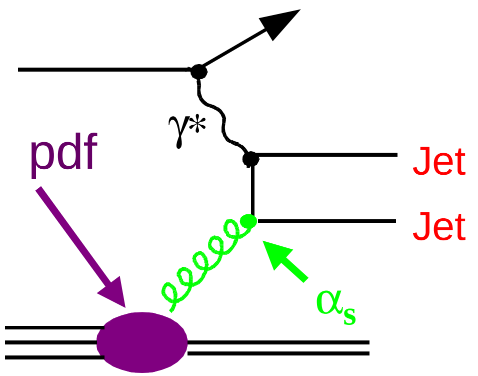

XIth Workshop on Deep-Inelastic Scattering
April 2003, St. Petersburg
Dijet Production at low Bjorken x
in Deep-Inelastic Scattering
at HERA
Roman Pöschl
DESY Hamburg
H1 Collaboration

Dijet Production in DIS

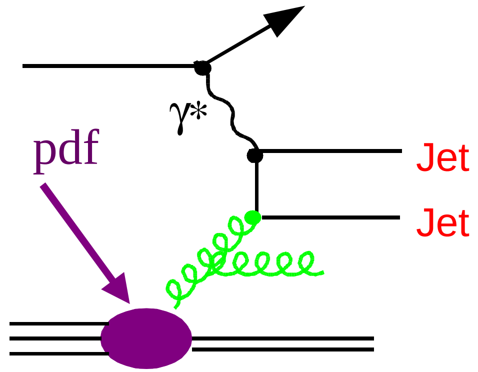
LO – Boson Gluon Fusion

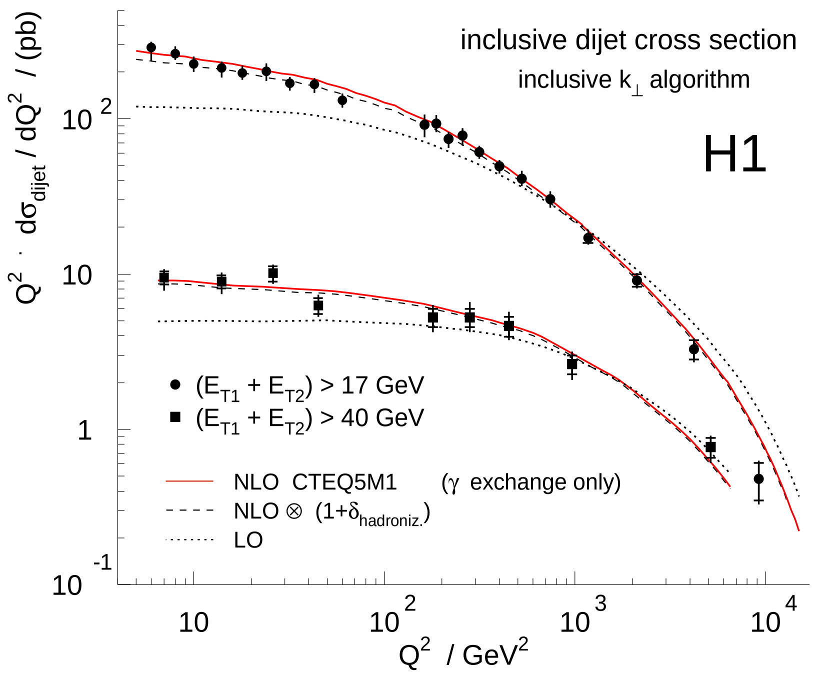


DIS jet cross section

$$\sigma_{Jet} = \sum \alpha_s^n(\mu_r^2) \sum_{a=q,\bar{q},g} pdf_a \otimes \hat{\sigma}(\mu_r^2, \mu_f^2)$$

