Negative Gluon Density and GVDM at low Q^2

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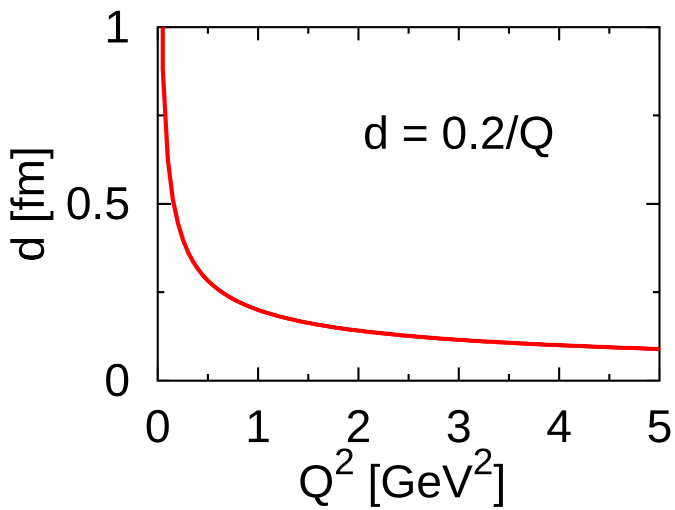
Problem:

DIS formalism and parton pdf's applied at very low Q^2

$$\frac{d\sigma}{dx dQ^2} \sim F_2(x, Q^2) \sim xq(x, Q^2)$$
$$\Downarrow$$

need quark densities, but no or negative gluon density to avoid too much DGLAP evolution

Solution: Low Q^2 does not resolve partons!



Generalised vector meson dominance model accounts for cross-section at $Q^2 \lesssim 1$ GeV^2

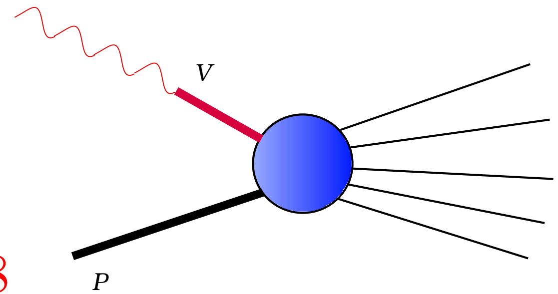
$\hookrightarrow$ parton pdf's work well for $Q^2 \gtrsim 1$ GeV^2

Generalised Vector Meson Dominance Model in ep at low Q^2

Quantum fluctuations $|\gamma\rangle = C_0|\gamma_0\rangle + \sum_V \frac{e}{f_V}|V\rangle + \int_{m_0} dm_V(\ldots)|V\rangle$

i.e. photon $\rightarrow$ vector mesons $V = \rho^0, \omega, \phi \ldots +$ continuum

followed by $Vp \rightarrow X$ with soft hadronic cross-section



$\sigma_{T,L}^{\mathrm{GVDM}} = P(\gamma \rightarrow V)\sigma_{Vp}$; $\sigma_{Vp} = A_V s^{\epsilon} + B_V s^{-\eta}$; $\epsilon \approx 0.08$

