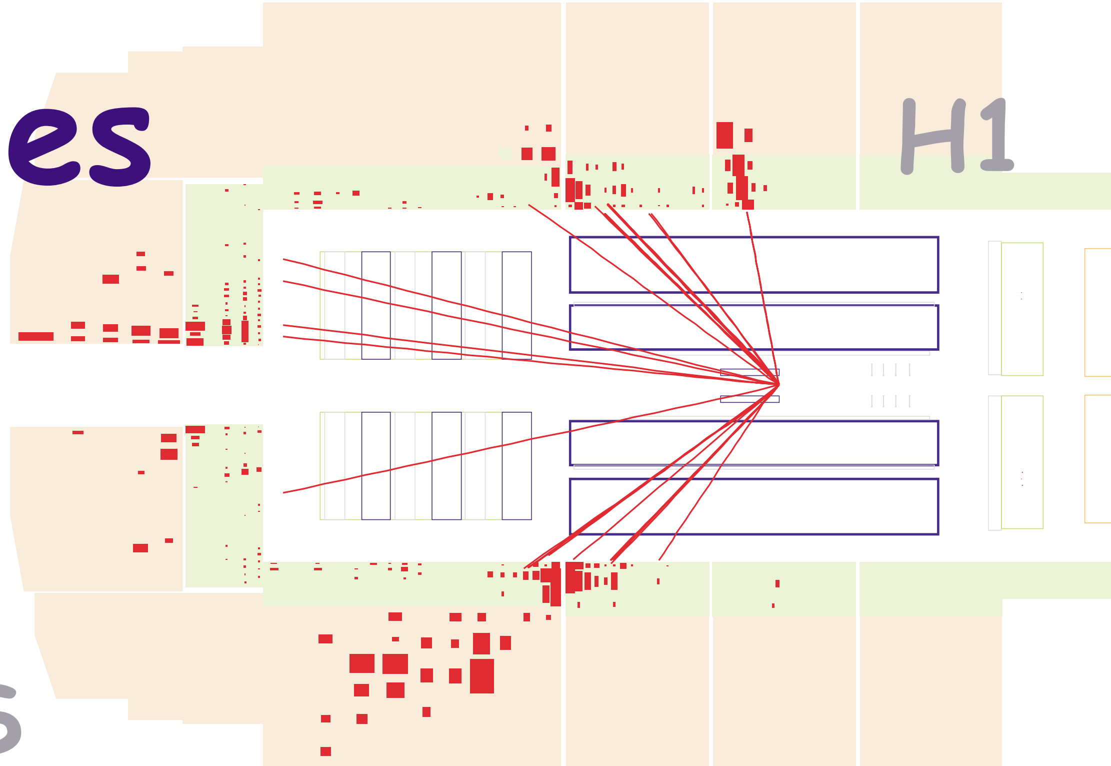
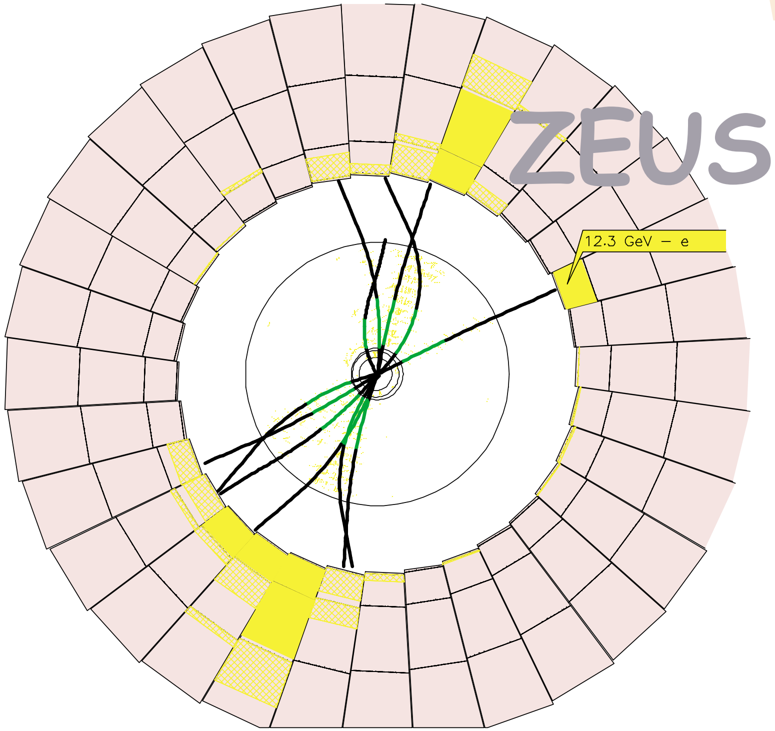
Jet Studies at HERA

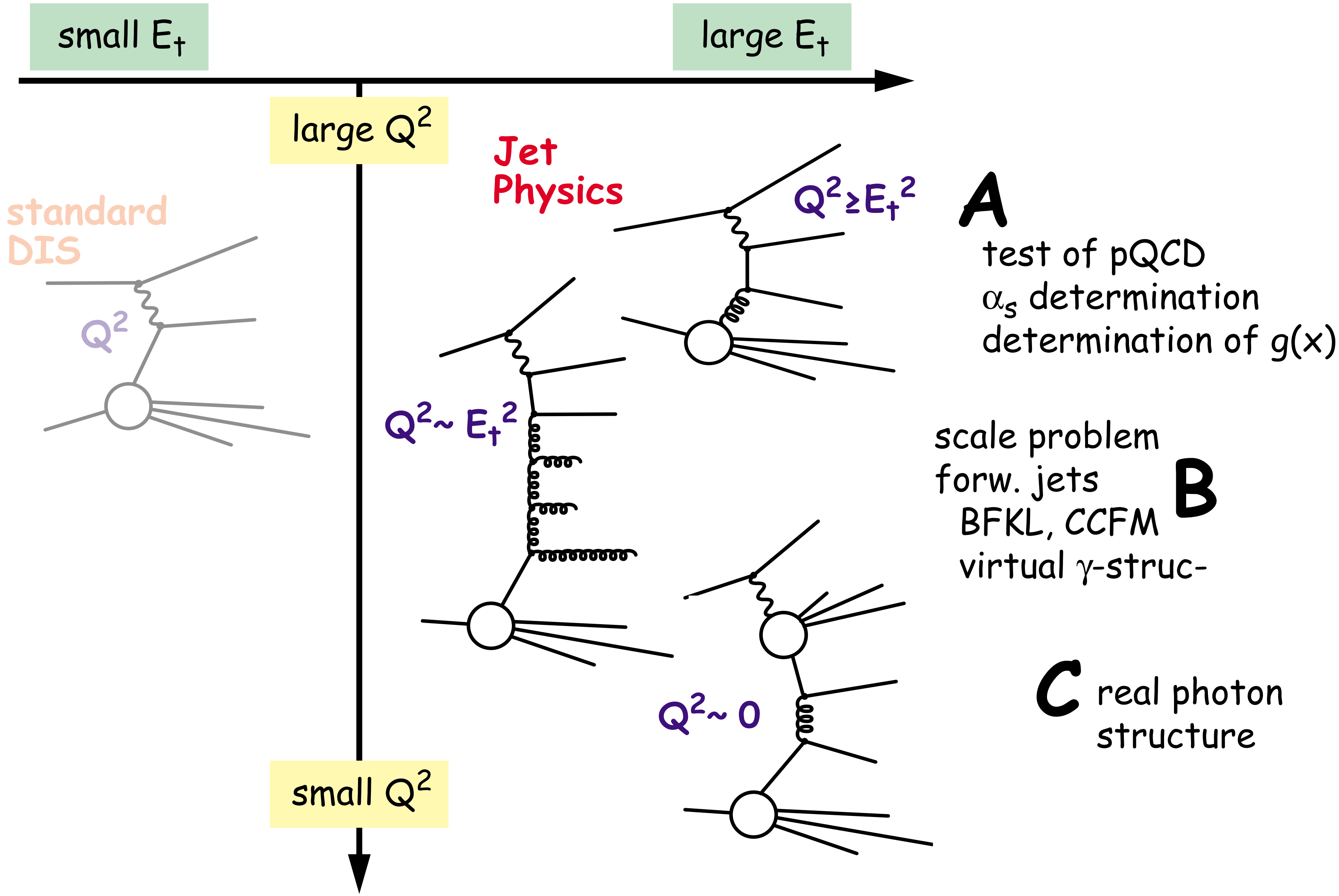




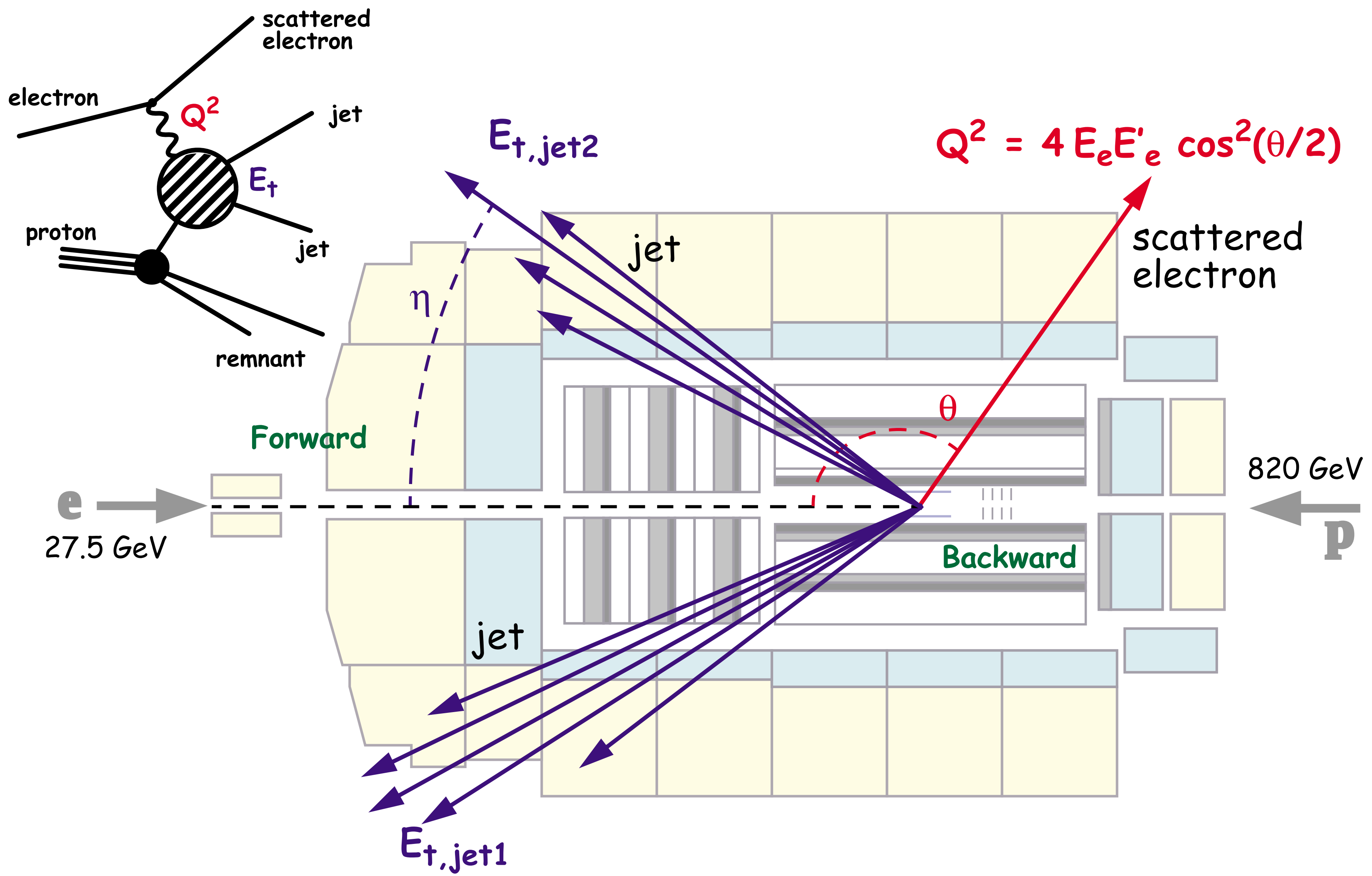
Hans-Christian Schultz-Coulon
Universität Dortmund

