Comparison of reaction planes determined from BBC and central arm at PHENIX

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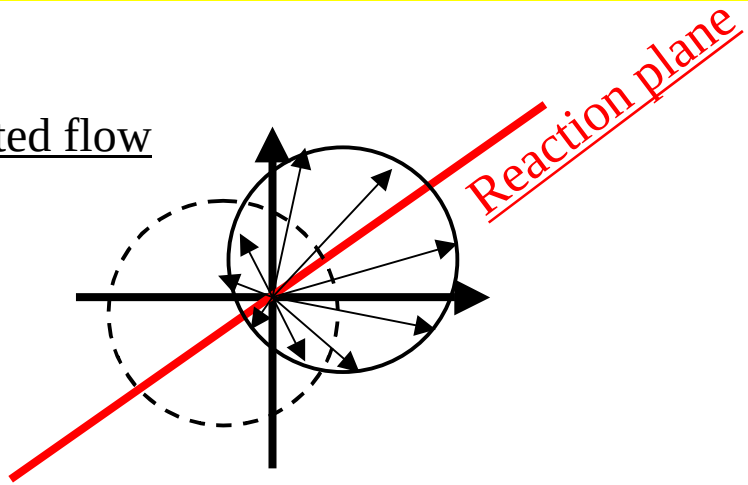
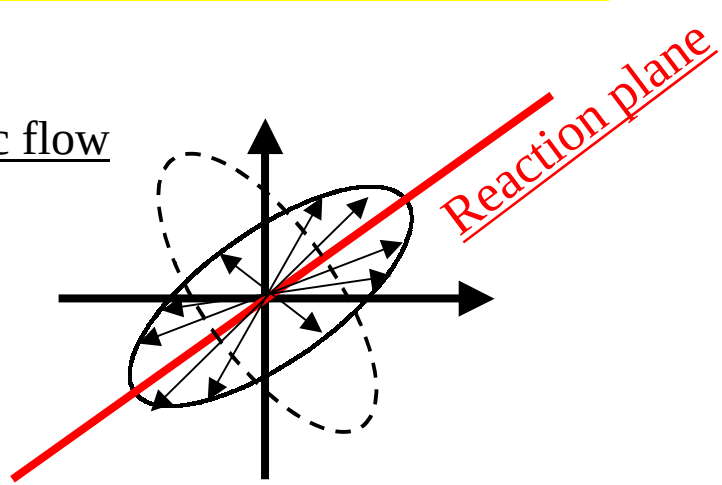
Motivation

- A standard analysis of the event anisotropy is to measure the azimuthal distribution with respect to the reaction plane.
- To find better resolution of reaction plane, we have calculated the reaction plane with several methods and sub samples.
- It is important to compare the various methods, it not only check systematic uncertainty, but also estimate non-flow effect such as jets, HBT, resonance decay and momentum conservation.

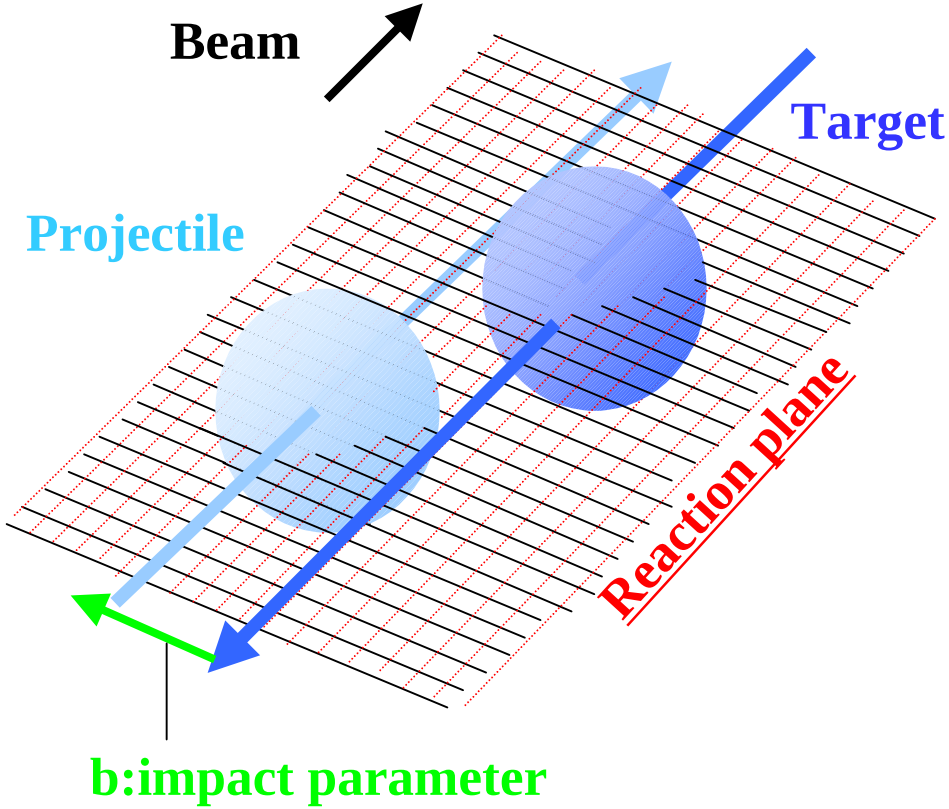
Directed flow



Elliptic flow



What's the reaction plane ?



The reaction plane is defined by the direction of the impact parameter and the beam direction.

In this presentation, we determined reaction plane with the Beam-Beam Counter (BBC) and the central arm detector (CNT).

