PROCEEDINGS OF SCIENCE

Di-hadron Correlations in pp and Pb+Pb Collisions at the LHC

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We discuss recent developments in the EPOS approach, concerning an event-by-event treatment of the hydrodynamical evolution in heavy ion collisions and also in high multiplicity pp scatterings at the LHC. The initial conditions are flux-tubes, which are formed following elementary (multiple) scatterings. We show that this picture leads in a natural way to the so-called ridge structures, observed in heavy ion and proton-proton collisions.

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EPOS is a multiple scattering model in the spirit of the Gribov-Regge approach[1]. Here, one does not mean simply multiple hard scatterings, the elementary processes correspond to complete parton ladders, which means hard scatterings plus initial state radiation. In this case, this elementary process carries an important fraction of the available energy, and therefore we treat very carefully the question of energy sharing in the multiple scattering process. Open and closed ladders have to be considered in order to have a consistent quantum mechanical treatment. The corresponding graphs are squared, and we employ cutting rule techniques and Markov chains to obtain finally partial cross sections. The cut parton ladders are identified with longitudinal color fields or flux tubes, treated via relativistic string theory.

In case of very high energy *pp* collisions (at the LHC) or heavy ion scatterings already at RHIC, many flux tubes overlap and produce high energy densities. We therefore employ a sophisticated hydrodynamical scenario (for details see [1]), for both heavy ions and proton-proton scatterings at the LHC, with initial conditions obtained from a flux tube approach (EPOS), compatible with the string model, used since many years for elementary collisions (electron-positron, proton proton), and the color glass condensate picture [2]. The equation-of-state is compatible with lattice gauge results of ref. [3]. We use a hadronic cascade procedure after hadronization from the thermal system at an early stage [4, 5].

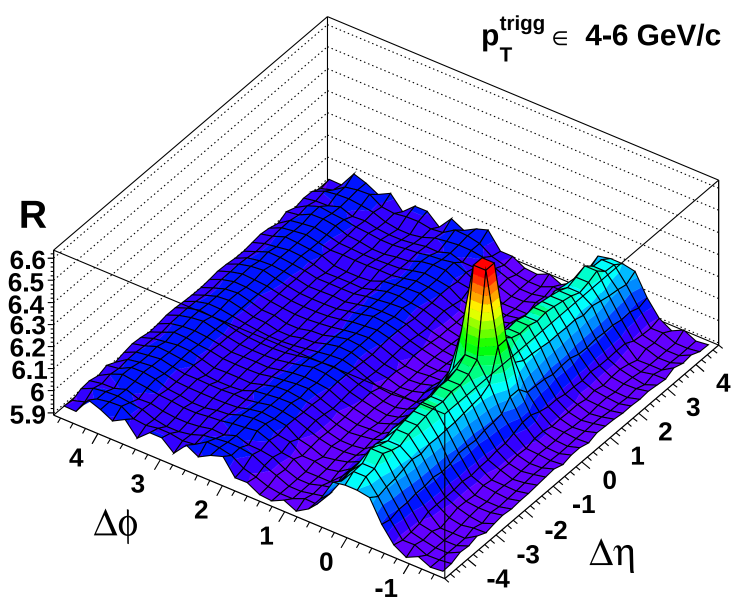

Figure 1: (Color online) Dihadron $\Delta\eta - \Delta\phi$ correlation in a central PbPb collision at 2.76 GeV. Trigger particles have transverse momenta between 4 and 6 GeV/c and associated particles 2 and 4 GeV/c.

In ref. [1] , we test the approach by investigating all soft observables of heavy ion physics, in case of AuAu scattering at 200 GeV. Here, we are going to discuss some selected (and interesting) topics, at LHC energies. The energy density in PbPb collisions has a complicated structure in the transverse plane, but this structure is longitudinally translational invariant (same structure

