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Silicon vertex tracker for PHENIX detector at the central rapidity region

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Abstract

We present the status of the silicon vertex tracker for the PHENIX experiment. The purpose of the PHENIX detector is to investigate very high-density and high-temperature matter, so called Quark Gluon Plasma in heavy ion collisions upto 100 GeV/nucleon and spin structure of the nucleon with polarized proton beam up to 250 GeV/beam. We plan to build the silicon vertex tracker to identify the charm and bottom quark decay by using displaced decay vertex, with two inner pixel layers and two outer stripixel layers. The design goal of the displaced vertex resolution is at the level of 30–50 μm in high charged multiplicity environment with minimum material budget requirement to avoid generating background for outer detectors in the PHENIX.

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1. Physics motivation

We are investigating characteristics of the Quark Gluon Plasma (QGP) by using heavy ion collisions and the origin of proton spin by using polarized proton–proton collisions.

If the gluon density is high enough, charm quark can be produced in addition to the initial proton–proton collisions. The bottom quark can be produced only in the initial proton–proton collisions, since its mass is much heavier than the charm mass. Measuring charm and bottom production will give us the information about early stage of the heavy ion collisions and later stage [1].

Protons consist of quarks and gluons. The spin of the proton should be explained by the sum of spin of quarks and gluons, and their orbital angular momentum. The contribution from quark spin has been measured by the polarized lepton

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deep inelastic scattering experiment (DIS). However, it is only 20% of the proton spin. Since the gluons cannot interact with leptons, DIS is not best way to investigate gluon contributions. Therefore polarized proton–proton collision will use gluon and quarks as probes to interact gluons. Heavy flavor quarks are mainly produced from gluon–gluon collisions. So, identifying the heavy flavor quarks and measuring their asymmetry of production cross-section will give us the gluon polarization in the nucleon [2].

In both of QGP and spin physics program, it is important to separate charm and bottom quarks as well separating from light flavor quarks.

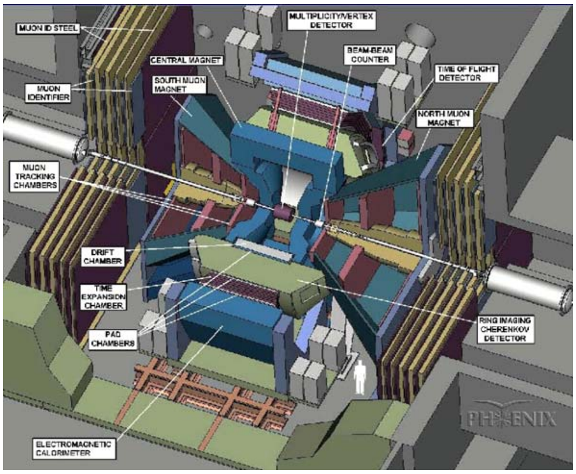

Fig. 1. View of the current PHENIX detector. It consists of central arms, muon arms, and forward detectors.

2. RHIC and PHENIX

RHIC can make collisions of heavy ions up to Au with beam energy up to 100 GeV/nucleon and polarized proton–proton up to 250 GeV/beam with 70% of polarization [3]. The summary of design goal of RHIC is shown in Table 1. Bunches are collided every 106 ns. PHENIX is one of the large scale detectors, which is constructed to detecting photons, electrons, muons, and hadrons with high rate data acquisition capability but having a limited geometrical acceptance [4]. Fig. 1 shows cut view of the current PHENIX detector without silicon vertex tracker. In the central Au–Au collisions at center of mass energy per nucleon 130 GeV, charged multiplicity has been measured as 622 per unit pseudo-rapidity at mid-rapidity region [5]. Typical central Au–Au event is shown in Fig. 2. There is no magnetic field in order to simplify the event display in this figure.

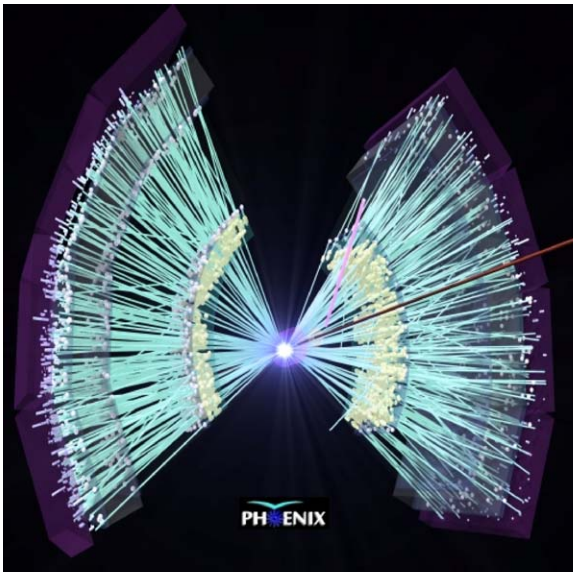

Fig. 2. Typical central Au–Au event at the PHENIX.

Table 1
Summary of RHIC design goal

	Heavy ion	Polarized proton
Beam energy	30–100 GeV/nucleon	30–250 GeV/beam
Luminosity	$2\times10^{26}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$	$2\times10^{32}\,\mathrm{cm}^{-2}\,\mathrm{s}^{-1}$
Ion species	Upto Gold	
Polarization		70%

3. Vertex tracker configuration

The charm and bottom quark have slightly longer life time than other light-flavor quarks. For example, the $c\tau$ of the neutral D° meson and B° meson are 123 and 462 μm, respectively [6]. Therefore, silicon vertex tracker near the beam pipe region, which measures displaced vertex from