DIS2000

The University of Liverpool, April 25^{th} to 30^{th}, 2000

Current Issues in Fragmentation in DIS

David Milstead

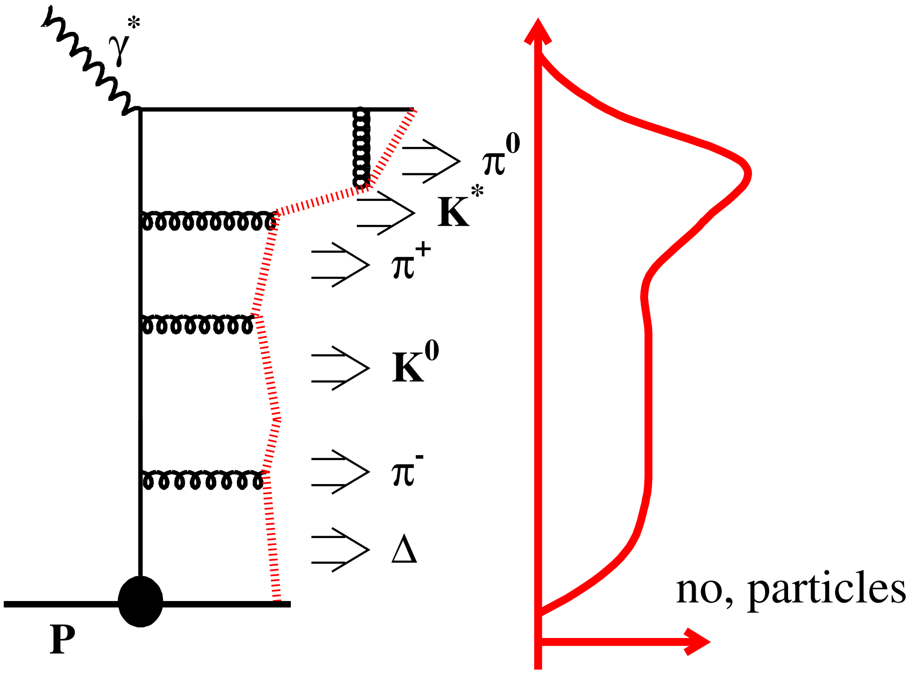
The University of Liverpool

Representing

H1 Collaboration **ZEUS Collaboration**

Using the Hadronic Final State at HERA

Test QCD with fundamental hadronic final state measurements



Particle spectra provide info.

on fragmentation universality with e^+e^-;

on the flavour content of DIS;

on pQCD radiation;

on baryon number propagation.....

To understand this we also need to understand the calculations....

When should we expect MLLA+LPHD to fail ?

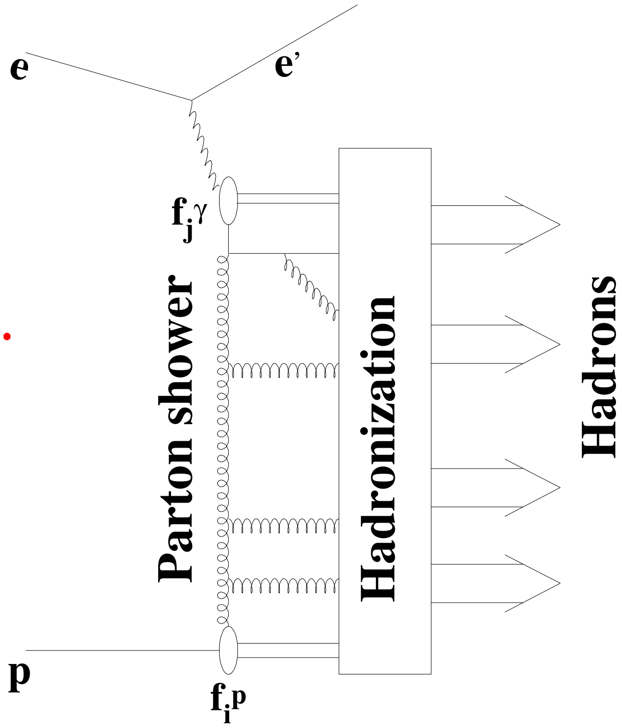
Can we expect LEP-style agreement with our major observables in the current region ?

Is it meaningful to compare LEP-tuned hadronisation models to our data ?

What else should we measure to kill/support your models ?

Calculating the Hadronic Final State

Universal prescriptions from QCD based Monte Carlo model.



Factorise into perturbative and non-perturbative pieces.

$\sigma_{obs}=f_i^p \otimes f_j^\gamma \otimes |ME| \otimes$ **frag.**

Most common models :

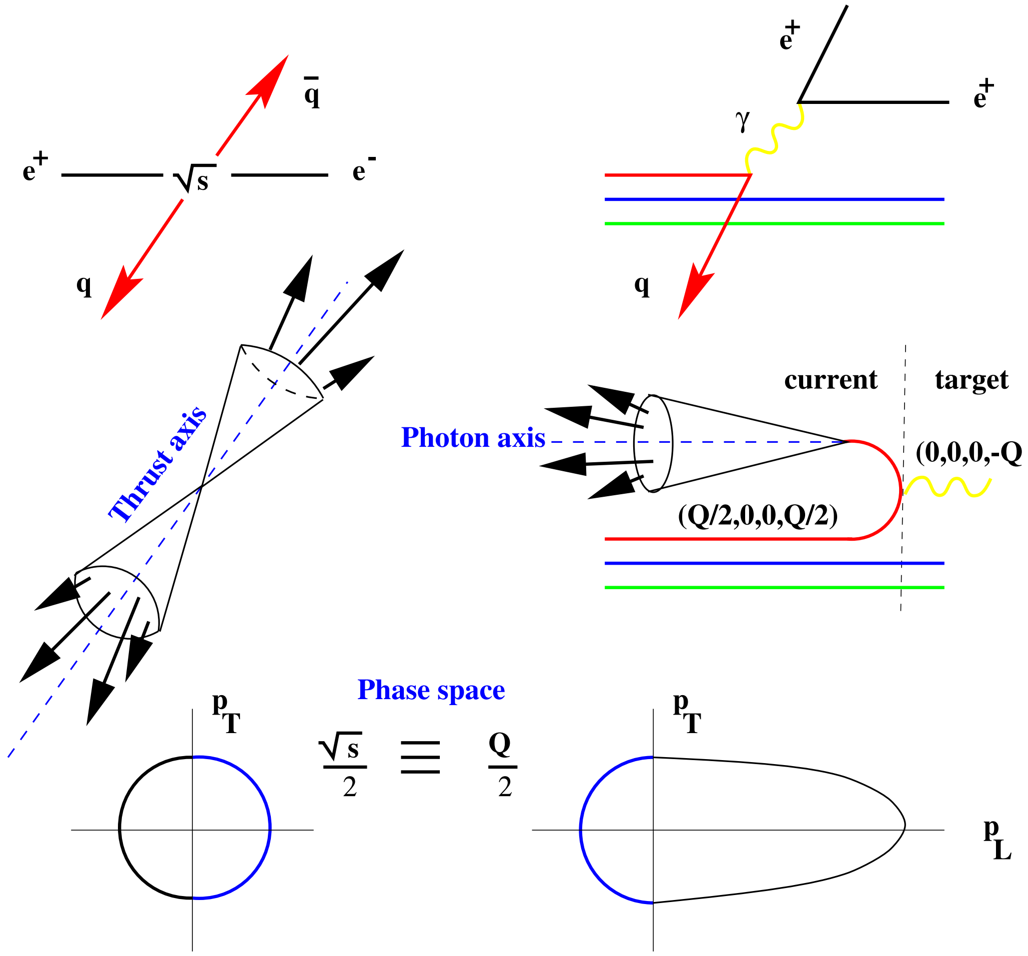
LEPTO - ME+PS + string
HERWIG - ME+PS + cluster
ARIADNE - ME + Colour Dipole Radiation + string

Many other options "on the market"

- **MLLA+LPHD**
- **Fragmentation functions**
- **Power Corrections**
- **Soft Colour Interactions, GAL..**
- **Gluonic baryon propagation**

Aim of this talk to identify strengths and weaknesses of QCD-based approaches.

