

Final tests of the EXOTIC beam line for Radioactive Ion Beam production

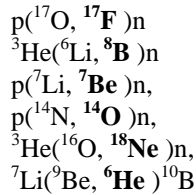
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I. INTRODUCTION

The EXOTIC apparatus has been designed to produce light exotic beams using the intense beams delivered by the XTU Tandem accelerator. The production reactions are performed in inverse kinematics on light targets to limit the emission of the exotic ions in a narrow forward cone. In such conditions almost all the ejectiles can be focused at the entrance of the separator which eliminates the residues of the primary beam and focuses the exotic beam on the reaction target. The layout of the beam line and the features of the separator have been designed to allow the focusing of the secondary beam on the target point of either an intermediate scattering chamber or the PRISMA magnetic spectrometer. Several beams of interest for the physics of the weakly bound light nuclei can be produced. Some of them are reported in the following table.

Production reactions accessible by Tandem beams



Besides the separator features, the achievable intensity of the exotic beams is mainly determined by the reaction cross section, the primary beam current and the density of the production target. To increase the last parameter a great attention has been paid to the design of a gas target which could be operated at both room and liquid Nitrogen temperature. To take advantage of the easy ^{17}O beam and to complete the research program initiated at the ANL ATLAS facility (Argonne, USA), the ^{17}F nucleus has been chosen as the first beam to be produced. The separator features are reported in the following table.

Separator characteristics

Solide angle $\Delta\omega$	20msr
Energy acceptance $\Delta E/E$	$\pm 10\%$
Momentum acceptance $\Delta\pi/\pi$	$\pm 5\%$
Horizontal acceptance $\Delta\theta$	$\pm 3.4^\circ$
Vertical acceptance $\Delta\phi$	$\pm 5.2^\circ$
Magnetic rigidity $B\rho$	0.98 Tm

They have been discussed in previous reports [1,2,3] here we report only on the final production tests of a ^{17}F beam.

II. SET UP

The previous tests pointed out the importance of the primary beam injection to reduce the background due to scattering on the gas target holder and to maximize the transmission of the secondary exotic beam through the separator. To improve the primary beam positioning and focusing a magnetic quadrupole of the standard LNL type, a four sector slit system and two steerer dipole magnets were mounted on the $+10^\circ$ beam line before the gas target. To monitor the secondary beam a two stage telescope detector was mounted on the beam line at the exit of the intermediate scattering chamber. The first stage of the detector was a gas ionization chamber while the second stage was a Silicon strip detector. The 16 strips, 3 mm wide each, were orthogonal to the deflection plane of the separator dipole magnet to measure the dispersion of the secondary beam at the reaction target point. The ionization chamber was operated at a gas pressure of 40 mb suitable to the charge identification of the ejectiles by means of the standard $\Delta E-E$ technique. The gas target was a cylinder 5 cm long with a 25 mm diameter. The entrance and exit windows were made of HAVAR 2.032 mm thick with 20 and 25 mm diameter respectively. The target was filled by H_2 gas at a pressure of 800 mb which at a temperature of 303 K determines a density of 0.83 mg/cm^2 . To prevent the beam monitor damage the tests were performed with a current of 0.05 pA ^{17}O beam from the tandem. Taking into account the energy loss in the HAVAR windows and in the gas target, to get a secondary ^{17}F beam having an energy distribution centered around 100 MeV, a ^{17}O primary beam of 7+ charge state and 119 MeV energy is required. After the measurement of the secondary beam parameters at low intensity of the primary beam, the ^{17}O current was raised up to 0.9 μA and the secondary beam intensity was measured, without charge and mass identification, by means of a ratemeter counting the pulses per second falling in a proper pulse height window. Some tests were also performed filling the gas target with Methane (CH_4) gas. The presence of the Carbon ions in the target did not determine any increase in the observed background while the ^{17}F beam intensity increased as

expected according to the effective Hydrogen density in the target.

III. RESULTS AND CONCLUSIONS

In this section we summarize the results of the final tests. In the upper panel of Fig.1 the energy spectrum of the ions transmitted through the separator when the Wien filter is switched off is reported. Each peak in the spectrum

