Initial Condition Fluctuations

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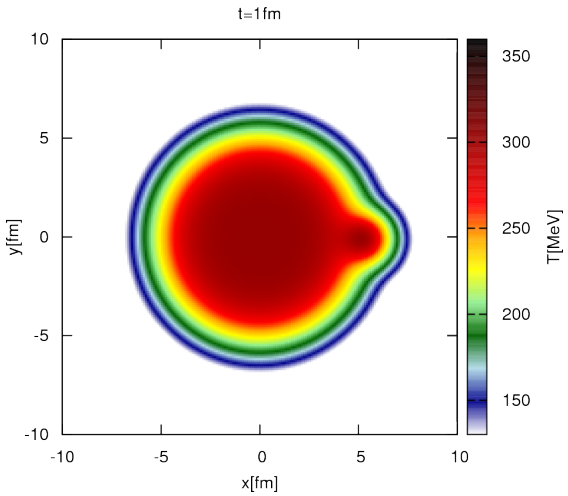
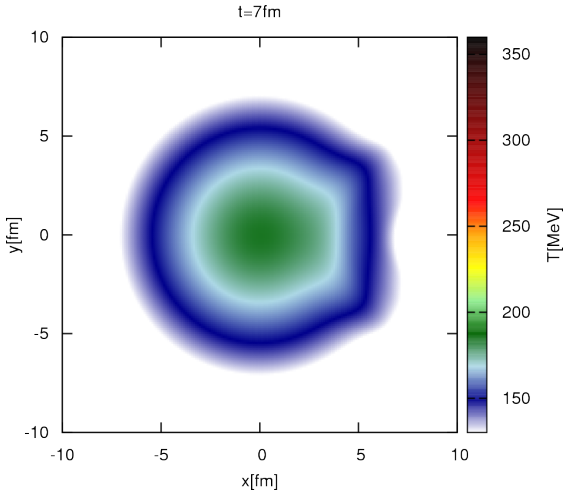
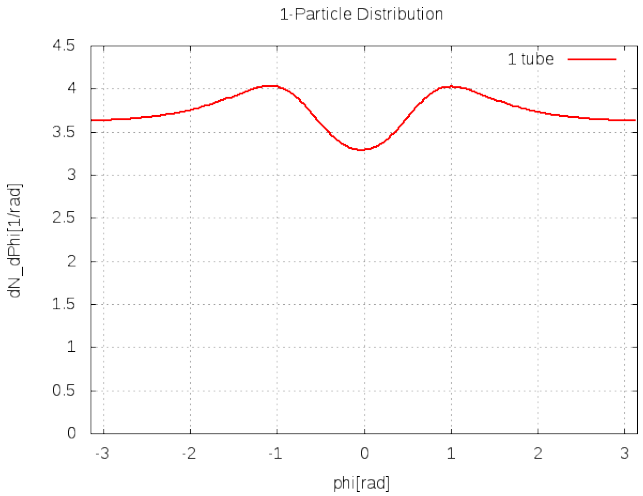
Quark Matter 2011

