# RAON: Rare isotope Accelerator complex for ON-line experiments

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ICABU

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

# RISP Overview

# Rare Isotope Science Project (RISP)

RAON

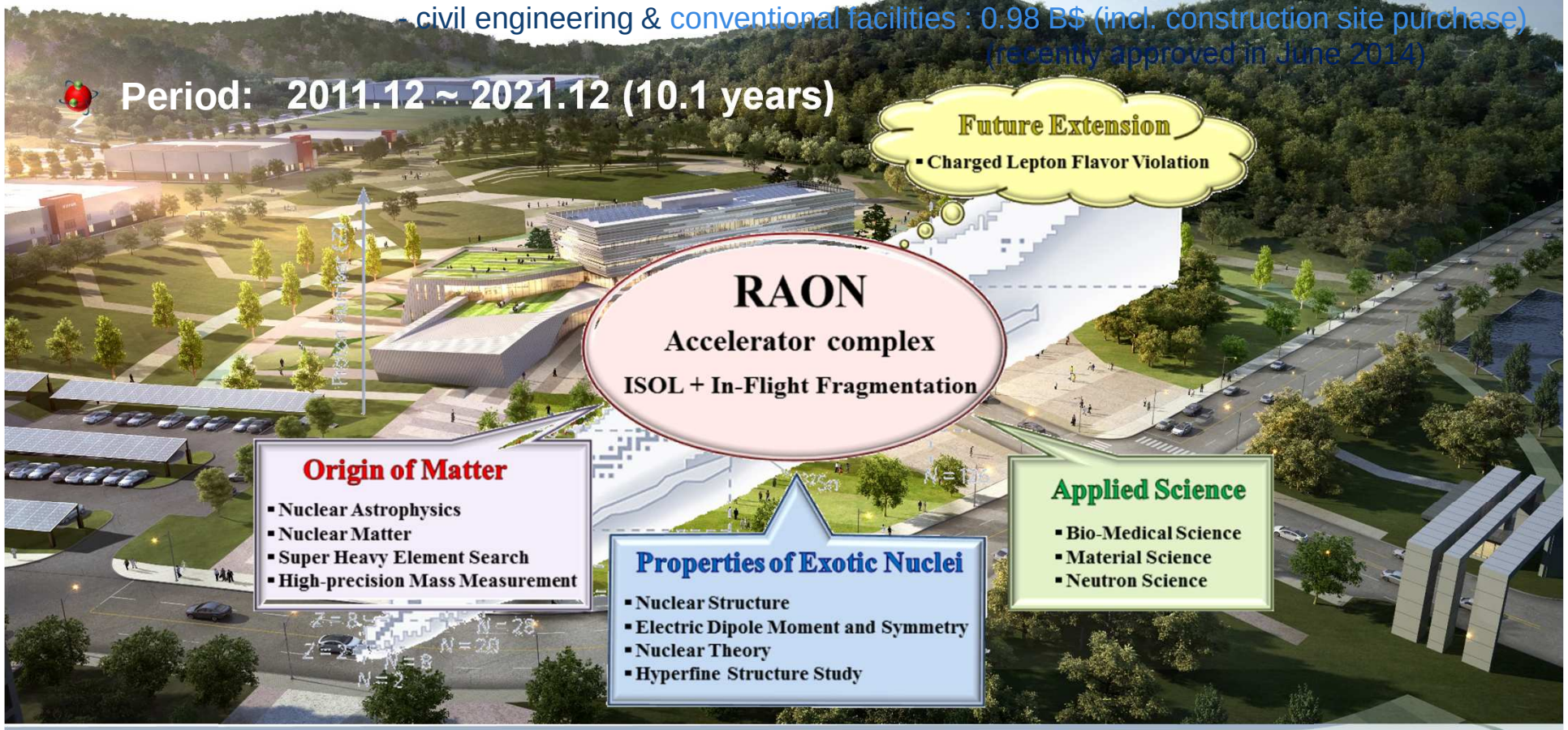
- **Goal:** To build **a heavy ion accelerator complex RAON,** for **rare isotope science** research in Korea.

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

- **Budget: 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)
    (recently approved in June 2014)

- **Period: 2011.12 ~ 2021.12 (10.1 years)**



# RAON Concept

: Accelerator complex for producing rare isotope beams

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

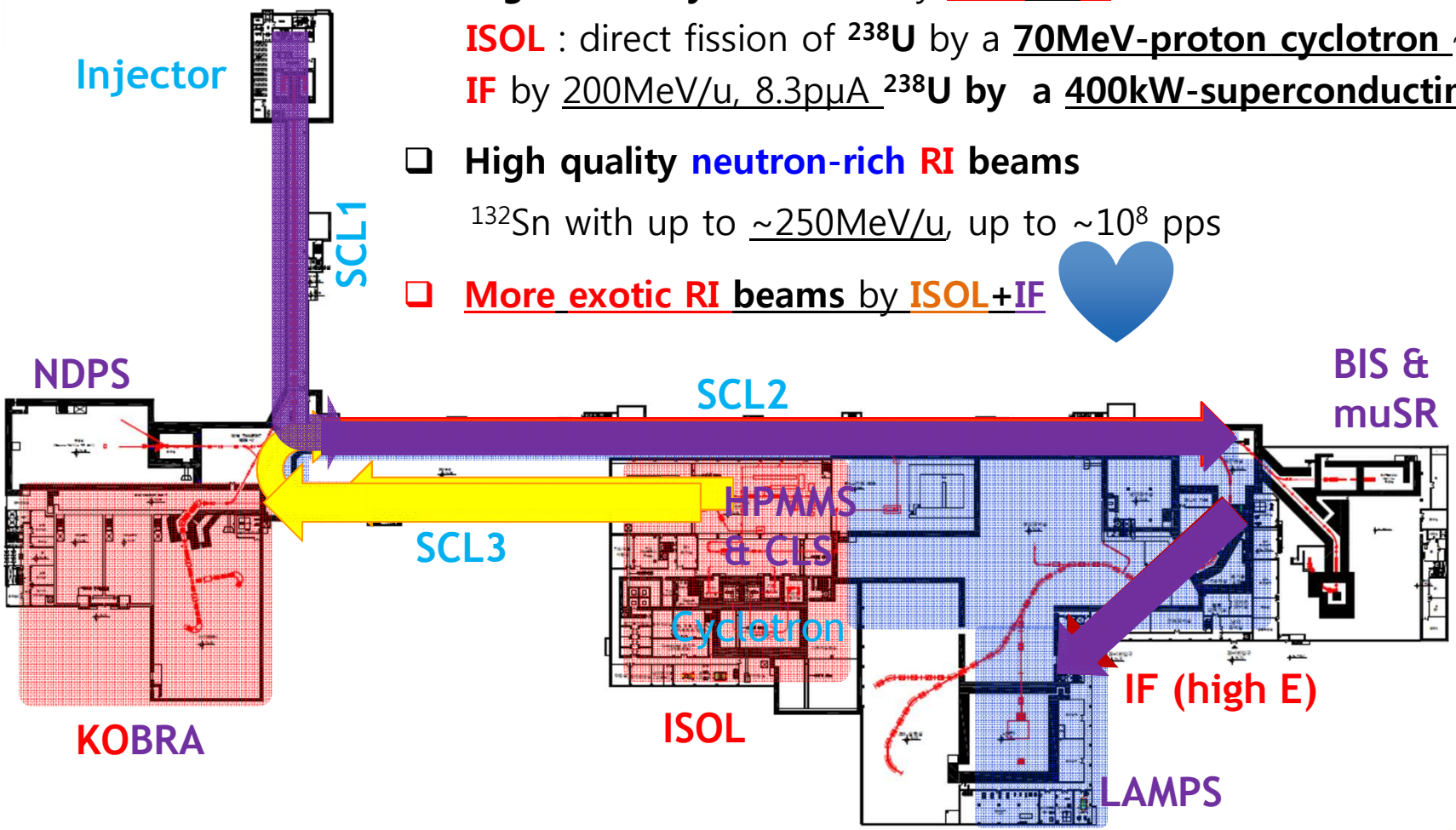
  **ISOL** : direct fission of **$^{238}$U** by a **70MeV-proton cyclotron** ~ $10^{14}$ f/s

