Evidence for a narrow dip structure at 1.9 GeV/c^2 in $3\pi^+ 3\pi^-$ diffractive photoproduction

E687 collaboration

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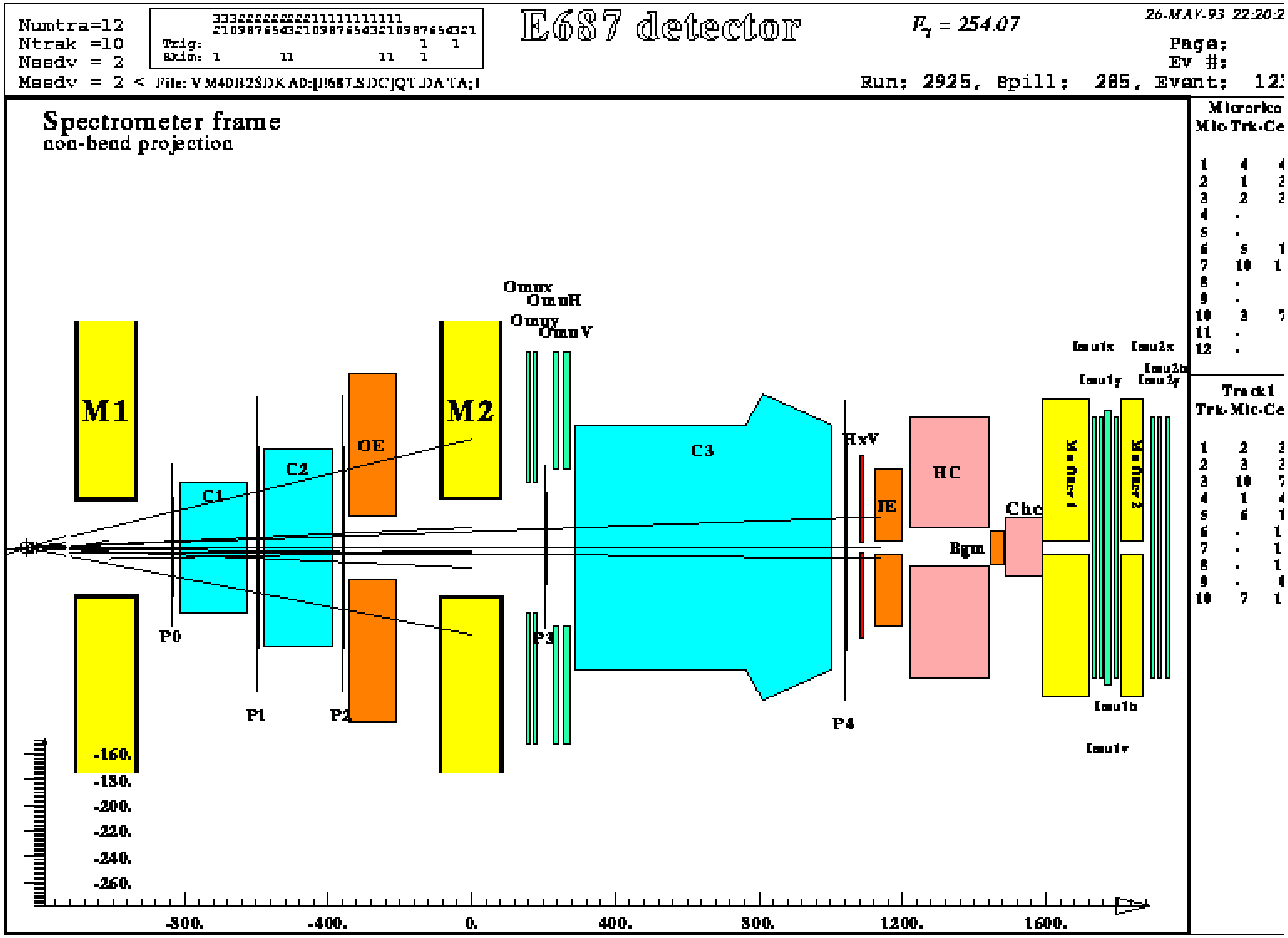
- The E687 Experiment.
- Selection of diffractive events.
- Fitting the data in the 1.6 ÷2.2 GeV/c^2mass range.
- Other possible structures.
- Conclusions.

The E687 experiment

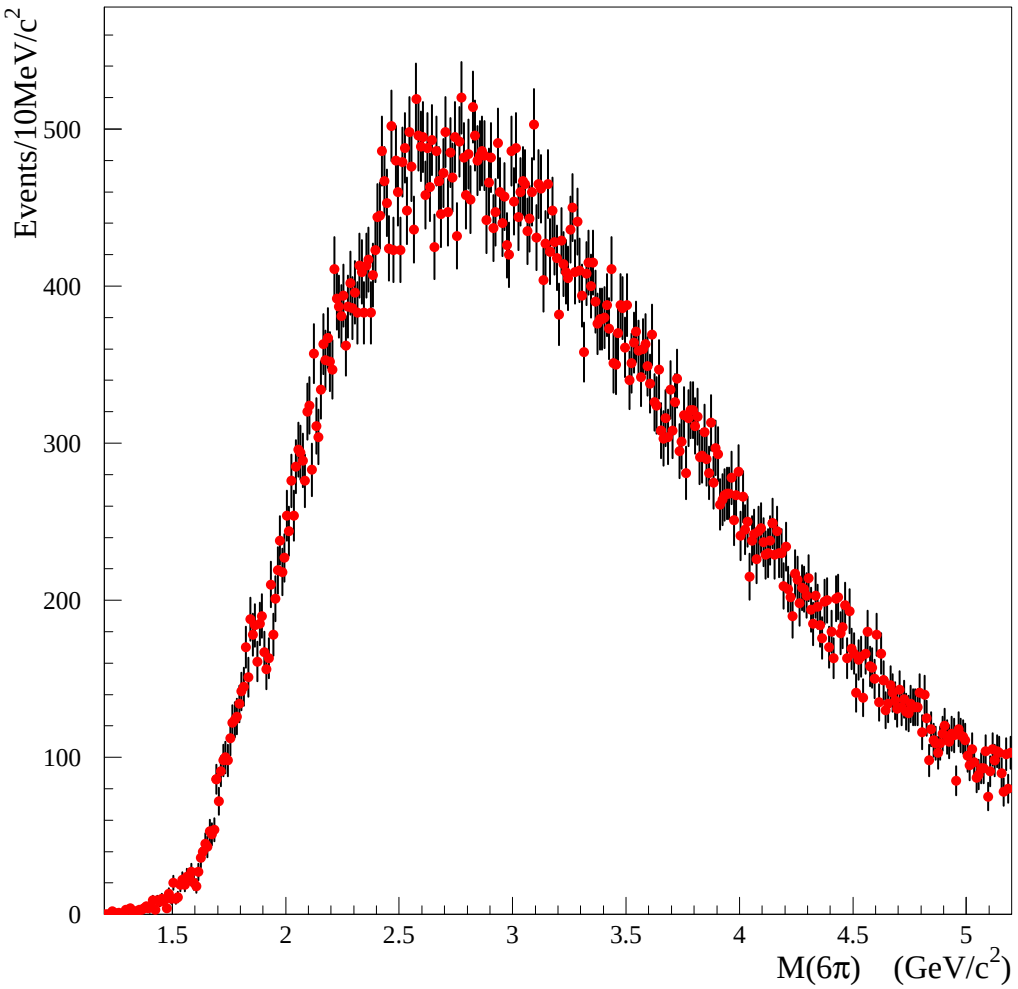
- The E687 collaboration has collected a large sample of high energy photoproduction events, recorded with the E687 spectrometer during the 1990/91 fixed runs at the wide band photon beam at Fermilab.
- E687 is a large acceptance multiparticle magnetic spectrometer optimized to study photoproduced charmed mesons.
- Pions are produced from the photon interaction in a 4 cm long Beryllium target.
- E687 is equipped with a very powerful vertex detector, electromagnetic and hadronic calorimeters, Cerenkov and muon detectors.
- A very large sample of events concerning vector meson diffractive photoproduction has become available too.



