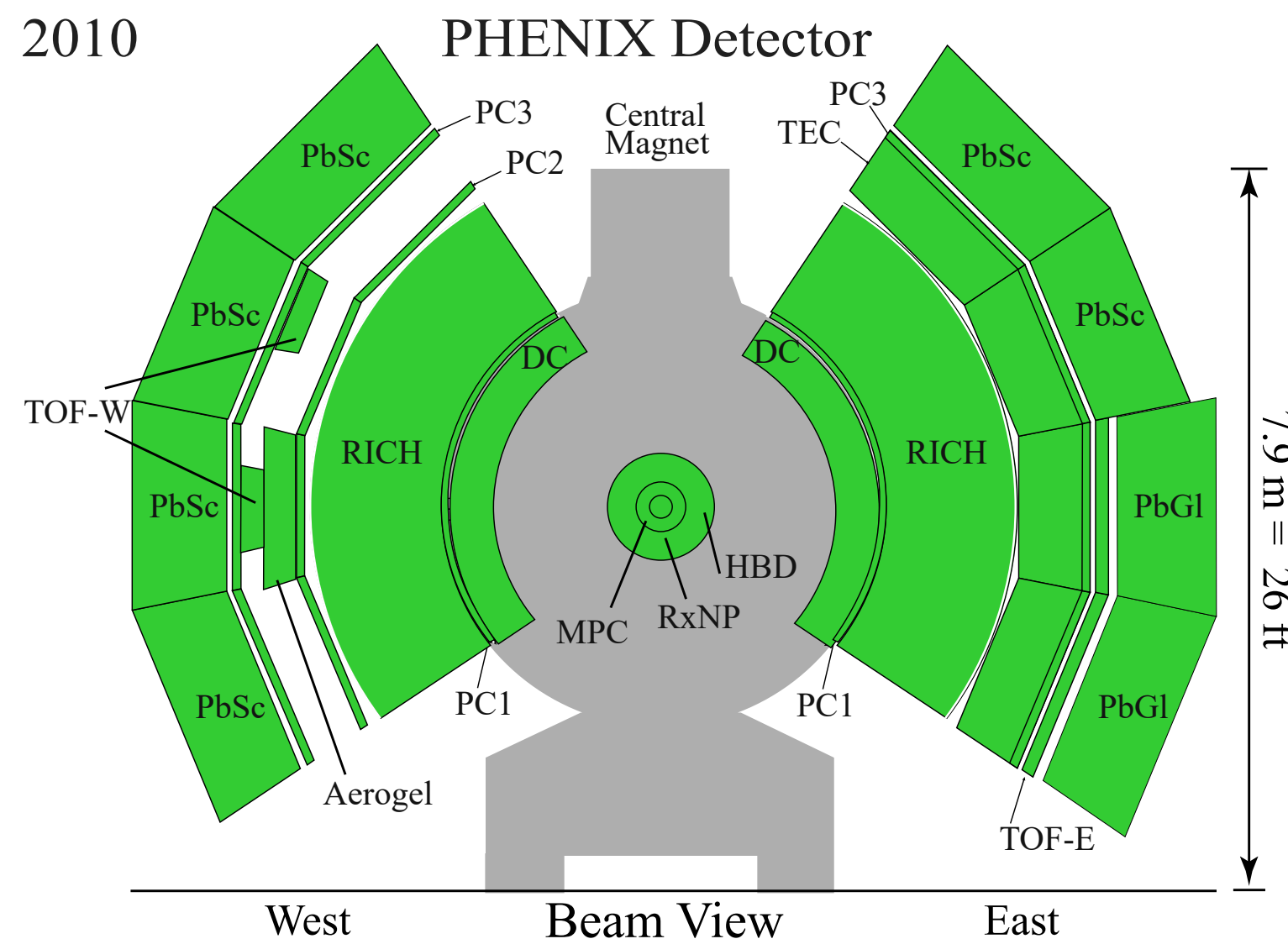
