# H1 Highlights for ICHEP 02

DESY Seminar 23/07/02

Rainer Stamen

Universität Dortmund

# New Results in 2002

## Structure Functions:

- F_2 at low $Q^2$
- QCD Analysis of F_2 data

## Diffraction

- Inclusive Diffraction at low $Q^2$
- Diffractive Parton Densities
- Diffractive Dijet Photoproduction
- $\rho$ Meson Production at high $Q^2$
- $\psi(2S)$ Production
- Diffractive Dissociation in Photoproduction

## Final States

- D Meson Production
- Prompt Photon Production
- D* Muon Correlations
- Forward $\pi^0$ Production
- Forward Jet Production
- Inelastic $J/\psi$ Production in DIS and Photoproduction

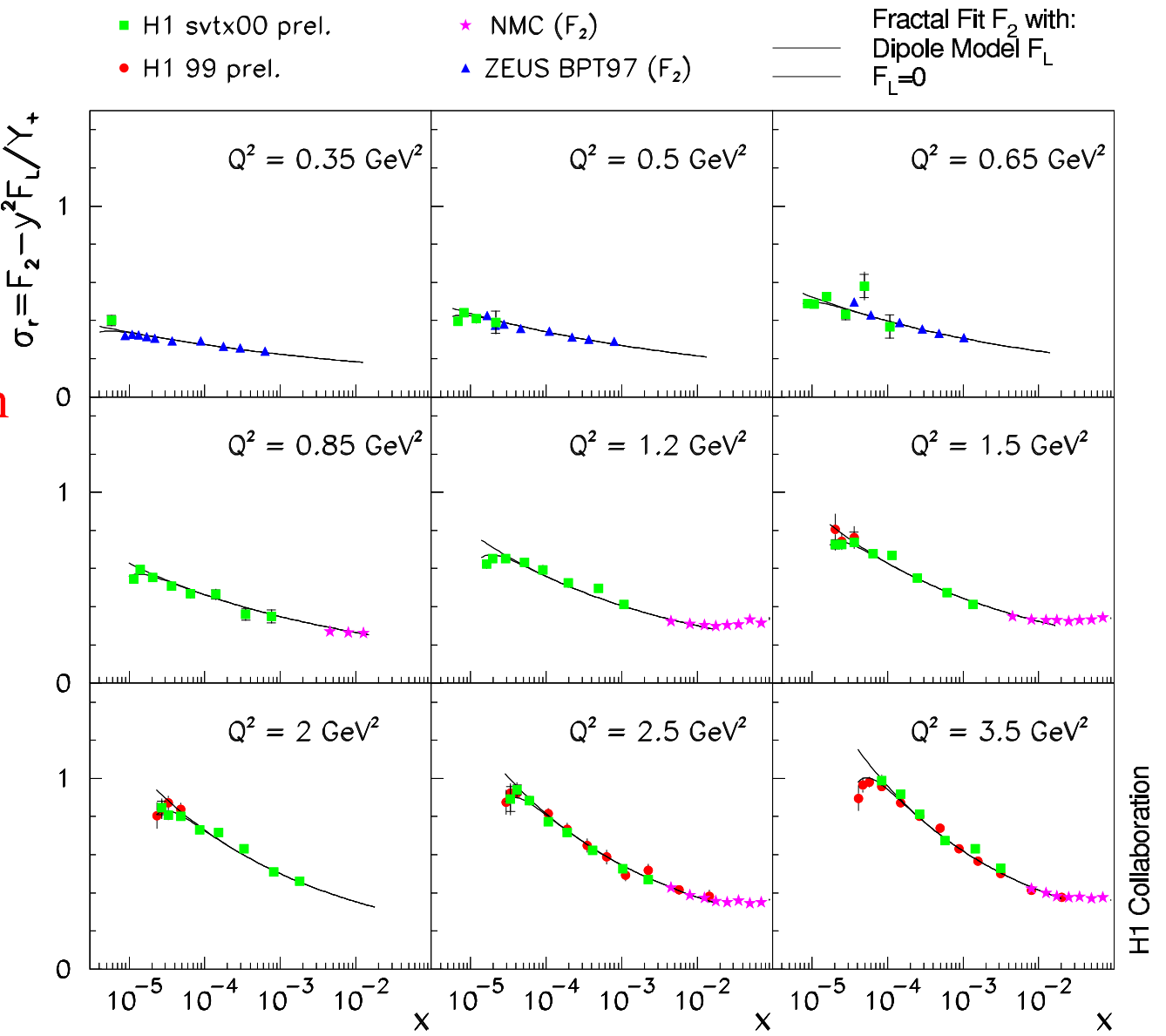
## Beyond the Standard Model

- Multilepton Production
- Search for Double Charged Higgs
- W Production
- Single Top Production
- Contact Interactions
- Excited Electrons
- Leptoquarks

# Reduced Cross Section at low Q2

vertex shifted: 0 –> 70 cm
=> access to lower values of Q2

=> data fill the gap between perturbative and non–perturbative region



# Local Derivatives of $F_2$

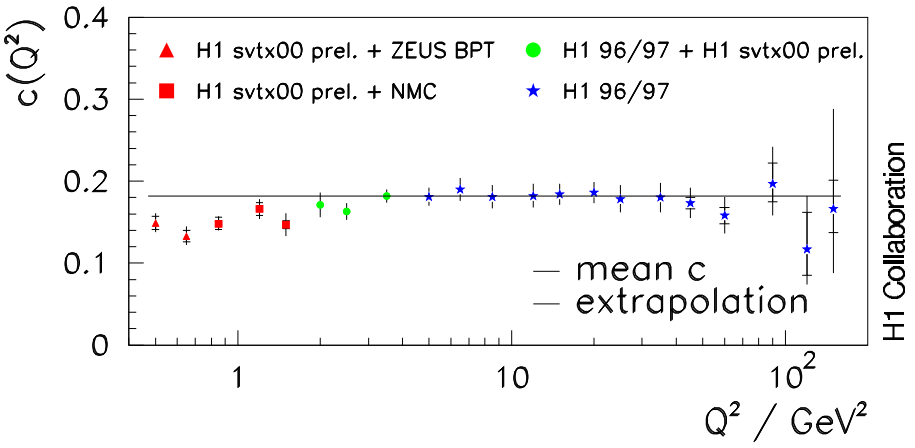
$F_2$ can be parametrised as

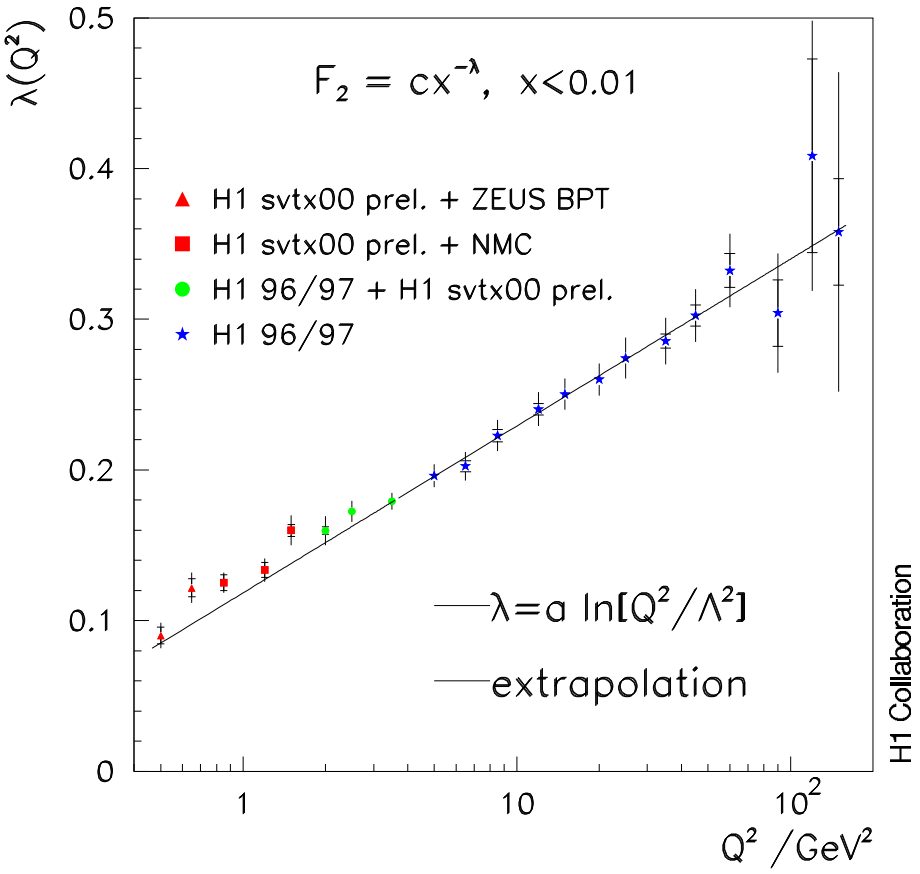
$$F_2 = c \cdot x^{-\lambda}$$

at small x for fixed values of $Q^2$.

$\lambda$ does not change with x

–> Extraction of $\lambda$ and c



# QCD Analysis

QCD Analysis of high and low $Q^2$ data: new method

$$U = u + c \qquad D = d + s \qquad \Rightarrow \qquad d_v = D - \bar{D}$$
$$\bar{U} = \bar{u} + \bar{c} \qquad \bar{D} = \bar{d} + \bar{s} \qquad\qquad u_v = U - \bar{U}$$

