

Hard Diffraction with Proton Tagging at the LHC

Maciej Trzebiński

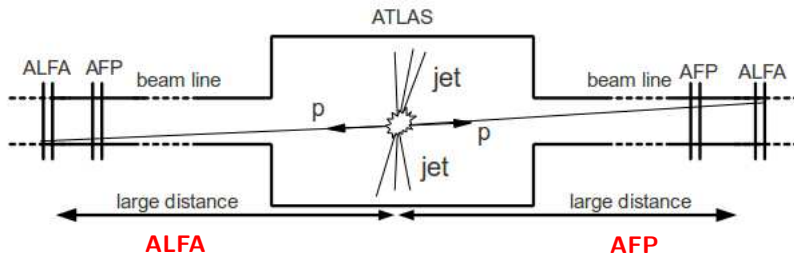
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Low-x 2015

Sandomierz, 2nd September 2015

Intact protons → natural diffractive signature → usually scattered at very small angles (μrad) → detectors must be located far from the Interaction Point.



- **Absolute Luminosity For ATLAS**
- exist, 240 m from ATLAS IP
- soft diffraction (elastic scattering)
- special runs (high β^* optics)
- vertically inserted Roman Pots
- tracking detectors, resolution:
 $\sigma_x = \sigma_y = 30 \mu\text{m}$

- **ATLAS Forward Proton**
- planned, 210 m from ATLAS IP
- hard diffraction
- nominal runs (collision optics)
- horizontally inserted Roman Pots
- tracking detectors, resolution:
 $\sigma_x = 10 \mu\text{m}, \sigma_y = 30 \mu\text{m}$
- timing detectors, resolution:
 $\sigma_t \sim 20 \text{ps}$

Similar Devices @ IP5: CMS-TOTEM.

Ratio of the number of protons with a given relative energy loss (ξ) and transverse momentum (p_T) that crossed the active detector area to the total number of the scattered protons having ξ and p_T .

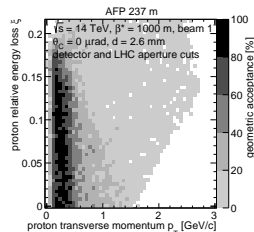
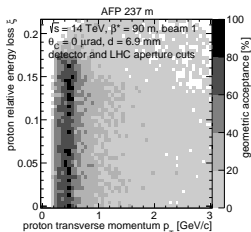
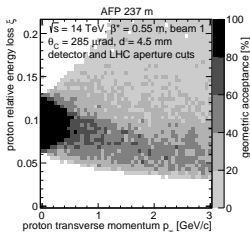
optics

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

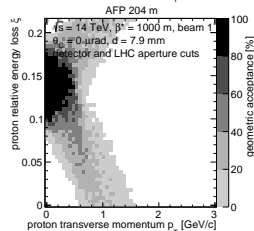
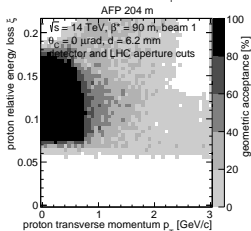
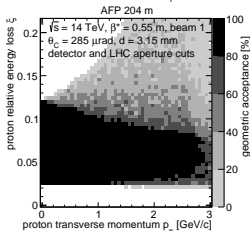
$\beta^* = 90$ m
special (*high- β^**)

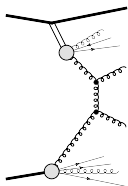
$\beta^* = 1000$ m
special (*high- β^**)

ALFA



AFP

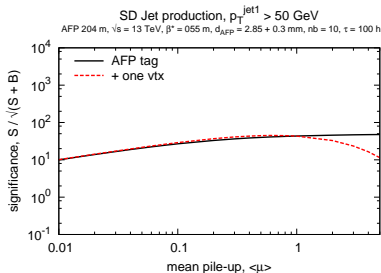
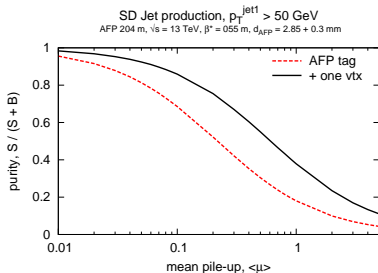




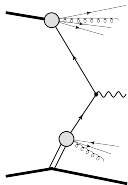
Motivation:

- measure cross section and gap survival probability,
- search for the presence of an additional contribution from Reggeon exchange,
- check Pomeron universality between ep and pp colliders.