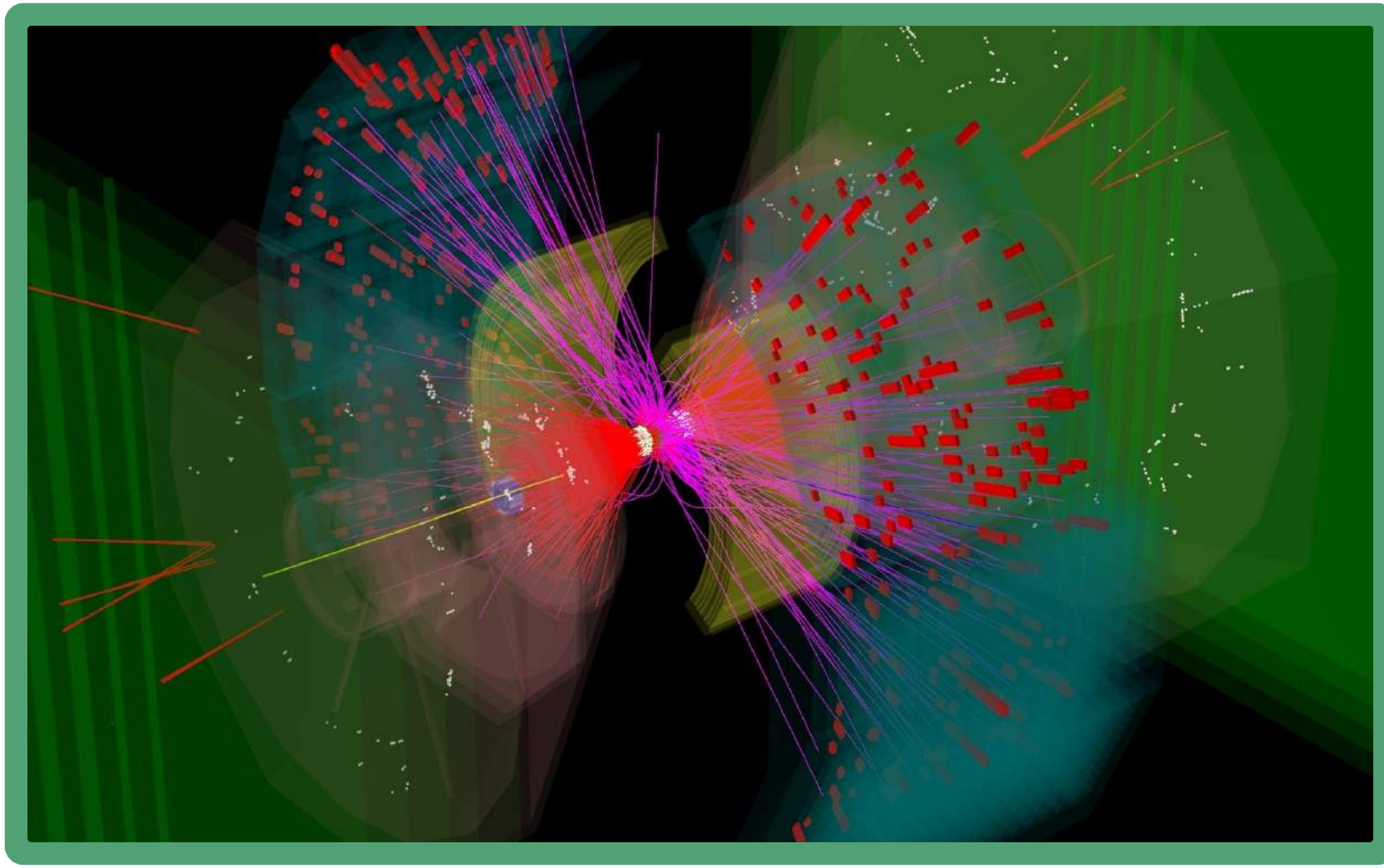


