Generation of Higher Flow Harmonics in Pb+Pb Collisions at LHC in HYDJET++ model

Bengt Henrik Brusheim Johansson

DUBNA 2015

The evolution of matter

The matter evolved on a cosmological scale during the early stages of the universe. The “known” matter evolves from extreme conditions, i.e. a hot and dense - ”Primordial Plasma”?

The matter evolves for $\sim 10^5$ years until observable.

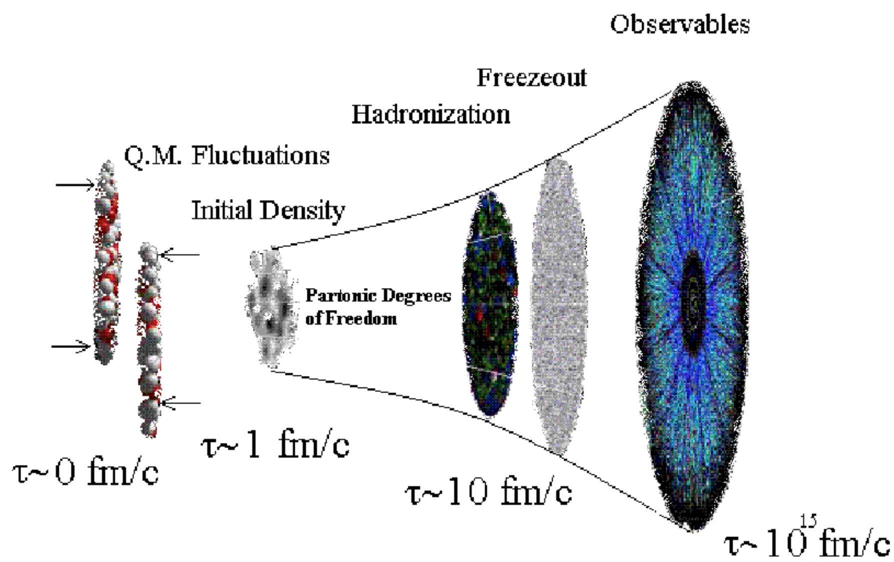

Figure 1: Accelerator collision of heavy ions. Hadronization and detection.

Evolution of participant matter

The participant matter is hypothesized to be described by hydrodynamics.

The collision participants form the initial conditions, which propagate as a consequence of pressure gradients, thus producing momentum anisotropy, observed in the detectors as e.g. “flow”.

Observables are *in medio* modulated.

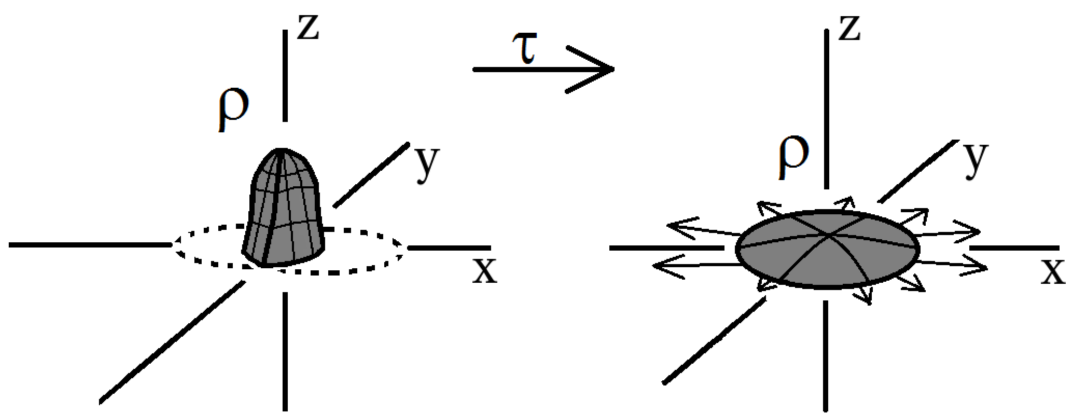

Figure 2: Participant matter propagation

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... to simulate the unidentified particle distributions, including elliptic and triangular flow under the hypothesis of the first order simulation of the elliptic and triangular planes, in order to provide an more complete view of the fireball geometry -thus, the hadronization modes of the heavy ion collision!

