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Central exclusive production of $\rho\rho$ pairs in proton collision

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Abstract. Model for $pp \to 4\pi$ via 2ρ was outlined. The prediction for the cross section for this process was given for ATLAS and ALICE experimental cuts. This process has sufficient cross section to be observed in these experiments.

1 Introduction

We investigate the central exclusive production of $\rho\rho$ pairs in pp collisions at LHC energies. At low central invariant mass this process can be considered as a possible non-resonant background for glueball searches in four-body final states. Above the resonance region non perturbative production mechanism can be studied. All calculations have been performed using generator GENEX [3], specially designed for effective integration of exclusive processes in restricted phase space.

2 General description of the model

The Lebiedowicz & Szczurek model [1] was used in the form

$$\begin{aligned} ME_{LS\,2\pi}(p_1, p_2, p_3, p_4) = M_{13}(t_1, s_{13})F(t_a)\tfrac{1}{t_a - m_\pi^2}F(t_a)M_{24}(t_2, s_{24}) + \\ M_{14}(t_1, s_{14})F(t_b)\tfrac{1}{t_b - m_\pi^2}F(t_b)M_{23}(t_2, s_{23}), \end{aligned} \tag{1}$$

where M_{ij} is the elastic $p\pi$ scattering amplitude and hadronic form-factor

$$F(t) = exp\left(\frac{t - m_\pi^2}{\Lambda^2}\right), \tag{2}$$

depends on parameter Λ. The following replacements were made:

- Replace M_{ij} for $p\pi$ amplitude with the amplitude for $p\rho$ scattering according to the Vector-Dominance model, see section 5.3 of [2],
- In (1) and (2) change m_π to m_ρ.

The above described matrix element for $pp \to pp + \rho\rho$ after addition of ρ decay amplitude and symmetrization for the identical particles in final state has the following form[1]:

$$ME = \frac{1}{\sqrt{2!}}(ME(p_1, p_2, p_3, p_4, p_5, p_6) + ME(p_1, p_2, p_5, p_4, p_3, p_6)), \tag{3}$$

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[1]The factor $\frac{1}{\sqrt{2!}}$ is the symmetry factor which usually appears in the formula for the cross section.

$$ME(p_1, p_2, p_3, p_4, p_5, p_6) = ME_{LS2\rho}(p_1, p_2, p_3, p_4, p_5, p_6) \times \frac{1}{3}(\sum_{\lambda\in\{-1,0,+1\}} ME_{\rho\to\pi^+ +\pi^-}(p_3, p_4, \lambda))\times (\sum_{\lambda'\in\{-1,0,+1\}} ME_{\rho\to\pi^+ +\pi^-}(p_5, p_6, \lambda')), \tag{4}$$

where $ME_{LS\rho}$ is the modified Lebiedowicz&Szczurek model [1] with Vector-Dominance model (1) and $\rho \to 2\pi$ is given by the standard Zemach formalism:

$$ME_{\rho\to\pi^+ +\pi^-}(1', 2', m) = N\frac{i\varepsilon_\mu(p_r, m)(p_{1'} - p_{2'})^\mu}{p_r^2 - M_\rho^2 + i\Gamma_\rho M_\rho}. \tag{5}$$

where ε is a ρ vector polarisation vector and $p_r = p_{1'} + p_{2'}$.

This simplified model gives similar cross section(to the order of magnitude) as the one recently presented in [5].

3 Results

Cross sections $\sigma_{pp\to pp+\rho\rho}$ are calculated for full and restricted phase space corresponding to ATLAS and ALICE detectors at $\sqrt{(s)} = 7\ TeV$.

For ATLAS we assume:

- Diffractively scattered protons detected in the ATLAS FORWARD DETECTOR (AFD),
- Pions detected in Silicon Central Tracker SCT $|\eta_\pi| < 2.5$ and $p_{t\pi} > 0.1\ GeV$ (enhanced track reconstruction [4]).

