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Measurement of the D^0 meson lifetime

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HRS COLLABORATION

Abstract

We report the measurement of the lifetime of the D^0 meson. The direct observation of the decay vertex distribution in the process $D^0 \to K^-\pi^+$ was made using a vertex chamber installed in the HRS detector at PEP. The measured lifetime is found to be $\tau_{D^0} = .42 \pm .09 \pm .06$ps.

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MASTER

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Charmed mesons have been studied extensively in the past few years. Measurements of D^*, D^0, D^+ cross sections and fragmentation functions have been made by the HRS and others. [1 2] Many branching modes of the D^*, D^0, D^+ have been measured,however the exclusive final states are not yet well understood. Since the semileptonic branching ratios of D^0, D^+ indicate that the ratio of lifetimes $\tau_{D^0}/\tau_{D^+} = 2.3 \pm .5$ [3] , a precise measurement of the individual lifetimes of the D^0 and $D^+$is important.

The process

$$e^+e^- \rightarrow D^{*+} + X^-$$
$$\longmapsto D^0 + \pi^+$$
$$\longmapsto K^-\pi^+$$

provides an opportunity to measure the D^0 lifetime in a decay that is nearly free of background. We have previously measured the fragmentation function of the D^*[1]. For an energy fraction $z_{D^*} > .4$, D^* production is dominated by direct charm quark production and the contribution from the decay of B mesons is thought to be small. The measurement of the D^0 lifetime in the HRS detector was made using decay vertices observed in the process $D^* \rightarrow D^0\pi^+$.

The details of the HRS detector and vertex chamber appear elsewhere. [4]

In the HRS detector tracks were measured over a radial path length of 1.9 meters in a 1.62 T magnetic field. The resulting mass resolution of the $K\pi$ mass is $\pm$13MeV . For the measurement of the D^0 decay vertex we used tracks that had been fit through the 4 layer tubular vertex chamber and the central drift chamber. A particularly beautiful D^* event is shown in Figure 1a,b,c,d,e. The central and outer drift chambers have an intrinsic resolution of $\sigma_R < 200\mu$. The vertex chamber occupies the region between 0.09 m and 0.11 m from the interaction point. The intrinsic resolution of the chamber is 100μ.

The event selection procedure was similar to that used in our previous D^* publications [1 2]. We started with the momenta obtained using the central and outer drift chambers. We required that the energy fraction z_{D^*} of the D^* be greater than

0.4. Then we applied a cut which removed events where $|\cos\theta| \leq 0.9$ where θ is the angle between the direction of the K^- and the D^0 in the D^0 rest frame. A plot of the mass difference $\Delta = M_{K\pi\pi} - M_{K\pi}$ is shown in Figure 2. A cut was made on the mass difference so that values between .143 and .148 GeV were accepted. The mass of the Kπ combinations for the remaining events is shown in Figure 3. We accepted events in the mass range $1.83 \leq M_{D^0} \leq 1.90$ GeV and reprocessed them using the vertex chamber and the central drift chamber. There were 122 events that passed successfully through this step from a data sample collected with 200 pb^{-1} integrated luminosity.

Several additional cuts on the D^0 events were imposed to insure track quality and reduce systematic error. All K and π tracks were required to have at least three hits in the vertex chamber.Events were removed if the K or π track shared one or more hits in the vertex chamber with another reconstructed track. With these cuts 59 D^0 events remained with about a 3 per cent background.

The vertex of the K and π tracks was determined by a least squares fit to the common point.The average beam position was measured for each run by using all the tracks in the combined Bhabha events.The typical uncertainty in the average beam position was $< 50\mu$ horizontally and $< 30\mu$ vertically.

Once the vertex was determined, the most probable decay distance from the beam center was calculated [5]. Only the events with errors on the decay distance less than 1.3mm were used in the lifetime determination. Using the measured D^0 momentum, the proper lifetime distribution for the remaining 55 events was then calculated from the decay distance distribution. The proper lifetime distribution is shown in Figure 4.

