Parton Dynamics at low x_{Bj} using DIS 3-jet events

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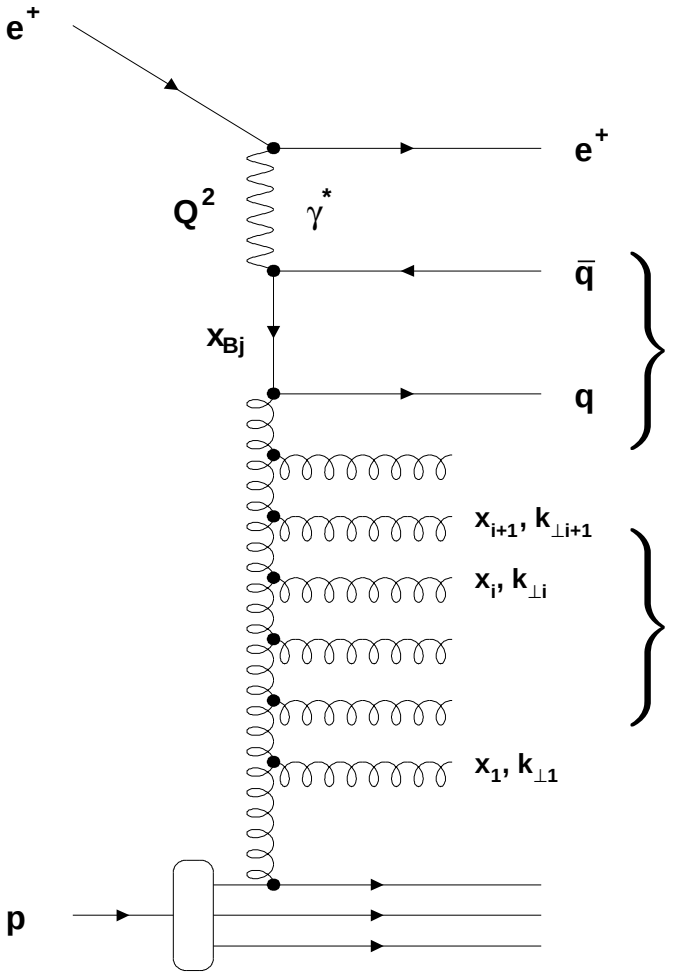
on behalf of the H1 collaboration



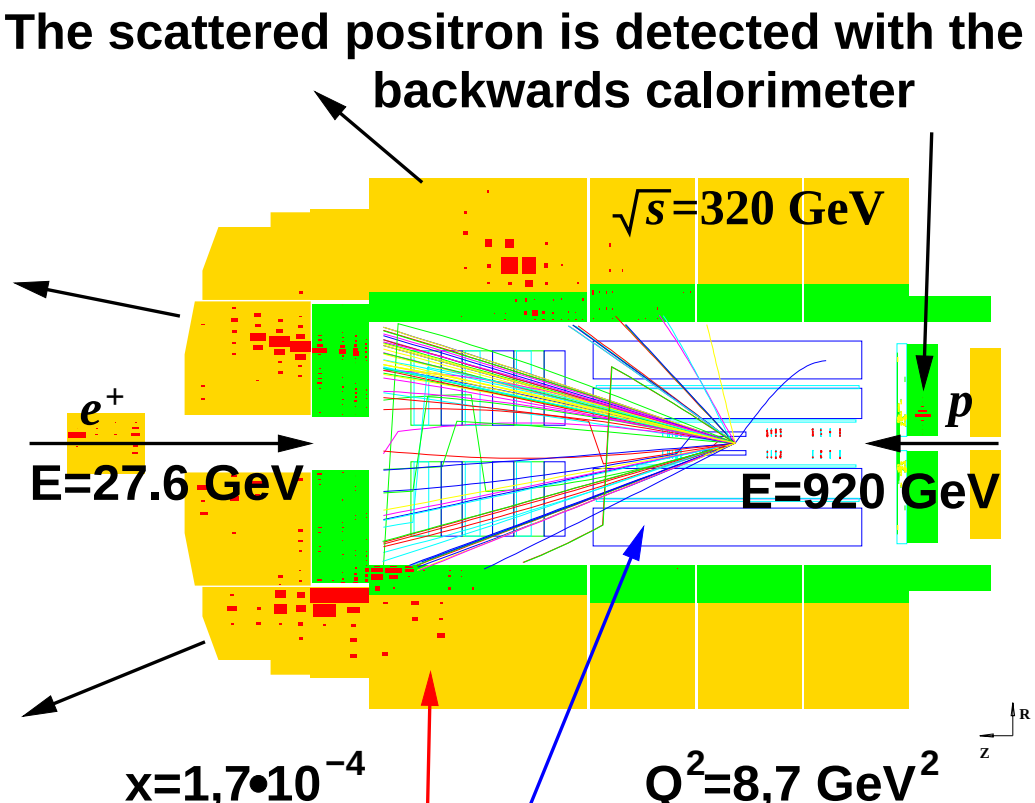
2 Jets emerging from the hard scattering process

