LHeC, Divonne, September 2009

Predictions for forward jets

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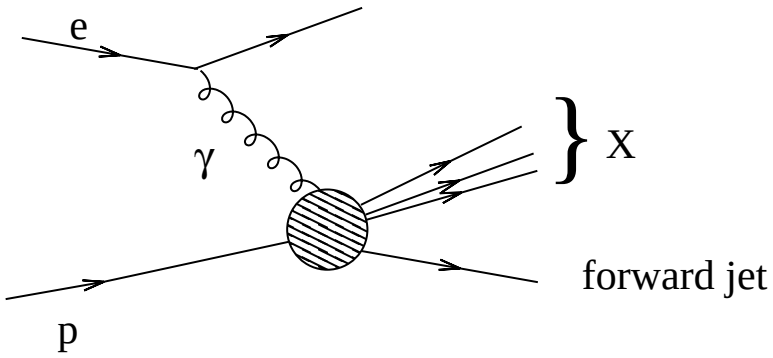
I. INTRODUCTION

High $p_\perp$ production at the LHeC



▷ phase space opening up for large $\sqrt{s}$

⇓

- physics of hard processes with multiple scales

and sensitive to parton dynamics at $x \to 0$

$\Rightarrow$ all-order summation of high-energy logarithmic corrections
e.g. evolution equation approach

Mueller & Navelet, 1987; Del Duca, Peskin & Tang, 1993; Stirling, 1994,...

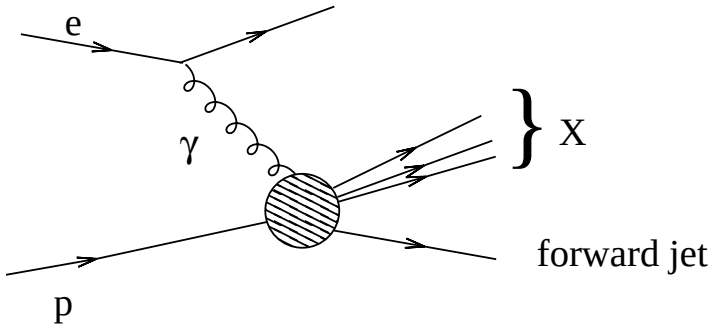
$\Rightarrow$ efforts toward Monte Carlos / semi-analytic appraoch approaches

Ewerz, Orr, Stirling and Webber, 2000;

Jung, Salam, 2001

Andersen, Del Duca, Frixione, Schmidt and Stirling, 2001;

Andersen; Andersen and Sabio Vera, 2003



• At present no satisfactory description by Monte Carlo or NLO calculations of forward jet ep data

[A. Knutsson, LUNFD6-NFFL-7225-2007 (2007); L. Jönsson, AIP Conf. Proc. 828 (2006) 175]

- High-energy factorization at fixed transverse momentum

$$\frac{d\sigma}{d\varphi dp_T^2} = \int \frac{d\widehat{\sigma}}{d\varphi dp_T^2} \otimes \phi_{g^*/B}$$

▷ needed to resum consistently both logs of rapidity and logs of hard scale *Catani et al., 1991;*

