

Progress of RAON Heavy Ion Accelerator Project in Korea

Sunchan Jeong

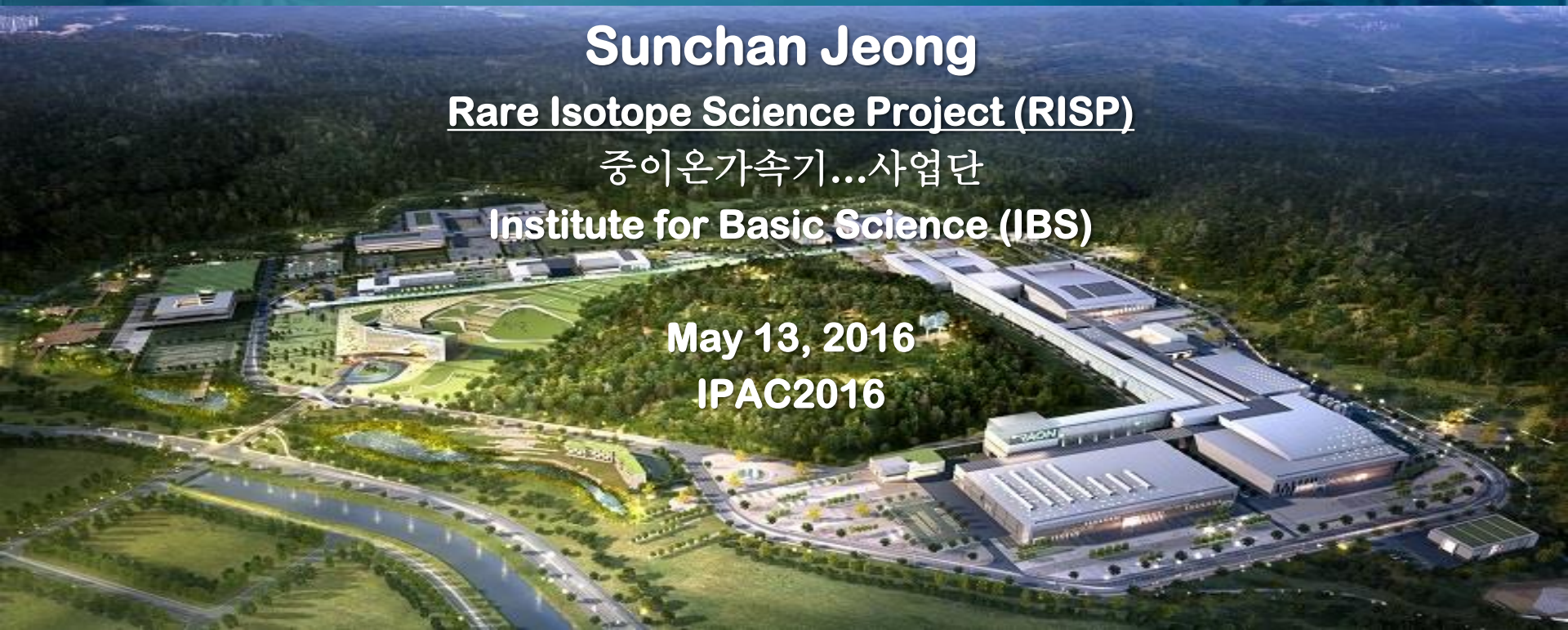
Rare Isotope Science Project (RISP)

중이온가속기...사업단

Institute for Basic Science (IBS)

May 13, 2016

IPAC2016





1

Project Overview

2

Project Status

- Accelerator system
- RI & Experimental system
- **Demonstration system @ off-site test facility**

Rare Isotope Science Project (RISP)

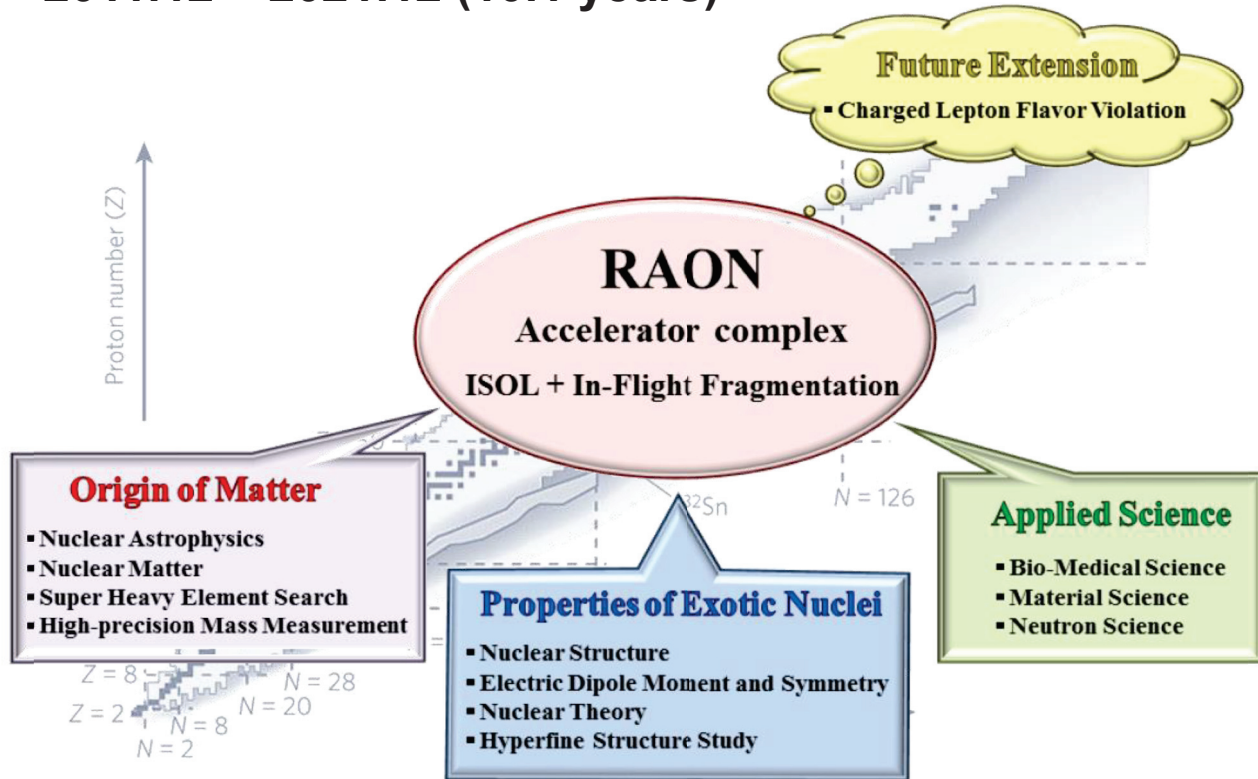
Goal: To build a heavy ion accelerator complex RAON, for rare isotope science research in Korea.

* RAON: Pure Korean word meaning Delightful, Joyful, Happy

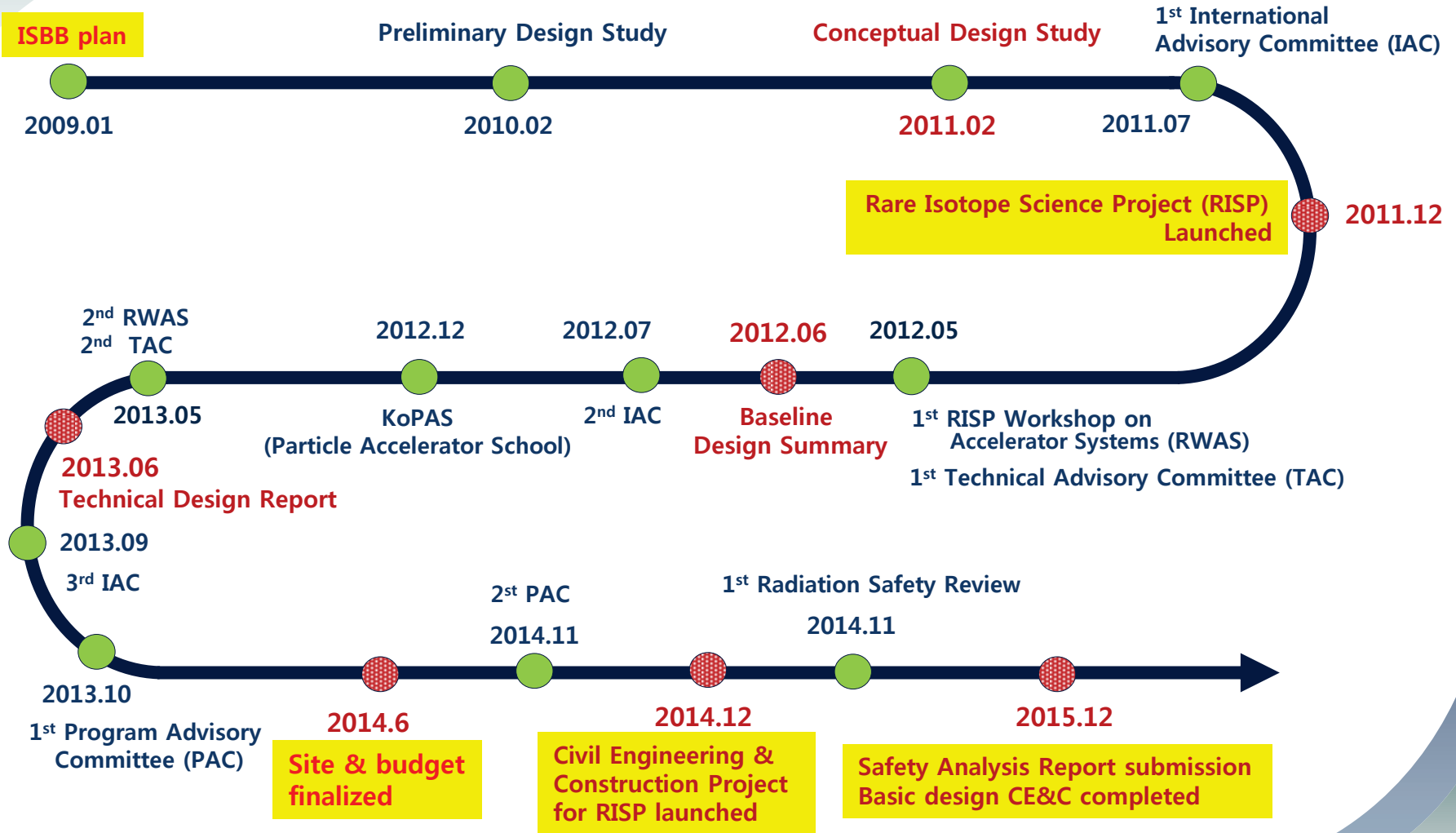
Budget: US\$ 1.44 B (1 B\$~1T Won)

- accelerators and experimental apparatus : 0.46 B\$
- civil engineering & conventional facilities : 0.98 B\$ (incl. construction site purchase)

Period: 2011.12 ~ 2021.12 (10.1 years)