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

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

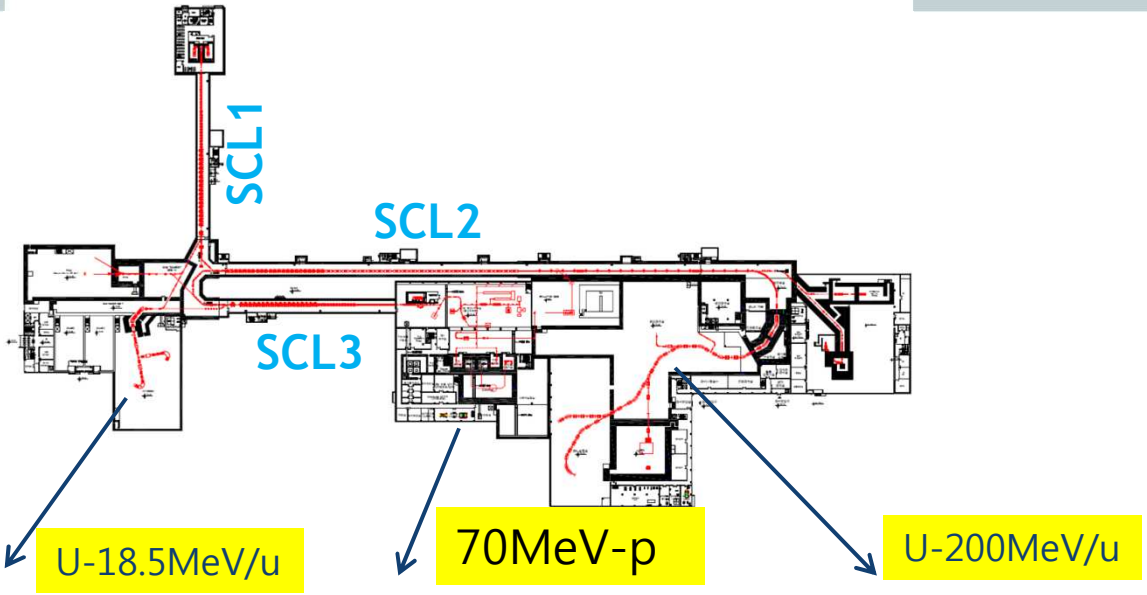
  $^{132}$Sn with up to ~250MeV/u, up to ~$10^{8}$ pps

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



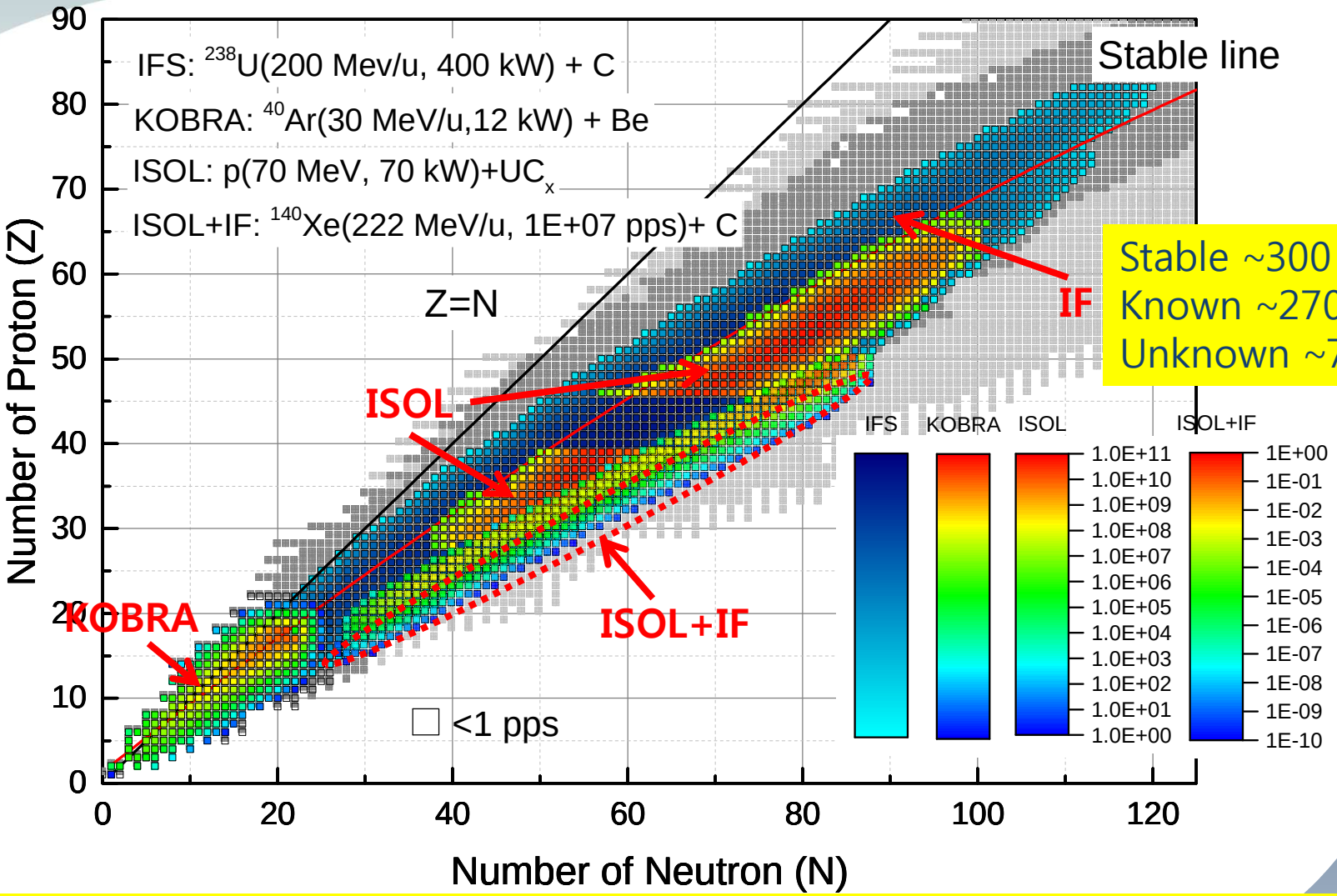
# Lineup of RIB production & separation

- 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 in nuclear landscape



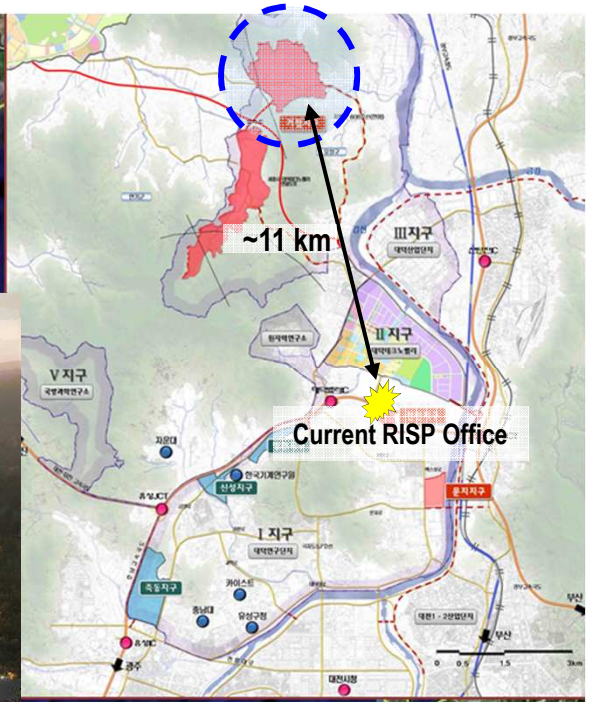

Stable ~300
Known ~2700
Unknown ~7000

- **RAON will provide access to unexplored regions of the nuclear chart !**
- **RAON will be a powerful RIBs' supplier to users globally**