The PHENIX experiment at RHIC



- Observing collisions of p, d, Cu, Au, Al, He, U
- Charged pion ID from ~ 0.2 to 2 GeV/c

Introduction to Bose-Einstein correlations

- $N_1(p), N_2(p)$ - invariant momentum distributions, the definition of the correlation function:

$$C_2(p_1, p_2) = \frac{N_2(p_1, p_2)}{N_1(p_1)N_1(p_2)}, \text{ where } N_2(p_1, p_2) = \int S(x_1, p_1)S(x_2, p_2)|\Psi_2(x_1, x_2)|^2 d^4x_2 d^4x_1 \quad (1)$$

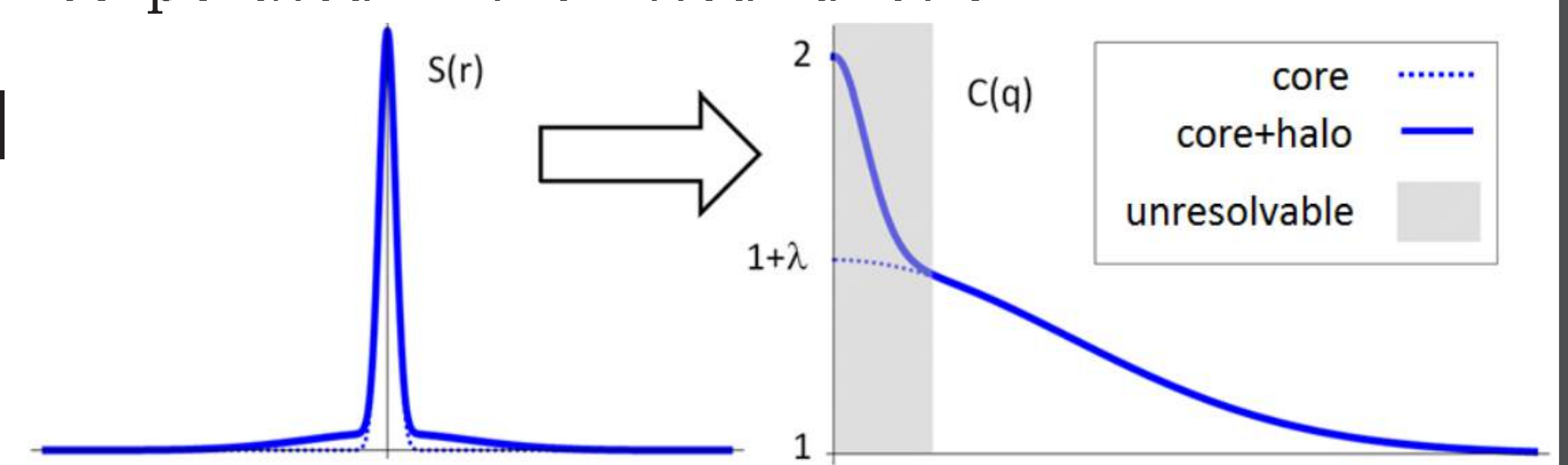
- $S(x, p)$ source function (usually assumed to be Gaussian - Levy is more general)
- Ψ_2 two-particle wave function - interaction free case: $|\Psi_2|^2 = 1 + \cos(qx)$
- If $k_1 \simeq k_2$: $C_2 \rightarrow$ inverse Fourier-trf. $\rightarrow S$

$$C_2(q, K) \simeq 1 + \left| \frac{\tilde{S}(q, K)}{\tilde{S}(0, K)} \right|^2, \quad \tilde{S}(q, k) = \int S(x, k) e^{iqx} d^4x \quad \begin{matrix} K = (k_1 + k_2)/2 \\ x = x_1 - x_2, q = k_1 - k_2 \end{matrix}$$

Final state interactions, resonances

- Identical charged pions - Coulomb interaction distort the simple picture
 - different methods of handling, e.g. Coulomb-correction: $C_{B-E}(q) = K(q) \cdot C_{\text{meas.}}(q)$
 - An other possibility to fit with the effect incorporated in the fitted function