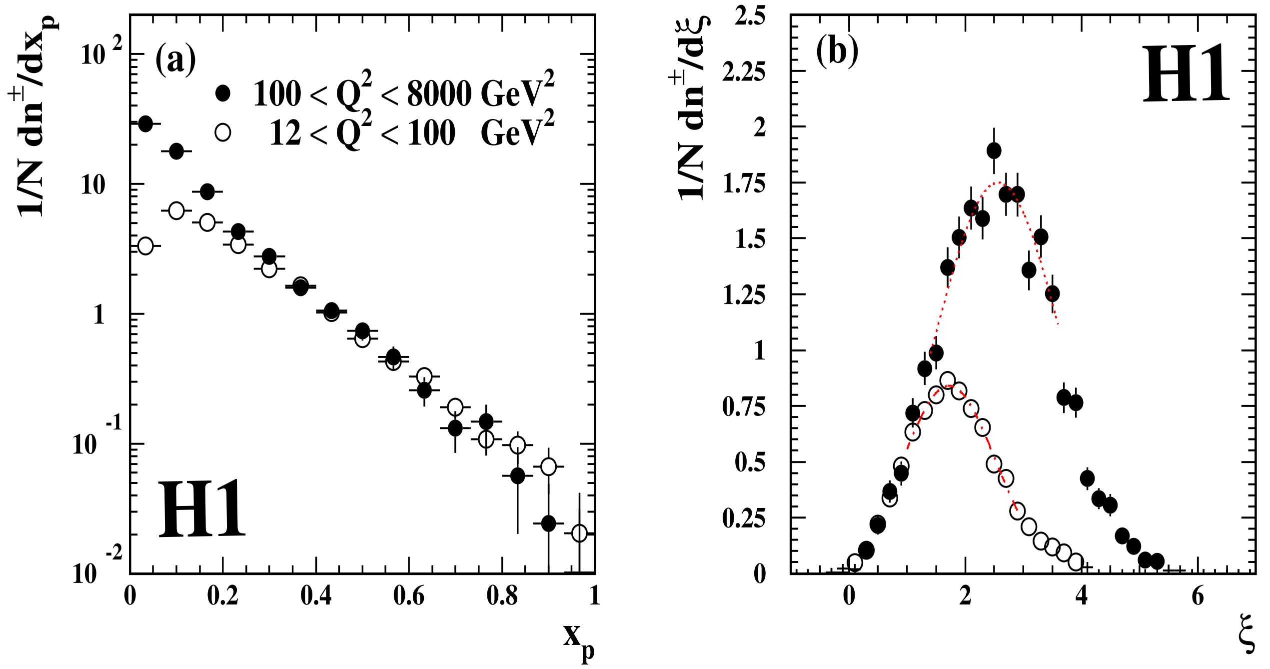
The Breit Frame



- **Clean separation between current and target fragmentation in Breit frame**
- **Phase space in current hemisphere of the Breit frame for $ep \to e'X$ events $Q/2$**

Evolving Fragmentation Functions in the Breit Frame

$$\mathbf{x}_p = 2p/Q,\ \xi = ln(1/x_p),\ D(\xi) = \frac{1}{N}\frac{dn}{d\xi}$$



- Assuming gluon coherence and LPHD the predicted MLLA behaviour of the peak and width is

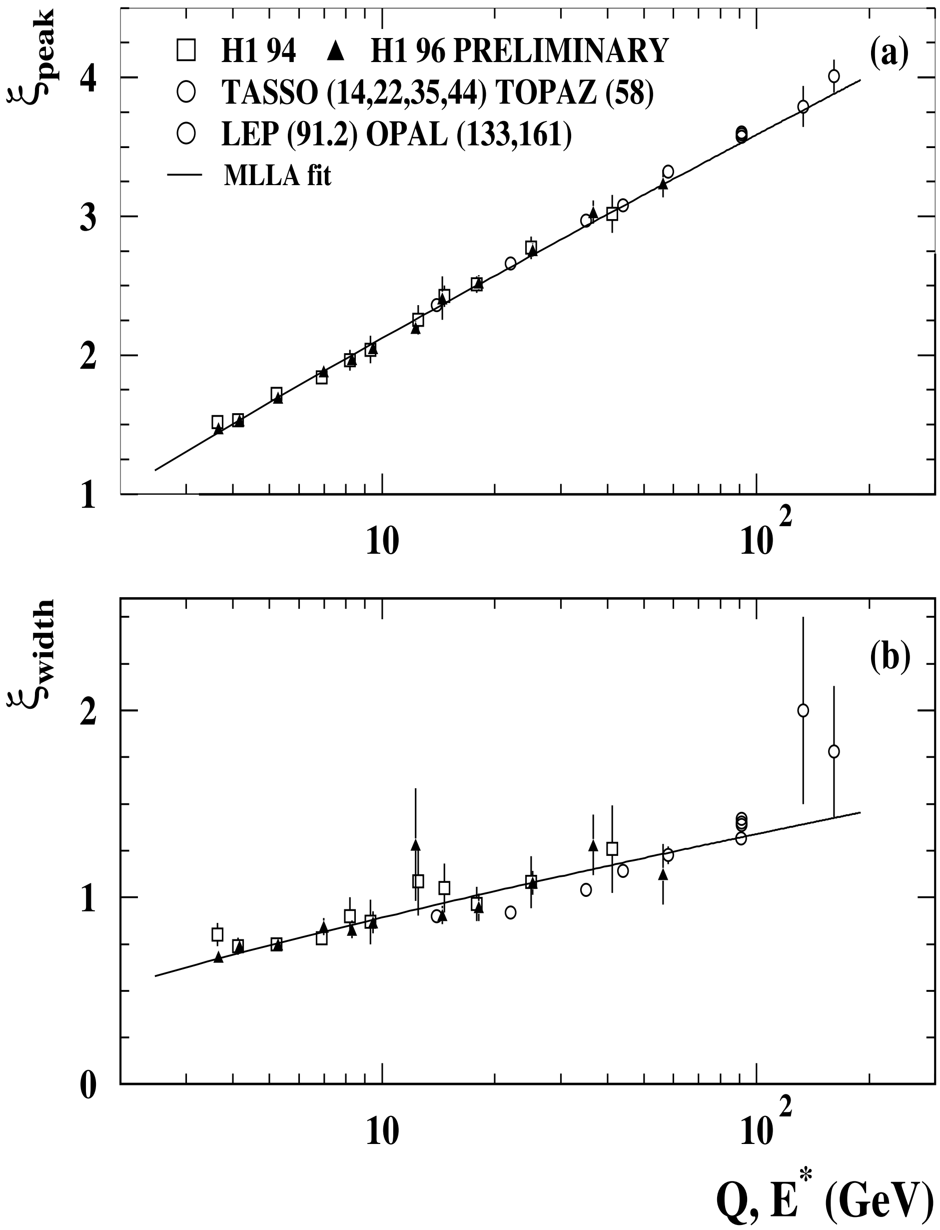
$$\mathrm{Y}{=}\mathrm{ln}(\mathrm{Q}/\Lambda_e f f)$$

$$\xi_{peak} = 0.5Y + c_2\sqrt{Y} + \mathrm{d}$$

$$\xi_{width} = \sqrt{Y^{3/2}/2c_1}$$

- Peak and width determined with Gaussian fit.

