H1 studies of parton cascades using jets

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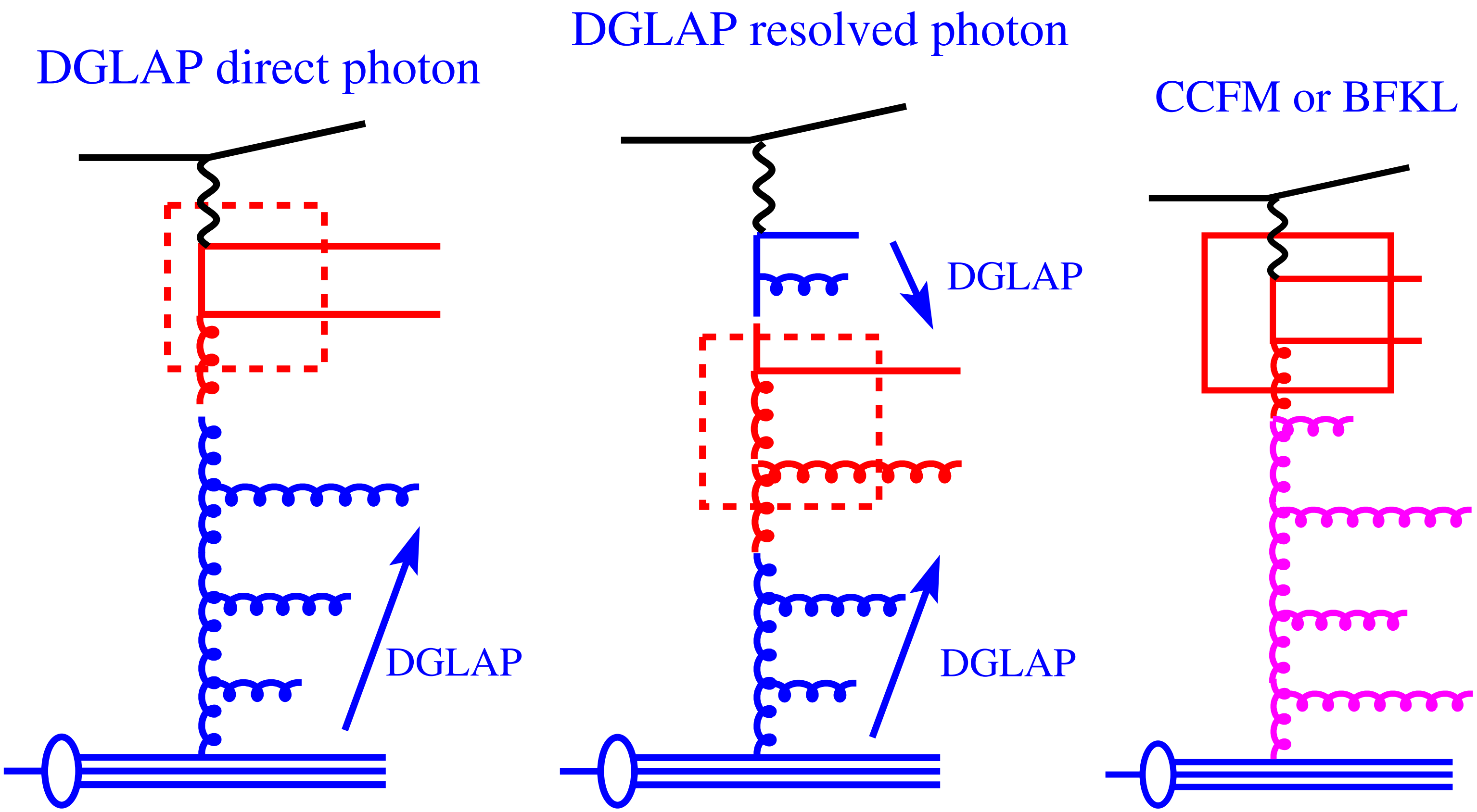
Representing **H1** Collaboration

- H1 analysis of forward π^0 [hep-ex/0404009]
- H1 analysis of forward Jets (Abstract 5-0172 at ICHEP04)
- H1 analysis of dijet production [hep-ex/0401010]
- Conclusions

JET PRODUCTION IN DIFFERENT EVOLUTION SCHEMES



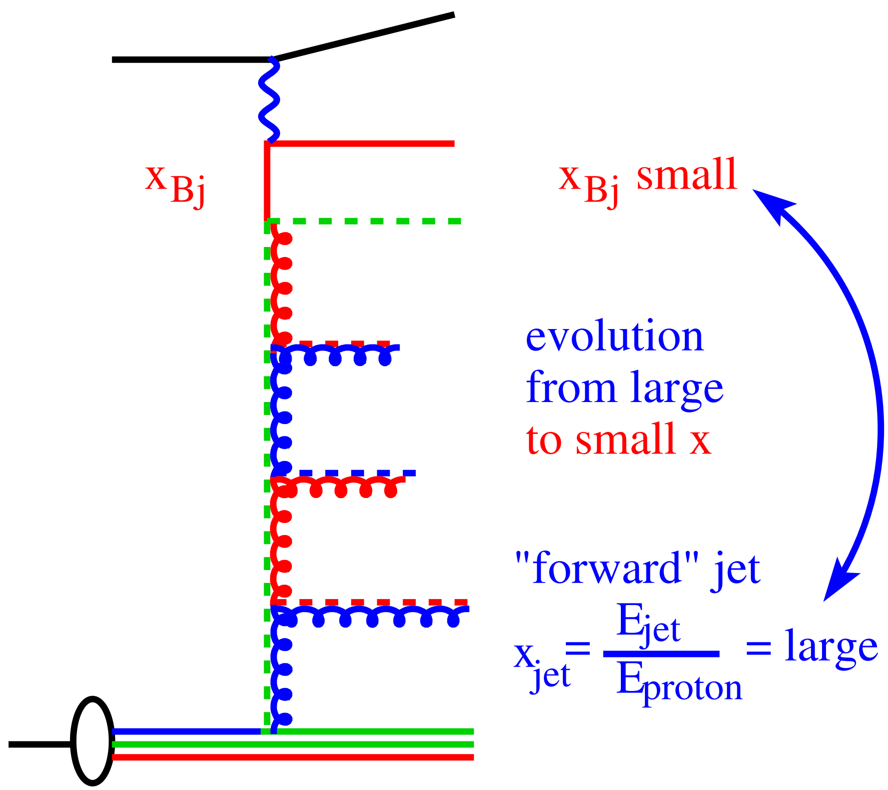
DGLAP: strong ordering of parton k_T

CCFM: angular ordering of parton emissions (“unintegrated” PDF)

