Estimates of heavy-ion collision symmetry planes

Jacobus Onderwaater (TU Darmstadt/EMMI/GSI)
On behalf of the ALICE Collaboration

TECHNISCHE UNIVERSITÄT DARMSTADT
XXIV QUARK MATTER DARMSTADT 2014

1. Introduction

The measurement of anisotropic flow and its fluctuations in heavy-ion collisions requires an estimate of the collision symmetry plane from the azimuthal distribution of produced particles. Non-uniformity of the detector response distorts azimuthal distributions. The performance of a correction procedure for detector non-uniformity is demonstrated for the event plane method:

$$v_n\{EP\} = \langle\cos(n(\phi-\Psi_n))\rangle = \langle\cos(n(\phi-\Psi_n^{EP}))\rangle/R_n^{EP}. \quad (1)$$

Here ϕ is the azimuthal angle of the particles and Ψ_n is the symmetry plane for harmonic n. The symmetry plane is estimated with the event plane (Ψ_n^{EP}) constructed from the measured azimuthal distributions. To calculate the event plane angle, the $\boldsymbol{q}$-vector is constructed ($\Psi_n^{EP} = \arctan 2(q_{n,y}, q_{n,x})/n$):

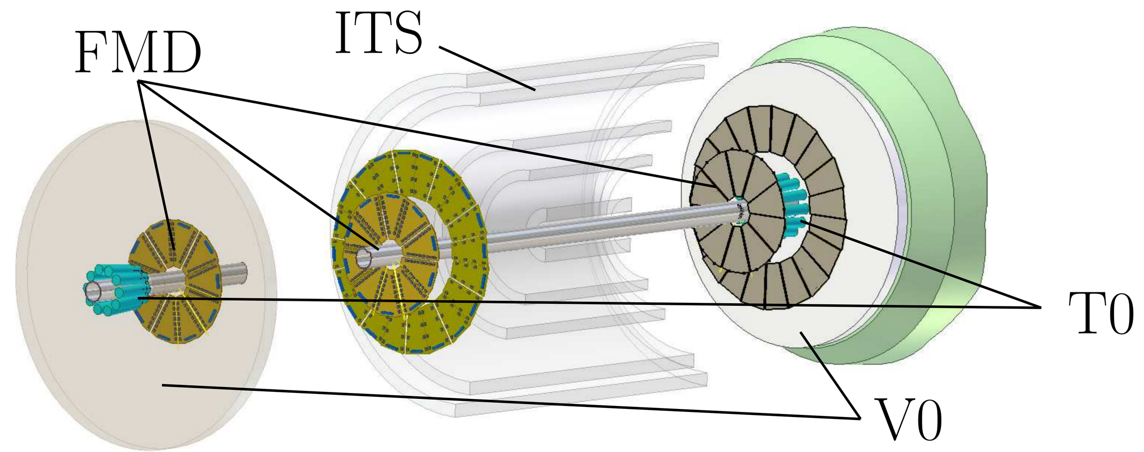
$$\boldsymbol{q}_n = (q_{n,x}, q_{n,y}) = \frac{1}{M}\sum_c^{N_c} M_c\,(\cos n\phi_c, \sin n\phi_c)\Big/\frac{1}{M}\sum_c^{N_c} M_c, \quad (2)$$

where ϕ_c is the azimuthal angle of a segment (track) c and M_c is the measured signal (one for tracks). N_c is the number of segments (tracks) in a given multiplicity (tracking) detector. The correlation between the symmetry and event plane determines the resolution correction: $R_n^{EP} = \langle\cos(n(\Psi_n^{EP}-\Psi_n))\rangle$.