Example: purity and statistical significance for AFP and $\beta^* = 0.55$ m.



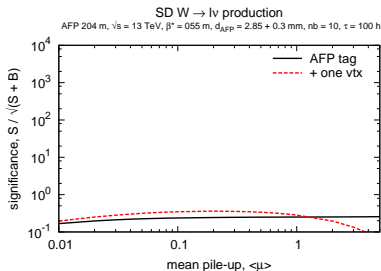
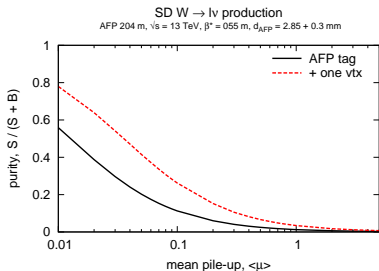
To be published in CERN Yellow Report.



Motivation:

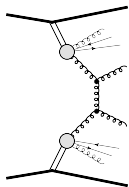
- measure cross section and gap survival probability,
- measure Pomeron structure and flavor composition,
- search for charge-asymmetry.

Example: $W \rightarrow l\nu$ – purity and stat. significance for AFP and $\beta^* = 0.55$ m.



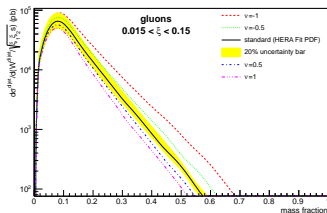
W asymmetry studies published in: Phys.Rev. D 84 (2011) 114006

To be published in CERN Yellow Report.

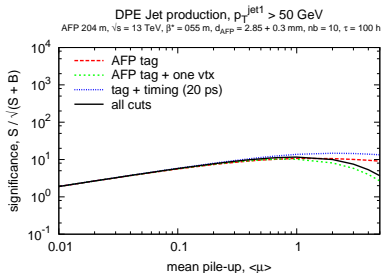
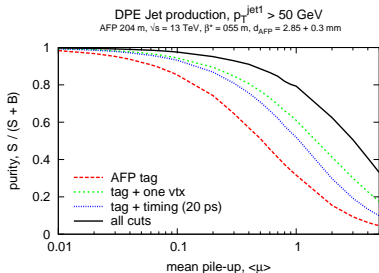


Motivation:

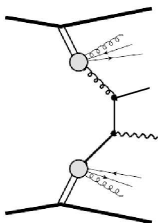
- measure cross section and gap survival probability,
- search for the presence of an additional contribution from Reggeon exchange,
- investigate gluon structure of the Pomeron.



Example: purity and statistical significance for AFP and $\beta^* = 0.55$ m.

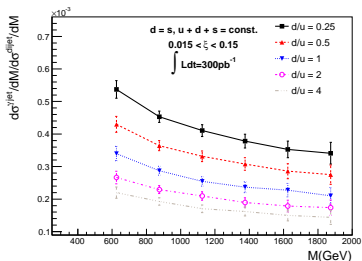
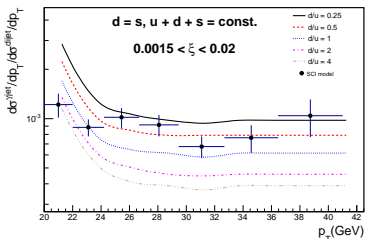


To be published in CERN Yellow Report.



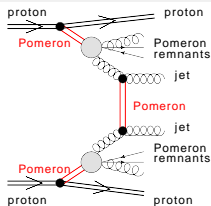
Motivation:

- measure cross section and gap survival probability,
- sensitive to quark content in Pomeron (at HERA it was assumed that $u = d = s = \bar{u} = \bar{d} = \bar{s}$).



