Hydrodynamic predictions for Pb+Pb collisions at 2.76 TeV per nucleon

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Outline

I. Hydrodynamic theory - a general overview

II. Initial conditions
  a. Glauber model and Monte Carlo formulation
  b. Multiplicity and initial entropy density

III. Freeze-out
  a. THERMINATOR

IV. Results, comparison to data

V. Conclusions

Based on P. Bożek, M. Chojnacki, W. Florkowski, B. Tomášik, Phys. Lett. B **694** (2010) 238.

Hydrodynamics: the theory

non-viscous hydrodynamics: energy and momentum conservation

$$\partial_\mu T^{\mu\nu} = 0$$

$$T^{\mu\nu} = (p + \varepsilon) u^\mu u^\nu - p g^{\mu\nu}$$

constraint for velocity:

$$u^\mu u_\nu = 1$$

5 unknowns: pressure, energy density, 3 components of velocity
need one more equation: the equation of state

$$p = p(\varepsilon)$$

In general, this is 3+1 dimensional problem. By **assuming** that the solution is boost-invariant, it can be simplified to 2+1.
Invariant in *η*

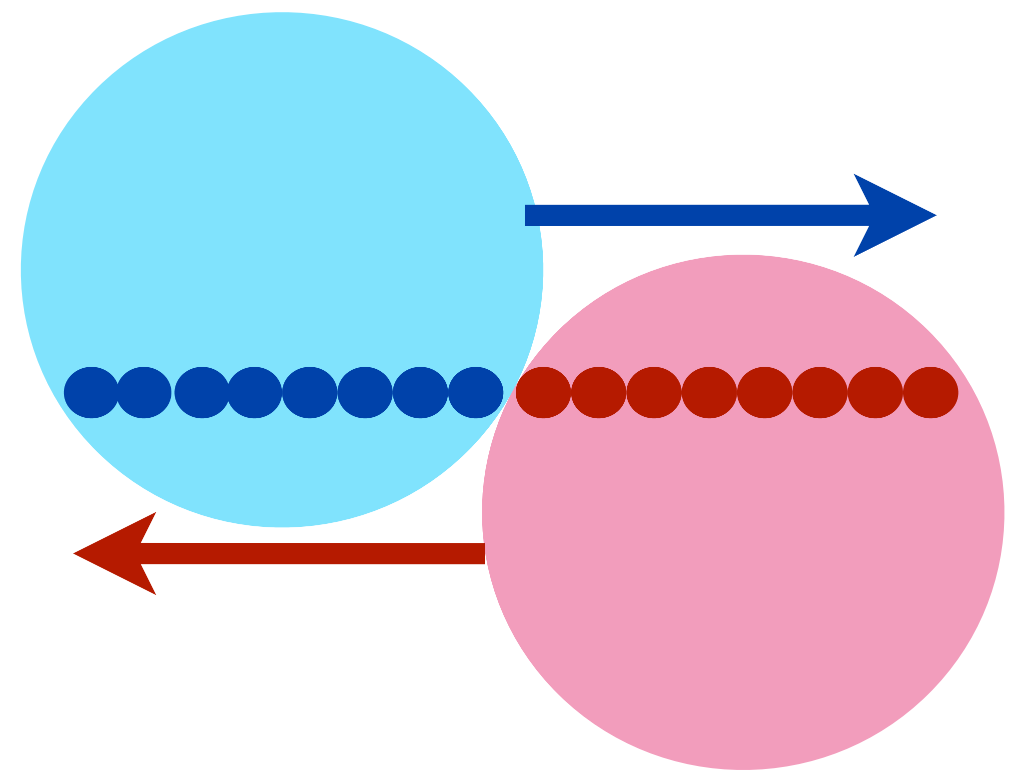
$$\eta = \frac{1}{2} \ln \frac{1+v}{1-v}$$

Initial conditions: Glauber model

$$T_A(\vec{b},\vec{x}) = \int_{z_{\rm min}}^{z_{\rm max}} \rho_A(\vec{x},z)\, dz$$

$$T_B(\vec{b},\vec{x}) = \int_{z_{\rm min}}^{z_{\rm max}} \rho_B(\vec{x},z)\, dz$$

$$T_{AB}(\vec{b}) = \int T_A(\vec{s})\, T_B(\vec{b}-\vec{s})\, d^2 s$$

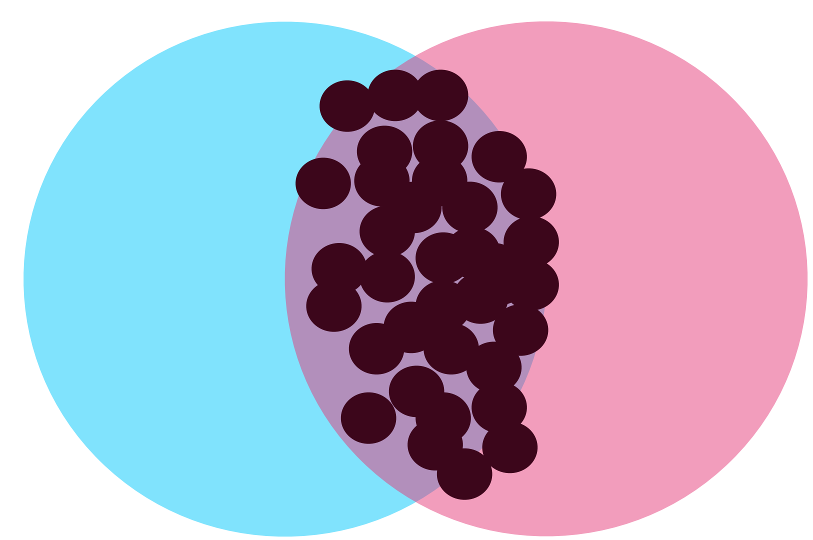


Number of binary collisions

$$\langle N_{\rm bin}\rangle = \sigma_0\, AB\, T_{AB}(\vec{b})$$

Number of wounded nucleons
(at least one inelastic scattering)

$$\langle N_{\rm wound}\rangle = \langle N_{\rm A,wound}\rangle + \langle N_{\rm B,wound}\rangle$$



