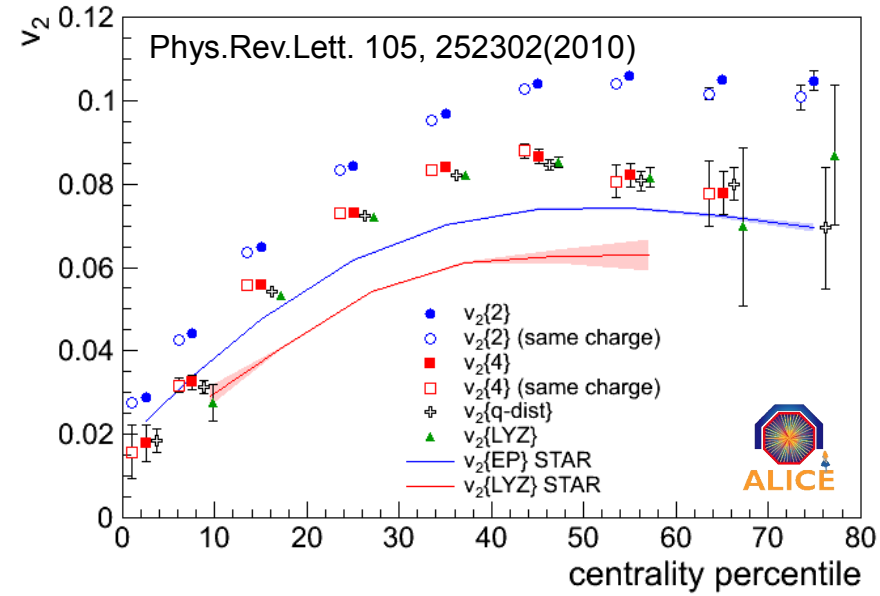
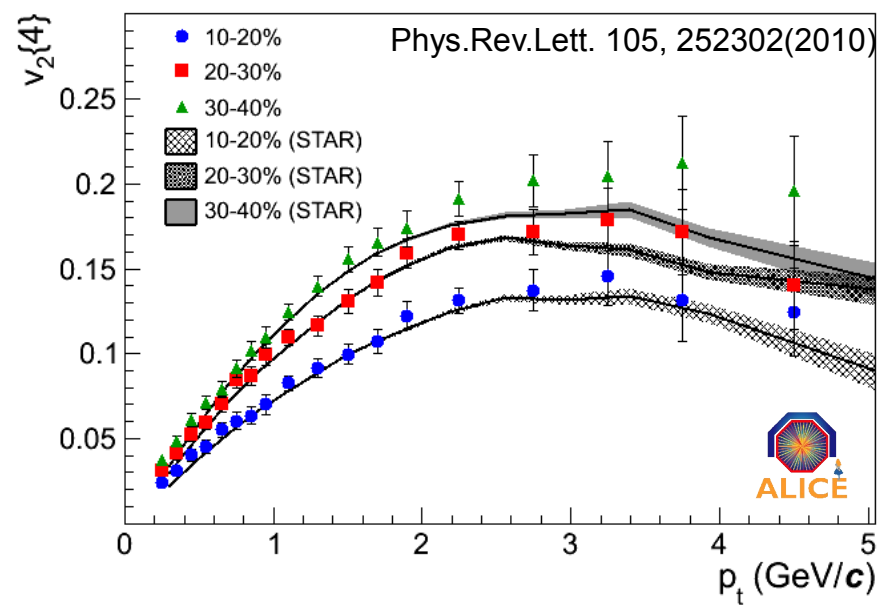
Elliptic and triangular flow of identified particles measured with the ALICE detector.

Mikołaj Krzewicki for the ALICE collaboration.

Motivation

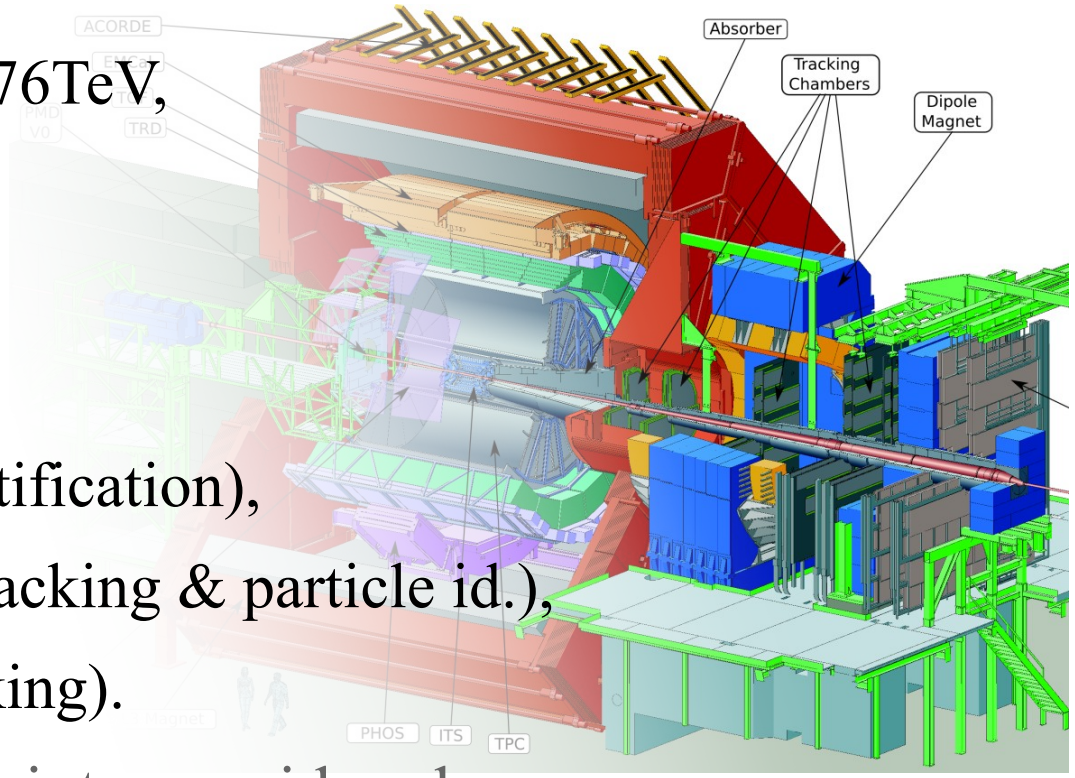
- Integrated flow larger by 30% than at RHIC.
- Differential flow of charged particles almost same.
- Is this expected in hydrodynamic models?
- Does quark scaling work at the LHC?
- Is triangular flow similar to elliptic flow?
  - Low p_t mass scaling?
  - Quark scaling?





