Final results of the first upgrade of the Oxford detector

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The Oxford detector [1] is one of the two focal plane detectors of the Multipole-Dipole-Spectrometer (MDM). It's a gridded ionization chamber with 4 avalanche counters and a scintillator. Particle identification is done using the energy loss in the gas, dE, and the stopping energy left in the scintillator, E. This detector was used successfully for nuclear astrophysics studies involving nuclei with A≤26. However at higher masses than that, it was found that the limited resolution of both dE (10-13%) and E (16-20%) signals was causing significant difficulties in particle identification. The upgrade of the Oxford detector was focused on improving the resolution of both of these signals. For details on the project see ref [2], [3], and [4]. The first step in this upgrade was to improve the dE signal by introducing Micromegas [5], a new technology shown to provide gains of ~ 10^4, as well as very good energy resolution.

The physical modifications required for this were completed in November 2014 and can be seen in Fig. 1. The original aluminum anode plate was replaced with a Micromegas one containing 28 individual detection pads. The signals were read using 2 D-SUB 25 connectors and processed through 2 Mesytec MPR-16 preamplifiers, 2 Mesytec MSCF-16 shapers and one Mesytec ADC.

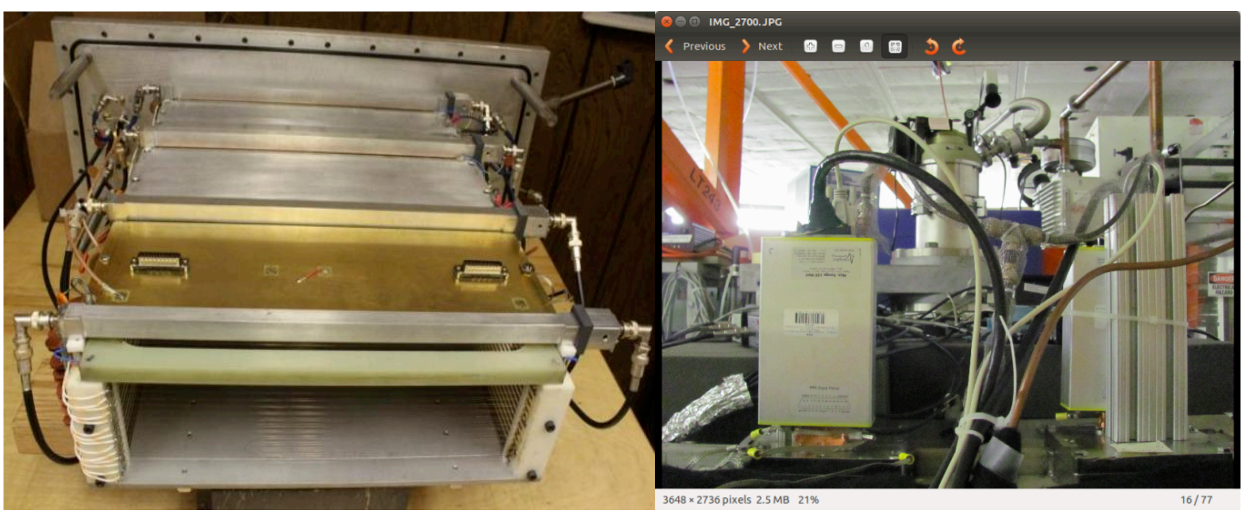

FIG. 1. (left) Photograph showing the detector components inside the chamber. (right) Photograph showing the outside of the detector chamber, including the new flanges and the MPR-16 modules.

Tests were done over a 14 month period with a variety of beams. Fig. 2 shows an example of the individual pad response as well as the full anode response for a tightly collimated ^{16}O beam. The

