A 70 MeV cyclotron facility of IBS for ISOL and other uses

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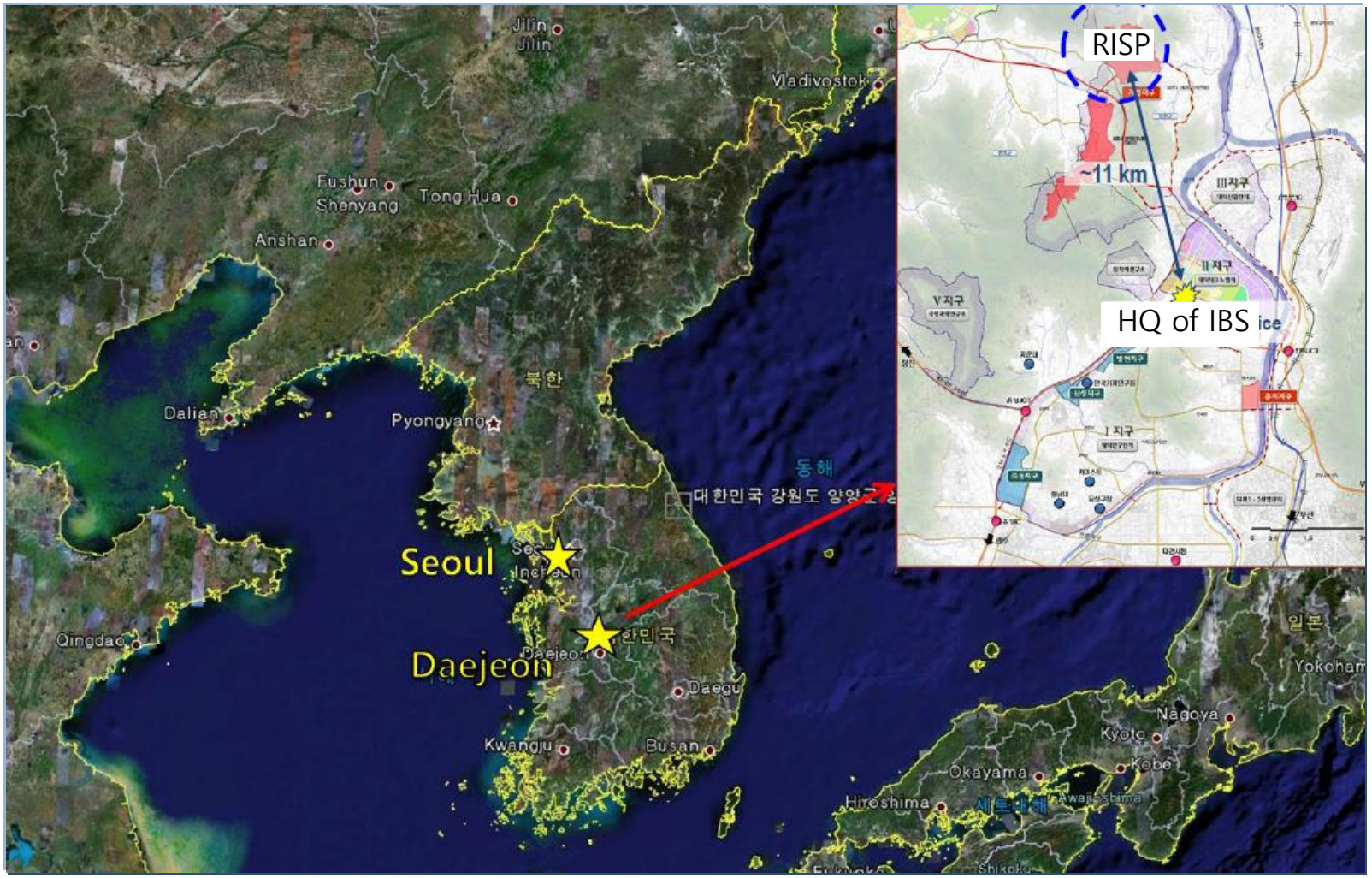
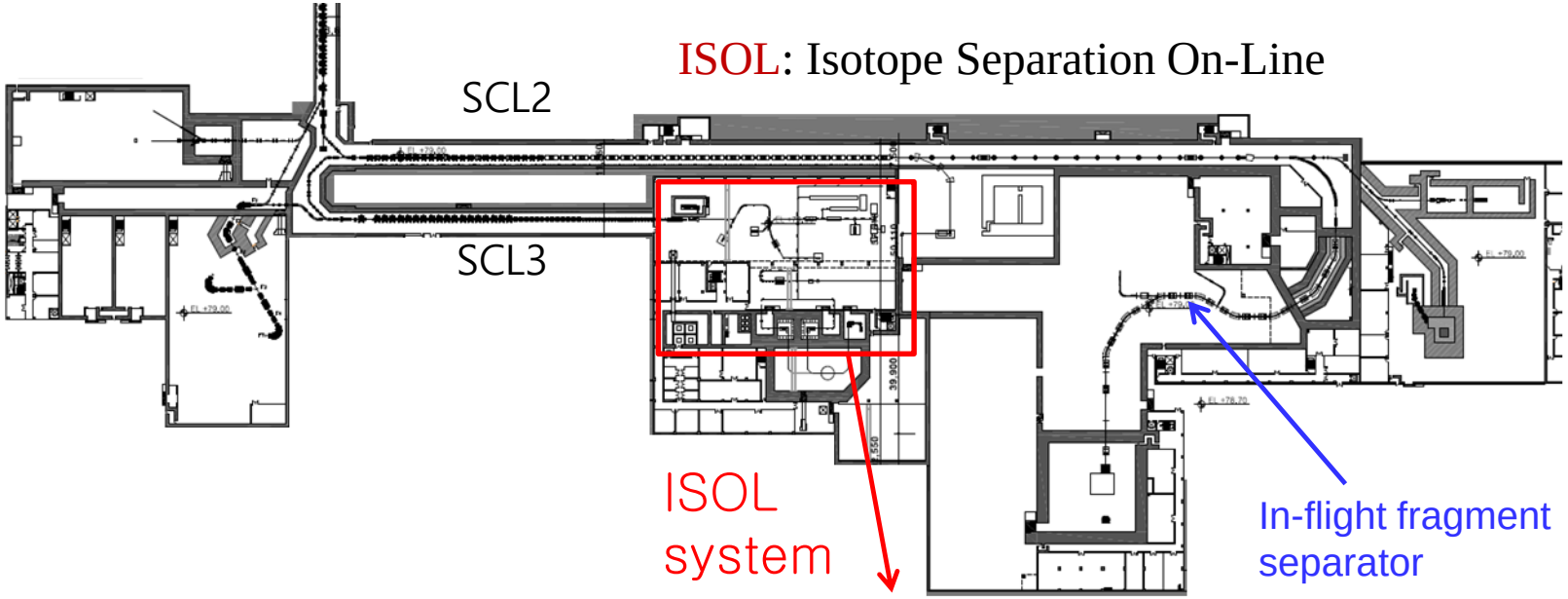
Location of RISP (Rare Isotope Science Project) of IBS