The proper time distribution was then fit using a maximum likelihood technique. An exponential decay distribution was convoluted with a gaussian distribution characteristic of each event. The resulting best fit to the proper time is

$$\tau_{D^0} = .42 \pm .09 \pm .06 ps.$$

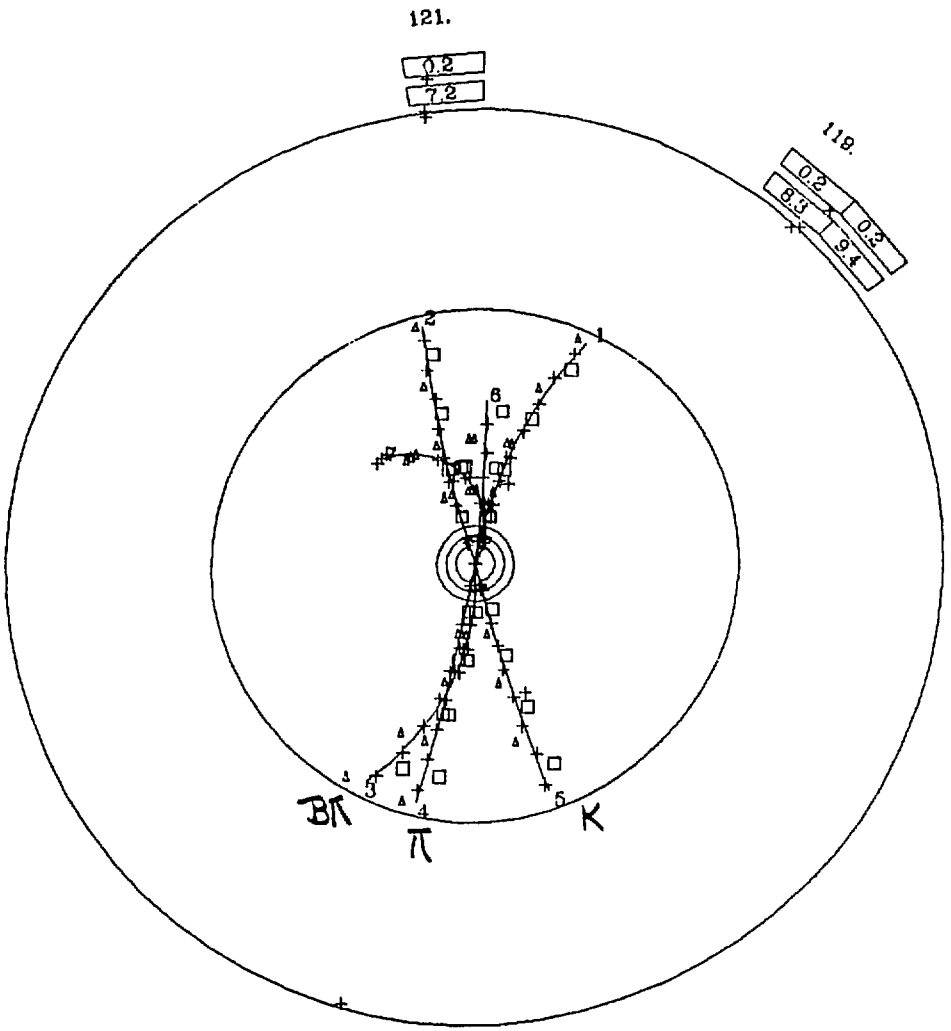
We estimate our systematic errors to be 0.06 ps, based on a variational study of our cuts and tracking errors and also including effects such as the error in the background fraction and error in the background lifetime. The resulting lifetime agrees well with previous measurements from other e^+e^- detector experiments.

REFERENCES

1. M. Derrick et al.,Phys.Rev.Lett. 53(1984) 1971
2. M. Derrick et al.,Phys.Lett. 146B(1984) 261
3. Baltrusaitis et al.,Phys.Rev.Lett. 54 (1985) 1976
4. D. Bender et al.,Phys.Rev. D30(1984) 515
5. The most probable distance is calculated as a weighted distance between the decay vertex and the average beam center. For details see Amidie, LBL# 17795, PhD Thesis.

FIGURE CAPTIONS

1. A $D^{*+} \rightarrow K^-\pi^+\pi^+$ event in the HRS detector. a) The full transverse view. b)The side and top views. c) Details of the central drift chamber tracking. d)Tracking in the vertex chamber. e)Projection near the interaction point with a 1mm grid.
2. The mass difference plot for $M_{K\pi\pi} - M_{K\pi}$ with $z_{D*} > 0.4$ and $|\cos\theta| \leq 0.9$.
3. The invariant mass of the Kπ combinations for the events with $0.143 \leq \Delta \leq 0.148$ GeV as well as the cuts on z and $\cos\theta$.
4. The proper lifetime distribution for the D^o.

