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The EXODET apparatus: Features and first experimental results

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Abstract. The low intensity of the RIBs presently available at the first generation production facilities (10^5–10^6 pps) and the necessity to reconstruct the event kinematics in RIB measurements require detection systems having both a large solid-angle coverage and a high granularity. The EXODET (EXOtic DETector) apparatus has been accomplished to respond to these requirements and the first experiment has been successfully performed studying the ^{17}F scattering on ^{208}Pb at 90.4 MeV.

PACS. 87.66.Pm Solid state detectors – 25.60.-t Reactions induced by unstable nuclei

The EXODET (EXOtic DETector) consists of 16 large area silicon detectors ($50 \times 50\,\text{mm}^2$), each of them having the front side segmented in 100 strips with a 0.5 mm pitch size and a 50 μm inter-strip distance. The detectors are arranged in 8 telescopes placed near the target both in the forward and backward hemispheres (see fig. 1), subtending a total solid angle of about 70% of 4π sr and covering the [26°, 82°] and [98°, 154°] theta-angle ranges [1]. The strips of the first-layer detectors (60 μm thick) are orthogonal to the beam direction and perpendicular to the strips of the second layer (500 μm thick), as shown in fig. 1, defining a position pixel of $0.5 \times 0.5\,\text{mm}^2$ for the particles passing through the first layer. For such particles, a Z identification is possible by using the usual ΔE-E technique, as well. The overall energy resolution, obtained with a standard electronic chain for the signals coming from the unsegmented rear side of the detectors, is about 1% for the E layer detectors, as it can be evinced from the spectrum reported in fig. 2, and about 3% for the ΔE ones. Due to the large number of channels (1600 for the whole apparatus) to be analyzed in order to get the position information, an innovative readout system based on highly integrated electronic circuitry (ASIC microchips) has been used. A chip originally developed for high-energy experiments [2] was found suitable for the EXODET position readout and an appropriate detector-chip interface has been designed. Each chip is connected to the

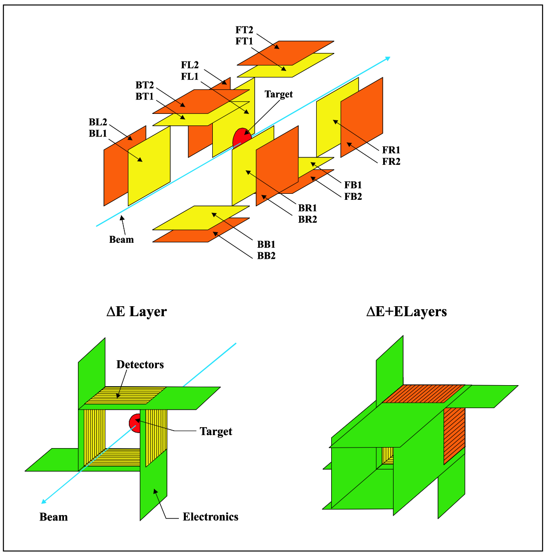

Fig. 1. Displacement of the EXODET telescopes around the target and assembling of the two layers.

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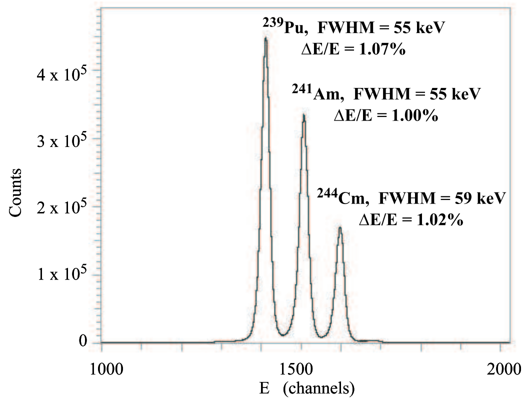

Fig. 2. E-detector energy spectrum for a three-peak alpha source.

