Jet effect on flow and PID improvement

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Flow

A geometry shape of overlap region may generate collective motion

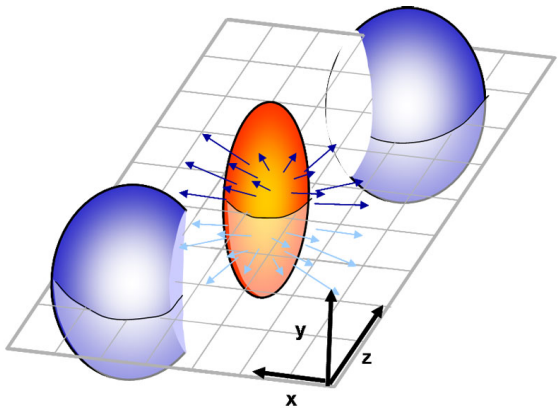


Figure: overlap region(red) after heavy ion collision

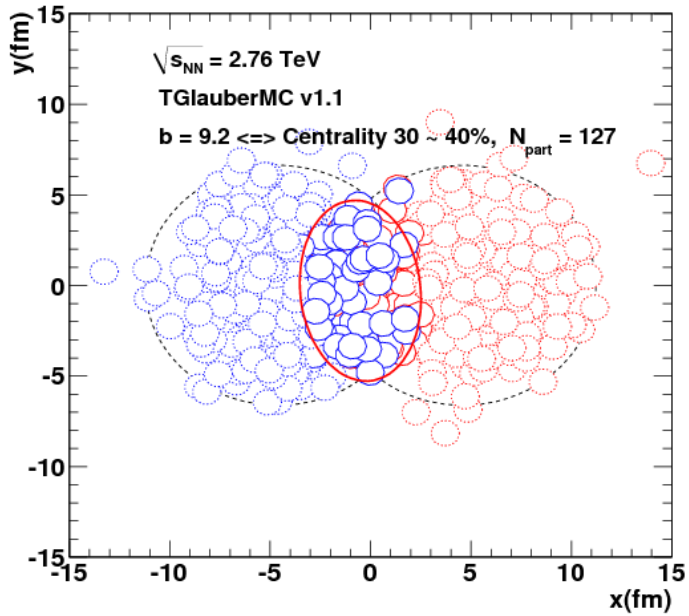


Figure: Glauber simulation by D.J.Kim B.S.Chang

Particle distribution in transverse direction($\frac{dN}{d\eta}$) can be used for finding reaction plane and other event plane of higher order harmonics

As $\frac{dN}{d\phi}$ is a periodic function, it can be expressed with Fourier transformation.

$$\frac{dN}{d\phi} = \frac{x_0}{2\pi} + \frac{1}{\pi}\sum_{n=1}(A_n \cos n\phi + B_n \sin n\phi) \quad (1)$$

If we define v_n and ψ_n such as,

$$v_n^2 = A_n^2 + B_n^2,\ 0 \leq \psi_n \leq \frac{2\pi}{n} \quad (2)$$

Then we can express A_n and B_n with v_n and ψ_n. if we put back these into original equation (1) then

$$\frac{dN}{d\phi} = \frac{x_0}{2\pi} + \frac{1}{2\pi}\sum_{n=1}(2v_n \cos n(\phi - \psi_n)) \quad (3)$$

And, we called v_n as flow constant, and ψ_n as event plane angle.

How to measure Event plane angle?

To calculate event plane angle, use Q-Vector method
(P. Danielewicz, G. Odyniec, Phys. Lett. 157B, 146 (1985))

The event flow vector Qn is a 2d vector in the transverse plane

$$Q_{n,x} = \sum W_i \cos(n\phi_i) = Q_n \cos(n\psi_n)$$
$$Q_{n,y} = \sum W_i \sin(n\phi_i) = Q_n \sin(n\psi_n)$$

And as we define A_n and B_n in equation (2)

$$A_n = \int_0^{2\pi} \frac{dN}{d\phi} \cos n\phi d\phi = \sum_\nu r_\nu \cos n\phi_\nu$$

$$B_n = \int_0^{2\pi} \frac{dN}{d\phi} \sin n\phi d\phi = \sum_\nu r_\nu \sin n\phi_\nu$$

$$\psi_n = (\arctan \frac{B_n}{A_n})/n \quad (4)$$

And v_n can be calculated from event plane angle with Fourier coefficient relation

