ANL-HEP-CP-83-41

HRS CP83-3

Properties of D* Production in e^+e^- Annihilation at 29 GeV

CONF-830810--4

HRS Collaboration

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ANL-HEP-CP--83-41

DE84 000573

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MASTER

(Submitted to the 1983 International Symposium on Lepton and Photon Interactions at High Energies Cornell University August 4-9 1983)

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ABSTRACT

D^* production is studied in the decay chain $D^{*+} \rightarrow D^0 \pi^+$ with the D^0 observed in the $K^-\pi^+$ mode and the corresponding charge conjugate decays. The results were obtained from a preliminary analysis of an 80 pb^{-1} data sample of e^+e^- annihilations at 29 GeV taken with the High Resolution Spectrometer at PEP. The excellent mass resolution of the HRS allows the study of the D^* production and decay with very low background. We present the fragmentation function over the range of Z from 0.2 to 1.0.

Charm fragmentation has been measured in e^+e^- annihilations at high energy in several experiments[1-5] by measuring the charged D* decay. We have also recently presented results[6] which study charm fragmentation using D^0 production without requiring the $D^{*+} \rightarrow D^0\pi^+$ decay[7]. In this paper we present results on D* production in the mode $D^{*+} \rightarrow D^0\pi^+(D^0 \rightarrow K^-\pi^+)$ (1) in the Z range from 0.2 to 1.0 where $Z = 2E_{D^*}/E_{cm}$. This decay has been isolated by utilizing the low Q-value of the $D^{*+} - D^0$ decay and selecting $K^-\pi^+$ mass combinations in the D^0 region. The previous measurements[1-5] have not observed D^{*+} production at z values less than 0.4-0.5, mainly due to the presence of high combinatorial background at low Z. In the present experiment, with significantly better mass resolution a sample of 66 D* events has been observed and analyzed over the Z range from 0.2 to 1.0 and the fragmentation function of the D^{*+} has been measured.

The data sample corresponds to an integrated luminosity[8] of 80 pb^{-1}, obtained with the High Resolution Spectrometer (HRS) at a center of mass energy of 29 GeV at the PEP e^+e^- intersecting storage ring facility. The detector, shown in Fig. 1 has been described in detail elsewhere[9,10]. It is a high resolution, general purpose solenoidal detector, placed inside a superconducting magnet with a field of 1.62 Tesla. The tracking is mainly done by a 15 layer central drift chamber, the innermost and the outermost layers being situated at radii of .21 m and 1.03 m respectively. Two layers of drift tubes provide additional coordinate measurements at a radius of 1.89 m for tracks contained in the central two-thirds of the solid angle. For the 1983 data taking, 11 high pressure Cerenkov tori were installed between the inner drift chamber and the outer drift tubes to

distinguish between pions and kaons. The measured momentum resolution for high momentum tracks at large angles is $\sigma_p/p = 1.0 \times 10^{-3}$ p (p in GeV/c). At 5 GeV/c, the corresponding numbers are 0.4×10^{-3} and 0.6×10^{-3}, without and with the Cerenkov counters respectively. The drift chamber system is surrounded by barrel and endcap electromagnetic calorimeters comprised of lead-scintillator sandwiches. The barrel shower counter scintillators also provide time-of-flight information to separate pions from kaons up to a momentum of 1 GeV/c. The positions of the showering particles in the shower counters are measured by a set of proportional tubes.

One photon annihilation events were triggered by two or more 'tracks' found by the trigger processor[9] in the central drift chambers or by ≥4.8 GeV energy deposited in the barrel and endcap calorimeters. The total data sample consists of two parts: the 1982 data sample of 19.6 pb^{-1}, in which all triggers have been fully analyzed[6], and 60 pb^{-1} of the 1983 data sample from which only multihadron triggers selected by an on-line fast filter have been analyzed to date. The fast filter selected events with both ≥3 tracks and ≥4.8 GeV energy deposited in the calorimeters. This paper reports a preliminary analysis of the combined data samples.