History of RISP



: Accelerator complex for producing rare isotope beams

- ❑ High intensity **RI** beams by **ISOL** & **IF**

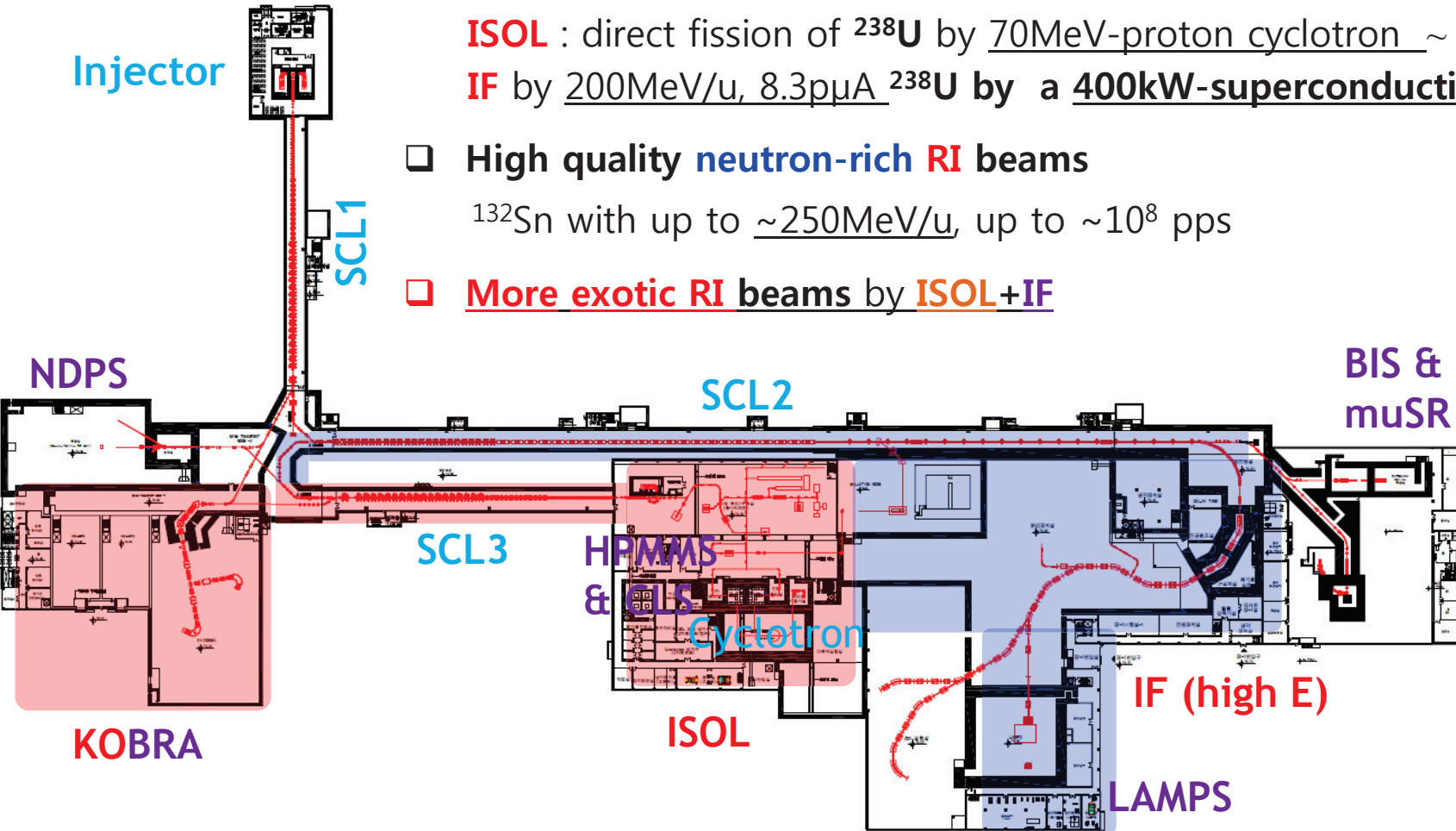
ISOL : direct fission of ^{238}U by 70MeV-proton cyclotron $\sim 10^{14}$ f/s

IF by 200MeV/u, 8.3pμA ^{238}U by a 400kW-superconducting LINAC

- ❑ High quality **neutron-rich RI** beams

^{132}Sn with up to $\sim 250\text{MeV/u}$, up to $\sim 10^8$ pps

- ❑ More exotic RI beams by **ISOL+IF**



: Accelerator complex for producing rare isotope beams

- High intensity **RI** beams by **ISOL** & **IF**

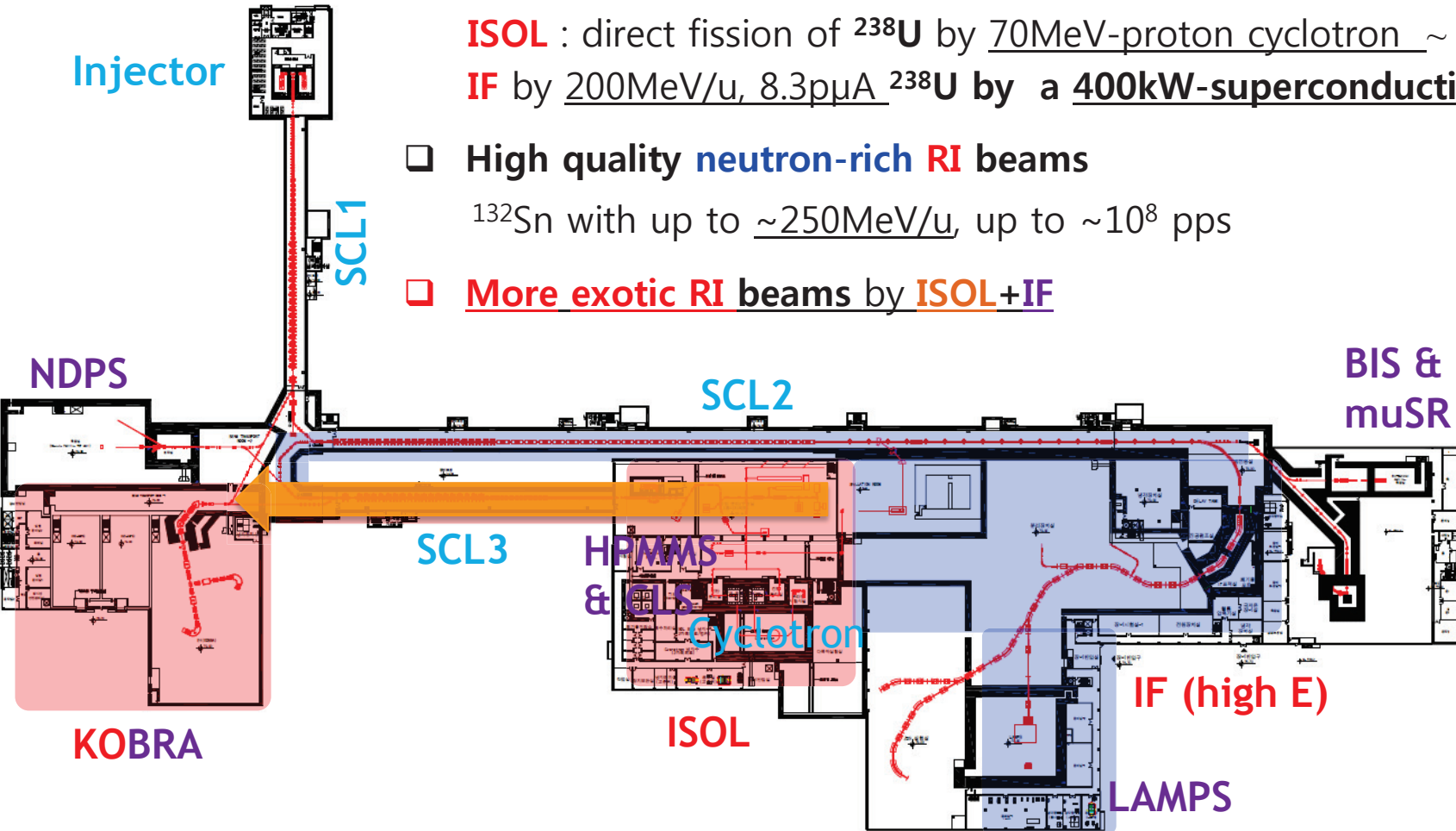
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- High quality **neutron-rich RI** beams

^{132}Sn with up to ~250MeV/u, up to $\sim 10^8$ pps

- More exotic RI beams by **ISOL+IF**



: Accelerator complex for producing rare isotope beams

- High intensity **RI** beams by **ISOL** & **IF**

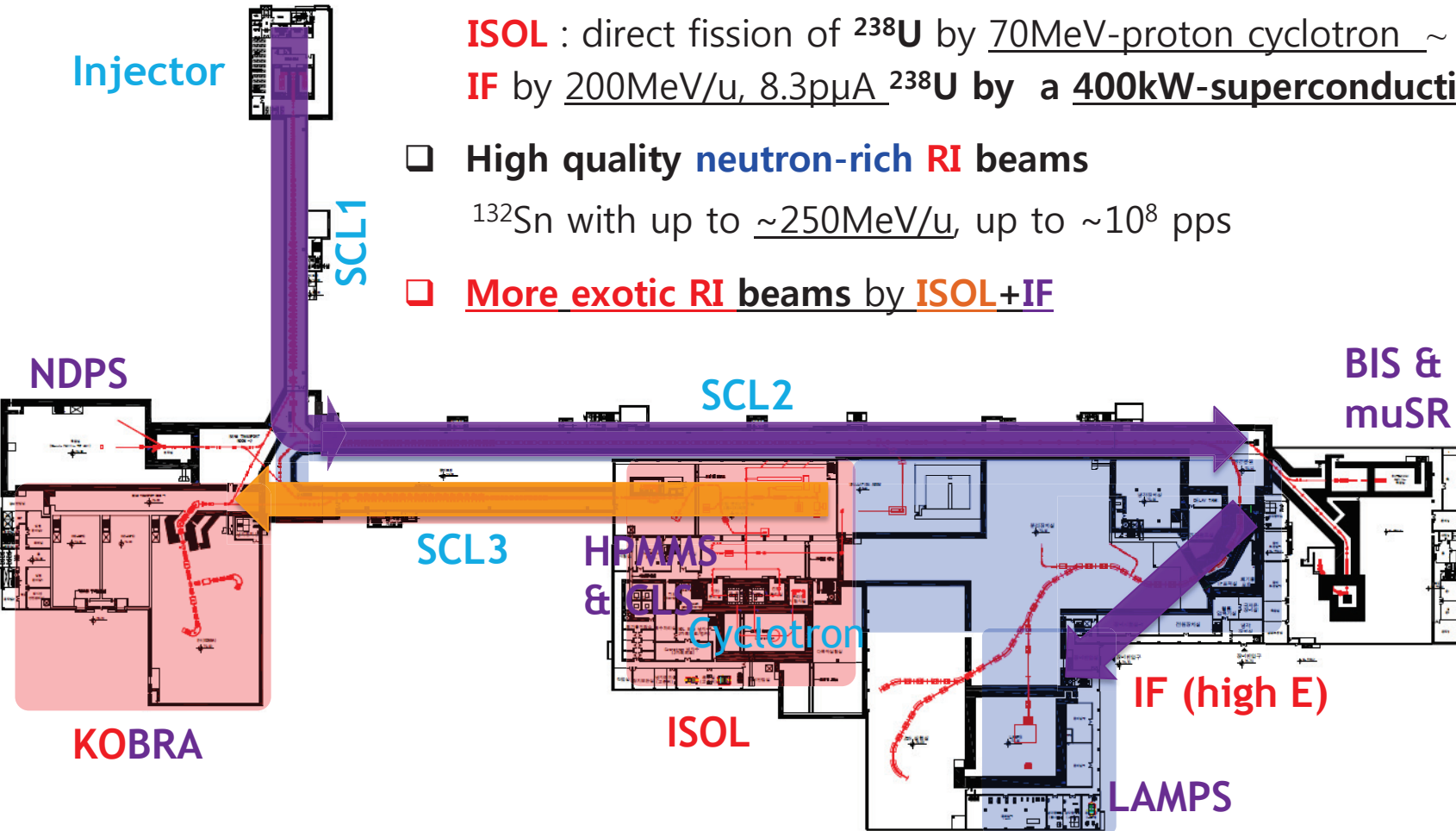
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: Accelerator complex for producing rare isotope beams

