Perspective for jet analysis in EIC

Grégory Soyez

Brookhaven National Laboratory

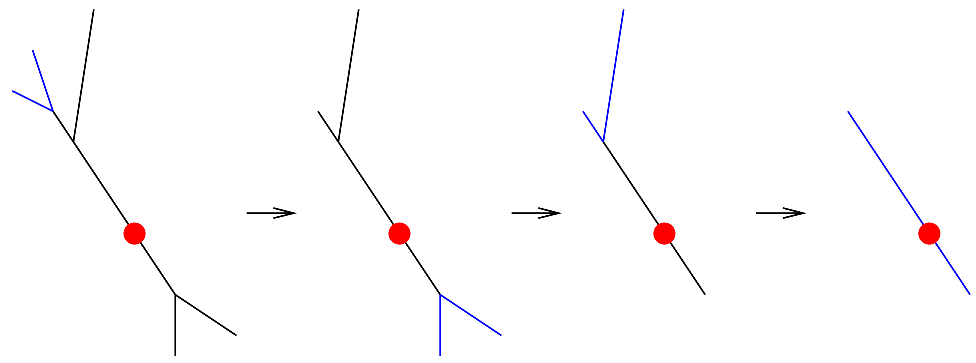
Outline

- Jet algorithms
- The gluon distribution
  - Difficulty in inclusive events
  - Looking at 2+1 jet events
  - What can we expect?
- Forward physics
  - DGLAP vs. BFKL in Mueller-Navelet jets
  - DGLAP vs. BFKL in forward jets (saturation?)

Two classes of algorithms

Class 1: recombination

Successive recombinations of the “closest” pair of particle



- Distance:

$$k_t: \quad d_{i,j} = \min(k_{t,i}^2, k_{t,j}^2)(\Delta\phi_{i,j}^2 + \Delta y_{i,j}^2)$$

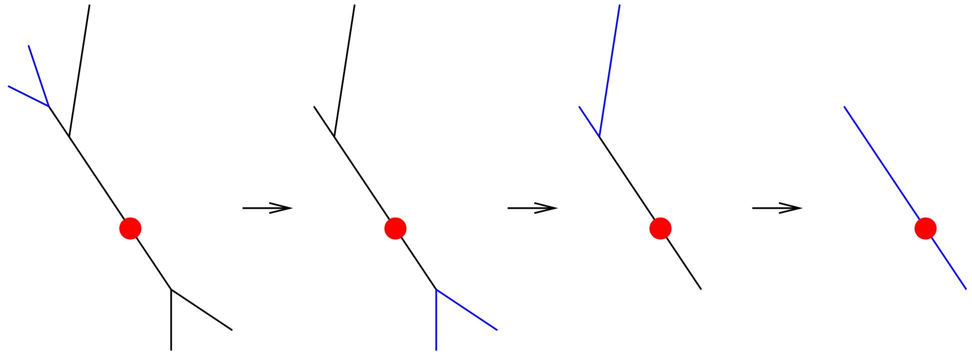
$$\text{Aachen/Cam.}: \quad d_{i,j} = \Delta\phi_{i,j}^2 + \Delta y_{i,j}^2$$

- stop when $d_{\text{min}} > R$

Two classes of algorithms

Class 1: recombination

Successive recombinations of the "closest" pair of particle



- Distance:

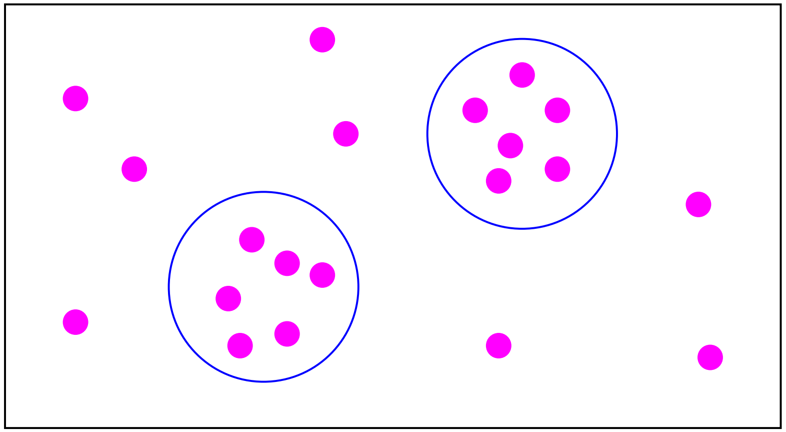
$$k_t: \quad d_{i,j} = \text{min}(k_{t,i}^2, k_{t,j}^2)(\Delta\phi_{i,j}^2 + \Delta y_{i,j}^2)$$

$$\text{Aachen/Cam.}: \quad d_{i,j} = \Delta\phi_{i,j}^2 + \Delta y_{i,j}^2$$

- stop when $d_{\text{min}} > R$
- Often used for $e^{\pm}e^{\pm}$ or $e^{\pm}p$
- `FastJet` : a fast implementation of those algorithms `www.lpthe.jussieu.fr/~salam/fastjet/` [M. Cacciari, G. Salam]