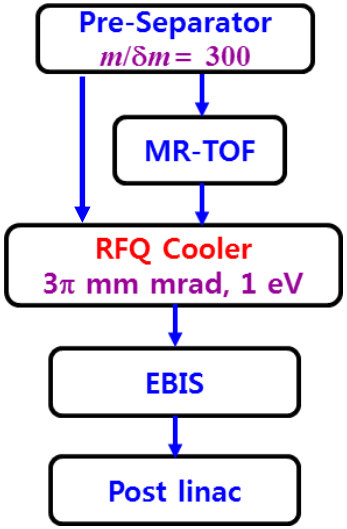
Layout of RISP

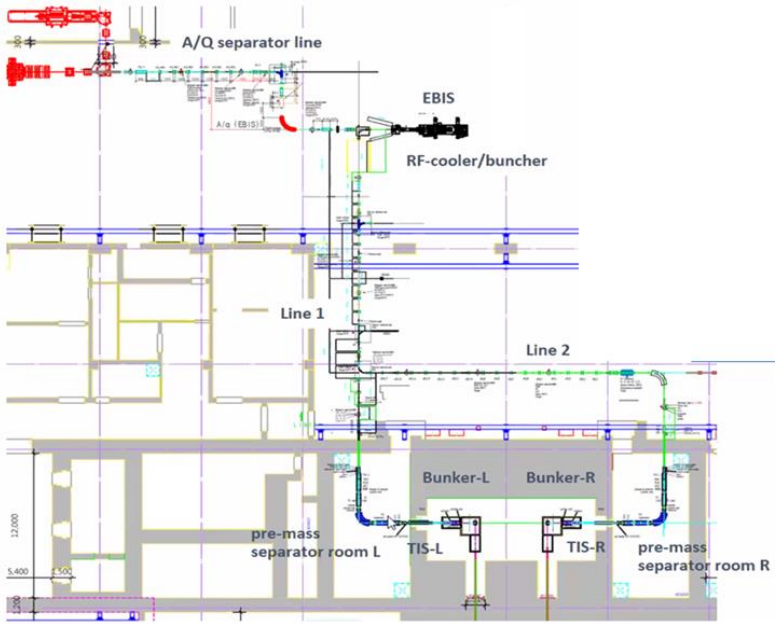
Period: 2011.12~ 2021.12 (1st phase)
Budget: ~1.3 billion USD (~0.9 billion for building and land)
Total area: ~0.95 km^2