Jets initiated by radiated gluons

Motivation

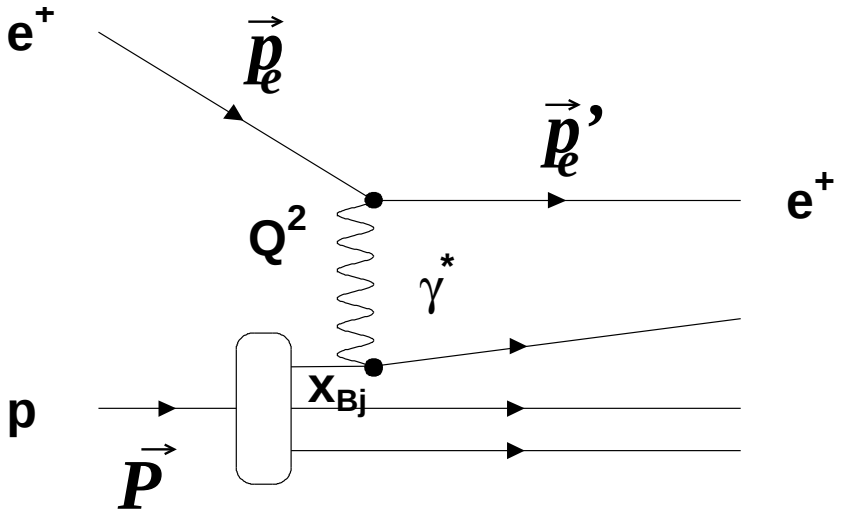
- QCD dynamics at small x_{Bj}:
  $10^{-4} < x_{\mathrm{Bj}} < 10^{-2}$
  DGLAP still valid at HERA?
  (neglects terms in $\alpha_s \log 1/x_{\mathrm{Bj}}$)
- important topic at HERA since 1993
- so far: too many forward jets in data compared to DGLAP predictions
- **now:** search for gluon radiation unordered in $p_\perp$
  $\leftrightarrow$ connected to $\log 1/x_{\mathrm{Bj}}$ terms
- events with ≥ 3 Jets
  $\Rightarrow$ at least one jet from radiated gluons

H1 Detector & DIS phase space



Data Sample

- 1999/2000 e^+-p data
- $\mathcal{L} \approx 44$ pb^{-1} (41000 events)



event kinematics: use only scattered positron

DIS phase space

$$10^{-4} \leq x \leq 10^{-2}$$
$$5\ \text{GeV}^2 \leq Q^2 \leq 80\ \text{GeV}^2$$

Event Selection — Predictions

jet selection

- objects: calorimeter cluster and tracks ($\gamma^\star$-p CMS), incl. $k_\perp$ Algorithm

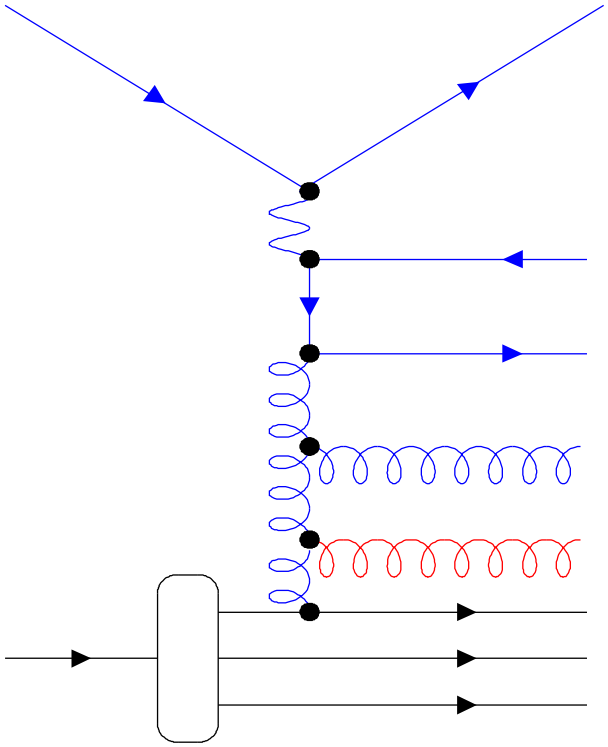
- $\geq$3 jets with $p^\star_\perp > 4$ GeV
- leading $p^\star_\perp$ jets: $p^\star_{\perp 1} + p^\star_{\perp 2} > 9$ GeV
- 1 jet in central tracking device

(LO) Monte Carlo (MC) Generators

to determine correction factors
(reweighted to improve agreement with data)

- Color Dipole Model (CDM) (djangoh13)
  $p_\perp$ unordered emission of gluons
- DGLAP MC (RG d+r) (RAPGAP),
  including resolved γ processes,
  gluon emissions ordered in $p_\perp$

(Comparison at hadron level)