Class 2: cone

Find directions of dominant energy flow

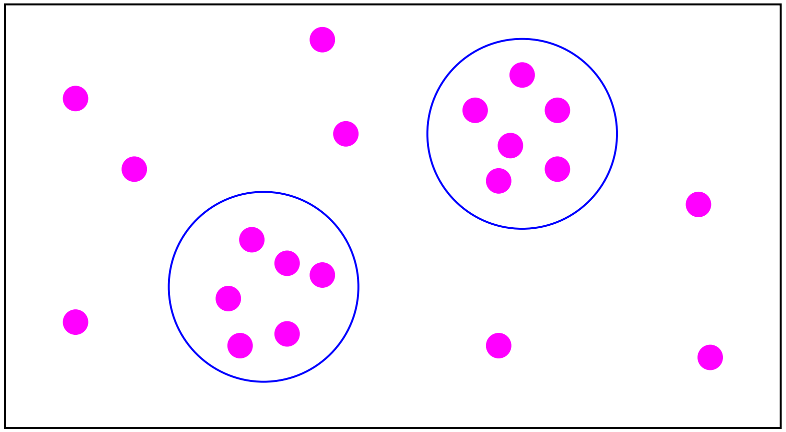


for a cone of radius R in the (y, ϕ) plane, **stable cones** are such that:

centre of the cone $\equiv$ direction of the total momentum of its particle contents

Class 2: cone

Find directions of dominant energy flow



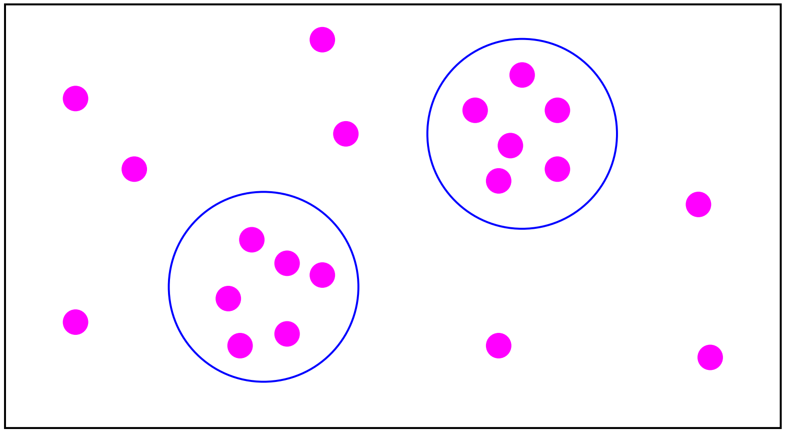
for a cone of radius R in the (y, ϕ) plane, **stable cones** are such that:
centre of the cone $\equiv$ direction of the total momentum of its particle contents

- Split-merge procedure to deal with overlapping stable cones
- Often used for pp
- Requirements specified in the Snowmass Accord (Fermilab, 1990)

Two classes of algorithms

Class 2: cone

Find directions of dominant energy flow



for a cone of radius R in the (y, ϕ) plane, **stable cones** are such that:

centre of the cone $\equiv$ direction of the total momentum of its particle contents

- Requirements specified in the Snowmass Accord (Fermilab, 1990)
- `SISCone`: first cone algorithms that satisfies all those constraints (noticeably Infrared Safety)

`projects.hepforge.org/siscone/` (+ `FastJet` plugin)

[G. Salam,G. Soyez, 07]

Gluon distribution from inclusive data

Standard way of extacting the gluon distribution:

- consider the inclusive F_2 (plus other inclusive quantities as Drell-Yan cross-sections)
- pdf parametrised at $Q^2 = Q_0^2$ and evolved with DGLAP