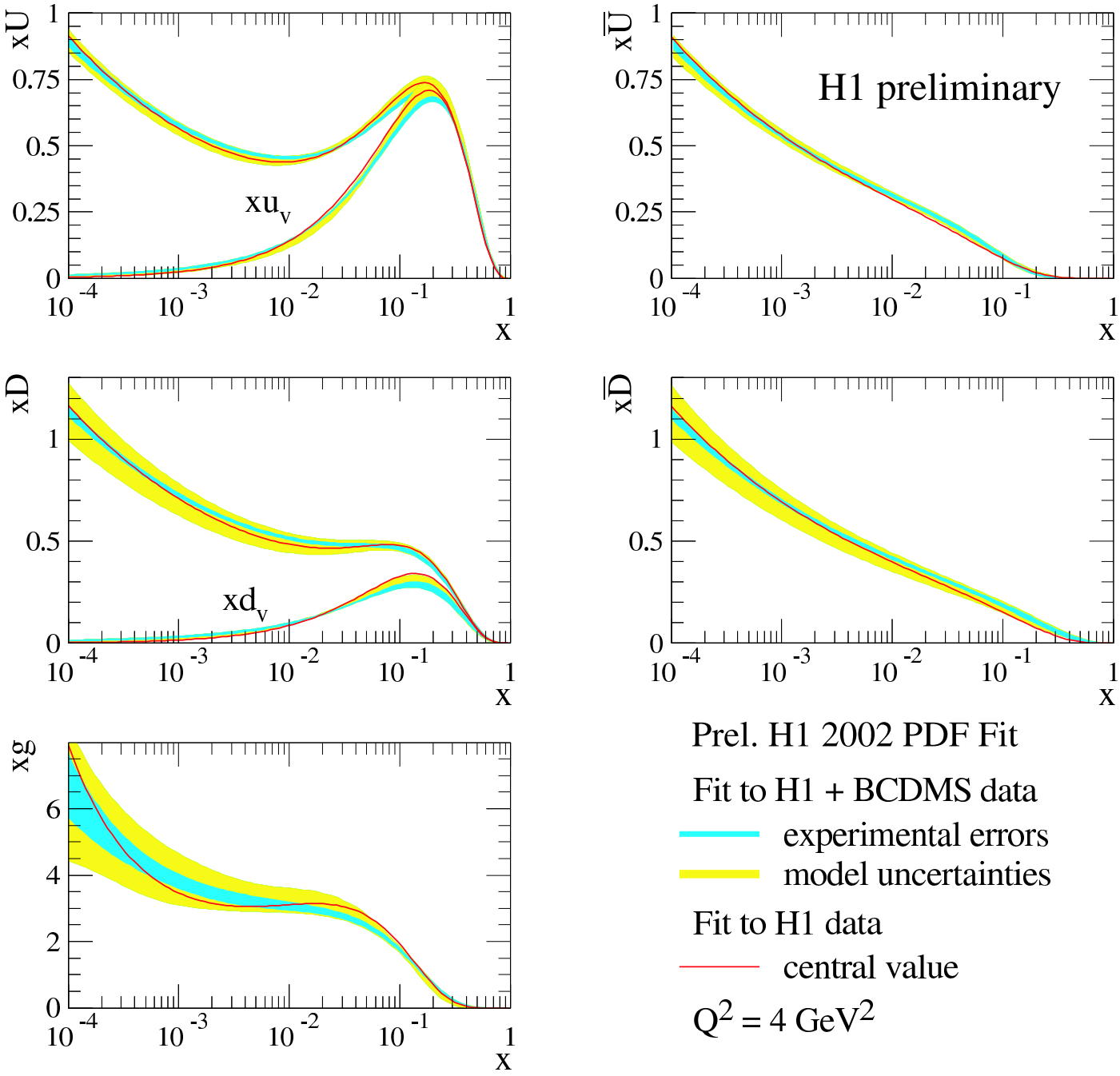
-> measurement is sensitiv to this kind of combination

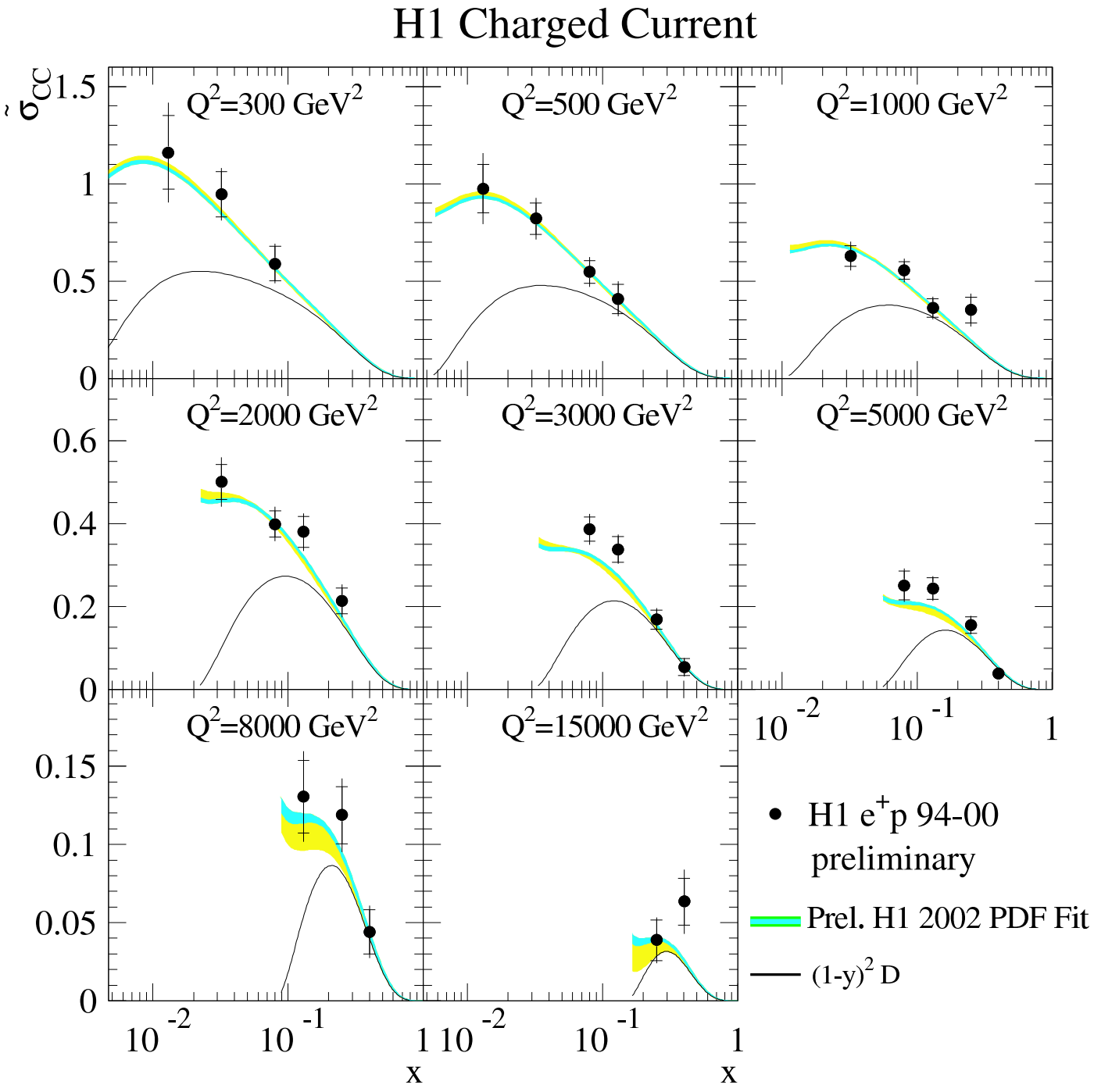
Charged Current $\quad \Phi^{+}_{CC} = x\bar{U} + (1-y)^2 xD \qquad \Phi^{-}_{CC} = xU + (1-y)^2 x\bar{D}$

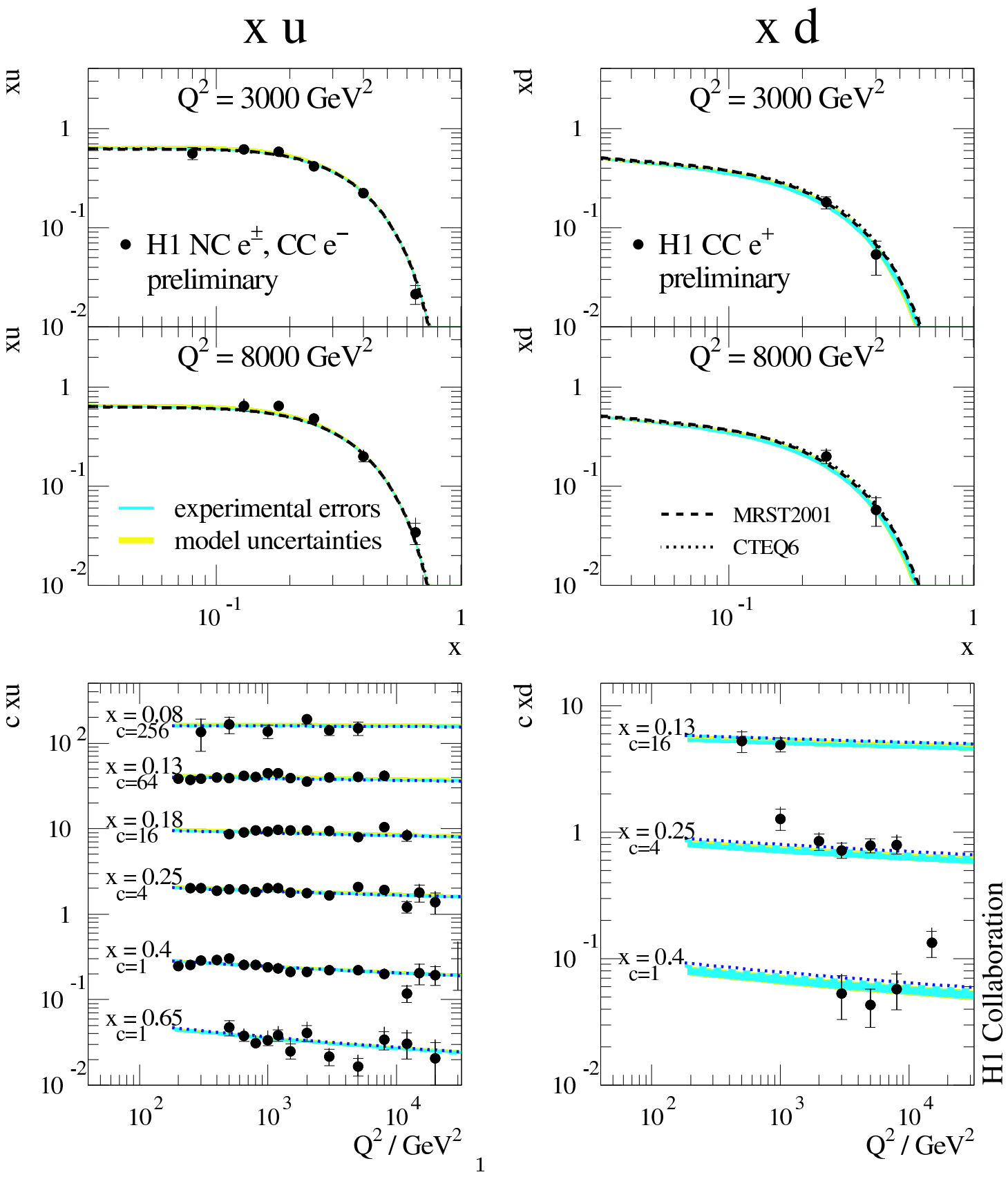
Neutral Current: $\quad F_2 = \frac{4}{9} \cdot (xU + x\bar{U}) + \frac{1}{9} \cdot (xD + x\bar{D})$

$$xF_3^{\gamma Z} \sim x\left[2(U - \bar{U}) + (D - \bar{D})\right] \qquad \text{(high } Q^2\text{)}$$