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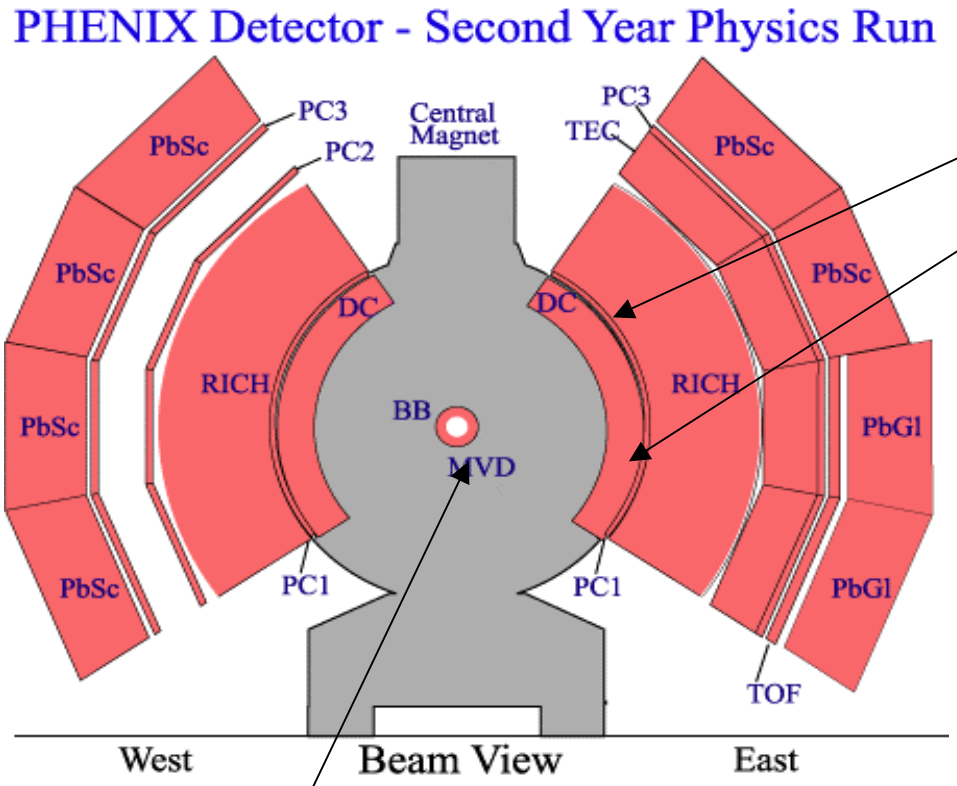
PHENIX detector



Central arm(CNT) | η |<0.35
Pad Chamber 1 (PC1)
Drift Chamber (DCH)

$$\tan(2\Psi_0) = \frac{\Sigma\, p_{Ti} * \sin(2\phi)}{\Sigma\, p_{Ti} * \cos(2\phi)}$$

Beam-Beam Counter (BBC), |η|=3-4

$$\tan(2\Psi_0) = \frac{\Sigma\, ADC_i * \sin(2\phi)}{\Sigma\, ADC_i * \cos(2\phi)}$$

Ψ_0 : reaction plane angle
ϕ : azimuthal angle of measured charged particle

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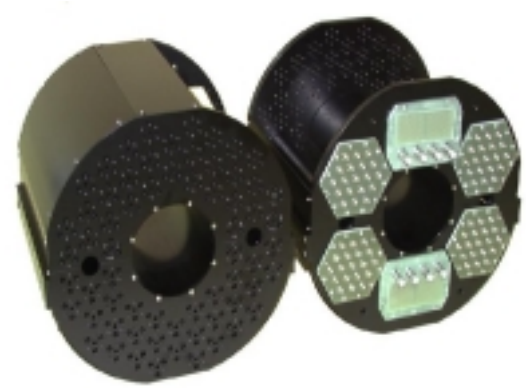
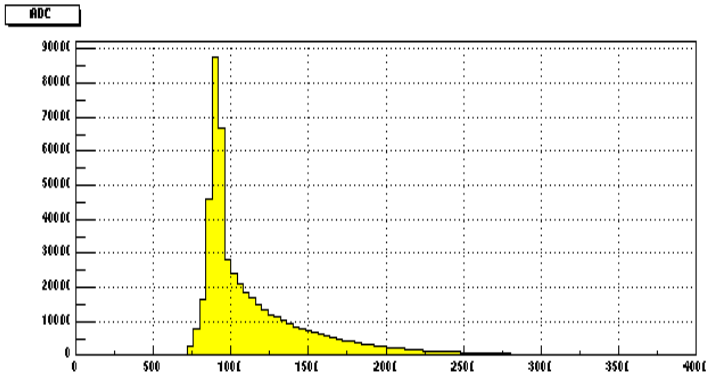
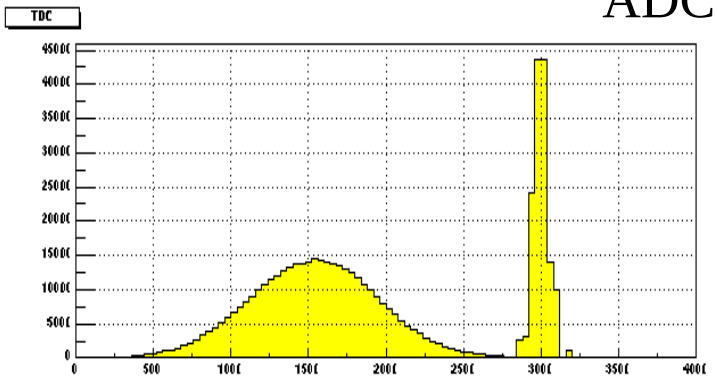
Beam-Beam Counter (BBC)



- 2 * 64 one inch diameter mesh-dynode PMT + 3cm quartz on the head of the PMT as a Cherenkov radiator.



