Scaling violation

Public transportation in a proton

Deep inelastic scattering

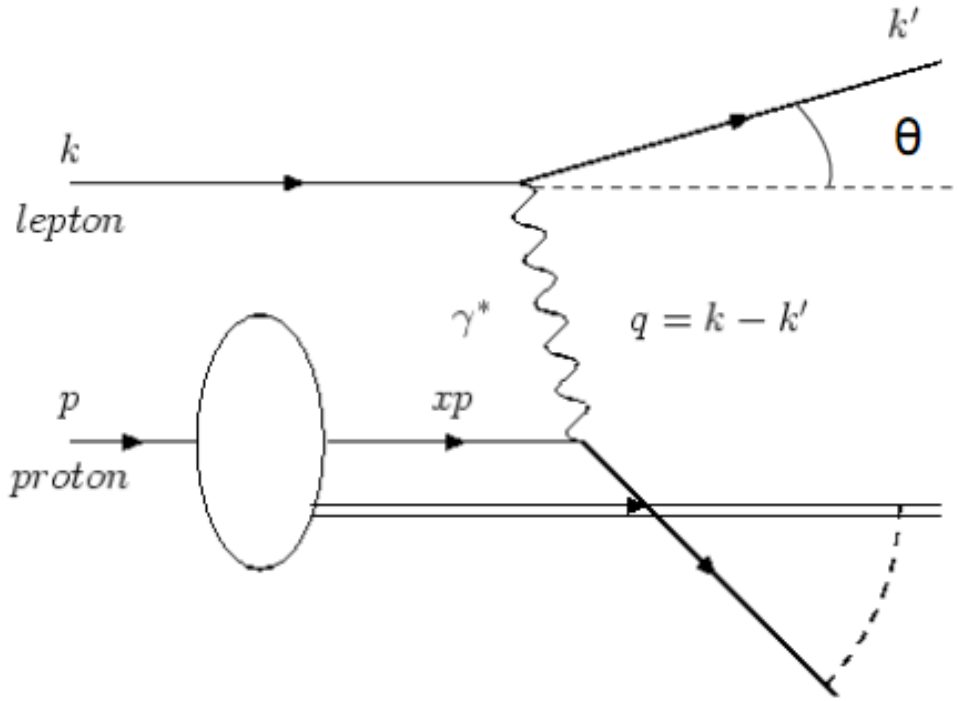
In order to evaluate the proton structure one scatters leptons at protons.

Def.:

Q → Momentum of

exchange photon

x→ Momentum fraction Q^2/(2mk)



Theoretical background

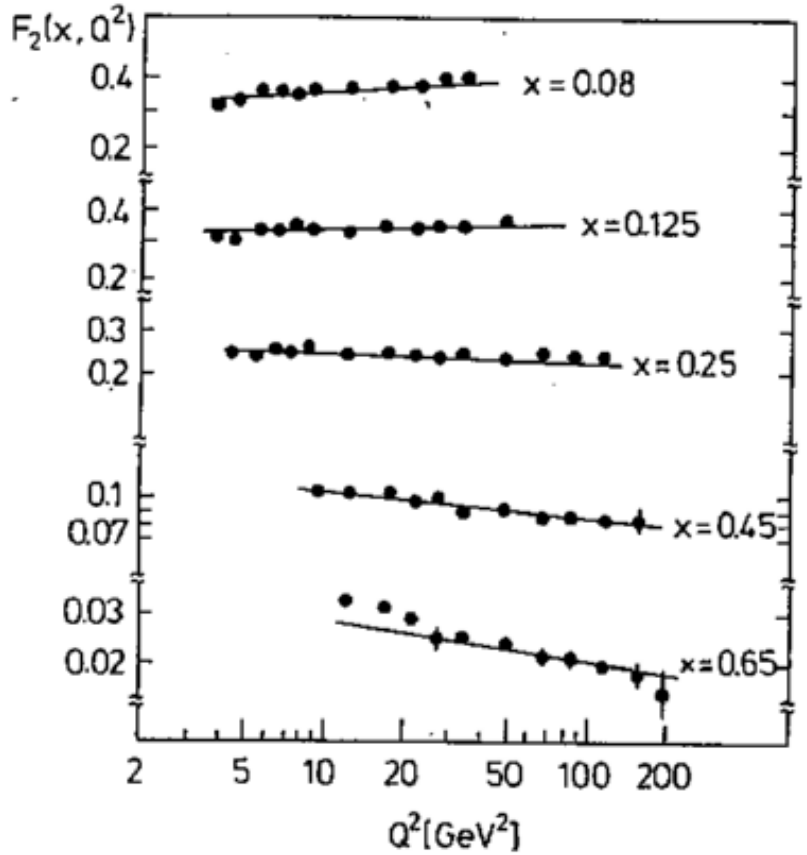
- For inelastic scattering one awaits structure functions depending on two kinematic variables, e.g.:

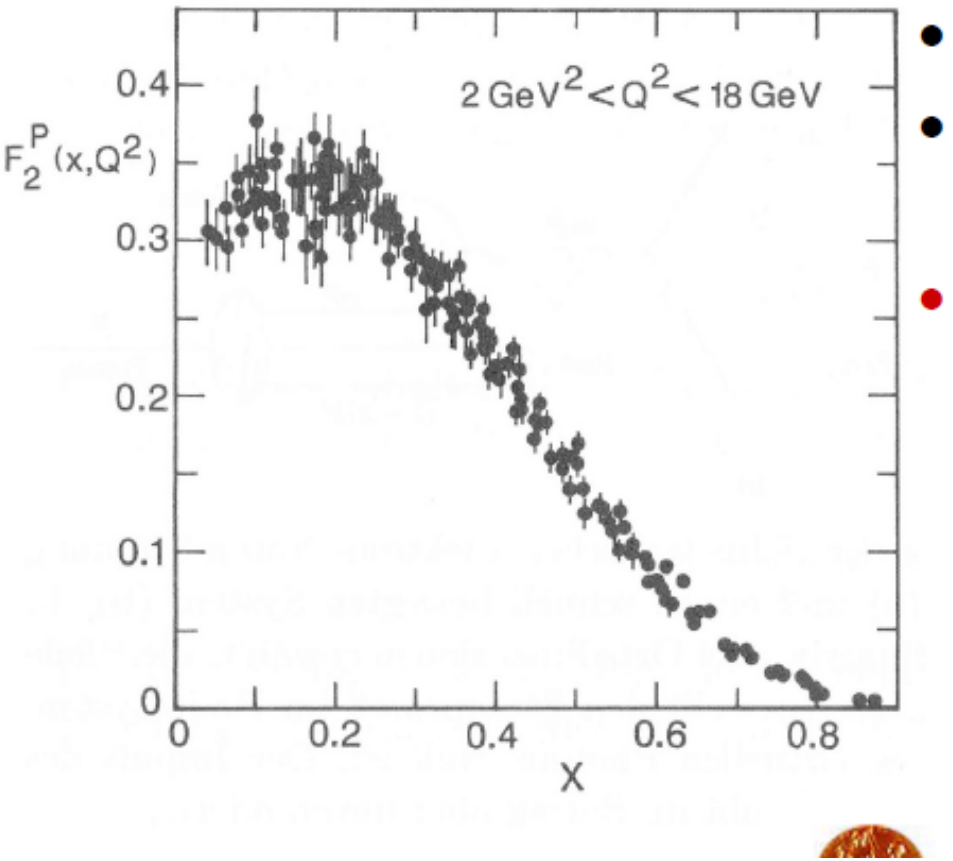
$$\frac{d^2\sigma}{dx\,dQ^2} = \frac{4\pi\alpha^2}{Q^4}\frac{1}{x}\frac{E'}{E}\left[F_2(x,Q^2)\cos^2\frac{\Theta}{2} + \frac{Q^2}{2x^2M_p^2}\,2x\,F_1(x,Q^2)\sin^2\frac{\Theta}{2}\right]$$

