Two-particle correlations at ultrarelativistic energies in QGSM.

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Outline

- Motivation
- Model
- 1D Correlations
- Choice of baseline
- Testing of fitting strategies
- 3D Correlations
- Conclusions

Motivation

- LHC has provided new 900 GeV and 7 TeV pp collision data.
- First pion 1D and 3D correlation radii have been measured.

- The Quark Gluon String Model (QGSM) describes well the dN/dη dN/dp_t and <p_t> of charged hadrons etc in pp collisions at LHC.

- It is natural to check how well it can describe the femtoscopic momentum correlations

General motivation: Within hydrodynamic models kT dependence of the correlation radii is considered as a signature of collective flow.

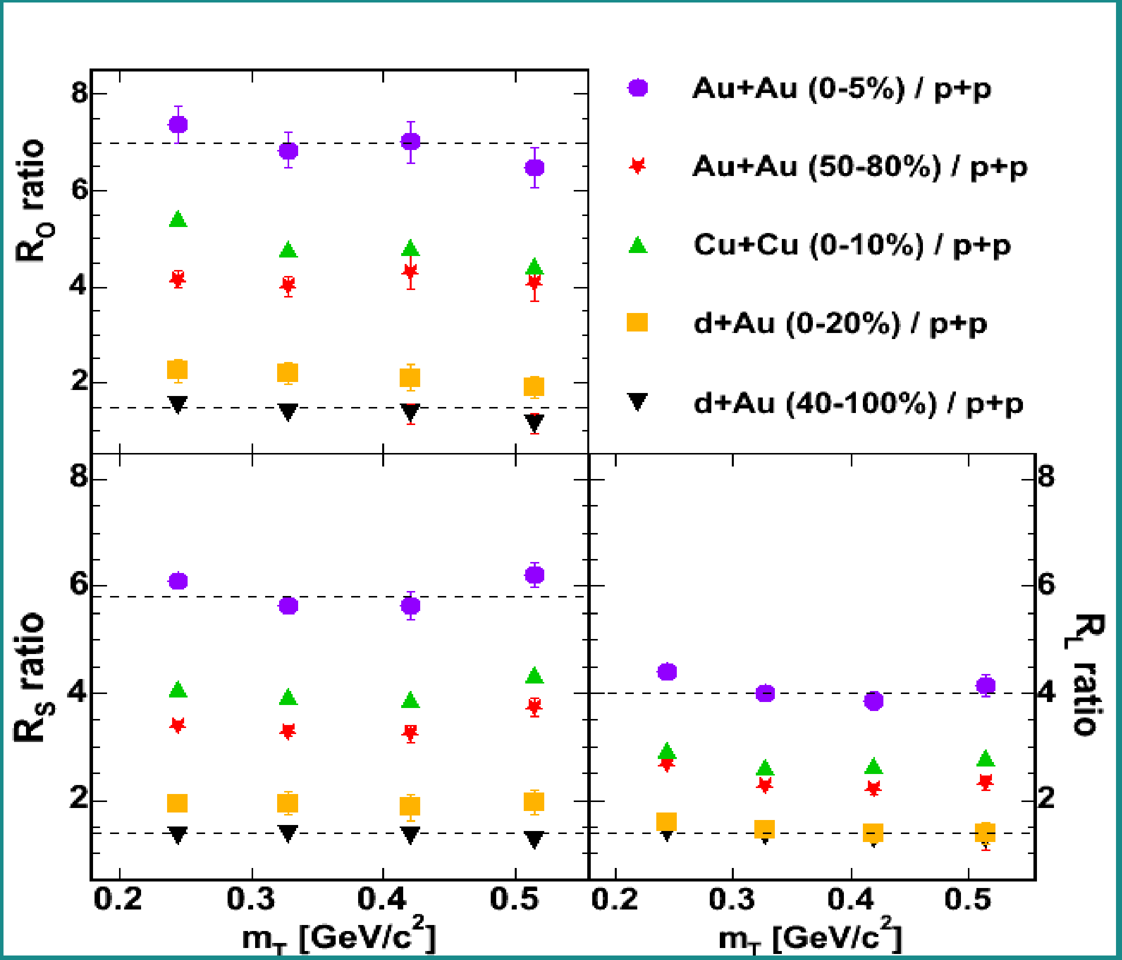
Transport models, considering the full microscopic picture of the particle production/emission/rescattering processes, might throw light on the other mechanisms generating the observed k_t-dependence of the correlation radii in pp and heavy ion collisions.

Femtoscopy in pp STAR data

Mt dependence ("x-p" correlations) in very small systems (pp, e+e-) is usually attributed to:
- -string fragmentation
- -resonance contribution
- -Heisenberg uncertainty
- -jets

All Kt(mt) dependences of correlation radii observed by STAR scale with pp (!?) although the expected origins of these dependences are different.

ALICE didn't observe a strong Kt dependence (!?)



Quark Gluon String Model

- Based on Gribov's Reggeon field theory
- Particles are created from the breaking of interacting strings.
- The string length $L=M_s/K$ is dependent on the string mass M_s and the string tension K.
- The length of the string varies, the maximum determined by the momentum of the incident hadron and the minimum determined by the pion mass.

Model Parameter

- In the Lund schema formation time and z-coordinate of the produced hadron are calculated in the string cms.

$$t_i^* = \frac{1}{2\kappa}\left(M_s - 2\sum_{j=1}^{i-1} p_{zj}^*\right)$$

$$z_i^* = \frac{1}{2\kappa}\left(M_s - 2\sum_{j=1}^{i-1} E_j^*\right)$$

$$a_i = a_{0\mathrm{i}} + t_i\, p_{ai} / E_i$$

$$a = x, y, z$$

Model Parameter

- An increase in string tension will cause a reduction in formation time.
- We introduce a scaling parameter α of the string tension K.
- $\alpha=1$ gives $K=K_0=0.88GeV/c$

