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On behalf of the
H1 Collaboration

Measurement of density matrix elements for ρ meson electroproduction as a function of $|t|$

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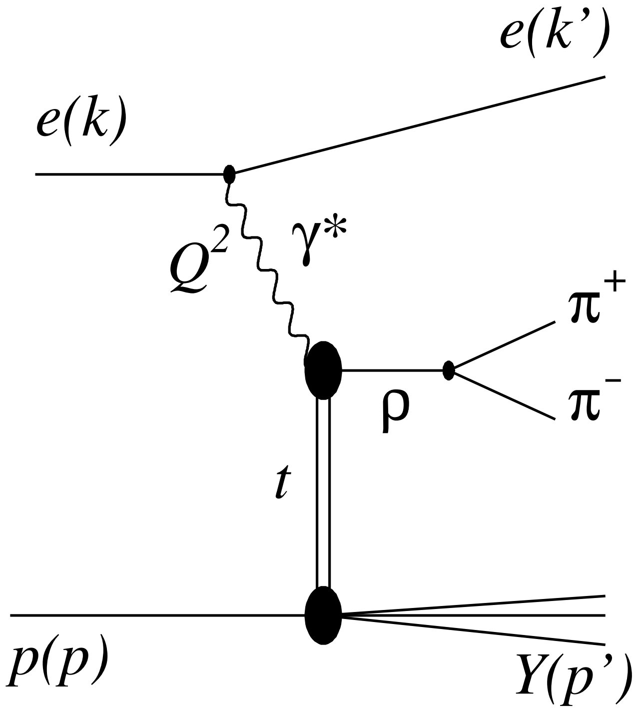
INTRODUCTION

Helicity structure of $\gamma^* \to \rho$ at large t'

