Fragmentation Functions at ZEUS

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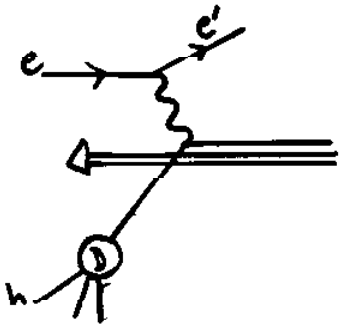
- Motivation
- Results from 1994 data
- Comparison with Theory
- Conclusions

Fragmentation Functions



- The fragmentation function $D^h(x_p, Q^2)$ for a parton represents the probability that that parton will fragment to form a hadron h carrying a fraction x_p of its momentum.

- They cannot be calculated in pQCD, but we know how to evolve them in Q^2.

- Measurements of scaling violations in fragmentation functions.

$$D(x_p, Q^2) \equiv \frac{1}{\sigma_t} \frac{d\sigma}{dx_p}$$

where $x_p = 2p/Q$

have already been done at LEP making use of low energy e^+e^- data.

A HERA measurement of this will be one of the first experiments

MEASUREMENT

We measure:

$$\frac{d^3\sigma_t}{dx\, dQ^2 dx_p} = P \otimes \hat{\sigma} \otimes F$$

P: Parton densities as a function of (x, Q^2) eg. MRST

$\hat{\sigma}$: Matrix element - calculable in pQCD eg. NLO calculation from D. Graudenz

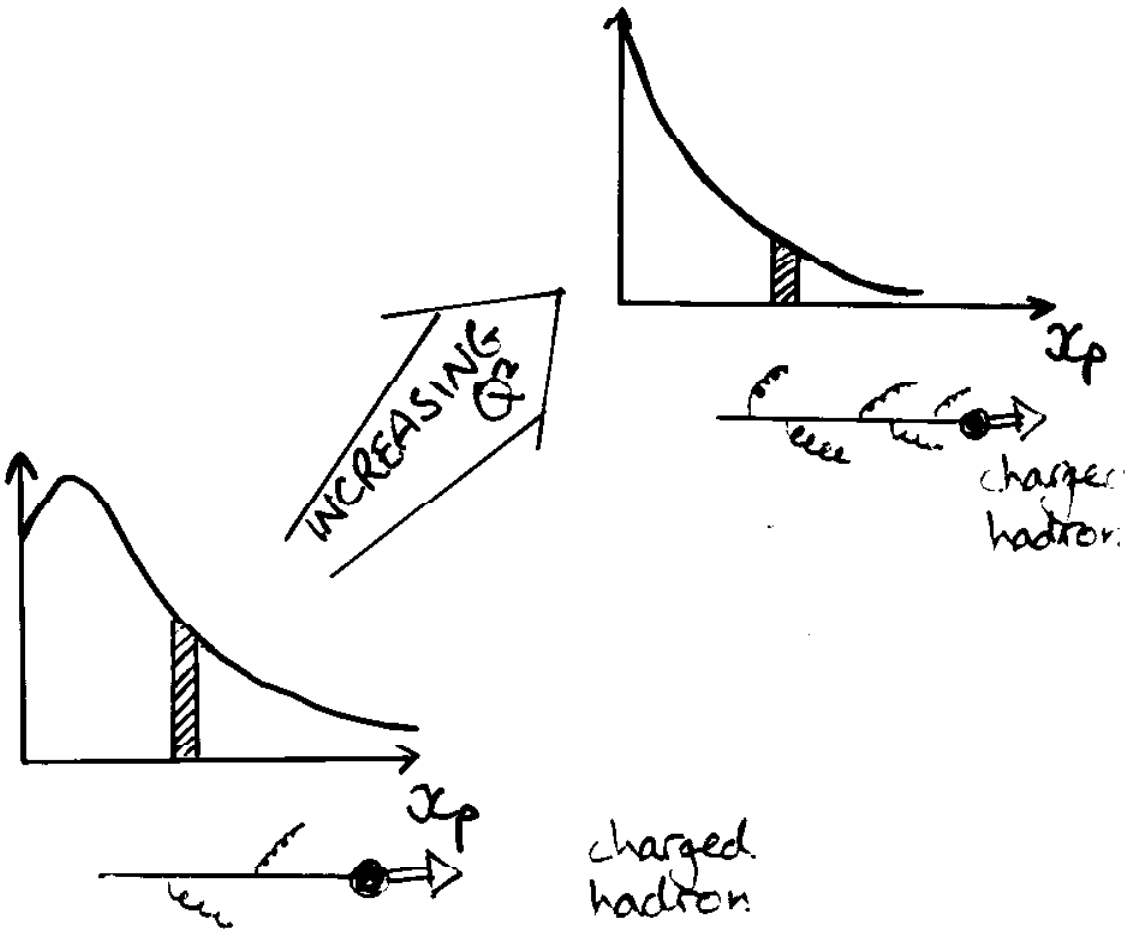
F: fragmentation functions, as a function of (x_p, Q^2) eg. determined from e^+e^- data by Binnewies et al.

Sensitivity to α_s comes through scaling violations of

$$D^h(x_p) \sim \hat{\sigma} \otimes F$$

as a function of Q^2

EXPECT:



At fixed $x_p \gtrsim 0.1$, expect the cross section to decrease with increasing Q^2 due to the increased phase space for gluon radiation and the running of α_s.

