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D^+, D^0 Signals and Lifetimes in E687 Photoproduction Experiment at Fermilab*

The E-687 Collaboration

presented by

L. Moroni
Dip. di Fisica dell'Universita' and INFN
Milano, Italy

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D^+, D° signals and lifetimes in E687 photoproduction experiment at Fermilab

P.L. Frabetti
Dip. di Fisica dell'Universita' and INFN - Bologna, I-40126 Bologna, Italy

C.W. Bogart, H. Cheung, P. Coteus, S. Culy, J.P. Cumalat, D. Kaplan
University of Colorado, Boulder, CO 80309, USA

J. Butler, F. Davenport, I. Gaines, P. Garbincius, S. Gourlay, D. Harding, P. Kasper, A. Kreymer, P. Lebrun, H. Mendez,
Fermilab, Batavia, IL 60510, USA

S. Bianco, M. Enorini, F.L. Fabbri, A. Spallone, A. Zallo
Laboratori Nazionali di Frascati, I-00044 Frascati, Italy

R. Culbertson, M. Diesburg, G. Jaross, K. Lingel, P. Sheldon, J.R. Wilson, J. Wiss
University of Illinois at Urbana-Champaign, Urbana, IL 61801, USA

G. Alimonti, G. Bellini, M. Di Corato, M. Giammarchi, P. Inzani, S. Malvezzi, P.F. Manfredi, D. Menasce, L. Moroni, D. Pedrini, L. Perasso, A. Sala, S. Sala, D. Torretta, M. Vittone
Dip. di Fisica dell'Universita' and INFN - Milano, I-20133 Milan, Italy

D. Buchholz, C. Castoldi, B. Gobbi, S. Park, R. Yoshida
Northwestern University, Evanston, IL 60208, USA

J.M. Bishop, J.K. Busenitz, N.M. Cason, J.D. Cunningham, R.W. Gardner, C.J. Kennedy, E.J. Mannel, R.J. Mountain, D.L. Puseljic, R.C. Ruchti, W.D. Shephard, M.E. Zanabria
University of Notre Dame, Notre Dame, IN 46556, USA

S.P. Ratti
Dip. di Fisica dell'Universita' and INFN - Pavia, I-27100 Pavia, Italy

A. Lopez
University of Puerto Rico at Mayaguez, Puerto Rico

Presented by L. Moroni for the FNAL E687 Collaboration

Vertex finding strategies for heavy flavour search in the E687 experiment are described. Preliminary D^+ and D^0 signals are presented as well as their lifetimes. Evidence of some Cabibbo suppressed modes is also given.

I. INTRODUCTION

The experiment E687, during the first run June 87 – February 88, collected $\sim 60 \times 10^6$ triggers on a $0.11 \times L_R$ Be target.

The preliminary reconstruction and analysis of these data is completed; large charm signals have been observed in a variety of channels including those with K_s^0, μ and e.

In this context the high performances of the microvertex detector played a crucial role.

II. THE VERTEX DETECTOR

The vertex detector(1) (Fig.1) consists of 12 Si microstrip planes on three views with a granularity ranging from 25 μm to 100 μm. The resolution of the system can be expressed by the predicted transversal error at the mean interaction point in the target

$$\sigma_{X,Y} \sim 9\ \mu m \quad \text{or equivalently} \quad \sigma_\tau \sim .03 \text{ psec}$$

for an infinite momentum track crossing the high resolution central regions of the 12 detectors.

III. VERTEXING

The charm selection has been essentially carried out by vertex reconstruction using two different approaches :

- a stand alone algorithm making use only of the geometrical track informations to reconstruct the whole vertex topology of the event;
- a candidate driven algorithm selecting a particular decay channel and using the candidate momentum as seed track to find the primary vertex.

The first algorithm selects events on the basis of a reconstructed evidence of secondary vertices, the latter simply tests an hypothesis. As a result, the efficiency of the first method will be definitively smaller, mainly at short lifetimes, but at the same time the signal will be very clean; on the other hand, the second approach has an efficiency which in principle does not depend on the proper time but a larger background at short lifetimes.