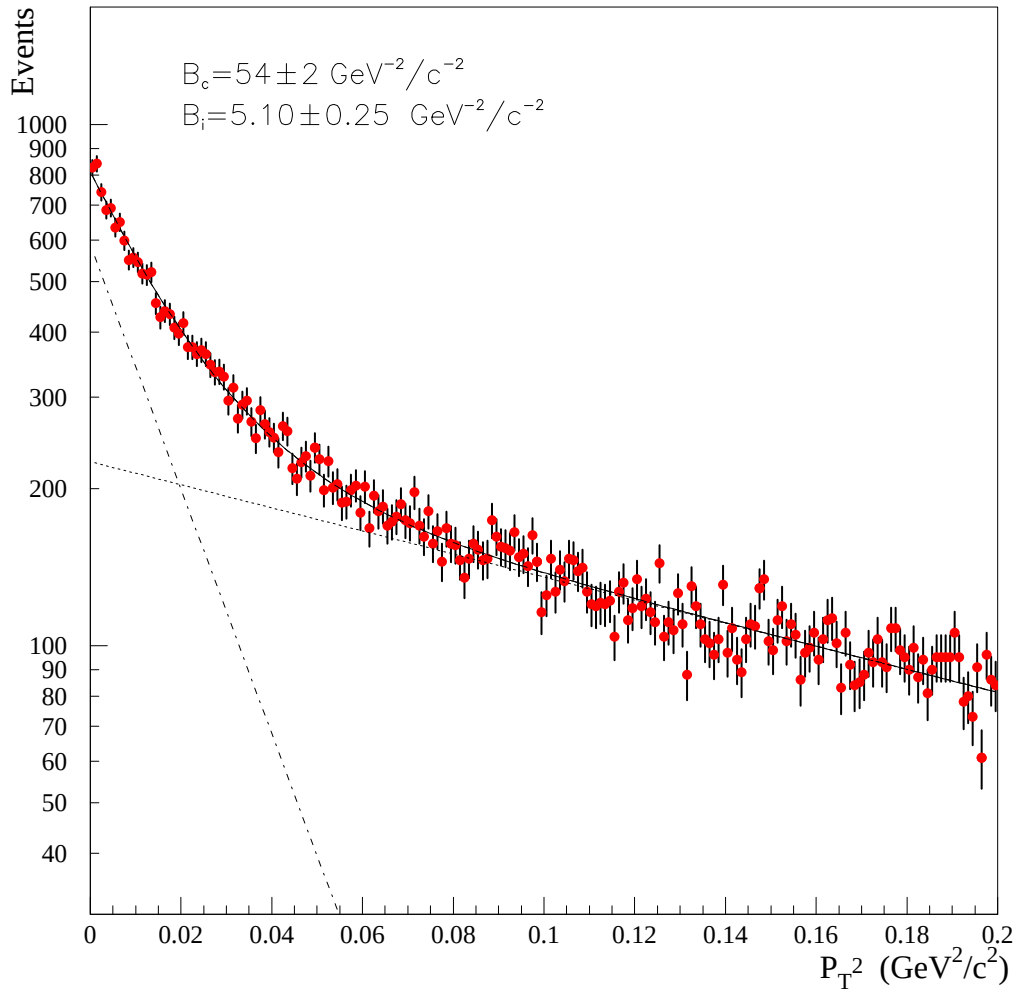
Numtra=12
Ntrak =10
Nsedv = 2
Msedv = 2 < File: VM40B2SDKA0:[E687.SDC]QT.DATA;1
E687 detector
26-MAY-93 22:20:2
Page:
Ev #:
Run: 2925, Spill: 285, Event: 12
Spectrometer frame
non-bend projection
M1
M2
C1
C2
C3
OE
P0
P1
P2
P3
P4
HxV
HC
IE
Bgm
Chc
-160.
-180.
-200.
-220.
-240.
-260.
-800.
-400.
0.
400.
800.
1200.
1600.
Track1
Trk-Mic-Ce

