Exclusive Jets and Pomeron Structure

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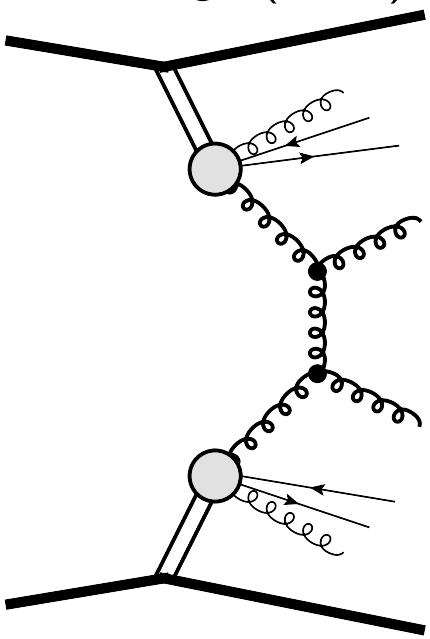
Results and Prospects of Forward Physics at the LHC

Implications for the Study of Diffraction, Cosmic Ray Interactions and More

12th February 2013

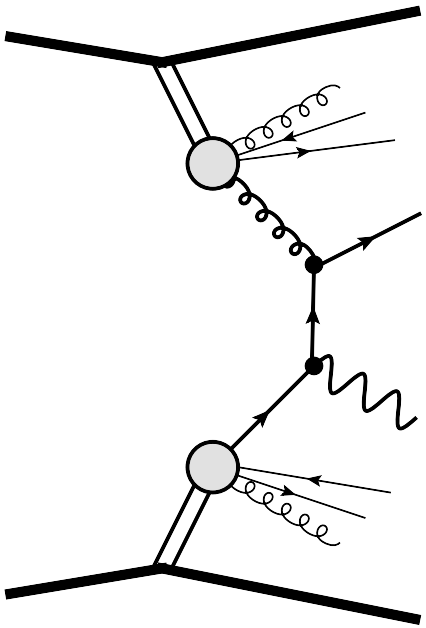
Diffractive Jet Production

Double Pomeron Exchange (DPE)



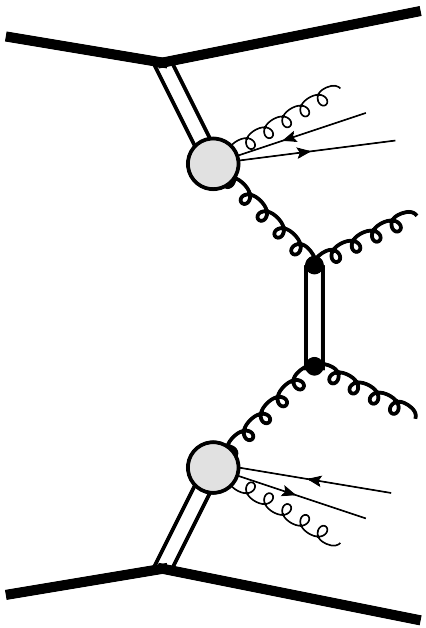
- two intact protons
- two jets

Double Pomeron Exchange (DPE)



