The measurement of identified charged hadron elliptic flow and higher order harmonics in $\sqrt{s_{NN}}$=2.76TeV Pb+Pb collisions at LHC-ALICE

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Outline

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  - Particle type dependence of v_2
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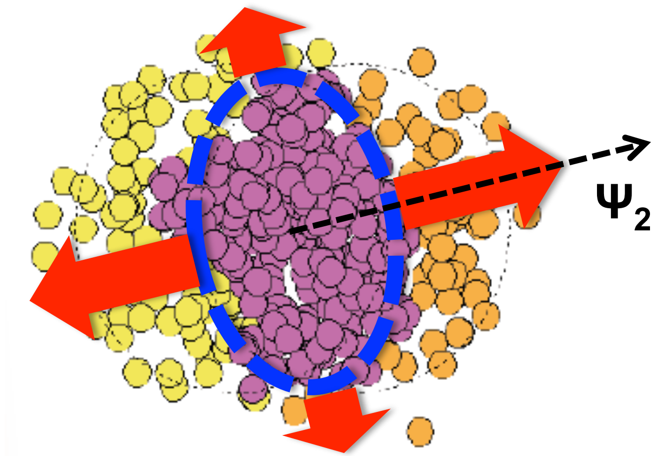
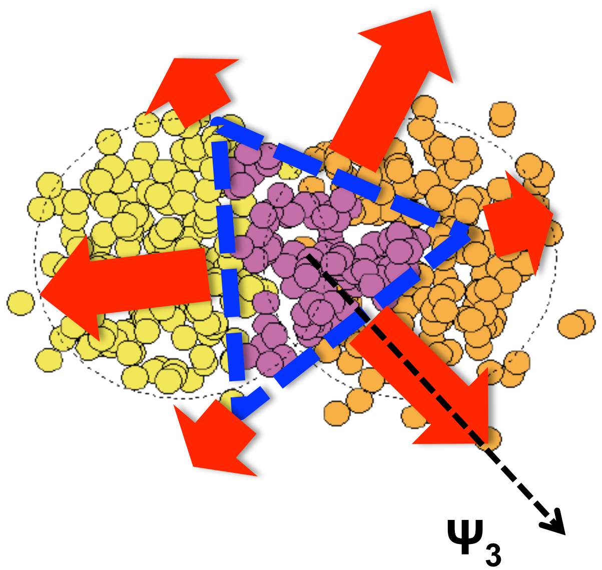
What's collective flow



Initial spatial anisotropy
eccentricity(n=2)
triangularity(n=3)
quadranglarity(n=4)
...

pressure gradient

Momentum space anisotropy



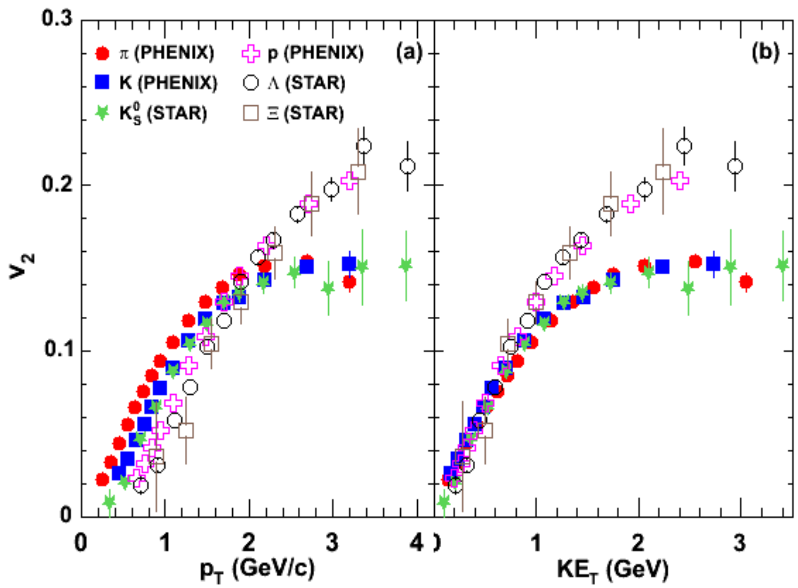
- n-th fourier coefficient of $dN/d(\varphi-\Psi_n)$

