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THE MIW DETECTOR – AN MWPC FOR INCLINED TRAJECTORIES

K.B. BEARD, W. BENENSON, E. KASHY, J. VAN DER PLICHT AND J. YURKON

National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, Michigan 48824, USA

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We have constructed an MWPC for detection of low ionizing particles at high count rates in the focal plane of an Enge split pole spectrograph. The general method is suitable for any spectrograph with non-normal incidence. A unique feature of the detector is that the cathodes and anode wires are parallel to the incident particles.

1. Introduction

A magnetic spectrograph distributes particles on its focal plane according to their charge to mass ratio. A variety of detectors have been built to measure the positions of these particles and to identify them. Special problems arise when the particles have low ionization and when they hit the focal plane at non-normal angles. The limitation of the spatial resolution of a single wire detector has been shown to be due to fluctuations in the ionization of the traversing particles, for both the charge division [1] and delay line readout [2] method. This problem is made more difficult when the particles are close to minimum ionizing or have ionization appreciably lower than other reaction products with the same rigidity.

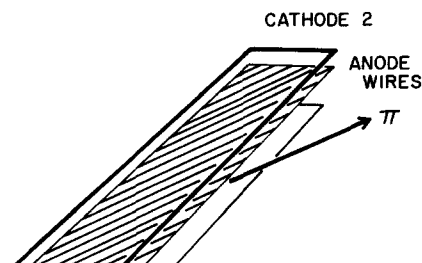
A high count rate limits the usefulness of a counter with a single wire since all the ionization collects on that wire, and pileup can occur at the preamplifiers connected to it. In addition, the ionization tends to spread out along the wire, reducing the position resolution of that counter. The multiwire proportional chamber (MWPC) [3] overcomes these difficulties by using many wires (with individual readout) instead of a single wire.

In a standard MWPC, the anode wires are vertical in the focal plane. The distance between anode wires and cathode planes is typically three to four times the anode wire spacing [4]. Particles which have been transmitted by an Enge spectrograph [5] enter the focal plane at incident angles ranging from 36° to 54° , and therefore in a conventional MWPC, the particle track would

be collected by a single wire. This configuration is shown in fig. 1 and is called the multi-inclined wire (MIW) counter.

2. Construction and operation

An exploded view of the MIW detector is shown in fig. 2. The detector operates in air rather than in vacuum. A $75\ \mu\text{m}$ thick kapton window foil mounted between dipole and camera box of the Enge spectrograph separates the spectrograph vacuum from the camera box which was at atmospheric pressure. The detector operates at 1 atm of CF_4 or $\text{Ar}/\text{C}_2\text{H}_6$ (50–50%) gas. The detector gas box (see fig. 2) has $75\ \mu\text{m}$ thick kapton entrance and exit pressure windows. The active detection area is $48\ \text{cm} \times 1.8\ \text{cm}$. The anode wires are $12.5\ \mu\text{m}$ diameter gold-plated tungsten with a spacing of 5 mm along the focal plane (and $3.5\ \text{mm}$ normal to the wires due to the inclination of 45°). The cathodes are aluminum plates at a distance of 20 mm (primary) and



