DIS 2006

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A New Measurement of Exclusive ρ° Photoproduction at HERA

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for the H1 Collaboration

Kinematic Variables

Q^2 < 4 GeV², electron not detected

<Q^2> = 0.01 GeV²

$W = \sqrt{2E_p(E_\rho - p_{z,\rho})}$

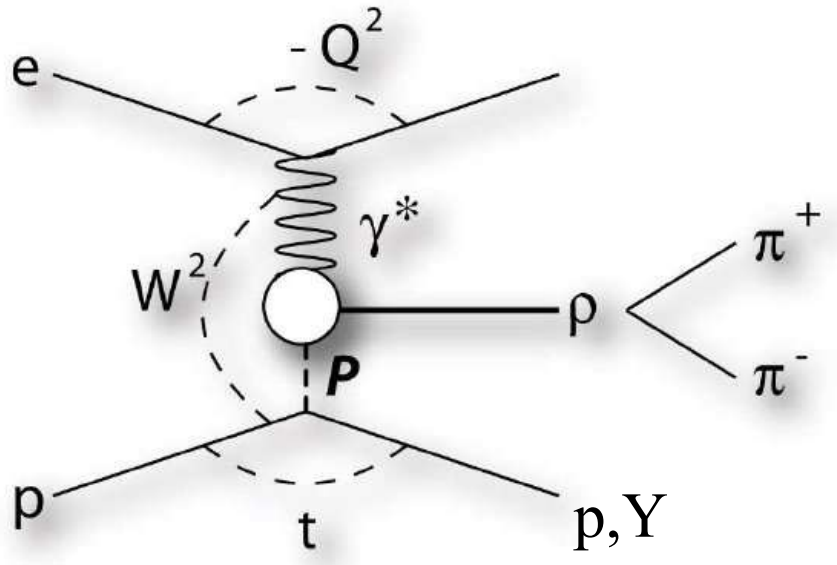
20 < W < 90 GeV

$t = -p^2_{t,\rho}$ |t| < 3 GeV²

M_Y : $(M_Y^2+Q^2)/(W^2+Q^2) < 0.01$

Cross Section Definition

Exclusive ρ° Photoproduction



- ρ° Photoproduction:
  a typical soft hadronic process
- Well described with
  VDM and Regge phenomenology

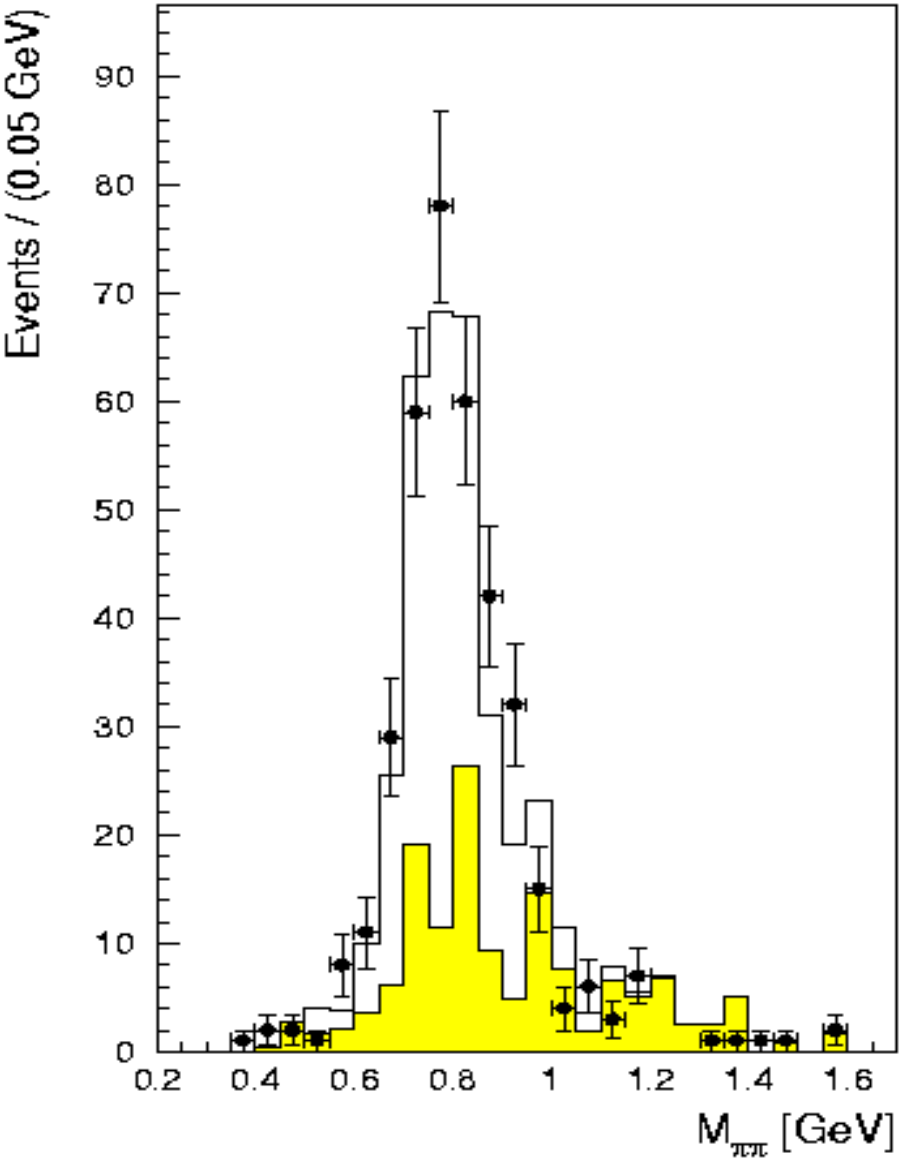
This reaction has been measured many times already.
Why do we need a new measurement?

Motivation

Last measurement from H1:

ρ° Photoproduction at low |t|,
1993 data, 358 events, 20 nb^{-1} !

Time for a New Measurement!



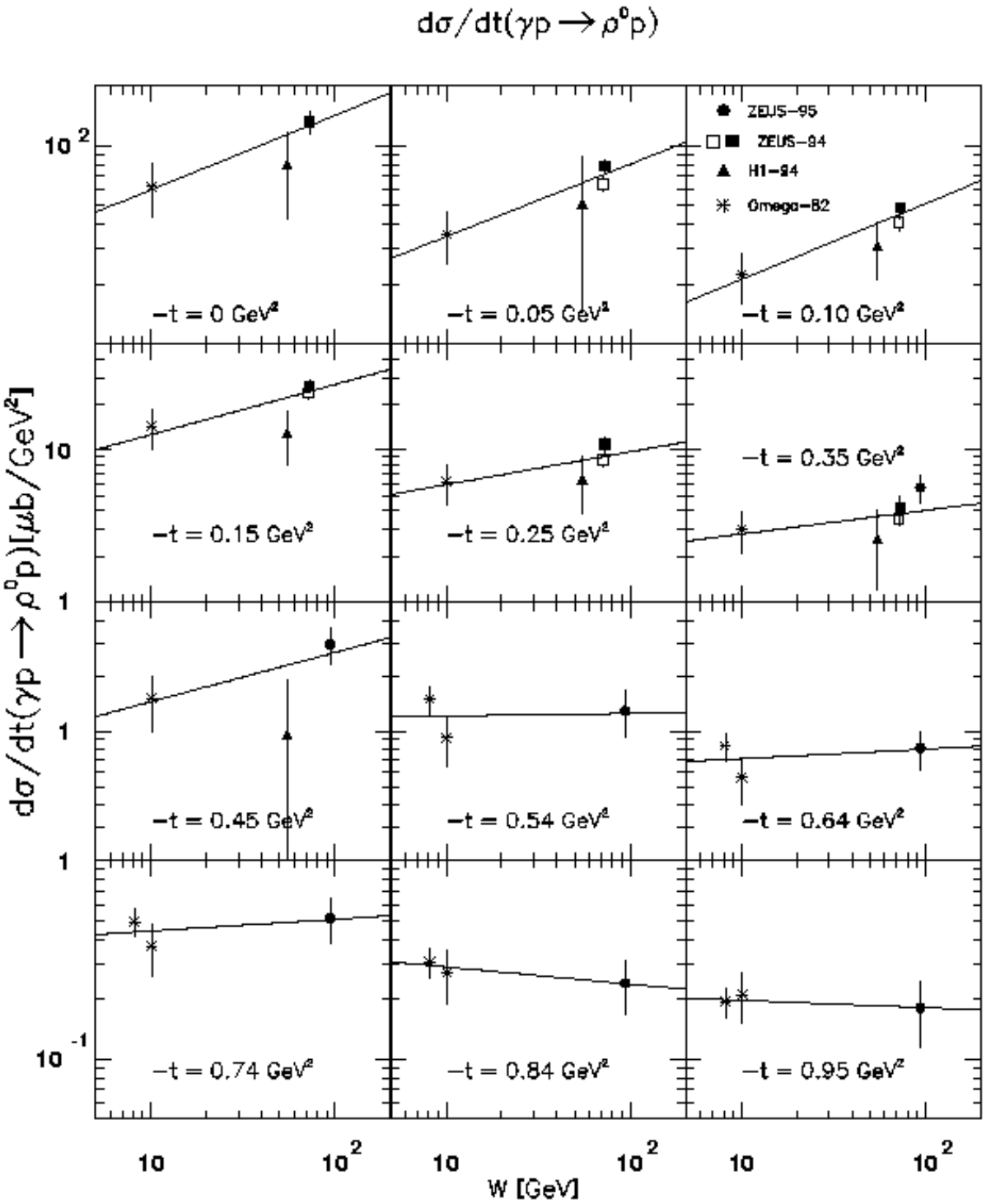
Motivation, cont.

