Quark Matter Wuhan 2019

STAR

Measurements of HBT correlations and Lévy source parameters in Au+Au collisions at the STAR experiment

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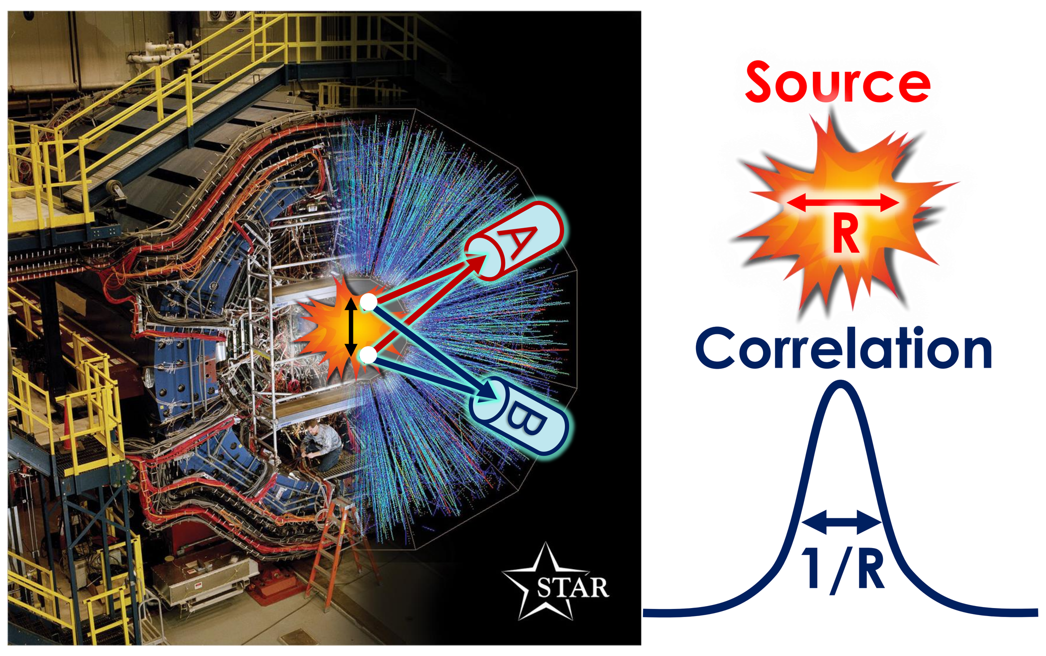
Abstract

To study the nature of the quark-hadron phase transition, it is important to investigate the space-time structure of the hadron emission source in heavy-ion collisions. Measurements of HBT correlations have proven to be a powerful tool to gain information about the particle emission region. In the study discussed in this poster, Gaussian and Lévy fits were performed to the measured one-dimensional two-pion correlation functions in Au+Au collisions at $\sqrt{s_{NN}}$=200 GeV.