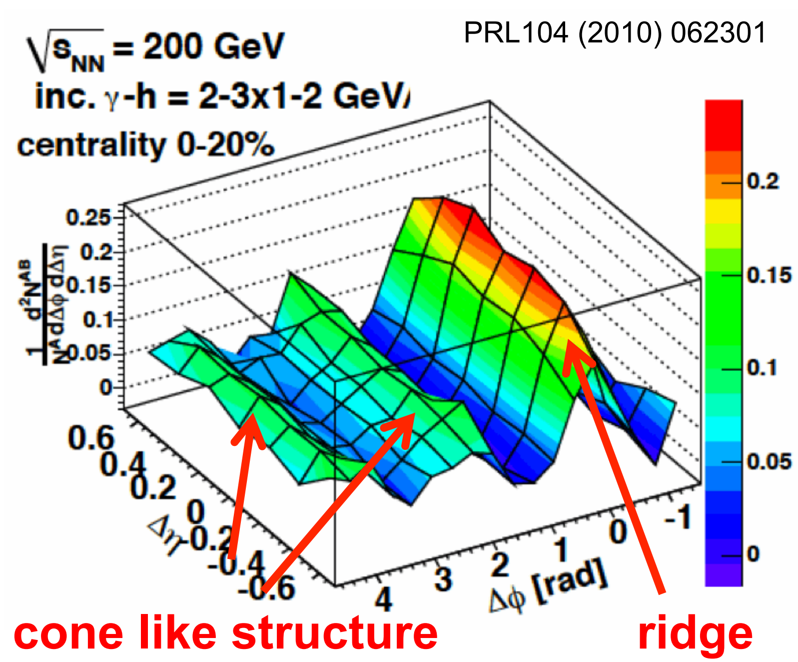
$$v_n = \langle cos(n(\phi - \Psi_n))\rangle$$