NLO



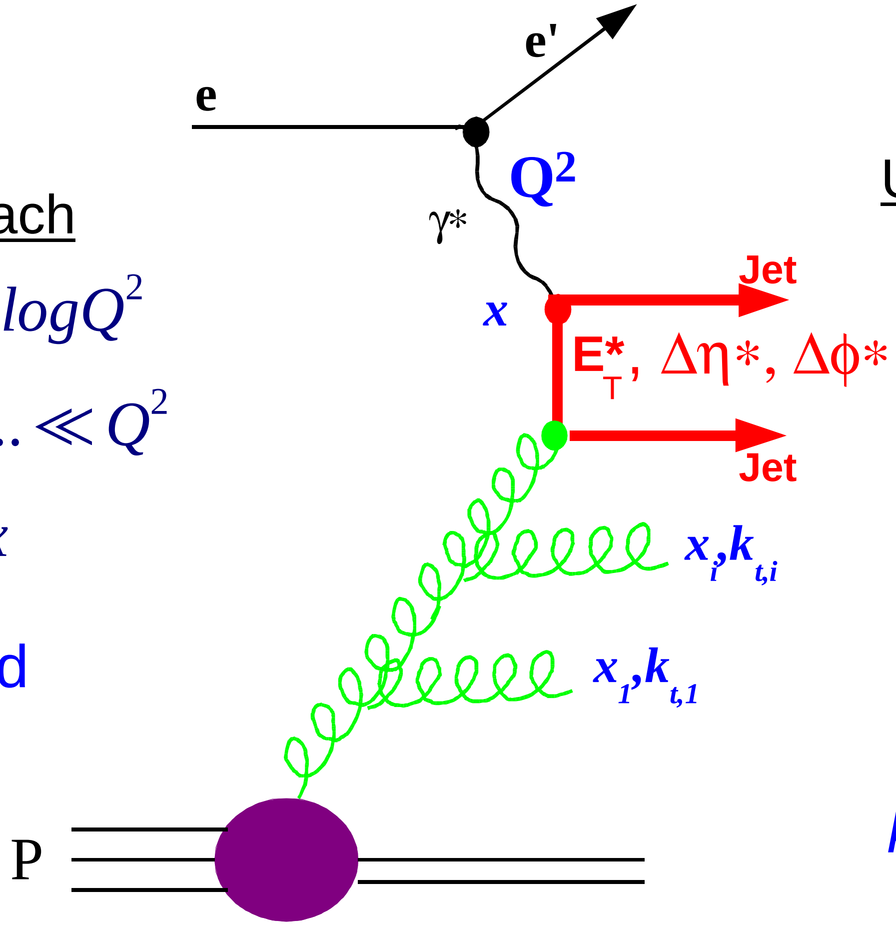


Precise QCD predictions
at $O(\alpha_s^2)$ = NLO
based on DGLAP type PDFs

Extraction of fundamental quantities

Parton Dynamics

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



DGLAP – Approach

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

$$k^2_{t,1} \ll \ldots \ll k^2_{t,i} \ll \ldots \ll Q^2$$

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

→ *strong* k_t ordered parton cascade

Universality of DGLAP approach ?

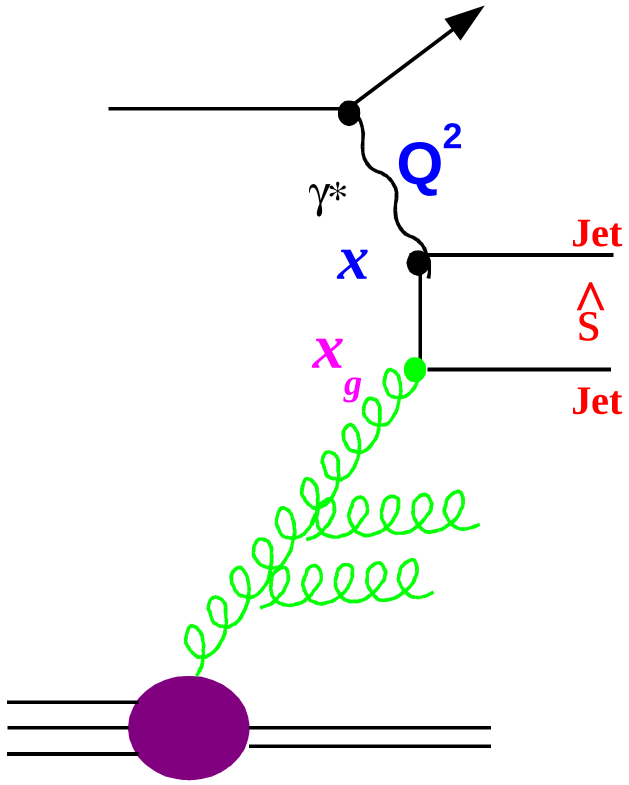
What if x<< 1,
~Terms ~ *log(1/x)* ?

↓

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:

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

Small E^*_T → Small $\hat{s}$, Small x_g

Small $\Delta\eta^*$ → Small $\hat{s}$, Small x_g

Small $\Delta\phi^*$ → Small $\hat{s}$, Small x_g

Observables ...

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

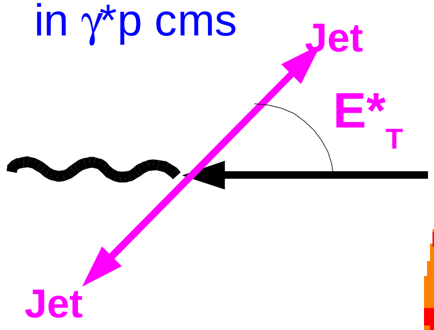
New: $$\frac{d^3\sigma}{dx\, dQ^2\, \Delta\phi^*}$$

