The strong coupling and the gluon density from jets in DIS

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on behalf of the
H1 and ZEUS Collaborations

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- α_s from Dijets
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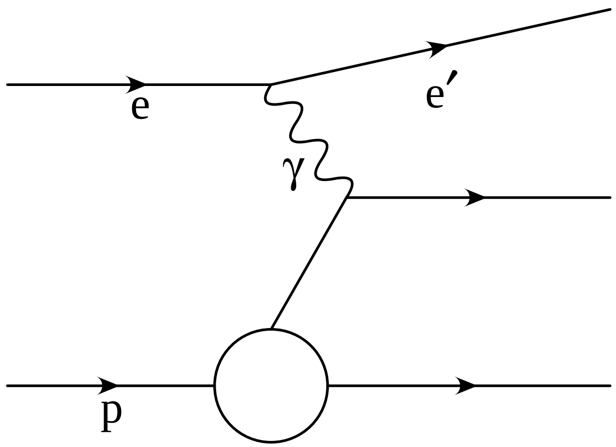
Introduction

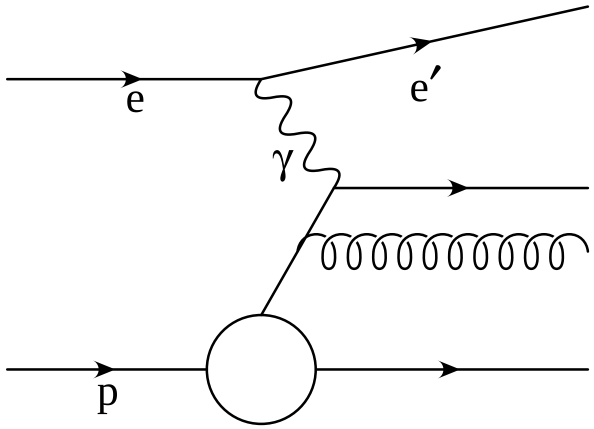
$\mathcal{O}(\alpha_s^0)$ graph:

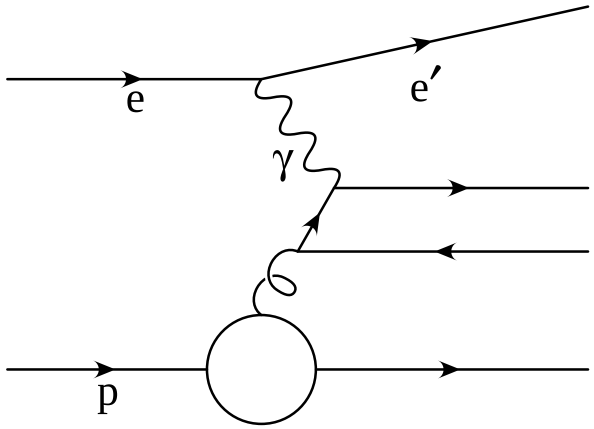
directly sensitive to quarks only
will produce one jet



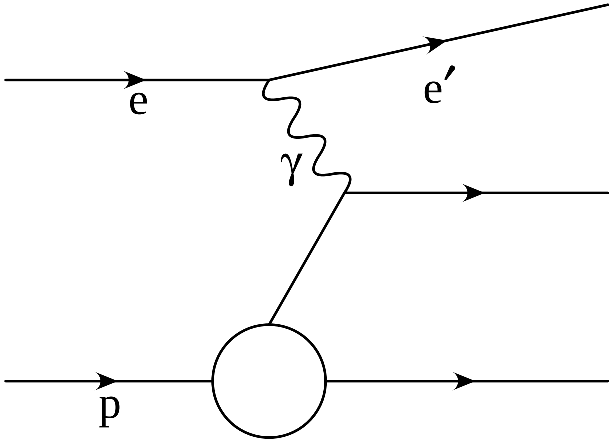
$\mathcal{O}(\alpha_s^1)$ graphs:

directly sensitive to α_s
directly sensitive to gluons in p





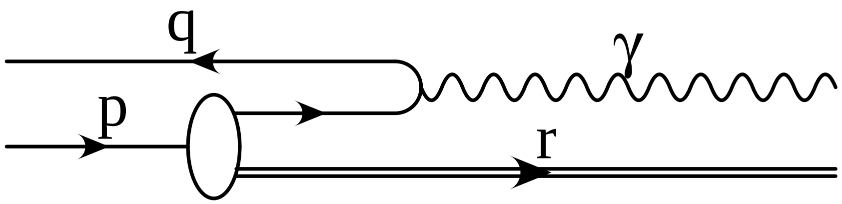
Introduction



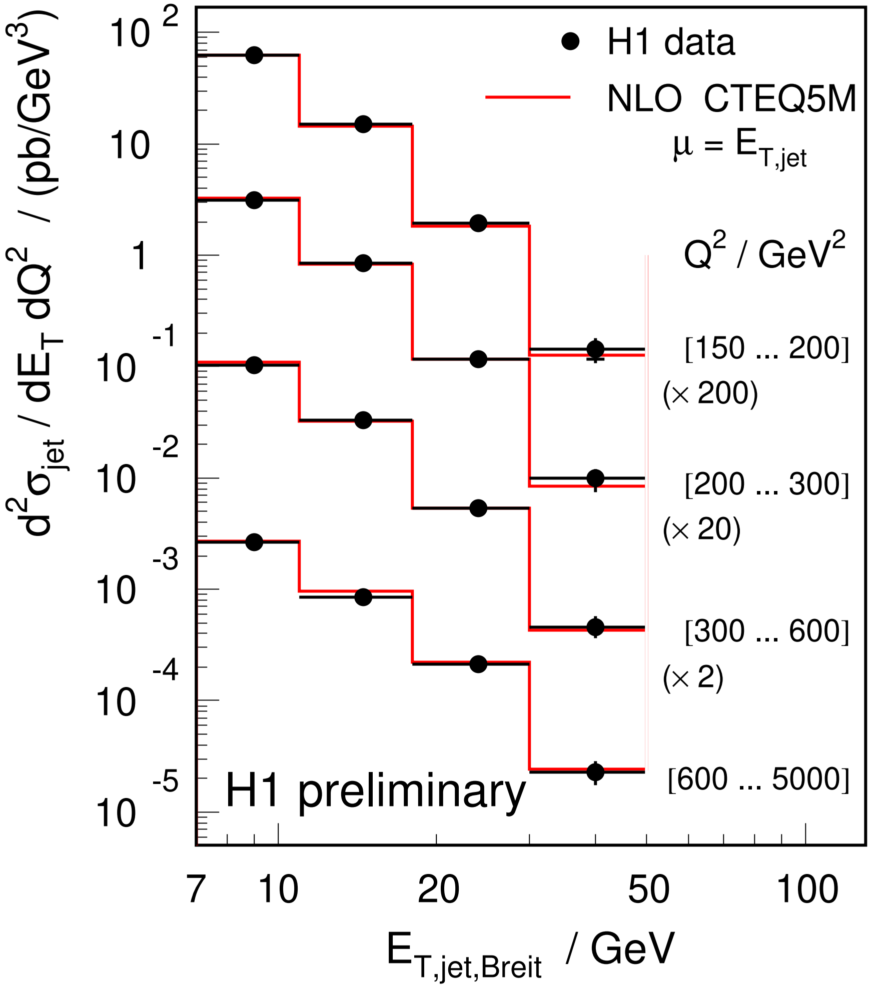
Breit frame:
head on collision of γ and p

