H1 Collab., Phys. Lett. B 681 (2009)
[hep-ex/0907.2666]

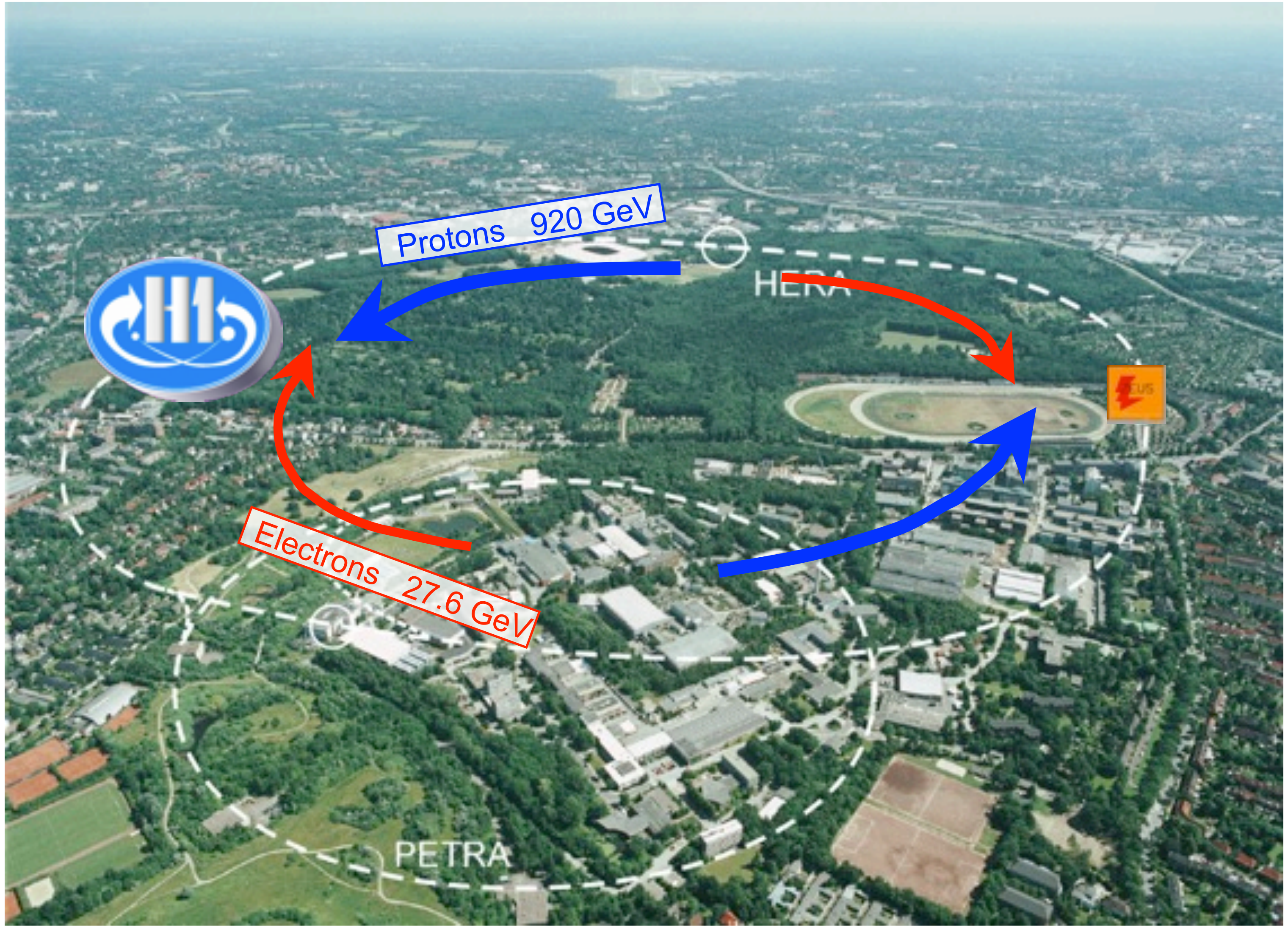
Hadronic Charge Asymmetry in DIS

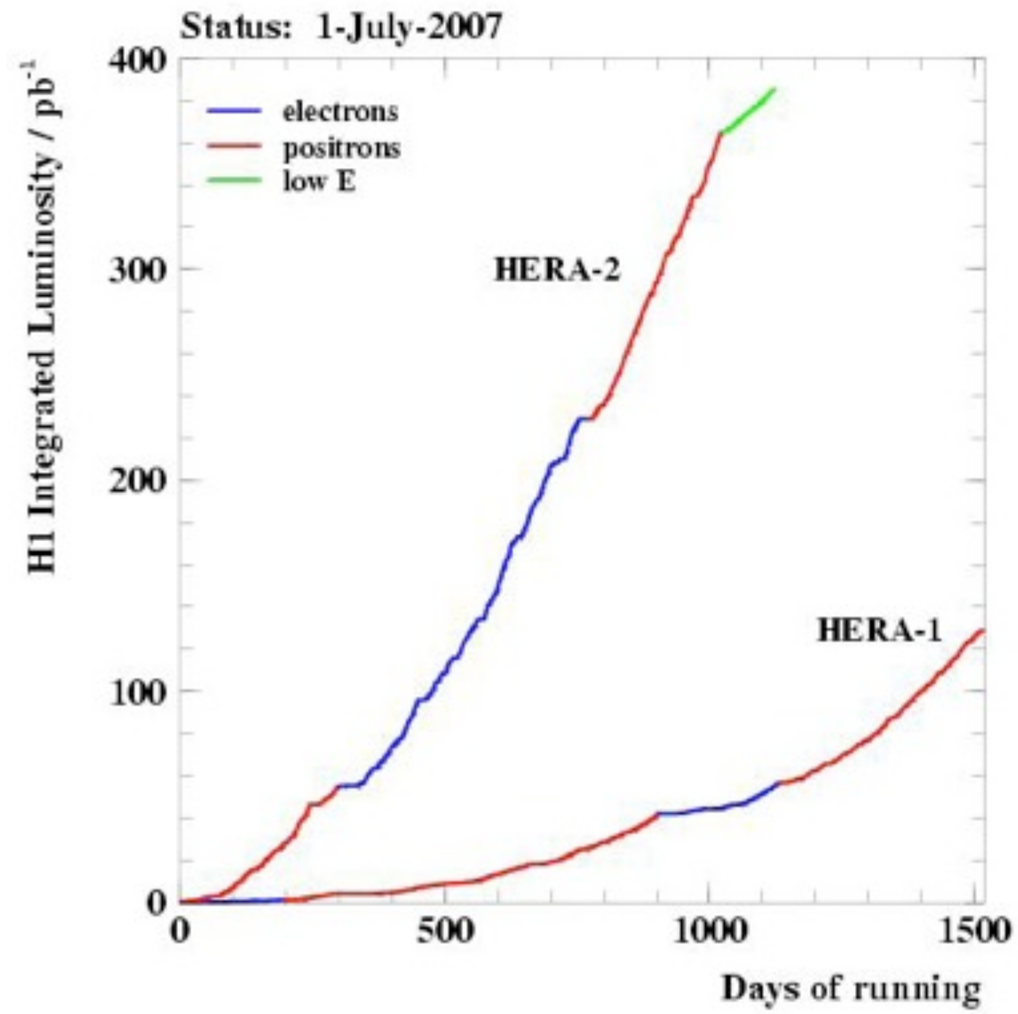
Daniel Traynor, DIS2010, 20/04/10

Queen Mary
University of London

Overview

- HERA, H1 and DIS
- Recap - Fragmentation Function results.
- Charge asymmetry of the hadronic final state!



