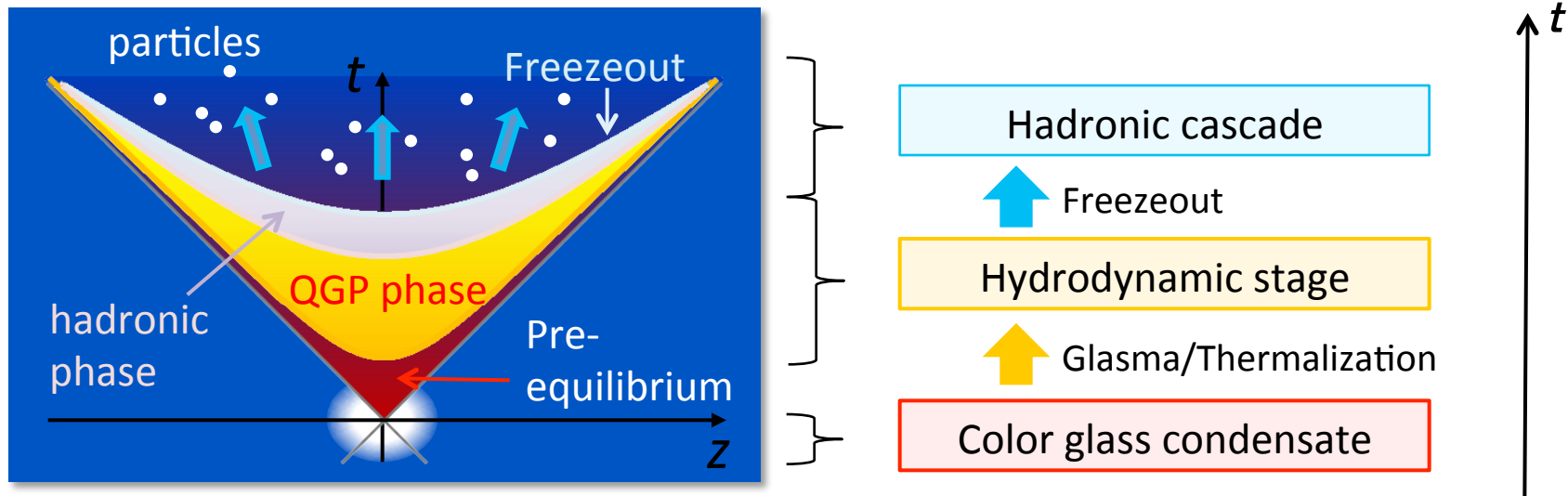# 重イオン衝突における粘性流体描像

門内 晶彦 （東大理）

第19回Heavy Ion Café並びに第12回Heavy Ion Pub合同研究会
「QCD物質の最前線」、2011年6月8日、名古屋大学

Introduction

■ "Standard model" of a high-energy heavy ion collision (at RHIC)

▶ Relativistic hydrodynamics

Description of collective motion of the QGP (τ ~ 1-10 fm/c)

