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A double sided silicon strip detector as a DRAGON end detector

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Abstract

The new DRAGON facility (detector of recoils and gammas of nuclear reactions), located at the TRIUMF-ISAC Radioactive Beams facility in Vancouver, Canada is now operational. This facility is used to study radiative proton capture reactions in inverse kinematics (heavy ion beam onto a light gaseous target) with both stable beams and radioactive beams of mass $A = 13$–26 in the energy range 0.15–1.5 MeV/u. A double sided silicon strip detector (DSSSD) has been used to detect recoil ions. Tests have been performed to determine the performance of this DSSSD.

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1. Introduction

The Micron Semiconductor [1] Model W(DS)-250 double sided silicon strip detector (DSSSD) used by the detector of recoils and gammas of nuclear reactions (DRAGON) separator consists of 16 front strips (numbered 0–15) and 16 back strips (numbered 16–31), each of width 3 mm. This provides 256×3 mm^2 pixels on the 5 cm^2 detector to encode *x–y* position. The detector was run at 70 V bias at which it is 20 V above its full depletion voltage.

The strips were connected by a 34-pin cable to a circuit board that holds two types of pre-amplifiers (RAL 108A,B) [2], one set for the front strips and another for the back strips. The pre-amplifiers were connected by two 34-pin cables to four amplifier modules, each containing eight RAL 109 amplifiers. Each of the 32 amplifiers produces an analogue pulse and an ECL-level fast-discriminator signal. Each analogue signal is fed directly to a Silena [3] 4418/V ADC. The ECL signals were ORed to produce the ADC gate. The gate width was adjusted to be 3 μs wide. MIDAS [4] software was used for data acquisition and PAW [5] was used to display data.

Bench tests were performed with ^{241}Am α-sources to determine the performance of the detector.

2. Experimental method and results

The energy resolution of the individual strips was measured by a thin 15 *n*Ci ^{241}Am source

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placed 25 cm from the detector's surface, flooding it with α-particles. A Gaussian function was fit to the 5.486 MeV peak. Individual front strips displayed energy resolution of 0.7–0.9% FWHM for the 5.486 MeV peak. The edge strips showed a somewhat poorer resolution.

As a test of the relative efficiency of the strips, a long flood run was performed with a 10 μCi ^{241}Am source positioned 25 cm from the detector's surface. It is evident from the projections of the 3-D histogram of *x*-position versus *y*-position, shown in Figs. 1 and 2, that the efficiency is roughly constant across the entire detector, with the exception of the edge strips. The slight curvature of the distributions is consistent with solid angle effects.

Neighboring strips are separated by an insulating gap. It has been observed by others [6] that a charged particle entering the detector through the gap between strips induces a reduced pulse height in the front strips in comparison to a particle entering through a strip. This effect is believed to be the result of charge trapping between strips due to the shape of the electric field between the strips [6]. We examined this effect using α-particles collimated to enter the detector through the gap between front strips.

First, a 10 μCi ^{241}Am source was fixed 25 cm from the detector's surface and collimated with a paper slit 280 μm wide. The collimated source was placed 5 mm in front of one of the front strips. Data was taken under the following conditions:

