XIII Workshop on Deep-Inelastic
Scattering 2005, Madison, Wisconsin

Multiplicity structure in inclusive and diffractive deep-inelastic ep collisions

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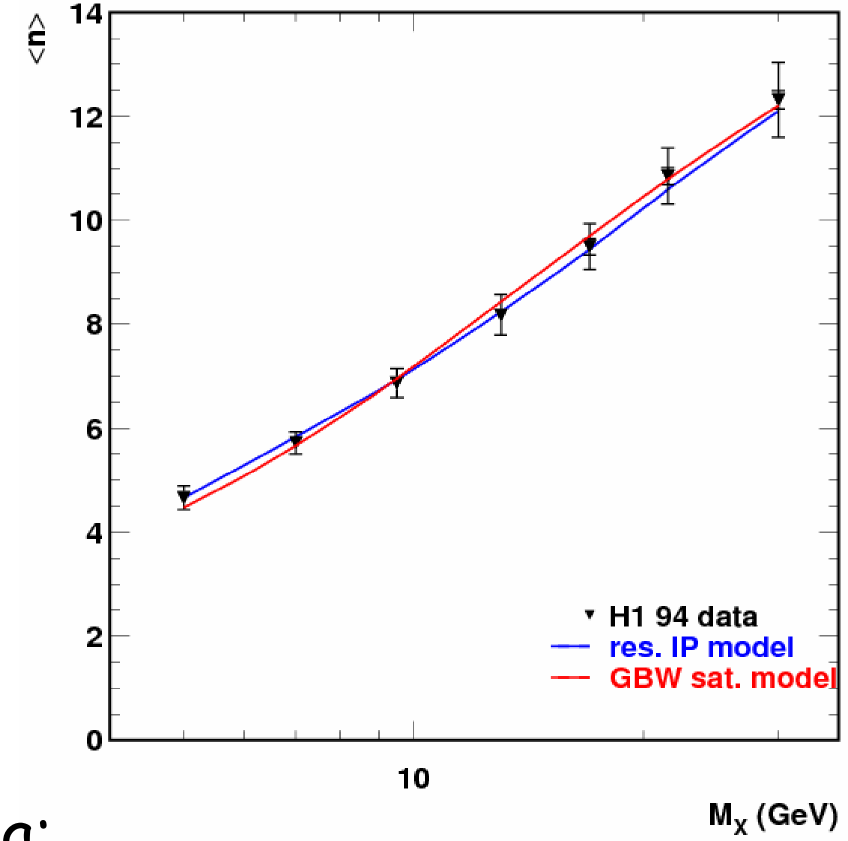
Outline

Introduction
Kinematic dependencies of DDIS
Comparison DIS/DDIS
Conclusions

Motivation

- H1 analysis on 94 DDIS data:
  - Dependence of <n> on M_X



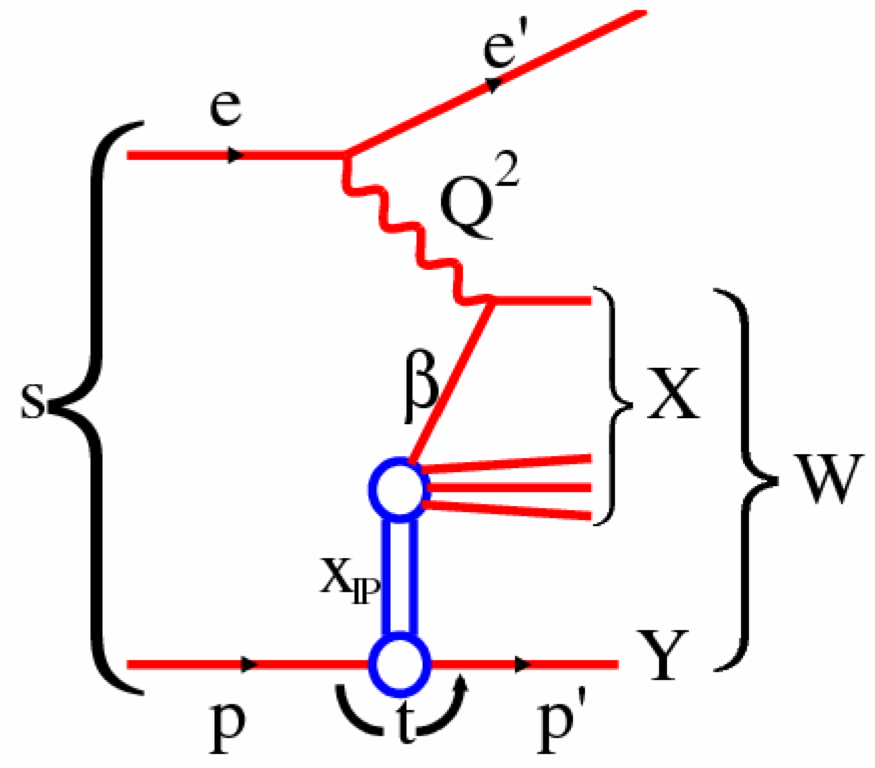
- H1 analysis on 2000 DDIS data:
  - Large statistics allows more differential study: W, Q^2, β dependences at fixed M_X
  - Compare DIS and DDIS

Multiplicity structure

Charged particle multiplicity of the hadronic final state

- Shape of multiplicity distribution P(n)
  - Independent emission of single particles: Poisson distribution
  - Deviations from Poisson reveal correlations and dynamics
- Mean multiplicity <n> of charged particles
- Rapidity spectra
- Koba-Nielsen-Olesen (KNO) scaling $\psi(z)$
  - energy scaling of the multiplicity distribution
  - $\psi(z) = \langle n \rangle P_n$ vs $z = n/\langle n \rangle$

Diffraction: ep ! e'XY



~ 10% of DIS events have a rapidity gap

$$t = (p - p')^2$$

$$\beta = x_{quark/IP}$$

$$x_{IP} = x_{IP/proton}$$

Cross section:

$$\frac{d\sigma^{ep \longrightarrow eXY}}{d\beta dQ^2 dx_{IP} dt} = \frac{4\pi\alpha^2}{\beta Q^4}\left(1 - y + \frac{y^2}{2}\right)\sigma_r^{D(4)}$$

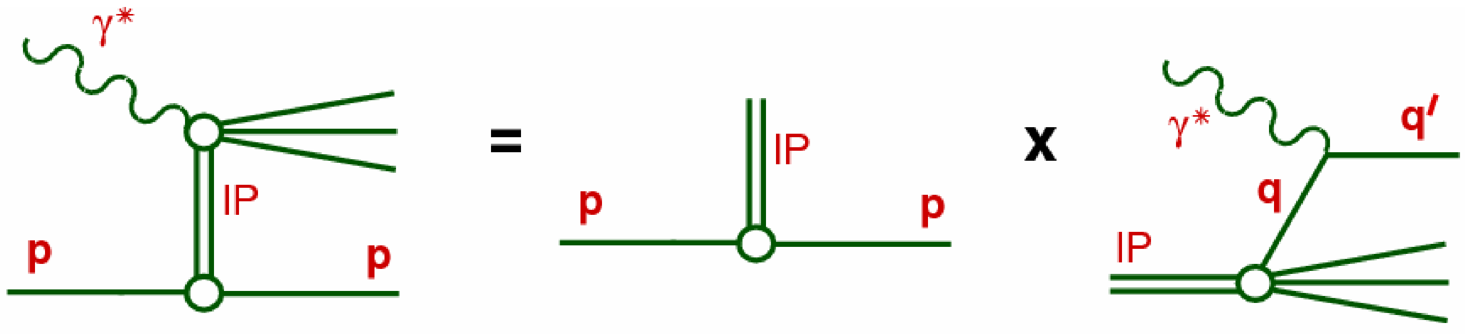
Reduced cross section:

$$\sigma_r^{D(4)} = F_2^{D(4)} - \frac{y^2}{1+(1-y)^2} F_L^{D(4)}$$

Models for diffraction

Combine QCD/Regge theory: resolved IP model

- Proton infinite momentum frame
- Colourless IP is built up of quarks/gluons
- Based on QCD and Regge factorization:



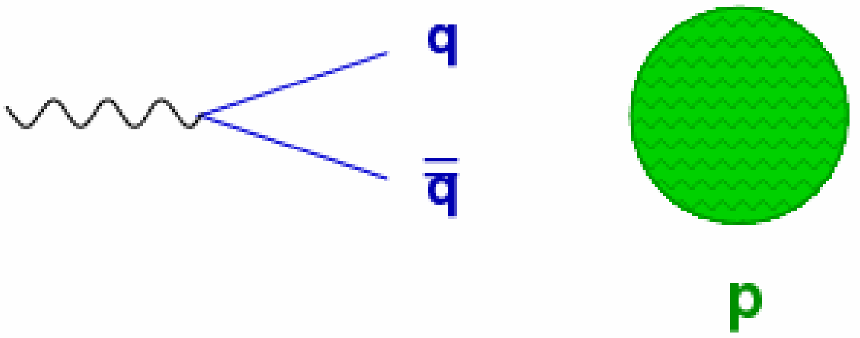
$$F_2^D(x_{I\!P}, t, \beta, Q^2) = f_{I\!P/p}(x_{I\!P}, t)\; F_2^{I\!P}(\beta, Q^2)$$

- Needs subleading IR component

Models for diffraction cont'd

Colour dipole approach

- In proton rest frame: γ^* splits up in *qq* dipole



$\Rightarrow$ factorizes into $\Psi_{q\bar{q}} \times \sigma_{(q\bar{q})p}$

$|\gamma> \; = q\bar{q} + q\bar{q}g + \ldots$ Fock states

- Model the dipole cross section:

  Saturation model Golec-Biernat and Wusthoff (GBW)

Data selection DIS and DDIS

2000 nominal vertex data: 46.65 pb^{-1}

Data corrected via Bayesian unfolding procedure:
-DIS MC: DJANGOH 1.3, proton pdf CTEQ5L
-DDIS MC: RAPGAP resolved pomeron

DIS selection:

- Good reconstruction of scattered electron
- Kinematic cuts:
  - $0.05 < y_{av} < 0.65$
  - $5 < Q^2 < 100 \text{ GeV}^2$
  - $80 < W < 220$ GeV

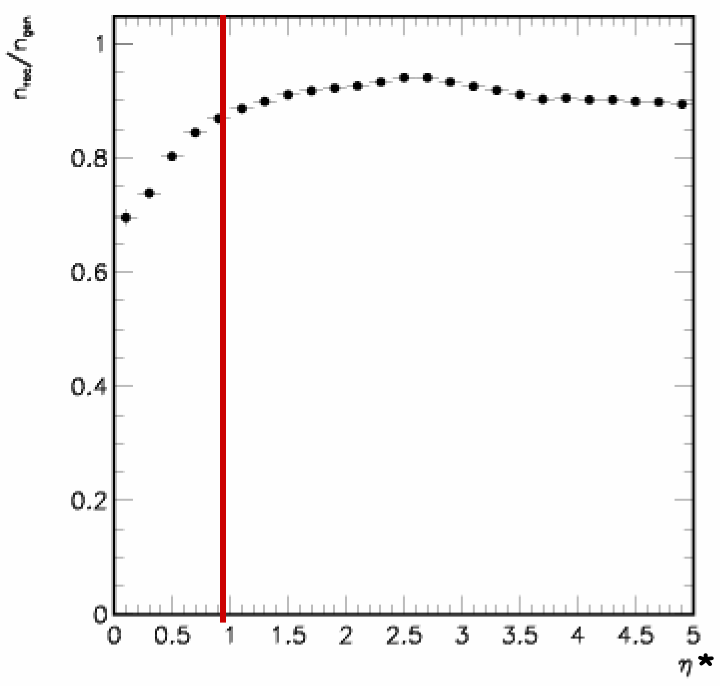
DDIS selection:

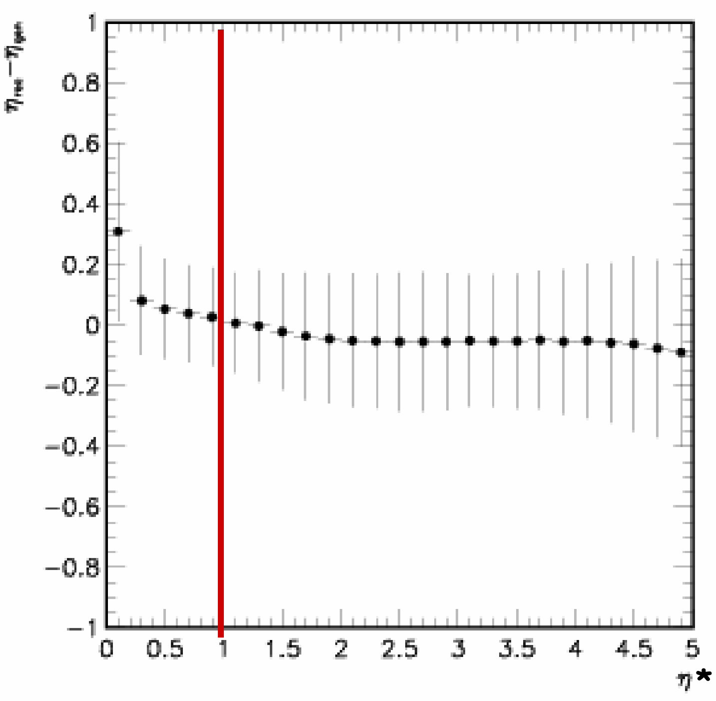
- Rapidity gap:
  - No activity in the forward detectors
  - $\eta_{max} < 3.3$
- Kinematic cuts:
  - $4 < M_X < 36$ GeV
  - $x_{IP} < 0.05$

Track selection

- Primary vertex fitted tracks
- 15 < θ < 165 and p_T > 150 MeV
- Boost to hadronic γ^*p CMS
- Acceptance:
- Resolution:

tracks with $\eta^* > 1$





Multiplicity structure results

Charged particles with $\eta^*>1$ in γ^*p CMS frame

- Multiplicity distribution and moments
  - Q^2 dependence of <n> in DIS/DDIS at fixed W
  - β dependence of <n> in DDIS at fixed M_X
  - W dependence of <n> in DDIS at fixed M_X

