Rapidity and k_T dependence of HBT correlations in Au+Au collisions at 200 GeV

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for

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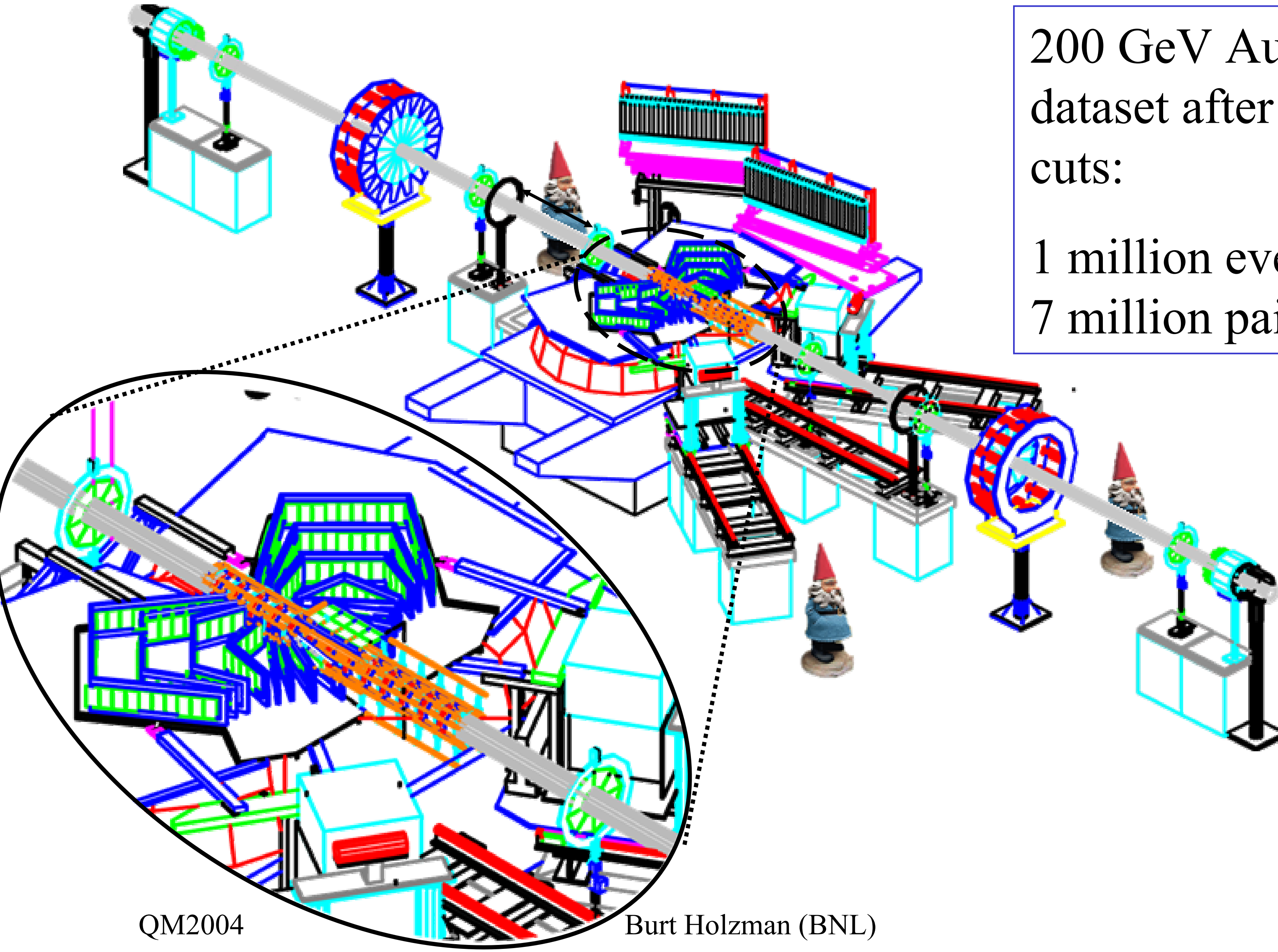
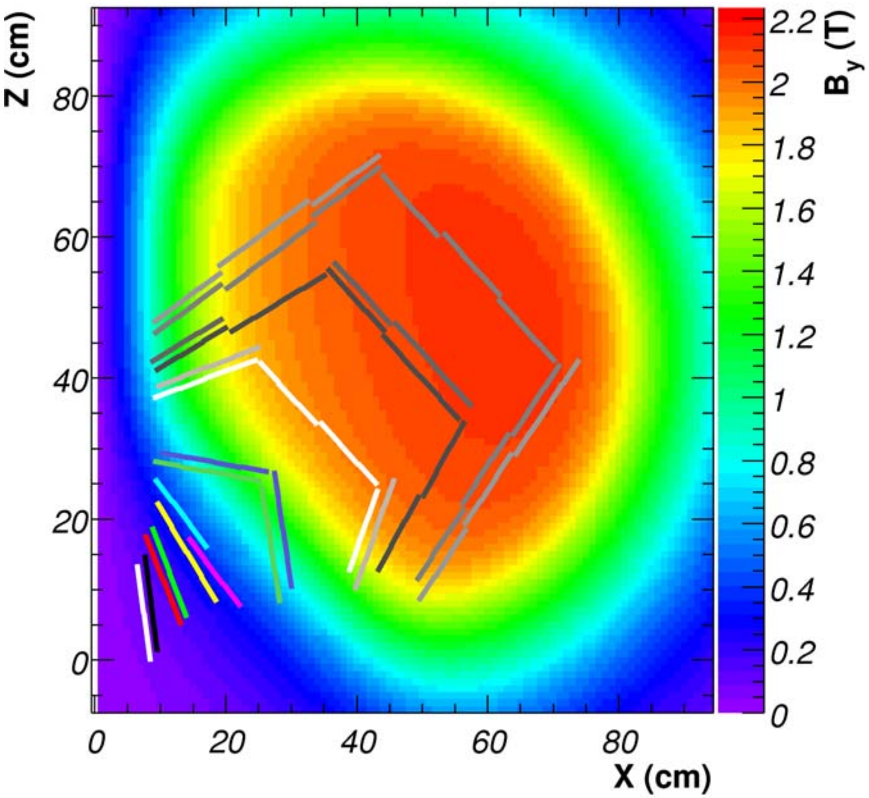
PHOBOS Schematic