$$v_n = \langle \cos n(\phi - \psi_n) \rangle$$

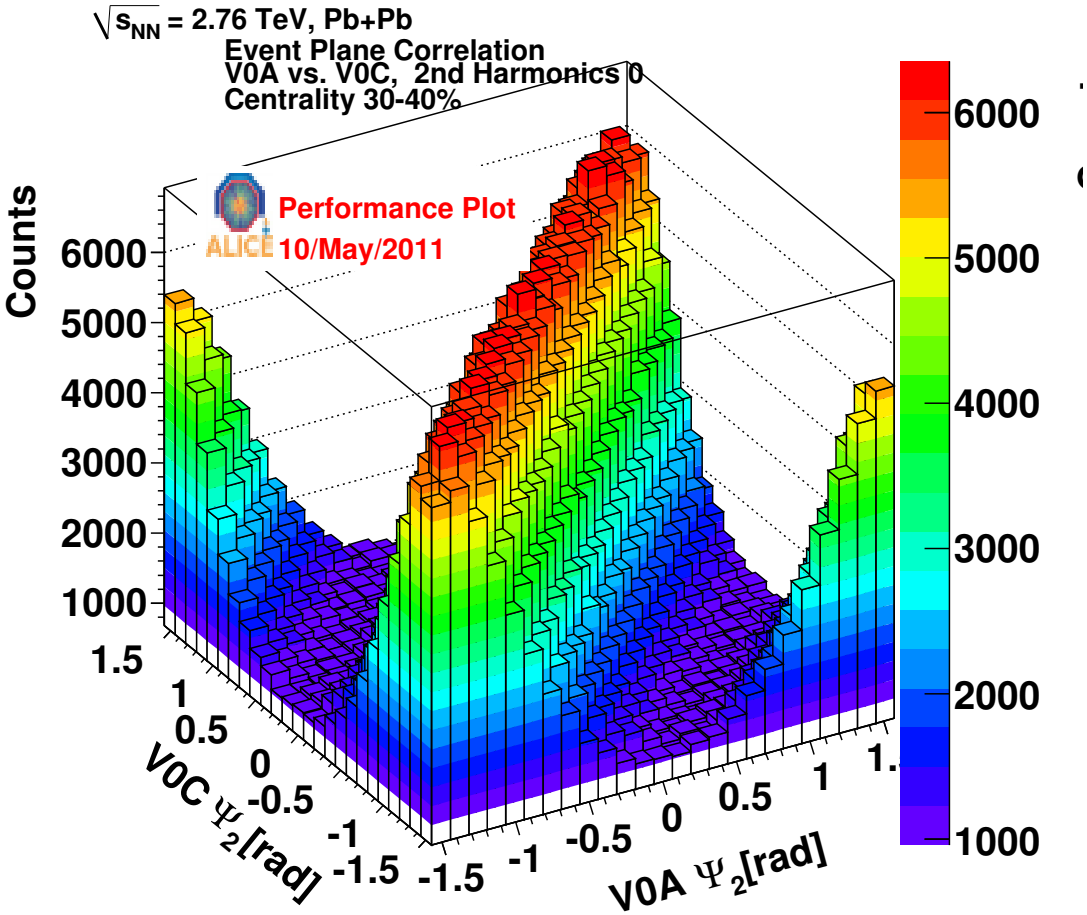
But, if there are some error when measurement event plane angle, we need to correct.

$$\begin{aligned} v_n^{obs} &= \langle \cos n(\phi - \psi_n^{obs}) \rangle \\ &= \langle \cos n(\phi - \psi_n + \psi_n - \psi_n^{obs}) \rangle \\ &= \langle \cos n(\phi - \psi_n) \rangle \langle \cos n(\psi_n - \psi_n^{obs}) \rangle \\ &= v_n \langle \cos n(\psi_n - \psi_n^{obs}) \rangle \end{aligned}$$

$$v_2 = \frac{v_2^{obs}}{\mathrm{Res}\{\Psi_n\}} \tag{5}$$

$\mathrm{Res}\{\Psi_n\} = \langle \cos(n\psi_n^{err}) \rangle$: resolution of event plane angle

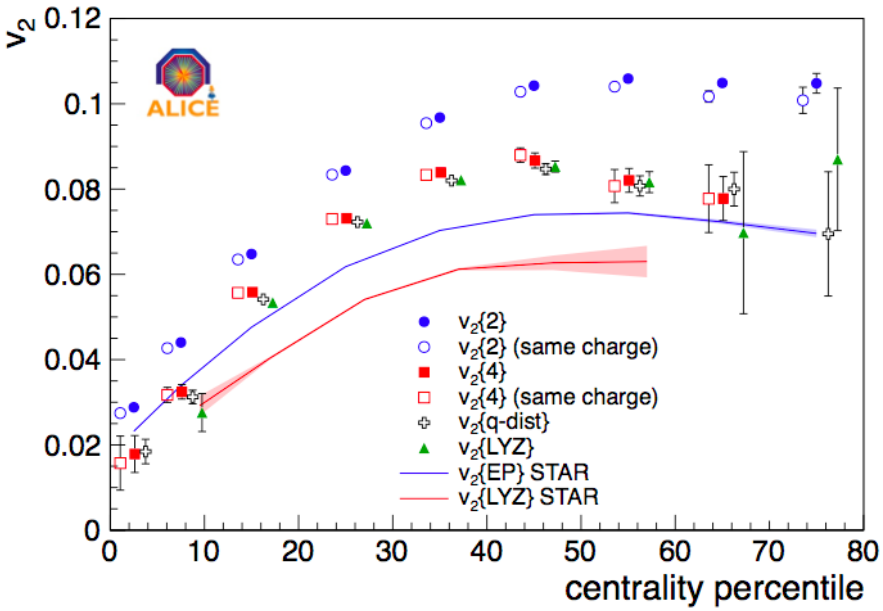
ALICE detector which can measure Event plane

