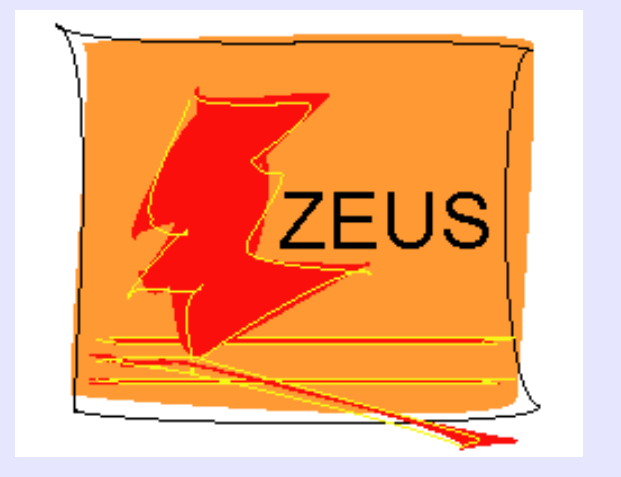




Vector Meson Production $ep \rightarrow ep \pi^+ \pi^-$

ZEUS Collaboration

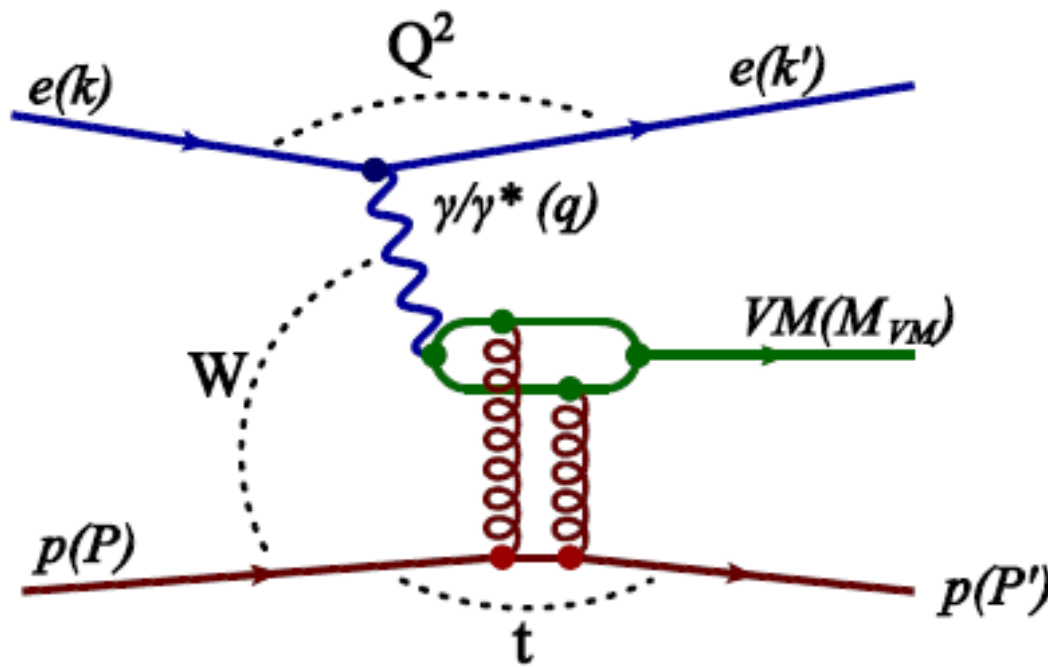


Two pion exclusive electroproduction, $e p \rightarrow e p \pi^+ \pi^-$, has been studied in the mass range $0.4 < M_{\pi\pi} < 2.5$ GeV. The two-pion invariant mass distribution is used to obtain the pion electromagnetic form factor. The Q^2 dependence of the ratios $\sigma(\rho'(1450) \rightarrow \pi\pi)/\sigma(\rho(770))$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

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

Exclusive electroproduction of vector mesons, $\gamma^* p \rightarrow ep \pi^+ \pi^-$, 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
- $2 < Q^2 < 80$ GeV²
- $32 < W < 180$ GeV
- $|t| < 0.6$ GeV²

