EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN/EP 85-179
4 November 1985

EVIDENCE FOR STRUCTURE IN THE 1.7 GeV MASS REGION OF THE K^+K^- FINAL STATE CENTRALLY PRODUCED IN THE REACTIONS $\pi^+p \rightarrow \pi^+(K^+K^-)p$ AND $pp \rightarrow p(K^+K^-)p$ AT 85 GeV/c

Athens[1]-Bari[2]-Birmingham[3]-CERN[4] Collaboration

T.A. Armstrong[4(*)], I.J. Bloodworth[3], J.N. Carney[3], B.R. French[4], B. Ghidini[2], J.B. Kinson[3], V. Lenti[2], A. Palano[2], R. Parrié[(**)], I.C. Print[3], G. Vassiliadis[1], O. Villalobos Baillie[3], M.F. Votruba[3], G. Zito[2] and R. Zitoun[(**)]

1 Athens University, Nuclear Physics Department, Athens, Greece
2 Dipartimento di Fisica dell'Università and Sezione INFN, Bari, Italy
3 University of Birmingham, Physics Department, Birmingham, UK
4 CERN, European Organization for Nuclear Research, Geneva, Switzerland

ABSTRACT

The reactions $\pi^+p \rightarrow \pi^+(K^+K^-)p$ and $pp \rightarrow p(K^+K^-)p$ where the K^+K^- system is centrally produced have been studied at 85 GeV/c. The K^+K^- spectrum contains several structures in the regions of S^*/ϕ, f/A_2 and f'. Structure is observed in the 1.7 GeV mass region which cannot be attributed to the g meson. The most likely interpretation of the data is that we observe the θ with a mass of 1.742 GeV and a new resonance at a mass of 1.629 ± 0.010 with a width of 0.082 ± 0.030 GeV.

Submitted to Physics Letters B

(*) Now at Pennsylvania State University
(**) LPNHE, Universités de Paris VI et VII, Paris, France

EP/2725P/AP/sb

In the past few years interest has increased in the field of light meson spectroscopy due to the QCD predictions that objects coupled to glue should exist somewhere in the low mass region between 1 and 2 GeV.

In the region 1.5 - 2.0 GeV two such states have been suggested recently as candidates for gluonium, the G(1590) decaying to $\eta\eta$ and $\eta\eta'$ [1] and the θ decaying to $\eta\eta$ [2], K^+K^- and $\pi^+\pi^-$ [3].

This paper describes part of a search for new states in the centrally produced exclusive final states in the reactions

$$\pi^+p \rightarrow \pi^+_f(X^o)p_s \text{ and } pp \rightarrow p_f(X^o)p_s$$

at 85 GeV/c (the subscripts f and s denote the fastest and slowest particle in the laboratory system).

The data come from the WA76 Experiment which has been performed using the CERN Omega Spectrometer. Details of the layout of the apparatus, trigger conditions and data processing have been given in a previous publication [4].

The reactions

$$\pi^+p \rightarrow \pi^+_f(K^+K^-)p_s \qquad (1)$$

and

$$pp \rightarrow p_f(K^+K^-)p_s \qquad (2)$$

have been isolated from the sample of events having four outgoing tracks. Fig. 1(a) shows the total missing P_t where a clear signal is evident from candidate "4C" events. Fig. 1(b) shows the resulting missing p_x distribution after requiring $|\text{missing } P_y| < 0.12$ GeV and $|\text{missing } P_z| < 0.10$ GeV. A momentum balanced sample (266 500 events) has been obtained by requiring, in addition, $|\text{missing } P_x| < 4.00$ GeV.

In order to select reactions (1) and (2) from the stronger channel with two pions in the final state we have requested that one of the two central particles be identified by the Cherenkov information as a K or ambiguous K/p. The remaining track was required, if reaching the Cherenkov system, to have a mass identification compatible with being a kaon.

Following the method of Ehrlich et al. [5], fig. 1(c) shows the mass squared of the two central particles (assumed to be equal). The strong peak centred on the squared mass of the K is the signal of reactions (1) and (2) while the smaller signal with a maximum on the pion mass is the residual of the $\pi\pi$ channel which has been left by an ~ 1% inefficiency of the Cherenkov identification. Part of the above contamination comes also from the $(K^{\pm}\pi^{\mp}K^{o})$ channel where the unseen K^{o} has a low momentum and falls inside our momentum balance cuts. The peak centred at the squared proton mass is the signal of the reactions with $p\bar{p}$ in the final state.

