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DISCLAIMER

IMPROVEMENTS TO RESISTIVE-WIRE FOCAL PLANE DETECTOR*

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Abstract:

A resistive-wire spectrometer focal plane proportional counter system has been improved by the addition of a thin foil scintillation timing detector near the spectrometer entrance and of a second proportional counter with larger energy loss and hence better resolution.

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Experience with the particle-identifying spectrometer focal plane detector system[1]) for heavy ion experiments showed that improvement of the resolution in time-of-flight (TOF) and energy loss (dE/dx) was desirable to obtain more complete separation of ions of different mass and atomic numbers.

In the system previously described, TOF was measured by a plastic scintillator in the focal plane with respect to the cyclotron radio frequency. Time resolution (∿ 2-3 ns with third harmonic and ∿ 6 ns with first harmonic beams) was equal to the microscopic beam pulse width and therefore very sensitive to details of cyclotron tuning.

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A thin ($\sim$ 30 μg/cm^2) NE 111 plastic scintillator of the type described by Muga[2] and Gelbke, et al.[3] was therefore installed at a distance of 25 cm from the target and just ahead of the spectrometer defining slits. The large vertical dimension of these slits required that the foil be very long - 5 cm $\times$ 1.5 cm. The system (fig. 1) consists of the thin foil attached to a Lucite frame (for easy replacement) inserted into a bi-conical Lucite light guide. Two RCA 8850 photo multipliers were required in order to obtain a constant detection efficiency over the vertical dimension of the foil. Flight time through the spectrometer is measured between the foil and the focal plane plastic scintillator.

The variation in pulse height along the foil was measured with a 2 mg/cm^2 foil and a collimated ^{241}Am α-source. Figure 2 shows the pulse height in a single PM (circles) and in the summed output of the two PM's (triangles). The summed pulse-height (and hence the detection efficiency) is roughly independent of the source position. Comparison of the summed and difference pulses could be used to make a rough position measurement.

With a foil of 80 μg/cm^2, a time resolution of 1.2 ns (FWHM) was obtained for 100 MeV ^{16}O ions between the foil and the focal plane scintillation counter using 2 mm wide spectrometer entrance slits. With the slits at 5 mm (corresponding to the normal solid angle of 1 msr), the resolution was 2 ns. The difference arises from the increased variation in flight path in the spectrometer as the slits are opened. Since the foil count-rate is always much higher than that of the focal plane system, its output, suitably delayed, is used as the stop signal of the TAC. The foil is highly sensitive to electrons coming from the target. They are removed by a parallel-plate electrostatic deflector 12 cm long with a field of 2 kv/cm.

The efficiency for detection of heavy ions was measured by comparing the number of TOF - proportional counter coincidences with the number of events in the proportional counter, for which it is safe to assume an efficiency of 100% when the particle spectrum is dominated by the elastic peak at small angles. The efficiency for a foil of 70 $\mu g/cm^2$ was 90% for 104 MeV ^{16}O ions and 84% for 78 MeV ^{12}C ions.

In the previously described system[1]), both position and dE/dx were measured in a 1 cm-deep resistive-wire proportional counter. The dE/dx resolution ($\sim$ 10% for 104 MeV ^{16}O at a counter gas pressure of 1/3 atmos.) was limited by energy-loss straggling and thus could be improved only by increasing the energy loss. Two methods are available - to increase the counter gas pressure or to increase the counter depth. We chose the latter since increased gas pressure would require a thicker Mylar entrance window.

A second proportional counter - 4 cm deep - was installed behind the original 1 cm deep resistive-wire counter. It has the same number of wires - five, 1.5 cm apart - as the front counter. They are 0.0025 cm dia. nickel. The depths of the two counters are defined with three planes of 0.0002 cm polycarbonate plastic foils operated at a common negative potential. The first and third foils are aluminized on the inner surfaces, the second foil on both surfaces.

The central three Ni wires of the second dE/dx counter are connected together and AC coupled to an external charge - sensitive preamplifier. The outer two wires are kept at the same potential as the others, but serve only as guard wires. The relative gas multiplication of the two counters can be adjusted by applying a separate bias to the Ni wires. For heavy-ion detection, the lower field strength in the second counter combines with its greater depth to give the optimum gas multiplication when no separate bias is applied. For light particles, an extra positive bias is usually applied. The counters are operated at gas multiplication of approximately 100 and 10, respectively.

