Boost-invariant one-tube model for two-particle correlation

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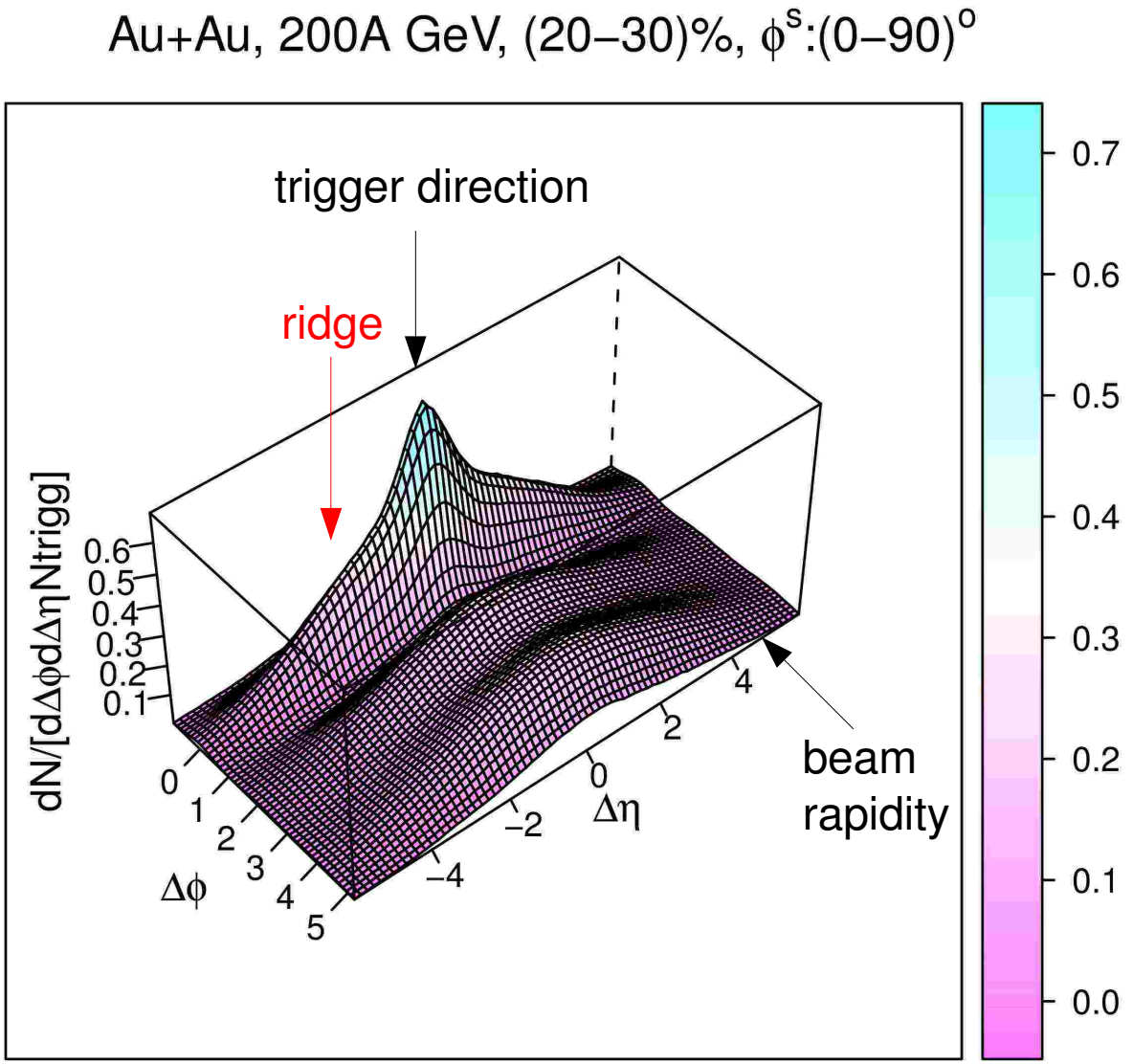
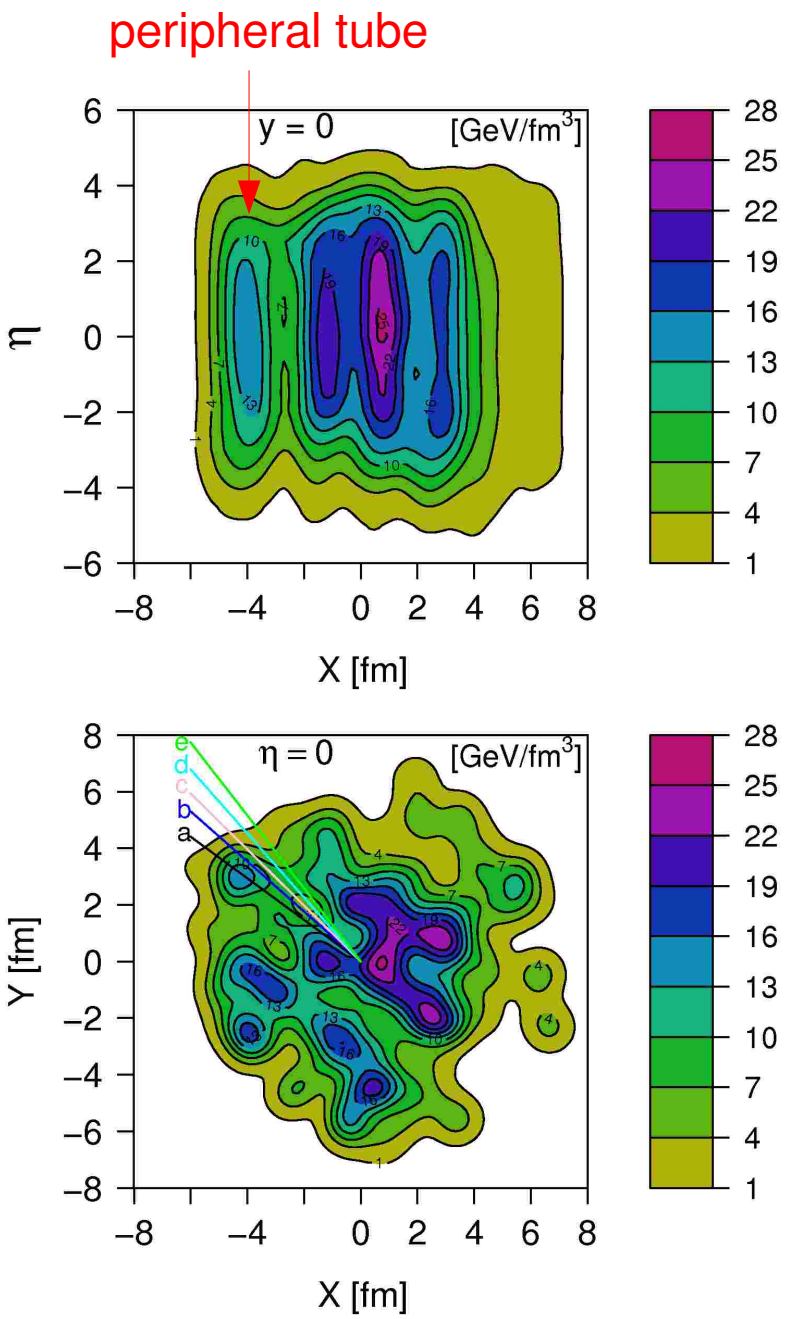
Outline

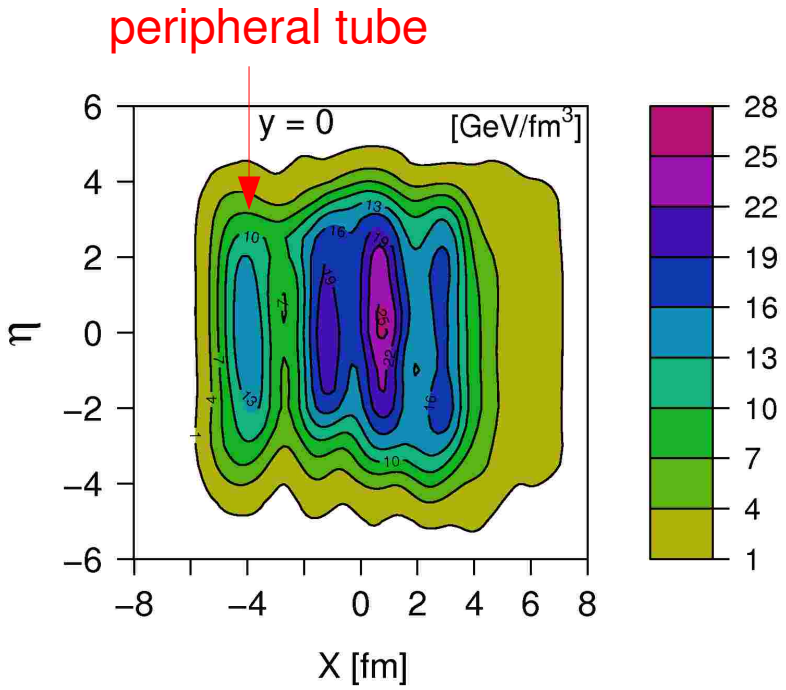
- 2-particle correlation with NexSPheRIO
- Nexus I.C.
- boost-invariant one-tube model
- in-plane and out-of-plane correlation
- conclusion



- NexSPheRIO is a junction of two codes: Nexus, which is an event generator, and SpheRIO, which solves the hydro-equations.
- A long range correlation is observed in the longitudinal direction and in the azimuthal direction a double peak structure is observed in the opposite direction to trigger particle. (Phys. Rev. Lett. **103:242301, 2009**).
- The aim of this presentation is to clarify, in the NexSPheRIO scenario, the origin of the 2-particle correlation structure.



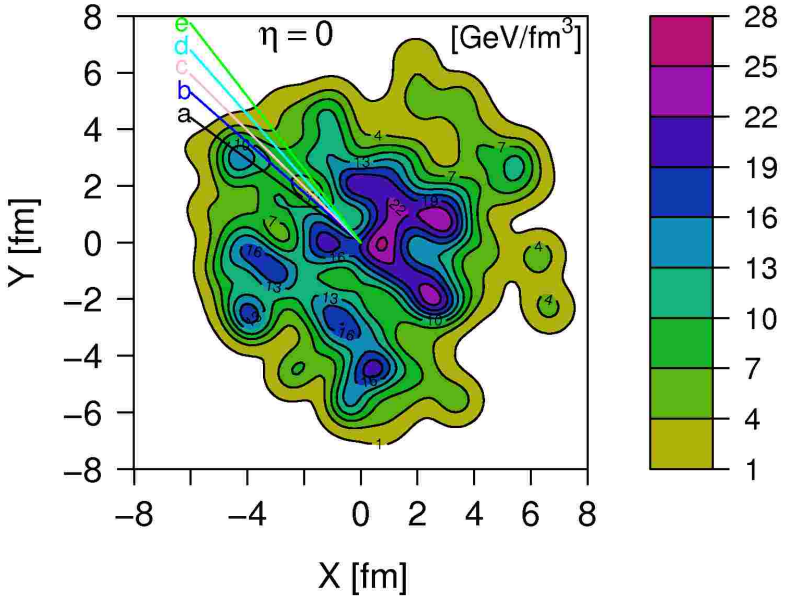
- The energy density distribution computed by Nexus is characterized by tubular structures along the collision axis.
- A peripheral tube emit correlated particles along the eta direction and this is the origin of the ridge structure in the 2-particle correlation function. However, the azimuthal structure is not clear yet.

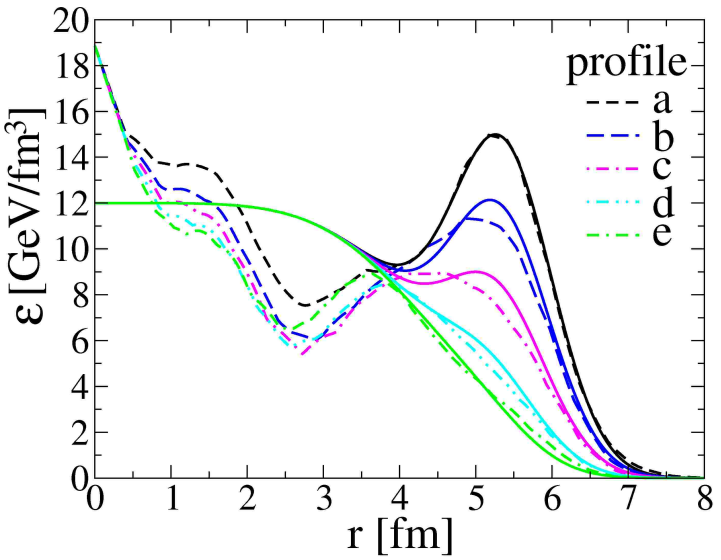


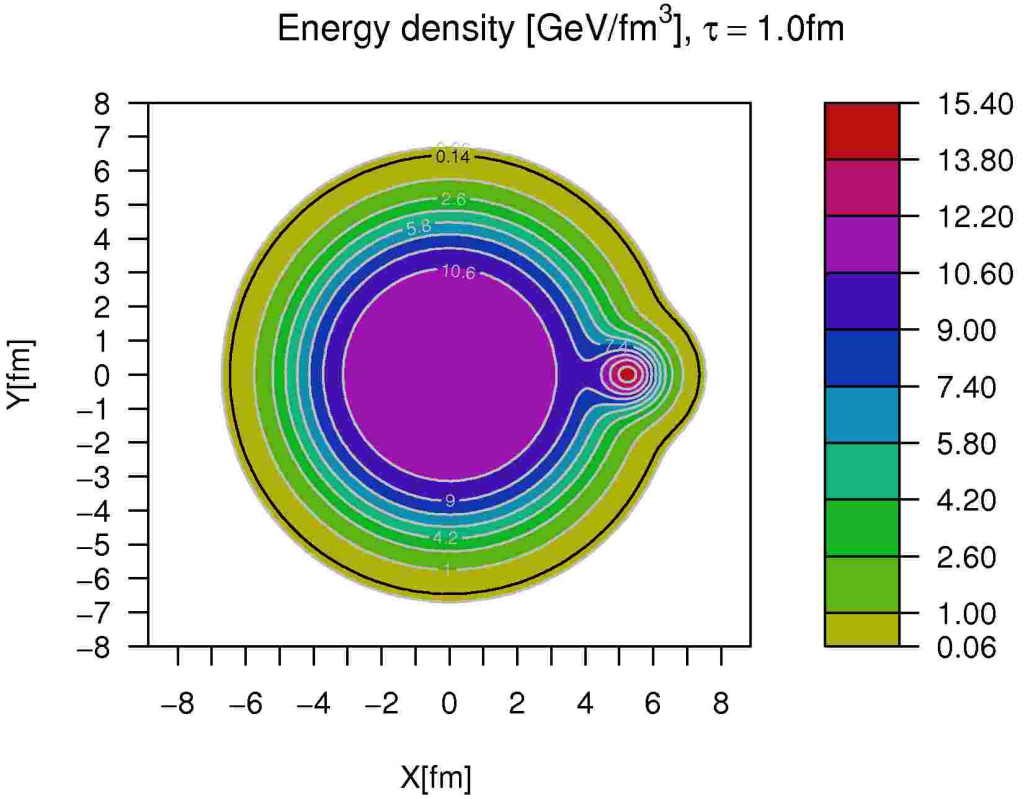
- Let us introduce a simplified model in which only one peripheral tube from NeXus is considered and the complex background is smoothed out by using the average over many events. This leads to the following parametrization of the initial energy density:

$$\epsilon_0 = 12\exp\left(-0.0004r^5\right) + \frac{34}{0.845\,\pi}\exp\left[\frac{-\left(\vec{r}-\vec{r}_0\right)^2}{0.845}\right]$$

where r_0 = 5.4fm.







- The one-tube model consists of a high-energy density peripheral tube in a smooth cylindrical back-ground, with longitudinal boost invariance.