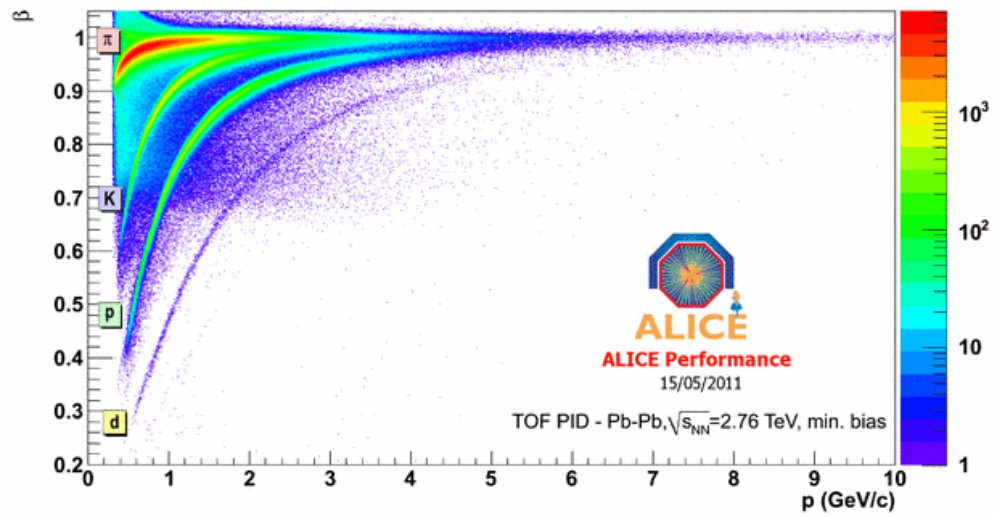
Analysis outline

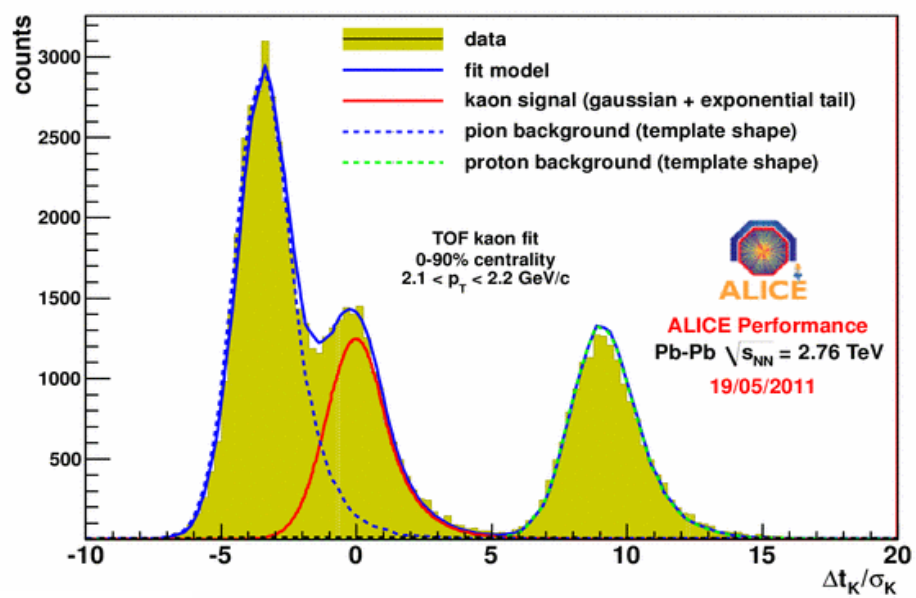
- Data sample:
  - ~4M Pb-Pb events at $\sqrt{s}$=2.76TeV,
  - minimum bias trigger,
  - acceptance: $-0.8<\eta<0.8$.
- Detectors used:
  - time-of-flight (particle identification),
  - time projection chamber (tracking & particle id.),
  - inner tracking system (tracking).
- Sources of systematic uncertainty considered:
  - non-flow,
  - feed-down,
  - centrality determination.



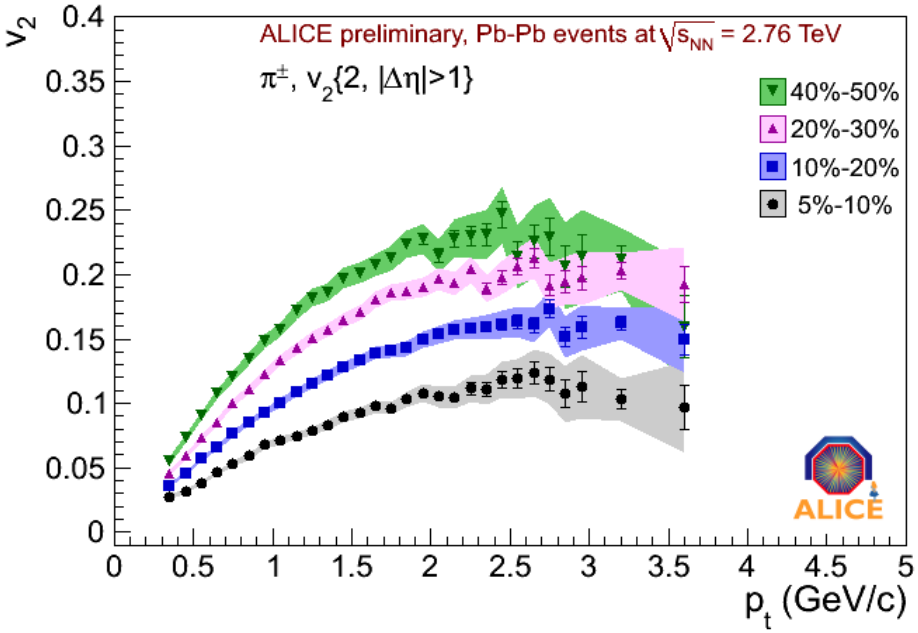
Particle identification

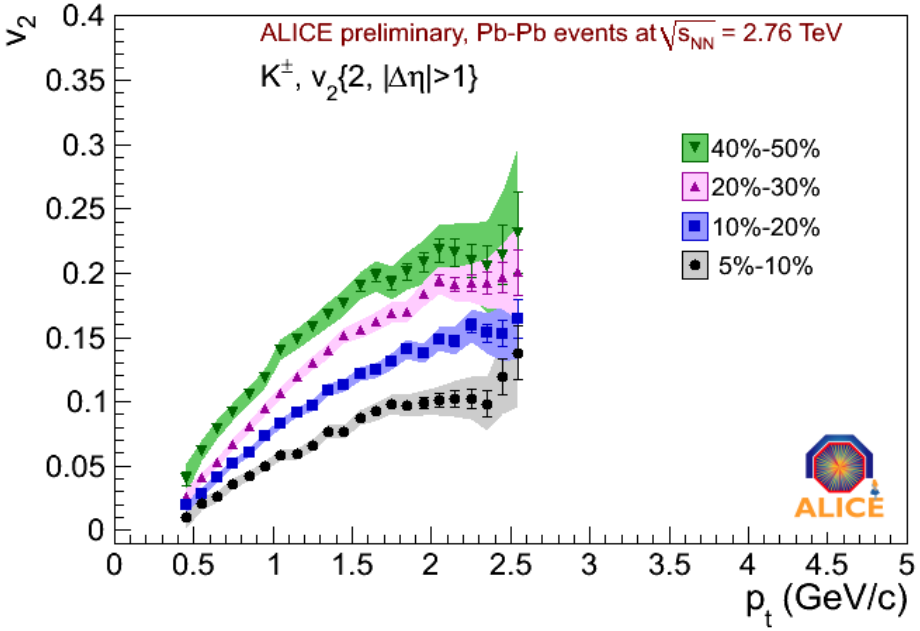
- Particle identification tuned for purity>95%:
  - π and K: p<3GeV/c,
  - proton: p<5GeV/c.
- PID cuts:
  - asymmetric cut on beta in the time-of-flight detector.
  - Additional 2σ cut on dE/dx in the time projection chamber to clean the data.

