HBT at LHC
in a Multiphase Transport Model

Z.W. Lin[1], B.W. Zhang[2], and C.M Ko[3]

[1]East Carolina University
[2]Huazhong Normal University
[3]Texas A&M University

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Hanbury-Brown-Twiss interferometry

Two-particle correlation function

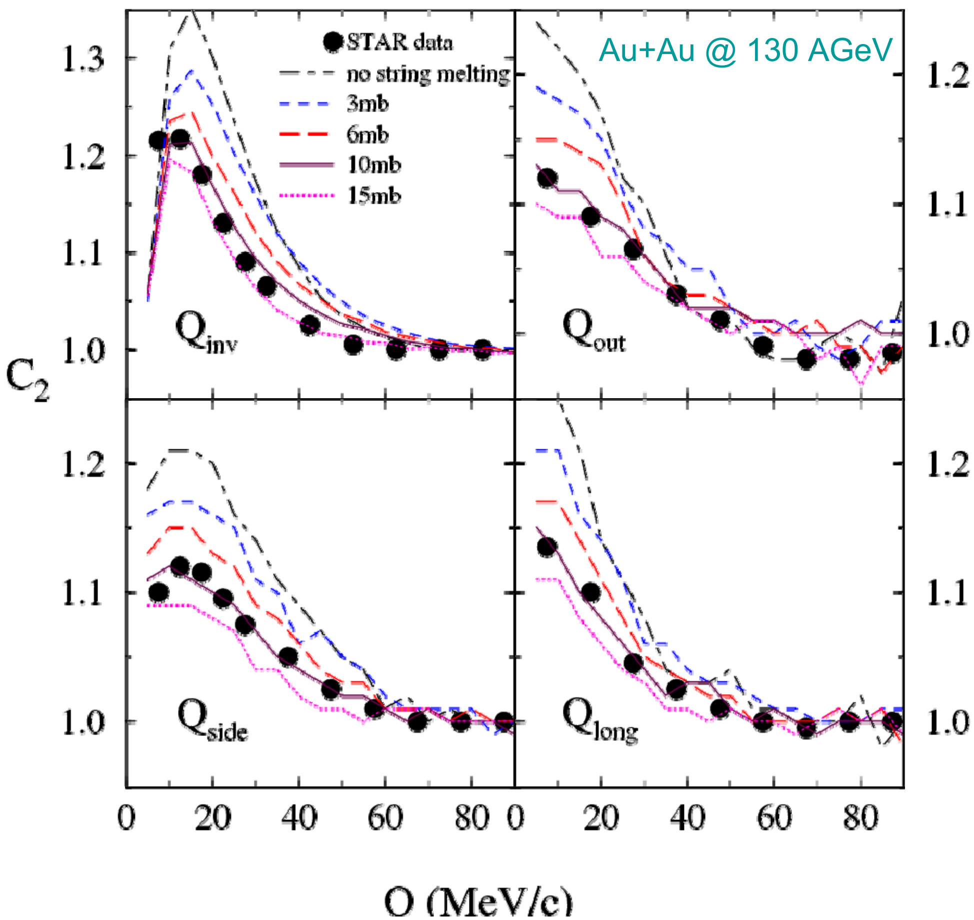
$$C(\vec{K},\vec{q}) = 1 + \frac{\int d^4x_1 d^4x_2 S(x_1,p_1) S(x_2,p_2) \cos[q\cdot(x_1-x_2)]}{\int d^4x_1 S(x_1,p_1) \int d^4x_2 S(x_2,p_2)}$$

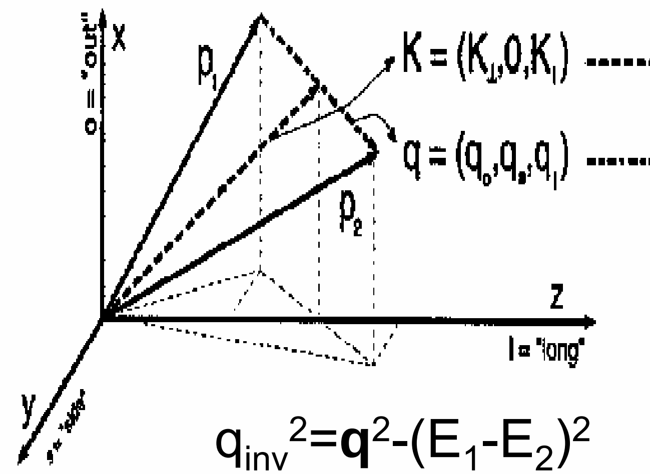
with $\vec{K} = \left(\vec{p}_1 + \vec{p}_2\right)/2,\ \ q = (\vec{p}_1 - \vec{p}_2,\ E_1 - E_2)$