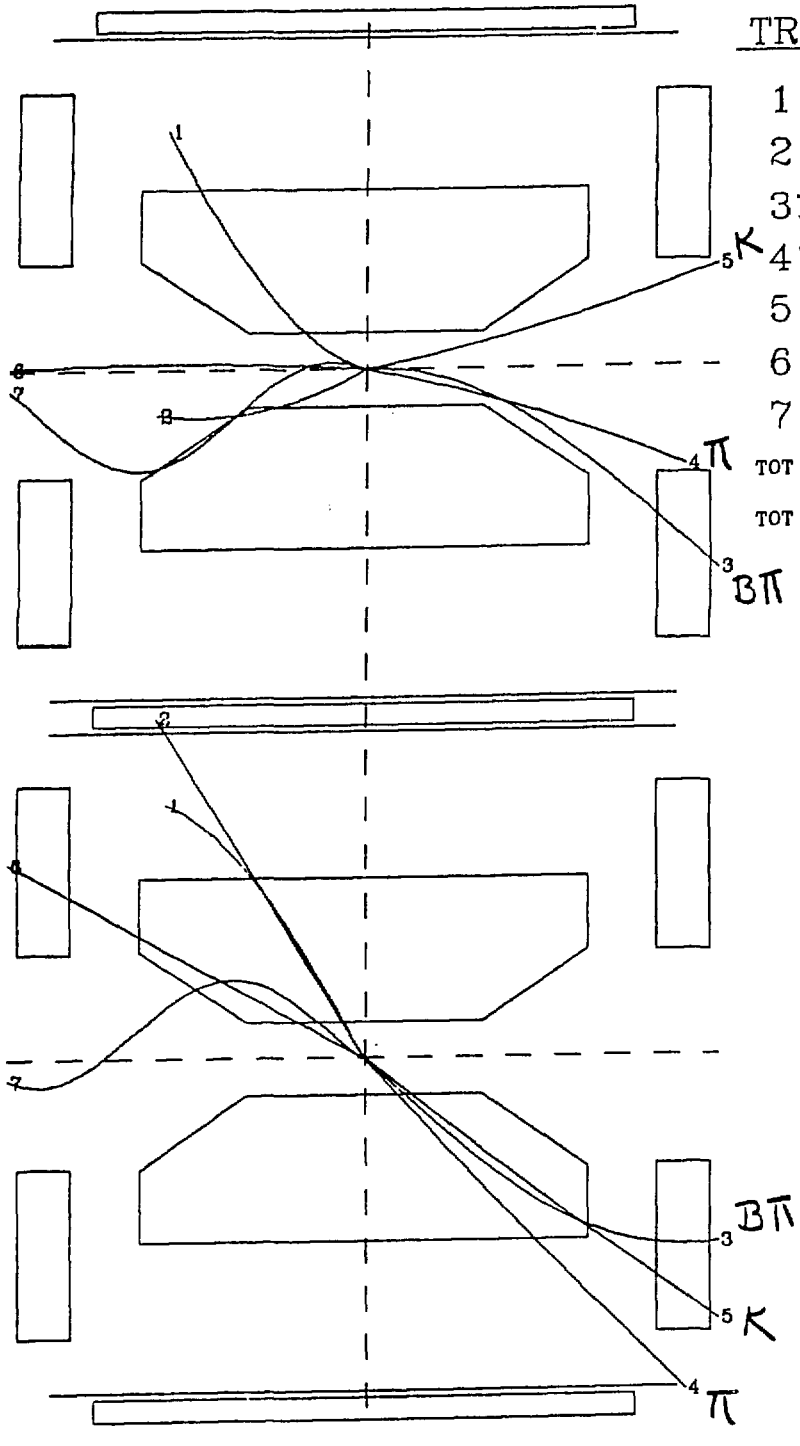


H R S RUN=5587

EVENT= 1009
DCHITS = 143
NPRNG = 7
SH SUM= 0.5 + 0.0

	TRACK	MOMENTUM	THETA
	1	1.0	117.4
	2	2.7	120.0
Bπ	3	0.7	42.2
π	4	5.7	47.7
K	5	−4.8	38.9
