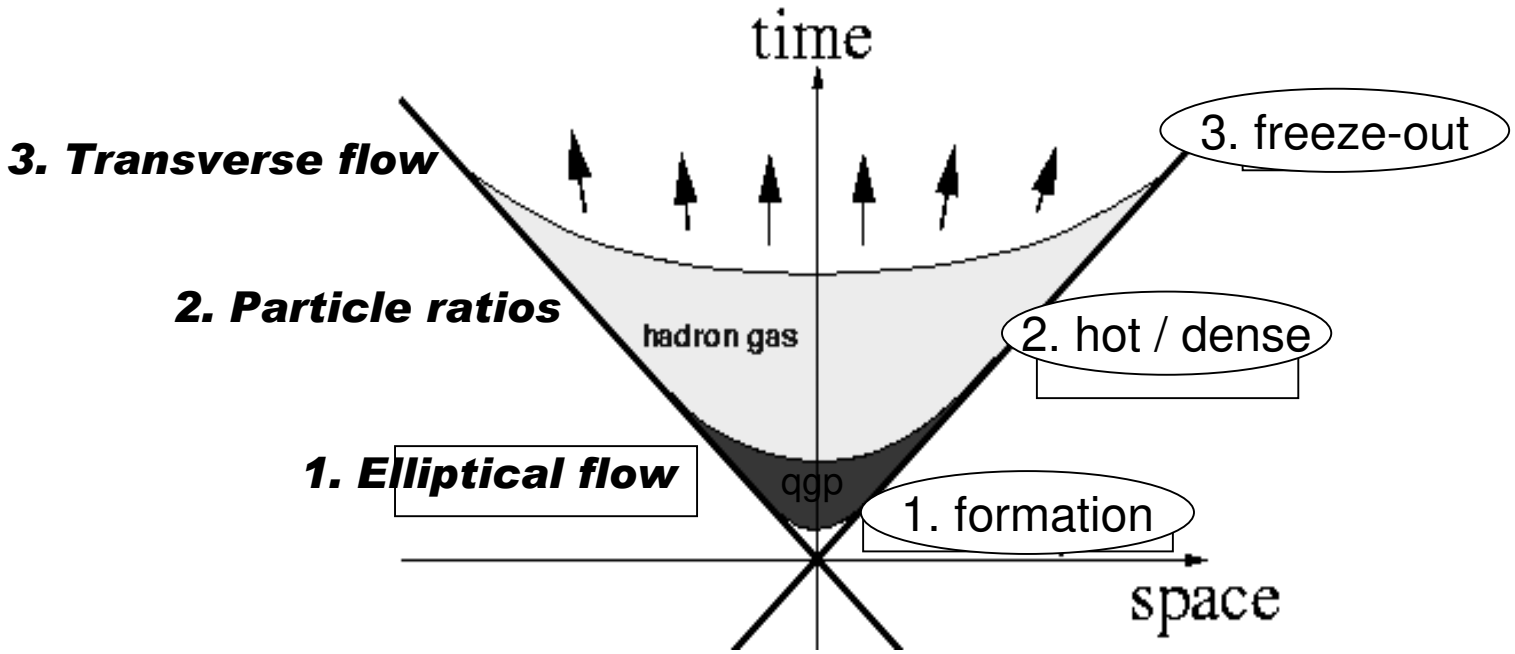
Study of Bulk Phenomena at RHIC

❶ Introduction

❷ Selected results

❸ Summary



Introduction

P.C. Sereno *et al*. **Science**, Nov. 13, 1298(1998).

(Spinosaurid)

Bulk properties $\Rightarrow$ Low momentum

(mid-rapidity, p_t < 1.0 GeV/c)

Topics

1) **Physics:**
   - initial conditions: early thermalization
     net-baryon distribution
   - freeze-out conditions: chemical and kinetic

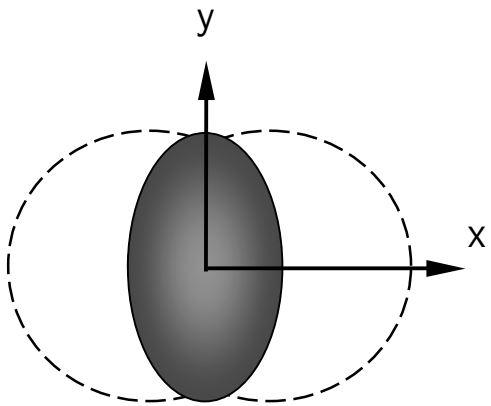
2) **Data analysis:**
   - *event anisotropy* v_2
   - *anti-proton over proton ratios*
   - *proton, anti-proton, and* ϕ *meson distributions*
   - anti-deuteron distributions
   - mid-rapidity kaon ratios