200 GeV Au+Au dataset after HBT cuts:

1 million events
7 million pairs

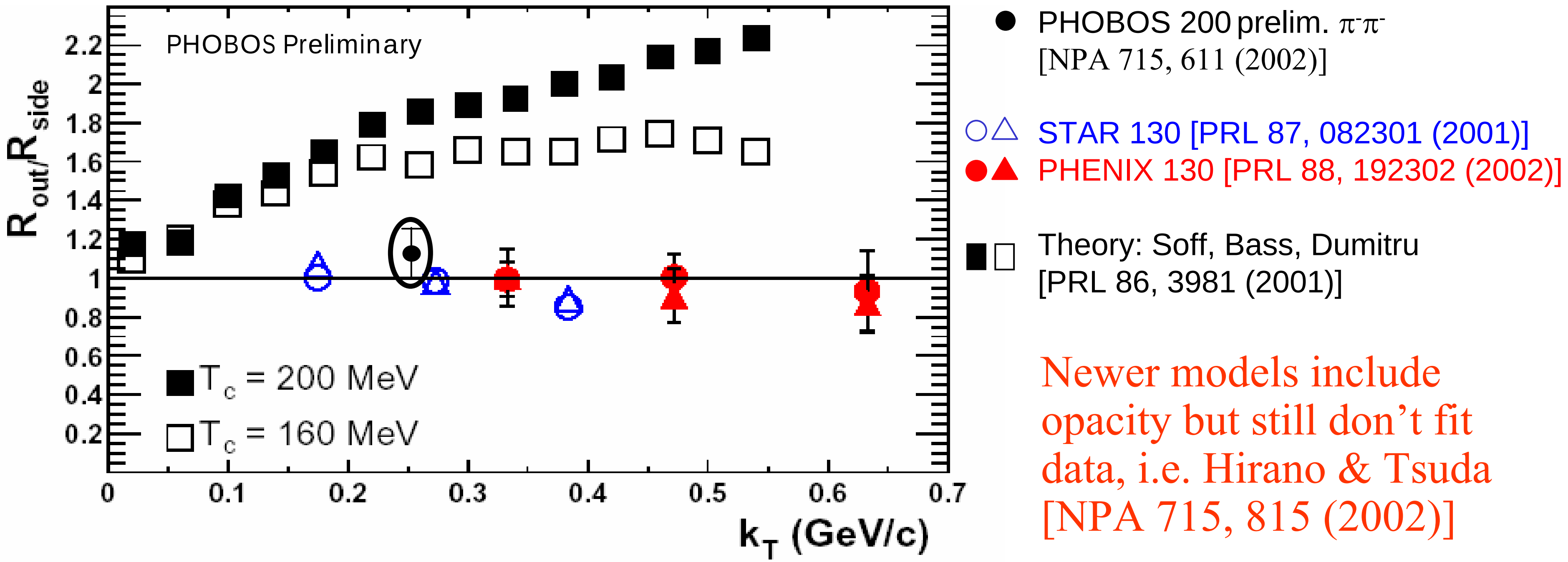
PHOBOS Spectrometer



- Reversible 2T field
- Two symmetric arms
- Fine pixel granularity gives small two-particle inefficiency region (25x50 mrad)
- $\Delta p/p < 1.5\%$
- Pairs with small Δq also have small separation at detector: small detectors are good for HBT!

HBT @ RHIC: Challenge for Theory

- Huge (15 fm) source doesn't exist at RHIC
- $R_o/R_s \sim 1$



Newer models include opacity but still don't fit data, i.e. Hirano & Tsuda [NPA 715, 815 (2002)]

- I will not be solving the HBT puzzle; but I will dump more pieces into the mix!

Some HBT definitions

- k_T: pair transverse momentum

$$k_T = \frac{1}{2}(\overrightarrow{p_1} + \overrightarrow{p_2})_\perp$$

- Bertsch-Pratt (BP) parameterization

$$C(Q) = 1 + \lambda e^{-Q_O^2 R_O^2 - Q_L^2 R_L^2 - Q_S^2 R_S^2 - 2 Q_O Q_L R_{OL}^2}$$

- Yano-Koonin-Podgoretsky (YKP) parameterization

$$C(Q) = 1 + \lambda e^{-R_{perp}^2 Q_{perp}^2 - R_{long}^2 \gamma^2 (Q_{long} - v_{YK} Q_{time})^2 - R_{time}^2 \gamma^2 (Q_{time} - v_{YK} Q_{long})^2}$$

Source velocity included in correlation function

MC studies

- First principles HBT generator [Kadija & Seyboth, PLB 287, 63, (1992)] - we can do 15 fm!