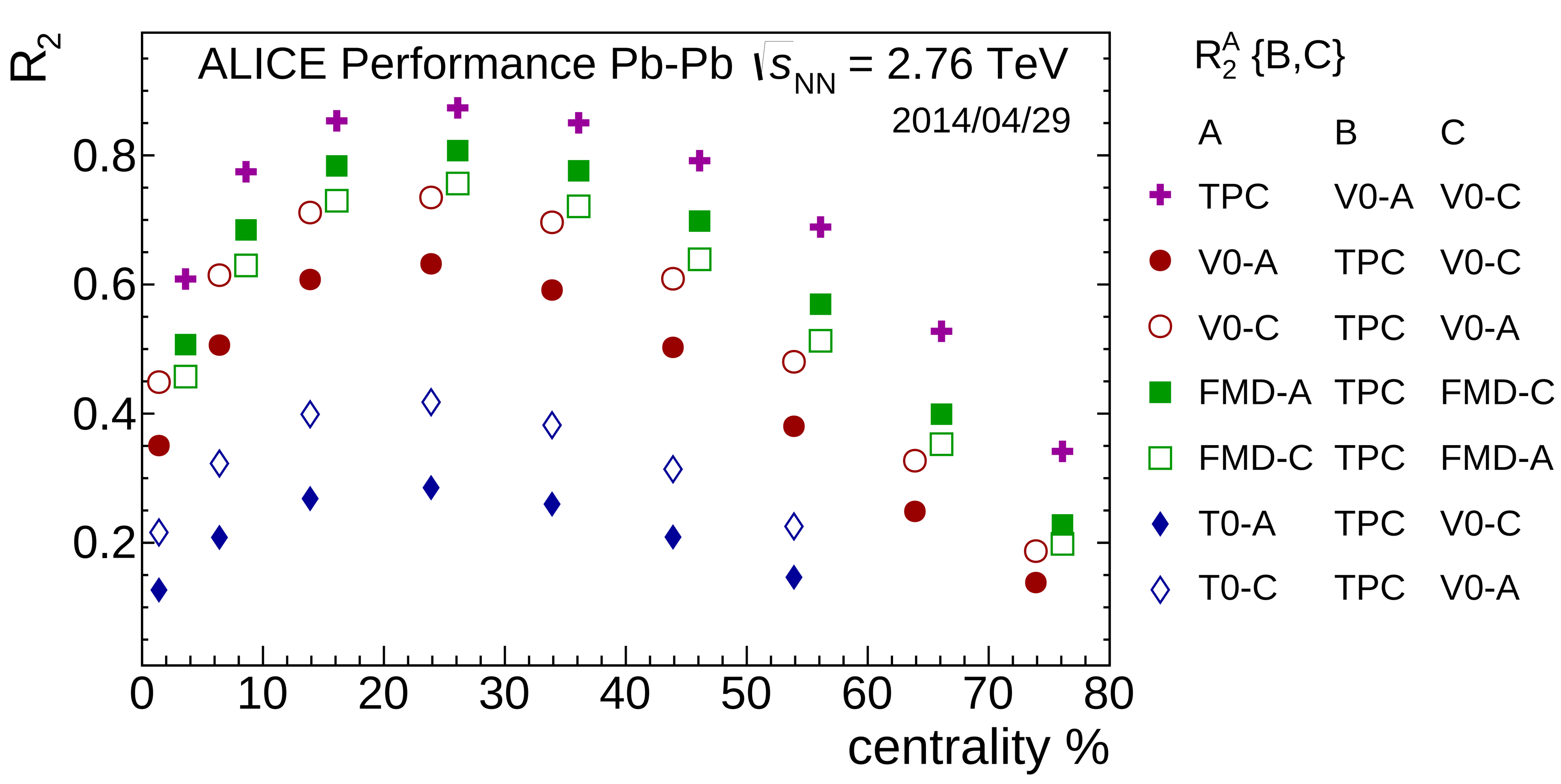
2. Detectors for symmetry plane estimation

A sample of 12×10^6 Pb-Pb minimum bias events is analyzed. Elliptic flow is measured for particles reconstructed with TPC and ITS detectors in the range of $|\eta|<0.8$ and $0.2<p_{\mathrm{T}}<20$ GeV/c. The collision symmetry plane is estimated from particle azimuthal distributions measured by the ALICE subsystems listed in the table below.