Reactions (1) and (2) were selected by requiring

$$0.18 < m^2(X) < 0.4\ \mathrm{GeV}^2$$

which gives 9330 events (36% from the π^+ beam and 64% from the proton beam). The $\pi\pi$ and πK contamination falling inside this cut has been estimated to be less than 7%.

We have studied the mass combinations which include the fast leading particle and the slow proton. The $\pi^+_f K^-$ mass combination shows a clear signal of $K^*(1430)$ which has been cut out from the data by requiring $m(\pi^+_f K^-) > 1.60$ GeV. The other mass spectra do not show any significant signals. The final sample consisted of 8590 events; the Feynman-x distributions for the slow particle, the K^+K^- system and the fast particle are shown in fig. 2(a) where it can be seen that the K^+K^- system is concentrated around $x_F \sim 0$.

The resulting K^+K^- mass spectrum is shown in fig. 2(b) along with the estimated contamination (dashed histogram) computed by using events in the $(\pi\pi)/(\pi K)$ peak of fig. 1(c) properly normalized.

The geometrical acceptance has been computed by using real events. Each event has been rotated isotropically around the beam direction, translated along the hydrogen target and the K^+ has been exchanged with the K^-. The two kaons were traced through the apparatus and the trigger conditions were applied. The resulting acceptance is smooth and slowly decreasing with increasing K^+K^- mass and does not generate holes or bumps in the mass spectrum or in the decay angular distributions.

The K^+K^- spectrum shows, in addition to signals in ϕ/S^*, A_2/f and f' regions, evidence of further structure above the f'.

In order to check if this structure can be attributed to the g meson we have fitted the K^+K^- spectrum in the mass region between 1.43 and 2.45 GeV by assuming f' and g mesons with Particle Data Group [6] fixed mass and width values and a background of the form $\exp(-am - bm^2)$. The resulting fit gives a $\chi^2/NDF = 77/65$. If the structure above the f' in the K^+K^- channel (fig. 3(a)) were due to the g meson we would expect to see a large signal in the $\pi^+\pi^-$ mass spectrum. The dashed curve in fig. 3(b) shows the expected g meson contribution to the $\pi^+\pi^-$ channel which is incompatible with the observed $\pi^+\pi^-$ spectrum. We conclude that the structure is not due to the g meson.

We have then fitted the full structure above the f' by using a single Breit-Wigner. The fit gives the following values for mass and width:

$$m = 1.700 \pm 0.010 \qquad \Gamma = 0.272 \pm 0.030 \text{ GeV}$$

with a $\chi^2/NDF = 74/63$.

A fit using two simple Breit-Wigners gives the following values for masses and widths (full line of fig. 3(a)):

$$m_1 = 1.629 \pm 0.010 \qquad \Gamma_1 = 0.082 \pm 0.030 \text{ GeV}$$

$$m_2 = 1.742 \pm 0.010 \qquad \Gamma_2 = 0.127 \pm 0.030 \text{ GeV}$$

with a $\chi^2/NDF = 56/60$.

The unnormalized Y_l^m moments have been evaluated in a frame where the z axis is along the $(\bar{p}_{beam} - \bar{p}_{fast})$ line, the y axis along $\bar{p}_{beam} \times \bar{p}_{fast}$, both in the K^+K^- decay system. Each event has been weighted by the geometrical acceptance and the two reactions have been summed together. The m = 0 moments are shown in fig. 4. The Y_2^0 moment shows activity over the entire mass range, in contrast with the Y_6^0 moment which is consistent with zero, as expected if the spin of the K^+K^- system is ≤ 2.

In conclusion, the analysis of the K^+K^- system centrally produced in reactions (1) and (2) at 85 GeV/c shows evidence for at least one resonance above the f' which cannot be attributed to the g meson. The most likely interpretation of the data is that we observe the θ with a mass of 1.742 GeV and a new resonance at a mass of 1.629 ± 0.010 GeV with a width of 0.082 ± 0.030 GeV.

REFERENCES

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FIGURE CAPTIONS

Fig. 1 (a) Missing transverse momentum distribution for events with four outgoing tracks;

(b) Missing longitudinal momentum after P_t cut;

(c) Ehrlich mass distribution for events which are candidates for reactions (1) and (2) after having used the Cherenkov information.