	λ	R_{out} (fm)	R_{side} (fm)	R_{long} (fm)	R_{ol} (fm)
MC	.48±.02	3.2 ± .14	18.0 ±.9	5.8 ± .2	1.2 ± .4
Recon	.43±.02	3.1 ± .15	16.1 ± .9	5.8 ± .3	1.5 ± .3

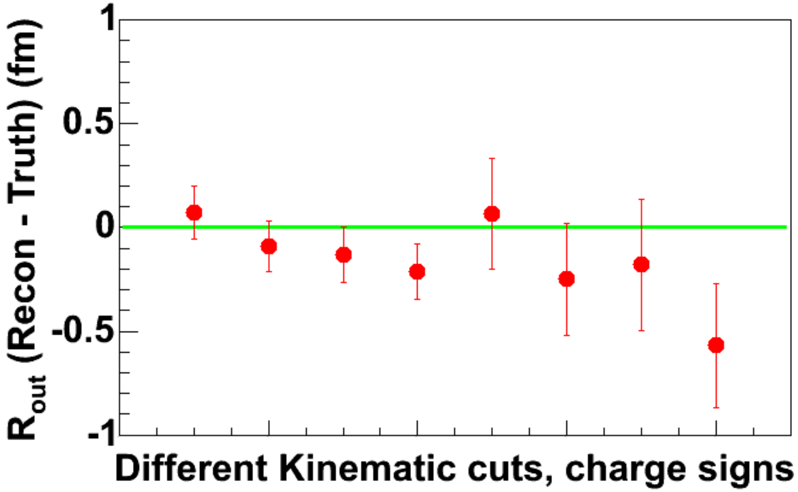
- That was our first naive attempt -- let’s try something else

MC studies

- HIJING (weight "actual" pairs), simulate detector with GEANT, real reconstruction

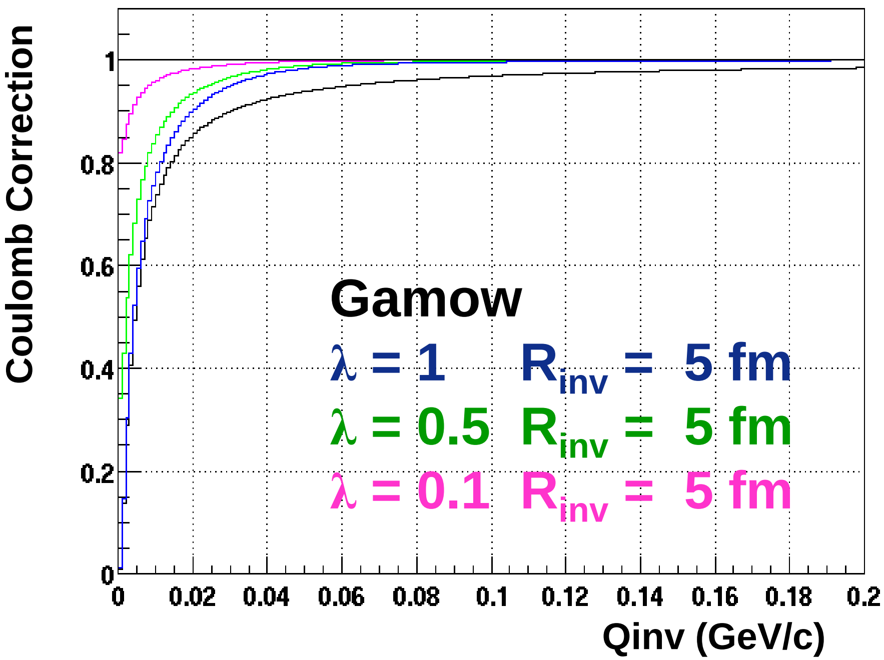
	λ	R_{out} (fm)	R_{side} (fm)	R_{long} (fm)	R_{ol} (fm)
MC	.5	4.0	4.0	4.0	2.0
Recon	.52 ± .02	4.1 ± .13	4.2 ± .4	4.2 ± .2	1.6 ± .7

- We can reproduce correlation functions quite well



PHOBOS Coulomb Correction

PHOBOS Coulomb Correction: Used from Day 1



PHOBOS data corrected with

	PHOBOS CoulCorr	Ceres02 CoulCorr
λ	$0.57 \pm .05$	0.57 ± 0.04
R_{out}	$4.7 \pm .3$ fm	4.8 ± 0.3 fm
R_{side}	$4.3 \pm .4$ fm	4.4 ± 0.4 fm
R_{long}	$5.1 \pm .3$ fm	5.0 ± 0.3 fm
R^2_{ol}	1.2 ± 1.9 fm^2	1.6 ± 1.8 fm^2

$$K_{Coul}(q,R) = \frac{\int d^3r\, S(\vec{r}) \left|\psi_{Coulomb}(\vec{r})\right|^2}{\int d^3r\, S(\vec{r}) \left|\psi_{Plane}(\vec{r})\right|^2}$$

$$\widetilde{K}^{PHO}_{Coul}(q,R,\lambda) = \frac{1-\lambda+\lambda(1+e^{-q^2R^2})K_{Coul}(q,R)}{1+\lambda e^{-q^2R^2}}$$

Coulomb Correction II

Bowler('91)/Sinyukov('98)/CERES('02)/STAR('03)/PHENIX('03)

