3D pion source images in 200 GeV Au+Au collisions with EPOS

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1. Femtoscopy and correlation functions Lévy-type source function

- Investigation of the correlation function of identical boson pairs

$$C_2(q,K) = \frac{\int d^4x\, D(x,K)\left|\psi_q(x)\right|^2}{\int d^4x\, D(x,K)}$$

- The pair source distribution:

$$D(x,K) = \int d^4X\ S\left(X+\frac{x}{2},K\right)S\left(X-\frac{x}{2},K\right)$$

- $C_2\ (q,K)$ can be measured in experiments
- The $D(x,K)$ function can be reconstructed in event generators
- General form of the function:

$$\mathcal{L}(r,R_x,R_y,R_z,\alpha) = \frac{1}{(2\pi)^3}\int d^3q\, e^{iqr}\, e^{-\frac{1}{2}\left|q_x^2R_x^2+q_y^2R_y^2+q_z^2R_z^2\right|^{\frac{\alpha}{2}}}$$

- K dependence: contained in R_x, R_y, R_z, α
- 1 dimensional case:

$$\mathcal{L}(r,R,\alpha) = \frac{1}{\pi}\int_0^\infty dq\cos qr\, e^{-\frac{1}{2}|qR|^\alpha}$$

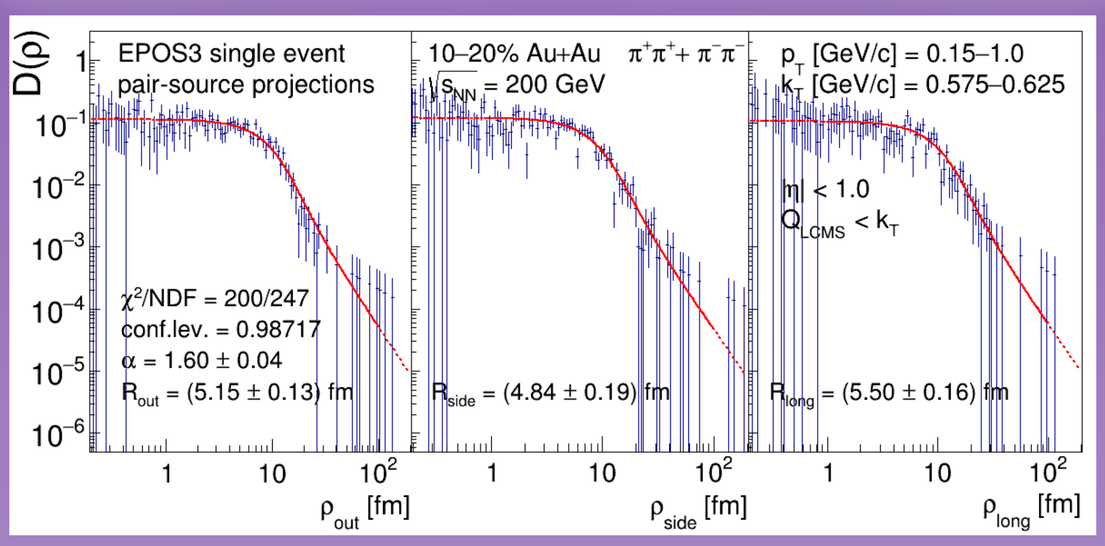
- Lévy exponent: $\alpha<2$ power-law, $\alpha=2$ Gaussian
- Lévy-scale: R, geometric properties

$$S(r) = \mathcal{L}(r,R,\alpha) \quad \Rightarrow \mathrm{D}(r) = \mathcal{L}\left(r,2^{\frac{1}{\alpha}}R,\alpha\right)$$