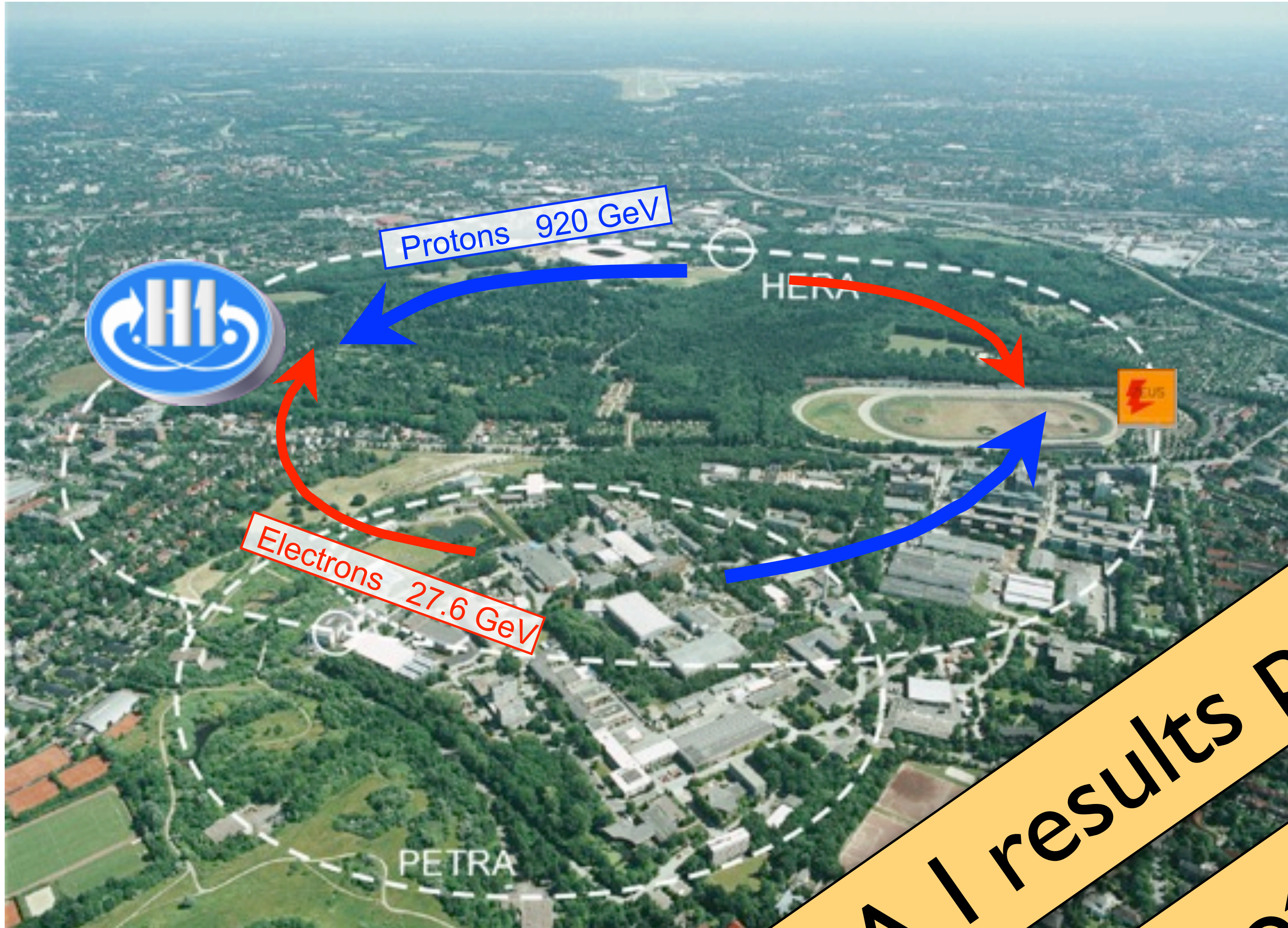


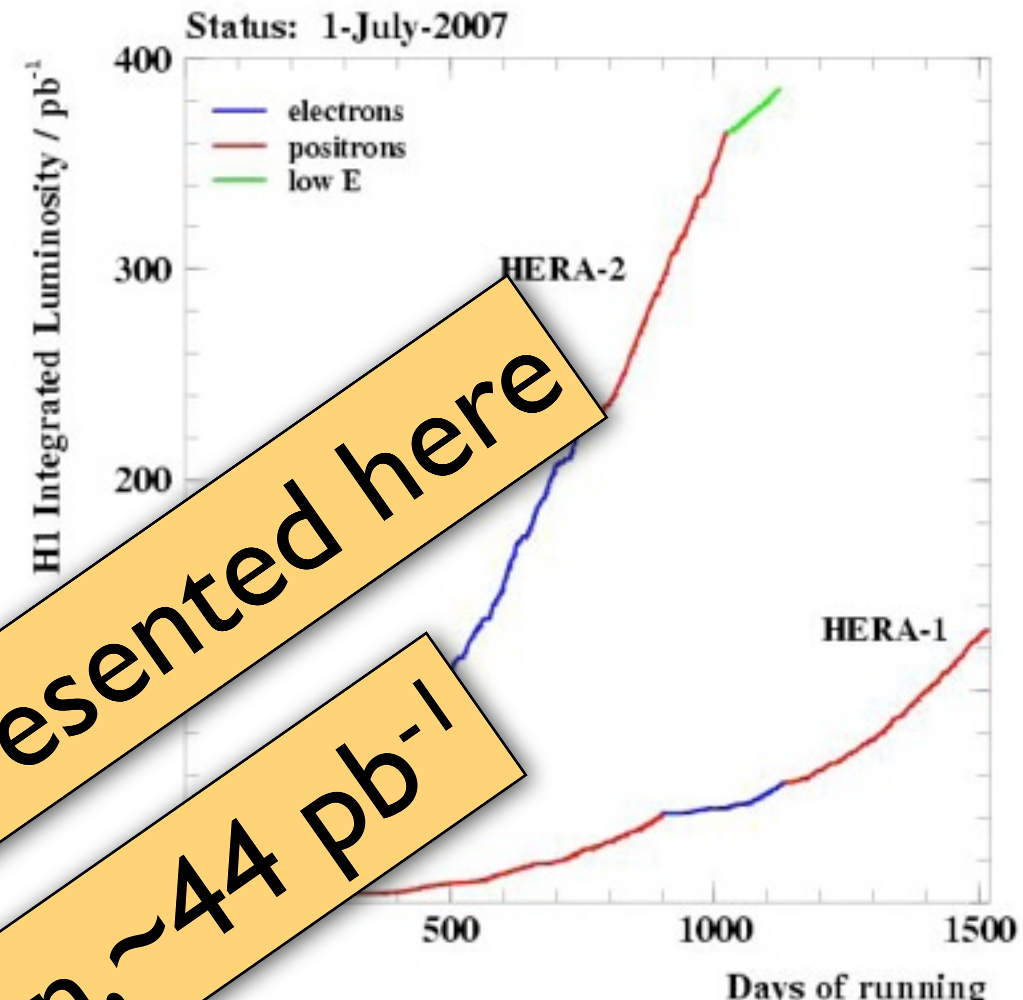
electrons or positrons

polarised lepton beams

4 different proton energies

H1 Physics usable sample ~500 pb^{-1}





Only HERA I results presented here

positron - proton, ~44 pb^{-1}

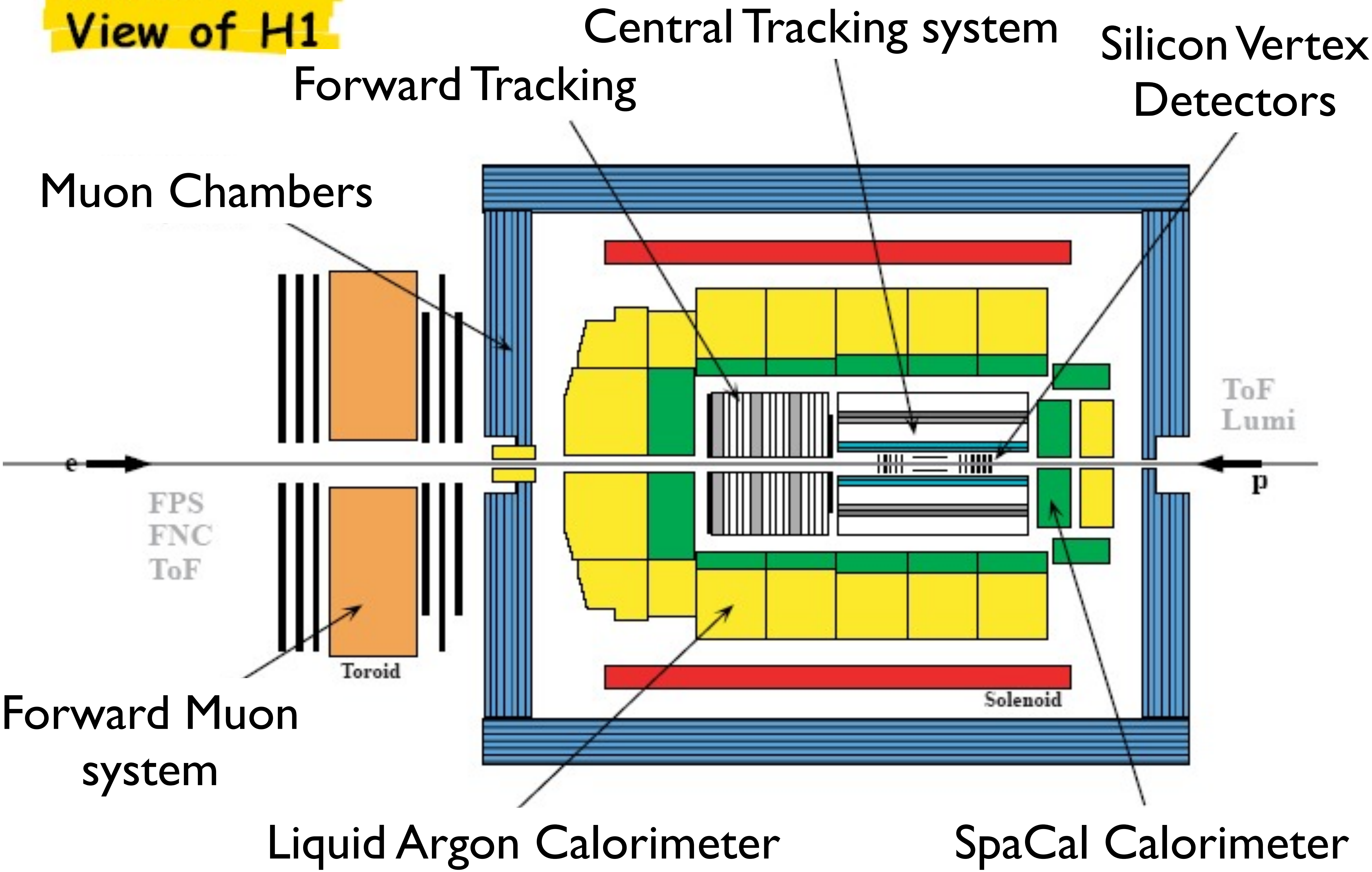
electrons or positrons

polarised lepton beams

4 different proton energies

H1 Physics usable sample ~500 pb^{-1}

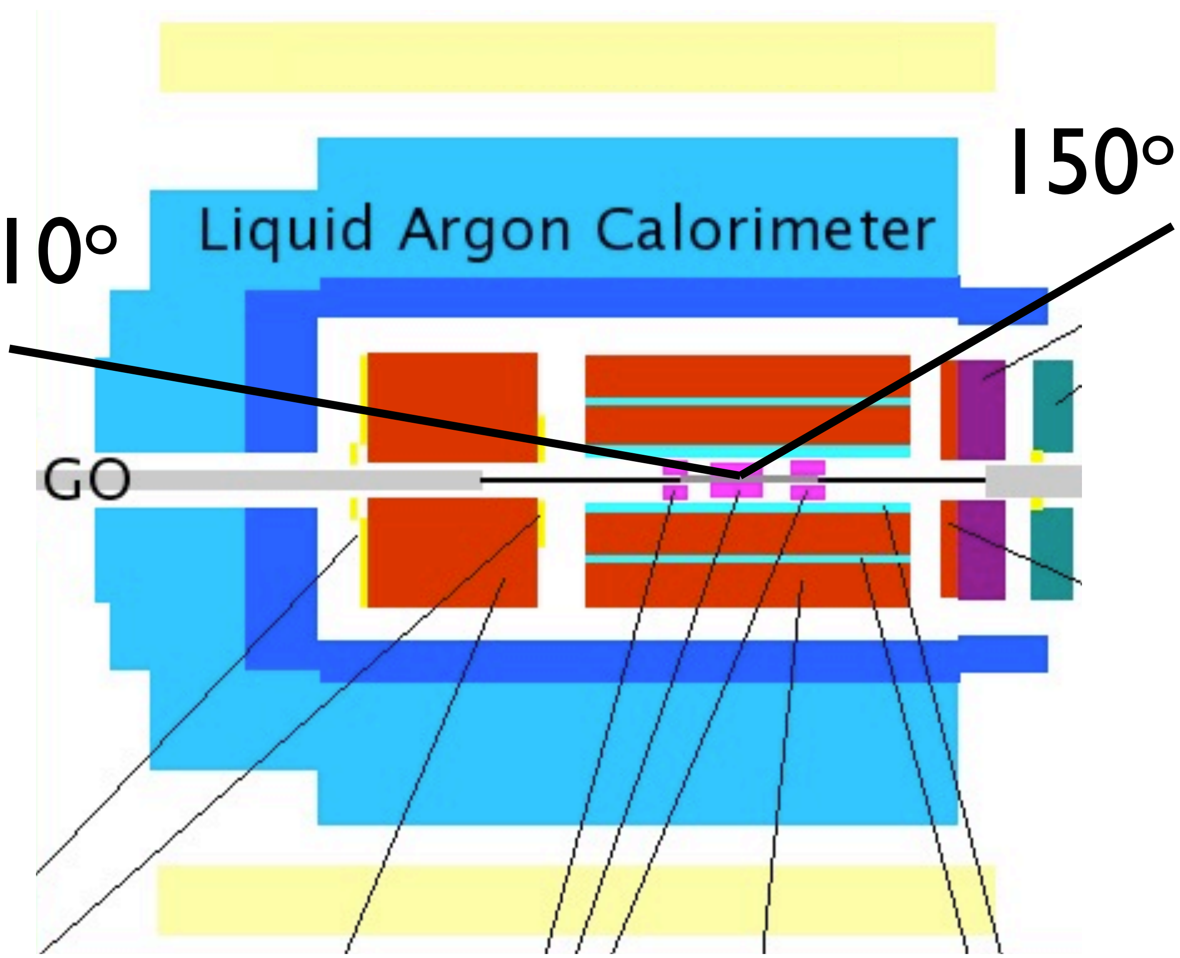
Schematic View of H1



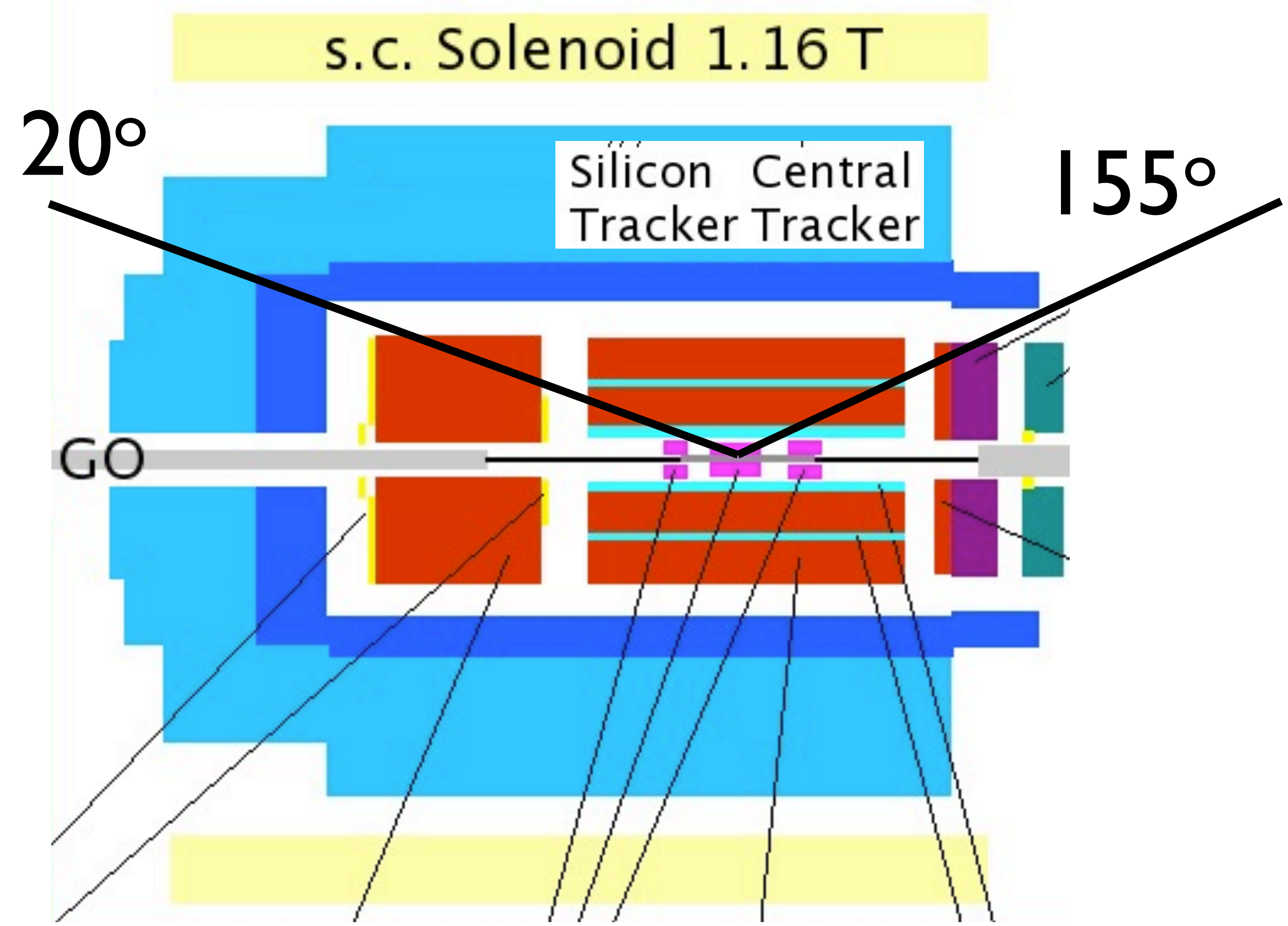
almost 4π detector coverage

15 metres long and 10 metres high, weighed 2800 tons.

Scattered electron acceptance at high Q^2



Tracking acceptance of hadronic final state



<u>Kinematic phase space</u>

$100 < Q^2 < 8{,}000\ \mathrm{GeV}^2$

$0.05 < y < 0.6$

$\theta_{electron} > 150°$

$30° < \theta_{q,lab} < 150°$

quark scattering angle, $\theta_{q,lab}$, calculated from kinematics. Ensures current region of Breit frame remains within tracking acceptance. Easy to calculate in theory!