Selection of $3\pi^+ 3\pi^-$ diffractive events

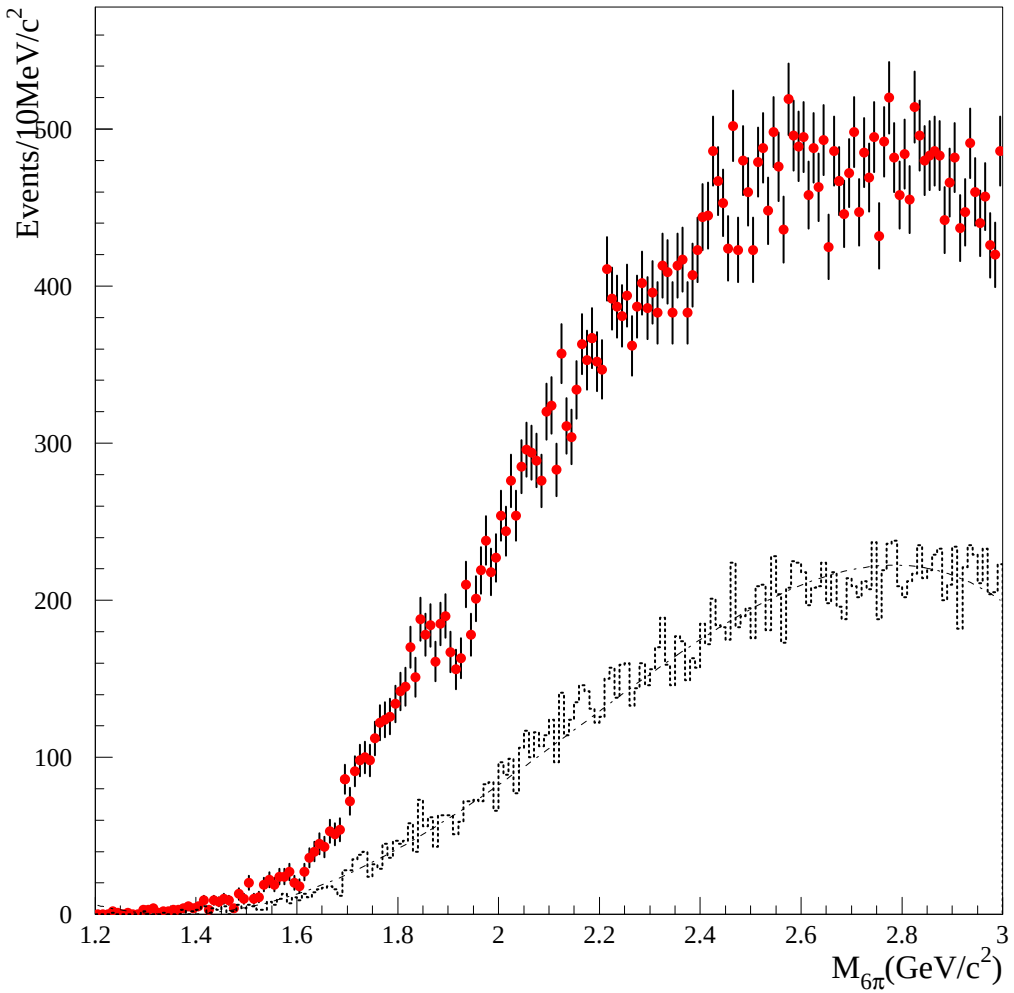
- Events with identified $K^{\pm}$ or p have been rejected and at least 4 out of the 6 particles are requested to be identified as $\pi^{\pm}$.
- The final states with π^0 are rejected by requiring no visible energy in the electromagnetic calorimeters.
- At our energies the four momentum transfer squared t has been approximated by the total transverse momentum squared P^2_T of the hadronic final state diffractively produced, because we don't measure the incoming photon energy, event by event.
- This distribution has been fit by two exponentials : a coherent contribution with a slope B_1=54 GeV^{-2} and an incoherent one with slope B_2= 5.1 GeV^{-2}.
- Taking only events with $P^2_T \leq 40\ MeV^2$ a contamination from non diffractive events of about 50% has been evaluated.The diffractive mass distribution is obtained subtracting the distribution of the rejected events, properly normalized.


Events/10MeV/c^2
500
400
300
200
100
0
1.5
2
2.5
3
3.5
4
4.5
5
M(6π) (GeV/c^2)