→ **More exotic, More intense, and More various RIBs**

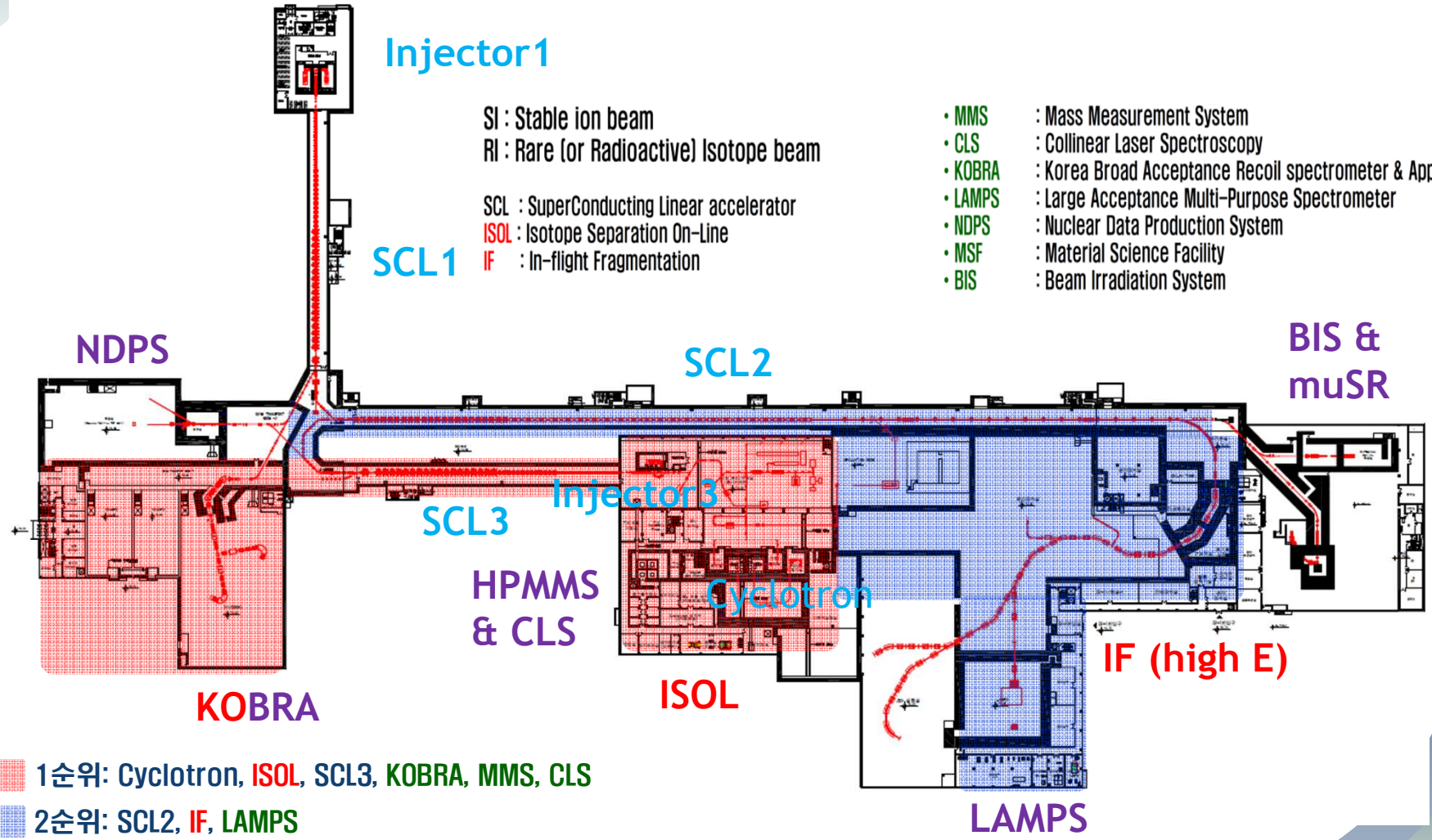
# RAON Site : Sindong in Daejeong

Final design under inspection
Fast-Track Construction underway from Feb. 2017
Main Construction is going to start in Aug. 2017.



# RAON Overview

# Layout of RAON



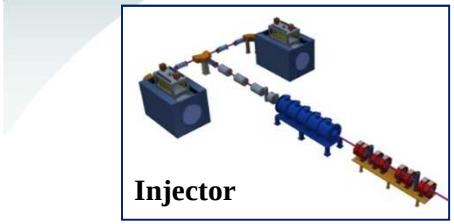

1순위: Cyclotron, ISOL, SCL3, KOBRA, MMS, CLS

2순위: SCL2, IF, LAMPS

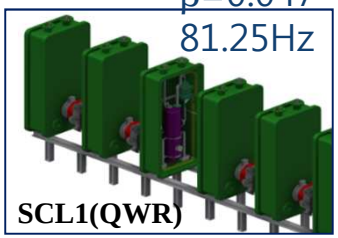
3순위: SCL1, NDPS, MSF, BIS

# Accelerator systems (Layout & Specs.)

RAON

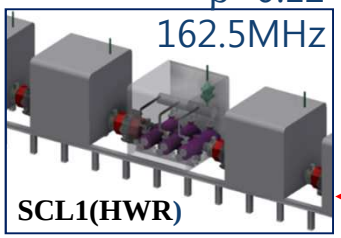



28-GHz ECRIS
(A/q<7 10keV/u)
81.25MHz 4-vane RFQ
(500keV/u)



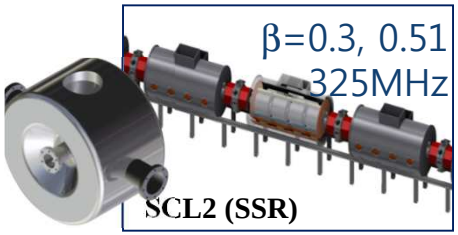

β=0.047
81.25Hz

1/22
(2.7MeV/u)



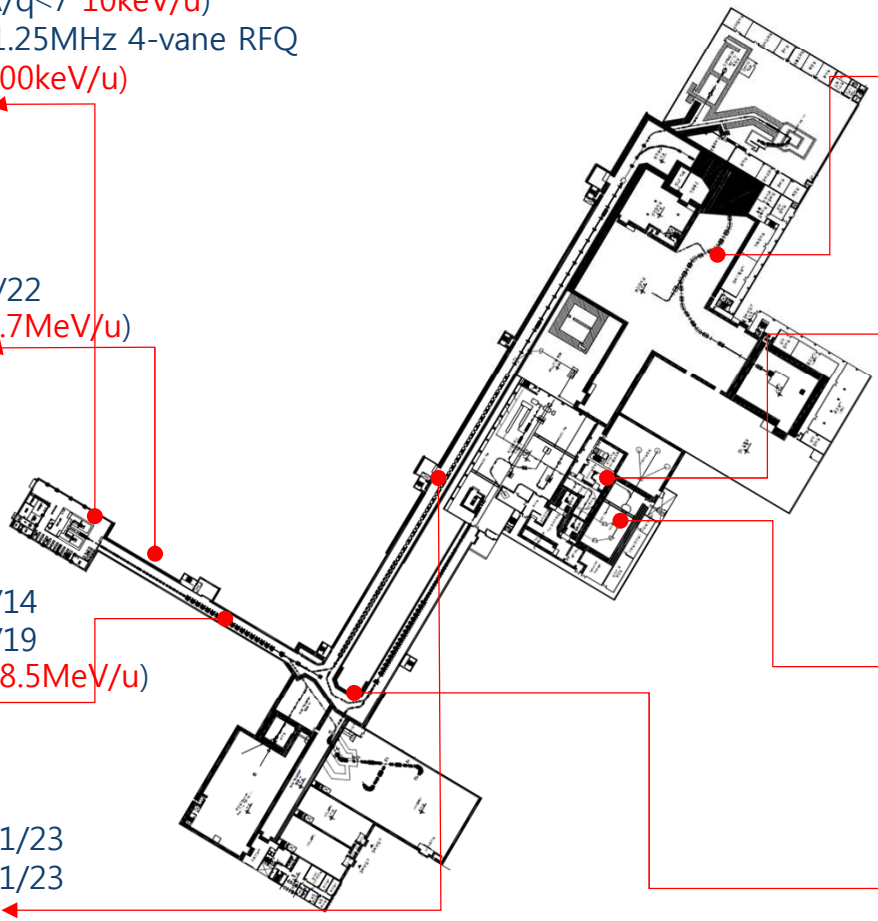

β=0.12
162.5MHz

2/14
4/19
(18.5MeV/u)

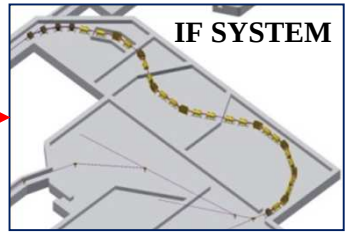



β=0.3, 0.51
325MHz

3/1/23
6/1/23
(200MeV/u)

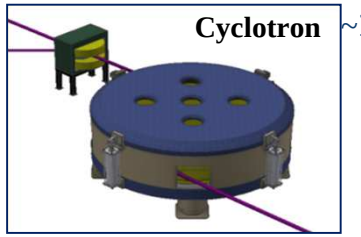


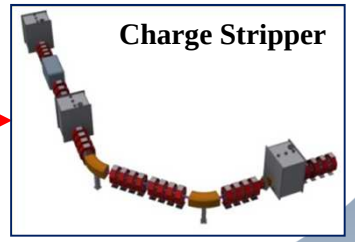
10Tm
F8



RILIS/SI
EBIS
MR-TOF

70-MeV $H^-$ cyclotron
~$10^{14}$ fis/s




Liq. Li
20μm
A/q
~7➔~3

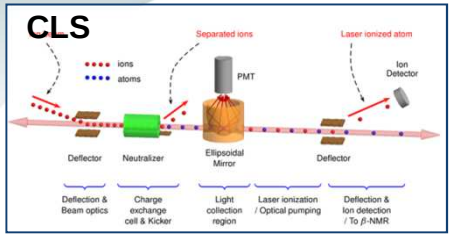
Warm sections for focusing components betw. CMs

# Experimental Systems

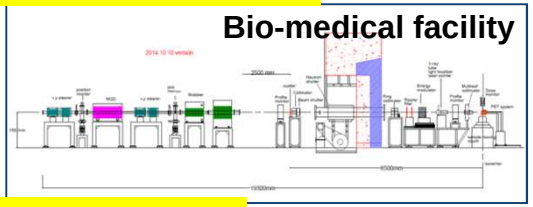
RAON

HI >200MeV/u

CLS




Bio-medical facility



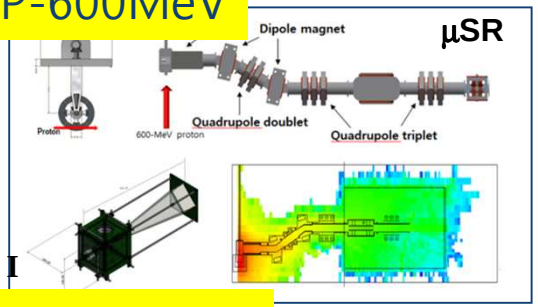
High Energy Exp. II

P-600MeV

HPMMS

~keV/u

μSR

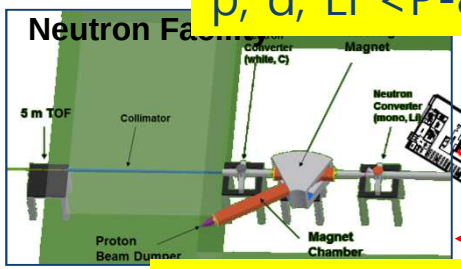



Very-low Energy Exp.

