Fragmentation in Diffractive DIS at HERA

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Overview

- Definitions and Descriptions
  - DIS and diffraction
  - The Breit Frame
  - Models of diffraction
- Rapidity
- Fragmentation Function
  - Peak and widths
  - Average Charged Multiplicity
- Conclusions

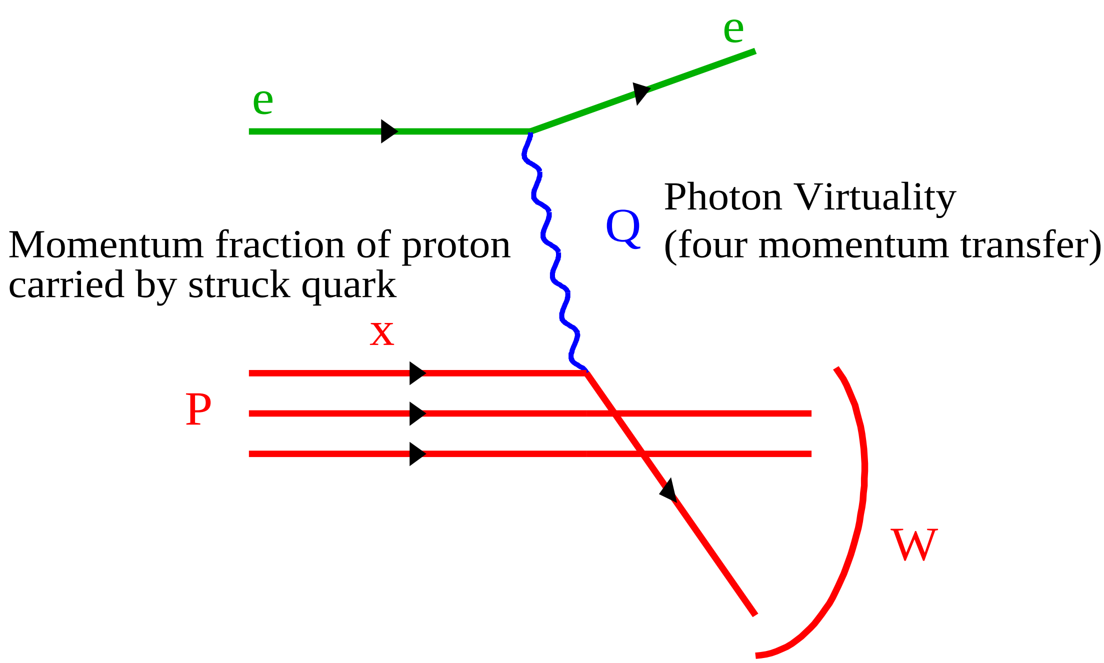
Motivation

- Compare the charged track longitudinal momentum spectra of DIS with diffraction.

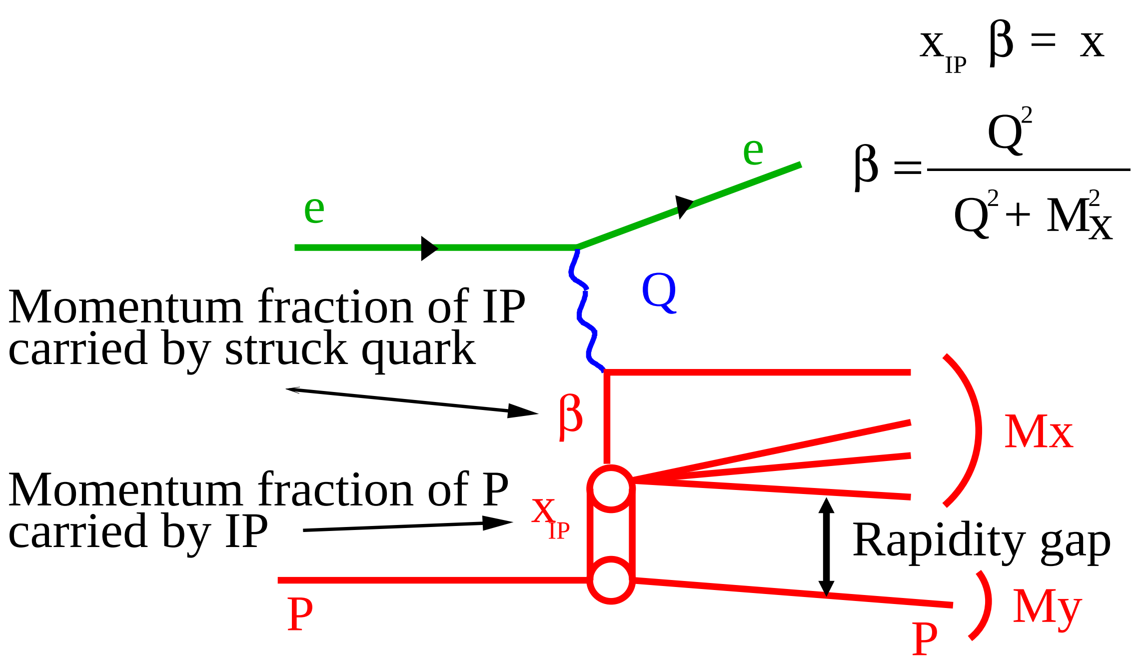
- Test quark fragmentation Universality (quark from $e^+e^- \rightarrow q\bar{q}$ $\equiv$ struck quark from $ep \equiv$ struck quark from $e\mathbb{P}$).

- Test various models of diffraction

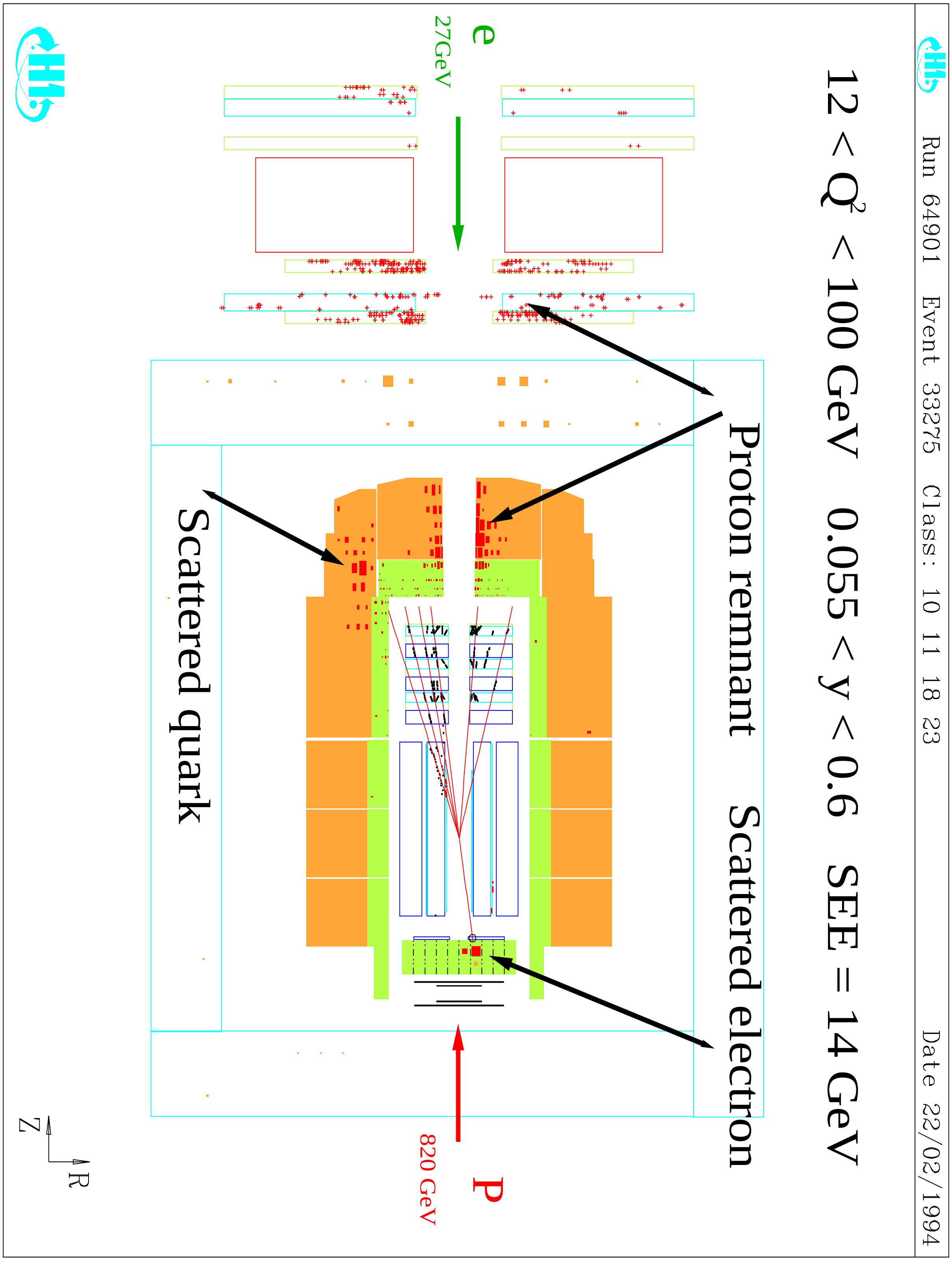
QPM Picture of DIS:



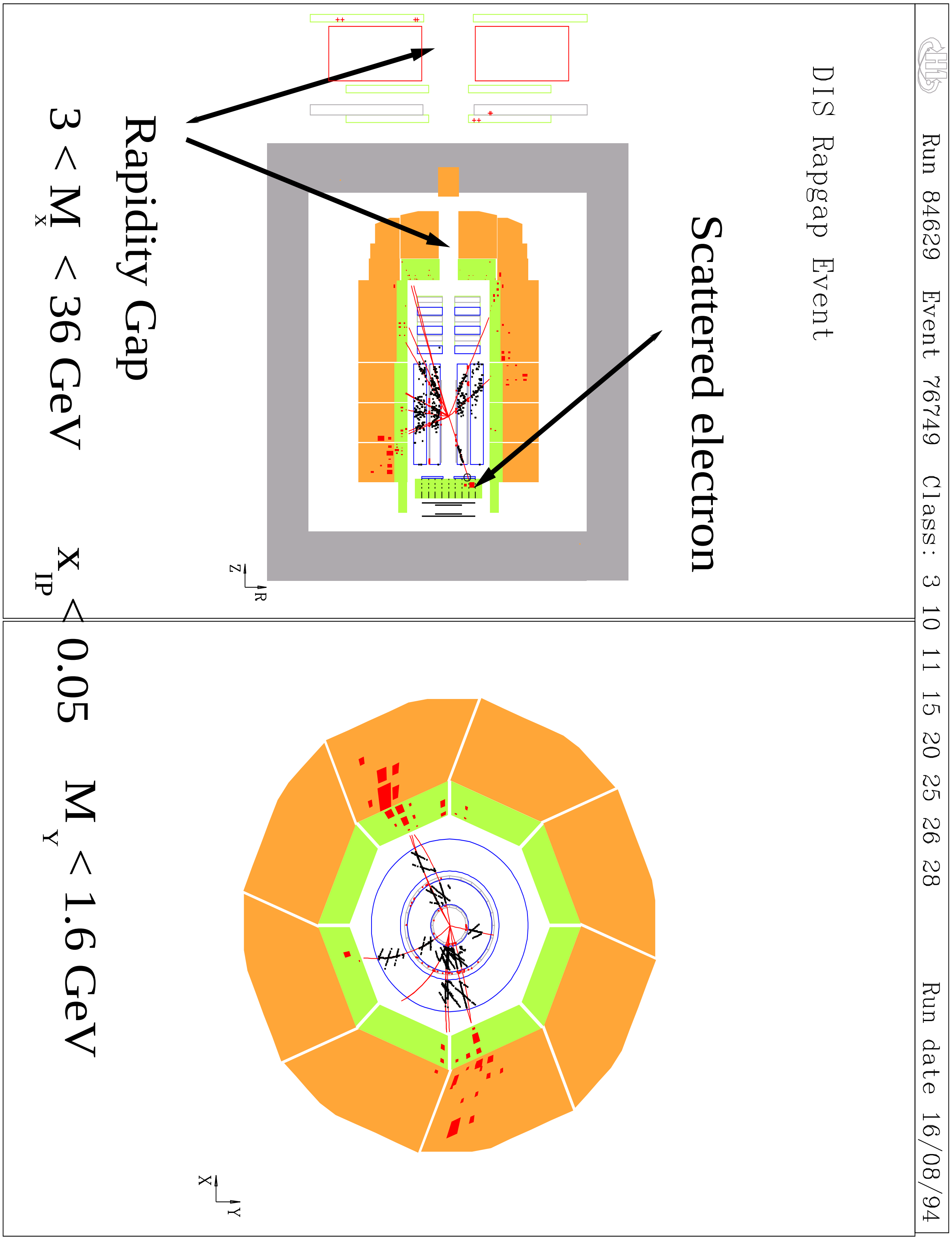
Diffractive DIS:



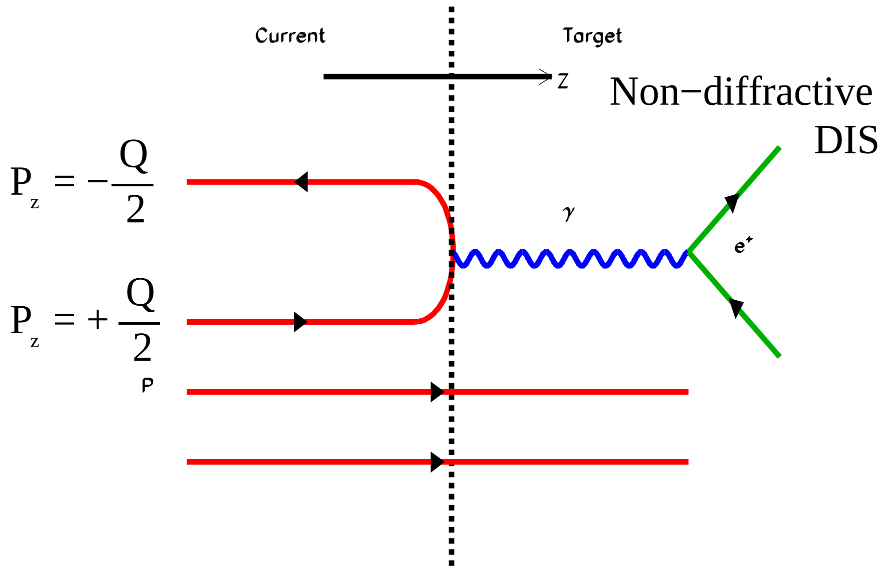
Event Selection



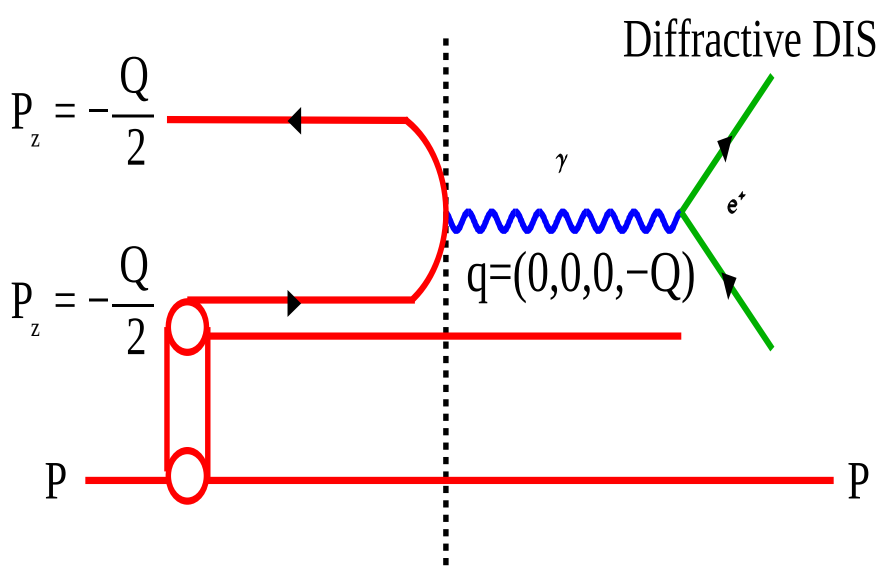
Event Selection



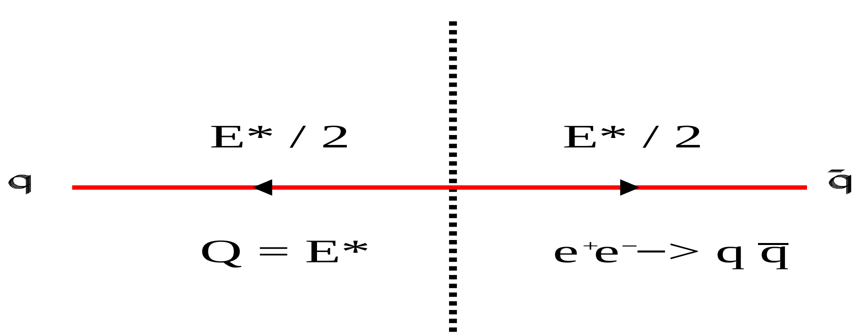
Breit Frame



Current
Target
z
Non−diffractive DIS
$P_z = -\frac{Q}{2}$
$P_z = +\frac{Q}{2}$
P
γ
e+

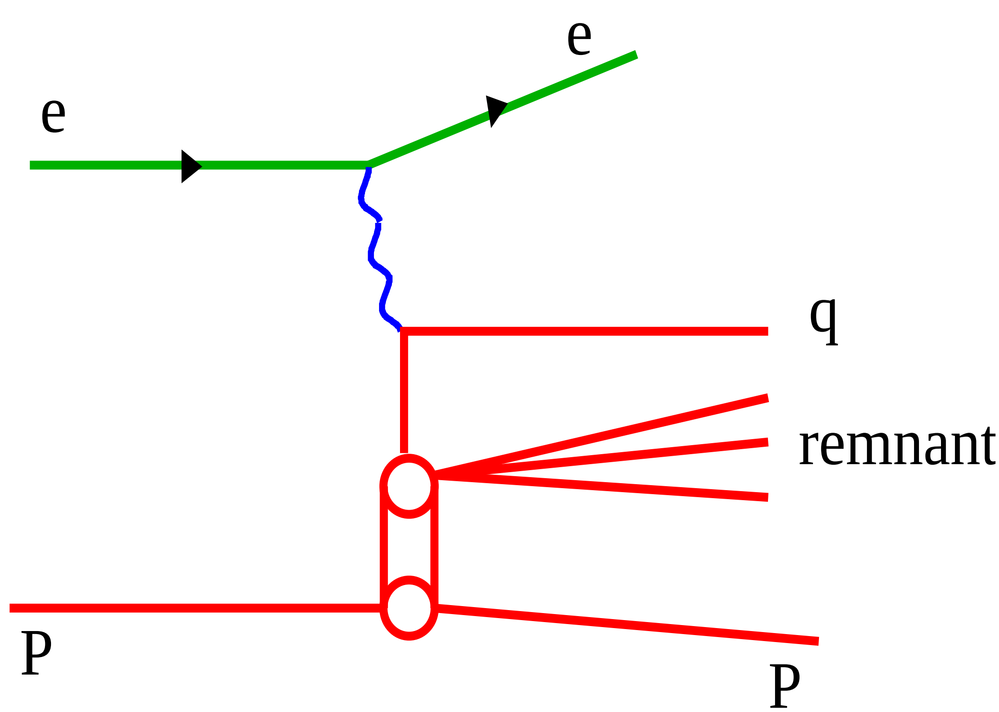


Diffractive DIS
$P_z = -\frac{Q}{2}$
$P_z = -\frac{Q}{2}$
γ
e+
q=(0,0,0,−Q)
P
P



E* / 2
E* / 2
q
$\bar{q}$
Q = E*
$e^+e^- \to q\,\bar{q}$

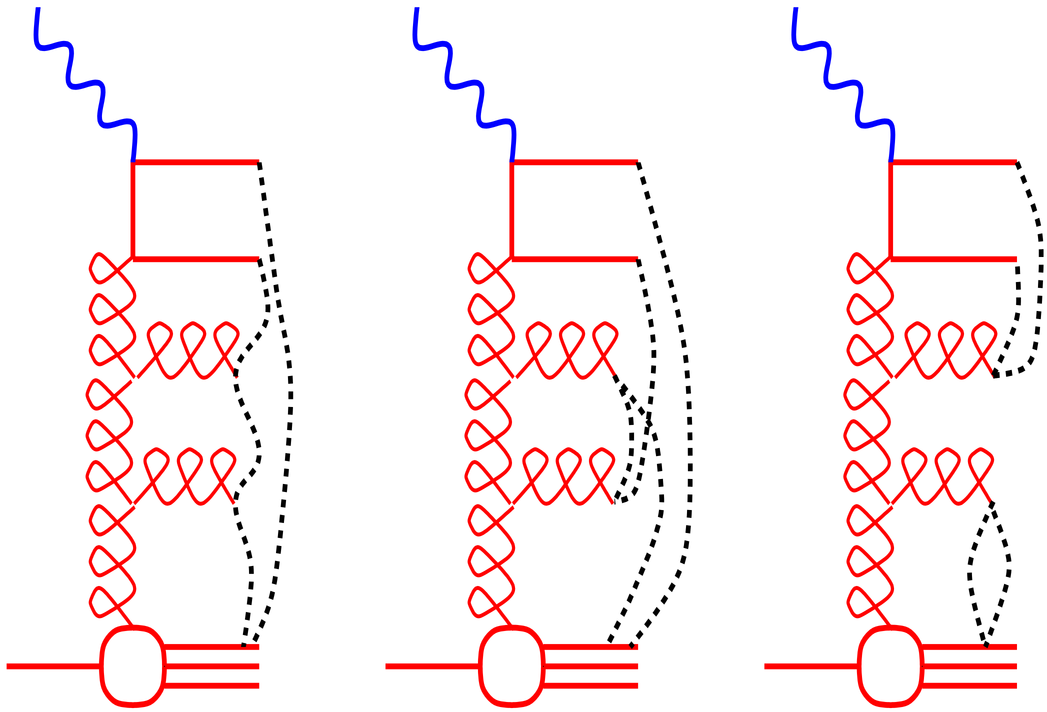
Resolved Pomeron Model



- Ingelman and Schlein[1]
- Treat pomeron as hadron within the proton.
- Similar to proton and photon structure functions
- H1 fits; quark dominated fit 1, flat gluon fit 2, peaked gluon fit 3
- Monte-Carlo: RAPGAP

[1] Phys. Lett. B152 (1985) 256

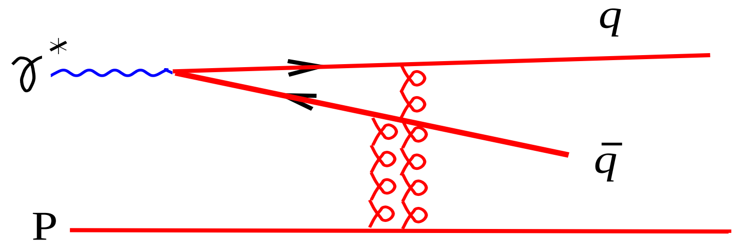
Soft Colour Interactions

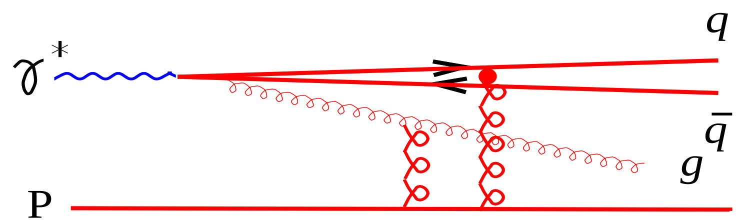


- Ingelman, Edin, Rathsman[2]
- Normal ep scattering + colour neutralisation through soft gluon
- Original model, universal colour rearrangement probability
- New model, generalised area law
- Monte-Carlo: LEPTO

[2] Phys. Lett. B 366 (1996) 371

Colour Dipole and 2-Gluon Models





Scattering of $q\bar{q}$ and $q\bar{q}g$ colour dipoles off the proton via 2 gluon exchange.

