INTRODUCTION

The EXOTIC facility at LNL has been used for in-flight production of $^7$Be, $^8$B, $^8$Li and $^{17}$F in inverse kinematics. The development of $^{15}$O beams was motivated by the wish to study energy levels in $^{19}$Ne via the resonant scattering of $^{15}$O on a thick, $\alpha$-gas target – the so called Thick Target in Inverse Kinematics (TTIK) technique [1,2]. Neon-19 is interesting from several aspects ranging from clustering in non-$\alpha$-conjugate nuclei to break-out from the hot CNO cycle via $^{15}$O($\alpha,\gamma$)$^{19}$Ne. Thus, by measuring the resonant $\alpha$-scattering reaction, the widths, spins and parities of the resonances can be extracted from a combination of energy and angular distributions and an $R$-Matrix analysis. Significant advantages of this method are the large excitation energy range obtained in a single measurement and the ability to use low intensity beams $\sim10^4$–$10^5$ pps.

OXYGEN-15 PRODUCTION

For the development of the $^{15}$O beam, Monte-Carlo simulations indicated that the reaction $p(^{15}N,^{15}O)n$ with $Q = -3.54$ MeV would be most effective. Therefore, a 75 MeV primary $^{15}$N beam from the LNL-XTU tandem accelerator was used to bombard the EXOTIC [3,4] H$_2$ target cooled to 90 K and comprising a 5 cm long gas cell double-walled with 2.2-$\mu$m thick Havar foils. This corresponds to a target thickness of 1.35 g/cm$^2$. The negative $Q$-value ensures that the reaction products are predominantly focused in the forward direction allowing their better transmission along the EXOTIC beam line. The $^{15}$O produced in the reaction at the primary gas target is focused by a first triplet of quadrupole magnets. Contaminants, primarily charge states of N and C from the $^{15}$N carbon-containing compound used in the ion source, are removed before the secondary target position via use of a 30° bending magnet, a Wien filter, slits and collimation systems. Two parallel-plate avalanche counters (PPACs) located 910 and 365 mm upstream from the secondary target provided event-by-event position and rate information. Finally, the $\approx$98% pure $^{15}$O beam was stopped in a 6.4×6.4 cm$^2$ double-sided strip detector (DSSSD) placed at the secondary target position in the final scattering chamber. Figure 1 shows the energy spectrum obtained for a typical strip. The FWHM of the energy spread of the beam is 1.3 MeV at a final $^{15}$O energy of 31 MeV.

Fig. 1. Example of a typical energy spectrum in a central channel of the $^{15}$O beam directly sent on the DSSSD.

Below, in Fig. 2, the physical size of the beam is shown in terms of hit pattern plotted as strip number, with each strip corresponding to 4 mm. As shown, the FWHM of the distribution is approximately 4 cm. The effect of this physical spread can mitigated by using the two PPACs to track the incoming $^{15}$O projectiles into the scattering chamber.

PERSPECTIVES

Following optimisation of the beam-line elements a counting rate of $2\times10^4$ pps was achieved, sufficient for the proposed resonant scattering measurement.

In general, one of the main disadvantages of beams produced by the in-flight technique is the typically large energy spread of the beam which in this case is almost 1.5 MeV. However, the TTK scattering technique for which this beam is to be used is not strongly affected by this problem and the inverse kinematics means that, typical resolutions for the final $^{19}$Ne excitation-energy spectrum will be around 40 keV. In fact using the TTK scattering method in order to
measure the elastic scattering excitation function of $^{15}$O+α, the energy spread of the $^{15}$O beam corresponds to a worsening in resolution of the elastic scattering excitation function of just a few tenths of a keV [5].

Fig. 2. Hit map (counts per pixel) for the $^{15}$O beam on the DSSSD.