iRiS 중이온가속기연구소
Institute for Rare Isotope Science

Status and Overview of RAON

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Institute for Rare Isotope Science(IRIS)

70TH ANNIVERSARY EMIS XX 2025

20th International Conference on Electromagnetic Isotope Separators and Related Topics (EMISXX)

Oct 19 – 24, 2025
Chateau Fairmont Whistler

PART 1

The Making of RAON

PART 2

Commissioning
in 2023

PART 3

Operation
in 2024

PART 4

Operation
in 2025

PART 5

R&D Status for
SCL2

PART 6

Summary

"Rare Isotope Science Project" (RISP) from 2011 to June 2022

Goal	To build a rare isotope accelerator complex RAON for rare isotope science research
Period	1st Phase: Dec. 2011 ~ Dec. 2022 R&D for the 2nd Phase: Dec. 2022 ~ Dec. 2027

RAON

Accelerator complex ISOL + In-Flight Fragmentation

Origin of Matter

- Nuclear Astrophysics
- Nuclear Matter
- Super Heavy Element Search
- High-precision Mass Measurement

Properties of Exotic Nuclei

- Nuclear Structure
- Electric Dipole Moment and Symmetry
- Hyperfine Structure Study

Applied Science

- Bio-Medical Sciences
- Material Sciences
- Neutron Science

라온 -> **RAON** -> **R**are isotope **A**ccelerator complex for **ON**-line experiments

From Project to Operation : From RISP to IRIS

2011~ 2025

2011 — **2019** — **2022** — **2025**

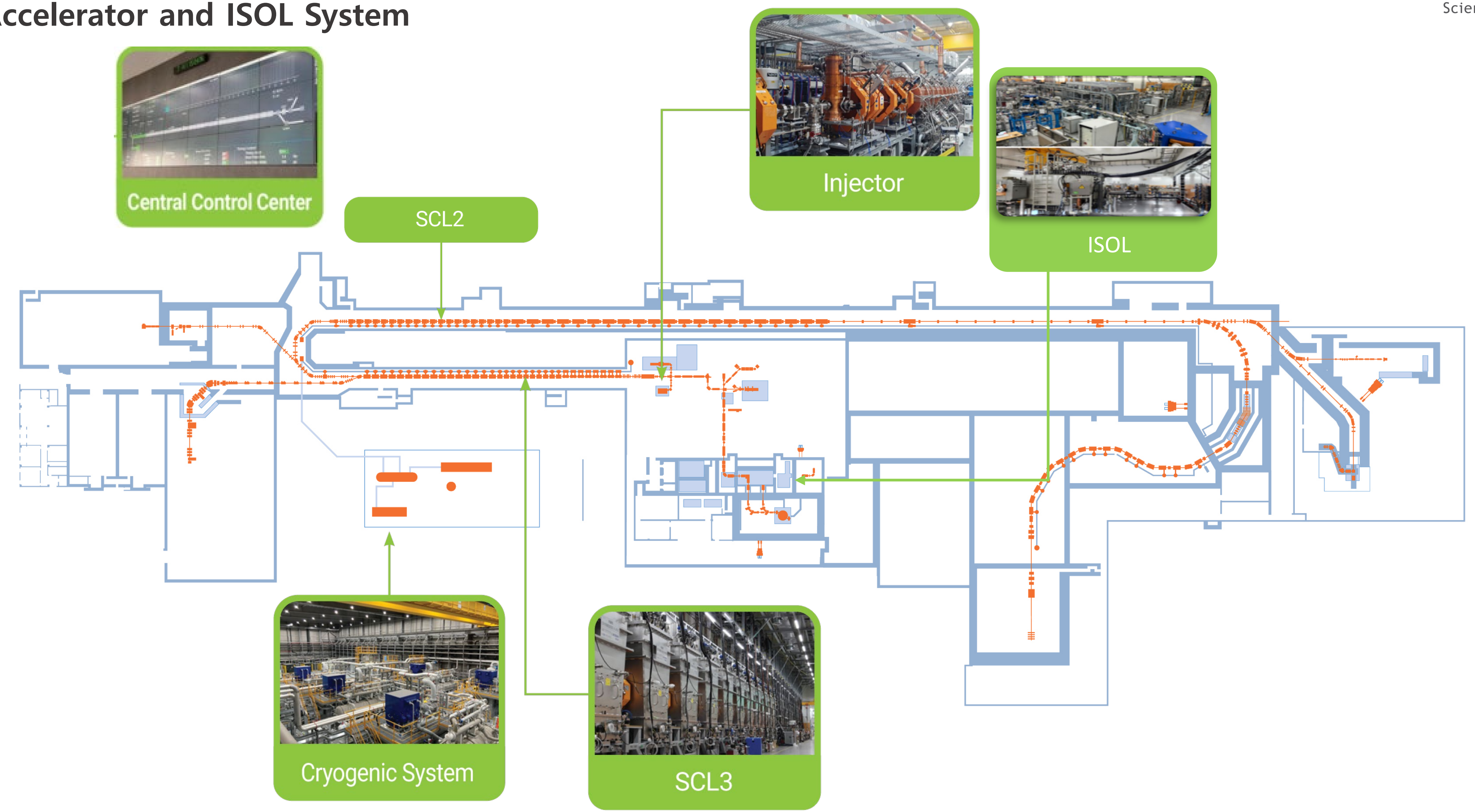
- **Feb, 2011**
  Conceptual Design Report (CDR)
- **Dec, 2011**
  Rare Isotope Science Project (RISP) launched
- **Sep, 2013**
  Technical Design Report (TDR)
- **Feb, 2014**
  Purchasing the Land (Sin-dong)
- **Feb, 2017**
  Civil Construction Project Started

- **Apr, 2019**
  Moved to Sin-dong Site
- **Apr, 2020**
  1st QWR Cryomodule installed
- **Sep, 2020**
  Installation of QWR completed
- **Jan, 2021**
  Installation of HWR completed
- **Jul, 2022**
  Institute for Rare Isotope Science (IRIS) established

- **Dec, 2022**
  Stage-1 of RISP completed
- **May, 2023**
  Commissioning of SCL3 Accelerator completed
- **Dec, 2023**
  First Call for Proposals
- **Mar, 2024**
  First PAC
- **May, 2025**
  Second PAC

PART 1.

Accelerator and ISOL System



PART 1.

Accelerator System: Installation

Apr, 2020: Installation of LEBT

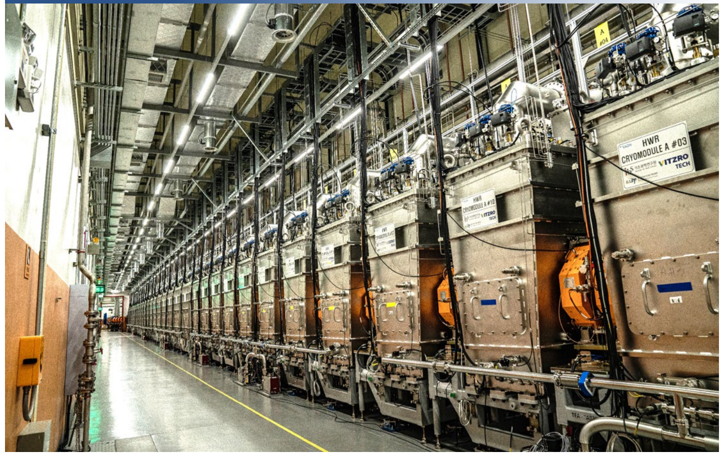
Jul, 2020: Installation of MEBT

Apr, 2020: First QWR

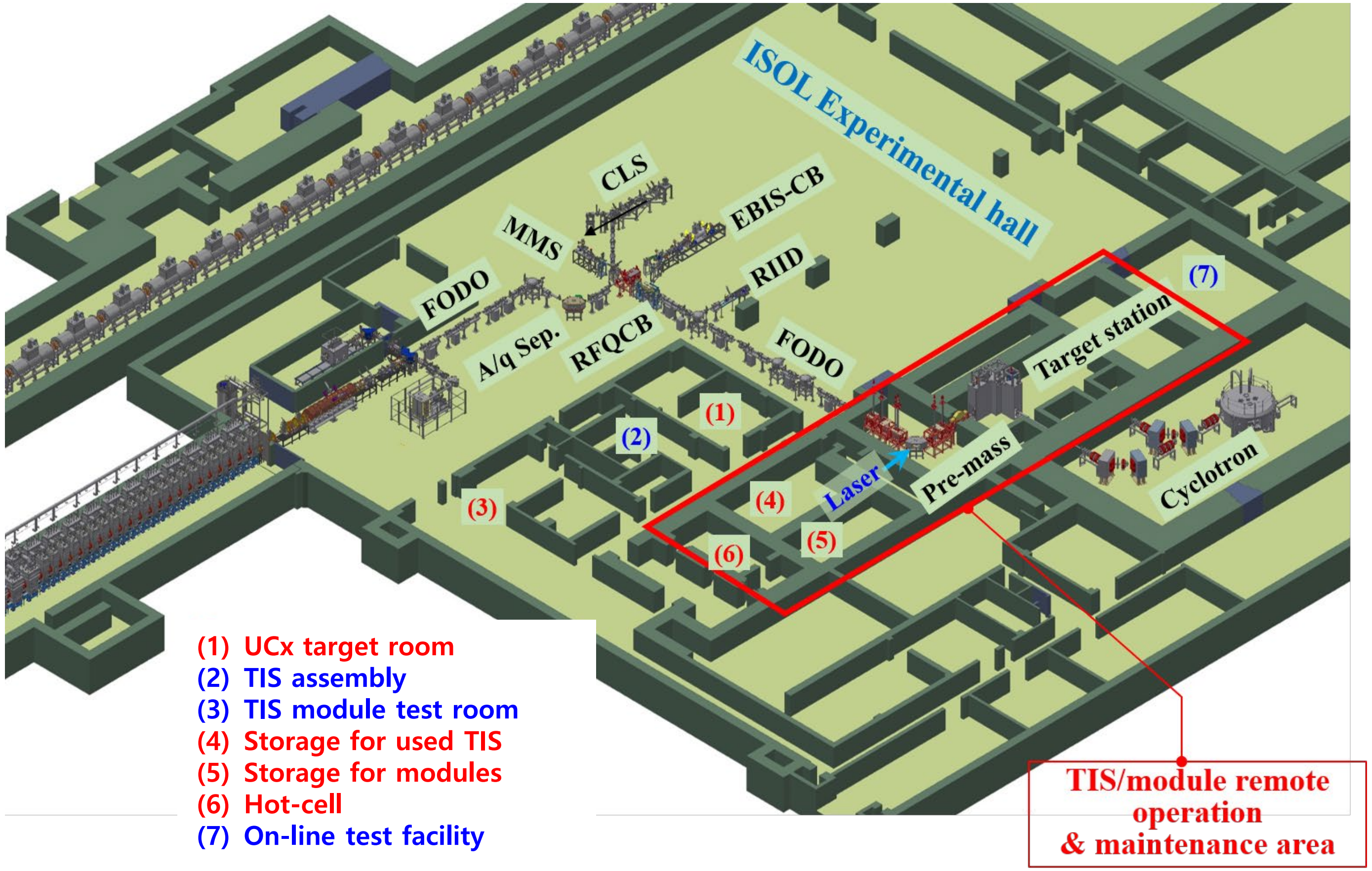
Sep, 2020: QWRs completed

Mar, 2021: HWRs started

Dec, 2021: HWRs completed

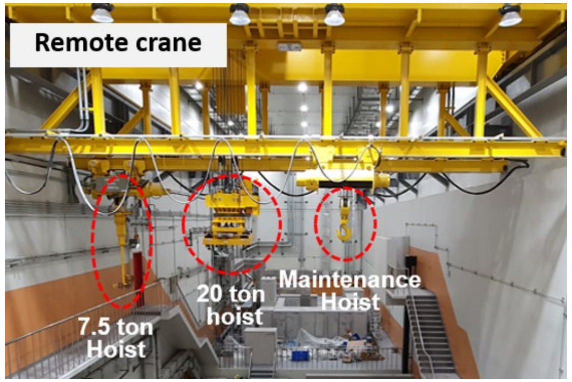


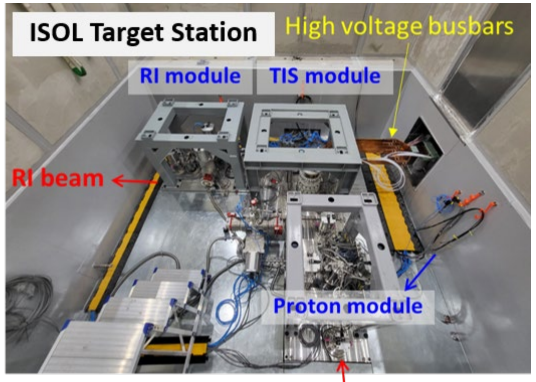
ISOL System



- **Proton cyclotron of 70 MeV and 50 kW (tested)**
  (35 MeV < E < 70 MeV)

Year	**2024**	**2025**	**2026**
Beam power	1 kW	2 kW	3 kW
Target	SiC, LaC_2	TiC	ThC_x, UC_x
Ion source	SIS	RILIS, FEBIAD	RILIS, FEBIAD



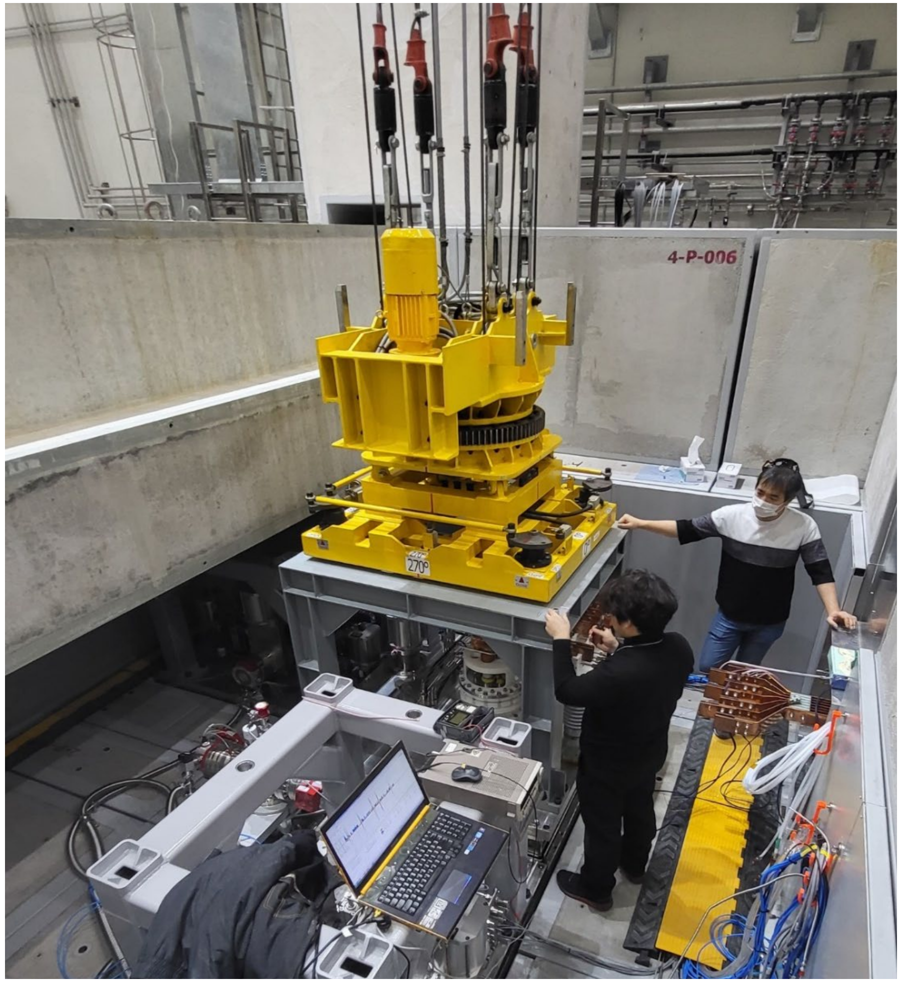


ISOL System: Target Ion Source in ISOL Bunker

Poster, Jinho Lee, "Status of Rare Isotope Beam Operation at RAON"

Oct. 2021 Installation of ISOL TIS

Feb. 2023 Installation of ISOL TIS



ISOL System: Target

- ^{8,9}Li
- ^{20,21,22,24,24m,25,26,27}Na
- ^{25,26,26m,28,29}Al

● SiC target (up to 1 kW)


- Density ~1.8 g/cm^3, Thermal diffusivity 3.1 mm^3/s (1,200 ℃)
- Proton beam : **70 MeV, up to 14 μ A** on SiC (T < 1,600 ℃)
- Surface ionized RIBs **(Li, Na, Al)** identified with **HPGe or scintillator**.
- Good release efficiency of isotopes from SiC target was confirmed (ex, **identification of ^{24m}Na with $T_{1/2}$ = 20 ms**)
- Aluminum with low diffusion coefficient and ionization efficiency was confirmed as a surface ion source

● Beam transmission efficiency (with 1 kW proton)

	Production rate [INCL++(pps)]	Measured intensity (pps) downstream of Mass separator	Transmission rate
20Na	1.65E+08	1.02E+07	6.2%
21Na	2.37E+09	2.46E+07	1.46%
25Na	3.80E+08	1.10E+07	2.89%

● LaC_2 target (up to 500W)

- Physical and chemical characteristics similar to UCx target
- **Same fabrication process as UCx/MWCNT target**
- To verify the fabrication and operation of UCx target
- Density ~1.8 g/cm^3, Φ 20 mm

<Installation in a target container>

<Installation in a TIS chamber>

- ^{130}Cs, ^{130m}Cs, ^{134}Cs, ^{134m}Cs, ^{135}Cs, ^{136}Cs, ^{138}Cs, ^{138m}Cs
- ^{131m}Ba, ^{133}Ba, ^{133m}Ba, ^{135m}Ba, ^{137m}Ba

- Cerium isotopes with a long sticking time could not be observed
- Cs-131 and Cs-136m have no gamma emission

● SiC and TiC (in 2025)

● ThC_x and/or UC_x (in 2026)

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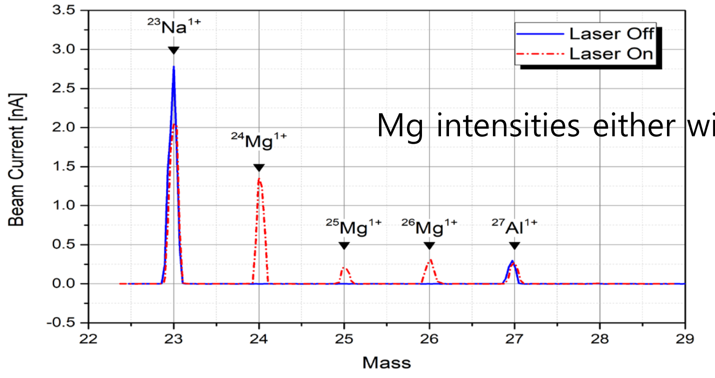
ISOL System: Target Ion Source

● Surface ion source

- Na isotopes : ^{20}Na, ^{21}Na, ^{22}Na, ^{24m}Na, ^{24}Na, ^{25}Na, ^{26}Na, ^{27}Na
- Al isotopes : ^{25}Al, ^{26}Al, ^{26m}Al, ^{28}Al, ^{29}Al
- Cs isotopes : ^{130}Cs, ^{130m}Cs, ^{134}Cs, ^{134m}Cs, ^{135}Cs, ^{136}Cs, ^{138}Cs, ^{138m}Cs
- Ba isotopes : ^{131m}Ba, ^{133}Ba, ^{133m}Ba, ^{135m}Ba, ^{137m}Ba

● Laser ion source

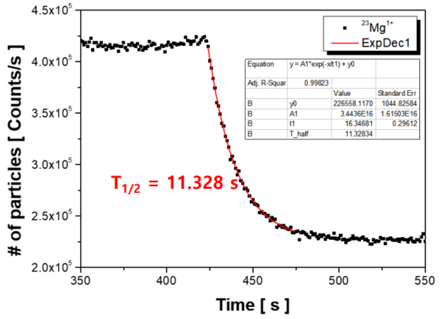
- 4 Ti:Sa lasers & 2 Nd:YAG
- Laser ionization test of Mg using off-line test facility done.



