Operation and performance of the ALICE Time Projection Chamber, a high-resolution detector for the highest particle multiplicities*

C. Lippmann[1] *and J. Thäder*[1] *for the ALICE Collaboration*

[1]ExtreMe Matter Institute EMMI and Research Division, GSI Helmhotzzentrum für Schwerionenforschung, Darmstadt, Germany

Introduction

The unique feature of ALICE [1], the general-purpose heavy-ion experiment at the LHC, is the optimization of the detector for the reconstruction and identification of particles over a broad momentum range and in an environment with the highest particle multiplicities. Using a large cylindrical Time Projection Chamber (TPC) [2] embedded in a solenoid magnet with a magnetic field of 0.5 T as the main element, ALICE is able to provide precision tracking and particle identification (PID) from 100 MeV/c to 50 GeV/c.

Running Conditions

During 2012 the LHC was performing outstandingly well. ALICE and the TPC were in continuous data taking mode, while the LHC delivered collisions of protons at high luminosity ($\sim 10^{31}\mathrm{cm}^{-2}\mathrm{s}^{-1}$). Compared to the other LHC experiments the luminosity in ALICE was limited by using special filling schemes, where some of the up to 1,368 main bunches per ring collide with the much less populated satellite bunches in the interaction region of ALICE. However, this scheme made the experiment quite sensitive to vacuum problems, which increase the rate of background events to a level that reached a significant fraction of the total event rate. Instabilities of the TPC readout chambers had already been an issue in the previous years (in particular in the 2011 Pb-Pb run) and were coped with by removing the high voltage capacitors from all TPC readout chambers in 2011 and by investing in higher performance high voltage power supplies in the beginning of 2012.

Performance

Fig. 1 shows the relative momentum resolution $\sigma(p_\mathrm{T})/p_\mathrm{T}$ as a function of the transverse momentum p_T. p_T is reconstructed from the track curvature, measured in the magnetic field, and combines the information from the TPC and from the silicon Inner Tracking System (ITS). At low momentum $\sigma(p_\mathrm{T})/p_\mathrm{T}$ is dominated by multiple scattering, but stays at only ∼1% at $p_\mathrm{T} \approx 1$ GeV/c, thanks to the small material budget (10% of a radiation length between the vertex and the outer wall of the TPC). At higher momenta the resolution increases linearly and reaches ∼10% at $p_\mathrm{T} = 50$ GeV/c for the data sample used here.

Charged particles are identified in the TPC in a broad momentum range. The PID in the TPC is based on the measurement of the momentum and the specific energy loss per unit path length $\mathrm{d}E/\mathrm{d}x$. For a particle with a given momentum $\mathrm{d}E/\mathrm{d}x$ depends only on its charge and mass.

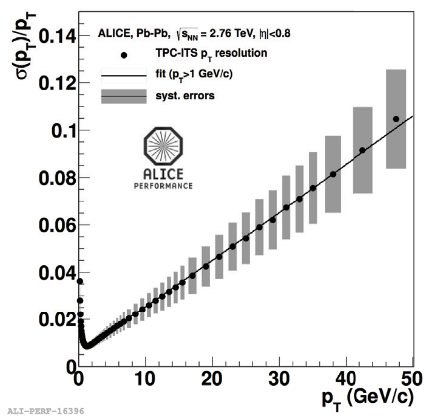

Figure 1: The relative p_T resolution $\sigma(p_\mathrm{T})/p_\mathrm{T}$ as a function of p_T for combined tracking in TPC and ITS.

The functional dependence of the specific energy loss on particle momenta is shown as lines together with data for negatively charged particles in Fig. 2. The particle separation capabilities are excellent; the method even allows for the observation of rare (with charge $|z| > 1$) anti-nuclei (these particles were enhanced in the data sample used for Fig. 2 by the use of an offline trigger).

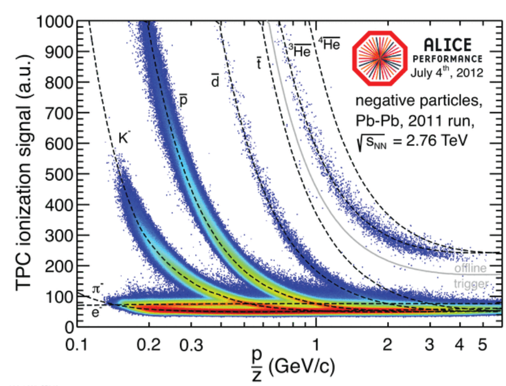

Figure 2: The TPC $\mathrm{d}E/\mathrm{d}x$ vs p/z in Pb–Pb collisions at $\sqrt{s_\mathrm{NN}} = 2.76$ TeV, highlighting the PID performance.

The TPC shows excellent performance. After the PbPb runs of November 2010 and 2011 the next highlight and milestone is the pPb run that is set to take place in January and February 2013. After the two-year LHC shutdown, where the LHC and the experiments will be consolidated, further Pb-Pb runs at nominal LHC energy are foreseen.

References

[1] K. Aamodt et al. (ALICE Collaboration), JINST 3 (2008) S08002.
[2] J. Alme et al., Nucl. Instr. Meth. A 622 (2010) 316.

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