Development of the Collinear Laser Spectroscopy system in RAON

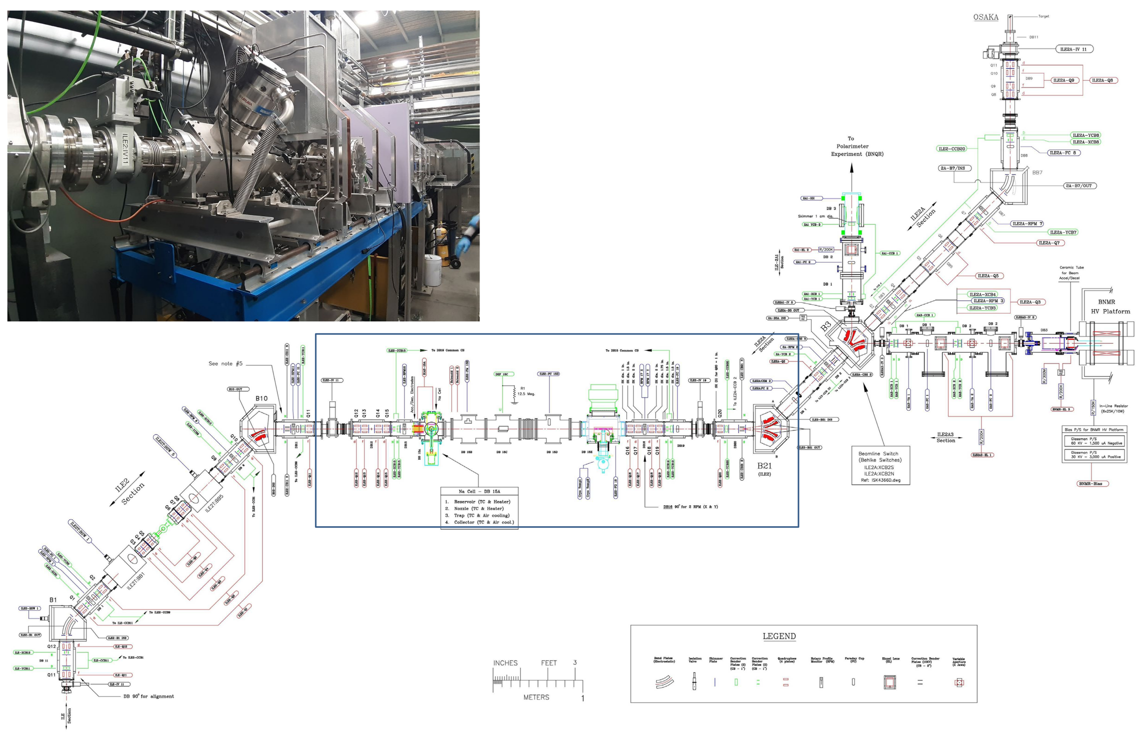
S. G. Jo[1], S. J. Park [1], J. H. Kim [1], S. Choi [2], D.-H. Kwon[3], G. D. Kim[4], R. LI[5], J. Lee[1], J. B. Kim[2], J. Lassen[5]

[1] RISP (Rare Isotope Science Project), IBS (Institute for Basic Science),
[2] Korea National University of Education (KNUE),
[3] Nuclear Physics Application Research Division, Korea Atomic Energy Research Institute (KAERI),
[4] Department of Accelerator Science, Korea University (KU),
[5] TRIUMF - Canada's particle accelerator centre

