XIIth Workshop on Deep-Inelastic Scattering
April 2004, Štrbské Pleso

Dijet Production at low Bjorken x in Deep-Inelastic Scattering at HERA

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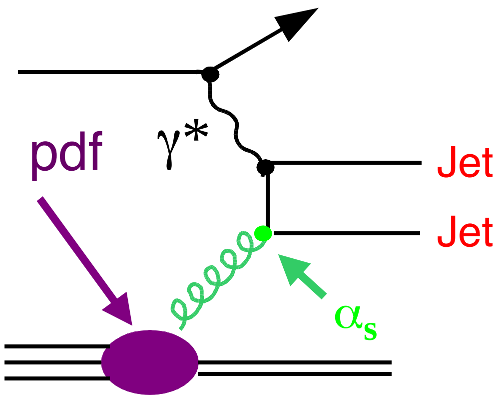
H1 Collaboration

Dijet Production in DIS

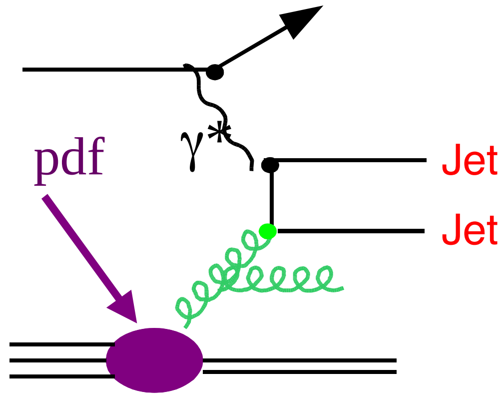
LO – Boson Gluon Fusion

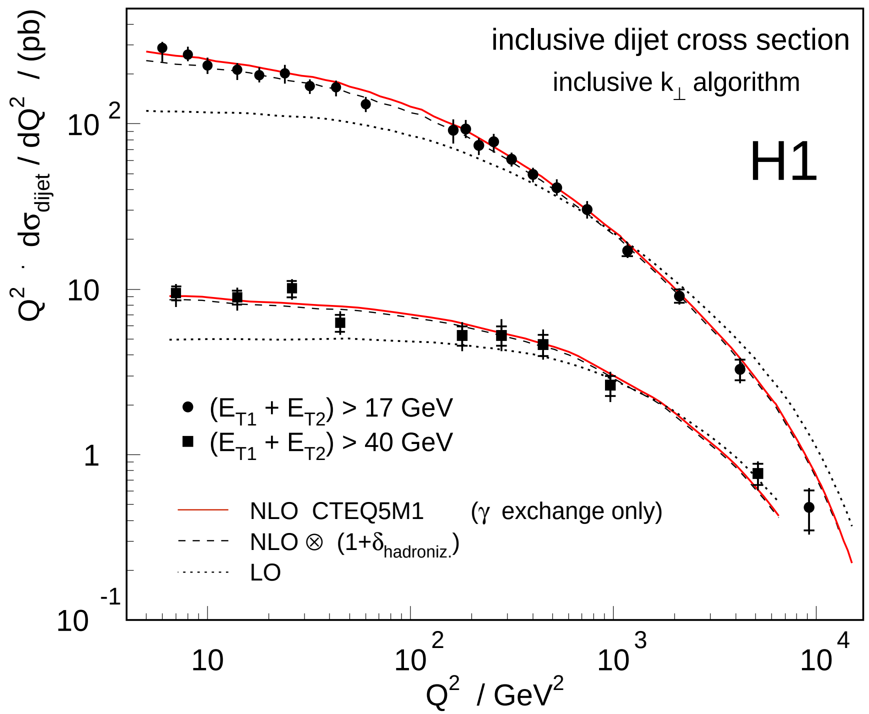


DIS jet cross section

$$\sigma_{Jet} = \sum \alpha_s^n(\mu_R^2) \sum \mathbf{pdf} \otimes \hat{\sigma}(\mu_R^2, \mu_F^2)$$

NLO



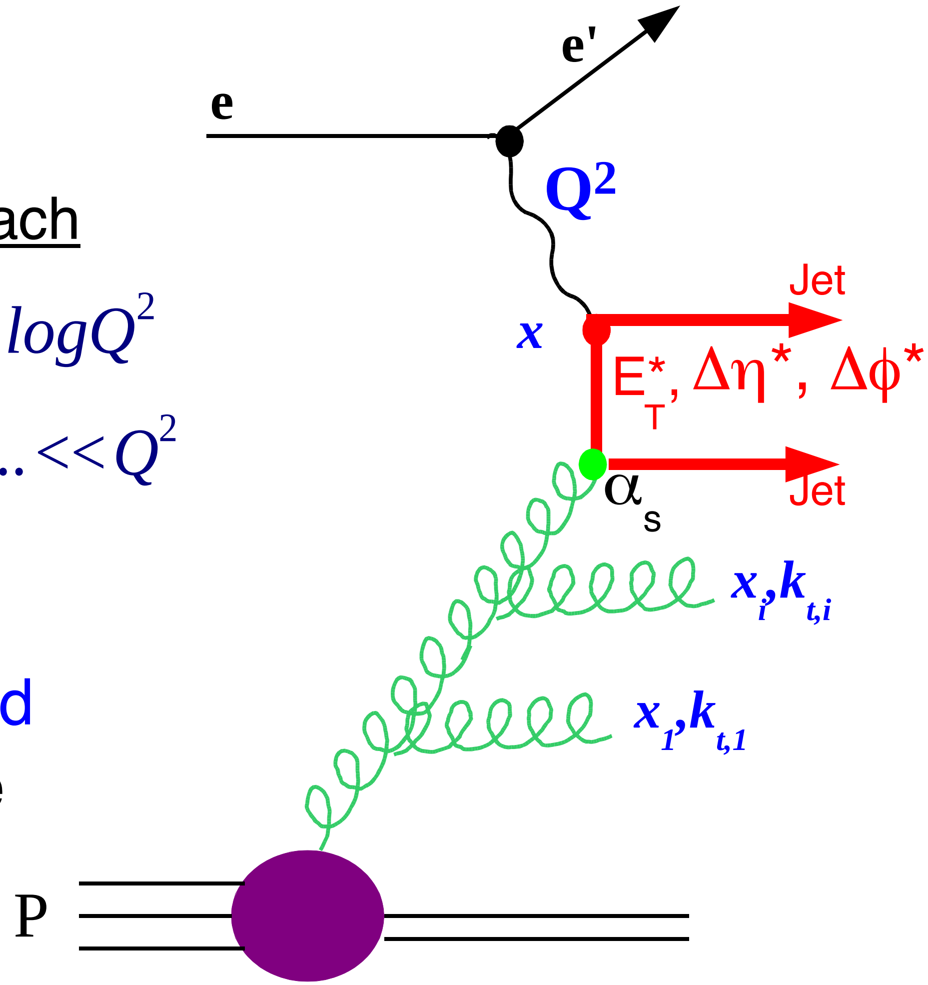


Dijet cross sections as a tool for

- Extraction of α_s
- Extraction of pdfs
- Study of parton dynamics in the Proton

