

Exclusive Jet Production at the LHC Feasibility Studies

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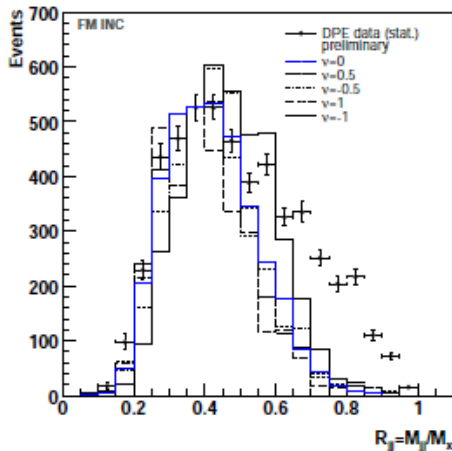
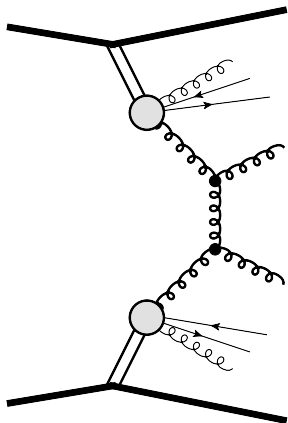
Diffraction and electromagnetic processes at high energies

Bad Honnef, 17th August 2015

Tevatron – Analysis of the DPE Jet Production

DPE – Double Pomeron Exchange

Signature: two jets in central region + two intact protons.



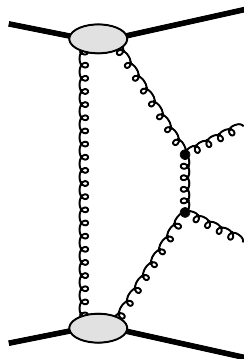
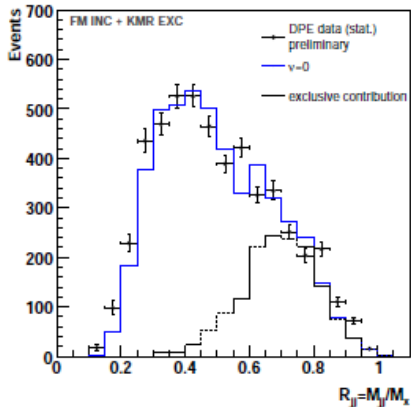
Goal: to probe the Pomeron Density Function.

Too much events in the high mass ratio (M_{jj}) region.

Mass ratio is defined as the ratio of the mass of the dijet system to missing mass.

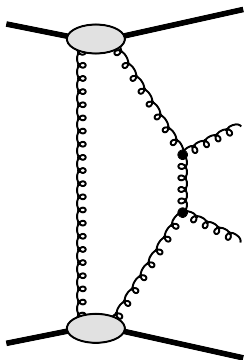
Exclusive Jet Production at the Tevatron

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

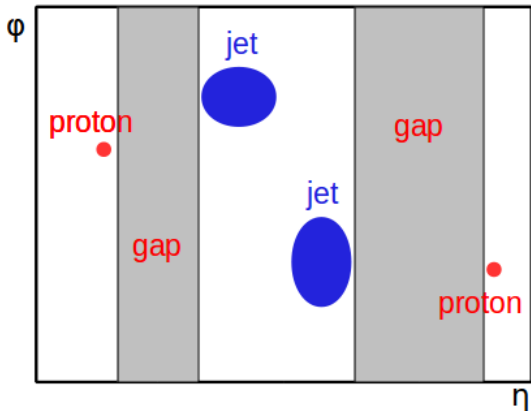


Exclusive Production

KMR model explains additional contribution in high mass ratio region. In such process there are no Pomeron remnants (in theory ratio = 1, smearing due to the detector effects).

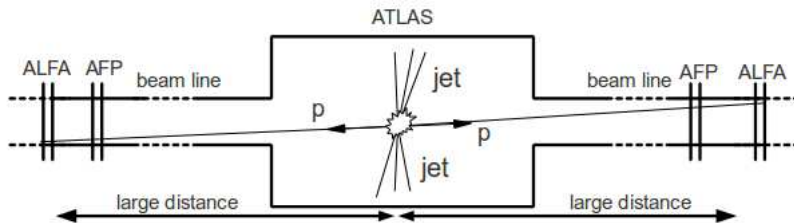


Exclusive Production



1. Gaps between jets and outgoing protons.
2. Intact proton tagging.

Intact protons – natural diffractive signature.



