Measurement of F_2 at low Q^2 using QED Compton Scattering at HERA

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DESY
H1 Collaboration

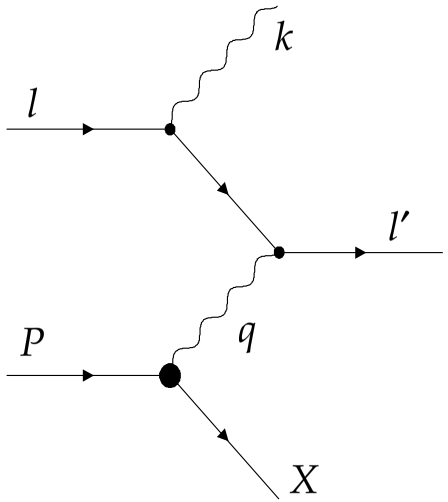
- Motivation
- Peculiarities of data analysis
- Results of F_2 measurement
- Summary

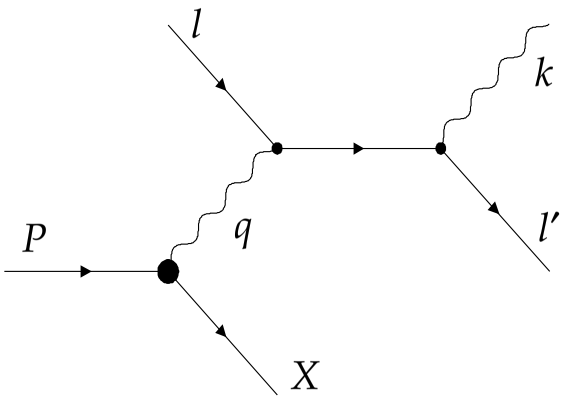
Workshop DIS 2003

St. Petersburg, April 2003

Radiative ep Scattering

$$e + p \longrightarrow e + \gamma + X$$





- Bethe – Heitler : $\vec{k} \parallel \vec{l} \parallel \vec{l'}$
  $\Longrightarrow$ Luminosity measurement

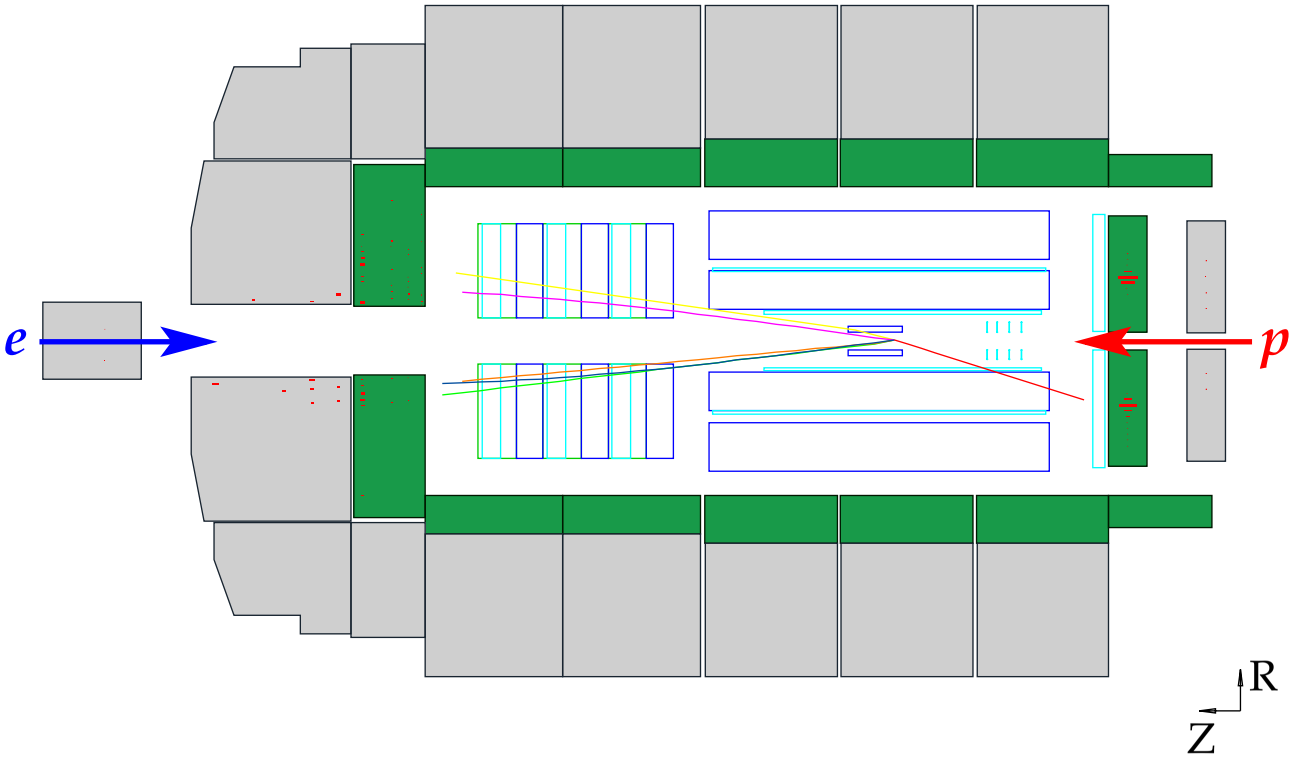
- Radiative Corrections to DIS :
  $\vec{k} \parallel \vec{l}$ — Initial State Radiation (ISR)
  $\vec{k} \parallel \vec{l'}$ — Final State Radiation (FSR)

- QED Compton : $q^2 \sim 0 \iff \vec{q} \parallel \vec{P}$
  Compton scattering of a quasi-real photon off an electron