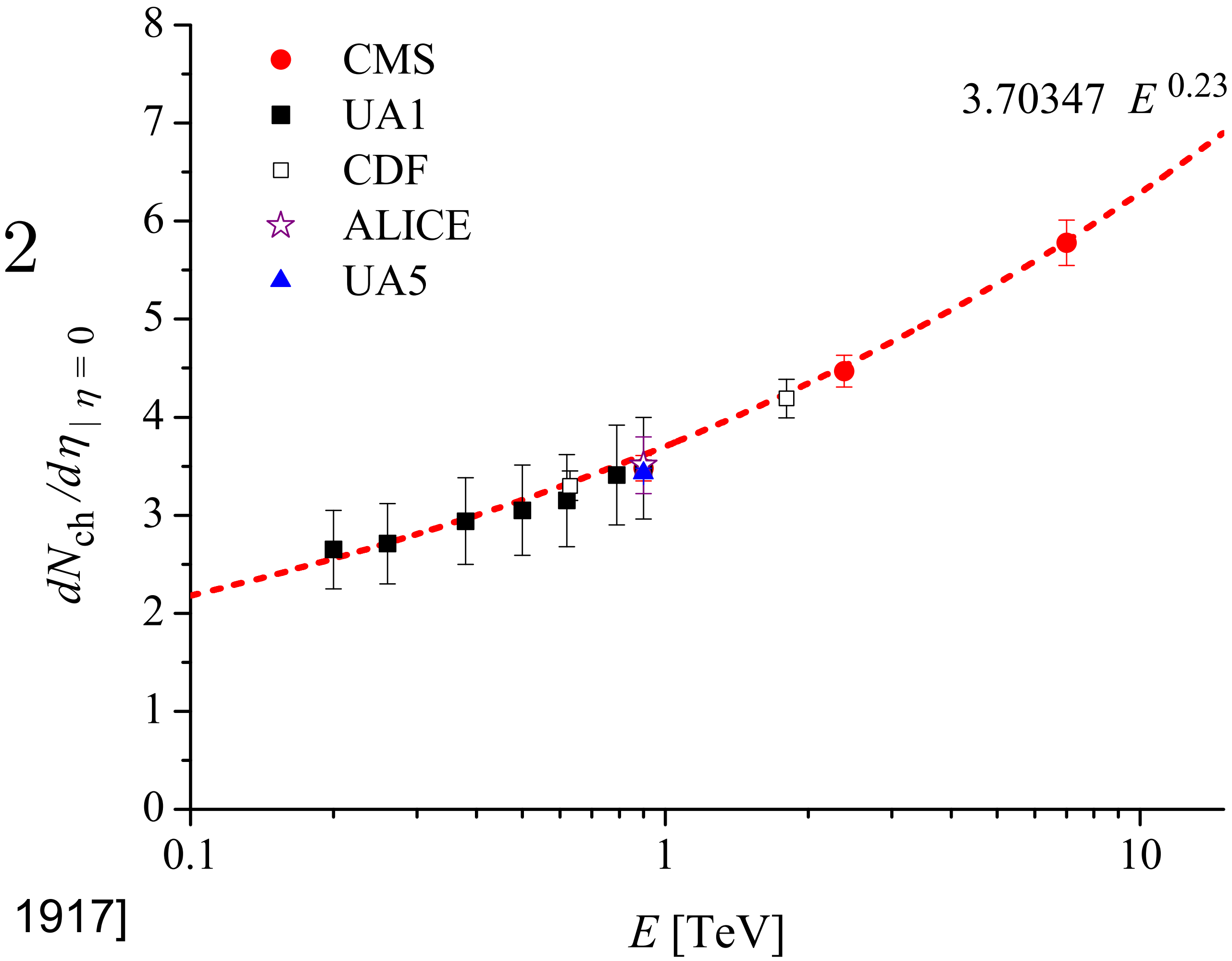
Multiplicity: interpolation for p+p

Parametrization of pp multiplicity data

$$\frac{dN^{\mathrm{pp}}(E)}{d\eta} = 3.70347 \left(\frac{E}{1\,\mathrm{TeV}}\right)^{0.23}$$

Extrapolate from 2.36 TeV measurement (closest data point) to 2.76 prediction

$$\frac{dN^{\mathrm{pp}}(2.76)}{d\eta} = \left(\frac{2.76}{2.36}\right)^{0.23} 4.65 = 4.82$$