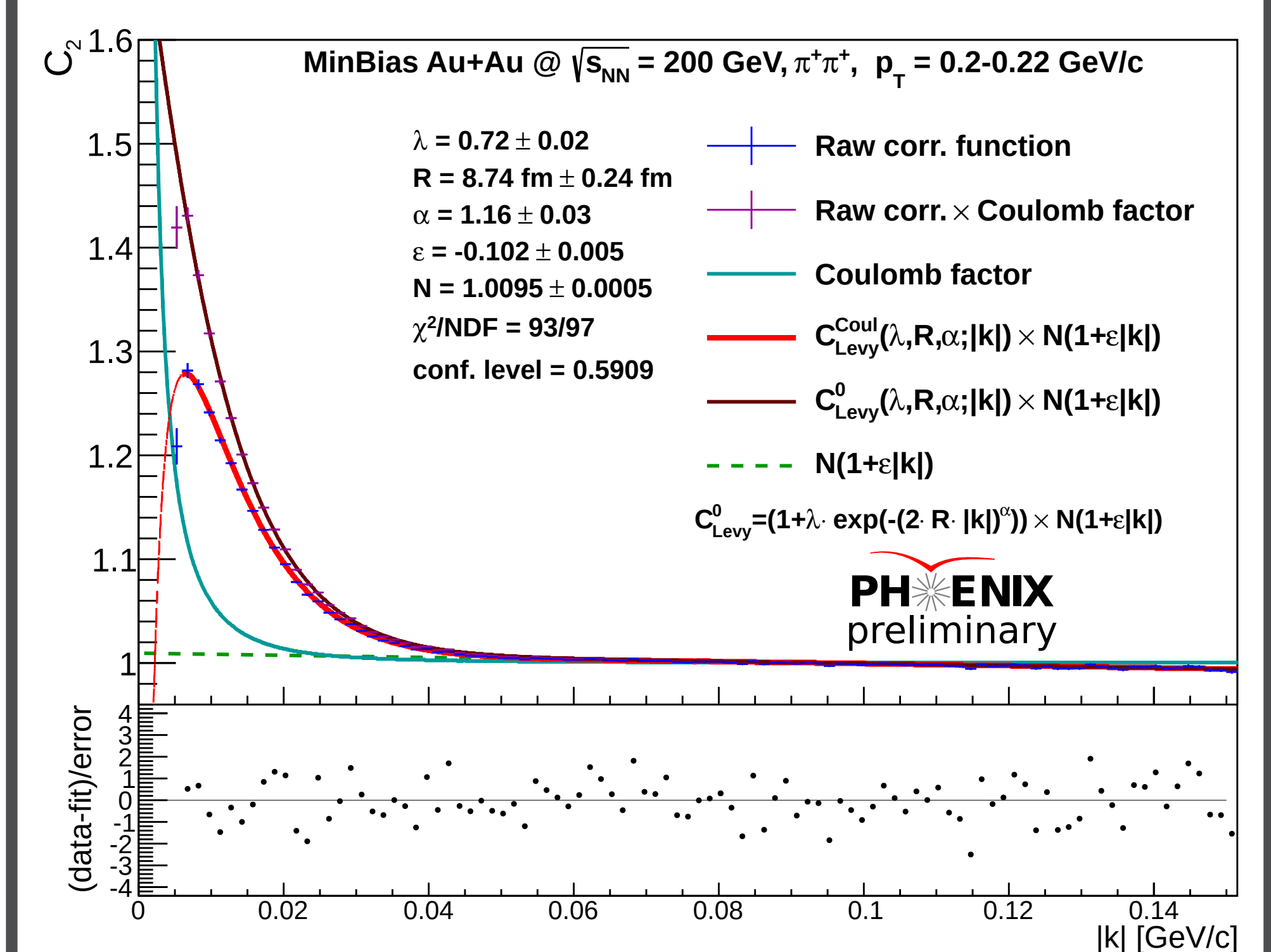
- Resonance pions reduce the corr. function [1, 2]
- $S = S_C + S_H$
- Primordial pions - Core $\lesssim 10$ fm
- Resonance pions - from very far regions - Halo