Parton Dynamics

$$\sigma_{Jet} = f(\alpha_s, C, q(x, Q^2))$$



DGLAP – Approach

$$LLA: q(x, Q^2) \sim \alpha_s \log Q^2$$

$$k_{t,1}^2 << \ldots << k_{t,i}^2 << \ldots << Q^2$$

$$x_1 < \ldots < x_i < \ldots < x$$

→ strong k_t ordered parton cascade

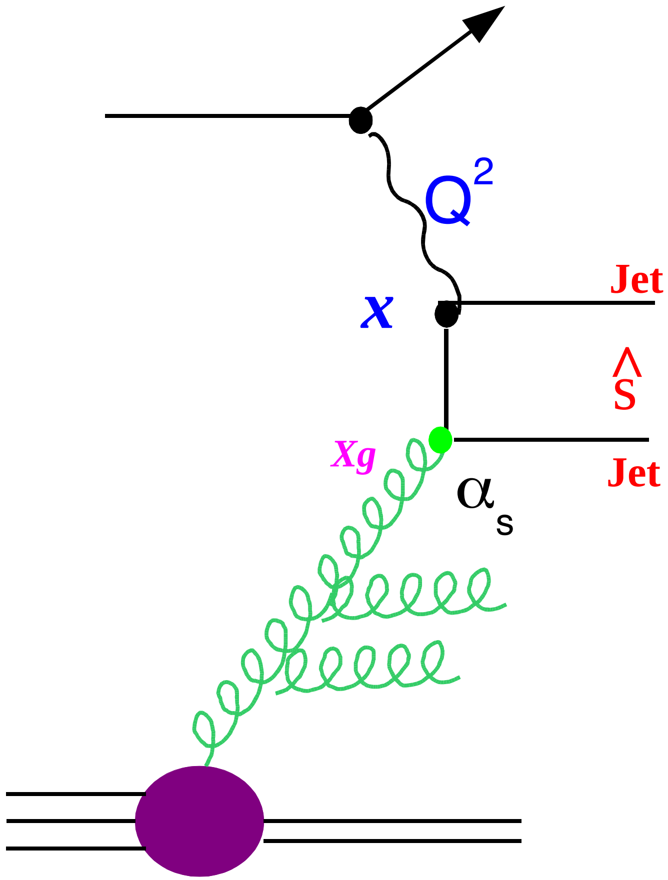
Universality of DGLAP approach ?

What if x<< 1,
→Terms ~ log(1/x) ?

k_t unordered cascade ?!

Do the properties of dijet system depend on dynamics in the ladder ?
→k_t ordered or unordered evolution of cascade

How to detect the Onset of Small-x Dynamics ?



Leading Order:

$$x_g = \left(1 + \frac{\hat{s}}{Q^2}\right) x$$

Small E^*_T →
Small $\Delta\eta^*$ →
Small $\Delta\phi^*$ →

Small $\hat{s}$, Small x_g

Observables ...

$$\frac{d^3\sigma}{dx\, dQ^2\, dE^*_T} \qquad \frac{d^3\sigma}{dx\, dQ^2\, \Delta\eta^*}$$

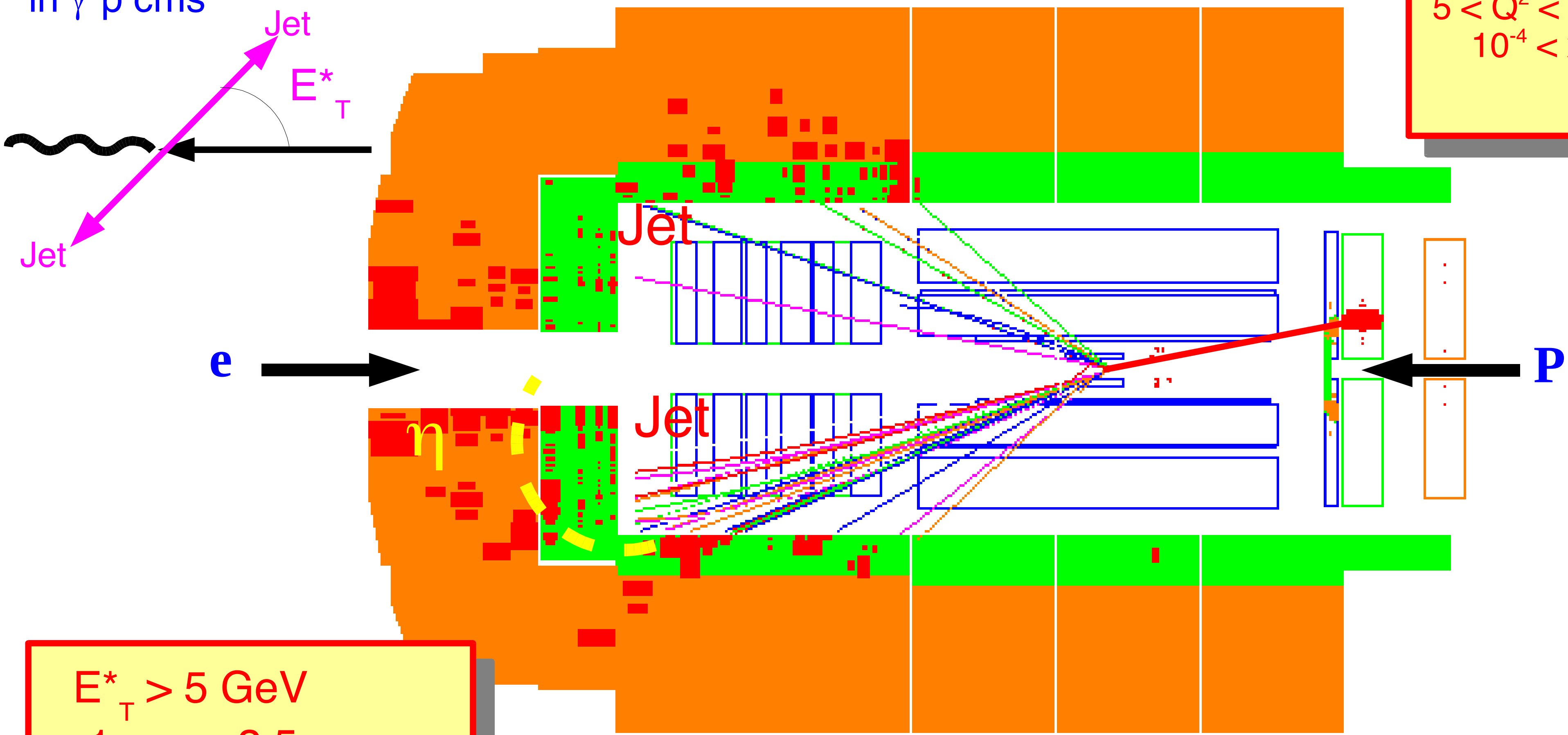
New:

$$\frac{d^3\sigma}{dx\, dQ^2\, \Delta\phi^*}$$

Data Sample and Cuts

H1 Data 1996/97 $\mathcal{L} \approx 21\ \mathrm{pb}^{-1}$

Long. invariant k_t-algorithm
in γ^*p cms

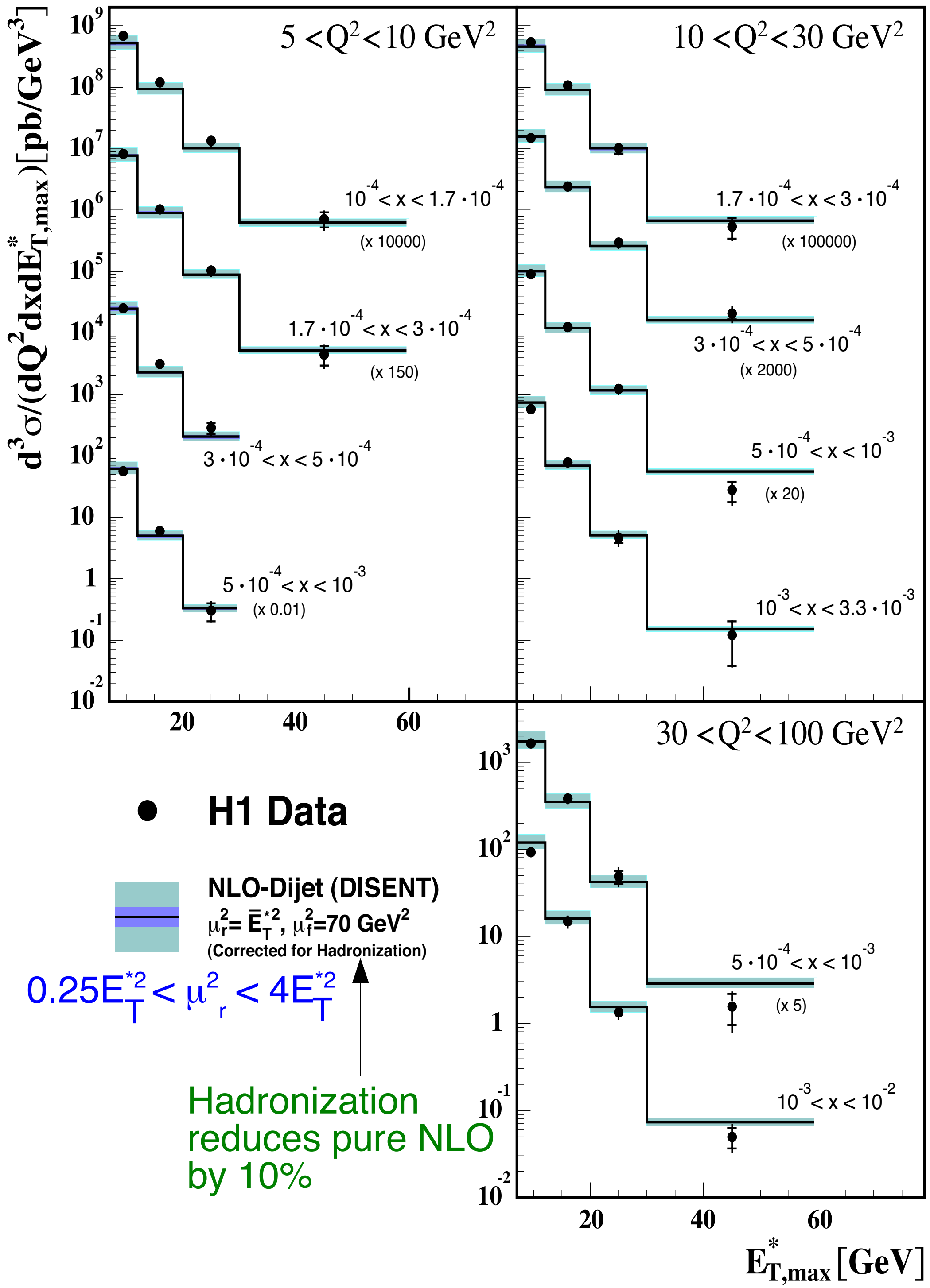


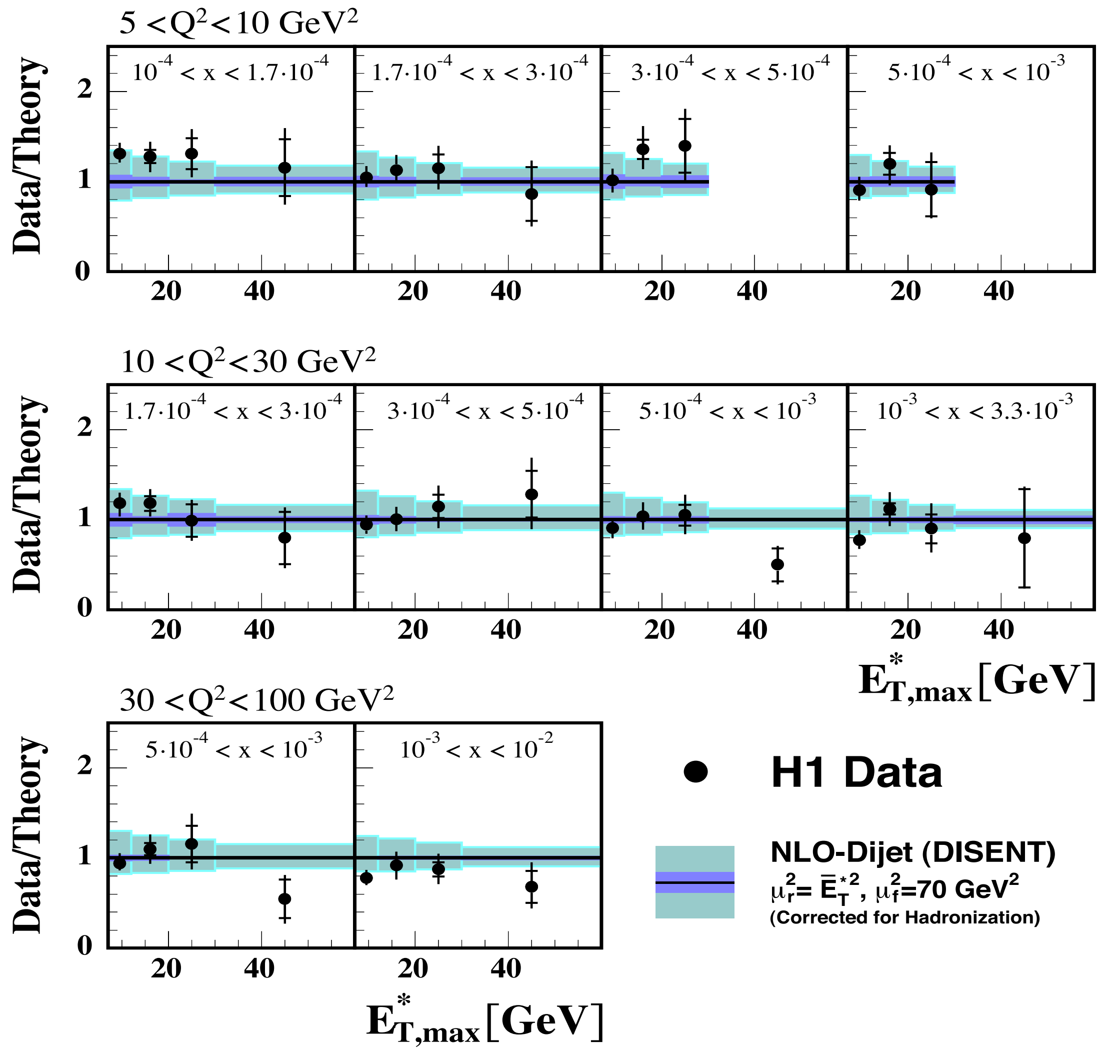
$5 < Q^2 < 100\ \mathrm{GeV}^2$
$10^{-4} < x < 10^{-2}$