Electric field of the parton
Magnetic field of the parton

- 1968 at the SLAC: For high energies no dependence of the structure functions on Q^2 → Scaling
- Sign for elastic scattering

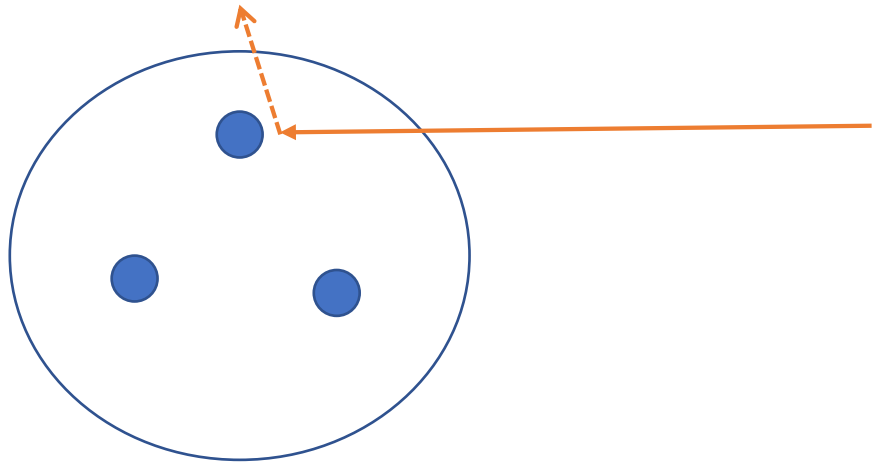
Results


$F_2(x,Q^2)$
0.4
0.2
0.4
0.2
0.3
0.2
0.1
0.07
0.03
0.02
x = 0.08
x = 0.125
x = 0.25
x = 0.45
x = 0.65
2
5
10
20
50
100
200
Q^2[GeV^2]

