



A Measurement of the Pomeron Trajectory from Elastic ρ^0 Photoproduction Data

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for the H1 Collaboration

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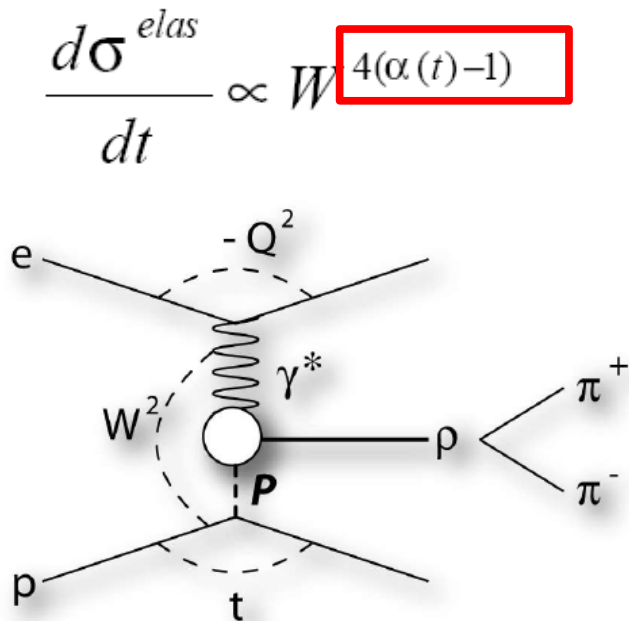
H1prelim-09-016

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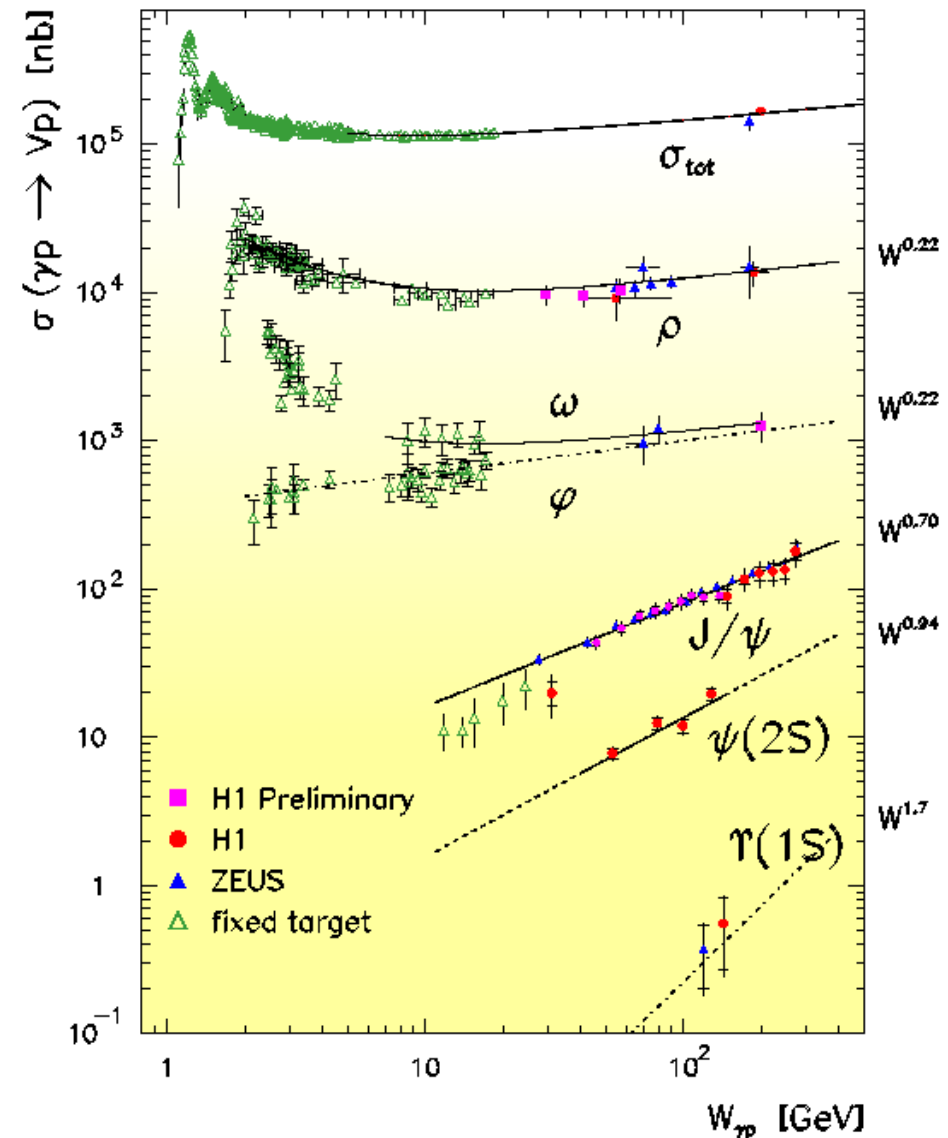


Federal Ministry
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- Photoproduction of ρ^0
 - ▶ No hard scales
 - ▶ Pure soft diffraction
- An ideal channel to investigate the soft pomeron
- Measurement in bins of t :
Can extract Pomeron trajectory



