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A SIMPLE POSITION-SENSITIVE PARALLEL-PLATE AVALANCHE DETECTOR WITH 2-DIMENSIONAL READOUT*

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ABSTRACT

A new design for an x-y position-sensitive avalanche detector is presented. The design is based on charge-division readout of resistive sheet electrodes. The position resolution is < 1 mm. In our application, the position-sensitive detector is operated in the transmission mode with a solid-state E-detector behind it.

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The detector was designed for coincidence measurements of the two fragments from deep-inelastic heavy-ion processes. One fragment is detected in a conventional ΔE-E telescope with a small solid angle. The other is then expected to be emitted at a correlated angle whose value lies within a finite range determined by light particle evaporation and other effects. The angles usually range from ~ 4° to 20° for various systems. A detector spanning such a range of angles is very useful for coincidence measurements of deep-inelastic reactions, giving almost 100% efficiency for the detection of the correlated fragment.

Operation of the detector depends on a combination of the principles of a parallel plate avalanche detector (PPAD) with those of charge division readout in 2 dimensions1,2). The active gas volume of the detector is confined between 3 foils, spaced 2 mm apart (Fig. 1). The polypropylene foils are ~ 40 $\mu g/cm^2$ thick and are made using a stretching technique reported by Barrus, et al3). We consider these thin polypropylene foils important in this application due to their exceptional strength which exceeds that of mylar, and due to their ability to maintain tension which is important for PPAD application. They were also the only foils tested by us that could be easily coated with a suitable resistive metal layer without any significant loss of tension. Formvar, Vyns, and Nitrocellulose foils were not satisfactory. The total thickness of the PPAD, including a grid-supported vacuum window is 160 to 200 $\mu g/cm^2$, which is thin enough to leave sufficient residual energy for an E measurement by a solid-state detector behind it (size 900 mm^2).

The center foil high-voltage electrode is coated on both sides with a Ni-Cr layer exhibiting a low sheet resistance (~ 100 Ω/sq). The outer foils are coated with resistive layer whose sheet resistance lies in the range of 1 to 5 kΩ/sq. Silver painted contacts are applied to opposite ends of each foil, one foil being contacted on top and bottom, the other at the left and right-hand side. Charge division at the contacts give the y position in one foil and the x position in the other. The four contacts are connected to charge-sensitive preamplifiers. A high value of the sheet resistance minimizes the system noise but foils with higher resistance tend to be uniform. A good compromise value in the region of 2 to 3 kΩ/sq is used. During the evaporation of the Ni-Cr onto the foils, the resistance is monitored with an ohm meter. Thus, any desired resistivity can be obtained, although allowance must be made for the oxide layer which develops on exposure to air.

Using three electrodes rather than two allows both outer electrodes to be operated near ground potential, thereby eliminating problems with charge collection in the neighboring gas volumes, i.e. between the vacuum window and the front foil, or between the back foil and the solid state detector mounted behind the PPAD. These areas will be used later for additional subsystems of the complete detector system (ΔE or E gas detectors).

In operation, a particle passing through the detector perpendicular to the foils initiates avalanches in the ~ 10 Torr hexane atmosphere in both sections of the detector. The current induced by the avalanche in each section divides into the preamplifiers according to the ratio of the resistances between the positions of the avalanche and the two contacts connected to the preamplifier inputs.

In a general test of the uniformity of the resistive foils, a mask with a grid of holes was placed in front of the counter and was illuminated with a ^{252}Cf-fission source. Figure 2 shows an example of the position spectra obtained using this mask. The signals x^+, x^-, y^+, y^- in the four channels were digitized and recorded event by event. The position for each event can be calculated from the equations:

$$\text{i)}\quad x = \frac{x^+}{x^+ + ax^-} \qquad ; \qquad \text{ii)}\quad y = \frac{y^+}{y^+ + by^-}$$

The constants a and b are used to equalize the gains of the signals x^+, x^- and y^+, y^-, respectively. They are adjusted to center counts through the central hole of the mask. The positional errors observed in the spectra which amount to approximately 1 mm are caused by nonuniformity of the resistive coating on the foils.

The differential resolution was determined using a mask with 5 holes of 1 mm diameter, spaced 5 mm apart. Figure 3 shows the results of a calibration run with 480 MeV ^{86}Kr. The observed position resolution is 1.05 mm FWHM in both x and y coordinates. No efforts were taken to optimize the electronics, such as using other kinds of preamplifiers, since the initial results were quite satisfactory for the purposes of the heavy ion experiments.