$$\kappa=\alpha\kappa_0$$

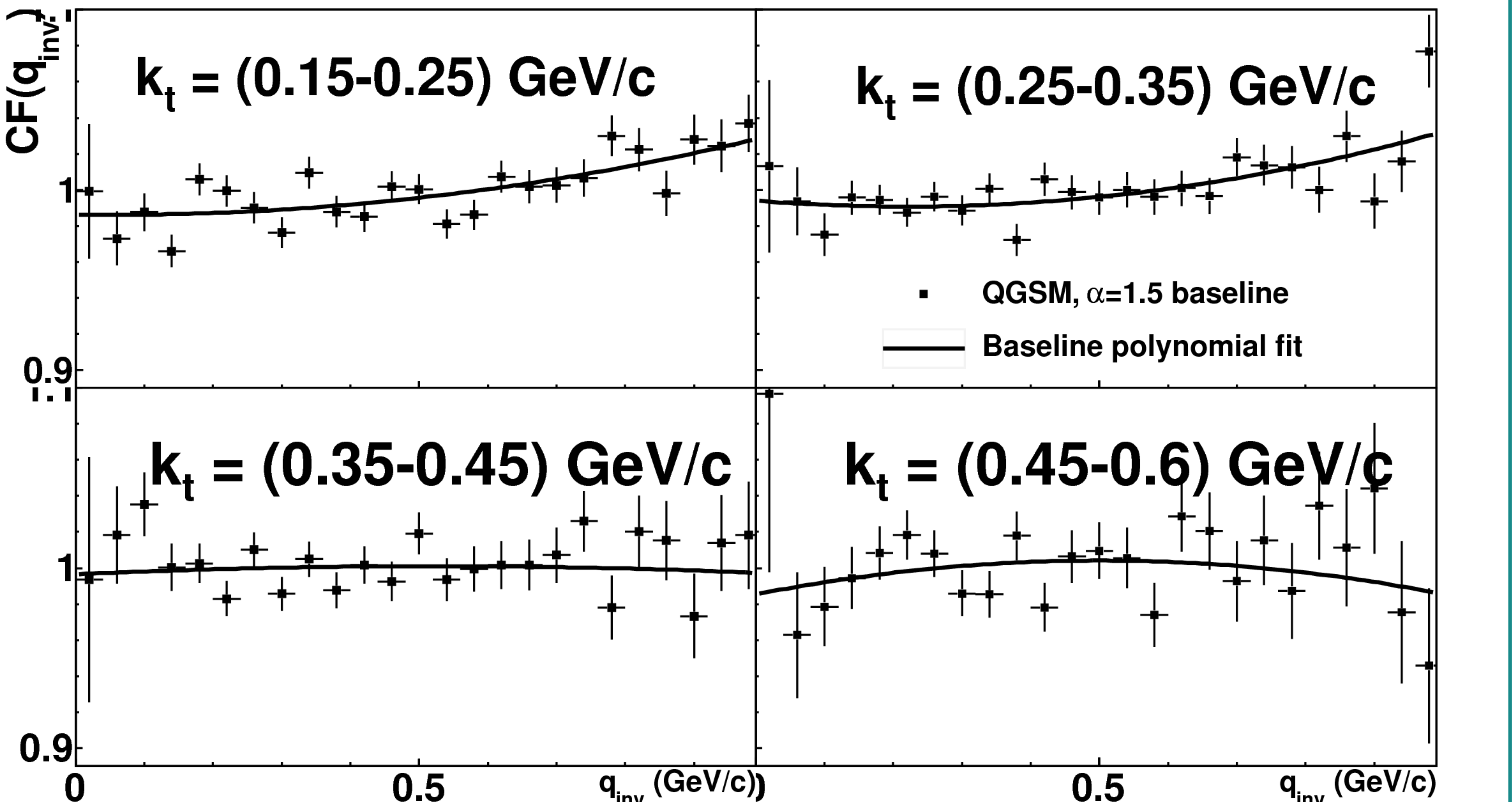
Correlation Functions

- The correlation function is defined as $C=\frac{P(q_{1,}q_2)}{Q(q_{1,}q_2)}$
- In the model $P(q_1,q_2)$ is obtained from weighting pairs from same events.
- In the model the "pure weights method" can be used: $Q(q_{1,}q_2)$ is obtained from unweighted pairs from same events.
- In experiment $Q(q_{1,}q_2)$ is obtained by mixing particles from different events.
- By using this method on the model data we obtain a more realistic correlation function.

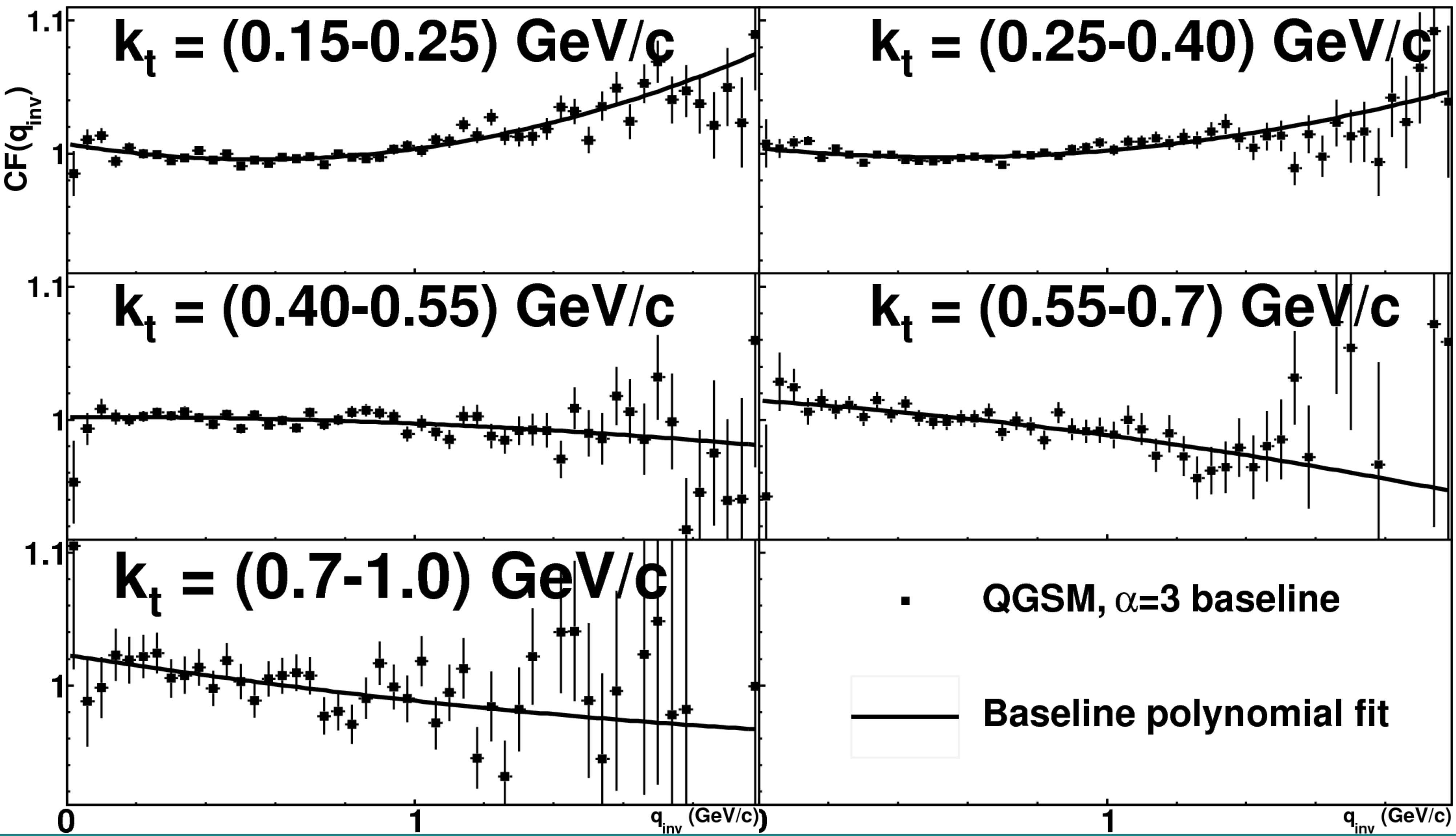
Fitting 1D correlation functions

- We use a gaussian fitting function for the correlation function. $C = N(1+\lambda e^{-q_{inv}{}^2 R_{inv}{}^2}) D(q_{inv})$
- The factor $D(q_{inv})$ accounts for long-range non-femtoscopic correlations
- We use $D(q_{inv})=1$ for “pure weights method” (no non-femtoscopic correlations)
- $D(q_{inv}) = aq_{inv}{}^2 + bq_{inv} + 1$ was used to fit the non-femtoscopic correlations.
- The parameters a and b were then fixed when fitting the correlation function.

