Study of identified particle harmonics azimuthal anisotropy in 200GeV Au+Au collisions at RHIC-PHENIX experiment

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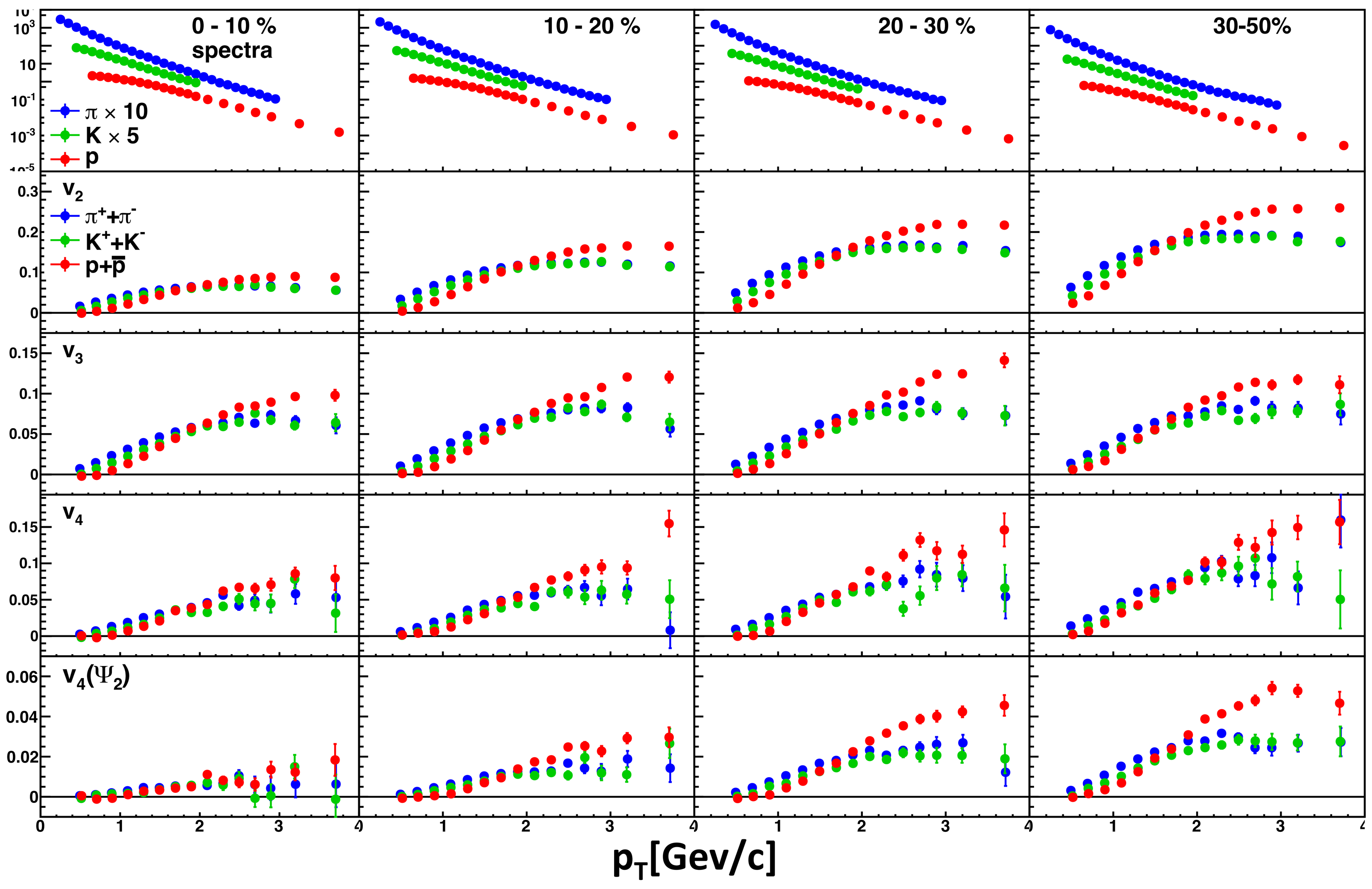
Introduction