Reconstructed individual tracks from each event were fitted to a primary vertex at the intersection point. The analysis was performed with successfully fitted tracks only to avoid contributions from obvious secondary vertices, e.g. K^0's and to improve mass resolution. To reduce beam gas and two photon backgrounds, the following cuts were made for event selection:

i) a minimum track multiplicity of 5

ii) sum of charged track momenta ≥ 7.25 GeV/c

iii) 1.45 GeV or more energy deposited in the barrel.

All events passing the preceding cuts were then used to isolate the D^{*+} sample. The analysis was carried out by forming all possible $K^{\mp}\pi^{\pm}$ mass combinations in every event using all tracks as both kaons and pions. $K^{\mp}\pi^{\pm}\pi^{\pm}$ mass combinations were formed in a similar fashion. No information on particle identification from the Cerenkov counters or from time-of-flight was used. The quantity

$$\Delta = M(K\pi\pi) - M(K\pi)$$

was then determined. Since the $K\pi\pi$ system contains two like sign pions, two values are calculated. The kinematics of the D^* decay is such, however, that invariably the lowest momentum pion comes from the initial decay of the D^* and not from the subsequent D^0 decay.

Figure 2 shows the scatter plot of those combinations of $M(K\pi)$ versus Δ with the highest momentum pion assigned to the $K\pi$ system and with $Z \geq 0.2$. An accumlation of D^{*+} events can clearly be seen at a value of $\Delta = 0.145$ GeV/c^2 and $M(K\pi) = 1.863$ GeV/c^2. Figure 3 shows the projections of this distribution onto the axes. Figure 3a shows Δ selected for $M(K\pi) = 1.81 - 1.92$ GeV/c^2 and Fig. 3b $M(K\pi)$ for $0.143 \leq \Delta \leq 0.148$ GeV/c^2. Figures 4 and 5 show similar distributions for various Z intervals. In all Z intervals clear peaks at $\Delta \simeq 0.145$ GeV/c^2 indicate D^{*+} production and in addition the D^0 is clearly observed with a mass of $1.863 \pm .004$ GeV/c^2 and a σ of 0.018 GeV/c^2 which is consistent with our expected resolution. The

number of D^{*+} events in total and for each z interval has been determined by measuring the number of events above background in the two dimensional $M(K\pi)$-Δ space using both values of Δ and $M(K\pi)$. A total of 66 events is found in the range Z from 0.2 to 1.0.

Preliminary cross-sections were determined using branching fractions[11] and an average acceptance of 65 ± 11% [12] which was obtained from events generated with the LUND Monte Carlo program[13]. Figure 6 shows the fragmentation function $D(Z) = \frac{1}{\sigma}\frac{d\sigma}{dZ}$ for the D^{*+} events. Fitting the data to the parameterization of Ref. 14 yields an ϵ of 0.29 ± 0.10.

Assuming $\sigma(D^{*+}) = \sigma(D^{*0})$ from isospin arguments, the measured total D^* cross-section, corrected for acceptance, is $\sigma(D^* + \overline{D^*}) = 0.22 \pm 0.08$nb. In units of the point cross-section, and using a radiative correction factor of 0.93, this yields an R value of $R\ (D^* + \overline{D^*}) = 2.0 \pm 0.7$, to be compared with 4.75 ± 2.37 of the MARK II collaboration[3] and 2.50 ± 0.64 ± 0.88 of the Tasso Collaboration.[4] The expected inclusive R value for all charm production using $\alpha_s = .17$ is 3.53 including 0.7 units of R expected for the b decay into charm.

In conclusion we have observed charmed D^* production over the Z range from 0.2 to 1.0 and the fragmentation function has been measured.

This work was supported by the U.S. Department of Energy. We acknowledge the work of the technical staffs of PEP and the collaborating institutions whose efforts made the experiment possible.