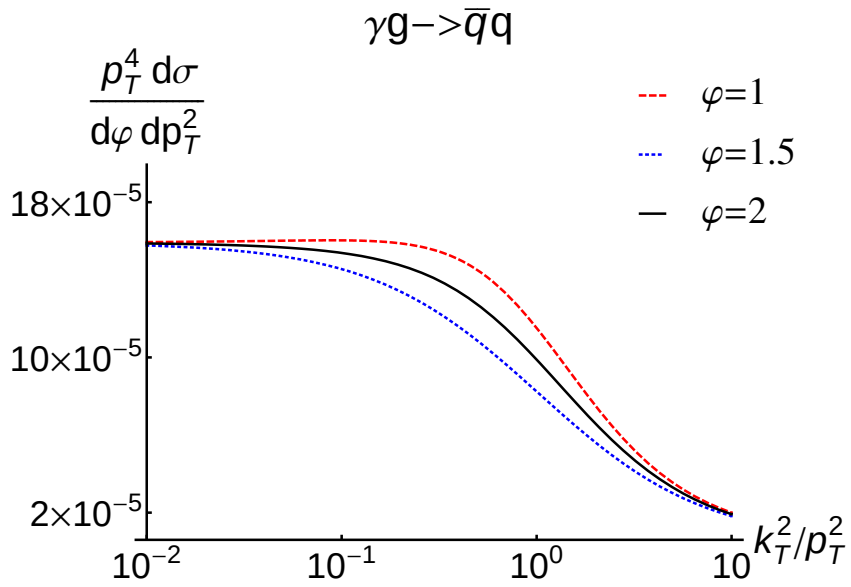


Figure 1: k_T dependent ME

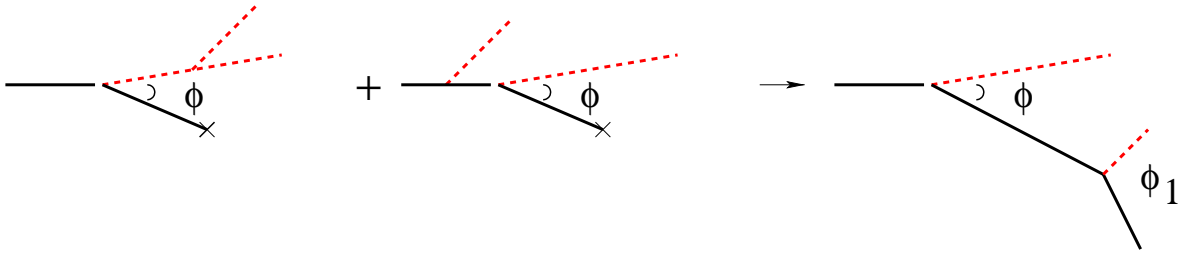
ϕ_{g^*} $k_\perp$-dependent, small-x

♢ $\widehat{\sigma}$ off-shell continuation of hard-scattering matrix elements

II. PARTON DISTRIBUTIONS BY SHOWERING METHODS

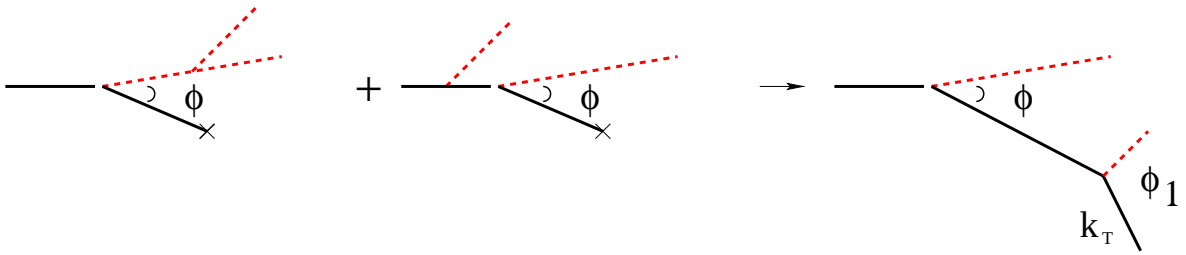
♢ Soft emission ⟶ interferences ⟶ ordering in decay angles

↪ gluon coherence for $x \sim 1$



♢ Gluon coherence for $x \ll 1$

↪ MC based on $k_\perp$-dependent unintegrated pdfs and MEs

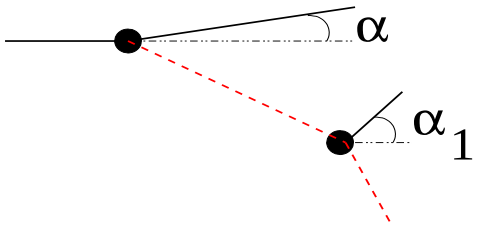


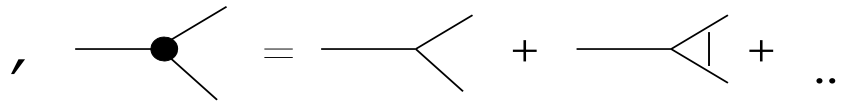
$K_\perp$-DEPENDENT PARTON BRANCHING

♢ CCFM gluon branching eq. based on angular ordering of emited gluons

♢ interpolates beetween BFKL (low x) and DGLAP (high x)

$$\mathcal{G}(x, k_T, \mu) \quad = \quad \mathcal{G}_0(x, k_T, \mu) + K \otimes \mathcal{G}(x, k_T, \mu)$$