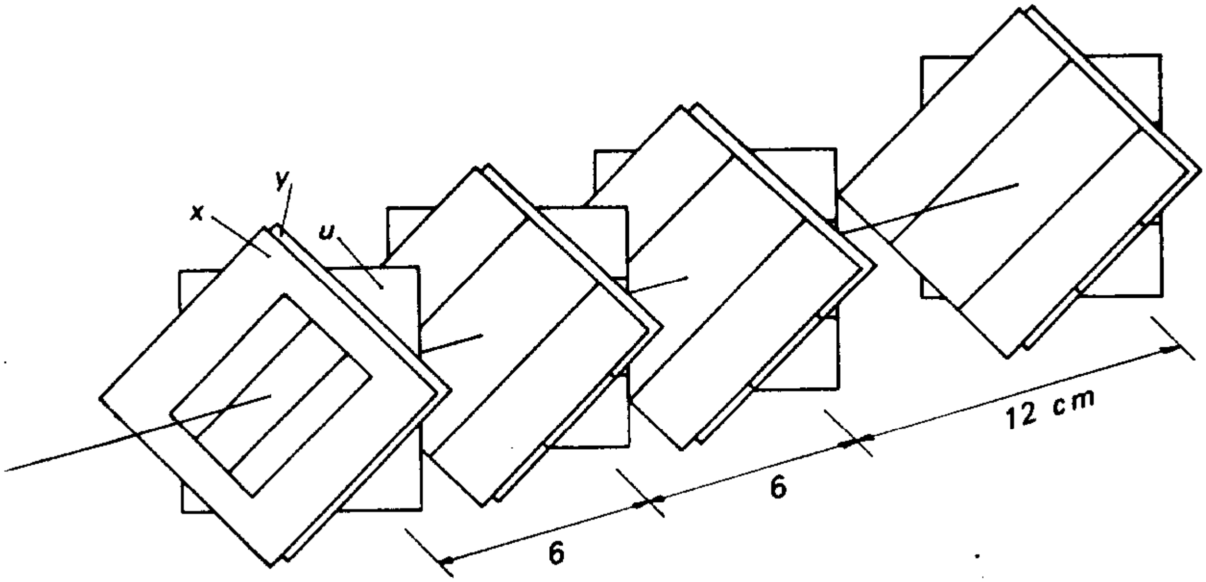

Fig.1
silicon microstrip detector layout

IV. D MESON SIGNALS

The E687 data sample was skimmed in accordance with the two previously described vertexing algorithms. The resulting D^+ signal in the channel $K^-\pi^+\pi^+$ is shown in Fig.2 as obtained by the stand alone vertexing method. The six plots of Fig.2 illustrate the effect of the different requirements applied to the original sample. In particular:

- a): D^+ mass combinations defined by a reconstructed vertex with 3 linked tracks and a net charge of $\pm$ 1 in events having at least one track not associated to the same vertex; K mass is attributed to the opposite sign track;
- b): candidates of the previous plot must be compatible with the Cerenkov identification;
- c): candidate vertices of plot 1 have to be secondaries, i.e. a primary vertex has been reconstructed in the target region;
- d): the requirements of plots 2 and 3 have to be satisfied simultaneously;
- e): D^+ candidates of plot 4 have to point back to the primary vertex within 60 μm;
- f): same selection of plot 5 but without any Cerenkov condition.

As shown by Fig.2.f in particular, the pure topological analysis is capable to evidence the D^+ signal.