CONCLUSION

In conclusion, the position-sensing principle presented here is a simple solution where an angular acceptance of up to 30° is sufficient. The absence of the large number of wires used in other schemes is advantageous in avoiding scattering from wires which can be a problem in many experiments.

REFERENCES

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FIGURE CAPTIONS

Fig. 1. Expanded view of the position-sensitive detector.

Fig. 2. A two-dimensional spectrum obtained by placing a mask of holes in front of the detector while it was being illuminated by ^{252}Cf-fission fragments. The holes form a 3 cm square. The spectrum was stored in 64 x 64 channels. Only channels whose counts exceeded 0.2 of the peak amplitude are plotted.

FIGURE CAPTIONS cont.

Fig. 3. Y-position spectrum obtained with 480 MeV ^{86}Kr projectiles through a mask having five 1 mm diameter holes, 5 mm apart.

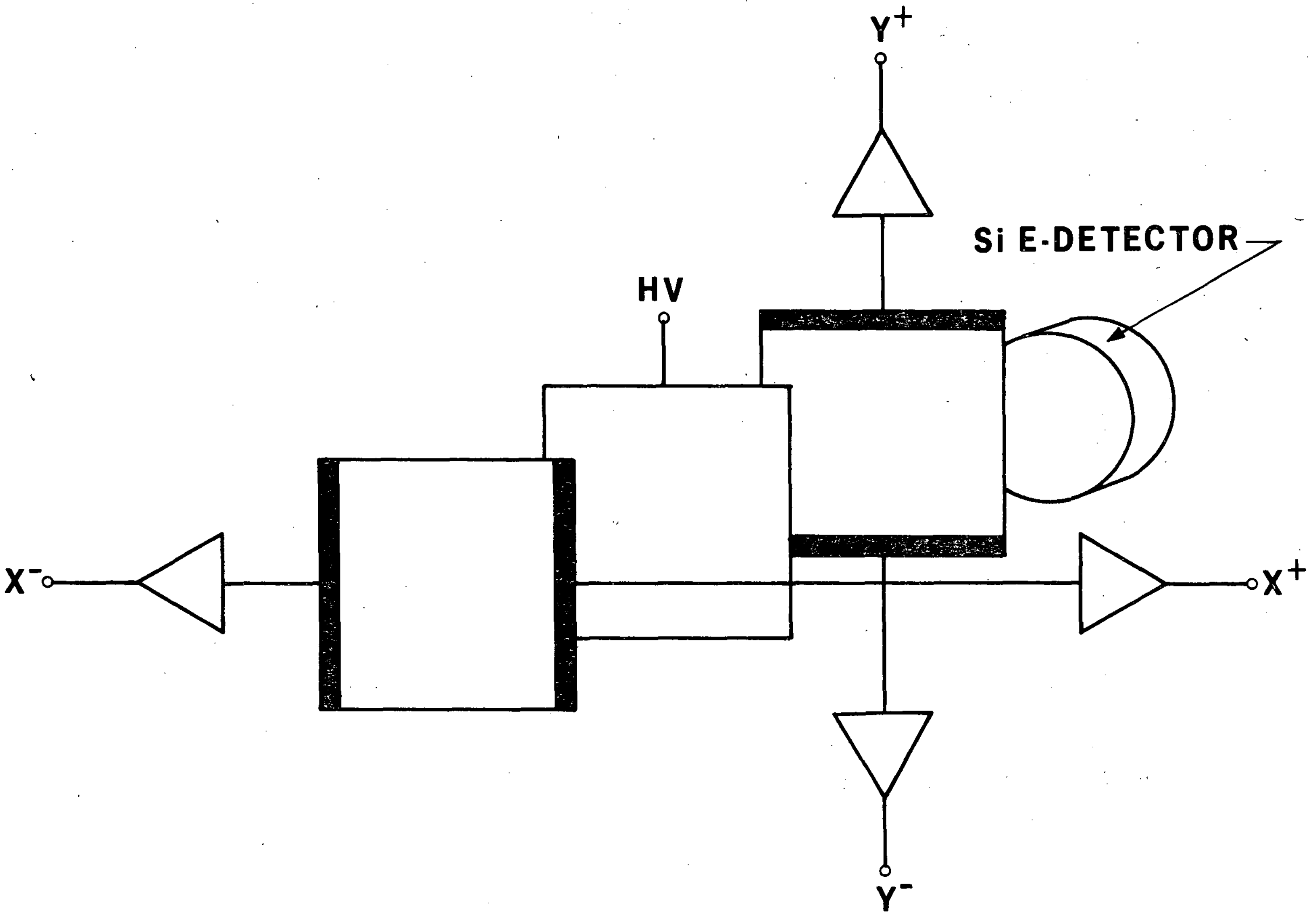

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Fig. 1. Expanded view of the position-sensitive detector.

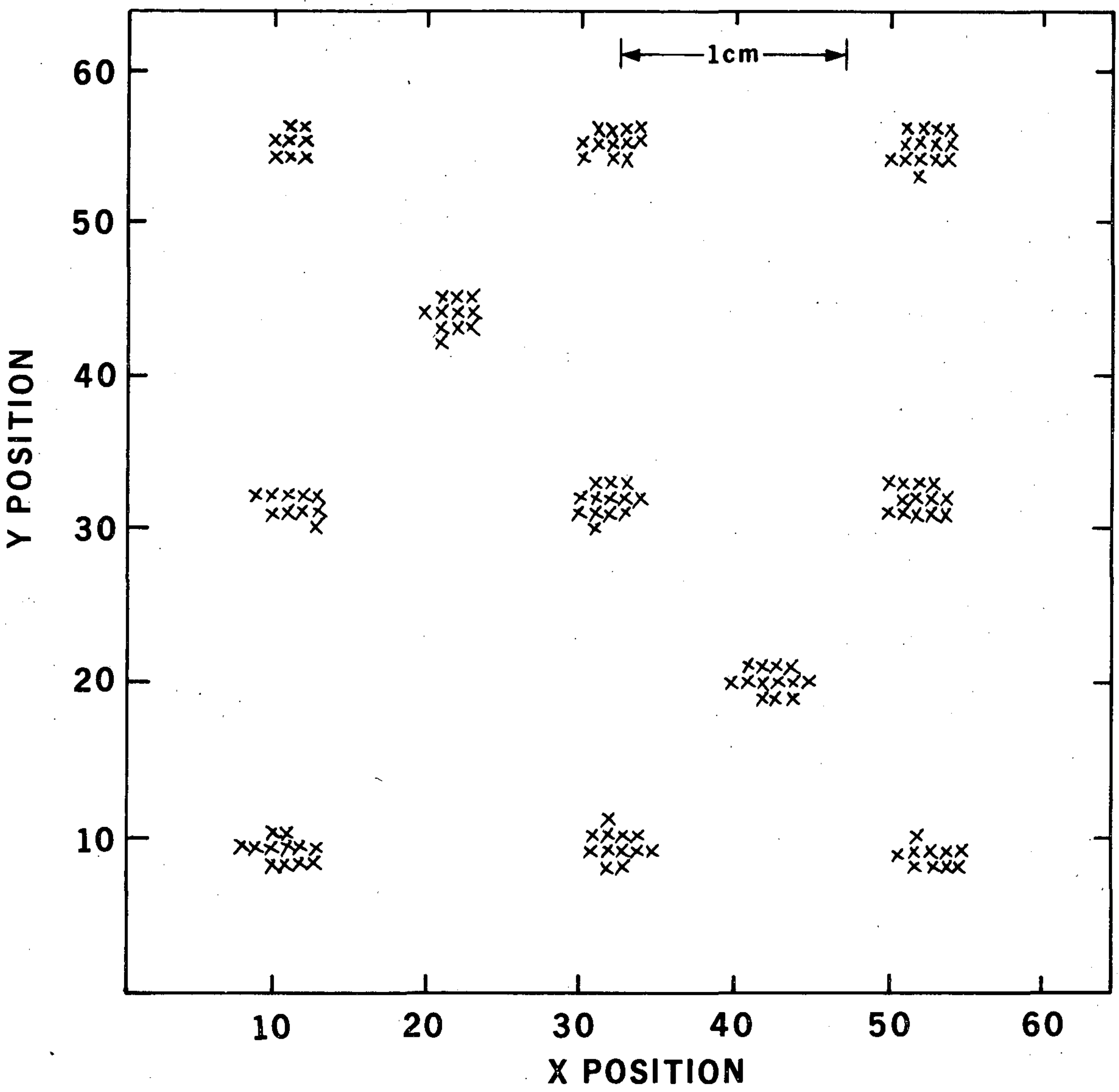

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Fig. 2. A two-dimensional spectrum.

