Probing the BFKL Pomeron
with Future ATLAS Forward Detectors

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Jet-Gap-Jet Events

dijet production

jet-gap-jet production
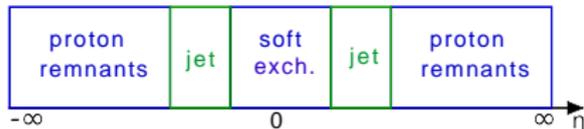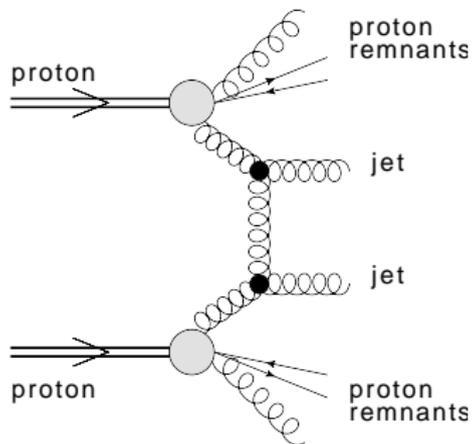
- protons are destroyed,

- protons remnants produced in forward direction,

- **possible soft exchange between jets.**
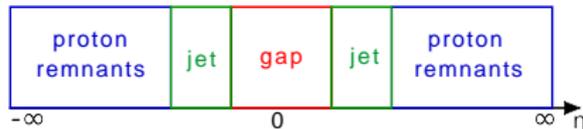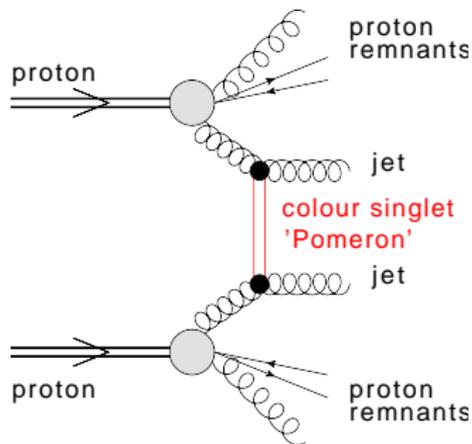
- protons are destroyed,

- protons remnants produced in forward direction,

- **no objects exchanged between jets – gap.**

Gap

Theory

Space in rapidity plane **devoid of particles**.

Experiment

Space in rapidity plane **devoid of reconstructed objects**:

- jets,
- calorimeter activity,
- tracks.
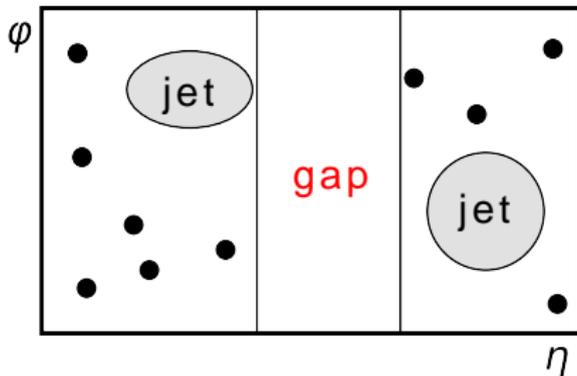
The BFKL Formalism

- BFKL jet gap jet cross section*: integration over ξ, p_T performed in HERWIG event generation:

$$\frac{d\sigma^{pp \to XJJY}}{dx_1 dx_2 dp_T^2} = S \frac{f_{eff}(x_1, p_T^2) f_{eff}(x_2, p_T^2)}{16\pi} \left| A(\Delta\eta, p_T^2) \right|^2,$$

where S is the survival probability (0.1 at Tevatron, 0.03 at LHC):

$$\left| A(\Delta\eta, p_T^2) \right|^2 = \frac{16 N_C \pi \alpha_S^2}{C_F p_T^2} \sum_{p=-\infty}^{\infty} \int \frac{d\gamma}{2\pi i} \frac{[p^2 - (\gamma - 1/2)^2]}{[(\gamma - 1/2)^2 - (p - 1/2)^2]}$$

$$\frac{exp\left(\frac{\alpha_S N_C}{\pi} \xi_{eff} \Delta\eta\right)}{[(\gamma - 1/2)^2 - (p + 1/2)^2]}.$$

- BFKL effective kernel ξ_{eff} determined numerically, solving the implicit equation: $\xi_{eff} = \xi_{NLL}(\gamma, \alpha, \xi_{eff})$,

Test of the BFKL Pomeron:
study the ratio of events with gap to all events with jets.

