ALICE COMMISSIONING: GETTING READY FOR PHYSICS

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ALICE is a general-purpose heavy-ion detector at the CERN LHC. We describe the commissioning activities in the years 2007-2009 and the status of the different subsystems at the time of this conference.

1 Introduction

ALICE (A Large Ion Collider Experiment) is the dedicated heavy-ion experiment at the Large Hadron Collider (LHC) in Geneva. It is designed to study the physics of strongly interacting matter at extreme energy densities by analysing the collisions of lead nuclei at $\sqrt{s} = 5.5$ TeV per nucleon pair, using as probes the hadrons, electrons, muons and photons that are produced in the collisions. ALICE must offer excellent particle identification (PID) in a large momentum range. As compared to proton collisions at the LHC, the charged track multiplicities will be extraordinary for the lead collisions but the momenta of the produced particles will be rather low. As a consequence, precision tracking capabilities over a large momentum range ($100 \text{MeV}/c < p < 100 \text{GeV}/c$), a low material budget and a rather low magnetic field are required. A very high granularity detector was chosen, which is however—at least when compared to the other large LHC experiments—limited in readout speed.

2 ALICE Commissioning in 2007-2009

The installation and commissioning of ALICE subdetectors continued well into the year 2008. Two global runs were organised in late 2007 and in early 2008 in order to integrate the individual subdetectors in the global experiment control system. From May to October 2008 the third global run took place, including 24 hour operation over many months, and calibration data taking for the various subdetectors. In this period, the first particles from the LHC reached the experiment on 15th June. During the LHC injection tests on 8th and 24th August the first beam-related events were seen in ALICE. The third global run then started on 5th May 2008. It was intended to converge into data taking with beam collisions, and on 10th September the first beams were actually circulated in the LHC. Unfortunately, on 19th September a serious fault damaged a number of LHC magnets and the beams stopped. The data taking however continued until 20th October with calibration triggers. The LHC will not see beam again before September 2009.

The resulting extended shutdown period is used for installation of more detector modules (TRD, PHOS and EMCAL, see below), and for upgrades and maintenance.

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*ALICE was optimised for a charged-track multiplicity $dN_{ch}/d\eta \leq 8000$.

The magnetic field of the ALICE solenoid magnet (L3) will be in the range $0.2 \text{T} \leq B \leq 0.5 \text{T}$.
3 ALICE Experimental Setup and Status of the Subdetectors

ALICE consists of a central barrel part for the measurement of hadrons, leptons and photons, and a forward muon spectrometer. The central part is embedded in a large solenoid magnet that is reused from the L3 experiment at LEP. More detailed descriptions of the detector systems can be found elsewhere. Their status at the time of this conference (March 2009) is described in the following.

3.1 ITS

The Inner Tracking System consists of three different silicon detector technologies with two layers each: High resolution silicon pixel (SPD), drift (SDD) and strip (SSD) detectors. The system is fully installed and commissioned. In general, the whole ITS was recording data during the LHC injection tests in August 2008 and during the first beam circulations. Preliminary results of the internal SPD alignment based on a sample of cosmic tracks and a beam induced event display are shown in Fig. 1. The achieved performance compares well to simulations; with the residual misalignment the design value for the primary vertex resolution (100 µm for proton collisions) is expected to be reached.

The SPD can provide a trigger decision at the first level. Each of the 1200 pixel chips transmits a digital pulse, when one or more of the pixels in the matrix are hit. Different simple and fast algorithms can be used to provide triggers based on multiplicities. ALICE is the only LHC experiment including the vertex detector in the first trigger decision from startup.

3.2 TPC

The main tracking detector in the central barrel is the Time Projection Chamber, offering also momentum measurement and PID. Its main advantage is the unequalled granularity (560 Mio pixels). However, some of the requirements are very challenging: The TPC has to cope with very high charged track multiplicities, but it also has to be read out very fast: 1 kHz (a few 100 Hz) for proton (lead) collisions. The TPC was running continuously for many months in 2008 and recorded $60 \times 10^6$ calibration events. The first round of calibrations is completed and reveals a performance already approaching the design values (Fig. 2). Very good temperature homogenisation in the drift volume was achieved, close to the design value ($\Delta T < 0.1$ K).

