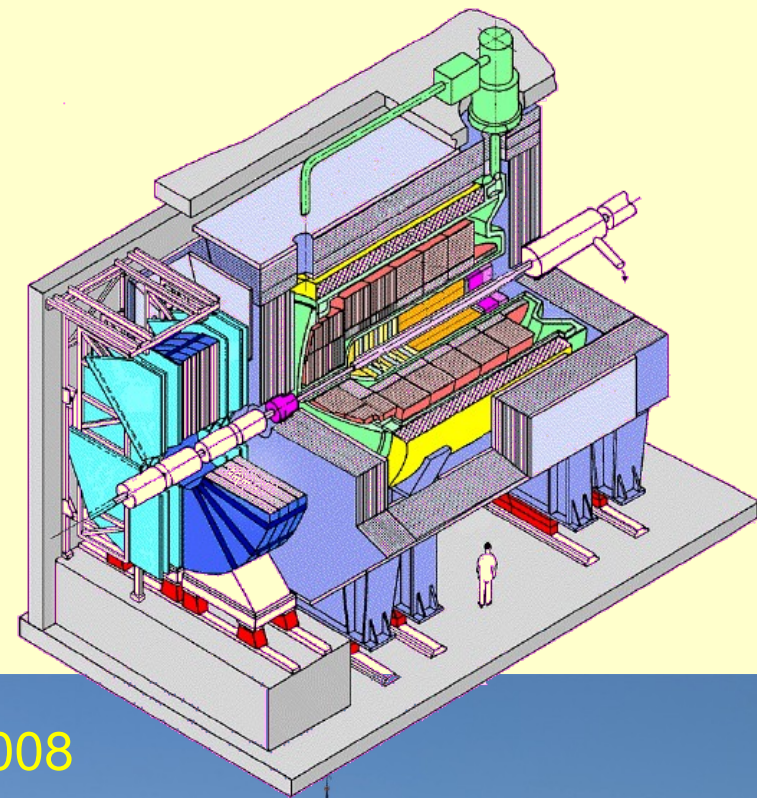




H1 Results

A. Schöning

University Zürich
Switzerland



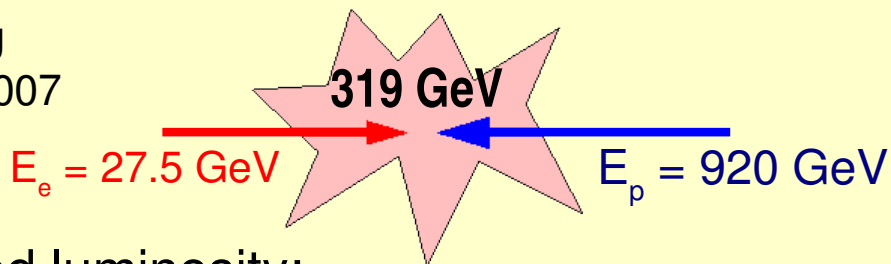
DIS Workshop, April 7, 2008



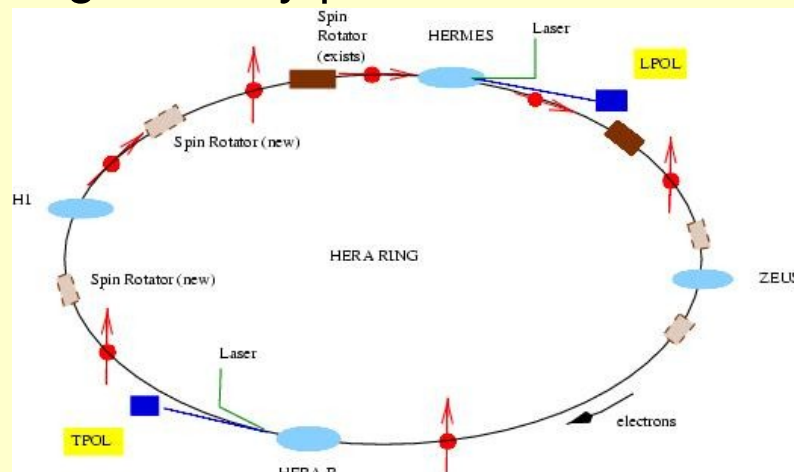


HERA Harvest

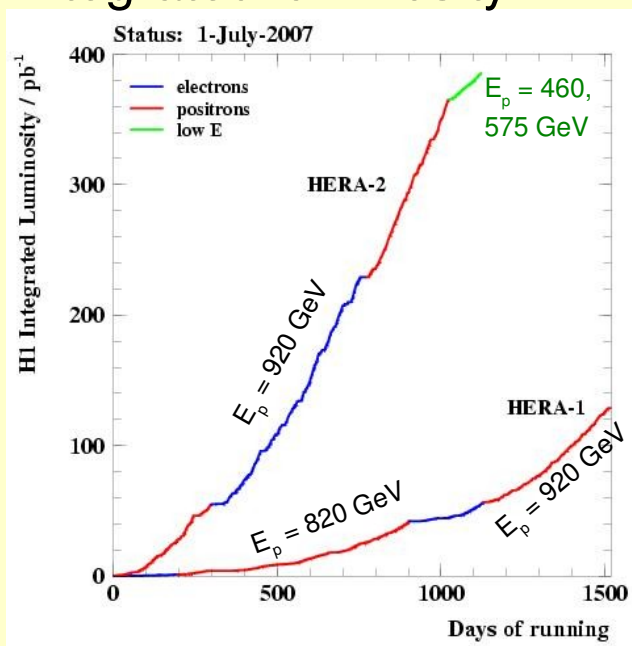
data taking
until mid 2007



longitudinally polarised e^\pm beams:



integrated luminosity:



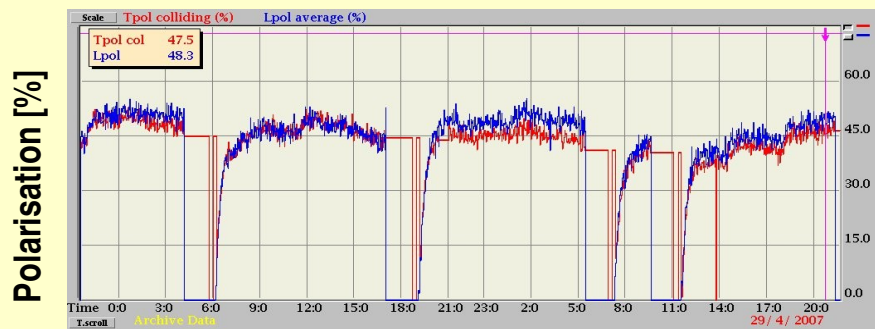
low energy: $\sim 20 \text{ pb}^{-1}$

high energy:

$184 \text{ pb}^{-1} e^-p$

$294 \text{ pb}^{-1} e^+p$

$488 \text{ pb}^{-1} \text{ total}$



polarisation of more than 45%

We thank the HERA machine people for delivering a vast amount of beautiful data on ep collisions



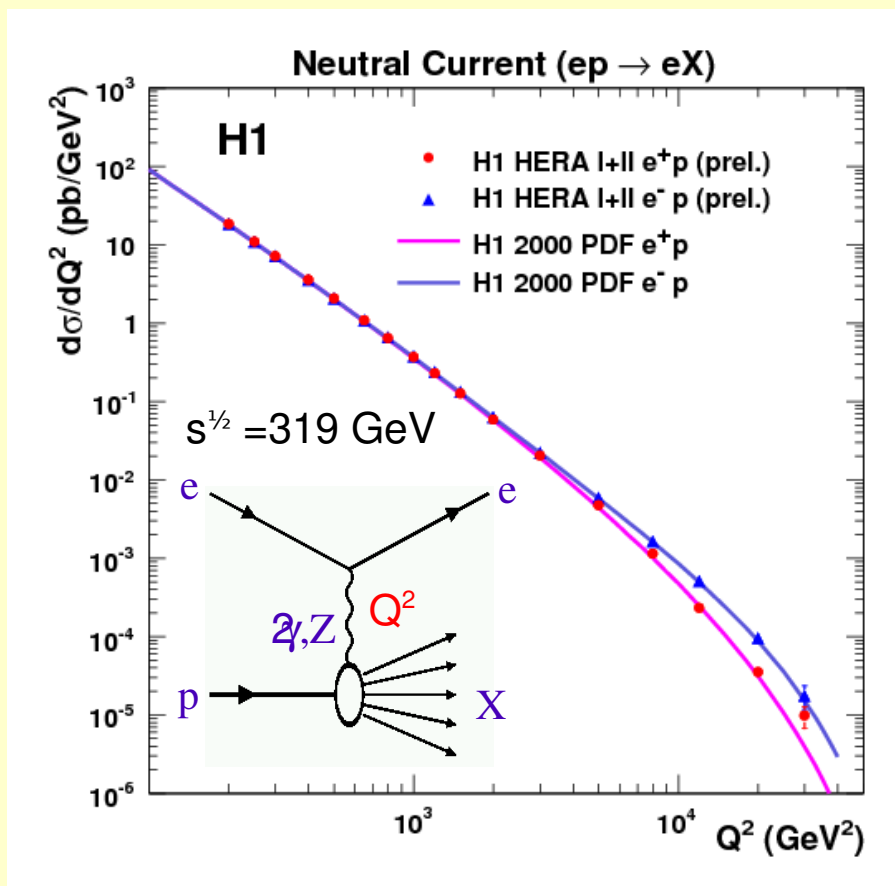
HERA Program/Outline

- Searches + Electroweak Physics
 - ⇒ HERA testing physics beyond the SM with ($2 \times 0.5 \text{ fb}^{-1}$)
- Proton Structure
 - ⇒ HERA the microscope
- Exclusive Processes:
 - Perturbative QCD
 - Soft QCD and Diffraction
 - Heavy Quarks
 - ⇒ HERA probing QCD at small x and high Q^2
- Conclusion

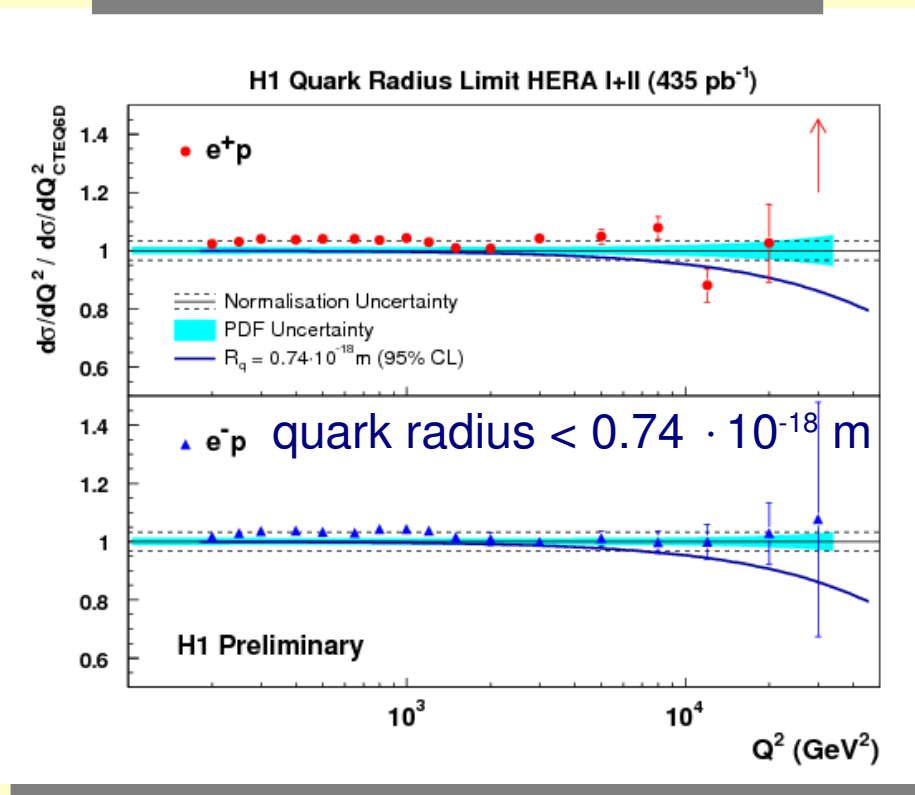
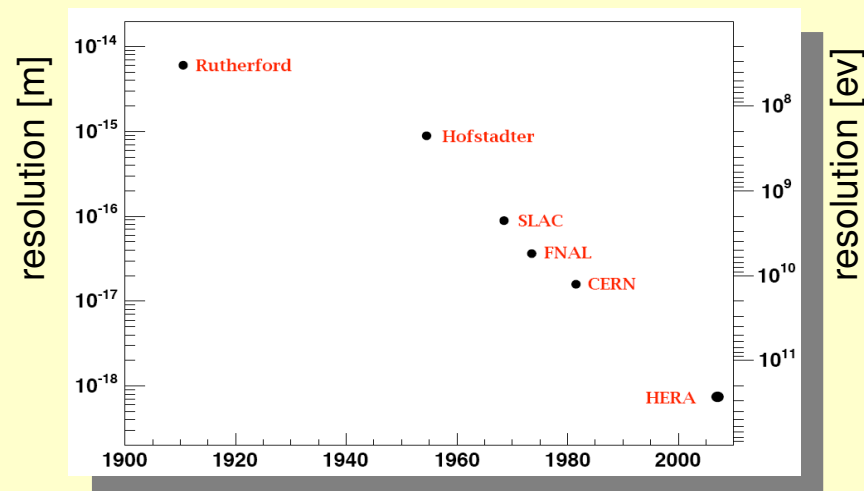


Neutral Currents @ high Q^2

full HERA statistics:

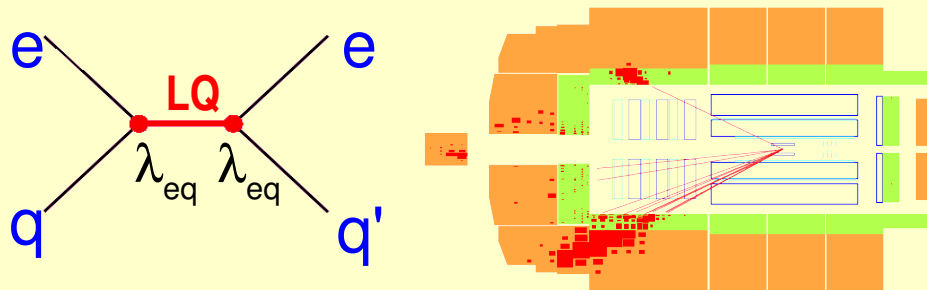


- high precision data
- γ -Z interference at high Q^2

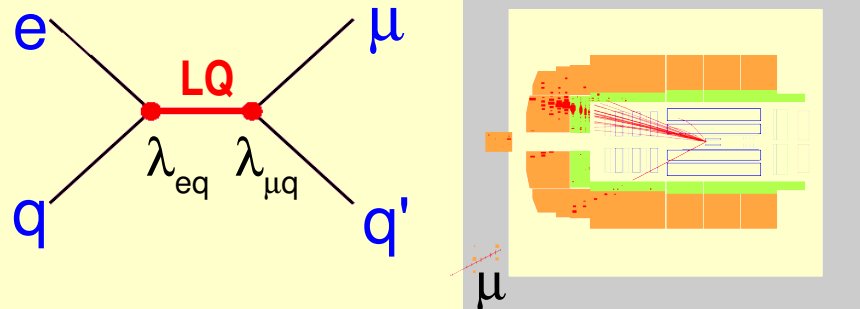




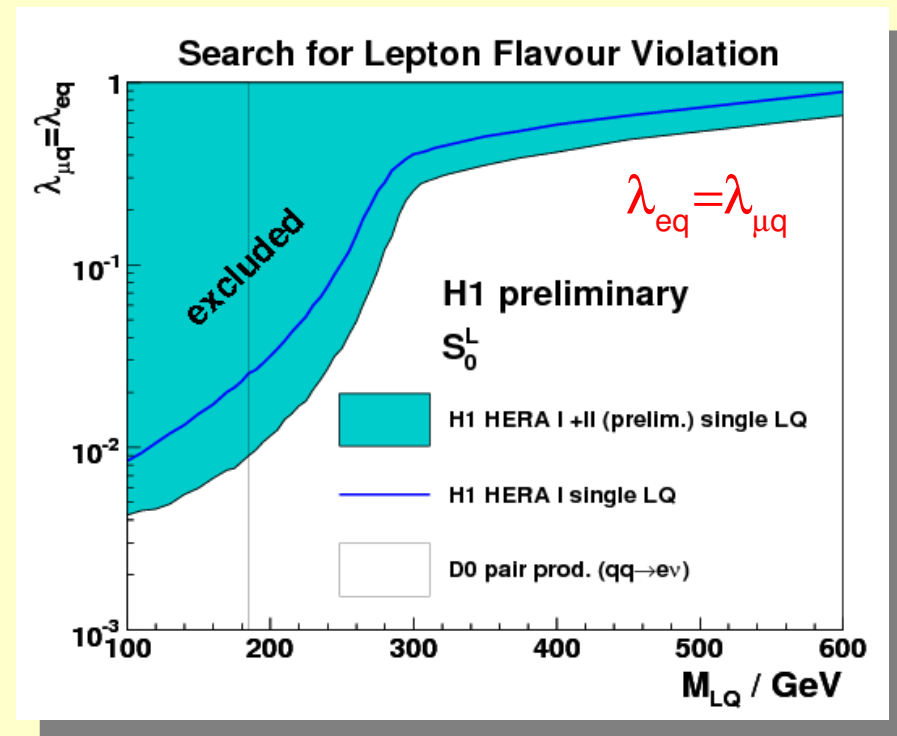
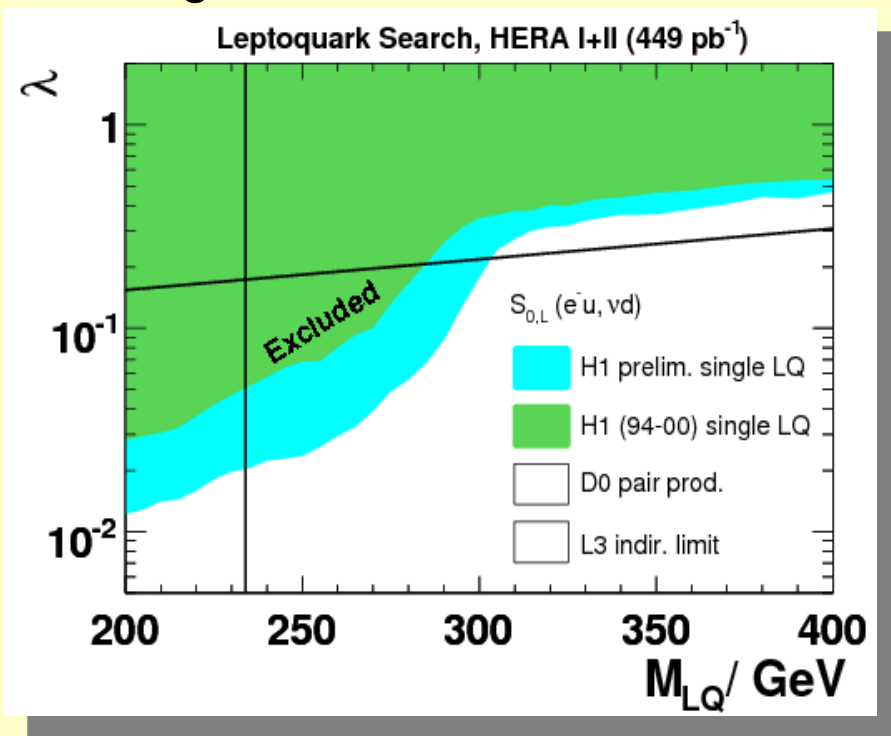
Search for Leptoquarks and LFV



first generation LQ search



LQ coupling to 1st and 2nd generation



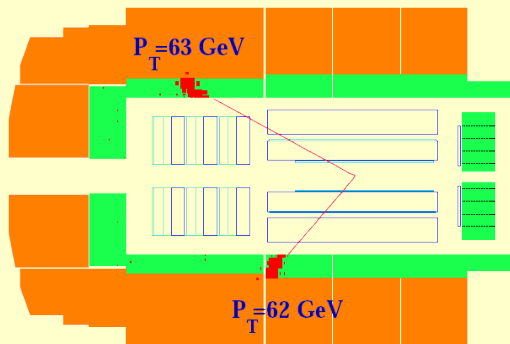
unique sensitivity to high mass LQs!



Multi-Lepton Final State



- Search for multi-electrons:
(Eur Phys J C31 (2003) 17)



possible signature for:

$$H^{++} \rightarrow e^+ e^+$$

High P_T results H1/ZEUS:

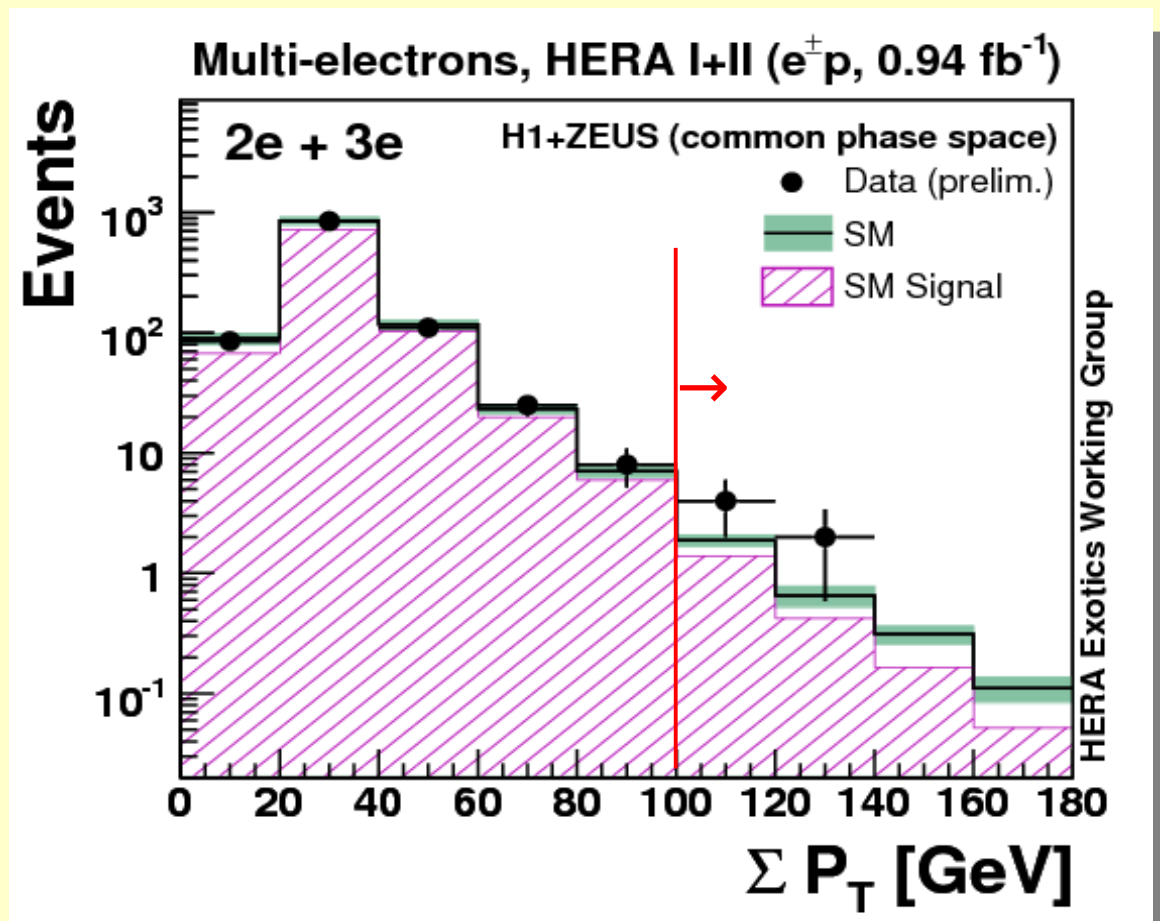
2e :	5	(3.41 ± 0.37)
3e :	4	(1.89 ± 0.24)

- Other Multi-Lepton channels investigated by H1:

$\mu\mu$, $e\mu\mu$, $e\mu$

⇒ to be combined with ZEUS

H1/ZEUS combined result



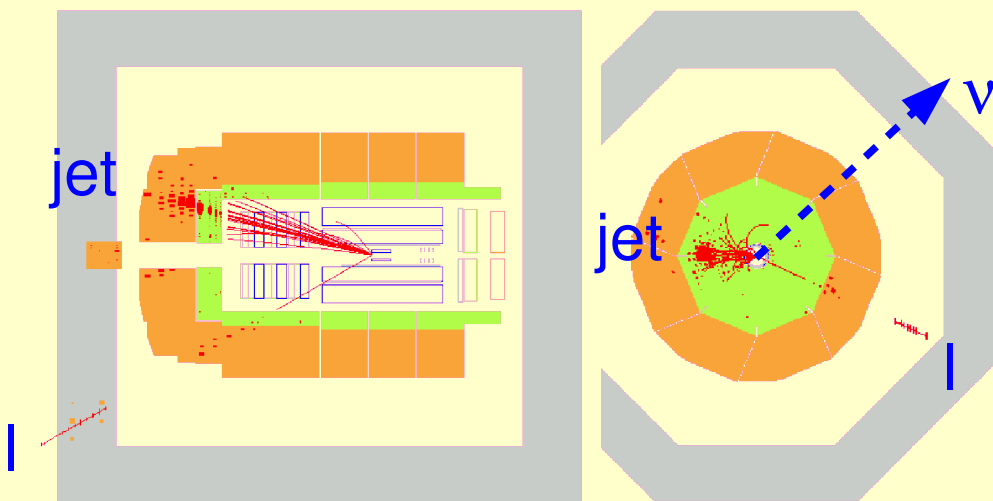
→ data consistent with SM prediction



Isolated Leptons and p_T^{miss}

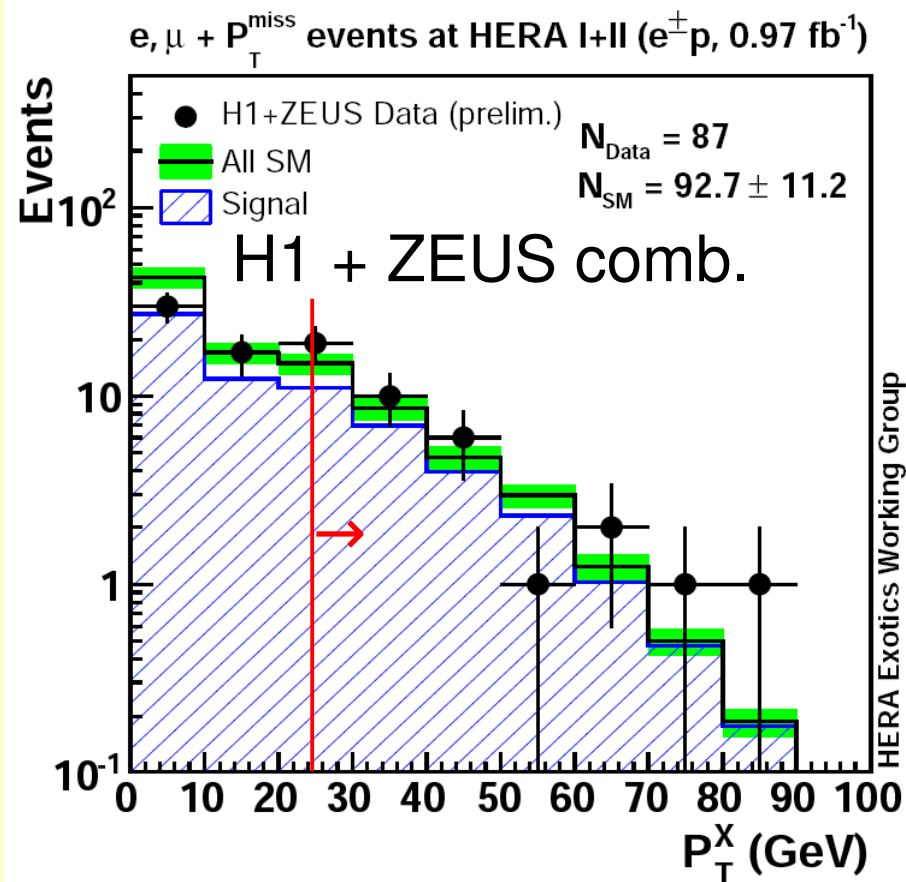


- topology: (H1 Collab., Phys. Lett. B561 (2003) 241)



signature for single W prod.

$$ep \rightarrow eX W \rightarrow l\nu$$



Results for $p_T^X > 25 \text{ GeV}$ (H1/ZEUS $e^\pm p$):

electron	muon	electron + muon
16 (13.3 ± 1.7)	13 (12.0 ± 0.24)	29 (25.3 ± 3.2)

