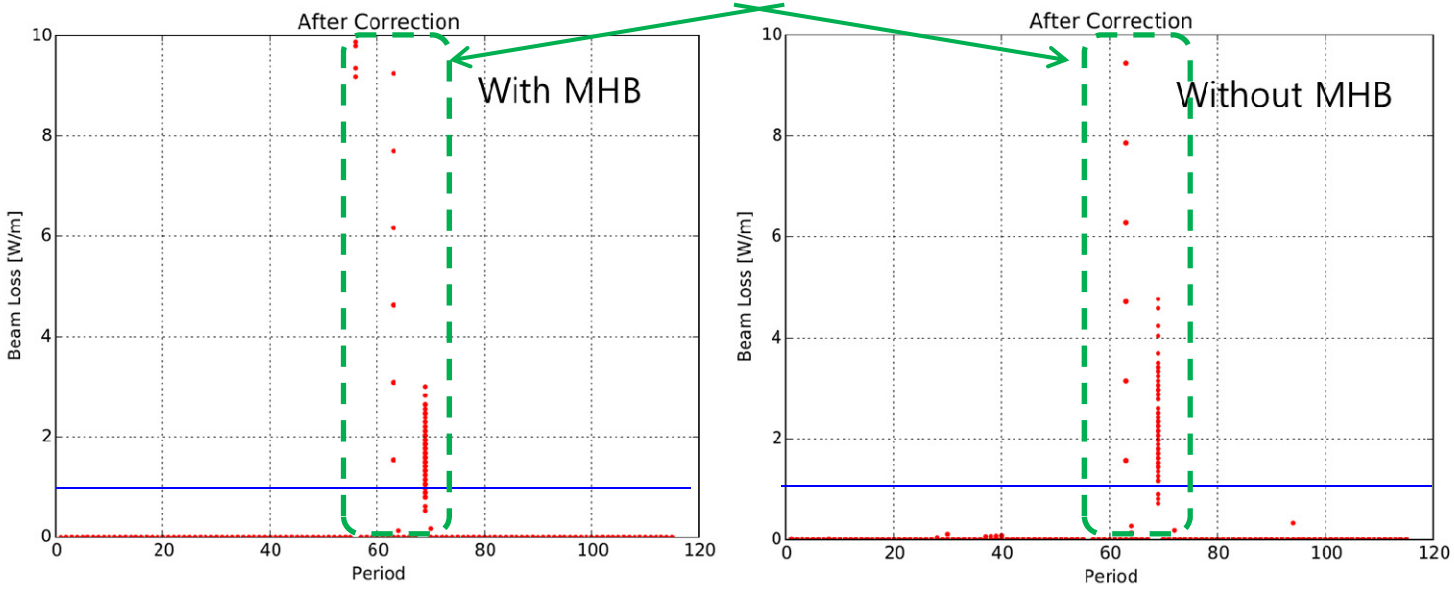
Machine Imperfection Studies

- Lattice is very robust and flexible.
- Beam loss requirement is met even without orbit correction (< 0.2 W/m)
- Beam operation is possible without multi-harmonic buncher. (< 0.4 W/m)

Imperfection budget

Item	Quantity	Error	Distribution
Cavity	Misalignment	1mm	Uniform
	Tilt	5 mrad	Uniform
	Voltage, phase	1%, 1°	Gaussian
Quadrupole	Misalignment	0.15mm	Uniform
	Tilt	5 mrad	Uniform
	Magnetic field	1%	Gaussian