RI beam production by ISOL method

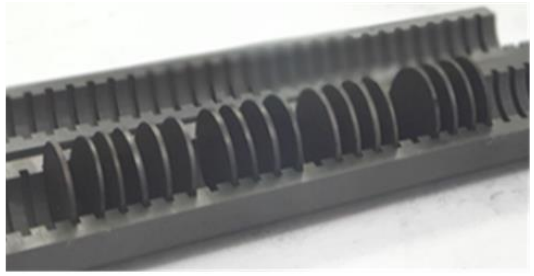


	TIS	EBIS
Ion	$^{132}Sn^{1+}$	$^{132}Sn^{33+}$
E	60 keV	5 keV/u



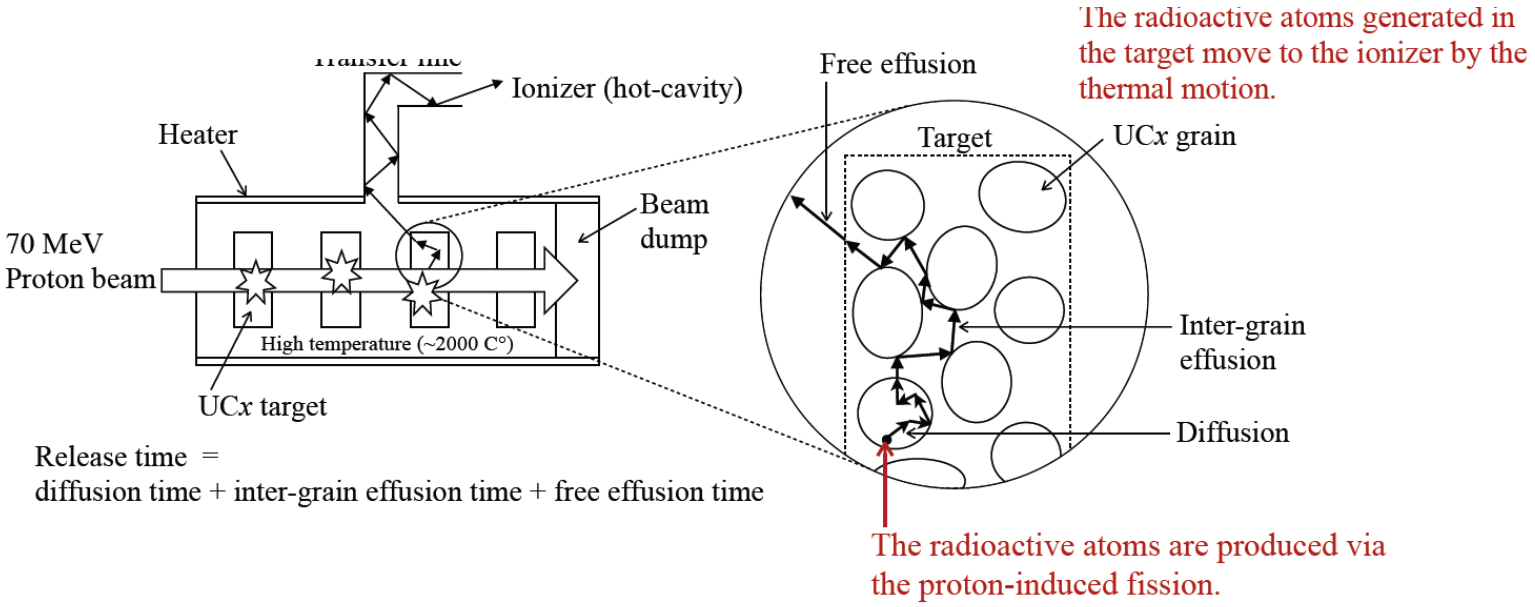


ISOL target development



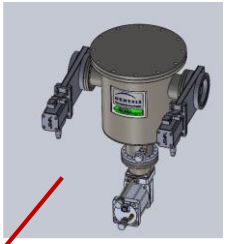
- **UCx** target development: <10 kW at 70 MeV (< ϕ5 cm)
- **SiCx** target for initial operation

A schematic of radio-isotope release in ISOL target

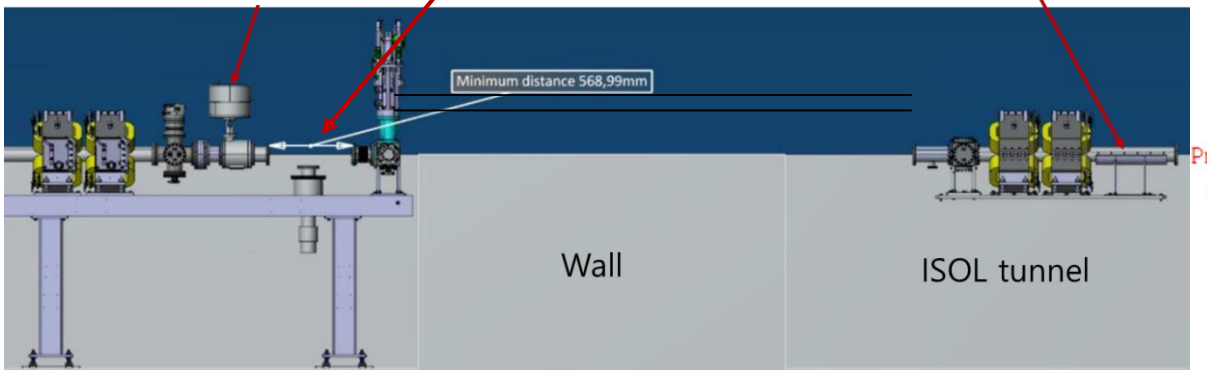


A fast closing valve system against ISOL target vacuum loss

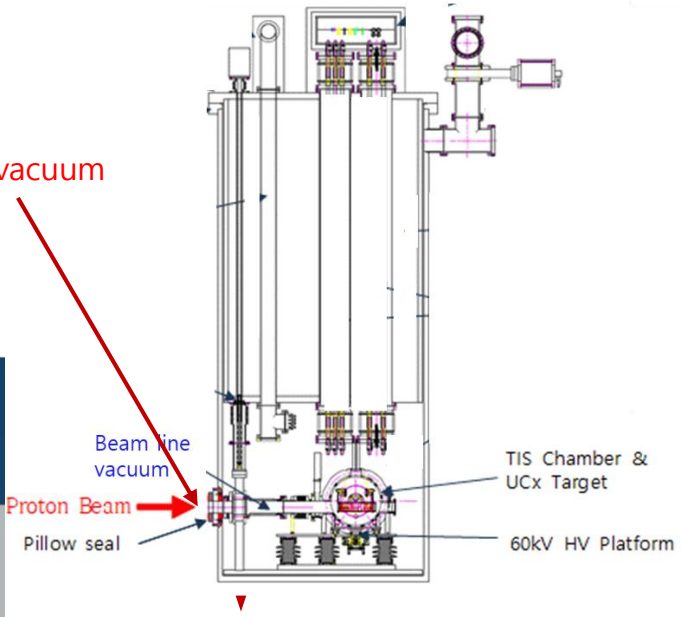
Cryogenic panel system to reduce molecular backflow



Fast closing valve(< 15 ms)