4. Methods

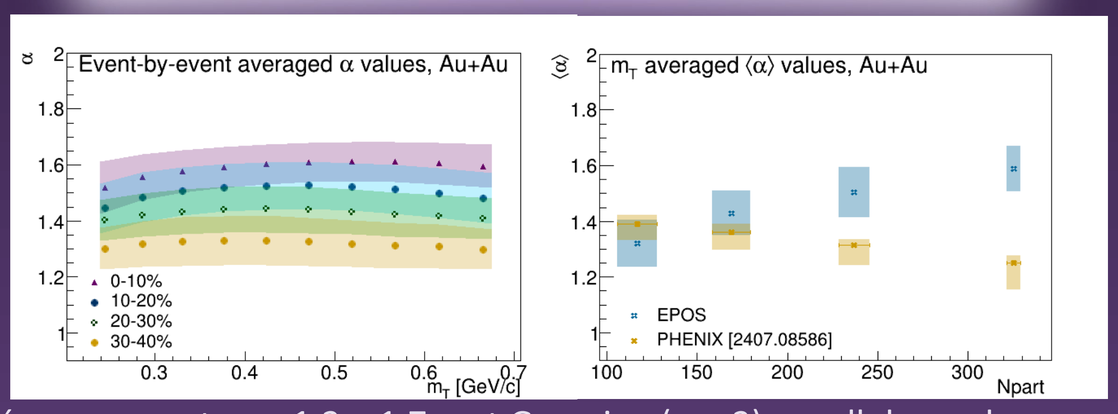
- $\sqrt{s_{NN}}$ = 200 GeV Au+Au collisions generated by the EPOS program package
- Separated the measurements into centrality and m_T classes
- 3 dimensional pair-distribution ⇒ 1 dimensional projections according Bertsch-Pratt-coordinates
- Fitting 1 dimensional Lévy-functions to the projections
- For the 3 projection of a 3D distribution: fitting simultaneously with same Lévy exponent but different Lévy scales

5. Examples of the fitted event by event distribution for the three projections

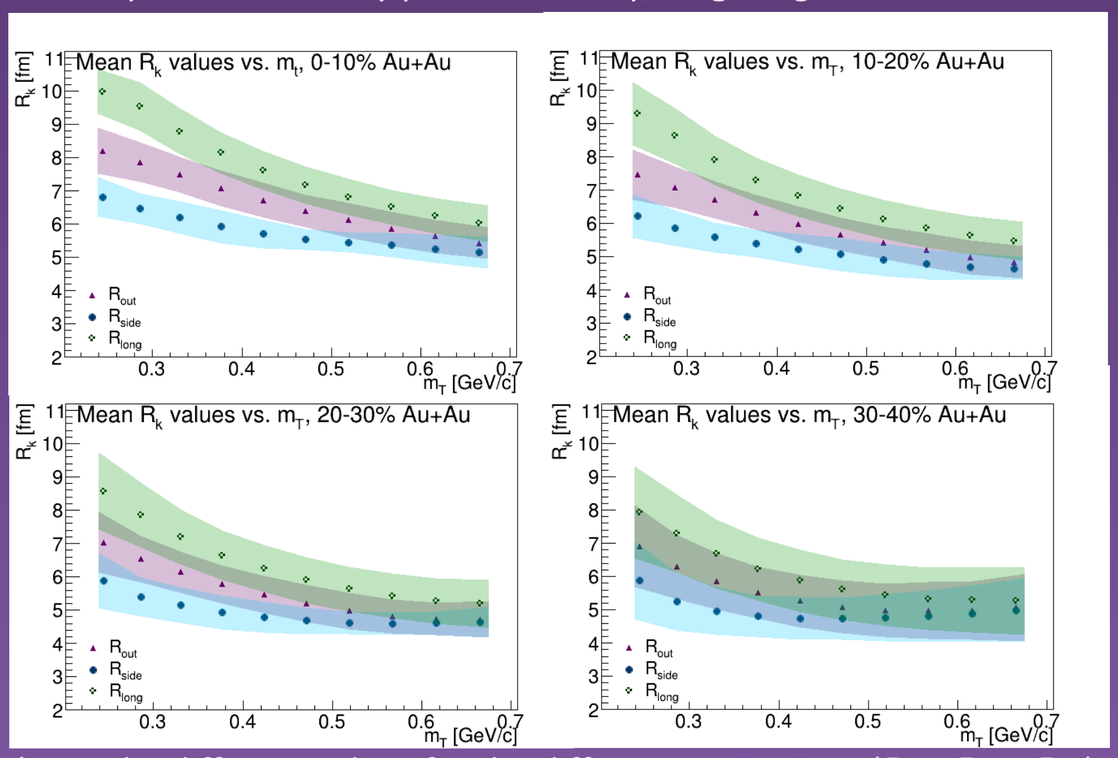


- Good description by elliptically contoured Lévy-stable distribution
- Similar fits repeated for thousands of events
- Event-by-event mean and standard deviation of parameters extracted