$\mathcal{O}(\alpha_s^0)$ quark jet: $E_T = 0$

Requiring $E_{T,\text{jet}} > E_{T,\min} > 0$:
selecting sample dominated by
$\mathcal{O}(\alpha_s^1)$ graphs



Inclusive Jets

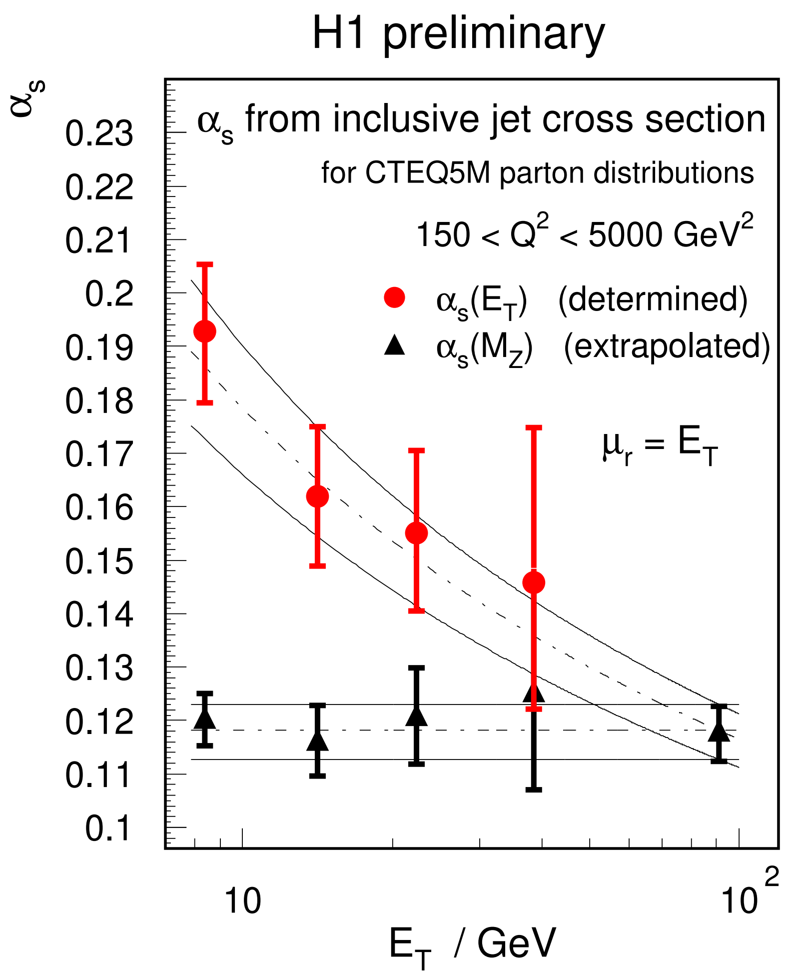


Incl. k_T algorithm
at least one jet in Breit frame

$150\ \text{GeV}^2 < Q^2 < 5000\ \text{GeV}^2$
$E_{t,\text{jet,Breit}} > 7$ GeV
$-1 < \eta_{\text{jet,Lab}} < 2.5$

Good description of data by NLO QCD over 4 orders of magnitude

α_s from Inclusive Jets

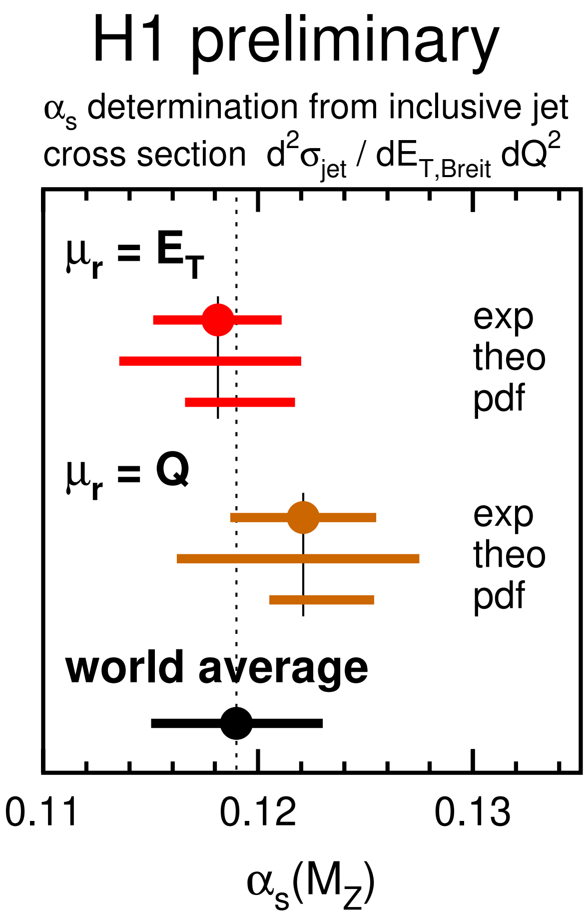


Determination of $\alpha_s(E_t)$ using NLO QCD calculation and CTEQ5M parton distributions