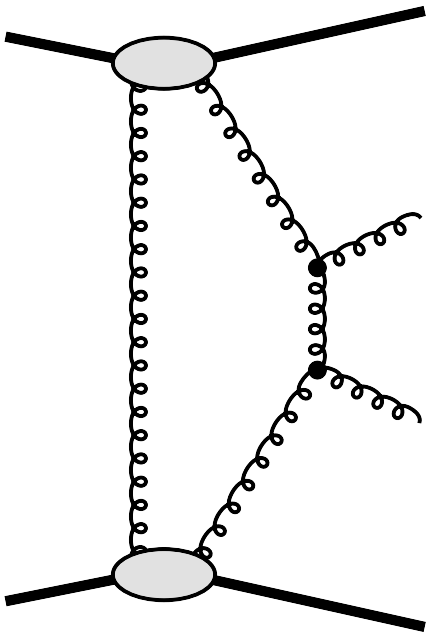
- two intact protons
- photon + jet

DPE Jet-Gap-Jet



- two intact protons
- gap in rapidity between two jets

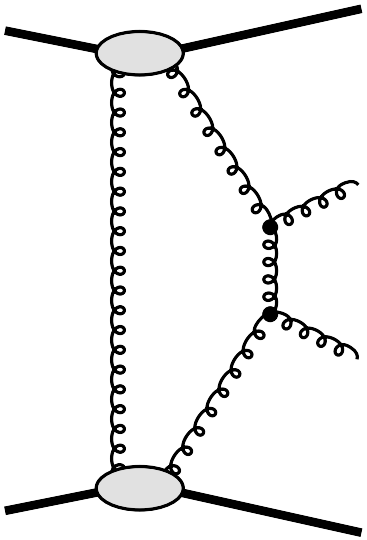
Exclusive



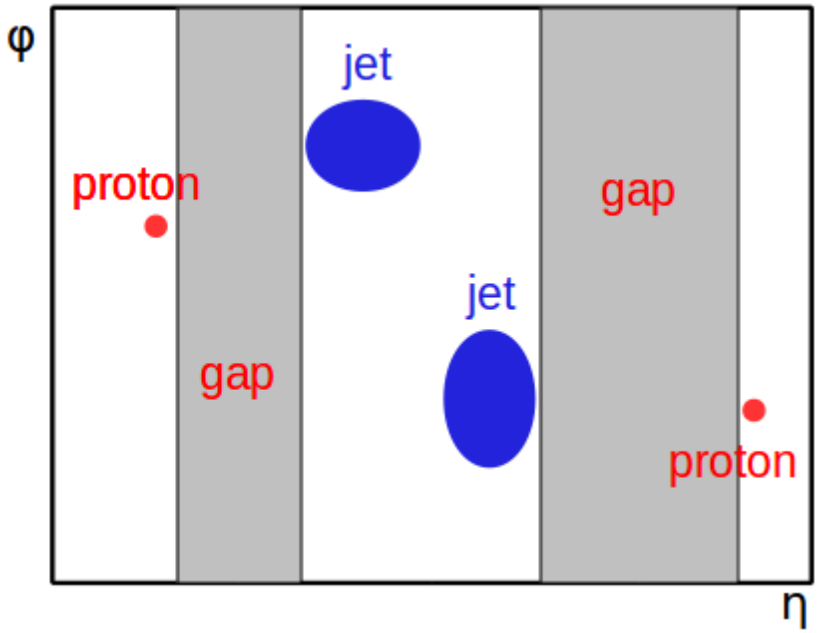
Exclusive Production

- two intact protons
- no remnants
- two jets

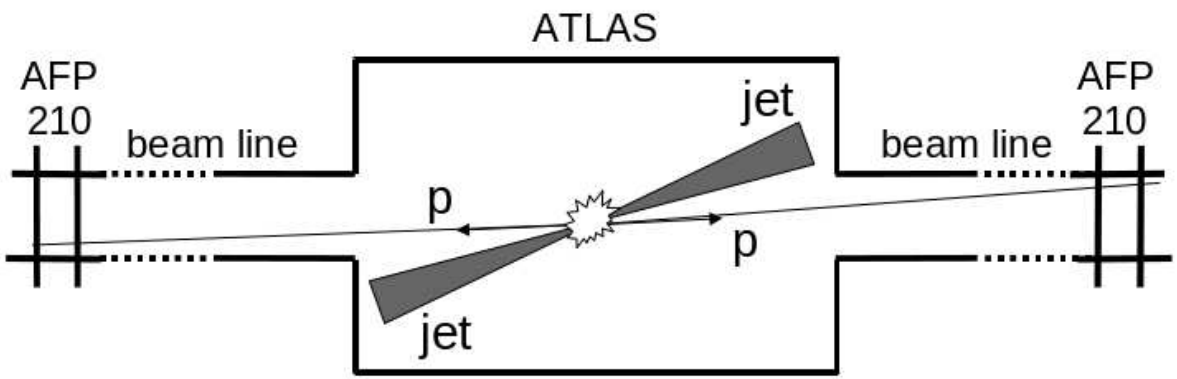
Detection Methods



Exclusive Production

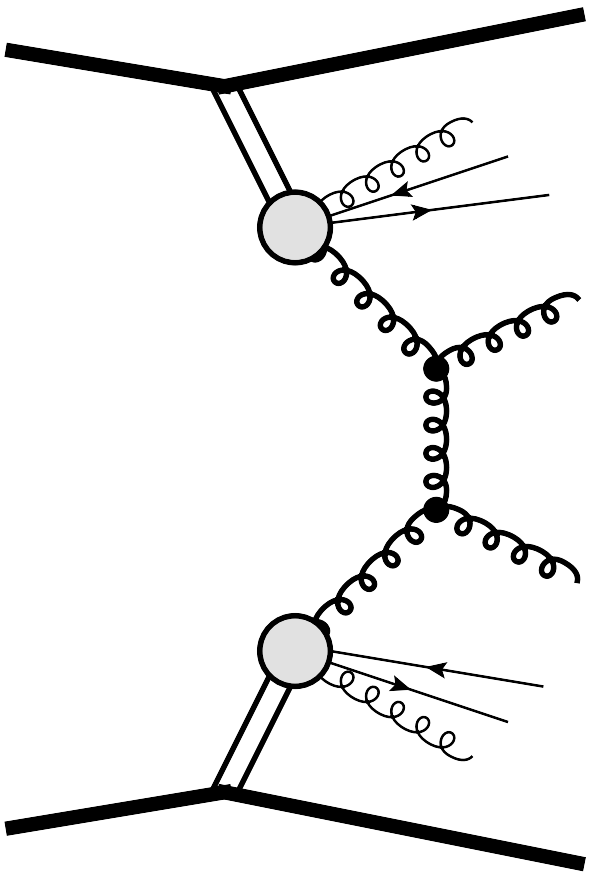


1. Gaps between jets and outgoing protons (not possible in high pile-up environment).
2. Intact proton tagging.



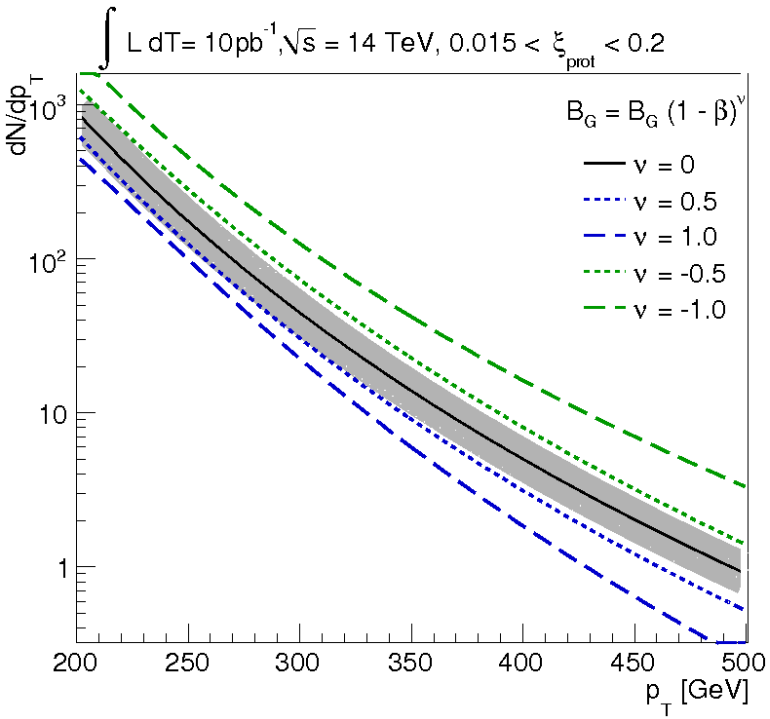
Double Pomeron Exchange Jet Production