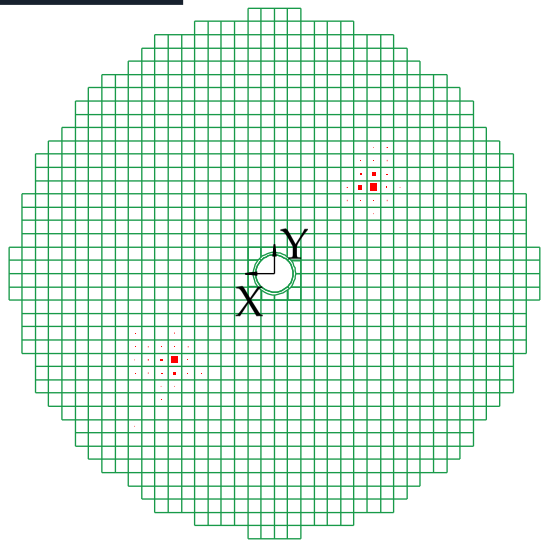
QEDC-Event in H1-Detector

Run range: 1997 $L = 9.25\,\mathrm{pb}^{-1}$

Beam energies: $E_e = 27.6\,\mathrm{GeV}$ $E_p = 820\,\mathrm{GeV}$

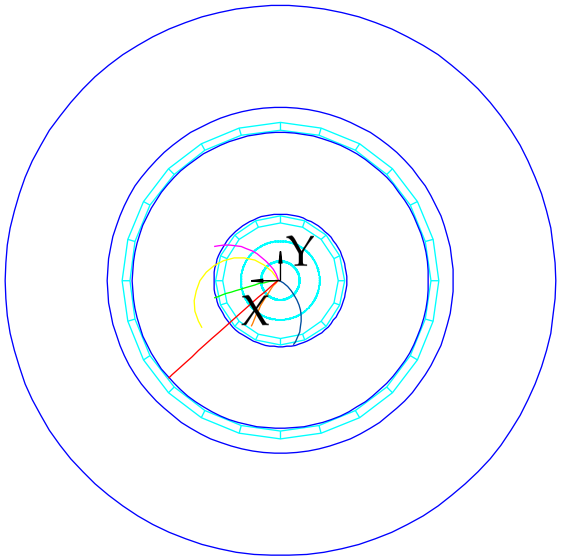


H1 Main Detector – side view



E.m. SpaCal – front view

Central Tracking Chambers



Contributions to QEDC Cross Section

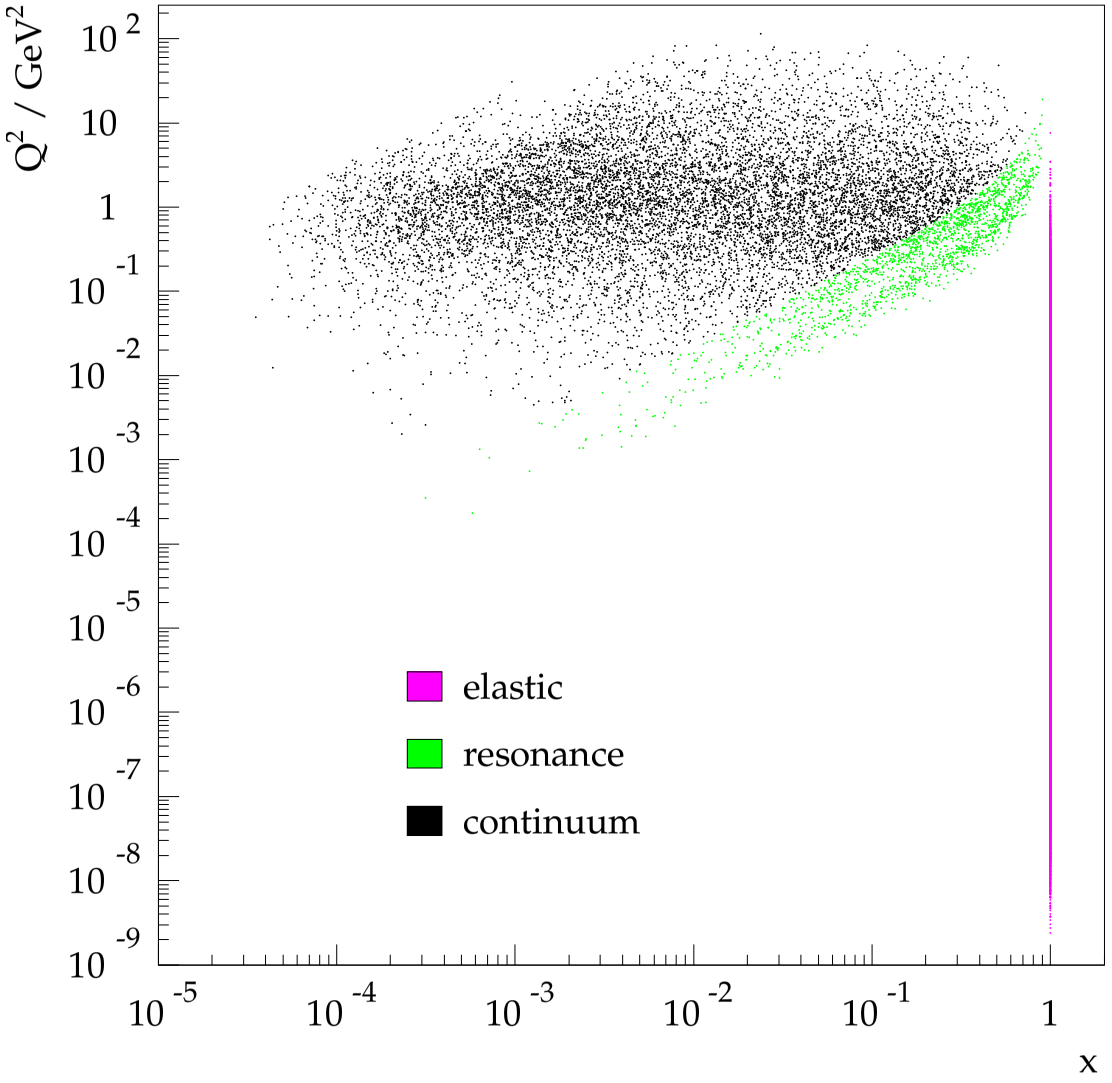
No acceptance limitations at low Q^2!