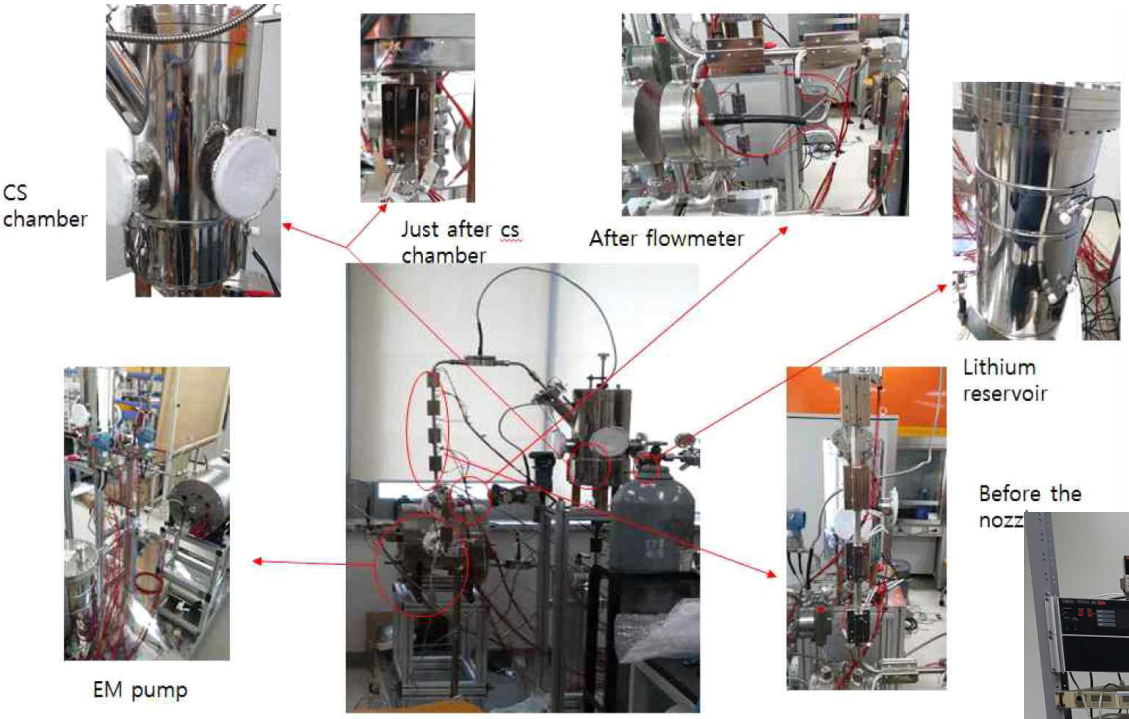
charge stripper & collimator section

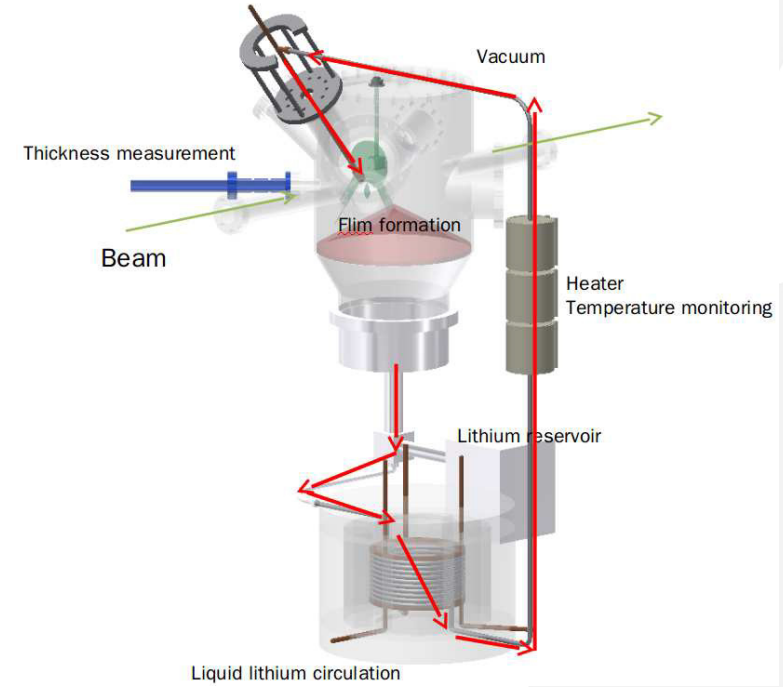


Lithium Charge Stripper

Prototyping of Li charge stripper is under way.

- Major parts are fabricated and under test.