*O. Kepka *at. al.*, *Gaps between jets in hadronic collisions*, Phys.Rev. **D83** 034036

MC Implementation

Implementation in HERWIG MC – necessity to take into account the jet size.
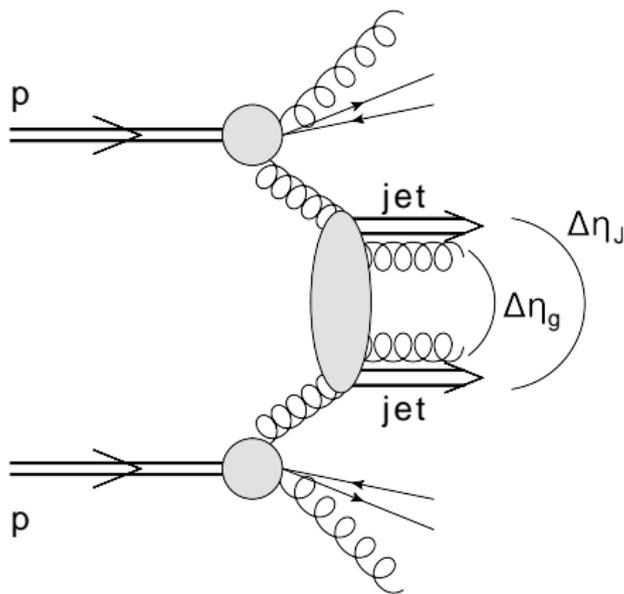
Parametrised distribution of $\frac{d\sigma}{dp^2}$ fitted to BFKL NLL cross section (2200 points fitted between $10 < p_T < 120$ GeV, $0.1 < \Delta\eta < 10$ with $\chi^2 \sim 0.1$).
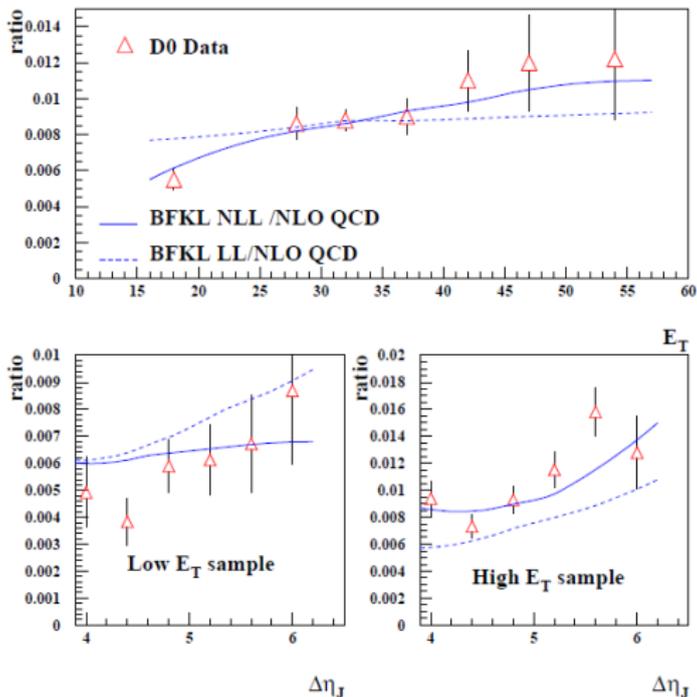
Comparisons between the D0 measurements of the jet-gap-jet event ratio with the NLL- and LL-BFKL calculations. The NLL calculation is in fair agreement with the data while the LL one leads to a worse description.