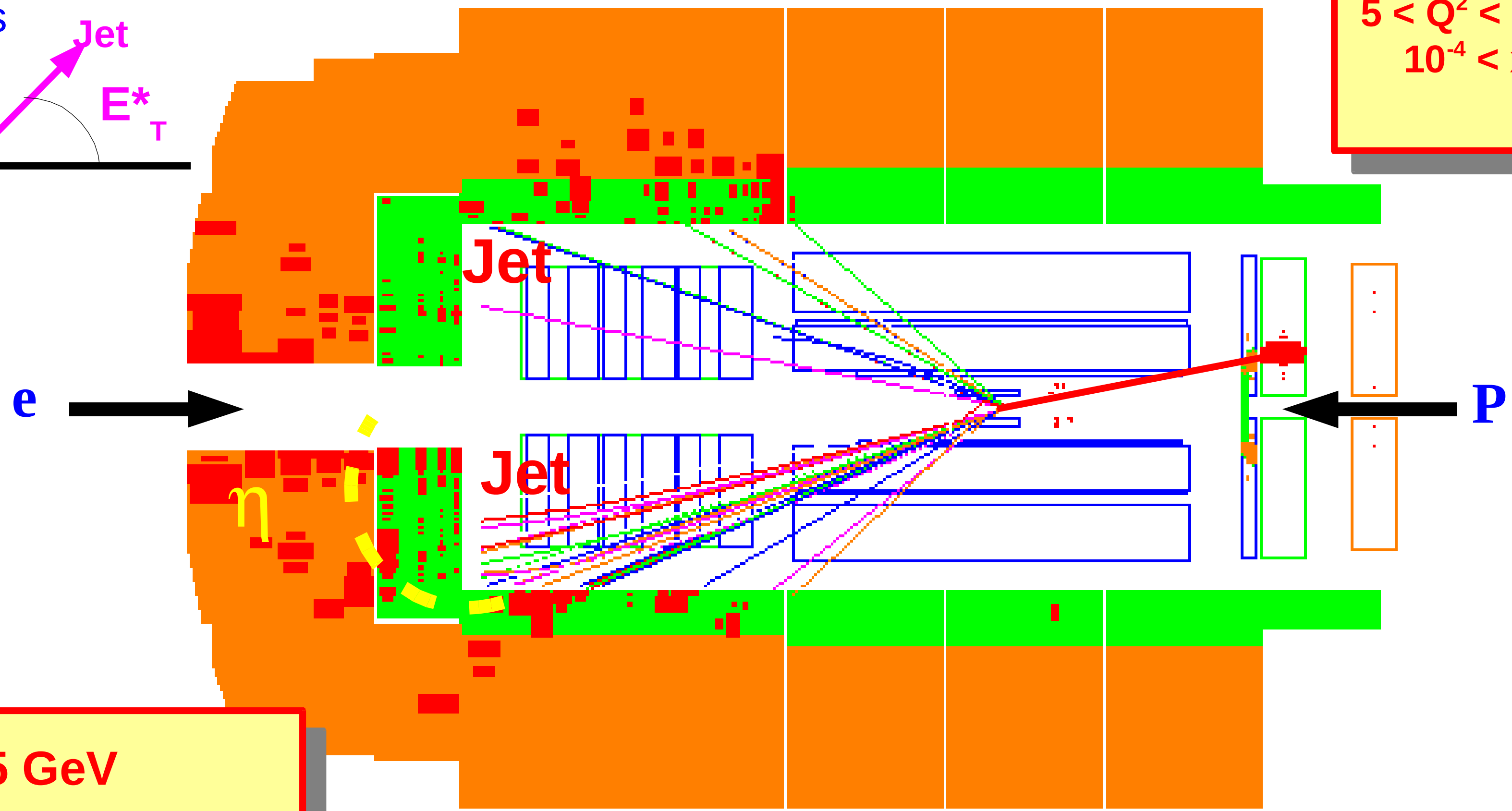
Data Sample and Cuts

H1 Data 1996/97 $\mathscr{L} \approx 21$ pb-1

Long. invariant k_t-algorithm

in γ*p cms

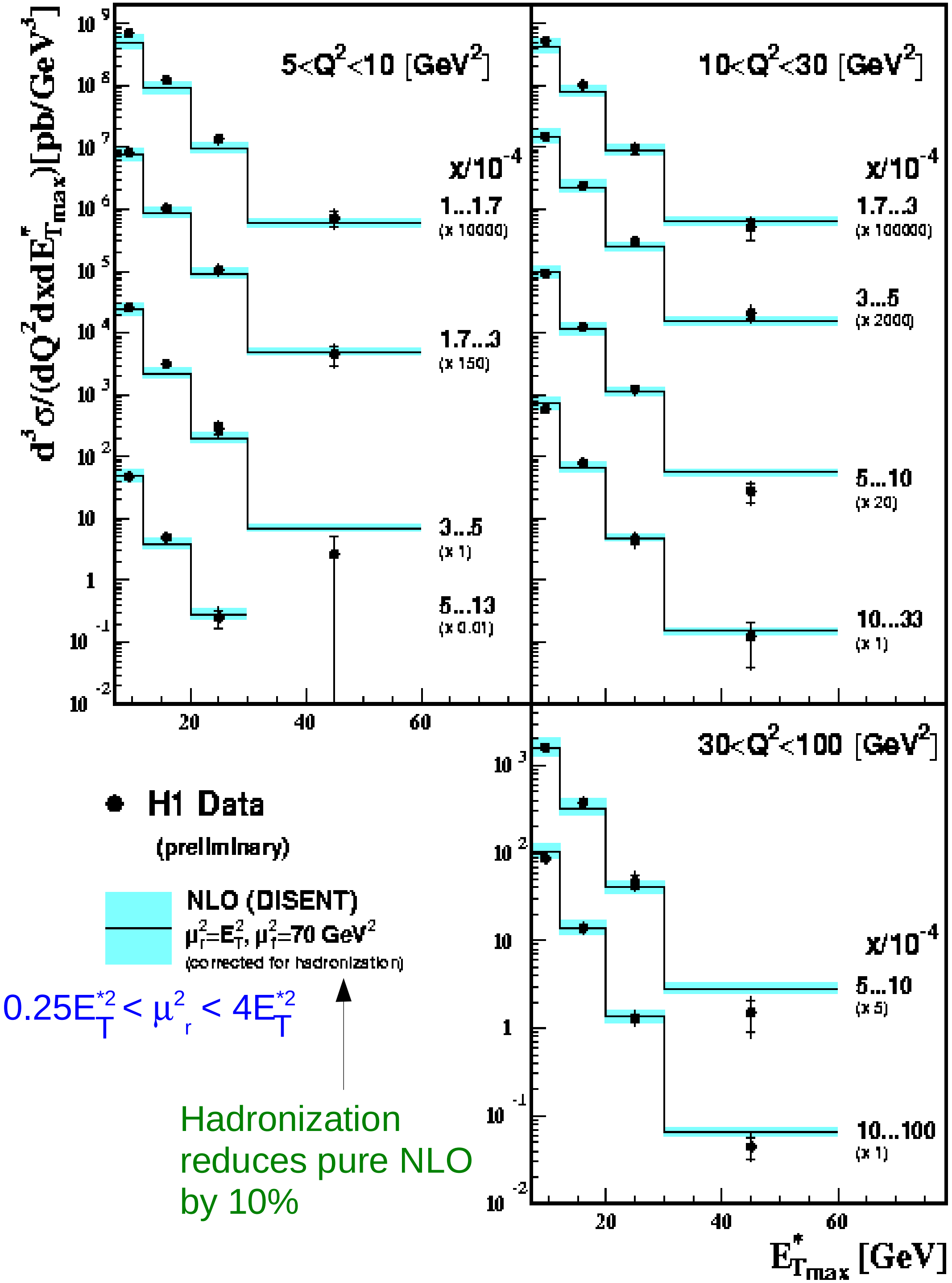




