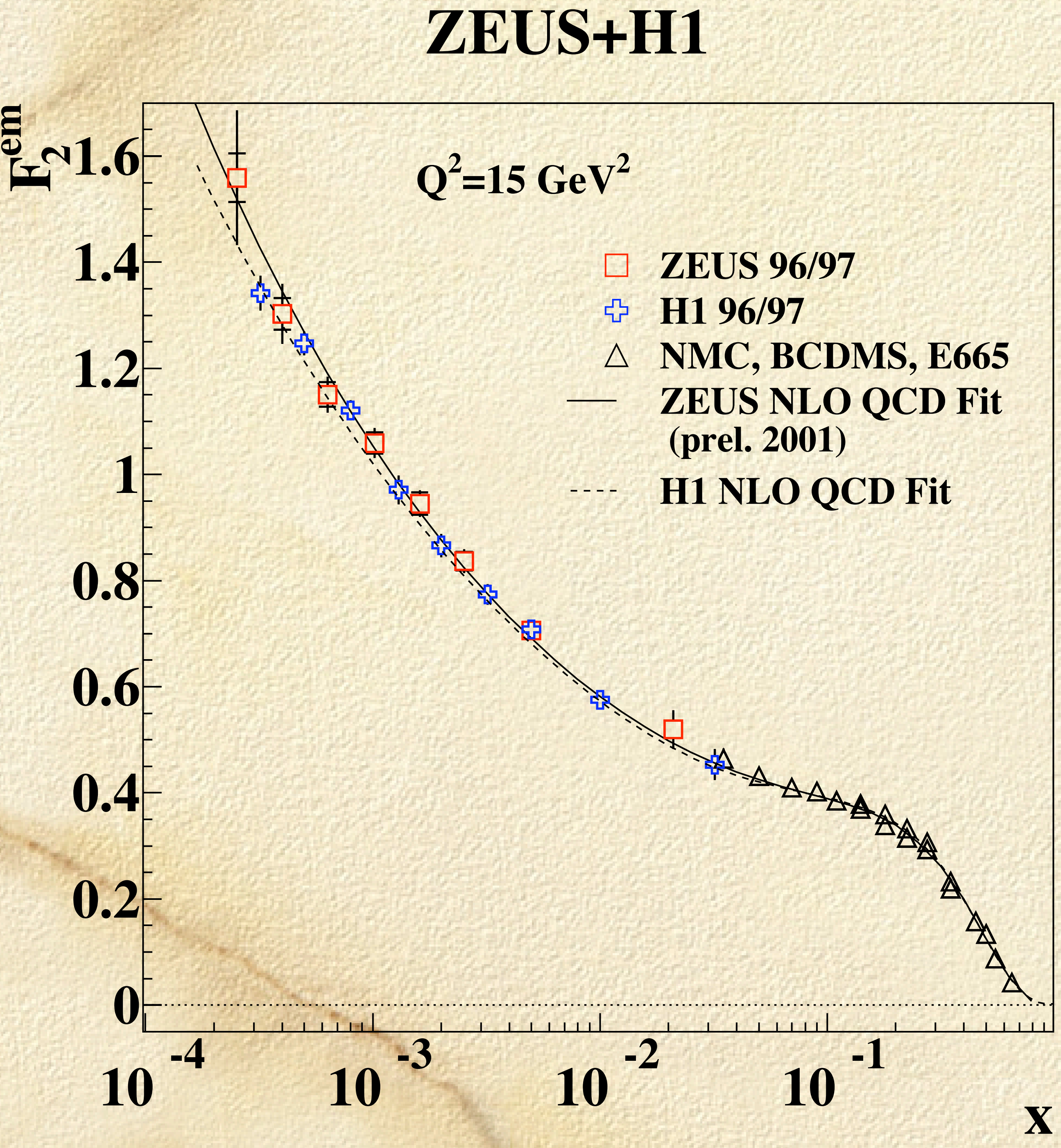
Status and Prospects for low x Physics at HERA