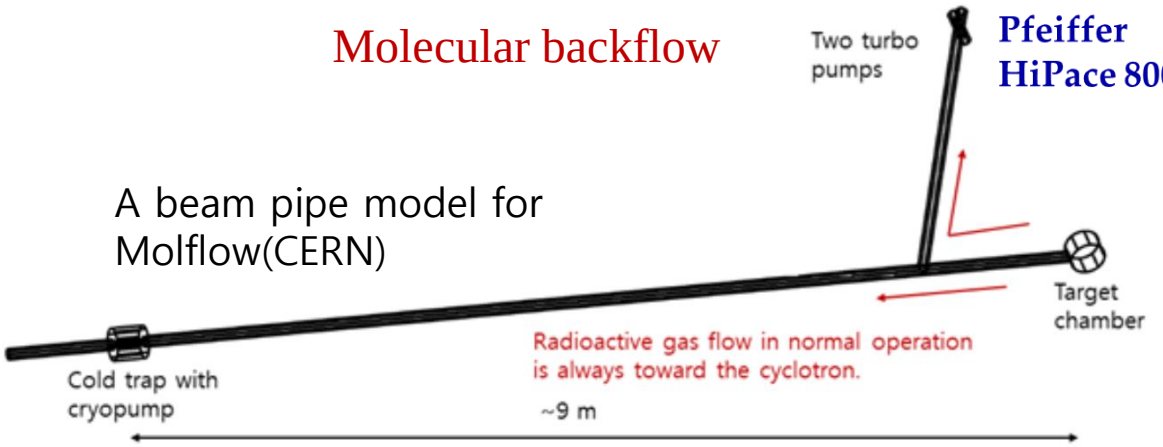


No foil to separate vacuum

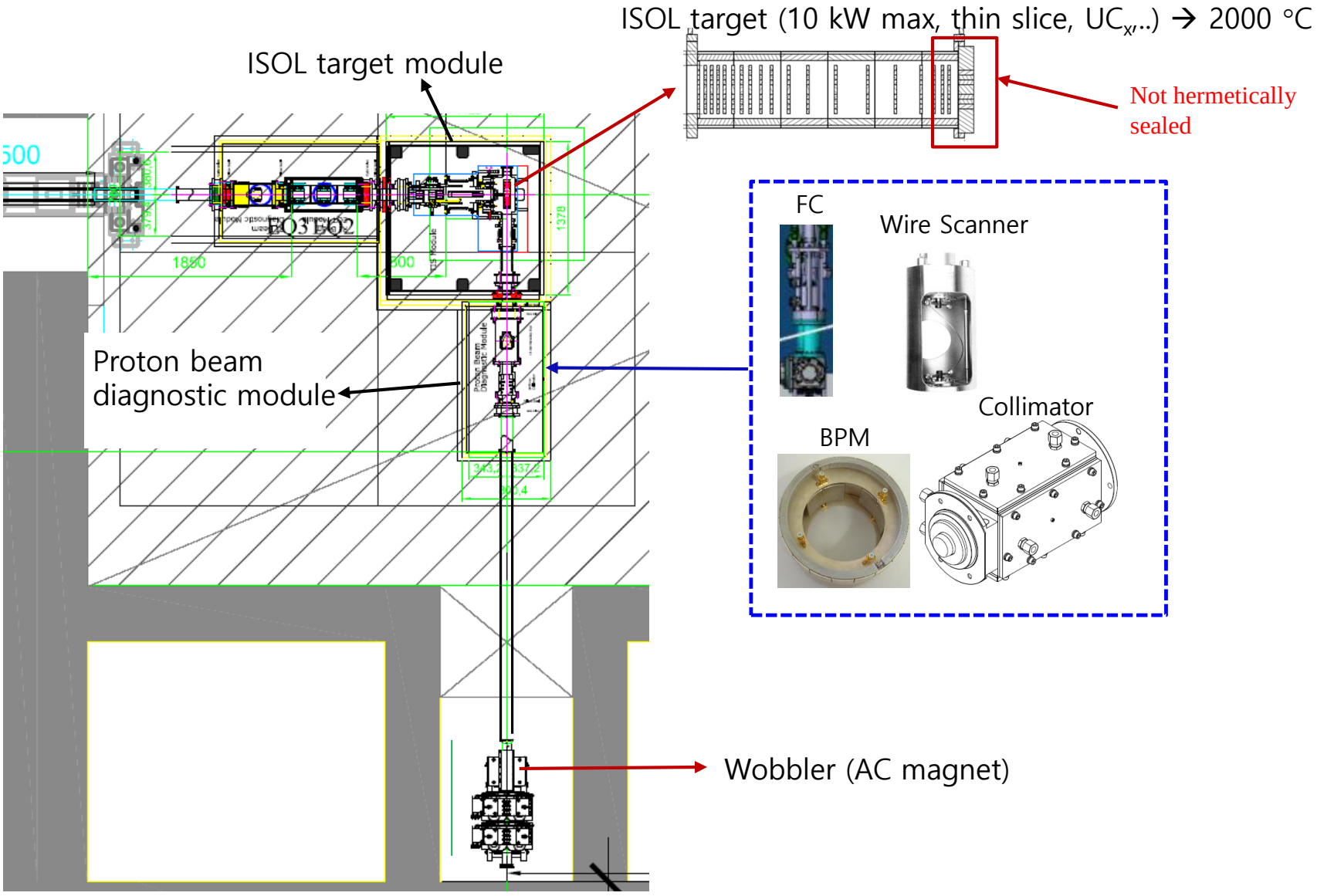


Molecular backflow

A beam pipe model for Molflow(CERN)