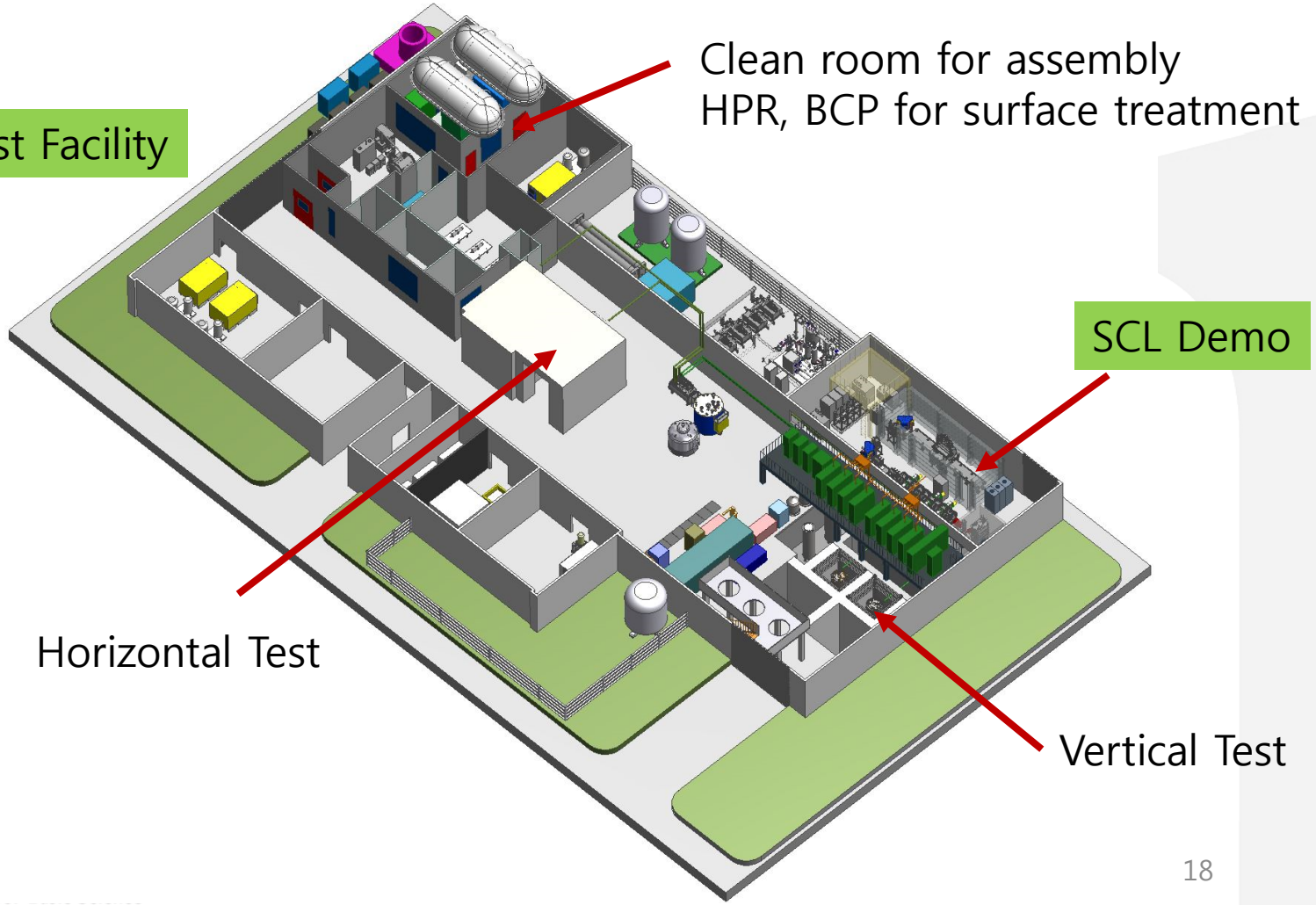




Test set-up to measure the Li film thickness.