ISMD 2000, Tihany, Hungary
11. October 2000

Contents of the Talk

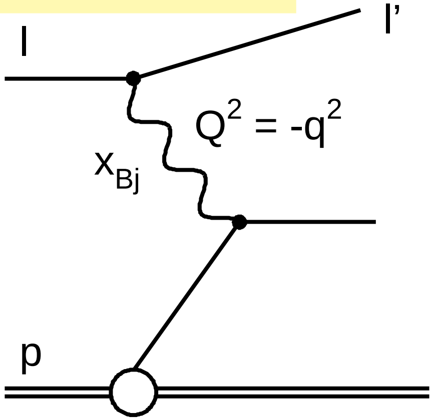


Dijet Kinematics

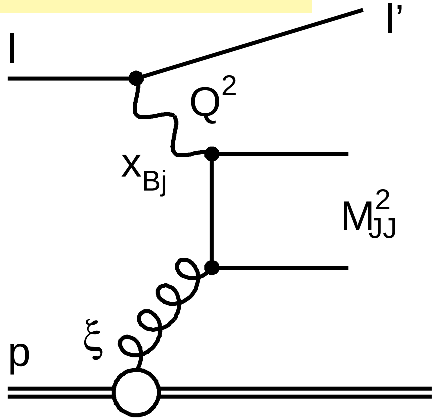


The Breit Frame

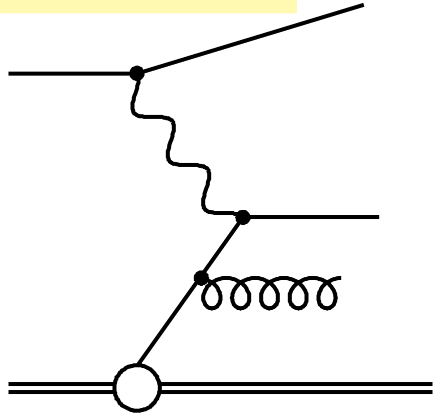
Born process



boson-gluon-fusion

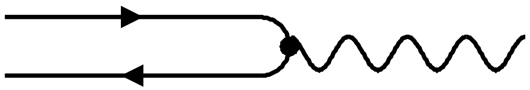


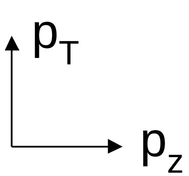
QCD-Compton

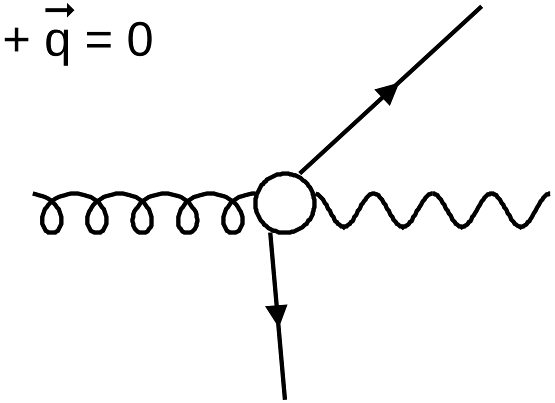


Large E_t only for $O(\alpha_s)$

Breit frame: $2x_{Bj}\,\vec{P} + \vec{q} = 0$



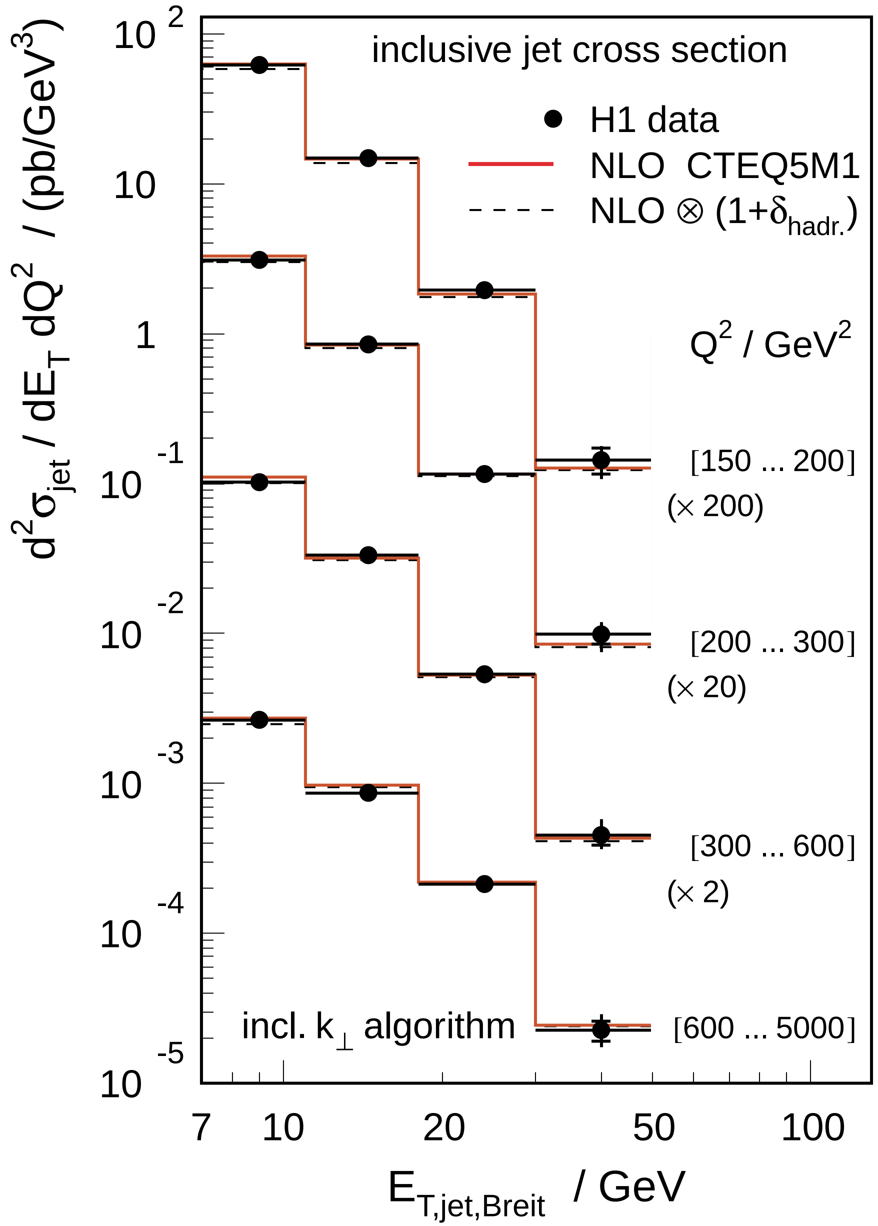




Born process

boson-gluon fusion

Inclusive Jet Cross Section



$$\sigma_{jet}^{pert} = \sum_n \alpha_s^n \left(\sum_{i=g,q} C_{i,n} \otimes pdf_i \right)$$

$$\sigma_{jet} = \sigma_{jet}^{pert} \cdot (1 + \delta_{hadr.\,corr.})$$

Hadronization Corrections < 10 %

Sensitivity to strong coupling constant α_s

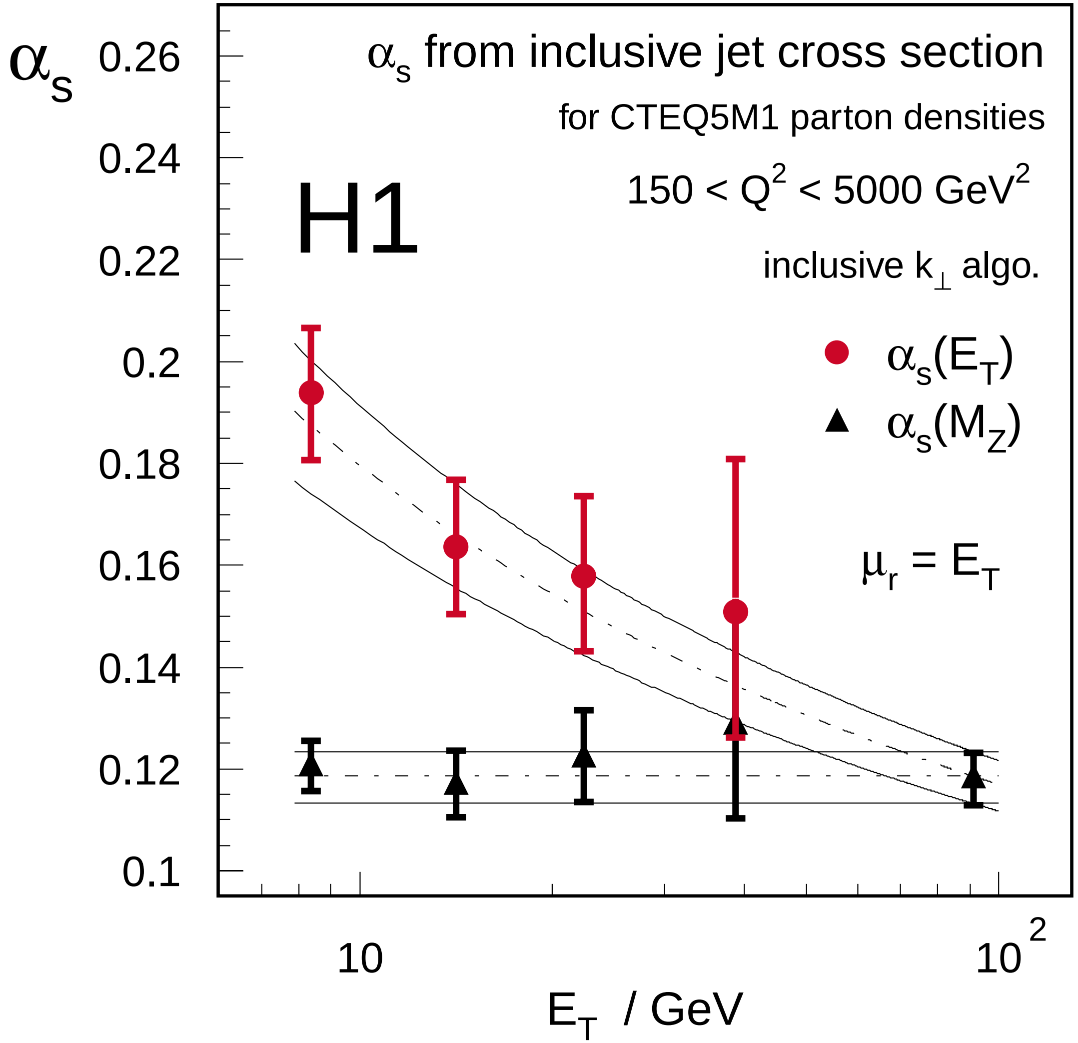
α_s Result from Inclusive Jets

exp.

$\alpha_s(M_Z) = 0.1186 \pm 0.0030$ $^{+0.0039}_{-0.0045}$ $^{+0.0033}_{-0.0023}$

theo.