E. Elsen
DESY

Status Structure Function

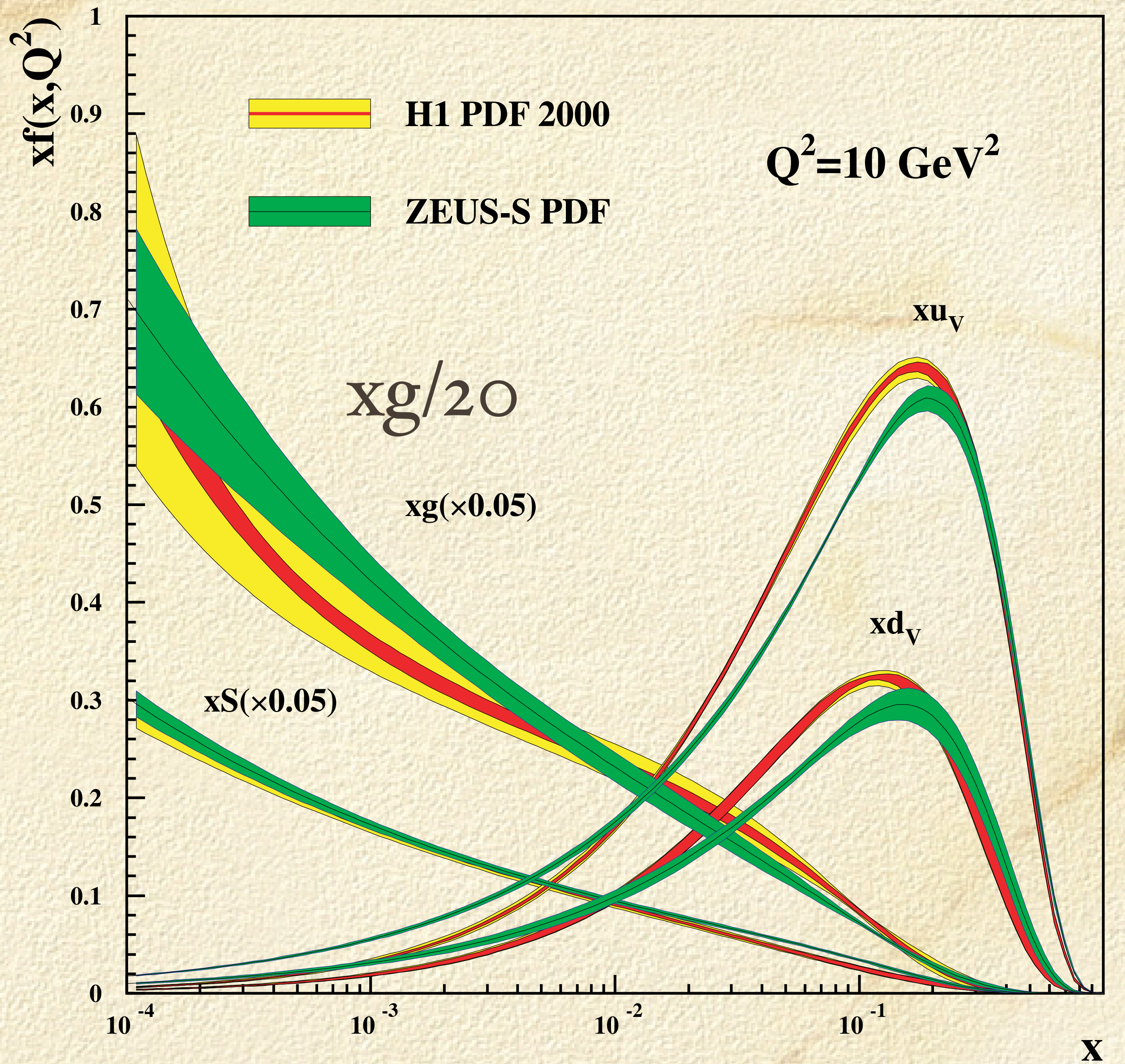


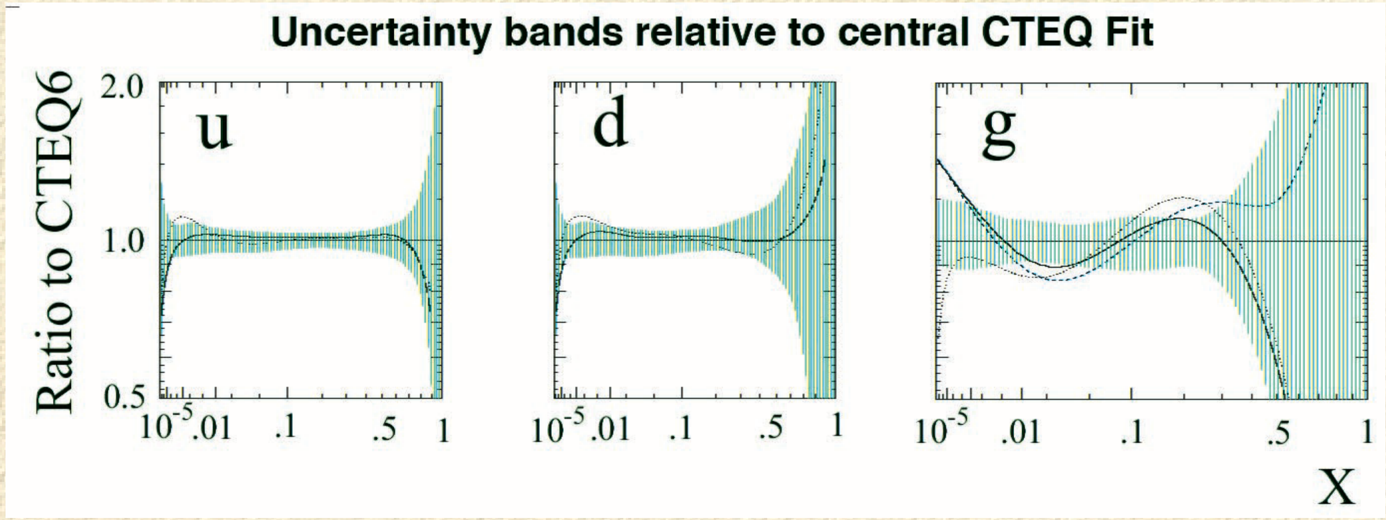
- rise of F2 at small x
- enhanced by scaling violations
- no ab initio distributions for each flavour and gluon

- $Q^2 = sxy$

Extraction of Parton Distributions

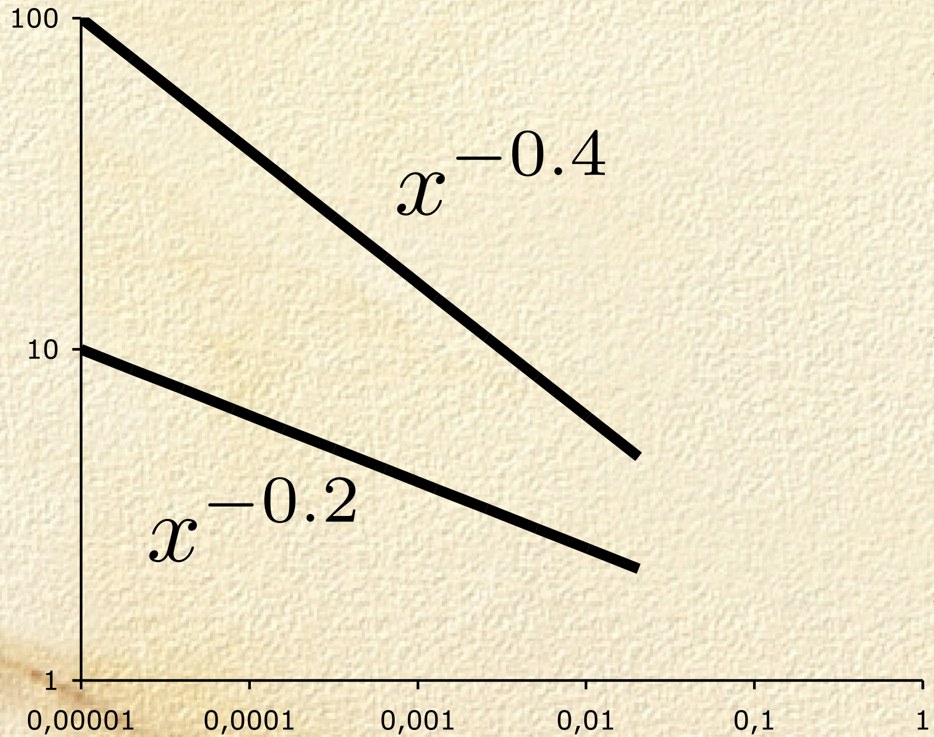
- Gluon dominates at small x (and not so small Q^2)
- Precision at very small x not sufficient for reliable extrapolations to the smallest x at the LHC