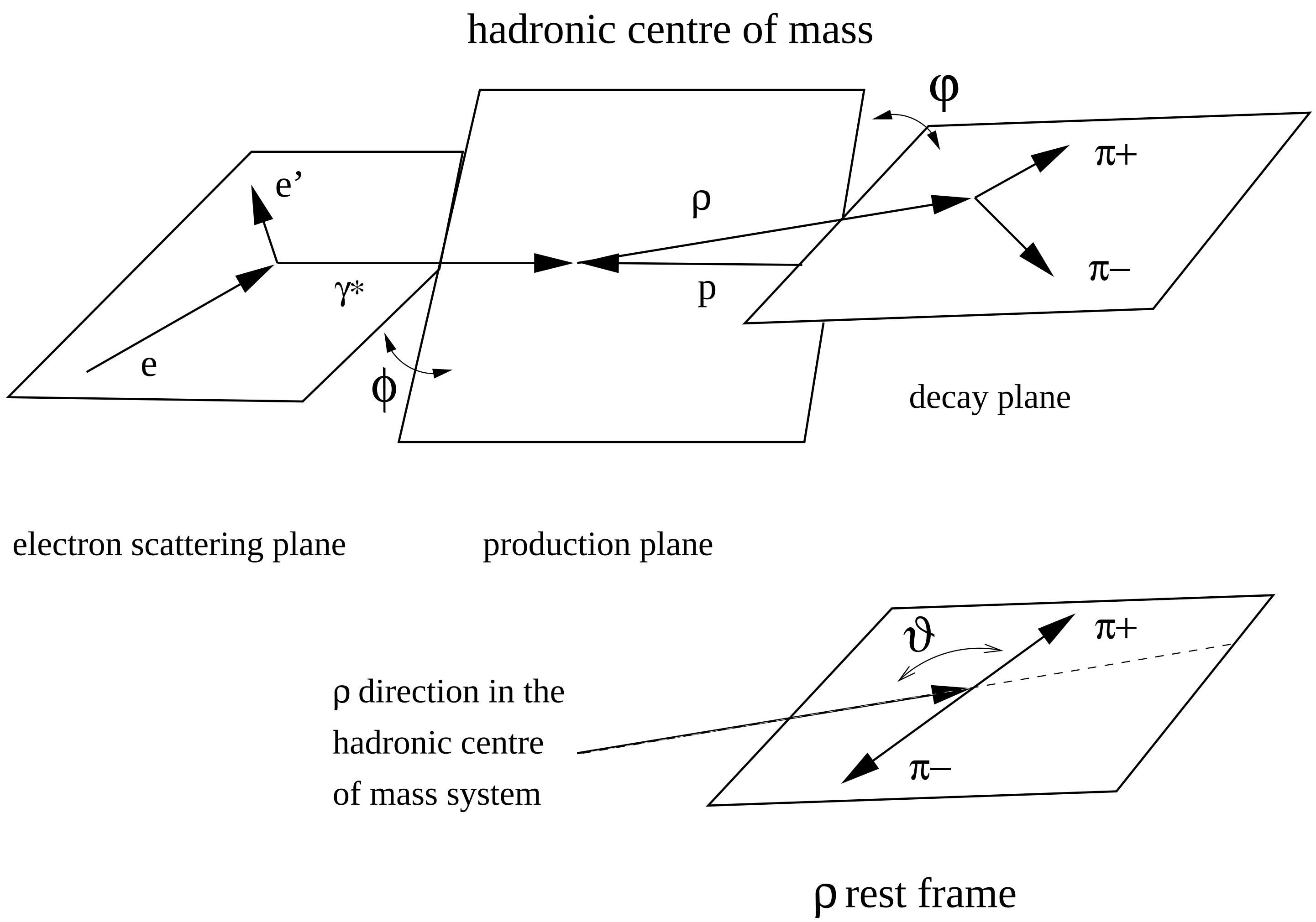
$$e + p \to e + \rho + Y$$

$$\rho \to \pi^+ + \pi^-$$



$$t' = |t| - |t_{min}| \simeq |P^T_{miss}|^2$$
$$\vec{P}^T_{miss} = \vec{P}^T_e + \vec{P}^T_{\pi^+} + \vec{P}^T_{\pi^-}$$

POLARISATION



$$\theta^* \ , \ \phi \ , \ \varphi \leftrightarrow \rho \ \text{Polarisation}$$

$$W(\cos\theta^*) \propto 1 - r^{04}_{00} + (3\ r^{04}_{00} - 1)\cos\theta^{*2}$$

$$W(\phi) \propto 1 + \sqrt{2\epsilon(1+\epsilon)}(r^5_{00} + 2r^5_{11})\cos\phi - \epsilon(r^1_{00} + 2r^1_{11})\cos 2\phi$$

DENSITY MATRIX ELEMENTS

Transition amplitudes:

No helicity flip

$$T_{00} : \gamma_L \to \rho_L$$
$$T_{11} : \gamma_T \to \rho_T$$

Single flip

$$T_{01} : \gamma_T \to \rho_L$$
$$T_{10} : \gamma_L \to \rho_T$$

Double flip

$$T_{1-1} : \gamma_T \to \rho_T$$

Relations (T purely imaginary):

$$r^{04}_{00} \propto \frac{|T_{00}|^2 + |T_{01}|^2}{N}$$

$$r^{5}_{00} \propto \frac{1}{N}(T_{00}\ T^{\dagger}_{01})$$

$$r^{5}_{11} \propto \frac{1}{N}(T_{11}\ T^{\dagger}_{10} - T_{10}\ T^{\dagger}_{1-1})$$

$$r^{1}_{00} \propto \frac{1}{N}|T_{01}|^2$$

$$r^{1}_{11} \propto \frac{1}{N}(T_{11}\ T^{\dagger}_{1-1})$$

$$N = \sum_{i,j} |T_{ij}|^2 \qquad i = \lambda_\rho, j = \lambda_\gamma \quad = -1, 0, 1$$

SCHC:

$$r^{04}_{00} \simeq \frac{|T_{00}|^2}{|T_{00}|^2 + |T_{11}|^2}$$

$$r^{5}_{00} \simeq 0, r^{5}_{11} \simeq 0, r^{1}_{00} \simeq 0, r^{1}_{11} \simeq 0$$

pQCD MODELS

- Ivanov and Kirschner hep-ph/9807324

applicable for $|t| < Q^2\ \gamma$
where γ : anomalous gluon density dimension
($\gamma \simeq 0.5$ - 0.7)

$\Rightarrow$ Hierarchy

$$|T_{00}| > |T_{11}| > |T_{01}| > |T_{10}| > |T_{1-1}|$$

$$r^1_{00} < 0,\ r^1_{11} > 0$$

$\Rightarrow$ t dependence

- no helicity flip : $T_{11} \propto T_{00}$
- single helicity flip : $T_{01},\ T_{10} \propto T_{00}\ \sqrt{t}$
- double helicity flip : $T_{1-1} \propto T_{00}\ t$

N.B.: p. dissociation expected to be similar to elastic
(Ivanov, pr. com.)

For other models, see
- Royen and Cudell hep-ph/0006044
- Kuraev, Nikolaev and Zakharov hep-ph/9809539

DATA SAMPLE

1997 data corresponding to a luminosity of 6 pb^{-1}

Selections based on the event topology in the H1 detector:

- 2 charged tracks $\rightarrow \pi^+ \pi^-$
- 1 electromagnetic cluster $\rightarrow$ e
- no additional cluster
- TAG : activity in forward detectors (PRT or FMD or forward LAr)
or NOTAG : empty forward detectors

Kinematical domain:

$$Q^2 > 2.5 \text{ GeV}^2$$

$$40 < W < 120 \text{ GeV}$$

$$0.5 < t^{'} < 3.0 \text{ GeV}^2$$

$$0.6 < M_{\pi\pi} < 1.1 \text{ GeV}$$

BACKGROUND

From small $t^{'}$:

$$e + p \rightarrow e + \pi^{+} + \pi^{-} + X^{0} + Y$$

X^0 not detected

$\Rightarrow$ mimicks large $t^{'}$

example :

• e + p $\rightarrow$ e + $\rho^{'}$ + Y

with $\rho^{'} \rightarrow \pi^{+} + \pi^{-} + \pi^{0} + \pi^{0}$

other processes:

• e + p $\rightarrow$ e + ω + Y with $\omega \rightarrow \pi^{+} + \pi^{-} + \pi^{0}$

