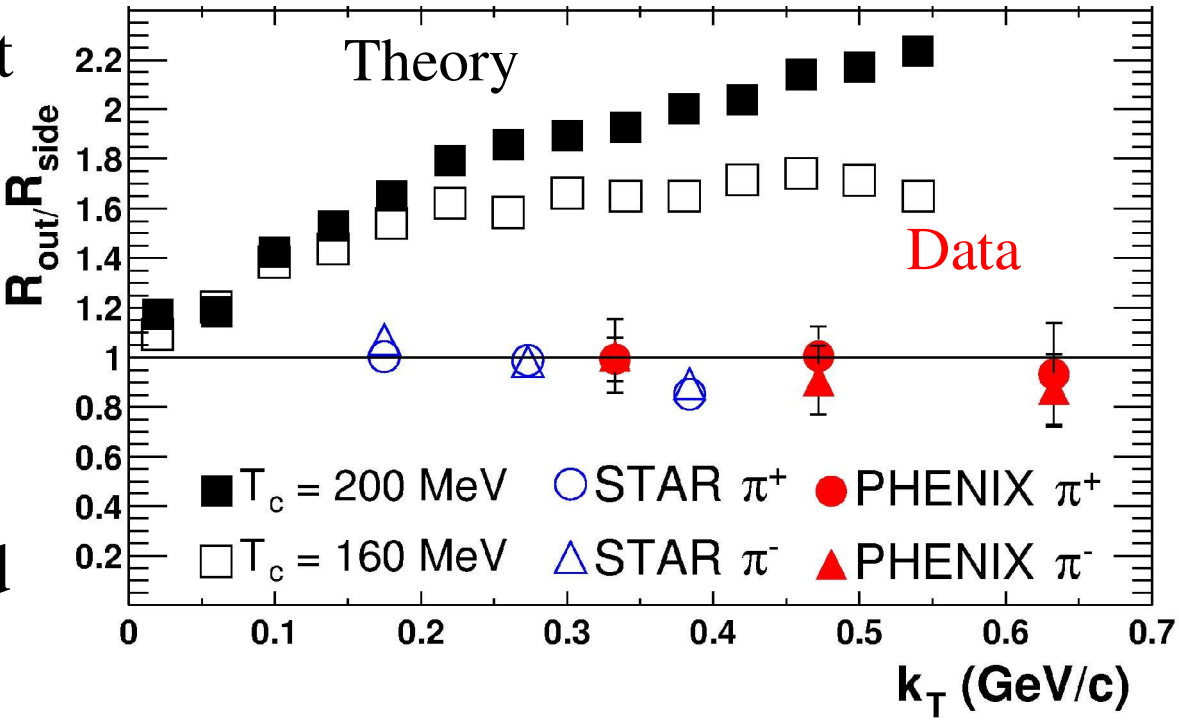
Two-Particle Interferometry at PHENIX

Mike Heffner
for the PHENIX collaboration

- Introduction
- Run2 (200GeV Au+Au) Pions
- Coulomb Correction
- Better Correlation Calculation
- Kaon and Proton Interferometry

An unresolved subject

- RHIC data and theory don't agree on Rout/Rside
- Rout/Rside =1 implies fast freeze out or opacity
- Hydro reproduces flow and spectra but not hbt radii



Considered Resolutions

Unlikely Solutions

- flow initial conditions
- latent heat /freeze out temperature
- early chemical freeze out

