NAL PROPOSAL No. 261

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FTS/Comm: 8 - 516-345-4784

PROPOSAL TO TEST TRANSITION COUNTERS AT NAL

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We propose to test transition counters that are expected to differentiate pions from kaons in multi-hundred GeV unseparated beams.

I. Introduction

A transition counter has been shown to be able to detect ultra-relativistic particles with high efficiency and differentiate electrons from heavier particles in an unseparated beam at the Brookhaven AGS.[1] Recent data indicate that the present counter should be able to differentiate pions from kaons at and above 400 GeV, and furthermore, to differentiate these particles in a beam of variable energy, one simply has to adjust the discriminator level or the threshold of the transition counter.[2] (Fig. 1) Note that this procedure is simpler than changing the pressure of gas Čerenkov counters.

It appears that transition counters of various types can now be constructed to differentiate pions from kaons above 400 GeV, where the Čerenkov counters are believed unable to differentiate these particles well. It is important therefore to test these counters in very high energy beams, in anticipation of their promising applications in the energy doubler program at NAL, and also to explore how πK differentiation can be improved below 400 GeV, where it is difficult to study the transition radiation by electrons of corresponding kaon Lorentz factor because of the multiple Coulomb scattering.

II. Experimental Arrangement

A. Transition Counter with Magnet

This scheme is similar to that of previous experiments[1,2] (see Fig. 1 of attached publication) in which the counter was shown to function just like a threshold Čerenkov counter. For beams of 0.2" diameter only 2" deflection is required to clear the NaI crystal detecting transition X-rays. Hence, one NAL dipole magnet such as Type 4-2-240 should suffice to serve the present purpose up to $\approx$400 GeV.

With a 500 foil mylar radiator placed upstream of the magnet, and a NaI detector (3" diameter, ½" thick) at downstream, the detection efficiencies are expected to be about 50% and 0% for 200 GeV pions and kaons respectively. A radiator of 1000 lithium foils being prepared by W.J. Willis, should give higher detection efficiencies.[3] This radiator will be tested soon at Brookhaven with electrons[4], and if the result shows high yield of transition X-rays as expected, πK differentiation at 200 GeV or lower energy may be achieved with such a radiator. However, even with lower efficiency mylar radiator, confirmation of the linear dependence of detection efficiency as a function of pion momentum should suffice to establish the applicability of the counter at higher energies.

We stress the advantage of this scheme. The system is very simple in construction and operation. The resolving time ($\approx 0.1\ \mu s$) is short and can be improved by clipping. There are usually at least two bending magnets in momentum analyzed secondary beams, and the downstream magnet can be used in conjunction with the transition counter. Hence no additional magnet is required practically. After the applicability of the counter is confirmed by the test, such counter can be built in as an integral part of secondary beams without much additional expenditure.

B. Magnetless Transition Counter

This is a transition radiator - multiwire proportional chamber (MWPC) sandwich array similar to those of previous experiments[5,6], and of another proposal[7], but entirely different in electronic logic. (Fig. 2) We list the major advantages of our system.

1. Good Resolving Time ($\approx 0.1\ \mu s$) Since our "discriminator - majority coincidence" is a fast circuit, the resolving time is determined by the MWPC. Our system is capable of handling beam intensities of 10^6 particles/sec at a 10% dead time loss for kaons.

2. Good Particle Identification - The ability of particle identification depends on resolving ionization signals from those accompanied by transition radiation. It is known that with single radiator and MWPC, the ability in resolving them is not adequate. This improves with the number of radiators and MWPC's. The majority coincidence logic offers the advantage of simplicity, speed, and good particle identification.

We give an example of what performance one can expect from 10 chambers and radiators which we propose here. This evaluation is based on the recent result[6] obtained with single Krypton chamber. Fig. 3 shows a pulse height distribution of a Krypton-filled MWPC detecting transition X-rays from 3 GeV electrons passing 100 foils of 1/2 mil mylar. If we place a discrimination level at 7 KeV, we would get 71% detection efficiency and 1.5:1 signal to noise ratio. If we have 10 such chambers, and demand a majority of 4 coincidence; i.e., at least 4 chambers trigger the discriminators, then by simple probability calculation, we obtain 99% detection efficiency and 32:1 signal to noise ratio[2]. Thus, by optimizing the radiator-detector array and the data handling system, one expects a significant improvement in particle identification over the results published recently[6,7].

