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PERFORMANCE OF THE E715 TRANSITION RADIATION DETECTOR*

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Performance of the E715 Transition Radiation Detector.

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High intensity hyperon beams now available at Fermilab made it possible to investigate rare decays of hyperons on a statistical level far beyond that achieved in previous studies. In Fermilab E715 we detected 90,000 beta-decays of polarized hyperons

$$\Sigma^- \to n e^- \nu \qquad (1)$$

Selection of this desired reaction from the 1000 times more copious background reaction

$$\Sigma^- \to n\pi \qquad (2)$$

was the challenge. It was necessary to suppress reaction (2) by at least 4 orders of magnitude and simultaneously provide high detection efficiency for reaction (1). Both reactions being very similar kinematically, the only way to separate them was to distinguish electrons from pions. This goal was achieved by using a transition radiation detector(TRD) followed by a lead glass calorimeter(LGC).

The TRD was designed and constructed at the Leningrad Nuclear Physics Institute. The detector (Fig. 1) consisted of 12 identical modules, each contained a radiator and a multiwire proportional chamber (MWPC). The radiators consisted of 210 layers of 17 μm polypropylene separated by 1.0 mm. The sensitive area of the MWPCs was 0.6 x 1.0 m^2. The anode wires were 20 μm in diameter spaced 2 mm apart. The two cathodes were made of 50 μm aluminized mylar foils each spaced 8.0 ± 0.1 mm from the wire anode planes.

The sensitive volume of the MWPCs contained 70% Xe and 30% CH_4 and was surrounded by two

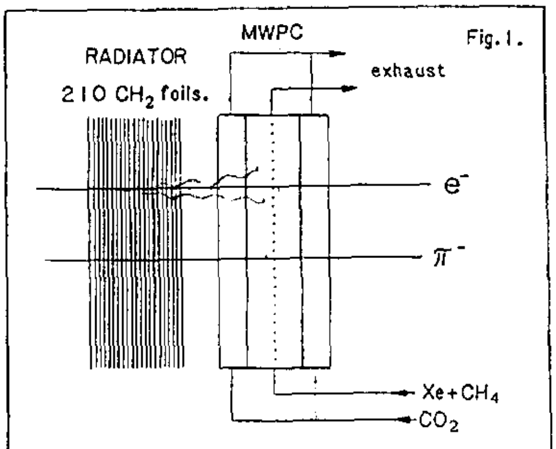
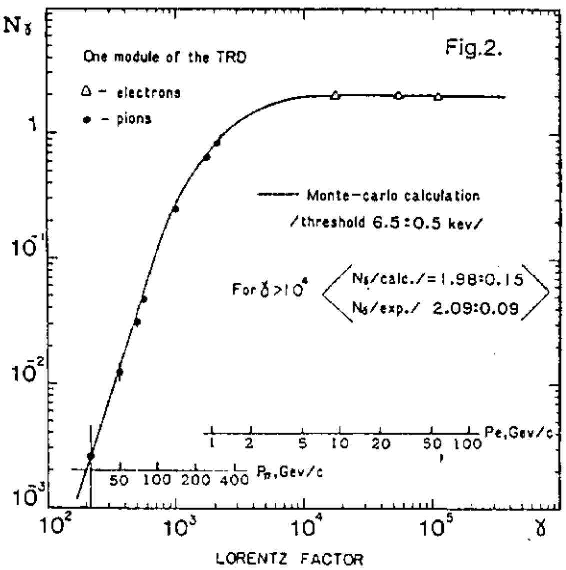


Fig. 1. One module of the TRD

"compensating" volumes filled with CO_2 at a pressure sufficient to keep the cathode planes parallel to the anodes plane. This provided uniform gas amplification (± 10%) throughout the entire sensitive volume. At the operating voltage of 4.7 kV the electron collection time was about 300 ns. The total length of the 12 TRDs was 3.6 m and corresponded to 0.06 absorbtion lenghts and 0.10 radiation lengths.

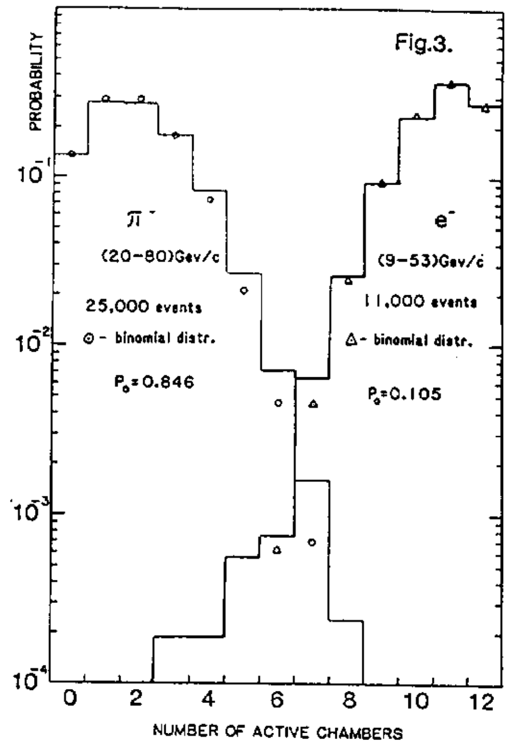
Every eight adjacent wires were connected together; their combined signals were amplifed and discriminated with a threshold corresponding to 6.5 kev. A logical OR was then formed of all the signals in each MWPC. Since the discriminator dead time was only about 30 ns, several signals from an individual MWPC could be recorded during the 400 ns gate. Each of these signals correspond to an ionization cluster and their total number from every MWPC constituted the TRD output.

