Diffractive Results from the ZEUS Leading Proton Spectrometer at HERA

Barbara Smalska

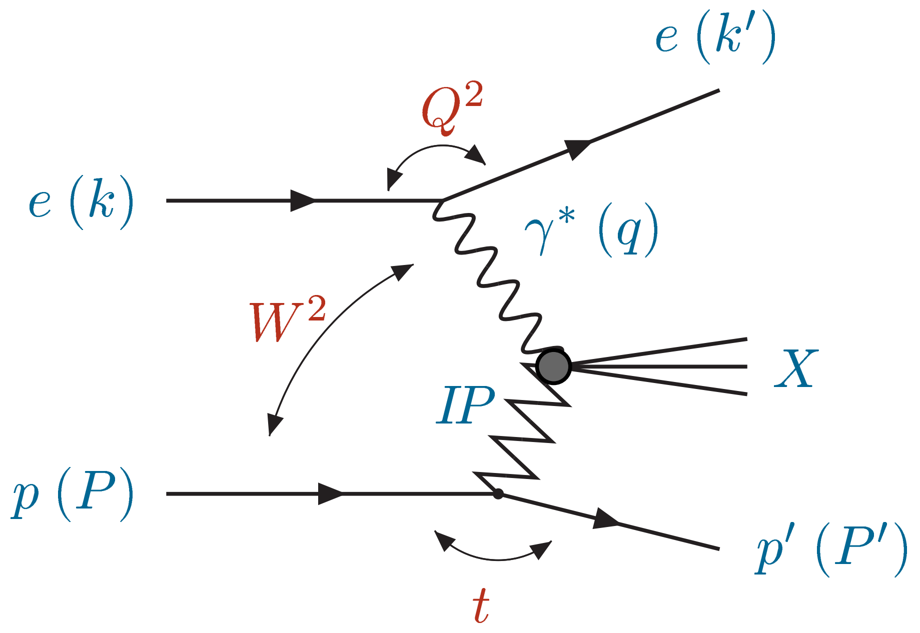
Warsaw University

9th International Workshop on Deep Inelastic Scattering

Bologna, April 27 – May 1, 2001

- diffraction at ZEUS with LPS
- results for diffractive t distribution
- results for azimuthal angle and asymmetries