MC COMPTON 2.1

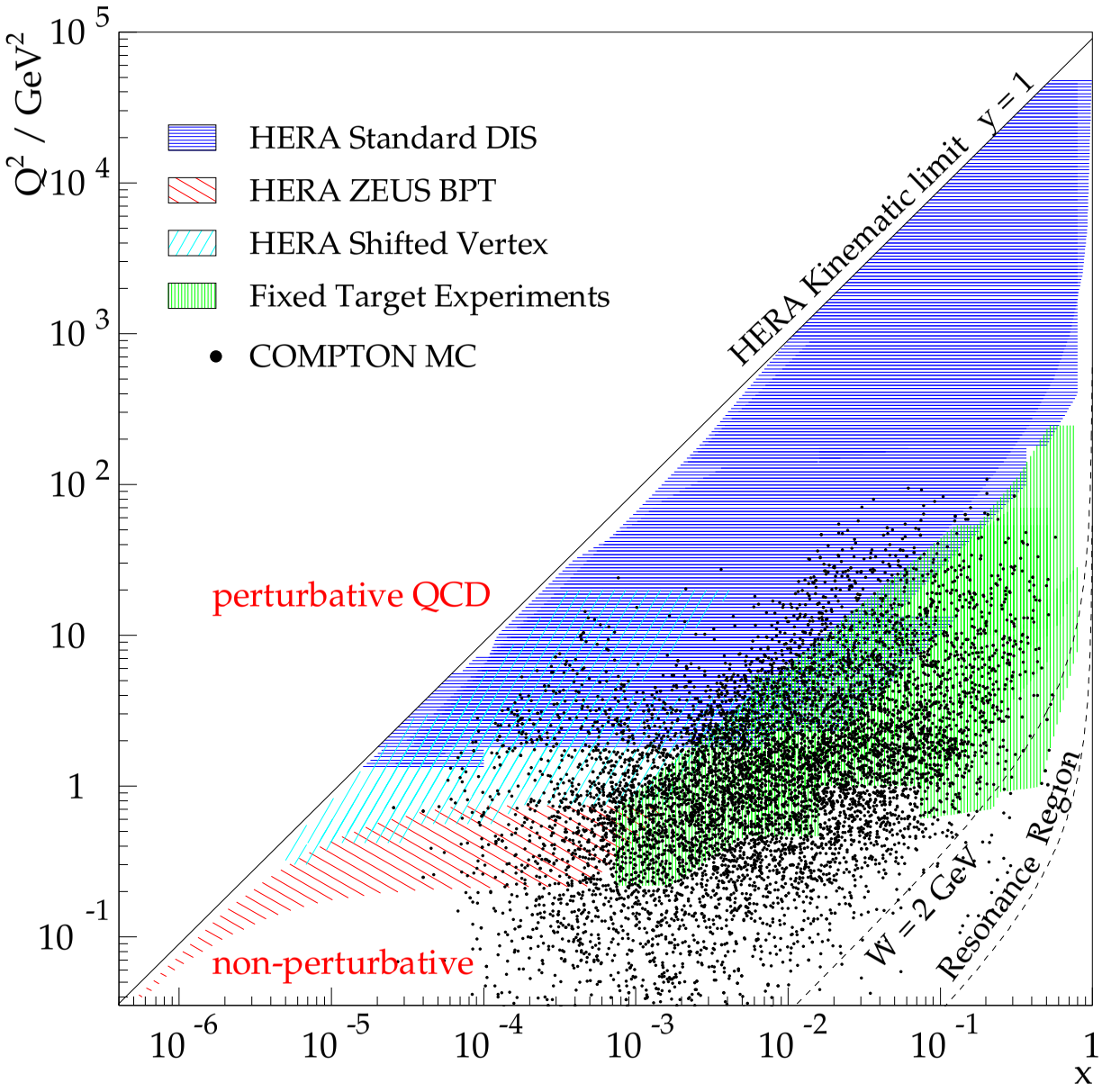
(Better F_2 parameterisations)

$$W^2 = Q^2 \frac{1-x}{x} + m_p^2$$

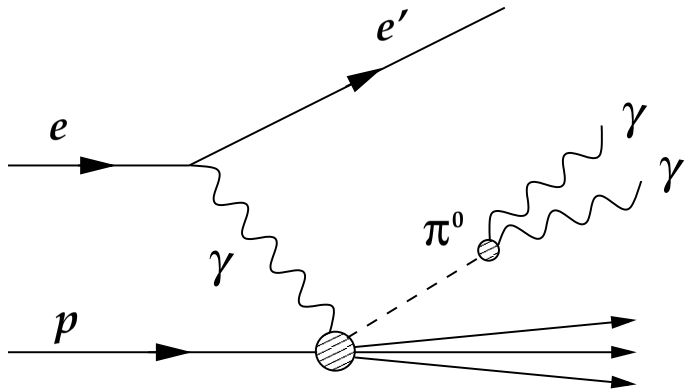
- Elastic : $W = m_p$ (Bethe–Heitler)
  σ_{el} *very well known* (form factors)
  $\Longrightarrow$ systematic studies
- Resonance : $m_p + m_\pi < W < 2\,\text{GeV}$
  $\Delta(1236), N^*(1520), N^*(1680) \ldots$
  σ_{res} *well known, relatively small*
- Continuum Inelastic : $W > 2\,\text{GeV}$
  $\sigma_{\text{in}} \sim F_2$ *at small* Q^2
  in transition region DIS — γp