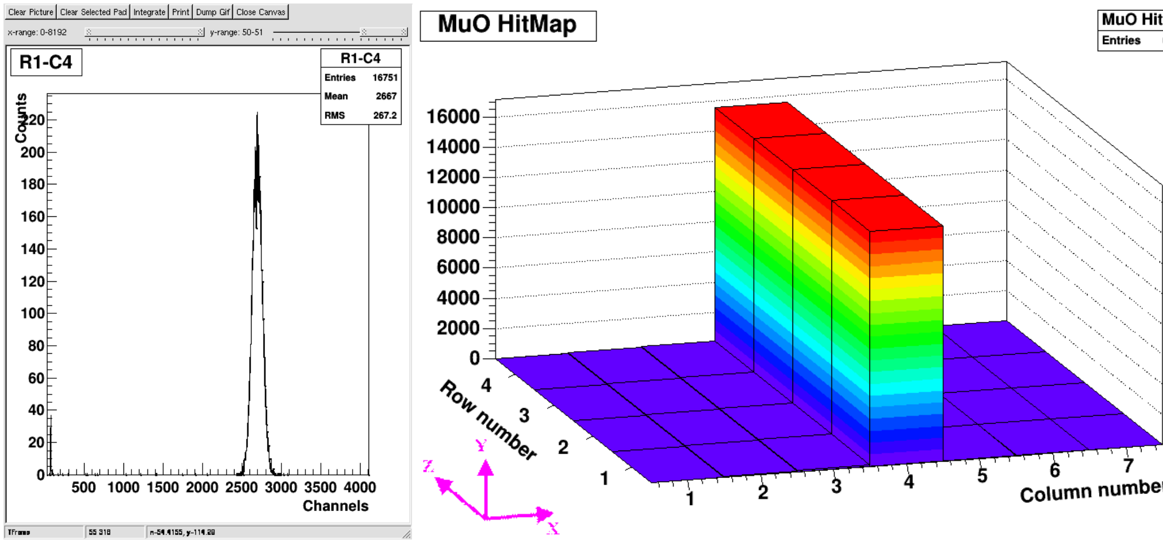

FIG. 2. (left) Hisogram showing the response of pad in row 1 column 4. (right) 3-D map of the column 4 pads 'hit' as a ^{16}O beam passes through the gas.

Micromegas behavior was observed for different gas (isobutane) pressures, different bias voltages, as well as different ionizing particles. Fig. 3 summarizes the determined micromegas gain behavior under these different conditions.

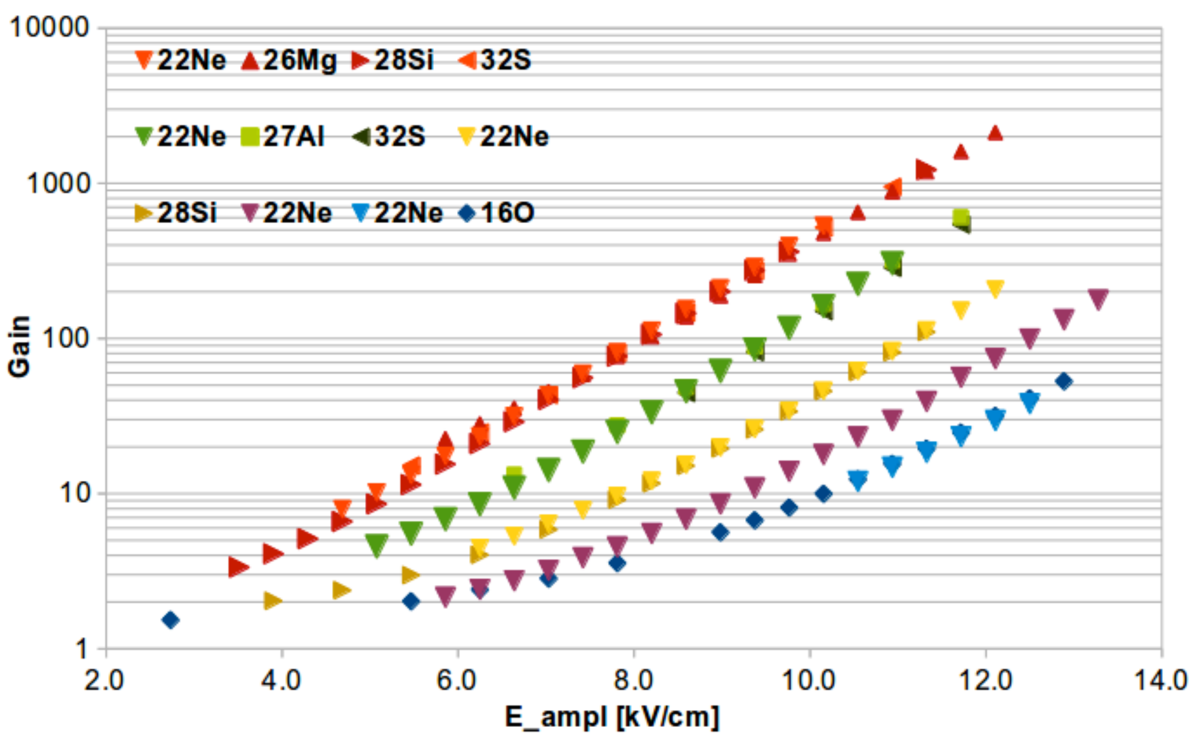

FIG. 3. Micromegas gain curves for all the ionizing particles used in the testing. The different gas pressures are color coded (Torr): red=30, green=50, yellow=70, purple=85, and blue=100.

Individual pad resolution varied with the gas pressure from ~5.5% (at 100 Torr) to ~10-11% (at 30 Torr). Averaging the energy over the 28 pads, the resolution improved by almost a factor of 2, as can be seen in Fig. 4.

FIG. 4. Plot showing the energy loss resolution for the Micromegas anode (averaged over the 28 pads) for different bias voltages of the Micromegas and different gas pressures.

At similar pressures, the Micromegas detect the energy lost in the gas with a resolution a factor of 3 better than the ionization chamber. In conclusion, the upgrade was considered successful and has already been in use for nuclear astrophysics studies focused on nuclei with A>26 (like, ^{28}Si and ^{32}S).

The second step of the upgrade will involve replacing another aluminum anode with a Micromegas plate. The 2-Micromegas anodes configuration is intended for use an independent dE-E telescope, where one anode will detect the energy loss signal, dE, and the second one will detect the stopping energy, E. This setup will allow the use of higher gas pressures (for better resolution), as well as studies at higher angles and/or at particle lower energies.

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