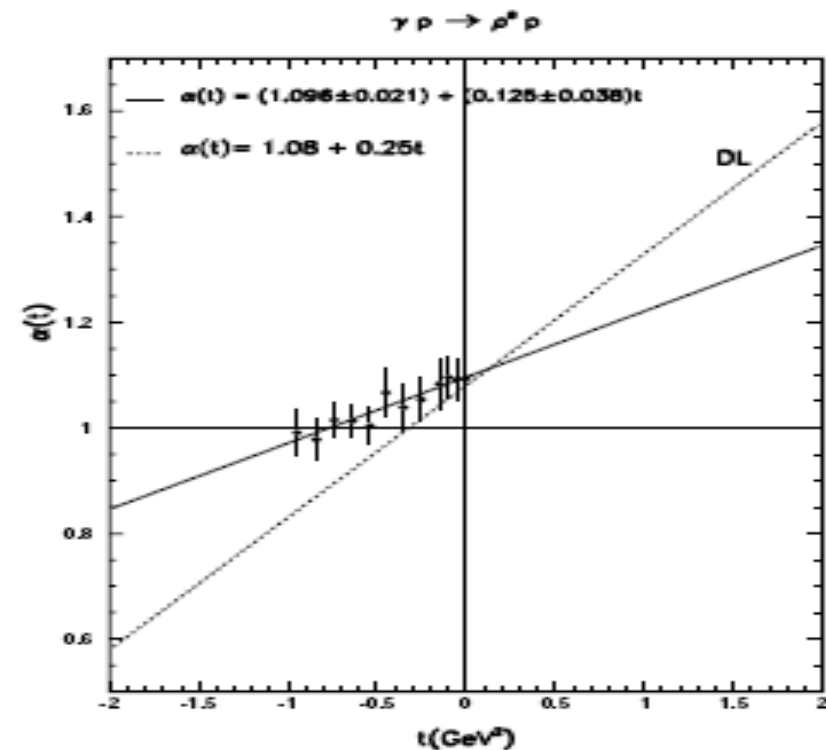
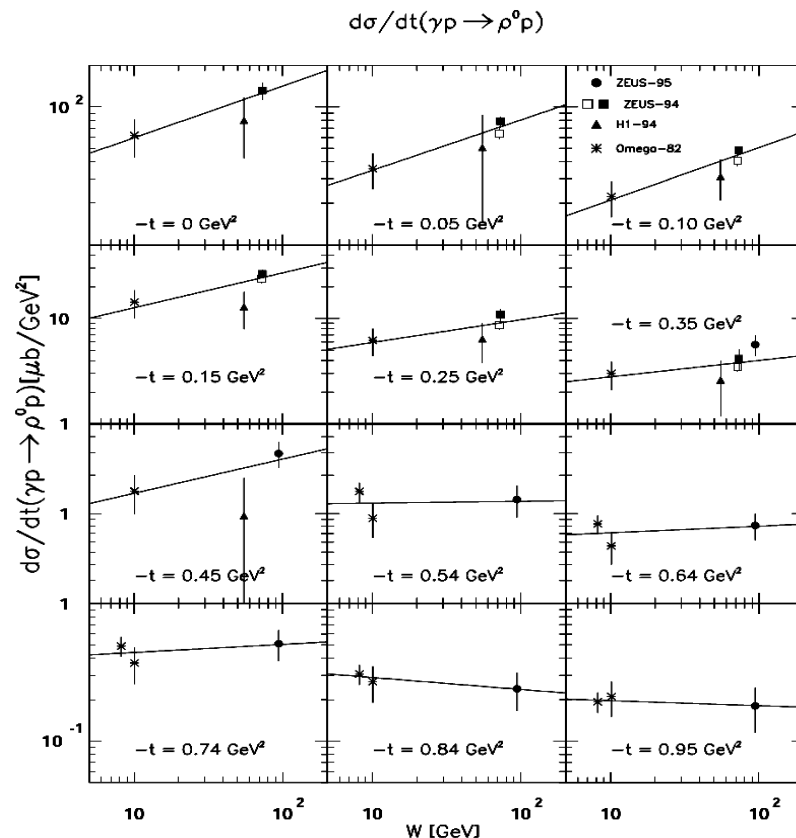
$$\frac{d\sigma^{elas}}{dt} \propto W^2 \boxed{4(\alpha(t)-1)}$$



The ZEUS Result from 2000



- ZEUS: EPJ **C14**(2000) 213-238.
- Combination of low-energy data (Omega) with ZEUS and H1('93) measurements at high W
- Result:
 - $\gamma p \rightarrow \rho^0 p$: $\alpha_{\mathbb{P}}(t) = (1.096 \pm 0.021) + (0.125 \pm 0.038)t$;
 - $\gamma p \rightarrow \phi p$: $\alpha_{\mathbb{P}}(t) = (1.081 \pm 0.010) + (0.158 \pm 0.028)t$.

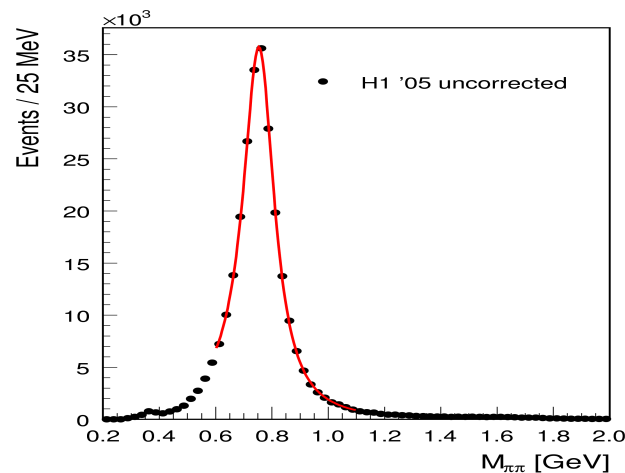


ZEUS, EPJ **C14**(2000)213.

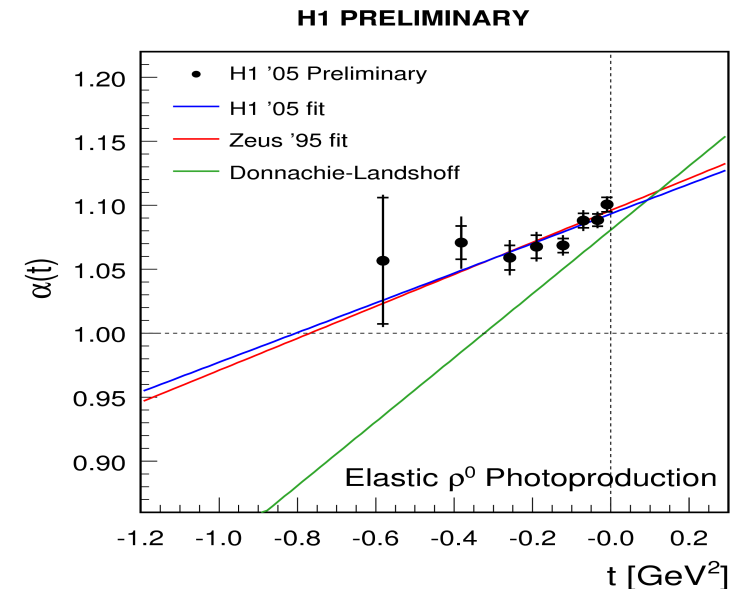
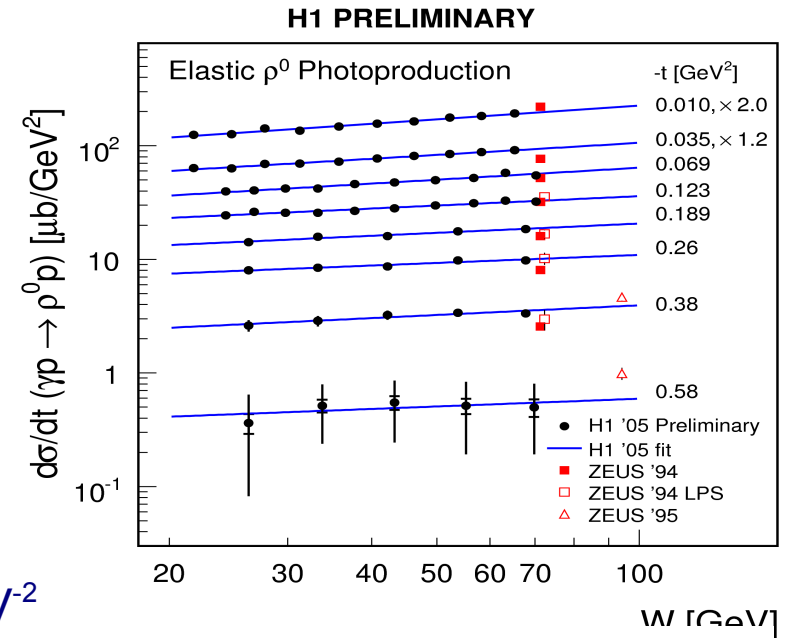
The 2005 H1 Analysis