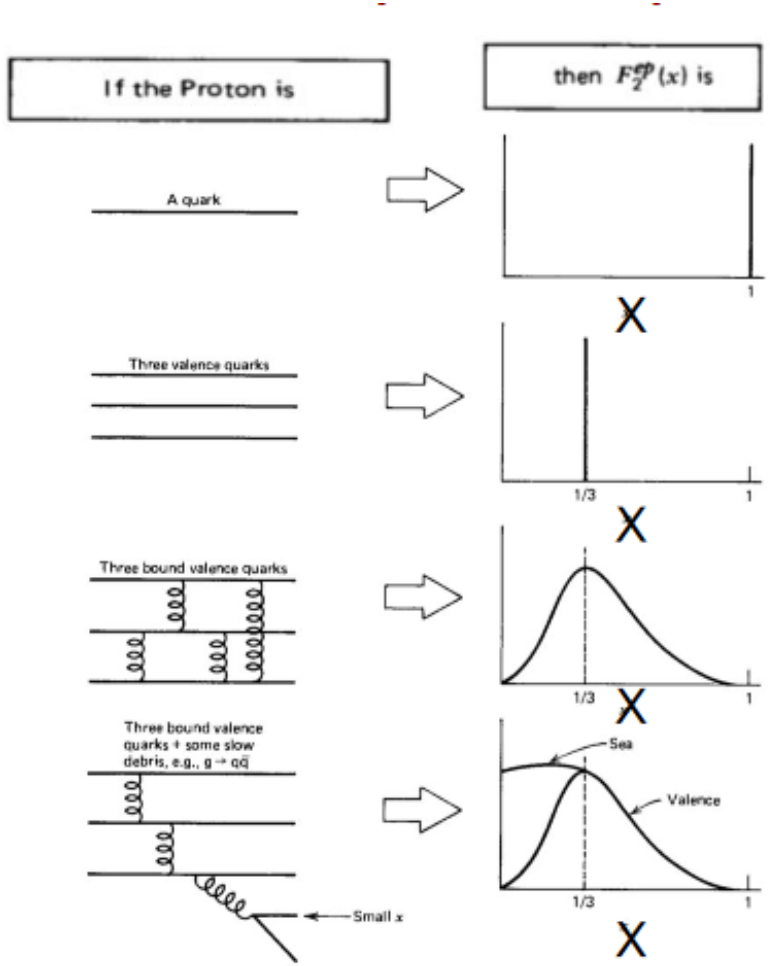

$F_2^P(x,Q^2)$
2 GeV^2 < Q^2 < 18 GeV
0.4
0.3
0.2
0.1
0
0
0.2
0.4
0.6
0.8
X

Quark Parton Model

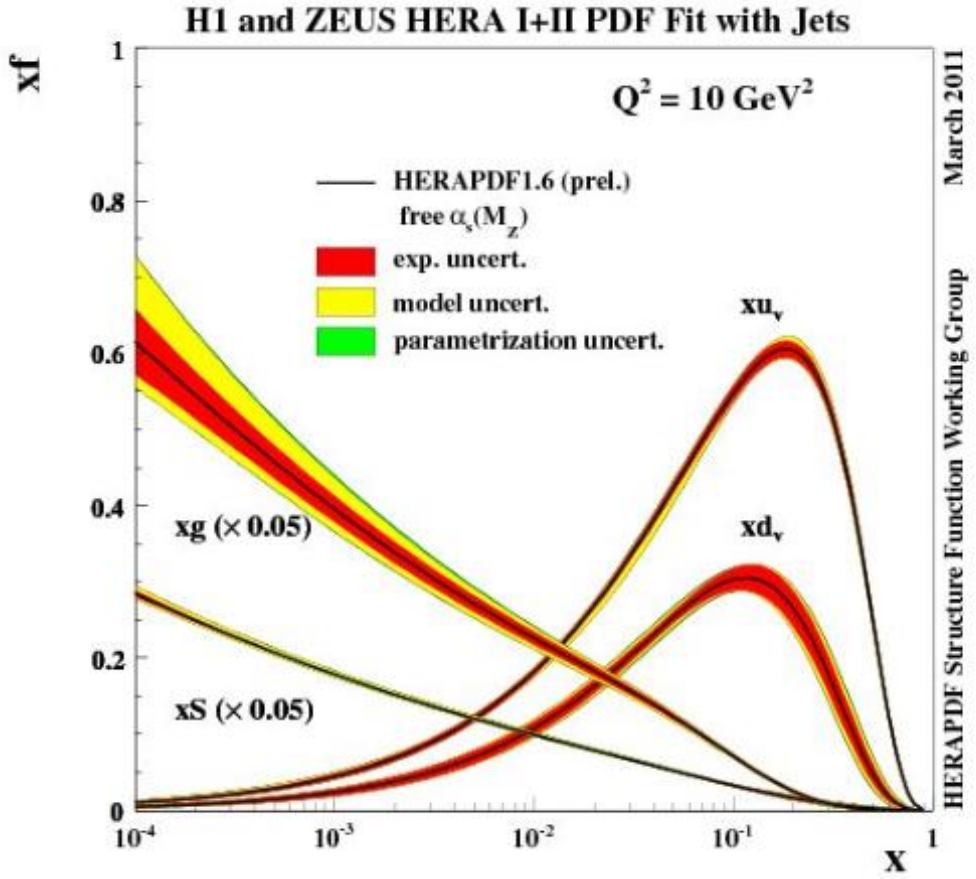
- Developed by Richard Feynman 1969
- Proton consists of pointlike subparticles
- Scattering happens elastically at these subparticles
- Parton distribution functions (PDFs) give information about the constituents