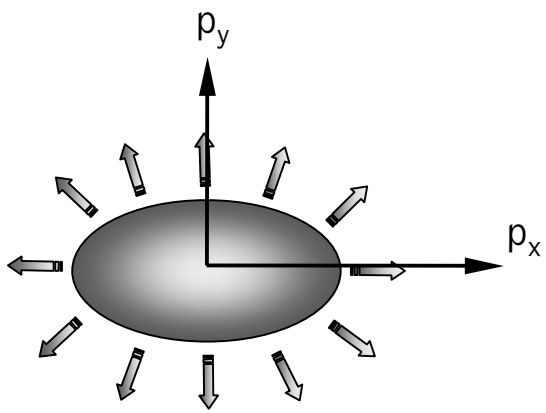
3) **Work together with universities**
   - Carnegie Mellon University,
   - Purdue University,
   - Wayne State University
   - Kent State University
   - UCLA

Event Anisotropy v_2

A. Poskanzer, *R. Snellings*, A. Tang*, S. Voloshin* – work in progress

Elliptical flow v_2 : coordinate-space-anisotropy ⇔ momentum-space-anisotropy
Sensitive to initial/freeze-out conditions and equation of state (EOS)!



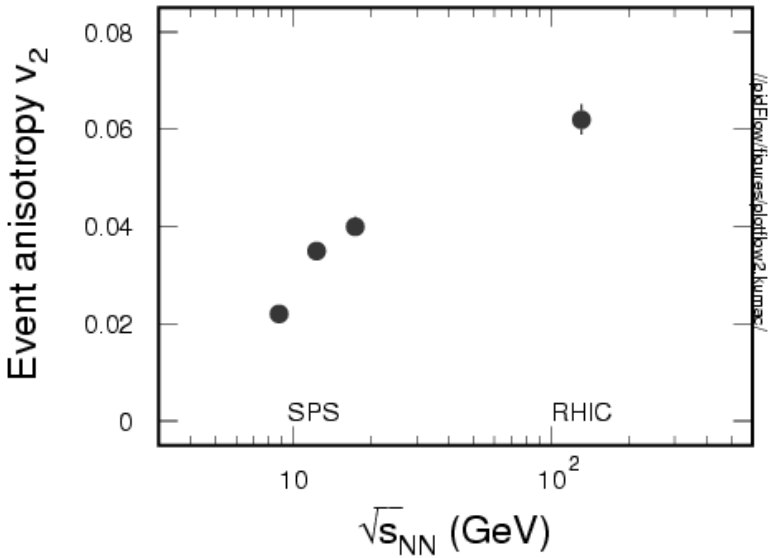


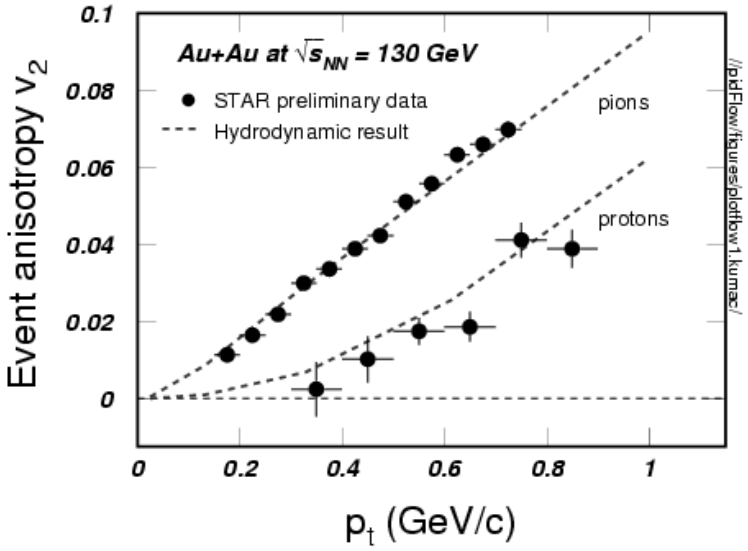
$$\varepsilon = \frac{\langle y^2 - x^2 \rangle}{\langle y^2 + x^2 \rangle}$$

$$v_2 = \langle \cos 2\varphi \rangle, \quad \varphi = \tan^{-1}\left(\frac{p_y}{p_x}\right)$$