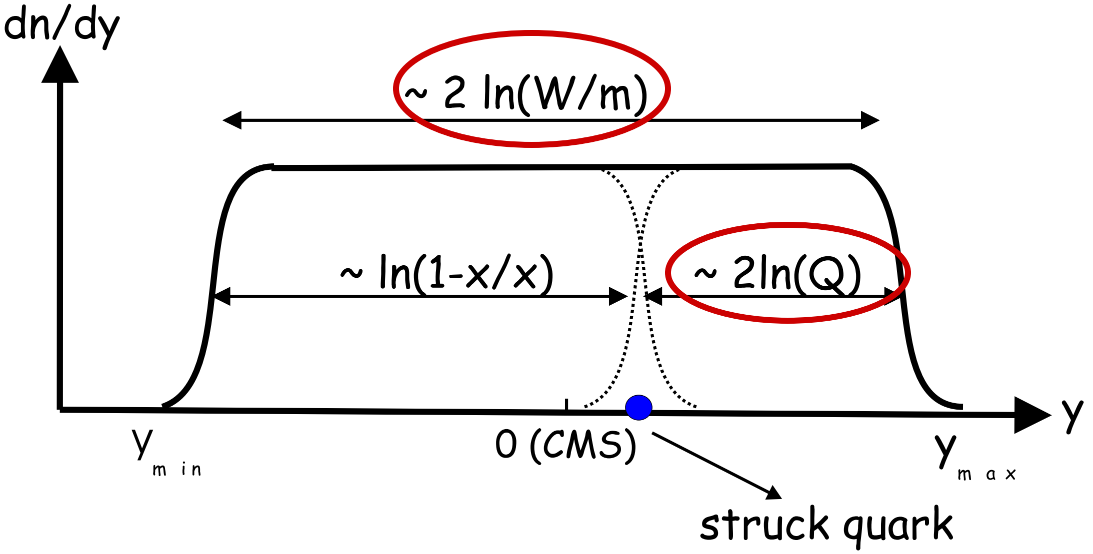
- Comparison of DIS and DDIS
  - Rapidity spectra
  - KNO scaling

Kinematic relations

DIS

$y_{max} = \ln(W/m_\pi)$

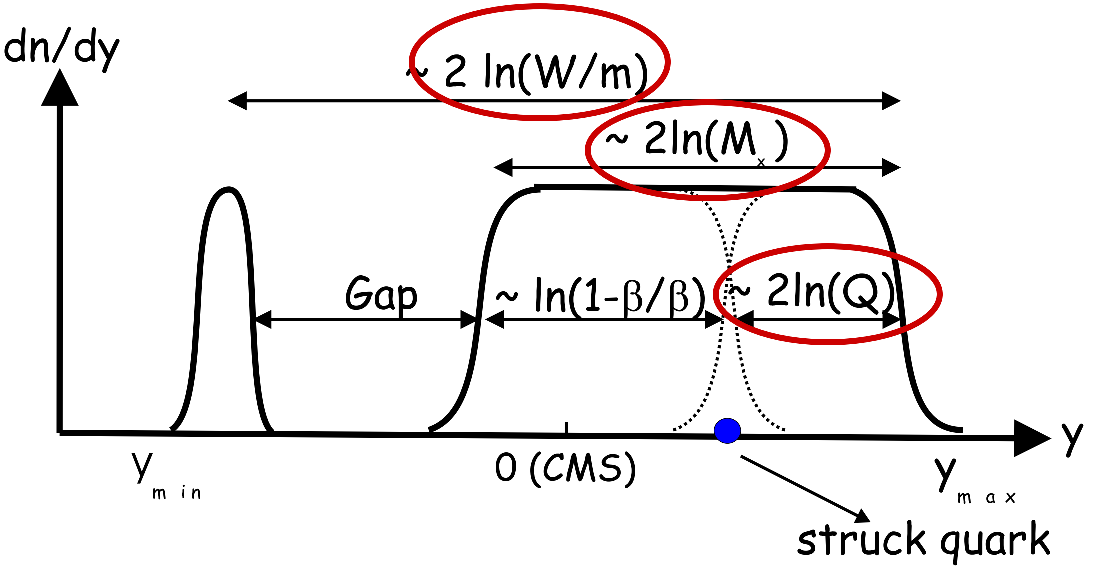
$W^2 \sim Q^2/x$



DDIS

$\beta = Q^2/(Q^2+M_X^2)$

$gap \sim \ln(1/x_{IP})$



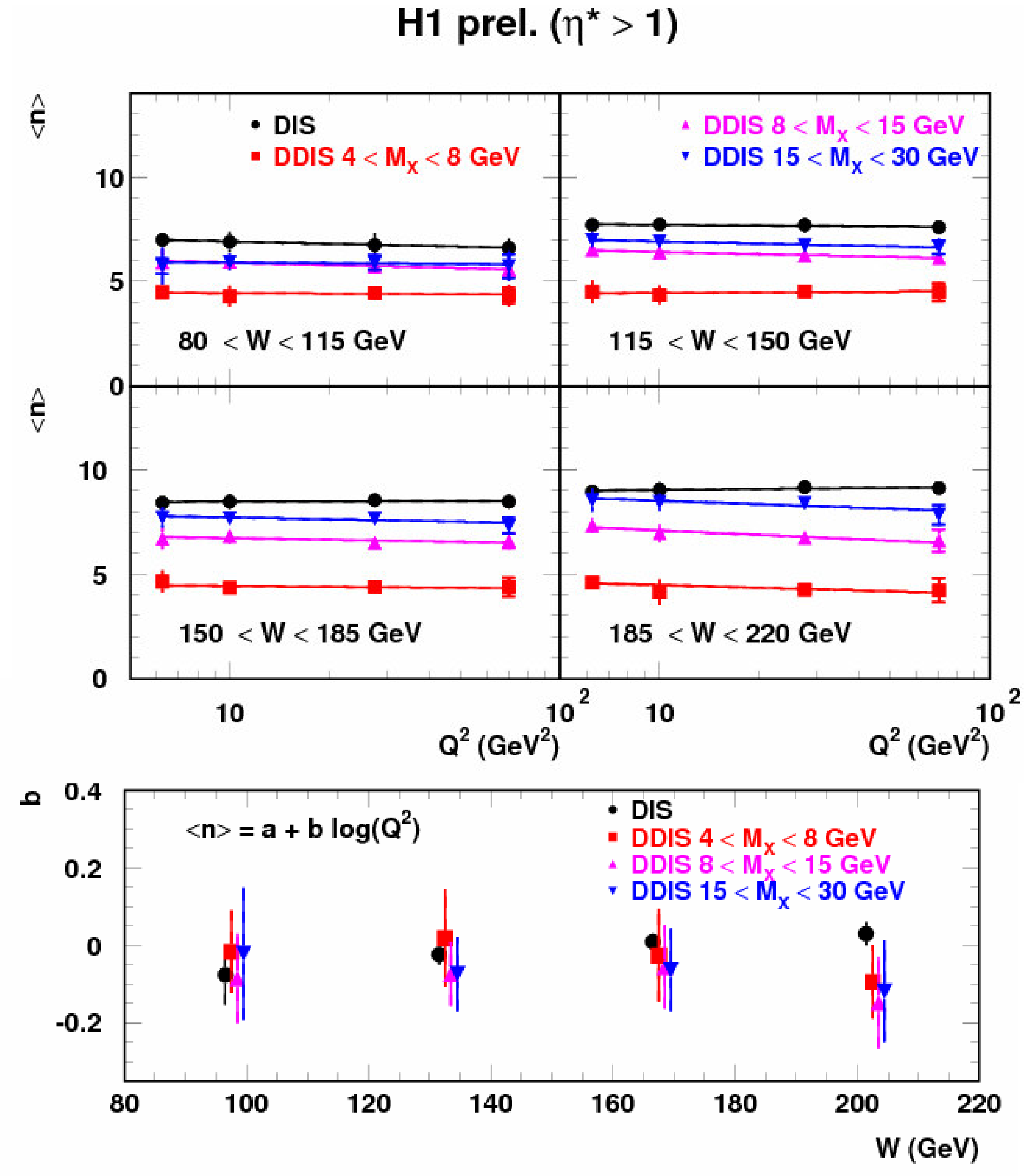
Q^2 dep. of <n> in DIS/DDIS at fixed W

- <n> vs Q^2
- DIS/DDIS data (at fixed M_X)