Measurement of dijet production with a veto on additional central jet activity in pp collisions at $\sqrt{s} = 7$ TeV using the ATLAS detector

The ATLAS Collaboration

Cross section measurement for simultaneous production of a central and a forward jet in proton-proton collisions at $\sqrt{s} = 7$ TeV

The CMS Collaboration

Diffractive Jet-Gap-Jet Events

jet-gap-jet production
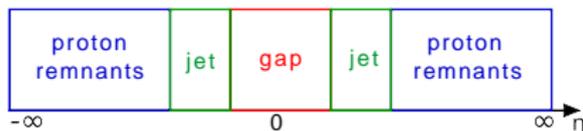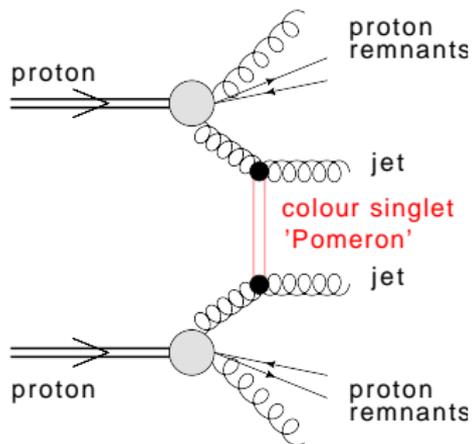
diffractive jet-gap-jet production

- **protons are destroyed,**
- protons remnants produced in forward ($|\eta| \gg 0$) direction,
- no objects exchanged between jets – gap.
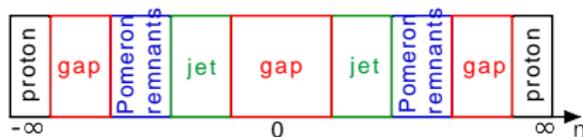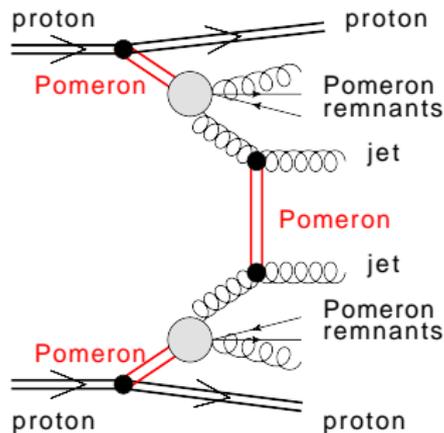
- **protons stay intact,**
- Pomeron remnants produced in forward ($|\eta| \gg 0$) direction,
- no objects exchanged between jets – gap.

Measurement in ATLAS

Idea of the measurement*:

- (forward) jets are measured in the ATLAS detector,
- veto on tracks or/and calorimeter in the central region,
- outcoming protons are tagged in the AFP stations.
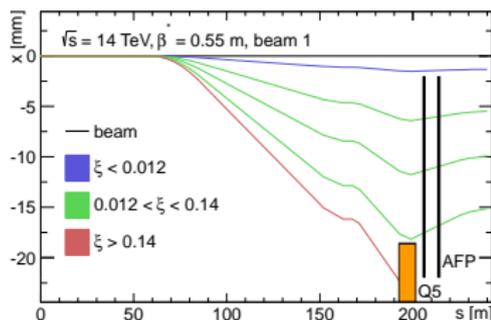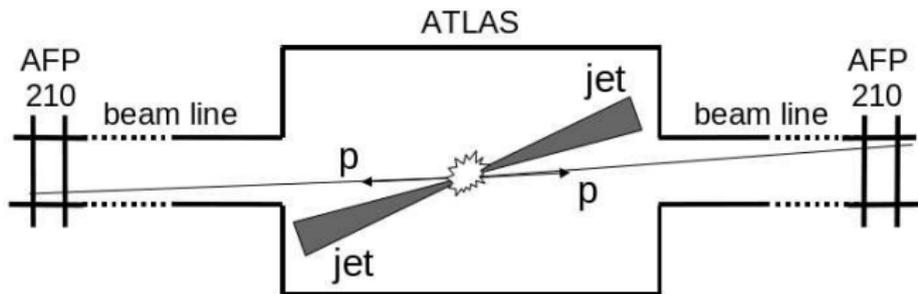
Path of protons with different energy loss through the LHC magnetic structure near the ATLAS Interaction Point. Protons were generated in IP $= (0, 0, 0)$ with transverse momentum $p_T = 0$