- **Sensitive probe for early stage of heavy ion collisions.**

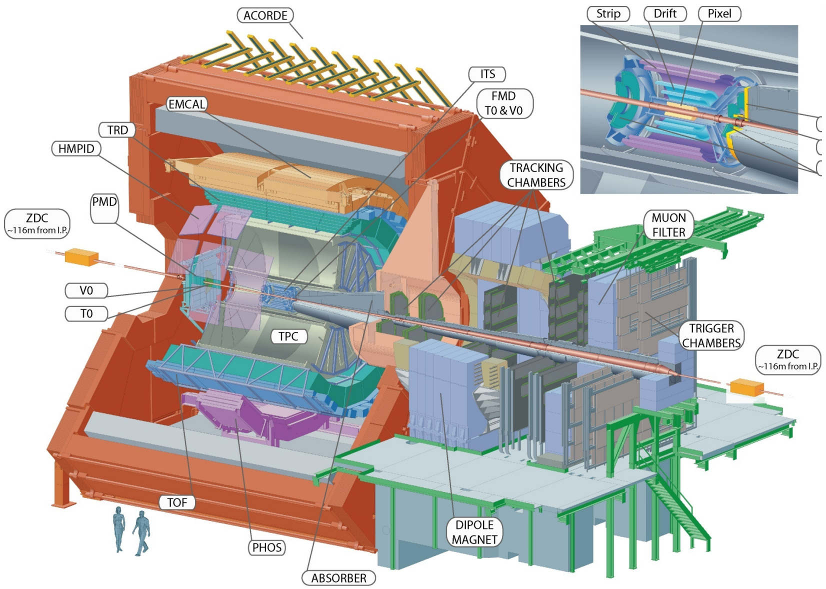
Motivation

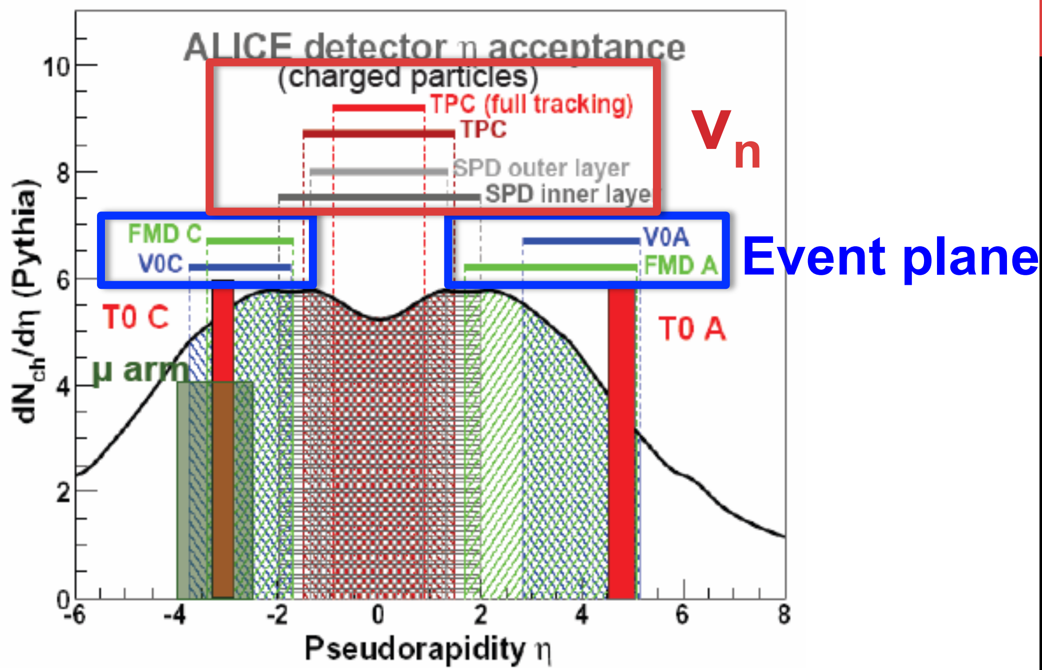
- How does collective flow is seen at LHC ?
  - Does quark number and KE_T scaling work at LHC?
  - How about η/s and initial condition(CGC/Glauber).
- Does ridge and mach cone like structure caused by higher order flow??





