REVIEW OF BARYON SPECTROSCOPY

BARYON = $|q^3\rangle$

$\Rightarrow$ N. ISGUR, G. KARL:

MISSING RESONANCES!

Low Masses: Too many resonances?

Example: ROPER $N^*(1440)$; $\frac{1}{2}^+$

- LATTICE
- MESON-NUCLEON DYNAMICS
- EXPERIMENTS:

$\pi N \to \pi\pi N$

$pp \to pp\,\pi\pi$

$\vec{e}\,\vec{p} \to \vec{e}\,'\,p\,\pi$

EXCITED BARYONS IN LATTICE QCD → D. LEINWEBER

hep-lat/0202022

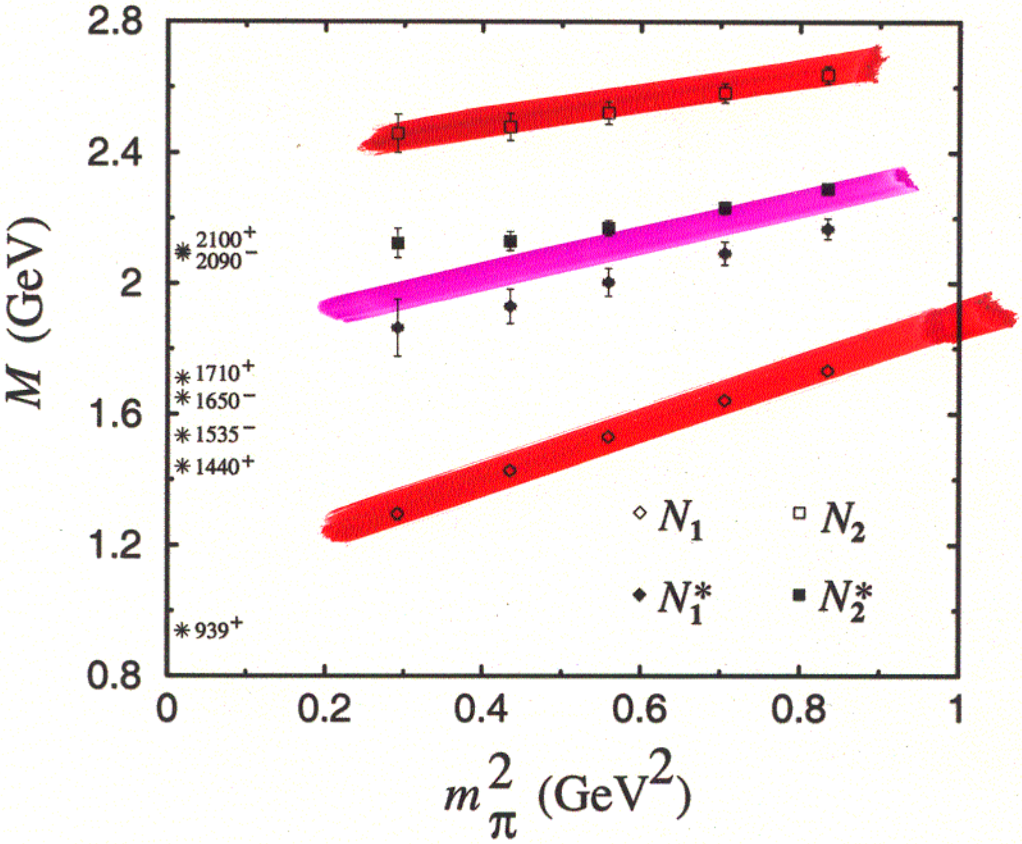
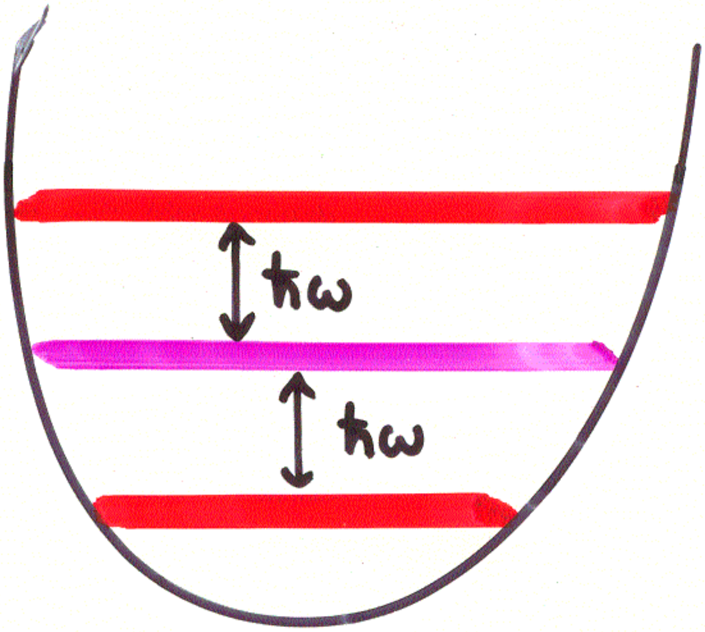


FIG. 5. Masses of the $J^P = \frac{1}{2}^+$ and $\frac{1}{2}^-$ nucleon states, for the FLIC action. The positive (negative) parity states labeled N_1 (N_1^*) and N_2 (N_2^*) are constructed from the χ_1 and χ_2 interpolating fields, respectively. Empirical masses of the low lying $\frac{1}{2}^\pm$ states are indicated by the asterisks.

the lowest mass state with the Roper quantum numbers is higher than the lowest P-wave excitation. It seems that neither the lattice data (at large quark masses and with our interpolating fields) nor the constituent quark model have good overlap with the Roper resonance. Better overlap with the Roper is likely to require more exotic interpolating fields.