Mg intensities either with or without a laser

< Mg stable beam test using RILIS >

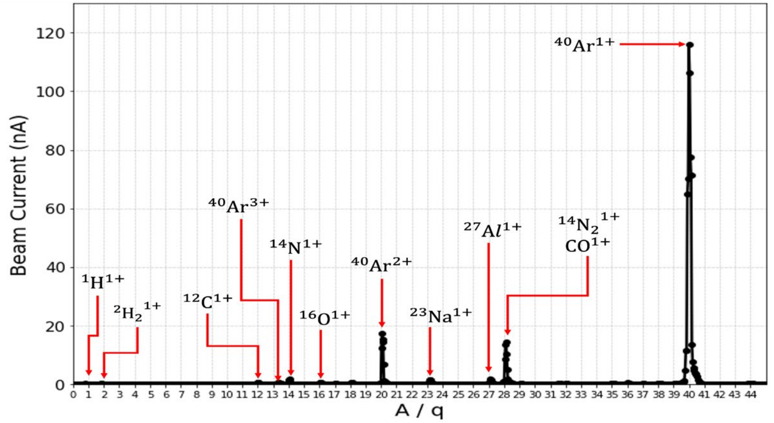
- **Mg RI beam extraction in progress** (~5x10^6 $^{23}Mg^{1+}$ extracted)

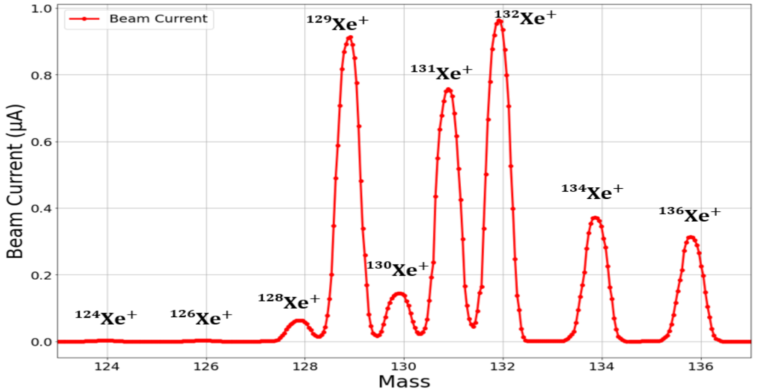


● Plasma ion source

- In the off-line test facility, Ar, Xe, and Kr gases are being tested.
- On-line plasma ion source is manufactured.

● Off-line test results of plasma ion source





< FEBIAD ion source test using Ar (top), Xe (bottom) gas >

Poster, Seongjin Heo, "Status of RFQ Cooler Buncher for rare isotope experiments with Isotope Separation On-Line system"

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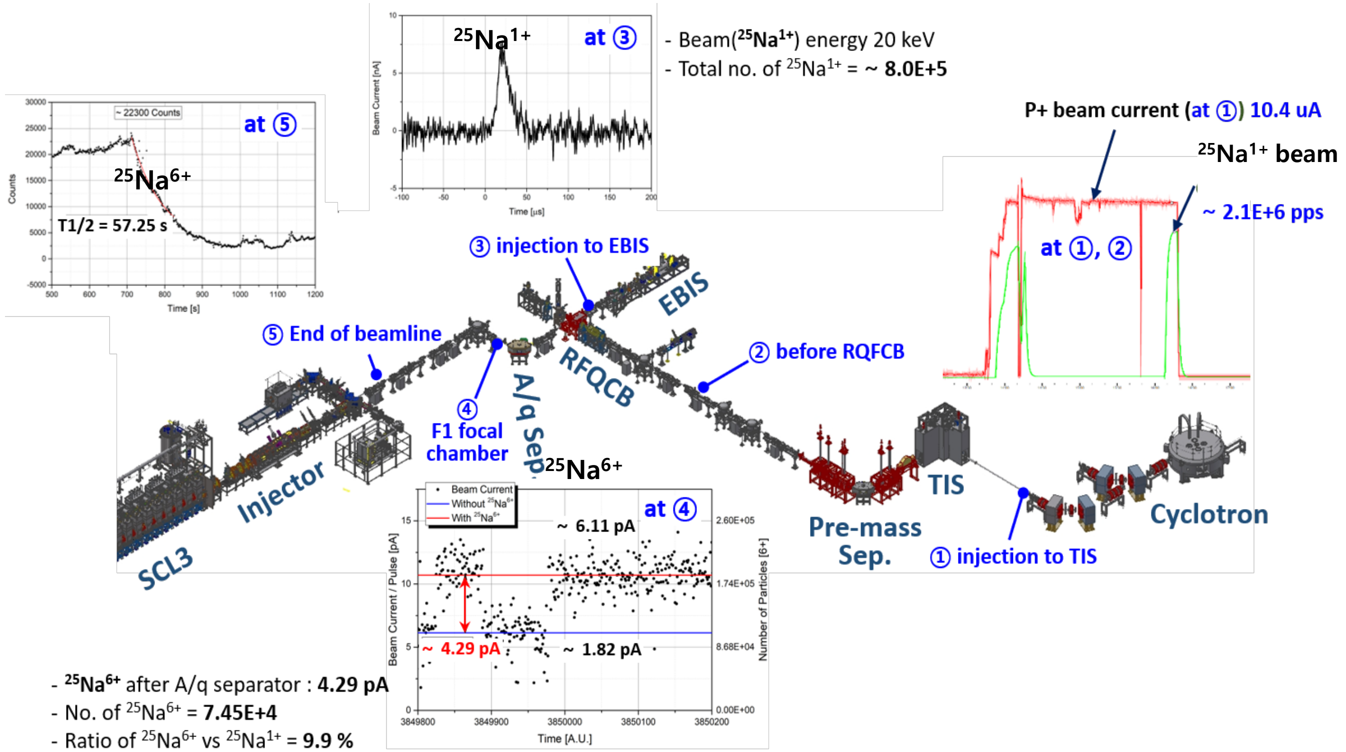
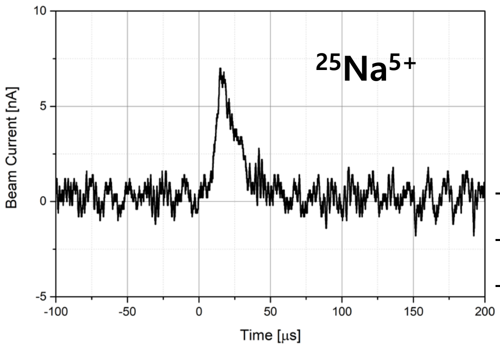
ISOL System: Transportation of ISOL beam to SCL3 for post-acceleration

- Preliminary experiments with $^{25}Na^{6+}$



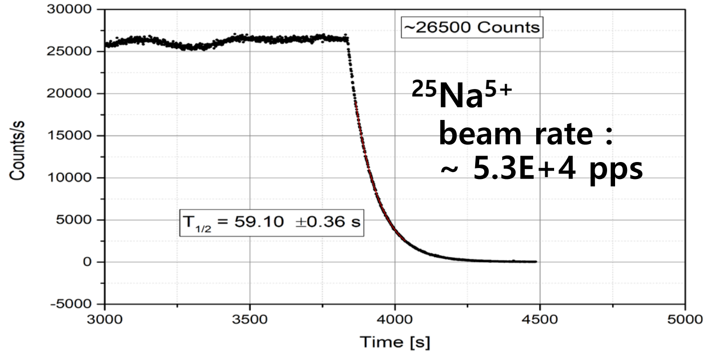
	Measurement Point	Beam Current ($^{25}Na^{6+}$)	Number of Particles	Transmission (each step)
③	EBIS Dipole	4.57 pA	7.93E+4	-
④	A/q Separator	4.29 pA	7.45E+4	93.9 %
⑤	End of ISOL Beamline	-	~ 4.46E+4	~ 59.8 %

- Charge breeding & SCL3 transportation of $^{25}Na^{5+}$
  - Injected Na Ions



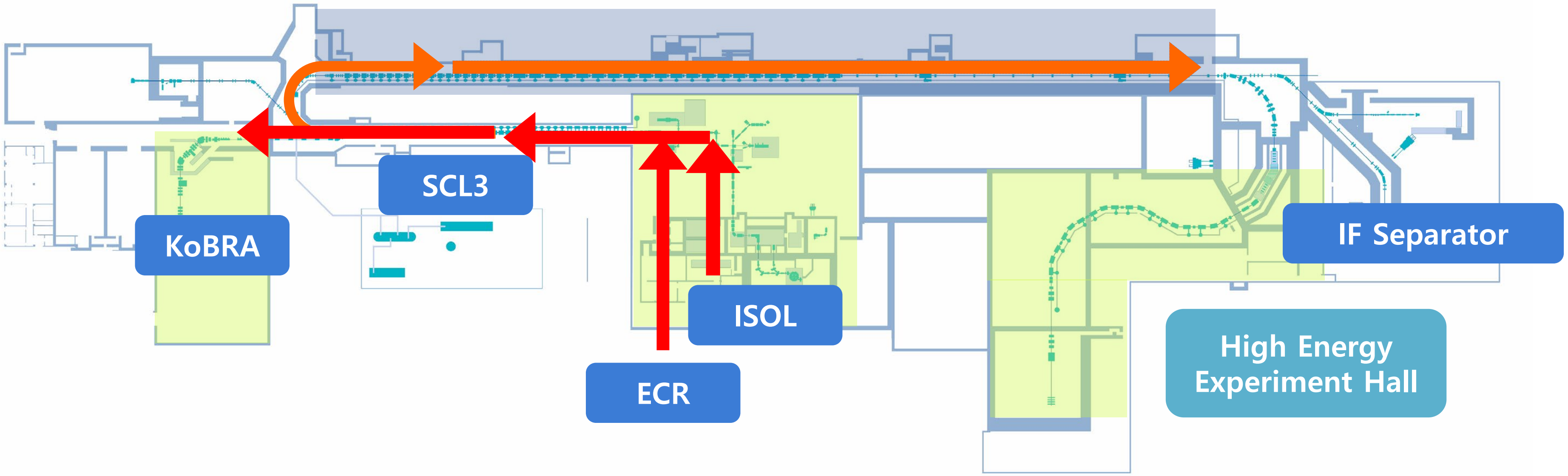
- Pulse Length : **40 μs** (end-to-end)
- Total ions of $^{25}Na^{1+}$ = **~ 7.32E+5**
- Repetition rate : **1 Hz**

  - EBIS Experimental Condition
    - SC Magnet : 6 T
    - E-Beam Energy : 13 keV
    - Breeding Time : 10 ms
    - Extracted ion Beam Energy : 10 keV/u ($^{25}Na^{5+}$)



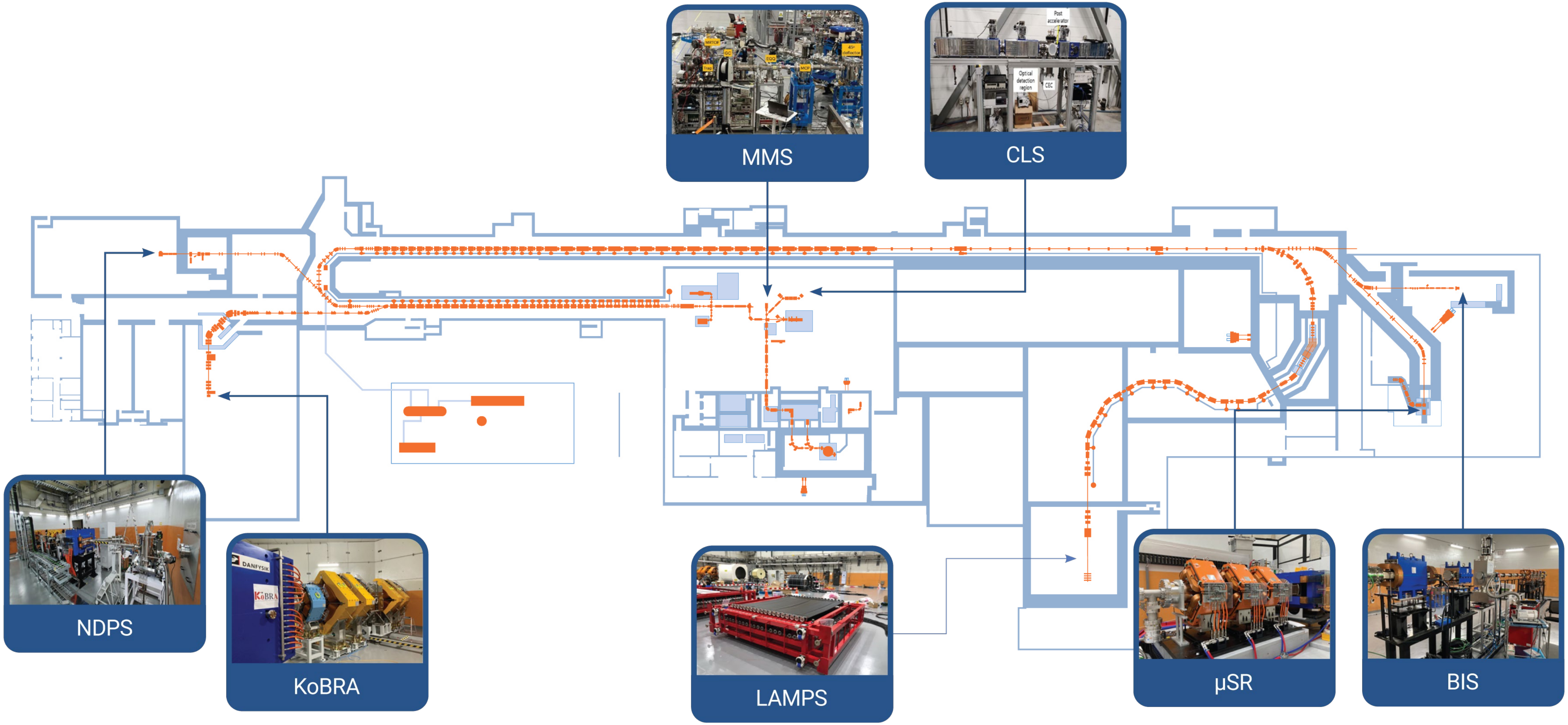
RIB Production: KoBRA, ISOL, IF, ISOL+IF

	KoBRA	ISOL	IF Separator
RIB Production & Acceleration Mode	ECR (SIB) → SCL3 → KoBRA production target	Cyclotron (p) → TIS (RIB) → SCL3	ECR (SIB) or ISOL (RIB) → SCL3 → SCL2 → IF (RIB)
Production Mechanism	Direct reactions & Multi Nucleon Transfer	p induced reactions and fission of U	Projectile Fragmentation (U fission)
RIB Energy	< a few tens of MeV/u	> a few keV/u	< hundreds of MeV/u



PART 1.

Experimental Systems



KoBRA (Korea Broad Acceptance Recoil spectrometer and Apparatus)

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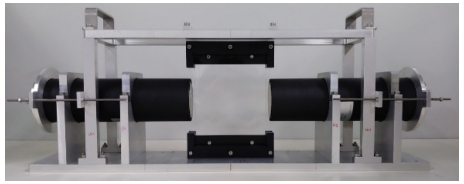
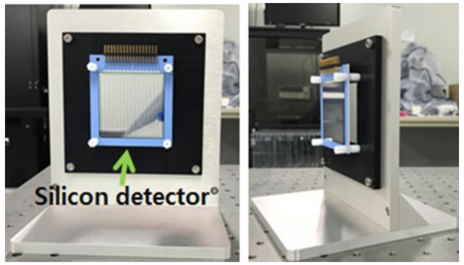
Science

Beam swinger	up to ± 12 degree for 3 Tm
Degrader at F1	Homogeneous or Curved
Magnetic rigidity	0.25 – 3.0 Tm
Angular acceptance	± 40 mrad (H) ± 100 mrad (V)
Momentum acceptance	± 4%
High order correction	up to 4^{th} order
Momentum resolving power at F1	2100 at 2 mm beam size
Mass resolving power (with Wien filter)	750 at 2 mm beam size

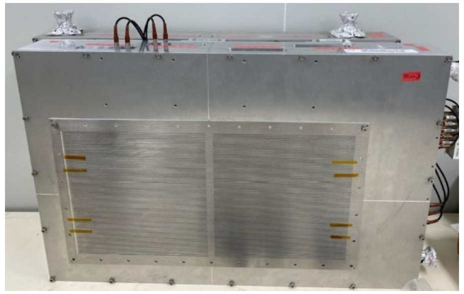
- **Plastic scintillator**

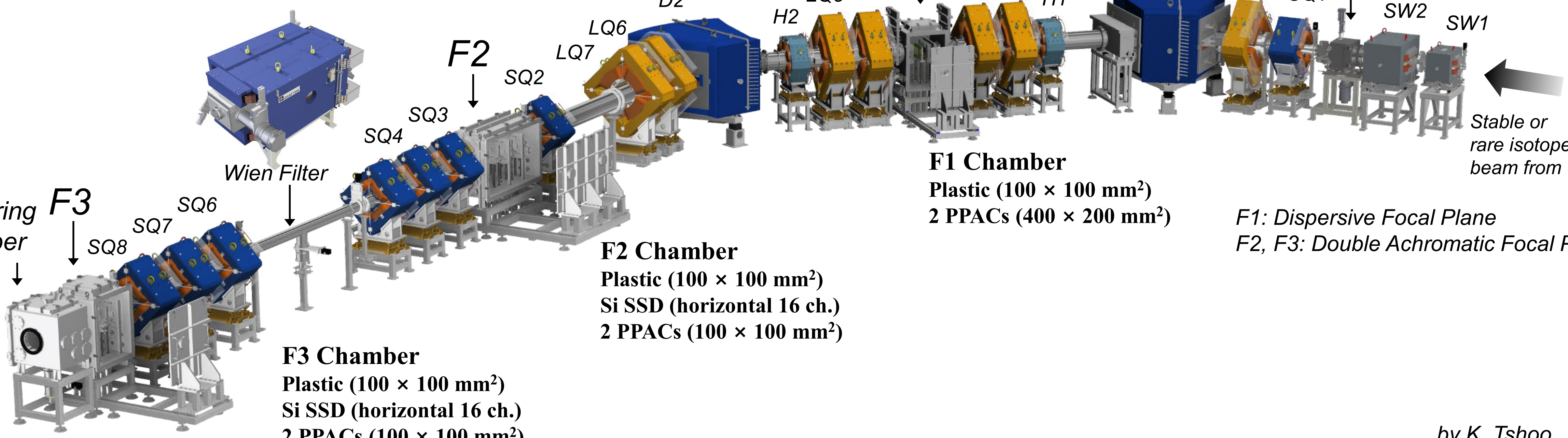


- **Si SSD**



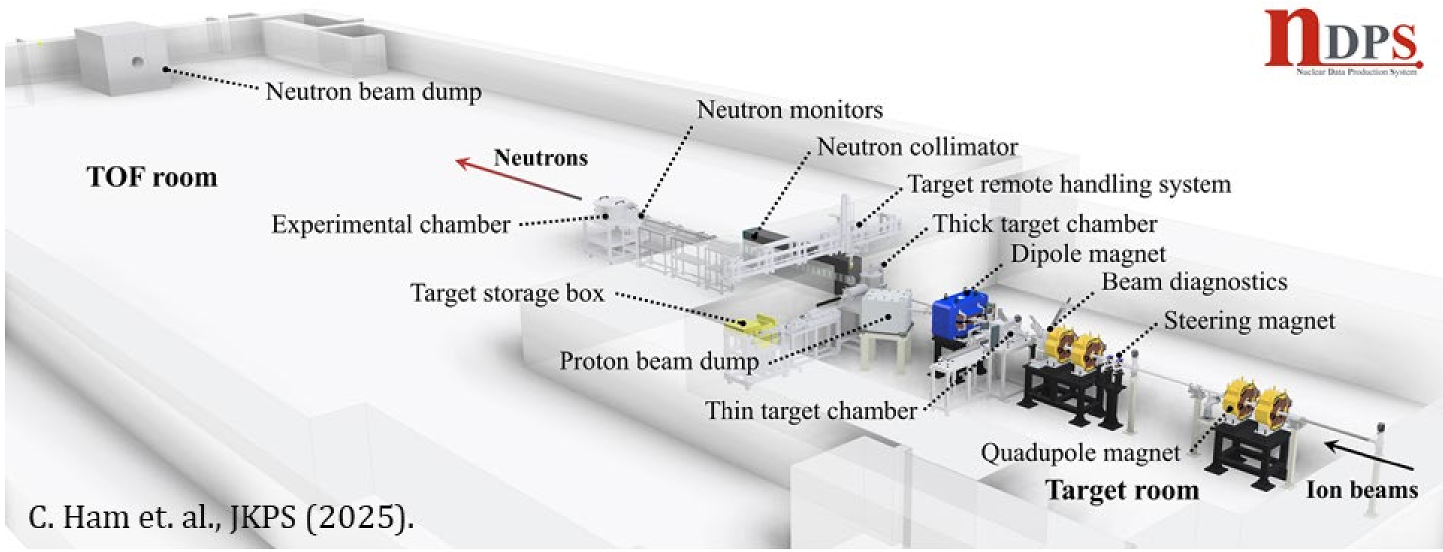
- **PPAC**





by K. Tshoo

NDPS (Nuclear Data Production System)



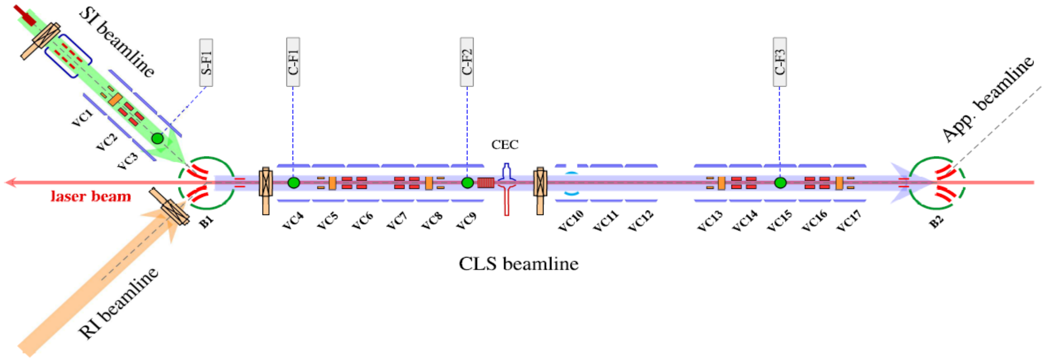
C. Ham et. al., JKPS (2025).