ADC [ch]



TDC [ch]

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Flow analysis with reaction plane method

$$\frac{dN}{d(\phi-\Psi_0)} = N_0\left(1+\sum_{n=1}^{\infty} 2v_n^{obs}\cos(n(\phi-\Psi_0))\right)$$

$$v_n = \frac{v_n^{obs}}{resolution}$$

- Required reaction plane determination.
- For BBC reaction plane

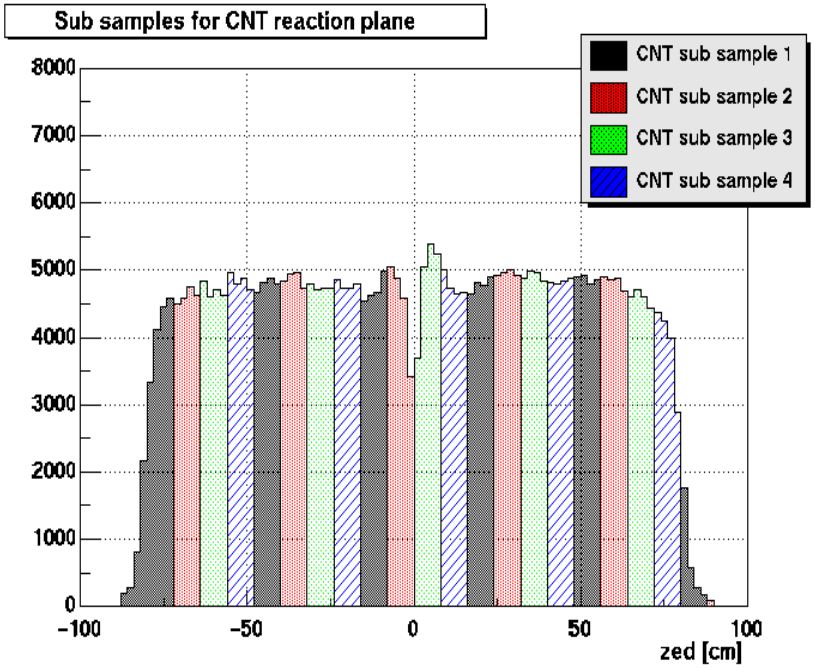
  (2 sub samples, BBC north and south)

  1. Ring gain correction.
  2. Average shift correction.
  3. Flattening method correction.
- For CNT(central arm) reaction plane

  (4 sub samples)

  1. Average shift correction.
  2. Flattening method correction.

- Event selection
- Trigger : minimum bias
- |BBC vertex| < 30 cm



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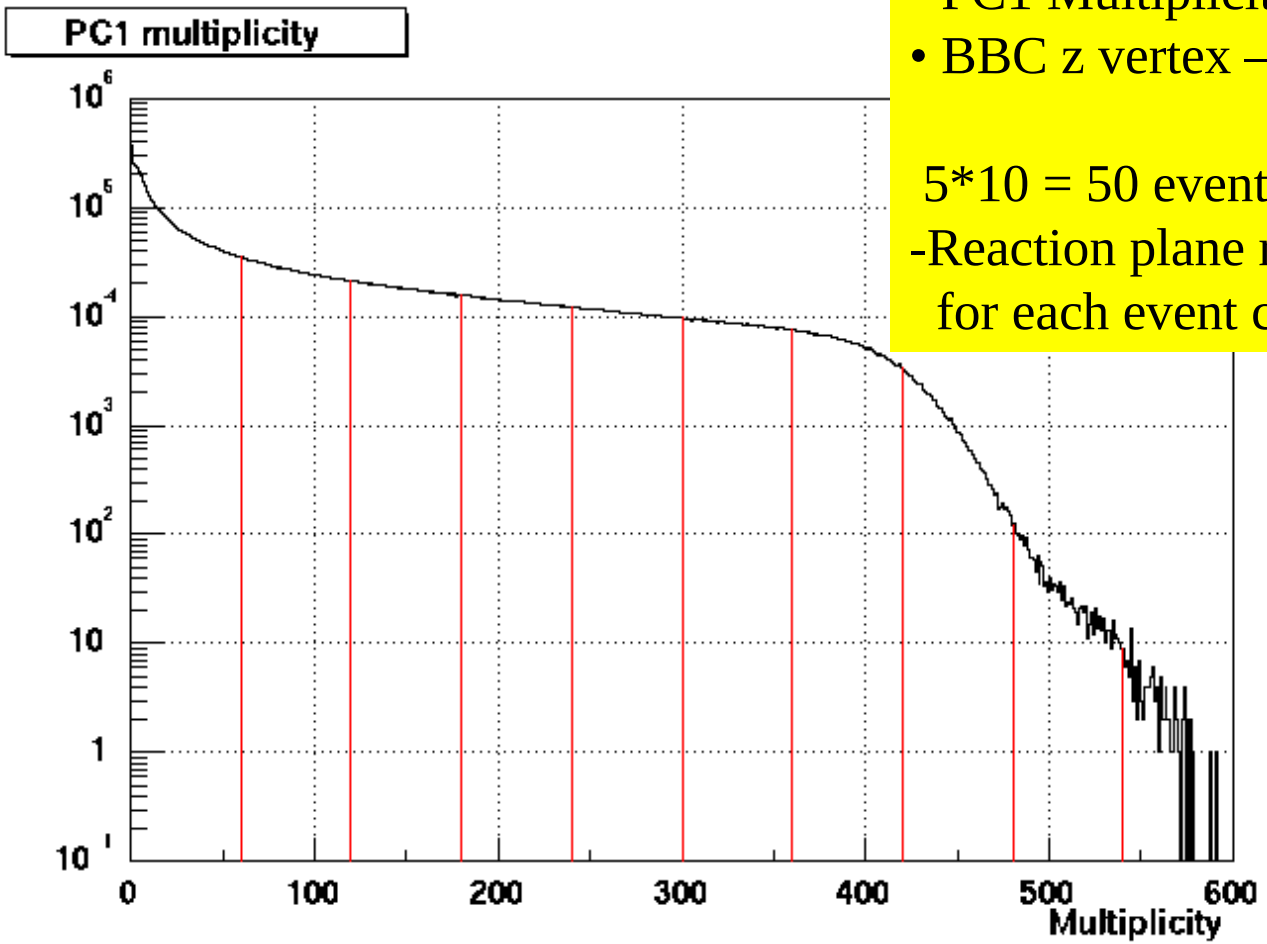
Event class of PC1 multiplicity and BBC z vertex