ZEUS analysis from 1999

Combine HERA measurements with fixed target data at low W, extract the Pomeron Trajectory:

$$\frac{d\sigma^{\gamma P}}{dt} = \left.\frac{d\sigma^{\gamma P}}{dt}\right|_{W_0} \left(\frac{W}{W_0}\right)^{4[\alpha(t)-1]}$$

$$\alpha(t) = \alpha_0 + \alpha' \cdot t$$



Motivation, cont.

Surprise: $\alpha' = 0.125 \pm 0.038$ GeV^{-2}

The extracted Pomeron trajectory has a slope, which is different from the canonical value of 0.25 GeV^{-2}

(Donnachie and Landshoff, 1992)

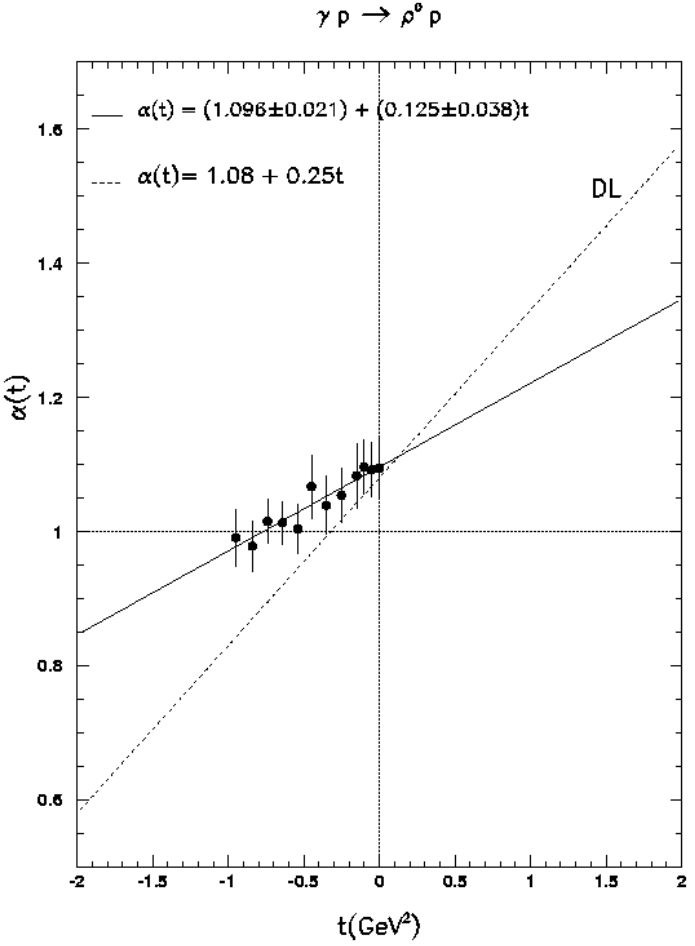
In an earlier analysis (ZEUS 97) the value $\mathbf{0.23 \pm 0.15}\ ^{+0.10}_{-0.07}$ GeV^{-2} was derived, using the low-t data at <W> = 72 GeV and the W-dependence $e^{b(W)t}$

$$b(W) = b(W_0) + 2\alpha'(W/W_0)^2$$

Warning (ZEUS 1995):

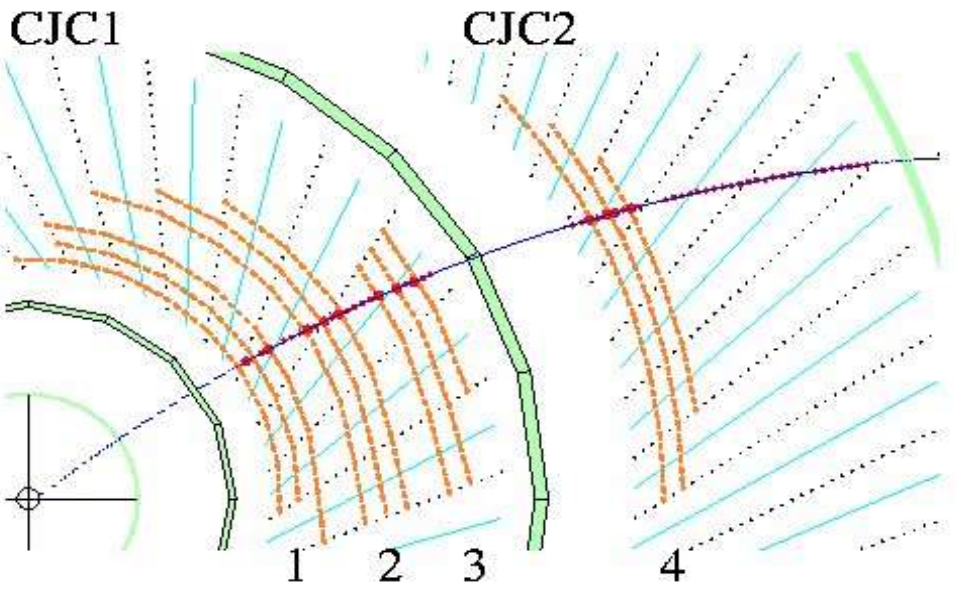
"There are however differences in the results obtained by individual experiments; these differences at least in part reflect the ambiguity in the definition of the rho production cross section due to the finite width of the rho.
The comparison between experiments ...should thus be taken with caution."

ZEUS, analysis from 1999



Clearly Needed:
Measure the Pomeron trajectory within one experiment!
However, this requires very large statistics

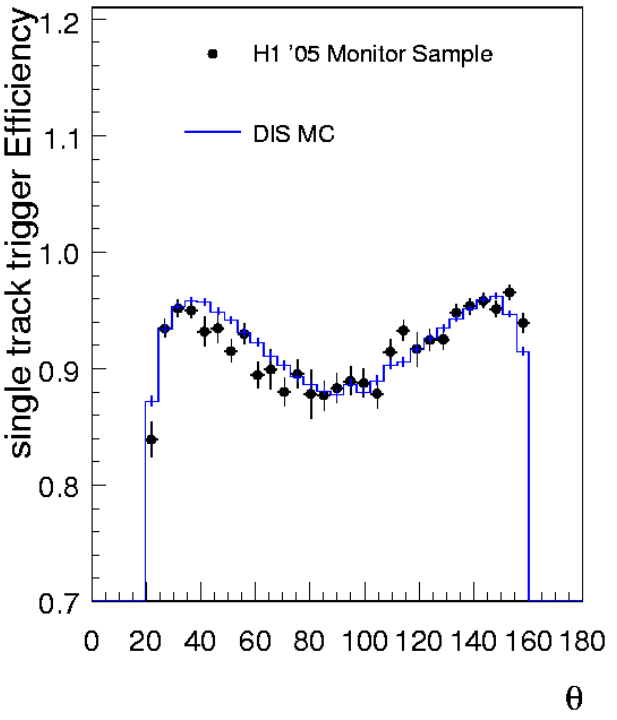
HERA-II data 2005

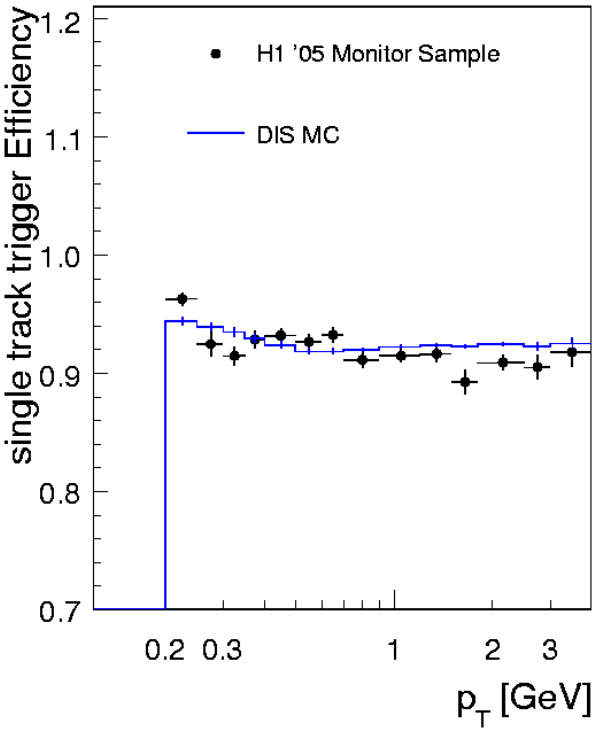


H1 Fast Track Trigger, FTT

- Trigger threshold: $p_t > 100$ MeV
- Allows selection on nr. of tracks
- Allows selection on total charge