Peak Position and Width of ξ of Charged Particle Spectra



- **MLLA+LPHD fit describes data well**
- **No deviation from e^+e^- behaviour**

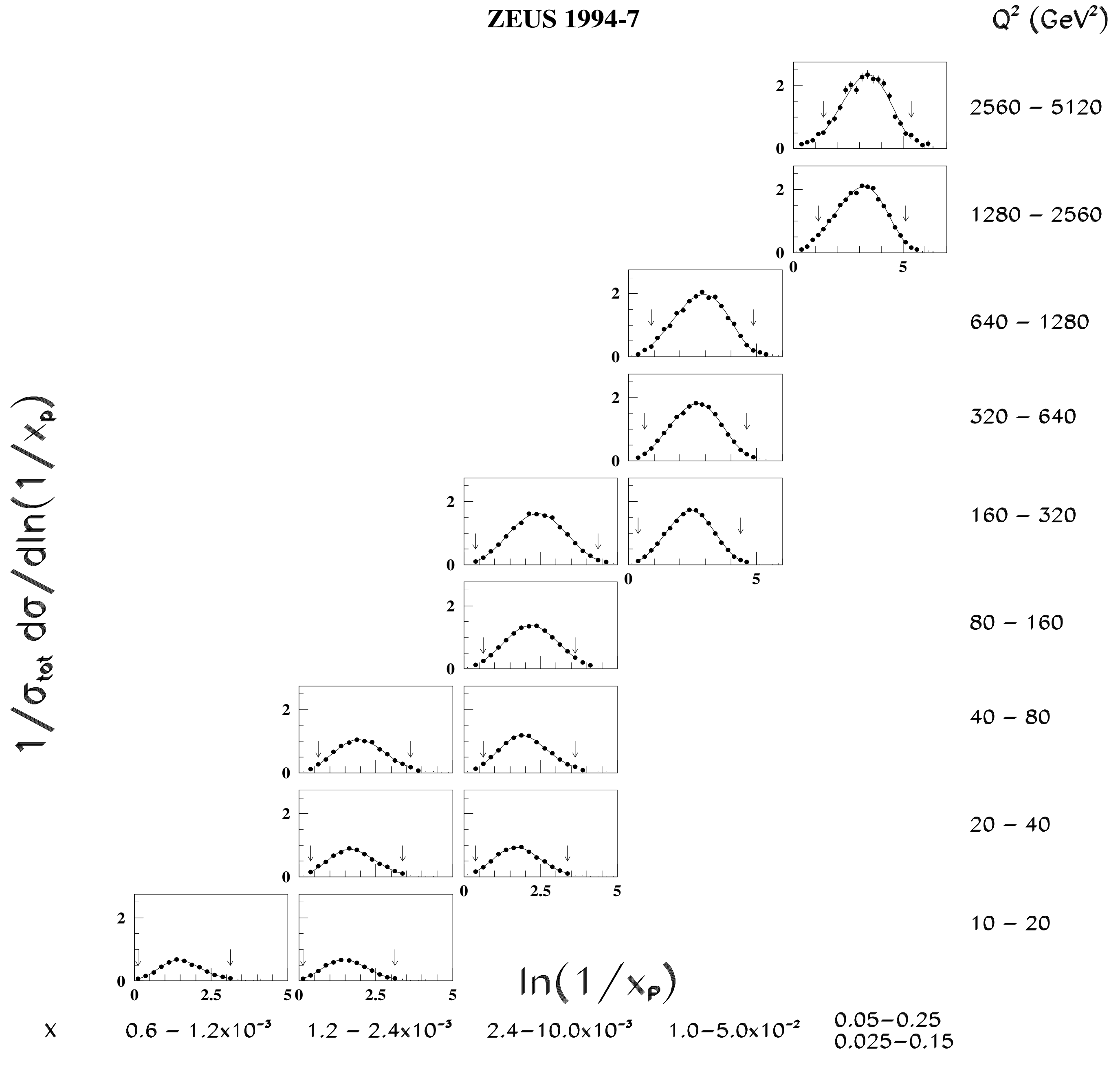
Higher Moments of Fragmentation Functions

Fit distorted Gaussian:

$$\exp\left(\frac{1}{8}k - \frac{1}{2}s\delta - \frac{1}{4}(2+k)\delta^2 + \frac{1}{6}s\delta^3 + \frac{1}{24}k\delta^4\right)$$

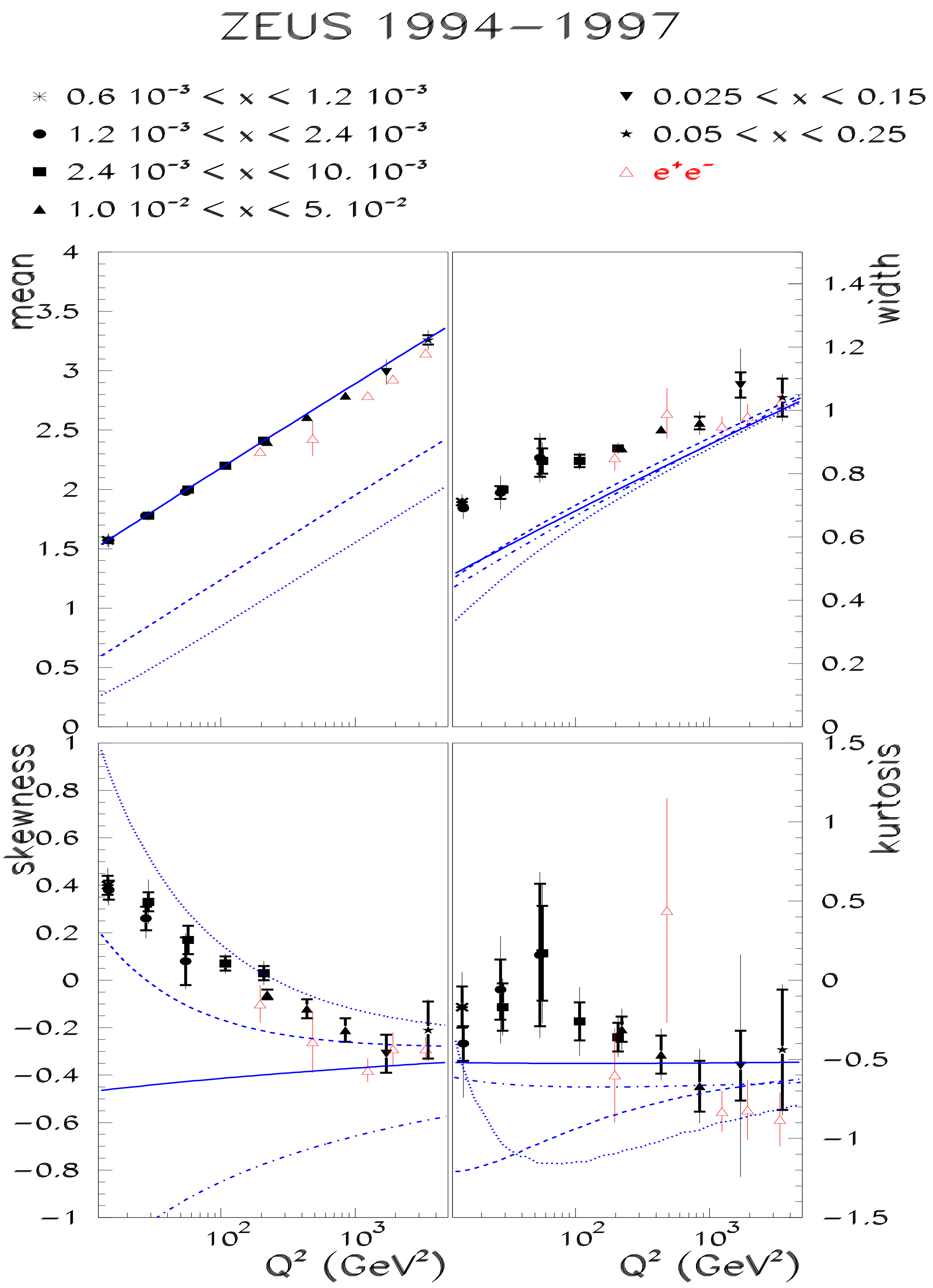
$\delta = (\ln(1/x_p) - l)/\sigma$

$l \equiv$ mean, $\sigma \equiv$ dispersion, $s \equiv$ skewness, $k \equiv$ kurtosis