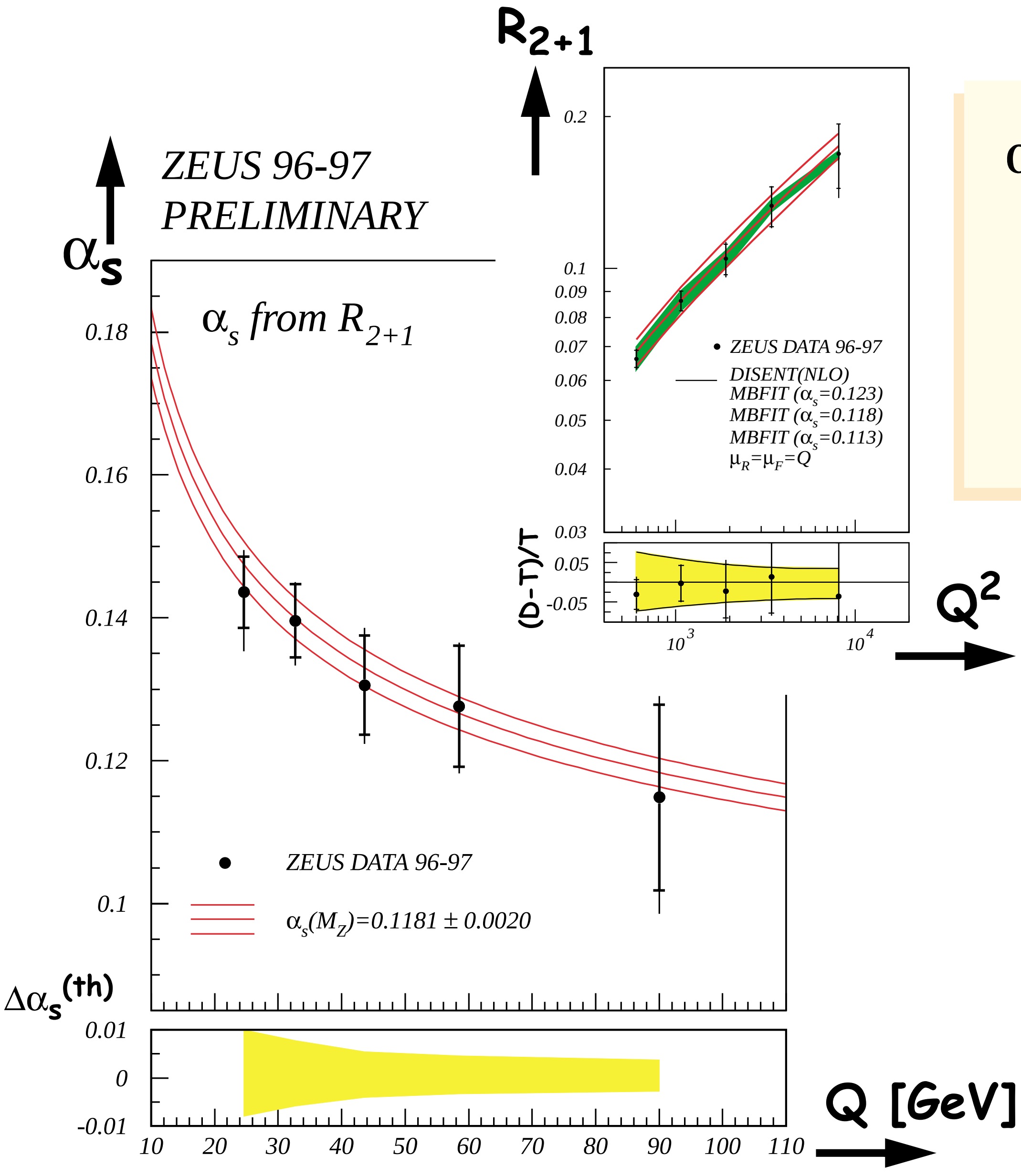
PDF



H1:

From fit to
incl. jet cross section
using CTEQ5M1 PDFs

α_s Result from R_{2+1}



$$\alpha_s(M_Z) = 0.1166 \begin{matrix} + 0.0039 \\ - 0.0047 \end{matrix} \text{ exp.}$$

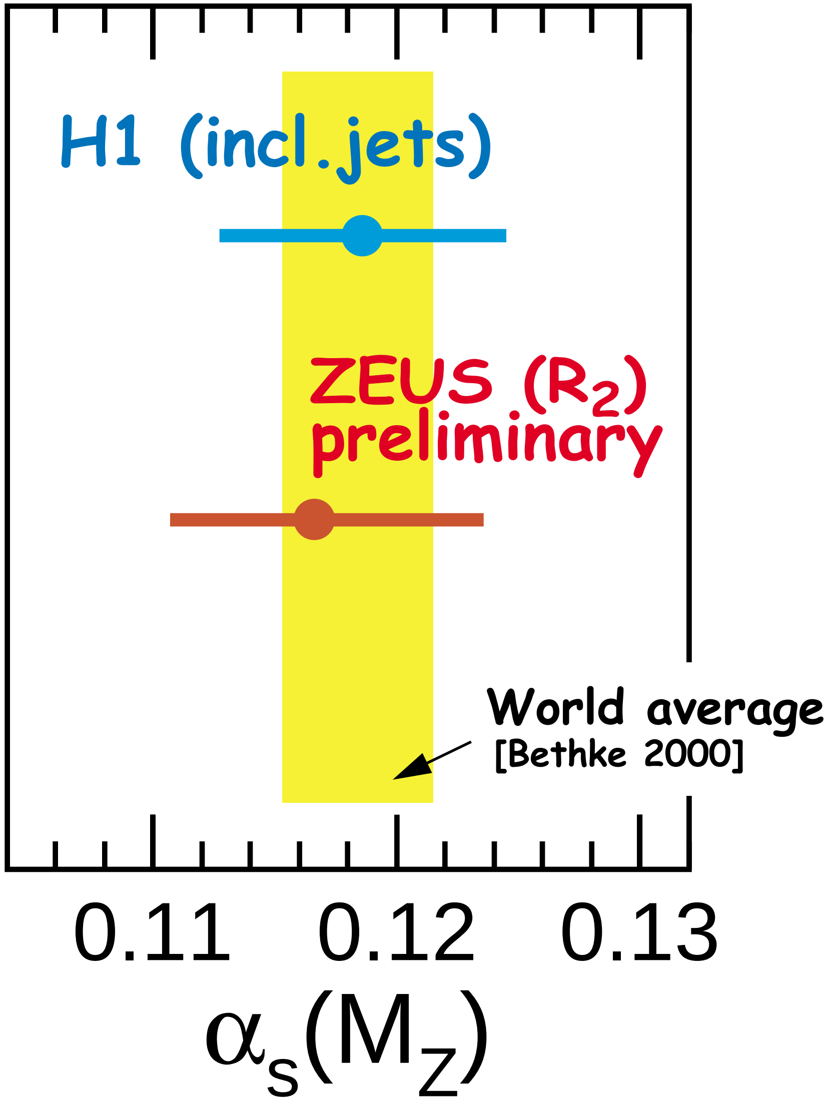
$$\begin{matrix} + 0.0055 \\ - 0.0042 \end{matrix} \text{ theo.}$$

$$\begin{matrix} + 0.0012 \\ - 0.0011 \end{matrix} \text{ PDF}$$

ZEUS:

From fit to dijet rate R_{2+1} using MBIFIT PDFs (Botje '99)

Comparison of α_s Results



H1:

$\alpha_s(M_Z) = 0.1186 \pm 0.0059$

ZEUS:

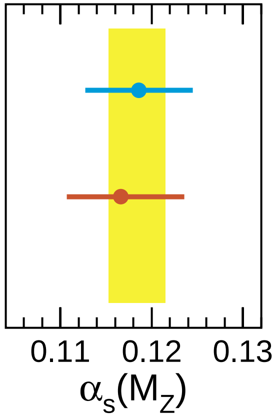
$\alpha_s(M_Z) = 0.1166 \, {}^{+0.0068}_{-0.0064}$

World average

[J. Phys. G26 (2000) R27]

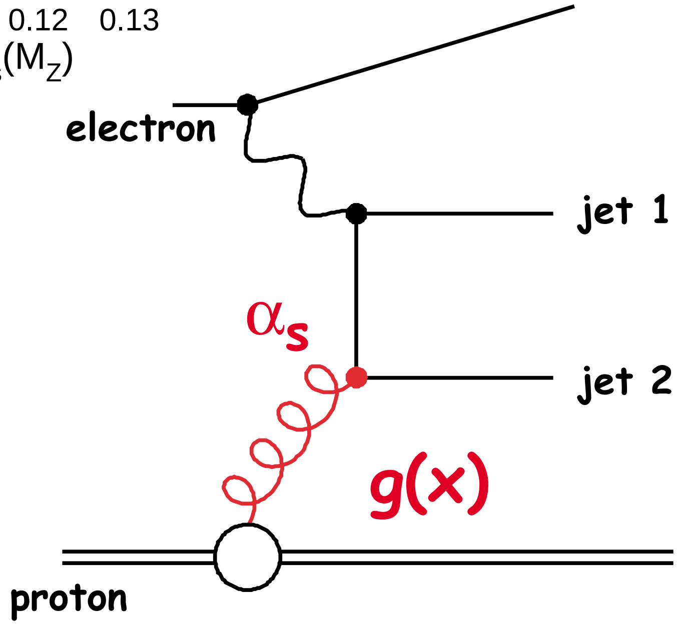
$\alpha_s(M_Z) = 0.1184 \pm 0.0031$

α_s vs. g(x) Determination



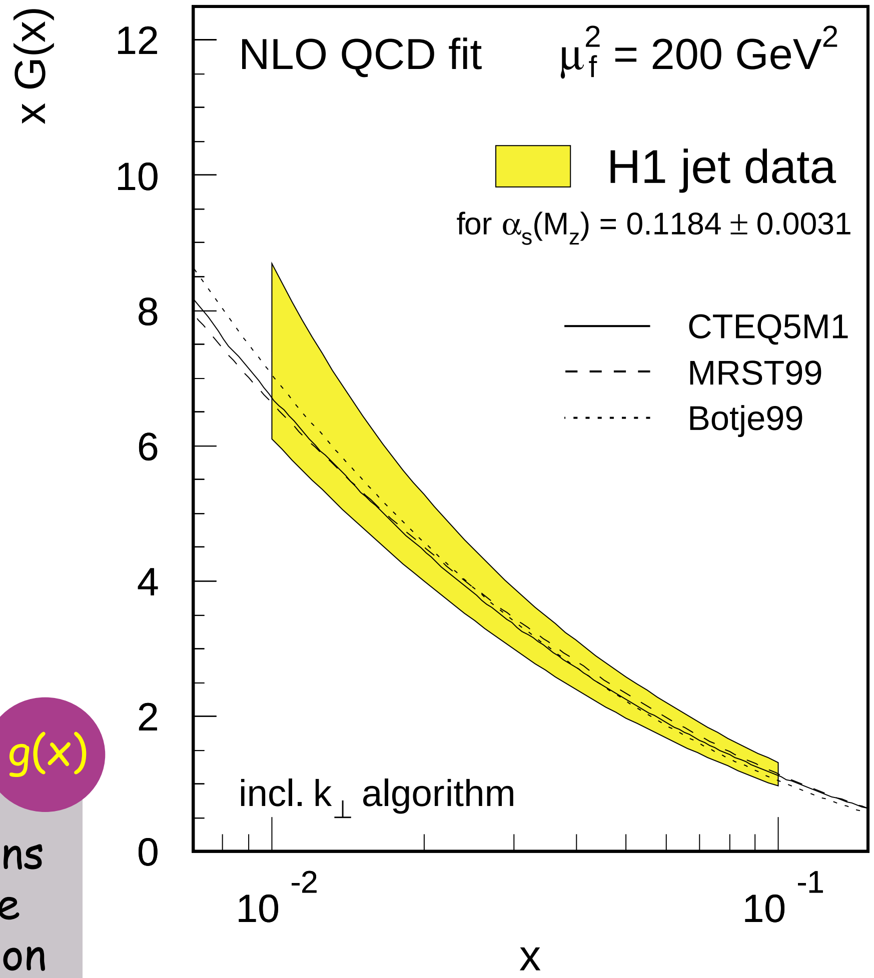
α_s

Input:
- jet cross sections
- PDFs



g(x)

Input:
- jet cross sections
- α_s world average
- DIS cross section



HERA “standalone” QCD Test

A simultaneous QCD fit of α_s and xg(x)

Basic idea:

Use three different cross sections to disentangle α_s, g(x), q(x)

$$\sigma_{DIS} \sim q(x)$$

$$\sigma_{jet} \sim \alpha_s \cdot (c_g g(x) + c_q q(x))$$

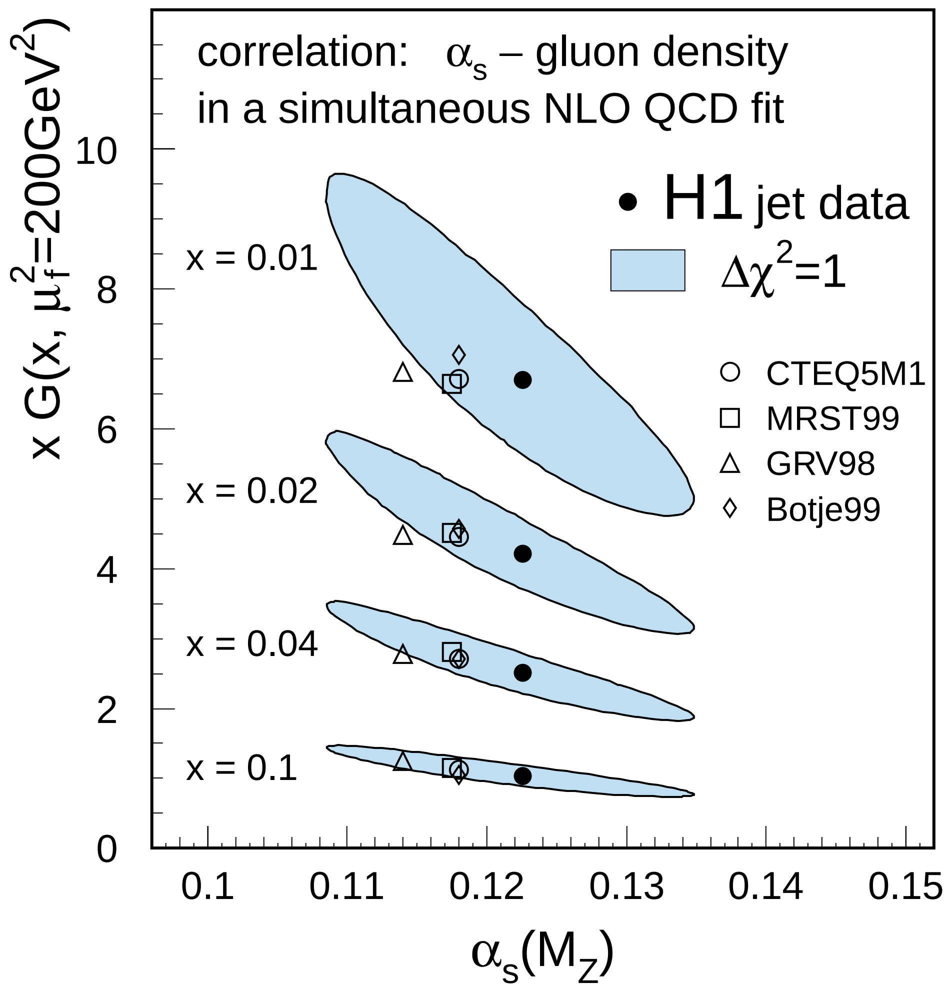
$$\sigma_{dijet} \sim \alpha_s \cdot (c'_g g(x) + c'_q q(x))$$