Event Anisotropy v_2

A. Poskanzer, *R. Snellings*, A. Tang*, S. Voloshin* – work in progress





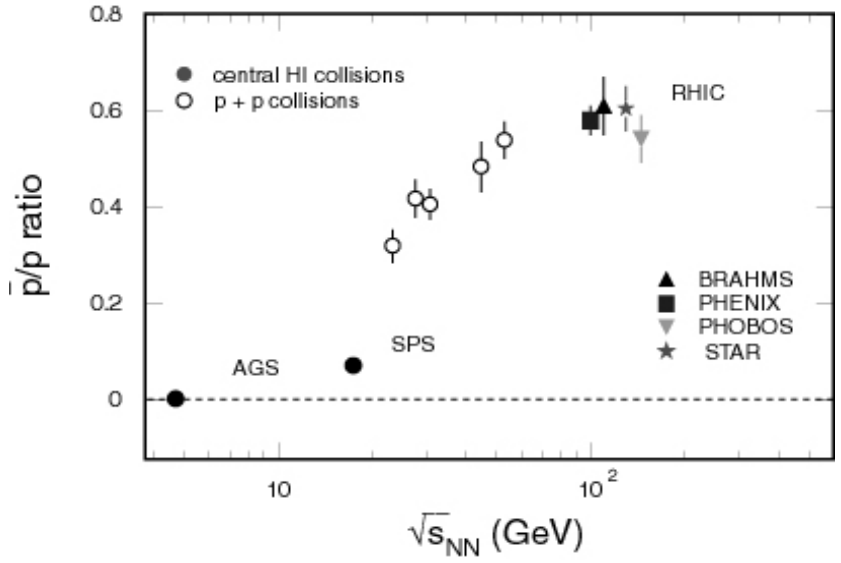
1) Elliptical flow v_2 increases with collision energy – early thermalization?

2) Mass dependence – typical hydrodynamic behavior !

* Kent State University / Wayne State University

Mid-rapidity $\bar{p}/p$ ratios in Au+Au collisions

C. Adler *et al.* (STAR Collaboration), Phys. Rev. Lett., in print, (2001)



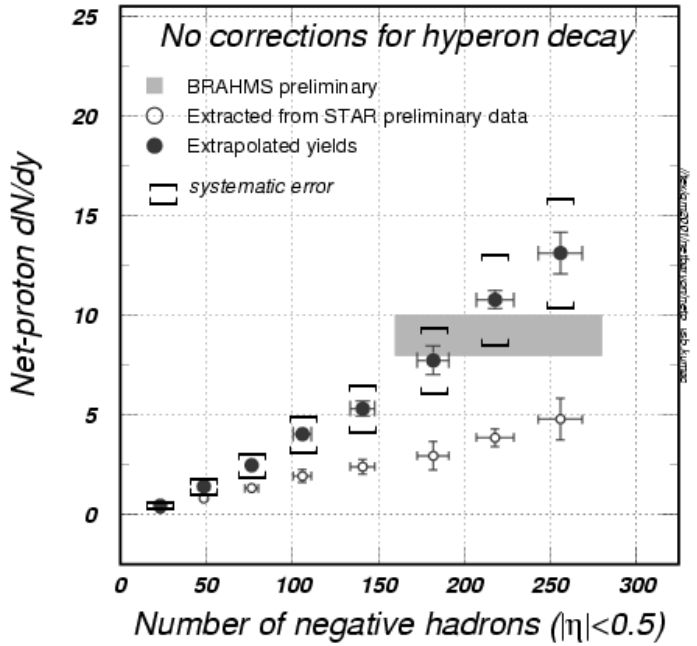
1) $\bar{p}/p$ ratio ~ 0.65 $\pm$ 0.01 $\pm$ 0.07. Approaching net-baryon free at RHIC !

2) Net-baryon/meson $\Rightarrow$ 0, close to the condition at early universe !