P^2_T Distribution

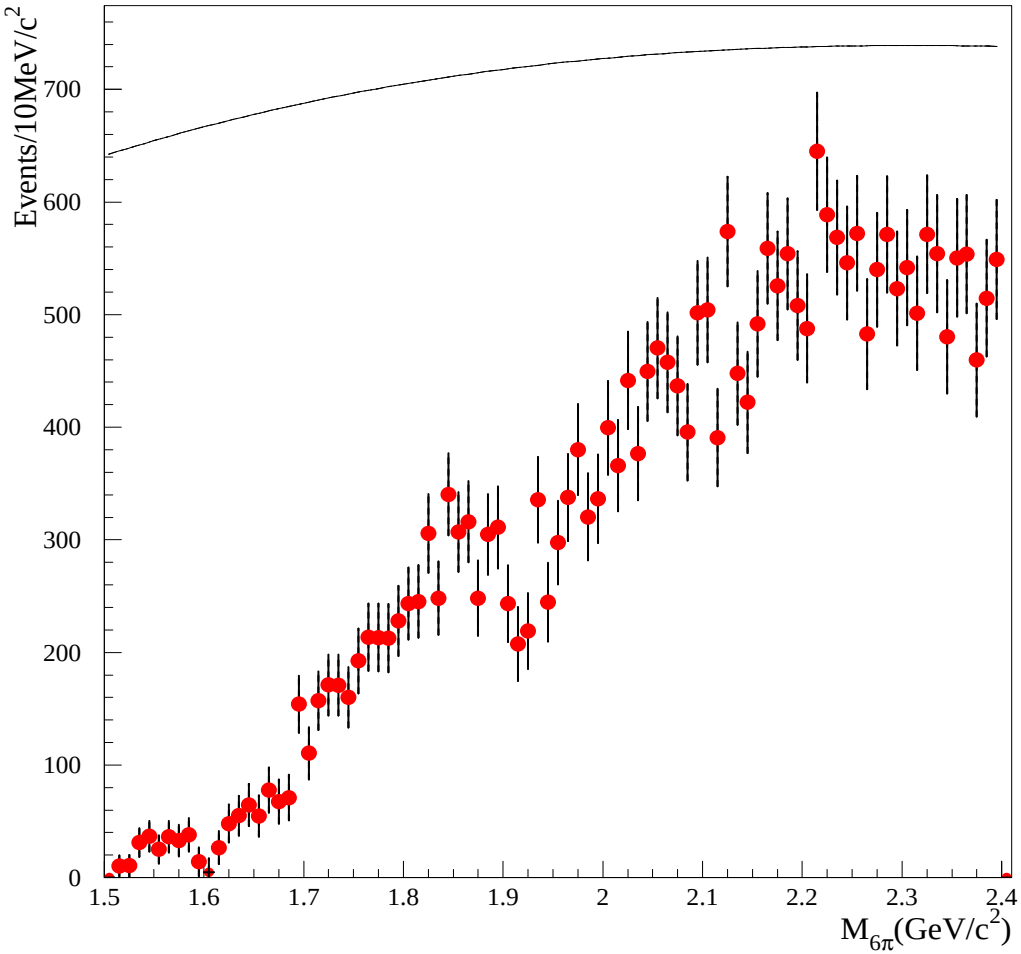


$3\pi^+ 3\pi^-$ Mass Distribution



$3\pi^+ 3\pi^-$ Mass Distribution

(incoherent part taken out)



Fitting the data in the 1.6 ÷ 2.2 GeV mass range

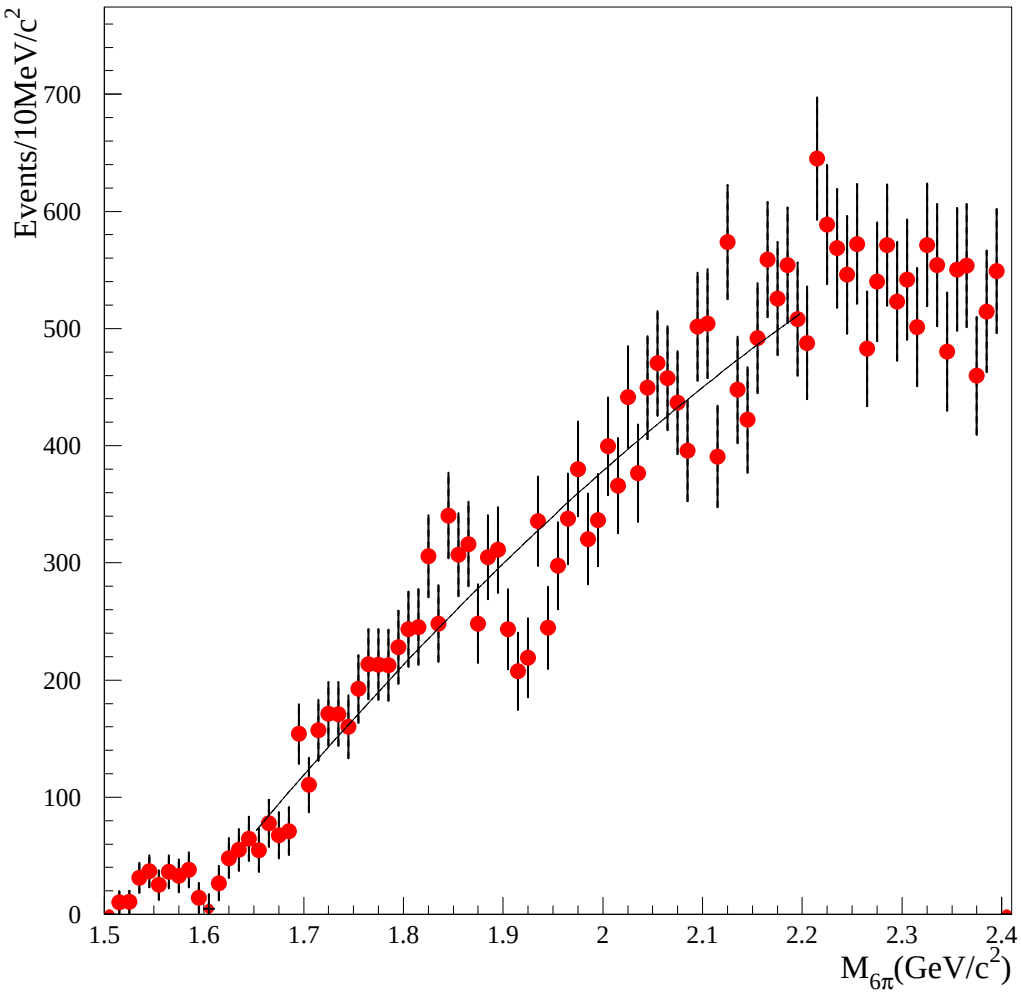
- A three parameter polynomial fit has been performed to explore the hypothesis that the structure is a statistical fluctuation.

- The confidence level (CL) of this fit is good everywhere with the exception of the interval centered at **1.9** GeV/c^2.

