Vector Meson Production ep-->ep $\pi^+ \pi^-$

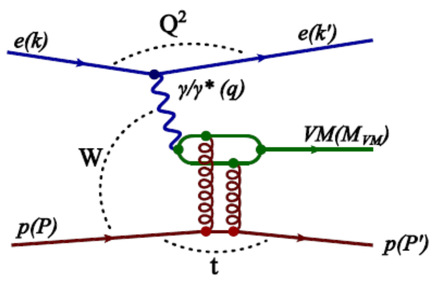
ZEUS Collaboration

Two pion exclusive electroproduction, e p → e p $\pi^+ \pi^-$, has been studied in the mass range $0.4 < M_{\pi\pi} < 2.5$ GeV. The two-pion invariant mass distribution is used to obtain the pion electromagnetic form factor. The Q^2 dependence of the ratios $\sigma(\rho'(1450)\rightarrow\pi\pi)/\sigma(\rho(770))$ and $\sigma(\rho''(1700)\rightarrow\pi\pi)/\sigma(\rho(770))$ is extracted.

Vector Meson Production ep → ep $\pi^+\pi^-$

Exclusive electroproduction of vector mesons, $\gamma^* p \rightarrow e p \pi^+\pi^-$, at large centre-of-mass energy, W, at large γ^* virtuality, Q^2:

- virtual photon fluctuates into a $q\bar{q}$ pair
- $q\bar{q}$ pair interacts with the proton through a two-gluon ladder
- hadronizes into a vector meson, V



Events Selection

- data collected by the ZEUS Detector 1998-2000 (82 pb^{-1})
- two pions and electron are measured in the detector
- no additional activity above noise level

Kinematical range:

- $0.4 < M_{\pi\pi} < 2.5$ GeV
- $2 < Q^2 < 80$ GeV^2
- $32 < W < 180$ GeV
- $|t| < 0.6$ GeV^2

Number of events ~63k

Pion From Factor $F_\pi(M_{\pi\pi})$

- is given by contribution from vector mesons ρ (770), ρ'(1450), ρ''(1700)
- known as Kuhn-Santamaria parametrization
- $F_\pi(M_{\pi\pi}) = [BW(\rho)+\beta BW(\rho')+\gamma BW(\rho'')] /(1+\beta+\gamma)$ where:
  - β,γ are relative amplitudes
  - BW – Breit Wigner amplitude

The mass fit

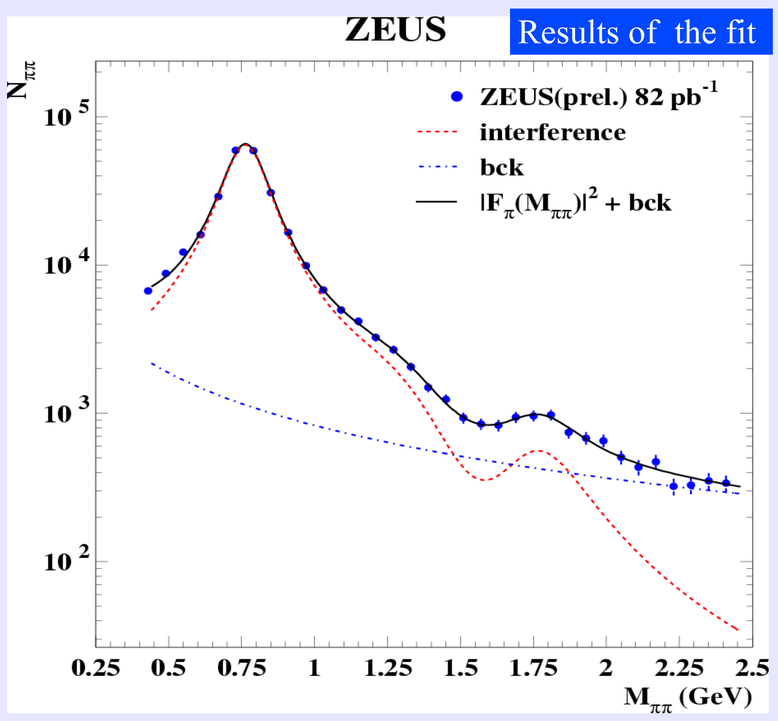
The two pion invariant mass is fitted as:

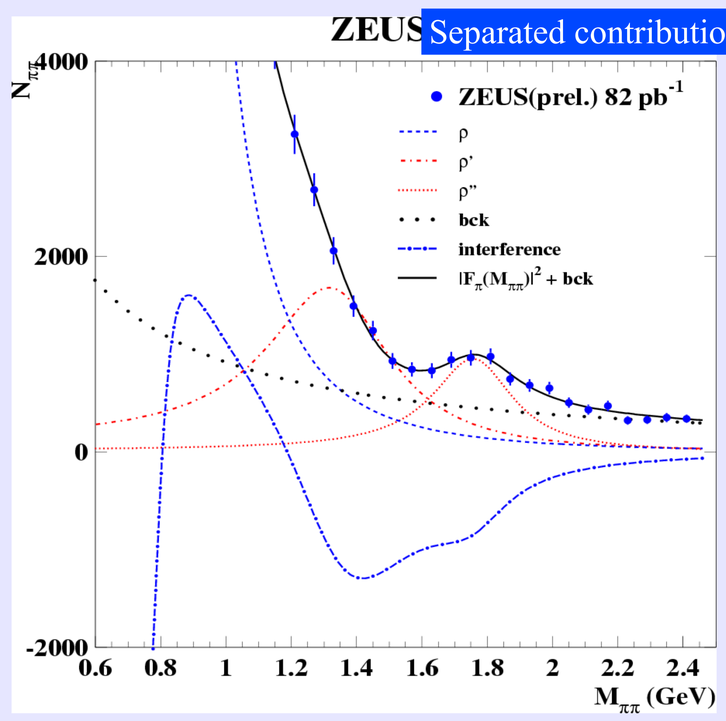
$$\frac{dN}{dM_{\pi\pi}} = N\left[\left|F_{\pi\pi}\right|^2 + B\left(\frac{M_\rho}{M_{\pi\pi}}\right)^n\right]$$

Fit includes 11 parameters: overall normalization N, parameters of non-resonant background: B and n, the masses and the widths of the three resonances and their relative contributions β and γ

Results:

- ρ (770) and ρ''(1700) are clearly visible, ρ'(1450) – a mere shoulder
- the masses and the widths of the ρ (770) and ρ''(1700) as well as the width of ρ'(1450) agree with PDG



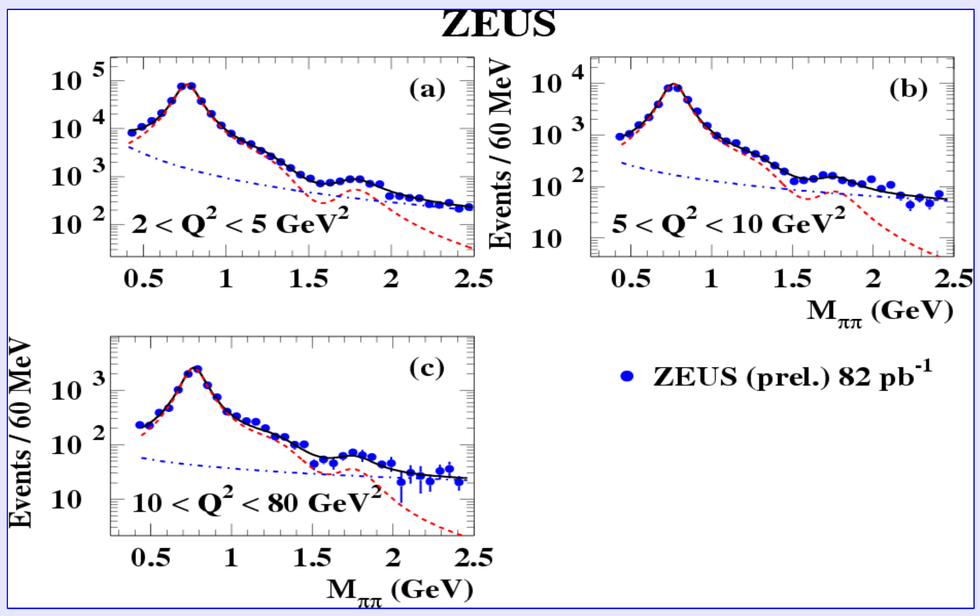


Q^2 dependence of relative amplitudes

Fit: the masses and the widths of the three resonances were fixed to the values found in overall fit.

