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OBSERVATION OF TRANSITION RADIATION FROM PIONS AT 100 - 250 GeV

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FROM PIONS AT 100 - 250 GeV*

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ABSTRACT

We report on the observation of transition radiation from pions at 100 - 250 GeV using a transition radiation detector (TRD). The detector consisted of multiwire proportional chambers and foil radiators. The observed spectra and efficiencies for separating pions from protons in this energy region are presented.

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A method to identify and separate different particles at very high energies using transition radiation has been reported in previous publications.[1,2]

In the present investigation, we report the observation of transition radiation from pions at energies from 100 to 250 GeV and the feasibility of separating pions from protons using a transition radiation detector (TRD) at these energies.

The experiment was carried out in the M1 meson beam at the Fermi National Accelerator Laboratory.

A transition radiation detector consisted of a series of multiwire proportional chambers interlaced with transition radiators in a sandwich array.[1] The chambers were 2.2 cm thick and 6" × 6" in area. The spacing of the sense wires were 1.0 cm. All the sense wires of a chamber were joined together to give a single output from the chamber. Signals from the chambers were added to give either a geometric mean[1] or an arithmetic mean value. This added signal was gated by a fast coincidence signal and stored in a pulse height analyzer. The fast coincidence signal was formed with a Cerenkov counter to identify pions or protons, scintillator S_1 upstream of the detector, S_2 and S_3 downstream. Scintillator S_3 was used as a veto to reject an event which has multiple particles. The chambers were filled with a gas mixture of 90% argon and 10% methane. The detector detects x-ray transition radiation as well as the ionization energy loss due to the primary charged particle.

The beam consisted of positive pions and protons, or negative pions and antiprotons. The Cerenkov counters[3] were used to identify pions or protons. The range of momentum covered in the experiment was 50 to 250 GeV/c. A typical intensity of the beam was 5×10^4/pulse. The percentage of pions in the positive beam at 100 GeV/c was 40%. The system was calibrated with Fe^{55} and Cd^{109} sources.

The pulse height spectra with a 30-element system are shown in Fig. 1. In Fig. 1(a) one can clearly see the separation of the peaks for pions and protons at 100 GeV/c. A typical transition radiator consisted of 100 foils of ½ mil Mylar spaced at 30 mils. In another measurement, it was found that using a five element radiator-MWPC detection system the separation of pions and protons at 100 GeV/c is quite good with 100 foils of ¼ mil Mylar as each radiator element. The ¼ mil radiator is better than the ½ mil radiator for this low γ value ($\gamma_\pi \simeq 700$, $\gamma_p \simeq 100$). Since the ¼ mil Mylar is better than the ½ mil, in the measurement shown in Fig. 1(a), 15 out of 30 chambers had a radiator consisting of 50 foils of ½ mil and 50 foils of ¼ mil (all the ¼ mil foils available on hand) instead of 100 foils of ½ mil. The separation of the two peaks is due to the combined effects of transition radiation and the relativistic rise of pions. The background radiation is negligible. The geometric mean device was used in these measurements.

The significance of these preliminary results is that, for the first time, we are able to measure the transition radiation emitted by pions with as low a γ value of 700, i.e. p_π = 100 GeV/c. It is to be noted, however, that the separation of the peaks would be appreciably larger if a Xenon gas mixture were used as evidenced by our earlier experiments.[4] Because of economical reasons, we plan to use Xe gas mixtures in our transition radiation detector system in the final run of our tests at FNAL.

The relative yield of transition radiation as a function of particle energy is shown in Fig. 2. A 30-element system with radiators of 100 foils was used. The relative yield was given by the difference between TR and background peak channels (less pedestal channel). This was done at 100, 200, and 250 GeV/c for both geometric mean (circles) and arithmetic mean (dots) values.

The curves of this figure indicate essentially linear response of the detector to the particle momentum in this energy region.