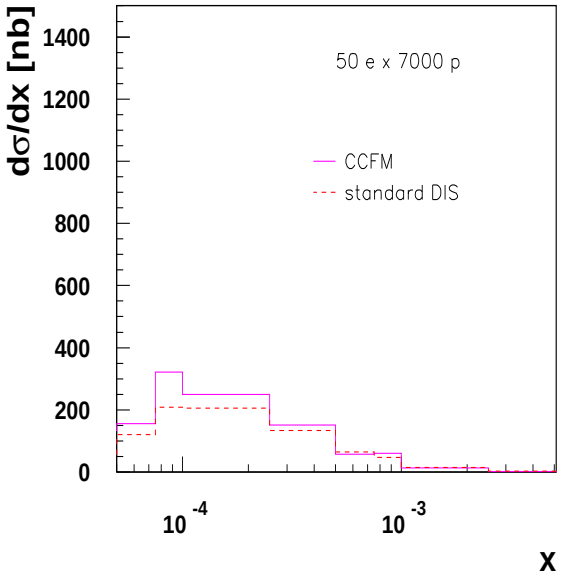


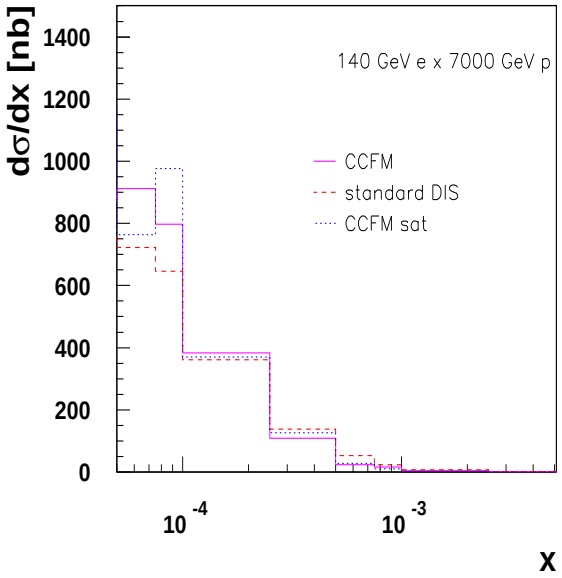


▷ implemented in CASCADE MC (H. Jung)

FORWARD JET CROSS SECTION AS A FUNCTION OF x_{Bj}

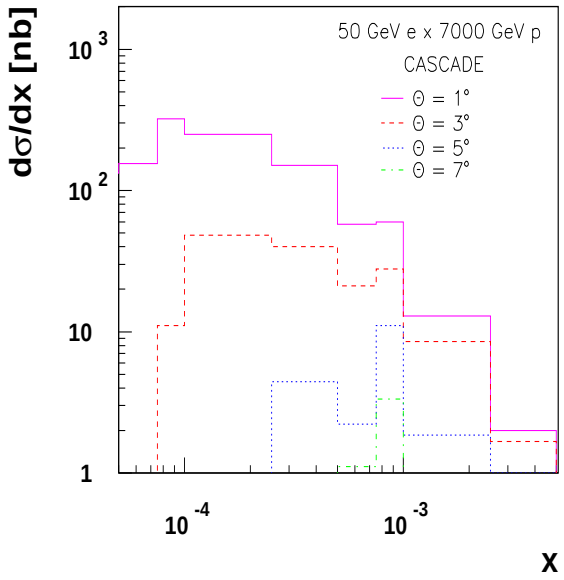
- Cross section for different energies of electron

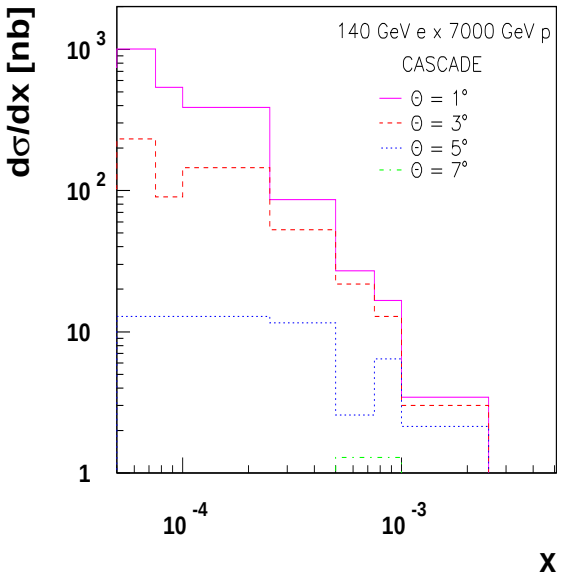




- small cross section for low energy run
  - one can not test different approaches