How to measure v_n : E.P. method





$$v_n\{EP_k\} = \frac{\langle \cos(n(\phi - \Psi_k))\rangle}{\sigma_k^n}$$

$$\sigma_k^n = \langle \cos(n(\Psi_k - \Psi))\rangle$$

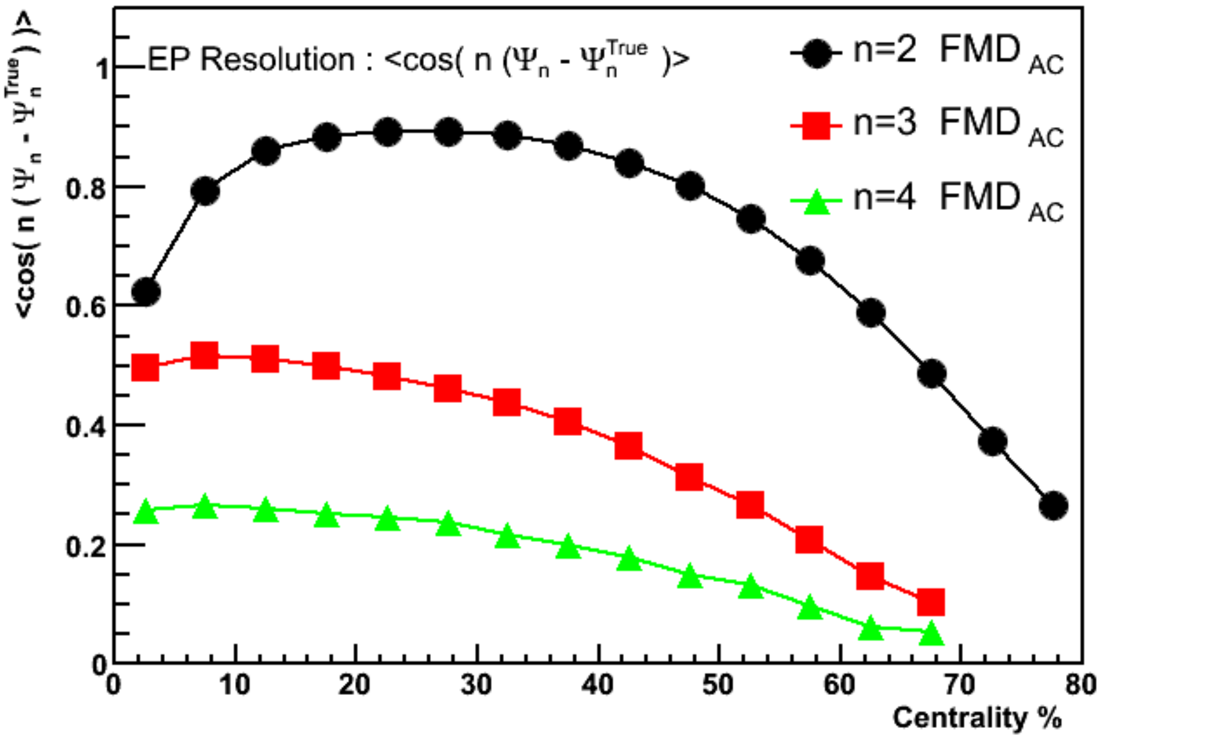
$$\tan(k\Psi_k) = \frac{\sum_i w_i \sin(k\phi_i)}{\sum_i w_i \cos(k\phi_i)}$$

- Data : 2010 Nov. About 10 million events
- Tracking : |η|<0.8
- E.P. defined by forward rapidity

2.8 < η ($V0_A$) < 5.1
-3.7 < η ($V0_C$) <-1.7
1.7 < η (FMD_A)< 5.0
-3.4 < η (FMD_C)<-1.7

- Reduce non-flow bias on v_n measurement. 0.9<|Δη|<5.9

E.P. resolution for n-th order plane



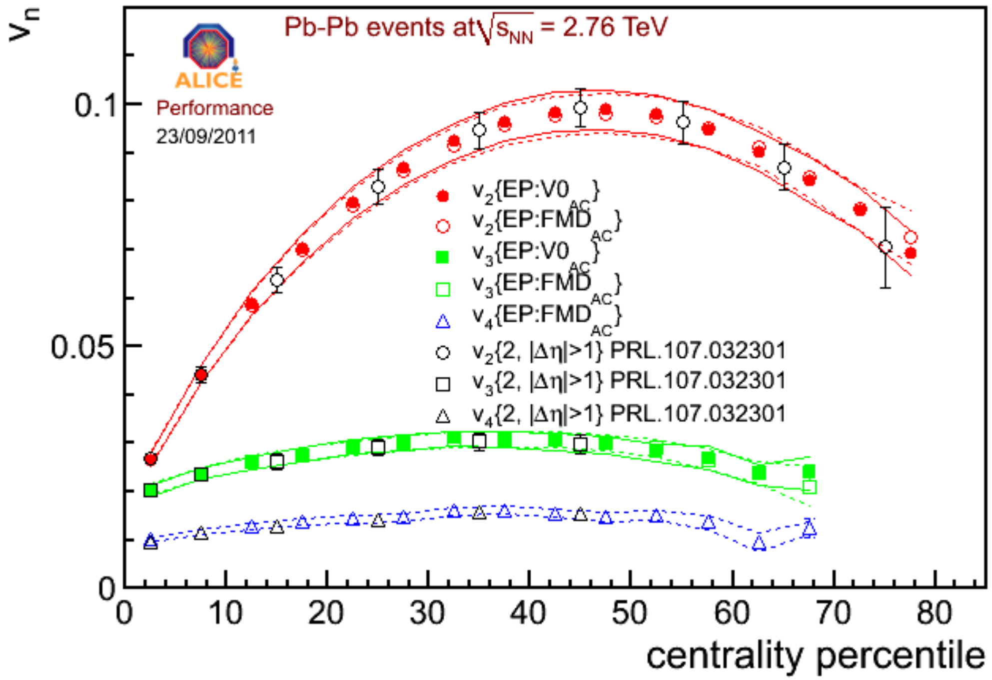
- 3 sub events method are applied to extract E.P. resolution.