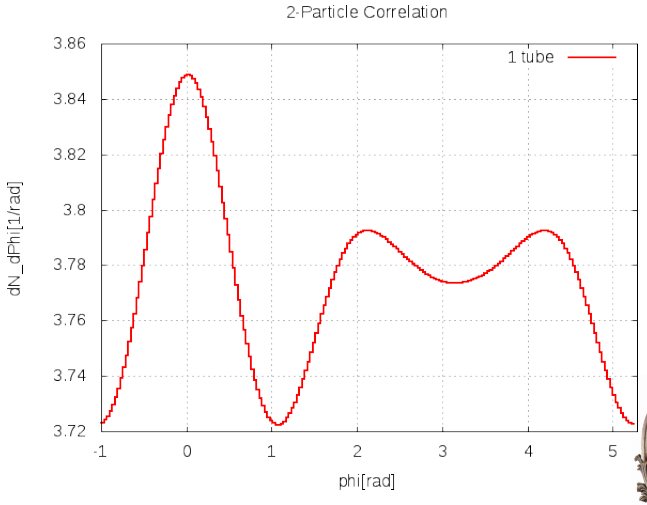
shadow effect

hydro IC = smooth BG + gaussian tube





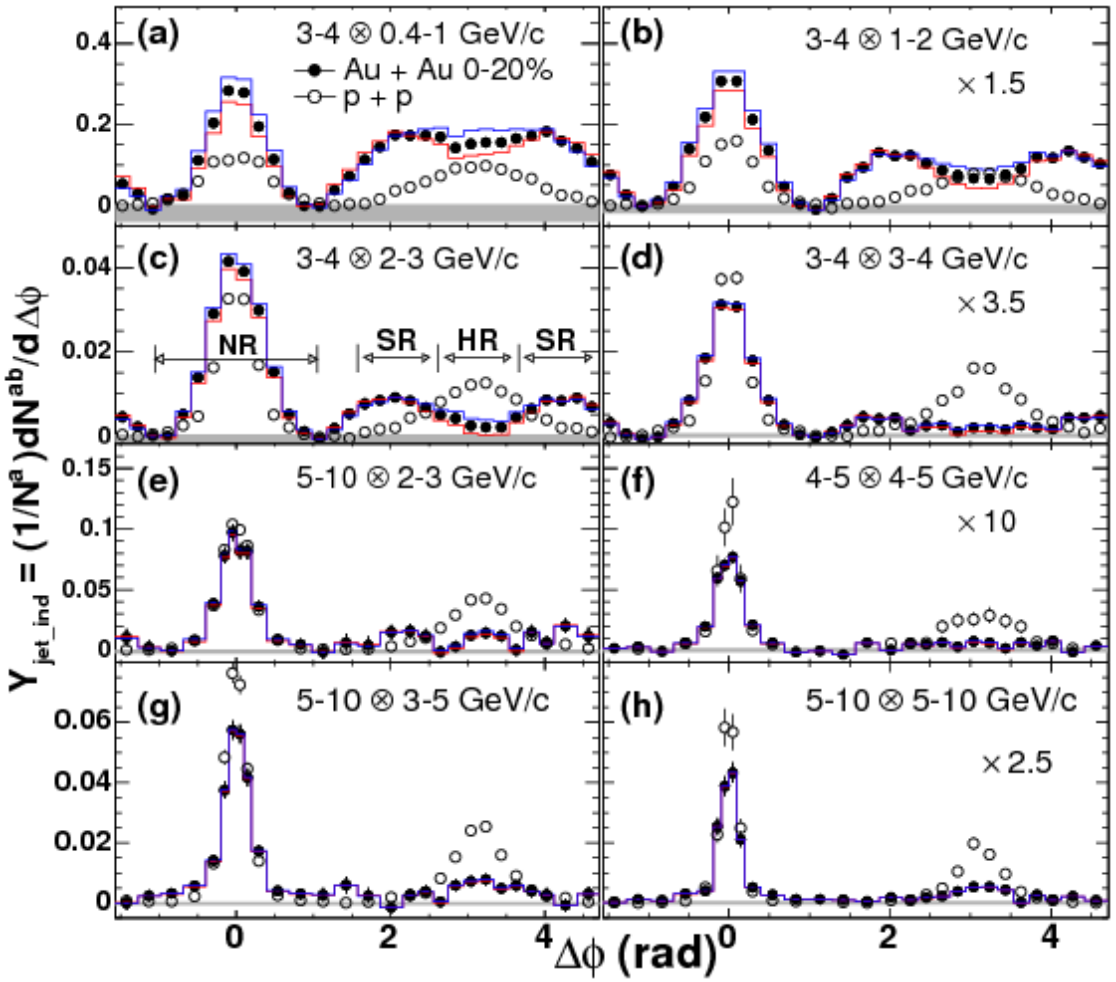




final distribution $\longrightarrow$ away-side dip

motivation

2-particle correlation @ RHIC

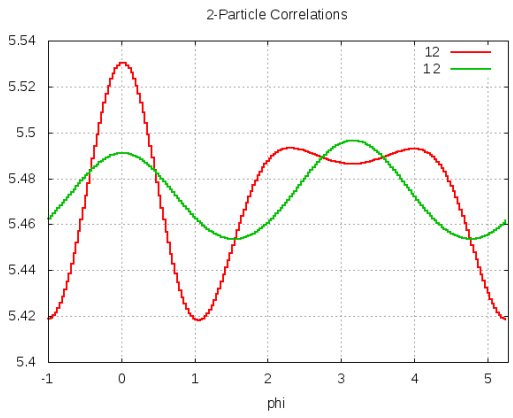


from sBG+tube:

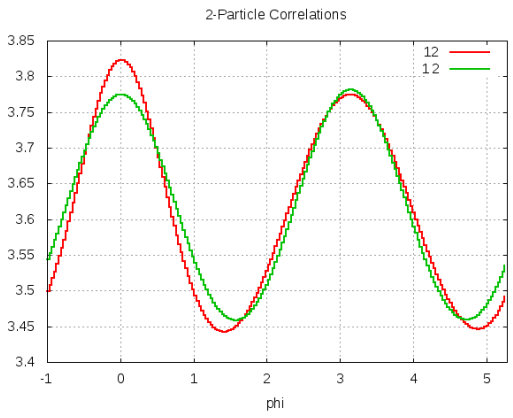
- qualitative behavior
- no jets
- purely geometrical

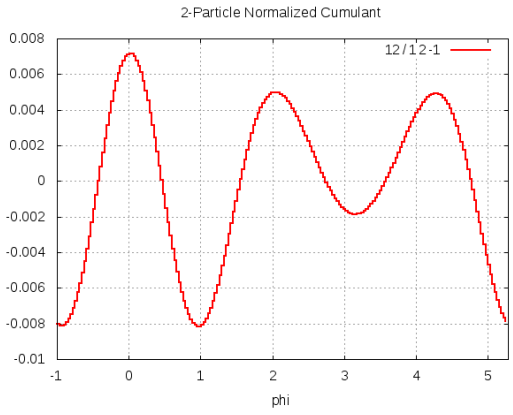
smooth + fluctuation

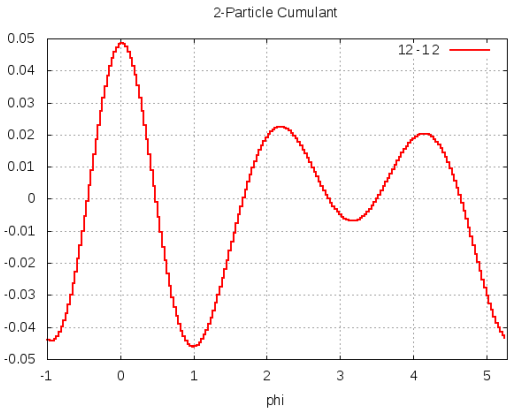
symmetric BG + fluctuations



non-symmetric BG + fluctuations







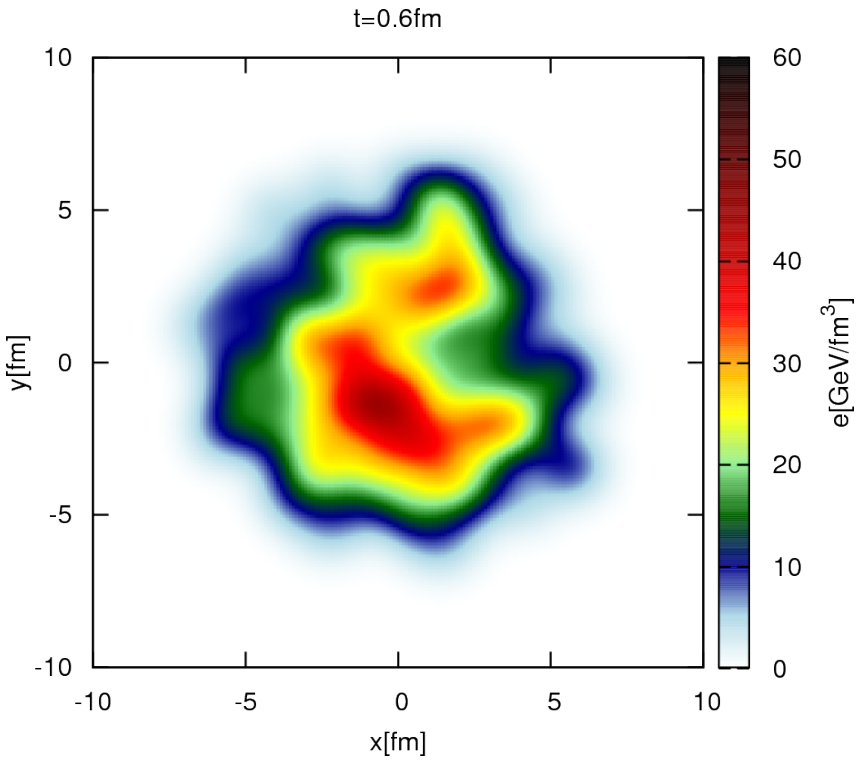
$$C(\Delta\phi) = \int \mathrm{d}\phi \langle f^1(\phi) f^2(\phi + \Delta\phi) \rangle - \langle f^1(\phi) \rangle \langle f^2(\phi + \Delta\phi) \rangle$$

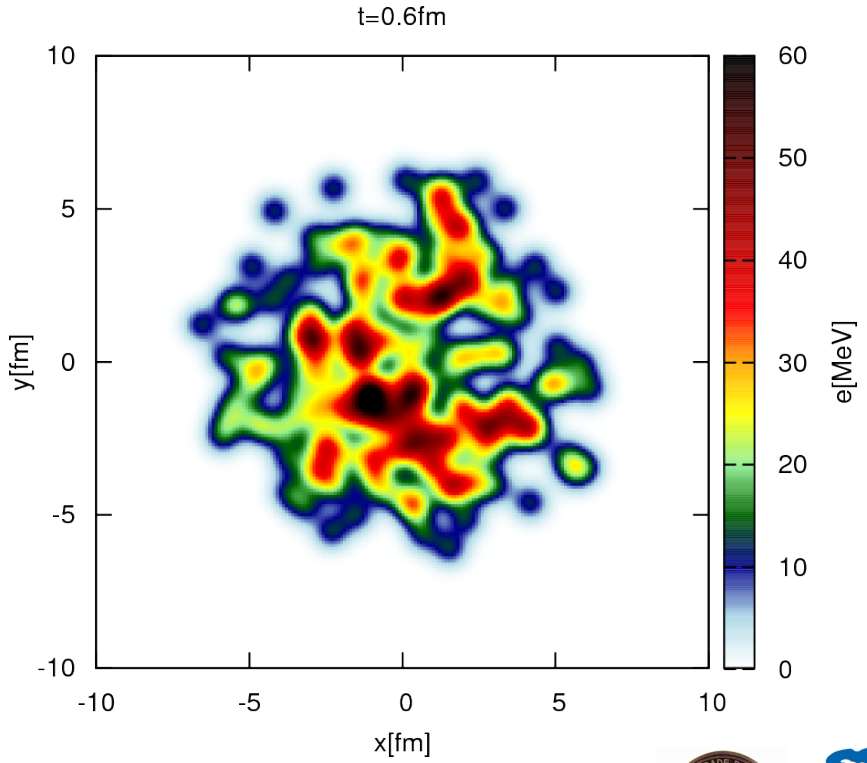
initial conditions with fluctuations

- parametrize the IC fluctuations in terms of longitudinal tubes
- apply event-by-event hydro to non-homogenous IC
- systematic study of the effects of the fluctuations on the observables

