# Event-by-Event Investigation of the Two-Particle Source Function in Heavy-Ion Collisions with EPOS

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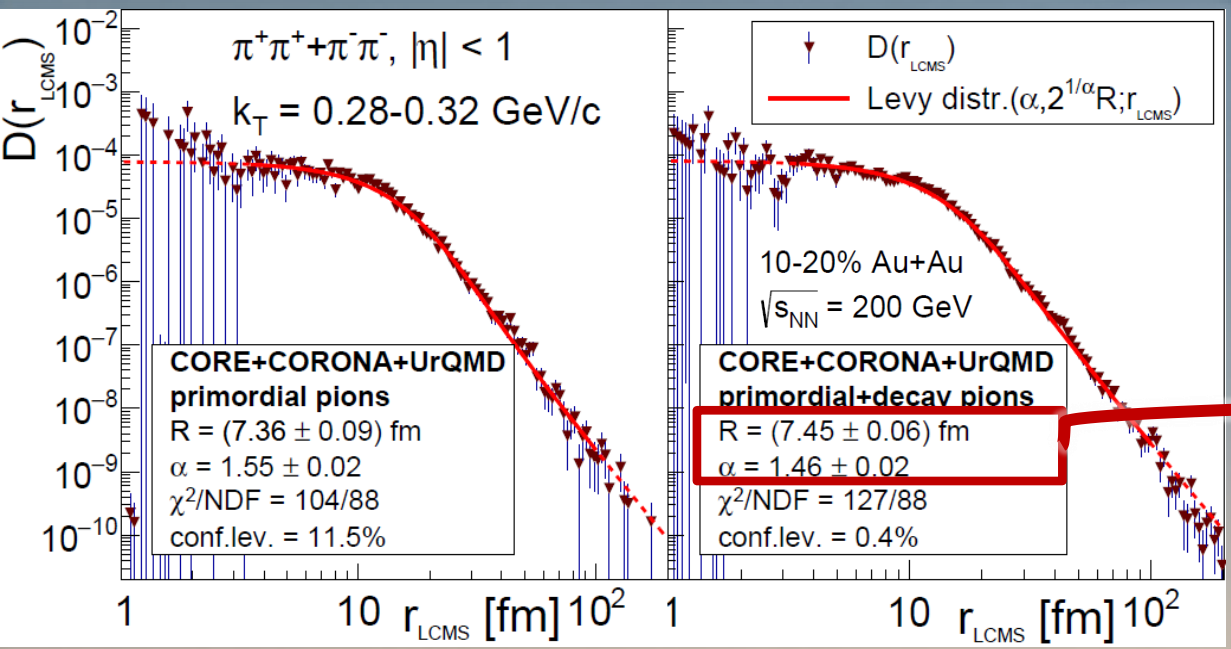## 1) Femtoscopy for identical boson pairs

- Momentum correlation: $C(Q) = \int D(r) |\psi_Q(r)|^2 dr$
- Spatial corr.: $D(r, K) = \int d^4\rho\, S\left(\rho + \frac{r}{2}, K\right) S\left(\rho - \frac{r}{2}, K\right)$
- Experiments – info about D(r) pair-source through C(Q)
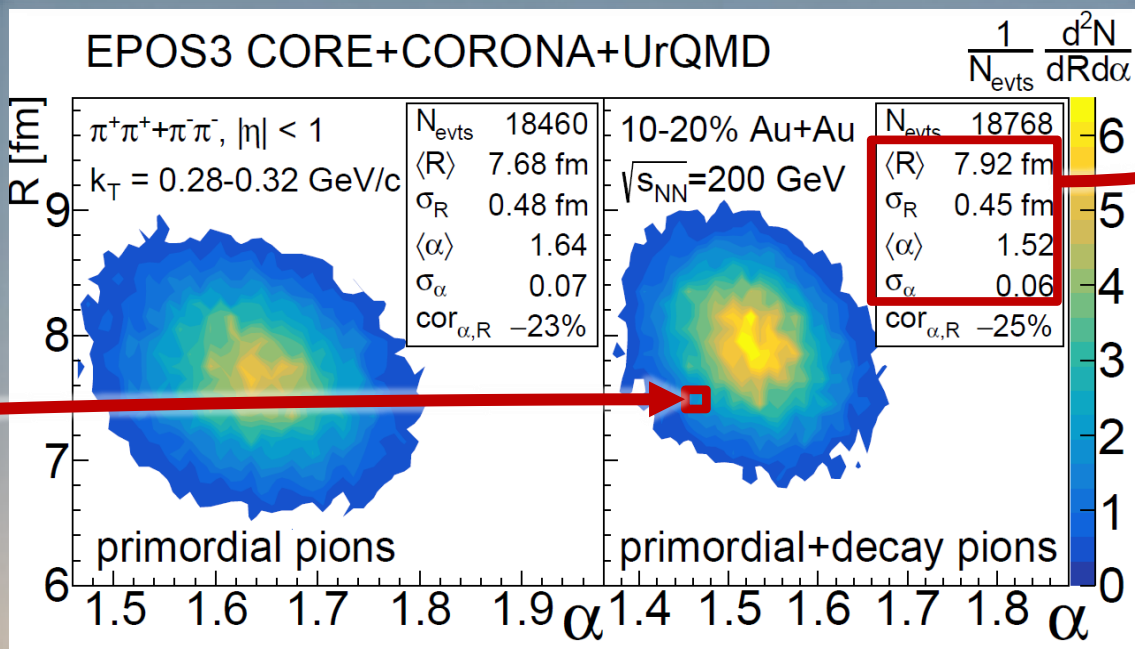- Event generator models – direct access to pair-source!

