Azimuthally differential pion femtoscopy with respect to second and third order event planes and deformation of the source shape with event engineering in Pb-Pb 2.76 TeV

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Motivation

In heavy ion collisions, initial geometrical fluctuation generates odd order anisotropies. But the relation between the fluctuation of initial geometry and higher order anisotropy is not trivial.

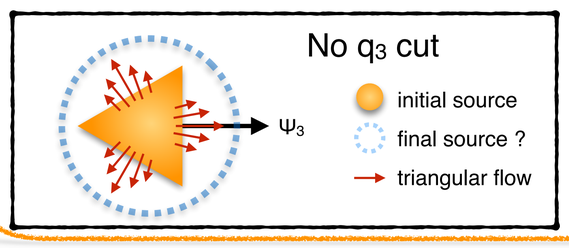
Azimuthally differential femtoscopy can help us to access the **geometrical source shape** and **flow velocity profile at freeze out**.

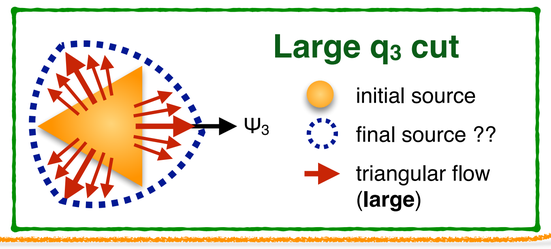
A detailed analysis of azimuthal dependence of HBT radii w.r.t. 3rd order event plane(Ψ_3) will provide us the key to the final source triangularity.

✦ **Event plane** $\Psi_n = \frac{1}{n}\tan^{-1}\left(\frac{\sum w_i \sin(n\phi_i)}{\sum w_i \cos(n\phi_i)}\right)$

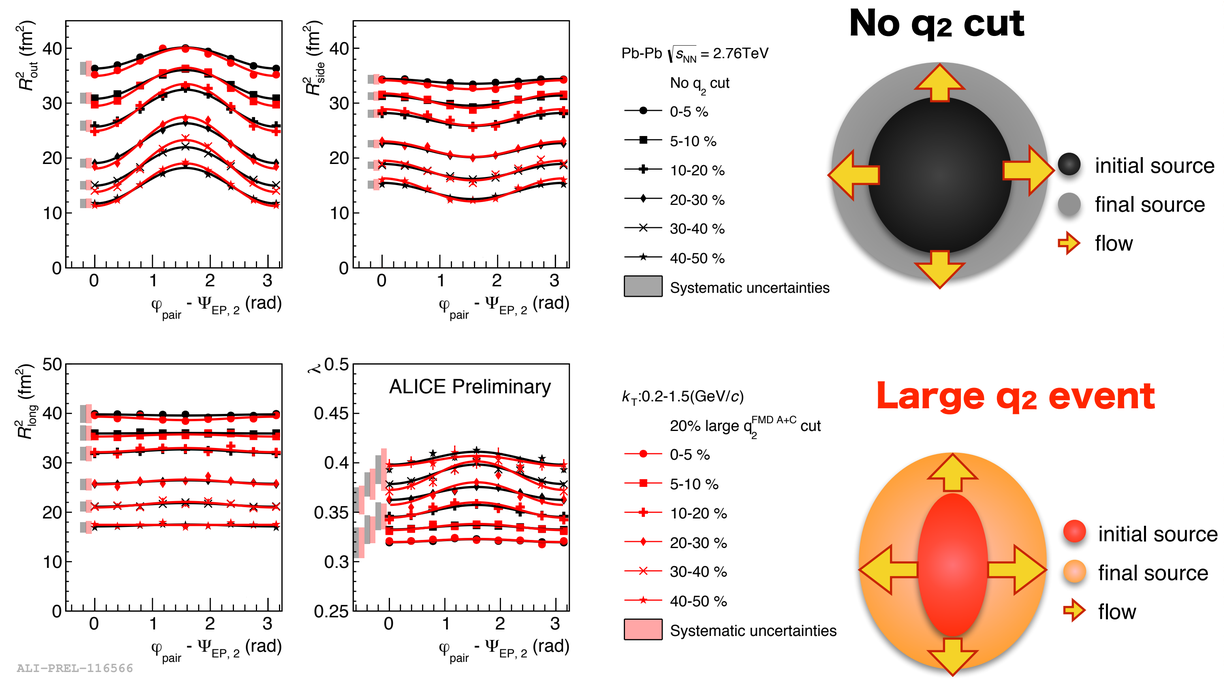
Event shape engineering(ESE) is a technique proposed to select event by event flow fluctuations[1].

Azimuthally differential HBT with large v_2 and v_3 event selection will give us the new insights into the **relation between anisotropic flow and the source shape at freeze out and the dynamics of system evolution**.





