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THE LASER OF THE ALICE TIME PROJECTION CHAMBER

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The large TPC (95 m^3) of the ALICE detector at the CERN LHC was commissioned in summer 2006. The first tracks were observed both from the cosmic ray muons and from the laser rays injected into the TPC. In this article the basic principles of operating the 266 nm lasers are presented, showing the installation and adjustment of the optical system and describing the control system. To generate the laser tracks, a wide laser beam is split into several hundred narrow beams by fixed micro-mirrors at stable and known positions throughout the TPC. In the drift volume, these narrow beams generate straight tracks at many angles. Here we describe the generation of the first tracks and compare them with simulations.

1. Introduction

The ALICE experiment will study heavy ion collisions at LHC. The main tracking detector of the ALICE experiment is the TPC[1]. The aim of the laser system is to generate straight tracks, similar to ionizing particle tracks, at known positions in the drift volume of the TPC. These tracks are generated by the two-photon ionization of the drift gas by a pulsed UV laser beam with a wavelength of 266 nm. Other electrons are emitted by photoelectric effect when the laser beam hits metallic surfaces such as the central electrode, the aluminized mylar strips of the electric field cage, or wires and pads of the readout system. After readout and track reconstruction using the TPC detector, distorsions related to ExB effects and mechanical misalignment will be measured and corrected using these tracks. The spatial and temporal variations of the drift velocity due to the drift field will be measured within a relative error of 10^{-4} and used as calibration data in the physics analysis.

2. The TPC laser system

The calibration system (Fig. 1) is composed of a static optical system with a few adjustable parts. The static optics is composed of beam splitters, mirrors and bending prisms guiding the laser beam outside the TPC field cage before it enters the

TPC volume. The guiding system ends with cameras that take pictures of the laser beam in order to monitor the position and the beam intensity. The adjustable part is mainly composed of remotely adjustable mirrors that will guide the beam into the static optics system. In order to generate multiple tracks in the TPC, the laser beam goes through several steps. First, a 25mm diameter laser beam is divided, at one end, into 6 by beam splitters before it enters the TPC. Each beam enters the TPC in a hollow rod, goes through the central electrode and, for monitoring purposes is detected by a camera located at the far end of the TPC. In each rod, 4 micro-mirror bundles, placed at fixed positions along the length of the rod, reflect a part of the laser beam into 7 one-millimeter diameter beams (20-40 μJ/pulse) that enter the TPC volume. A second laser generates similar rays in the second half of the TPC. Thus, on the whole 336 laser beams (Fig. 2) are created inside the TPC volume[2].

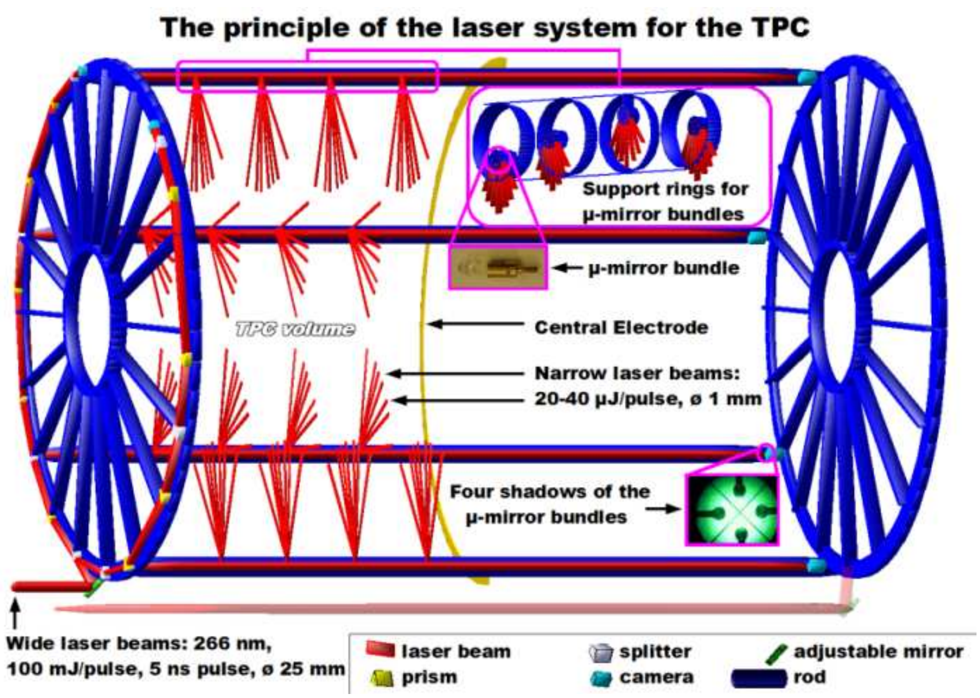

Fig. 1. The principle of the laser system for the TPC. A 25 mm wide and 5 ns long pulse hits an adjustable mirror and is guided inside the TPC. In the laser rode, the beam is split into one-millimeter diameter rays to simulate ionizing particle tracks in the TPC drift volume.