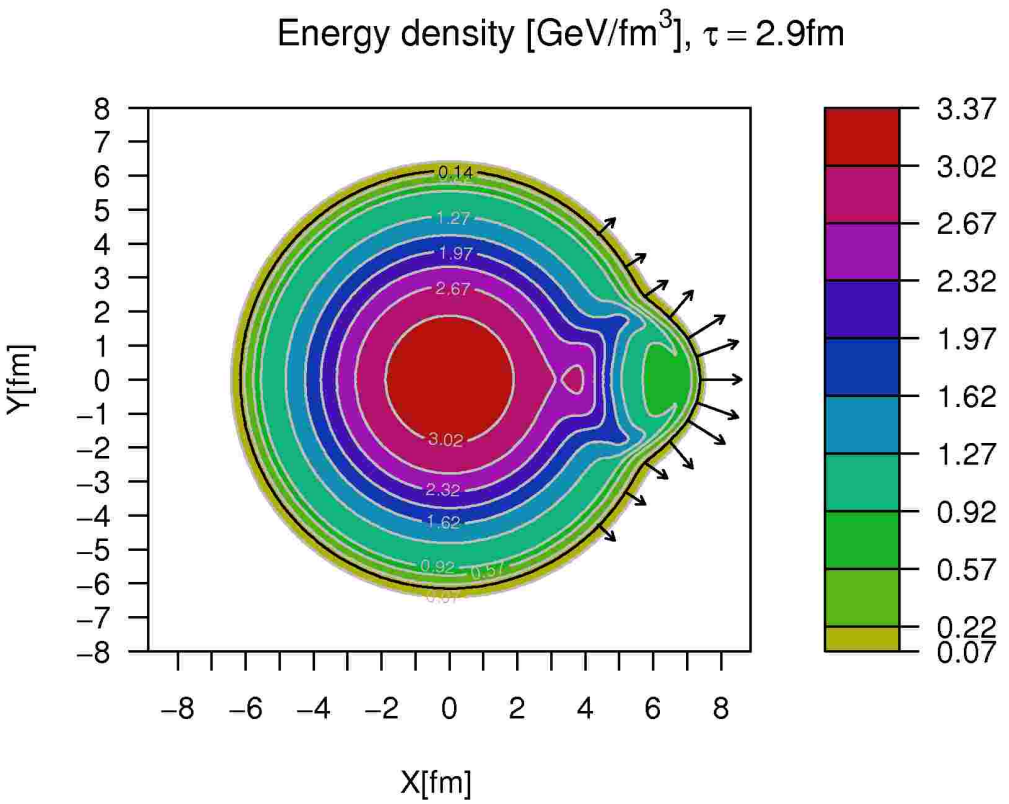
- The initial conditions are given by:

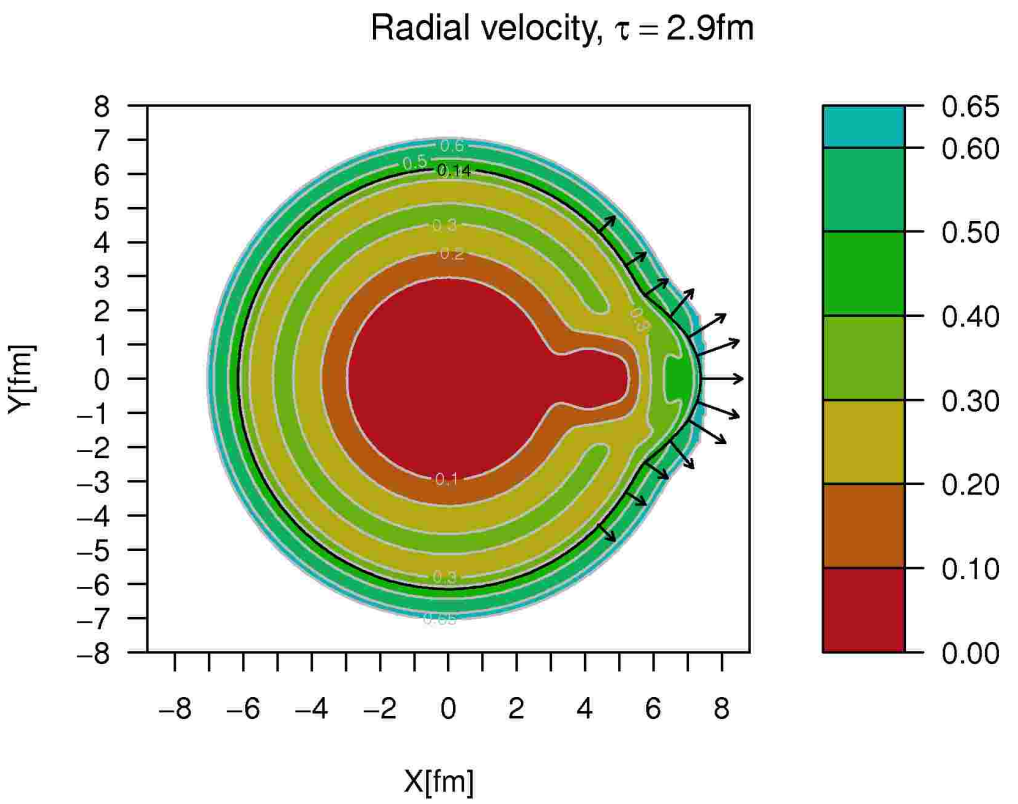
$$\epsilon_0 = 12\exp\left(-0.0004\mathrm{r}^5\right) + \frac{34}{0.845\,\pi}\exp\left[\frac{-\left(\vec{r}-\vec{r}_0\right)^2}{0.845}\right],$$

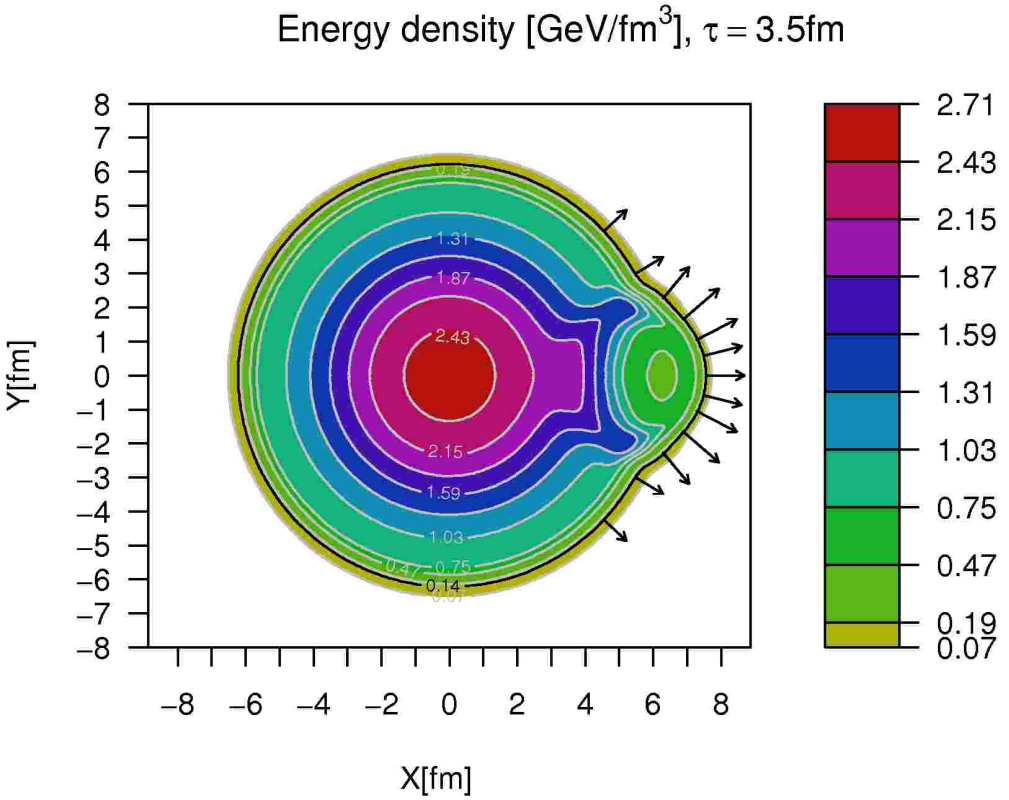
$$n_B = 0,$$

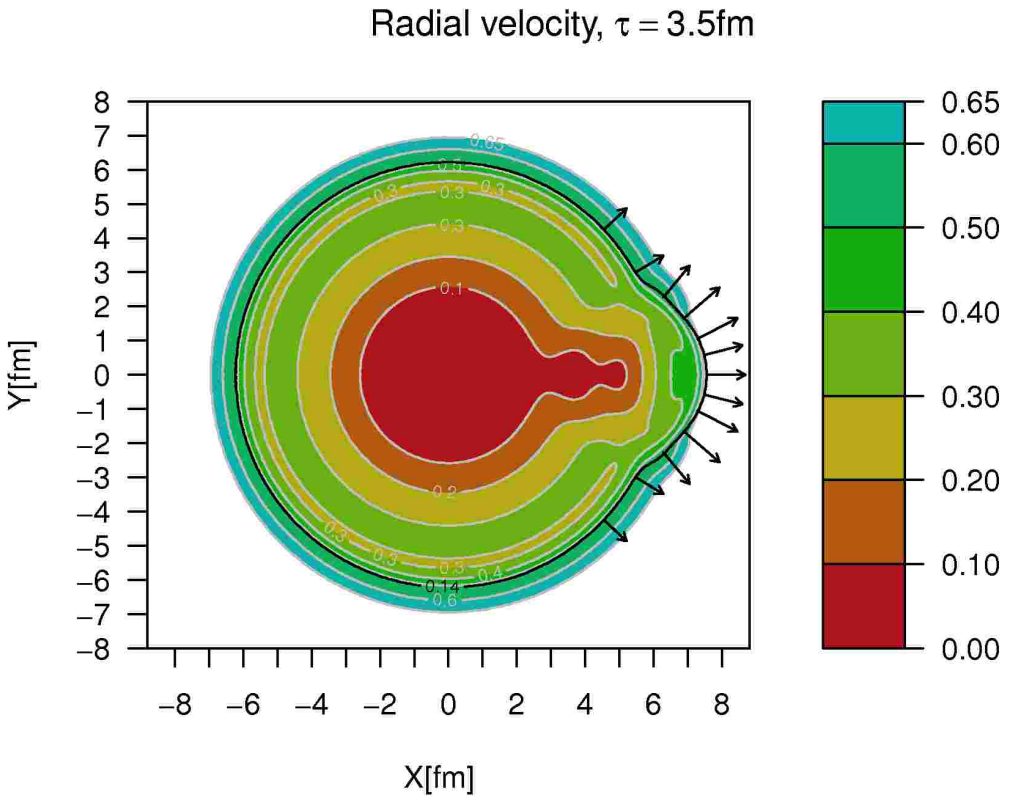
and

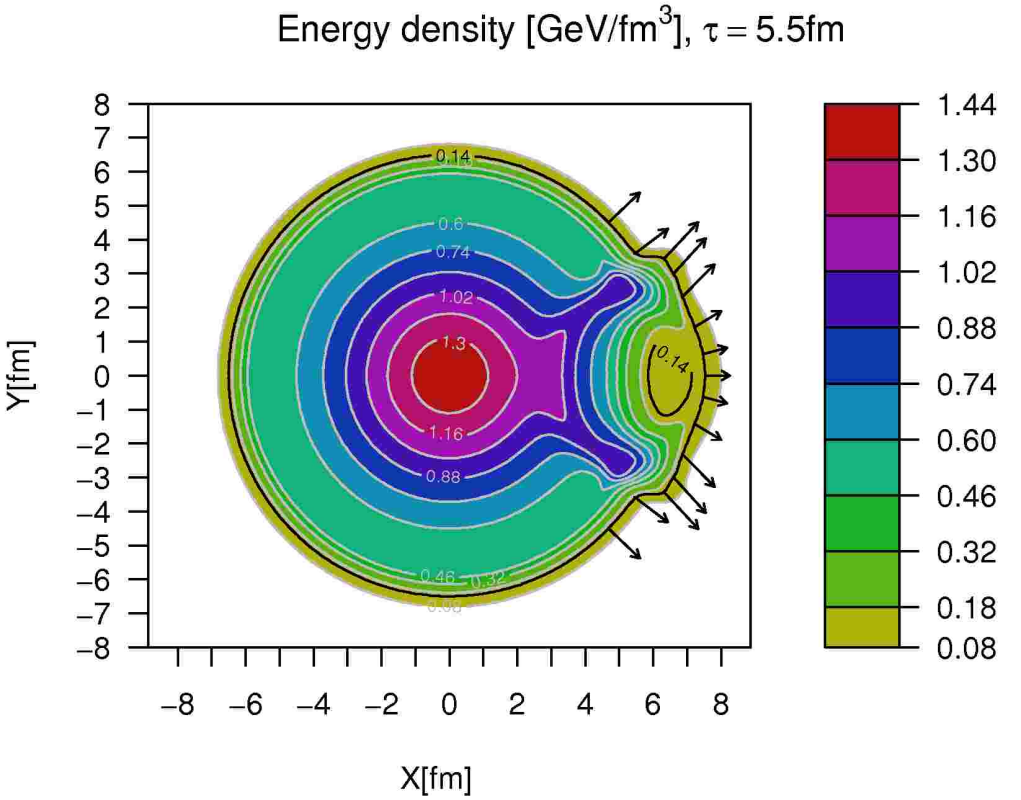
$$v_0^T = 0.$$

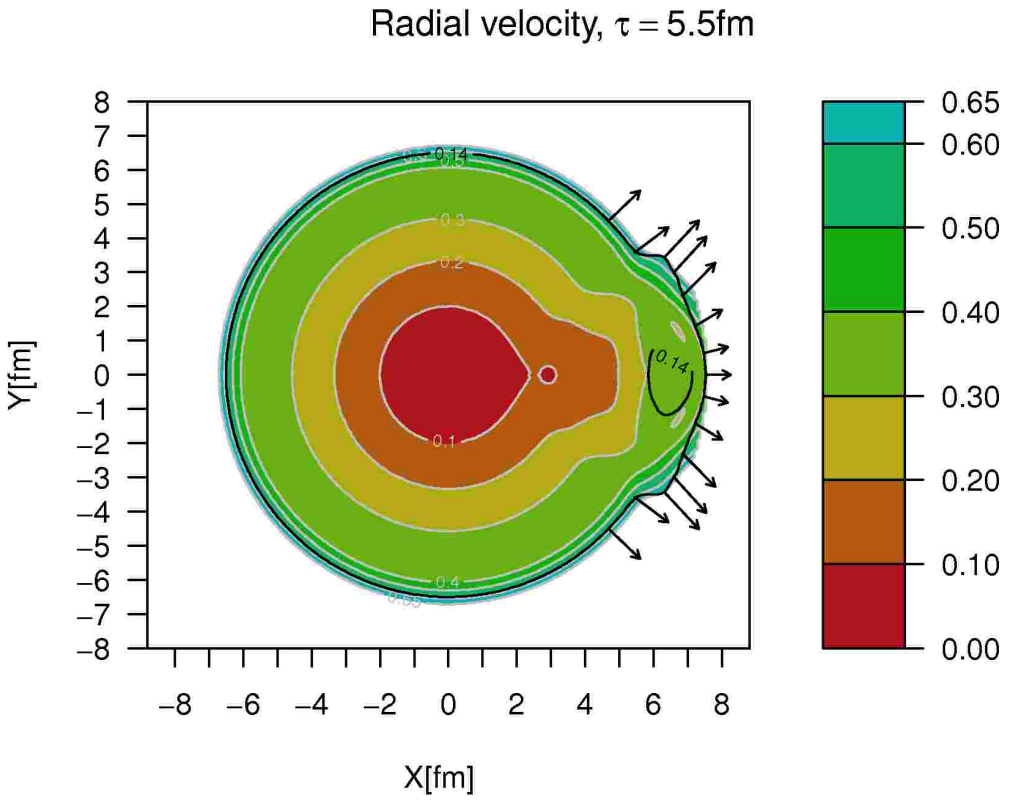

Energy density [GeV/fm^3], $\tau = 2.9$fm
Y[fm]
X[fm]
0.14
1.27
1.97
2.67
3.02
2.32
1.62
0.92
0.57
3.37
3.02
2.67
2.32
1.97
1.62
1.27
0.92
0.57
0.22
0.07

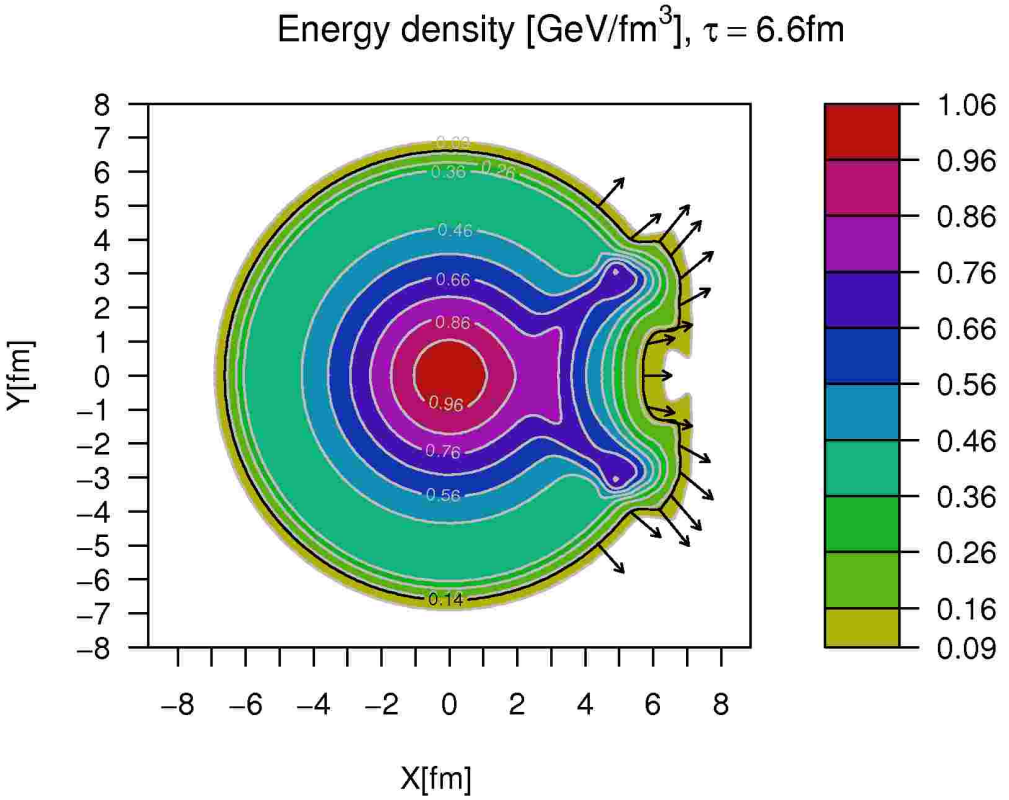

Radial velocity, $\tau = 2.9$fm
Y[fm]
X[fm]
0.6
0.5
0.14
0.3
0.2
0.1
0.65
0.60
0.50
0.40
0.30
0.20
0.10
0.00

