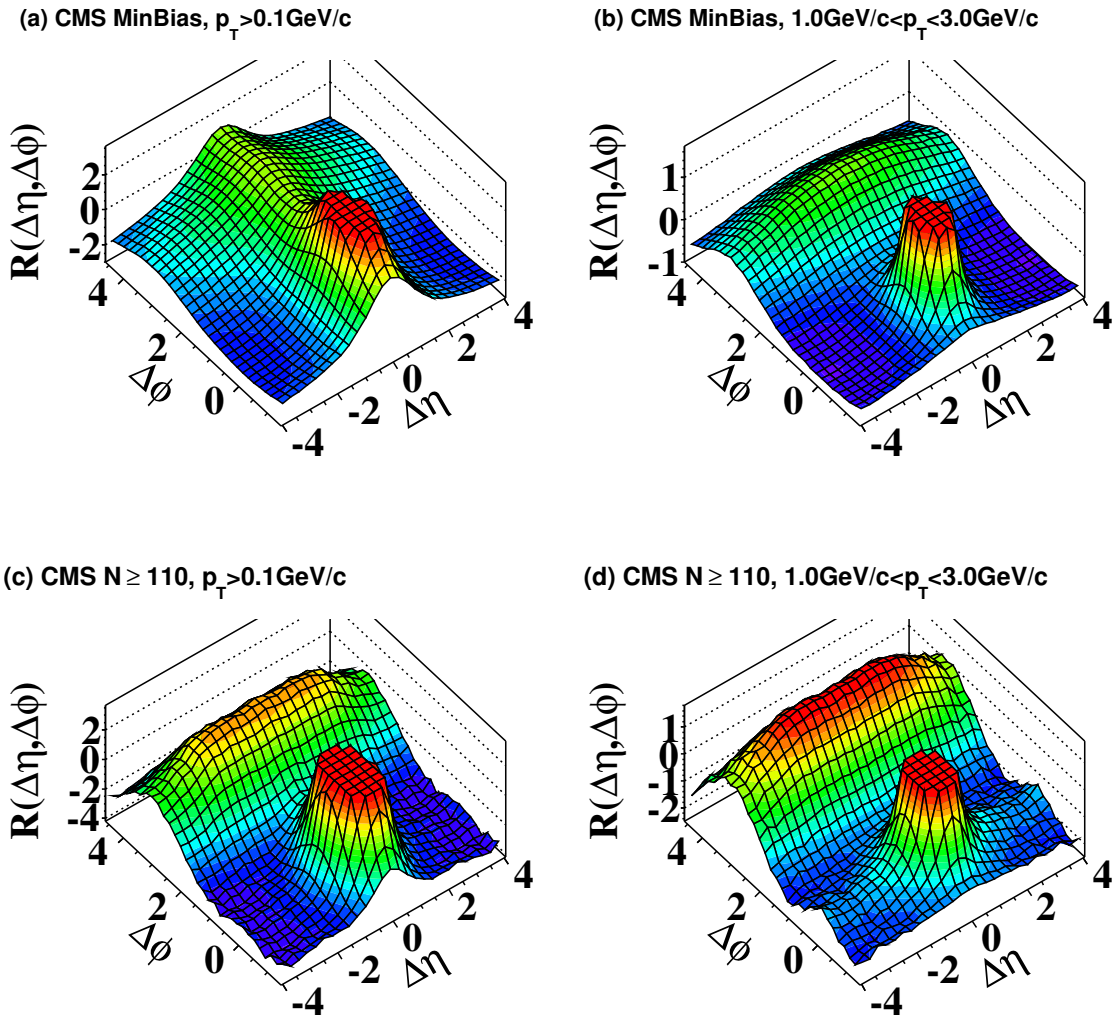
Ridge correlations in pp/pPb: hydro perspective

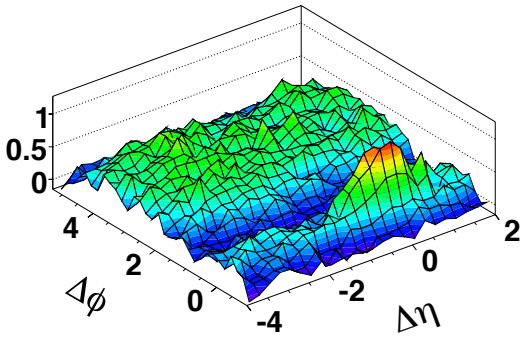
Piotr Bożek

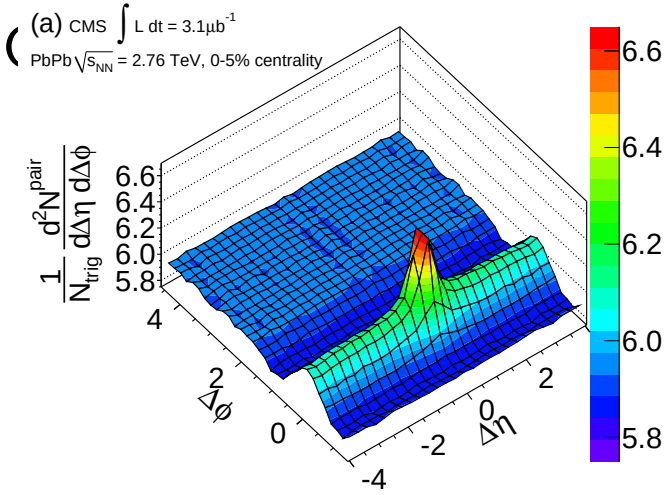
PB Phys. Rev. C85 (2012) 014911
PB, W. Broniowski Phys. Lett. B718 (2013) 1557
PB, W. Broniowski Phys. Lett. B720 (2013) 250
PB, W. Broniowski arXiv:1304.3044

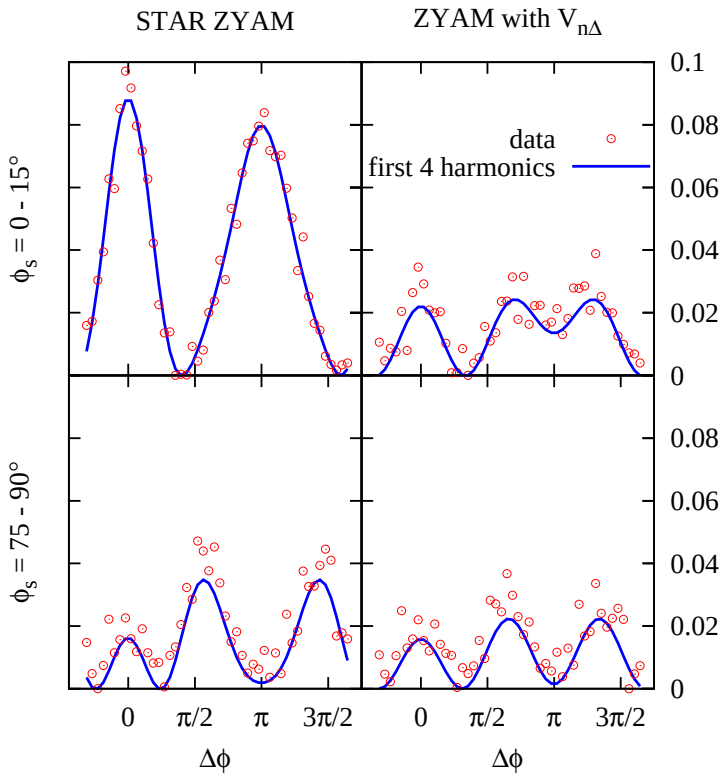


intriguing ridge seen in p-p

Flow in A-A





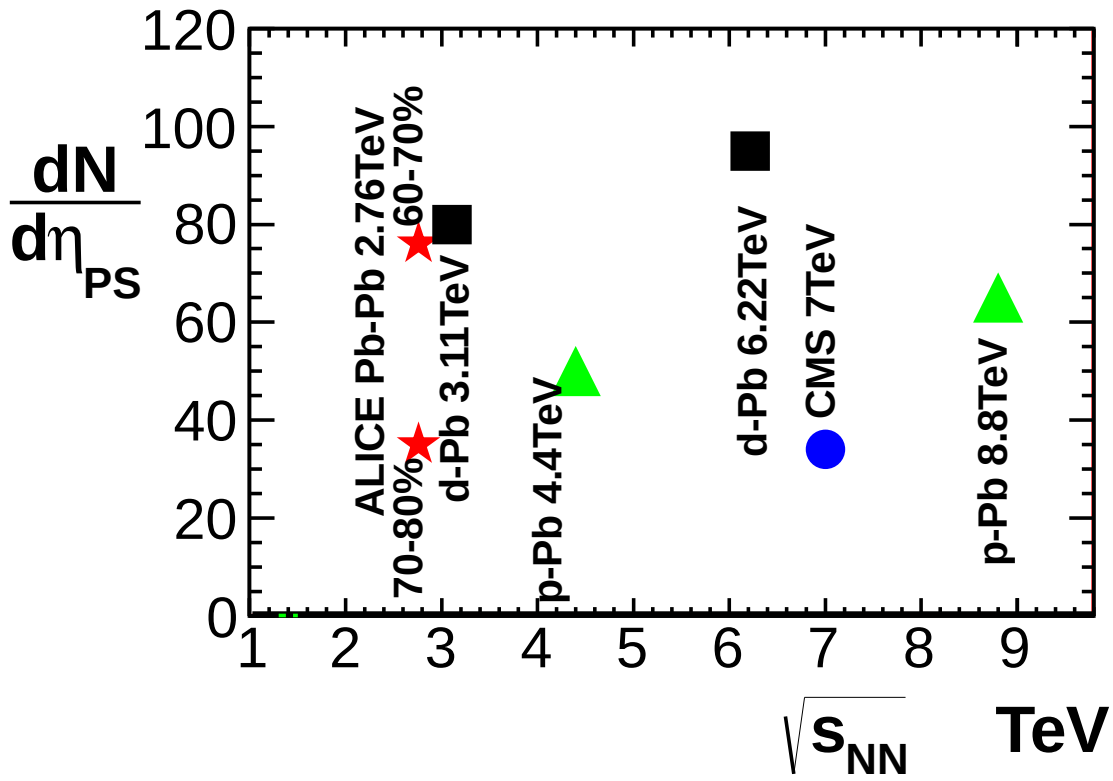


Luzum arXiv: 1011.5773 - flow harmonics

Collective elliptic flow in p-Pb?

