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Upgrade of the TAMU MDM-focal plane detector with MicroMegas technology

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ABSTRACT

A gridded ionization chamber used as a focal plane detector at the back of the TAMU-MDM spectrometer was modified to use MicroMegas technology for the purpose of improving energy resolution and particle identification. The upgraded system was tested in experimental conditions with several heavy-ion beams at 12 MeV/u and found to achieve resolutions between 3.2% and 4.8%. This is a significant improvement over the previous performance of 10–15% obtained using the existing, conventional ionization chambers.

1. Introduction

X-ray bursts are the most frequent thermonuclear explosion occurring in the universe and represent one type of phenomena responsible for heavier element nucleosynthesis. For this reason and others, a number of powerful X-ray observatories have been used to take large amounts of data on these bursts. The interpretation of these observations, however, is problematic due to the lack of a complete understanding of the nuclear physics at the base of these phenomena [1]. Among the various processes occurring in X-ray bursts, the most important is the rp-process. It is dominated by (p, γ), (α, p) reactions and β-decays. Critical nuclear data is needed related to these processes such as: nuclear masses, β-decay rates and reaction rates. Of the three, reaction rates are the most difficult to determine with direct methods due to the fact that most of the nuclei involved in these reactions are unstable [2].

At Cyclotron Institute, Texas A&M University, we have measured various proton capture reactions indirectly using the Asymptotic Normalization Coefficient (ANC) method [3] and experiments involving proton and neutron transfer reactions. These experiments were done primarily with the Multipole-Dipole-Multipole (MDM) spectrometer [4]. The Oxford focal plane detector sitting at the back was used to identify particles and measure their positions along the dispersive *x*-direction. Using raytrace reconstruction we could determine the scattering angle at the target as a function of the angle of the particle path in the detector [5]. The reactions studied so far involved nuclei with A $\leqslant$26. For masses in that region, we found that we were having significant difficulties with the particle identification (PID) due to the insufficient resolution of both the ΔE (energy lost in the gas) and E_{res} (residual energy, deposited in the stopping material) signals (see Fig. 1). Specifically, we needed to analyze isotopes of masses A and A + 1 separately but could not gate on each exclusively due to overlap.

In order to improve ΔE, we decided to use a MicroMegas detector. This is a relatively new detector technology that we have successfully used in a different system, called Astrobox [6], which is built specifically for low noise and is used to detect very low-energy protons from beta-delayed proton emitters.

The MicroMegas detector operates as a two-stage parallel-plate avalanche chamber. It consists of a small amplification gap (50–300 μm) and a much larger drift gap (on the order of cm) separated by a thin electroformed micromesh. It has been shown to provide gains of up to 10^5 [7].

In the course of testing and using the Astrobox, we observed that the MicroMegas also detected the incoming energetic heaver ions with good resolution for particle identification. In light of that,

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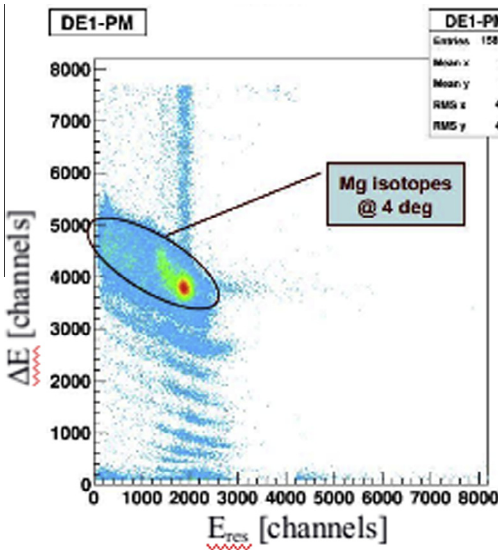

Fig. 1. Standard 2D ΔE–E_{res} spectrum produced by the Oxford detector and used for PID.

