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

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High-energy heavy-ion collision experiments have been carried out since 2000 at the Relativistic Heavy Ion Collider (RHIC), to study the properties of quark-gluon plasma (QGP). Direct photons are defined as all photons except for those coming from hadron decays. Photons do not strongly interact with the medium. Furthermore, they are emitted from various sources, such as initial hard scattering, jet fragmentation, and thermal radiation, during all stages of collisions. Thus, direct photon is a powerful tool to study QGP.

Direct photon p_T spectra have been measured via a calorimeter method[1)], virtual photon method[2)], and conversion photon method[3)]. It is found that the p_T spectra of Au+Au collisions include an additional exponential p_T spectra compared to those of p+p collisions scaled by the number of binary collisions. The effective temperature is obtained from the inverse slope of the exponential p_T spectra, it is approximately 240 MeV. It is found that photons mainly originate from a very hot medium in the early stage of collisions, since the kinetic freeze-out temperature obtained is approximately 100 MeV.

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

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

where ϕ is the azimuthal angle of photons, and v_n and Ψ_n are the strength and event plane of the n^{th}-order harmonic azimuthal anisotropy, respectively. The mechanism of azimuthal anisotropy has been studied, and it is understood that it strongly depends on the initial geometry shape. The photon emission angle is expected to depend on the photon sources and initial geometry of the participant shape: thermal photons have $v_2 > 0$, photons fragmented from a jet have $v_2 > 0$, and prompt photons have zero v_2,. Direct photon v_2 is measured[4)] to identify the photon sources. It is found that the strength of direct photon v_2 at around 2 GeV/c is comparable to that of hadron v_2. Because photons are emitted during all stages of collisions, emitted photons should include photons emitted from the medium, which is not yet expanded. This is why direct photon v_2 was predicted to be smaller than hadron v_2 in many theoretical models. Since a photon has large v_2, the results suggest that photons in the low p_T region are mainly generated from in the late stage of collisions.

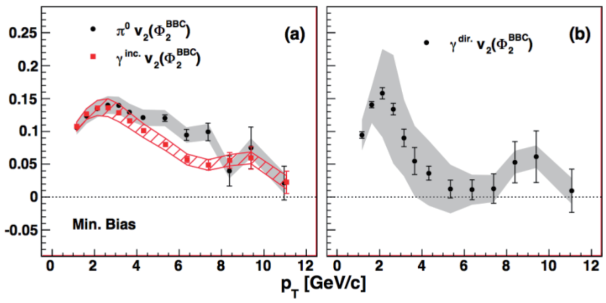

Fig. 1. (Left) v_2 as a function of p_T of a neutral pion (black) and inclusive photon (red). (Right) v_2 as a function of p_T of a direct photon[4)].

There is a discrepancy called "photon puzzle". There are no models to explain both the results simultaneously. In order to constrain the photon production mechanism, the third-order azimuthal anisotropy v_3 is measured. Figure 2 shows direct photon v_3 for $p_T < 4$ GeV/c. It is found that the strength of direct photon v_3 is comparable to that of hadron v_3. It shows a similar trend to direct photon v_2. It can be interpreted that photons emitted in the late stage of collisions are dominant in the low p_T region. These results would be helpful for understanding the photon puzzle.

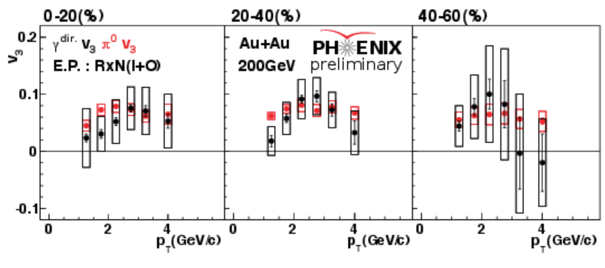

Fig. 2. v_3 as a function of p_T of a neutral pion (red) and direct photon (black) by 20% centrality steps from 0 to 60%.

References
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3) A. Adare et al.: arXiv:1405.3940 [nucl-ex] (2014)
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