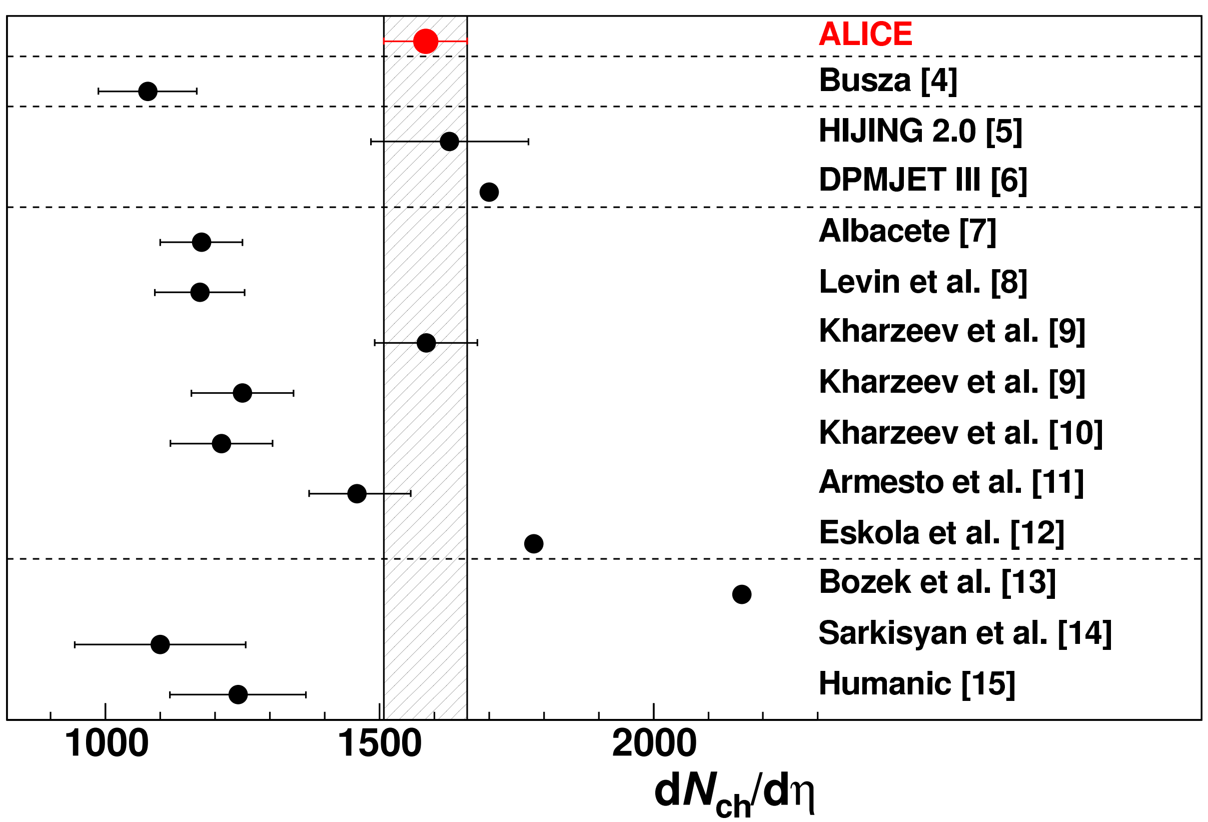


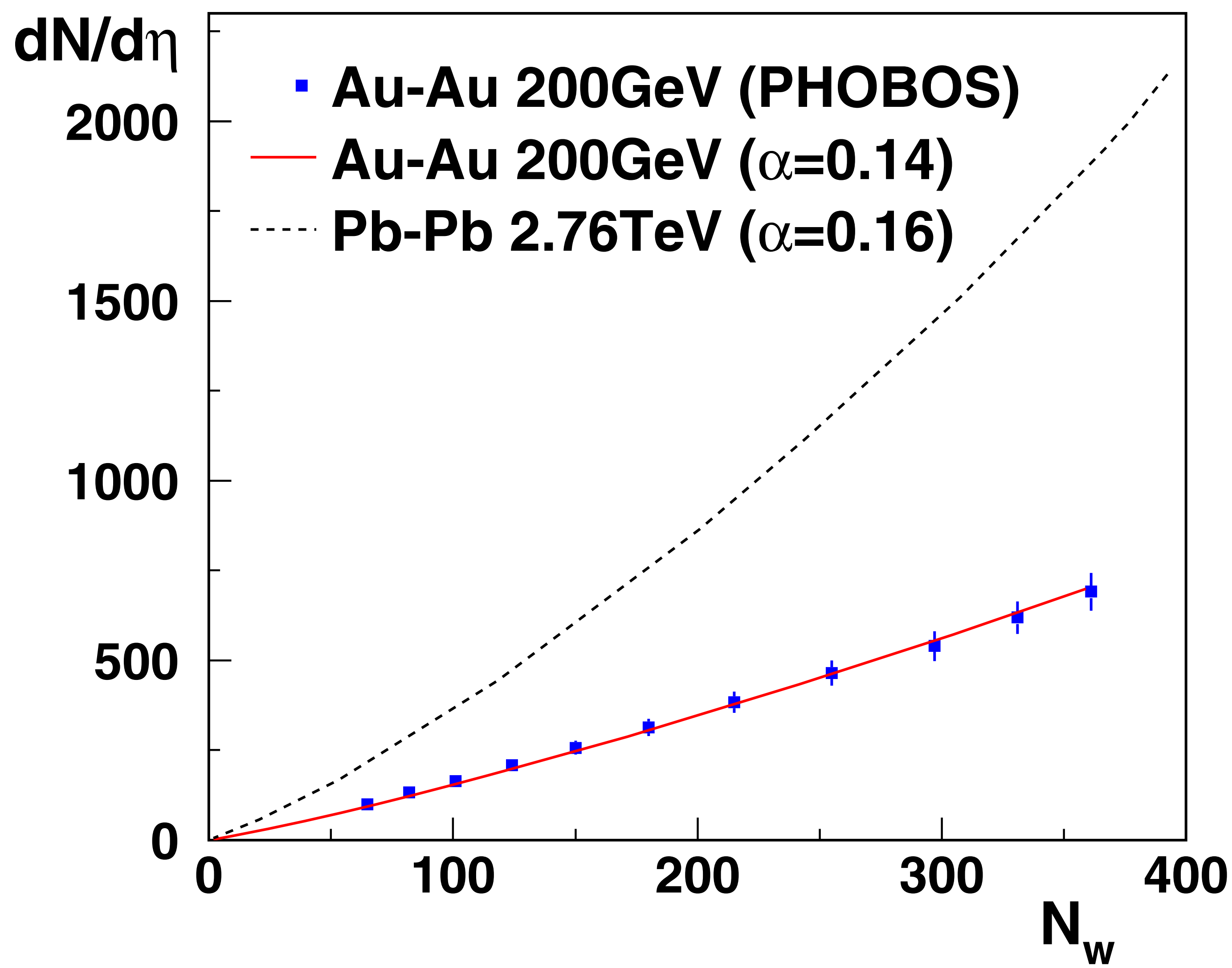
[L. McLerran, M. Praszalowicz, Acta Phys. Polonica B **41** (2010) 1917]