*C. Marquet et. al., Gaps between jets in double-Pomeron-exchange processes at the LHC

AFP geometric acceptance

Geometric acceptance (left): ratio of the number of protons of 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.
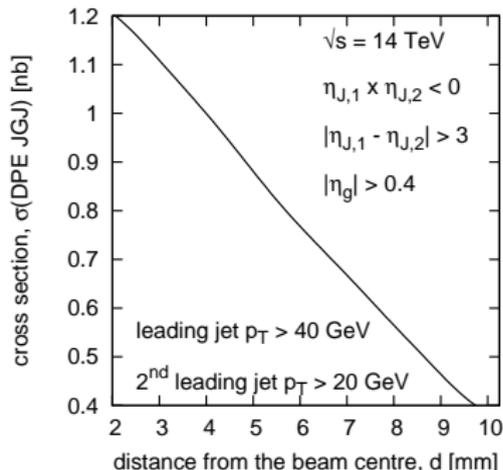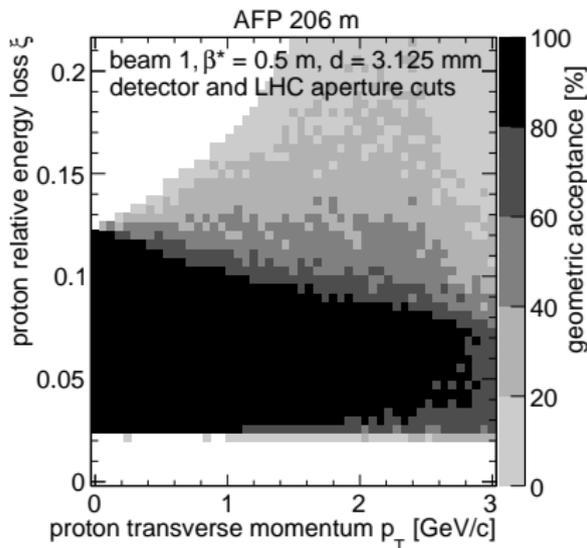

Right: **visible cross-section** as a function of the distance between the detector and the beam centre.

Central jets
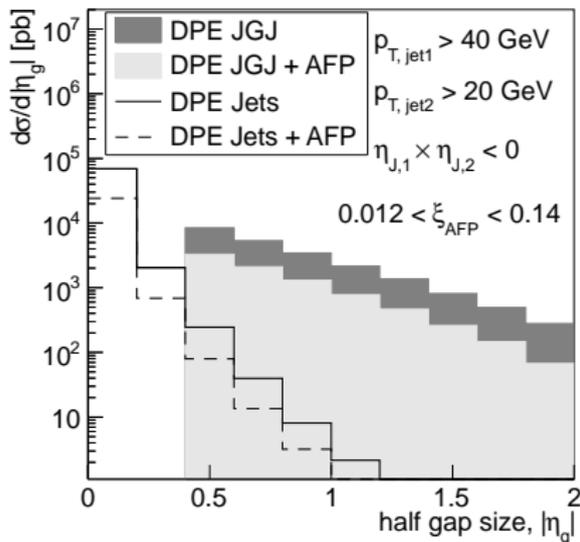
The gap size distribution for non-diffractive jets and diffractive jet-gap-jet events.
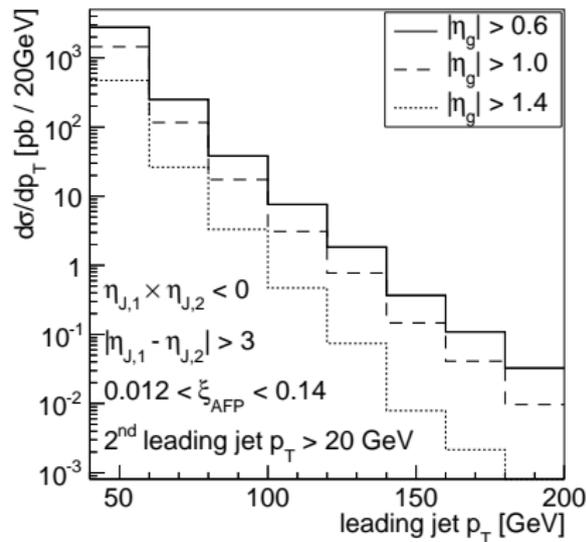
The jet transverse momentum distribution for different gap sizes with AFP tag requirement.