$E^*_T > 5$ GeV
$-1 < \eta < 2.5$
$N_{jet} > 1$
$E^*_{T,max} > 7$ GeV

Triple Differential Dijet Cross Section I

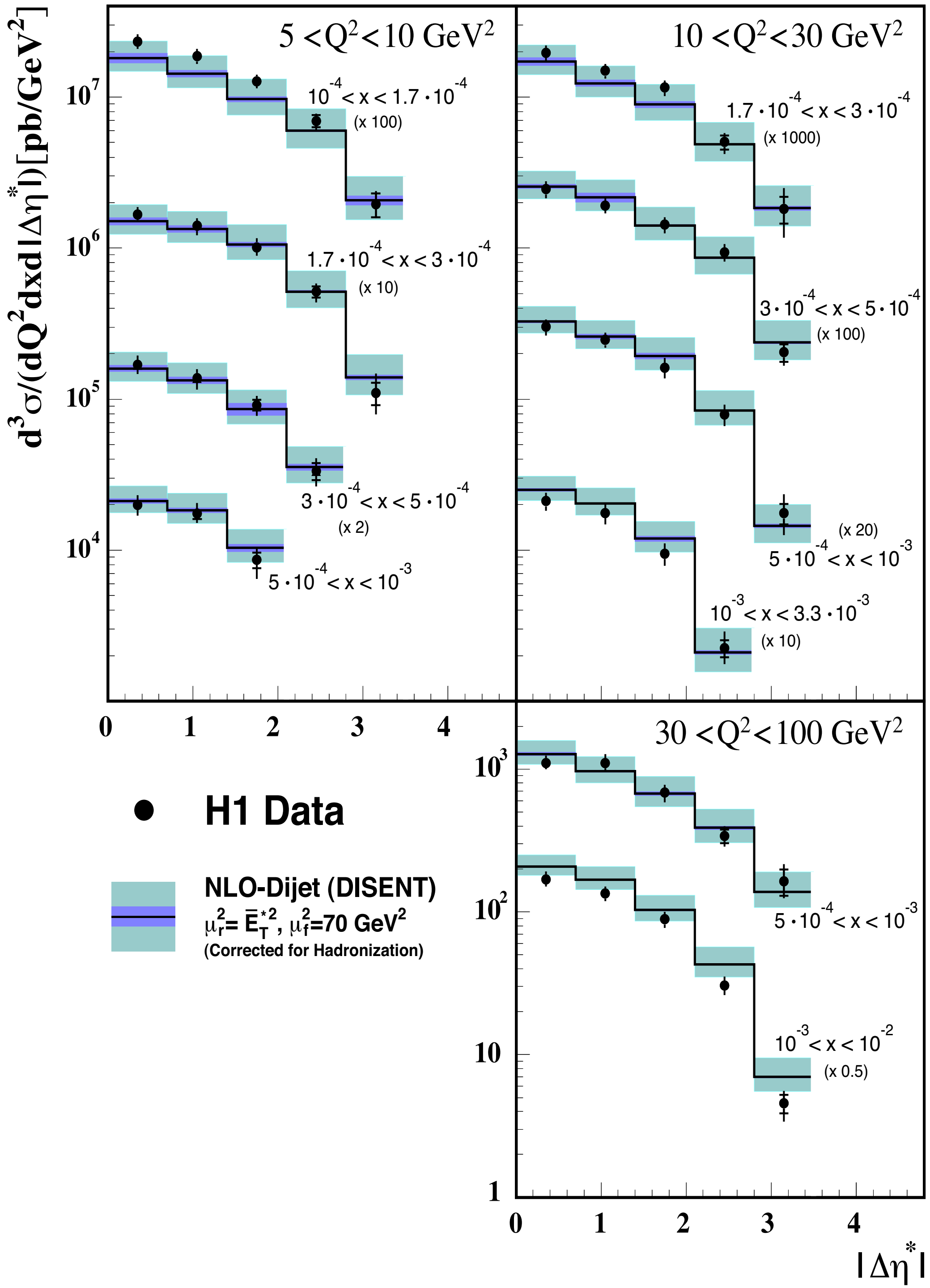
Inclusive Dijet Cross Section



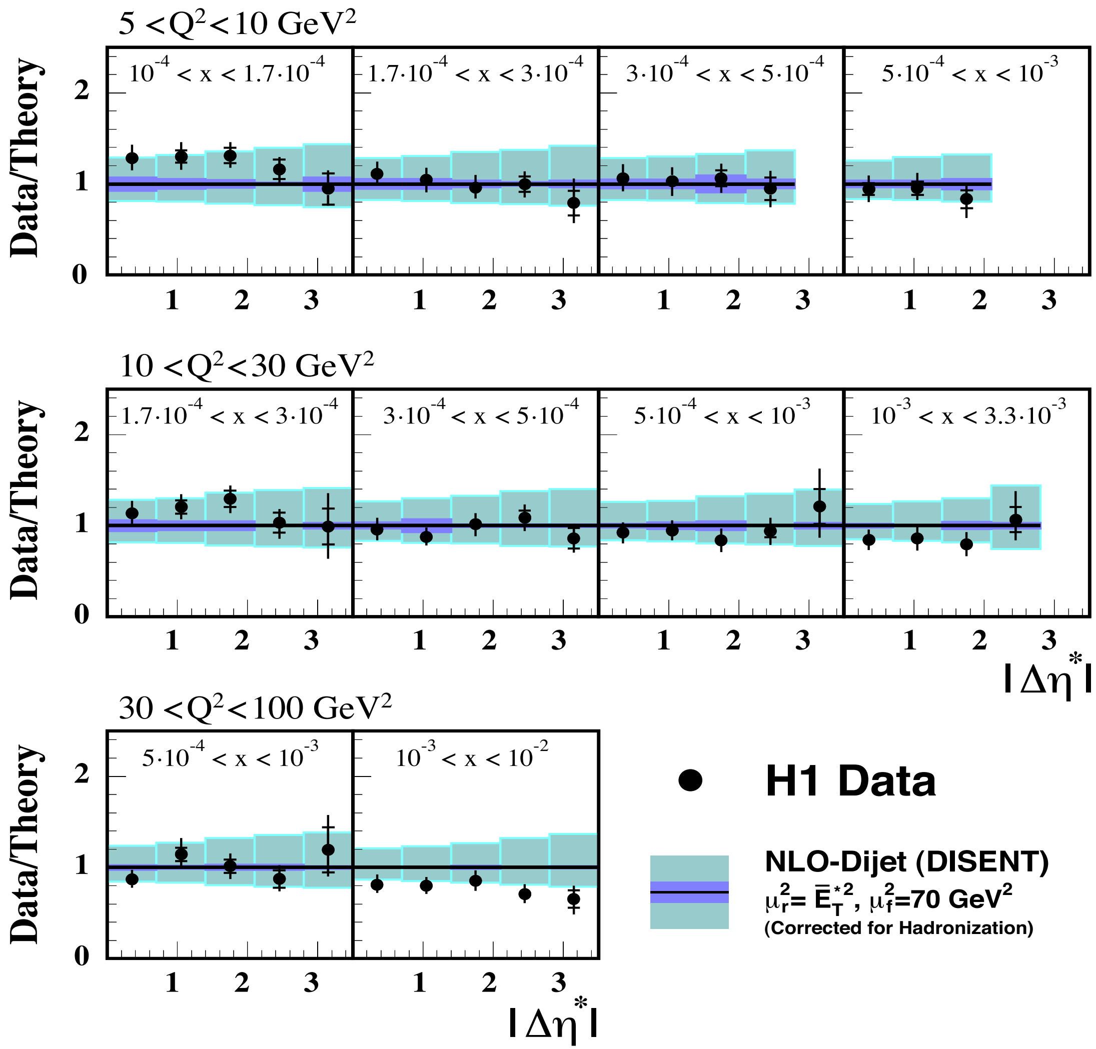


- No significant disagreement between data and NLO QCD predictions