- Measurement of elastic ρ^0 photoproduction from ~ 240000 events
- Kinematic range $20 < W < 90$ GeV
 $0 < |t| < 0.7$ GeV² (elastic data)
 \rightarrow could measure W -dependence of $d\sigma/dt$ in a single experiment
- Result:
 $\alpha_{P,0} = 1.093 \pm 0.003(\text{stat}) + 0.008/-0.007 (\text{syst})$
 $\alpha_{P'} = 0.116 \pm 0.027(\text{stat}) + 0.036/-0.046 (\text{syst}) \text{ GeV}^{-2}$
 \rightarrow almost identical with ZEUS result



H1prelim-06-011



Goal of the present analysis:

Make a global fit of all data on elastic ρ^0 photoproduction data in bins of t .

We confine this analysis to $W > 8\text{GeV}$, to minimize the influence of subleading exchanges

- Input Data:

- ▶ Omega: D. Aston et al., Nucl. Phys. **B209** (1982) 56.
- ▶ H1 1995: Nucl. Phys. **B463** (1996) 3.
- ▶ H1 2005: H1prelim-06-011
- ▶ ZEUS 1994 LPS: Z. Phys. **C73** (1997) 253.
- ▶ ZEUS 1994 low- t : EPJ **C2** (1998) 247.
- ▶ ZEUS 2000 high- t : EPJ **C14** (2000) 213.

- Fit data in bins of t

- ▶ needs partially swimming of data to common t bins
- ▶ For each t bin: 2 parameters: $d\sigma/dt(W_0)$, $\alpha(t)$
- ▶ Do a global fit, keeping correlations

- Use similar method as used in F_2 averaging (H1, arXiv:0904.0929)

$$\chi^2 = \sum_i \frac{(m_i + \sum_k \sigma_{ik} b_k - f_i)^2}{\sigma_i^2} + \sum_k b_k^2$$

m_i Measured values ($i = 1 \dots M$)

σ_i Errors (systematic and uncorrelated systematic)

$f_i(a_j)$ Function values

a_j Parameters ($j = 1 \dots N$)

b_k Systematic error shifts ($k = 1 \dots K$)

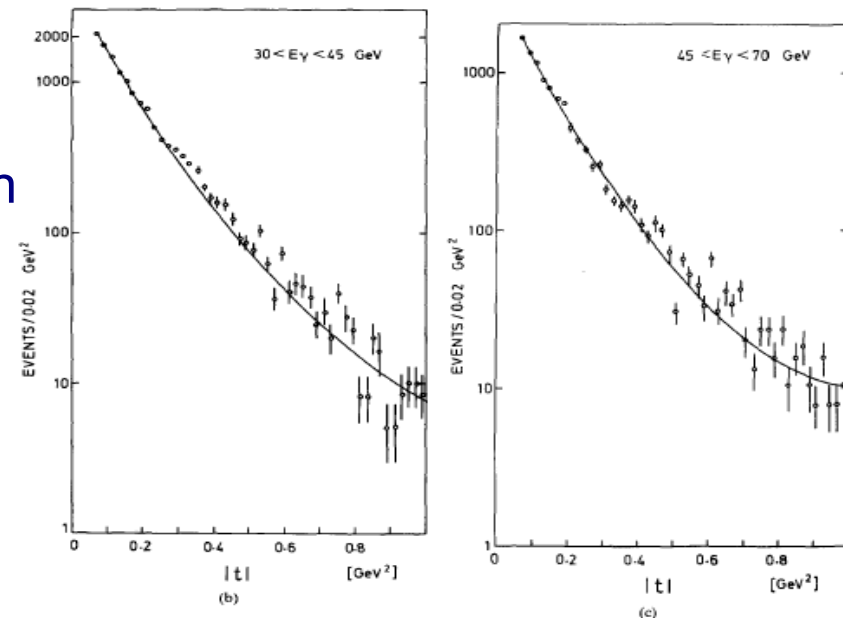
σ_{ik} Coefficients for systematic errors

- Function parameters are defined separately for each t bin
- Result of the fit:
 - ▶ Function parameters a_j , i.e. $d\sigma/dt$ (W_0) and $\alpha(t_i)$ in each t bin
 - ▶ Shifts and errors for all sources of correlated errors