• e + p $\rightarrow$ e + ϕ + Y with $\phi \rightarrow K_S + K_L$

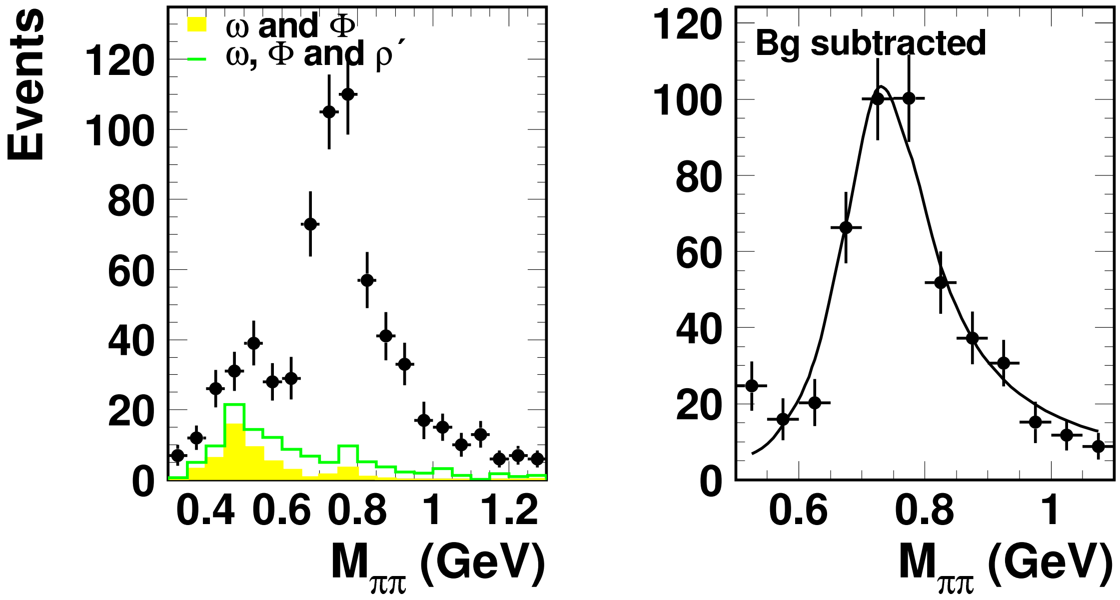
not important background because $M_{\pi\pi} < M_{\rho}$

BACKGROUND SUBTRACTION

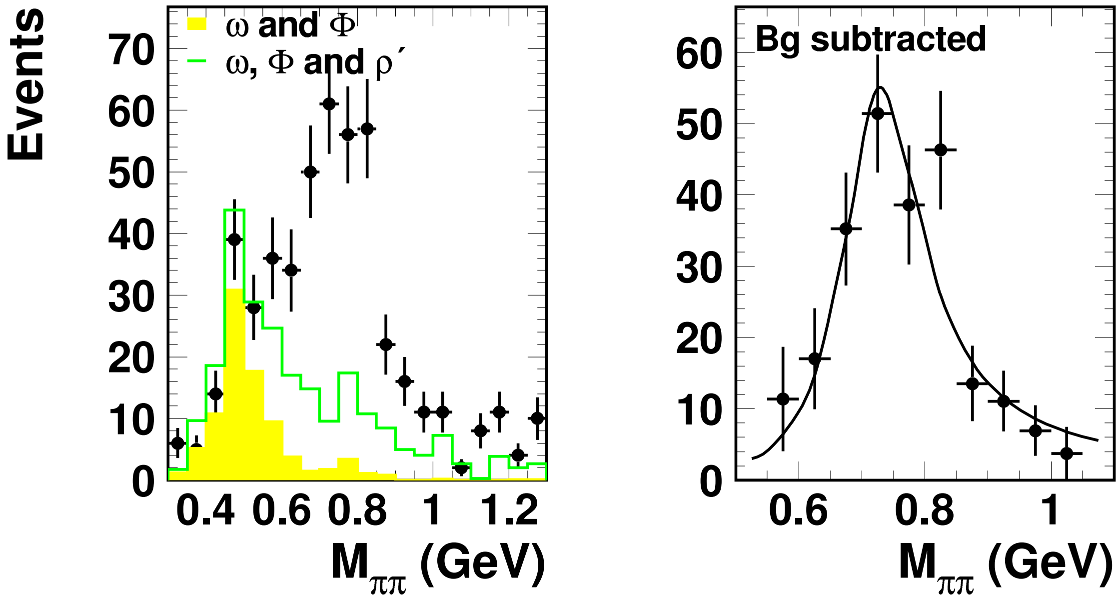
- ω and ϕ (from measurements)
- ρ' from fits of $\sharp$ events in different subsamples with contraints coming from Monte Carlo Simulations.