- S(x,p) is the emission source function and is given by the phase space distribution at freeze out in the AMPT model
- C(K,q) can be evaluated using Correlation After Burner (Pratt, NPA 566, 103c (94))

Two-pion correlation functions at RHIC

Lin, Ko & Pal, PRL 89, 152301 (2002)



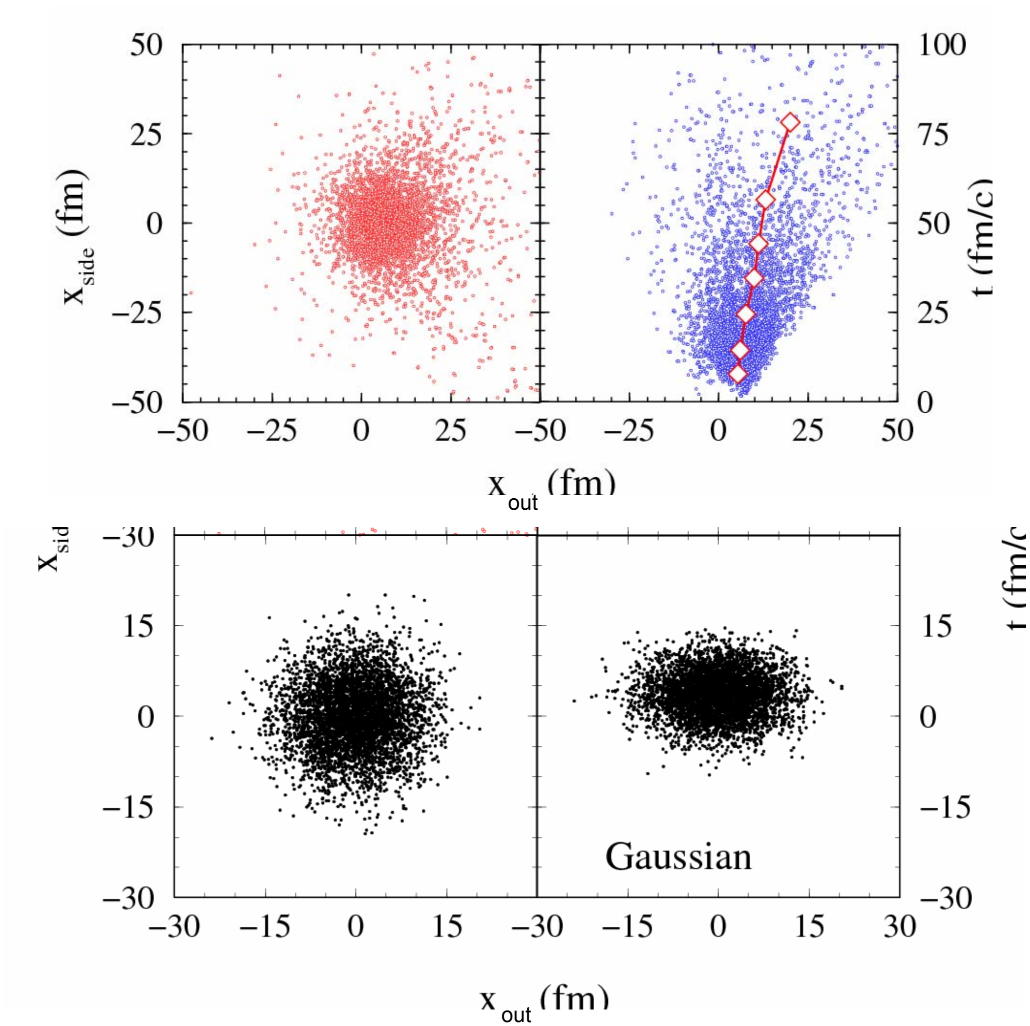


$q_{inv}^2 = \mathbf{q}^2 - (E_1 - E_2)^2$

- For pions with -0.5< y < 0.5 and 125 < p_T < 225 MeV/c in central collisions
- Projected correlation functions evaluated with other two Q components integrated from 0 to 35 MeV/c

- Need string melting and large parton scattering cross section to reproduce data

Emission source function for pions



- Upper: emission source from AMPT
  - Shift in out direction
  - Strong correlation between out position and emission time
  - Large halo due to resonance (ω) decay and explosion
  - → non-Gaussian source
- Lower: Gaussian source fitted to correlation functions