The average number, N_γ, of TRD quanta detected by one MPWC are shown in Figure 2 as a function of the Lorentz factor (γ = total energy divided by rest mass) of the incident particle. Electronically tagged beams of electrons and pions were used for these special measurements. Lower energy pion beams (10-30 GeV/c) were used to determine N_δ = 0.22, the number of ionization cluster produced in a regime where TR is negligible. Our measurements of N_γ as a function γ are in good agreement with Monte Carlo calculations using theoretical expectations[1] (solid line in Figure 2).



The momentum range (5-80 GeV/c) of the pions and electrons from 250 GeV/c Σ^- decay are ideally suited for a TRD as can be seen in Figure 2. The electrons produce maximum TR while the pion signal is almost entirely due to ionization loss given by N_δ. Although we have found that at $\gamma \geq 100$, N_δ increased by ≈ 2 due to relativistic rise, yet it remains much lower that N_γ for electrons of interest.

We define N_{ac} as the number of active chambers (maximum 12); namely those which detect at least one cluster. Figure 3 shows the measured probability of N_{ac} for 9-53 GeV/c electrons in a test beam and 20-80 GeV/c pions from reaction 2. If we only accept events with $N_{ac} \geq 7$, this selection would provide a pion rejection of about 500 and an electron inefficiency of 0.2%.



The TRD discrimination can be increased if we also require that the total number of clusters, N_{cl}, exceed some threshold value (Fig.4.) For example, with the combined requirement of $N_{ac} \geq 7$ and $N_{cl} \geq 14$ we have a pion rejection of 1500 and an electron inefficiency of 0.5%. These cuts can be easily implemented in an on-line trigger and further refined off-line with a likelyhood analysis.

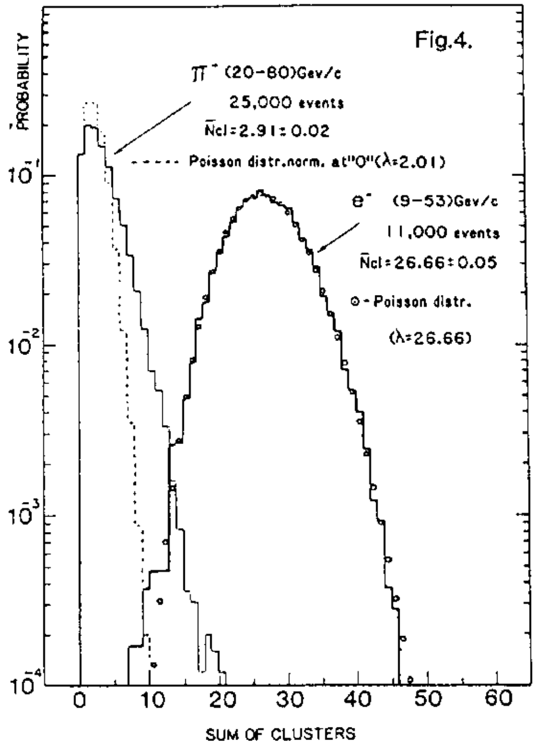
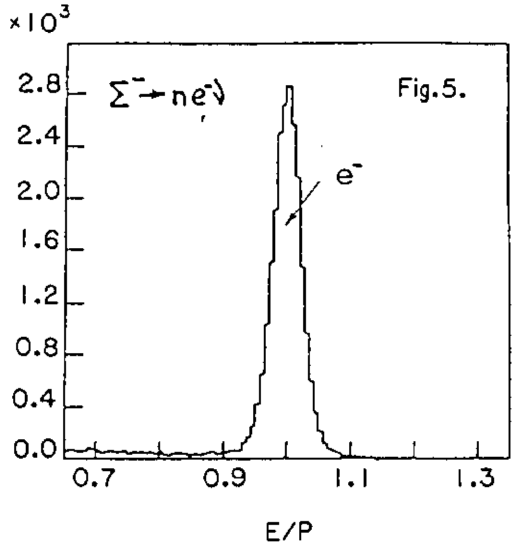


Figure 5 displays a sample of events from E715 using information from the TRD. The events are plotted as a function of the ratio of the energy measured by the LGC to the momentum of the particle as measured by a magnetic spectrometer. The clean peak of the electrons from Σ^- beta decay is evident.

The TRD performance is complicated by interactions of the incident particles. Particles which interacted are not included in the data presented so far. Scintillation counters placed behind the TRD were used off-line to reject such events. During the acquisition of Σ^- beta decay data, the on-line TRD requirements was $N_{cl} \geq 12$ and $N_{ac} \geq 7$ with no rejection of interactions. These conservative running conditions gave an acceptable on-line rejection factor of about 40.



This can certainly be improved with the additional on-line requirement of interaction rejection.

We conclude that a TRD is an effective device for the identification of electrons in a large hadron background at Tevatron energies. The TRD itself proved to be a stable and reliable device with performance parameters in close agreement with theoretical predictions. The combination of a TRD with a LGC proved a very powerful method of electron identification.

I. Garibian et al, Nucl. Instr. and Meth. 125, 133(1975).