DPE Jet Production

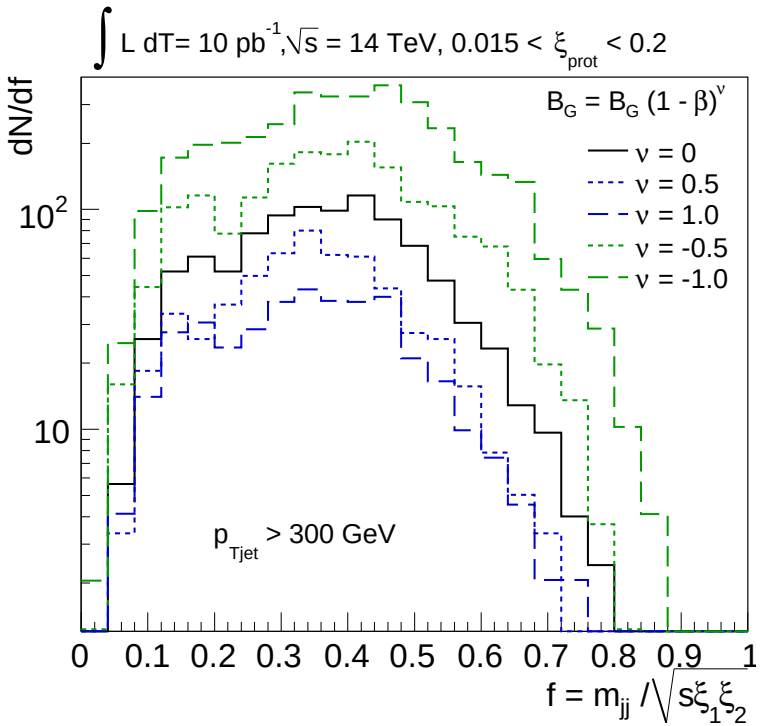


- Probe QCD and diffraction in a new kinematic domain.
- Jet production in DPE events: sensitivity to gluon density in Pomeron (especially at high β) in double tagged events.
- low dependence of production cross section on quark PDF.
- $\int L = 10$ pb^{-1} with low $< \mu >$ is enough to obtain some interesting informations about Pomeron structure when p_T of the leading jet > 200 GeV.

Leading Jet Transverse Momentum



Transverse momentum of the leading jet.

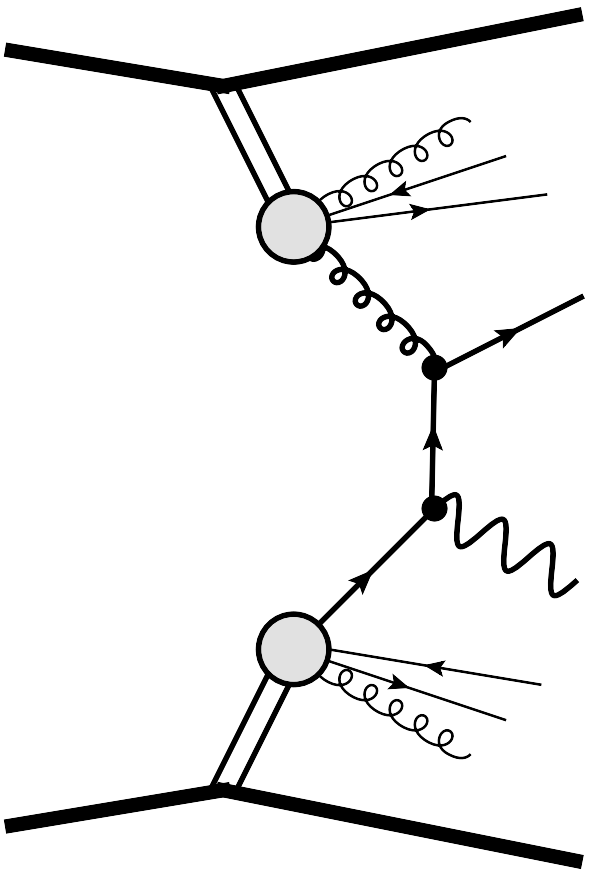


Mass fraction – mass of the jet system / missing mass (calculated from protons).

