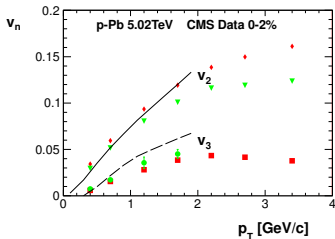# Elliptic and triangular flow in p-Pb

Hydro consistent with data
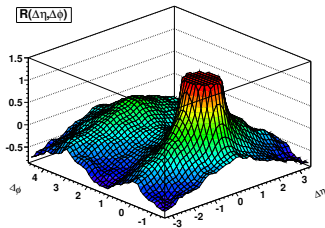

PB, W.Broniowski, G. Torrieri arXiv:1306.5442; G.Y. Qin, B.

Müller 1306.3439; I. Kozlov et al. 1405.3976; A. Bzdak et al.

1304.34003, ...

Hydro generates the ridge

Werner, Karpenko, Pierog, 1011.0375

▶ v_2, v_3 consistent with hydro
(Glauber MC, EPOS3)

$v_{2,3}$ - hydro response to initial deformation !

Elliptic and triangular flow in p-AU, d-Au, ^{3}He-Au

(small) deformed projectile
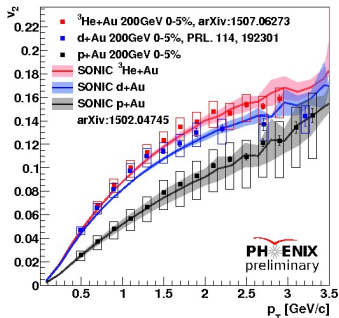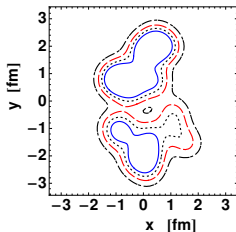

deuteron projectile(PB 1112.091

intrinsic deformation dominates over fluctuations

- ▶ hierarchy of v_2 and v_3 consistent with fireball geometry

large eccentricity - large flow component
collective response to geometry

1. **Elliptic and triangular flow**

2. **Hierarchy of v_2 and v_3 in p-A, d-A, He-A**
   collective response to geometry (final state effect)

3. **Flow from higher cumulants**
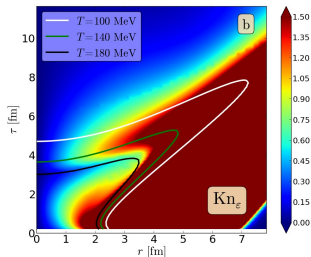
4. **Interferometry radii**
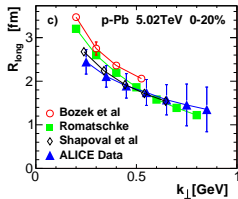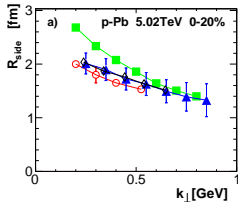
right magnitude and $k_\perp$ dependence of HBT radii
indication of space-momentum correlations

5. **Factorization at intermediate $p_\perp$ and large $\Delta\eta$**
   particles at intermediate $p_\perp$, large η, correlated to geometry

6. **Mass splitting of v_2**

7. Mass hierarchy of spectra   ($< p_\perp >$)
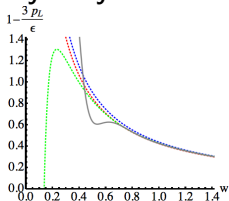
Validity of hydrodynamics?
$K < 1$

H. Niemi, G. Denicol 1404.7327

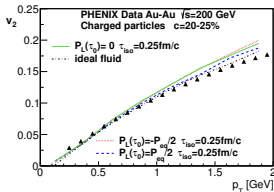large gradients in the evolution

pressure asymmetry

1. **Hydrodynamics works with $P_L \ll P_\perp$**

Heller, Janik, Witaszczyk 1103.3452, solution converges to hydro

2. **Pressure asymmetry $P_L \ll P_\perp$ irrelevant**

PB, I. Wyskiel-Piekarska 1011.6210; J. Vredevoogt, S. Pratt

0810.4325, pressure asymmetry irrelevant for flow

Collective expansion observed in pA

- ▶ Is it hydrodynamics ?

Requires dominance of hydrodynamic modes

- estimate for a system size R (Spalinski 1607.06381)

$$RT > 2\pi\sqrt{2T\tau_\pi \; \eta/s} \simeq 1 - 3$$

in numerical AdS/CFT: $RT > 1$, (Chesler 1601.01583)

Hydrodynamics works down to $N_{ch} = 10 - 30$ (ATLAS, CMS)

Success of hydrodynamics not accidental!

Break down of hydrodynamics difficult to observe (non-flow, jets . . .)