High Energy Exp. I

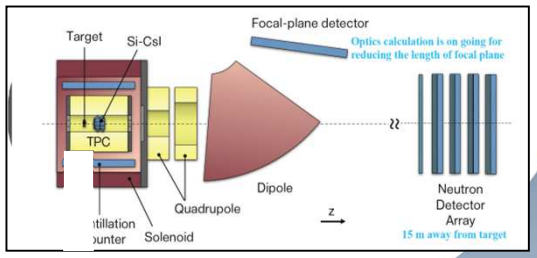
p, d, Li <P-88MeV/u

Neutron Facility



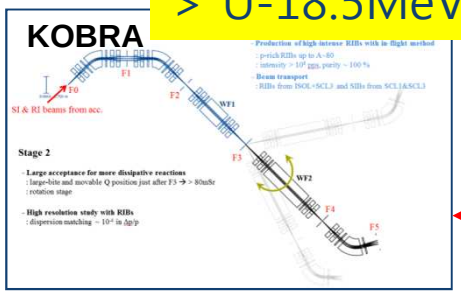

> U-200 MeV/u

LAMPS




> U-18.5MeV/u

KOBRA

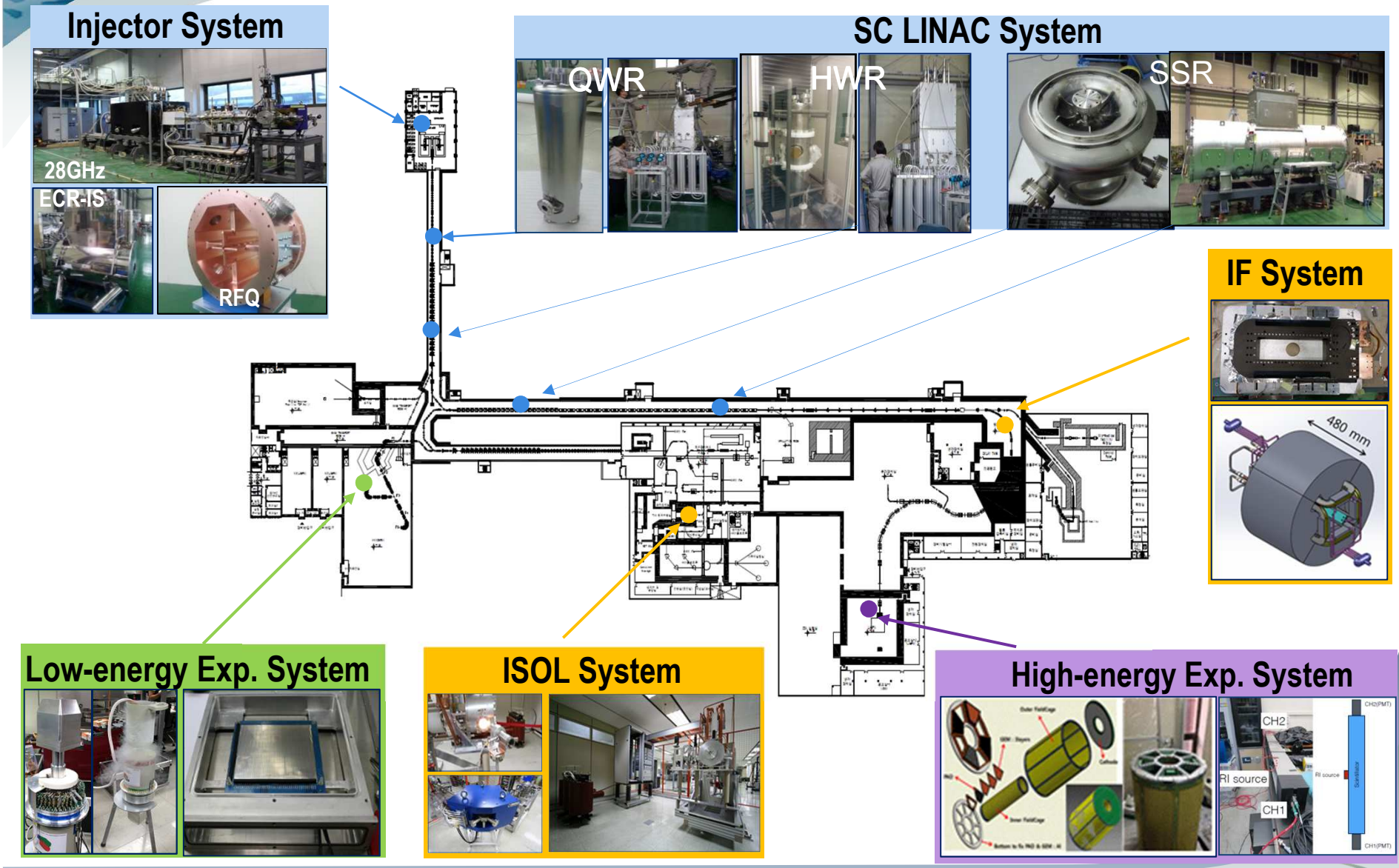



Low Energy Exp.