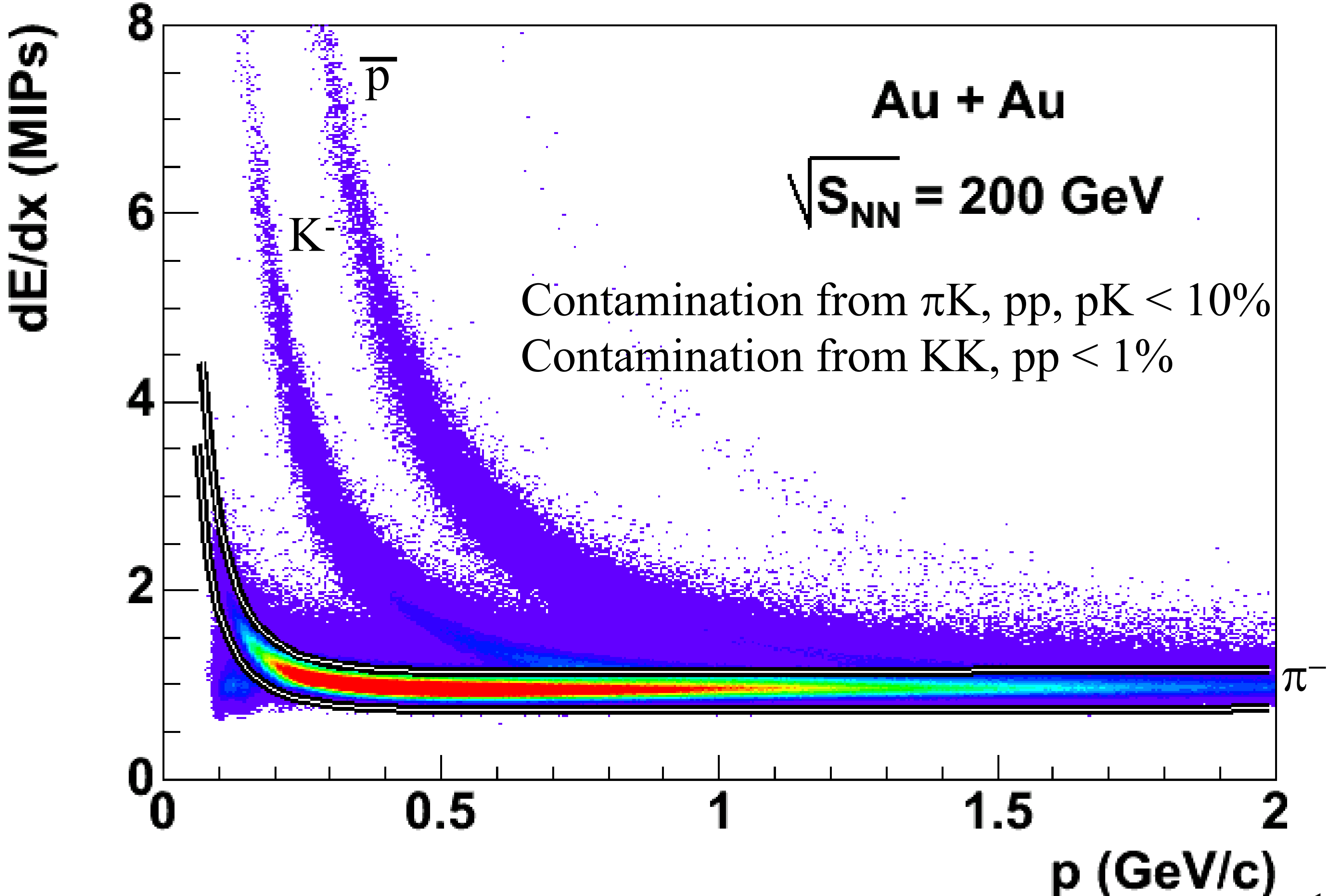
$$\frac{A(q)}{B(q)} = N\left(1+\lambda\left\{K_{coul}(q)\left[1+\exp(-R_{ij}^2 q_i q_j)\right]-1\right\}\right)$$

$$\frac{A(q)}{B(q)} = \underbrace{\frac{N\left(1+\lambda\left\{K_{coul}(q)\left[1+\exp(-R_{ij}^2 q_i q_j)\right]-1\right\}\right)}{1+\lambda\exp(-R_{ij}^2 q_i q_j)}}_{\widetilde{K}_{coul}(\lambda,q)}\left[1+\lambda\exp(-R_{ij}^2 q_i q_j)\right]$$

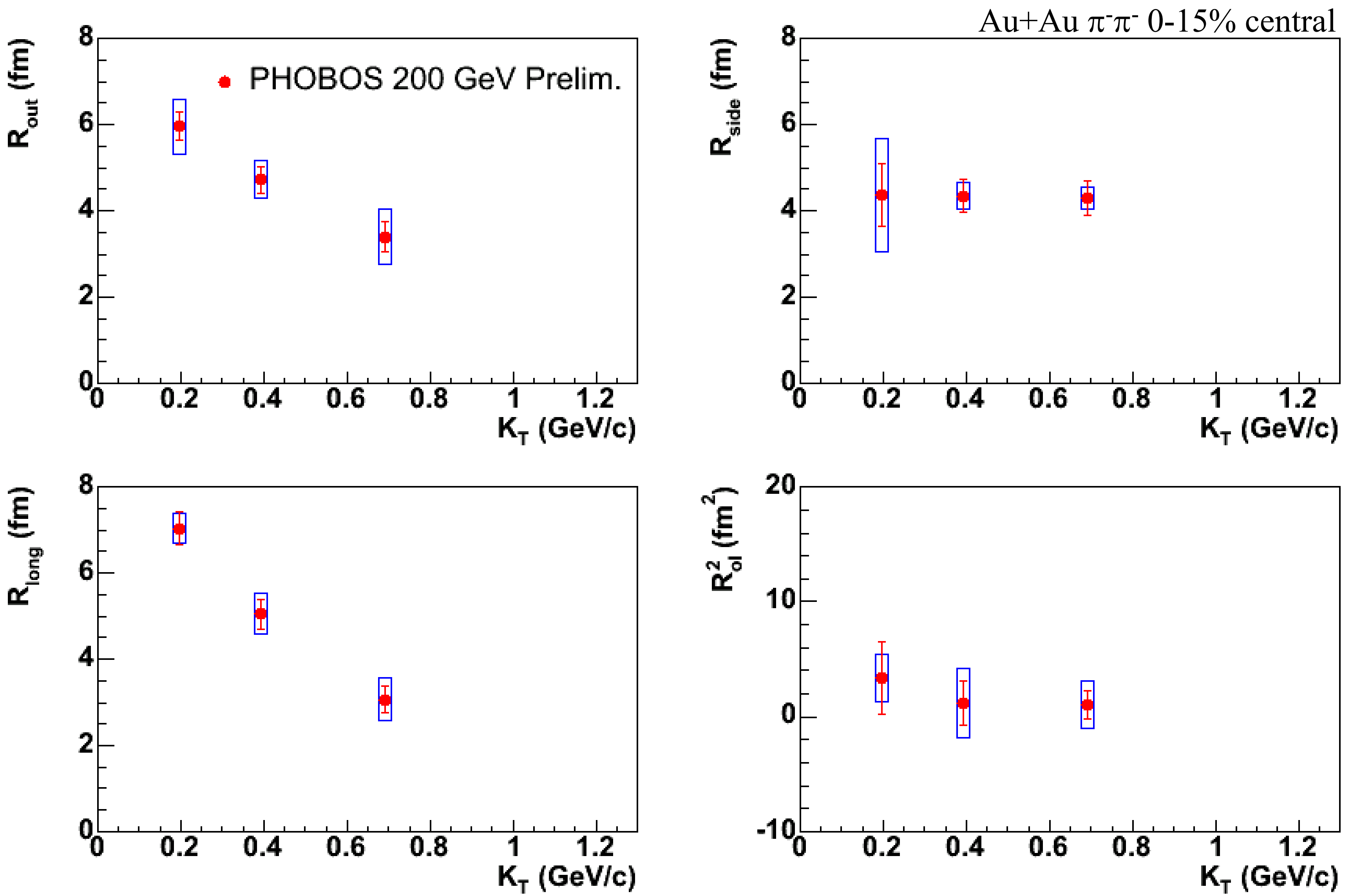
PHOBOS('02)