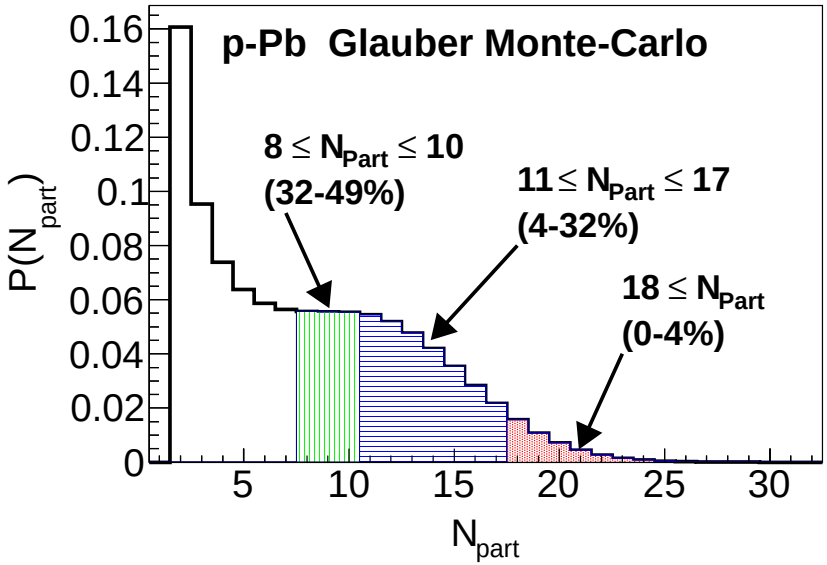
- Large enough density? yes
- Large enough eccentricity? yes?
- Large enough size? (?) but should and can be tested in pA
- Small enough gradients? no - beyond viscous hydro

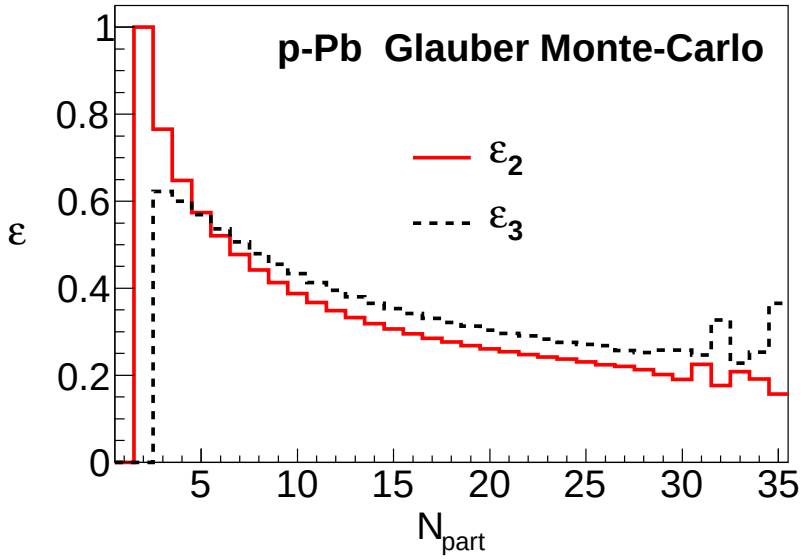
p-Pb, d-Pb @ LHC

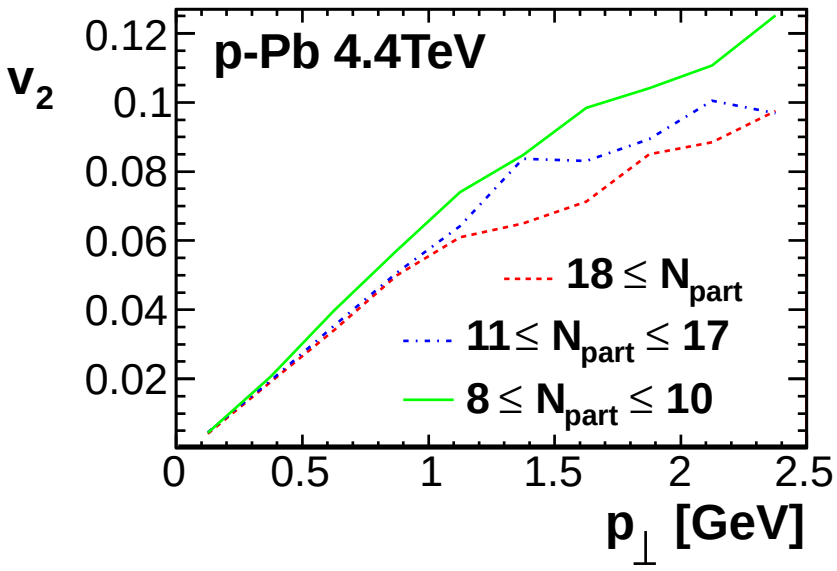


large multiplicity - large fireball - collective expansion?