longitudinal flux tubes

- $\sigma = 0.7$ fm, $N = 200$
- $\sigma = 0.35$ fm, $N = 200$





random tubes model

- samples Wounded Nucleons model

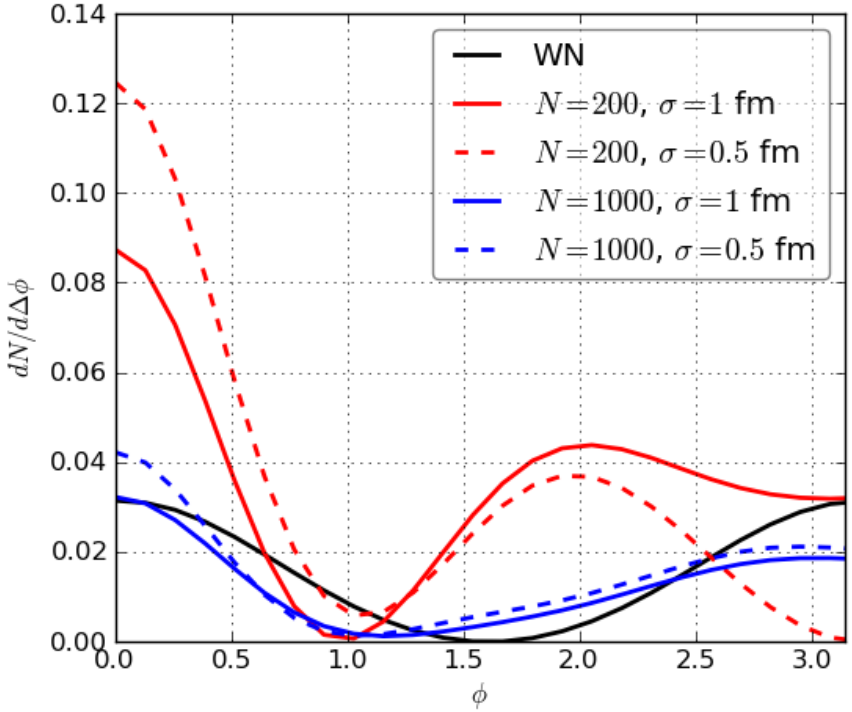
$$\mathcal{P}(\mathbf{r}_\perp; b) \propto \varepsilon^{\mathrm{WN}}(\mathbf{r}_\perp; b)$$

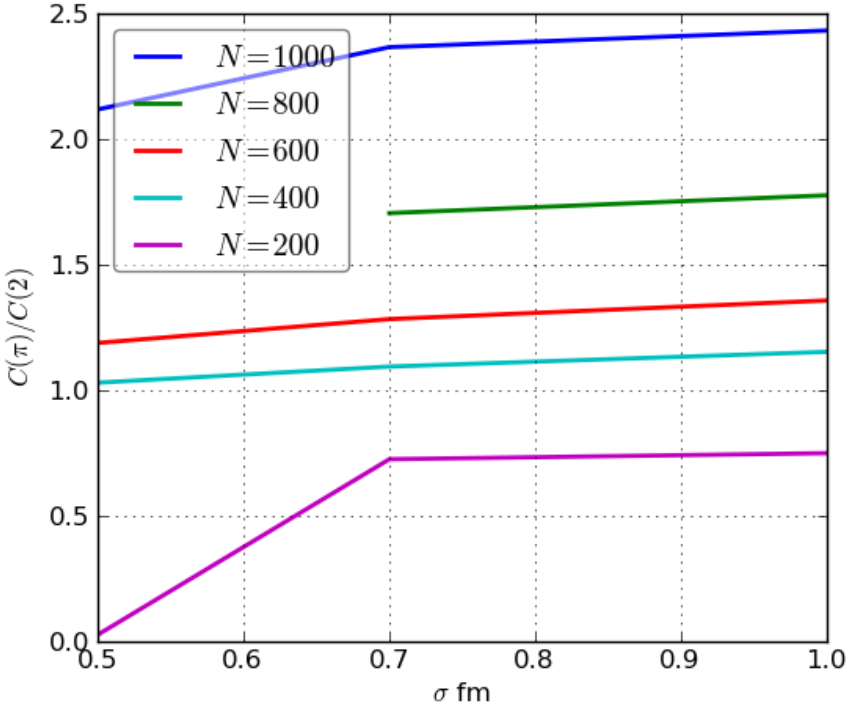
- total energy per tube independent of b

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

- gaussian transverse profile
- model parameters σ and N
- impact parameter $db \propto b$

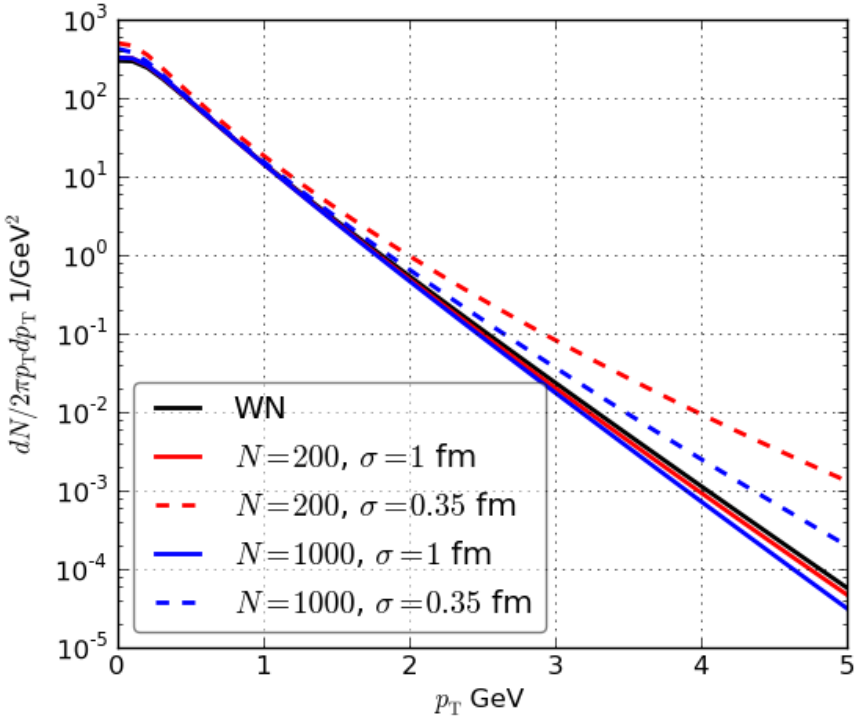
azimuthal distribution (.4–1×2–3)