- No dependence on Q^2

- Fit <n>:

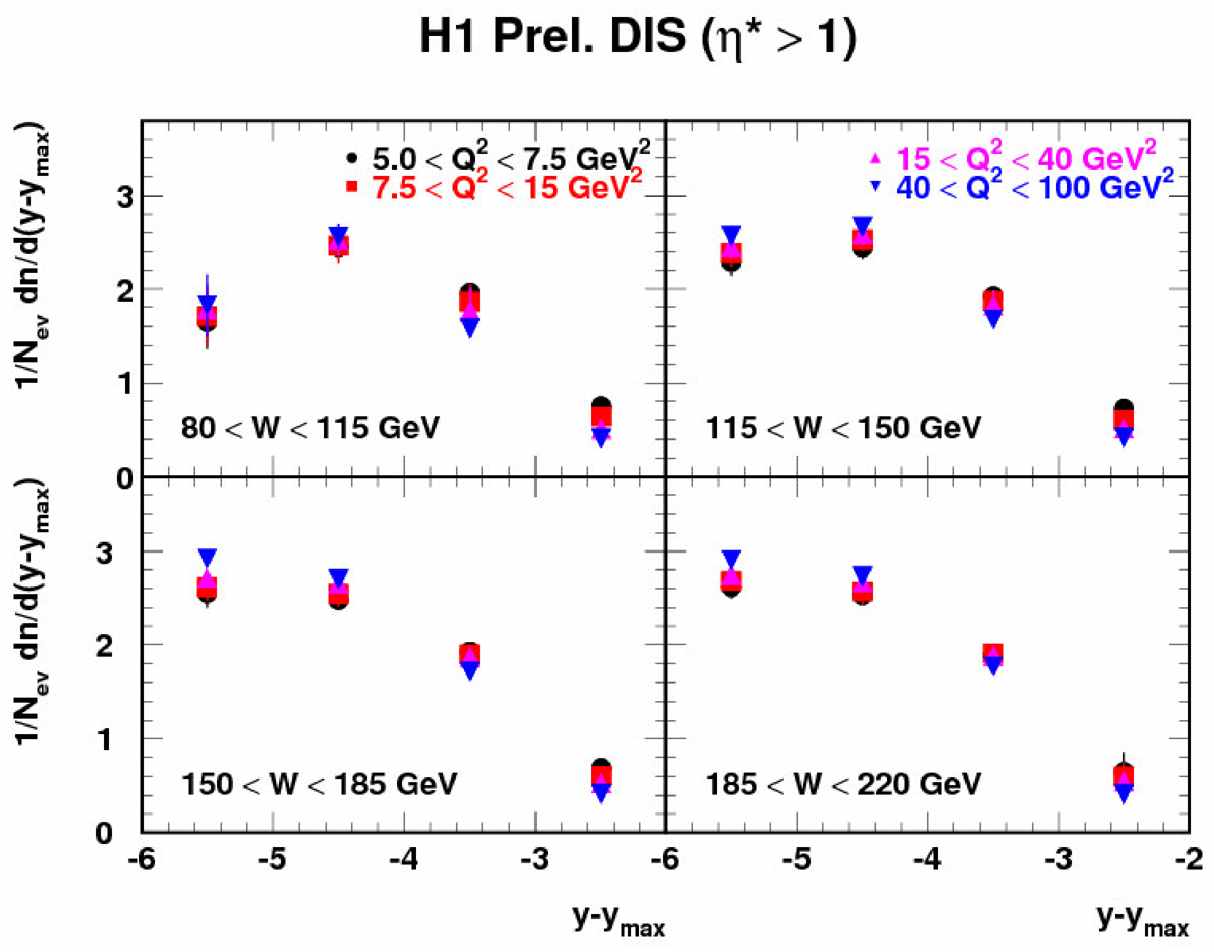
  <n> = a + b log(Q^2)



Q^2 dep. of $dn/d(y-y_{max})$ in DIS at fixed W

- $dn/d(y-y_{max})$ vs $y-y_{max}$
- $y_{max} = \ln(W/m_{\pi})$

- Weak Q^2 dependence ($\longrightarrow$ scaling violations in QCD)



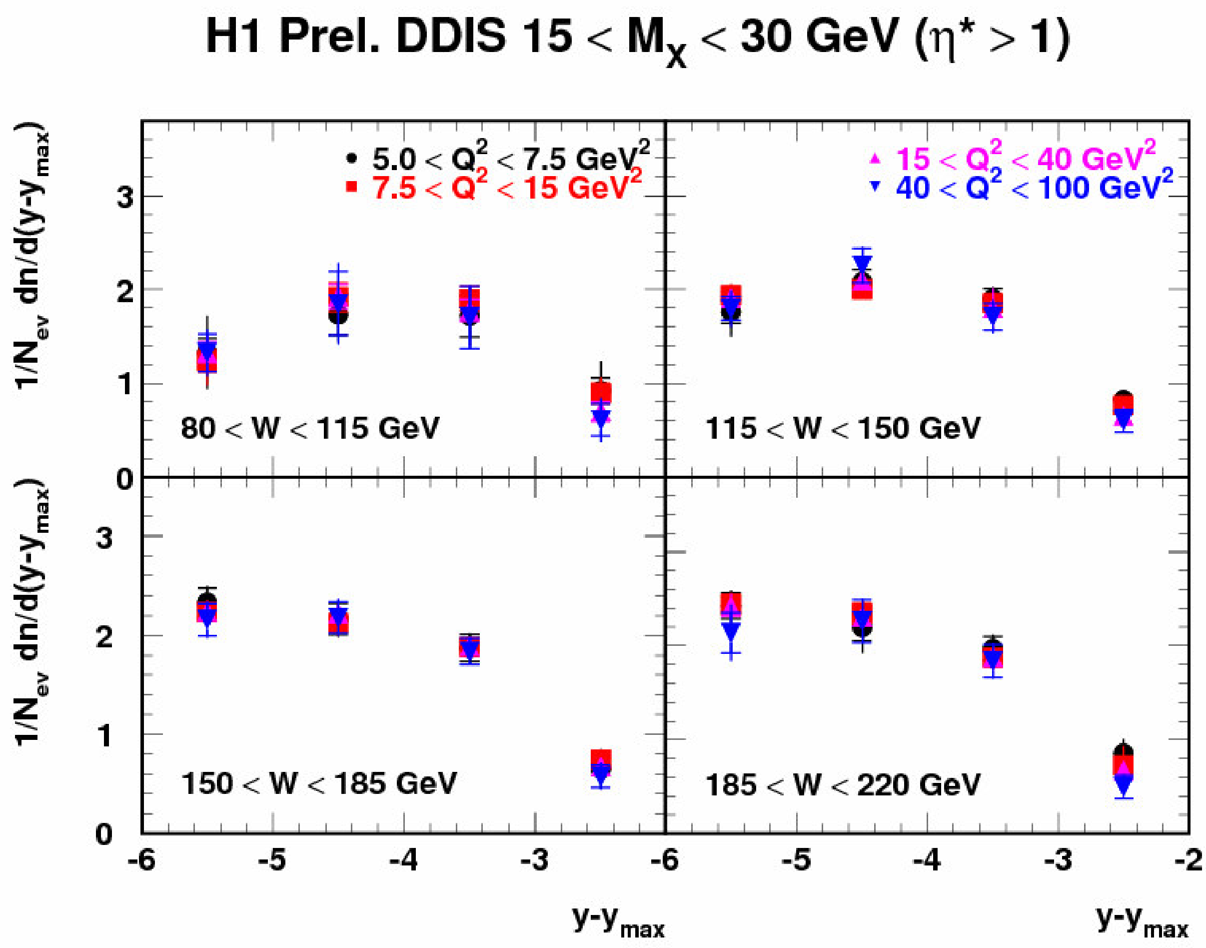
DIS: <n> predominantly function of W, not Q^2