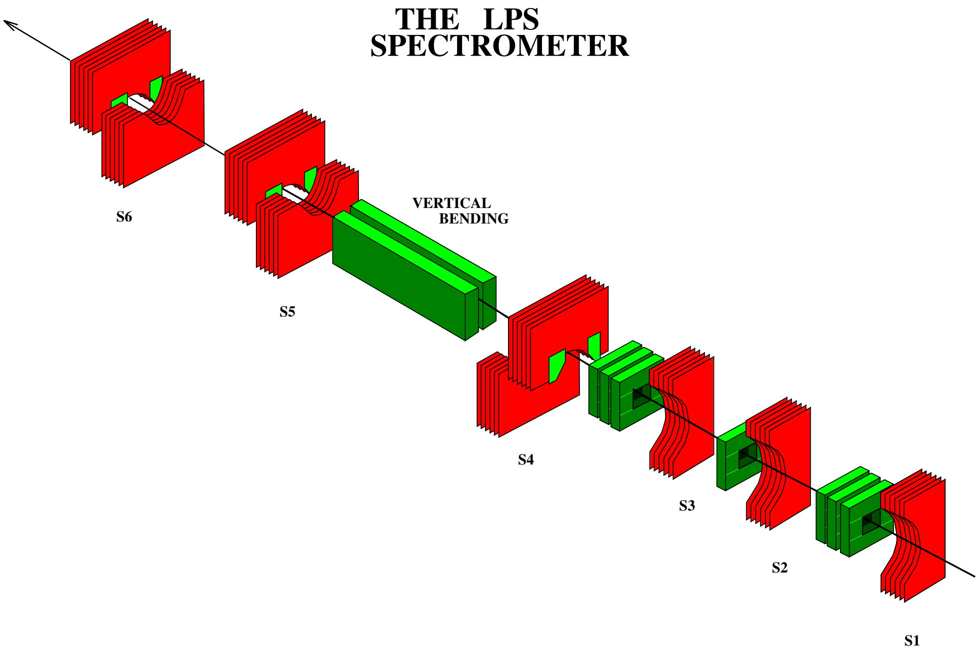
Inclusive diffraction at HERA



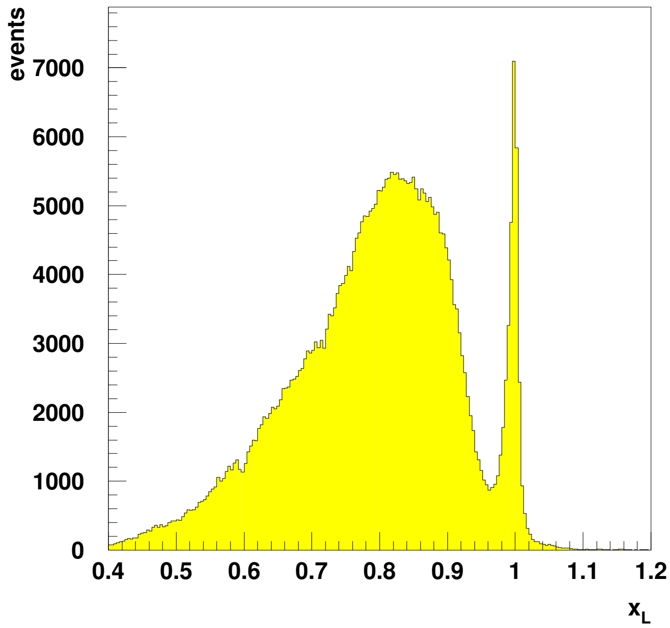
- momentum transfer at proton vertex
  $t \equiv (P - P')^2 \approx -\frac{p_t^2}{x_L}$
- fraction of proton momentum carried by IP
  $x_{IP} \equiv \frac{q\cdot(P-P')}{q\cdot P} = \frac{M_X^2+Q^2}{W^2+Q^2+m_p^2} \approx 1 - x_L$
- fraction of IP momentum carried by quark
  $\beta \equiv \frac{x_{Bj}}{x_{IP}} = \frac{Q^2}{2q\cdot(P-P')} \approx \frac{Q^2}{M_X^2+Q^2}$
- γ-IP invariant mass
  $M_X{}^2 = (\Sigma\ \text{momenta of final state hadrons})^2$
- fraction of incoming proton momentum
  $x_L = \frac{P_z'}{P_z}$

Leading Proton Spectrometer

- 6 silicon μ-strip stations situated 24-90m downstream the of interaction point, last 3 used in this analysis



- diffractive peak $x_L \approx 1$
- t measurement
- free of non-diffractive and proton dissociation background
- no limit on M_X



Data sample

- 12.8 pb^{-1} of data (last published: 0.9 pb^{-1})
- scattered positron detected in the calorimeter
- proton track with $x_L >$ 0.95 detected in LPS
- random overlay of beam halo with non-diffractive DIS events subtracted statistically ($\approx 11\%$)