One point of interest is the ~ 40% relative yield obtained at 250 GeV/c (γ = 1800) for pions. This compares with previously measured yield of ~ 25% made with 1 GeV/c electrons (γ = 2000) for 100 foils of ½ mil Mylar in five chambers.

In Fig. 3 the rejection ratios for protons as a function of detection efficiency for pions at three different momenta are shown. The rejection ratio is the inverse of the fraction of the number of counts of protons which triggers the detector when the detection efficiency for pions is set at a certain value. These curves are for a 30-chamber system with 100 foils of ¼ and ½ mil Mylar per chamber using a geometric mean device. Figure 3 shows that one can get a rejection ratio of 50 for protons with detection efficiency of 50% for pions in a beam of 250 GeV/c, even with argon-filled chambers.

In summary, the data analyzed show a good yield of TR as a function of momentum and show good separation of events with and without TR at good detection efficiency for TR events.

A transition radiation detector will be effective in separating pions from protons or pions from kaons above 300 GeV with Ar. The use of Xe instead of Ar will improve the rejection ratio appreciably.

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REFERENCES

1. Luke C.L. Yuan, Proc. 12th Intern. Conf. on Cosmic Rays, Tasmania, Australia, 1971, Vol. 4, p. 1499; H. Uto, Luke C.L. Yuan, G.F. Dell, and C.L. Wang, Nucl. Instrum. Methods 97, 389 (1971).

2. Luke C.L. Yuan, H. Uto, G.F. Dell, and P.W. Alley, Phys. Lett. 40B, 689 (1972); C.L. Wang, G.F. Dell, H. Uto, and Luke C.L. Yuan, Phys. Rev. Lett. 29, 814 (1972); A. Bamberger, G.F. Dell, H. Uto, Luke C.L. Yuan, and P.W. Alley, Phys. Lett. 43B, 153 (1973); F. Harris, T. Katsura, S.I. Parker, V.Z. Peterson, R. Ellsworth, G.B. Yodh, W.W.M. Allison, C.B. Brooks, J.H. Cobb, and J.H. Mulvey, Nucl. Instrum. Methods 107, 413 (1973); M.L. Cherry, D. Müller, and T.A. Prince, Nucl. Instrum. Methods 115, 141 (1974).

3. S.M. Pruss, NAL Report No. TM-470, to be published; D.D. Yovanovitch, D.R. Rust, I. Ambats, R.A. Lundy, S.M. Pruss, C.W. Akerlof, Nucl. Instrum. Methods 94, 477 (1971); Cerenkov counter signals were provided us by D. Meyer and others.

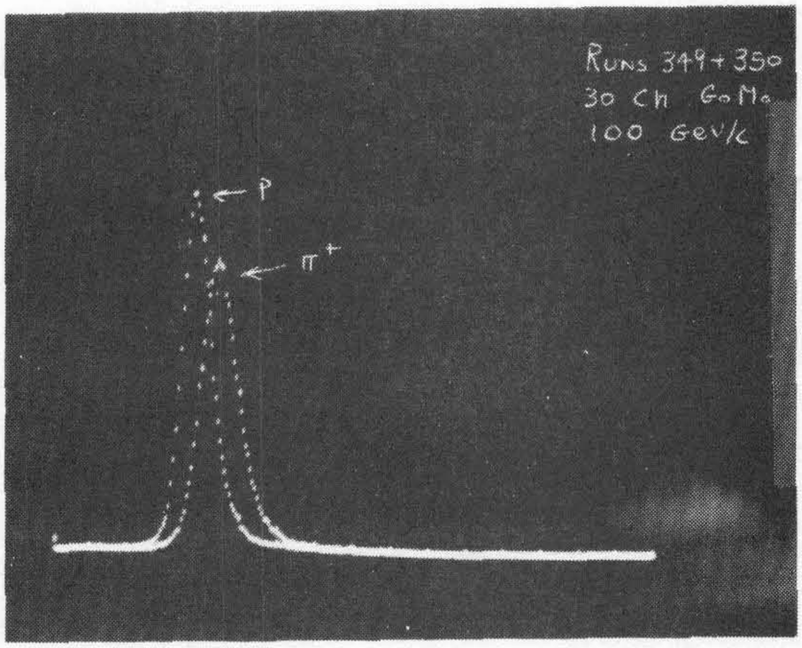
4. Luke C.L. Yuan, Proc. Intern. Conf. on Instrumentation for High-Energy Physics, Frascati, Italy, May 1973; Luke C.L. Yuan, P.W. Alley, A. Bamberger, G.F. Dell, and H. Uto, to be published.