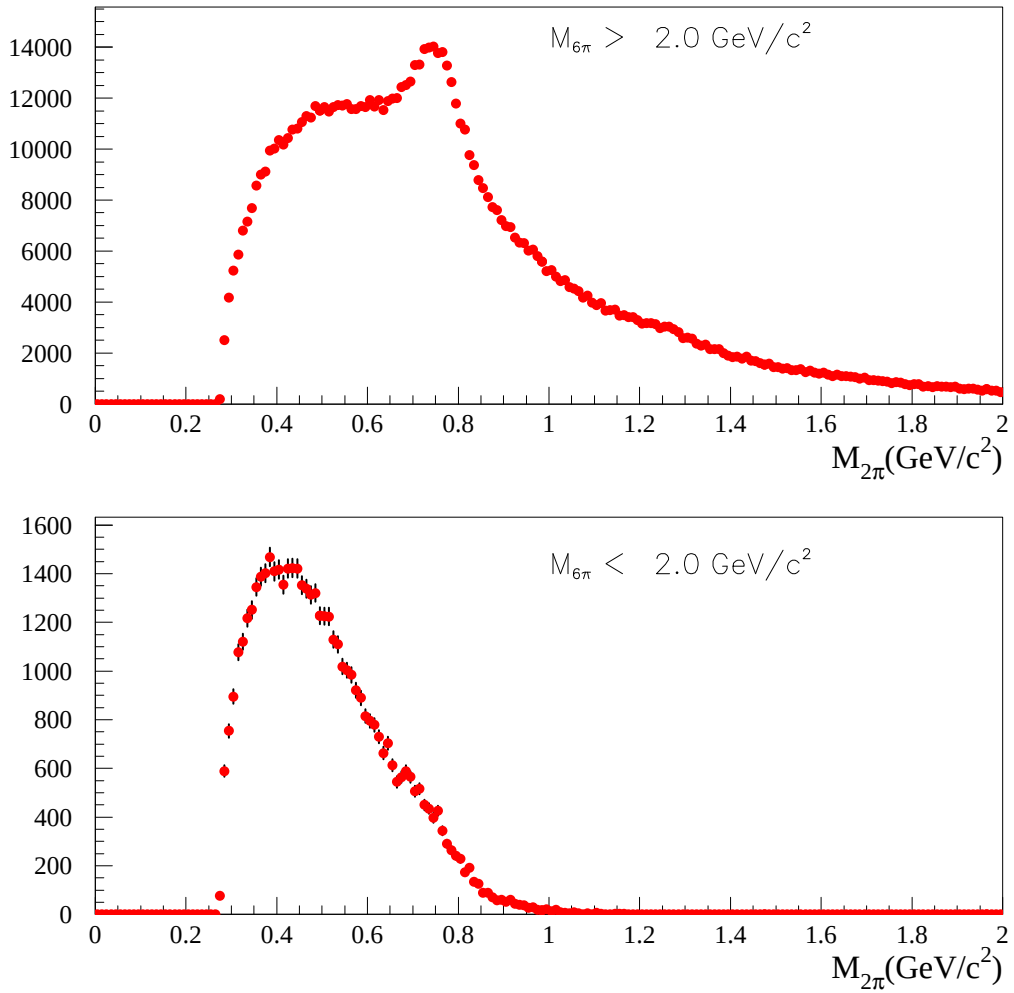
- Adding a Breit Wigner does not improve the fit :

  CL ~10^{-3} are obtained.

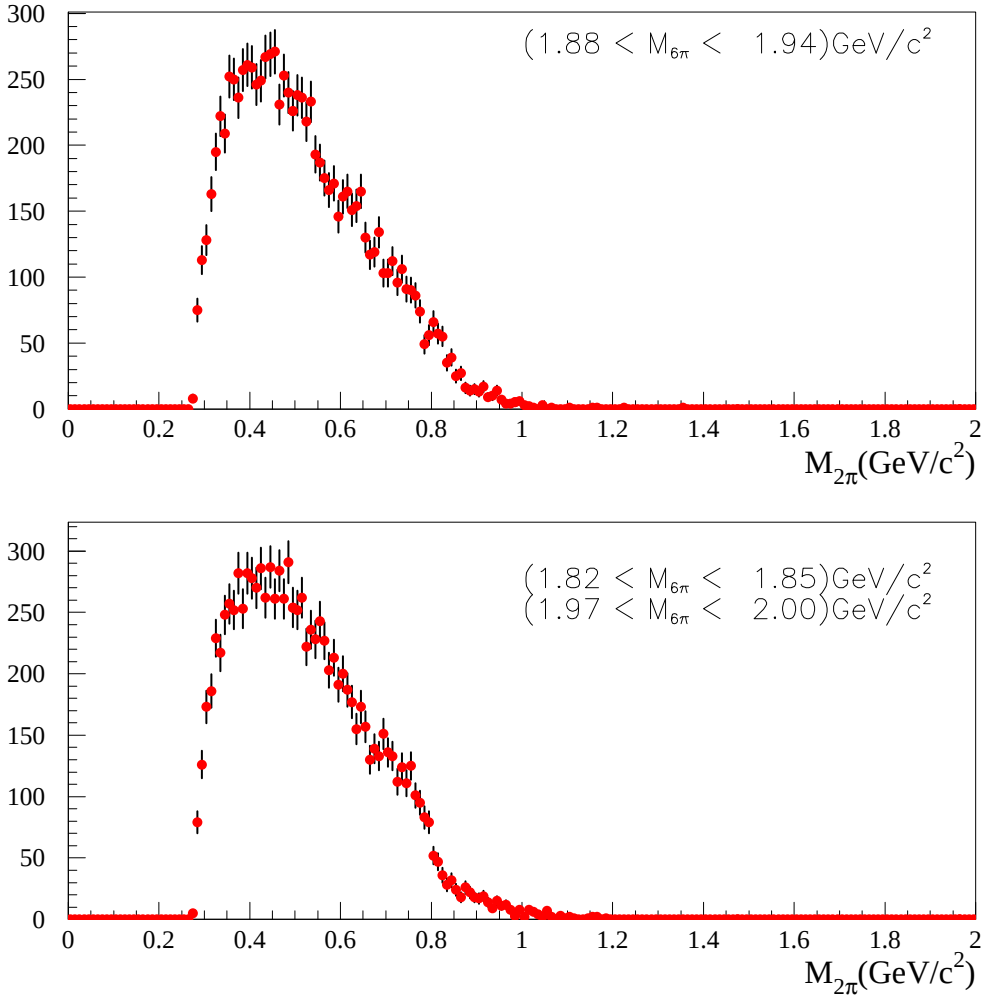
Fitting the data in the 1.6 ÷ 2.2 GeV mass range



The ρ content in the dip region



The ρ content in the dip region



Unfolding the mass resolution

- Because of the narrow width of the dip, the unfolding of the E687 mass resolution (~10 MeV) has been done .

- The experimental distribution *b(x)* and the unfolded one *a(x)* are related,in first approximation,

$$a(x) \sim b(x) - 0.5\sigma^2 \cdot b(x)''$$

- The fit is used to achieve *b(x)"*.

Fitting the data in the 1.6 ÷ 2.2 GeV mass range

- A fit has been performed adding coherently a relativistic Breit-Wigner resonance to a diffractive continuum contribution

- The continuum probability distribution $F_{JS}(M)$ has been modeled after a Jacob-Slansky diffractive parameterization

$$F_{JS}(M) = c_0 + c_1 \frac{e^{\frac{-\beta}{M-M_0}}}{(M - M_0)^{2-\alpha}} = f^2_{JS}(M)$$

- $f_{JS}(M)$ is assumed to be purely real, square root of the probability function $F_{JS}(M)$

Fitting the data in the 1.6 ÷ 2.2 GeV mass range

- For the fit , a relative phase factor $e^{i\phi}$,independent of mass and a normalizing factor a_r multiplied a relativistic Breit-Wigner resonance term, giving the overall amplitude

$$A(M) = f_{JS}(M) + a_r \frac{- M_r \Gamma e^{i\varphi}}{M_2 - M_r^2 + iM_r\Gamma}$$

- Masses and widths are shown in Table 1.