Higher Moments of Fragmentation Distributions

Kinematic dependence of peak, width, skewness and kurtosis



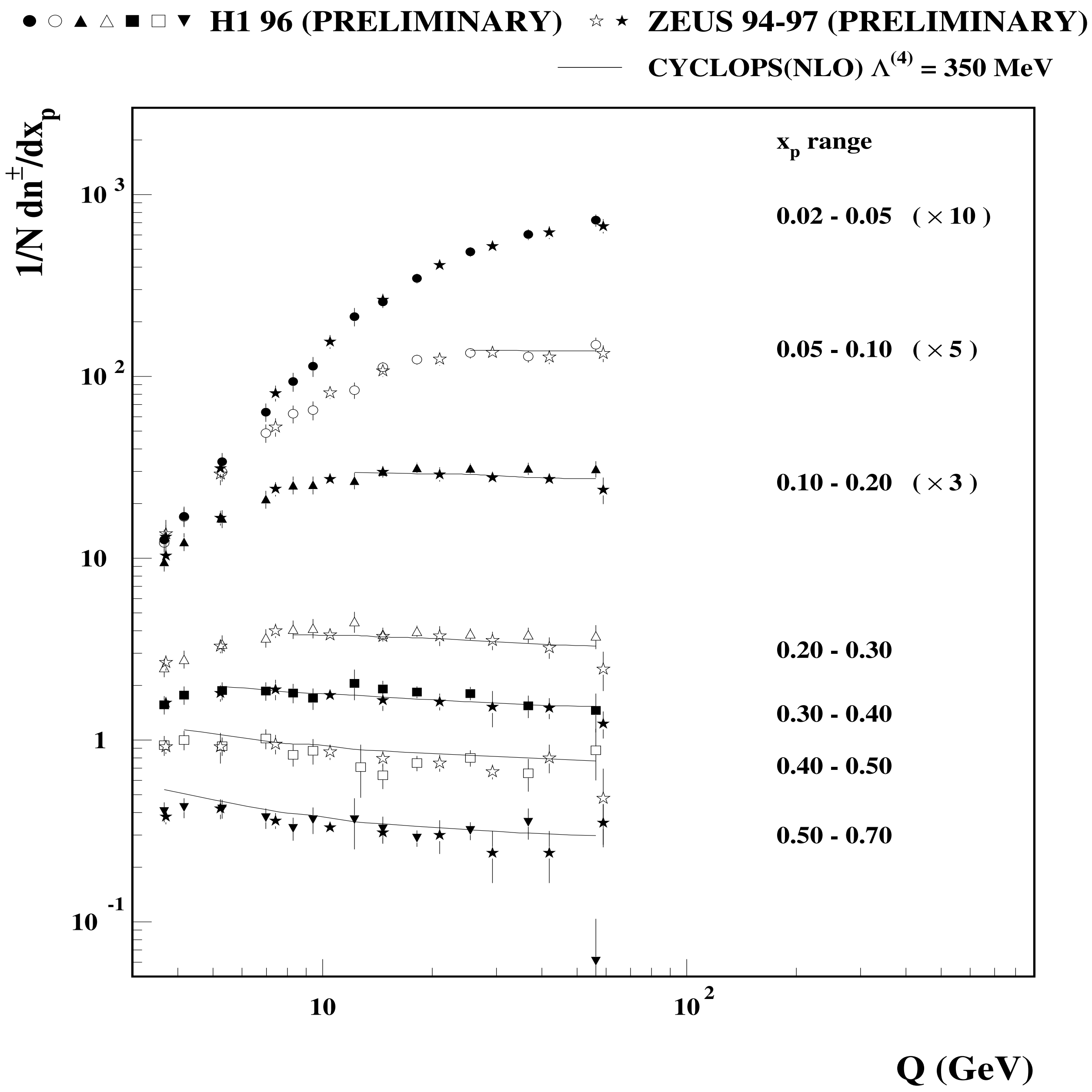
Agreements with e^+e^-

MLLA fails to describe higher moments !

Massless assumptions valid ?

Scaling Violations in Charged Particle Fragmentation Functions

Measure variation of x_p with Q in current region of Breit Frame



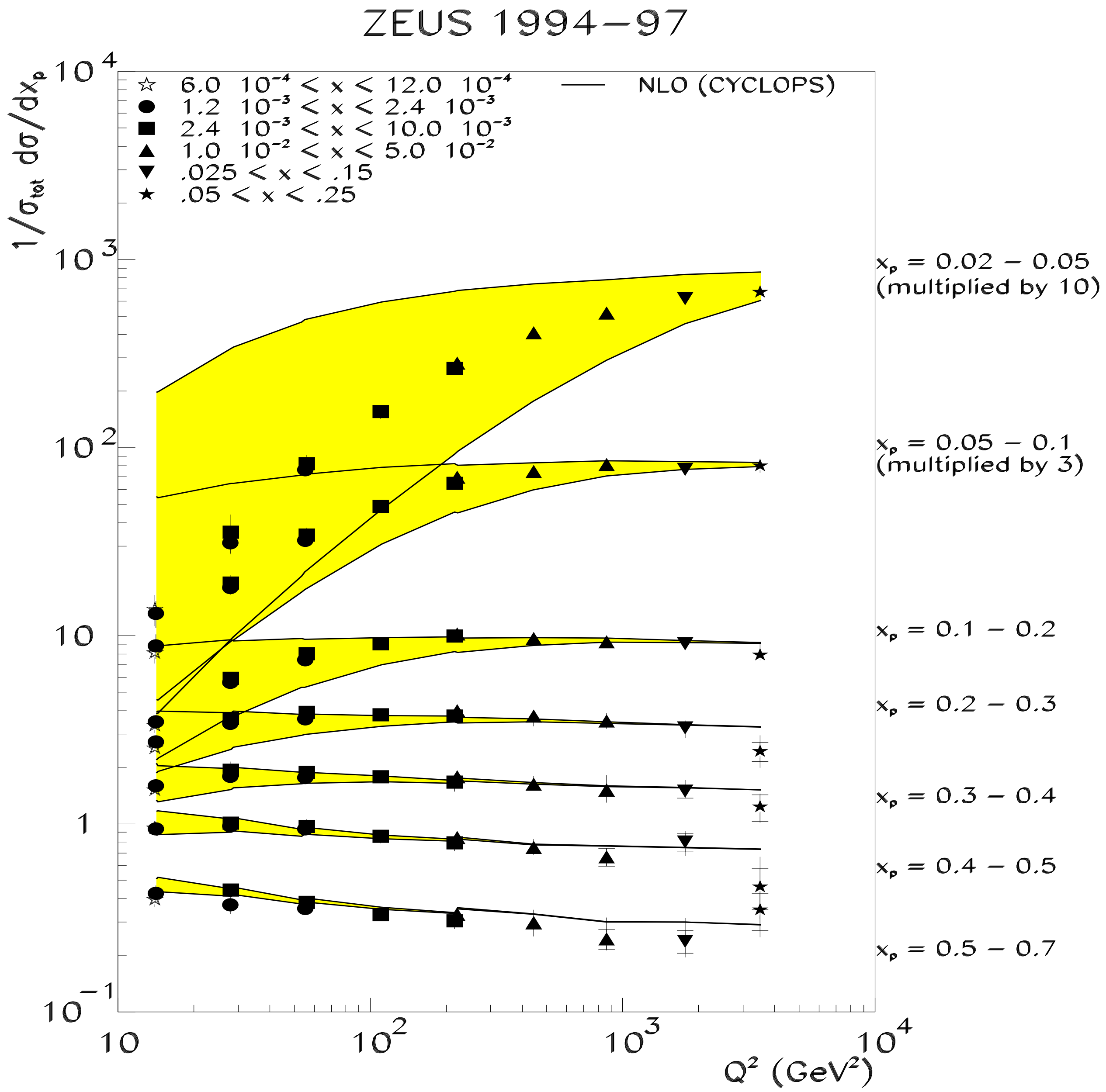
Measurements span orders of magnitude in Q and x_p

More phase space for QCD emissions with higher Q

NLO calculations provide excellent description of the data

Using Power Corrections to Describe Scaling Violations

Can a power corrections ansatz perform hadronisation step ?

