CERN TECHNOLOGY NOTE

B34 MULTIWIRE PROPORTIONAL CHAMBERS AS POSITION-SENSITIVE X AND γ-RAY DETECTORS

The multiwire proportional chamber consists basically of a flat sandwich of three wire planes. The central plane is made of very thin (10-20μm) wires and held at a high (3-4kV) positive DC voltage with respect to the outer planes. An ionising particle traversing such a chamber will, due to the very high electric field around the central wires, cause an electron-avalanche on the wire nearest to its path. The avalanche records as a fast negative pulse on that wire. Such a chamber forms the basis of the one-dimensional multiwire proportional chamber, now firmly entrenched in the front line of high energy particle physics research. At CERN these chambers are now made as big as 1 x $1\frac{1}{2}m^2$ with thousands of wires (1).

Since the pioneering of the MWPC at CERN in 1968 (2) it has been known that the avalanches produce not only negative pulses on the central plane, but also positive pulses on the outer planes. If the chamber is constructed with the wire directions of these outer planes orthogonal then a two dimensional resulution may be obtained by processing the positive pulses. For detecting high energy particles, this is not necessarily of great importance as two separate chambers may be placed at right angles, However, for two-dimensional detection of low energy neutral particles (e.g. X-rays) it is vital; the ionising particle resulting from an X-ray conversion does not, in general, emerge from the chamber.

Thus this technique affords a means of X-ray imaging, or taking X-ray 'photographs'. Resolution is restricted, in one dimension, to the wire spacing (∿1mm) but the sensitivity is much greater than photography since each converted X-ray quantum is counted. Furthermore exact counts may be accumulated over the complete chamber providing highly accurate grey-scale information.

Present System

Different techniques have been developed to record the positive pulses. Well known are the delay line method of Perez-Mendez (3) and rise-time method of Borkowski and Kopp (4). We are developing the centre-of-gravity method, the principle of which is shown in Fig. 1. The largest positive pulse is recorded on the wire (or group of wires) nearest to the avalanche. Smaller pulses appear on adjacent wires. By measuring the heights of these pulses a'centre-of-gravity' may be calculated. This has proved to be a very accurate method (5).

The advantages of this method are:-

1) High accuracy

2) No special circuits or components are required

3) Each channel is independent; large chambers present no basic problem other than increasing the number of channels

4) Combinations of channels may be 'ANDed' together to generate a veto signal. Thus high local rates such as the central spot of an X-ray photograph may be ignored

5) Good sensitivity; each channel feeds an amplifier with no coupling losses.

The only disadvantage - cost - is fast disappearing as the cost of electronic components drops.

A chamber of 10 x $10cm^2$ has been equipped with 36X and 36Y channels. Each channel has an amplifier and a CAMAC analogue to digital converter (ADC) attached to it. A PDP 11/20 computer reads out the ADCs and calculates the X and Y centre of gravities by software. Fig. 2 shows a picture taken with a 1 millicurie 6keV radioactive source (Fe^{55}) placed 50cm from the chamber. Exposure time was about 30 minutes. The horizontal lines are the central wires of the chamber spaced at 1mm.

Future Development

Chambers

Chamber development is directed towards better resolution, higher and lower energies, and detection of other particles, e.g. neutrons. Chambers have been constructed with two and four wires per millimetre. Investigations are under way on interpolating between wires in the case where adjacent wires share an avalanche. For other energies, chambers have been designed with special metal collimators. A 0.5MeV γ-ray chamber with a lead collimator is working well.

Read-out

The software in the present system limits data rates to 10^3-10^4 events/s. By replacing the software by dedicated hardware orders of magnitude may be gained. Such a hardware system is now under construction for 96X and 96Y channels at a data rate > 1MHz.

Capital cost should be about 100 000 SF.

Applications of this system are extensive, covering high energy particle beams, crystallography, X-ray astronomy, medical and biological uses, and solid-state physics.

References

1) R. Bouclier et al. Submitted to Nuclear Instruments and Methods (May 1973)

2) G. Charpak, R. Bouclier, T. Bressani, J. Favier and Č. Zupančič. Nuclear Instruments and Methods 62, 262 (1968)

3) R. Grove, V. Perez-Mendez and J. Sperinde. Nuclear Instruments and Methods 106, 407 (1973)

4) C.J. Borkowski and M.K. Kopp, IEEE Trans. Nuclear Sci. 17, 340 (1970)

5) G. Charpak, A. Jeavons, F. Sauli and R. Stubbs, CERN 73-11.