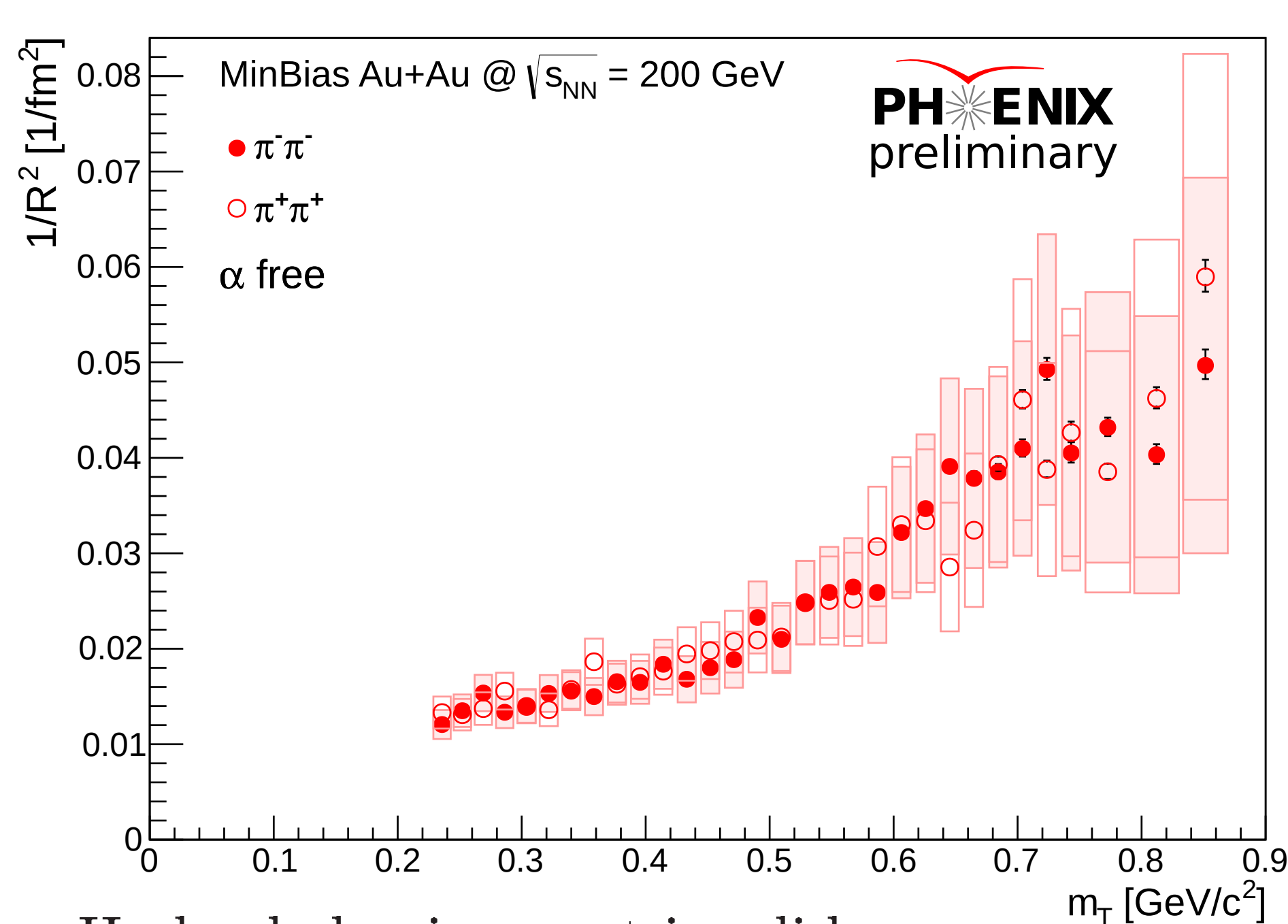
The Levy-distribution and the critical point

- Generalized Gaussian - Levy-distribution
 - Anomalous diffusion
 - Generalized central limit th.
- Shape of the corr. func. with Levy source [3]: $C_2(|k|) = 1 + \lambda \cdot e^{-(2R|k|)^\alpha}$
 - $\alpha = 2$: Gaussian
 - $\alpha = 1$: Cauchy
 - $\alpha = 2$: Gaussian
 - $\alpha = 1$: Exponential
- Critical behaviour $\rightarrow$ described by critical exponents
- Spatial corr. $\propto r^{-(d-2+\eta)} \rightarrow$ defines η exponent
- Symmetric stable distributions (Levy) $\rightarrow$ spatial corr. $\propto r^{-1-\alpha}$ } $\alpha \equiv$ critical exponent η
- QCD universality class $\leftrightarrow$ 3D Ising [4, 5]
 - $\eta(\text{CEP}) = 0.03631(3)$ from 3D Ising [6]
 - $\eta(\text{CEP}) = 0.5 \pm 0.05$ from rfd.3D Ising [7]