$\pi^+\pi^+$ Baseline pp 200GeV



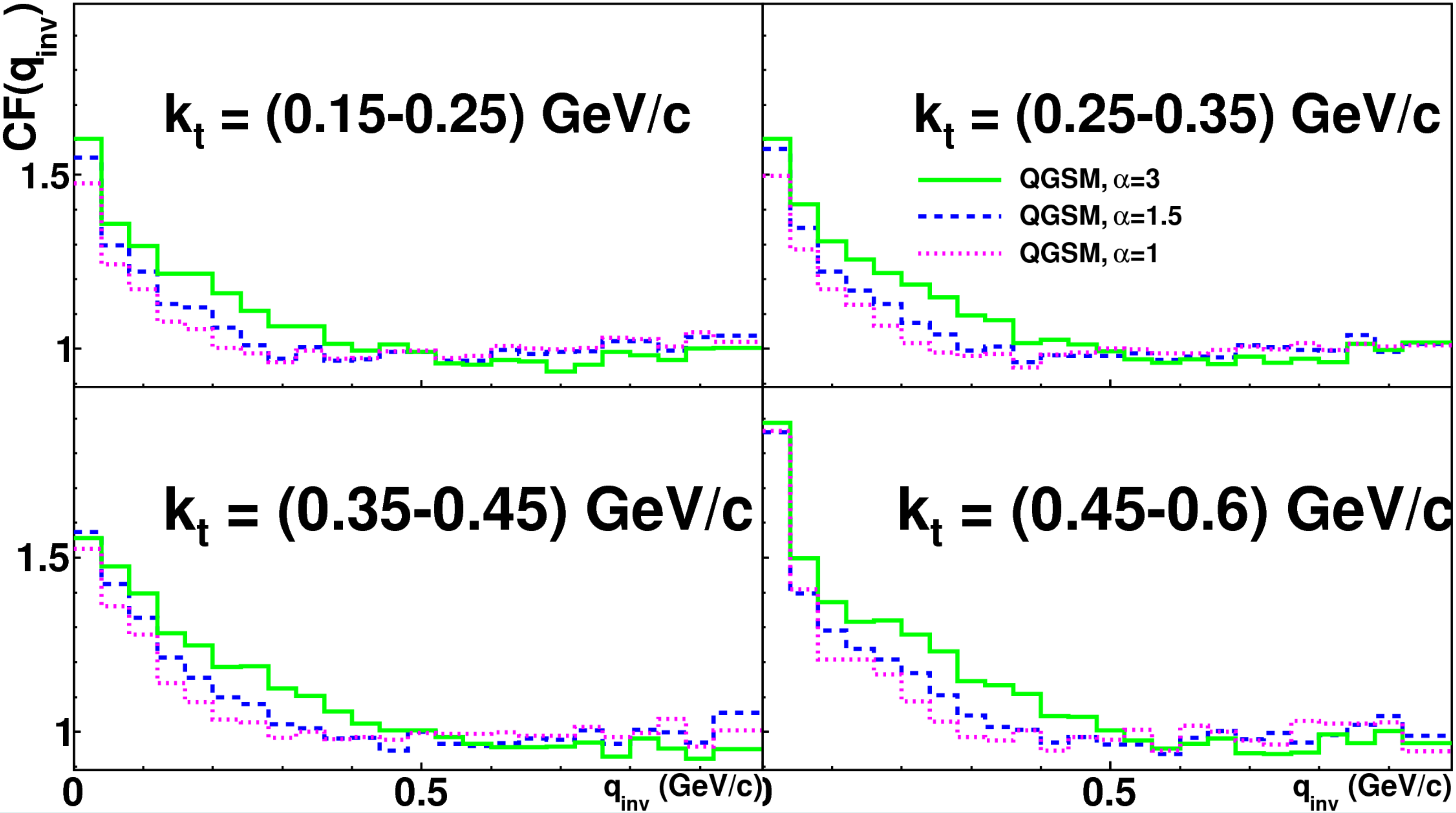
$\pi^+\pi^+$ Baseline pp 900GeV



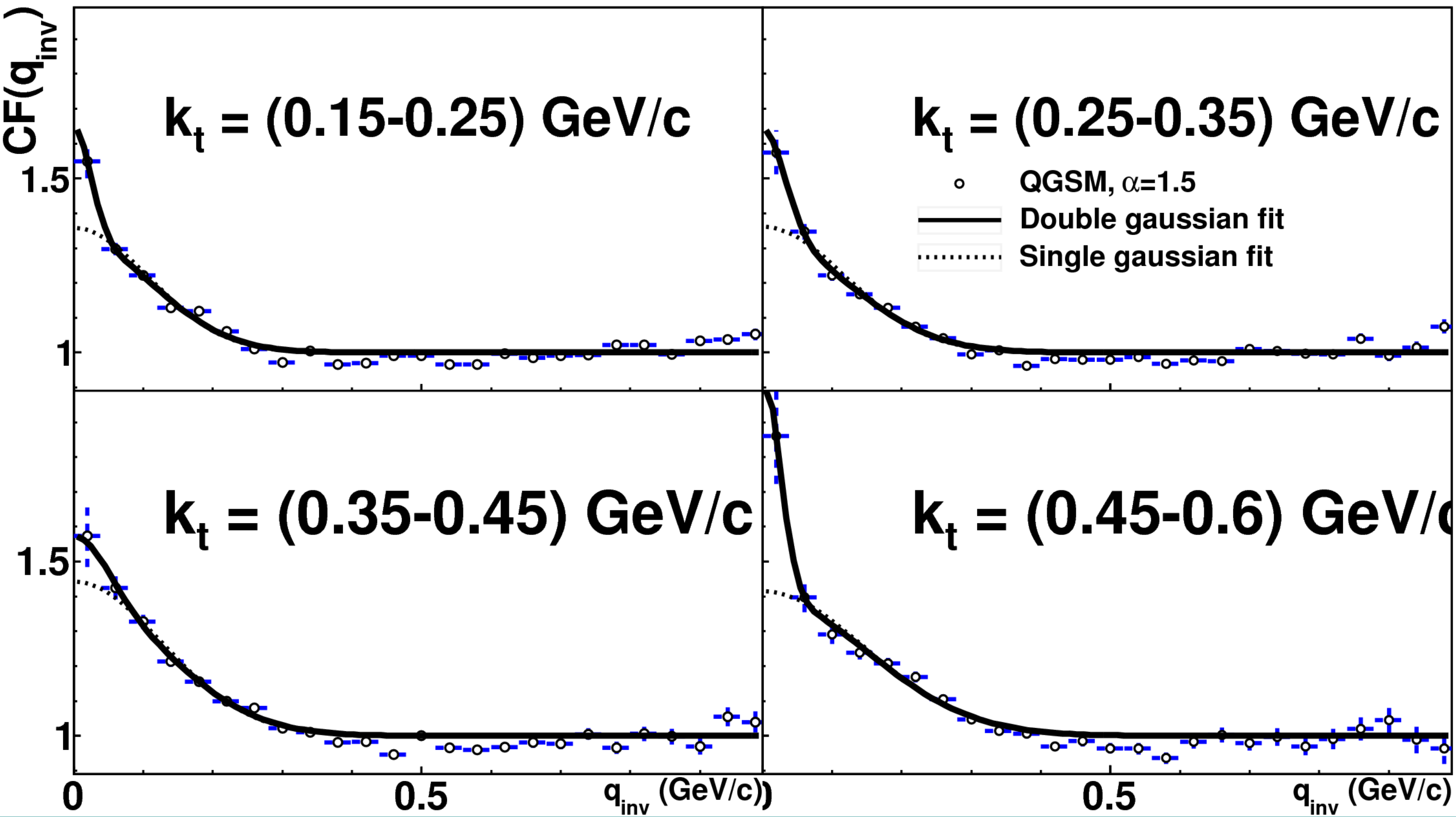
Baseline in experiment

- The STAR experiment have fitted their data using a flat baseline and other parametrisations e.g. EMCICS.
- The ALICE experiment have fitted their data using the polynomial baseline obtained from PYTHIA.
- ALICE have also published fitting results using flat baseline
- In order to easily compare results between 200GeV and 900GeV we will do our fitting using a flat baseline. This is also supported by the shape of the QGSM non-femtoscopic correlations