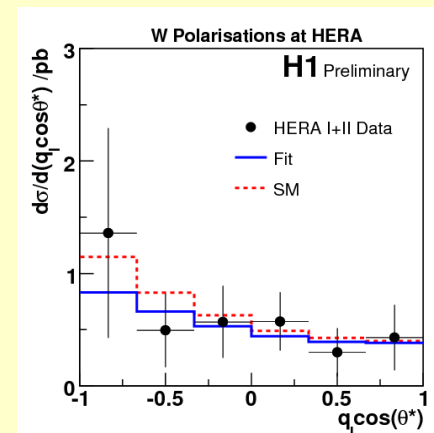
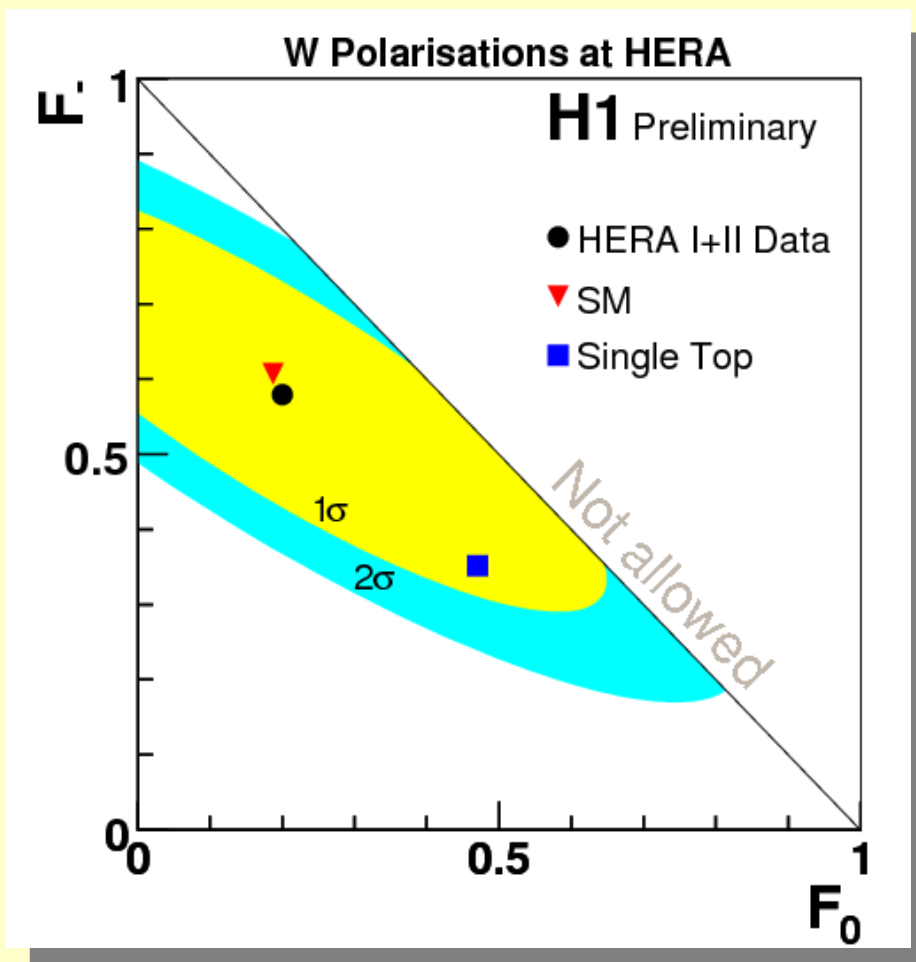
→ H1/ZEUS combined data consistent with SM prediction



W-Production and Polarisation

Determination of the W polarisation:

$$\frac{dN}{d\cos\theta^*} \propto F_+ \cdot (1 + \cos\theta^*)^2 + F_0 \cdot 2(1 + \cos\theta^{*2}) + F_- \cdot (1 - \cos\theta^*)^2$$



fit W decay angle

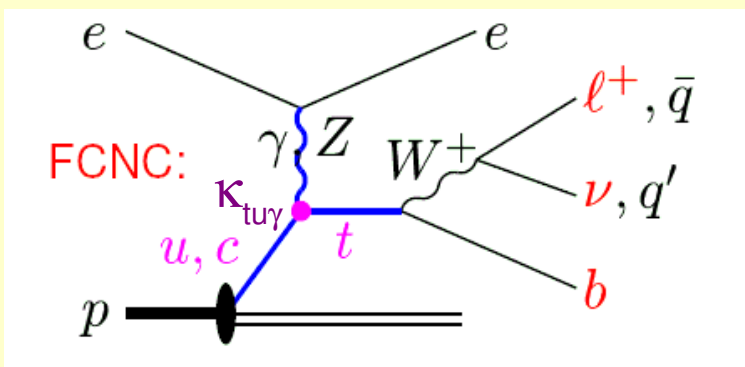
→ H1 data consistent with SM prediction



Anomalous Single Top Production

SM cross section negligible at HERA

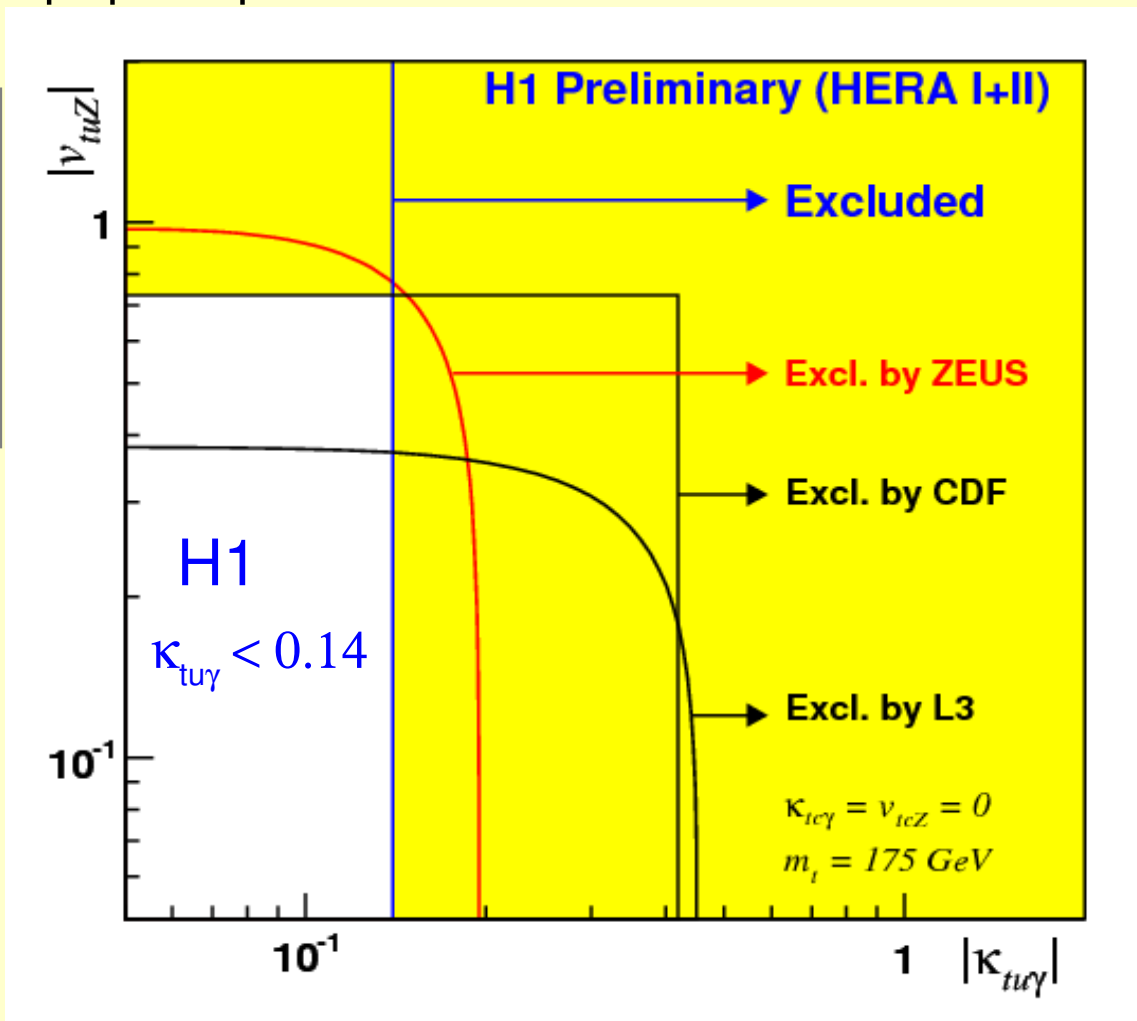
→ high sensitivity to anomalous top quark production



final states:

- 3-jet
- lepton + jet + p_T^{miss}

HERA most sensitive
on coupling κ_{tuy}





Proton Structure

- New Neutral Current Cross Sections from H1/ZEUS combination
 - ⇒ highest statistical precision
- Measurement of the longitudinal structure function F_L :
 - ⇒ first direct measurement at low x

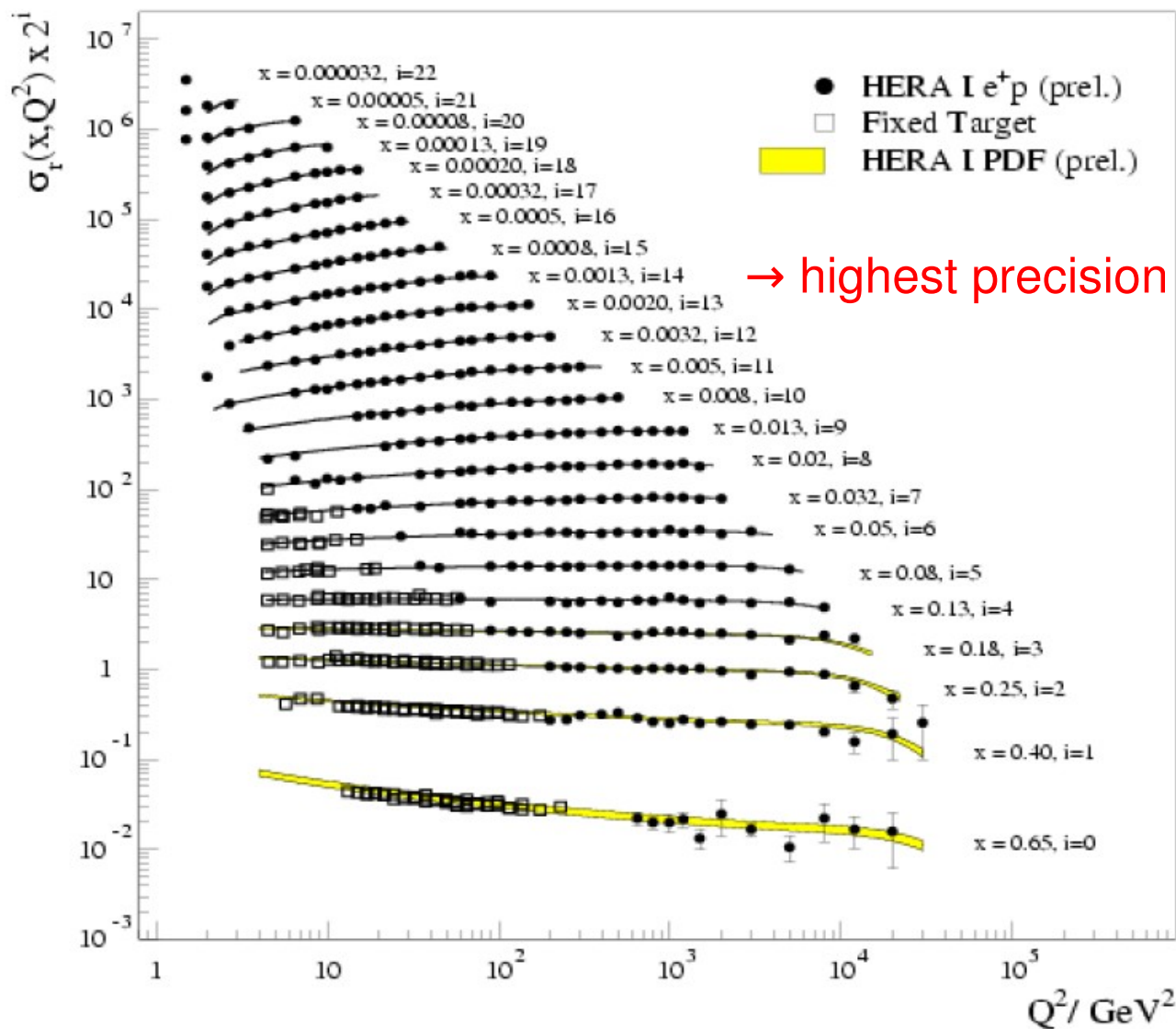


Proton Structure



Combination of H1/ZEUS HERA I cross sections (NC):

H1 and ZEUS Combined PDF Fit



April 2008

HERA Structure Functions Working Group

→ statistical and also systematic errors largely reduced

also new preliminary HERA I PDF fit

see next talk by
→ H. Abramovicz



Measurement of F_L

NC cross section:

$$\sigma_r = F_2(x, Q^2) - \frac{y^2}{1+(1-y)^2} F_L(x, Q^2)$$

$$F_2 \sim \sigma_T + \sigma_L$$

$$F_L \sim \sigma_L$$

(F_L term contributes only at high y !)

QCD:
$$F_L = \frac{\alpha_s}{4\pi} x^2 \int_x^1 \frac{dz}{z^3} \left[\frac{16}{3} F_2 + 8 \sum_q w_q^2 \left(1 - \frac{x}{z}\right) z g(z) \right]$$

- indirect method:

- F_2 extrapolation method (Phys.Lett.B393:452,1997)

- direct method:

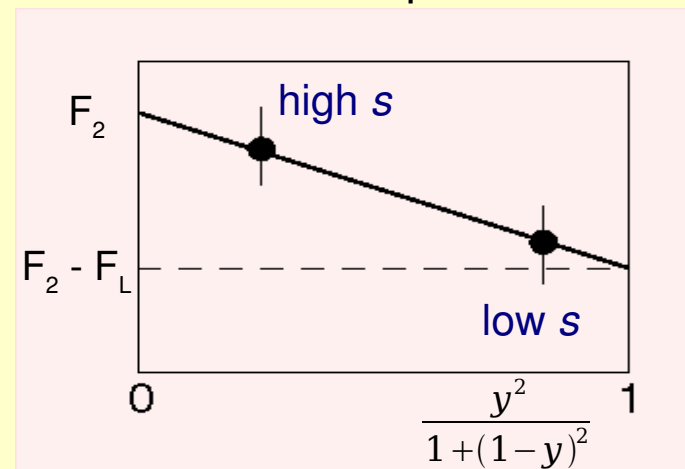
- measure σ_r for same (Q^2, x) at different y :

$$s = \frac{Q^2}{xy} \quad \rightarrow \text{measure at different beam energies}$$

$$E_p = 920 \text{ GeV} \quad \rightarrow \text{lower } y$$

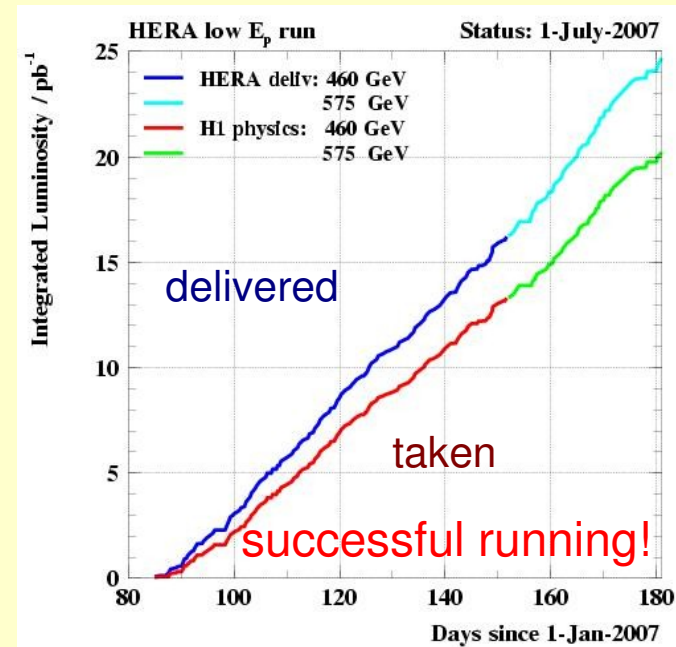
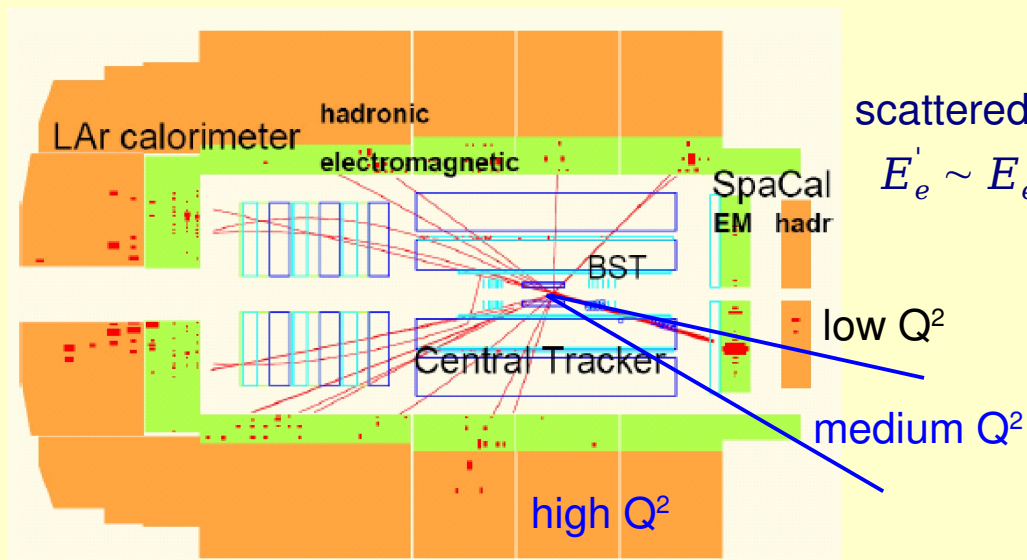
$$E_p = 460 \text{ GeV} \quad \rightarrow \text{high } y \text{ (high BG!)}$$

