UNIVERSITÄT DORTMUND

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H1 Collaboration

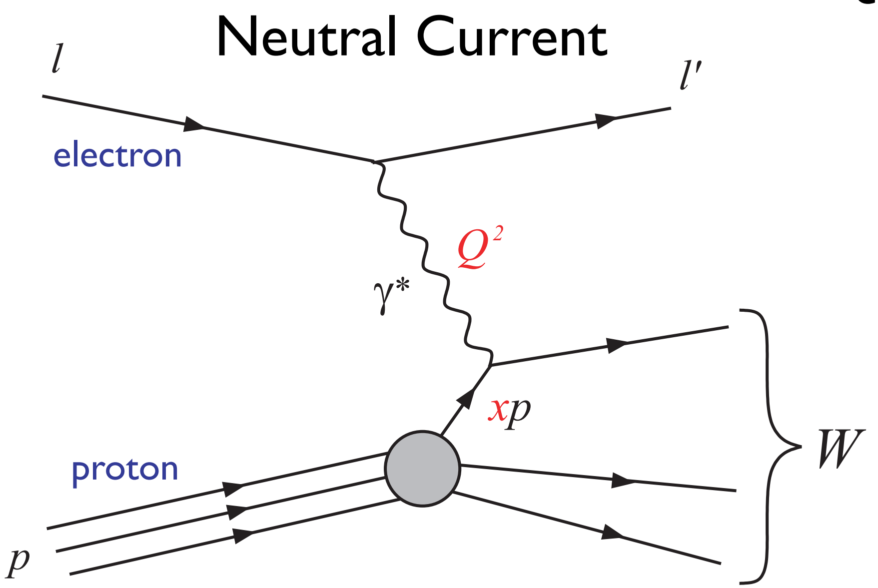
Measurements of the Proton Structure Function F_2 at Low Q^2 at HERA

- Deep Inelastic Scattering at HERA
- Initial State Radiation Events
- QED Compton Scattering

HEPP-EPS 2005

Lisbon, 21.07.05

Deep Inelastic Scattering



cms energy $\sqrt{s} = \sqrt{(l+p)^2} \approx 300/320\,\mathrm{GeV}$

Photon virtuality $Q^2 = -(l-l')^2$

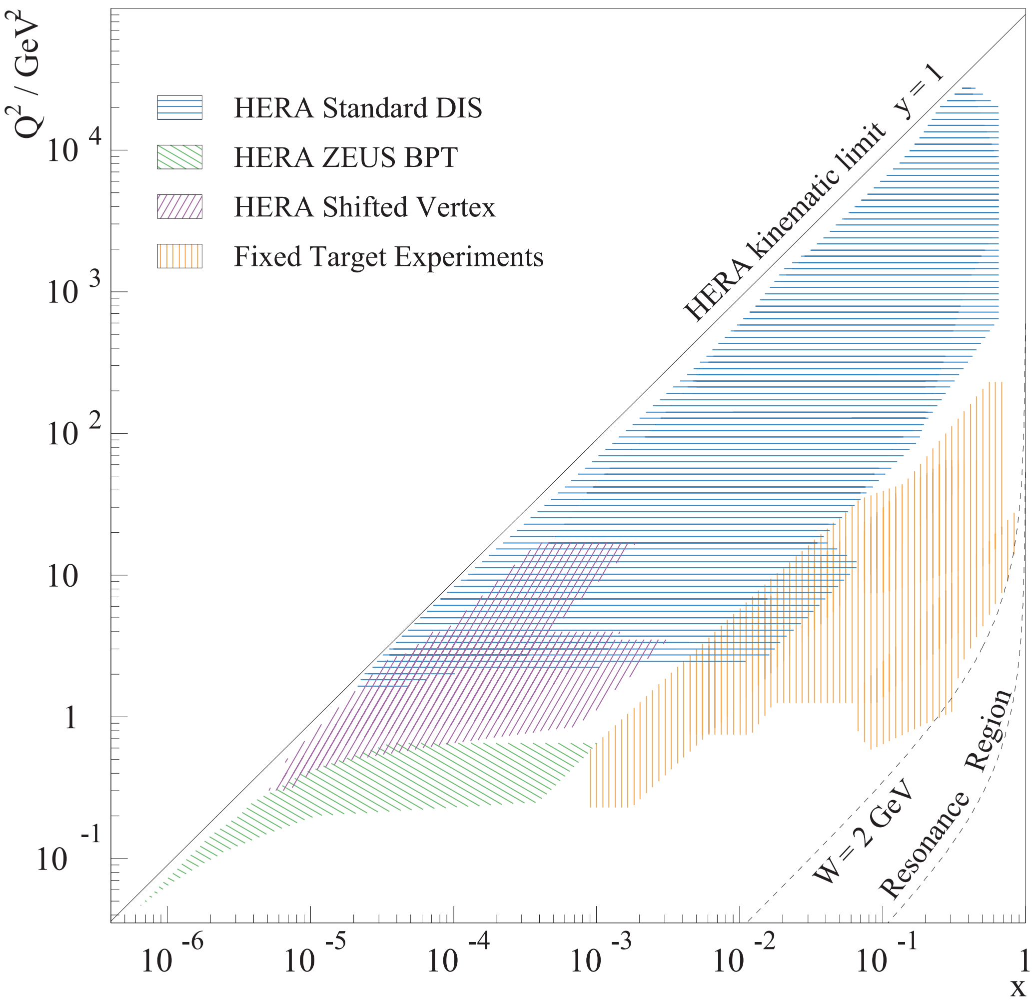
Bjorken variable $x = \dfrac{Q^2}{2p\cdot(l-l')}$

Inelasticity $y \approx \dfrac{Q^2}{xs}$

Invariant mass of the hadronic final state $W = \sqrt{Q^2\dfrac{1-x}{x} + m_p^2}$

$$\frac{\mathrm{d}^2\sigma}{\mathrm{d}x\mathrm{d}Q^2} = \frac{2\pi\alpha^2}{Q^4 x}\left(Y_+ F_2(x,Q^2) - \underbrace{y^2\cdot F_L(x,Q^2)}_{\text{negligible at low y}}\right) \qquad Y_+ = 1+(1-y)^2$$