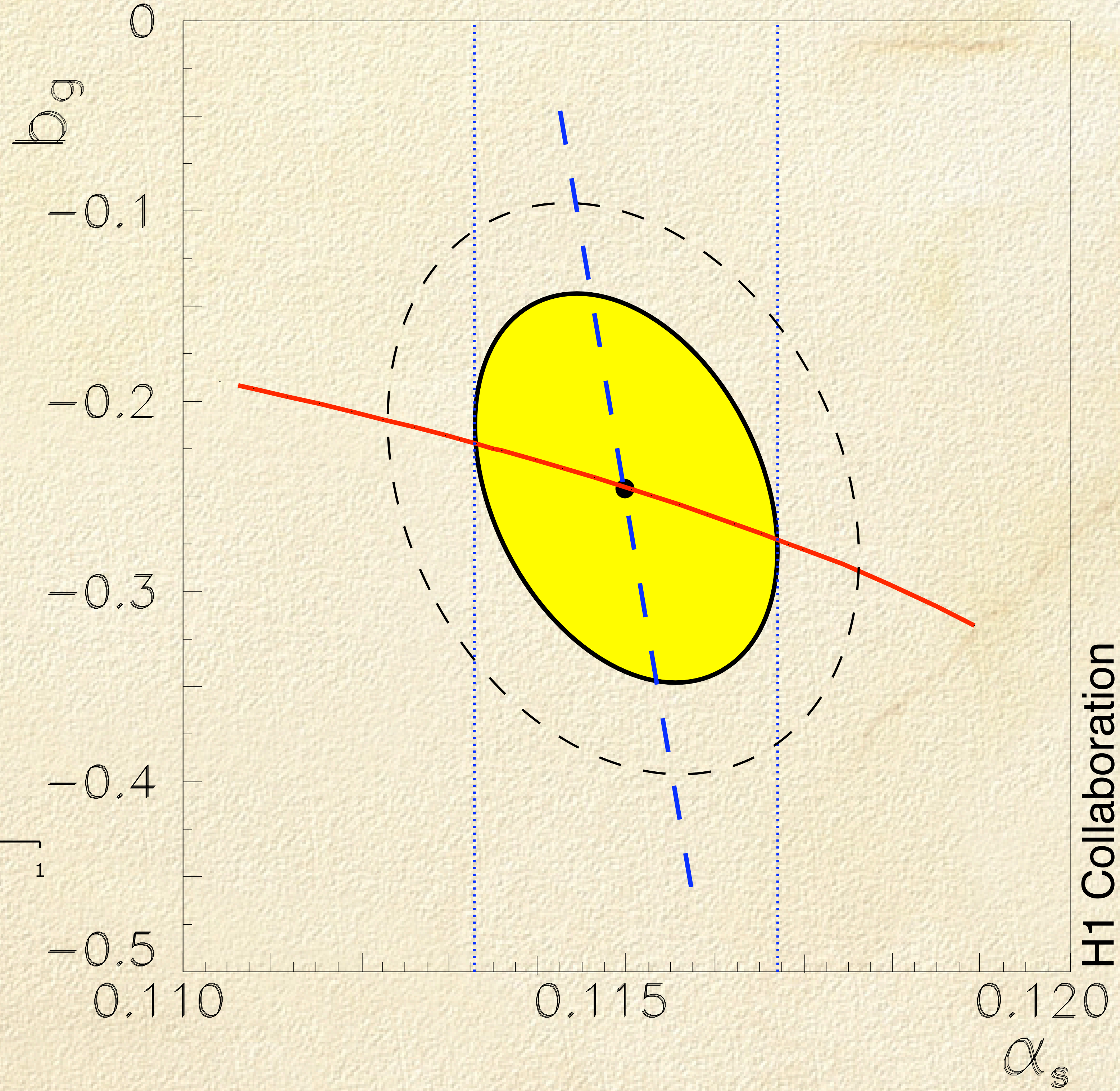




Uncertainty of Gluon Extraction from Structure Function analysis

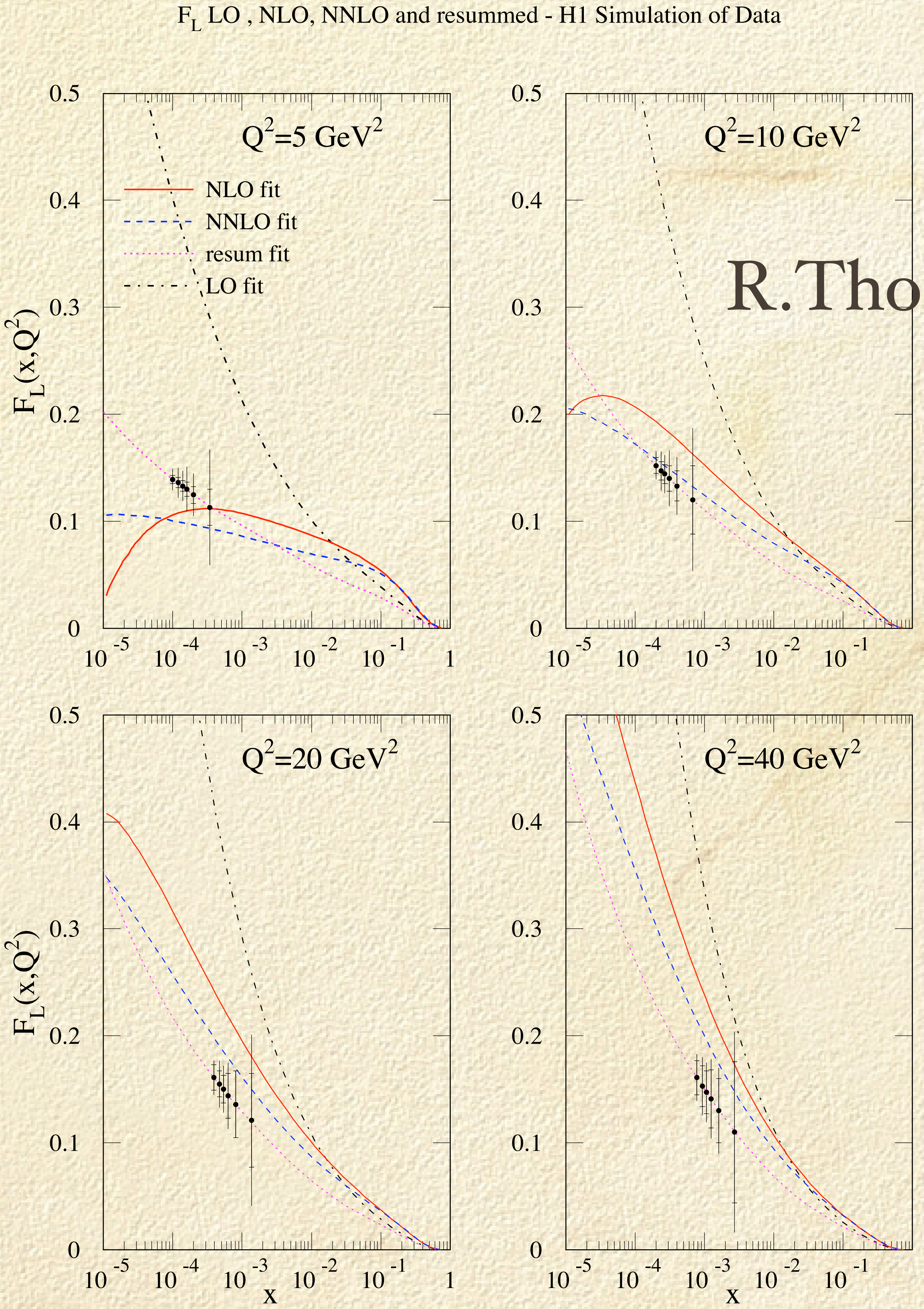
$$xg \propto x^{b_g}$$





Need for F_L measurement

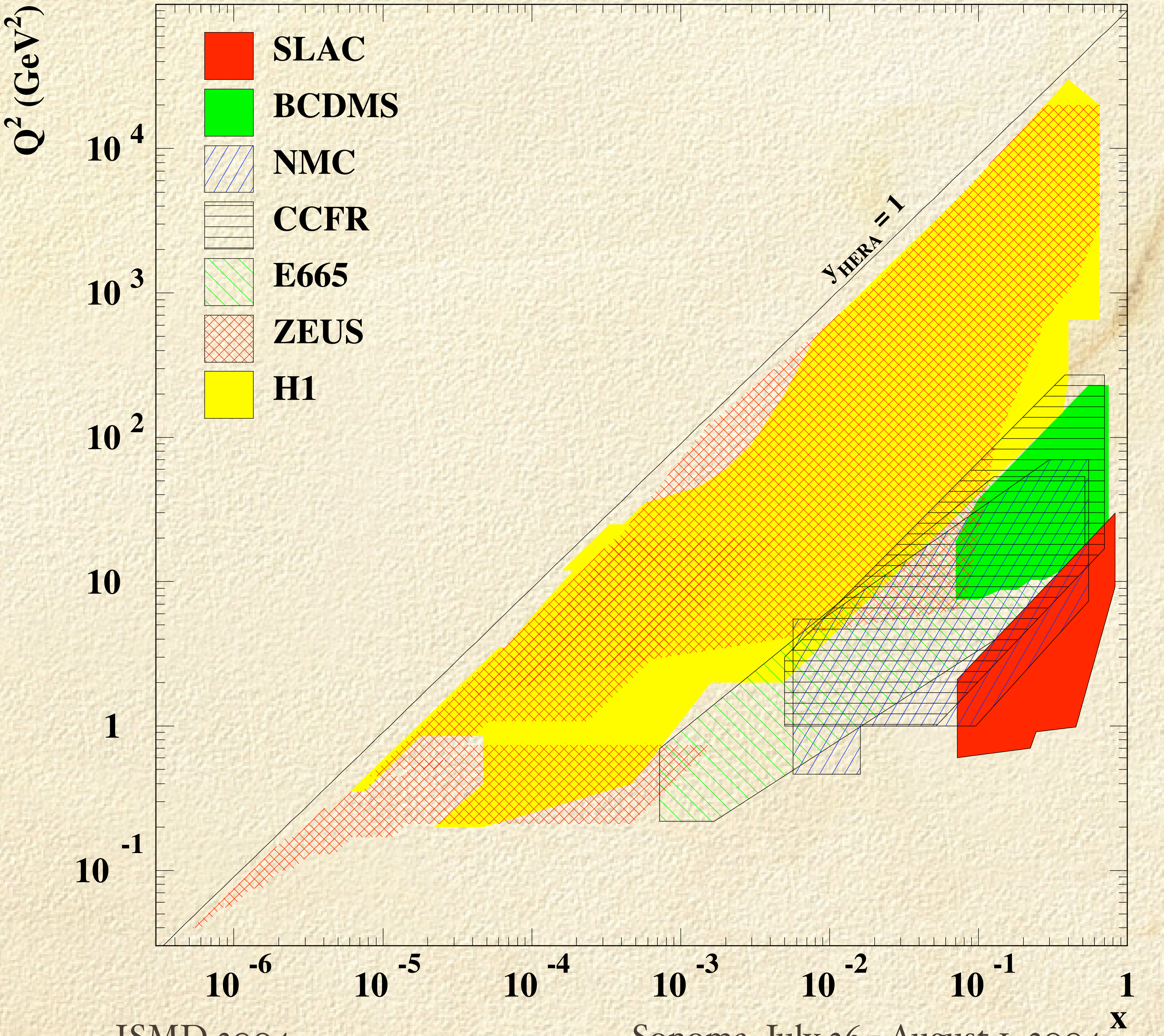
- F_L is directly sensitive to the gluon content
- Measurement requires runs at various proton energies
- necessary to pin down the gluon, i.e. effects of resummation etc. in NNLO at low x