3. Low Cost - Taking advantage of the small size of the actual high energy beams, our MWPC are made small, only 2" in diameter. The chambers are 1/4" to 1/2" thick and will be filled with Xe and Krypton gas. A total of 10 chambers will be interleaved with transition radiators consisting of 100 polyethylene foils of 1/2 mil thickness and 32 mil air spacing. The polyethylene radiator should yield ~10% more photons than similar mylar radiators. The system is being constructed and should be ready soon. The cost of the system is ~$10,000.

III. Beam Requirement

Following the suggestion of J.R. Sanford, we propose to test our magnetless counter in Beam M6 downstream of Exp. 69. About 10 feet beam line is needed. The parasitic test run is acceptable to Exp. 69 according to J. Sandweiss. Access to the Čerenkov counter signal in this beam is needed. Setup time ≈ 1 week. Running time ≈ 100 hours, distributed over a few periods.

For the transition counter with magnet, we hope to use the downstream analyzing magnet of Exp. 69, either at the end or during breaks in that experiment when it does not interfere. If other arrangements with magnet can be made, the opportunity is always welcome. Setup time ≈1 week. Running time ≈100 hrs.

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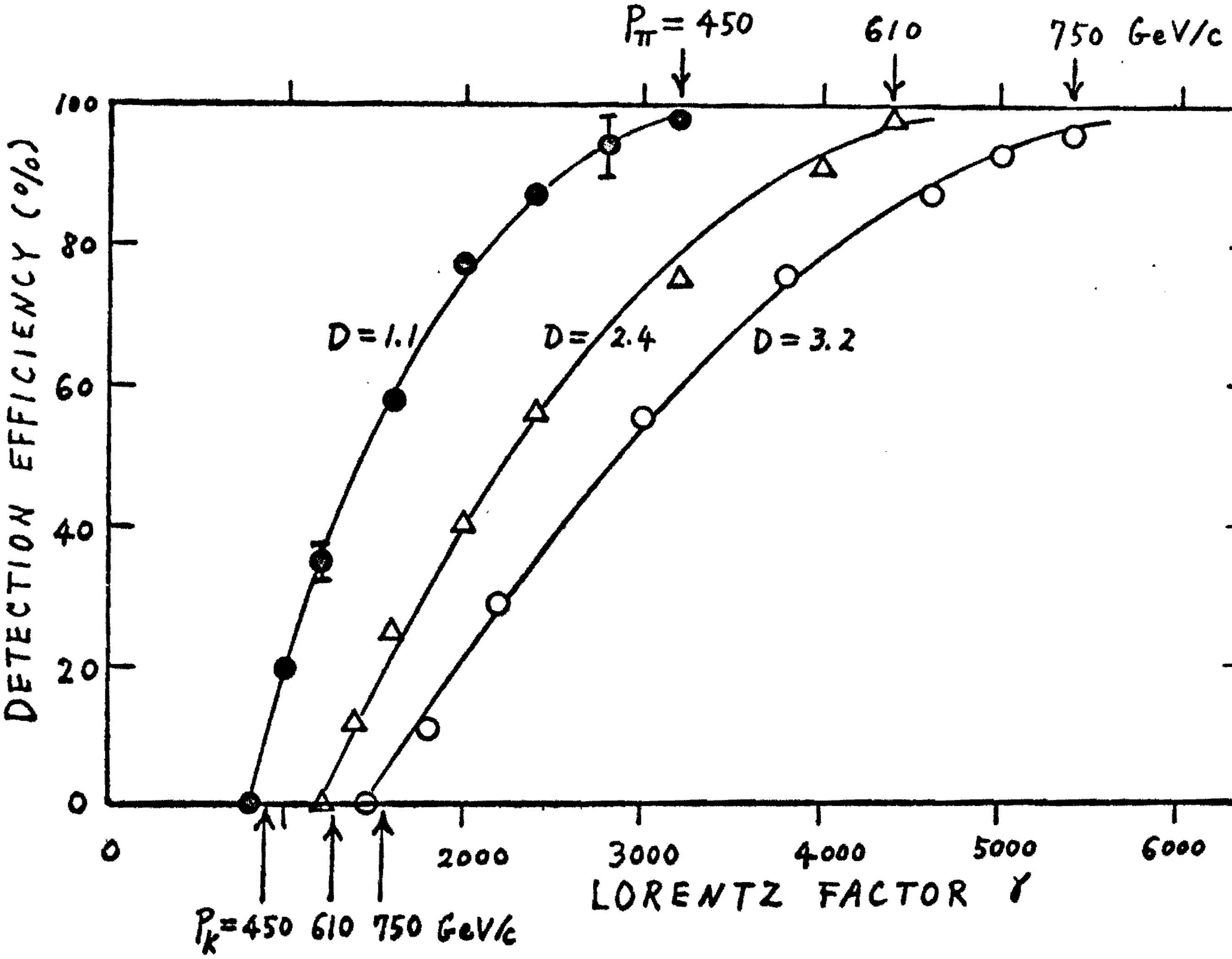
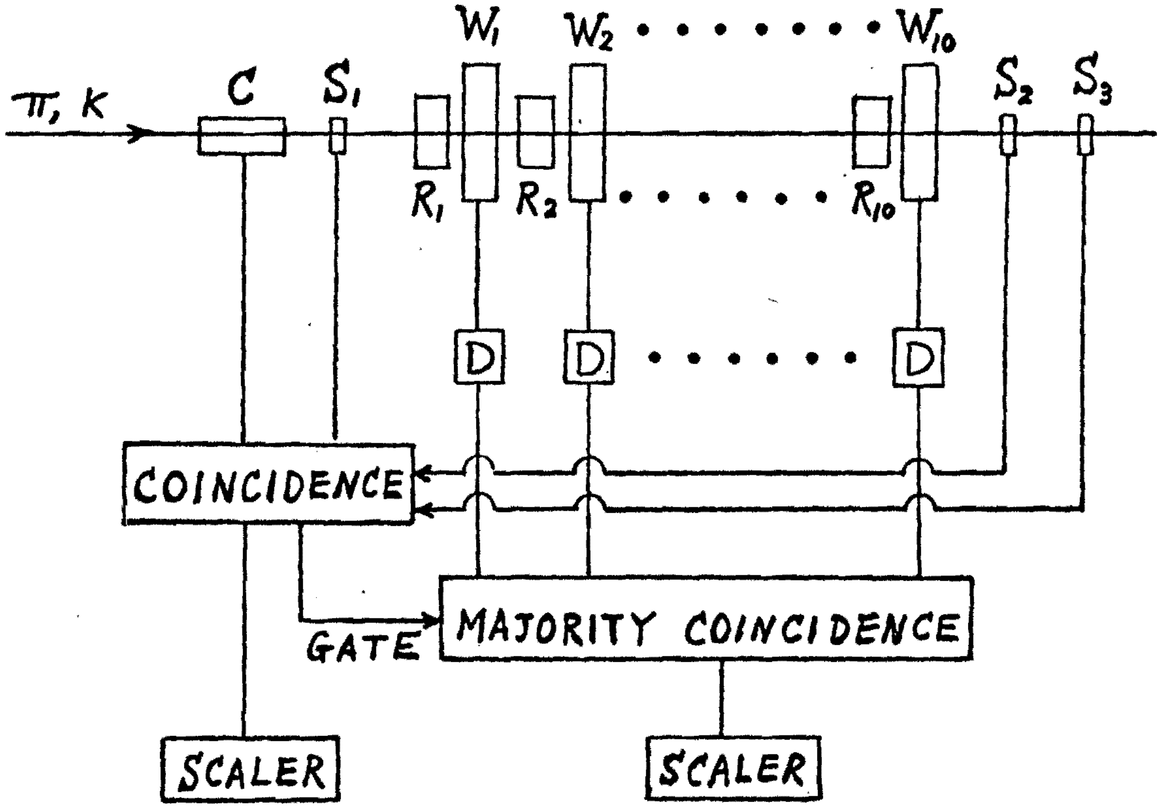


Fig. 1. Detection efficiency of transition radiation from 0.4 - 2.8 GeV electrons. For setup, see Fig.1 of Ref.1 (attached). π K differentiation at 450 , 610 and 750 GeV can be expected by adjusting the discriminator setting D.



W : MULTIWIRE PROPORTIONAL CHAMBER
R : TRANSITION RADIATOR
C : CERENKOV COUNTER
S : PLASTIC SCINTILLATOR

Fig. 2. Setup of a " magnetless " transition counter with discriminator-majority coincidence logic.