Accessible Phase Space



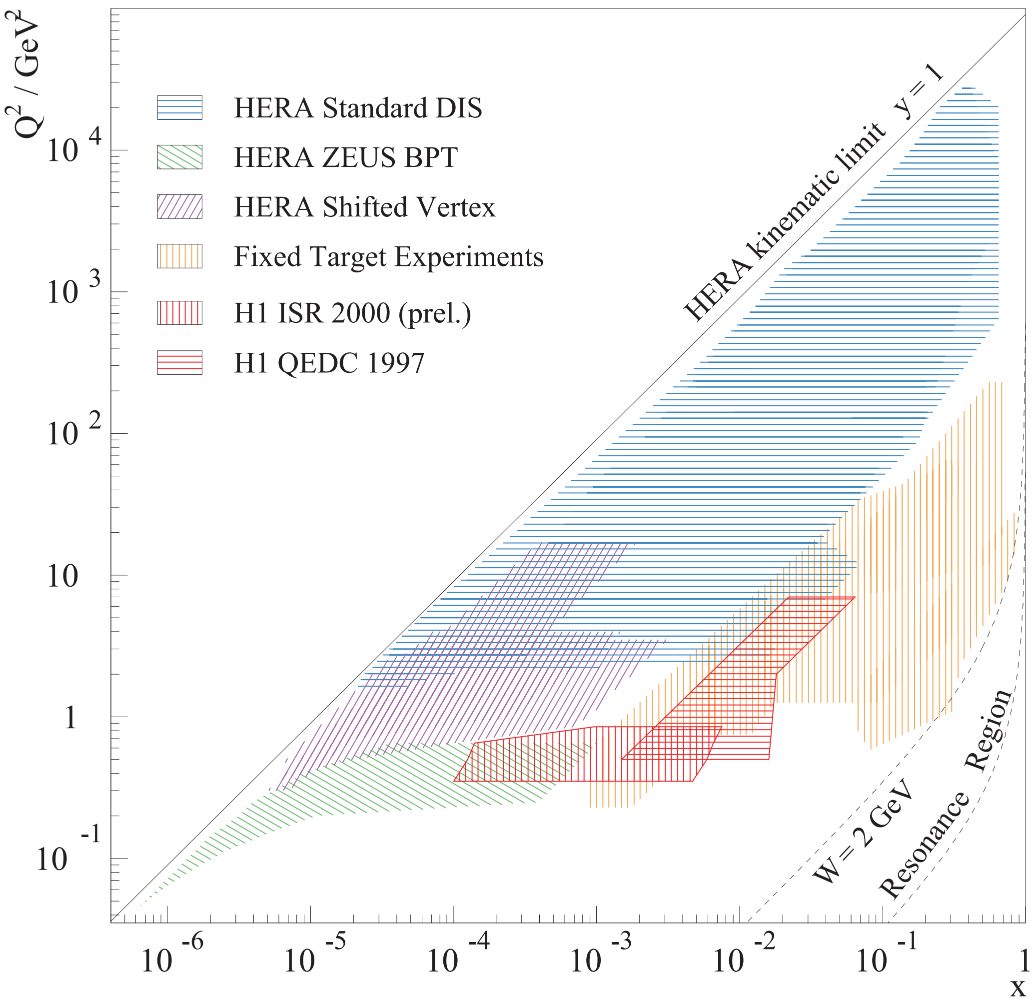
Medium - high Q^2:

- asymptotic freedom
- perturbative QCD

Low Q^2:

- transition to soft hadronic physics
- $\alpha_s(Q^2)$ becomes large
- phenomenological models

Accessible Phase Space



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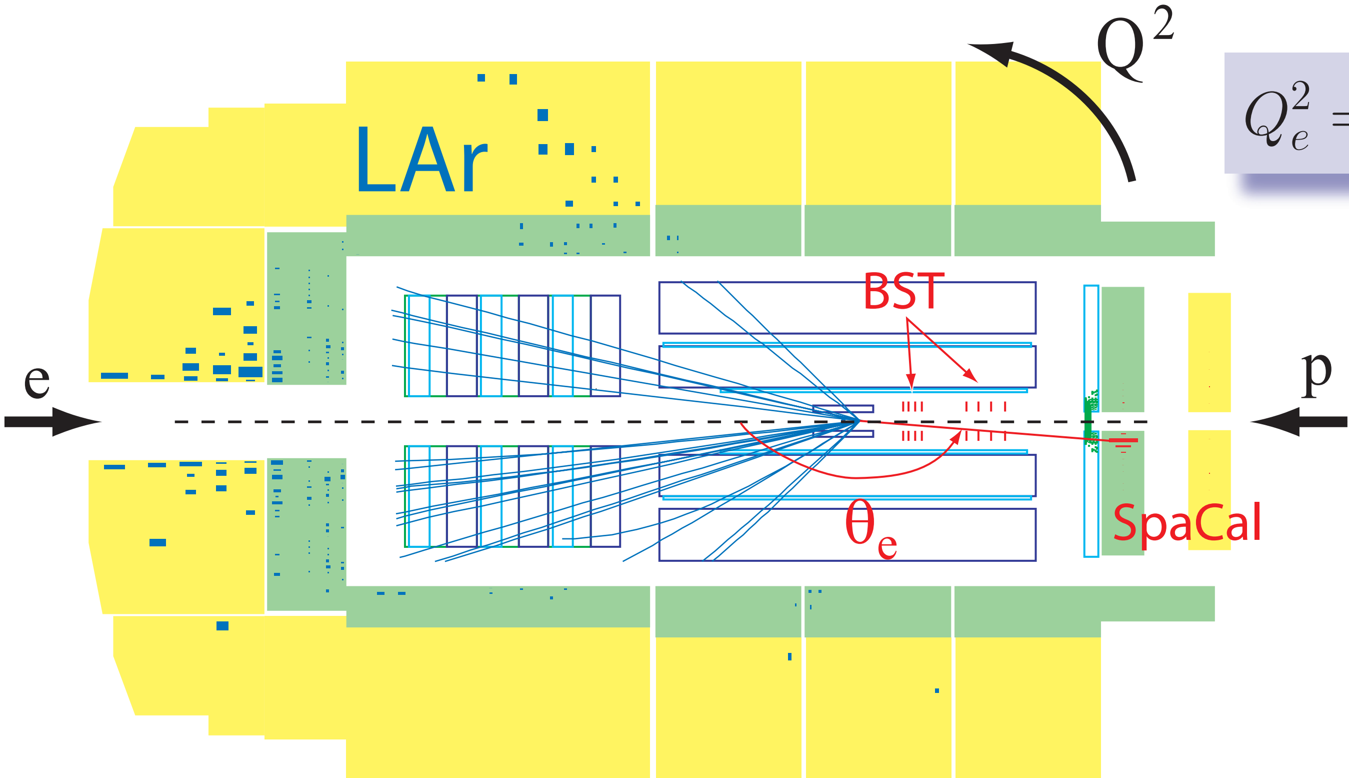
Experimental Techniques to Access Low Q^2



$$Q_e^2 = 2E_eE_e'(1+\cos\theta_e)$$

- standard DIS in main detector:

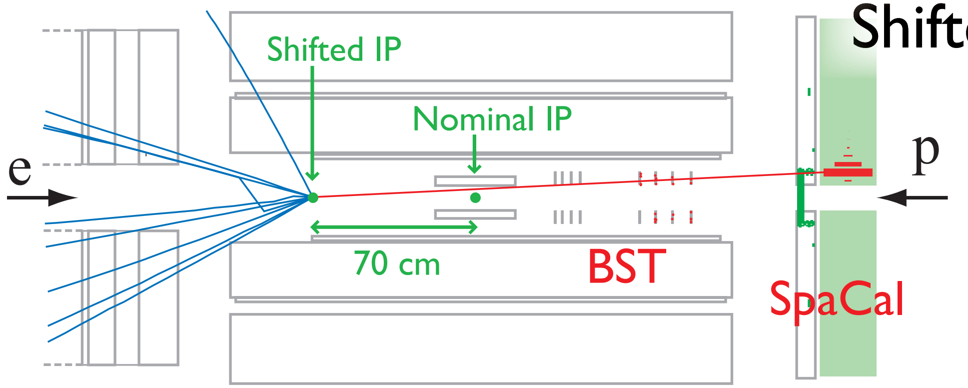
$Q^2 > 2$ GeV^2

Possibilities to access lower Q^2:

- larger polar angles
- lower initial electron energy

Experimental Techniques to Access Low Q^2

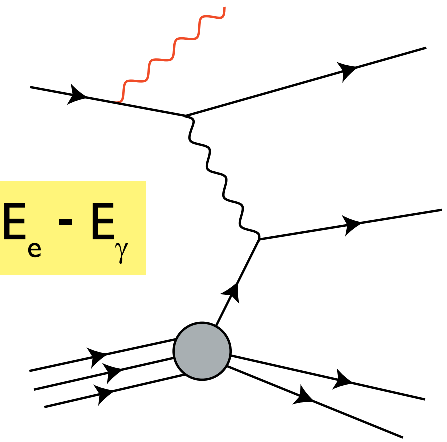
A



Shifted Vertex Runs

larger θ_e

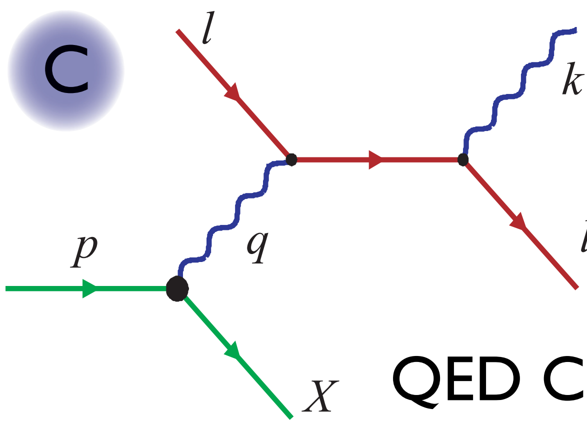
B



$E_e \rightarrow E_e - E_\gamma$

Initial State Radiation (ISR)

C



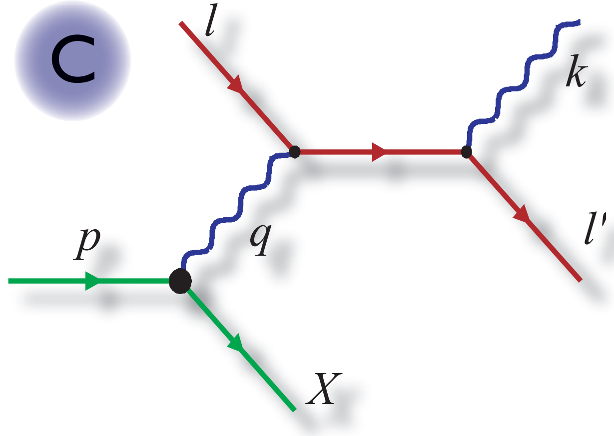
larger θ_e

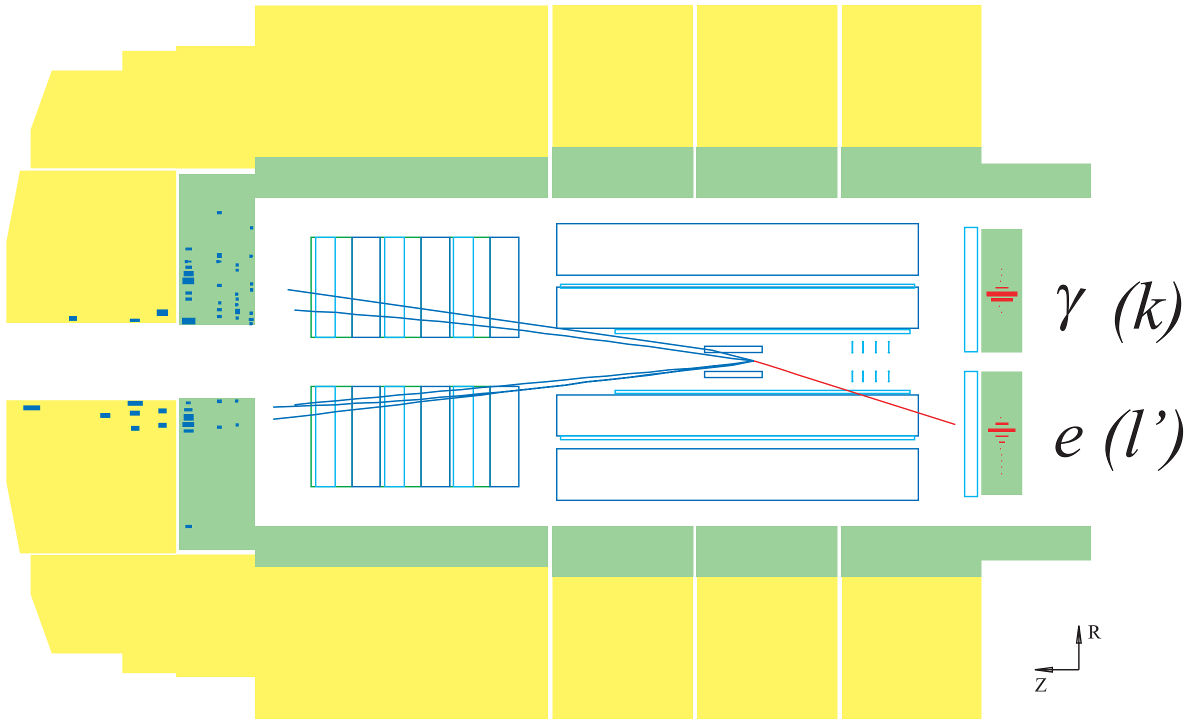
QED Compton (QEDC)