Kinematic range:

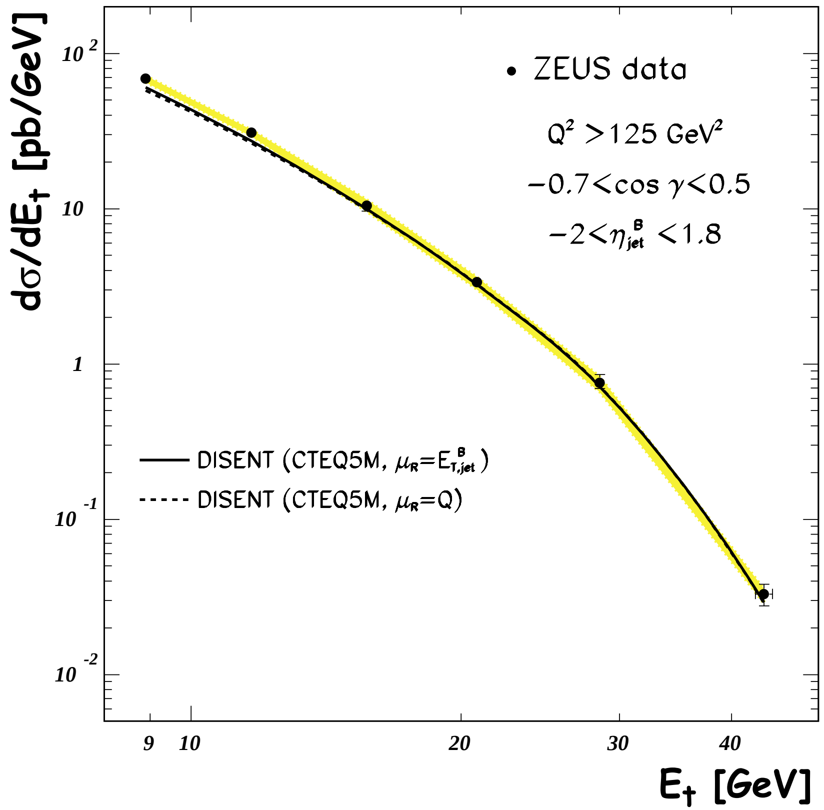
- DIS x-section: $150 < Q^2 < 1000$ GeV^2
- Jet cross section: $150 < Q^2 < 5000$ GeV^2

Fit:

- fixed factorization scale μ_f
- systematics include experimental, scale and hadronization uncertainties

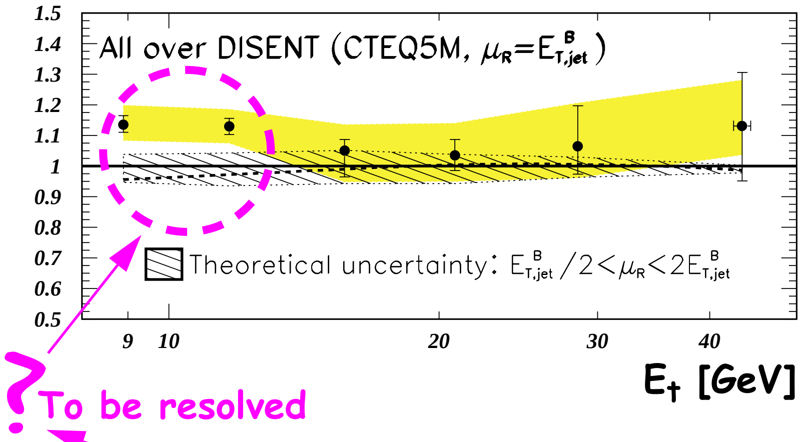


Inclusive Jets: Comparison with NLO



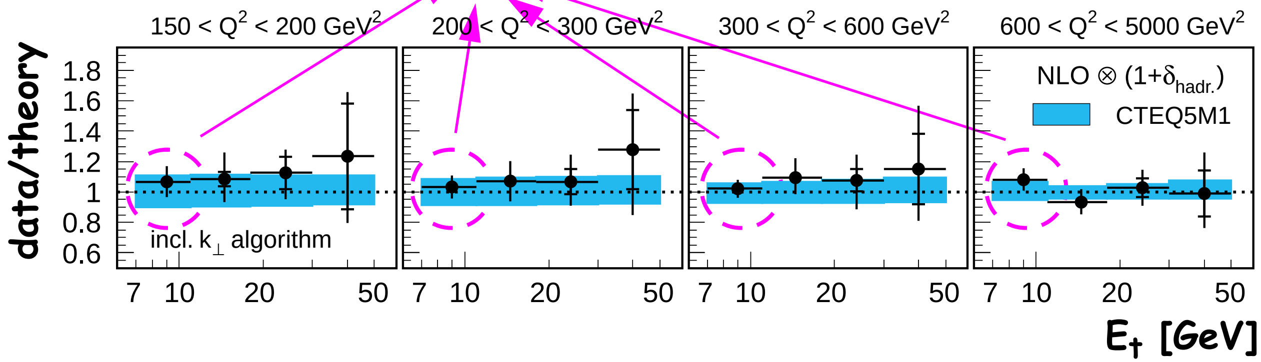
ZEUS preliminary

Inclusive jet cross section as a function of the jet transv. energy E_t in the Breit frame