Interesting Possibilities

- opaque source/ high emissivity
- supercooling
- viscosity

interferometry

Submitted for publication
preprint on server now
nucl-ex 0401003

is work of Akitomo Enokizono

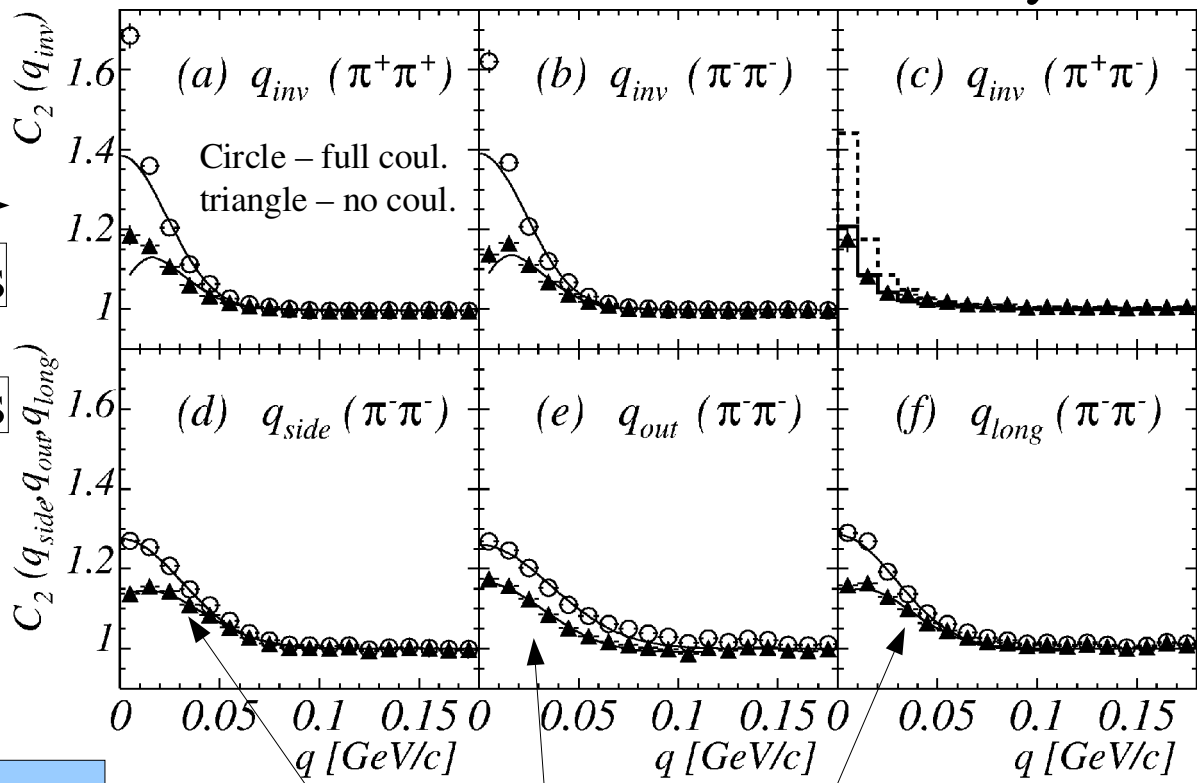
200GeV Au+Au 0-30% centrality

23M min. bias events

1D correlations

3D correlations

Bertsch-Pratt coordinate system



Coulomb correction does significantly effect radii

widening

narrowing

Better Coulomb Correction

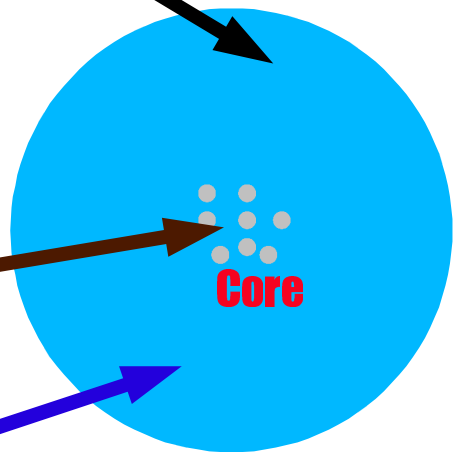
The coulomb correction is problematic in general, but the biggest error is over correcting.

Bowler, Phys Lett B 270 (1991) 69-74

Particles that do not directly originate from the collision should not be corrected. weak decays, bad pid, etc...

Solution:

Reduce the coulomb correction by λ to prevent over correction. Similar to CERES in QM02.



$$C_2 = [\lambda(1+G)F] + [1-\lambda]$$

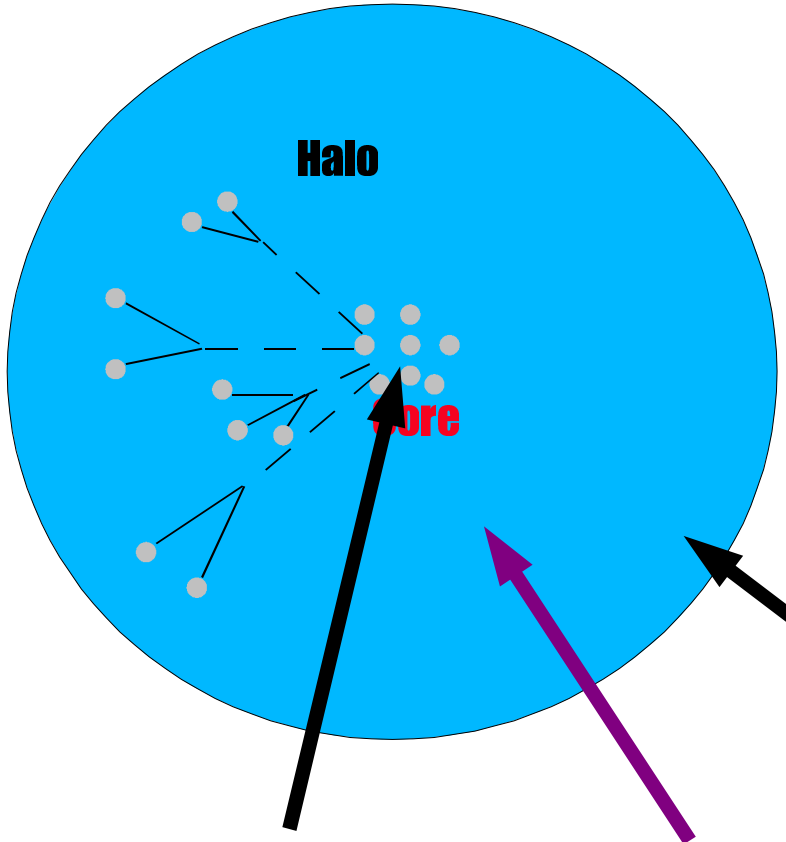
G = parameterized gaussian
F= coulomb correction