- High intensity **RI** beams by **ISOL & IF**

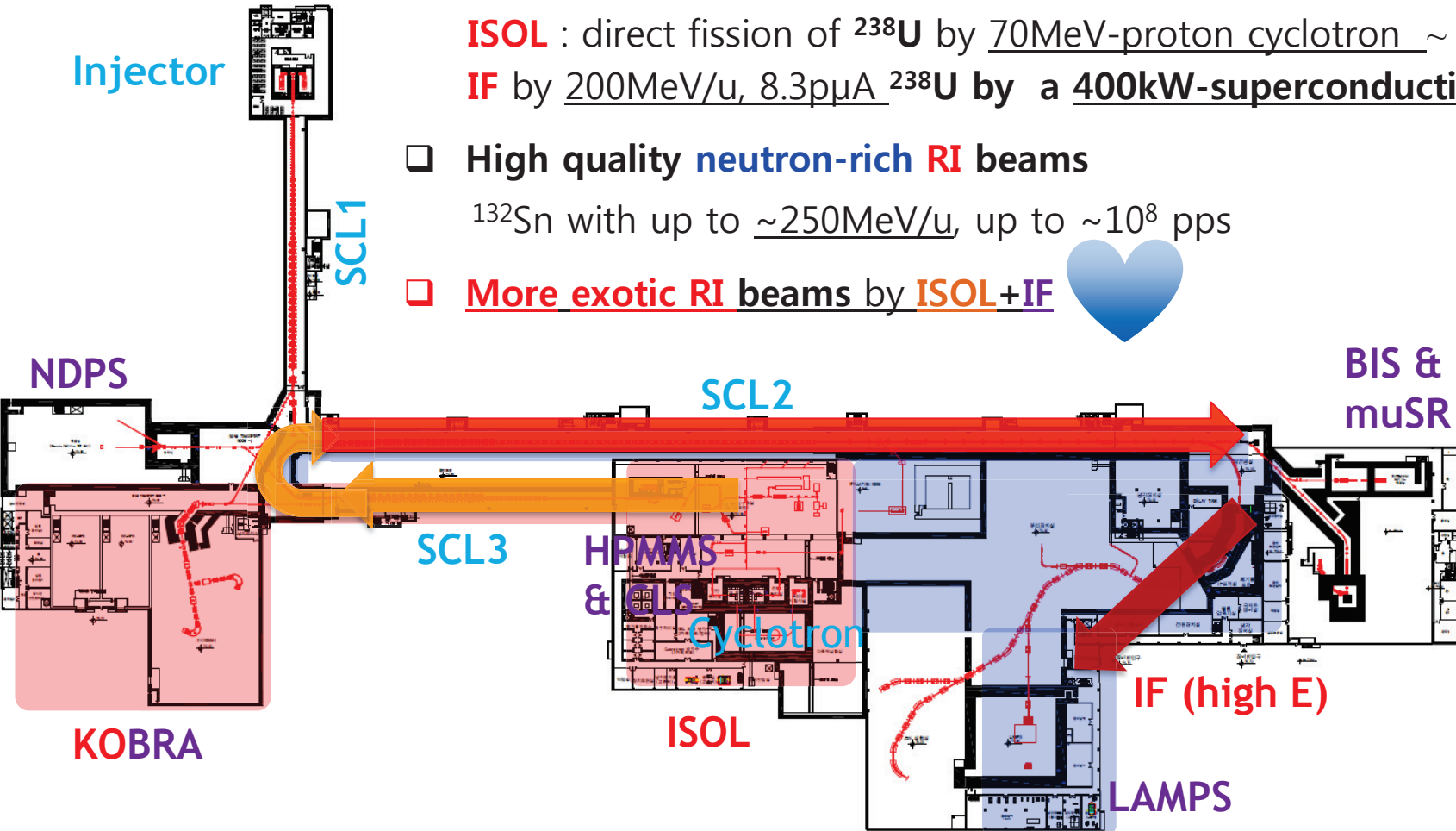
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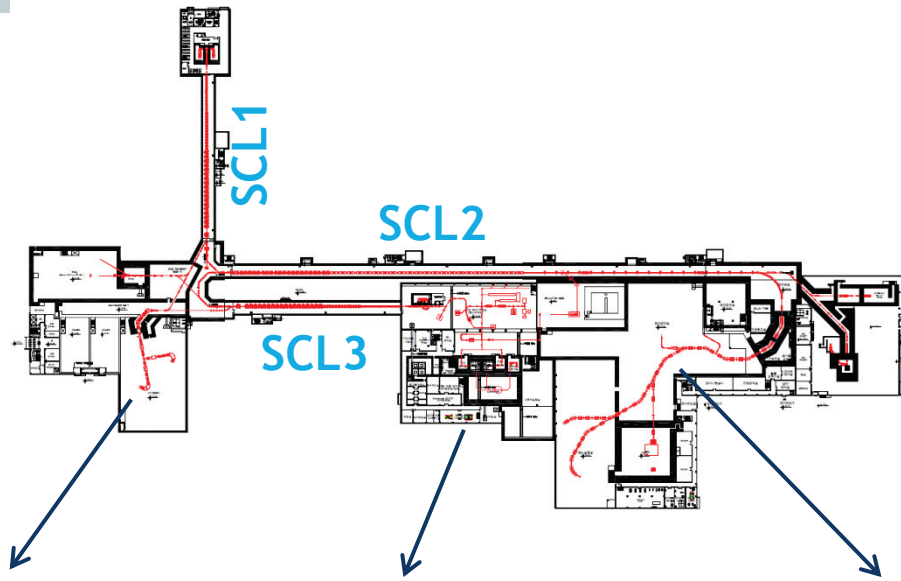
^{132}Sn with up to $\sim 250\text{MeV/u}$, up to $\sim 10^8$ pps

- More exotic RI beams by **ISOL+IF** 



Lineup of RIB production & separation

- ☀ ISOL → IF
- : ISOL → SCL3 → SCL2 → IF
- : ISOL → SCL3 → KOBRA
- ☀ IF → Re-Acc (future upgrade)
- : IF → stopped beam → SCL



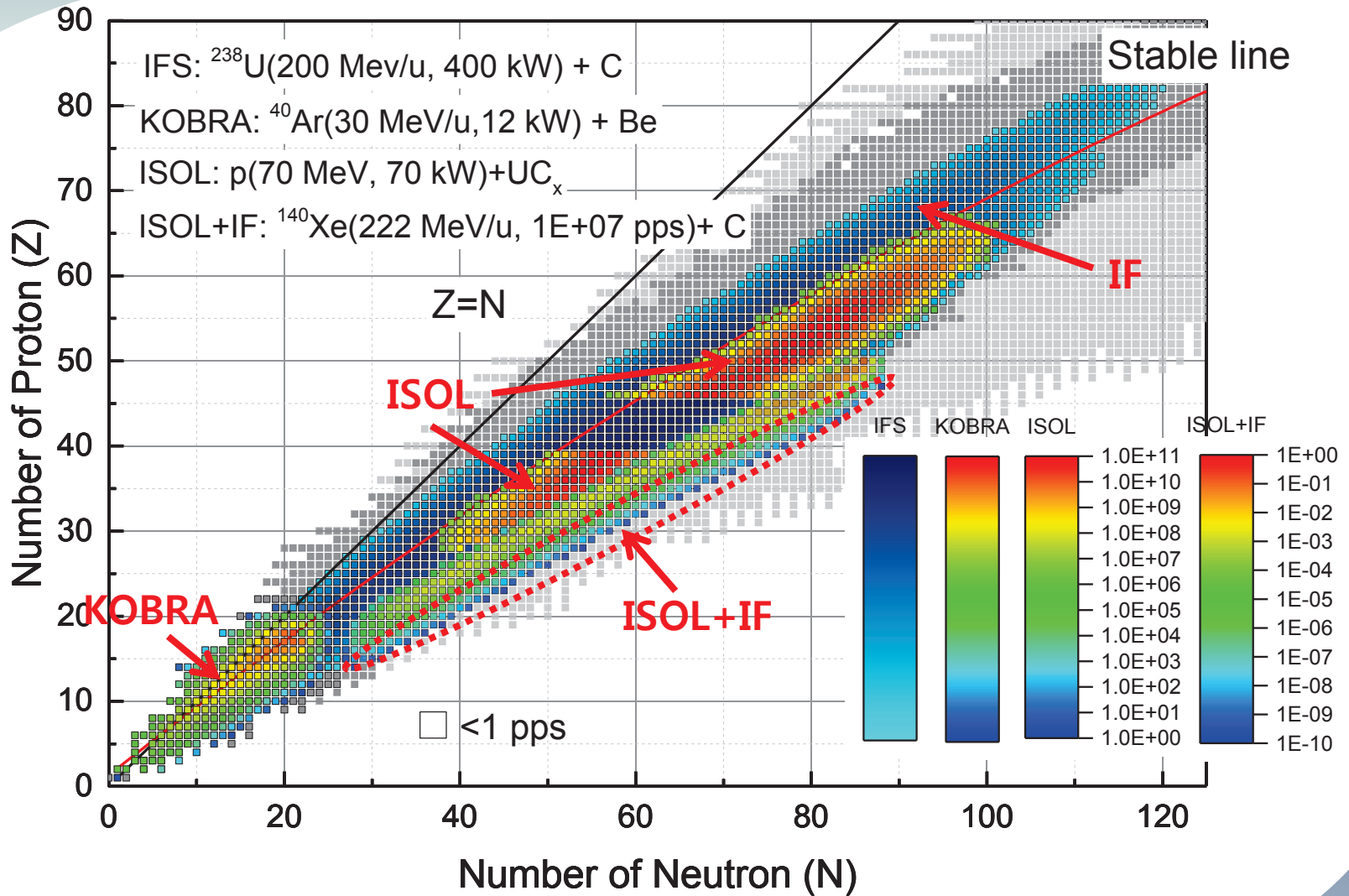
KOBRA (low E IF)

ISOL

IF (high E)

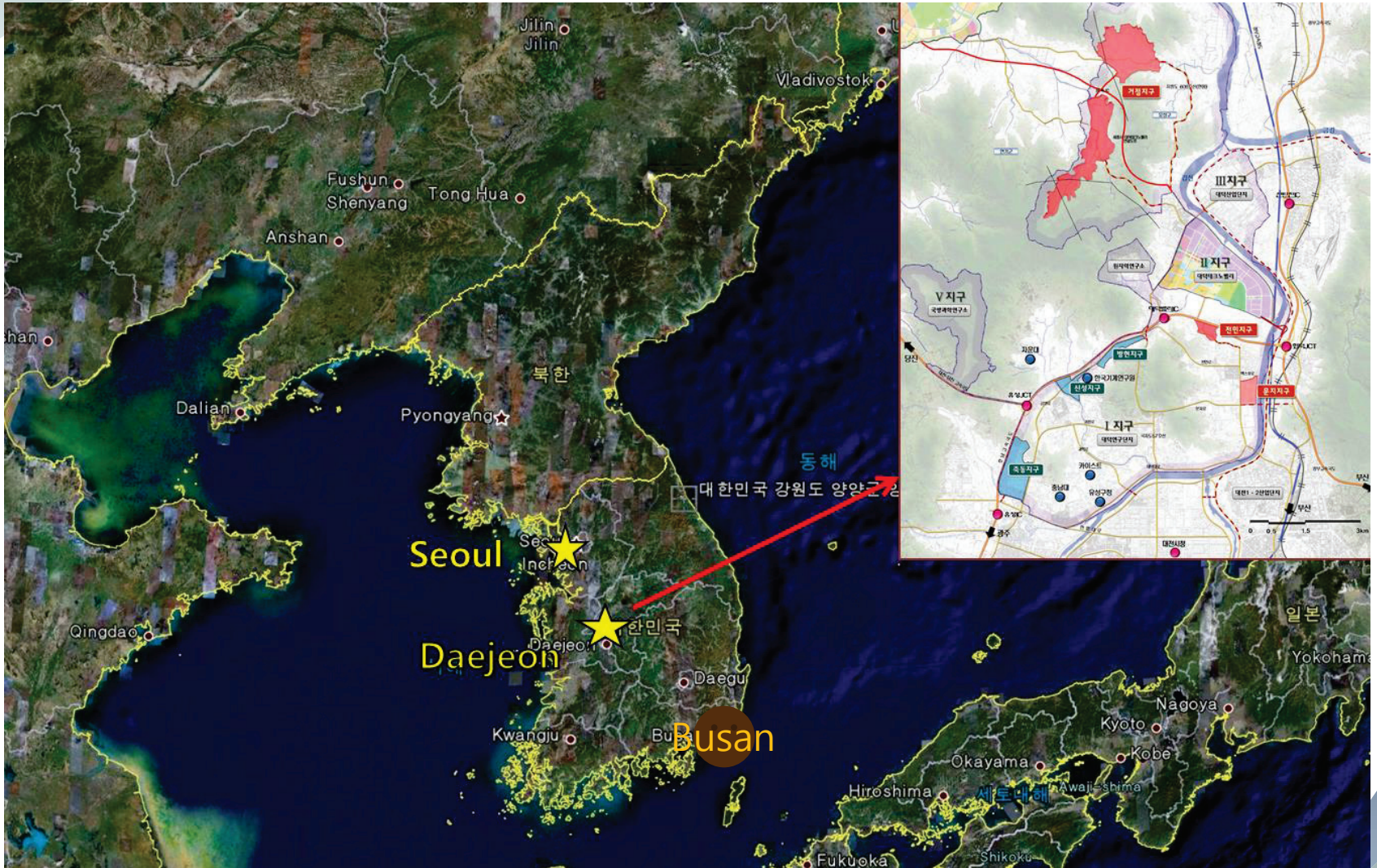
Driver	SCL3 or SCL1	Cyclotron	SCL3 → 2 or SCL1 → 2
Post Acc		SCL3 or SCL3 → 2	
Production mechanism	Direct reactions - (p,d), (³ He,n) etc , MNT	p induced U fission	PF, U fission
Available RIB energy	< a tens of MeV/u	> a few of keV/u	< a hundreds of MeV/u

