Initial Condition Fluctuations for Heavy Ion Collisions

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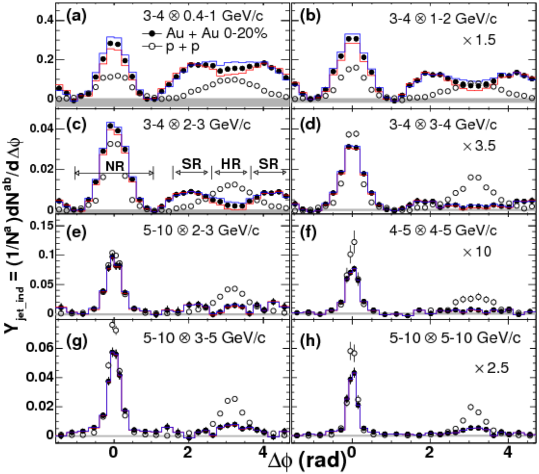
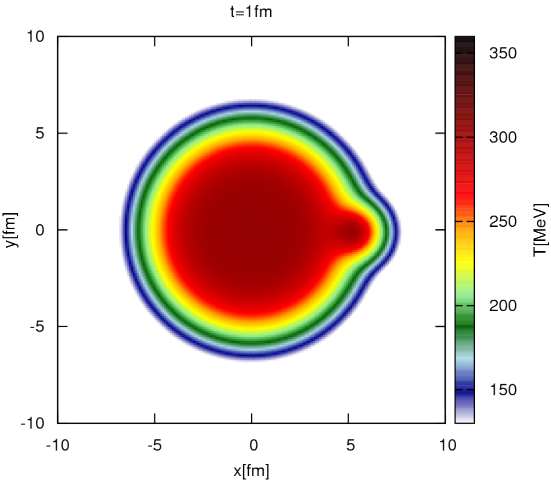
Two particle correlation observed at RHIC.