3) Baryons transferred from beam rapidity to mid-rapidity (Δy ~ 6) !

p, $\bar{p}$ production in Au+Au collisions

O.Barnnikova*, *M. Kaneta*, *K. Schweda*, F. Wang*, and N. Xu – work in progress

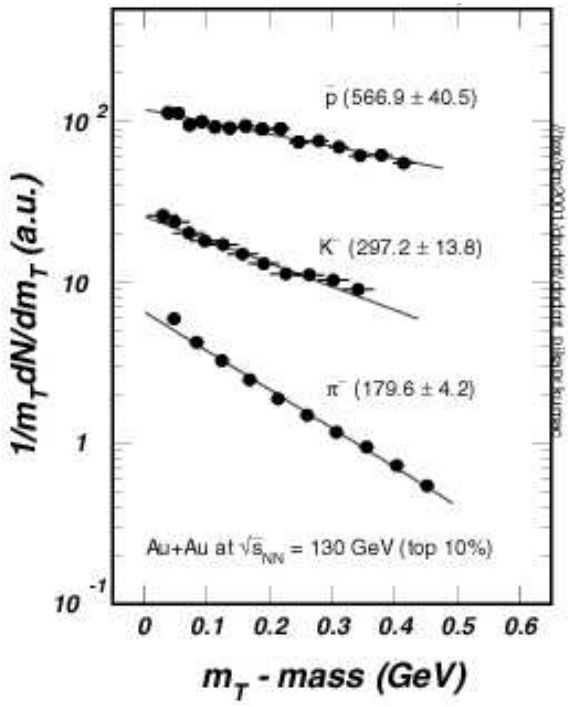


1) Net-proton increase with centrality ⇒ more baryon transferred !

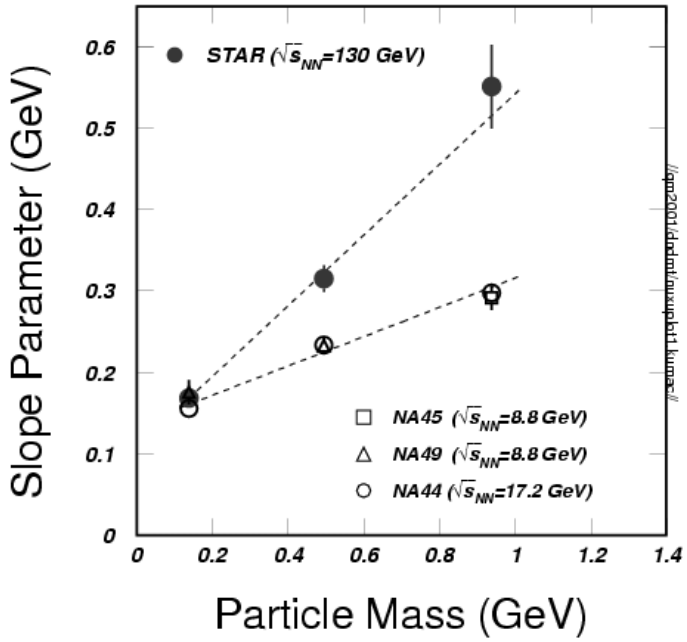
2) Slope parameters increase with centrality ⇒ stronger collective flow!