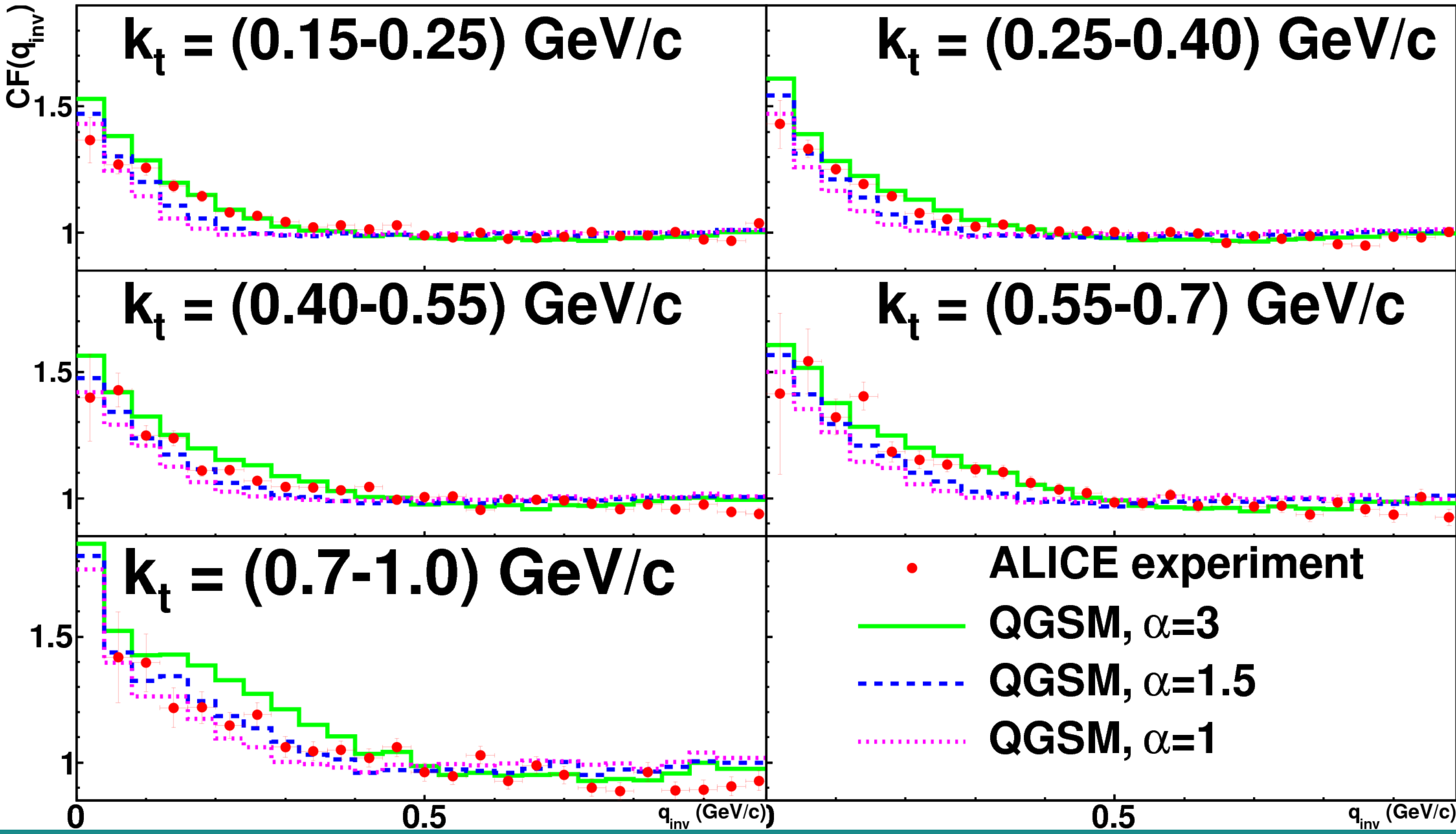
$\pi^+\pi^+$ Correlation function pp 200GeV



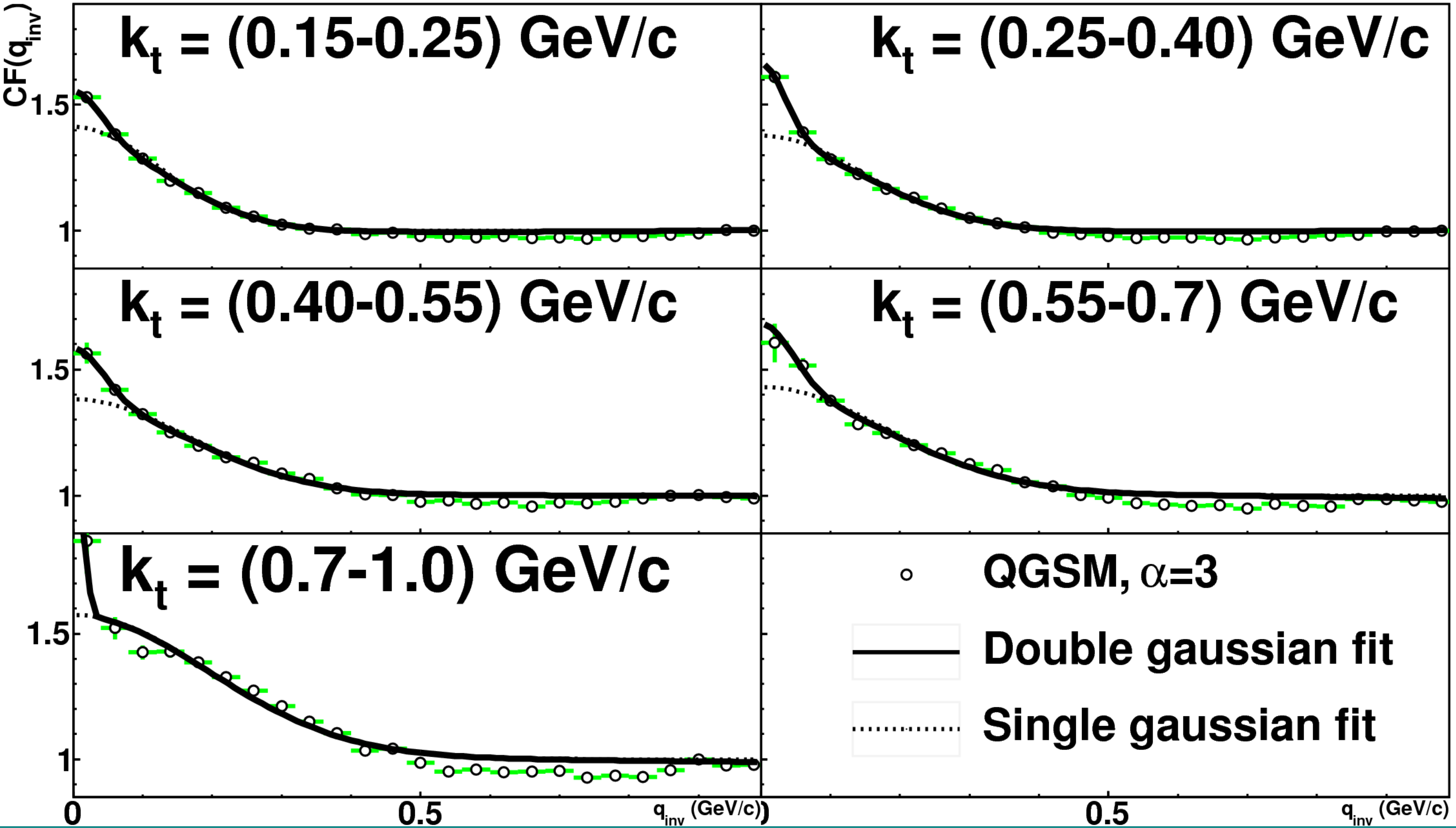
$\pi^+\pi^+$ Correlation function fit pp 200GeV, using α=1.5