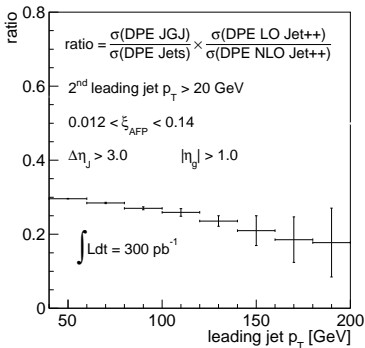
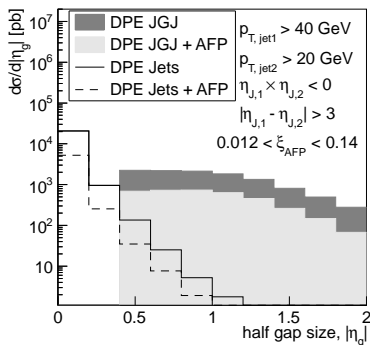
Published in: Phys.Rev. D 88 (2013) 7, 074029

Double Pomeron Exchange Jet-Gap-Jet Production

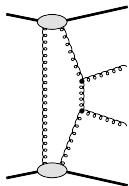


Motivation:

- measure cross section and gap survival probability,
- test BFKL model.

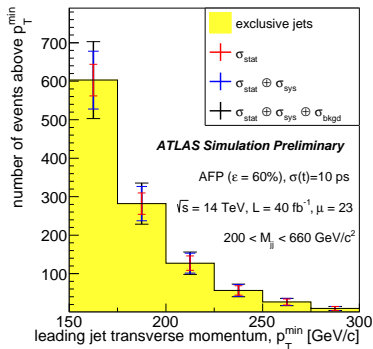
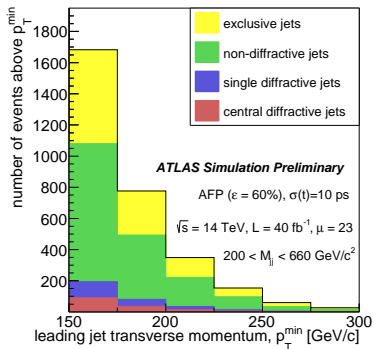
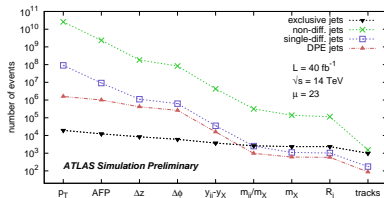


Published in: Phys.Rev. D 87 (2013) 3, 034010

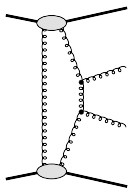


Motivation:

- cross section measurement,
- constrain other exclusive productions (e.g. Higgs).

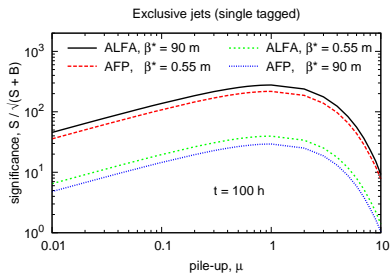
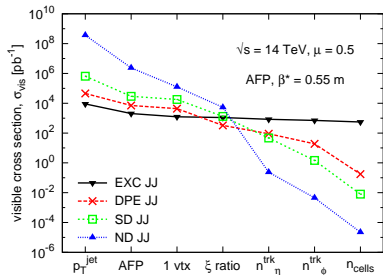


Public ATLAS note: ATL-PHYS-PUB-2015-003



Motivation:

- cross section measurement,
- constrain other exclusive productions (e.g. Higgs).



Published in: Eur. Phys. J. C 75 (2015) 320

- Intact protons → natural diffractive signature → usually scattered at very small angles (μrad) → detectors must be located far from the IP.
- Two forward detectors systems in ATLAS (similar situation in CMS):
 - ALFA – existing vertical RPs located 240 m from IP1,
 - AFP – planned horizontal RPs located 210 m from IP1.
- Various data taking strategies (LHC optics):
 - very low pile-up ($\mu \sim 0.05$):
 - detectors: ALFA or AFP,
 - optics: collision or high β^* , few very low intensity bunches,
 - measure total cross section and properties of soft diffraction,
 - low pile-up ($\mu \sim 1$):
 - detectors: ALFA or AFP,
 - optics: collision or high β^* , low intensity bunches,
 - measure properties of hard diffraction:
SD JJ, SD JGJ, SD W, SD Z, DPE JJ, DPE JGJ, DPE γ +jet, exclusive jets (single tag),
 - high pile-up ($\mu \sim 50$):
 - detectors: AFP,
 - optics: collision, join all ATLAS runs,
 - measure exclusive production and discovery physics:
exclusive jets, anomalous couplings: $\gamma\gamma WW$, $\gamma\gamma ZZ$, $\gamma\gamma\gamma\gamma$.