- High efficiency, determined with DIS triggered Monitor sample



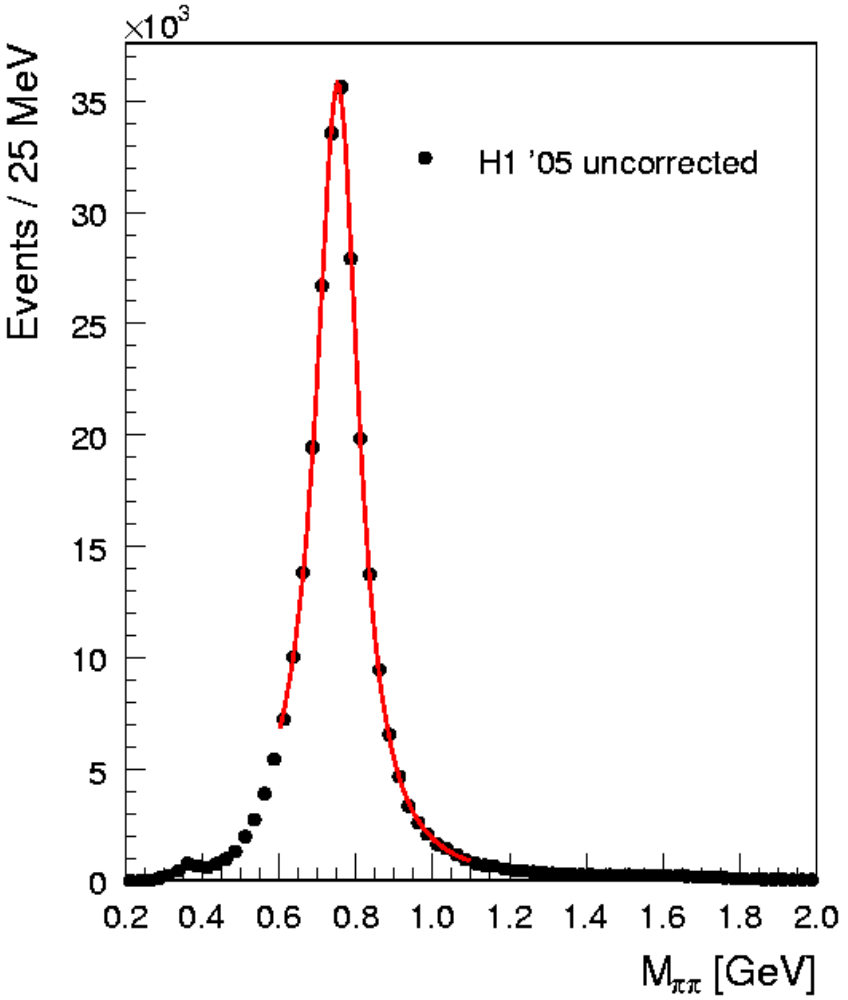


For this analysis:

- Clean 2-prong trigger, maximum 3 tracks
- Total charge between -1 and +1

Event Selection

570 nb^{-1} collected in 2005
1 Million triggered events,
267785 selected ρ° candidates



- Vertex within 25cm of nominal Int.Point
- 2 tracks, opposite charge
- track $p_t > 200$ MeV
- Theta of track in range $20° - 160°$
- No electron detected in calorimeters
- Unassociated calorimeter energy <500 MeV

DIFFVM MC Generator:

- Monte Carlo simulation of elastic and p-dissociative production of VM
- Produces events at all Q^2 and M_Y
- Signal events restricted to the kinematic region

$$Q^2 < 4\ \mathrm{GeV}^2\ , \quad (M_Y^2+Q^2)/(W^2+Q^2) < 0.01$$

otherwise treated as background

Backgrounds

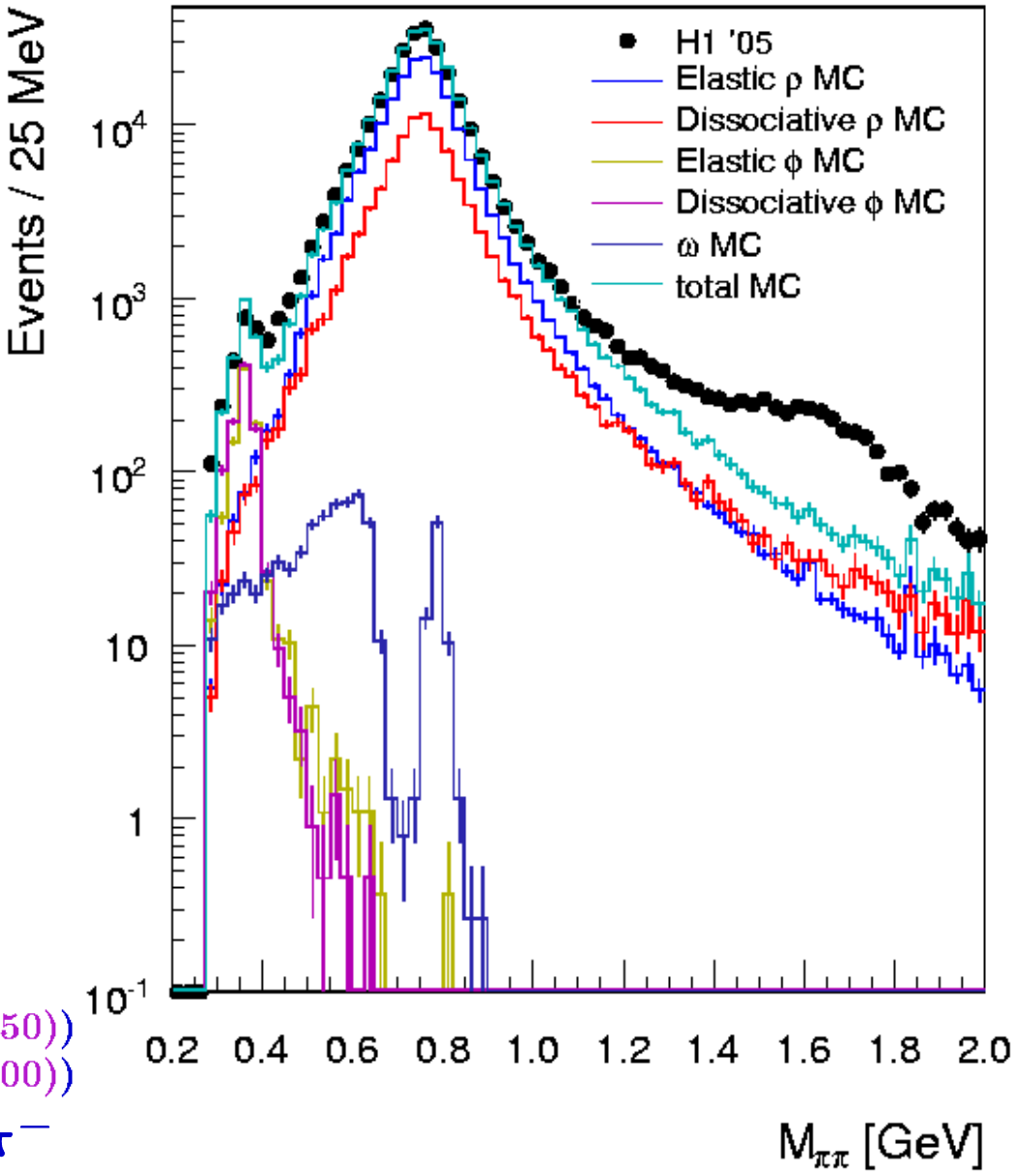
Mainly from other exclusive Vector Meson production:

$$\phi \rightarrow K^+K^-$$
$$\omega \rightarrow \pi^+\pi^-$$
$$\omega, \phi \rightarrow \pi^+\pi^-\pi^\circ$$