EMIS 2022

Introduction

❖ Laser polarizer in TRIUMF



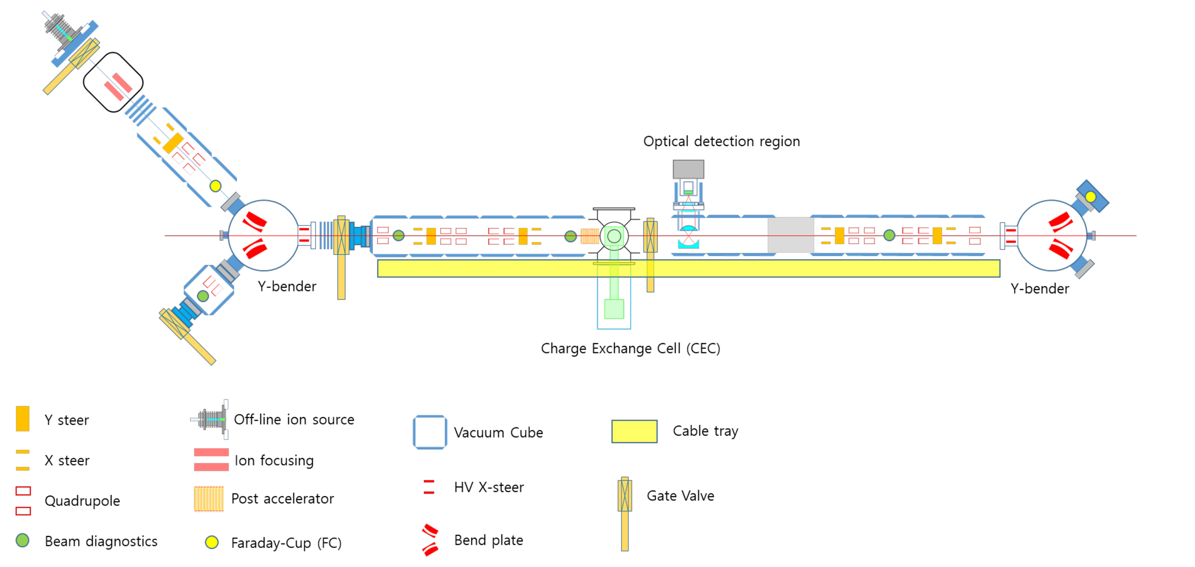
- Motivation
  - Collinear Laser Spectroscopy (CLS) has been developed as a method that can infer fundamental nuclear properties using laser spectroscopy technology at a rare isotope accelerator facility.
  - RAON CLS is one of the core applications of RAON and is in the process of producing at TRIUMF in Canada.
  - TRIUMF's ISAC facility has been performing β-NMR and β-NQR (Nuclear Quadrupole Resonance) experiments by polarizing nuclear spin, and an optical pumping method is used to polarize nuclear spin.
  - The optical pumping method can polarize the nucleus by irradiating a laser beam to a rapidly moving ion/atom beam. For this, a polarizer based on the CLS system used in the accelerator facility is used.
  - The figure shows the polarizer beamline of TRIUMF, and part of this device is similar to the CLS system planned by RAON.
  - TRIUMF is developing a polarizer for use in the ARIEL facility by upgrading the beamline used in the existing ISAC facility.
  - The RAON CLS system is being manufactured based on the polarizer of the ISAC facility as shown in the figure and is manufactured with the same specifications as the upgraded laser spectrometer to be used in the ARIEL facility.

- Ion beam path at the polarizer

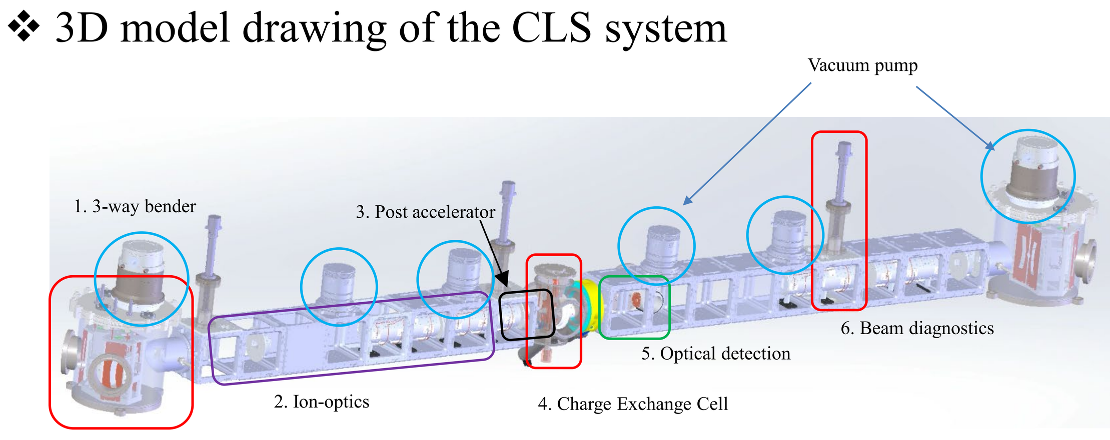
  Beam bending (ion optics) → post accelerator → charge exchange cell → polarizing section → re-ionizer → beam bending to the experimental system