Expected RIBs at RAON

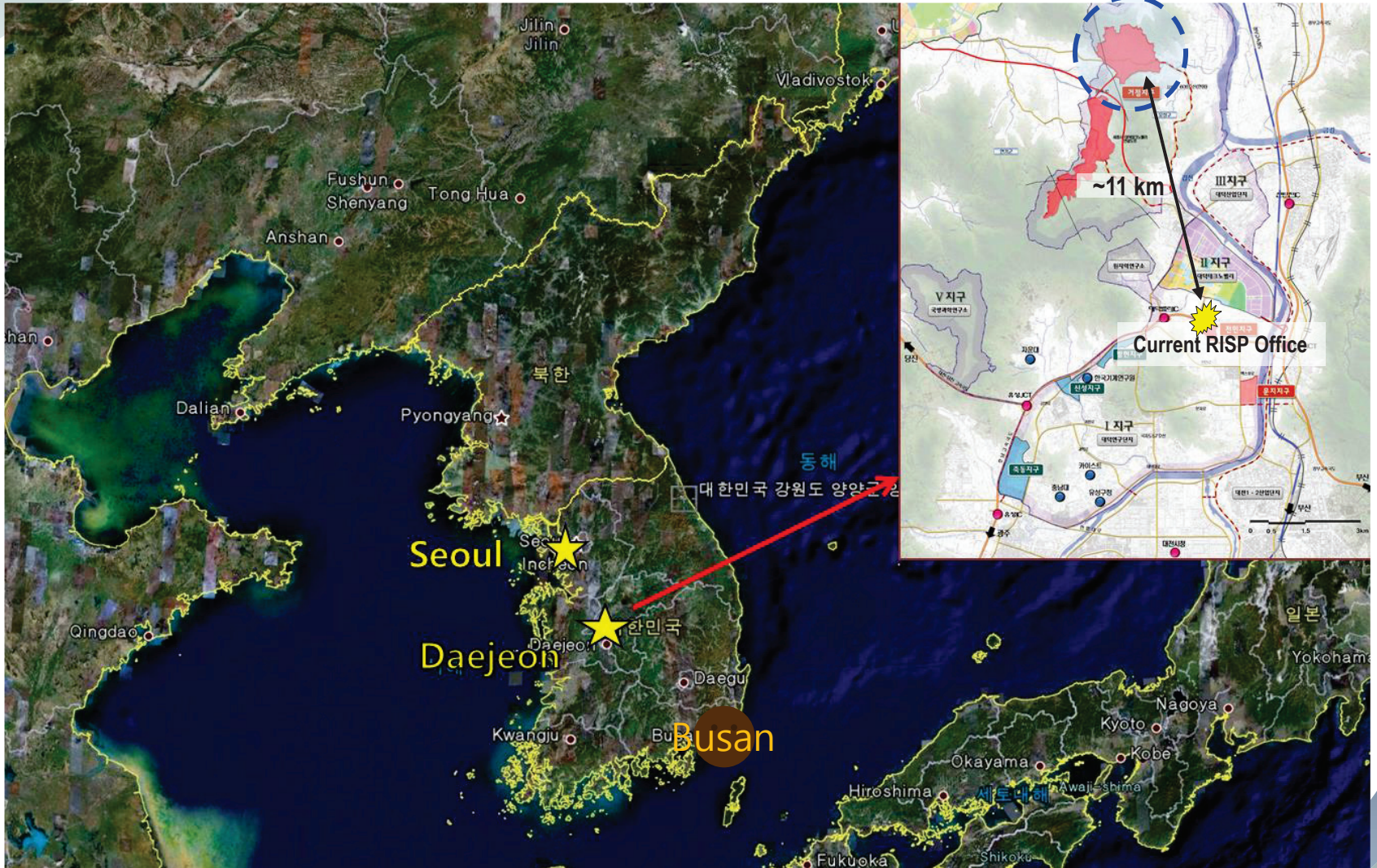


▪ RAON will provide access to unexplored regions of the nuclear chart !

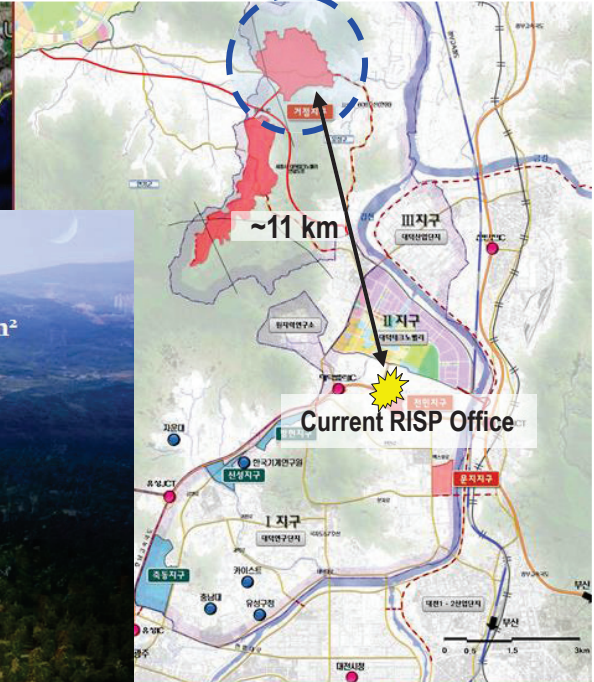
RAON Site :



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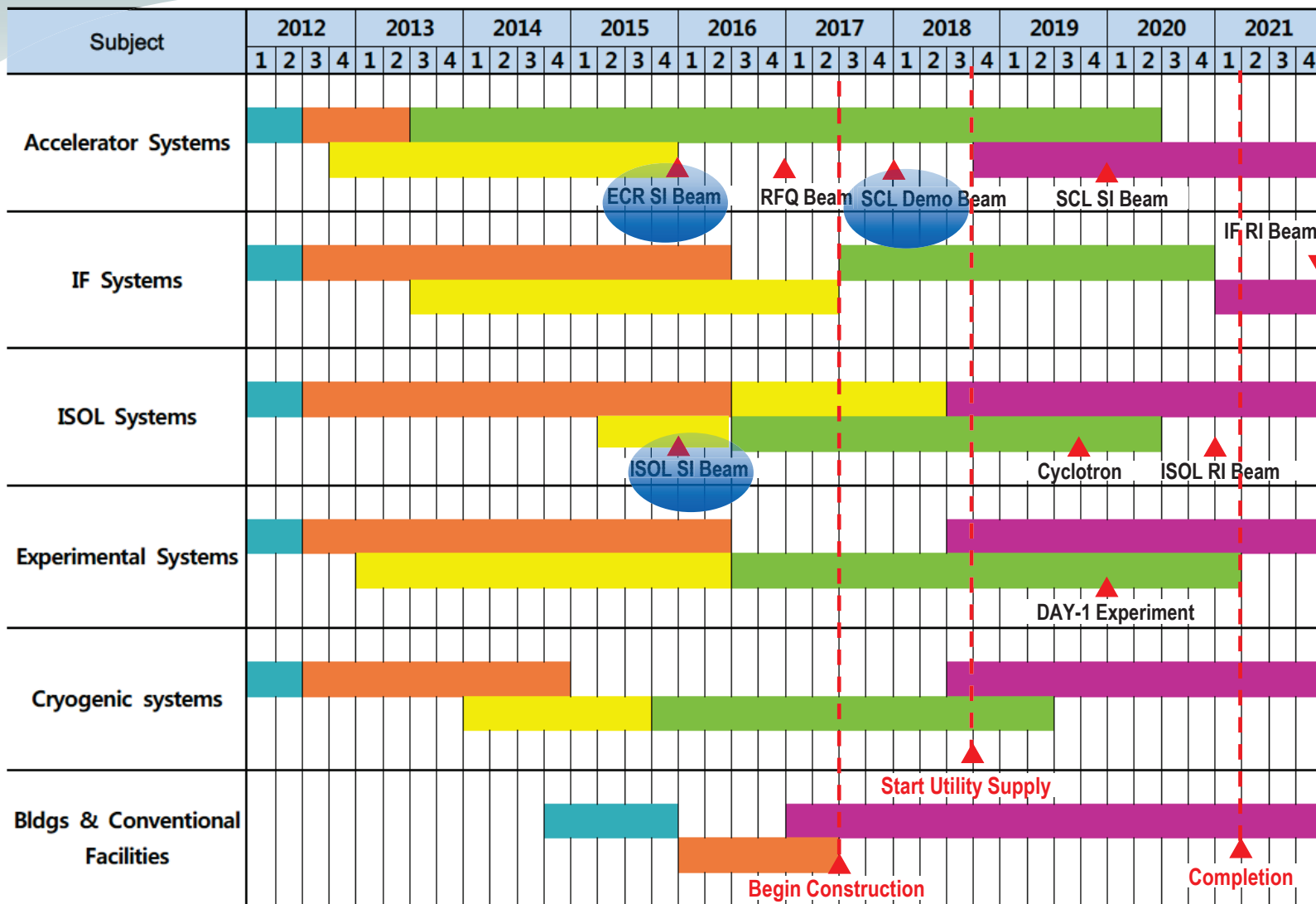


RAON Site :



Basic design was finished Dec., 2105
A construction company will be selected in August 2016.