References

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2. M.W. Coles et al., Phys. Rev. D26 2190 (1982).
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7. Reference to particle states in this paper is taken to include their charge conjugates.
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11. We use the D branching fractions $BR(D^0 \to K^- \pi^+) = 0.030 \pm 0.006$ and $BR(D^+ \to K^- \pi^+ \pi^+) = 0.063 \pm 0.011$ from R. Schindler et al., Phys. Rev. D24 78 (1981). These D branching fractions, together with the D* branching fraction $BR(D^{*+} \to D^0 \pi^+) = 0.44 \pm 0.10$ provide a self-consistent fit to the SPEAR data of reference (2).
12. An additional correction of 0.25 was applied to the region Z from 0.2 to 0.4.
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14. C. Petersen et al., SLAC-PUB-2912 (1982).

Figure Captions

Figure 1	The High Resolution Spectrometer (HRS)
Figure 2	$M(K\pi)$ versus Δ for $Z \geq 0.2$ using all possible combinations.
Figure 3a	Δ with $1.81 \leq M(K\pi) \leq 1.92$ GeV/c^2
Figure 3b	$M(K\pi)$ with $0.143 \leq \Delta \leq 0.148$ GeV/c^2
Figure 4	Δ with $1.81 \leq M(K\pi) \leq 1.92$ GeV/c^2 for the Z intervals indicated
Figure 5	$M(K\pi)$ with $0.143 \leq \Delta \leq 0.148$ GeV/c^2 for the Z intervals indicated
Figure 6	The D* fragmentation function