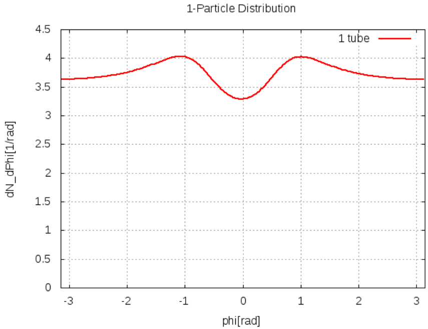
shadow effect

smooth initial condition plus gaussian tube



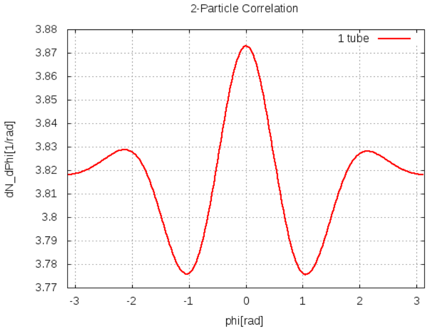
shadow effect

- single particle distribution



dip at the tube position and shoulders around it

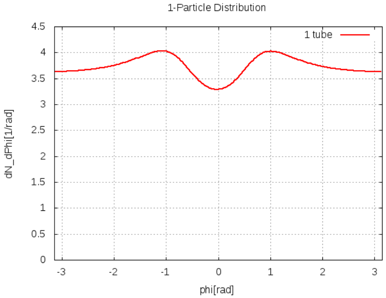
- two particle correlation



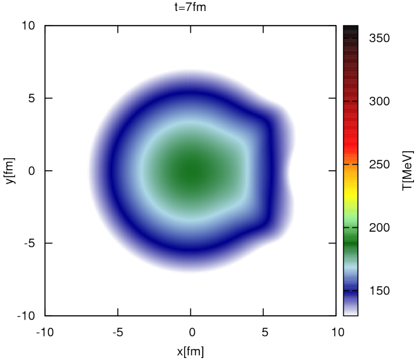
features dip at away side

smooth + 1 tube

- single particle distribution

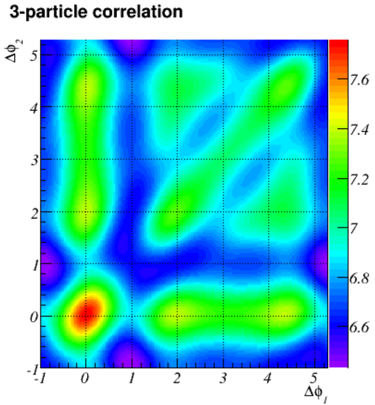


- perfil de temperatura em $t = 7\,\text{fm}$

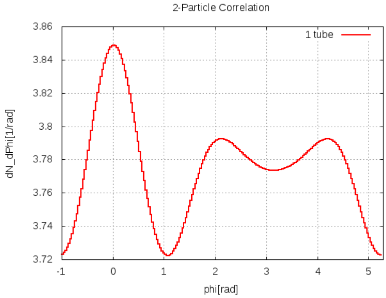


medium blocked by tube expansion which is much more explosive

- 3 particle correlation



- 2 particle correlation

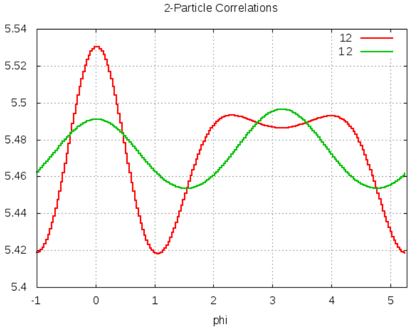


$$\frac{dN^{123}}{d\Delta\phi_{12}\Delta\phi_{13}} = \int d\phi \frac{dN^1}{d\phi}(\phi)\frac{dN^2}{d\phi}(\phi+\Delta\phi_{12})\frac{dN^3}{d\phi}(\phi+\Delta\phi_{13})$$

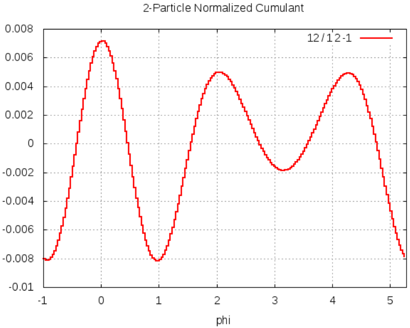
smooth + fluctuation

3 tubes, average over different events

- average of correlation



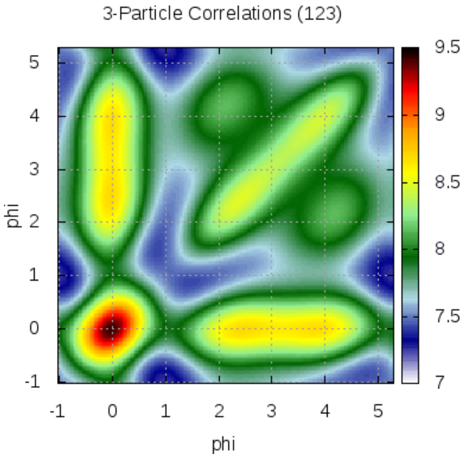
- correlation of averages



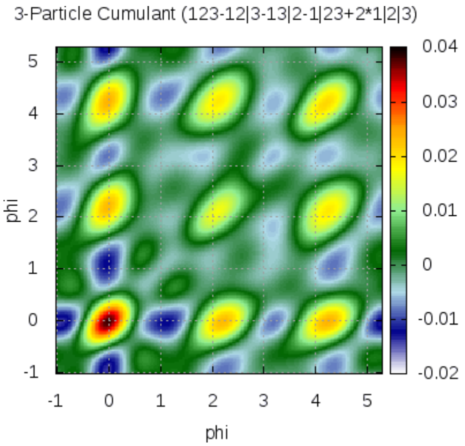
$$C(\Delta\phi) = \int \mathrm{d}\phi \langle f^1(\phi) f^2(\phi+\Delta\phi)\rangle - \langle f^1(\phi)\rangle\langle f^2(\phi+\Delta\phi)\rangle$$