- PC1 Multiplicity – 10 bins
- BBC z vertex – 5 bins

5*10 = 50 event class

-Reaction plane resolution is calculated for each event class.

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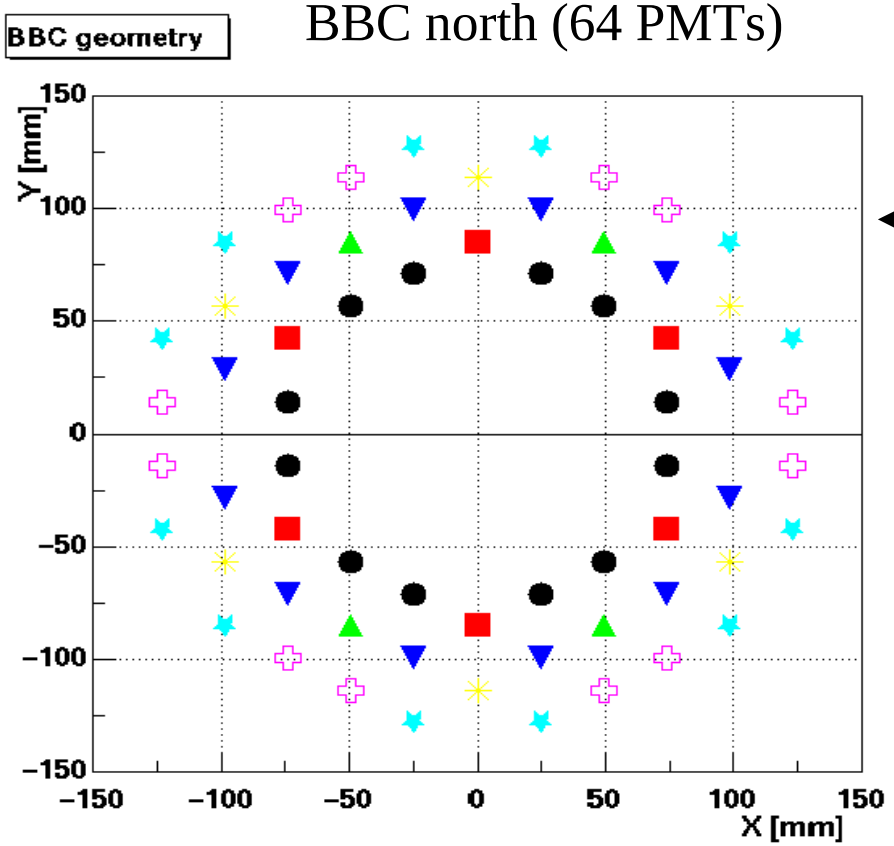
Ring gain correction for BBC

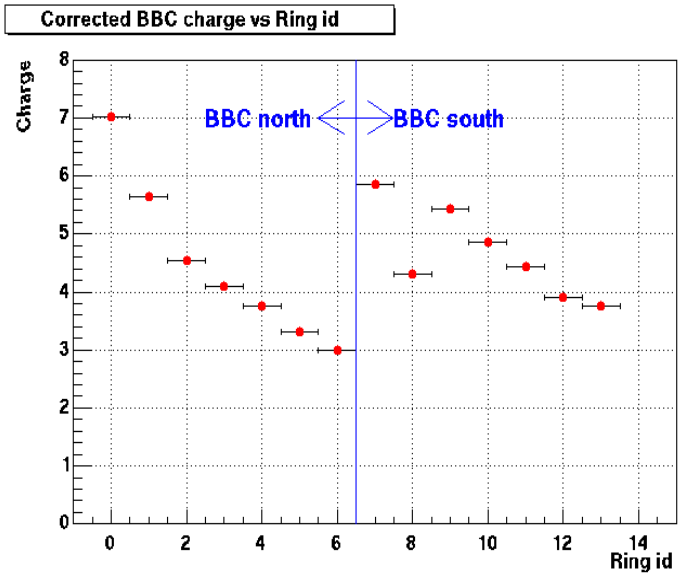
BBC north (64 PMTs)



R : radius (mm)