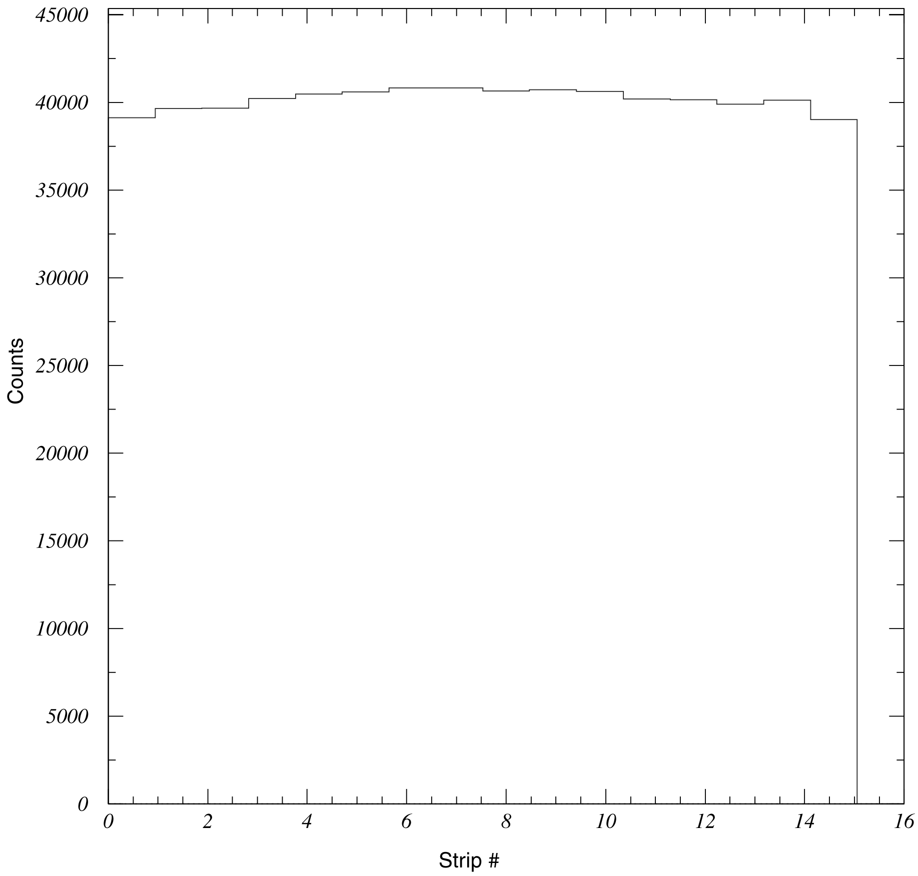

Fig. 1. Projection of the front strips.

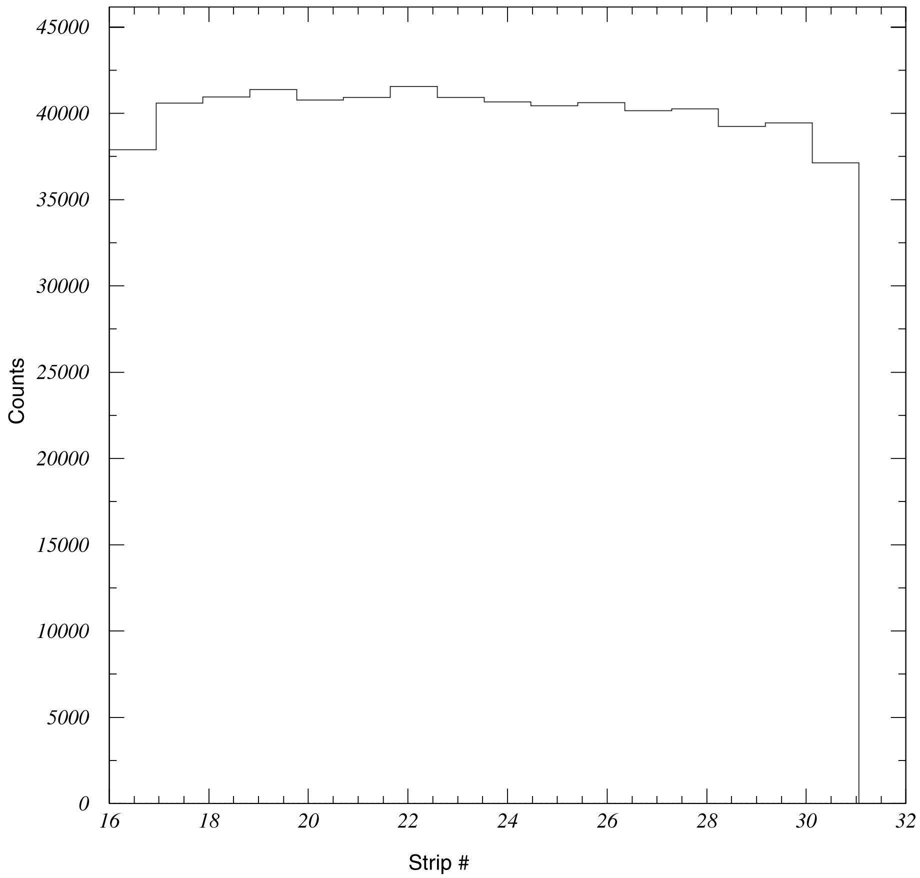

Fig. 2. Projection of the back strips.

1. the slit was placed parallel to the strip positioned at its center, and
2. the slit was positioned to straddle a gap between two front strips.

The count rate under the full energy peak for case (2) was ≈41% of that for case (1). This is consistent with the ratio of the gap width (110 μm) to the slit width, suggesting that none of the α-particles entering through the gap produced signals with pulse heights corresponding to the full energy. The slit was then aligned orthogonal to the strips so that it crossed several gaps. The deficiency of full energy counts in the relevant strips was slightly greater than the ratio of the gap width to the strip width, confirming that none of the α-particles entering the gap produced a signal of full energy.