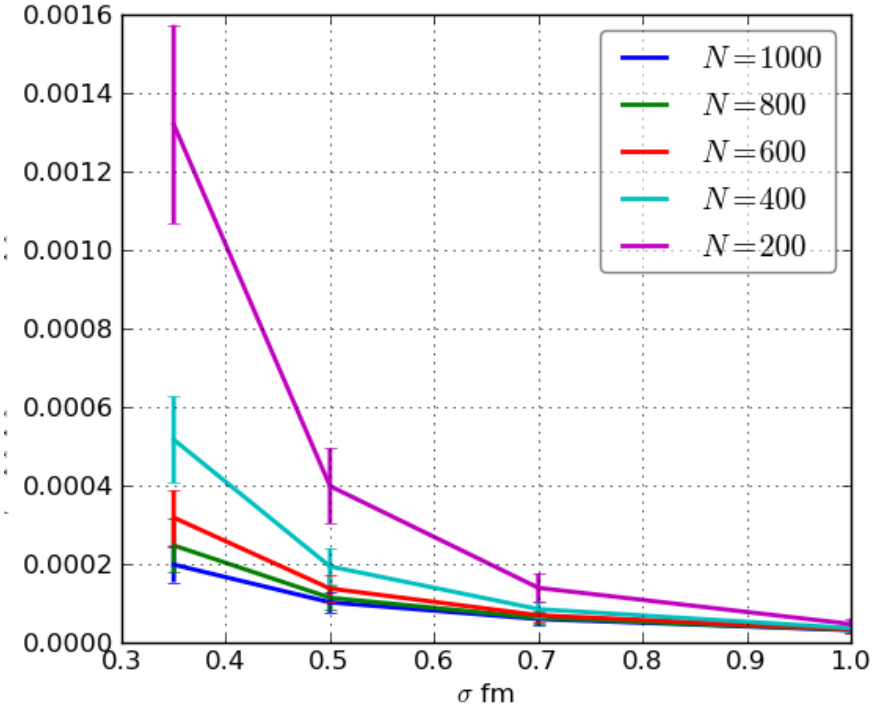




- dip for $N \lesssim 400$
- no dip for higher N, still different from WN
- more sensitive to N than σ

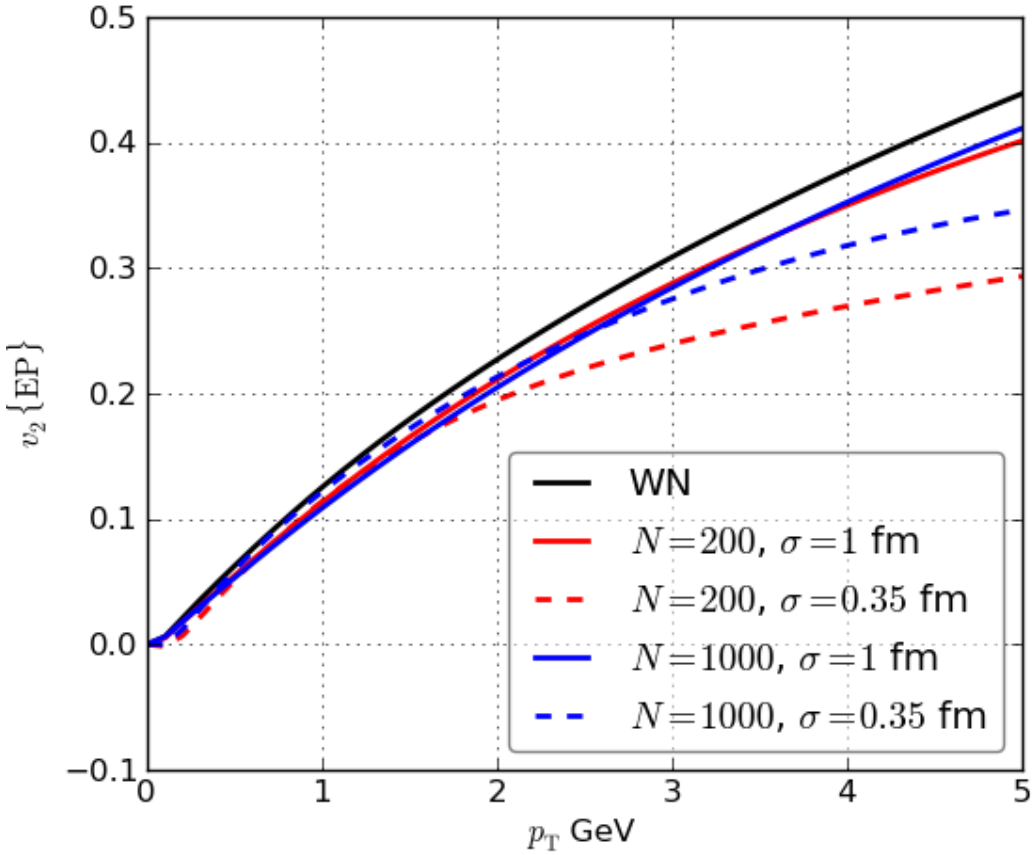
spectrum





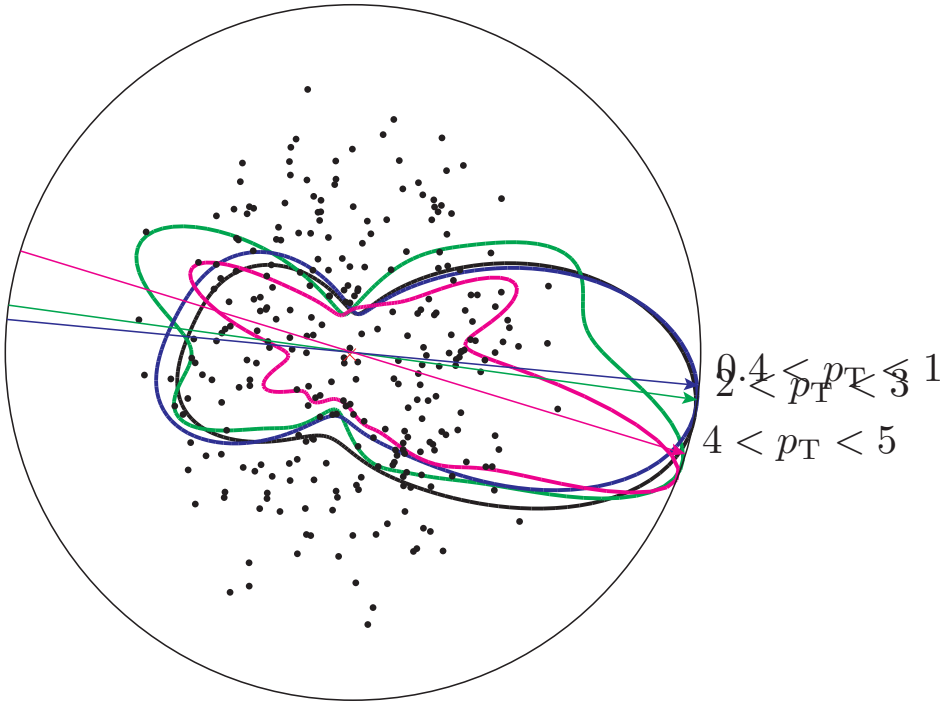
- little effect @ low p_T
- smaller N and σ increase spectra @ high p_T