Inelastic QED Compton Events

$$e + p \rightarrow e + \gamma + X$$

C





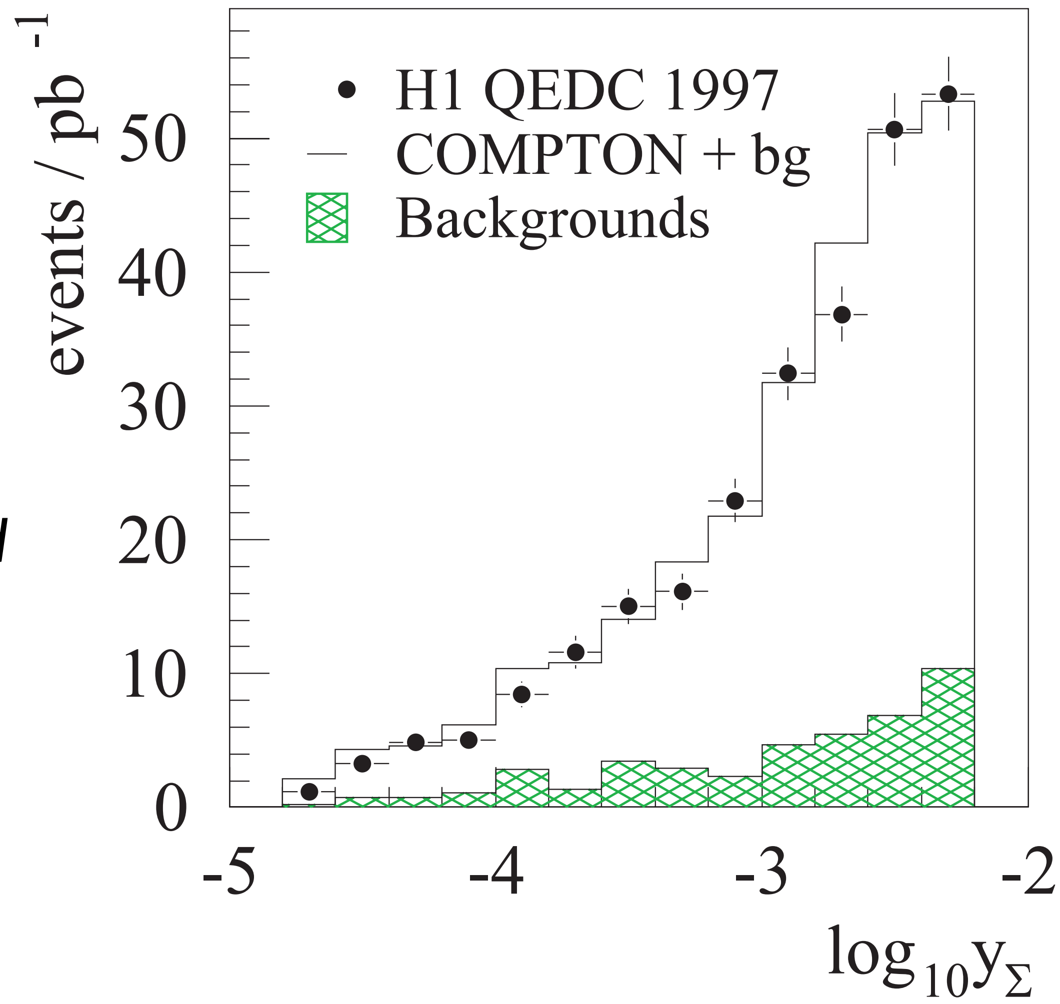
- smaller polar angle of final state e and γ
- larger polar angle of the intermediate e