- For the narrow resonance at $M=1.911 \pm 0.004$ GeV/c^2 we quote a width $\Gamma = 29 \pm 11$ MeV/c^2

Fitting the data in the 1.6 ÷ 2.2 GeV mass range

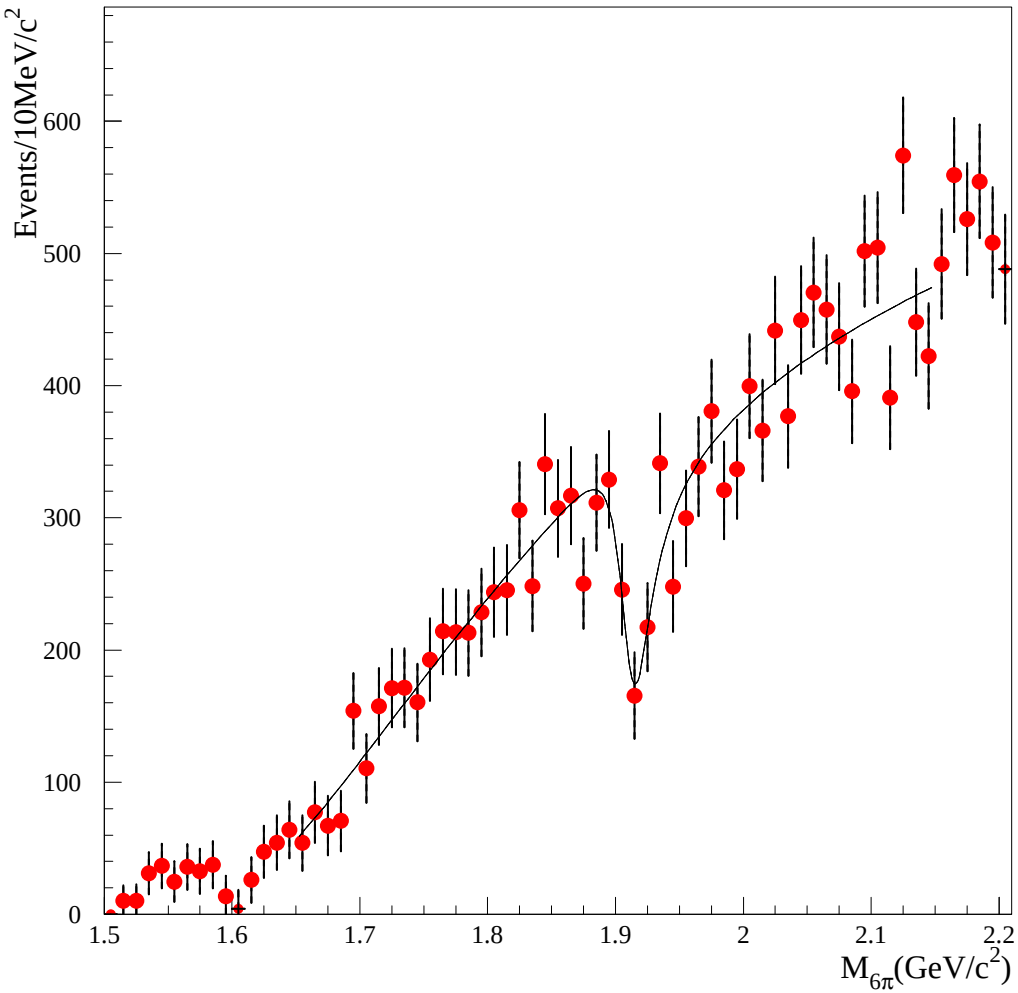


Table 1

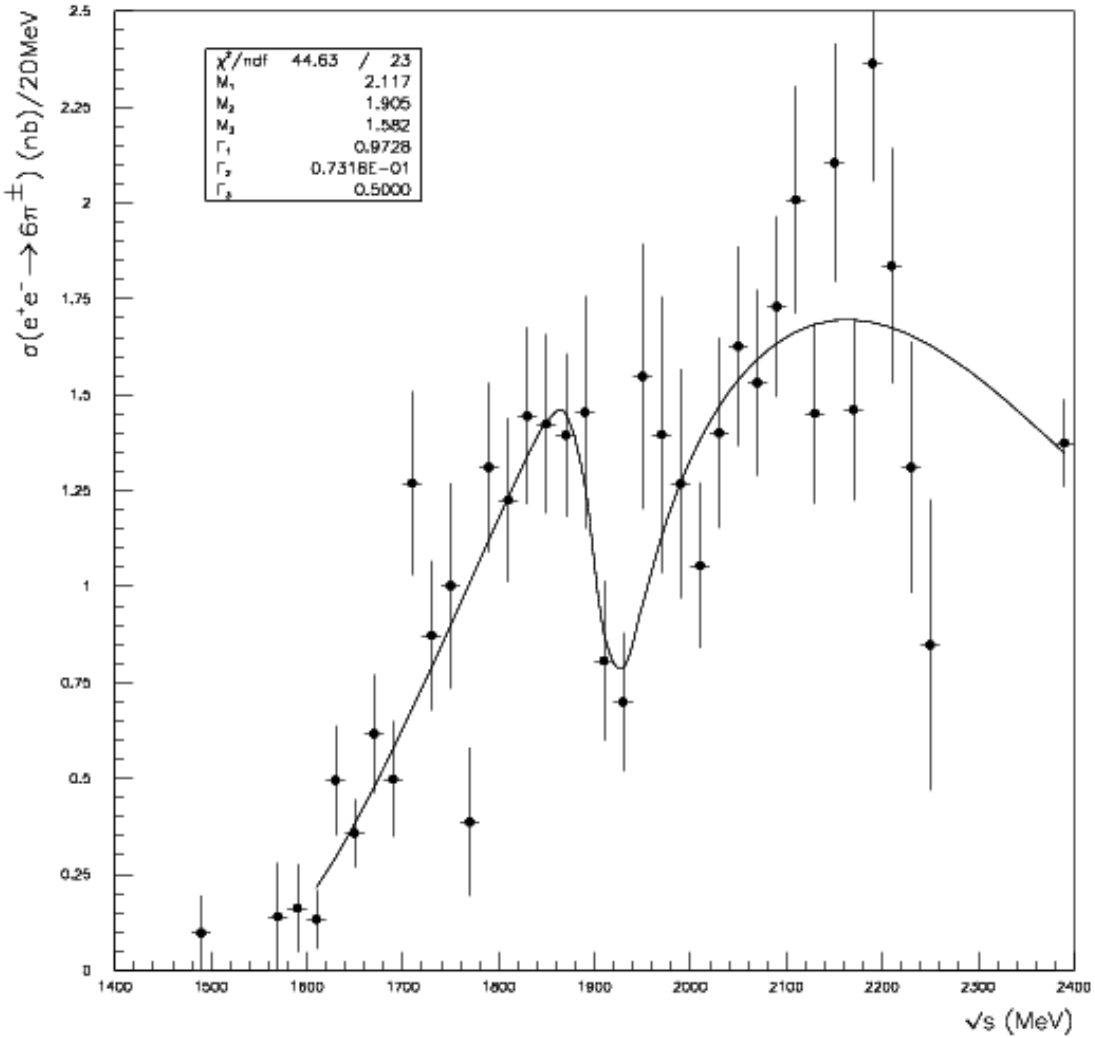
M_r (GeV/c^2)	1.911 ± 0.004
Γ (MeV/c^2)	29 ± 11
$a_r/f_{JS}(M_r)$	0.31 ± 0.07
ϕ(deg.)	62 ± 12
χ^2/dof	1.1
M_0	1.49 ± 0.02
c_0	0 ± 50
c_1	960 ± 80
β	0.5 ± 0.3
α	1.8 ± 0.2