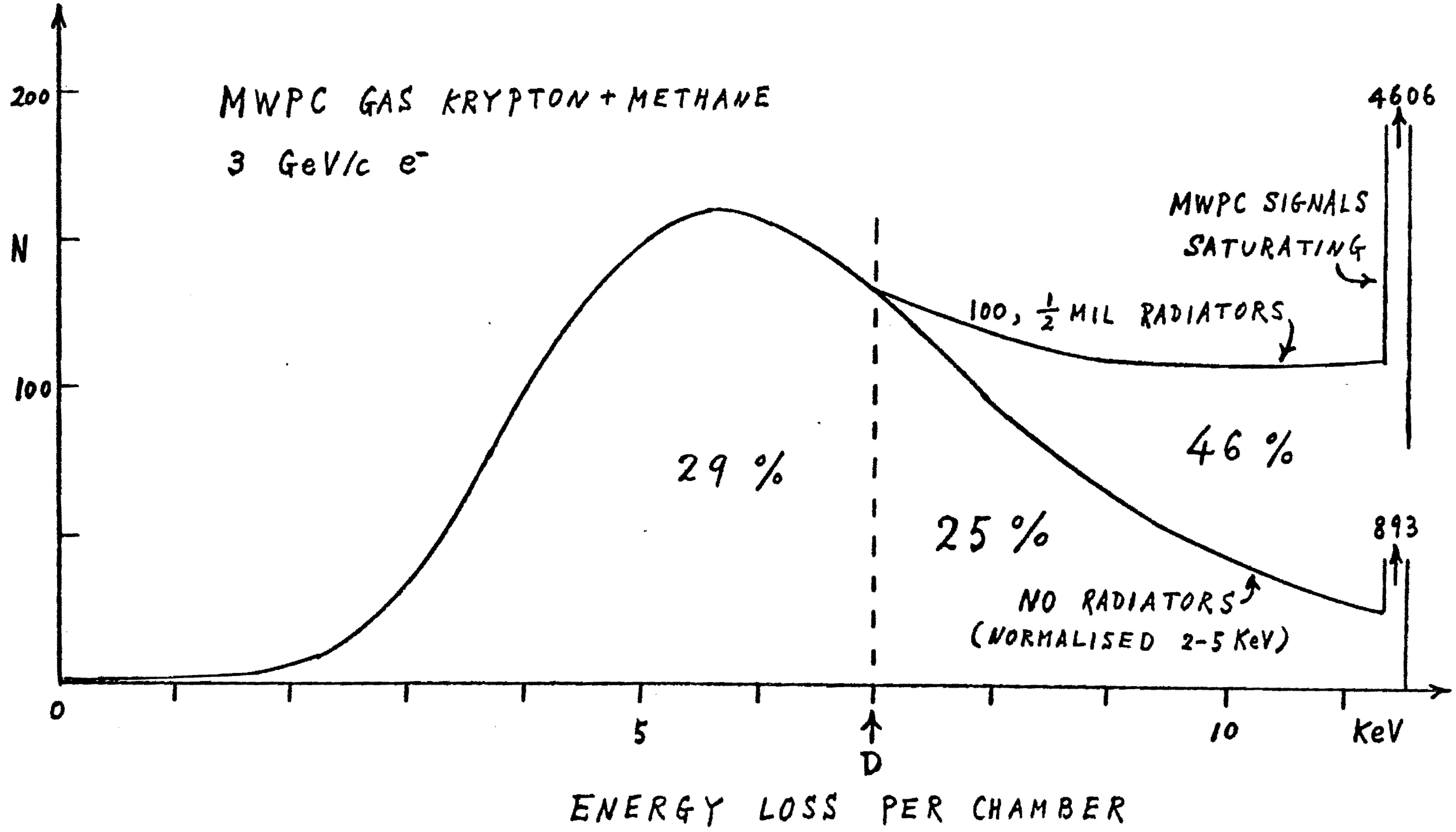


Fig. 3. Pulse height distribution of single multiwire proportional chamber (MWPC) detecting transition X-rays. (Ref.6) Relative size of the three areas is indicated. With the discriminator set at D, The detection efficiencies of signal and noise are 71 and 46 % (25/54) respectively. 10 such chambers with majority of 4 coincidence should give 32:1 signal to noise ratio at 99 % efficiency.