New pion HBT results from STAR

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STAR Collaboration

Outline

- Introduction and motivation
- 62 GeV AuAu
- 200 GeV CuCu
- Summary

Identical meson correlations

$$C(q_o, q_s, q_l) = 1 + \lambda \cdot e^{-\left(q_o^2 R_o^2 + q_s^2 R_s^2 + q_l^2 R_l^2\right)}$$

$$q = p_1 - p_2$$
$$k = (p_1 + p_2)/2$$

Decompose q into components:

q_{Long} : in beam direction

q_{Out} : in direction of transverse momentum K_T

q_{Side} : $\perp$ q_{Long} & q_{Out}

$$\tilde{x} \equiv x - \langle x \rangle$$
$$\langle f \rangle \equiv \frac{\int d^4x \cdot S(x,K) \cdot f(x)}{\int d^4x \cdot S(x,K)}$$

Radii are related to source variances:

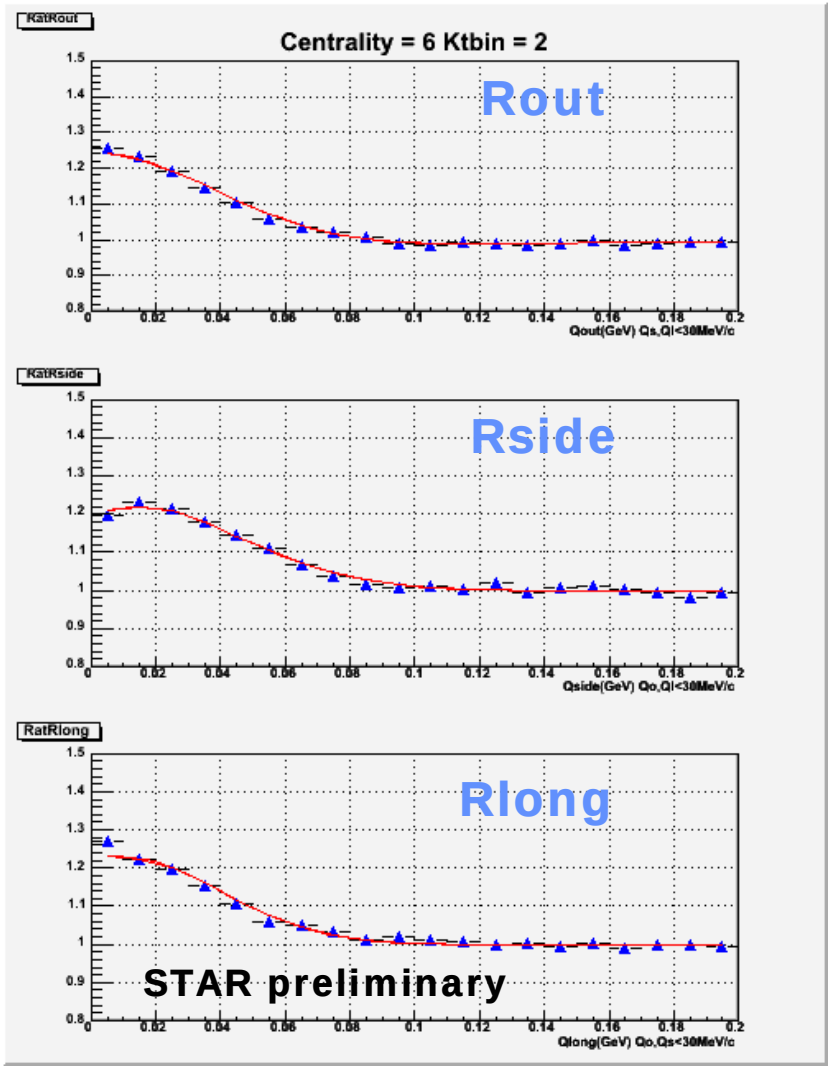
$$R_o^2(\vec{K}) = \left\langle \left(\tilde{x}_{out} - \beta_\perp \tilde{t}\right)^2 \right\rangle (\vec{K})$$ **Sensitive to emission time**

$$R_s^2(\vec{K}) = \left\langle \tilde{x}_{side}^{\,2} \right\rangle (\vec{K})$$ **Sensitive to transverse extent**

$$R_l^2(\vec{K}) = \left\langle \left(\tilde{x}_{long} - \beta_l \tilde{t}\right)^2 \right\rangle (\vec{K})$$ **Sensitive to longitudinal extent**