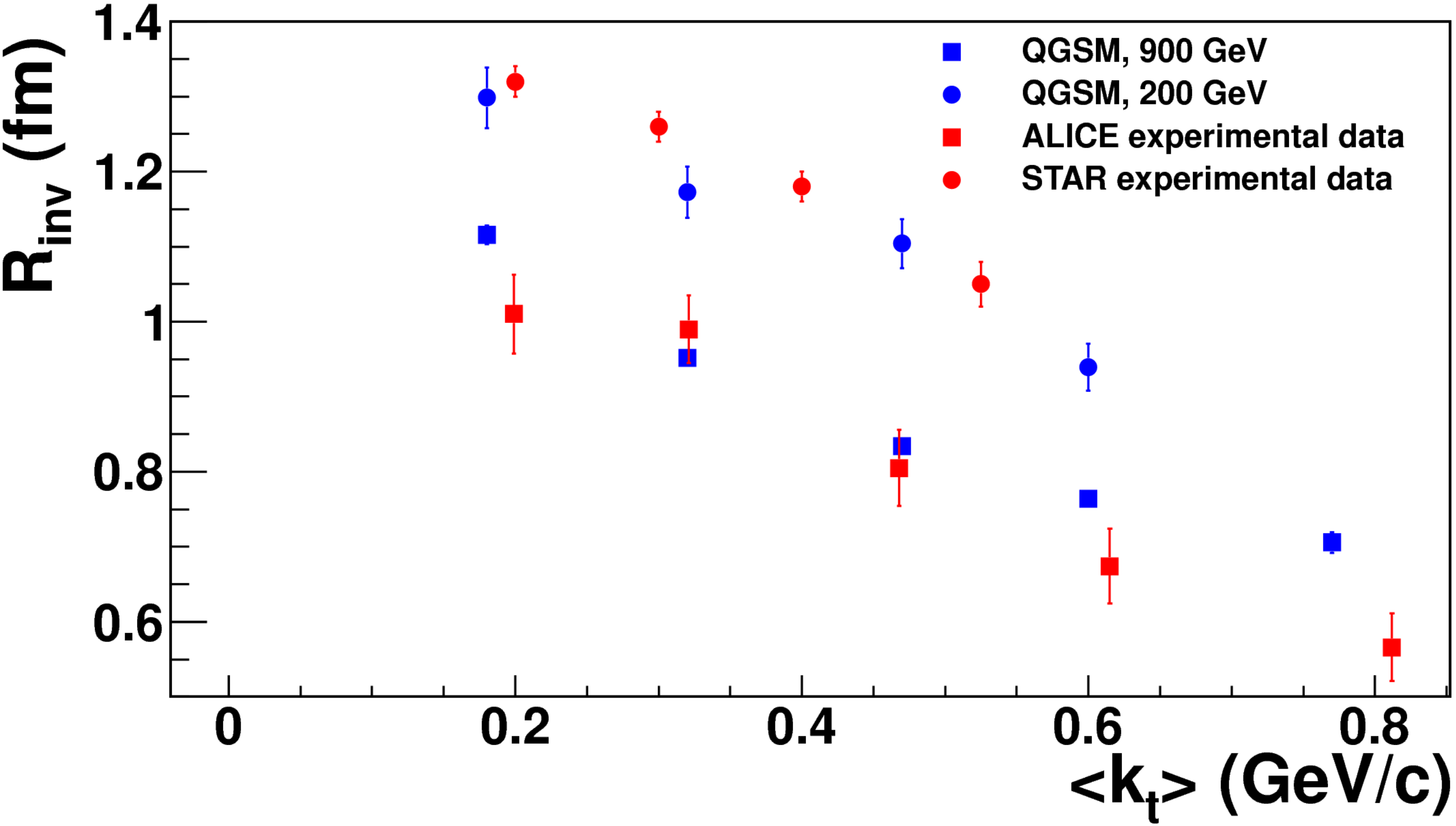
$\pi^+\pi^+$ Correlation function pp 900GeV



$\pi^+\pi^+$ Correlation function fit pp 900GeV, using α=3



R_{inv} for pp 200GeV and 900GeV



Study of fitting methods

1. Ideal
2. Real, flat baseline
3. Real, poly baseline
4. Real, double gauss flat baseline
5. Real, double gauss poly baseline

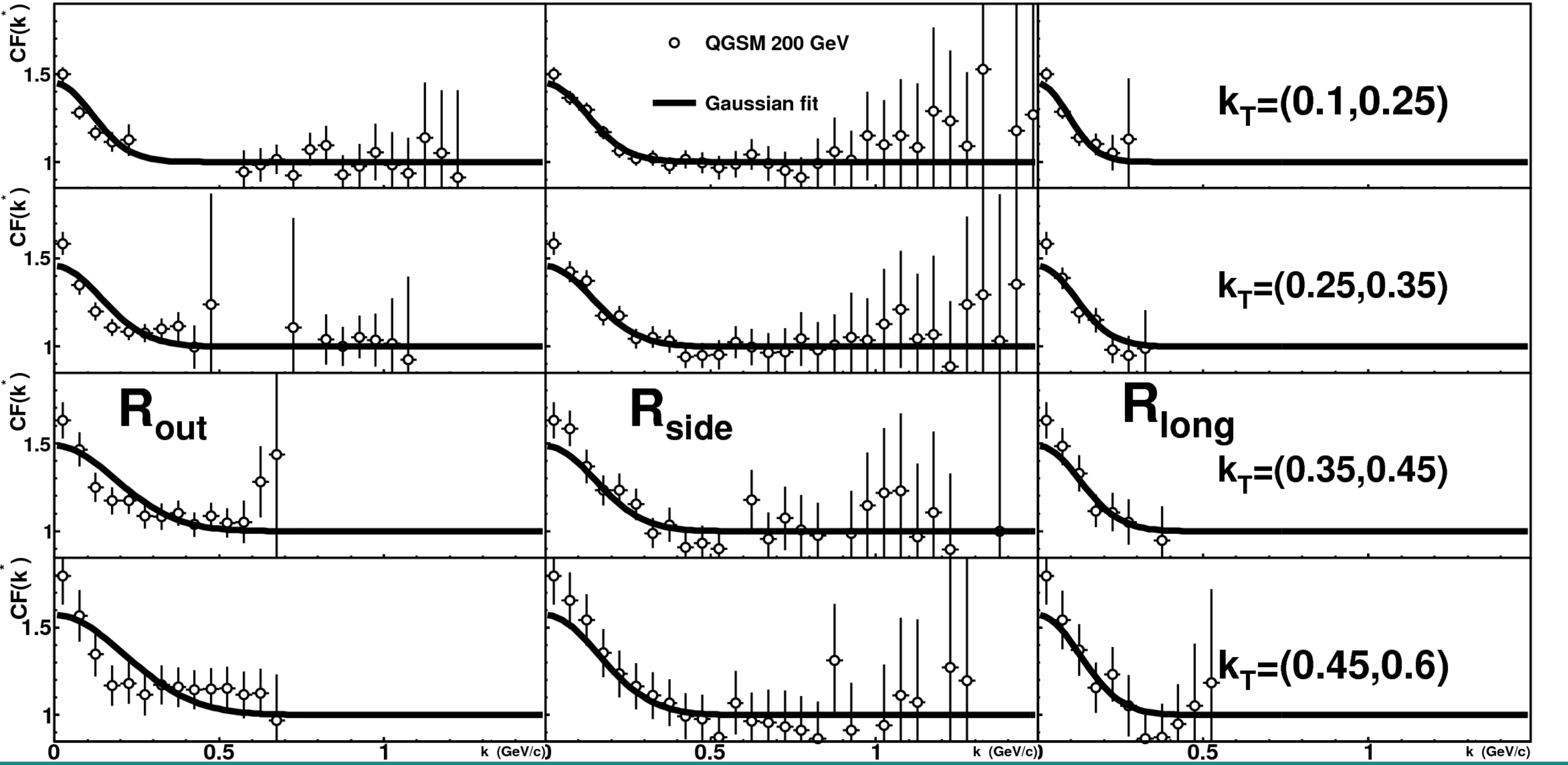
Method	Kt bin 1	Kt bin 3	Kt bin 5
1, Rinv (fm)	1.00	0.77	0.66
2, Rinv (fm)	1.26	0.84	0.71
3, Rinv (fm)	1.10	0.84	0.71
4, Rinv1 (fm)	1.23	0.81	0.71
Rinv2 (fm)	5.04	3.26	13.97
5, Rinv1 (fm)	1.05	0.81	0.71
Rinv2 (fm)	3.61	3.25	13.83