RISP Milestone Schedule



■: Conceptual Design
 ■: Technical Design
 ■: Prototyping & Test
 ■: Fabrication & Test
 ■: Installation & Commissioning

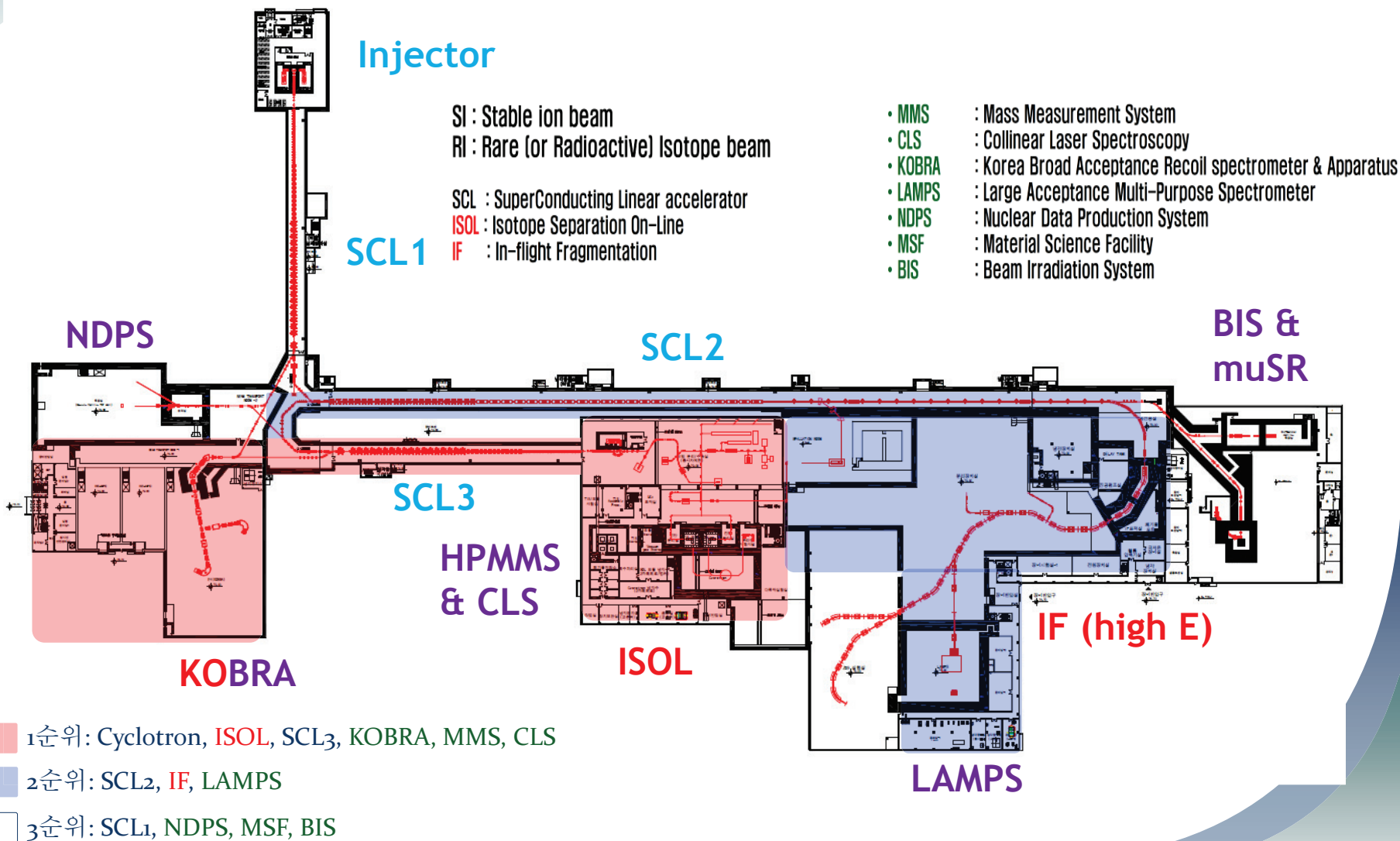


Status of RAON

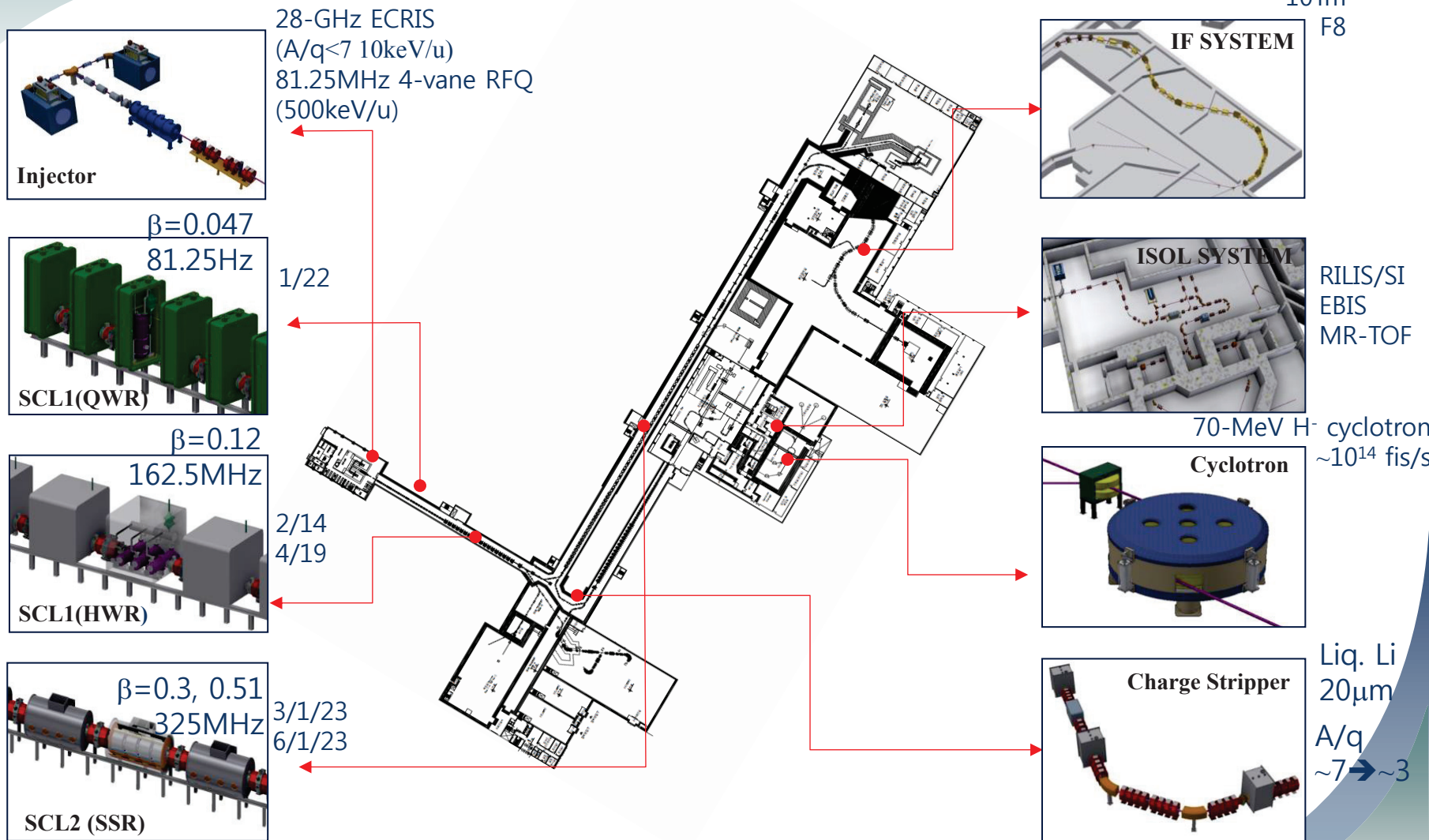


32 contributions in this conference from RISP!

Layout of RAON

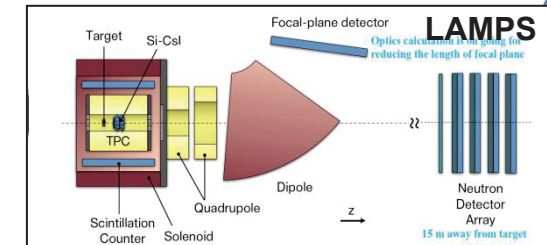
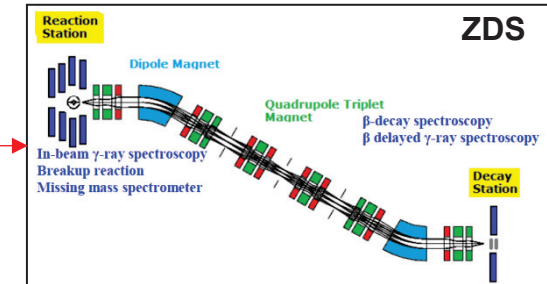
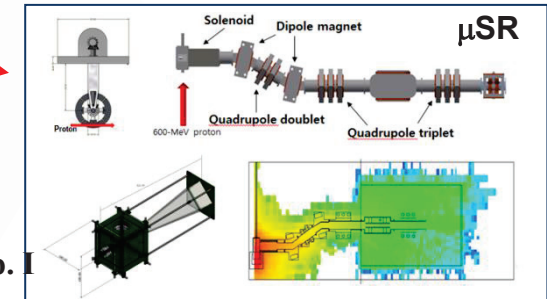
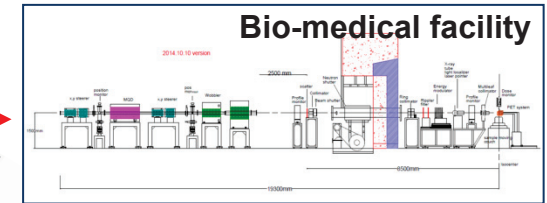
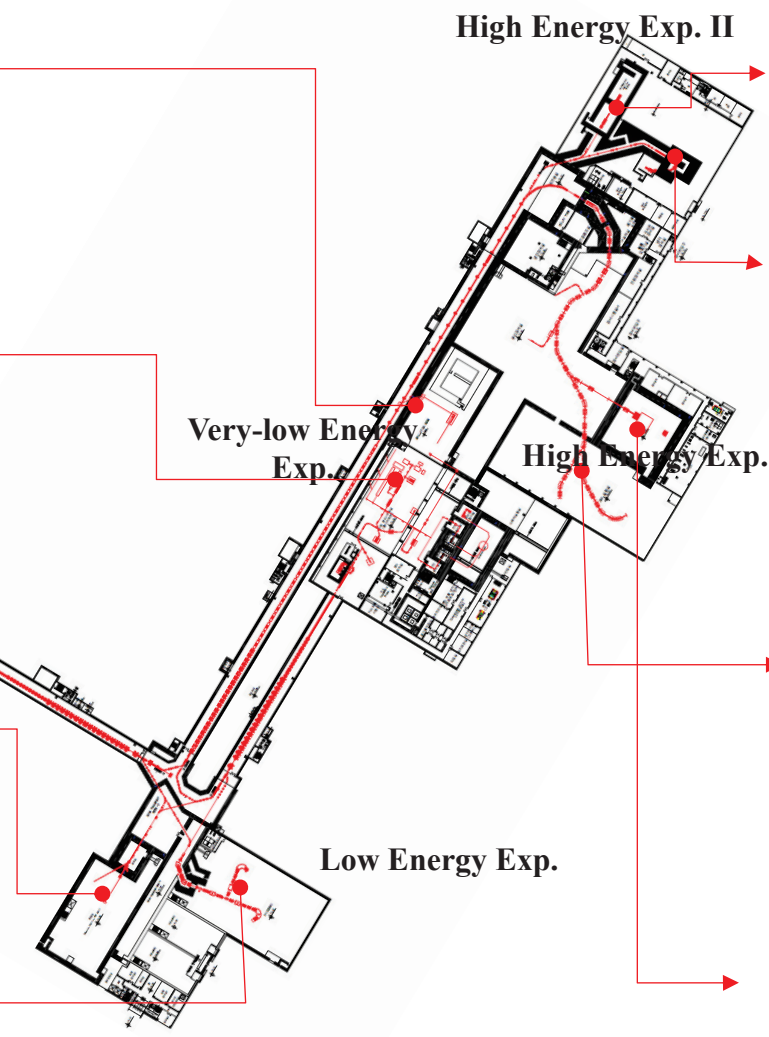
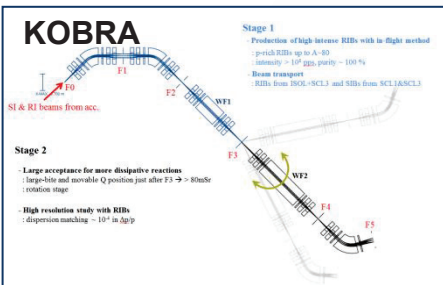
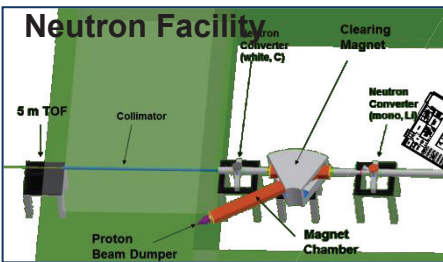
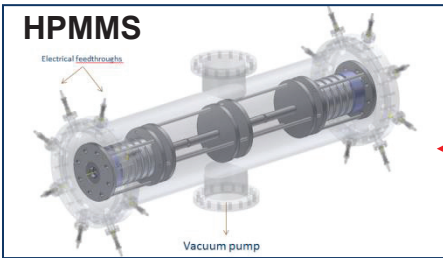
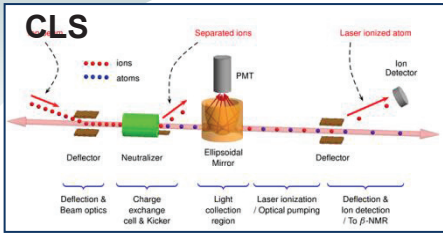