DM2 Data

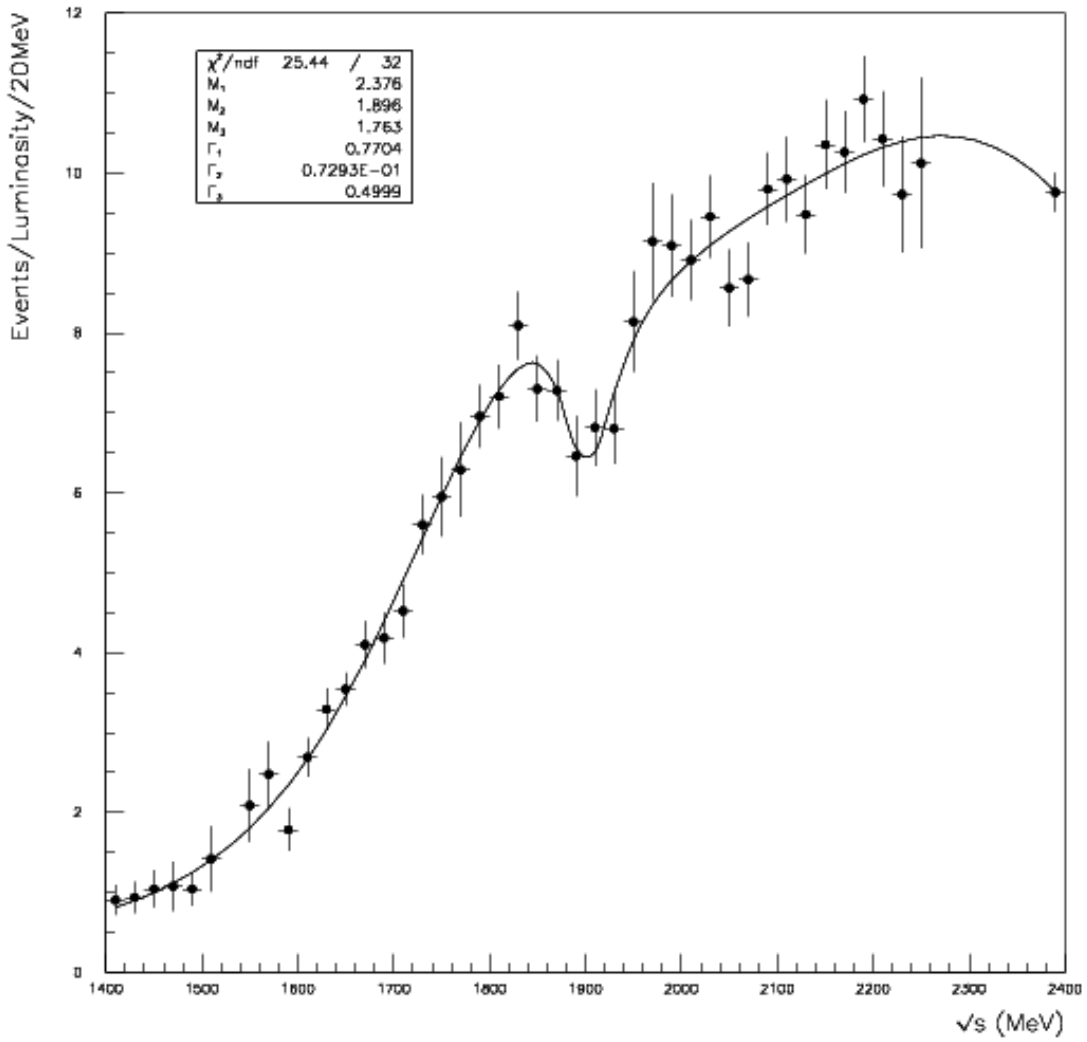
- Indications for a dip at 1.9 GeV/c^2 threshold came also from DM2 data that showed a narrow structure at M~ 1.90 GeV/c^2.

- The statistical significance of $e^+ e^- \rightarrow 3\pi^+ 3\pi^{--}$ is poor.
- The other plot shows the yield of ≥ 3 charged particles plus ≥ 2 photons or ≥ 5 charged particles.
- The detection efficiency for π^0 reconstruction was poor and additional hypothesis are needed to disentangle the various channels contributing to this plot,even if it is likely that $e^+ e^- \rightarrow 2\pi^+ 2\pi^- 2\pi^0$ is the main contribution.