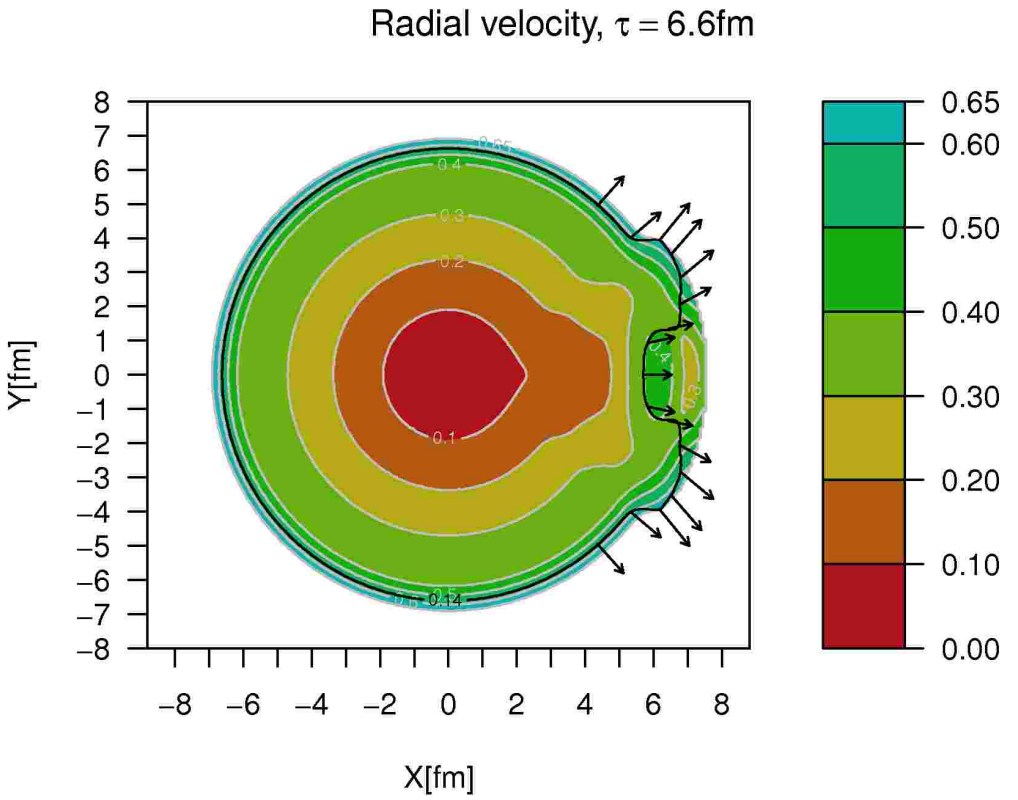

Energy density [GeV/fm^3], $\tau = 3.5$fm
Y[fm]
X[fm]
2.71
2.43
2.15
1.87
1.59
1.31
1.03
0.75
0.47
0.19
0.07


Radial velocity, $\tau = 3.5$fm
Y[fm]
X[fm]
0.65
0.60
0.50
0.40
0.30
0.20
0.10
0.00

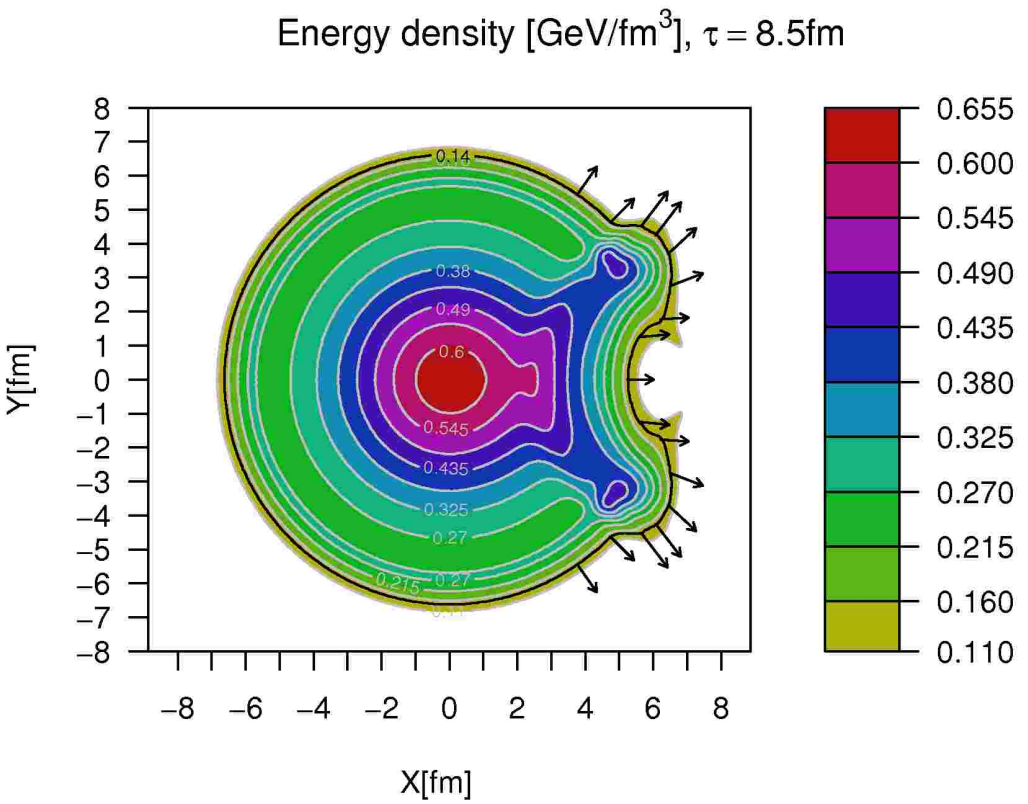

Energy density [GeV/fm^3], $\tau = 5.5$fm
Y[fm]
X[fm]
1.44
1.30
1.16
1.02
0.88
0.74
0.60
0.46
0.32
0.18
0.08

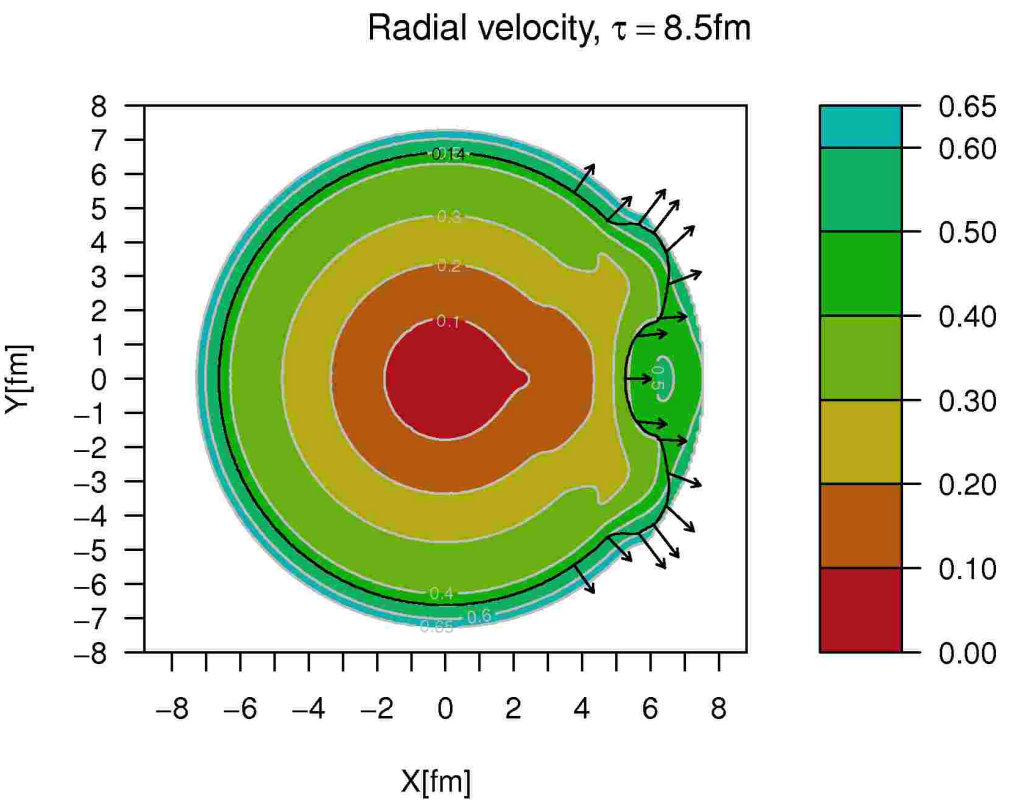

Radial velocity, $\tau = 5.5$fm
Y[fm]
X[fm]
0.65
0.60
0.50
0.40
0.30
0.20
0.10
0.00


Energy density [GeV/fm^3], $\tau = 6.6$fm
Y[fm]
X[fm]
1.06
0.96
0.86
0.76
0.66
0.56
0.46
0.36
0.26
0.16
0.09

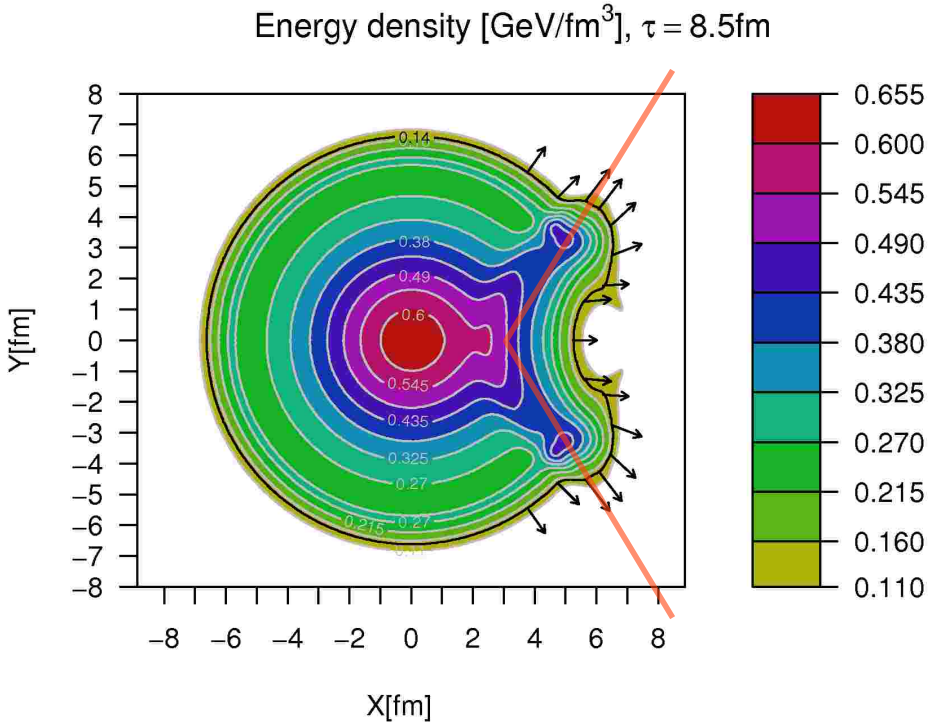

Radial velocity, $\tau = 6.6$fm
Y[fm]
X[fm]
0.65
0.60
0.50
0.40
0.30
0.20
0.10
0.00

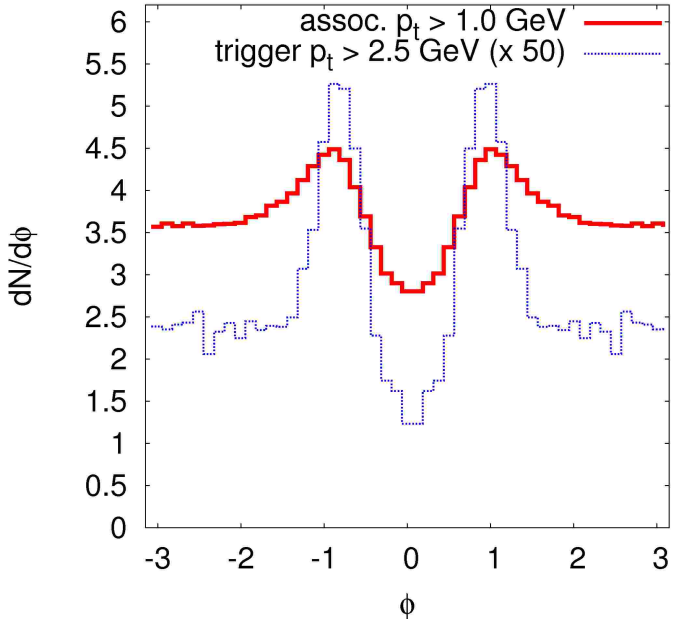
boost-invariant one-tube model



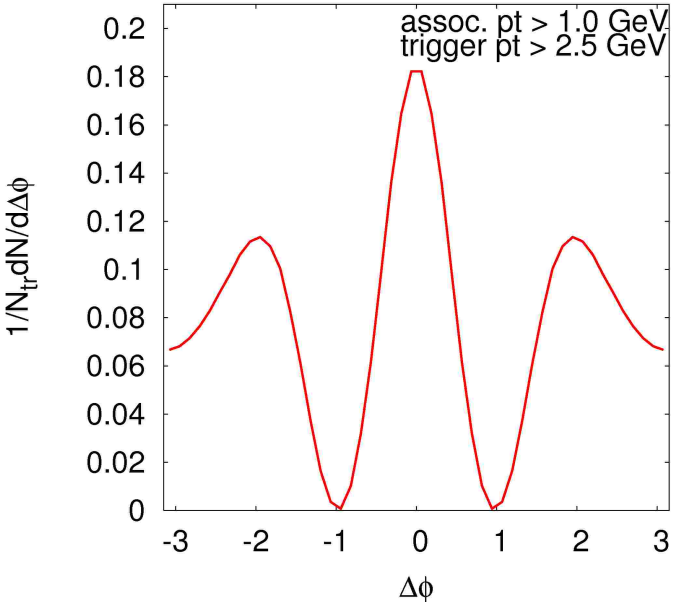


boost-invariant one-tube model



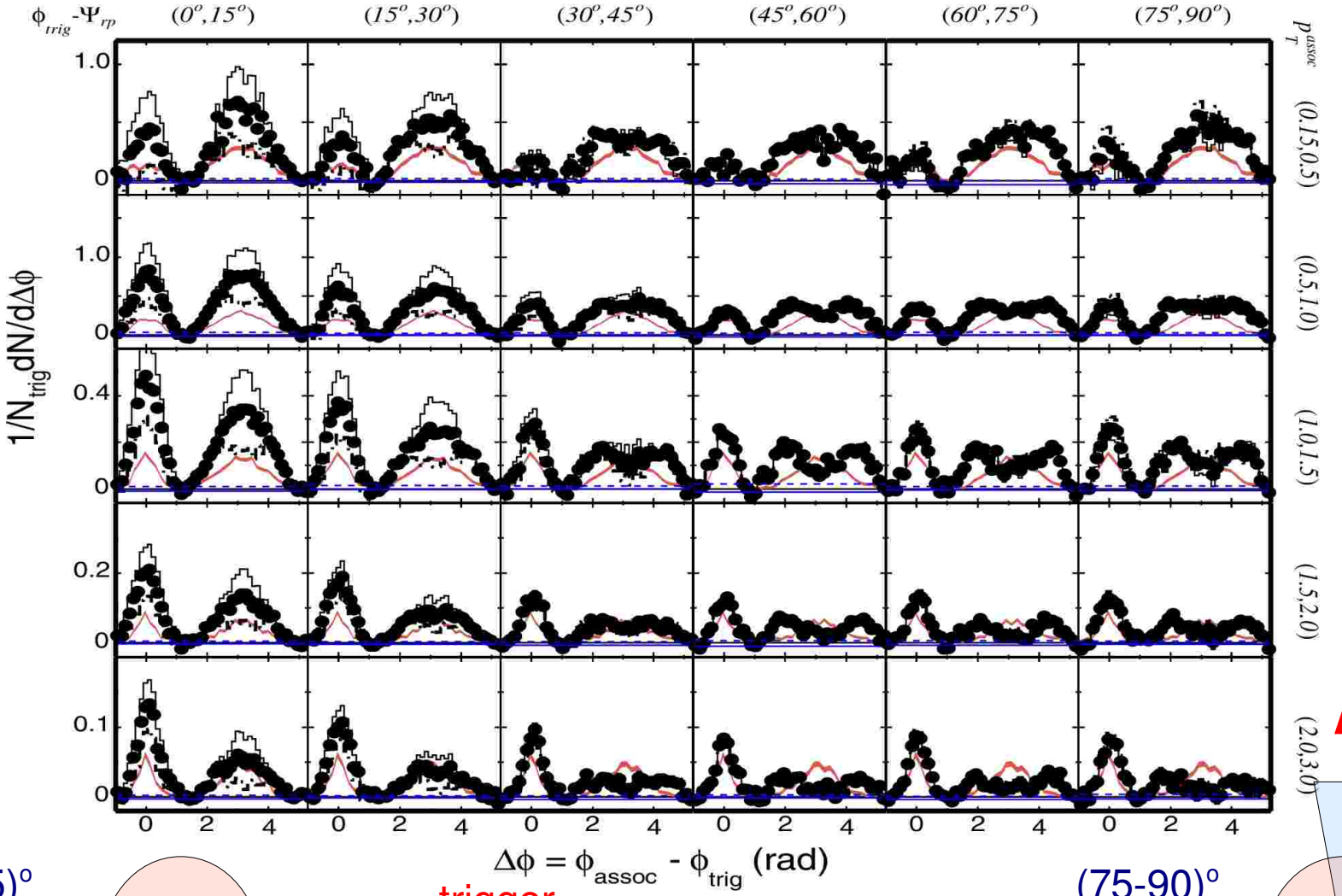


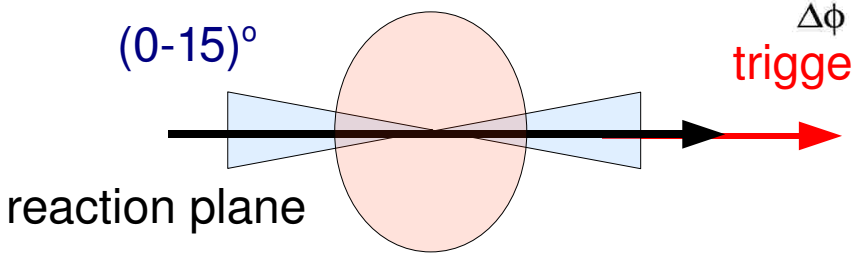
- The resulting single-particle angular distribution has two peaks located on both sides of the angular position of the tube.
- We have checked that this structure is robust by studying the effect of the height and shape of the back-ground, initial velocity, height, radius and position of the tube.
- The same two peak structure is observed, on average, when we study the hydro-evolution of the Nexus IC.