Running can be clearly seen

Extrapolation to $\alpha_s(M_z)$

α_s from Inclusive Jets



Value extracted using $\mu_r = E_t$

$$\alpha_s(M_Z) = 0.1181 \pm 0.0030(\text{exp})^{+0.0039}_{-0.0046}(\text{th})^{+0.0036}_{-0.0015}(\text{pdf})$$

Value extracted using $\mu_r = Q$

$$\alpha_s(M_Z) = 0.1221 \pm 0.0034(\text{exp})^{+0.0054}_{-0.0059}(\text{th})^{+0.0033}_{-0.0016}(\text{pdf})$$

Theoretical uncertainties dominate

Important contribution to uncertainty from PDF

Dijet cross sections

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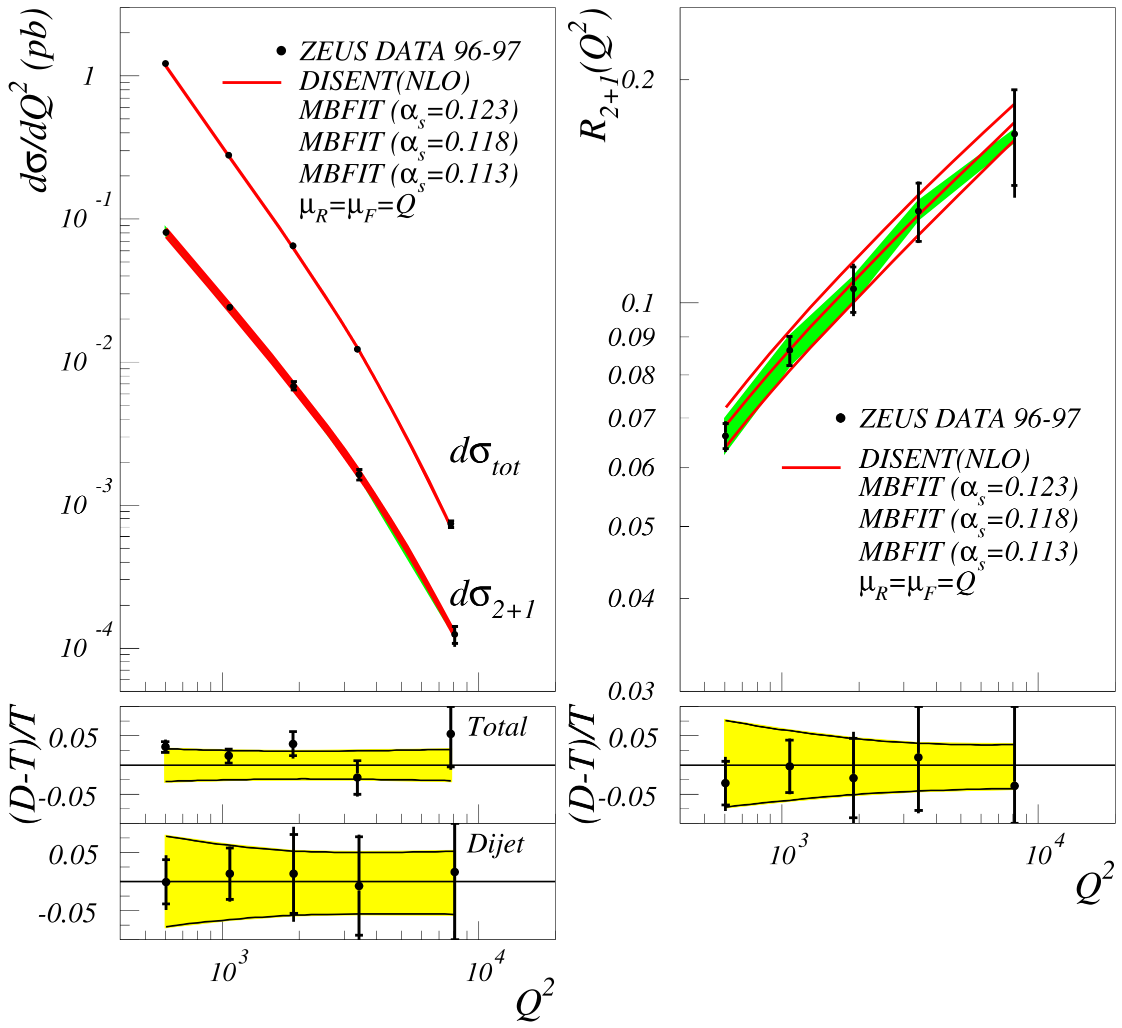


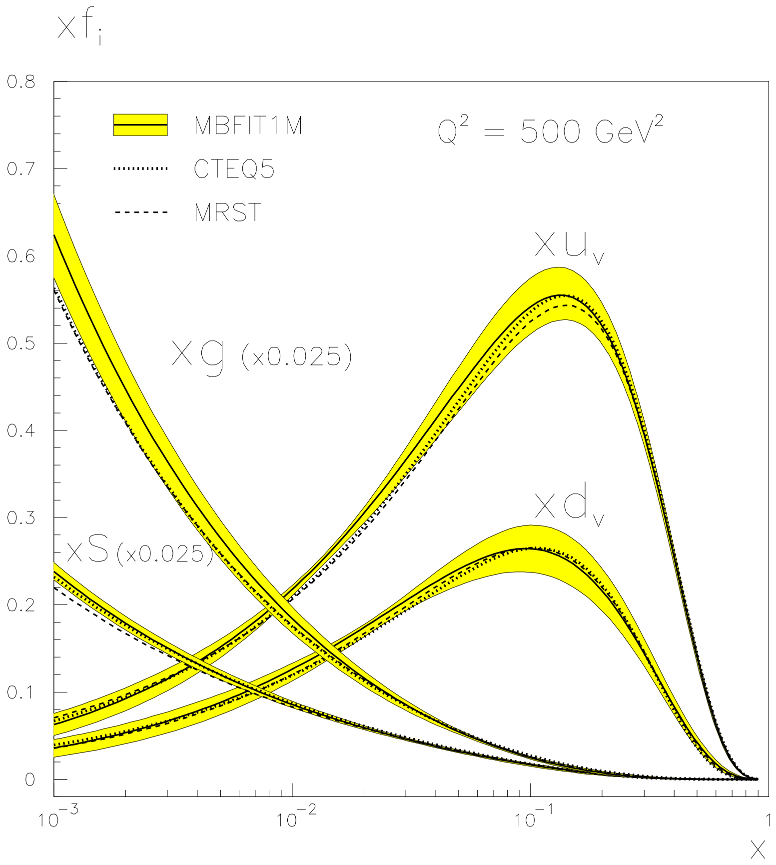
Measurement of dijet cross section and dijet rate