* Purdue University

Transverse mass distributions



$$T = T_{fo} + mass * \beta_r^2$$

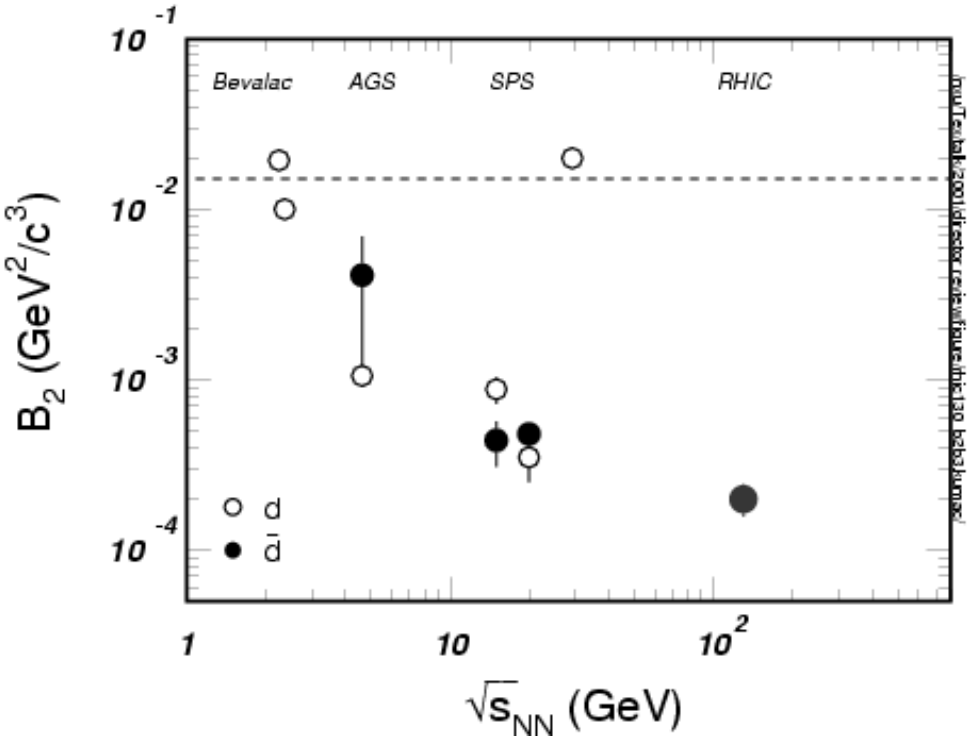


1) Slope parameters depend on particle mass – Hydrodynamic flow!

2) β_r (RHIC) > β_r (SPS/AGS) – More explosive expansion at this RHIC energy!

Light anti-nuclei measurement

H. Crawford, *D. Hardtke* – work in progress



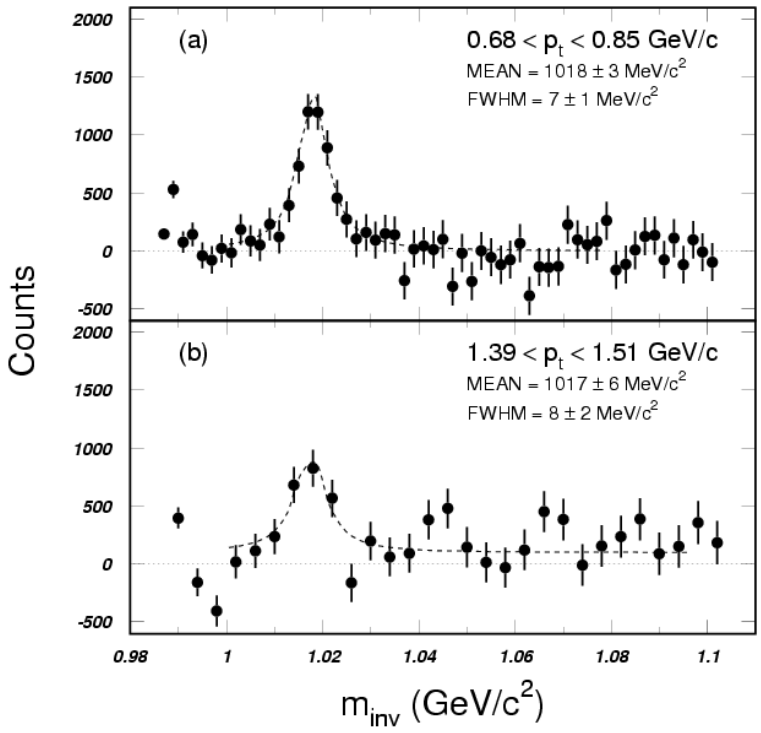
1) Coalescence: $B_2 \sim 1/V \Rightarrow$ V(RHIC) > V(SPS)