Source radii from emission function

Pratt showed in ’84 $C(\vec{K},\vec{q}) \cong 1 + \left| \left\langle \exp\left[i\vec{q} \cdot (\vec{x} - \vec{\beta} t) \right] \right\rangle \right|^2$

with β=K/(E_1+E_2) and averaging over emission function S(x,p)

Source radii
$$R_{ij}^2 = -\frac{1}{2} \frac{\partial^2 C(\vec{K},\vec{q})}{\partial q_i \partial q_j} \Big|_{q=0} = \left\langle (\tilde{x}_i - \beta_i \tilde{t})(\tilde{x}_j - \beta_j \tilde{t}) \right\rangle$$
$$= D_{x_i,x_j} - D_{x_i,\beta_j t} - D_{\beta_i t, x_j} + D_{\beta_i t, \beta_j t}$$

with $\tilde{x} = x - \langle x \rangle, \quad D_{x,y} = \langle xy \rangle - \langle x \rangle \langle y \rangle$

Source radii from Gaussian fit to correlation function

$$C(\vec{K},\vec{q}) = 1 + \lambda \exp\left[-\sum_{i,j} R_{ij}^2 \left(\vec{K} \right) q_{ij}^2 \right]$$

Similar radii only for a Gaussian emission function without strong space-momentum correlation

Source radii in the out-side-long coordinates

$$R_{out}^{2} = D_{x_{out},x_{out}} - 2D_{x_{out},\beta_{\perp}t} + D_{\beta_{\perp}t,\beta_{\perp}t}$$

$$R_{side}^{2} = D_{x_{side},x_{side}}$$

$$R_{long}^{2} = D_{x_{long},x_{long}} + D_{\beta_{\parallel}t,\beta_{\parallel}t}$$

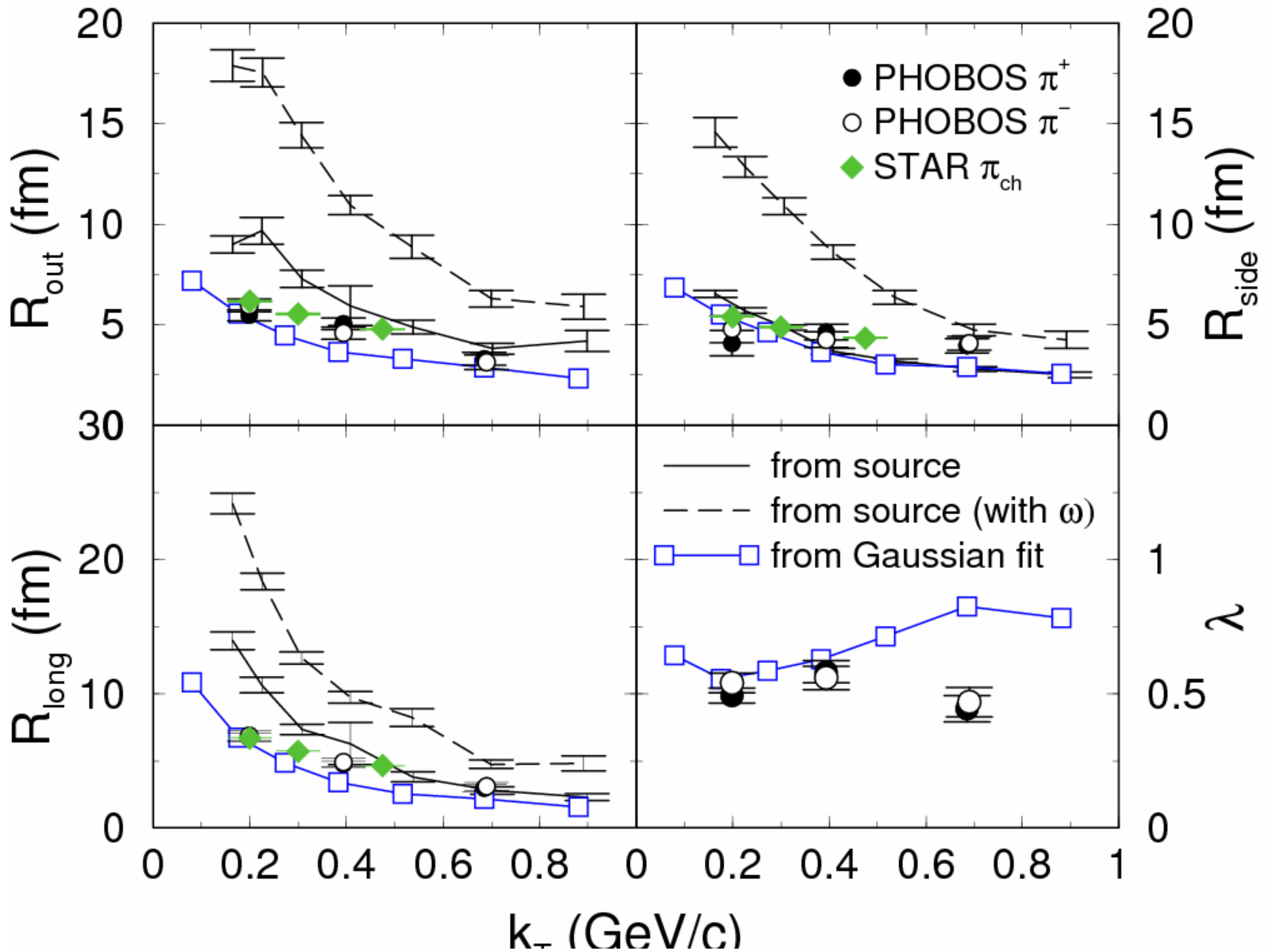
For pion pairs with K_T~200 MeV/c, AMPT gives