Detector	η C-side	η A-side
Time Projection Chamber (TPC)	[-0.9 , 0.9]	
Inner Tracking System (ITS)	[-2.0 , 2.0]	
Scintillator multiplicity counter (V0)	[-3.7 , -1.7]	[2.8 , 5.1]
Cherenkov multiplicity counter (T0)	[-3.3 , -3.0]	[4.6 , 4.9]
Forward Multiplicity Detector (FMD)	[-3.4 , -1.7]	[1.7 , 5.0]



4. Event plane resolution correction



The T0, V0 and FMD detector resolution correction is shown separately for both sides of the interaction point. The event plane resolution correction is calculated with the 3-subevent method [1],

$$R_n^A\{B,C\} = \sqrt{\frac{\langle\cos n(\Psi_n^A-\Psi_n^B)\rangle\langle\cos n(\Psi_n^A-\Psi_n^C)\rangle}{\langle\cos n(\Psi_n^B-\Psi_n^C)\rangle}}. \quad (3)$$

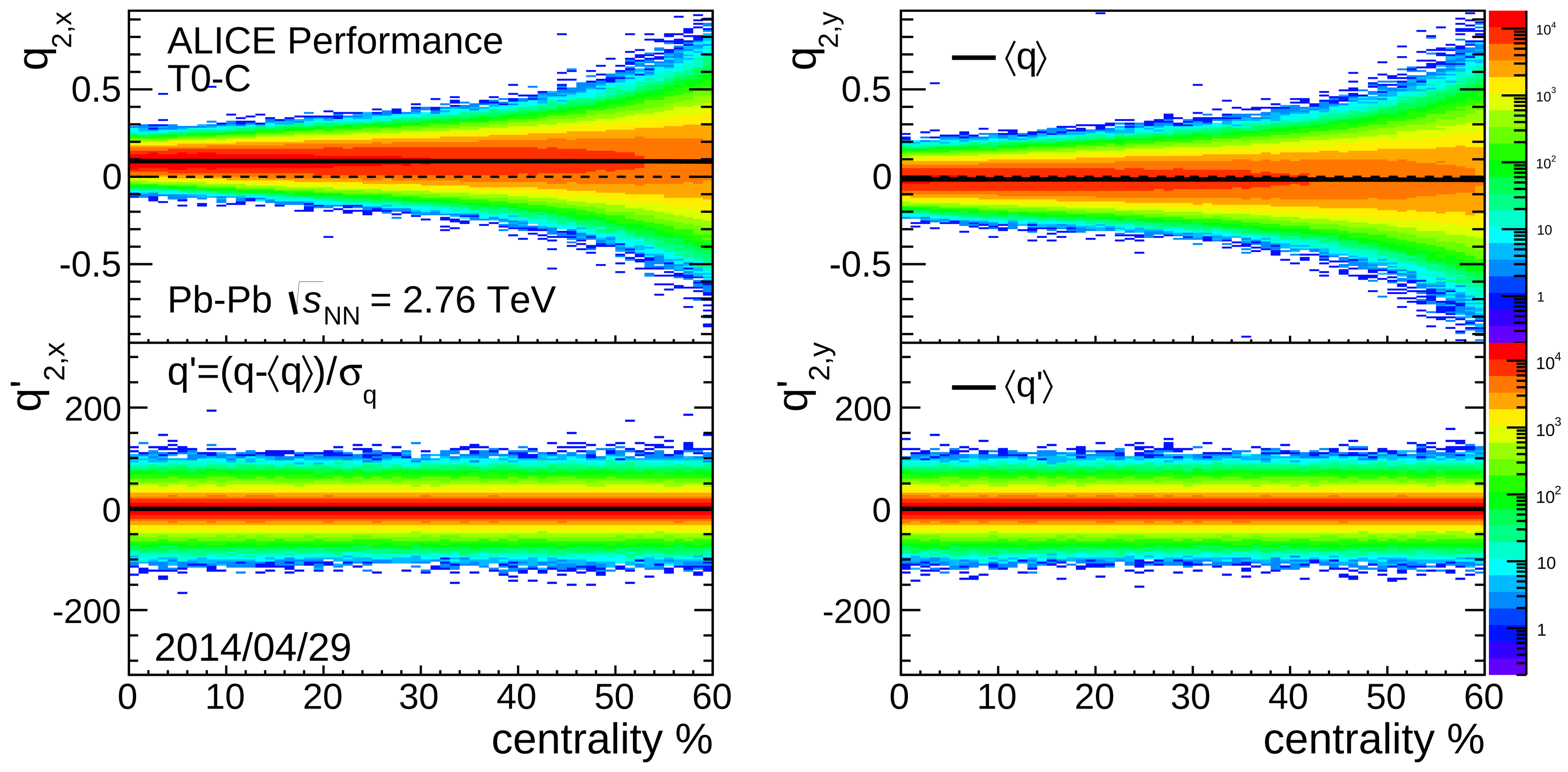
The subevents A, B and C are chosen to have a large rapidity gap to minimize non-flow correlations. The T0 detector arms are often empty for peripheral events due to their narrow acceptance and the correction is shown up to 60% centrality.