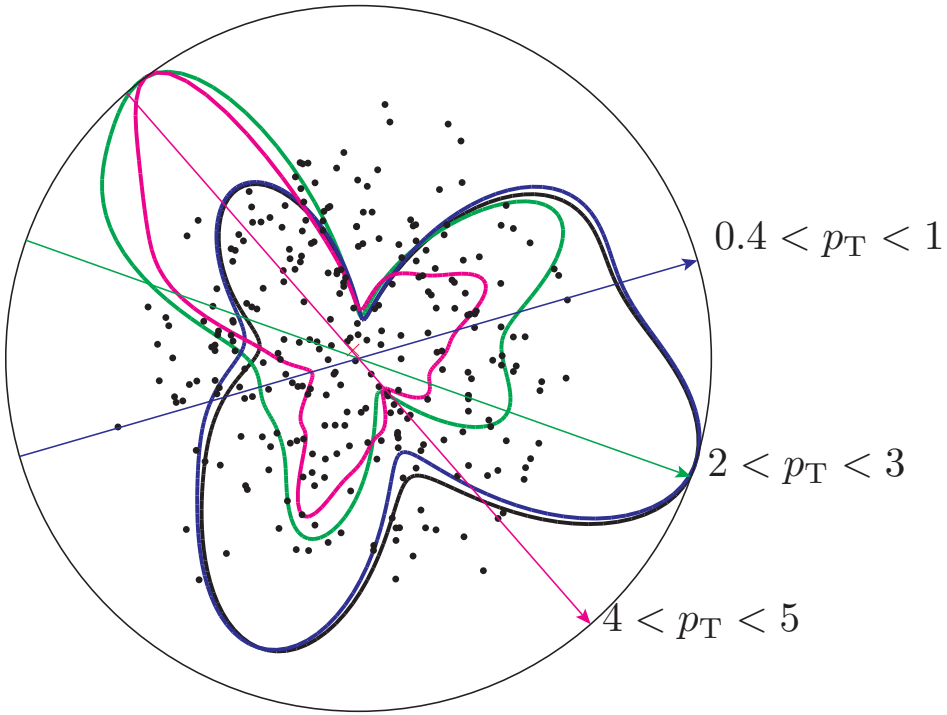
elliptic flow



- little change @ low p_T
- σ reduces v_2 @ high p_T

event plane

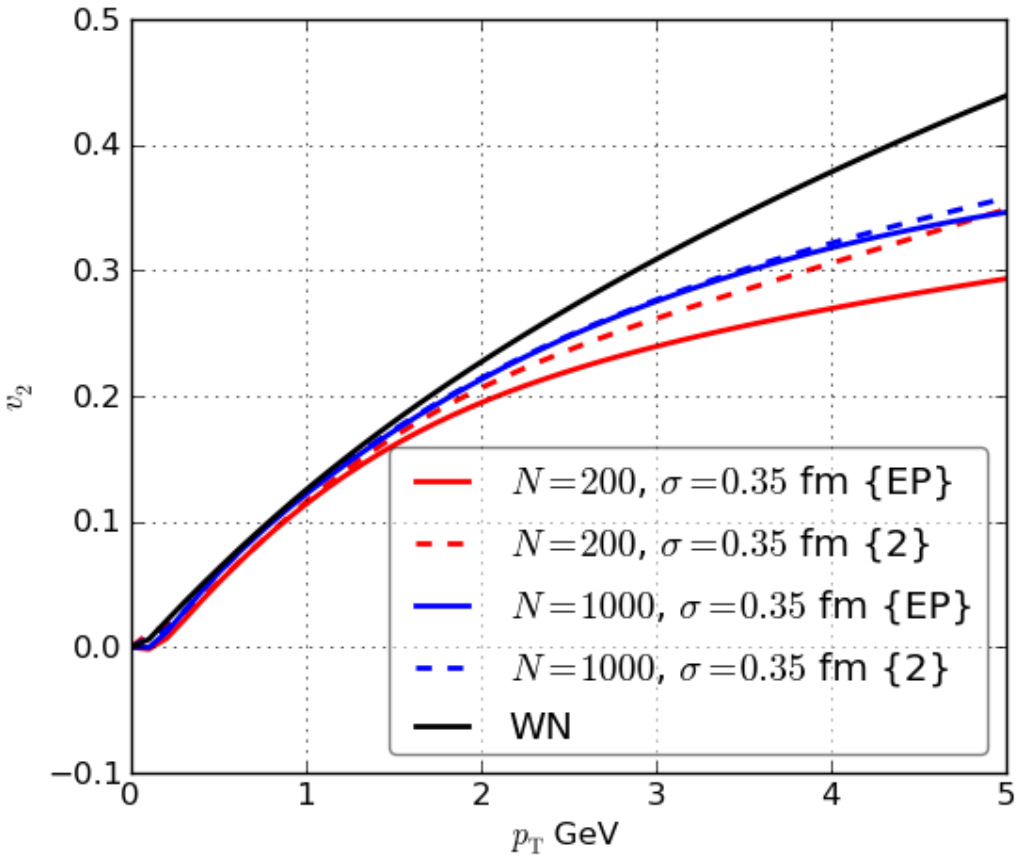




- high v_2 @ high p_T
- $\Delta\psi_{EP}(p_T) \sim 0$
- two main peaks

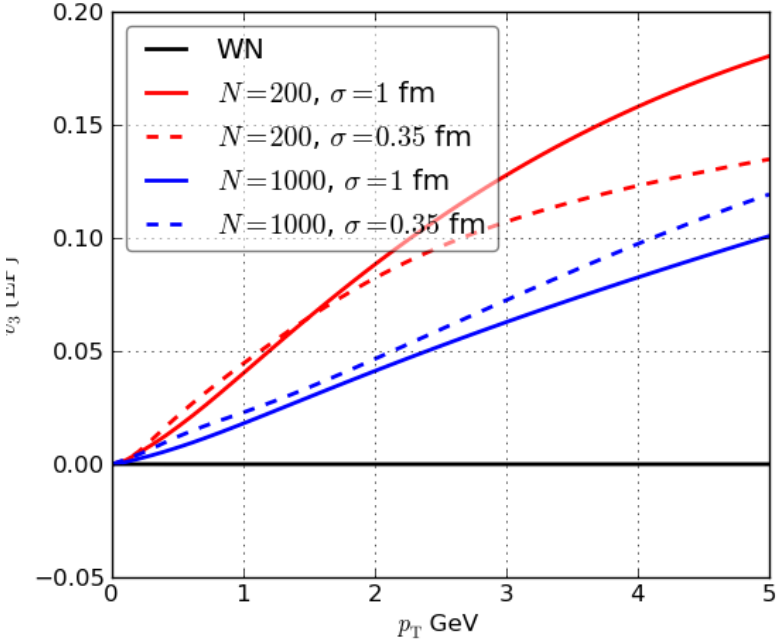
- negative v_2 @ high p_T
- $\Delta\psi_{EP}(p_T) \sim \pi/2$
- three main peaks