## 2) EPOS

- Monte-Carlo heavy-ion event generator model [1]
- Core-Corona division (based on dE/dx of strings)
- vHLLE 3D+1 viscous hydrodynamics
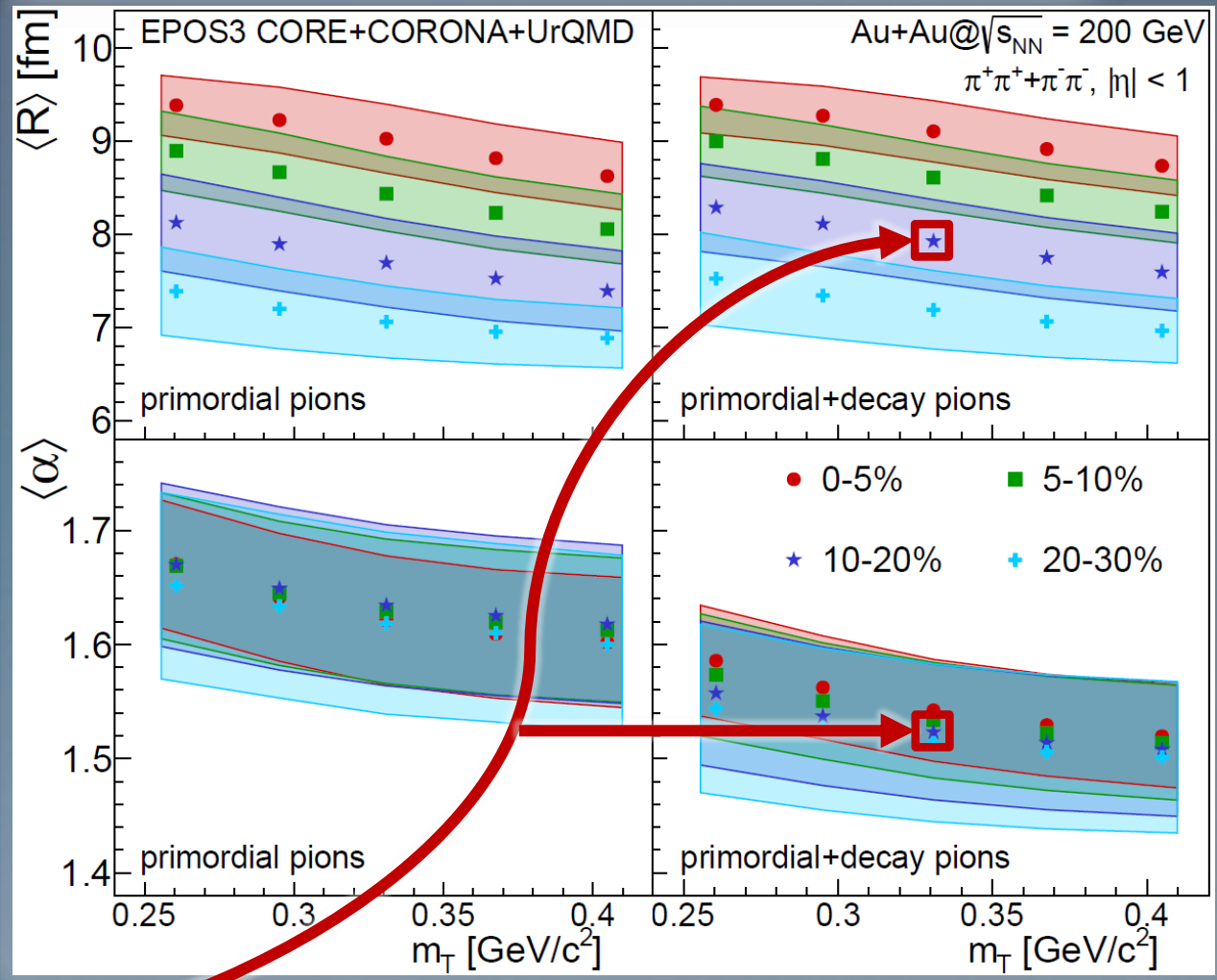- Hadronic rescattering (UrQMD)

