CHARGED PION IDENTIFICATION AT HIGH p_{T} IN ALICE USING THE TPC dE/dx*

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The ALICE TPC provides excellent charged particle tracking to study *pp* and Pb–Pb collisions at LHC. The TPC allows also particle identification (PID) via the measurement of the specific ionisation dE/dx. At high p_{T} ($p_{\mathrm{T}} > 3$ GeV/c) this is accomplished in the region of the relativistic rise of the energy loss, and provides a measurement of the yields of charged pions, kaons, and protons. Here, we present the performance of such an analysis in *pp* collisions at 7 TeV for charged pions up to 10 GeV/c. On the relativistic rise, statistical PID can be used to evaluate the yields for pions, protons and kaons for $p_{\mathrm{T}} > 3$ GeV/c. Here, we show first performance results from such an analysis for charged pions up to 10 GeV/c.

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1. Introduction

The ALICE Time Projection Chamber (TPC) is the main tracking detector in the central region ($|\eta| < 0.9$) of the ALICE heavy ion experiment at the LHC [1]. In addition to excellent tracking performance, the TPC has particle identification (PID) capabilities through the measurement of specific ionisation (dE/dx). This is of particular interest in the region of the relativistic rise of the Bethe–Bloch curves, *i.e.* at $p_{\mathrm{T}} > 3$ GeV/c, where other ALICE detectors have little or no PID capabilities for charged pions, kaons, and protons. The STAR experiment at RHIC has successfully used TPC PID in the relativistic rise region in both $p+p$ and $\mathrm{Au}+\mathrm{Au}$ collisions to measure important features of heavy ion collisions in the regime of intermediate and high p_{T} [2, 3], such as kinetic energy and valence quark scaling of the elliptic flow and the anomalous proton to pion ratio [3, 4]. These results have given rise to speculations that hadronisation at intermediate

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p_T might be due to recombination of lower momentum "constituent quark like" degrees of freedom rather than fragmentation of high momentum partons [5]. At LHC energies recombination might result in even larger p/π ratios in the momentum interval $p_{\mathrm{T}} = 10$–20 GeV/c [6] because of the larger jet cross-section.

Recently, the ALICE Collaboration has published first results from Pb–Pb collisions at $\sqrt{s_{NN}} = 2.76$ TeV on elliptic flow of unidentified charged particles [7], and the nuclear modification factor at LHC for unidentified charged hadrons [8]. In this article the method is presented which allows to extend these results to charged pions, kaons, and protons based on dE/dx measurements in the relativistic rise region, and the present performance in pp collisions at 7 TeV is discussed.

2. ALICE TPC performance

The ALICE TPC is composed of a cylindrical gas volume, divided into two half volumes of equal size, separated by a 30 μm thick central HV electrode at -100 kV which generates a drift field of 400 V/cm. The field cage has an inner radius of about 80 cm, and an outer radius of about 280 cm, with an overall length of 500 cm in the beam direction. At both ends of the TPC, multi-wire proportional chambers (MWPC) are mounted into two end plates with 18 trapezoidal sectors each. The MWPCs have highly segmented pad readout with a total of about 560,000 pads, optimised for tracking in the high multiplicity environment of central heavy ion collisions at LHC. The front end electronics are equipped with on-board digital filters to allow baseline restoration and cancellation of the signal tails due to ion drift.

Each particle track can have up to 159 individual ionisation measurements in the TPC. The so-called TPC signal is determined as the truncated mean of the 60% lowest hit charges associated with the track. The TPC signal determined in this way is related to the most probable energy deposit and yields a much better estimate of the dE/dx than the mean value, which is influenced by large ionisation deposits in the Landau tail.

The calibration of the TPC signal (readout chambers and electronics) has been carried out by injecting radioactive Krypton in the TPC gas and inspecting the signal amplitudes resulting from the decays [1]. The dE/dx resolution ($\sigma_{dE/dx}/dE/dx$) after gain calibration was measured to be better than 5% for full length tracks which is better than the design value of 5.5%. The TPC signal distribution as a function of the particle momentum p in pp collisions at 7 TeV is shown in Fig. 1.

The p_{T} resolution $\Delta(p_{\mathrm{T}})/p_{\mathrm{T}}$ of the TPC was measured using cosmic muons by matching the upper and lower halves of tracks crossing the whole TPC (see Fig. 2). At the present level of the calibration, the p_{T} resolution $\Delta(p_{\mathrm{T}})/p_{\mathrm{T}}$ is 7% at 10 GeV/c.

