Diffractive Dijets with Gap

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Workshop on Exclusive and Diffractive Processes in High Energy

Proton-Proton and Nucleus-Nucleus Collisions

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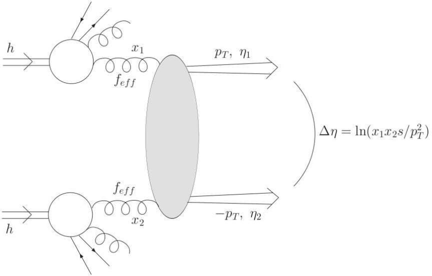
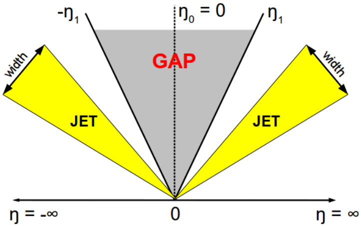




$$\Lambda_{QCD} \ll E_T \ll \sqrt{s}$$

Gap (theory) – rapidity region devoid of particles.
Gap (practise) – rapidity region without reconstructed objects.

BFKL formalism

- BFKL jet gap jet cross section:

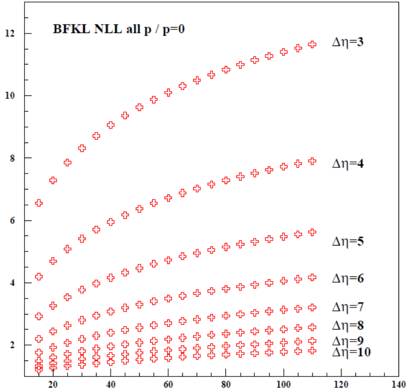
$$\frac{d\sigma^{pp\to XJJY}}{dx_1\,dx_2\,dp_T^2} = S\,\frac{f_{eff}(x_1, p_T^2) f_{eff}(x_2, p_T^2)}{16\pi}\left|A(\Delta\eta, p_T^2)\right|^2,$$

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

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

- α_S constant (0.17) at LL, running at NLL.
- BFKL effective kernel ξ_{eff} determined numerically, solving the implicit equation: $\xi_{eff} = \xi_{NLL}(\gamma, \alpha, \xi_{eff})$,
- Implementation in HERWIG MC: absolutely needed to take into account jet size, at parton level the gap size is equal to $\Delta\eta$ between jets.
- Parametrised distribution of $\frac{d\sigma}{dp_T^2}$ fitted to BFKL NLL cross section (2200 points fitted between $10 < p_T < 120$ GeV, $0.1 < \Delta\eta < 10$ with a $\chi^2 \sim 0.1$).

- Study of the ratio $\frac{d\sigma/dp_{T\ (all\ p)}}{d\sigma/dp_{T\ (p=0)}}$.
- Resummation over p needed: modifies the p_T and $\Delta\eta$ dependences.



Gaps between jets in hadronic collisions

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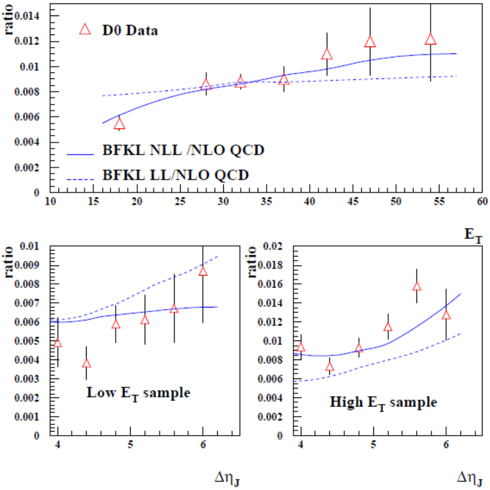


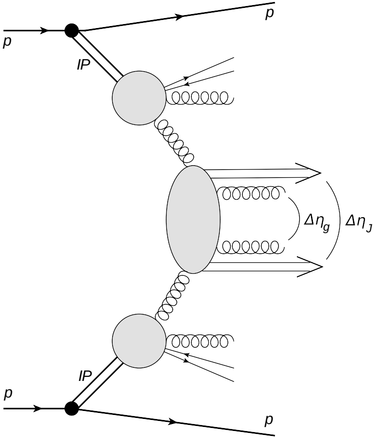
Comparisons between the D0 measurements of the jet-gap-jet event ratio with the NLL- and LL-BFKL calculations. The NLL calculation is in fair agreement with the data while the LL one leads to a worse description.