BFKL: strong ordering in x_i (“unintegrated” PDF)

ANALYSES OF FORWARD JET AND π^0 PRODUCTION

- F_2: very inclusive, well described by DGLAP
- Jet / π^0 in the forward region: information on full evolution ladder
- To suppress DGLAP: $k^2_{T,jet/\pi^0} \sim Q^2$
- To enhance BFKL: $x_{jet/\pi^0} \equiv E_{jet/\pi^0}/E_P \gg x_B$



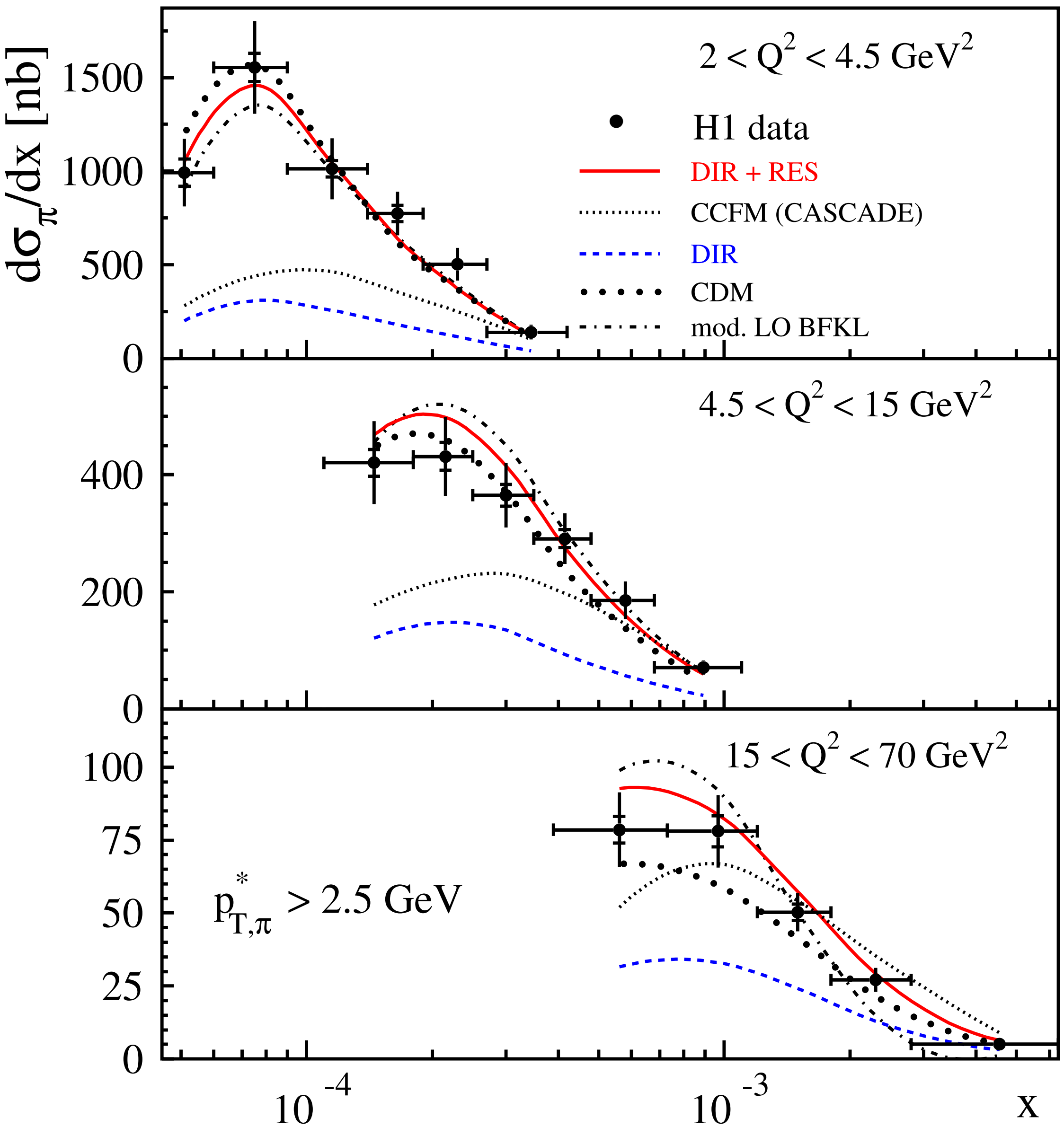
FORWARD JET AND FORWARD π^0 MEASUREMENTS

	forward π^0 measurements		**forward jet measurements**
—	fragmentation effects more significant	+	better parton correlation
—	smaller rate	+	higher rates
+	identification possible in more forward region	—	exp. difficult in very forward (p) region
		—	ambiguities of jet algorithm

FORWARD JET AND FORWARD π^0 MEASUREMENTS

	$e + P \to e + \pi^0 + X$	$e + P \to e + \text{jet} + X$
Data sample	21 pb^{-1}, 1996/97	14 pb^{-1}, 1997
Forward jet / π^0	$5^\circ < \theta_{\pi^0} < 25^\circ$	$7^\circ < \theta_{\text{jet}} < 20^\circ$
Hard forward jet / π^0	$p_{T,\pi^0} > 2.5(3.5)\,\text{GeV}$	$p_{T,\text{jet}} > 3.5\,\text{GeV}$
Suppress DGLAP:	$2 < Q^2 < 70\,\text{GeV}^2$	$5 < Q^2 < 85\,\text{GeV}^2$
		$0.5 < p^2_{T,\text{jet}}/Q^2 < 5$
Target BFKL:	$x_{\pi^0} \equiv E_{\pi^0}/E_P > 0.01$	$x_{jet} \equiv E_{jet}/E_P > 0.035$
Kinematic cuts:	$0.1 < y < 0.6$	$0.1 < y < 0.7$
	$0.000\,01 < x_B$	$0.000\,1 < x_B < 0.004$