ALFA

- exists, 240 m from ATLAS IP
- elastic scattering
- special runs (high β^* optics)
- position detectors
- vertically inserted Roman Pots
- soft events, pile-up background

AFP

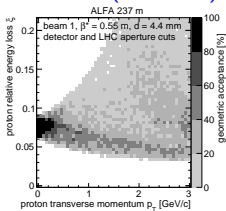
- planned, 210 m from ATLAS IP
- hard diffraction
- nominal runs (collision optics)
- position and timing detectors
- horizontally inserted RP
- proton detector for hard events

Geometric Acceptance

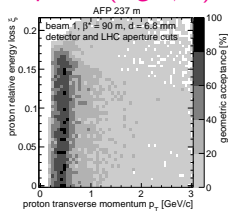
optics

ALFA

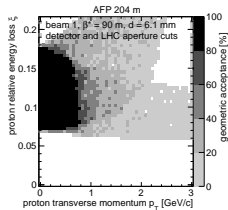
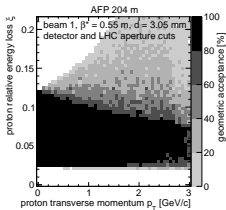
$\beta^* = 0.55$ m
nominal (*collision*)



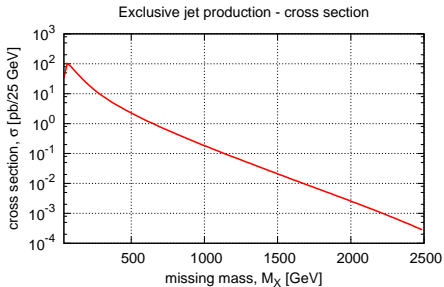
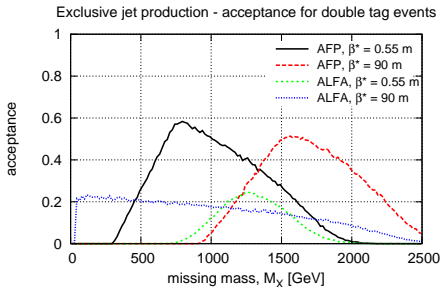
$\beta^* = 90$ m
special (*high- β^**)



AFP



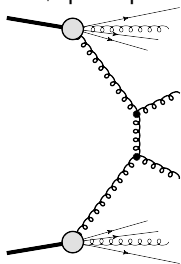
Mass Acceptance



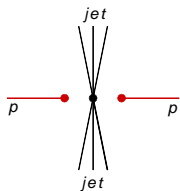
Background

Pile-up – multiple collisions during one bunch crossing (mostly min-bias).

Non-diffractive jets
+ pile-up.

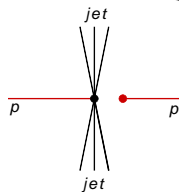
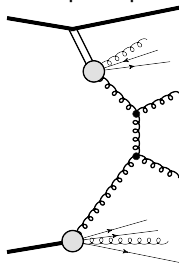


Non-diffractive Production



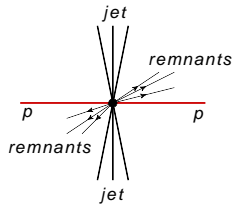
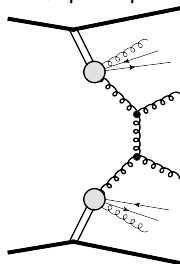
$\sigma(p_T > 150 \text{ GeV})$:
645 nb

Single-diffractive jets
+ pile-up.



$\sigma(p_T > 150 \text{ GeV})$:
2.26 nb

DPE jets
+ pile-up.



