Jet-gap-jet: studies of gap survival factor

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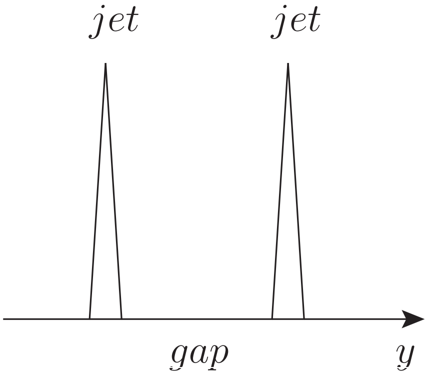
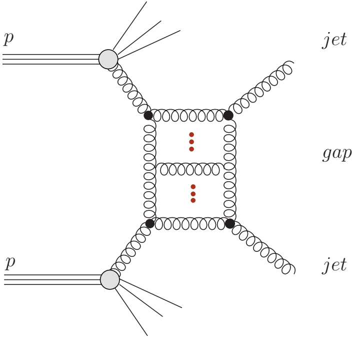
Jet-gap-jet dissucussion

The jet-gap-jet process is an example of the diffractive jet production, in which the pomeron is exchanged between the produced jets.



One can understand jet-gap-jet event as an event where particle production in the rapidity region between the jets is suppressed.

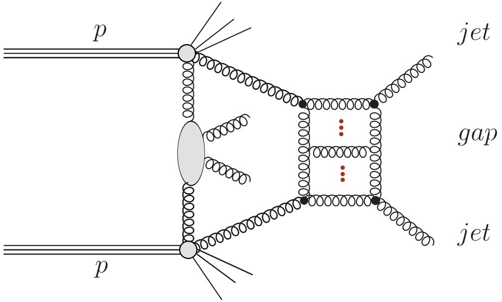
Feynman diagrams



Measurments of the jet-gap-jet process where done by collaborations: D∅,CDF (disscussed in *O. Kepka, C. Marquet, and C. Royon,Phys. Rev. D 83, 034036*) and CMS (*Dijet production with a large rapidity between jets,CMS-PAS-FSQ-12-001*)

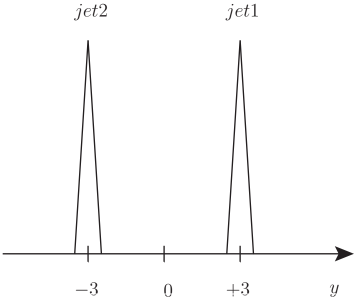
Feynman diagrams

Mechanism of destroying rapidity gap, here this will be Multi Parton Interactions (MPI)



Particle production in jet events

We selected the following example

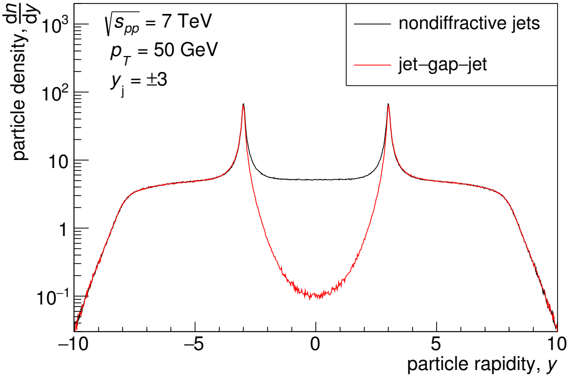


with fixed position of jets and fixed $p_T = 50 GeV$

The difference between nondiffractive and jet-gap-jet event originates from a different flow of the colour charges in the events, which affects the hadron formation process.

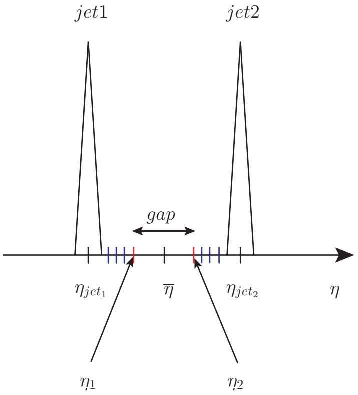
Particle production in jet events

Hadronisation process was obtained with Pythia 8.



The density of produced particles is reduced by two orders of magnitude, when no colour is transfered between the jets.

