3D kaon source extraction from 200GeV Au+Au collisions

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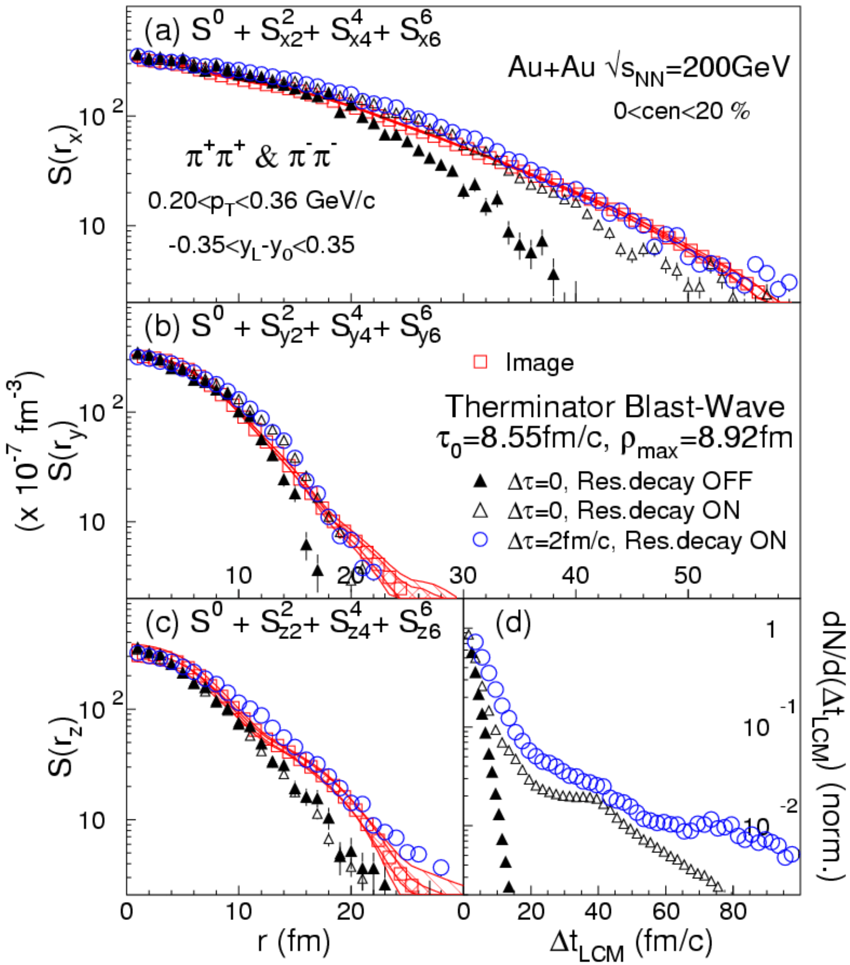
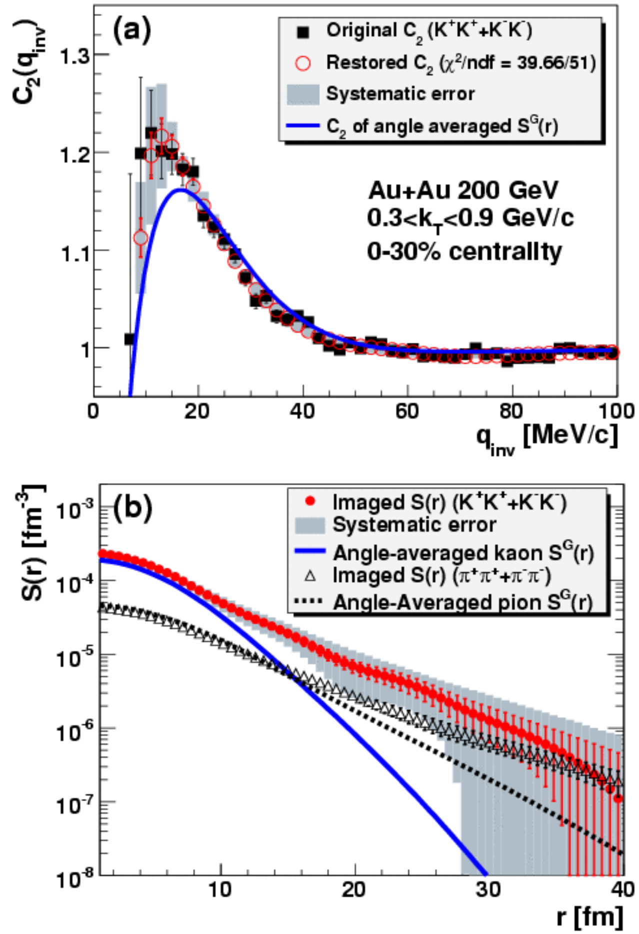
PHENIX Pion & Kaon Source Extrac.