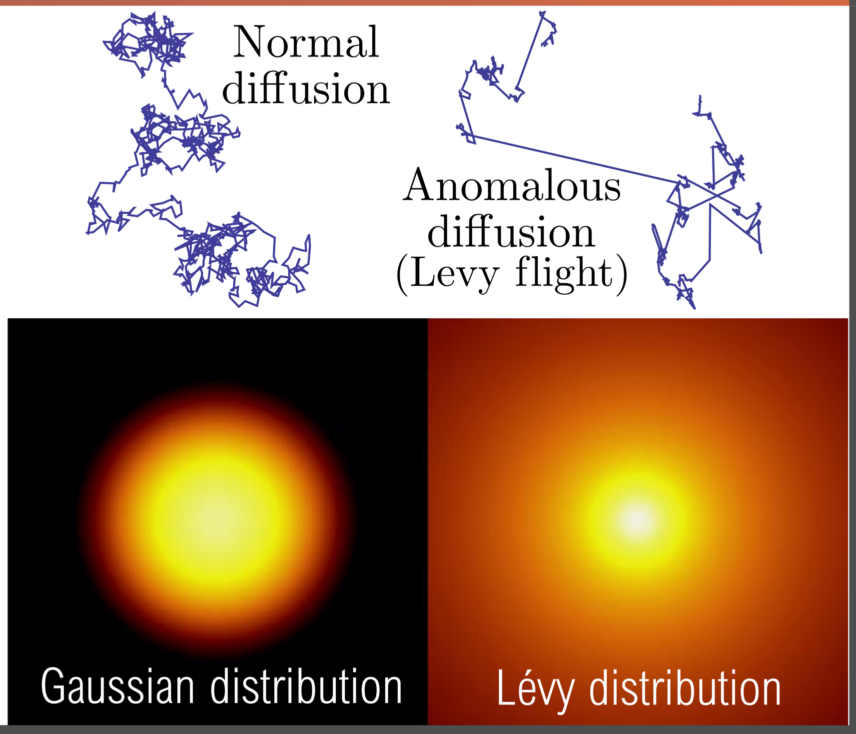
Identical boson femtoscopy



- Momentum correlations of identical boson pairs
- Information about the geometry of the source
- $C(Q) \approx 1 + |\widetilde{S}(Q)|^2$
- Assumed source-shape: usually Gaussian
- More general approach?

Appearance of Lévy-type sources

- Univariate Lévy distribution:
  $$\mathcal{L}(r;\alpha,R) = \frac{1}{2\pi}\int_{-\infty}^{\infty} e^{-|qR|^{\alpha}} e^{iqr} dq$$
- $\alpha = 2$: Gaussian, $\alpha < 2$: power-law
- What could lead to such sources?
  - anomalous diffusion
  - jet fragmentation
  - proximity of critical endpoint
- Lévy-type correlation function:
  $$C(Q) = 1 + \lambda \cdot e^{-(RQ)^{\alpha}}$$