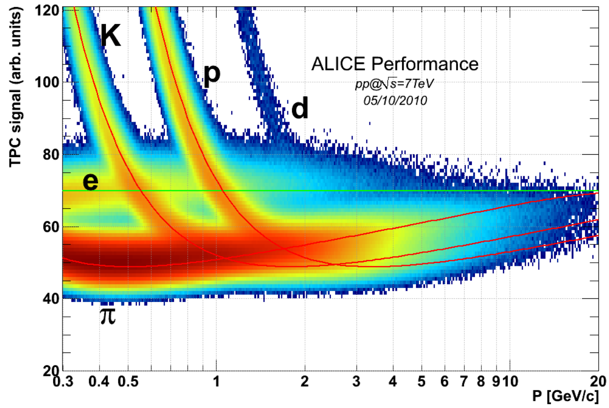

Fig. 1. TPC signal as a function of momentum in pp collisions at 7 TeV.

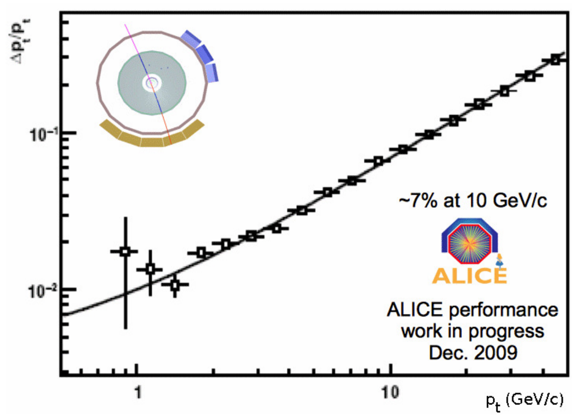

Fig. 2. Transverse momentum resolution as a function of transverse momentum measured by matching cosmic tracks corresponding to the same muon in the two halves of the TPC.

3. Analysis method

In this study we use the same event and track selections as for the analysis of the unidentified charged hadron p_{T} spectra [9]. Additionally, a track selection based on the azimuthal angle ϕ is applied to remove tracks which pass through the insensitive regions between the read-out chambers, which have a smaller number of ionisation measurements and thus a worse dE/dx resolution.

The challenge of using the TPC signal on the relativistic rise is that the TPC signal distributions of different particle species partially overlap, so that the particle yields have to be extracted statistically, *i.e.* from a fit to the TPC signal distribution. The TPC signal in a narrow momentum interval can be fit with a sum of four Gaussians (π, K, p and e) with a total of twelve parameters: four amplitudes, four mean positions, and four widths. The main challenge of the analysis is therefore to constrain as many parameters as possible. To this end we parametrise the resolution $\sigma_{dE/dx}$ and constrain the mean values by employing the dependence on $\beta\gamma$ of the energy loss curve. In this way the mean value and the width of each Gaussian can be constrained, *i.e.* nine of the twelve parameters can be fixed [10].

The resolution $\sigma_{dE/dx}$ is extrapolated using a clean sample of pions in the region of minimum ionisation (MIP) and depends on the number of hits in the track. The mean values are obtained from fits to the data with a Bethe–Bloch like parametrisation in the following way: The distribution of TPC signals is fitted in bins of p with three Gaussian functions, where the amplitudes are free parameters, the widths are fixed to the resolution, and the mean values have to follow the parametrised Bethe–Bloch function for the $\beta\gamma$ corresponding respectively to pion, proton and kaon masses. For particle identification we subtract from the measured TPC signal the mean values for pions obtained from the fits. We call this difference Δ_π. This first step is done using intervals in p which are relevant for the parametrisation, the following steps are performed in intervals of $p_{\rm T}$.

The Δ_π distributions are finally fitted in different bins of $p_{\rm T}$ with the sum of four Gaussians where σ and mean are constrained within 5% of the values calculated above for the pions, kaons and protons, and extrapolated from low $p_{\rm T}$ regions for electrons. Examples of such fits are shown in Fig. 3. The pion peak is centred close to $\Delta_\pi = 0$, and the width is compatible with the determined resolution function used for the fit.

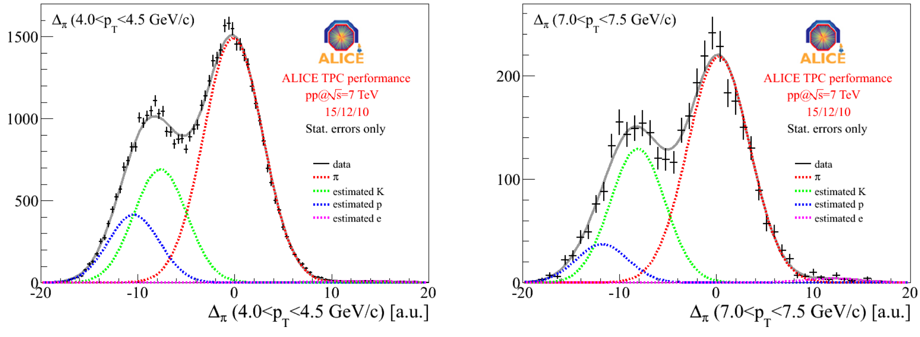

Fig. 3. Examples of dE/dx distributions in two $p_{\rm T}$ bins. The distribution is fitted with a sum of 4 Gaussians for pions, protons, kaons and electrons. The electron contribution is very small and barely visible under the right tail of the pions distributions.