$5 < Q^2 < 100$ GeV^2
$10^{-4} < x < 10^{-2}$

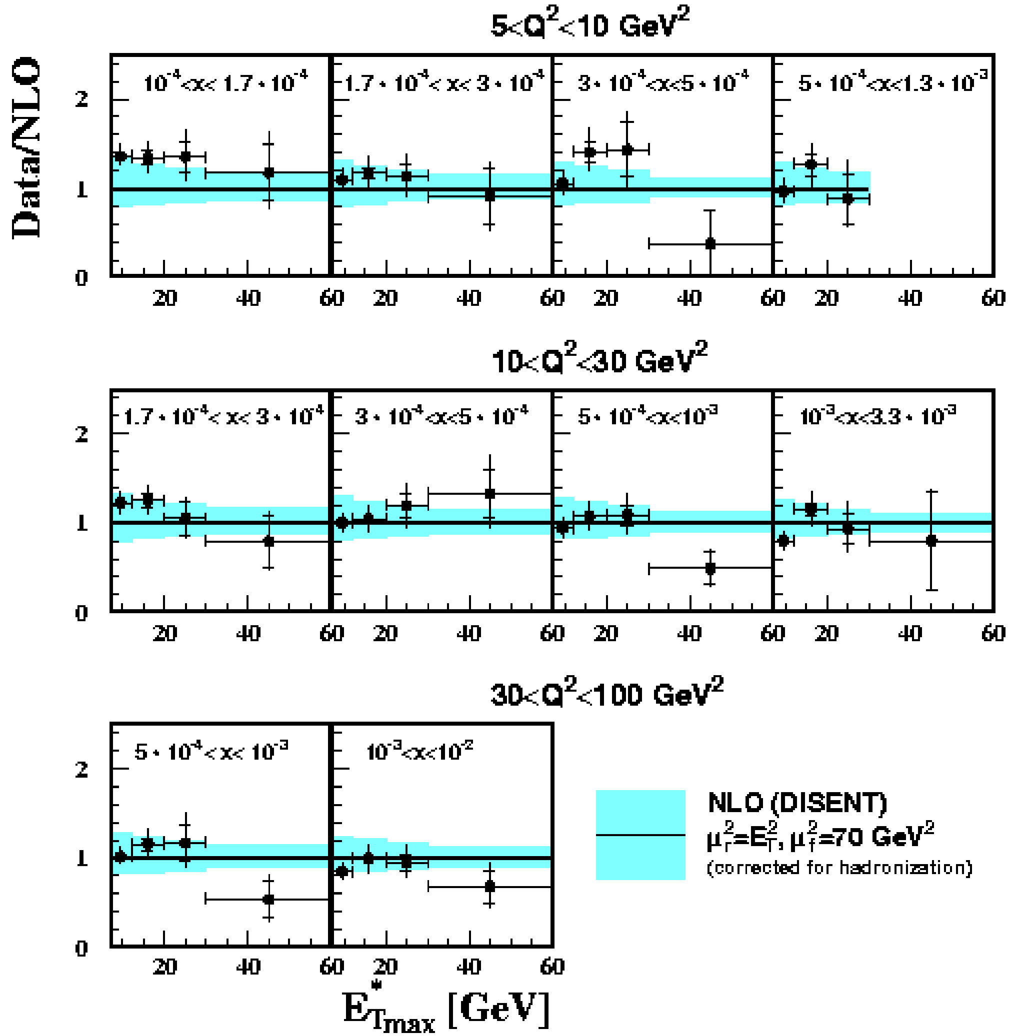
$E^*_T > 5$ GeV
$-1 < \eta < 2.5$
$N_{jet} \geq 2$
$E^*_{T,max} > 7$ GeV