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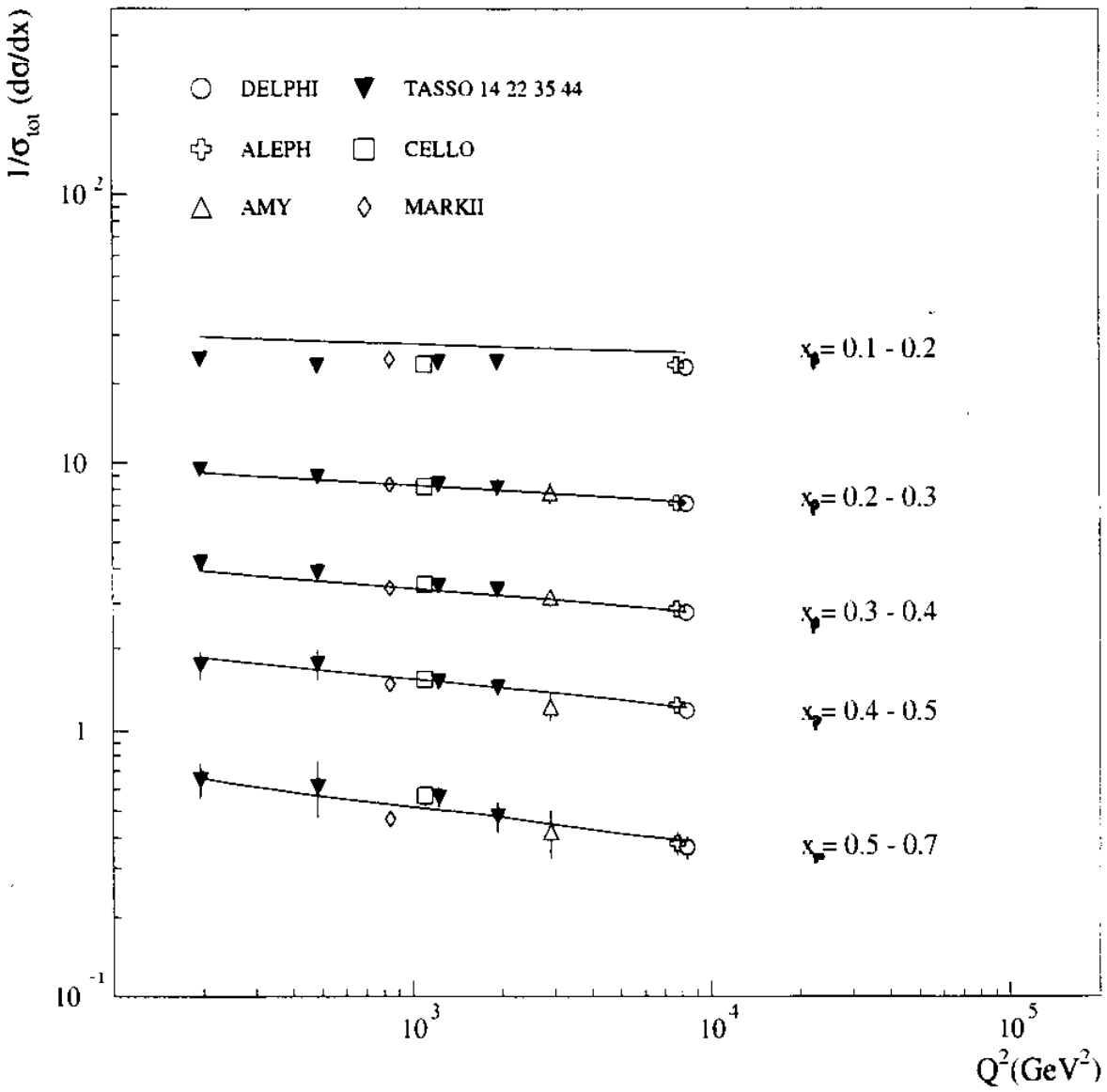
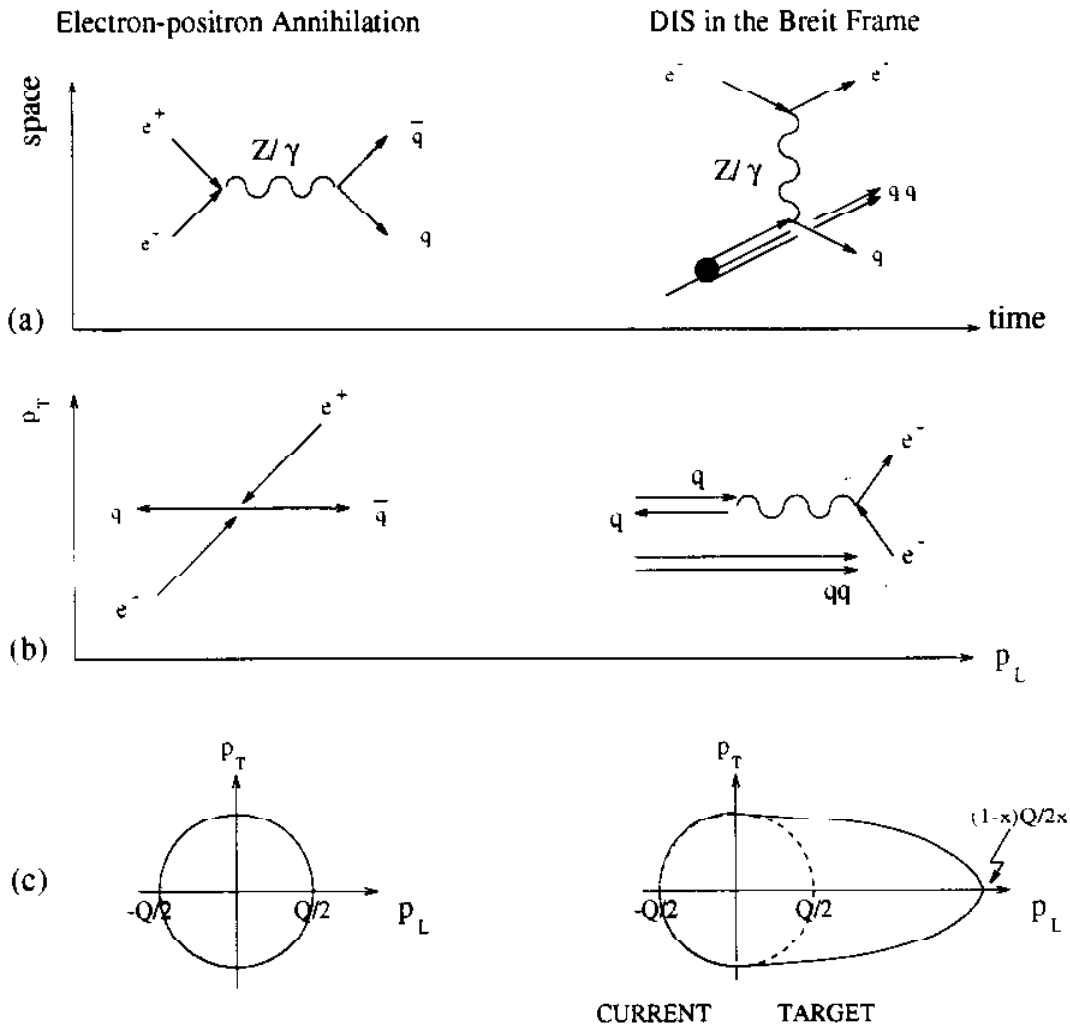