Rho' background:

$$\rho' \rightarrow \pi^+\pi^-\pi^\circ\pi^\circ$$

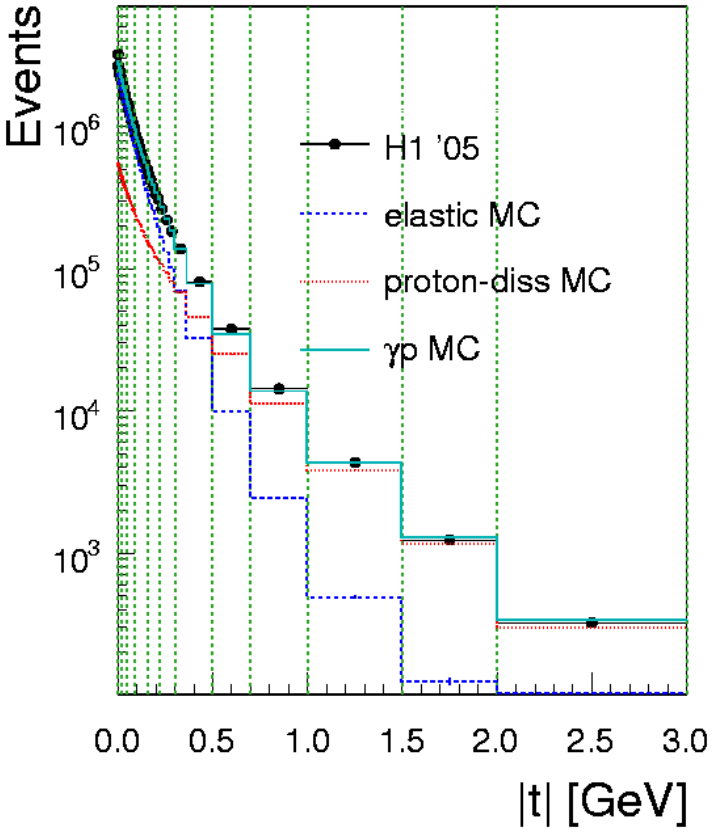
- $\rho' \rightarrow \pi^+\pi^-$ seen in the data
  <0.5% of $\rho^\circ \rightarrow \pi^+\pi^-$
- Crystal Barrel:
  $\mathrm{BR}(\rho' \rightarrow 4\pi)/\mathrm{BR}(\rho' \rightarrow 2\pi) = 0.37 \pm 0.10$ $(\rho'(1450))$
  $\mathrm{BR}(\rho' \rightarrow 4\pi)/\mathrm{BR}(\rho' \rightarrow 2\pi) = 0.16 \pm 0.04$ $(\rho'(1700))$
- $\rho' \rightarrow 4\pi$ dominated by $\rho' \rightarrow 2\pi^+2\pi^-$

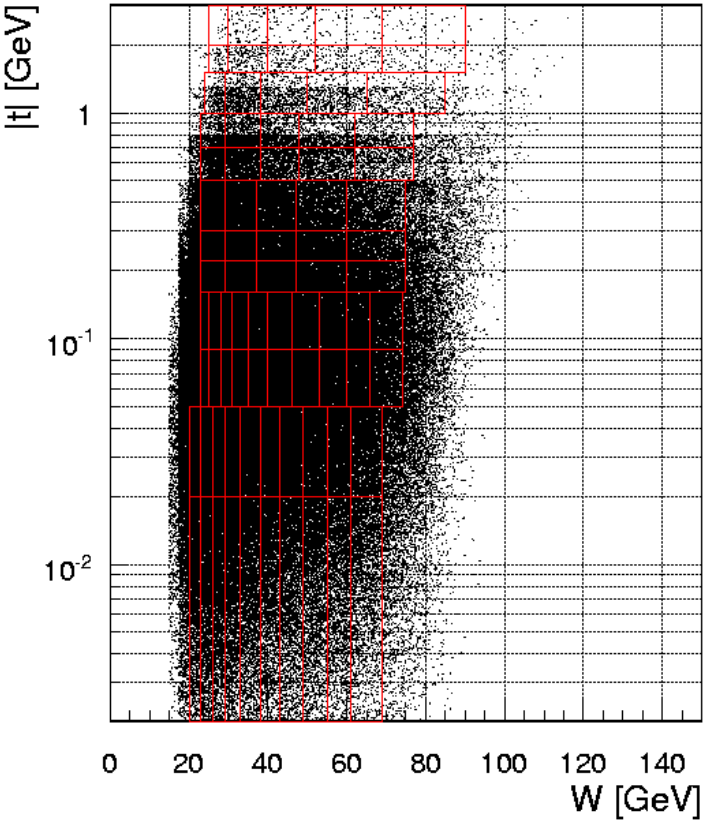


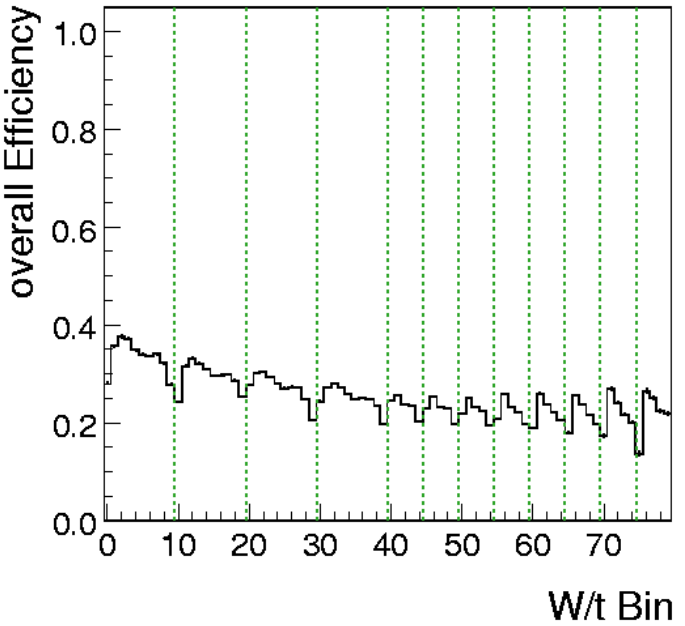
Altogether, <2% background from ρ', ω and ϕ

=> normalisation uncertainty in the final result

Binning in W and t







- 12 bins in |t|, 0 – 3 GeV²
- 5 to 10 bins in W, depending on t-value
- 80 "W/t"-bins
- Average total efficiency: 20-35%

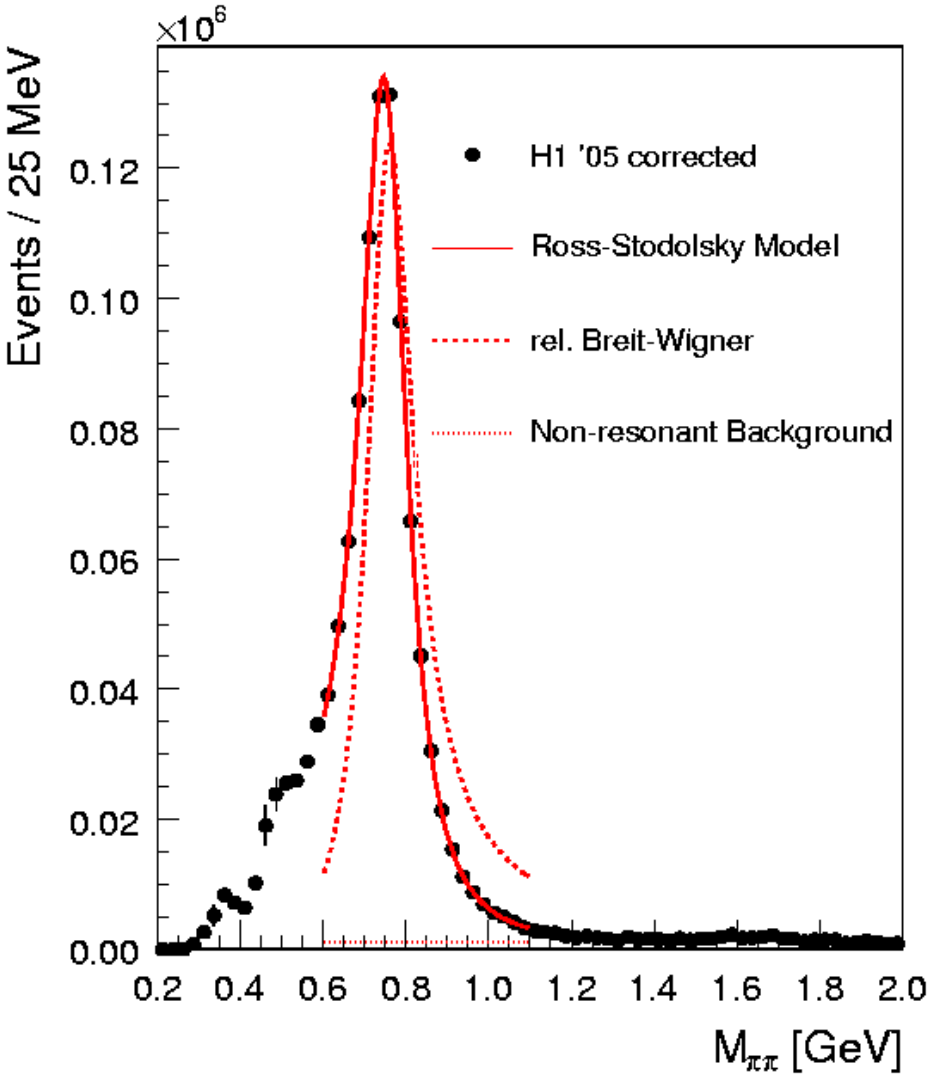
Corrected Mass Distribution

- Mass distribution distorted, due to non-resonant $\pi^+\pi^-$ production

- Fit with rel. Breit-Wigner, including a skewing factor (Ross-Stodolsky)

$$\frac{dN}{dm_{\pi\pi}} = N_0 \frac{m_\rho \Gamma_\rho m_{\pi\pi}}{(m_\rho^2 - m_{\pi\pi}^2)^2 + m_\rho^2 \Gamma_\rho^2} \left(\frac{m_\rho}{m_{\pi\pi}}\right)^n + B$$

$$\Gamma_\rho = \Gamma_{\rho,0} \left(\frac{m_{\pi\pi}^2 - 4m_\pi^2}{m_\rho^2 - 4m_\pi^2}\right)^{\frac{3}{2}} \frac{m_\rho}{m_{\pi\pi}}$$