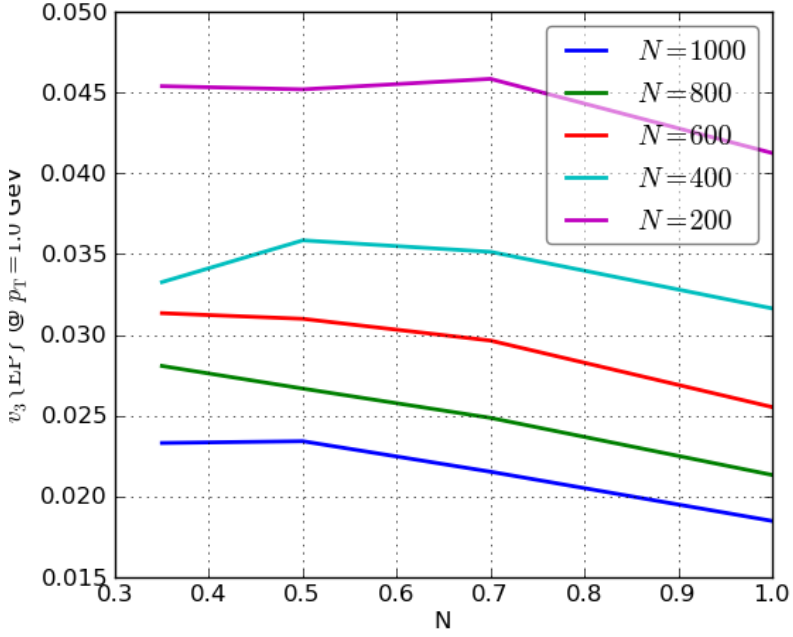
elliptic flow 2-particle method



- increases v_2 @ high p_{T} for very granular
- does not affect fluctuations

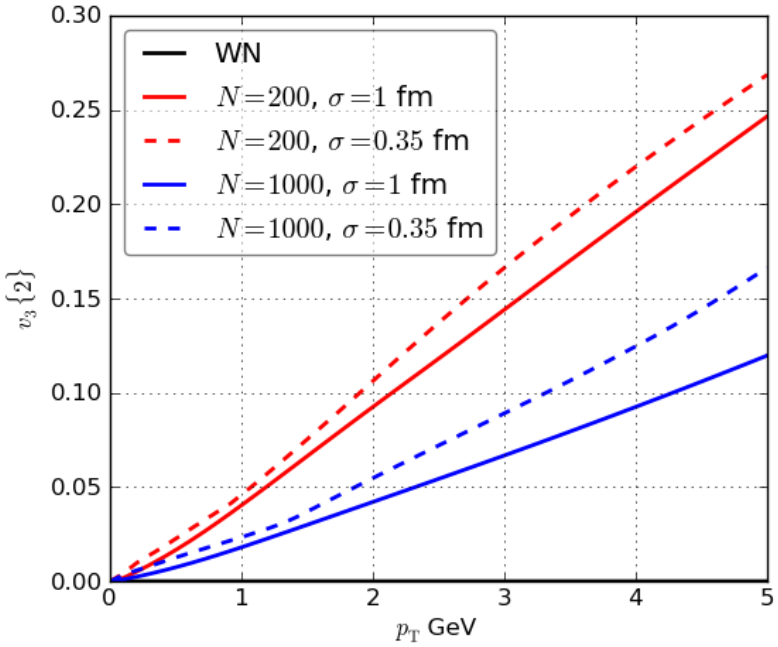
triangular flow, event plane method

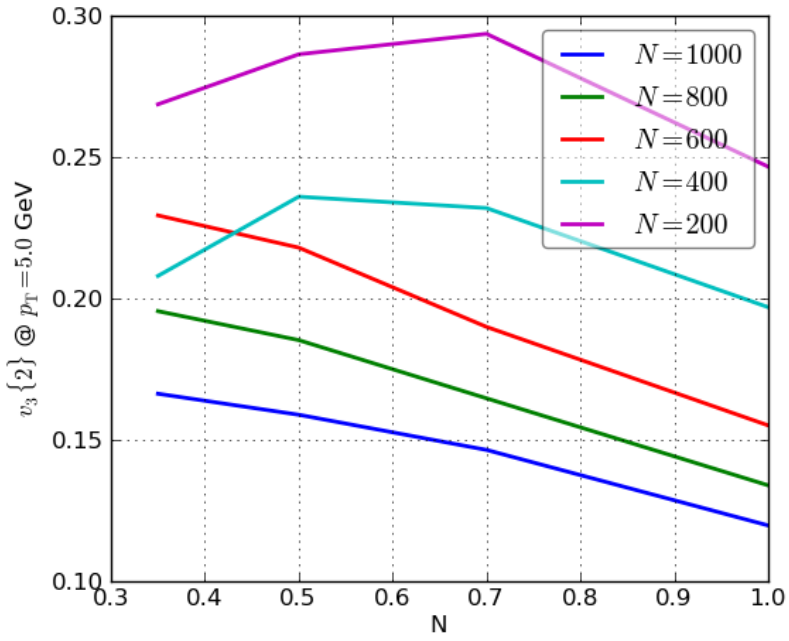




- $v_3/v_2 = 0.25$–0.5 @ $p_T = 1$ GeV/c
- fairly independent of σ @ low p_T

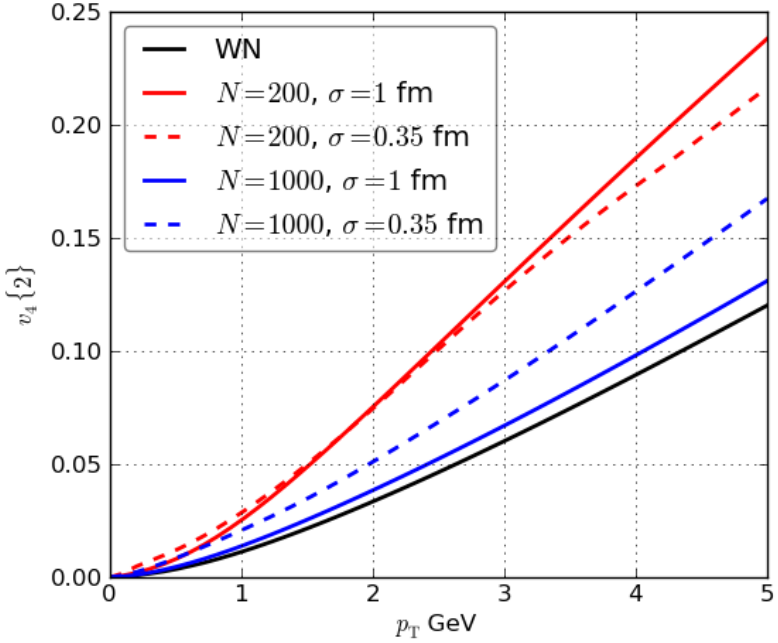
triangular flow, 2-particle method

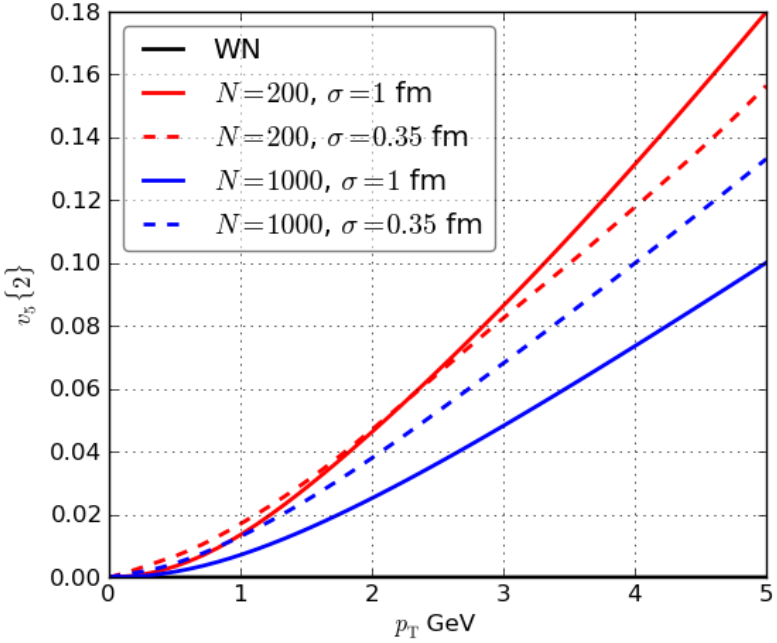




- $v_3/v_2 = 0.25$–0.5 @ $p_T = 1$ GeV/c
- fairly independent of σ @ low p_T

v_4 and v_5





- v_5, v_4 and v_3 have similar magnitude
- saturation happens also for $v_4\{\mathrm{EP}\}$ and $v_5\{\mathrm{EP}\}$

summary and perspectives

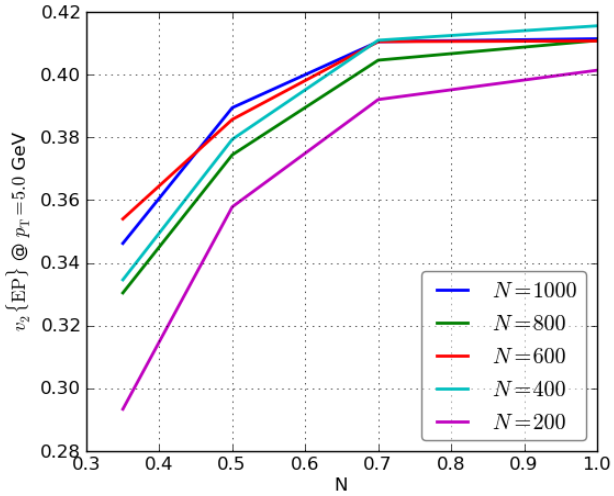
summary

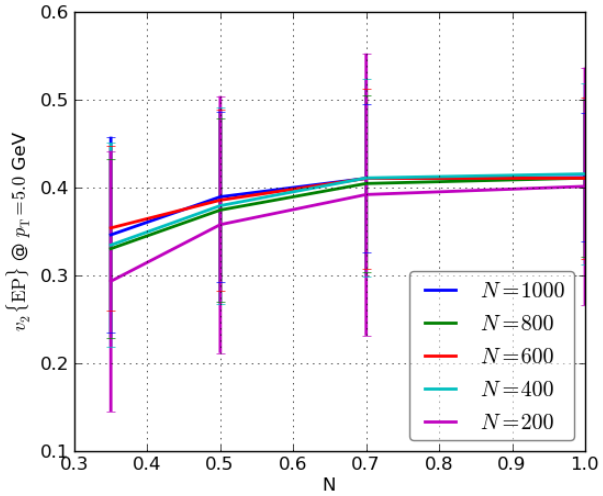
- systematic study of the effects of granularity on the observables