PRL100, 232301 (2008)



PRL103, 142301 (2009)



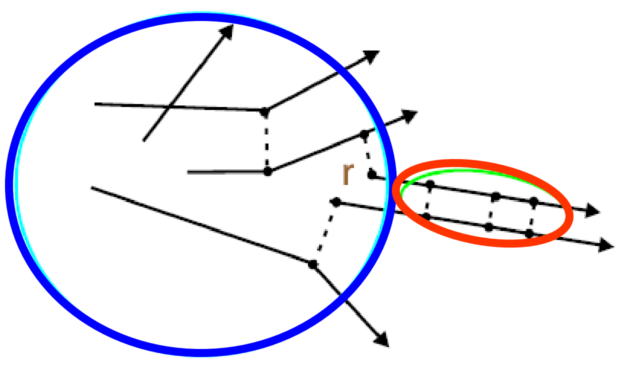
Outline

- Overview of 3D source shape analysis : Cartesian Spherical Harmonic decomposition & Imaging/Fitting Technique
- Kaon correlation moments & extracted 3D S(r) from Run 4 central Au+Au collisions @ low K_T
- Model comparison (Therminator & Hydjet) for extracting Kaon source freeze-out parameters (lifetime & emission duration)
- K_T dependence of extracted source dimensions & model comparison (Buda-Lund & Hydro Kinetic Model)

1D Imaging Formulation

Technique Devised by:

D. Brown, P. Danielewicz,
PLB 398:252 (1997).
PRC 57:2474 (1998).



Emitting source

No Shape assumption for S(r)

Extracted S(r) in pair CM frame

Inversion of Linear integral equation to obtain source function

1D Koonin Pratt Eqn.

$$C(\vec{q}) - 1 = 4\pi \int dr r^2 K_0(q, r) S(r)$$

Encodes FSI

Correlation function

Source function
(Distribution of pair separations)

Inversion of this integral equation ==➔ Source Function

Hence Model-independent i.e Kernel independent of freeze-out conditions

3D Analysis Basics [Danielewicz and Pratt nucl-th/0501003 (v1)]

Expansion of R(q) and S(r) in Cartesian Harmonic basis

$$R(\vec{q}) = \sum_{l} \sum_{\alpha_1 \ldots \alpha_l} R^l_{\alpha_1 \ldots \alpha_l}(q)\, \mathcal{A}^l_{\alpha_1 \ldots \alpha_l}(\Omega_q) \quad (1)$$

$$S(\vec{r}) = \sum_{l} \sum_{\alpha_1 \ldots \alpha_l} S^l_{\alpha_1 \ldots \alpha_l}(r)\, \mathcal{A}^l_{\alpha_1 \ldots \alpha_l}(\Omega_r) \quad (2)$$

x=out-direction

y=side-direction

z=long-direction

3D Koonin Pratt

$$R(\vec{q}) = C(\vec{q}) - 1 = 4\pi \int dr^3 K(\vec{q},\vec{r}) S(\vec{r}) \quad (3)$$

Plug in (1) and (2) into (3) ➔

$$R^l_{\alpha_1 \ldots \alpha_l}(q) = 4\pi \int dr r^2 K_l(q,r) S^l_{\alpha_1 \ldots \alpha_l}(r) \quad (4)$$

Invert (1) ➔

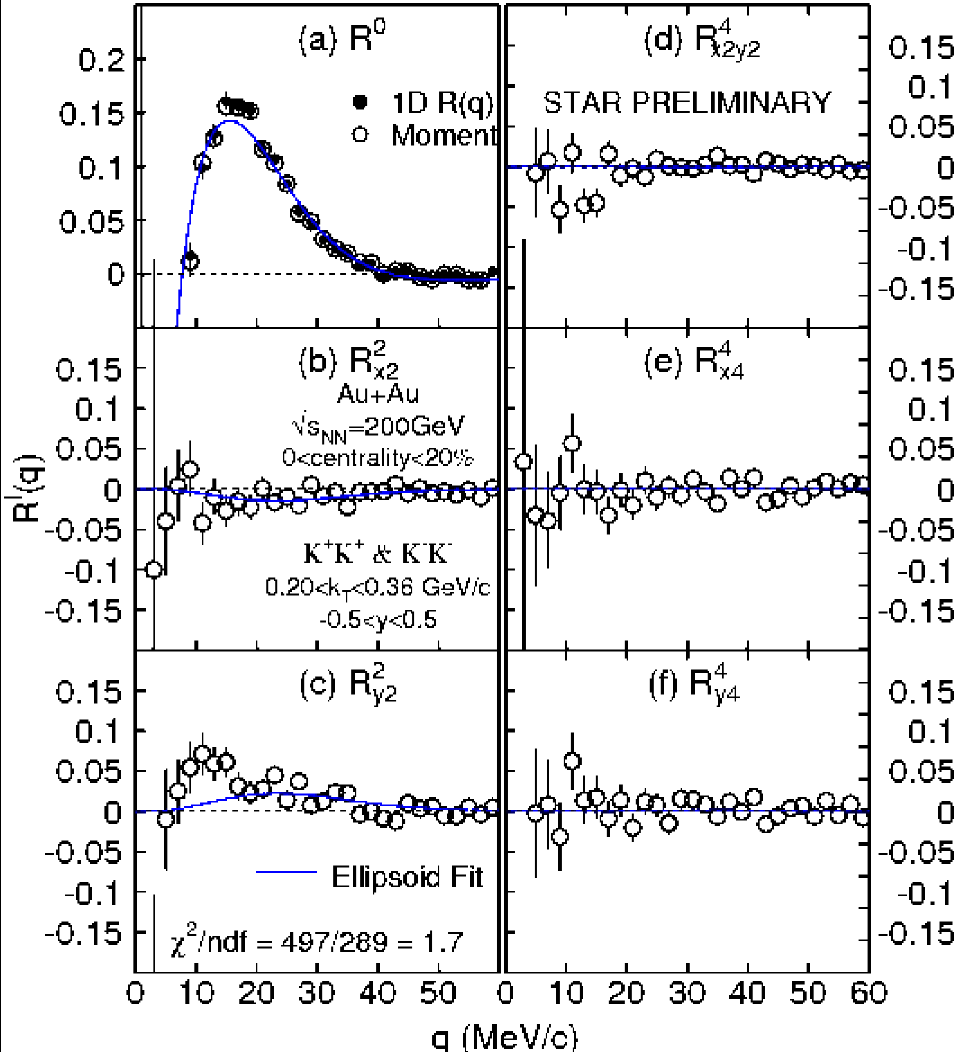
$$R^l_{\alpha_1 \ldots \alpha_l}(q) = \frac{(2l+1)!!}{l!} \int \frac{d\Omega_q}{4\pi} \mathcal{A}^l_{\alpha_1 \ldots \alpha_l}(\Omega_q) R(\vec{q}) \quad (4)$$