Double Pomeron Exchange Photon + Jet Production

C. Royon, M. Saimpert, Phys. Lett. in preparation

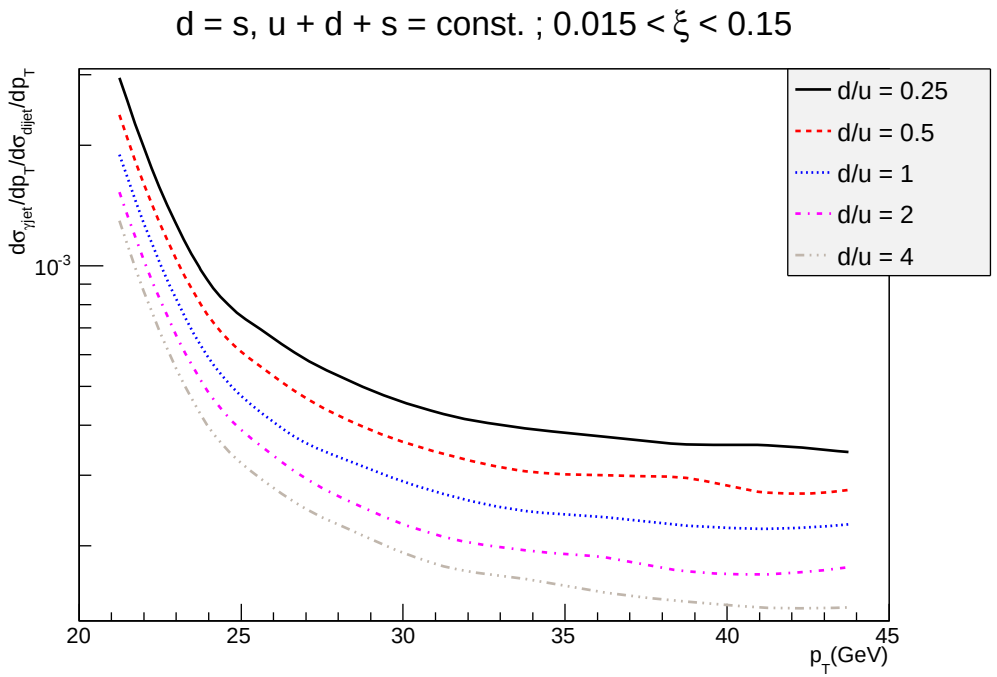
DPE γ + Jet Production



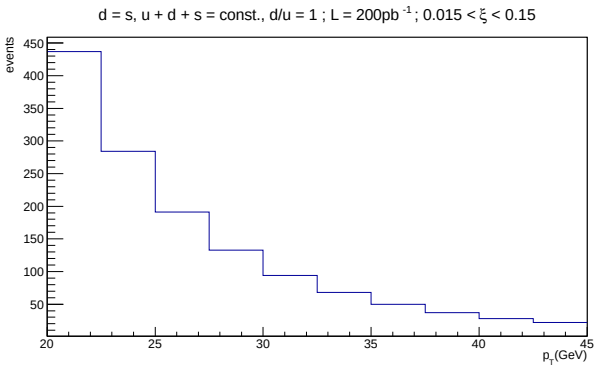
- Probe QCD and diffraction in a new kinematic domain.
- Constraints exist on the sum of quark density and the gluon distribution from F_2^D measurement (HERA) assuming the Pomeron is made of quarks and gluons.
- u=d=s and q=qbar have been assumed so far.
- Production highly depends on quark PDF.
- $\int L = 200$ pb^{-1} with low $< \mu >$ is enough to obtain some interesting informations about Pomeron structure.

d/u Results: $p_{T,jet}$ Differential CS Ratio

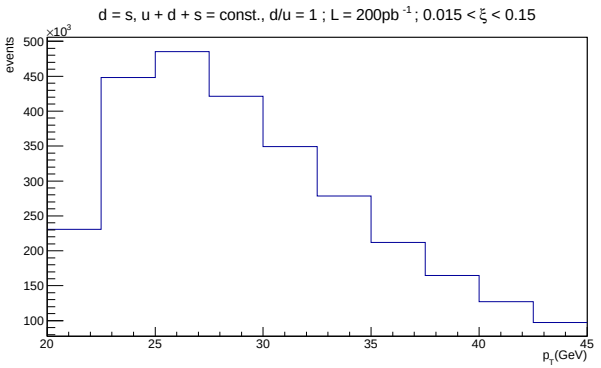
Central detector (ATLAS) measurements:



γ + jet:



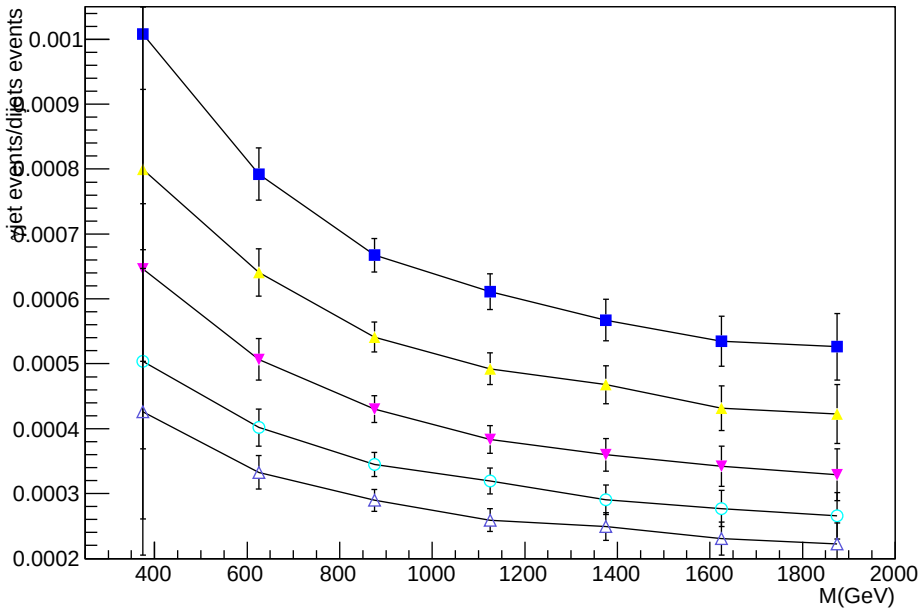
dijets:



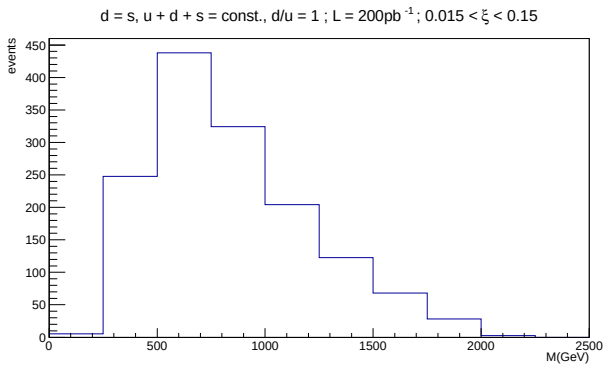
- Cross-sections integrated on 2.5 GeV bins.
- Cross-sections ratio varies by a factor 4.
- Jet Energy Scale (JES) systematics should compensate (but not Jet Energy Resolution).
- Low dependence on survival probability.
- Statistical uncertainty driven by γ + jet.