  based on CTEQ6M pdf
- Scale Uncertainties O(20%) ≥ Error of data

Triple Differential Dijet Cross Section II



Inclusive Dijet Cross Section



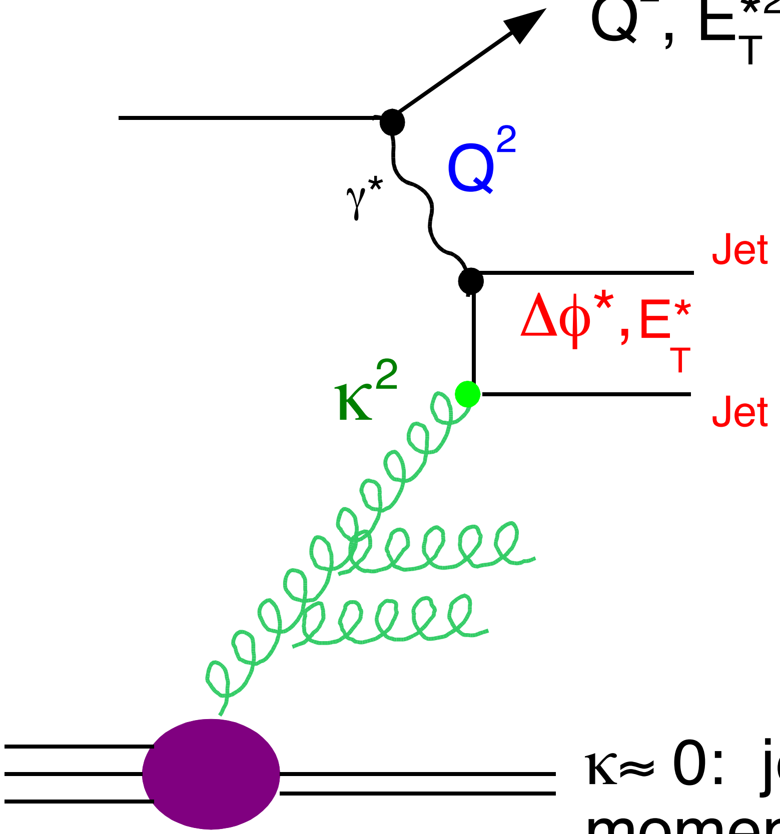
- No significant disagreement between data and NLO predictions