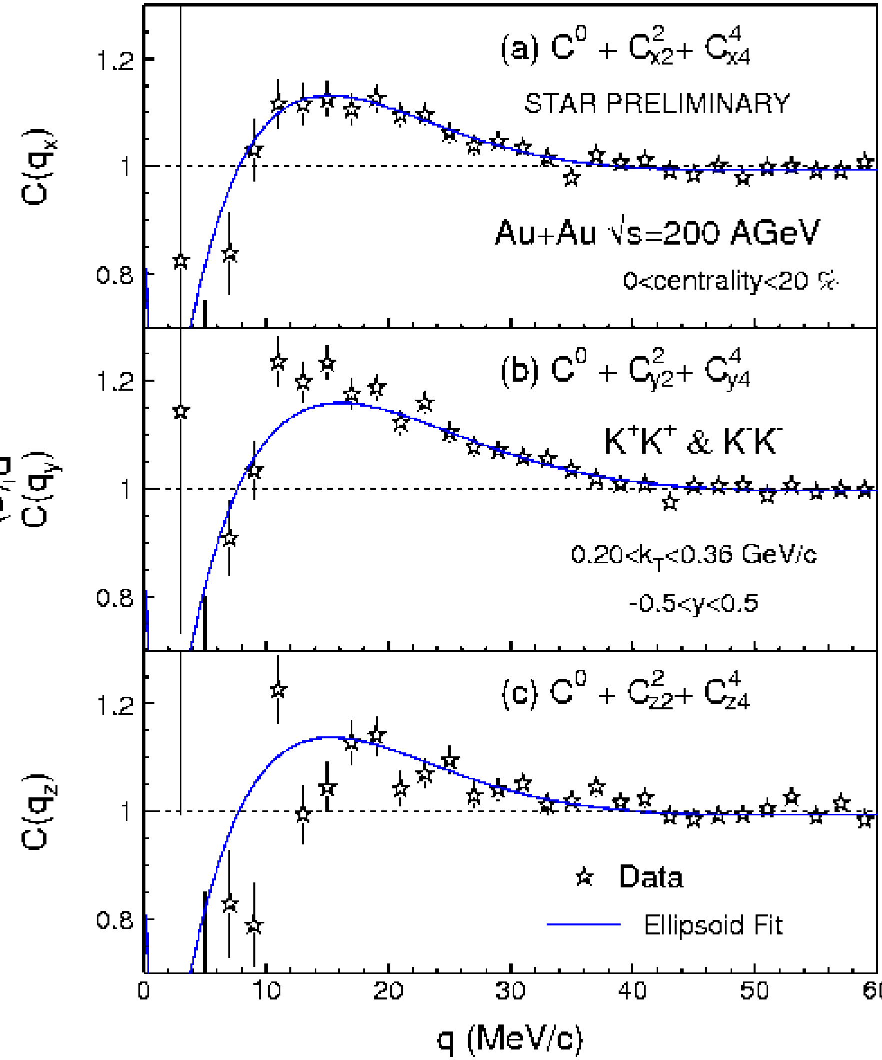
Invert (2) ➔

$$S^l_{\alpha_1 \ldots \alpha_l}(r) = \frac{(2l+1)!!}{l!} \int \frac{d\Omega_r}{4\pi} \mathcal{A}^l_{\alpha_1 \ldots \alpha_l}(\Omega_r) S(\vec{r}) \quad (5)$$

Kaon correlation moments (Runs 4 &7)

Ellipsoid shape adequate representation of 3D S(r)