Figure 1: The Q^2 dependence of the inclusive momentum cross section in GeV^2 for various x bins. For most data points the errors are smaller than the symbols. The solid curves are results of the fit for $0.20 < x < 0.8$.

$\longrightarrow \alpha_S(M_Z) = 0.122 \pm 0.012$

The Breit Frame

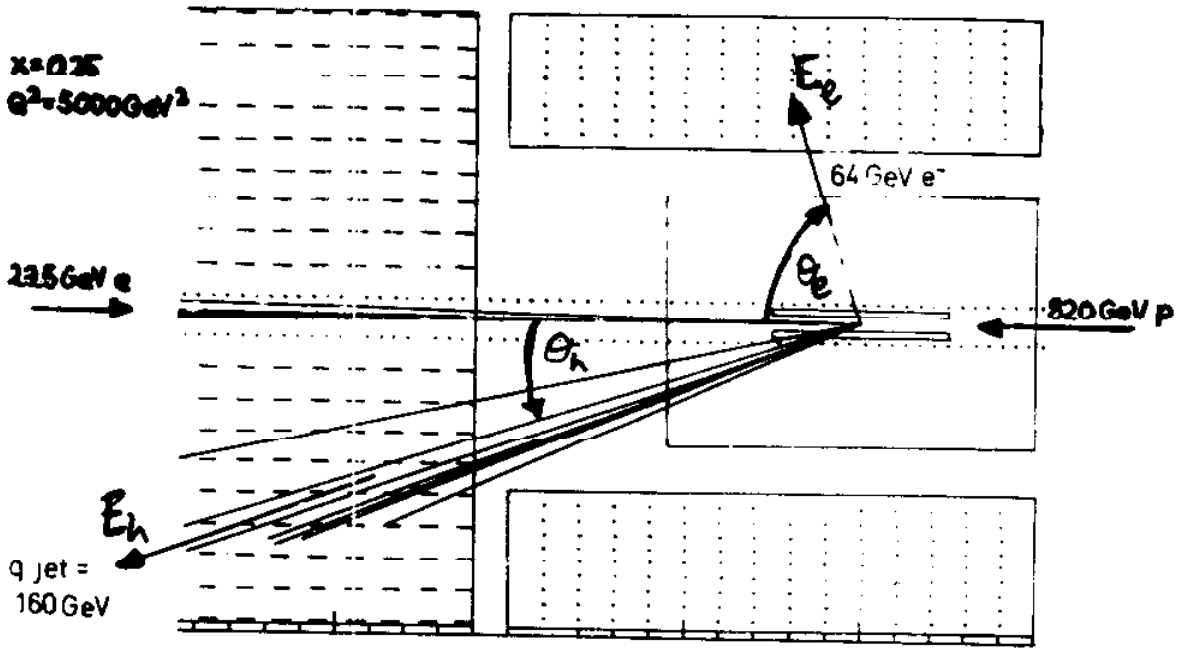


Phase Space for e^+e^- annihilations evolves with $Q^2 = s$

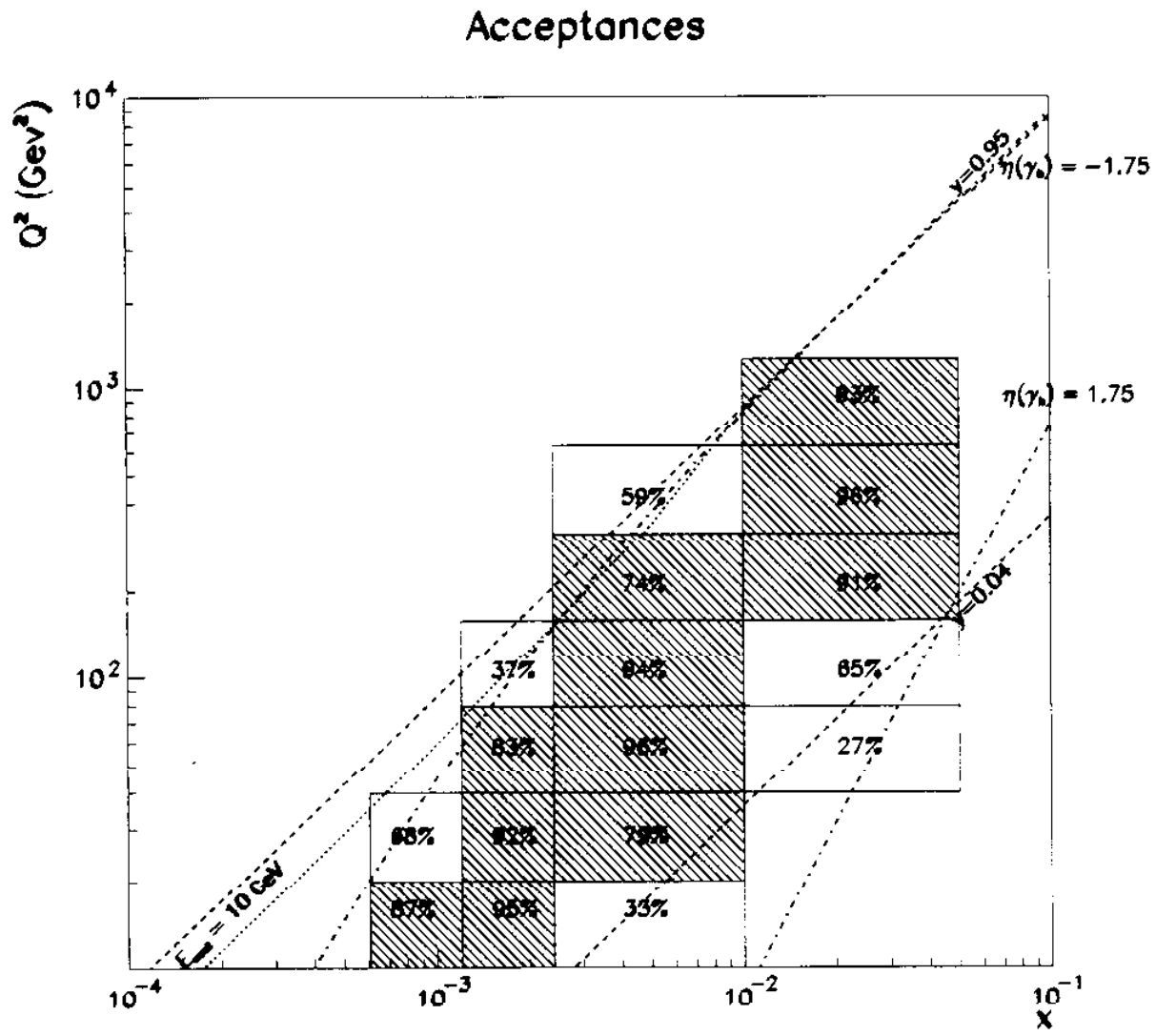
Current region of Breit frame evolves with Q^2