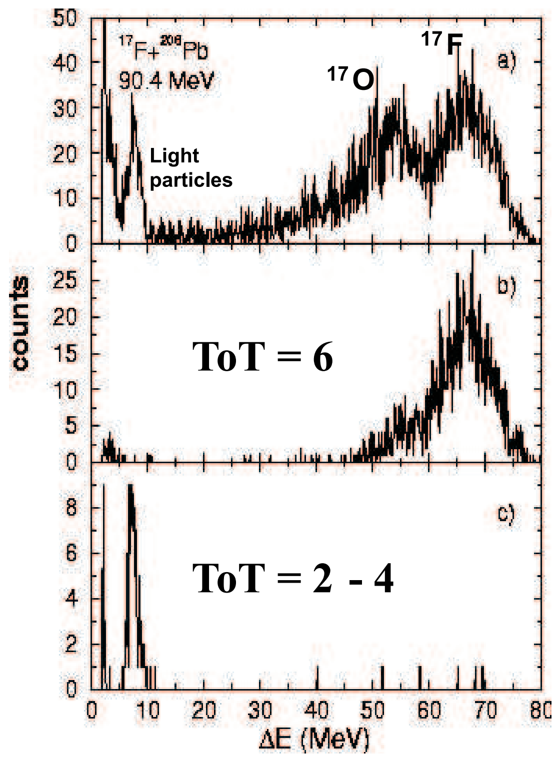

Fig. 3. a) ΔE spectrum collected from the backward detector of the EXODET apparatus; b) ΔE spectrum gated by JT = 10 and ToT = 6; c) ΔE spectrum gated by JT = 10 and ToT ranging from 2 to 4.

strips of one EXODET detector. The signals outcoming from each strip are separately treated: they are amplified, shaped, sampled at a 15 MHz frequency, compared with an externally settable threshold, and stored in a 193 cells memory buffer. When a validated trigger command arrives to the chip the buffer is analyzed and, if a signal is present, a digitalized data stream is sent as output. It contains the identification number of the strips hit, the time spent by the signals over the threshold (ToT) and the time distance between the signals and the trigger (JT, Jitter Time), both measured in clock cycles. Front-end modules based on VME standard bus and an appropriate

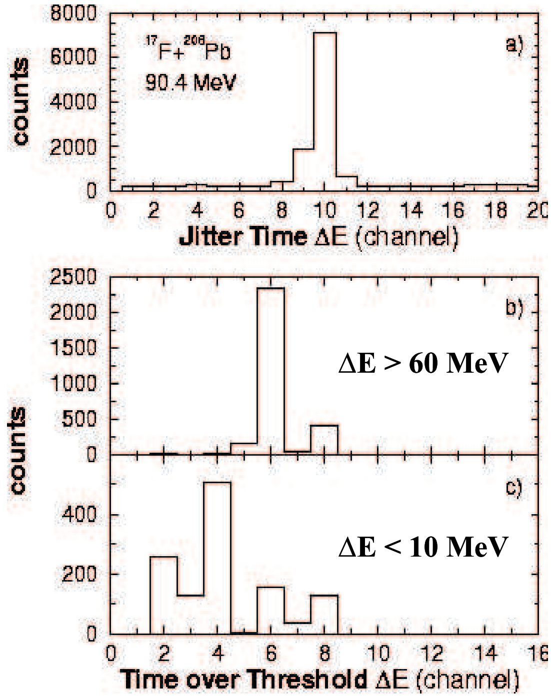

Fig. 4. a) JT spectrum of the backward ΔE detector; b) and c) ToT spectrum for the same detector corresponding to the ^{17}F-peak and light particles, respectively.

acquisition system have been developed. The first successful experiment [3] has been performed, using a part of the EXODET apparatus, at the Argonne National Laboratory (USA). The scattering of a ^{17}F exotic beam by a ^{208}Pb target has been measured in the angular range $\theta_{\rm lab} = 98°$ to 154° at an incident energy of 90.4 MeV. The data collected have been analyzed in terms of the optical model to find the best-fit parameter set of the nuclear potential and a comparison with the behavior for other stable nuclei in the same mass region has been discussed. The ^{17}F seems to behave more similarly to the oxygen stable isotopes (^{16}O and ^{17}O) than to the stable ^{19}F nucleus. The cross section for the $^{17}\mathrm{F} \longrightarrow {}^{16}\mathrm{O} + \mathrm{p}$ break-up process has been evaluated giving an average value of 2.6 ± 1.2 mb/sr at backward angles. In fig. 3a) we report the energy spectrum of the collected events showing the peaks of the ^{17}F scattered ions, of the ^{17}O beam contaminant and of light particles. In fig. 4a) the JT spectrum of the strip signals is presented. The sharp peak at JT = 10 indicates that all events classified as "good ones" are correlated to the trigger within a 67 ns time window. In panels b) and c) of fig. 3 and fig. 4 is evidenced the correlation between ToT and energy and the system capability to disentangle different contributions by selecting the events with appropriate gates.

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