d/u Results: Missing Mass Differential CS Ratio

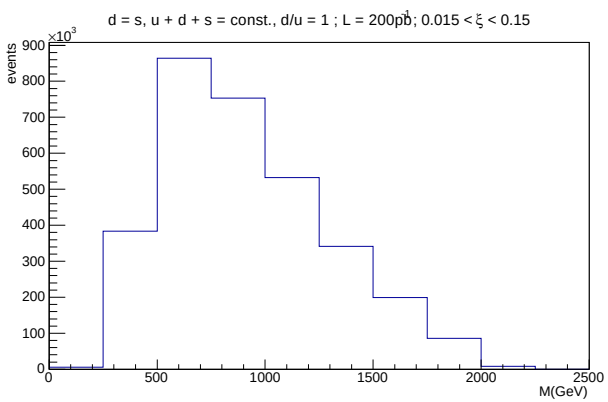
Forward detector (AFP) measurements:



γ + jet:



dijets:

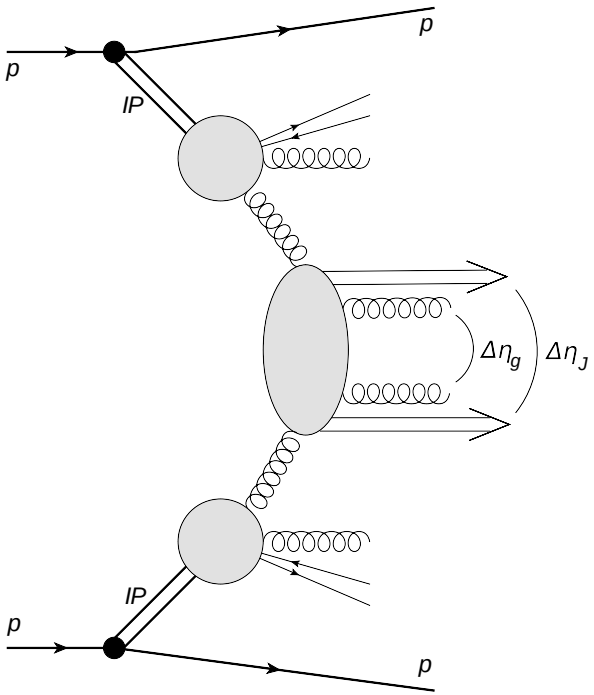


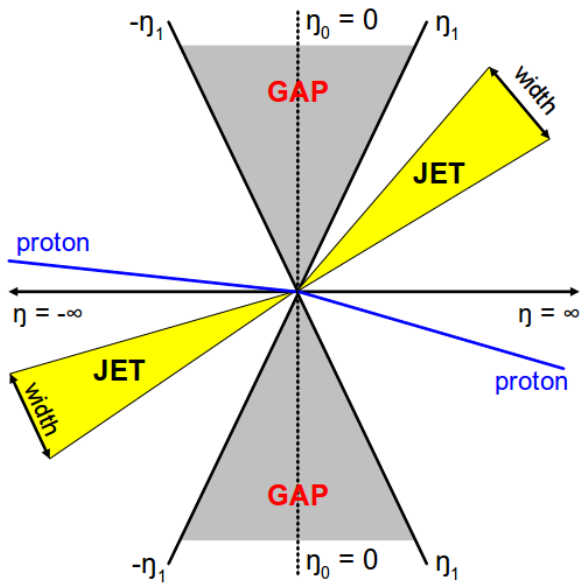
- Cross-sections integrated on 250 GeV bins.
- Cross-sections ratio varies by a factor 2.5.
- No impact of Jet Energy Scale (JES) and Jet Energy Resolution (JER).
- Statistical uncertainty driven by γ + jet.

Double Pomeron Exchange Jet-Gap-Jet Production

C. Marquet, C. Royon, M. Trzebinski, R. Zlebcik, to be published in PRD

Diffractive jet-gap-jet event



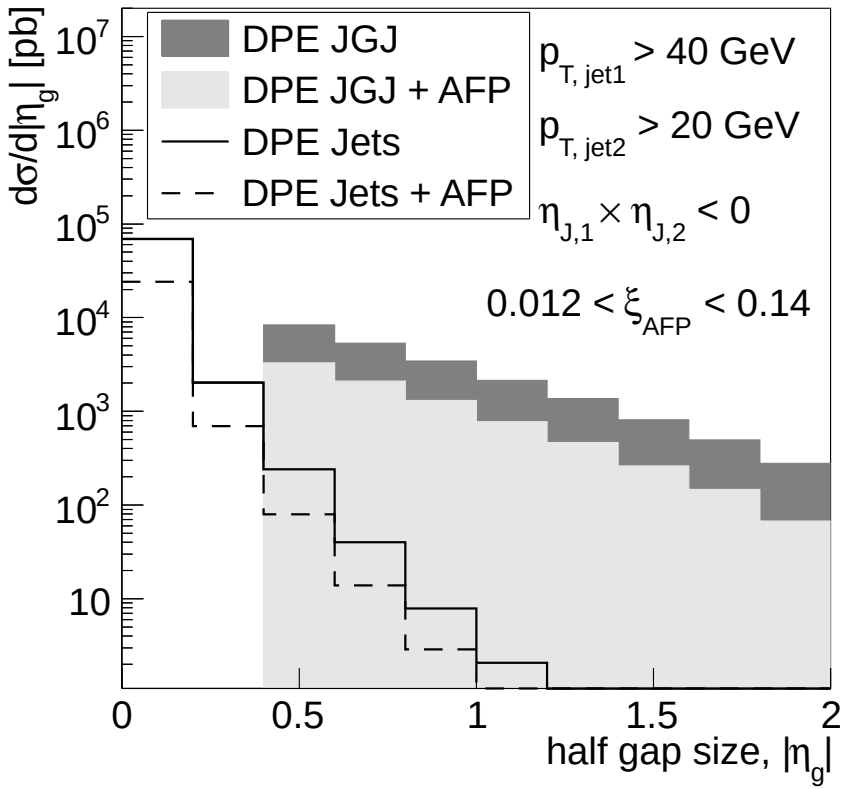


- Cleaner test of BFKL model than usual JGJ measurement (events not polluted by proton remnants).
- Access to larger di-jets with a larger rapidity difference.
- $\int L = 300$ pb^{-1} with low $< \mu >$ is enough to make the test.