⇨ *Discuss the latest experimental data at LHC and RHIC from the perspectives of* *viscous fluids*
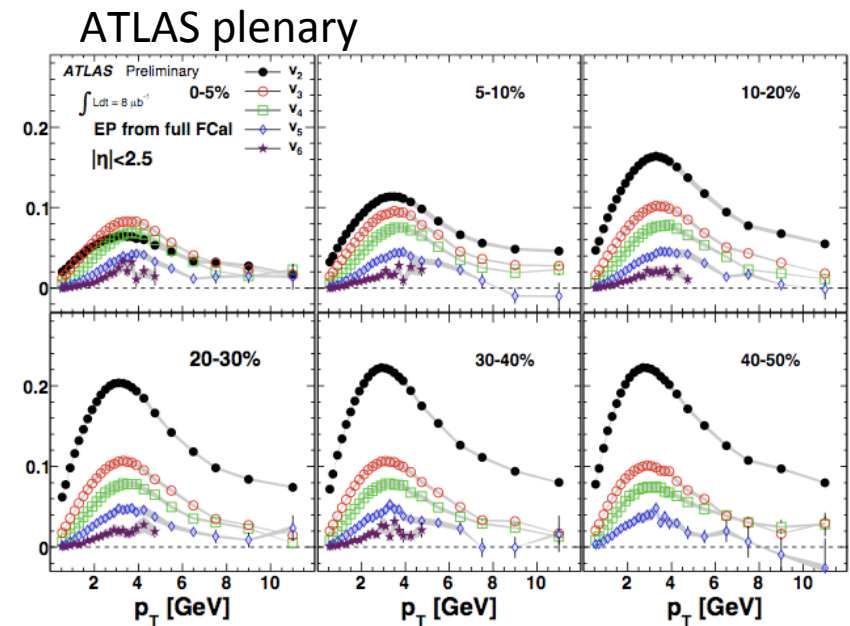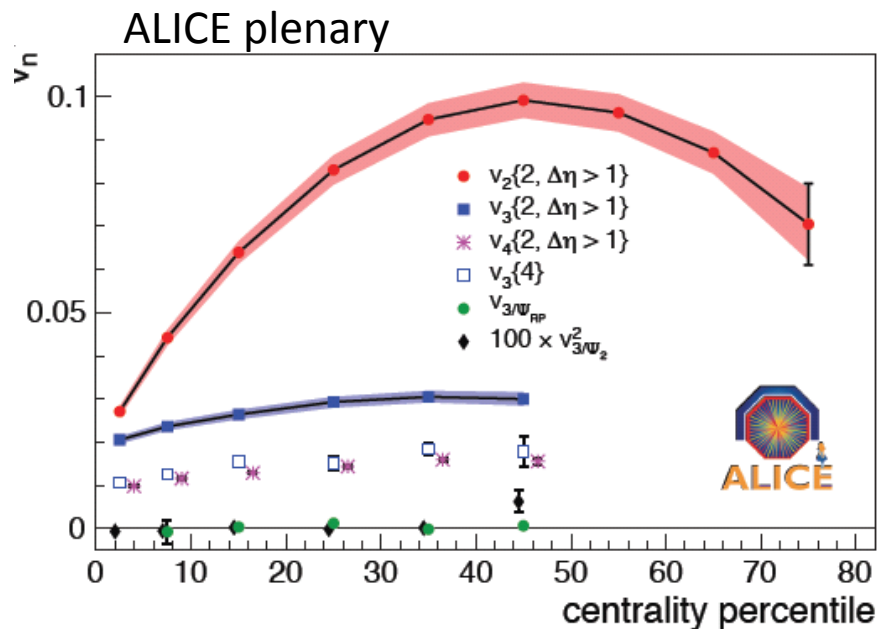
New Developments