Specification of NDPS	
Beam Ion	Proton, deuteron, ^{40}Ar, etc
Ion Beam Energy	20~80 MeV for proton ~50 MeV/u for deuteron Up to 18 MeV/u for heavy ion
Target	^{nat}C for white neutron Li for monoenergetic neutron
Flight length of neutron	5 – 50 m
Calculated neutron flux	~ 10^{10} n/sec/sr/pμA (@ 0°)
Neutron beam size	Minimum 4 cm in diameter


TOF Room

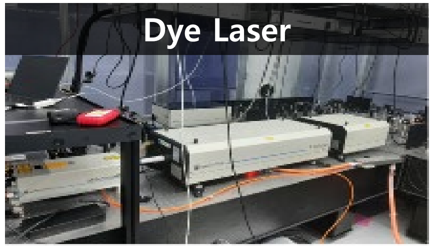

Target Room

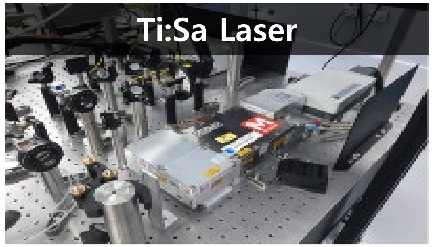
CLaSsy (Collinear Laser Spectroscopy)

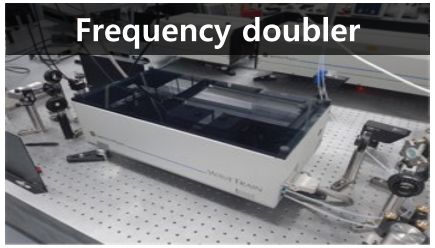


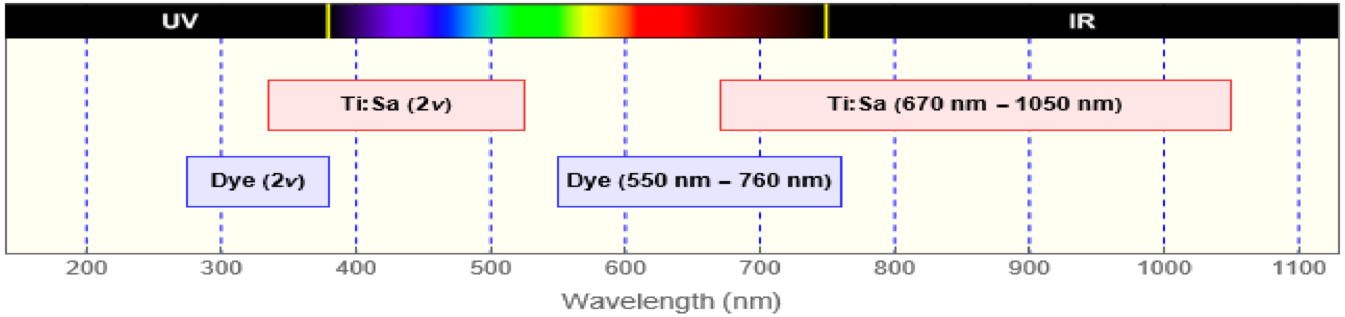
- **CLS beamline was developed at TRIUMF, Canada.**
  Equipped with a vertical charge-exchange cell for neutralization
  Enables Doppler frequency tuning of the ion beam (±10 kV)
  Resonance signals are detected at the light collection system.
- **SI beamline utilizes a commercial hot cathode plasma ion source.**
  Extracts various ion beams depending on the injected sample.
- **RI beam is transmitted from the ISOL facility.**
- **Laser system** includes Ti:Sa laser and Dye lasers

Laser system for CLaSsy and its wavelength coverage

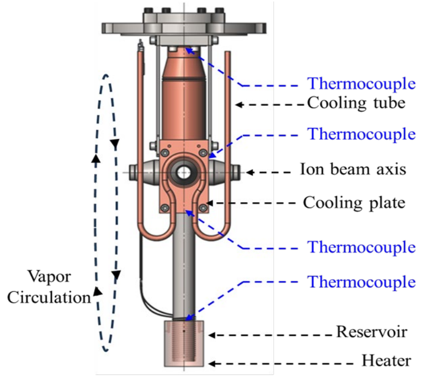




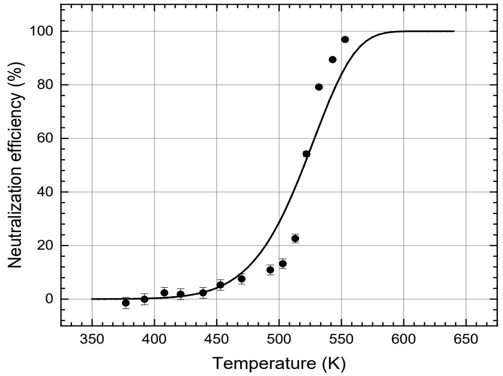




① Ti:Sa laser: 670 – 1050 nm ③ Ti:Sa & SHG: 335 – 525 nm
② Dye laser: 550 – 760 nm ④ Dye & SHG: 275 – 380 nm



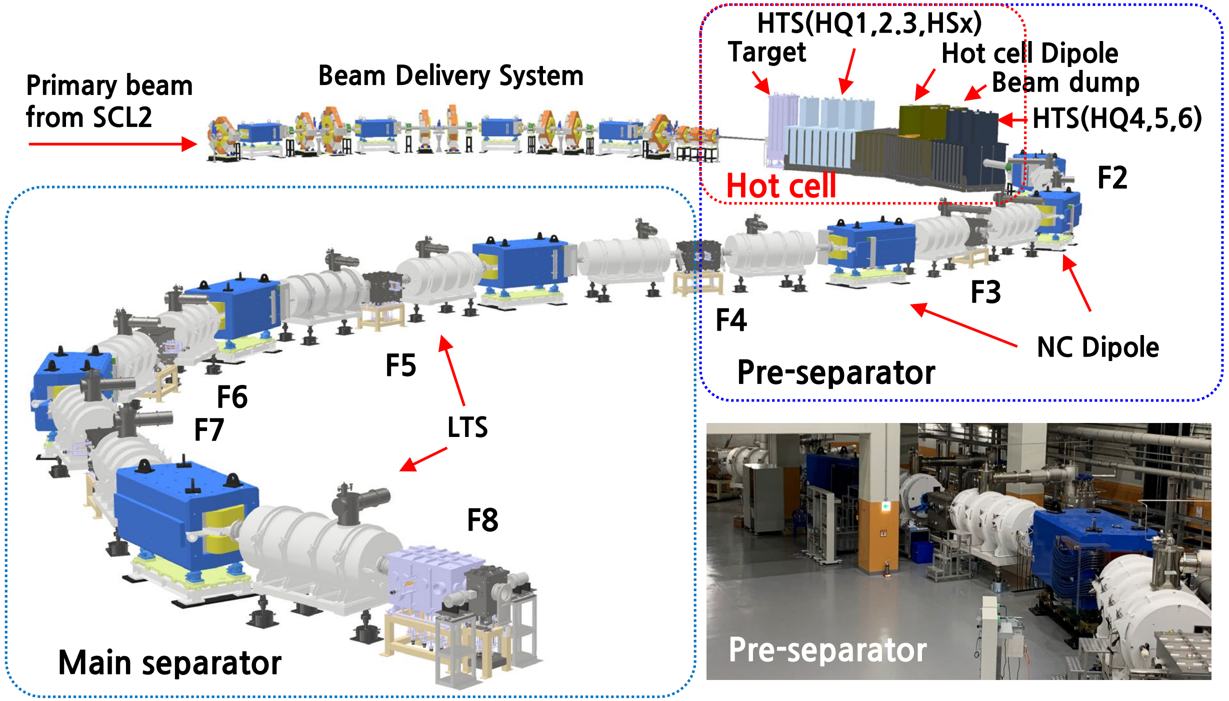
Charge-exchange cell (CEC)

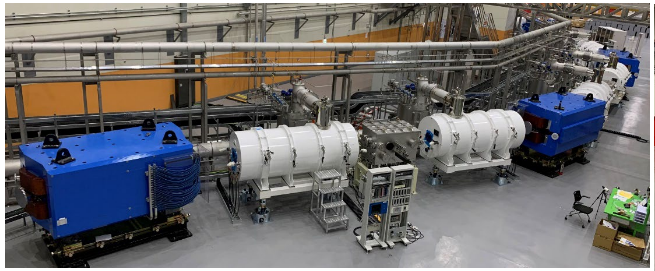


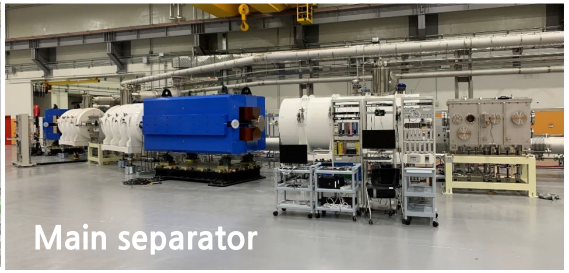
Neutralization efficiency of CEC

by S. J. Park and C. Lim

IF Separator (In-flight Fragment Separator)

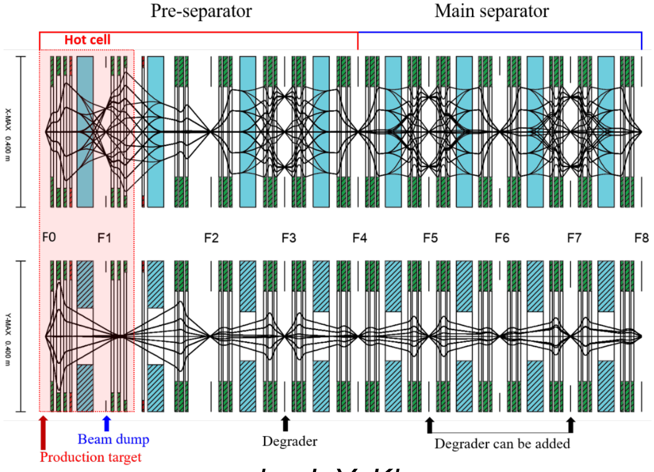






- Specification of IF separator
  - ○ 2 stage separator
    - → Pre-separator : Production RI beam and separation
    - → Main separator : Tagging and Particle Identification
  - ○ Large acceptance for In-Flight fission
    - → Angular acceptance: ± 40(H) & 50(V) mrad
    - → Momentum acceptance: ± 3 %
  - ○ HTS : 6 quadrupole (HQ1 ~ HQ6), 1 sextupole (HSx)
  - ○ LTS : 13 quadrupole triplet (LQT01 ~ LQT13)
  - ○ NC : 8 dipole (D1 ~ D8), 1 sextupole

- The optics of IF separator



by J. Y. Kim

- ○ Magnetic rigidity: ~ 7.5 Tm
- ○ Focal plane
  - Achromatic: F2, F4, F6, F8
  - Momentum dispersive: F1, F3, F5, F7
  - Doubly achromatic: F8
- ○ Momentum resolving power*
  - Pre-separator
    - : 1270 at F1, 3200 at F3
  - Main separator
    - : 3300 at F6, 3300 at F8
  - (* 1mm beam spot size @ target)

PART 2

Commissioning in 2023

PART 3

Operation in 2024

PART 4

Operation in 2025

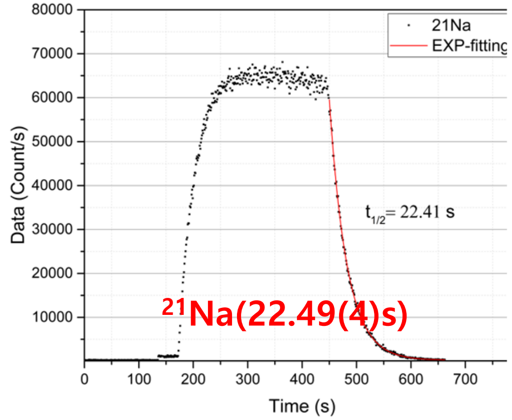
PART 5

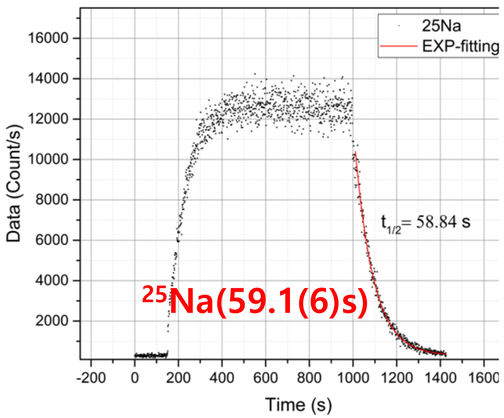
R&D Status for SCL2

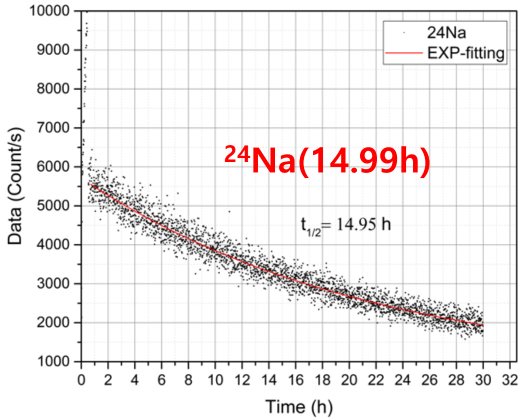
PART 6

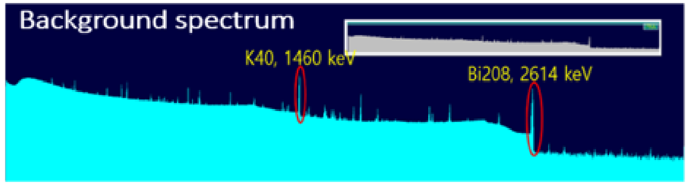
Summary

Commissioning of ISOL: First production and transport of RI from ISOL (with SiC in March, 2023)

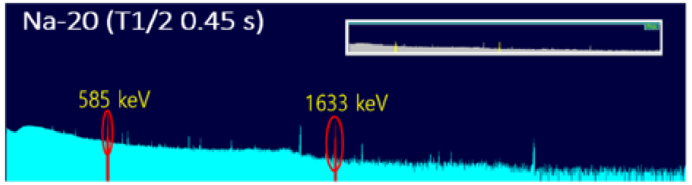




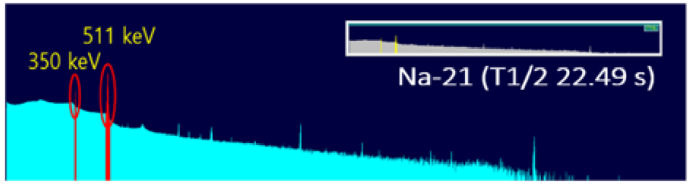




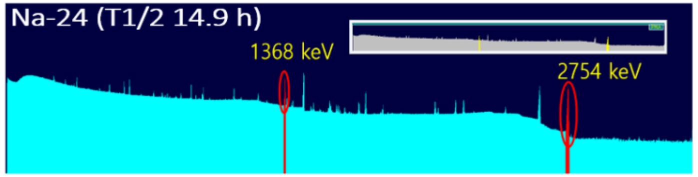
< Measurement of 534,632 sec >



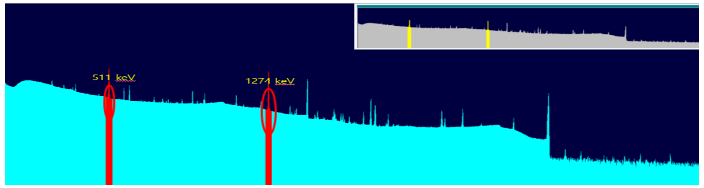
< 2uA p+ irradiated 3,180 sec, measured 3,260 sec >



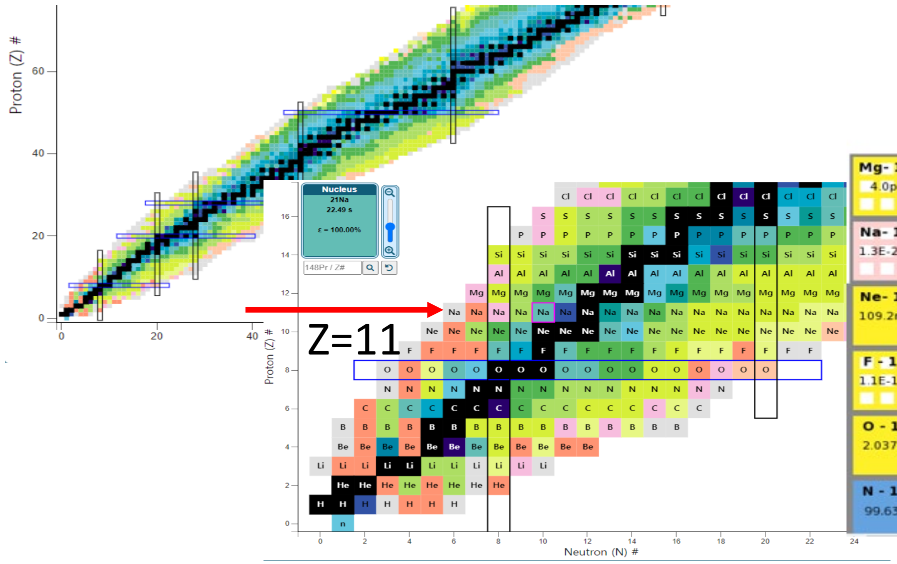
< 1.71uA p+ irradiated 1,000 sec, measured 1300 sec >

