Search for the strong magnetic field via di-electron measurement in heavy-ion collisions at RHIC-PHENIX

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A strong magnetic field is expected to be created in high-energy heavy-ion collisions. The intensity of the magnetic field created in the collisions at BNL-RHIC is estimated to reach about 10^{14} teslas. The field creation can be considered to be due to the effect of both of collision participants and collision spectators and the field direction is perpendicular to the reaction plane (Fig. 1).

The possibility of field creation was presented first about 35 years ago[1)]. In recent years, this began to attract attention because achieving an increase in the field intensity with increasing energy of the collider is well beyond the critical field of an electron ($eB_c = m_e^2$). The time evolution of this field is also calculated based on theories. According to the theoretical calculation, the field intensity decreases rapidly, but maintains for a few fm/c above the critical magnetic field of an electron[2)]. Chiral magnetic effects and other interesting effects, such as non-linear QED effects, are discussed based on the theories to be caused by the strong field. From experimental studies, charged particle asymmetry with respect to the reaction plane[3)] and direct-photon azimuthal anisotropy[4)] suggest the presence of the strong field. However, the field itself is yet to be directly detected experimentally.

Direct detection of the field in high-energy nuclear collisions is a very important issue. Detection of the strongest field in the universe has a major impact in itself. Further, the observation of the field leads to the confirmation of the chiral magnetic effect. Moreover, there is a possibility to verify non-linear quantum electrodynamics effects such as vacuum-birefringence and the decay of real photons.

Direct photons/virtual photons are good candidates for probing the field detection, because they are not affected by the strong interaction and they maintain the initial information. Pi0 decay photons/Dalitz-decay electron pairs are candidates for control probes because they are from the later time. Combinatorial pairs from mixed events could also be used as a control probe.

According to the calculation of photon vacuum polarization in a strong magnetic field, the production rate of di-electrons from virtual photon decay depends on the field direction[5)]. Since PHENIX has a good electron-identification capability, we focus on virtual photon decays with a dependence on the magnetic field direction. By using electron pairs from virtual-photon decays as the probe, polarization measurement is possible without the using of a polarimeter.

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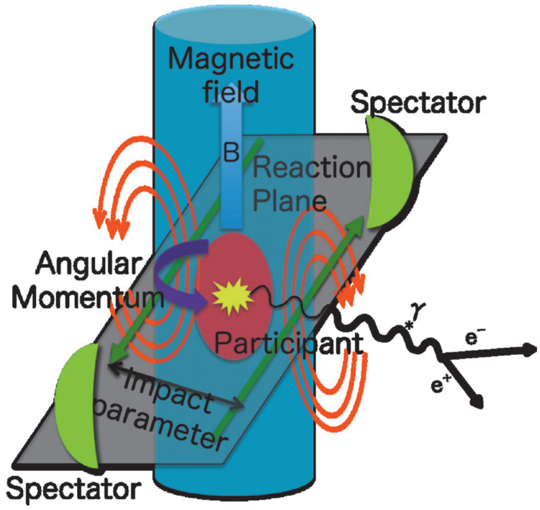

Fig. 1. Schematic image of the magnetic field creation in heavy-ion collision

We are using the $\sqrt{s_{NN}} = 200$ GeV Au+Au collisions data set collected in 2004 at the RHIC-PHENIX. Electrons and positrons are identified by RICH and EMCal, and momentum is decided by Drift Chamber and Pad Chamber. Global variables, z-vertex, centrality and reaction plane, are decided by Beam-Beam Counter.

We select two di-electron invariant-mass region, $0.12 < m_{ee} < 0.3$ GeV/c^2 and $0 < m_{ee} < 0.1$ GeV/c^2. The first region contains virtual photon components, and thus, this region is expected to contain the signal. The second is dominant Dalitz-decay di-electron, which has no-physics effect to polarization. The polarization is measured using the angular distributions of di-electron with a correlation to the reaction plane, as a function of centrality, because it depends on the strength of the created field. Now, we focus on polarizations of Dalitz-dacay pairs and combinatorial pairs, which is important for background subtraction. We discuss what kind of background is included, how to subtract backgrounds, and how to extract the signal.

References

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