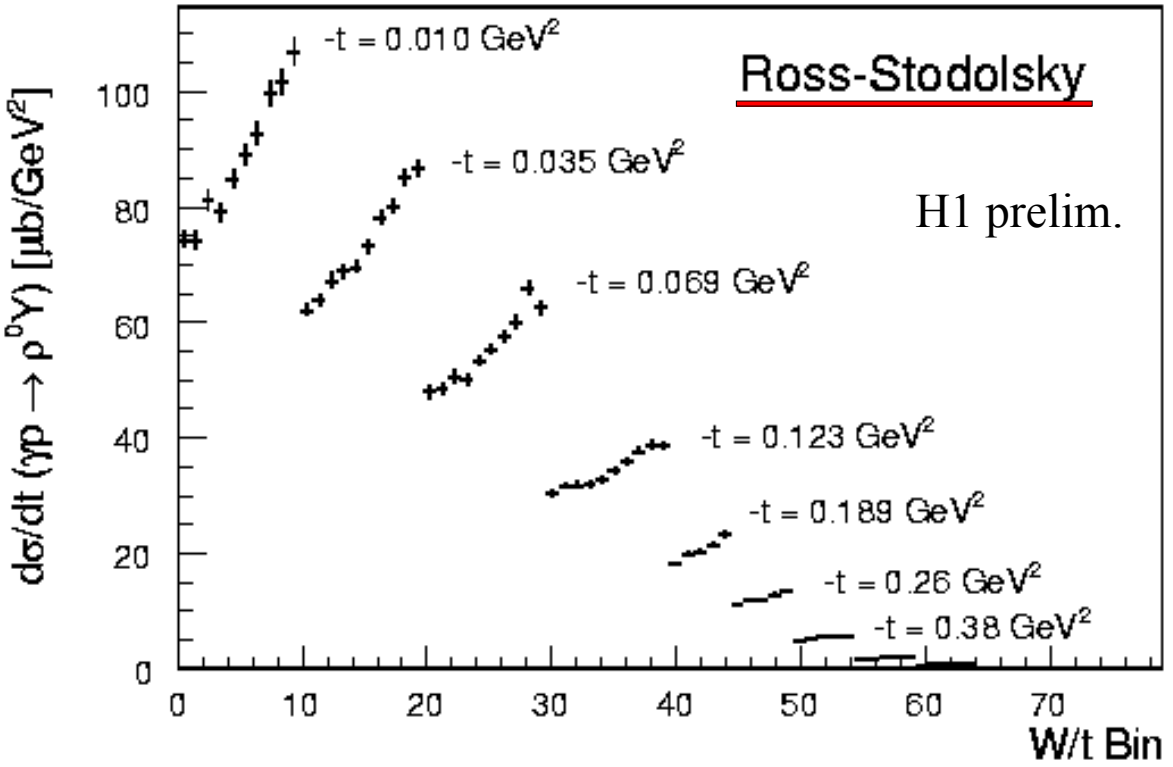
- In each "W/t"-bin, perform the fit and fix the mass and width of ρ° to the average values as obtained from fits in all W/t bins

Average : $m_\rho = 766.4\text{MeV}$ $\Gamma_\rho = 145\text{MeV}$
PDG : $m_{\rho,0} = 768.5\text{MeV}$ $\Gamma_{\rho,0} = 150 \pm 3\text{MeV}$

- N_{cor} gives the number ρ° in each bin, after integrating over the BW

$$N_{\text{cor}} = N_0 \int_{m_{\pi\pi}=2m_\pi}^{m_{\rho,0}+5\Gamma_{\rho,0}} \frac{m_\rho \Gamma_\rho m_{\pi\pi}}{(m_\rho^2 - m_{\pi\pi}^2)^2 + m_\rho^2 \Gamma_\rho^2} dm_{\pi\pi}$$

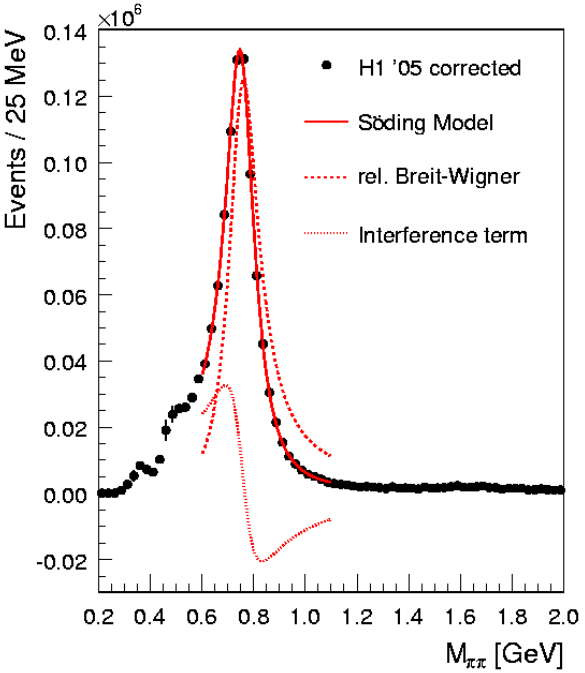
Cross Sections

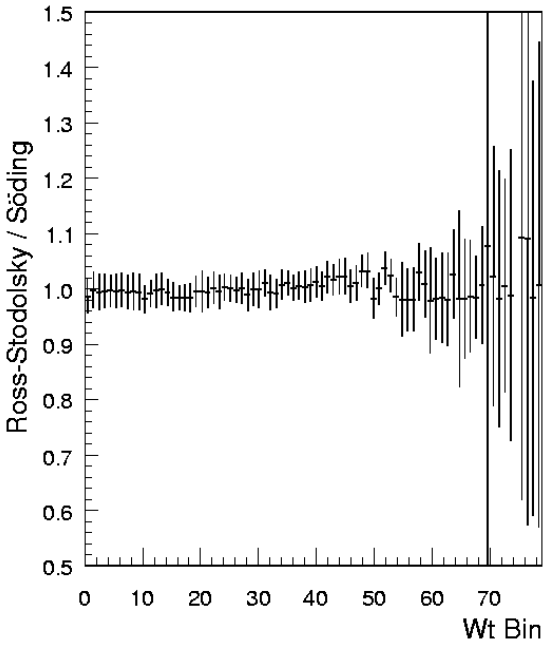


Obtained using the
Ross-Stodolsky fit results

Alternative fit,
using the Söding model

$$\frac{dN}{dm_{\pi\pi}} = \frac{N_0 m_\rho \Gamma_\rho m_{\pi\pi} + I(m_\rho^2 - m_{\pi\pi}^2)}{(m_\rho^2 - m_{\pi\pi}^2)^2 + m_\rho^2 \Gamma_\rho^2} + B$$





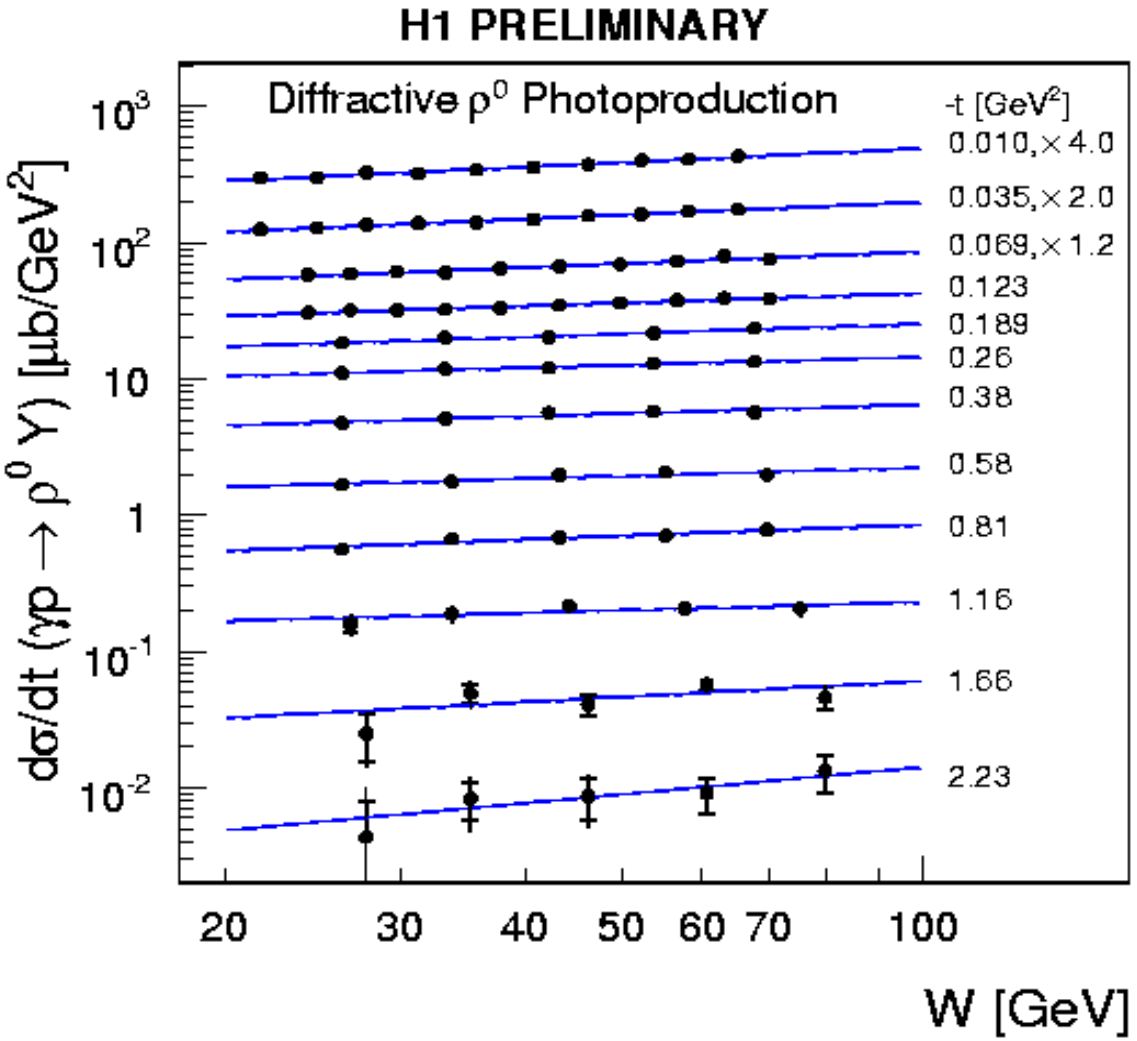
Ratio of Cross Sections shows:
results fully compatible