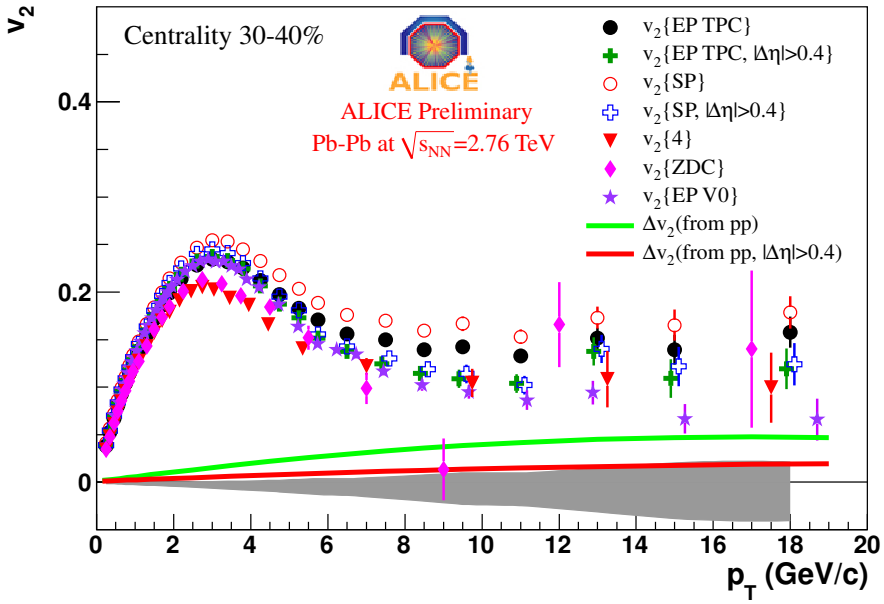


- TPC
  Central barrel
  $-0.8 \leq \eta \leq 0.8$
- V0
  Forward region
  V0A : $2.8 \leq \eta \leq 5.1$
  V0C : $-3.7 \leq \eta \leq -1.7$

v_2 measurement with various method

v_2 measurement result at ALICE



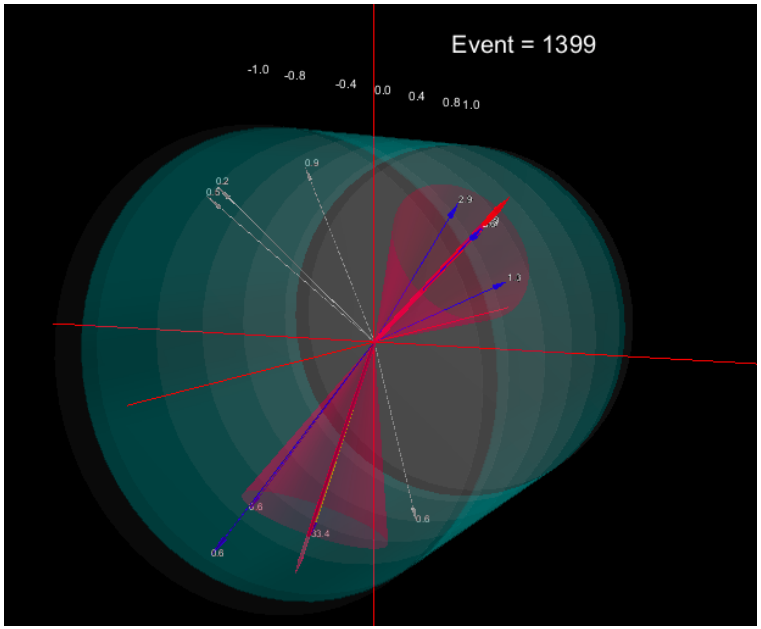


non-flow effect (comes from other source of azimuthal correlaltion)

- jet

Jet embedding

To check jet effect on flow, make jet particles with PYTHIA8 and embed these into ToyMC simulation.