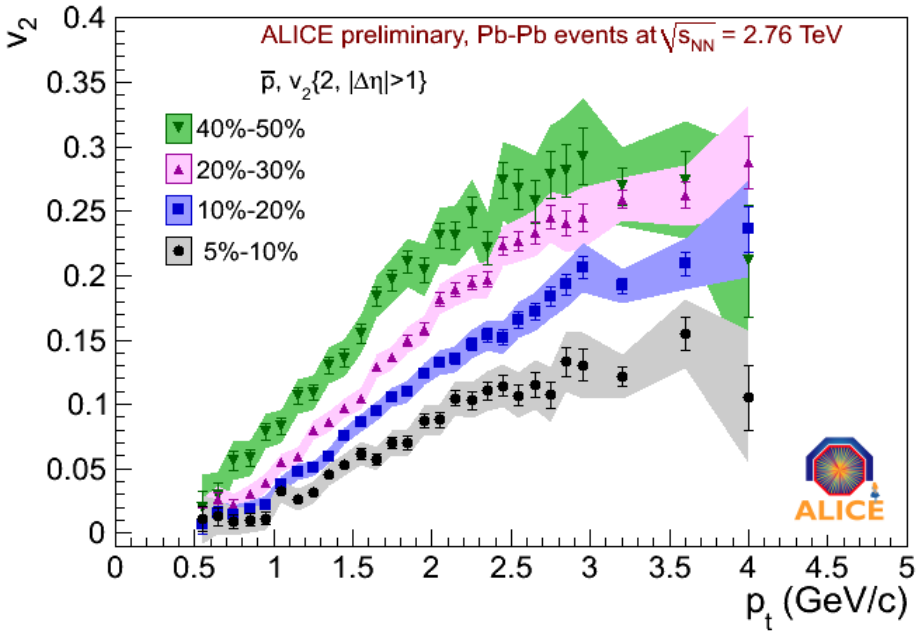




Elliptic flow of identified particles

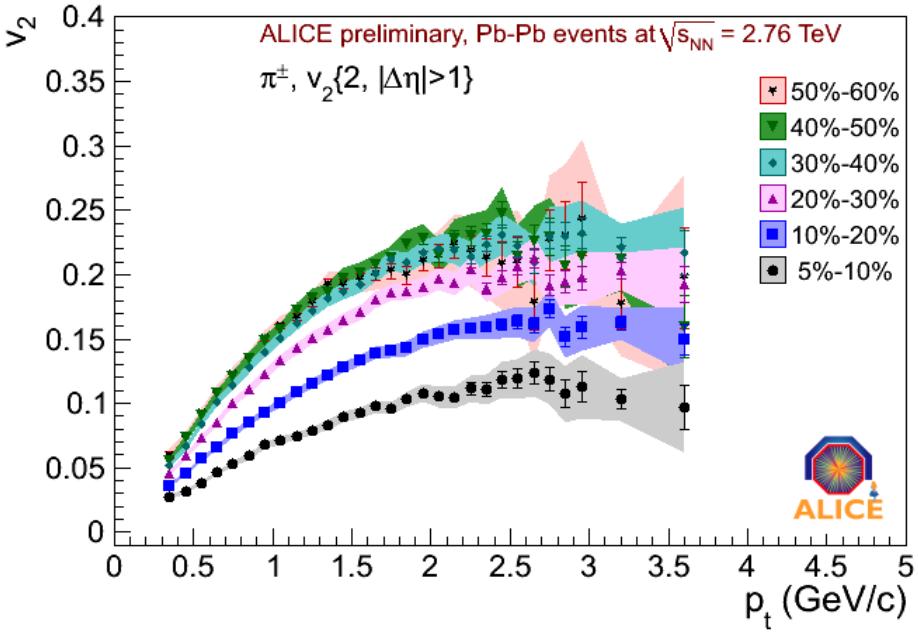


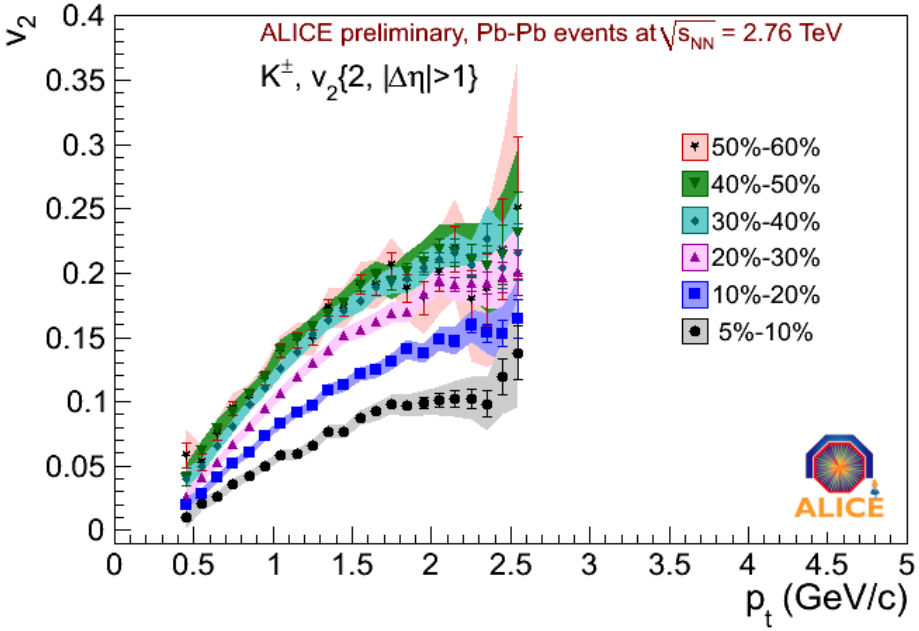


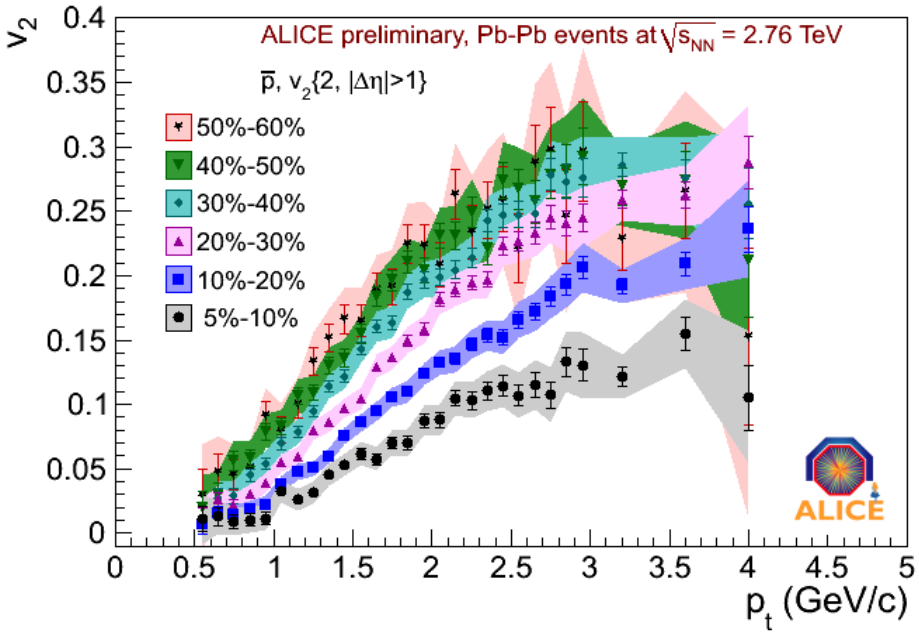


- Centrality dependence of v_2 for pions, kaons and antiprotons.
- Method: scalar product with $|\Delta\eta|>1$ to reduce non-flow correlations.