Kinematic region

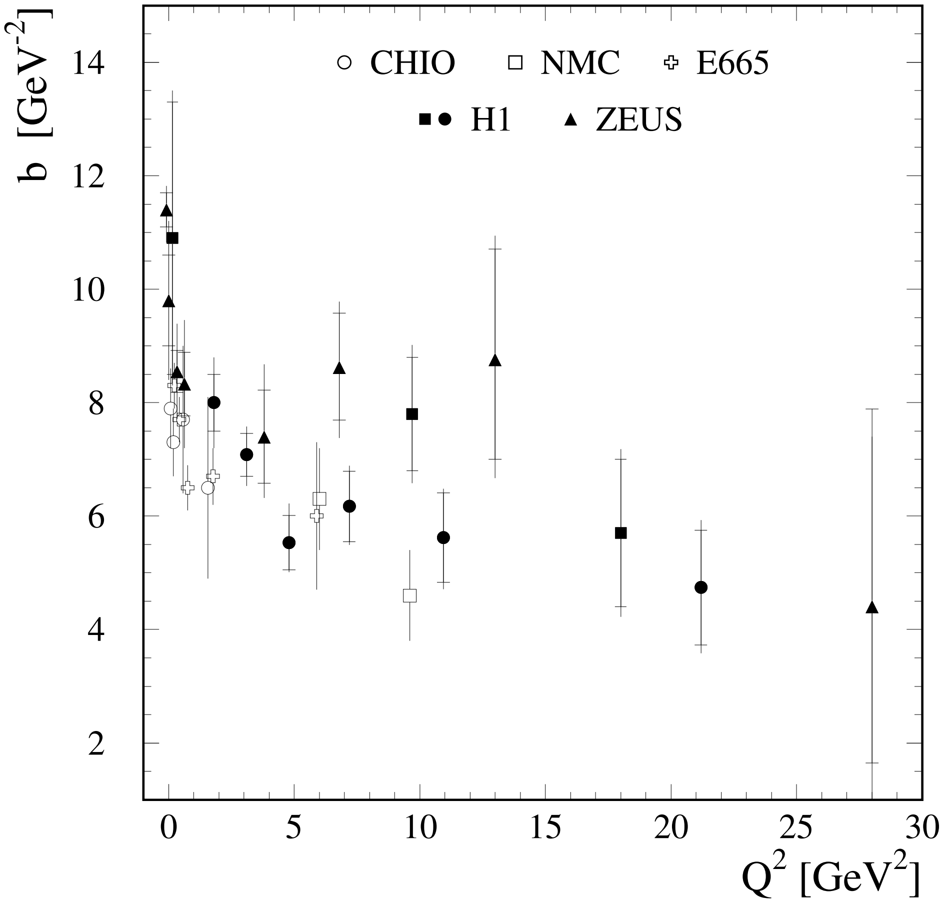
$$4 \text{ GeV}^2 < Q^2 < 100 \text{ GeV}^2$$
$$x_{IP} < 0.03$$
$$M_X > 2 \text{ GeV}$$
$$0.075 \text{ GeV}^2 < |t| < 0.35 \text{ GeV}^2$$

t distribution

- measure of the interaction radius
- at small $|t|$: $\frac{d\sigma}{d|t|} \propto \exp(-b|t|)$