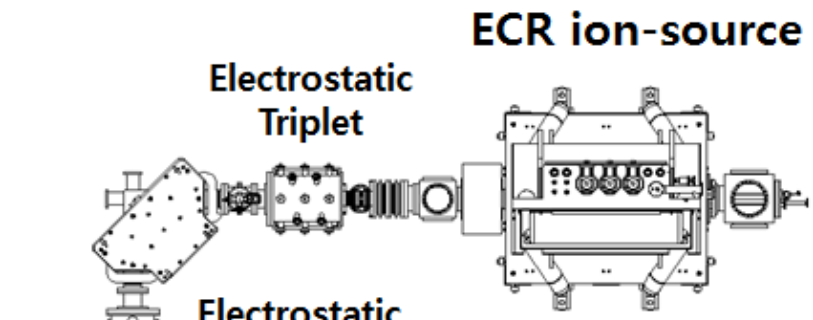
SRF Test Facility & SCL Demo

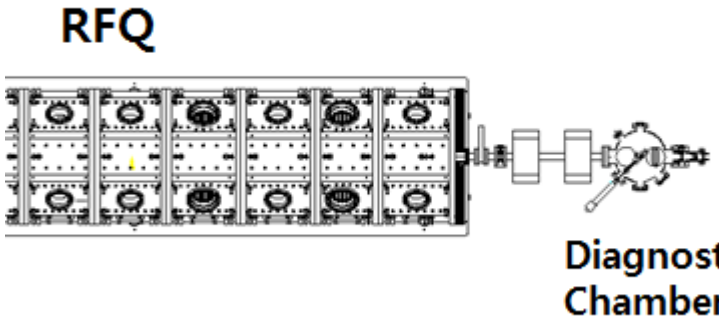
- SRF Test Facility is in operation.
- SCL Demo is in the SRF Test Facility and beam test is planned Sep/2017.



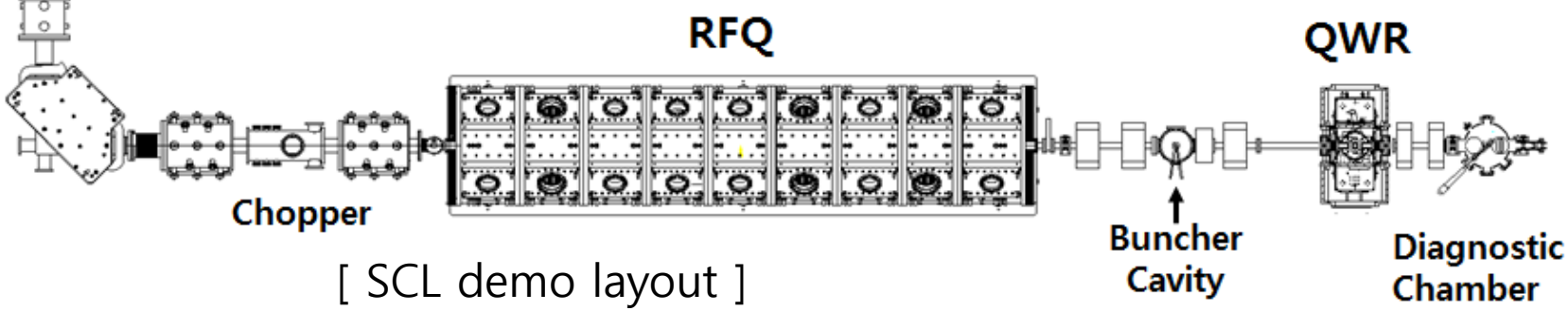
SCL Demo Layout

- SCL demo consists of ECR ion source, LEBT, RFQ, MEBT, a set of QWR cryomodule.
- Limited space of SCL demo room: simplified layout





[RFQ beam commissioning in 2016]