$q\bar{q}$ production at medium and high β (small M_x)

$q\bar{q}g$ production at Low β (large M_x)

Saturation model

- Golec-Biernat & Wusthoff[3]
- Monte-Carlo: RAPGAP

Other Models

- Bartels, Jung, Lotter, Wusthoff

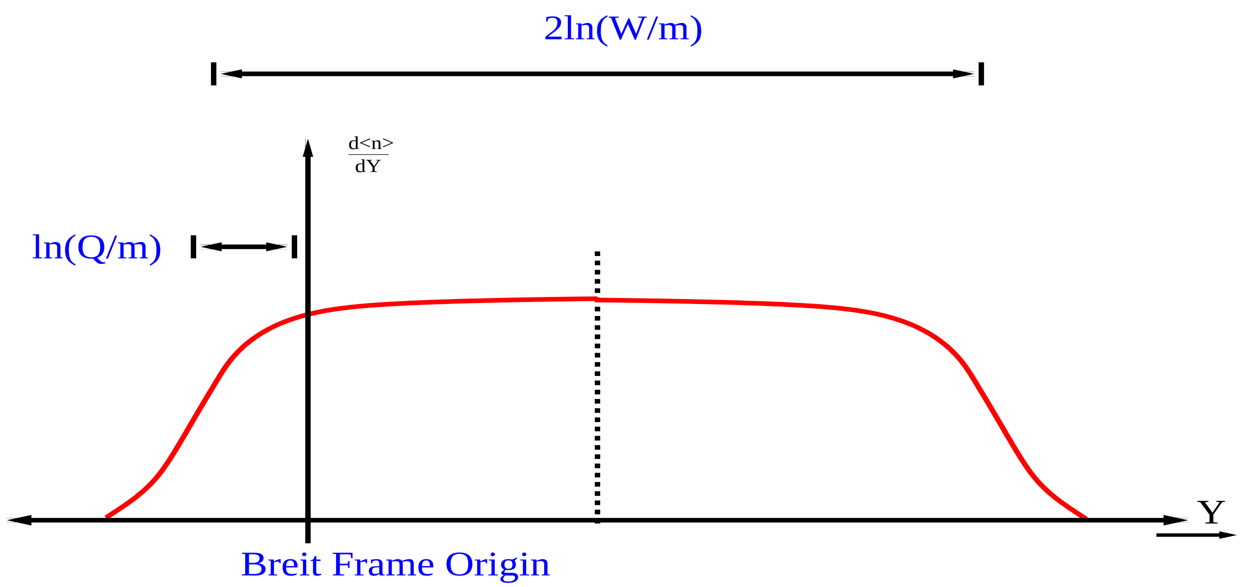
[3] Phys. Rev D 59 (1999) 014017

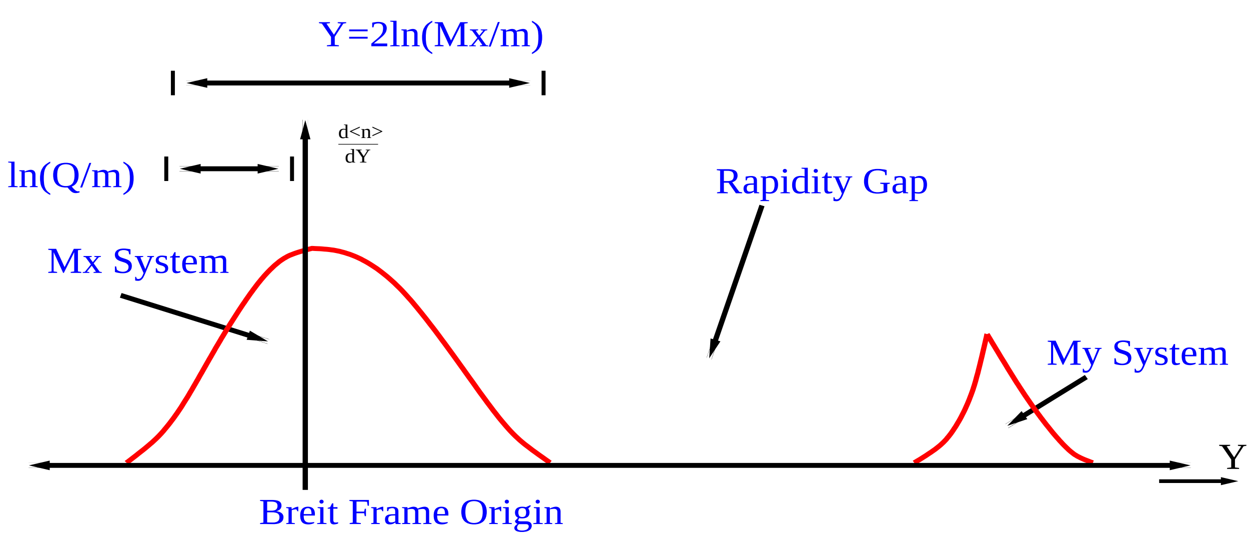
Rapidity Spectra (1)