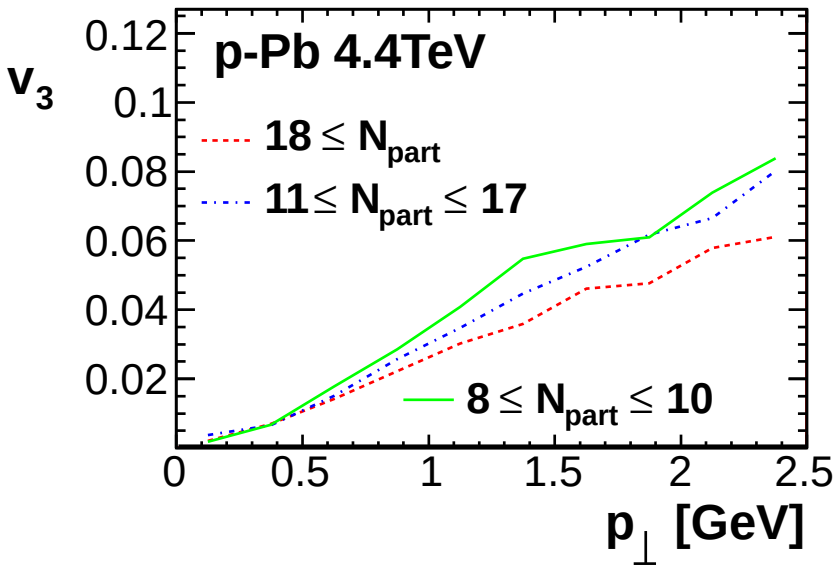
Fireball in p-Pb





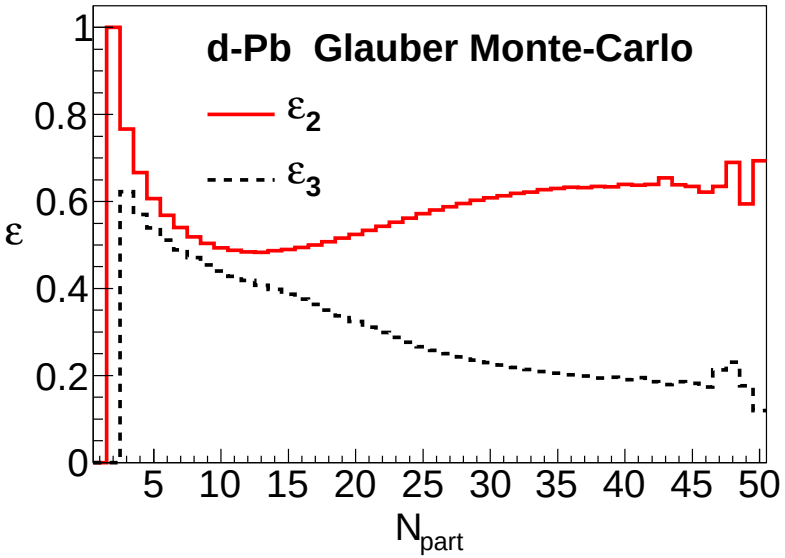


elliptic flow in p-Pb

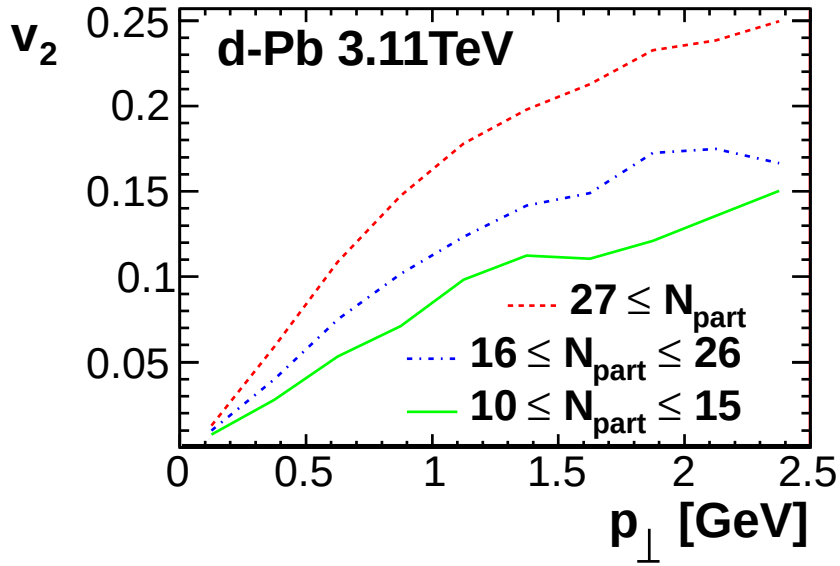


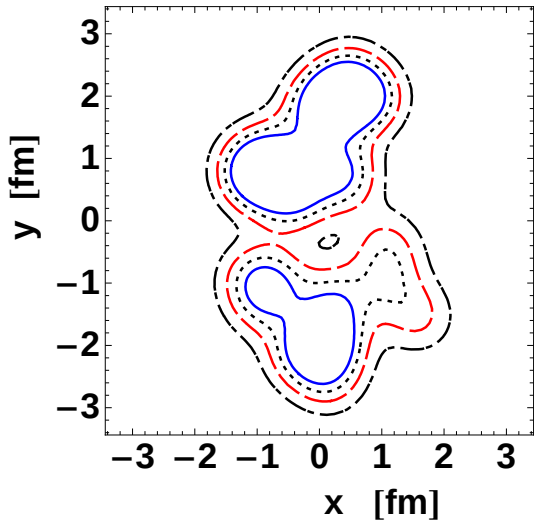
triangular flow

d-Pb

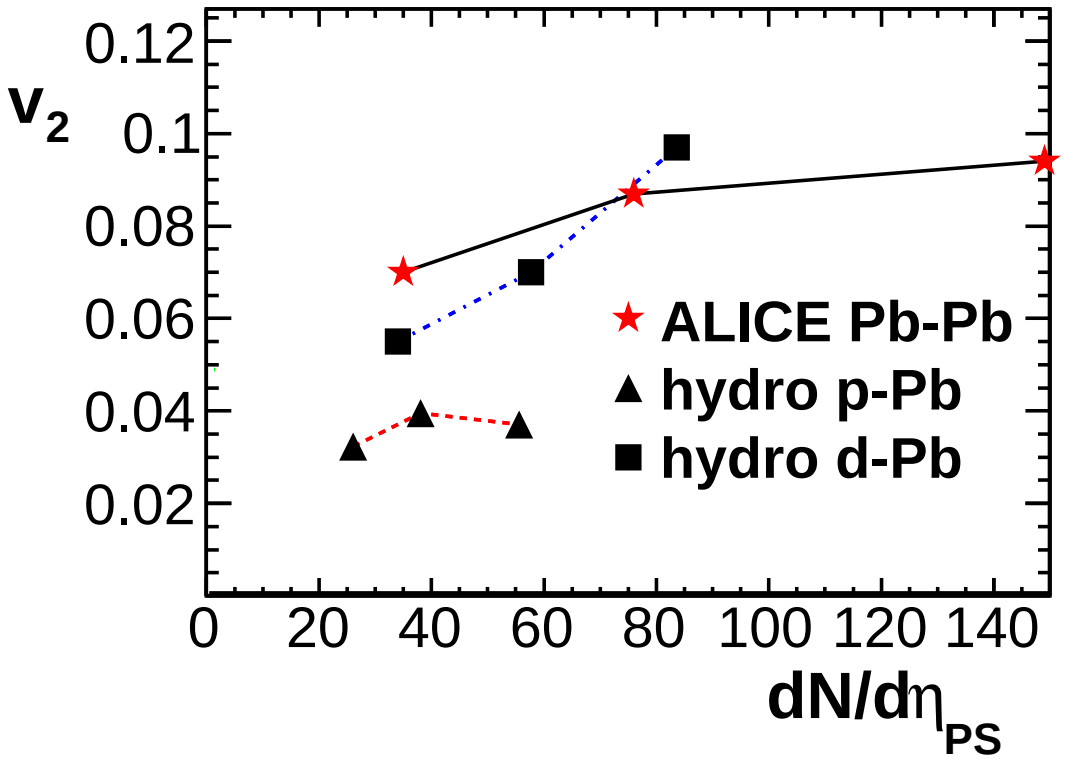


large elliptic flow



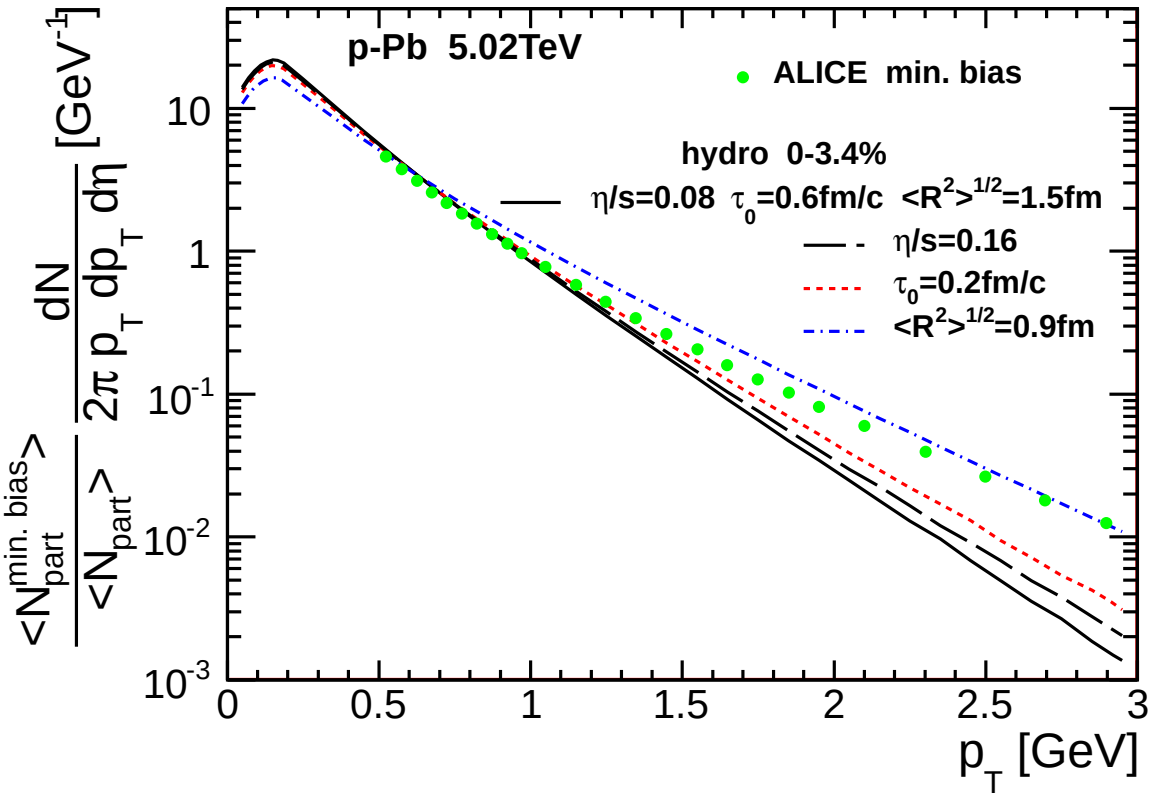


prediction 11.2011



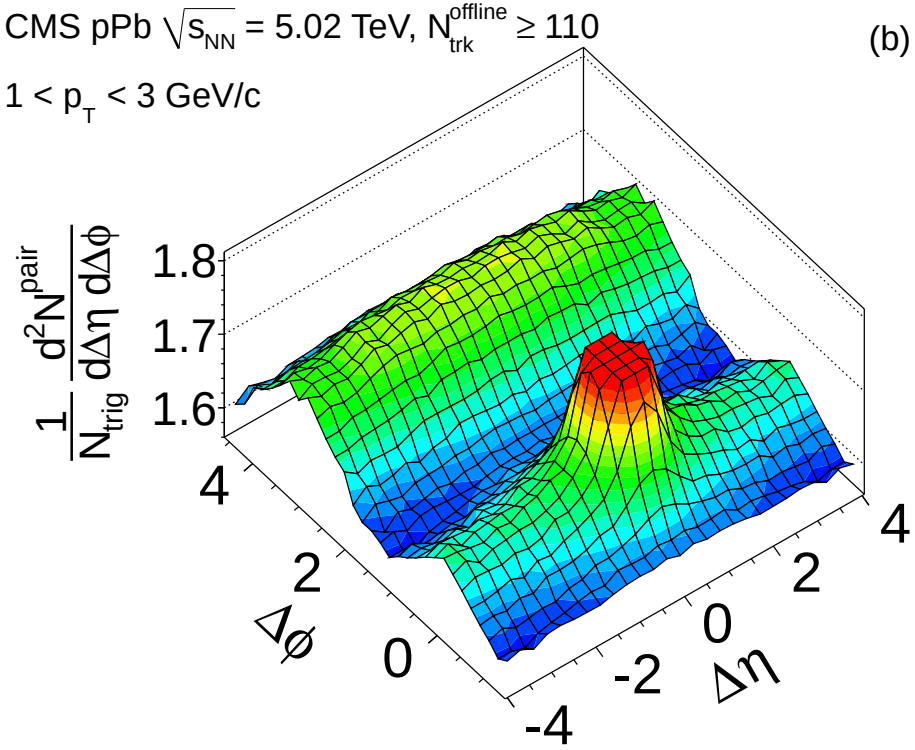
- collective flow effects $\simeq$ peripheral Pb-Pb
- can be observed
- p-Pb (d-Pb) is not p-p superposition
- only p-p as baseline

First results on pPb@5.02TeV - ALICE, CMS, ATLAS

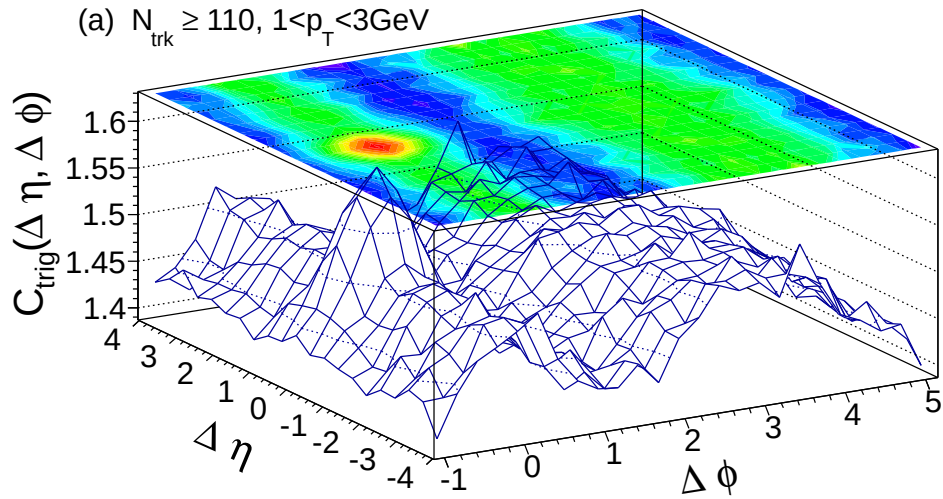


- statistical for $p_\perp < 1.5$-2Gev
- early flow, viscosity, density profile?