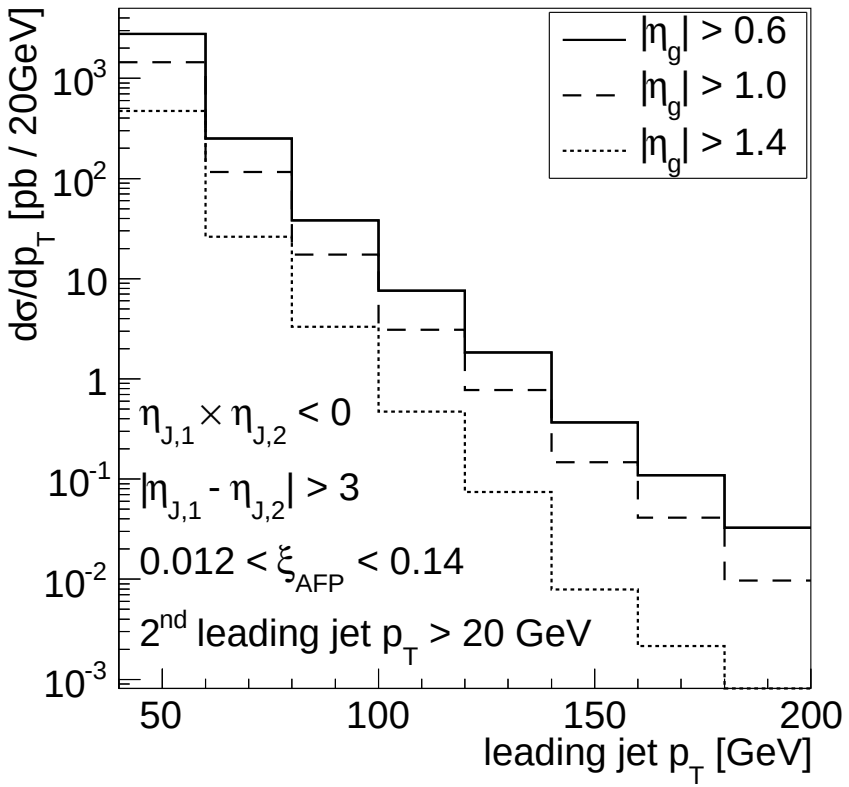
Event signature:

- two outgoing protons,
- two jets in opposite hemispheres,
- gap (symmetric in η) between jets.