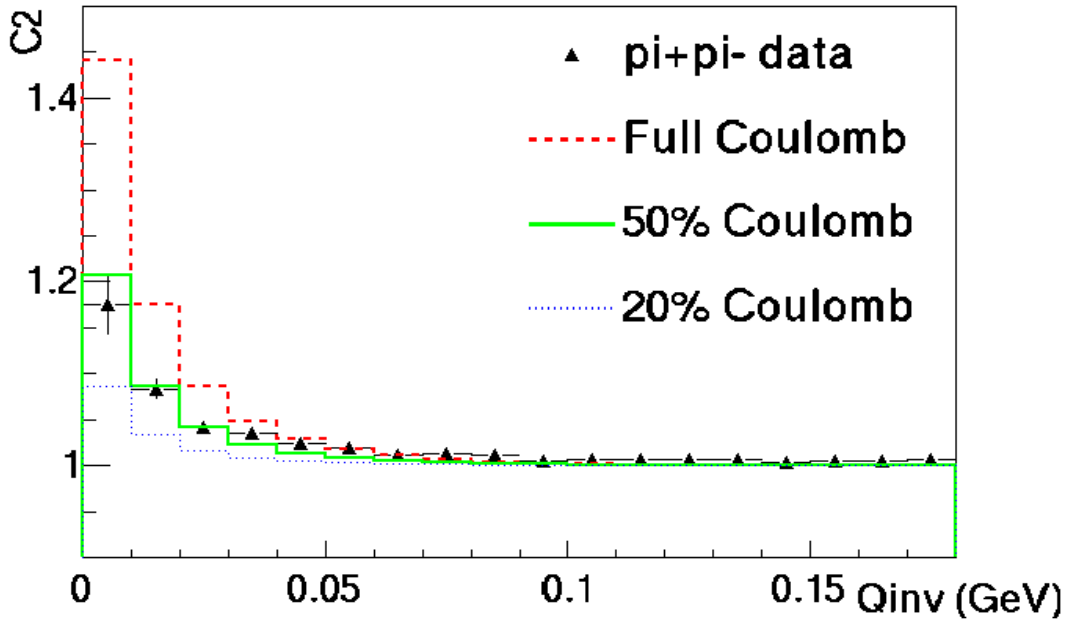
Bose-Einstein + Coulomb

No Interactions

Core-halo model

pi+pi- correlation is clearly inconsistent with a full correction





$$\lambda_{\mathrm{unlike}} = 0.5$$

$$\lambda_{\mathrm{like}} < \lambda_{\mathrm{unlike}}$$

Perhaps difference between λ_{like} and λ_{unlike} is ω daughters

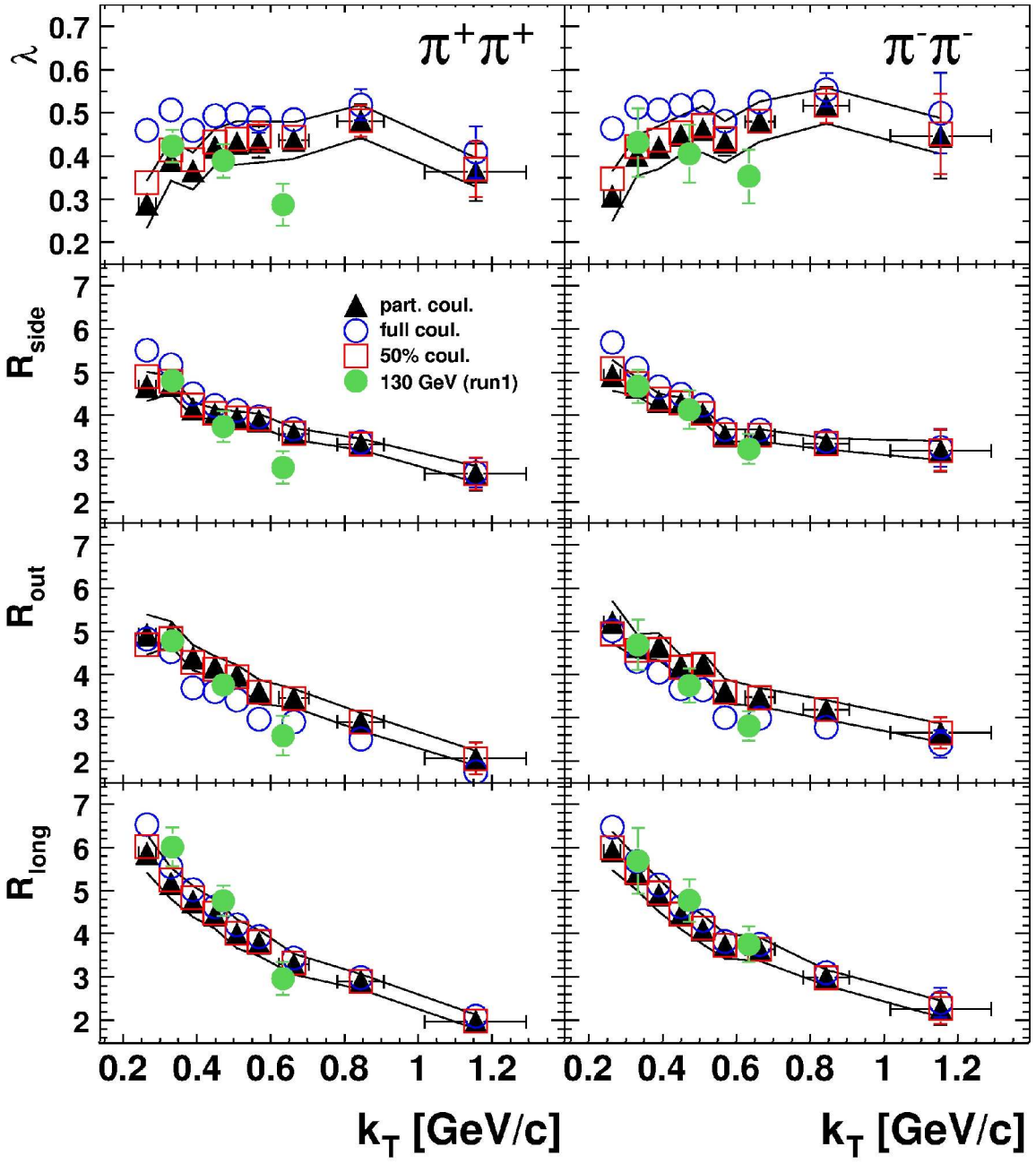
$$C_2 = [\lambda(1+G)F] + [(\lambda_{unlike} - \lambda)F] + [1 - \lambda_{unlike}]$$