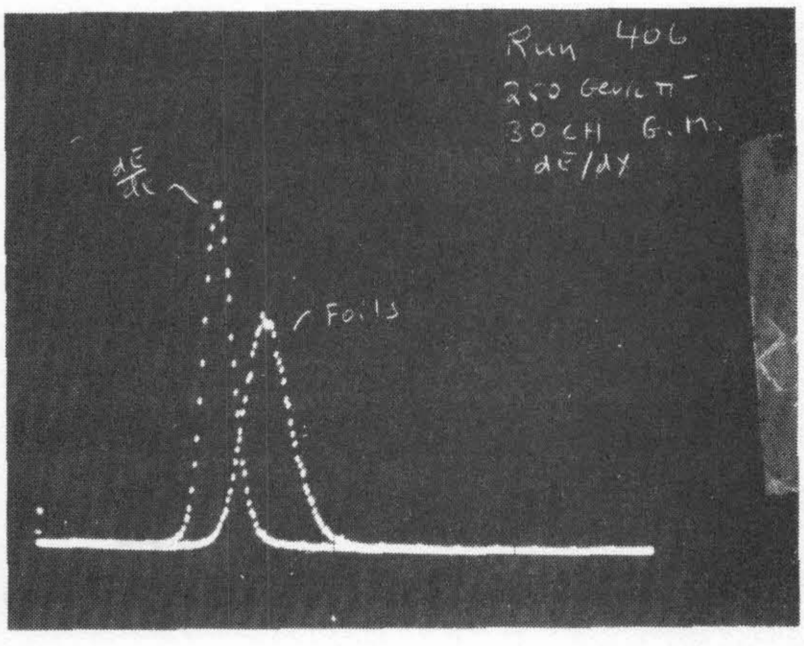
FIGURE CAPTIONS

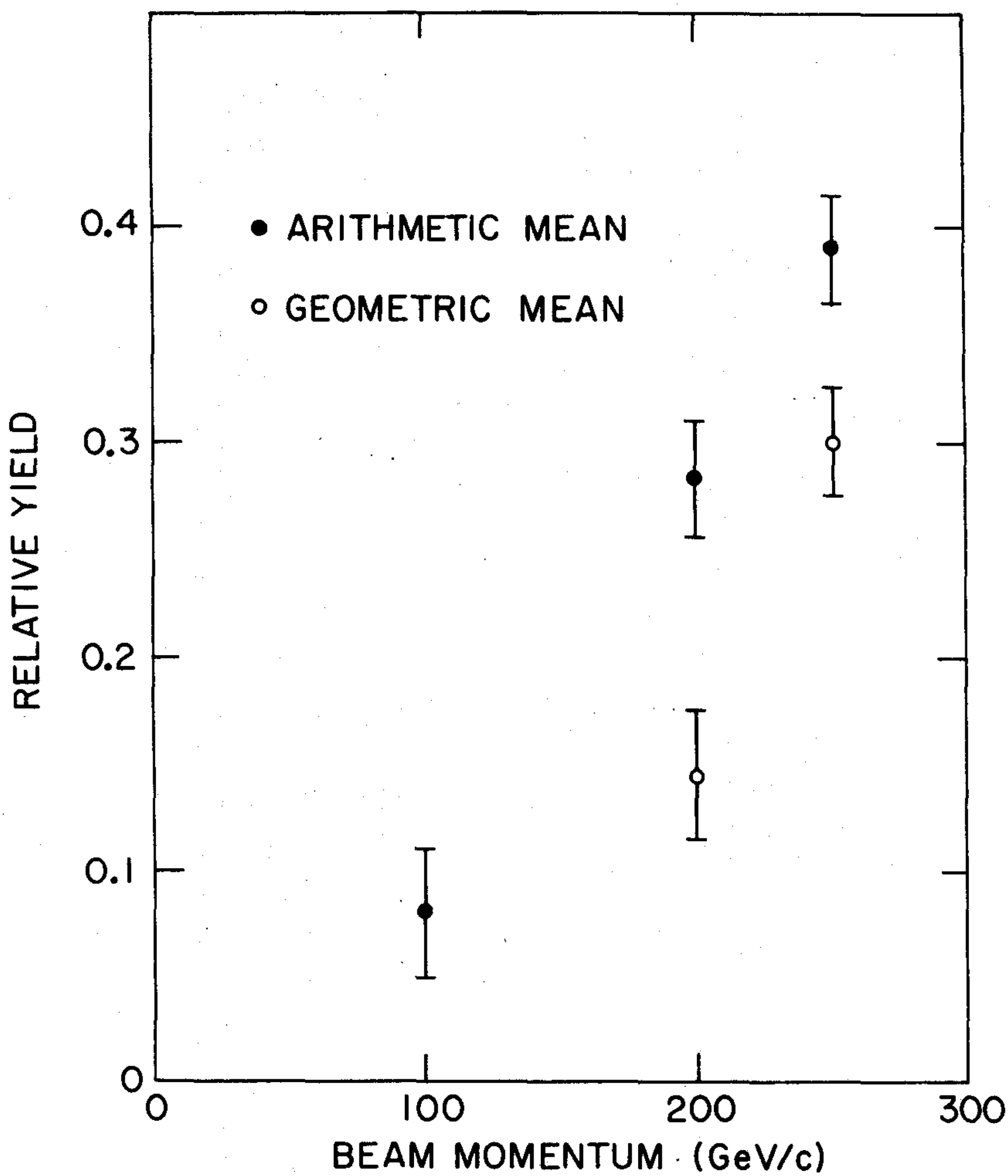
Fig. 1 Pulse height spectra with a 30-element system. A typical transition radiator consisted of 100 foils of ½ mil Mylar spaced at 30 mils. In this measurement 15 out of 30 chambers had radiators consisting of 50 foils of ½ mil and 50 foils of ¼ mil instead of 100 foils of ½ mil. (a) Observed pulse height spectra with a geometric mean device for pions and protons at 100 GeV/c. (b) Observed pulse height spectra with a geometric mean device for pions and protons at 250 GeV/c.

Fig. 2 Relative yield of transition radiation as a function of particle momentum for both geometric mean (circles) and arithmetic mean (dots) configurations.