- Higher-order harmonics (v_3, v_4, v_5…)
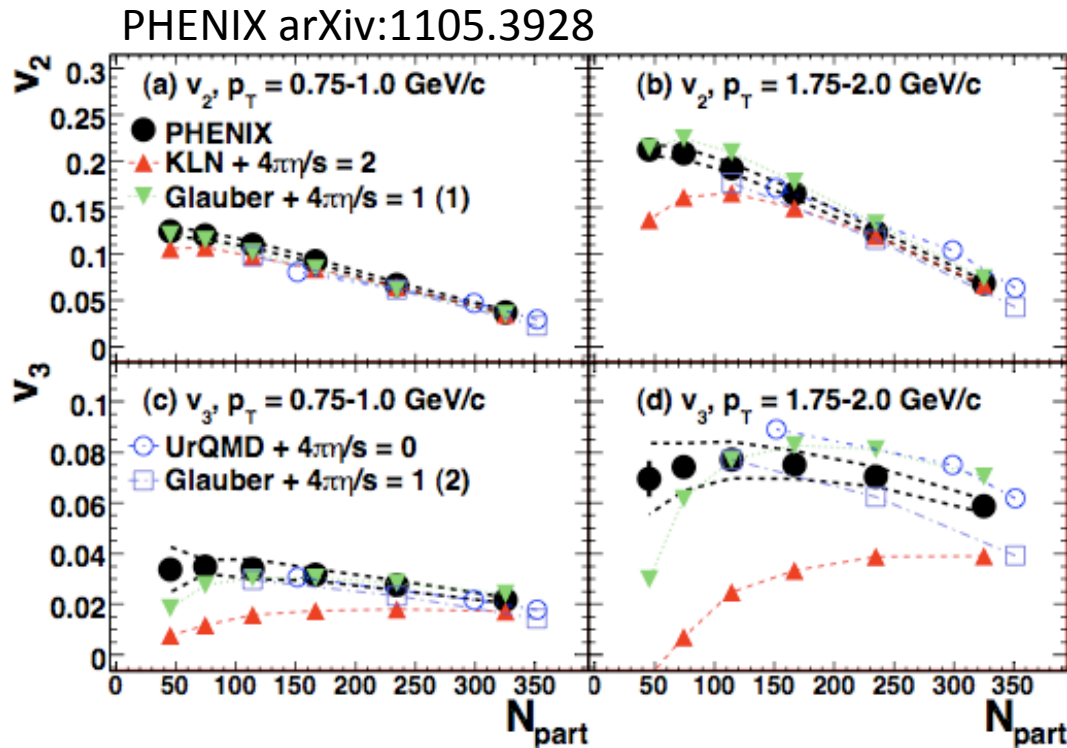
  - Quantified in hydrodynamic models

    More observables = more constraints on models

  - Product of initial fluctuations

Higher-Order Harmonics

■ Initial conditions: Glauber (η/s = 1/4π) vs. MC-KLN (η/s = 2/4π)

PHENIX arXiv:1105.3928

▶ v_3 in favor of Glauber?

▶ This does *not* rule out the KLN

- η/s would not be indep. of temperature

- Bumpy initial conditions may mimic viscosity

- Thermalization (CGC⇔hydro)

*CGC w/o resonance decay and multiplied by factors obtained in Glauber

Higher-Order Harmonics

- Shear viscosity: Glauber ($\eta/s = 0$) vs. Glauber ($\eta/s = 1/4\pi$)

ALICE (Talk by J. Schukraft)