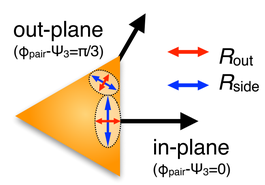
Radii oscillation with ESE



- ✦ Opposite sign oscillation of R_{out} and R_{side}
  - ✓ Initial out-plane extended elliptic shape preserved at freeze out
- ✦ Large q_2 event cut enhances the R_{out} oscillation
- ✦ R_{side} slightly changed with q_2 cut

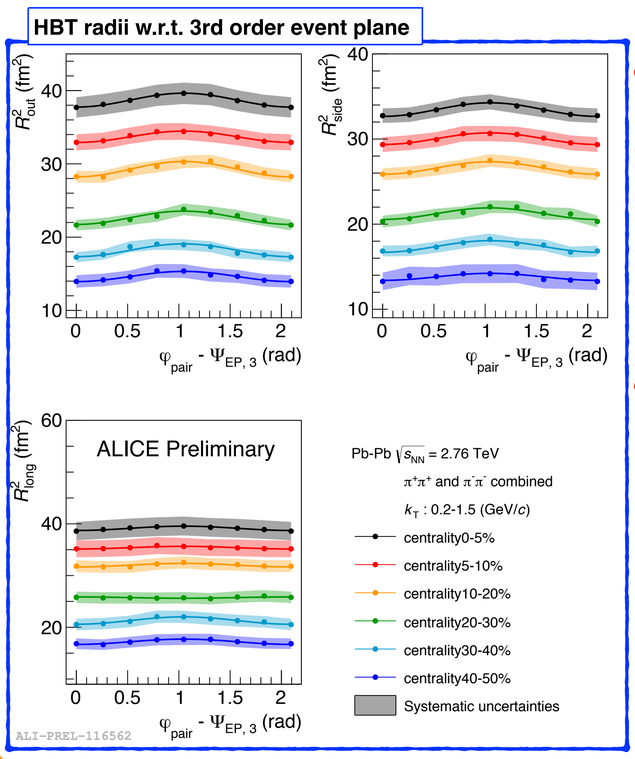
HBT radii w.r.t Ψ_3

- ✓ 3rd order oscillation of HBT radii was observed in R_{out} and R_{side}
- ✓ **Same sign oscillation of R_{out} and R_{side}**, while opposite sign in 2nd order event plane dependence
- ✓ $R^2_{side,3}/R^2_{side,0}$ is **negative** without strong centrality dependence
- ✓ $R^2_{side,2}/R^2_{side,0}$ is positive with substantial centrality dependence
- ✓ $R^2_{side,3}/R^2_{side,0}$ in lowest k_T is smaller than that in highest k_T
  - ➡ Indication of k_T dependence?
- ✓ $R^2_{side,2}/R^2_{side,0}$ has clear k_T dependence