# H1 Parton Distributions



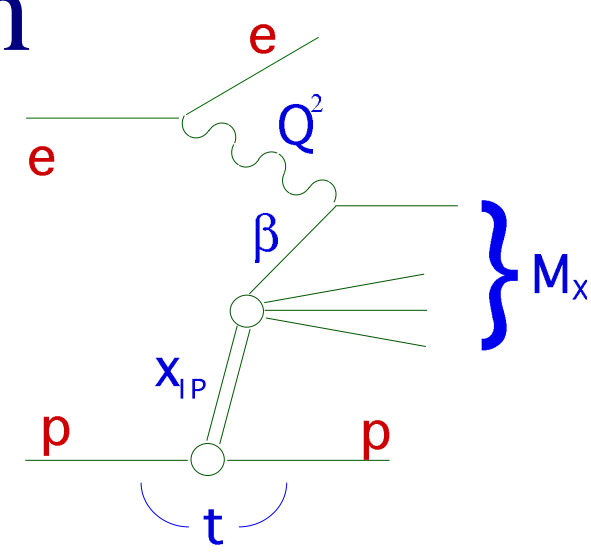

H1 Charged Current
$\tilde{\sigma}_{CC}$
$Q^2$=300 GeV$^2$
$Q^2$=500 GeV$^2$
$Q^2$=1000 GeV$^2$
$Q^2$=2000 GeV$^2$
$Q^2$=3000 GeV$^2$
$Q^2$=5000 GeV$^2$
$Q^2$=8000 GeV$^2$
$Q^2$=15000 GeV$^2$
H1 $e^+p$ 94-00
preliminary
Prel. H1 2002 PDF Fit
$(1-y)^2$ D
x
x


x u
x d
xu
xd
$Q^2 = 3000$ GeV$^2$
$Q^2 = 8000$ GeV$^2$
H1 NC e$^{\pm}$, CC e$^-$
preliminary
H1 CC e$^+$
preliminary
experimental errors
model uncertainties
MRST2001
CTEQ6
x
c xu
c xd
x = 0.08
c=256
x = 0.13
c=64
x = 0.18
c=16
x = 0.25
c=4
x = 0.4
c=1
x = 0.65
c=1
x = 0.13
c=16
x = 0.25
c=4
x = 0.4
c=1
$Q^2$ / GeV$^2$
H1 Collaboration

# Inclusive Diffraction

QCD hard scattering factorisation (Collins '97):

$$\frac{d^2\sigma\left(x,Q^2,,x_{I\!P},t\right)^{\gamma^* p \longrightarrow p' X}}{dx_{I\!P}dt} = \Sigma_i \int_x^{x_{I\!P}} d\xi \hat{\sigma}^{\gamma^*}\left(x,Q^2,\xi\right) \cdot f_i^D(\xi,Q^2,x_{I\!P},t)$$



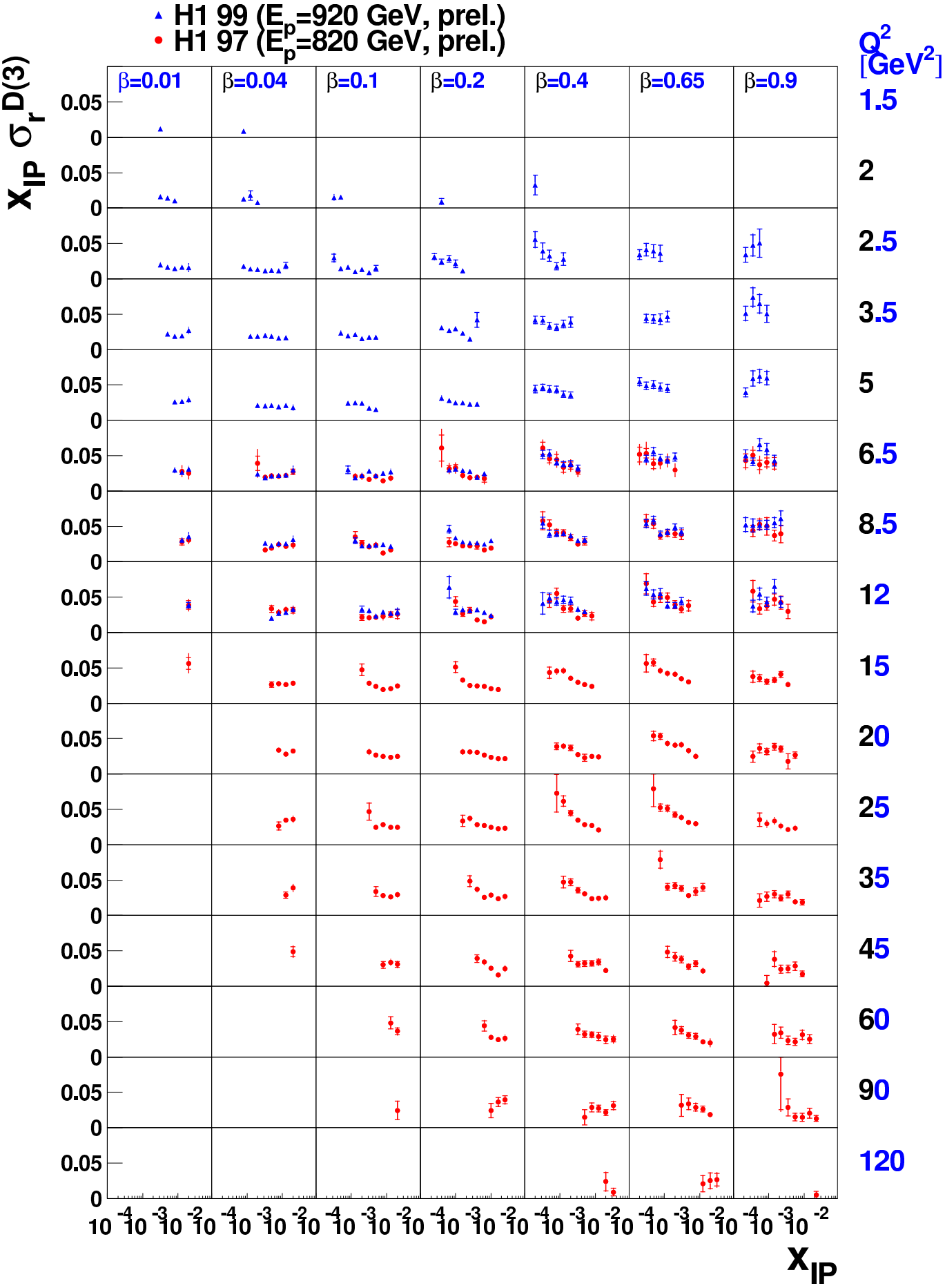

Diffractive Parton Densities obey DGLAP evolution

–> LO and NLO QCD Analysis

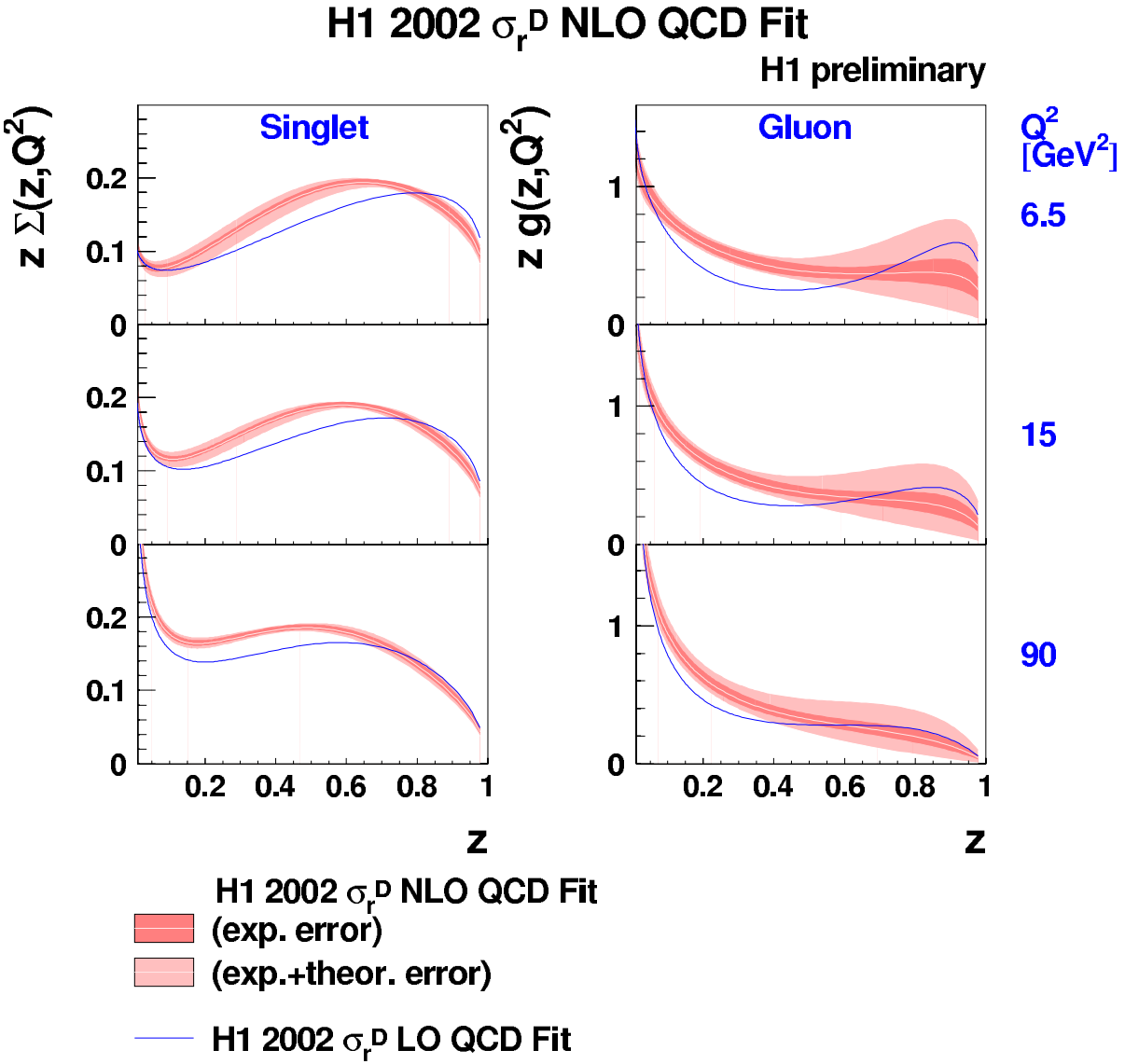
Additional Assumption:

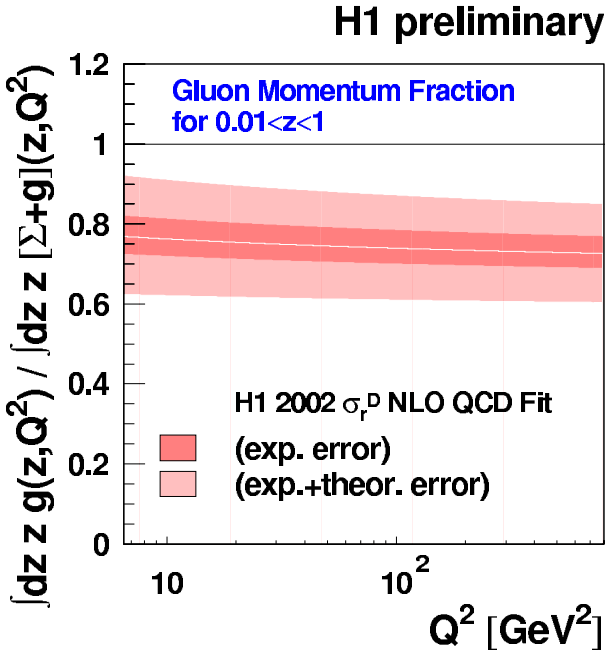
$$f_i^D(\xi,Q^2,x_{I\!P},t) = f_{x_{I\!P}/P}\left(x_{I\!P},t\right) \cdot f_i^{x_{I\!P}}\left(\beta = x/x_{I\!P},Q^2\right)$$

*''flux factor''* *''structure function''*


H1 99 ($E_p$=920 GeV, prel.)
H1 97 ($E_p$=820 GeV, prel.)
$x_{IP}\,\sigma_r^{D(3)}$
$Q^2$ [GeV$^2$]
β=0.01
β=0.04
β=0.1
β=0.2
β=0.4
β=0.65
β=0.9
1.5
2
2.5
3.5
5
6.5
8.5
12
15
20
25
35
45
60
90
120
0.05
0
$10^{-4}$ $10^{-3}$ $10^{-2}$
$x_{IP}$