Connection of the beam line to the ISOL target system



Schedule of 70 MeV cyclotron installation

2019

Jan.: Termination of a contract with Best Cyclotron Inc. (2017)

June: Contact with IBA

Aug.: Start the contract with first payment

2020

Jan.: Finalizing the beam line design for ISOL

Oct.: Field Mapping and shimming completed

CYCLONE®70

Energy	30-70 MeV
Maximum proton intensity	750 μA
Simultaneous extracted beams	2
Number of sectors	4
Hill field	1.6 Tesla
Harmonic mode	4
Frequency (fixed)	62MHz
Injected H-current	10 mA (H-)
Total weight	140 tons
Cyclotron dia.	3.8 m
Cyclotron Cryo-pumps	6

2021

July~Aug.: Factory Acceptance Test and shipping

Oct.~Nov.: Cyclotron rigging and start installation

2022

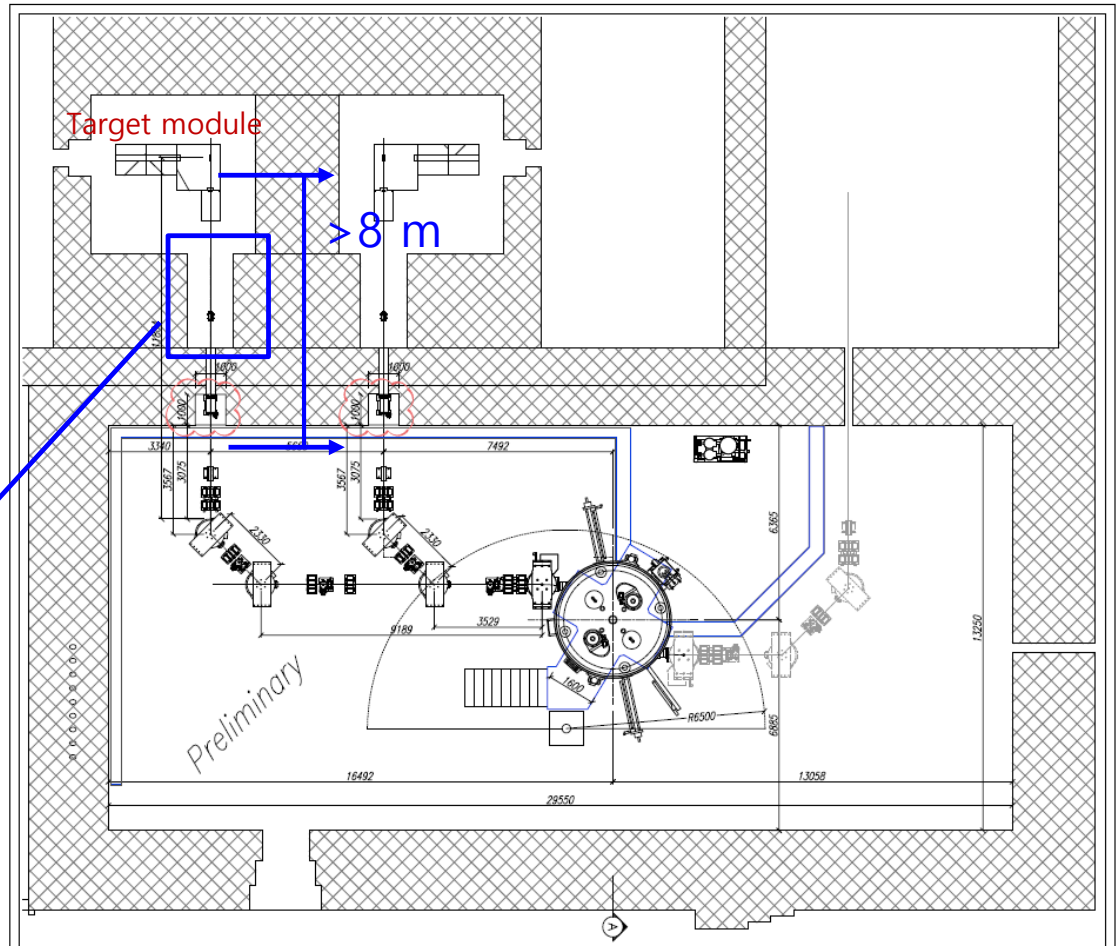
Aug.: End of the contract

Beam line design finalized in Jan. 2020

An issue:

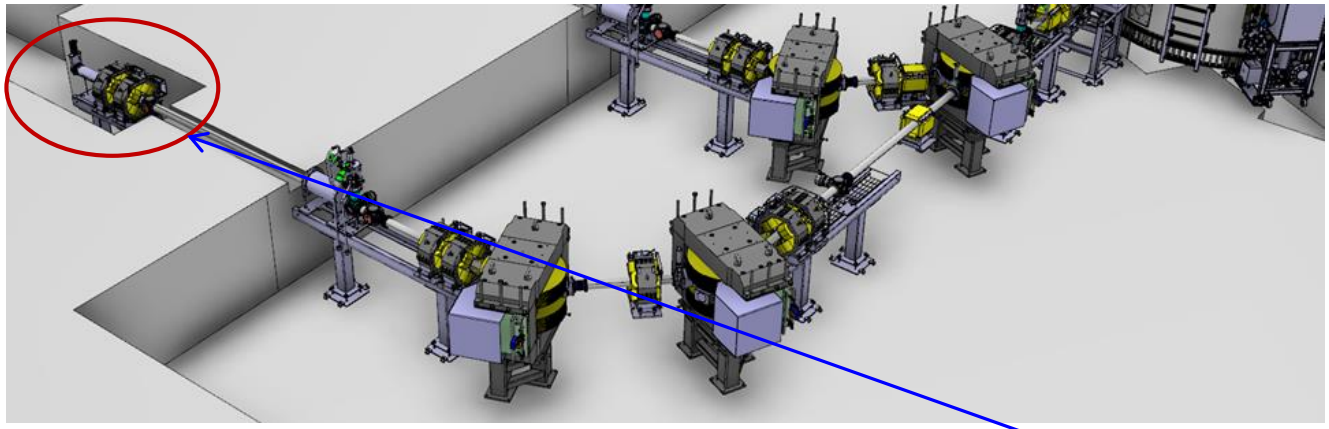
A long distance (>8m) from last quadrupole doublet to the ISOL target if a doublet is in the cyclotron room while uniform beam distribution being kept for a size of ϕ2-5 cm.