- framework to study the effects of IC models on the final observables
- double peak probes the number of tubes
- tube fluctuations generate sizable higher flow moments which can used to probe the properties of ICs
- approach based on the existence of longitudinal tubes

perspectives

- increase statistics and perform multiplicity based analysis
- compare random tubes with MC Glauber
- particle decays and compare to data
- compute the longitudinal dynamics (3+1D)
- apply to high multiplicity pp collisions

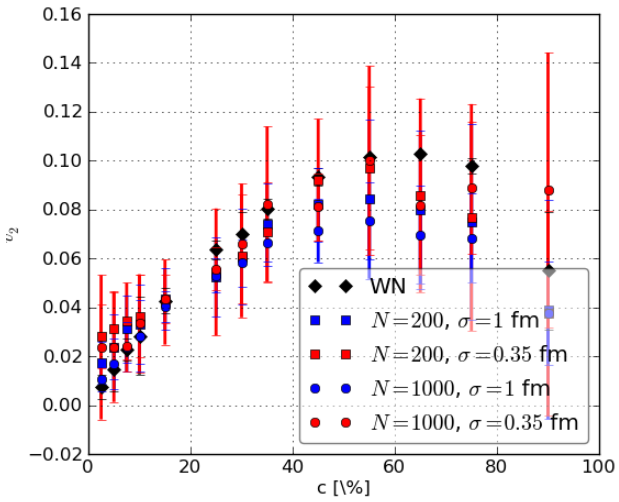
backup


0.42
0.40
0.38
0.36
0.34
0.32
0.30
0.28
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
N
$v_2\{\mathrm{EP}\}$ @ p_T=5.0 GeV
N=1000
N=800
N=600
N=400
N=200

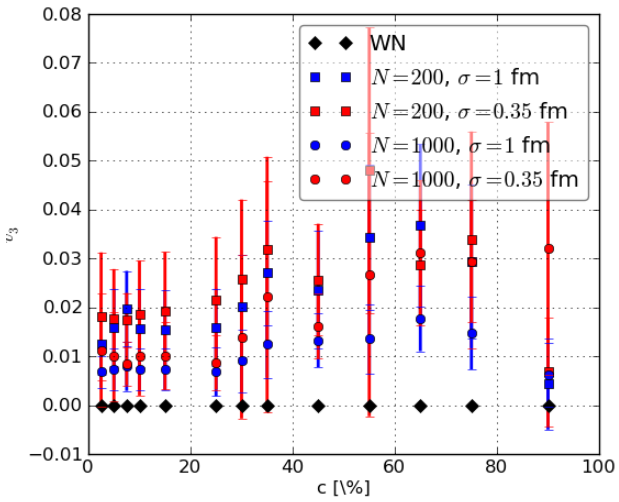

0.6
0.5
0.4
0.3
0.2
0.1
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
N
$v_2\{\mathrm{EP}\}$ @ p_T=5.0 GeV
N=1000
N=800
N=600
N=400
N=200