FORWARD π^0 $(p^*_{T,\pi} > 2.5\text{GeV})$



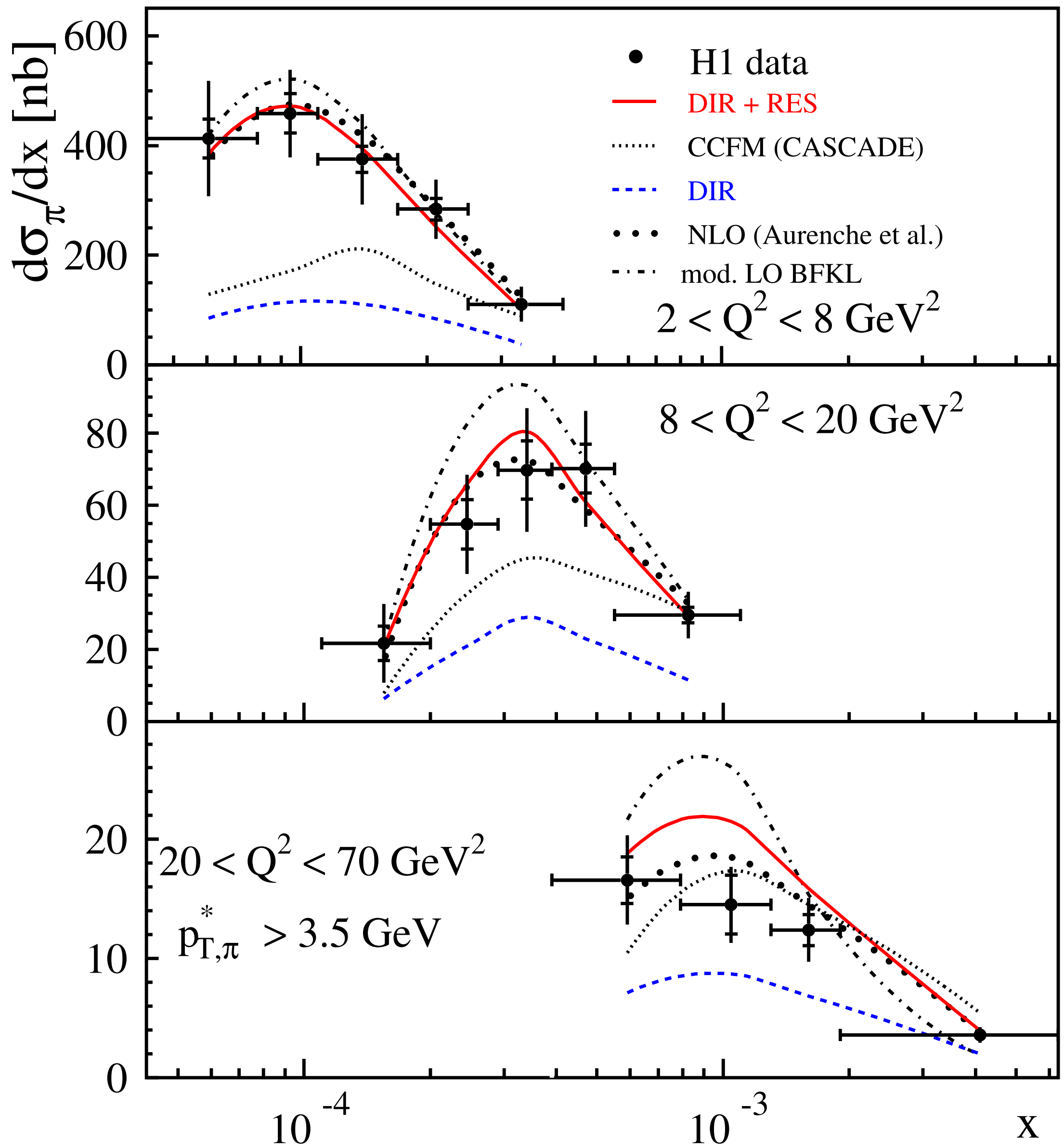
DGLAP (DIR + RES) : resolved photon component improves the description $(\mu^2 = Q^2 + 4p_T^2)$.

CCFM (CASCADE) : below the data at low x and Q^2.

CDM : reasonable description of the data.

Mod. LO BFKL (Kwieciński, Martin, Outhwaite hep-ph/9903439): reasonable description of the data, however sensitive to a particular parameter choice.

FORWARD π^0 $(p^*_{T,\pi} > 3.5\mathrm{GeV})$



NLO calculations :

describe the data well

$\mu^2 = (Q^2 + p^{*2}_{T,parton})/2$

BFKL-like diagrams important

CCFM (CASCADE) :