Azimuthal anisotropy and particle species dependence of transverse momentum distribution have been studied actively because they reveal information about the QGP generated in high energy heavy ion collisions. From the study of elliptic event anisotropy v_2, we have understood that azimuthal anisotropy is generated by initial participant geometry, with a role for the QGP property η/s (the ratio of shear viscosity(η) to entropy density(s)). In recent years, higher harmonics azimuthal anisotropies $v_{n,n>3}$ are analyzed so hard to improve study of QGP, because they are expected to be more sensitive to initial participant geometry and η/s than will be v_2.

identified particle collective flow

It is known that elliptic anisotropy v_2 and transverse momentum distribution have particle dependence, and recent year it is studied higher harmonic anisotropy v_3, v_4 and $v_4(\Psi_2)$ have also particle dependence. Specially, they have mass dependence in low p_T range.



Blast Wave model

It is known that hydrodynamic model can describe in less than KE_T=1.0[GeV] for spectra and v_2. In this poster, simple hydrodynamic model called Blast Wave is used for comparison with the data, this model can describe the final state from the information at freeze-out such as temperature(T_f), average velocity(ρ_0), anisotropic velocity(ρ_n) and spatially anisotropic(s_n). Spectra is calculated by temperature and average velocity, and v_n is described by temperature, average velocity, anisotropic velocity and spatially anisotropic.

Fitting for not only spectra and v_2 but also v_3, v_4 and $v_4(\Psi_2)$, the informations at freeze-out are extracted.

T_f : temperature at freeze-out
ρ_0 : average velocity w.r.t. azimuthal angle
ρ_n : anisotropic velocity
s_n : spatially anisotropic(like eccentricity at freeze-out)
I_0, I_n, K_1 are modified bessel function
$\alpha_T = (p_T/T_f)\sinh(\rho(\phi))$
$\beta_T = (m_T/T_f)\cosh(\rho(\phi))$

fitting range
π : 0.5 - 1.13[GeV/c]
K : 0.4 - 1.40[GeV/c]
p : 0.6 - 1.70[GeV/c]

radius integration BW

$$\frac{dN}{p_T dp_T} \propto \int\int r\,dr\,d\phi\, m_T I_0(\alpha_T) K_1(\beta_T)$$

$$v_n = \frac{\int\int r\,dr\,d\phi \cos(n\phi) I_n(\alpha_T) K_1(\beta_T)\{1+2s_n\cos(n\phi)\}}{\int\int r\,dr\,d\phi\, I_0(\alpha_T) K_1(\beta_T)\{1+2s_n\cos(n\phi)\}}$$

$\rho(\phi,r) = \rho_0(1+2\rho_n\cos(n\phi))*r$

This model has hypothesis that particle emits with $\rho(\phi,r)$ velocity from Tf temperature matter.

surface BW

$$\frac{dN}{p_T dp_T} \propto \int d\phi\, m_T I_0(\alpha_T) K_1(\beta_T)$$

$$v_n = \frac{\int d\phi \cos(n\phi) I_n(\alpha_T) K_1(\beta_T)\{1+2s_n\cos(n\phi)\}}{\int d\phi\, I_0(\alpha_T) K_1(\beta_T)\{1+2s_n\cos(n\phi)\}}$$

