Reduction factor study at large isospin asymmetry using the (α,αp) reaction (NP2212-SAMURAI64R1)

Sunji Kim

Center for Exotic Nuclear Studies (CENS), Institute for Basic Science (IBS)

NP2212-SAMURAI64R1

Title: **Reduction factor study at large isospin asymmetry using the (a,ap) reaction**

Spokesperson(s): **Sunji Kim**

Approved — Grade A
5.0days
5.0 days (including 0.5 days for the BigRIPS tuning)

The resubmitted proposal is better focused on the most critical cases of O isotopes. A consistent theoretical approach is now presented, which shows a clear goal of the measurement. Mentioned are also consequences for our understanding of the phenomena using two different wave function shapes: WS vs GF and their difficulties when nuclear removal is considered in a nucleus-induced knock-out reactions. The experimental setup was modified according to the availability of new and most suitable detectors. The NP-PAC recognizes the importance of clarifying the reduction factor dependence on the isospin asymmetry and therefore grants 5 days with grade A to this proposal, and at the same time prioritizes the ^{14}O and ^{24}O measurements as the most essential ones.

- Spokesperson: Sunji Kim
  Co-Spokesperson: Yohei Matsuda (Konan Univ.)
- 9 days for ^{14,22,24}O proposed
  → 5 days approved, with priority given to ^{14,24}O
- **Rough plan**
  - LHe system construction by summer
  - LHe system test in the SAMURAI area
  - Beamtime request for the experiment to be conducted in the first half of 2026

Motivation

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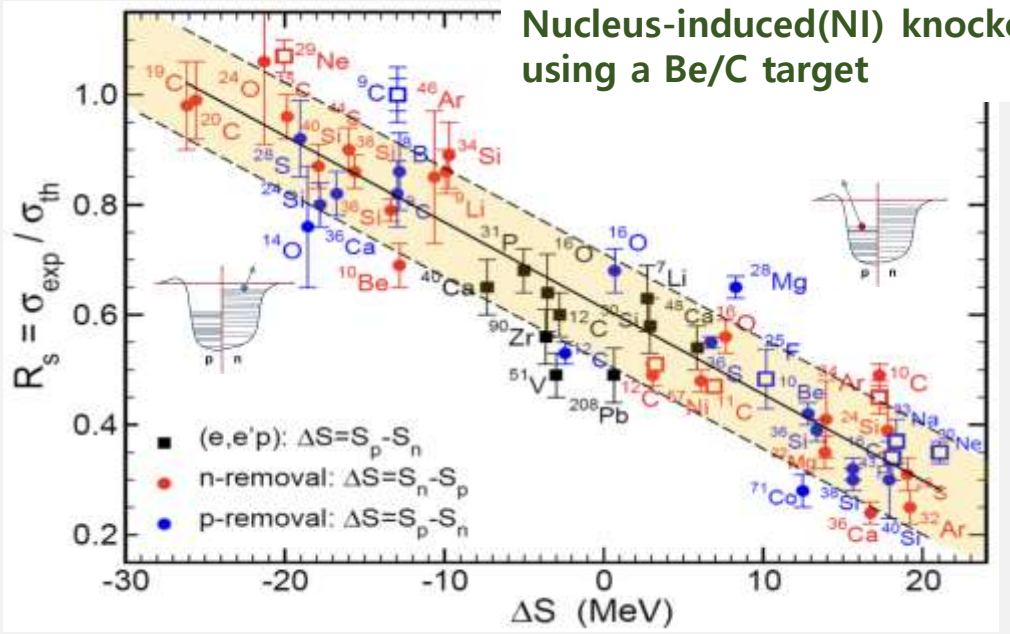
- In a wide range of isospin asymmetry, σ_{exp}/σ_{th} **(Reduction factors)** of one-nucleon knockout reactions