Schematic images of the CLS system

❖ Schematic image of the CLS system



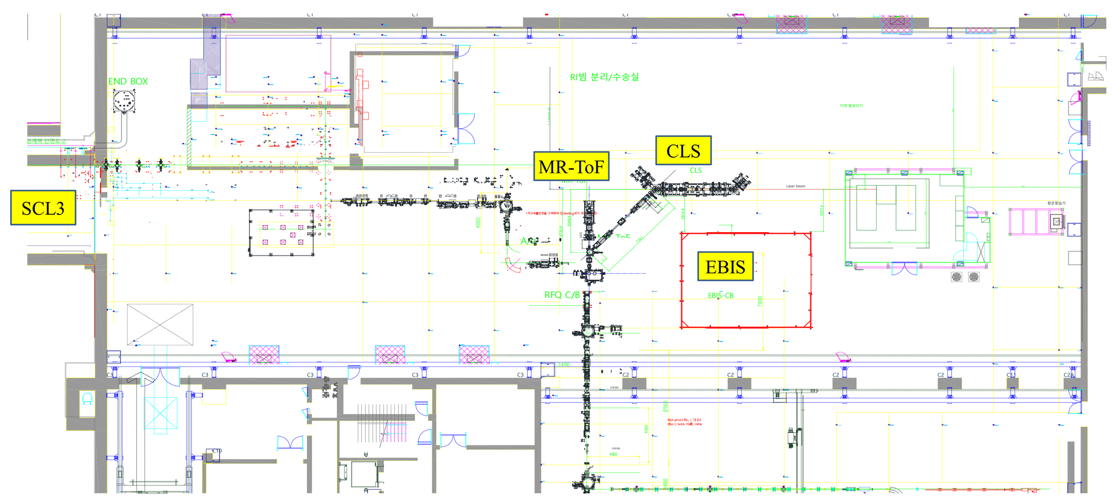
❖ 3D model drawing of the CLS system



1. 3-way bender: bends the path of Ion-Beam (IB) to overlap with a laser beam
2. Ion-optics: control the shape and path of the IB by electric fields
3. Post accelerator: control the IB velocity by applying an electric field (±10 kV) to IB for Doppler tuning
4. Charge Exchange Cell: Neutralize an IB into an atomic beam
5. Optical detection: Measure the fluorescence signal
6. Beam diagnostics: Faraday-Cup (measurement a charge of IB) + Beam profile monitor (measurement a shape of IB)