In Fig. 4 we show the ratio of the masses of the $N^*(\frac{1}{2}^-)$ and the nucleon, using the χ_1 interpolating field. Once again, there is good agreement between the FLIC and DWF actions. However, the results for the Wilson action lie above the others, as do those for the anisotropic D_{234} action [21]. The D_{234} action has been mean-field improved, and uses an anisotropic lattice which is relatively coarse in the spatial direction ($a \approx 0.24$ fm). This is perhaps an indication of the need for nonperturbative or fat-link improvement.

The mass splitting between the two lightest $N^*(\frac{1}{2}^-)$ states ($N^*(1535)$ and $N^*(1650)$) can be studied by considering the odd parity content of the χ_1 and χ_2 interpolating fields in Eqs. (6) and (7). Recall that the "diquarks" in χ_1 and χ_2 couple differently to spin, so that even though the correlation functions built up from the χ_1 and χ_2 fields will be made up of a mixture of many excited states, they will have dominant overlap with different states,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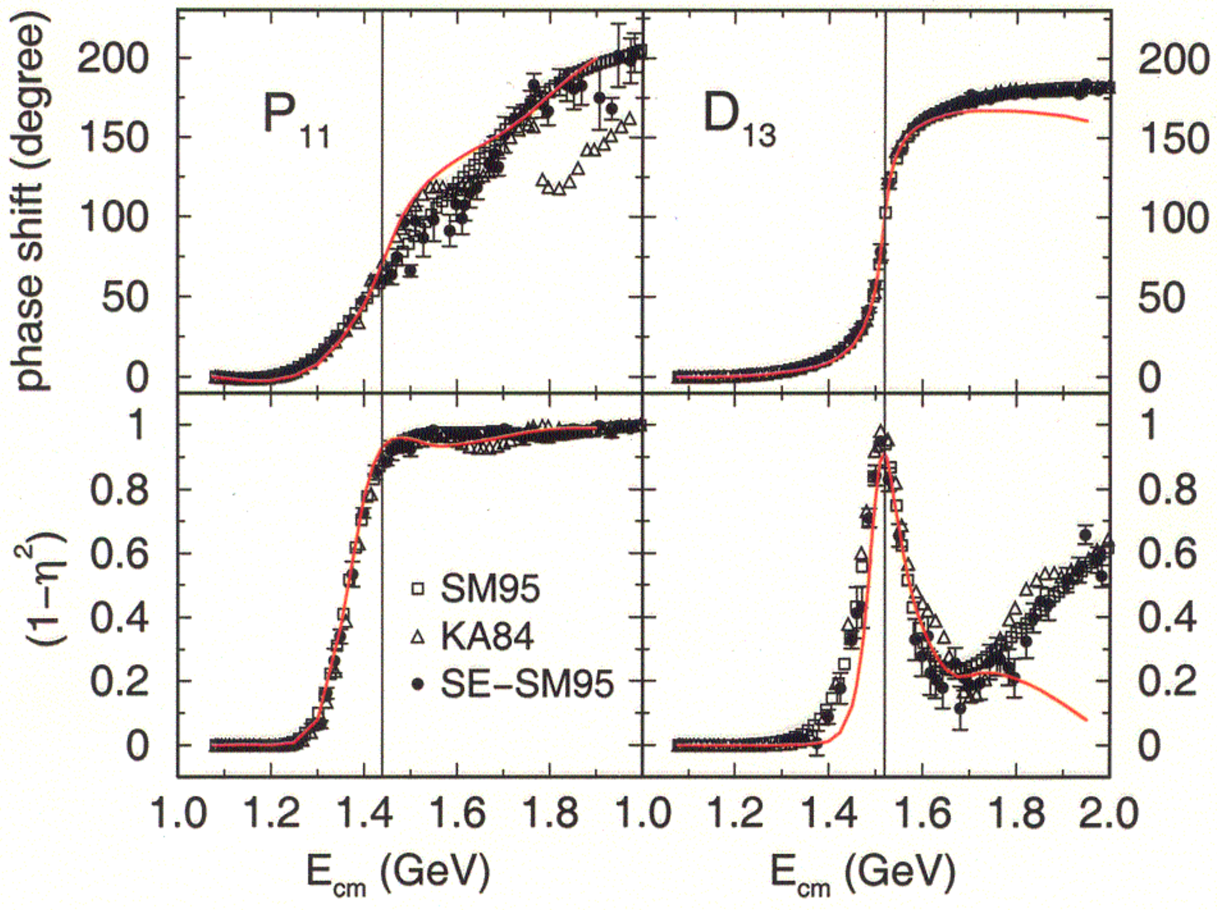
N^* Physics: Decay of Resonances

One–Pion decay:

Unitary Model for πN scattering:

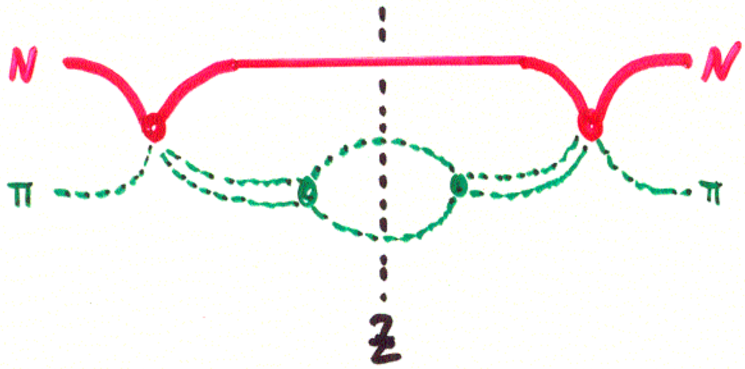
- Coupled Channels πN and $[\pi\pi N]$



Challenge: Two–Pion decay

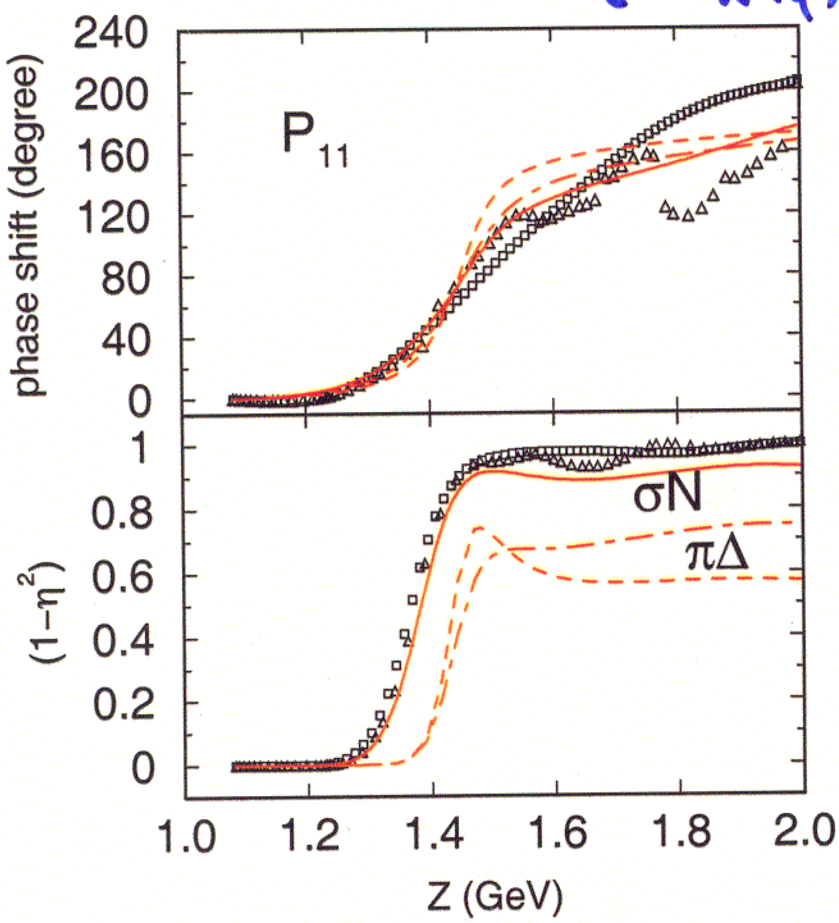
WHY EARLY ONSET OF INELASTICITY?

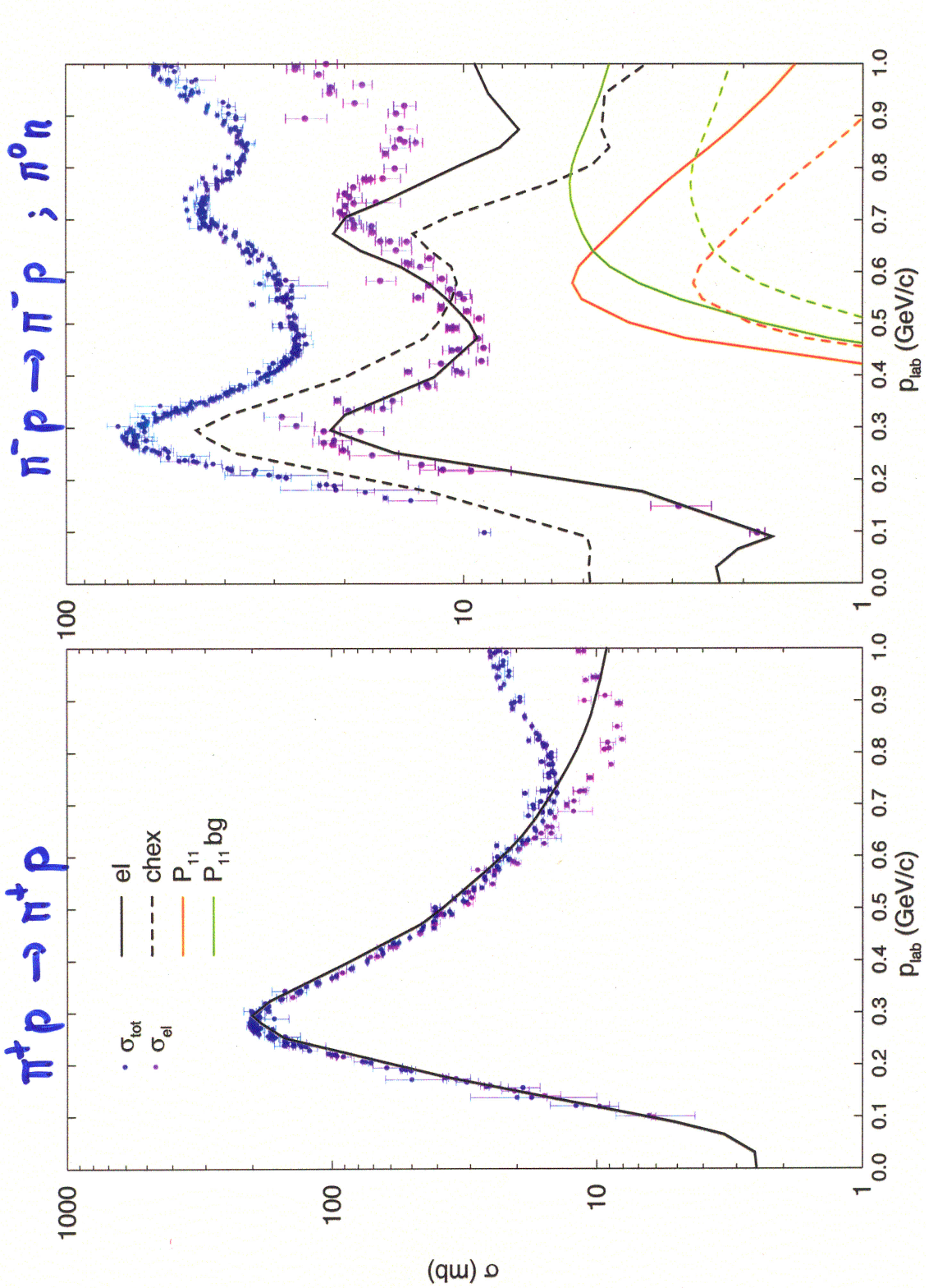
SIMPLIFIED MODEL:



$$T(z) = \frac{f^{+} f}{z - m_0 - \Sigma(z)}$$

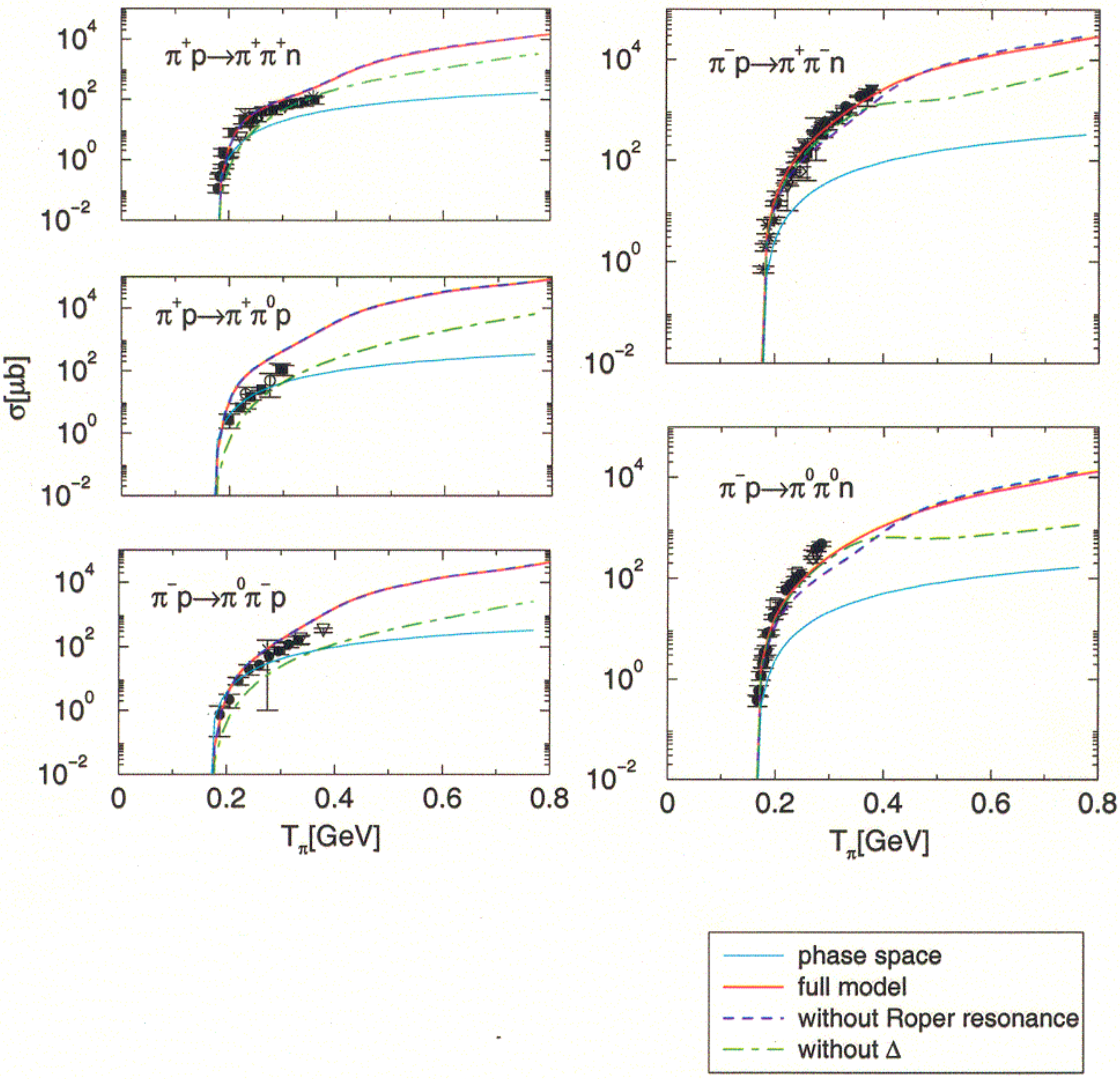
$$\Sigma(z) = \sum_{\gamma} \int d^3q \; \frac{f_\gamma(q)\, f_\gamma(q)}{z - W(q)}$$




π+p → π+p
π−p → π−p ; π0n
σ (mb)
σtot
σel
el
chex
P11
P11 bg
plab (GeV/c)
plab (GeV/c)
1000
100
10
1
0.0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0

$\pi N \to \pi\pi N$

Total cross sections



EXP. → B. NEFKENS, J. COMFORT, M. SADLER, ...