We define gap between the jets as follows:



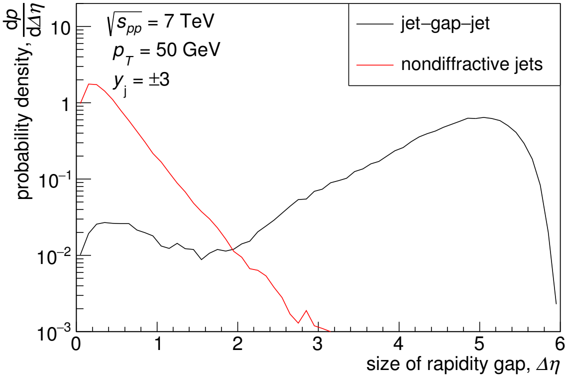
Fixed configuration:

$$\overline{\eta} = 0$$

$$\eta_{jet_1} = -3$$

$$\eta_{jet_2} = +3$$

Particle production in jet events

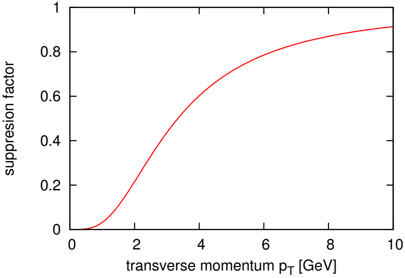


Rapidity gap distributions for the selected kinematical configuration.

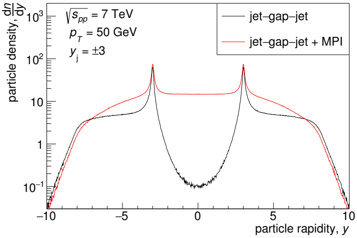
Multi parton interactions

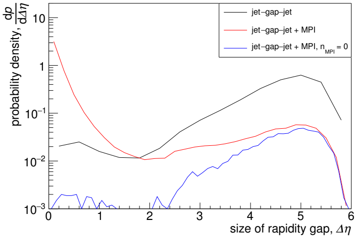
The MPIs are modeled in Pythia with the help of minijets calculated in collinear factorization approach with a special treatment at low transverse momenta by multiplying standard cross section by a suppression factor.

$$F_{sup}(p_t) = \frac{p_t^4}{(p_{t0}^2 + p_t^2)^2}\theta(p_t - p_{t,cut})$$



Multi parton interactions in jet-gap-jet events





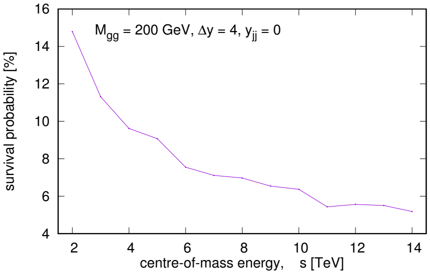
- additional particles are produced in the region where gap was expected

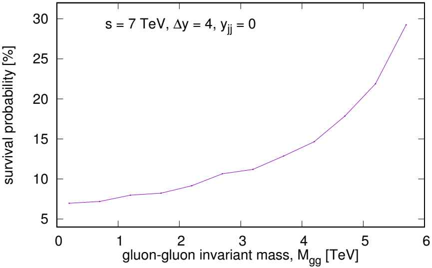
- the blue curve contains MPI effects but only for events without additional interactions
- gap greater than 5 - no additional interactions occured

Kinematics depedence of gap survival probability, defined as a fraction of events in which any additional parton-parton interactions occured.

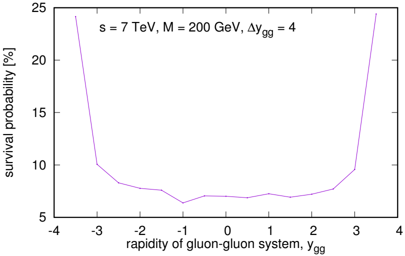
$$S_G = \frac{\text{result with MPI}, n_{MPI}=0}{\text{result without MPI's}}$$

Survival probality of gap





Survival probality of gap



A sudden effect appears at the borders of y_{gg} where less energy is avaible for MPI's.

More realistic situations - integration over phase space (Monte Carlo simulations).
We impose only cuts on transverse momentum $200 GeV > p_T > 40 GeV$.
For illustration process dynamics we take LL BFKL amplitude as disscussed in *O. Kepka, C. Marquet, and C. Royon,Phys. Rev. D 83, 034036*

$$A(\Delta\eta, p_T^2) = \frac{16 N_C \pi \alpha_s^2}{C_F p_T^2}$$

$$\sum_{p=-\infty}^{\infty} \int \frac{d\gamma}{2i\pi} \frac{[p^2 - (\gamma - 1/2)^2] exp(\alpha \chi_{eff}[2p, \gamma, \alpha] \Delta\eta)}{[(\gamma - 1/2)^2 - (p - 1/2)^2][(\gamma - 1/2)^2 - (p + 1/2)^2]}$$