3D Correlation functions

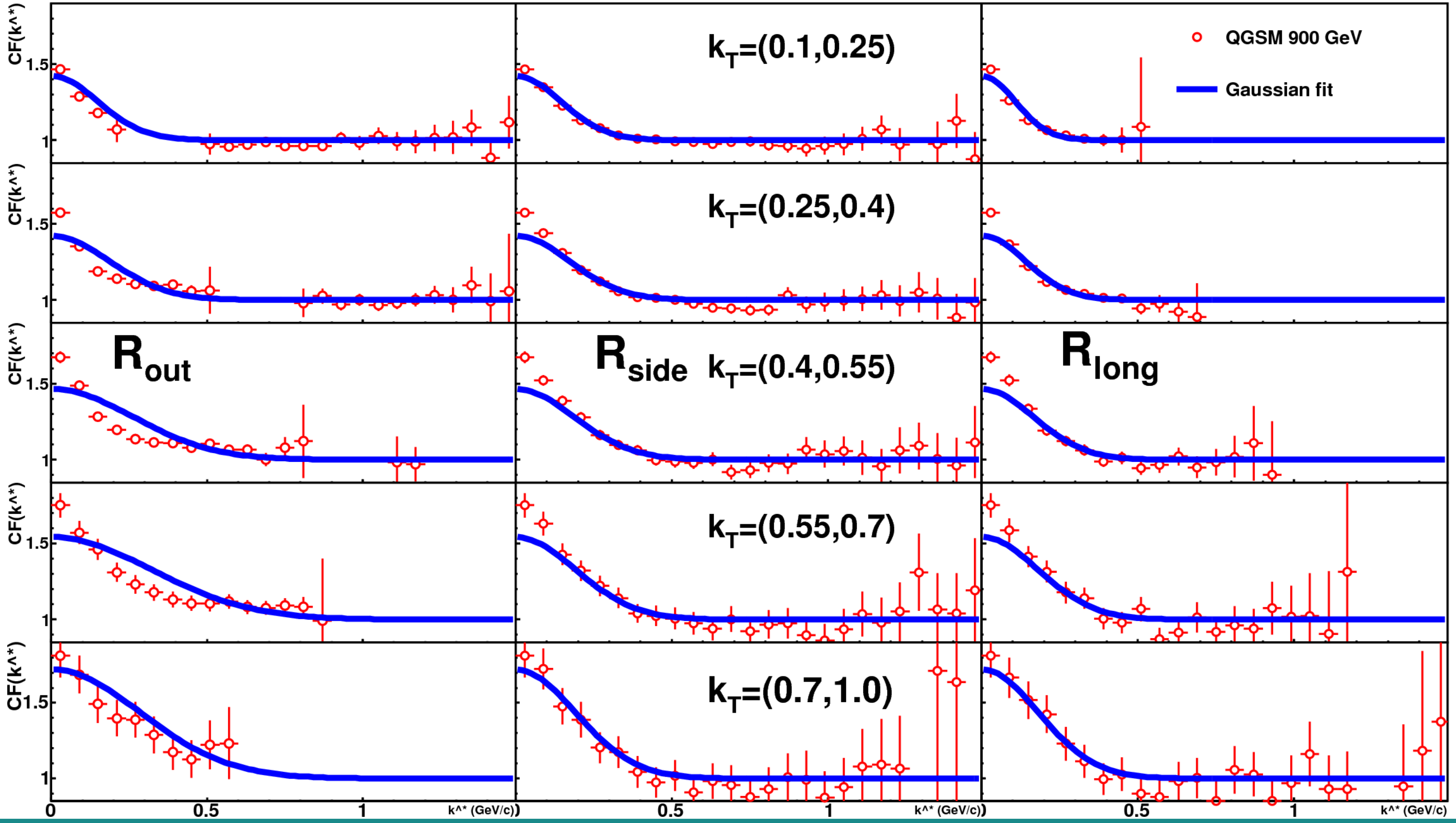
- 3D fit CF=1+ $\lambda \exp(-R_{out}^2 Q_{out}^2 - R_{side}^2 Q_{side}^2 - R_{long}^2 Q_{long}^2)$

- We have extracted correlation radii in out-side-long directions from QGSM using a full 3d fit.