FORWARD JET CROSS SECTION FOR DIFFERENT JET ANGLE

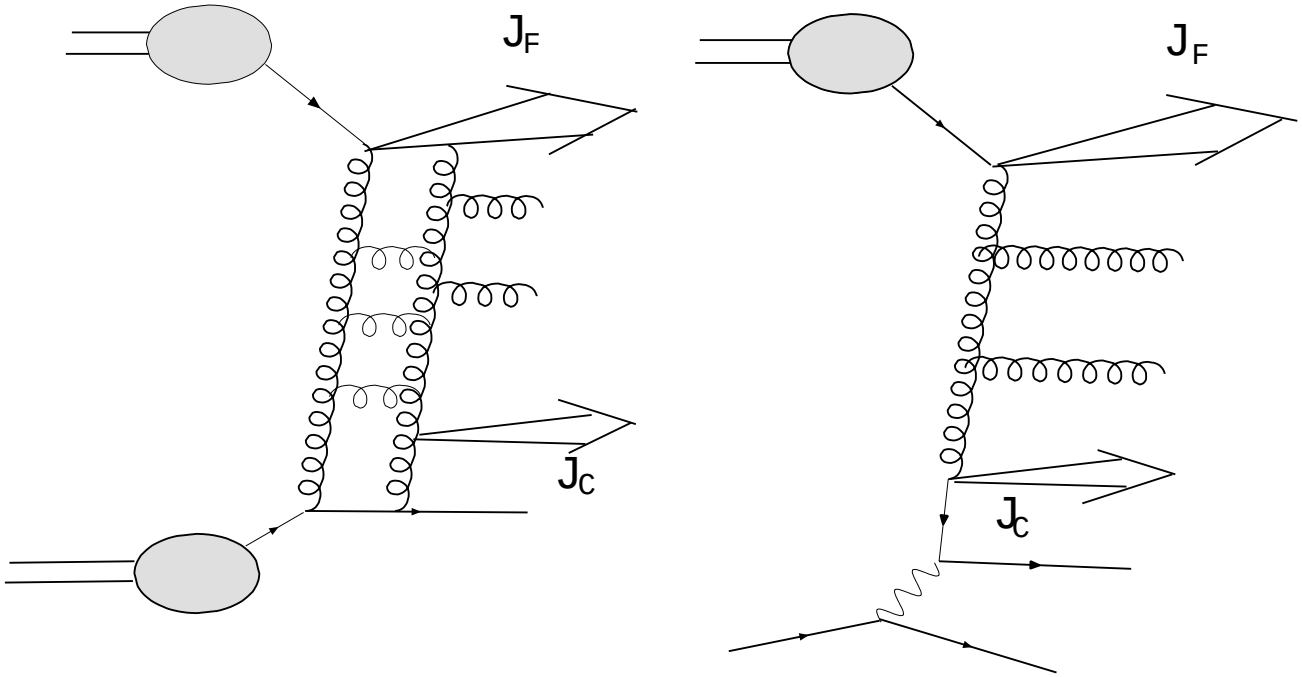




- large cross section only for small angle
  - one needs large energy run

FROM LHeC TO LHC AND BACK

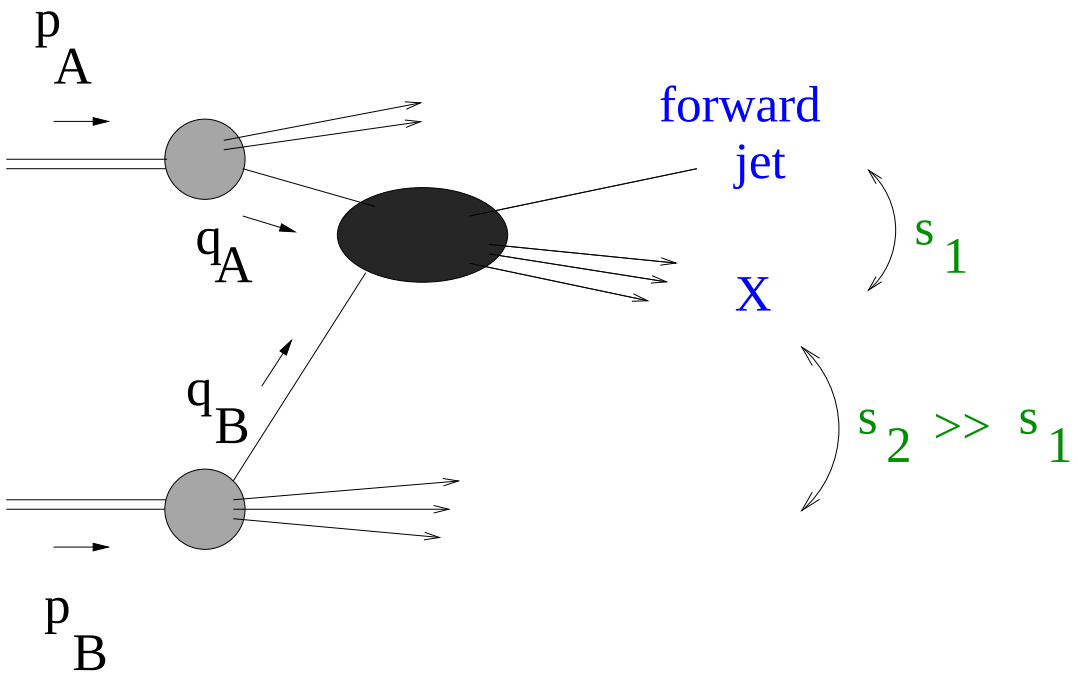
- the same requirements for final states



  - one could try to disantangle saturation and multiple interactions
- one can study other underlying events for pp

FORWARD JETS AT LHC