- statistics sufficient measure t versus x_{IP}, β, Q^2 and M_X:
  - in Regge theory expect shrinkage:
    $b = b_0 + 2\alpha' \ln \frac{W^2}{M_X^2} \approx b_0 + 2\alpha' \ln \frac{1}{x_{IP}}$
  - b expected to grow with β up to $\beta \approx 0.5$ and then decrease

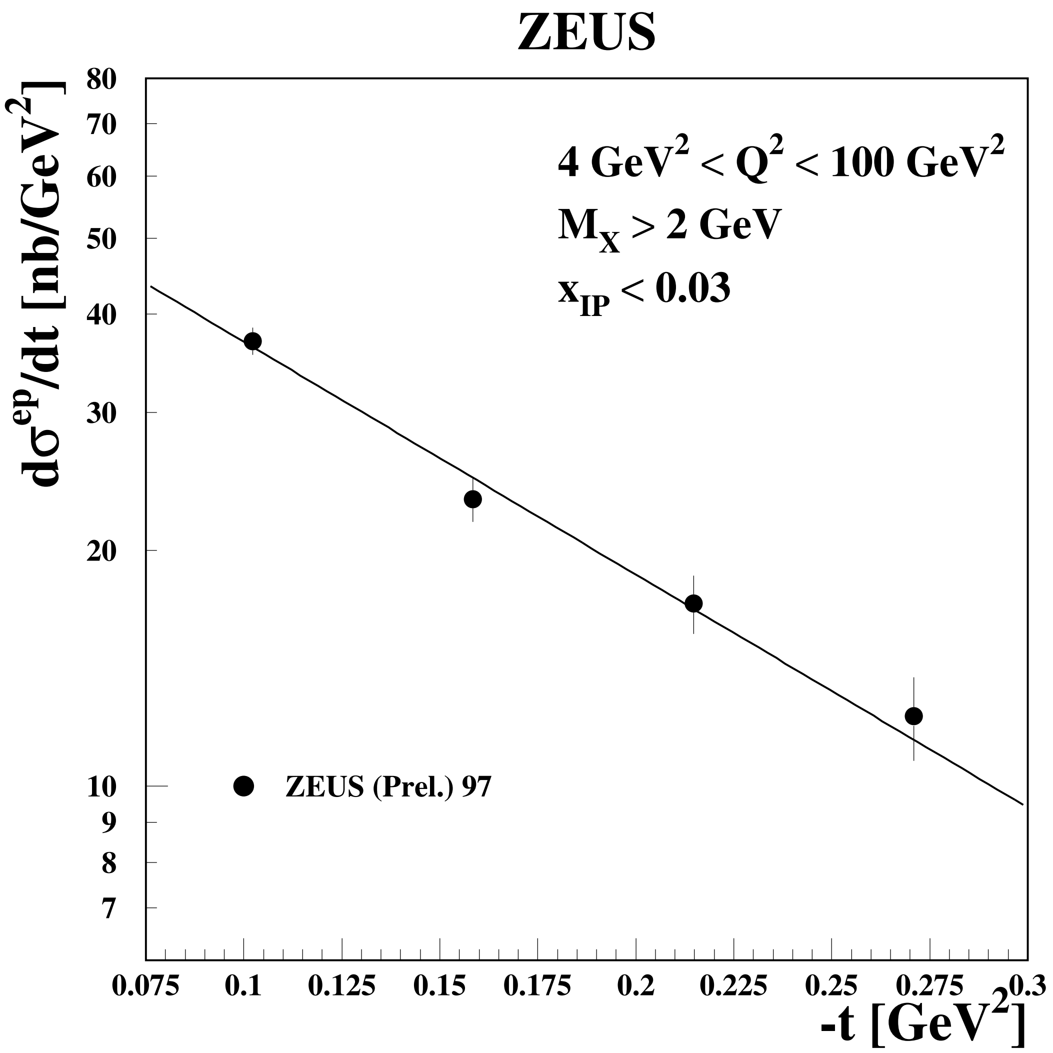
    (Nikolaev *et al.* hep-ph/9809444)