BFKL amplitude for gg→gg with color singlet exchange

$$A(\Delta\eta, p_T^2) = \frac{16 N_C \pi \alpha_s^2}{C_F p_T^2}$$

$$\sum_{p=-\infty}^{\infty} \int \frac{d\gamma}{2i\pi} \frac{[p^2 - (\gamma - 1/2)^2] exp(\alpha \chi_{eff}[2p, \gamma, \alpha]\Delta\eta)}{[(\gamma - 1/2)^2 - (p - 1/2)^2][(\gamma - 1/2)^2 - (p + 1/2)^2]}$$

with the normalization: $\frac{d\sigma}{dt} = \frac{|A_{gg \to gg}|^2}{16\pi}$

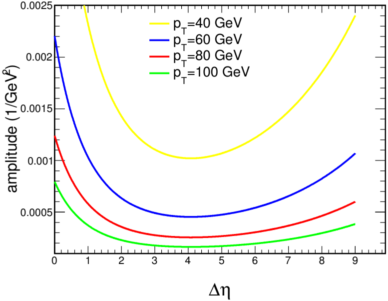
$$\chi_{eff} = 2\psi(1) - \psi\left(1 - \gamma + \frac{|p|}{2}\right) - \psi\left(\gamma + \frac{|p|}{2}\right)$$

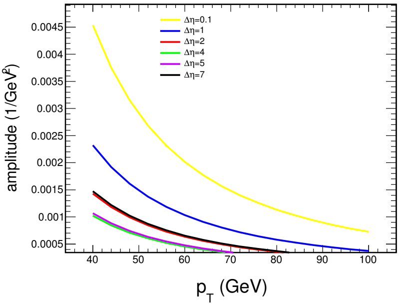
$\psi(\gamma) = d \log \Gamma(\gamma)/d\gamma$ is derivative of Gamma function

α_s in leading-logarithmic calculations is taken as a constant value

p is called conformal spin

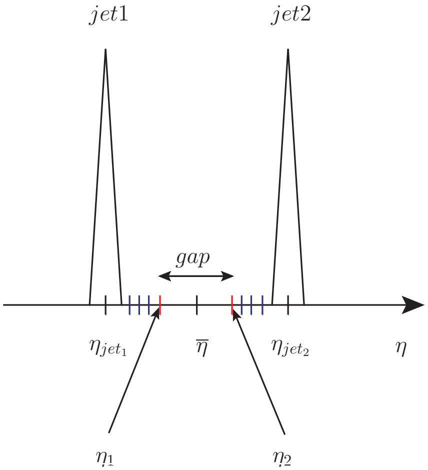
BFKL amplitude for gg→gg with color singlet exchange



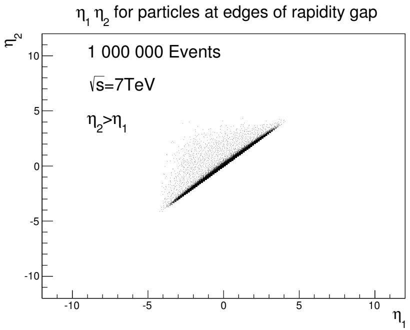


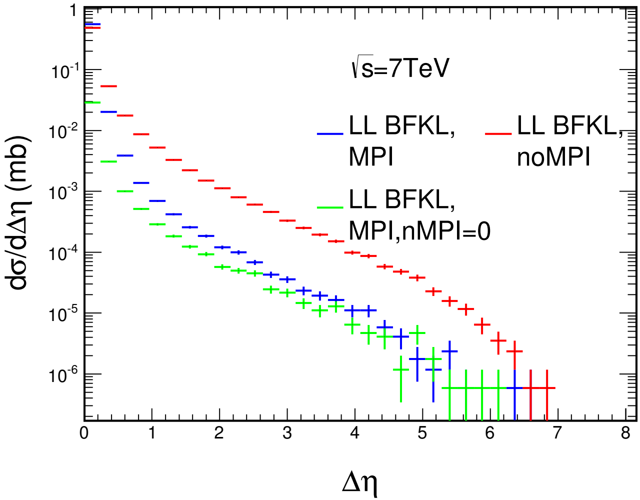
The gap between jets

We find gaps between jets as follows: $\overline{\eta} = \frac{\eta_{jet_1}+\eta_{jet_2}}{2}$