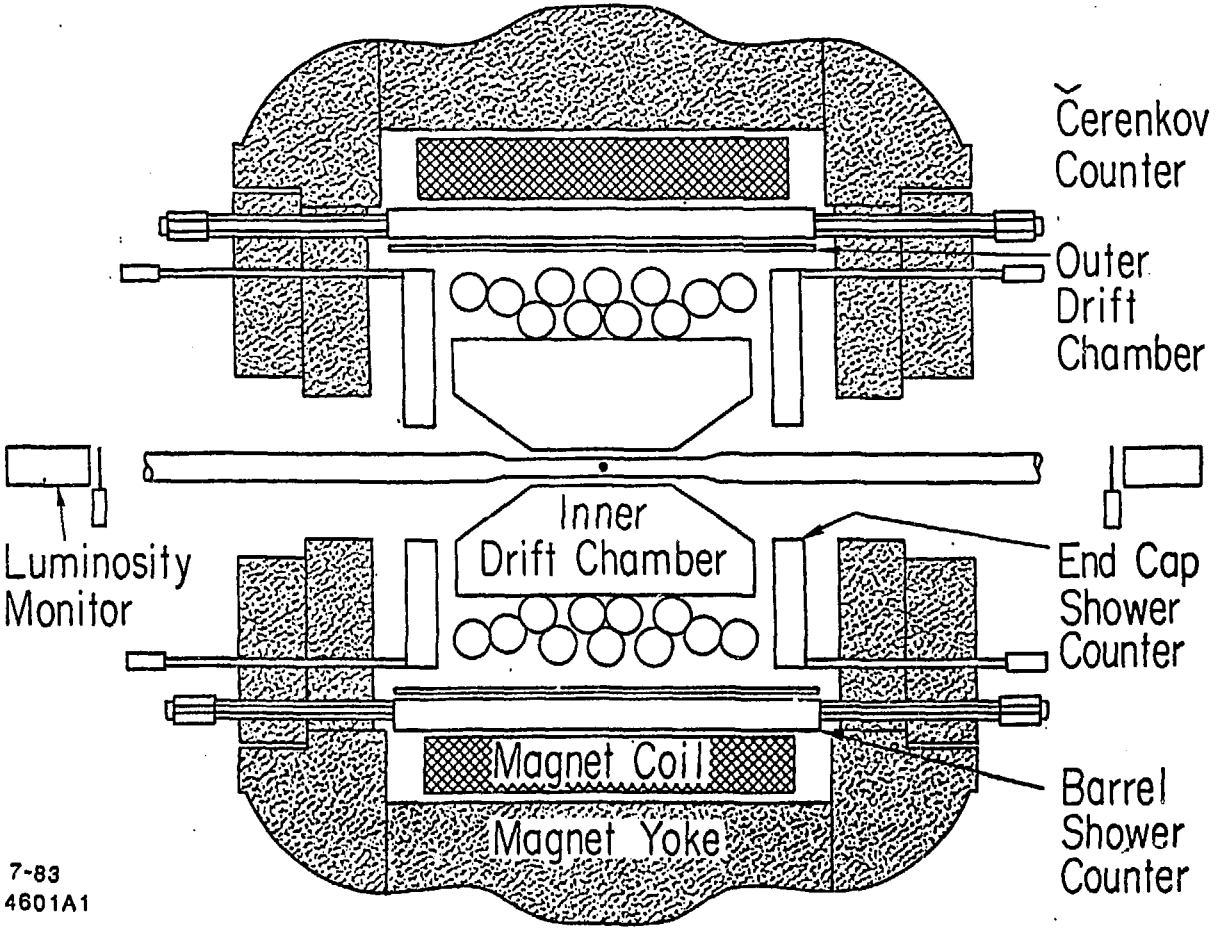

Čerenkov Counter
Outer Drift Chamber
Luminosity Monitor
Inner Drift Chamber
End Cap Shower Counter
Magnet Coil
Magnet Yoke
Barrel Shower Counter
7-83
4601A1

