# Study of direct photon azimuthal anisotropy in $\sqrt{s_{NN}}$=200GeV Au+Au in RHIC-PHENIX experiment

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High energy heavy ion collision experiments have been performed since 2000 at the Relativistic Heavy Ion Collider (RHIC), in order to study properties of quark-gluon plasma (QGP). Direct photon, which includes all sources from various processes except one from hadron decay, has been measured as a powerful tool. It is expected not to interact strongly with QGP, thus providing information on when it is created. Furthermore, because direct photons are created in various processes during the entire space-time history of collisions, they provide different probes from all stages, for example, initial hard scattering, thermal radiation from QGP, and bremsstrahlung from partonic energy loss. Photons originating from various sources are measured inclusively in the experiment, so there are dificulities in measuring photons while identifying their sources. To circumvent the difficulty, we measure the direct photon azimuthal anisotropy.

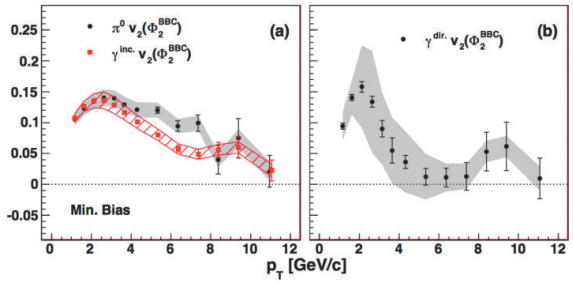


Fig. 1. $v_2$ as a function of $p_T$ of $\pi^0$(Black) and inclusive photon(Red) in the left plots. Direct photon $v_2$ as a function of $p_T$ is in the right plots.[1)]

Azimuthal anisotropy is defined as a relative amplitude of anisotropic azimuthal distribution with respect to the reaction plane. To quantify the anisotropy, Fourier series is used for the azimuthal distribution of the number of emitted particles.

$$dN/d\phi = N_0[1 + \sum 2v_n cos\{n(\phi - \Psi_n)\}] \quad (1)$$

$$v_n = < \cos\{n(\phi - \Psi_n\} > \quad (2)$$

where $\phi$ is the azimuthal angle of photons, and $v_n$ and $\Psi_n$ are the strength and direction of the $n^{th}$-order harmonic azimuthal anisotropy, respectively. The second component ($v_2$) is referred to as elliptic flow and is measured for various dependences (e.g. $p_T$, particle species). It provides the collective properties of the high density matter, possibly QGP, that interacts and expands hydro-dynamically under given initial conditions. In addition, $v_2$ is found to be affected by the initial geometry.

It is found that direct photon $v_2$ is close to zero in the high $p_T$ region, although $\pi^0$ has finite $v_2$. This is consistent with the expectation that prompt photons from intial hard scattering are dominant at high $p_T$. It is also found that direct photon $v_2$ is almost the same as $\pi^0$ at low $p_T$, where thermal photons are thought to be dominant. The precise reason of this large $v_2$ is not well understood yet.

Higher order azimuthal anisotropy $v_n(n > 2)$ is considered to be more sensitive to initial geometry and QGP shear viscosity $\eta/s$ (the ratio of shear viscosity *eta* to entropy density s) under expansion. Hence, $v_n(n > 2)$ has been actively studied recently, and it is considered to be important for calculating the initial state model and the viscosity of QGP. The results of $\pi^{\pm}$, $K^{\pm}$, and $p\bar{p}$ are shown in Fig. 2. It is found that $v_n(n > 2)$ also has collective motion.

The ongoing studies on direct photon $v_n(n > 2)$ could help in understanding the puzzle of direct photon $v_2$.

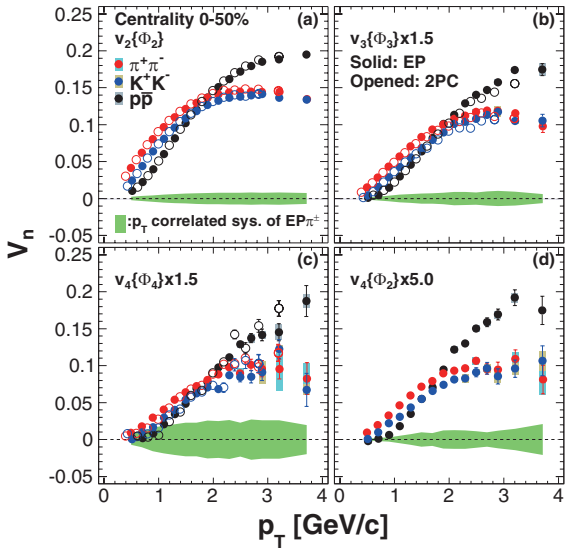


Fig. 2. $\pi^{\pm}$,$K^{\pm}$, and $p\bar{p}$ (a) $v_2$, (b) $v_3 \times 1.5$, (c) $v_4 \times 1.5$, and (d) $v_4(\Psi_2) \times 5.0$ as functions of $p_T$. The green band indicates $p_T$ correlated systematic uncertainties.

References

1) A. Adare et al.: P.R.L. 109, 122302 (2012)

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