R.Thorne

x-Q^2 Correlation at HERA

- small x implies small Q^2
- need for medium x and small Q^2 data



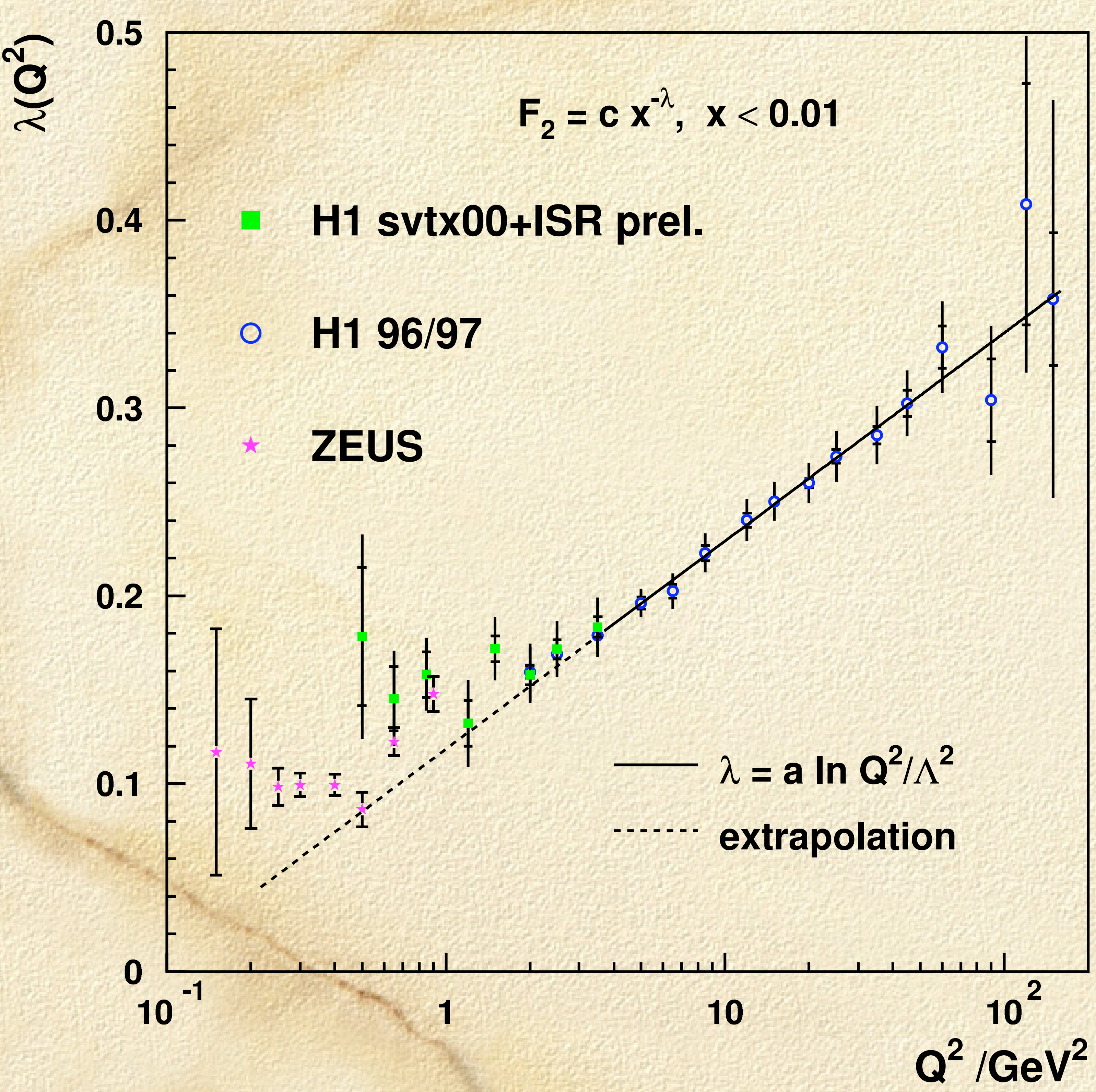
F_2 at small x (<0.01)

- small x region described by

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

- coefficient c fairly independent of Q^2

Q^2 Dependence



- low Q^2 barely understood

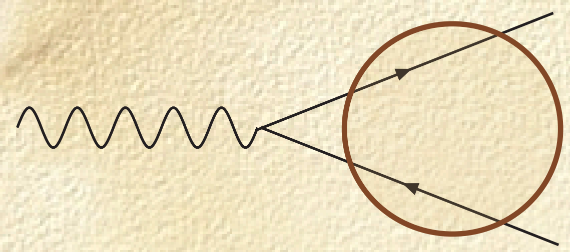
  $Q^2 \approx 1\ \mathrm{GeV}^2$

- transition occurs in region where “size of photon” considerably smaller than proton

Dipole Model

$$\sigma^{\gamma^* p}(x, Q^2) = \int \mathrm{d}^2 r \mathrm{d}z \underbrace{P^{\gamma^*}(Q^2, r, z)}_{\text{Dipole Form.}} \hat{\sigma}(x, r)$$