$\rho(\phi) = \rho_0(1+2\rho_n\cos(n\phi))$

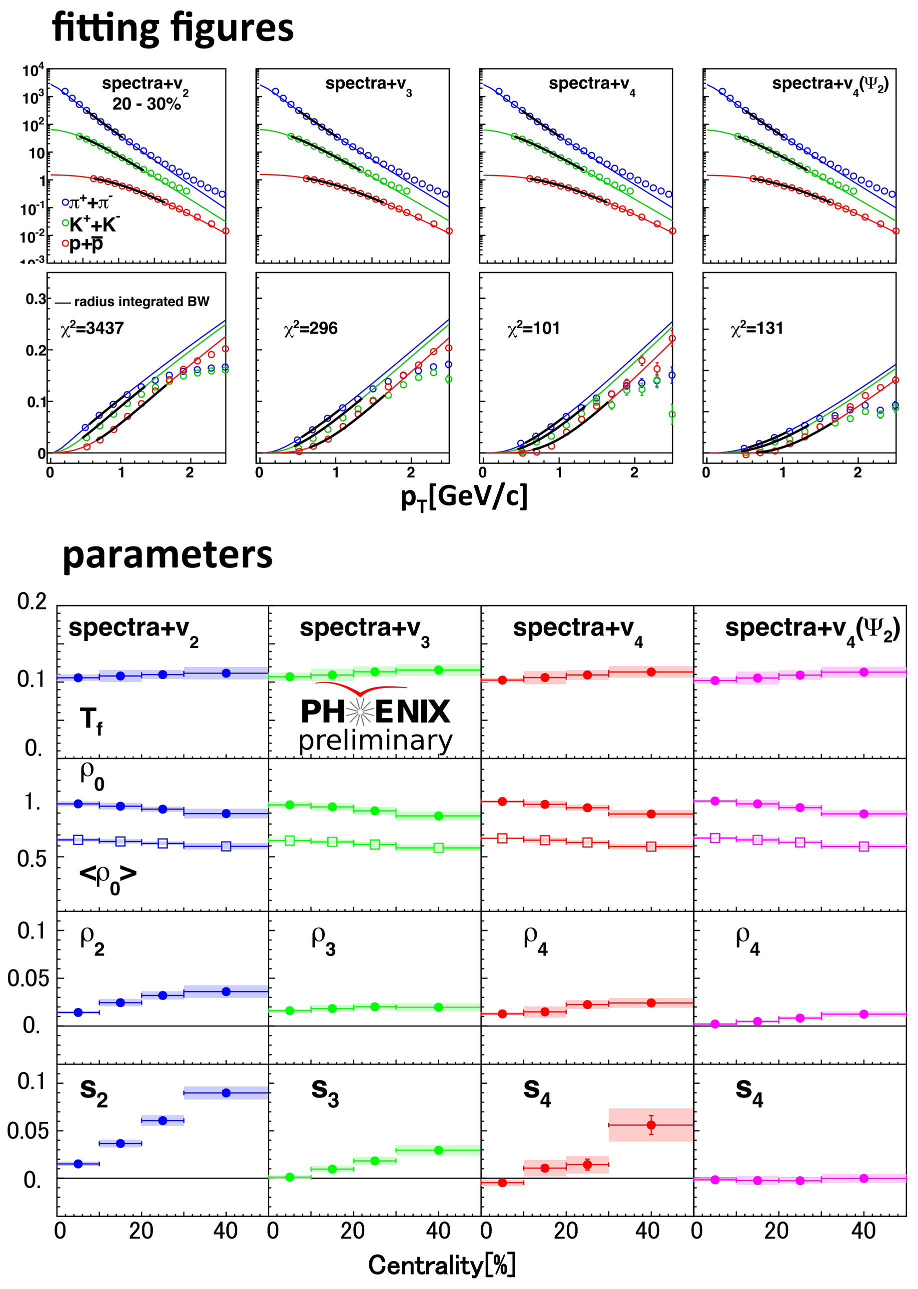
This model is a special edition of radius integration BW, which is particle emits from only surface of matter.