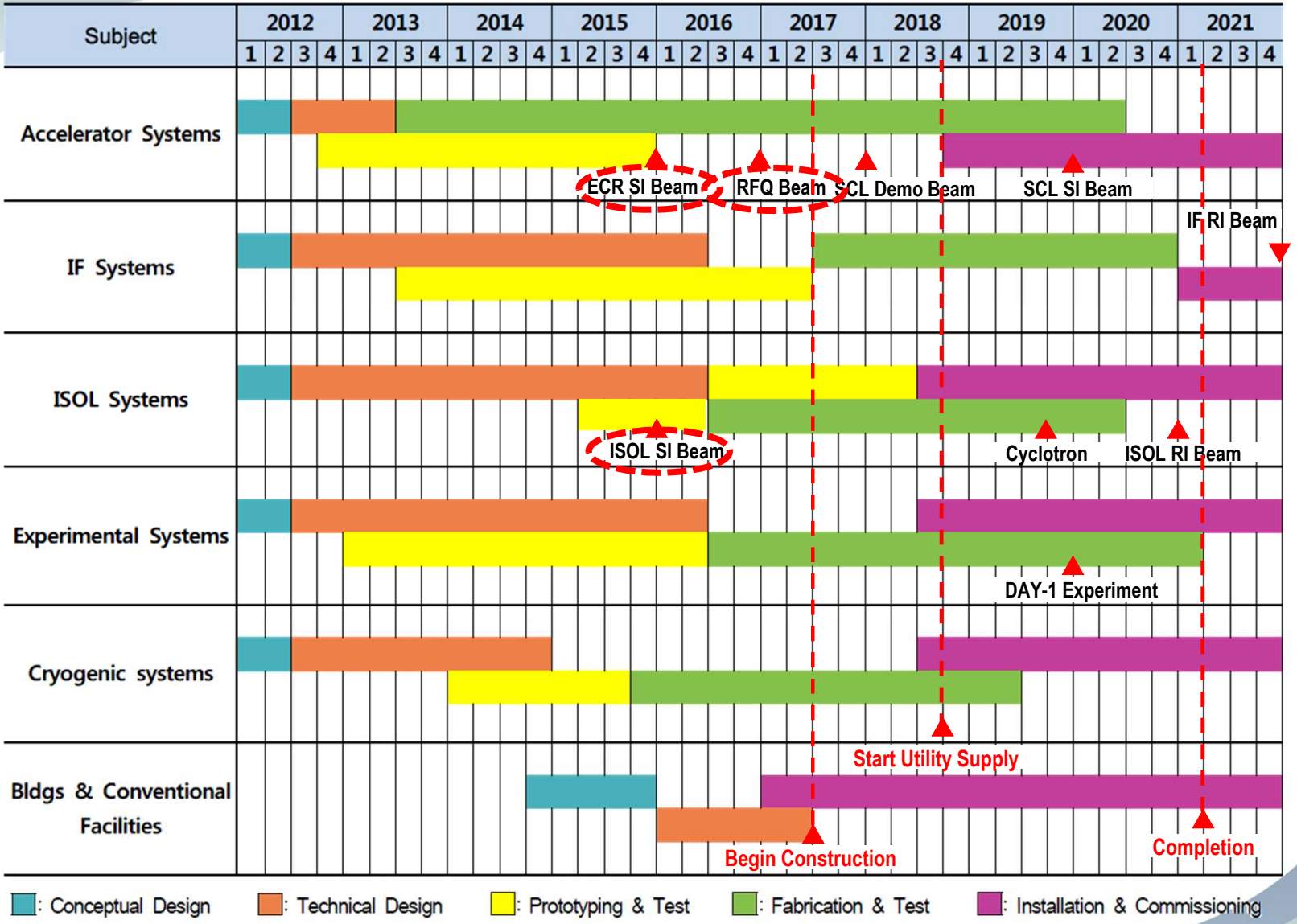
# Project Status

# Prototyping & test… under progress

RAON

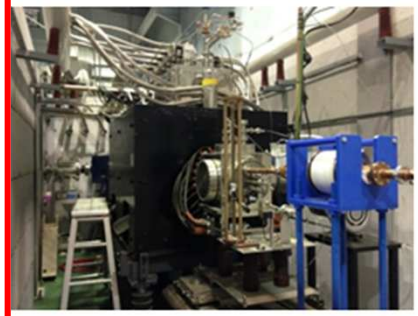


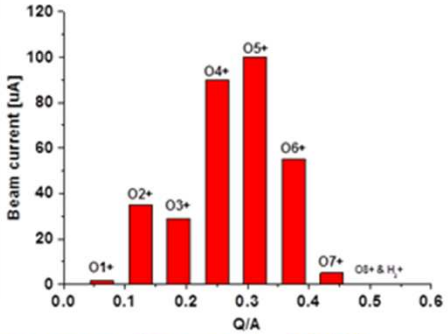
# RISP Milestone Schedule



# Ion beam extraction from ion sources in 2015

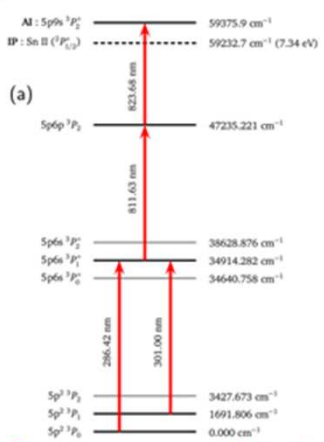
Stable Beam from 28-GHz ECRIS for SCL drivers



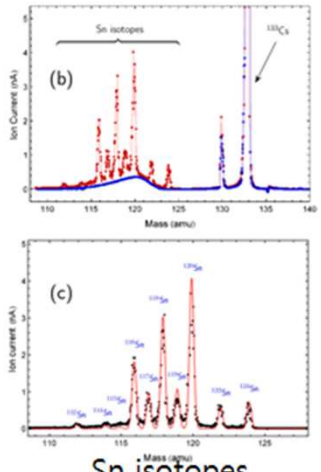



Beam current vs. charge state (Oxygen), 2015

ISOL Test bench



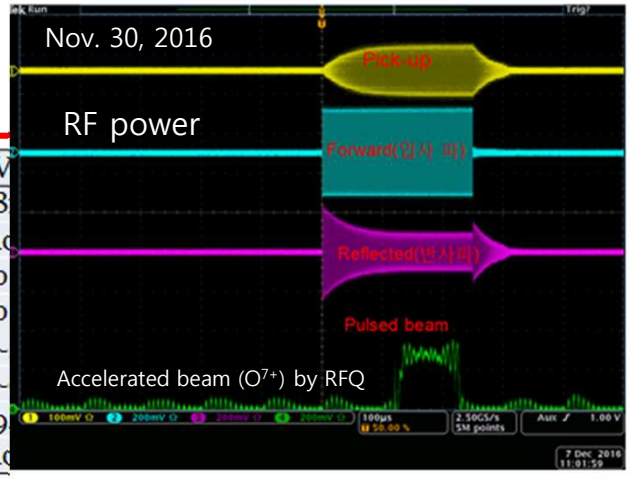

Sn atom energy level and Laser Ionization

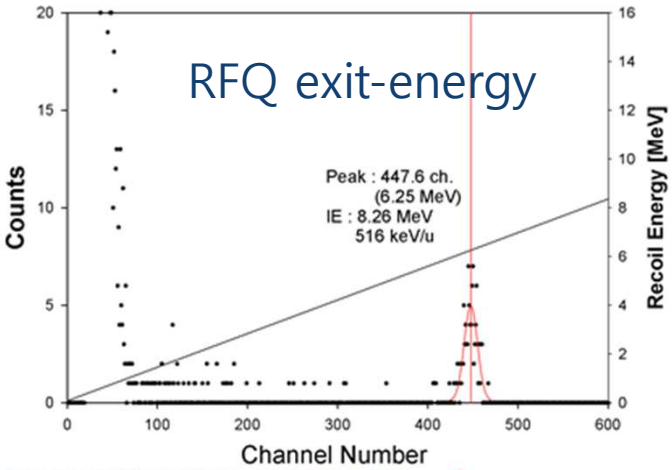



Sn isotopes

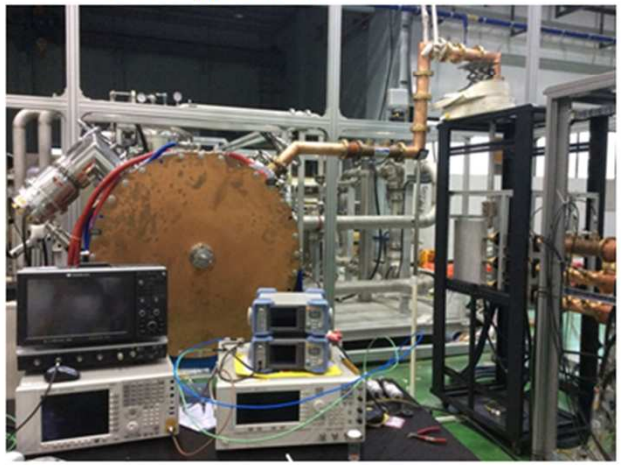
# Beam acceleration by RFQ in 2016

| Parameter | V |
|---|---|
| f | 8 |
| $E_{in}$ | 1 |
| $E_{out}$ | 0 |
| $\varepsilon_{out}$ | 0 |
| | ~ |
| Transmission | ~ |
| $P_{loss}$ | 9 |
| Duty factor | 1 |