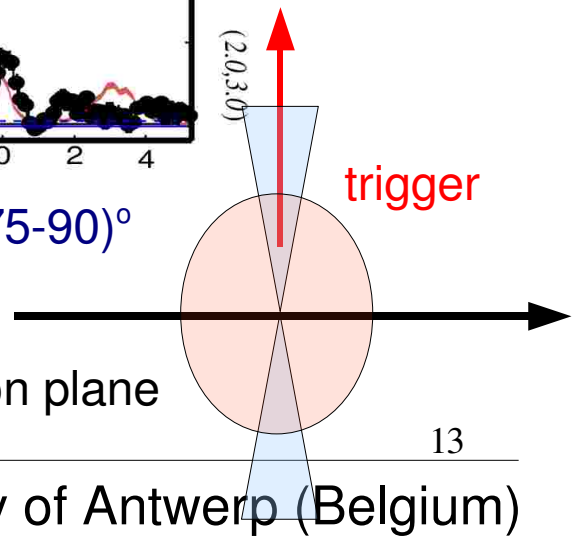


STAR in-plane and out-of-plane correlation

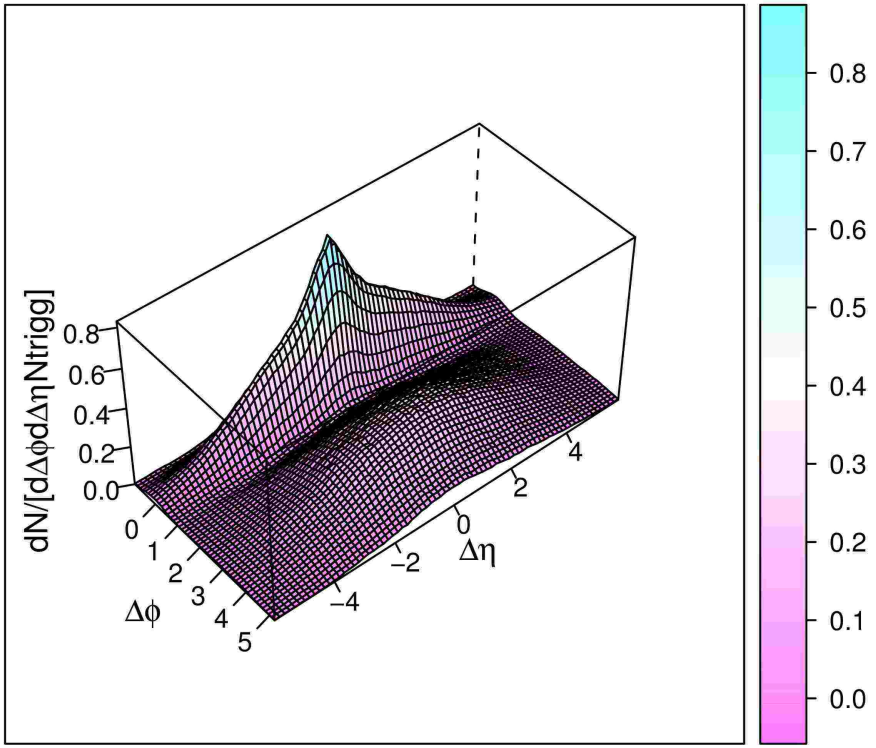
(J. Phys. G: Nucl. Part. Phys. **35** (2008) 104082)







Au+Au, 200A GeV, (20–30)%, ϕ^s:(0–15)°



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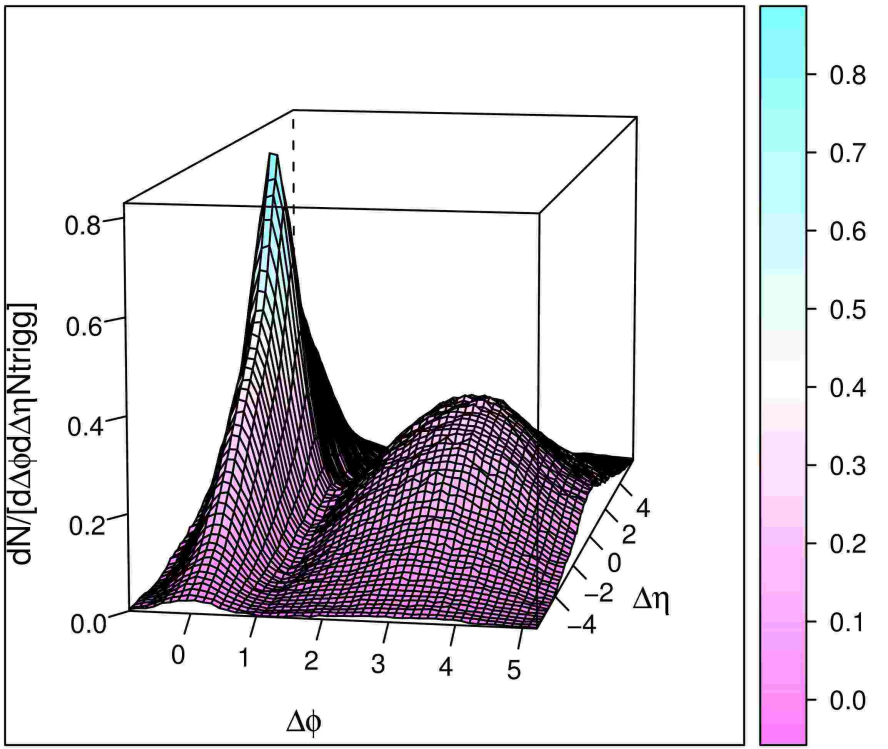
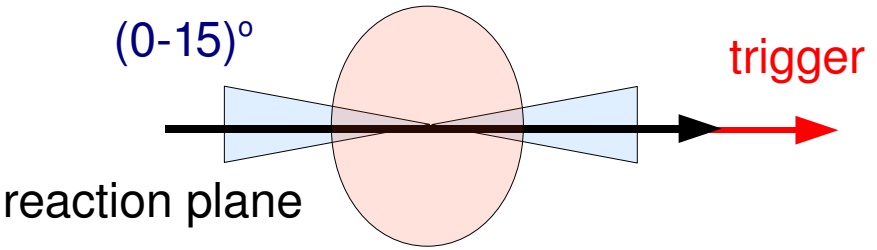
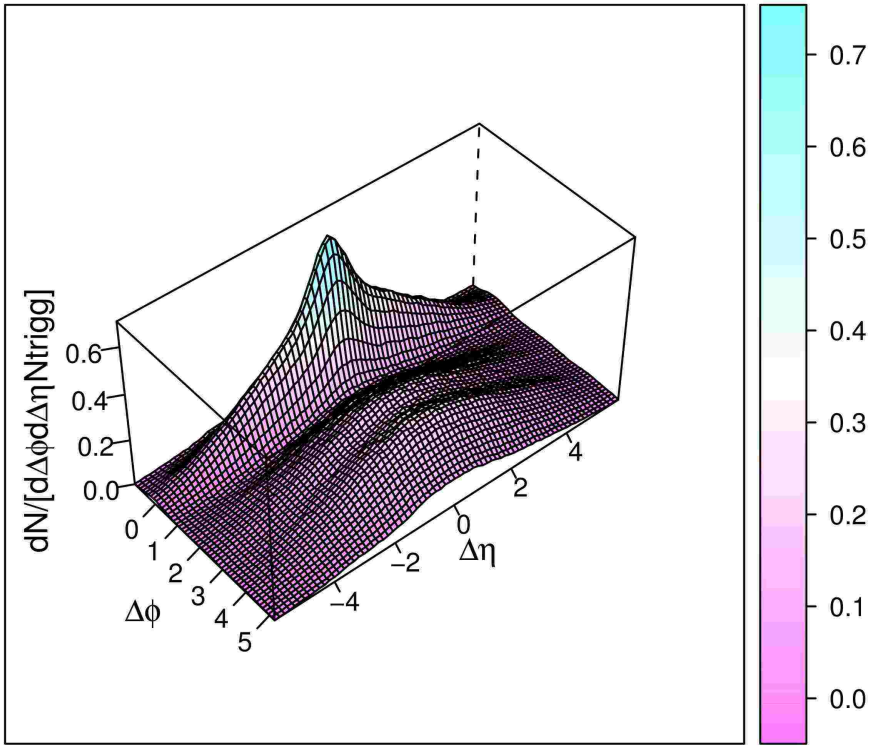




Au+Au, 200A GeV, (20–30)%, ϕ^s:(15–30)°



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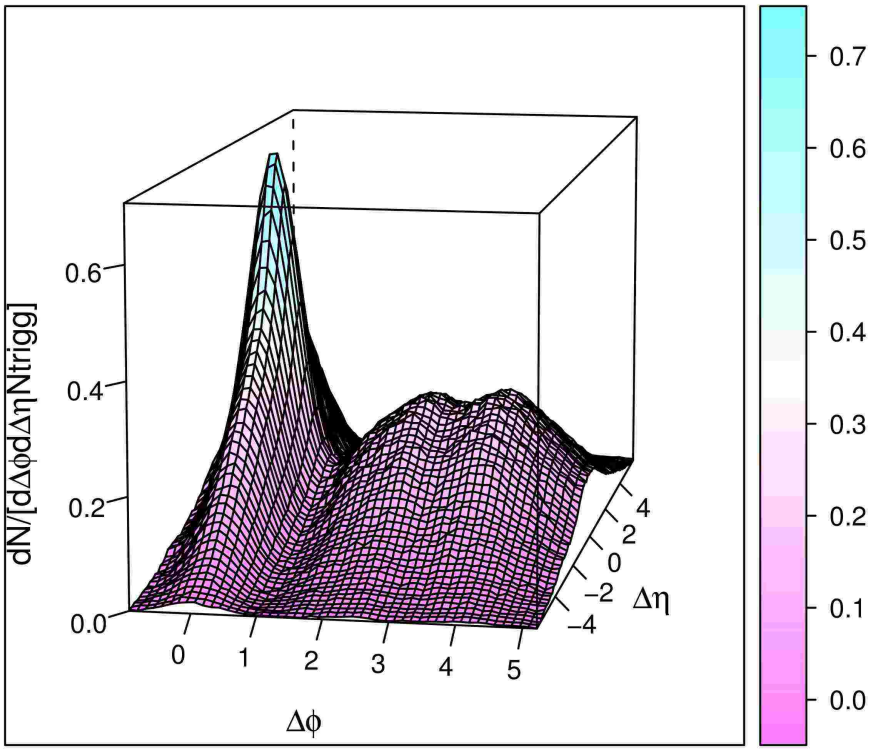
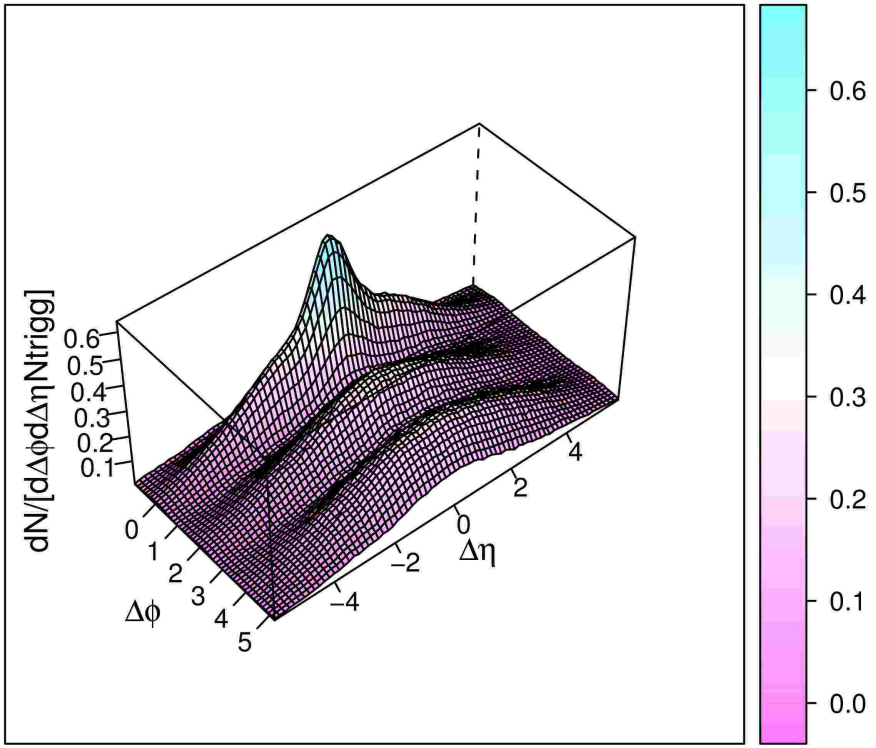


Au+Au, 200A GeV, (20–30)%, ϕ^s:(30–45)^o



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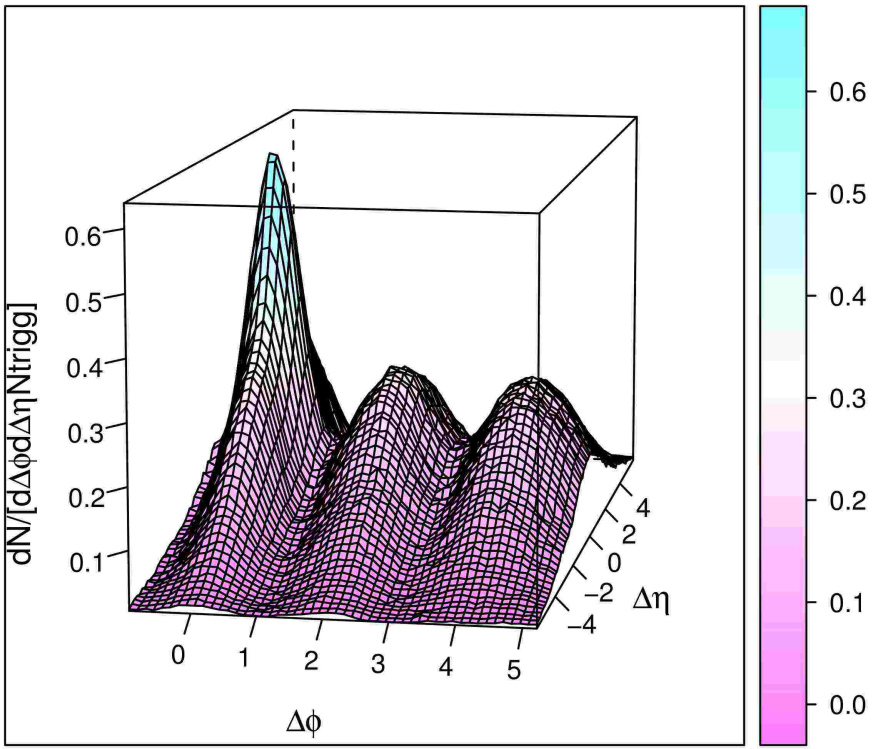
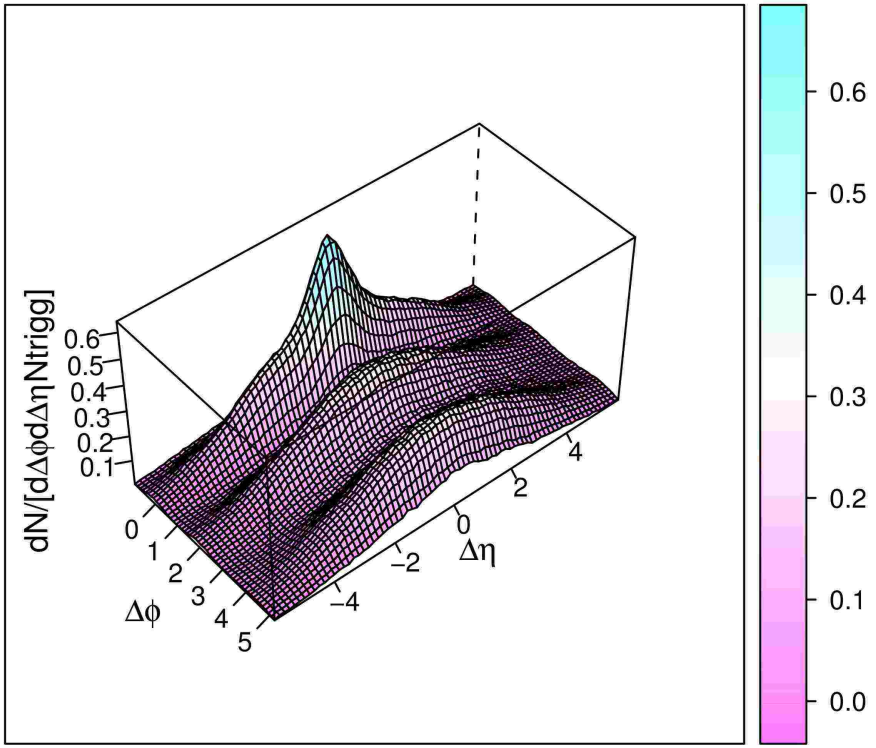