Green band : energy uncertainty

Yellow band : theoretical uncertainty (μ_r, pdf)

Data corrected for : Detector, EW, QED, Z^0 effects

PDF Uncertainty



Mostly estimated by variation of PDF

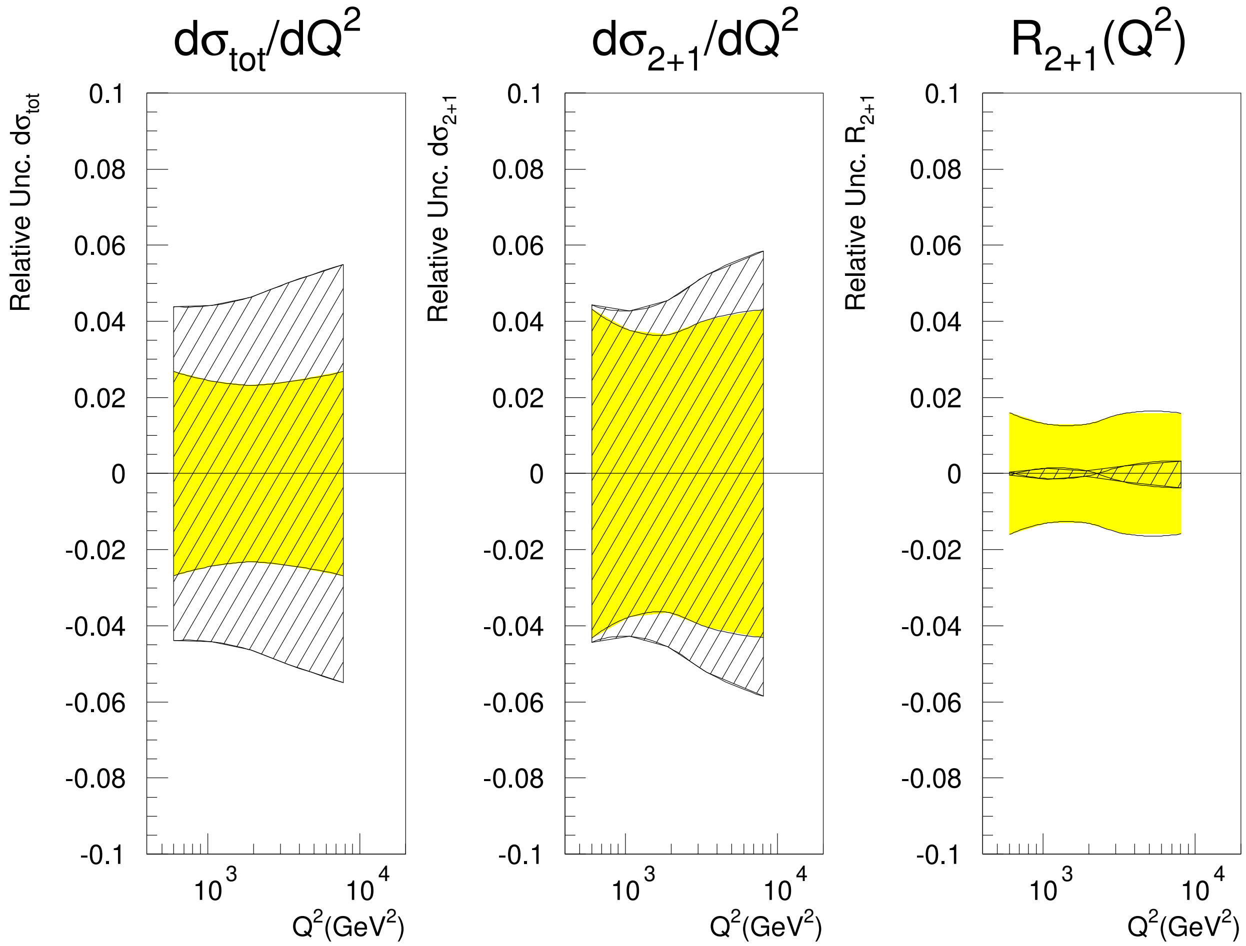
Newly available: epdflib by M. Botje

Contains PDF fit with uncertainties including correlations

Also in MBFIT fit program

Errors larger than PDF variation

PDF uncertainty



Yellow band: Taking into account correlations of PDFs

Hashed band: Neglecting this correlation

Correlations of errors are important !