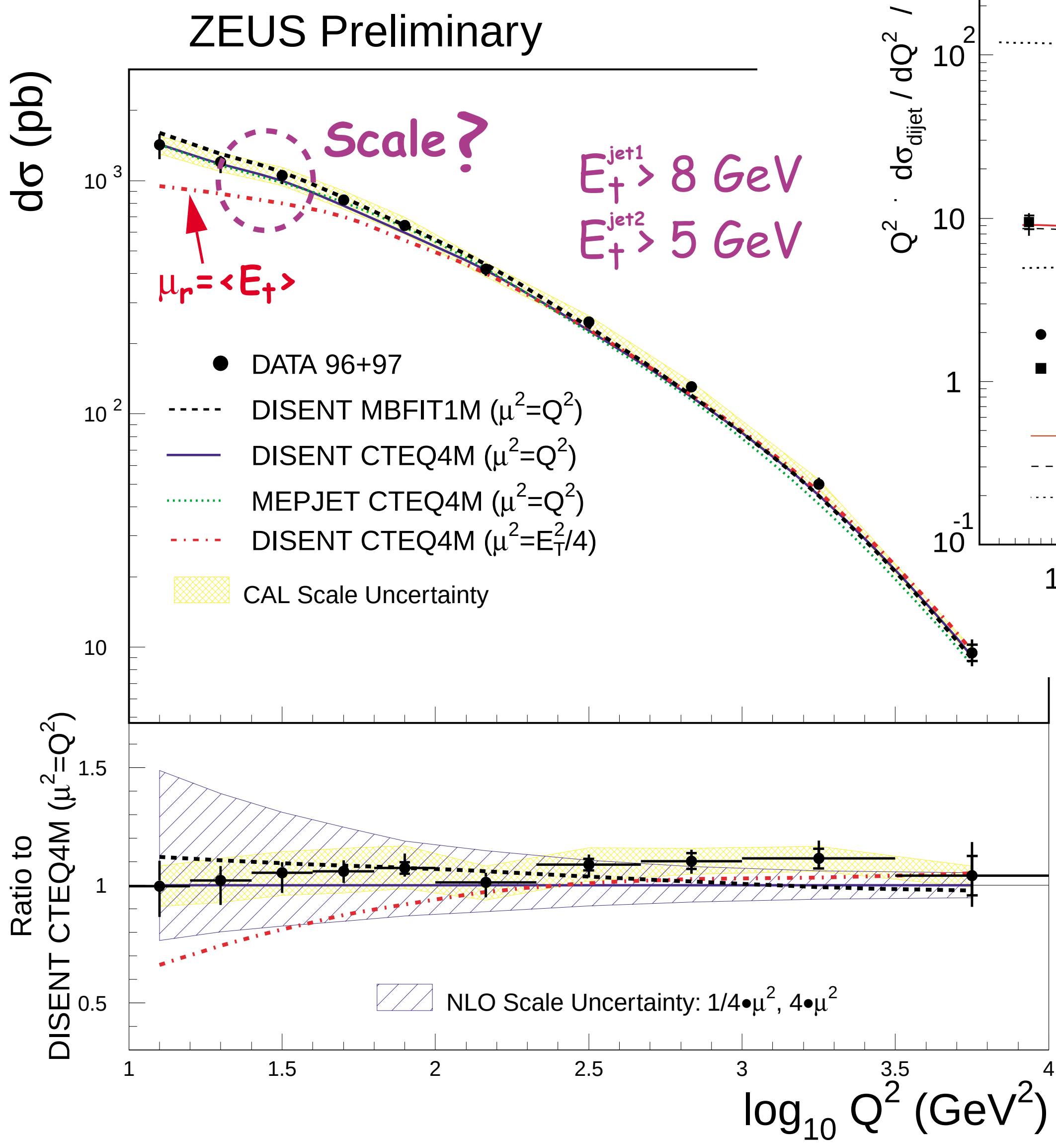


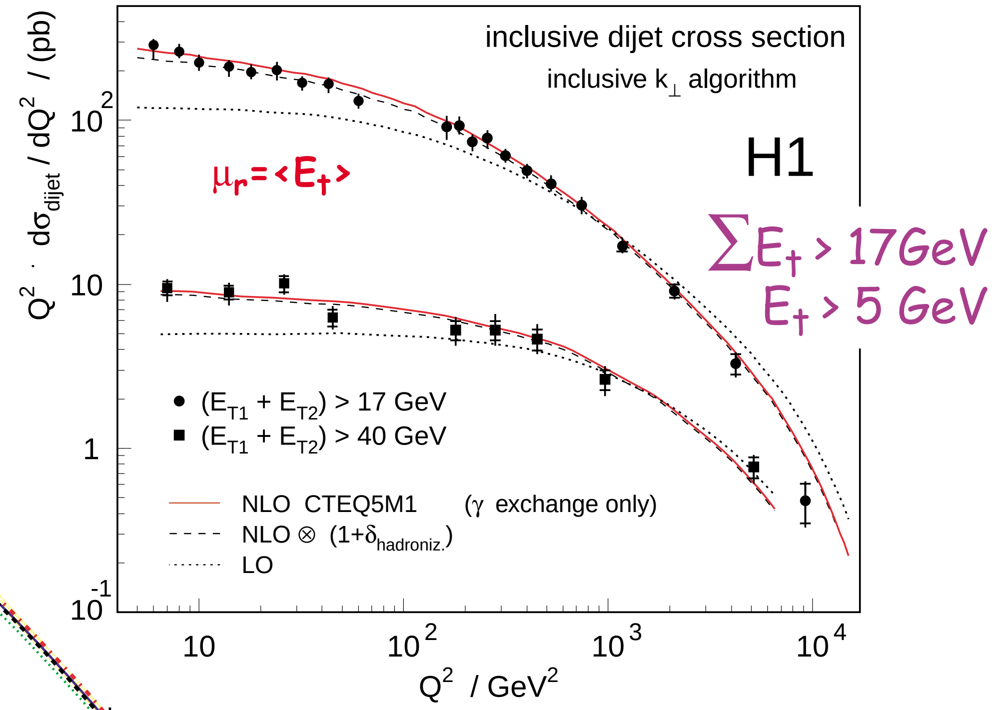
H1 data

Inclusive jet cross section in the Breit frame



Dijet Cross Sections

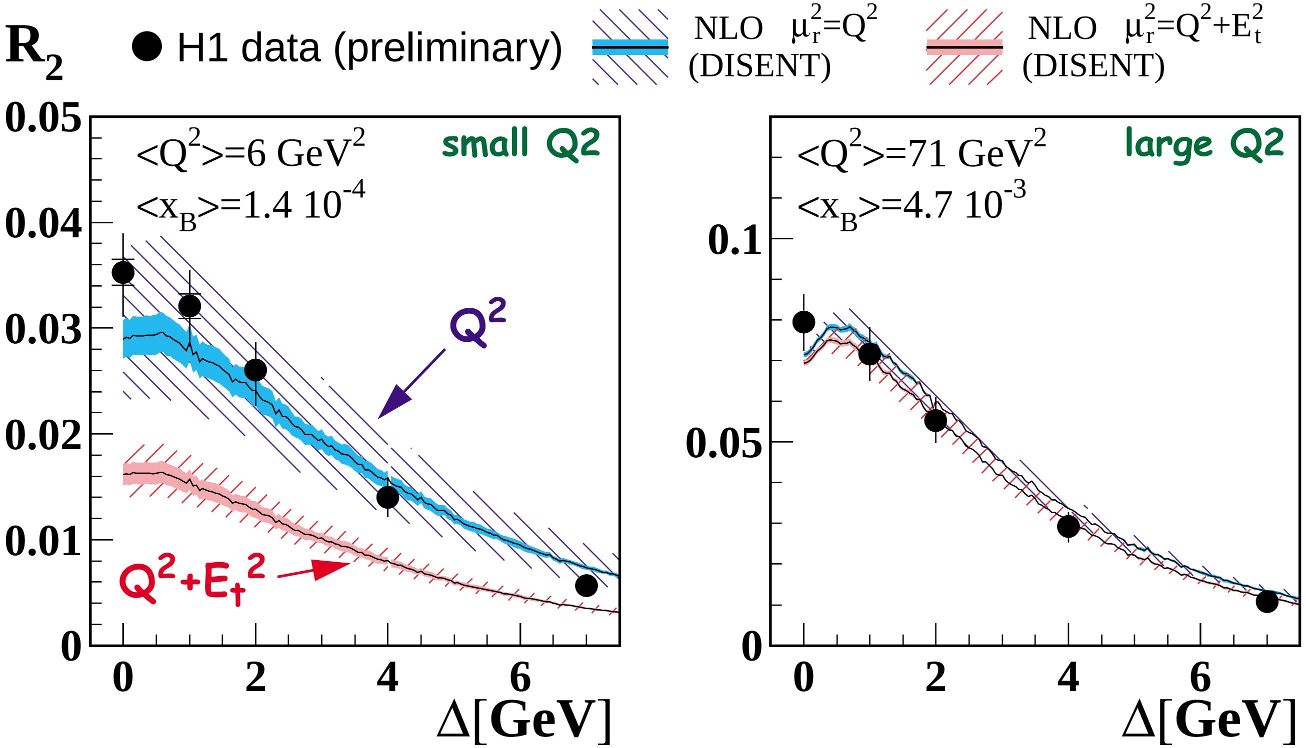


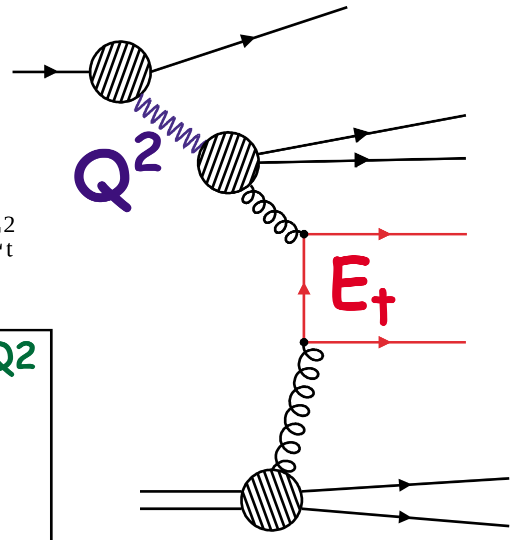


Good description of data by NLO for both experiments if $Q^2 > 150$ GeV^2

The Scale Problem

Δ dependence of R_2 for two bins of x_B and Q^2

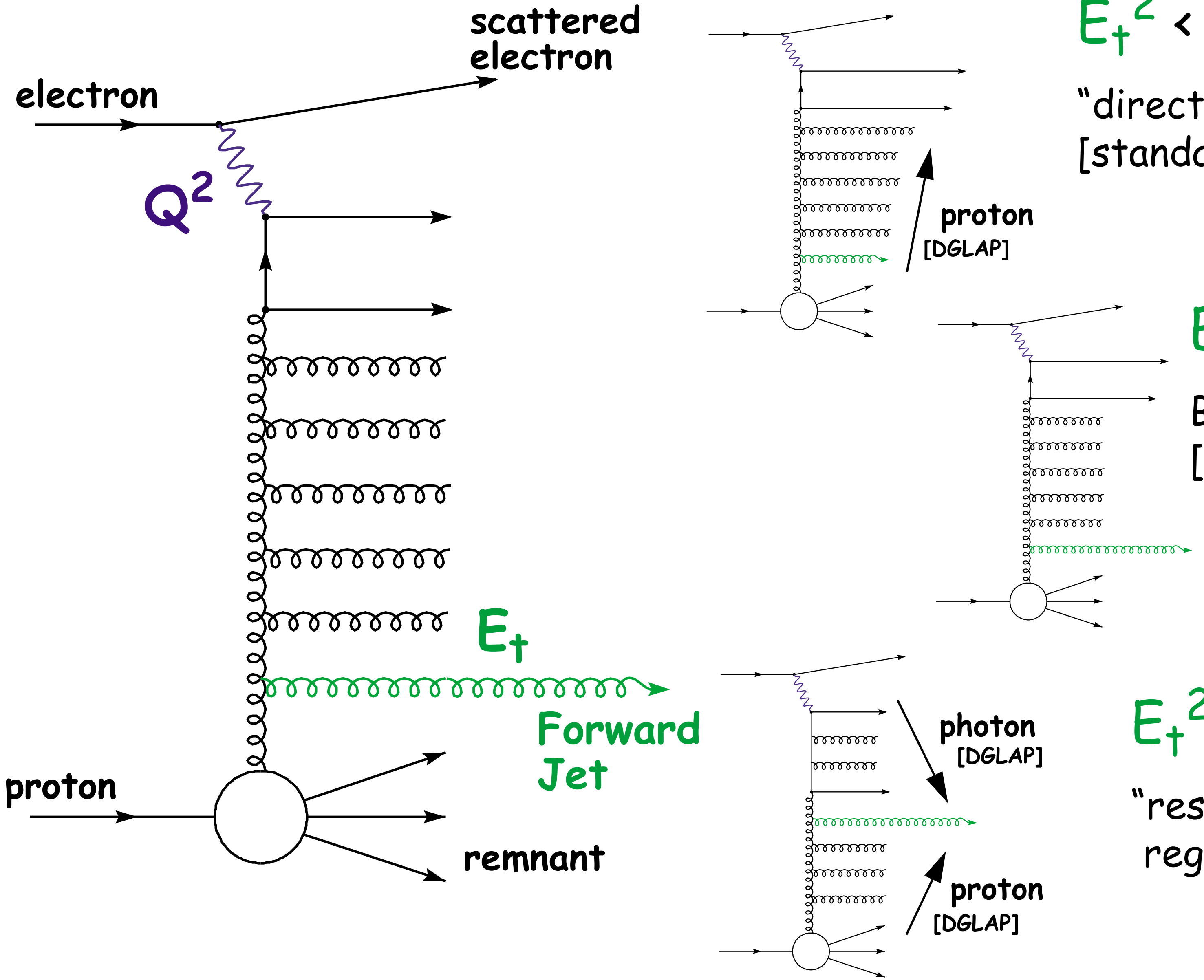




Scale ?

$E_T^{jet1} > 5 + \Delta$ GeV & $E_T^{jet2} > 5$ GeV

Forward Jet Production in DIS



$E_t^2 < Q^2$

"direct γ" region
[standard DIS]

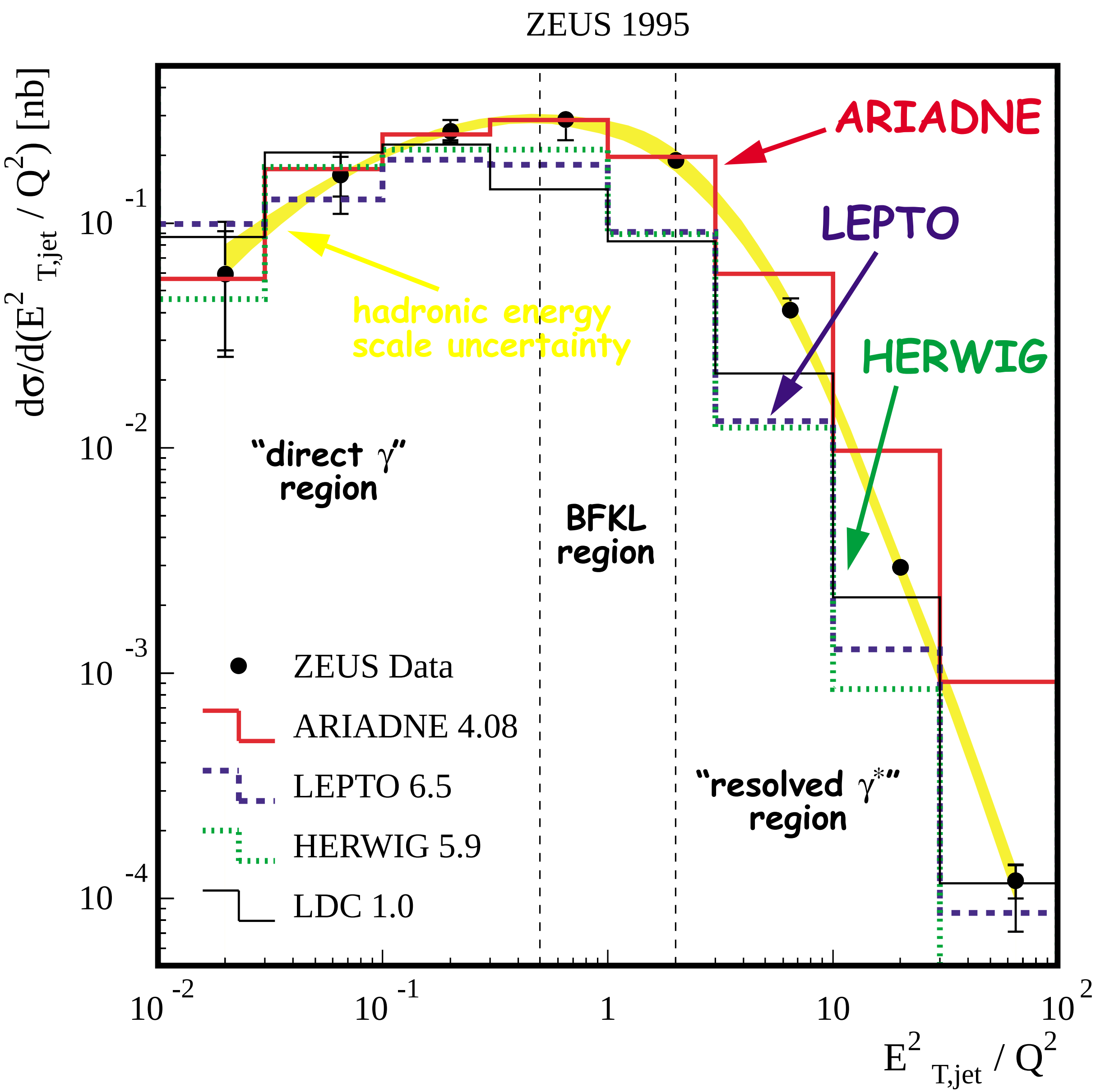
$E_t^2 \sim Q^2$

BFKL region
[2 scales]

$E_t^2 > Q^2$

"resolved γ^*"
region

Forward Jets: E_t/Q^2 Dependence



Event selection:

- $Q^2 > 10\ \text{GeV}^2$
- $y > 0.1$, $E'_e > 10$ GeV

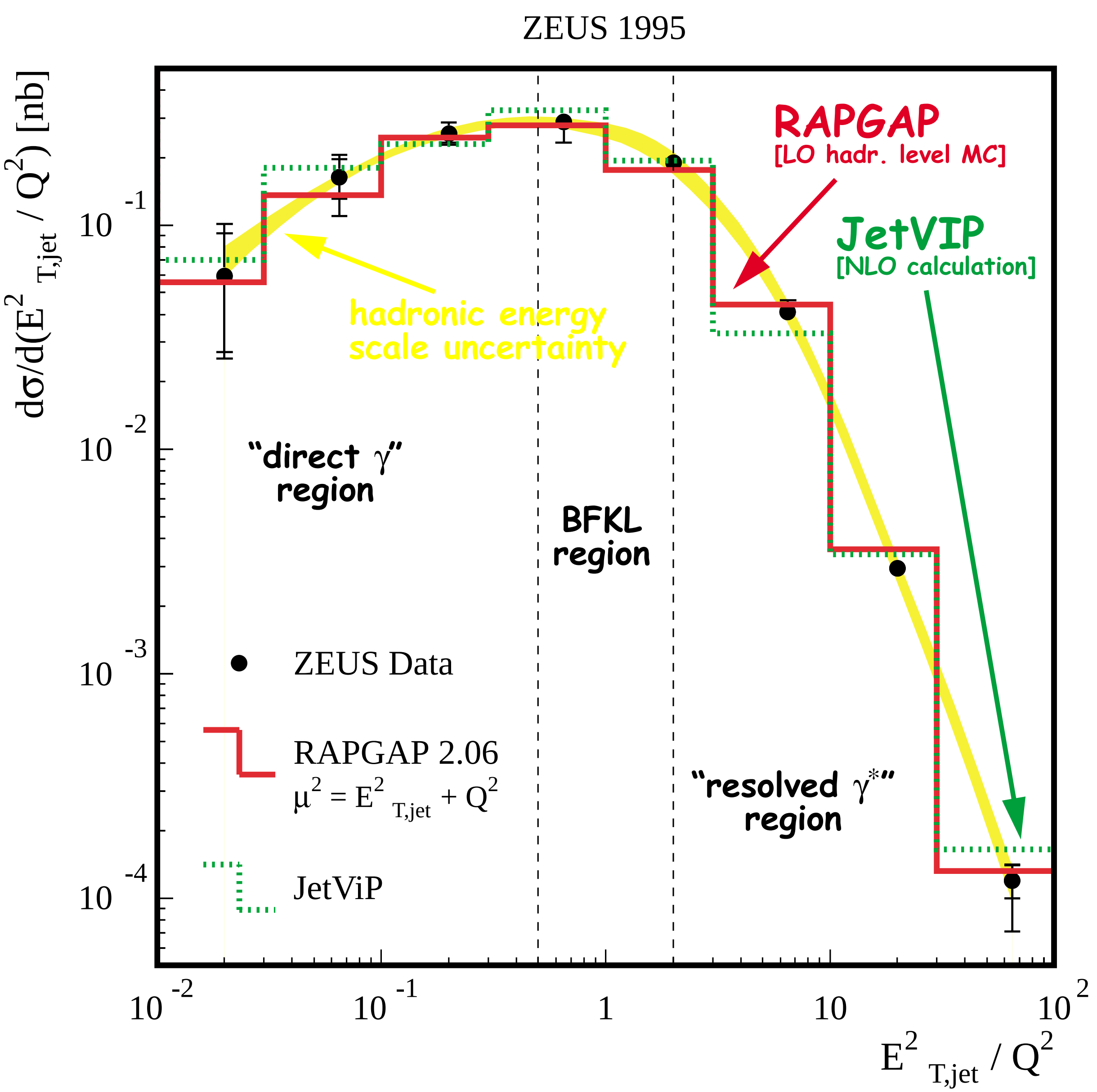
- $\eta_{jet} < 2.6$ ($\theta_{jet} > 8.5°$)
- $E_{t,jet} > 5$ GeV

- $x_{jet} = p_{z,jet}/p_{beam} > .036$
- $p_{z,Breit} > 0$

Something in addition to standard direct γ (LO) predictions needed

resolved γ*
BFKL
...

Forward Jets & Resolved Virtual γ's

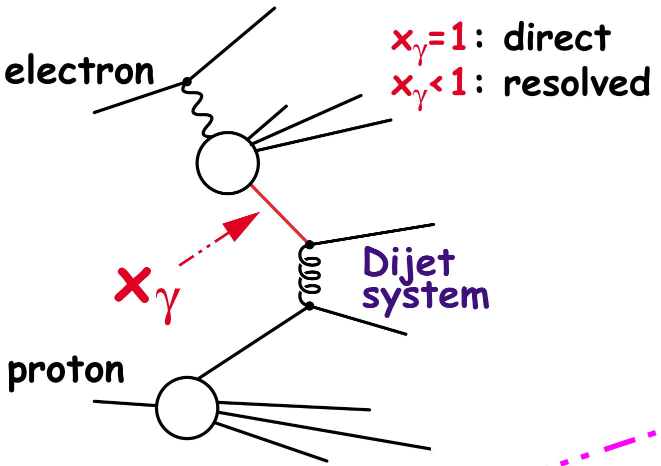


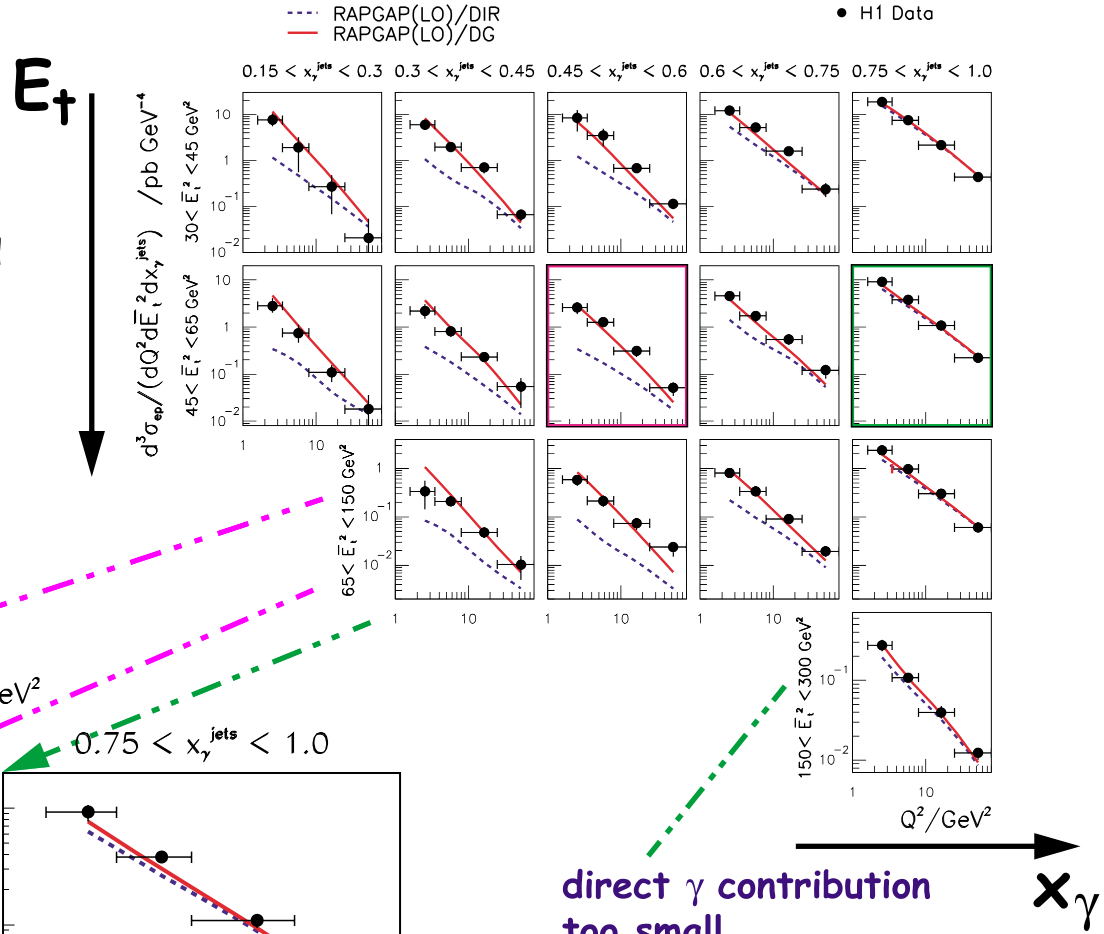
Include resolved γ^* structure in models [via photon pdf's]

