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Simulations of charged hadron and charmed meson production in Pb+Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV with HYDJET++ generator

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HYDJET++ is a Monte Carlo event generator merging parametrized soft part inspired by hydrodynamics with hard part containing jets. It has been successful to describe particle production in Pb+Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV energies. In this contribution, particle spectra and collective flow for the top LHC energy $\sqrt{s_{NN}} = 5.02$ TeV Pb+Pb collisions are presented for the first time. Specifically, the HYDJET++ model version 2.4 has been used to simulate spectra of charged particles, D^0 and J/ψ mesons and related v_2 and v_3 azimuthal flow harmonics. The particle spectra and flow haromincs are studied in different centrality bins ranging from 0–10% up to 30–40% centrality in midrapidity region for charged particles and D^0 mesons and in forward rapidity in case of J/ψ mesons. The simulated results have been compared with the LHC data to tune HYDJET++ parameters.

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1. Introduction

In central ultra-relativistic heavy ion collisions, extreme energy densities are reached such that quark-gluon plasma (QGP), a novel phase of matter where quarks and gluons are deconfined, can be observed [1]. Different effects, e.g. modified yields of particle species with regards to a proton-proton collision, collective behavior of particles produced in the collision or jet quenching[1], can be recognized as phenomena of the QGP. Different physical models are used to predict the outcome of an experiment and correctly understand the main physical processes.

2. HYDJET++

HYDJET++ is a Monte Carlo (MC) generator for simulation of relativistic heavy ion collisions and merges hydro-inspired blast wave parameterization (soft) with jet quenching (hard) [2, 3]. In the soft part, hadrons are generated at chemical freeze-out hypersurface and thermal equilibrium is assumed during the thermal emission. The hard part is based on PYQUEN (PYthia QUENched) partonic energy loss model [4] which employs jet quenching in PYTHIA [5] generated jet events.

In former studies, production of charged hadrons and charmed mesons was successfully described in Au+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV [2, 6] and in Pb+Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV [7]. It has been found that different simulation parameters need to be used for a correct description of different particle species at different collisions energies. The temperature at thermal freeze-out T_{th} needs to be the same for charged hadrons and D mesons (T_{th} = 105 MeV) and different for J/ψ meson (T_{th} = 165 MeV) at $\sqrt{s_{NN}}$ = 2.76 TeV energy [7]. The values of T_{th} at $\sqrt{s_{NN}}$ = 5.02 TeV energy are studied in this proceedings using the most recent version 2.4 of the HYDJET++.

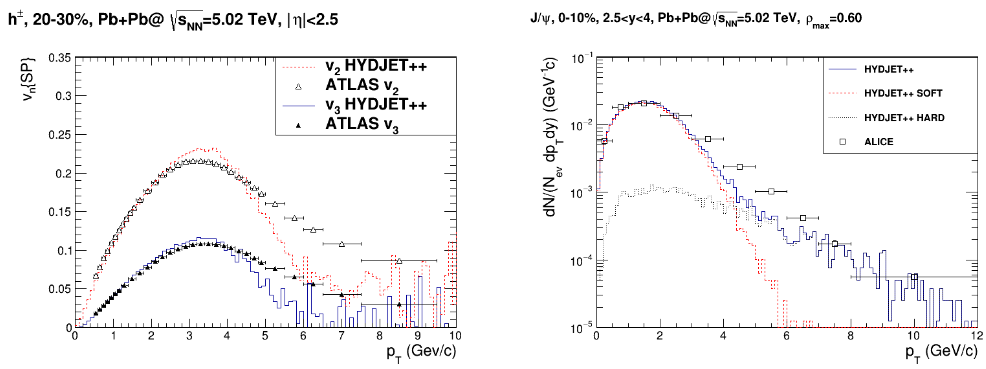

Figure 1: *Left:* Comparison of the HYDJET++ simulated elliptic and triangular flow coefficients of all charged hadrons $h^{\pm}$ with the ATLAS experimental data [8] in 20–30% centrality bin. *Right:* Comparison of the HYDJET++ simulated p_{T} distribution histogram of the J/ψ meson yield to the ALICE experimental data [9].

[1] Jet quenching is the modification of a jet caused by the QGP medium.