Central Jets

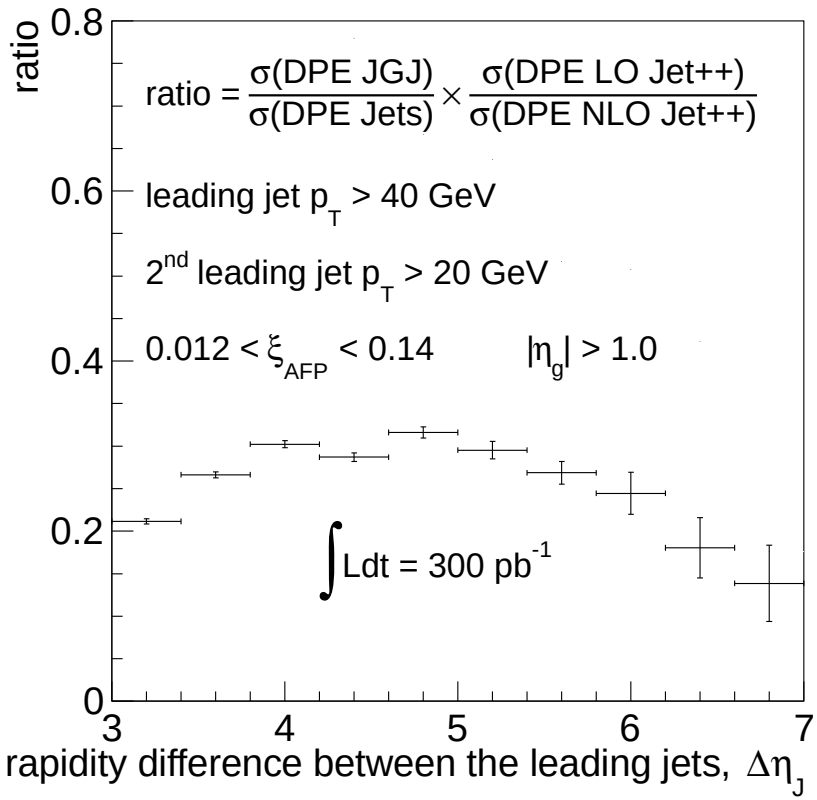


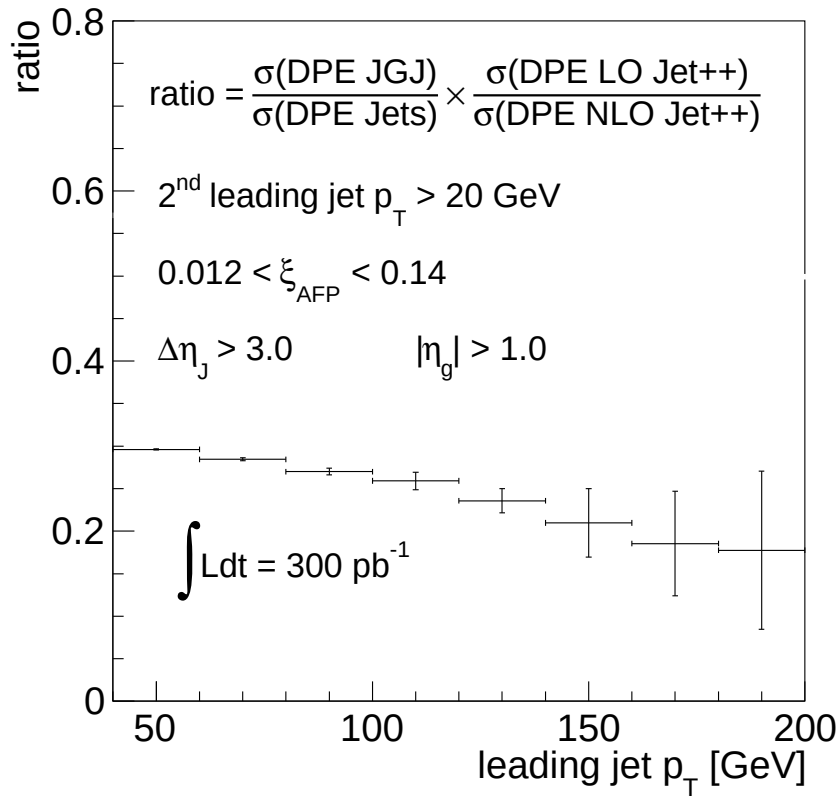
The gap size distribution for non-diffractive jets and diffractive jet-gap-jet events.



The jet transverse momentum distribution for different gap sizes with AFP tag requirement.

Predictions



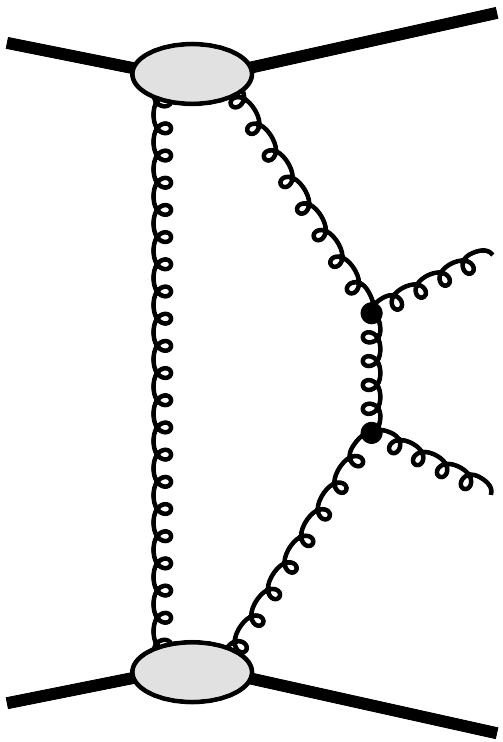


Exclusive Jet Production

M. Trzebinski, ATL-PHYS-SLIDE-2012-618

Exclusive Jet Production

Signature: two jets in central region + two intact protons
+ gap in rapidity between jet and proton (no remnants).



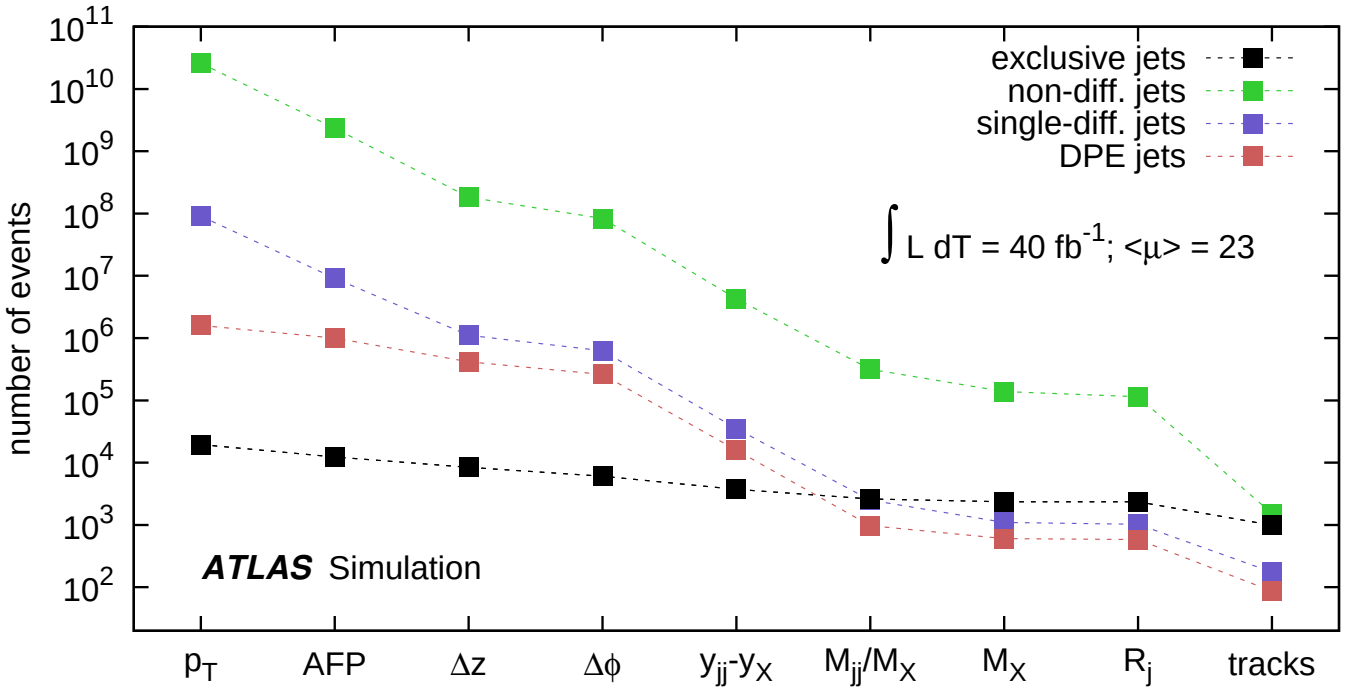
Exclusive Production

- Theoretical description – KMR model.
- No Pomeron remnants.
- Measurement constrain theoretical models.
- Limits on exclusive Higgs production.
- $\int L = 300$ fb^{-1} with high $< \mu > \sim 50$ is enough to make the measurement.

