The Gas-Silicon-Scintillator Hybrid Detectors

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Introduction

A preliminary study of the 170 MeV ^{24}Mg + 377 μgcm^{-2} ^{12}C target data taken at the Australian National University in June 1996 has been made. This analysis has concentrated on the performance of the CsI scintillator detectors mounted at the rear of the hybrid telescopes. This is to allow a comparison with the the data taken using the MEGHA array during the same running period, as discused by R. Cowin in the report "Effects seen in the MEGHA telescopes."

The experimental setup for this run consisted of two of the new Gas-Silicon-Scintillator hybrid detectors placed at 170mm from the target position in the 2m chamber. For the 170 MeV ^{24}Mg + ^{12}C target data analysed the detector telescopes were centred at 16°/16°. Both the in-plane and out-of-plane angular coverage of each of the detector telescopes was approximately $\pm$ 8.0°.

Gas and Silicon Particle Identification

The upper data in Figure 1 shows the particle identification spectrum obtained by plotting the energy measured in a silicon detector against the corresponding gas ionisation chamber for the hybrid run. Although the calibrations of the silicon detector energy are currently at a preliminary stage (degrading the resolution of this plot), loci can be seen for particles ranging from He to Si. The data shown includes singles, coincident and pulser events. Due to the preliminary state of the analysis, no TDC gating has been applied to any of the hybrid data presented in this report.

In the lower graph the corresponding particle identification spectrum obtained from the analysis of data taken with MEGHA is seen (this is discussed in greater detail in the report "Effects seen in the MEGHA telescopes"). This has been expanded along both the gas and silicon energy axes (with respect to the hybrid data) to emphasis the un-physical gas energy signal corresponding to Li and He ions. There is no evidence for such un-physical gas signals in the hybrid data, suggesting that the cross-contamination of gas and scintillator signals observed in the MEGHA data is a feature of the signal read-outs on the MEGHA back plates, and not a physical feature of the gas and scintillator detectors themselves. This idea is supported by the gas energy against scintillator energy spectra, which are shown in a later section.

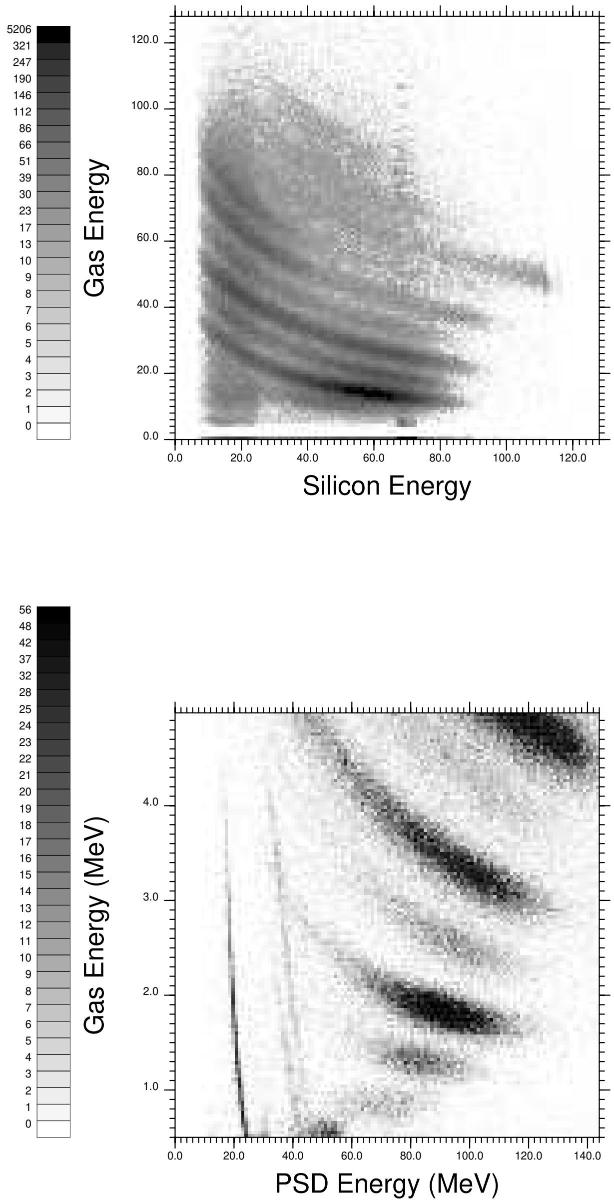

Figure 1: Particle identification spectra obtained from 170 MeV ^{24}Mg + ^{12}C target data. In the top spectrum the data were taken using a Gas-Silicon-Scintillator hybrid telescope. In the lower spectrum the data were obtained from MEGHA.

Silicon and Scintillator Particle Identification

In Figure 2 light ion particle identification spectra obtained from the silicon and scintillator detector energy signals are shown (hybrid data). In the upper plot the data were taken with the amplifier used for the scintillator signal set to a positive input, in the lower graph the amplifier was set for a negative signal. It is seen that the "negative signal" data displays the same overall form as the "positive signal" data, but that the scintillator signal covers a greater range of channels (voltage). This suggests that the correct setting is for negative signals, and that in the positive signal case it is only the lower amplitude, second, part of the bi-polar signal that is being amplified, and not the correct, full-amplitude, first peak.