*This is necessary in order to limit changes in the drift velocity.*
3.3 ACORDE

The Alice COsmic Ray DEtector is an array of plastic scintillator paddles mounted on the L3 magnet. It serves as a cosmic ray trigger at the first trigger level. Only cosmic muons with energies $\geq 10$ GeV reach the ACORDE, at rates $\leq 5$ Hz/m$^2$. The system is fully commissioned and is used heavily in the commissioning of other ALICE detectors.

3.4 Outer Central Detectors

The TRD (Transition Radiation Detector) is not yet fully installed (4 out of 18 TRD modules during 2008). For the run in 2009/2010 up to 8 modules will be installed. The TRD trigger contribution (second level) on high momentum particles was sucessfully used in 2008 (Fig. 3). The TOF (Time Of Flight) implements Multigap Resistive Plate Chambers to obtain a very good system time resolution sufficient to provide PID in the intermediate momentum range. All 18 TOF modules are installed and fully commissioned. During 2008 a system time resolution of 130 ps was achieved in the experiment (Fig. 3). This number has to be compared to a design value of around 100 ps and is expected to improve significantly following more detailed calibrations. The HMPID (High Momentum Particle IDentification) extends the useful PID range ($\pi/K, K/p$). It was the first detector to be installed in the L3 magnet and is fully commissioned. The PHOS (PHOton Spectrometer) provides PID ($\gamma, \pi^0$ and $\eta$) and contributes to the first level trigger decision. One out of 5 modules was installed in 2008. For the run in 2009/2010 up to 3 modules will be installed. The aim of the EMCAL (ElectroMagnetic CALorimeter) is to do high momentum jet physics. The project was approved only in the end of 2007 and up to 4 out of 12 modules will be installed for the run in 2009/2010.

3.5 Muon Spectrometer

The muon spectrometer will study the complete spectrum of heavy quarkonia ($J/\Psi, \Psi'$ and the $\Upsilon$ family) via their decay in the $\mu^+\mu^-$ channel. It consists of 5 tracking stations (2 planes of cathode pad chambers each), 2 trigger stations (2 planes of Resistive Plate Chambers each), a dipole magnet, and two absorbers. It covers the pseudorapidity interval $2.5 \leq \eta \leq 4$ and the whole system is now fully commissioned.

3.6 Forward Detectors

A number of small and specialized detector systems in the forward region are used for triggering or to measure global event characteristics. All of them were already fully installed and
commissioned in 2008.

The FMD (Forward Multiplicity Detector) consists of 3 planes of silicon strip detectors to measure charged particle multiplicities. During the LHC injection tests and beam circulation the FMD was in general recording data and operated as expected at hit densities of 10 to several $10^3$ charged particles per cm$^2$. The T0 detector serves as time reference for TOF ($\sim 30$ ps time resolution) and provides vertex measurement. The V0 detector provides a centrality trigger at the first level, serves as a luminosity monitor and can be used to reject beam-gas events. During the LHC injection tests and beam circulation the V0 was in general recording data and for the beam-induced events clear correlations between the measured signal charge and, e.g. the number of fired chips in the SPD were observed. The ZDC (Zero Degree Calorimeter) is composed of four calorimeters, two each to detect protons and neutrons. They are located 115 meters away from the interaction point on both sides, exactly along the beam line. The PMD (Photon Multiplicity Detector) measures multiplicity and spatial distributions of photons in the forward pseudorapidity region.

4 Summary & Conclusions

Where possible the detector performance was evaluated using cosmic muons and the first few beam particles delivered by the LHC. All installed detectors are fully commissioned and shown to be performing close to their specifications. The current shutdown period is used to install additional detectors.

The ALICE experiment is ready for recording the first proton-proton collisions in the LHC, expected in late 2009, and the collaboration eagerly awaits the first heavy-ion collisions at the end of the upcoming run.

References

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