$$Y = \frac{1}{2} \ln \left(\frac{E + P_z}{E - P_z} \right)$$

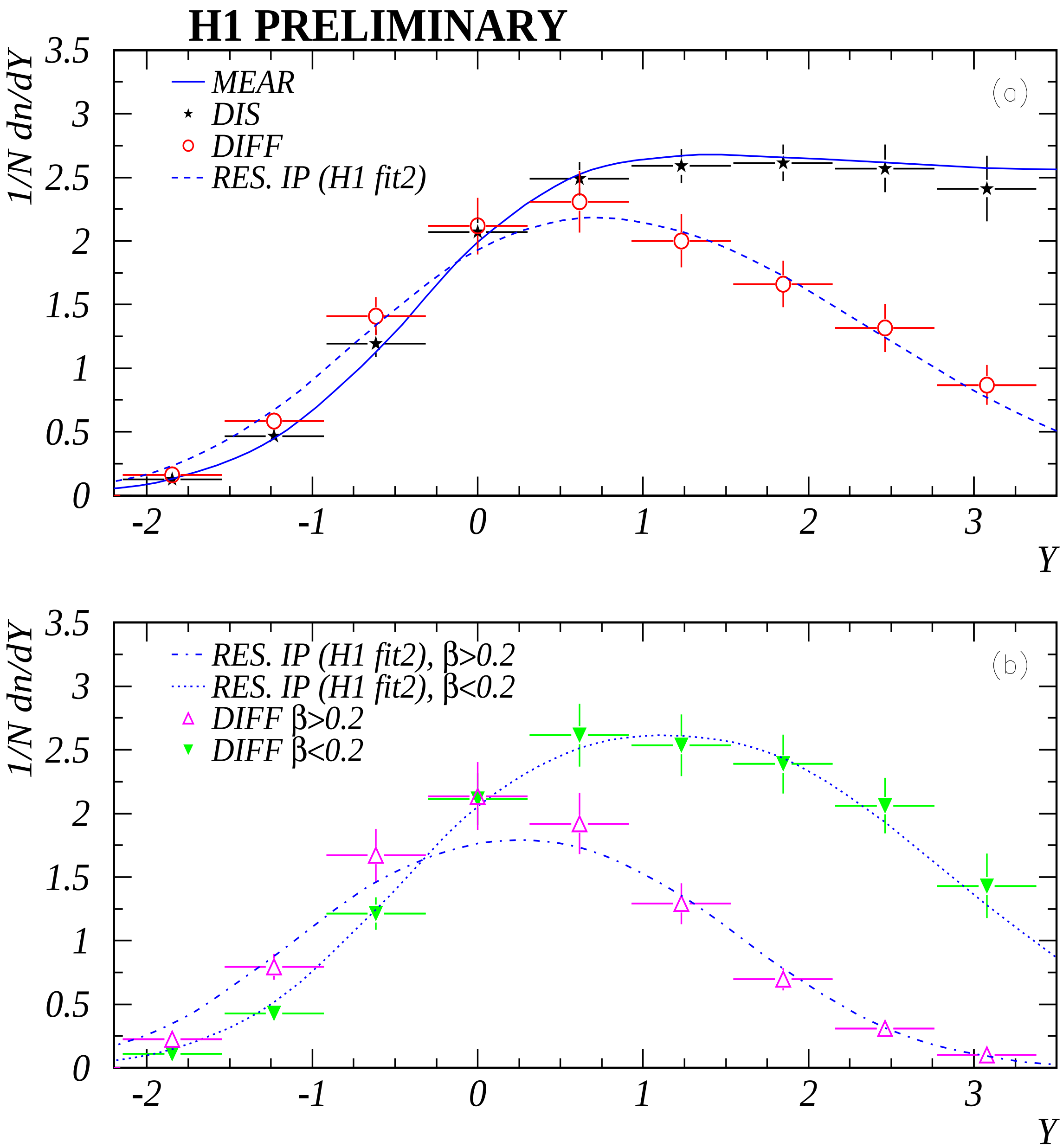
E = energy of particle (assuming pion mass - corrections made using Monte-Carlo)

P_z = Longitudinal Momentum



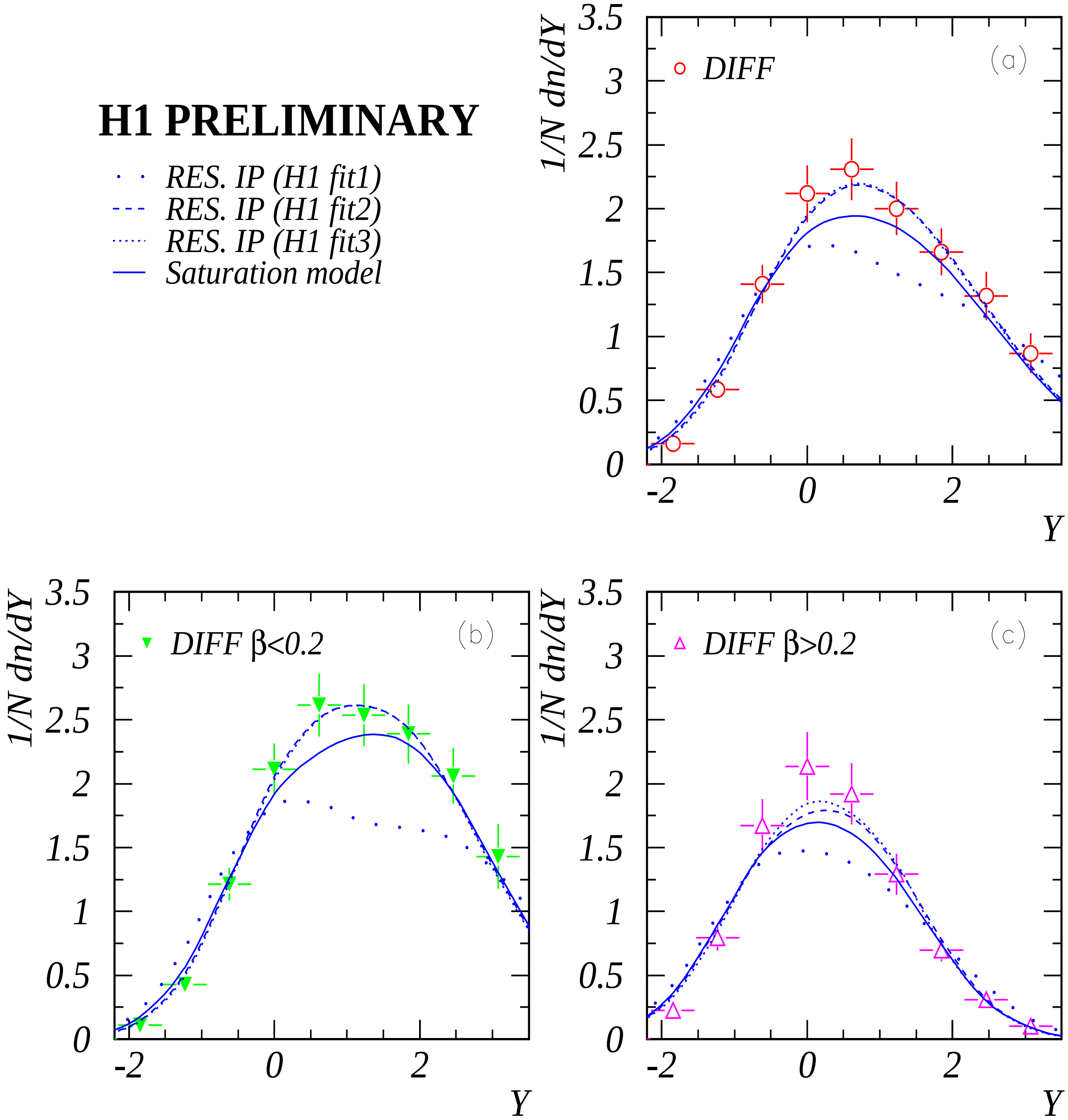


Rapidity Spectra (2)