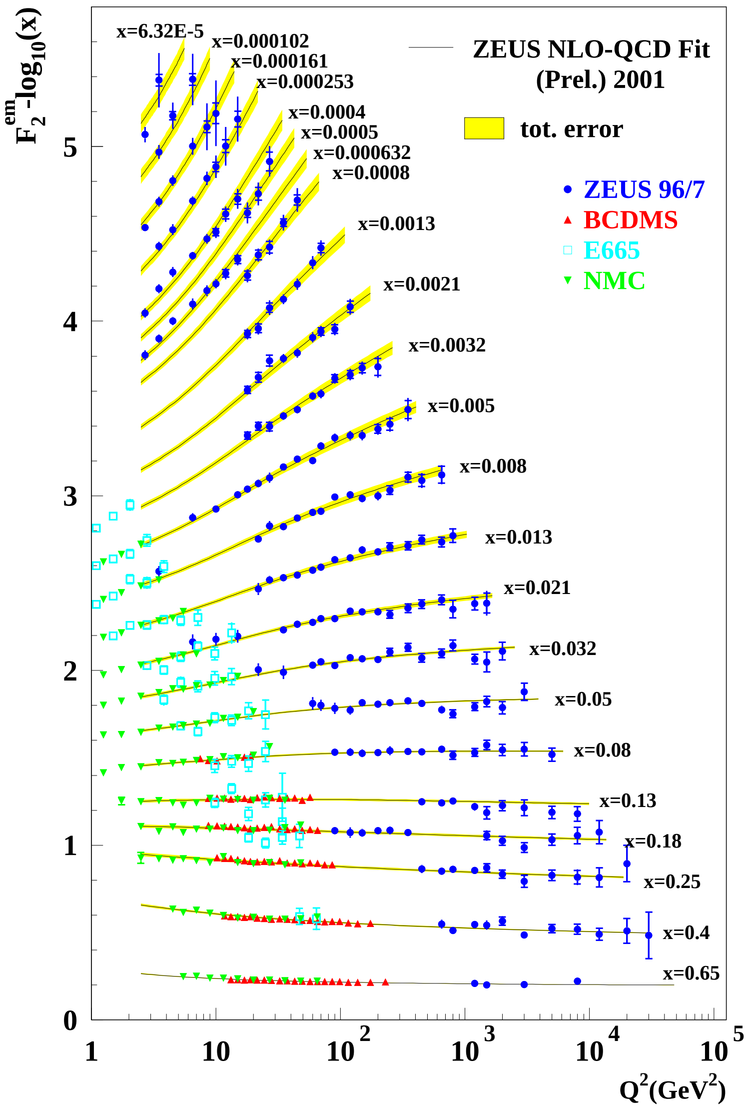
At LO:

$$\begin{aligned} F_2(x,Q^2) &\propto xq(x,Q^2) \\ \partial_{\log(Q^2)} q(x,Q^2) &= \alpha_s[P_{qq}\otimes q(\xi,Q^2) + P_{qg}\otimes g(\xi,Q^2)] \\ \partial_{\log(Q^2)} g(x,Q^2) &= \alpha_s[P_{gq}\otimes q(\xi,Q^2) + P_{gg}\otimes g(\xi,Q^2)] \end{aligned}$$

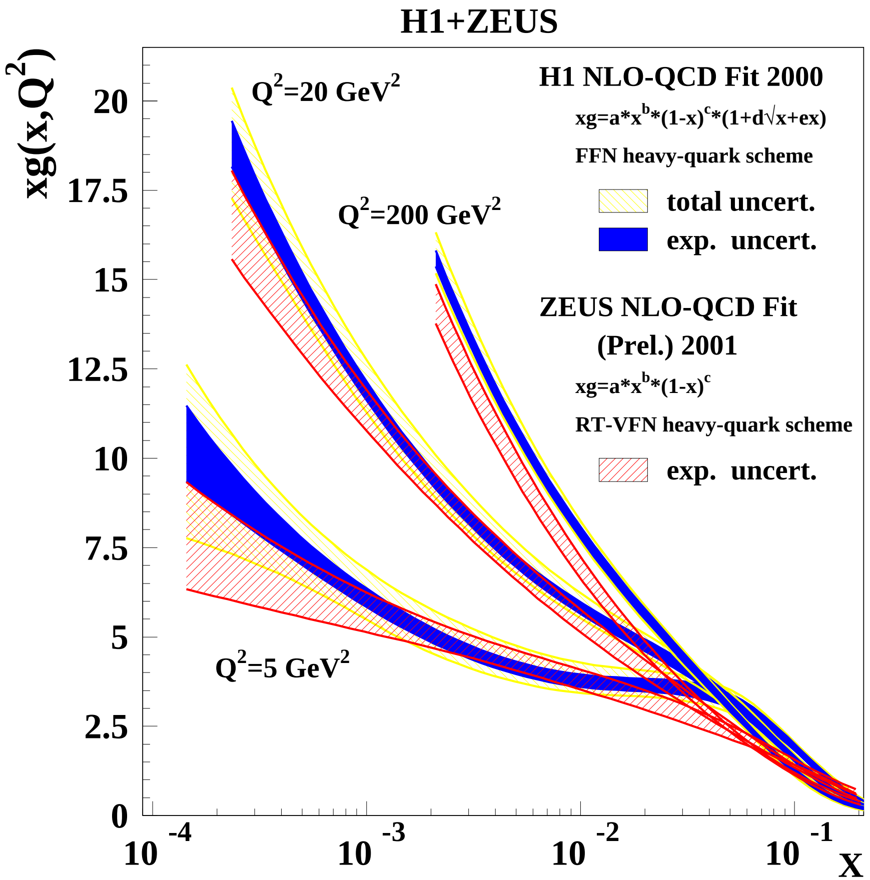
The gluon distribution is accessed through the slope of F_2, and through a convolution!

