Development of the COREA Detector System for the Measurement of 12 **C** (α, γ) 16 **O Reactions**



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12 C(α , γ) 16 O Reaction with COREA



REA

Carbon Oxygen Reaction Experiment with Active-target TPC



${}^{12}C(\alpha, \gamma){}^{16}O$ Cross-Sections and Event Rates



$^{12}\mathbf{C}(\alpha,\gamma)^{16}\mathbf{O}$ Measurement with COREA

- \odot 500-keV/u 100 p μ A ¹²C^{*q*+} ion beam.
- Large acceptance windowless ⁴He gas TPC
- LaBr₃ detector array for the *E*1/*E*2 capture ratio measurement
- **Coincidence measurement** of recoil ¹⁶O and γ with (Silicon, Scintillation crystal, or TPC signal)
- Measurement of p/q with the 3 T magnet (dE/dx in TPC)



Low-Energy Heavy Ion Accelerator

KBSI Busan Ion Beam Accelerator BIBA (28-GHz ECRIS + 500-keV/u RFQ at 81.25 MHz / 100 kW)





- BIBA currently delivers low-energy ion beams with the 28-GHz ECRIS.
- A full operation is anticipated in late 2025.

3-T Conduction-cooled Superconducting Magnet

○ Superconducting Helmholtz magnet ($B_{max} = 3$ T, RT Bore = 300 mm, 270° opening) operated successfully in 70 hours at 3 T. ^{*a*}

^aS.H. Kim and J.K. Ahn, NIMA1049, 168062(2023).



Active Target TPC (aTPC)

- The aTPC prototype's assembly and test are ongoing. It reads 1000 channels using four AsAd boards of GET electronics.
- \odot It will operate with a 0.05–1.0 atm He/CO₂ gas mixture.



Active Target TPC (aTPC) with a Gating GEM







Gate opens $(V_1 < V_2)$ when the trigger is on. Otherwise, it keeps closed.



Masked region always blocks electron's penetration.

Simulation on the aTPC Performance

E_{beam} = 9 MeV



Effective Charge States of Recoil ¹⁶O^{*q*+}



- Recoil nuclei quickly take up electrons in He gas to change their charge states.
- A focal-plane spectrometer measures Q_{eff} of ${}^{12}C^{q+}$ and ${}^{16}O^{q+}$ in He gas at different energies and gas pressures.



LaBr₃(Ce) γ -ray Detector Array



500 600 700 800 900 1000

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1200 1300 ADC [Channel]

KIST 2MV Pelletron and KU Beamline







 $${}^{4}\text{He}{}^{2+}, E=3.9$ MeV, I=1.2-2 μA ${}^{12}\text{C}{}^{2+}, E=5.92$ MeV, I=3 μA / ${}^{12}\text{C}{}^{3+}, E=7.85$ MeV, I=10 μA ${}^{12}\text{C}{}^{5+}, E=9.80$ MeV, I=3 μA / ${}^{12}\text{C}{}^{5+}, E=11.75$ MeV, I=50 nA





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Gamma-ray Energy Spectra from ${}^{27}Al(p, \gamma){}^{28}Si$



Performance of LaBr₃(Ce) γ **-ray Detector Array**



Triggerless Streaming-Mode Data Acquisition

 We successfully collected data using a triggerless streaming-mode DAQ system in collaboration with a RCNP group.









Our Challenges for the ${}^{12}C(\alpha, \gamma){}^{16}O$ Measurement

- Beam guide with Gating GEMs mitigates space charge effect and ion backflows.
- Small detector prototype will prove the operation principle with high-intensity beams in early 2025.
- The COREA experiment will run in three years from early 2026 after the beam commissioning in late 2025.