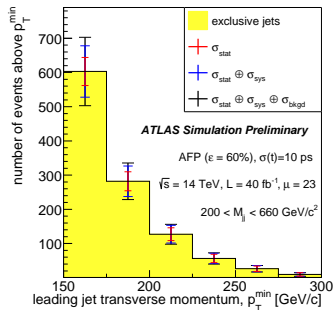
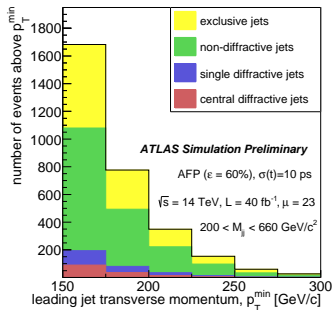
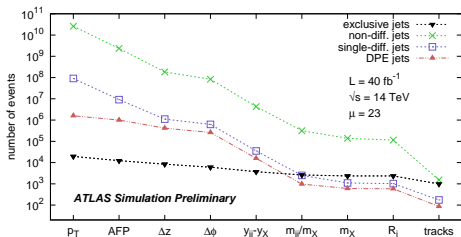
$\sigma(p_T > 150 \text{ GeV})$:
40 pb

Double Tagged Events

Exclusive Jet Production with Forward Proton Tagging
ATL-PHYS-PUB-2015-003

Number of Events ($\mu = 23$)

large masses \rightarrow high p_T jets \rightarrow smaller cross sections \rightarrow large pile-up \rightarrow very challenging measurement



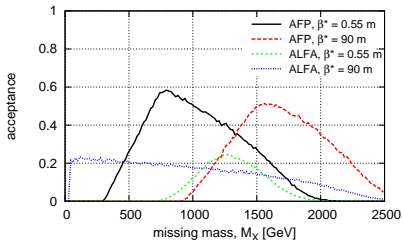
Single Tagged Events

*On the Possibility of Measuring the Single-tagged Exclusive Jets
at the LHC*

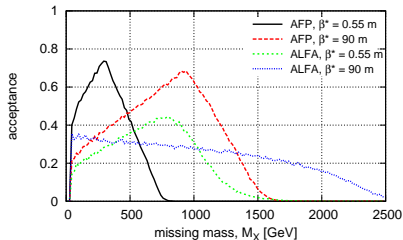
Eur. Phys. J. C **75** (2015) 320; arXiv:1503.00699

Motivation

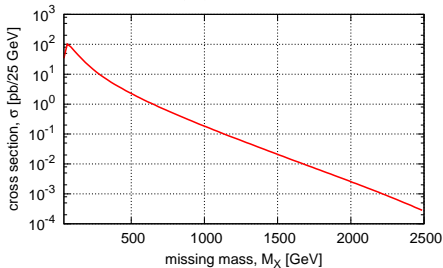
Exclusive jet production - acceptance for double tag events



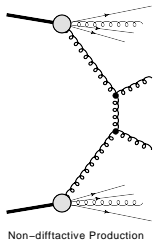
Exclusive jet production - acceptance for single tag events



Exclusive jet production - cross section



Non-diffractive jets + pile-up

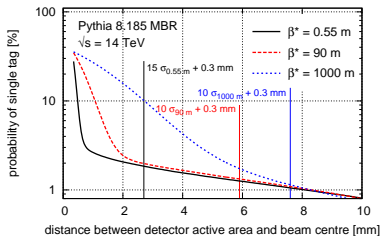


Cuts:

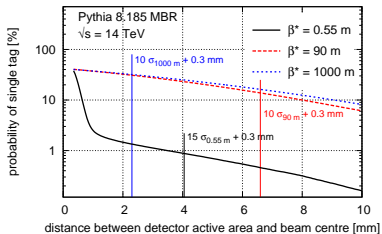
- proton in AFP/ALFA,
- one reconstructed vertex.

Soft single tag probability

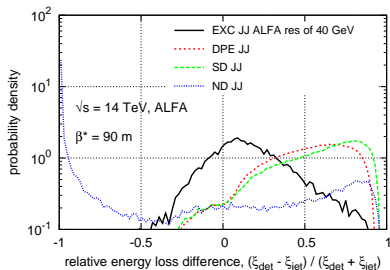
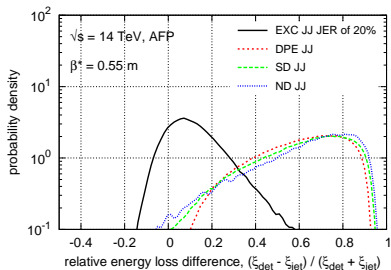
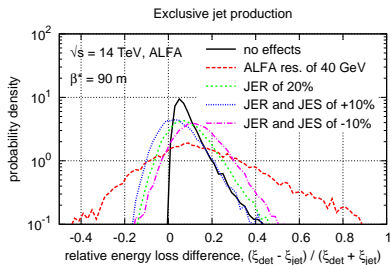
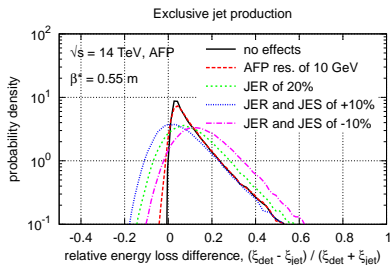
Minimum-bias and elastic protons in AFP station at 204 m