backup

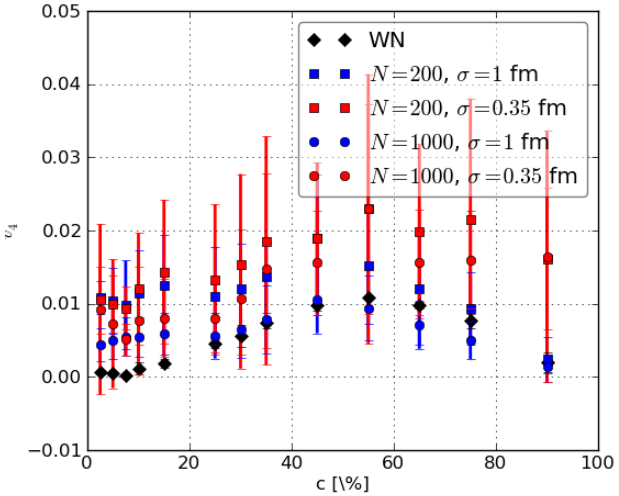
v2

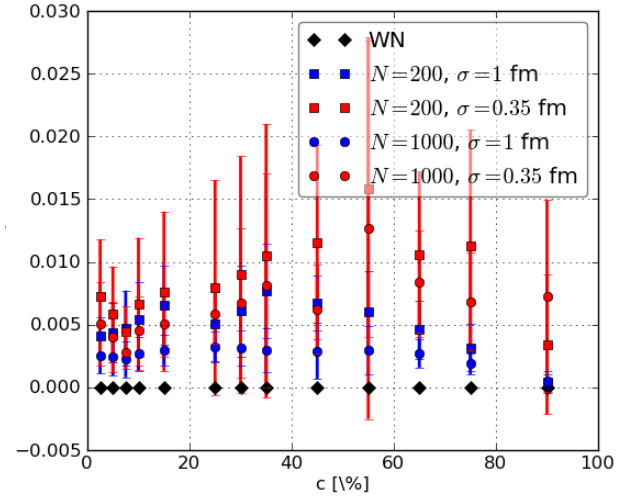

0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
−0.02
v_2
0
20
40
60
80
100
c [\%]
WN
$N=200$, $\sigma=1$ fm
$N=200$, $\sigma=0.35$ fm
$N=1000$, $\sigma=1$ fm
$N=1000$, $\sigma=0.35$ fm

v3

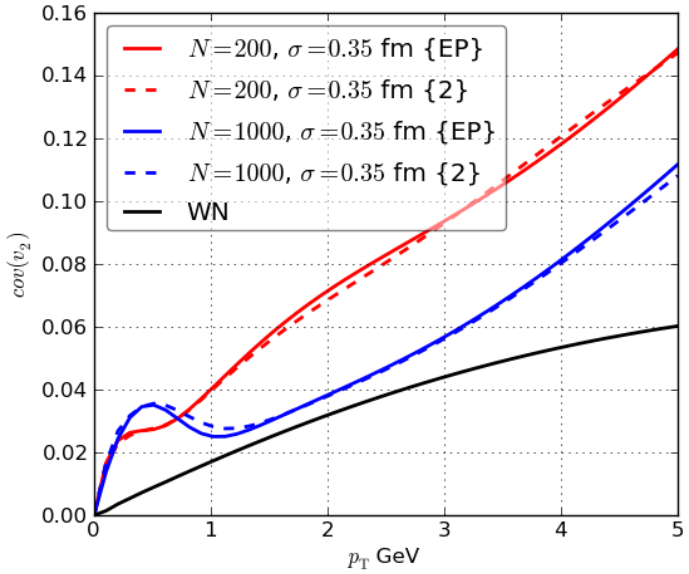

0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0.00
−0.01
v_3
0
20
40
60
80
100
c [\%]
WN
$N=200$, $\sigma=1$ fm
$N=200$, $\sigma=0.35$ fm
$N=1000$, $\sigma=1$ fm
$N=1000$, $\sigma=0.35$ fm

backup

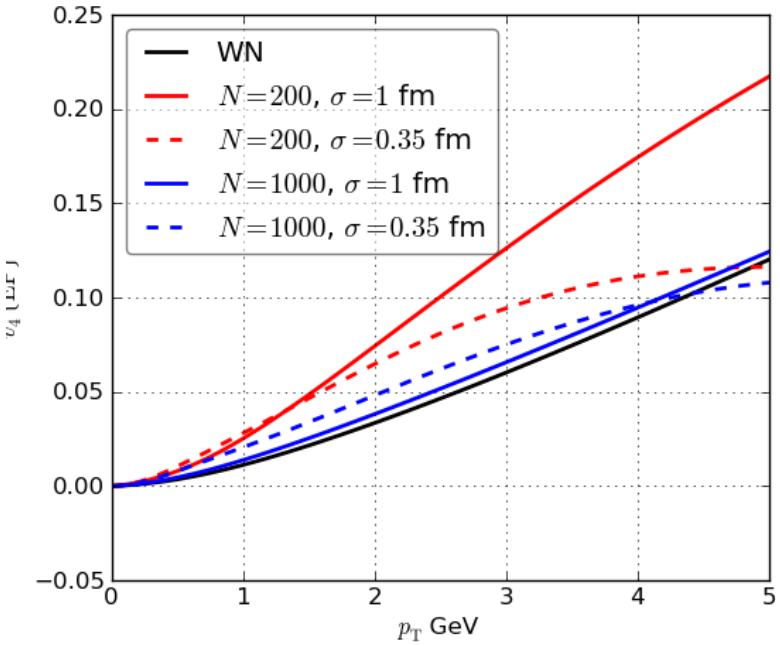

WN
$N=200,\ \sigma=1$ fm
$N=200,\ \sigma=0.35$ fm
$N=1000,\ \sigma=1$ fm
$N=1000,\ \sigma=0.35$ fm
v_4
c [\%]

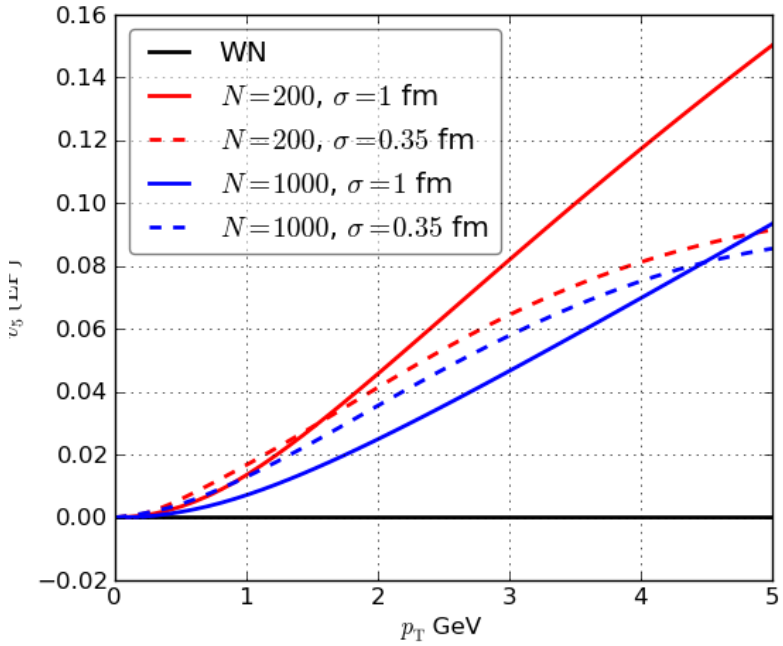

WN
$N=200,\ \sigma=1$ fm
$N=200,\ \sigma=0.35$ fm
$N=1000,\ \sigma=1$ fm
$N=1000,\ \sigma=0.35$ fm
c [\%]

backup


0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.00
0
1
2
3
4
5
$cov(v_2)$
p_T GeV
$N=200$, $\sigma=0.35$ fm {EP}
$N=200$, $\sigma=0.35$ fm {2}
$N=1000$, $\sigma=0.35$ fm {EP}
$N=1000$, $\sigma=0.35$ fm {2}
WN

v_4 and v_5





- saturation happens also for $v_4\{\mathrm{EP}\}$ and $v_5\{\mathrm{EP}\}$