# Diffractive Parton Density Functions



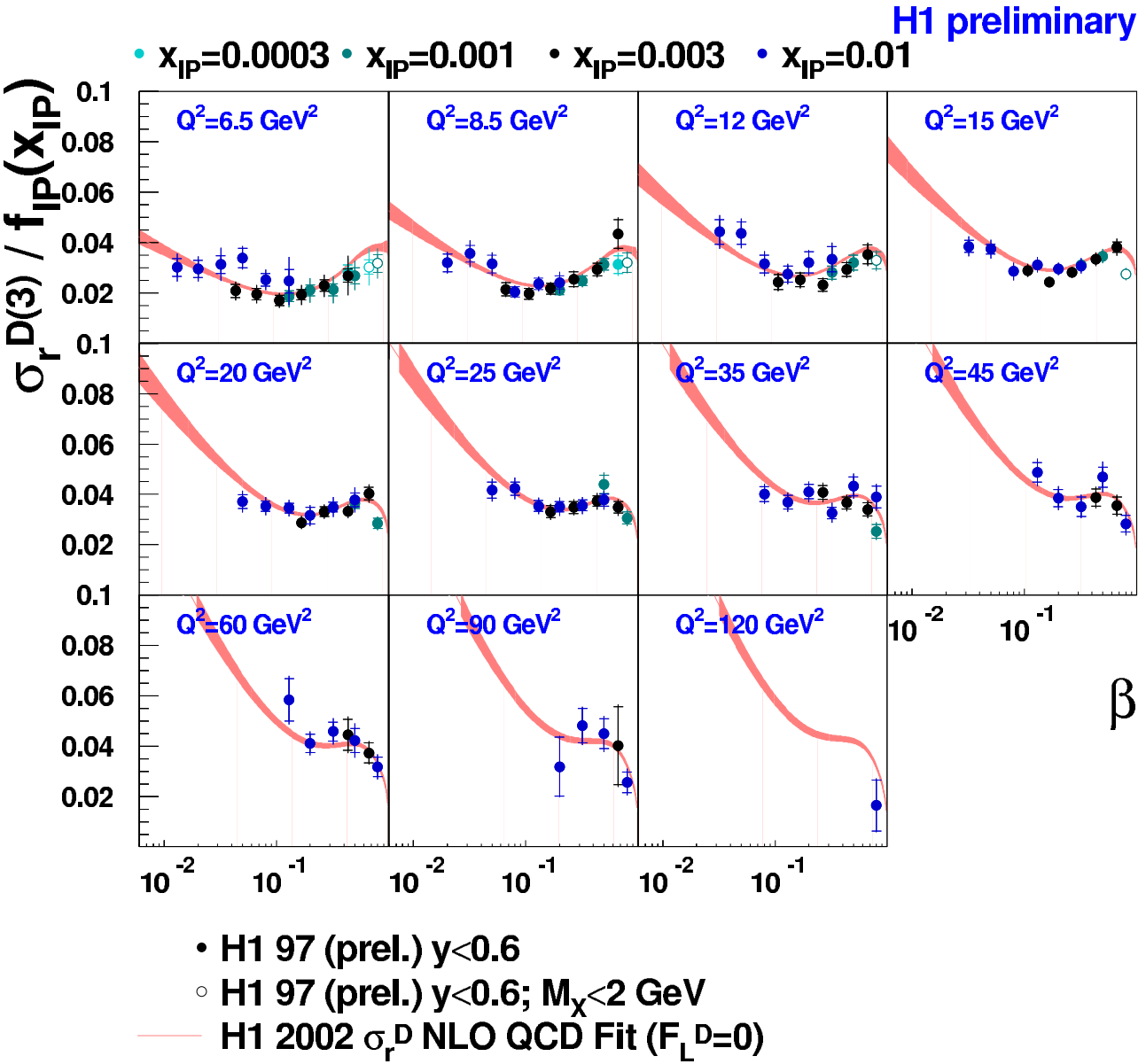




—> large gluon content
up to high values of z

# Inclusive Diffraction

reduced cross section divided by $x_{IP}$ dependence

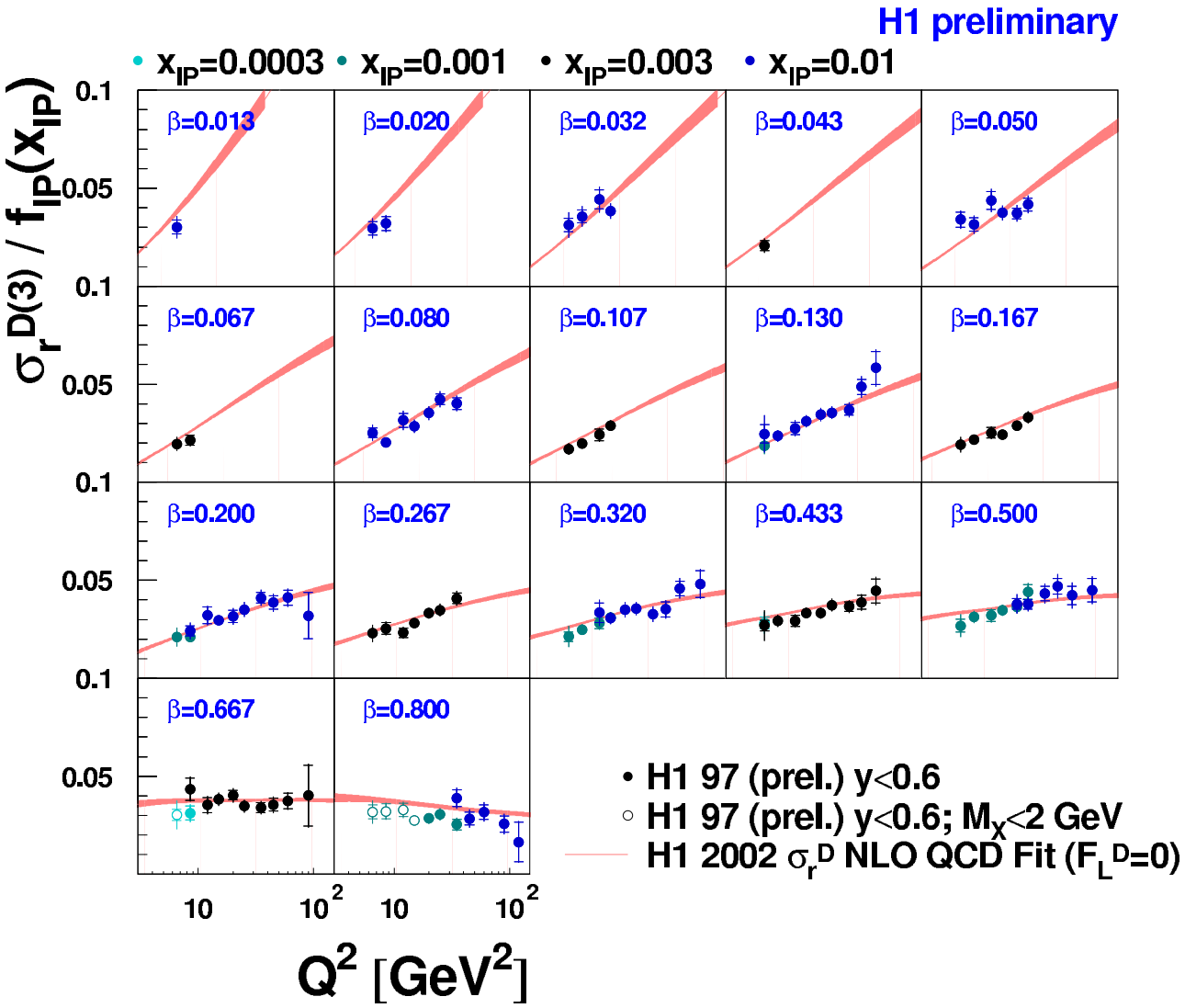
–> factorisation justified



# Inclusive Diffraction

–> strong positive scaling violations

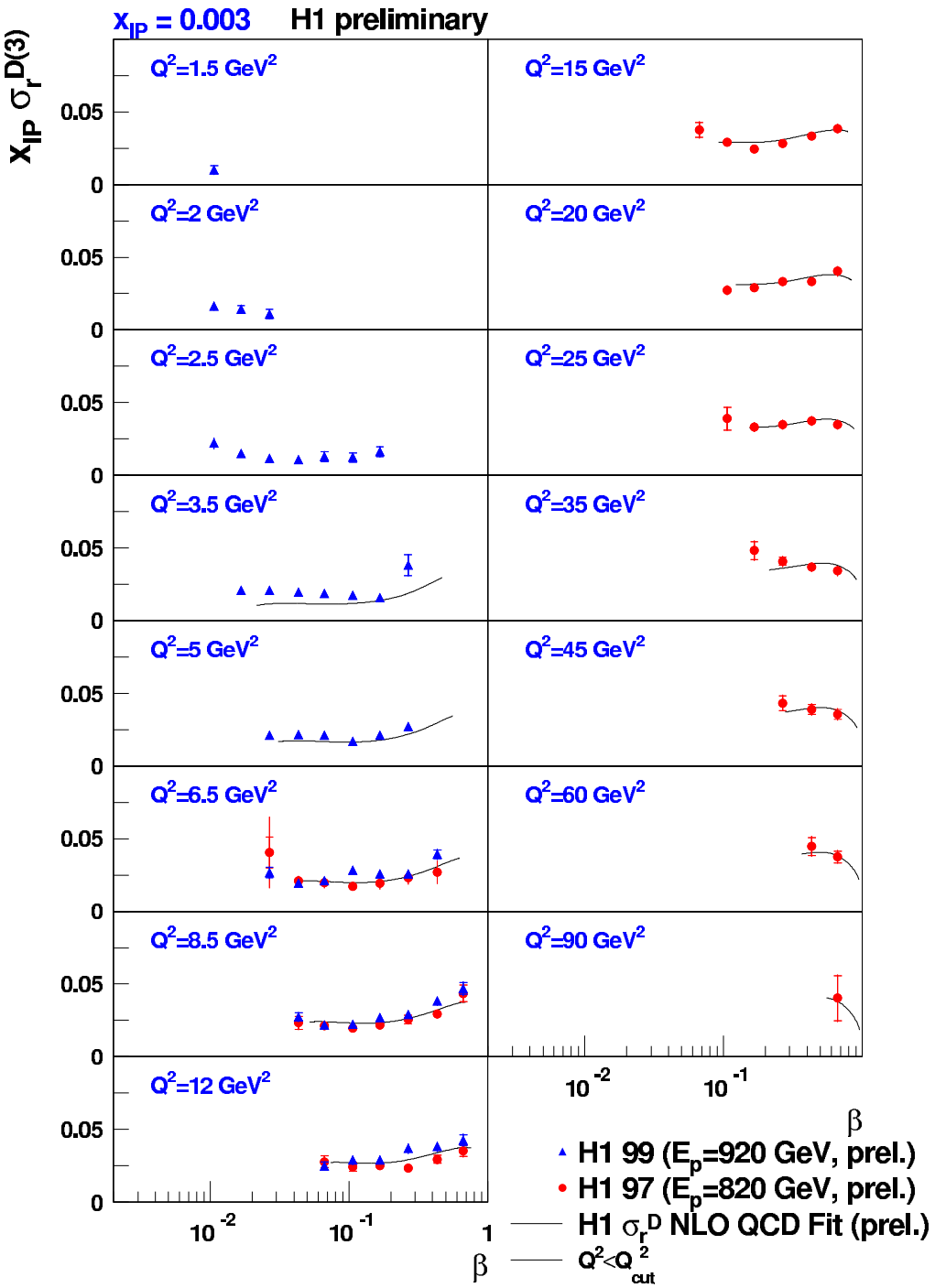
–> large gluon contents

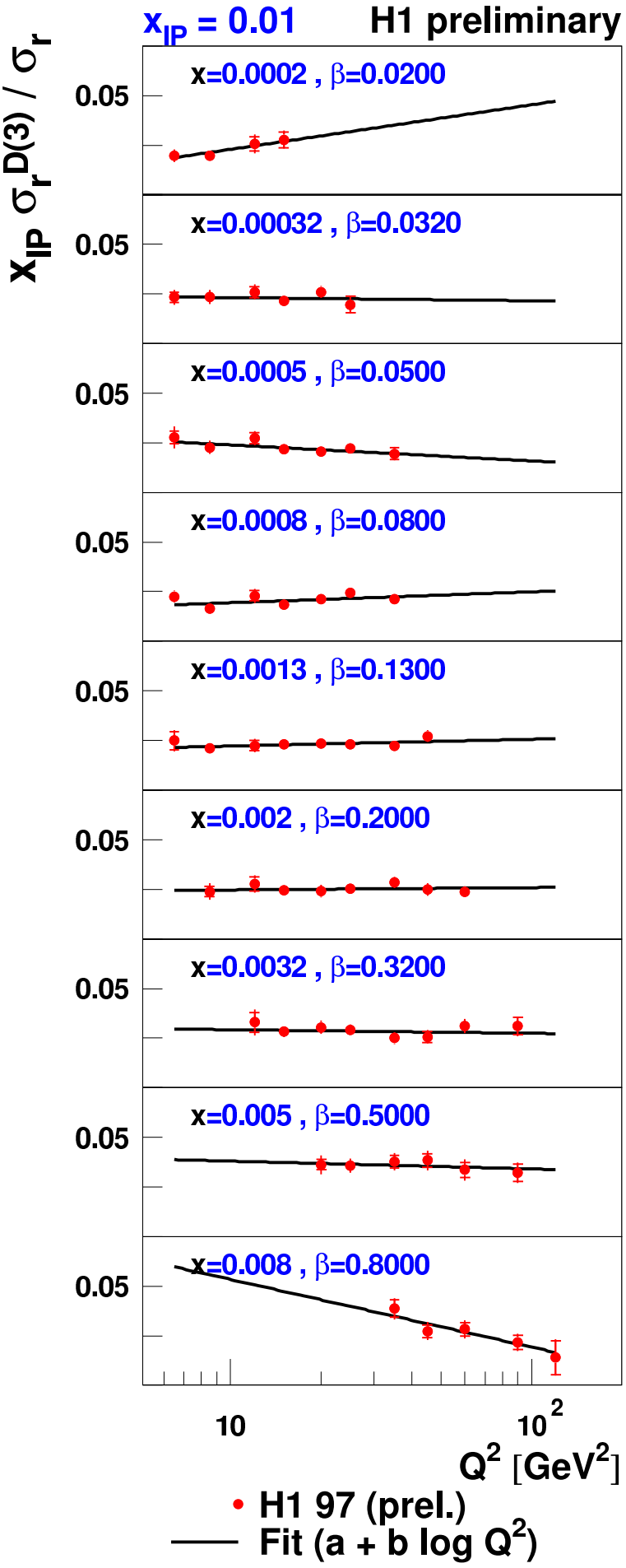


# Comparison to low $Q^2$ data

–> Extrapolation of fit to smaller values of $Q^2$

–> good agreement



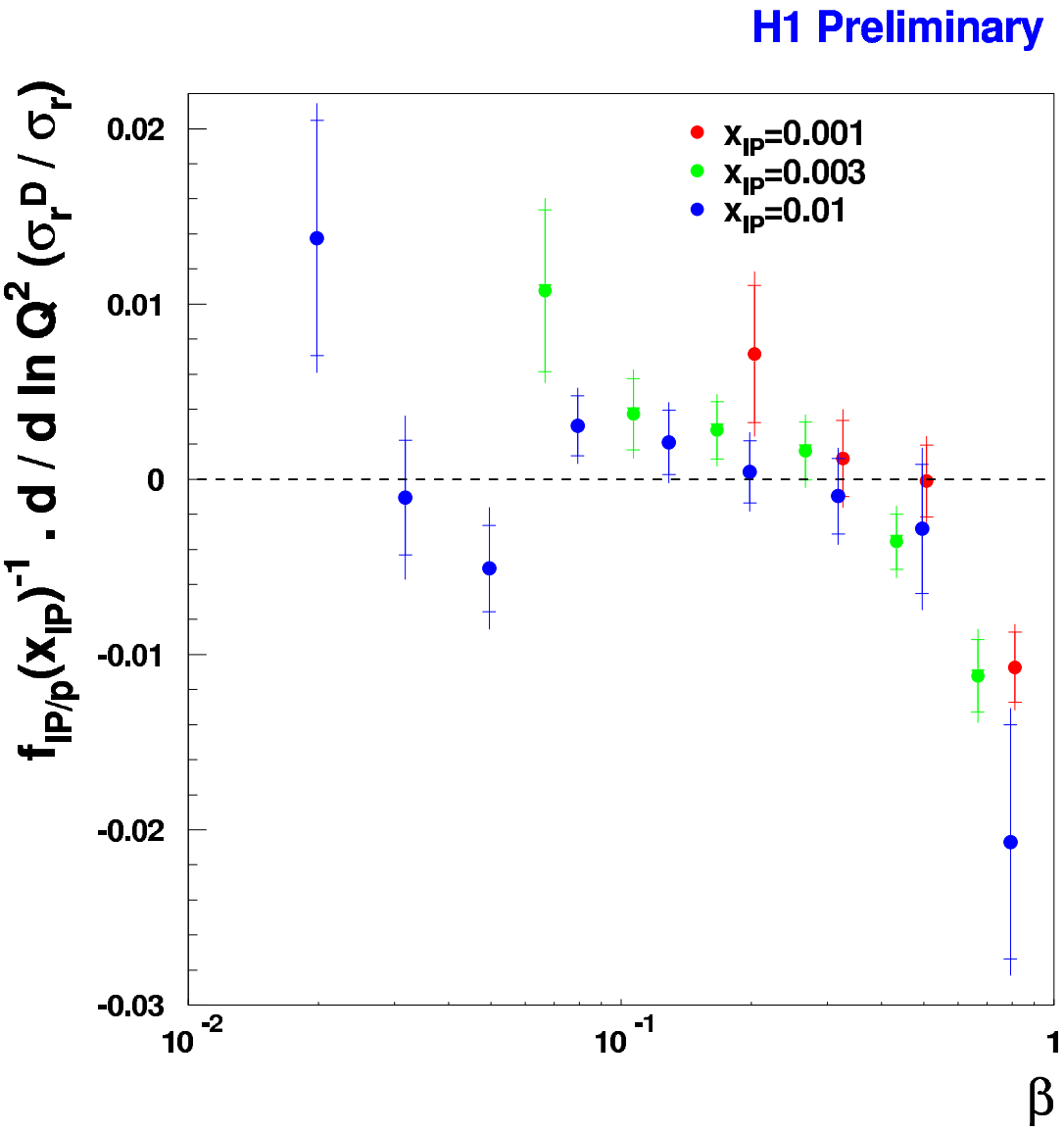

$x_{IP}$ = 0.01
H1 preliminary
$x_{IP}\,\sigma_r^{D(3)} / \sigma_r$
x=0.0002 , β=0.0200
x=0.00032 , β=0.0320
x=0.0005 , β=0.0500
x=0.0008 , β=0.0800
x=0.0013 , β=0.1300
x=0.002 , β=0.2000
x=0.0032 , β=0.3200
x=0.005 , β=0.5000
x=0.008 , β=0.8000
0.05
10
$10^2$
$Q^2$ [GeV$^2$]
H1 97 (prel.)
Fit (a + b log $Q^2$)