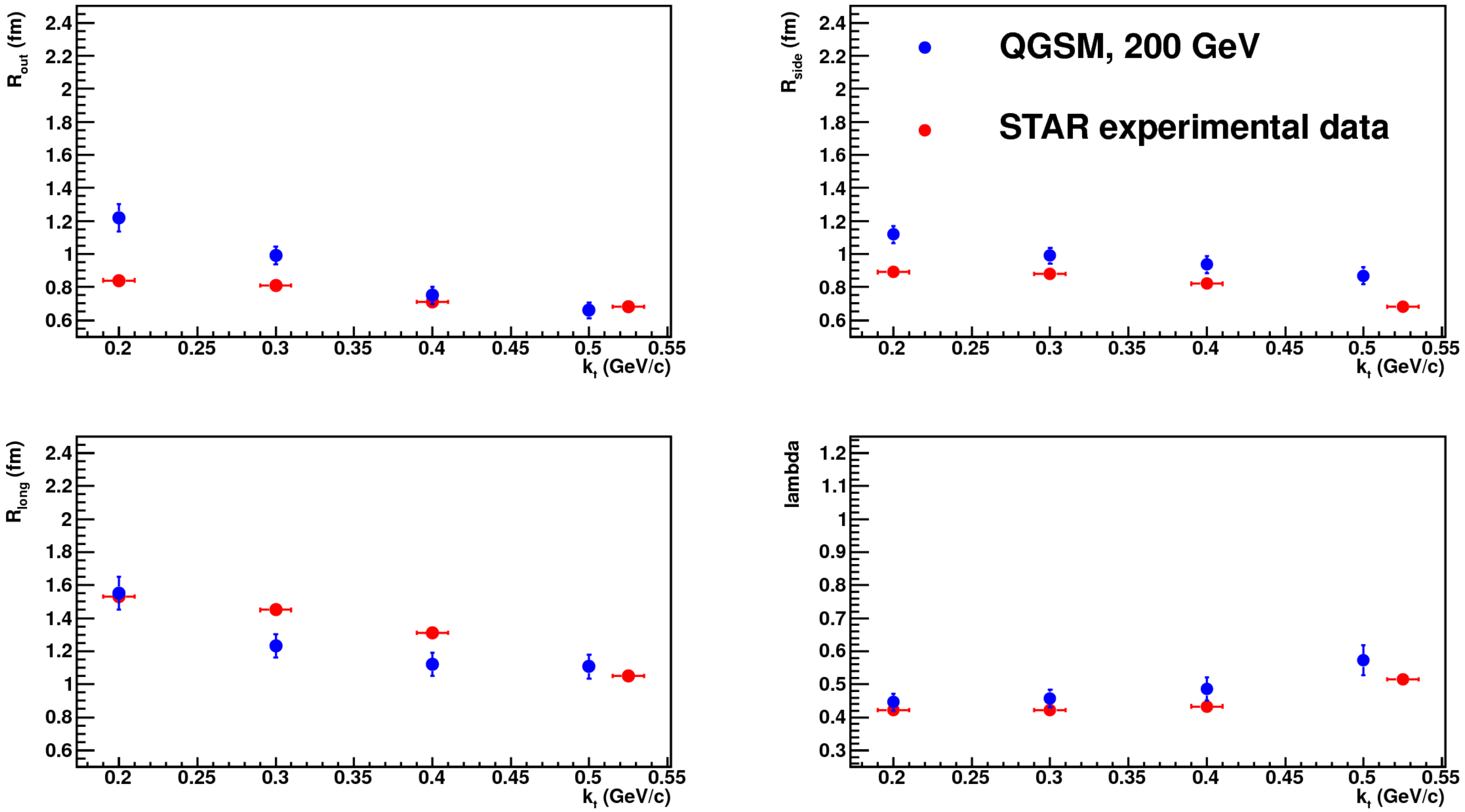
$\pi^+\pi^+$ 3D Correlation function pp 200GeV



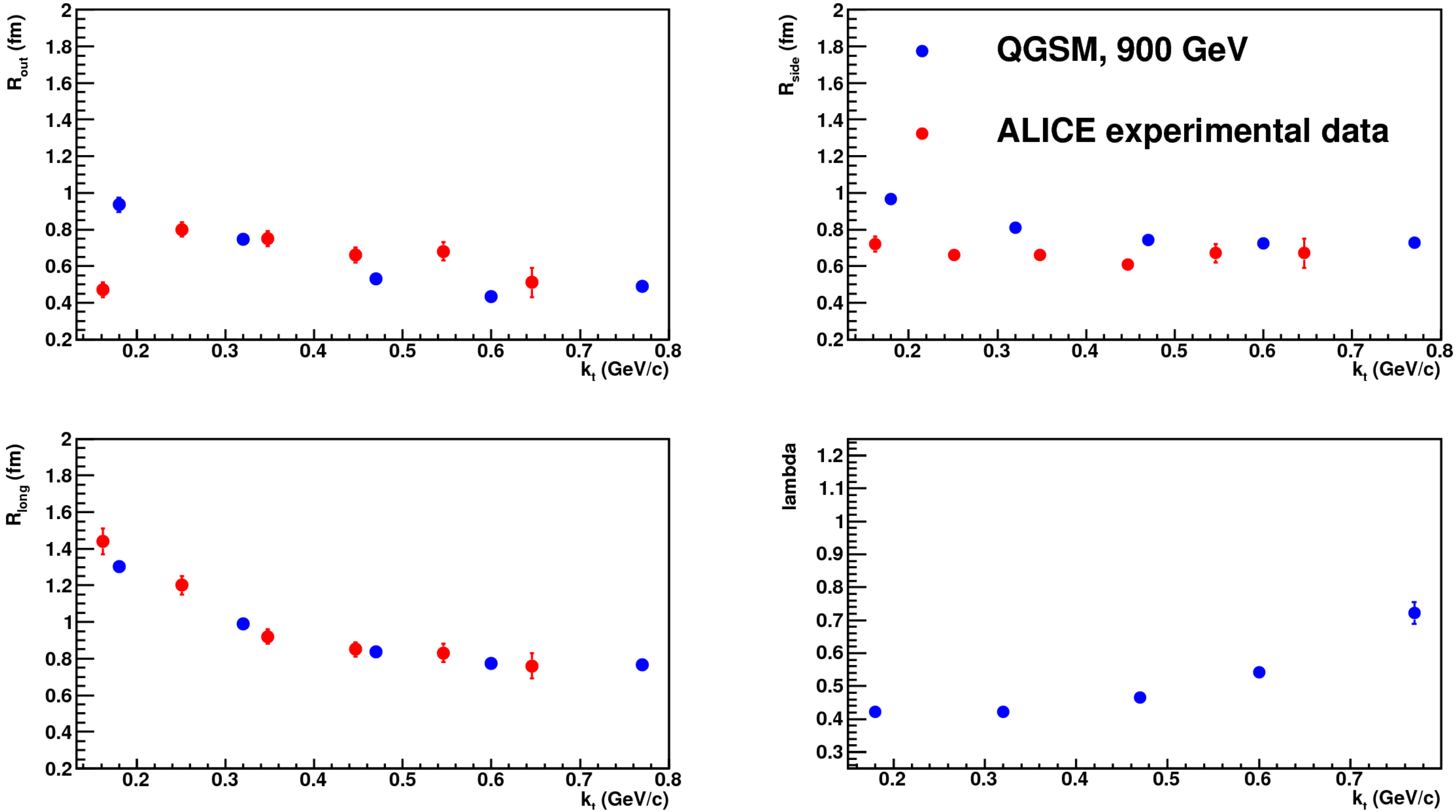
$\pi^+\pi^+$ 3D Correlation function pp 900GeV