	6	−5.2	150.5
	7	−0.2	138.2

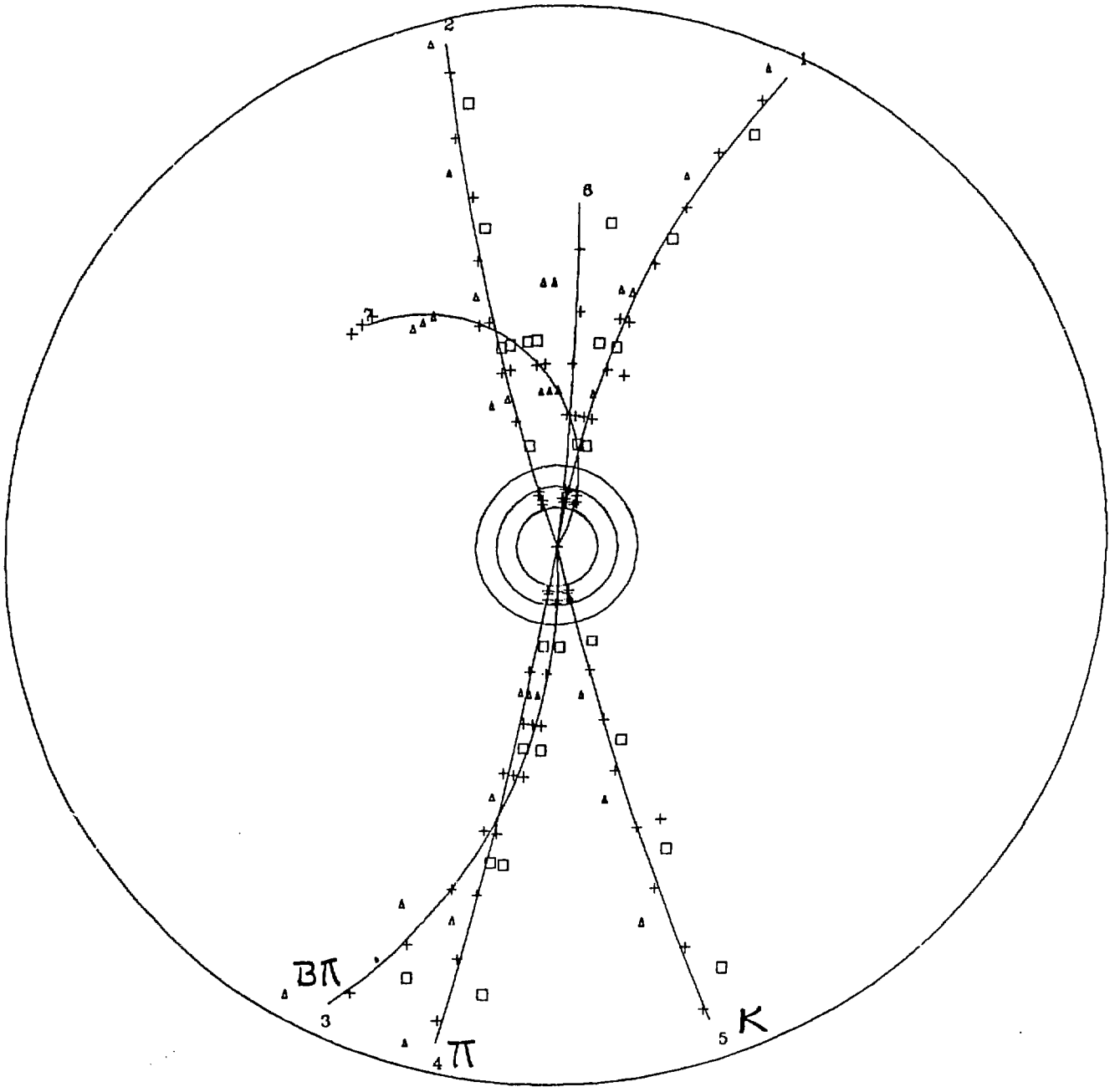
TRIG.= F2 F3 F4 S6 A2 B1 D2

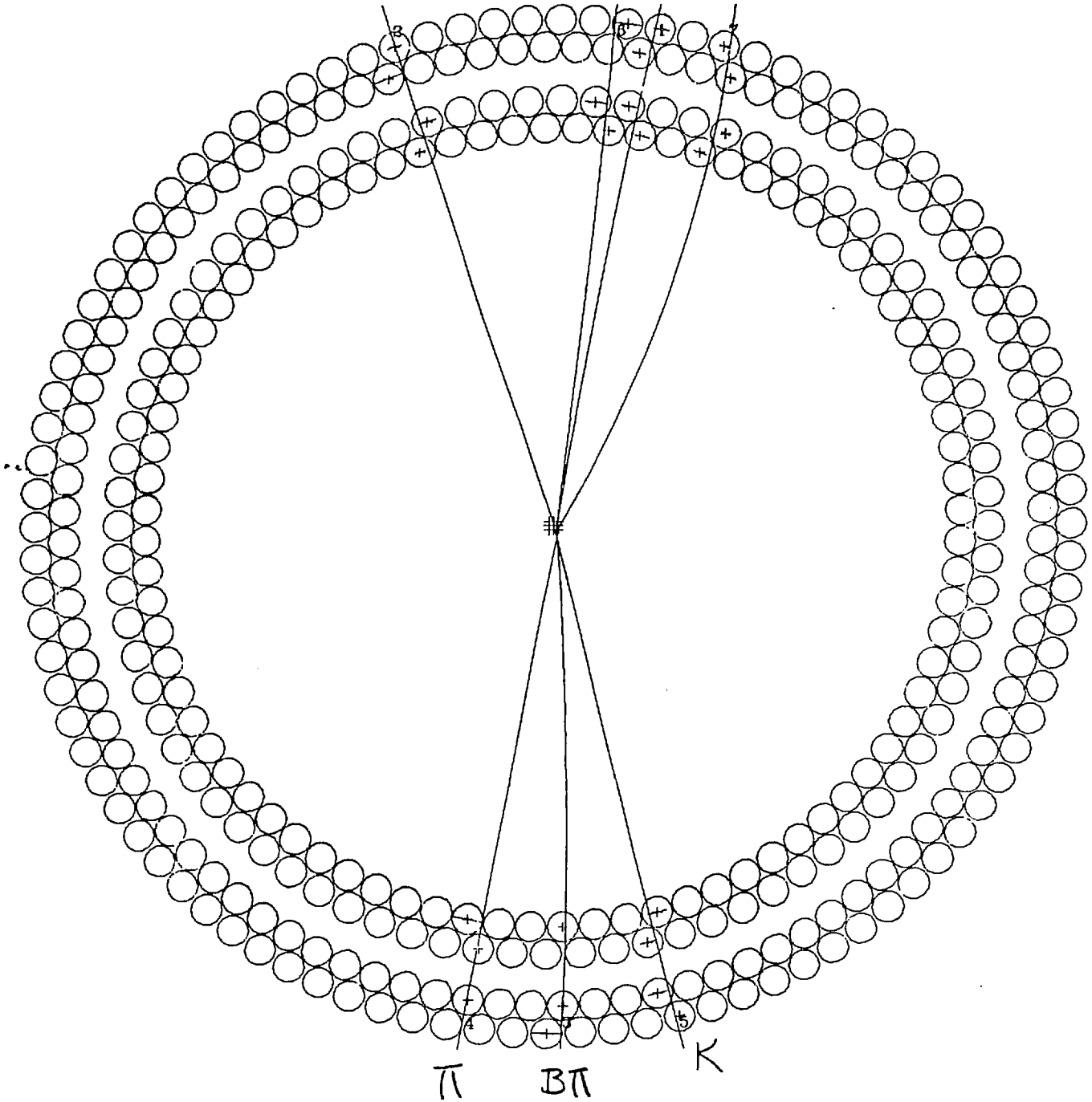


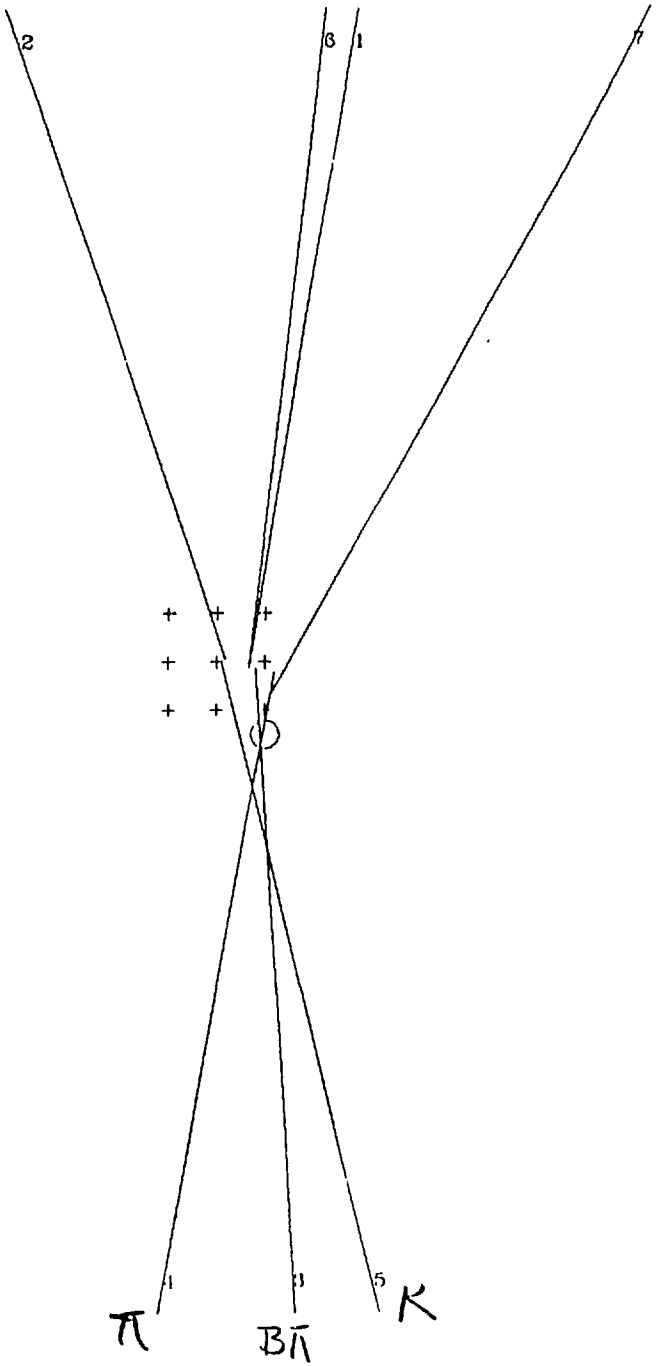
TRK		P	+/- DP	PHI	DIP	
1		0.969	0.003	81.5	−27.4	
2		2.679	0.015	109.3	−30.0	2
3	Bπ	0.725	0.003	274.4	47.8	1
4	π	5.734	0.063	260.2	42.3	1
5	K	−4.835	0.044	283.7	51.1	1
6		−5.236	0.115	83.4	−60.5	
7		−0.225	0.003	60.2	−48.2	

