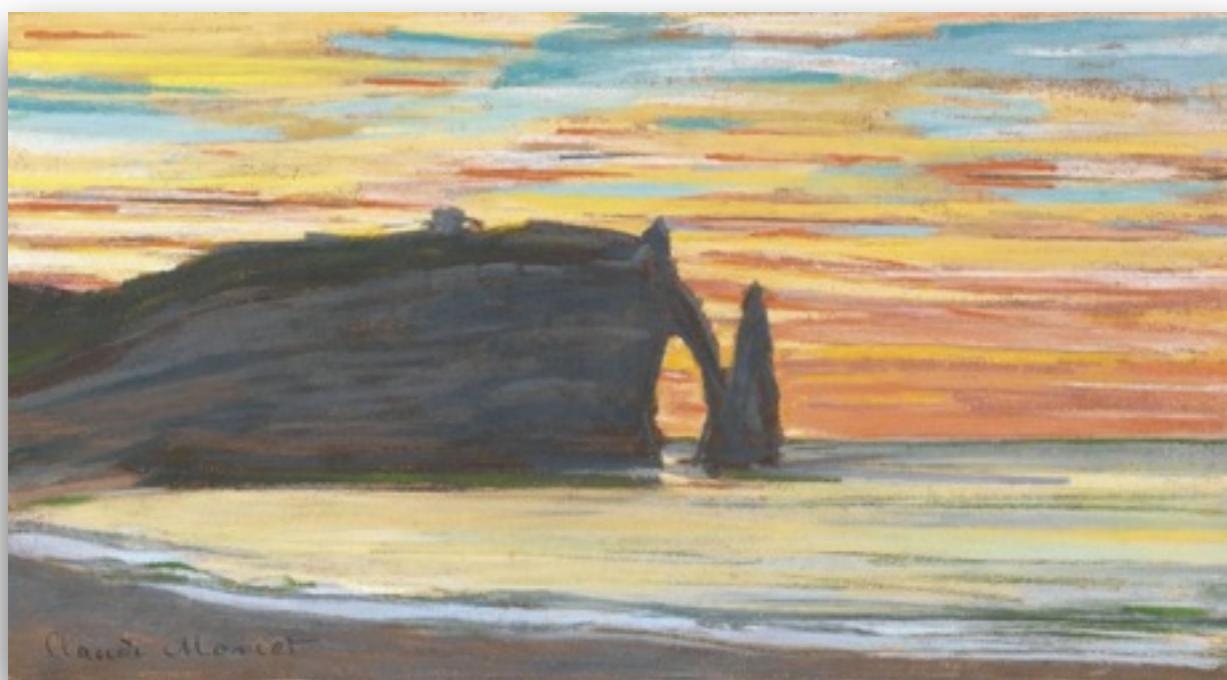


# J/ $\psi$ v<sub>2</sub> in PbPb collisions at $\sqrt{s_{NN}}=5.02\text{TeV}$ with the muon spectrometer



ALICE



Audrey Francisco



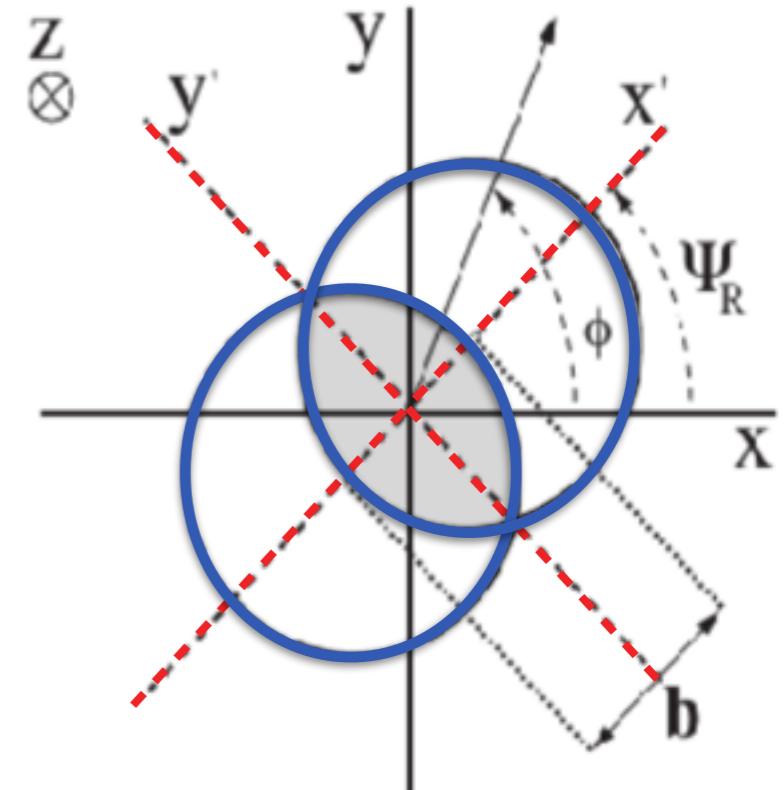