K^0, Λ, etc.. considered as stable

$D(x_p)$ correction factor < 1.2.

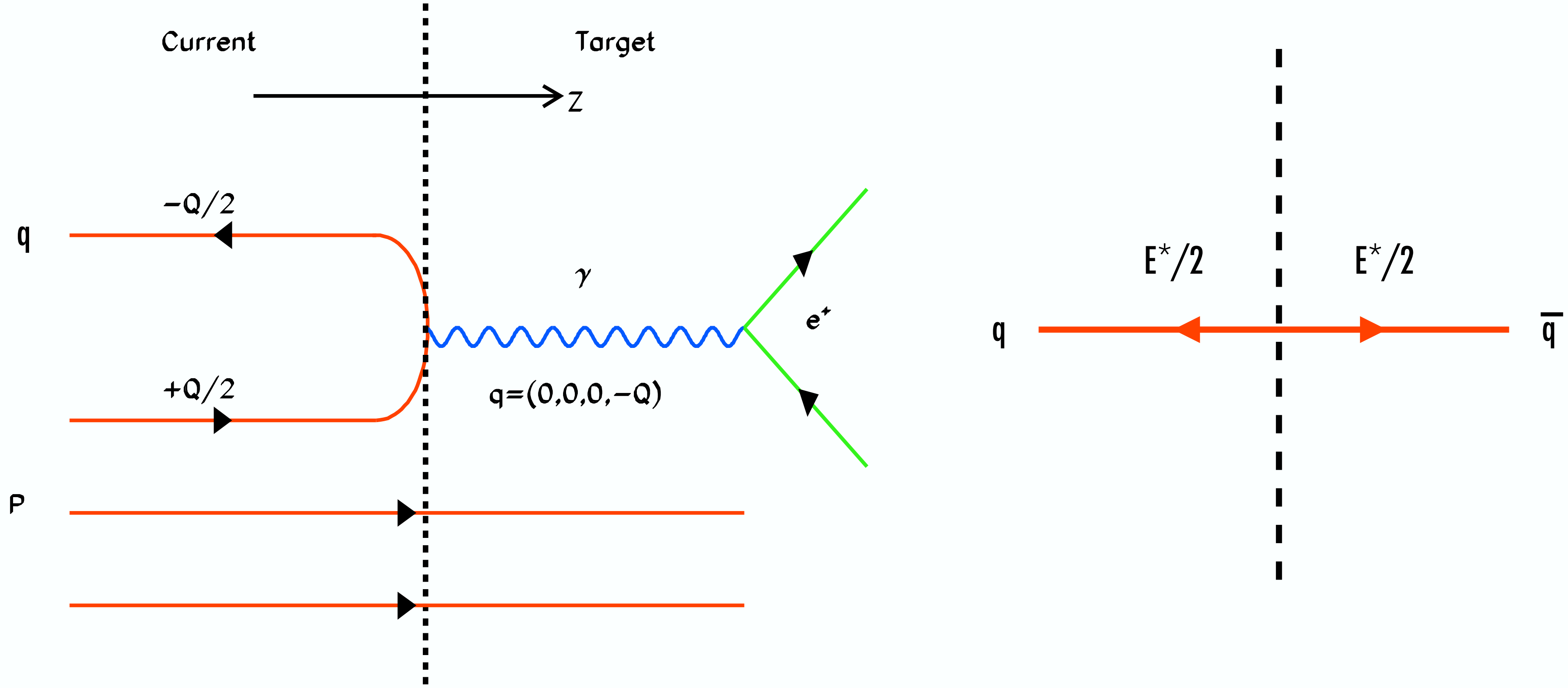
Asymmetry correction factor ~1.0

systematics partial cancel

D(xp) systematic error ~5%

$ep \rightarrow eX$ $e^+e^- \rightarrow q\bar{q}$

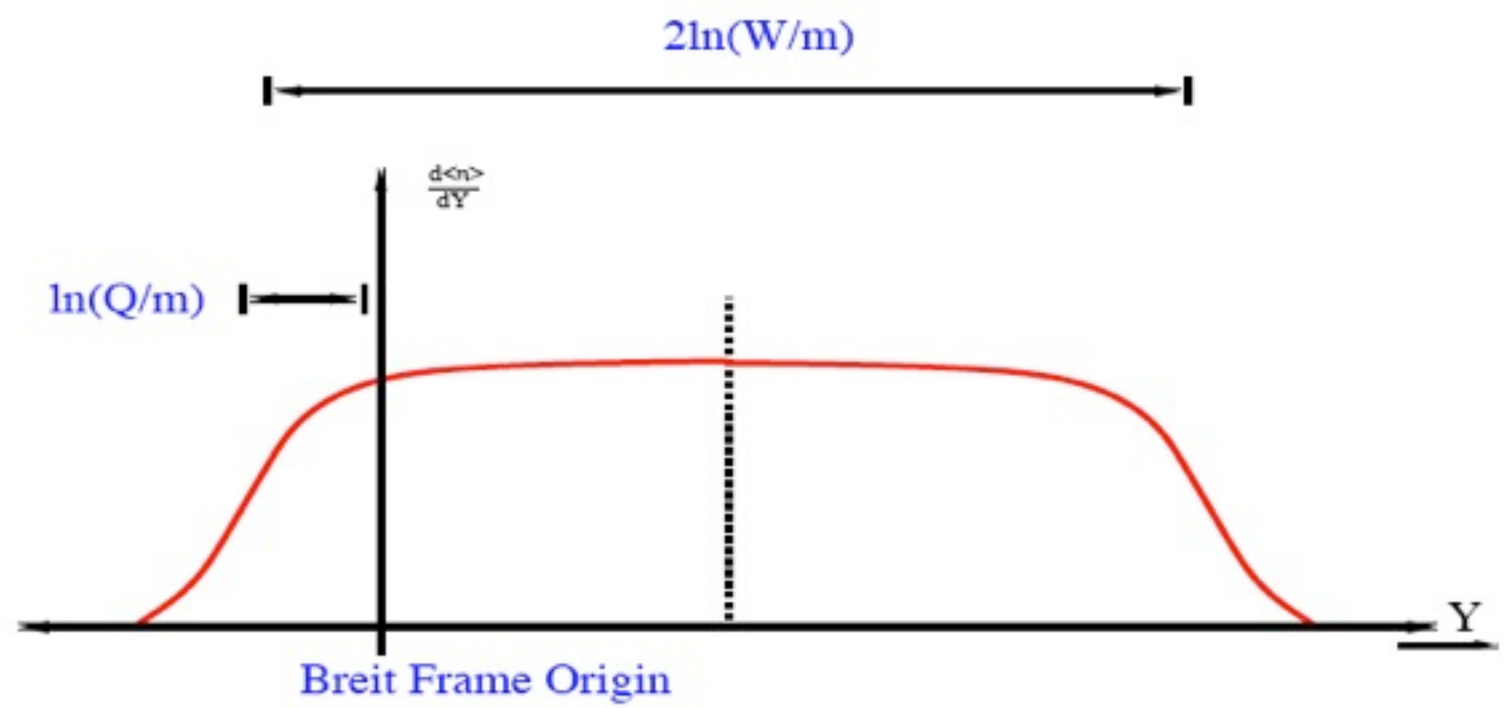
Breit Frame



Provides clearest separation between particles from hard scattering and proton remnant. Allows for easy comparison with e^+e^- data

current region energy scale is Q/2

boost to breit frame means we measure down to p_{breit} =0!