ISOL tunnel



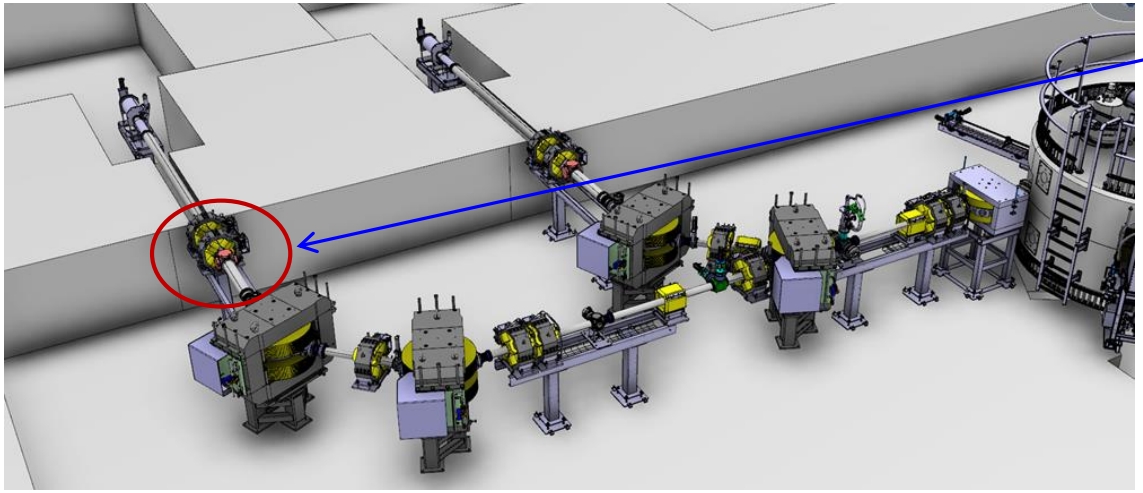
Two configurations considered in optimizing beam optics

Configure 1: Quadrupole doublet in ISOL tunnel (chosen)



Quadrupole doublet

Configure 2: No quadrupole magnets in ISOL tunnel



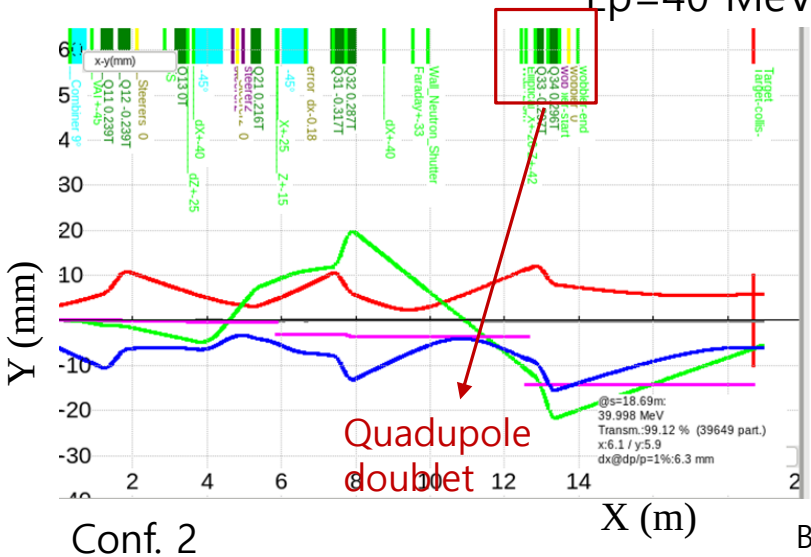
Beam optics summary with nominal emittance at 70 & 40 MeV

Nominal emittance of Cyclone70

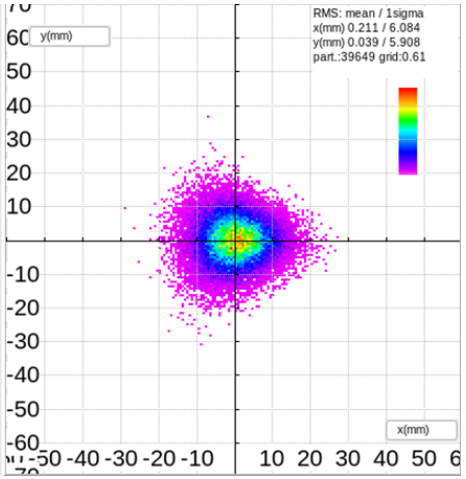
	70 MeV	40 MeV	Normalzied
εx (π·mm·mrad)	9.7	12.9	3.8
εy (π·mm·mrad)	5.8	7.8	2.3