Accelerator systems



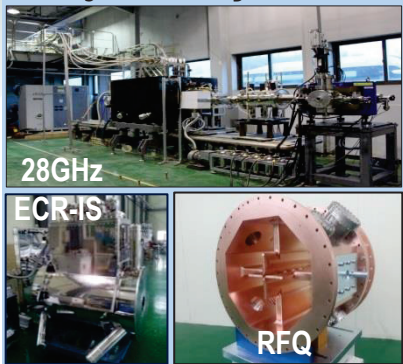
Warm sections for focusing components inbtw. CMs

Experimental Systems

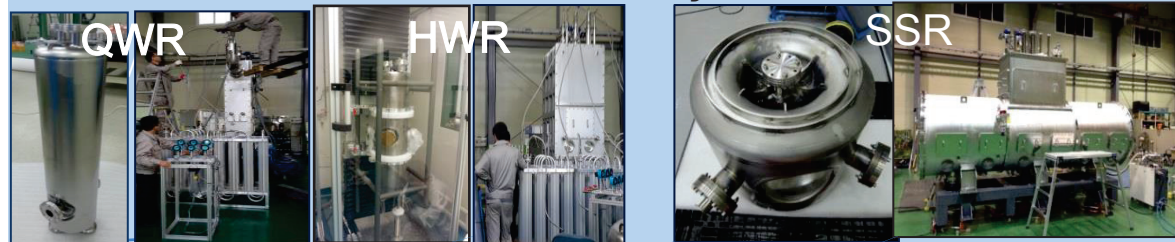


Accelerator and Experiment systems

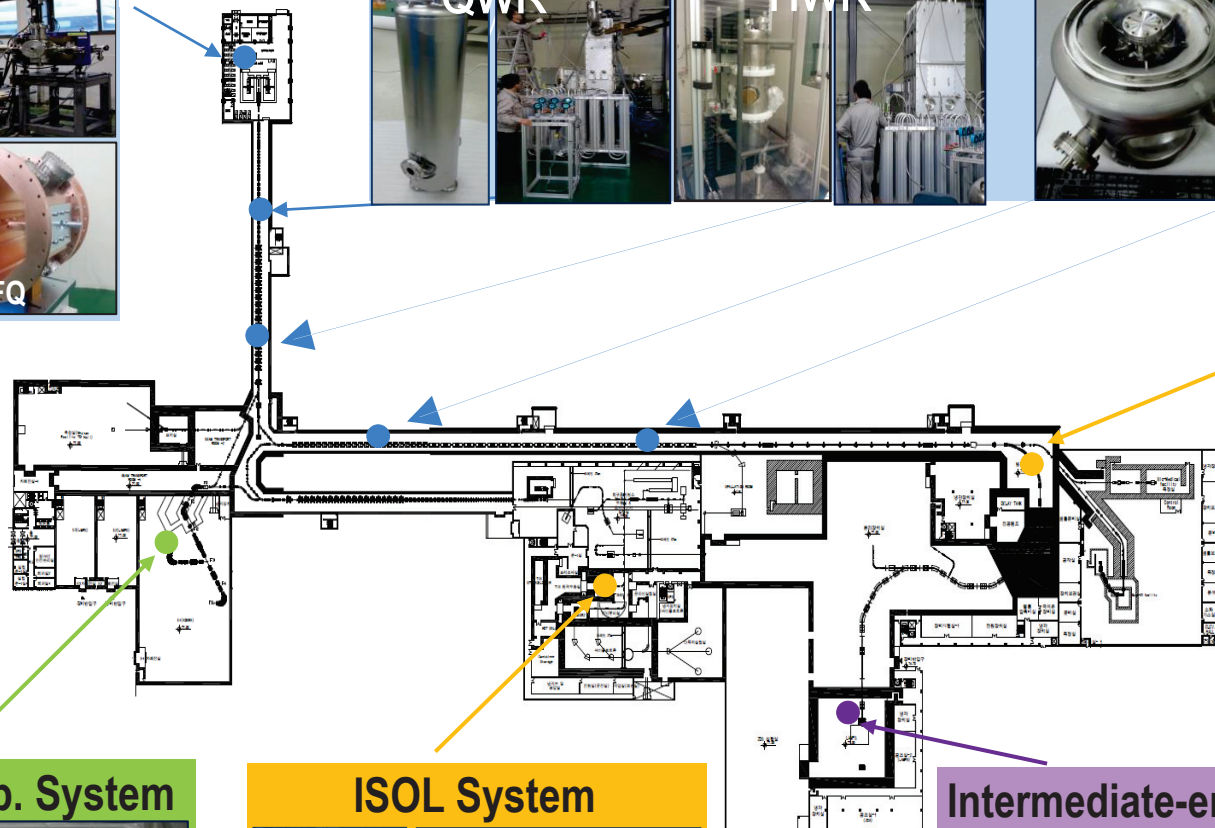
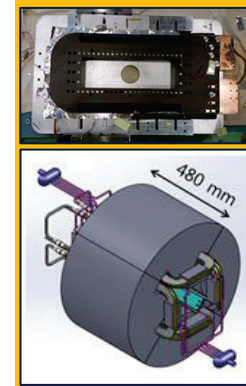
Injector System



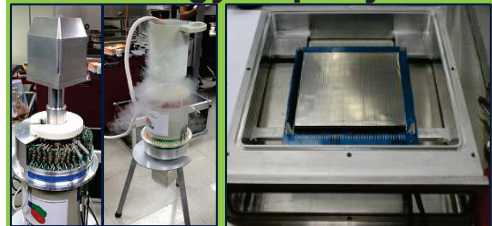
SC LINAC System



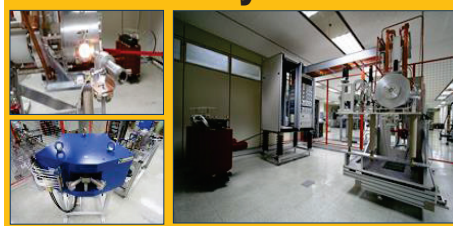
IF System



Low-energy Exp. System



ISOL System



Intermediate-energy Exp. System



Demonstration system @ off-site test facility SRF-TF

SRF Test Infrastructure

Remodeling design: '15.06 ~ '15.08

Remodeling construction: '15.11~ '16.02

He Cryoplant (300W) comissioning is under way. (2016,5-)

From June, 2016, the operation (VT, HT) will start.

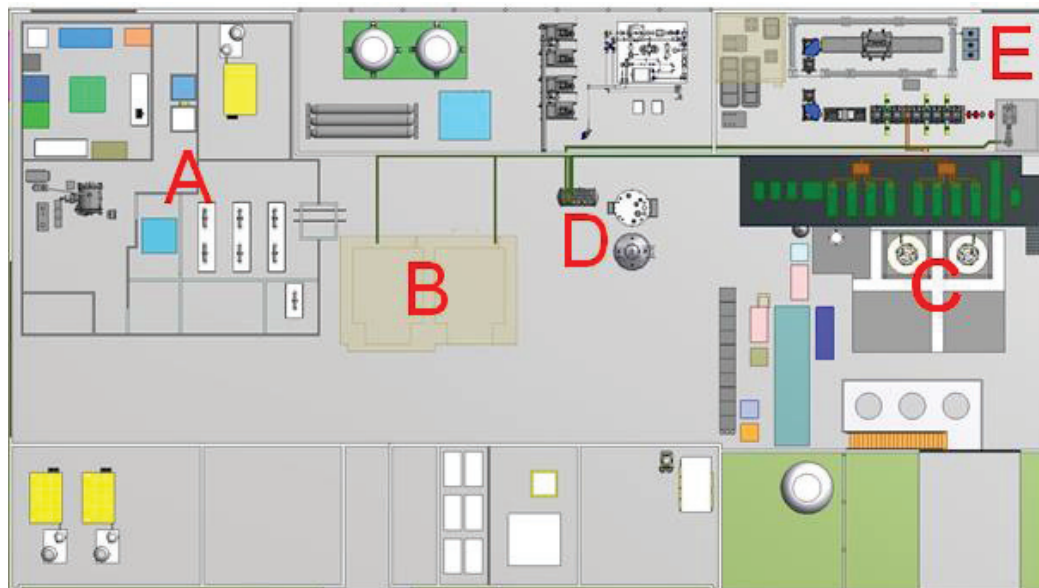
Current status of construction

(~2015. Dec.)

Cleanroom area

Horizontal test area

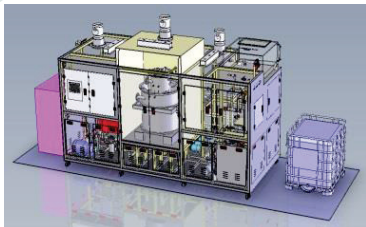
Vertical test area



- (A) Cleanroom area,
- (B) (B) Horizontal test area,
- (C) Vertical test area,
- (D) Cryoplant area (300W + 900W to be upgrade),
- (E) Demonstration area



BCP (under fabrication)



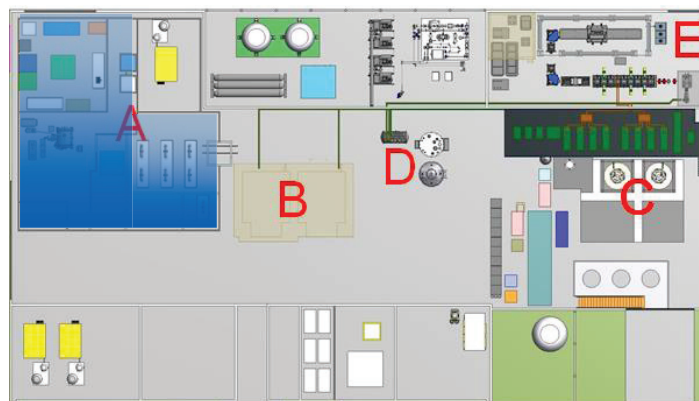
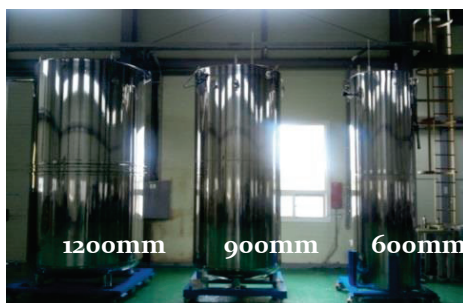
Vacuum Furnace (completed)



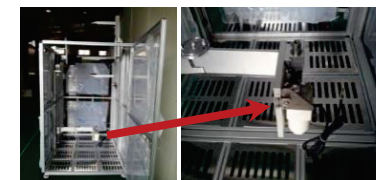
Field profiler (completed)