High-p_T production at the LHC



▷ phase space opening up for large $\sqrt{s}$

▷ unique coverage of large rapidities (calorimeters+proton taggers)

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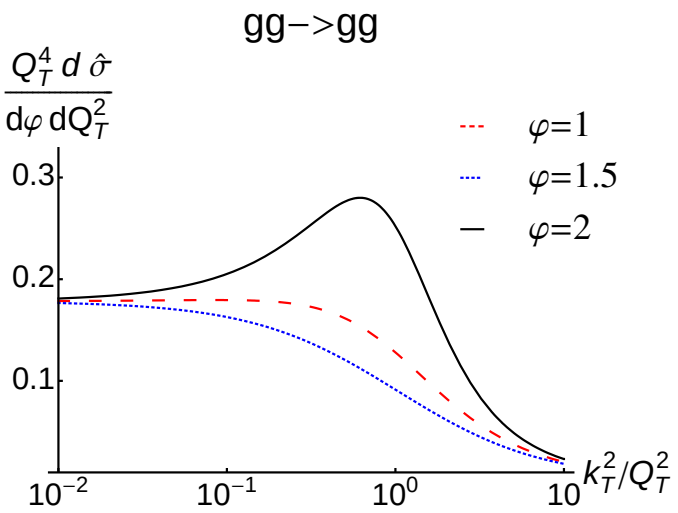
- physics of hard processes with multiple hard scales

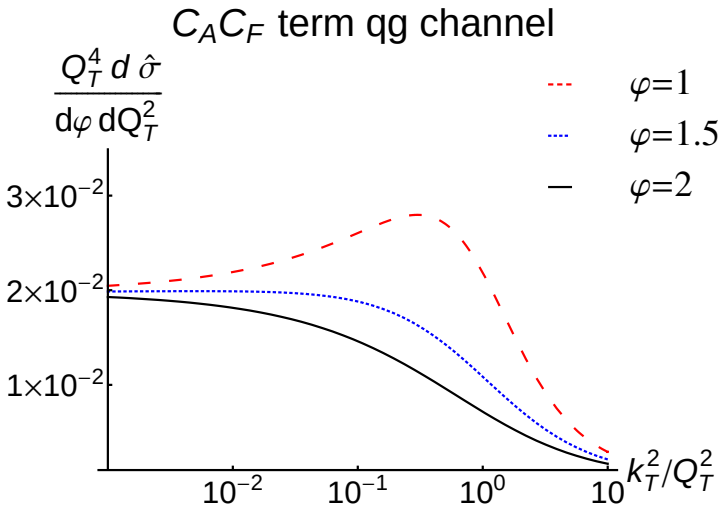
and highly sensitive to parton dynamics at $x \to 0$ and $x \to 1$