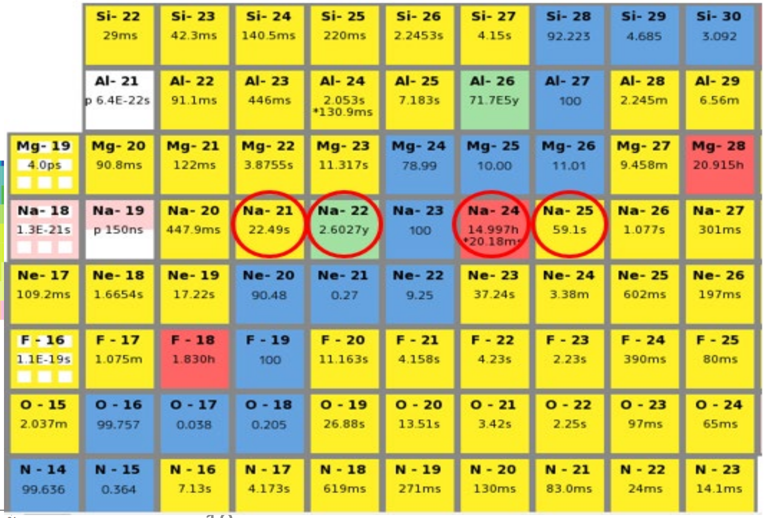


< 1.7uA p+ irradiated 1,060 sec, measured 489,146 sec >



The measured half-lives of Na isotopes by using scintillators & PMT





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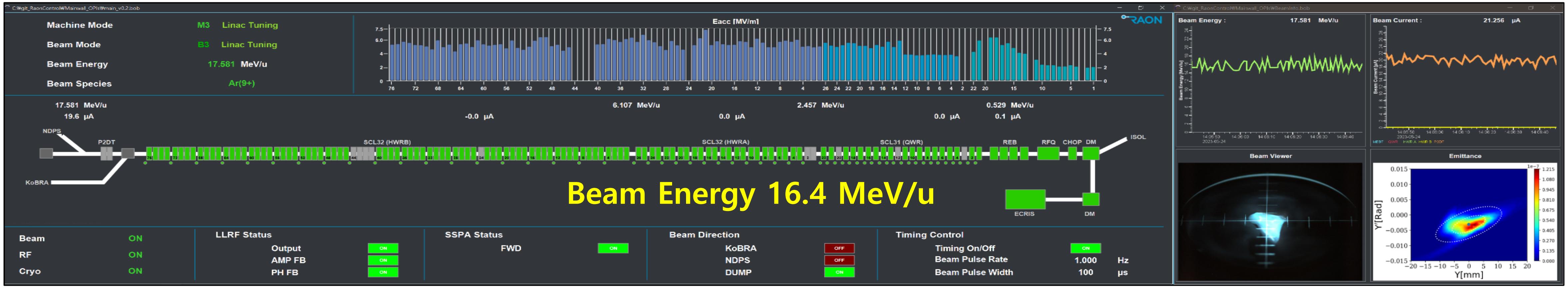
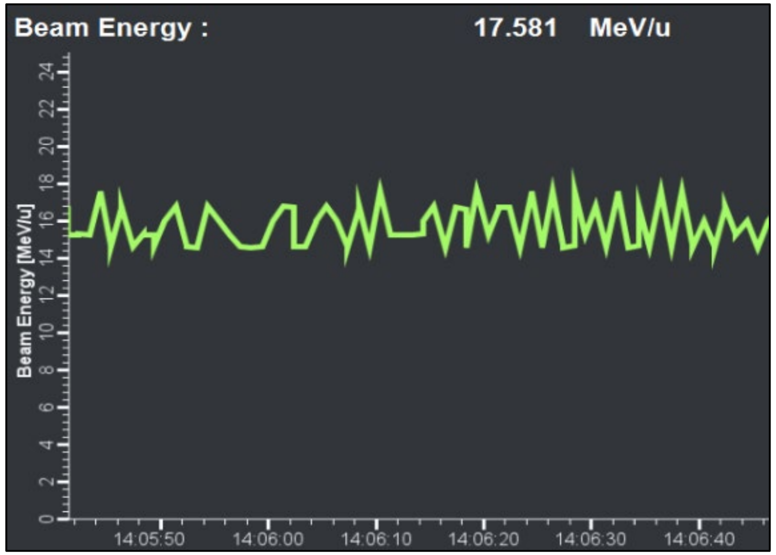
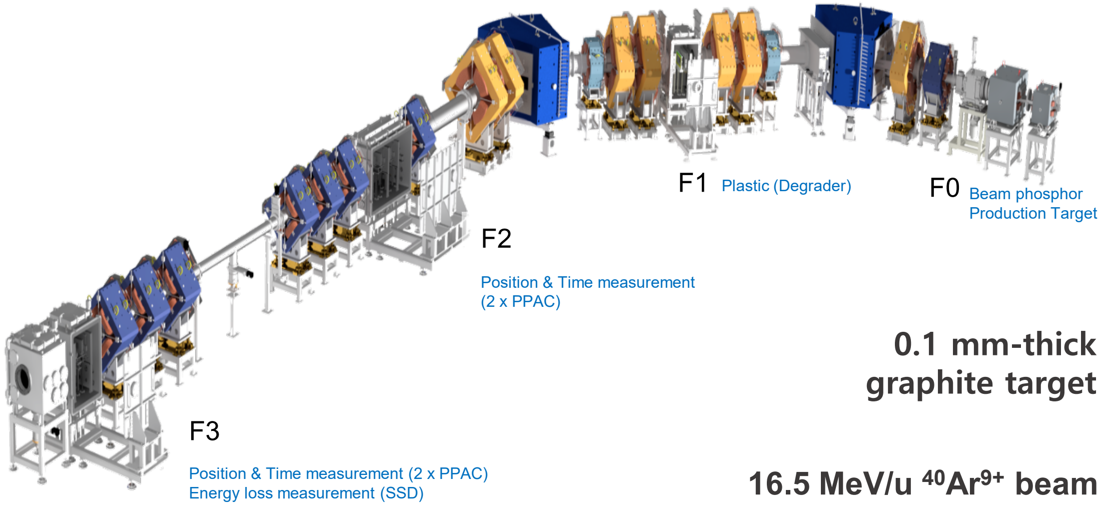
First full beam commissioning of SCL3 (May, 2023)

Ar^{9+} beams accelerated by entire SCL3(QWR/HWR) on May 23, 2023





First Beam Commissioning of KoBRA (May 31 ~ June 2, 2023)



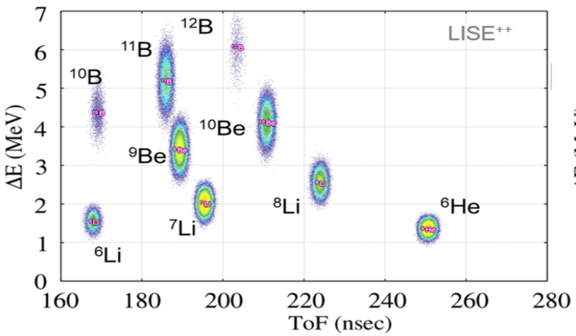
0.1 mm-thick graphite target

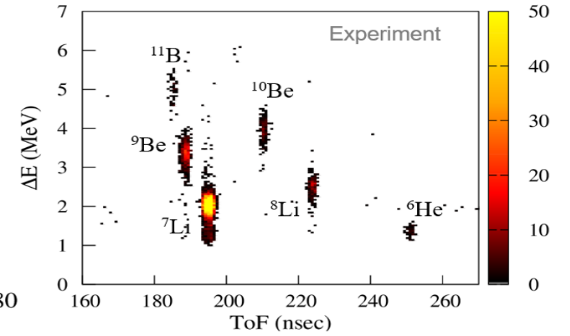
16.5 MeV/u $^{40}Ar^{9+}$ beam

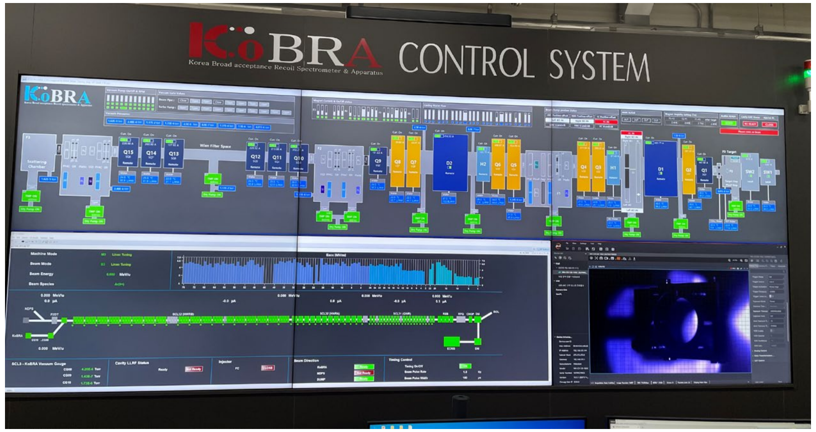
Particle Identification

Particle identification with ΔE-ToF method

- SSD: Energy loss measurement
- PPACs: Time-of-flight measurement







First Call for Proposals (2024)

2024 Call for Proposals of Low-Energy Beam at RAON

December 12, 2023 to January 19, 2024
Institute for Rare Isotope Science
Asia/Seoul timezone

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- Overview
- Registration
- Call for Proposals
- Facility Information
  - KoBRA
  - MRTOF-MS
  - Cyclotron
  - CLS
- Important Dates
- Program Advisory Committee (PAC)
- IRIS Homepage
- RAON Users Association Homepage

User Support Office
user_support@ibs.re.kr
+42 878 8746

CALL FOR PROPOSALS

The Institute for Rare Isotope Science (IRIS) invites proposals for beam times extended to domestic users in Korea. The primary beams to be provided in 2024 will be Ne-20 and Ar-40 accelerated by the superconducting linac SCL3 at the energies of ~20 MeV/u or less with a maximum current of ~40 μA. Proton beams of 40 and 70 MeV can be provided by a cyclotron up to 10 kW or less.

The beam times will be provided for non-proprietary experiments based on the scientific merits through the review of proposals by the PAC members. There will be no beam time charge for non-proprietary experiments as long as the results are expected to be published.

The experimental systems such as KoBRA, MMS, and CLS can be used for experiments. Details of the experimental conditions can be discussed with the contact person of each experimental system.

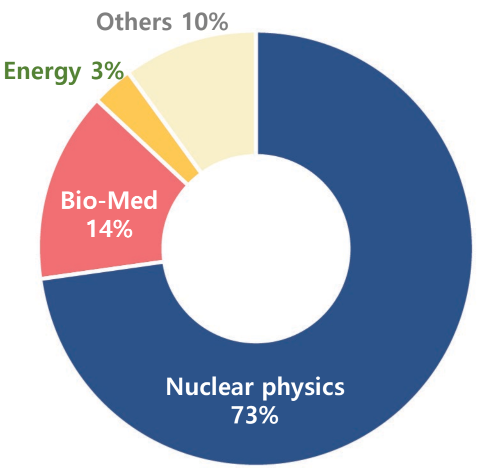
The proposals need to be submitted by January 19, 2024 to allow for scientific and technical reviews of the proposals prior to the PAC meeting, which will take place in early March, 2024.

Important dates

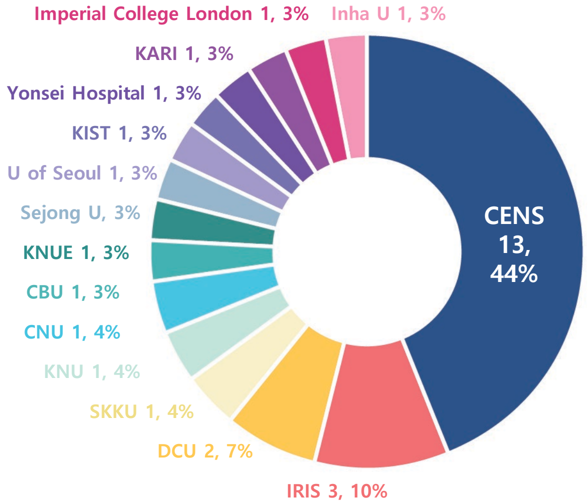
- 12 December, 2023: Call for proposals
- 19 January, 2024: Deadline for submission of proposals
- Early March, 2024: First PAC Meeting
- Middle of March, 2024: Notification of approved experiments
- May ~ June, 2024: Ne-20 and Ar-40 beams provided from the SCL3
- Beam times for proton beams/ISOL can be discussed and fixed individually

- From Dec. 12, 2023 ~ Jan. 19, 2024 (6 weeks)
- For domestic users
- 30 proposals
- 313 participants
- 15 institutions

Research areas



Institutions which submitted proposals



PART 3

Operation
in 2024

PART 4

Operation
in 2025

PART 5

R&D Status for
SCL2

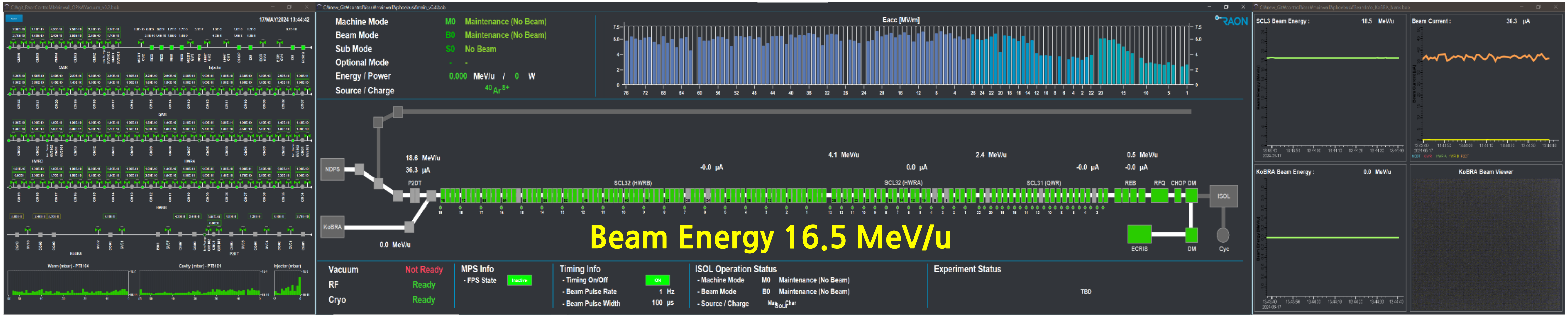
PART 6

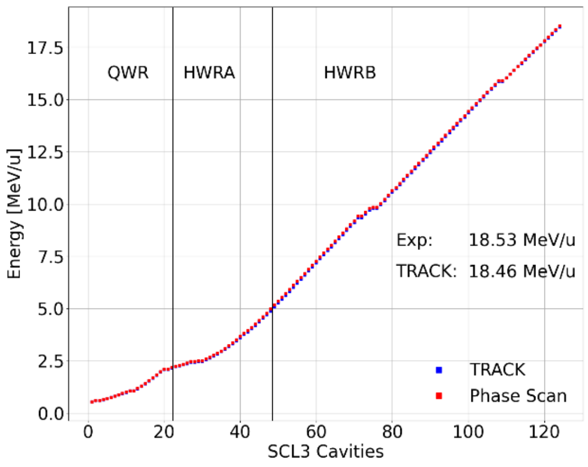
Summary

Operation of SCL3 in 2024

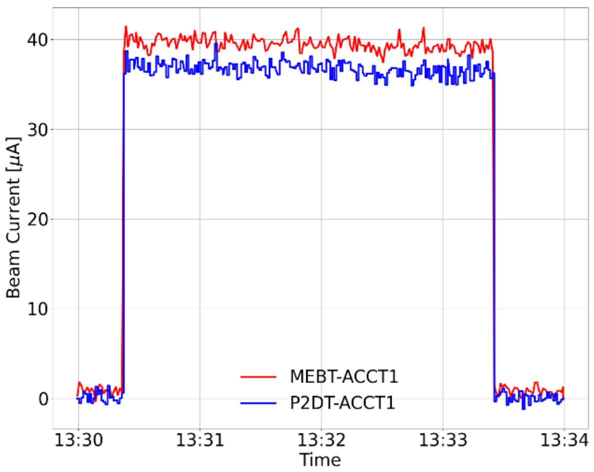
Institute for Rare Isotope Science

$^{40}Ar^{8+}$ beam accelerated by the entire SCL3(QWR/HWR) on May 17, 2024

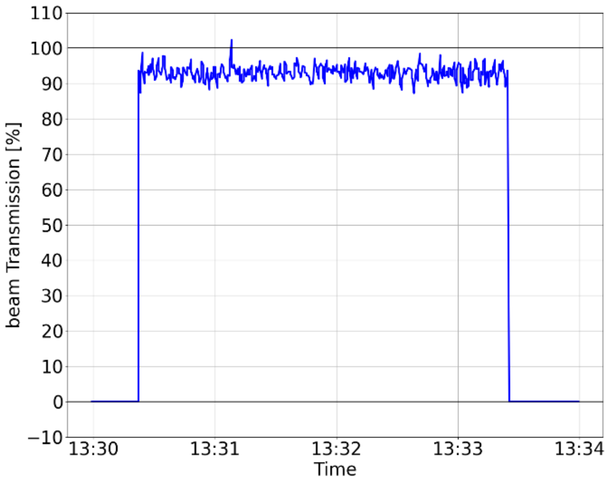




[Energy in SCL cavities]

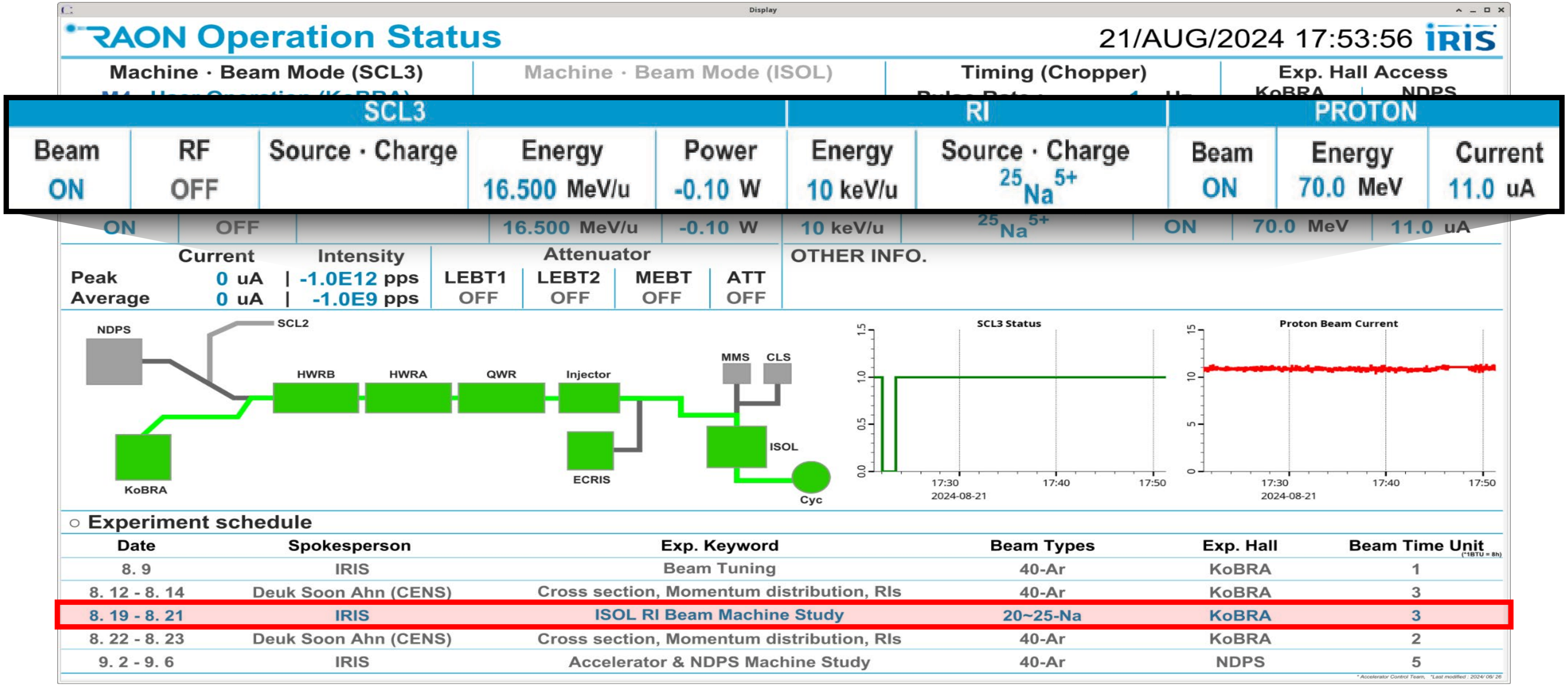


[Beam current measured by ACCT in MEBT and P2DT]



[Beam transmission through SCL3]

First Acceleration of ISOL RIB with $^{25}Na^{5+}$ (Aug.19~21, 2024)



ISOL production of RIs in 2024 (with SiC and LaC_2)

Measurement of short-lived Na beams

- Proton beam : 70 MeV, 7 μ A
- Na-24m (T1/2 20 ms) & Na-27 (T1/2 301 ms) detected at RIID
- RIs with very short half-lives can be produced and transported

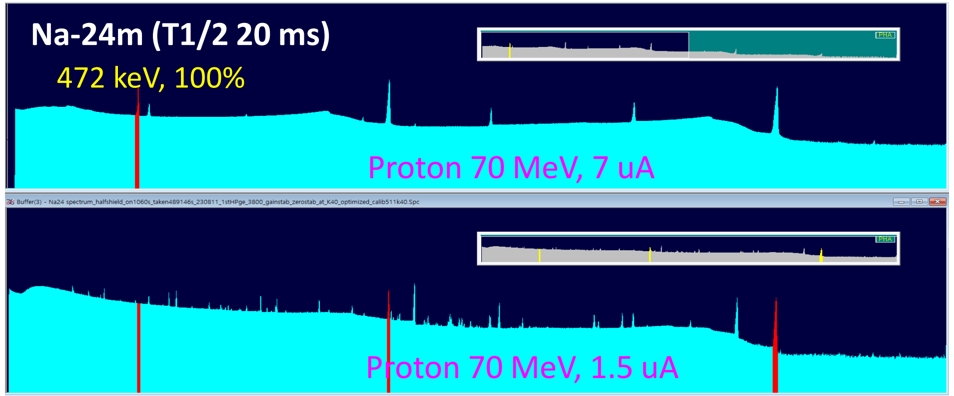
Aluminum isotopes

- Release of Al isotopes is very slow
- Low ionization efficiency with a surface ion source
- Al yield is low (in SiC target)