smooth + fluctuation

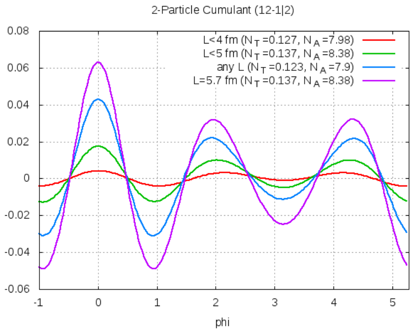
- 3 particle correlation



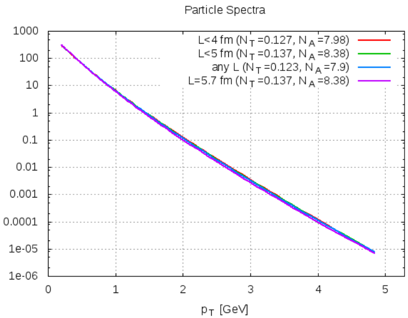
- 3 particle cumulant



- 2 particle cumulant



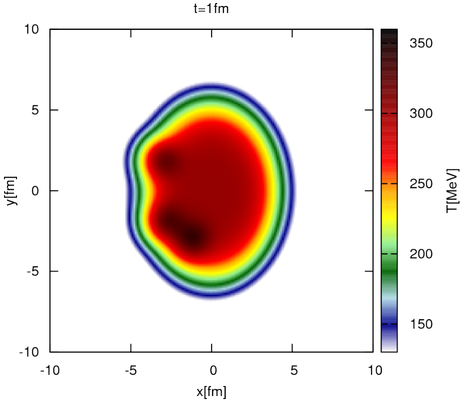
- particle spectra



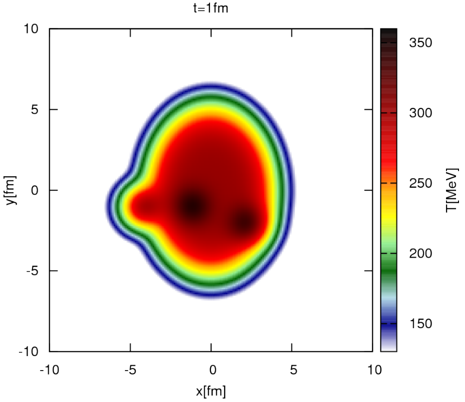
strongly affects the cumulant but does not changes the spectrum

peripheral collisions

- temperature profile

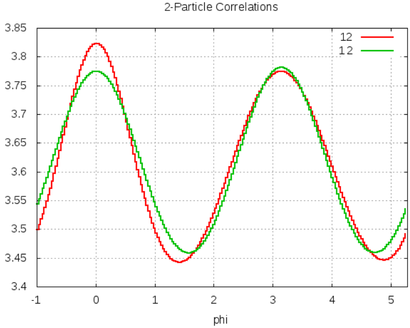


- temperature profile

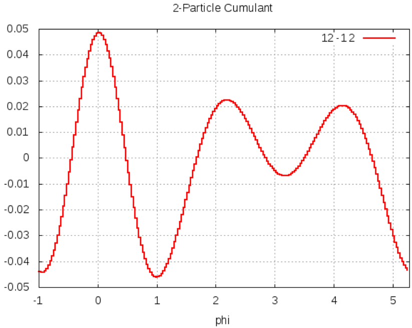


peripheral collisions

- medium + shadow



- shadow



initial conditions with fluctuations

- event-by-event hydro (non-homogenous IC)
- systematic study of observables
- focus in the 2 particle correlations
- (2+1)D with HG+lQCD EoS

random tubes model

- energy density profile

$$\varepsilon(\mathbf{x}_\perp; b) = \sum_i^{N(b)} \varepsilon^{\text{tube}}(\mathbf{x}_\perp - \mathbf{R}_\perp^i)$$

- spatial probablity

$$\mathcal{P}(\mathbf{R}_\perp; b) \propto \varepsilon^{\text{WN}}(\mathbf{R}_\perp; b)$$

- tube energy density

$$\varepsilon_i^{\text{tube}}(\mathbf{x}_\perp)$$
$$= \varepsilon_0^{\text{tube}} \exp\left(-\frac{(\mathbf{x}_\perp - \mathbf{R}_\perp^i)^2}{2(\sigma^{\text{tube}})^2}\right)$$