Q^2 dep. of $dn/d(y-y_{max})$ in DDIS at fixed W

- $dn/d(y-y_{max})$ vs $y-y_{max}$
- $y_{max} = \ln(W/m_\pi)$

- Weak Q^2 dependence

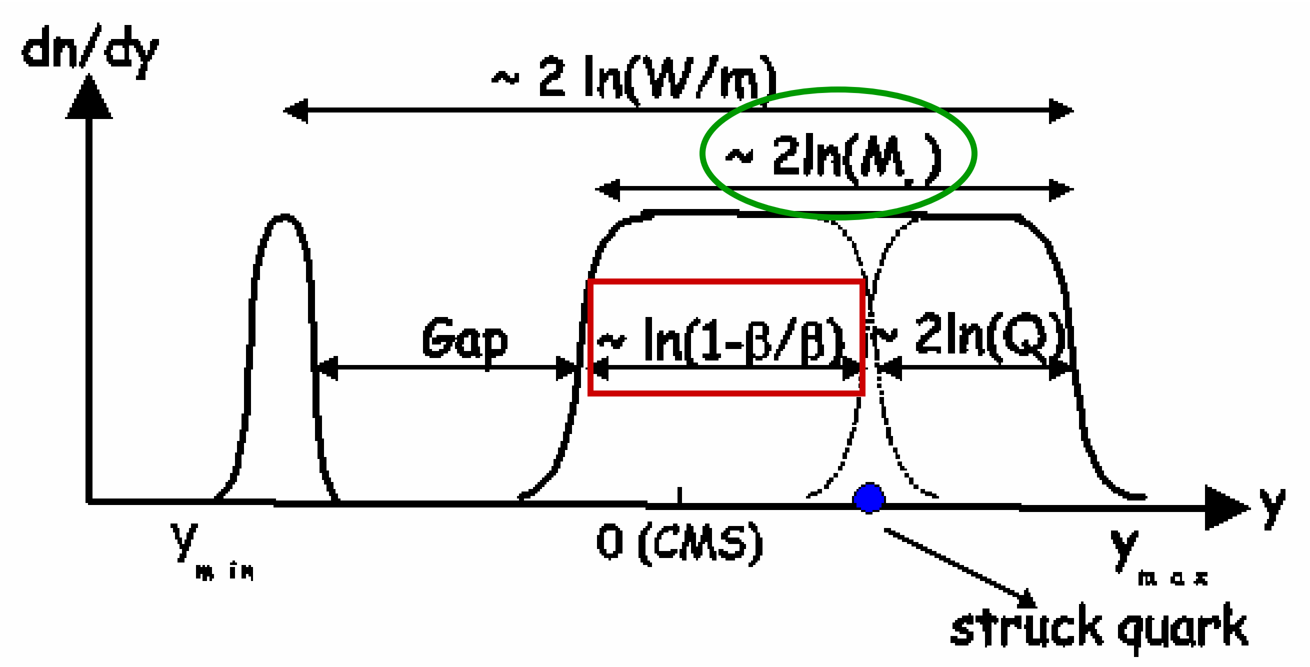
- Weak W dependence



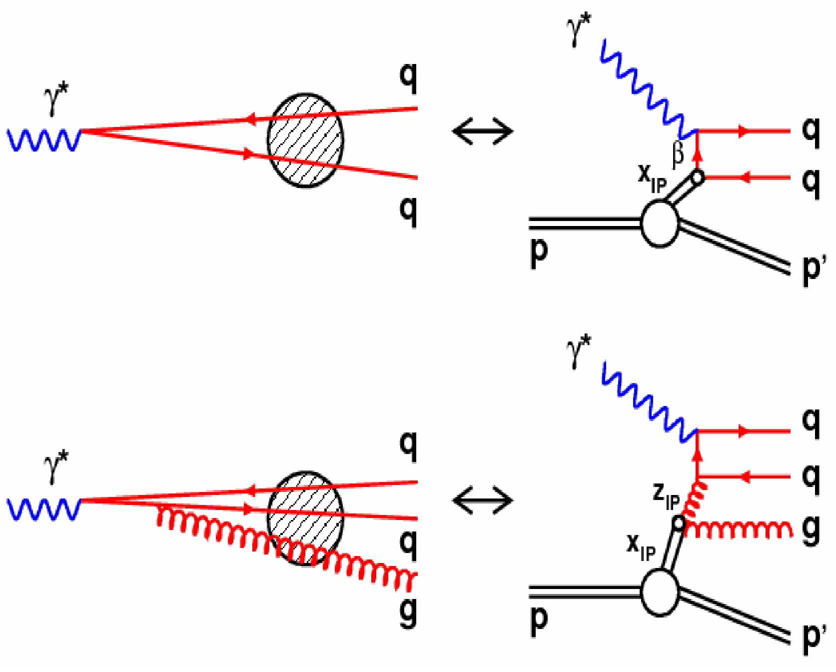
DDIS: <n> predominantly function of M_X, not Q^2

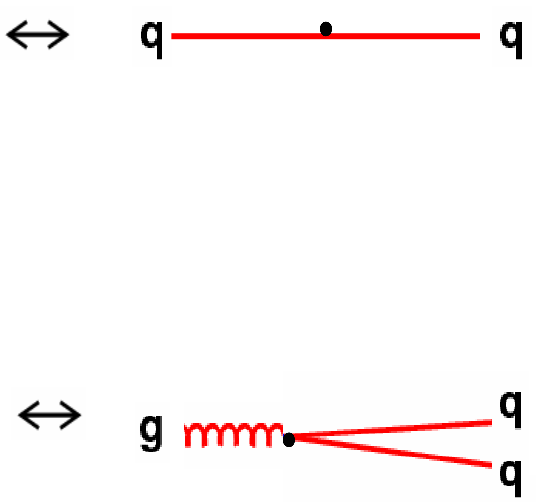
β dependence of <n>

- Intuitive picture: expect no β dependence
  (no Q^2 dependence measured)