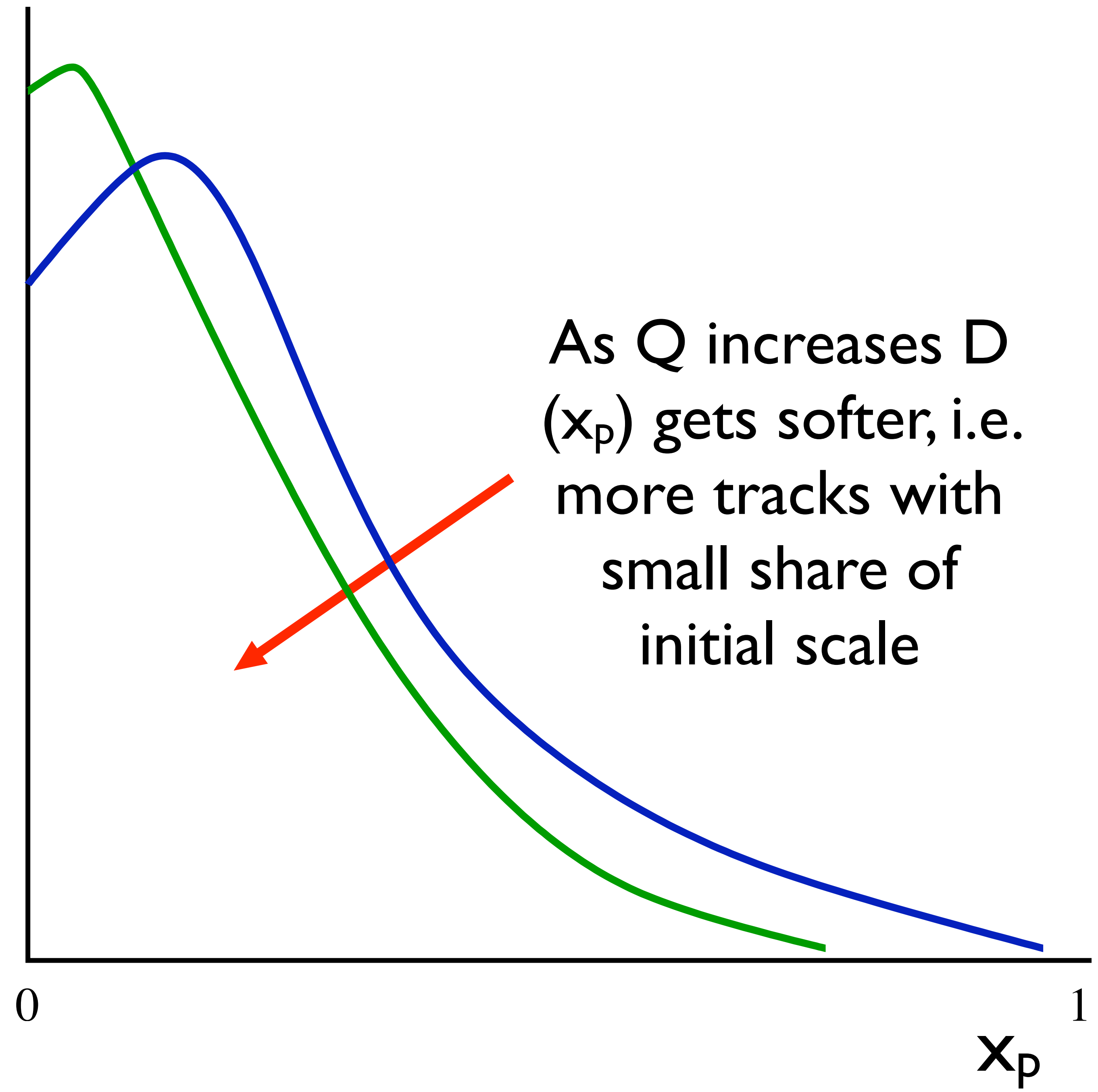
$$x_p = \frac{(2P_h)}{Q}$$

$$D(x_p) = \frac{1}{N_{event}} dn/dx_p$$

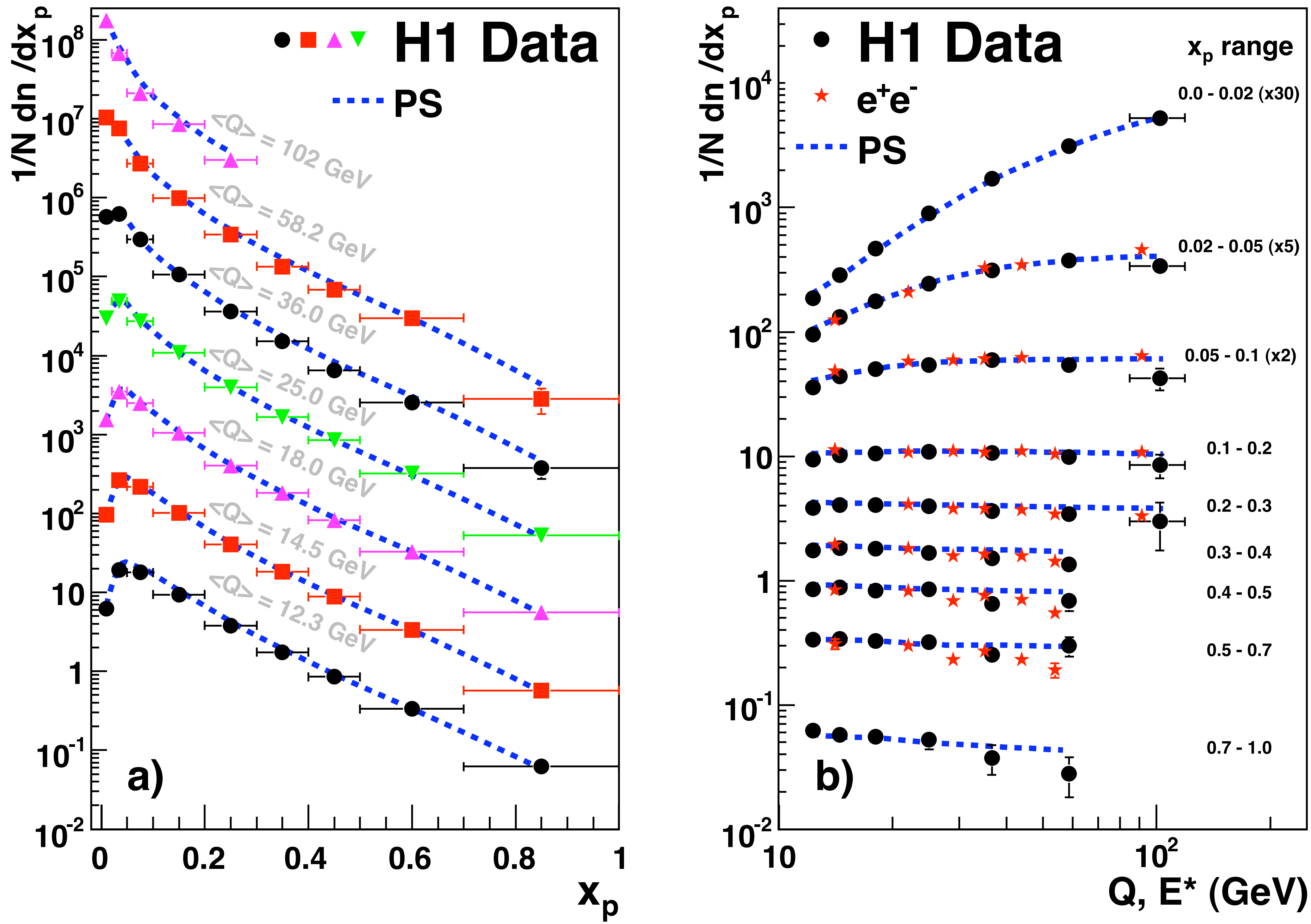
x_p = scaled momentum variable

Q/2 = Scale in current region of Breit Frame

p_h = momentum of charged particle in current region of Breit frame



$D(x_p)$ = event normalised, charged particle, scaled momentum distribution

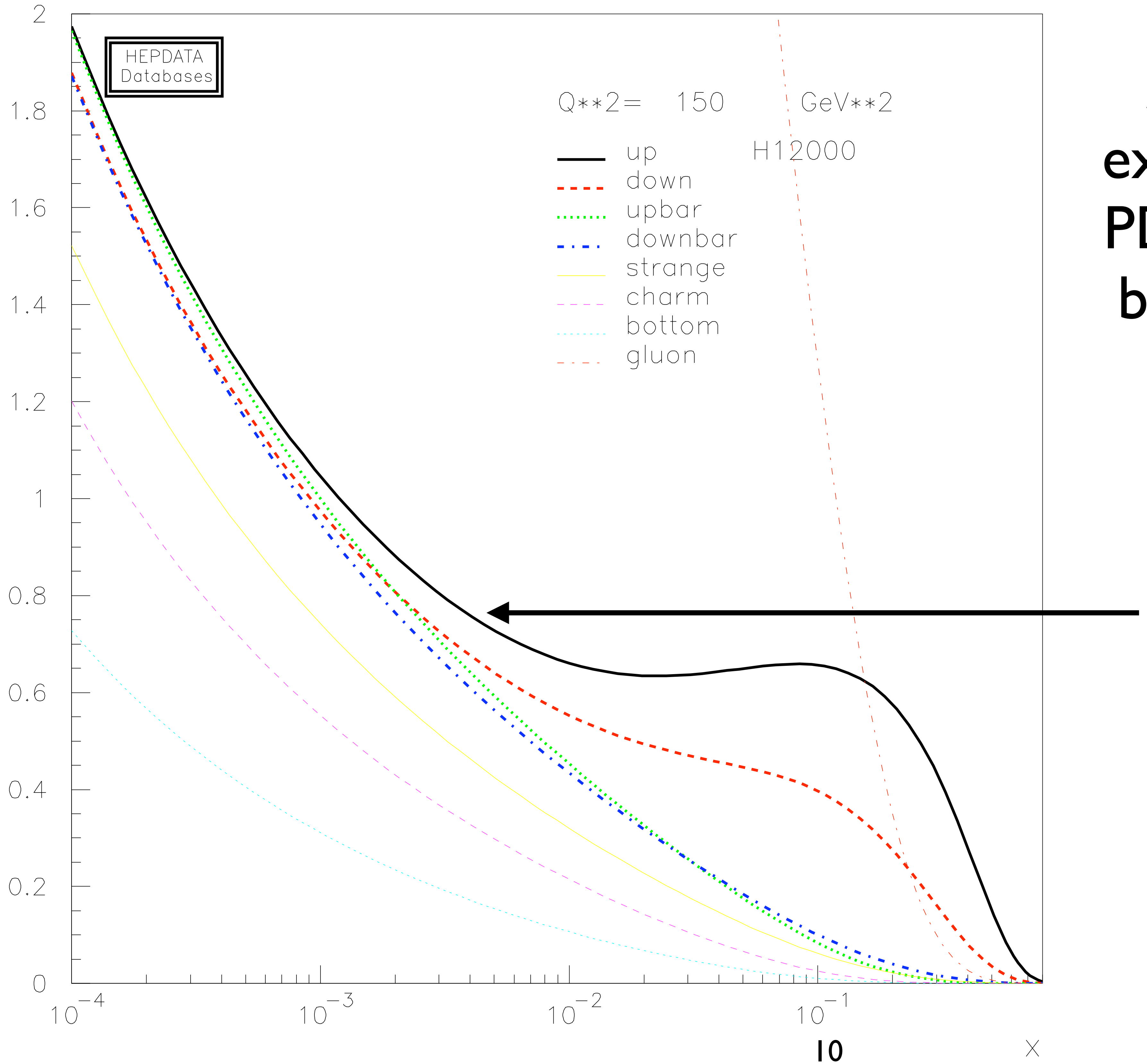


Reasonable agreement between ep and e^+e^- / Monte Carlo - broadly supports quark fragmentation universality.

H1 Collab., F.D. Aaron et al., Phys.Lett.B654:148-159,2007

Charge Asymmetry Motivation

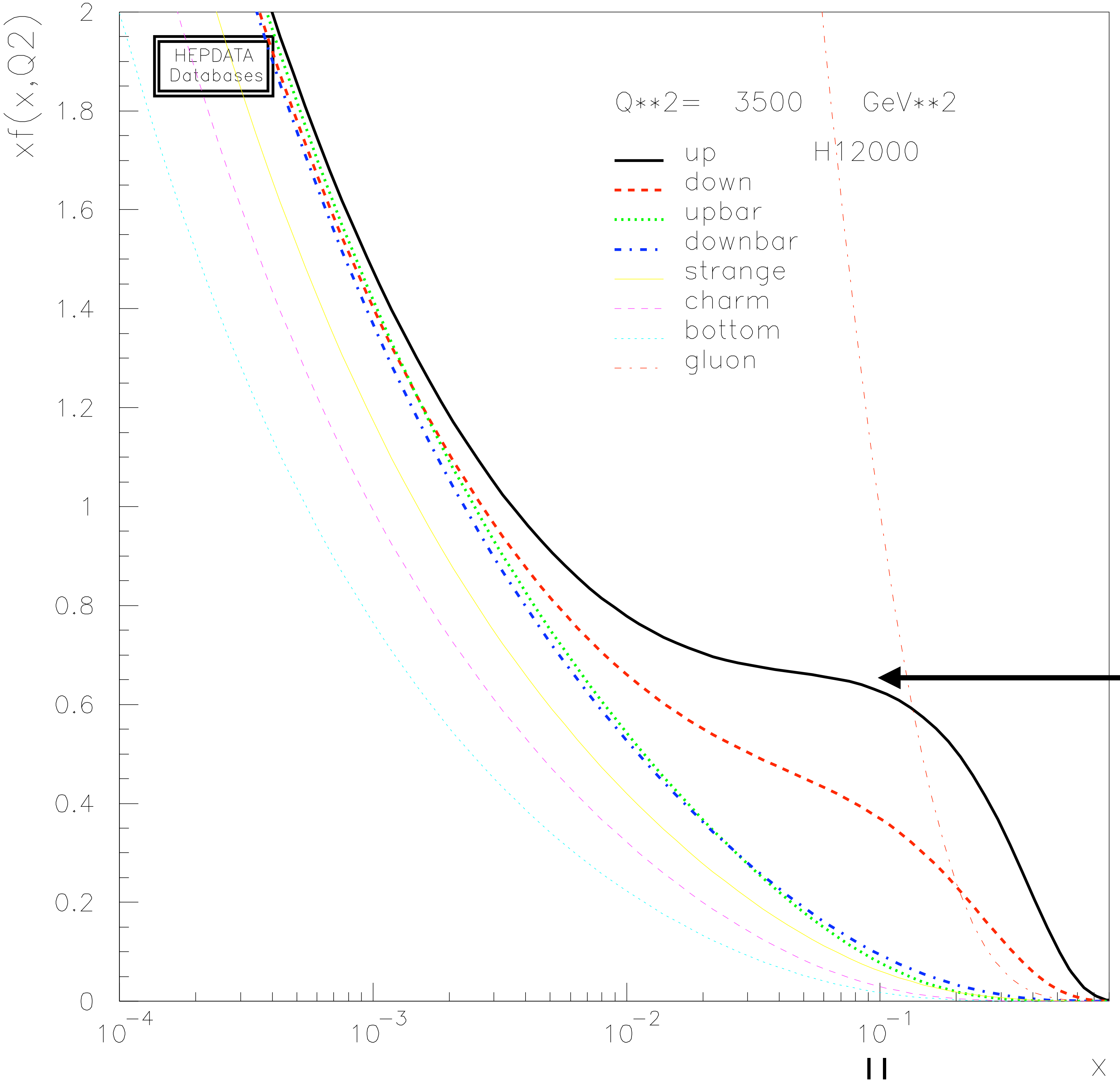
Quark contribution to PDF



At low Q^2 / low x_{BJ} expect that the proton PDF will be dominated by sea quarks and the gluon

Lowest Q^2 bin has average x~ 0.005. sea quarks dominate - u≈d≈s≈ ubar≈dbar≈sbar

Quark contribution to PDF

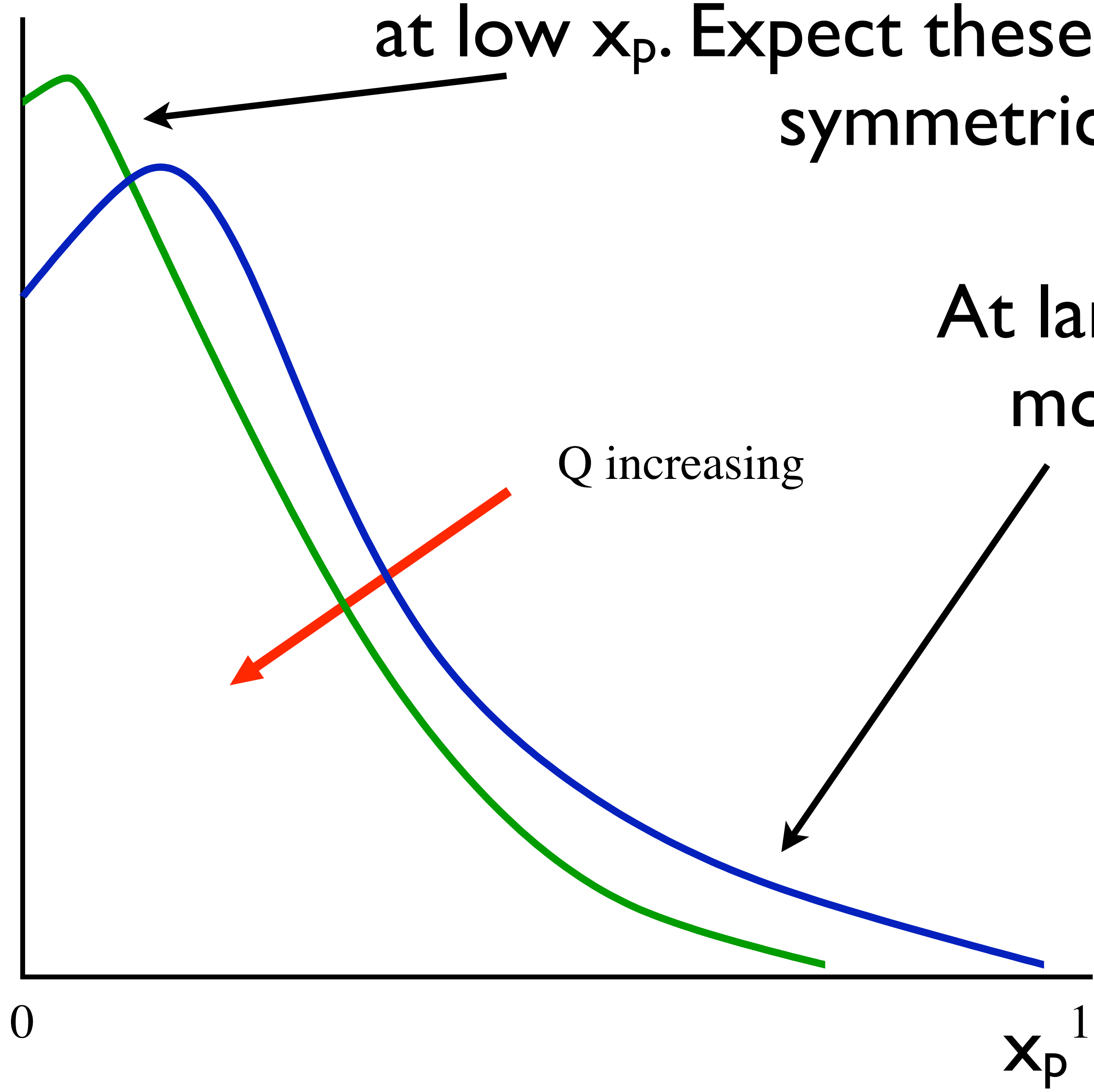


At higher Q^2 / large x_{bj} expect that the proton valence quarks will make significant contribution

Highest Q^2 bin has average x~ 0.1. valence quarks dominate u>d>>s, ubar, dbar, sbar

Expect that the $D(x_p)$ distribution good way of separating fragmentation effects (low x_p) from hard interaction (large x_p).