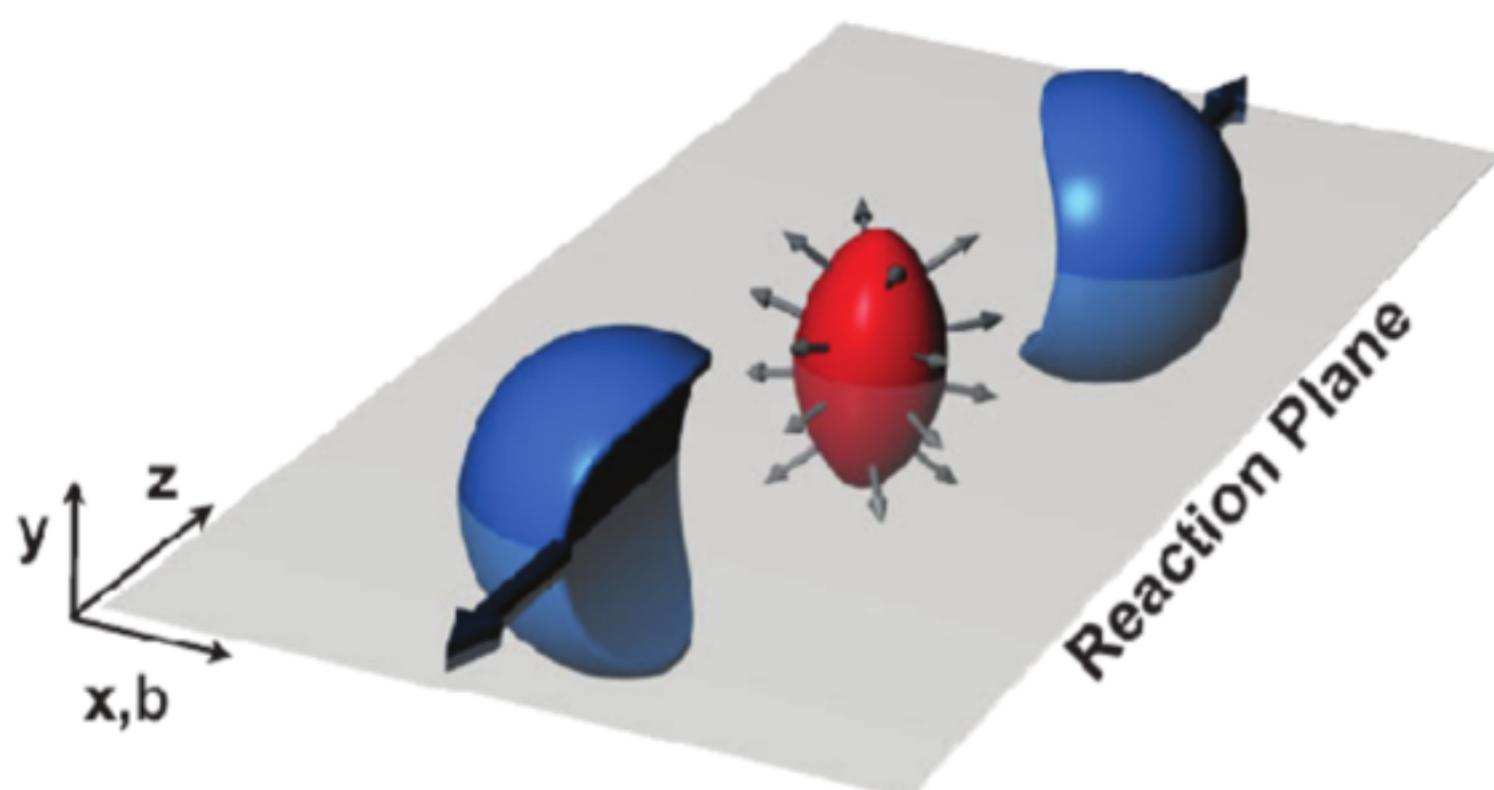
Octobre 11th 2016  
Rencontres QGP-France

# Summary

- Motivations for  $\text{J}/\Psi$   $v_2$  study
- Event plane method
- Detector equalization
- $\text{J}/\Psi$   $v_2$  extraction