Elliptic flow of identified particles







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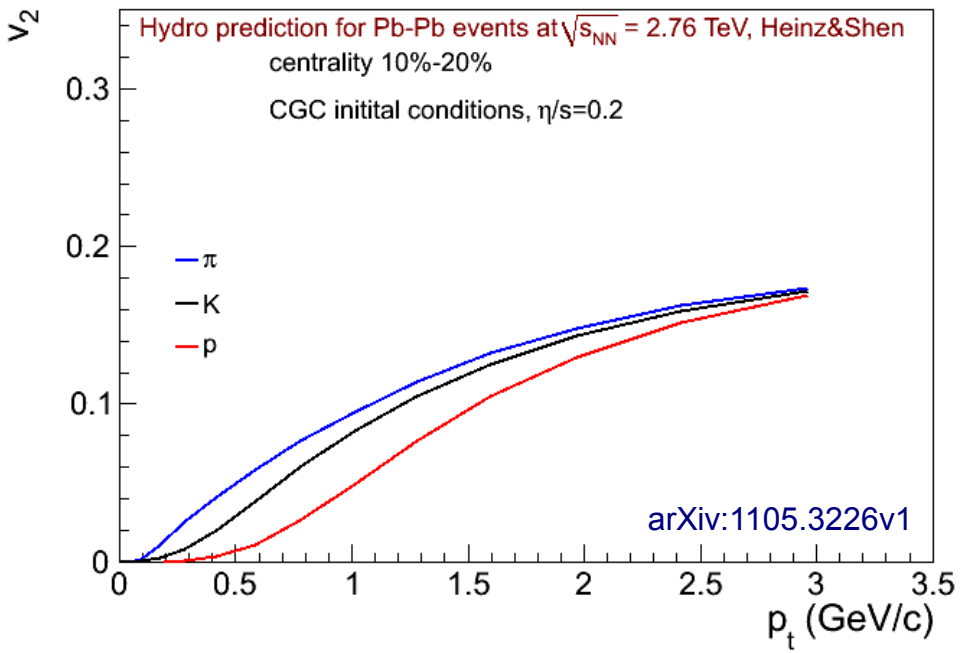
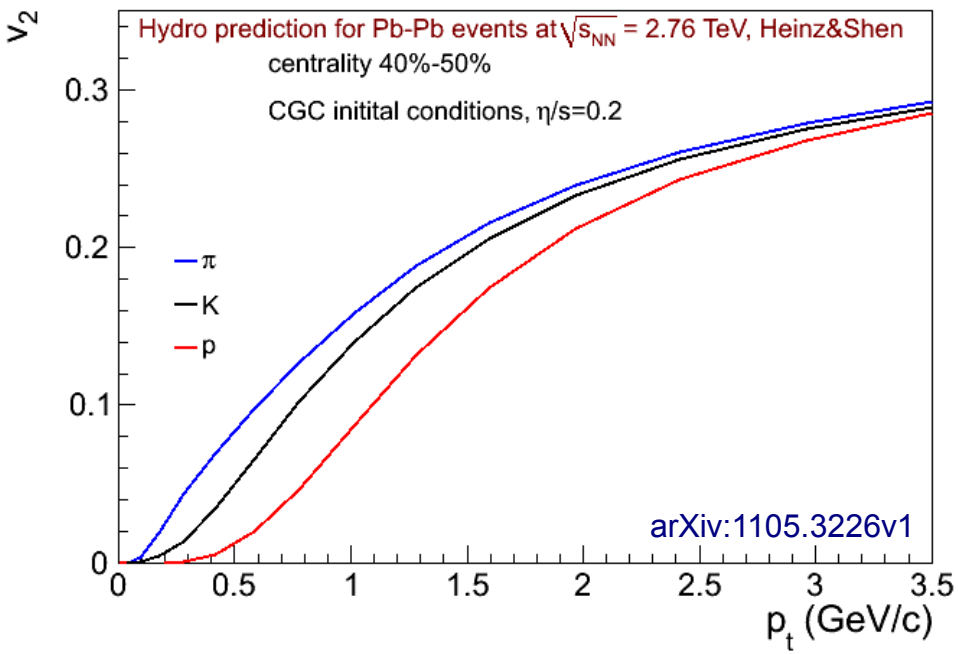
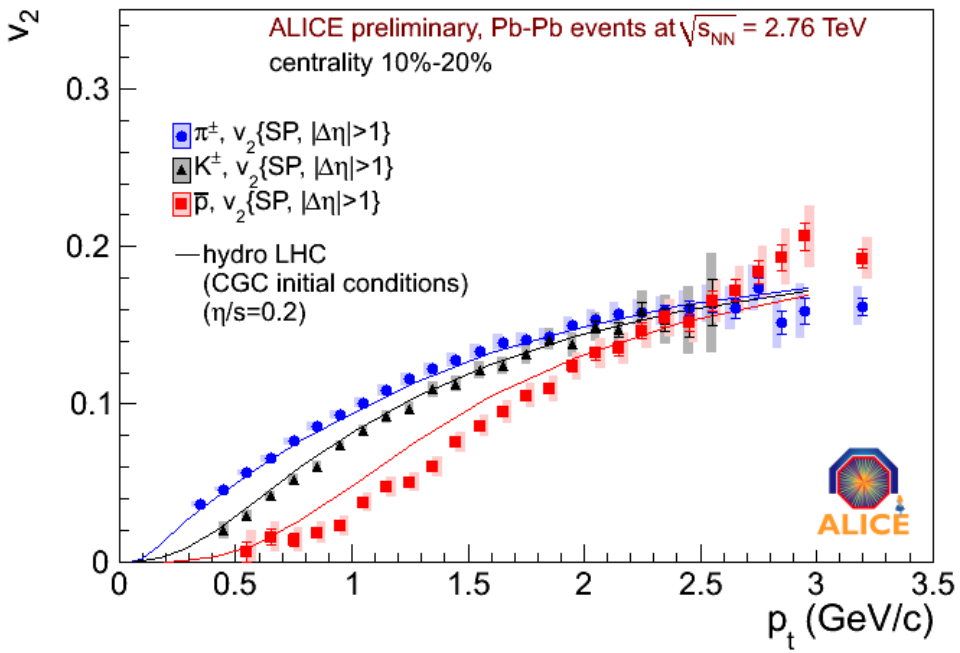
Viscous hydro & data

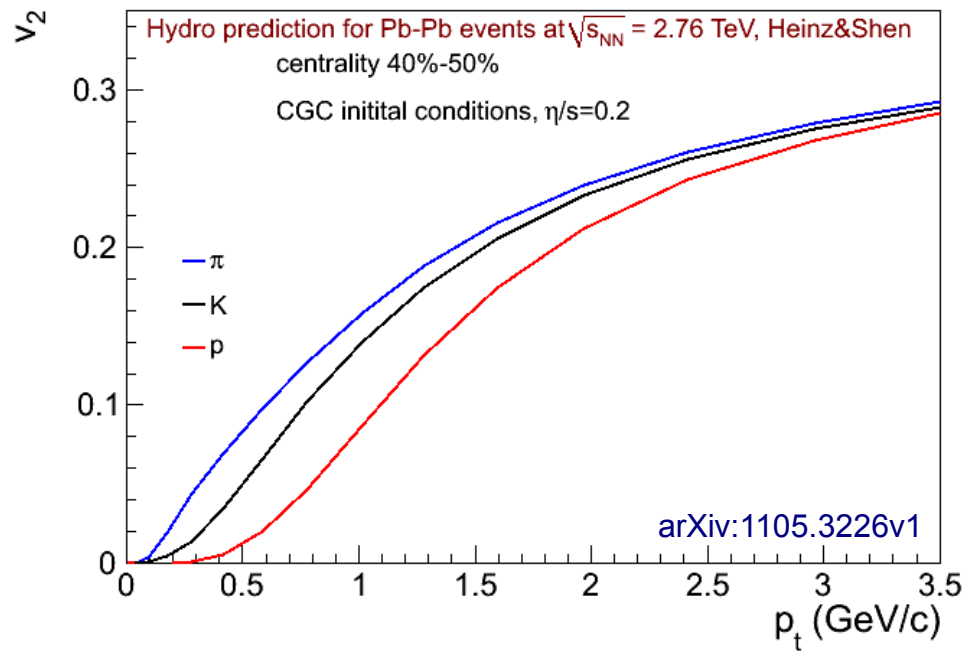




- Hydrodynamic models predict magnitude and mass splitting for Pb-Pb events @LHC.

Viscous hydro & data





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- Data and prediction disagree for protons in more central events.