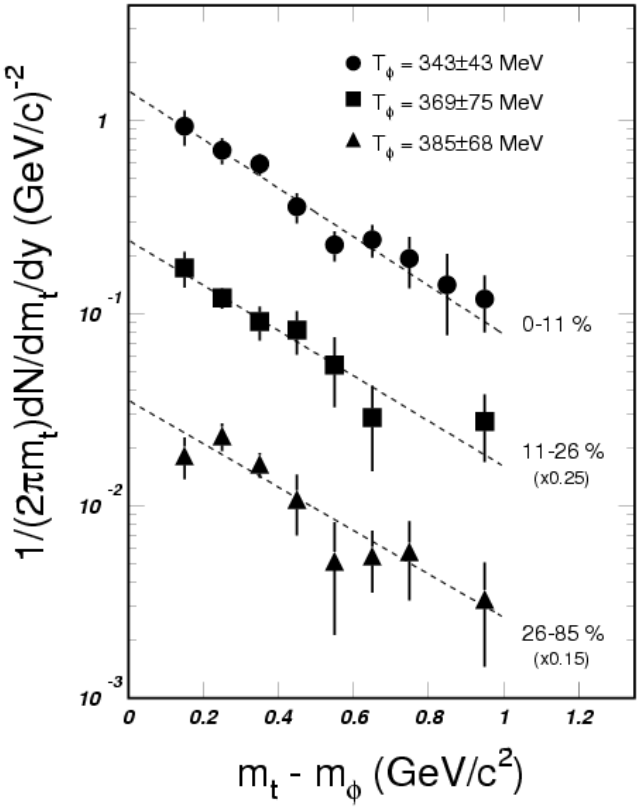
2) More expansion at high energy!

ϕ production in Au+Au collisions

H. Huang#, F. Laue#, N. Xu, Z. Xu#, and *E. Yamamoto#* – work in progress

$$\phi(1019) \rightarrow K^+ + K^-$$





ϕ production in Au+Au collisions

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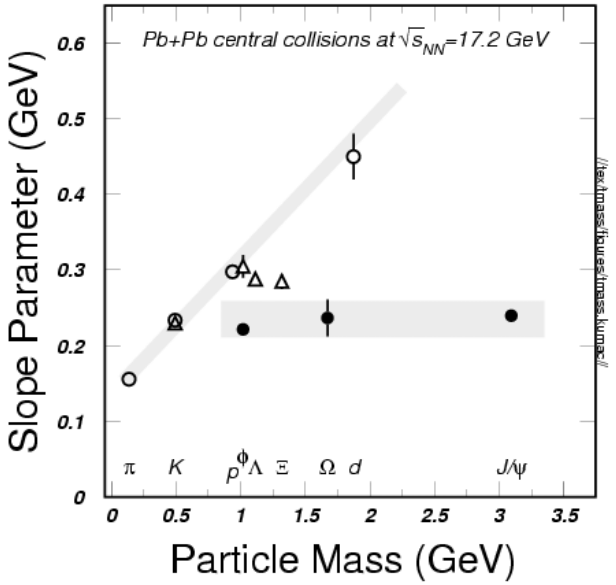
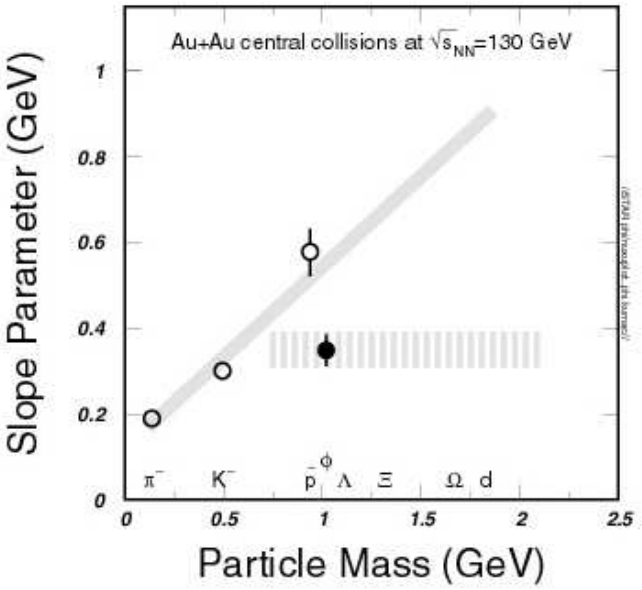