TAG events : p. diss. large t'
NOTAG events : elastic ρ' mimicking large t'

TAG EVENTS



NOTAG EVENTS

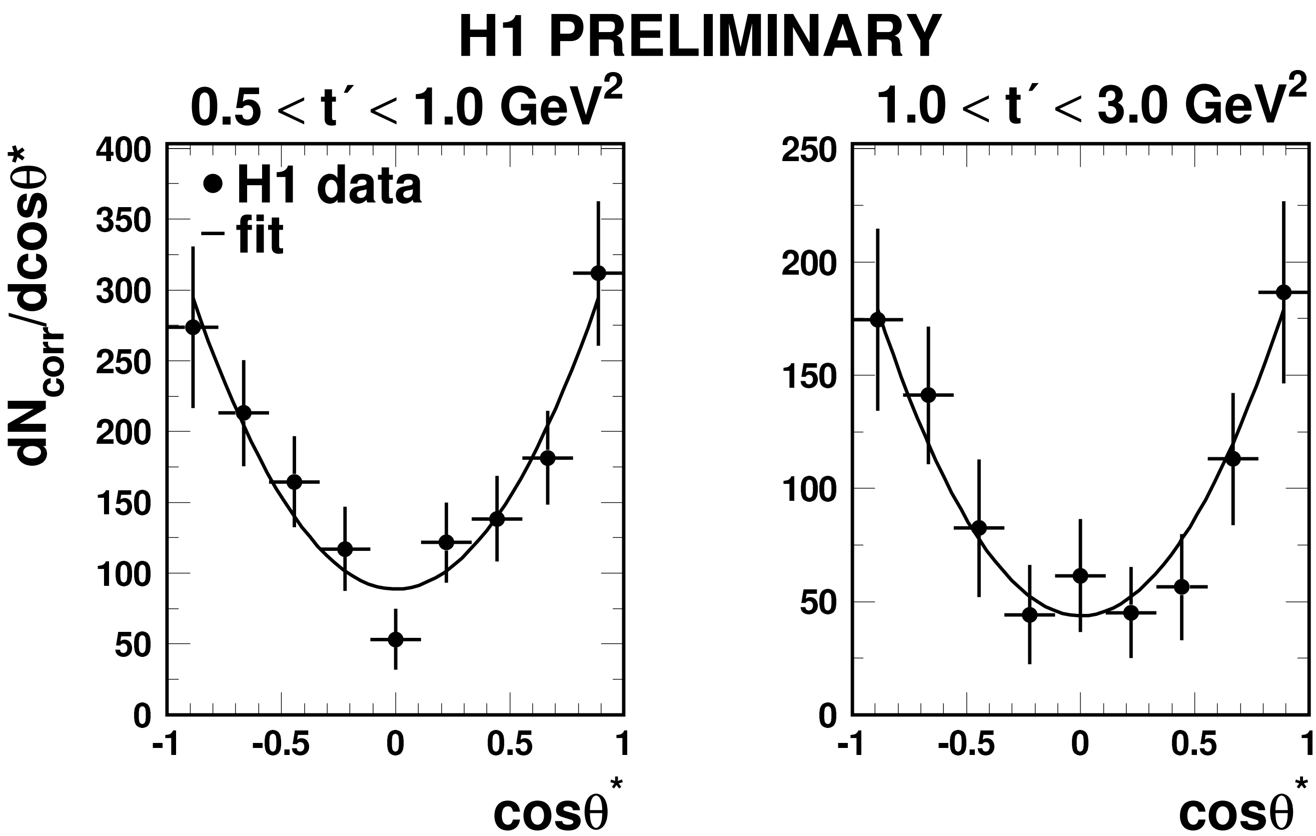


$\Rightarrow$ use only TAG sample (smaller background)