$$\widetilde{K}_{coul}^{PHO}(\lambda,q) = \frac{N\left(1+\lambda\left\{K_{coul}(q)\left[1+\exp(-R_{inv}^2 Q_{inv}^2)\right]-1\right\}\right)}{1+\lambda\exp(-R_{inv}^2 Q_{inv}^2)}$$

Particle Identification

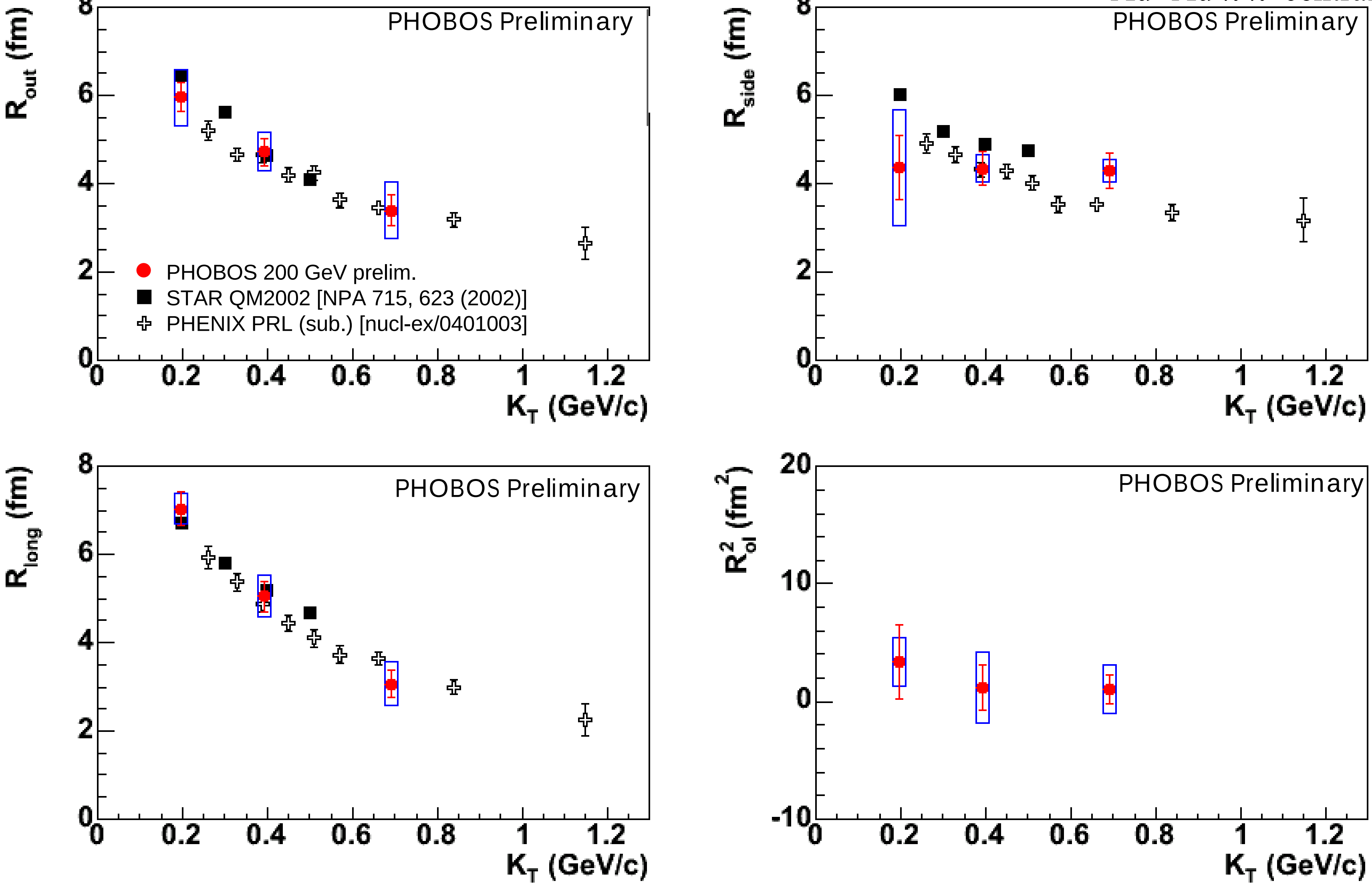


Bertsch-Pratt vs. k_T