In ep: $\quad F_2(x,Q^2) = \frac{(1-x)Q^2}{4\pi^2\alpha}(\sigma_T + \sigma_L)$

$s_{\gamma p} = Q^2 \frac{1-x}{x} + m_p^2 \approx Q^2/x$ at small-x

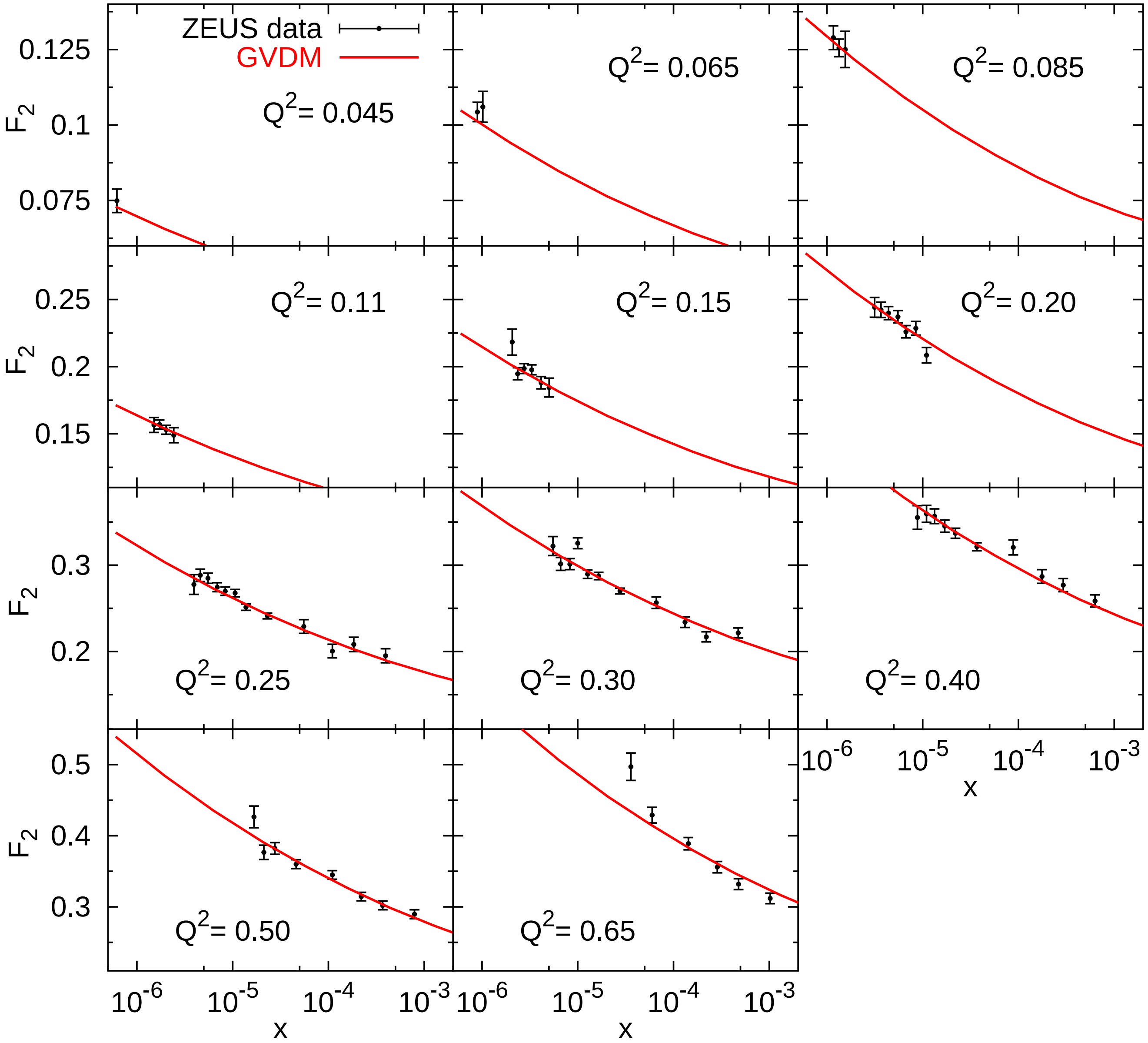
$$\Rightarrow F_2^{\mathrm{GVDM}}(x,Q^2) = \frac{(1-x)Q^2}{4\pi^2\alpha}\left\{\sum_V r_V \left(\frac{m_V^2}{Q^2+m_V^2}\right)^2\left(1+\xi\frac{Q^2}{m_V^2}\right) + r_C\frac{m_0^2}{Q^2+m_0^2}\right\} A\left(\frac{Q^2}{x}\right)^{\epsilon}$$