In Figure 2 it is possible to see a clear locus of events tracking across the lower left hand of the data, and these are attributed to events where an α-particle has been detected. To confirm this a second scintillator-silicon particle identification spectrum has been produced, and this is shown in Figure 3. This was obtained by gating on the gas-silicon particle identification spectrum (shown in Figure 1), so that only events corresponding to α-particles were incremented into this new scintillator-silicon spectrum (these data were taken with the amplifier used for the scintillator signal set to a negative input). The locus of events is clearly seen in this new plot (Figure 3), confirming that the identification of the particles as alphas was correct.

One feature of the data shown in Figure 2 is the smooth fall-off of events with increasing scintillator energy, indicating that saturation of the signal or signal cut-off was not occurring at any stage of the signal processing. In the MEGHA data taken in July 1996 evidence was seen for the saturation of signals obtained from the CsI detectors, which has been suggested to be a result of an insufficient current supply to the scintillator pre-amplifiers. In the hybrid data the scintillator pre-amplifiers were powered by the MEGHA scintillator power supply, effectively five separate supplies, each designed to power one module. In the hybrid data two of the five supplies were used, so that each was loaded by one scintillator only. The lack of evidence for saturation in the hybrid data, but appearance in the MEGHA data, therefore suggests that the power supplies used can correctly supply one scintillator, but may be overloaded when used to power an entire module. It is clear that this problem warrants further investigation.

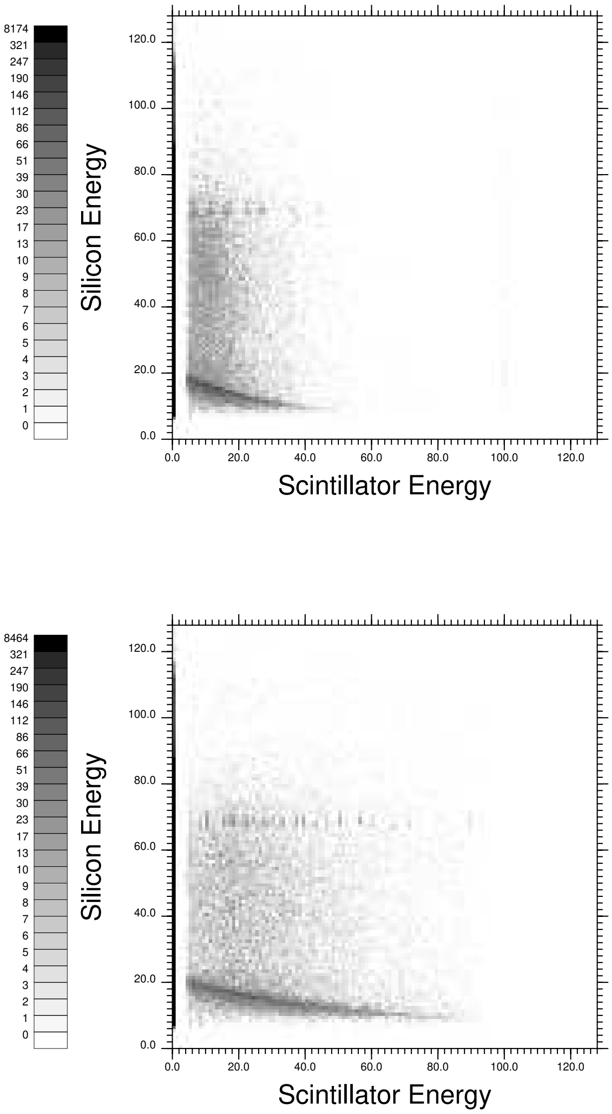

Figure 2: Particle identification spectra obtained by plotting the energy deposited in a CsI detector against that lost in the silicon strip detector for a hybrid run. In the upper plot the amplifier corresponding to the scintillator signal was set to receive a positive input. In the lower plot the amplifier was switched to a negative input.

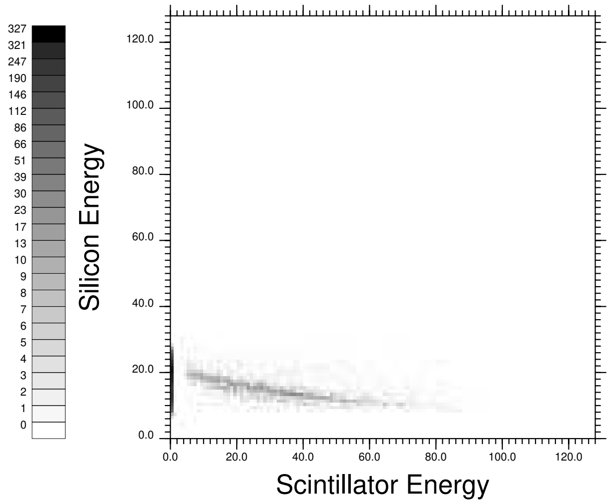

Figure 3: Particle identification spectra obtained by plotting the energy deposited in a CsI detector against that lost in the silicon strip detector for a hybrid run. The data have been filtered by placing a software gate on the silicon-gas particle identification spectrum shown in Figure 1. Only particles identified as alphas in the silicon-gas spectrum have been incremented into the above plot. This confirms that the clear locus of events seen in Figure 2 corresponds to α-particles.