Transverse momentum

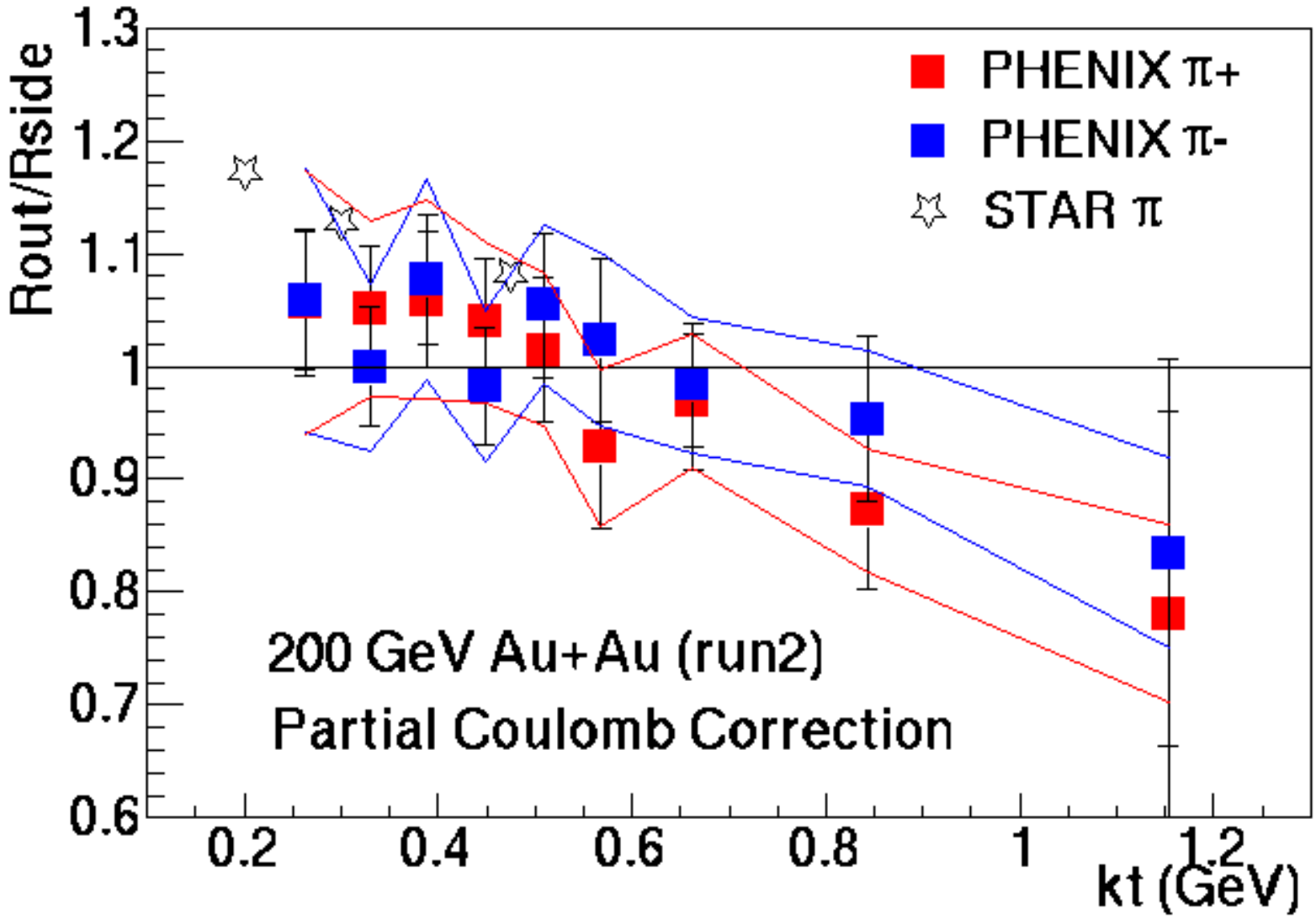
130GeV and 200GeV Au+Au

- 130GeV and 200GeV results are consistent
- Two Coulomb models within systematic errors

0-30% centrality
<N_{part}>=281



Rout/Rside

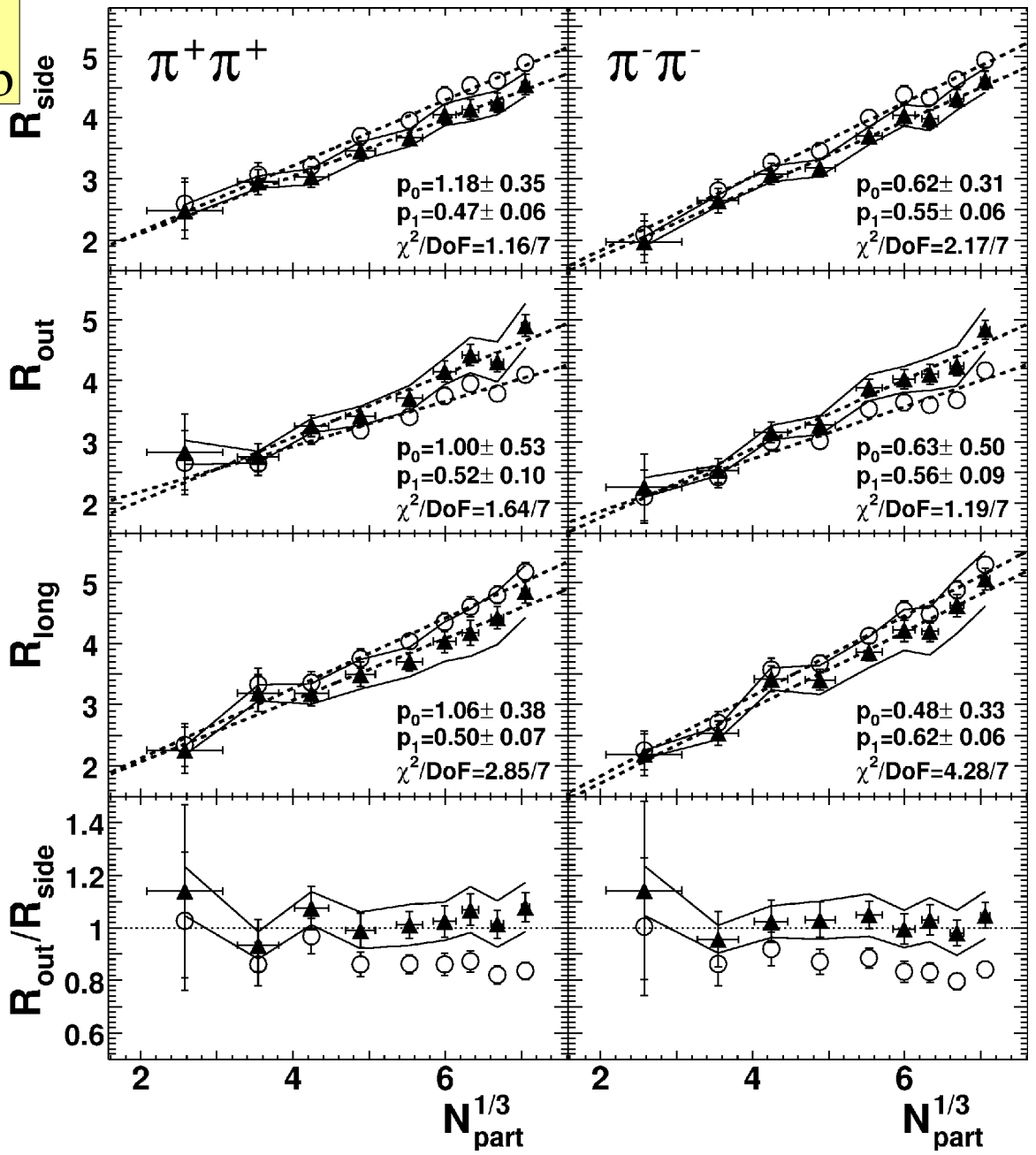

Rout/Rside
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.2
0.4
0.6
0.8
1
1.2
kt (GeV)
PHENIX π+
PHENIX π-
STAR π
200 GeV Au+Au (run2)
Partial Coulomb Correction