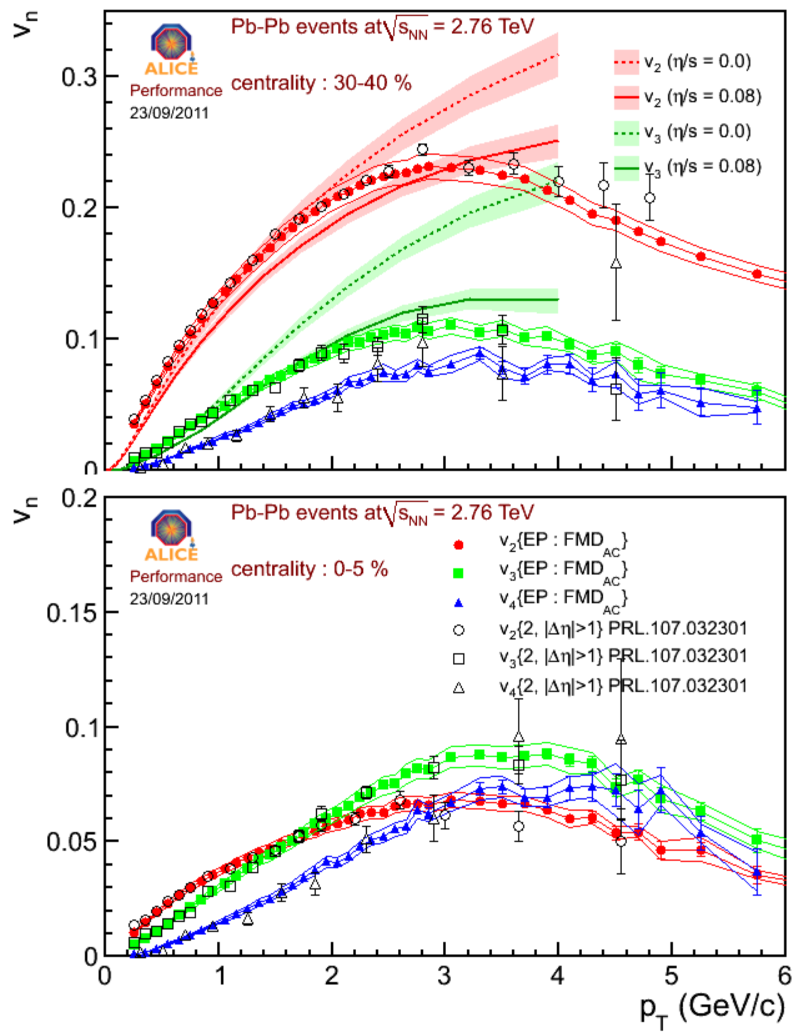
$$\langle \cos\left(n(\Psi_n^i - \Psi_n^{True})\right)\rangle = \sqrt{\frac{\langle \cos\left(n(\Psi_n^i - \Psi_n^j)\right)\rangle \langle \cos\left(n(\Psi_n^i - \Psi_n^k)\right)\rangle}{\langle \cos\left(n(\Psi_n^j - \Psi_n^k)\right)\rangle}}$$

- These excellent resolutions allow us to measure v_2, v_3 and v_4 .

centrality / p_T dep. of v_n

Hydro. prediction from B. Schenke, S. Jeon, C. Gale, [arXiv:1102.0575]