In Longitudinally Co-Moving System (LCMS) $\beta_l = 0$

CuCu 200 GeV Gaussian Fit

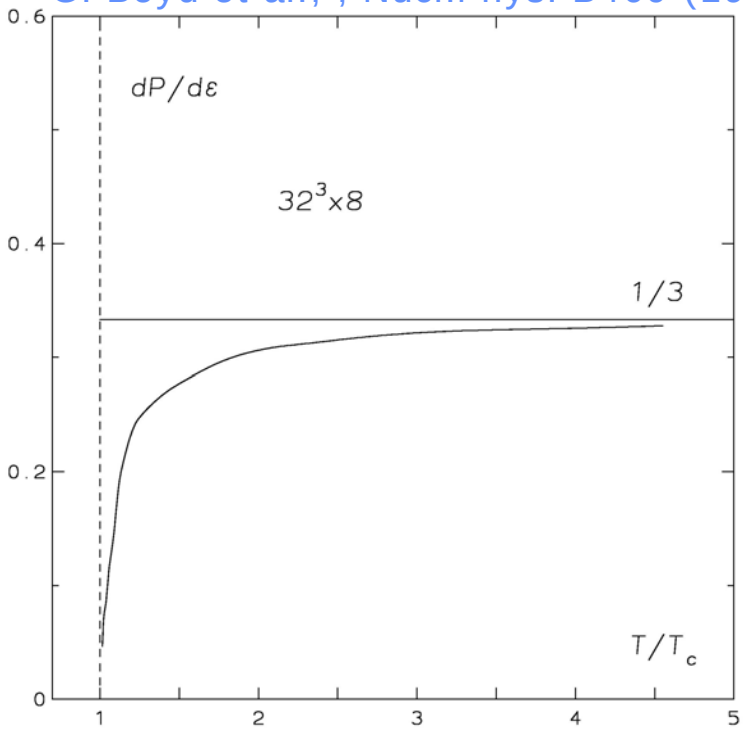


0-10% Centrality
Kt [0.25-0.35] GeV/c
30 MeV/c projections

Bowler-Sinykov Gaussian fit

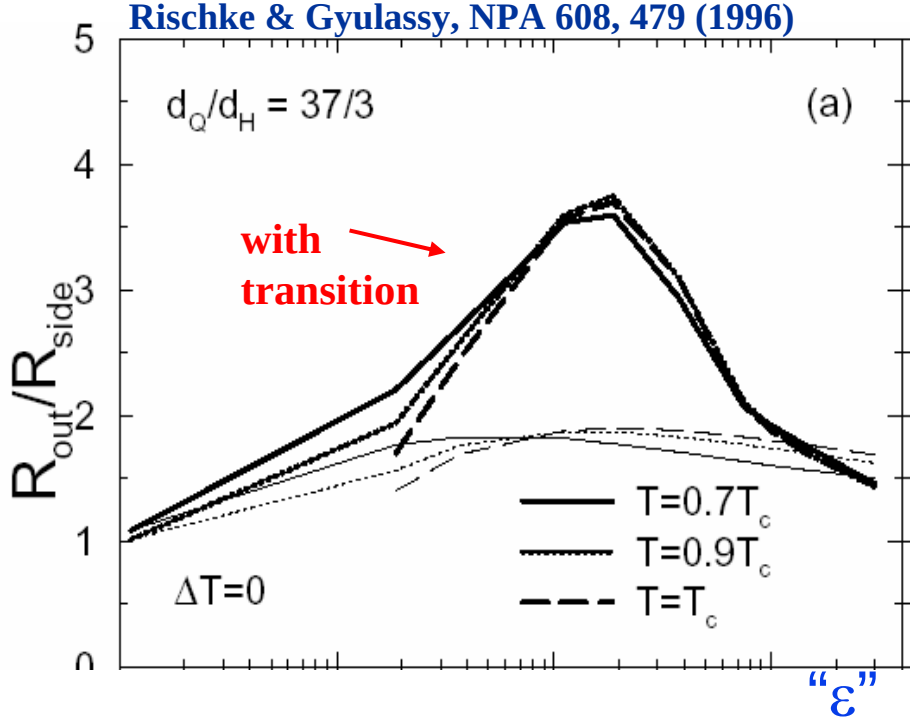
Femtoscopic signature of QGP

G. Boyd et al., , Nucl.Phys. B469 (1996) 419



3D 1-fluid Hydrodynamics

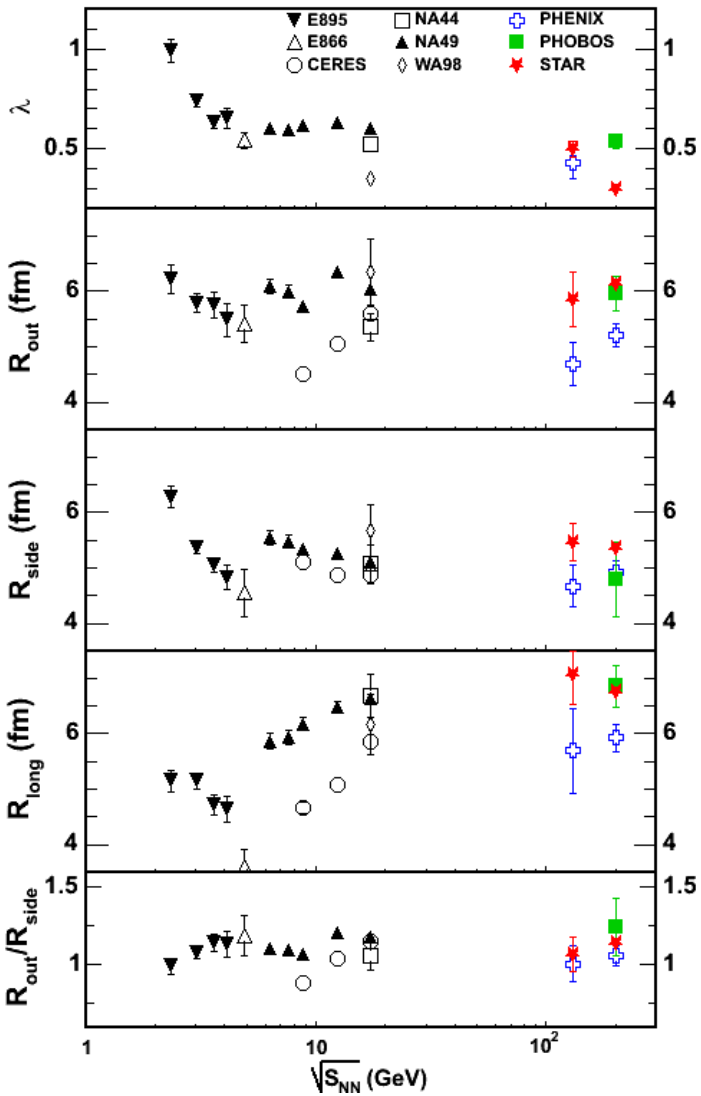
Rischke & Gyulassy, NPA 608, 479 (1996)