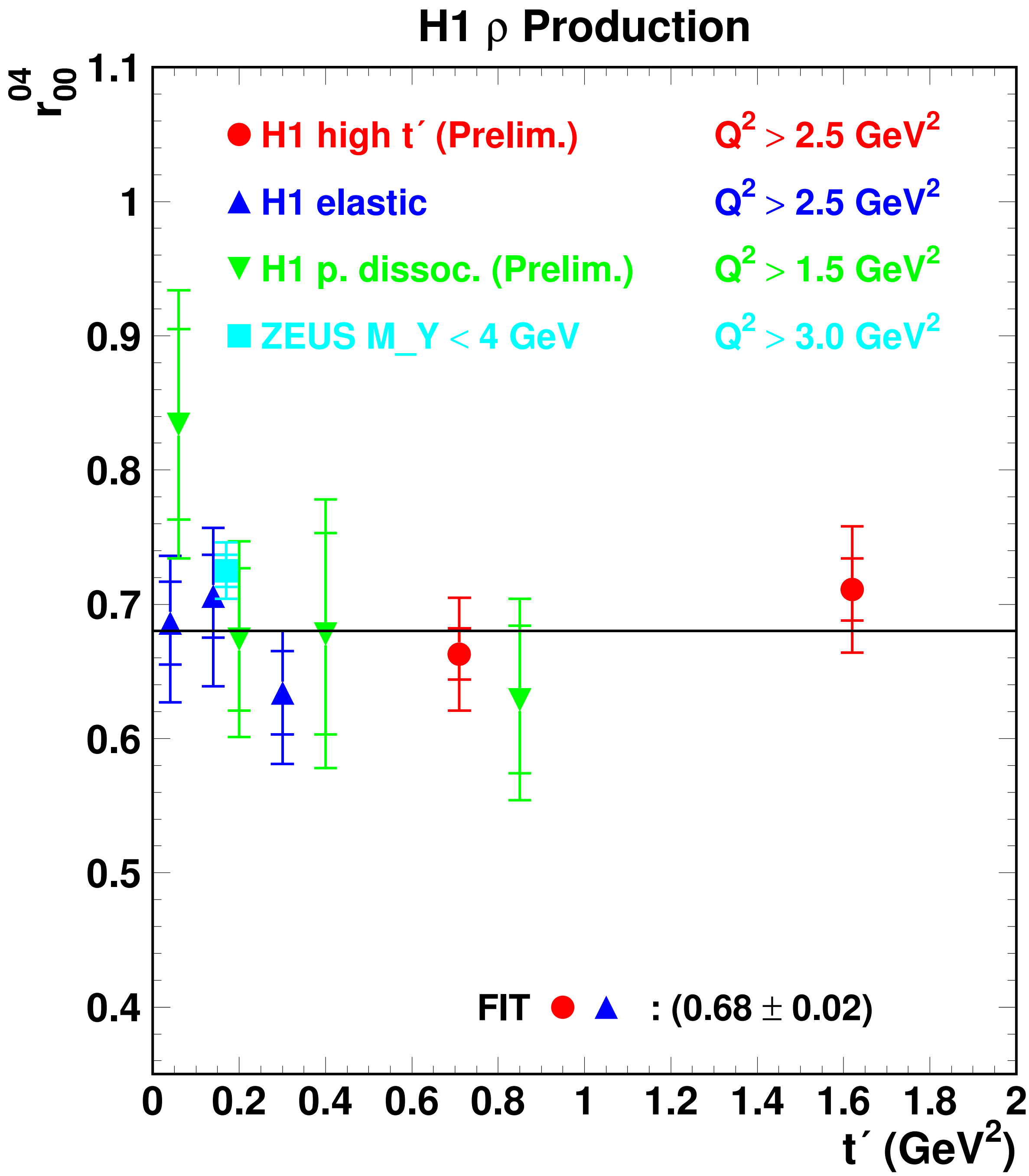
DENSITY MATRIX ELEMENTS

- flat background subtraction
- correction for acceptance and efficencies

$$W(\cos\theta^*) \propto 1 - r_{00}^{04} + (3\ r_{00}^{04} - 1)\cos\theta^{*2}$$