Ridge in p-Pb

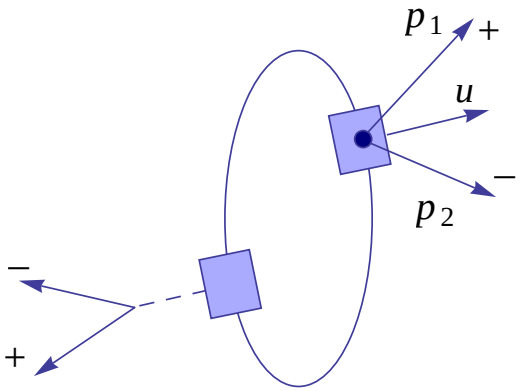


(b)

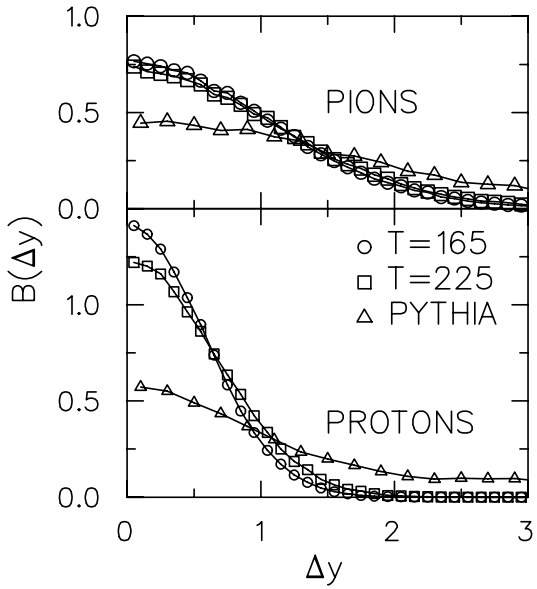


Charge balancing

local charge conservation



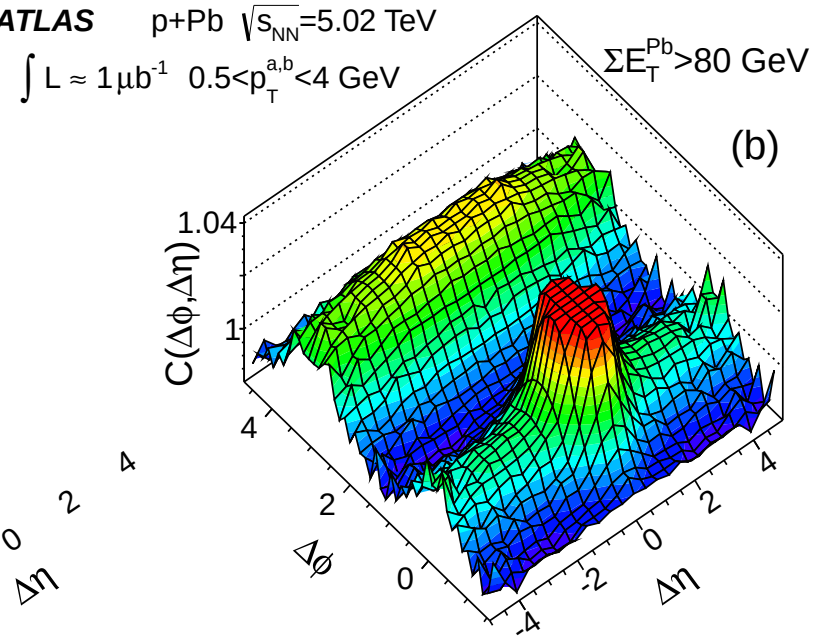
charge balance function



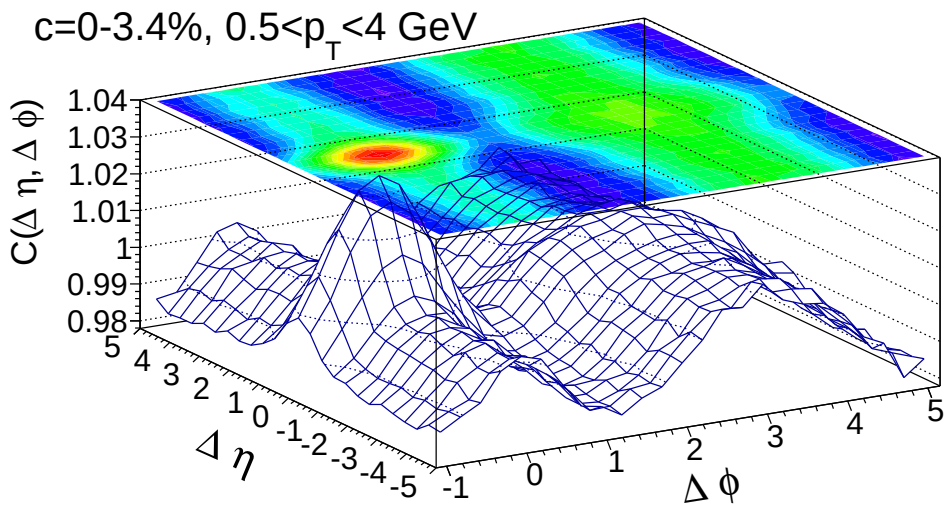
Bass et al. (2000)

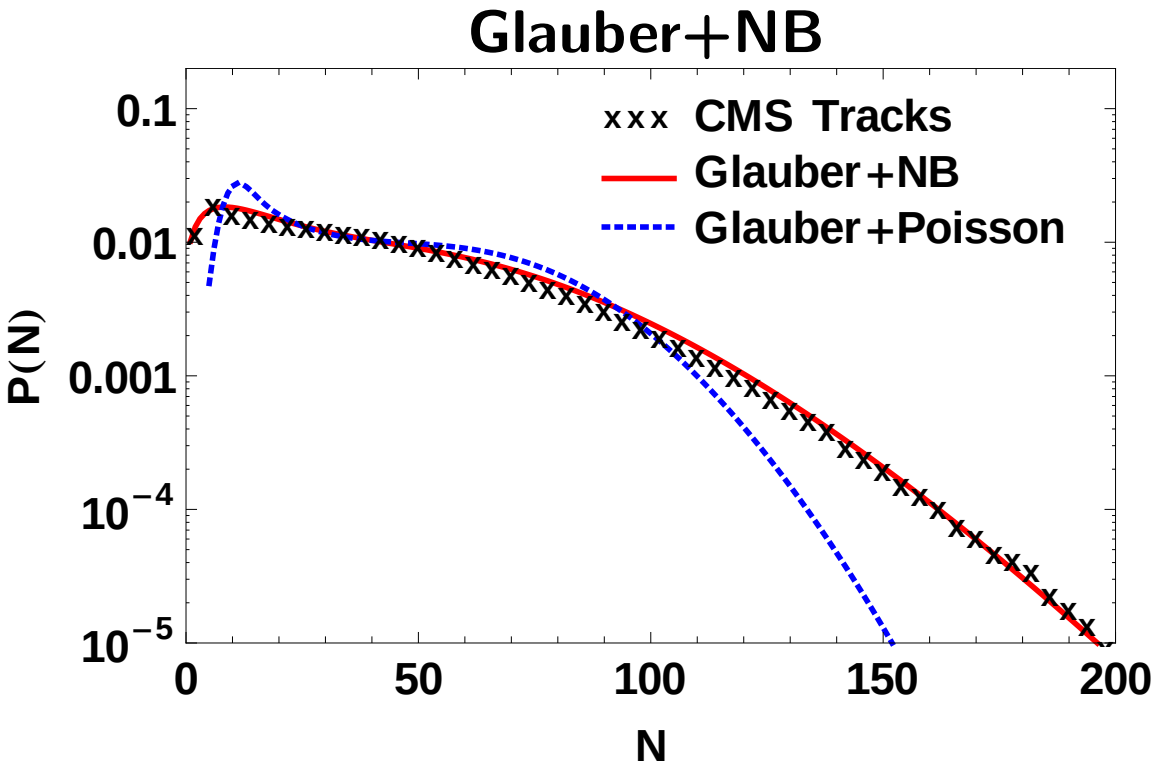
Correlation function per pair

ATLAS



hydro

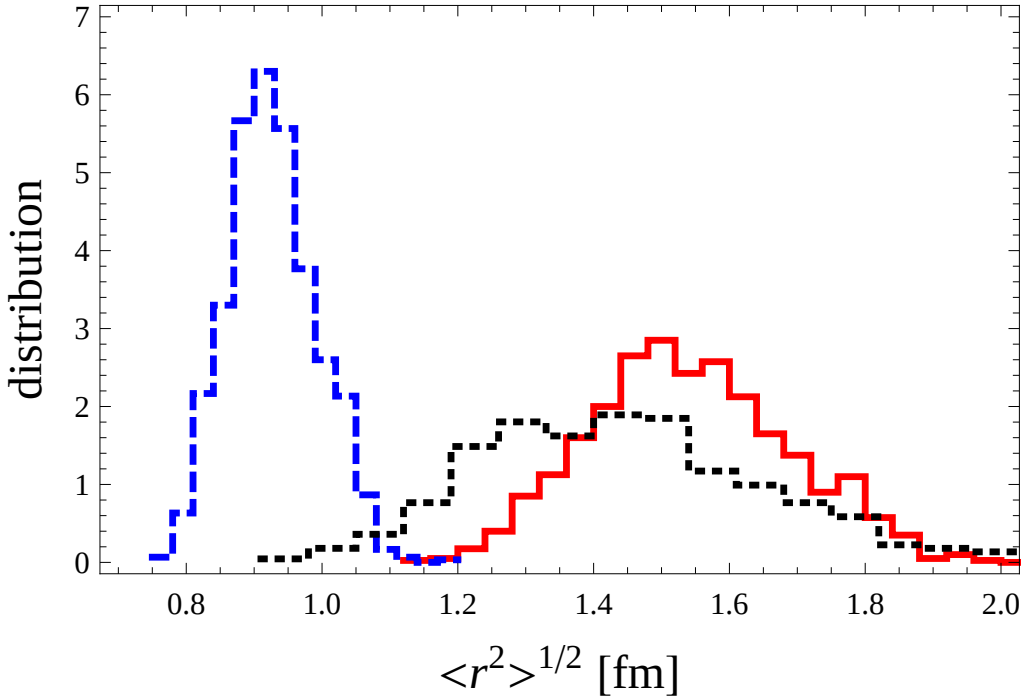




$P(n) = \sum_i P_{part}(i) N_{p\lambda i,\kappa i}(n)$

Additional fluctuations of density (compared to Glauber)