Results:

- reasonable description of data in three Q^2 regions
- the absolute value of β increases with Q^2
- γ remains Q^2 independent within the uncertainties

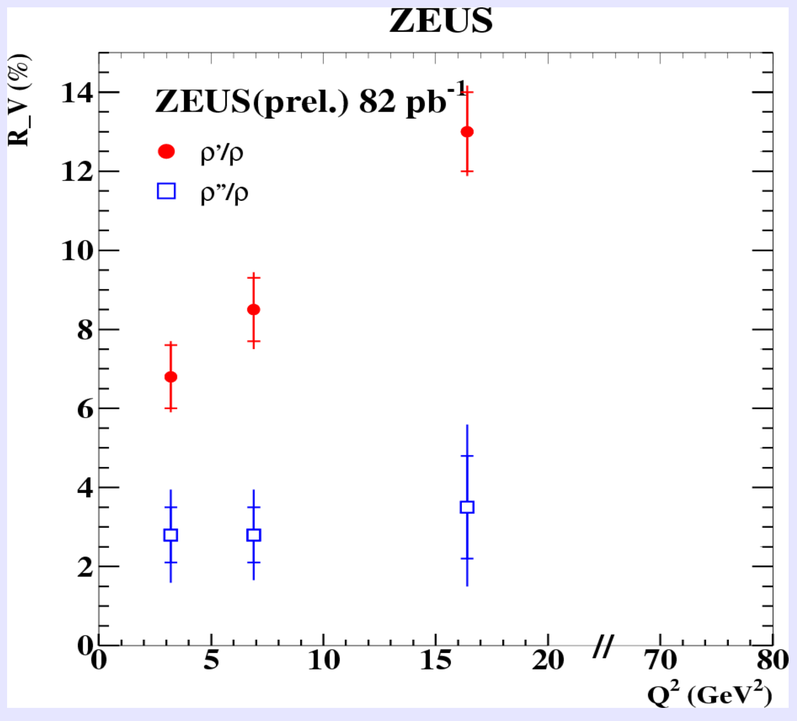


Cross section ratios as a function of Q^2

Ratio is defined as:

$$R_V = \frac{\sigma(V\rightarrow\pi\pi)}{\sigma(\rho(770))}$$

- the value of $R_{\rho'(1450)}$ increases with Q^2
- the value of $R_{\rho''(1700)}$ is approximately constant or slightly increases
- this behaviour is predicted by several models



Discussion

- The Q^2 dependence of the suppression of the states ρ'(1450) and ρ''(1700) with respect to ρ(770) is different.
- The suppression of the 2S state (ρ'(1450)) is connected to a node effect which results in cancellations of contributions from different impact parameter regions at lower Q^2, while at higher Q^2 the effect of cancellation vanishes.
- The D state (ρ''(1700)) suppression is connected to the spinorial structure of the qq state into which the photon fluctuates. It is not a pure S wave but contains also a small admixture of D wave, which is Q^2 independent.

Summary

- The $M_{\pi\pi}$ mass distribution of the reaction ep-> ep$\pi^+\pi^-$ in the range $0.4 < M\pi\pi < 2.5$ GeV is well described by the pion electromagnetic form factor which includes three resonances: ρ(770), ρ'(1450), ρ''(1700)
- The cross section ratios $\sigma(\rho' \rightarrow \pi\pi)/\sigma(\rho)$ and $\sigma(\rho'' \rightarrow \pi\pi)/\sigma(\rho)$ show different Q^2 behaviour.