Dijet cross sections

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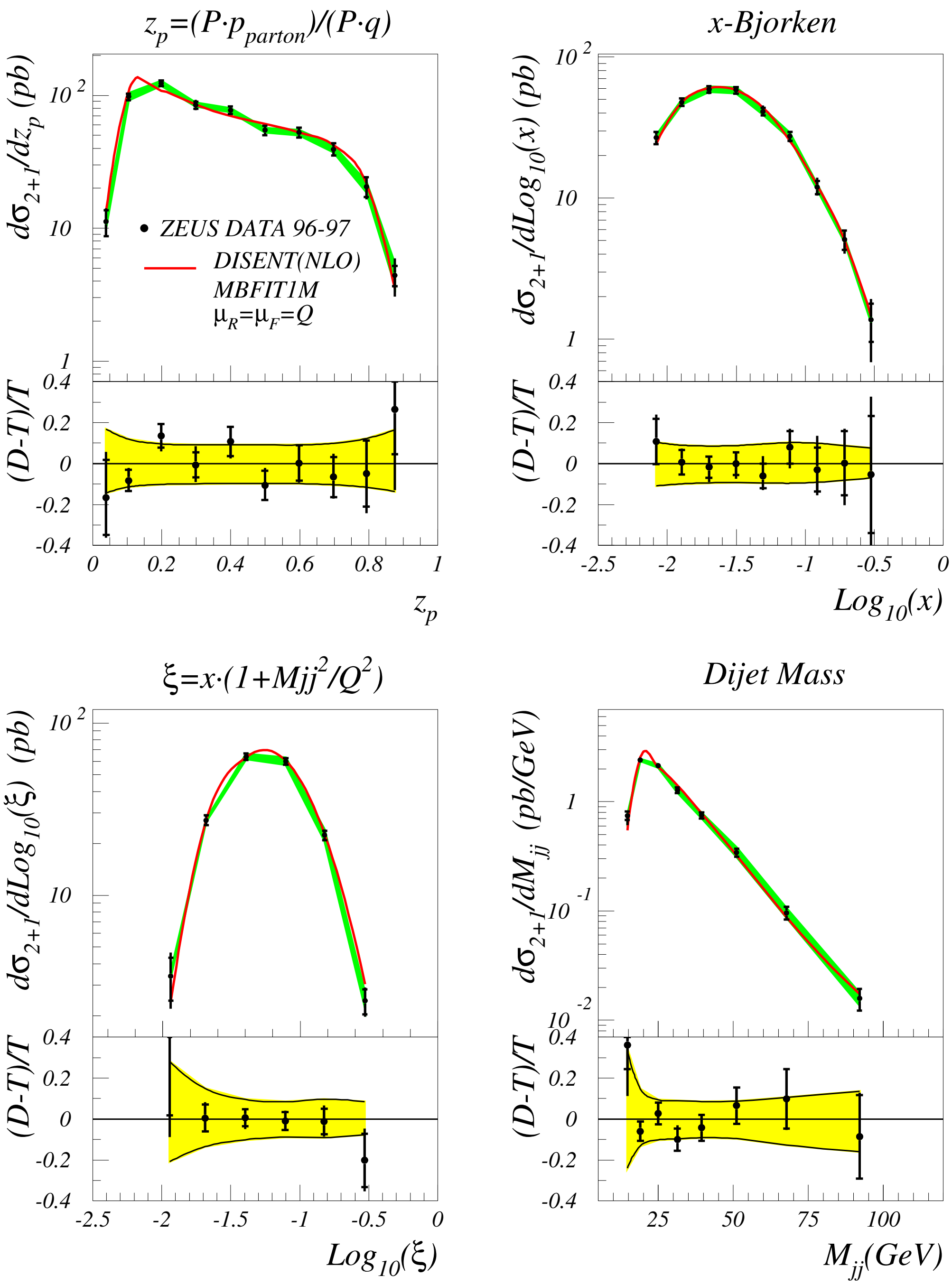
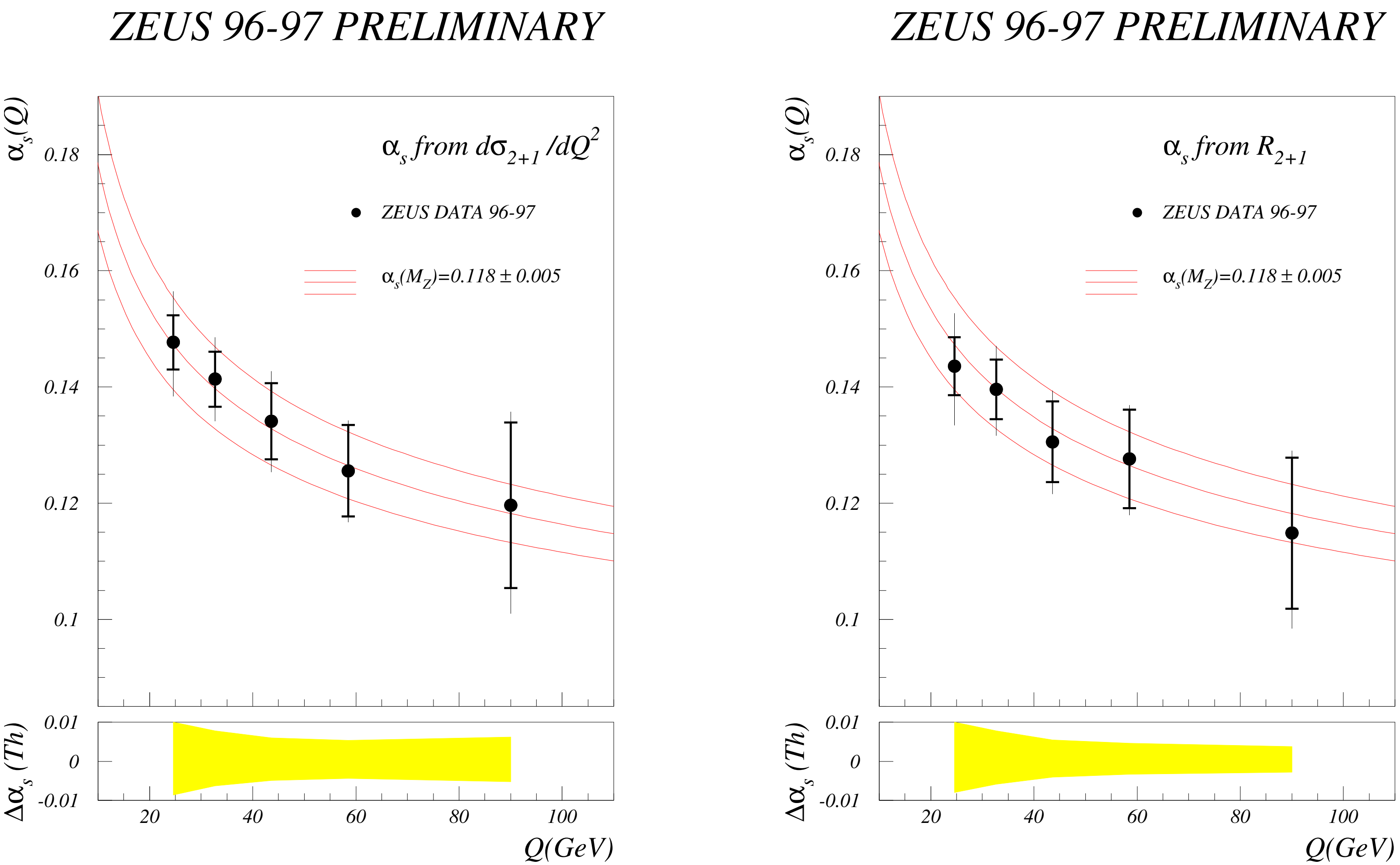