		"nominal" beam size			
	minimizing:	spot size	spot size	spot size	losses
	target diameter(mm)	20	30	30	30
	μA on target	100	100	700	700
	Energy(MeV)	70	70	70	70
Transmis.(%)	target col.	91.9	98.7	98.7	98.7
	last doublet col.	99.1	99.1	99.1	99.8
	45° entrance col. – Z15	99.97	99.97	99.97	99.97
	Quad Q12 col- Z35	99.97	99.97	99.97	99.97
μA on collis	Cyclo (μA)	108.1	101.3	709.1	709.1
	target col.	7.8	0.4	2.8	7.8
	last doublet col.	0.9	0.9	6.2	1.2
	45° entrance col. – Z15	0.0	0.0	0.0	0.0
	Quad Q12 col- Z35	0.0	0.0	0.2	0.2
Power(W)	target col.	545	28	199	546
	last doublet col.	66	62	432	84
	45° entrance col. – Z15	0	0	0	0
	Quad Q12 col- Z35	2	2	15	15
X/Y On target:					

Ep=40 MeV



Conf. 2

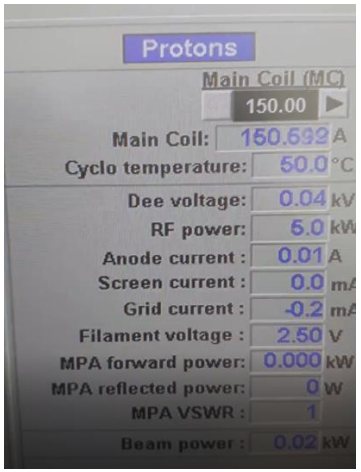


Beam profiles at target entrance

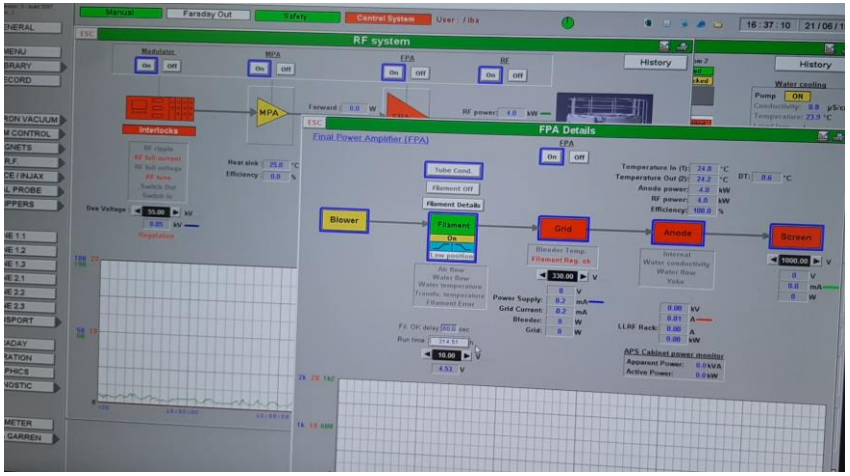
Factory Acceptance Tests remotely in June, 2021