Fig. 2 (a) Feynman-x distributions for the fast and slow particles and the central KK system;

(b) (K^+K^-) effective mass. The dashed histogram shows the estimated contamination coming form the $(\pi\pi)/(\pi K)$ channels.

Fig. 3 (a) Fit of the (K^+K^-) spectrum by using (full line) two non-interfering Breit-Wigners and (dashed line) a single Breit-Wigner to describe the structure above the f';

(b) Plot of the $(\pi^+\pi^-)$ mass spectrum and expected signal for a g meson.

Fig. 4 Unnormalized m = 0 Y_1^m moments. The small insert shows an expanded view of the Y_2^o moment in the ϕ region.

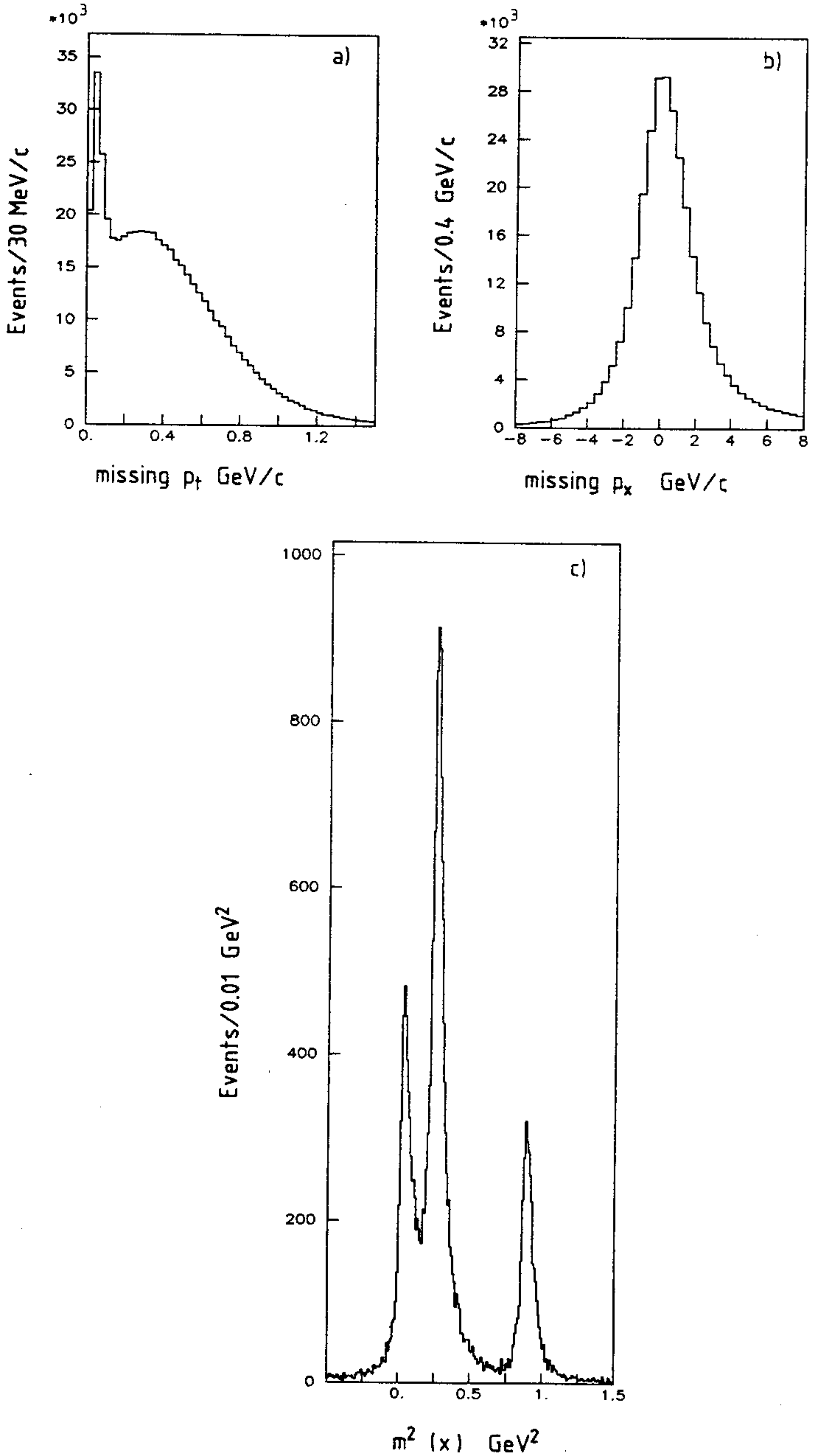
*10^3
35
30
25
20
15
10
5
0
Events/30 MeV/c
a)
0.
0.4
0.8
1.2
missing p_t GeV/c
*10^3
32
28
24
20
16
12
8
4
0
Events/0.4 GeV/c
b)
-8
-6
-4
-2
0
2
4
6
8
missing p_x GeV/c
1000
800
600
400
200
0
Events/0.01 GeV^2
c)
0.
0.5
1.
1.5
m^2 (x) GeV^2