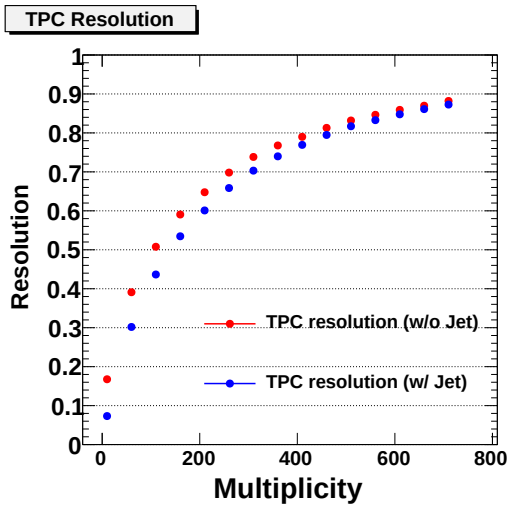


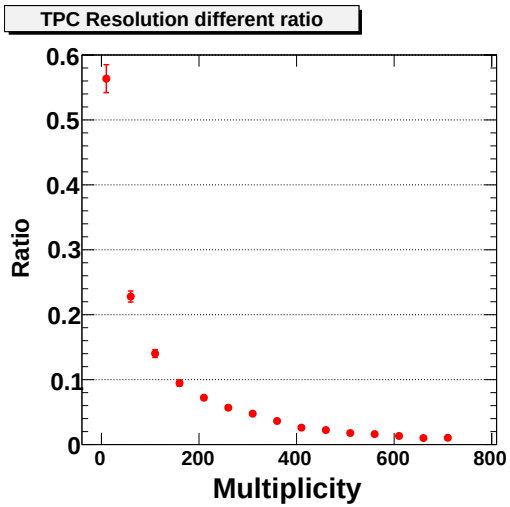
$$v_n = v_n^{obs}/\mathrm{RES}$$

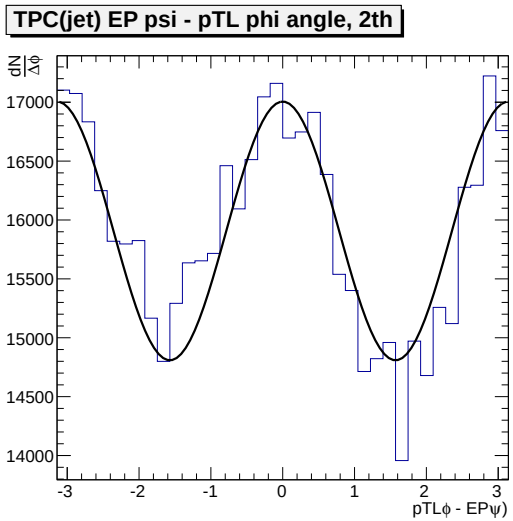
- check jet effect on RES
- check jet effect on v_n^{obs}

- Make bulk particle with equation(1)
- Make Jet particle with PYTHIA8
  - P_T of Leading particles $\geq$ 6GeV

Jet effect on resolution(TPC)