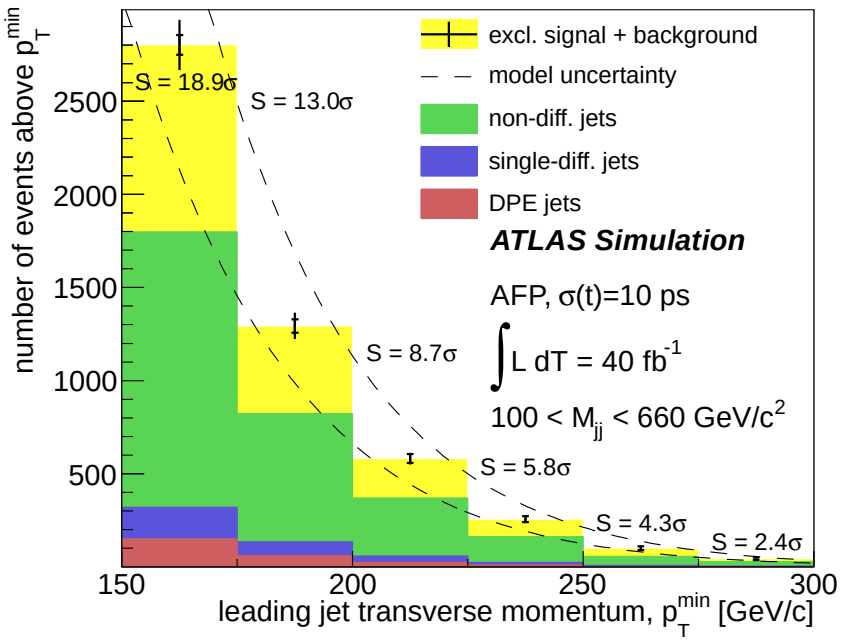
Discriminating Power

Event selection:

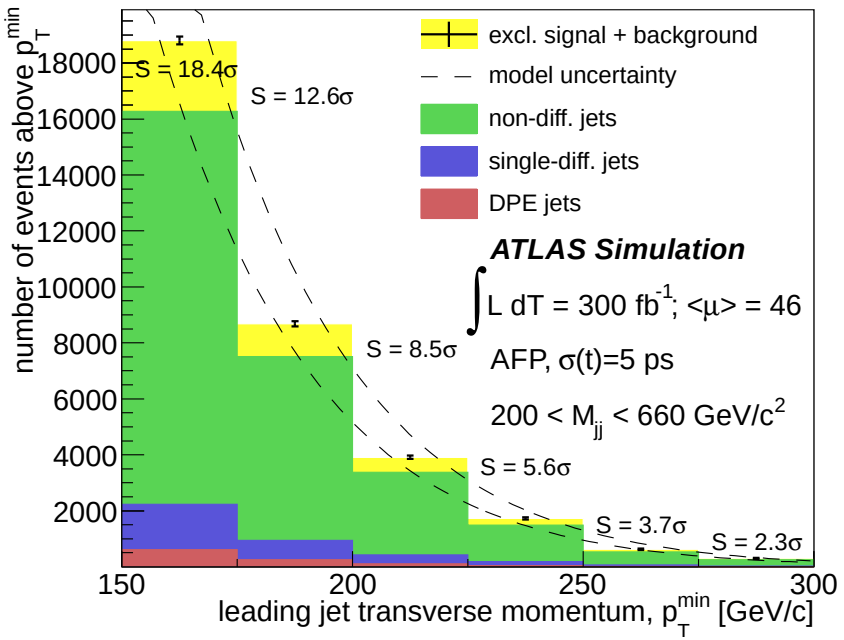
- At least one proton tagged in each AFP station.
- Rapidity Difference $|y_{jj} - y_X| < 0.075$ and Mass Fraction $0.9 < M_{jj}/M_X < 1.15$.
- Number of tracks outside the jet system < 4.
- Angle between two leading jets $2.9 < \Delta\phi < 3.3$.
- Missing mass $M_x < 550$ GeV$/c^2$.
- The distance between hard vertex reconstructed by ATLAS and from the AFP time measurement $|\Delta z| < 3.5$ mm.



Number of Events



$< \mu >= 23$



$< \mu >= 46$

Summary

- Possibility of tagging intact protons provides cleaner experimental environment.
- One week of data taking with low pile-up roughly corresponds to $\int L = 100$ pb^{-1}.
- Double Pomeron Exchange Jets Production:
  - Measure gluon density in Pomeron.
  - $\sigma \sim 5 \times 10^4$ pb for $p_{T,jet1} > 20$ GeV, low pile-up.
- Double Pomeron Exchange γ + Jet Production:
  - New constraints on quark densities difference.
  - $\sigma \sim 10$ pb for $p_{T,jet1} > 20$ GeV, low pile-up.
- Double Pomeron Exchange Jet-Gap-Jet Production:
  - Provide a test of the BFKL Pomeron.
  - $\sigma \sim 10^3$ pb for $p_{T,jet1} > 40$ GeV, low pile-up.
- Exclusive Jets Production:
  - Measure the cross-section, probe exclusive KMR mechanism to constrain predictions for the exclusive Higgs production.
  - $\sigma \sim 1$ pb for $p_{T,jet1} > 150$ GeV, high pile-up.