Analysis Note
of the STAR Experiment

Measurement of Central Exclusive Production with Roman Pot detectors in diffractive proton-proton interactions at $\sqrt{s} = 200$ GeV

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Abstract

In this note we present analysis of the Central Exclusive Production process using data from proton-proton collisions collected in 2015. This data was collected using the Roman Pot detectors which ensured efficient triggering and measuring diffractively scattered protons. We describe all intermediate stages of analysis involving extraction of the acceptance and effciency corrections, comparison of data with Monte Carlo simulations of detector response, and study of systematic uncertainties. Finally, we show the physics outcome of the analysis.

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1. Introduction

1.1 Central Exclusive Production

The Central Exclusive Production (CEP) takes place when interacting particles form in the mid-rapidity region a state ("central production") whose all constituents/decay products are measured in the detector ("exclusive"). The initial state particles can either dissociate, excite or stay intact. The latter case of CEP in proton-proton collisions can be written as

$$p \; + \; p \quad \rightarrow \quad p \; + \; X \; + \; p \tag{1.1}$$

and depicted as in Fig. 1.1. Mass and rapidity of state X is given by

$$M_X = \sqrt{s\Big(\xi_1\xi_2 \sin^2(\alpha/2) - (1-\xi_1-\xi_2)\cos^2(\alpha/2)\Big)} \overset{\alpha=\pi}{=} \sqrt{s\xi_1\xi_2}, \tag{1.2}$$

$$y_X = \frac{1}{2}\ln\frac{\xi_1}{\xi_2}, \tag{1.3}$$

where α is angle between scattered protons and $\xi = (p_0 - p)/p_0$ is the fractional momentum loss of proton.

1.2 Double IPomeron Exchange

Reaction from Eq. 1.1 can exhibit purely electromagnetic (γ-γ), mixed (γ-$\mathcal{O}$) or purely strong nature ($\mathcal{O}$-$\mathcal{O}$). The last type is dominant at RHIC energies. It is characterized by the lack of hard scale (if protons are scattered at small angles), therefore perturbative QCD cannot be applied and Regge theory [1] is used instead. An object $\mathcal{O}$ does not have direct QCD representation - in Regge framework it is the so-called "trajectory" (IReggeon, IR). IReggeon with quantum numbers of vacuum is called "IPomeron" (IP) and IP-IP reaction (Fig. 1.2) is called "Double IPomeron Exchange".

Processes involing IPomeron exchange are referred as diffraction due to cross-section in scattering angle resembling similar shape to instesity pattern of diffracted light. Diffractive events have specific property of the "rapidity gap" which is an angular region free of hadrons. In DIPE two such gaps are present, marked in Fig. 1.1 as $\Delta\eta_1$ and $\Delta\eta_2$.

DIPE is a spin-parity filter - from the fact that scattered particles have all quantum numbers unchanged after the interaction, central states must satisfy

$$I^G J^{PC} = 0^+\text{even}^{++}. \tag{1.4}$$

The lowest order QCD representation of the IPomeron is a pair of oppositely colored gluons. This fact makes the DIPE recognized as the gluon-rich environment process which should enhance production of the bound states of gluons ("glueballs"), whose existence has not yet been proven experimentally.

For detailed introduction to the topic of diffraction see [2,3].

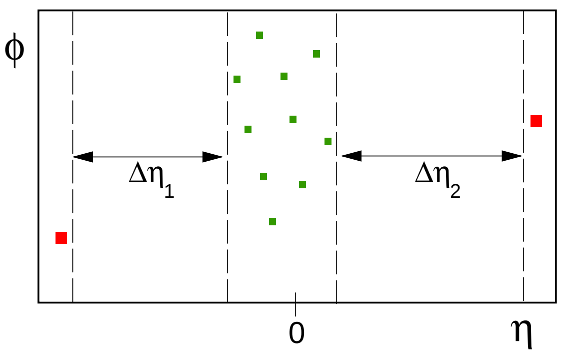

Figure 1.1: Central Exclusive Production in η-ϕ space.

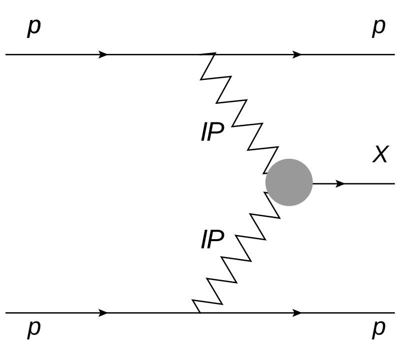

Figure 1.2: Diagram of DIPE process.

1.3 Physics motivation for the measurement

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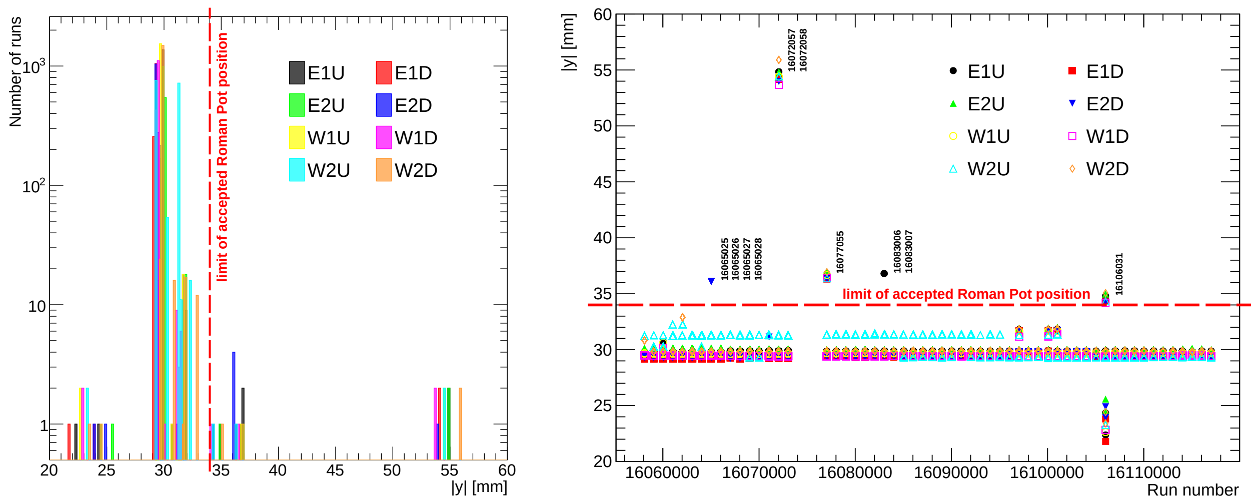
2. Data set

2.1 Bad runs



(a) (b)

Figure 2.1: map of elastic proton hits in .

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