Collaboration with Javier Castillo  
and Corentin Cot from Saclay

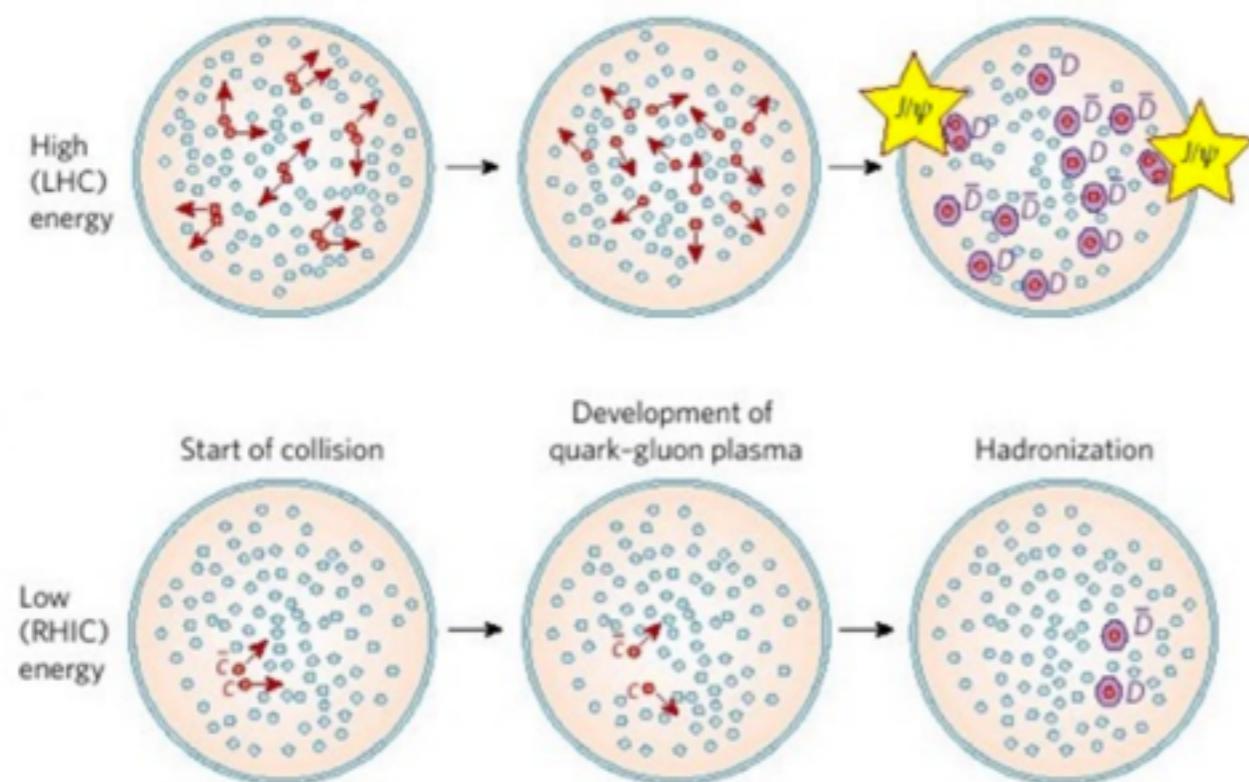
# Momentum anisotropy in the QGP



- For **non-central** collisions, **anisotropic** geometrical overlap
- Particle azimuthal distribution w.r.t. the reaction plane :  $E \frac{d^3N}{d^3p} = \frac{1}{2\pi} \frac{d^2N}{p_T dp_T dy} \left( 1 + \sum_{n=1}^{\infty} 2v_n \cos(n(\phi - \Psi_{RP})) \right)$
- 2nd harmonic of the Fourier series : **elliptic flow** ( $v_2$ )  $v_n^{\text{obs}} = \langle \cos(n[\phi - \Psi_{EP}]) \rangle$