Au+Au, 200A GeV, (20–30)%, ϕ^s:(45–60)^o



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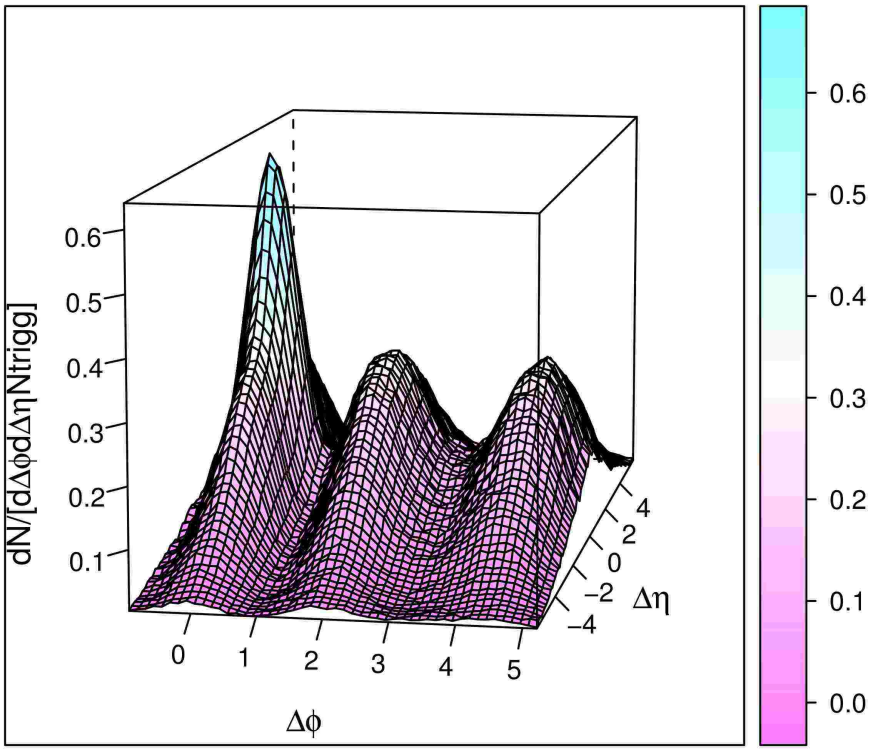
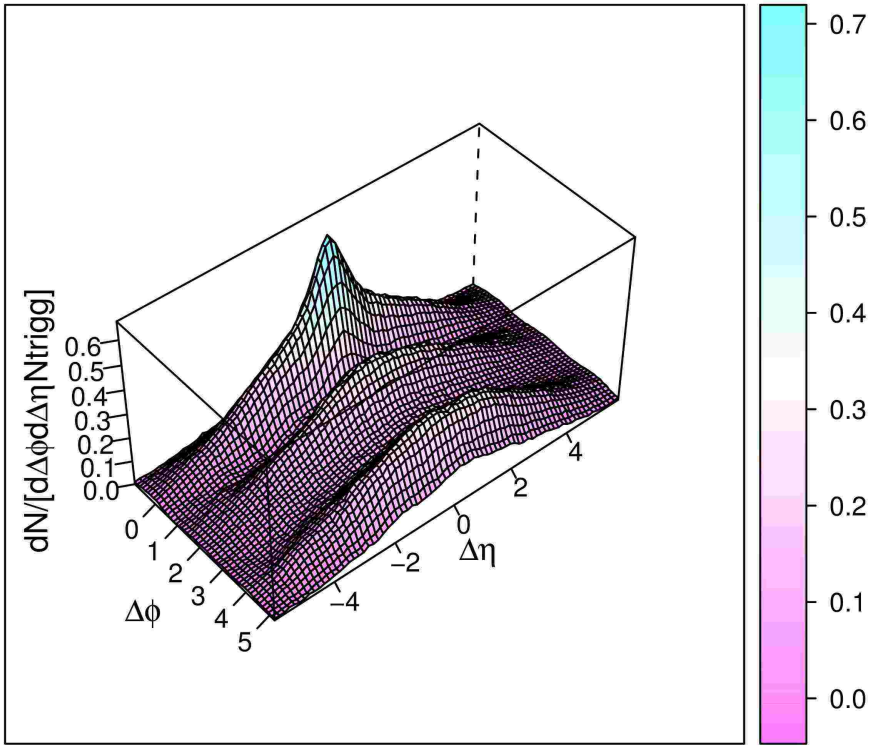


Au+Au, 200A GeV, (20–30)%, ϕ^s:(60–75)^o



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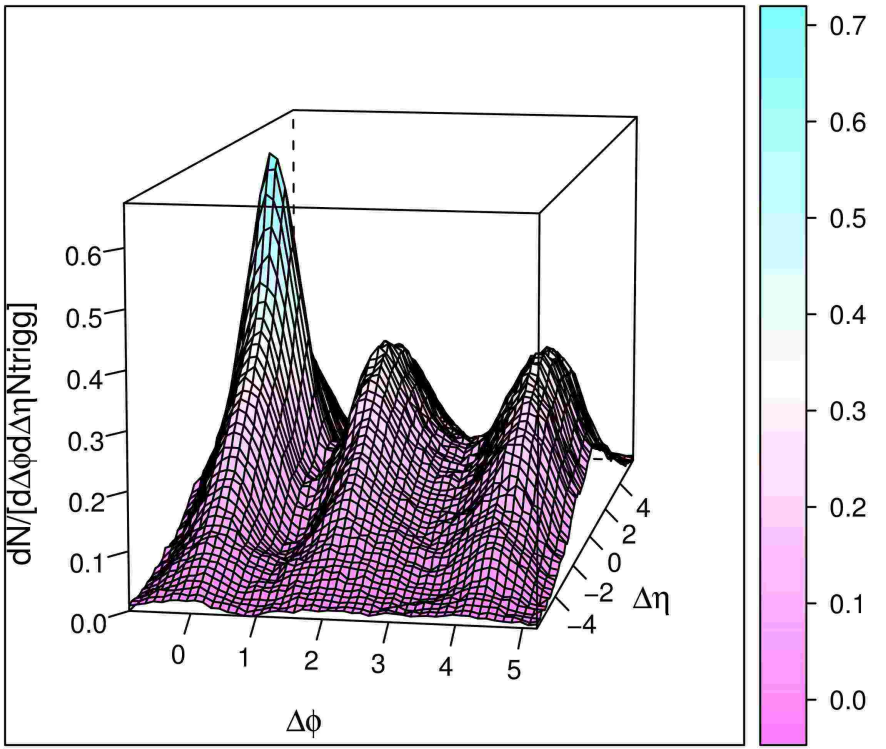
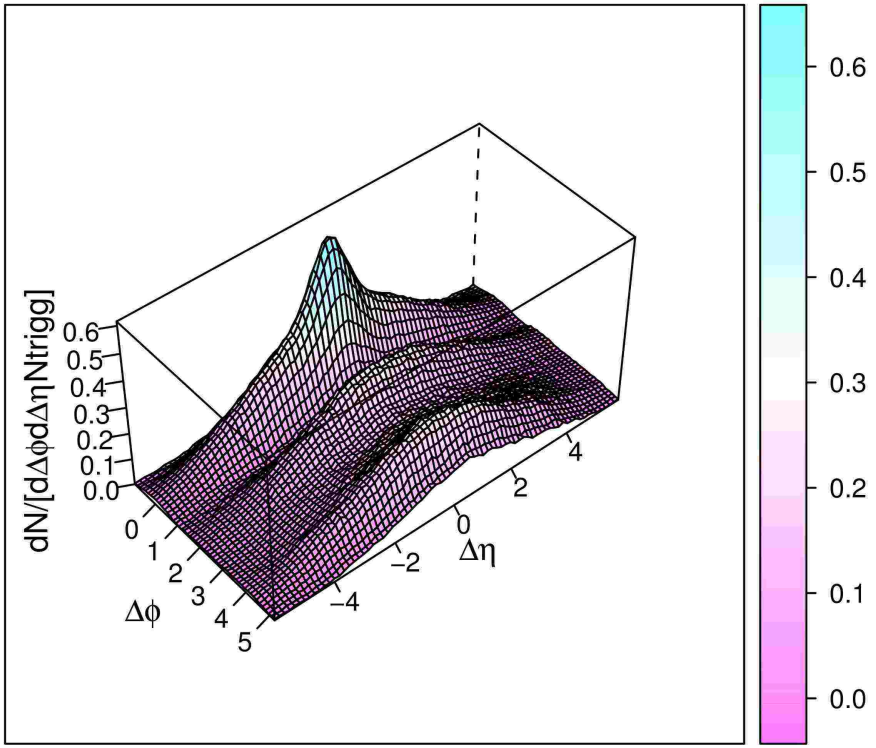


Au+Au, 200A GeV, (20–30)%, ϕ^s:(75–90)°



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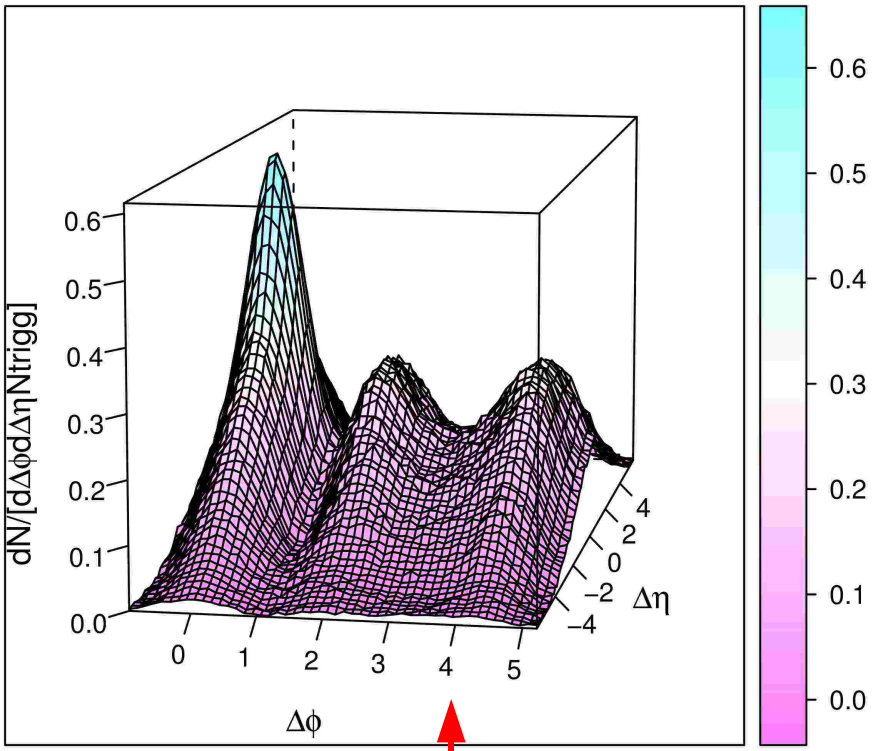
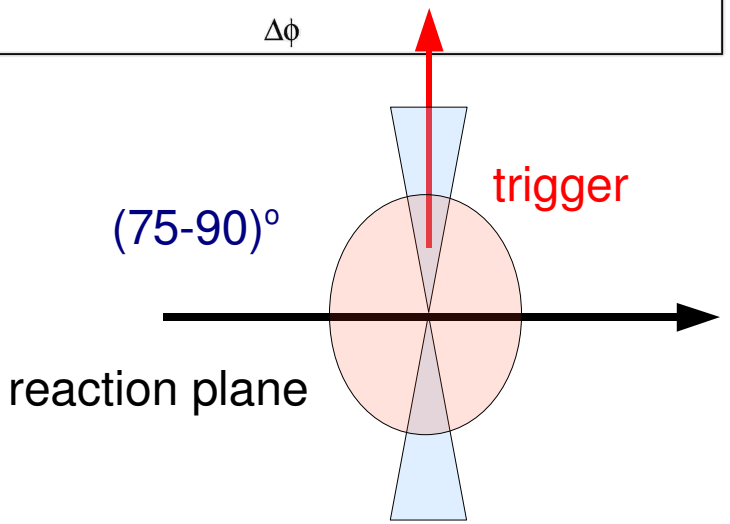
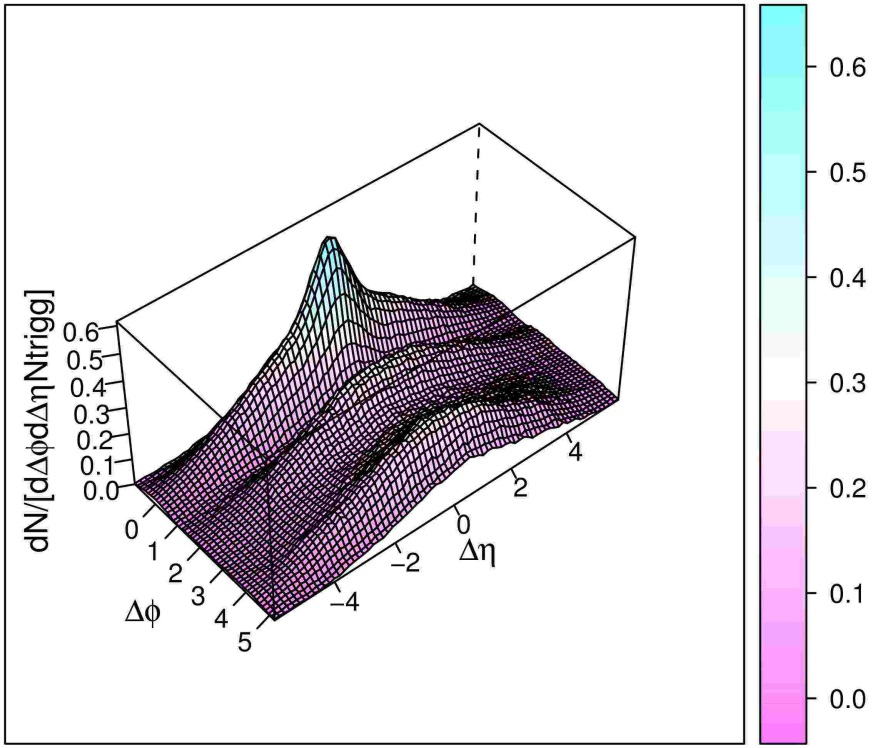