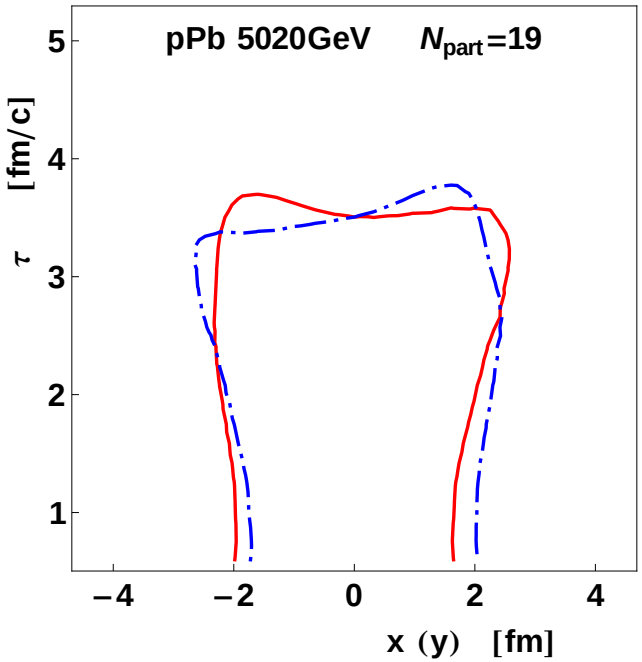
Very different fireball size



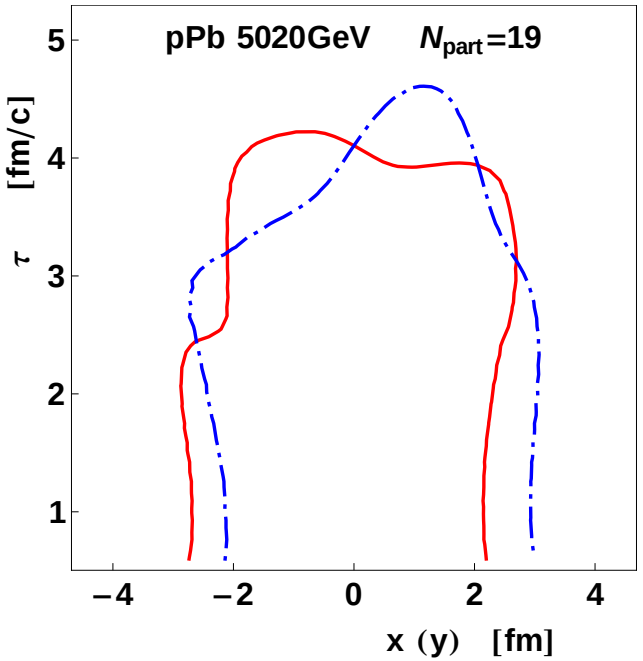
Compact (0.9fm), Glauber+NB (1.4fm), Standard (1.5fm)