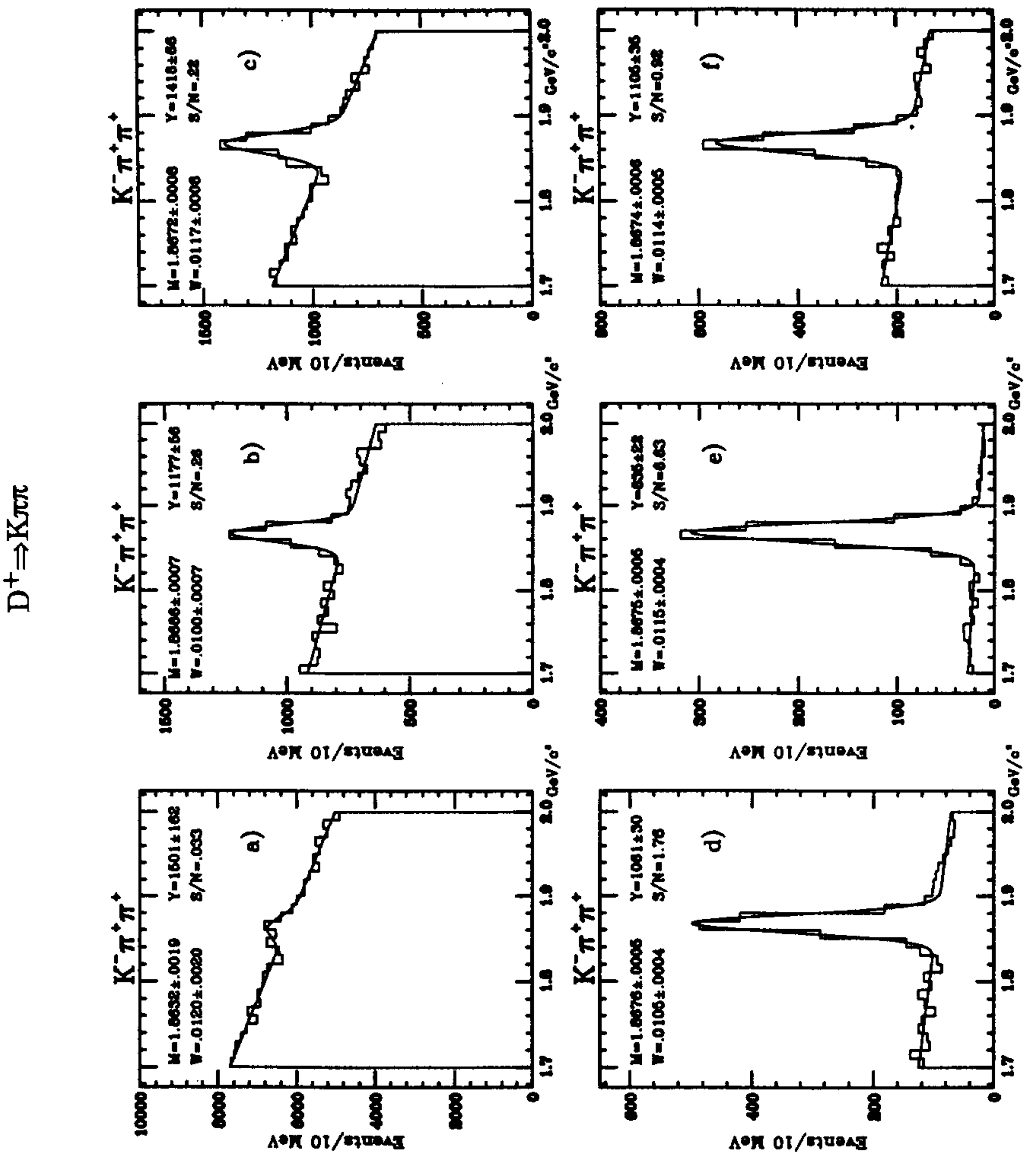

Fig.2

See page 3 for description of individual plots

$D^+ \Rightarrow K\pi\pi$ for various L/σ cuts

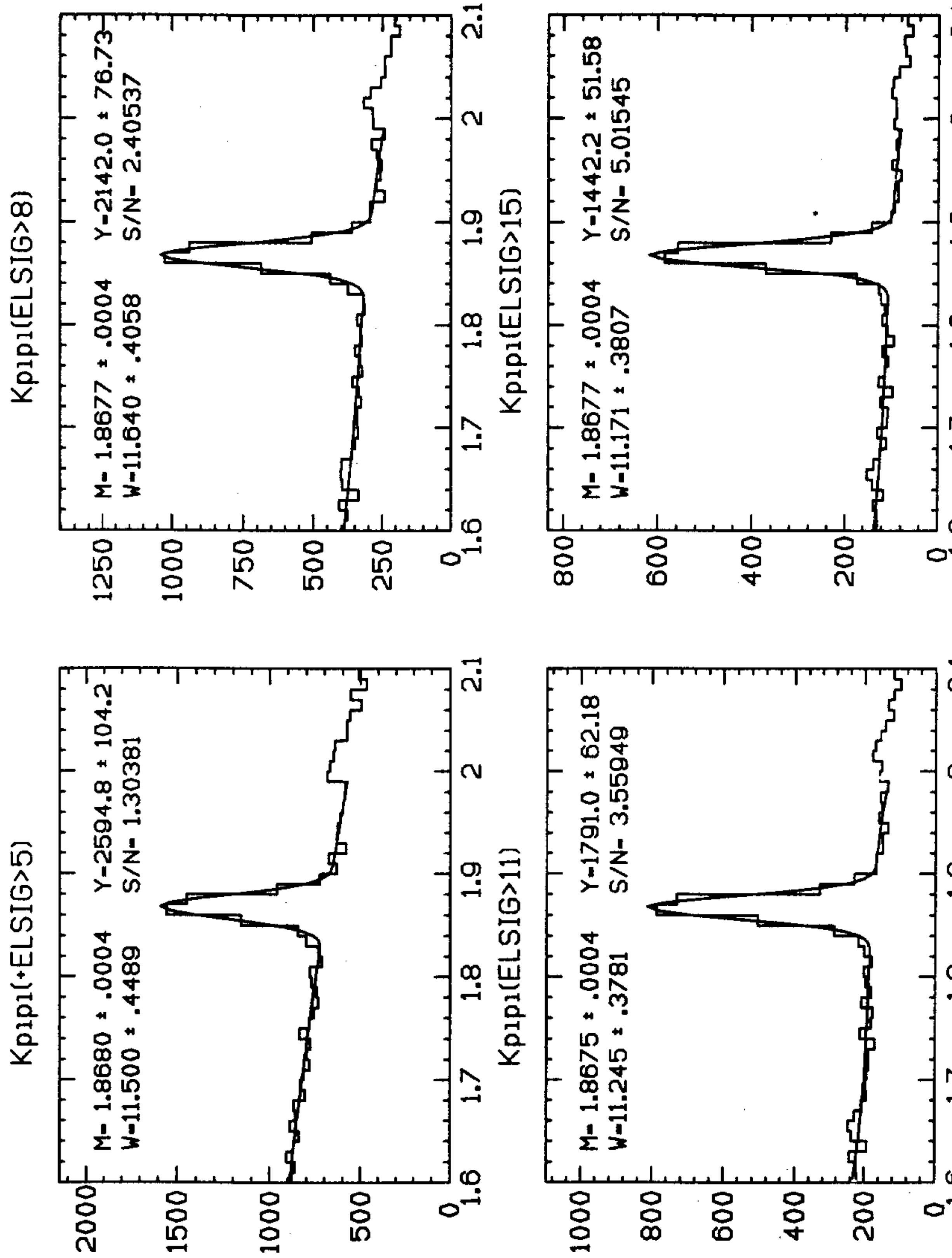

Fig.3

See page 9 for description of individual plots

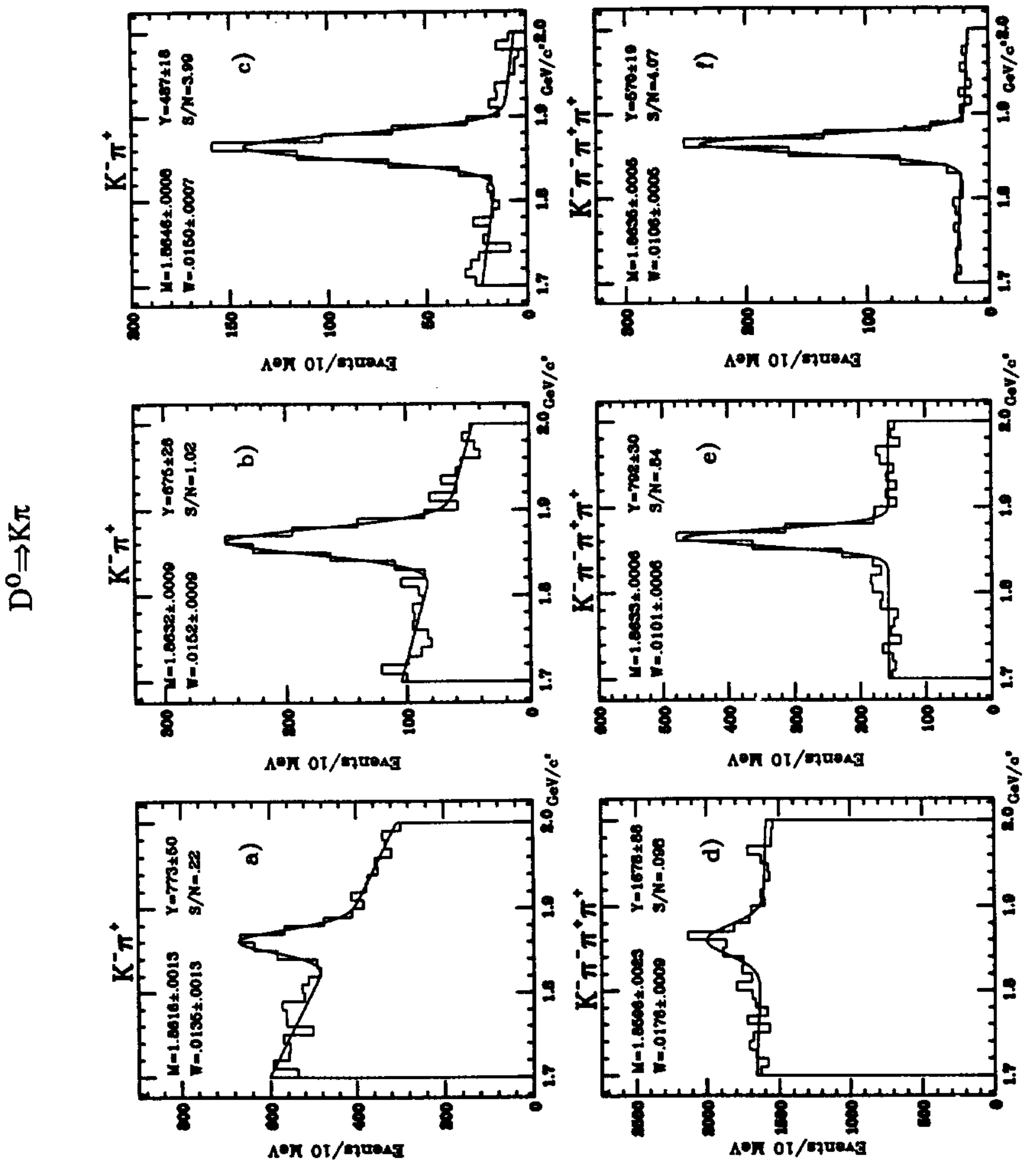

Fig.4

See page 9 for description of individual plots

$D^0 \Rightarrow K\pi$ for various L/σ cuts

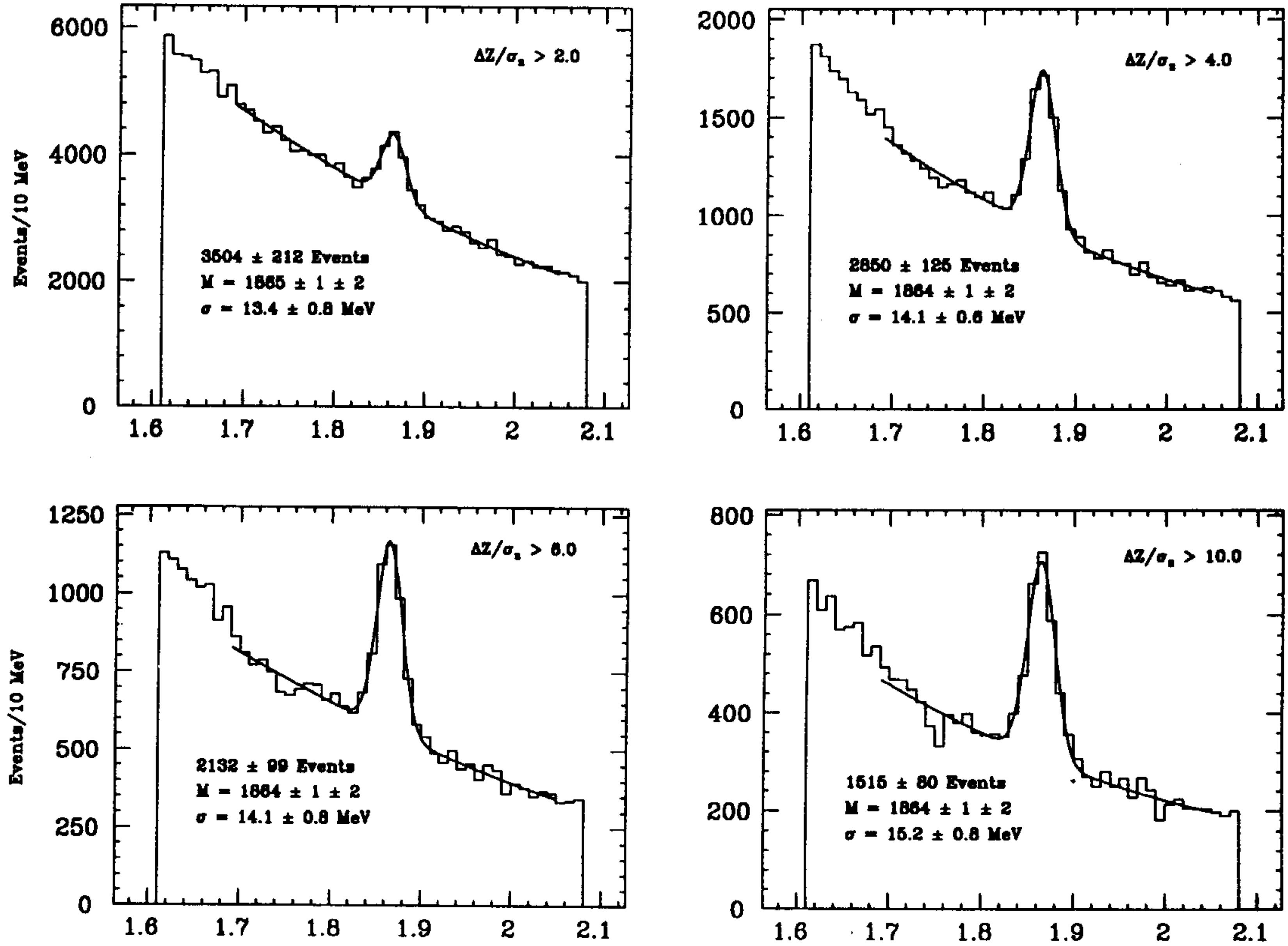

Fig.5

$D^0 \Rightarrow K\pi\pi\pi$ for various L/σ cuts

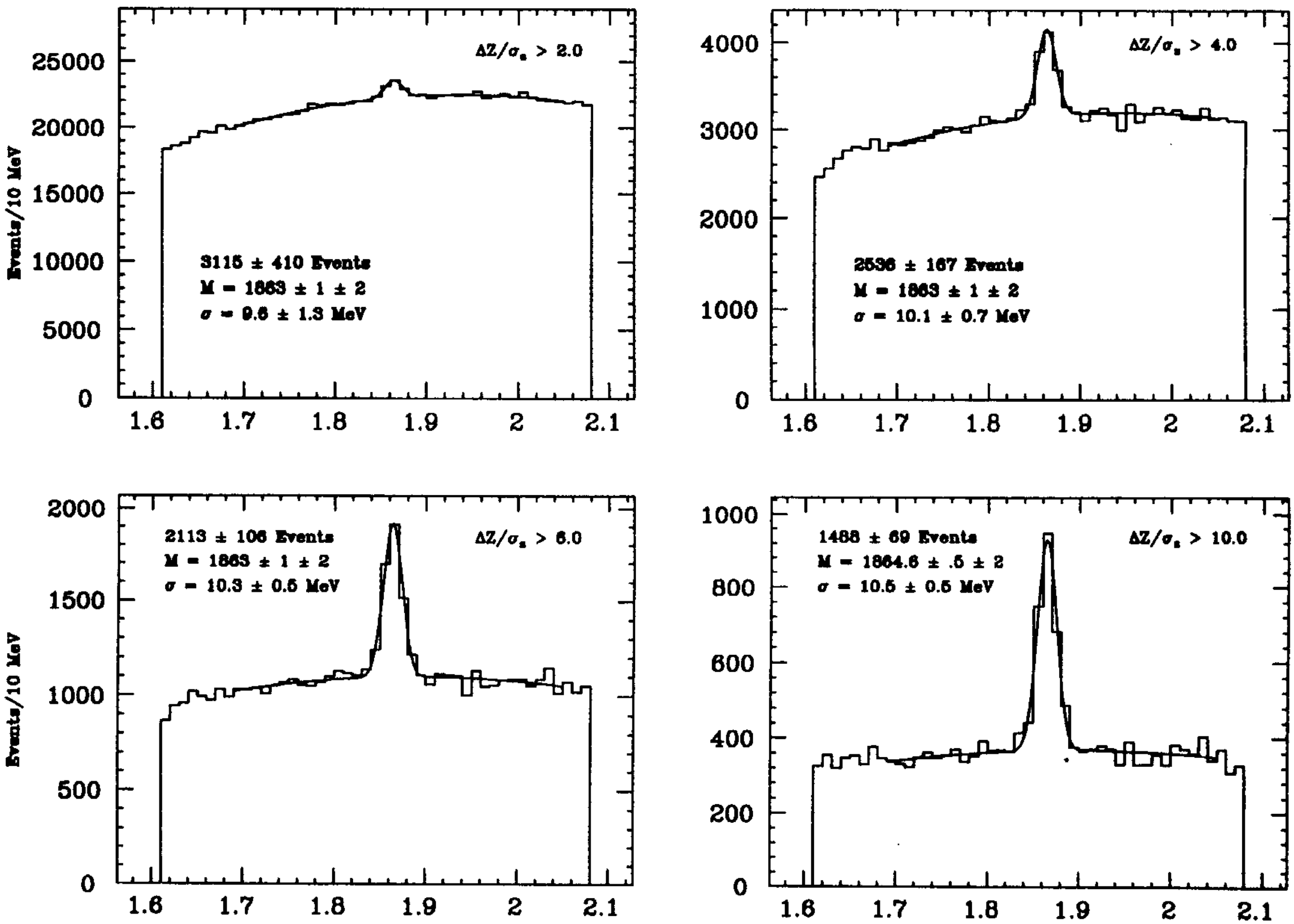