The greater depth of the second proportional counter makes it more sensitive to end effects in both the horizontal and vertical directions. The gas multiplication is therefore a function of the horizontal position of a particle and each wire must be separately calibrated along its length. The wire responsible for an event is assumed to be the one directly behind the resistive wire in the first counter, from which a wire - identifying logic pulse is obtained[1]).

The dE/dx resolution in the second counter is 5% (FWHM) for 104 MeV ^{16}O - twice as good as from the first counter. The atomic number resolution is therefore 2.5%. The system has been used for the detection of 42 MeV protons with a position resolution of 0.6 mm, corresponding to an energy resolution of 13 keV. The four-fold coincidence requirement (thin foil, two proportional counters, focal plane scintillator) assures an extremely low background count rate. In the reaction (^{11}B,^{8}B), peaks of ^{8}B were readily detected at 10 nb/sr.

References

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2. M. L. Muga, Nucl. Instr. Methods 95 (1971) 349.
3. C. K. Gelbke, K. D. Hildenbrand and R. Bock, Nucl. Instr. Methods 95 (1971) 397.

Figure Captions

Fig. 1. Schematic diagram of thin scintillator foil holder and light guide.

Fig. 2. Signal from one PM (circles) and sum of two PM signals (triangles) as functions of distance α-particle source from one PM.