Current region $\equiv$ e^+e^- annihilation

Analysis of 94 data

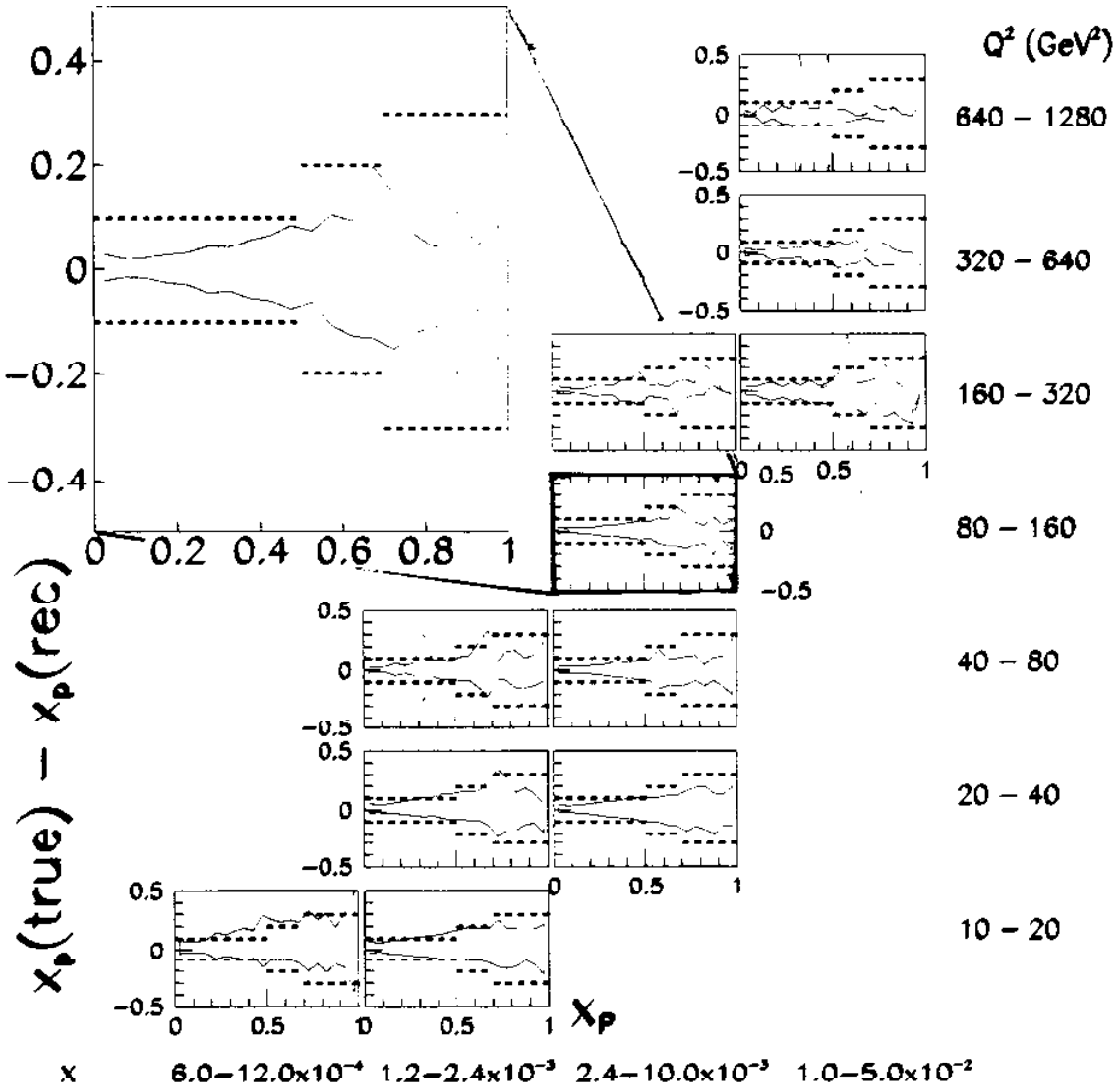


- Cuts for DIS : $35 < \Sigma(\mathrm{E\text{-}p}_z) < 60$;
  $E'_e > 10$ GeV; $y_e < 0.95$; $y_{JB} > 0.04$
- Track cuts : $|\eta| < 1.75$ and $p_T > 150$ MeV
- Reconstruct boost using Double Angle method
- Tracks assigned to current region if $p_z^{\mathrm{Breit}} < 0$.
- Calculate $x_P = \frac{2}{Q}$



Percentage acceptances due to the event and track selection cuts.