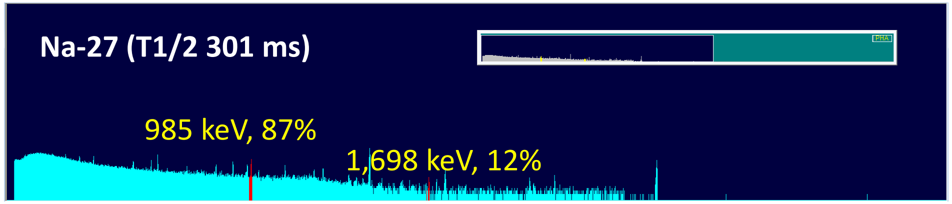
LaC_2 target

Cs130, Cs130m, Ba131m, Ba133, Ba133m, Cs134, Cs134m, Cs135m, Ba135m, Cs136, Ba137m, Cs138, Cs138m observed

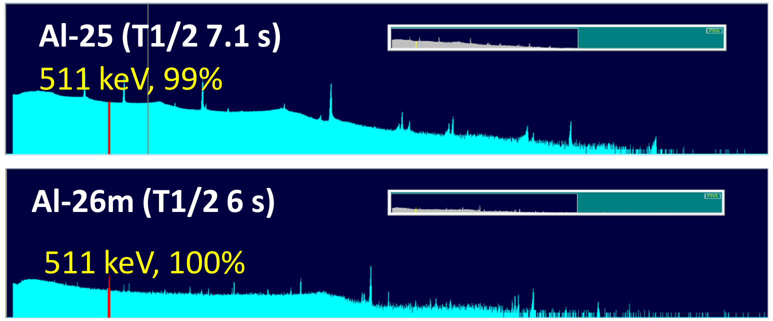
SiC Target



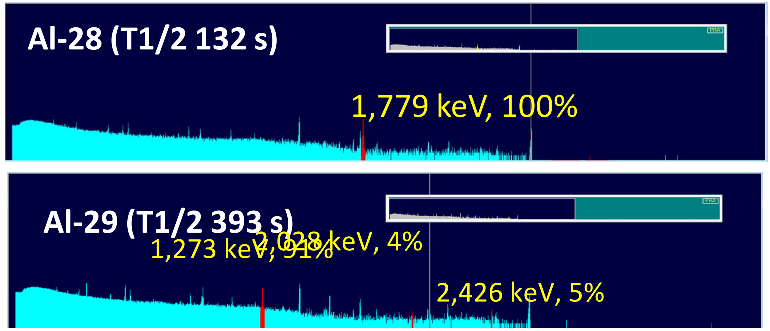
< Gamma spectrum of Na-24 measured by HPGe >
Proton 7 uA (upper) & 1.5 uA (lower)



< Gamma spectrum of Na-27 measured by HPGe >

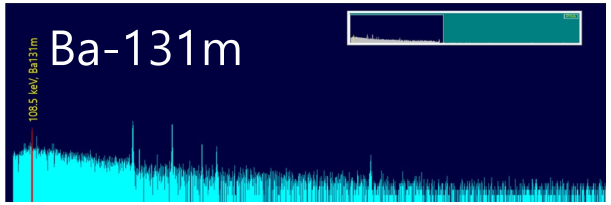


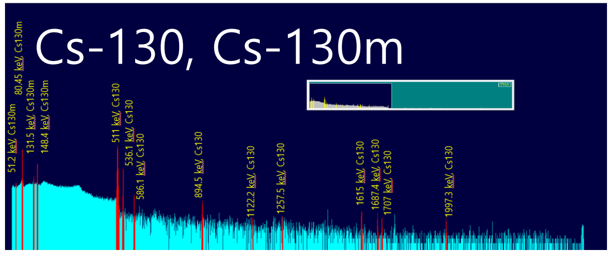
< Gamma spectrum of Al-25(upper) & Al-26m(lower) >

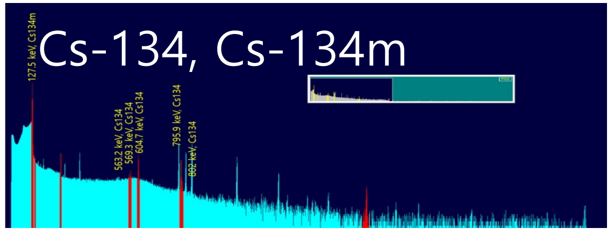


< Gamma spectrum of Al-28(upper) & Al-29(lower) >

LaC_2 Target







First PAC on March, 2024, and commissioning user services

Commissioning experiments in 2024

- 23 out of 30 proposals were reviewed by the PAC.
- In total, ~680 hours of beam time were requested.
- 5 out of 23 proposals were granted beam time in 2024.
- A total of 220 hrs of beam time were provided in 2024, including the beam time for KINS inspection.

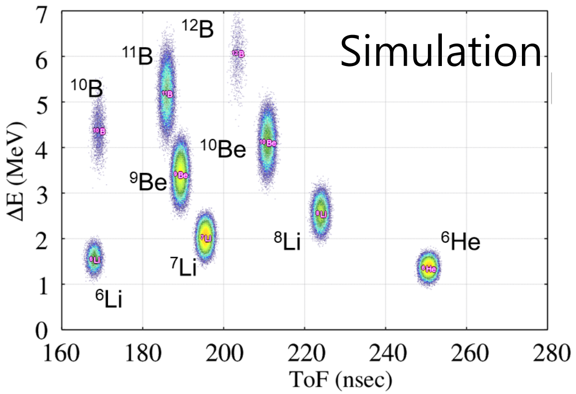
First Commissioning User Services in 2024

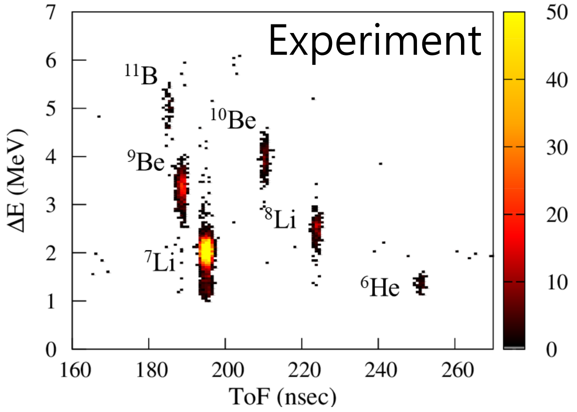
Name (affiliation)	Experiments	Dates	Beams	Beam time	Exp. facility
D. S. Ahn (CENS/IBS)	Measurement for production cross section and momentum distribution of projectile fragmentation	July 9 ~ Aug 23, 2024	^{40}Ar (16.4 Mev/u, 5 pnA)	75.7 hrs	KoBRA
J. B. Kim (KNUE)	High-resolution laser spectroscopy for the study of sodium	Nov 25 ~ 28, 2024	$^{22,23}Na$ (20 keV, 3.3E7 ppb)	15 hrs	CLaSsy
D. H. Kim (CENS/IBS)	40Ar + p elastic scattering experiment for a study of optical model potential	Aug 5 ~ 8, 2024	^{40}Ar (8.1 Mev/u, 5 pnA)	27.6 hrs	KoBRA
W. J. Lee (KARI)	Single event effects test for space semiconductor at KoBRA	July 24, 2024	^{40}Ar (16.4 Mev/u, 5 pnA)	6.2 hrs	KoBRA
J. H. Won (CENS/IBS)	Collinear laser spectroscopy of neutron-deficient Na isotopes	Nov 29 ~ Dec 3, 2024	$^{21,23}Na$ (20 keV, 1.3E6 ppb)	15 hrs	CLaSsy

KoBRA spectrometer

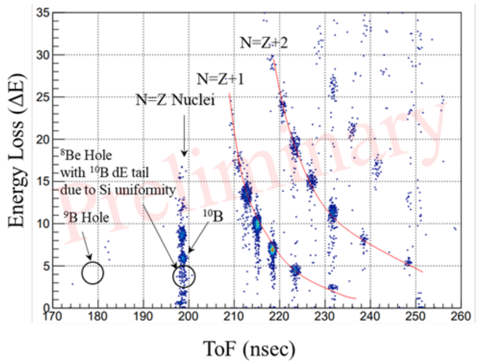
- Further commissioning and user services

- First production of low-Z RI beams **(2023)**
  - $^{40}Ar^{9+}$ beam on the graphite target
  - ✓ 2 PPACs (F2, F3): ToF measurement
  - ✓ Si SSD (F3): ΔE measurement



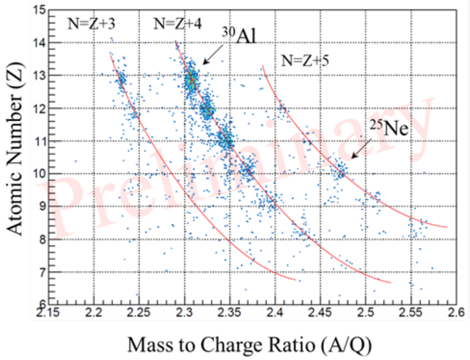


- RI beam production extended to higher-Z isotopes with $^{40}Ar^{8+}$ beam **(2024)**
  - $^{40}Ar^{8+}$ beam on the graphite target
  - ✓ PPAC (F1): Bρ measurement
  - ✓ 2 PPACs (F2, F3): ToF measurement
  - ✓ Si SSD (F3): ΔE measurement

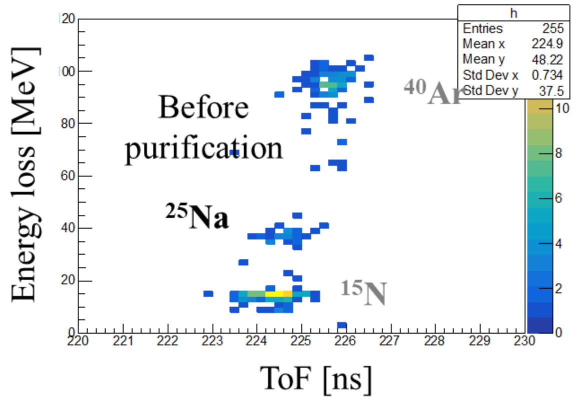


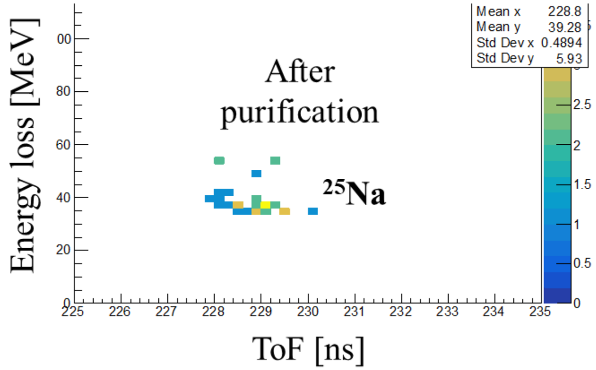
- ✓ Bρ Setting for ^{10}B
- ✓ Without F1 Al degrader & PPACs
- ✓ $\Delta p/p = 0.2\%$

- ✓ Bρ Setting for ^{25}Ne
- ✓ With F1 PPACs
- ✓ $\Delta p/p = 8\%$



- **First acceleration** of the ISOL RI beam ($^{25}Na^{5+}$) delivered to KoBRA **(2024)**
  - $^{25}Na^{5+}$ RI beam was identified and purified
  - ✓ PPAC (F1): Energy degrader
  - ✓ 2 PPACs (F2, F3): ToF measurement
  - ✓ Si SSD (F3): ΔE measurement



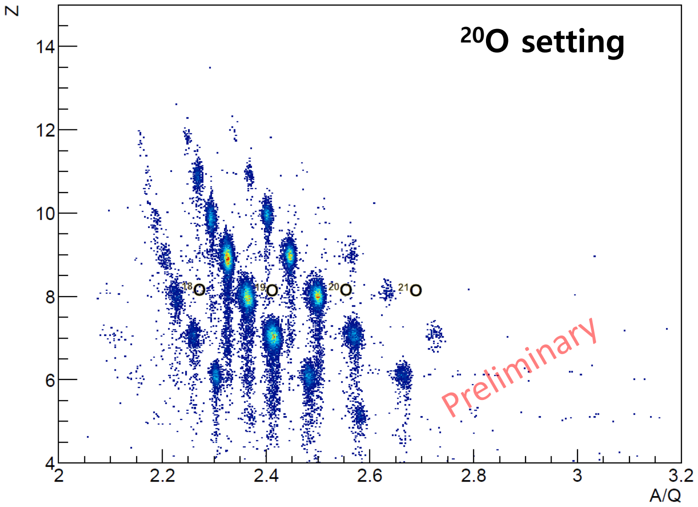


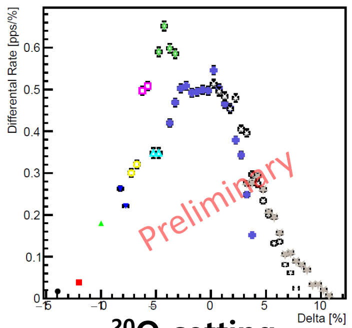
By K. Tshoo, D.G. Kim, M.S. Kwag, K.B. Lee et al. of IRIS

- First commissioning user experiments conducted with ^{40}Ar beam

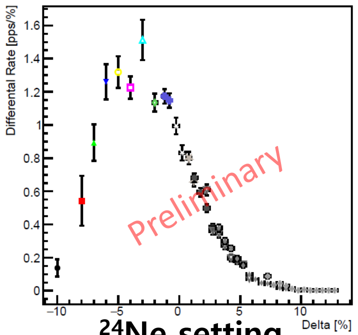
(1) Measurement of production cross section and momentum distribution (**D. S. Ahn et al., CENS**)

- ^{40}Ar beam on graphite target
- Bρ scanning for neutron-rich Oxygen ($^{16-22}$O) and Neon ($^{20-26}$Ne) isotopes





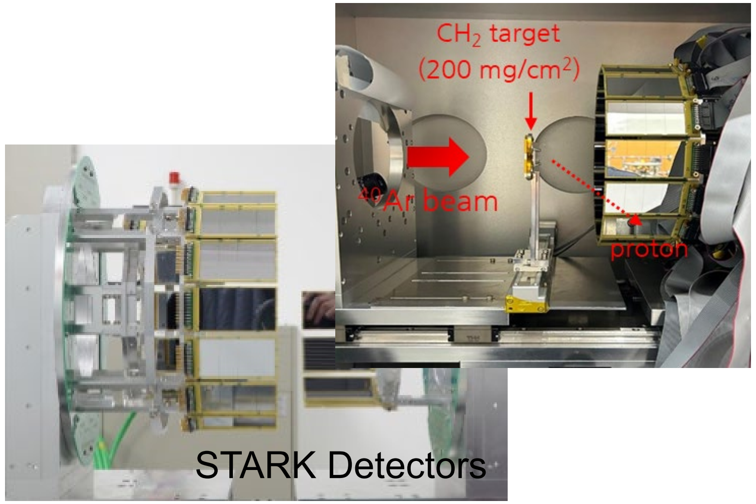
^{20}O setting

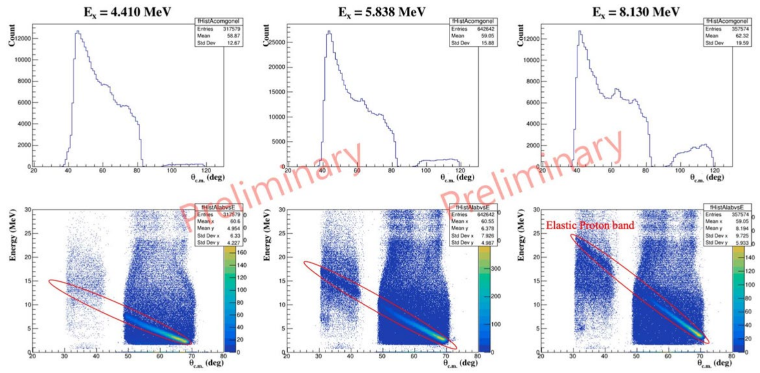


^{24}Ne setting

(2) Extraction of optical potential parameters from 40Ar(p,p) elastic scattering (**D. Kim et al., CENS**)

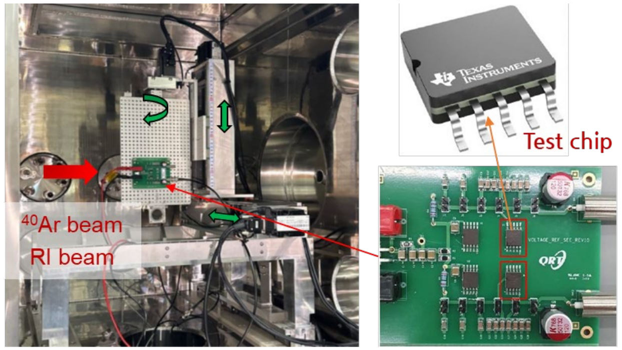
- ^{40}Ar beams at 4.4, 5.9, and 8.3 MeV/u
- CH_2 target at F3, scattered proton detection

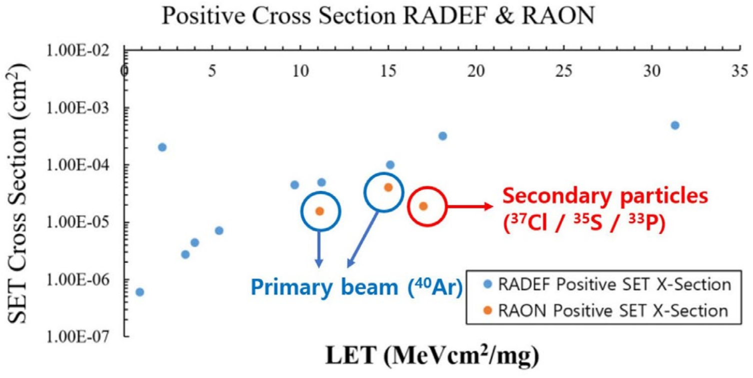




(3) Evaluate Single Event Transient (SET) effects for space semiconductors (**W. Lee et al., KARI**)

- ^{40}Ar & RI (^{37}Cl, ^{35}S, ^{33}P) beams on test chip
- SET cross section was measured with linear energy transfers (LET) by adjusting effective range of the semiconductor





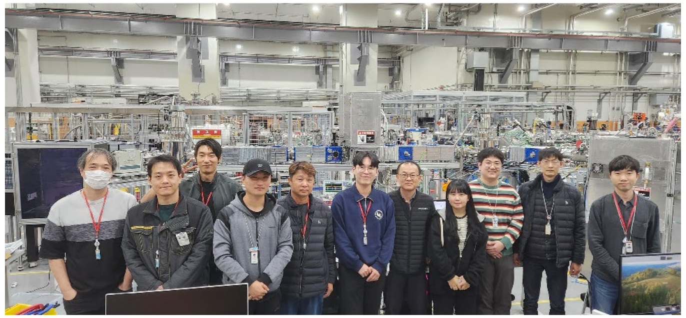
SET cross section measured vs LET

Institute for
Rare Isotope
Science

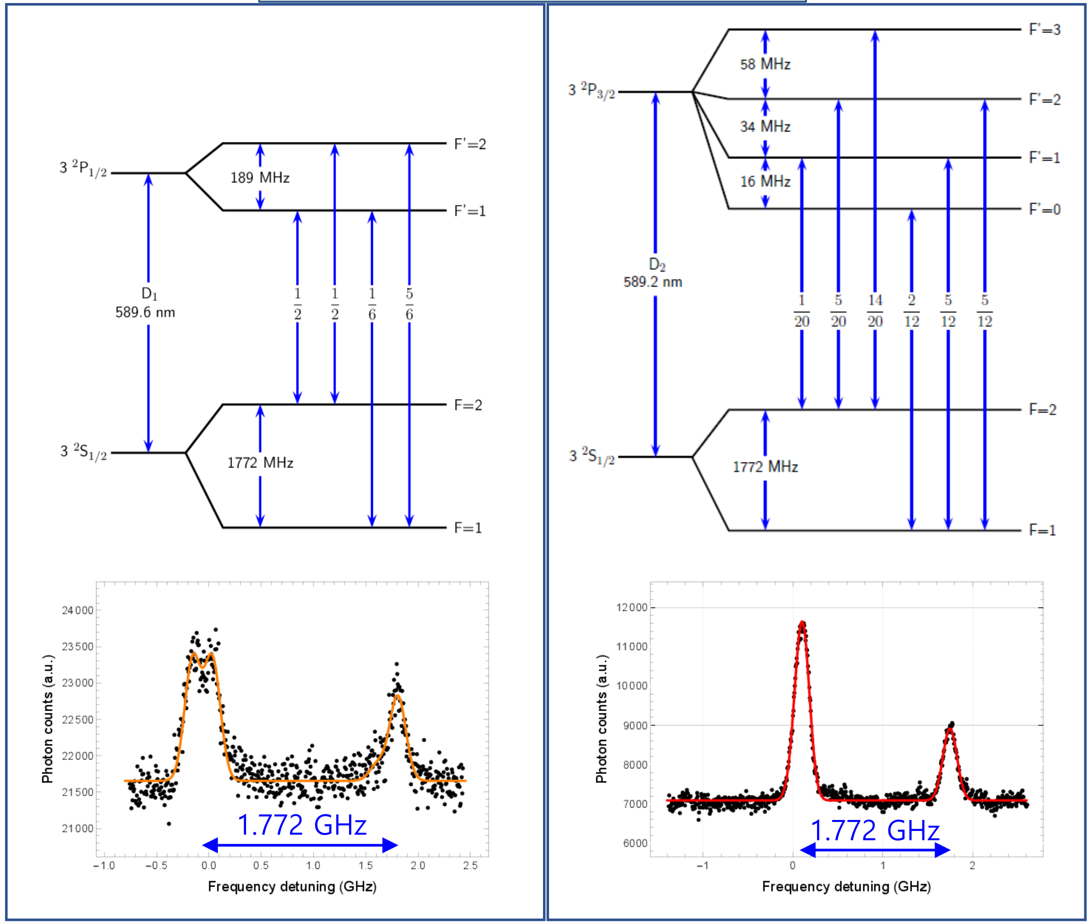
CLaSsy (Collinear Laser Spectroscopy)