$$R_{out} \approx 17\ \text{fm}, \quad D_{x_{out},x_{out}} \approx 185\ \text{fm}^2,$$

$$D_{x_{out},\beta_{\perp}t} \approx 168\ \text{fm}^2, \quad D_{\beta_{\perp}t,\beta_{\perp}t} \approx 431\ \text{fm}^2$$

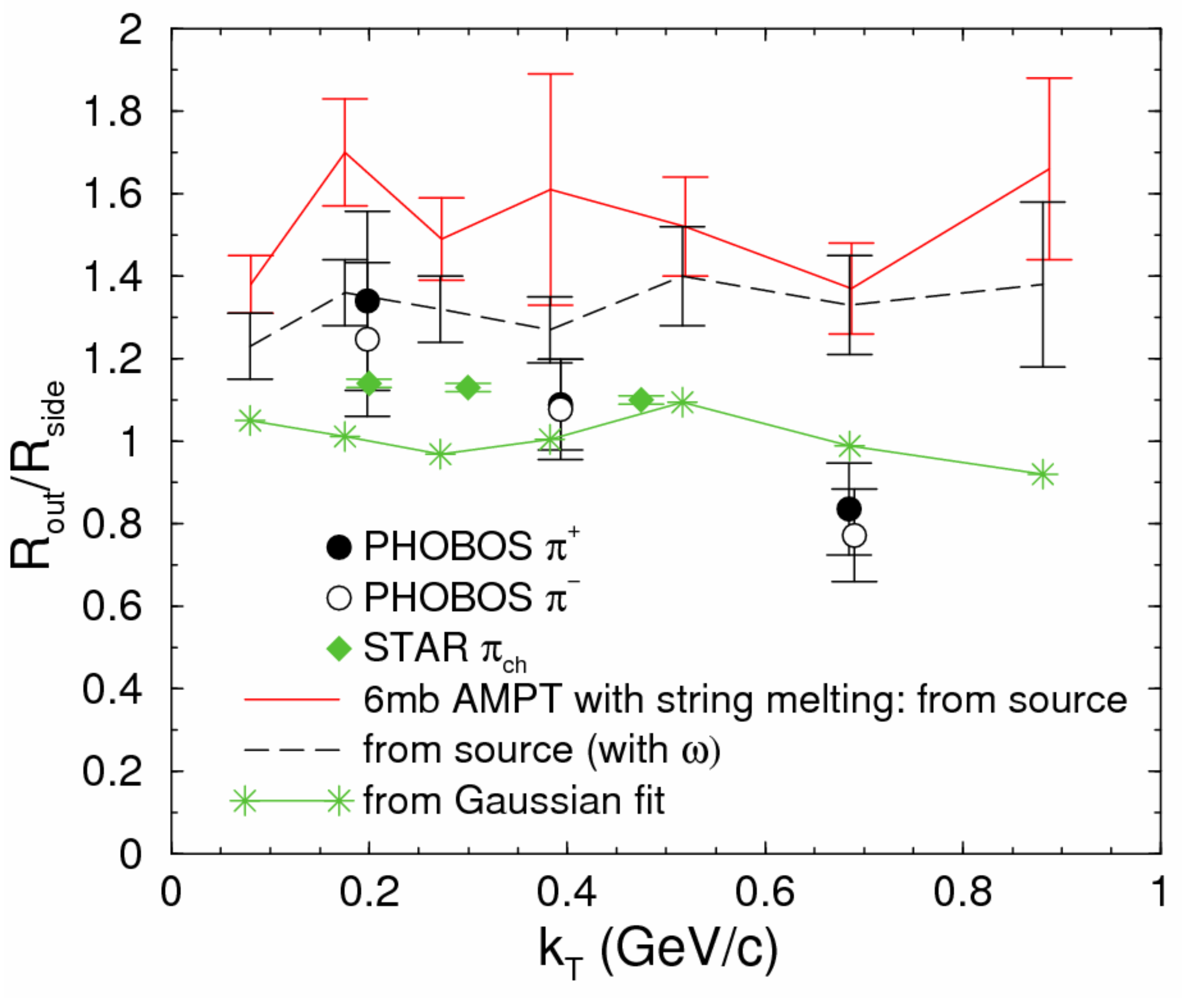
- Large positive out position and emission time correlation reduces out radius
- Without x_{out}-t correlation, R_{out} will be even larger