Gluon distribution from inclusive data

The gluon distribution is accessed through the slope of F_2

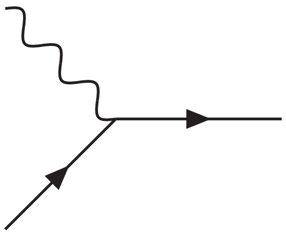


- more difficult to estimate
- particularly at small x where the Q^2 range is smaller



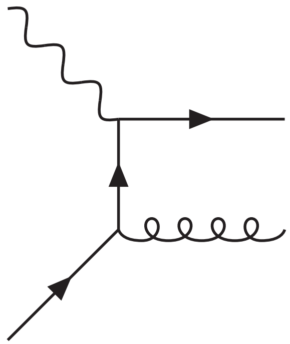
Jets in DIS

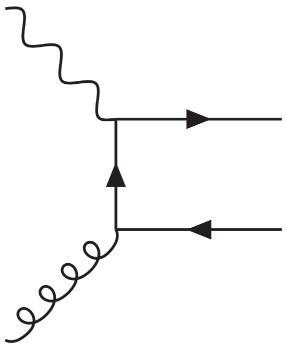
"1+1 jet" dominated by



i.e. dominated by quarks (gluons at NLO)

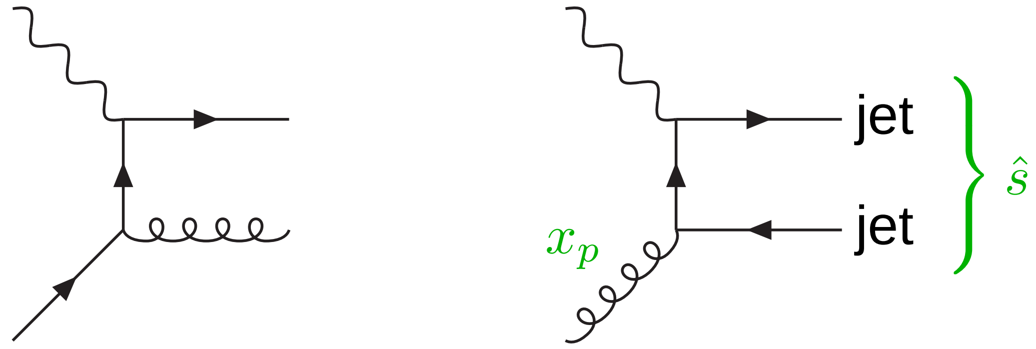
"2+1 jets" becomes more interesting





- involve quarks and gluons
- dominated by gluons at small x

“2+1 jets” becomes more interesting

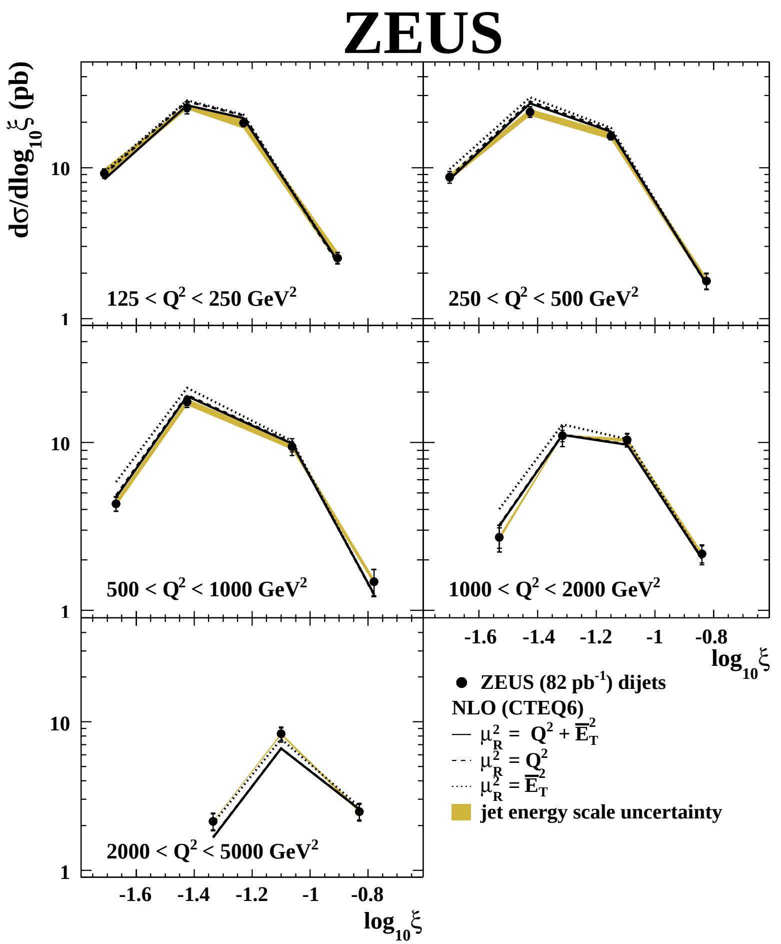


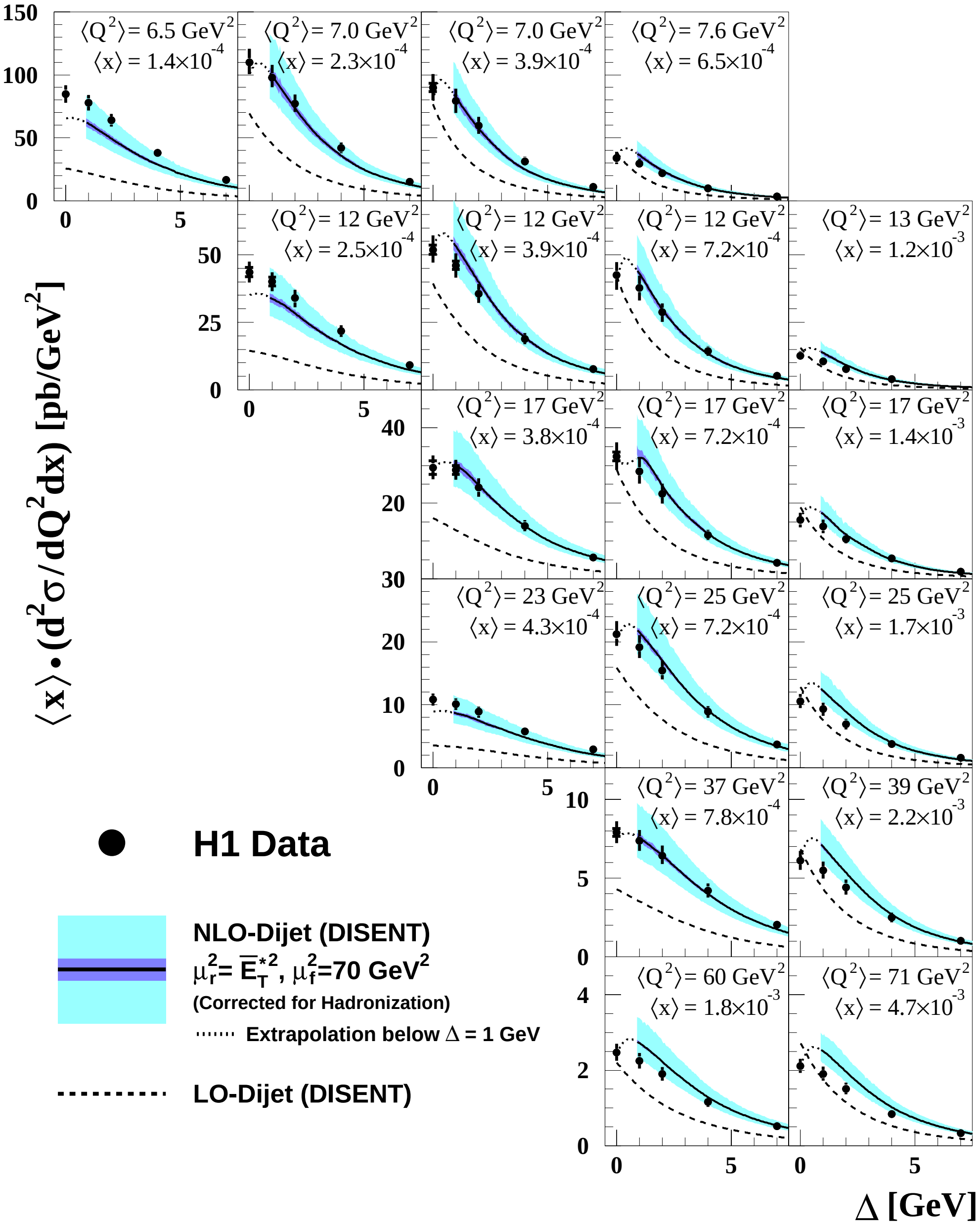
$$\frac{d^2\sigma^{2+1}}{dx_p dQ^2} = \alpha_s \left[a\, g(x_p, Q^2) + b\, q(x_p, Q^2)\right]$$

