Momentum spectra of identified particles in pp collisions with the ALICE detector

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The performance of the ALICE detector for charged hadrons identification turned out to be effective immediately after the start of the first pp collisions. The central barrel detectors (ITS, TPC and TOF) have provided $\pi$, $K$, $p$ identification in a wide range of momenta. The ALICE detector was designed to perform such a study in a very efficient way by using the energy-loss dependence in the lower $p_T$ region (with the ITS and the TPC) and the time-of-flight measurement in the higher $p_T$ region (with the TOF). The capability to reconstruct a wide set of particles is also shown.

1 Introduction

The study presented here is based on the excellent capability of the ALICE detector in particle identification. The Time-Projection Chamber (TPC), the main tracking system, provides $dE/dx$ information in a momentum range limited by the absorption in the material closer to the collision zone and by the crossing of the $dE/dx$ curves to high momenta. The $dE/dx$ information from the Inner Tracking System (ITS) allows us to extend the limits towards lower momenta, while the additional information in the Time-Of-Flight detector (TOF) makes the identification possible up to 2.5 GeV/c.

The ALICE detector is a dedicated heavy ion experiment, designed to cope with the high particle multiplicities expected for central $Pb$–$Pb$ collisions at $\sqrt{s} = 5.5$ TeV. The central barrel (midrapidity) detectors of ALICE consist of a six-layer silicon detector (ITS), located at 3.9 - 48.9 cm from the beam axis, a Time Projection Chamber (TPC) at 85 - 250 cm, a Transition Radiation Detector (TRD) for electron identification at 290 - 368 cm (not presented in this analysis), and a Time-Of-Flight (TOF) detector at 370 - 399 cm. The detectors are sitting in a solenoidal magnetic field of $B = 0.5$ T with a rapidity coverage of $-0.9 < \eta < 0.9$. The experiment setup and the expected performance are described in detail in and respectively.

The results presented in this article are based on the analysis of charged particle tracks in the ITS, TPC and TOF.

The data presented were collected during the commissioning of the LHC at CERN in the fall of 2009 with pp collisions. The energy of each beam was 450 GeV (i.e. injection energy). The collider was run with $4 \times 4$ bunches per beam, resulting in two bunch crossing (BC) per beam circulation period (89 $\mu$s) at the ALICE interaction point. The remaining two bunches were passing through the ALICE detector and served to estimate the contribution of beam-gas interactions. The average rate was a few events per second and pile-up within one bunch crossing was, therefore, negligible.

Moreover, the ITS capability in reconstructing secondary vertex allowed us to identify un-
stable particles like $K^0_s$, $Λ$ and $Ξ$ in the first collisions at 900 GeV.

2 Particle identification performance

As mentioned before the PID (Particle IDentification) performance is very good in a wide range of momenta. Combining the information of the three detectors is possible to cover a range from 0.1 GeV/c to 2.5 GeV/c. The ITS dE/dx covers the range at very low momenta ($0.1 < p < 0.5$ GeV/c), the TPC dE/dx is good at intermediate momenta ($0.3 < p < 1$ GeV/c) and the TOF is ideal for high momenta ($0.5 < p < 2.5$ GeV/c). A summary of the performance is reported in Fig. 1, where dE/dx vs. momentum (ITS and TPC) and $β$ vs. momentum (TOF) plots are shown. In the same figure is also reported a sketch with the detector momentum ranges and the complementarity of the three detectors can be noted.

Figure 1: dE/dx vs momentum and $β$ vs. momentum for the ALICE subdetectors (top: ITS and TPC, bottom: TOF) in the central barrel ($|η| < 0.9$). A sketch on the performance of combined Particle IDentification (PID) is also shown.

A more detailed picture is given in Fig. 2, Fig. 3 and Fig. 4 where fits to the different detector response functions were performed in order to extract the yields in different $p_T$ slices. In order to improve the particle identification with TOF a proper variable was chosen to guarantee the gaussian response, especially for the pion and kaon cases. In fact the variable $(t^π + t^K)_{calc}/2 - t_{TOF}$ is a good compromise to realize a symmetric behaviour for pions and kaons; where $t^π_{calc}$ and $t^K_{calc}$ are the expected times for pion and kaon hypotheses and $t_{TOF}$ is the time measured by TOF.

These plots represent the main way to extracts yields for different particle species and so to measure identified particle spectra in the first $pp$ collisions at 900 GeV with the ALICE detector. These preliminary results are very promising so that the final identified spectra will be published very soon in a future article.
Another topic of this work is the measurement of resonances and weak decaying particles. Some of the first observations of ALICE were the $K_0^*$ and $\Lambda$ particle using the secondary vertex reconstruction. Some results are reported in Fig. 5 which show the good capability of the Inner Tracking System in resolving these signals from the combinatorial background.

Moreover the PID in the central barrel allowed us to reconstruct several resonances decaying in the kaon channel. In particular $\phi$ and $K^{*0}$ mesons were identified using the TPC and TOF response.

In Fig. 6 the results for TOF stand alone analysis are reported for both of these resonances.
The requirement of the TOF identification selects the transverse momentum region above 1 GeV/c for both decay channels.

4 Conclusion

The ALICE performance for particle identification has been shown in this work. It is quite good also considering that it was obtained for the very first pp collision in 2009 ($\sqrt{s} = 900$ GeV).

It was shown how the several subdetectors (ITS, TPC and TOF) at midrapidity allow to perform the measurement for identified particle spectra in a wide $p_T$-region and in a complementary way, even if final results will be available in a future work.

The PID performance can be also used to identify several particles in a number of different channels, taking advantage both from the secondary vertex reconstrucion in the ITS and from the good K/$\pi$ separation up to high momenta.

References