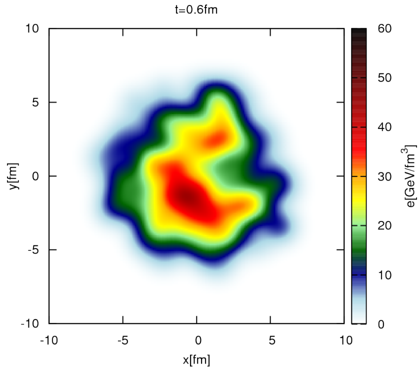
- number of tubes

$$N(b) = \frac{E^{\text{WN}}(b)}{E^{\text{WN}}(0)} N(0)$$

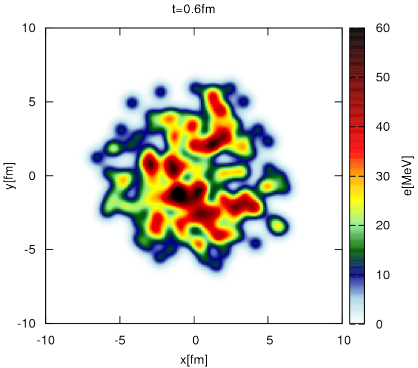
- model parameters σ e N

random tubes

- $\sigma = 0.7$ fm, $N = 200$

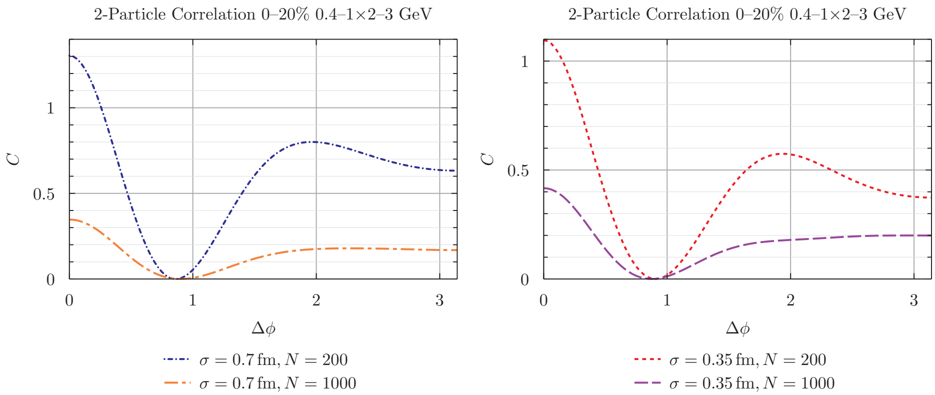


- $\sigma = 0.35$ fm, $N = 200$



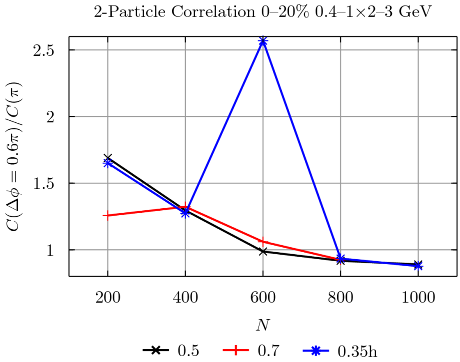
same tube positions $(b = 0.4)$
MC Glauber: 0–20% $(b < 6.6\,\text{fm})$

azimuthal distribution (.4–1×2–3)



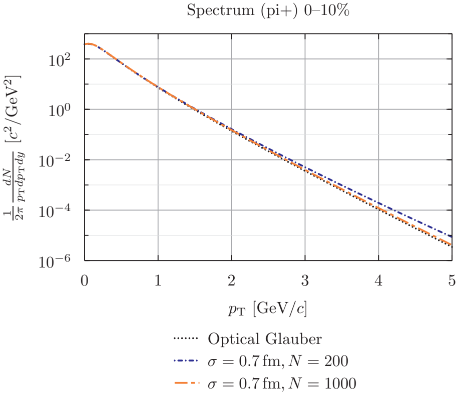
- dip appearence favors smaller N
- no dip for higher N
- σ plays smaller role