Rosenbluth plot:

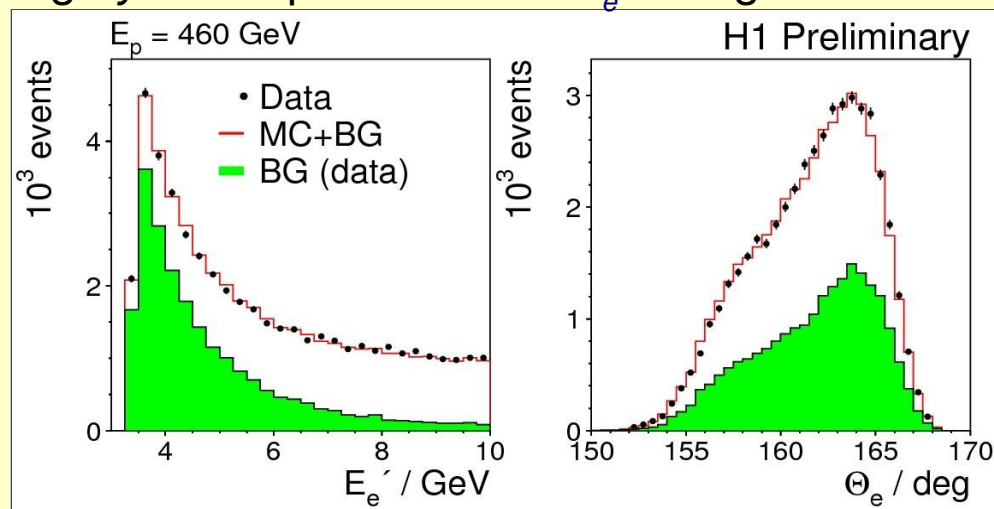




Data from Low Energy Run



high y corresponds to low E_e' \rightarrow high BG!



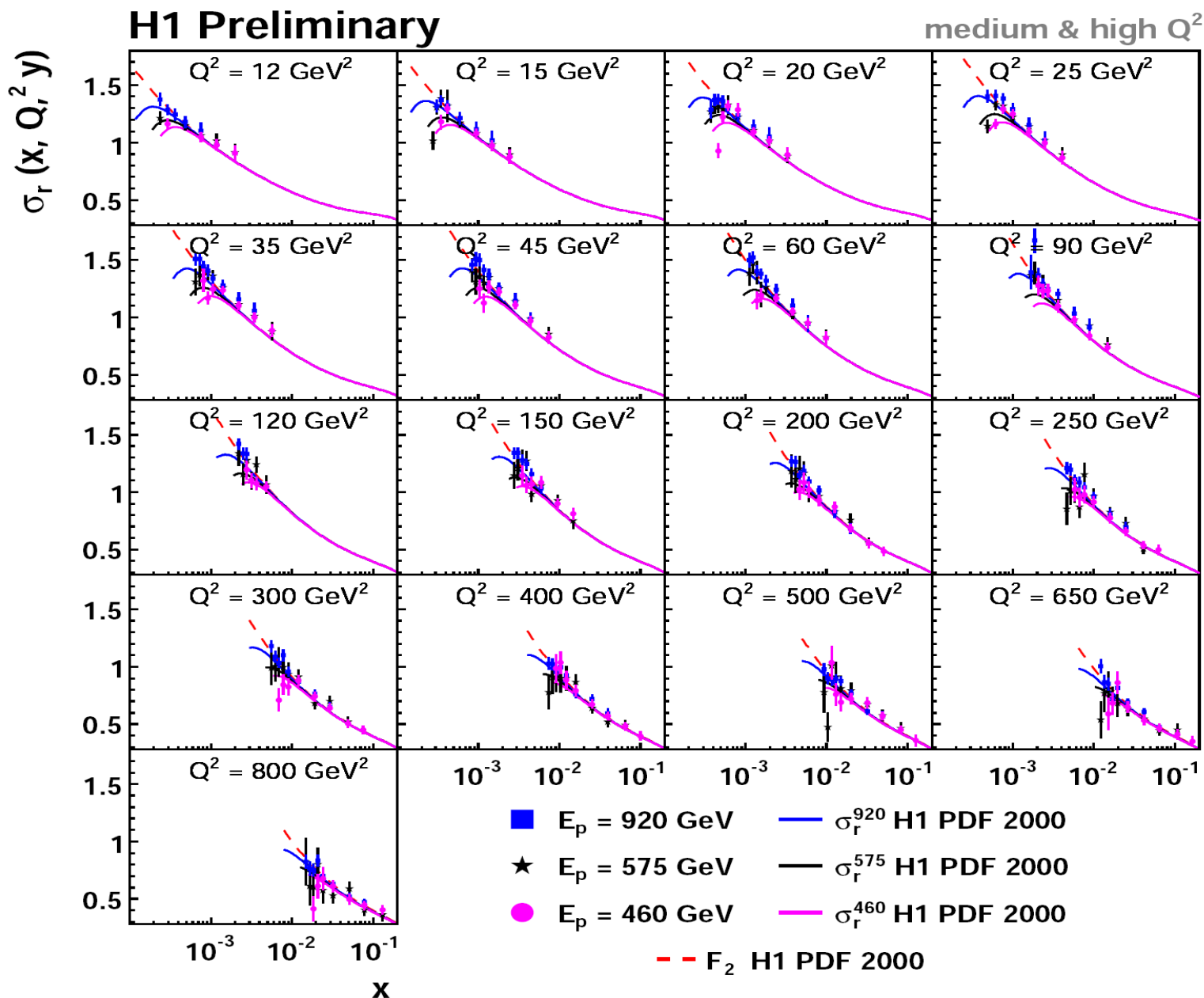
H1 data 2007 e^+p	
Lumi	E_p
21.9 pb^{-1}	920 GeV
6.2 pb^{-1}	575 GeV
12.4 pb^{-1}	460 GeV

background controlled by wrong charge tracks



Cross Sections for F_L

$y \sim 1/x$



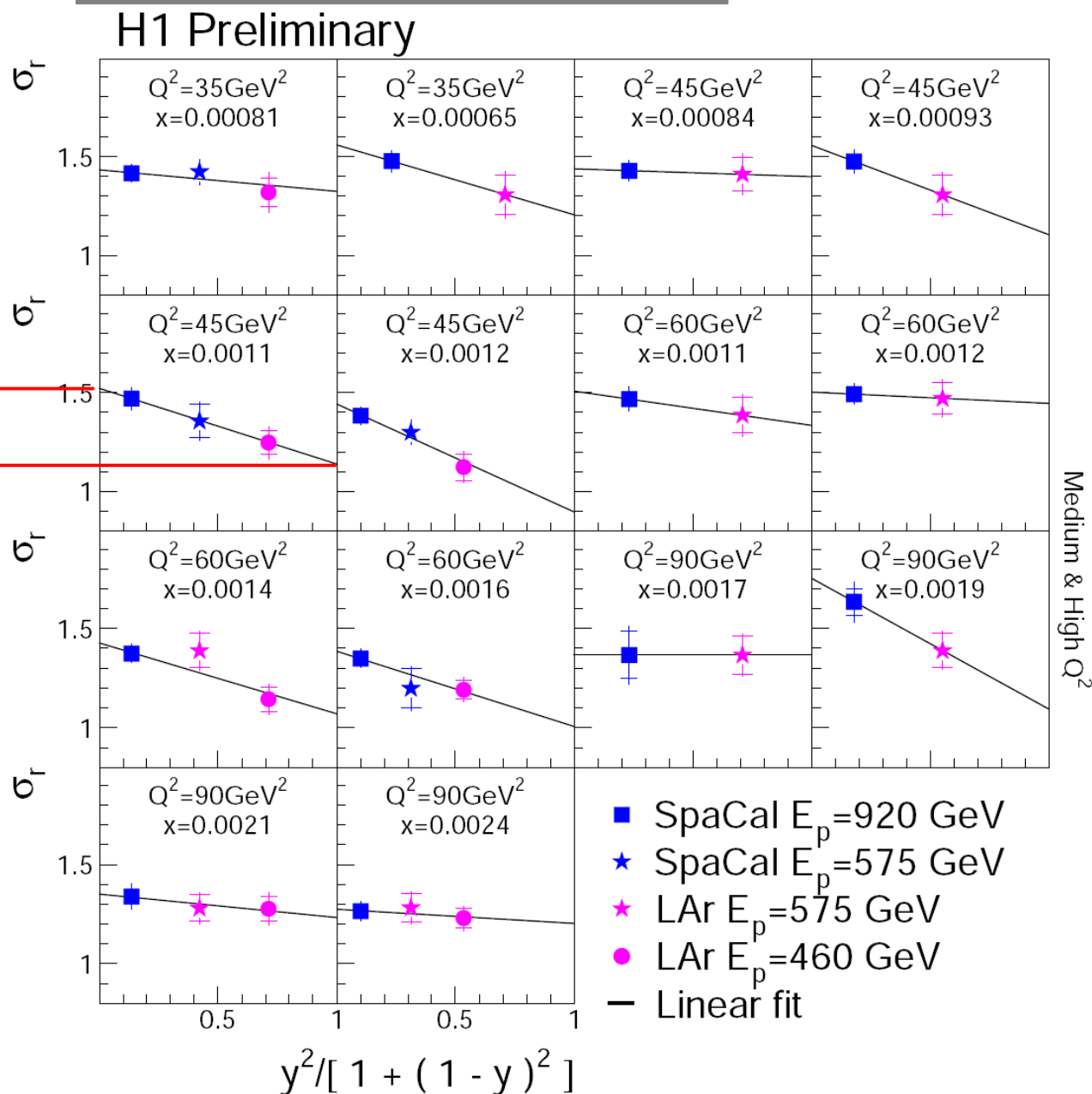


Rosenbluth Plot

Rosenbluth Plot for
Q² range:

35 < Q² < 90 GeV²

F_2
 $F_2 - F_L$

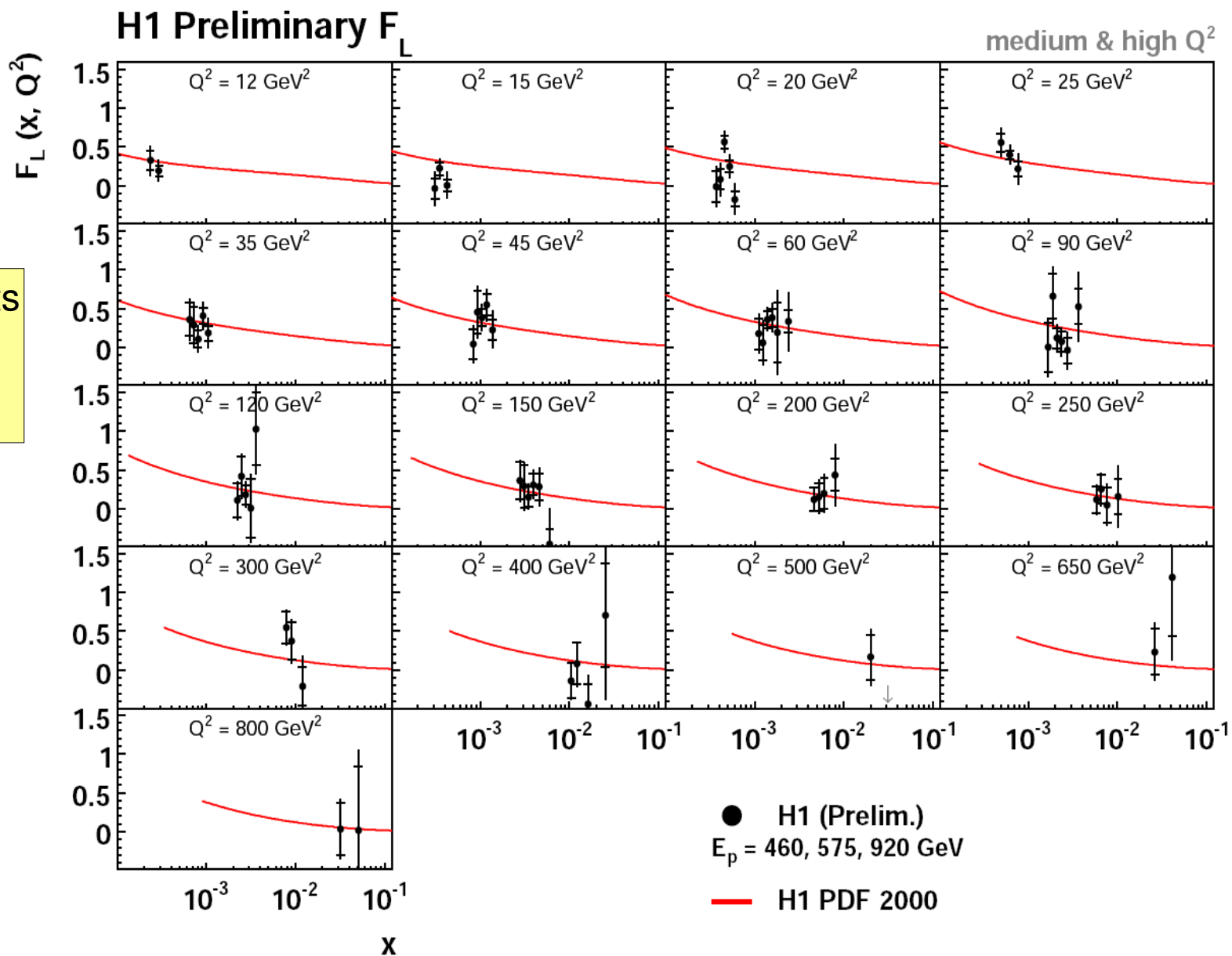




Direct Measurement of F_L

66 measurements
bins for:

$Q^2 > 10 \text{ GeV}^2$

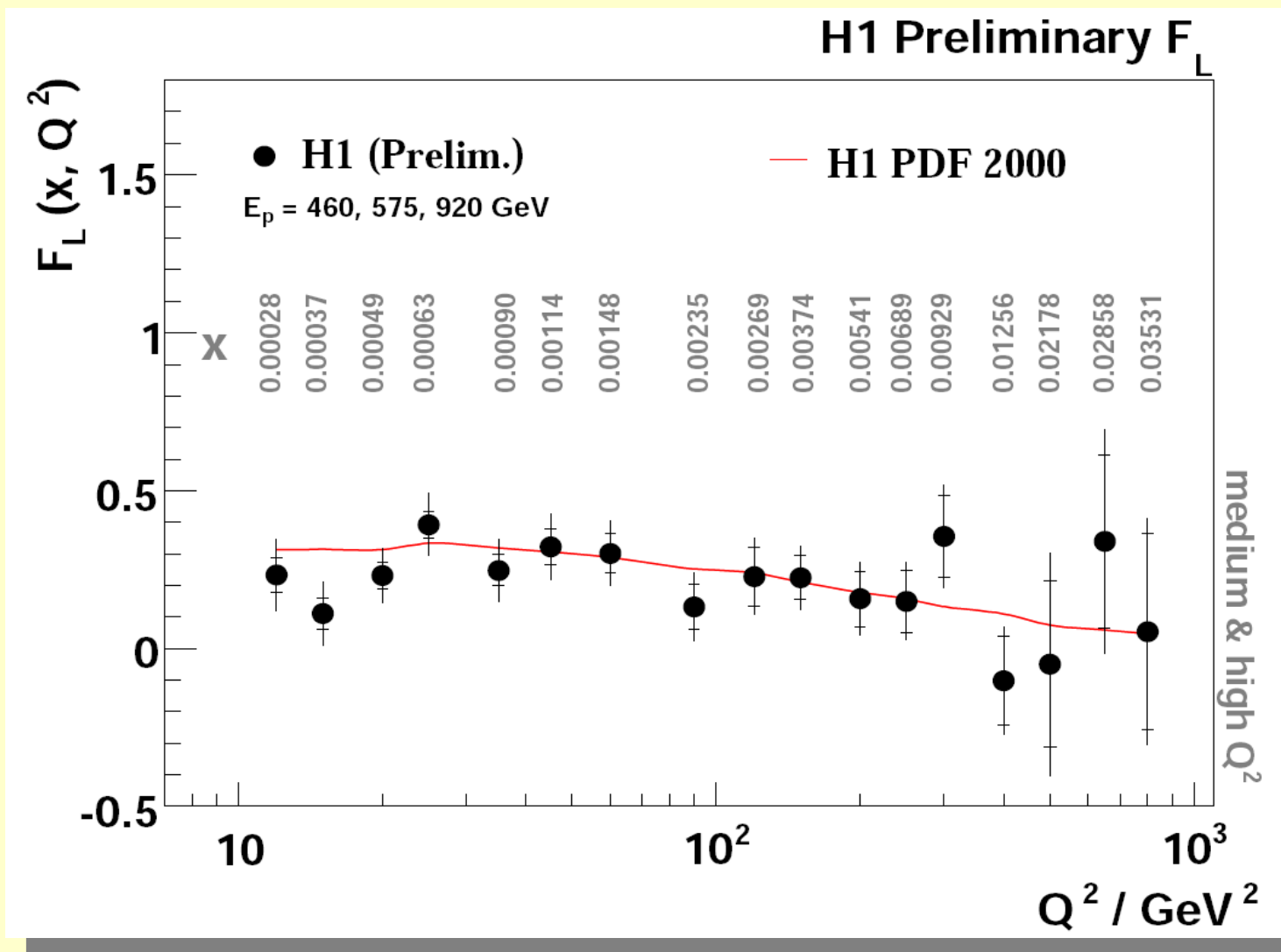




Direct Measurement of F_L

x-averaged F_L as function of Q^2 :

(first F_L results released at Moriond 2008)

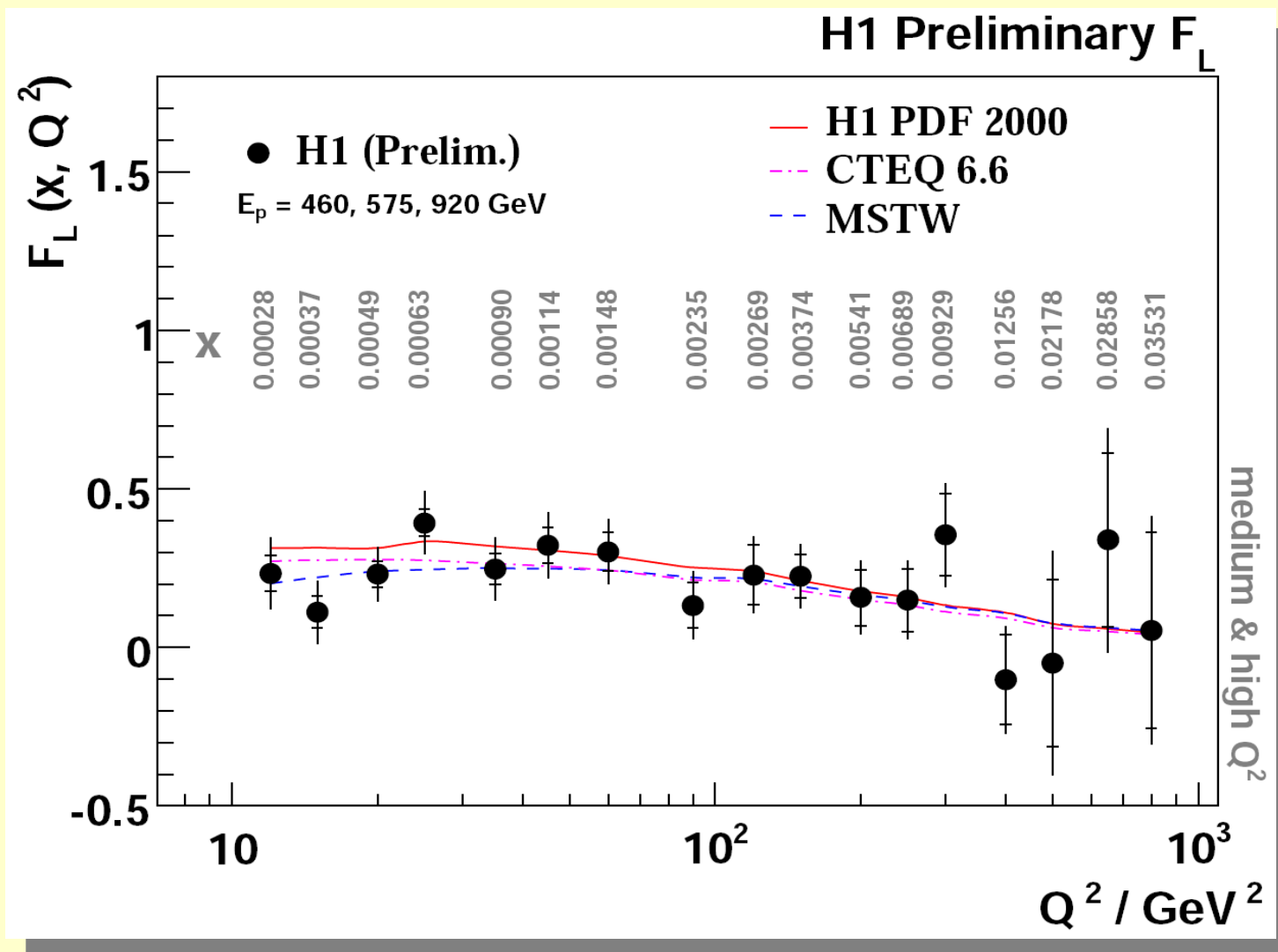




Direct Measurement of F_L

x-averaged F_L as function of Q^2 :

(first F_L results release at Moriond 2008)



→ consistent with QCD prediction

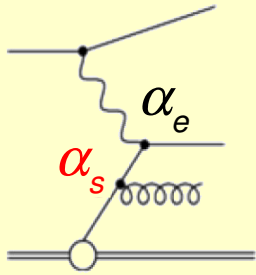


Exclusive Final States

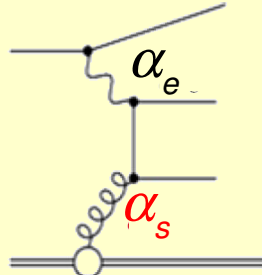
- Perturbative QCD
 - jet production and fit of α_s
 - prompt photon production
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 - charm production (D^*)
 - F_2^{charm} and F_2^{beauty}



Jets in Deep Inelastic Scattering



QCD-Compton



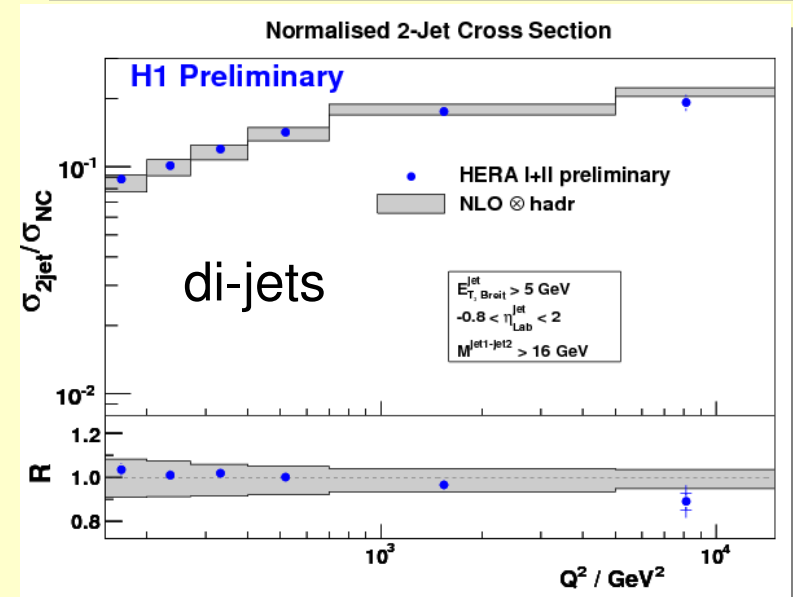
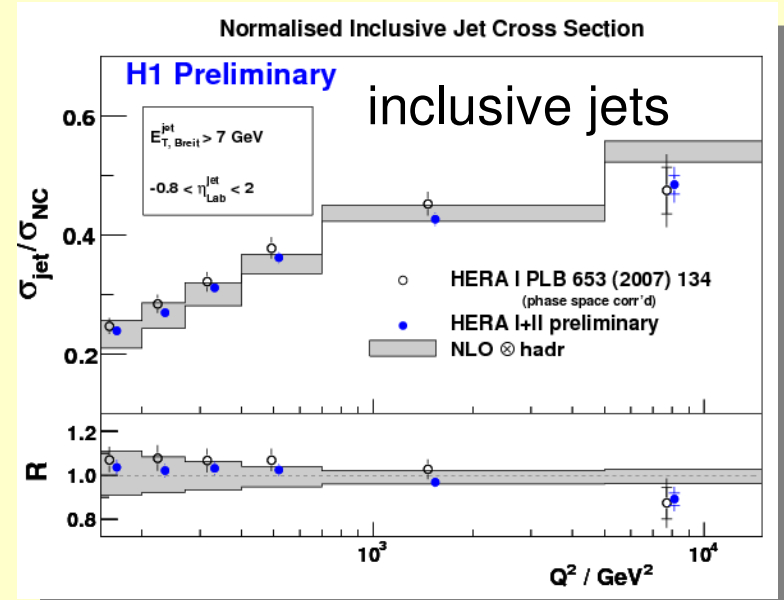
Boson-Gluon-Fusion

measurement of relative jet rates:
 → sensitive to strong coupling
 → partial cancellation of exp. errors

normalised inclusive and 2,3-jet rates measured for HERA I+II:

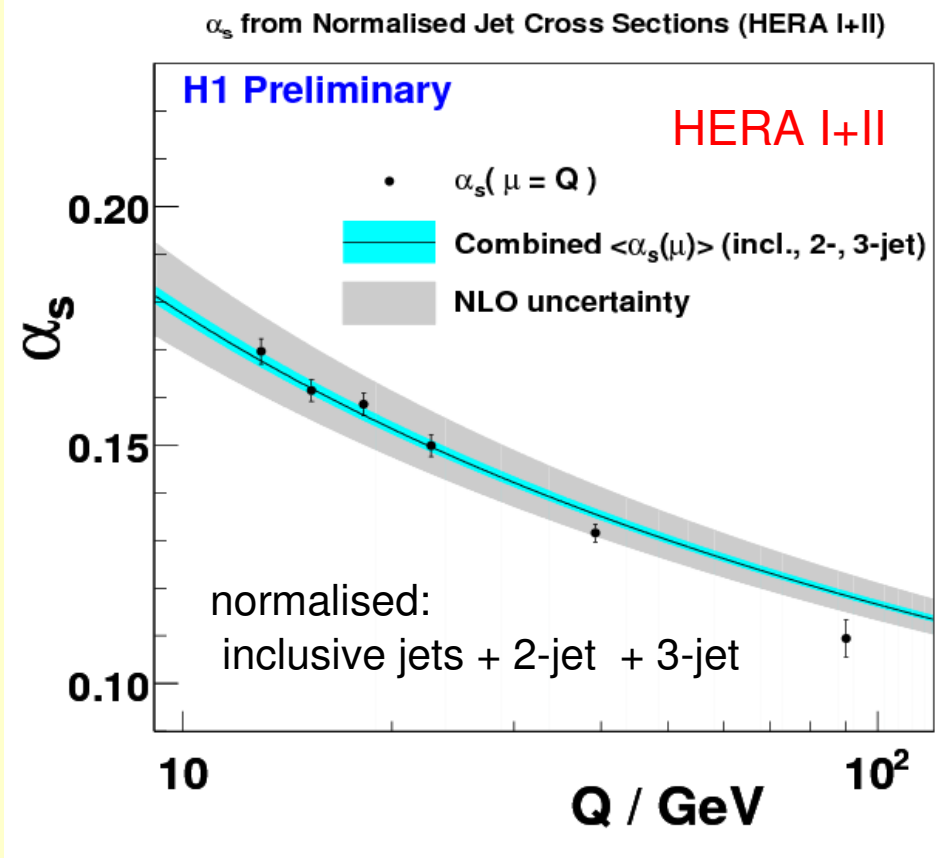
$$Q^2 > 150 \text{ GeV}^2$$

→ fit strong coupling α_s





Strong Coupling α_s



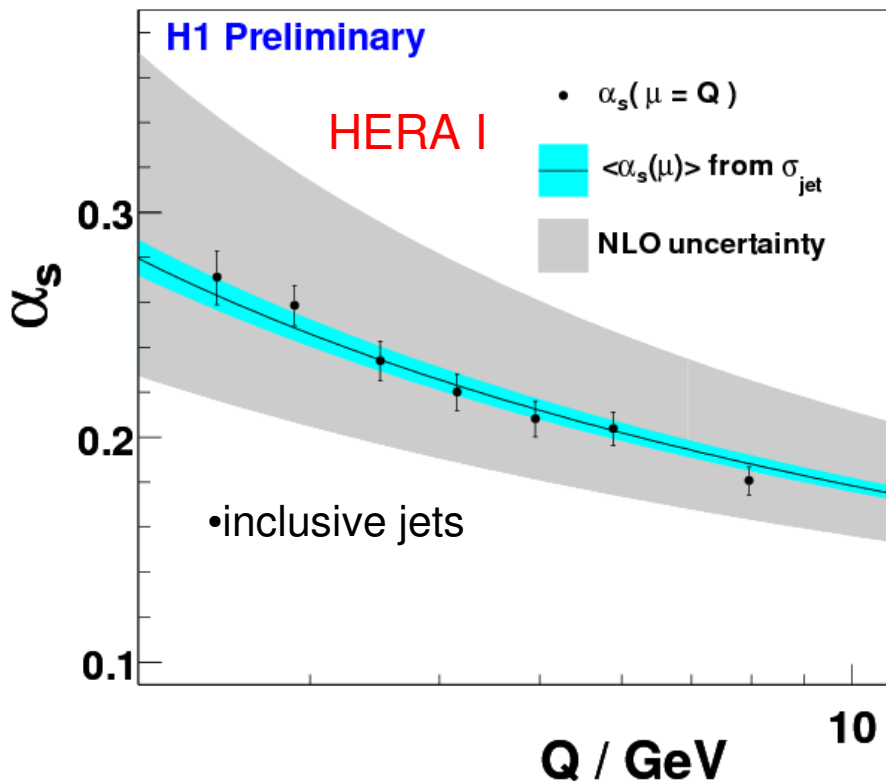
NEW H1: high Q^2

$$\alpha_s = 0.1182 \pm 0.0008(\text{exp.})^{+0.0041}_{-0.0031}(\text{scale}) \pm 0.0018(\text{pdf})$$

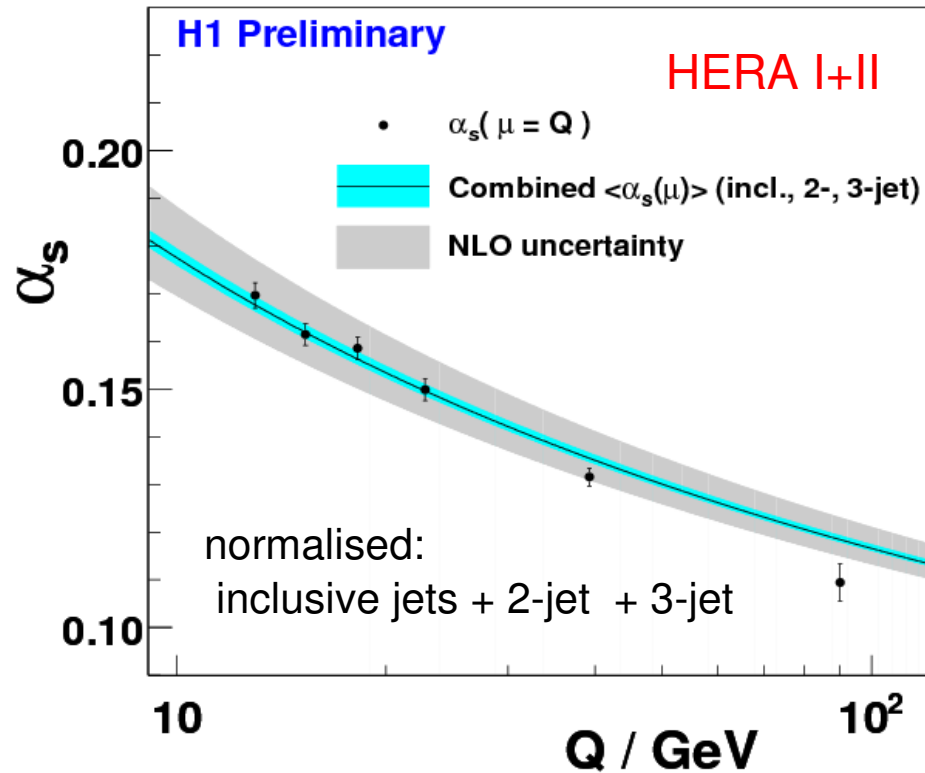


Strong Coupling α_s

α_s from Inclusive Jet Cross Section (HERA-I)



α_s from Normalised Jet Cross Sections (HERA I+II)



NEW H1: low Q^2

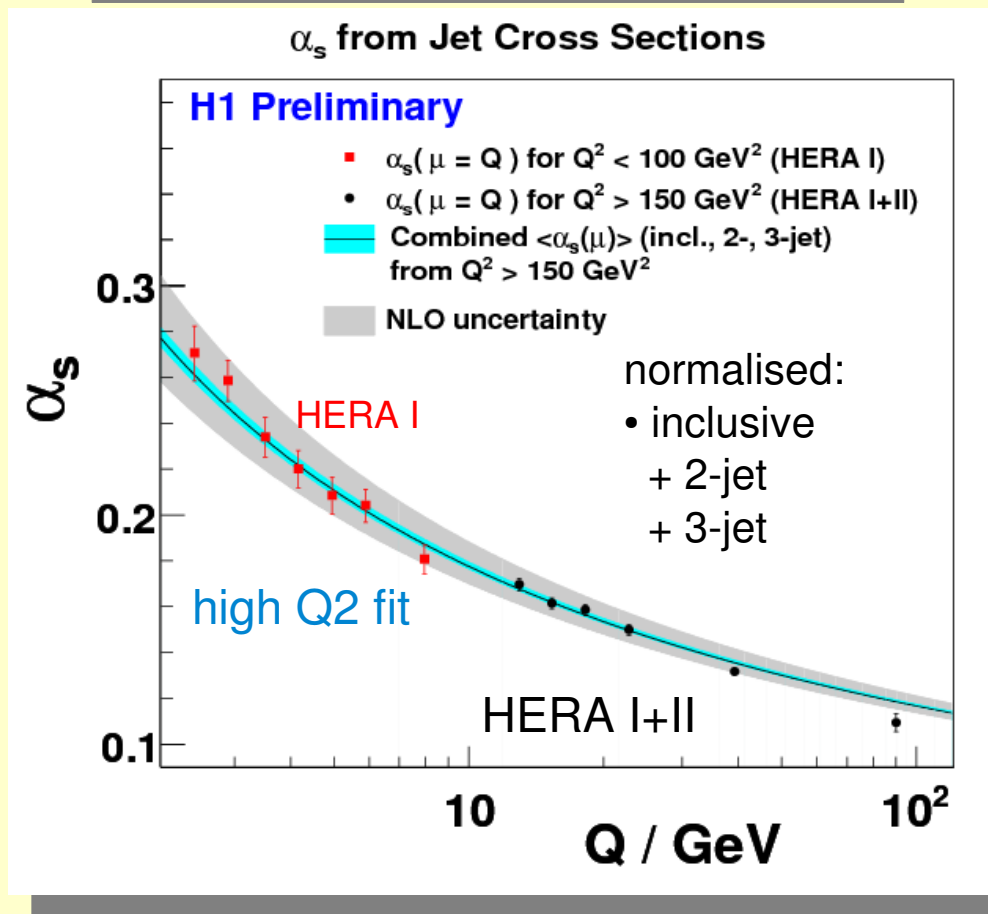
$$\alpha_s = 0.1186 \pm 0.0014(\text{exp.})_{-0.0101}^{+0.0132}(\text{scale}) \pm 0.0021(\text{pdf})$$

NEW H1: high Q^2

$$\alpha_s = 0.1182 \pm 0.0008(\text{exp.})_{-0.0031}^{+0.0041}(\text{scale}) \pm 0.0018(\text{pdf})$$



Strong Coupling α_s



NEW H1: low Q^2

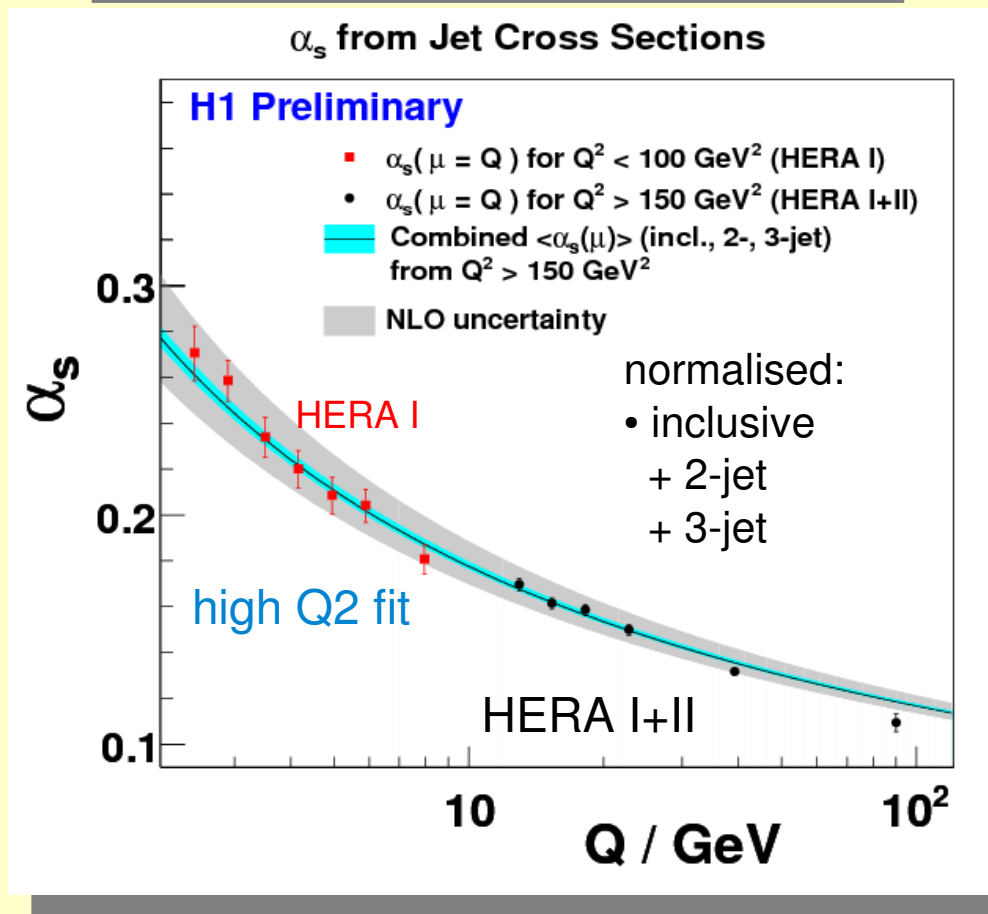
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Strong Coupling α_s



NEW H1: low Q^2

$$\alpha_s = 0.1186 \pm 0.0014(\text{exp.})^{+0.0132}_{-0.0101}(\text{scale}) \pm 0.0021(\text{pdf})$$

NEW H1: high Q^2

$$\alpha_s = 0.1182 \pm \boxed{0.0008(\text{exp.})}^{+0.0041}_{-0.0031}(\text{scale}) \pm 0.0018(\text{pdf})$$

H1/ZEUS combination (2007):

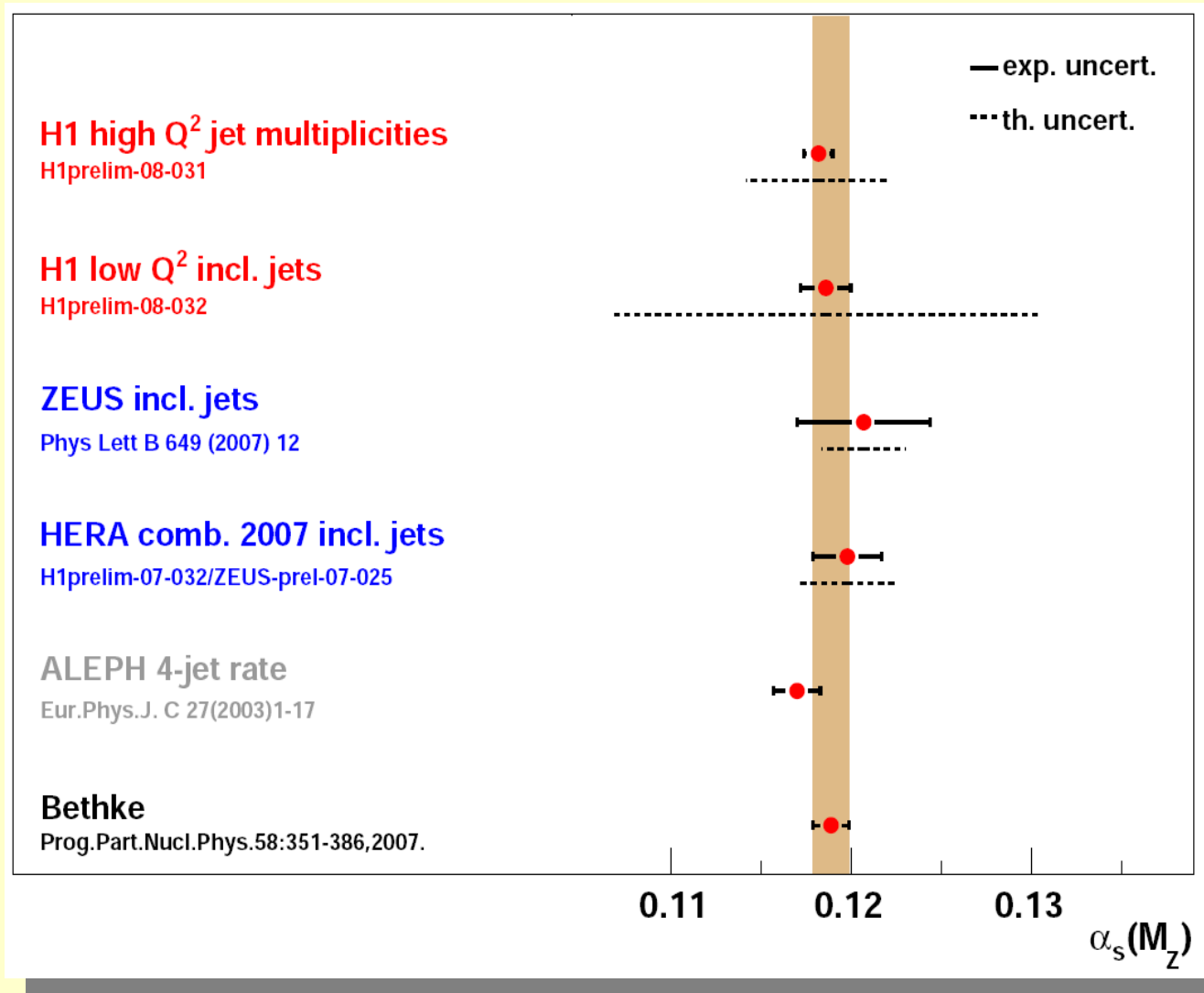
$$\alpha_s = 0.1198 \pm 0.0019(\text{exp.}) \pm 0.0026(\text{theory})$$



all consistent
with world
average !