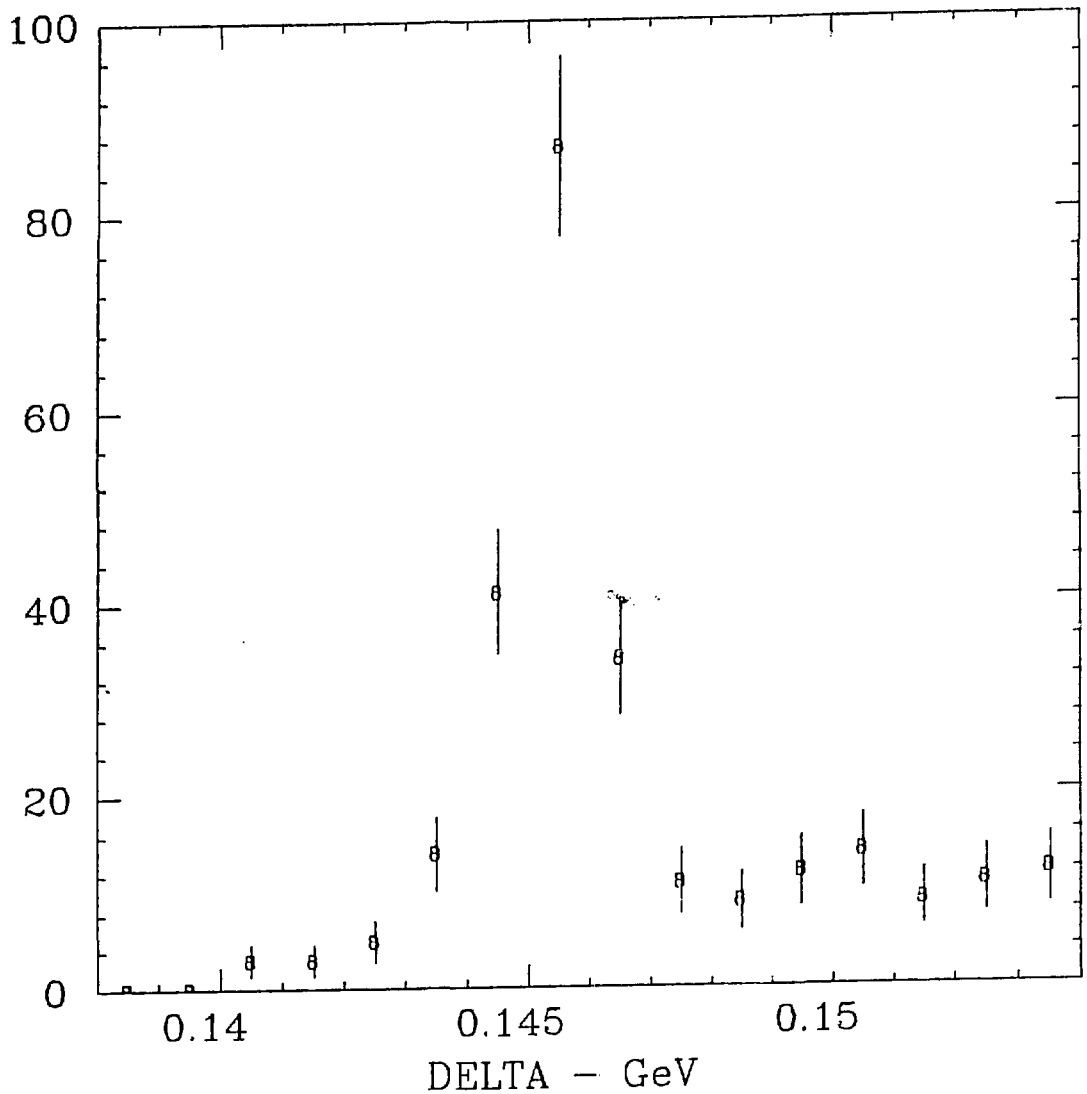
TOT CHARGED E 20.403

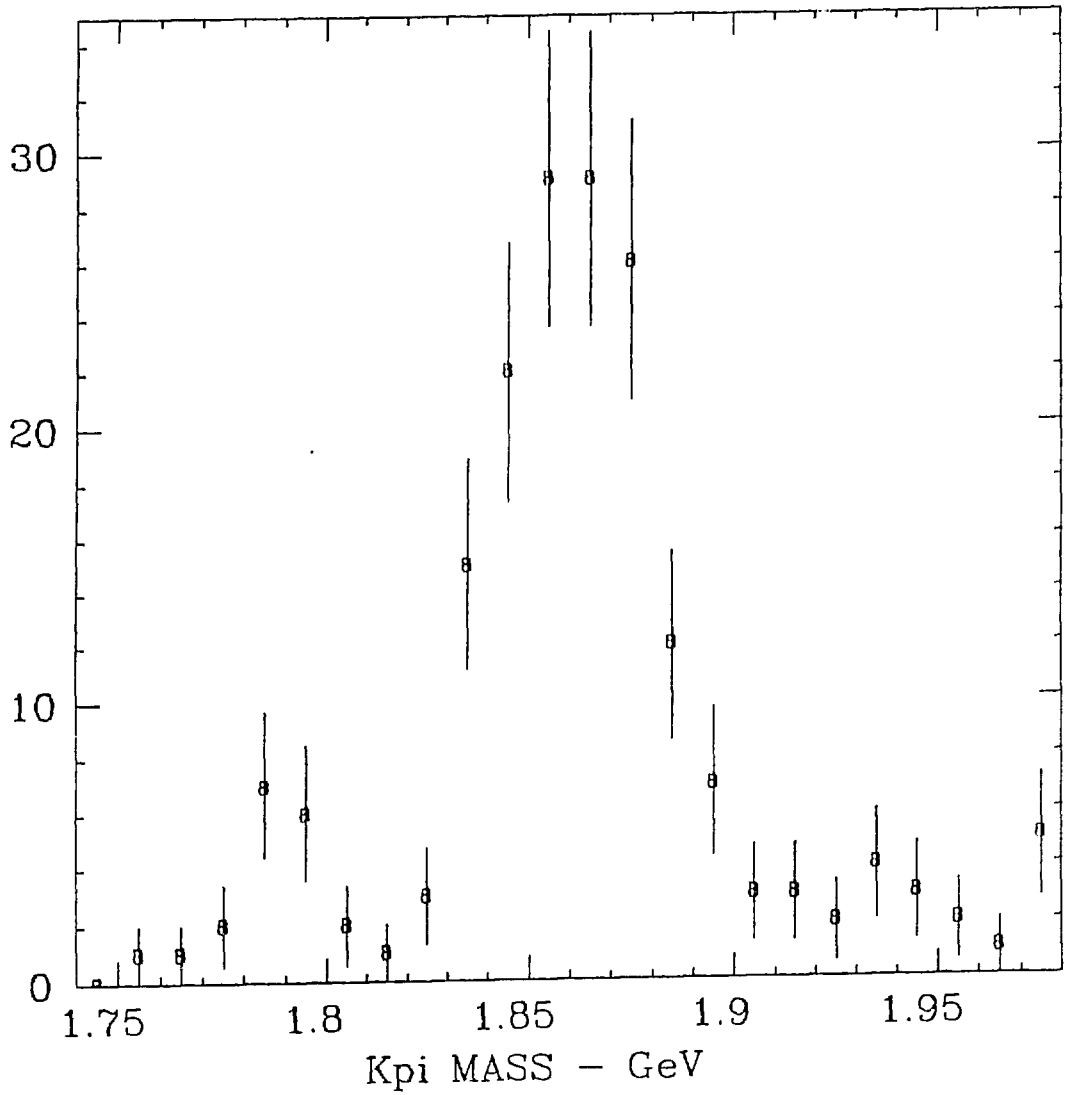
TOT NEUTRAL E 0.630