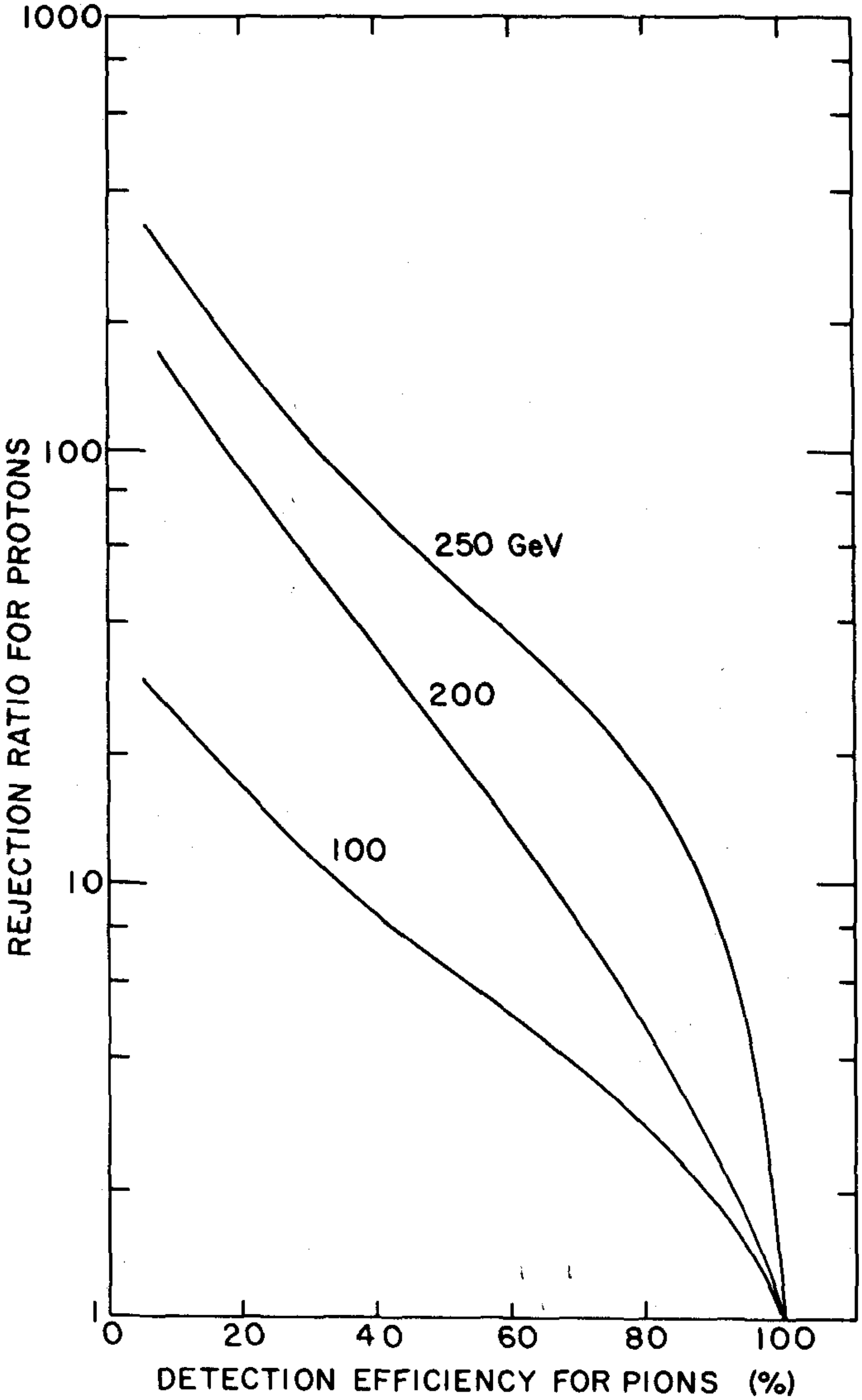
Fig. 3 Rejection ratios for protons as a function of detection efficiency for pions at 100, 200, and 250 GeV/c. A 30-chamber system is used with 100 foils of ¼ and ½ mil Mylar per chamber using a geometric mean device.


Runs 349+350
30 CH G.M.
100 GeV/c
P
π^+


Run 406
250 GeV/c π^-
30 CH G.M.
dE/dY
$\frac{dE}{dx}$
Foils



ARITHMETIC MEAN
GEOMETRIC MEAN
RELATIVE YIELD
0.4
0.3
0.2
0.1
0
0
100
200
300
BEAM MOMENTUM (GeV/c)



1000
100
10
1
0
20
40
60
80
100
REJECTION RATIO FOR PROTONS
DETECTION EFFICIENCY FOR PIONS (%)
250 GeV
200
100