DENSITY MATRIX ELEMENTS



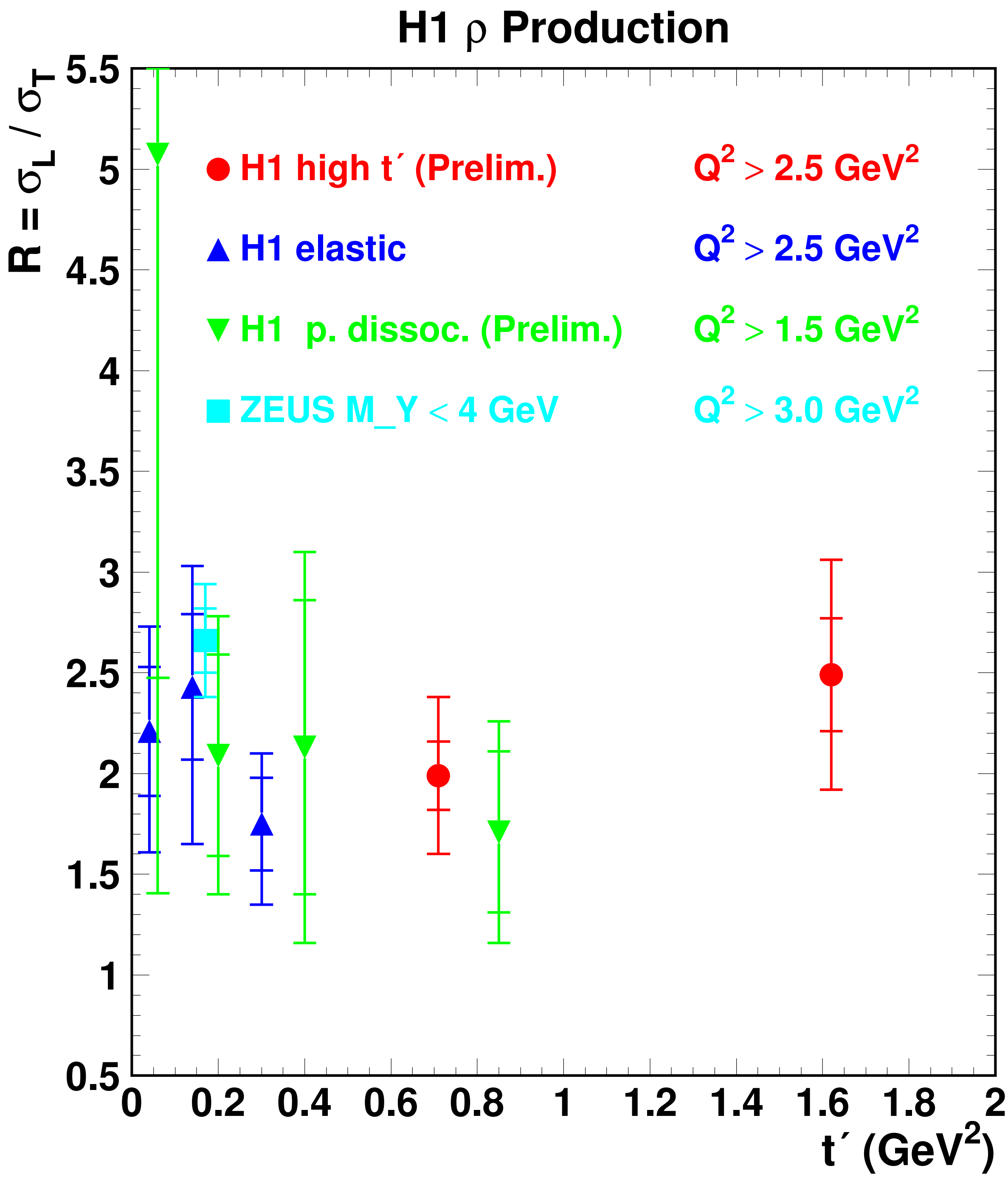
$$\chi^2_{\mathrm{fit/ndf}} = 0.38$$

$$r^{04}_{00} \simeq \frac{|T_{00}|^2 + |T_{01}|^2}{|T_{00}|^2 + |T_{11}|^2 + |T_{01}|^2}$$