C70 cyclotron at IBA

Magnet current ramping



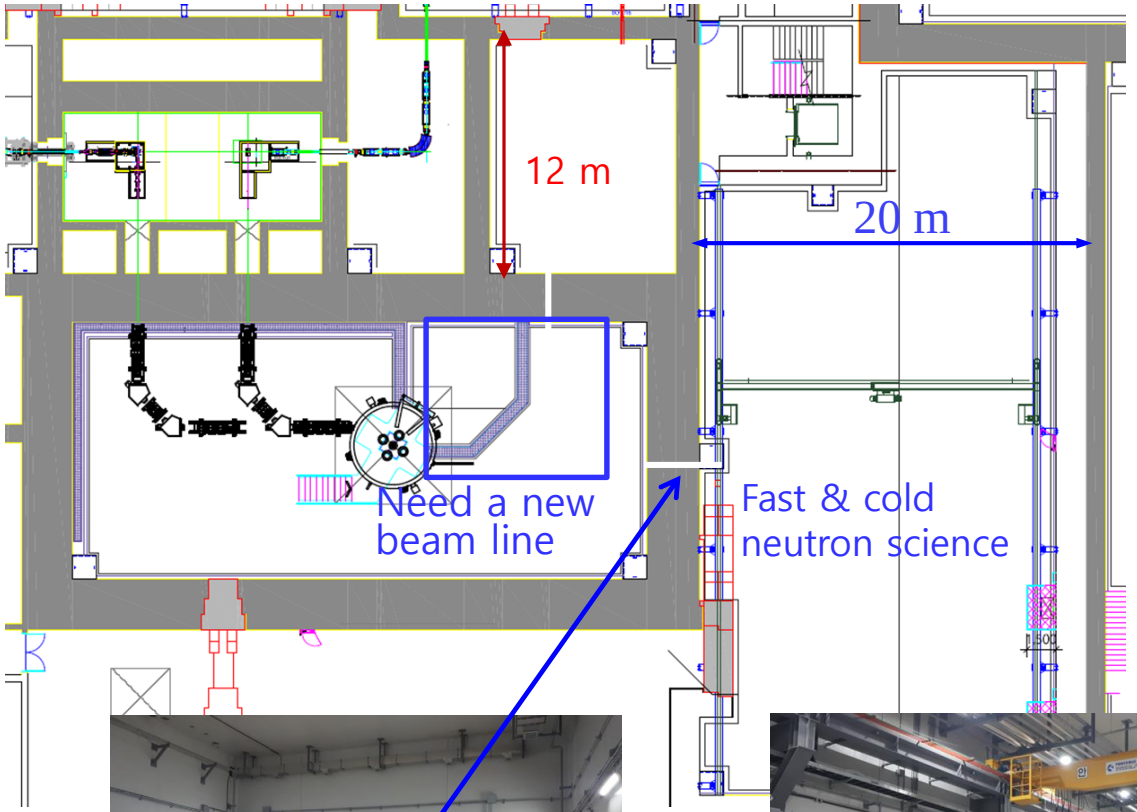
RF power test

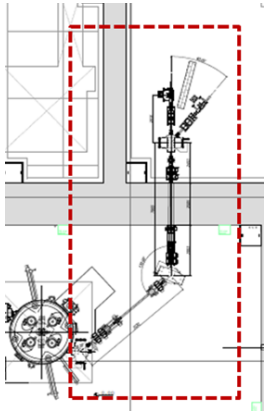


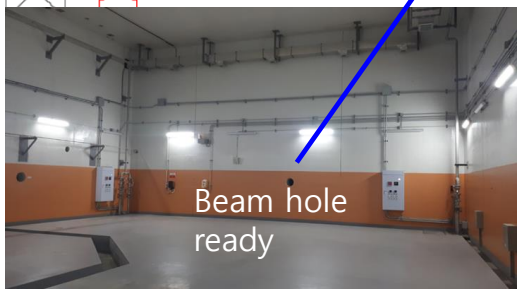
Layout for other users

70 MeV protons: ^{67}Cu (therapy+diagnostic applications)
^{82}Sr/^{82}Rb (heart function) and ^{68}Ga/^{68}Ge generator

Medical isotope production?

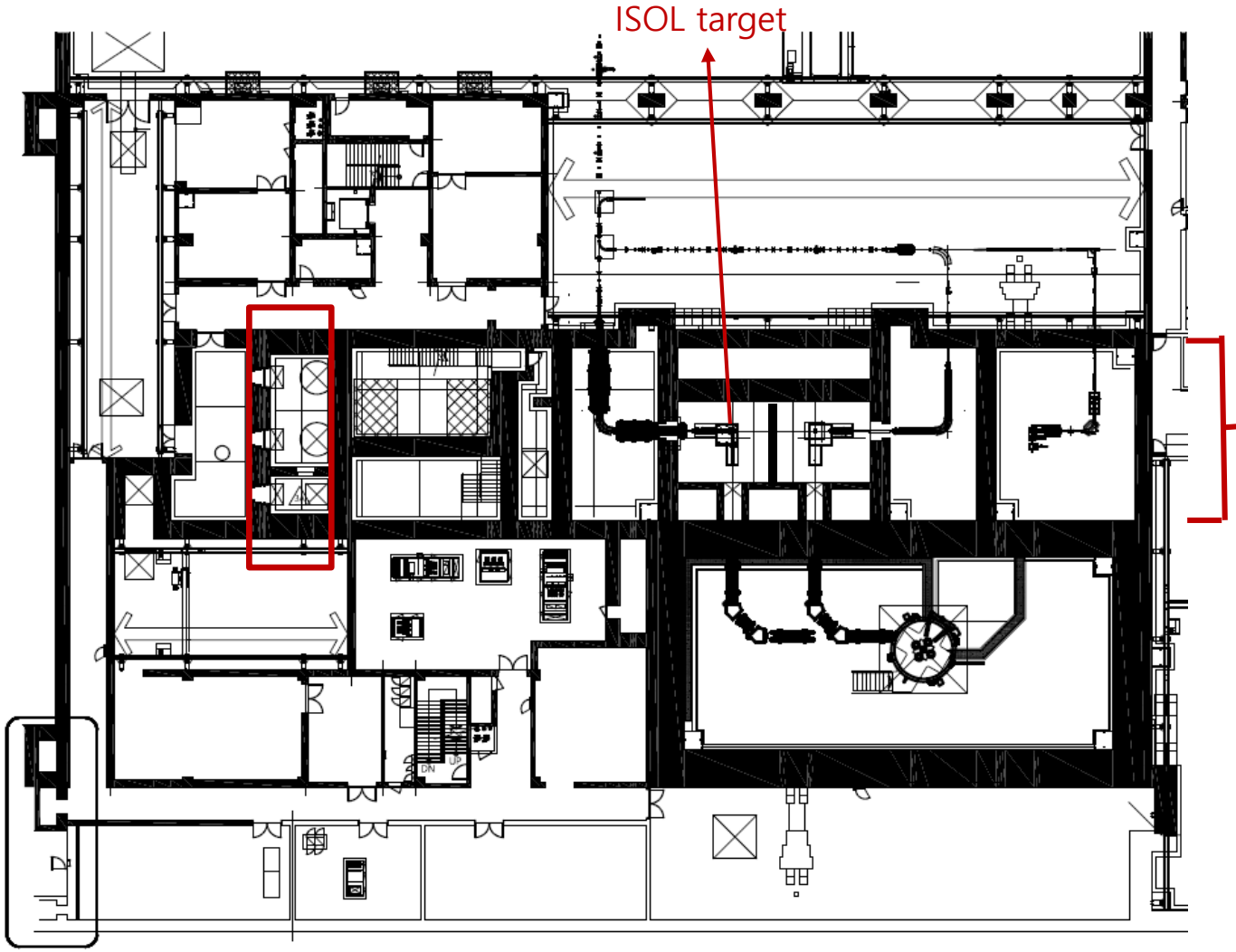






Availability of beam time for other uses

- ISOL target's lifetime is ~2 weeks and it will take 1-2 weeks for replacement.
- Simultaneous two beam extraction is possible at the same energy.



Concluding remarks

- A 70 MeV proton cyclotron is to be installed from Oct. 2021 and site acceptance tests will be started from early next year.

- Considerable beam time can be available for other users besides ISOL when 2nd extraction beam line is installed.

- There are strong demands of 70 MeV proton beams in the nuclear medicine and neutron science communities of Korea.