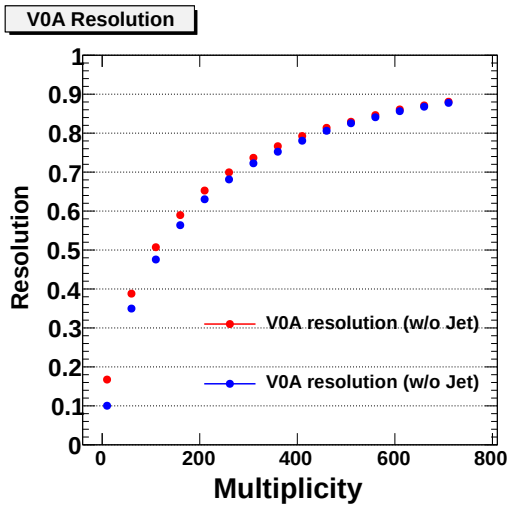


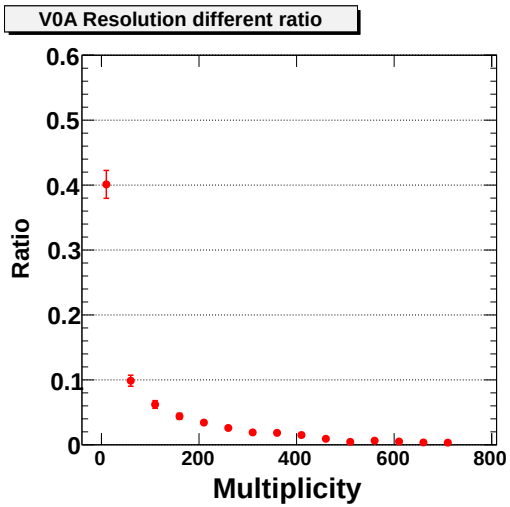


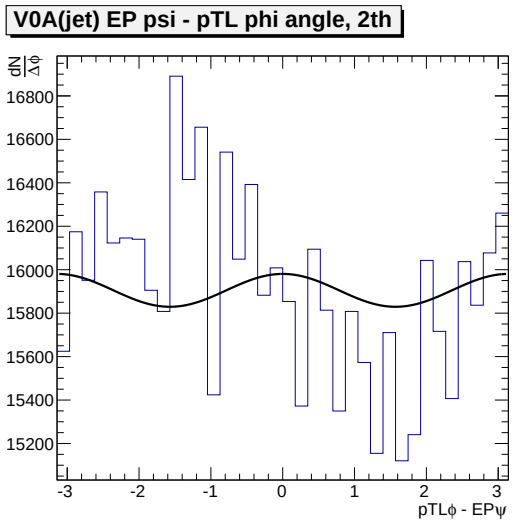


Strong correlation between leading particle direction(Jet direction) and measured Event plane angle shows that Event plane angle measurement in TPC is affected by Jet particles

Jet effect on resolution(V0A)



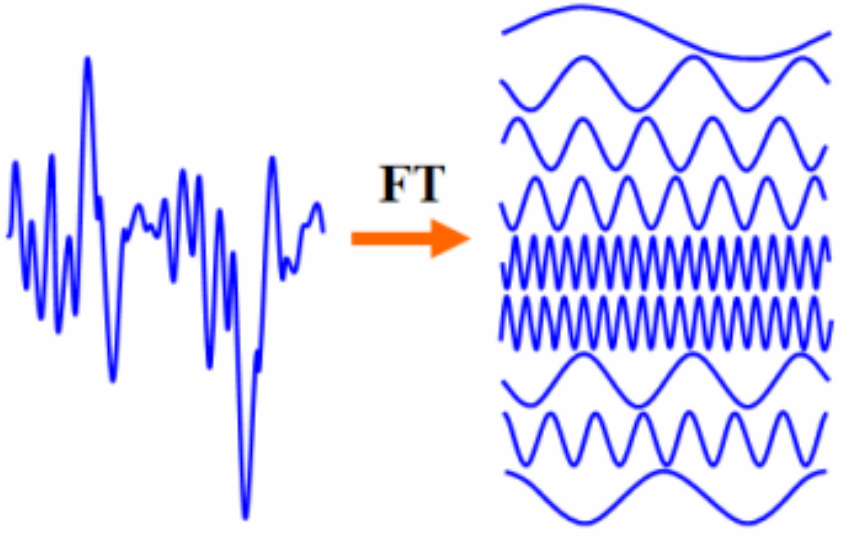


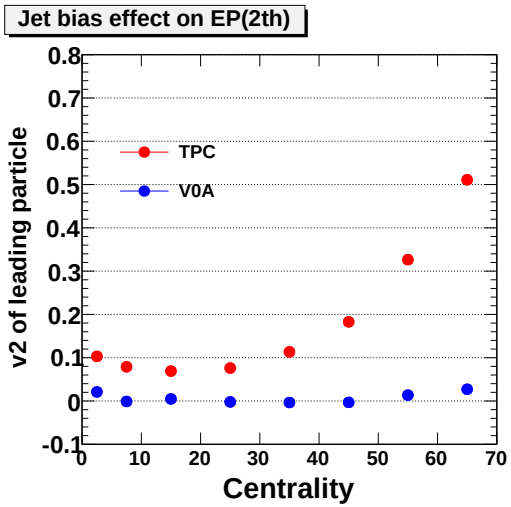


For V0A detector, which is located in forward region, has less effect when Jet particles are embedded into