Radii of pion emission source



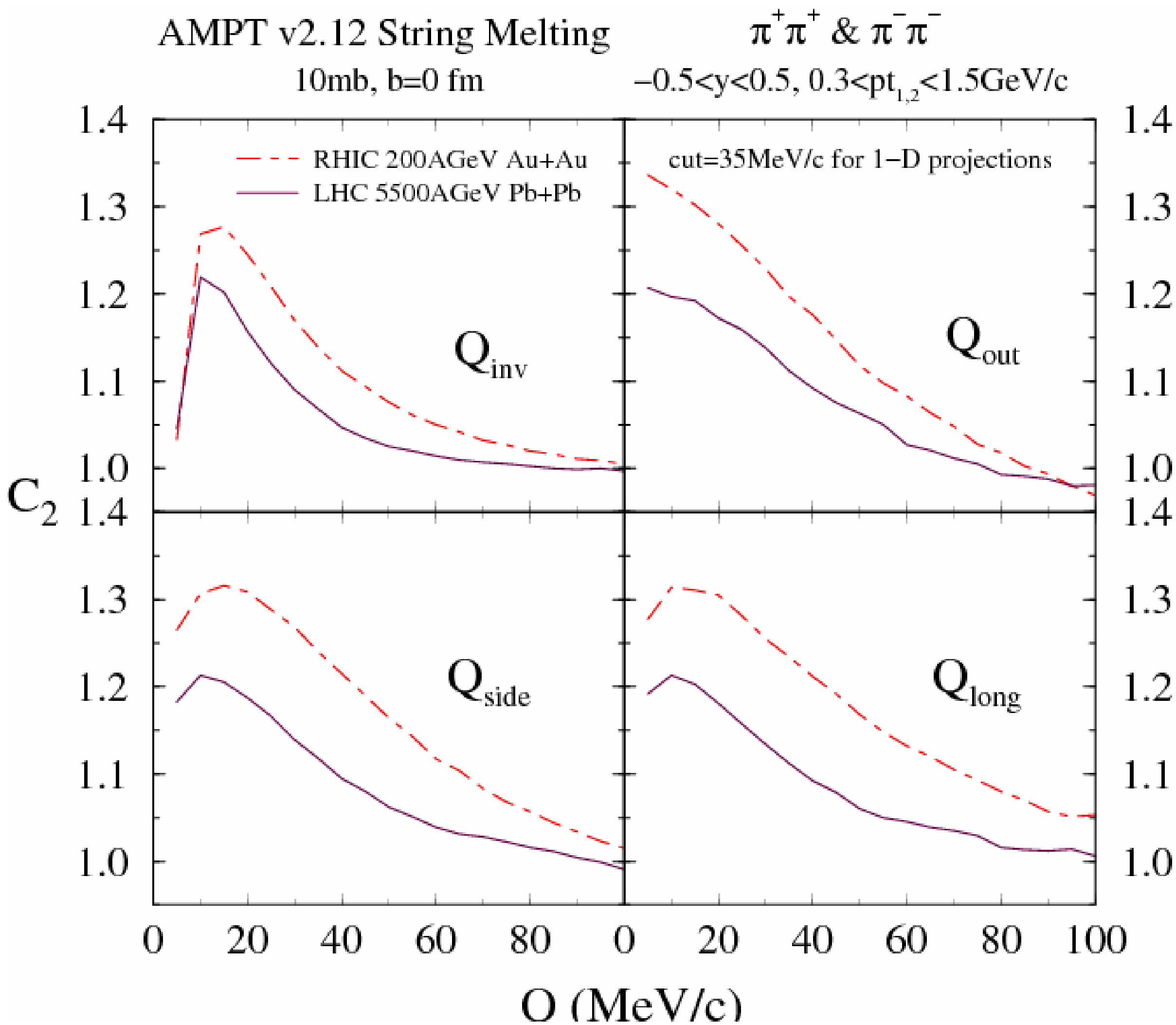
- Radii from emission function > radii from Gaussian fit
- Including ω decay leads to larger radii