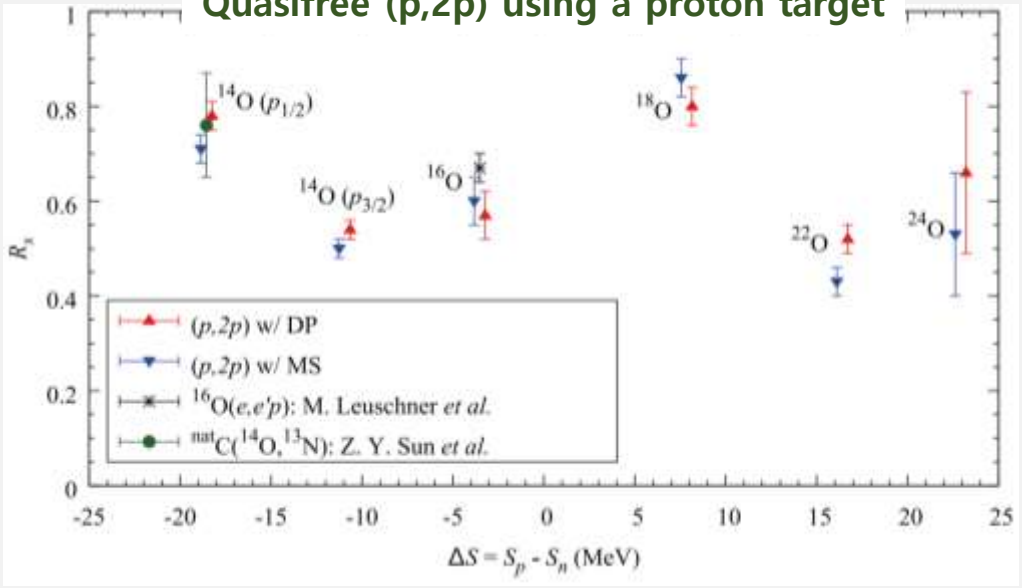
Nucleus-induced(NI) knockout using a Be/C target



(J.A Tostevin and A. Gade, PRC 103, 054610 (2021))

VS

Quasifree (p,2p) using a proton target



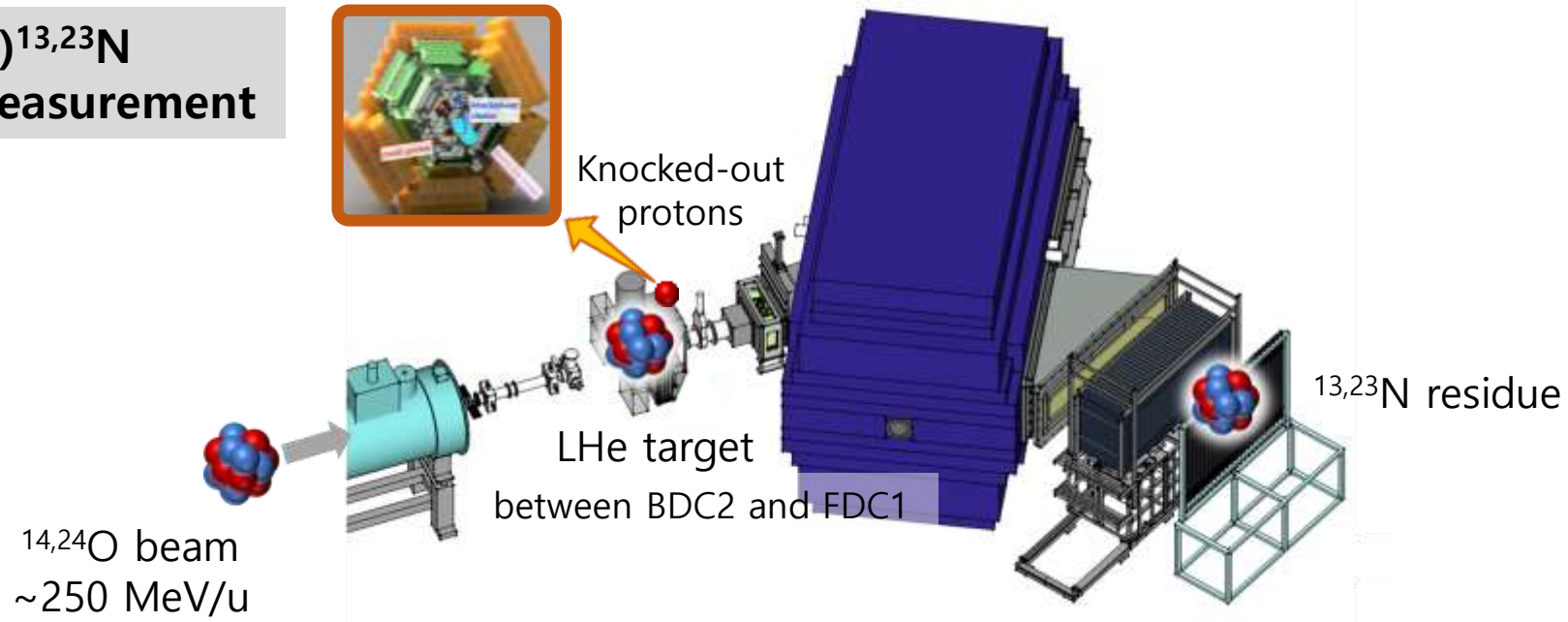
(S. Kawase et al., PTEP 021D01(2018))