Expansion of the fireball

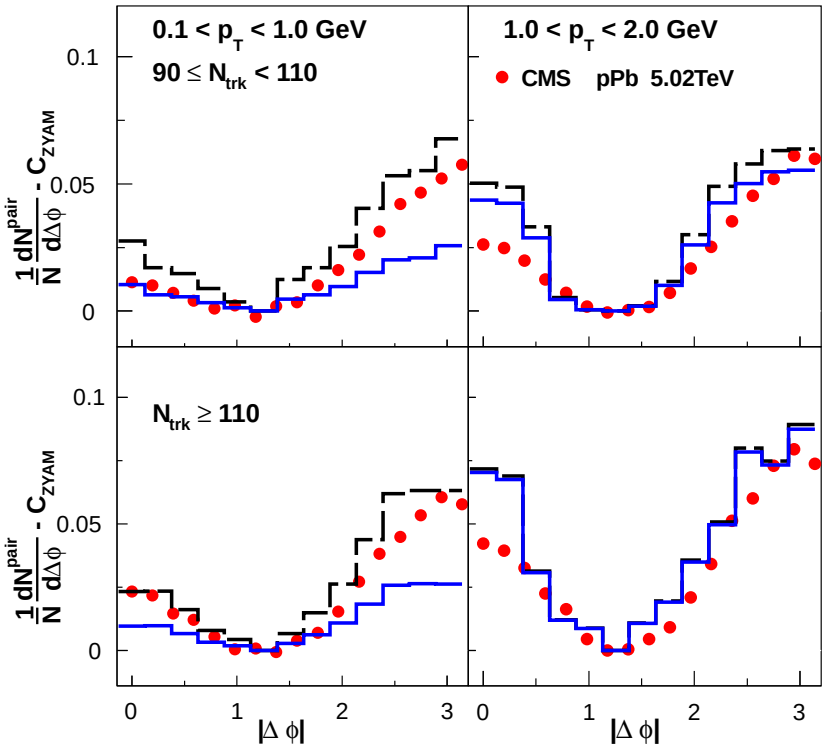
Compact source



Standard (large) source

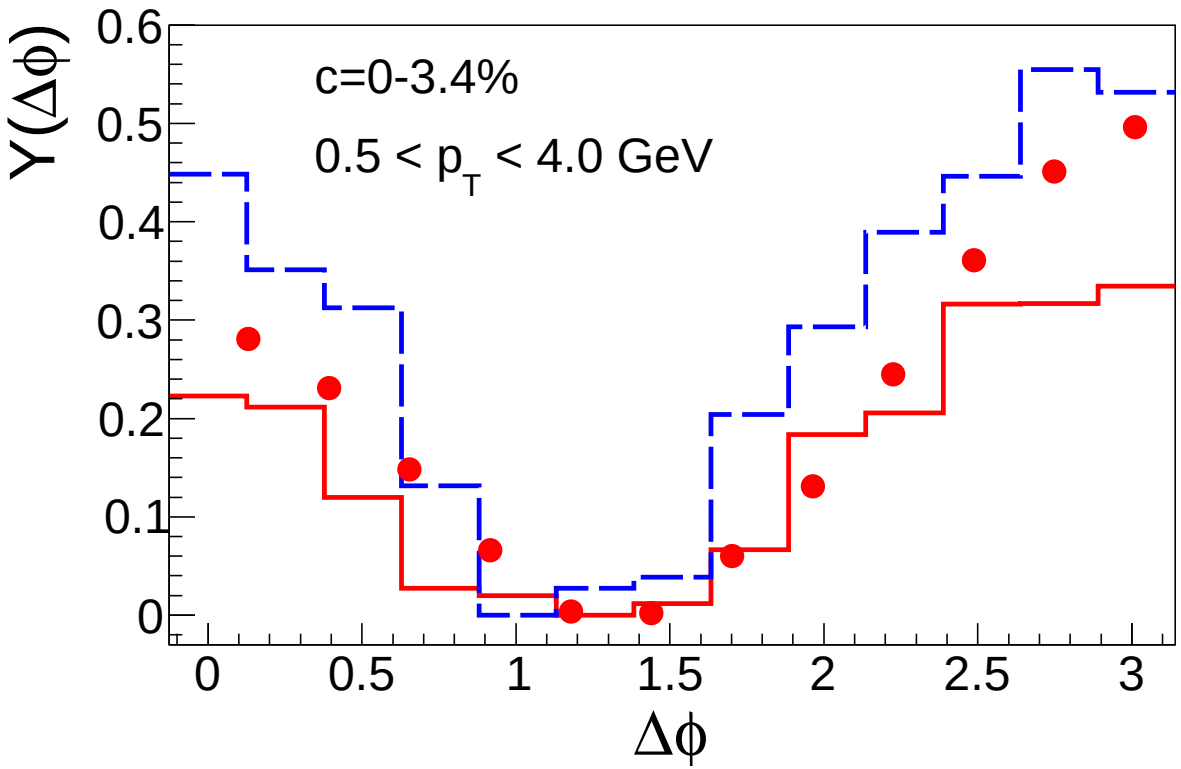


Azimuthal correlations

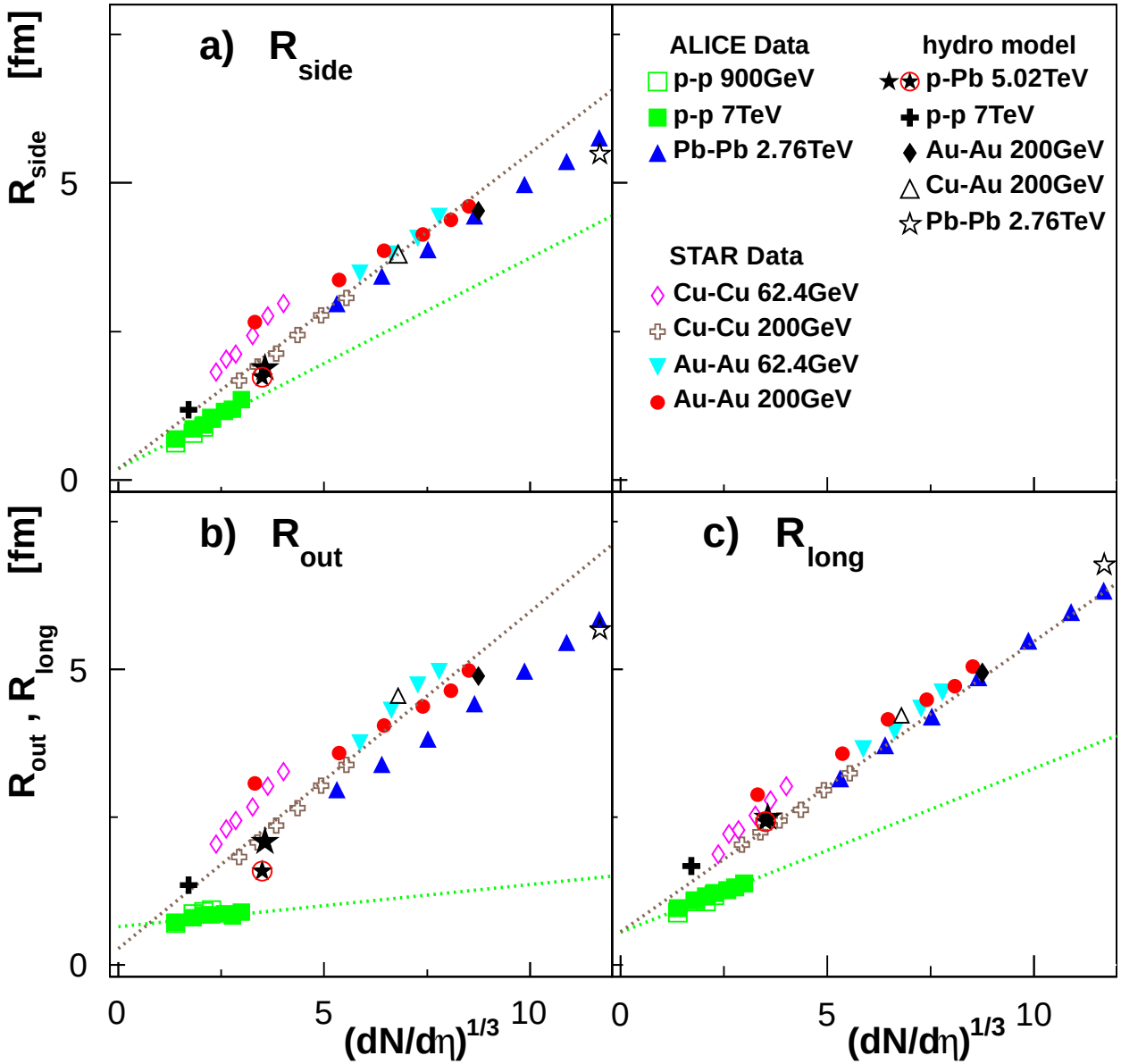


- collective flow

Azimuthal correlations ATLAS

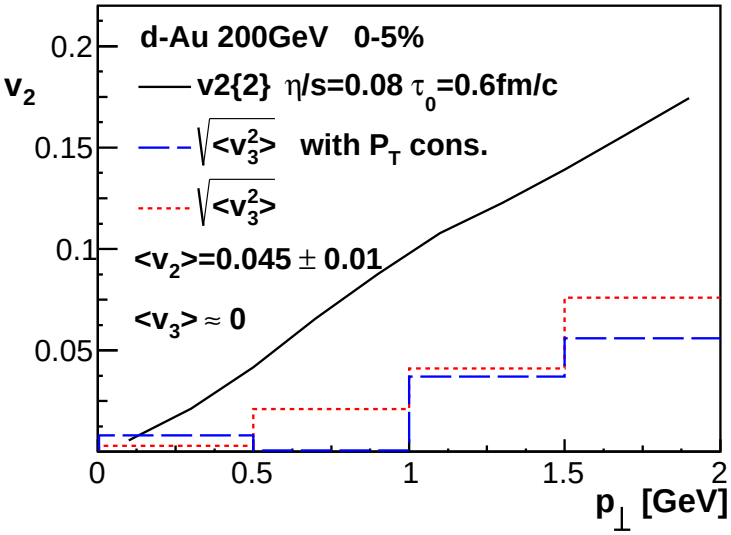


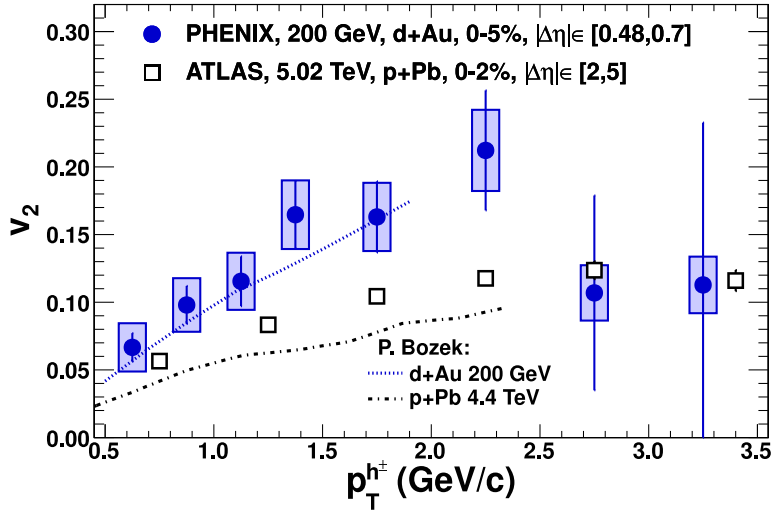
HBT systematics

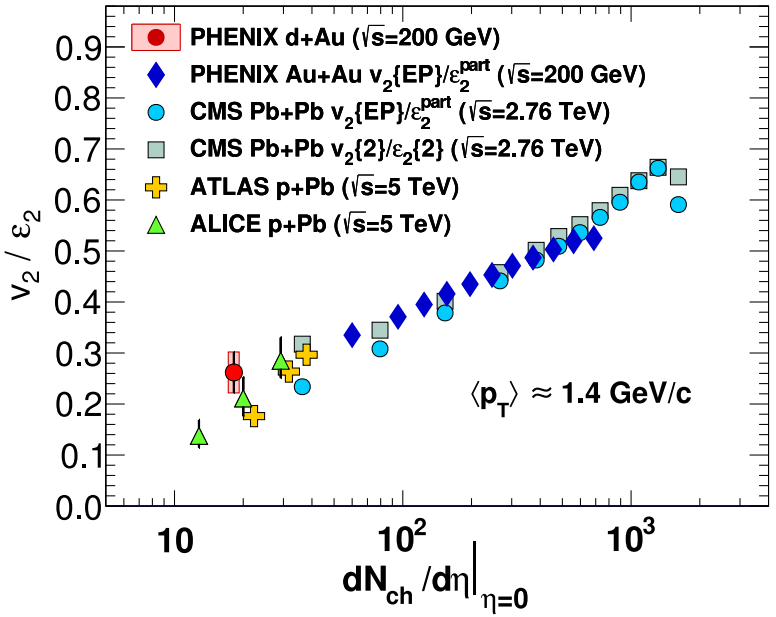


d-Au 200GeV

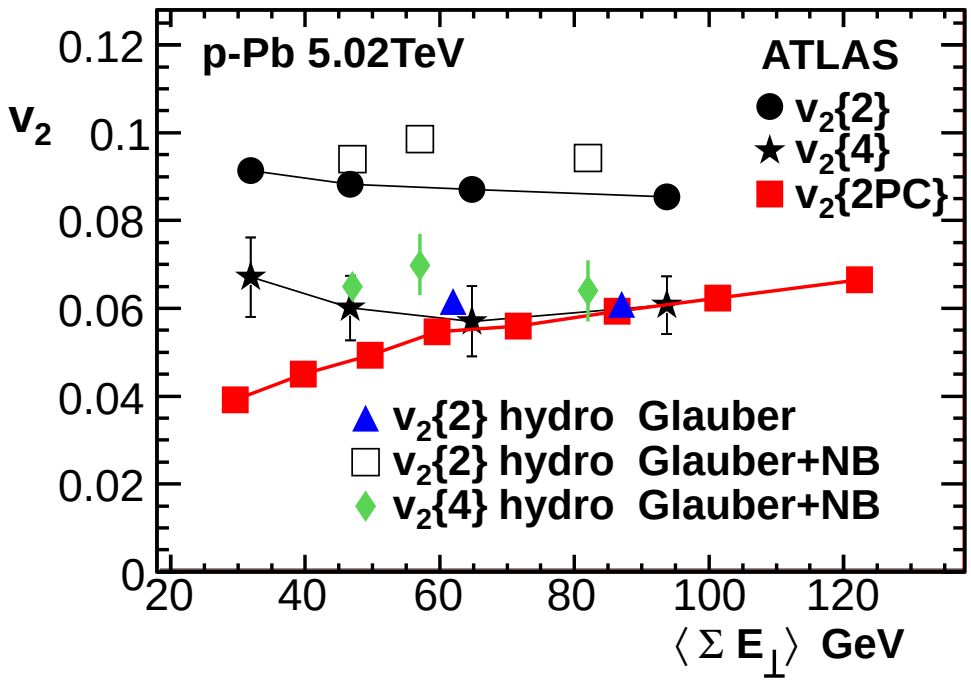
- large eccentricity
- large v_2
- small v_3







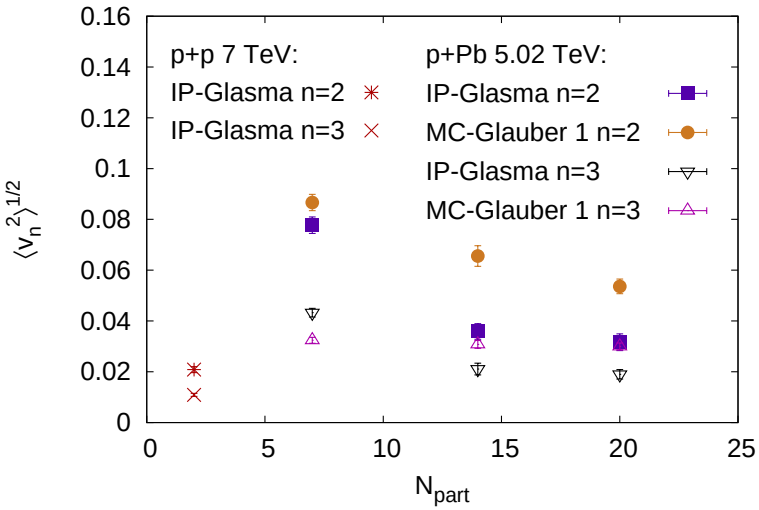
Hydro in pA, dA compares well with data



Initial conditions matter a lot!