Au+Au, 200A GeV, (20–30)%, ϕ^s:(75–90)°



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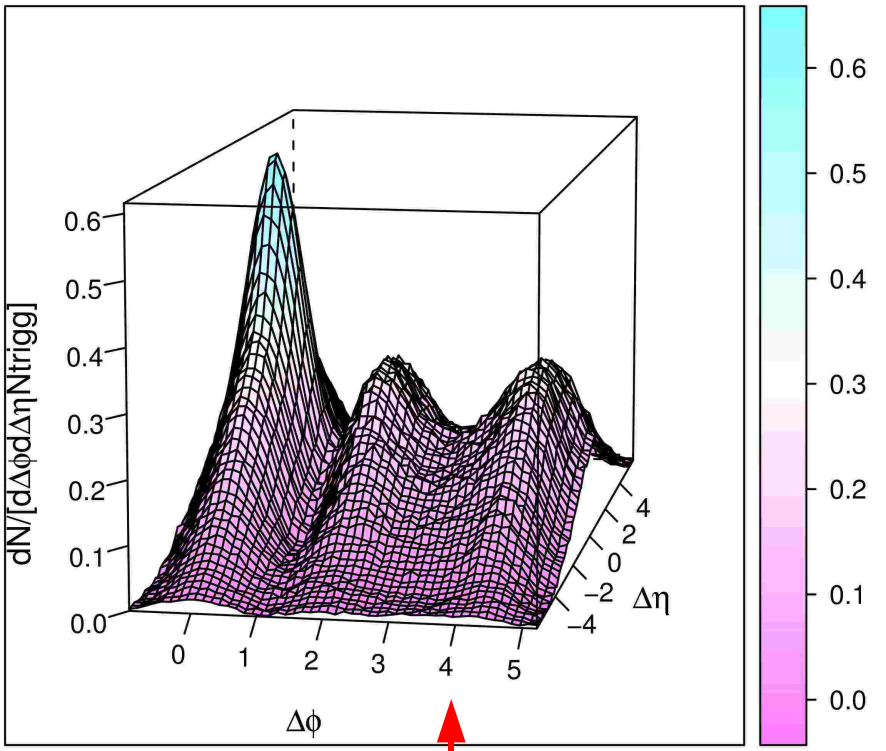
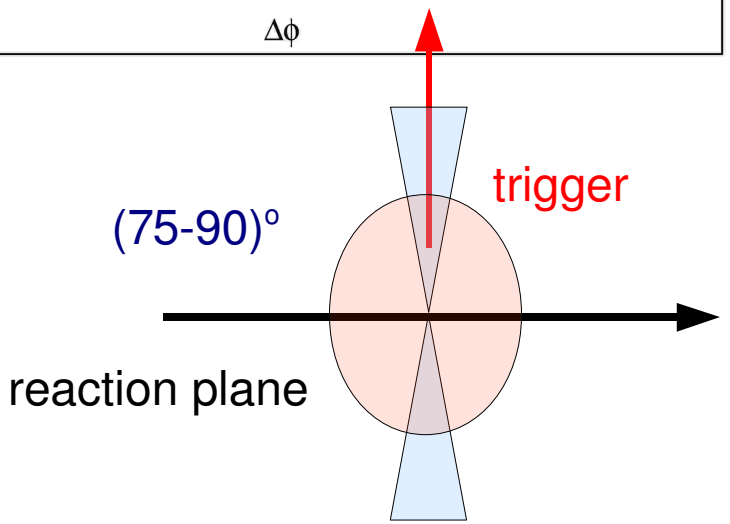
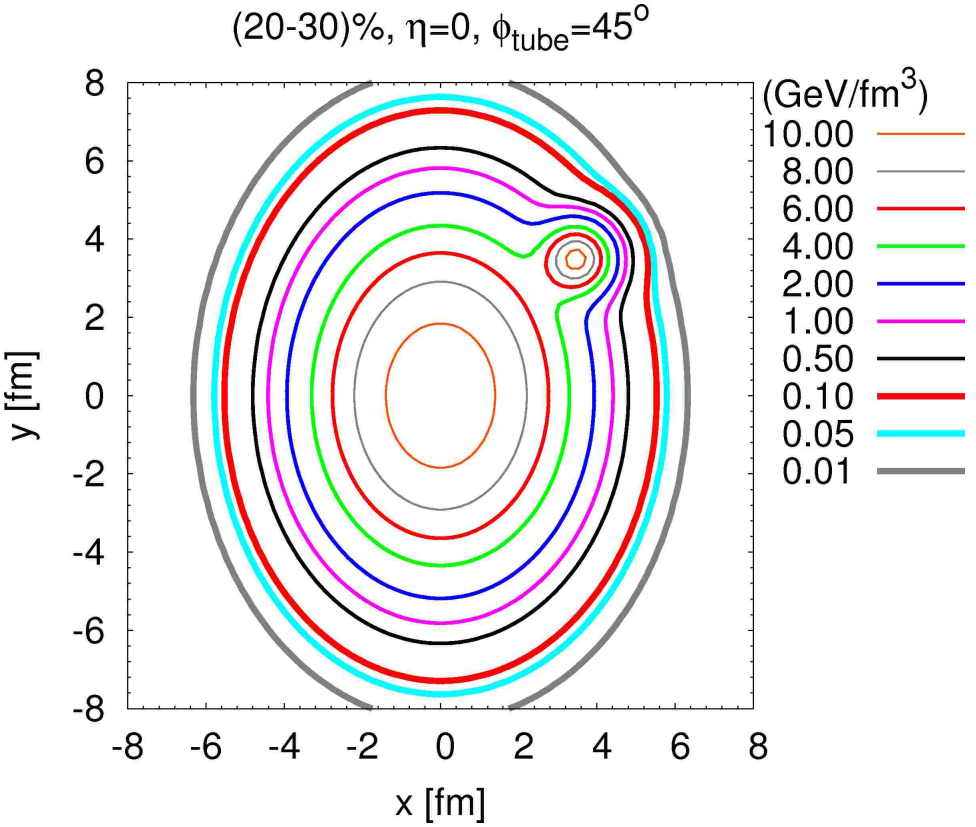
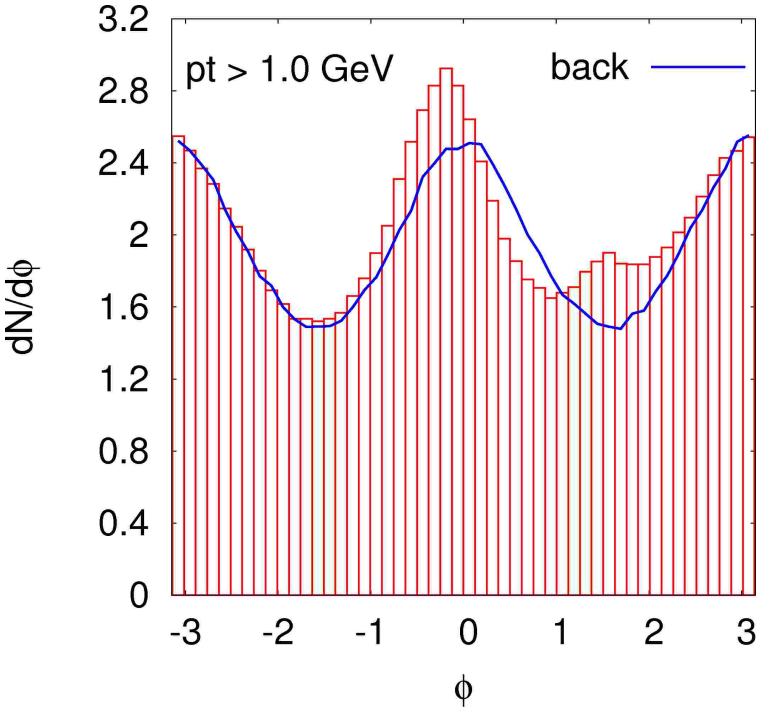


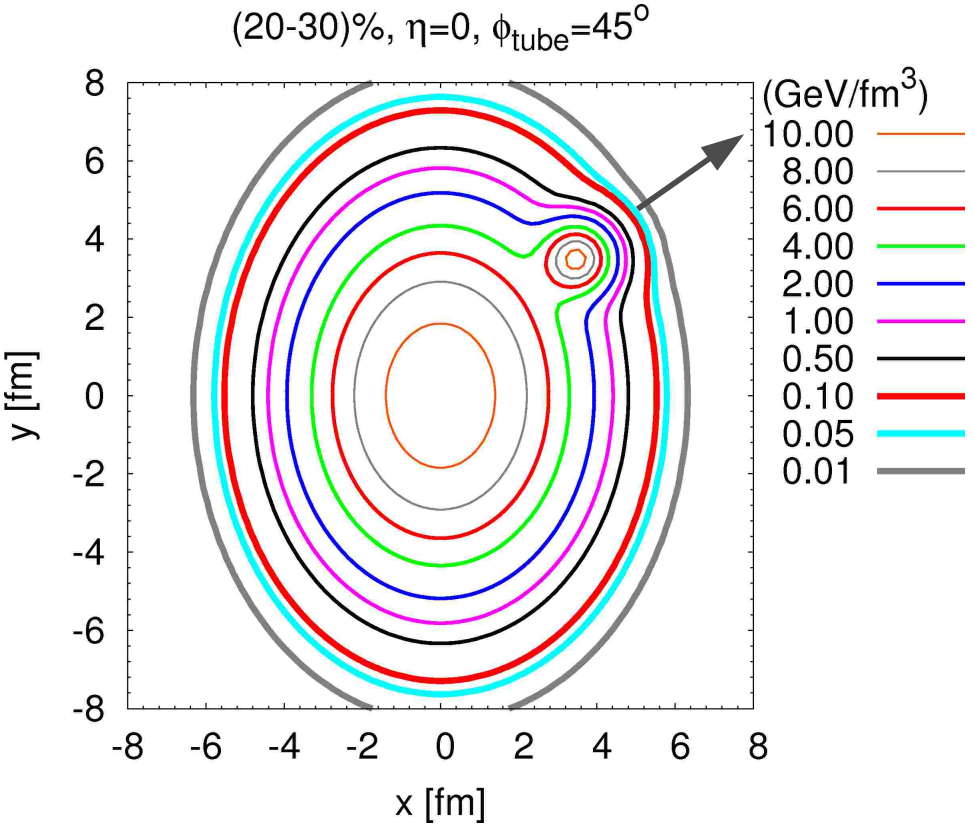
- Question: is it possible to explain the in-plane and out-of-plane correlation by using the one-tube model?

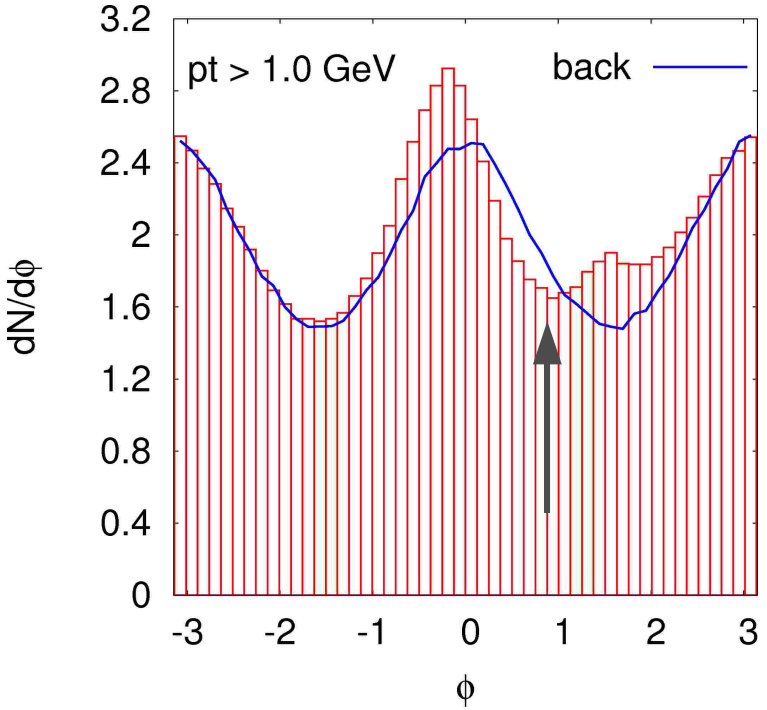






- The one-tube model for non-central collisions (20-30% of centrality). In this case, the background, which is an average of Nexus IC, has some eccentricity.





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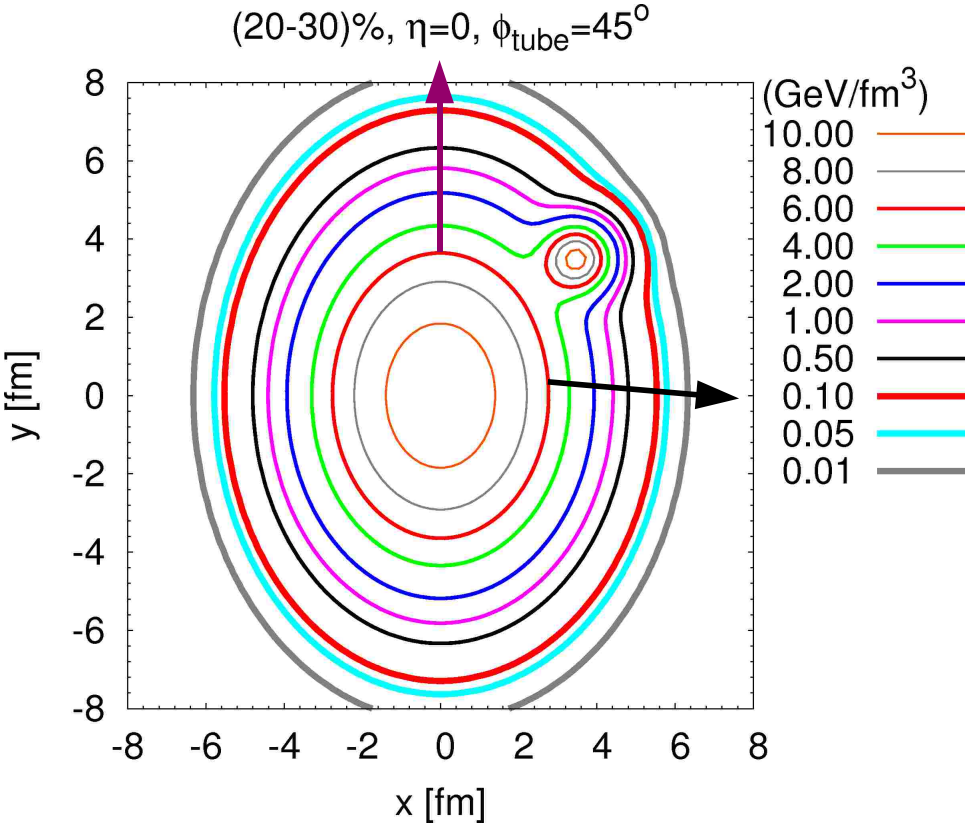

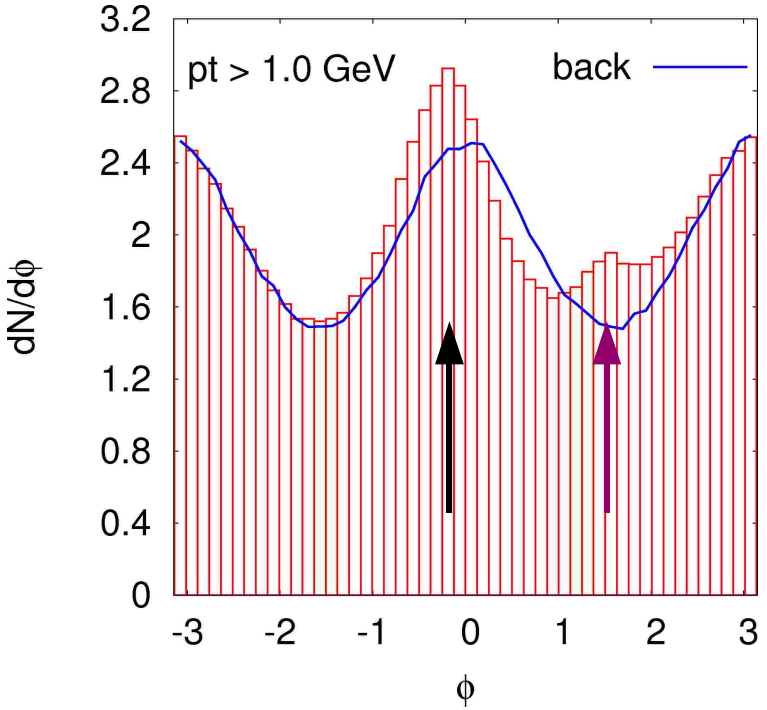

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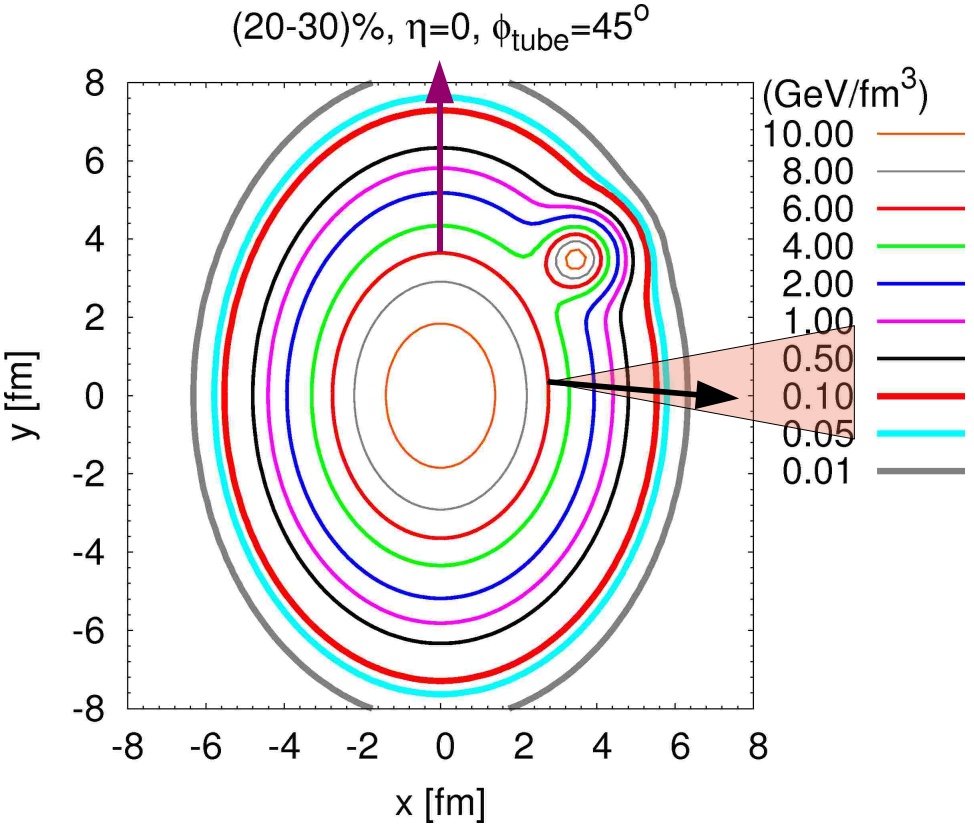