β dependence of <n>

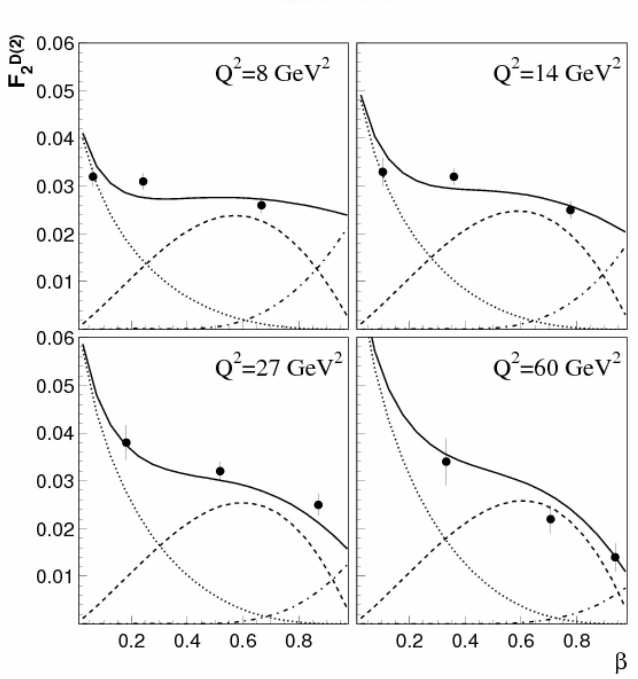




low <n>

high <n>

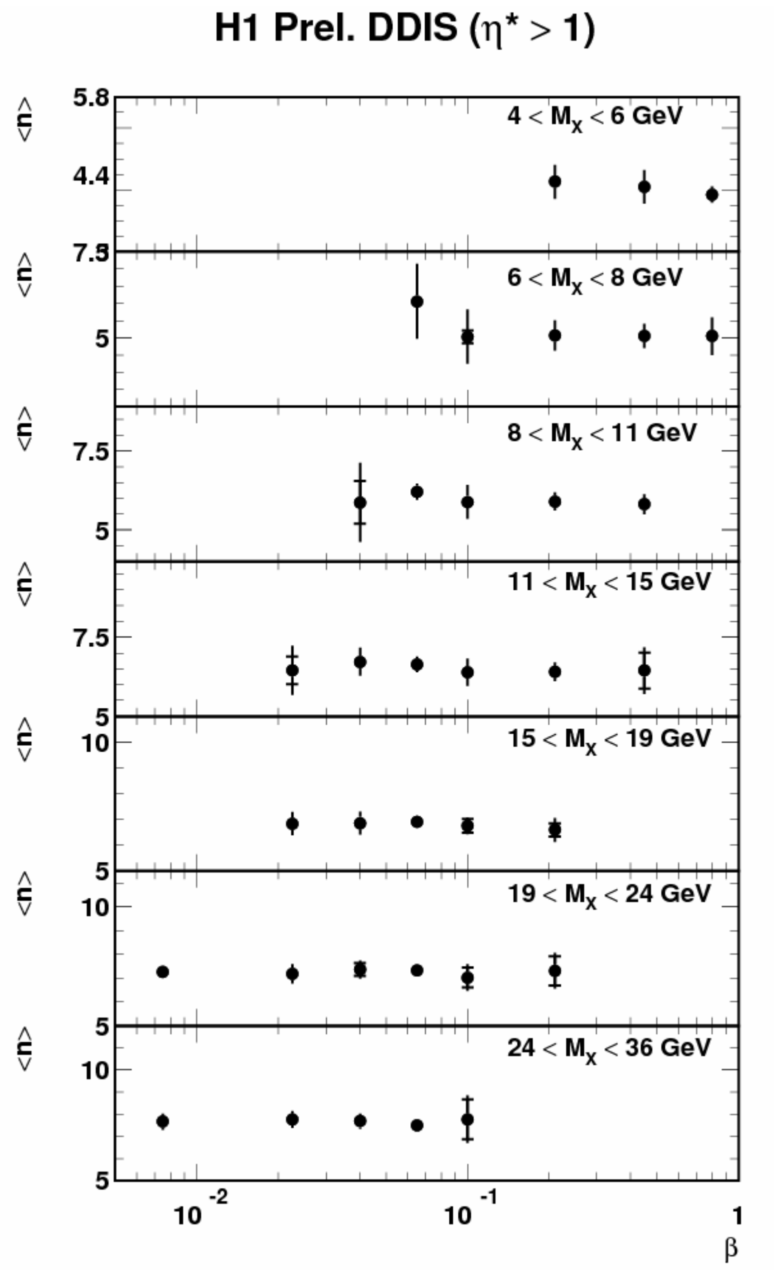
ZEUS 1994



- γ* fluctuation models: relative fraction of q and g fragmentation depends strongly on β