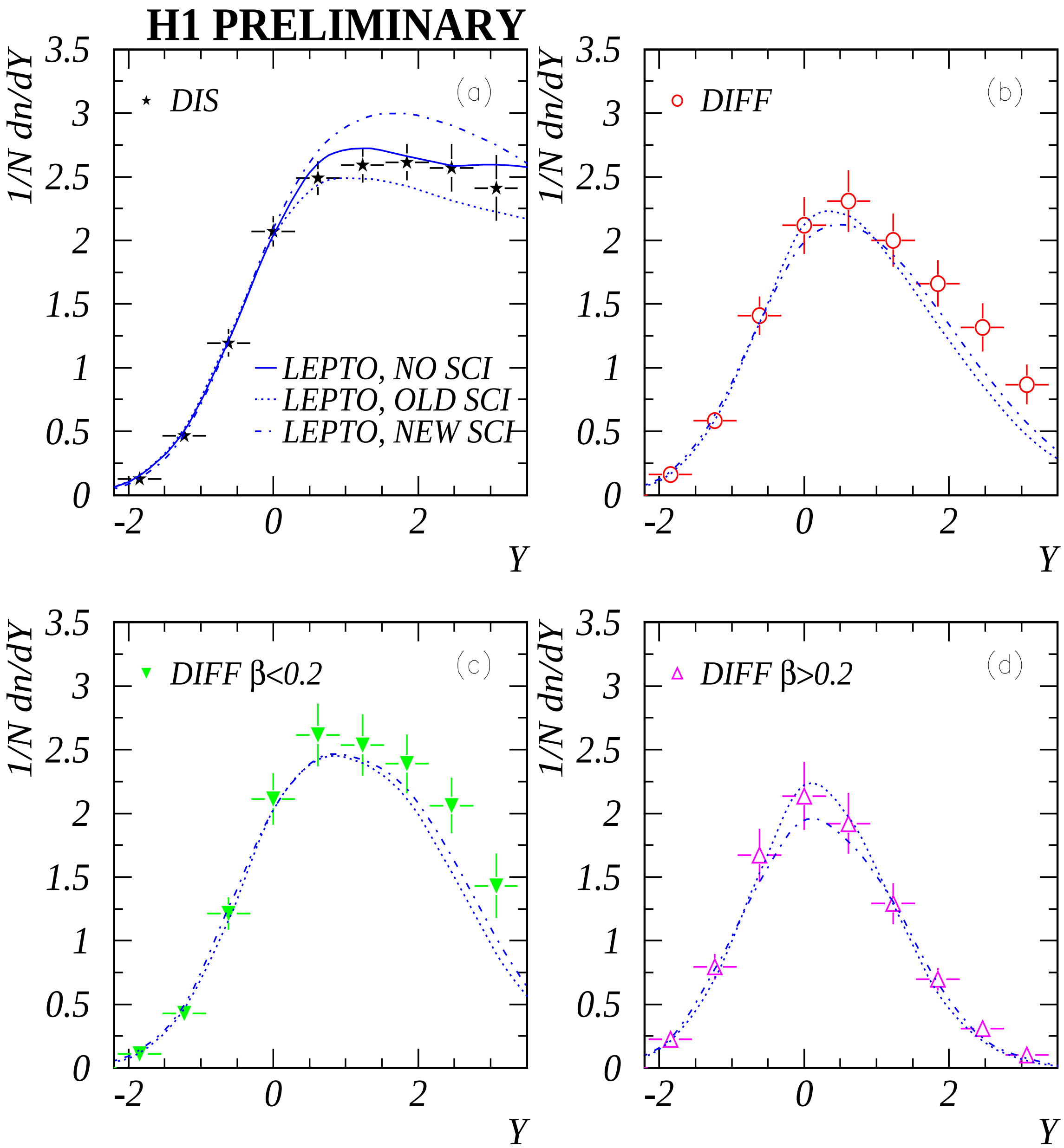
- Best Models
- Difference between DIS and DIFF.
- Difference between high and low β DIFF.

Rapidity: Model Comparison (1)



- Fit 2 and 3 indistinguishable.
- Fit 1 fails (already known), sensitivity to different models.
- Saturation Model, low central multiplicity
- Sensitivity at low β.

Rapidity: Model comparison (2)



- Best description of DIS given by LEPTO with no SCI.
- Large difference between NEW and OLD SCI versions for DIS
- Little difference between versions for DIFF.
- Multiplicity too low in target region at low β.

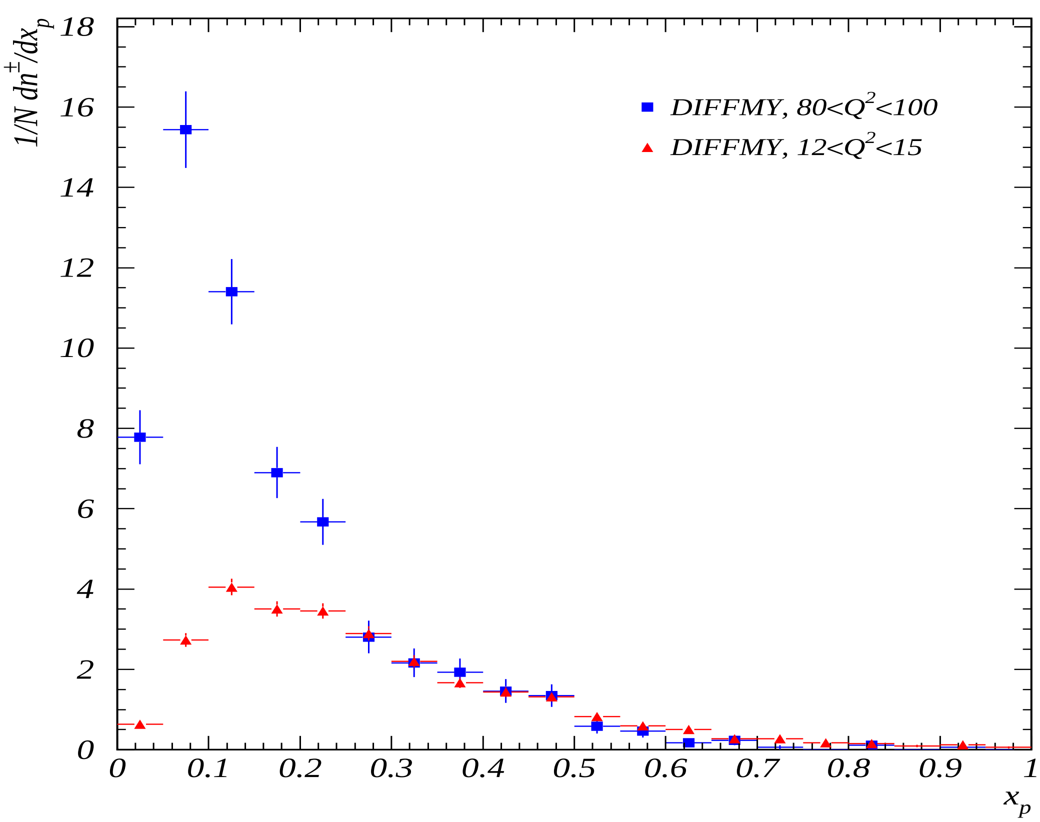
Fragmentation Function (1)

Inclusive Scaled Momentum distribution,

$$x_p = \frac{2p}{Q}$$

Event Normalised Charged track density

$$D\left(x_p\right) = \frac{1}{N_{events}}\left(\frac{dn^{\pm}}{dx_p}\right)$$

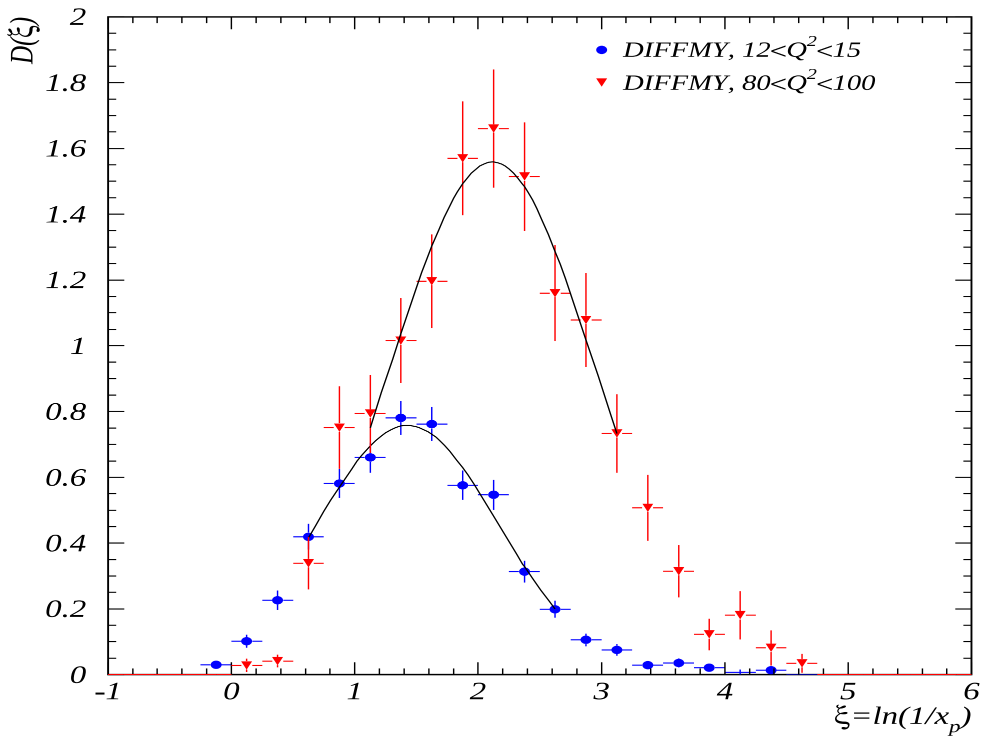


Fragmentation Function (2)