Long-standing favorite signature of QGP:

- **Lattice QCD -> Speed of sound goes to zero (pressure drop) at phase transition**
- **increase in τ, R_{OUT}/R_{SIDE} due to deconfinement $\leftrightarrow$ confinement transition**
- **hoped-for "turn on" as QGP threshold is reached ("softest point")**

Energy dependence of pion HBT



- AuAu (PbPb)
- Y ~ 0
- <Kt> ~ 170 MeV
- Central ~ 10 %

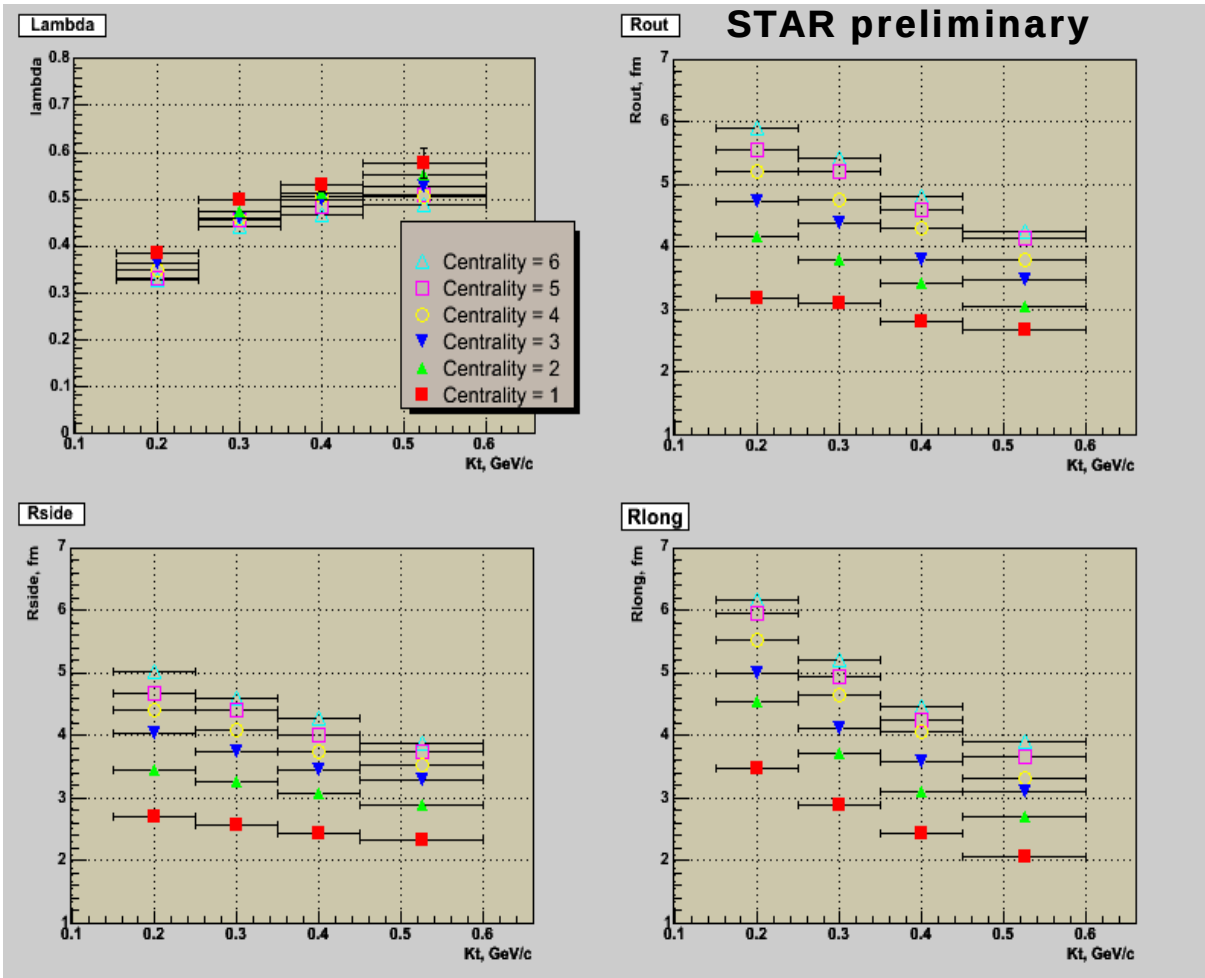
Smooth energy dependence

Where is the softest point ?

Lower energies?
Lighter systems?