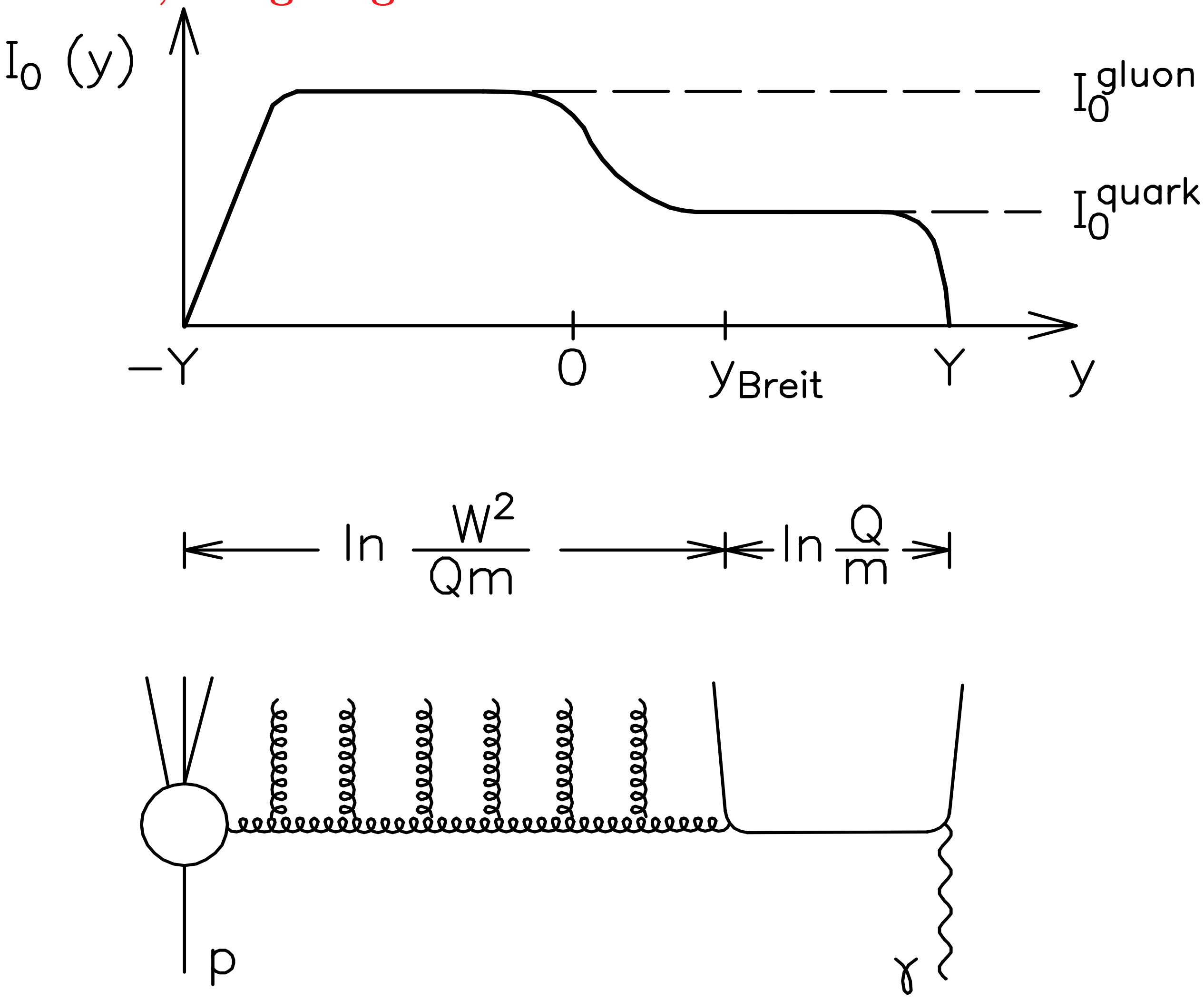


Excellent description from such a simple approach.