Fig.6

On the other hand, the corresponding D^+ signal, as obtained by the candidate driven algorithm, is shown in Fig.3. In this selection a detachment cut was applied: the distance, L , between the primary and the secondary vertices, must be 5, 8, 11 and 15 times larger than the error σ, on the distance itself.

Similar analysis has been carried out for D^0 signal. Fig.4 shows the results of the stand alone vertexing method for the two decays, $D^0 \to K^-\pi^+$ (first row) and $D^0 \to K^-\pi^+\pi^+\pi^-$ (second row). The sequence of histograms in each row is obtained applying the following requirements in cascade:

- a), d): a reconstructed vertex with the right number of linked tracks, having zero net charge and Cerenkov compatibility;
- b), e): the candidate vertices must be secondaries;
- c), f): the D^0 reconstructed momentum has to point back to the primary vertex.

The corresponding selections of D^0 signals, based on the candidate driven approach, are shown in Fig.5 and 6 for different cuts on L/σ.

A very preliminary study of the Cabibbo suppressed modes has been performed in the stand alone approach. Fig.7 gives evidence of the decay $D_s^+ \to K^-K^+\pi^+$ together with the Cabibbo suppressed D^+ decay; the D^0 decay into 4π is shown by Fig.8.

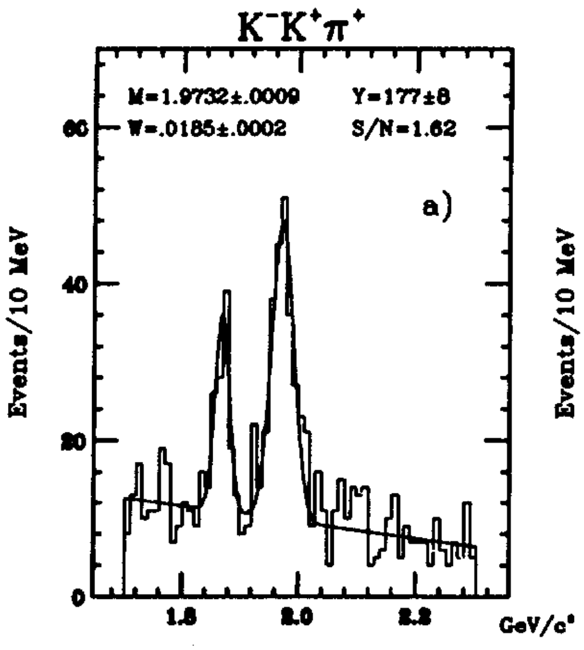

Fig.7

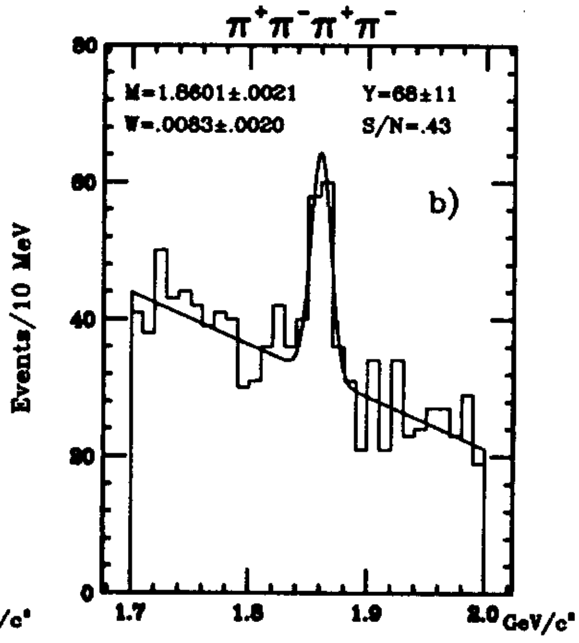

Fig.8

V. D^+, D^o LIFETIME ANALYSIS

D^+ and D^0 candidates, as obtained by the two different selections, have been employed to measure their lifetimes.