Triple Differential Dijet Cross Section I



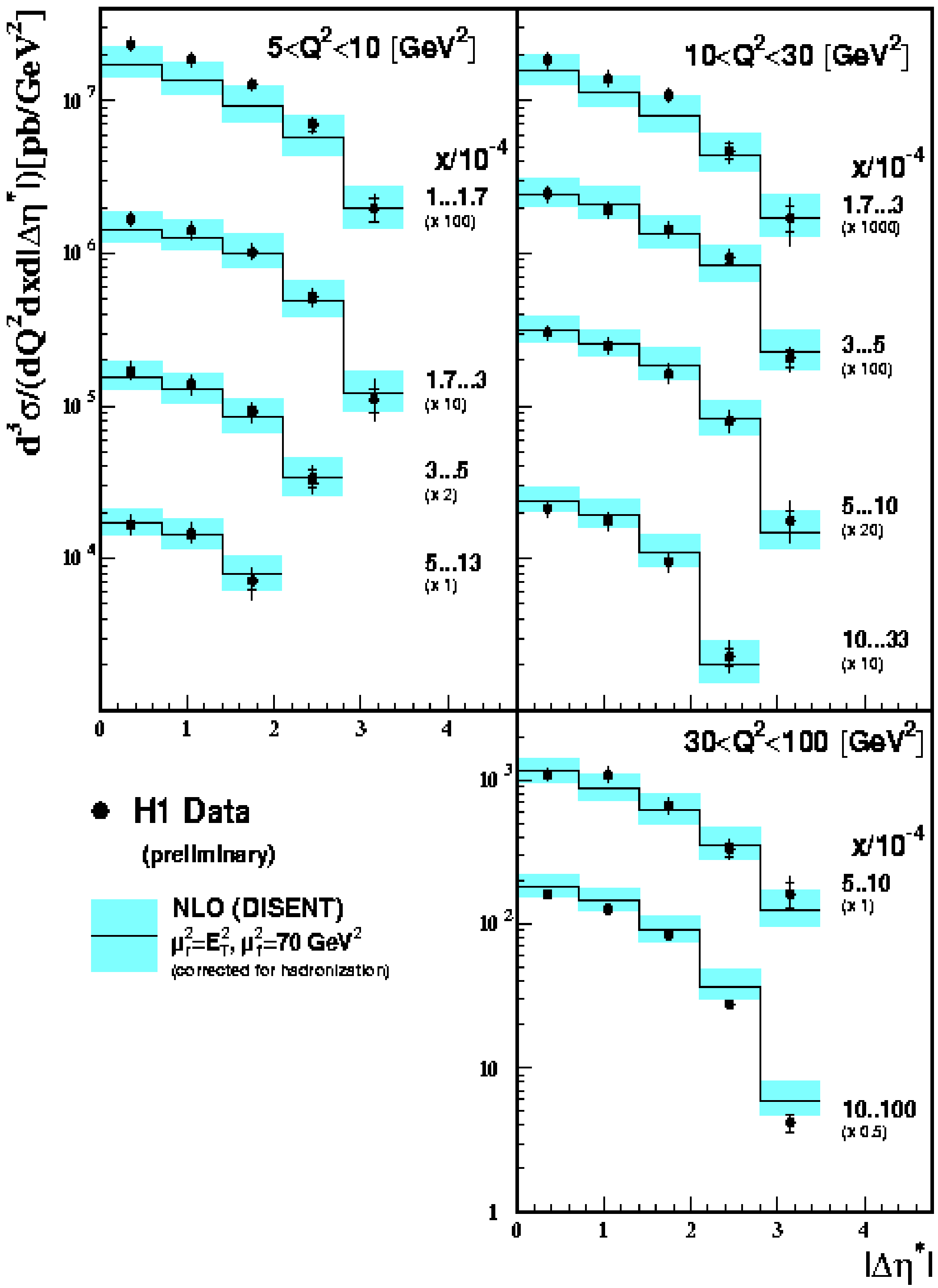
$0.25E_T^{*2} < \mu_r^2 < 4E_T^{*2}$

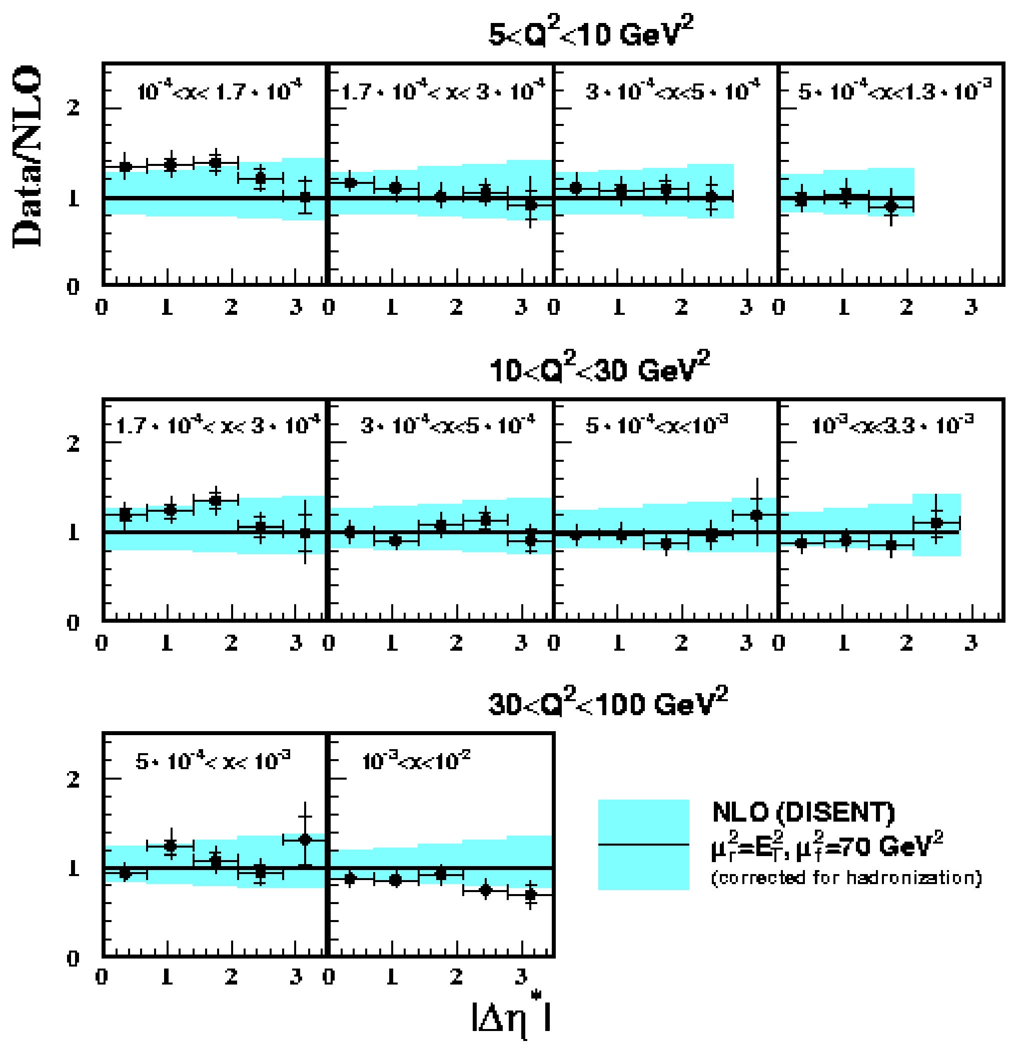
Hadronization reduces pure NLO by 10%



- 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

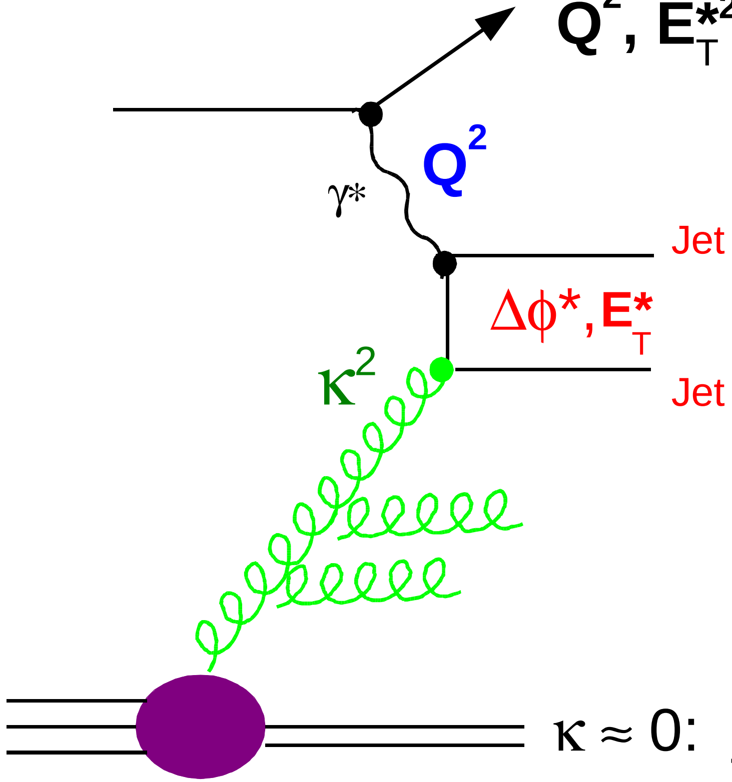




- No significant disagreement between data and NLO predictions
  - Deviations at small $x, Q^2, |\Delta\eta^*|$
- Scale Uncertainties O(20%) > Error of data

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 k

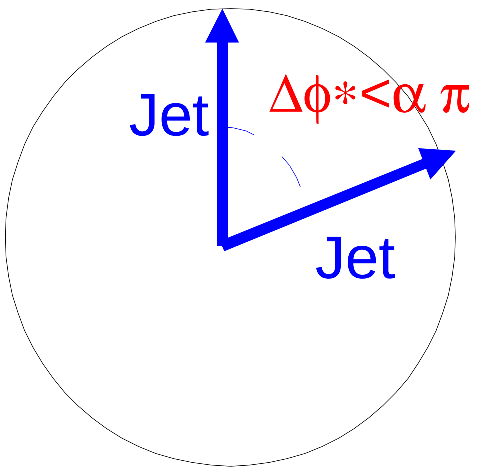