FORWARD JETS pp CASE BEHAVIOR AT LARGE $k_\perp$

k_T = transverse momentum carried away by extra jets

$k_T/Q_T \to 0$ leading order process



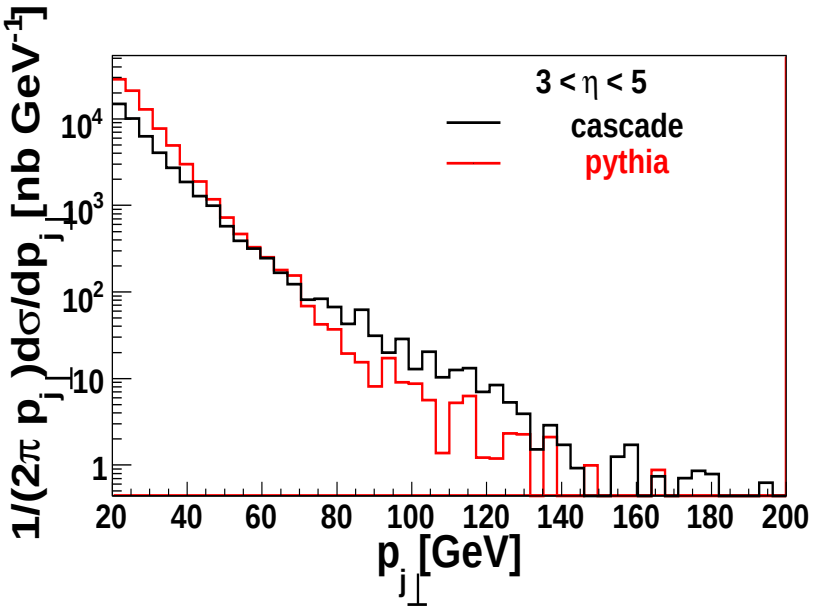


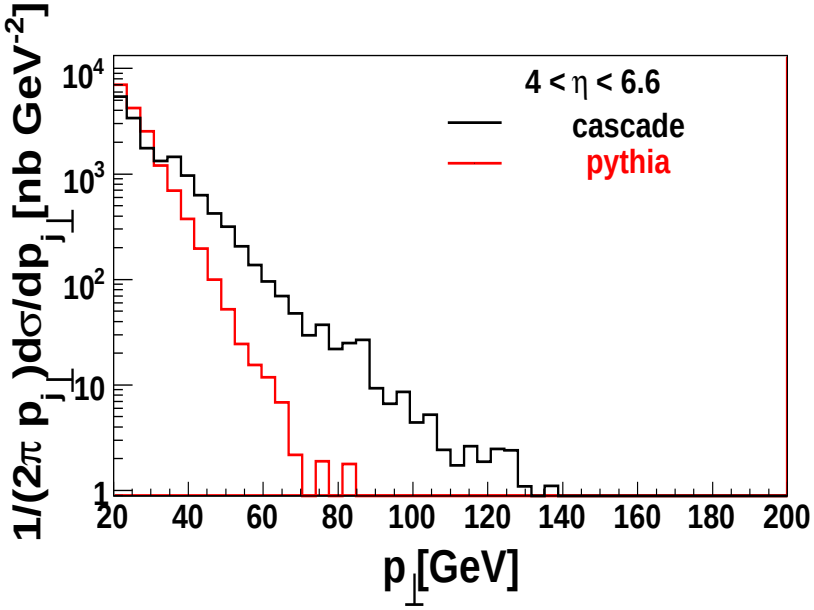
[Deák, Hautmann, Jung, & K arxiv:0908.0538]

- dynamical cut-off at $k_T \sim Q_T$ set by coherence effects
  - non-negligible terms from finite k_T tail

$p_\perp$ SPECTRA OF PRODUCED JETS in pp

Central jet	Forward jet	Central jet	Forward jet
$\|y_j\| < 2$	$3 < y_j < 5$	$\|y_j\| < 2$	$4.4 < y_j < 6$
$p_{jt} > 20$GeV	$p_{jt} > 20$GeV	$p_{jt} > 20$GeV	$p_{jt} > 20$GeV