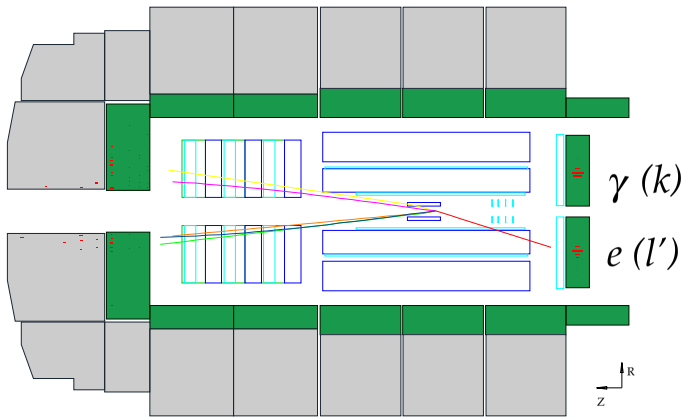


Kinematic Region of Inelastic QEDC



DIS background at low x





Only medium – high x can be measured

x and Q^2 Reconstruction

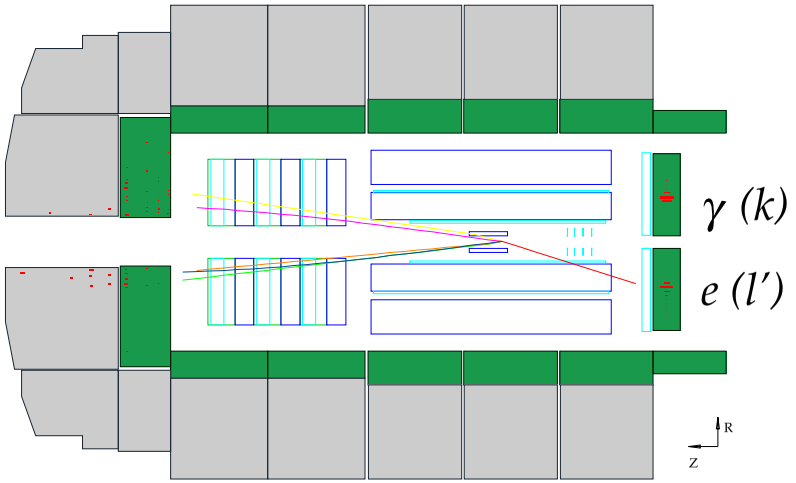
- Using e and γ: $Q^2 = -(l - l' - k)^2 \ldots$

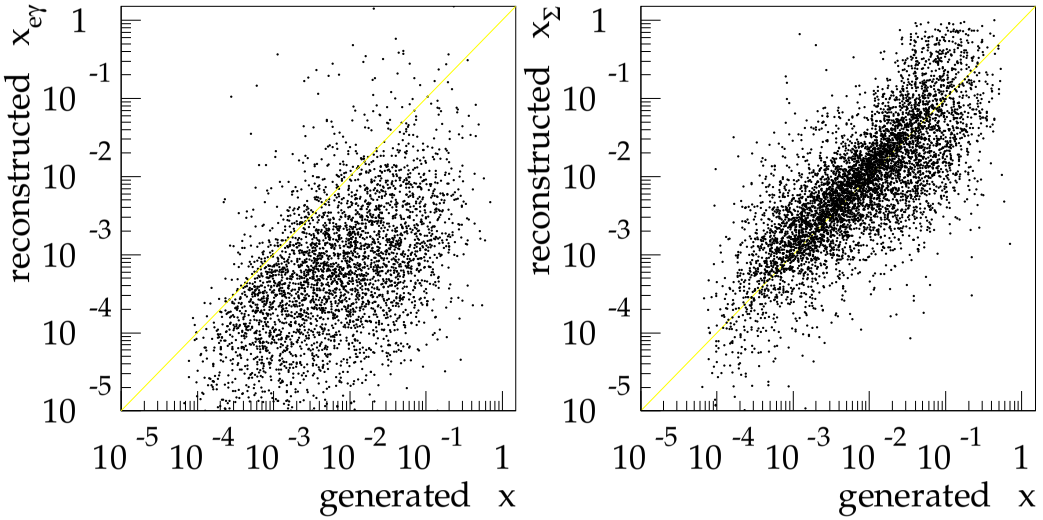
or

- Sigma method at low y

  x and y using hadronic final state:

$$\Sigma = \sum_{i=1}^{N_h} (E_i - p_{z,i})$$





Hadronic final state in COMPTON 2.1

- Low W – problems with Lund MC
  Low Q^2 – no pQCD
  3 special models at low W or low Q^2
  DIFFVM or EPSOFT or SOPHIA
- QPM + PYTHIA
  at high W and high Q^2

SOPHIA Model

Simulations Of PhotoHadronic processes In Astrophysics

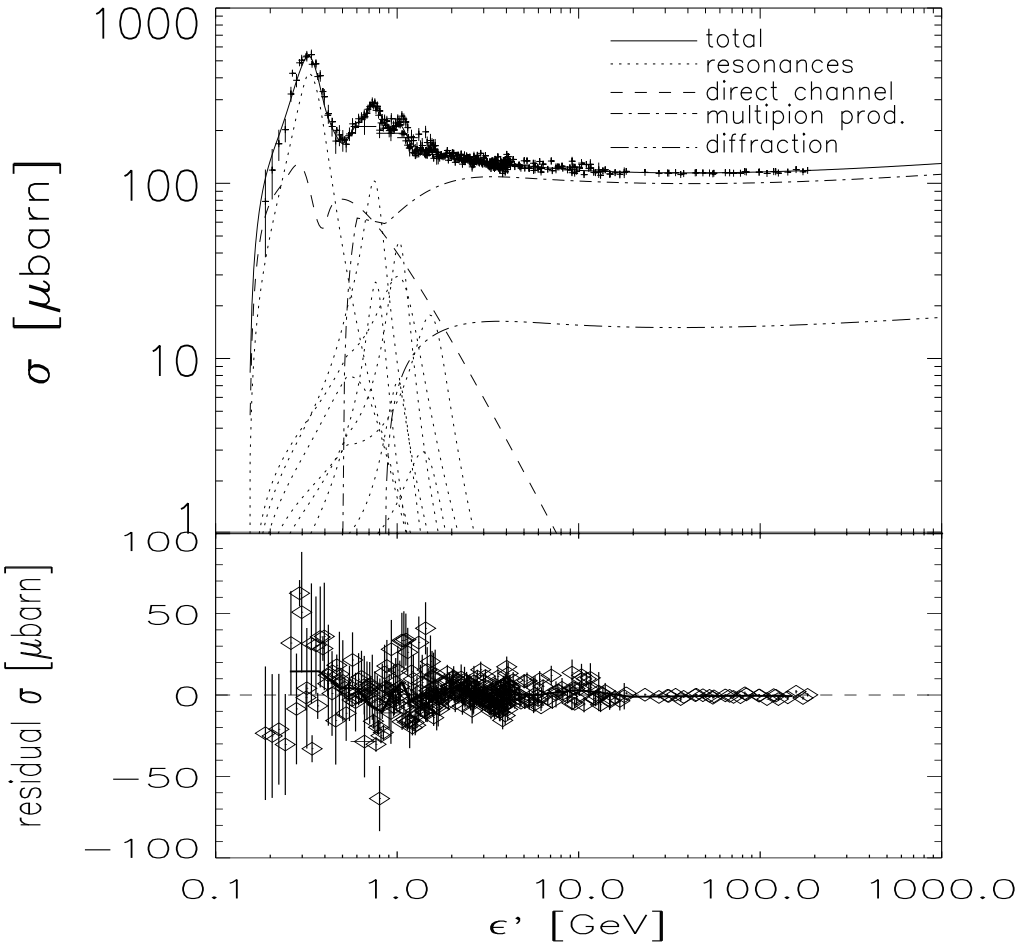
(A. MÜCKE, R. ENGEL, J. P. RACHEN, R. J. PROTHEROE, T. STANEV)