Example correlation function

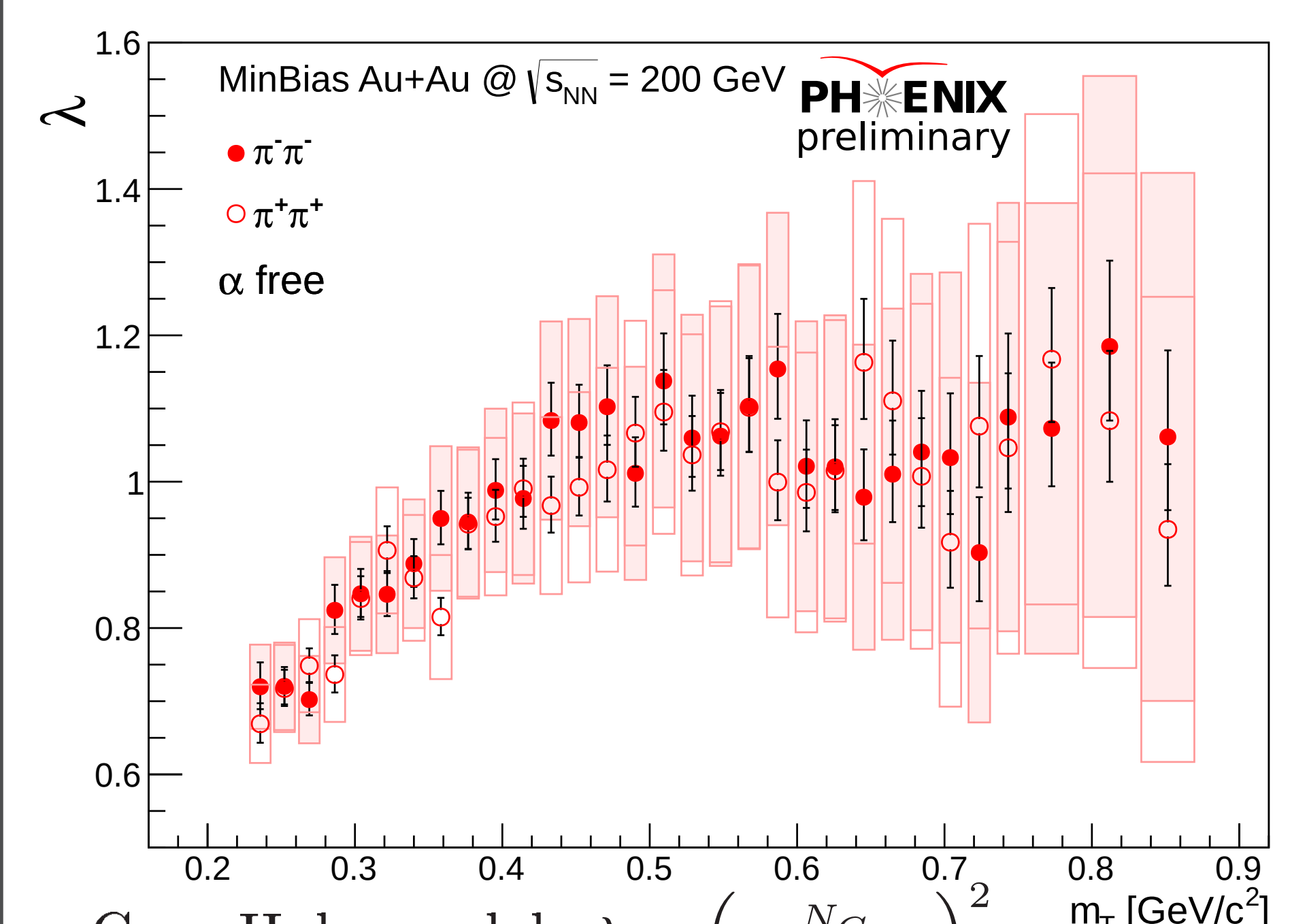


Levy scale parameter R vs. m_T