1,8	R < 80
2,9	80 < R < 90
3,10	90 < R < 100
4,11	100 < R < 110
5,12	110 < R < 120
6,13	120 < R < 126
7,14	R > 126

Correct asymmetric ADC distribution



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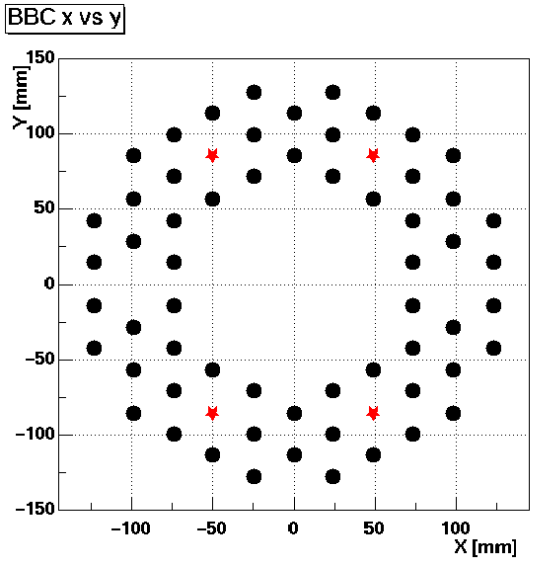
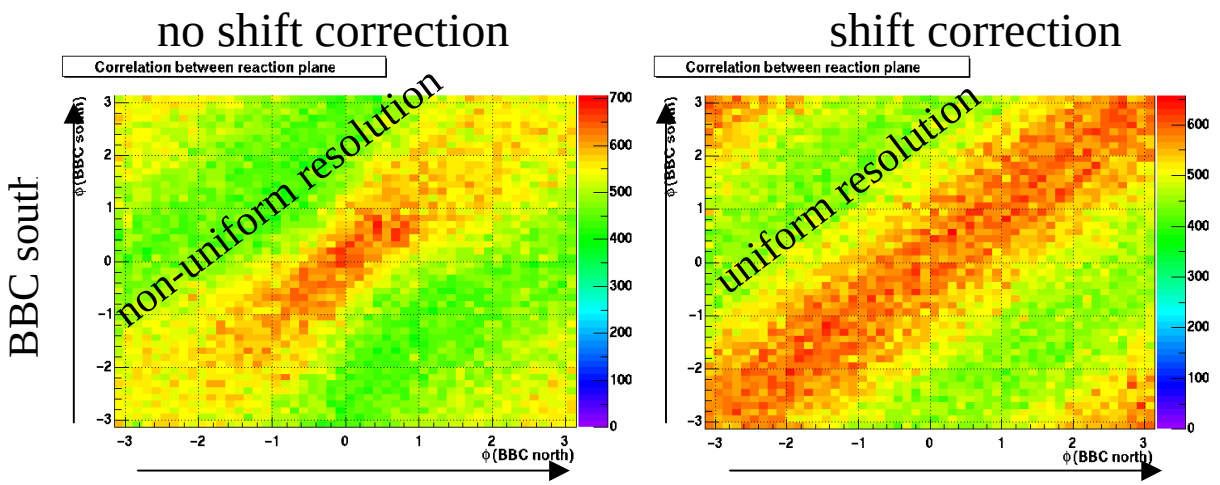
Average shift correction

$$\tan(2\Psi_0) = \frac{\Sigma\, w_i * \sin(2\phi) \; - \langle \Sigma\, w_i * \sin(2\phi) \rangle}{\Sigma\, w_i * \cos(2\phi) \; - \langle \Sigma\, w_i * \cos(2\phi) \rangle} \quad (w = \text{ADC or } p_T)$$



The symmetry is important for uniform resolution when using only the flattening correction.

Average shift correction before flattening correction was found to have the similar effect we get by removing the 4 PMTs from each BBC.