α_s from Dijet Cross Section and Rate



α_s from Dijet Cross Section and Rate

Dijet cross section

$$\alpha_s(M_Z) = 0.1186 \pm 0.0019(\mathsf{stat})\,{}^{+0.0020}_{-0.0007}(\mathsf{exp})\,{}^{+0.0035}_{-0.0033}(\mathsf{e.scale})\,{}^{+0.0048}_{-0.0038}(\mathsf{ren.scale}) \pm \mathbf{0.0031}(\mathbf{pdf}) \pm 0.0005(\mathsf{hadr})$$

Dijet rate

$$\alpha_s(M_Z) = 0.1166 \pm 0.0019(\mathsf{stat})\,{}^{+0.0023}_{-0.0005}(\mathsf{exp})\,{}^{+0.0036}_{-0.0034}(\mathsf{e.scale})\,{}^{+0.0050}_{-0.0042}(\mathsf{ren.scale})\,{}^{\mathbf{+0.0012}}_{\mathbf{-0.0011}}(\mathbf{pdf}) \pm 0.0005(\mathsf{hadr})$$

PDF uncertainties now better under control, cancel partially for rate

α_s from HERA

Incl. jet cross sections, $\mu_r = E_T$, H1 preliminary

$$\alpha_s(M_Z) = 0.1181 \begin{array}{l} +0.0061 \\ -0.0057 \end{array}$$

Incl. jet cross sections, $\mu_r = Q$, H1 preliminary

$$\alpha_s(M_Z) = 0.1221 \begin{array}{l} +0.0072 \\ -0.0070 \end{array}$$

Dijet cross section ZEUS preliminary

$$\alpha_s(M_Z) = 0.1186 \begin{array}{l} +0.0072 \\ -0.0063 \end{array}$$

Dijet rate ZEUS preliminary

$$\alpha_s(M_Z) = 0.1166 \begin{array}{l} +0.0070 \\ -0.0059 \end{array}$$

Gluon Density at HERA

Two major sources of information on gluon density

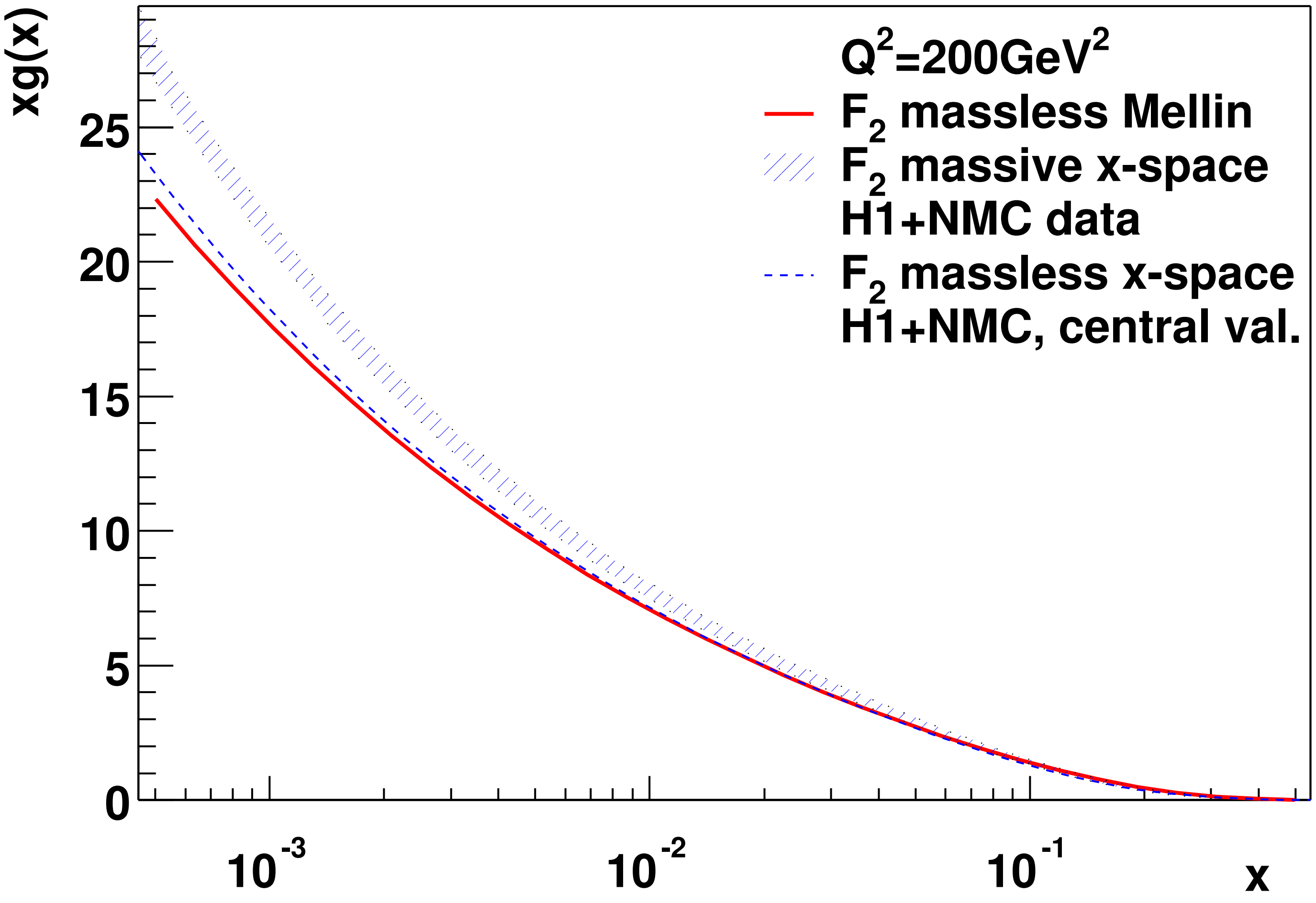
- Scaling violations in inclusive cross sections
- BGF graph in dijet cross sections