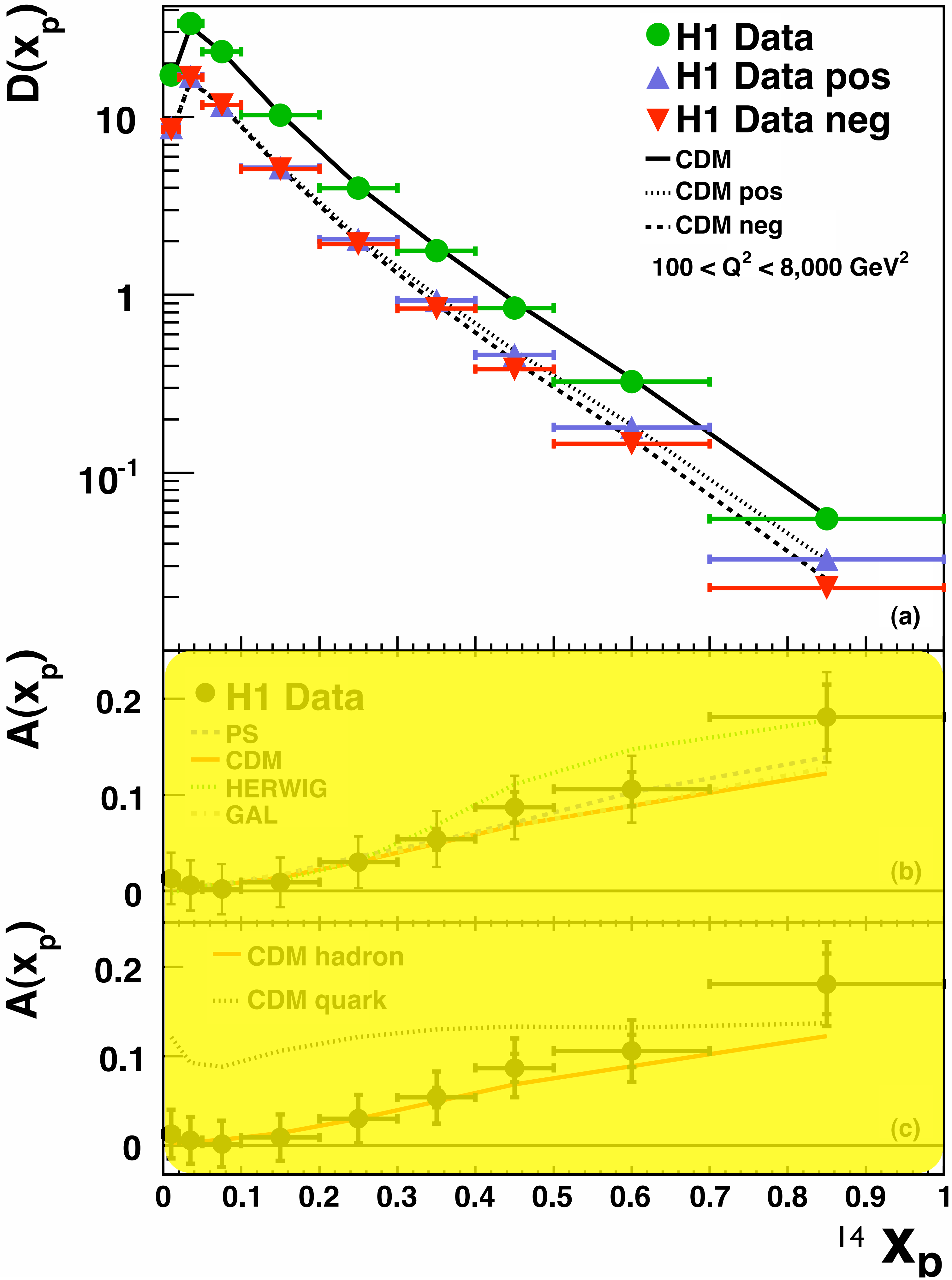
Hadrons from fragmentation are produced at low x_p. Expect these to be charge symmetric



At large x_p single hadron caries most of the momentum of scattered quark.

Possible that this hadron also carries other quantum numbers? (charge, strangeness, etc...)