In the case of the stand alone method, the analysis was performed using the following Likelihood function

$$\mathcal{L} = \prod_{i=1}^{\#bins} \frac{(N_i)^{n_i}}{n_i!} e^{-N_i}$$

where n_i are the observed entries of the i^{th} bin of the proper time distribution and N_i the expected number. N_i was derived from the model

$$N(t) = N_0 \frac{f(t)e^{-t/\tau}}{\int_0^{t_{max}} f(t)e^{-t/\tau}dt} + N_{bkg}(t)$$

where t is the proper time, τ the lifetime, N_{bkg} the background time distribution and $f(t)$ the efficiency of the employed method; $f(t)$ was estimated by a suitable Montecarlo simulation and the background contribution from the sidebands of the corresponding mass peak.

Fig.9 shows the proper time distribution of the events in the mass peak of $D^+ \rightarrow K^-\pi^+\pi^+$ of Fig.2.e including the background: the crosses indicate the measured points, while the continous line represents the best fit to the data.

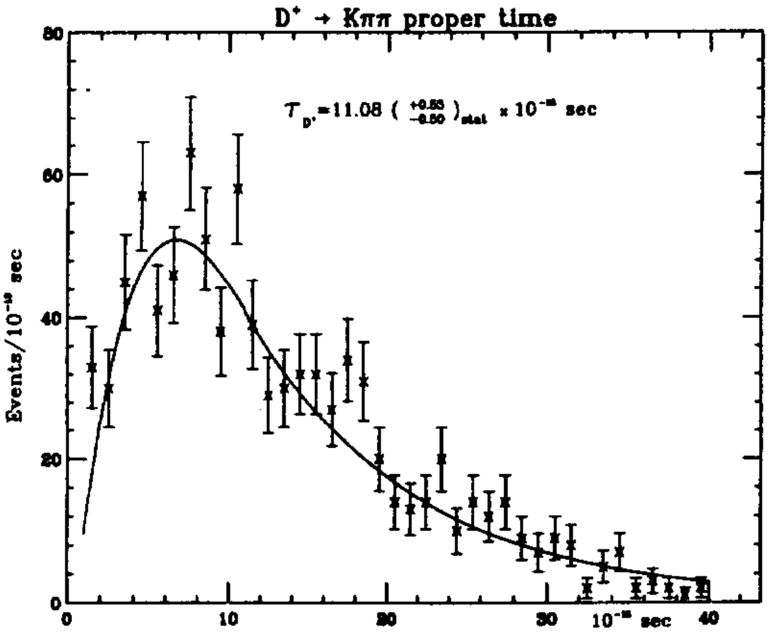

Fig.9

The fitted lifetime value turns out to be:

$$\tau_{D^+} = 1.108 \; + \; .053 \; - \; .050 \;\; (stat) \;\; psec$$

The same kind of analysis for $D^0 \to K^-\pi^+$ using the mass peak of Fig.4.c gives a lifetime estimate of

$$\tau_{D^0}(2body) = 0.456 \; + \; .022 \; - \; .020 \;\; (stat) \;\; psec$$

Fig.10 shows the measured values together with the best fitted model.

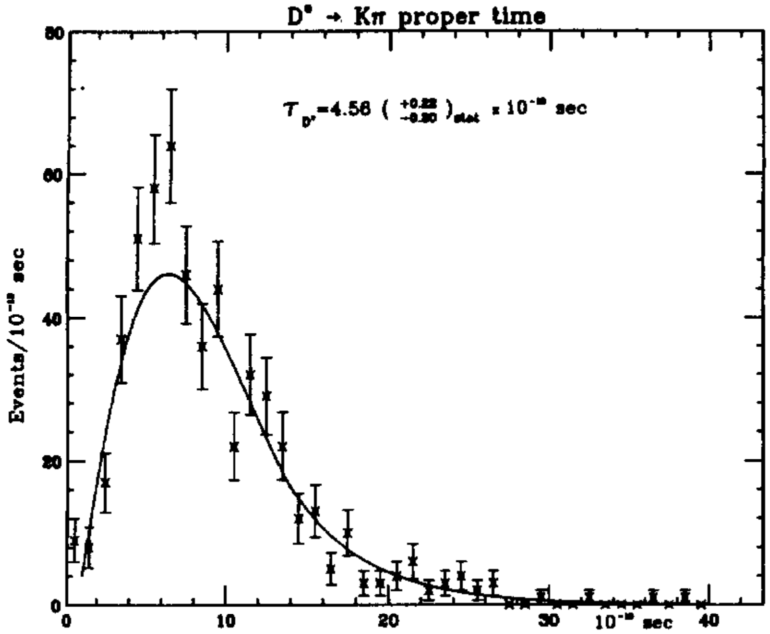

Fig.10

The lifetime measurement by this method strongly depends on the efficiency function $f(t)$ which has to be estimated from Montecarlo; as a consequence, the evaluation of the related systematic error becomes very difficult. For this reason, the systematic errors on the previous lifetimes are still under study as well as the D^0 lifetime in the channel $K^-\pi^+\pi^-\pi^+$.