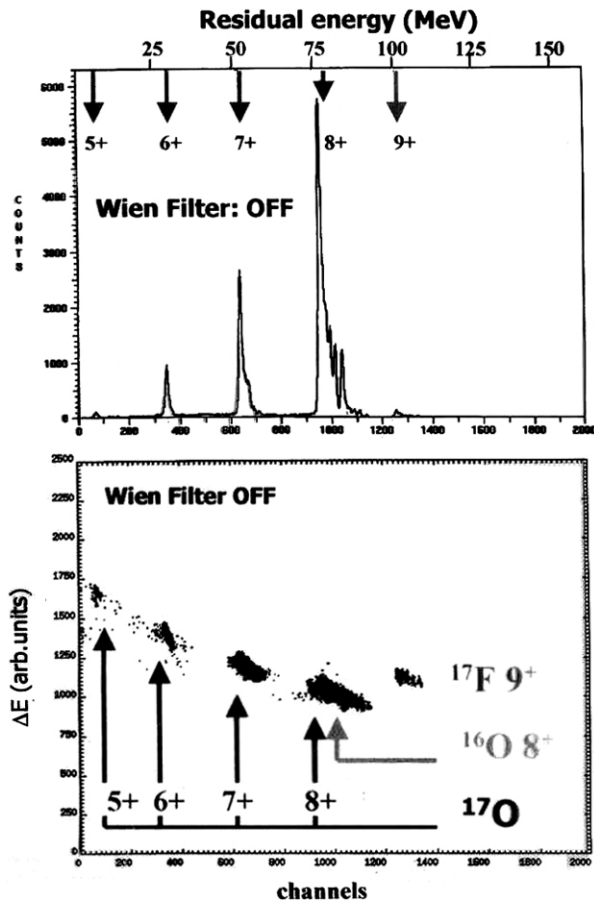


Fig. 1

is characterized by a different charge of the ions. The energy calibration was performed by standard alpha sources. In the lower panel the corresponding ΔE -E matrix is reported with the mass identification. The field of the dipole magnet was tuned at $B=0.885$ T to optimize the transmission of the ^{17}F ions. However all the ions having the same magnetic rigidity as the ^{17}F ones are transmitted according to the equation:

$$(ME)_{ion} = (ME)_{^{17}\text{F}} \left(\frac{q_{ion}}{q_{^{17}\text{F}}} \right)^2$$

The suppression of the unwanted residues of the

primary beam is performed by the Wien filter. Such an effect is visible in Fig. 2 where in the upper panel the same spectrum as in Fig.1 is reported while the Wien filter was tuned at 70 kV which is about 70% of its maximum operation voltage. The ions with 8^+ charge were not completely suppressed to allow direct comparison with the data of Fig.1. In the lower panel of the figure the corresponding ΔE -E matrix is reported.

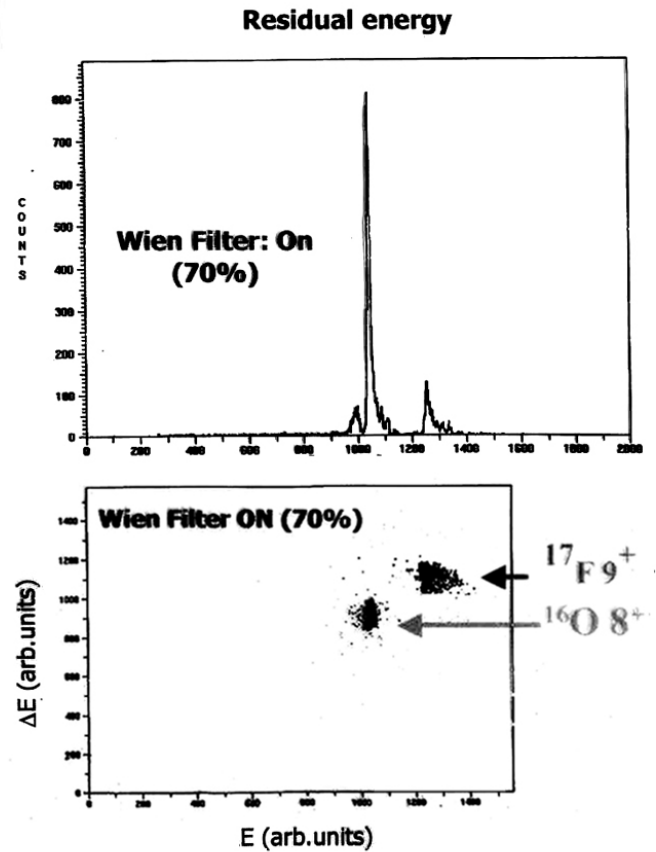


Fig.2

The measured yield of ^{17}F ions was 380 pps/[mg/cm²(H₂)*pnA(^{17}O)]. The extrapolated yield with a primary current of 1.1 μA of ^{17}O is in the range of 10⁵ pps. An accurate measurement of the ^{17}F current, which was impossible with the actual beam monitor, will be performed during the first experiment scheduled in the first semester of 2005.

IV. REFERENCES

- 1- M.Sandoli et al. LNL Annual Report 2001 pag.192
- 2- V.Z. Maidikov et al. LNL Annual Report 2002 pag.166
- 3 -T. Glodariu et al. LNL Annual Report 2003 pag.153