$\kappa \approx 0$: jets back-to-back in ϕ^*

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

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

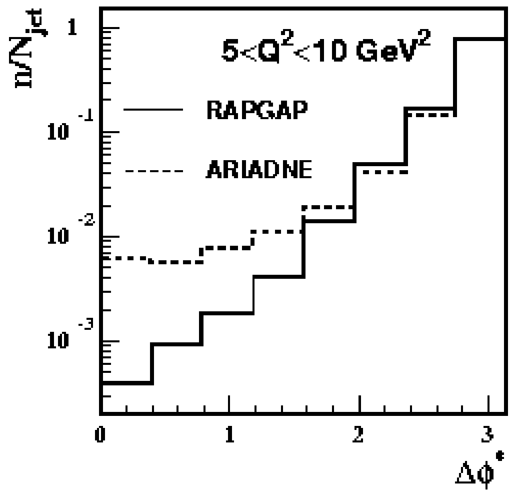
$\Delta\phi^*$ cross sections sensitive to radiation pattern in gluon ladder ?!

Observables to study Azimuthal Correlations ?



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

Experimentally difficult



Easier:

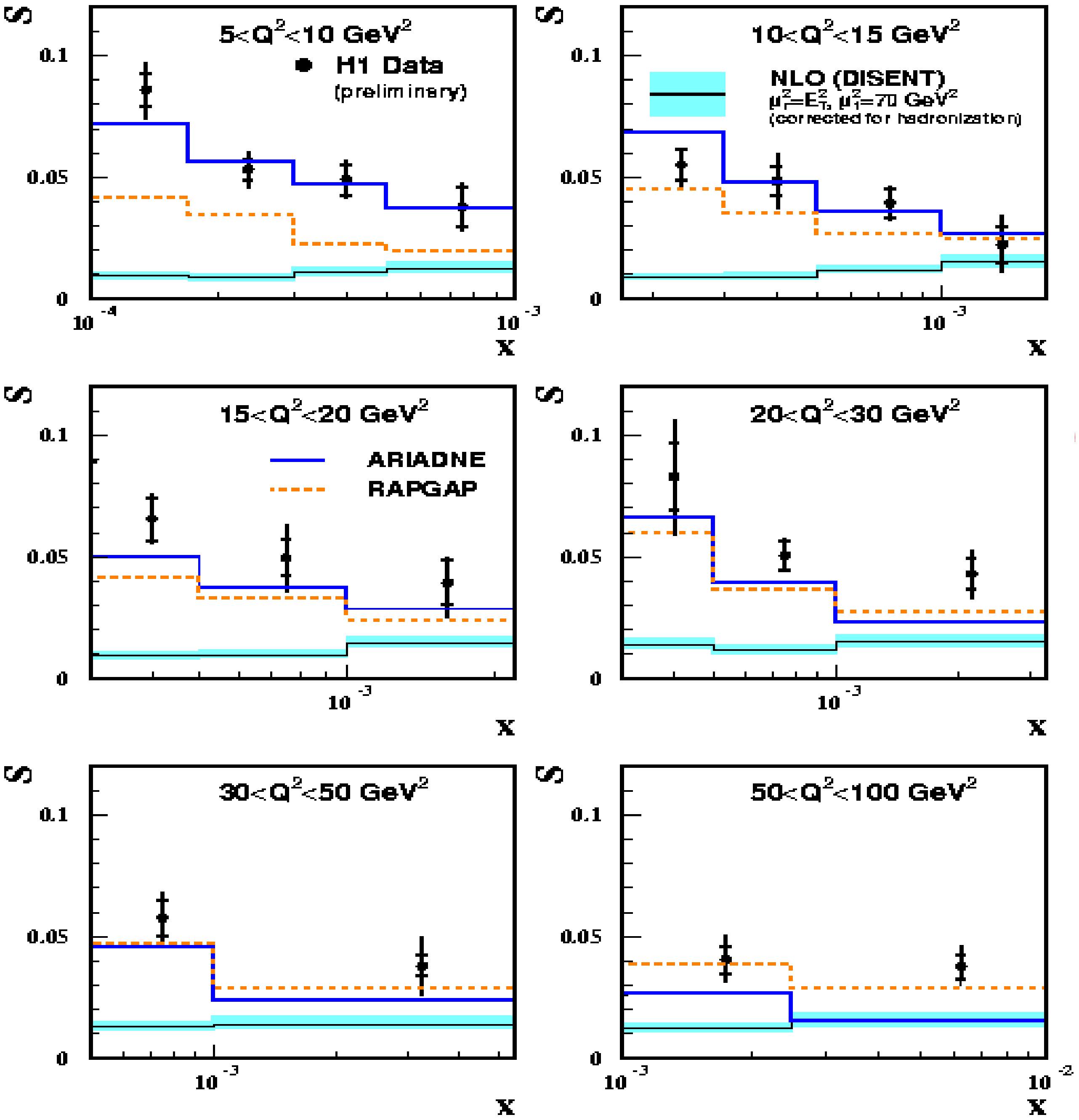
$$S(x,Q^2,\Delta\phi^*) = \frac{\int_0^{\alpha\pi} w(\Delta\phi^*,x,Q^2)}{\int_0^{\pi} w(\Delta\phi^*,x,Q^2)}$$