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WASA-PROMICE : $pp \to pp\pi^+\pi^-$

PRL 88, 2002

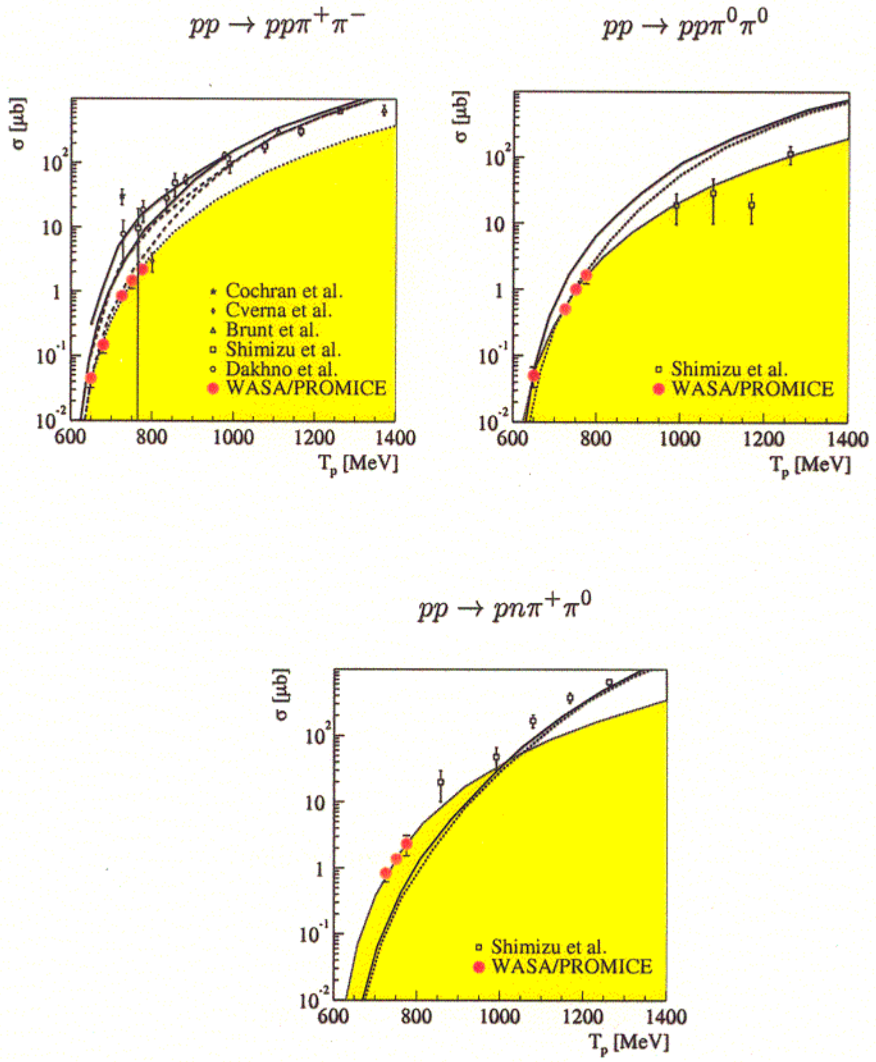

Fig. 1: Integral cross sections for the two-pion production channels $pp \to pp\pi^+\pi^-$ (top, left), $pp \to pp\pi^0\pi^0$ (top, right) and $pp \to pn\pi^+\pi^0$ (bottom). The results obtained at WASA/PROMICE [18-21] are compared to previous measurements [10-16]. Pure phase space behaviour — arbitrarily normalized to our values at $T_p = 750$ MeV — is shown by the shaded areas. Solid and dotted lines in the figures at the top, right, and at the bottom show the predictions of the Valencia model [9] for two different parameter sets. In the figure at the top, left, these calculations are shown as dashed lines, whereas the solid lines include the effect of a pp-FSI in these model calculations.

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WASA-PROMICE: $pp \to pp\pi^+\pi^-$

PRL 88, 2002

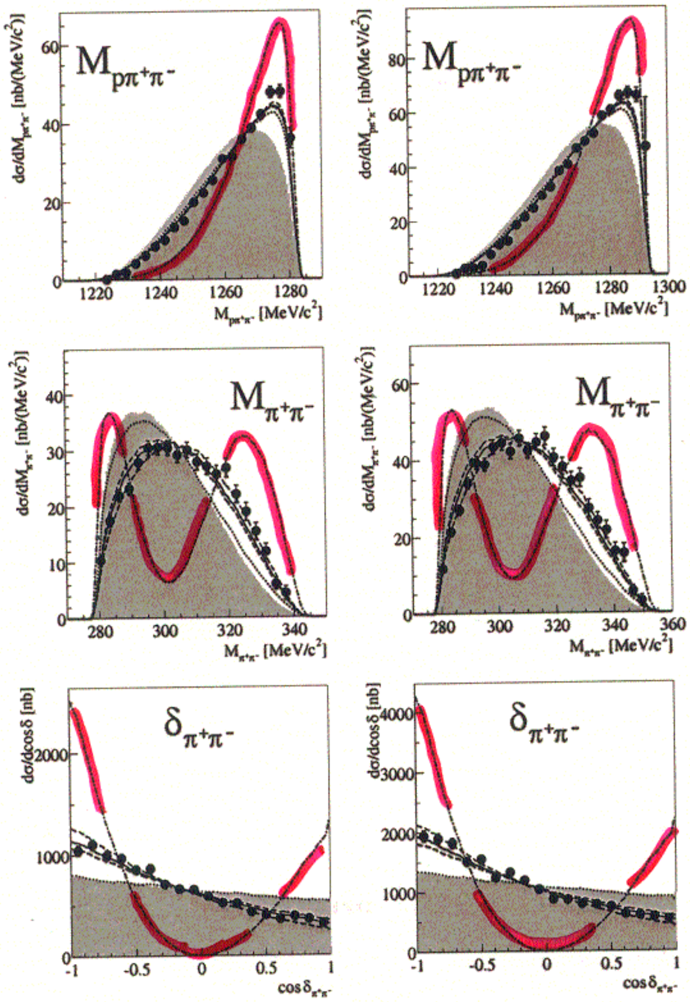
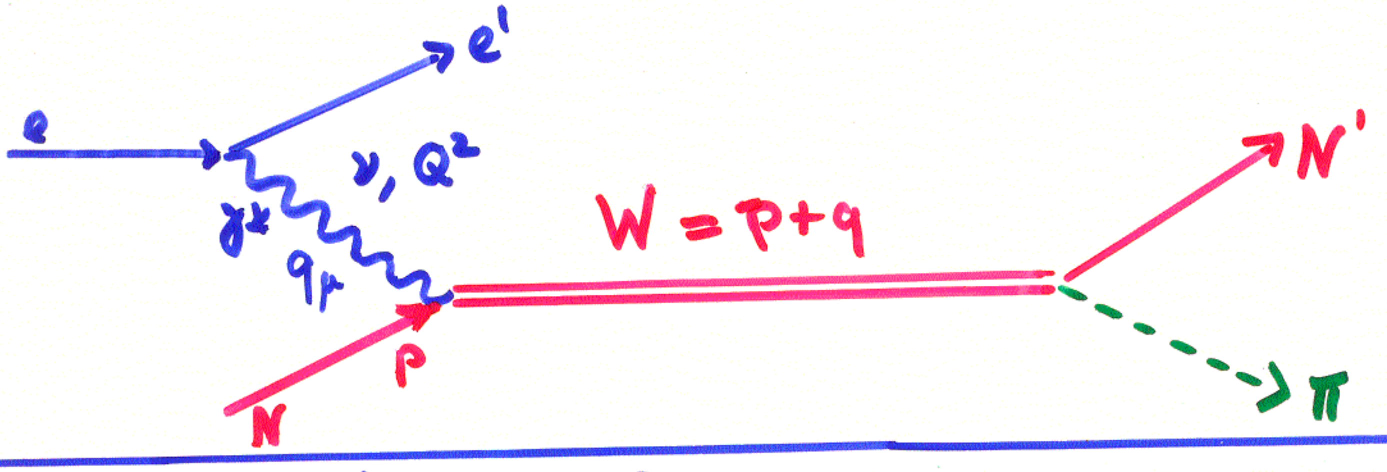