Multiplicity: extrapolation from pp to PbPb

$$\frac{dN^{\mathrm{PbPb}}(b,2.76)}{d\eta} = \frac{dN^{\mathrm{pp}}(2.76)}{d\eta}\left(\frac{1-\alpha}{2}N_{\mathrm{wound}}(b) + \alpha N_{\mathrm{bin}}(b)\right)$$

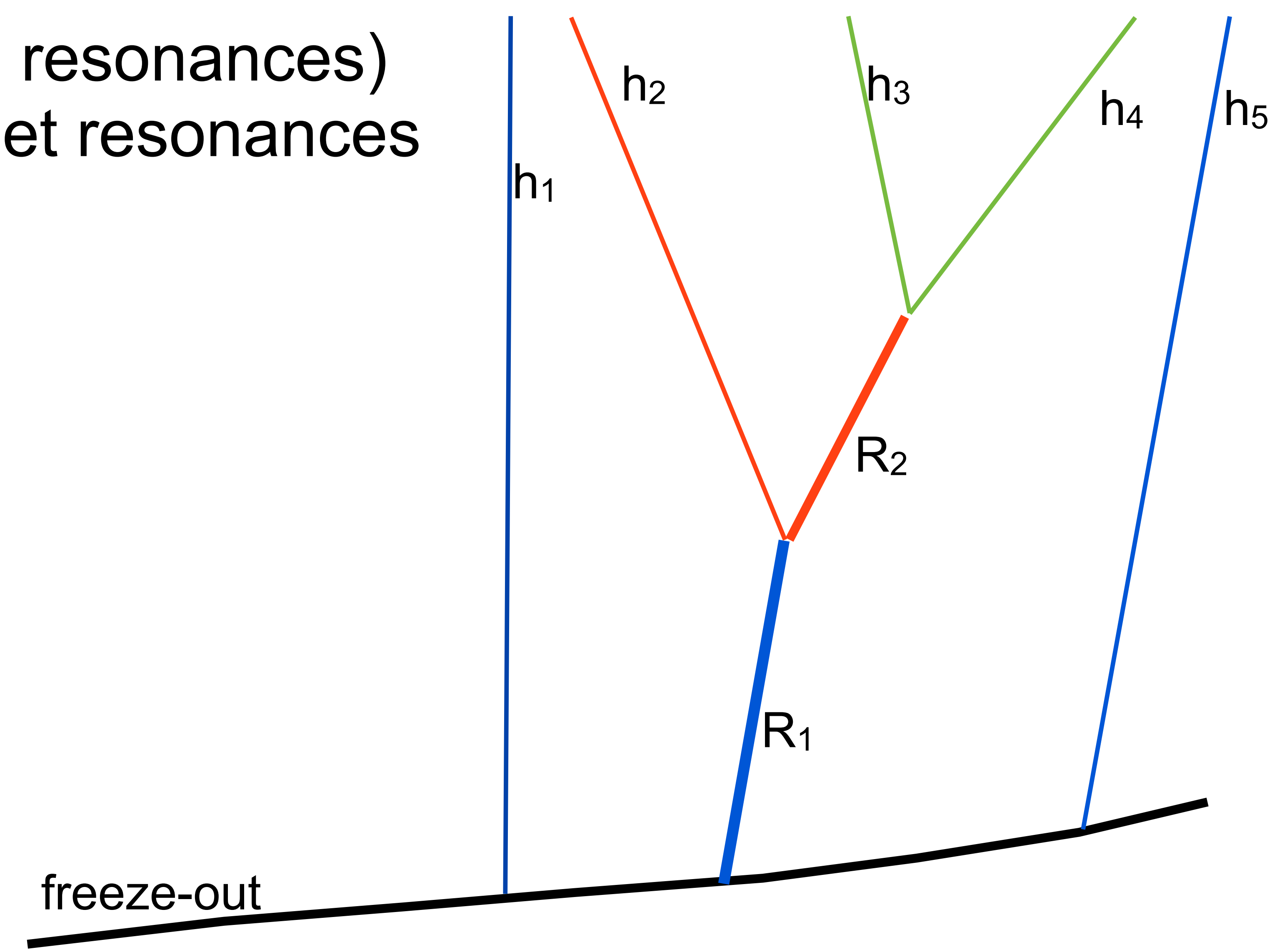
$\sqrt{s_{NN}}$/GeV	19.6	200	2 760
α	0.12	0.145	0.16





