Diffractively produced charm final states in pp interactions at 800 GeV/c

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We report the observation of charm final states produced by the diffractive dissociation reaction $pp \to pX$ at a c.m. energy of $\sqrt{s} = 40$ GeV. Signals are observed for the decay modes $D^{*+} \to D^0(K^-\pi^+)\pi^+$ and $D^{*-} \to \overline{D^0}(K^+\pi^-)\pi^-$. Our results are based on analysis of data representing over 50% of the 5.5 billion events acquired by experiment E690 in the Fermilab fixed target run of 1991.

1. Experiment

Experiment E690 was a fixed target experiment that investigated diffractive pp interactions using an 800 GeV/c proton beam incident on a fixed liquid hydrogen target. The E690 detector was made up of a beam spectrometer system and a multi-particle spectrometer. The beam spectrometer system consisted of two separate spectrometers– an incoming beam spectrometer which detected the incident beam proton and an outgoing beam spectrometer which measured the forward or scattered beam proton. Together they allowed measurement of the momentum difference between the beam proton and the fast, outgoing proton. The multi-particle spectrometer, on the other hand, which was made up of 6 drift chambers, a time-of-flight (TOF) system and a Cerenkov counter for particle identification, measured the particles produced by the interaction of the beam proton in the LH_2 target.

During the run, events were written to tape when they met the following requirements:

1. An incident beam proton in the incoming beam spectrometer.
2. A fast proton in the outgoing beam spectrometer.
3. At least one extra charged track in the main spectrometer.

By the end of the fixed target run in 1991, E690 had acquired about 5.5 billion events meeting these requirements. The number of events used for this analysis was about 2.8 billion events, representing over half of the entire data sample.

2. Charm selection

In the search for diffractive charm, the charm decay mode $D^* \to D^0(K\pi)\pi$ was used due to its low Q value (where $Q = M(K\pi\pi) - M(K\pi) - M(\pi)$) which provided a valuable signature for reducing combinatorial backgrounds. The following criteria were used to select charm candidates from the E690 data sample:

1. At least 3 tracks with the appropriate charges to form a $K\pi\pi$ invariant mass combination.
2. Track assigned as the K from the D^0 decay must have Cerenkov identification consistent with a K.
3. Track assigned as the π from the D^0 decay must have Cerenkov identification consistent with a π.
4. $1.810\ GeV/c^2 < M(K\pi\pi) < 2.210\ GeV/c^2$.
5. $|Q - .00583\ GeV/c^2| < .0005\ GeV/c^2$.
6. Only for the D^{*+}: TOF identification for slow π from the D^* decay consistent with a π.

3. Results

Applying all of these cuts to the 2.8 billion events used for this analysis resulted in 446 events for the D^{*+} and 4,916 events (without the TOF requirement for the slow π) for the the D^{*-}. Fitting a Gaussian plus a linear background to the invariant $K\pi\pi$ mass distributions of the events meeting these requirements provided an estimate of 45 events for the D^{*+} and 157 events for the D^{*-}. To select diffractive events, the

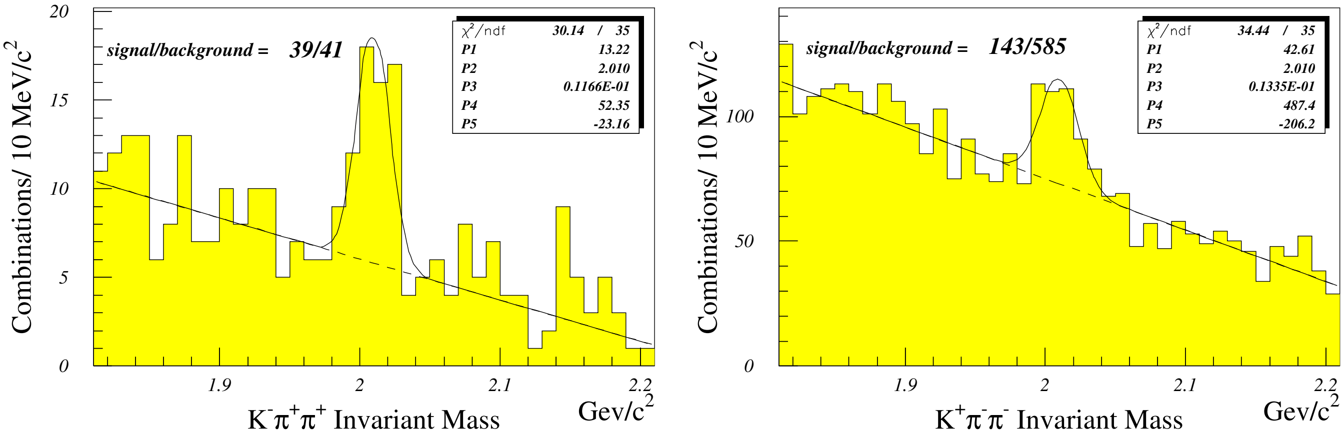

Figure 1. Invariant $K\pi\pi$ mass distributions for D^{*+} and D^{*-} events meeting the coherence condition, $x_F > 0.85$, fitted to a Gaussian plus a linear background