→ This can be understood by properties of Fourier transform

Fourier transformation

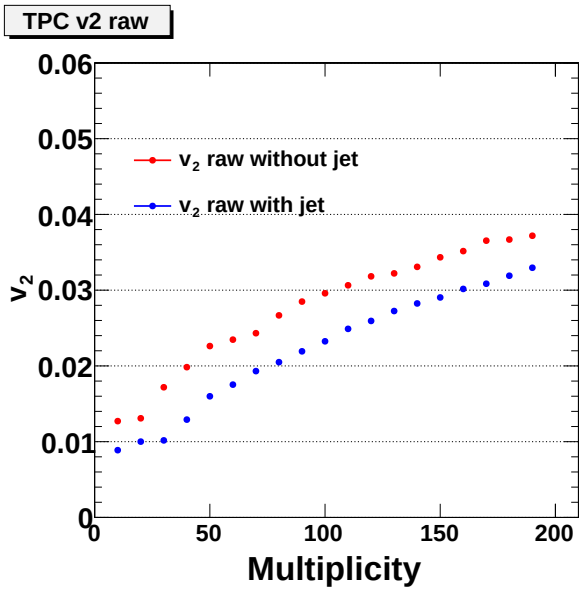


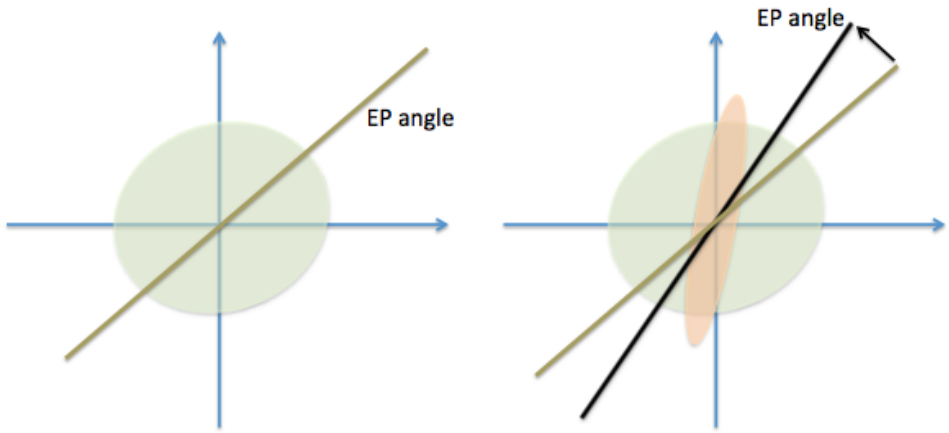


The Fourier transformation can extract out the frequencies of the a wave function which contribute to the signal. 2_{nd} order harmonics has period $-\frac{\pi}{2}$ to $\frac{\pi}{2}$.

- Di-jet $\rightarrow$ affect on v_2 event plane.
- One-side jet$\rightarrow$ affect on v_1 event plane

v_2^{obs} effect on TPC

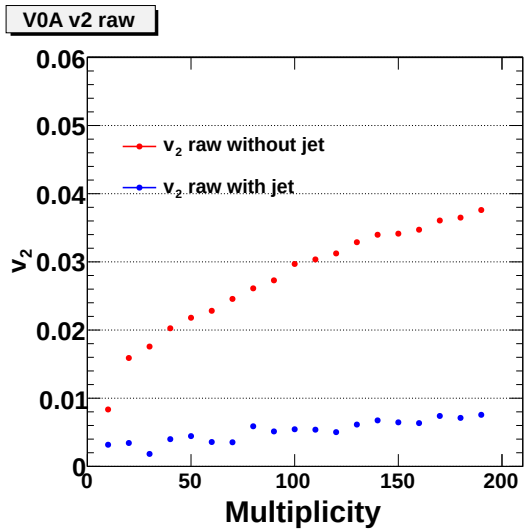




Measured event angle(black line on right Fig.)

- make v_2 low for bulk particles (green circle)
- make v_2 high for Jet particles(orange circle)

v_2^{obs} effect on V0



$$\langle \cos 2\Delta\phi \rangle_{bulk+jet} = \frac{\sum N_{bulk} \cos 2\Delta\phi_{Bulk} + \sum N_{jet} \cos 2\Delta\phi_{Jet}}{N_{bulk} + N_{jet}}$$

$$= \frac{\sum N_{bulk} \cos 2\Delta\phi_{Bulk}}{N_{bulk} + N_{jet}}$$

$$< \frac{\sum N_{bulk} \cos 2\Delta\phi_{Bulk}}{N_{bulk}}$$

$$= \langle \cos 2\Delta\phi \rangle_{bulk}$$

In case of V0 detector, EP bias effect are relatively small. And it is possible to assume that Jet direction and Event plane angle are independent. So, v_2^{obs} goes down by average effect