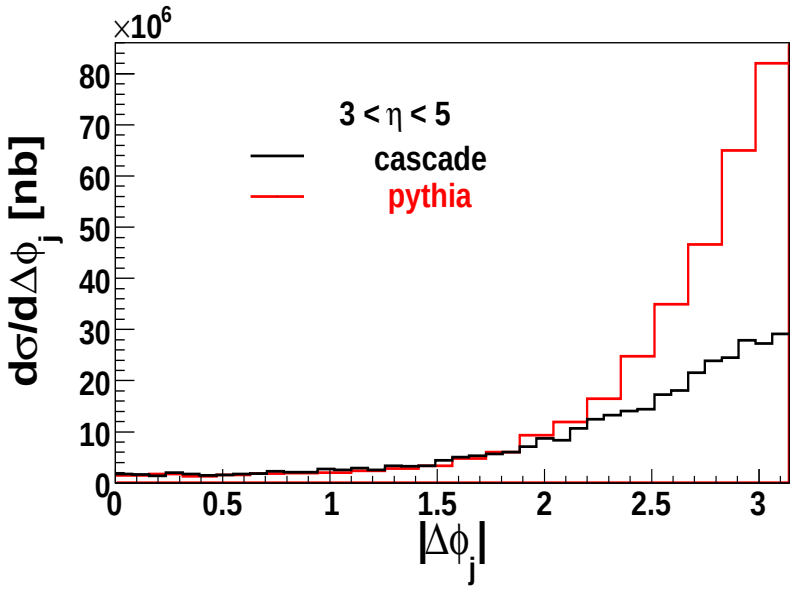


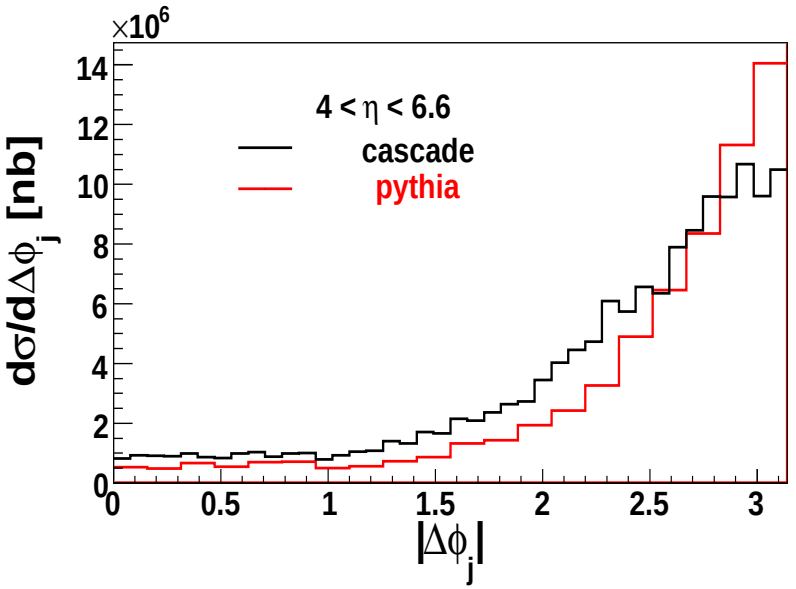
[Deák, Hautmann, Jung, & K in preparation]

- k_T of incoming gluon allows for harder spectrum
  - CASCADE uses CCFM like parton showers which are not ordered in k_T

FORWARD-CENTRAL JET pp $\Delta\phi$ CORRELATION

Central jet	Forward jet	Central jet	Forward jet
$\lvert y_j \rvert < 2$	$3 < y_j < 5$	$\lvert y_j \rvert < 2$	$4.4 < y_j < 6$
$p_{jt} > 20$GeV	$p_{jt} > 20$GeV	$p_{jt} > 20$GeV	$p_{jt} > 20$GeV