Next, a 180 μm slit was aligned parallel to a gap and moved across two gaps in small steps with a micrometer. To ensure that the slit was actually parallel to the gap, the slit orientation was adjusted until the two strips adjacent to the gap had a nearly constant count rate along the strips (Fig. 3). Fig. 4 shows the full energy count rate of the three relevant strips versus position of the slit. The two troughs correspond to the positions of two gaps. The width and depth of the troughs is consistent with the assumption that the effective gap width is 120 μm and no α-particles entering the gap produce full energy pulses. The effective gap width is defined here to be the gap width which would account for the loss of counts in the full energy peak, assuming that no gap events produce a signal of full pulse height. The strip width is 3 mm, so $(3.85 \pm 0.10)\%$ of all α-particles incident on the

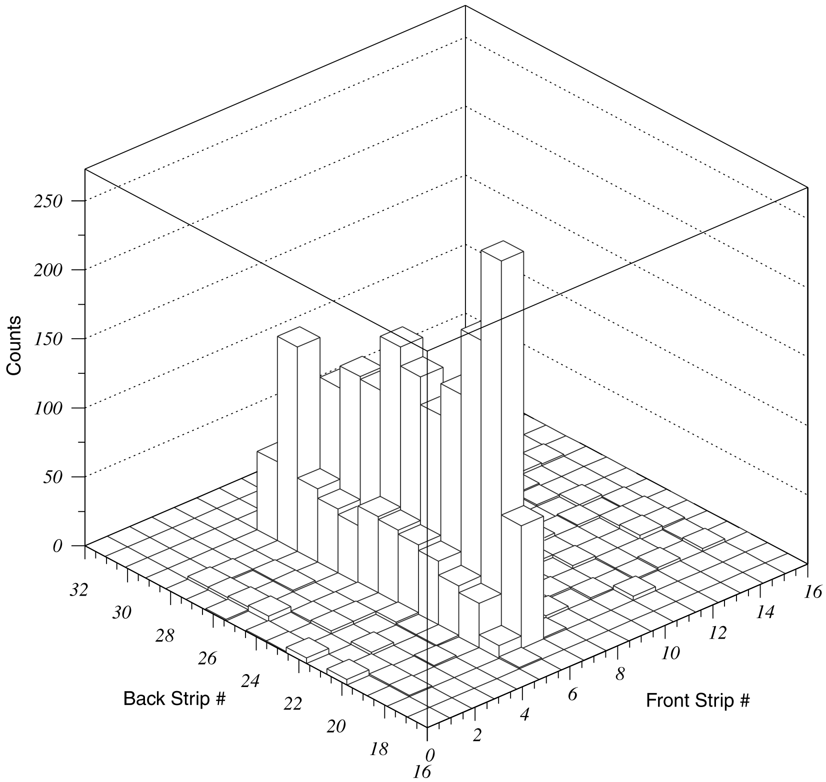

Fig. 3. Counts as a function of position for a slit-collimated α-source.

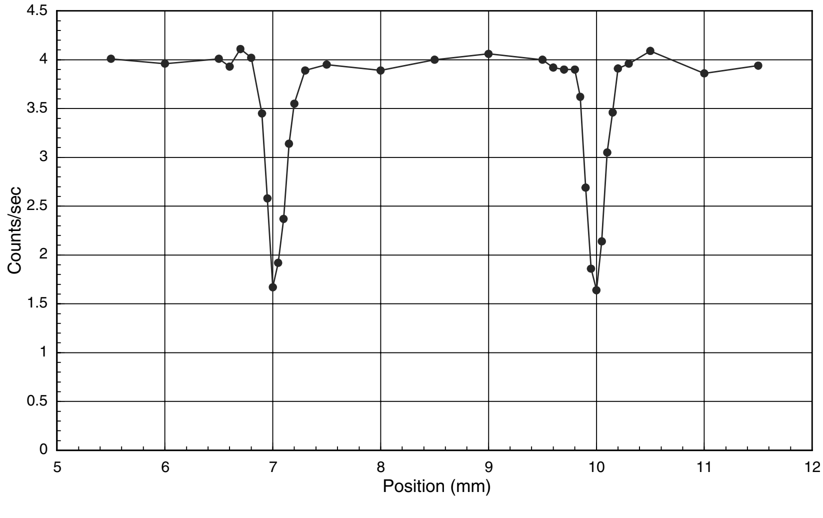

Fig. 4. Count rate versus slit position.