Precise measurements of the structure function



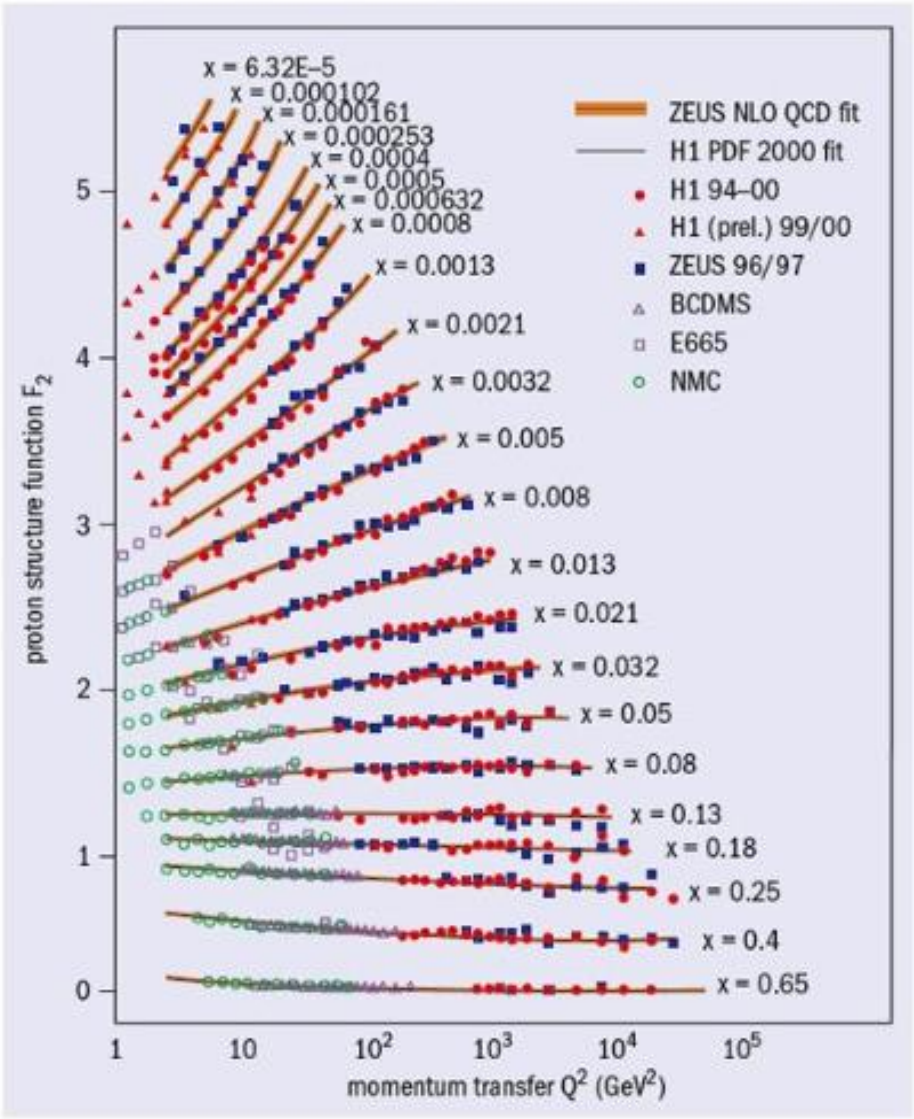
Source: Halzen and Martin, Quarks and Leptons



Scaling violation

Small values of x: Sea quarks and gluons dominate.
The higher Q the more gluons and sea quarks can be seen.