- a and b from pQCD
- $x_p = x\left(1 + \frac{\hat{s}}{Q^2}\right)$

Gluons from 2+1 jets

Measured at HERA





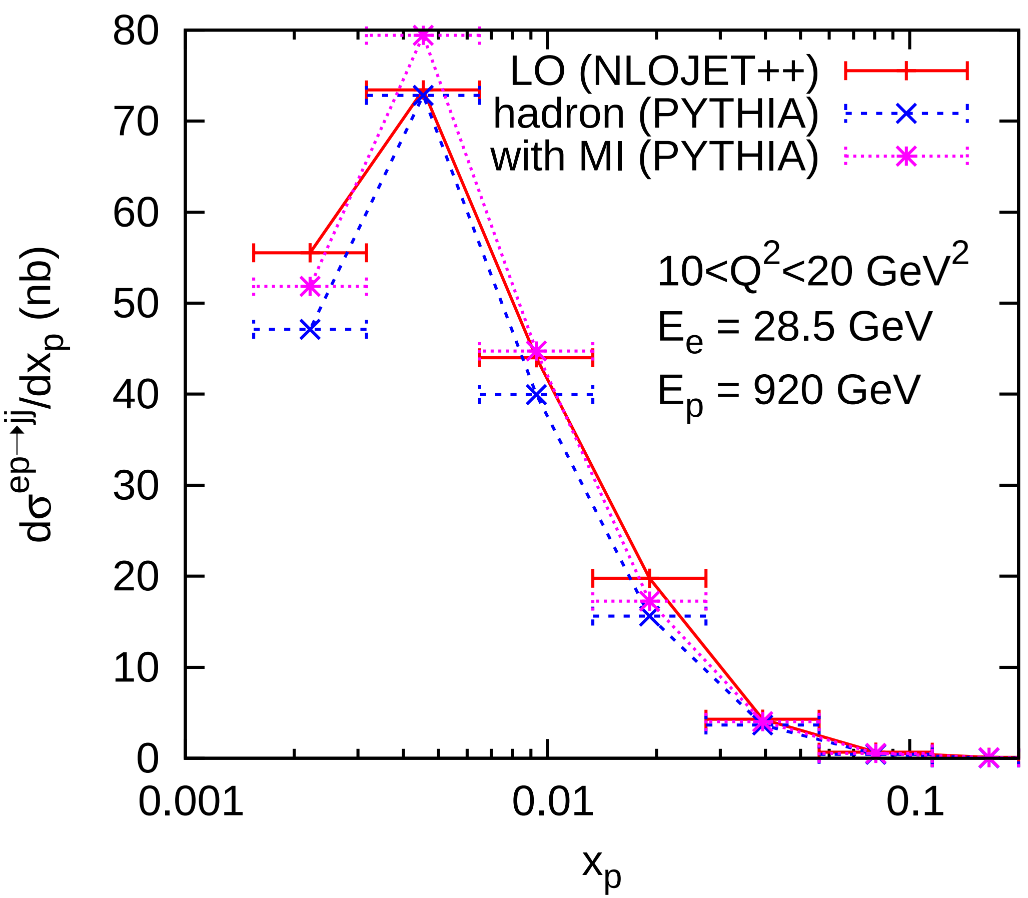
Gluons from 2+1 jets

Other possibilities

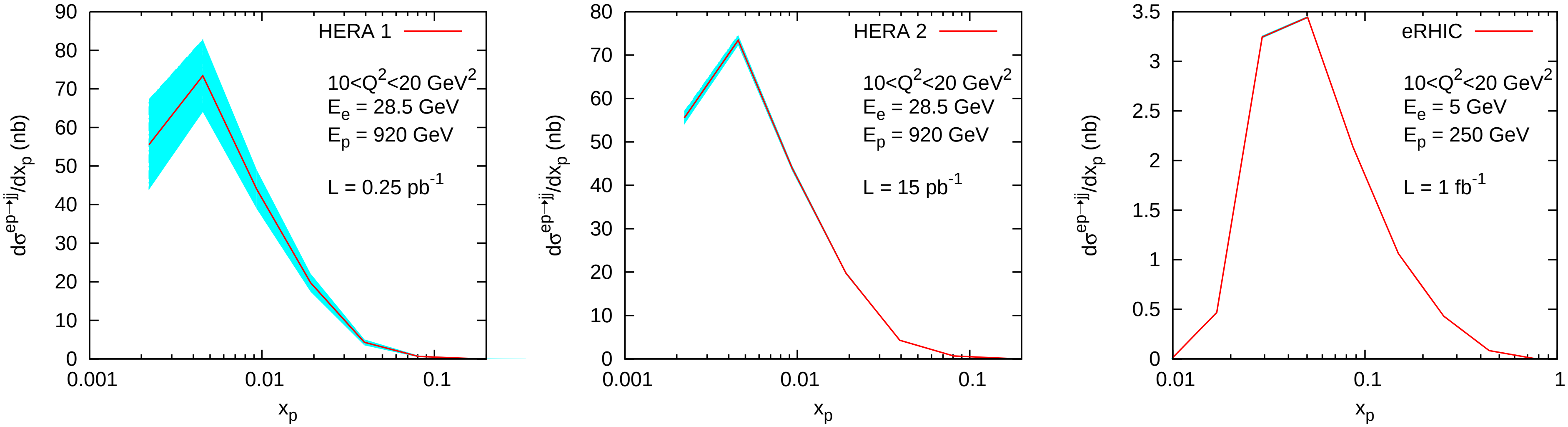
- Diffractive events (g_{IP})
- Leading neutron

One needs to be careful

- Effect of hadonisation
- Effect of multiple-interactions
- Effect of clustering