# Ratio Diffraction/Inclusive

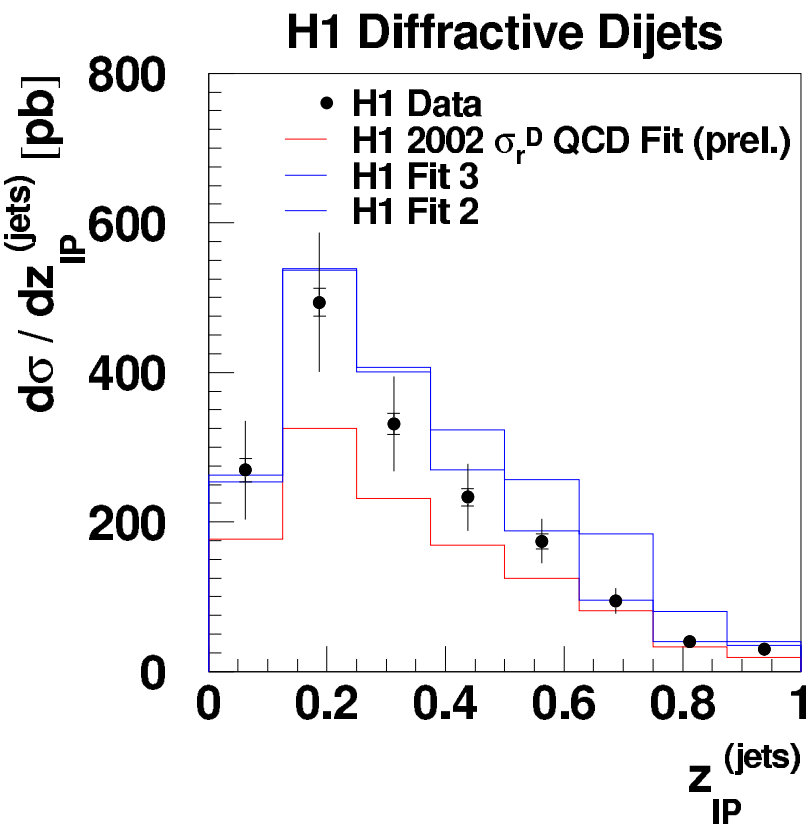
$$\frac{\sigma_r^D}{\sigma_r} \sim A + B \ln Q^2$$

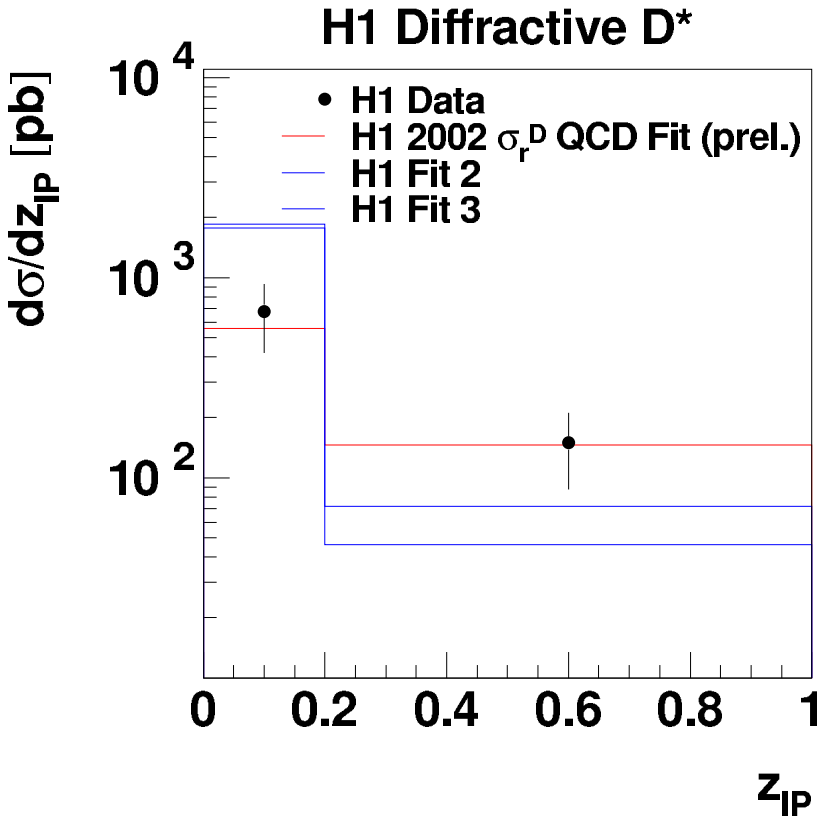
–> ratio is flat

Similar QCD dynamics underly proton and colour singlet exchange structure



# Test of Diffractive Factorisation in DIS



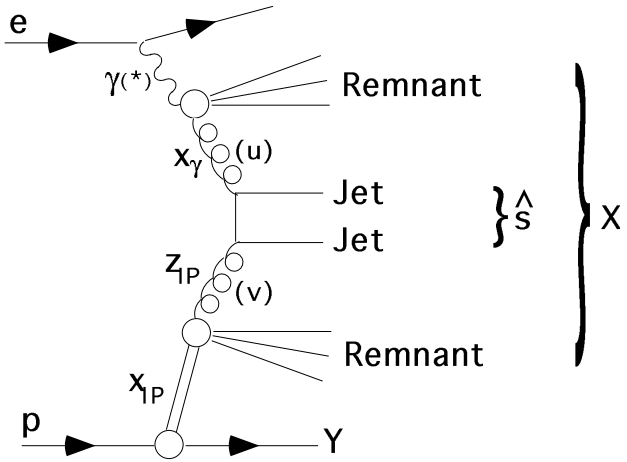



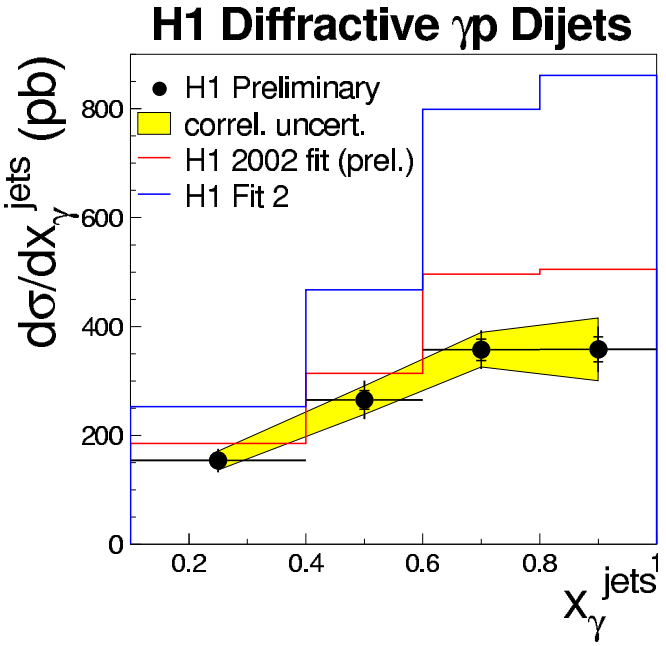

LO fits used to predict jet and charm production

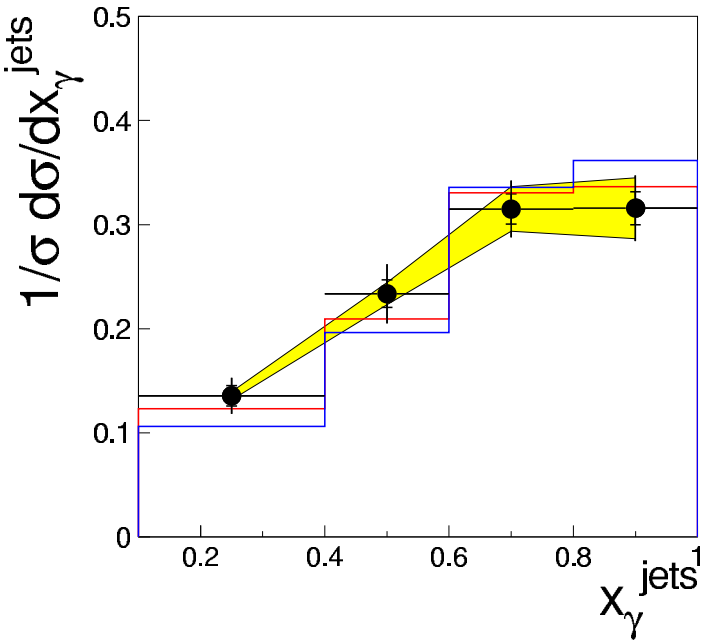
(NLO effects, scale uncertainties, pdf uncertainties)