Ratio BFKL NLL/QCD NLO
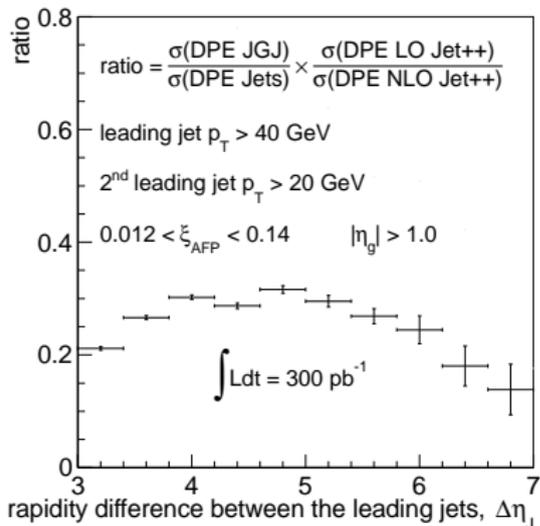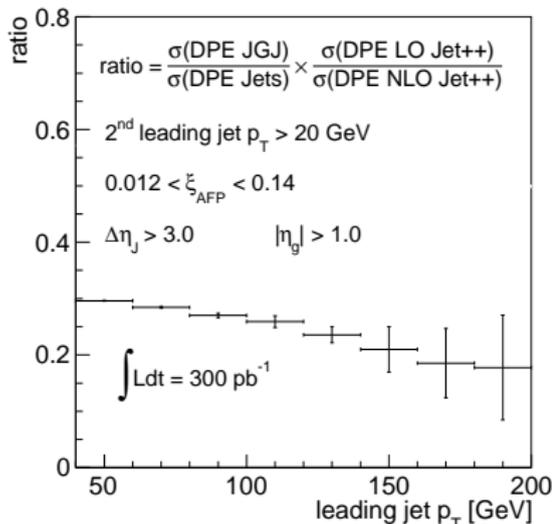
Predictions for the ratio of the cross section for the diffractive jet-gap-jet to the inclusive jet cross section at the LHC as a function of the leading jet transverse momentum p_T (left) and rapidity difference between the leading jets $\Delta\eta_J$ (right).

Summary

- The measurement of the ratio of jet-gap-jet events to the total number of jets can add information about the BFKL Pomeron.

- Such ratio was measured at the Tevatron.

- Both ATLAS and CMS measured the fraction of events where there is no activity (defined as lack of jets with $p_T > 20$ GeV) between two leading jets. However, according to *eg.* Y. Hatta *et. al.* '*A QCD description of the ATLAS jet veto measurement*', this approach might not be sensitive to the BFKL effects.

- The measurement can be done in DPE processes, which provides cleaner events not polluted by proton remnants, and consequently also gives access to larger dijets with a larger rapidity difference, for which BFKL effects are more important.

- The fraction of jet-gap-jet to inclusive dijets events in DPE processes is larger than the corresponding fraction in non-diffractive processes, since in DPE events one is not penalized by the gap survival probability, which applies to both the jet-gap-jet and inclusive dijet cross section.

- Such measurement should be possible with the AFP detectors and 300 pb^{-1} of data.