Result

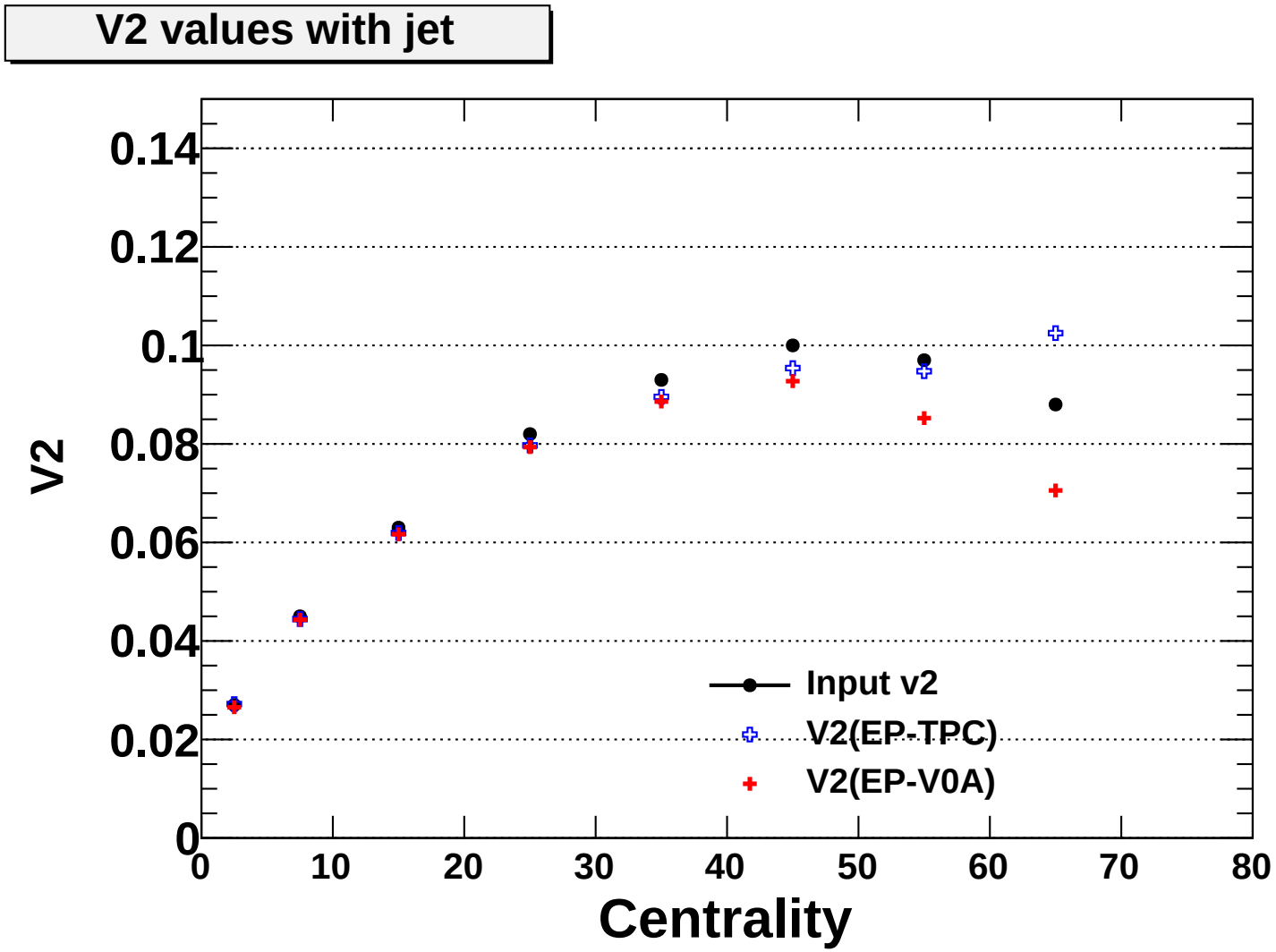
When Jet particles are embedded into bulk particles,

	TPC $(-0.8 \leq \eta \leq 0.8)$	V0A $(2.8 \leq \eta \leq 5.1)$
v_2^{obs}	Decrease (EP tilt effect)	Decrease (Average effect)
Res	Decrease (EP bias)	Decrease (EP bias)