To examine turnover region recast in terms of ξ

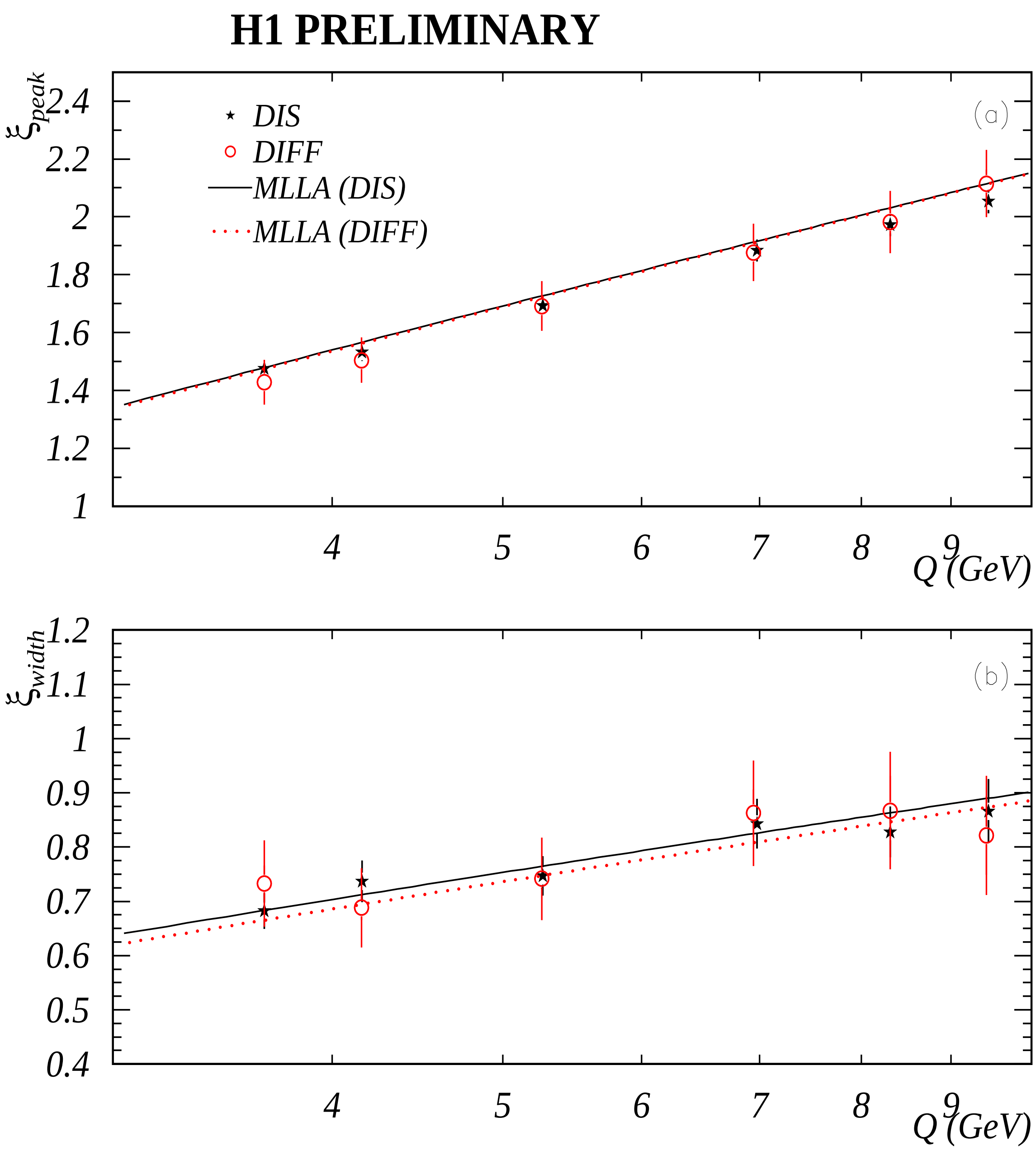
$$\xi = \ln\left(\frac{1}{x_p}\right)$$

$$D^{\pm}(\xi) = \frac{1}{N}\left(\frac{dn^{\pm}}{d\xi}\right)$$



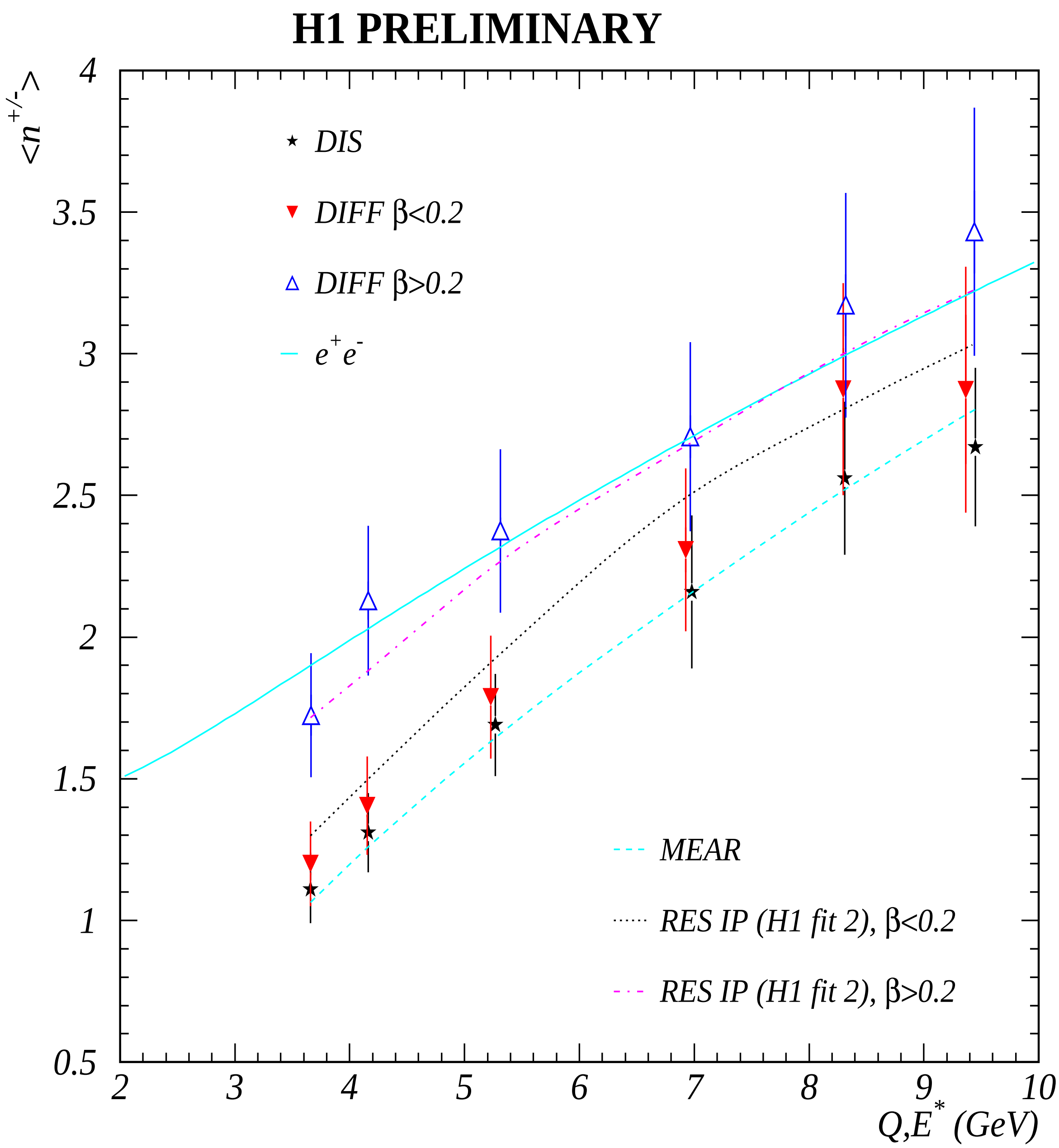
- MLLA predicts that in the region of the peak the shape is approximately Gaussian. Predicts evolution with Q.