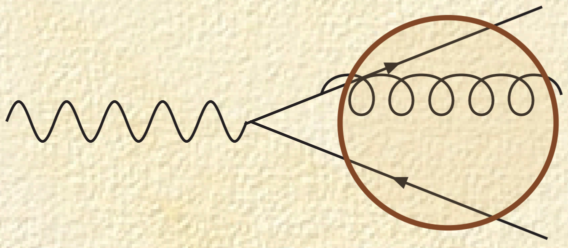
Saturation Model à la GBW



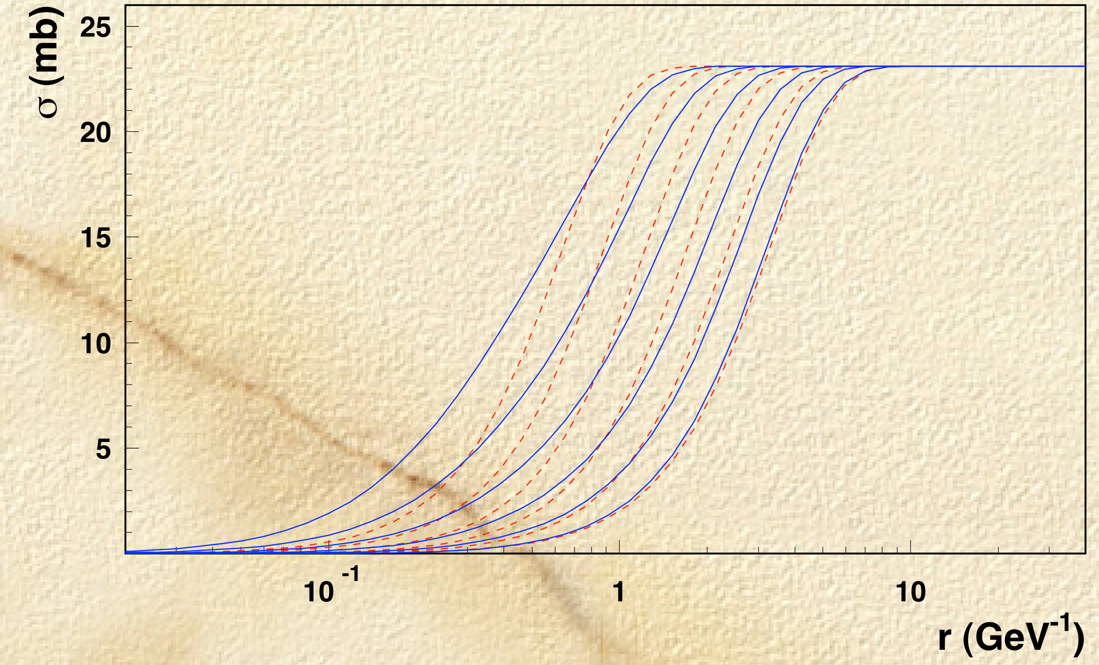
$$\hat{\sigma}(x, r) = \sigma_0 \left\{1 - \exp\left(-r^2/4R_0^2(x)\right)\right\}$$

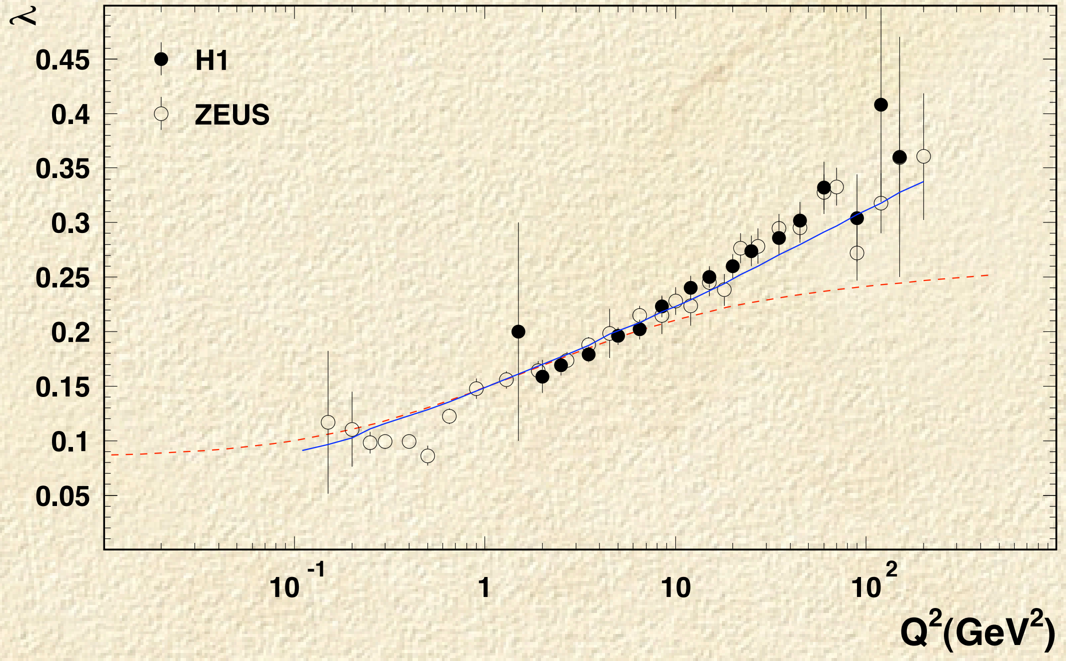
$$R_0^2(x) = \frac{1}{\mathrm{GeV}^2} \left(\frac{x}{x_0}\right)^{\lambda}$$

including gluon evolution



$$\hat{\sigma}(x, r) = \sigma_0 \left\{1 - \exp\left(-\frac{\pi^2 r^2 \alpha_s(\mu^2)\, xg(x, \mu^2)}{3\,\sigma_0}\right)\right\}$$