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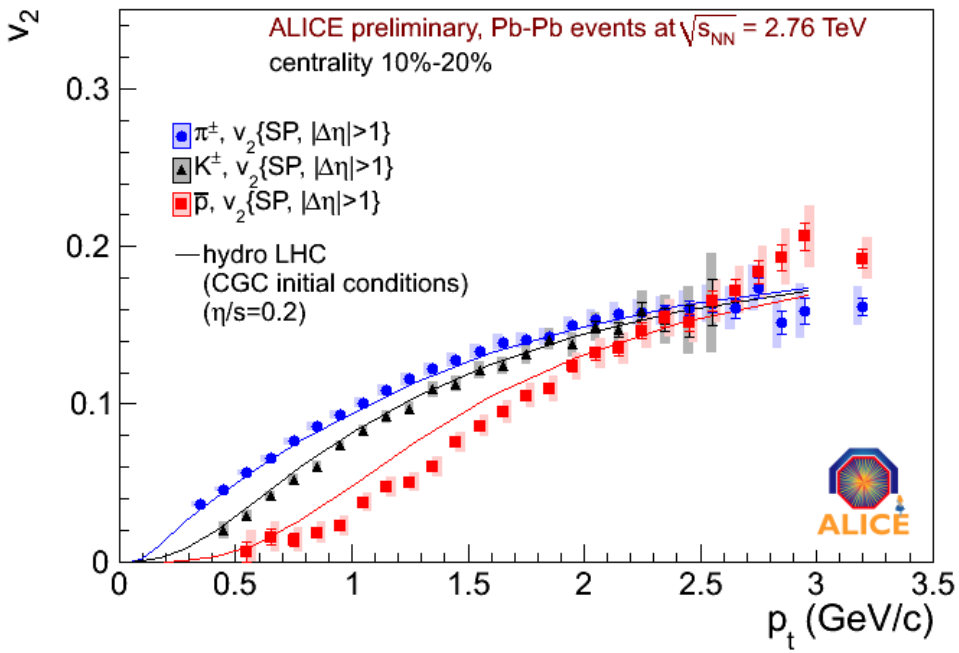
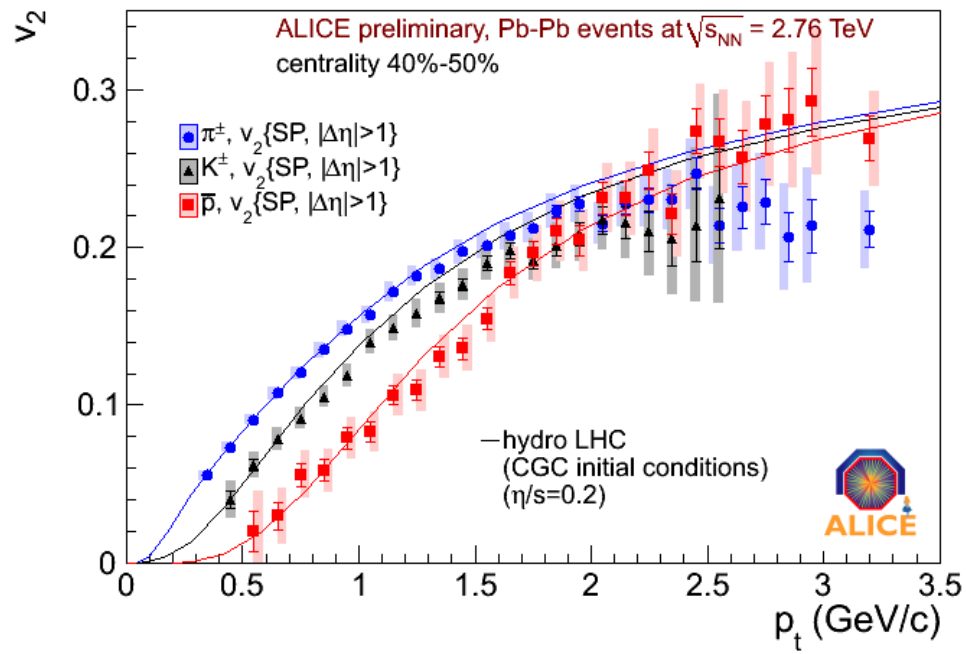
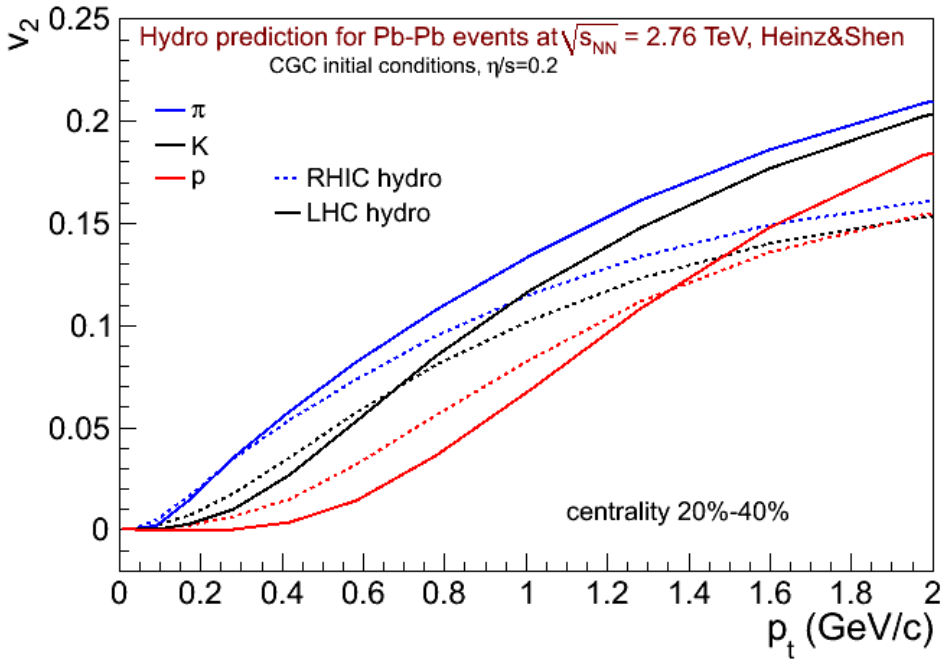
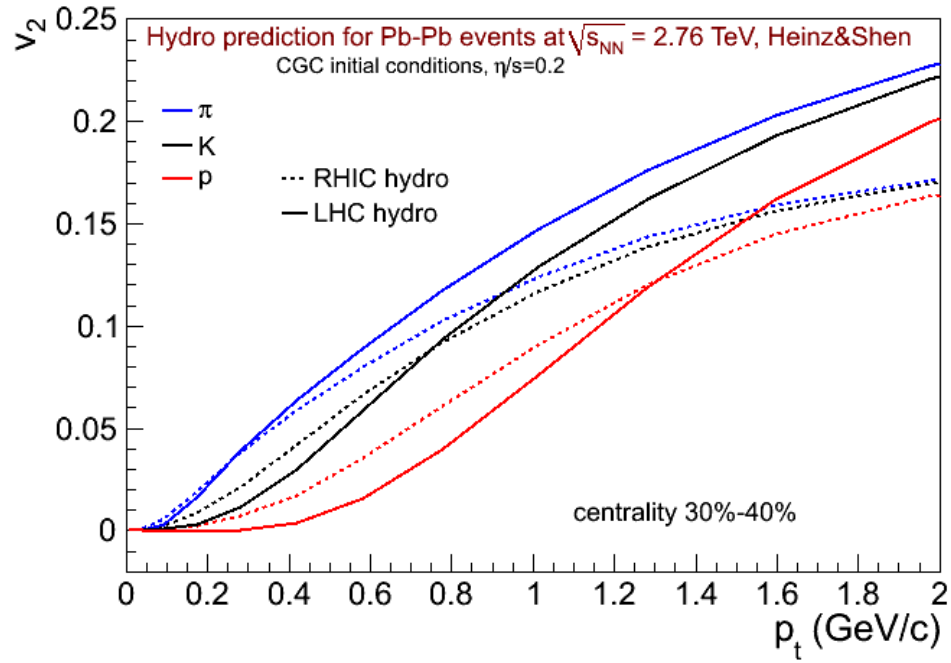




- Hydrodynamic models predict magnitude and mass splitting for Pb-Pb events @LHC.
- Data and prediction disagree for protons in more central events.
- Hydro prediction better for peripheral events at low p_t.