  Deviations at small $x, Q^2, |\Delta\eta^*|$ and larger $x, Q^2, |\Delta\eta^*|$
- Scale Uncertainties O(20%) > Error of data

Study of Azimuthal Correlations – $\Delta\phi^*$

Insight into unintegrated gluon density

$Q^2, E_T^{*2} >> \kappa^2$: $g(x, \kappa^2, Q^2) \rightarrow g(x,Q^2)$



Pdf depends on virtuality κ of incoming particle

Assumption on radiation pattern e.g. DGLAP strong k_t-ordering integrated over κ

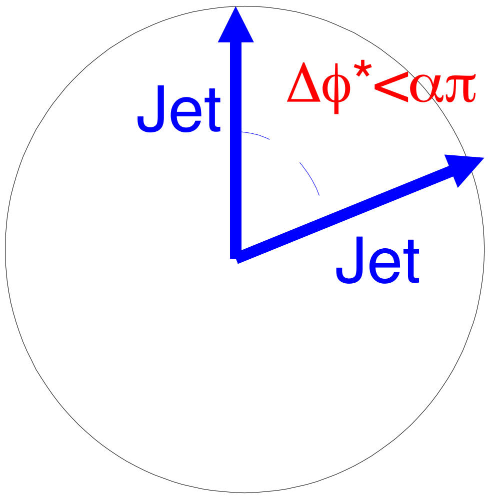
$\kappa \approx 0$: jets back-to-back in $\Delta\phi^*$

momentum-conservation: $\Delta\phi^*$ -jet compensates κ

$$\overrightarrow{p_{t,1}} = \vec{\kappa} - \overrightarrow{p_{t,2}} , \kappa_T^2 + p_{t,1}^2 + p_{t,2}^2 + 2p_{t,1}\, p_{t,2} \cos \Delta\phi$$

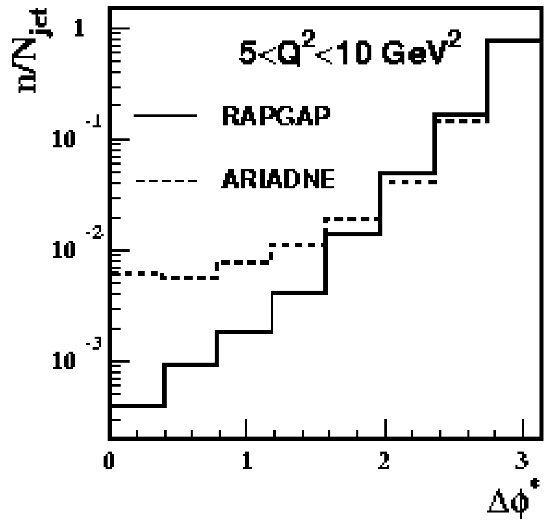
$\Delta\phi^*$-cross sections sensitive to radiation pattern in gluon ladder ?!

Observables to study Azimuthal Correlations ?



→ Measurement of $d\sigma_{2jet}/d\Delta\phi^*$

Experimentally difficult



Easier:

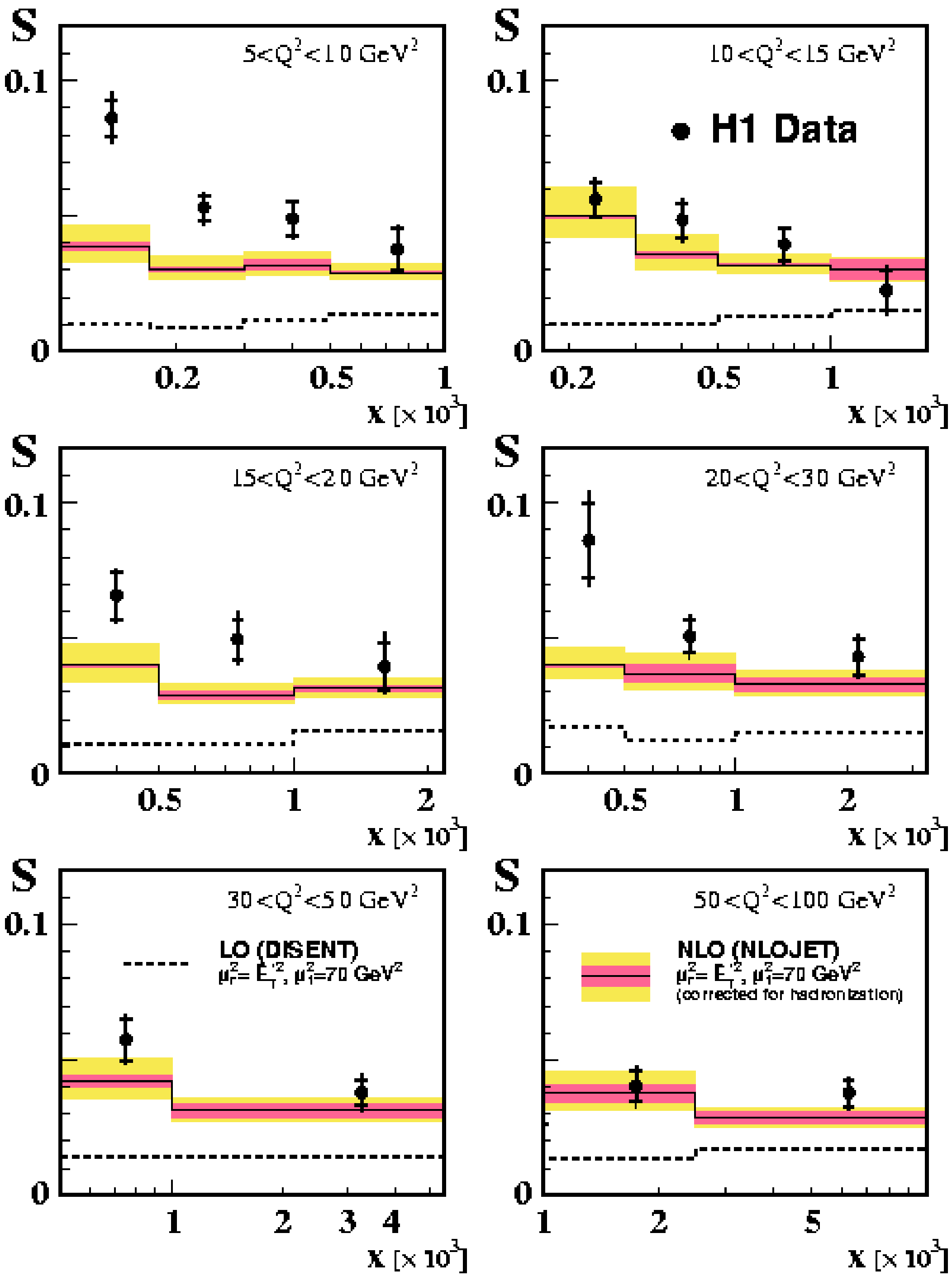
$$S(x, Q^2, \Delta\phi^*) = \frac{\int_0^{\alpha\pi} w(\Delta\phi^*, x, Q^2)}{\int_0^{\pi} w(\Delta\phi^*, x, Q^2)}$$