– for $\beta \ll 1$ no dependence on Q^2 expected, in contrast to elastic vector meson production ($\beta = 1$):



– b decreases with M_X for exclusively produced vector mesons

Diffractive slope

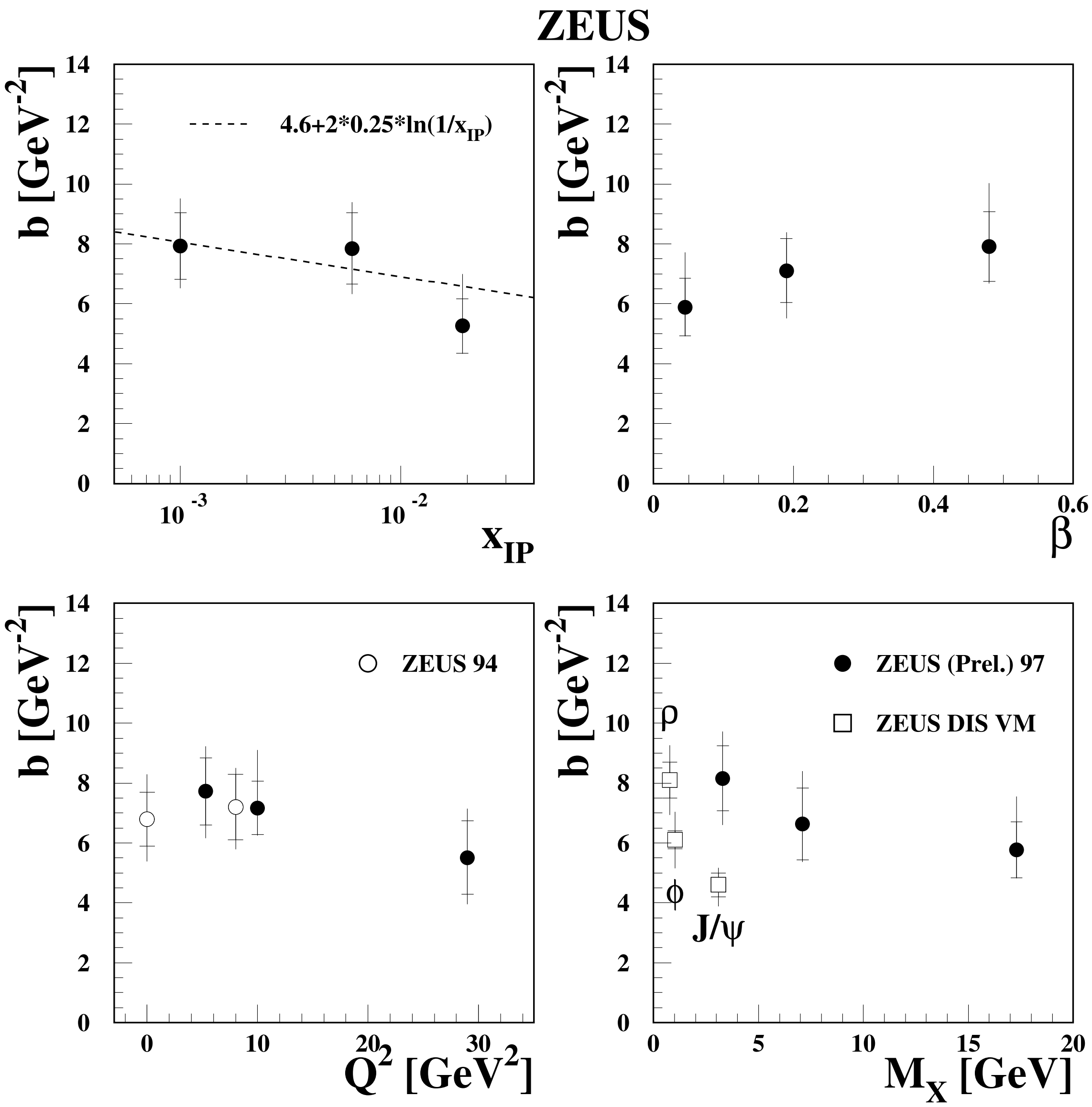


$$b = 6.8 \pm 0.6(stat.)^{+1.2}_{-0.7}(syst.)$$

- previous published result (Eur. Phys. J. C1 (1998) 81.):

$$b = 7.2 \pm 1.1(stat.)^{+0.7}_{-0.9}(syst.)$$

Results for t slope



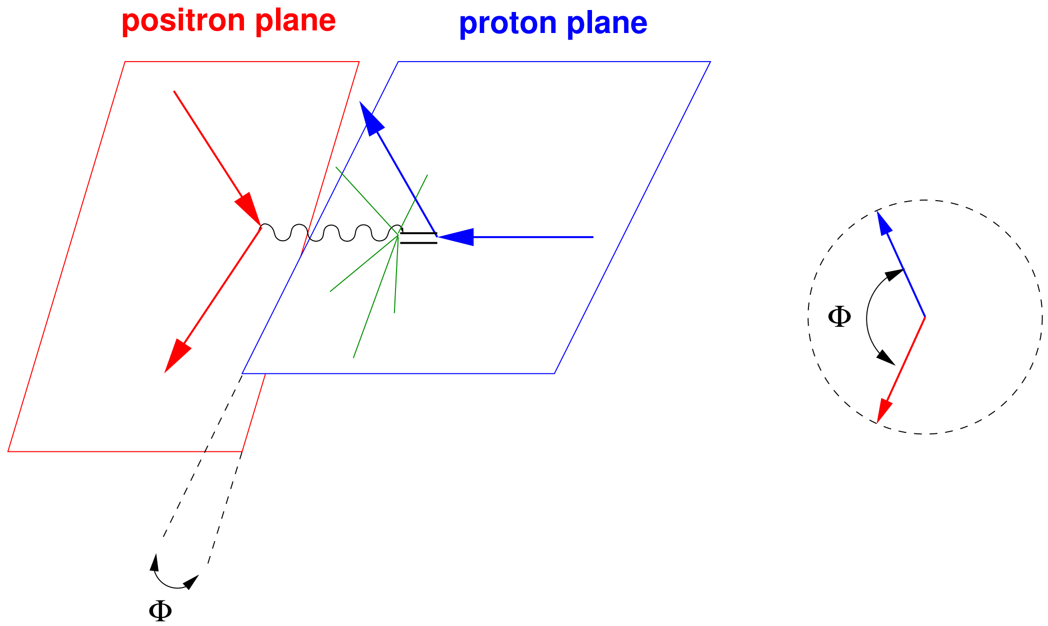
- expected trends are visible (shrinkage ?, growth with β, no Q^2 dependence) but errors still large

Azimuthal asymmetry

- for unpolarised positrons the diffractive cross section can be decomposed:

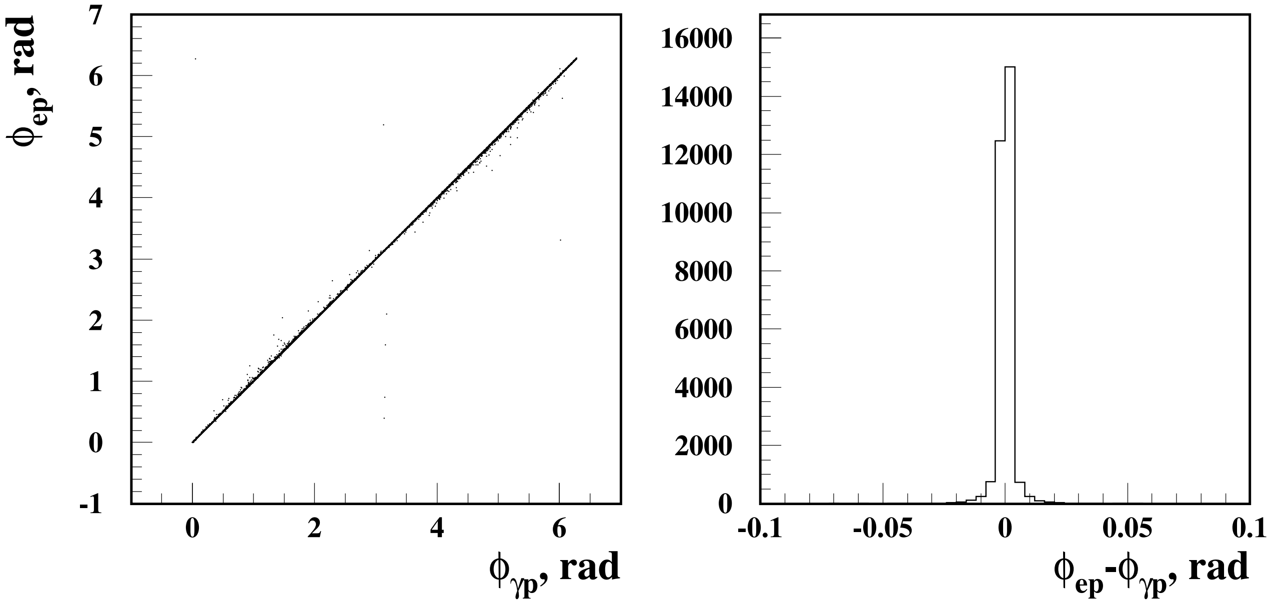
$$\frac{d\sigma^D}{d\Phi} \propto \sigma_T^D + \epsilon\sigma_L^D + \\ -2\sqrt{\epsilon(1+\epsilon)}\sigma_{LT}^D \cos\Phi - \epsilon\sigma_{TT}^D \cos 2\Phi$$

where Φ – angle between positron and proton scattering planes in $\gamma^* p$ rest frame:



($\epsilon = (1-y)/(1-y+\frac{1}{2}y^2) \approx 1$ for HERA kinematics)

- in HERA kinematics Φ can be well approximated by the azimuthal angle between scattered positron and proton in LAB frame: (Arens *et al.*, hep-ph/9605376)