includes large set of experimental data:

- resonance production
- direct pion production
- diffractive vector meson production
- multiparticle production based on Dual Parton Model + tuned JETSET/PYTHIA

DPM – also part of PHOJET

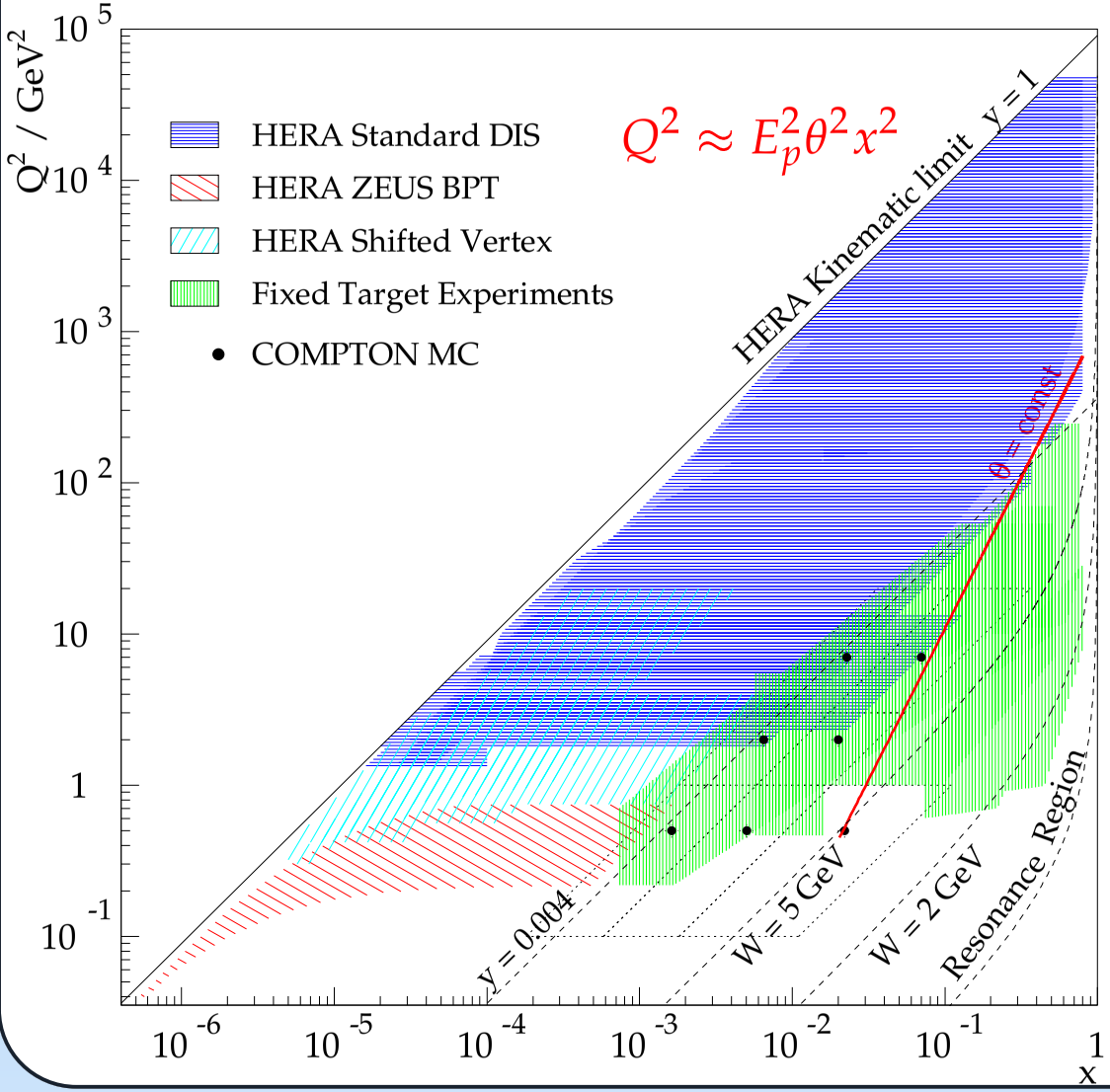
SOPHIA – also in GRAPE dilepton MC

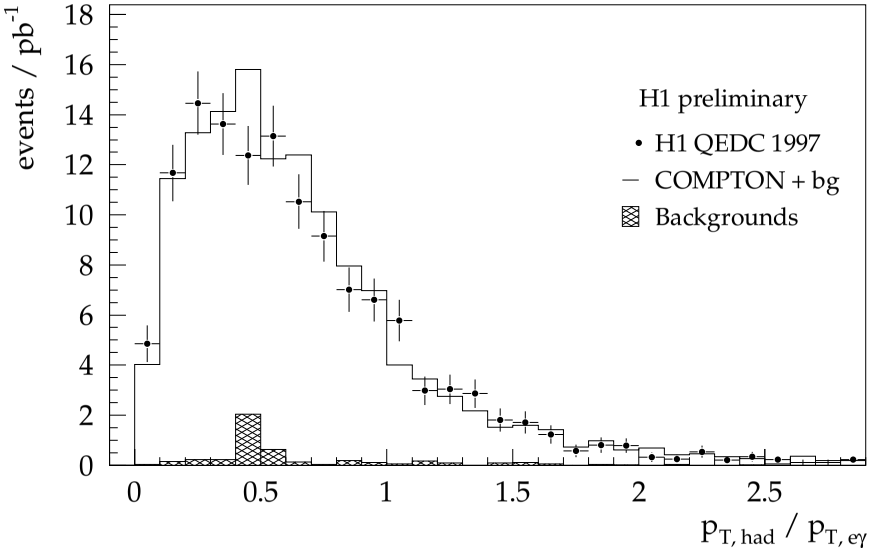


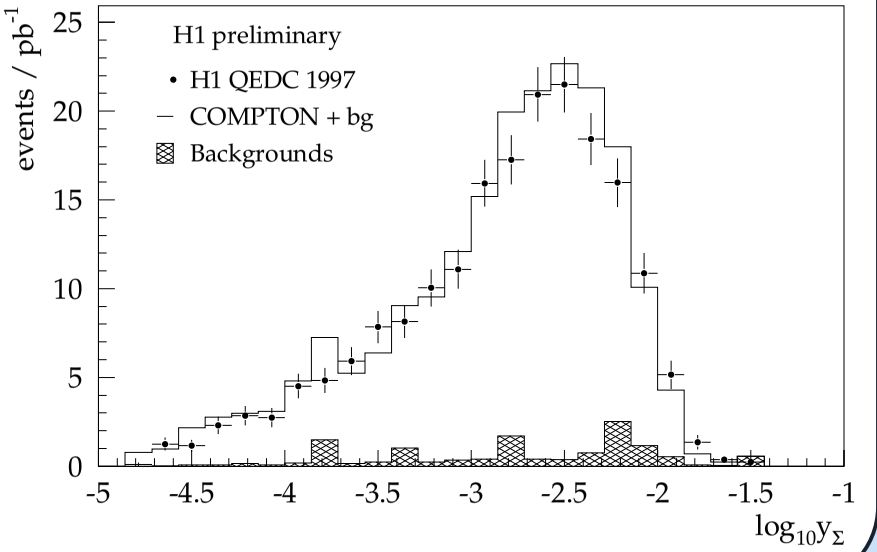
Calorimeter Acceptance

$$y = \frac{(E - P_z)_{\text{had}}}{2E_{0e}} = \frac{E(1-\cos\theta)_{\text{had}}}{2E_{0e}} \sim E\theta^2_{\text{had}} \qquad Q^2 = \frac{p_t^2}{1-y} \approx p_t^2 \approx E^2\theta^2_{\text{had}}$$

At const θ_{had}: lower $Q^2 \Longleftrightarrow$ lower y (lower W)