low at small x and Q^2

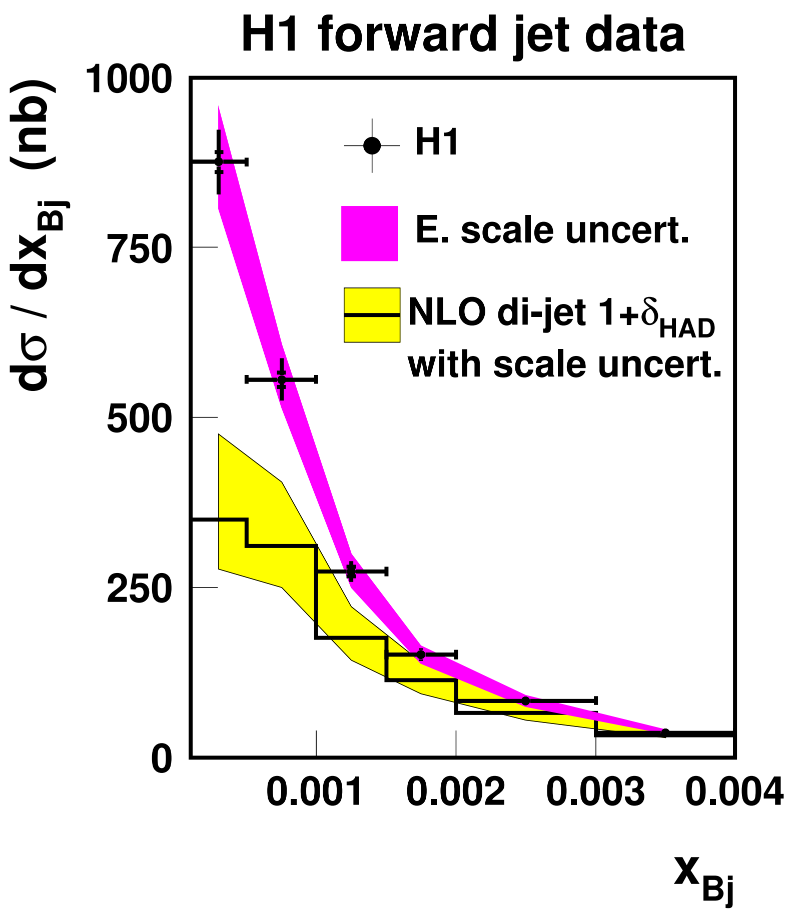
(would the inclusion of quarks

in the evolution help ??)

mod. LO BFKL :

too high at higher Q^2

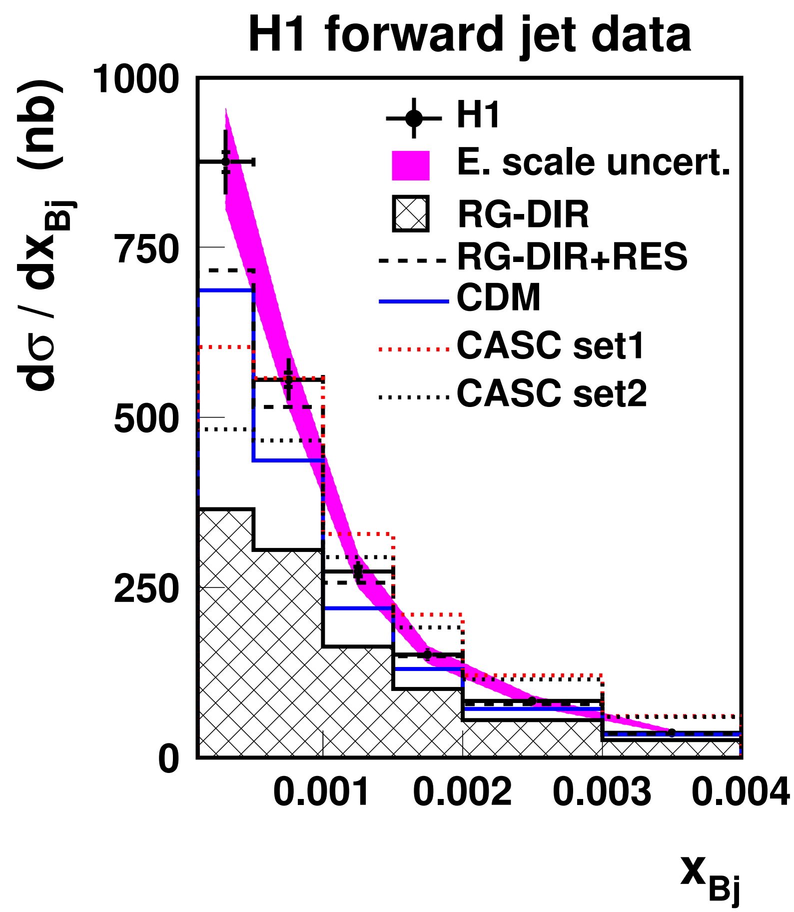
FORWARD JET ANALYSIS



$\mu_f^2 = \langle p_{T,\text{jet}}^2 \rangle$.

$0.25 p_{T,\text{jet}}^2 < \mu_r^2 < 4 p_{T,\text{jet}}^2$.

CTEQ6M.