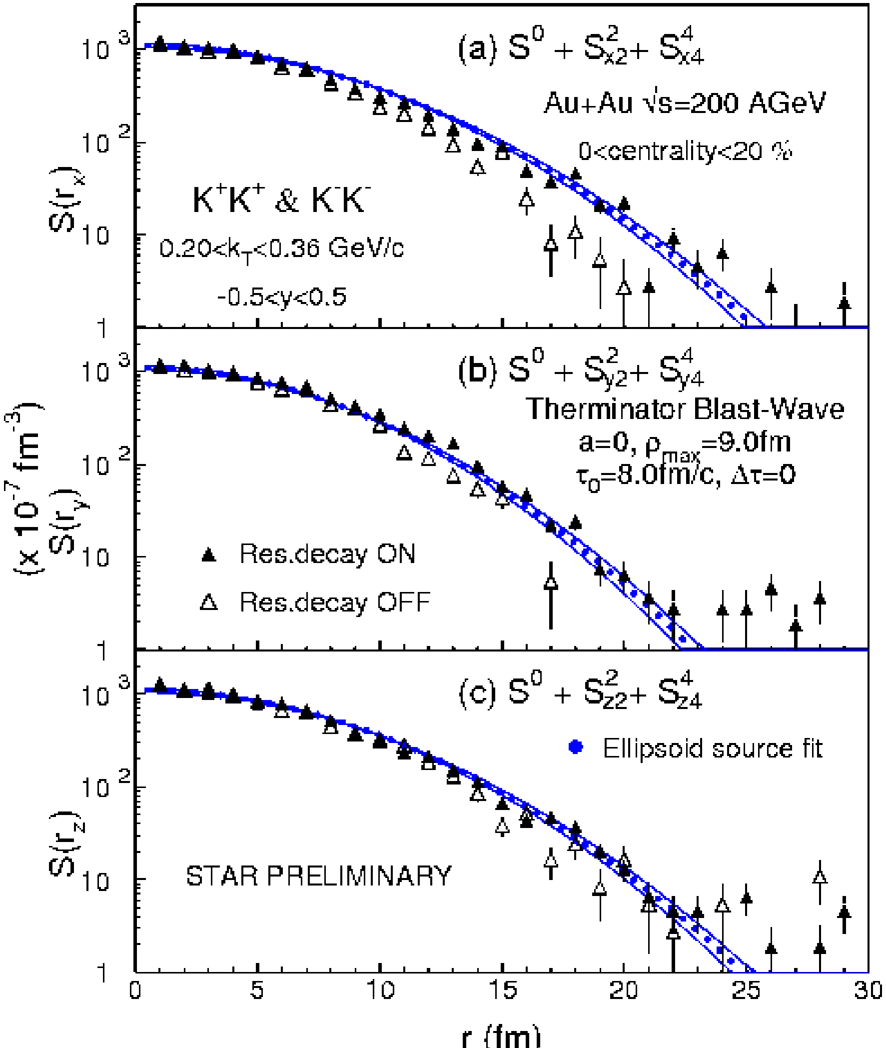


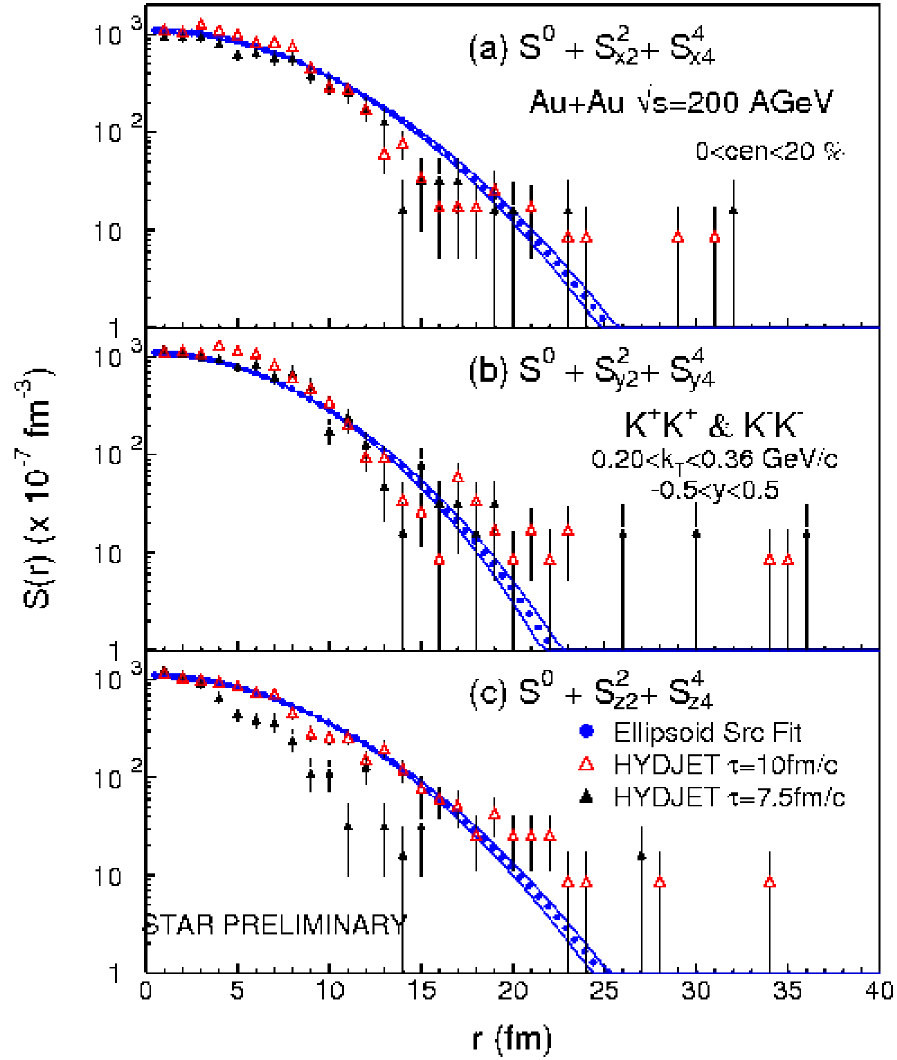


Kaon 3D Source Function

Therminator: Comput.Phys.Commun. 174, 669 (2006)