Resolution on the measurement of x_p



The largest contribution to the resolution comes from uncertainties in the boost

$$\beta^i = \frac{p_\gamma^i + 2x p_p^i}{E_\gamma + 2x E_p}$$

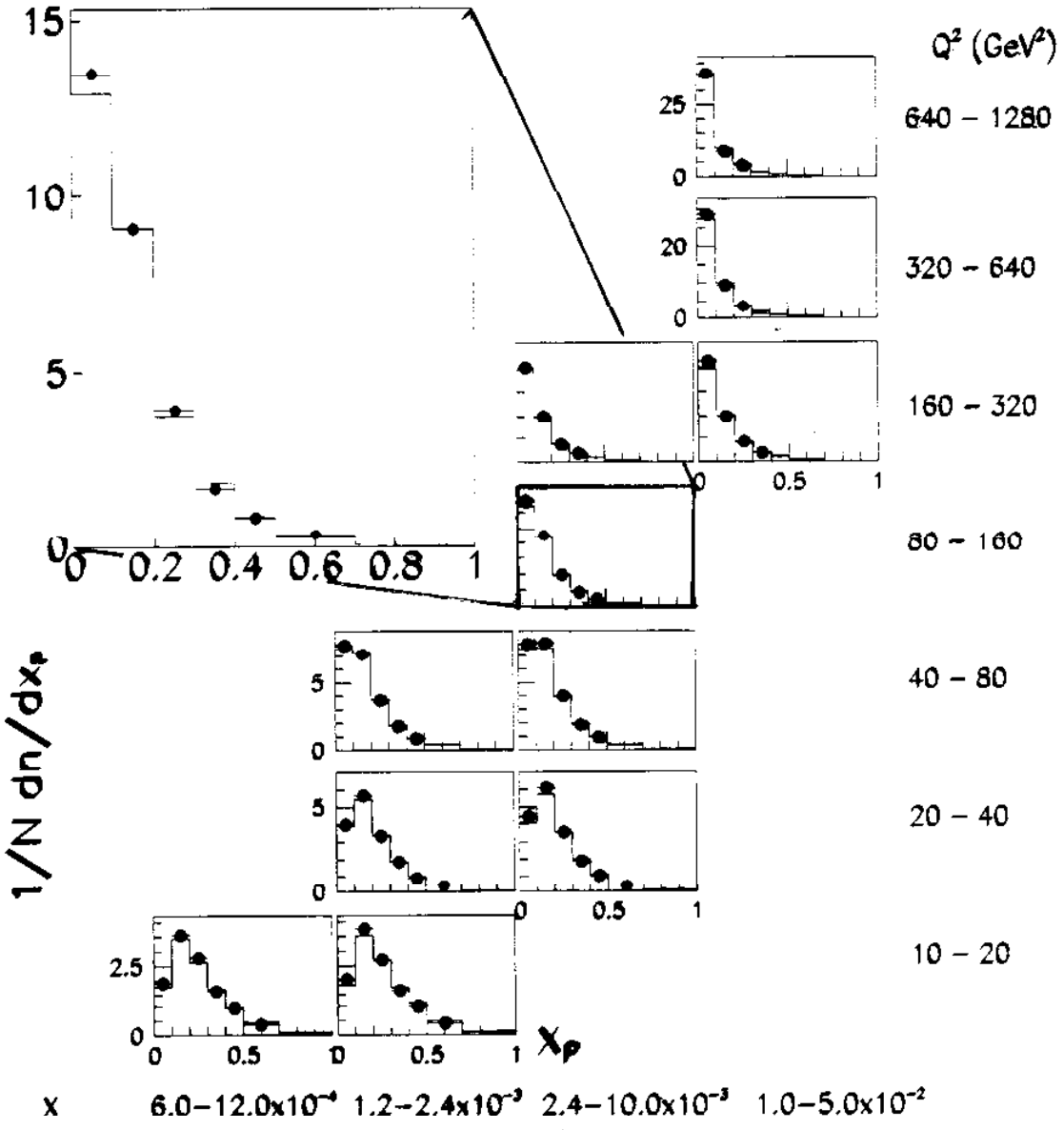
Correcting the Data

The data have to be corrected for the effects of:

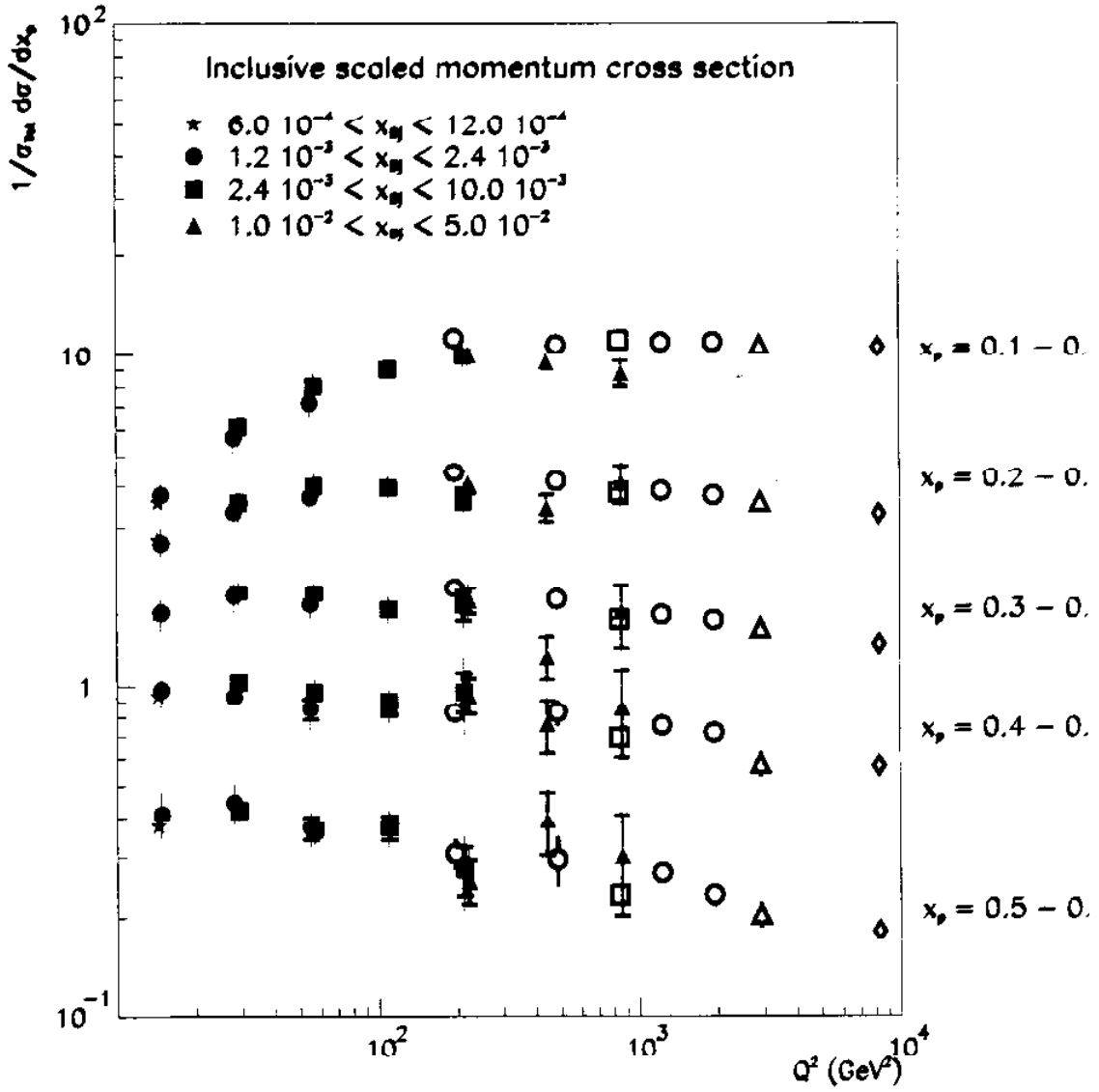
- Migrations between the Current and Target regions;
- Migrations between (x_{Bj},Q^2) bins;
- Trigger and event selection cuts;
- K^0 and Λ decay products being assigned to the primary vertex;
- Track reconstruction; and
- QED radiative effects.

We do this by applying bin-by-bin correction factors to the data

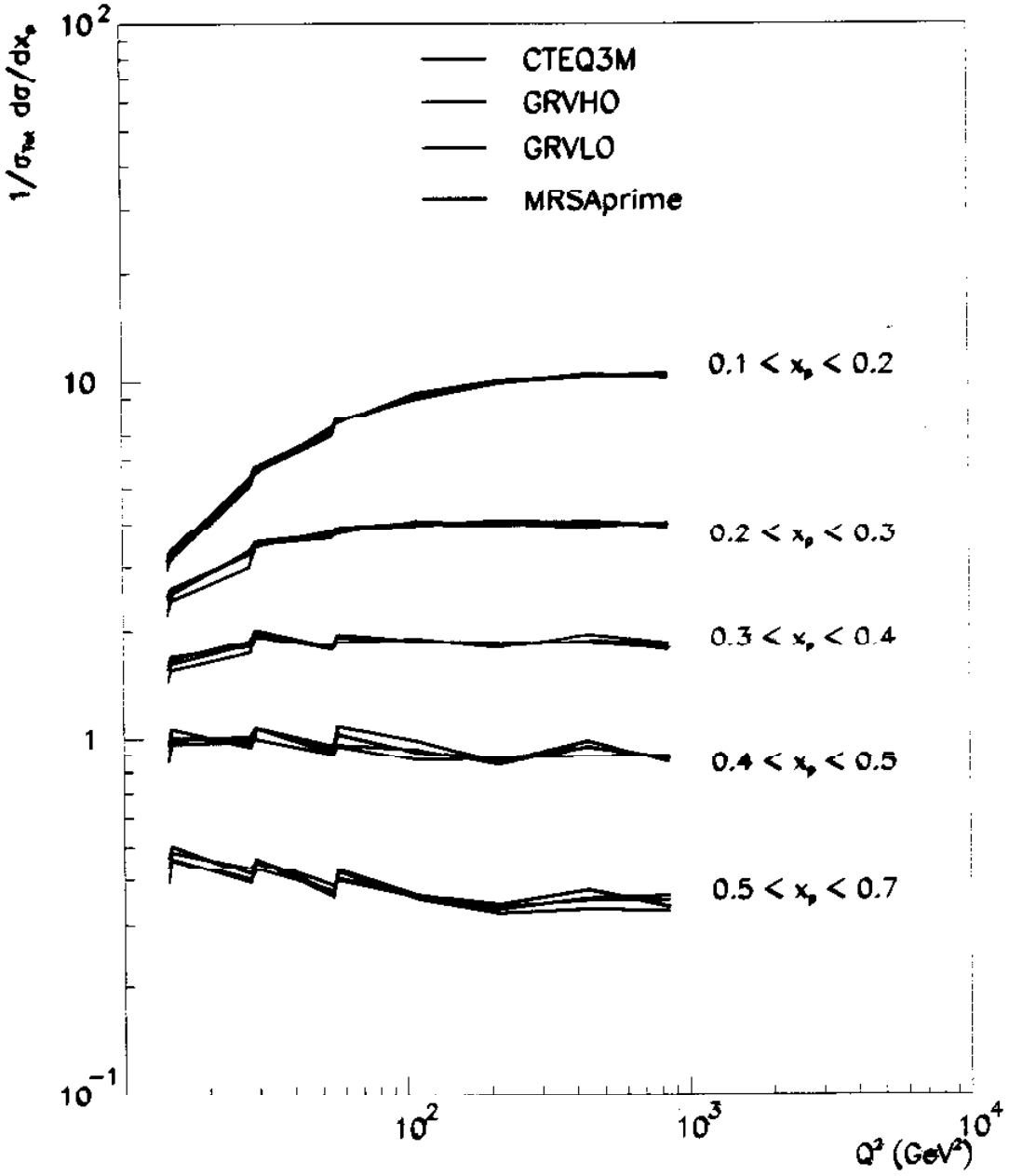
$$F(x_p) = \frac{1}{N_{\rm gen}} \left(\frac{dn}{dx_p}\right)_{\rm gen} \Big/ \frac{1}{N_{\rm obs}} \left(\frac{dn}{dx_p}\right)_{\rm obs}$$