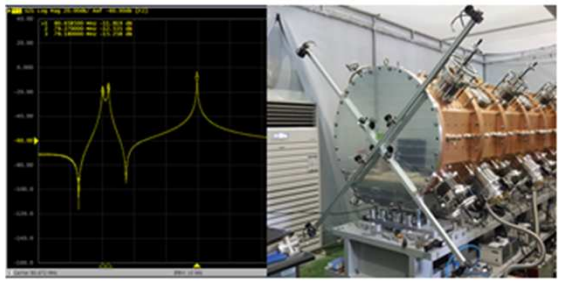



Prototype test: ~15 kW CW

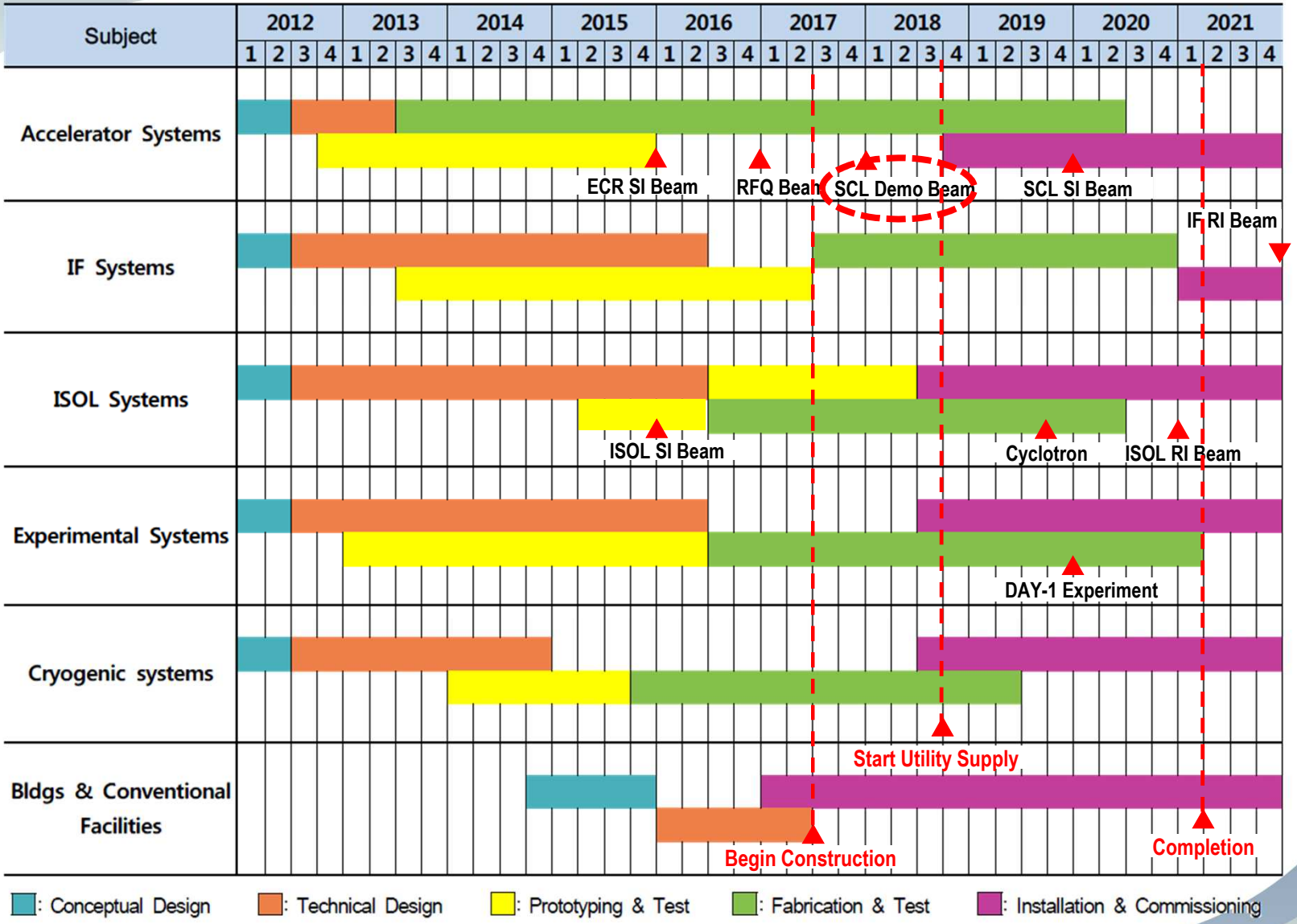


Nine segments of the RFQ aligned



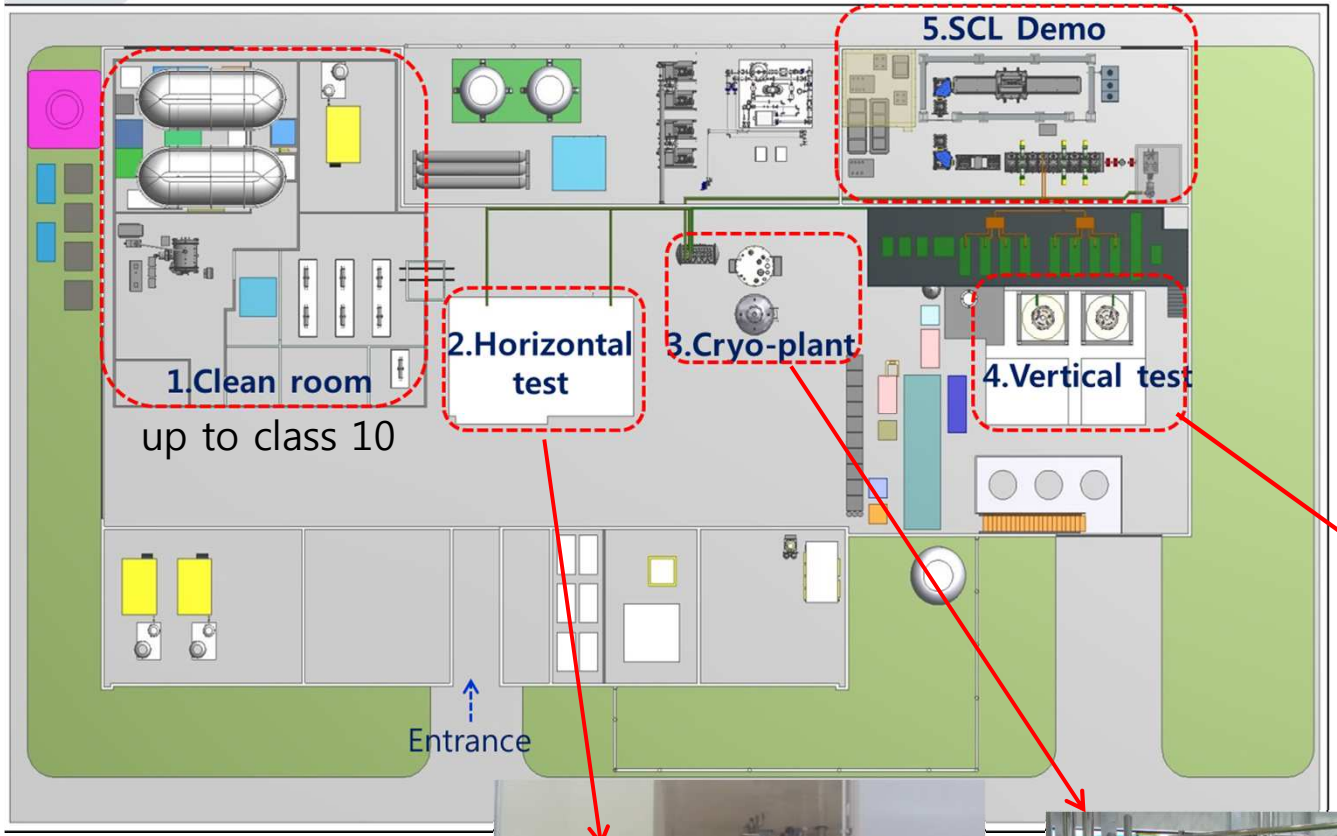
Field tuning underway with a bead-pull method (Aug. 2016)

# RISP Milestone Schedule



# SRF Test Infrastructure (off-site test facility)

Performance test of SC cavities and cryomodules
Quality control of SC cavities and CMs delivered by vendors in mass production




Start operating from June, 2016.

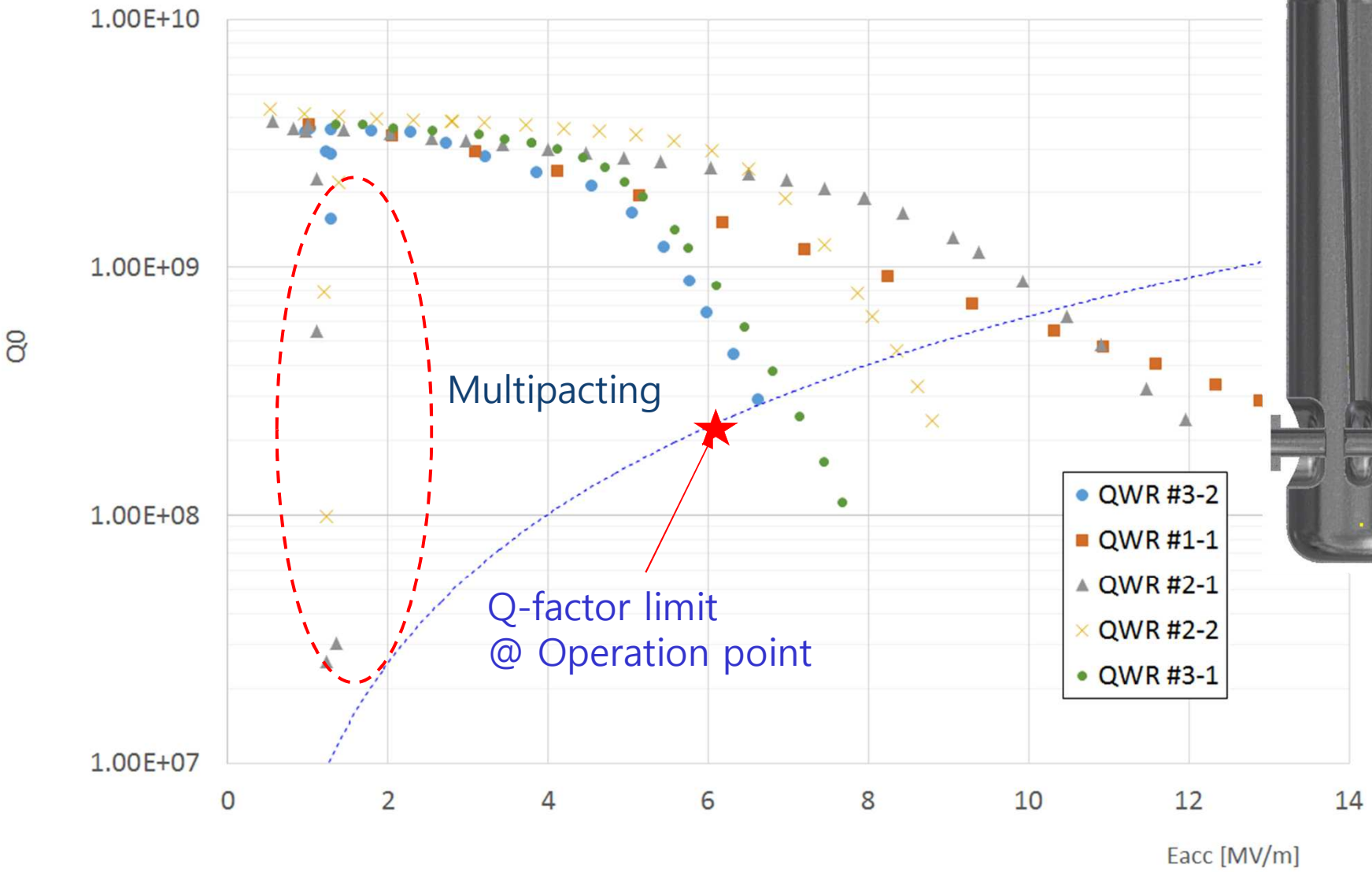
Cryomodule test

LHe system (330 W at 4.5 K)