No visible t' dependence, as expected

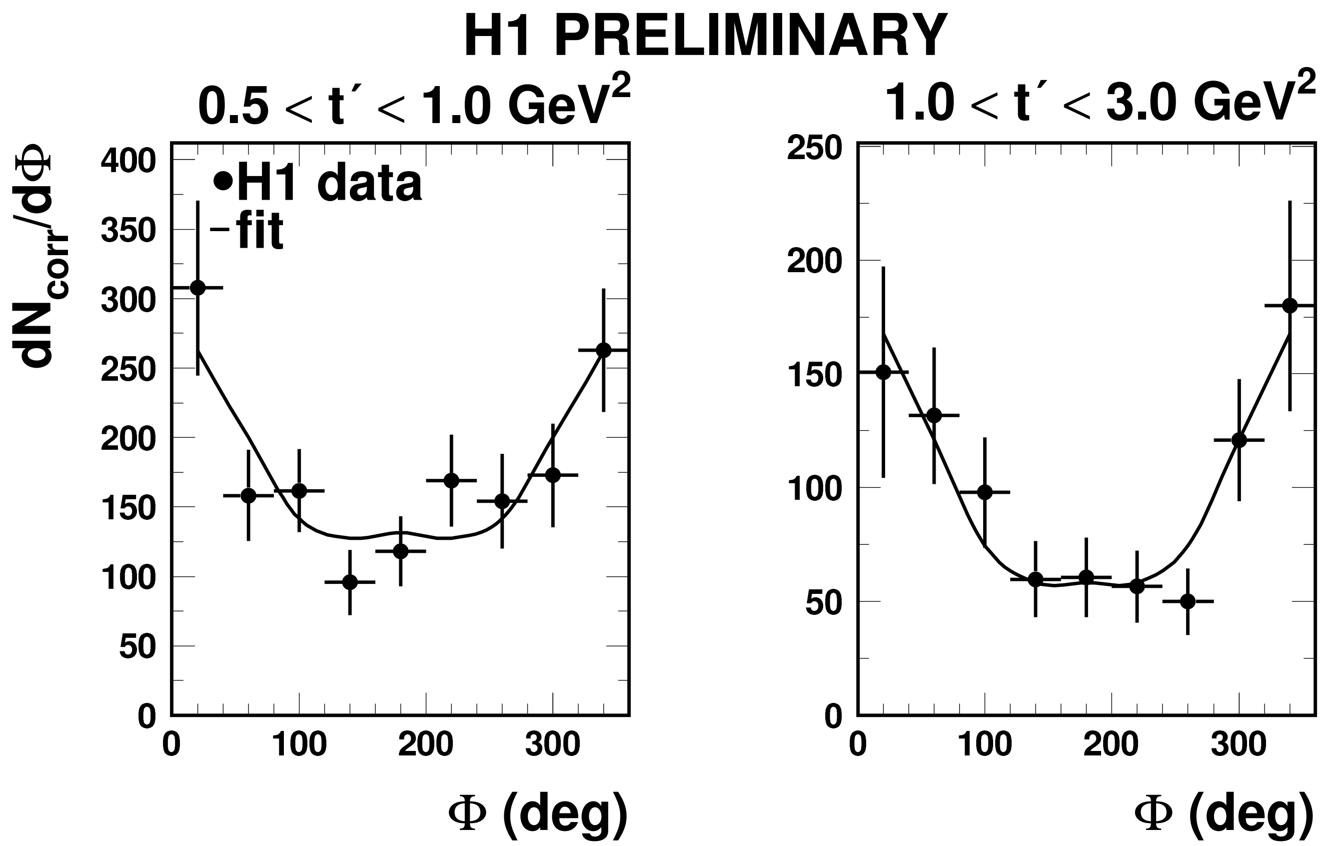
DENSITY MATRIX ELEMENTS

SCHC approximation: $R = \frac{1}{\epsilon}\frac{r^{04}_{00}}{1-r^{04}_{00}}$



No visible t' dependence

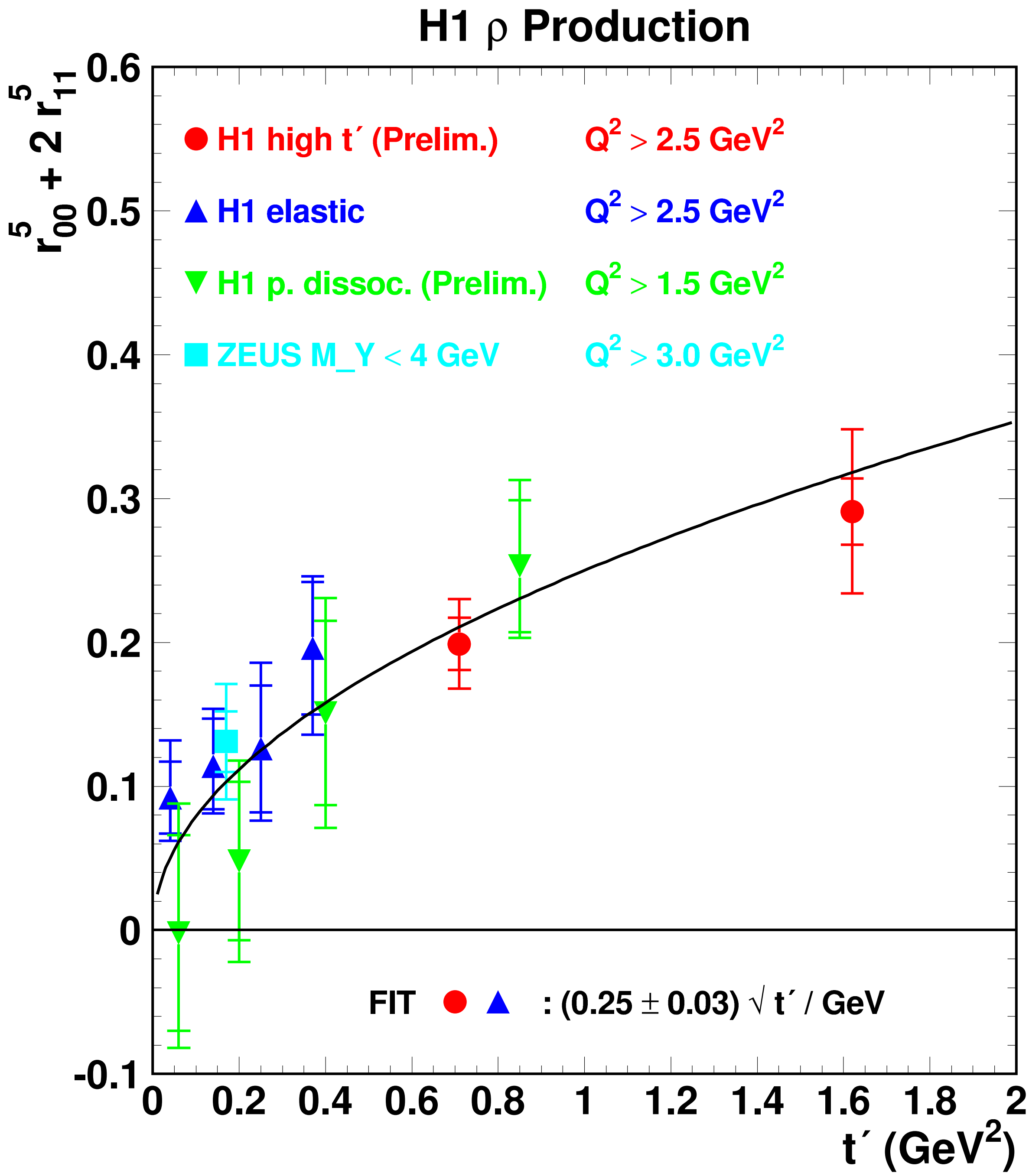
DENSITY MATRIX ELEMENTS



$$W(\phi) \propto 1+\sqrt{2\epsilon(1+\epsilon)}(r^5_{00}+2r^5_{11})\cos\phi-\epsilon(r^1_{00}+2r^1_{11})\cos 2\phi$$