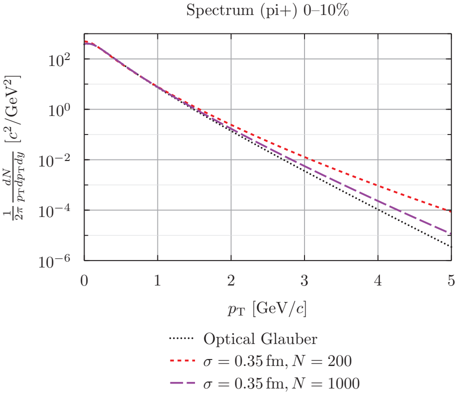
Ratio shoulder/head



- trend shows ratio depends strongly on N
- no dip for $N \gtrsim 800$

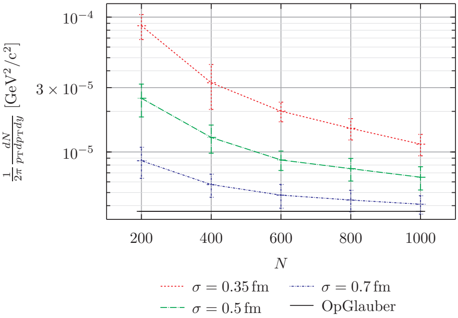
spectrum

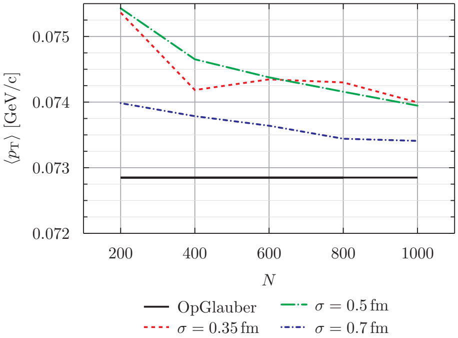




- small differences for low p_T
- granularity enhances high p_T

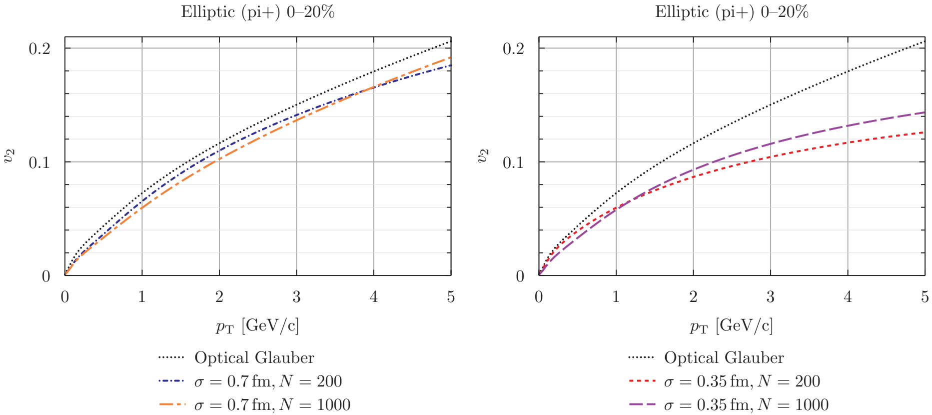
spectrum





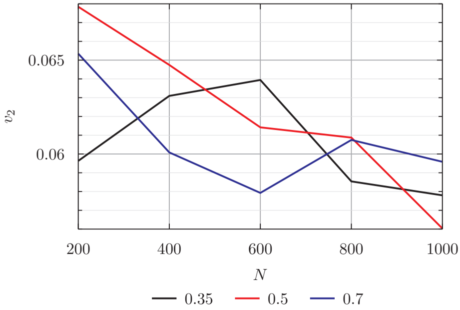
- sensitive to both N and σ
- $\langle p_T \rangle$ trend increases with granularity

elliptic flow

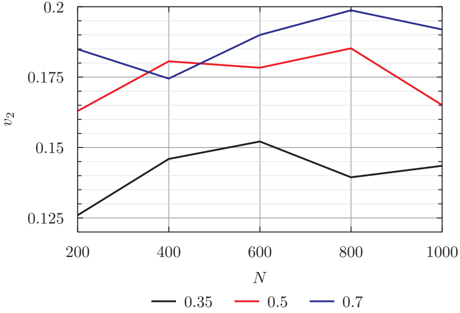


- v_2 for high p_T is strongly affected by σ
- possible saturation of v_2 for $\sigma \lesssim 0.35$ fm

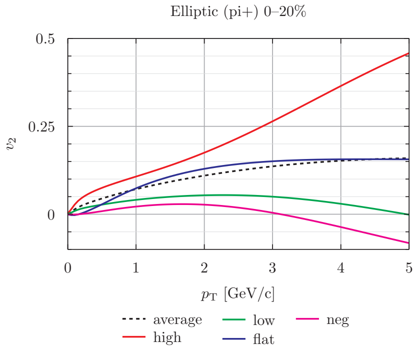
$p_T = 1$ GeV



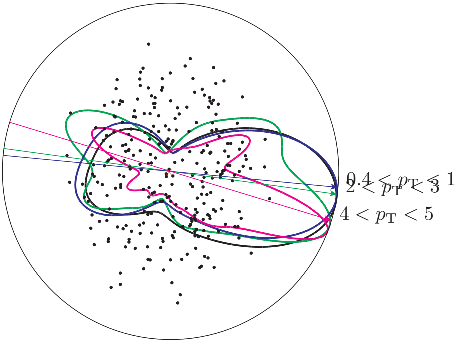
$p_T = 5$ GeV



- v_2 slowly converging
- N affects v_2 stronger for low p_T
- σ affects v_2 stronger for high p_T



