^{17}F elastic scattering as a test of the EXODET experimental apparatus

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I. INTRODUCTION

The study of exotic features of RIB requires the design of detector arrays that cover the maximum possible solid angle and that can provide high energy and position resolution. One of such detector apparatus, consisting of 16 silicon SSD having large area and high segmentation (100 strips each), will be installed at the LNL on the EXOTIC beam line. The description of this experimental apparatus, named EXODET, has been reported elsewhere [1]. Here we report about the preliminary results of a first measurement performed at the ANL (Argonne, USA) with the EXODET system. An exotic beam of ^{17}F, produced with an intensity of about 10^6 pps and an incident energy of 90 MeV, impinging on a 1 mg/cm^2 thick ^{208}Pb self-supporting target, has been used to test the performances of the detector system.

II. EXPERIMENTAL SETUP AND DATA ANALYSIS DISCUSSION

The first preliminary results of the data analysis show how the requirements of the detector design have been fulfilled. We consider here the EXODET telescope covering the θ_{lab} angular range [98°-154°] and named BT1-BT2 (where B=Backward, T=Top, 1=ΔE and 2=E) in [1].

In FIG.1 it is shown the energy spectrum of the particles arrived onto the ΔE detector, which has a thickness of 60 μm. There are two peaks at higher energies: one corresponds to the elastic scattering of the ^{17}F beam and the other to the beam of ^{17}O, which is a contaminant. At lower energies there are structures due to the energy loss of the light particles. The overall energy resolution of the detector is about 1%, measured with α-particle sources at ~ 8.5 MeV. To test the performances of the position readout system, we have taken into account only the events related to the ^{17}F elastic peak, in the channel interval [613, 860], as indicated in FIG.1.

The readout of the position information is obtained using ASIC chips as described in [2] and in [3]. The data stream outcoming from the chip, when a valid trigger is accepted, contains, for each strip hit, the identification number of the strip, the TOT (Time Over Threshold) and the Jitter Time. FIG.2 shows the number of elastically scattered ^{17}F vs. the strip number of the ΔE detector.

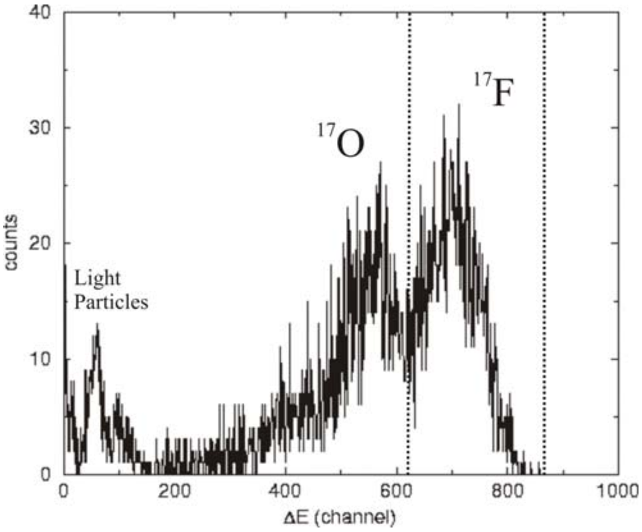

FIG. 1*: The energy spectrum of the particles detected by the ΔE layer of the telescope.*

The strips are perpendicular to the beam direction and the scattered ^{17}F ions do not have enough energy for passing through the ΔE layer. It is possible to see a decreasing behavior of the distribution (triangles) for an increasing distance of the strips from the target, i.e. for higher value of the θ_{lab} angle. The slope of the distribution is consistent with the Coulomb scattering behavior also if we consider the different geometrical efficiency of the strips. In fact, in FIG.2 it is also reported the angular distribution of the events emitted by an isotropic source, as calculated by means of a Monte Carlo code, that represents the effective solid angle subtended by the strips (circles). Also shown is the curve, obtained by the ratio of the two previous ones and which represents the efficiency corrected angular distribution (diamonds). The strips nearest to the target are partially shadowed by the target holder and their efficiency is lower than the calculated one.

In FIG.3, the Jitter Time spectrum for the ^{17}F elastic scattering events is shown. The Jitter Time represents the time interval, measured in number of clock hits, between the arrival of the trigger and that of the particle signal. It is a kind of time correlation measurement and it is useful to disentangle spurious and/or uncorrelated events. The best time resolution achievable with the used electronics was 67 ns. The presence of a sharp peak in the spectrum shows how all the elastic scattering events, here considered, are strictly correlated in time.

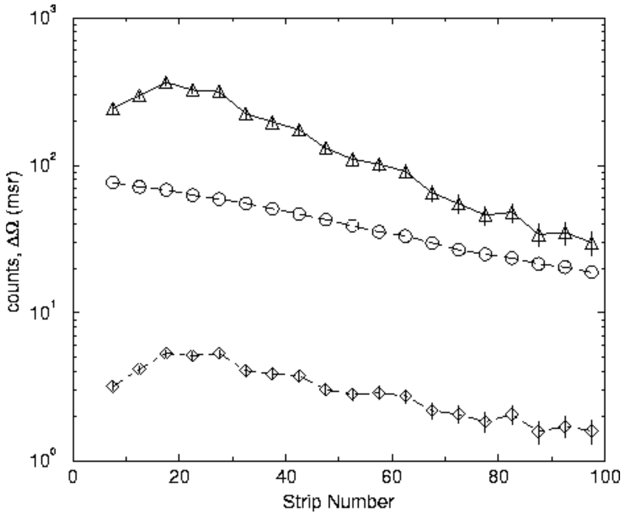

***FIG. 2**: ^{17}F elastic scattering events distribution in the strip number (triangles). The solid angle subtended by the strips (circles), calculated with a Monte Carlo code, is also reported. The decreasing Coulomb behavior of the distribution remains also after such geometrical efficiency correction (diamonds). A bin size of 5 strips has been considered.*