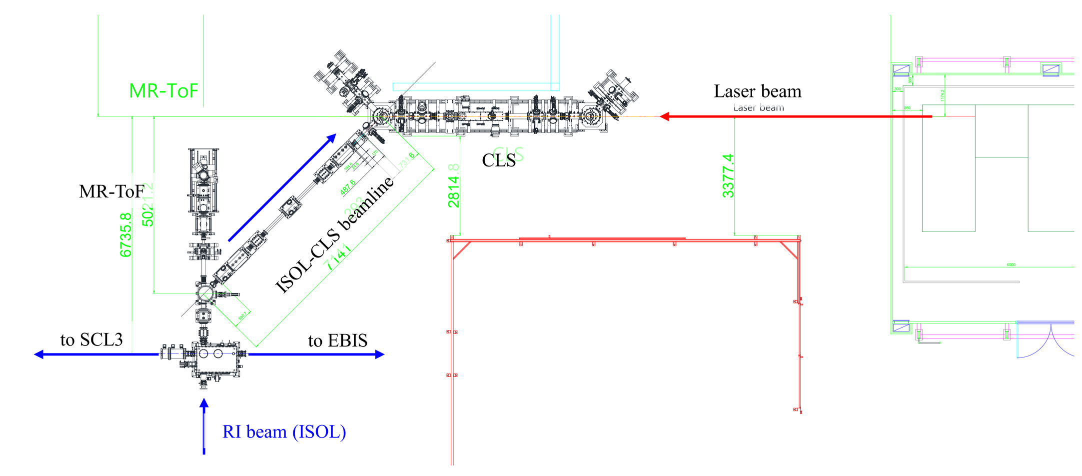
Align plan of the CLS system in RAON

❖ ISOL basement - RI beam separation transport room



- The CLS system in ISOL experimental hall

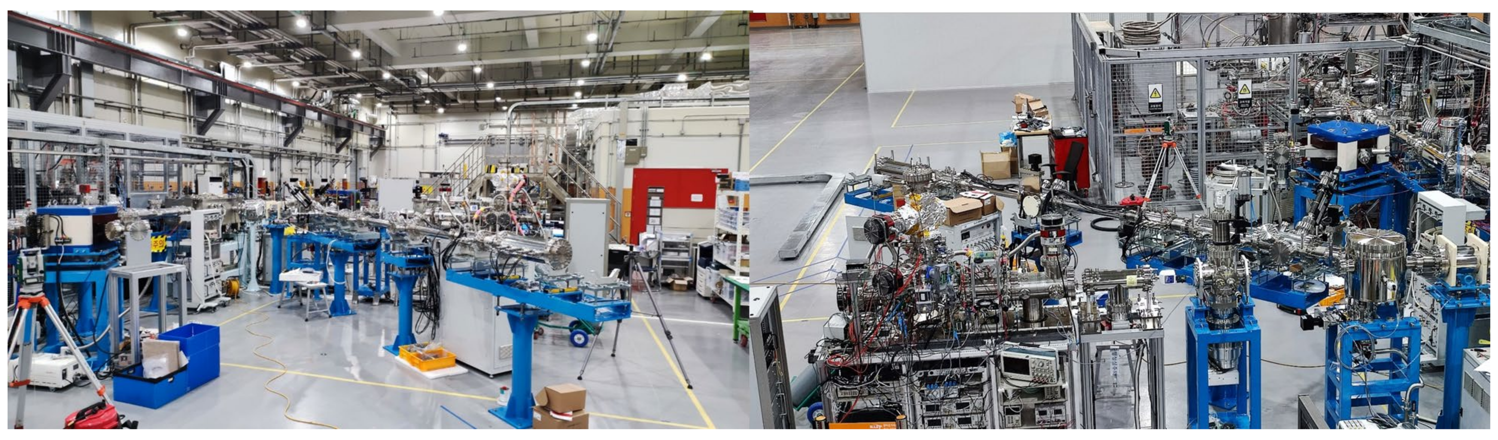
❖ ISOL-CLS beamline + the CLS system



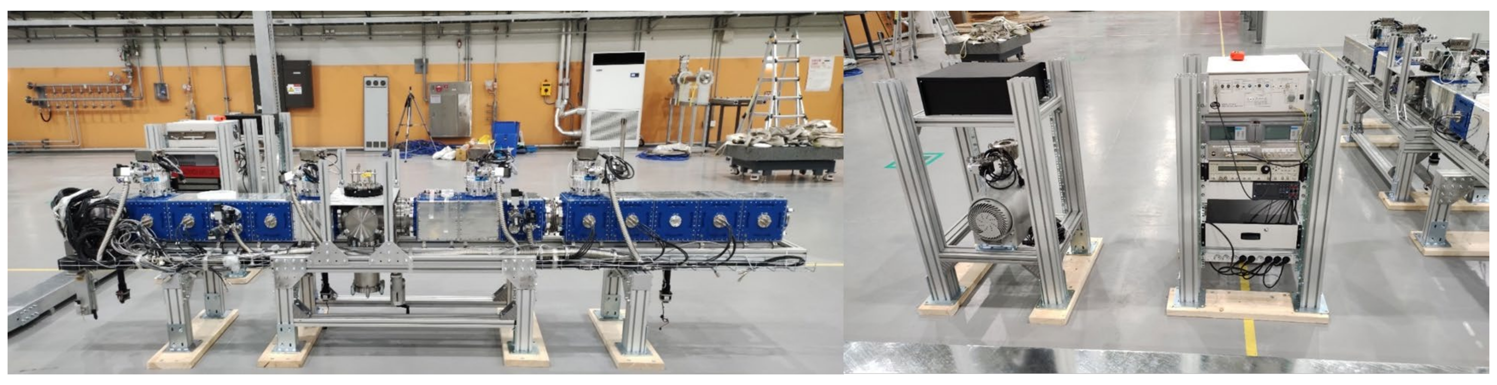
- Rare isotope (RI) beam → ISOL-CLS beamline → CLS system