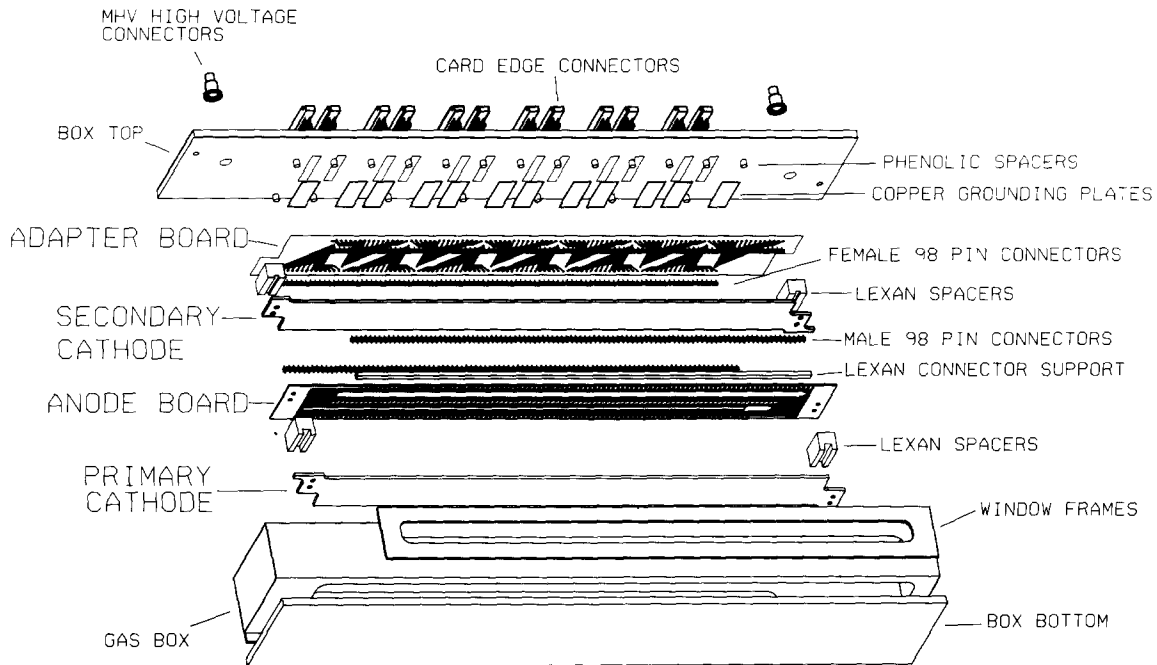


Fig. 2. Exploded view of the MIW detector box.

1.5 mm (secondary). Typical voltages are 5.5 kV for the primary, and 2.0 kV for the secondary cathode. The anode wires are at ground potential. Behind the anode wires in the focal plane, a second anode wire plane is placed at a distance of 28.5 mm in the same gas volume. Thus the MIW consists basically of two independent detectors, each with 96 wires per plane, one behind the other. The MIW therefore measures the angle of incidence to permit trajectory reconstruction.

The MIW was designed to be used with the LeCroy PCOS III readout system [6]. This system consists of 16 channel integrated circuit boards with amplifiers and programmable discriminators. The readout system is one reason why the detector is used in air rather than in vacuum, since each amplifier/discriminator card dissipates about 5 W. The connections between the wires and the PCOS cards outside the gas box were made using mating Samtec [7] model TS-132-G-A male connectors on the anode board with every other pin removed (to provide the correct spacing) and an adapter printed circuit board with similarly modified female SS-132-G-2 connectors. The adapter board runners connected the pins of the Samtec connectors to the pins of the wire-wrap style 36 pin card edge connectors epoxied to the lid of the gas box. In this way, a large number of reliable, gas tight connections were made to the PCOS card. This consideration was important, since the detector has nearly 200 wires to feed through a gas tight seal. Each cathode is connected to a 1 M Ω resistor for

current limiting and a 0.01 μ F capacitor for signal pickoff.

The PCOS cards can be replaced by printed circuit boards containing delay lines. These cards connect each of the 16 wires to a tap on a delay line, each wire being separated by 5 ns. The printed circuit boards have the advantage of being simple and inexpensive, and requiring no cooling, and they are therefore very useful for testing purposes.

3. Results

The MIW detector was designed for detection of particles such as protons, diprotons (^2He) and charged pions produced in heavy ion induced reactions. Thus far, the detector has been tested and used extensively with α particles, protons, electrons and positrons produced in nuclear reactions, and 3.54 MeV electrons from a ^{106}Ru source. Since the MIW is a transmission detector for these particles, scintillator and/or Cherenkov counters can be placed behind the MIW for particle identification purposes and additional range measurements.