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... to investigate finer aspect of the distributions. Coherence, or hadronization physics are to be investigated in the present model.

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... fundamental physics is possible to investigate through a detailed model.

Generating the particle spectra

The generated spectra agrees with experimental data.

...provides a base for the investigation of RHIC's.

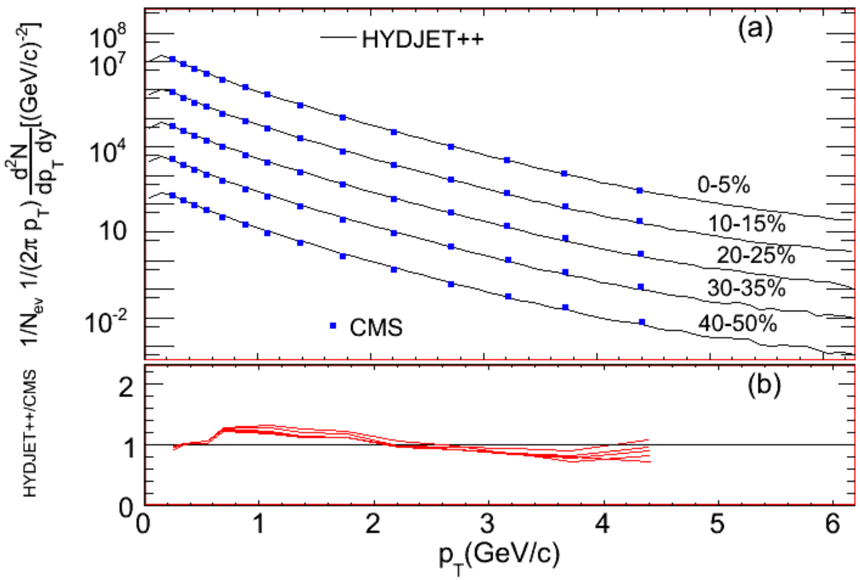

Figure 3: Particle spectra. Simulations are compared with experimental data. Simulations made for centralities: $\sigma/\sigma_0 = 0-5\%$, $10-20\%$, $20-30\%$, $30-40\%$, $40-50\%$ [3].

Simulating the elliptic flow

The azimuthal anisotropy is investigated through the ellipticity dependent elliptic flow.

Centralities simulated between $0 - 50\%$ in this model.

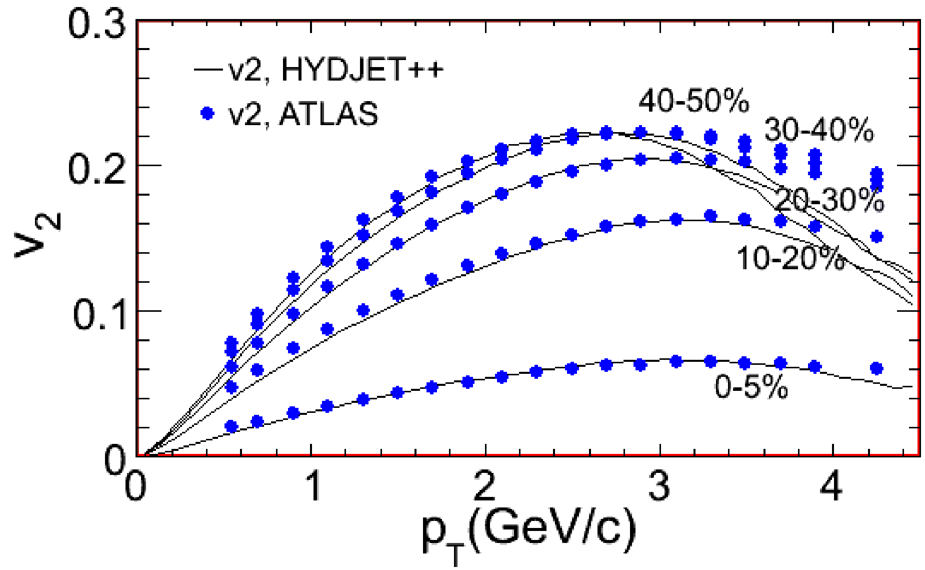

Figure 4: Elliptic Flow. The elliptic flow is simulated for the centralities: $\sigma/\sigma_0 = 0{-}5\%$, $10{-}20\%$, $20-30\%$, $30-40\%$, $40-50\%$ [4].