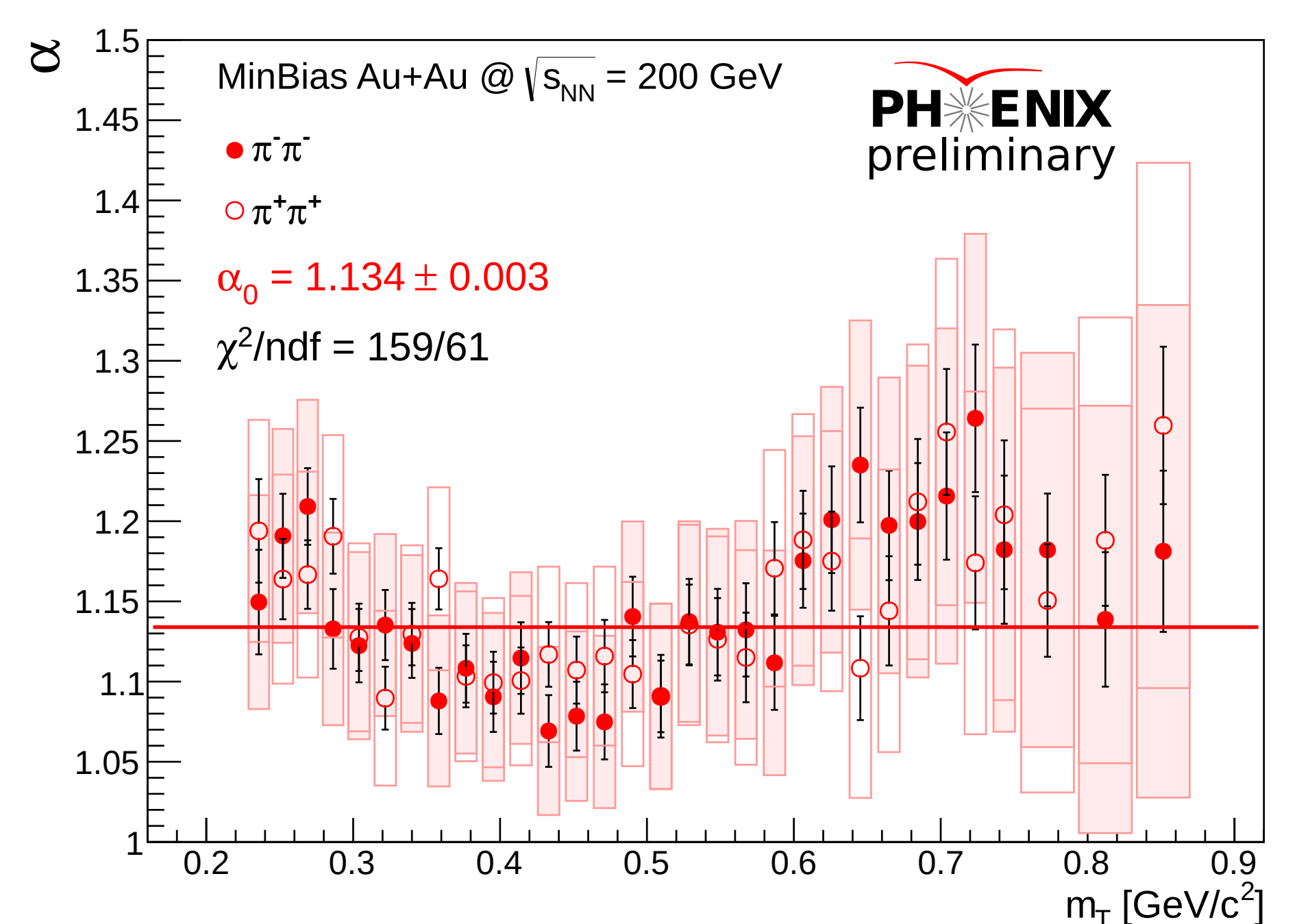
- Hydro behaviour not invalid
- Linear scaling of $1/R^2$ not clear for high m_T