The Omega Data Set



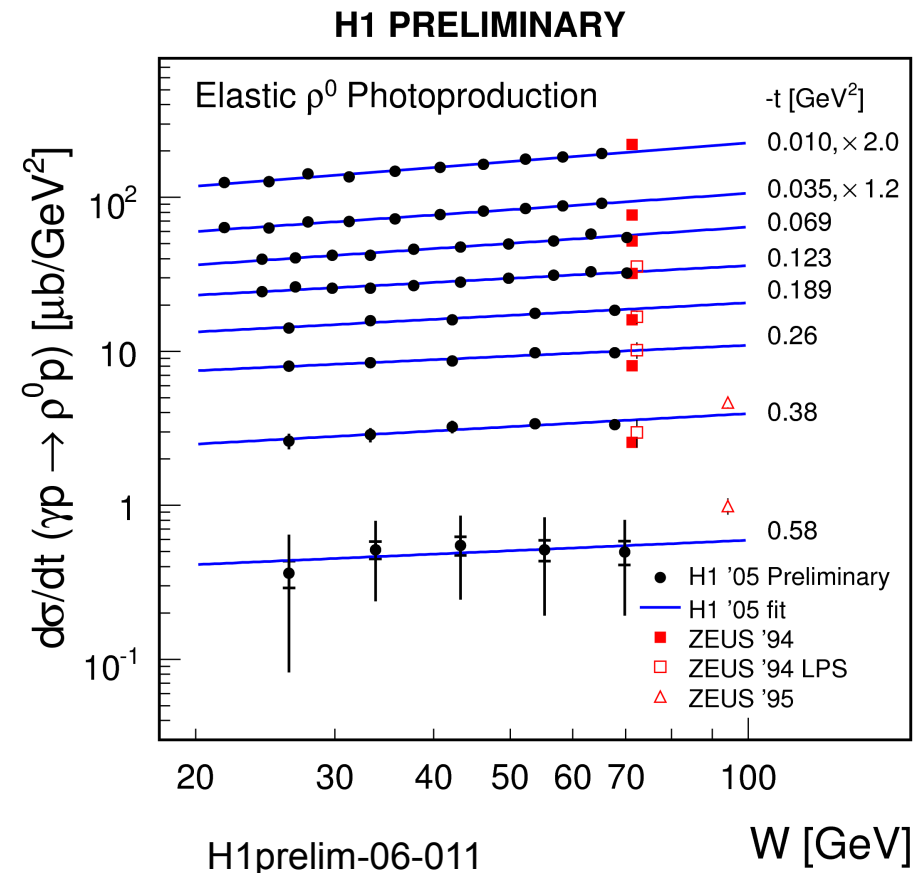
- Reference: D. Aston et al., *Photoproduction of ρ^0 and ω on hydrogen at photon energies of 20 to 70 GeV*, Nucl. Phys. B 209 (1982) 56.
- 3 Bins of E_γ : 20-30, 30-45, 45-70 GeV $\rightarrow \langle W \rangle = 6.8, 8.3, 10.3$ GeV
use data at 8.3 and 10.3 GeV (subleading trajectory largest at 6.8 GeV)
- $0.06 < |t| < 1 \text{ GeV}^2$
- Original data recovered from plots in paper, moved to bin centres of fit and averaged
- Statistical errors scaled by $\sqrt{(\chi^2/\text{df})}$ of t-fit
- Correct for mass range of x-section definition
 $0.56 < m_{\pi\pi\pi} < 0.92 \text{ GeV} \rightarrow 0.27 < m_{\pi\pi\pi} < 1.52 \text{ GeV}$:
factor 1.187 ± 0.053
- Overall normalization taken from t-integrated cross section, normalization error 10-13%



The H1 2005 Data Set



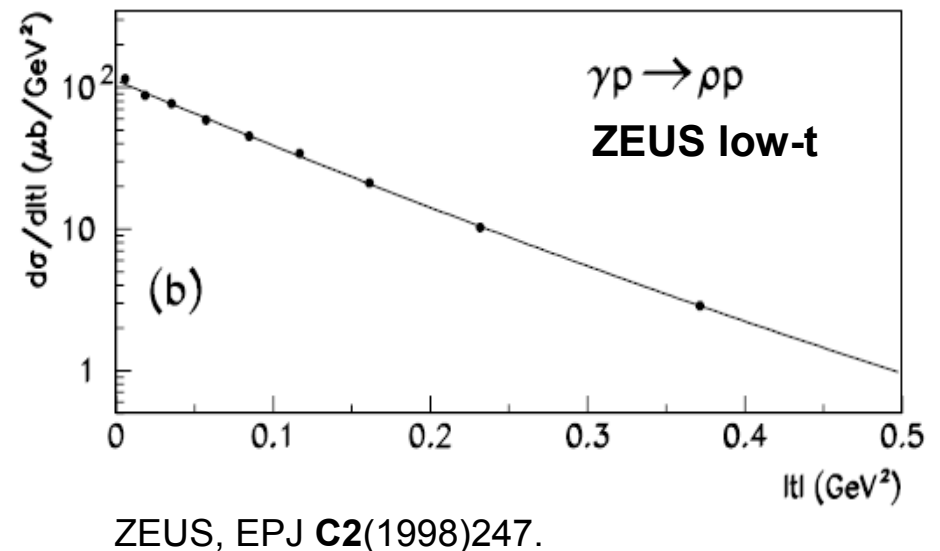
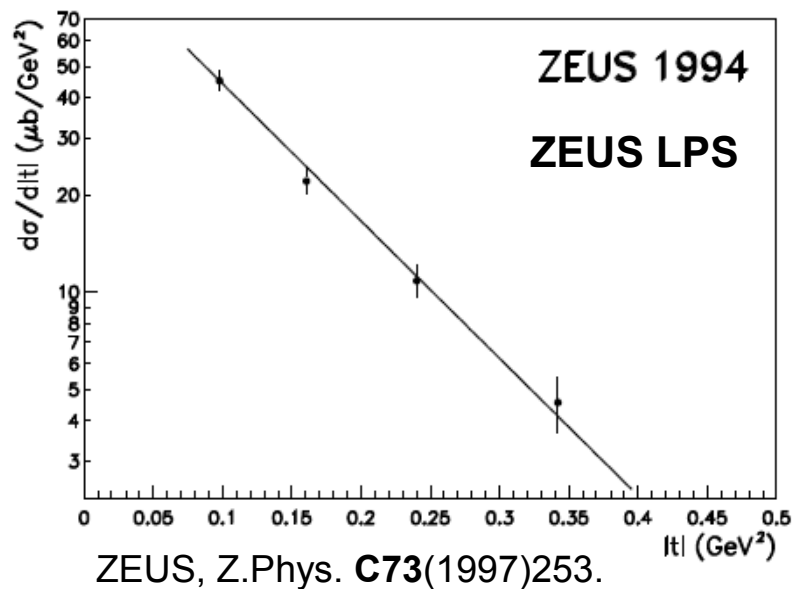
- Very precise data set, covering a large W range
- 10 sources of correlated systematic errors are considered
- Correlations are fully kept in the fit
- Dominant uncertainty: subtraction of p -dissociative bg. at large $|t|$
- Normalization uncertainty 5.3%
- Sufficient for $\alpha(t)$ determination at $|t| < 0.6$ GeV



