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Charged hadrons production in p-p and Pb-Pb interactions at the ALICE experiment

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Summary. — The aim of the ALICE experiment at the LHC is the study of the nuclear matter under conditions of extreme energy density and temperature. Under these conditions a deconfined phase, in which quarks and gluons are no longer confined to individual nucleons, the Quark Gluon Plasma, is predicted by Lattice-QCD. In this context the precise measurement of charged particles spectra produced in heavy ions and proton-proton collisions is a fundamental tool to study the physics of the Quark Gluon Plasma. After a brief review of ALICE identification techniques to extract particle yields, we present the identified pions, kaons and protons spectra obtained in p-p ($\sqrt{s} = 7\,\text{TeV}$) and Pb-Pb ($\sqrt{s_{\text{NN}}} = 2.76\,\text{TeV}$) collisions.

PACS 25.75.-q – Relativistic heavy-ion collisions.
PACS 25.75.Dw – Particle and resonance production.

1. – Description

The ALICE detector [1,2] is capable of performing particle identification (PID) over a broad range of transverse momentum using different PID techniques. The *Inner Tracking System* (ITS) and the *Time Projection Chamber* (TPC) can provide PID via $\mathrm{d}E/\mathrm{d}x$ measurements, while the *Time of Flight* (TOF) detector PID is based on the measurement of particle velocity. The hadron identification can be further extended in momentum via Cherenkov angle measurements with the *High Momentum Particle Identification Detector* (HMPID) and with the TPC via $\mathrm{d}E/\mathrm{d}x$ measurements in the relativistic rise region of the Bethe-Bloch curve. Results for the p-p data at $\sqrt{s} = 7\,\text{TeV}$ and Pb-Pb at $\sqrt{s_{\text{NN}}} = 2.76\,\text{TeV}$ at mid-rapidity ($|y| < 0.5$) are presented. The centrality of the Pb-Pb collisions has been evaluated using the information of the event multiplicity in the VZERO detectors in combination with a Monte Carlo Glauber model study [3].

2. – pt distribution of identified hadrons

Transverse-momentum distributions and yields of particles play a fundamental role in the study of collective and thermal properties of nuclear matter under extreme conditions,

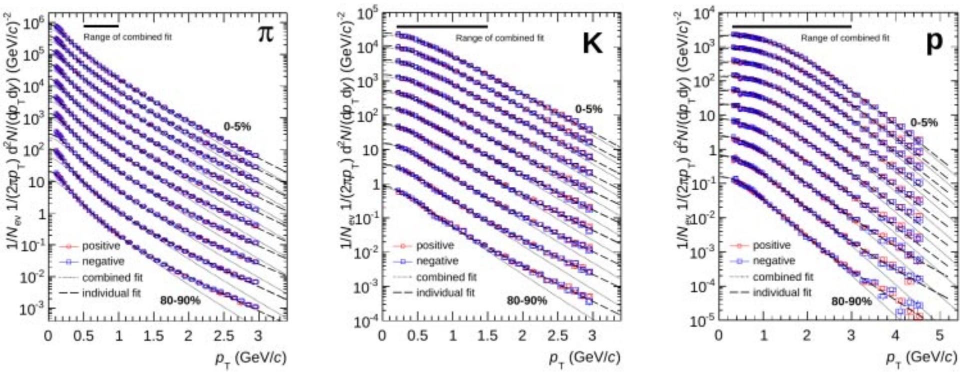

Fig. 1. – The invariant yields of charged pions, kaons and proton as function of p_T for different centrality bins, for positive (circles) and negative (squares) hadrons [4]. Statistical and systematic uncertainties are shown as error bars and box. Dashed curves: blast-wave fits to individual particles; dotted curves: combined blast-wave fits.

as reached in Pb-Pb collisions at the LHC. This allows to extract information about the collective transverse expansion (radial flow) and the temperature of the kinetic freeze-out.