Into the Target Hemisphere

Target Fragmentation - Particle densities

Ochs, Ringberg Proc'97

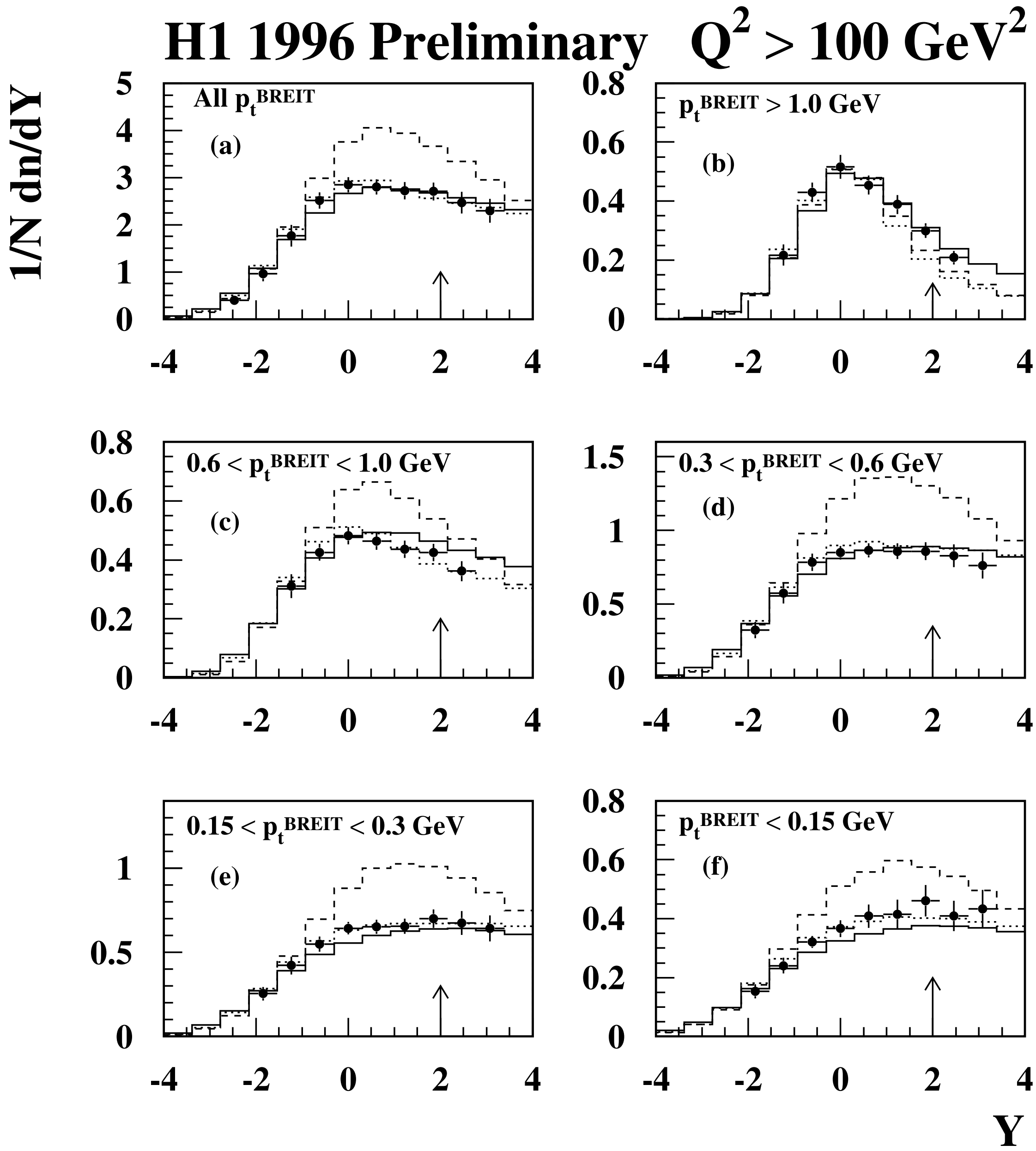


colour octet sources yield

$$I_0^{\text{gluon}} = \frac{9}{4} I_0^{\text{quark}}$$

as $p_t \rightarrow 0$

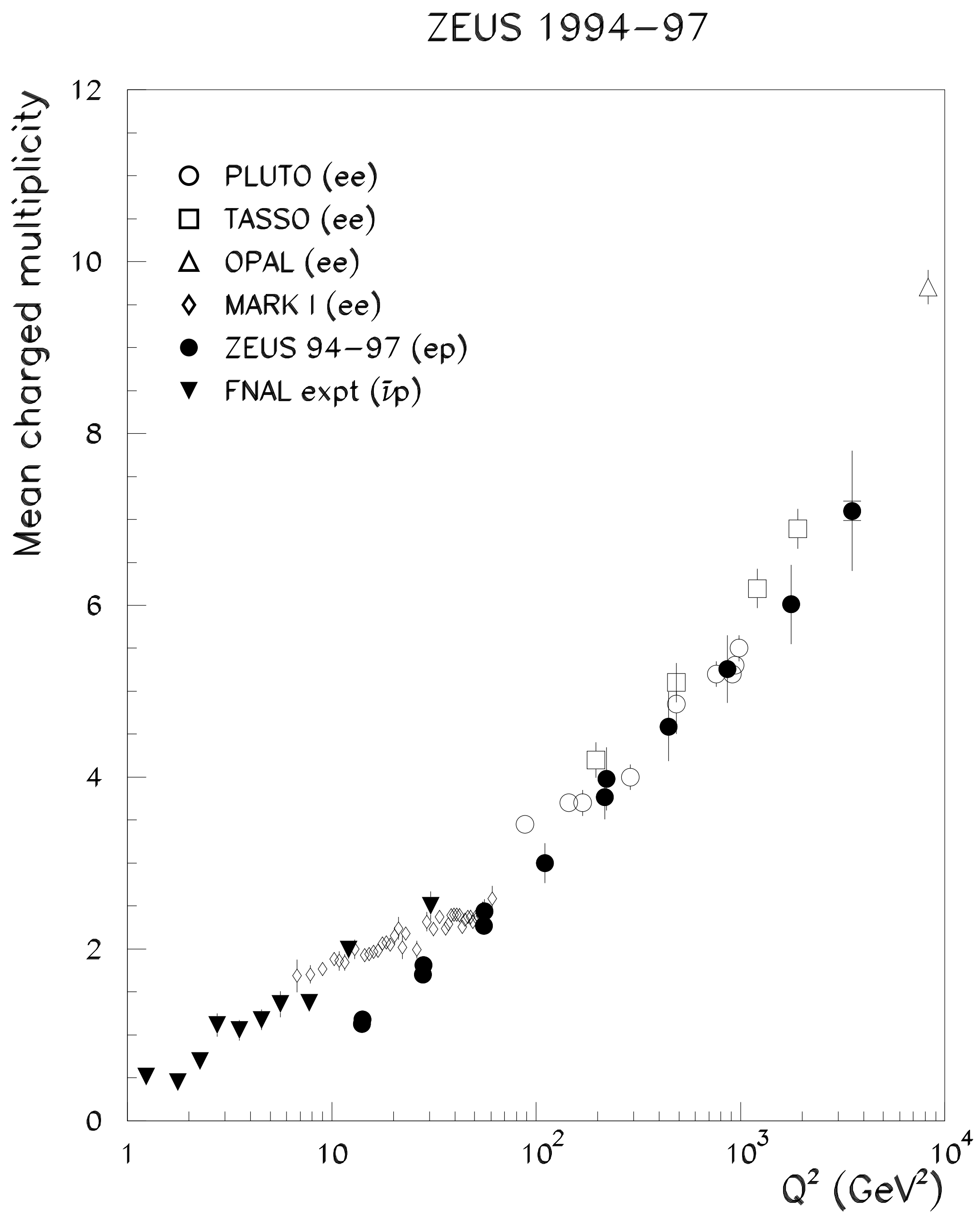
Beyond the Current Hemisphere : Charged Particle Rapidity Spectra



No plateaux seen.

Soft Colour Interactions produce too many soft particles.

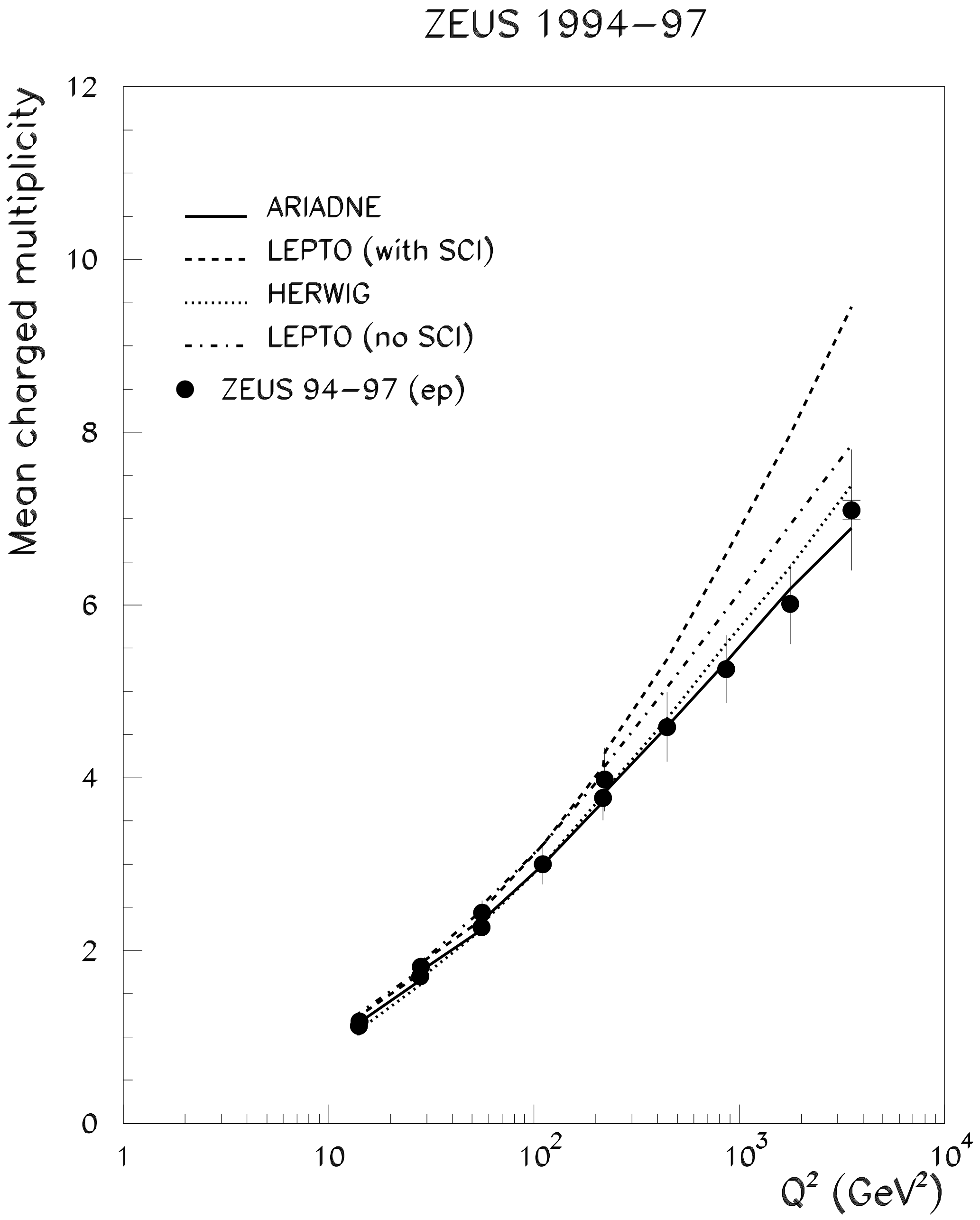
Charged Particle Multiplicity Compared with e^+e^-



Good agreement with e^+e^- for $Q^2 \gtrsim 70$ GeV^2 .

Deviation due to LO QCD processes.