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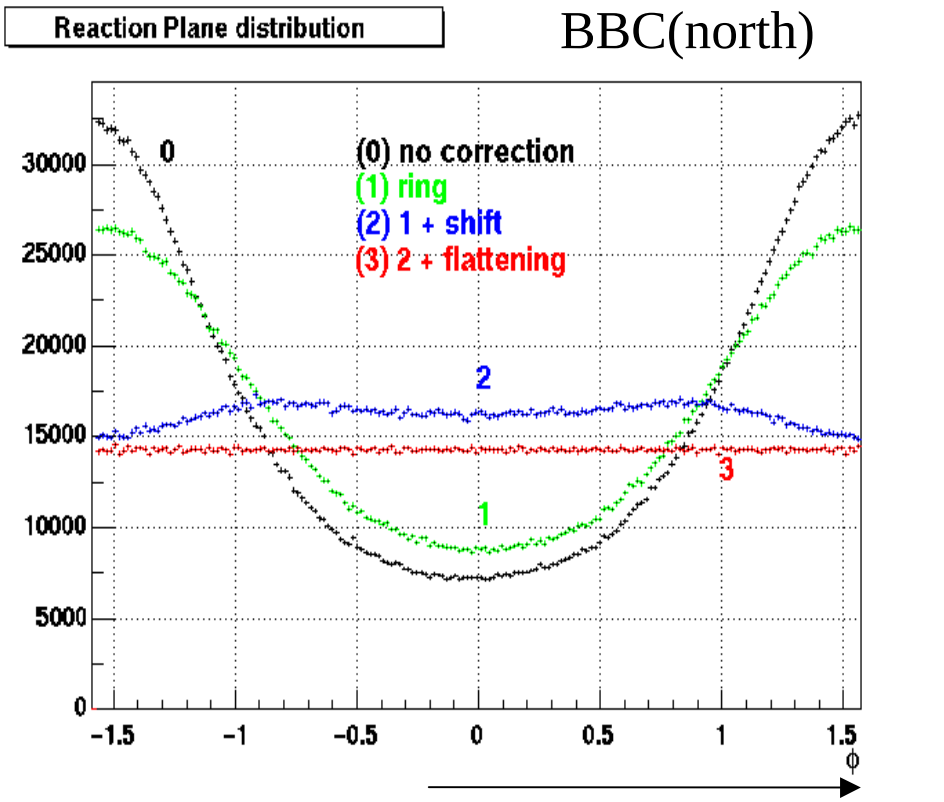
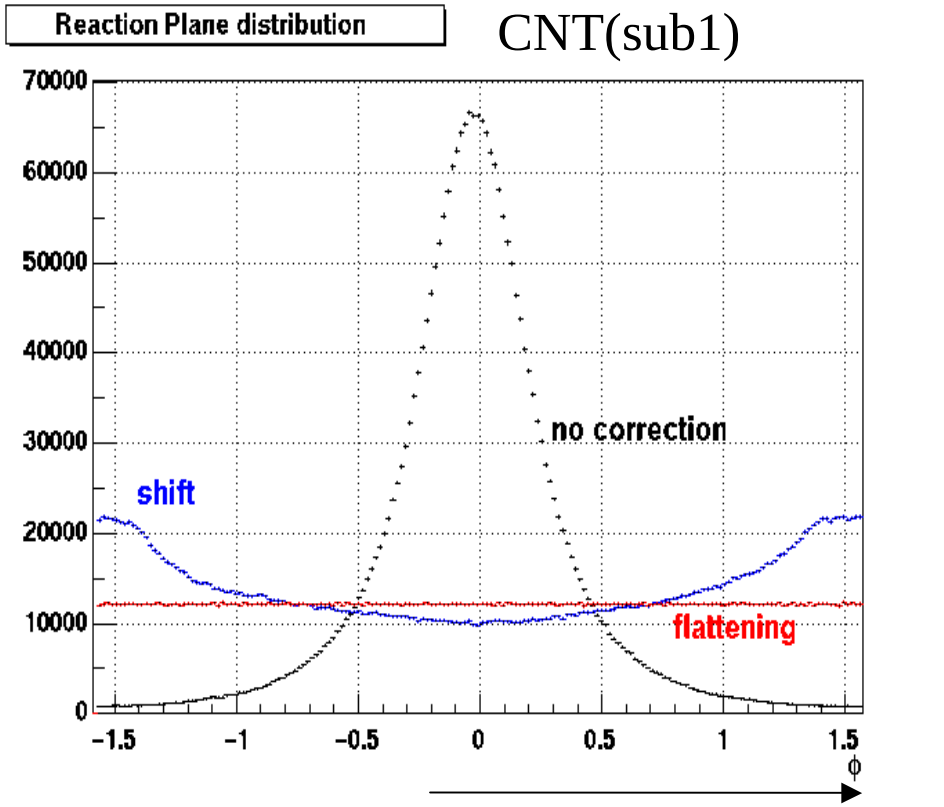
Reaction plane flattening

BBC(north)



Ψ_0 (reaction plane angle)

CNT(sub1)



Ψ_0 (reaction plane angle)