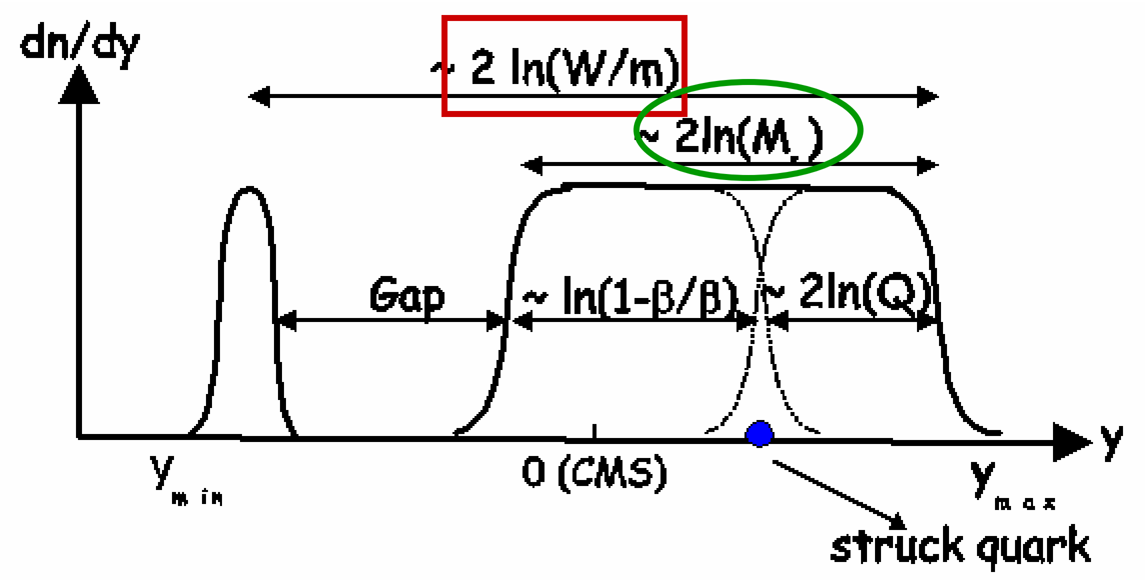
β dep. of <n> at fixed M_X in DDIS

- M_X kept fixed
- No β dependence



DDIS: <n> predominantly function of M_X, not Q^2 or β

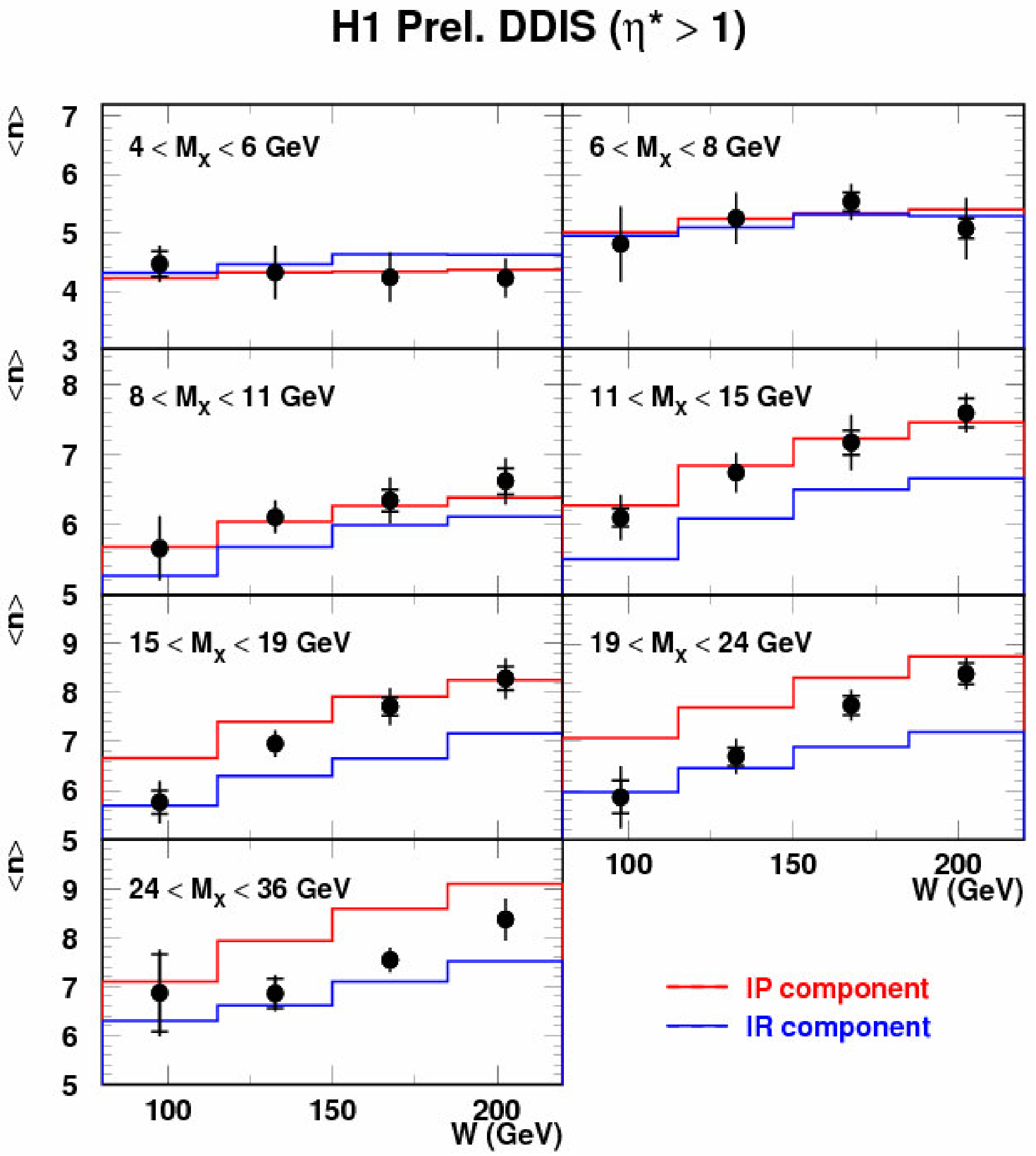
W dependence of <n>?



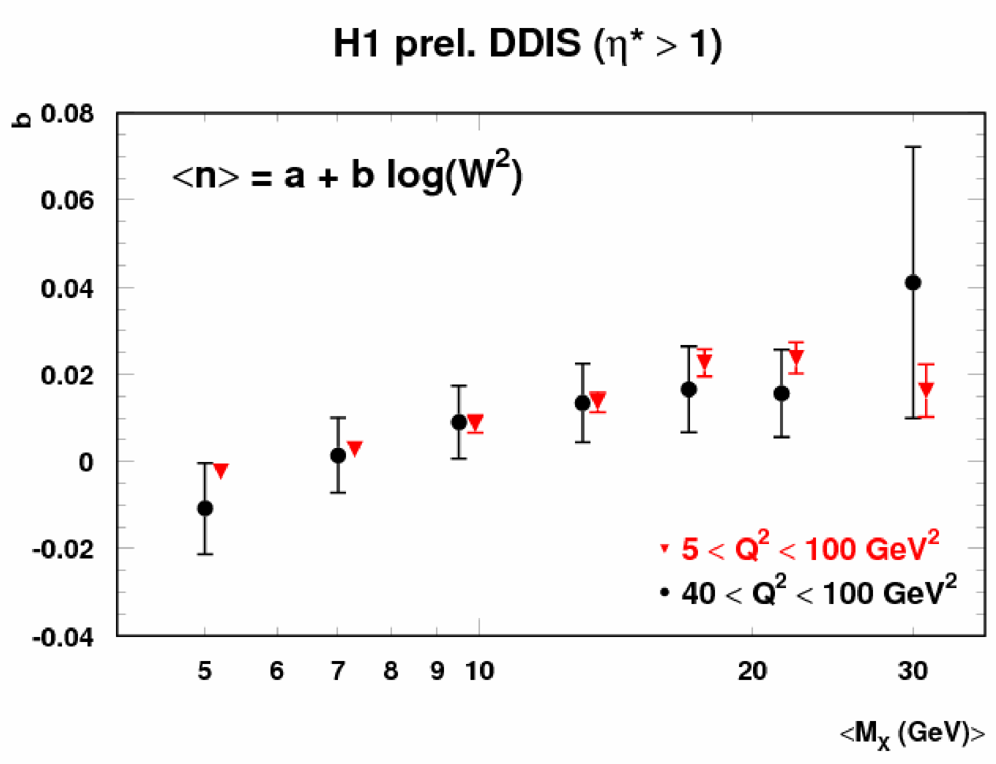
- Change of W means change the 'gap'
- Gap ~ $\ln(1/x_{IP})$
- Investigate <n> dependence on x_{IP}

W dep. of ‹n› at fixed M_X in DDIS

- Change W: change x_{IP}
- Regge factorisation: diffractive pdf's independent of x_{IP}
- Breaking of Regge factorisation
- In resolved IP model: pomeron + reggeon