The ZEUS 1994 Data Sets



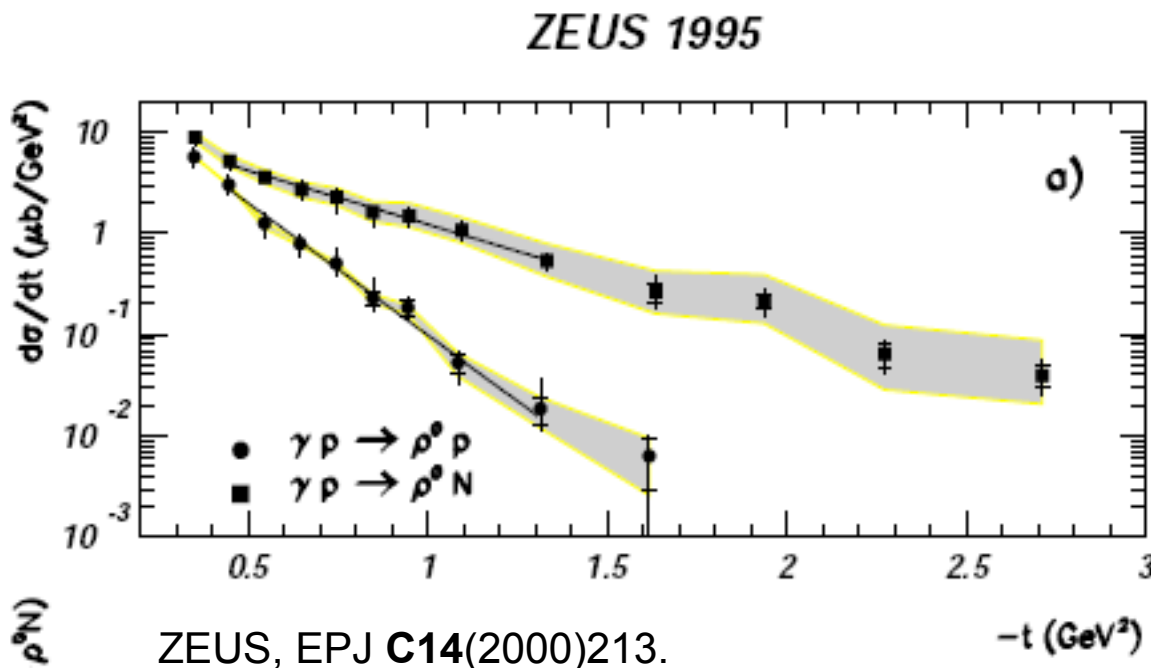
- References:
M. Derrick *et al.* (ZEUS Collab.): Z.Phys. **C73**(1997)253. (ZEUS LPS)
J. Breitweg *et al.* (ZEUS Collab.): EPJ **C2**(1998)247. (ZEUS low-t)
- ZEUS LPS: $\langle W \rangle = 73 \text{ GeV}$, 4 t bins, $0.073 < |t| < 0.4 \text{ GeV}^2$,
mass range correction 1.09,
syst. errors: 11% uncorrelated, 6% normalization
- ZEUS low-t: $\langle W \rangle = 71.7 \text{ GeV}$, 12 t bins for $0 < |t| < 0.5 \text{ GeV}^2$
syst. Errors: 10% uncorrelated, 5% normalization
measurements are corrected for different t-binning and averaged



The ZEUS High- t Data Set



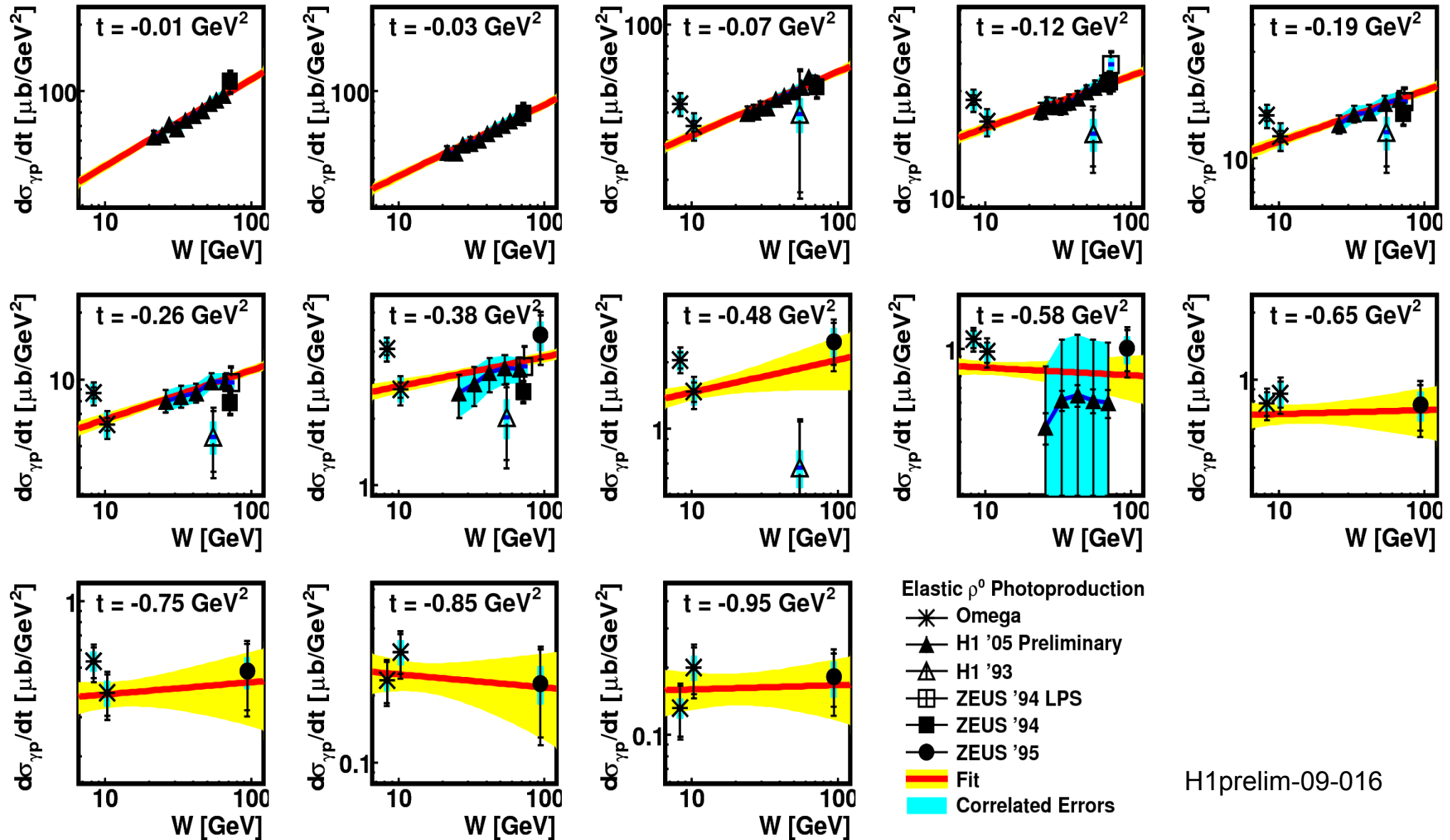
- ZEUS, EPJ **C14**(2000)213.
- Measurement of elastic ρ production from 1995 data at $\langle W \rangle = 94 \text{ GeV}$ for $0.3 < |t| < 1.6 \text{ GeV}^2$
- Correlated errors from proton dissociation subtraction are available and taken into account, plus 15% normalization uncertainty