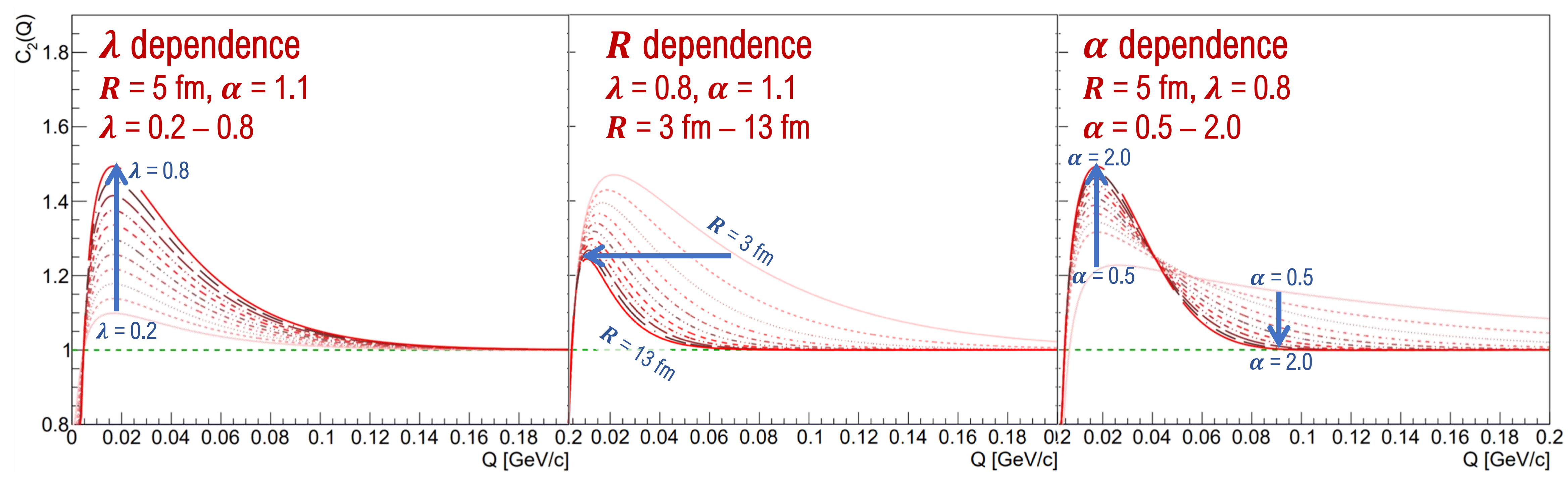


Final-state effects

- Identical charged pions → Coulomb repulsion!
- Bowler-Sinyukov procedure: correction factor $K(Q;\alpha,R)$
- Coulomb correction calculated numerically
- More details: M. Csanád *et al.*, Universe 5 (2019) 133

Shape of the correlation functions with the Coulomb interaction included

$$C^{Coul.}(Q) = 1 - \lambda + \lambda \cdot K(Q;\alpha,R) \cdot (1 + \exp(-(RQ)^{\alpha}))$$



Correlation strength λ

- Core-Halo model: $\lambda = N_C^2/(N_C+N_H)^2$

J. Bolz et al., Phys. Rev. 1993, D47

Lévy scale parameter R

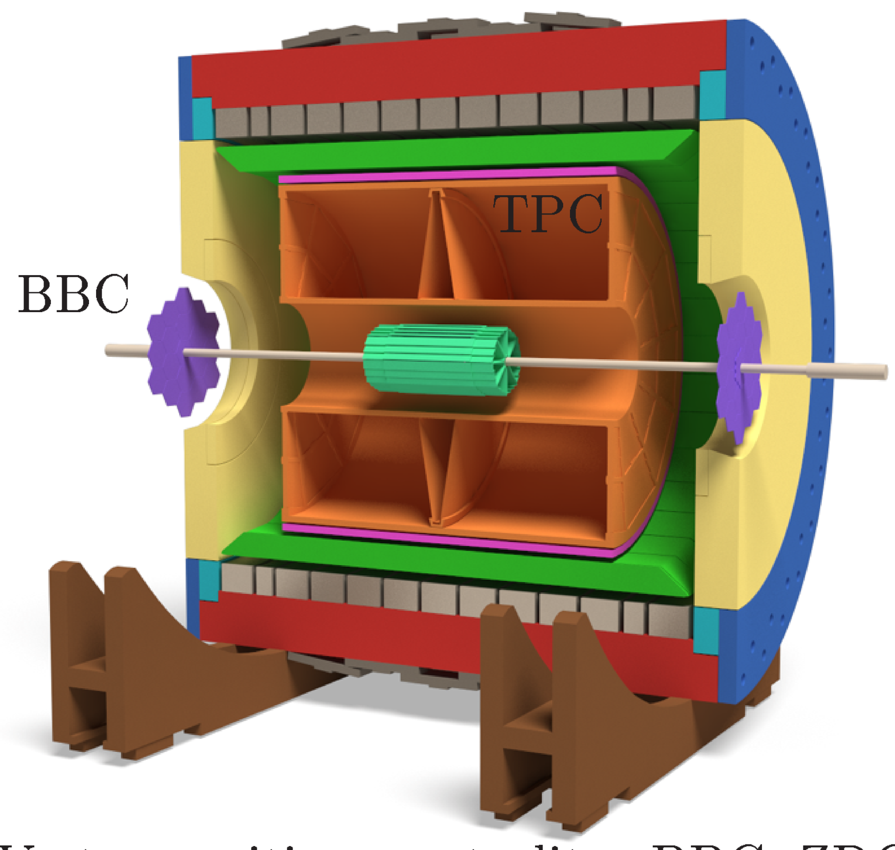
- Size of the source
- Usually decreases with m_T