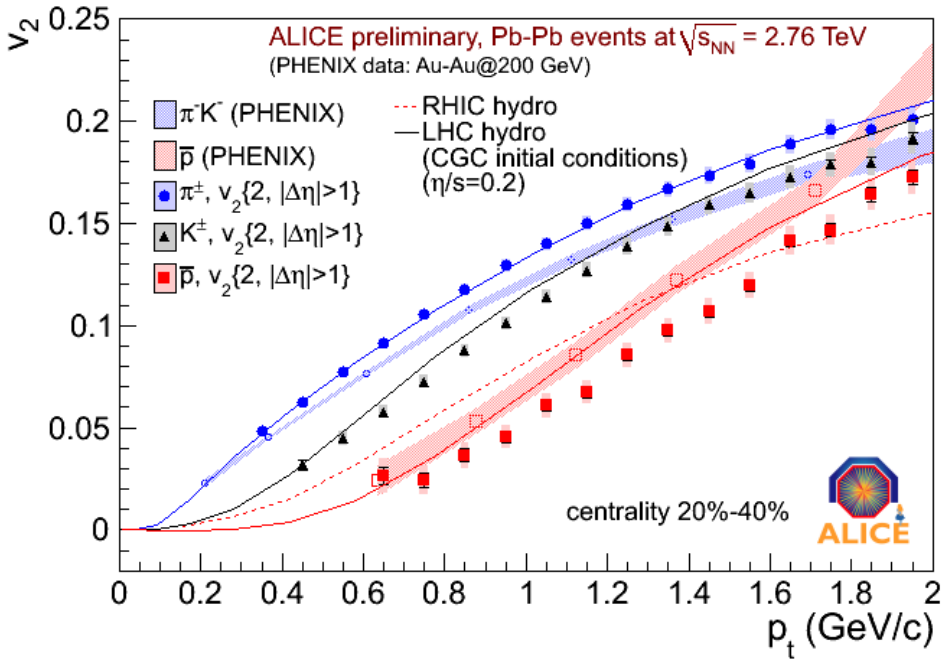
From RHIC to LHC



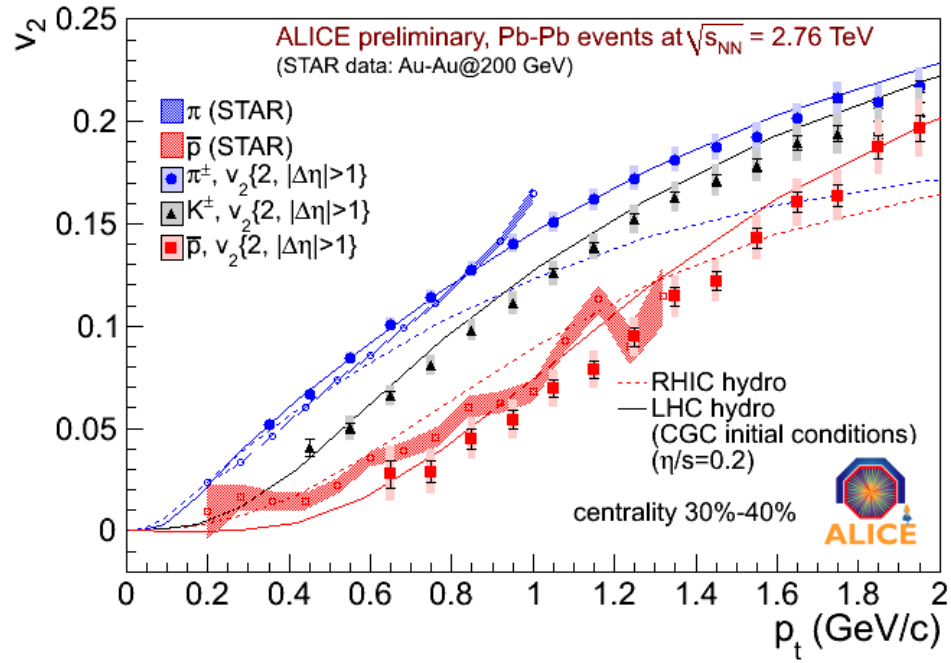


- Hydrodynamic models predict a larger mass splitting at low p_t, mostly due to shift in proton flow.

From RHIC to LHC



PHENIX data: Phys. Rev. Lett. 91, 182301 (2003)

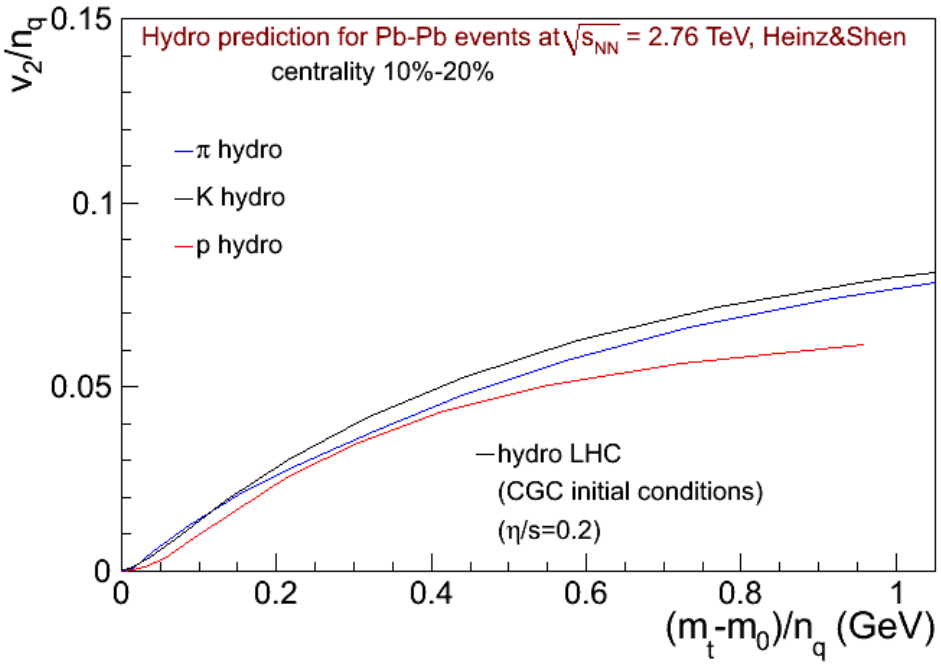


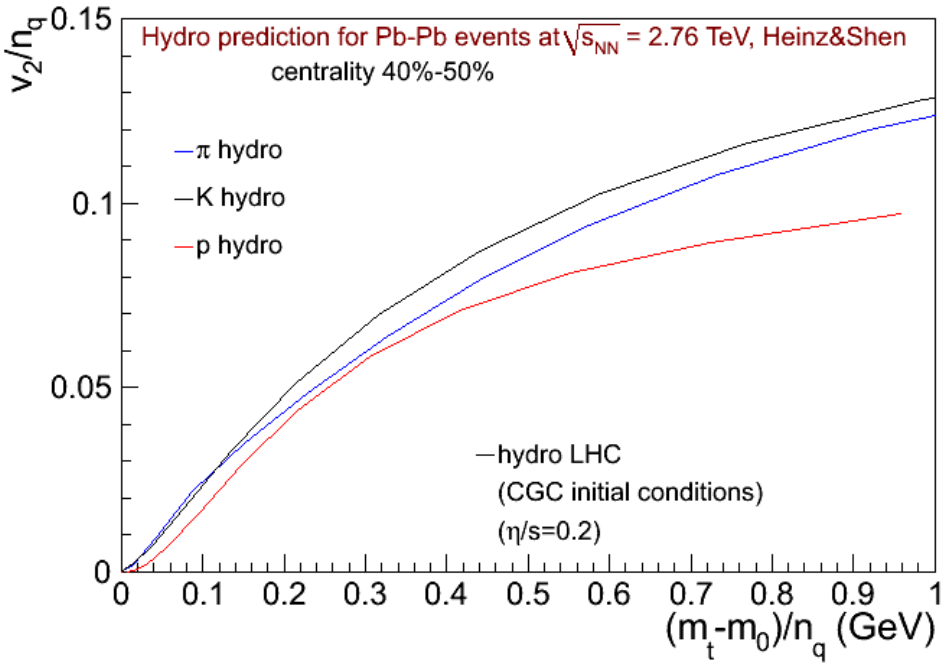
STAR data: Phys. Rev. C 77, 054901 (2008)

- Hydrodynamic models predict a larger mass splitting at low p_t, mostly due to shift in proton flow.
- Flow of anti-protons at LHC shows a shift similar to prediction.

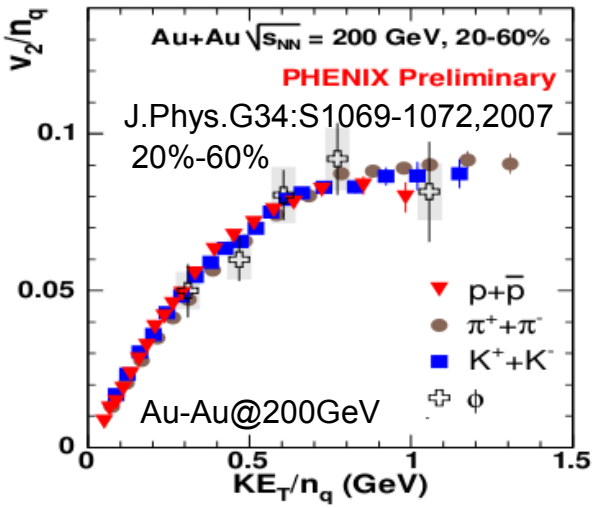
➔ Larger mass splitting.