3. Charged hadrons $h^{\pm}$

The transverse momentum, p_{T}, and pseudorapidity η distributions of charged hadrons[2] can be described well by HYDJET++ in 0–40% centrality range. HYDJET++ also correctly reproduces elliptic and triangular flow distributions v_2, v_3 calculated by experiment adapted scalar product method in 10–30% semi-central events in $0 < p_{\mathrm{T}} < 4$ GeV/c region, however, it underestimates the data in $4 < p_{\mathrm{T}} < 10$ GeV/c region as shown in left graph in Fig. 1. Thermal freeze-out temperature $T_{\mathrm{th}} = 105$ MeV has been set for the simulation.

4. J/ψ meson

In the right graph in Fig. 1, HYDJET++ J/ψ transverse momentum p_{T} distribution is compared to the ALICE experimental data in 0–10% centrality bin. Parameter γ_{c}, which accounts for deviations of charm multiplicity from the complete thermal equilibrium value, has been set to $\gamma_c = 15$ for a correct description. One can see an underestimation of the experimental data in the $4 < p_{\mathrm{T}} < 6$ GeV/c region. The mismatch can be slightly eliminated by tuning the maximal fluid flow transverse rapidity at thermal freeze-out ρ_{max} parameter. Nevertheless, no significant impact on elliptic flow of the J/ψ is observed in central collisions and $v_2^{J/\psi}$ is well described in the left graph in Fig. 2 up to $p_{\mathrm{T}} < 6$ GeV/c. Thermal freeze-out temperature $T_{\mathrm{th}} = 165$ MeV has been used for the J/ψ simulations.

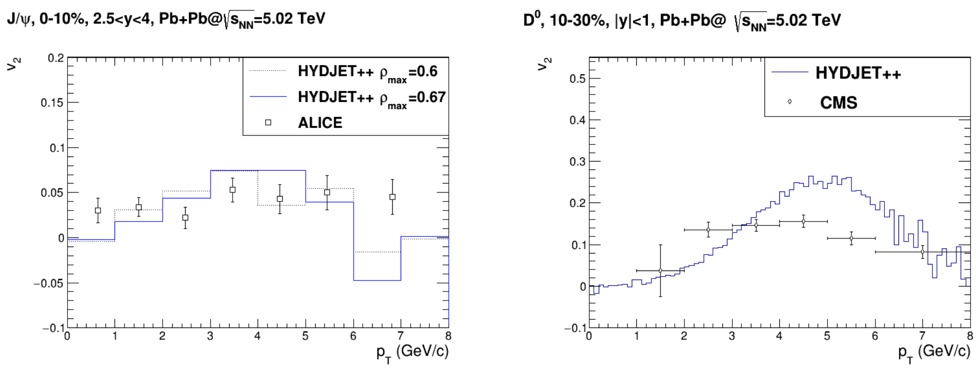

Figure 2: *Left:* Comparison of the HYDJET++ simulated J/ψ elliptic flow coefficient v_2 with ALICE experimental data [10] in 0–10% centrality bin for two ρ_{max} values. *Right:* Comparison of the HYDJET++ simulated D^0 elliptic flow coefficient v_2 with the CMS experimental data [11] in 10–30% centrality bin.

5. D^0 mesons

Charm production enhancement parameter γ_c obtained from J/ψ simulations has been also used for the D^0 p_{T} distribution resulting in a very good match between the HYDJET++ simulation and ALICE experimental data in $3 < p_{\mathrm{T}} < 14$ GeV/c region. Elliptic flow of the D^0 meson has been also studied in 10–30% centrality as can be seen in the right graph in Fig. 2. HYDJET++

[2]Inclusive charged hadrons $h^{\pm}$ are $\pi^{\pm}$, $K^{\pm}$, protons p and antiprotons $\bar{p}$.

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generally follows the trend of the experimental data but overestimation in $4 < p_{\mathrm{T}} < 6$ GeV/c region is observed.

The same thermal freeze-out temperature $T_{\mathrm{th}} = 105$ MeV as for the charged hadrons has been used for HYDJET++ D^0 simulations.

6. Conclusion

For all the studied distributions, a good description of the LHC data has been achieved by the HYDJET++ model. It appears that raising Pb+Pb collision energy from $\sqrt{s_{NN}} = 2.76$ TeV to $\sqrt{s_{NN}} = 5.02$ TeV does not have a significant impact on the thermal freeze-out temperature T_{th} which is the same value for $h^{\pm}$ and D^0 meson and different value for J/ψ. Correct description of charm meson spectra has been achieved by tuning charm enhancement parameter $\gamma_c = 15$ and the maximal fluid flow transverse rapidity at thermal freeze-out ρ_{max} parameter is found to have only a small impact on the J/ψ elliptic flow in central events.

7. Acknowledgement

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