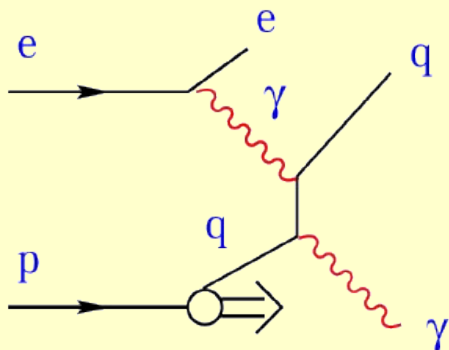
Summary α_s



- experimental error below 1% reached
- unknown NLO scale uncertainty dominating error



Prompt Photons in Photoproduction



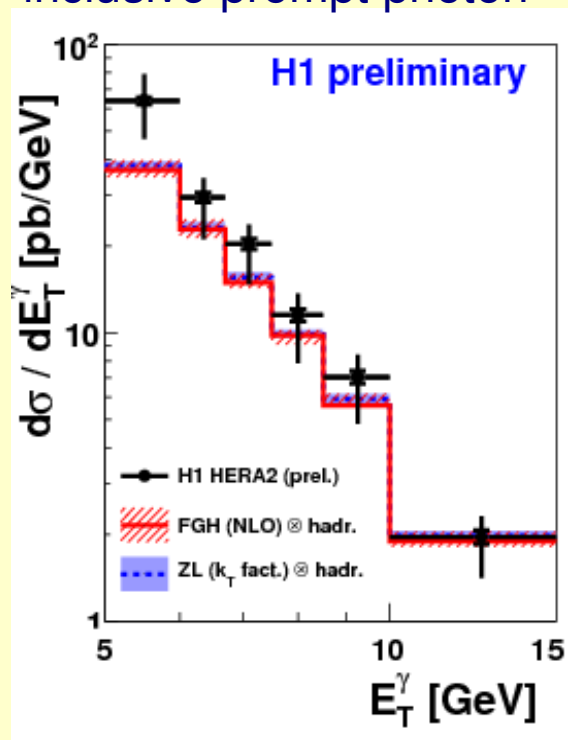
- photon appears directly from hard interaction
→ test of QCD
- important background process also relevant for LHC (e.g. $H \rightarrow \gamma\gamma$)

data compared to models

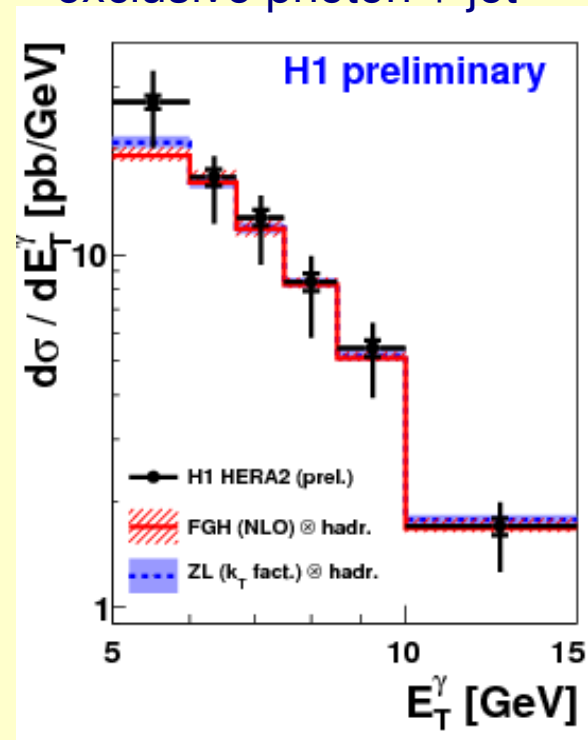
- LO k_T factorisation (Zotov, Lipatov)
- NLO calculation (Fontannaz et al.)

general:
good agreement

inclusive prompt photon



exclusive photon + jet



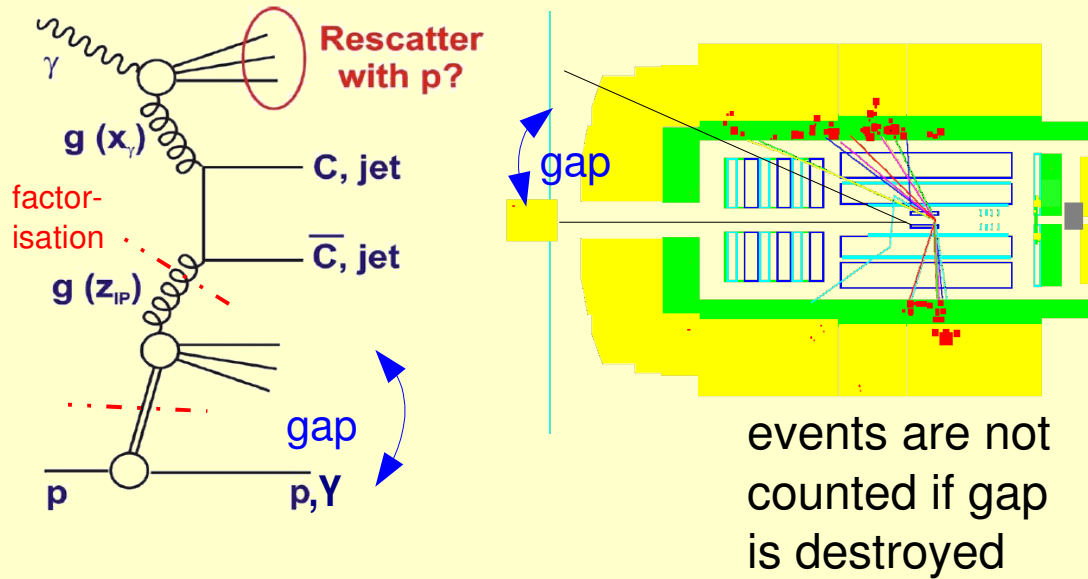


Exclusive Final States

- Perturbative QCD
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 - diffractive dijet photoproduction
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 - F_2^{charm} and F_2^{beauty}



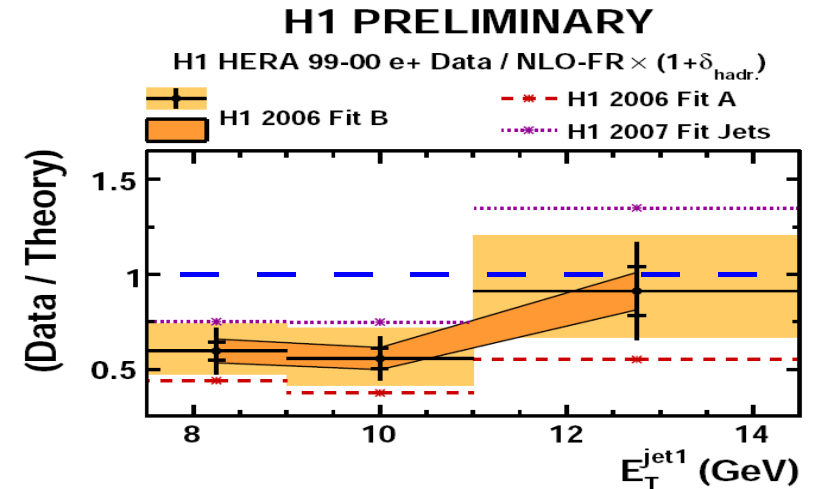
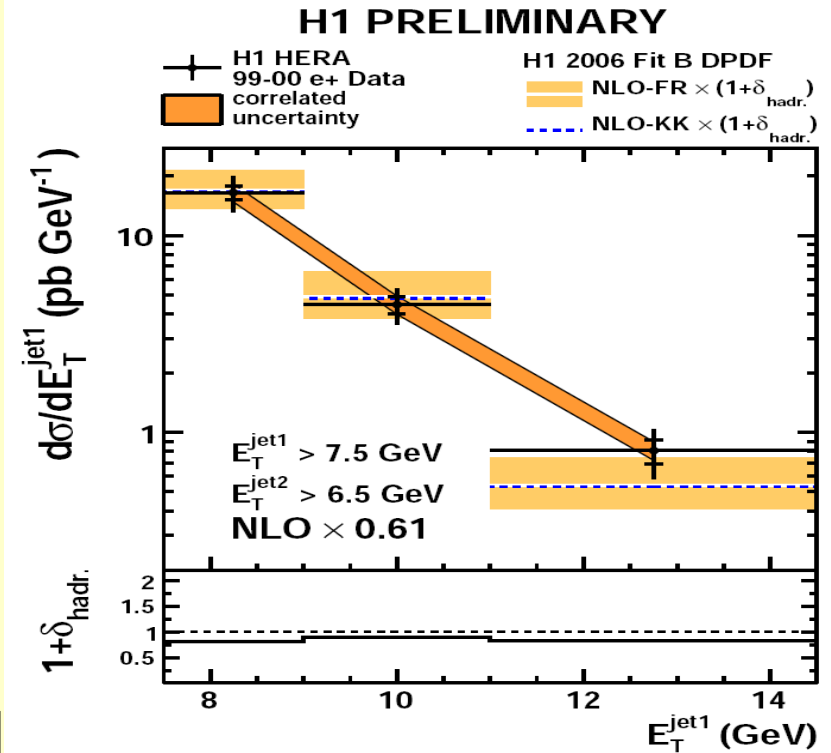
Diffraction in Photoproduction



H1 96-97: $E_T^{\text{jet1}} > 5 \text{ GeV}$ suppression by 0.5
 ZEUS 99-00: $E_T^{\text{jet1}} > 7.5 \text{ GeV}$ weak suppression

both analyses with different E_T cuts repeated by H1 using 99-00 data:

→ consistent with previous H1/ZEUS findings





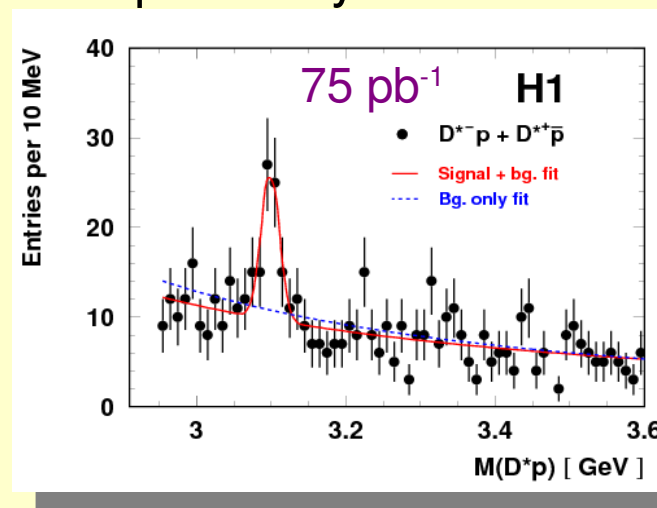
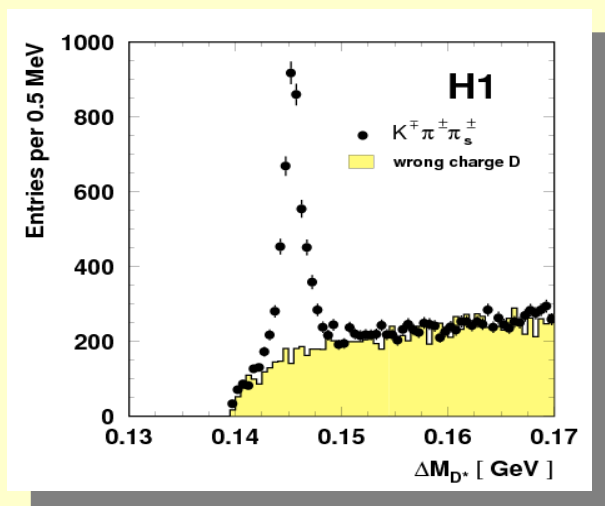
Exclusive Final States

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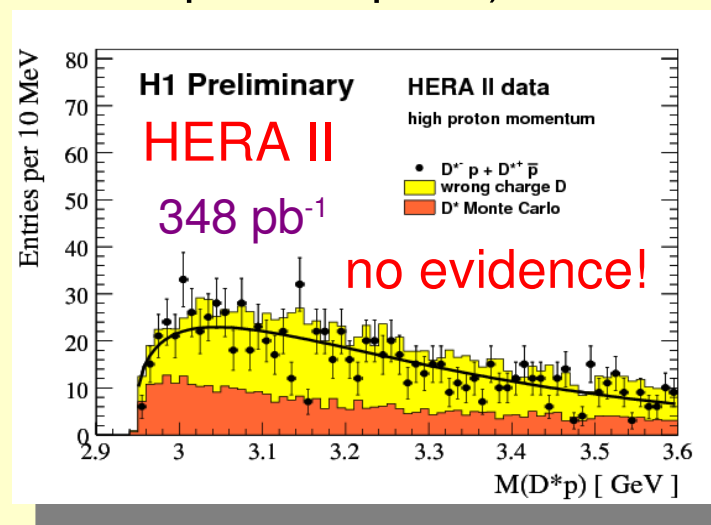
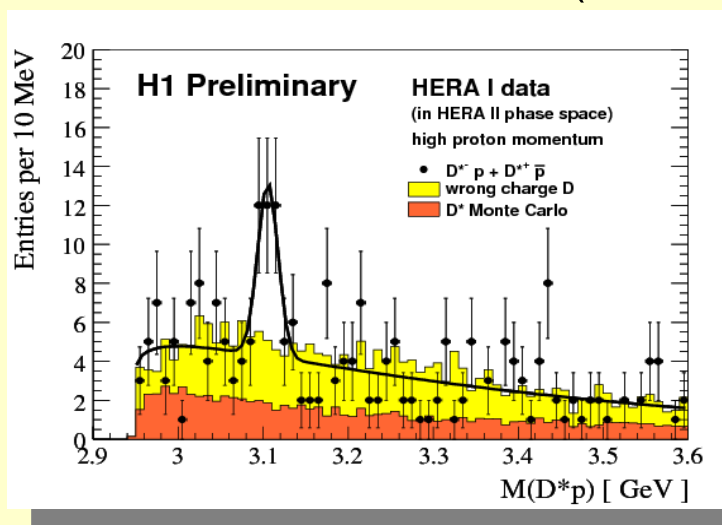