HydroDynamics with Jets (HYDJET) : arXiv: 0809.2708v2

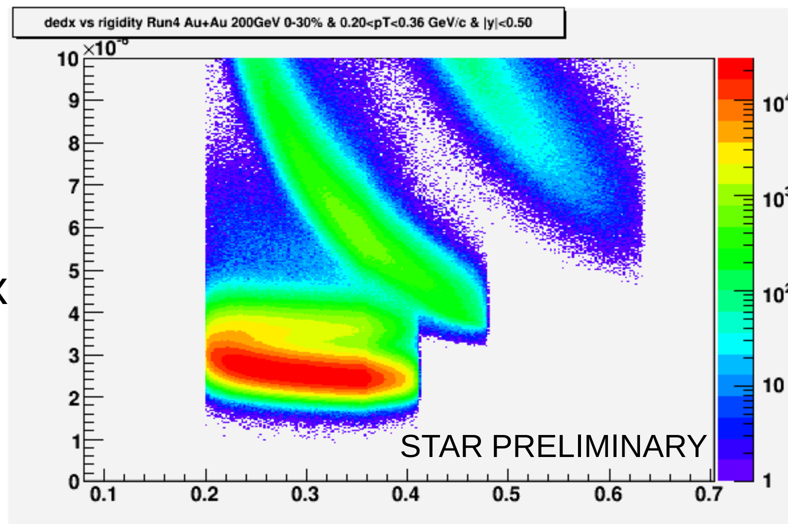




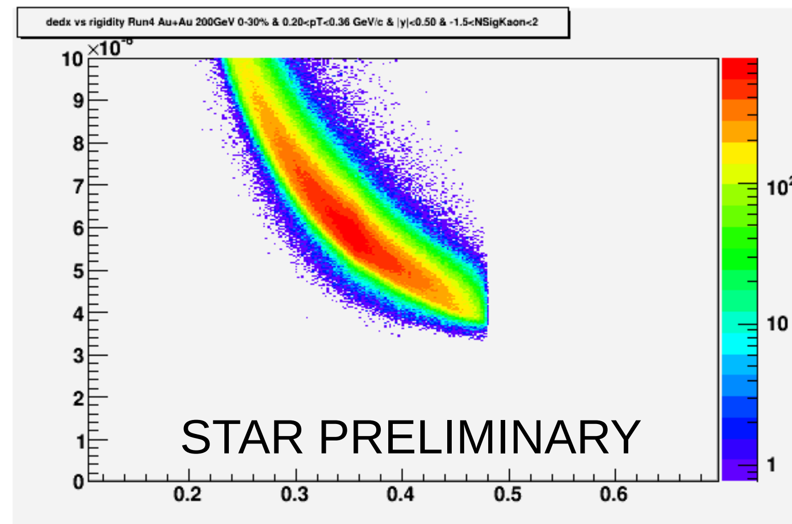
HYDJET gives larger source lifetime than THM

kaon PID @ $0.2<pT<0.36$ GeV/c
Au+Au (0-30%)

No PID selection



-1.5<Number of Sigma<2.0



dE/dx

Rigidity (GeV/c)

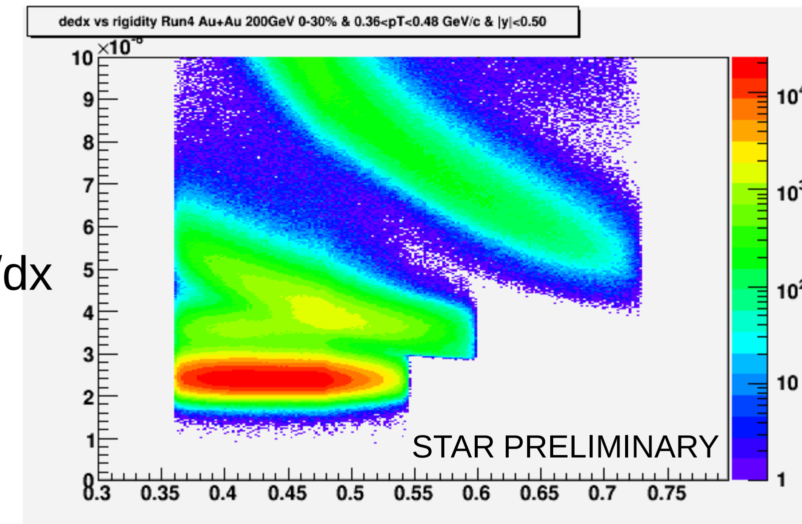
Rigidity (GeV/c)

kaon PID @ 0.36<pT<0.48 GeV/c Au+Au (0-30%)