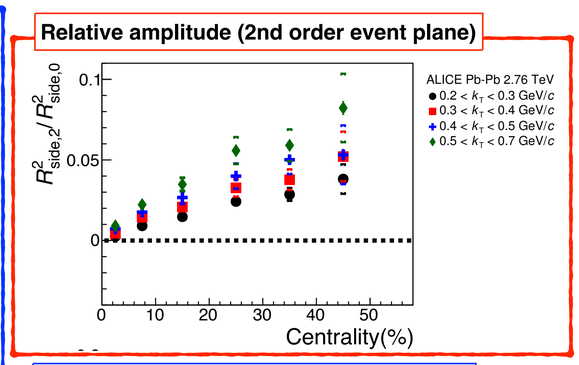


$$\vec{k_T} = \frac{(\vec{p_{T1}} + \vec{p_{T2}})}{2}$$

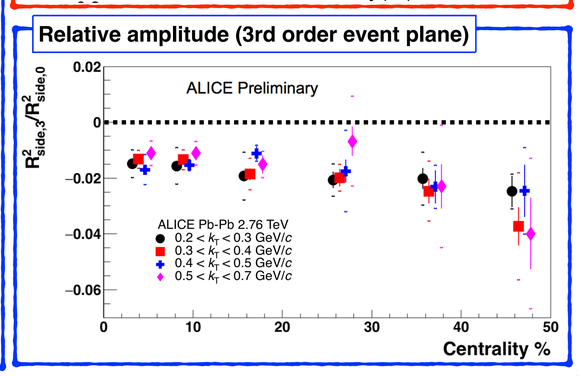
HBT radii w.r.t. 3rd order event plane



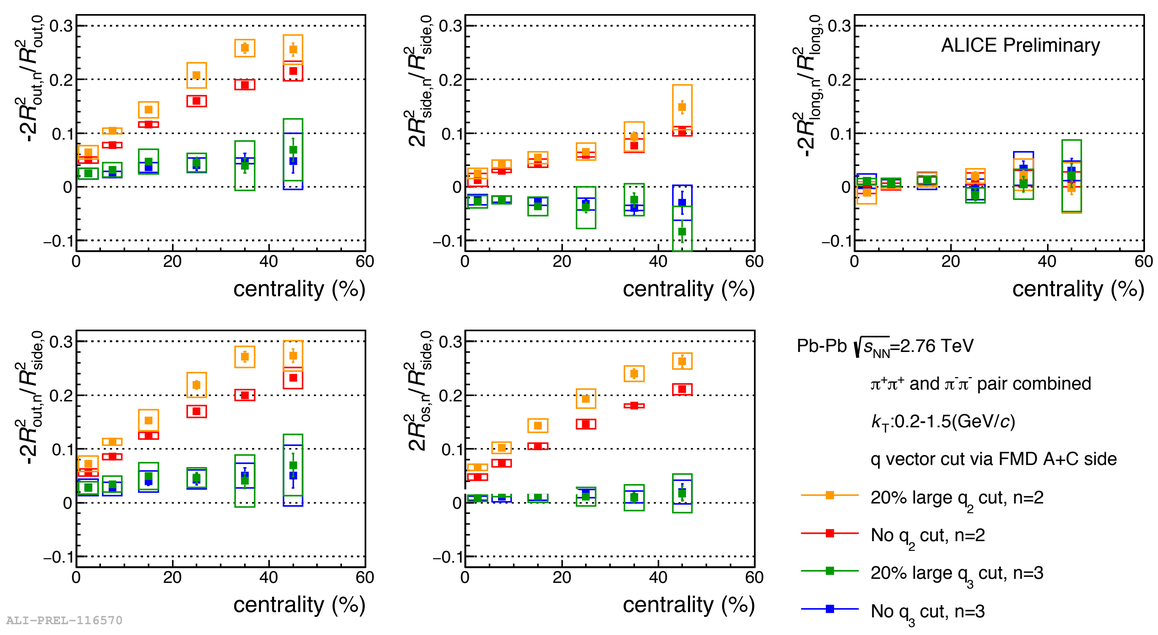
Relative amplitude (2nd order event plane)



Relative amplitude (3rd order event plane)



Relative amplitude with ESE



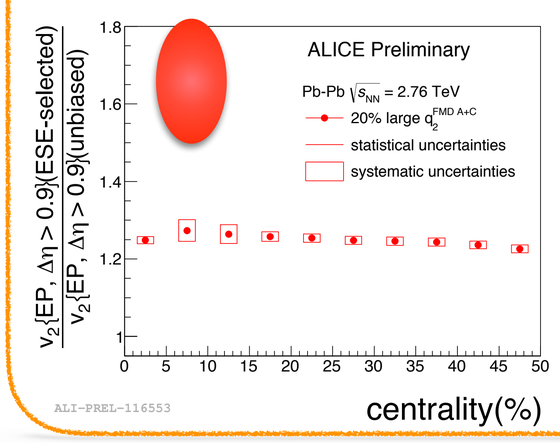
- ✦ 20% largest q_2 cut
  - ✓ **$R^2_{out,2}/R^2_{out,0}$, $R^2_{out,2}/R^2_{side,0}$, $R^2_{os,2}/R^2_{out,0}$ increase by ~20% larger, while $R^2_{side,2}/R^2_{side,0}$ grows by ~10%**
- ✦ 20% largest q_3 cut
  - ✓ Although v_3 is 20% enhanced with q vector cut, **relative amplitude does not change significantly**

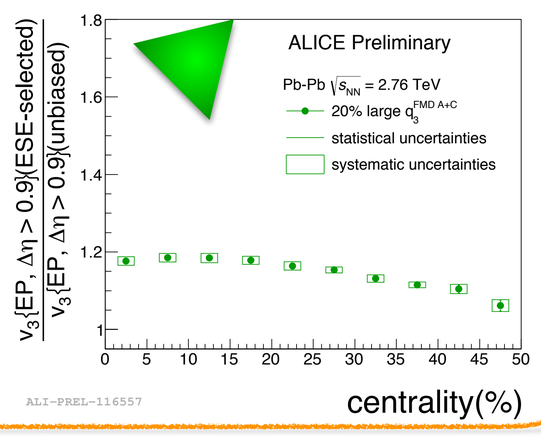
Event shape engineering

- ✓ v_2 and v_3 fluctuate event by event even in a same centrality
- ✓ Q vector selection allows us to select event by event flow amplitude

$$q_n = (q^2_{n,x} + q^2_{n,y})/\sqrt{M}$$

- ✦ **Large v_2 and v_3 events can be selected with 20% largest q_2 and q_3 vector selection**





Conclusion

- ✓ Oscillation w.r.t. 3rd order event plane can be seen in R_{out} and R_{side}
- ✓ ALICE has performed the first measurement of azimuthally sensitive femtoscopy with q_2 and q_3 selection
- ✓ Large q_2 selection enhances the oscillation of HBT radii
- ✓ A significant effect of large q_3 selection on 3rd order oscillation of HBT radii is not observed

References

[1] J. Schukraft, A. Timmins and S. A. Voloshin, Phys. Lett. B719, 394 (2013)

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