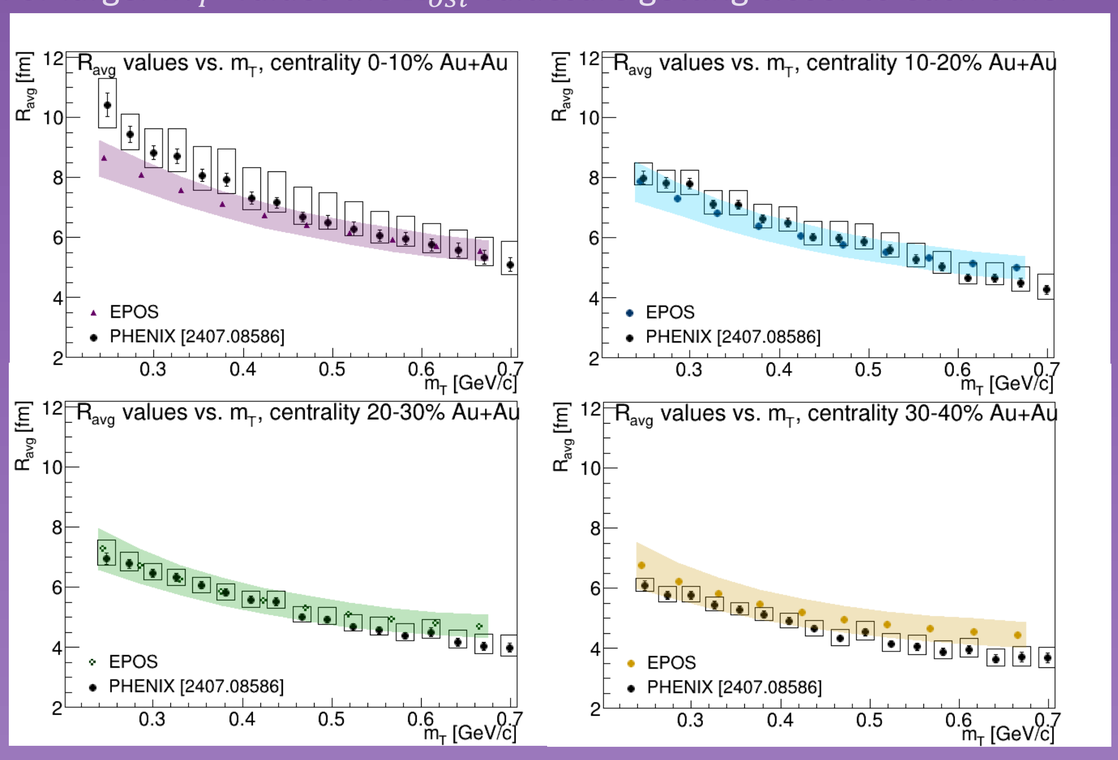
6. Results



- Lévy-exponent: $\alpha \approx 1.2 - 1.7$, not Gaussian ($\alpha < 2$), small dependence on m_T
- Decrease with increasing N_{part} → opposite trend compared to PHENIX
- $\langle\alpha\rangle_{m_T}$ vs PHENIX →good agreement for peripheral, deviation for central
- Centrality trend driven by particle density, long-range Coulomb scattering?



- Lévy scale: different values for the different projections ($R_l > R_o > R_s$)
- Lévy scale is decreasing with increasing m_T → collective behavior
- Geometrical centrality dependence
- For larger m_T values the R_{osl} valuesare getting closer to each other



- Average R values vs. new final 1D PHENIX analysis (Ref[4])
- Good agreement with the experiment!
- EPOS seems to describe the source scales well

Summary

- 3-dimensional pion pair source investigated in 200 GeV Au+Au collisions generated with EPOS
- Source shape described well by 3D Lévy-stable distributions on an event-by-event basis
  - In 1D the observed Lévy shape is not due to angle-, nor event-averaging
  - Event-by-event 3D Lévy → due to Lévy walk in scatterings & decays
- Parameters compared to new final PHENIX angle-averaged results (Ref [4])
  - Exponent (α) agrees with experiment for peripheral,deviates for central events, opposite centrality trend observed
  - Average scale (Ravg) captured well by the model, shows good agreement

References

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[3] A. Adare et al. [PHENIX], Phys. Rev. C 97 (2018) no.6, 064911
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[5] S. Afanasiev et al. [PHENIX], Phys. Rev. Lett. 100 (2008), 232301
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