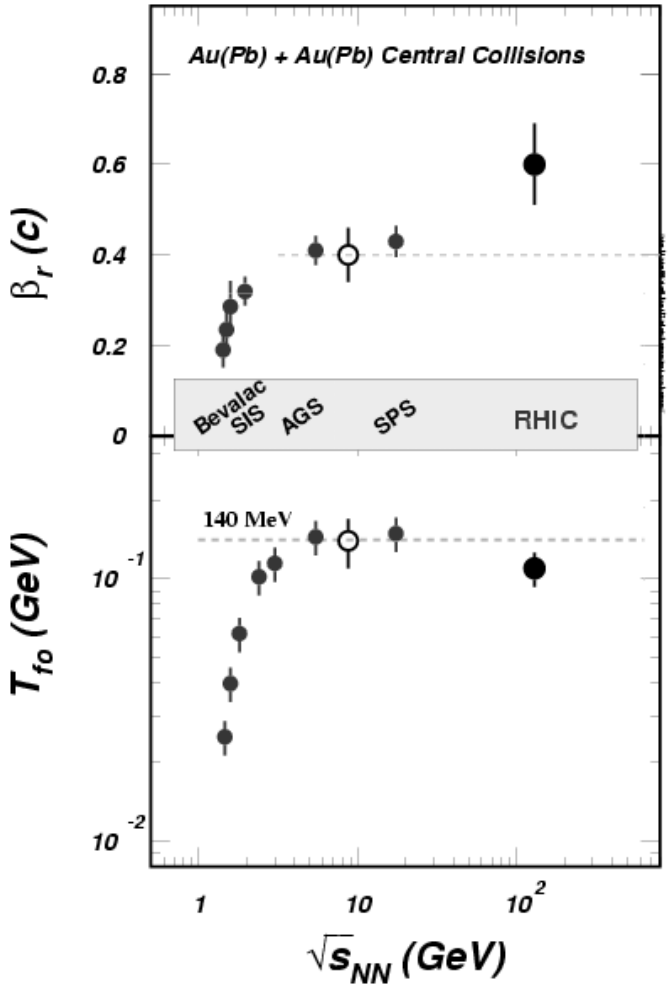


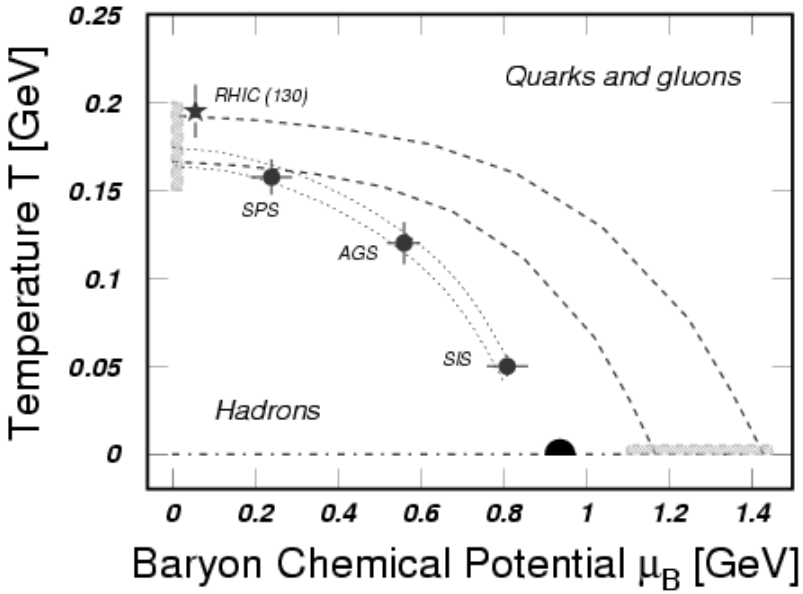
1) Slope parameter of ϕ meson is less than protons'

2) ϕ, weakly interacting particles like (Ω, J/ψ) freeze-out earlier?

UCLA / BNL / Yale

Summary: *What We Have Learned*





1) Smaller baryon chemical potential
μ_B = 45 MeV with T_{ch} = 200 MeV
$\Rightarrow$ ***Approaching net-baryon free !***

2) Stranger transverse flow, β_t = 0.6(c)
$\Rightarrow$ ***More explosive expansion !***

Outlook

- Publish v_2 as a function of particle mass;
- Publish proton and anti-proton distributions;
- Publish anti-deuteron results;
- Publish ϕ results.

- Prepare for the analysis of collisions at 200 GeV
  1) Bulk properties: pion,kaon, proton;
  2) ϕ, Ω, J/ψ low p_t phenomena – closer to hadronization

Discover the possible new phase with partonic degrees of freedom!