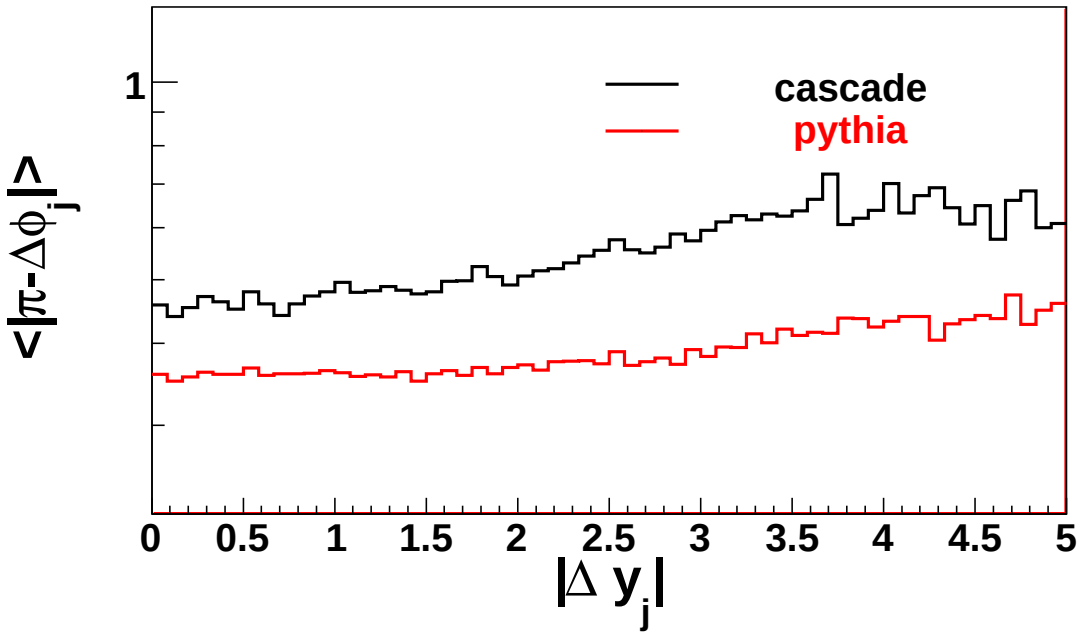


[Deák, Hautmann, Jung, & K in preparation]

- parton shower produces $k_T \rightarrow$ decorrelations
  - larger decolerrations for CASCADE than for PYTHIA

DECORRELATION

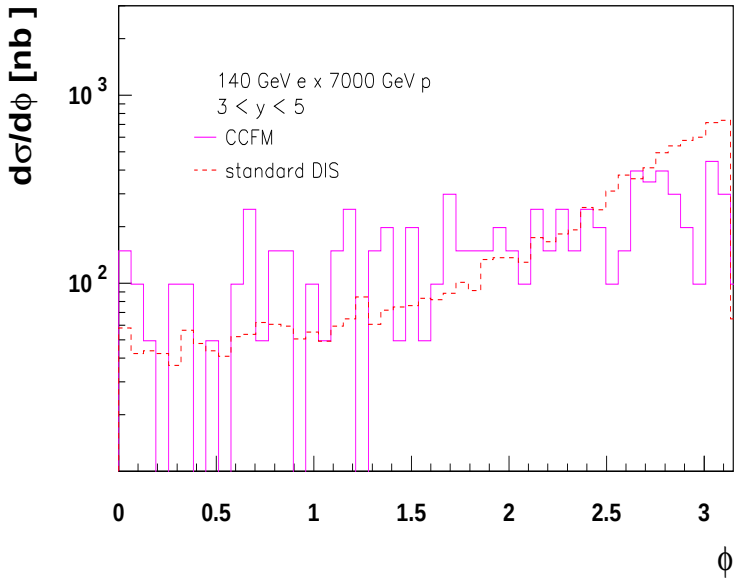
Average deviation from back-to-back configuration depending on the rapidity distance



- jets with $p_t > 20$GeV and any rapidity
- larger decorrelatios from CASCADE
- consistent with more jet activity

ep CASE FORWARD-CENTRAL JET $\Delta\phi$ CORRELATION

Central jet	Forward jet
$\|y_j\| < 2$	$3 < y_j < 5$
$p_{jt} > 20$GeV	$p_{jt} > 20$GeV



- parton shower produces $k_T \longrightarrow$ decorrelations
- larger decolerrations for CASCADE than for RAPGAP, like in pp

Conclusions

- LHeC offers possibility to study forward jets phenomenon (in general) more deeply than in HERA
- Comparison of pp at LHC to ep at LHeC $\longrightarrow$ studies of underlying events, multiple interactions, saturation
- One needs however, large energy run