Number of events ~63k

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

- is given by contribution from vector mesons $\rho(770)$, $\rho'(1450)$, $\rho''(1700)$
- 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

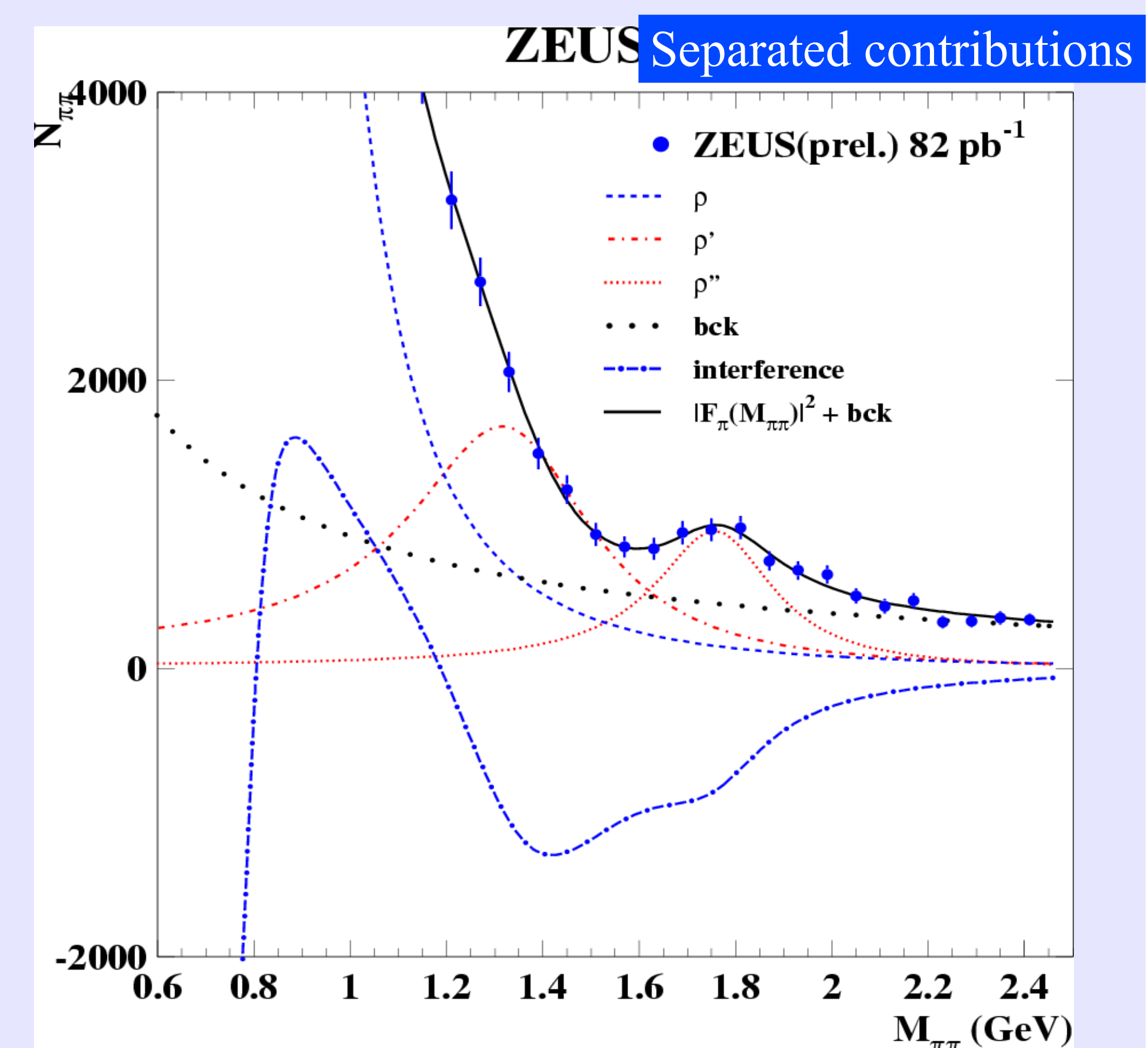
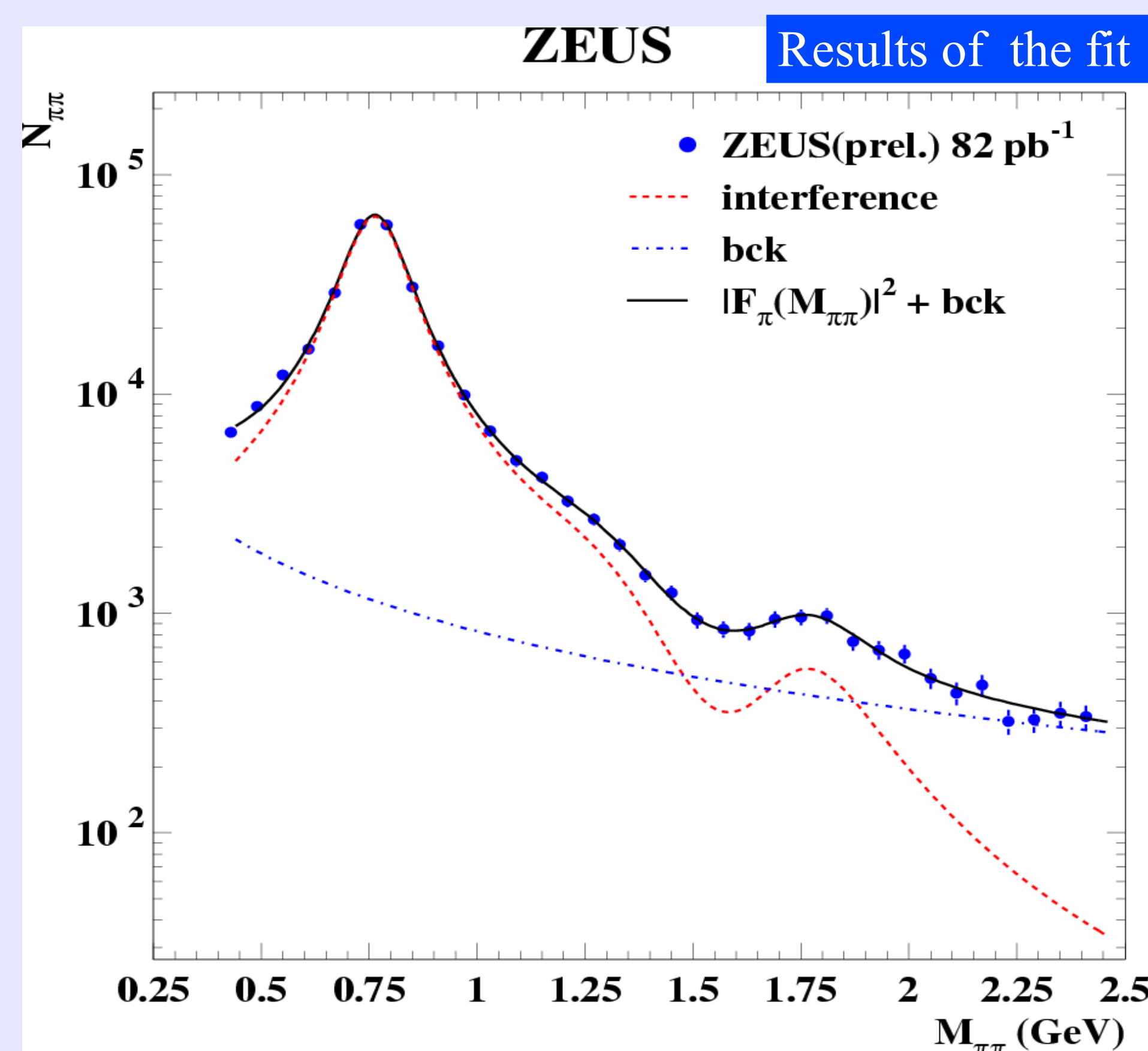
The two pion invariant mass is fitted as:

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

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:

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

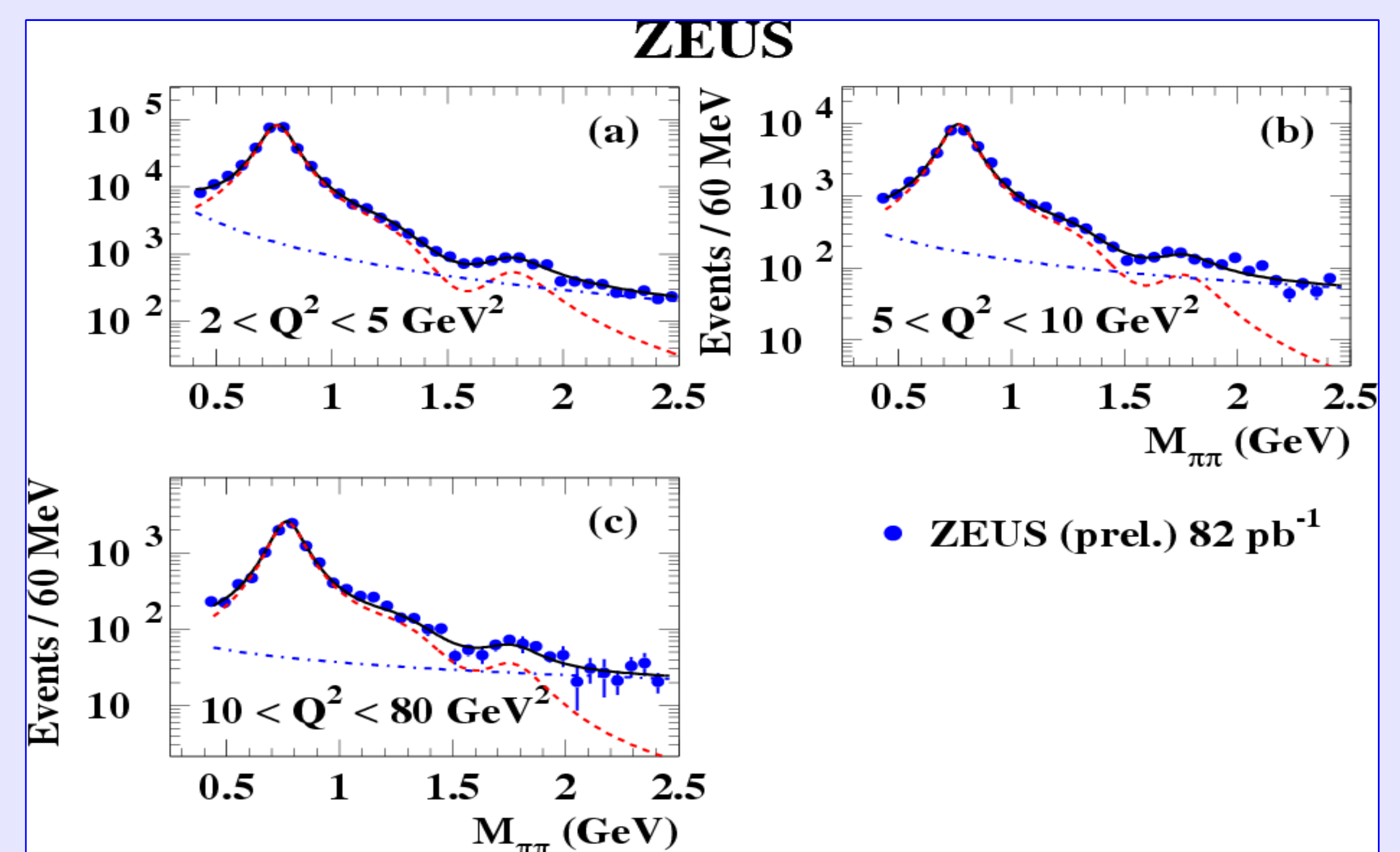


Q^2 dependence of relative amplitudes

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

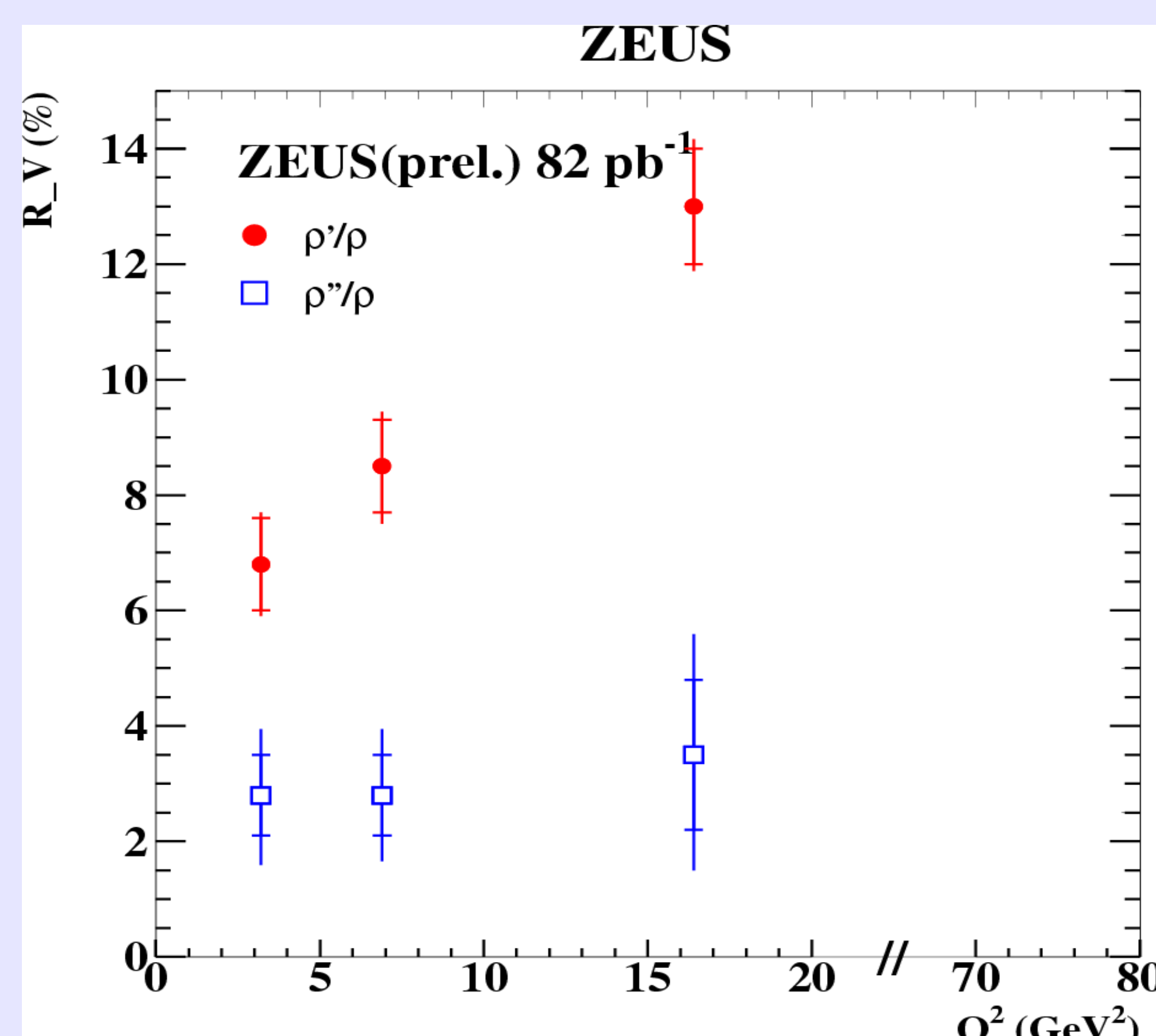
Ratio is defined as:

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

- 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 $\rho'(1450)$ and $\rho''(1700)$ with respect to $\rho(770)$ is different.
- The suppression of the 2S state ($\rho'(1450)$) 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 ($\rho''(1700)$) suppression is connected to the spinorial structure of the $q\bar{q}$ 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 $ep \rightarrow ep \pi^+ \pi^-$ in the range $0.4 < M_{\pi\pi} < 2.5$ GeV is well described by the pion electromagnetic form factor which includes three resonances: $\rho(770)$, $\rho'(1450)$, $\rho''(1700)$
- The cross section ratios $\sigma(\rho' \rightarrow \pi\pi)/\sigma(\rho)$ and $\sigma(\rho'' \rightarrow \pi\pi)/\sigma(\rho)$ show different Q^2 behaviour.