Improved ^{6}He beam production at CRIB with MWDC and degraders

H. Yamaguchi,[*1] M. Sferrazza,[*2] S. Hayakawa,[*1] K. Okawa,[*1] Q. Zhang,[*1,*3] S. Cherubini,[*4] M. La Cognata,[*4] R. G. Pizzone,[*4] T. Chillery,[*1] S. Hanai,[*1] N. Imai,[*1] S. Masuoka,[*1] and K. Yako[*1]

The first production test of ^{6}He beam at CRIB was performed in 2021,[1)] in which ^{6}He beams at two different energies (8.0 and 5.7 MeV/nucleon) were successfully produced with an intensity of the order of 10^5–10^6 pps. However, the practical beam intensity was limited to $\sim 2 \times 10^5$ pps due to the low detection efficiency of the PPAC for such a light-ion beam. The ^{6}He beam purity was 73% for the 8 MeV/nucleon beam, where the main contaminant was $^3H^{1+}$, having an almost identical charge-to-mass ratio as $^6He^{2+}$.

The second test was carried out in Oct. 2022 as a two-day machine study (MS-EXP22-05), to improve the effective intensity and purity of the ^{6}He beam by introducing wire chambers (MWDC[2)]) and degraders. The primary beam was $^7Li^{3+}$ accelerated with the AVF cyclotron to an energy of 8.3 MeV/nucleon, and the RI beam was produced with the ^{7}Li(d, ^{3}He)^{6}He reaction in inverse kinematics. The major differences from the first test were the maximum ^{7}Li beam current of 1.5 particle μA (= 4.4 electric μA) at the entrance of CRIB and the pressure of the production target (around 410 Torr), which were both lower than the previous values (3 particle μA and 730 Torr, respectively).

To purify the ^{6}He beam, we installed degraders with two different thicknesses (10-μm-thick aluminized and 20-μm-thick normal Mylar films) at the F1 (momentum dispersive) focal plane. We confirmed a position offset between ^{6}He and ^{3}H was produced at F2 with each degrader, as shown in Fig. 1. Using the 20-μm-thick degrader, the beam purity at F3 measured with a plastic scintillator was 91%, much improved from the previous value, 73%.

The MWDC had already been developed and used at CNS for SHARAQ/OEDO experiments,[2)] and introduced for the first time at CRIB. In the present test, we employed two MWDCs operated at 10 kPa (76 Torr), having an XX-YY anode configuration and cell sizes of 3 mm and 5 mm for the upstream and downstream ones, respectively. Even with a high-rate secondary beam at 6.0×10^5 pps, the MWDCs maintained an efficiency $\epsilon > 90\%$ with high voltages of up to 900 V, and no significant reduction of the efficiency was observed. This is in contrast to the previous test, where we had to limit the primary beam current to 0.3 particle μA in order to keep the stable PPAC operation with an acceptable efficiency ($\epsilon = 70\%$). The basic beam parameters are summarized in Table 1 and compared with those of the optimum case in the previous test. The new ^{6}He rate is roughly consistent with the previous value, considering the higher ^{7}Li beam current (×5) and nearly half F0 pressure. However, the previous rate (200 kcps) was severely limited with the PPAC, while in the present work we successfully obtained a higher ^{6}He rate (520 kcps) with a better beam purity (91%), even though the F0 pressure was not at its best value. The new condition well satisfies the requirements by the approved experiments,[3)] to be performed in the near future.

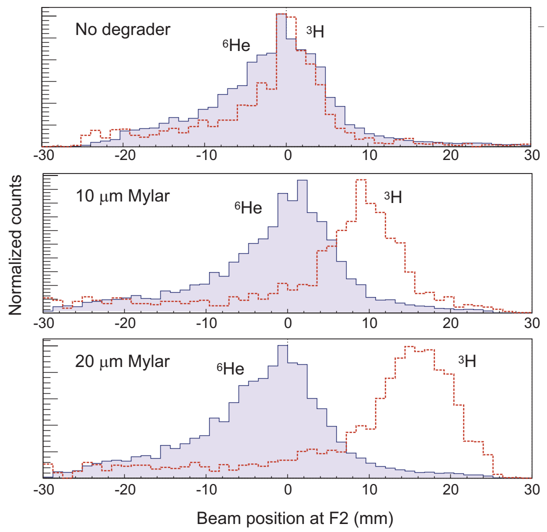

Fig. 1. The beam profiles of ^{6}He (solid line) and ^{3}H (dashed line), with different degrader settings. The counts are scaled to show the profiles as similar heights.

Table 1. Summary of the basic beam parameters. ϵ is the efficiency of the beam-monitoring detector.

Test year	^{7}Li (particle μA)	F0 Pres. (Torr)	ϵ	^{6}He purity	^{6}He rate (kcps)
2021	0.3	730	70%	73%	200
2022	1.5	410	94%	91%	520

*1 Center for Nuclear Study, University of Tokyo
*2 Department of Physics, Université Libre de Bruxelles
*3 Department of Physics, Lanzhou University
*4 Laboratori Nazionali del Sud, Istituto Nazionale di Fisica Nucleare (INFN)

References

1) H. Yamaguchi *et al.*, RIKEN Accel. Prog. Rep. **55**, 94 (2022).
2) H. Miya *et al.*, Nucl. Instrum. Meth. Phys. Res. B **317**, 701 (2013).
3) M. Sferrazza *et al.*, proposal for RIBF NP-PAC-21, NP2021-AVF70 (2020, unpublished) and others.