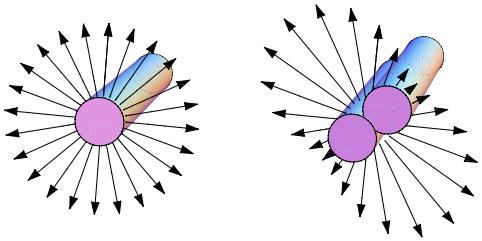
Hydrodynamic flow in p-p?

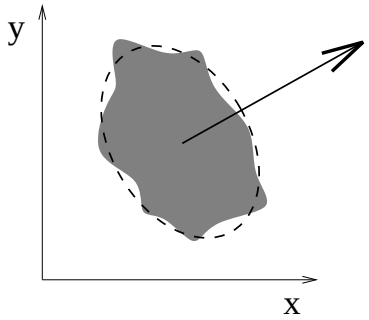
- Romatschke, Luzum - arXiv: 0901.4588 (overlap)
- Bozek - arXiv: 0911.2392 (flux-tubes)
- Chaudhuri - arXiv: 0912.2578 (hot-spots)
- Werner, Karpenko, Pierog - arXiv: 1011.0375 (EPOS)
- Bzdak, Schenke, Tribedy, Venugopalan - arXiv: 1304.3403 (IP-Glasma)

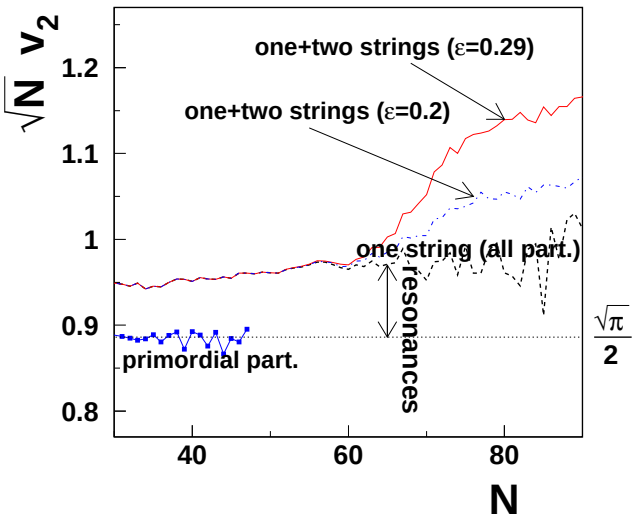


- Is hydrodynamics valid?
- What is the initial eccentricity ?

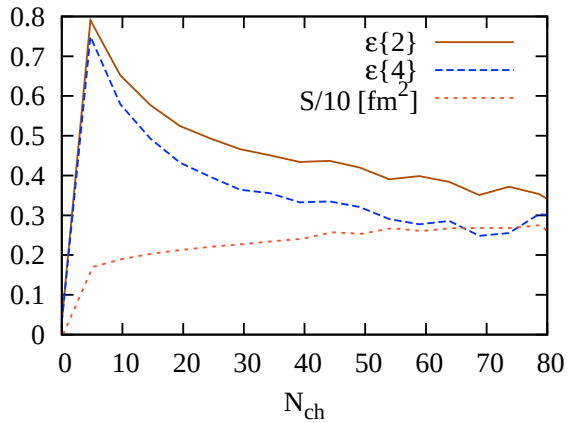
Fireball shape in pp







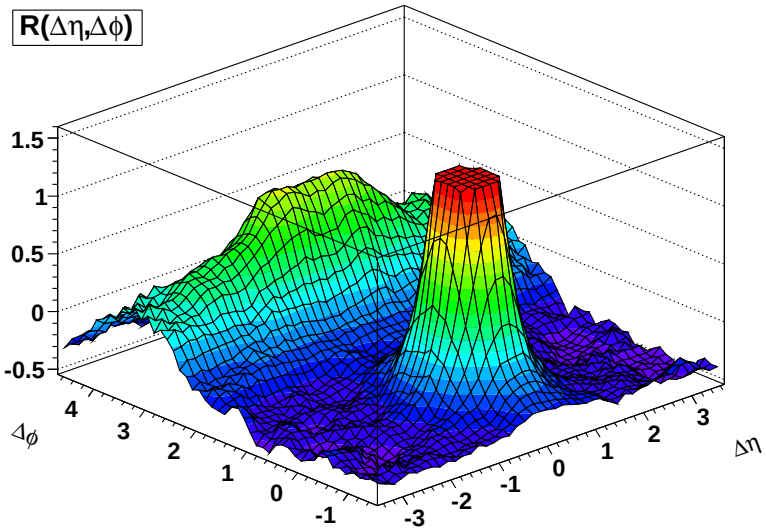
PB, 0911.2397



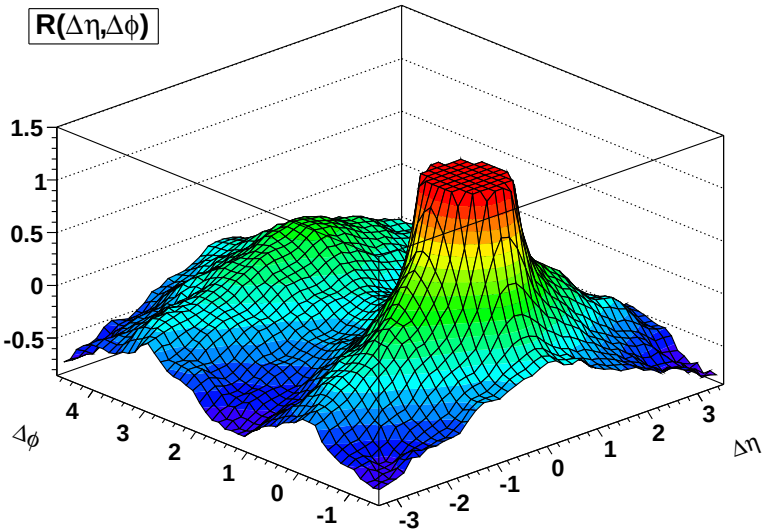
E.Asar et al., 1009.5643

EbE v_2 deconvolution? (ATLAS, Jia, Mohapatra)