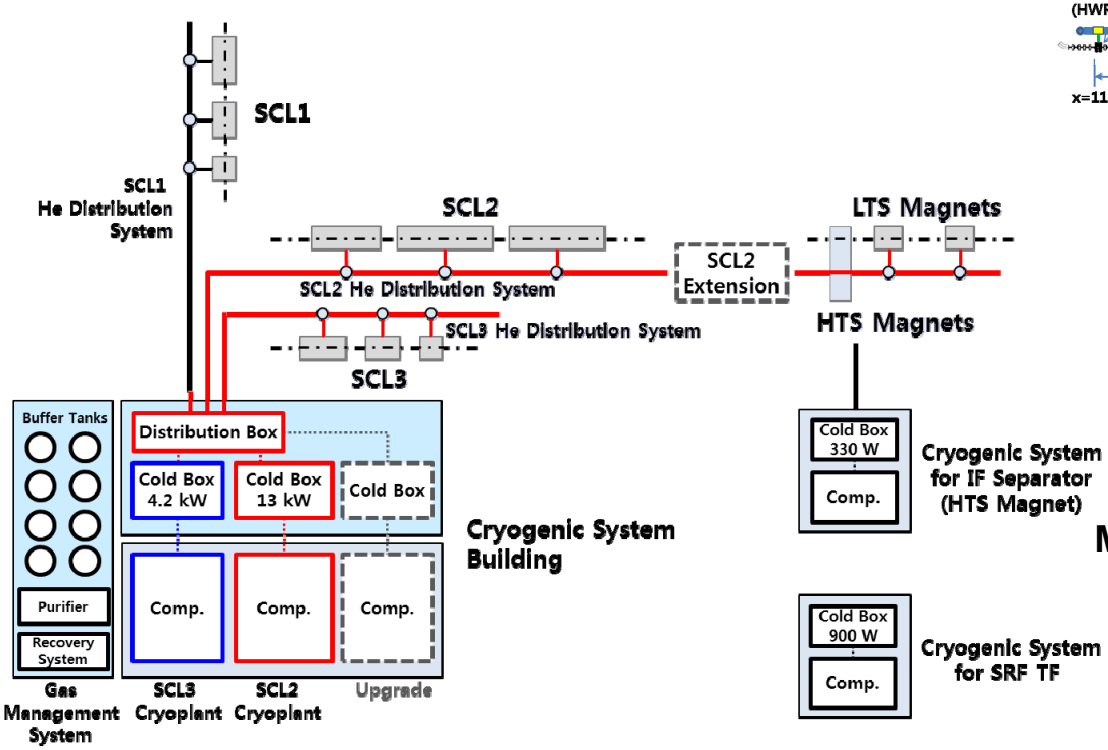


[SCL demo layout]

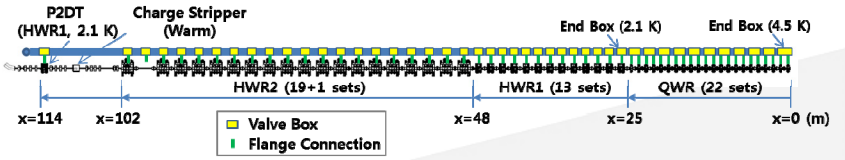
Cryogenic System

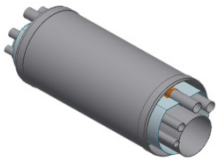
Tender process is under way for the 4.2-kW cryogenic system.