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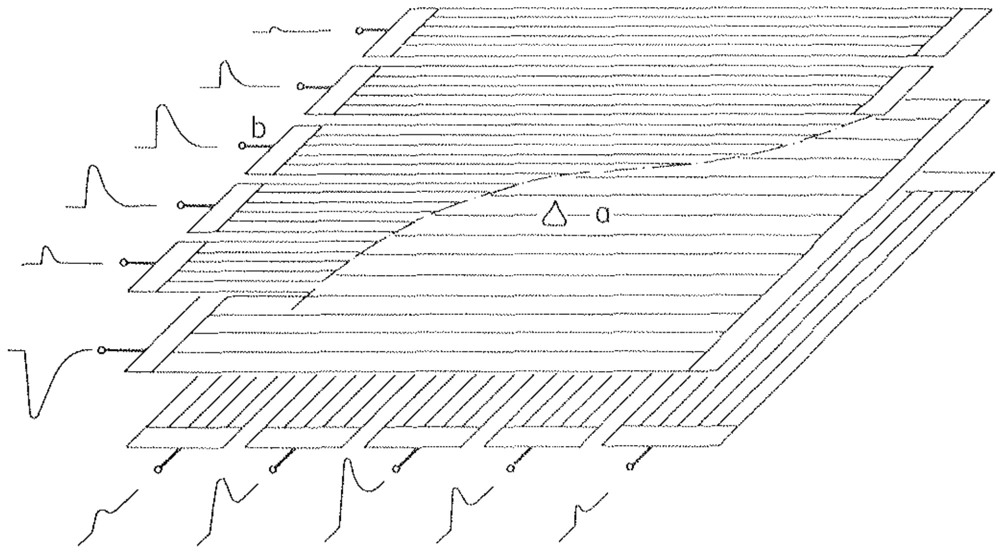

Figure 1 - Principle of the method
The avalanches surrounding a wire a induce a positive pulse on the cathode strips b. The pulse height of the induced pulse is measured and the centre of gravity of the pulse-height distribution gives the position of the avalanche.

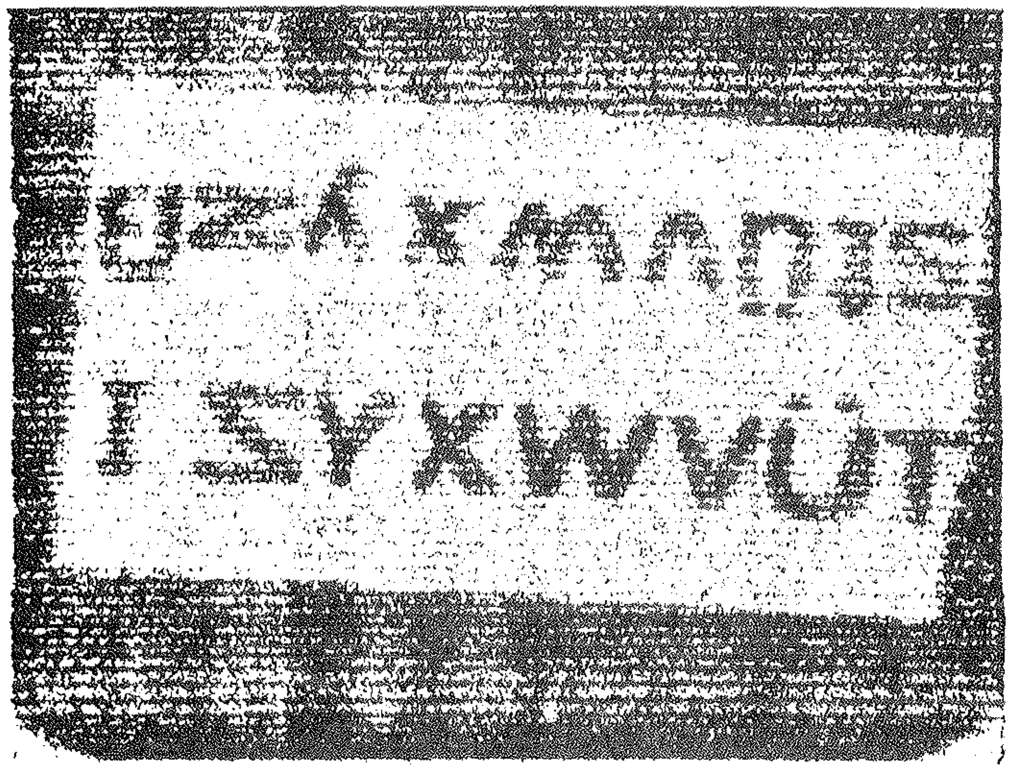

Figure 2 - X-ray imaging by a 6 keV radioactive source.