▪ First commissioning user experiments in 2024

- Jung Bok Kim et al. (KNUE), "High-resolution laser spectroscopy for the study of sodium"
- Junho Won et al. (CENS, IBS), "Collinear laser spectroscopy of neutron-deficient Na isotopes"

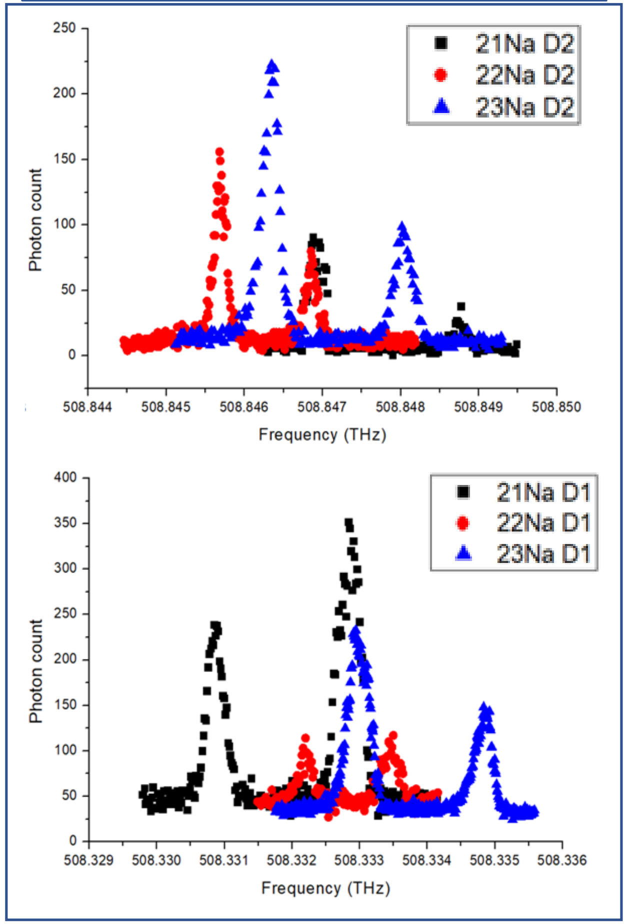


Na-23 D1 & D2 line spectrum



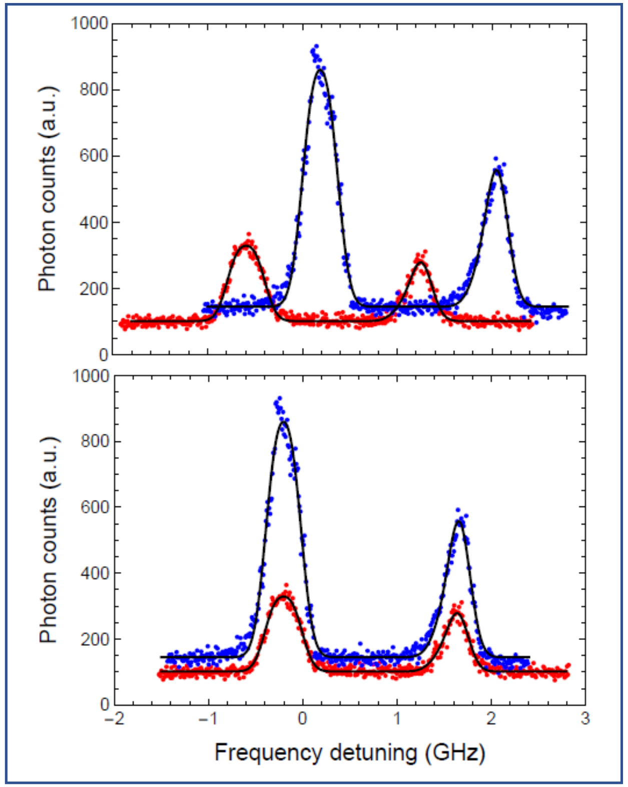
by S. J. Park and J. B. Kim et al.

Hyperfine and isotope shift of Na-21,22,23



by S. J. Park and J. Won et al.

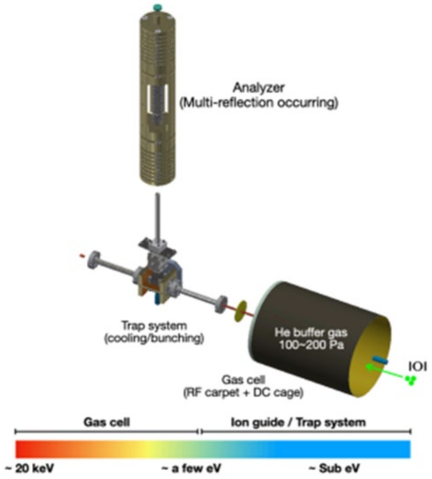
Collinear & Anti-collinear scheme



by S. J. Park

MMS (Mass Measurement System)

- Commissioning Experiments with Na and Al isotopes

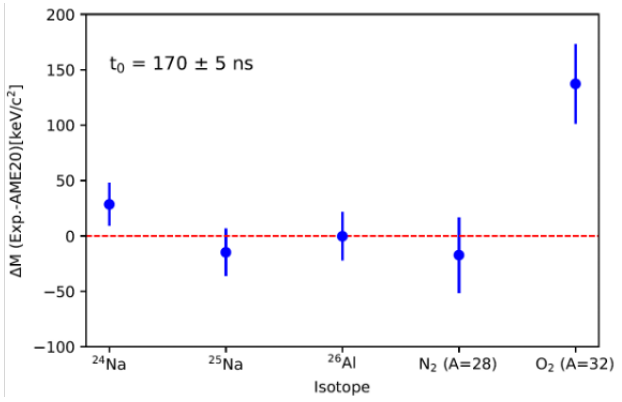


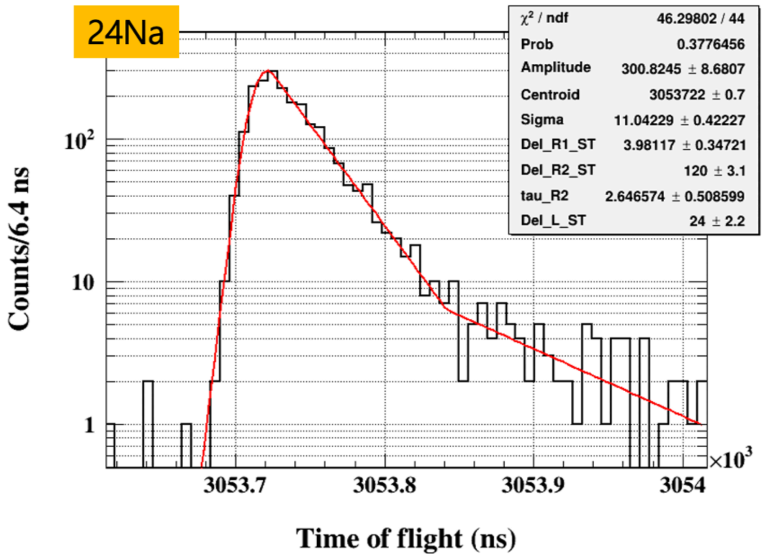
- Multiple reflections between a pair of electrostatic mirror electrodes
- Installed in the ISOL bldg and can receive RIs of E < 60 keV
- Preparation of cooled and bunched ions for MRTOF: Gas cell (P < 200 Pa, Room temp. He gas), triple-trap system

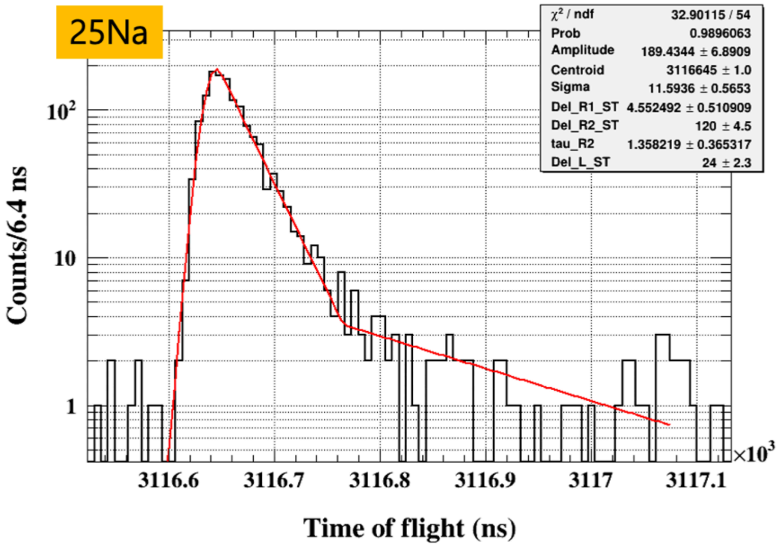
- Tested with RIs, ^{24,25}Na and ^{26g,m}Al, selected by the pre-mass separator
- Single-pass (Mass band width ~ infinite), before higher laps (n = 350 laps) for the precise measurement.
- Measured values agree with the reported ones within uncertainties.
- Achieved mass resolving power :

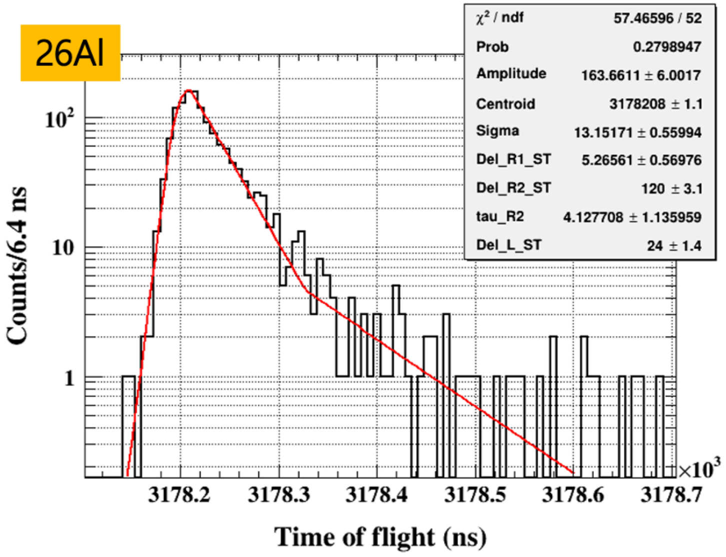
  R_m ~ 190,000

  R_m (FWHM) ~ 120,000







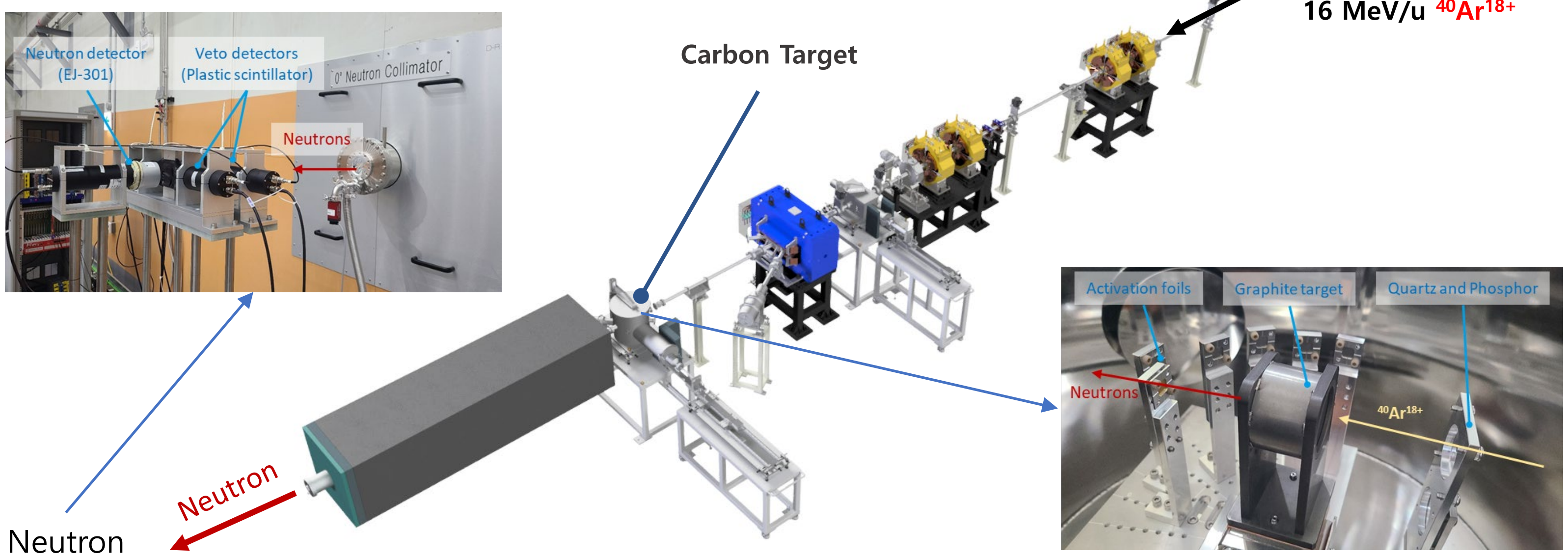


NDPS (Nuclear Data Production System)

▪ Commissioning of NDPS

Radiation Safety Inspection by KINS

- **White neutrons produced by ^{40}Ar 16.3 MeV/u from SCL3**

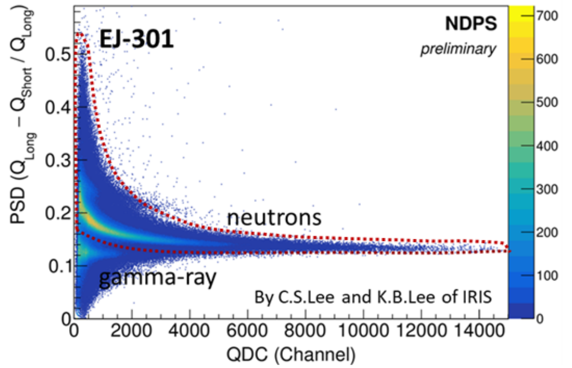


Neutron detector (EJ-301)

Activation foils at target chamber (Fe, Al, Ti, Ni, Zr, Nb, Au, Bi)

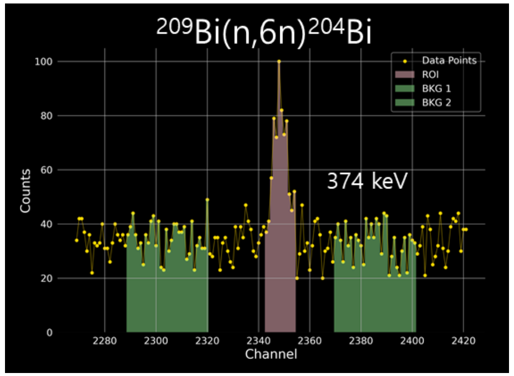
By CM Ham, G Oh of IRIS

● Neutron detection using EJ-301



- Gamma rays and neutrons were distinguished using the EJ-301 scintillator and pulse shape discrimination (PSD).

● Activation foils: Gamma rays were measured using an HPGe detector.



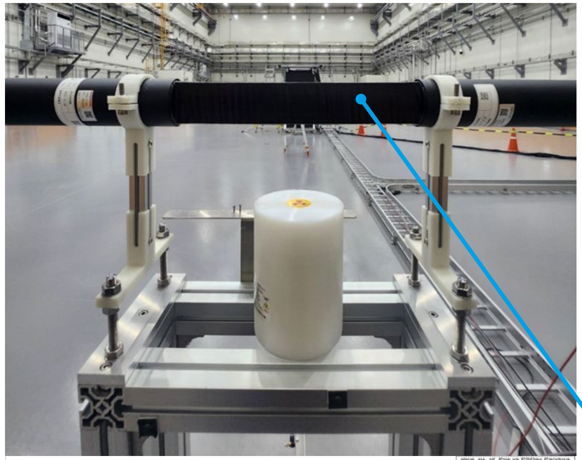
Bi foil (374 keV γ-ray from 204 Bi)

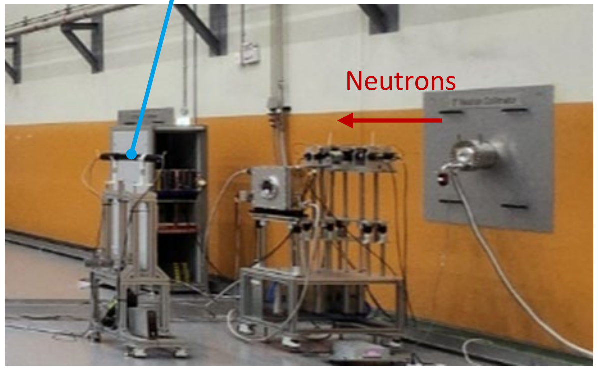
- High-energy neutrons above 40 MeV were confirmed based on the 209Bi(n,6n)204Bi reaction cross-section.

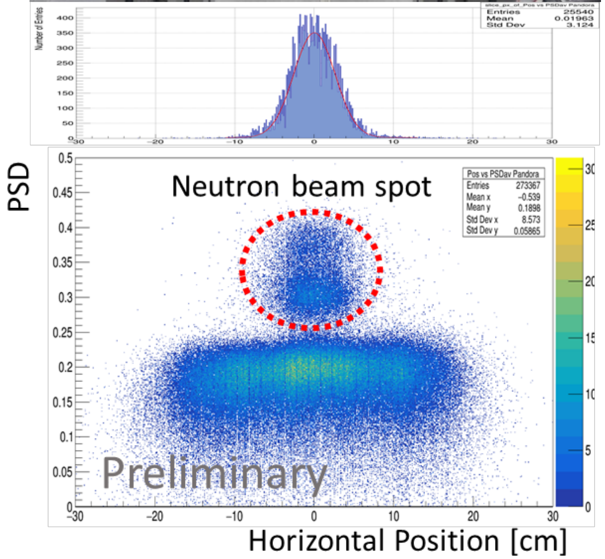
NDPS (Nuclear Data Production System)

- Neutron distribution measurement by IRIS and CENS (Courtesy of Y. H. Kim and CENS)

PSD available plastic Scintillator (PANDORA)





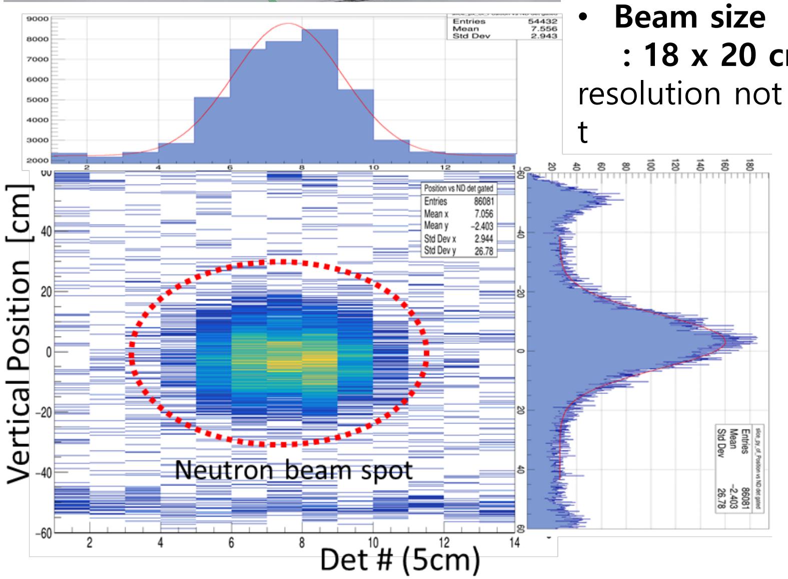


- Horizontal beam size:
  2.6 cm (in 1σ)

- EJ-276: pulse-shape discriminating (PSD) plastic scintillator enables the separation of gamma and fast neutron signals on the basis of their timing characteristics

Plastic detector arrays (LaPANE)

- Beam position
  : 5 mm off-center
- **Beam size**
  : 18 x 20 cm (FWHM),
  resolution not taken into accoun
  t