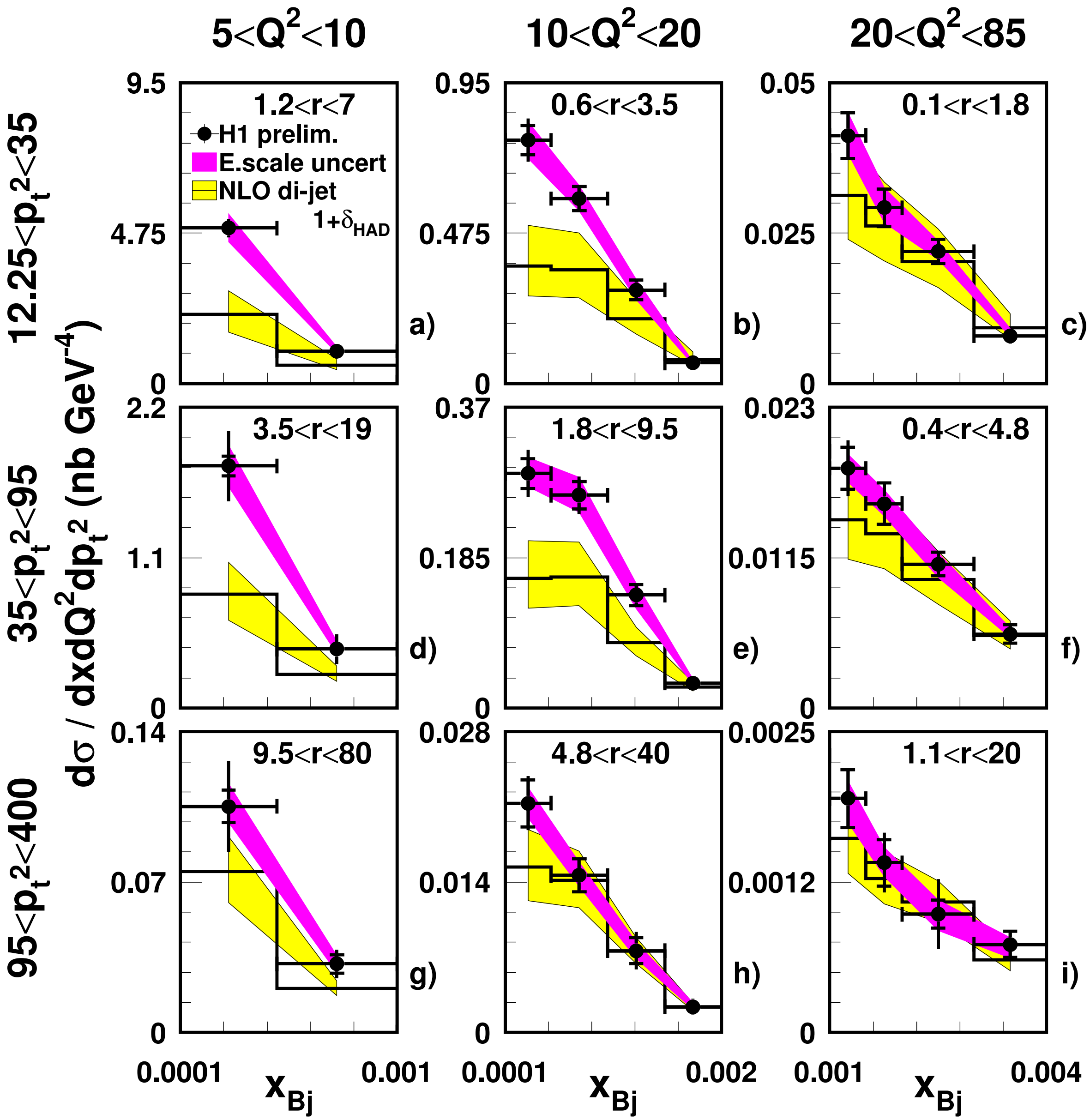


All models low in the lowest x_B bin.

CASCADE high at higher x_B.

DGLAP DIR+RES best.

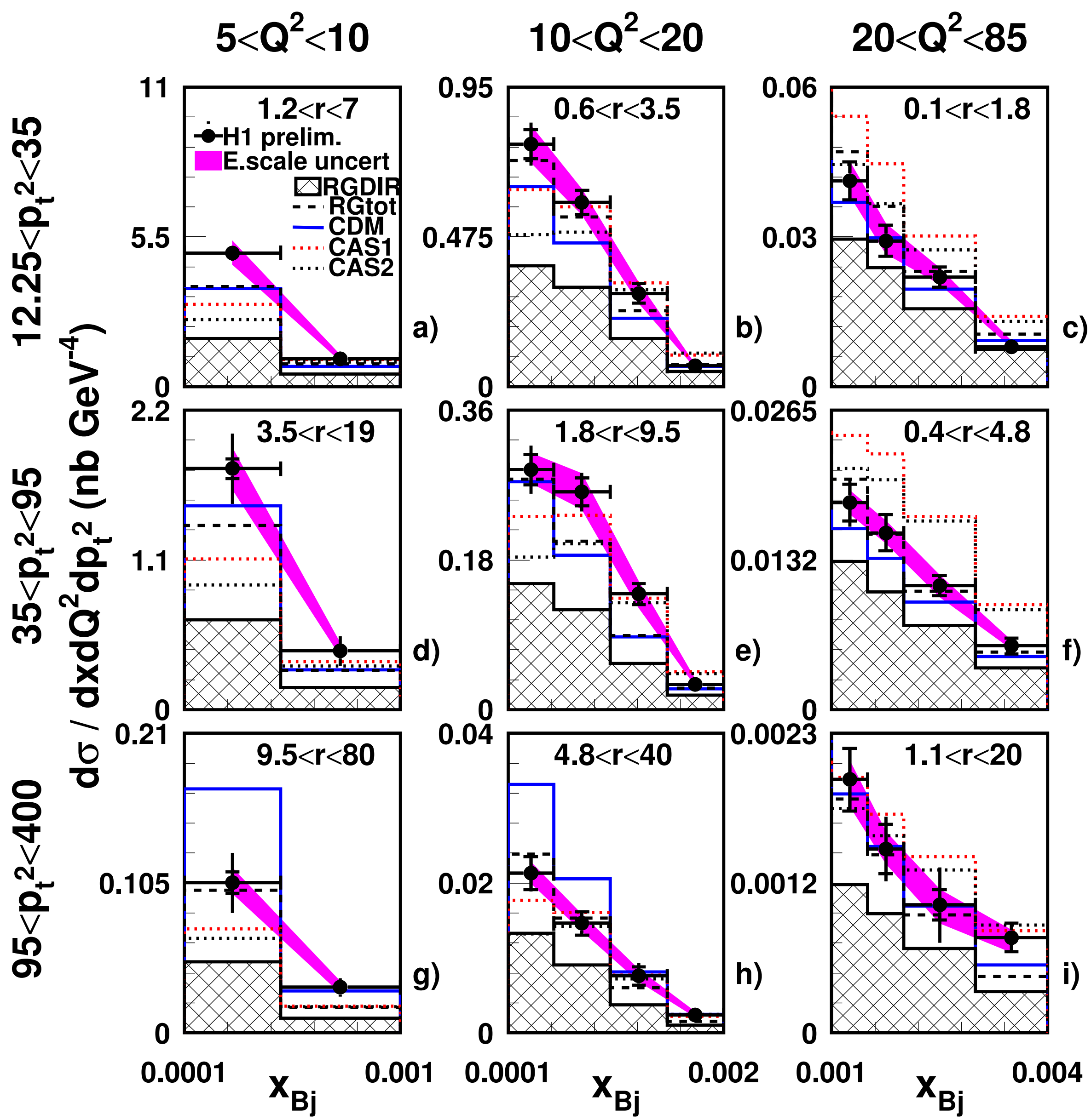
FORWARD JET ANALYSIS



- Good description at high Q^2, high $p^2_{T,\mathrm{jet}}$ and (or) high x_B.
- Higher orders seem to be needed at low Q^2, $p^2_{T,\mathrm{jet}}$ and x_B.