# Motivations

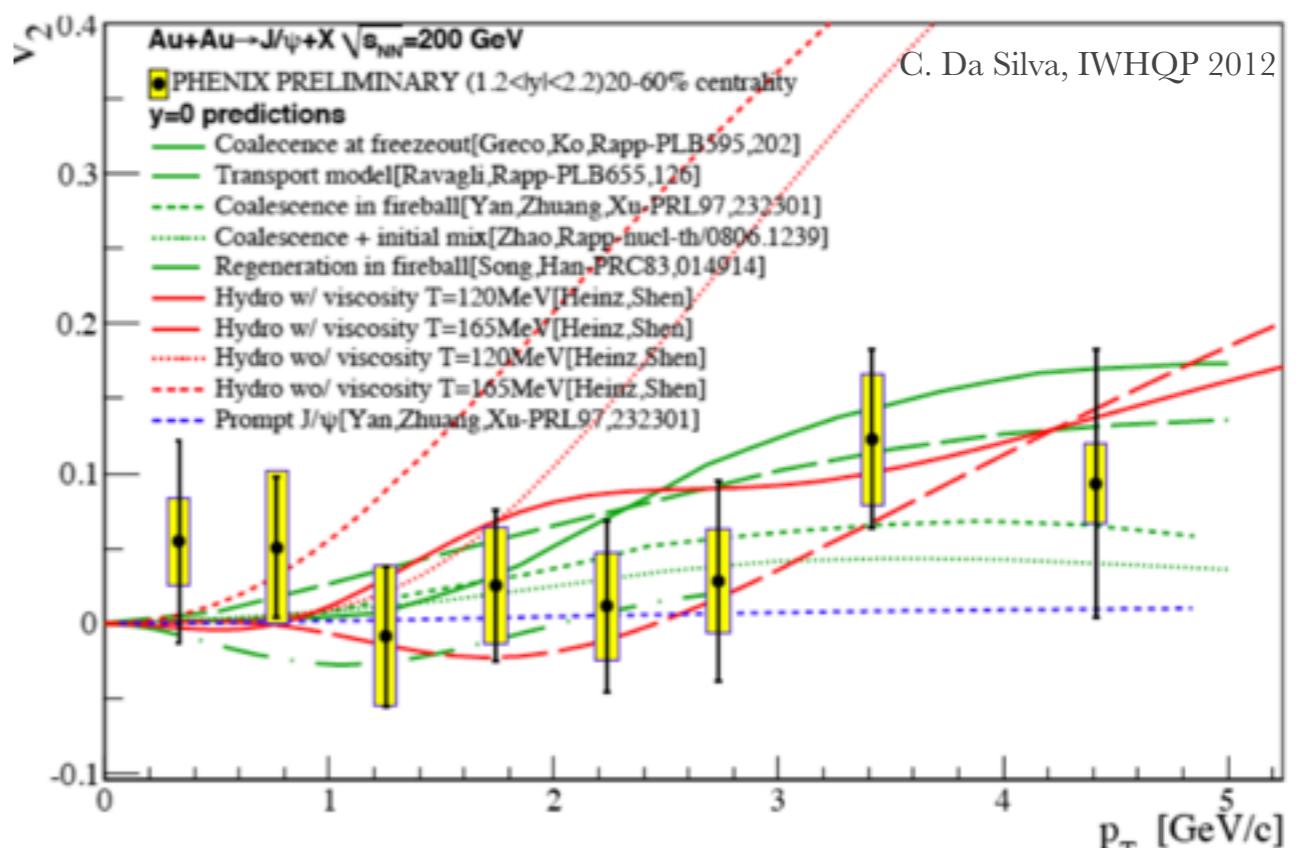
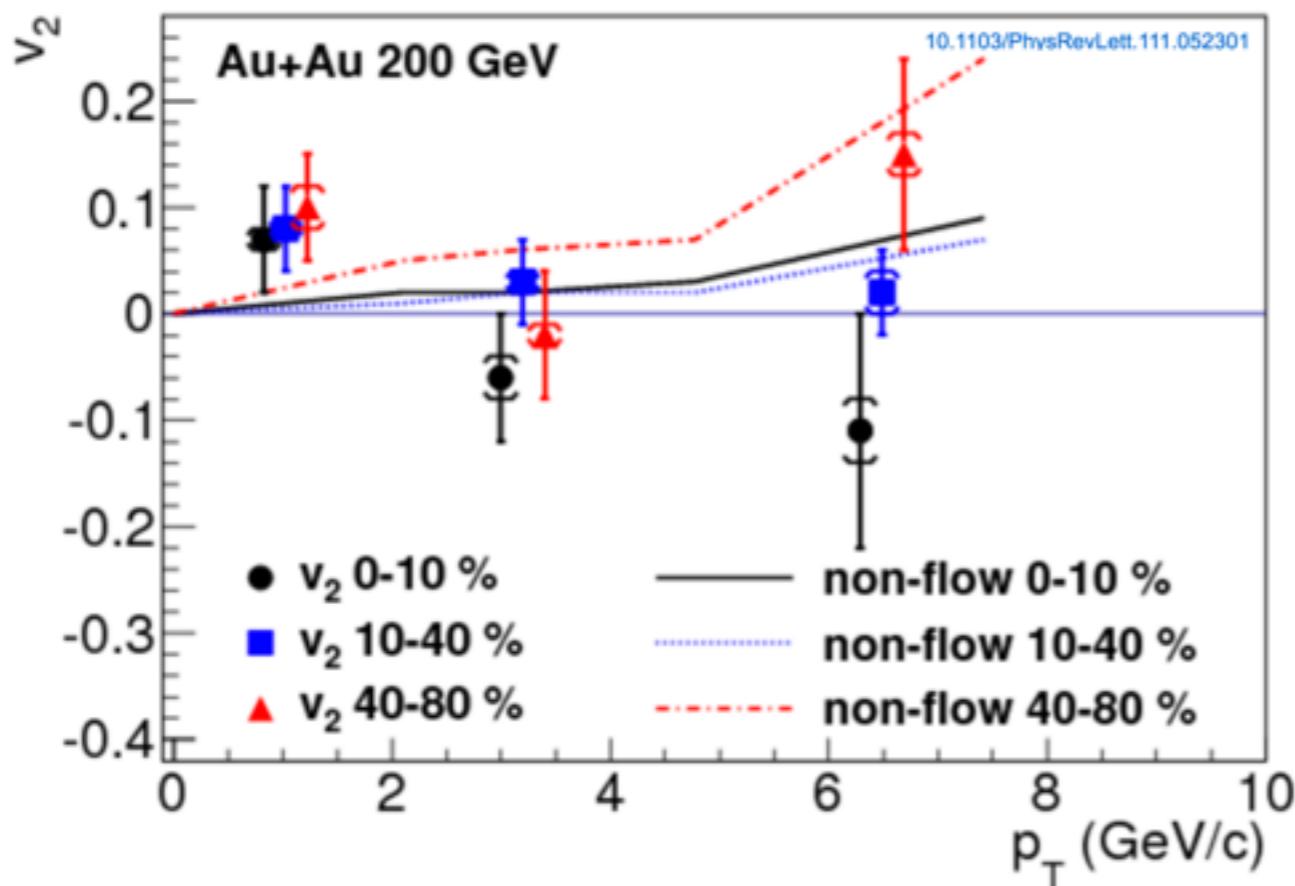
- $J/\psi$  are produced at early stages of the collision → insensitive to collective phenomena
- suppression by Debye like color screening mechanism
- recombination of  $c\bar{c}$  pairs → inherit the flow of charm quarks