'Same Side' Jets

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

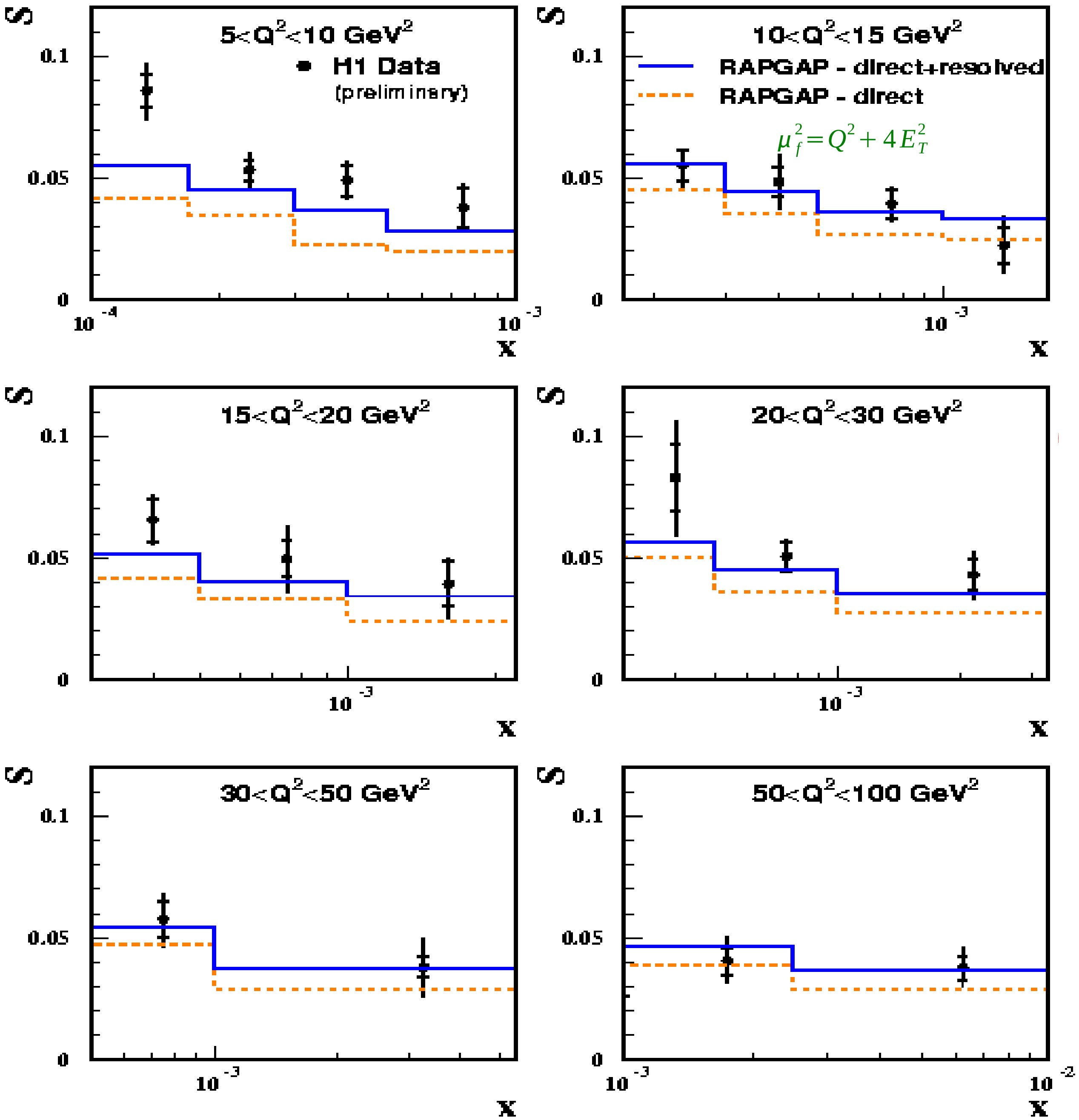
(proposed by A.Szczurek et al. hep-ph/0011281)

Results for $\Delta\phi^* < 120^o$

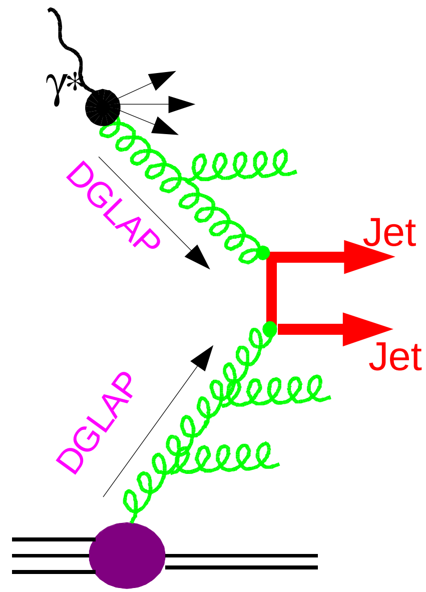


- Data rises towards low x
  Increasing parton virtuality due to longer parton ladder ?
- NLO is significantly away from data
- Indication that virtuality of incoming parton *cannot* be neglected ?
- LO Models give (at least) right order of magnitude