Idea: Combine both data sets in common fit

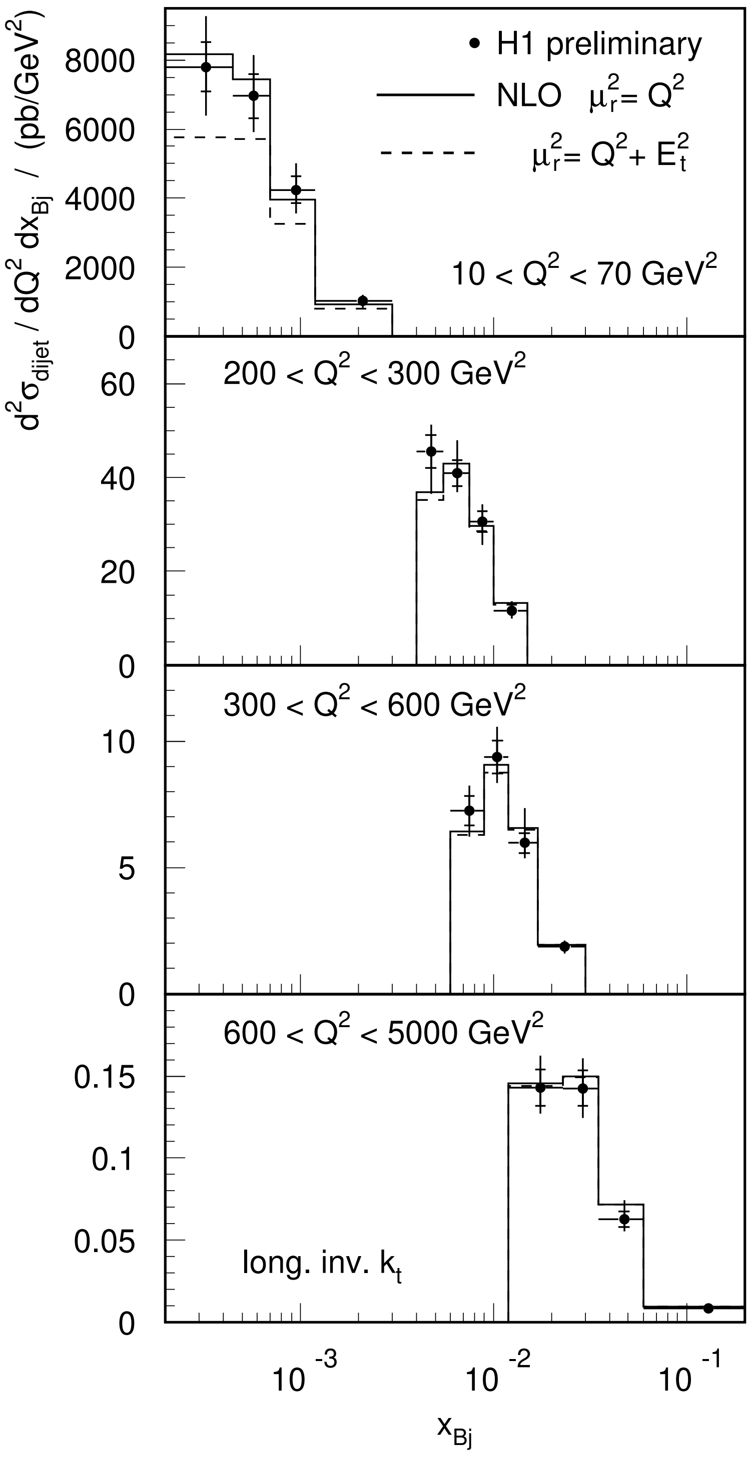
To show influence : H1 data only
Inclusive cross sections for $Q^2 > 20$ GeV^2
Dijet cross section $\frac{d^2\sigma_2}{dQ^2 dx_B}$ in the range 200 GeV$^2 < Q^2 < 5000$ GeV^2

Fitting $g(x), u_v(x), S(x)$ at $Q_0^2 = 4$ GeV^2
Using $d_v(x) = R(1-x)^\gamma u_v(x), \gamma = 2$

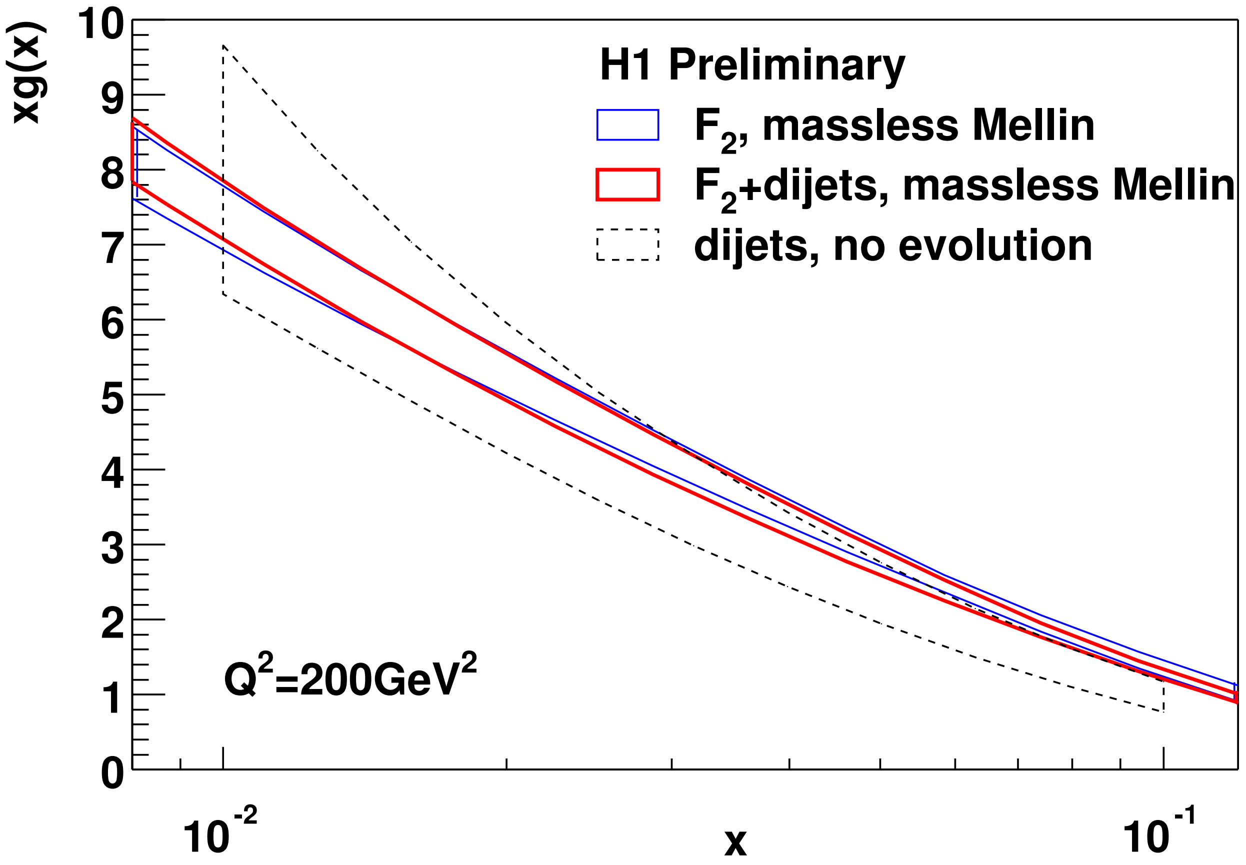
Gluon from Inclusive Cross Section (F_2)