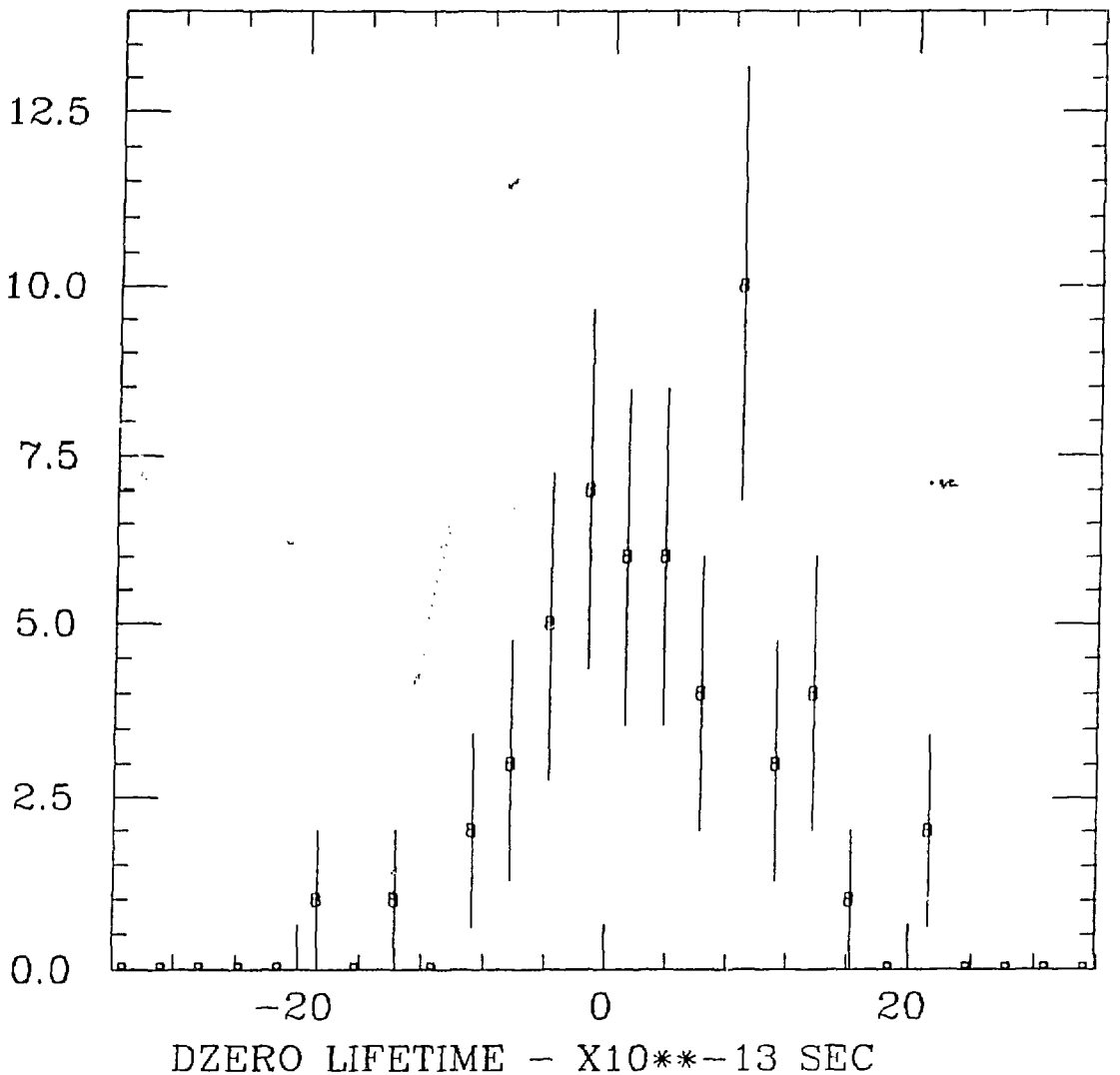

2
1
6
7
Bπ
3
4
π
5
K


3
6
7
1
2
4
5
П
ВП
К


2
6
1
7
1
3
5
π
Bπ
K


100
80
60
40
20
0
0.14
0.145
0.15
DELTA – GeV


30
20
10
0
1.75
1.8
1.85
1.9
1.95
Kpi MASS - GeV


12.5
10.0
7.5
5.0
2.5
0.0
-20
0
20
DZERO LIFETIME - X10**-13 SEC