Projecting the triangular flow

The triangular flow is also simulated in the HYDJET++ model.

The fluctuation dependent triangular flow is extracted from the distribution, thus displaying a nice first order simulation of the initial geometry.

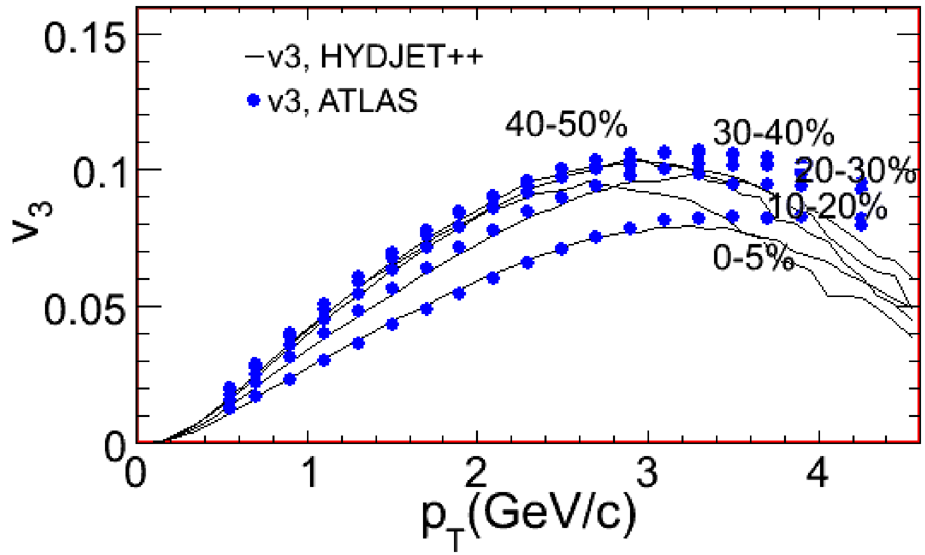

Figure 5: Triangular flow is simulated for the centralities: $\sigma/\sigma_0 = 0-5\%$, $10-20\%$, $20-30\%$, $30-40\%$, $40-50\%$ [4].

Recaption

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... the elliptic and triangular flow are also reproduced for the same regimes.

Transverse momentum dependence of the ratio v_3^2/v_2^3

The scaled ratio of the fluctuation dependent triangular v_3 and ellipticity dependent v_2 is observed in order to investigate coherence.