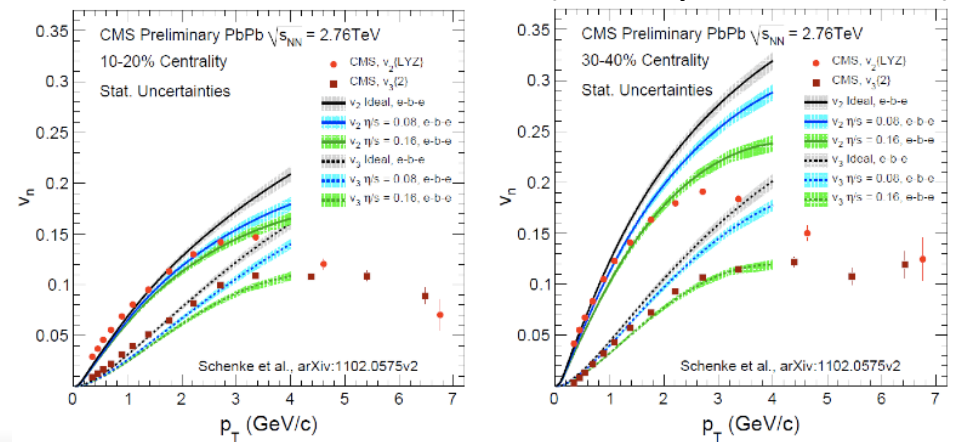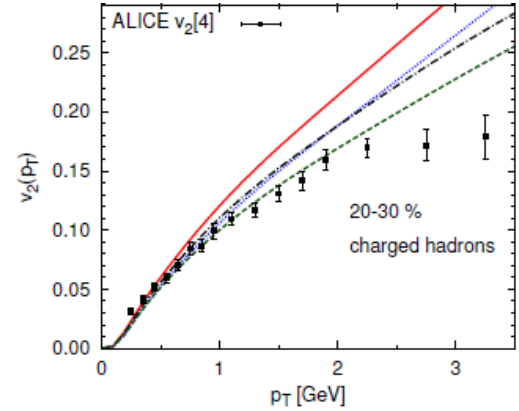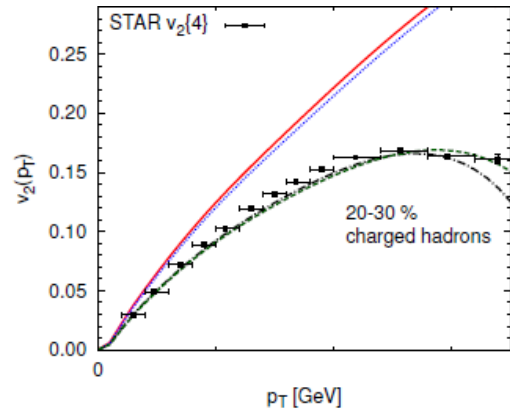v_3 "has different sensitivity to η/s than v_2!"

➡ In other words, no complete data fit by a single η/s (at least for now)

CMS (Talk by J. Velkovska)

▶ Bulk viscosity $\zeta/s \neq 0$ around T_c ; can become non-negligible

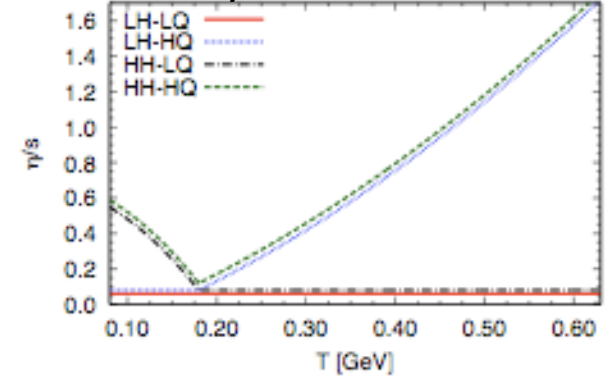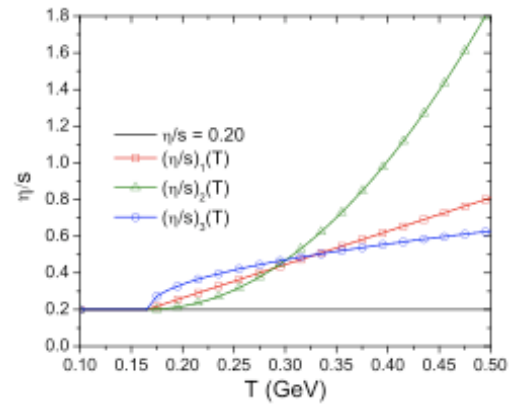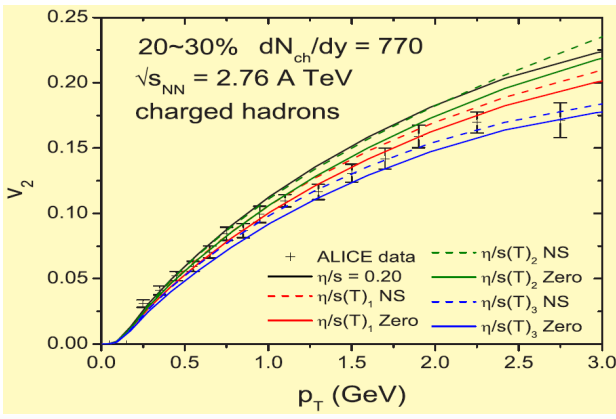# Higher-Order Harmonics