Centrality dependence of the Kt dependence

AuAu at 62 GeV



Bin 6 - 0-5%
Bin 5 - 5-10%
Bin 4 - 10-20%
Bin 3 -20-30%
Bin2 - 30-50%
Bin 1 - 50-80%

Radii decrease for less central events
Radii decrease with Kt (consistent with flow)
Lambda parameter grows with Kt

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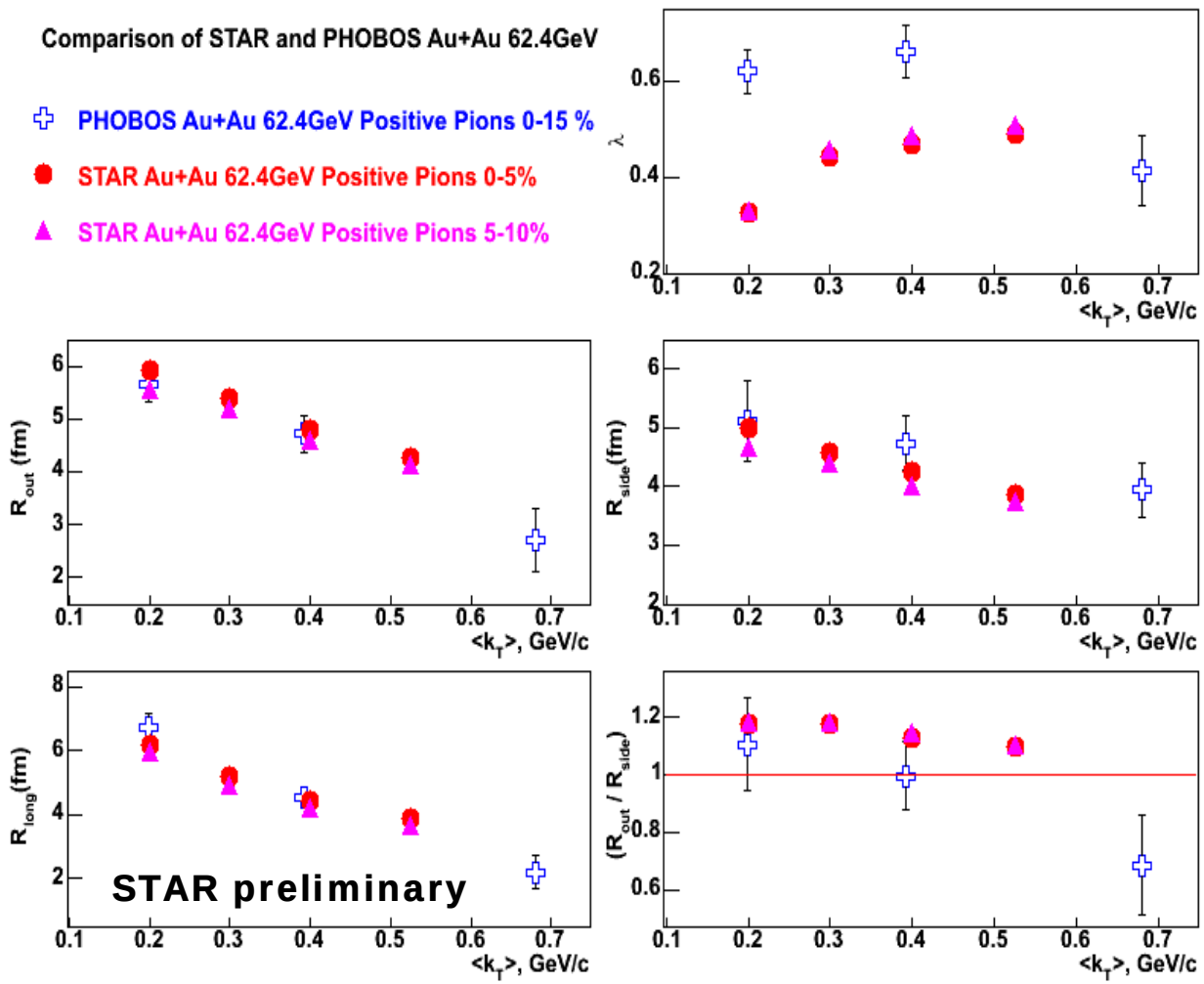
AuAu 62 GeV. Comparison to PHOBOS