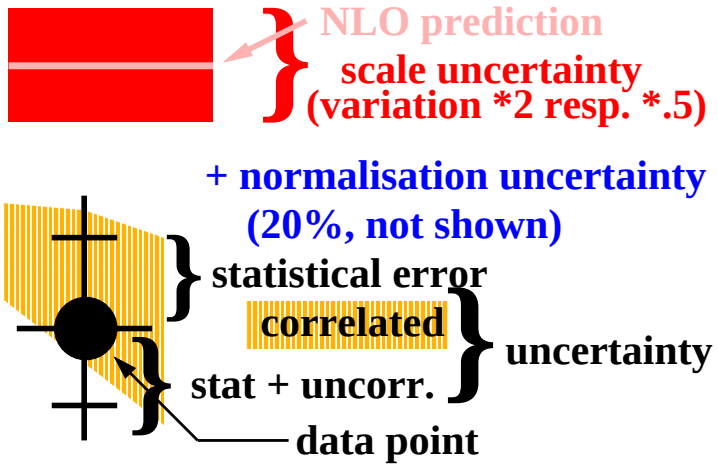


fixed order QCD calculation

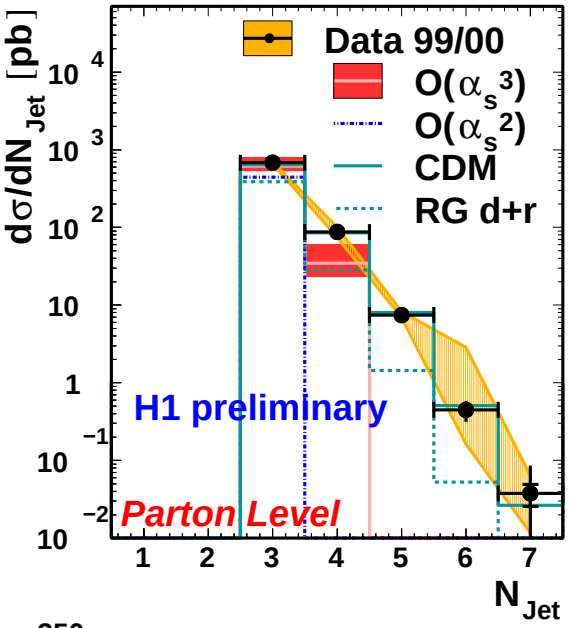
- NLOjet++ 3-Jet LO ($\mathcal{O}(\alpha_s^2)$) and
  NLO ($\mathcal{O}(\alpha_s^3)$) cross sections

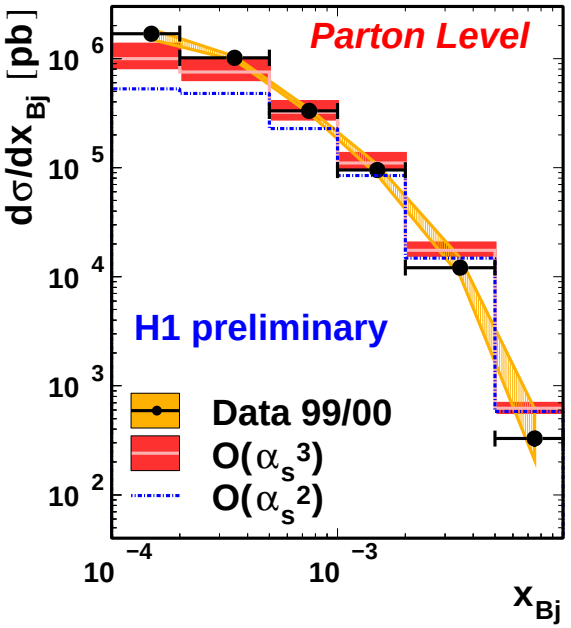
(Comparison at parton level)

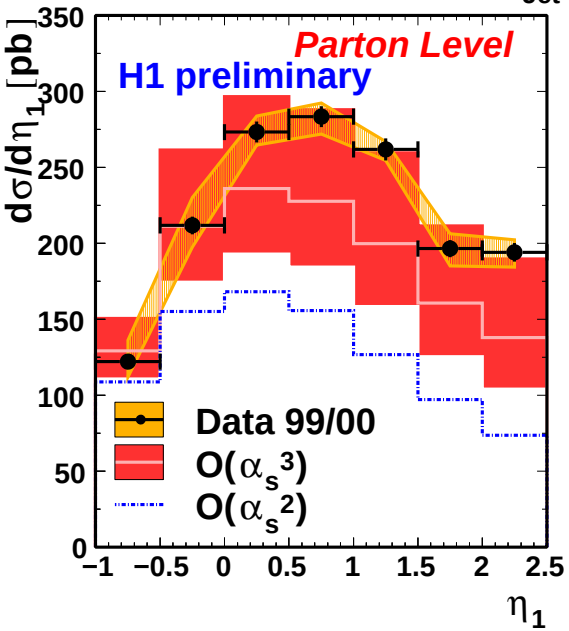
3-Jet cross sections (parton level) (I)