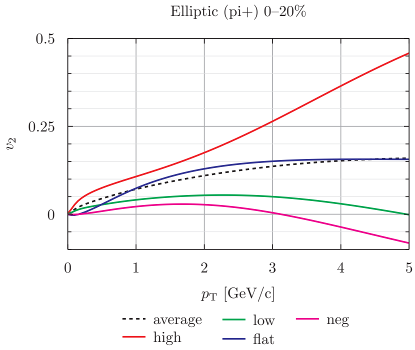
tube positions and particle distribution



event: high

- same b
- 1PD reflects IC
- v_2^{ebe} is highly sensitive to IC

tube fluctuation



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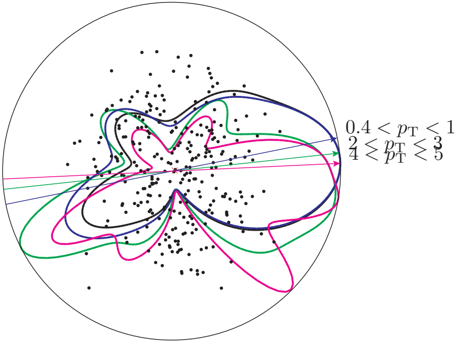
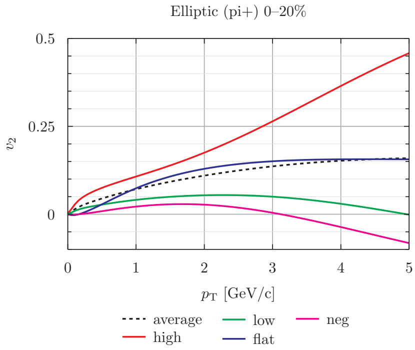
tube positions and particle distribution



event: flat



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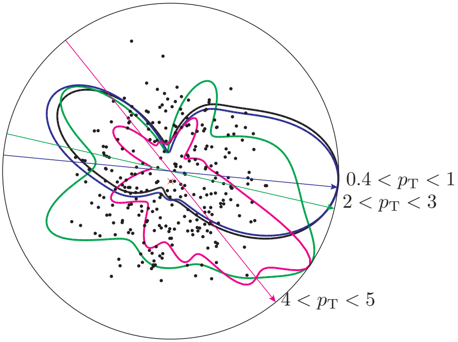
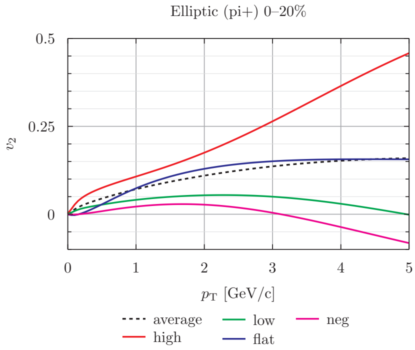
tube positions and particle distribution



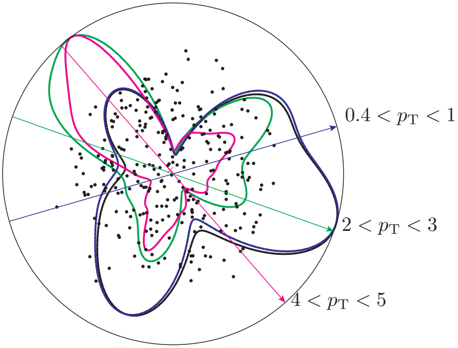
event: low

tube fluctuation



- same b
- 1PD reflects IC
- v_2^{ebe} is highly sensitive to IC

tube positions and particle distribution



event: neg

summary

- systematic study on the effects of granularity on the observables
- shadow effect survives throuth 2-particle correlations
- non-trivial results come from event-by-event study
- tubes lead to double peak structure and reduce v_2 for high p_{T}
- v_2 depends more on tube width
- correlation depends more on number of tubes

perspectives

- particle decays
- use microscopic models of IC
- apply to high multiplicity pp collisions