Minimum-bias and elastic protons in ALFA station at 237 m

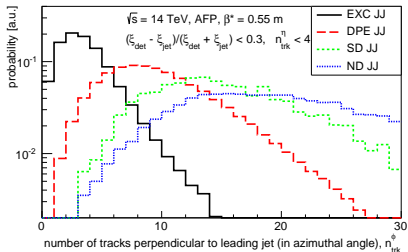
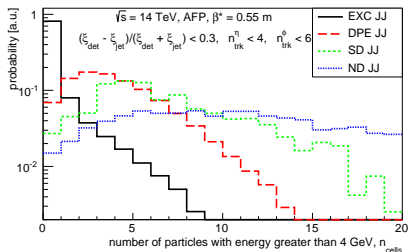
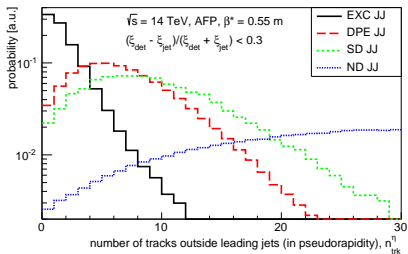


Relative Energy Loss Difference



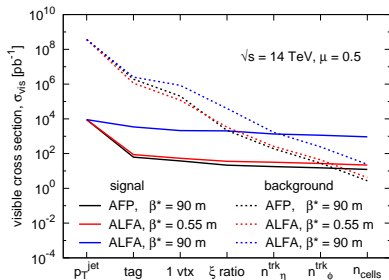
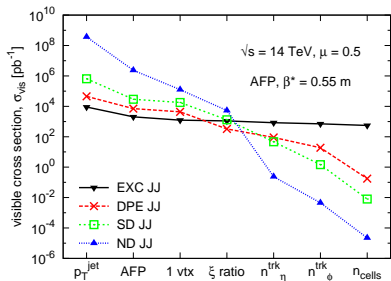
$$\xi^{\text{jet}} = \exp(\pm y_{jj}) \frac{M_{jj}}{\sqrt{s}}$$

Veto on Additional Activity

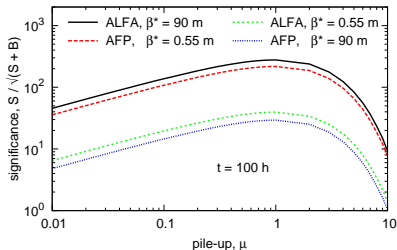


- number of tracks outside jet system (in η): $n_{\text{trk}} < 4$,
- number of tracks perpendicular to the leading jet (in ϕ): $n_{\text{phi}} < 6$,
- number of particles with energy greater than 4 GeV, $n_{\text{cells}} < 2$.

Purity and statistical significance



Exclusive jets (single tagged)



- Top: cutflow.
- Bottom: statistical significance ($\frac{S}{\sqrt{S+B}}$) for 100 hours.

Double tagged events.

- Measurement of the exclusive jet production will be possible in the ATLAS detector during normal runs (low beta, high pile-up) using the AFP detectors.
- Very challenging measurement – difference of six orders of magnitude between signal and background cross-sections (impossible to measure without AFP)!
- Results published in: ATL-PHY-PUB-2015-003

Single tagged events.

- Smaller masses \rightarrow larger cross sections \rightarrow smaller pile-up \rightarrow cleaner events.
- High signal-to-background ratio (between 5 and 10 000, depending on the settings).
- High significance.
- Results published in: Eur. Phys. J. C **75** (2015) 320; arXiv:1503.00699.