Cryostat (completed)



HPR (completed)



Liquefier (completed)



DB box (completed)



ECT (completed)



DI water system (completed)

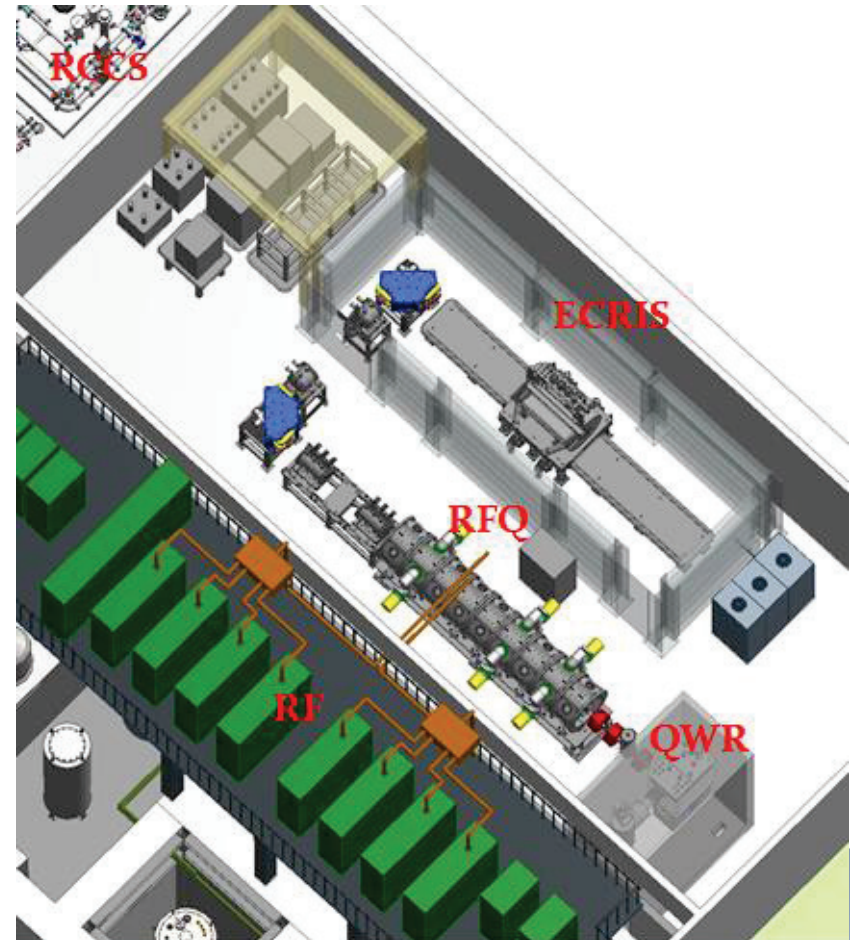


○ Goal

$A/q = 7.2$, beam energy = 530 keV/u

- ECRIS beam energy : 10 keV/u
- RFQ beam energy : 500 keV/u
- QWR beam energy : 530 keV/u

	Beam spec.	Detailed action item
2016.12	Oxygen 0.01 mA ($A/q \sim 3$)	SCL Demo : Hardware installation ECRIS : beam extraction (Oxygen ~1 mA)
2017.12	Oxygen 0.01 mA ($A/q \sim 3$)	SCL Demo : Beam acceleration (Oxygen) ECRIS : metal ion extraction (Bismuth 0.1 mA)
2018.09	Metal 0.01 mA ($A/q \sim 7.2$)	SCL Demo : metal ion acceleration



Injector Specification

❑ ECR-IS

- Output norm(rms) emittance 0.12π mm-mrad
- Beam current $400 \mu\text{A}$ for $^{238}\text{U}^{33+} + ^{238}\text{U}^{34+}$
- Output beam energy 10 keV/u
- RF frequency 28 GHz
- Magnets Fully superconducting NbTi

❑ LEBT

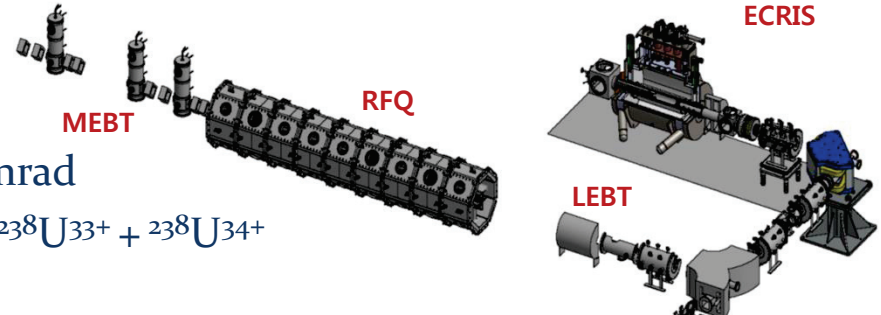
- Pre-bunchers Multi-harmonic buncher, Velocity equalizer
- Two Bends 90 deg.

❑ RFQ

- RF frequency 81.25 MHz
- Output beam energy 500 keV/u
- 4 Vane types

❑ MEBT

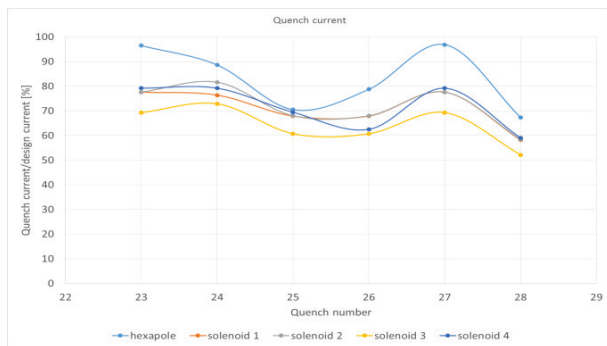
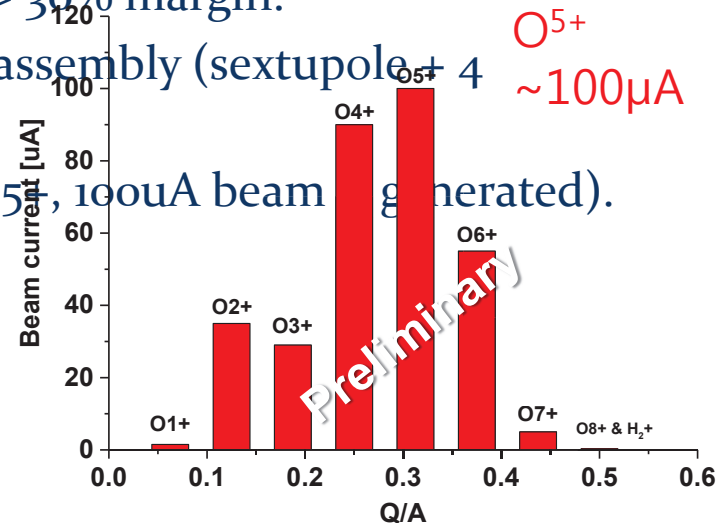
- 3 Re-bunchers RF freq. 81.25 MHz



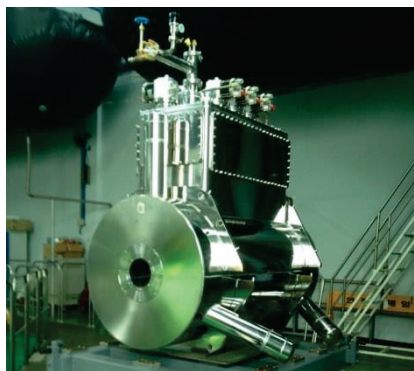
28 GHz ECR Ion Source



- Superconducting sextupole and solenoid prototypes were tested and achieved > 30% margin.
- Superconducting magnet assembly (sextupole + 4 solenoids) was completed.
- Beam test is in progress (O^{5+} , 100 μA beam generated).



SC Magnet training



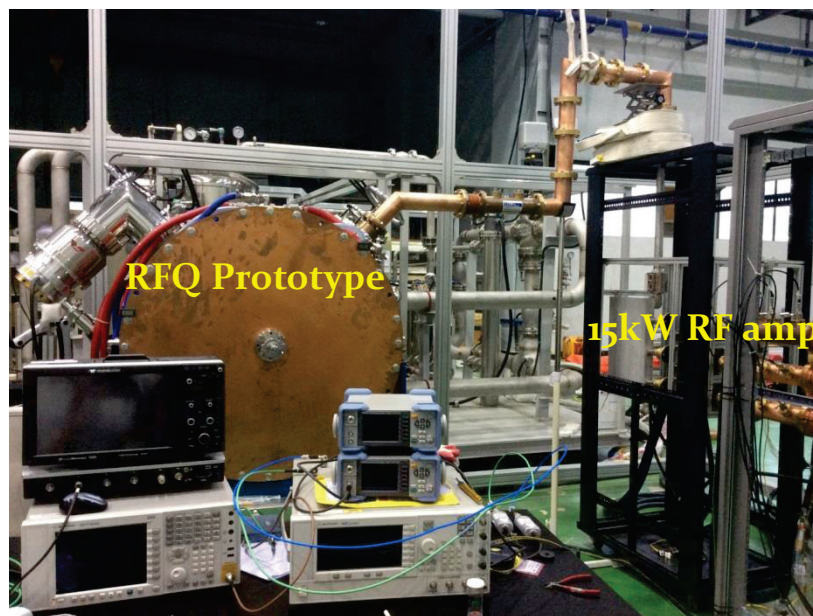
Six 4K cryocoolers,
One single stage cryocooler



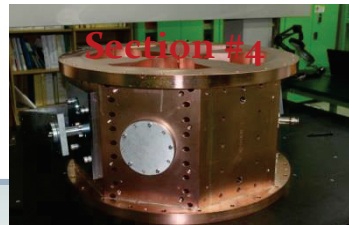
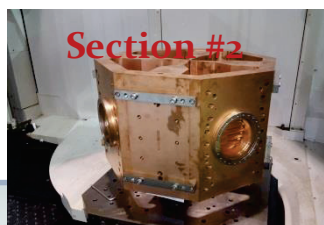
Inside Shielding Block