Exotic D^*p Resonance

Evidence for an exotic D^*p resonance reported by H1 at HERA I

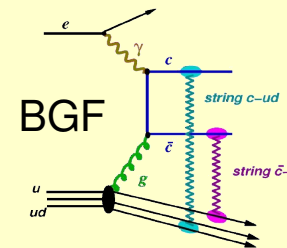


New results from HERA (reduced HERA II phase space)





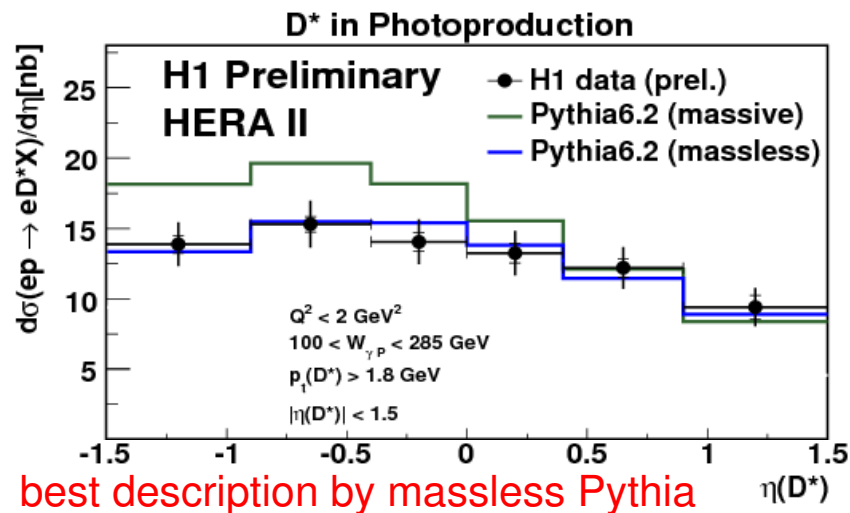
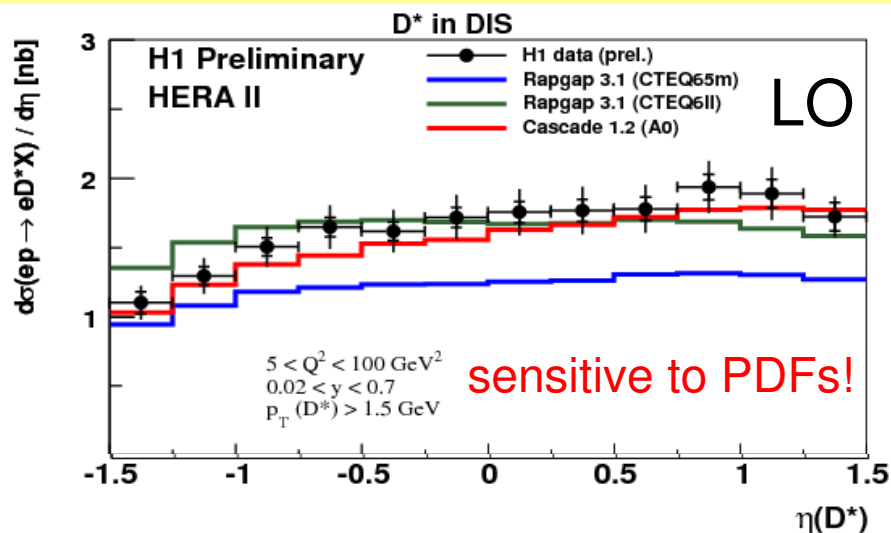
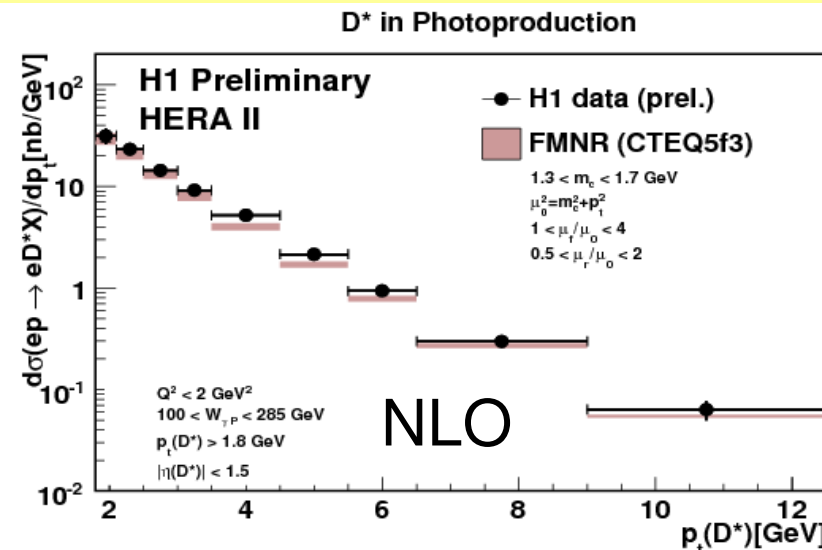
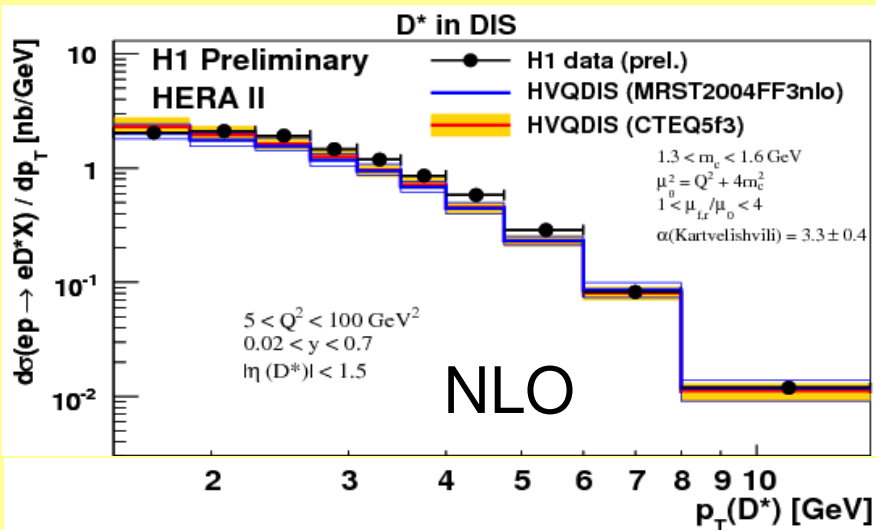
D* Production at HERA II



D* Electroproduction

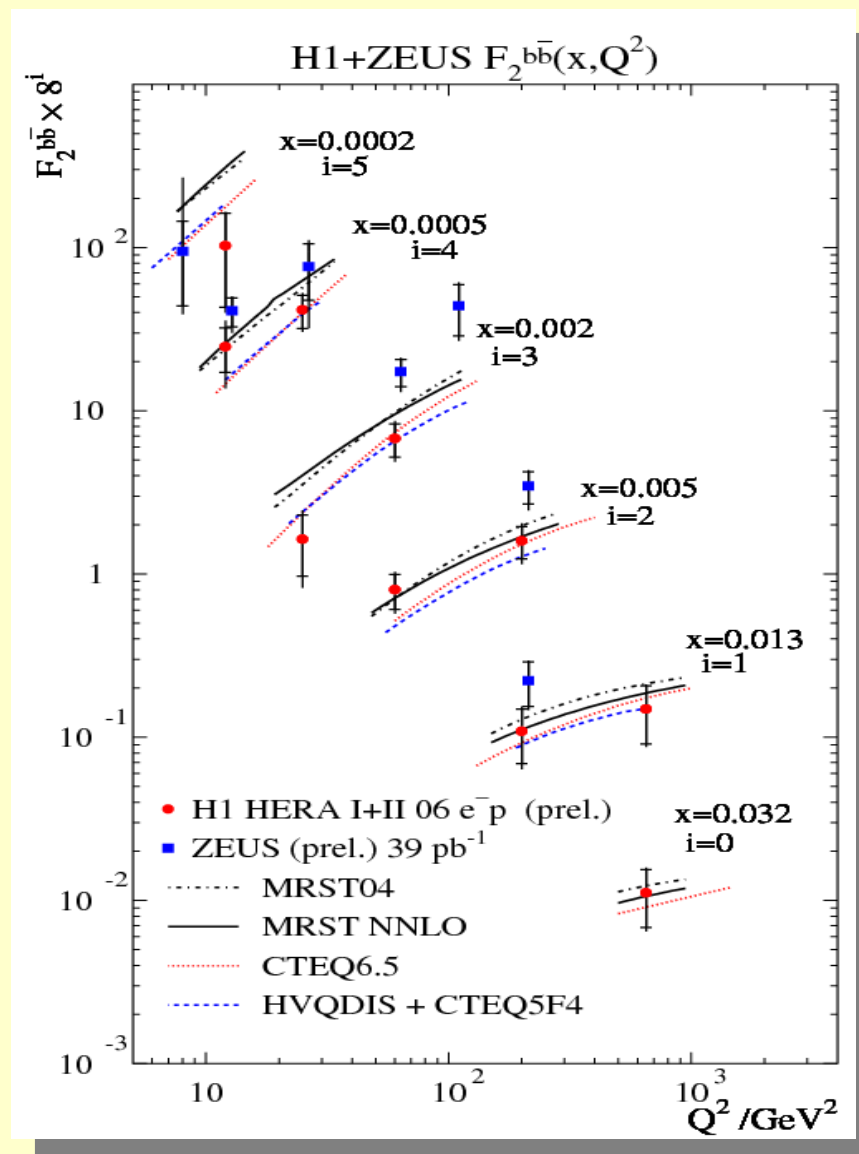
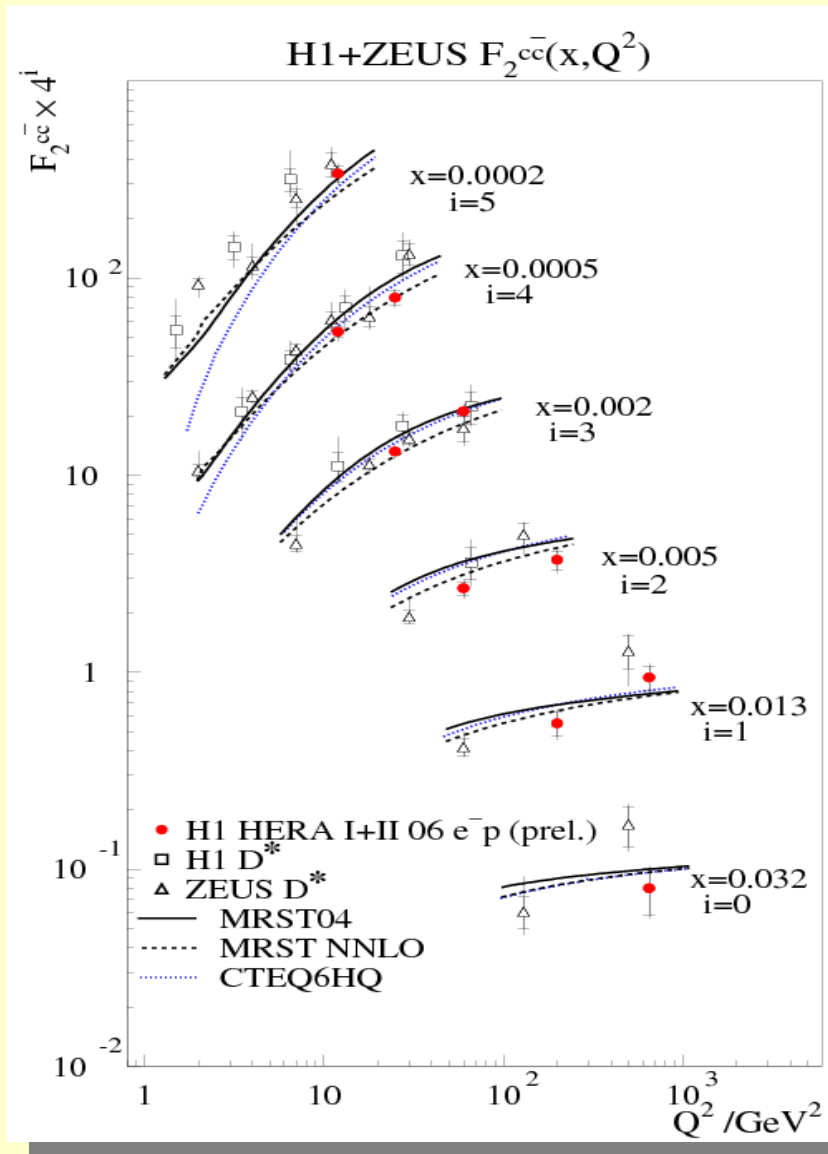
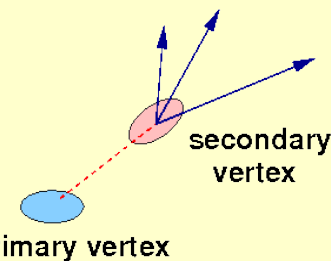
$D^* \rightarrow K\pi\pi$

D* Photoproduction





F_2^{charm} and F_2^{bottom} using lifetime



→ reduced statistical uncertainties



List of New H1 Results

Searches

- Leptoquarks + LFV → Ilias Panagoulas
- Excited Fermions → Marie Jacquet
- W Polarisation and Single Top → Eram Rizvi
- Contact Interactions → Filip Zarnecki
- Multi-Leptons and General Search
→ Andrea Parenti
- Isolated Leptons → James Ferrando

Inclusive

- Low Q² FL → Biljana Antunovic
- High y Cross-sections and High Q² FL
→ Vladimir Shekelyan
- H1-ZEUS Structure Function Combinations
→ Joel Feltesse
- H1-ZEUS Combined Fits → Amanda C.-Sarkar

- covered
- not discussed

Heavy Flavours

- F_{2c} and F_{2b} → Andrew Mehta
- D* Production → Andreas Jung
- D* Fragmentation → Juraj Bracinik
- Inelastic J/Psi → Karin Daum
- Search for a D*_p resonance → Katja Krueger

Diffraction

- DVCS → Laurent Favart
- Diffractive rho's and phi's in DIS → Xavier Janssen
- Dijets in Photoproduction → Karel Cerny
- Dijet Diffractive PDF's → Paul Laycock

Final States

- Prompt Photons in Photoproduction
→ Krzysztof Nowak
- Strangeness at Low Q² → Anna Falkiewicz
- Jets in High Q² and alpha_s → Maxime Gouzevitch
- H1-ZEUS Combined alpha_s fits → Thomas Kluge
- Charged Particles in DIS → Dan Traynor
- Low x Dynamics with Final States → Jacek Turnau



Summary

Recent highlights from H1:

- finalising **Searches** with full HERA I + HERA II statistics and in combination with ZEUS ($\sim 1\text{fb}^{-1}$)
- first **direct measurement of F_L** at low x
- jets and hadronic final state physics with full HERA data
→ e.g. **α_s** with experimental errors below 1%
- high **precision PDFs** from H1/ZEUS combination

Entering the era of high precision measurements with full HERA data.