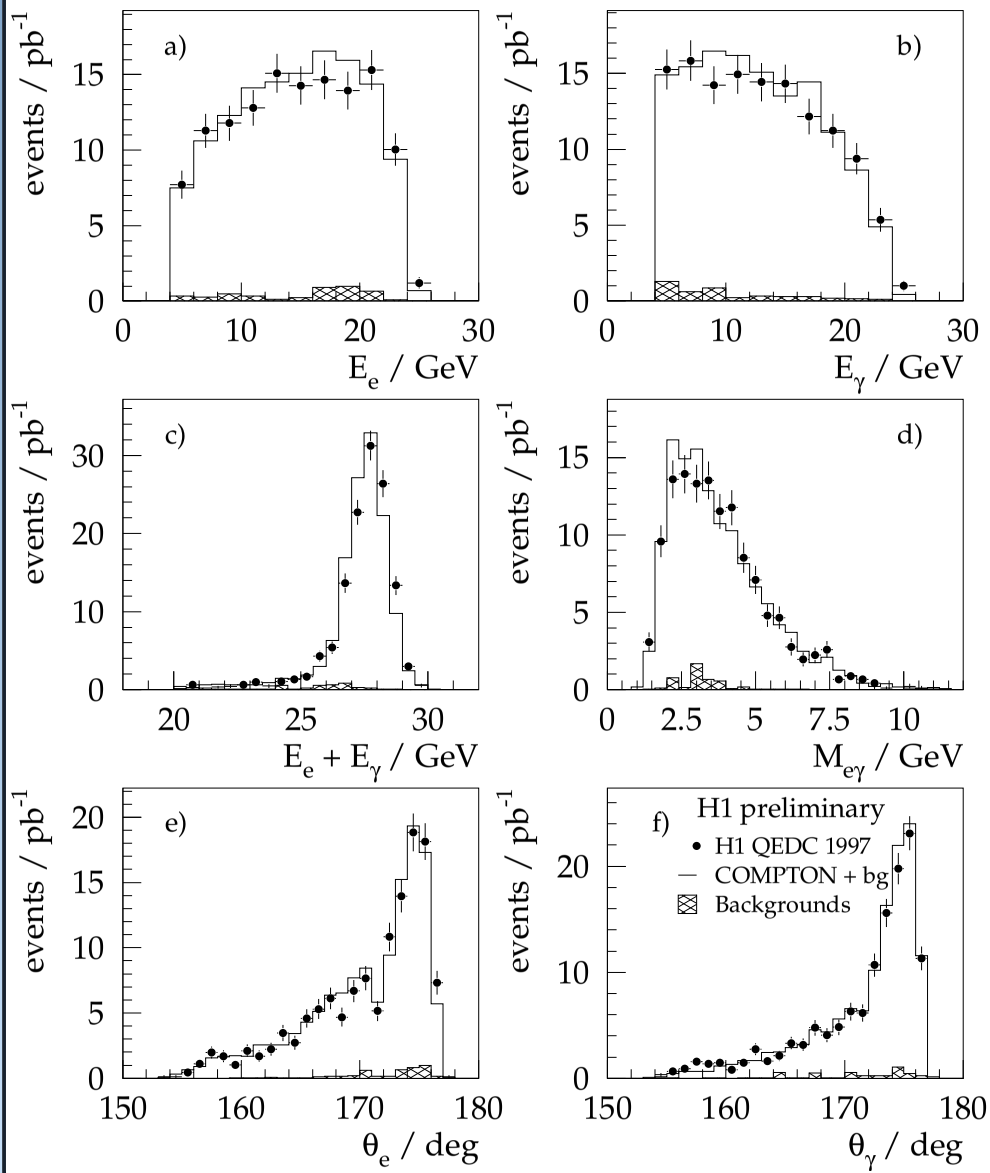




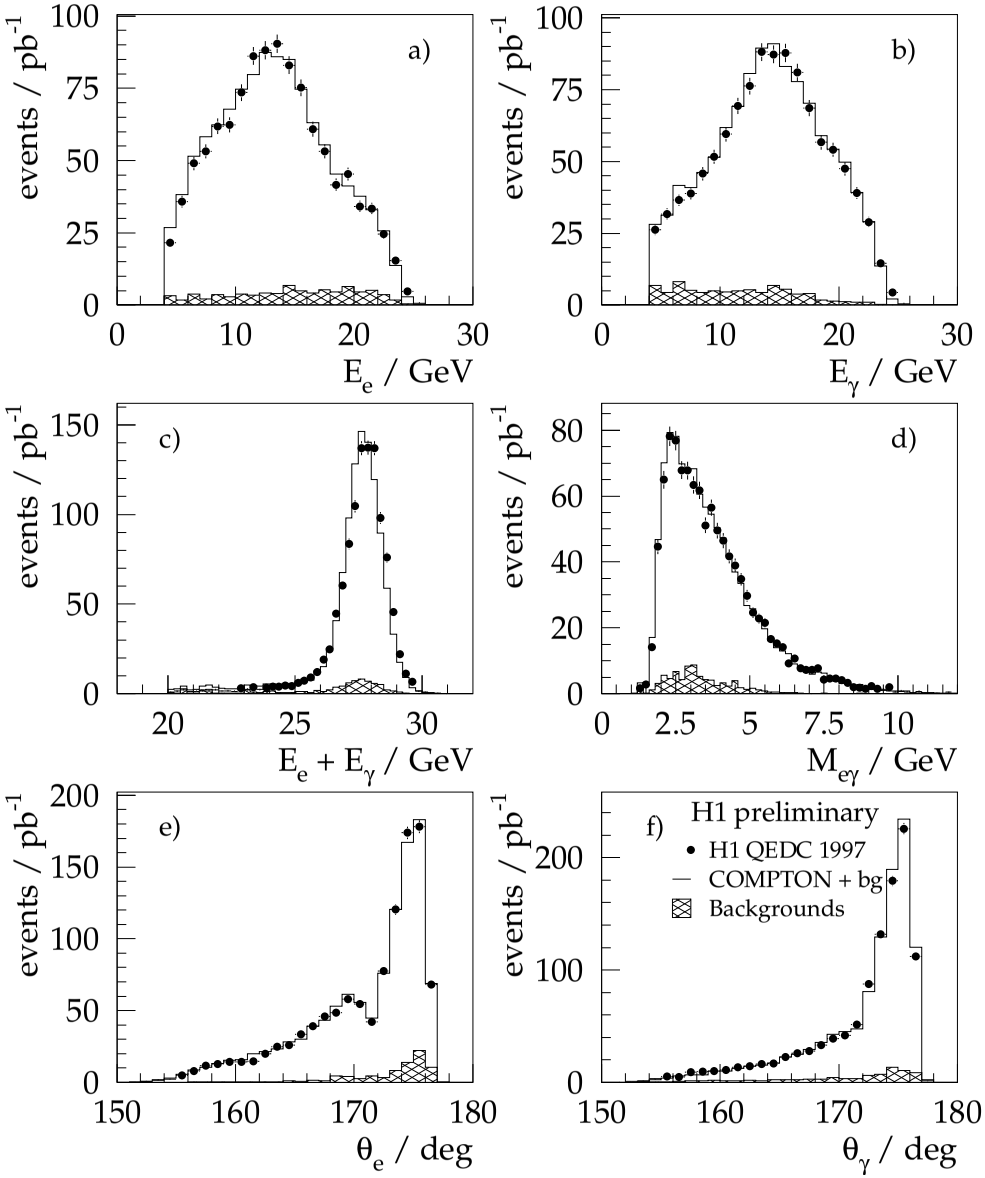


$e\gamma$ Control Distributions

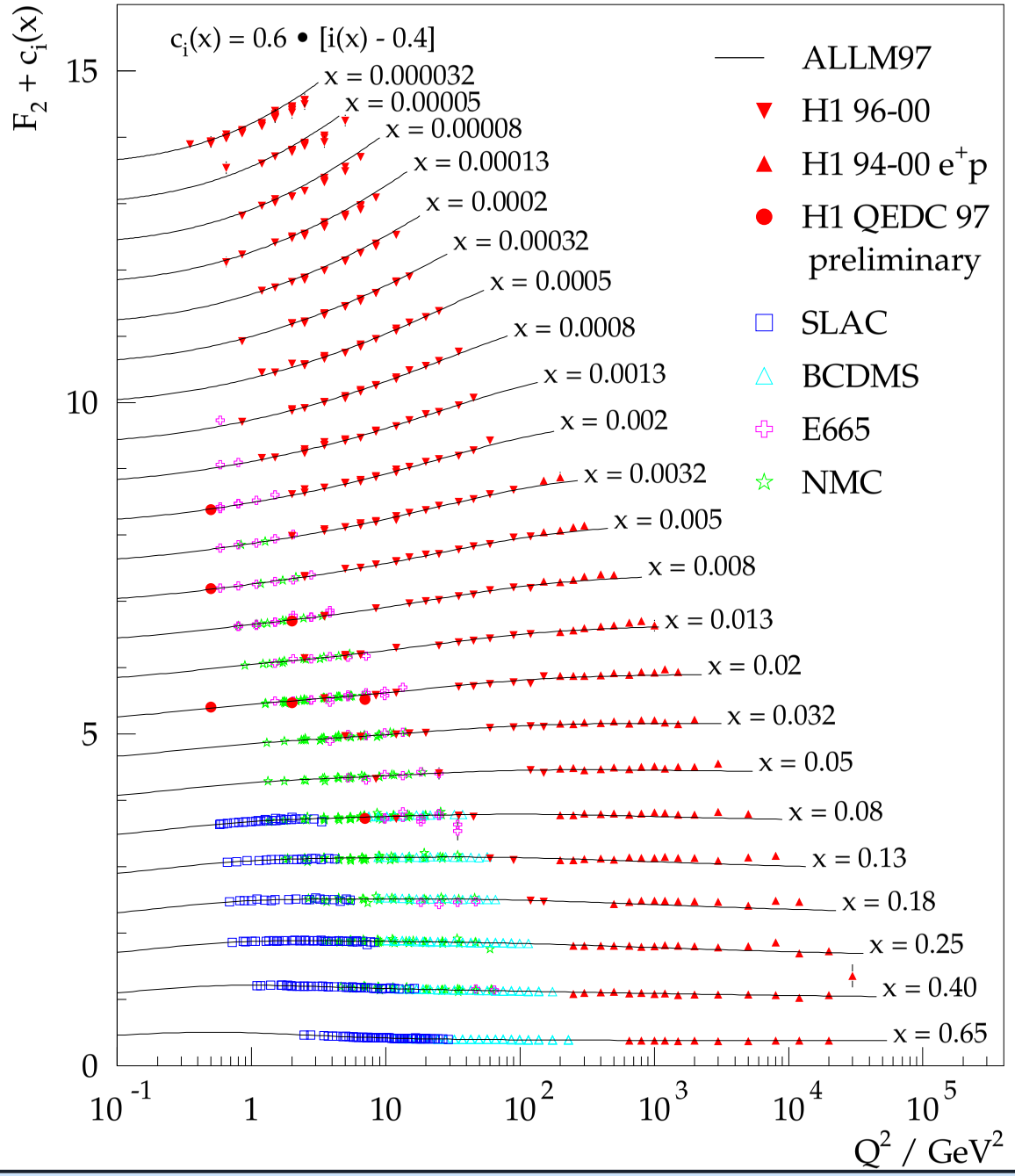
Inelastic Used for Measurement



Elastic + Inelastic



