CHARM HADROPRODUCTION AT FERMILAB E769

The TPL Collaboration

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ABSTRACT

E769 has just recorded on tape the interactions of 500 million pions, kaons, and protons. A Čerenkov counter and a TRD were used to tag beam particle types in both positive and negative 250 GeV/c hadron beams. Thin foil Be, Al, Cu, and W targets were used with a spectrometer including silicon microstrips to look for charm decay vertices. Preliminary results show \( D^0 \to K^-\pi^+ \) and \( D^+ \to K^-\pi^+\pi^+ \) mass peaks. As the event reconstruction progresses on numerous parallel microprocessors, we intend to explore the \( p_T, x_F, A, \) and flavor dependence of the production of charmed mesons and baryons.
INTRODUCTION

Experiment 769 was designed to explore how pions, kaons, and protons produce charmed mesons and baryons. To achieve this goal we modified and upgraded the Tagged Photon Laboratory (TPL) at Fermilab. Previously, this apparatus had been used by E691 [1] to photoproduce and fully reconstruct over 10,000 charmed particles. Silicon microstrip planes are employed to separate the primary vertex in an event from secondary charm decay vertices. We used a fast data acquisition system to record a large quantity of data with a fairly open global \( E_T \) trigger. We rely on offline vertexing, mass reconstruction, and particle identification to find charm. Production event filtering and reconstruction will soon be ready to start on an ACP [2] microprocessor farm.

BEAM PARTICLE IDENTIFICATION AND TRACKING

Data was taken with both positive and negative 250 GeV/c hadron beams at maximum rates of 2 to 4 MHz. The positive beam was a mixture of approximately 59% \( \pi^+ \), 35% \( p \), and 6% \( K^+ \) and the negative beam 91% \( \pi^- \), 2% \( p \), and 7% \( K^- \).

To explore kaon production of the \( D_s^+ \) and other charmed particles, it was necessary to identify and trigger on kaons to increase the number of recorded kaon interactions. This was done with a Differential Isochronous Self–Focusing Čerenkov Counter (DISC) developed at CERN and Fermilab. The DISC helium gas pressure was adjusted so that Čerenkov light from a desired particle type would be focused onto a narrow annular slit with adjustable width. Eight phototubes sensed this light. The counter was capable of resolving the 0.069 milliradian difference in the opening half angle of pion and kaon light cones. Figure 1 shows the number of times 7 or 8 phototubes were above threshold as a function of pressure during a calibration run. For data taking, at least one phototube in each of 4 quadrants was required and the annular slit was made somewhat wider. Pion contamination of kaon triggers is less than 10%.

To differentiate between \( \pi^+ \) and \( p \) beam particles, we built a Transition Radiation Detector (TRD). It consisted of 24 stacks of 200 12.7\( \mu \)m sheets of polypropylene radiators, \((CH_2)_n\). Each stack was spaced over 50mm and was followed by two xenon gas proportional wire chamber (PWC) planes to detect x-rays. Figure 2 shows the distribution of the number of PWC planes per event which were above threshold during a run for non-kaon triggers. Note the proton peak at 5 and the pion peak at 19. Pion and proton events with another beam particle arriving within 150 ns were vetoed to improve particle identification.
A system of eight 1mm pitch PWC planes far upstream of the target and two 25µ pitch silicon microstrip planes just upstream of the target were used to find the beam track. This yields a line pointing to the primary vertex.

**FOIL TARGETS, SILICON MICROSTRIPS, AND SPECTROMETER**

Twenty-six thin foil targets spaced at 1.7 mm intervals (4 × 100µ W, 3 × 250µ Cu, 5 × 250µ Al, and 14 × 250µ Be) were used to quantize the $z$ position of primary interactions and to explore A dependence. Both primary interactions and downstream charm decays were examined with 2 planes of 25µ pitch silicon microstrip detectors and 9 planes of 50µ pitch [3]. The downstream spectrometer [4] has 35 planes of drift chambers, two PWC planes (2mm pitch), two momentum analyzing magnets, two Čerenkov counters, electromagnetic plus hadronic calorimeters, and a plane of scintillators for muon detection.

**TRIGGER AND FAST DATA ACQUISITION**

A loose global transverse energy ($E_T$) trigger enhanced the number of charm events. A second high $E_T$ trigger further enhanced total recorded charm, but at the expense of low $p_T$ charm events. All but DISC–tagged kaon interaction triggers were prescaled to enrich the kaon fraction on tape.

The data acquisition system [5], which reads out up to 400 4 KB events/sec, is based on seven smart CAMAC crate controllers (SCCs) connected in parallel to seven VMEbus double memory buffers (RBUFs). A farm of Motorola 68020 microprocessor boards, also in VMEbus, processed events. The event processor board and some of the associated software were designed by Fermilab’s Advanced Computing Project (ACP) [6]. Because of the double buffering, an SCC could be reading one event from a CAMAC crate into an RBUF at 0.6µs/word; while an event processor was extracting the previous event from the same RBUF. Data was written directly to a 6250 bpi tape drive at 600 KB/s using a Ciprico VMEbus tape controller. Two MB of memory on each of 16 ACP boards was used to buffer events taken during a 22s spill. This allowed continuous tape writing during a 56s spill cycle.

The data run lasted from June 1987 until February 1988. Five hundred million events were recorded on 10,000 tapes. These included 180 million $\pi^-$, 25 million $K^-$, 100 million $\pi^+$, 70 million $K^+$, and 70 million $p$ induced events.

**OFFLINE RECONSTRUCTION, CHARM PEAKS, AND PHYSICS GOALS**

To analyze 500 million events, we are using a farm of 55 ACP processors based on 16 MHz Motorola 68020s and programmed in FORTRAN [2]. The computing power is equal to 40 VAX 11/780s. If all events were fully reconstructed, about three years of farm time would be required. To reduce this to one year or less, we are devising a fast filter which demands the possibility of a secondary vertex in an event.

Preliminary results shown in Figure 3 display $D^+ \rightarrow K^-\pi^+\pi^+$, $D^0 \rightarrow K^-\pi^+$, and $D^{*+} \rightarrow D^0\pi^+(D^0 \rightarrow K^-\pi^+)$ mass peaks. Charge conjugates are implicitly included. The $D^+$ result comes from 8 million events and the $D^0$ peaks come from 1.2 million events. An incomplete reconstruction program employing 9 out of 13 silicon microstrip planes was used. The cut $\sigma(\Delta z)$ measures the significance of the separation between primary and secondary vertices. For the events in Figure 3c, the measured $D^{*+} - D^0$ mass difference was within 3 MeV/c$^2$ of the accepted value, 145.5 MeV/c$^2$.

As analysis progresses, we intend to explore a number of physics topics including:

- The cross section for charm production by pions, kaons, and protons; including $d\sigma/dp_T$.
- Measuring $x_F$ distributions and parameterizing the gluon structure functions of the projectiles in the context of the gluon fusion model.
- Charm production A dependence. Given $\sigma \propto A^\alpha$ and A = (9, 27, 63.5, 183.8); find $\alpha$.
- Leading effects (e.g. more forward $\pi^+(ud) \rightarrow D^+(cd)$ than $\pi^+(ud) \rightarrow D^-(\bar{c}d)$).
- Explore $D_s^+$ production by kaons and $\Lambda_c^+$ production by protons.
- Exploit target foils and 25µ silicon microstrips to measure $D_s^+$ and $\Lambda_c^+$ lifetimes.
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