# The pomeron mechanism particles at hadron colliders.

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#### Major task

The main challenge is to get the total and differential cross sections for the process of pomeron mechanism creation quark pairs in proton–proton process at LHC at the leading and the next–to–leading order. The total and differential cross sections were obtained by TwoPhotonGen program written in C++. We used Monte–Carlo method. The total and differential cross sections were obtained for elastic cases.

#### Major task

The Dijet production by double pomeron exchange was studied in many articles at leading order (Can see theoretical studying at arXiv:1704.04387 (Monte Carlo generator ExDiff), arXiv:1102.2531 (FPMC: a generator for forward physics, arxiv 1611.05079v1 (LHC Forward Physics), etc.),can see experimental studying at Phys. Lett. B754 No. 10, P.214-234 ant etc.).

#### Leading Order

The following diagram of the processes is shown:



Figure 1: The diagrams of the process

Where P1 and P2–4–momentum for initial hadron, Where P1' and P2'–4–momentum for hadrons at forward detectors, p1 and p2–4-momentums initial gluons, k1 and k2–4-momentums finite particles.

#### Leading Order

The following diagram of the subprocesses is shown in the leading order:

$$g \hspace{0.1in} g \hspace{0.1in} \rightarrow \hspace{0.1in} u \hspace{0.1in} u$$



#### Figure 2: The diagrams of the subprocess in the leading order

#### Next-Leading Order

The Selves–Energies diagram of the subprocesses is shown in the next–leading order:



Figure 3: The selves-energies diagrams of the subprocess in the next-to-leading order

#### Next-Leading Order

The Vertex diagram of the subprocesses is shown in the next-to-leading order:



Figure 4: The vertex diagrams of the subprocess in the next-to-leading order

The pomeron flux was created by Bruni[P. Bruni, G. Ingelman. Phys. Lett. B311 (1993) 317–323] is used to obtain of total and differential cross sections.

$$f_{P/p}(x_P,t) = \frac{1}{x_P} (6.38 * e^{8t} + 0.424 * e^{3t}) \frac{1}{2.3},$$
(1)

where  $f_{P/p}$  - the pomeron flux's distribution in proton.

$$f_{g/P} = 6(1-x)^5,$$
 (2)

where  $f_{g/P}$  the gluon flux's distribution in pomeron. Total cross section is given:

$$\sigma(s) = \int dx_{P1} dx_{P2} dx_1 dx_2 dt_1 dt_2 f_{P/p}(x_{P1}, t1) f_{P/p}(x_{P2}, t2) f_{g/P}(x_1) f_{g/P}(x_2) \hat{\sigma},$$
(3)

where  $\hat{\sigma}$ -total cross section of subprocess,  $t1 = (P1 - p1)^2$ ,  $t2 = (P2 - p2)^2$ ,  $t1_{max} = t2_{max} = 2 \text{ Gev}^2$ ,  $t1_{min} = -\frac{m_p x_{P1}^2}{1 - x_{P1}}$ ,  $t2_{min} = -\frac{m_p x_{P2}^2}{1 - x_{P2}}$ and  $x_P < 0.1$ . We used Mandelstam variables for a description of the square module of the matrix elements of the investigated process. The amplitudes and diagrams of the matrix element were obtained in the program Mathematica using the package FeynArts 3.9. The square module matrix element was obtained in the program Mathematica using the package FeynCalc 9.0.1.

The dimensional regularization developed by 't Hooft[G. 't Hooft, 1971, Nucl. Phys. B33, 173] and Veltman[G. 't Hooft, M Velman 1972, Nucl. Phys. B44, 189] and the scheme of renormalization were used to calculate the UV- and IR-finite amplitudes. The packages LoopTools was used to calculate numerical loops integrals.

The cuts for ATLAS shown at table 1 were used to calculate total and differential cross section.

Cut	Value	
$m_{q^-\bar{q}^+}$	20 GeV	
<i>p</i> <sub>t</sub>	10 GeV	
$ \eta $	2.4	
Forward detector: $ \eta_{ ho} $	4.3 $< \eta_{ ho} $ $<$ 4.9	

Table 1: The cuts for ATLAS

There are total cross section at the table 2 for the leading and the next–leading order at Tevatron and LHC at the elastic case.

Collider	LO $\sigma$ pb	NLO $\sigma$ pb
LHC $\sqrt{s} = 7$ TEV	910.8	1181
LHC $\sqrt{s} = 8$ TEV	995.7	1303
LHC $\sqrt{s} = 13$ TEV	1402	1882
LHC $\sqrt{s} = 14$ TEV	1497	1992

Table 2: Total Cross sections  $\sigma$  pb

The differential cross section as a function of the invariant mass of the  $b\bar{b}$ , where the blue line – the leading order and the red line – the next–leading order at  $\sqrt{s} = 7.0$  TeV.



Figure 5: Distribution in the invariant mass  $b\overline{b}$ 

The differential cross section as a function of the transverse momentum of b-quark, where the blue line – the leading order and the red line – the next-leading the order at  $\sqrt{s} = 7.0$  TeV.



Figure 6: Distribution in the momentum b-quark

The differential cross section as a function of the invariant mass of the  $b\bar{b}$ , where the blue line – the leading order and the red line – the next–leading order at  $\sqrt{s} = 8.0$  TeV.



Figure 7: Distribution in the invariant mass  $b\bar{b}$ 

The differential cross section as a function of the transverse momentum of b-quark, where the blue line – the leading order and the red line – the next-leading the order at  $\sqrt{s} = 8.0$  TeV.



Figure 8: Distribution in the momentum b-quark

The differential cross section as a function of the invariant mass of the  $b\bar{b}$ , where the blue line – the leading order and the red line – the next–leading order at  $\sqrt{s} = 13.0$  TeV.



Figure 9: Distribution in the invariant mass  $b\overline{b}$ 

The differential cross section as a function of the transverse momentum of b-quark, where the blue line – the leading order and the red line – the next-leading the order at  $\sqrt{s} = 13.0$  TeV.



Figure 10: Distribution in the momentum b-quark

The differential cross section as a function of the invariant mass of the  $b\bar{b}$ , where the blue line – the leading order and the red line – the next–leading order at  $\sqrt{s} = 14.0$  TeV.



Figure 11: Distribution in the invariant mass  $b\bar{b}$ 

The differential cross section as a function of the transverse momentum of b-quark, where the blue line – the leading order and the red line – the next-leading the order at  $\sqrt{s} = 14.0$  TeV.



Figure 12: Distribution in the momentum b-quark

We obtained total and differential cross section in the leading and the next-to-leading order for the process of pomeron mechanism production quark pair in the proton-proton processes at LHC using the cuts for the quark and the final hadrons. We obtained what the total cross section for the leading order less than the total cross sections for the next-leading order. We showed what the process of pomeron mechanism production quark pair in the proton-proton process at LHC can be used to studying perturbation and nonperturbation QCD of the collider LHC and to search "new physics"

Thank you for your attention!