$\Rightarrow$ access to low Q^2

- DIS background: - π^0 fakes QEDC γ
  - dominates QEDC signature at low x

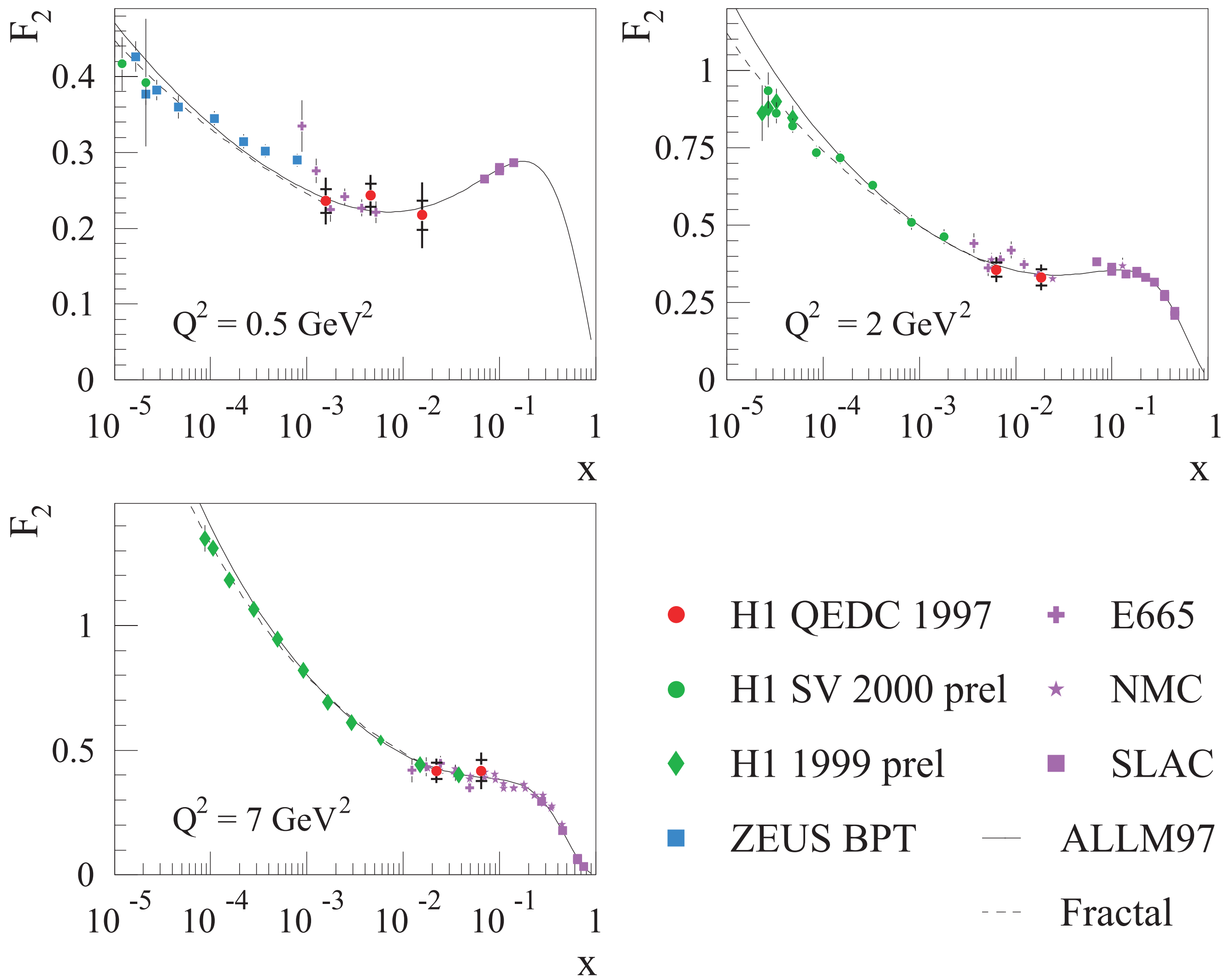
Inelastic QED Compton Events

Medium - high x are measured



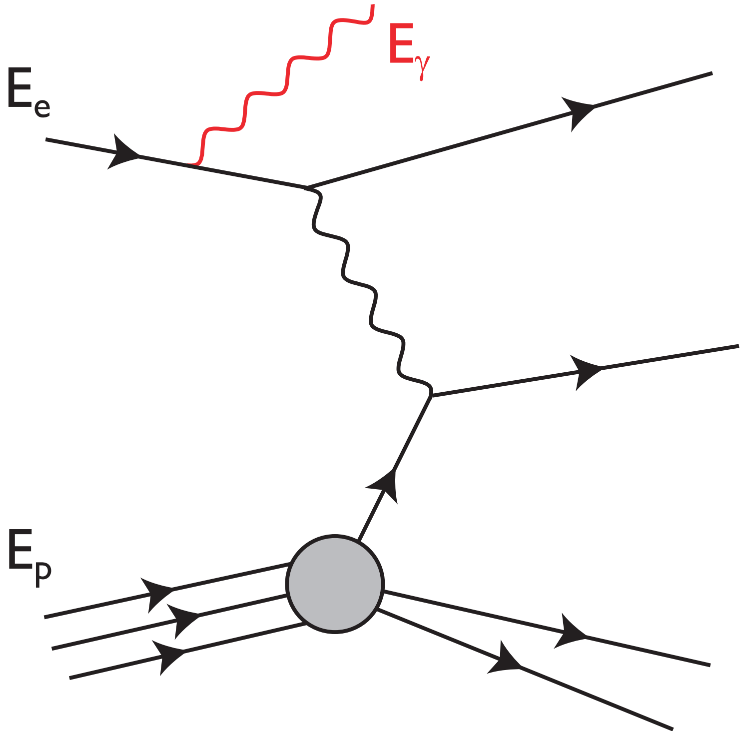
- understanding of hadronic final state at low W
- use of SOPHIA Monte Carlo model

F_2 Measurement with QEDC Events



- good agreement with fixed target experiments

Initial State Radiation (ISR)



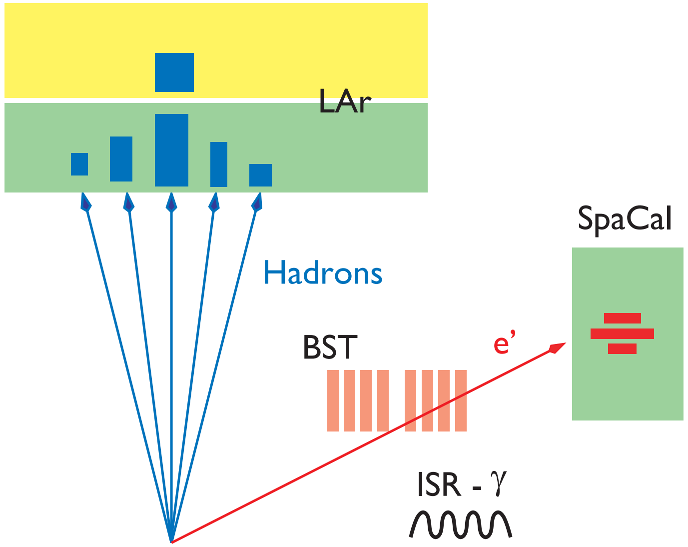
- γ is radiated from incoming e
- equivalent to inclusive DIS at reduced $s = 4(E_e - E_\gamma)E_p$
- $Q^2 = sxy$
  $\Rightarrow$ larger x at fixed Q^2

Previous ISR measurements:

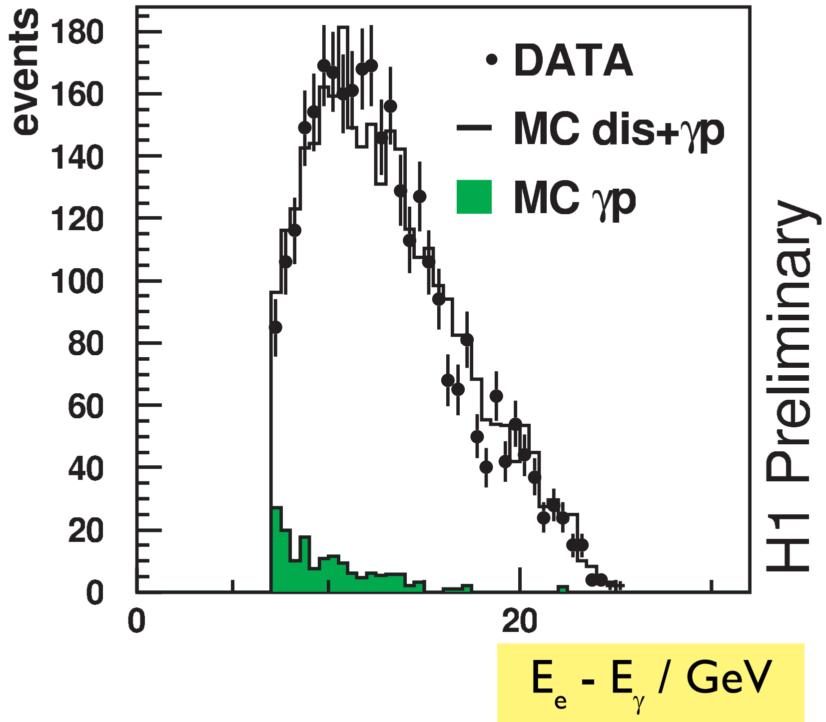
- γ directly detected

Untagged ISR in Shifted Vertex (H1)

A + B



- γ is undetected
- γp background rejected by BST

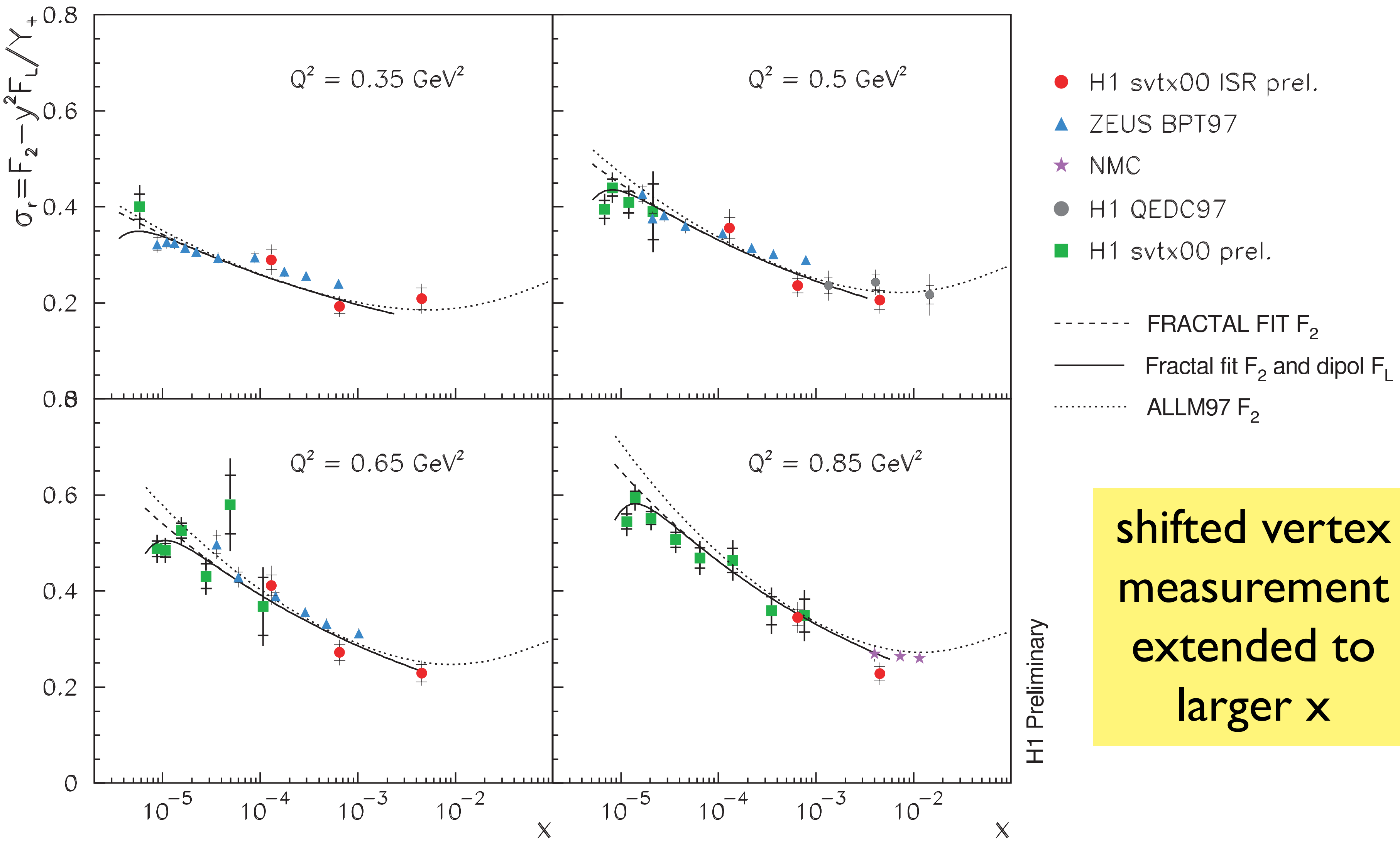


Kinematics:

- $E - p_z$ is used to determine initial electron energy

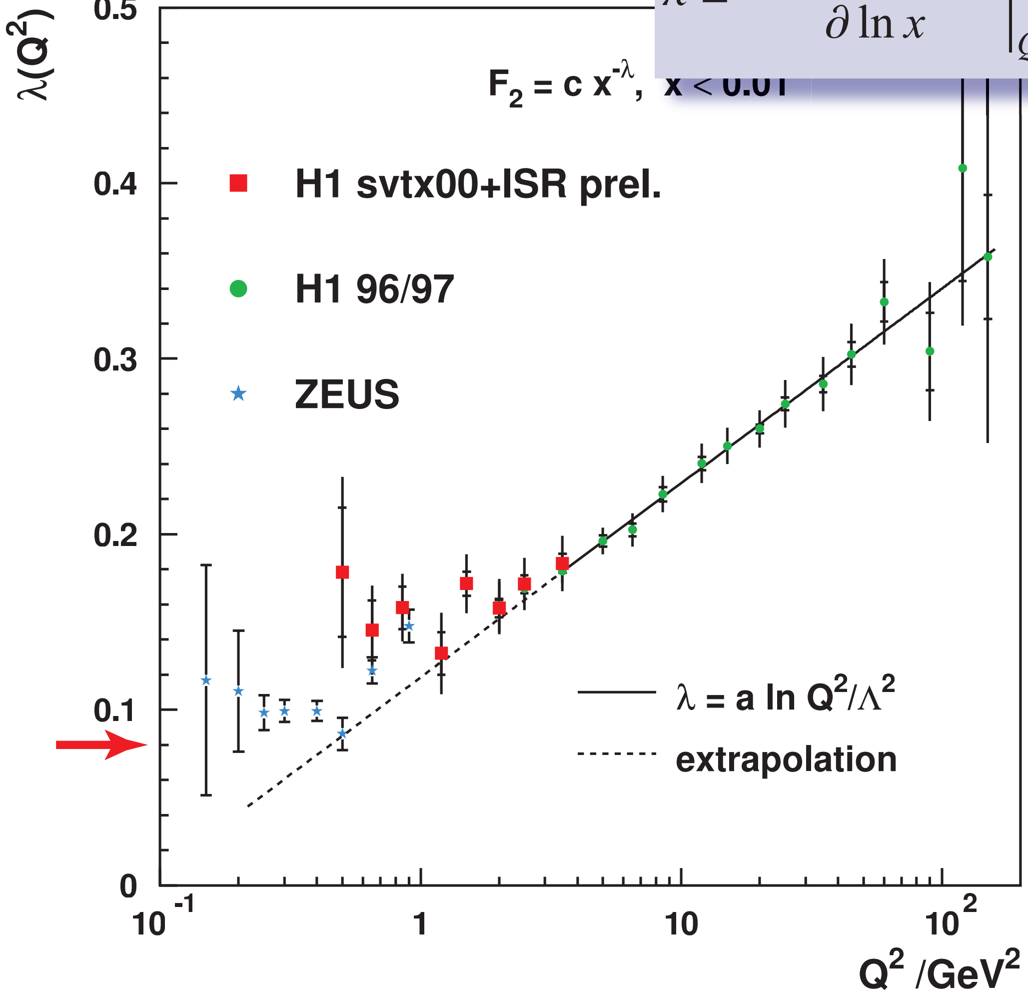
$$2(E_e - E_\gamma) = (E - p_z)_{had} + (E - p_z)_{e'}$$

F_2 in Shifted Vertex ISR



shifted vertex measurement extended to larger x

Improved Extraction of λ(Q²)



$$\lambda \equiv \left.\frac{\partial \ln F_2(x, Q^2)}{\partial \ln x}\right|_{Q^2}$$

- rise of F_2 for x < 0.01 well parameterised by:

$$F_2(x, Q^2) = c(Q^2)x^{-\lambda(Q^2)}$$

- at $Q^2 \gtrsim 3\,\mathrm{GeV}^2$:

$$\lambda \propto \ln Q^2, c \approx \mathrm{const}$$

partonic degrees of freedom

- at $Q^2 \lesssim 0.5\,\mathrm{GeV}$:

$$\lambda(Q^2) \rightarrow 0.08$$

hadronic degrees of freedom

new data cover transition region

Summary

New measurements of F_2 at low Q^2
which extend the
accessible phase space towards larger x

inelastic QEDC scattering

$$0.5 < Q^2 < 7\,\mathrm{GeV}^2$$

$$2 \cdot 10^{-3} \lesssim x \lesssim 0.1$$

- good agreement with fixed target data
- better modelling of the hadronic final state