$$(r = p^2_{T,\mathrm{jet}}/Q^2)$$

FORWARD JET ANALYSIS



- RAPGAP DIR fails.
- RAPGAP DIR+RES – best description.
- CDM – good, but problems at high $p^2_{T,\mathrm{jet}}$.
- CASCADE – Too low at small Q^2, too high at large Q^2.

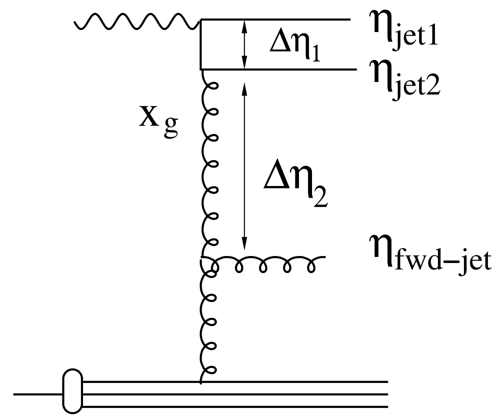
2+FORWARD JET ANALYSIS

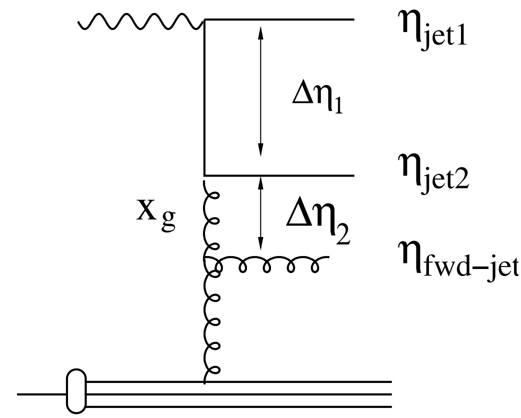
Two hard jets ($p_T > 6$ GeV) in addition to the forward jet.

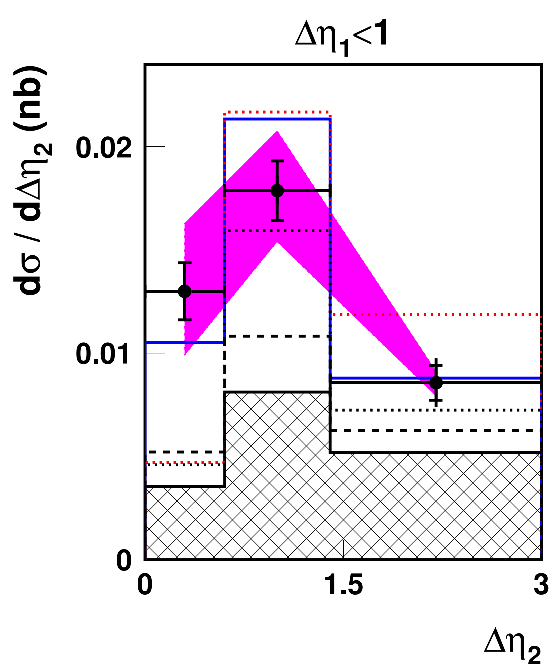
$\Delta\eta_1 < 1$: small x_g, i.e. room for many emissions in x (BFKL-like ladder).

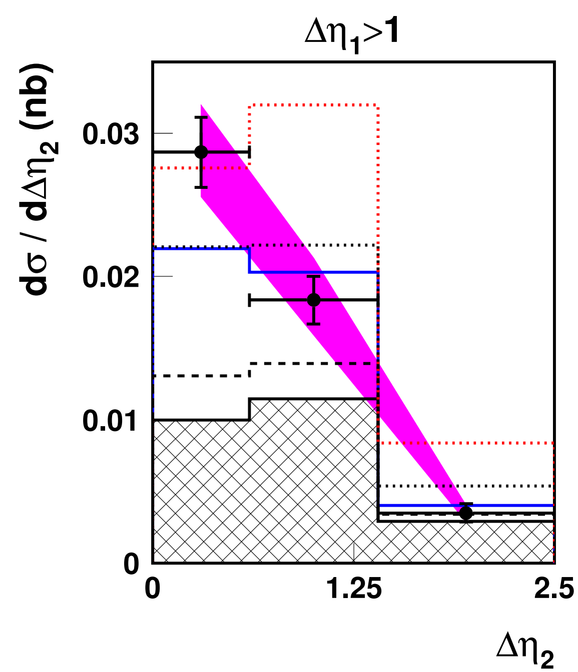
$\Delta\eta_1 > 1$: Shorter parton ladder (not that BFKL-like).

(No p_T^2/Q^2 cut.)