- To provide complementary spectroscopy information, we proposed one-proton removal experiment **using a NEW probe, an alpha target.**

Experimental Setup: SAMURAI+TOGAXSI

Equipment	Measurement	Observables
TOGAXSI	Momenta of knocked-out protons	Proton removal cross sections (Recoil alpha momenta in missing mass method)
SAMURAI **(Plastics at F7,F13, BDC1,2, FDC1,2, HODF)**	Momenta of beams and residues	Particle identification

^{14,24}O(α,αp)^{13,23}N
Cross section measurement



Target and TOGAXSI geometry

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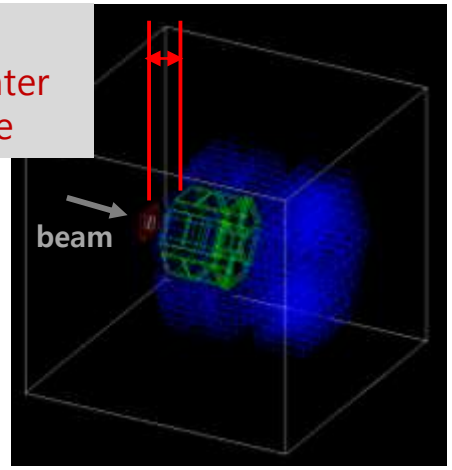
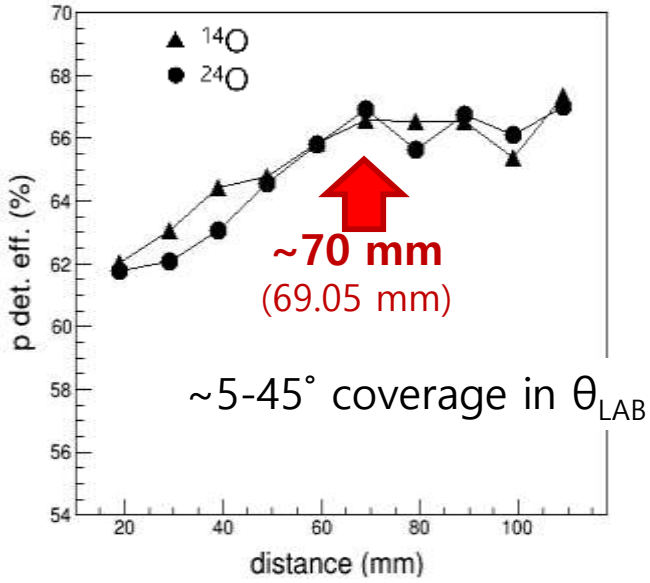
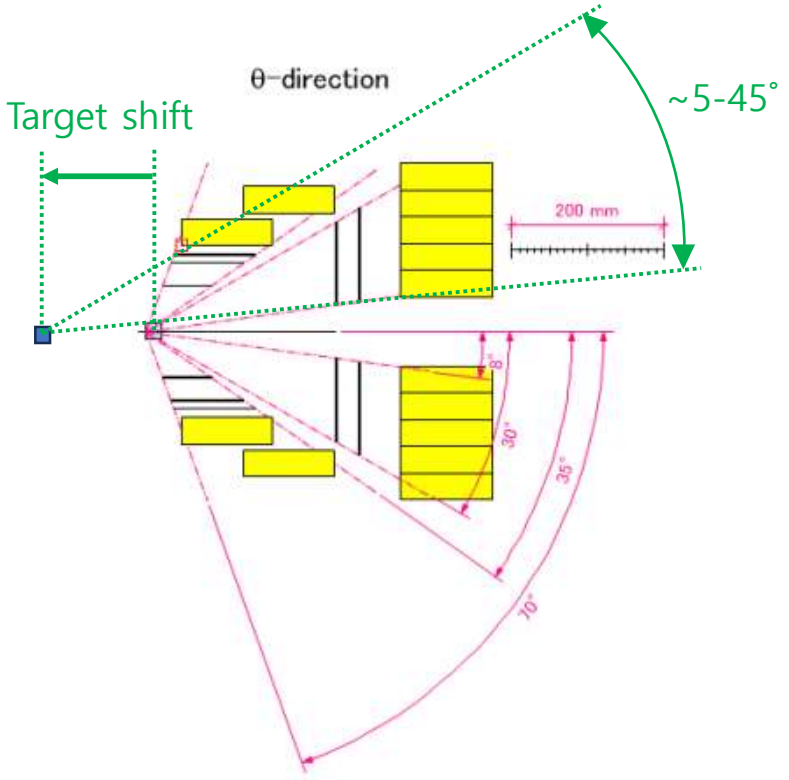
➢ Simulation result (using the full-array design, the number of GAGG crystals=109 applied in the simulation, while the total number is 118)