Gas and Scintillator Signal Cross-talk

In Figure 4 the energy deposited in the CsI scintillator is plotted against that lost in the gas ionisation chamber. In the upper plot the data are those obtained with a Gas-Silicon-Scintillator hybrid, whilst those in the lower graph were taken with MEGHA. The hybrid data is as expected, with the majority of events (80%) lying along the Y-axis, corresponding to particles which deposited energy in the gas ionisation chamber and which were then stopped by the silicon detector. A further 11.5% of the data lie along the X-axis, corresponding to high energy light ions which are stopped in the scintillator, but which leave insufficient energy in the gas to produce a gas detector signal. Only 8.5% of the events produce both a gas and scintillator signal, either a “genuine” coincidence (it has already been noted that no TDC gates have been applied to any of the spectra taken with the hybrids) or events where a light ion and heavy ion are detected at the same time (such events are seen in the gas-silicon particle identification plot shown in Figure 1 as a broad locus of data running vertically between silicon energy channels 10 to 24).

In the MEGHA data a clear correlation between gas and scintillator energy can be seen as a diagonal band tracking across the spectrum. The saturation of the scintillator signal may also be seen as the upturn in the data at the end of this locus. This correlation is seen as an indication of cross-talk between the signals from the gas and CsI detectors. However, there is no evidence for such a correlation in the hybrid data, indicating that the problem with the MEGHA data lies with the MEGHA feedthroughs and cabling, and not the detectors themselves. It is noted that the scintillator signals are pre-amplified inside the MEGHA modules, as the scintillator pre-amplifiers are mounted directly above the photodiodes on the rear of the scintillators. The gas signals, however, are not pre-

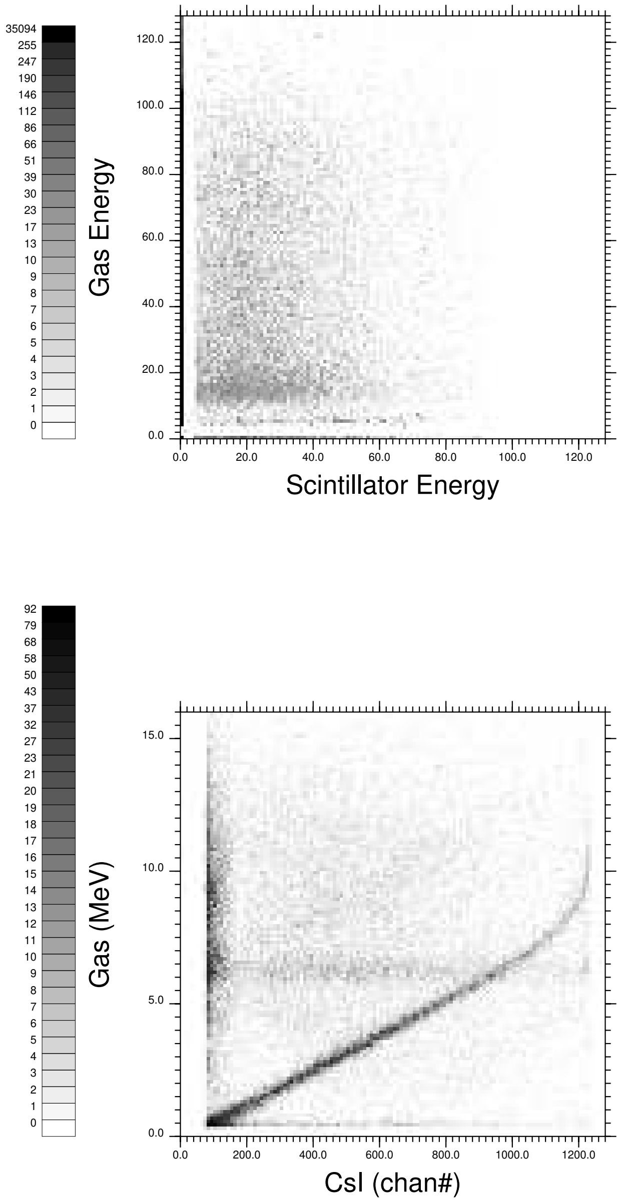

Figure 4: Spectra of scintillator energy against gas energy. The upper data were obtained during the hybrid run, and the lower data were taken with MEGHA.

amplified until outside the MEGHA module, and are thus extremely susceptible to noise pick-up inside the detector housing (before pre-amplification the gas detector signals are very weak, due to a combination of the low energy deposited in the gas by passing ions and the relatively large amount of energy needed to create an ion/electron pair). This suggests that it is more likely to be the gas signals which pick up noise from the scintillator signals, rather than the opposite.