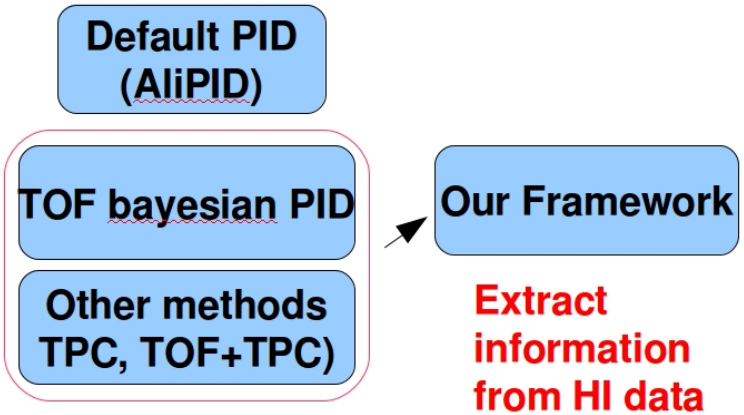
$v_n = \frac{v_n^{obs}}{\text{Res}}$

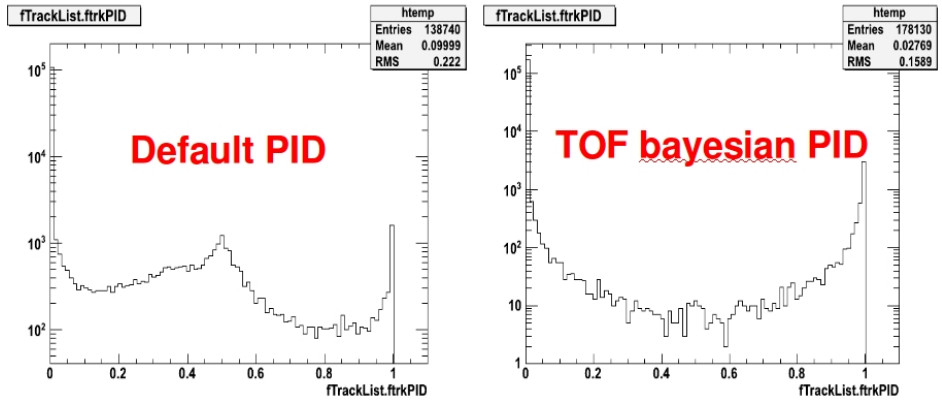
- measure v_2 with TPC Event angle: $\Delta v_2^{obs} < \Delta Res$
- measure v_2 with V0 Event angle: $\Delta v_2^{obs} > \Delta Res$

Result


V2 values with jet
V2
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
0
10
20
30
40
50
60
70
80
Centrality
Input v2
V2(EP-TPC)
V2(EP-V0A)

PID improvement

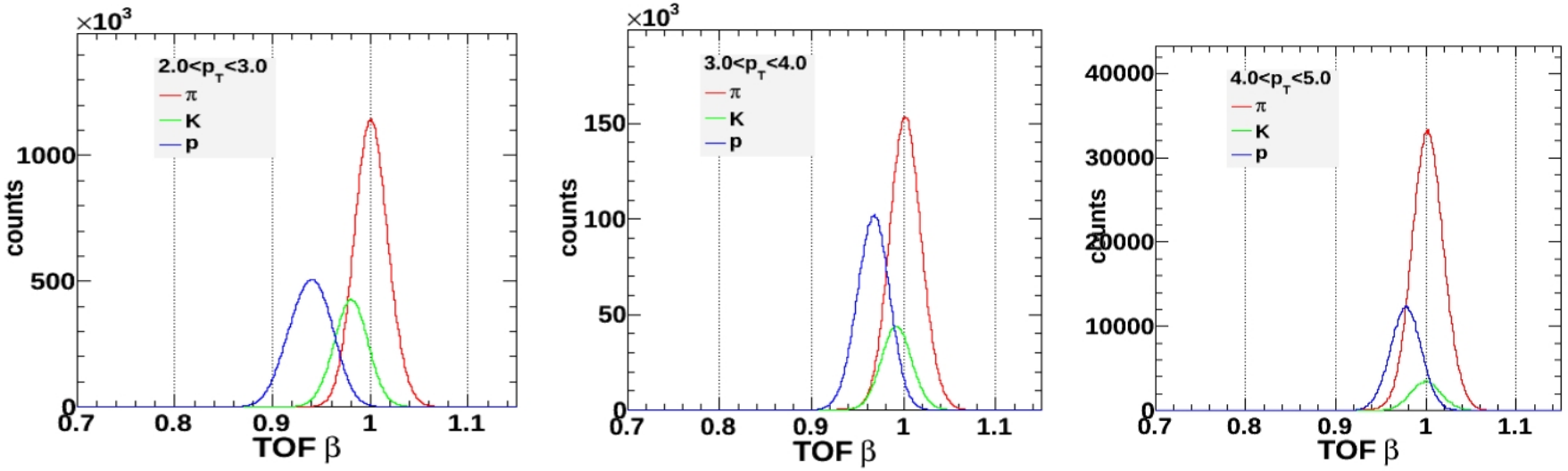




- Calculate probability per track by TOF
- Compute weight to consider response and resolution of TOF and TPC
- Calculate probability, beta and the mass from TOF

Storing these probabilities and information to check

PID improvement



- LHC10h 19.1M events
- MB event selection
- Same cut which used in R_{AA} group

PID : $P_i \geq 0.9$ (i : Pion, Kaon, Proton)

Summary

Flow study to understand non-flow effect is going on @ Yonsei. Group

- Jet effect study
- PID flow study

And below activities will be done

- Resolution study
- Calculate flow with V0 in LHC11h data
- EventPlane calibration with V0 detector (EP flatness)
- PID improvement

Thank you a lot for your attention!