Vertical cavity test

# Performance Test of Superconducting Cavities

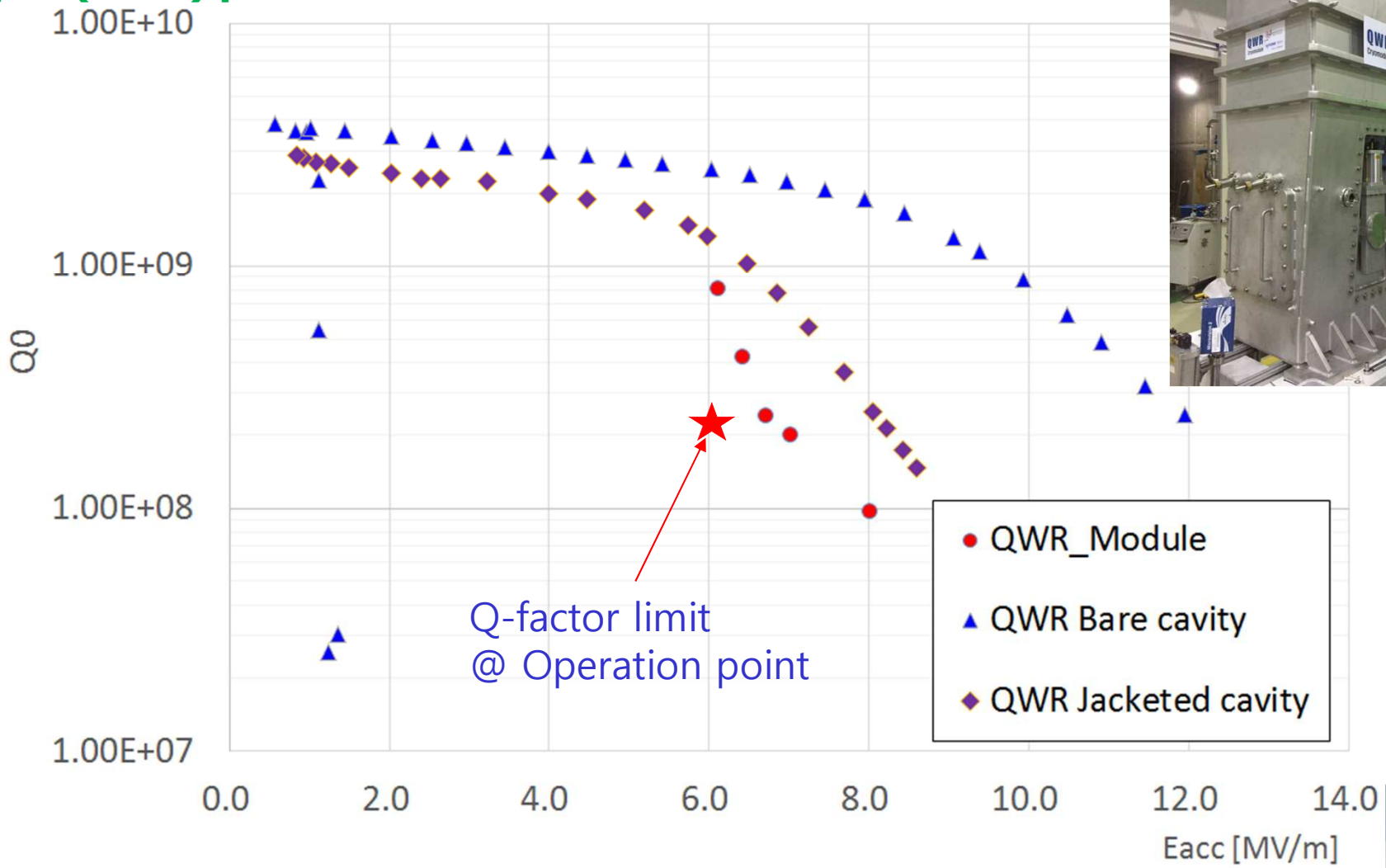
5 Quarter Wave Resonators(QWRs) are fabricated and tested



# Performance Test of Cryomodules

RAON

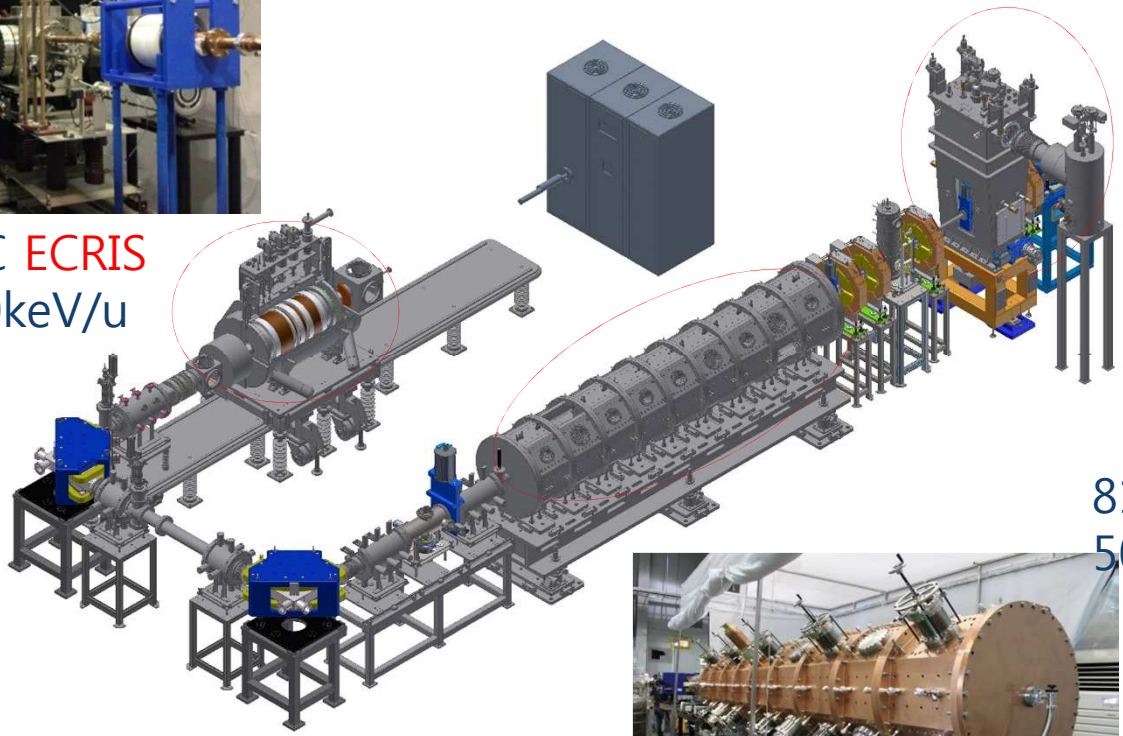
## QWR(#2-1) performance test



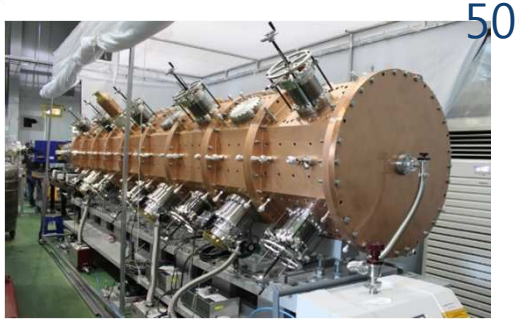
# Demonstration System

- For integral test of key accelerator systems
- Sub-systems is installed
  - ECR-IS, LEBT, RFQ, MEBT, QWR
  - Aux systems: Cryogenic system,RF system, Beam diagnostics, Beam dump, etc.