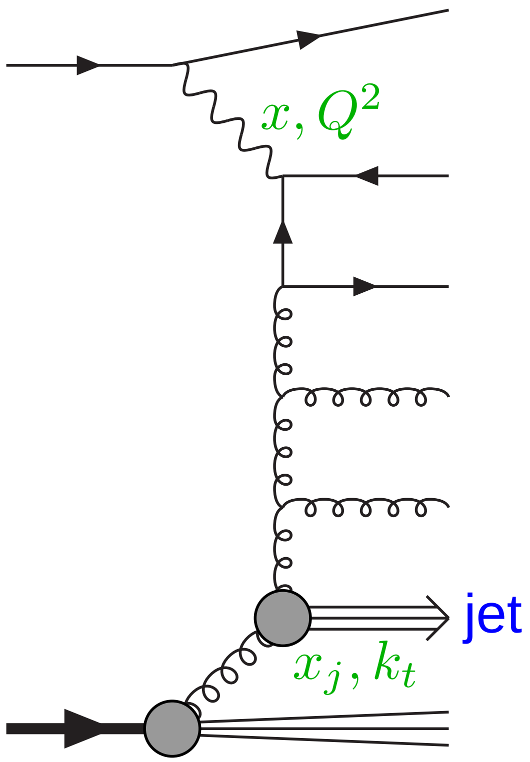
Gluons from 2+1 jets



- High luminosity ⇒ low statistical errors
- eRHIC:
  - slightly smaller kinemtical range
  - eA vs. $(A\times)$ ep ⇒ information on shadowing/saturation/multiple interactions
  - How low can you go in p_T?

Forward jets

Tag a forward jet with $x \ll x_j$.

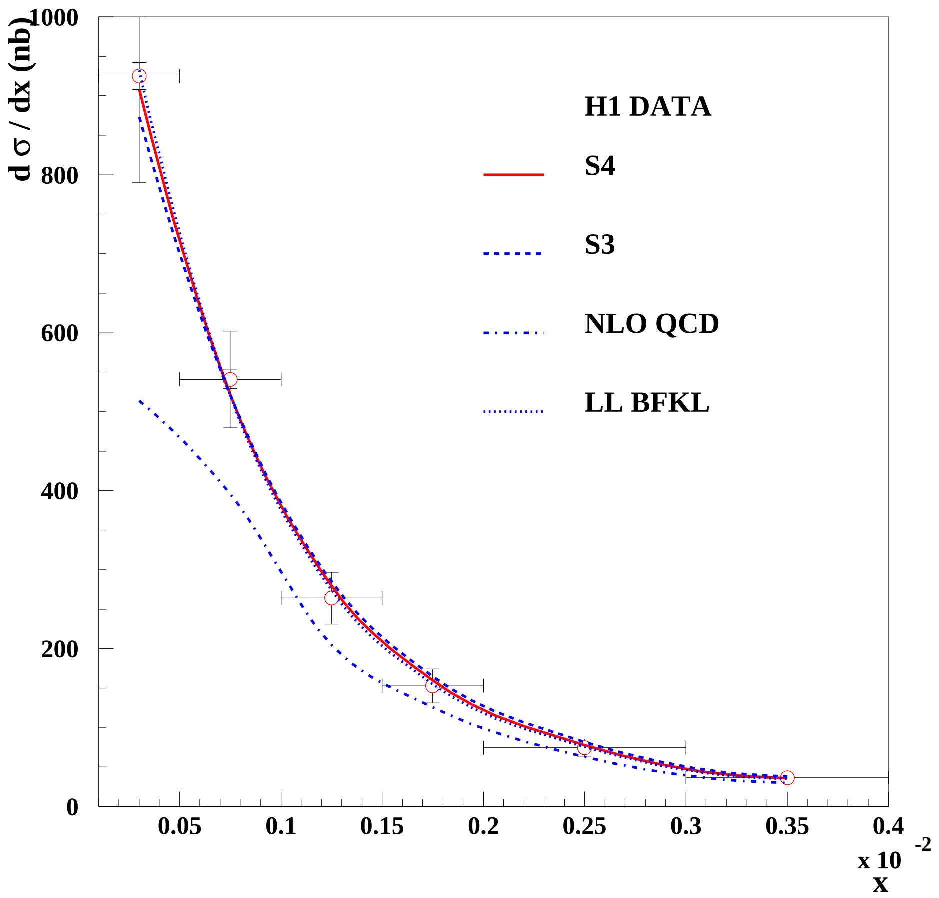


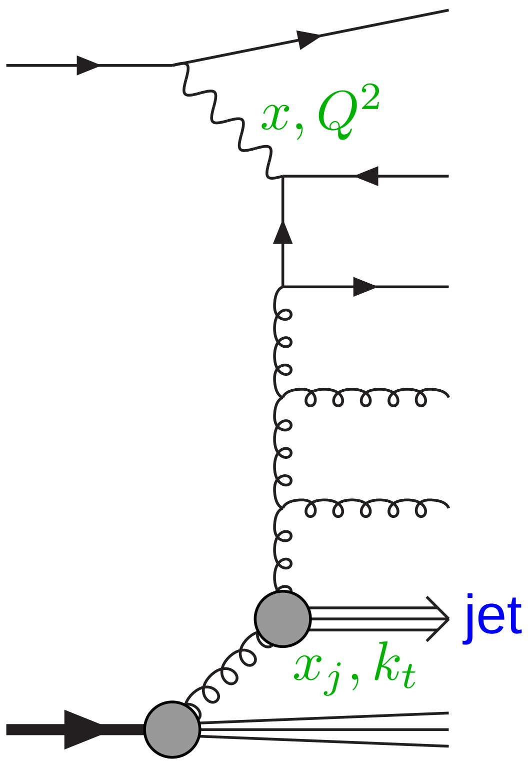
Forward jets

Tag a forward jet with $x \ll x_j$.