Distance
: from the target center
to the TOGAXSI edge





The original design had a missing angular range at 30-35 deg., but by shifting the target, we have no missing angular range.



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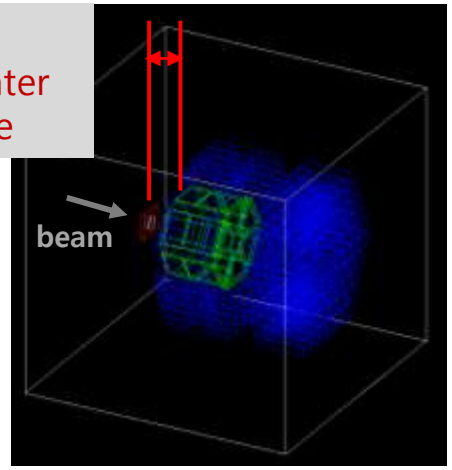

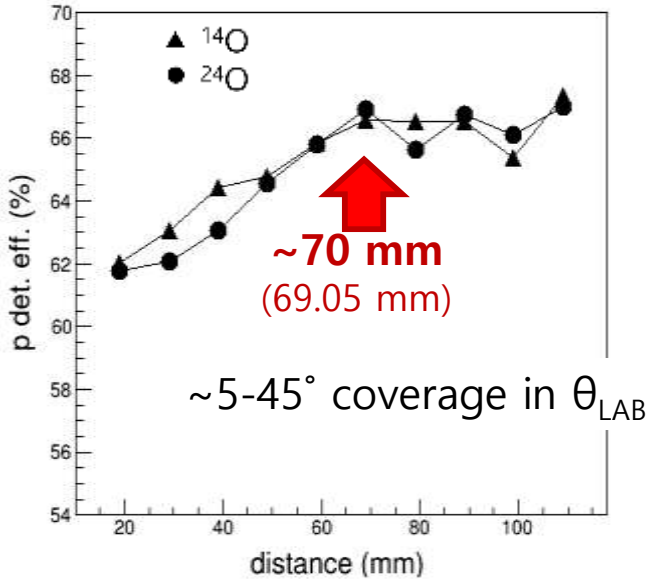

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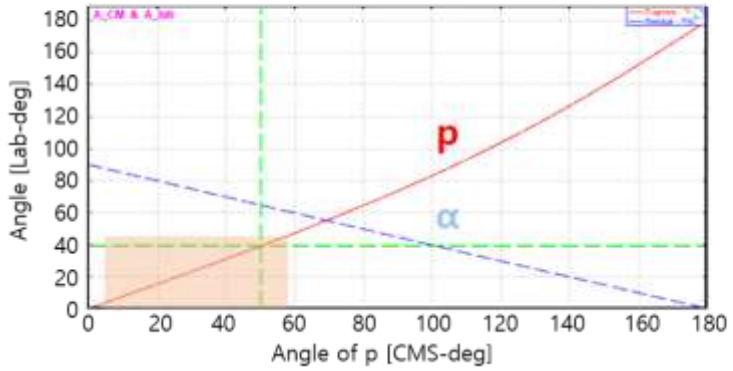
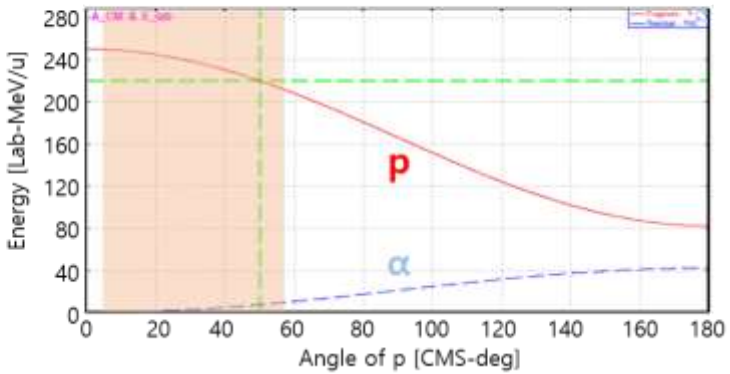
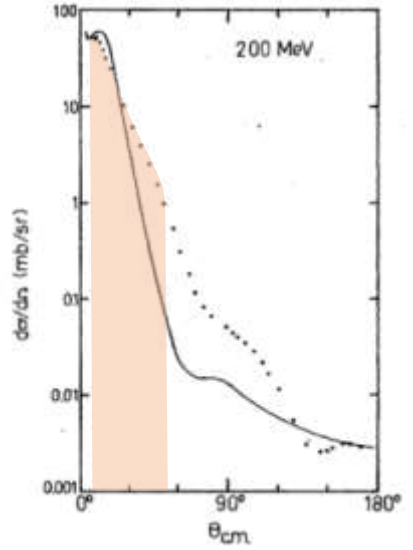
- Angular coverage to be measured: ~5-45° in θ in the lab frame (~7-57° in θ_{cm})