28GHz SC ECRIS
A/q~7, 10keV/u



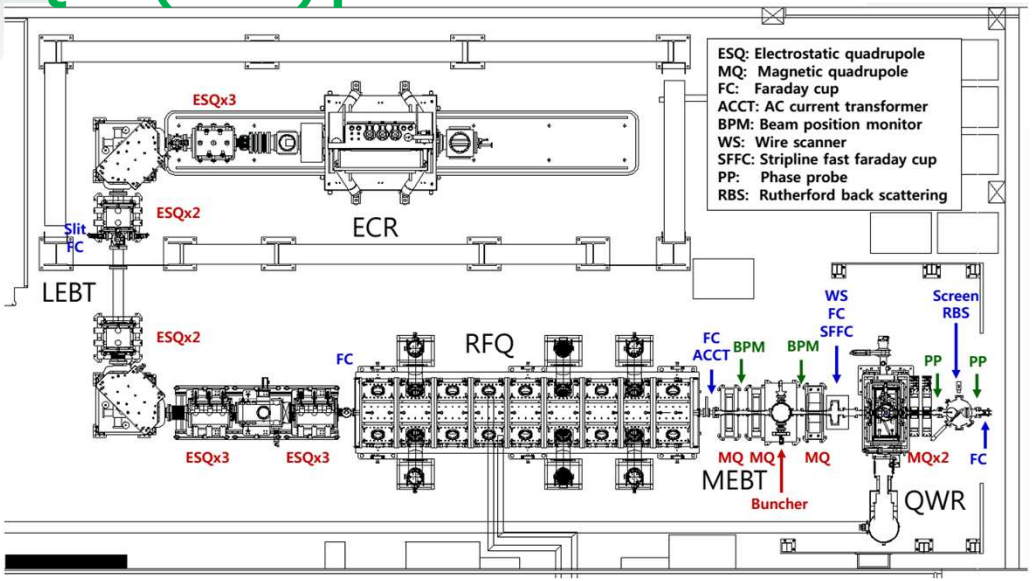
81.25MHz QWR
500keV/u➔ >530KeV/u

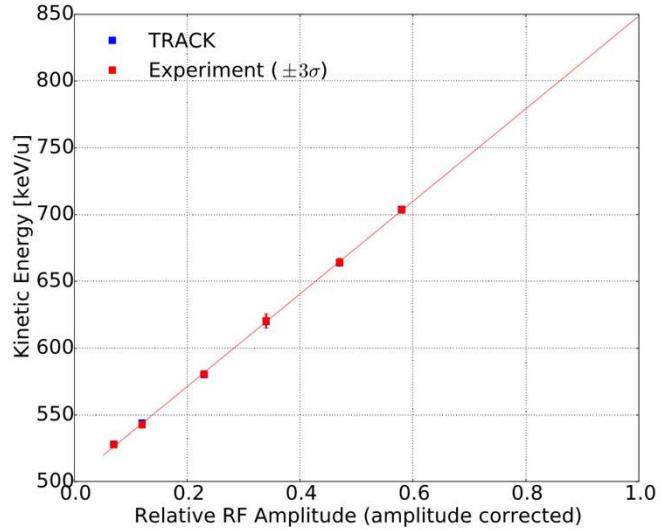


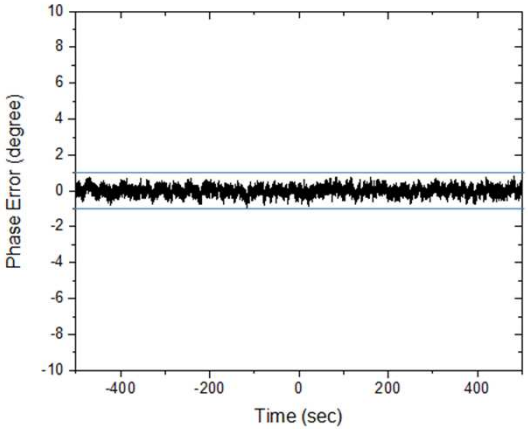
81.25MHz RFQ
10keV/u➔500keV/u

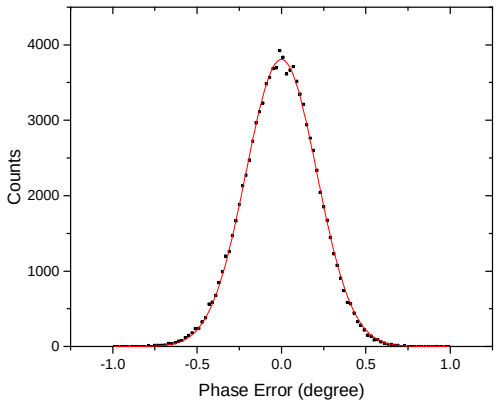
# Test Results of Demonstration System

## QWR(#2-1) performance test



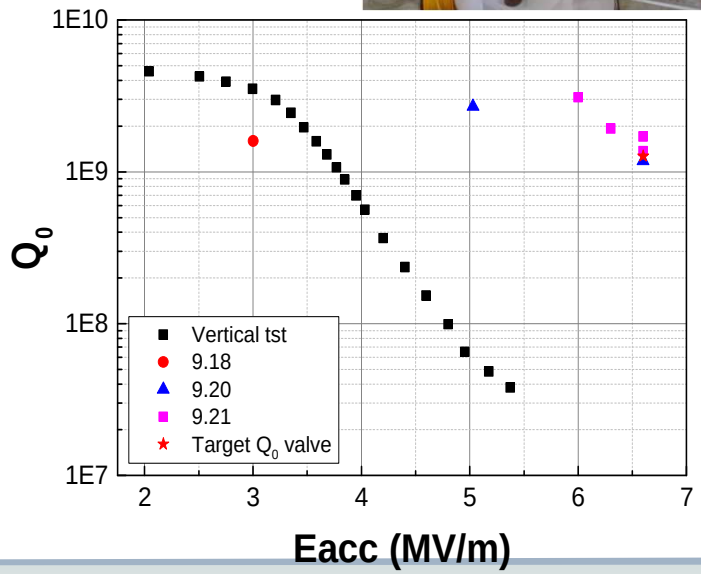



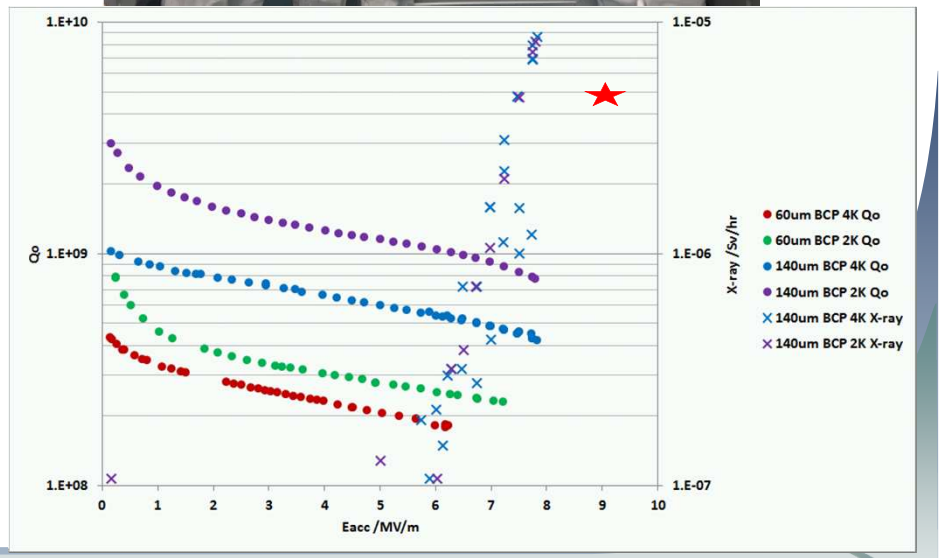

Beam: $O^{+7}$, 7uA
Accelerating:
507keV/u → 530keV/u ~700keV/u
RF control
- Phase: ±0.8(PtoP), ±0.2(RMS)

# SRF Cavities for Higher betas are developing…

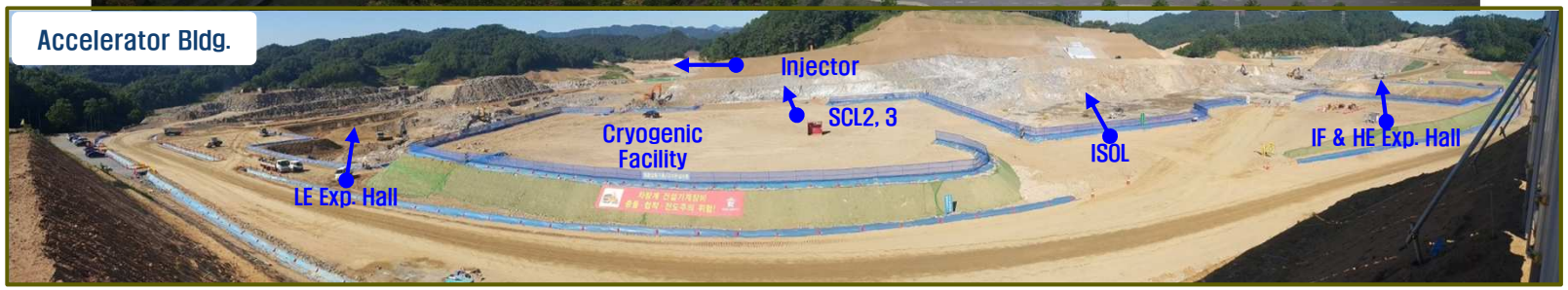
HWRs are Tested in Cryomodules

SSRs are fabricated and Tested in TRIUMF



# Fast track: Ground breaking for Accelerator Bldg.



# As closing

**Development of accelerator and experimental systems of the RISP is on track with civil constructions**

- Prototyping of major accelerator parts has been in progress since 2013 (after TDR)
- Some prototypes are in testing stage.
- SRF test facility is operating from June 2016.
- QWR Cryomodule is tested with $O^{+7}$ beam(2017.10)
- Under progress for the procurement of cavities, cryomodules etc… of SCL3 in 2017 (for mass-production)

중이온가속기 시설건설사업 건립공사