Mean Charged Multiplicity Compared to QCD Models



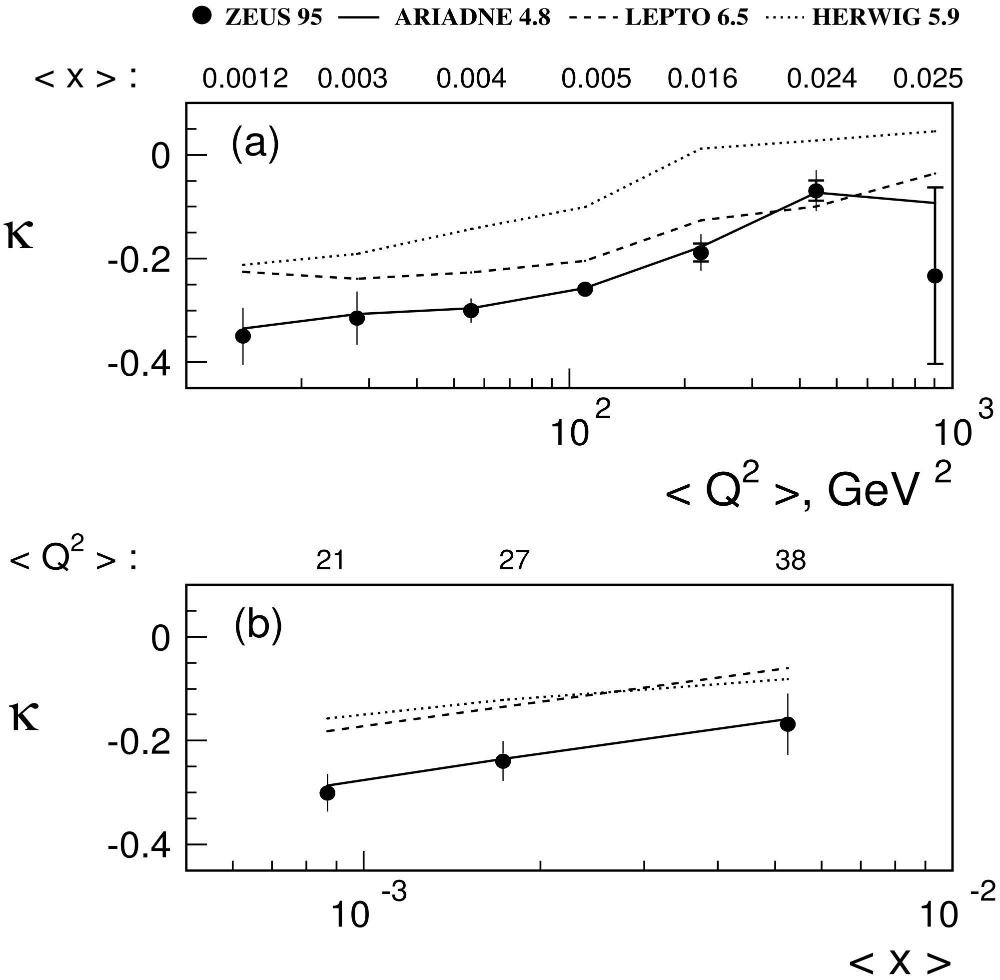
Soft Colour Interactions fail to describe high Q^2 data.

Generalised Area Law String Rearrangment agrees.

Current-Target Correlations in the Breit Frame

$$\kappa = \frac{\langle n_c n_t \rangle - \langle n_c \rangle \langle n_t \rangle}{\sigma_c \sigma_t}$$

$n_{c,t}$ - ch particle multiplicity in current(target) region
$\sigma_{c,t}$ - rms of multiplicity distbn in current(target) region

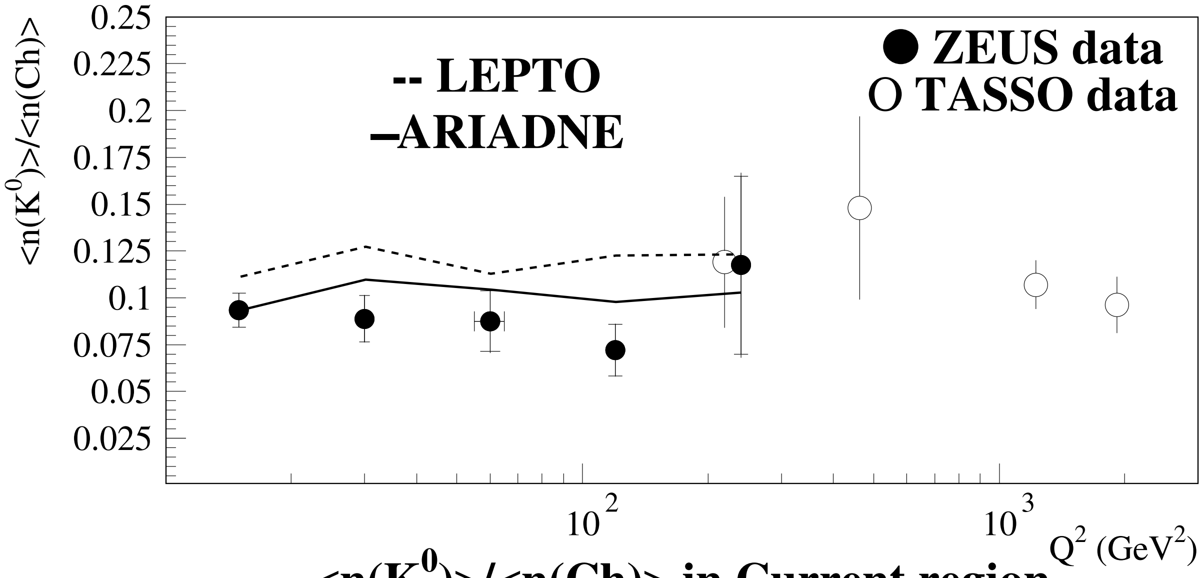


Anti-correlations observed
κ increases as $x\uparrow$
κ increases as $Q^2\uparrow$

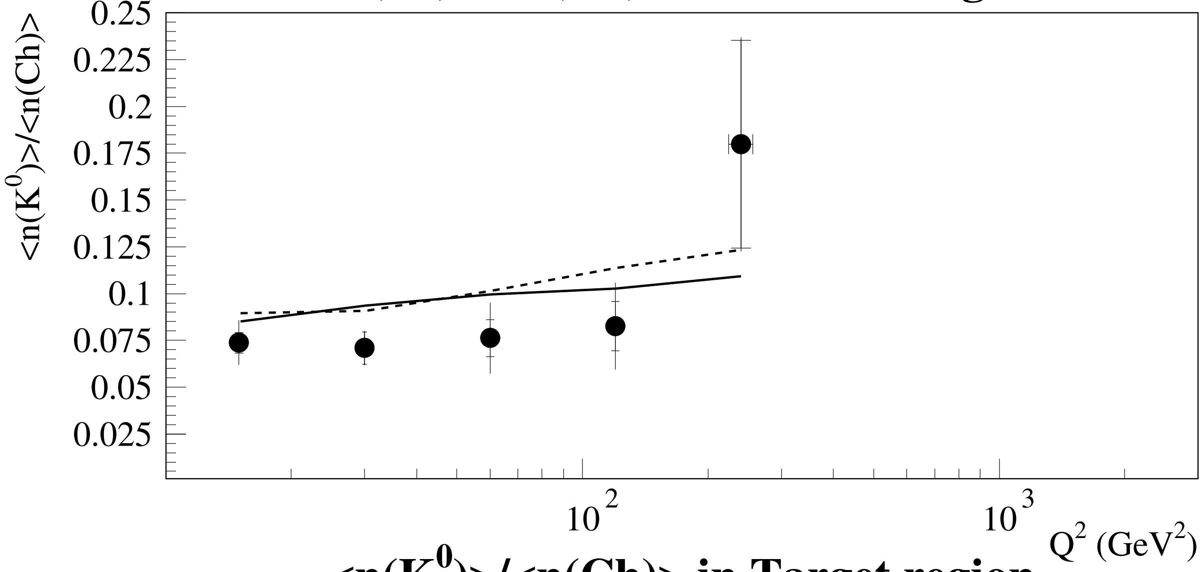
Strangeness Composition of the DIS Hadronic Final State

Study the $< K^0 >$: <charged particle> ratio in the current and target regions of the Breit frame