The Diffractive ρ° Photoproduction Cross Section

Kinematic region:

$$Q^2 < 4 \text{ GeV}^2$$

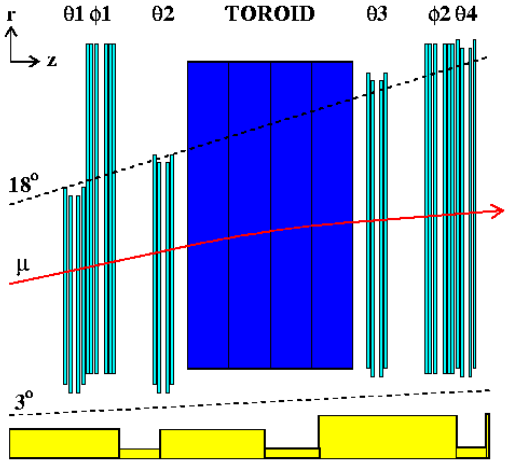
$$(M_Y^2+Q^2)/(W^2+Q^2) < 0.01$$



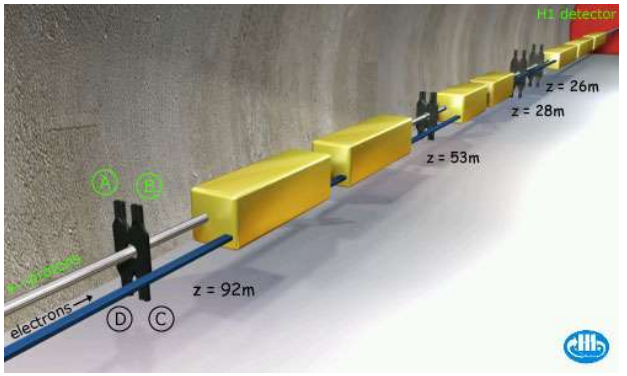
Cross Sections include both elastic and proton-dissociative components!

Elastic and p-Dissociative Cross Sections

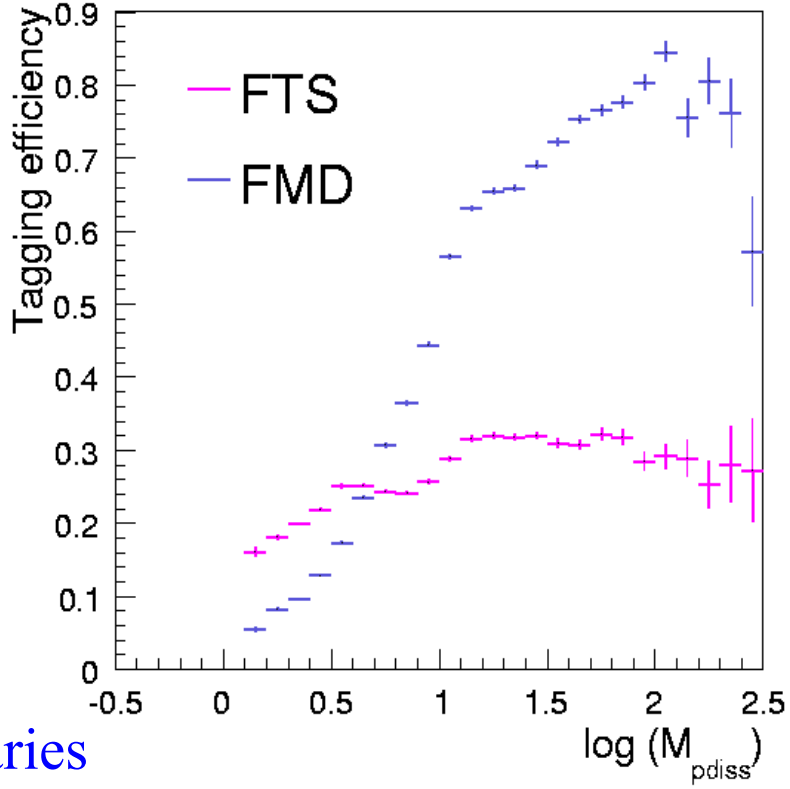
To separate the Elastic from the proton-Dissociative events,
use additional subdetectors in the forward direction:



Forward Muon Detector, FMD



Forward Tagging Scintillators, FTS
use FTS26, FTS28



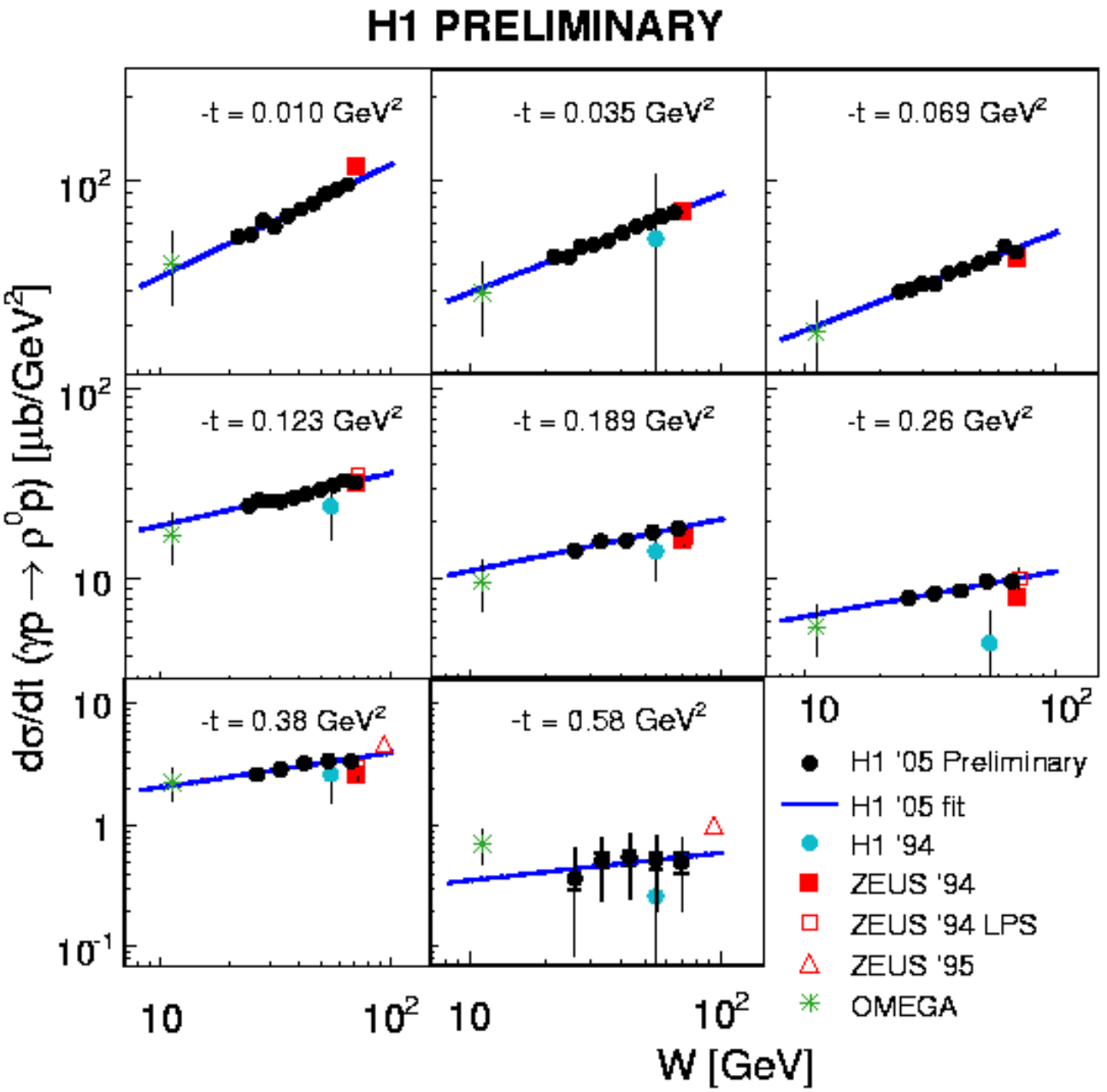
- The p-dissociative system generates secondary particles, which cause hits in these detectors
- Also elastic protons at large |t| can generate secondaries
- Use MC simulation and real data to determine the elastic and p-dissociative fractions in each W/t bin
- $\epsilon_{pd}, \epsilon_{el}$ are the tagging efficiencies (depend on t)