flow = relevant observable for  $J/\Psi$   
regeneration study

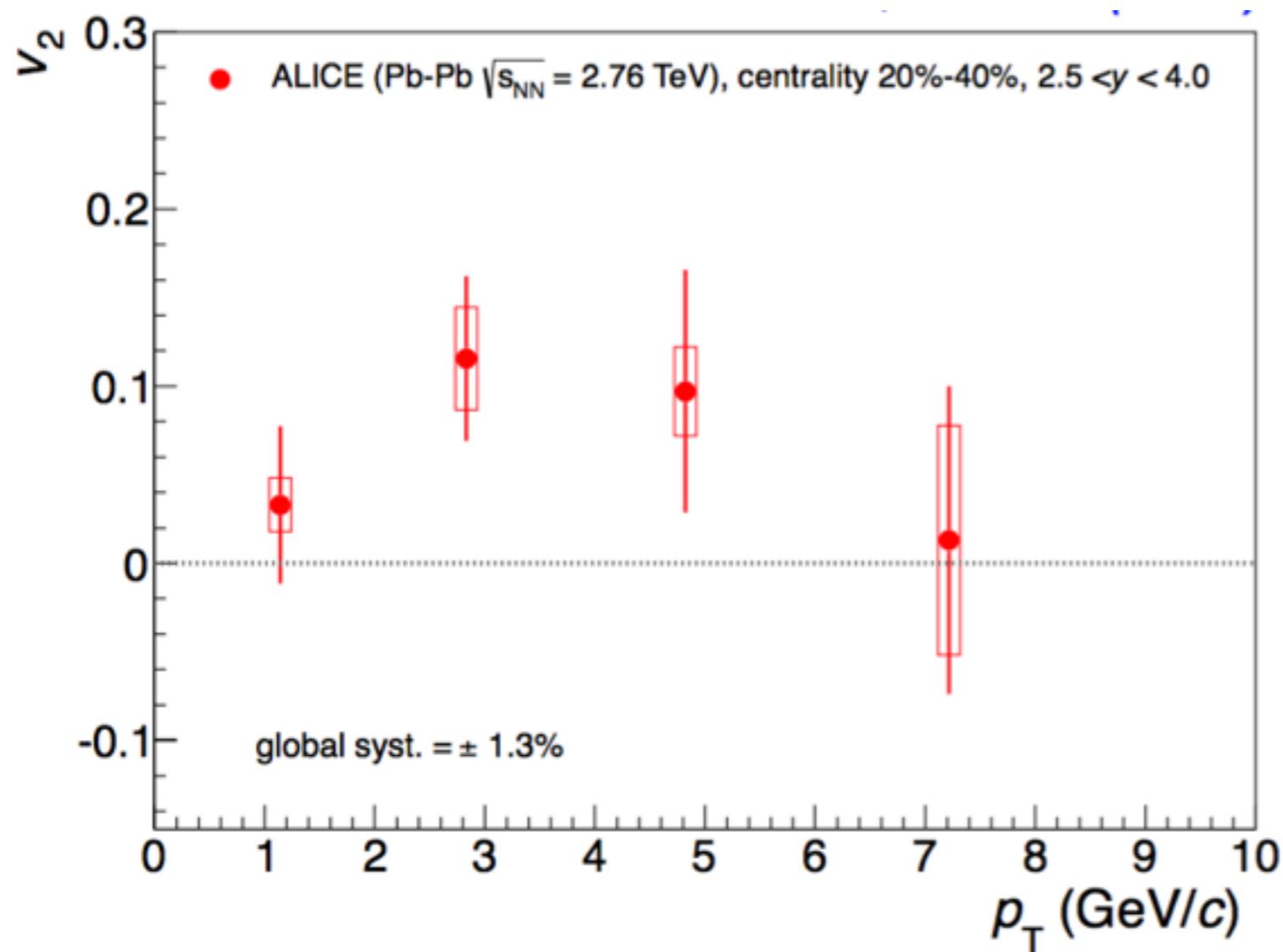
# Results at RHIC

→  $J/\Psi$   $v_2$  compatible with zero



# Results from LHC for run 1

- First hints of non-zero  $\text{J}/\Psi v_2$



# Event plane method

- From the Fourier distribution

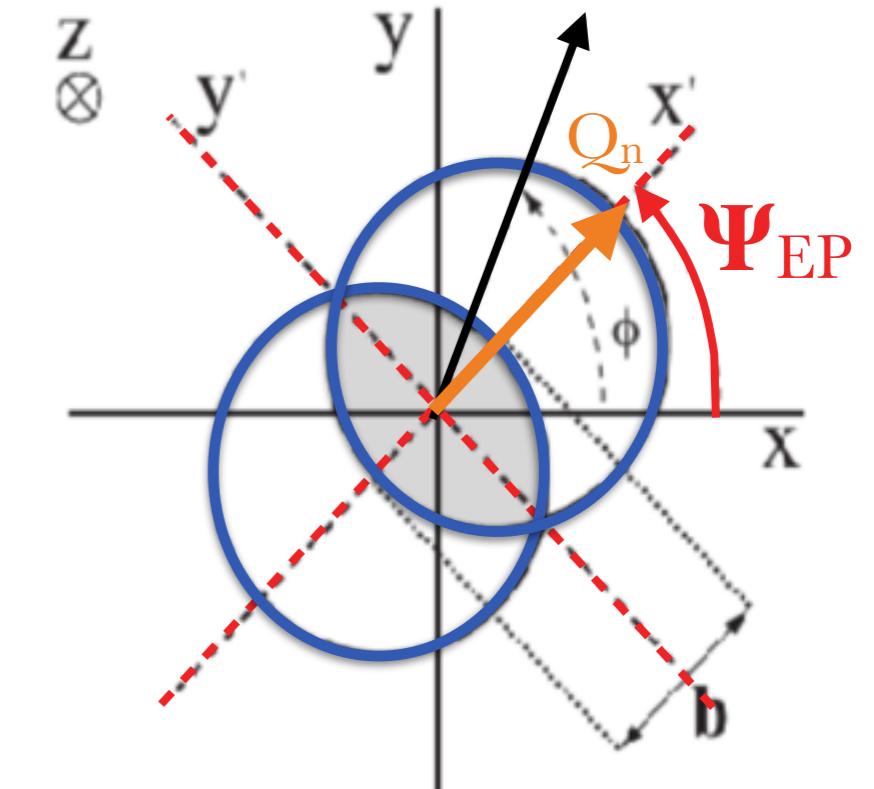