Ratio of source radii from AMPT



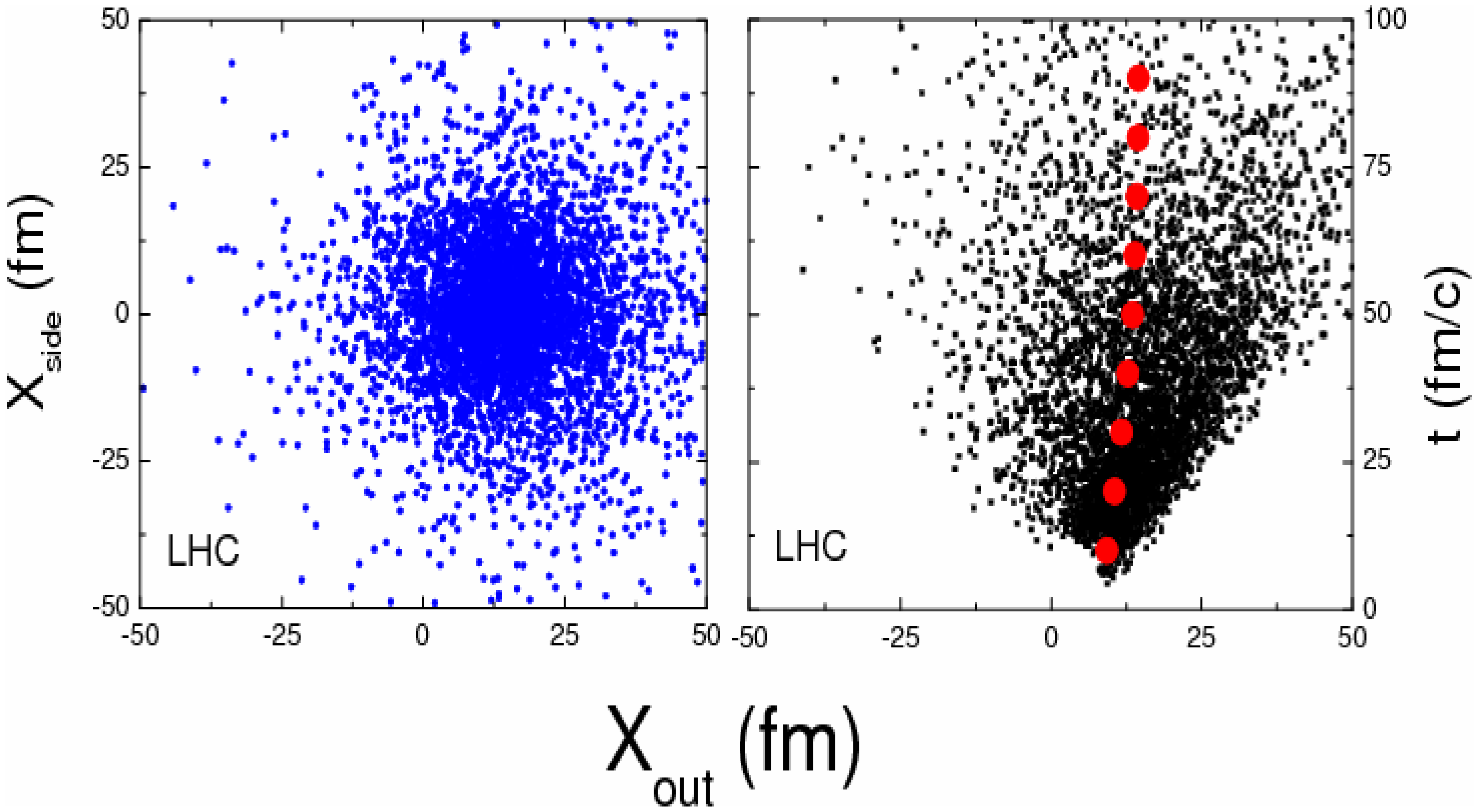
R_{out}/R_{side} >1 is larger from emission function than from Gaussian fit