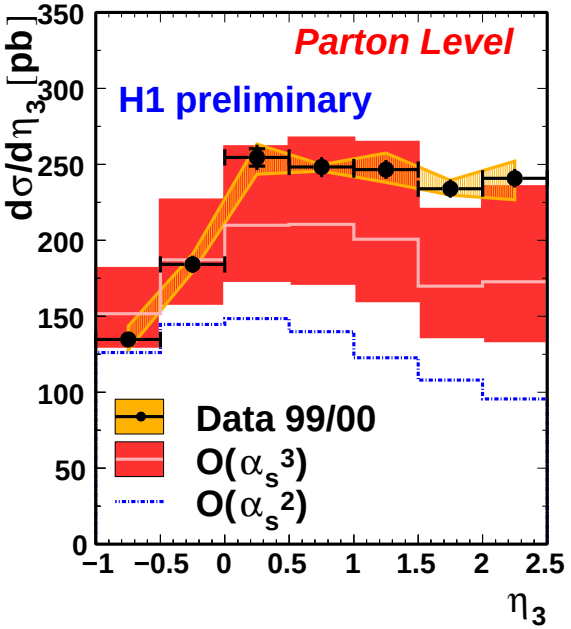


- CDM (ordered radiation) describes N_{Jet}; RG d+r (unordered rad.) below data
- $\mathcal{O}(\alpha_s^{3(2)})$ max. 4 (3) Jets;
- $\mathcal{O}(\alpha_s^2) \rightarrow \mathcal{O}(\alpha_s^3)$: systematic improvement in all regions where deficits are observed (low x_{Bj}, $\eta > 0$) $\mathcal{O}(\alpha_s^3)$ 18% below data









3-jet cross sections (parton level) (II)

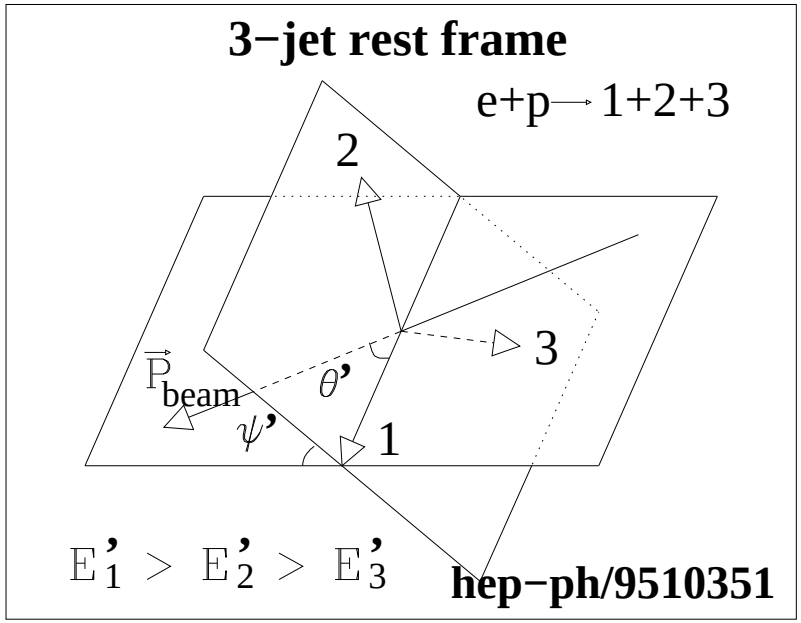
Observables describing the topology of 3-jet events

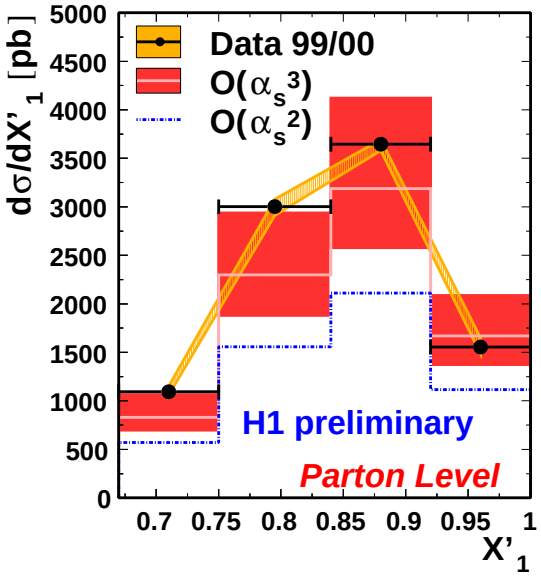
- boost into the 3-jet CMS

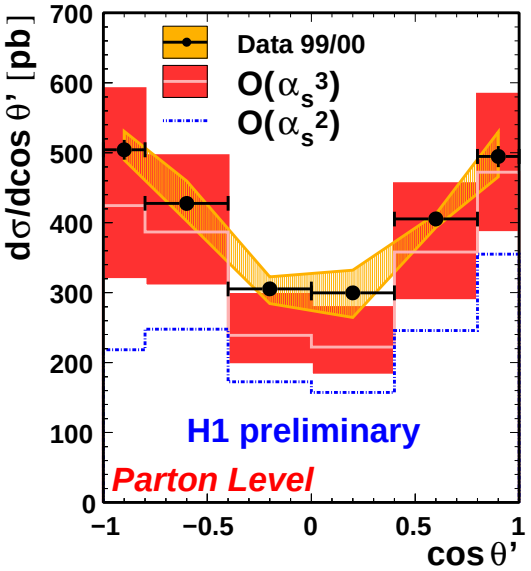
1. relative energies:

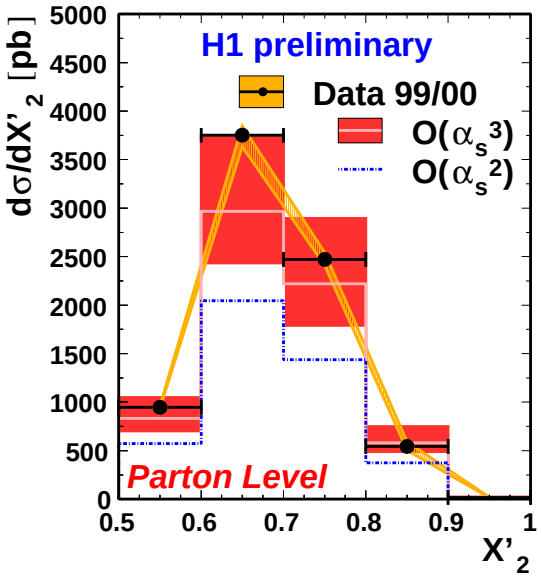
$$X_i' = \frac{E_i}{E_1 + E_2 + E_3}$$

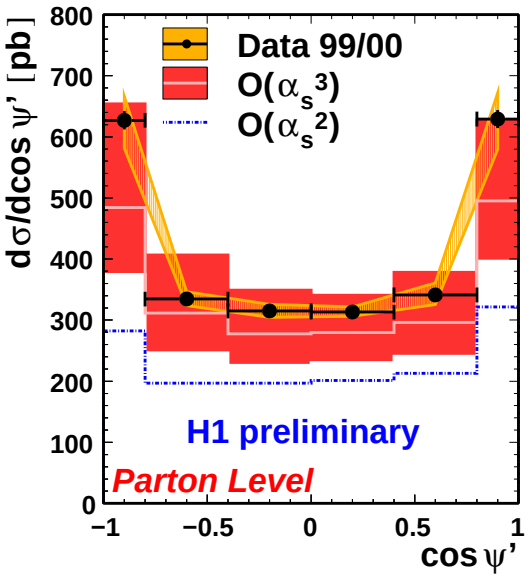
2. relative angles:







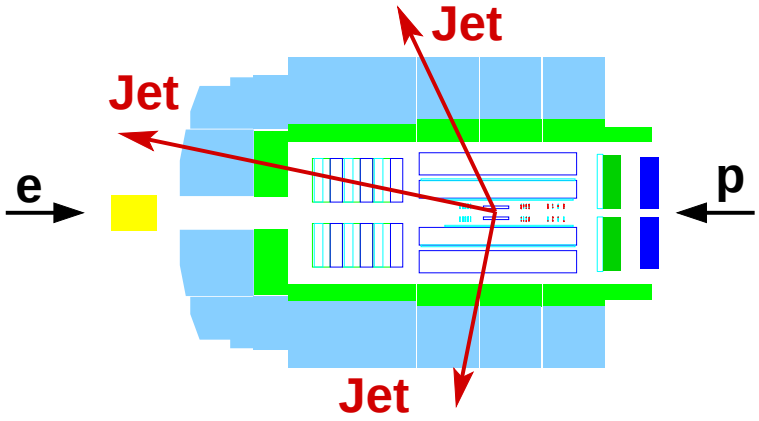




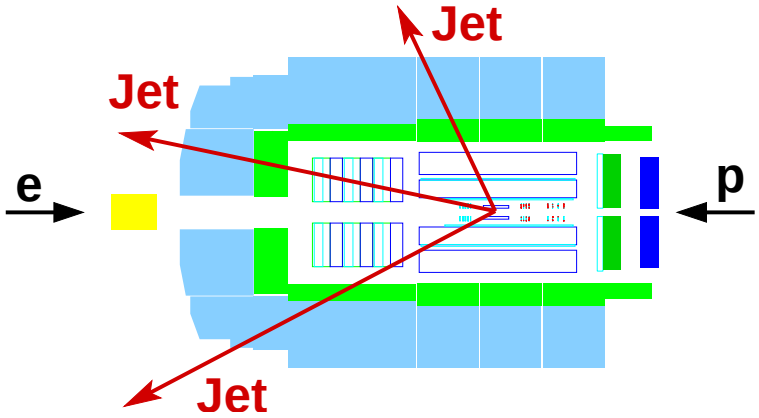
→ shape of cross sections described by $\mathcal{O}(\alpha_s)^3$ ←