Fig. 2: Influence of the Roper resonance decay onto the differential cross sections for the invariant masses $M_{p\pi^+\pi^-}$ and $M_{\pi^+\pi^-}$ as well as for the opening angle $\delta_{\pi^+\pi^-}$ between both pions in the reaction $pp \to pp\pi^+\pi^-$ at T_p = 750 MeV (left) and T_p = 775 MeV (right). Pure phase space calculations are shown by the shaded area, dotted lines show the case of a pure $N^* \to N\sigma \to N(\pi^+\pi^-)_{I=\ell=0}$ decay, whereas the dash-dotted lines exhibit the scenario for a pure $N^* \to \Delta\pi \to N(\pi^+\pi^-)_{I=\ell=0}$ decay. Solid and dashed curves finally show calcualtions assuming interference from both decay routes and having an admixture of 20%, 25% and 33% of the $\Delta\pi$ route in the total decay amplitude [20].

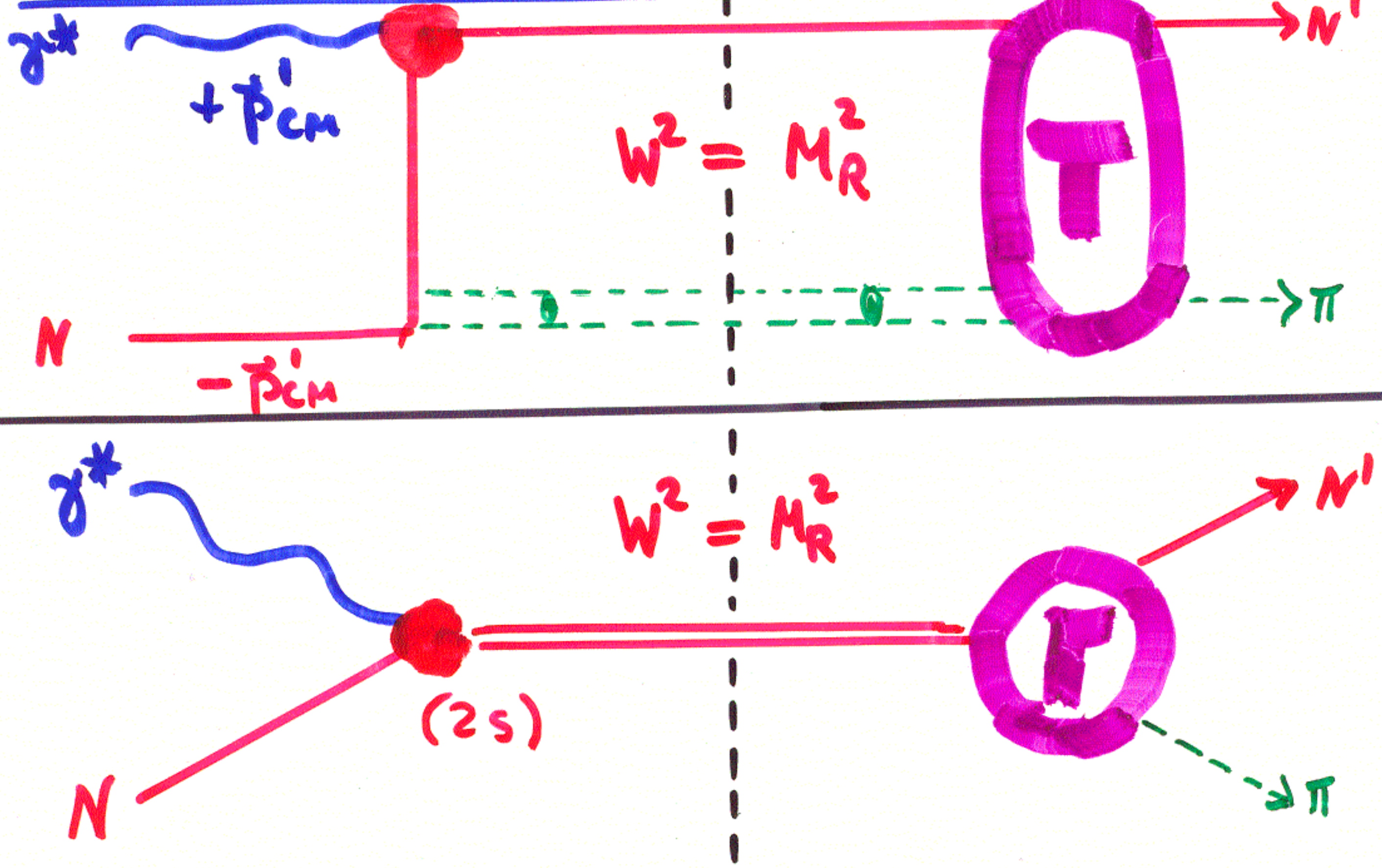
THEORY: L. ALVAREZ-RUSO

E. OSET

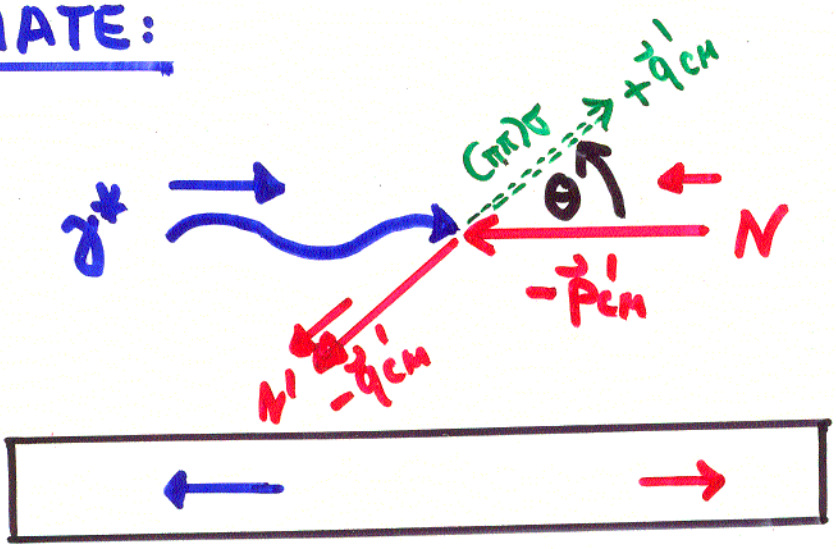
ELECTROPRODUCTION



THEORIST'S FRAME:

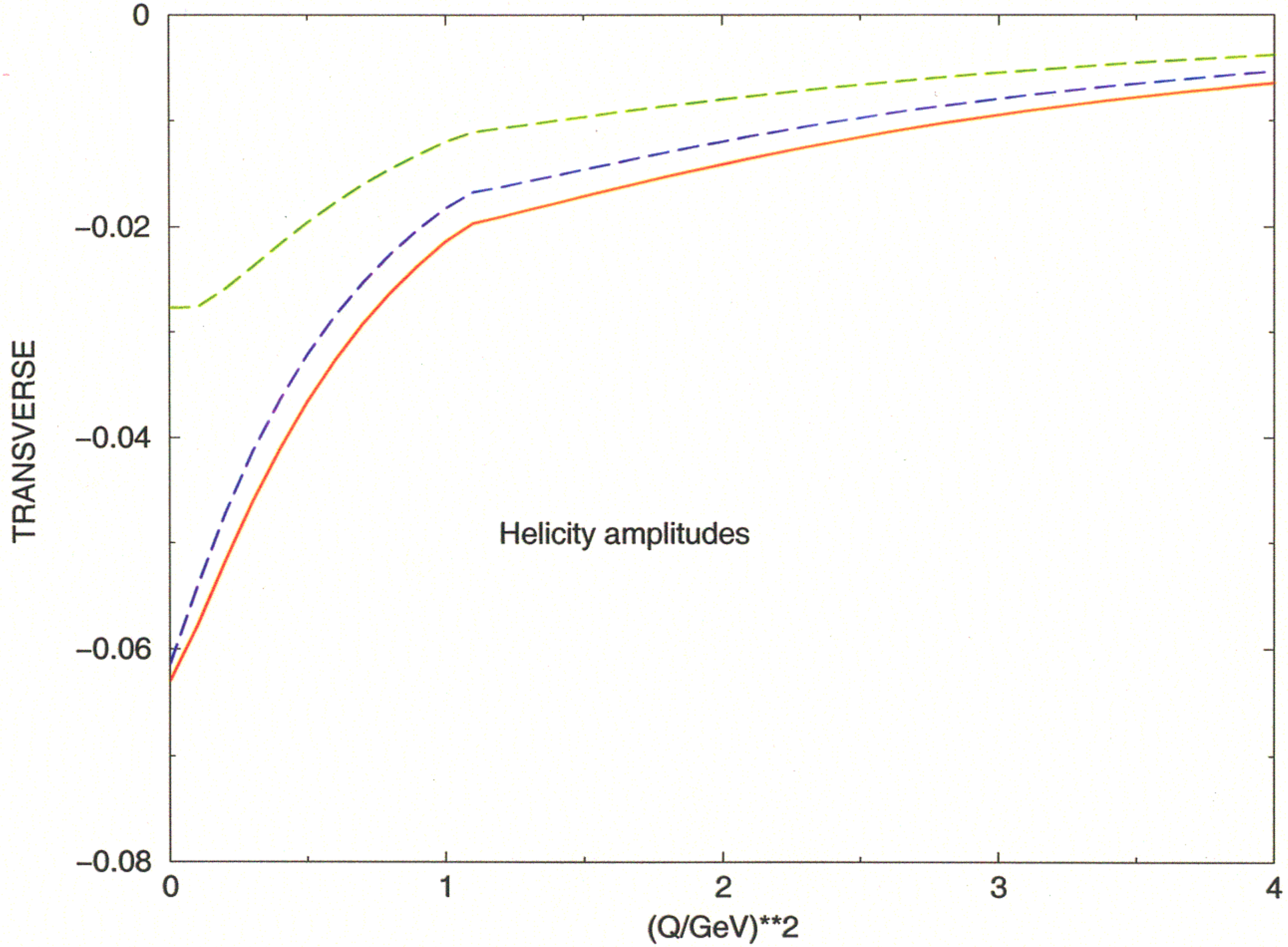


ESTIMATE:



ELECTROPRODUCTION

preliminary



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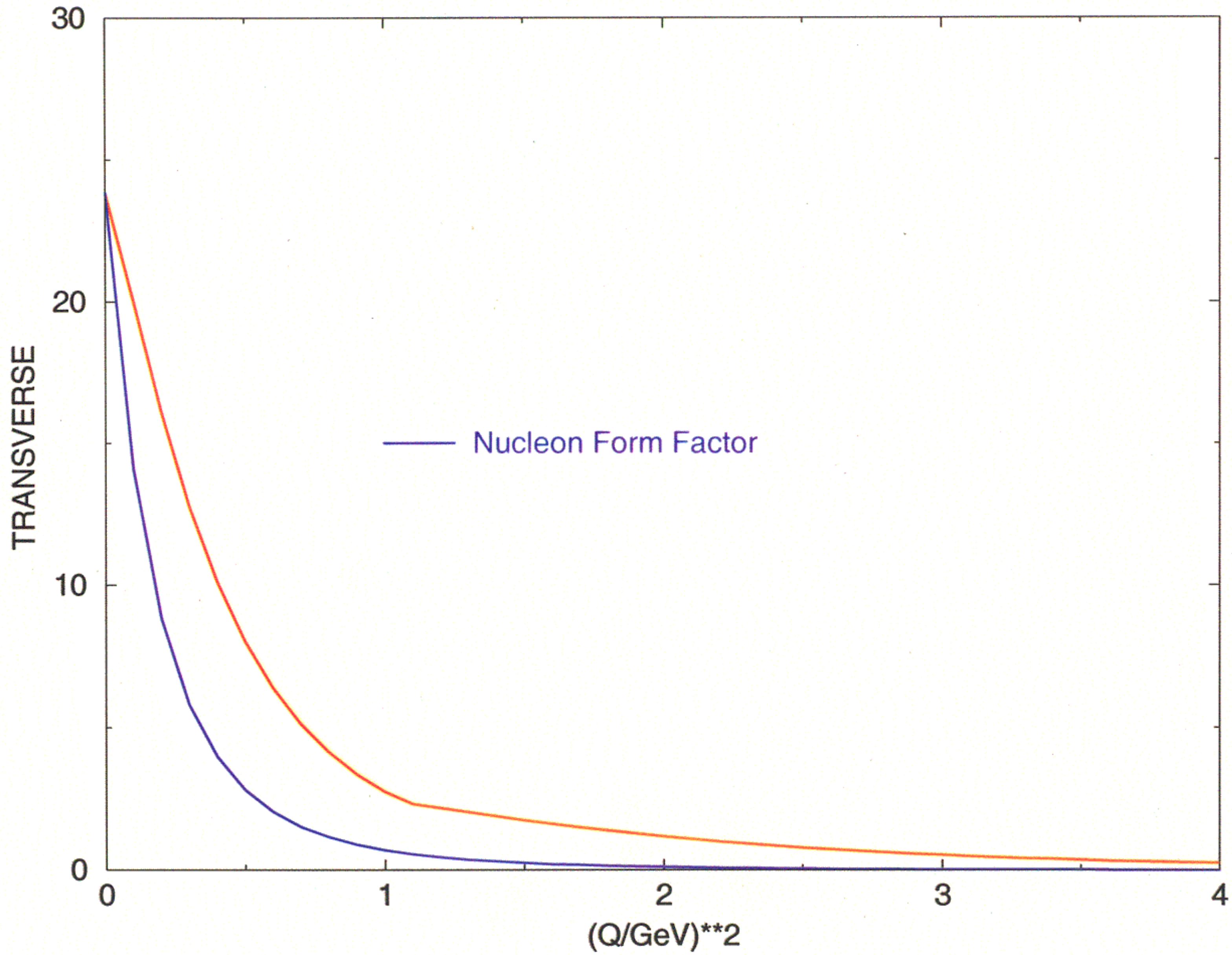
ELECTROPRODUCTION

preliminary



CONCLUSIONS

Roper $N^*(1440)$, $\frac{1}{2}^+$:

- Lattice: $N^*(1440) \neq |q^3\rangle$
- Meson-Nucleon Dynamics:

$$N^*(1440) = \sum |q^3 (q\bar{q})^2\rangle \oplus \ldots$$

- WASA-PROMICE:

$$N^*(1440) \longrightarrow N\pi\pi$$

→ CRYSTAL BALL

→ Photoproduction : MAINZ

→ Electroproduction: JLAB

- HELICITY AMPLITUDE

$$\sim F_{NN\gamma}(q^2) * \underset{\sim}{F}(q^2) \;\; ?$$

- Is there a zero in the helicity amplitude ??