$$E \frac{d^3N}{d^3p} = \frac{1}{2\pi} \frac{d^2N}{p_T dp_T dy} \left( 1 + \sum_{n=1}^{\infty} 2v_n \cos(n(\phi - \Psi_{EP})) \right)$$

$$v_n^{\text{obs}} = \langle \cos(n[\phi - \Psi_{EP}]) \rangle$$

- Extraction of the nth harmonic

$$Q_{n,x} = \sum w_i \cos(n\phi_i) = |Q_n| \cos(n\Psi_{EP}^n)$$

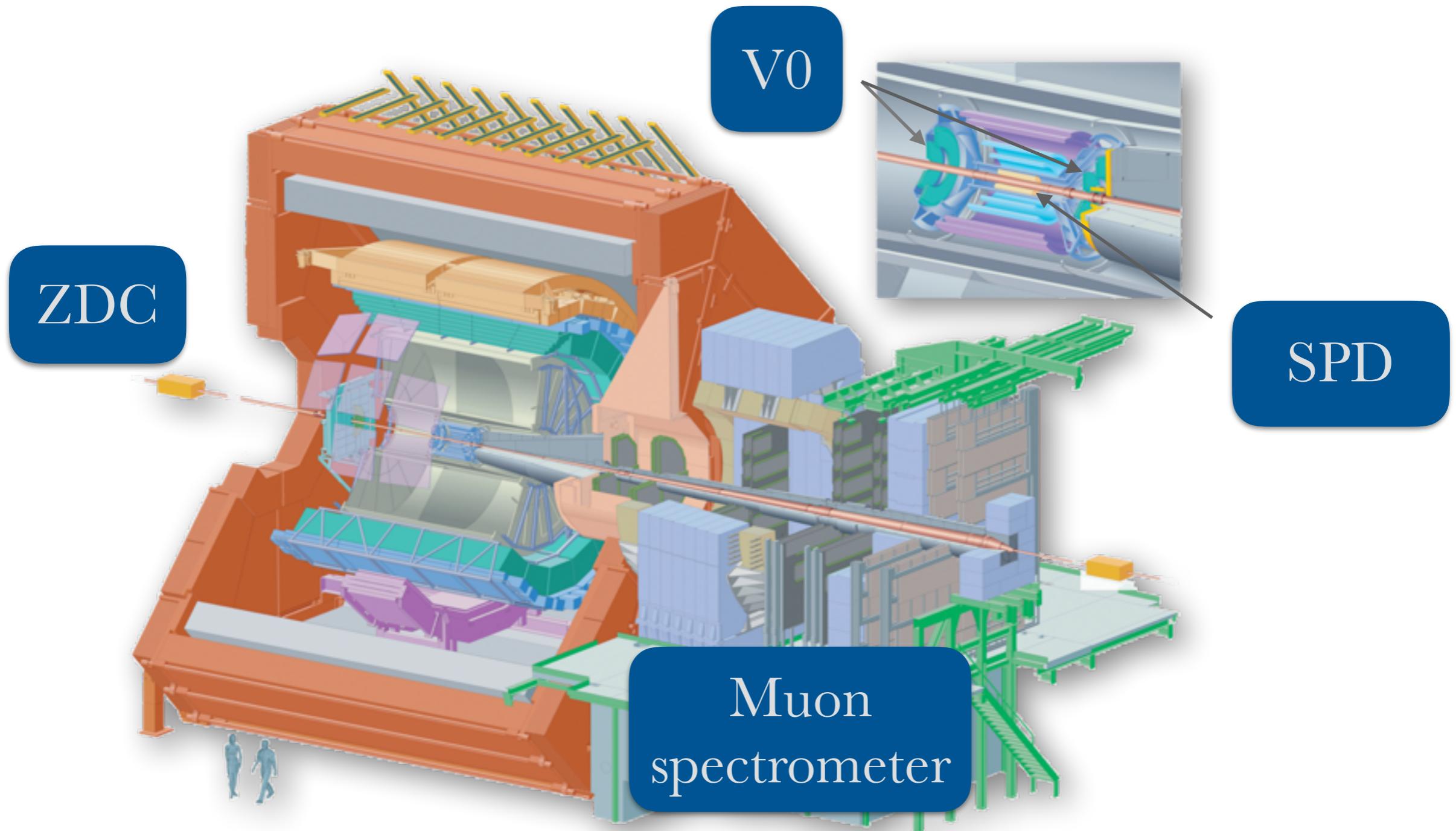
$$Q_{n,y} = \sum w_i \sin(n\phi_i) = |Q_n| \sin(n\Psi_{EP}^n)$$