3-jet cross section including forward jets (parton level)

2 central jets

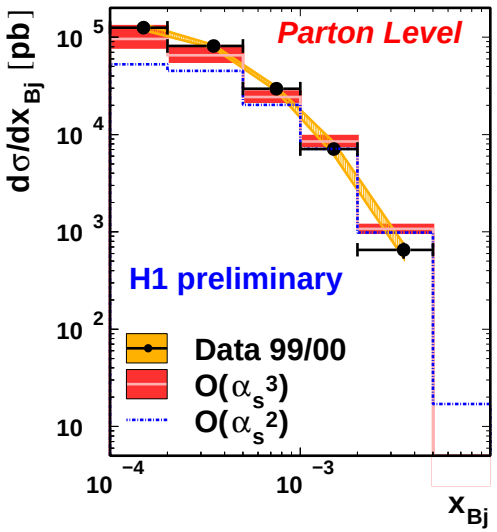


2 forward jets

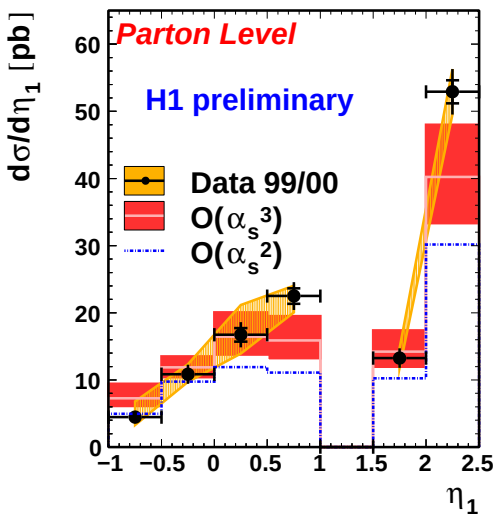


$\mathcal{O}(\alpha_s^3)$ improves at low x, $\eta > 1$
2 central jets reasonnably described;
main deviation found in 2 forward jets