On the other hand, the lifetime measurement in the candidate driven approach makes use of the approximate independence of the efficiency function from the proper time, requiring the background estimate only. In this approach, the lifetime analysis has been performed using the reduced variable $t' = t - t_{min}$, where t_{min} is the proper time corresponding to a suitable detachment value, $L = n\sigma_L$.

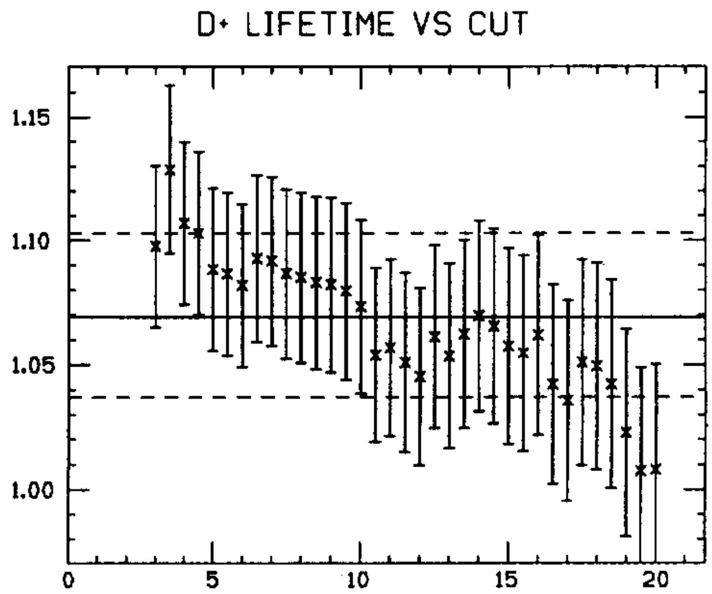

Fig.11

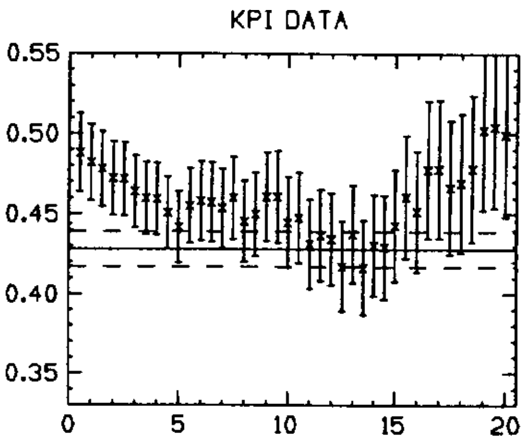

Fig.12

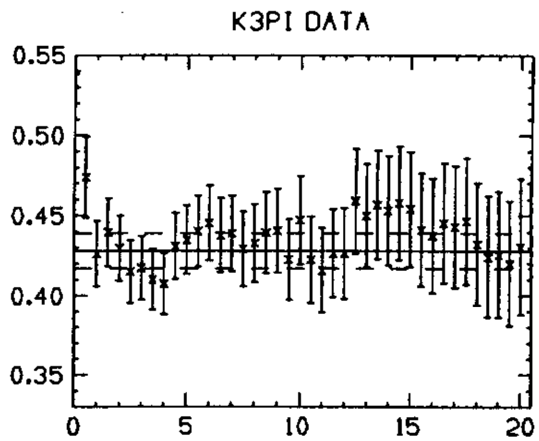

Fig.13

The measured lifetimes (in *psec*) at different L/σ cuts are shown in Fig.11 for $D^+ \rightarrow K^-\pi^+\pi^+$ and in Fig.12 and 13 for $D^0 \rightarrow K^-\pi^+$ and $D^0 \rightarrow K^-\pi^+\pi^-\pi^+$ respectively; the horizontal lines in the figures indicate the world average lifetimes. The quoted values are corrected for the background only, as estimated from the side bands of the corresponding mass peak. Taking into account the small corrections due to absorption in the target and acceptance, which has been evaluated by Montecarlo, the lifetime values turn out to be:

$$\tau_{D^+} = 1.061 \pm .039 \ (stat) \pm .014 \ (syst) \ psec$$

and

$$\tau_{D^0}(2\,\&\,4body) = .432 \pm .016 \ (stat) \pm .02 \ (syst) \ psec$$

All the quoted lifetime results have to be considered preliminary.

VI. CONCLUSIONS

We found a good agreement between our preliminary results and the other experiments.

The topological approach to the charm selection, based on the stand alone vertex algorithm here described, seems to be very promising mainly for its rejection of the background. The candidate driven approach, on the other hand, results in higher signal yields and appears to have an efficiency not depending on the proper time.

We think we possess two complementary methods, which, depending on their different characteristics and performances, can be successfully employed to study heavy flavour decays.

References

1) G. Bellini et al., *The microstrip vertex detector for the E687 experiment at Tevatron, Nucl. Instr. & Meth. A252, 366 (1986)*