4. Performance of the dE/dx analysis

The fits explained above give a good estimate of the pion yield for different $p_{\rm T}$ values. The smaller difference in inverse mass (and therefore $\beta\gamma$ at fixed p) between kaons and protons makes the separation between these two species more difficult, and a better understanding of the constraints is required to get the yield for these particles.

The fit results are first tested for consistency by checking that the ratio between positive and negative pions is close to unity as expected. The plot shown in Fig. 4 confirms this consistency.

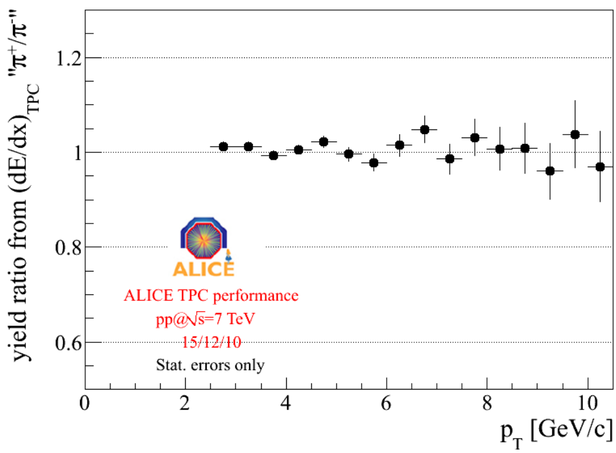

Fig. 4. Ratio of the yield obtained for π^+ and π^-. The value is around unity, as expected, which confirms the consistency of the method.

The resulting fraction of pions among the charged particles is shown on Fig. 5. The ratio shown here does not include any correction for secondary particles and decays. Figure 6 shows the yields *versus* $p_{\rm T}$ without any normalisation and corrections.

5. Conclusion

We presented the performance of the ALICE TPC for charged pion identification at high $p_{\rm T}$, employing dE/dx measurements in the relativistic rise region. The results demonstrate the capability to study pion production at large transverse momenta, which is of particular interest in heavy-ion collisions. Increased statistics will allow to extend the study to even higher $p_{\rm T}$.

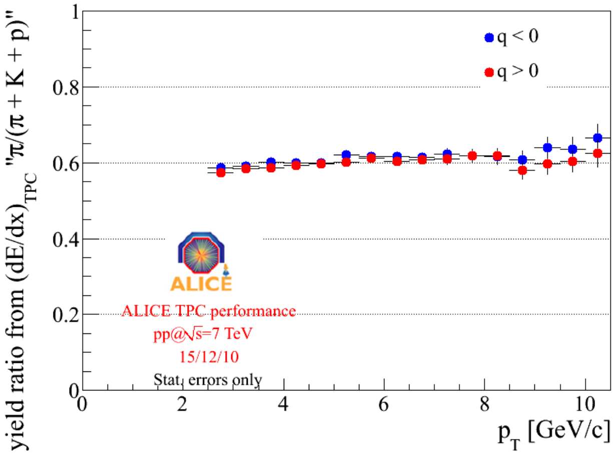

Fig. 5. Estimated fraction of π^+ (resp. π^-) among the positive (resp. negative) hadrons. The data represent the results from the fits to the Δ_π distributions without further corrections.

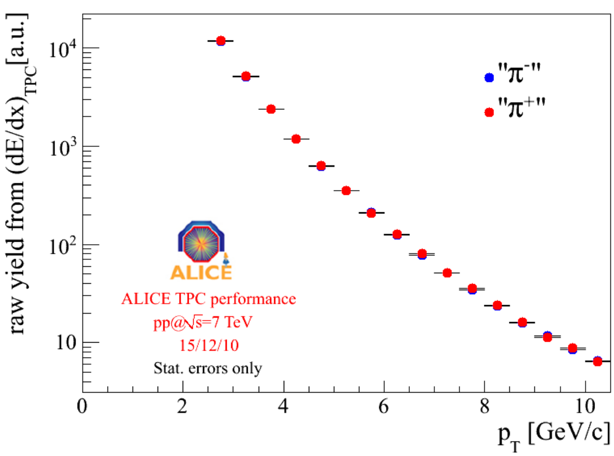

Fig. 6. Uncorrected yields for π^+ and π^- from the fits to the Δ_π distributions.

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