$$\Psi_{EP}^n = 1/n \arctan(Q_{n,y}, Q_{n,x})$$

- Extraction of  $N_{J/\psi}$  in bins of  $\Delta\phi = \phi - \Psi_{EP}$  and fit of  $dN_{J/\psi}/d\Delta\phi$

# The ALICE detector



# V0 equalization

- Reaction plane should be **isotropic**
- Correction steps : compensate **non-uniform acceptance** effects of the detector on Qvectors (algebraic operations)
- Involved detectors: V0A and V0C with SPD as tracker
- Equalization of PbPb@5.02TeV dataset
  - minimum bias trigger
  - Centrality V0M [00,90%] and  $|z_{\text{vertex}}| < 10.0\text{cm}$

# Event selection for v<sub>2</sub> analysis

137 runs from PbPb@5.02TeV period

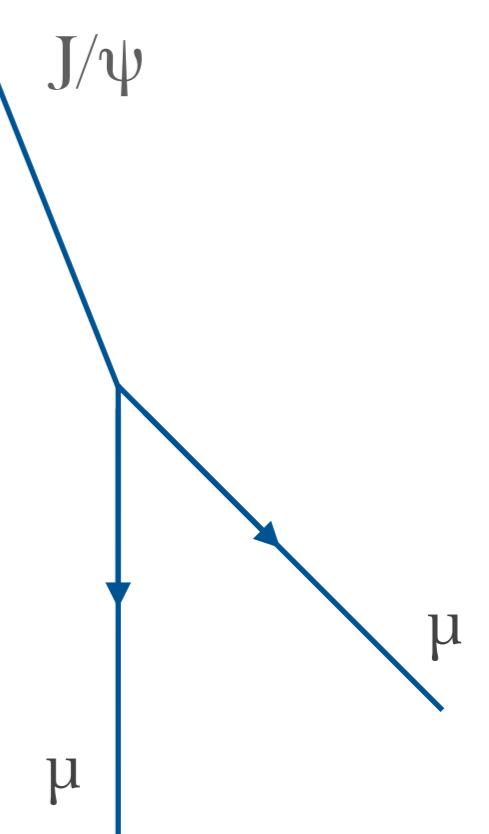
Trigger : Minimum bias + 2 opposite sign muons firing the muon trigger

Centrality : 20-40%

$|z_{\text{vtx}}| < 10\text{cm}$

**standard cuts for  
J/ $\psi$  analysis with  
ALICE spectrometer**

$-4 < \eta < -2.5$	for single muons
$2.5 < y < 4$	for dimuons
$0 < p_T < 12 \text{ GeV}$	



# Summary

- Extract  $v_2$  is ongoing...
- ... And a lot of work to do !
  - flow from different  $p_T$  and centrality ranges
  - Correction for detector resolution
  - Others  $v_2$  extraction techniques (inv. mass fit, ...)