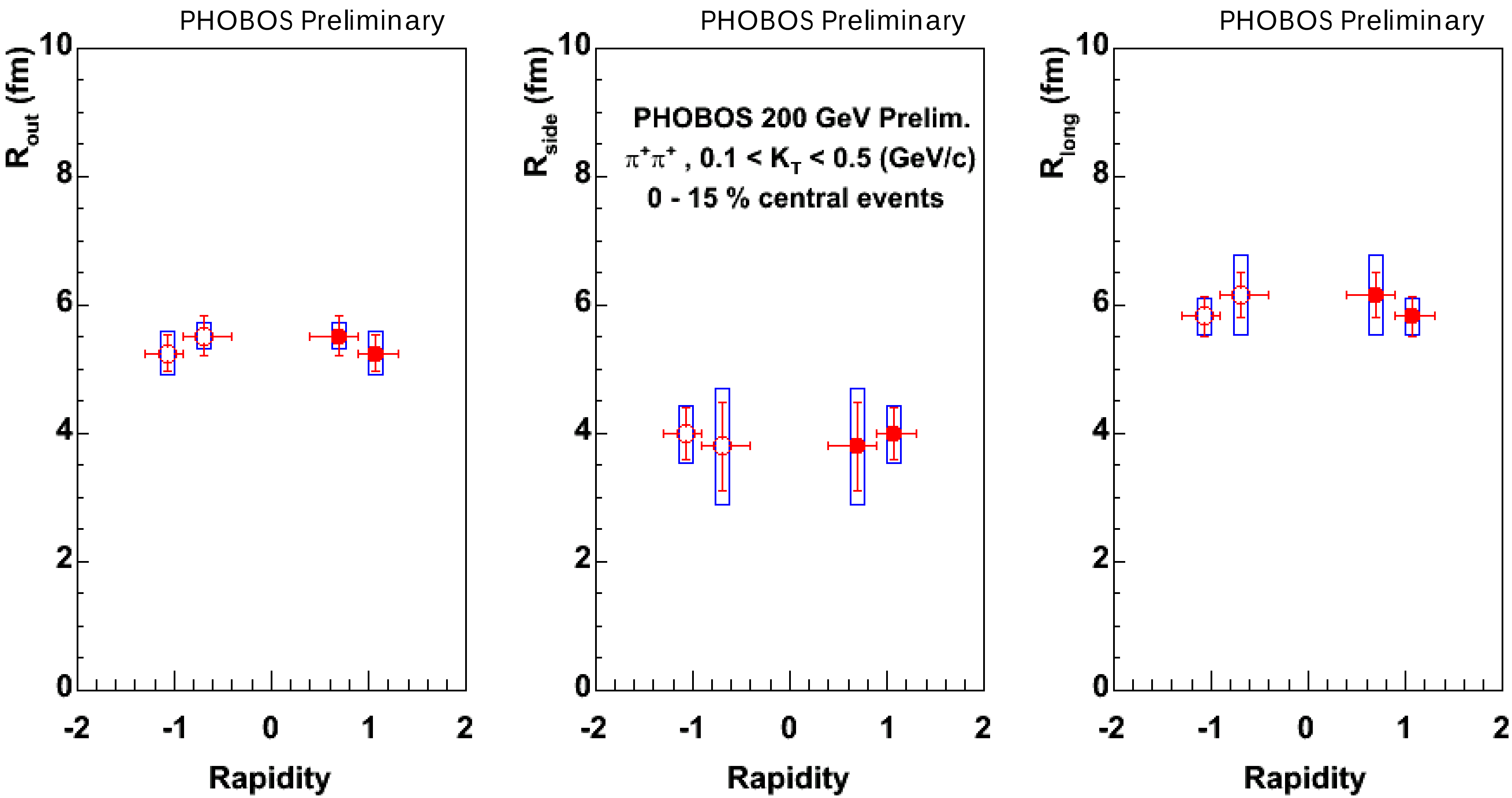


Bertsch-Pratt vs. k_T: RHIC data

Au+Au $\pi^-\pi^-$ central



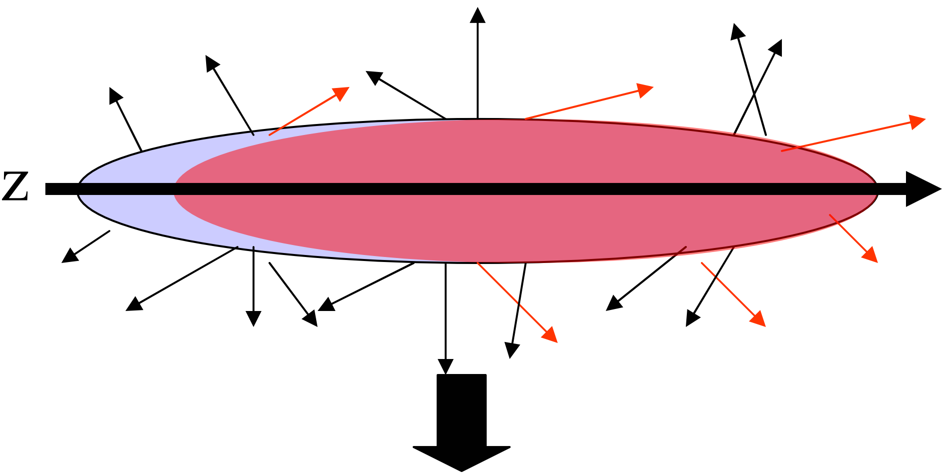
Bertsch-Pratt vs. Y



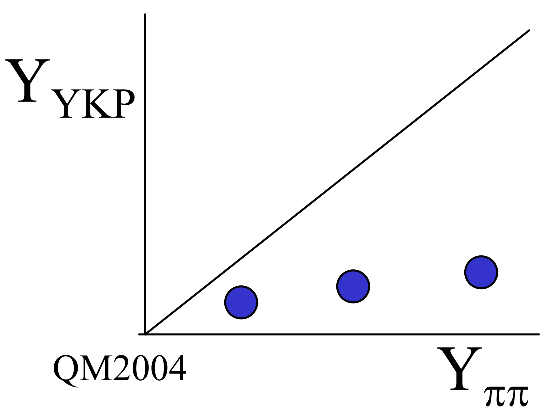
Within errors, no BP Y-dependence in our acceptance

Why Y_{YKP} ?