Pion interferometry at LHC



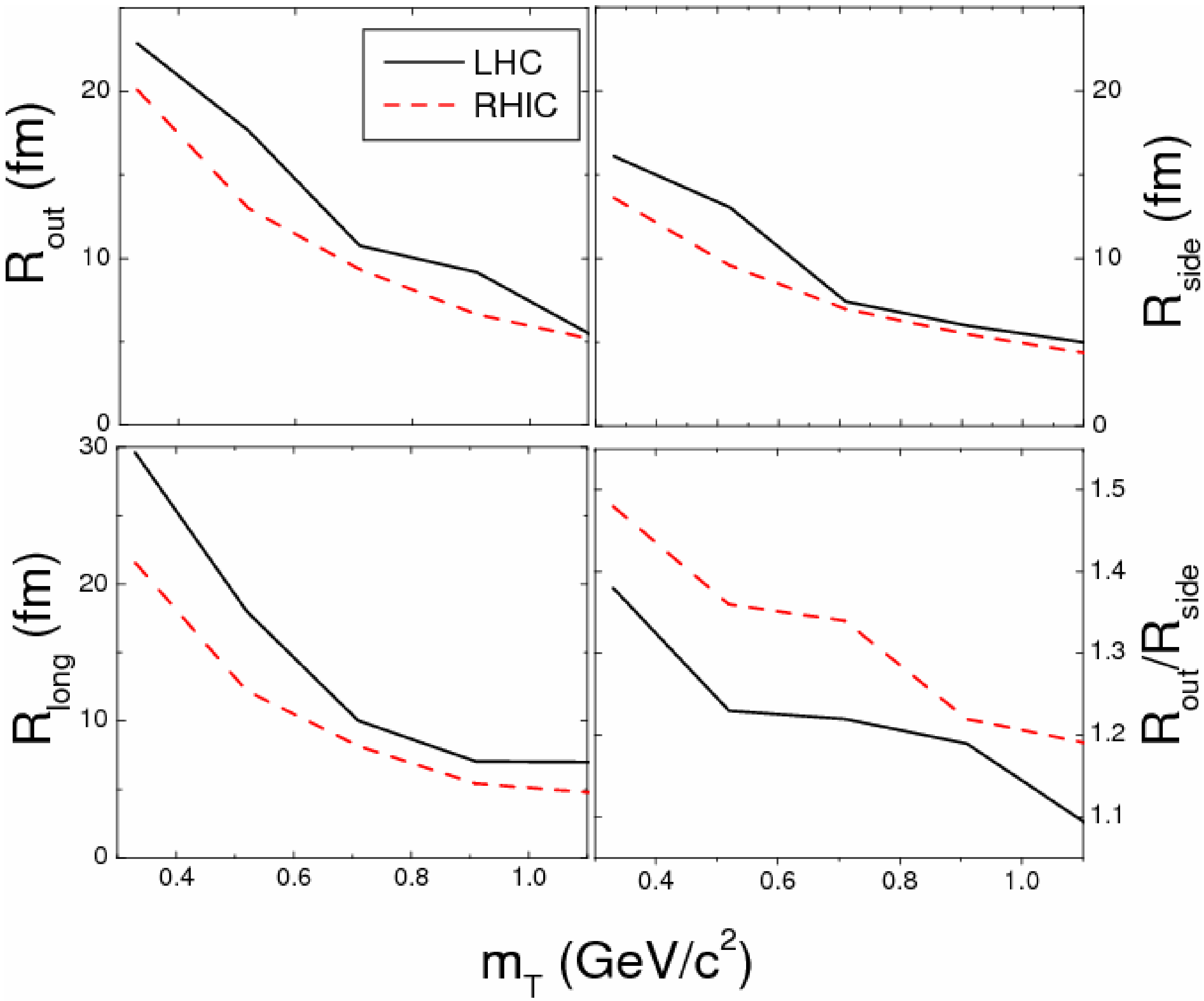
Two-pion correlation functions smaller at LHC than at RHIC