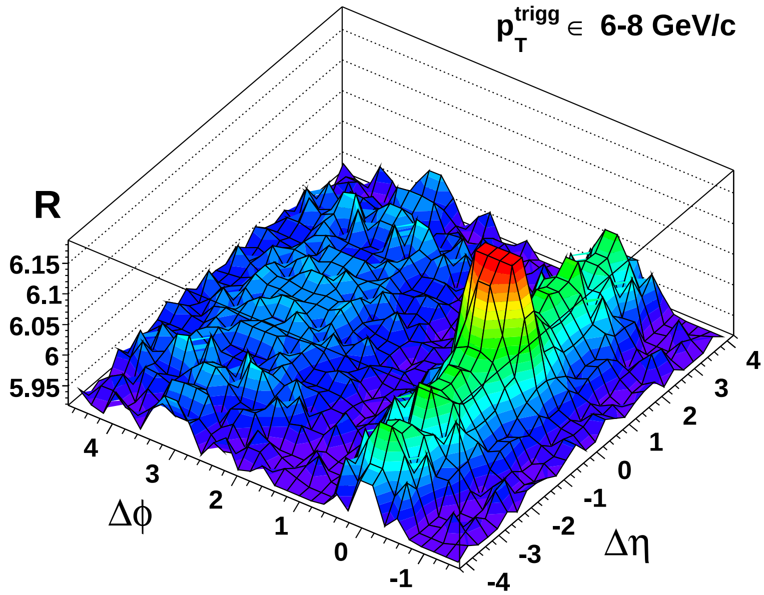

Figure 2: (Color online) Dihadron $\Delta\eta - \Delta\phi$ correlation in a central PbPb collision at 2.76 GeV. Trigger particles have transverse momenta between 6 and 8 GeV/c and associated particles between 2 and 4 GeV/c.

at different values of η_s). The equations of hydrodynamics preserve this translational invariance, and transport it to different quantities, as the radial flow. As a consequence, particles emitted from different longitudinal positions get the same transverse boost, when their emission points correspond to the azimuthal angle of a common flow peak position. And since longitudinal coordinate and (pseudo)rapidity are correlated, one obtains finally a strong $\Delta\eta - \Delta\phi$ correlation, as seen in figs. 1 and 2, where we plot the dihadron correlation $dN/d\Delta\eta\, d\Delta\phi$, with $\Delta\eta$ and $\Delta\phi$ being respectively the difference in pseudorapidity and azimuthal angle of a pair of particles. Here, we consider trigger particles with transverse momenta between 4 and 6 GeV/c (6 and 8 GeV/c), and associated particles with transverse momenta between 2 and 4 GeV/c. Our ridge is very similar to the structure observed by the CMS collaboration [6].

It is actually far from trivial to get such a perfectly flat ridge structure. In an earlier version, a string was represented by the string segments, created in a random fashion. This means that the different pieces were situated at different rapidities, with fluctuating distances (in rapidity) between neighbors. This provided – after averaging over all the strings – some bumpy structure of the energy density in longitudinal direction, leading to a correlation peak rather than a flat shoulder. In the present version, a string is treated as a continuous object, the energy density shows a smooth behavior, see fig. 3.

So the initial energy density obtained from flux tubes (strings) – if they are treated correctly – shows random azimuthal asymmetries, but since the flux tubes are long we observe similar asymmetries at different longitudinal positions. So we observe an almost translationally invariant azimuthal asymmetry!

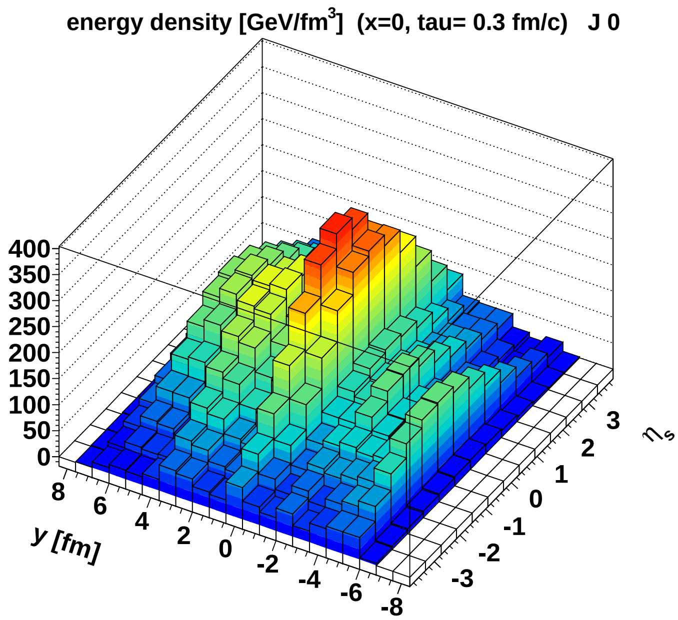

Figure 3: (Color online) Energy density as a function of y and η_s, for a central PbPb collision at 2.76 GeV.

As already said earlier, this translationally invariant asymmetry of the initial energy density is conserved during the hydrodynamical evolution, and in particular translated into other quantities, like the flow and finally particle production.

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