3. Corrections for non-uniform azimuthal acceptance

To account for non-uniform acceptance of the detectors, corrections are applied to the $\boldsymbol{q}$-vector [2]:

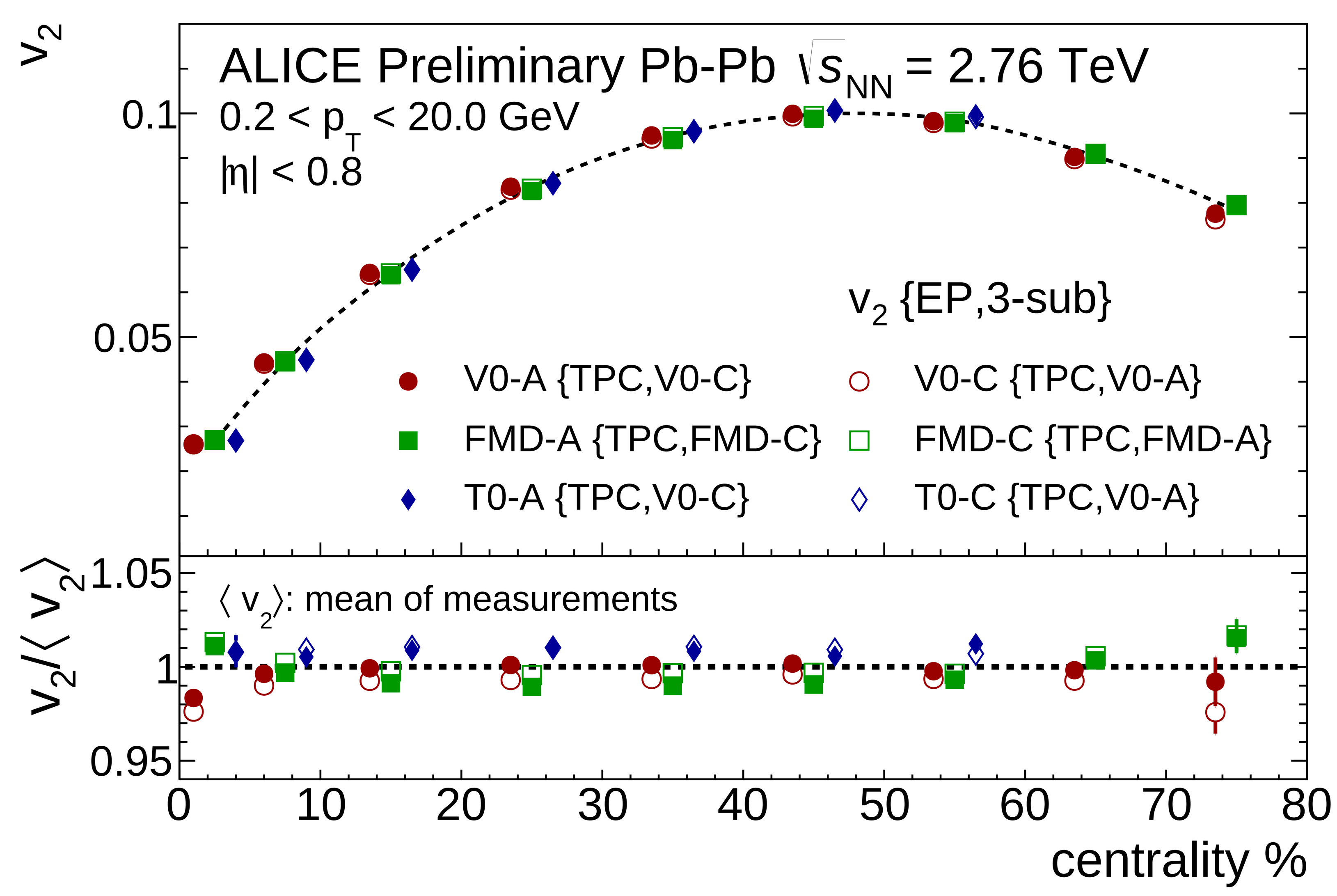
1. Gain equalization of individual detector channels $M_c' = M_c/\langle M_c\rangle$
2. Recentering $\boldsymbol{q}_n' = \boldsymbol{q}_n - \langle\boldsymbol{q}_n\rangle$
3. Width equalization $\boldsymbol{q}_n'' = \boldsymbol{q}_n'/\sigma_{\boldsymbol{q}_n}$
4. Alignment $\boldsymbol{q}_n''' = \boldsymbol{q}_n'' + \boldsymbol{q}_{n,\phi}''$
5. Twist $q_{n,(x,y)}'''' = (q_{n,(x,y)}''' - \Lambda_{2n}^{s(+,-)} q_{n,(y,x)}''')/(1-\Lambda_{2n}^{s-}\Lambda_{2n}^{s+})$
6. Rescaling $q_{n,(x,y)}''''' = q_{n,(x,y)}''''/A_{2n}^{(+,-)}$

The first three corrections are applied for the results presented in this poster. Effects of twist, rescaling, and alignment correction for effective detector misalignment, are found to be insignificant.



The figure illustrates the effect of $\boldsymbol{q}$-vector recentering and width equalization for the T0-C measurement as a function of collision centrality for both $\boldsymbol{q}$-vector components. The correction is applied as a function of event centrality and vertex position along the beam direction.

5. Elliptic flow



Elliptic flow (v_2) measured with symmetry plane estimates from T0-A/C, V0-A/C and FMD-A/C detectors is consistent within 4% for the 0-80% centrality range.

6. Conclusion

The results for elliptic flow in Pb-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$=2.76 TeV measured with symmetry plane estimates from a set of ALICE forward multiplicity detectors are consistent within 4%. The observed effect is smaller than in the hydrodynamic model calculations [3] which show variation of v_2 up to 6% (peripheral) and 13% (central) with the magnitude of the event plane resolution correction.

References

[1] A. M. Poskanzer and S. Voloshin, Phys.Rev. **C58**, 1671 (1998), nucl-ex/9805001.

[2] I. Selyuzhenkov and S. Voloshin, Phys.Rev. **C77**, 034904 (2008), 0707.4672.

[3] M. Luzum and J.-Y. Ollitrault, Phys.Rev. **C87**, 044907 (2013), 1209.2323.