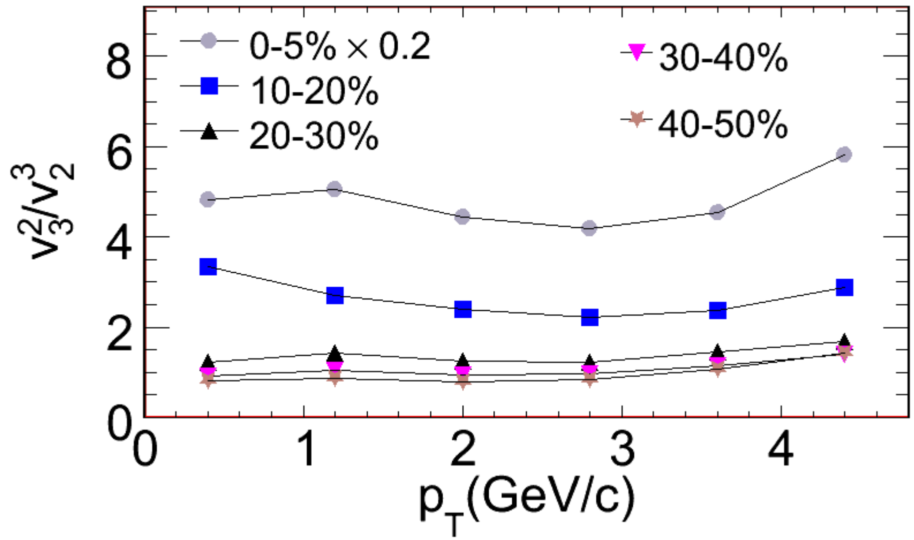

Figure 6: Ratio v_3^2/v_2^3 is simulated for the centralities: $\sigma/\sigma_0 = 0-5\%,\ 10-20\%,\ 20-30\%,\ 30-40\%,\ 40-50\%.$

Integration of the ratio v_3^2/v_2^3

The v_3^2/v_2^3 ratio is integrated.

A hydro dynamical projection is included.

The hydro ratio is seen to depend on centrality in favour of elliptic flow.

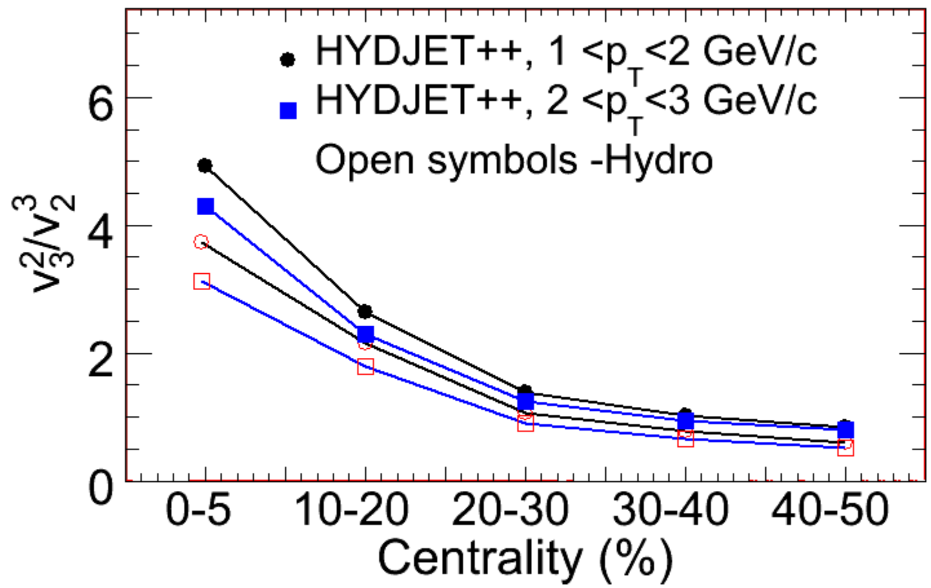

Figure 7: Ratio v_3^2/v_2^3 is simulated for the centralities: $\sigma/\sigma_0 = 0-5\%, 10-20\%, 20-30\%, 30-40\%, 40-50\%$.

Deviation from hydrodynamics for the ratio v_3^2/v_2^3

The ratio is dependent on transverse momentum.

A minimum for the least relative deviation is found -onset of fragmentation.