$$f_{tag} = \frac{N_{tag}}{N_{tag}+N_{untag}} \qquad N_{el} = N_{cor}\frac{\epsilon_{pd}-f_{tag}}{\epsilon_{pd}-\epsilon_{el}}$$

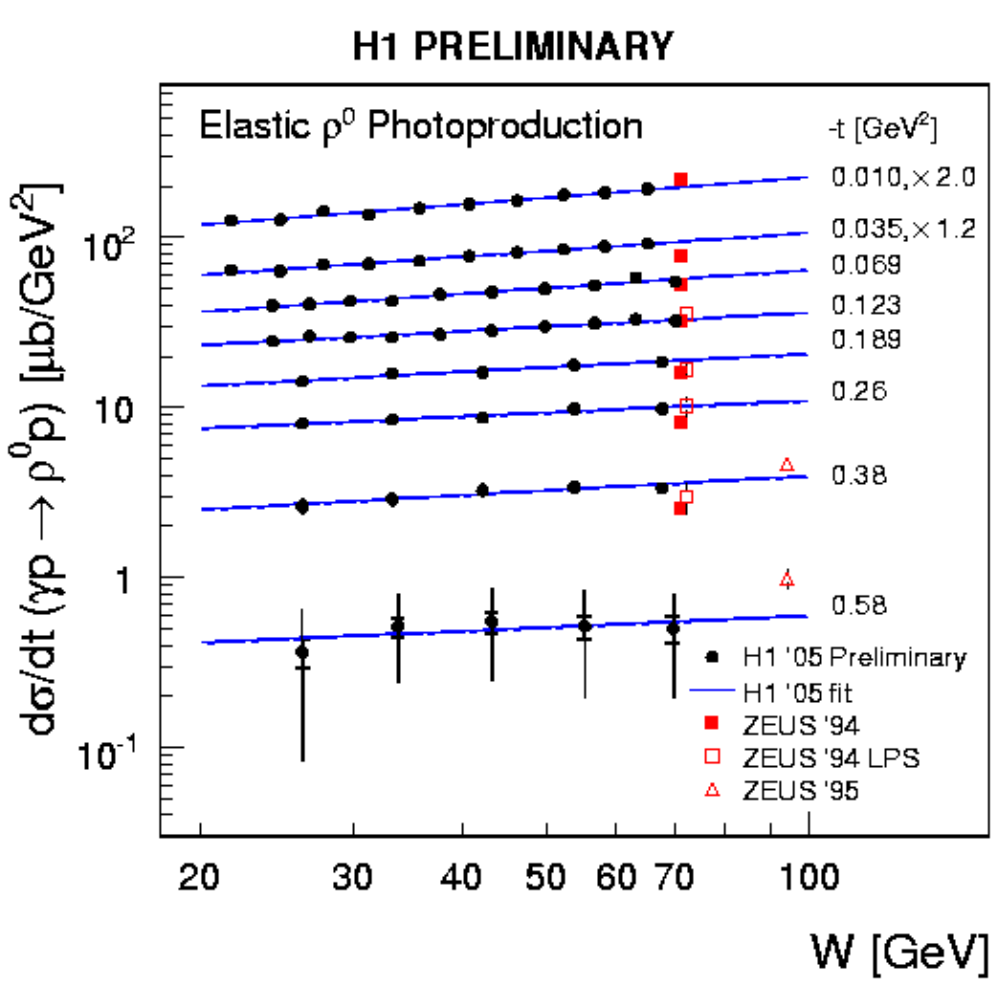
The Elastic ρ° Photoproduction Cross section

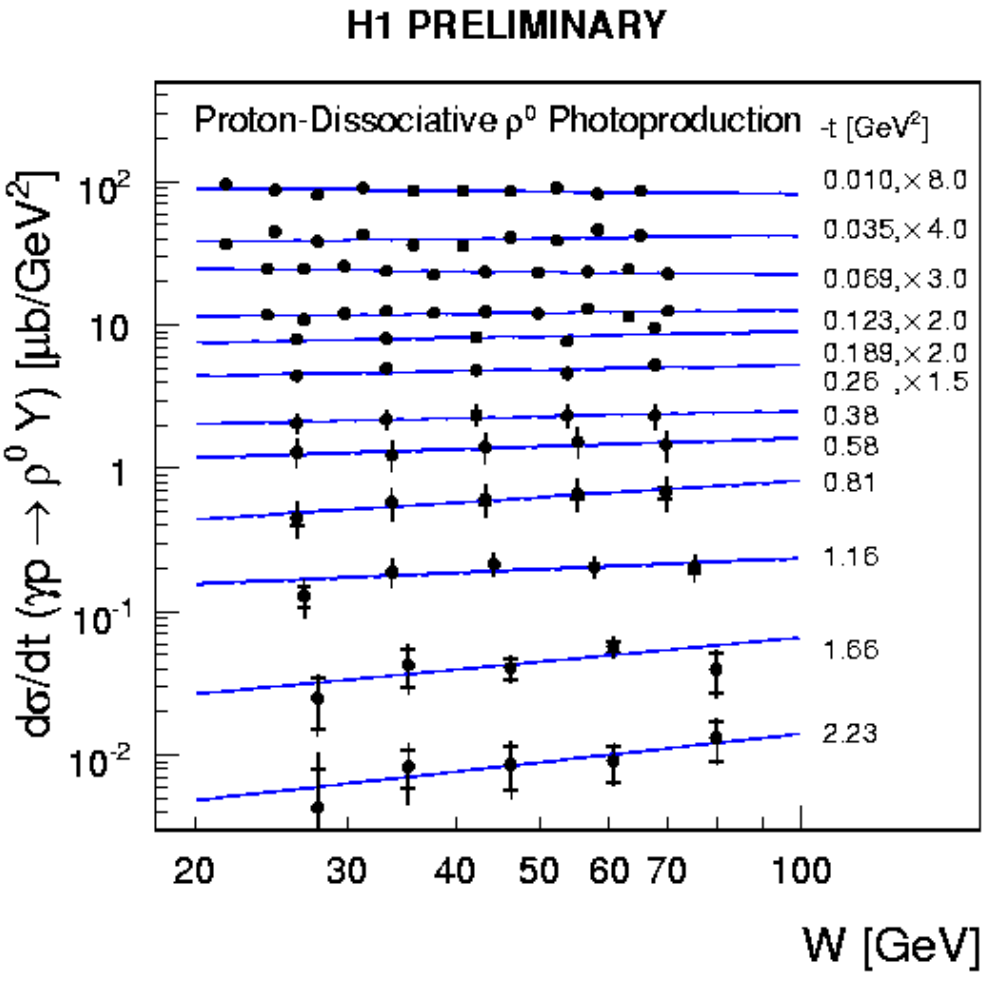
Good agreement with previous results from H1, ZEUS and OMEGA