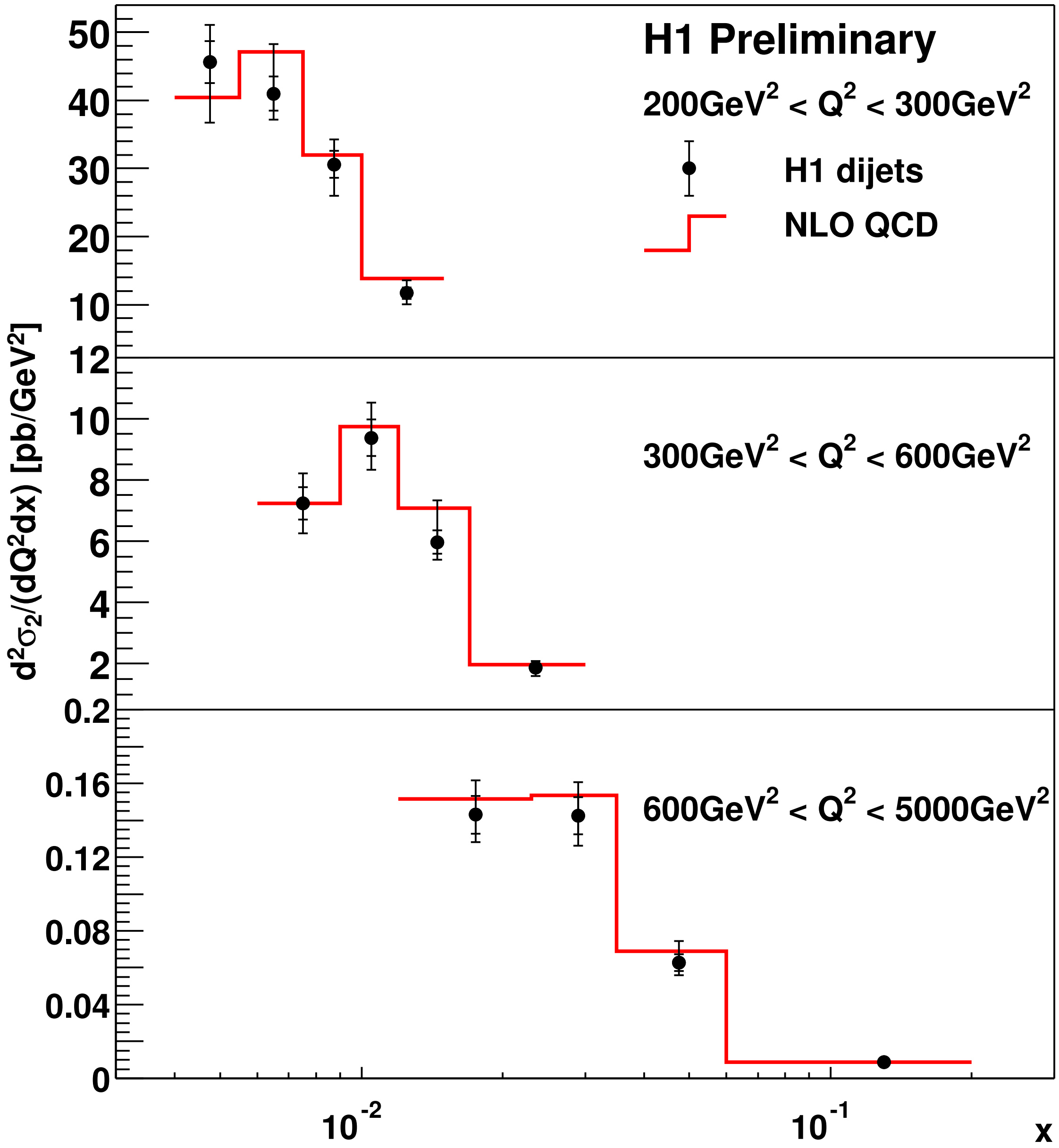
Double Differential Dijet Cross Section



Combined fit of dijet and inclusive data



Double Differential Dijet Cross Section



- Double differential dijet cross section well described
- Inclusive cross section well described
- Dijet data help to constrain the gluon at high x

Conclusions

QCD describes data very well in a large region of phase space

Strong coupling strength from jets at HERA:

- Determination from several observables
- Value and error compatible with world average
- Improved estimate of PDF uncertainty
- Precision limited by systematics and theory

Gluon density at HERA:

- Dijet and inclusive data give compatible result
- Dijet data improve fit stability at high x