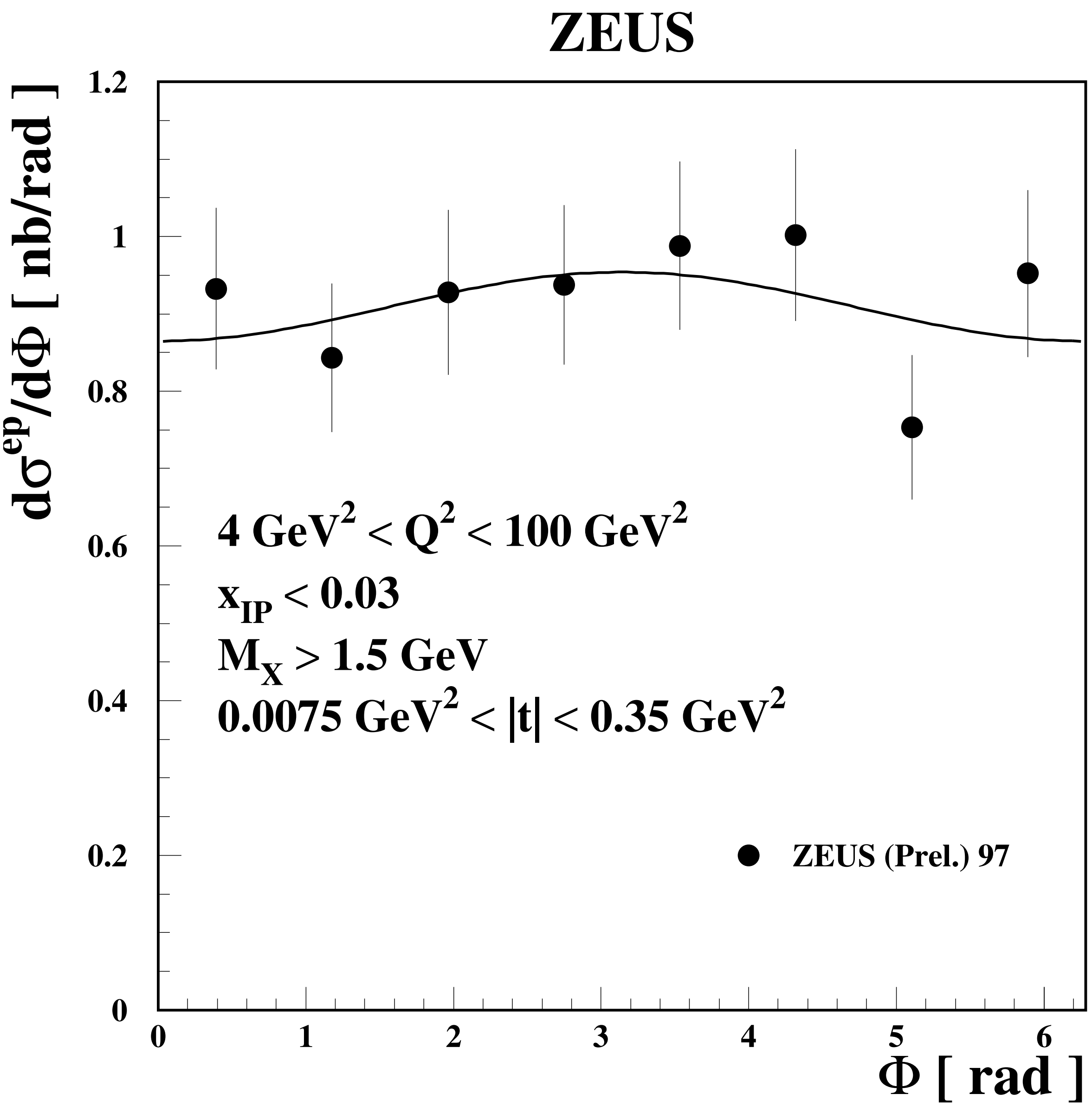
$\Longrightarrow$ no boosts needed in analysis and possibility to use predictions for both $\Phi_{\gamma p}$ and Φ_{ep}

- non-uniform Φ distribution – possibility to deduce the interference term (between amplitudes for L and T photons) and $R^D = \sigma_L^D / \sigma_T^D$

- analogy with Φ in VM helicity analysis:

$$A_{LT} = \sqrt{2\epsilon(1+\epsilon)} \cdot (r_{00}^5 + 2r_{11}^5) \approx 0.2$$

Φ distribution



- fit $\frac{d\sigma}{d\Phi} \propto 1 + A_{LT} \cos\Phi$
  $\longrightarrow A_{LT} = -0.049 \pm 0.058(stat.)^{+0.056}_{-0.009}(syst.)$
- consistent with flat, interference terms small

Azimuthal asymmetry

- for $\frac{d\sigma}{d\Phi} \propto 1 + A_{LT} \cos\Phi$:

$$A_{LT} = \frac{\pi}{2} \cdot \frac{\sigma(\cos\Phi > 0) - \sigma(\cos\Phi < 0)}{\sigma(\cos\Phi > 0) + \sigma(\cos\Phi < 0)}$$

($A_{LT} < 0 \Leftrightarrow$ back-to-back configuration more frequent)