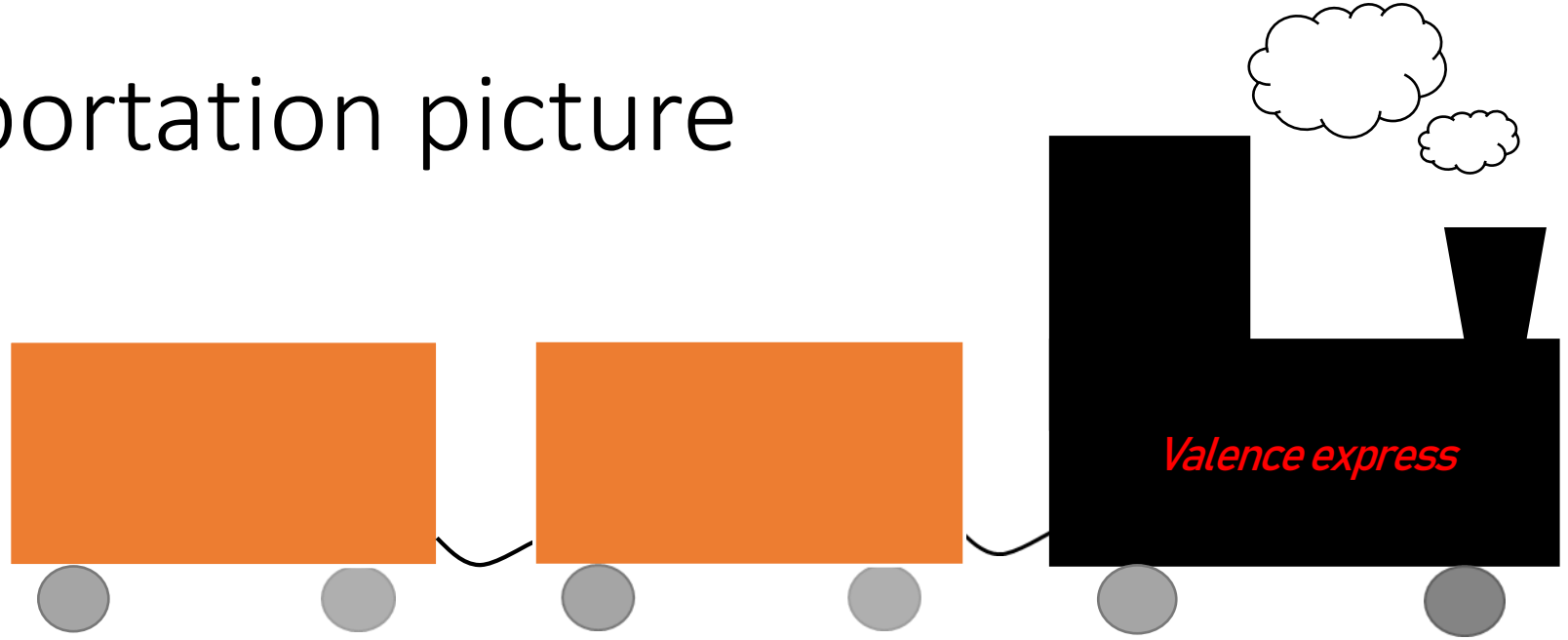
High values of x: Valence quarks dominate. The higher Q the more gluon emission is visible.



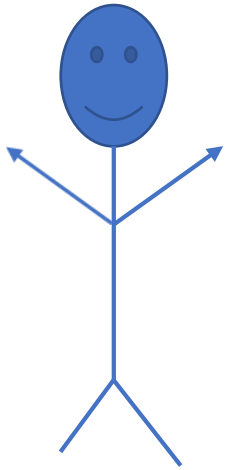
Public transportation picture

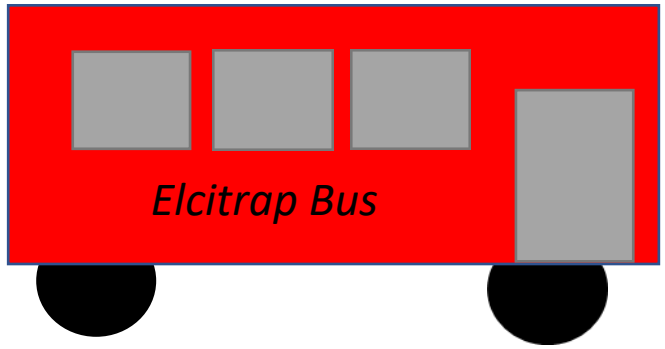
People = energy

Trains → high energy



Bus, bikes, pedestrians
→ low energy





Different resolutions

Low resolution (small Q)

High resolution (high Q)