The parton-level NLL-BFKL calculation was embedded into the HERWIG MC.

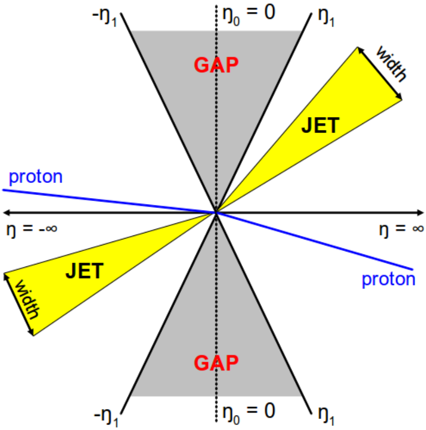
After adjusting the overall normalization the NLL-BFKL calculation was able to describe all Tevatron data, except the higher end of the $\Delta_{\eta J}$ dependence measured by CDF.

Diffractive jet-gap-jet event

Extension of the BFKL tests: the measurement of the diffractive jet-gap-jet events.



Feynman diagram of *pp* → *p-jet-gap-jet-p* process.



Event signature:

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

HERWIG 6.510 Monte Carlo with function (HWHSNM) modified by Ch. Royon is used. Matrix element for colour-singlet parton-parton scattering includes spin and colour averages and sums.
C.R. modification allows to use BFKL LL and NLL with all conformal spin resumed.

Modified HERWIG included in **Forward Physics Monte Carlo** (FPMC) – tool designed to simulated central particle production with one or two leading intact protons and some hard scale in the event. In FPMC the following production mechanisms are implemented: single diffractive dissociation, double pomeron exchange, and exclusive production due to two-gluon or two-photon exchanges.

FPMC : a generator for forward physics

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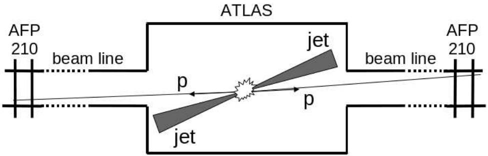
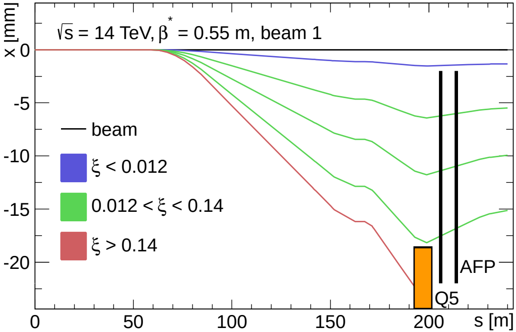
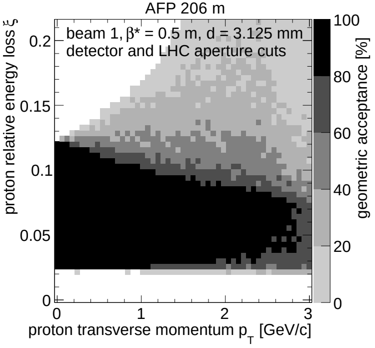
Idea of the measurement: (forward) jets are measured in the ATLAS detector with veto on tracks and calorimeter in the central region, out-coming protons are tagged in the AFP stations.