$\Delta\Psi_0 = \Sigma(A_k\cos(2k\Psi_{obs}) + B_k\sin(2k\Psi_{obs}))$

$A_k = -2/k*\langle\sin(2k\Psi_{obs})\rangle$

$B_k = 2/k*\langle\cos(2k\Psi_{obs})\rangle$

$\Psi_0 = \Psi_{obs} + \Delta\Psi_0$

Ψ_{obs} : measured reaction plane

$\Delta\Psi_0$: correction factor

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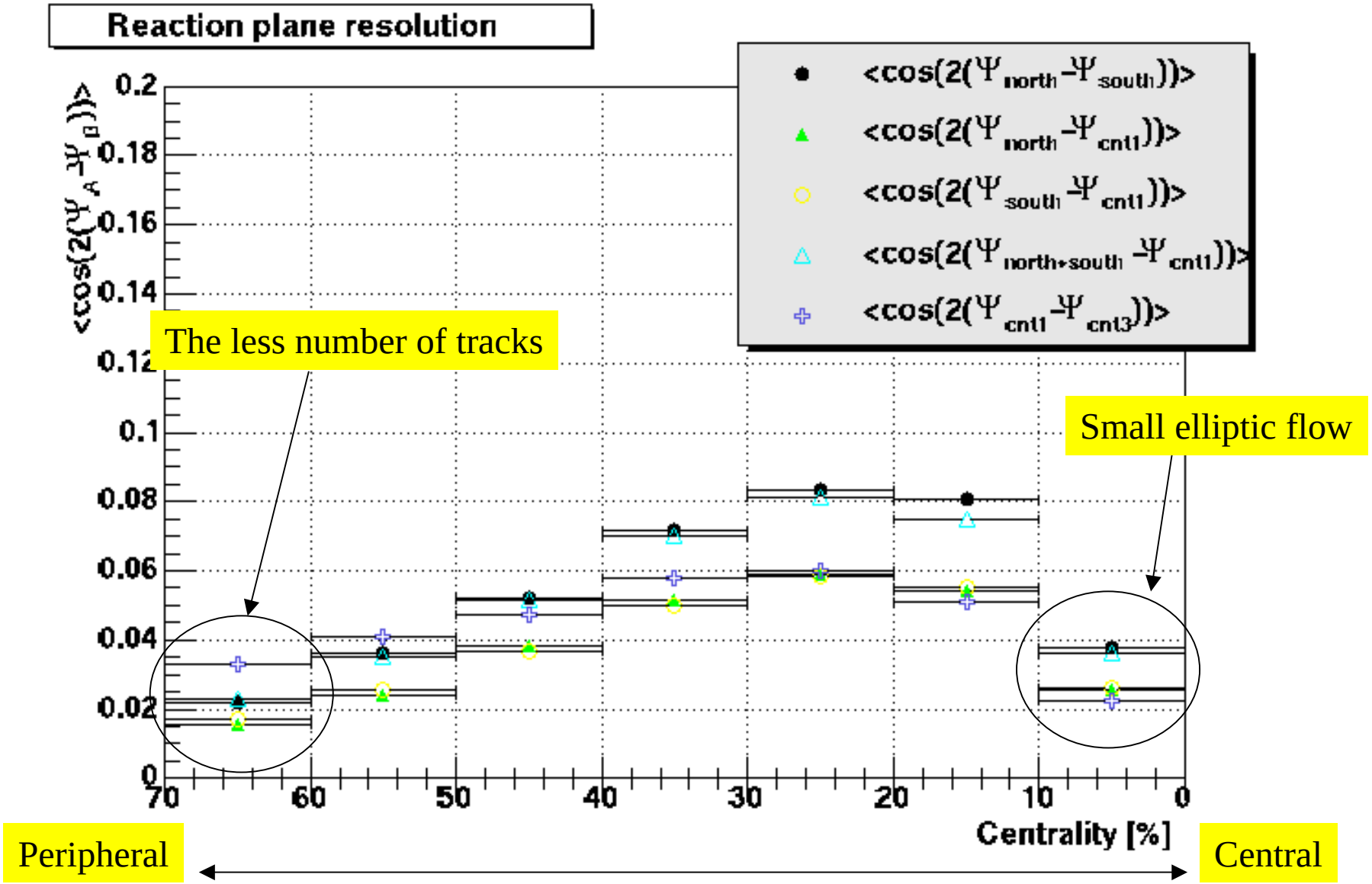
Reaction plane resolution



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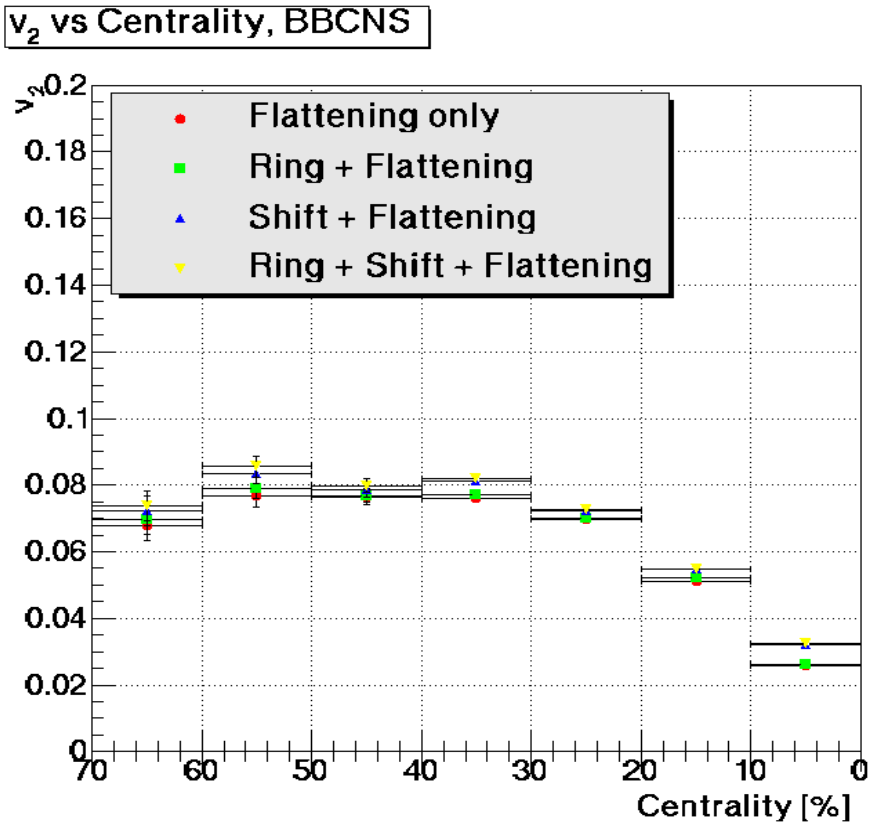
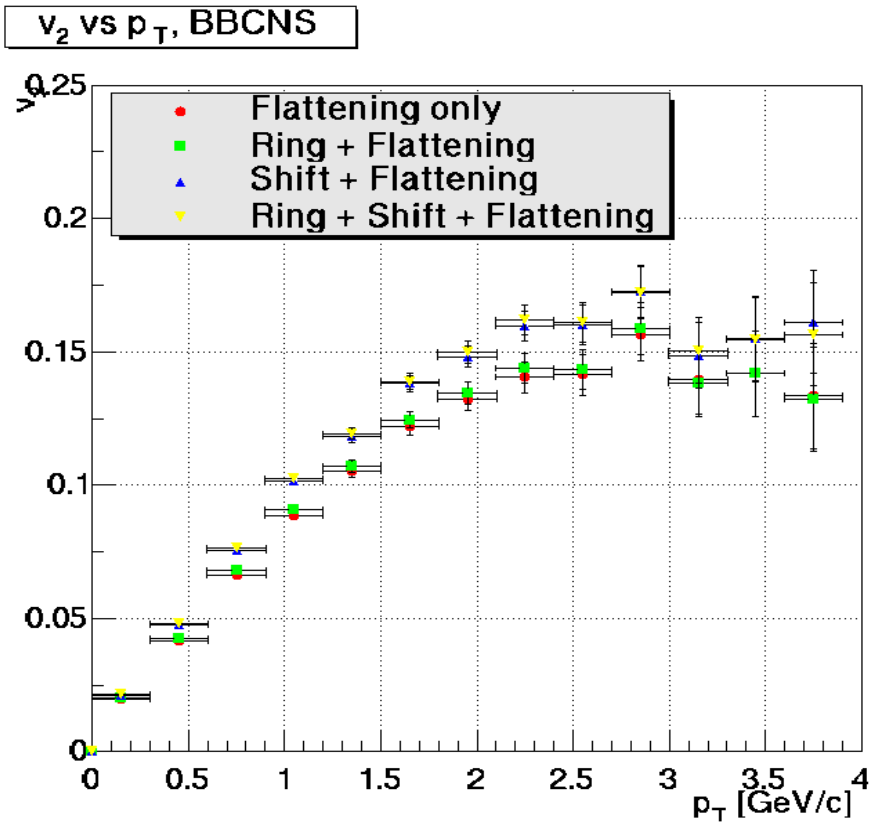
Estimation of systematic error