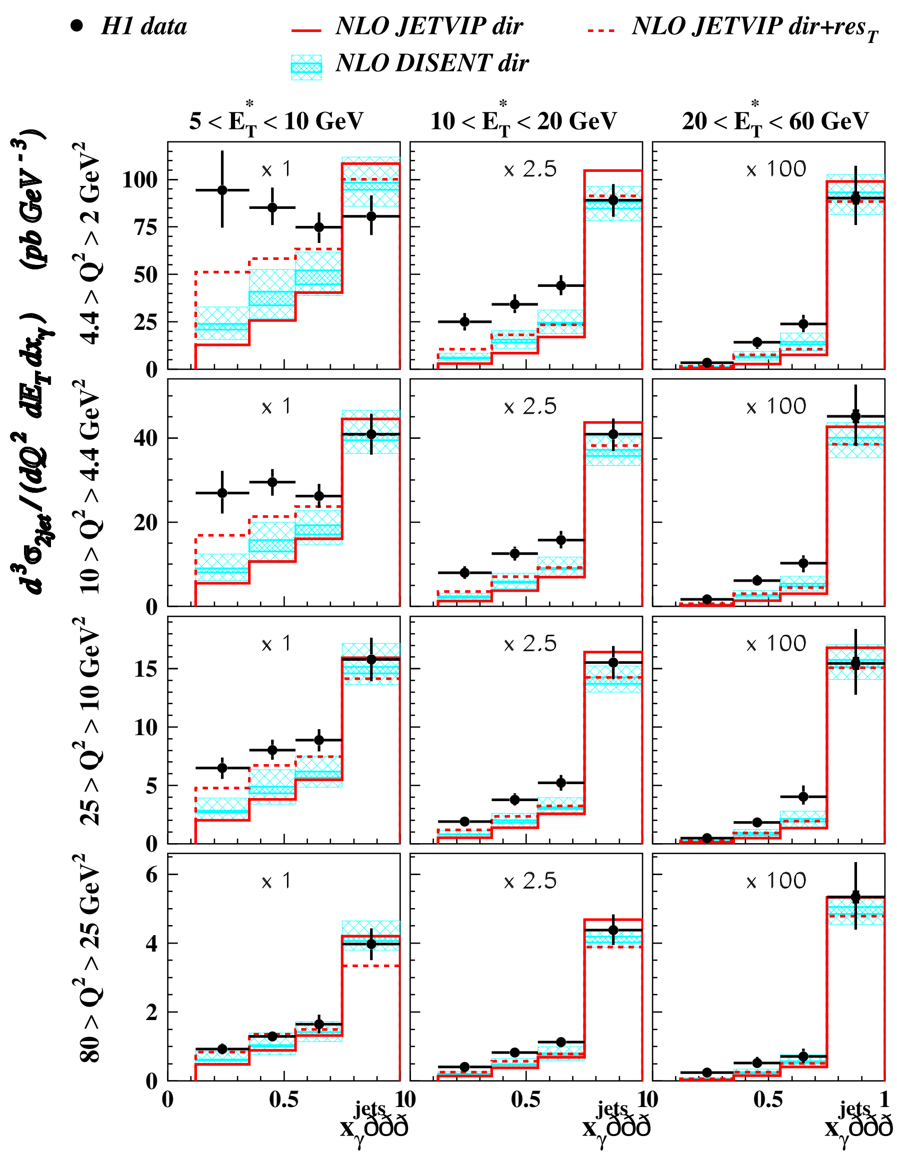
DIJET PRODUCTION

57 pb^{-1}, 1999-2000, $\sqrt{s} = 318\,\mathrm{GeV}$
$2 < Q^2 < 80\,\mathrm{GeV}^2; \quad 0.1 < y < 0.85$
$E^*_{T1} > 7\,\mathrm{GeV}; \quad E^*_{T2} > 5\,\mathrm{GeV}$
$-2.5 < \eta^*_{1,2} < 0$
longitudinally invariant k_t jet algorithm, $\gamma^* p$ CMS
More details: [hep-ex/0401010]

$$x_\gamma^{\mathrm{jets}} = \frac{\sum_{\mathrm{jet}\,1,2} (E^*_{\mathrm{jet}} - p^*_{z,\mathrm{jet}})}{\sum_{\mathrm{hadrons}} (E^* - p^*_z)}$$ = fraction of the photon momentum taken

by a parton into the hard process

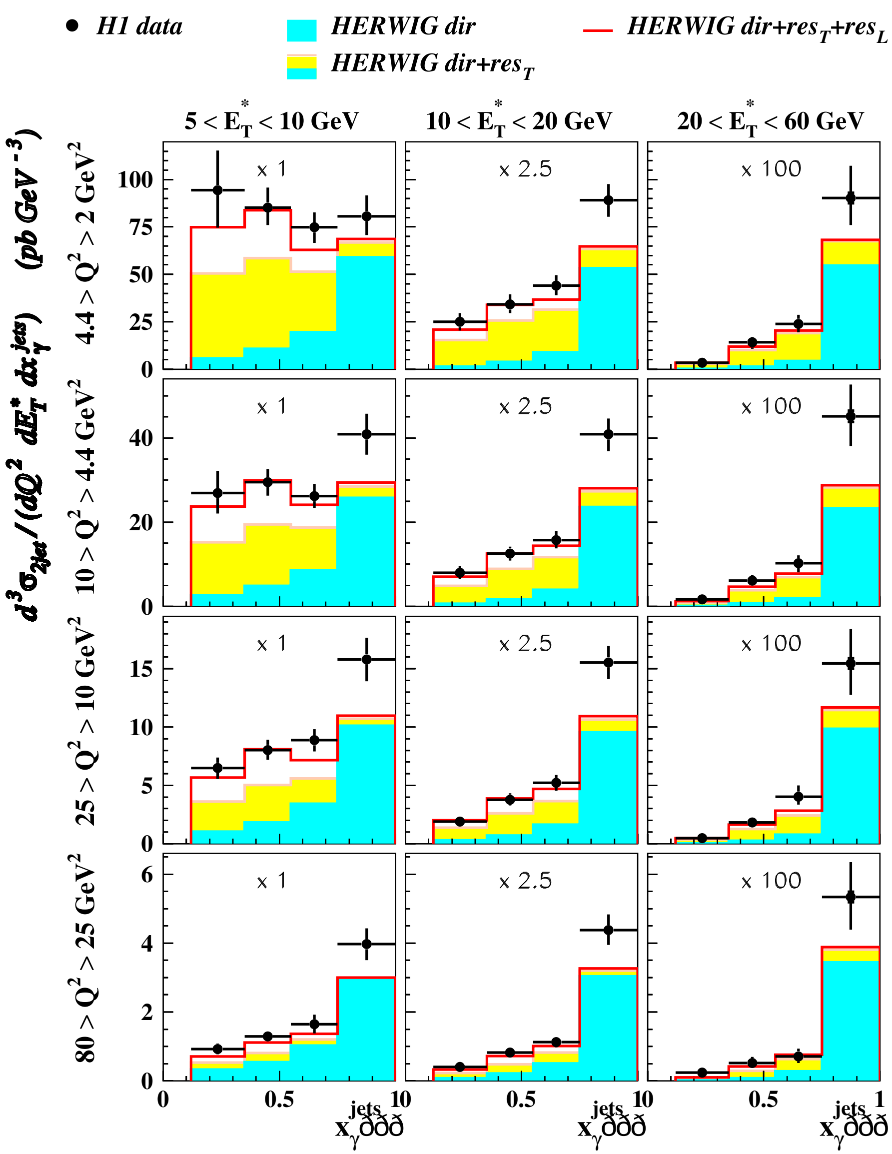
Dijet cross sections – comparison with NLO