Centrality

200GeV Au+Au

Open Circles – Full coulomb
Closes Triangles – partial coulomb

- Radii show linear dependence on $N_{part}^{1/3}$
- Full coulomb correction reduces Rout, increases Rside and Rlong
- Effect of full coulomb on Rout/Rside is amplified

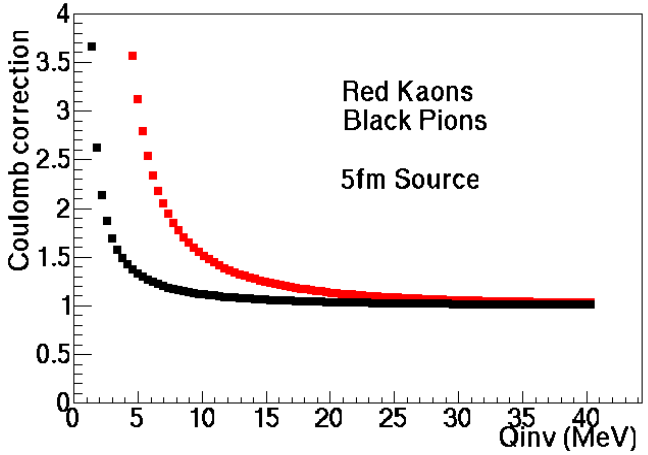


0.2 < kt < 2.0 GeV
<kt> = 0.45 GeV

Kaon and Proton Issues

Correlation formed by:
Quantum Statistics
Coulomb
Strong Potential (small for pions)

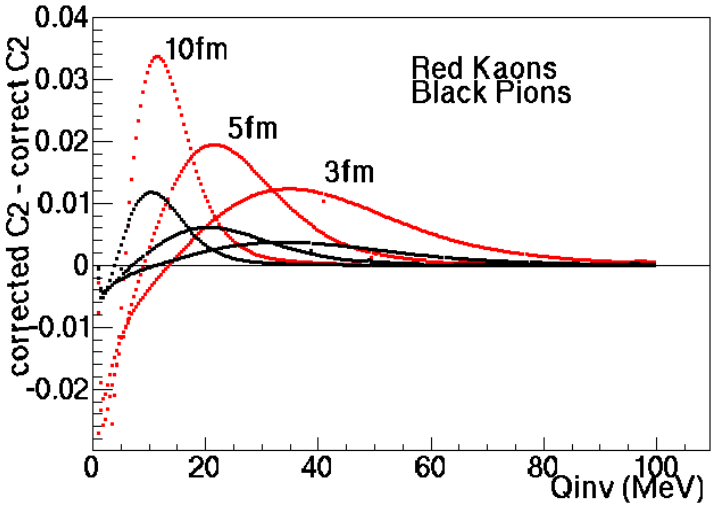
Coulomb correction



- Coulomb correction increases with mass
- Error from coulomb correction increases with mass
- Protons have strong potential with spin

Standard fitting => Error for kaons impossible for protons

Error using coulomb correction



Putting Interactions into the Fit

Koonin-Pratt eq.

Correlation

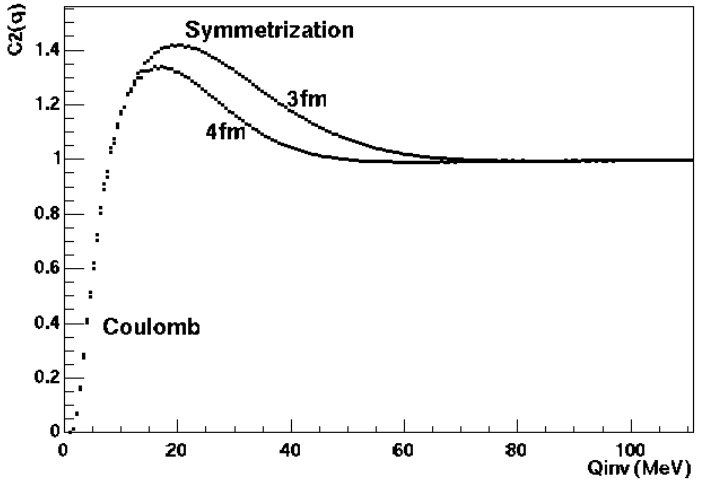
$$C_2(q) = \int d^3 r \, |\psi(q, r)|^2 \, S(r)$$

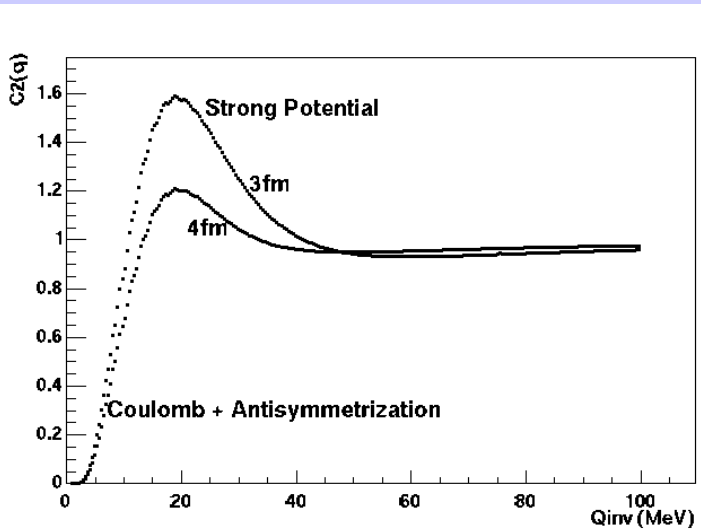
Relative Wavefunction

Source

$$S_K(r) \equiv \int d^3 R \, D(R + r/2) \times D(R - r/2)$$

Convolution of single particle distribution





$$H\,\psi = E\,\psi$$

$$\psi(r, \theta) = \sum_l (2l+1)\, i^l \frac{\phi(r)}{r} P_l(\cos\theta)$$

Coulomb+ Strong Potential

$$\left[\frac{d^2}{dr^2} - \frac{l(l+1)}{r^2} - \frac{2m}{\hbar^2}[V(r) + E]\right]\phi(r) = 0$$