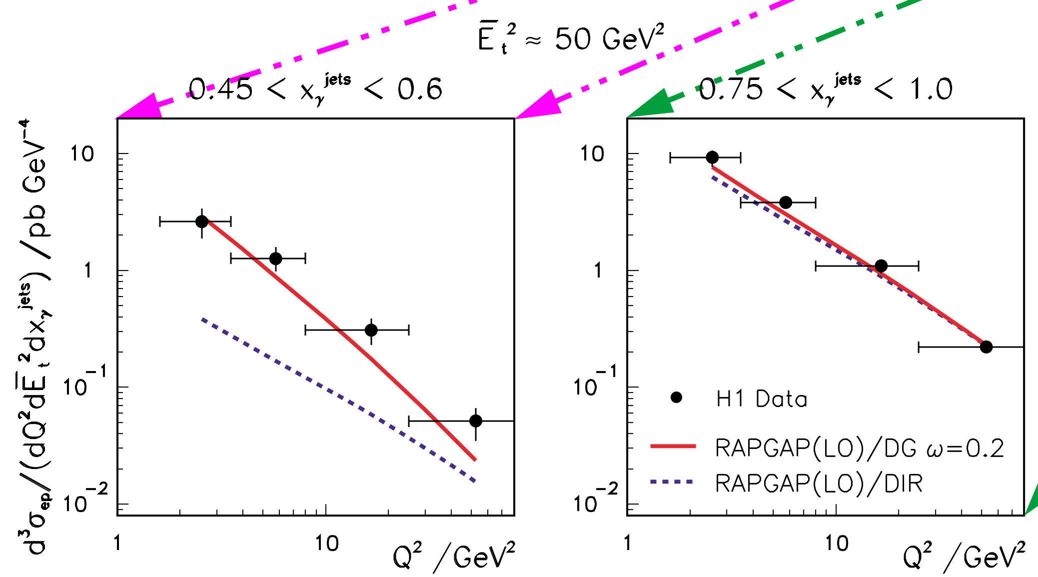
"direct γ"	ok
"resolved γ^*"	ok
BFKL	ok

Virtual γ Structure: Dijet x-Section

Study region $Q^2 < E_t^2$





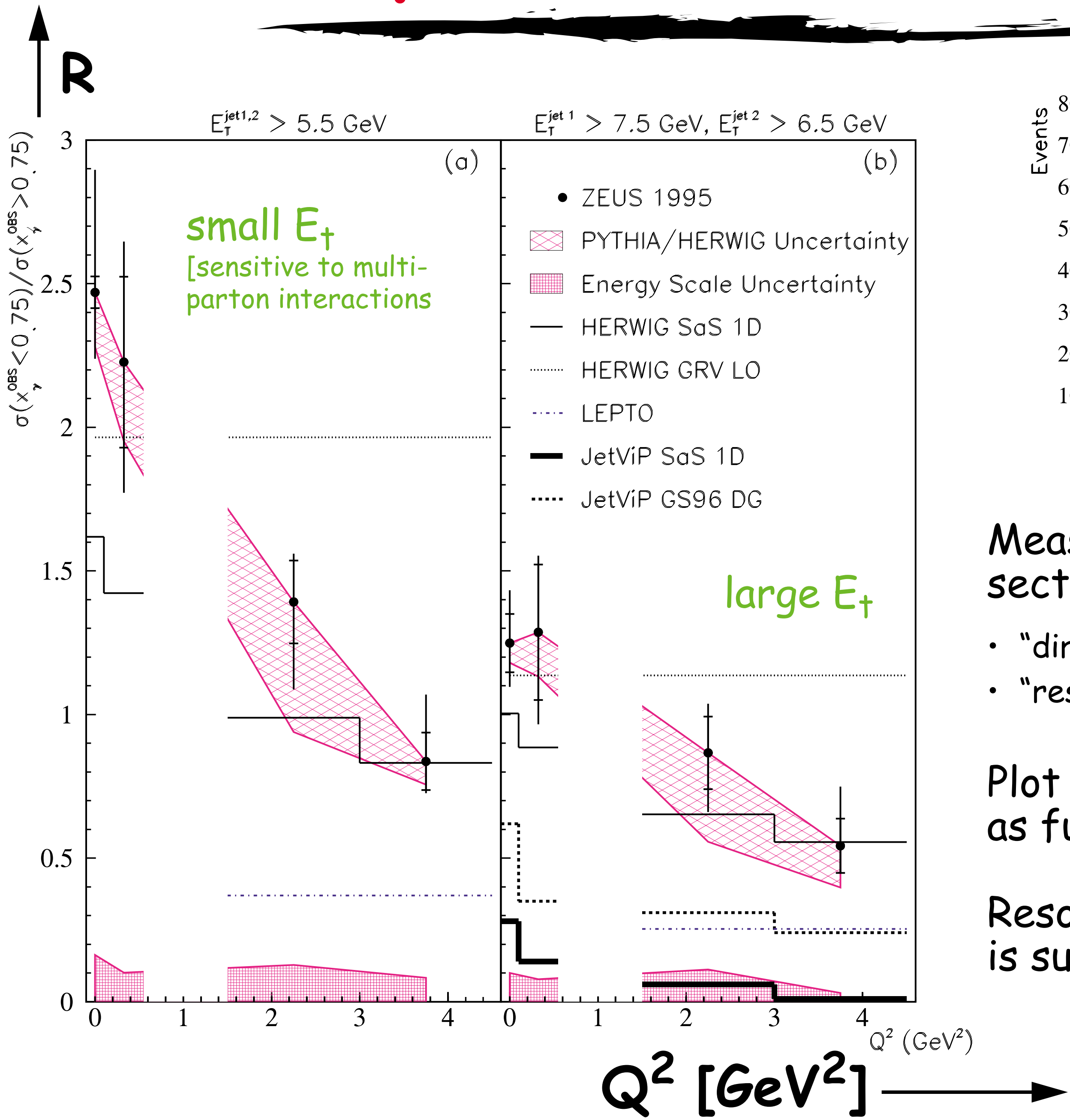


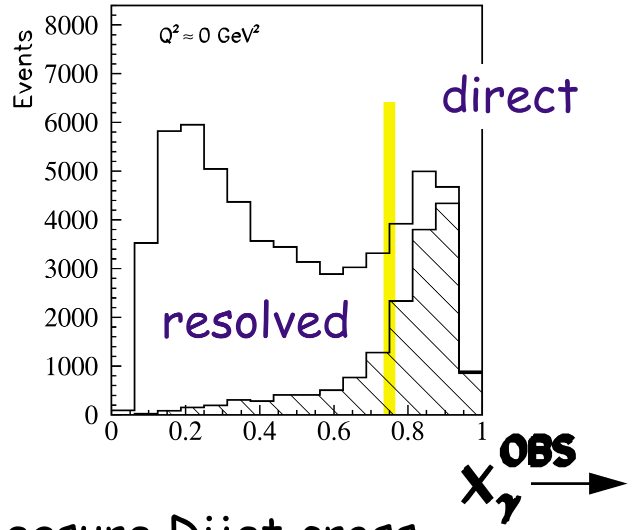
direct γ contribution too small

resolved γ* component needed

Scale: E_t^2

Q^2 Dependence of γ^* Structure





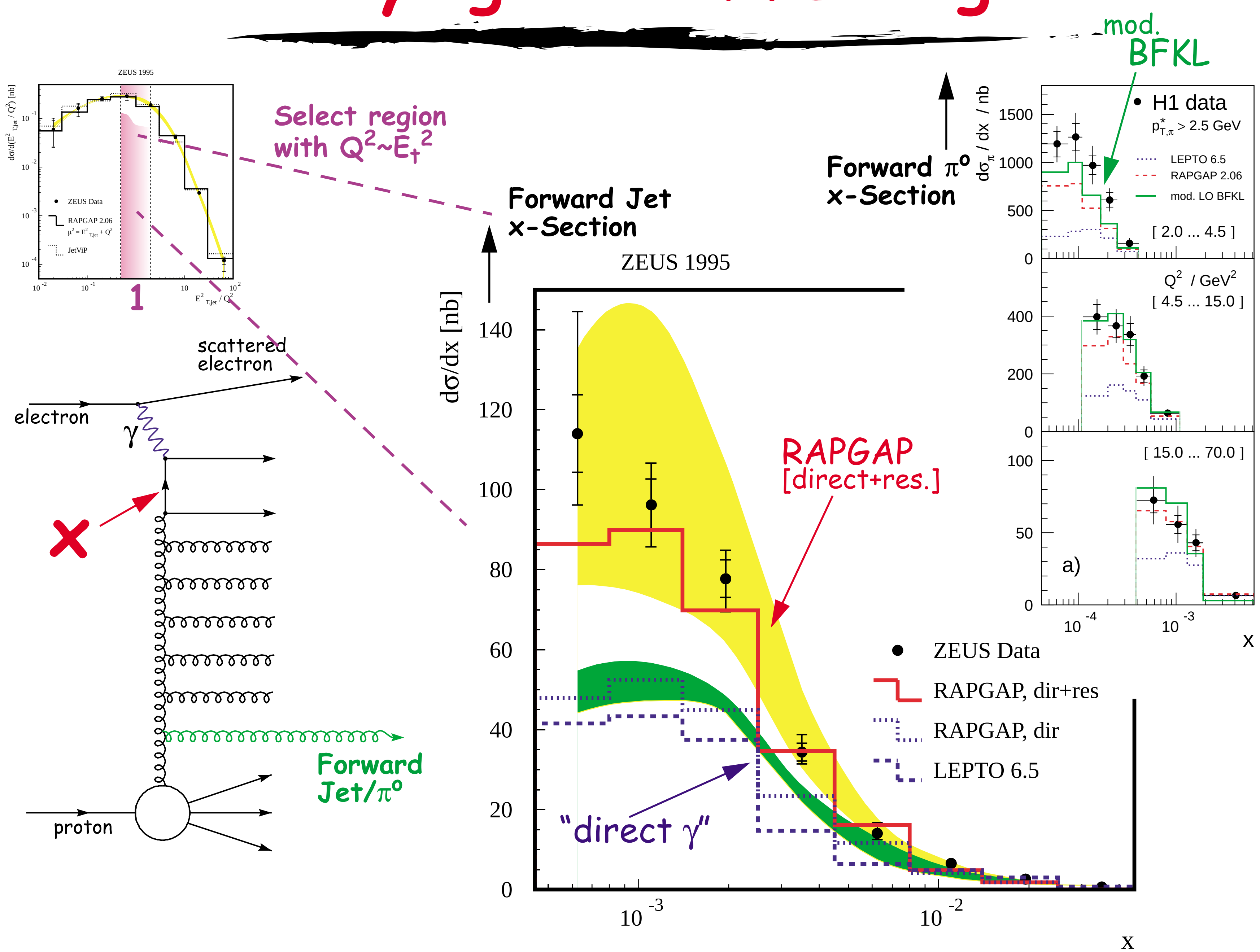
Measure Dijet cross section for:

- "direct" part (x_γ > .75)
- "resolved part (x_γ < .75)

Plot R = "res./direct" as function of Q^2

Resolved contributions is suppressed at large Q^2

Studying the BFKL Region



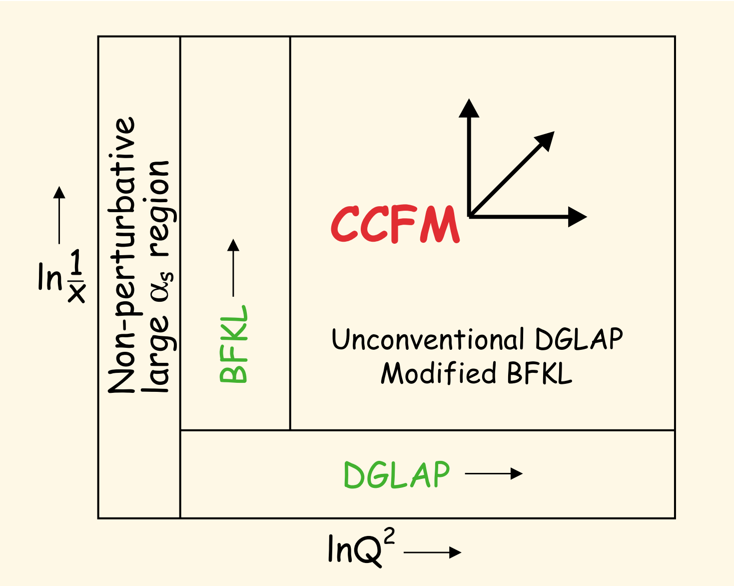
Combining BFKL & DGLAP: CCFM

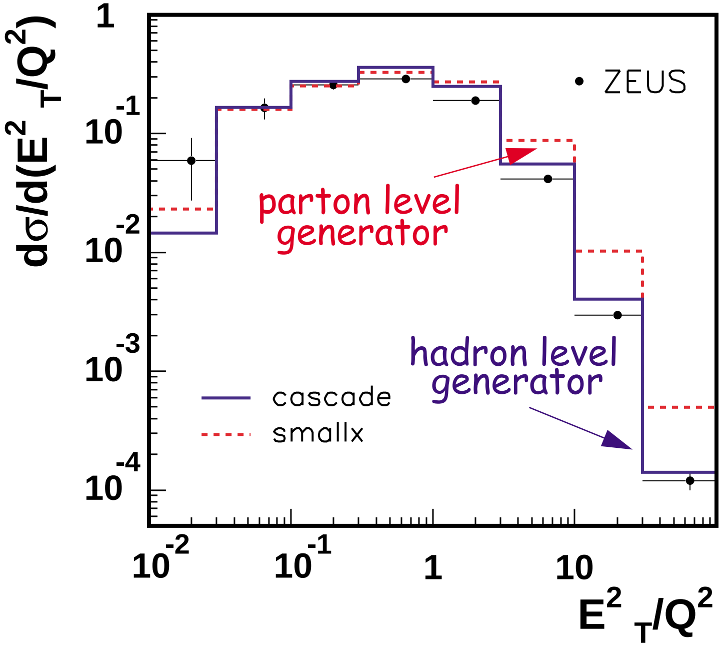
Jet physics
→ relevant scale: E_t^2 [?]
→ present picture:

DIS = "direct γ" + BFKL + "resolved γ"

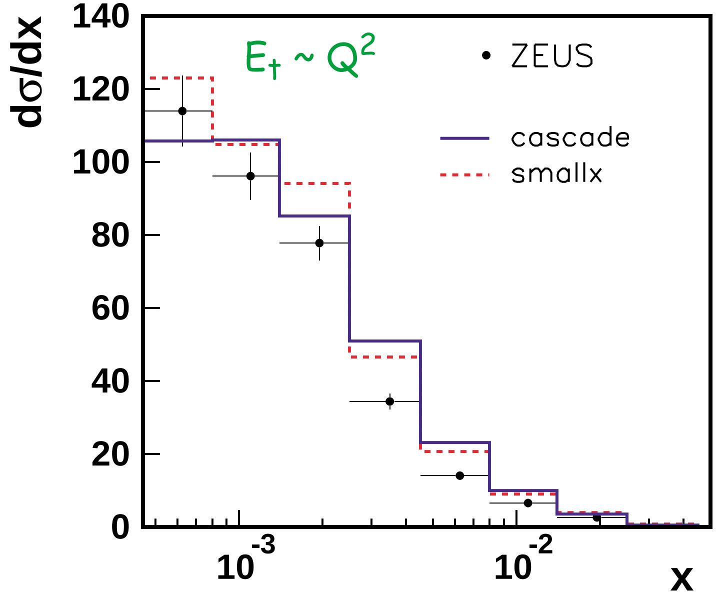
k_t-factorization + CCFM evolution

- angular ordered parton emission
- uses unintegrated gluon density $g(x,k_t,Q^2)$
- reproduces BFKL $x \to 0$ and DGLAP for large x