Fig. 1

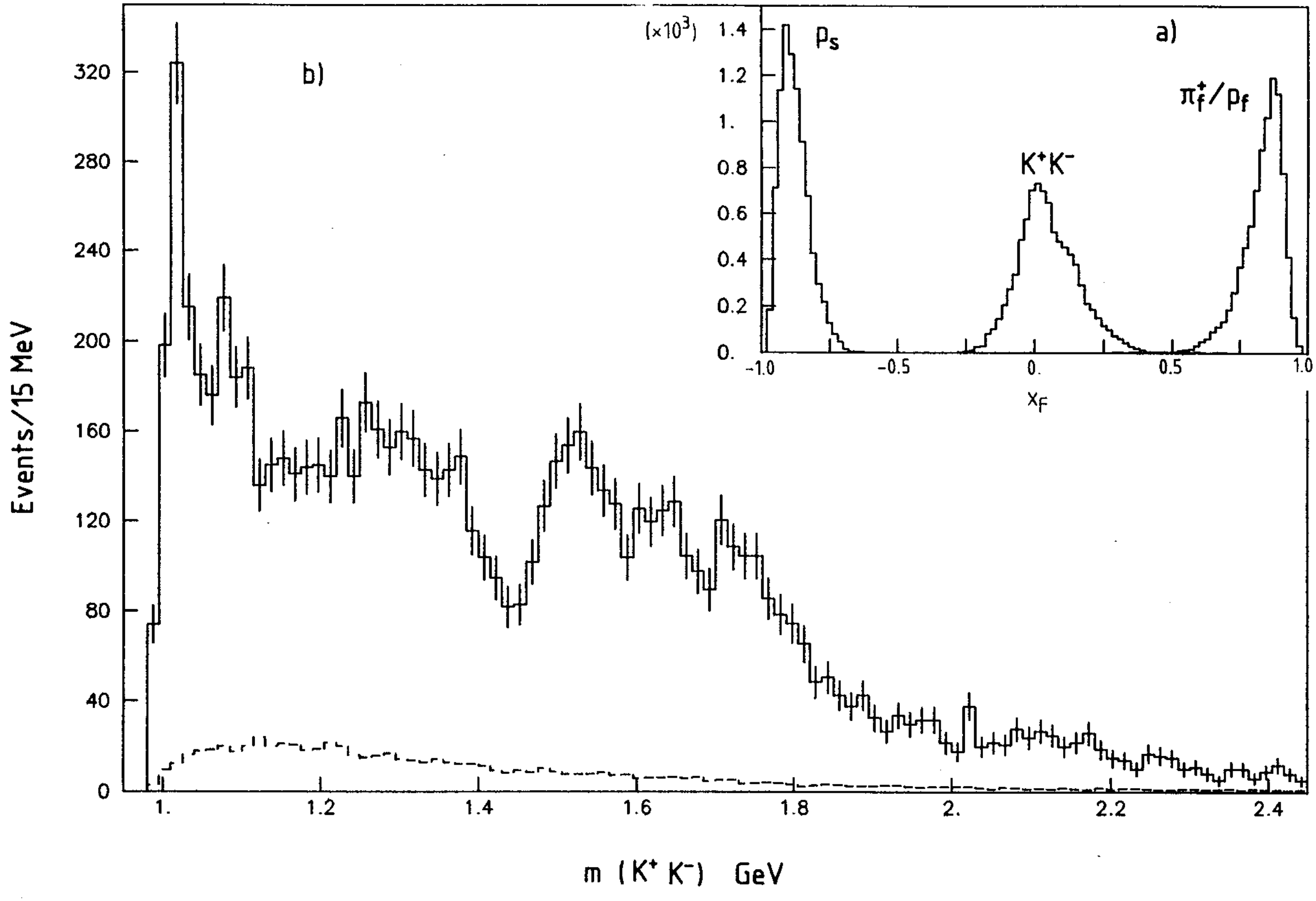

Fig. 2

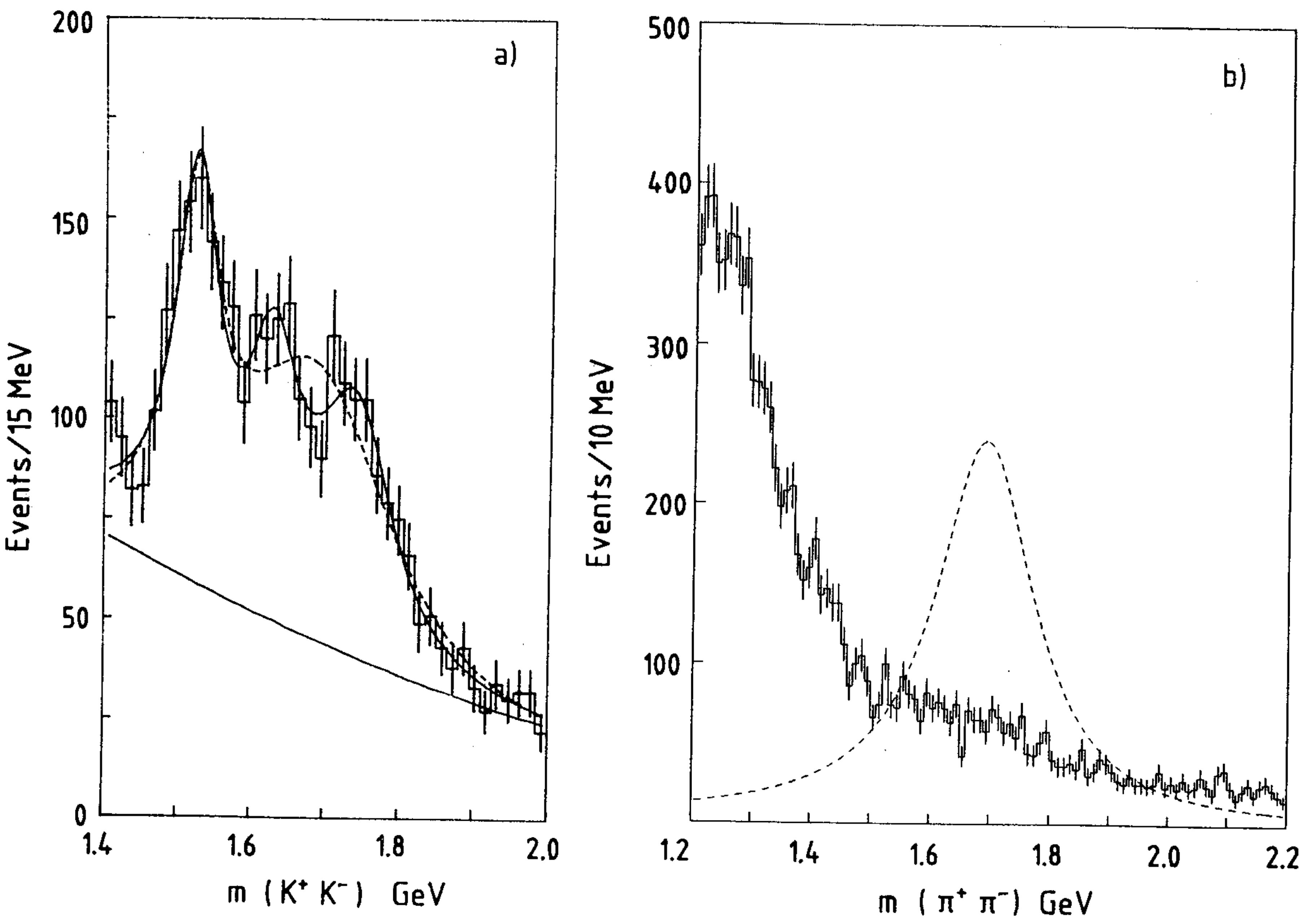
a)
Events/15 MeV
200
150
100
50
0
1.4
1.6
1.8
2.0
m (K+ K-) GeV
b)
Events/10 MeV
500
400
300
200
100
1.2
1.4
1.6
1.8
2.0
2.2
m (π+ π-) GeV