'Same Side' Jets

Rate of dijet events separated by an azimuthal angle (much) smaller than π

(proposed by A.Szczurek et al. hep-ph/0011281)

Results for Δφ*<120°



$$S(x, Q^2, \Delta\phi) = \frac{\int_0^{\alpha\pi} w(\Delta\phi, x, Q^2)}{\int_0^{\pi} w(\Delta\phi, x, Q^2)}$$

- Data rises towards low x

  Increasing parton virtuality due to longer parton ladder ?

- LO-predictions (α_s^2) are significantly away from data

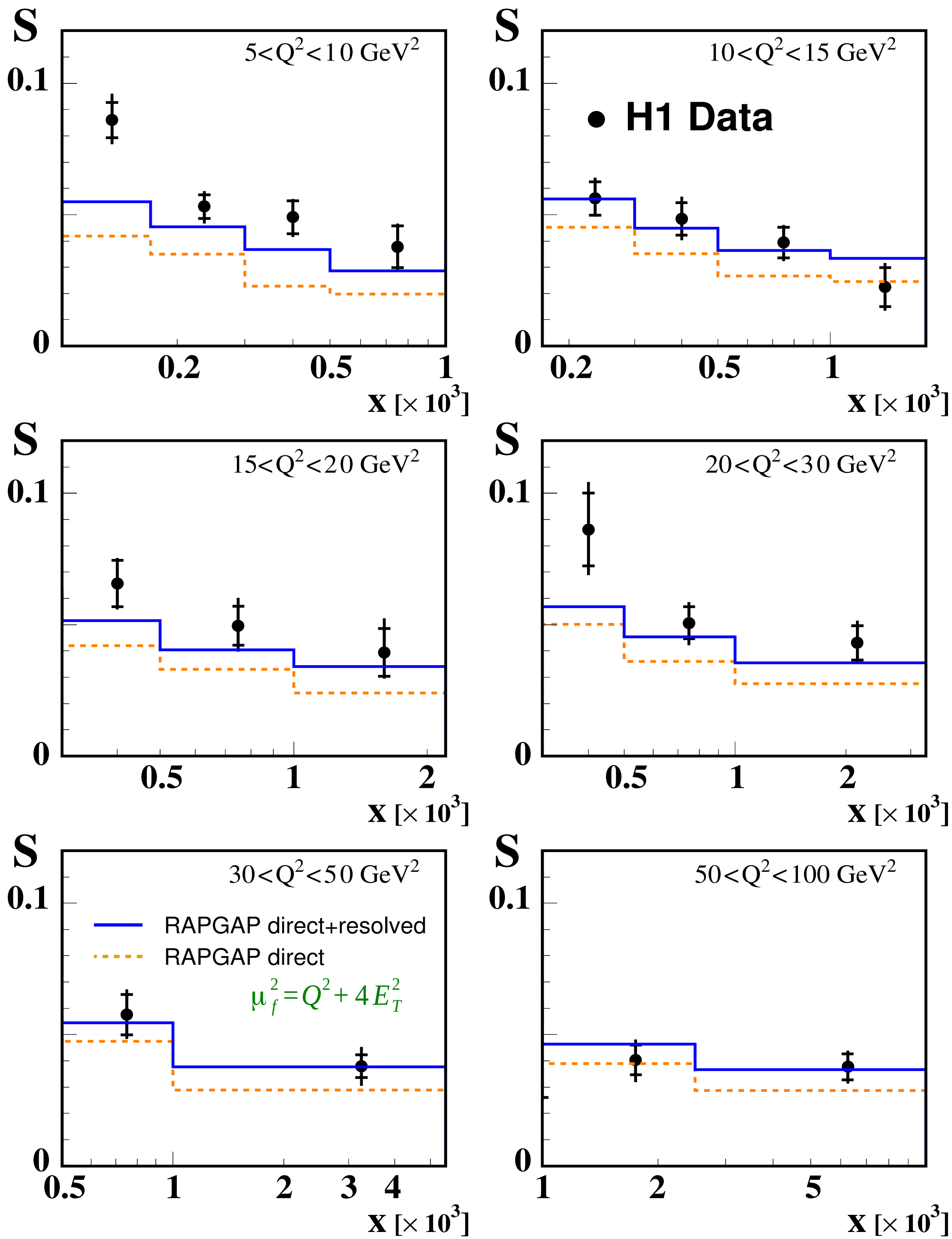
  At most three jets in final state

- NLO calculations (α_s^3) closer to data

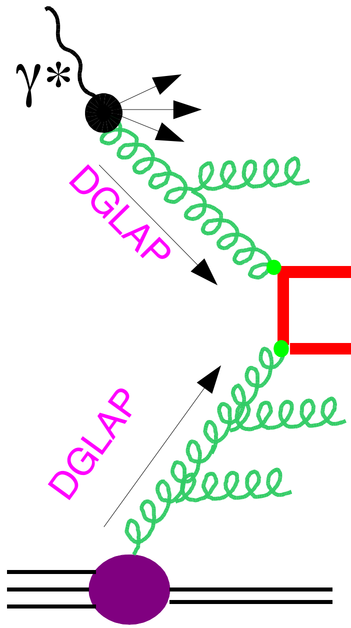
  3 or 4 jets in final state

  Still problems towards low-x

Contributions from resolved γ^*

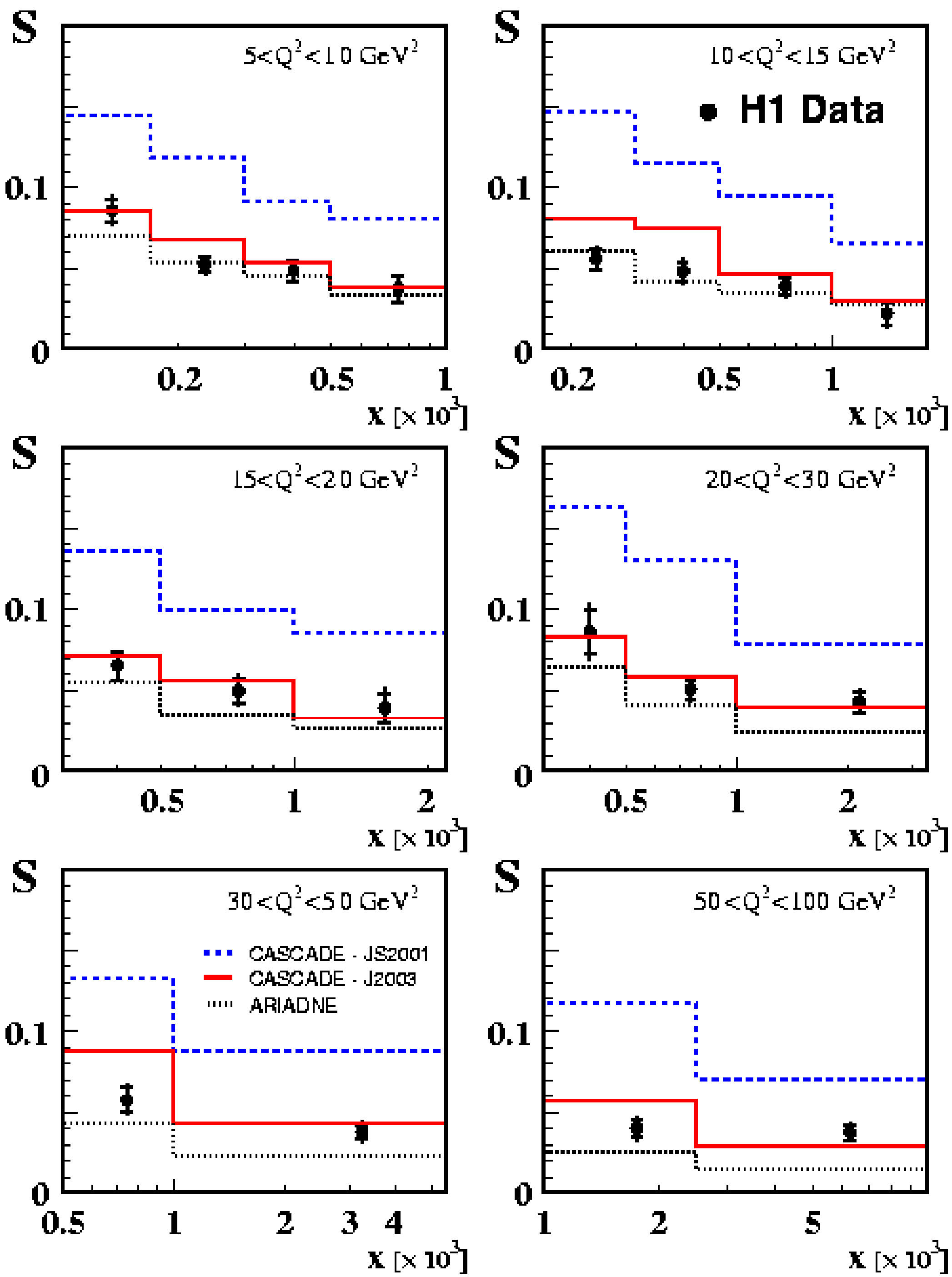


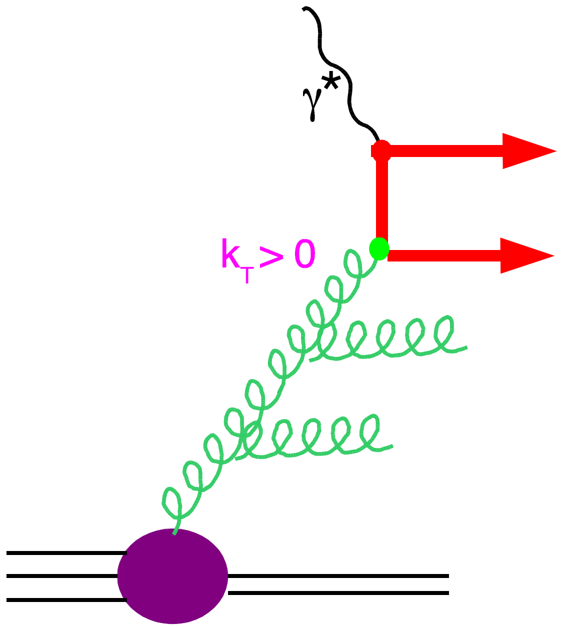
Mimic non-DGLAP type evolution



S increases by contributions from γ^*

Predictions based on Unintegrated Pdfs





- Unintegrated pdfs provide mechanism to produce Same Side Jets
- Data useful to constrain unintegrated pdf
  S described by CASCADE using recent unintegrated pdfs
- Colour Dipole Model (ARIADNE) describes data, too

Summary and Conclusion

- Results of analysis on dijet production at low x, Q^2 presented
  Eur.Phys.J. C33 (2004) 477

Physics Messages:

- Multi differential cross sections
  NLO QCD describes data in analysed phase space
  when measured as function of E^*_T, $|\Delta\eta^*|$

- Azimuthal distances
  Descrepencies between data and NLO-QCD predictions

  Good description of data by recent unintegrated pdf
  Rate of Same Side Jets sensitive to different unintegrated pdfs

- Azimuthal correlation is powerful tool to improve understanding of virtuality of incoming gluon