Radio Frequency Quadrupole

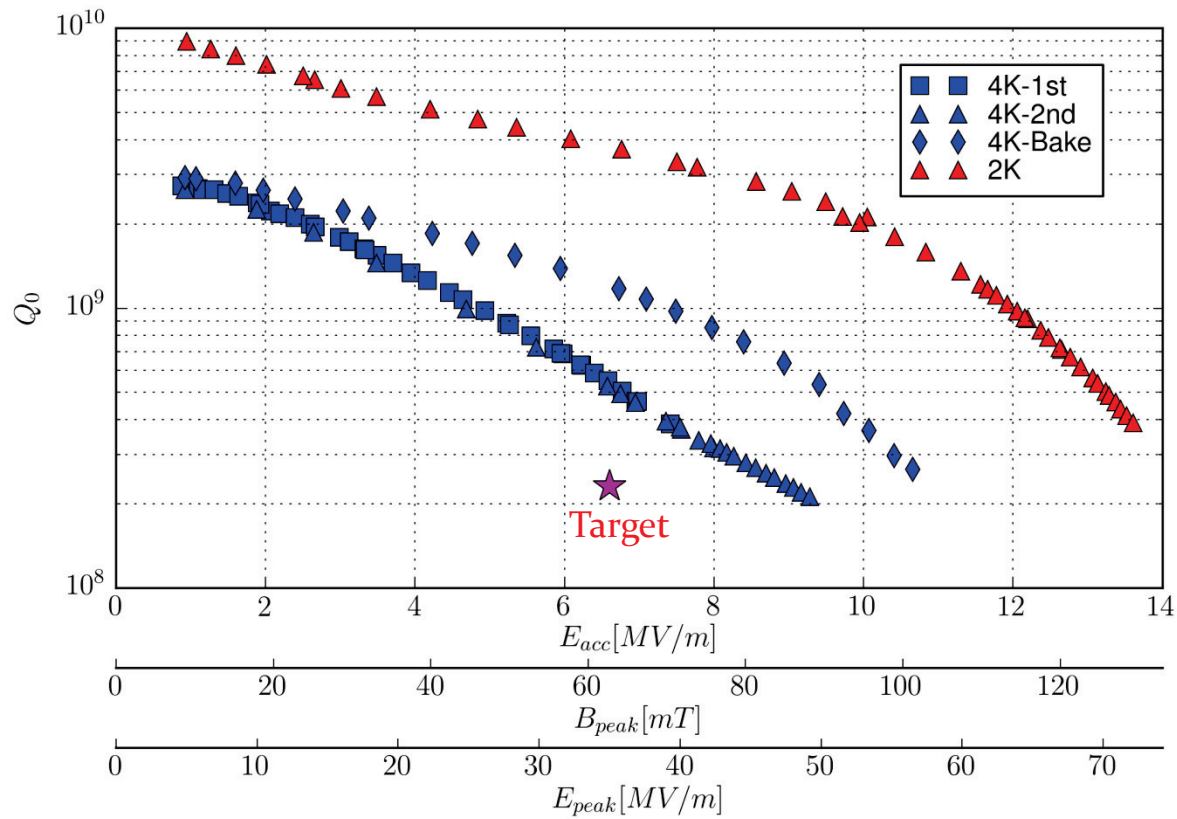
PARAMETER	VALUE
Beam Properties:	
Frequency	81.250 MHz
Particle	H ⁺ to U ₂₃₈ ⁺³³
Input Energy	10 keV/u
Input Current	0.4 mA
Input Emittance	0.012 .cm. mrad
Output Energy	0.507 MeV/u
Output Emittance	0.0125 .cm. mrad ~26 keV/u-Degree
Transmission	~98 %
Total Power	94 kW
Duty Factor	100%



RFQ Fabrication is under way: fabrication, low-power tuning complete in 2016.08
Frequent RISP staff visits & risk mitigation (contacted with domestic vendor)



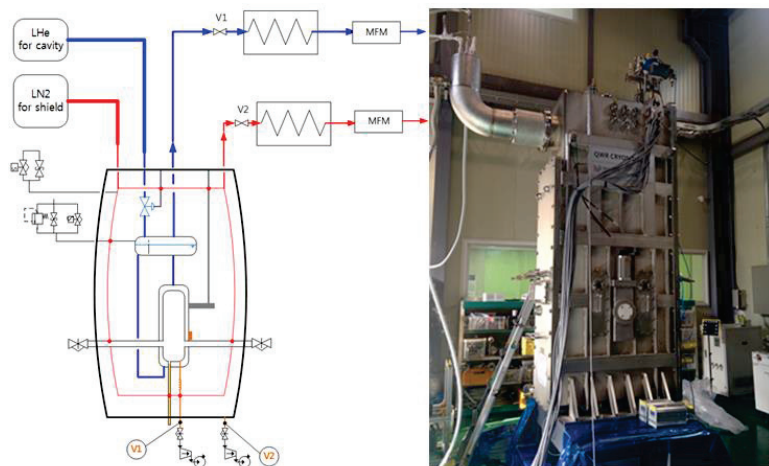
Vertical Test of QWR Cavity



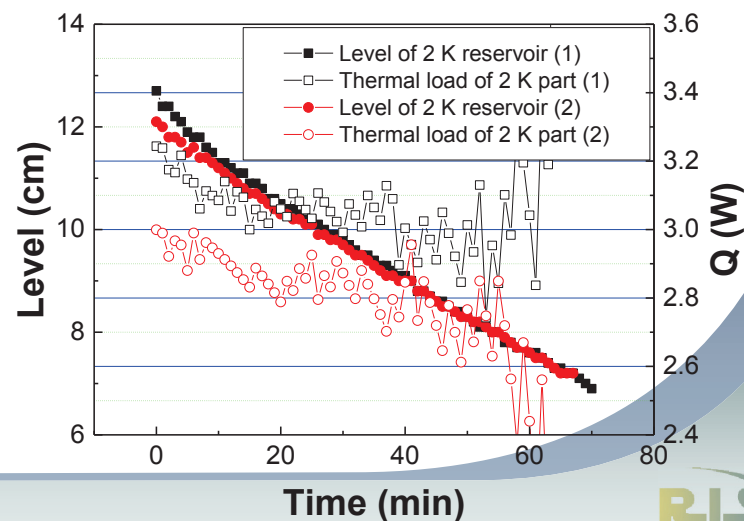
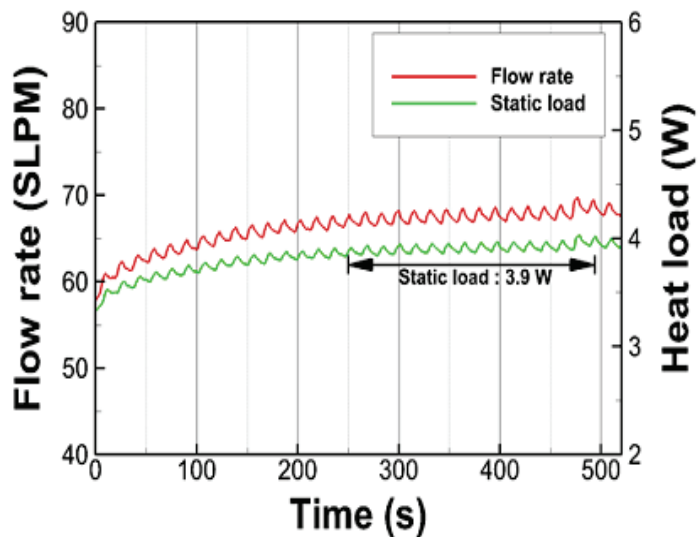
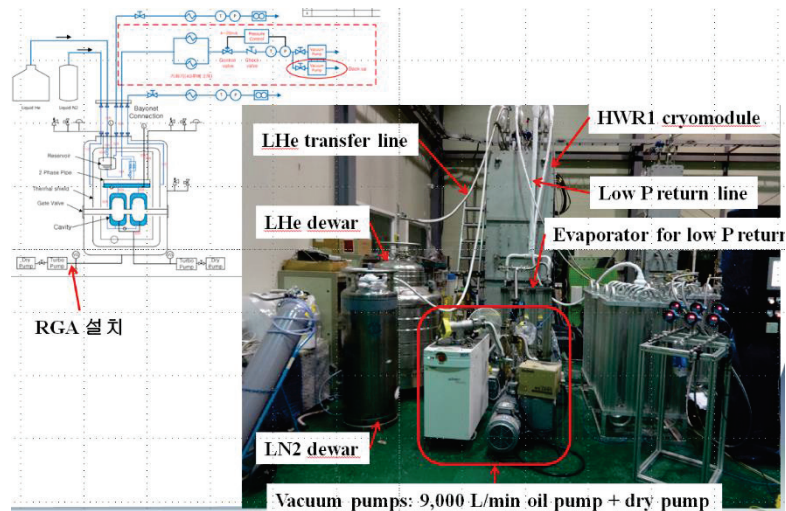
(TRIUMF SRF Facility)

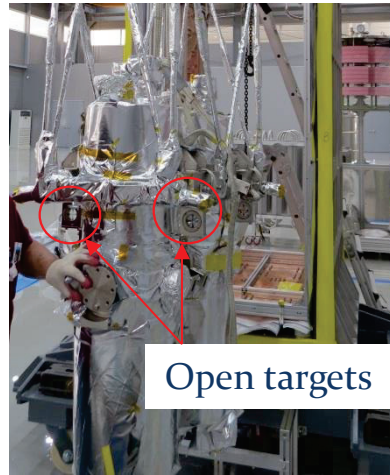
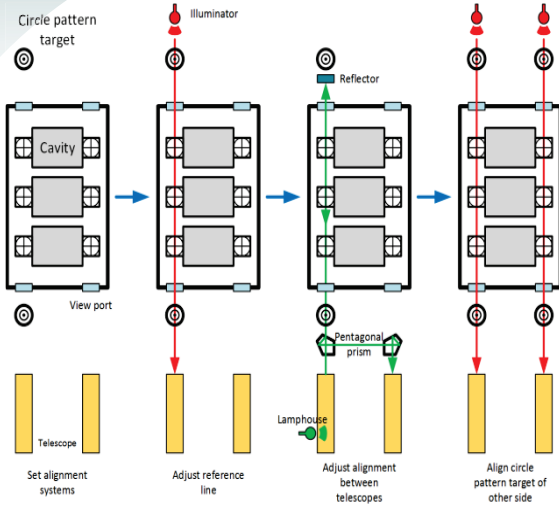
Static Load of Cryomodule

- QWR static load: 3.9 W (expectation: 5 W)

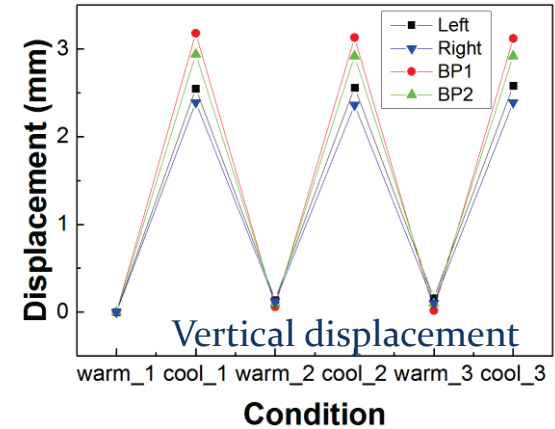
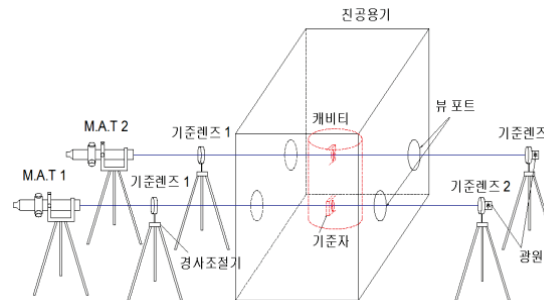
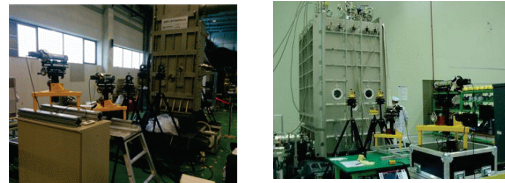
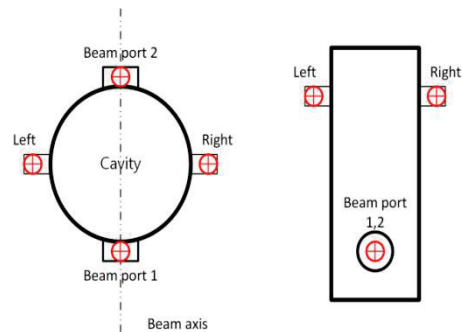


- HWR static load: 11.4 W (expectation: 12 W)





MAT + open target



Good repeatability:
less than ± 0.04 mm

- Prototyping of major accelerator parts has been in progress since 2013 through domestic vendors.
 - ECR ion source cryostat was fabricated (2014.09)
 - RFQ prototype fabricated successfully (2014.10)
 - SC cavity prototypes were delivered for test (since 2014.05)
 - Cryomodule prototypes were delivered for test (since 2014.12)

- Some prototypes are in testing stage.
 - ECR ion source, RFQ, MEBT buncher
 - High power RF and low-level RF
 - Superconducting cavities and cryomodules (QWR, HWR)
- Plan for proceeding the procurement of cavities, cryomodules in 2016.4Q
- Ready for bidding the cryoplant and contract award at 2016.3Q
- SRF test facility is under construction and will be ready for installation in Feb. 2016.



감사합니다.