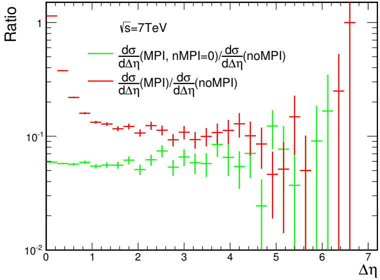


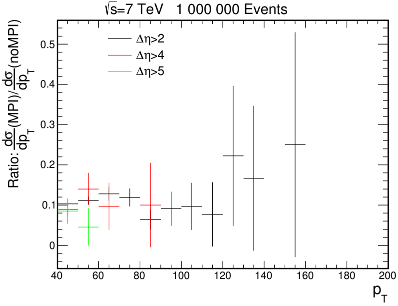
$$\Delta\eta_{gap} < \left|\eta_{jet_1} - \eta_{jet_2}\right|$$




√s=7TeV
LL BFKL, MPI
LL BFKL, noMPI
LL BFKL, MPI,nMPI=0
dσ/dΔη (mb)
Δη
1
10^-1
10^-2
10^-3
10^-4
10^-5
10^-6
0
1
2
3
4
5
6
7
8

Ratio MPI/noMPI

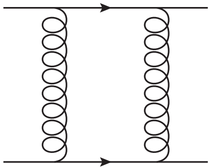


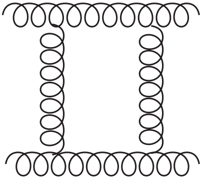


Color singlet two-gluon exchange

The two-gluon exchange is disscussed for egxample in: *The Pomeron in QCD*, V. Barone E. Predazzi

We need also:





with extra color factor: $(\frac{81}{16})^2$

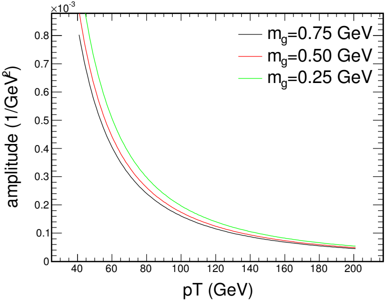
Color singlet two-gluon exchange

Two-gluon exchange amplitude:

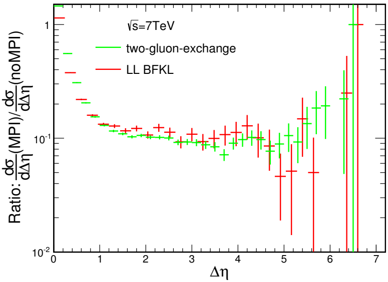
$$A_{gg\to gg} = \frac{16}{9}\frac{\pi\alpha_s^2}{p_T^2}\log\left(\frac{p_T^2}{m_g^2}\right)$$

with normalization:

$$\frac{d\sigma}{dt} = \frac{|A_{gg\to gg}|^2}{16\pi}$$



Jet-gap-jet vs two-gluon color singlet exchange

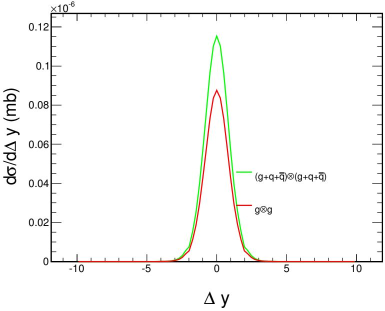


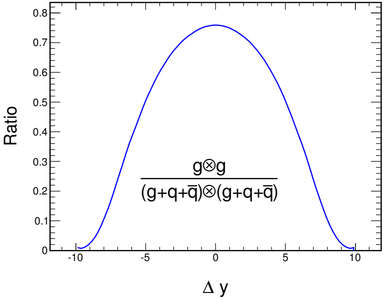
- MPI effects destroy large rapidity gaps and cause increasing number of events with small rapidity gaps.
- In the the two-gluon exchange aproximation one can observe a similar effect

Conclusions

- Detailed studies of the role of multi parton interactions in jet-gap-jet process have been performed.
- Fixed kinematical configurations have been studied.
- To describe dynamics of jet-gap-jet process LL BFKL framework has been used.
- The two-gluon simple approximation has been performed for comaprison.
- The subprocess amplitudes for the color singlet exchange have been implemented in PYTHIA 8.

The MPI effects lead to depedence on kinematical variables of the gap survival factor, in contrast what is ussally assumed in the literature.


×10⁻⁶
dσ/dΔ y (mb)
0.12
0.1
0.08
0.06
0.04
0.02
0
-10
-5
0
5
10
Δ y
(g+q+q̄)⊗(g+q+q̄)
g⊗g


Ratio
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
-10
-5
0
5
10
Δ y
g⊗g
(g+q+q̄)⊗(g+q+q̄)