The Global Fit



H1 PRELIMINARY

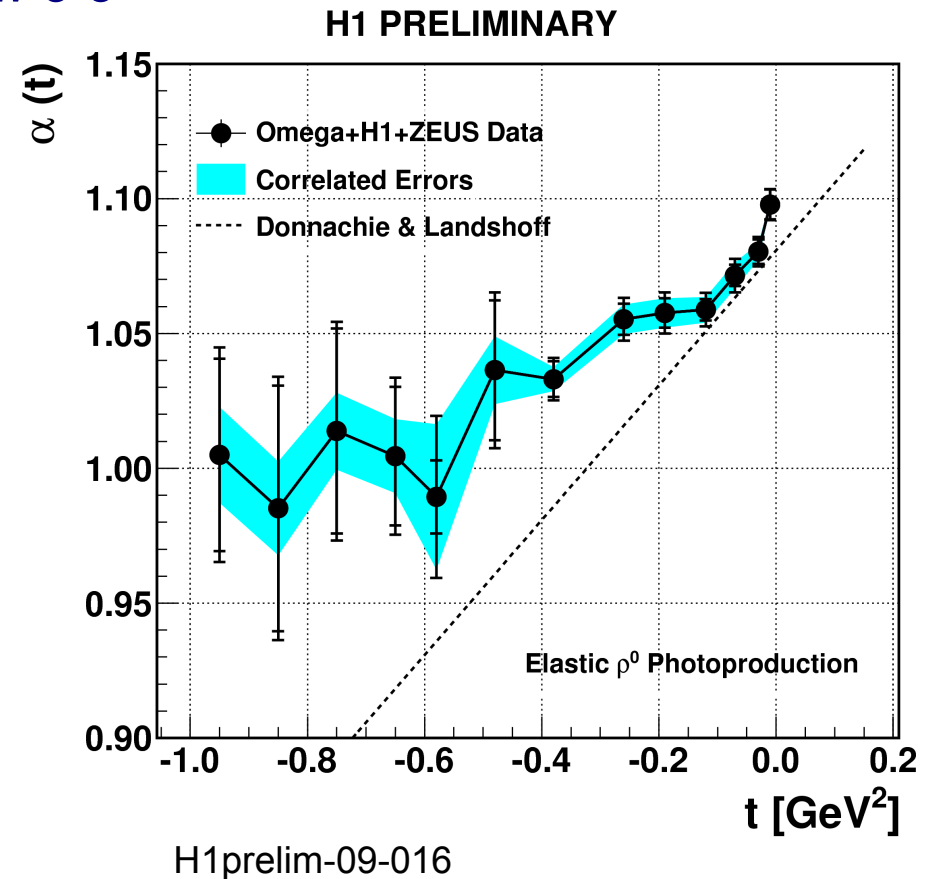


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The Fit Result



- Overall $\chi^2/\text{df} = 111.7 / 80$
(106 data points - 2x13 parameters)
→ satisfactory fit quality
- Omega data at $W=8.3\text{GeV}$ lie systematically high
→ some tension in normalization, below 3σ
- Error correlations (especially from normalization) are fully propagated
- High $|t|$ bins profit from precise data at low $|t|$, which constrains the relative normalization of data sets



New Pomeron Trajectory Result: Linear Fit



- The new result from the global fit:

$$\alpha_0 = 1.0871 \pm 0.0026(\text{stat}) \pm 0.0030(\text{syst})$$

$$\alpha' = 0.126 \pm 0.013(\text{stat}) \pm 0.012(\text{syst}) \text{ GeV}^{-2}$$

$$\chi^2/\text{df} = 14.7 / (13-2)$$

(correlations taken into account)

- H1Prelim-06-011 (H1 data alone):

$$\alpha_0 = 1.093 \pm 0.003(\text{stat}) \begin{matrix} +0.008 \\ -0.007 \end{matrix} (\text{syst})$$

$$\alpha' = 0.116 \pm 0.027(\text{stat}) \begin{matrix} +0.036 \\ -0.046 \end{matrix} (\text{syst}) \text{ GeV}^{-2}$$

- ZEUS EPJ C14(2000)213:

$$\alpha_0 = 1.096 \pm 0.021$$

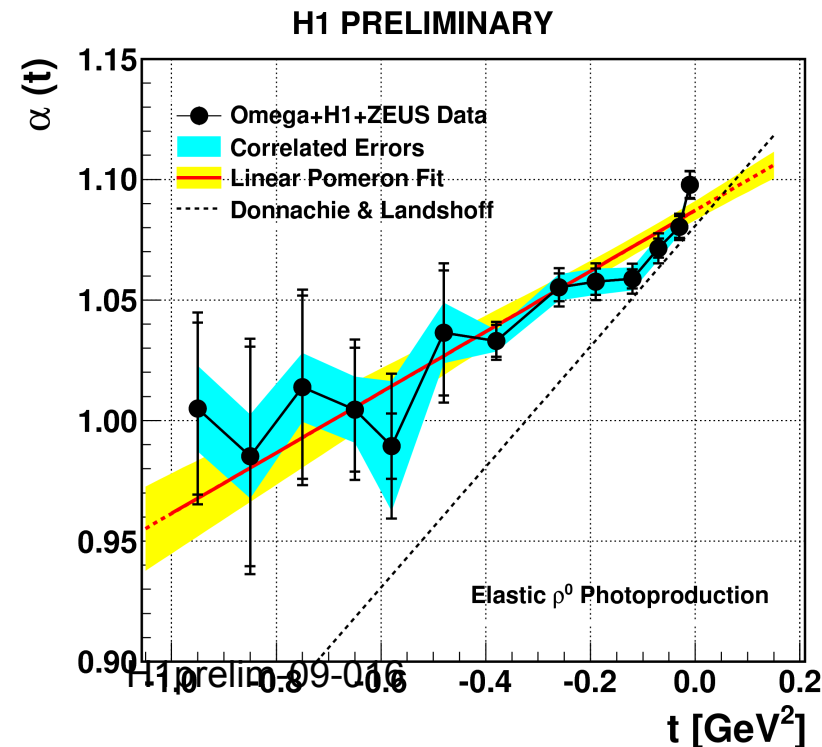
$$\alpha' = 0.125 \pm 0.038 \text{ GeV}^{-2}$$