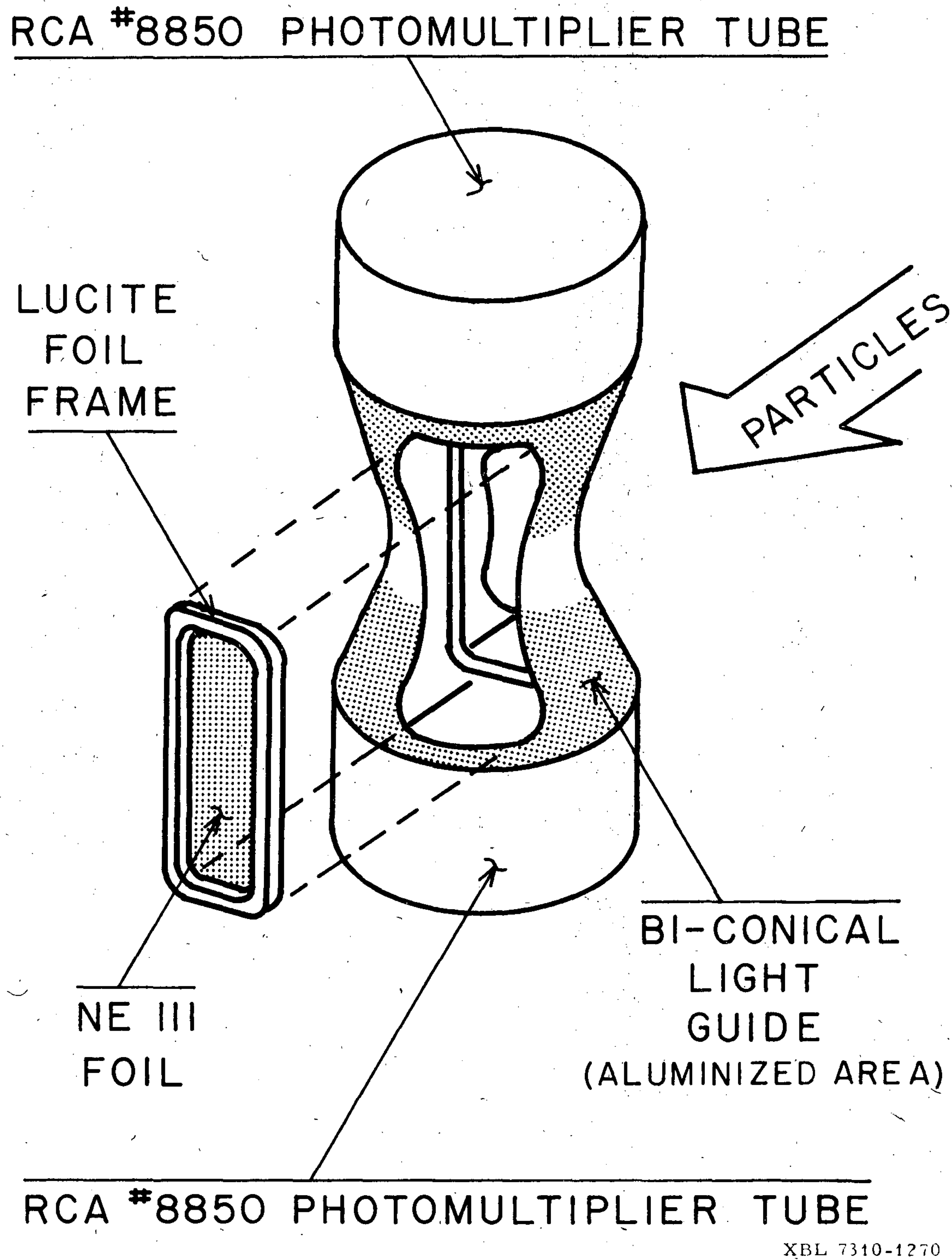
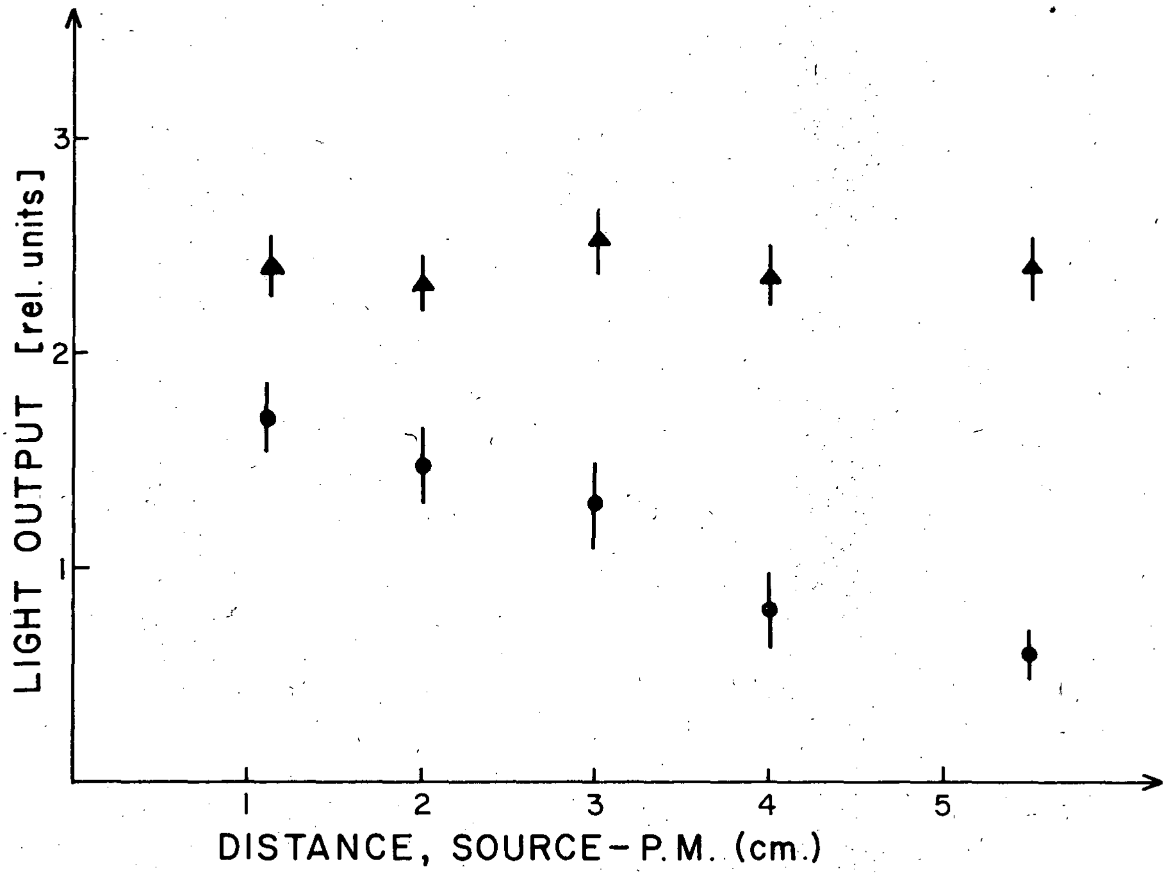

RCA #8850 PHOTOMULTIPLIER TUBE
LUCITE FOIL FRAME
PARTICLES
NE 111 FOIL
BI-CONICAL LIGHT GUIDE (ALUMINIZED AREA)
RCA #8850 PHOTOMULTIPLIER TUBE
XBL 7310-1270

Fig. 1



XBL 7310-1269

Fig. 2

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