Q^2 (GeV^2)
640 – 1280
320 – 640
160 – 320
80 – 160
40 – 80
20 – 40
10 – 20
1/N dn/dx$_p$
x$_p$
x
6.0–12.0x10^{-4}
1.2–2.4x10^{-3}
2.4–10.0x10^{-3}
1.0–5.0x10^{-2}

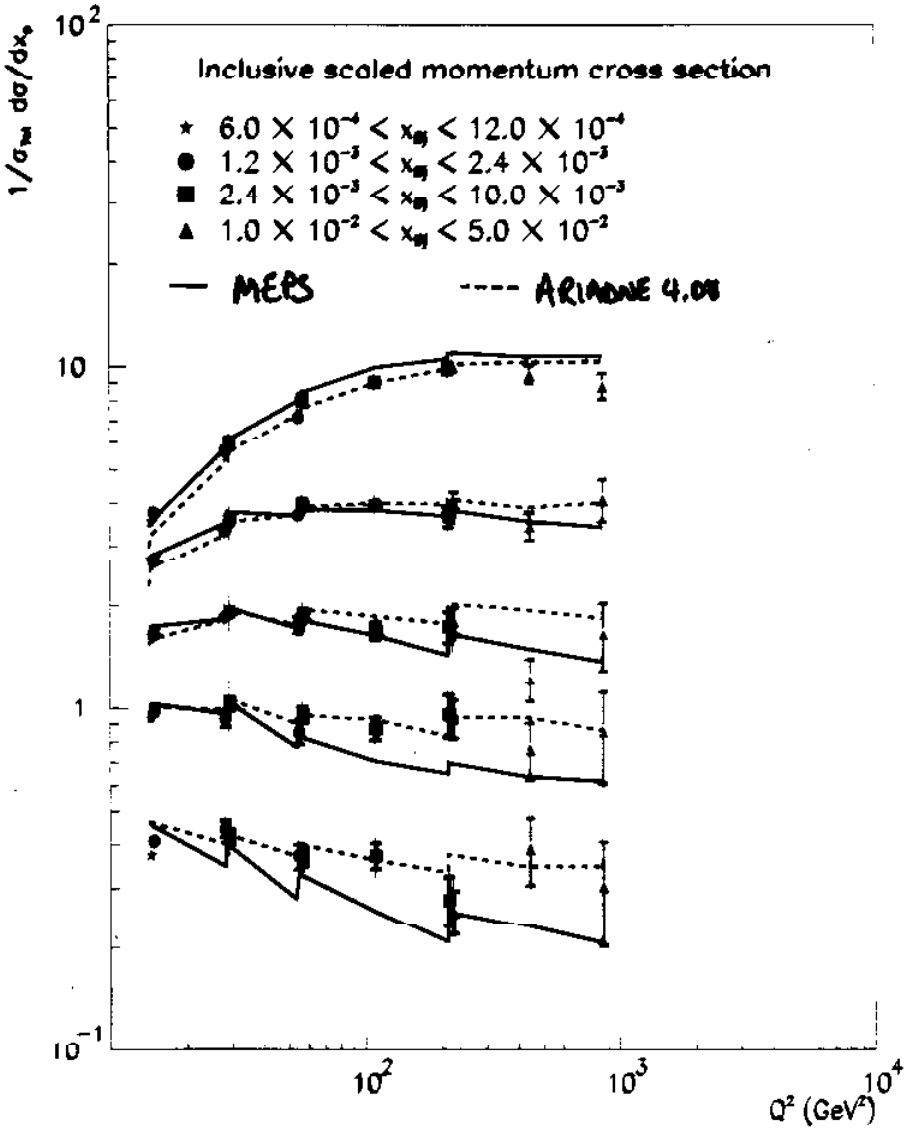
Comparison of the Scaled Momentum Cross Sections at LEP and at HERA