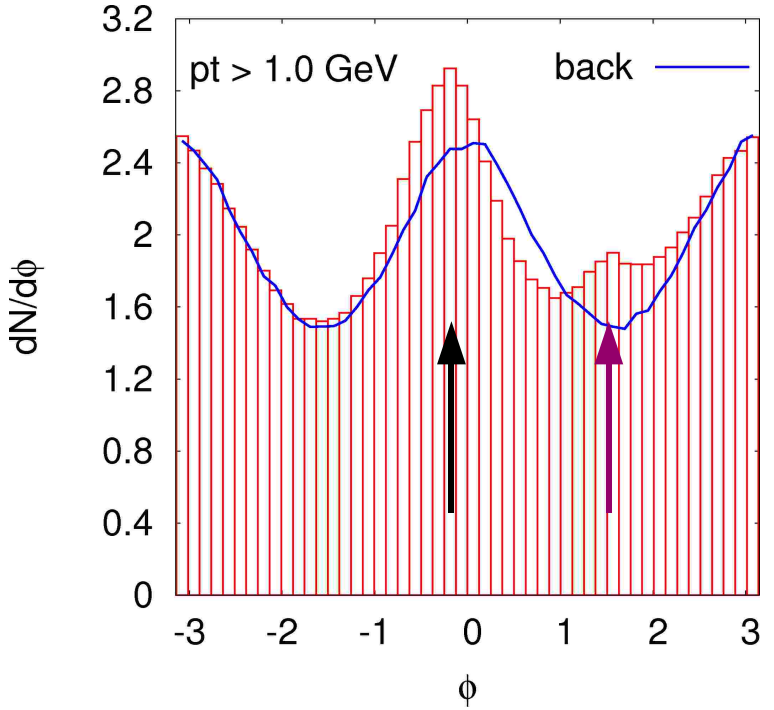

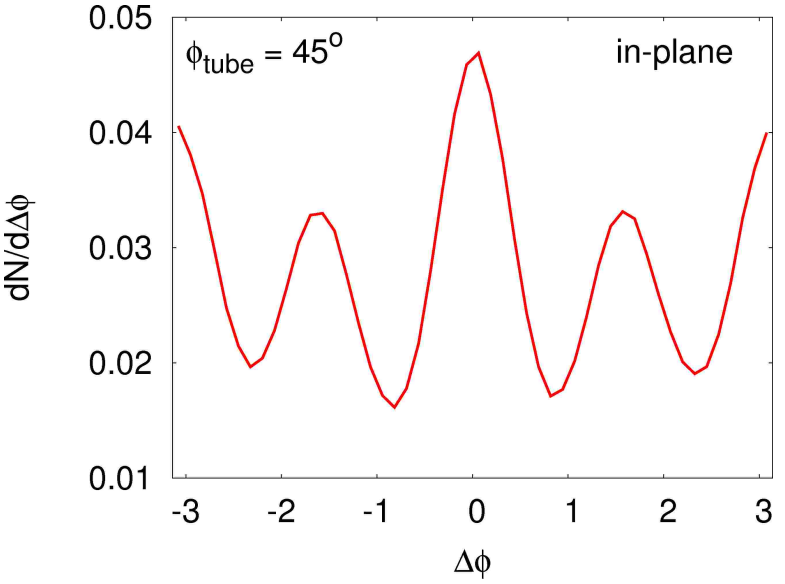

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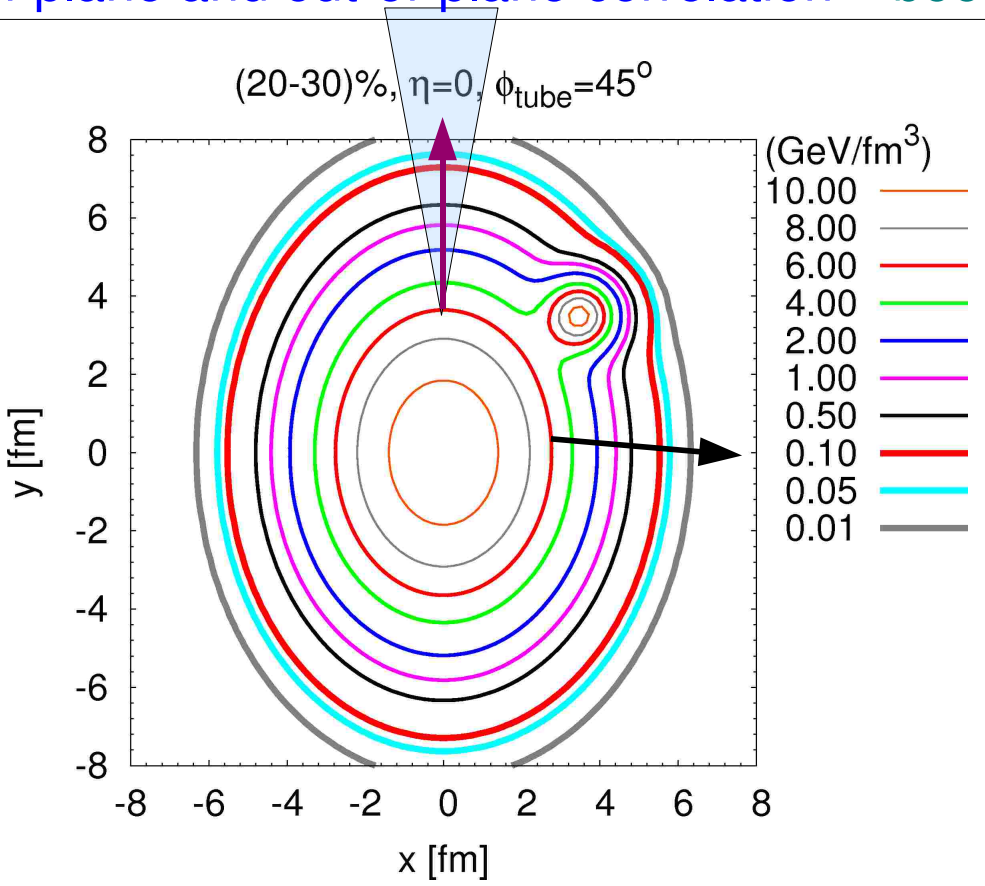
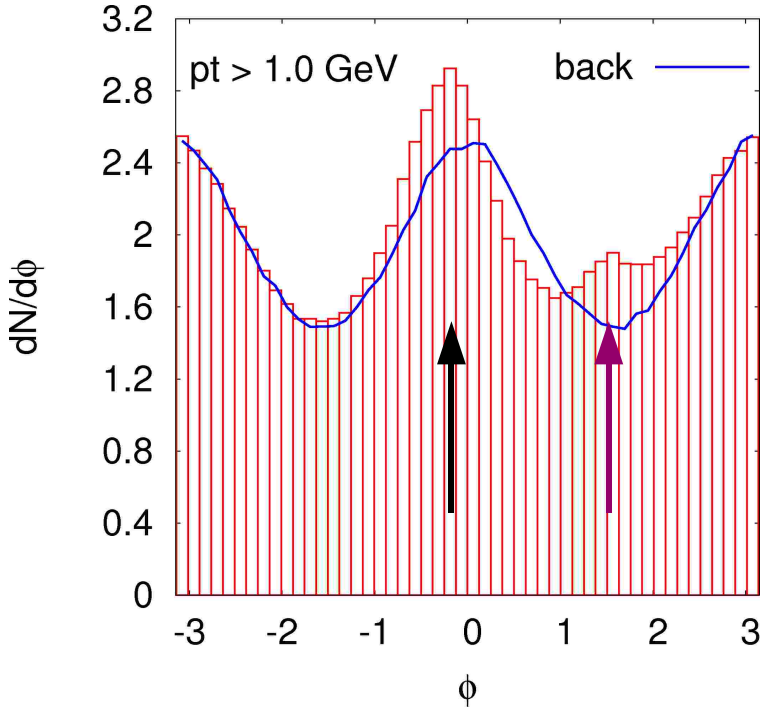
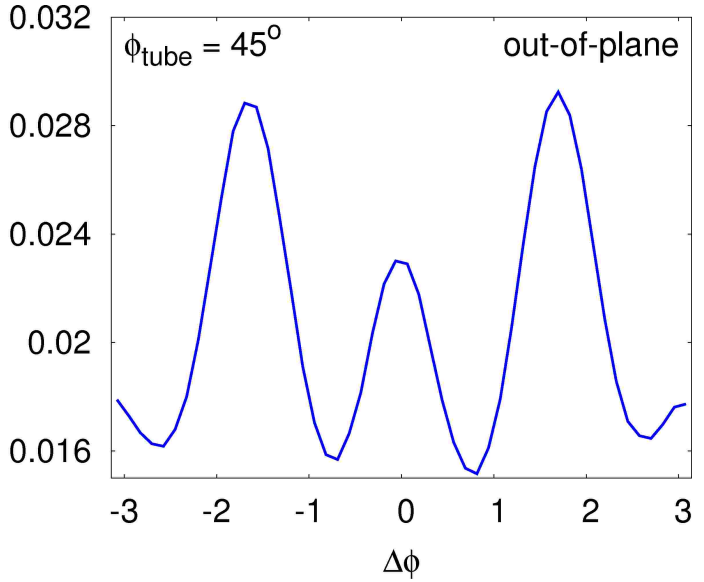
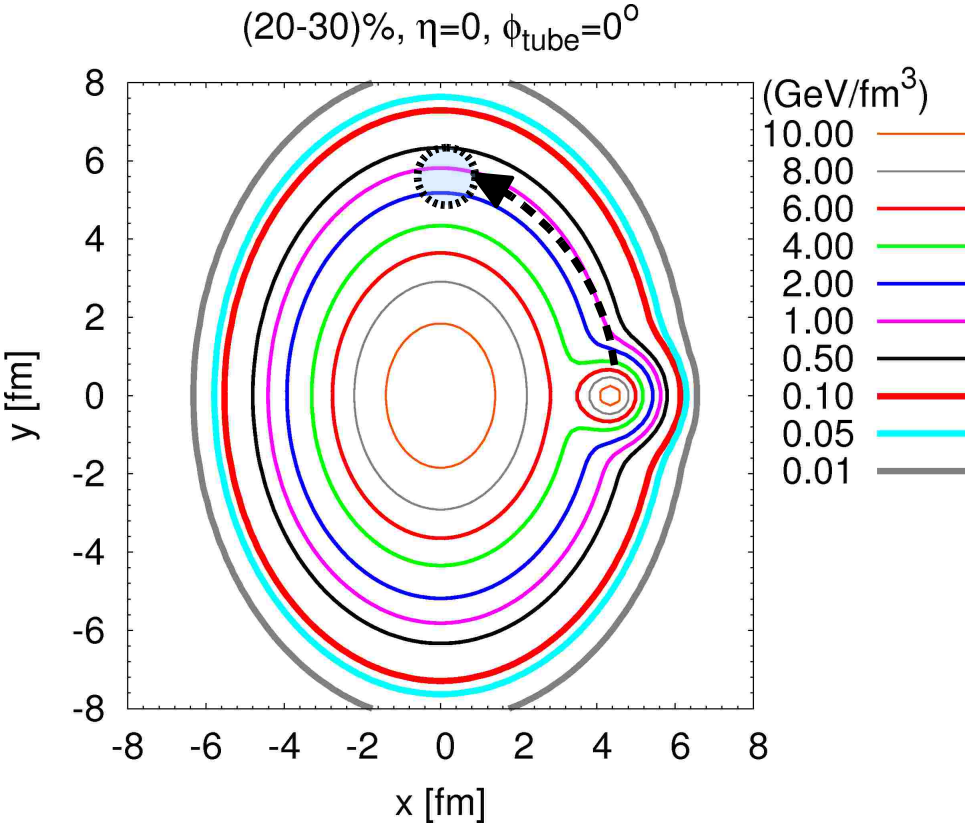


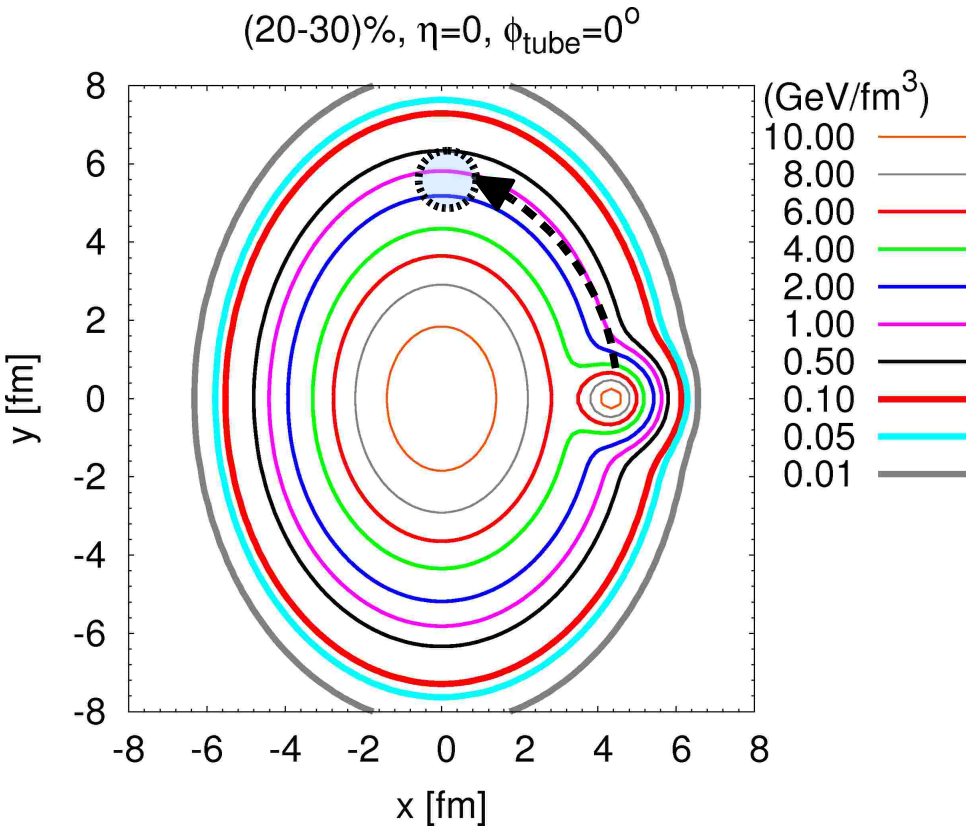


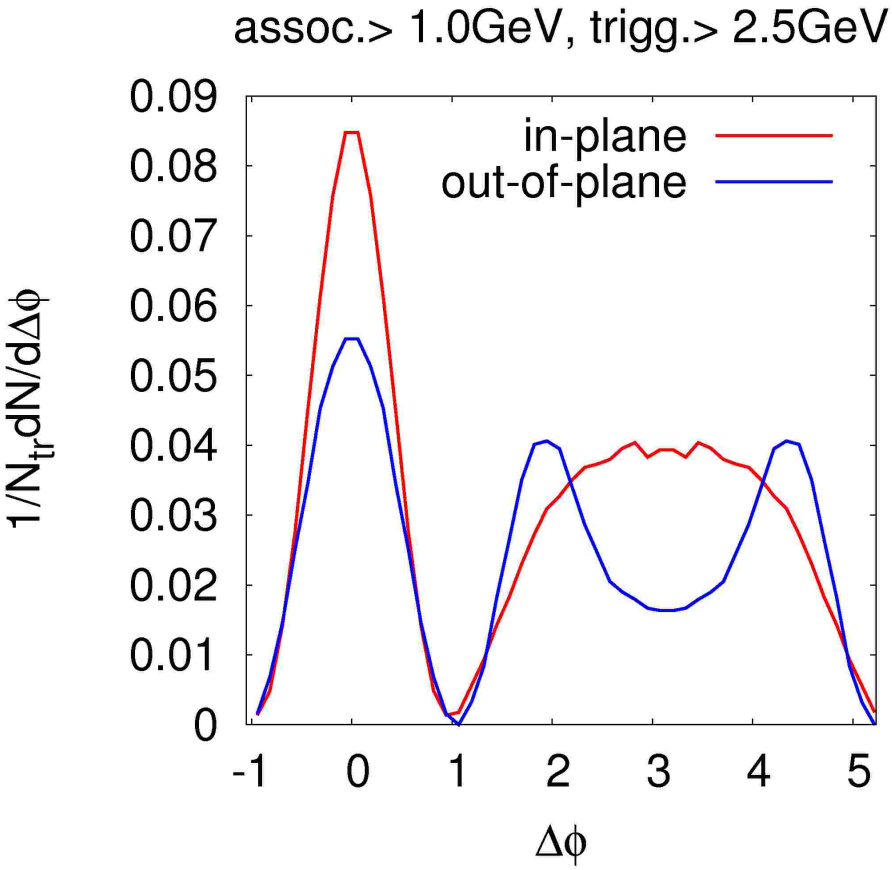


- The one-tube model for non-central collisions (20-30% of centrality). In this case, the background, which is an average of Nexus IC, has some eccentricity.