Fig. 1

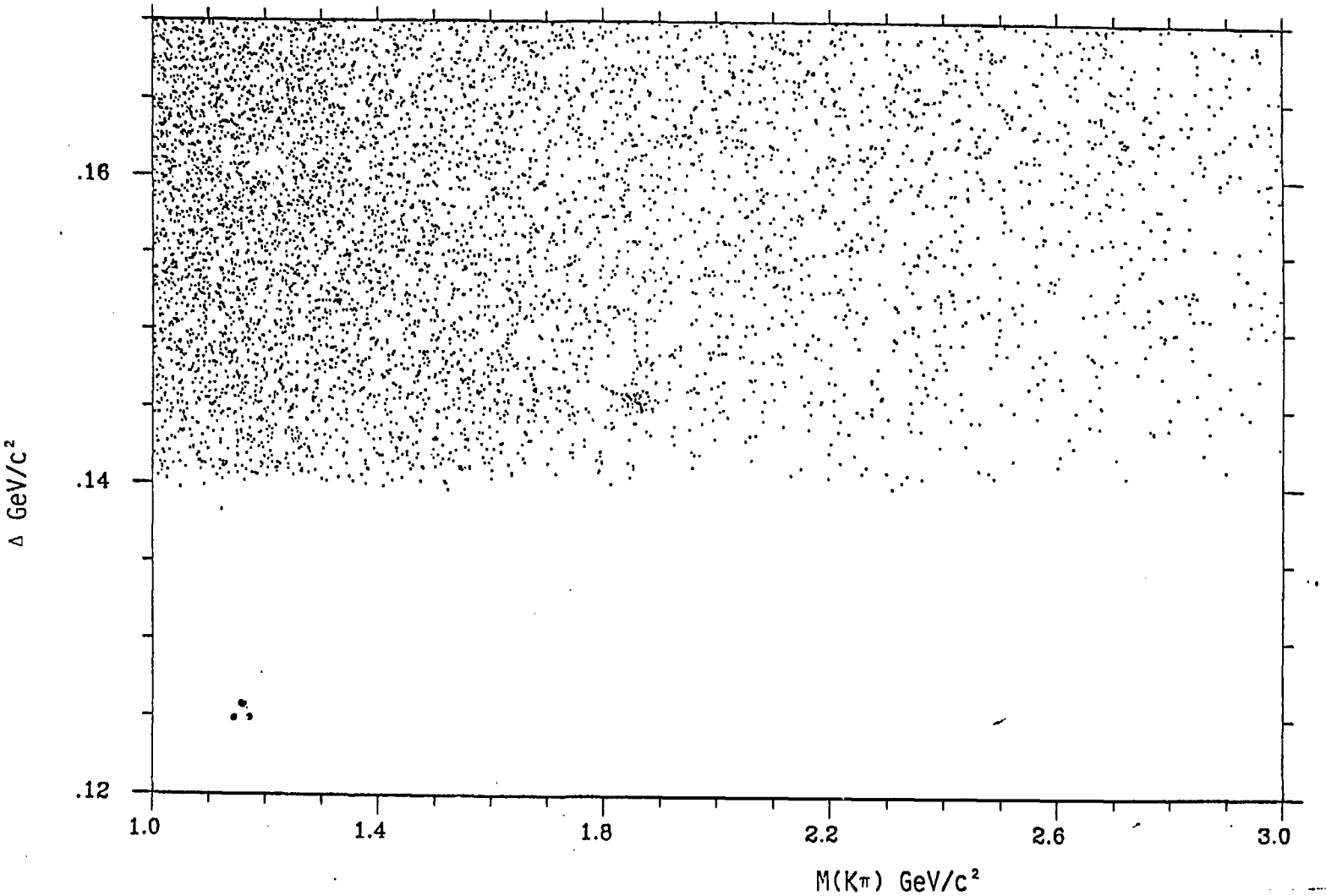
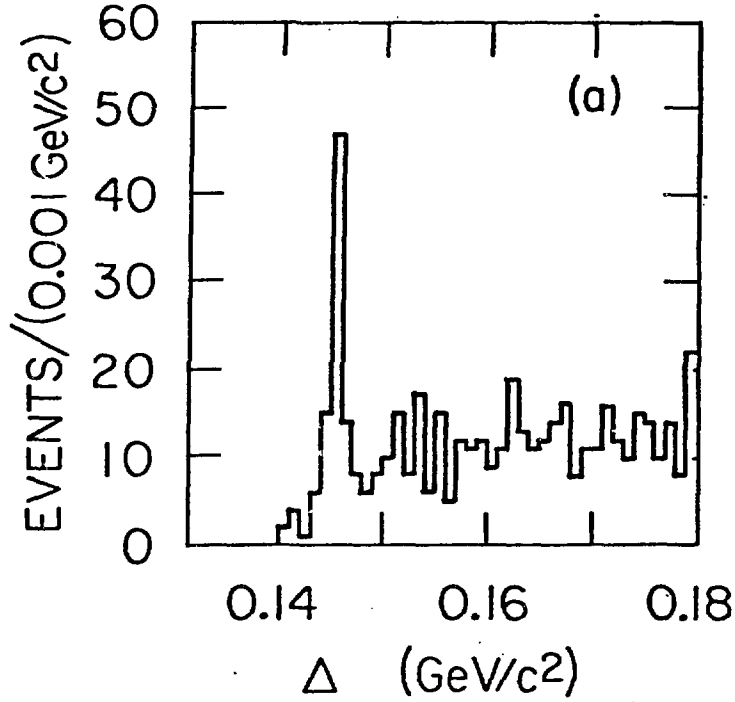