Current progress of the CLS system

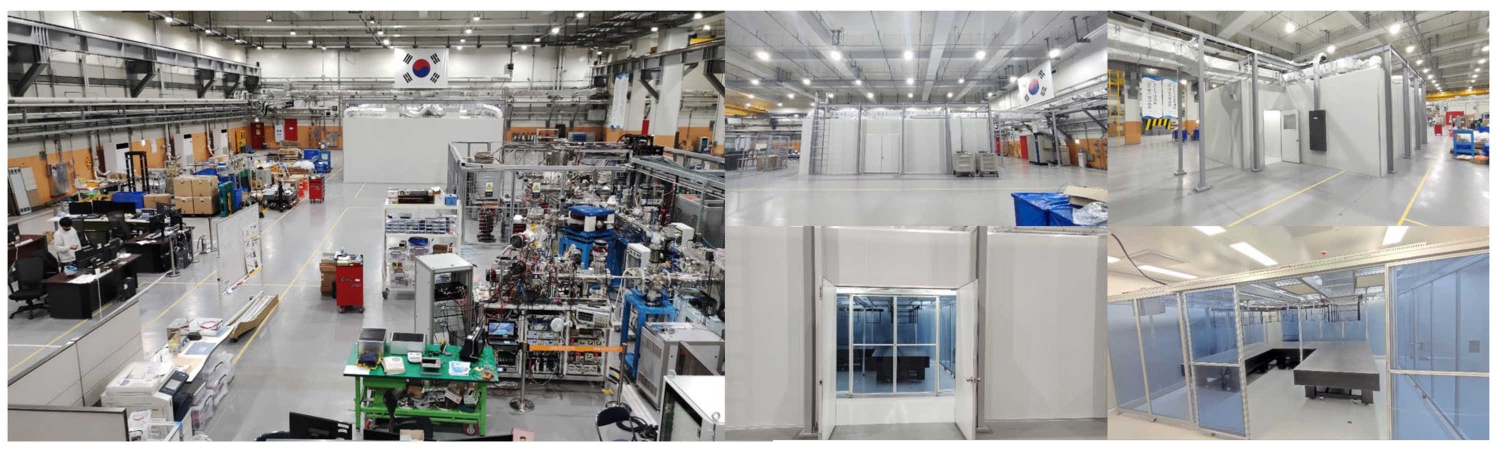
❖ ISOL-CLS beamline is built in ISOL experimental hall



❖ CLS center beamline delivered



❖ Clean room for laser systems

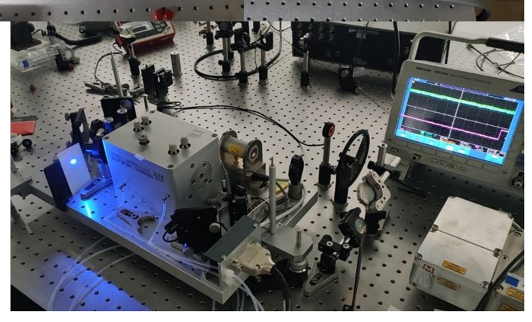


Laser systems for the CLS system

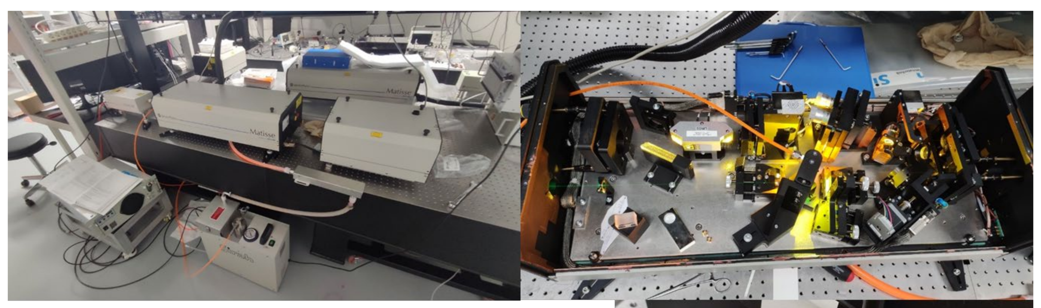
❖ Ti:Sa laser system

Ti:Sa laser system (792 nm)

→ frequency doubler (396 nm)



❖ Ring Dye laser system



Ring dye laser system (565 ~ 610 nm)

Future experimental plan

❖ OLIS part is shipping progress

❖ The full CLS system set up

1. 3-way bender part set up
2. CLS center beamline set up
3. OLIS part set up

❖ Commissioning using Al ion beam

1. Al ion beam generated by OLIS
2. overlap Al IB to center beamline through 3-way bender
3. control the IB velocity by applying an electric field (±10 kV) to IB for Doppler tuning at post accelerator
4. Neutralize an IB into an atomic beam at CEC
5. Measure the fluorescence signal at optical detection

Summary

❖ The current progress of the CLS system
- CLS center beamline part delivered at ISOL experimental hall
- CLS off-line ion source part is shipping progress
- ISOL-CLS beamline is built in ISOL experimental hall
- Clean room for laser systems in ISOL experimental hall

❖ Laser system prepared for the CLS system
- Ti:Sa laser system 1 set (700 ~ 1050 nm)
- Ring Dye laser system 2 set (565 ~ 610 nm / 610 ~ 665 nm)
- Laser frequency doubler 1 set

❖ Commissioning experiment using Al ion beam

Acknowledgements

This work is supported by the Ministry of Science, ICT, and Future Planning (MSIP) and the National Research Foundation (NRF) of the Republic of Korea under Contract 2011-0032011.

Contact : SeongGi Jo (sjo41@ibs.re.kr)

Very Low Energy experimental system team