DIS 2000

Azimuthal Asymmetries in DIS

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- *Introduction*
- *Analysis*
- *Comparison with theory*
- *Summary*

ZEUS

Azimuthal Distribution

Which angle ?

➥ fig

Proposed by Georgi & Politzer (Phys Rev Lett 40 (1978) 3.)

as a clean test of QCD

BUT

Cahn pointed out (Phys Lett B78 (1978) 269) also non-pert effects (intrinsic kt)

"Recently"

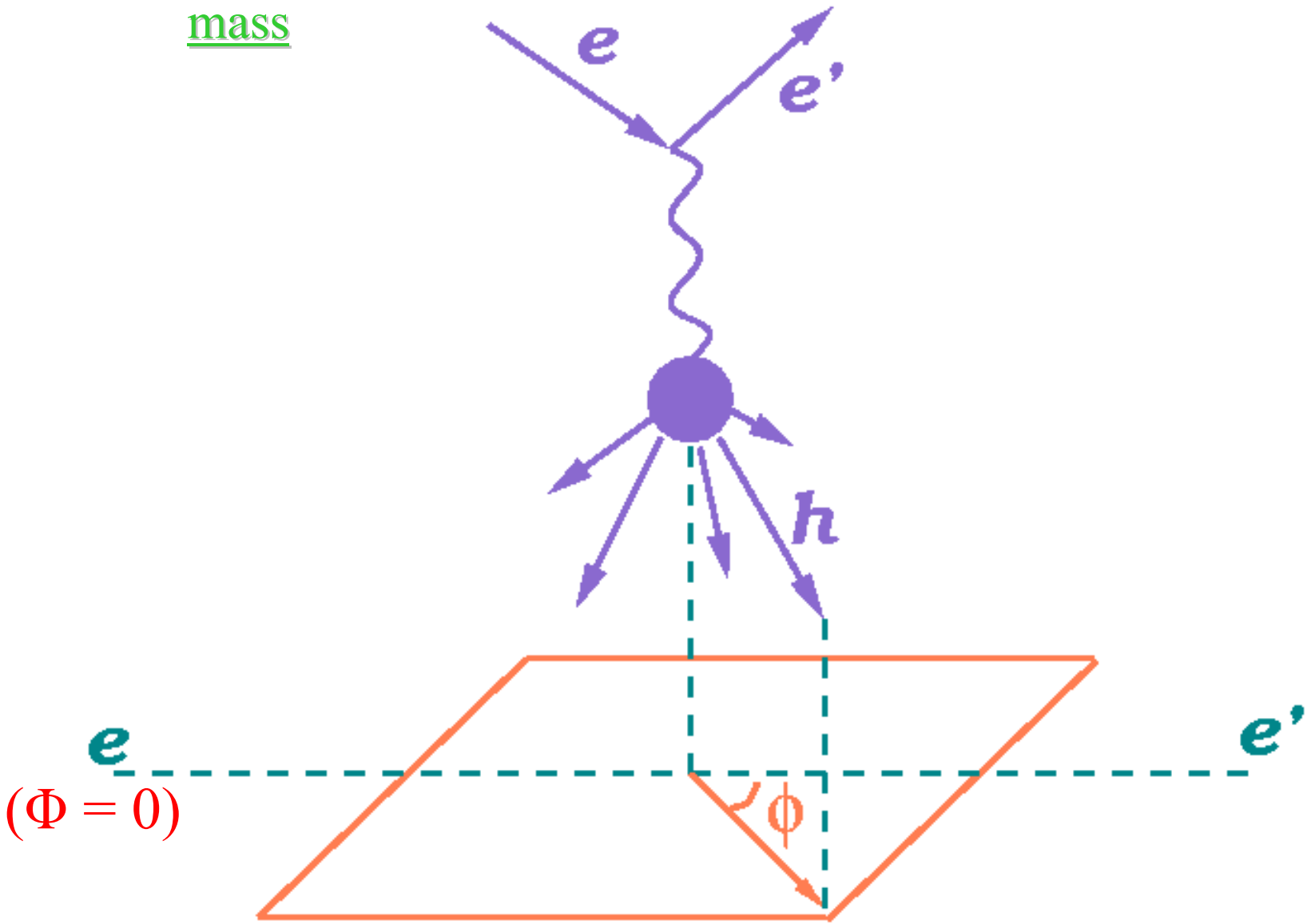
Chay, Ellis & Stirling (Phys Lett B269 (1991) 175) showed in HERA regime pert. effect can dominate

Where does azimuthal asymmetries manifest themselves from ?