FIG. 2



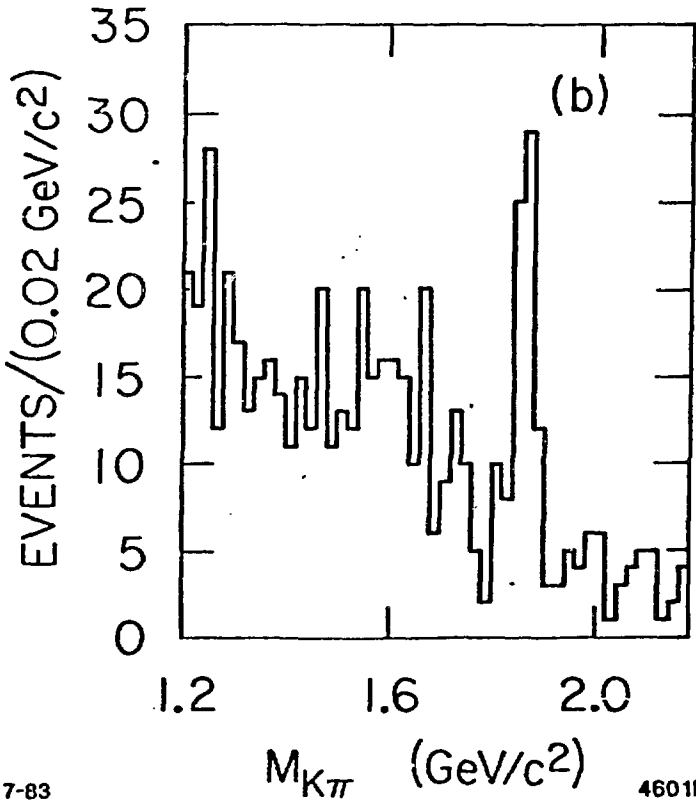


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