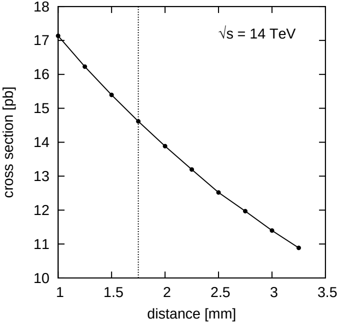


Path of protons with different energy loss through the LHC magnetic structure near the ATLAS Interaction Point.
Protons were generated in IP $= (0, 0, 0)$ with transverse momentum $p_T = 0$

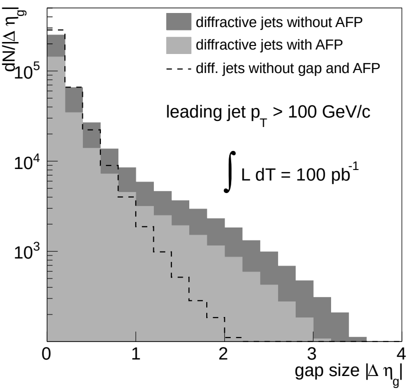
Geometric acceptance (left): ratio of the number of protons of a given relative energy loss (ξ) and transverse momentum (p_T) that crossed the active detector area to the total number of the scattered protons having ξ and p_T.



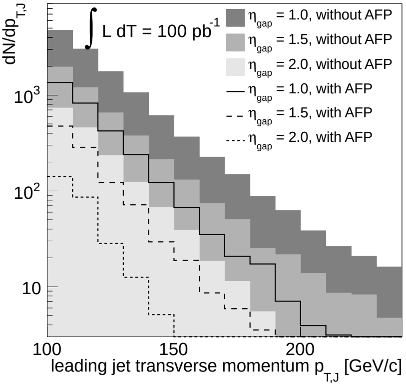
$0.02 < \xi < 0.13$



Right: **visible cross-section** as a function of the distance between the detector and the beam centre (for leading jet with $p_T > 100$ GeV/c).

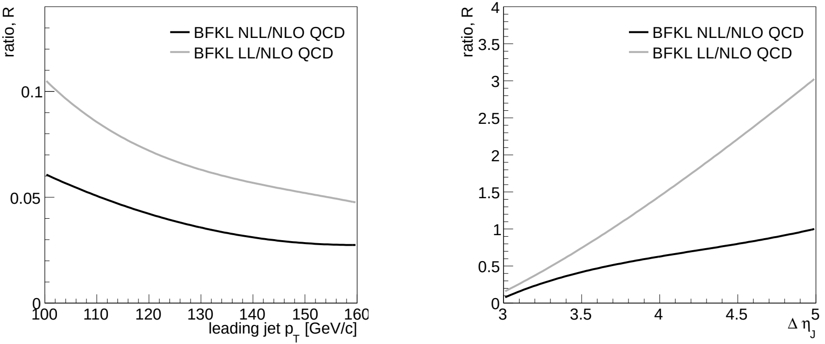


The gap size distribution for diffractive jets and diffractive jet-gap-jet events.



The jet transverse momentum distribution for different gap sizes with and without AFP tag requirement.

$$R = \frac{\sigma(NLL\ BFKL\ FPMC)}{\sigma(Jet\ FPMC)}$$



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, $|\Delta\eta_J| > 3$) and the rapidity difference between the two leading jets $|\Delta\eta_J|$ (right, $p_T > 100$ GeV/c^2).

Summary

- Diffractive jet-gap-jet measurement allows to extend tests of the BFKL model.
- The HERWIG parton-level NLL-BFKL calculation was implemented into the FPMC Monte Carlo program, in order to obtain hadron-level results for the diffractive jet-gap-jet cross-section in hadron-hadron collisions, corresponding to the production of two high-pT jets around a large rapidity gap.
- Predictions for the ratio of the diffractive jet-gap-jet to the inclusive-jet cross section at the LHC, as a function of the leading-jet transverse momentum, and the rapidity difference between the two leading jets $\Delta\eta_J$ were presented.
- Diffractive jet-gap-jet measurement will be possible with help of the AFP detectors in special LHC runs.