Pion emission source at LHC: Pb+Pb @ 5.5 ATeV



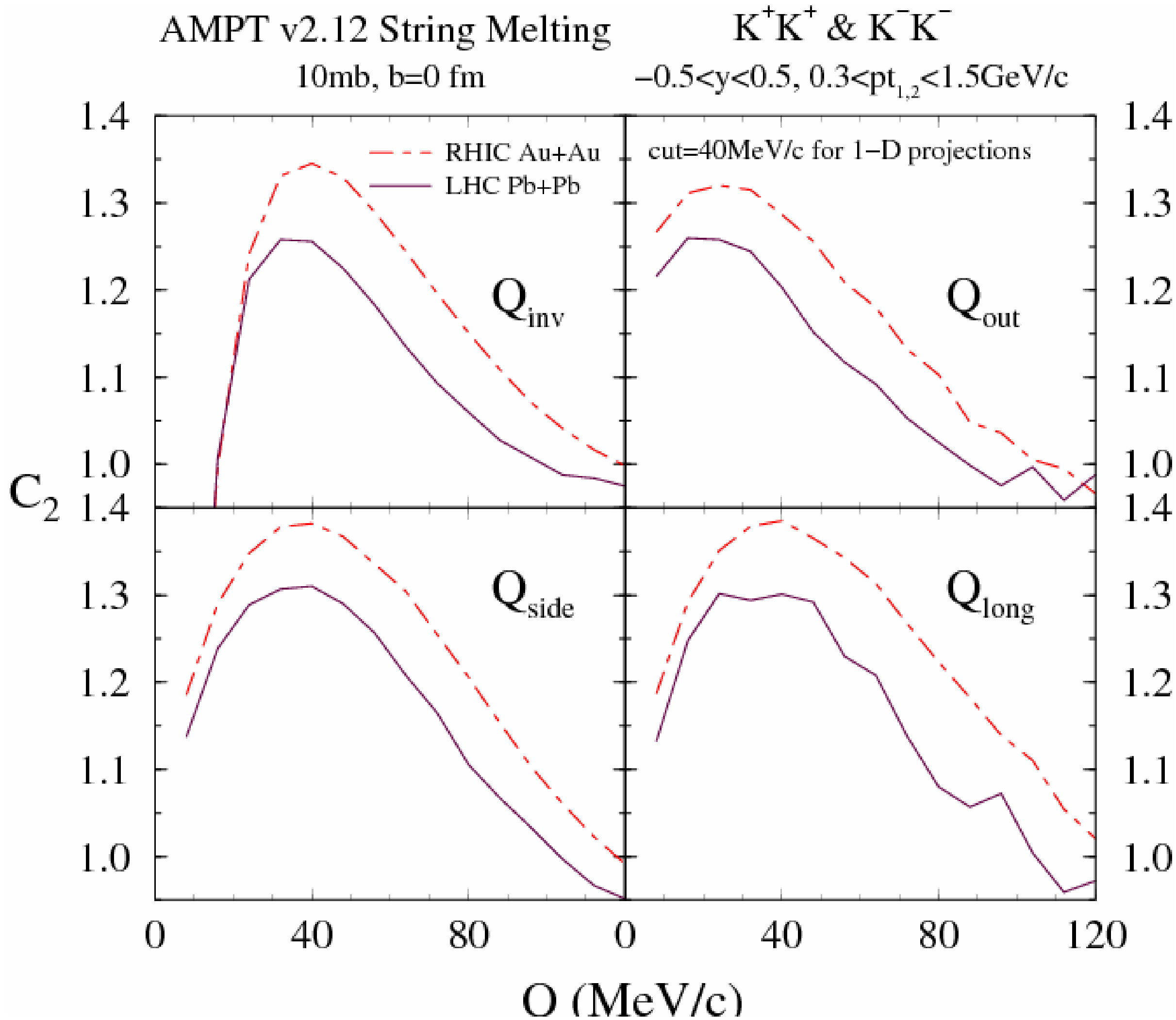
As at RHIC, the source is shifted in out direction, has strong correlation in out position and emission time, has a large halo, and is non-Gaussian

Radii of pion source at LHC: Pb+Pb @ 5.5 ATeV



Larger source radii at LHC than at RHIC

Kaon interferometry



Two-kaon correlation functions smaller at LHC than at RHIC

Radii from Gaussian fit to correlation functions

$$C_2(\vec{Q},\vec{K}) = 1 + \lambda \exp\left(-\sum_{i=1}^{3} R_{ii}^2(K) Q_i^2 \right)$$

	R_{out}(fm)	R_{side}(fm)	R_{long}(fm)	λ	R_{out}/R_{side}
RHIC (π)	3.60	3.52	3.23	0.50	1.02
LHC (π)	4.23	4.70	4.86	0.43	0.90
RHIC (K)	2.95	2.79	2.62	0.94	1.06
LHC (K)	3.56	3.20	3.16	0.89	1.11

Source radii for pions are larger than for kaons and both are larger at LHC than at RHIC

Summary

Compared to RHIC, heavy ion collisions at LHC have

- also non-Gaussian emission source that is shifted in the out direction, has strong correlation in out position and emission time as well as a large halo
- smaller two-pion and two-kaon correlation functions and larger source radii