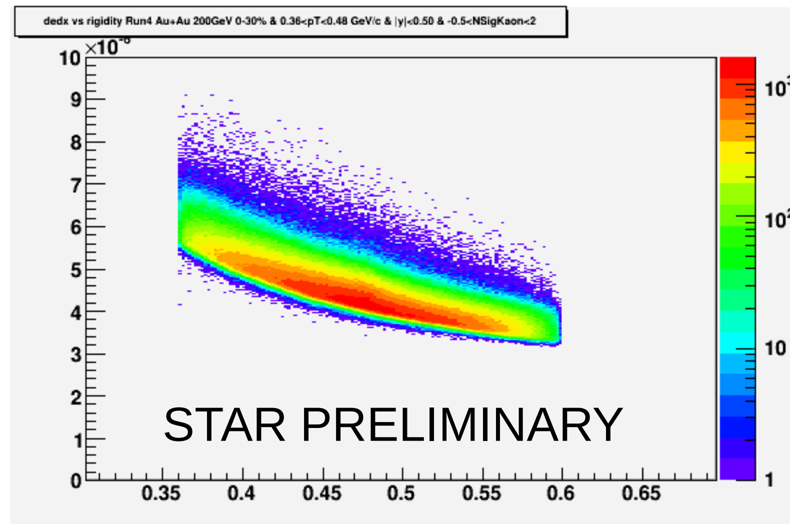
No PID selection

-0.5<Number of Sigma<2.0

dE/dx

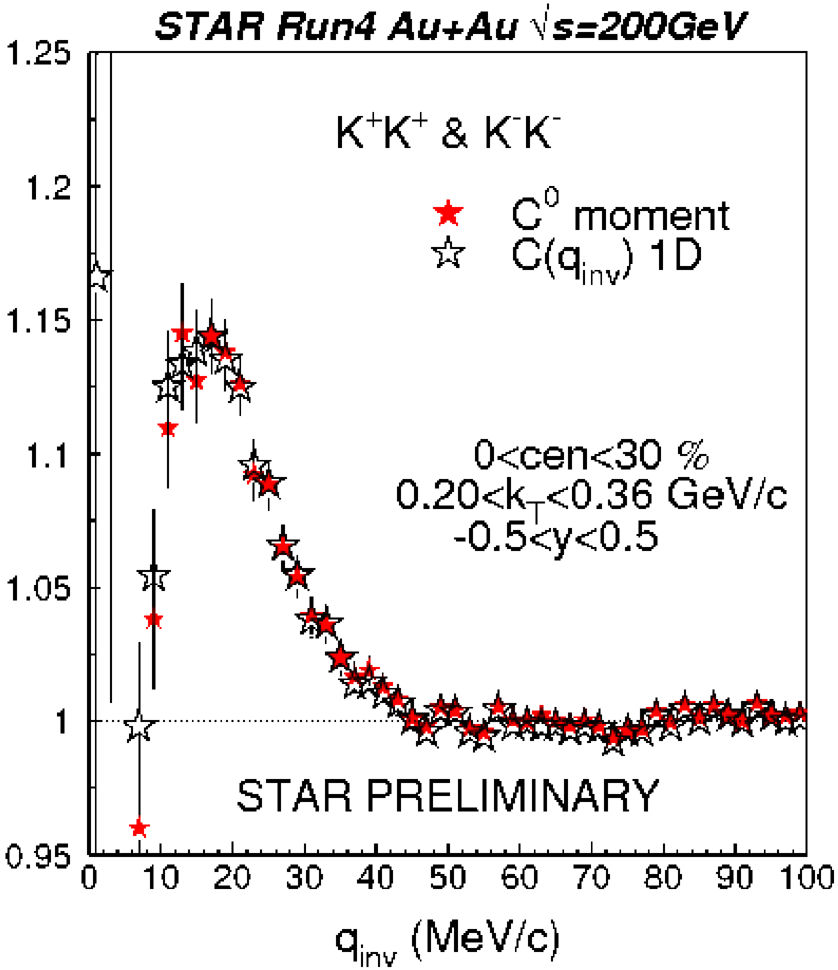


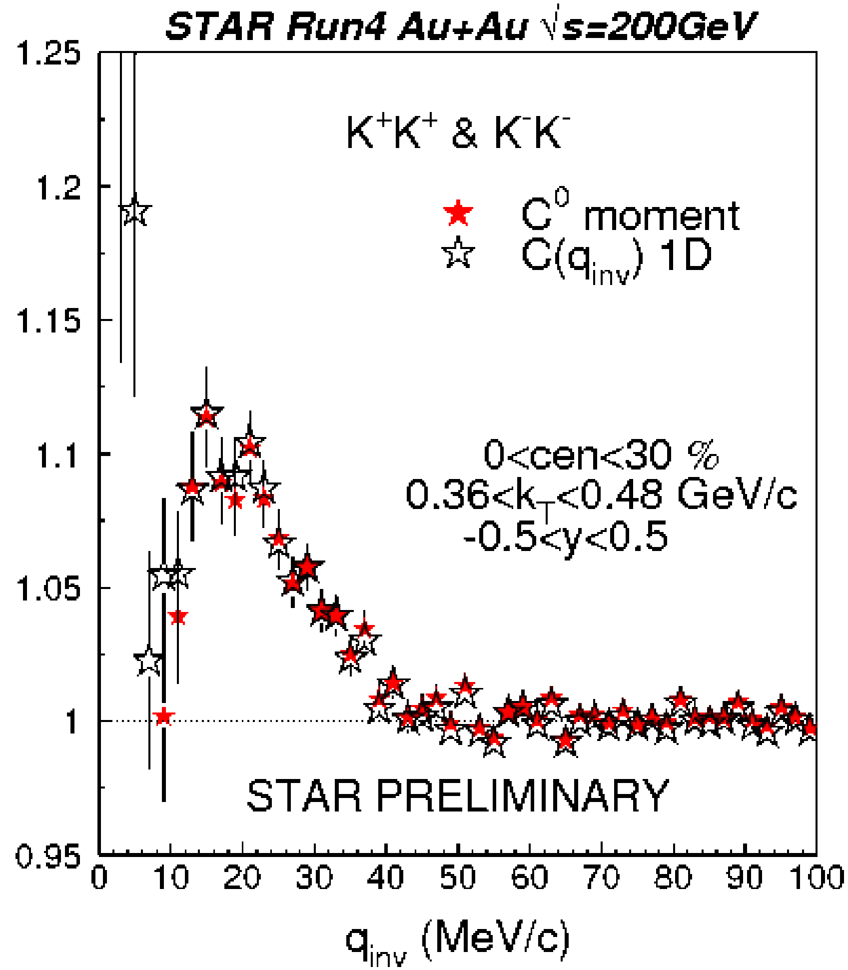