Systematic error
- ~ 5-10% over all centrality class
- ~ 5-15% , p_T < 4 GeV/c

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Conclusion

- Reaction plane is determined by the Beam-Beam Counter and the central arm detector at PHENIX.
- To correct the asymmetric charge distribution of BBC, ring gain correction is applied.
- After average shift correction is applied both BBC and CNT reaction plane, we get uniform resolution.
- The resolution of reaction plane is the best at mid-central region.
- Systematic error is estimated about 5-15 % by using different corrections.
- You can find other physics plots of this analysis, see the Shingo's poster !!!

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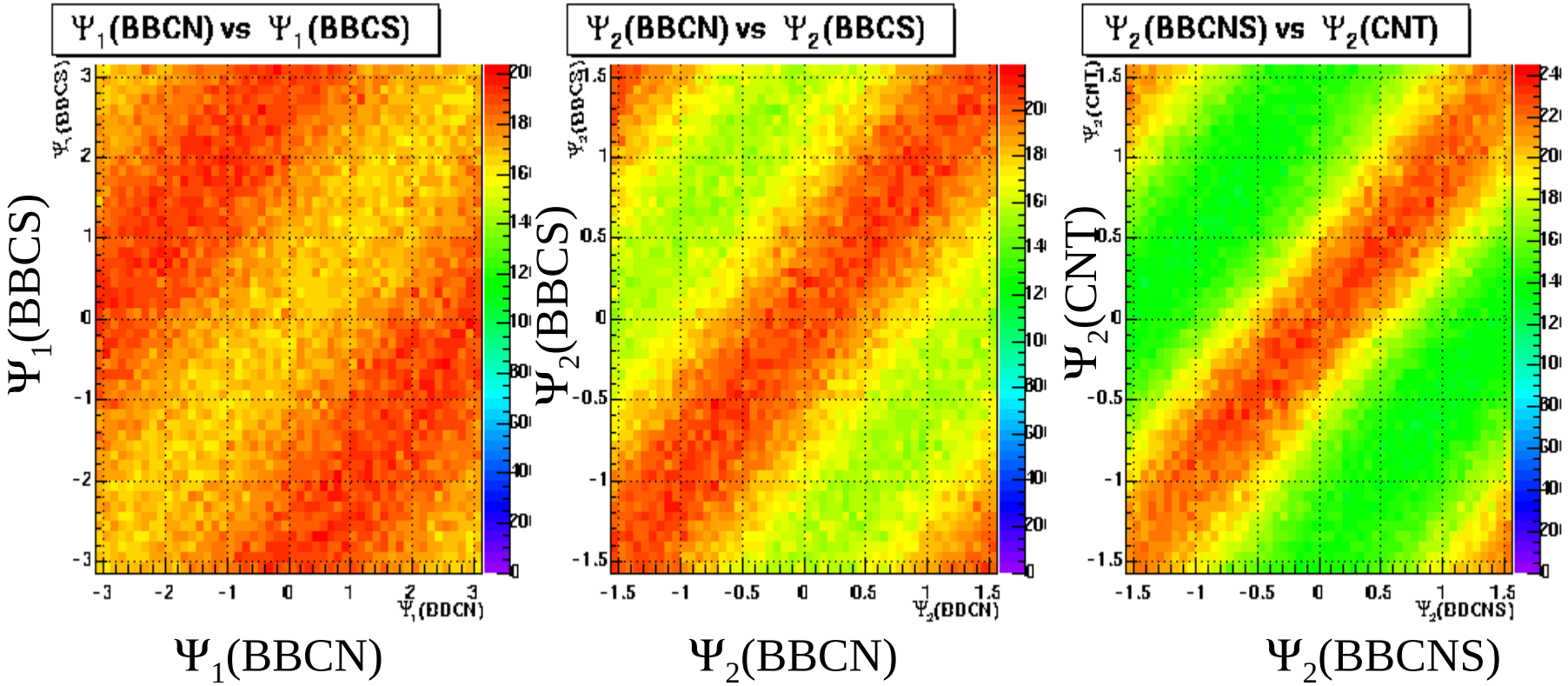
Correlation between two reaction planes



Ψ_1 : directed plane
Ψ_2 : elliptic plane

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