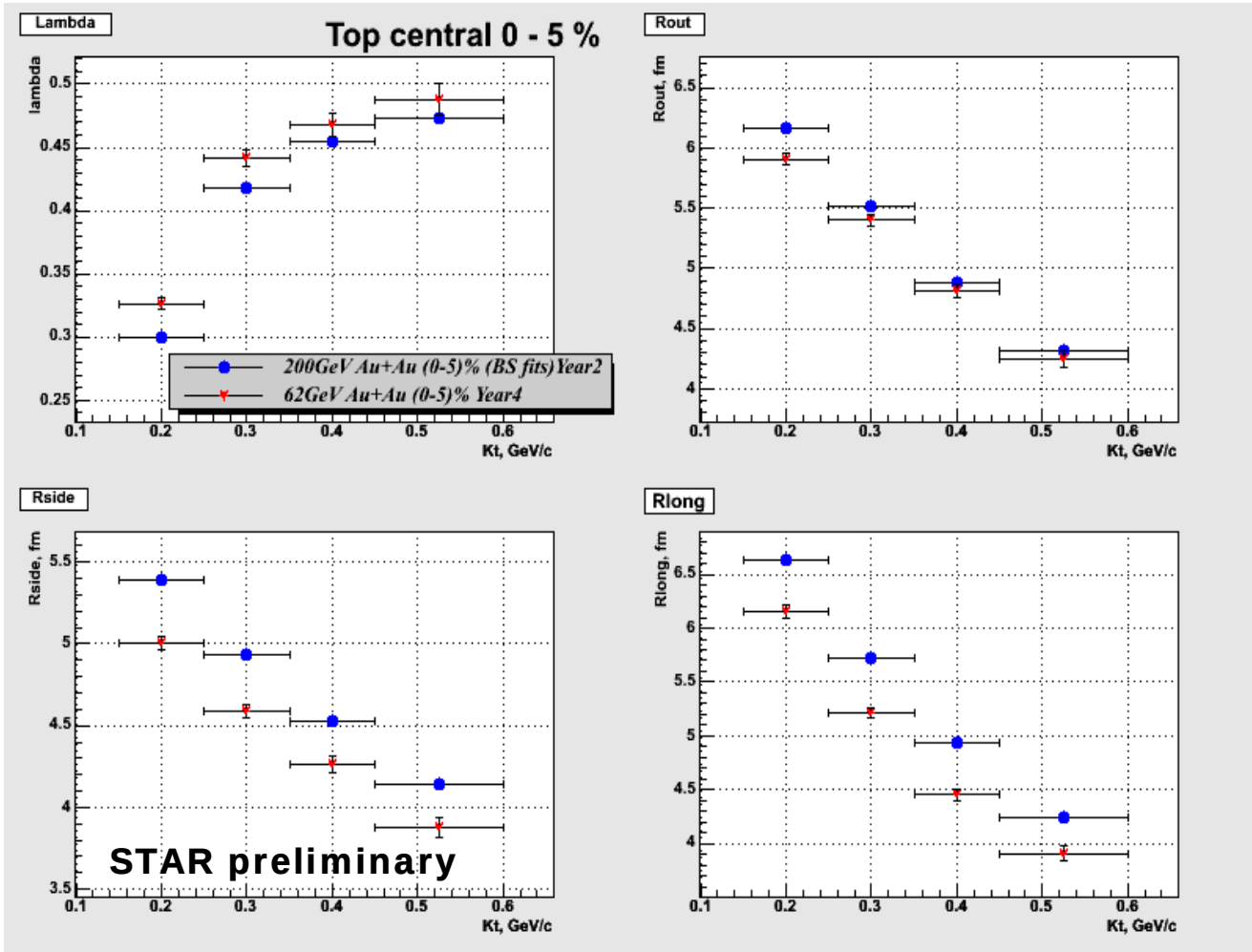


PHOBOS
<y>~0.9
0-15% Centrality

STAR
<y>~0
<10% Centralities

PHOBOS nucl-ex/0409001

Comparison between 62 and 200 GeV AuAu



200 GeV **published PRC 71 (2005)**
62 GeV **preliminary**

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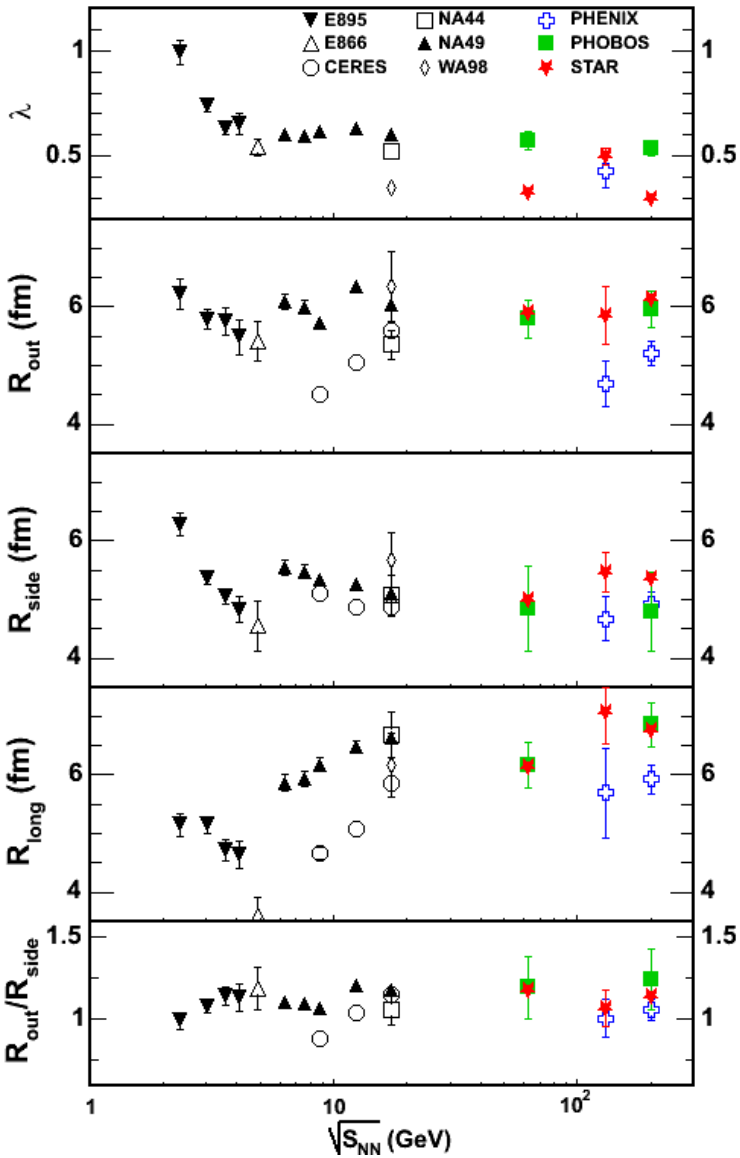
Energy dependence of pion HBT