Rigidity (GeV/c)



Rigidity (GeV/c)

Run4 Kaon CF: L=0 moment

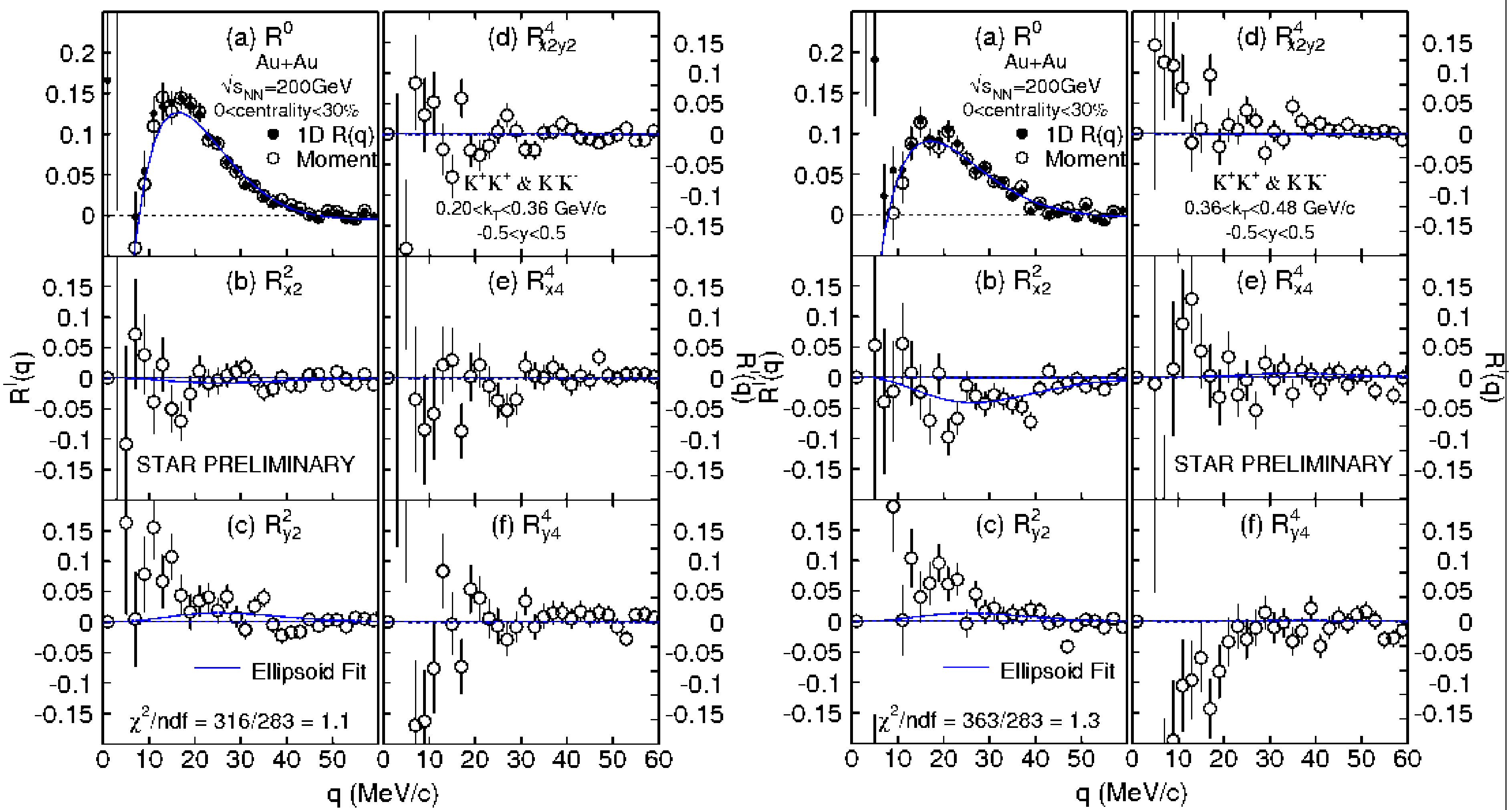




L=0 moment in agreement with 1D C(q)