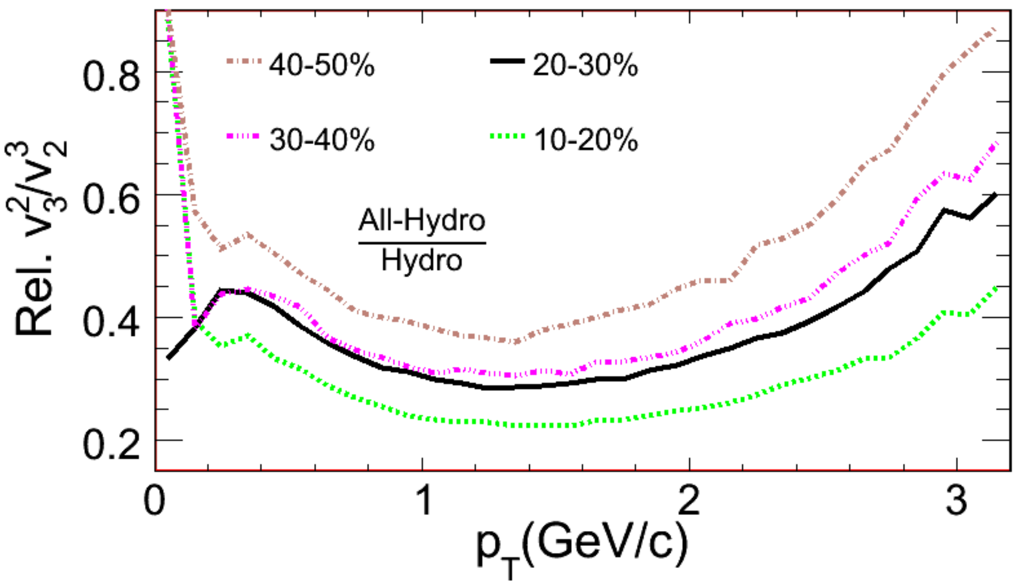

Figure 8: Relative deviation from hydro dynamical projection for v_3^2/v_2^3 is simulated for the centralities: $\sigma/\sigma_0 = 0-5\%$, $10-20\%$, $20-30\%$, $30-40\%$, $40-50\%$.

The ratio width dependence of v_3^2/v_2^3

The ratio is displaying coherence dependence.

The elliptic flow is displaying sensitivity to coherence.

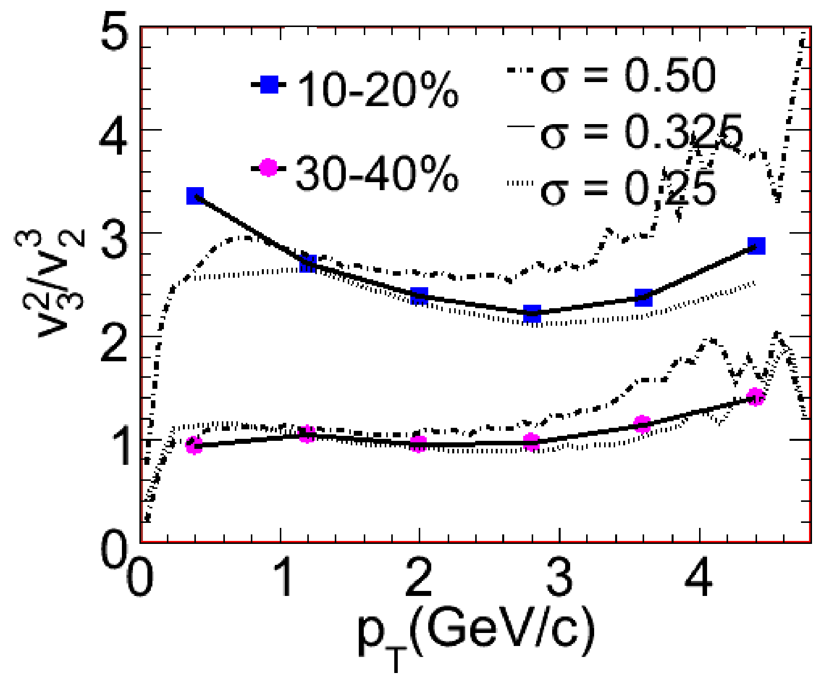

Figure 9: Ratio v_3^2/v_2^3 is simulated for the centralities: $\sigma/\sigma_0 = 0-5\%, 10-20\%, 20-30\%, 30-40\%, 40-50\%$, and three different fragmentation widths.