Smooth dependence at RHIC energies

Some growth in Rlong – longer evolution

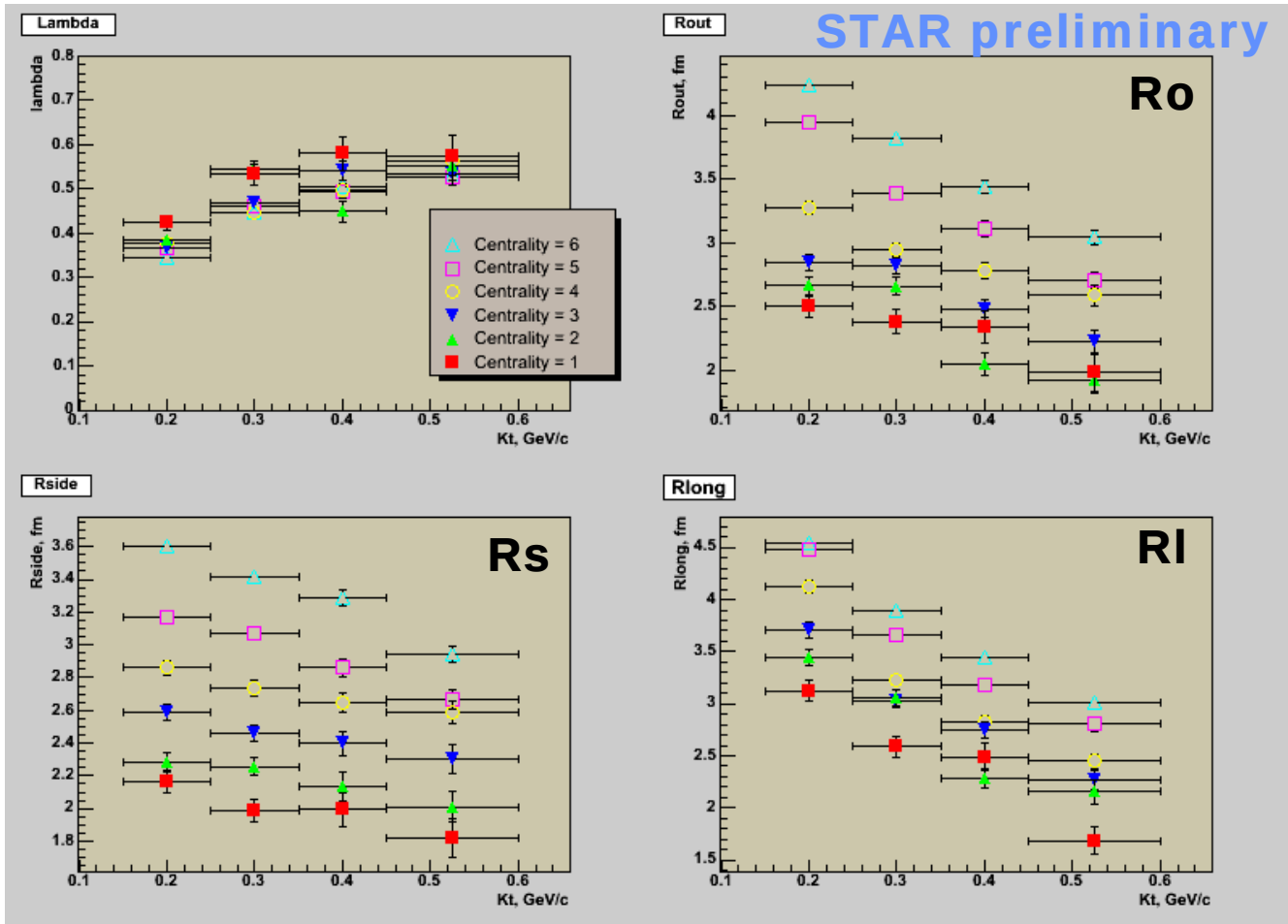
What does it tell us about order of phase transition ?

Is 1st order phase transition ruled out ?

Do we need to run at 40 GeV ?