Kaon Ellipsoid Fits

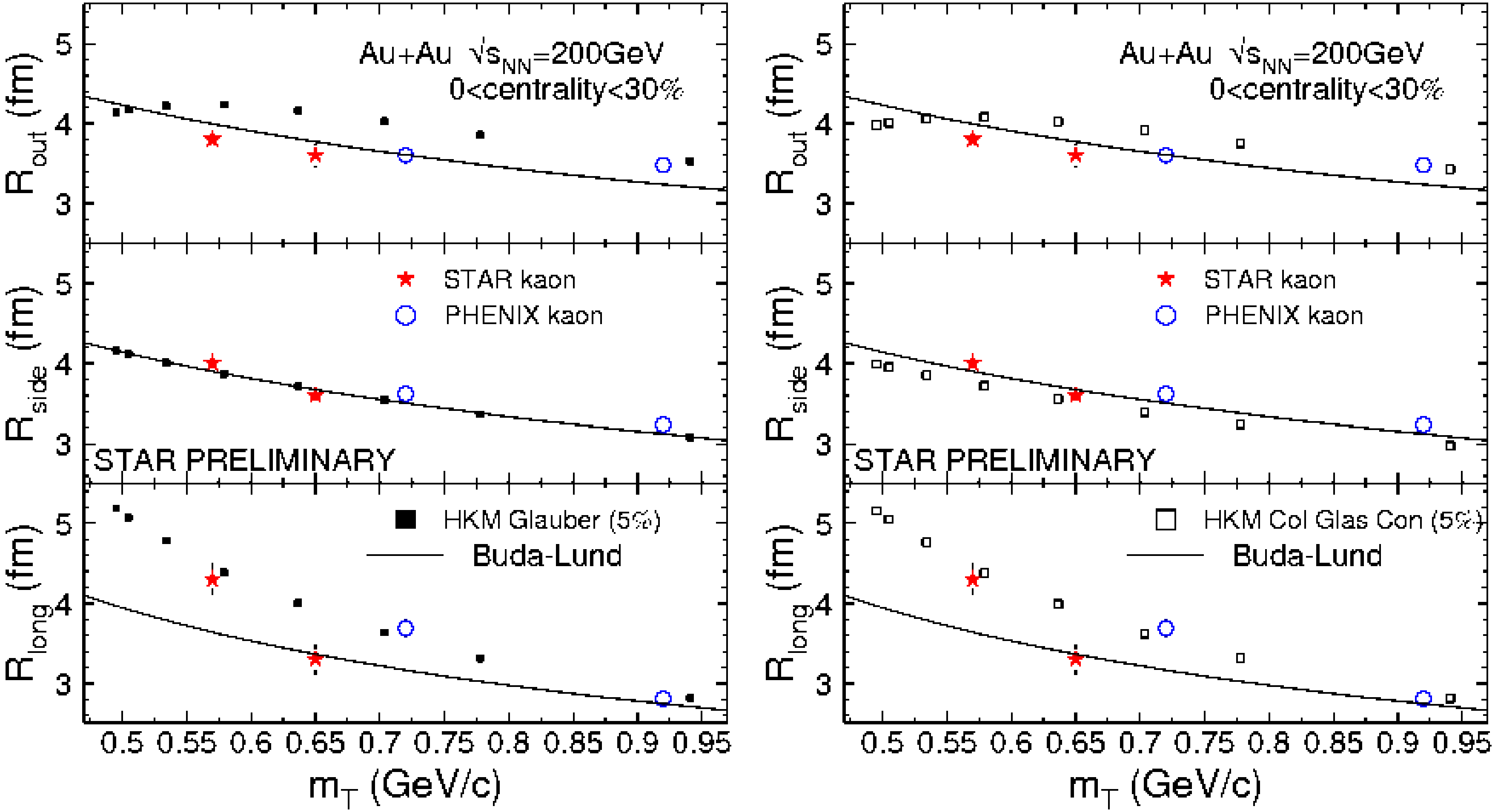
Ellipsoid shape adequate representation at both K_T bins



Buda-Lund & HKM model comp.

Buda-Lund: arXiv:0801.4434v2

HKM: PRC81, 054903 (2010)



Conclusion

- Extracted Kaon source functions from 200GeV Au+Au collisions essentially Gaussian in shape
- Gaussian source well reproduced by Therminator calcs: compatible source freeze-out conditions as for pions
- Hydjet (2-Temperature model) vs Therminator (1-temperature model) => larger source lifetime
- Gaussian radii in agreement with Buda-Lund prediction at higher K_T bin, disagrees at lower K_T bin => apparent violation of mT scaling between pion and kaon Gaussian radii
- HKM prediction looks promising but for centrality difference