Contributions from resolved virtual γ^*

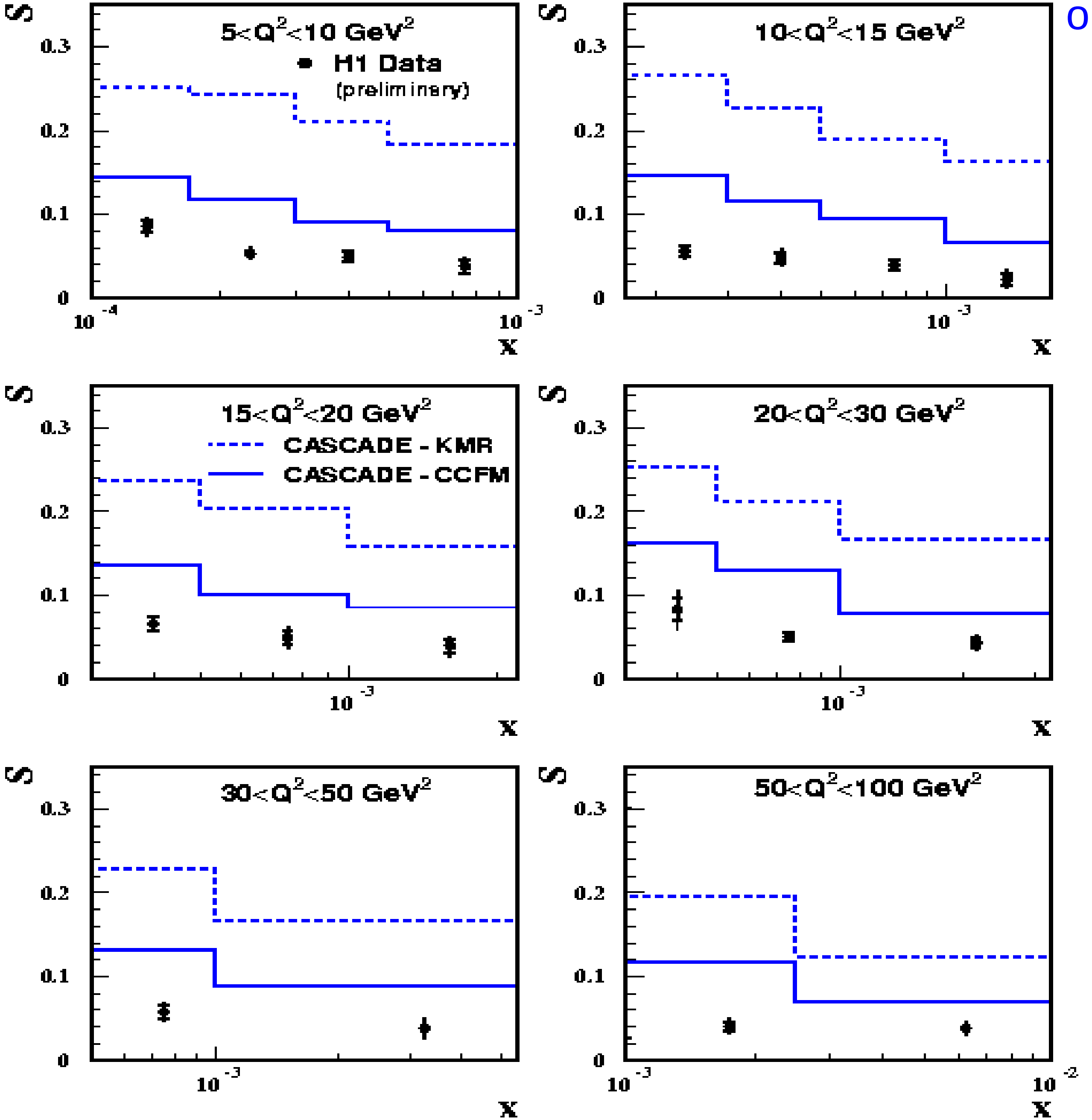


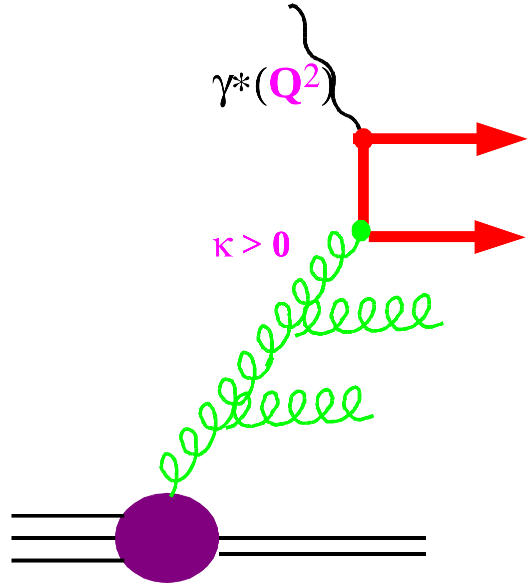
→ Mimic of non DGLAP type radiation



S increases when including resolved γ^* in prediction

Predictions based on Unintegrated Pdfs





- Unintegrated pdfs provide Mechanism to produce Same Side Jets
- S predicted by CASCADE exceeds data
- Differences among predictions based on different pdfs

Summary and Conclusion

- Results of analysis on dijet production at low x, Q^2 presented

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

  Data allow for distinction between various prediction

  Huge descrepencies between data and NLO-QCD predictions

  Rate of Same Side Jets sensitive to different unintegrated pdfs
  Predictions exceed data

  Best description by LO QCD Models

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