PART 4

Operation in 2025

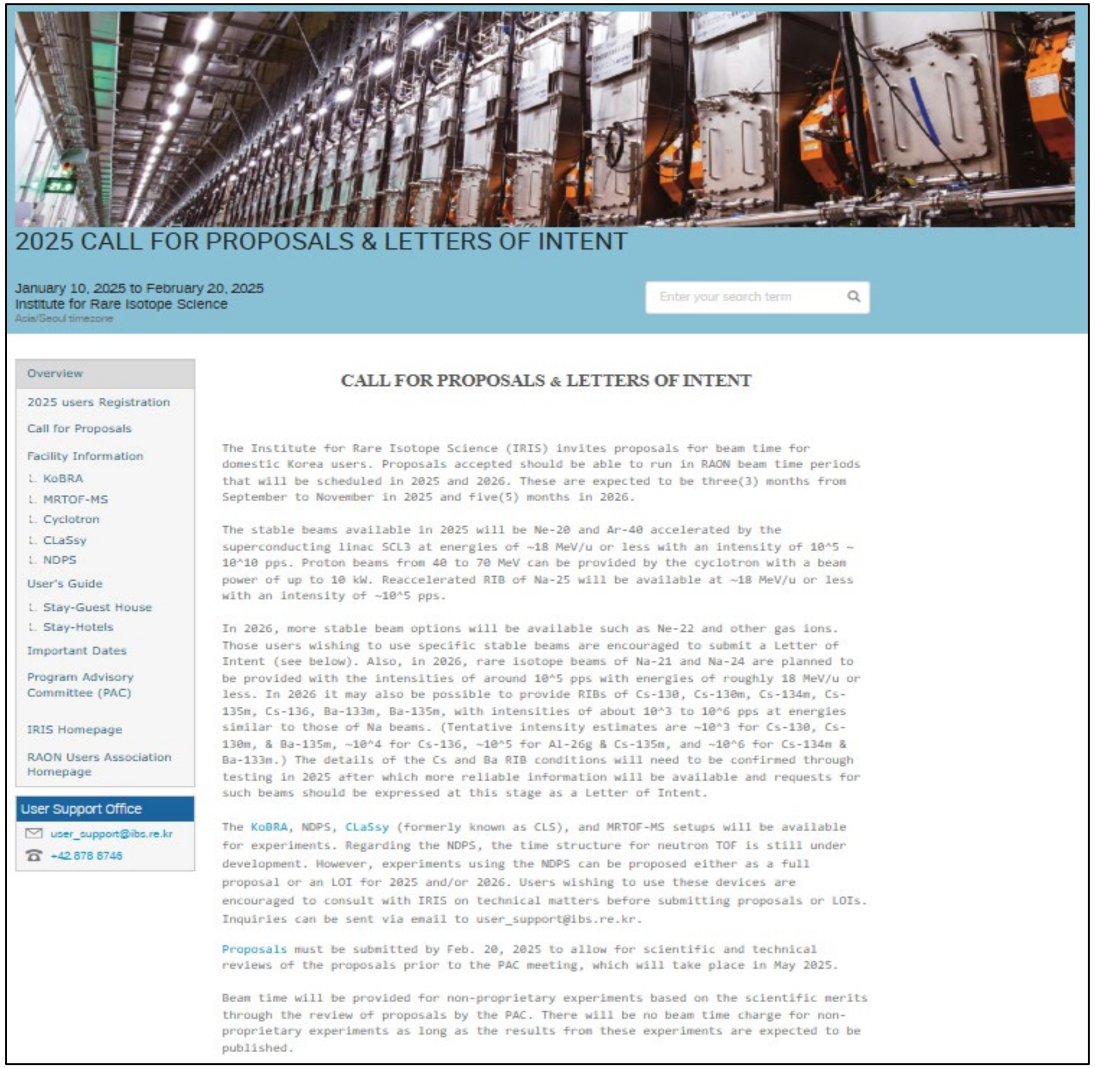
PART 5

R&D Status for SCL2

PART 6

Summary

Second Call for Proposals in 2025



2025 CALL FOR PROPOSALS & LETTERS OF INTENT

January 10, 2025 to February 20, 2025
Institute for Rare Isotope Science
Asia/Seoul timezone

Enter your search term

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  - Stay-Hotels
- Important Dates
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- IRIS Homepage
- RAON Users Association Homepage

User Support Office
user_support@ibs.re.kr
+42 878 8746

CALL FOR PROPOSALS & LETTERS OF INTENT

The Institute for Rare Isotope Science (IRIS) invites proposals for beam time for domestic Korea users. Proposals accepted should be able to run in RAON beam time periods that will be scheduled in 2025 and 2026. These are expected to be three(3) months from September to November in 2025 and five(5) months in 2026.

The stable beams available in 2025 will be Ne-20 and Ar-40 accelerated by the superconducting linac SCL3 at energies of ~18 MeV/u or less with an intensity of 10^5 ~ 10^10 pps. Proton beams from 40 to 70 MeV can be provided by the cyclotron with a beam power of up to 10 kW. Reaccelerated RIB of Na-25 will be available at ~18 MeV/u or less with an intensity of ~10^5 pps.

In 2026, more stable beam options will be available such as Ne-22 and other gas ions. Those users wishing to use specific stable beams are encouraged to submit a Letter of Intent (see below). Also, in 2026, rare isotope beams of Na-21 and Na-24 are planned to be provided with the intensities of around 10^5 pps with energies of roughly 18 MeV/u or less. In 2026 it may also be possible to provide RIBs of Cs-130, Cs-130m, Cs-134m, Cs-135m, Cs-136, Ba-133m, Ba-135m, with intensities of about 10^3 to 10^6 pps at energies similar to those of Na beams. (Tentative intensity estimates are ~10^3 for Cs-130, Cs-130m, & Ba-135m, ~10^4 for Cs-136, ~10^5 for Al-26g & Cs-135m, and ~10^6 for Cs-134m & Ba-133m.) The details of the Cs and Ba RIB conditions will need to be confirmed through testing in 2025 after which more reliable information will be available and requests for such beams should be expressed at this stage as a Letter of Intent.

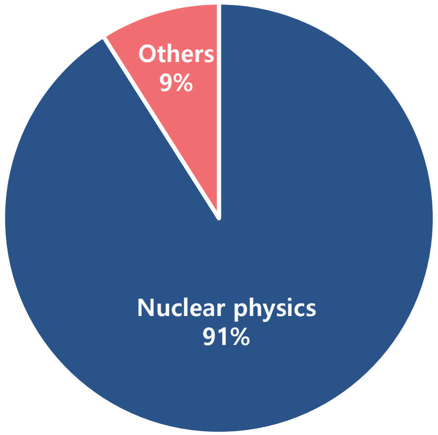
The KoBRA, NDPS, CLaSsy (formerly known as CLS), and MRTOF-MS setups will be available for experiments. Regarding the NDPS, the time structure for neutron TOF is still under development. However, experiments using the NDPS can be proposed either as a full proposal or an LOI for 2025 and/or 2026. Users wishing to use these devices are encouraged to consult with IRIS on technical matters before submitting proposals or LOIs. Inquiries can be sent via email to user_support@ibs.re.kr.

Proposals must be submitted by Feb. 20, 2025 to allow for scientific and technical reviews of the proposals prior to the PAC meeting, which will take place in May 2025.

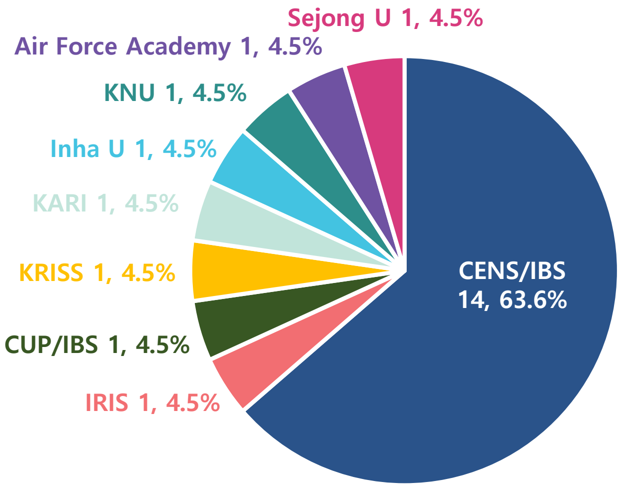
Beam time will be provided for non-proprietary experiments based on the scientific merits through the review of proposals by the PAC. There will be no beam time charge for non-proprietary experiments as long as the results from these experiments are expected to be published.

- From Jan. 9, 2025 ~ Feb. 20, 2025 (6 weeks)
- For domestic users
- 22 Proposals & 8 LoIs (28 in Nuclear physics and 2 in applications)
- 429 participants
- 7 institutions

Research areas



Institutions which submitted proposals



SCL3 Operation Plan (2025 ~ 2026)

2024 | 2025 | 2026

12 1 2 3 4 5 6 7 8 9 10 11 12 1 2 3 4 5 6 7 8 9 10 11 12

SCL3 Operation

- SCL3 Cryoplant Overhaul (3 yr)
- SCL3 cool down / RF Cond./Control / Beam Tuning
- Beam to Exp. (>300 hrs)
- Break
- Machine Study
- Beam to Exp. (500 hrs)
- Warm Up
- Maintenance

- Results of the PAC review have been released.
- Beam time scheduling will be discussed with users.

PART 5

R&D Status for SCL2

PART 6

Summary

SCL2 (High energy section)

Phase 1 (2011 ~2022)

1st Prototyping of SSR
Fabrication & Test

- Verification of 1st prototype SSR Production
- Verification of 1st prototype SSR Assembly
- Vertical Test / Horizontal Test

R&D Stage (2023~2027)

2nd Prototyping of SSR
Fabrication, Test & Standardization

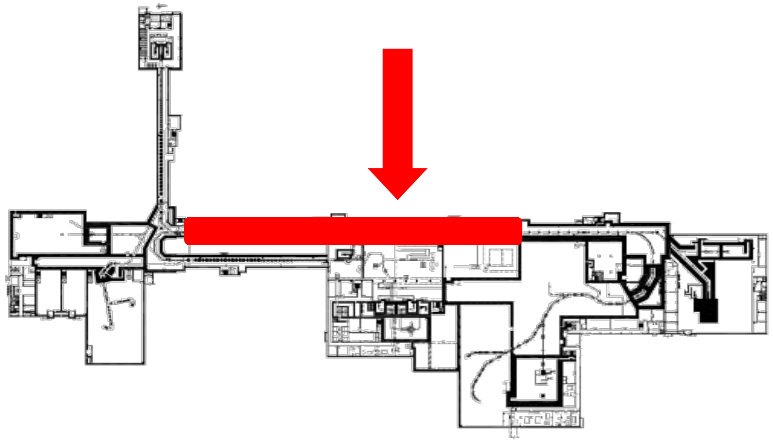
- Production of SSR1 and SSR2 Cryomodules
- Performance Test : Vertical and Horizontal Test
- Verification for Mass-production
- Standardization of fabrication/surface treatment/assembly
- New design of HWR type is also being done.

2nd Stage (2028~)

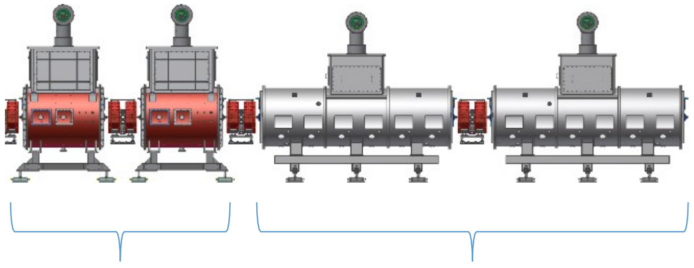
Mass Production

- Production of 23 SSR1 CMs, 25 SSR2 CMs
- Performance Test (VT/HT)
- Installation in tunnel & beam commissioning

Length	180 m (SSR1 160 m, SSR2 120 m)
Beam energy (for uranium)	(Input) 18.5 MeV/u (Output) 200 MeV/u
Specification	β = 0.32 (SSR1), 0.51 (SSR2) RF frequency = 325 MHz



SCL2 Layout



PART 6

Summary

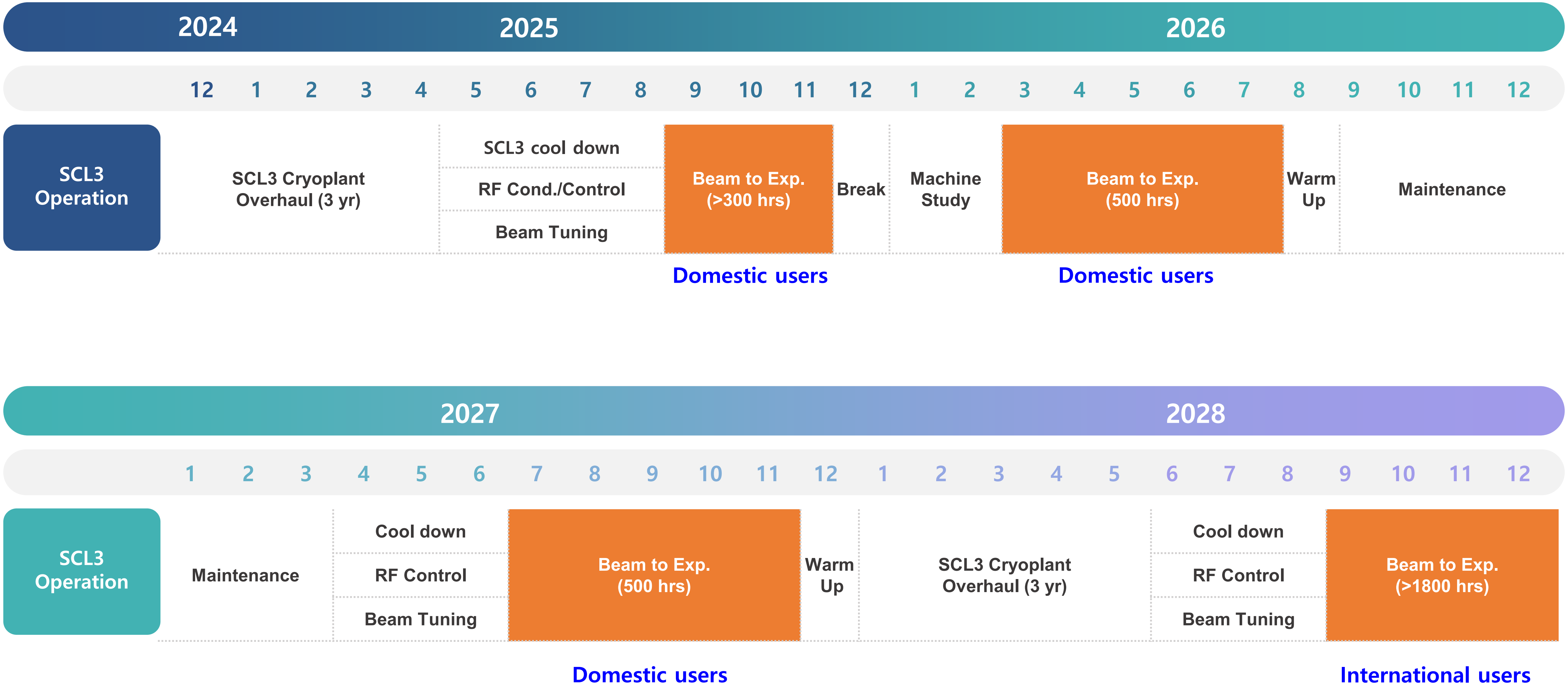
Oral

Mon 20/10, 13:00 – 13:30, **T. SHIN**, "RIB production & Overview of RAON"
Tue 21/10, 09:40 – 10:00, **Jaehyun Song**, "Online commissioning and current status of CLaSsy at RAON"
Fri 24/10, 08:30 – 09:00, **Do Gyun Kim**, "Beam Commissioning and First User Experiments at the RAON Low-Energy Experimental Systems"

Poster

Tue 21/10, 18:00 – 20:00,
Sung Jong Park, "High-resolution collinear laser spectroscopy in a combined collinear and anti-collinear geometry"
Ha-Na Kim, "Current Status of Laser Ion Source Development at RAON"
Seongjin Heo, "Status of RFQ Cooler Buncher for rare isotope experiments with Isotope Separation On-Line system"
Jinho Lee, "Status of Rare Isotope Beam Operation at RAON"

SCL3 Operation Plan (2025 ~ 2028)



Summary

- **SC Linac (SCL3)** : commissioning done (E = from a few MeV/u to ~20 MeV/u)
- **ISOL system** : commissioning done with $^{25}Na^{5+}$ at 16.4 MeV/u (SiC, TiC, Ta, LaC_2, ThC_2, UC_X)
- **KoBRA spectrometer** : commissioning done (Secondary isotopes produced and identified)
- **NDPS, MMS (MR-TOF) and CLaSsy** : commissioning done
- First call for proposals among domestic users in Dec. 2023 (30 proposals submitted)
- **First PAC** in March 2024
- **First commissioning user services** in 2024 (Five experiments done: **KoBRA, CLaSsy**)
- Second call for proposals/LOIs in Jan 2025 ~2026 (22 Proposals and 8 LoIs)
- **Second PAC** in May 2024
- **Many issues and challenges, but we are learning and making progress.**
- Plan to **request LOIs from international users** in **2026**. (Possibly, organizing a RAON Users Workshop.)
- Plan to **call for proposals from international users** in **2027** (PAC in 2027)
- Will **provide beams to international users in the latter half of 2028**.

Special thanks to

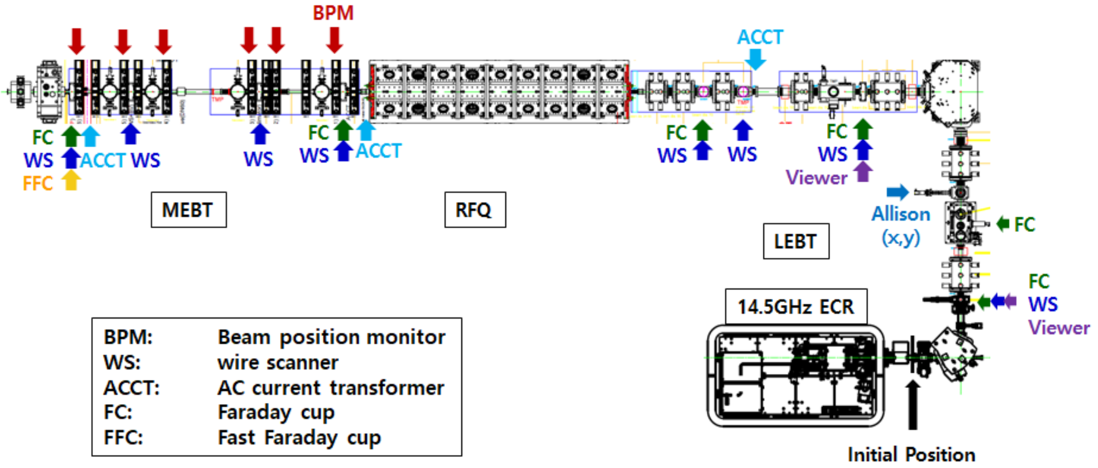
and many other institutes for international collaboration


Thank You
본부동 Headquarters Building

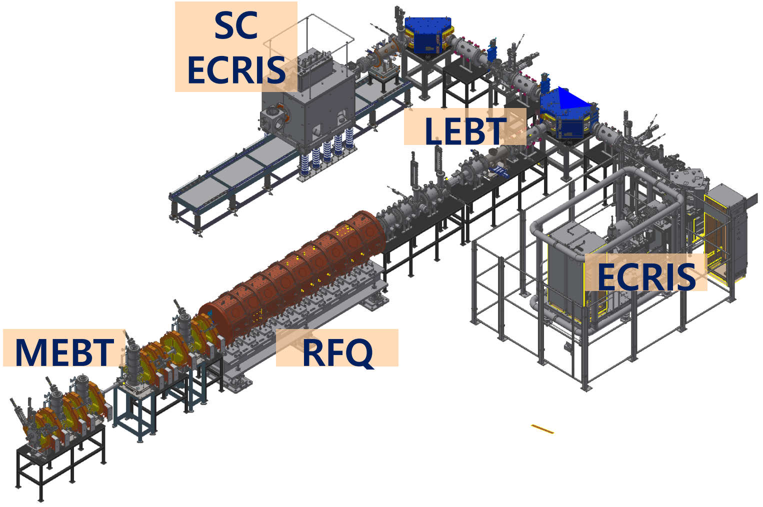
Accelerator System: Injector

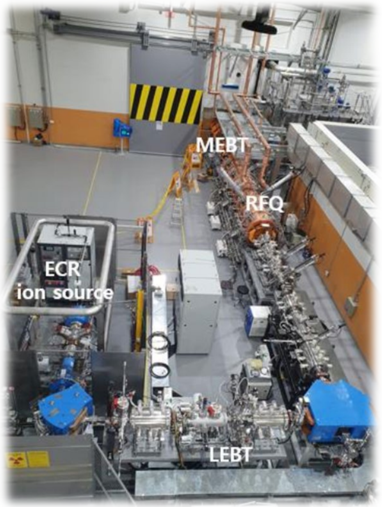
- **Two ECR-IS on high voltage platforms**
  - 14.5 GHz ECR ion source
  - 28 GHz superconducting ECR ion source
- **LEBT (E = 10 keV/u)**
  - 10 keV/u, Dual bending magnet
  - Chopper & Electrostatic quads, Instrumentation
- **RFQ (E = 500 keV/u)**
  - 81.25 MHz, Transmission Eff. ~98%
  - CW RF Power 94 kW (SSPA: 150 kW)
- **MEBT (E = 500 keV/u)**
  - Four RF bunchers (SSPA: 20, 15, 2×4 kW)
  - Simple quadrupole magnets, Instrumentation