Hydro ridge in p-p



No collectivity

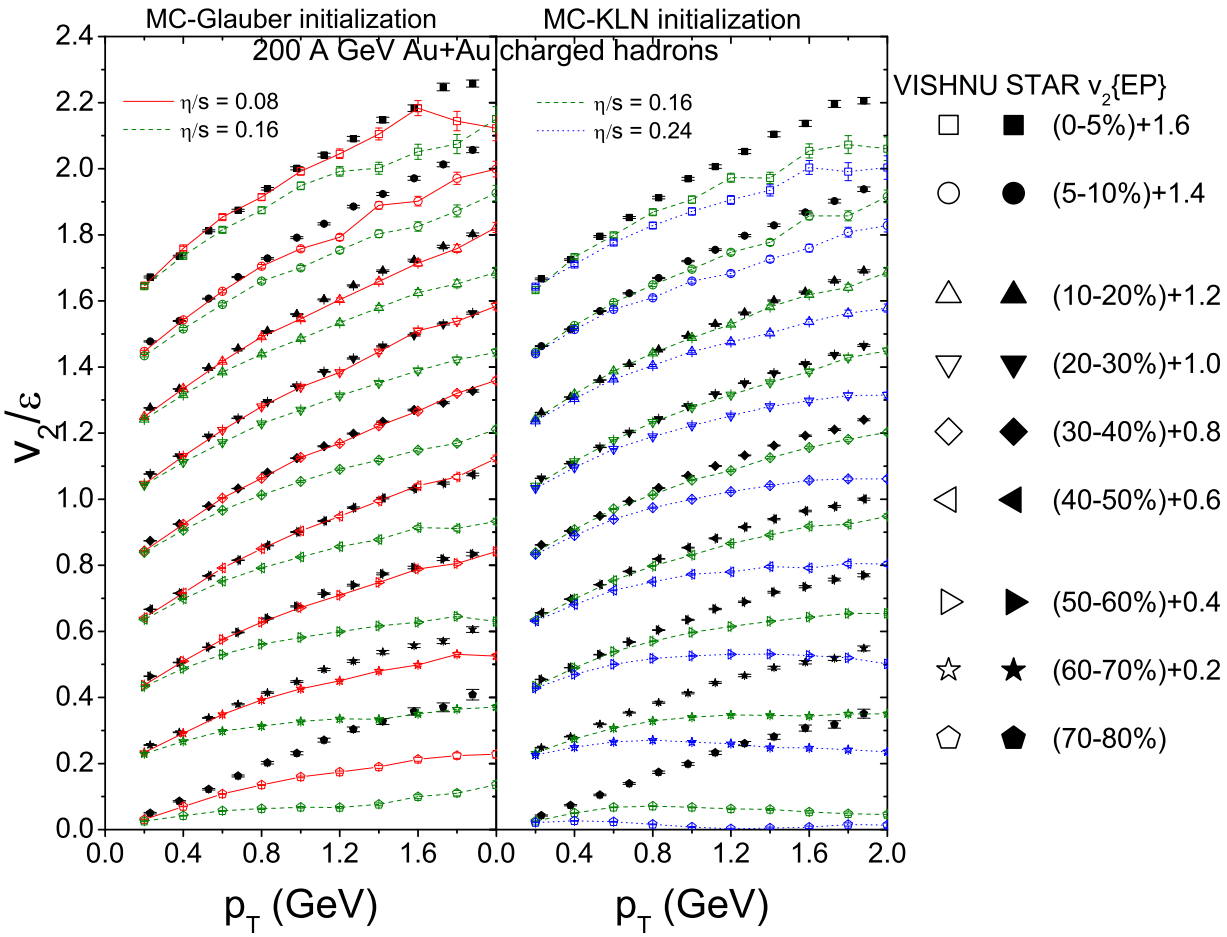


EPOS+hydro

Werner, Karpenko, Pierog arXiv: 1011.0375

Can we reduce the uncertainties

go back to very peripheral A-A



Song, Bass, Heinz, Hirano, Shen arXiv: 1101.4638

Summary

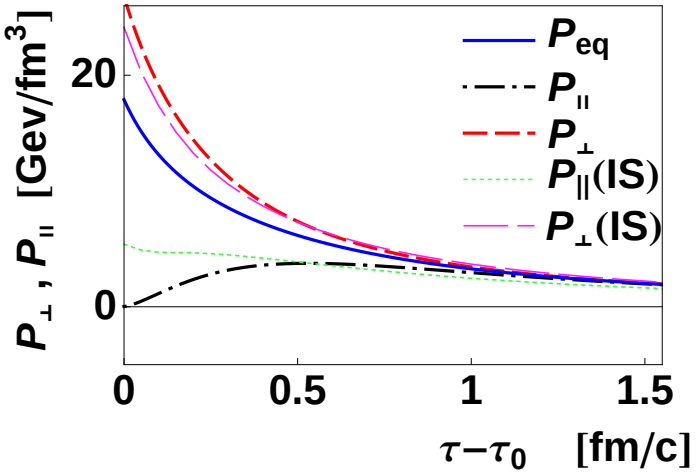
- Ev-by-ev hydro for pA, dA
- Collectivity (FSI) in pPb@LHC , explains observed ridge and v_2
- d-Au data consistent with collective picture
- HBT radii in p-Pb ?
- Is it collective flow ? - In manys ascpects consistent
- Other sources of correlations !
- Limits of hydro!

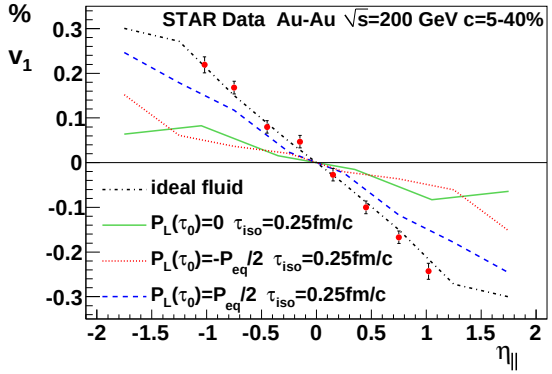
- Why hydrodynamics would work?

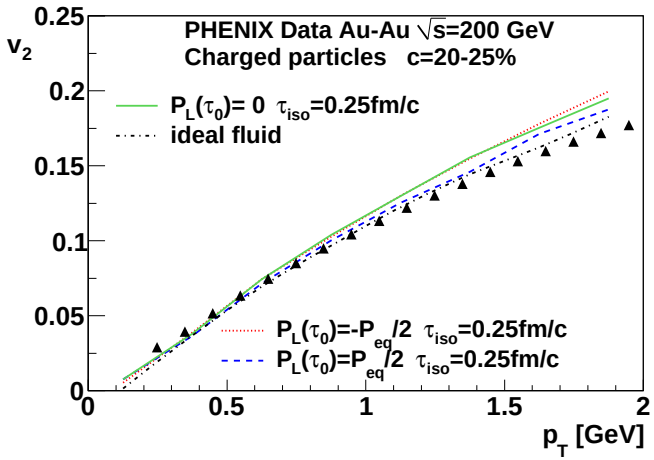
- Prospects: **Experiment**

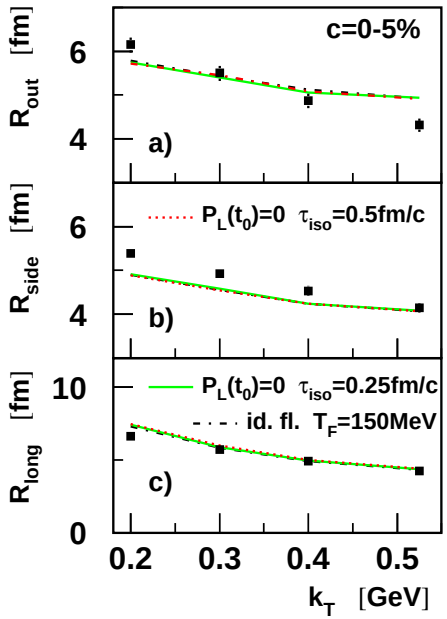
... and initial state, peripheral A-A, p-p??, core-corona, disantengling: collectivity, CGC, jets ...

Pressure anisotropy







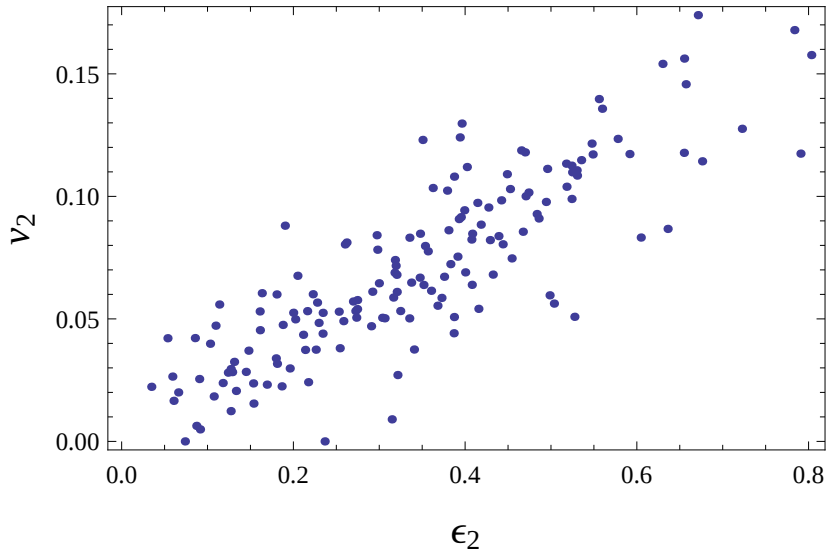


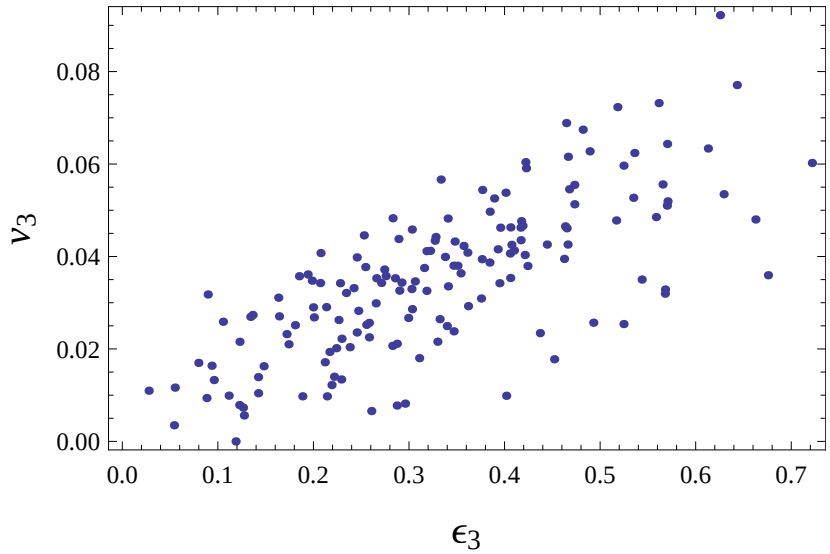
PB, I.Wyskiel, 2010

early pressure anisotropy irrelevant - Vredevoogd, Pratt, 2009

other higher gradients could be important ?

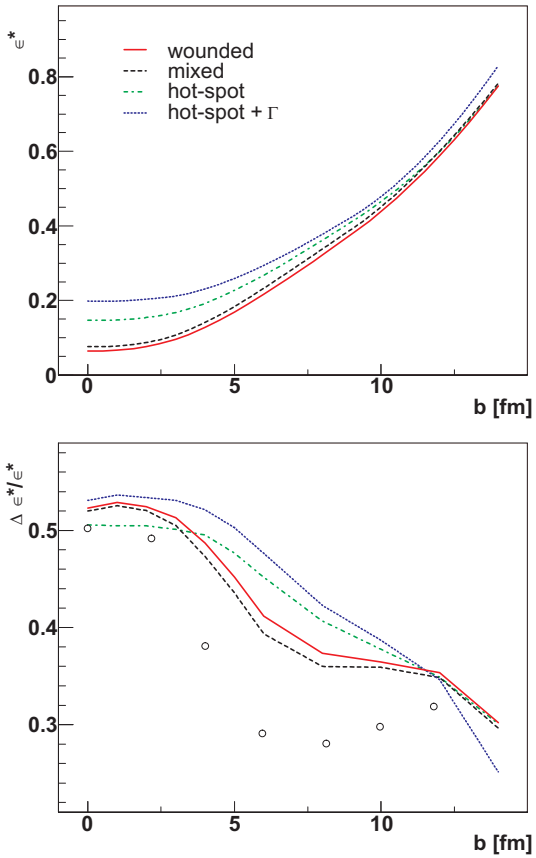
Fireball anisotropy - flow asymmetry





- Ev-by-Ev hydro response to geometry valid
- response strength depends on details

Eccentricity fluctuations, central collisions



$$\frac{\Delta\epsilon}{\epsilon} = \sqrt{\frac{4}{\pi} - 1}$$

Broniowski, Bozek, Rybczynski arXiv: 0706.4266

central A-A, Gaussian limit $\longrightarrow$ $v_2\{4\} \simeq 0$

central p-A (Glauber+NB) $\frac{\Delta\epsilon}{\epsilon} < \sqrt{\frac{4}{\pi} - 1}$ and $v_2\{4\} > 0$