Cryogenic System for RAON



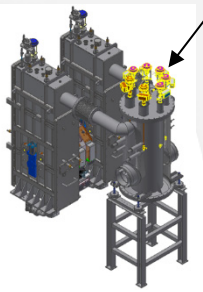
Helium Distribution System





Main Transfer Line

Valve Boxes



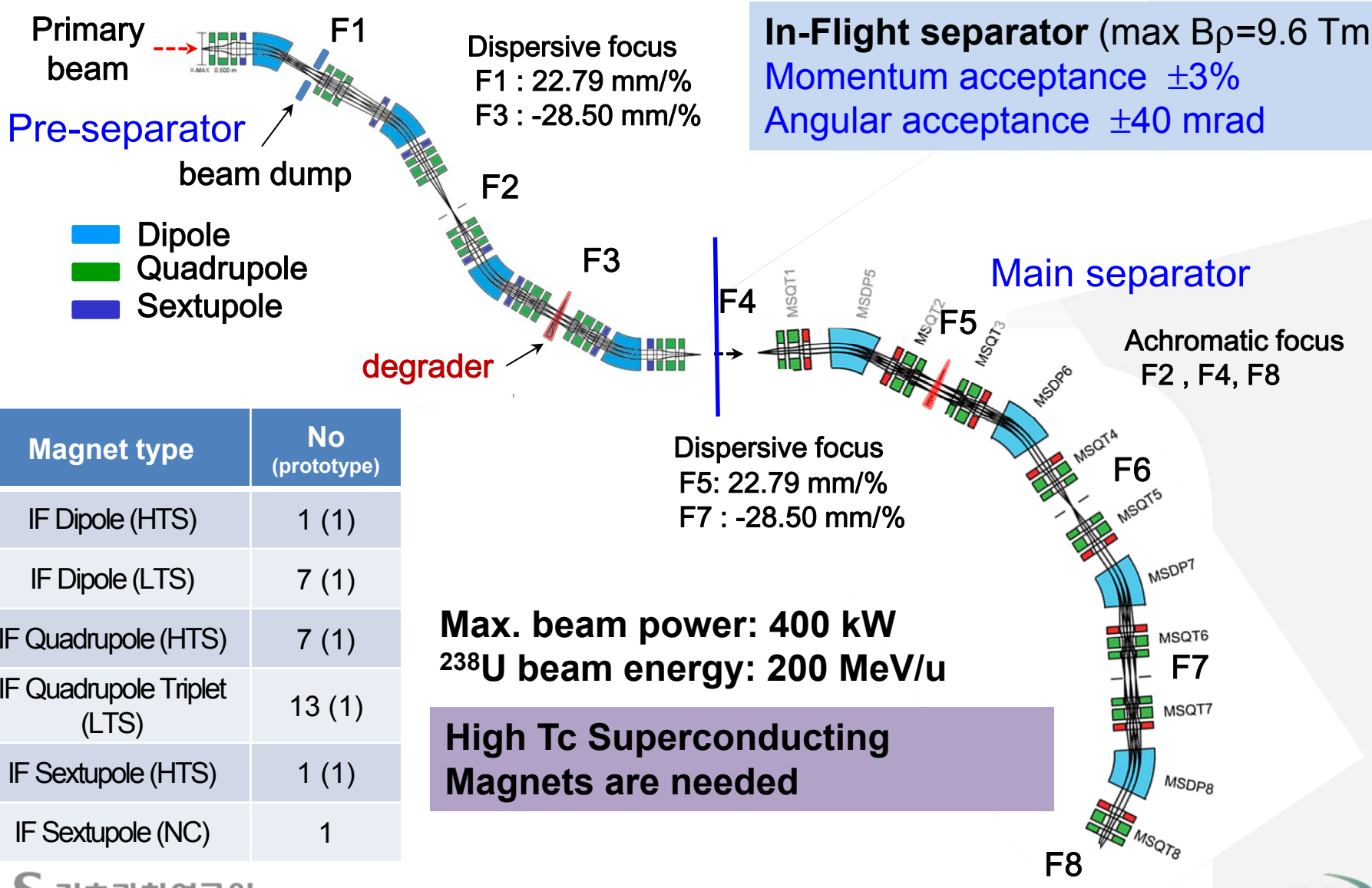
QWR

HWR

SSR1 for SCL2

SSR2 for SCL2

Design of the IF Separator



In-Flight separator (max Bρ=9.6 Tm)
Momentum acceptance ±3%
Angular acceptance ±40 mrad

Magnet type	No (prototype)
IF Dipole (HTS)	1 (1)
IF Dipole (LTS)	7 (1)
IF Quadrupole (HTS)	7 (1)
IF Quadrupole Triplet (LTS)	13 (1)
IF Sextupole (HTS)	1 (1)
IF Sextupole (NC)	1

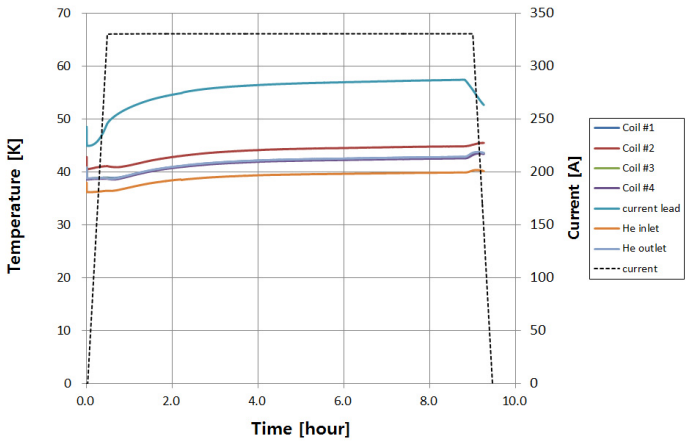
Max. beam power: 400 kW
^{238}U beam energy: 200 MeV/u