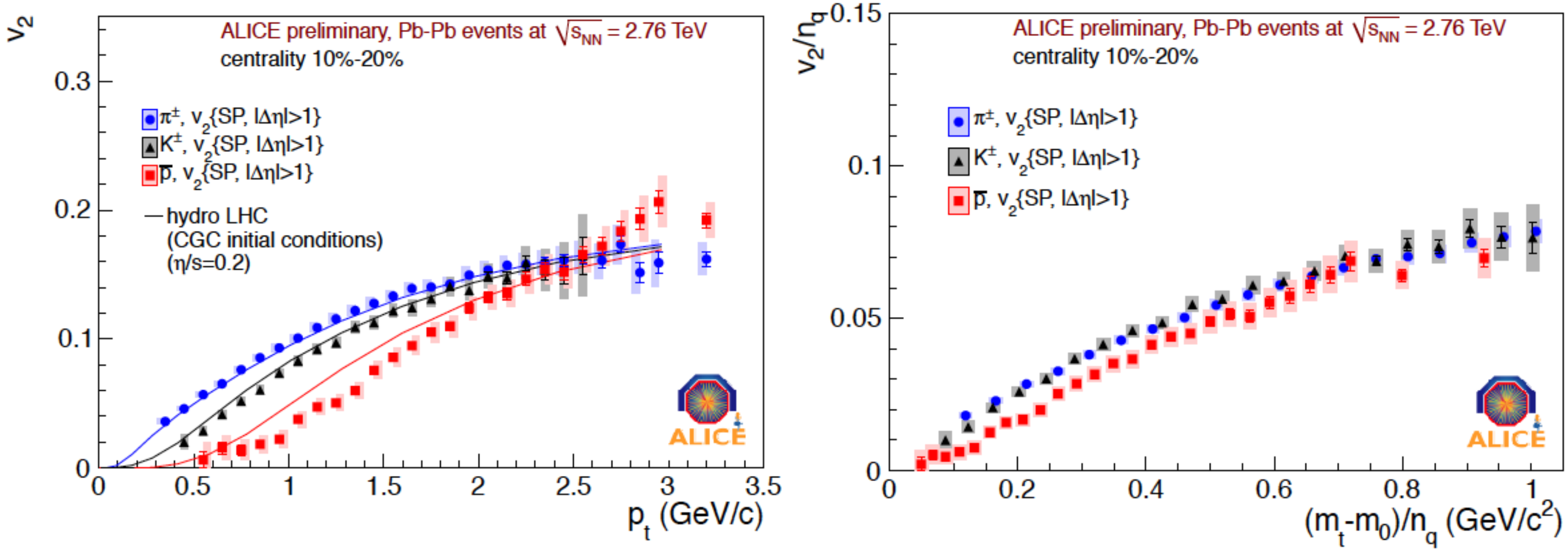




- Weak centrality dep. for v_3 and v_4 compared to v_2
- similar amplitude for v_2 and $v_{3,4}$ at most central and high p_T.

Particle type dep. of v_2 (charged pion kaon proton)

M. Krzewicki, QM11



- PID by TOF.
- Mass ordering is clearly seen.
- KE_T scaling is not working so much as for RHIC, especially for proton.
  - Can be due to increase of radial flow.

Summary & Outlook

- v_n (n=2,3,4) measurement in Pb-Pb collisions at sqrt(s_{NN})=2.76TeV with ALICE detector.
  - Centrality dependence of v_2, v_3, v_4 .
    - Weak centrality dependence for v_3 and v_4 compared to v_2
      - Indication of initial geometry fluctuation
  - p_T dependence of v_2, v_3, v_4 .
    - v_3(v_4) is as large as v_2 at about 1.5GeV/c (3.0GeV/c) for 0-5% central
    - Comparison with hydro. prediction (only Glauber init. condition)
      - η/s=0.08 seems better than ideal hydro.

  - Particle type dependence of v_2 .
    - Mass ordering are clearly seen.
    - Quark number + KE_T scaling is not so much working for proton as at RHIC.
      - Deu to larger radial flow than RHIC.