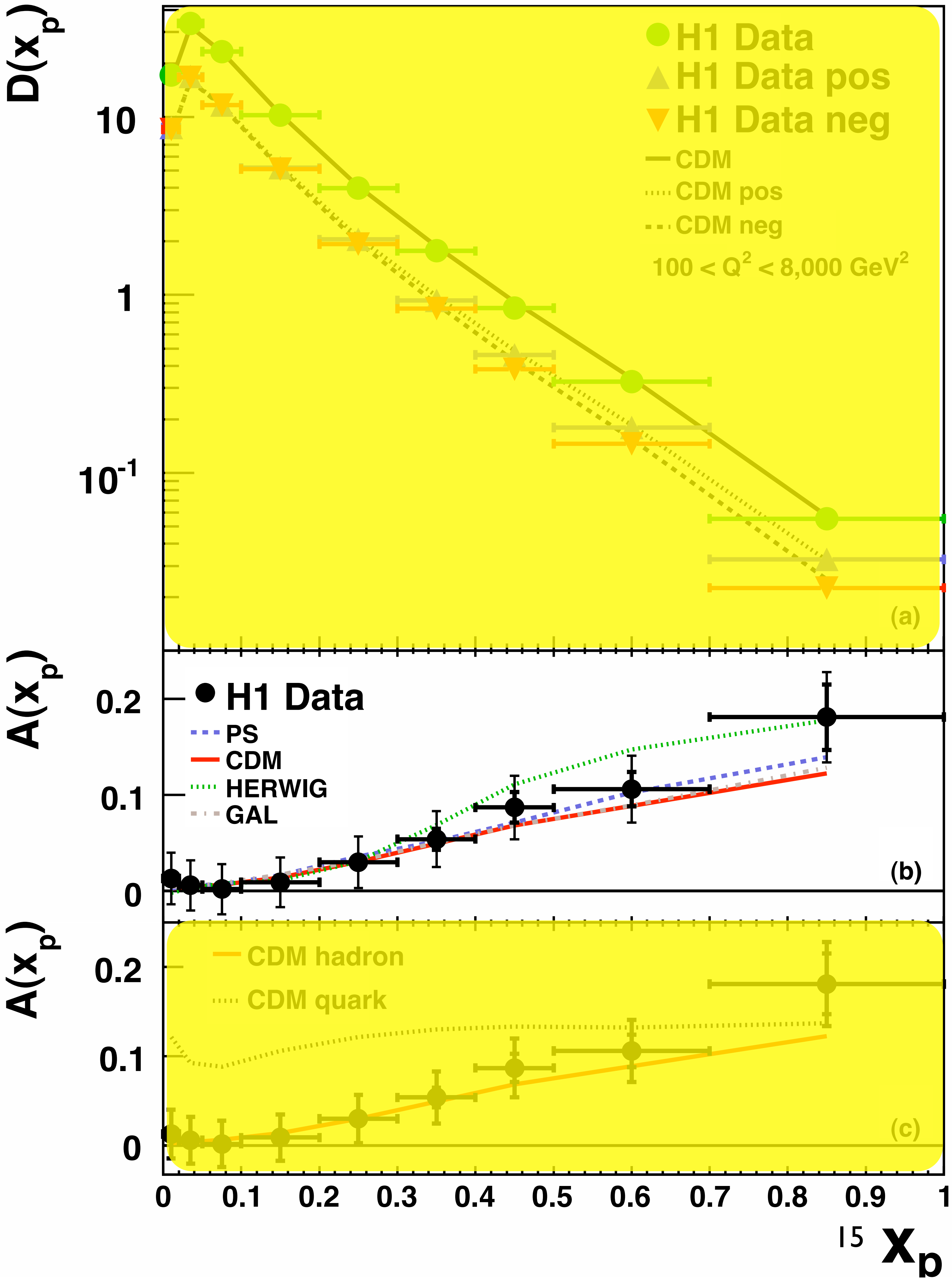
Charge Asymmetry Results



At low x_p similar distribution for positive and negative particles

At large x_p there is a clear difference between the pos and neg distributions

Difference described by Monte Carlo

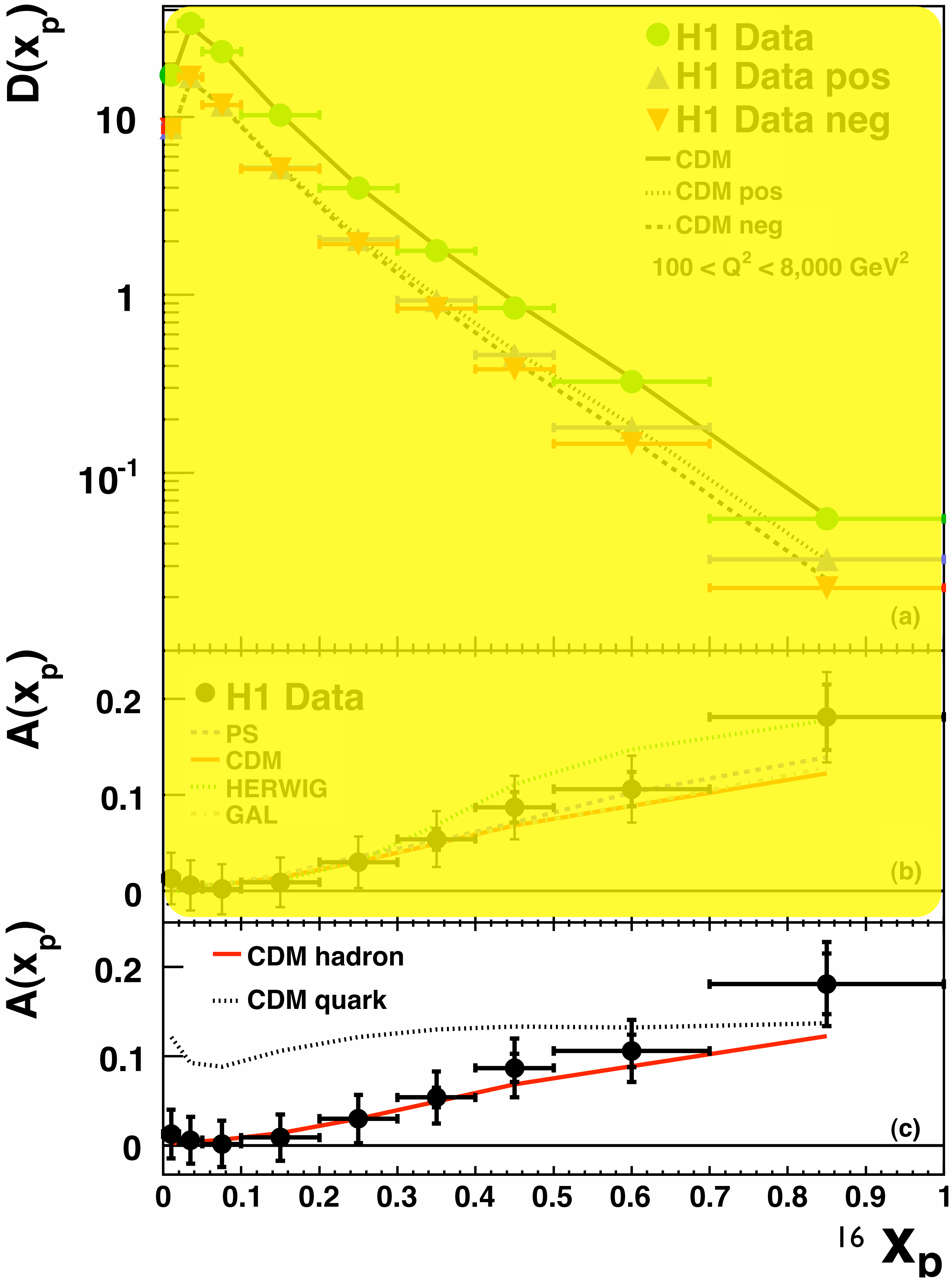


Asymmetry =

Compatible with zero at low x_p, reaches ~20% at high x_p

Magnitude and evolution described by various Monte Carlo models

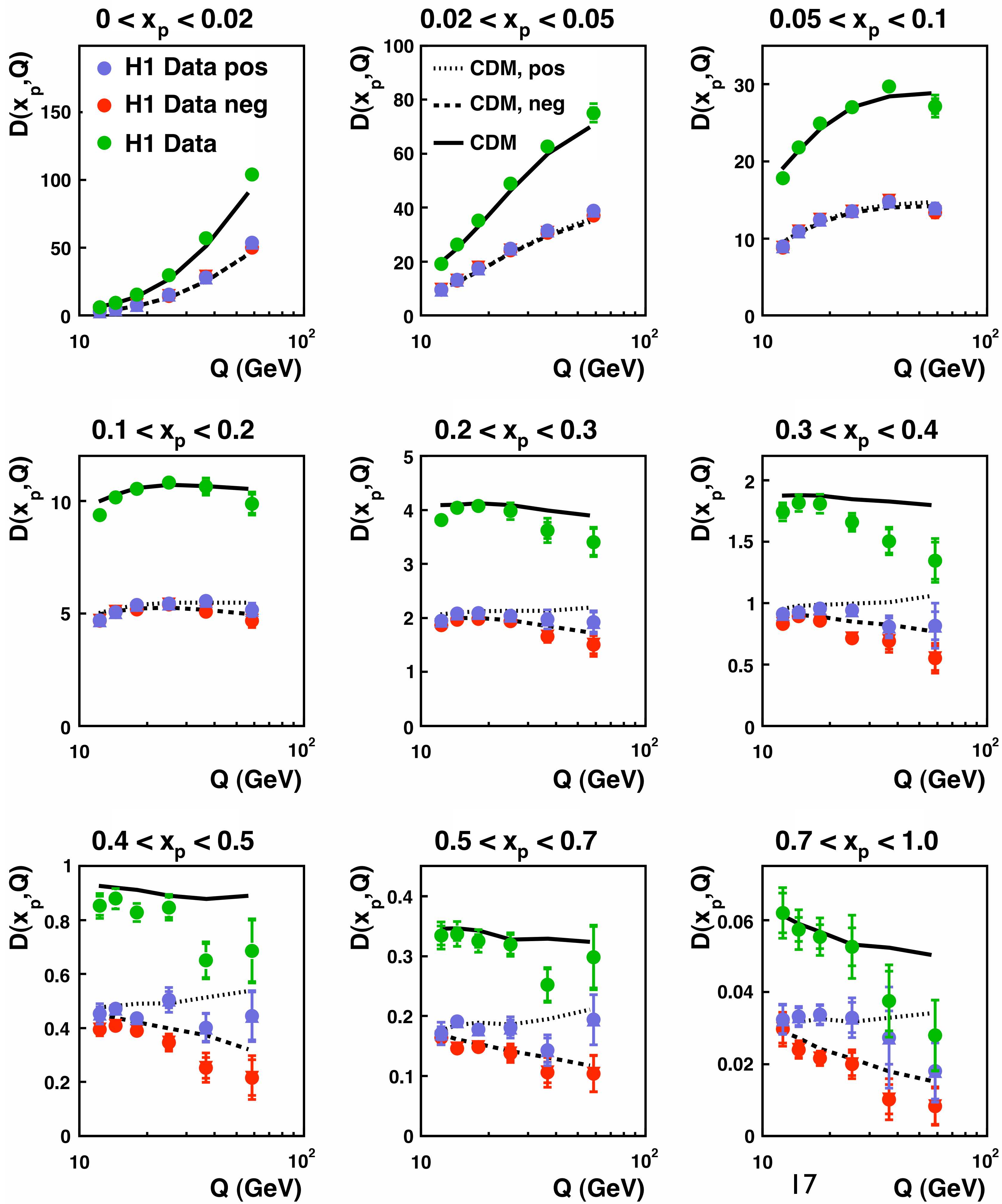
HERWIG has some differences at large x_p but still consistent with data



Quark level prediction obtained from CDM Monte Carlo with hadronisation turned off

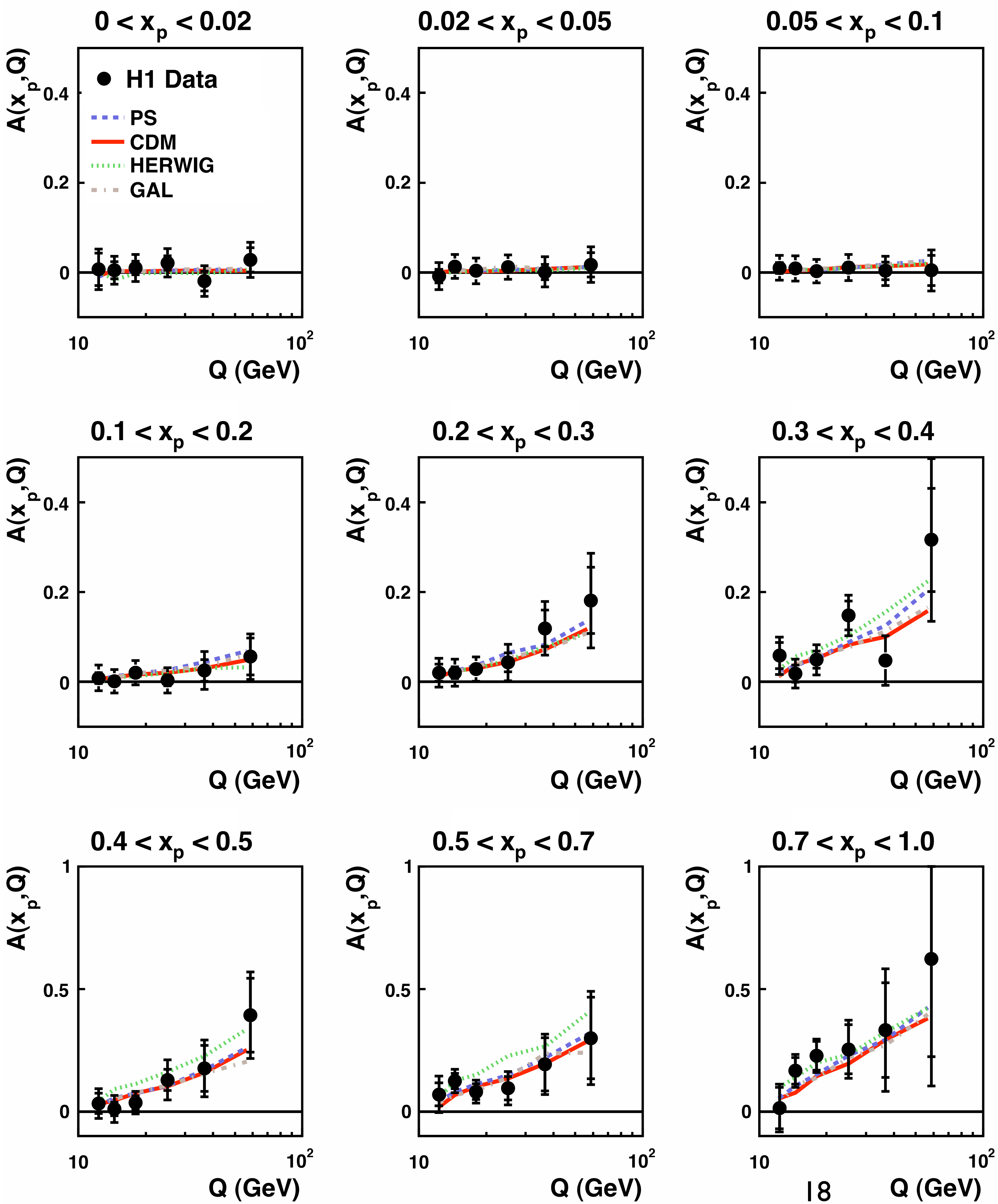
Similar asymmetry between data and CDM at large xp

Consistent with expectation that fragmentation dominates at low x_p, hard interaction at large x_p



At low Q^2 (low x_{BJ}) all x_P, pos and neg distribution similar

As Q^2 increases clear differences develop at high x_P, low x_P they remain consistent



At low Q^2 (low x_{BJ}) all x_p, asymmetry ~0

As Q^2 increases asymmetry develops at high x_p, low x_p it remains ~0

Monte Carlo models are able to describe the magnitude and evolution of the asymmetry

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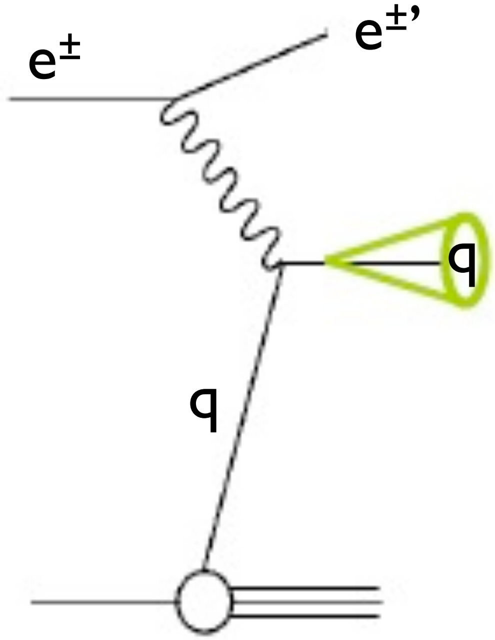
Conclusions

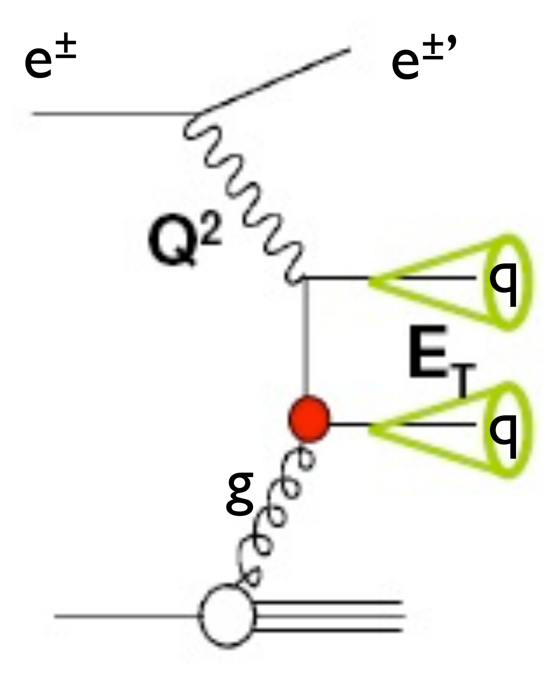
- First Observation of the charge asymmetry of the Hadronic final state in High Q^2 DIS.
- Method is general and can be applied to other environments (γP, PPbar,PP).
- Asymmetry dependent on x_p and gets larger with larger Q^2 (x_{BJ}). Results consistent with expectation from charge asymmetry of valence quarks.
- Provides useful data for extraction of fragmentation functions and valence quark distribution