Note:
Extrapolation of H1 fit



Elastic and p-Dissociative Cross Sections





Using only H1 data, fit the form:

$$\frac{d\sigma^{\gamma P}}{dt} = \frac{d\sigma^{\gamma P}}{dt}\Big|_{W_0} \left(\frac{W}{W_0}\right)^{4[\alpha(t)-1]}$$

p-dissociative cross section in range

$$(M_Y^2+Q^2)/(W^2+Q^2) \; < \; 0.01$$

Pomeron Trajectory

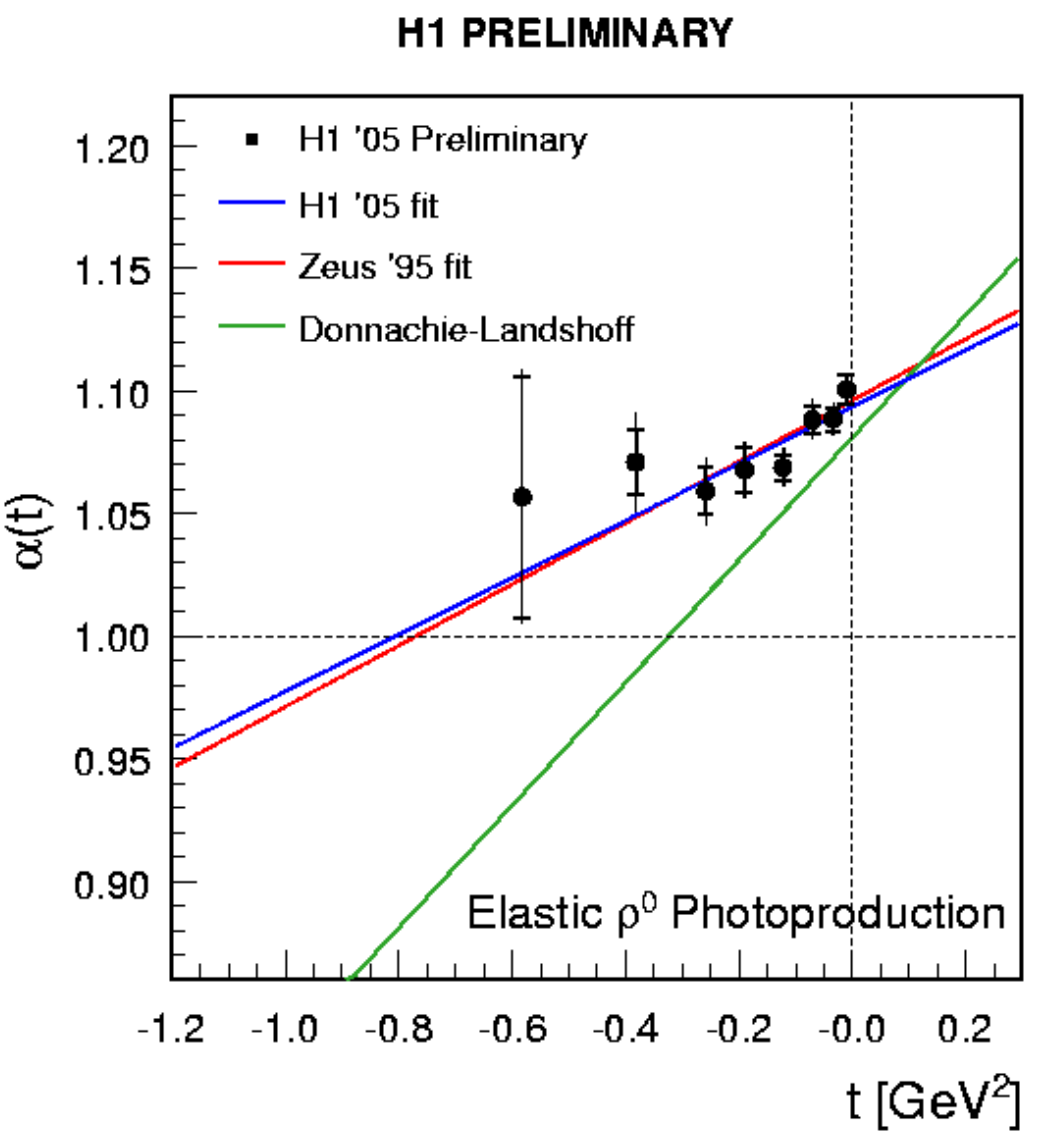
Fit to the data, assuming linear form

$$\alpha(t) = \alpha_0 + \alpha' \cdot t$$

Excellent agreement with the previous result, which used ZEUS data and data at lower W

α' significantly smaller than the canonical value $0.25\ \mathrm{GeV}^{-2}$, derived from other elastic data.

(Donnachie and Landshoff, 1992)

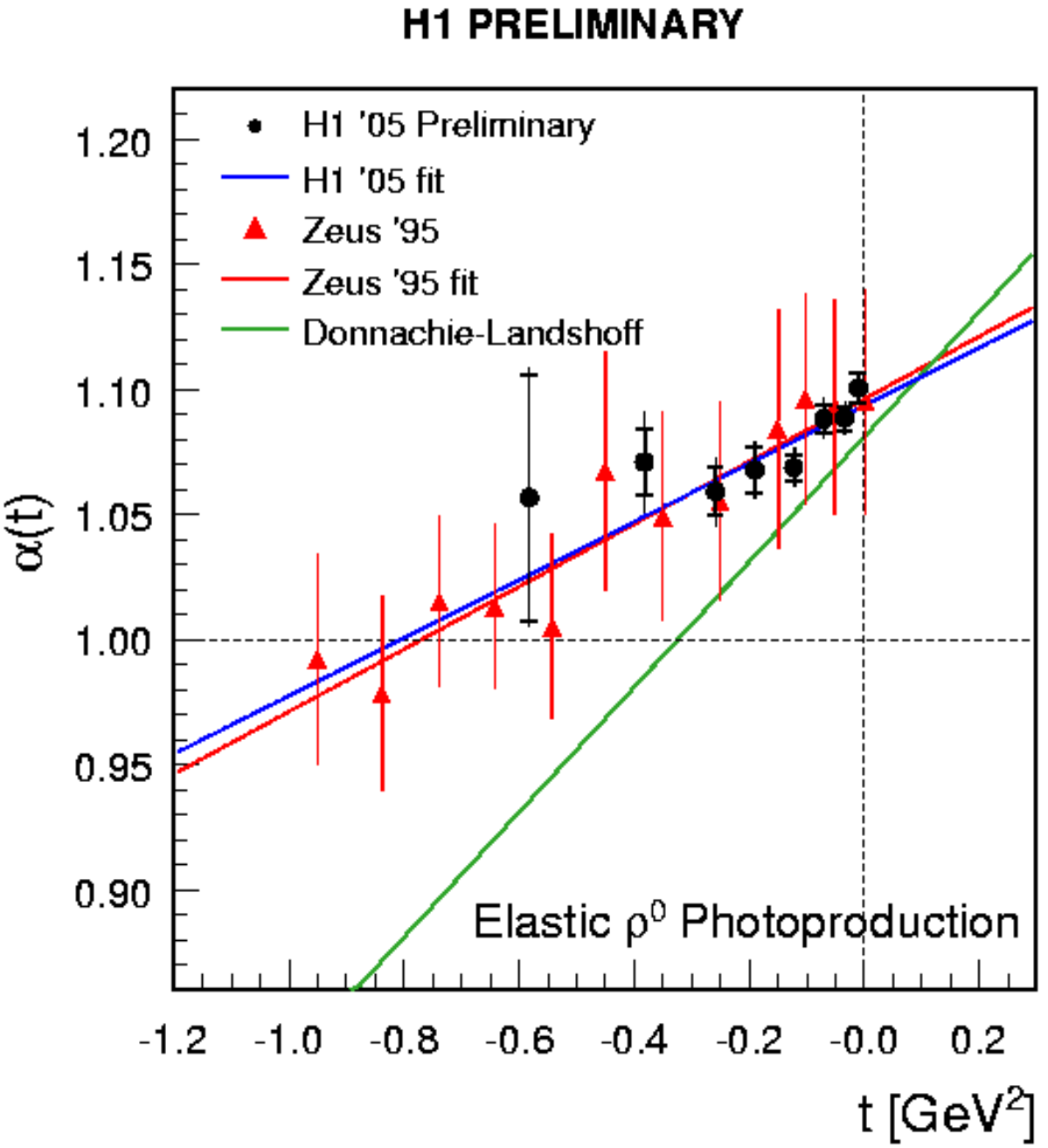


$$\alpha_{\mathbf{P}}(t) = (1.093 \pm 0.003\ ^{+0.008}_{-0.007}) + (0.116 \pm 0.027\ ^{+0.036}_{-0.046})\,\mathrm{GeV}^{-2} \cdot t$$

$$\alpha_{\mathbf{P}}(t) = (1.096 \pm 0.021) + (0.125 \pm 0.038)\,\mathrm{GeV}^{-2} \cdot t$$ (ZEUS data and lower W data)

Pomeron Trajectory

Statistics increase:
one Order of Magnitude



SUMMARY

- First Physics Results using the H1 Fast Track Trigger FTT
- 267000 ρ^0 candidates triggered in 570 nb^{-1} of 2005 data

Elastic and p-Dissociative ρ^0 Photoproduction Cross Sections, differential in W and t, measured in the kinematic range

$$Q^2 < 4\,\mathrm{GeV}^2 \qquad 20 < W < 90\,\mathrm{GeV}$$

$$|t| < 3\,\mathrm{GeV}^2 \qquad (M_Y^2+Q^2)/(W^2+Q^2) < 0.01$$

- The Pomeron Trajectory determined, for the first time using data within one experiment
- α' significantly smaller than $0.25\,\mathrm{GeV}^{-2}$

$$\alpha_{I\!P}(t) = (1.093 \pm 0.003\ ^{+0.008}_{-0.007}) + (0.116 \pm 0.027\ ^{+0.036}_{-0.046})\,\mathrm{GeV}^{-2} \cdot t$$

In good agreement with previous result using ZEUS data and data at lower W