■ Temperature dependent η/s
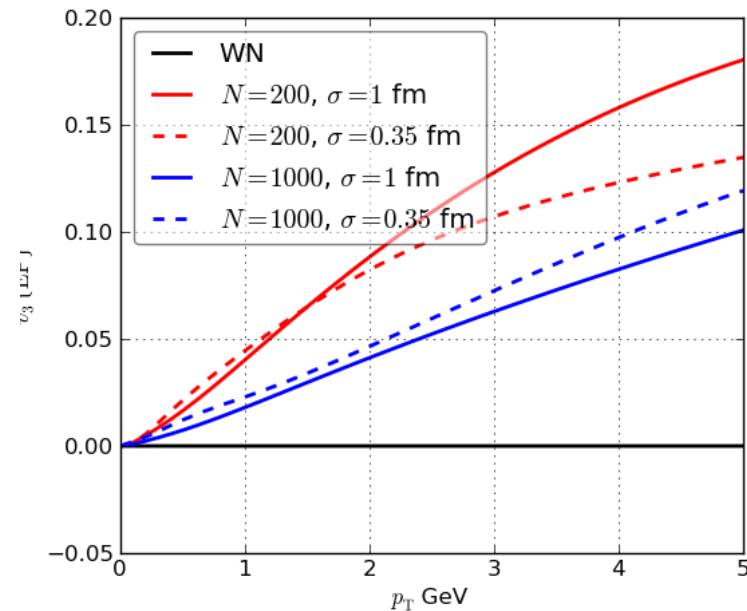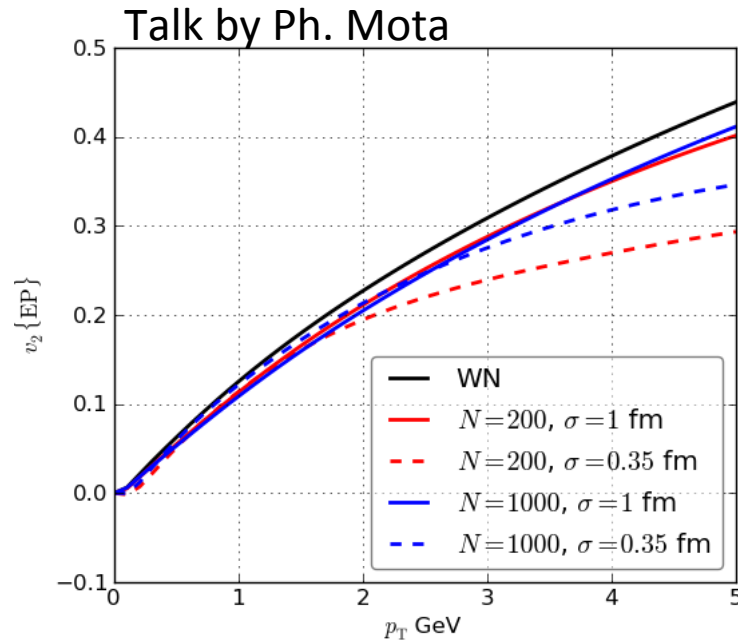
Talk by H. Niemi

➡ Hadronic viscosity always important; QGP viscosity more important at LHC than at RHIC?