## 3) Lévy-type sources

- Reasons for the appearance of such sources [2-5]: critical behavior, anomalous diffusion, jet fragmentation
- $\alpha = 2$ Gaussian, $\alpha < 2$ power-law (RMS controlled by cutoff)

$$\mathcal{L}(\alpha, R; r) = \frac{1}{(2\pi)^3} \int d^3q\, e^{iqr} e^{-\frac{1}{2}|qR|^\alpha}$$

## 4) Analysis method

- $\sqrt{s_{NN}}$ = 200 GeV Au + Au coll. generated by EPOS359
- Angle-avg. radial pion pair-source distr. constructed
- D(r) fitted with a Lévy distribution event-by-event
- Lévy params. $R$ and $\alpha$ extracted for thousands of evts.
- Effect of decay products investigated separately

## 5) Example single-event fits



$\pi^+\pi^+ + \pi^-\pi^-$, $|\eta| < 1$
$k_T$ = 0.28-0.32 GeV/c

$D(r_{LCMS})$
Levy distr.$(\alpha, 2^{1/\alpha}R; r_{LCMS})$

CORE+CORONA+UrQMD
primordial pions
R = (7.36 ± 0.09) fm
$\alpha$ = 1.55 ± 0.02
$\chi^2$/NDF = 104/88
conf.lev. = 11.5%

10-20% Au+Au
$\sqrt{s_{NN}}$ = 200 GeV

CORE+CORONA+UrQMD
primordial+decay pions
R = (7.45 ± 0.06) fm
$\alpha$ = 1.46 ± 0.02
$\chi^2$/NDF = 127/88
conf.lev. = 0.4%

## 6) Example source param. distribution



EPOS3 CORE+CORONA+UrQMD
$\frac{1}{N_{evts}} \frac{d^2N}{dRd\alpha}$

$\pi^+\pi^+ + \pi^-\pi^-$, $|\eta| < 1$
$k_T$ = 0.28-0.32 GeV/c
$\sqrt{s_{NN}}$ = 200 GeV

| | primordial pions |
|---|---|
| $N_{evts}$ | 18460 |
| $\langle R \rangle$ | 7.68 fm |
| $\sigma_R$ | 0.48 fm |
| $\langle \alpha \rangle$ | 1.64 |
| $\sigma_\alpha$ | 0.07 |
| $cor_{\alpha,R}$ | −23% |

10-20% Au+Au

| | primordial+decay pions |
|---|---|
| $N_{evts}$ | 18768 |
| $\langle R \rangle$ | 7.92 fm |
| $\sigma_R$ | 0.45 fm |
| $\langle \alpha \rangle$ | 1.52 |
| $\sigma_\alpha$ | 0.06 |
| $cor_{\alpha,R}$ | −25% |

## 7) Event-by-event mean source-params.



EPOS3 CORE+CORONA+UrQMD
Au+Au@$\sqrt{s_{NN}}$ = 200 GeV
$\pi^+\pi^+ + \pi^-\pi^-$, $|\eta| < 1$

primordial pions
primordial+decay pions

- 0-5%
- 5-10%
- 10-20%
- 20-30%

$\langle R \rangle$ [fm]
$\langle \alpha \rangle$
$m_T$ [GeV/c$^2$]

## 8) Summary

- Initial stage of EPOS (CORE+hydro): Gaussian source
- Final stage of EPOS (CORE+CORONA+UrQMD): Rescattering and decays both play an important role in event-by-event non-Gaussianity
- Mean Lévy source params. close to exp. results [6]

[1] Werner, K. et al., Phys. Rev.C82, 044904 (2010);
[2] Csörgő, Hegyi, Zajc, Eur.Phys.J. C36;
[3] Csörgő, Hegyi, Novák, Zajc, AIP Conf.Proc. 828;
[4] Metzler, Klafter, Physics Reports 339 (2000) 1-77;
[5] Csörgő, Hegyi, Novák, Zajc, Acta Phys.Polon. B36
[6] PHENIX Collaboration, Phys. Rev. C97(6), 064911 (2018);

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