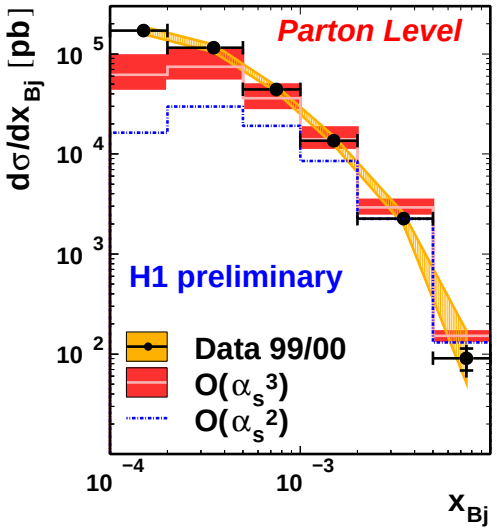
2 central jets



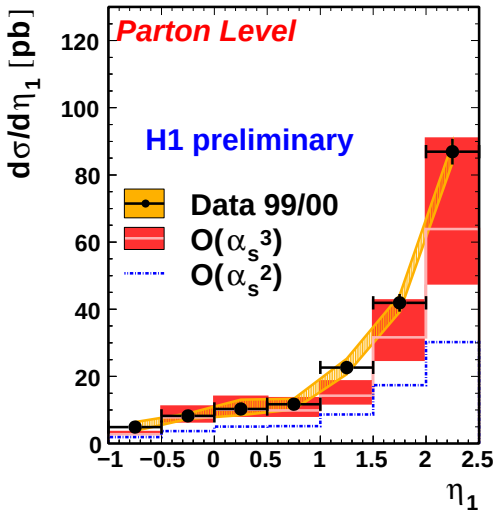
2 central jets



2 forward jets

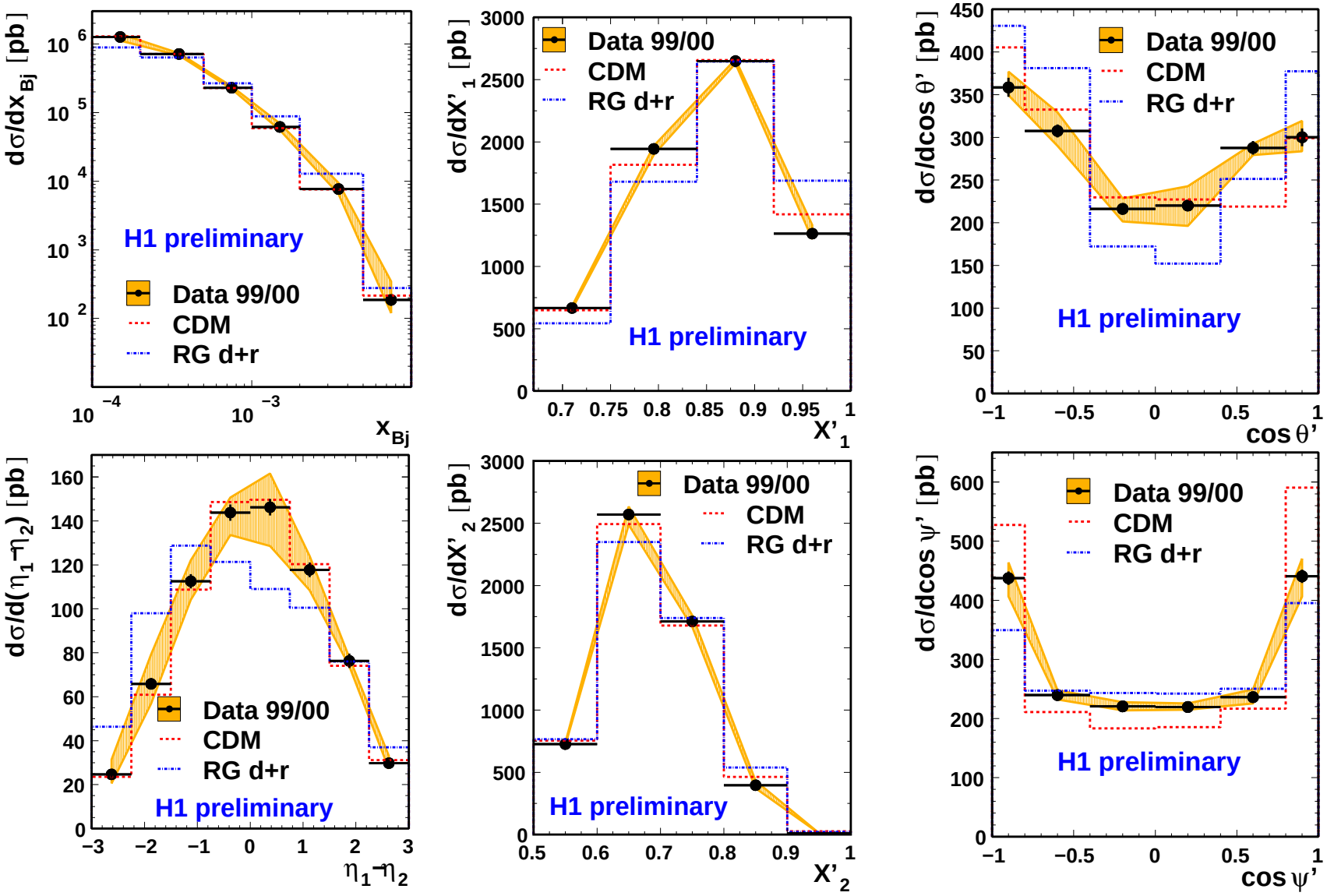


2 forward jets



Shape Comparison with LO MC-Generators (hadron level) (I)

compare shapes: cross section by CDM (+6%) resp. RG d+r (+57%) normalised to data