Dipole Model

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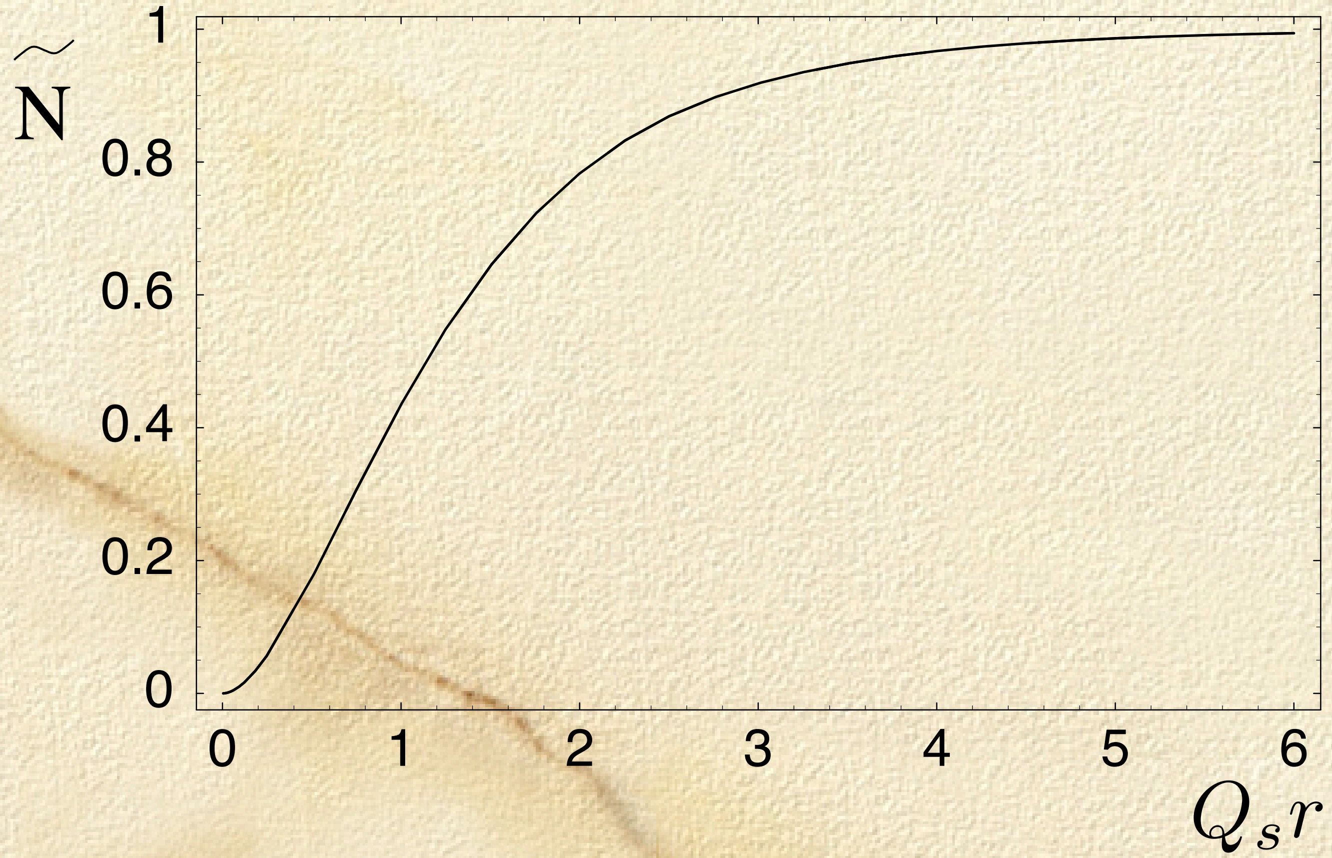
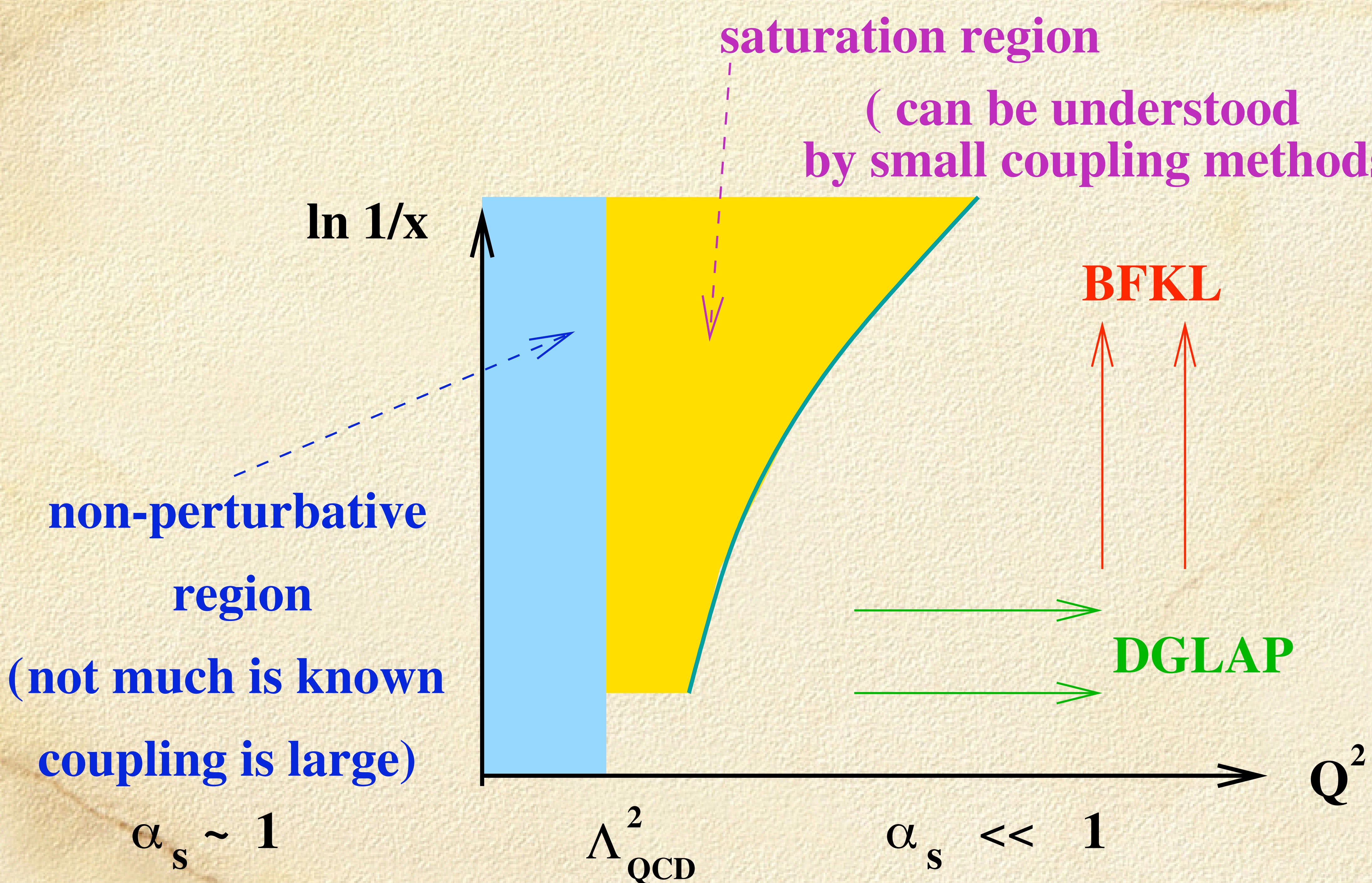
...motivating the dipole term using the Balitsky-Kovchegov non-linear evolution equations... (see J. Bartels talk)



successful ansatz for description of

- photoproduction
- DIS
- Diffraction

Kinematic Plane

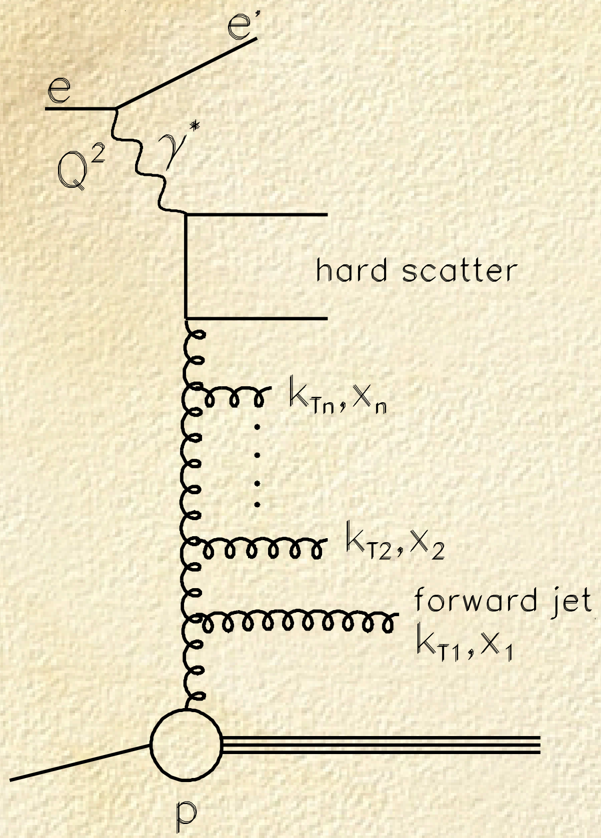


Why small x?