Result

radius integrated BW

fitting figures

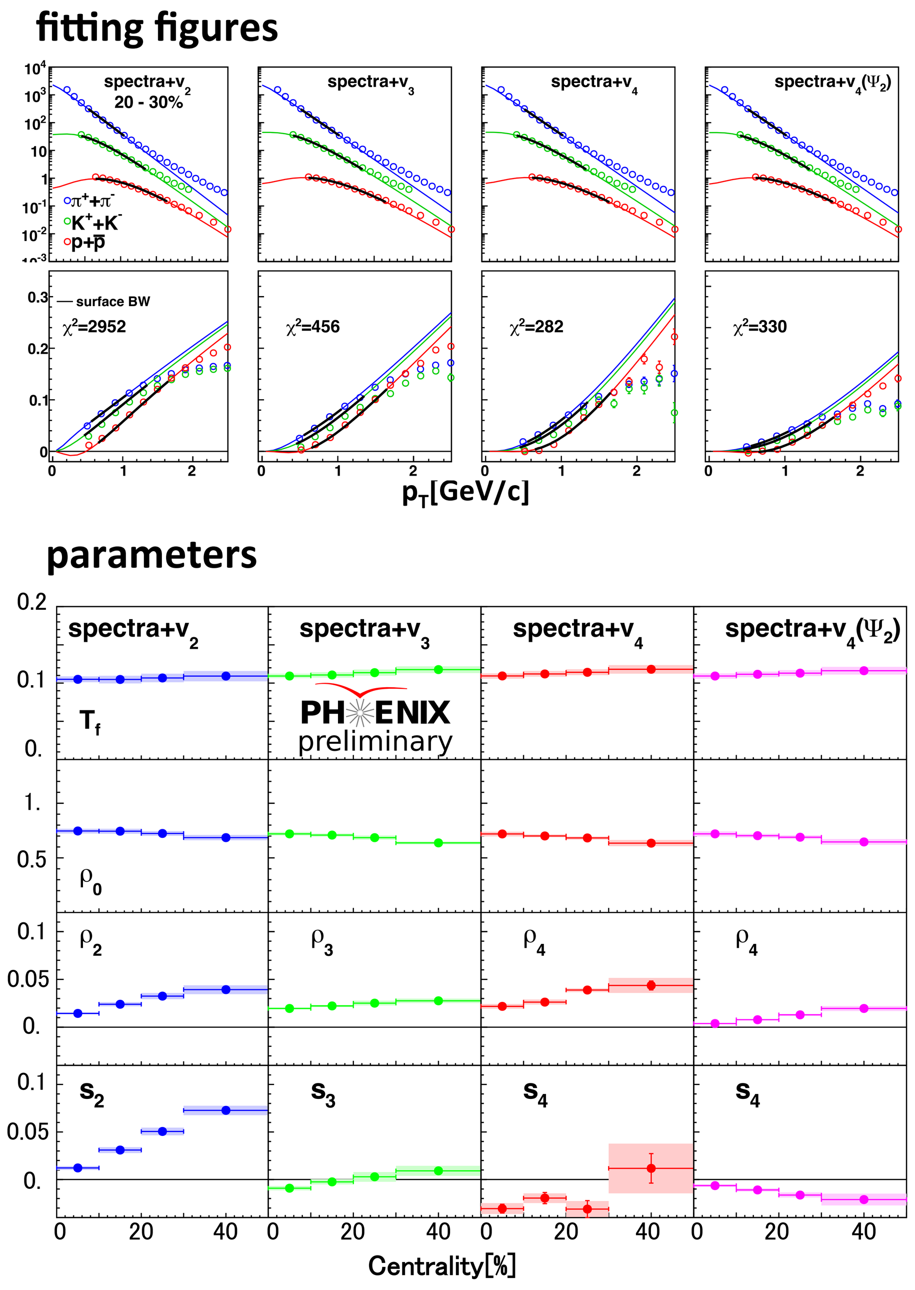
parameters



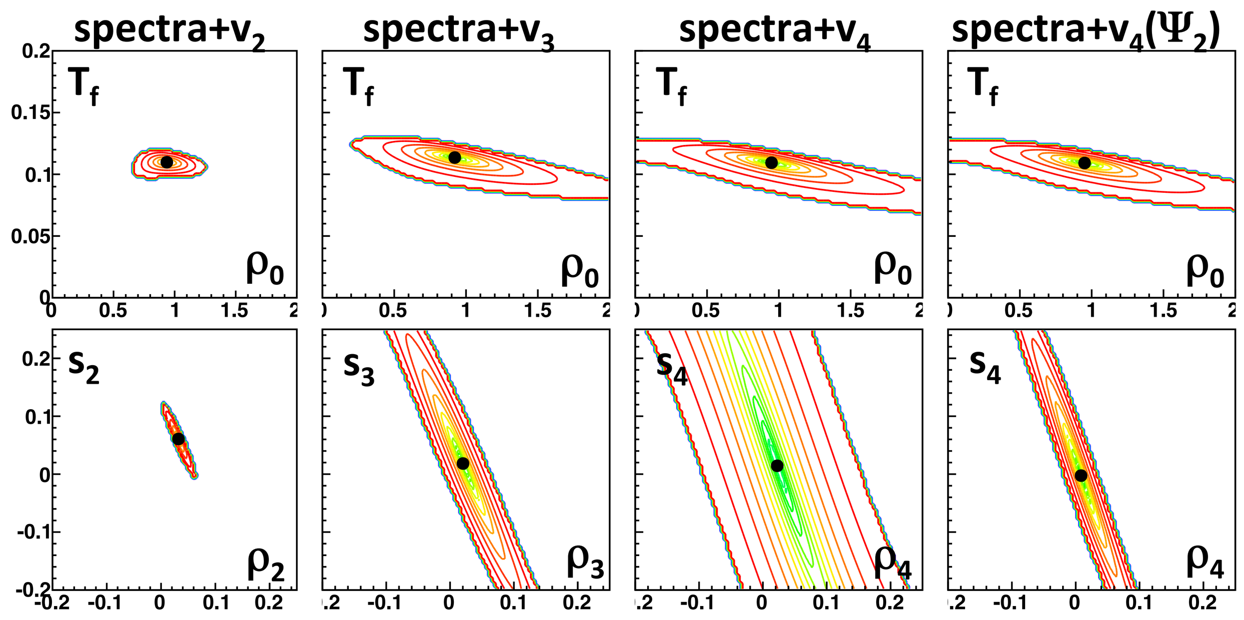
surface BW

fitting figures

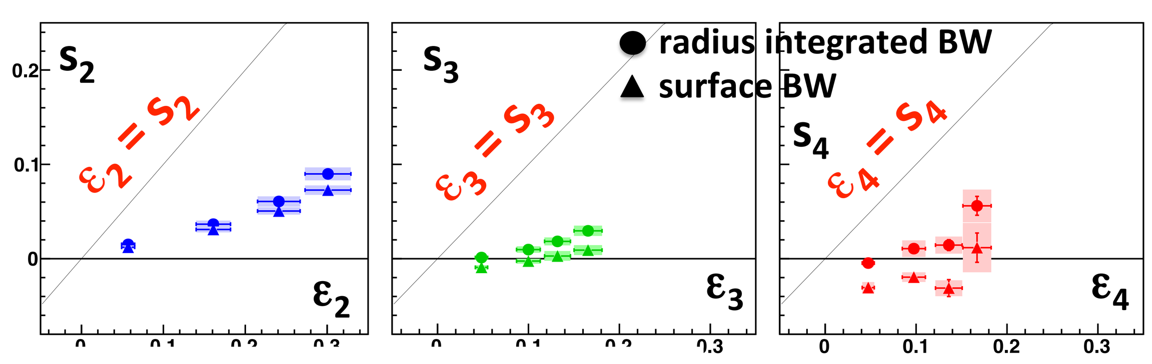
parameters



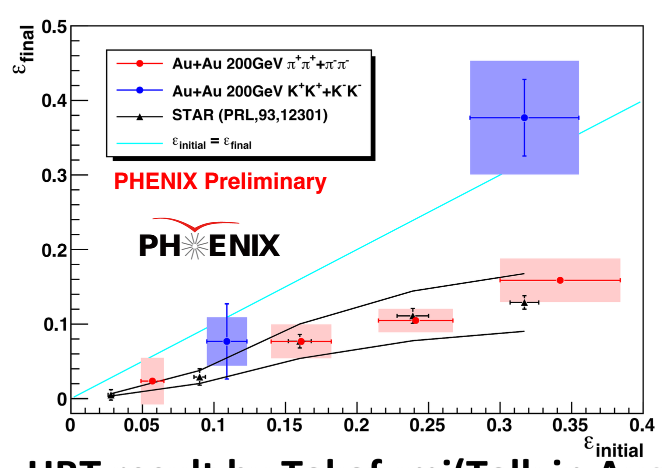
χ^2 contour plots 20-30%



Comparison eccentricity between initial and freeze-out

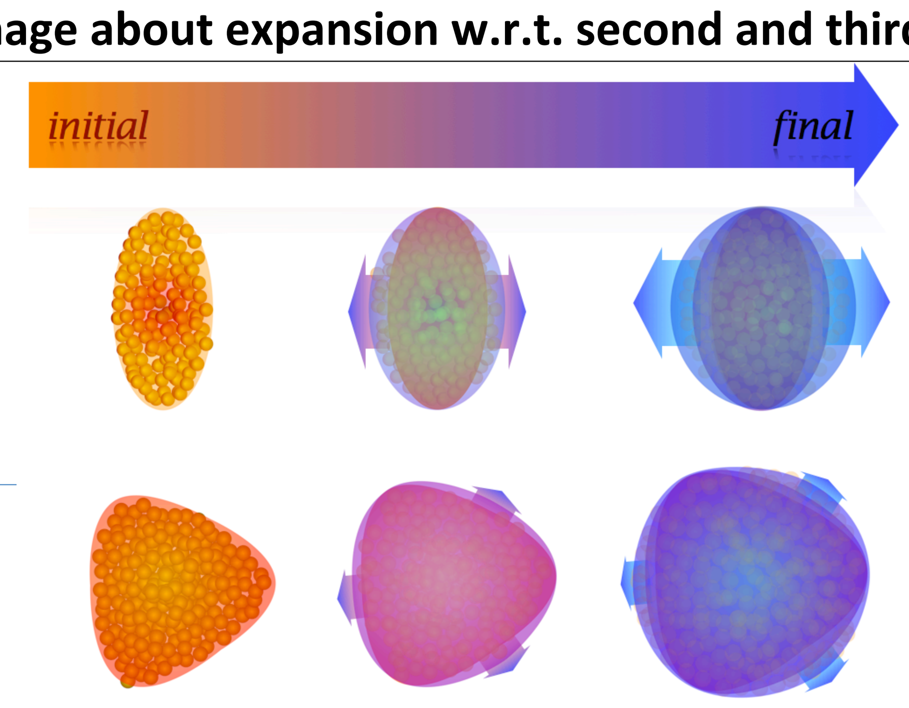


From comparison initial and freeze-out, spatially anisotropic gets small, but doesn't disappear.



HBT result by Takafumi(Talk in Aug.14)

Image about expansion w.r.t. second and third



Conclusion

The experimental results (spectra and azimuthal anisotropies) and BW model are compared.
Similar behaviors of parameters are obtained regardless harmonics.
These results indicate v_3, v_4 and $v_4(\Psi_2)$ are generated due to the effect of initial fluctuation and hydrodynamic expansion of QGP.

The anisotropic velocity ρ_n at freeze-out seems to have similar centrality dependence to the measured higher harmonic anisotropies themselves, which show large centrality dependence for ρ_2 like v_2, while the higher moments ρ_3 and ρ_4 do have flatter/weak dependences like v_3 and v_4.

In terms of spatial or density anisotropies s_n at freeze-out(I would call ε_{fn}), the final eccentricity ε_{f2} does still show sizable magnitude (which can also be taken as consistent observation of Ψ_2 dependence of HBT radius), however the final triangularity ε_{f3} or rectangularity ε_{f4} are both small especially in the central collisions. This tells us that the initial higher harmonic spatial anisotropies ε_{in} are mostly converted to the velocity anisotropy at freeze-out with rather small final higher harmonic spatial anisotropies ε_{fn}, while it is still finite ε_{f2}, which is consistent with the large initial eccentricity ε_{i2}.

From comparison spatially anisotropy between initial and final, that gets weak but doesn't disappear.
This is similar to HBT results.