ZEUS 1995 preliminary



$\langle n(K^0)\rangle / \langle n(Ch)\rangle$ in Current region

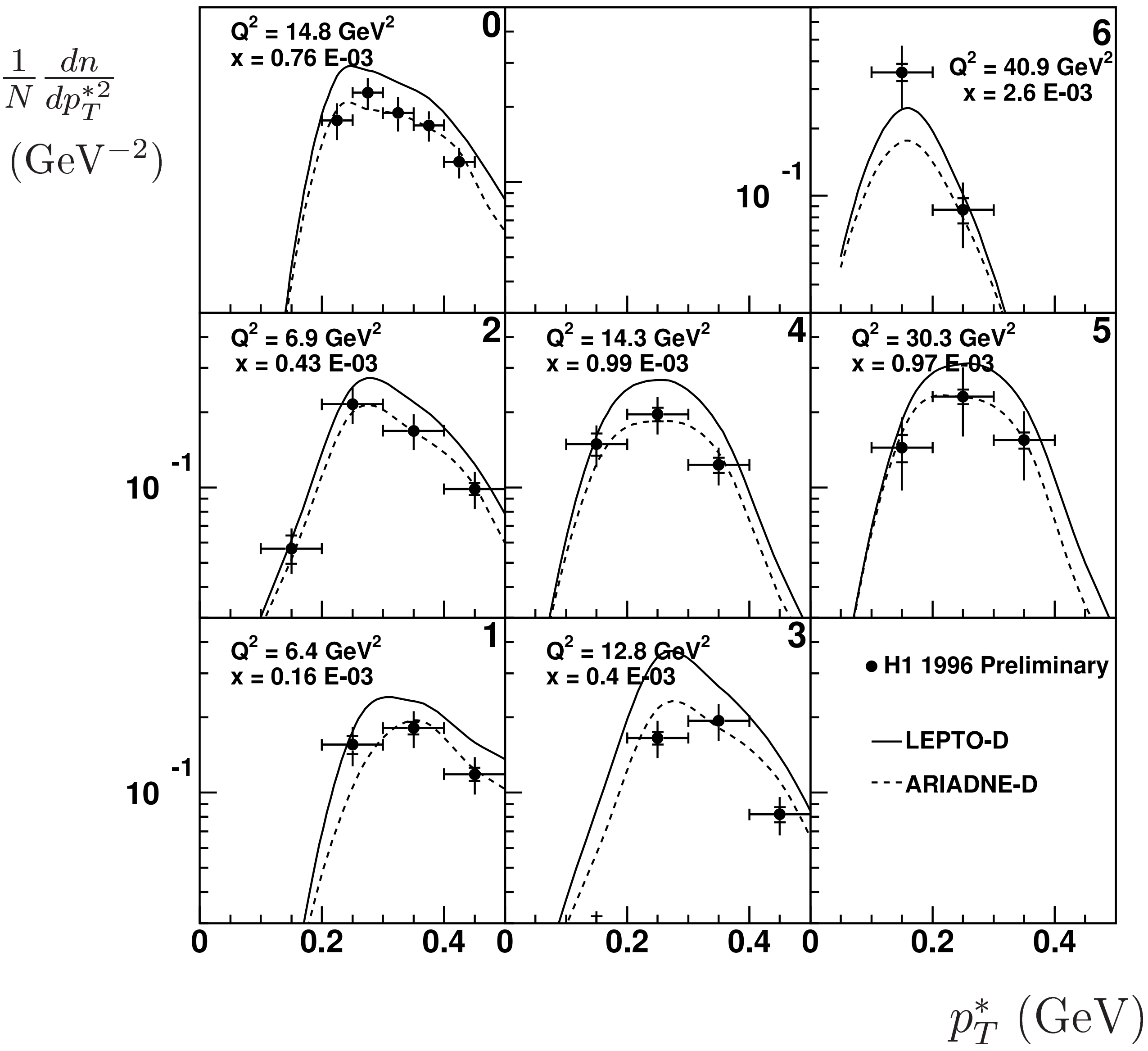


$\langle n(K^0)\rangle / \langle n(Ch)\rangle$ in Target region

Strangeness suppression consistent with e^+e^- in current region

QCD models wit strangeness suppression factor of 0.3 fail to describe data

Strangeness Dependence on x and Q^2.



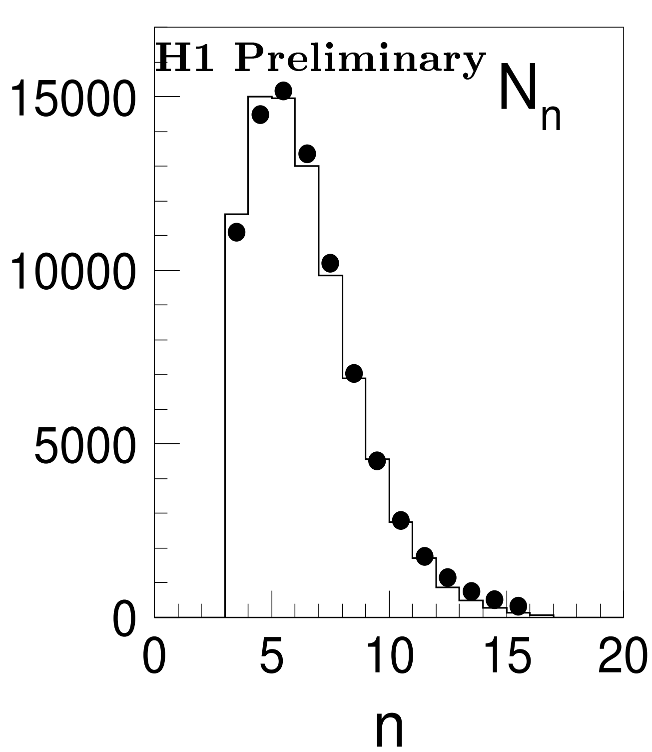
QCD Model discrimination

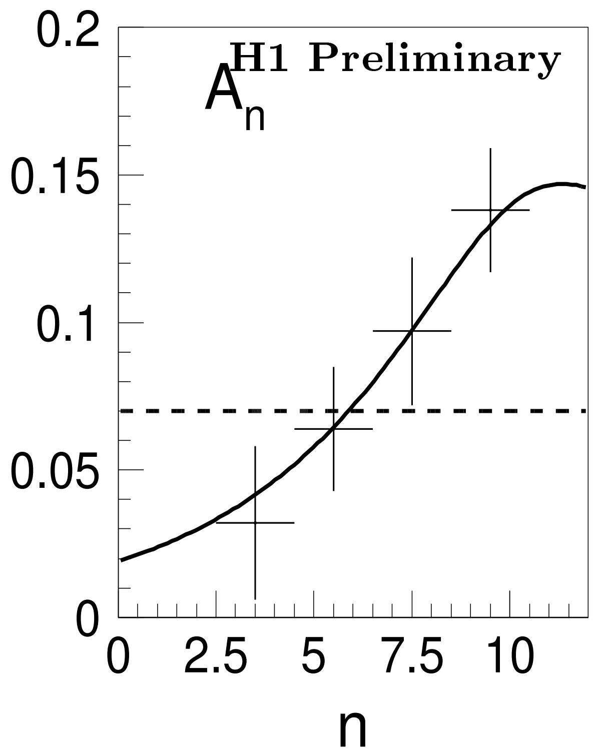
Strangeness suppression factor < 0.3 favoured.

Propagation of Baryon Number

$p - \bar{p}$ asymmetry measured in photon hemisphere !

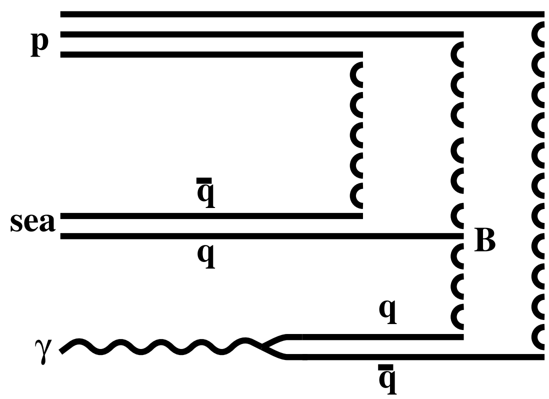
$A_N = 2 \cdot \frac{N_p - N_{\bar{p}}}{N_p + N_{\bar{p}}}$

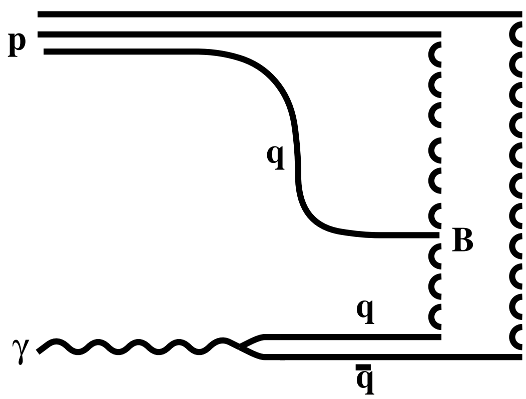




Model baryon flow through gluon exchange

(phys. lett. B446:321-325,1999)





Summary

Current Results on Particle Spectra in DIS Presented.

- **Universality with e^+e^- for $Q^2 > 70$ GeV^2.**
- **NLO QCD describe scaling violations.**
- **MLLA fails to describe higher fragmentation moments.**
- **Baryon asymmetry seen in photon hemisphere.**
- **Strange particle composition at low x described with e^+e^- string fragmentation.**

Data points approaching LEP-precision.

QCD-based models perform reasonably well so far.

What kind of model precision can we expect ?

Will we be able to see new physics from fragmentation variables ?