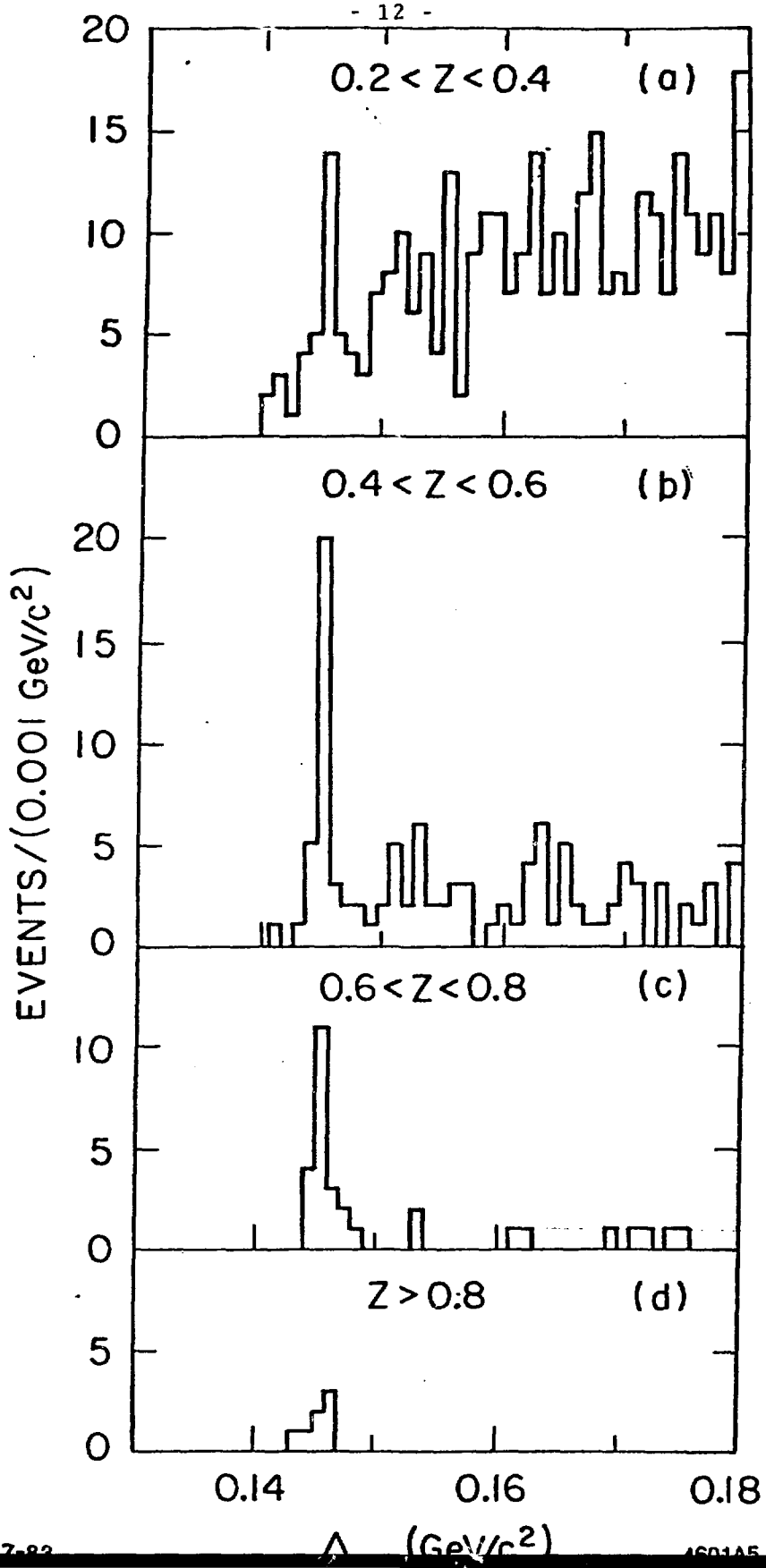
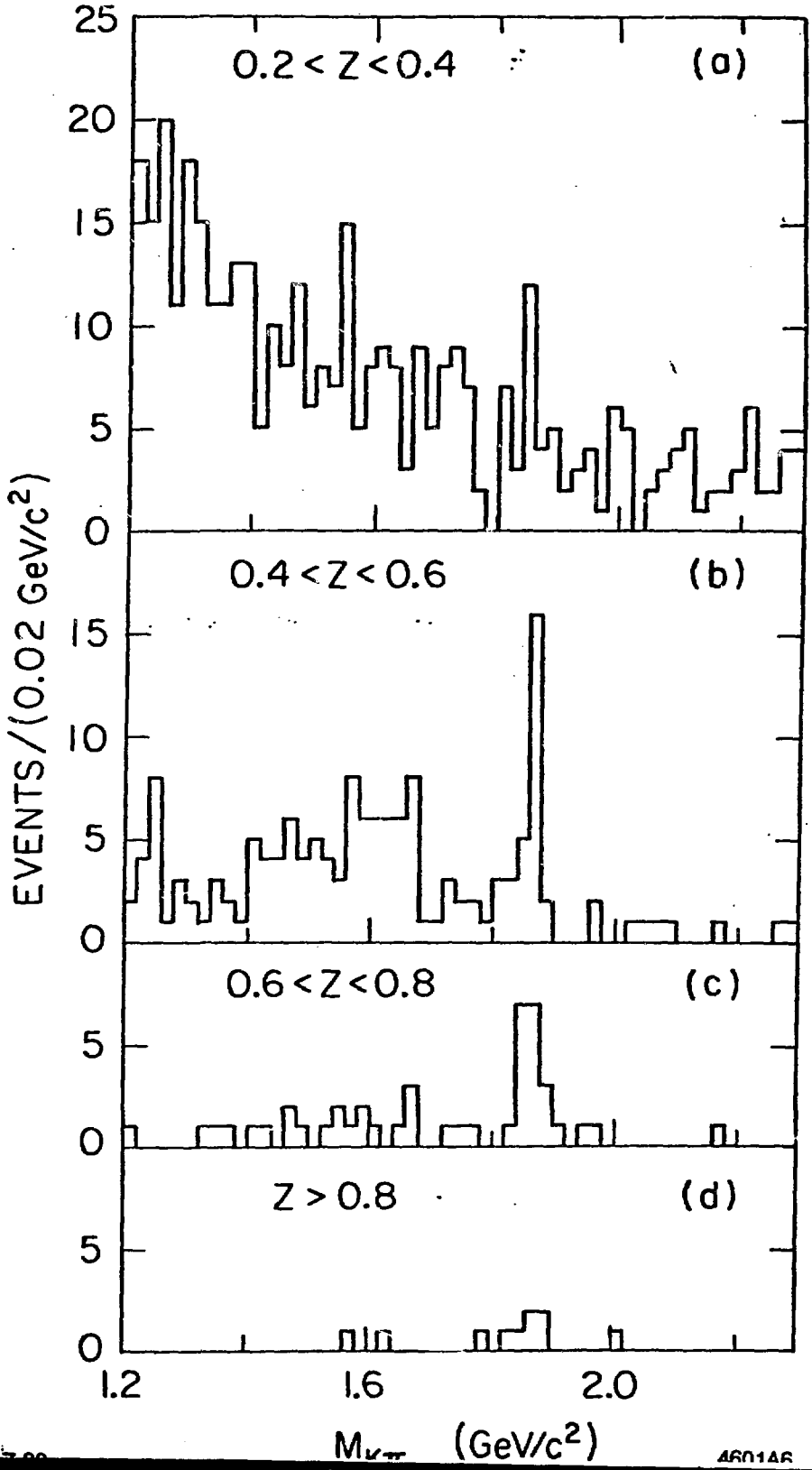
Fig. 3


