

Production of two pairs of J/ψ mesons and simultaneous production of D and B mesons in the context of double parton scattering

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Phenomena of multiple-parton interaction (MPI) have become very essential for precise description of high-energy proton-proton collisions in the ongoing LHC era.

Some time ago we have proposed and discussed double open charm meson production $pp \rightarrow DD X$ as a potentially one of the best reaction to study hard double-parton scattering effects at the LHC.

This conclusion was further confirmed by the LHCb collaboration that has reported surprisingly large cross sections for DD meson-meson pair production in pp -scattering at 7 TeV.

Here we discuss production of two pairs of J/ψ quarkonia in the context of recent results obtained at the LHC at large and intermediate p_t .

The leading-order $\mathcal{O}(\alpha_s^4)$, called here also box, contribution is calculated in both collinear and the k_t -factorization approach with the KMR unintegrated gluon distributions.

We include also two-gluon exchange (between two $c\bar{c}$ intermediate pairs) contribution which is of the order of $\mathcal{O}(\alpha_s^6)$, in the moment only in the collinear approximation.

We calculate cross sections for $pp \rightarrow \chi_c(J_1)\chi_c(J_2)$.

A feed-down from double χ_c single-parton-scattering production is estimated for the first time.

The double parton scattering is calculated using an educated parametrization of single J/ψ differential distributions in rapidity and transverse momentum at the LHC energies.

Many differential distributions are calculated.

Results of our calculations are compared with very recent ATLAS data.

We find that the two-gluon exchange mechanism and the double feed down lead to very similar (in shape) distributions in rapidity distance between the J/ψ mesons.

Much larger cross sections are obtained in the k_t -factorization approach.

Including the mechanisms, some of them for a first time, leaves much less room for the double parton scattering contribution which cannot be calculated from first principle.

The σ_{eff} parameter for DPS needed to describe the ATLAS data is therefore much larger than from previous studies of double quarkonium production, where a smaller number of mechanisms was included.

In addition here, we present results of phenomenological studies of DPS effects in the case of associated open charm and bottom

$pp \rightarrow D^0 B^+ X$ as well as double open bottom

$pp \rightarrow B^+ B^+ X$ production. In particular, we will show

theoretical predictions of integrated and differential cross sections for different energies that could help to conclude whether and how the DPS effects for these two cases can be observed experimentally by the LHCb/CMS collaborations.

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