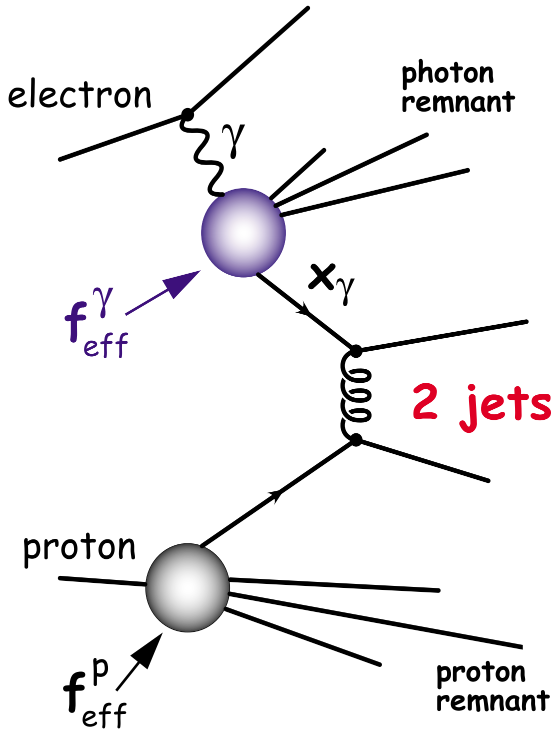


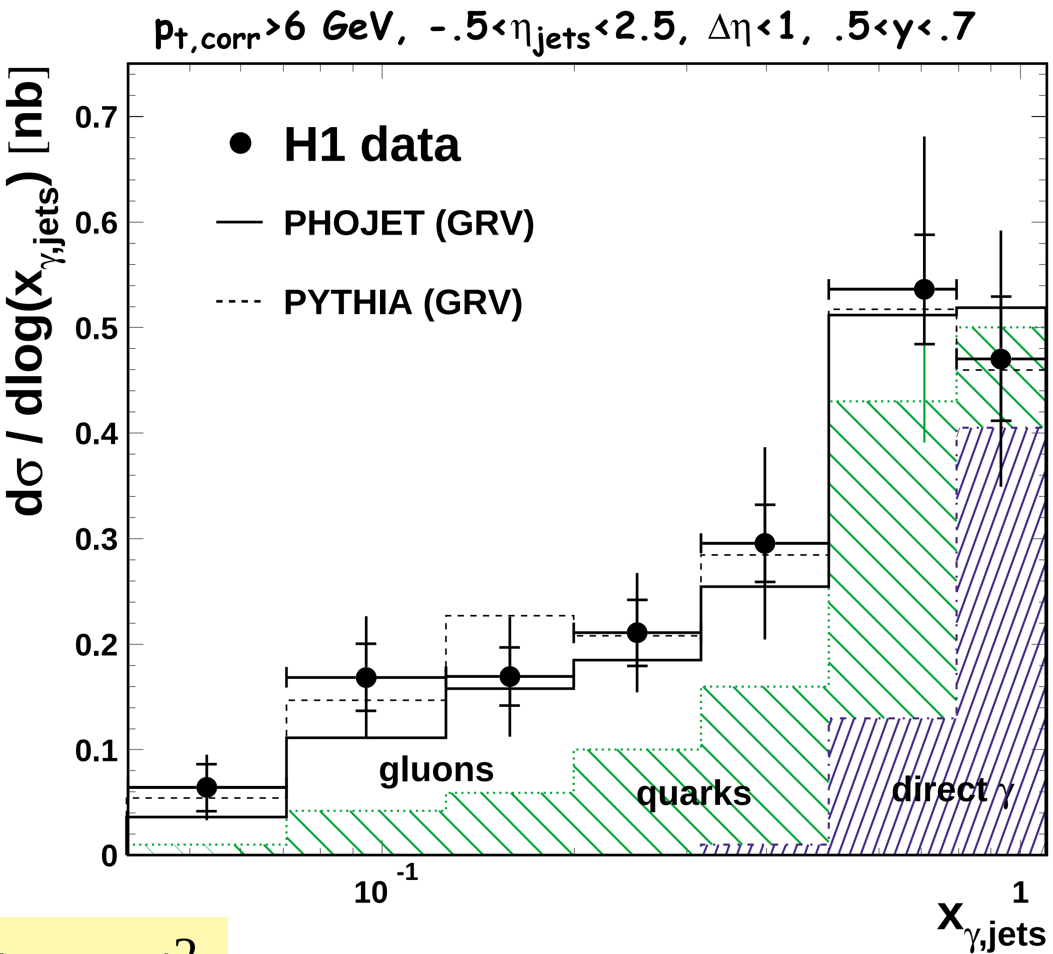
Forw. Jet x-section



H. Jung et. al.

γp Dijet Cross Section

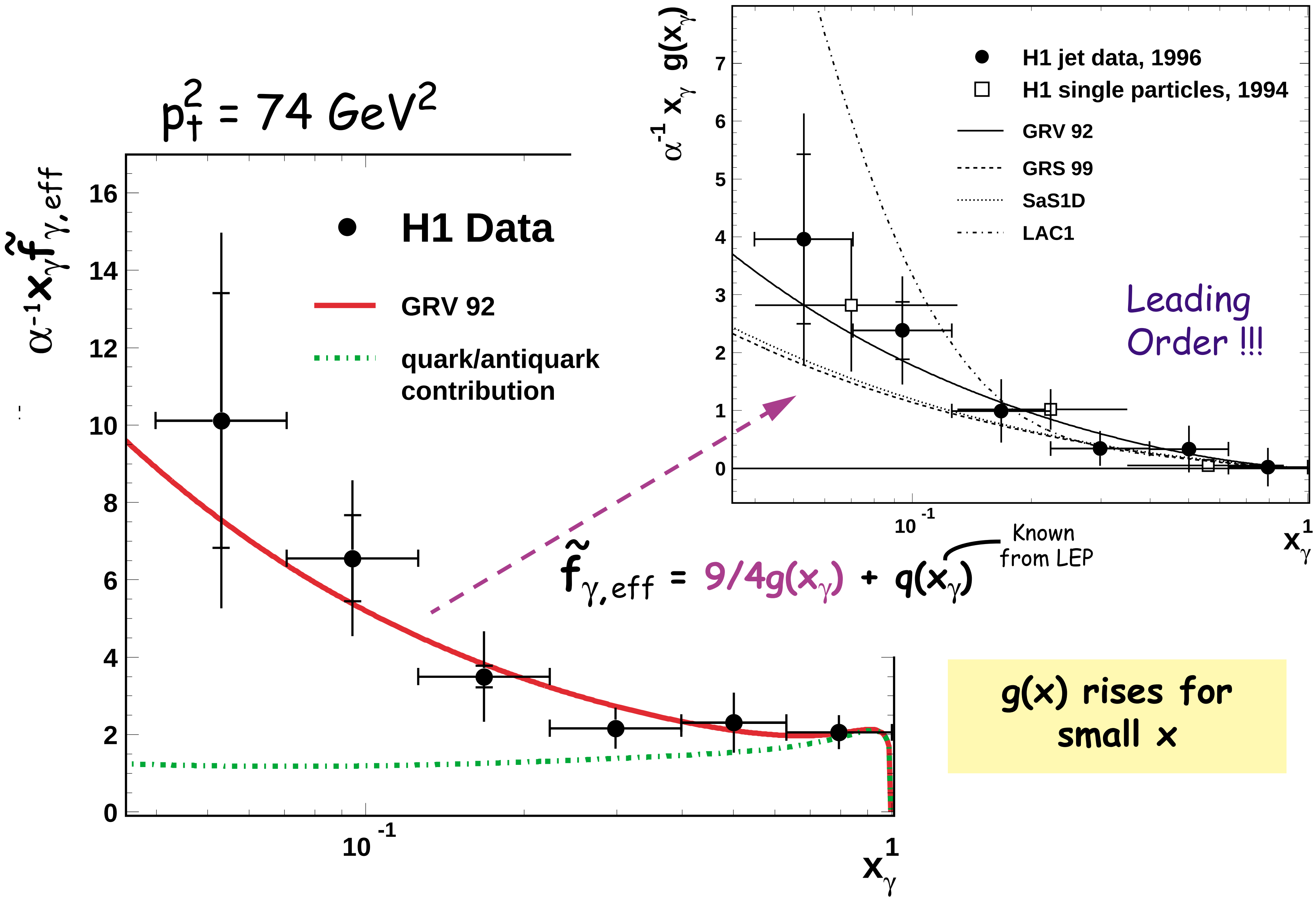




$$\sigma_{2jet} \sim f_{\gamma/e}(y)\, f^{p}_{eff}\, f^{\gamma}_{eff}\, |ME_{eff}|^2$$

$$f^{\gamma}_{eff} = f^{\gamma}_{q} + f^{\gamma}_{\bar{q}} + 9/4\, f^{\gamma}_{g}$$!!!

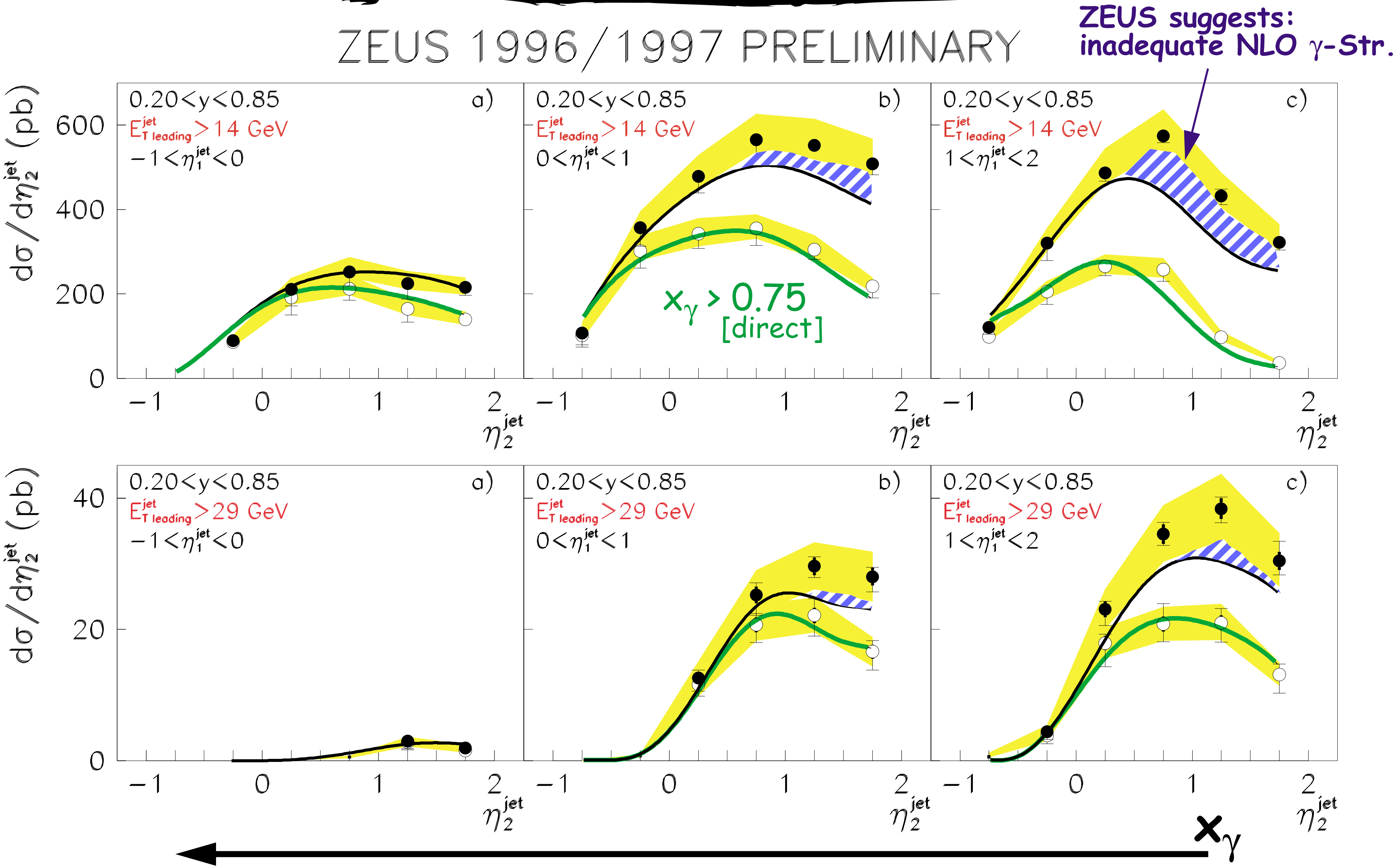
The Gluon Density of the Photon



g(x) rises for small x

γp Dijet x-Section @ Large E_t

Comparison of data with NLO + γ-structure



Conclusion

DIS region:
[Q^2,E_t^2 large; $Q^2 \geq E_t^2$]

- pQCD works
- $\alpha_s \otimes g(x)$
- scale ?

Intermediate regime:
[$E_t^2 \sim Q^2$]

- scale problem
- DGLAP breakdown
- resolved γ
- BFKL, CCFM etc.

resolved γ^* region:
[$Q^2 < E_t^2$]

- concept of γ structure “ok”
- $g^\gamma(x)$ in LO
- NLO photon pdf's ?