Ans: polarization of the photon and spin of the quarks & gluons

(& also coherence effects)

Hadronic Centre of mass



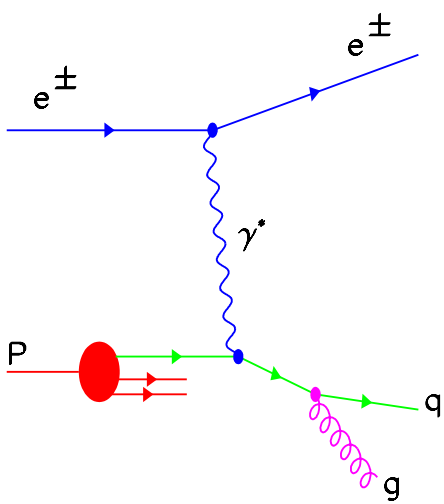
Non-zero p_T to Φ asymmetries ie $\cos\Phi$ & $\cos 2\Phi$ terms

$\cos\Phi$: transverse/longitudinal interference

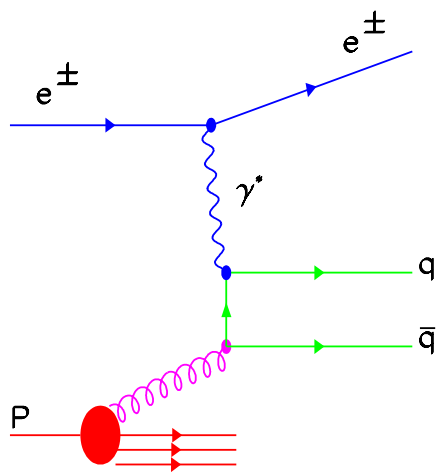
$\cos 2\Phi$: interference of amplitudes of +1 & -1 helicity components

Non-pert contribution arises from intrinsic k_T of quark in proton (should fall rapidly with increasing p_T)

Perturbative contribution from leading order diagrams...



(a)



(b)

...weakly dependent on Q^2 & persists at high p_T

Event & Track Selection

38pb^{-1} of data

$0.01 < x < 0.1$

$0.2 < y < 0.8$

$180 < Q^2 < 7220$ GeV^2

`track' cut on z_h variable to select 'leading' particle

$$z_h = \frac{P.p_h}{P.q}$$

where P is proton 4-vec; q exch boson 4-vec ; p_h hadron 4-vec

$$0.2 < z_h < 1.0$$

boosted to hadronic centre of mass ($\gamma^* P$ frame)

13,800 events & 7,700 charged tracks

Theoretical Form

$$\frac{1}{N}\frac{dn}{d\Phi} = A + B\cos\Phi + C\cos 2\Phi + D\sin\Phi$$

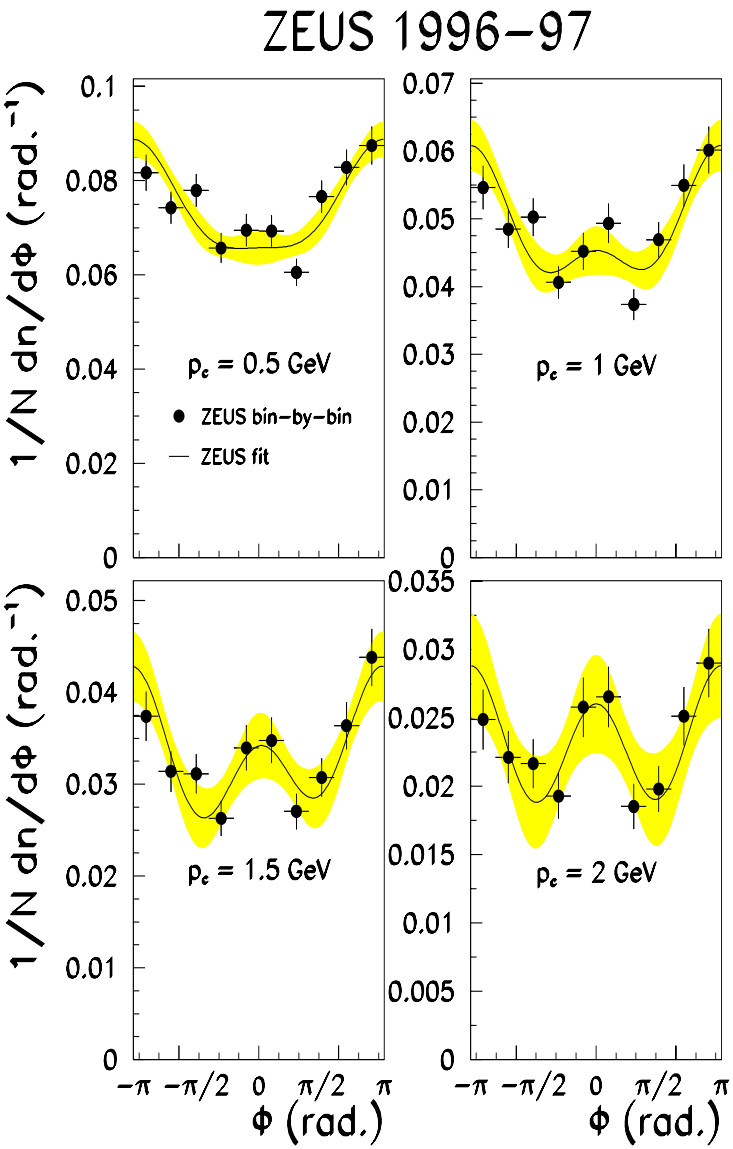
Moments:

$$\langle\cos\Phi\rangle = \frac{B}{2A} \qquad \langle\cos 2\Phi\rangle = \frac{C}{2A} \qquad \langle\sin\Phi\rangle = \frac{D}{2A}$$

Theoretical code gives predictions for moments:

- ZEUS - based on work of Chay et al
- Ahmed/Gehrmann (Phys Lett B465 (1999) 297) - based on work of Hagiwara et al Phys Rev D27 (1983) 84

Azimuthal Distributions

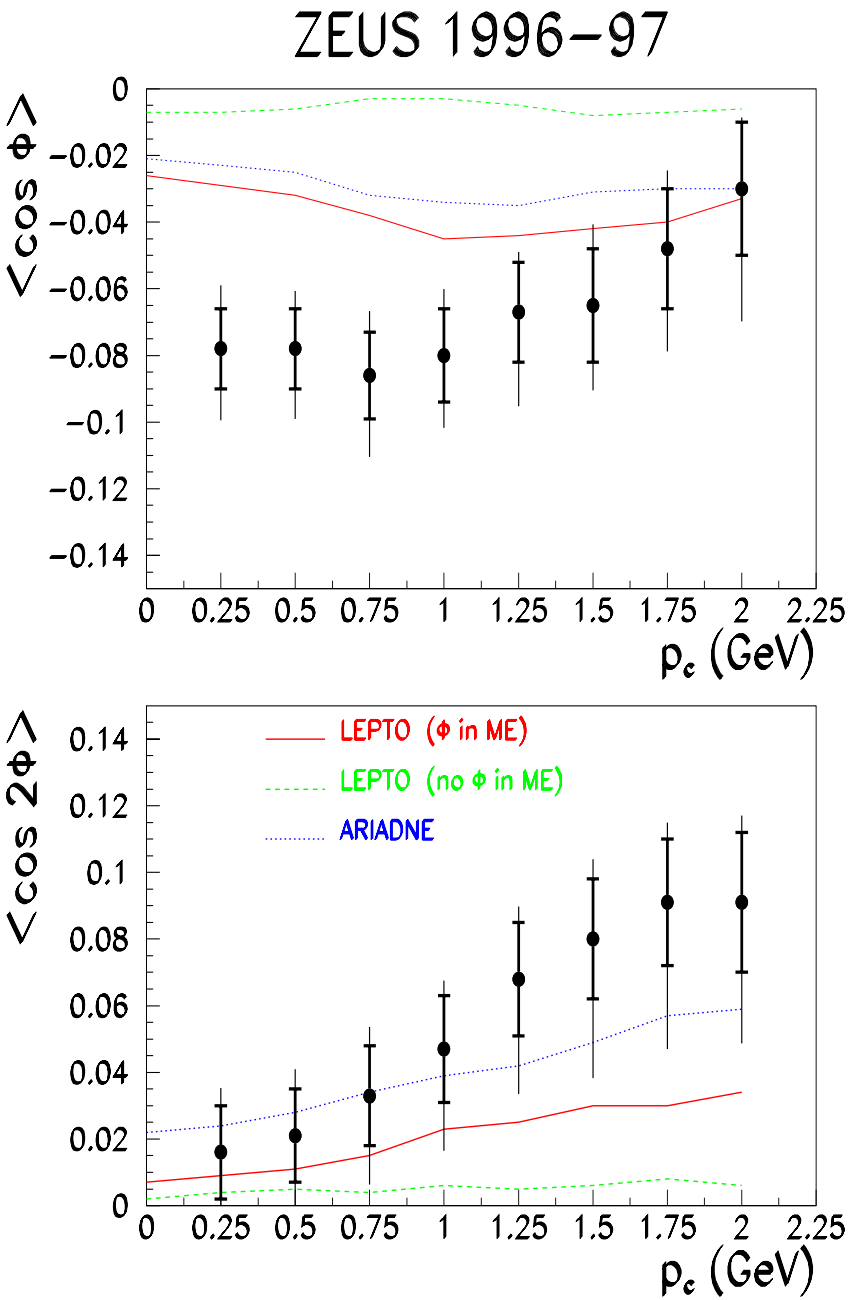


main analysis method & bin-by-bin corrections in agreement

at low p_c a clear cosΦ term

as $p_c \uparrow$ cos2Φ term becomes prominent

Moments vs. p_T cut



$p_T > p_c$

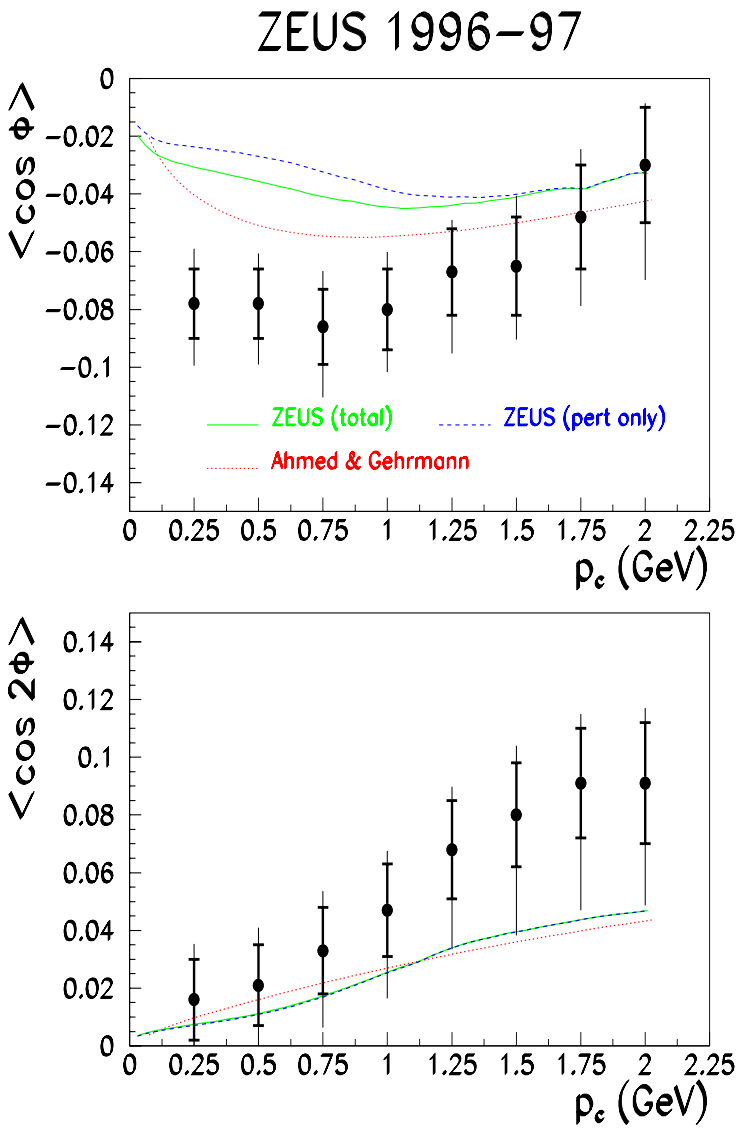
<cosΦ> -ve value

<cos2Φ> +ve rising as p_T cut is increased

LO Monte Carlos qualitatively describe the data - underestimate the effect. Difference between MC models associated with fractions of BGF & QCDC evts generated

(Released version of ARIADNE is incorrect in implementation of Φ - version compared is a corrected pre-release.)

Comparison to LO theory



LO curves qualitatively reproduce the trends observed in the data - though they underestimate the magnitude

Difference between curves are calculation from ZEUS includes non-pert effects & integrates over x and Q^2

Non-pert effects (for mean intrinsic kt & frag p_T both set to 0.5 GeV) is at most 20% for cosΦ and negligible for cos2Φ

Summary

- cosΦ term is –ve
- first measurement of a cos2Φ term
- cos2Φ insensitive to non-pert effects
- first measurement of azimuthal asymmetry due to pert QCD
- LO predictions qualitatively describe the data