On Results

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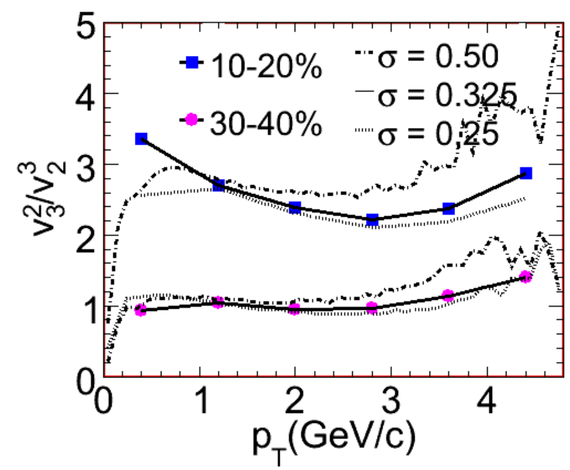
The fundamental angular modes are thus considered reproduced and correspond to hadronization. Coherence is investigated in the v_3^2/v_2^3 ratio in terms of fragmentation width.



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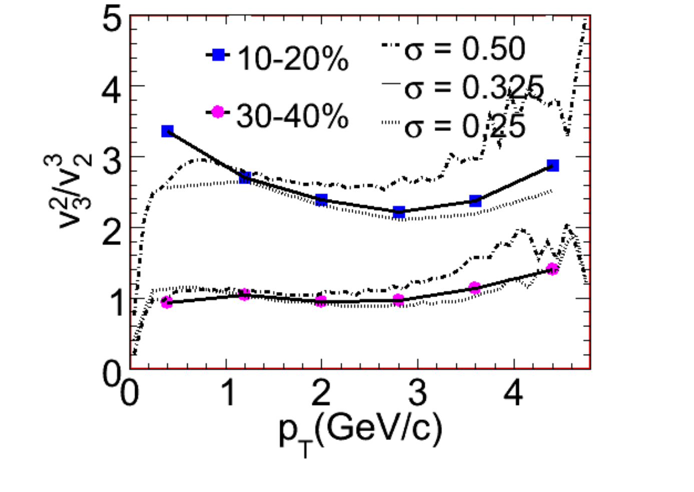
The sensitivity to fragmentation width is here seen as centrality dependent.



In Conclusion

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Coherence observables provides information on fundamental physics.

Triangular flow is here displaying less relative sensitivity to coherence levels.

References

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Summary

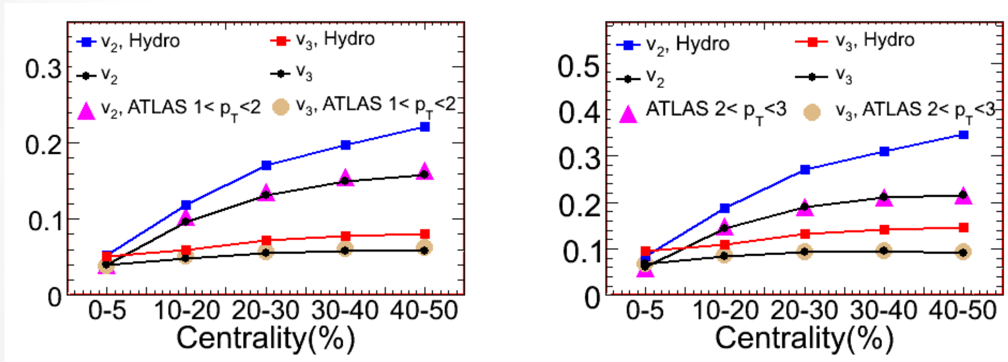


Figure 10: Elliptic and triangular flow.