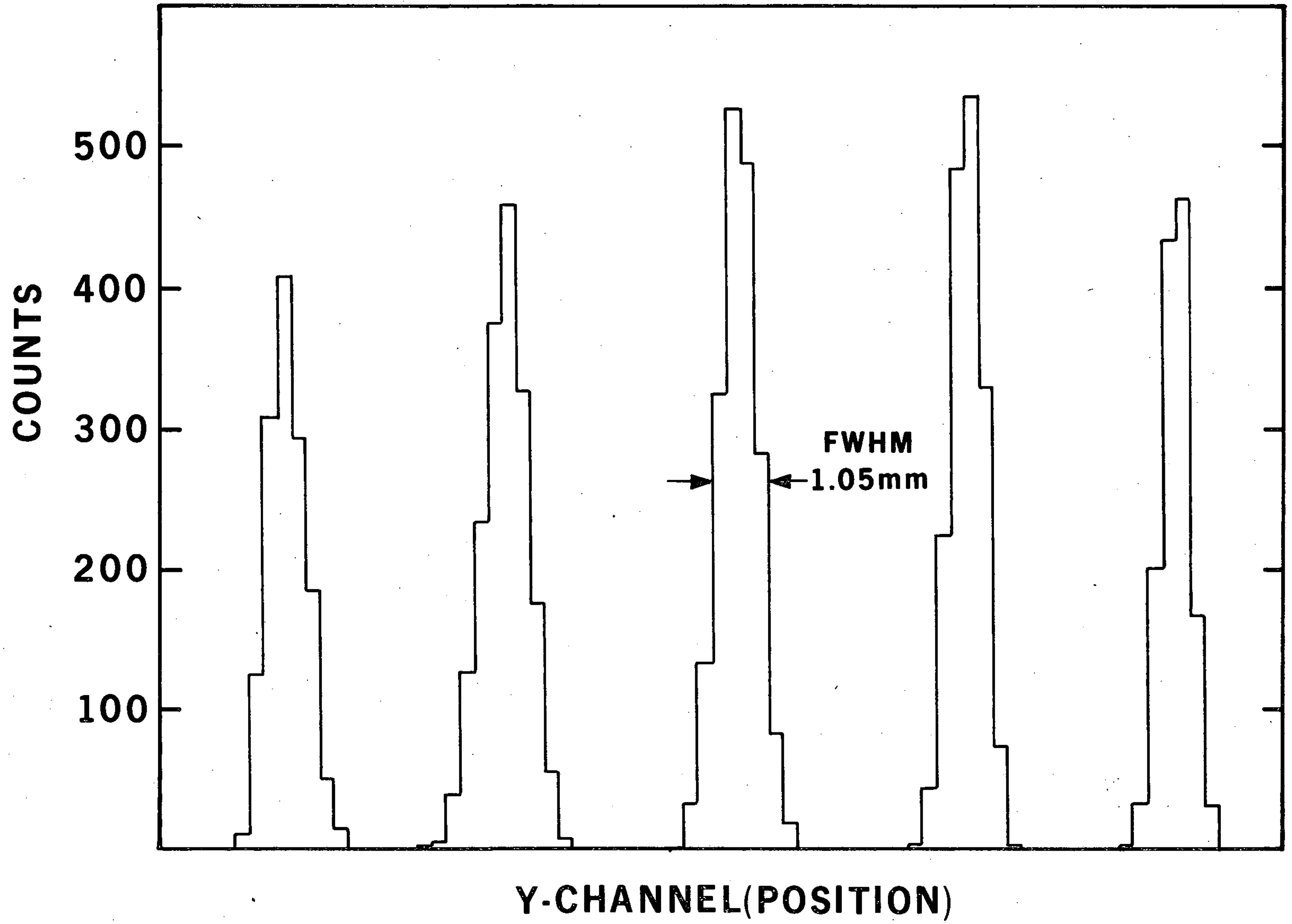

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Fig. 3. Y-position spectrum.

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