(DM2 unpublished) $e^+ e^- \rightarrow 3\pi^+ 3\pi^-$



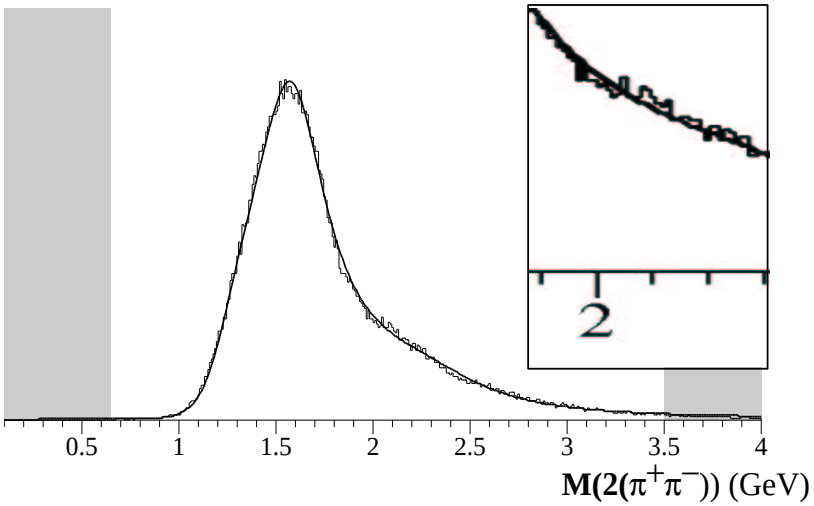
$e^+ e^- \to 4\pi^{\pm} 2\pi^0$, $3\pi^+ 3\pi^-$, $\geq 6\pi$



Other possible structures in diffractive photoproduction by E687 ?

- E687 data suggest also other structures in $2\pi^+2\pi^-$ data when plotting the residual (fit-data) distributions.

- These structures are absent in the $\pi^+\pi^-$ data.



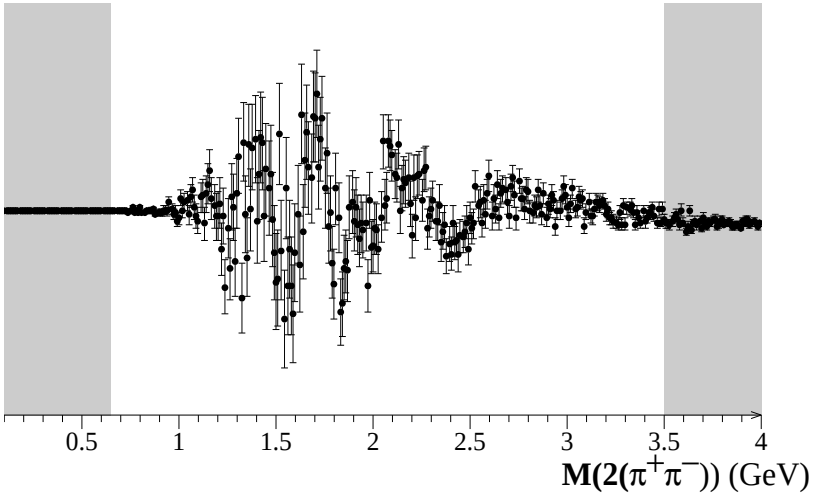
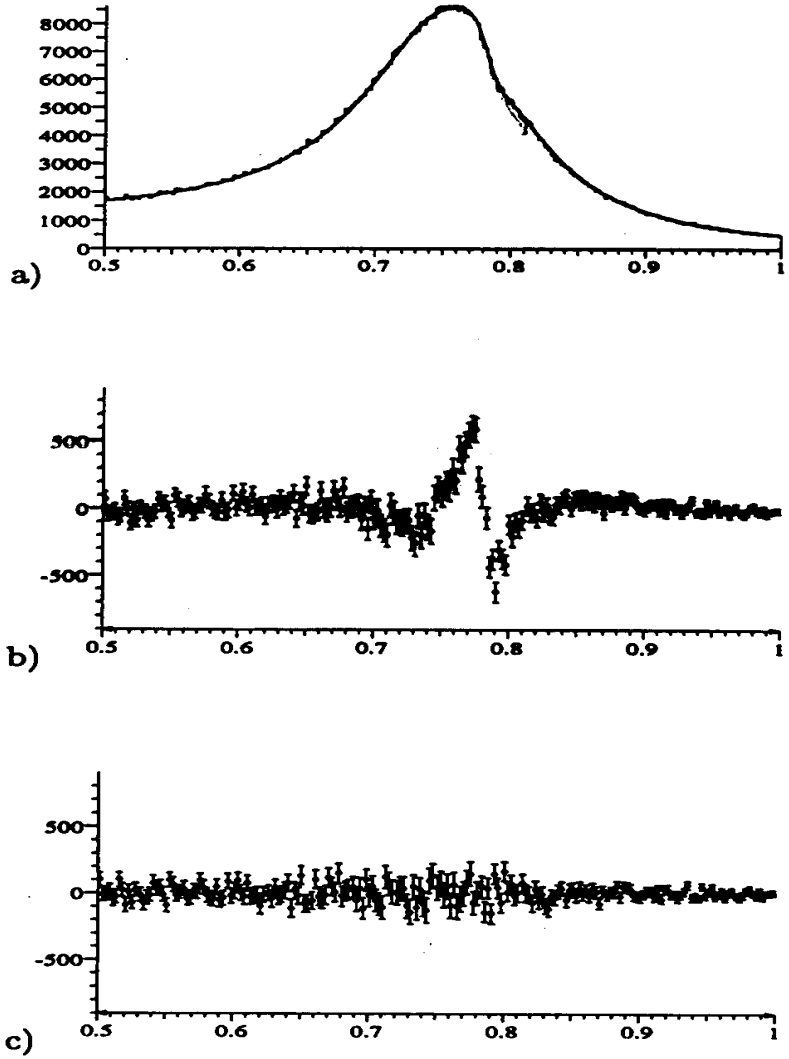


figure 3.

E687 $\pi^+\pi^-$ diffractive photoproduction



Conclusions

- The diffractive photoproduction of $3\pi^+ 3\pi^-$ final states has been measured by E687.
- Evidence has been found for a new structure at:

$$M = 1.911 \pm 0.004 \text{ GeV}$$

$$\Gamma = 29 \pm 11 \text{ MeV}$$

(preliminary)

- The possible presence of other structures in $2\pi^+ 2\pi^-$ data should be further investigated .