For ALICE we assume:

- Pions detected in the Central Barrel (CB) $|\eta_\pi| < 0.9$ and $|p_{t\pi}| > 0.017\ GeV$,
- particles in the rapidity range $-3.7 < \eta_\pi < -0.9$ or $0.9 < \eta_\pi < 5.1$ can be anti-selected in the trigger detectors veto system (TDV) VZERO+FMD+SPD.

W define five phase space regions corresponding to the following event selection setups:

- ATLAS-I: Protons in AFD with $|t_p| < 1\ GeV^2$ and 4π in SCT,
- ATLAS-II: Protons in AFD with $|t_p| < 1\ GeV^2$ and two opposite-sign pions in SCT,
- ATLAS-III: Protons in AFD with $|t_p| < 1\ GeV^2$ and two same-sign pions in SCT,
- ALICE: 4π in CB.

Table 1. Cross section estimation.

Phase Space	$\Lambda[GeV]$	σ
Full	0.5	6.027 nb
Full	1.0	0.41 μb
ATLAS-I	1.0	49.2 nb
ATLAS-II	1.0	60.4 nb
ATLAS-III	1.0	5.97 nb
ALICE	1.0	3.05 nb

The results are presented in Table 1 and in Figs. 1 and 2. In the figures the cross section ratio $R = \sigma_{pp\to pp+\rho\rho}/\sigma_{pp\to pp+\pi\pi}$ was drawn as absorption is to large extent cancelled using this variable. It should be noted that recently presented model calculations for the same process [5] give results differing from ours by more than order of magnitude. This model is based on the tensor pomeron exchange in $p\rho \to p\rho$. The source of so large differences will be investigated.

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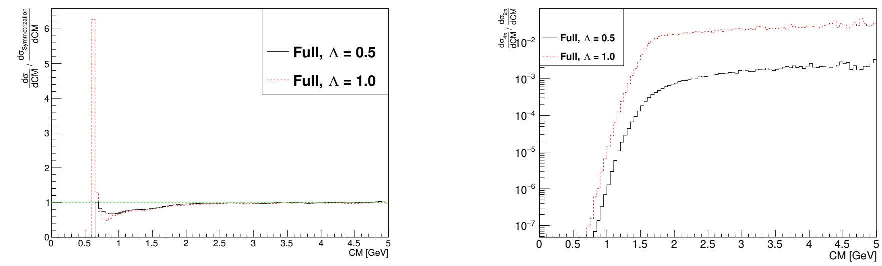

Figure 1. Left: Symmetrization effect full phase space. Right: Cross section ratio full phase space.

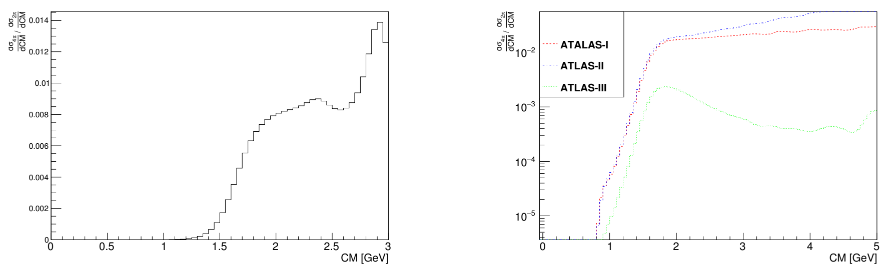

Figure 2. Left: Cross section ratio ALICE. Right: Cross section ratio ATLAS-I/II/III.

4 Conclusions

The cross section for central exclusive production of $\rho\rho$ pairs at LHC energies is rather small in comparison with central exclusive production of pion pairs and depends strongly on parameter Λ. The process $pp \rightarrow pp + \rho\rho \rightarrow pp + 4\pi$ does not contribute to the background of the exclusive production of pion pairs, neither in ALICE nor in the ATLAS experiment. In the resonance region of the central invariant mass $M_{central} < 2.0\ GeV$ the effect of the symmetrisation for identical particles ($\rho\rho$ mixing) is significant, making the signal identification event more difficult.

References

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