Poster by C. Shen
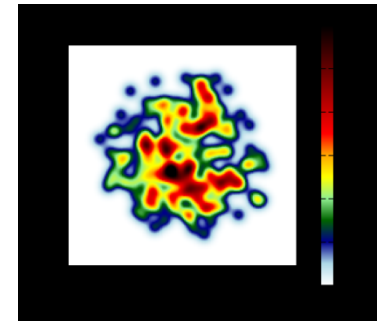
Higher-Order Harmonics

■ Flux tubes in initial conditions

Talk by Ph. Mota

⇨ v_n may depend on "bumpiness" of the initial geometry which mimics viscosity
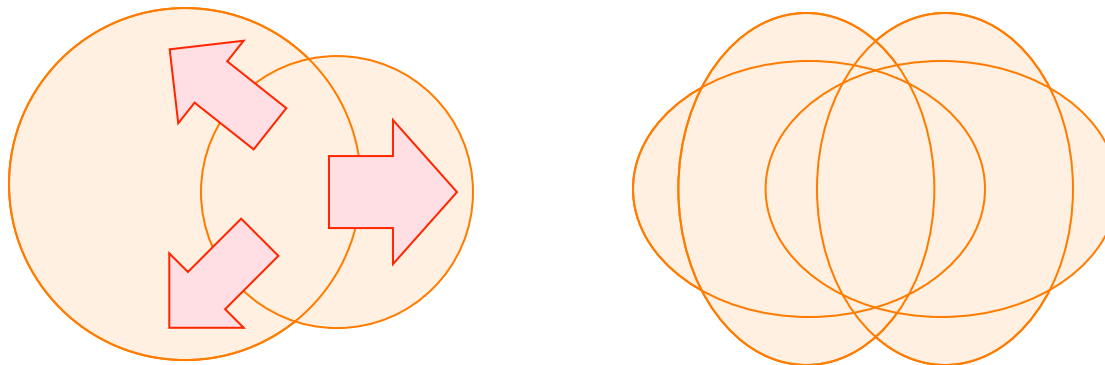
Higher-Order Harmonics

- **More observables translate into more constraints**

  - Higher order harmonics in Au-Au and Pb-Pb collisions

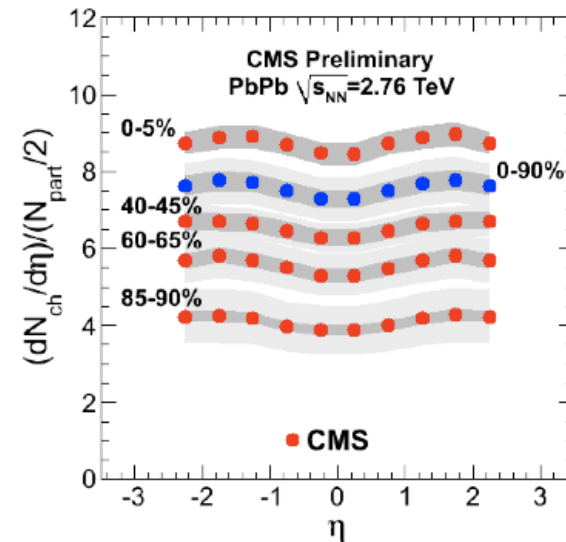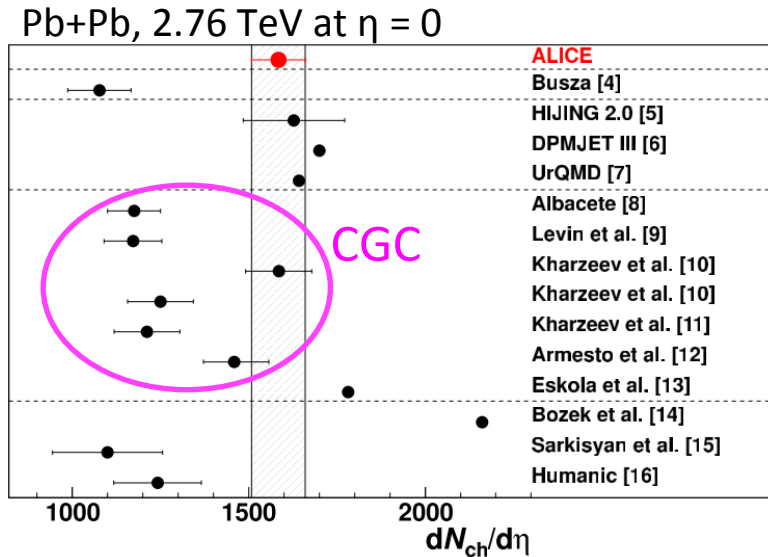   Product of fluctuation in initial conditions; centrality independent

  Possible "other" observables

  - U-U collisions at RHIC for clearer intrinsic v_4?