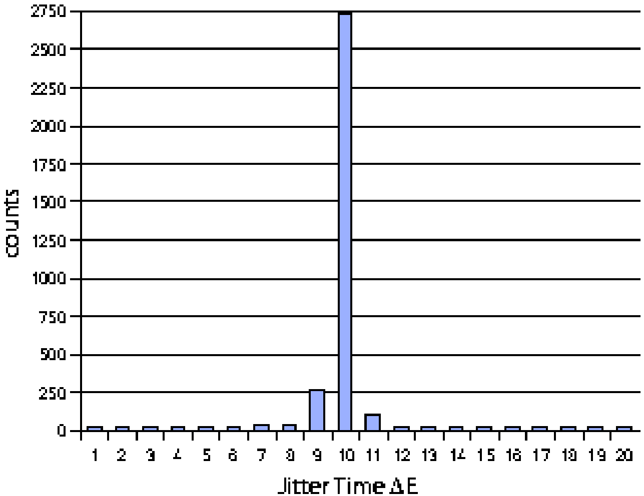

***FIG. 3**: The Jitter Time spectrum for the ^{17}F ions elastically scattered and stopped into the ΔE layer of the telescope. The sharp peak indicates that all the considered events are correlated in time with the trigger. Conditions on this parameter can clean the analysis from spurious and uncorrelated events.*

The spectrum reported in FIG.4 shows the TOT of the signals produced by the ^{17}F elastically scattered ions inside the strips. The TOT is the time, measured in clock hits, spent by such signals, after their amplification and shaping, over an externally settable threshold. A 6-bit threshold DAC, which is an internal component of the ASIC chip, allows the threshold to be varied up to 480 mV but, since only 4 bits are available for the TOT counter, the TOT spectrum is distributed only over 15 channels. Thus, the TOT gives a rough information about the energy lost by the particles in the strips, with a very low resolution yet useful to distinguish, for example, particles contemporarily impinging on the same detector but in different strips and with very different energy loss. In FIG.4 it is possible to note that the ^{17}F elastic scattering events have a TOT sharply peaked around 400 ns (6x67 ns) demonstrating that their signals have similar shaping and amplitude, i.e. roughly the same energy.

Finally, we have seen that the behavior of elastically scattered ^{17}O ions is similar to that of ^{17}F ones, which, in turn, is quite different from that of light particles passing through the ΔE layer. We have performed an exclusive analysis to search for break-up events ^{17}F –> p + ^{16}O in which the ^{16}O is stopped in the ΔE layer while the proton arrives onto the E detector. We have imposed the following conditions: a) two strips of the ΔE detector and only one of the E detector should be hit; b) the Jitter Time of all the strips should be in the correlation peak; c) the TOT of one strip of the ΔE should be in the ^{17}F or ^{17}O range while the TOT of the others should be lower; d) the total energy released in the ΔE detector should be in the spectrum region of the ^{17}F and ^{17}O elastic peaks (total energy of ^{16}O added to the proton energy loss). The preliminary results of the analysis show the presence of five break-up events, unambiguously identified, and of 21 good candidates. The positions of the break-up protons and their energies have been completely determined. The low statistics analyzed (less than 17 hours of effective beam time) does not allow a significant cross section measurement. Nevertheless is indicative of the potential of the EXODET apparatus also for these exclusive experiments.

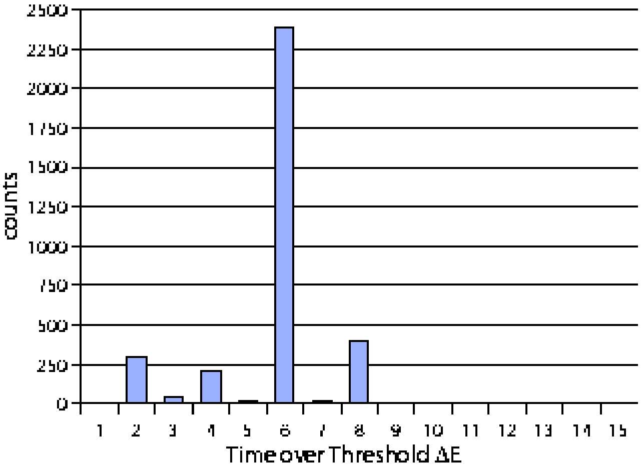

***FIG. 4**: The TOT spectrum of the ^{17}F elastic scattering events. The presence of a sharp peak indicates that the energy released into the ΔE detector is roughly the same for all the considered events. Particles contemporarily impinging on different strips of the same detector can be distinguished if they leave considerably different energies into the detector.*

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[1] M. Romoli et al., "*EXODET.....*", this Report.
[2] A. Perazzo et al., BABAR Note #501 (1999).
[3] E. Vardaci et al., "*VIPER.....*", this Report.