Results from the reactions (α , α') and (α , p) on a ^{12}C target of 30 mg/cm 2 thickness are shown in fig. 3. The beam energy was 80 MeV, and the spectrograph was set at a laboratory angle of $\theta = 10^\circ$. In this case, the MIW is followed by a 6.3 mm thick ΔE and a 75

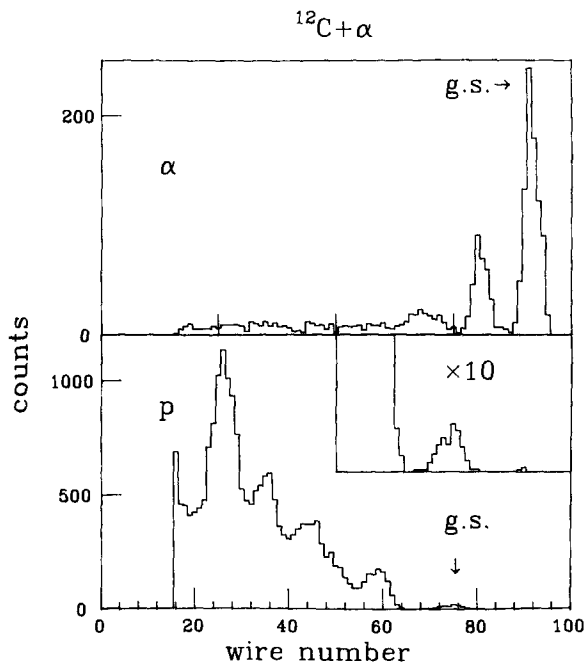


Fig. 3. Spectra for the reactions (α , α') and (α , p) on ^{12}C at a beam energy of 80 MeV, measured with the MIW detector.

mm thick E scintillator detector. The first excited state of ^{15}N is about 5.3 MeV above the ground state [8].

Elastically scattered α -particles, however, have nearly the same momentum to charge ratio as the ground state protons but much smaller range. These α 's were numerous enough that reactions taking place within the ΔE scintillator were triggering the E scintillator as often as protons were. The use of particle identification with the scintillators, however, allowed the complete elimination of the α -particle background and produced a clean ^{15}N spectrum (bottom part of fig. 3) despite the large number of α 's passing through the MIW. In the plots shown in fig. 3, one channel corresponds to the wire spacing of the MIW (which is 5 mm), which in turn corresponds to about 380 keV.

The MIW detector has also been used recently for detection of high energy electrons and positrons, produced in medium energy nucleus-nucleus collisions [9]. The MIW detector was in this case backed by a plastic scintillator and two Cherenkov counters for electron/positron identification. Fig. 4 shows a plot of the number of wires in the front detector prevent for positrons with energies ranging from 20 to 30 MeV. Most events correspond to a single wire firing. The positrons resulted from conversion of high energy gamma rays, which were produced by stopping a 560 MeV ^{14}N beam

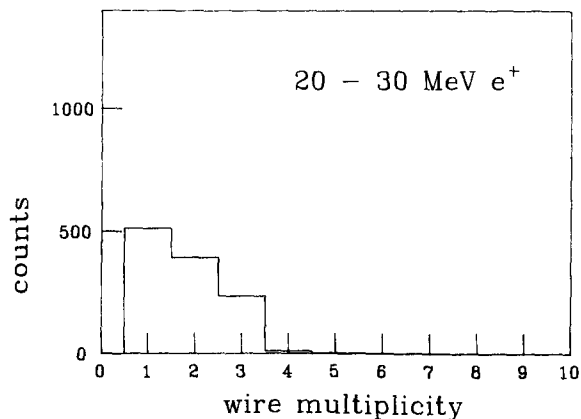


Fig. 4. Wire multiplicity for 20–30 MeV positrons.

in a 770 mg/cm² Cu target. This experiment yielded interesting results for high energy photon production in intermediate energy nucleus-nucleus collisions [9,10].

In summary, we have shown that a detector with a novel geometry, the MIW, can make MWPC type counters useful for high count rate, non-normal incidence low ionizing particles on the focal plane of a magnetic spectrograph. Although the detector has not been used this way, it maintains the multiparticle detection capability of an MWPC and would make a good correlated particle device, for example for ^2He detection.

Acknowledgement

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