Backup

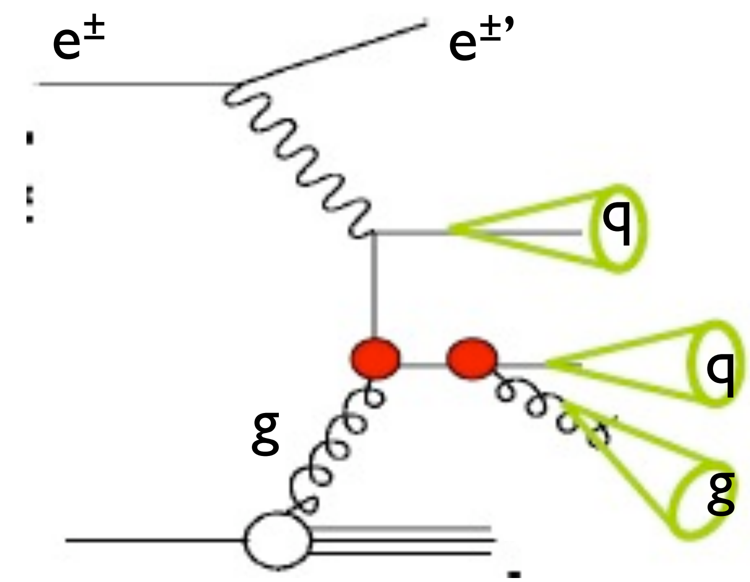
BORN



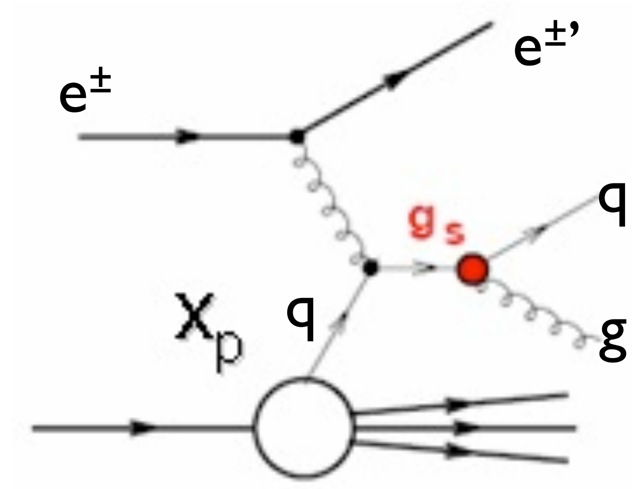
LO BGF

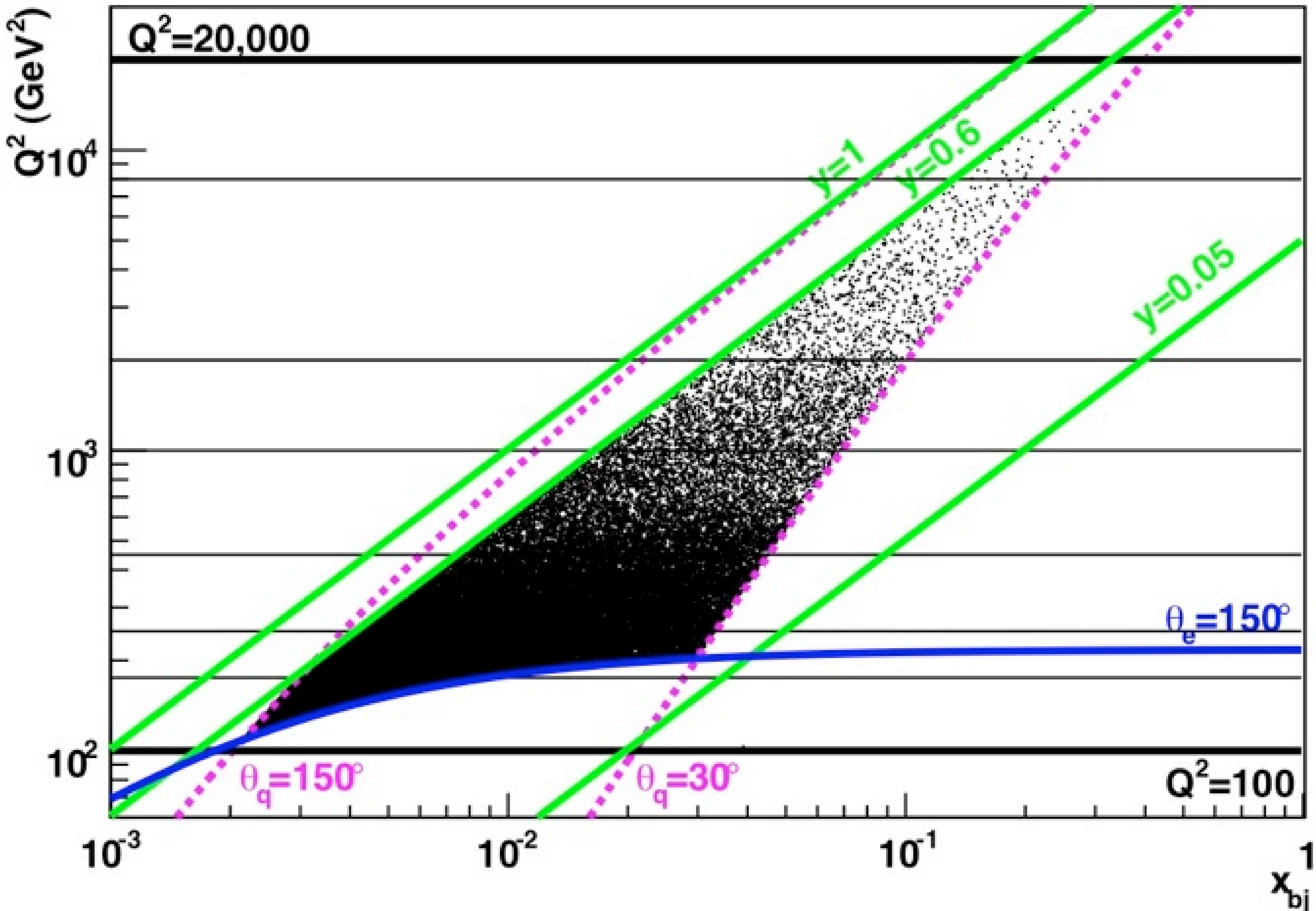


NLO



LO QCD Compton





Q^2 (GeV^2)
Q^2=20,000
10^4
10^3
10^2
y=1
y=0.6
y=0.05
θ_e=150°
θ_q=150°
θ_q=30°
Q^2=100
10^{-3}
10^{-2}
10^{-1}
1
x_{bj}

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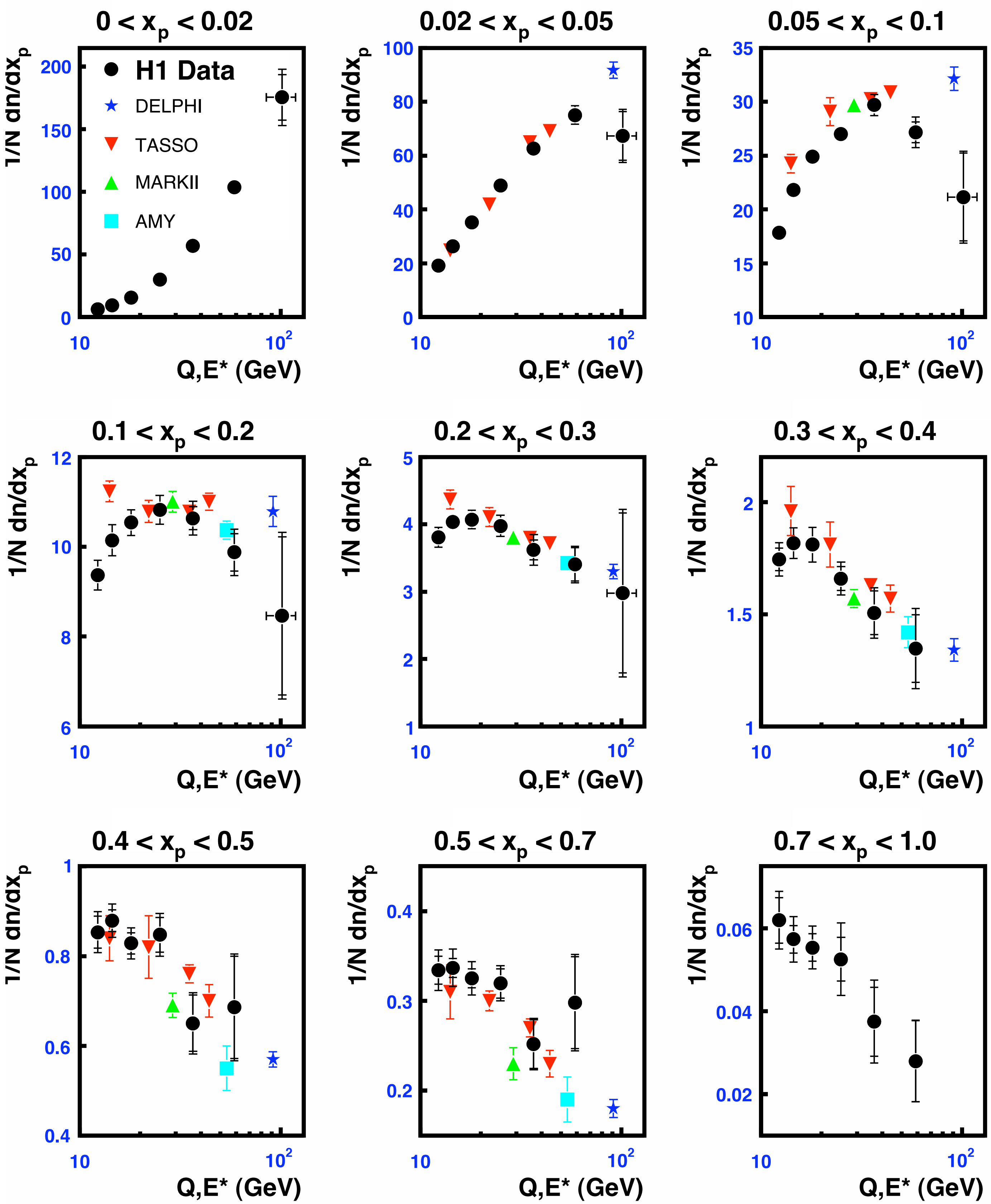
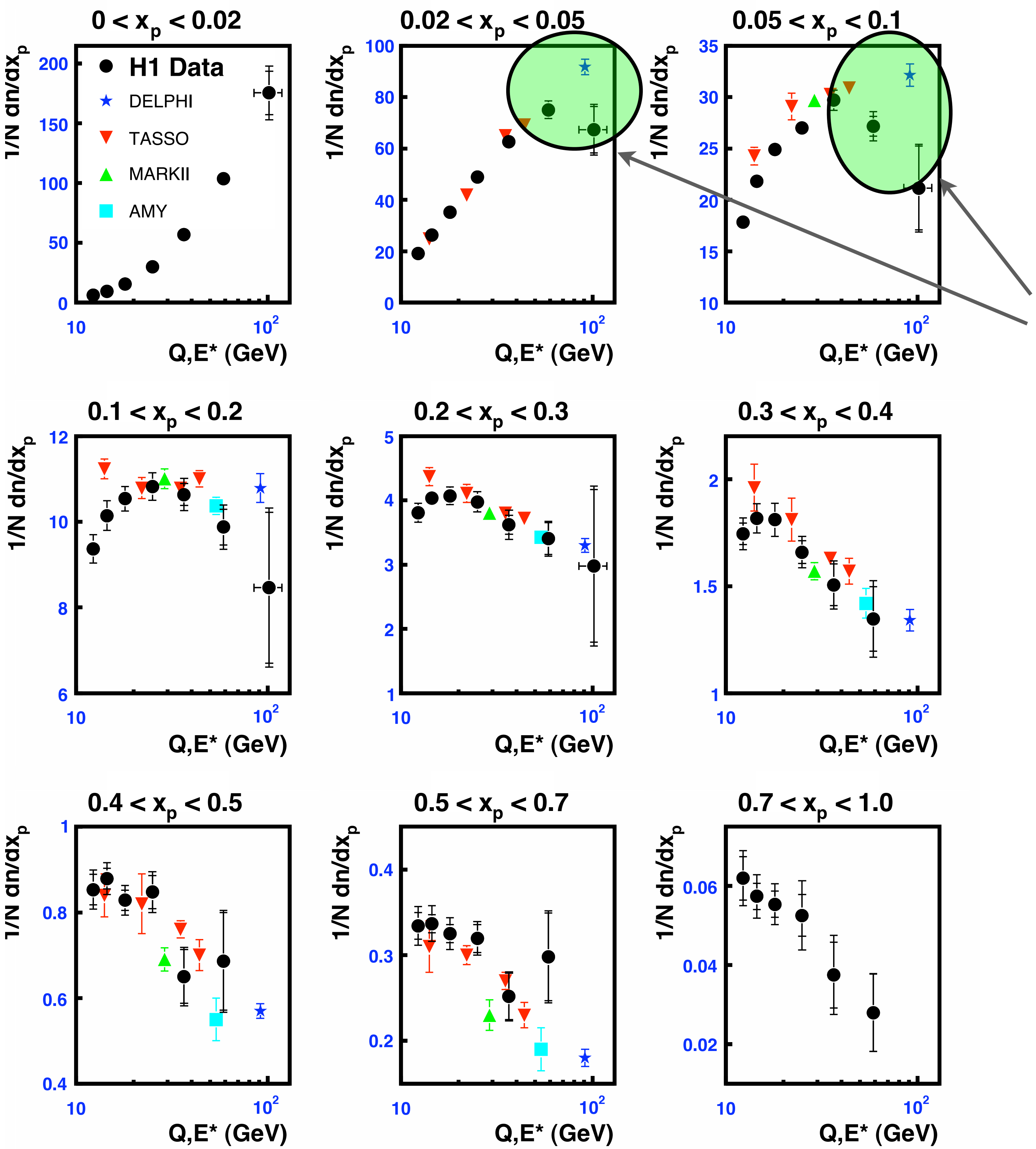


Pretty good agreement between ep and e^+e^- !

high Q^2 and small x_p reason unclear

low Q^2, mid x_p. expected to be due to BGF kinematics producing empty current region

NB: suppressed zeros



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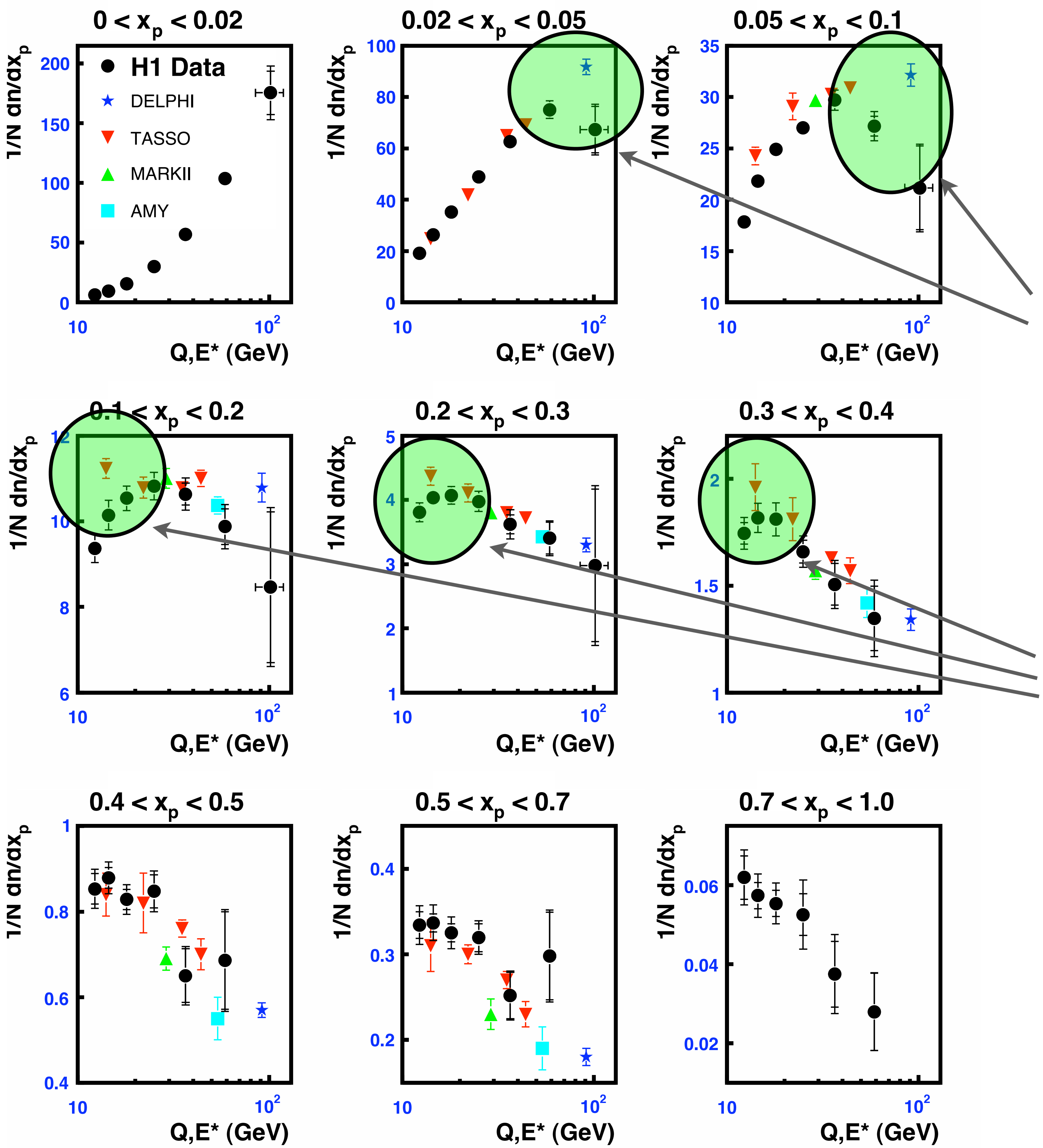