Freeze-out, THERMINATOR

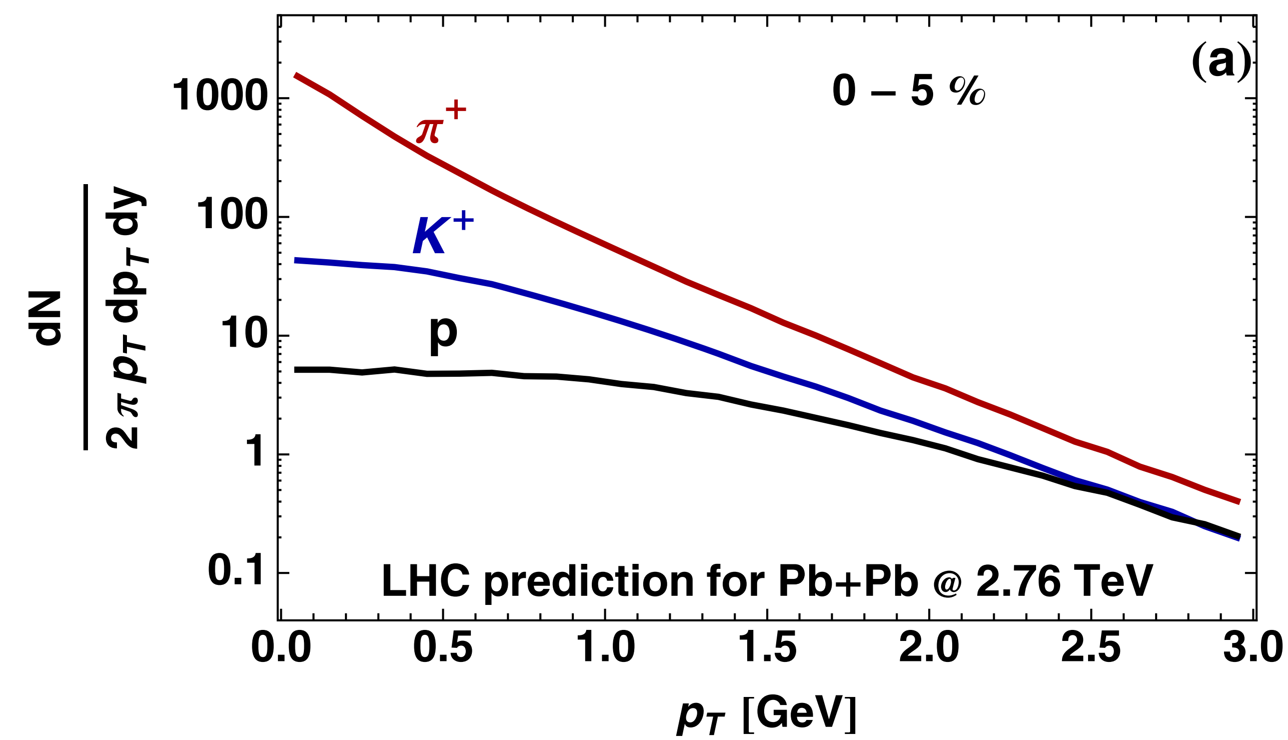
- freeze-out - at some hypersurface assume **sudden** change from hydrodynamic behaviour to free streaming
- here use hypersurface *T*=150 MeV
- produce all hadrons (incl. resonances) at this hypersurface and let resonances decay