Fragmentation Function (3)



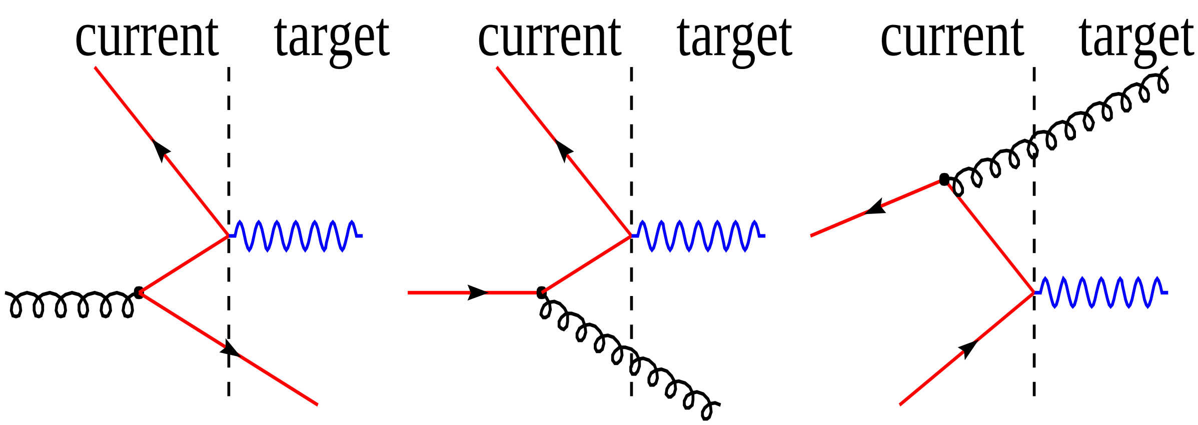
- Very Good agreement between DIS and DIFF.
- Very similar MLLA fits.
- Results lend further support for concept of quark fragmentation universality. ($e^+e^- \rightarrow q\overline{q}$, $ep \rightarrow e'X$, $ep \rightarrow e'XY$)

Average Charged Multiplicity (1)



- Difference between $e^+e^- \to q\overline{q}$ and DIS due to LO QCD effects.
- High β DIFF similar to $e^+e^- \to q\overline{q}$.
- Low β DIFF similar to DIS.
- Models describe data.

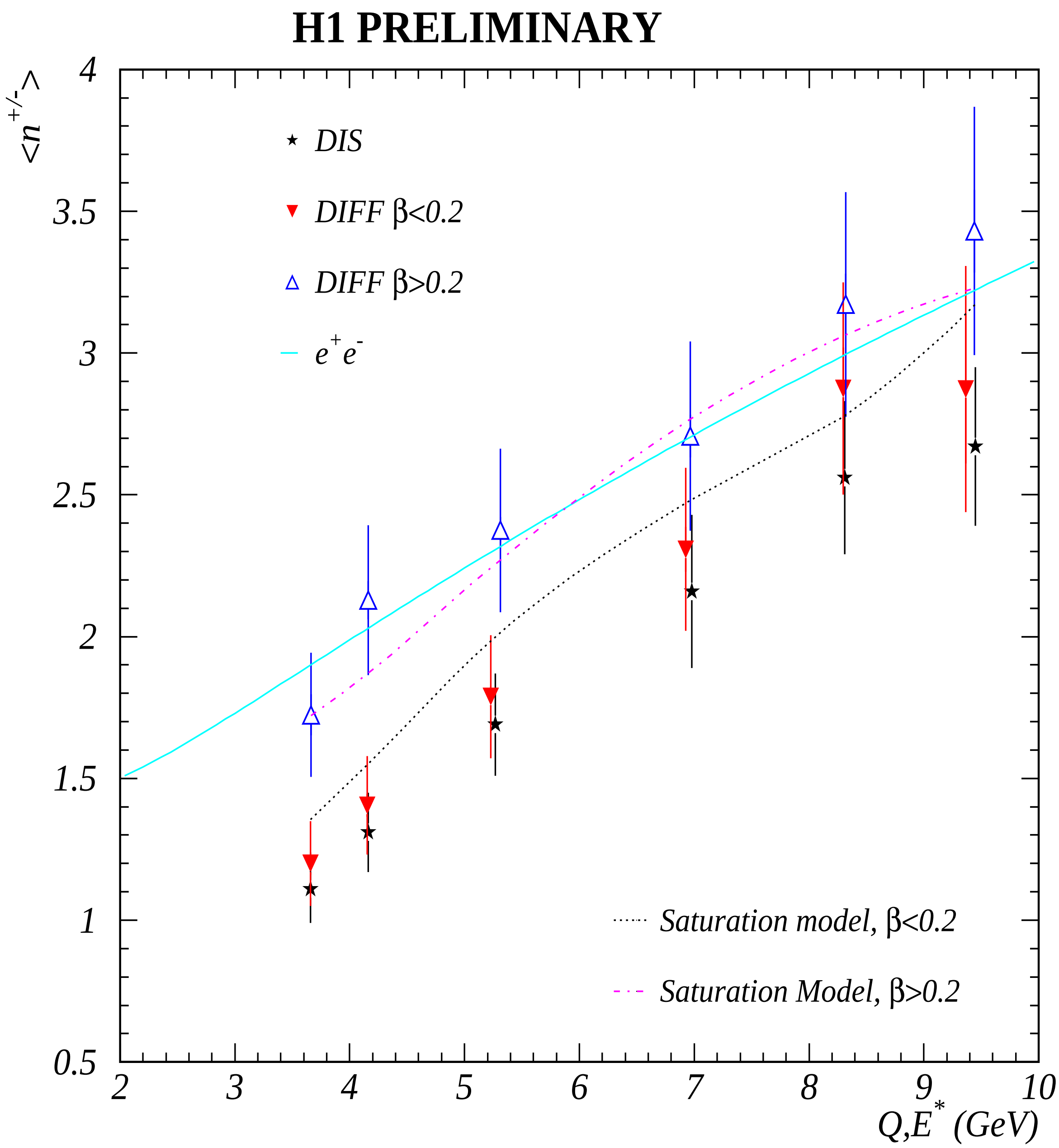
QCD LO Processes



(a) (b) (c)

- Lower Multiplicity in current region due to LO QCD.
- Similar effect seen in Diffraction?
- Difference also seen in most Diffractive models.

Average Charged Multiplicity (2)



- Saturation overestimates multiplicity in current region at low β.
- Otherwise description of data reasonable.

Conclusions

- Best description of data obtained from Resolved pomeron model (H1 fit 2 or 3) for diffraction and MEAR for DIS.

- Other models able to at least qualitatively describe the various distributions.

- Differences between high and low β can be interpreted the as result of gluon emission at low β (large M_x) leading to a depleted or empty current region and hence multiplicity is similar to DIS.

- At high β (small M_x) the limited phase space restricts gluon emission and hence multiplicity is similar to $e^+e^- \to q\bar{q}$.

- Phase space effect, not restricted to any one particular model.

- Further support for concept of quark fragmentation universality