**–> H1 internal consistent picture: factorisation holds**

# Diffractive Dijets in Photoproduction



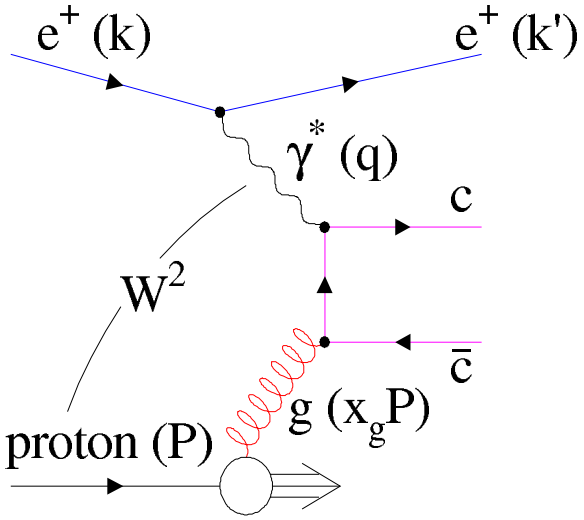




–> only small suppression factor needed

–> any factorisation breaking is small and x_g independent

–> factorisation breakdown at Tevatron not yet understood

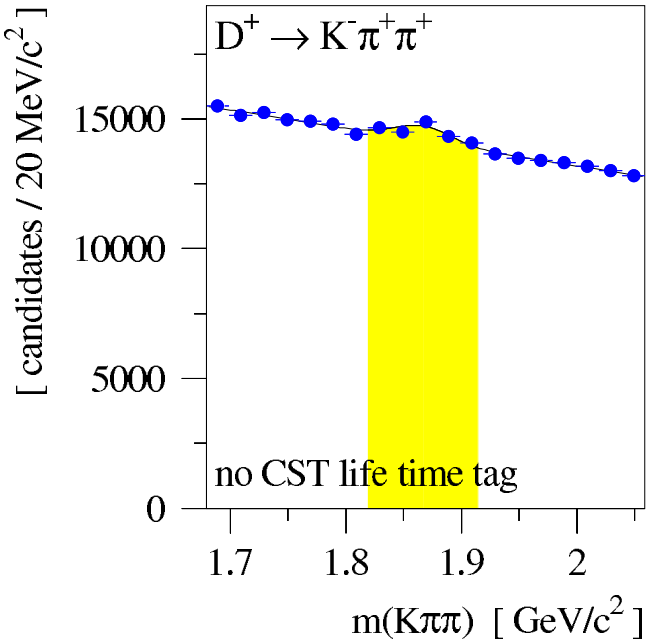
# D meson production

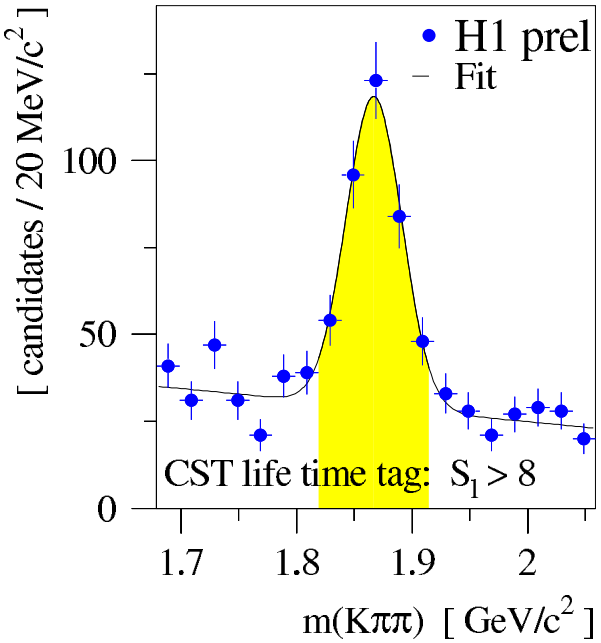



- charm production
- charm fragmentation

- improved vertex reconstruction using silicon detectors

–> lifetime tag




$D^{*+} \longrightarrow (K^- pi^+)\pi^+$
$D^0 \longrightarrow K^-\pi^+$
$D_S^+ \longrightarrow (K^+K^-)\pi^+$
$D^+ \longrightarrow K^-\pi^+\pi^+$

(first time at HERA)

# D meson production

Ratios of D cross section used to extract charm fragmentation factors and ratios

$R_{u/d} = 1.26 \pm 0.20(stat) \pm 0.13(syst) \pm 0.04(theory)$ *World average:* $1.00 \pm 0.09$

$\gamma_s = 0.36 \pm 0.10(stat) \pm 0.01(syst) \pm 0.08(theory)$ *World average:* $0.26 \pm 0.07$

$$P_V = \frac{VM}{PS+VM} = 0.693 \pm 0.045(stat) \pm 0.004(syst) \pm 0.009(theory)$$