Results of F_2 Measurement in QEDC



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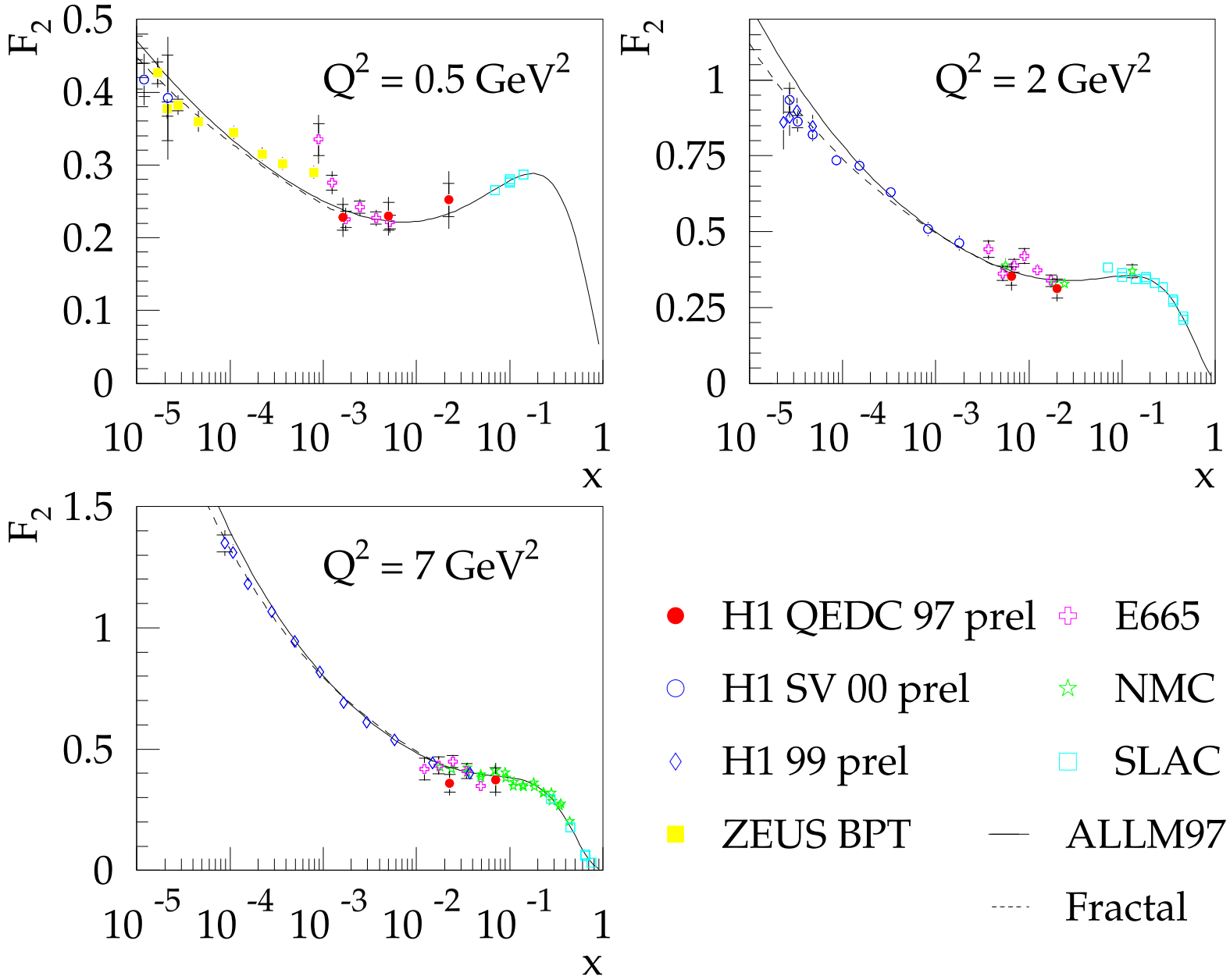

Good agreement with fixed target experiments

Summary

- F_2 is measured in QED Compton scattering at HERA
  at $Q^2 \to 0.1$ and $0.001 \lesssim x \lesssim 0.1$
  in transition region from γp to DIS

- Extended kinematic domain of HERA
  complementing standard inclusive
  low Q^2 and shifted vertex data

- Good agreement with fixed target data