  - Intrinsic odd-order harmonics (v_3, v_5...) in asymmetric collisions (e.g. Cu-Pb) ?   Clear centrality dependences may be observed
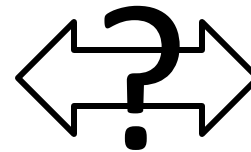
Towards Integrated Pictures

■ Not only transverse; Longitudinal dynamics

Pb+Pb, 2.76 TeV at η = 0

Charged particle multiplicity (0-5%)

ALICE: $dN_{ch}/d\eta$ = 1584 ± 4 ± 76

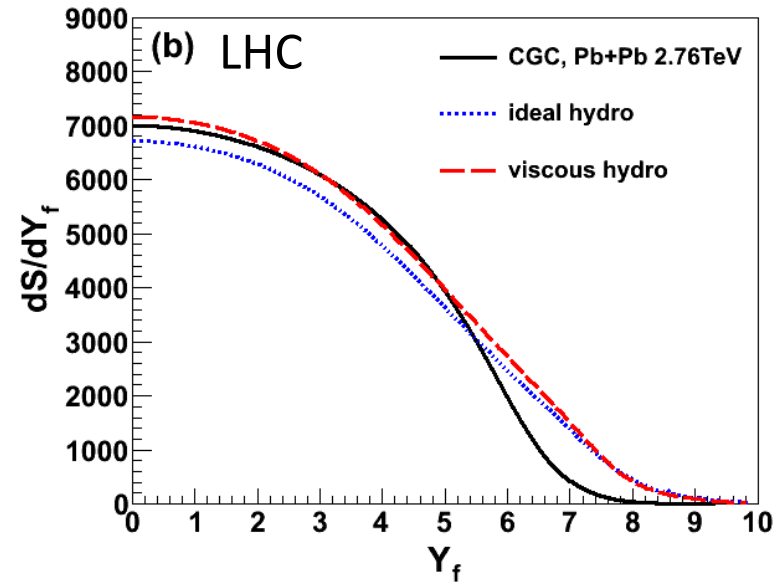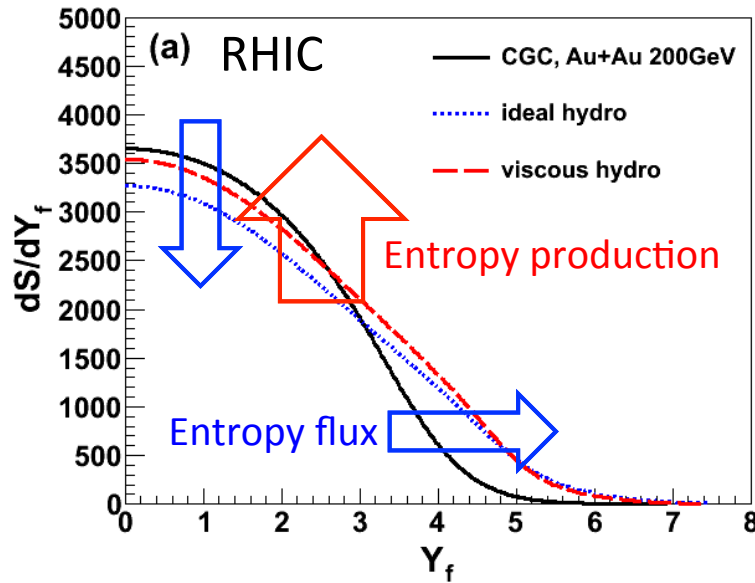CMS: $dN_{ch}/d\eta$ = 1610 ± 55