untagged ISR in shifted vertex

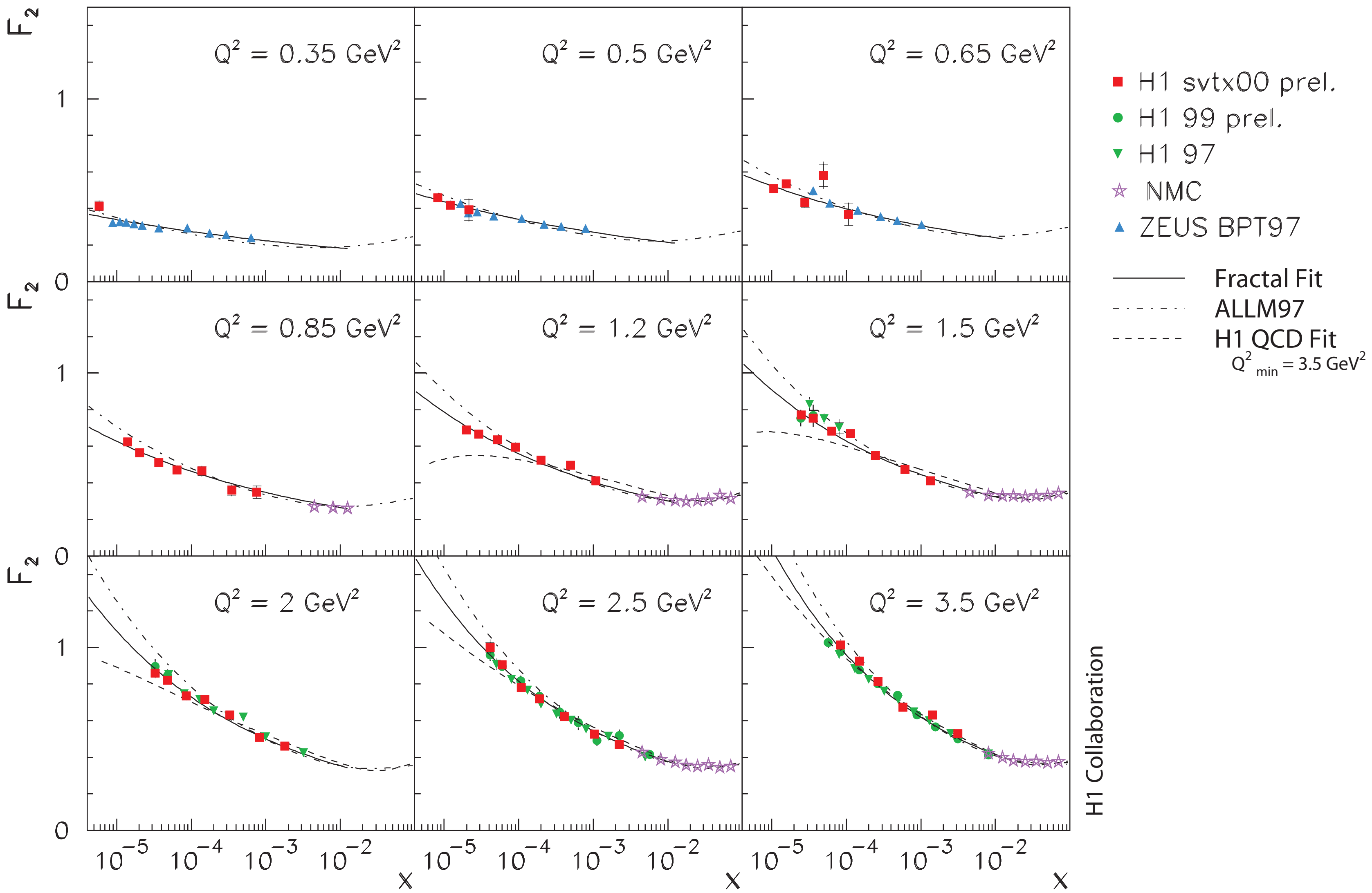
$$0.35 < Q^2 < 0.85\,\mathrm{GeV}^2$$

$$10^{-4} \lesssim x \lesssim 5 \cdot 10^{-3}$$

- improved extraction of $\lambda(Q^2)$

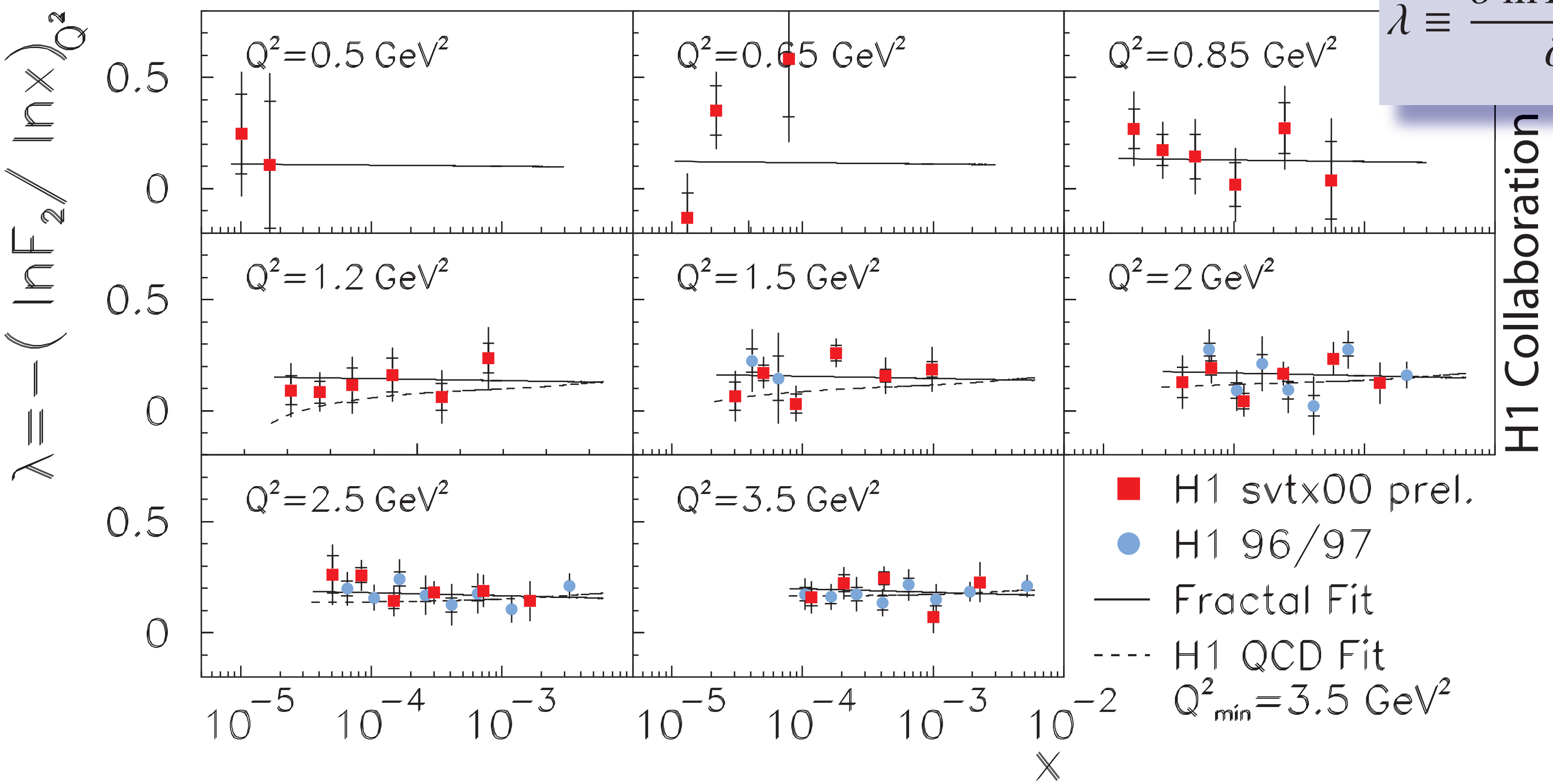
Backup Transparencies

Previous Results at low Q^2



Rise of F_2 at Low x

$$\lambda \equiv \left. \frac{\partial \ln F_2(x,Q^2)}{\partial \ln x} \right|_{Q^2}$$



- derivative independent of x for x < 0.01
- rise of F_2 well parameterised by

$$F_2(x,Q^2) = c(Q^2)x^{-\lambda(Q^2)}$$