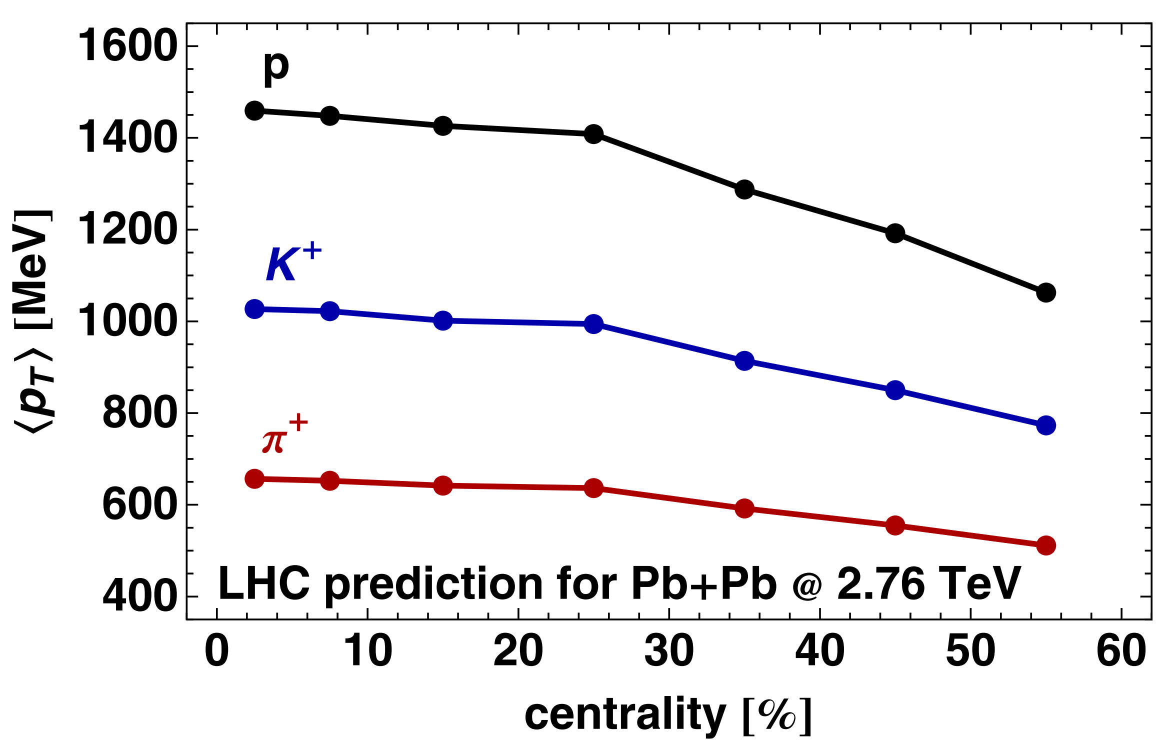


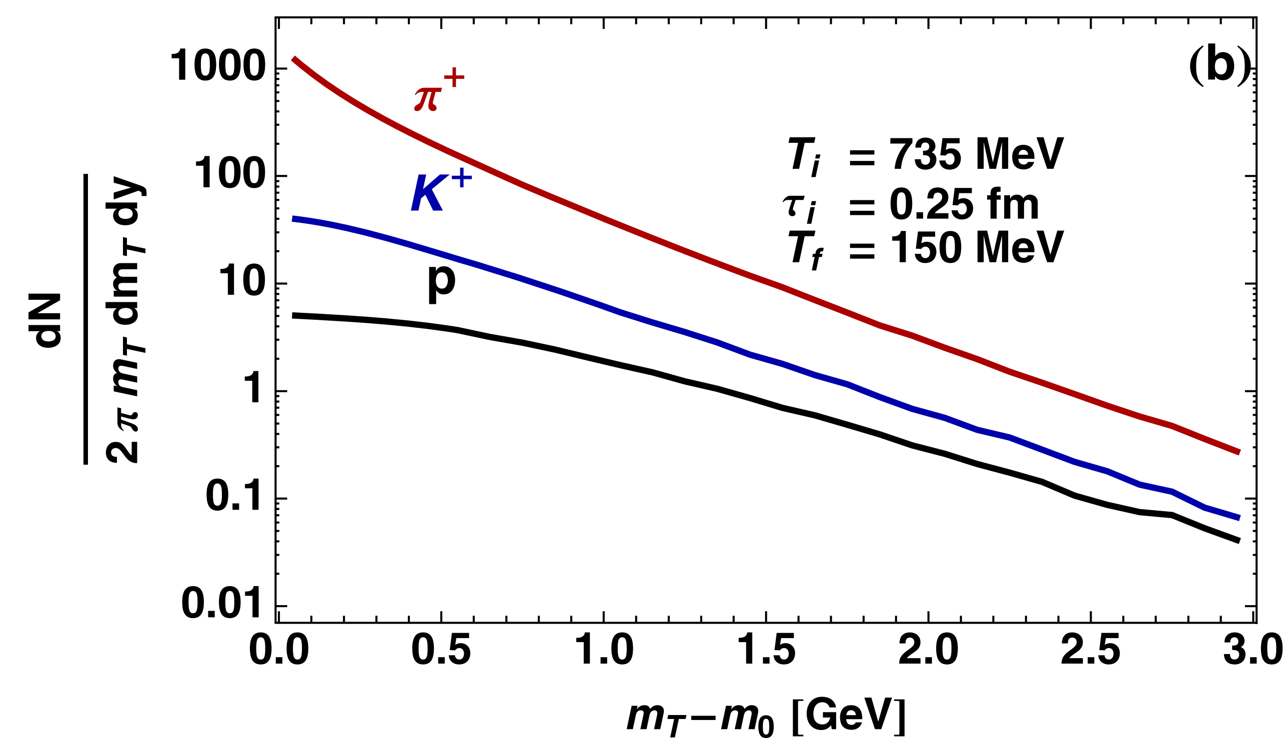
Results: the spectra

freeze-out at T=150 MeV

resonance decays by THERMINATOR





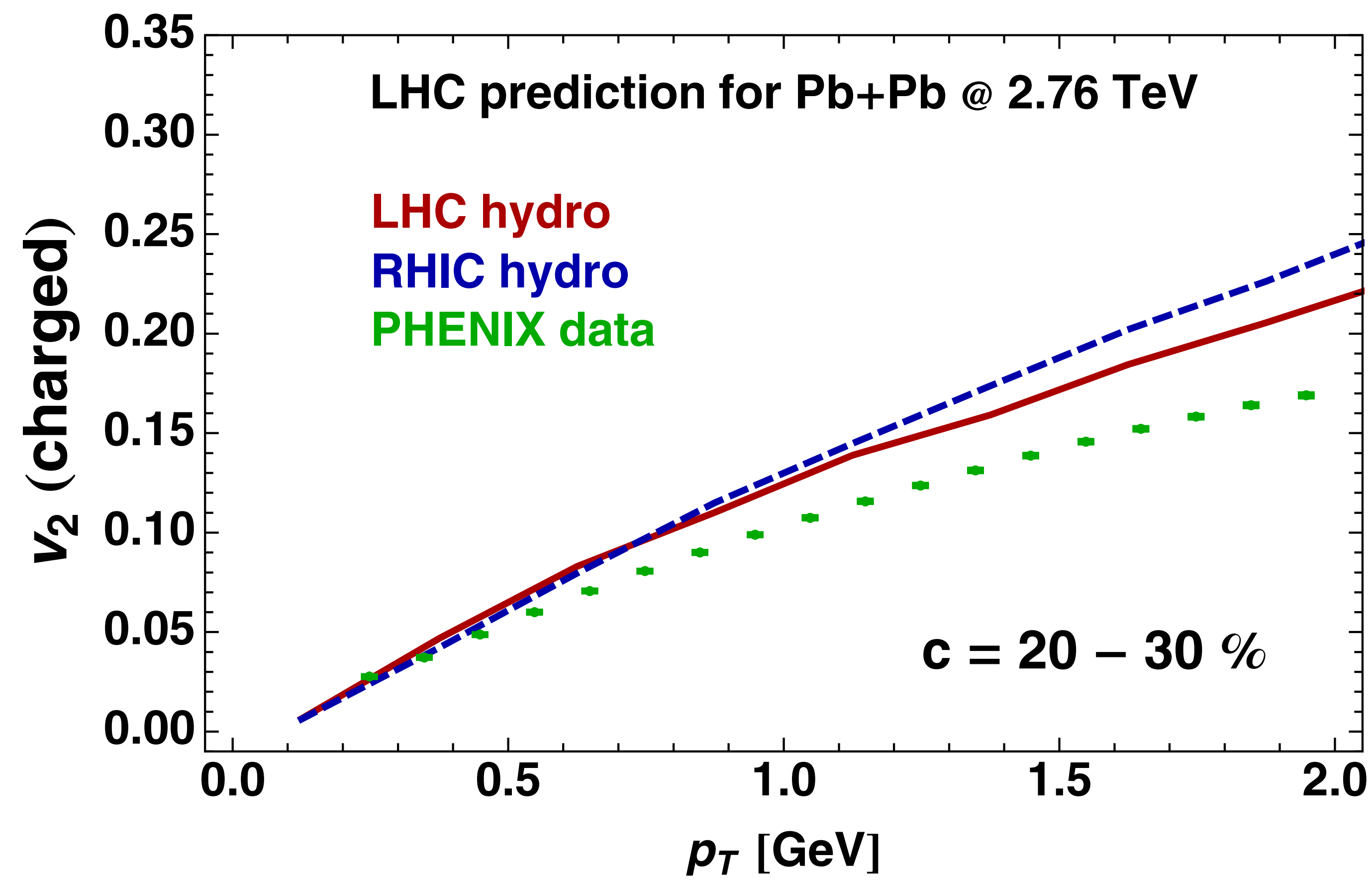


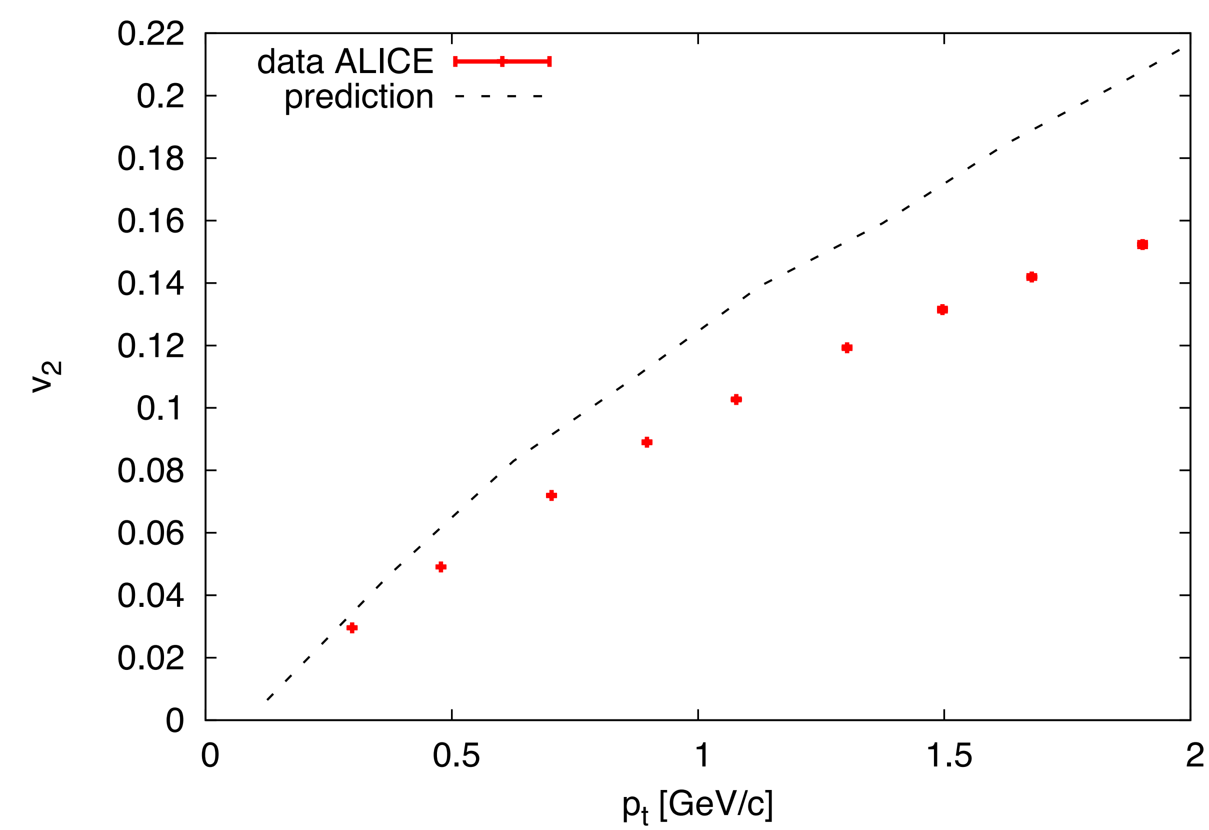
Results: the elliptic flow