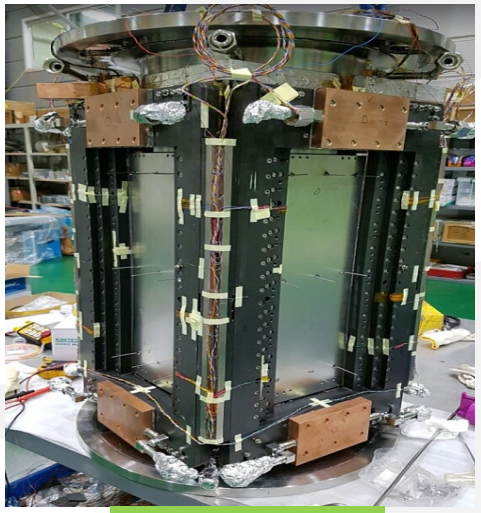
High Tc Superconducting Magnets are needed

HTS Quadrupole Test

◆ 8-hour operation test

- Operation current: 330A (9.0 T/m)
- Operation time: 8 hours
- Temperature rise of coil: ~4K

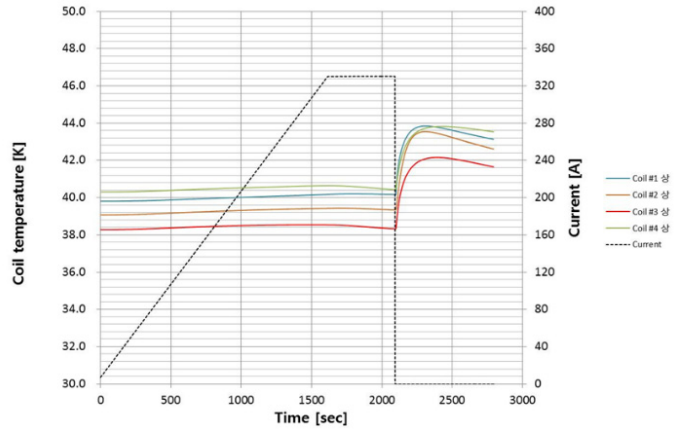




HTS Quadrupole

◆ Quench (current cut off) test

- Assume power suppling failure (ex. Blackout)
- Current bypassed through the bobbin and coil turn
- magnet is not damaged
- Temperature rise of coil: ~4K



Summary

- Construction of the RAON is in progress.
- Prototyping and testing of major components have been in progress through domestic/international vendors :
  - QWR HT in the cryomodule was conducted (May/2017)
  - HWR HT in the cryomodule is planned (Aug/2017)
  - SSR1 cavity VT is planned (Aug/2017)
  - HTS (High Tc Superconductor) quadrupole was tested successfully
- Beam commissioning is conducted
  - RFQ beam test was conducted (Nov/2016)
  - QWR beam test is planned (Sep/2017)

Collaboration

The RAON appreciates the collaboration with

- ANL, Cornell Univ, FNAL
- CEA, GANIL
- IHEP, IMP
- KEK, RIKEN
- TRIUMF

You are welcome to join the collaboration.

Contributors

- D. Jeon, H.C. Jung, H.M. Jang, Y.K. Kwon, S.C. Jeong, S.J. Choi, H.J. Jang, J.H. Jang, T.K. Ki, J.H. Kim, Y.K. Kim, S.I. Lee, B.S. Park, H.J. Cha, B.H. Choi, C.J. Choi, J.W. Choi, O.R. Choi, Y.J. Choi, I.W. Chun, I.S. Hong, M.O. Hyun, H.Y. Jeong, H.C. Jin, H.C. Jo, Y.B. Jo, Y.W. Jo, J.D. Joo, M.J. Joung, Y.C. Jung, I.I. Jung, J.S. Kang, D.G. Kim, D.M. Kim, H.J. Kim, H.T. Kim, J.W. Kim, W.K. Kim, Y.H. Kim, D.Y. Lee, J.W. Lee, K.W. Lee, M.K. Lee, S.B. Lee, S.H. Nam, M.J. Park, K.T. Seol, I.K. Shin, J.H. Shin, C.W. Son, H.J. Son, K.T. Son, K.S. Yang, S.W. Yoon, A. Zaghloul


Thank you for your attention
谢谢