# Backup

# Equalization steps

1. Gain equalization of individual detector channels

$$M'_c = M_c / \langle M_c \rangle$$

2. Recentering

$$\mathbf{q}'_n = \mathbf{q}_n - \langle \mathbf{q}_n \rangle$$

3. Width equalization

$$\mathbf{q}''_n = \mathbf{q}'_n / \sigma_{\mathbf{q}_n}$$

4. Alignment

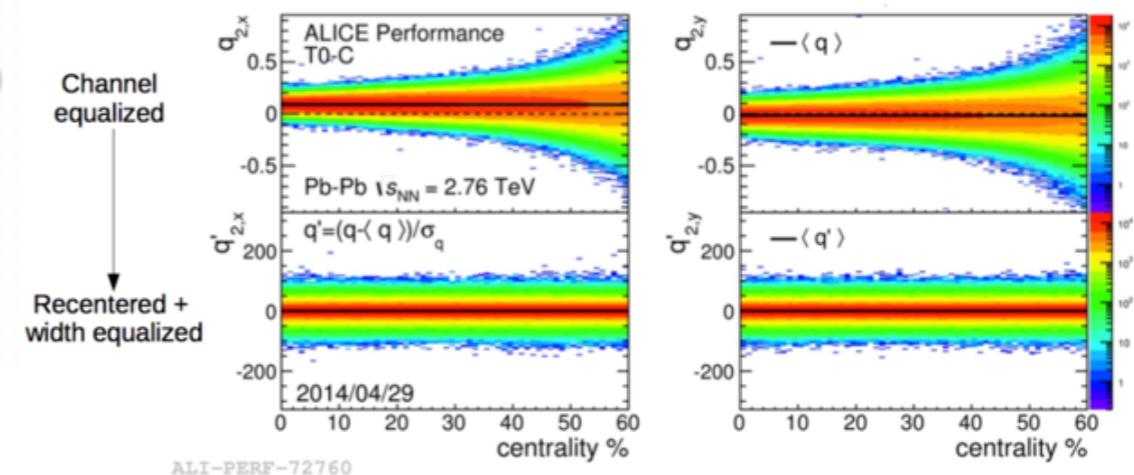
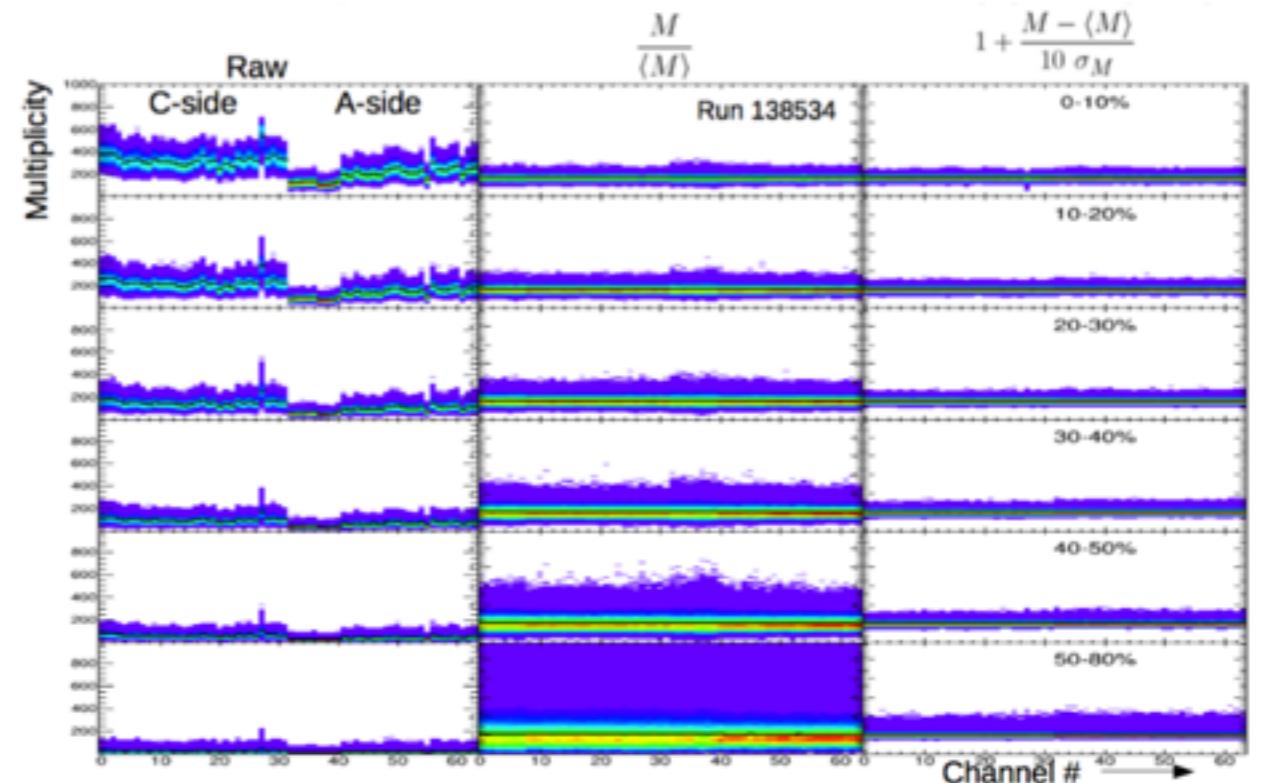
$$\mathbf{q}'''_n = \mathbf{q}''_n + \mathbf{q}''_{n,\phi}$$

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

$$q''''_{n,(x,y)} = q''''_{n,(x,y)} / A_{2n}^{(+,-)}$$



# Motivations

- J/ $\Psi$  sources**
- Apparition
    - formation at early stage of the collision
    - decay of heavier quarkonia states
    - recombination of charm quarks
      - + cold nuclear matter effects !
  - J/ $\Psi$  suppression/recombination in the QGP
    - Primordial J/ $\Psi$  → **insensitive to collective phenomena**
    - $c\bar{c}$  recombination → **inherit the flow of charm quarks**
- flow = relevant observable for J/ $\Psi$  suppression/regeneration study

# Biblio

- Effects of non-uniform acceptance in anisotropic flow measurements, Ilya Selyuzhenkov and Sergei Voloshin Phys. Rev. C 77, 034904 (2008)
- <https://twiki.cern.ch/twiki/bin/viewauth/ALICE/FlowVectorCorrections>
- <https://twiki.cern.ch/twiki/bin/view/ALICE/QnVectorCorrections>
- Event Plane Calibration, 16/09/2016, Flow pag, J. C. Castellanos
- Elliptic flow of  $J/\psi$  in Pb-Pb collisions at  $\sqrt{s_{_{NN}}} = 2.76$  TeV Analysis Note, L. Massacrer, H. Yang & al., July 2012
- Measurement of  $J/\psi$  elliptic flow in PbPb collisions at 5Tev, Corentin Cot, 21/07/2016