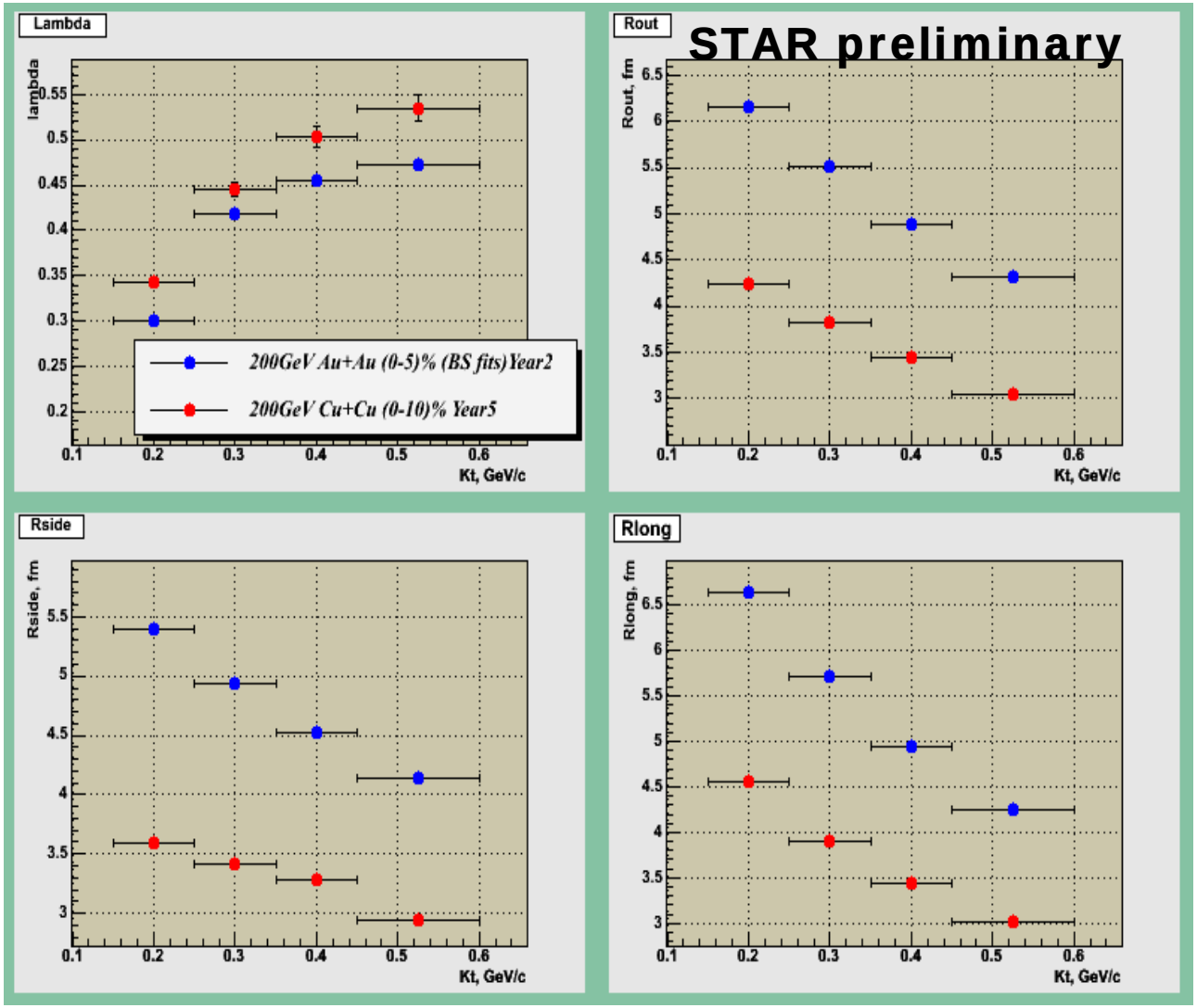
Centrality dependence of the Kt dependence

Cu+Cu @ 200 GeV, positive pions



Radii decrease for less central events
Radii decrease with Kt (consistent with flow)
Lambda parameter grows with Kt

Comparison to Au+Au at 200 GeV



Most central:

AuAu 0 - 5%

CuCu 0 – 10%

Sure, Cu is smaller than Au !