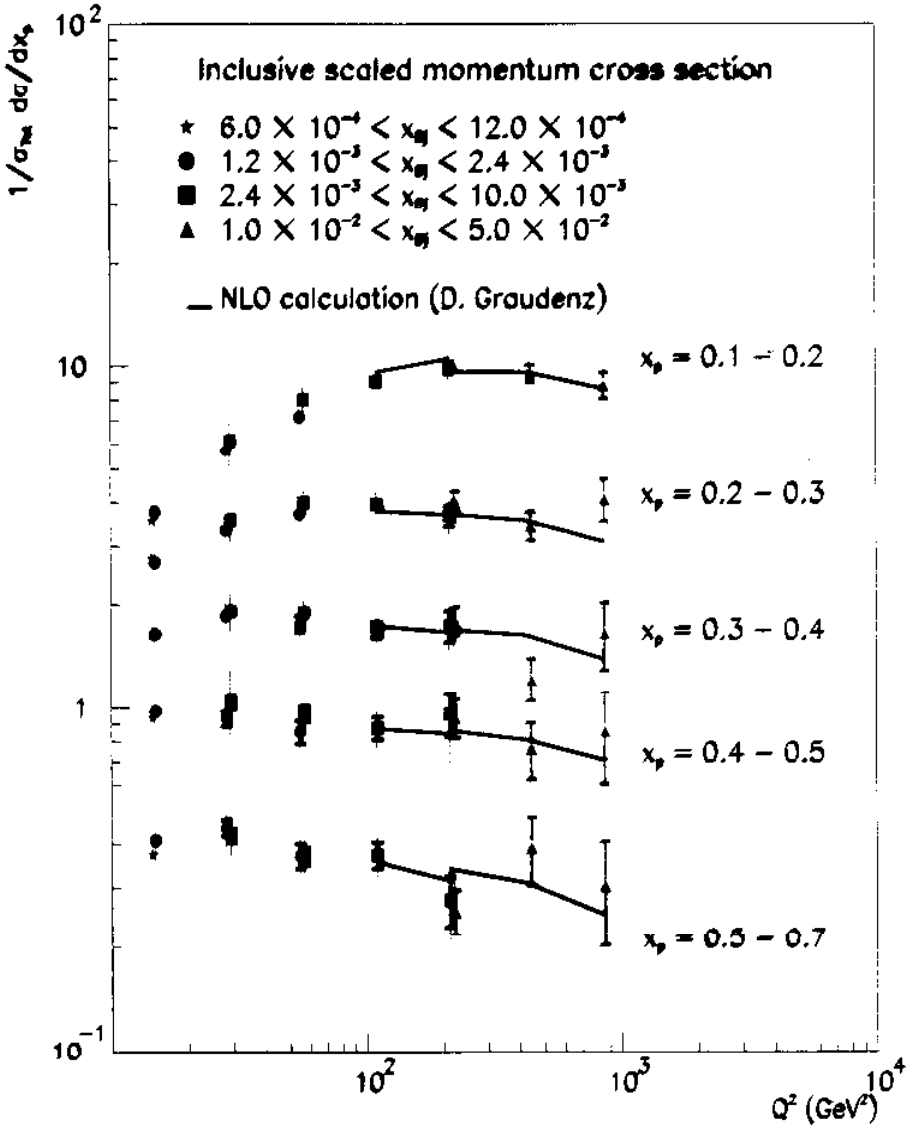
SENSITIVITY TO PDF



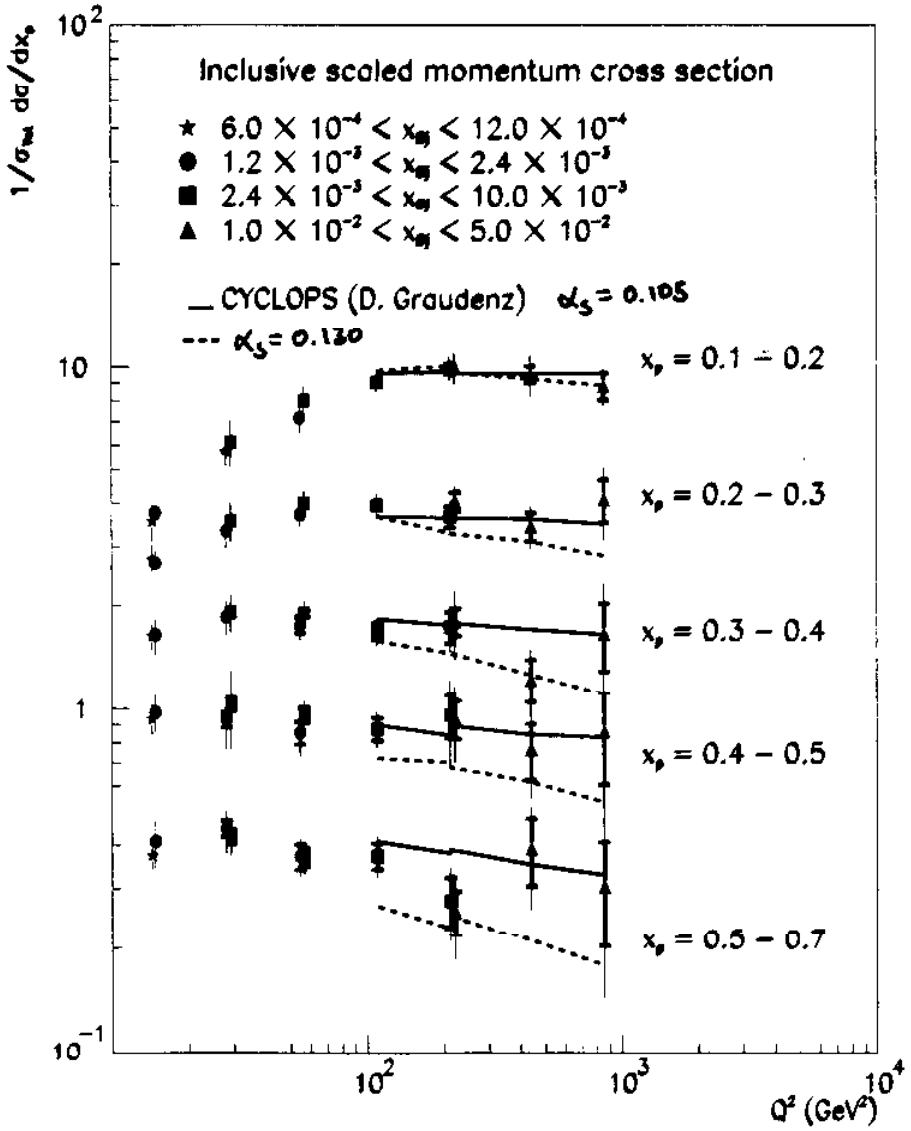
Scaled Momentum Distributions with LO Monte Carlos:



Comparing the Data with a Next-to-Leading Order Calculation (CYCLOPS)



NLO calculation with different input values of Λ_{QCD}



Conclusions

- **The x_p distributions for the current region of the Breit frame have been measured using 1994 ZEUS data;**

- **Comparison with e^+e^- data indicates universality of quark fragmentation.**

- **There is good agreement with NLO calculation**

- Future work is on:

  the analysis of high Q^2 1995 data

  Ultimately —

  the fitting of NLO calculation to data from one experiment in order to extract α_s.