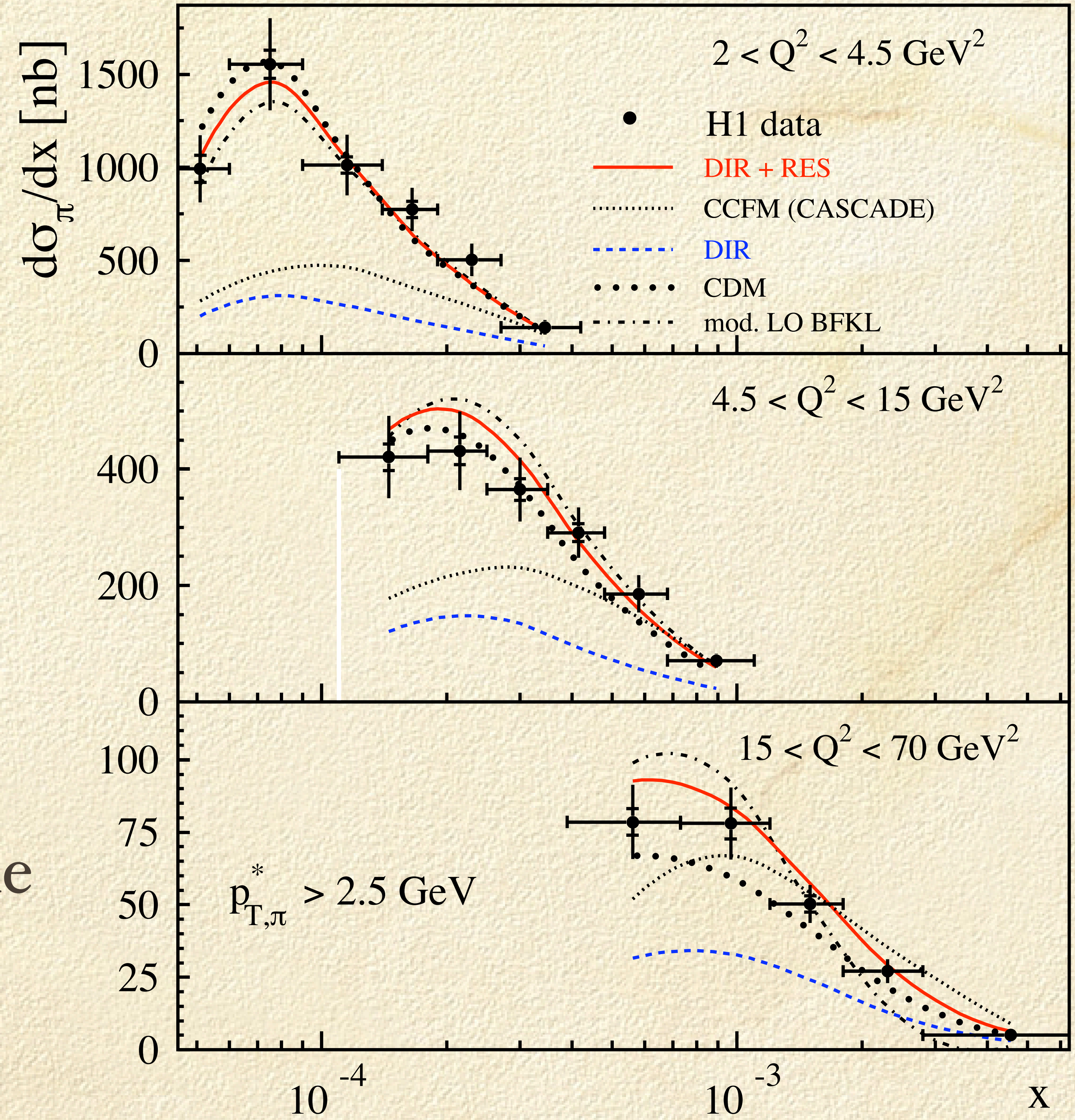
- small x refers to the high energy limit of QCD since $$W^2 = \frac{Q^2}{x}(1-x) \approx Q^2/x$$
- enter regions of
  - large gluon densities while retaining potentially the power of (modified) perturbative calculations
  - new QCD dynamics
    - correlated gluon emission

Example: Forward Jet Production

- forward going pion serves as poor man's jet



- BFKL like MC implementations are able to describe data
- require better forward reconstruction for full assessment