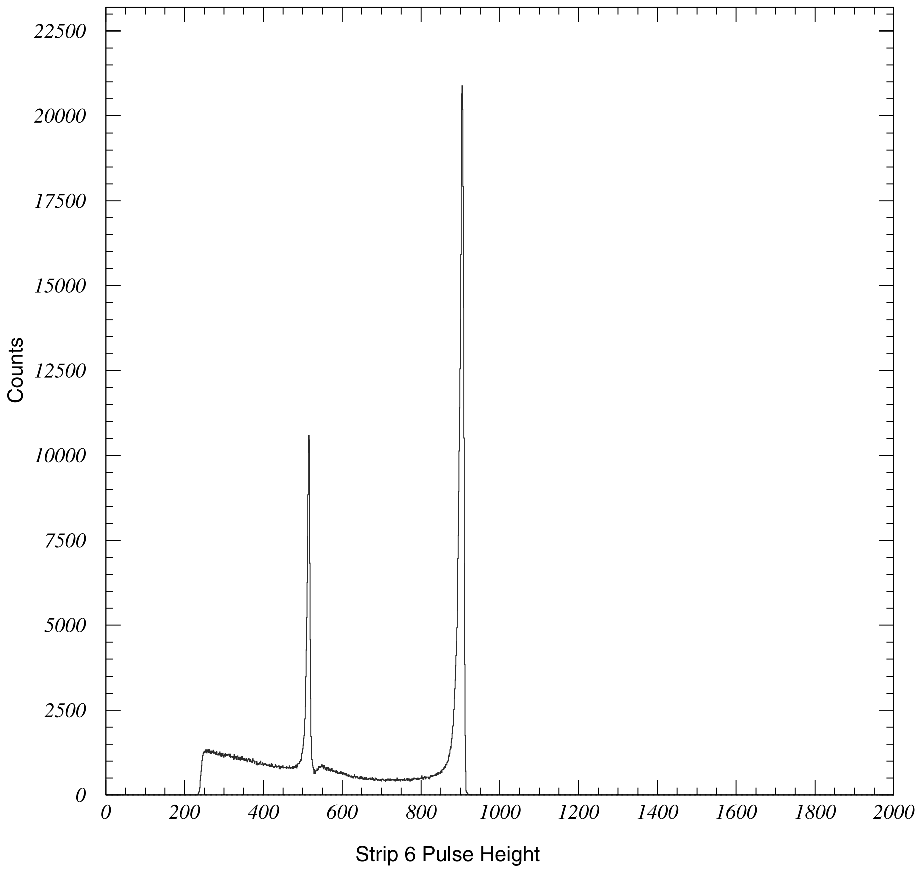

Fig. 5. Low energy peak from gap events at about 1/2 the full pulse height.

detector's surface will not be detected at full pulse height by the detector.

There is a slight discrepancy between the measured gap width of 110 μm and the effective gap width of 120 μm When a particle enters the detector, the column of plasma produced has a diameter on the order of microns [7]. If a particle enters a strip at a location that is within a few microns of a gap then some of the plasma column will lie within the gap and may be trapped, causing a pulse height defect. This may be the reason that the effective gap width is larger than the actual gap width.

By integrating the energy spectra of the relevant front strip(s) in case (1) and case (2) above, and subtracting the background (α-particles that penetrated the paper collimator), it was observed that the total count rate in the relevant front strip(s) was constant, Therefore, α-particles that entered through the gap each produced one signal on one front strip, but at reduced pulse height. Most of these gap events are present under a peak in the energy spectrum that is at about half the energy of the full energy peak, however there is also a continuum of gap events from zero energy up to the full energy. Qualitatively, this distribution of pulse heights is in agreement with the proposed model of Schotter et al. [6], with the exception of an anomalous trough visible at an energy just above that of the gap peak (Fig. 5).

3. Conclusion

The Micron Semiconductor DSSSD used in the DRAGON experiments is composed of strips with roughly the same efficiency, with the exception of the edge strips. It displays energy resolution as good as 0.7% for 5.486 MeV α-particles. α-particles entering the gap between strips on the front face of the detector are counted with the same efficiency by the front strips as those entering through a strip. However, the signal produced by these gap events is reduced in pulse height. The concentration of gap events in a distinct peak and their simple explanation from the geometry of the DSSSD allows for reliable correction of DRAGON data to account for gap events.

References

[1] Micron Semiconductor, www.micronsemiconductor.co.uk.
[2] Rutherford Appleton Laboratory, www.rl.ac.uk.
[3] Silena International S.p.A., www.silena.com.
[4] MIDAS is TRIUMF's standard data acquisition system and was developed at the Paul Scherrer Institute (Switzerland) and at TRIUMF.
[5] PAW (Physics Analysis Workstation) is public domain software package from CERN.
[6] A.C. Schotter, J. Yorkston, D.B. Syme, G. Huxtable, Nucl. Instr. and Meth. A 262 (1987) 353.
[7] W. Seibt, K.E. Sundstrom, P.A. Tove, Nucl. Instr. and Meth. 113 (1973) 317.