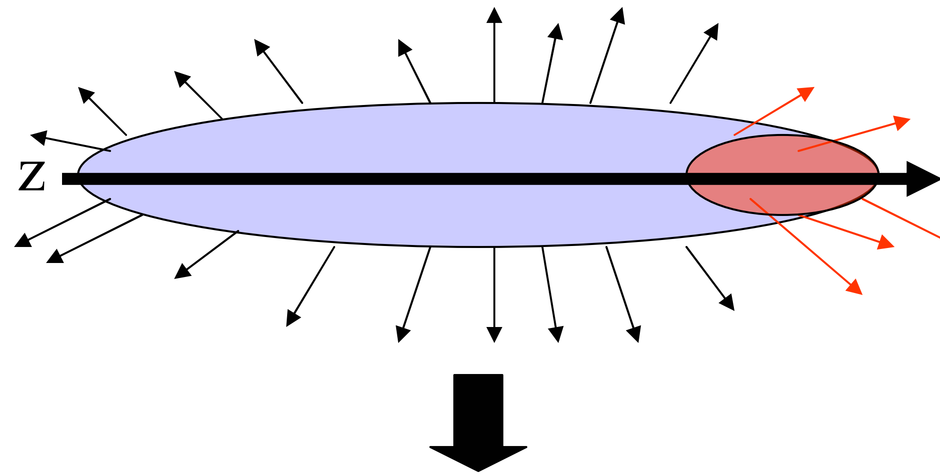
Slowly expanding source in z
weak p-z correlations