Correlation radii 200GeV

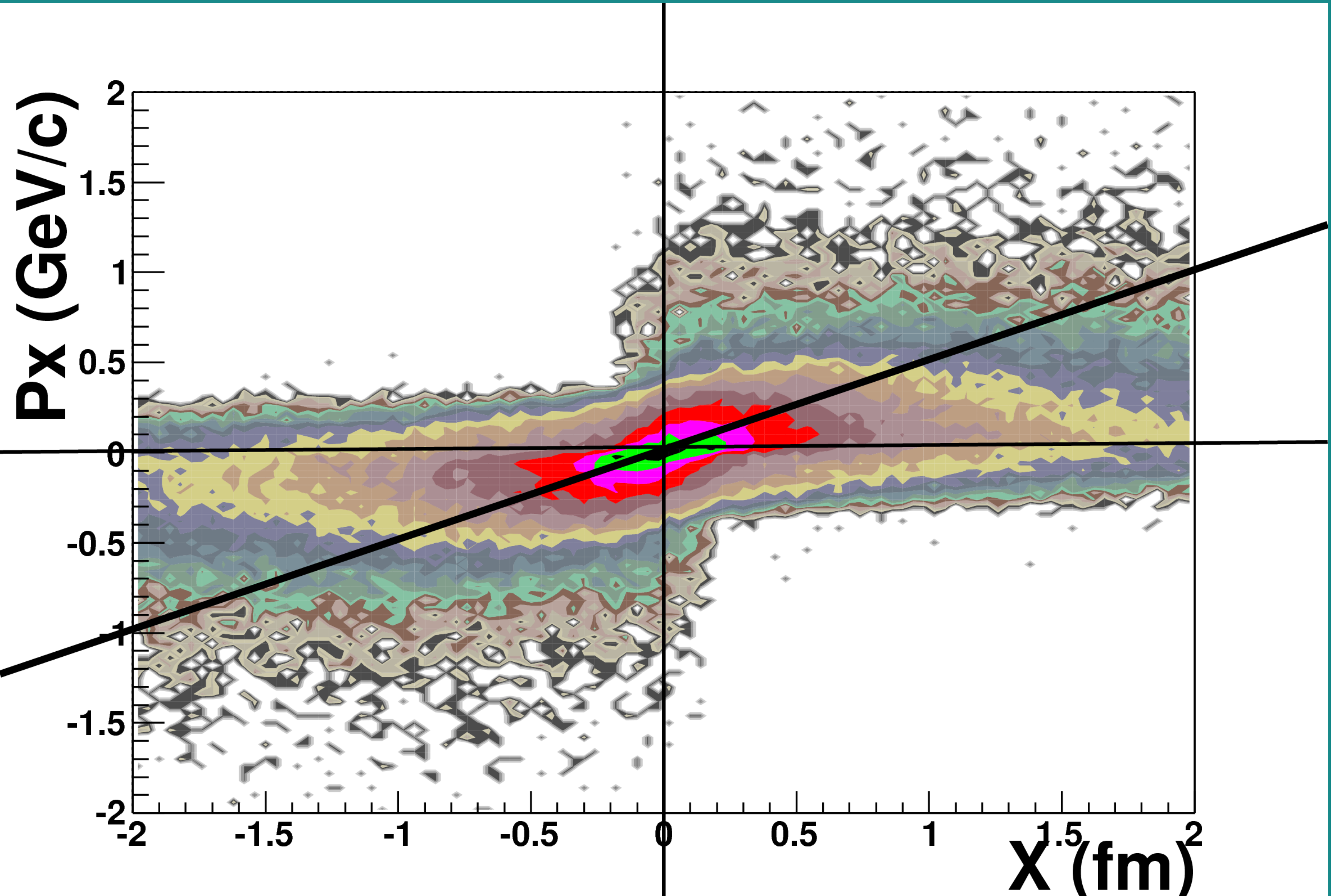


Correlation radii 900 GeV



Kt-dependence

- What is the origin of the kt-dependence in QGSM?
- We have studied the contribution from pion-decay from resonances.
- Px-x dependence for direct particles

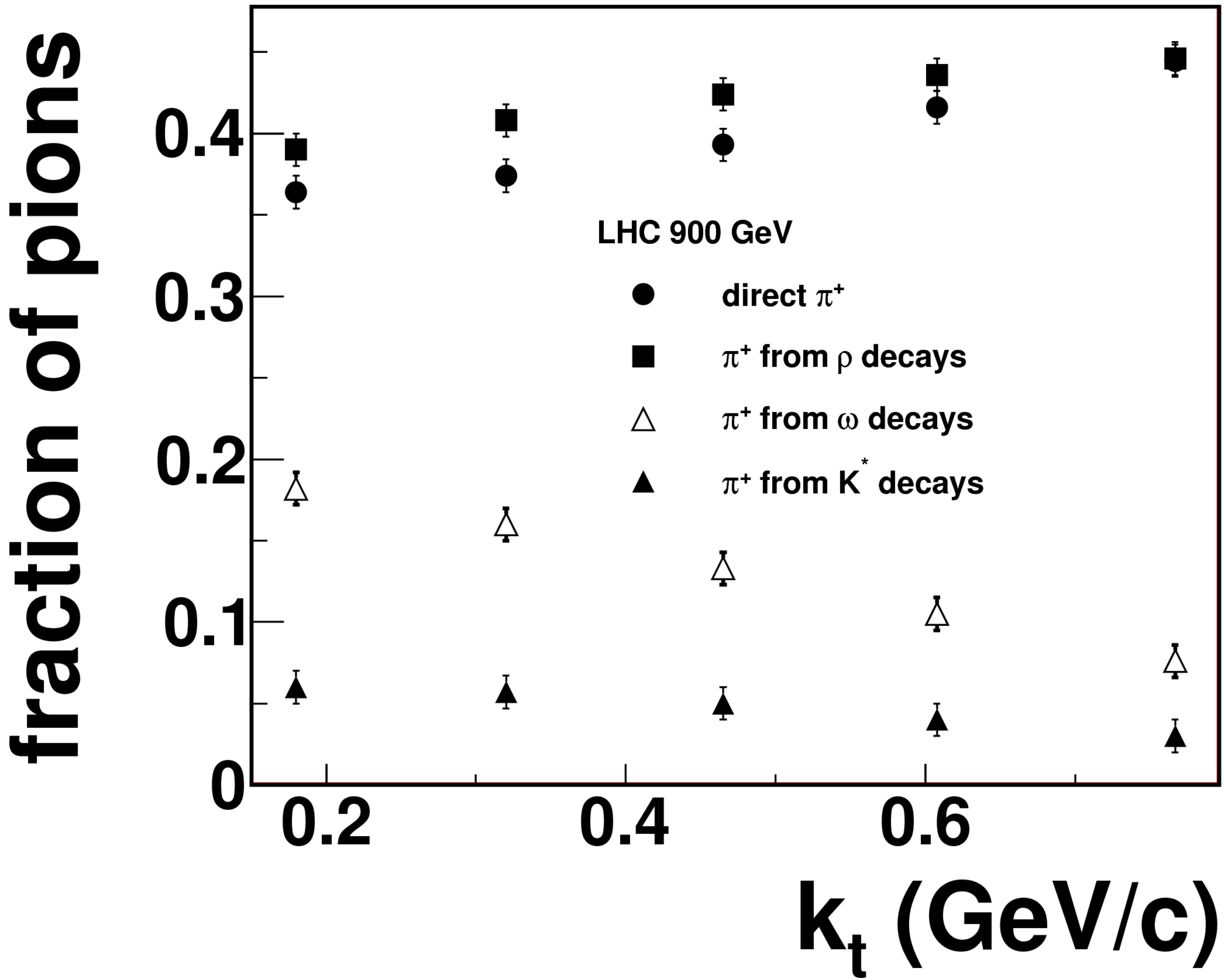


Px (GeV/c)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
X (fm)

Pions from resonances

- The number of pions from resonances directly affects the shape of the correlation function

	l*(fm)	200 GeV	900 GeV
Direct π^+	-	46.9%	37.5%
π^+ from $\rho^{0,+} \rightarrow \pi^{-,0}\pi^+$	3.3	37.1%	40.7%
π^+ from $\omega \rightarrow \pi^0,\pi^-,\pi^+$	28.1	11.2%	15.9%
π^+ from K*,+($\overline{K^{*,0}}$) $\rightarrow K\pi^+$	8.0	4.2%	5.5%



fraction of pions
0.4
0.3
0.2
0.1
0
0.2
0.4
0.6
k_t (GeV/c)
LHC 900 GeV
direct π^+
π^+ from ρ decays
π^+ from ω decays
π^+ from K^* decays

Conclusions

- Experimental results are reasonably well described in lower kt-bin using a simple string model.
- Testing of different fitting strategies reveal a systematic error of about 20%
- Study of resonances help explain the kt-dependence of the HBT radii in QGSM.
- Paper: arXiV:1106.1786v1 [hep-ph]