0.2 < Z < 0.4
(a)
0.4 < Z < 0.6
(b)
0.6 < Z < 0.8
(c)
Z > 0.8
(d)
EVENTS/(0.001 GeV/c²)
0.14
0.16
0.18
Δ (GeV/c²)


0.2 < Z < 0.4
(a)
0.4 < Z < 0.6
(b)
0.6 < Z < 0.8
(c)
Z > 0.8
(d)
EVENTS/(0.02 GeV/c²)
25
20
15
10
5
0
1.2
1.6
2.0
M (GeV/c²)

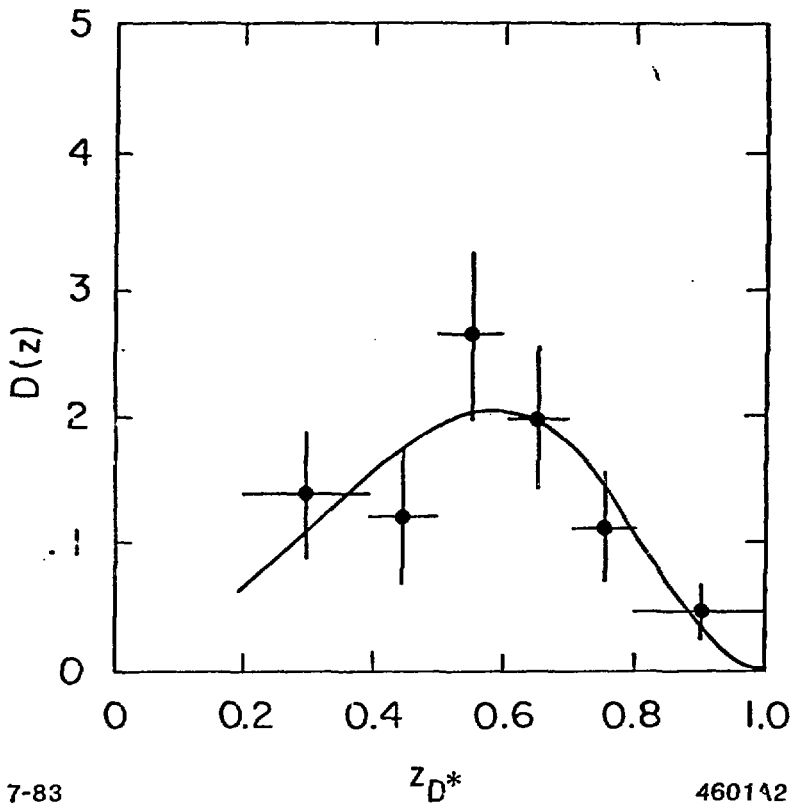


Fig. 6