Fig. 3

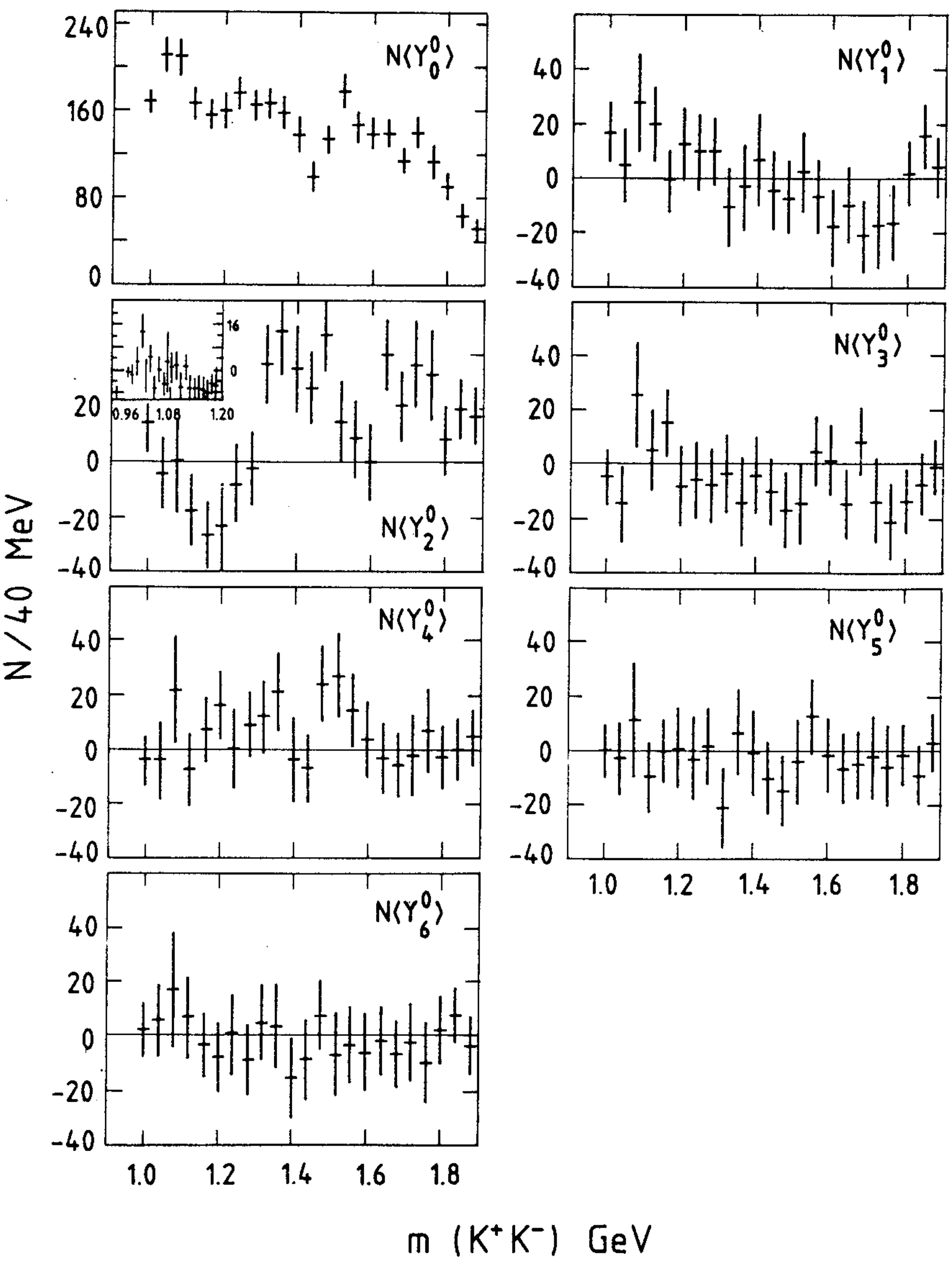

Fig. 4