hydro tuned to multiplicity overshoots v_2

needs reduction due to viscosity (here perfect fluid)

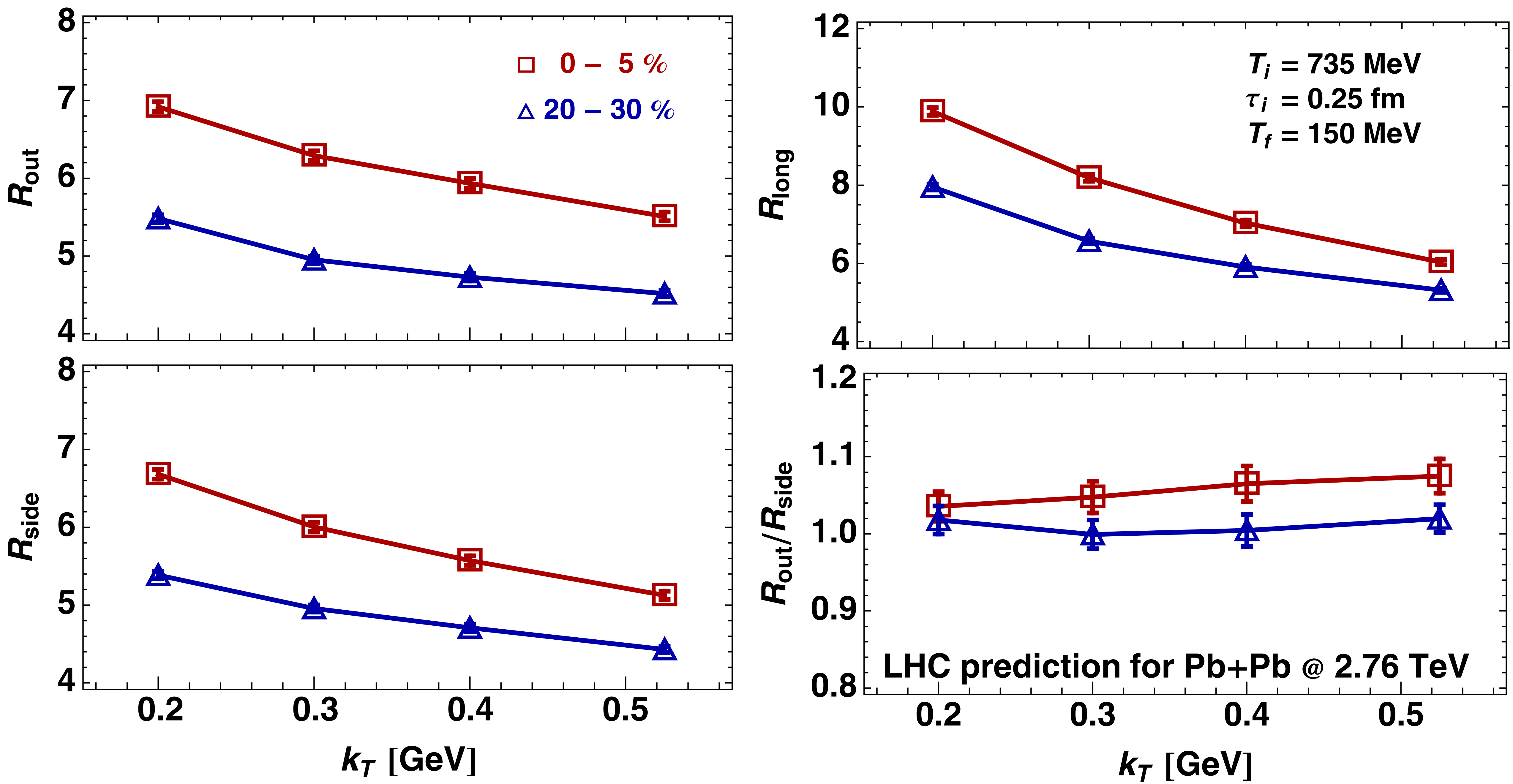
LHC calculation gives less elliptic flow than RHIC because of long lifetime





Results: femtoscopy radii

$$C(\vec{q},\vec{K}) - 1 = \exp\left(-q_s^2 R_s^2 - q_o^2 R_o^2 - q_l^2 R_l^2\right)$$



Conclusions

- calculated multiplicity overshoots data ⇒ smaller contribution of binary collision scaling
- elliptic flow data comparable to RHIC - contrary to prediction ⇒ very fast break up of the fireball
- will be interesting to see the azimuthally sensitive correlation radii