[Beam Diagnostics in injector]



Ion	Argon	Neon	Oxygen	Helium	Proton
A (Q)	40 (8, 9, 11)	20 (4)	16 (6)	4 (2)	1 (1)
Current [μA]	50, 30, 50	40	40	50	50~160





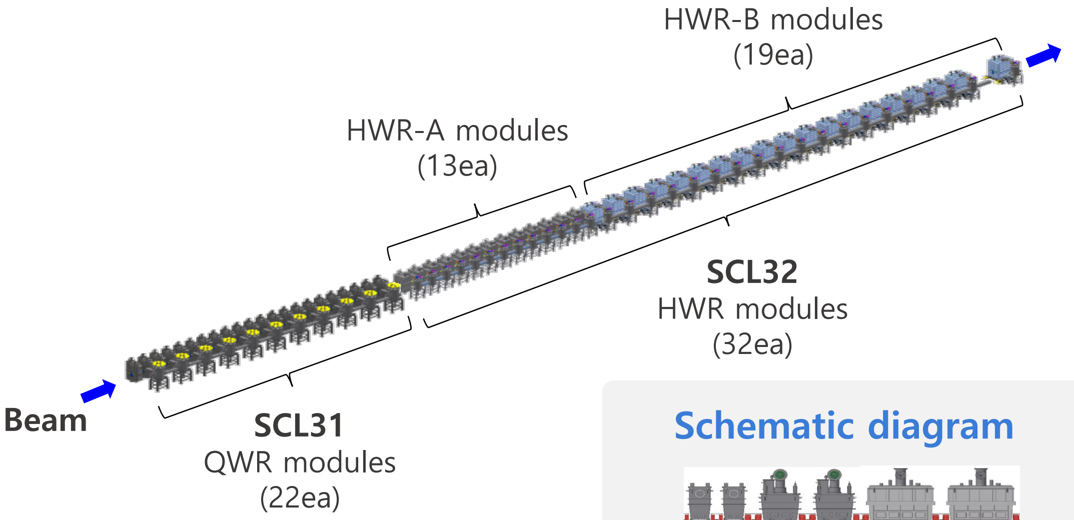
- **Injector:** 14.5 GHz and 28 GHz ECR (10keV/u)
  LEBT (charge selection, matching)
  RFQ (507 keV/u, 98% transmission),
  MEBT (matching)

Accelerator System: Superconducting Linac (SCL3 & SCL2)

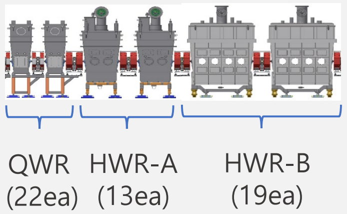
※ SCL1 is postponed.

Injector				SC Linac					IF	
	0.01 MeV/u	0.5 MeV/u			18 MeV/u			200 MeV/u	for Uranium	
ECR	LEBT	RFQ	MEBT	SCL3-1	SCL3-2	CSS	SCL2-1	SCL2-2	HEBT	IF
ISOL -> LEBT				β=0.049	β=0.13		Under development			

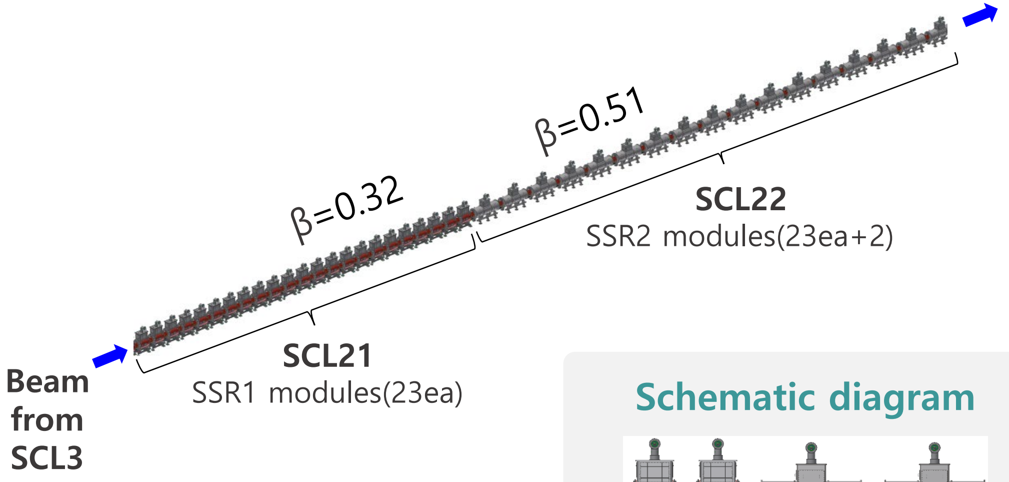
SCL3



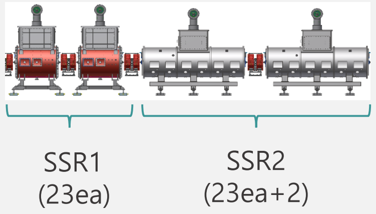
Schematic diagram



SCL2



Schematic diagram



Accelerator tunnel (SCL3)

ISOL Beam Operation Plan

	Target Material	Isotopes	Ion Source	Expected yields (pps) at Exp. Hall (with a 1 kW proton beam)	
2025	SiC	$^{20-26}$Na, ^{26}Al	SIS	4.0E+06 ~ 1.9E+09 / > 6.5E+05 (measured)	
		$^{17-20}$F	FEBIAD	4.5E+05 ~ 2.2E+07	
		$^{22, 23, 27}$Mg $^{24-26, 28, 29}$Al	RILIS	2.3E+06 ~ 3.8E+08 8.0E+07 ~ 9.3+E09	
2026~	TiC	$^{18, 19, 23}$Ne $^{37, 41}$Ar, $^{38, 42, 43}$K	FEBIAD	1.8E+05 ~ 1.3E+07 5.0E+05 ~ 3.4E+07 4.2E+06 ~ 3.4E+07	SiC, LaC2, Ta targets will also used
	ThCx, UCx	Kr, Sr, Ag, Sn, Xe, Cs, etc	SIS / FEBIAD / RILIS		

Beam schedule and experiments

['24.5~8] SCL3 SIB and RIB Operation : 40Ar8+, 25Na5+ (A/q = 5.0)

- [IRIS] KoBRA beam commissioning experiment
- [IRIS] NDPS beam commissioning experiment
- [IRIS] Radiation Safety inspection experiment
- [PAC] [KO-24-30] Measurement for production cross section and momentum distribution of projectile fragmentation
- [PAC] [KO-24-22] Single event effects test for space semiconductor at KoBRA
- [PAC] [KO-24-21] 40Ar + p elastic scattering experiment for a study of optical model potential
- [PAC] [KO-24-26] Coulomb excitation of 181Ta and 197Au with 40Ar (postponed to 2025 due to schedule conflict)
- [IRIS] SCL3-KoBRA beamline Rebuncher beam commissioning experiment(SAT)
- [IRIS] ISOL RIB(25Na5+) post-acceleration experiment using SCL3
- [IRIS] SCL3 Machine Study

- Call for Proposals ('23.12.12~'24.1.19)
- 1st PAC ('24.3.7~3.8)

['24.10~12] ISOL 21,22Na RIB Operation

- [IRIS] ISOL Colinear Laser Spectroscopy(CLS, now named as CLaSsy) beam commissioning experiment
- [PAC] [CL-24-12] High-resolution laser spectroscopy for the study of sodium
- [PAC] [CL-24-16] Collinear laser spectroscopy of neutron-deficient Na isotopes

RAON Glossary

IBS

Institute for Basic Science

RISP

Rare Isotope Science Project

RAON

Rare isotope Accelerator complex for ON-line experiments

IRIS

Institute for Rare Isotope Science

RAON Glossary

IBS

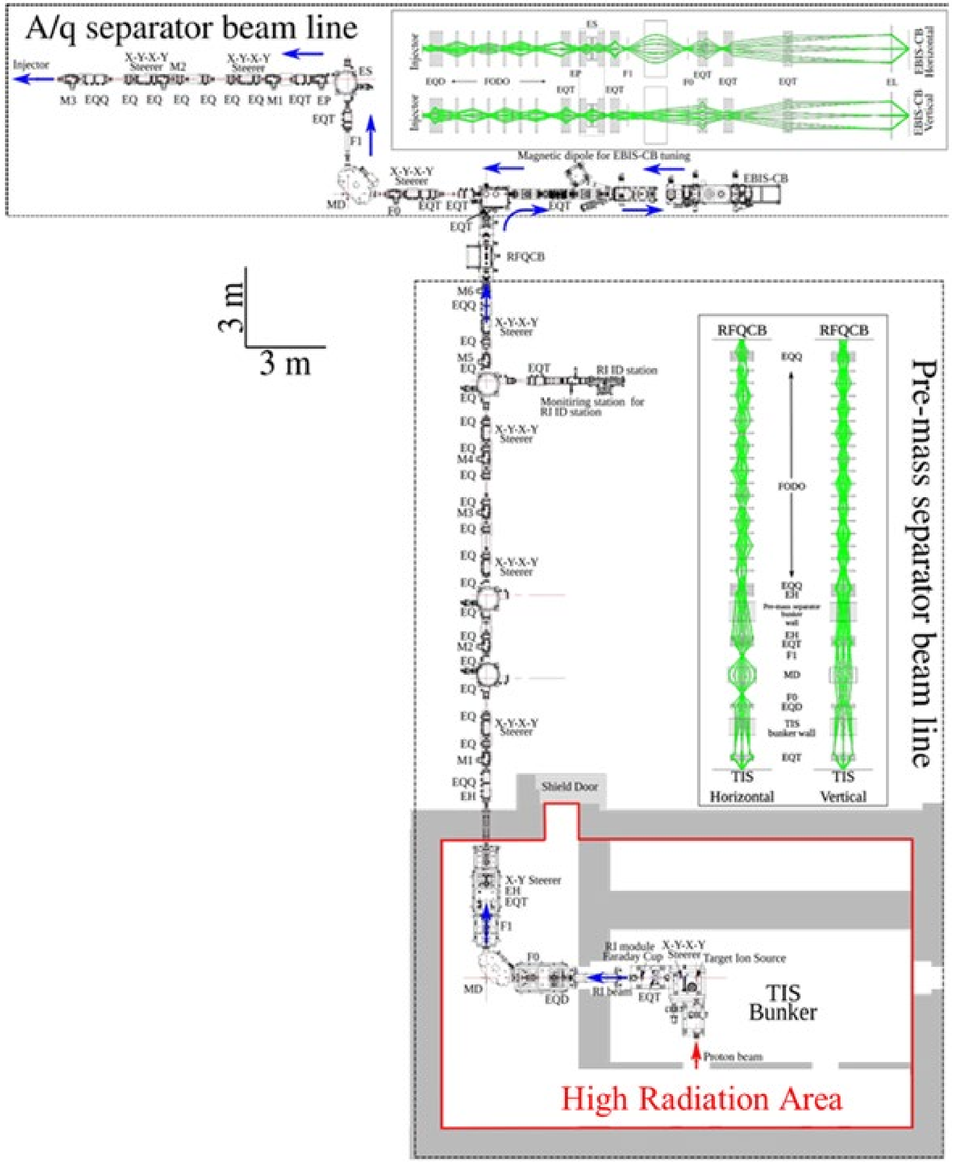
Institute for Basic Science

IRIS

Institute for Rare Isotope Science

RAON

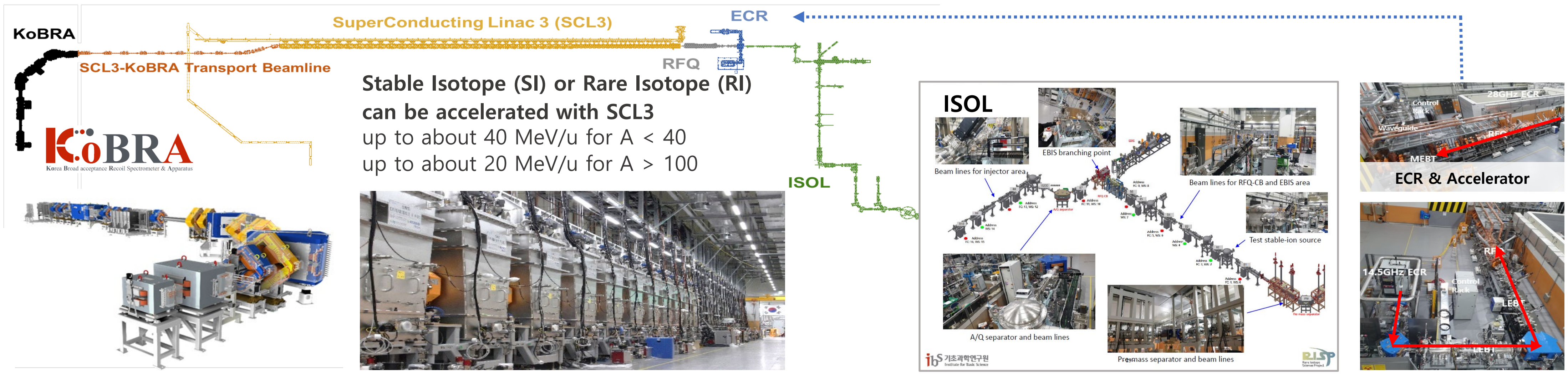
Rare isotope Accelerator complex
for ON-line experiments



A/q separator beam line
Injector
X-Y-X-Y Steerer
M2
M3
EQQ
EQ
M1
EQT
EP
ES
F1
MD
F0
Magnetic dipole for EBIS-CB tuning
EBIS-CB
EBIS-CB Horizontal
EBIS-CB Vertical
FODO
EQD
EL
RFQCB
3 m
3 m
Pre-mass separator beam line
M6
M5
M4
RI ID station
Monitiring station for RI ID station
EH
Shield Door
X-Y Steerer
RI module
Faraday Cup
Target Ion Source
RI beam
TIS Bunker
Proton beam
High Radiation Area
TIS Horizontal
TIS Vertical
Pre-mass separator bunker wall
TIS bunker wall

KoBRA (Korea Broad acceptance Recoil Spectrometer & Apparatus)

Multi-purpose experimental instrument using stable/rare isotope beams at **low energy of 1 - 40 MeV/u including Fermi energy regime** for the purpose of nuclear physics studies such as **nuclear structure/astrophysics, and multi-nucleon transfer reaction**



- **(Current) RI beam production at a few MeV/u or at about 20 – 40 MeV/u with stable or rare isotope beams using ECR source or ISOL system**
- (Future extension*) Recoil mass separator for experiments requiring very precise mass resolution (mass resolving power, m/Δm ≈ 750)
  - Such as direct measurements of radiative-capture cross sections at less than a few MeV/u

  ※ Under discussion for detailed concept with RAON Users Association

SCL2 R&D Project

SSR1 Balloon-type

Design(engineering) is led by IRIS, while the manufacturing process development is carried using domestic companies('24.1)

※ Focus on managing process risks and schedules throughout the entire process, including the manufacturing company's Ti-Nb bonding process development and accelerator tube fabrication, to enhance success rates without additional delays.

SSR2 Cylinder-type

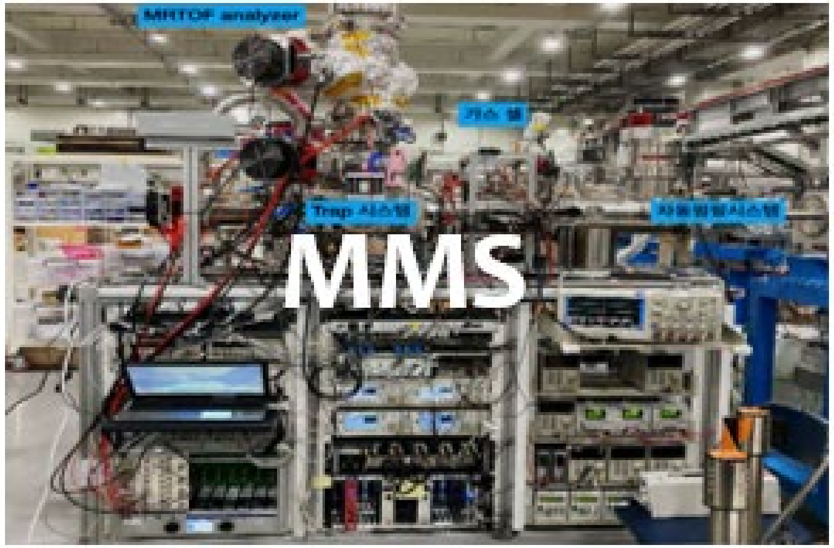
Considering the high technical complexity, maximize the use of external resources (such as services) from engineering design to manufacturing.

※ Utilize external institutions while maintaining close collaboration throughout the entire process to ensure thorough risk management and secure essential technologies


IF Separator
Institute for
Rare Isotope
Science

NDPS

CLS

muSR

MRTOF analyzer
MMS

LAMPS

BIS

Issues : Energy of beams

In 2023, first commissioning with $^{40}Ar^{9+}$

Beam energy from TRACK : 17.2 MeV/u

TOF with 2 BPMs : 16.3 MeV/u

Bending magnet before KoBRA: 16.1 MeV/u

* Due to the uncertainties in the beam phase measurement, orbit corrections and some changes of RF reference.

In 2024, beam services for users with $^{40}Ar^{8+}$

Beam energy from TRACK : 18.5 MeV/u

TOF with 2 BPMs : 16.5 MeV/u

Bending magnet before KoBRA : 16.2 MeV/u

Bending magnet of KoBRA : 16.4 MeV/u

TOF with 2 phase probes : 16.3 MeV/u

* We still have differences between the measured beam energies and TRACK results mainly due to the uncertainties in the phase measurement

In 2025, beam energies will be studied and better determined before the user service!

ISOL operation plan for 2025, 2026, and 2027

2025 – 2026

Cyclotron		2025.1 – 2025.11	Proton Beam → ISOL
Cyclotron		2025.12 – 2026.2	Maintenance
Cyclotron		2026.3 – 2026.7	Proton Beam → ISOL (beam power ramp-up)
Cyclotron		2025.7 – 2025.11	Build of Beam Irradiation Device
Cyclotron		2026.3 – 2026.7	p-beam irradiation test / Medical RI study
ISOL		2025.1 – 2025.8	Beam operation & ISOL beam → CLS/MMS
ISOL		2025.9 – 2025.11	ISOL beam Exp.
ISOL		2026.3 – 2026.7	ISOL beam Exp.
ISOL	Ion source	2025.1 – 2025.6	RILIS
ISOL	Ion source	2025.7 – 2025.11	SIS / FEBIAD
ISOL	Ion source	2026.3 – 2026.7	SIS / RILIS / FEBIAD
ISOL	Target / beam power	2025.1 – 2025.11	SiC, TiC / 1 kW
ISOL	Target / beam power	2026.3 – 2026.7	SiC, TiC, Ta target / 2~3 kW

2026 – 2027

Cyclotron		2026.8 – 2026.11	Proton Beam → ISOL (beam power ramp-up)
Cyclotron		2026.12 – 2027.2	Maintenance
Cyclotron		2027.3 – 2027.11	Proton Beam → ISOL (beam power ramp-up)
Cyclotron		2026.8 – 2026.11	p-beam irradiation test / Medical RI study
Cyclotron		2027.3 – 2027.11	p-beam irradiation
ISOL		2026.8 – 2026.11	U-target test
ISOL		2027.3 – 2027.6	Beam operation
ISOL		2027.7 – 2027.11	ISOL beam Exp.
ISOL	Ion source	2026.8 – 2026.11	SIS / RILIS / FEBIAD
ISOL	Ion source	2027.3 – 2027.11	SIS / RILIS / FEBIAD
ISOL	Target / beam power	2026.8 – 2026.11	UCx target / < 1 kW
ISOL	Target / beam power	2027.3 – 2027.11	UCx / 1 kW + non-actinide target / 5 kW