Lévy exponent α

- Connected to crit. exponent η
- Could be a good signal of CEP

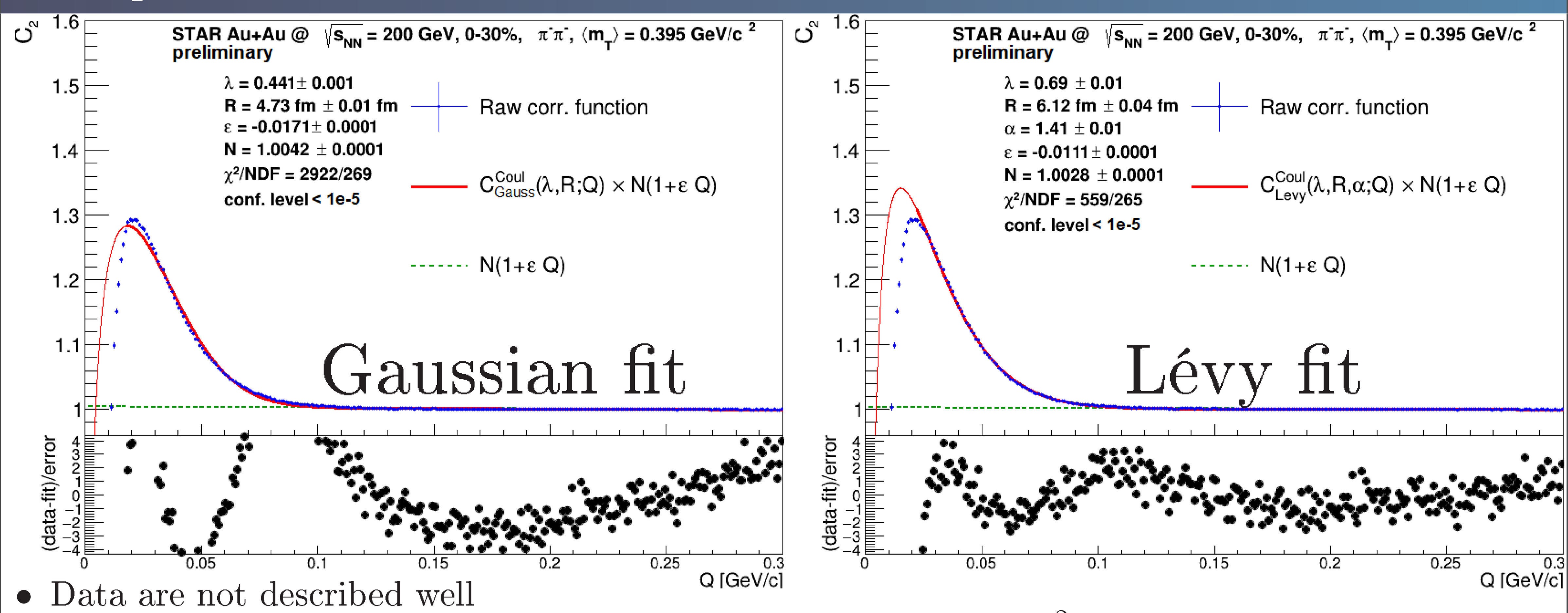
T. Csörgő, PoS 2008, HIGH-PTLHC08, 027

The STAR experimental setup



- Vertex position, centrality: BBC, ZDC, VPD
- Tracking and particle identification: TPC
- Analyzed data: $\sqrt{s_{NN}} = 200$ GeV Au+Au
- Measurements of 1D two-pion HBT correlation functions

Example fits to the measured correlation functions



Gaussian fit:

- Data are not described well
- χ^2 is very high (χ^2/NDF ~ 10)
- R is compatible with previously measured 3D Gaussian radii ($R_{out}, R_{side}, R_{long}$)

Lévy fit:

- Releasing α: χ^2 decreases by a factor of 3-5
- Description highly improves at $Q \gtrsim 25$ MeV/c
- Low Q behavior is not described well

Summary

- Two hypotheses tested on the data
- Lévy fits provide a higher quality description than Gaussian ones at $Q \gtrsim 25$ MeV/c
- Low Q behavior is currently not clear
- More detailed investigations are ongoing

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