(We will focus on the proton measurement, as the alpha detection efficiency is less than 1% due to the kinematics.)







(G.A. Moss et al., PRC 21, 1932 (1980))

Target thickness and diameter

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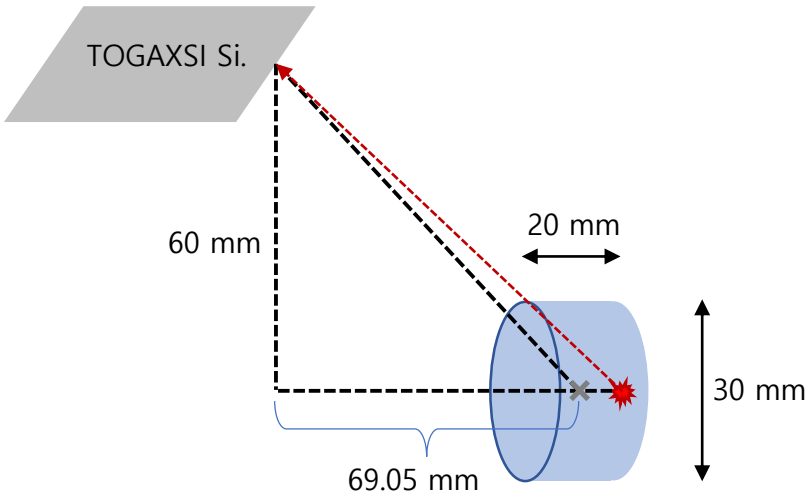
➢ At a fixed distance of 69.05 mm, the window diameter restricts the target thickness.



➢ When an event occurs near the entrance window of the target, a produced particle can reach the TOGAXSI silicon detectors with

Window Φ30: target thickness 20 mm ✓
Window Φ40: target thickness 28 mm
Window Φ50: target thickness 36 mm

Status of the liquid He target

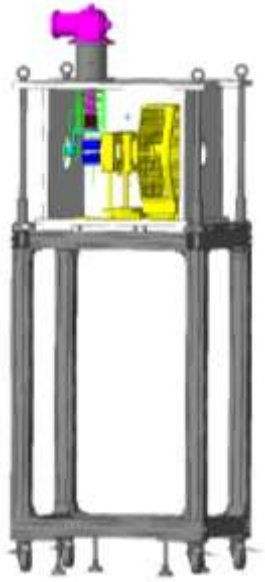
(courtesy of Yohei Matsuda)