- All 3 results are in perfect agreement
(expected, as ZEUS and H1prelim-06-011 are consistent)

- Compare to Donnachie & Landshoff:

$$\alpha_0 = 1.0808 \quad \text{Donnachie, Landshoff PL B296(1992)227}$$

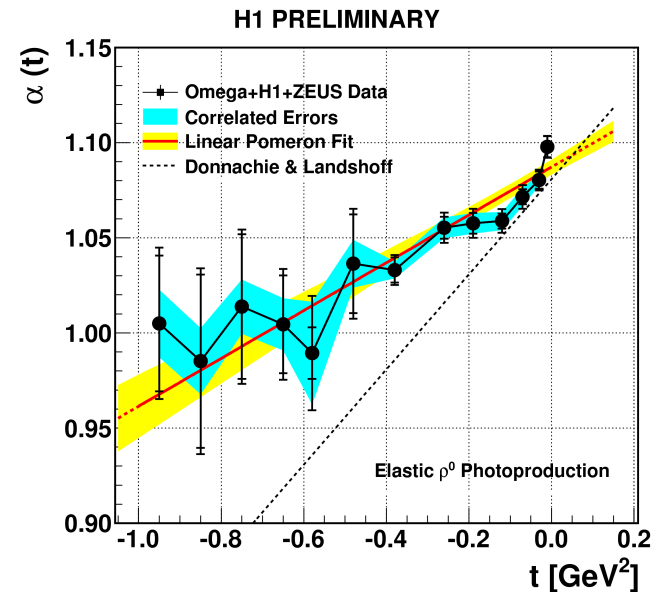
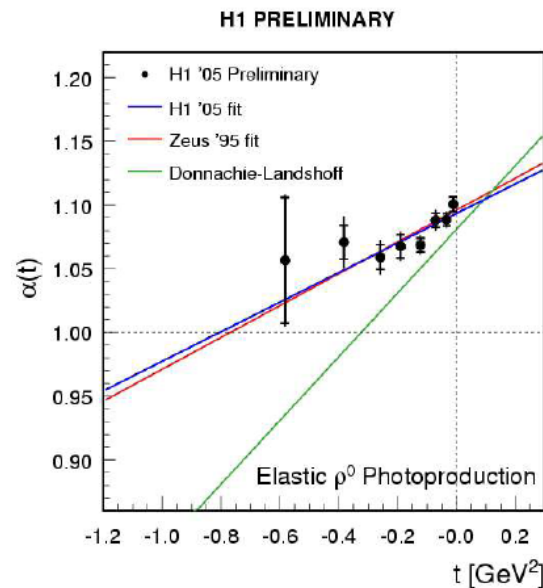
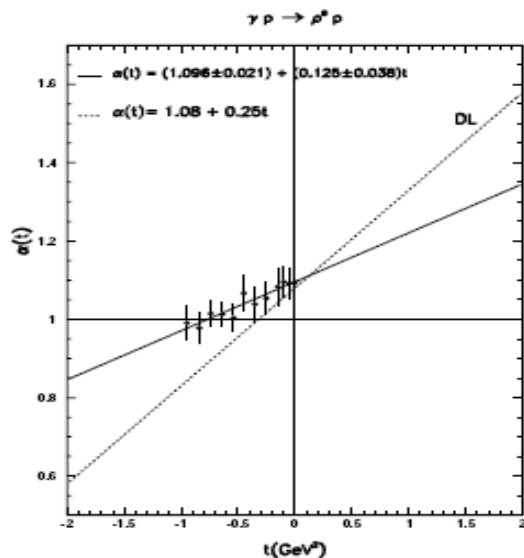
$$\alpha' = 0.25 \text{ GeV}^{-2} \quad \text{Jaroszkiewicz, Landshoff, PR D10(1997)170; Landshoff, NP Proc.Suppl.12(1990)397}$$



The Three Results

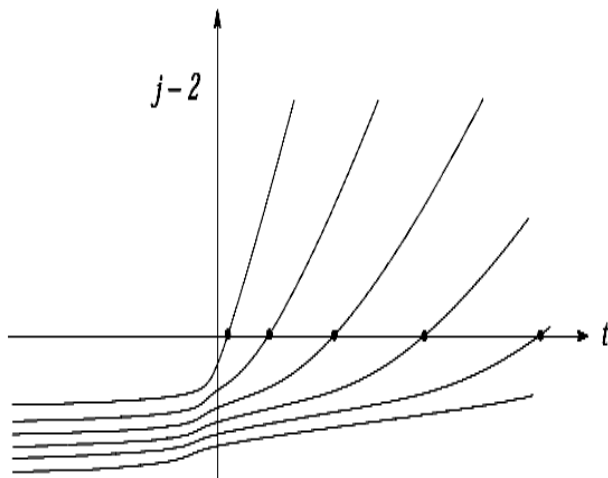


- ZEUS (+Omega+H1 '94): suggests completely linear trajectory
- H1 '05: agrees with D&L slope at low t , is from a single experiment
- New result: gives same slope again, as expected
BUT: is much more precise than ZEUS '00 result at low $|t|$,
may hint at flattening of trajectory,
compatible with D&L slope at low $|t|$!