It is shown in fig. 1 the centrality dependence of the $\pi^{\pm}$, $K^{\pm}$, p and $\bar{p}$ spectra measured in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [4]. In this analysis are reported the p_T distributions of primary particles, *i.e.* produced directly in the collision or in the decay of short-lived resonances and not particles from the weak decay of strange hadrons or from interactions with material. A detailed description of the systematic errors and PID procedure can be found in [4]. In fig. 1 the change of the shape of p_T distributions as a function of centrality is clear. Kaons and (anti)protons show a significant flattening with increasing centrality, the effect being stronger for protons. That is an indication of a stronger radial flow, which increases with centrality. At low p_T the pion spectrum is steeper, due to the large contribution of resonance decays. p_T distributions are well described by the blast-wave model [5], that allows to extract the kinetic freeze-out pa-

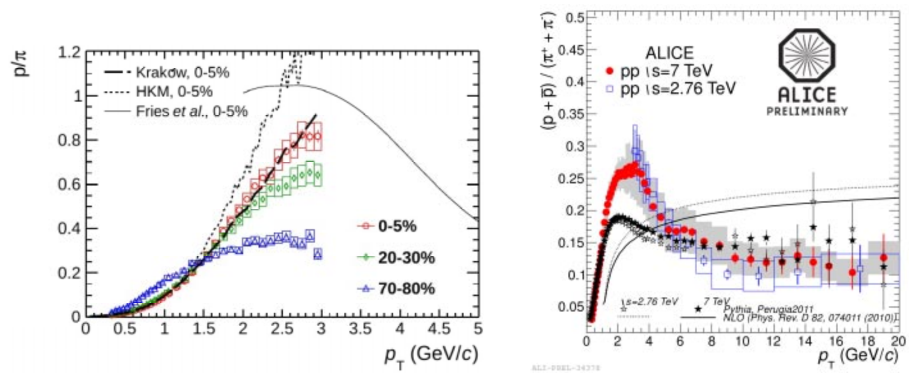

Fig. 2. – Left: p/π ratio as a function of in different centrality bins compared with the HKM, Krakòv and recombination models, in Pb-Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV [4]. Right: p/π production ratio in p-p collisions compared with PYTHIA Monte Carlo predictions and NLO calculations.

rameters by a combined fit of π, K and p spectra. The horizontal bars on top of spectra in fig. 1 show the range used for each particle species in the blast wave combined fit. For central collisions (0–5%), a collective radial flow velocity $\langle \beta_{\rm T} \rangle = 0.651 \pm 0.004 \pm 0.020$ is observed, about 10% higher than at RHIC (Au-Au collisions at $\sqrt{s_{\rm NN}} = 200\,{\rm GeV}$ [6]), while the kinetic freeze-out temperature $T_{kin} = 0.95 \pm 0.004 \pm 0.010\,{\rm GeV}/c$ is compatible with RHIC.

The proton-to-pion ratio as a function of $p_{\rm T}$ is shown in fig. 2. On the right panel, the p/π ratio measured in Pb-Pb at $\sqrt{s_{\rm NN}} = 2.76\,{\rm TeV}$ is presented [4]. The ratio increases with centrality at intermediate $p_{\rm T}$, reaching the value of about 0.9 at $p_{\rm T} = 3\,{\rm GeV}/c$. A similar behaviour of baryon to meson ratio has been already seen at RHIC [7]. The contribution of both coalescence and radial flow could explain the observed $p_{\rm T}$ dependence of the ratio [8]. The picture shows also the predictions of HKM [9] and the Krakòv [10] hydrodynamical models and the prediction from a recombination model [11]. HKM reproduces the ratio up to $1.5\,{\rm GeV}/c$, while the Krakòv model reproduces correctly the behaviour in the 0–5% centrality bin. The recombination prediction overestimate the measured ratio. On the left panel, the p/π ratio, measured in p-p collisions, $\sqrt{s} = 2.76\,{\rm TeV}$ and $7\,{\rm TeV}$, is compared with theoretical model predictions. No energy dependence is observed within the systematic uncertainties. The baryon to meson ratio exhibits a maximum around $p_{\rm T} = 3\,{\rm GeV}/c$ and then decreases. A similar behaviour has been observed in Pb-Pb collisions [12].

3. – Conclusions

We presented charged hadron transverse momentum distributions measured by the ALICE experiment, from the analysis of p-p and Pb-Pb collisions. The invariant yield of charged pions, kaons and protons, as a function of $p_{\rm T}$ strongly depends on event centrality in Pb-Pb collisions, showing, in the low $p_{\rm T}$ region, a flattening behaviour, compatible with a stronger radial flow than previously measured at RHIC.

Proton proton results does not show, above $p_{\rm T} \sim 3\,{\rm GeV}/c$, an evident $\sqrt{s}$ dependence in the p/π ratio. Current tunes of Monte Carlo generators cannot reproduce the data. PYTHIA qualitatively reproduces data, the small enhancement is due to color reconnection manifested as flow-like [13]. In Pb-Pb data an enhancement of the baryon-to-meson ratio is observed at intermediate $p_{\rm T}$, as a function of centrality.

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