If $Q^2 \sim k_t^2$,

- DGLAP and fixed-order fail
- BFKL works



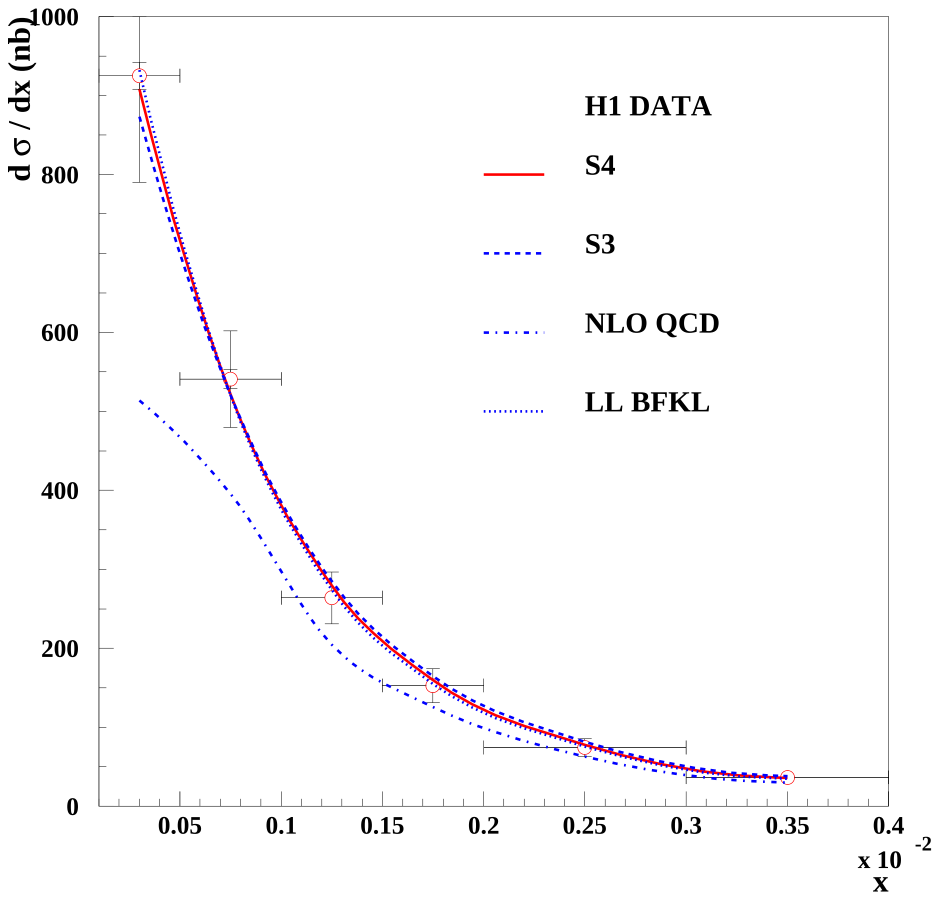


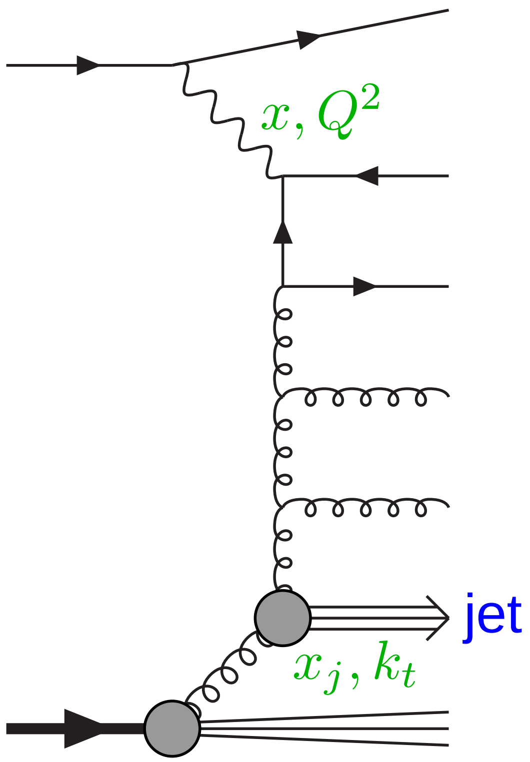
[Kepka, Marquet, Peschanski, Royon]

Tag a forward jet with $x \ll x_j$.

If $Q^2 \sim k_t^2$,

- DGLAP and fixed-order fail
- BFKL works





Question for EIC:

Hints for BFKL, saturation & multiple interactions effects in eA collisions?

Conclusions

What can we learn from jet physics at EIC

- gluon PDF
  - from 2+1 jets
  - ep vs. eA: shadowing, multiple interactions
- BFKL (and saturation) tests from forward jets
- ...