*World average:* $0.601 \pm 0.032$

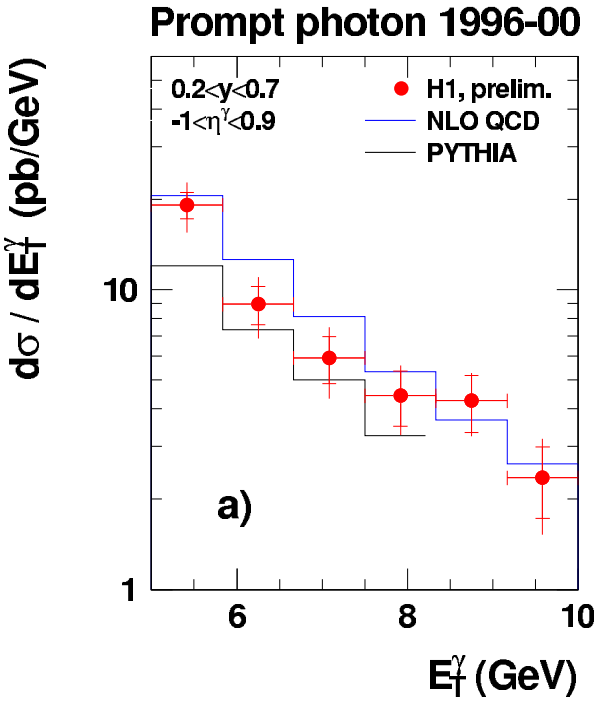
–> Errors not far from world averages

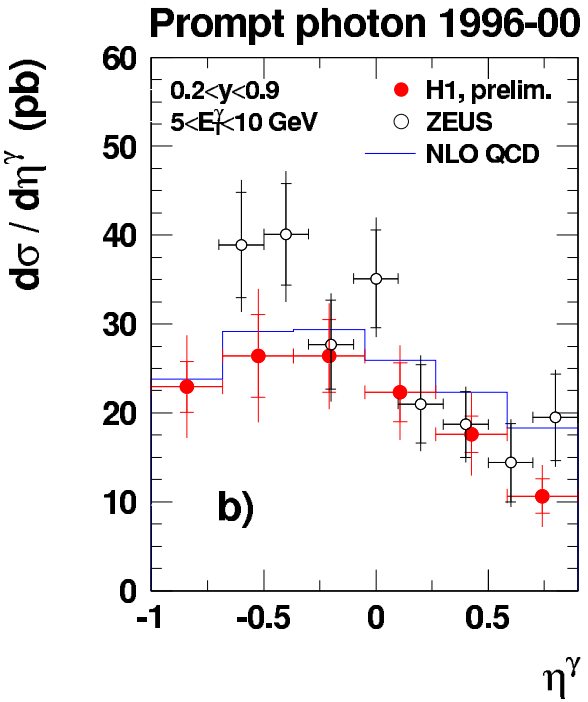
–> universality of charm fragmentation

# Prompt Photons in Photoproduction

Studying QCD without fragmentation or jet finding issues

Signal extracted by shower shape analyis

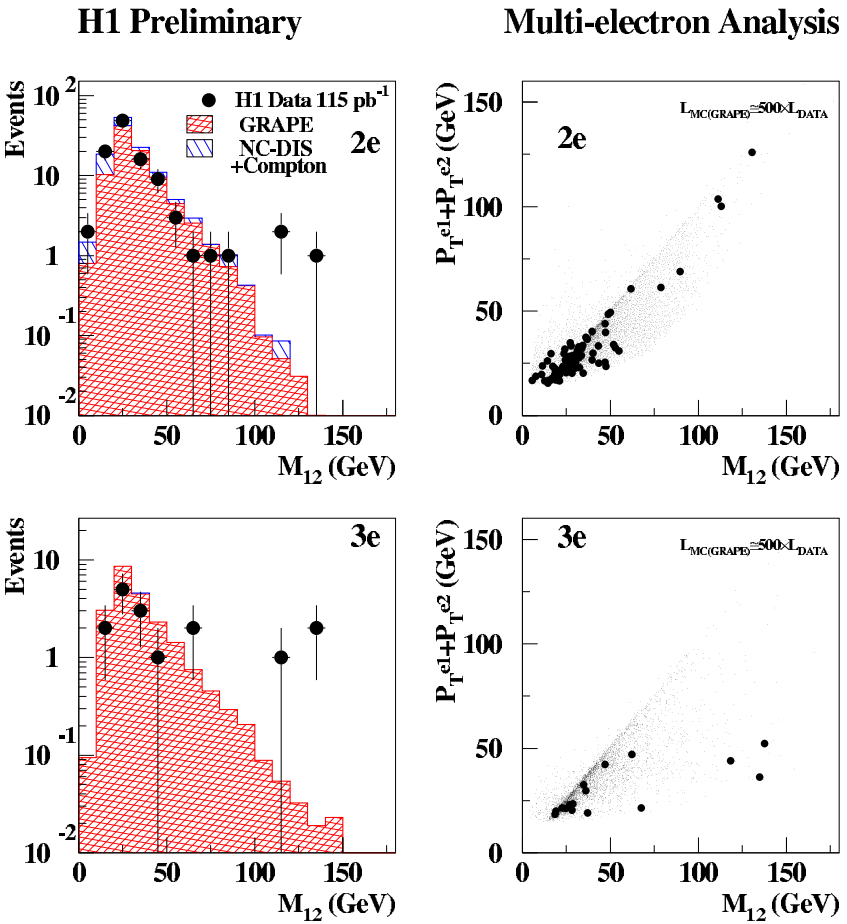


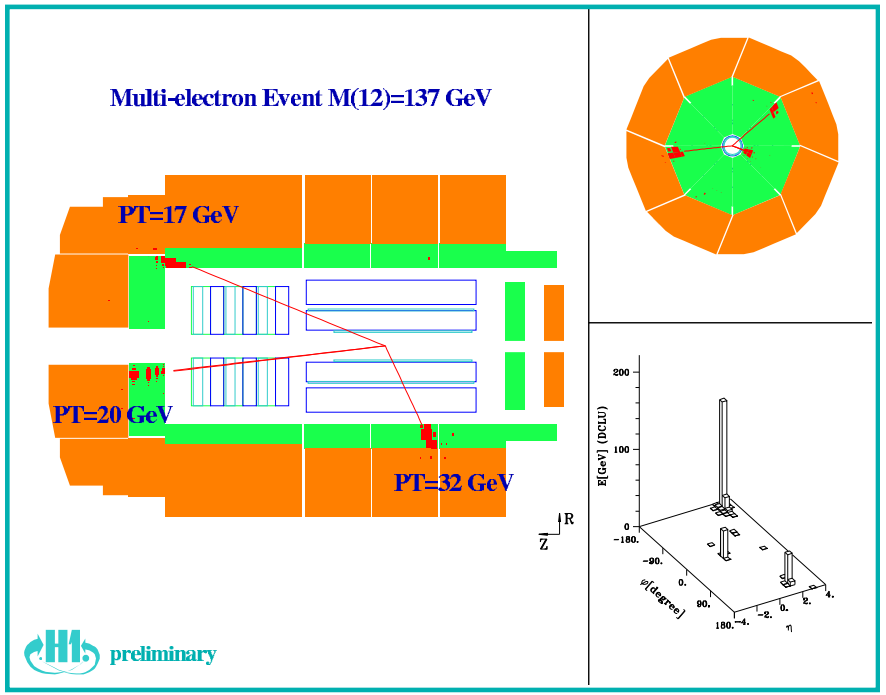




–> well in agreement with ZEUS results

–> well reproduced by NLO QCD

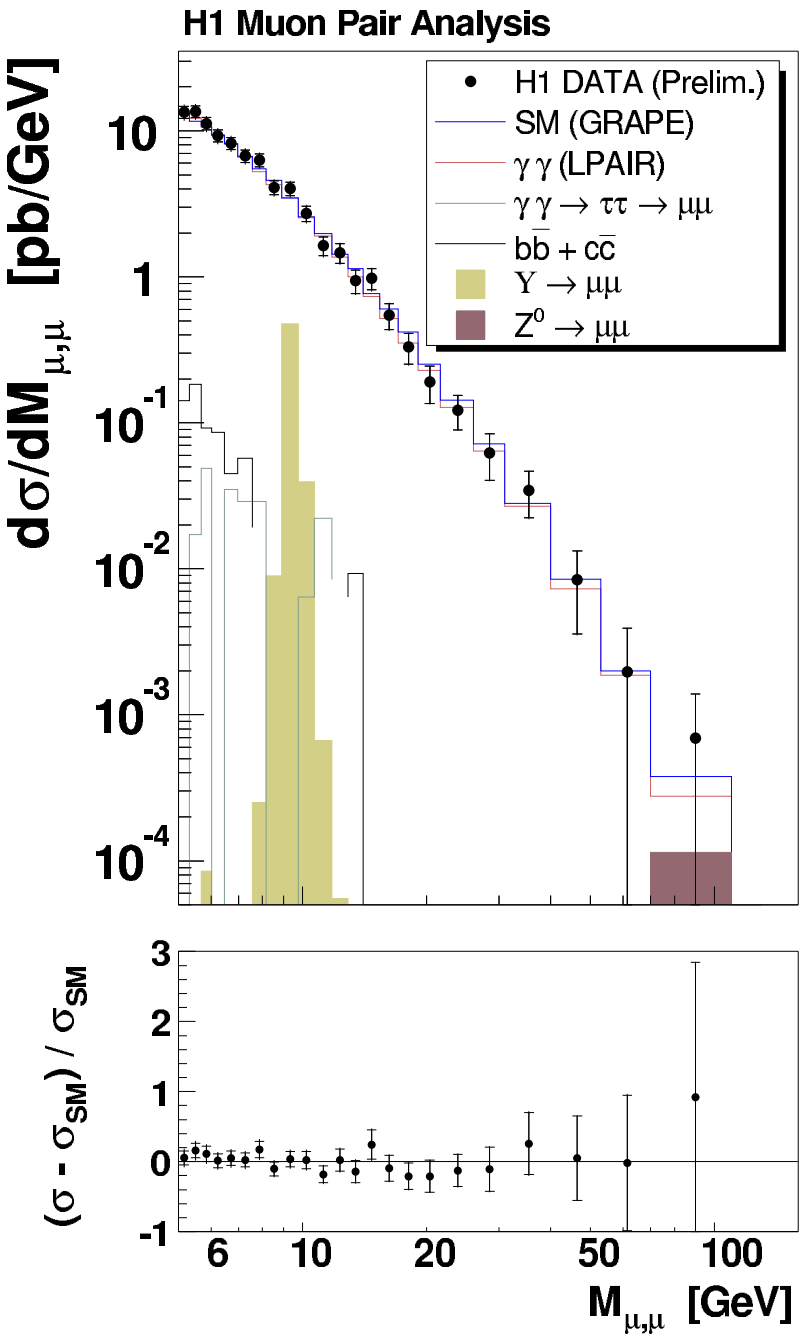
# Multi Electron Analysis




M > 100 GeV

| | Data | SM |
|---|---|---|
| 2e | 3 | 0.25 +– 0.05 |
| 3e | 3 | 0.23 +– 0.04 |




# Multi Muon Analysis

require 2 muons in central region

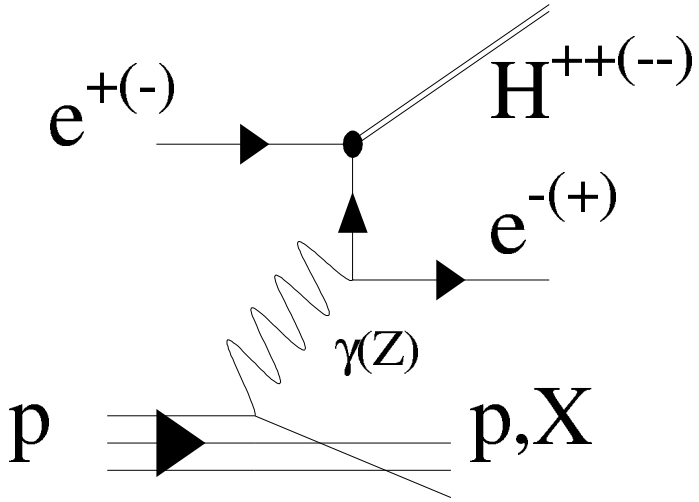
No event for: M > 100 GeV
(reduced lumi and efficiencies)

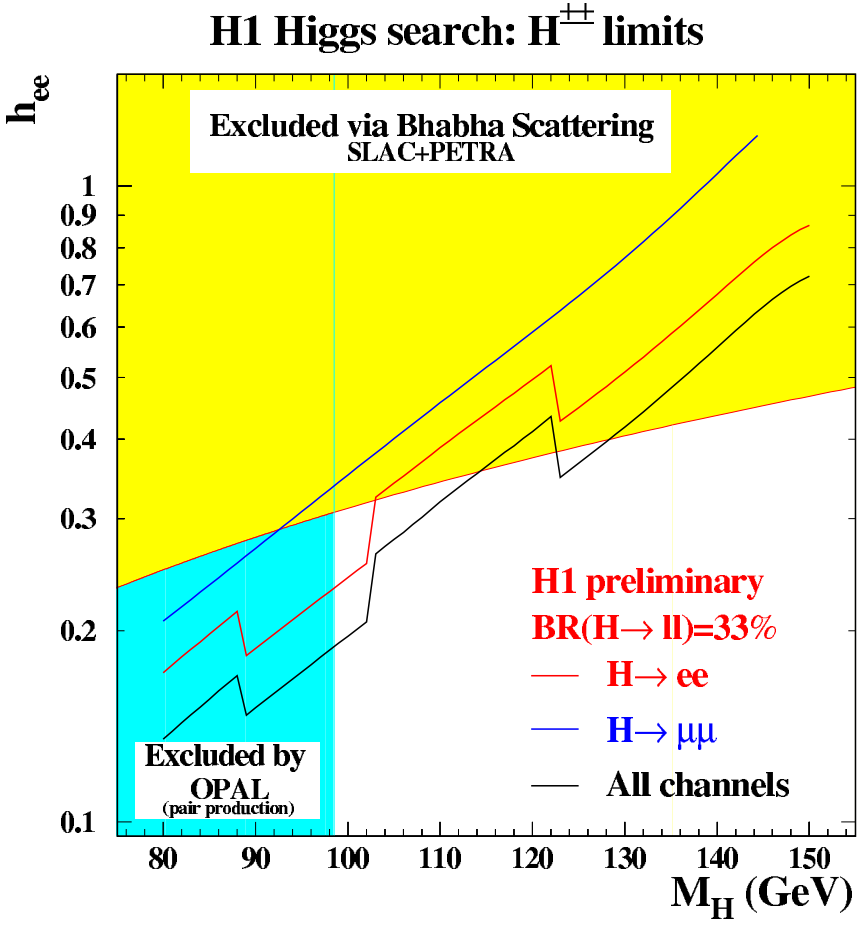
Good overall agreement with SM

Extrapolation from 2–electron events:
–> expect ~1 event with M > 100 GeV

–> not yet conclusive

# Double Charged Higgs Analysis



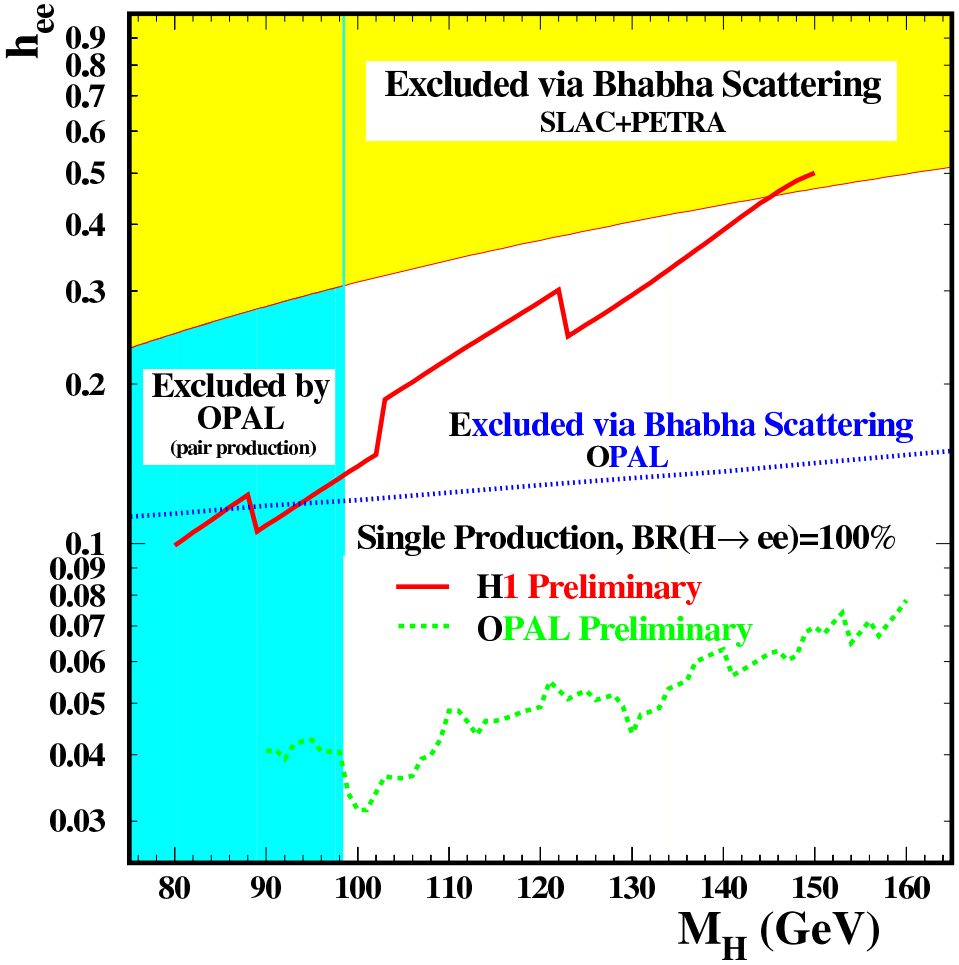




–> tighter cuts: transverse momentum charge

(reduction of background, high efficiency for double charged higgs)

–> only 1 dielectron event survives

# $H^{++}$ Experimental Results and Interpretion




- $H^{++}$ interpretation disfavoured by H1

- $H^{++}$ interpretation also disfavoured by new (more sensitive) OPAL results

→ Excess of 6 multi−electron events remains unexplained