Jet-gap-jet in diffraction

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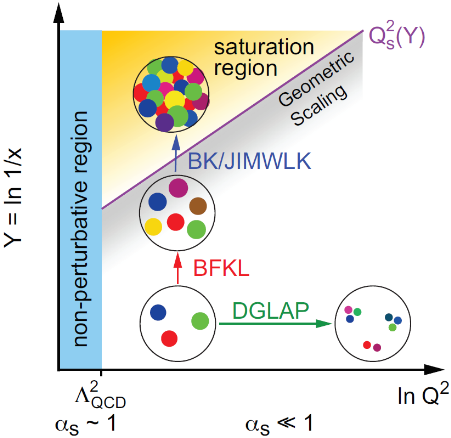
Balitsky-Fadin-Kuraev-Lipatov (BFKL) equations



- BFKL evolution equation in x, the fraction of momentum of the interacting parton.
- DGLAP describes the evolution in Q^2, the transferred energy squared.

Jet-gap-jet as a probe for BFKL resummation effects

Color singlet exchanged in the t-channel; the BFKL Pomeron.
Signature: Dijet with gap in rapidity. $(\sqrt{s} \gg p_T \gg \Lambda_{QCD})$

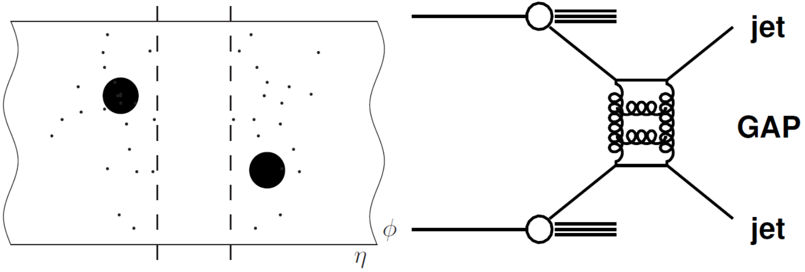
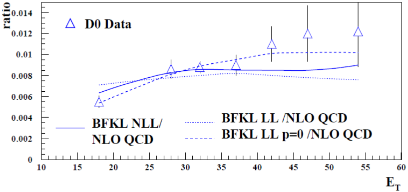
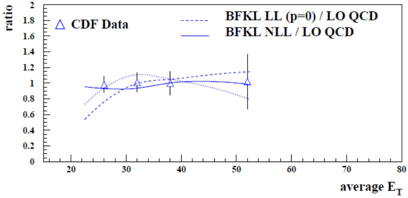


Figure: Left: Dijet with rapidity gap in η-ϕ plane. Right: Inclusive jet-gap-jet event.

Previous measurements (D0, CDF)

D0 and CDF at Tevatron comparison with BFKL NLL at $\sqrt{s} = 1.8\,TeV$ (O. Kepka, C. Marquet, C. Royon arXiv:1012.3849v2)





Previous measurements (CMS, ATLAS)

Dijet production with a large rapidity between jets, CMS-PAS-FSQ-12-001

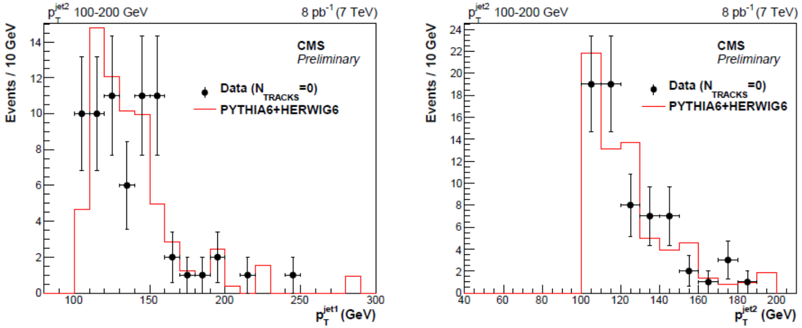
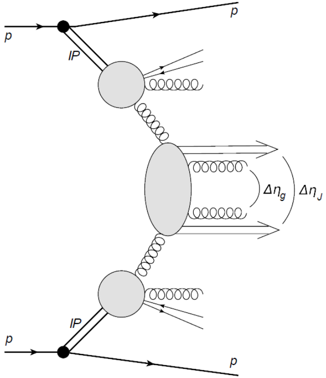


Figure: $8pb^{-1}$ sample of 2010 run at $\sqrt{s} = 7\,TeV$

ATLAS performed the so-called jet veto measurement; cuts the BFKL effects.

