EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-EP/84-01

6 January 1984

A SIMPLE "VERNIER" METHOD FOR IMPROVING THE ACCURACY OF COORDINATE READ-OUT IN LARGE WIRE CHAMBERS

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ABSTRACT

A method is proposed to improve position accuracy in large wire chambers. A localization of an avalanche is obtained simply by printing a series of double wedges on a narrow cathode strip parallel to the anode wire of a wire chamber. This method seems to be well adapted as a "vernier" technique: a gross method provides the address of a wedge subsection which then gives, with a greater accuracy, the position within the subsection.

(Submitted as "Letter to Editor" to Nuclear Instruments and Methods in Physics Research)

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The 1σ localization accuracy of an avalanche along a wire, in large-area wire chambers, is limited with most of present read-out techniques to about 1% of the wire length. We propose a “vernier” method to improve the coordinate read-out considerably, using a series of wedged cathode strips located in parallel to the sensing wires.

Varieties of wedge and strip methods can be used to obtain the coordinates of charge deposition on electrodes [1]. In multiwire proportional chambers, the work of Allemand et al. [2] has shown that it is possible to obtain easily the coordinates along the wires, within the limits of accuracy permitted by the physical extension of the avalanches. They have reached, with X-rays of 8 keV, an accuracy of 0.2 mm (FWHM), for a chamber of 6 cm length. The implementation of this method is in some respects easier than charge division along the wires, since it relies only on the geometry of the printed wedges which can be easily adjusted.

Several variations of this method [3] have been introduced which permit two-dimensional read-out to be obtained from single planes. This method has been extended to detectors others than wire chambers [4]. Figure 1 illustrates the wedge-and-strip cathode discussed in ref. 4. The cathode surface is subdivided into three domains, A, B, and C. The induced signals vary, as a function of events two-dimensional position, according to the relations

$$\begin{aligned}x &\propto Q_A/(Q_A + Q_B + Q_C) \\y &\propto Q_C/(Q_A + Q_B + Q_C),\end{aligned}$$

where Q_A is the induced charge measured on the A electrode, etc.

In a search for a “vernier” method permitting the coordinates of avalanches along a wire in large wire chambers to be obtained with a high accuracy we have been attracted by the potential advantage of this approach. A series of double-wedge strips on a narrow circuit facing an anode wire can give with accuracy the coordinate of an avalanche along the strip that faces a portion of the wire. A gross method, such as charge division along the anode, provides the address of the strip, while the ratio between the charge induced on one wedge to the total charge induced on both wedges provides the localization along the particular strip (Fig. 2). We have checked this idea by building a simple proportional counter in a tube with a square cross-section ($11 \times 11 \text{ mm}^2$). A printed circuit read-out strip, 9 mm wide, was glued along one side, carrying double wedges of various lengths from 10–30 cm length. The detector is shown schematically in Fig. 3.

The detector was operated with an argon-isobutane gas mixture (80/20) in a proportional mode. X-ray photons of 5.9 keV from a ^{55}Fe source, collimated to 0.5 mm, could enter the counter through some window openings, as shown in Fig. 3.

With simple electronics, we have obtained the following accuracies:

0.8 mm (FWHM)	for 10 cm wedge length
1.2 mm (FWHM)	for 20 cm wedge length
1.9 mm (FWHM)	for 30 cm wedge length.

The position spectra are shown in Fig. 4. These numbers are not corrected for the source collimation width or for any systematic errors due to a displacement of the source off the centre of the counter, which may strongly influence the resolution. The resolution is quite constant along the strips, except for a minor degradation (30–40%) at distances of a few mm from the end owing to

geometric problems in the design when going from one section to another. Linearity is also slightly degraded at the edges for the same reason. The results shown in Fig. 4 correspond to information extracted from individual strips. When interconnecting all three strips externally to the same amplifier the resolution was degraded by about 5–10% owing to increased noise due to increased capacitance. The capacitance of a long chain of strips may deteriorate the present resolution.

We can thus envisage a printed strip made of a series of short wedges in series. The read-out of the charges at both ends gives the position along a wedge. Various methods, such as charge division, along the wire, can be used to localize the wedges which have detected the induced charge. This technique is possible for large-size detectors of several metres length and may offer resolutions of the order of 1 mm along the wire.

For smaller detectors of the type planned for some vertex detectors, one can think of a succession of strips giving alternatively a gross coordinate and a precise interpolated coordinate. A redundancy in the number of coordinates read-out would permit one to solve easily the ambiguity problems encountered when the avalanches are close to the junction points of successive wedges. This problem may also be solved by using two independent read-out strips, with displaced sections, per wire cell.

For detectors based on individual proportional tubes this method would permit the good accuracy obtained from the measurement of the drift time to be combined with the good localization of the avalanches along wires.

In the present study, the wedged read-out strips were placed inside the sensitive volume of the detector. With high-resistive cathode surfaces, which are known to be transparent to fast pulses, the strips might be placed as external pads and provide a simple and accurate localization technique.

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Figure captions

- Fig. 1** Two-dimensional wedge and strip method (see text).
- Fig. 2** Principle of the “vernier” method. A charge is induced on a double wedge subsection of a read-out strip. The position along the subsection is accurately obtained by the ratio of charges. The gross subsection address location can be performed by current or charge division along the wire.
- Fig. 3** A schematic view of the test detector. Only one cell was used.
- Fig. 4** Position distribution of induced charges for: a) 100 mm long strip (5 mm between peaks), FWHM = 0.8 mm; b) 200 mm long strip (10 mm between peaks), FWHM = 1.2 mm; c) 300 mm long strip (10 mm between peaks), FWHM = 1.9 mm.

Fig. 1

$$X_i = Q_2 / (Q_1 + Q_2)$$

$$i = Q_4 / (Q_3 + Q_4) \quad (\text{or by other gross method})$$

Fig. 2

Fig. 3

a)

b)

c)

Fig. 4