DENSITY MATRIX ELEMENTS

Access to single helicity flip amplitudes



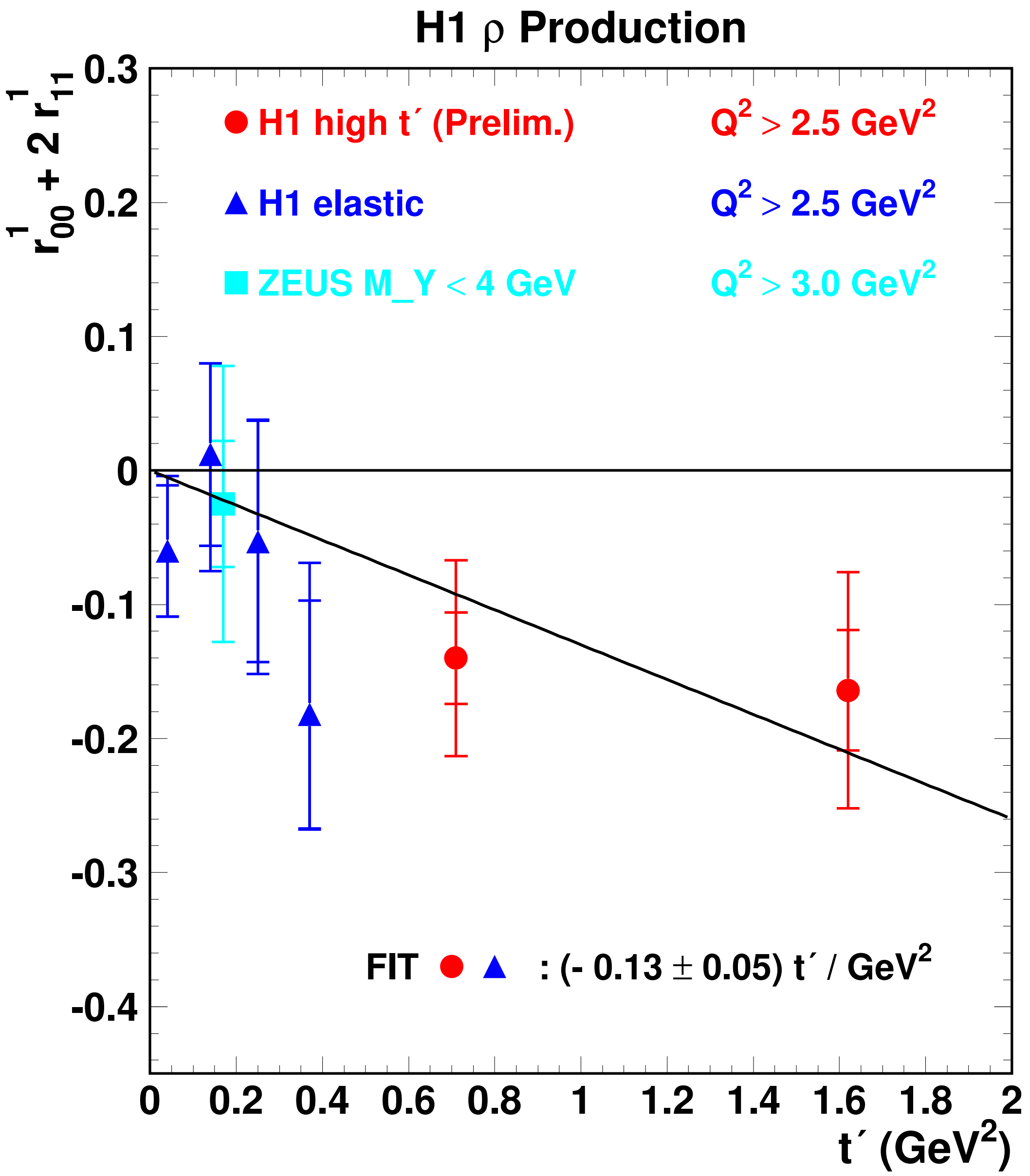
$$\chi^2_{\mathrm{fit/ndf}} = 0.45$$

$$r^5_{00} + 2r^5_{11} \propto \frac{1}{N}(T_{00}T^\dagger_{01} + 2\ T_{11}\ T^\dagger_{10} - 2\ T_{10}\ T^\dagger_{1-1})$$

T_{01} dominant single flip $\gamma_T \to \rho_L$

proportional to $\sqrt{t'}$, as expected

DENSITY MATRIX ELEMENTS



$\chi^2_{\mathrm{fit/ndf}} = 0.65$

Proportional to t' (large errors)

Expectations:

- $r^1_{00} \propto \frac{1}{N}|T_{01}|^2 \propto (\sqrt{t'})^2$ $\qquad$ (T_{01} = single flip)
- $r^1_{11} \propto \frac{1}{N}(T_{11}\ T^\dagger_{1-1}) \propto t'$ $\qquad$ (T_{1-1} = double flip)

$r^1_{00} < 0\ ,\ r^1_{11} > 0$ $\qquad \Rightarrow$ Hierarchy:

$$|T_{01}|^2 > 2\ T_{11}\ T^\dagger_{1-1}$$

CONCLUSIONS

Measurement in an extended t' range

$0.5 < t' < 3.0$ GeV^2 for $Q^2 > 2.5$ GeV^2, $40 < W < 120$ GeV

Hierarchy information about matrix amplitudes

$$|T_{00}| > |T_{11}| > |T_{01}| > (|T_{10}|, |T_{1-1}|)$$
$$|T_{01}|^2 > 2\ T_{11}\ T^{\dagger}_{1-1}$$

t' dependence

• no helicity flip amplitudes

r^{04}_{00} DME consistent with no t' dependence

$$\rightarrow T_{11} \propto T_{00}$$

• single helicity flip amplitude T_{01}

r^{5}_{00} DME consistent with $\propto \sqrt{t'}$ dependence

r^{1}_{00} DME consistent with $\propto t'$ dependence

$$\rightarrow T_{01} \propto T_{00}\sqrt{t'}$$

Agreement with pQCD calculations