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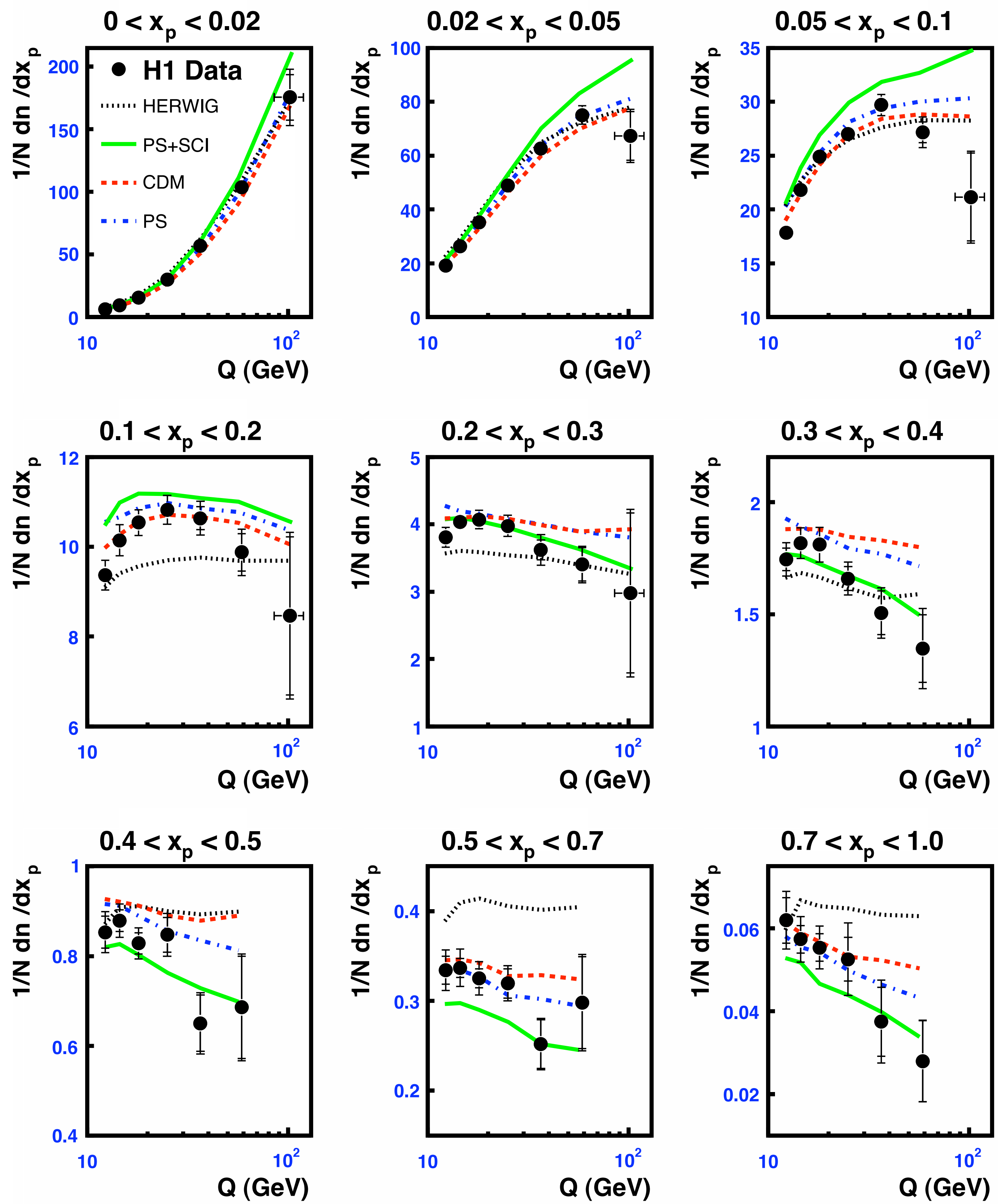
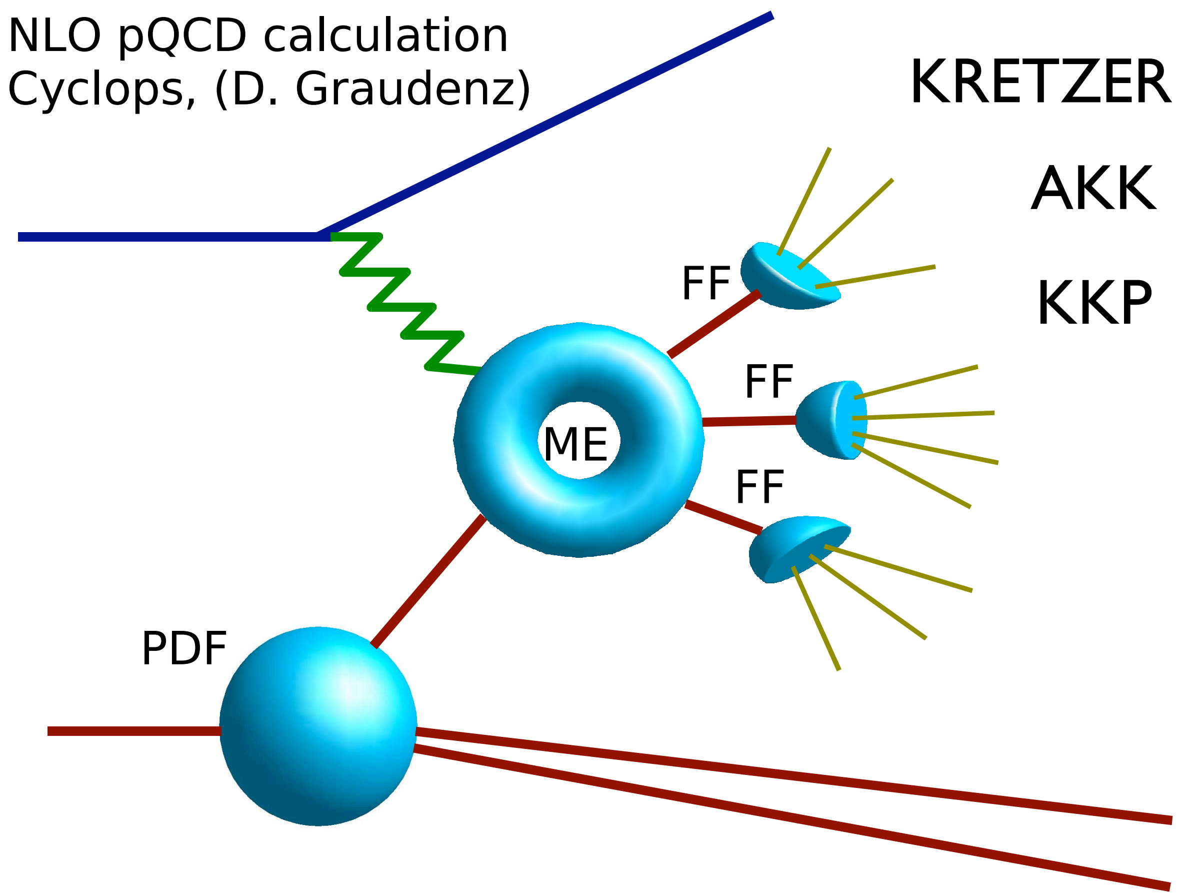


CDM and PS acceptable description of data.
both tend to overestimate the multiplicity at high Q^2

SCI model predicts too soft a spectrum

HERWIG is too hard and fails to reproduce scaling violations seen in the data



KRETZER

AKK

KKP

NLO pQCD CYCLOPS

Fragmentation Functions - e^+e^- fits

Infra red safe region (Q2>100), xp > 0.1

FF parameterised from xp>0.1

CTEQ6M, Λ(5)QCD = 226 MeV (also ME + FF)

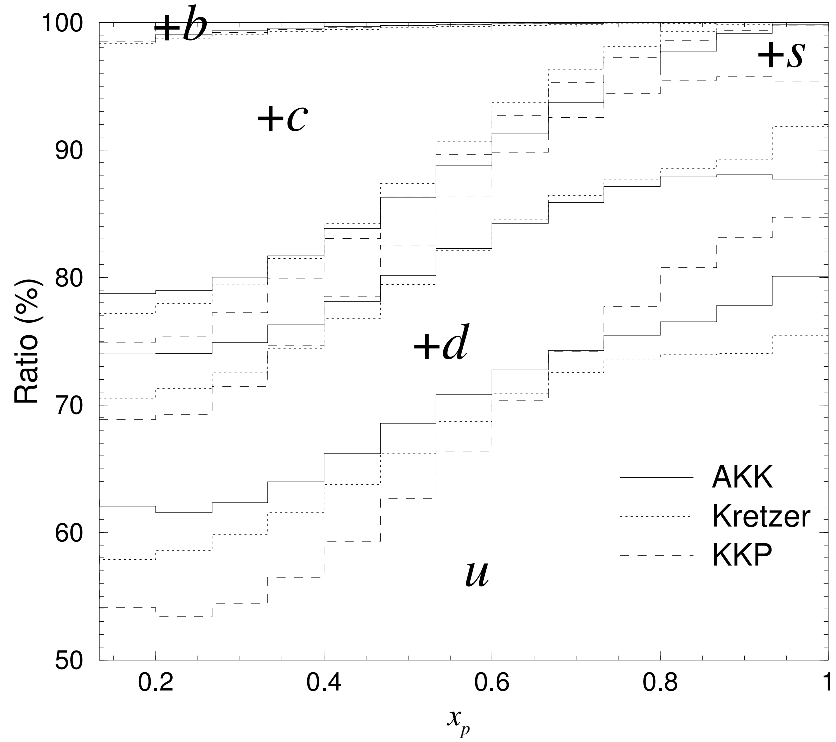
σ_h = PDF $\otimes$ M.E. $\otimes$ FF

Quark tagging (H1)

Identify quark flavour at e.w. vertex

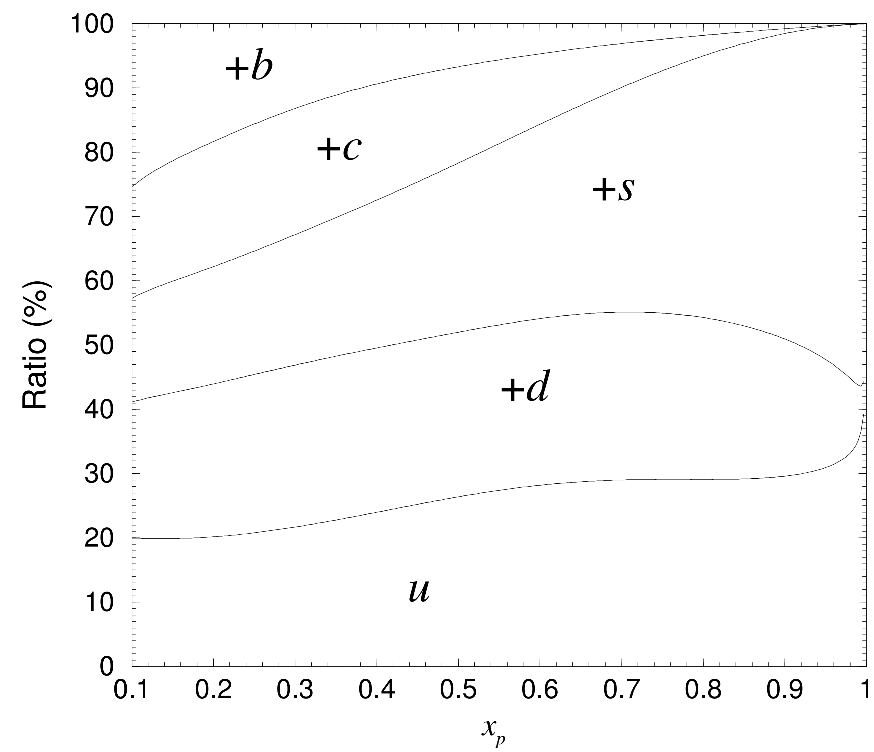
$ep \to h + X$

100 GeV^2 < Q^2 < 8000 GeV^2



$e^+e^- \to h + X$

$\sqrt{s} = 91$ GeV



Proton is good source of u

s relatively large

In principle, ep and e^+e^- together can separate uds FFs