BFKL resummation effects in $pp \to pJGJp$

Cleaner measurement and access to greater rapidity gaps $\Delta\eta$.



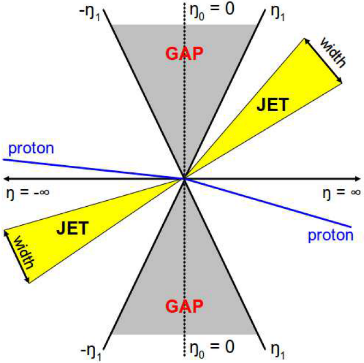


Figure: Left: DPE event with jet-gap-jet. Right: DPE jet-gap-jet event in rapidity plane.

Implementation in Forward Physics Monte Carlo

The differential cross-section for two jets production reads,

$$\frac{d\sigma^{pp\to XJJY}}{dx_1 dx_2 dp_T^2} = \mathcal{S} f_{eff}(x_1, p_T^2) f_{eff}(x_2, p_T^2) \frac{d\sigma^{gg\to gg}}{dp_T^2} \qquad (1)$$

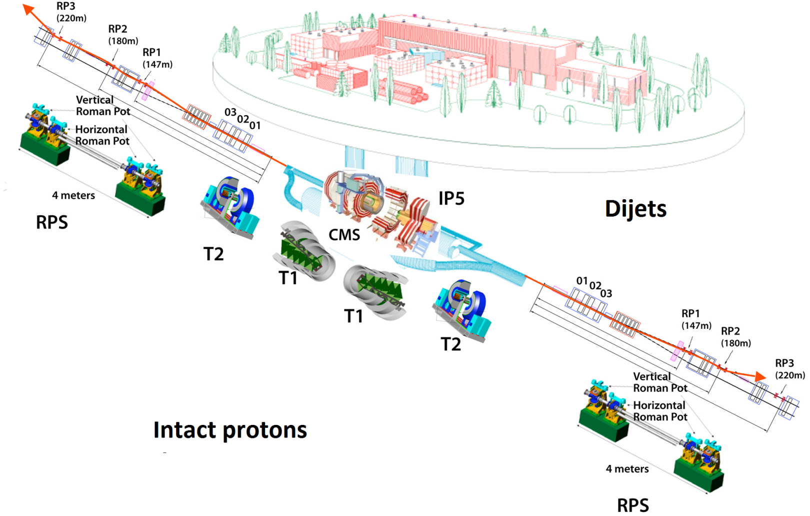
x_i is the fractional momentum of the interacting parton, f_{eff} the effective parton density functions, $\mathcal{S}$ the survival probability (0.03 at the LHC). The BFKL formalism allows to compute the parton level 2-to-2 cross-section,

$$\frac{d\sigma^{gg\to gg}}{dp_T^2} = \frac{1}{6\pi} |\mathcal{A}(\Delta\eta, p_T^2)|^2 \qquad (2)$$

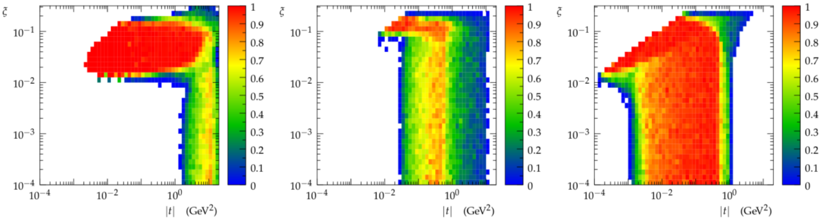
Where $\Delta\eta = \ln(\frac{x_1 x_2 s}{p_T^2})$. The parton level cross-section at NLL is parametrized in order to be implemented in **FPMC**. (P. Świerska, M. Trzebiński, arXiv:1504.06271v2)

CMS and TOTEM

Jet-gap-jet deposited in CMS and intact protons in Roman Pots located at $\approx 220m$ from the IP.