Quant. Stat.

$$\psi_{(anti)sym} = \frac{1}{\sqrt{2}}[\psi(q, r) \pm \psi(q, -r)]$$

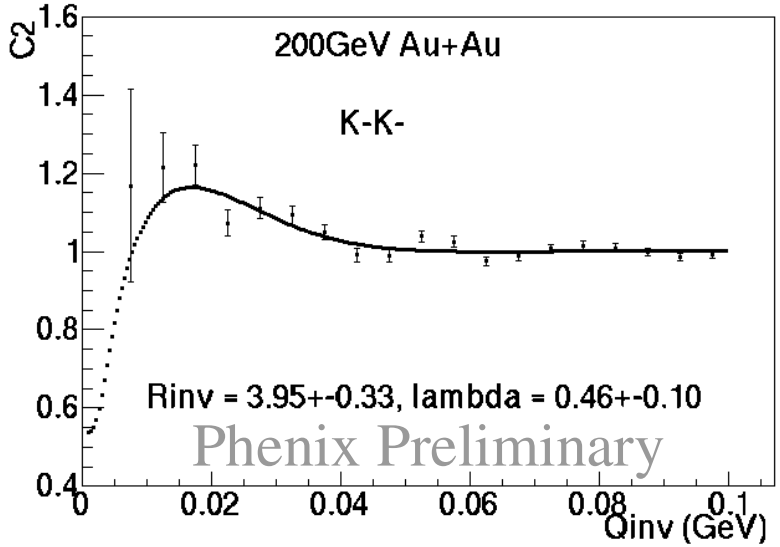
$$|\psi(q, r)|^2 = \frac{1}{4}|{}^1\psi(q, r)|^2 + \frac{3}{4}|{}^3\psi(q, r)|^2$$

Spin

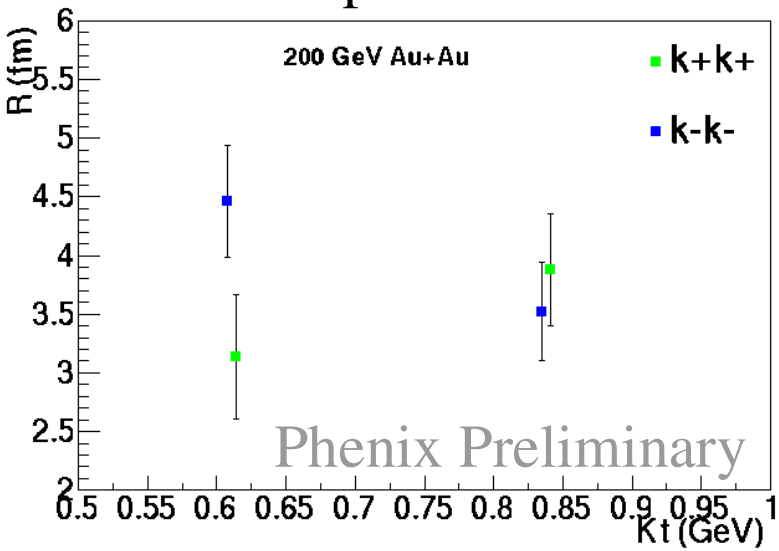
Kaons

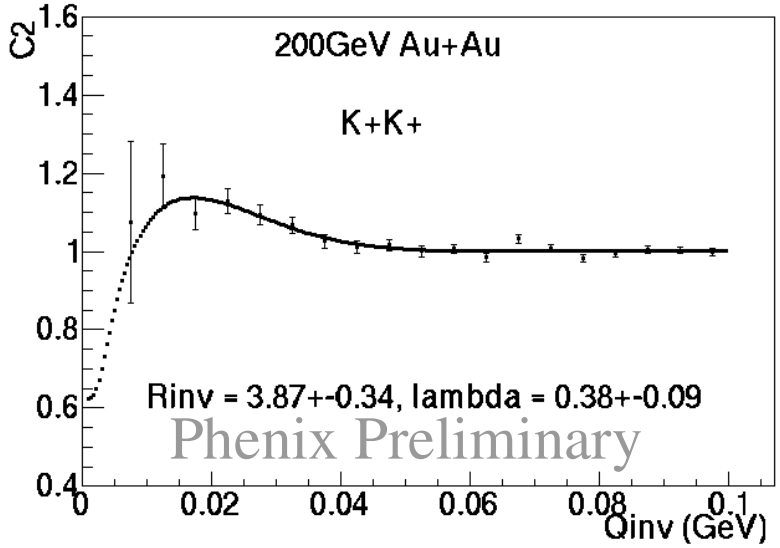
Coulomb in Fit
no Coulomb correction
to data