coherence condition [1] was imposed requiring the x_F of the fast, outgoing proton to be greater than 0.85. With this additonal requirement, fits to the $K\pi\pi$ mass distributions shown in Figure 1 yielded 39 events for the D^{*+} and 143 events for the D^{*-}. A plot of the rapidity y (where $y = \frac{1}{2}ln(\frac{E+P_L}{E-P_L})$) is shown in Figure 2 for the D^{*+}, the scattered proton, and the Y system where Y represents all the particles in the X system excluding the D^* in a single diffractive reaction of the type $pp \rightarrow p_{fast}X(D^*Y)$. This plot shows a rapidity gap of nearly 5 units between the D^* and the fast, outgoing proton p_{fast} which is characteristic of a single diffractive interaction.

4. Conclusion

In conclusion, after analyzing over half of the entire E690 data sample, we observe signals of 39 events in the $D^{*+} \rightarrow D^0(K^-\pi^+)\pi^+$ channel and 143 events in the $D^{*-} \rightarrow \overline{D^0}(K^+\pi^-)\pi^-$ channel meeting the coherence condition of $x_F > 0.85$ for the fast, outgoing proton. To our knowledge this is the first observation of open charm production in single diffractive pp interactions. A search conducted by a previous experiment, FNAL E653, found no evidence for diffractively produced charm in $p - Si$ interactions [2] resulting in an upper limit of $\sigma_{diff}(c\overline{c}) < 26$ μb for $p - Si$. If we assume that the dependence of the cross section σ on the atomic weight A goes like $\sigma \propto A^{2/3}$, this upper limit translates to $\sigma_{diff}(c\overline{c}) < 2.8$ μb in the case of pp interactions at 800 GeV/c. Preliminary cross section estimates based on the E690 results using some crude assumptions and models yielded figures consistent with this upper limit.

REFERENCES

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2. K. Kodama et al., Phys. Lett. B 316 (1993) 188.

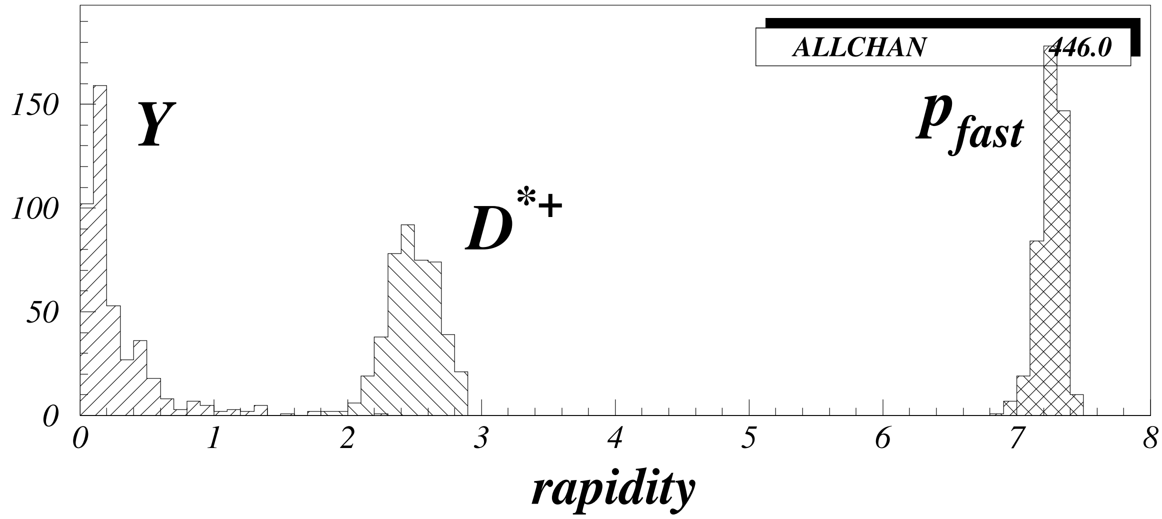

Figure 2. Rapidity plot of the D^*, Y system, and p_{fast} for $D^{*+} \to D^0(K^-\pi^+)\pi^+$ events