LHC flow rescaled

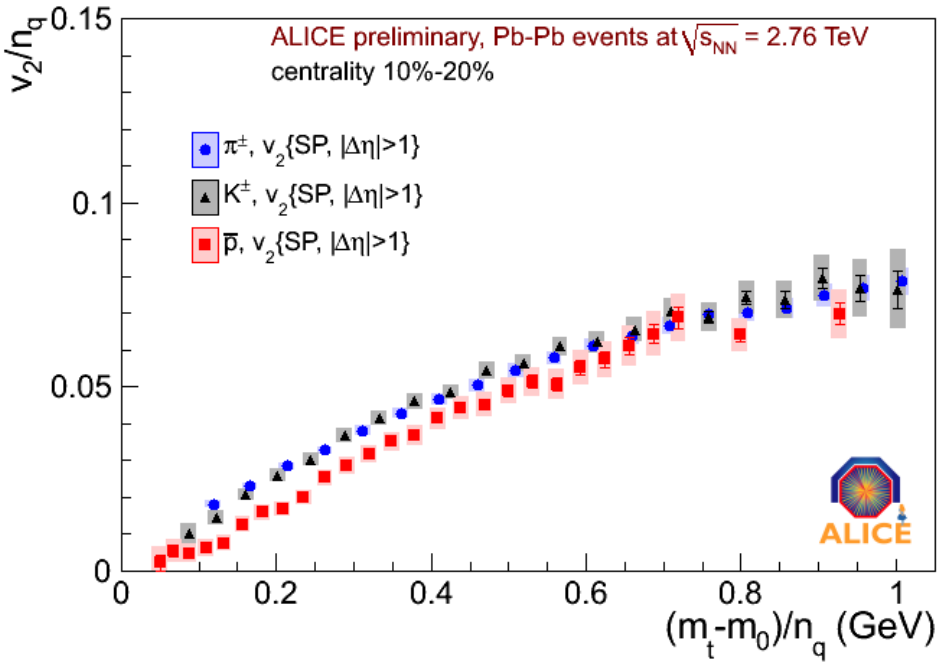


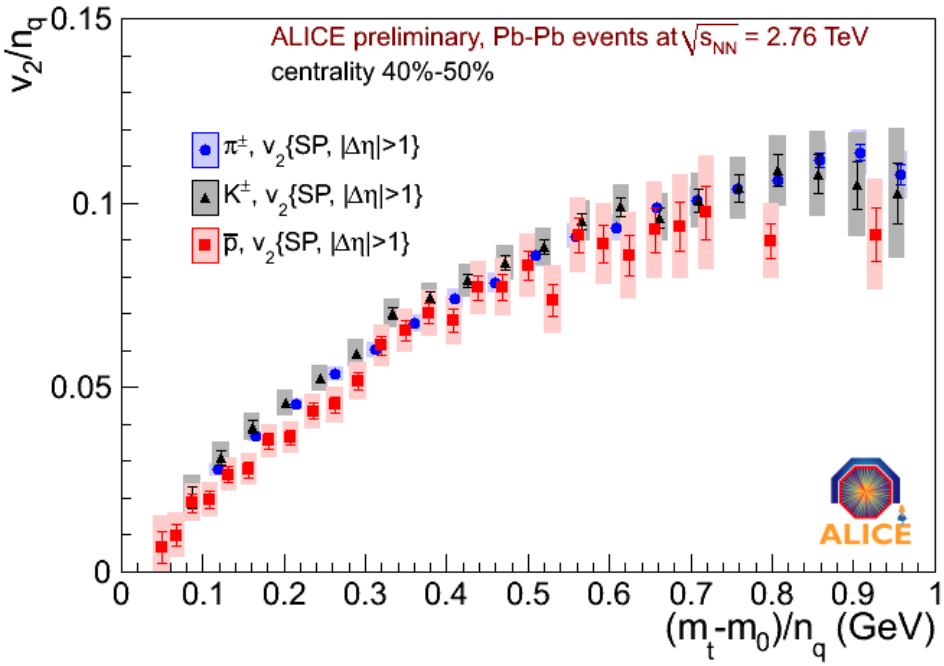


- Elliptic flow per quark vs transverse kinetic energy per quark (KE_t scaling).
- Hydro prediction shows compression;
  - At low p_t better agreement between π and K.



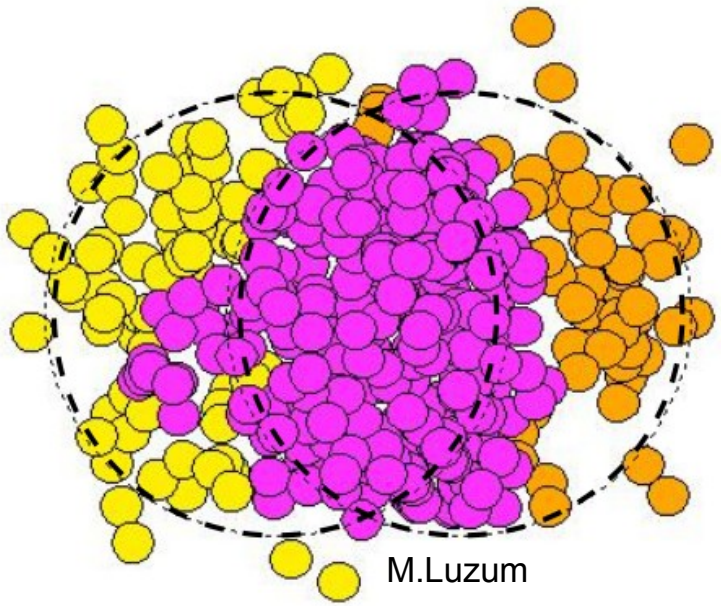
LHC flow rescaled

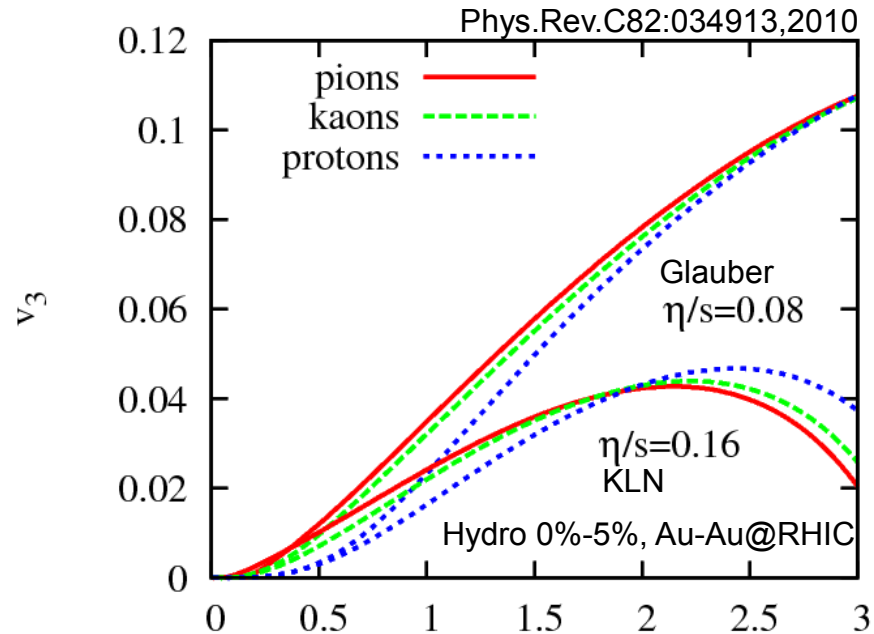




- Elliptic flow per quark vs transverse kinetic energy per quark (KE_t scaling).
- Hydro prediction shows compression;
  - At low p_t better agreement between π and K.
- Data shows agreement between π and K, anti-protons do not follow the scaling.