Fit Model
- Koonin-Pratt
- Gaussian Source
- No strong potential
- Coulomb



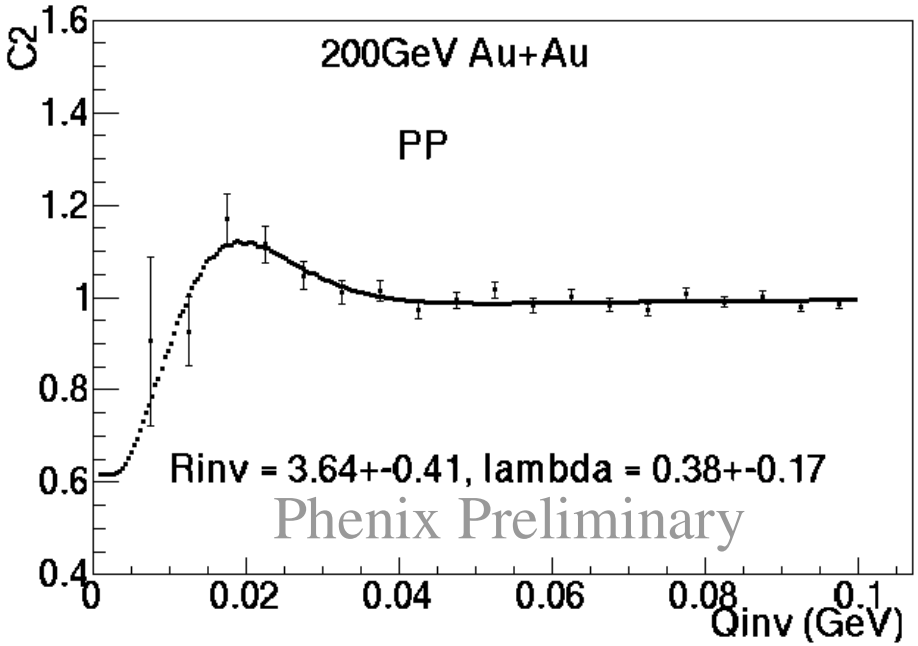
No obvious kt dependence

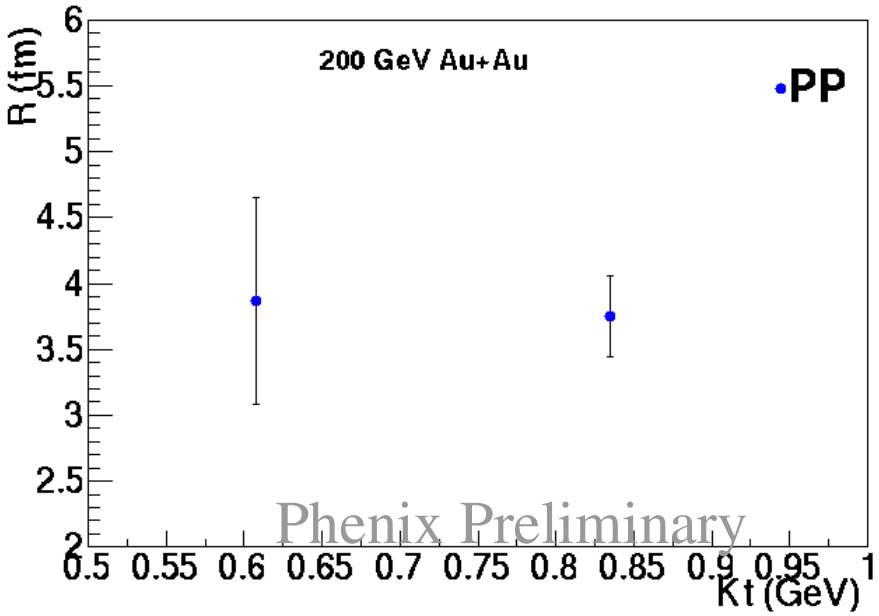




Protons

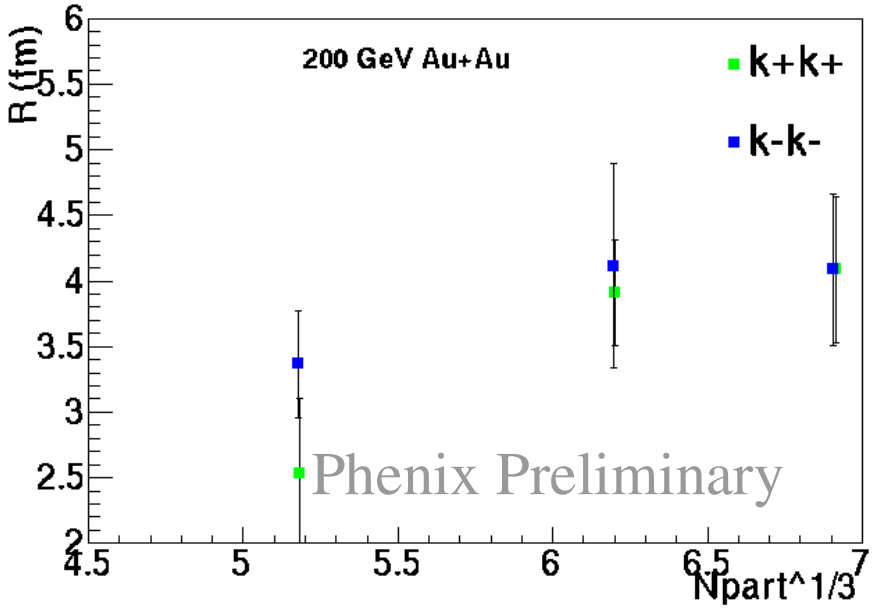
Fit model
- Koonin-Pratt
- Gaussian Source
- Nucleon-Nucleon potential
- Coulomb