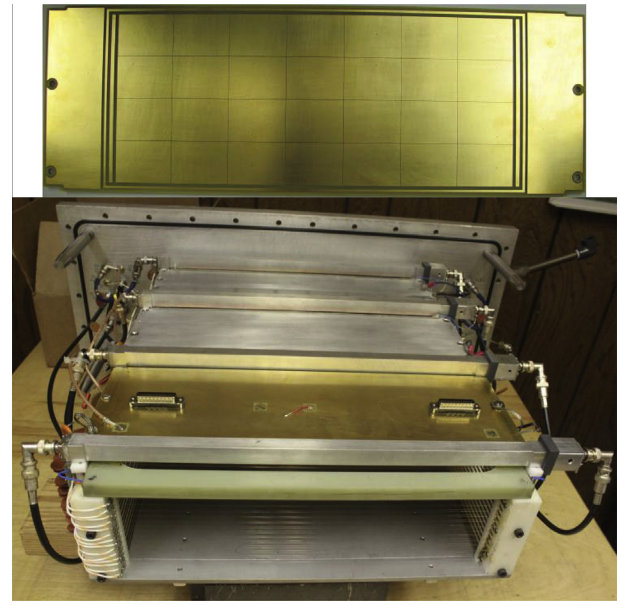

Fig. 3. (Top) The MicroMegas anode. (Bottom) Oxford detector with the new Anode mounted.

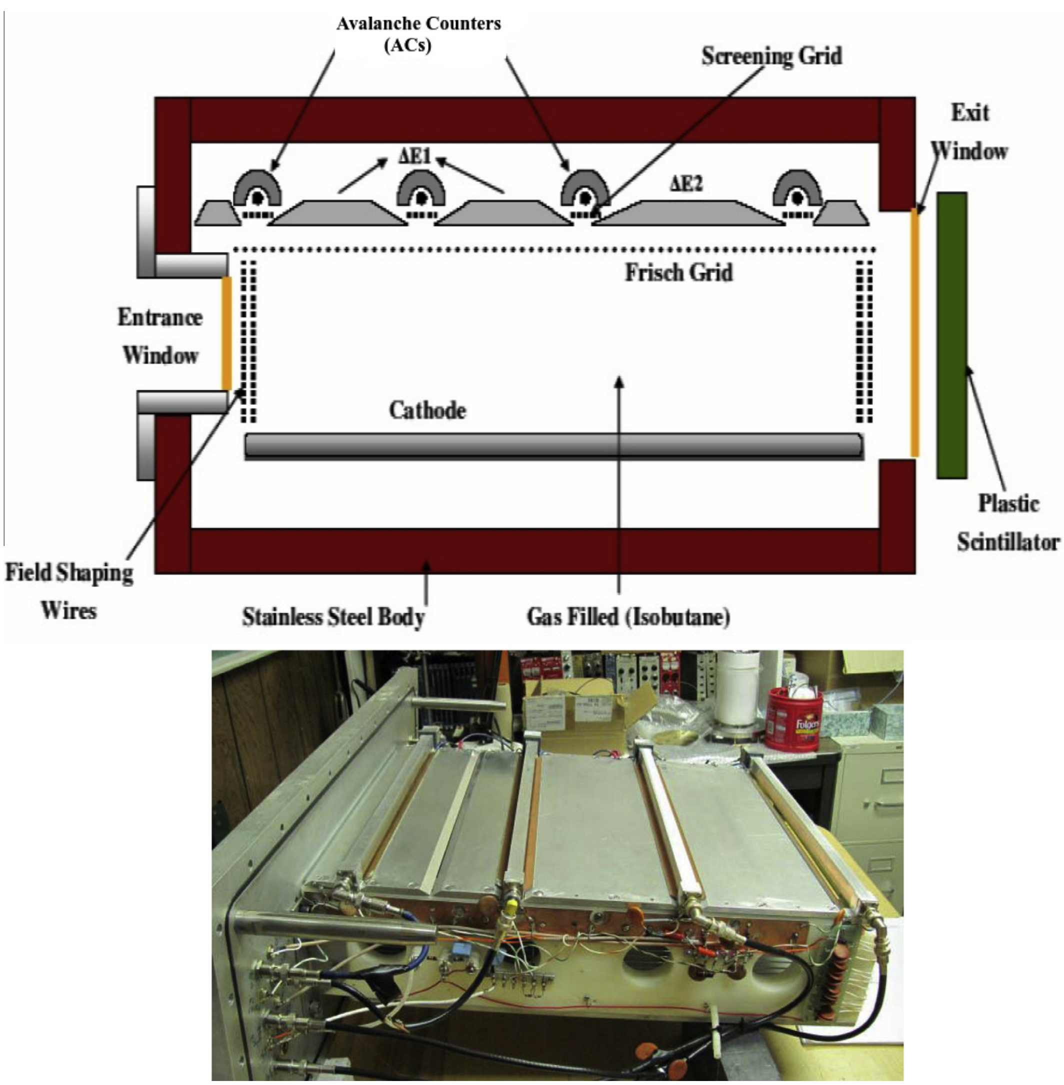

Fig. 2. (Top) Schematic drawing of the Oxford. (Bottom) Photo showing the Oxford detector.