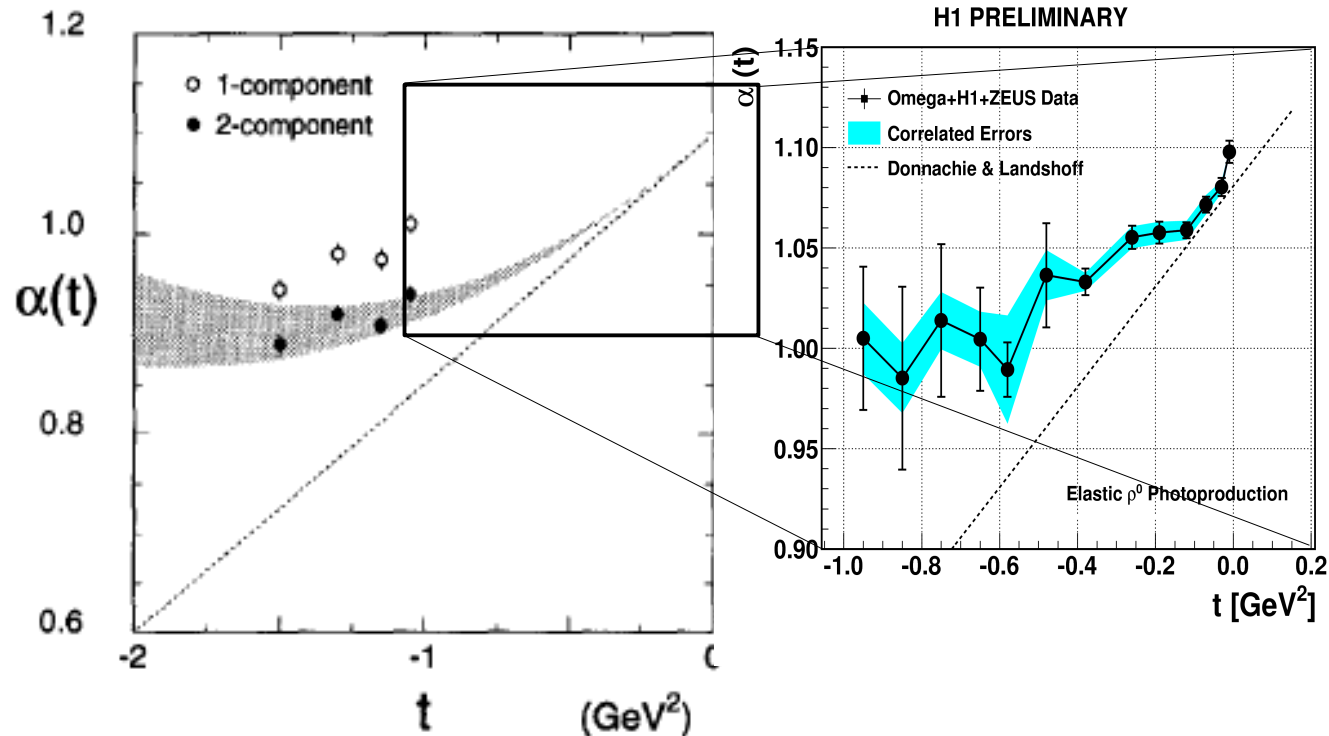


Flattening of the Pomeron Trajectory?

- Do we see a flattening of the Pomeron trajectory?
Has been predicted from Gauge/String duality and observed by UA8
- It seems that even at large $|t|$, the rho cross section does never fall with W , it seems to stay constant $\Rightarrow \alpha(t) \geq 1$



Brower et al., *The pomeron and Gauge/String duality*, JHEP 0712(2007)005
[arXiv:hep-th/0603115]

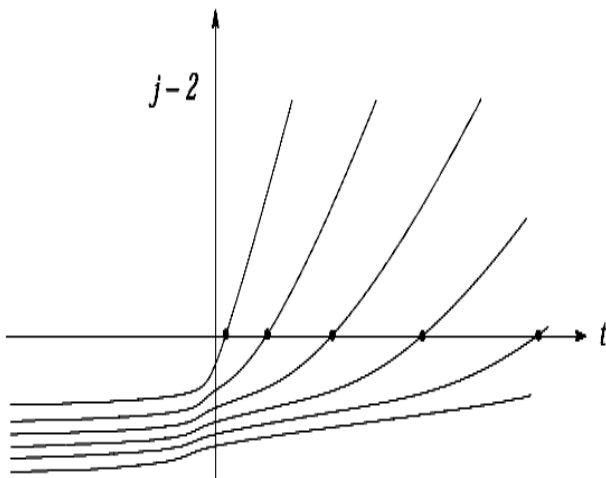


A. Brandt [UA8], NP **B5141**(1998)3.

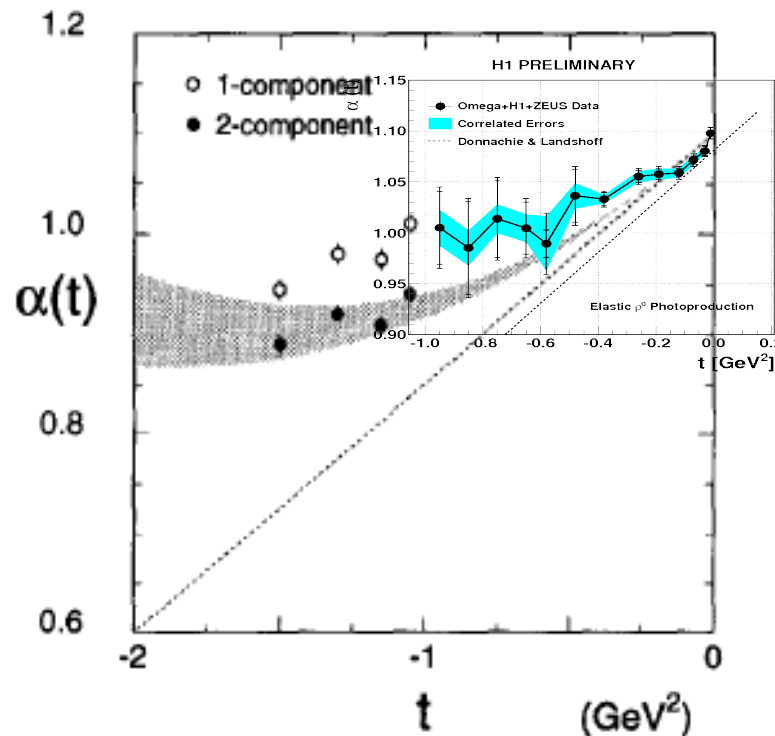
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A. Brandt [UA8], NP **B5141**(1998)3.

- A new global fit of elastic ρ^0 photoproduction data for $8 < W < 100$ GeV has been performed in 13 bins of t , at $0.01 < |t| < 0.95 \text{ GeV}^2$, taking into account error correlations
- From the W -dependence of $d\sigma/dt \sim W^{4(\alpha(t)-1)}$, the Pomeron trajectory has been extracted
- The resulting values for $\alpha_P(t)$ are in agreement with
 - ▶ A fit to Omega+H1'93+ZEUS data
 - ▶ A fit to the H1 2005 data alone
- The new global fit shows significant deviation from D&L pomeron at $|t| > 0.5 \text{ GeV}^2$
- A linear Pomeron trajectory with slope $\alpha' = 0.125 \text{ GeV}^{-2}$ is not excluded
- But: data is also compatible with (and suggestive of)
 - ▶ the D&L pomeron at low $|t|$
 - ▶ and a constant trajectory at larger $|t|$