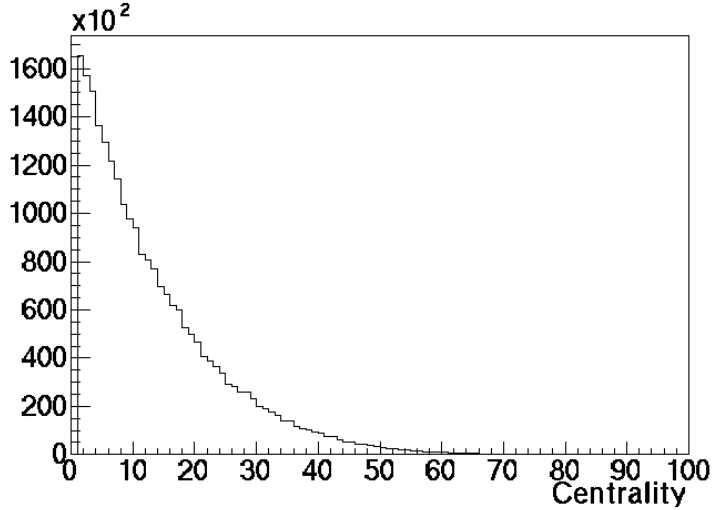




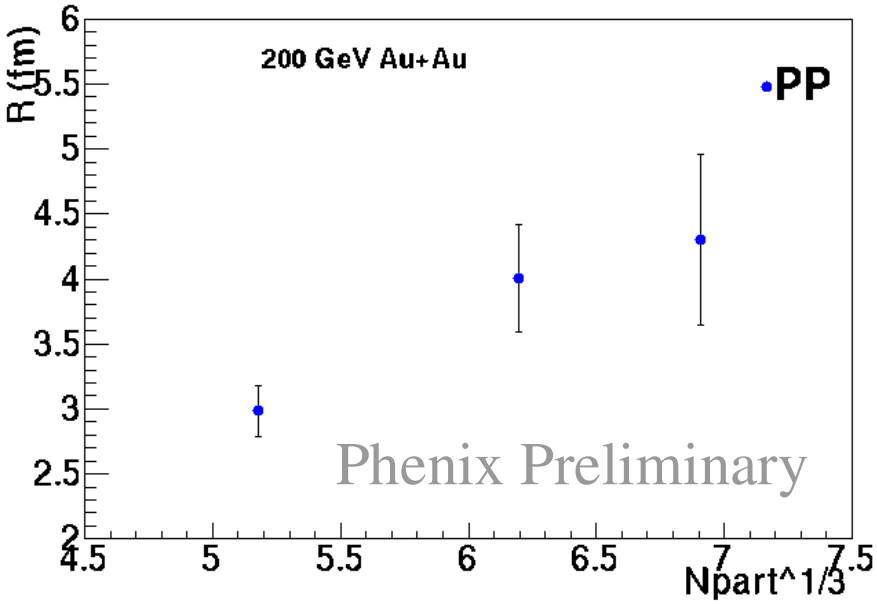
No obvious kt dependence

centrality





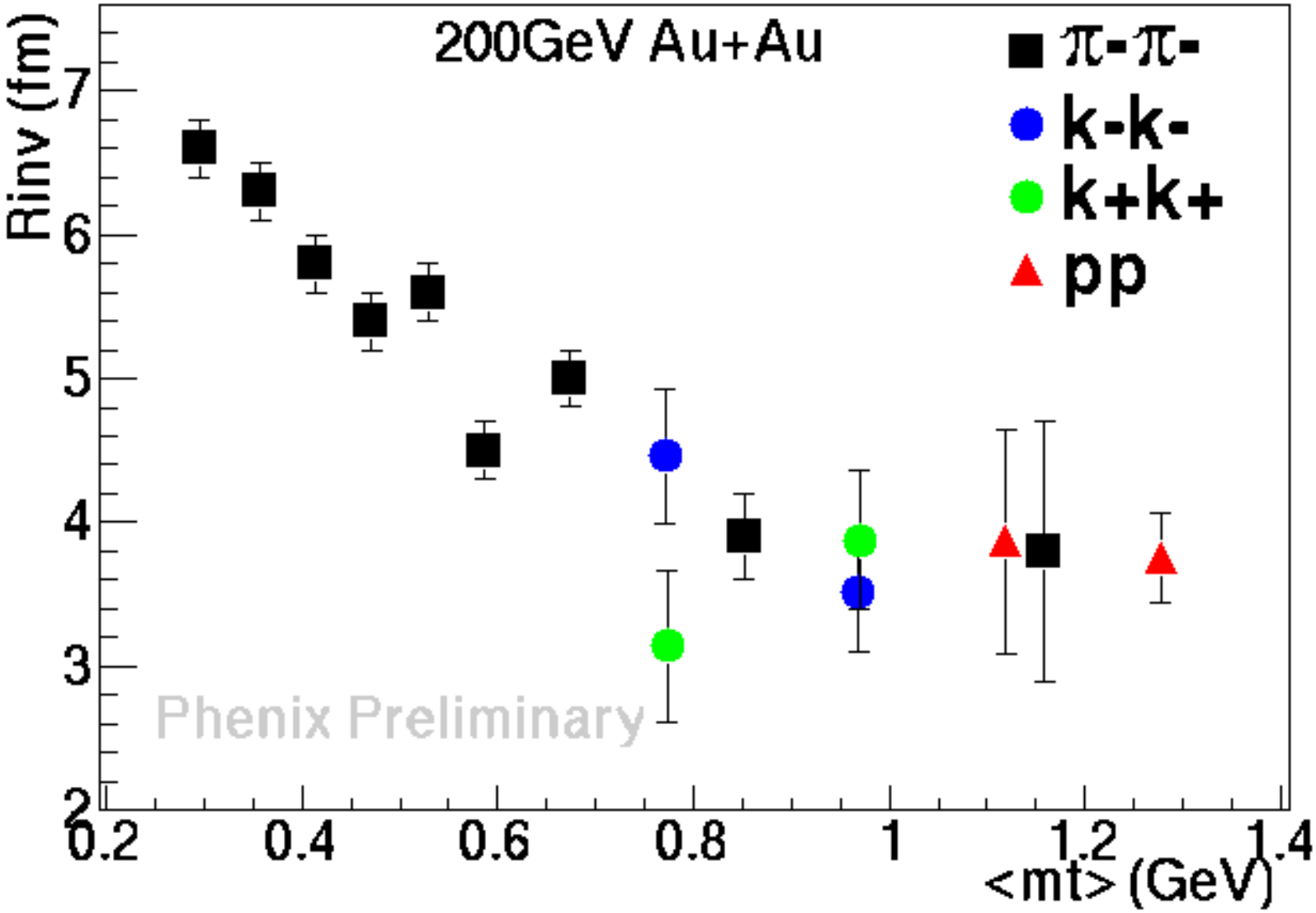
Bins 0-10%, 10-20%, >20%



Central events have higher probability of a kaon or proton pair... limits centrality range

Both kaons and protons show increase of radius with number of participants

1D Radii Comparison



Summary

- Run2 (200GeV) statistics have provided so far:
  - kt range to 1.15 GeV
  - centrality
  - kaons/protons
- Rout/Rside is effected significantly by coulomb correction
- Best coulomb correction gives Rout/Rside consistent with 1.0
- Protons and Kaons consistent with pions and mt scaling

Outlook

- Non-identical
- Reaction plane
- 3D protons and kaons
- Higher kt range