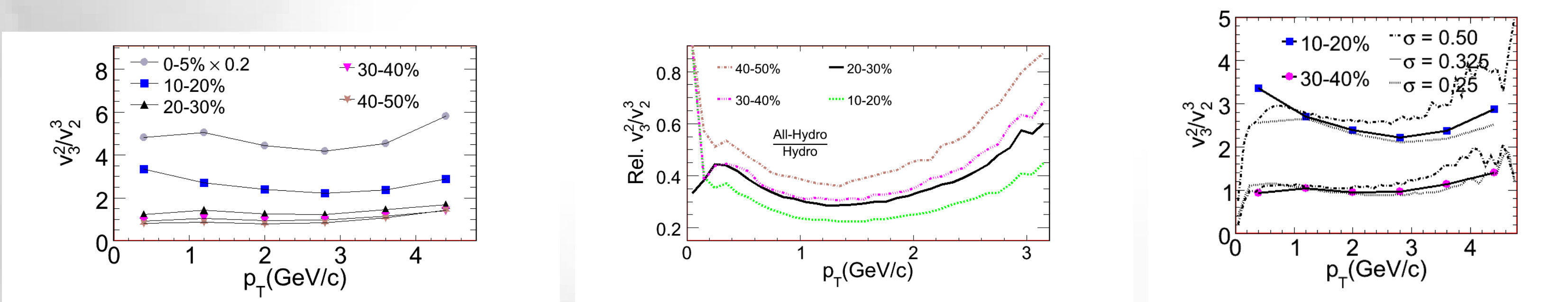


Figure 11: Coherence dependence.

The thermal projection of the particle spectra

The hydro dynamical spectra are projected.

In the model, hydrodynamics is seen to dominate the $0 < p_T < 1.5$ GeV/c regime of the particle spectra.

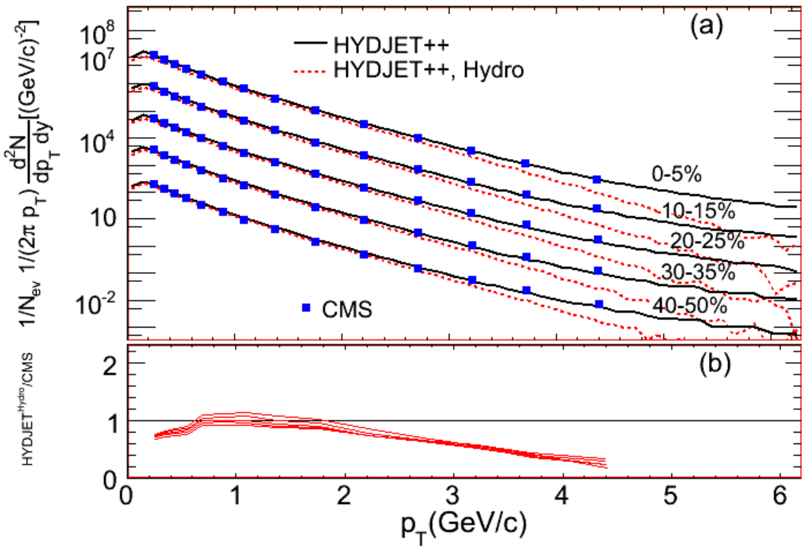
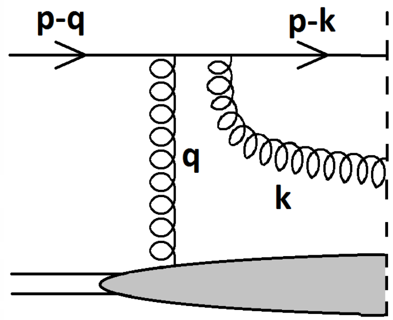


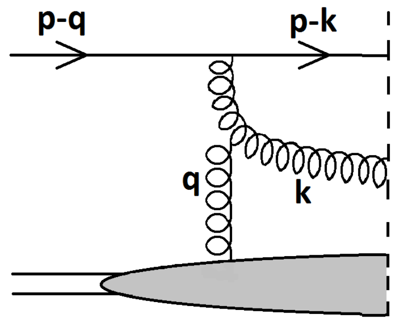
Figure 12: Particle spectra with hydro dynamical projection included.

In Medio Modulation

The *in medio* radiative modulation of the parton energy is treated in the BDMS framework.

Born amplitudes of the different radiation modes are calculated as





$$f = \frac{2}{N_C} \sum_i \int d^2 Q V(Q^2) \bar{T}_i F_i, \quad V(Q^2) = \frac{1}{\pi\sigma} \frac{d\sigma}{dQ^2} \tag{1}$$

Emission factors $\bar{T}_i F_i$ are diagram specific.

Collisional energy loss

The energy loss due to in-media collisions in the high momentum transfer limit is

$$\Delta E = \frac{1}{4T\rho} \int_0^L dl \int_{\mu_D^2}^{t_{max}} dt \frac{d\sigma}{dt} t \quad (2)$$