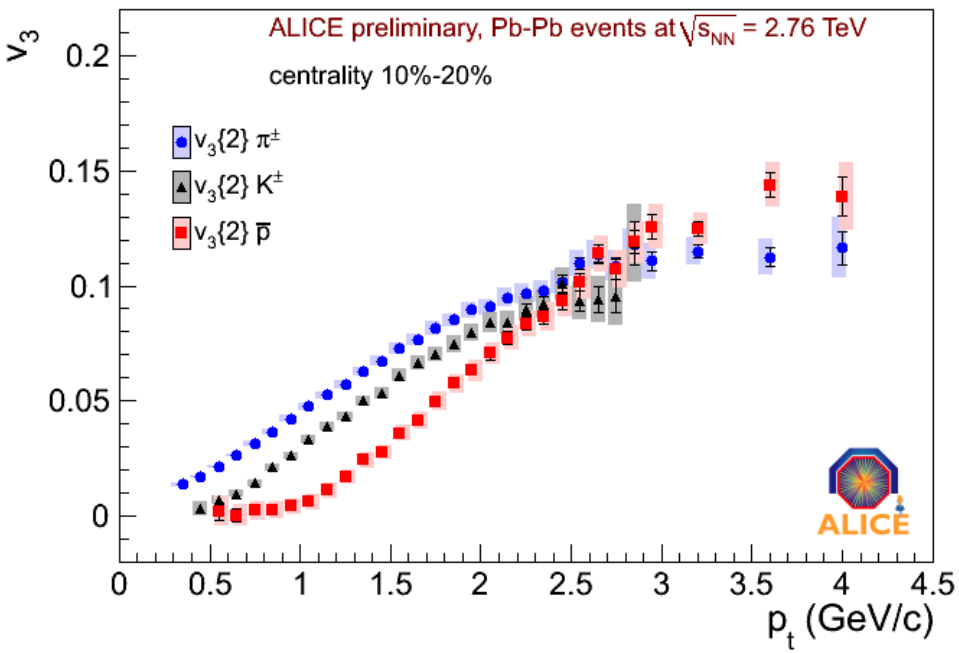
Triangular flow

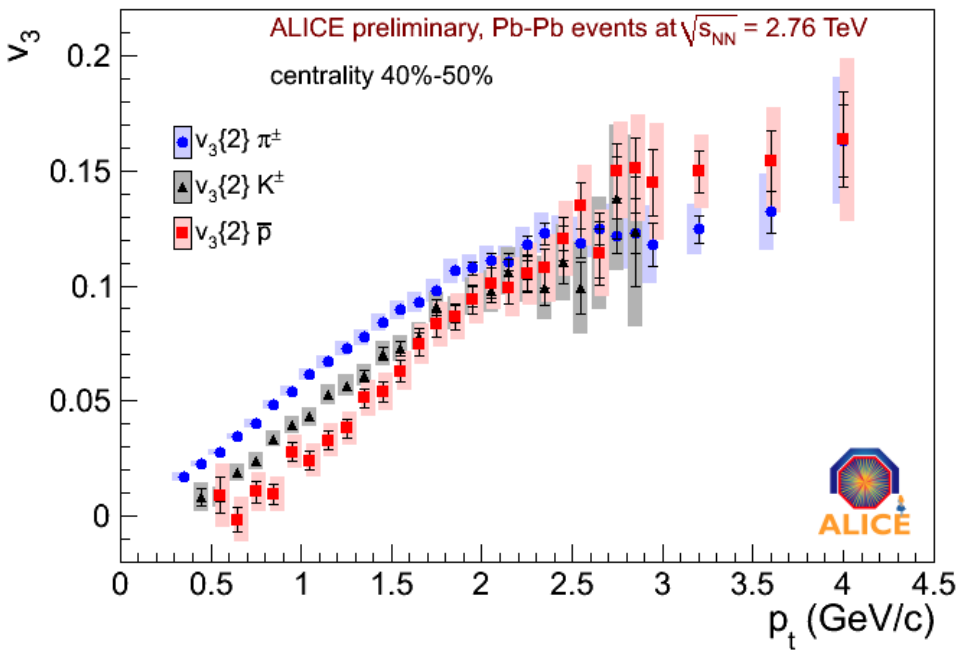




- In the Glauber picture triangularity due to fluctuations of initial state.
- Magnitude of (final state) v_3 sensitive to η/s.
- How large is the triangular flow (v_3)?
- Does it show hydro-like features like v_2?

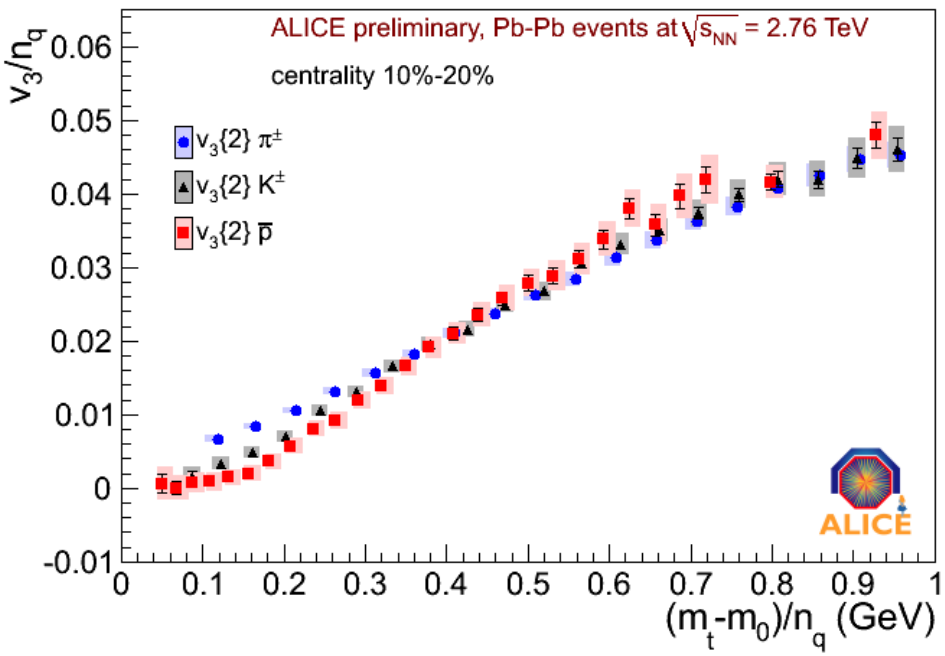
Triangular flow

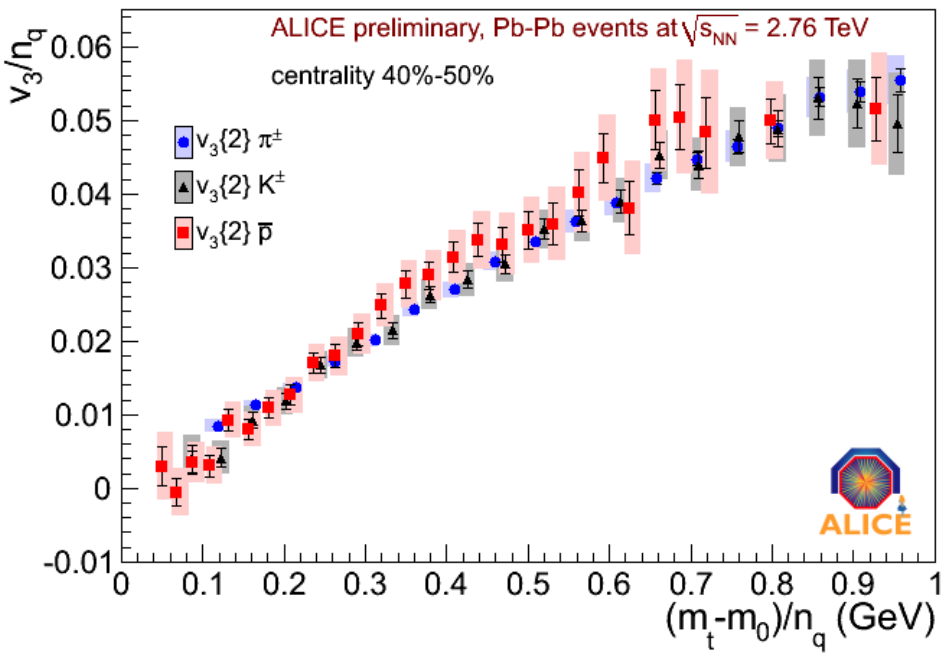




- v_3 in two centrality bins, two-particle method, no eta gap.
- Low pt mass scaling as expected from the hydro picture.
- v3 of pions and protons cross at intermediate p_t as expected from coalescence.
- Magnitude suggests $\eta/s < 0.16$.

Triangular flow rescaled





- v_3 per quark vs transverse kinetic energy per quark.
- mid-central: at low p_t no scaling.
- mid-peripheral: scaling different than for v_2.

Summary

- We have shown the elliptic flow of identified particles at LHC:
  - Hydrodynamics describes peripheral events quite well.
  - In more central events hydro and data disagree.
  - Results consistent with larger mass splitting compared to RHIC.
  - KE_t scaling for v_2 seems worse than at RHIC.
- Triangular flow of identified particles at LHC:
  - Mass scaling as expected based on hydro.
  - Crossing point as expected based on coalescence.
  - Indication of $\eta/s<0.16$.
  - KE_t scaling qualitatively differs from scaling of v_2.

merci