CGC predictions

$dN_{ch}/d\eta$ ~ 1200

Towards Integrated Pictures

AM and T. Hirano, arXiv:1102.5053

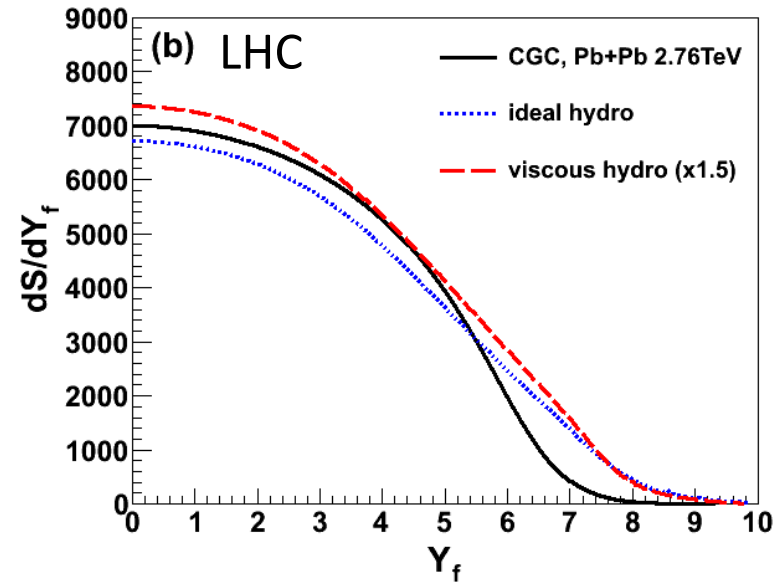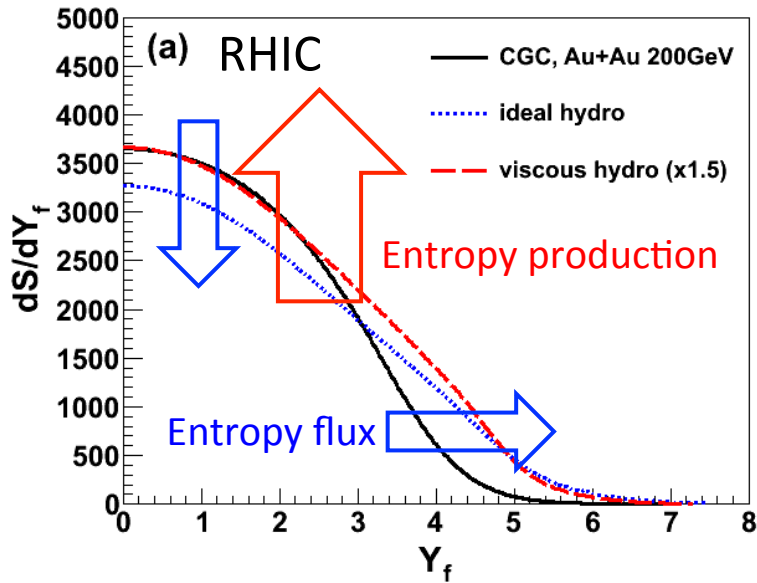■ CGC rapidity distribution + Full 2nd order viscous hydro

If the true λ is larger at RHIC, it enhances dN/dy at LHC;
Hydro effect is an important factor in explaining the LHC data

▶ Currently (1+1)D; (3+1)D viscous hydro under development

Towards Integrated Pictures

AM and T. Hirano, arXiv:1102.5053

■ CGC rapidity distribution + Full 2nd order viscous hydro

If the λ is unchanged at RHIC, dN/dy is still enhanced at LHC;
Hydro effect is an important factor in explaining the LHC data

▶ Currently (1+1)D; (3+1)D viscous hydro under development