Correlation strength λ vs. m_T



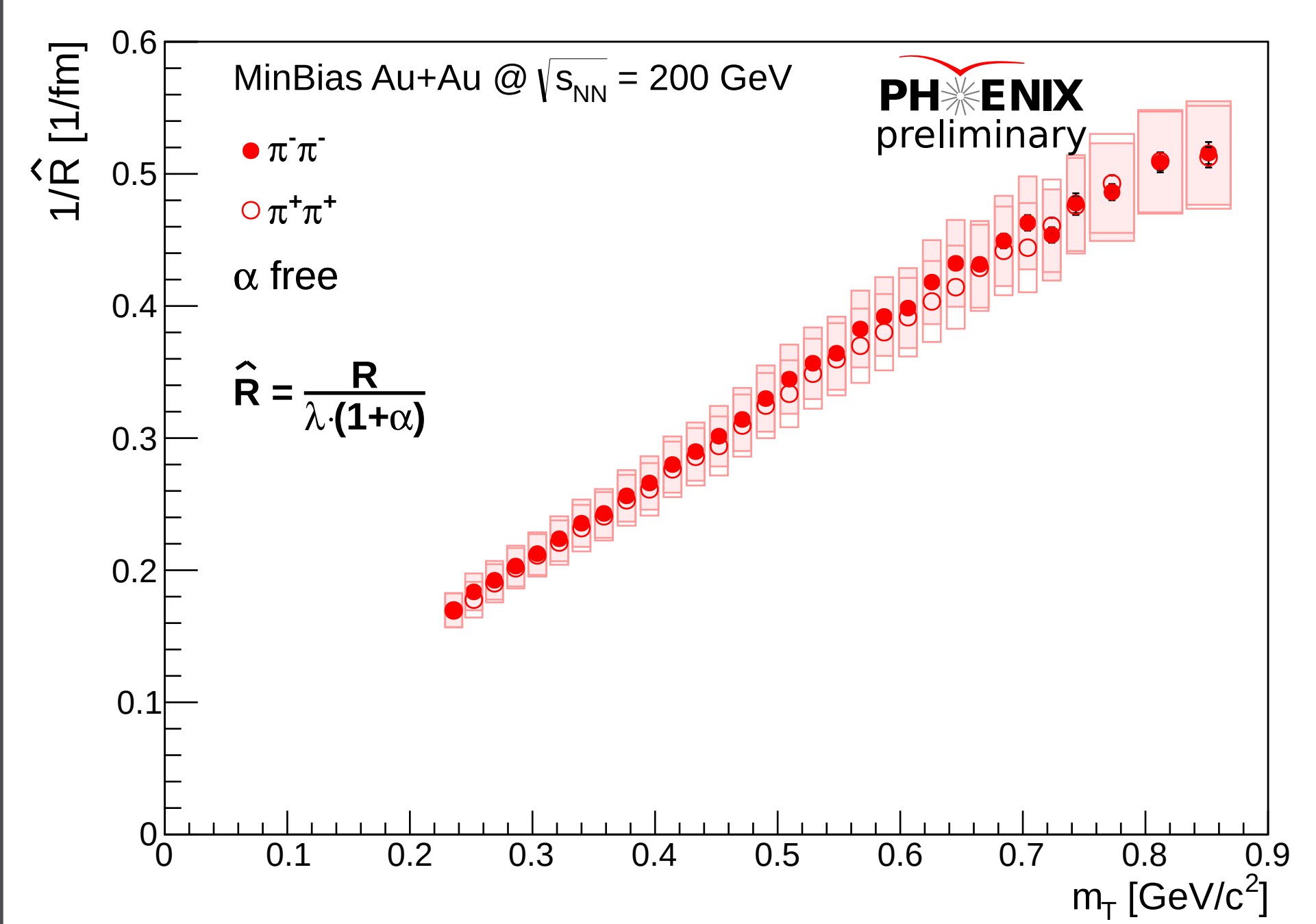
- Core-Halo model: $\lambda = \left(\frac{N_C}{N_C + N_H} \right)^2$
- Decrease at small $m_T \rightarrow$ increase of halo frac.

Levy exponent α vs. m_T



- Far from Gaussian ($\alpha = 2$) and expo. ($\alpha = 1$)
- Far from rfd.3D Ising value at CEP ($\alpha = 0.5$)

Newly found scale param. $\hat{R}$ vs. m_T



- Empirically found, linear in m_T
- Physical interpretation still an open question

Summary and references

- Bose-Einstein corr. with Levy-source
 - Good agreement with data
 - Levy exponent $\alpha \equiv$ critical exponent η
 - Motivation for precise Levy HBT meas.!
- Preliminary Levy HBT results
 - α at $\sqrt{s_{NN}} = 200\text{GeV} \sim 1.134$
 - Hydro not invalid even with $\alpha \neq 2$
 - With fixed α the linearity of $1/R^2$ holds
 - Increase of halo fraction at small m_T
 - * Resonance effects?
 - * Partial coherence of the fireball?
- Future plans
 - Lower energies
 - Three-pion correlations
 - Pion-kaon comparison

References

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- [2] T. Csörgő et al., Z.Phys. C71 (1996) 491
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