Typical run scenarios (Jan Kašpar)



$\beta^* = 0.55$ m	medium $\beta^* = 90$ m	high $\beta^* = 1535$ m
$\mathcal{L} \approx 10^{33}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$	$\mathcal{L} \approx 10^{28}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$	$\mathcal{L} \approx 10^{27}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$
elastic scattering: high $\lvert t \rvert$	*elastic scattering*: low to mid $\lvert t \rvert$	*elastic scattering*: very low $\lvert t \rvert$ (Coulomb-nuclear interference)
diffraction: $\xi \gtrsim 0.03$, low cross-section processes	*diffraction*: any ξ for $\lvert t \rvert \gtrsim 0.01$ GeV^2	

Figure: ξ is the fractional momentum loss of the proton, t the transferred four-momentum squared.

Experimental environment

Inclusive DPE jets production is the main background. Can be reduced with large-rapidity gap requirement and proton tagging.

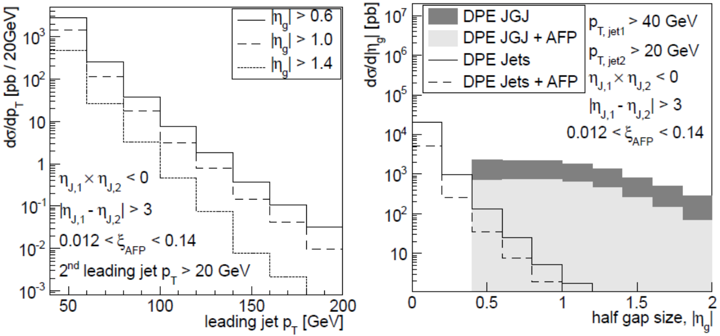


Figure: DPE-Jets and DPE jet-gap-jet distributions with and without proton tagging. (C. Marquet, C. Royon, M. Trzebiński, R. Žlebčik, arxiv:1212.2059)

Test of BFKL at the LHC

The ratio $R = \frac{\sigma(\text{DPE}-\text{JGJ})}{\sigma(\text{DPE}-\text{Jets})}$ as an observable for resummation effects

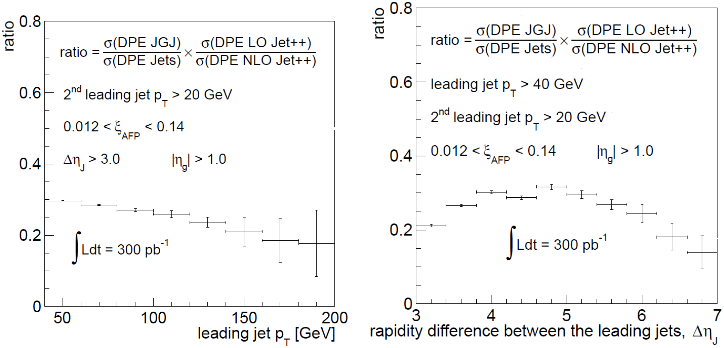


Figure: Predictions for R as function of p_T (Left) and $\Delta\eta$ (Right). $\mathcal{L} = 300pb^{-1}$ and $\beta^* = 0.6m$ is assumed in this study. (C. Marquet, C. Royon, M. Trzebiński, R. Žlebčik, arxiv:1212.2059)

Outlook

- Update Monte Carlo studies for double-tagging in the light of $\beta^* = 90m$ optics and CMS-TOTEM specs.
- Monte Carlo studies for jet-gap-jet with single proton tagging, also to be measured at the LHC.
- Analyze currently available jet-gap-jet events from the $\sqrt{s} = 7TeV$ and $13TeV$ runs.
- Analyze jet-gap-jet with intact protons events for CMS-TOTEM 2017 runs (To be discussed after this workshop).

Back-up

$$\mathcal{A}(\Delta\eta, p_T^2) = \frac{16 N_c \pi \alpha_S^2(p_T^2)}{C_F p_T^2} \sum_{p=-\infty}^{\infty} \int \frac{d\gamma}{2i\pi} \frac{p^2-(\gamma-1/2)^2 \exp(\bar{\alpha}(p_T^2)\chi_{eff}[2p,\gamma,\bar{\alpha}(p_T^2)]\Delta\eta)}{[(\gamma-1/2)^2-(p-1/2)^2][(\gamma-1/2)^2-(p+1/2)^2]}$$