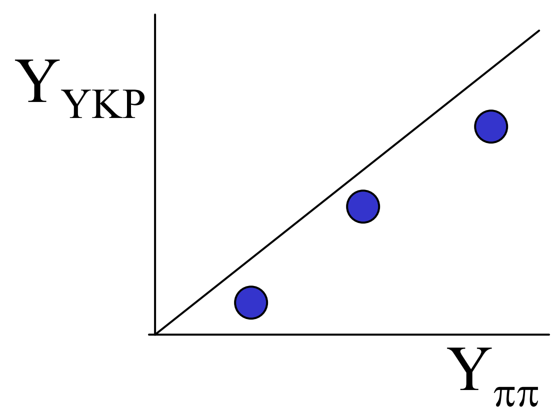
$Y_{\pi\pi}$ slowly varies



Exploding source in z
strong p-z correlations

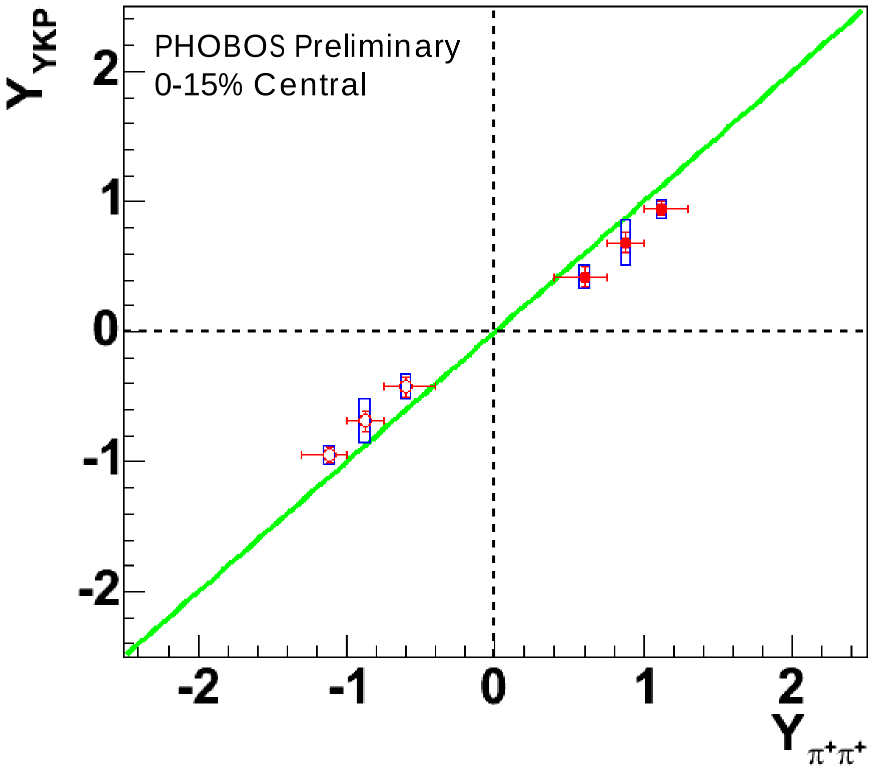


$Y_{\pi\pi}$ scales with Y_{YKP}

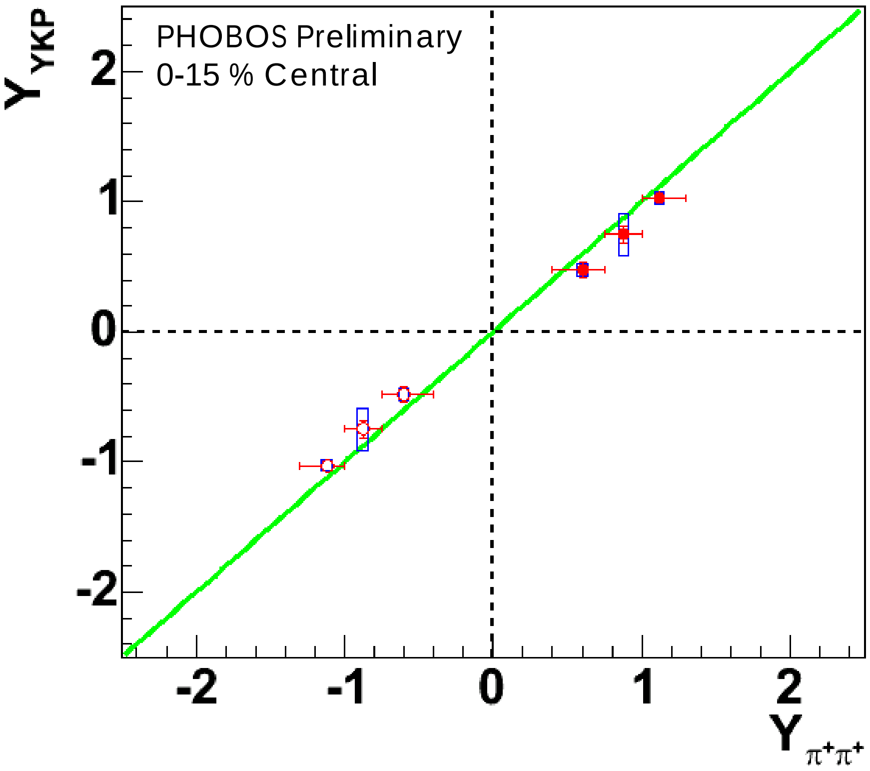


Yano-Koonin-Podgoretsky vs. Y

Fit in Lab frame



Fit in LCMS frame

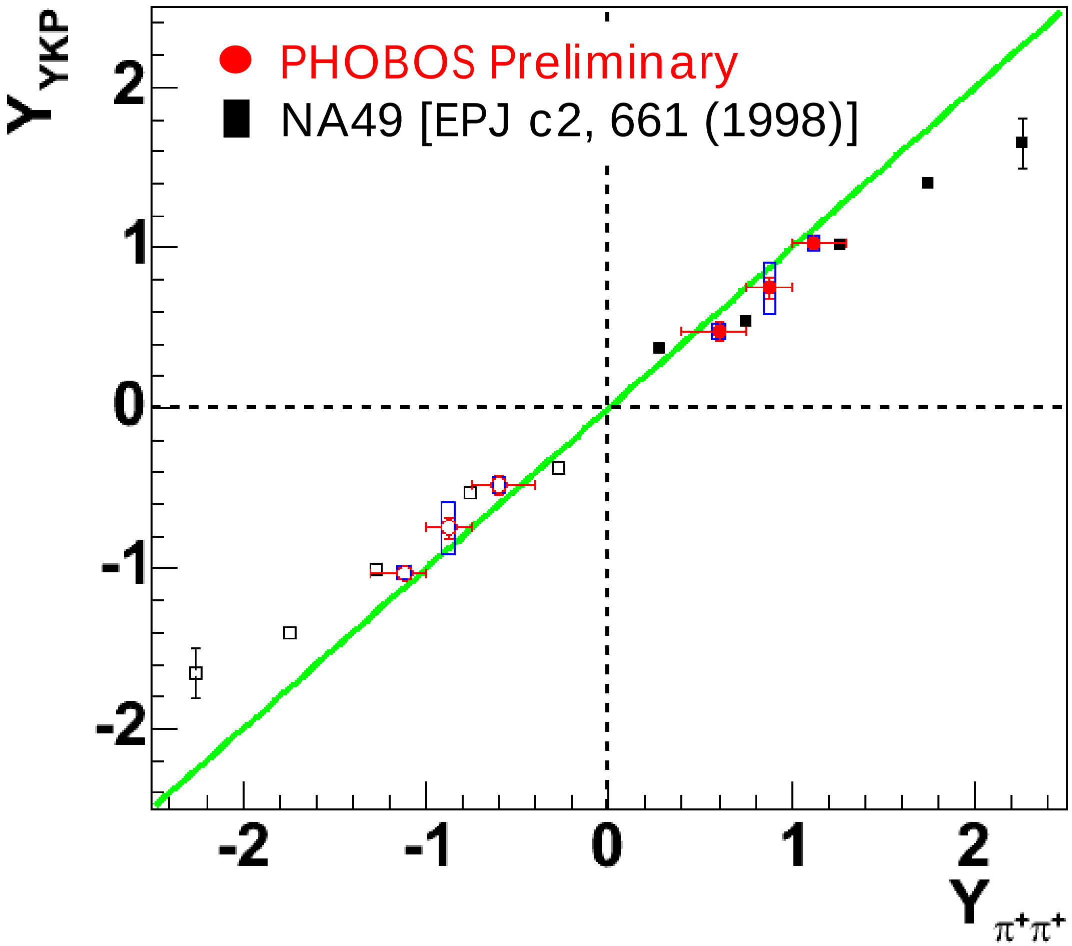


All results presented in lab frame

- Pair rapidity scales with source rapidity

Comparison to NA49

Fit in LCMS frame



- SPS ($\sqrt{s_{NN}}$ = 17.2 GeV) RHIC ($\sqrt{s_{NN}}$ = 200 GeV) both exhibit similar scaling behavior

NA49: $.1 < k_T < .2$ GeV/c

PHOBOS: $.1 < k_T < 1.4$ GeV/c

?

Conclusions & Outlook

- More pieces added to the puzzle
  - PHOBOS nicely complements the current RHIC HBT dataset in k_T and Y
- R_{out}, R_{side}, R_{long}: consistent with weak or no rapidity dependence from $.4 < Y < 1.3$
- Pair rapidity scales with source rapidity
- High statistics from current RHIC run will decrease errors and increase k_T reach
- **See C. Ming Kuo's poster at 5 pm**