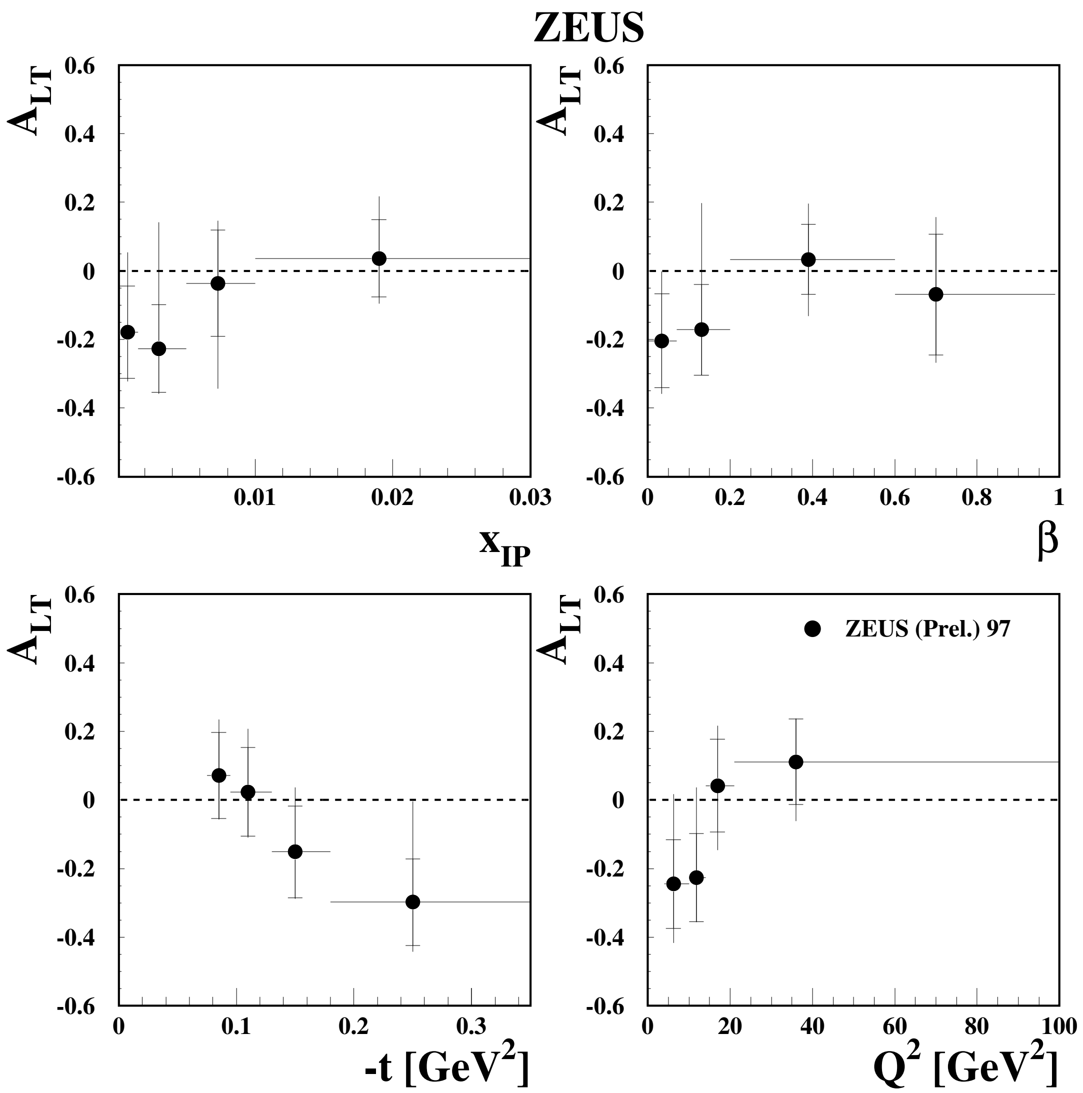
- dependence of A_{LT} on kinematic variables – for most models back-to-back configuration favoured
  - for $\beta < 0.9$ decreasing with Q^2
  - almost independent of x_{IP}
  - large for large β ($\beta >$ 0.6, $\beta >$ 0.9)
  - increasing with t

Gehrmann, Stirling, hep-ph/9503351

Nikolaev *et al.*, hep-ph/9706343, hep-ph/9812212

Arens *et al.*, hep-ph/9605376

- first results:



- expected trends visible ?, but results not conclusive yet

Summary

- 12.8 pb^{-1} of LPS data collected in 1997 allow us to measure diffractive t slope and azimuthal asymmetry as functions of kinematic variables
- no dependence of b on Q^2 observed, in contrast to exclusive production of vector mesons, dependence on M_X much weaker than dependence on M_V for vector mesons
- indications ? of shrinkage in diffractive dissociation and expected growth of b with β
- first measurement of azimuthal asymmetry: interference term between L and T photons small