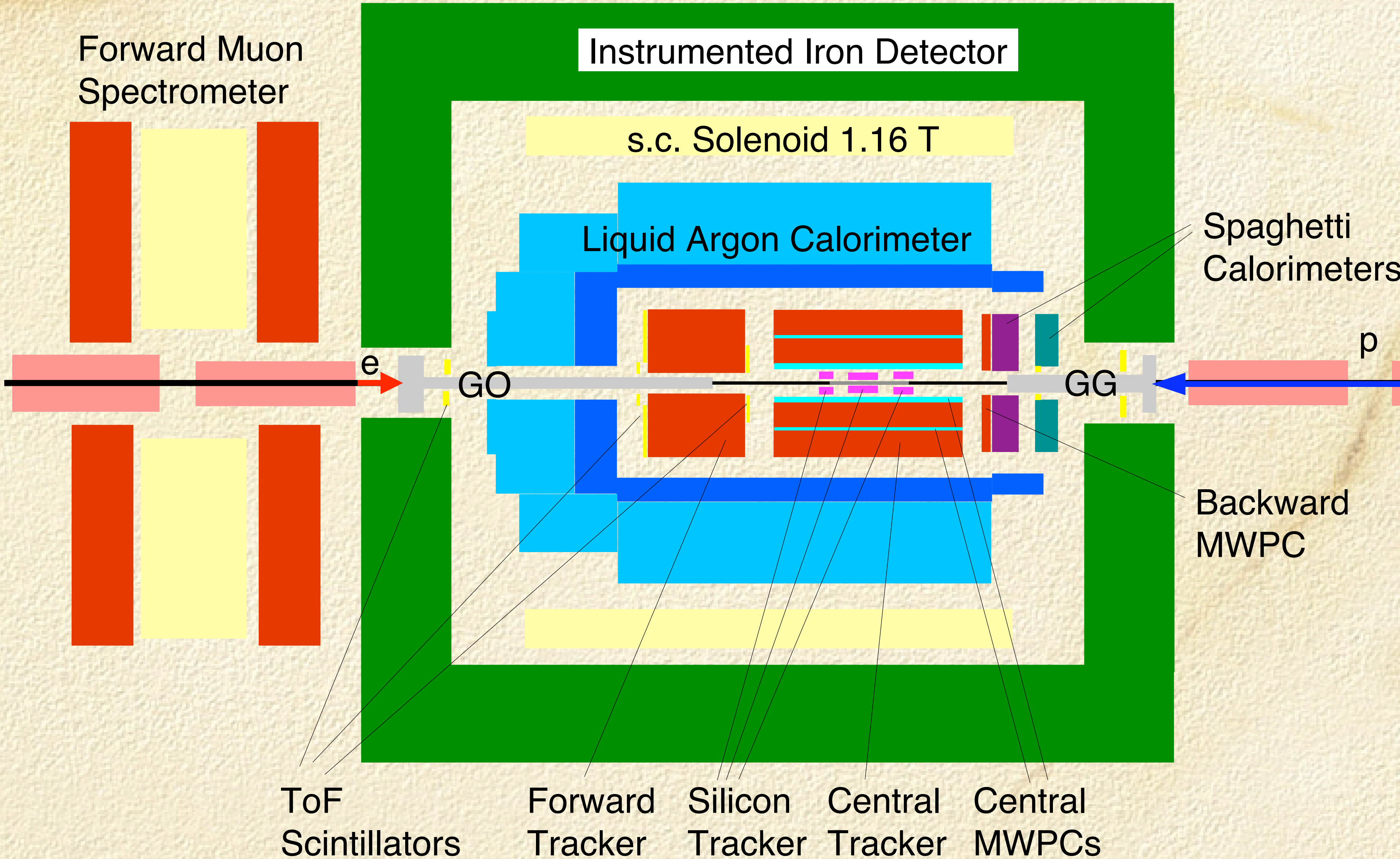


Experimental Prospects at HERA II

improved forward instrumentation

H1: FST, FTD, VFPS

ZEUS: STD, MVD



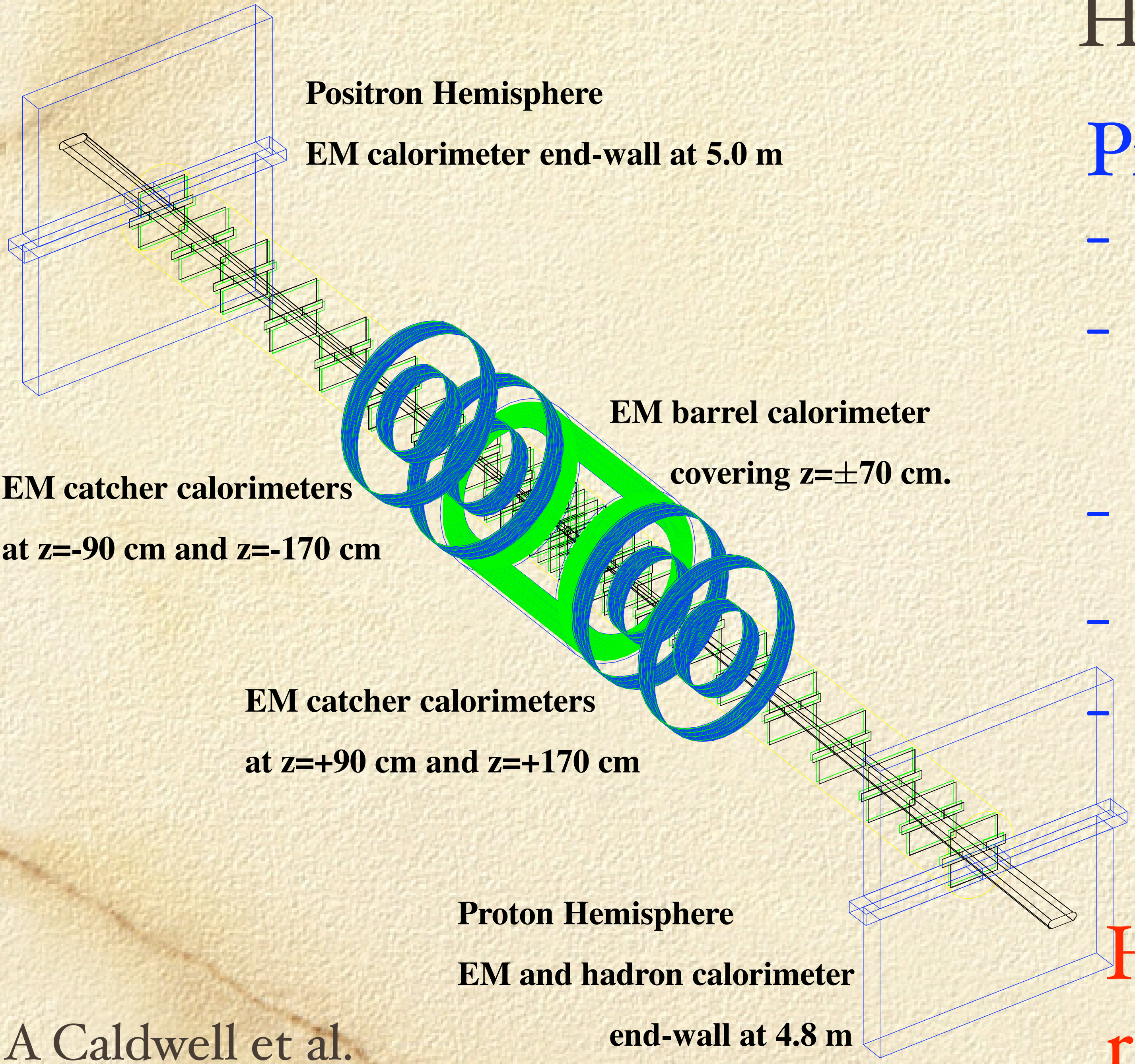
Limitation

- mini beta magnet restrict acceptance at HERA II
- HERA accelerator operation ends in 2007

Expect some improvement over HERA I data but smallest x is excluded.

If HERA were to remain operational...

Dedicated new experiment



A Caldwell et al.

and upgrade proposal for H1 expt.

Program

- low x
- pA (increased gluon density); $Q_S^2 \propto A^{1/3}$
- F_L
- t-dependence of VM
- DVCS

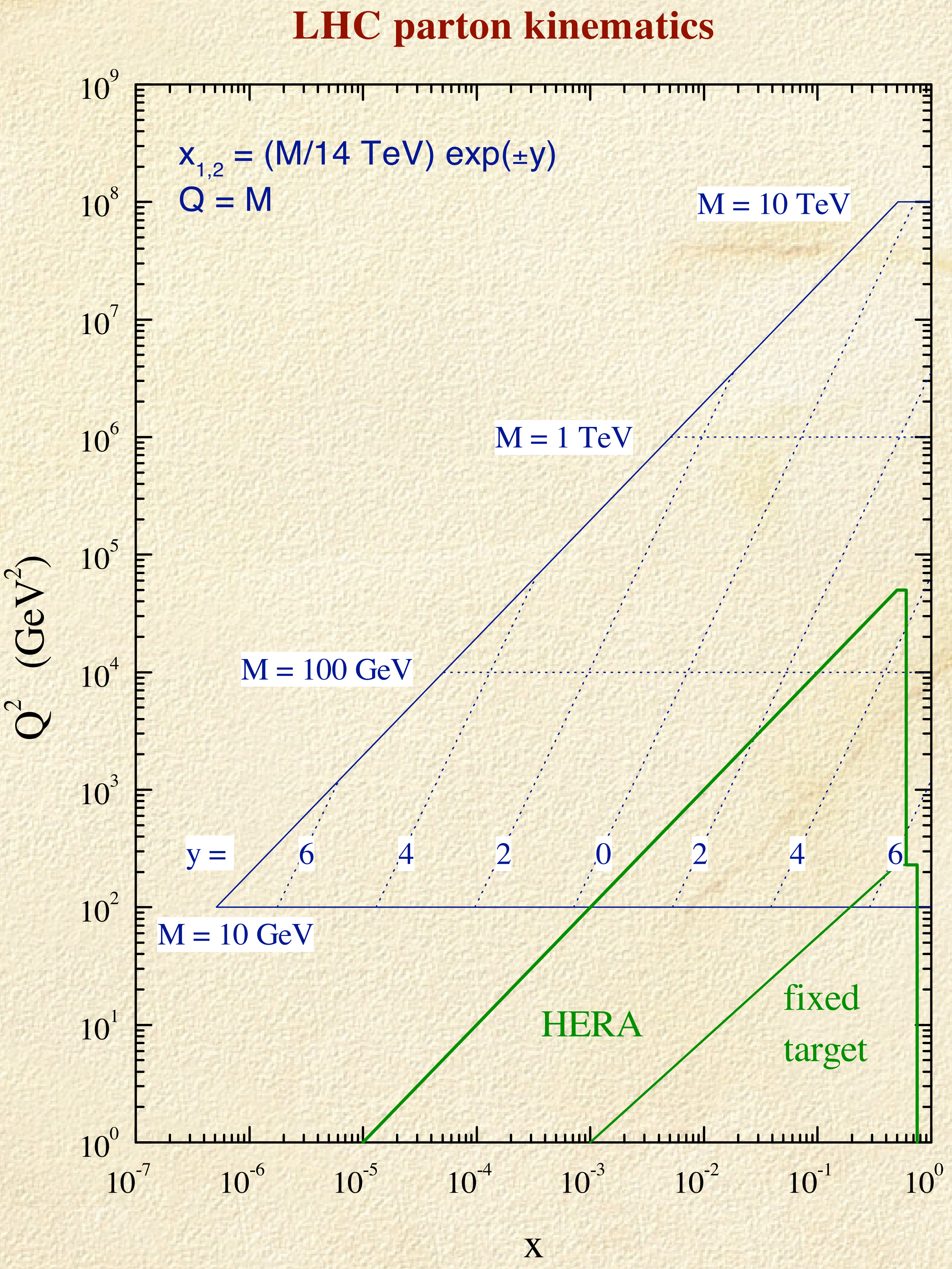
However little chance of realisation given DESY's other commitments.

Role of LHC

Largely self-consistent approach since same physics can be measured in various combinations of x_1 and x_2

Assess pdfs in
- in W + jet events
- jet + photon events

Limitation
- absolute energy scale
- missing cross calibration



Conclusions

- low x is key to QCD understanding
  - high gluon density ⇨ non-linear evolution
  - saturation? link to diffraction.
- Future progress depends on
  - ep scattering,
    possibly with modified detectors/acceptance
  - LHC at low luminosity