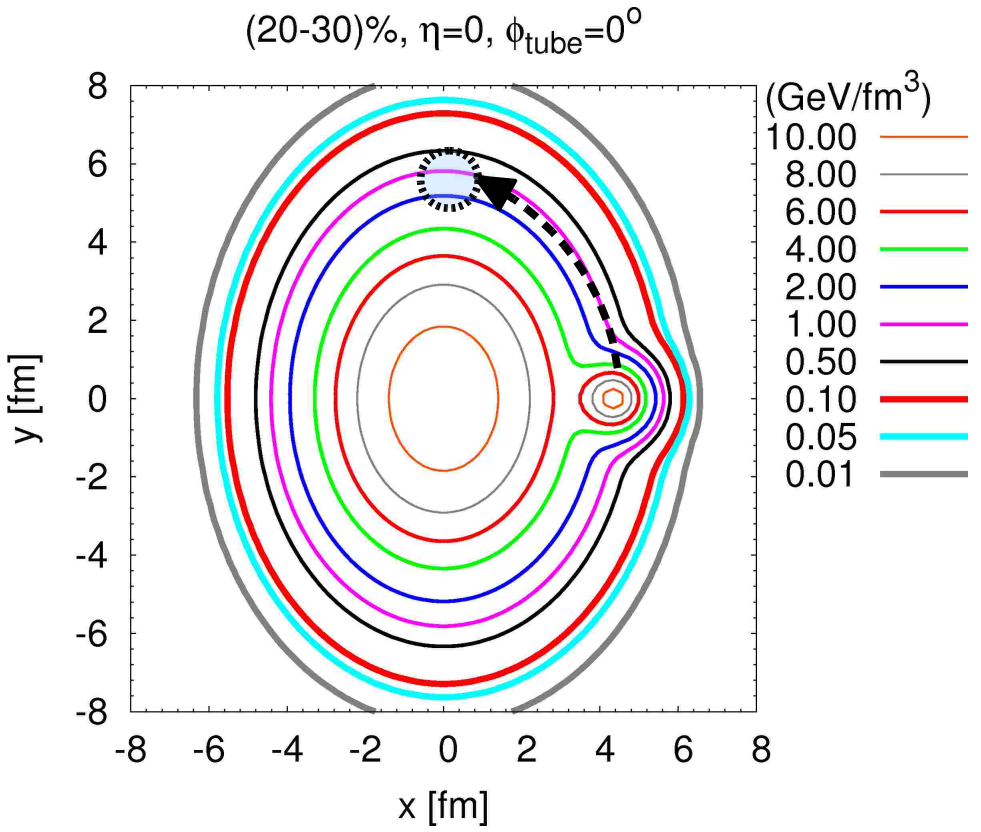
- Let us add the contribution of events in which the tube is placed at a different angular position, along the line of same energy density, starting from 0^0 until 90^0.

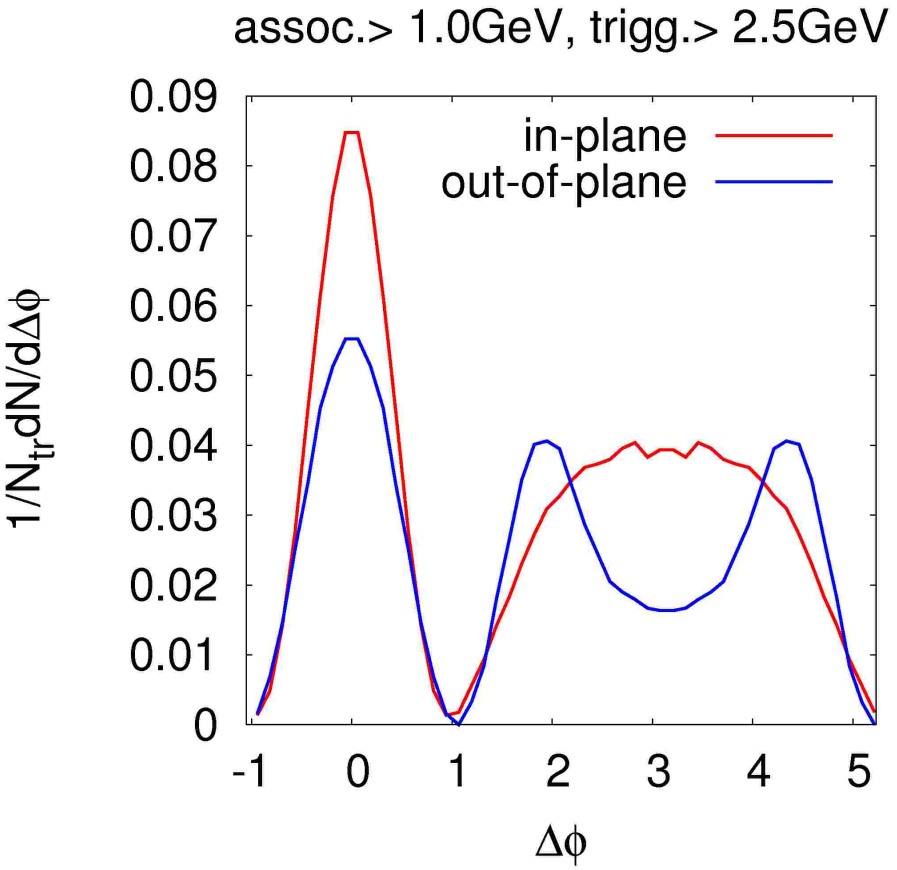




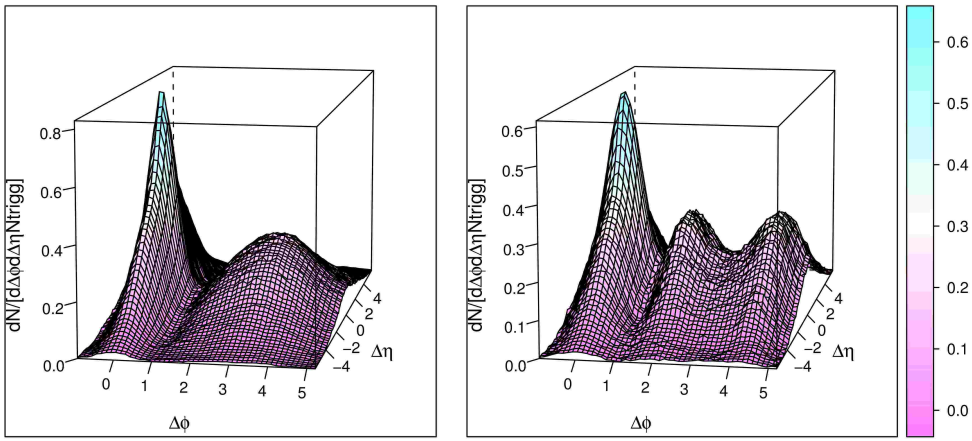
- Let us add the contribution of events in which the tube is placed at a different angular position, along the line of same energy density, starting from 0° until 90°.

in-plane and out-of-plane correlation – boost-invariant one-tube model



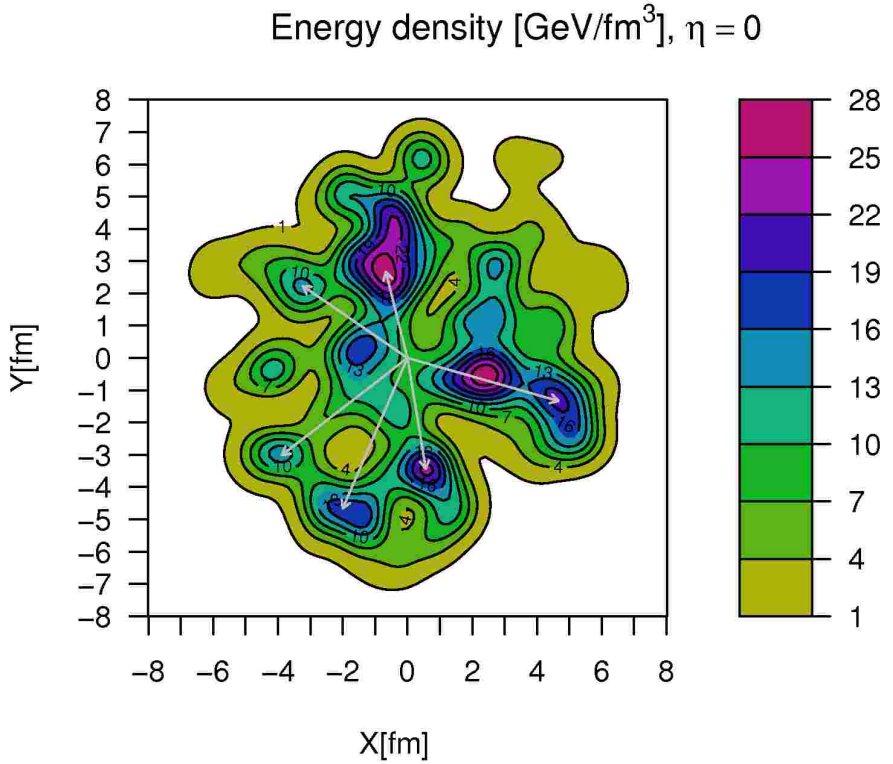


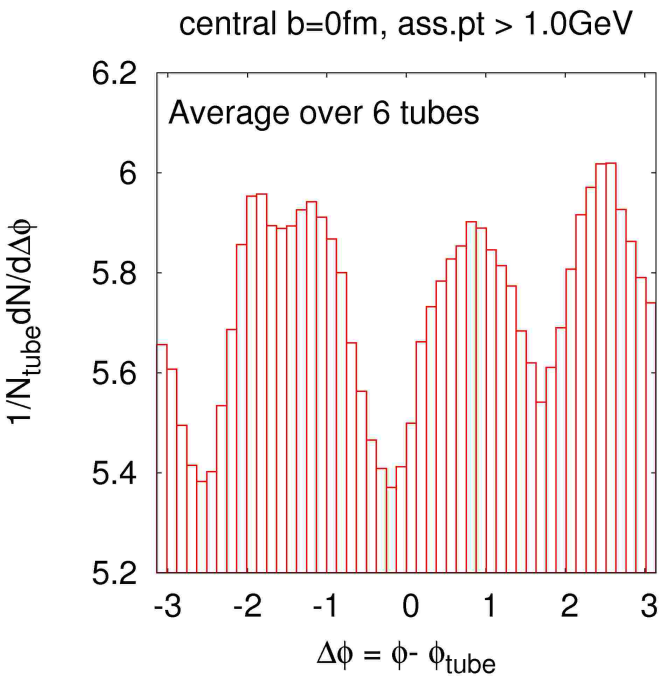
- Let us add the contribution of events in which the tube is placed at a different angular position, along the line of same energy density, starting from 0⁰ until 90⁰.

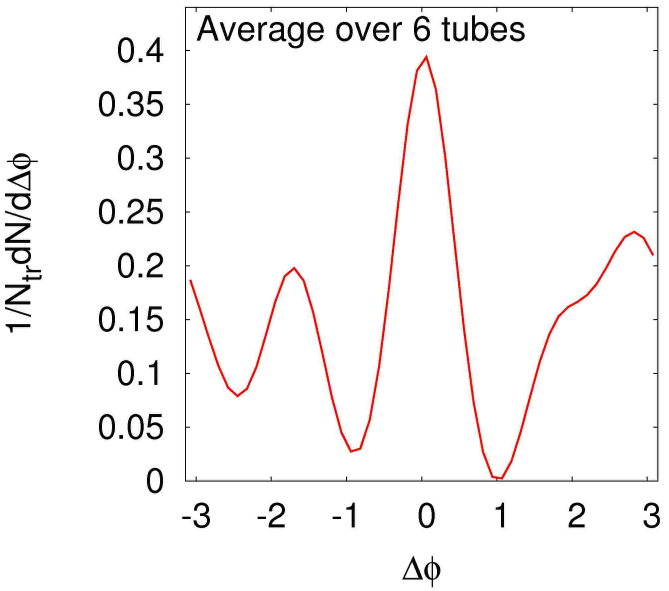


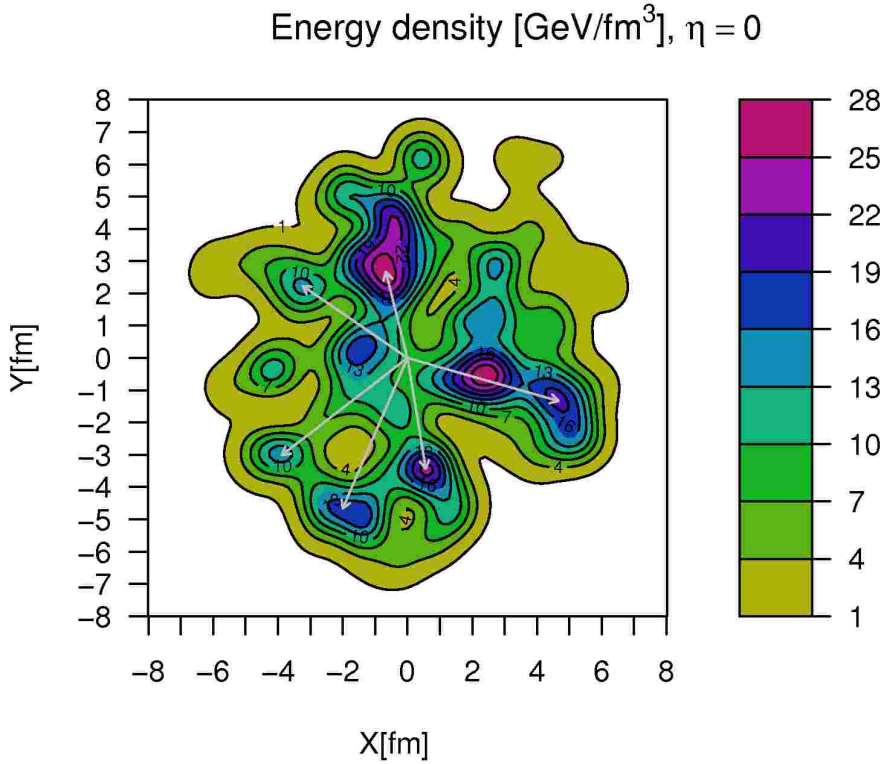
conclusion

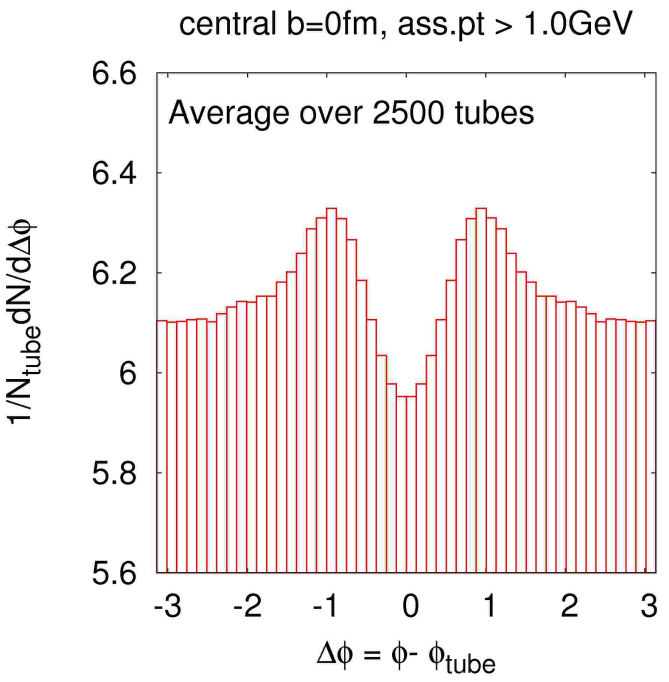
- The long range correlation in the longitudinal direction can be understood in terms of tubular structures that are present in the Nexus IC.
- The boost-invariant one-tube model clarifies, in the NexSPheRIO scenario, the origin of the azimuthal structure of the 2-particle correlation function, including: in-plane and out-of-plane effect.

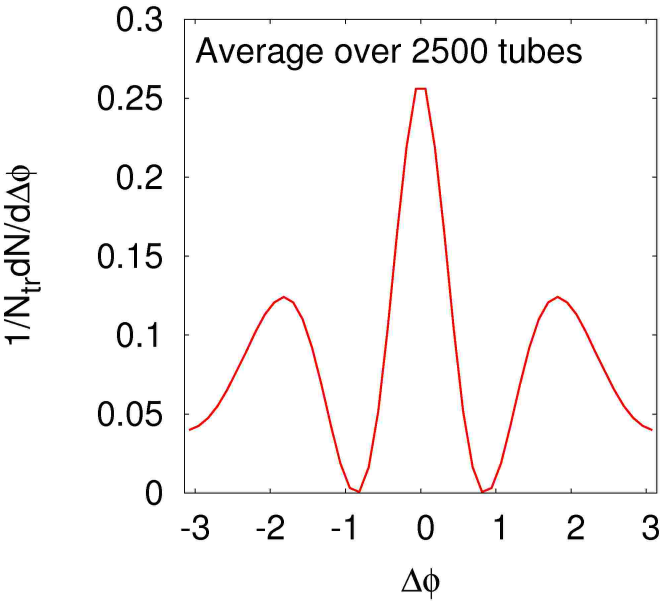

Energy density [GeV/fm^3], $\eta = 0$
Y[fm]
X[fm]
28
25
22
19
16
13
10
7
4
1


central b=0fm, ass.pt > 1.0GeV
Average over 6 tubes
$1/N_{tube} dN/d\Delta\phi$
$\Delta\phi = \phi - \phi_{tube}$


Average over 6 tubes
$1/N_{tr} dN/d\Delta\phi$
$\Delta\phi$


Energy density [GeV/fm^3], $\eta = 0$
Y[fm]
X[fm]
28
25
22
19
16
13
10
7
4
1


central b=0fm, ass.pt > 1.0GeV
Average over 2500 tubes
$1/N_{tube} dN/d\Delta\phi$
$\Delta\phi = \phi - \phi_{tube}$


Average over 2500 tubes
$1/N_{tr} dN/d\Delta\phi$
$\Delta\phi$