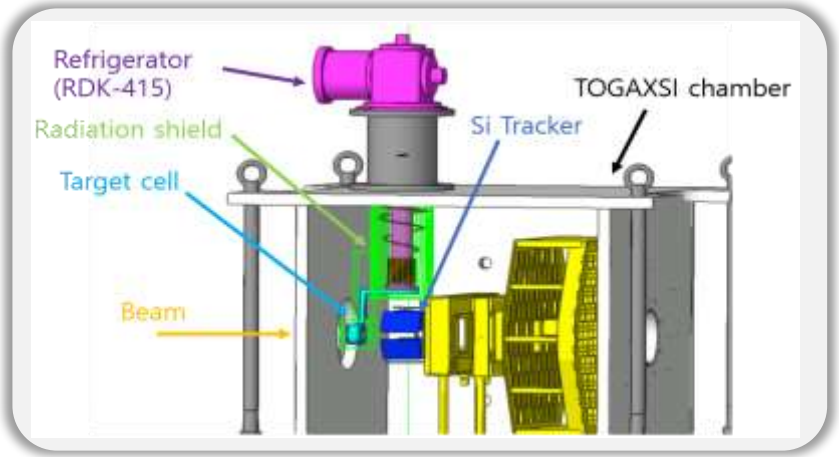
➢ Finished

- First design of the target system with the TOGAXSI (target thickness: 20 mm, Φ: 30 mm)
- Preparation of a test chamber and a gas handler

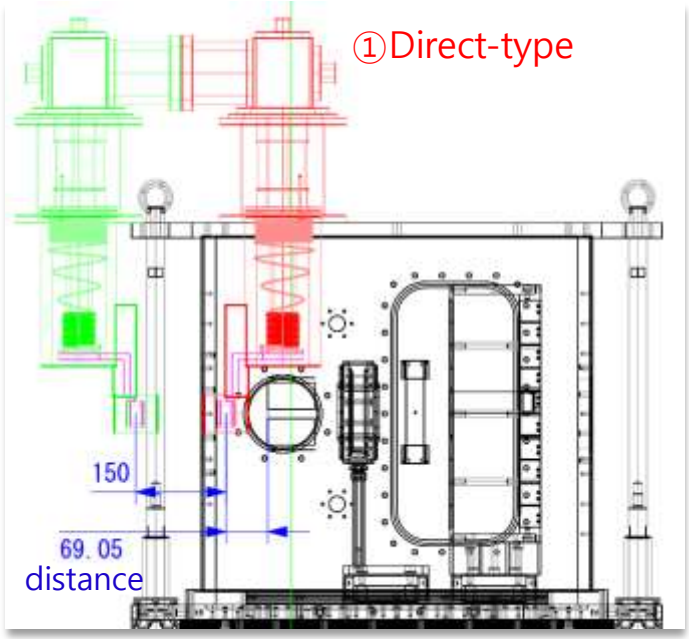
➢ Next step

- Technical drawing of the target system, 3D temperature simulation
- LHe production in the test chamber
- Construction and test of the LHe target system in the SAMURAI area for a month around summer
  (after the TOGAXSI experiments, if the experiments are performed in the first half of 2025)





②Strasse-type: ~150 mm extension needed



Test chamber and the gas handler at Konan University

Beams, beamtime, and triggers

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➢ Secondary beam production (LISE++, EPAX3)

Primary beam	Secondary beam	Primary beam intensity (pnA)	Total intensity @F13 (pps)	E @F13 (MeV/u)
^{18}O	^{14}O	40 (scaled by 5)	3.30e+5 (^{14}O, 3.29e+5)	254
^{40}Ar	^{14}O	60	2.85e+5 (^{14}O, 2.82e+5)	241
^{40}Ar	^{24}O	500	8.54e+3 (^{24}O, 8.58e+2)	254

(Due to the SAMURAI detectors to be operated properly, the total secondary beam intensities were estimated less than ~3X10^5 pps.)

➢ Triggers

- 1/200 downscaled beam
- Beam ⓧ HODF
- Beam ⓧ HODF ⓧ TOGAXSI

➢ Beamtime and counts

Run	Beamtime (days)	Counts (det. eff.=0.7)	ΔR
BigRIPS tuning	0.5		
^{14}O(α,αp)	0.4	2.44e+5	0.001
^{14}O empty	0.1		
^{24}O(α,αp)	3.5	7.48e+3	0.007
^{24}O empty	0.5		
Total	**5.0**		

(Theoretical cross sections were calculated by private communication with Yoshida-san and PRC 104, L061602(2021))

(Depending on the experiment schedule, proton beamtime may be needed for the TOGAXSI tuning and calibration.)

Summary and Discussion

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Summary

- We plan to perform the $^{14,24}O(\alpha,\alpha p)$ experiment using the SAMURAI+TOGAXSI setup together with a LHe target.

- A distance of 69.05 mm between the LHe target center and the TOGAXSI edge is optimal for achieving high proton detection efficiency, covering the angular coverage of ~5-45° .

Discussion

- Schedule for the LHe target system test in the SAMURAI area (after the TOGAXSI experiments)

- Availability of the target position, considering the interference with the Si detector system

Thank you for your attention!