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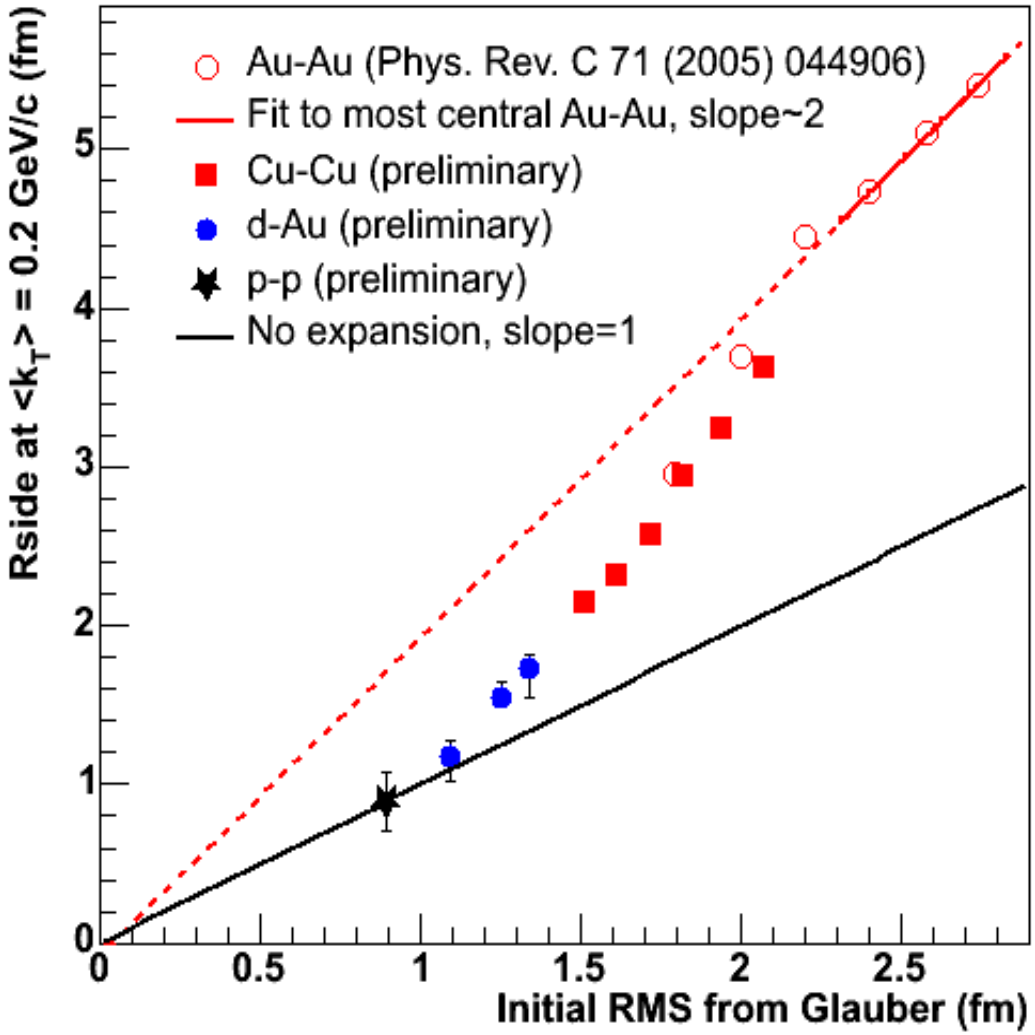
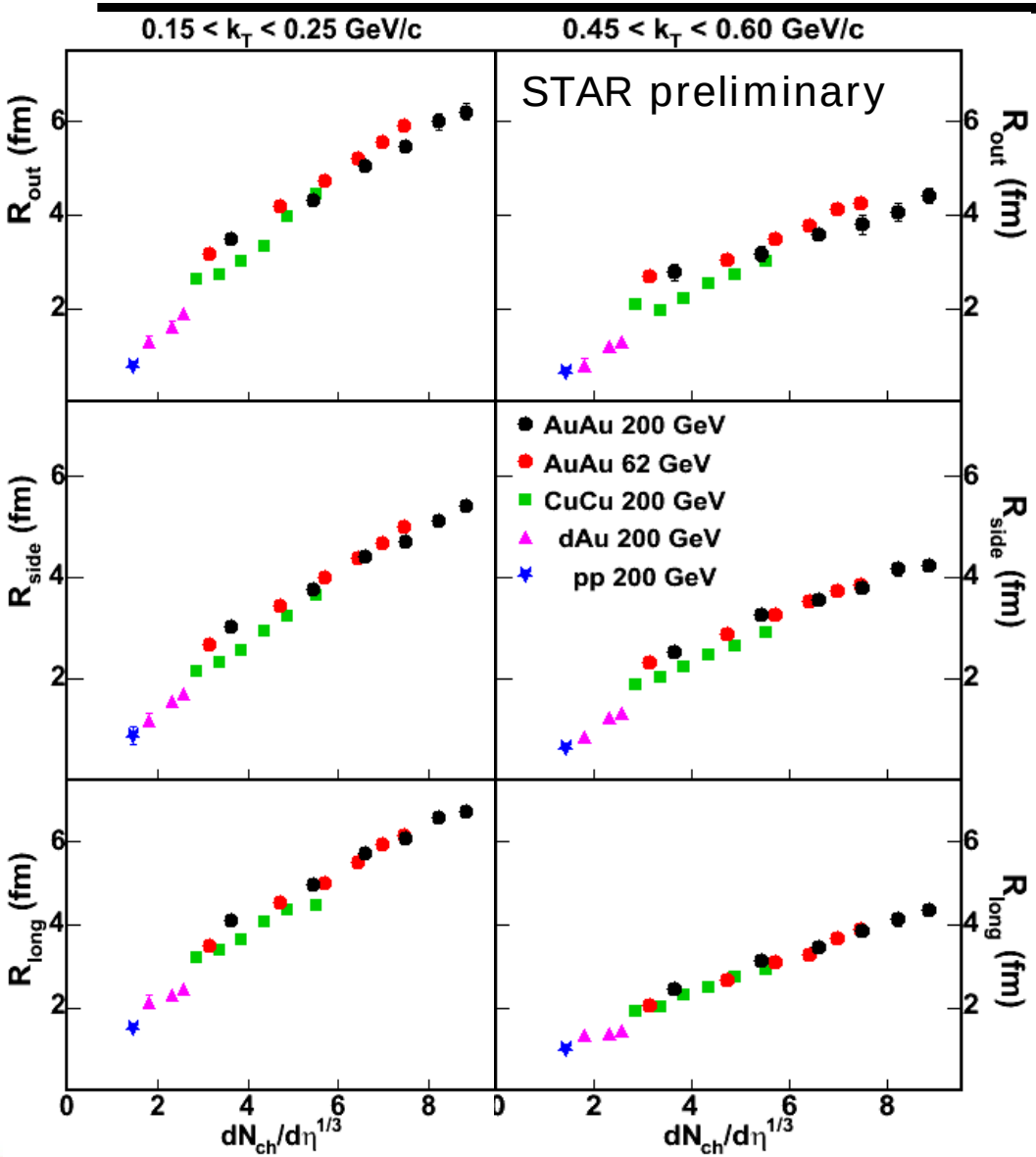
Comparison to initial size



- Same energy: 200 GeV
- Glauber model estimate of initial size
- x2 expansion in AuAu
- Cu bridges dAu and AuAu

Multiplicity scaling of pion radii at RHIC



- **CuCu** bridges multiplicity range between dAu and AuAu
- Radii scale with multiplicity from peripheral dAu to central AuAu
- Scaling holds with Kt
- 62 GeV AuAu data follow the same systematics

No change in (expansion) physics between 64 and 200 GeV?

Summary

- First HBT measurements in Cu+Cu collisions at RHIC at 200 GeV
- Preliminary pion HBT radii in Cu+Cu show clear centrality and Kt dependence, similar to Au+Au
- Expansion in heavy ion collisions , x2 in AuAu at 200 GeV
- Preliminary results from AuAu at 62 GeV confirm weak energy dependence of HBT radii at RHIC
- Multiplicity scaling of pion ($N_{ch}^{1/3}$) radii is observed, similar to lower (AGS, SPS) energies
- Multiplicity scaling is consistent with no change in dynamics between CuCu and AuAu

One relevant story

- **A marine biologist, after a long and careful study using a net with 10 inch cells, concluded that all fish is bigger than 10 inches.**