More complex Q^2-dependence from σ_L and continuum than simple VDM

Parameters 'known' from GVDM: $r_V = \frac{4\pi\alpha}{f_V^2}\frac{A_V}{A}$, $r_C = 1 - \sum_V r_V$

$m_0 \approx 1$ GeV, $r_{V=\rho,\omega,\phi,C} = 0.67, 0.062, 0.059, 0.21$; $\xi \approx 0.25$

HERA F_2 at low Q^2



ZEUS 1997 data

GVDM model fits well

$\chi^2 = 87/(70-4) = 1.3$

with parameter values

$\epsilon = 0.091$

$m_0 = 1.5$ GeV

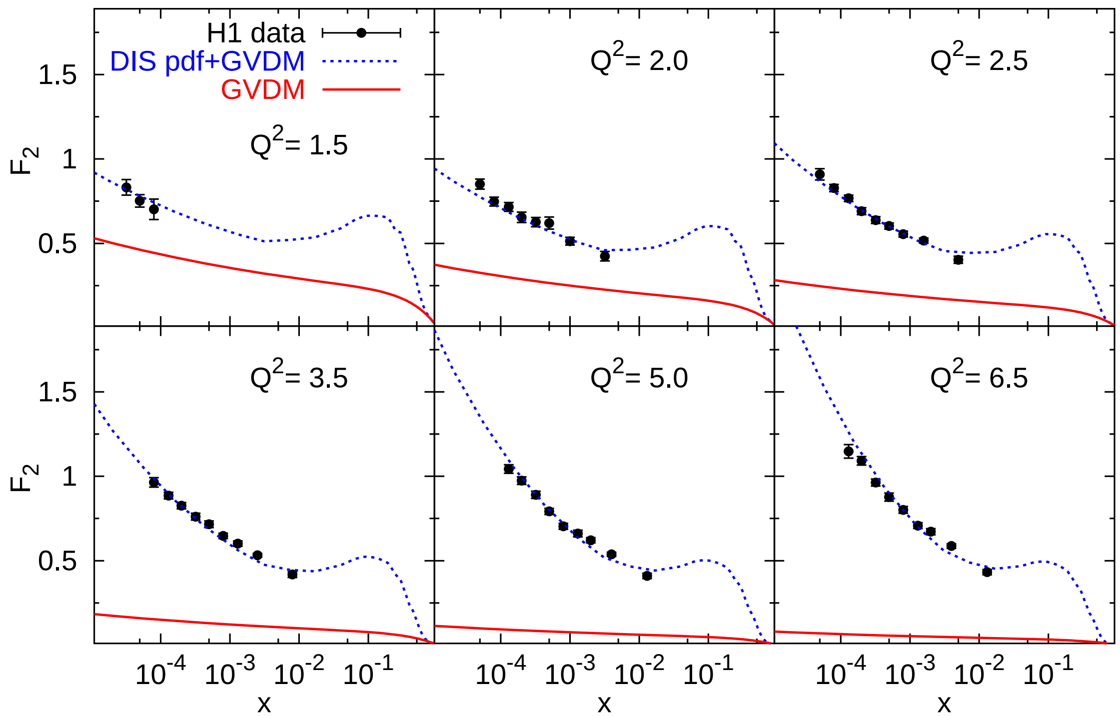
$A = 71\,\mu\text{b}$

$\xi = 0.34$

as expected

HERA F_2 at intermediate Q^2

In DIS-region: GVDM needs scale-down (form factor) with Q^2



GVDM $\times \left(\frac{Q_0^2}{Q^2}\right)^a$ with $a = 1.8$

for $Q^2 > Q_0^2 = 1.26$ (fitted)

$\rightarrow$ GVDM negligible for $Q^2 \gtrsim 3$

Adding parton densities,

here Alwall-Edin-Ingelman model,

gives good description of data

without negative gluon density