Upgrade plan for the Oxford detector

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The Oxford detector is one of the two focal plane detectors of the Multipole-Dipole-Multipole (MDM) spectrometer. It is used to identify particles and measure their positions along the dispersive x-direction. Using raytrace reconstruction we can determine the scattering angle at the target as a function of the angle of the particle path in the detector.

It has been used primarily to study scattering and transfer reactions involving nuclei with A≤26. However at higher masses, we are having significant difficulties in particle identification and realized that in order to study nuclei above this range we would need to improve the existing setup.

In the simplest terms, the Oxford detector is an ionization chamber with a plastic scintillator at the back. Four resistive wires working in avalanche conditions allow for position determination at four different depths in the detector and therefore permit raytrace reconstruction. A detailed description can be found in ref [1]. **Error! Reference source not found.** shows a schematic side view of the detector and its components.

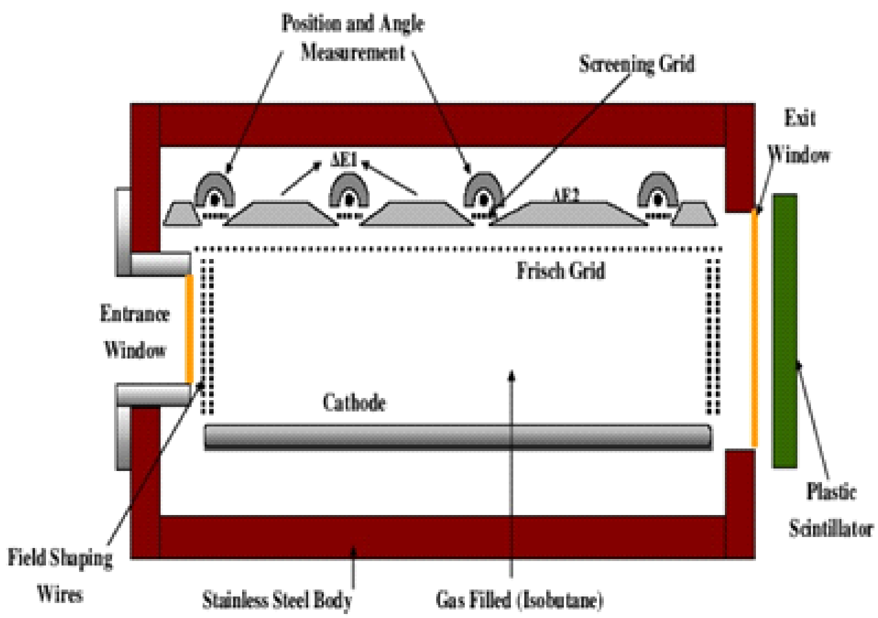

FIG. 1. Schematic of the Oxford detector.

Identification of the ions is done by the usual ΔE-E method: a plot of the energy that particles lose as they pass through the ionization chamber versus the residual energy left when they stop in the scintillator. These are the parameters we seek to detect with better resolution at this time.

Energy lost in the ionization gas is measured by the three anode plates at the top that can be seen in the figure above. Currently, with only the first two plates connected to produce a signal we call ΔE1, we obtain a reasonable energy resolution. The third plate, ΔE2, gives a signal that is too noisy to be of any use. We propose to improve this by introducing Micromegas (see ref [2] for description). These micro-mesh structures have been used in AstroBox [3], a detector system built specially for low noise and used to detect very low-energy protons from beta-delayed proton emitters. However, this different detection setup used in the MARS beam line has been shown to give also very good energy resolution with the incoming energetic ions of the beam. In a first step, we will temporarily affix the Micromegas over the ΔE2 anode and test how well this works with the usual Oxford settings, particularly the gas pressure. If the results are positive we would then proceed by replacing all the anode plates with the micro-mesh structures and test again. A challenge we see here is how well these micromegas will work at the low pressures we use (p=50 torr), as they were used at above 1 atm in AstroBox.

Regarding the residual energy, we are looking to improve this by replacing the plastic scintillator with a different detection material. We see two possibilities for this.

The first is to use Si pads to cover the back of the Oxford detector (8.1cm x33.6 cm). However the size of the area raises the issue of how to cover it given current production costs and availability. At the moment, we expect we might need two rows of Si pads (6 pads in each row, with the size of a quadratic form detector of 5.6 cm and a dead area ~1 cm wide). The thickness of a Si pad is roughly 400 μm with an energy resolution for α-particles of 5.5 MeV of 1.2%. As we have not yet decided on the optimum size of each pad and number that we need, we ordered two small α-detectors (diameter of 2.5 cm) for testing and expect them to arrive soon.

The second possibility to improve residual energy detection would be to add another volume of gas at a higher pressure (~ 800 torr) then in the first space and stop the particles there. The setup would be similar to the recently developed AstroBox detector [3], which we know to have much better resolution than the scintillator.

Our aim is to complete and test the first step by the end of summer 2013.

[1] D. H. Youngblood, Y.-W. Lui, H. L. Clark, P. Oliver, G. Simler, and Nucl. Instrum. Methods Phys. Res. A**361**, 359 (1995); M. McCleskey, Ph.D Dissertation, Texas A&M University, 2011.

[2] Y. Giomataris *et al.*, Nucl. Instrum. Methods Phys. Res. **A376**, 29 (1996).

[3] E. Pollacco et al., Nucl. Instrum. Methods Phys. Res. (accepted).