W dep. of <n> at fixed M_X in DDIS

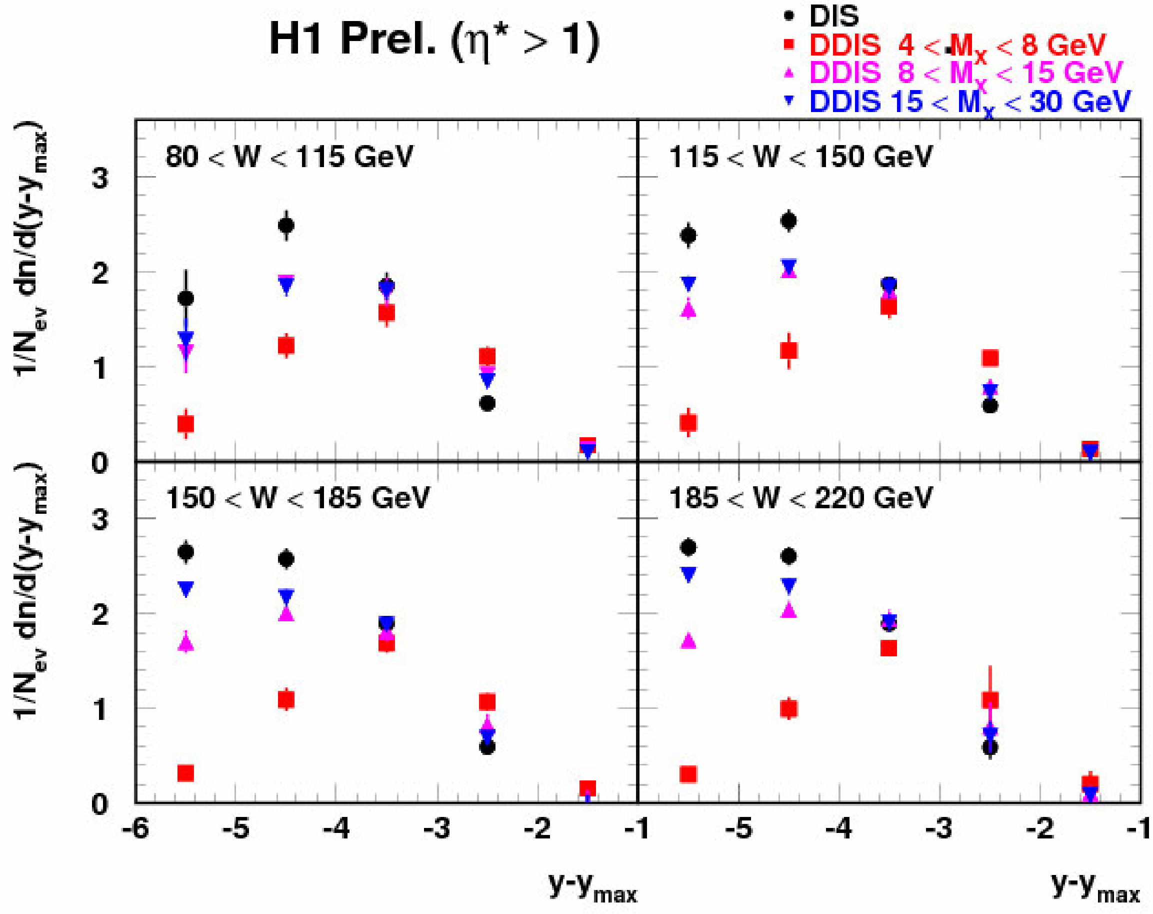


Factorisation breaking within errors, not dependent on Q^2

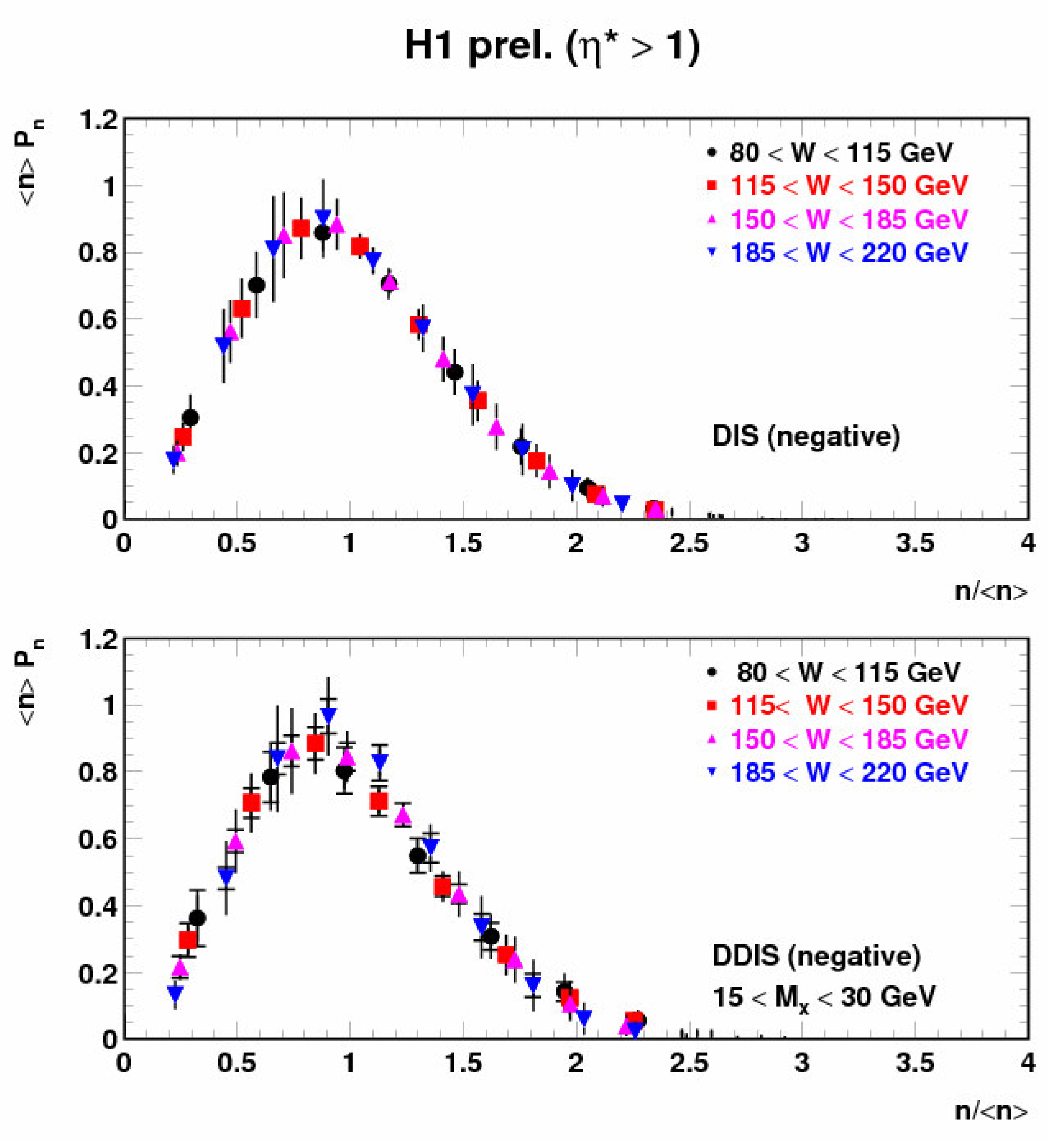
- Fit <n>:
  $\langle n \rangle = a + b \log(W^2)$
- Regge factorisation breaking expected in multiple scattering models
- Effects predicted to diminish with increasing Q^2 (shorter interaction time)

Comparison DIS/DDIS: rapidity spectra

- dn/d(y-y_{max}) vs y-y_{max}
- Central region: particle density similar for DIS and high M_X DDIS
- Lowest M_X bin: systematically different



Comparison DIS/DDIS: KNO scaling



- Negative particles
- $\psi(z) = \langle n \rangle P_n$ vs $z = n/\langle n \rangle$
- Approximate KNO scaling for DIS and DDIS
- Shape of KNO distribution similar for DIS and DDIS

Conclusions

Charged particle multiplicity

- studied for DIS and DDIS

Kinematic dependencies

- $\langle n \rangle$ in DIS depends only on W, not Q^2 or x
- $\langle n \rangle$ in DDIS depends mainly on M_X and W, not Q^2 or β

Comparison DIS and DDIS

- DIS and DDIS: rapidity spectra similar for highest M_X
- DIS and DDIS: approximate KNO scaling