- NLO DIR fails at low Q^2, E_T^* and $x_\gamma^{\rm jets}$.
- NLO DIR+RES (JETVIP) – better description, problems with technical parameter y_c.

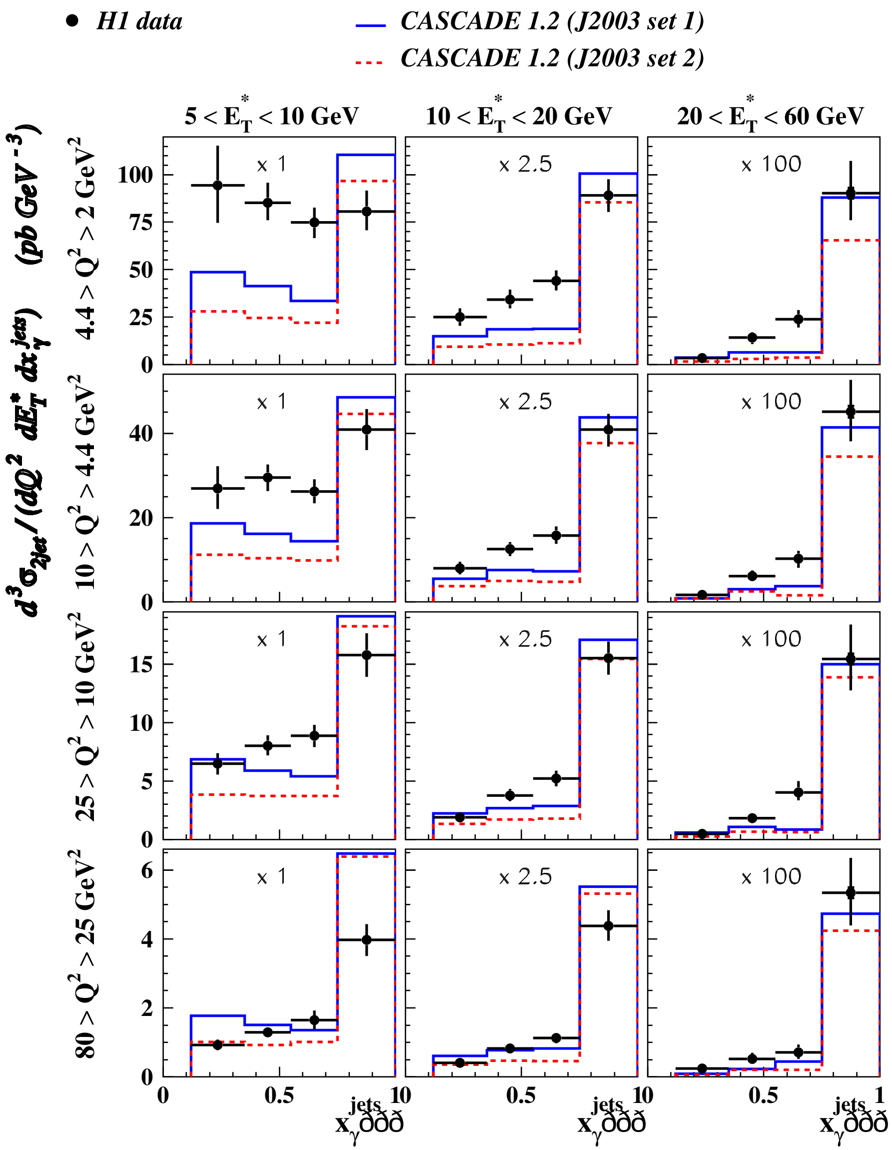
(Low $x_\gamma^{\rm jets}$ corresponds to jets in the forward region.)

Dijet cross section – comparison with LO MC



- HERWIG TOT describes well the region where NLO calculations fail, but problems at high $x_\gamma^{\rm jets}$.
- HERWIG RES γ_L^* helps to improve the description of the data.

CASCADE, a MC model based on CCFM eq.



- CASCADE fails at low Q^2 and low $x_\gamma^{\rm jets}$.
- CASCADE at low E_T^* underestimates the dijet cross sections at low Q^2 and overestimates them at high Q^2.

(Low $x_\gamma^{\rm jets}$ corresponds to jets in the forward region.)

Conclusions

The three recent H1 analyses show that:

- The largest discrepancies between the theory and data in the region of low Q^2, low p_T and low x (either x_B or $x_\gamma^{\rm jets}$).
- The data usually best described by the DGLAP-like LO MC programs including the resolved photon contributions.
- NLO predictions under the data at low $\mathbf{Q^2}$, $\mathbf{E_T^*}$ and x_B ($x_\gamma^{\rm jets}$).
- CASCADE underestimates the cross sections at low Q^2.
- CDM slightly worse than full DGLAP MC predictions but slightly better than CCFM MC.

NO EVIDENCE FOR CCFM OR BFKL SUPERIORITY

WITH RESPECT TO DGLAP.

Dijet cross sections – comparison with NLO