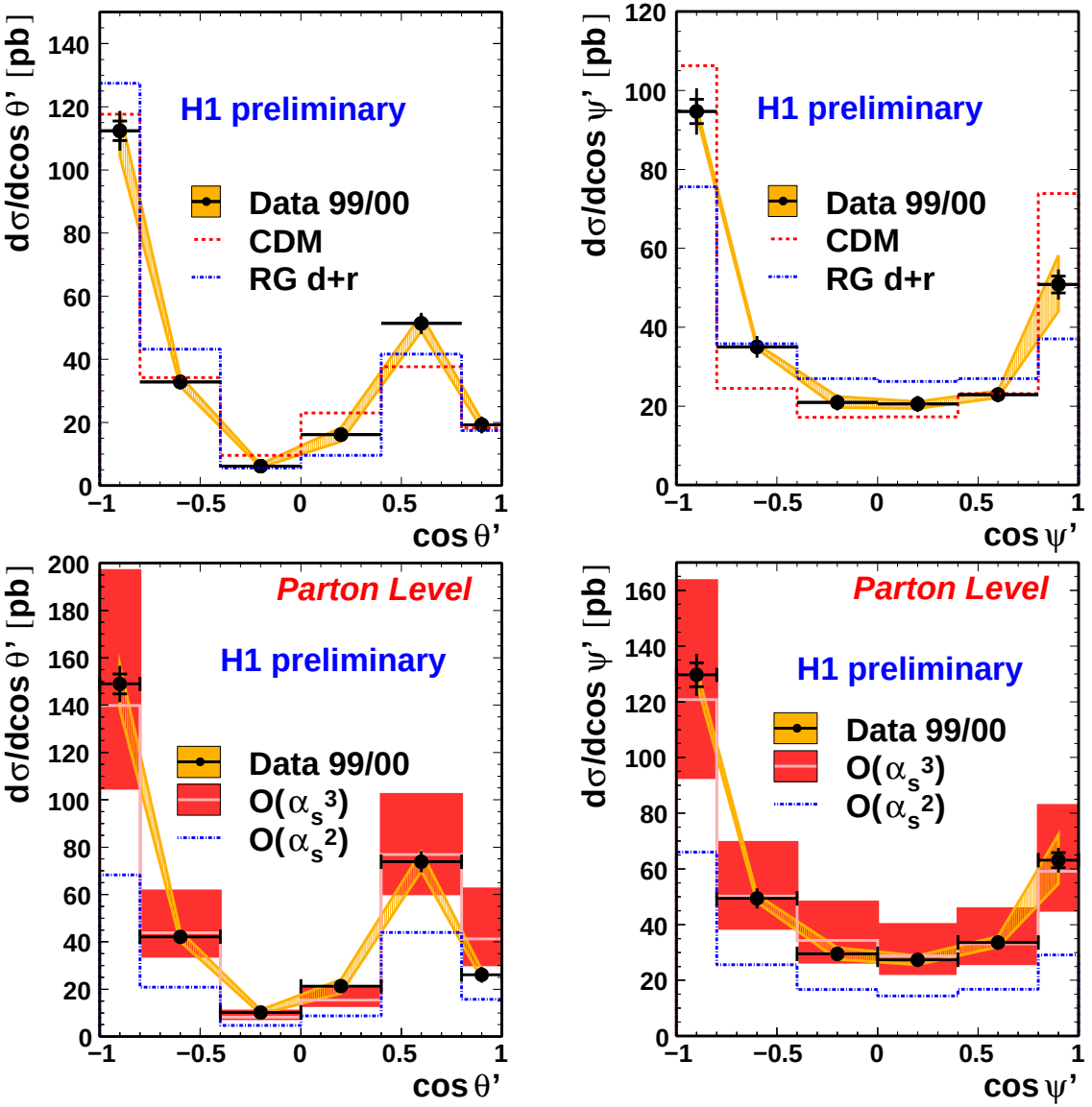


Shape Comparison with LO MC-Generators (had. level) (II)

- again: compare shapes
- CDM (unordered gluon radiation) describes data reasonnably
- RG d+r (ordered gluon radiation) fails to describe data
- CDM describes most distributions better than NLOjet++, has some problems with angular topology, especially visible in 2 forward jet sample

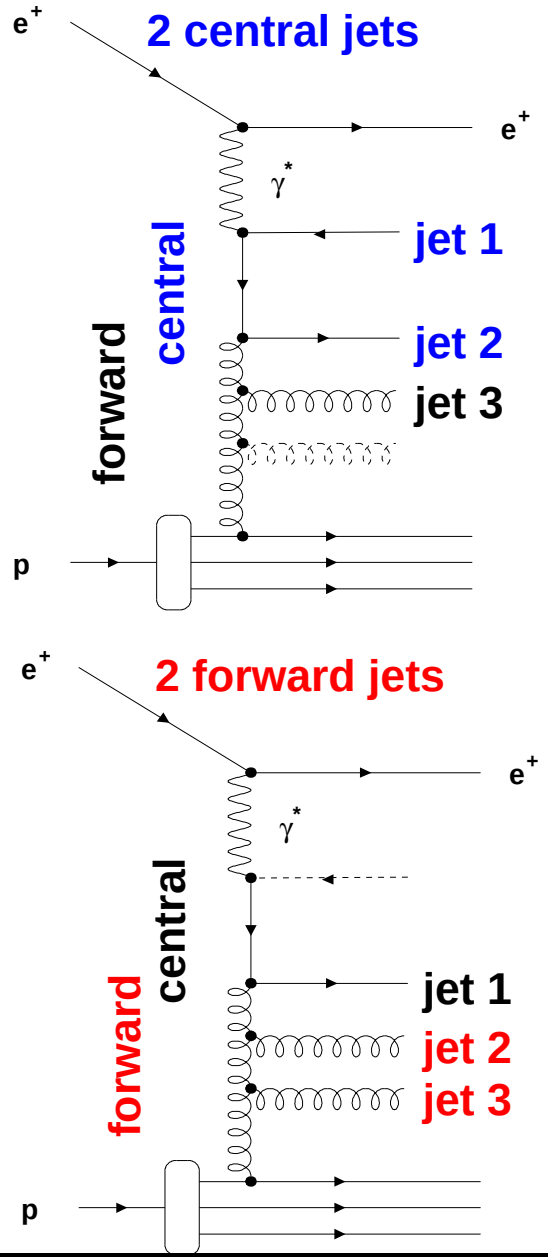
  here: NLOjet++ better than CDM

2 forward jets



Summary

- only MC Generator with unordered radiation of gluons describes data satisfactory
- $\mathcal{O}(\alpha_s^3)$ calculation: huge improvement w. r. t. $\mathcal{O}(\alpha_s^2)$ deficit (total 18%) concentrated at low x, high η and N_{Jet}
  (**rem.:** in $\mathcal{O}(\alpha_s^3)$ first terms $\propto \log 1/x_{\mathrm{Bj}}$ enter)
  highest deviations in topology with 2 forward jets
  $\rightarrow$ presumably due to higher fraction of gluon jets



Interpretation

- strong hints for radiation of gluons unordered in $p_\perp$