A laser from Spectron Laser Systems Ltd (model SL805-UPG) is set up in the laser hut. A second laser from Ekspla company[3] (model NL313) will be set up in the experimental area. These lasers deliver 266 nm wavelength pulses of 5 ns

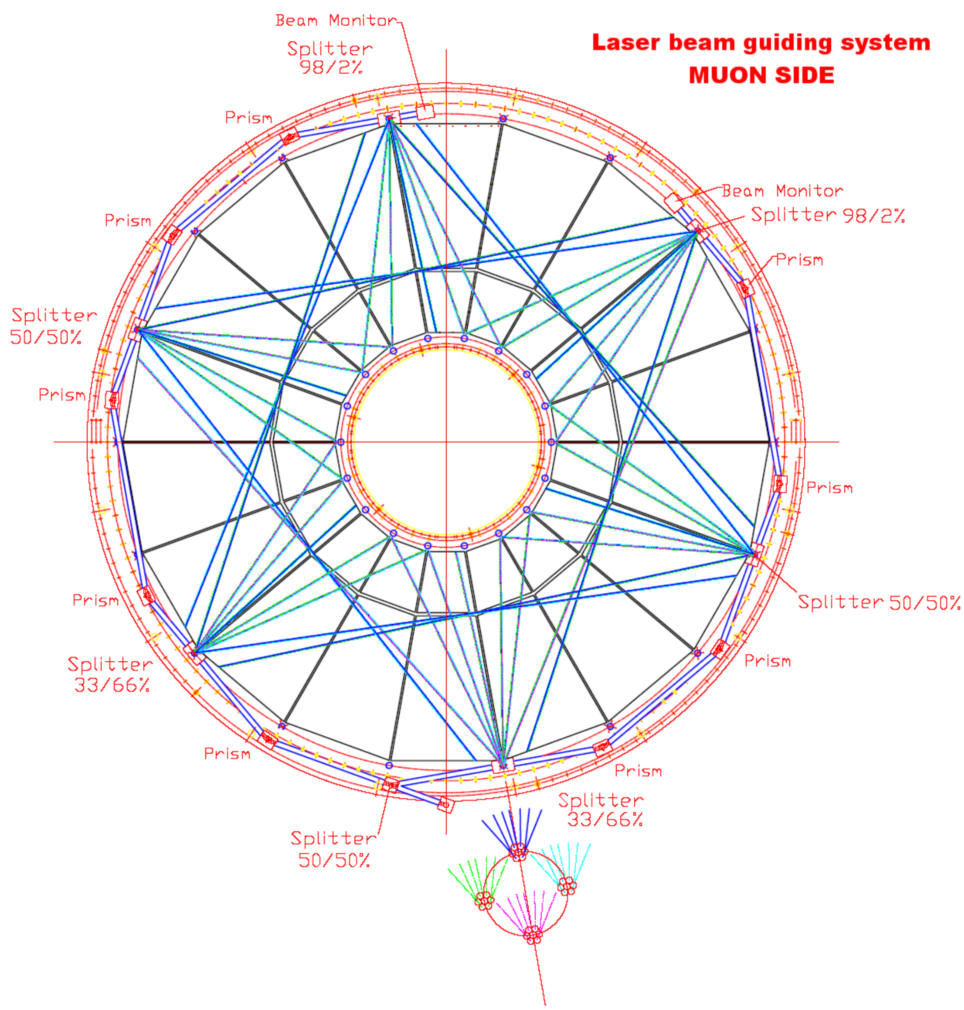

Fig. 2. The design of the laser beam guiding system. In each of the 6 rods, 4 micro-mirror bundles reflect a part of the laser beam into 7 one-millimeter diameter beams that enter the TPC volume.

duration at a repetition rate of 10 Hz and the energy of a pulse is 100 mJ at the entrance of the end cap. Each laser device has two RS232 connections for control and monitoring purposes. They are converted into a TCP/IP connection with an interface from Digi International[4] company in order to be able to control the lasers over long distances. Each laser is controled by C++ serial port drivers included in two separate DIM[5] servers running on Windows XP. The servers communicate with DIM clients included in the user interfaces. The two lasers can be used in parallel, one for each end cap, or one for both end caps, the other one being kept as a backup [2,6].

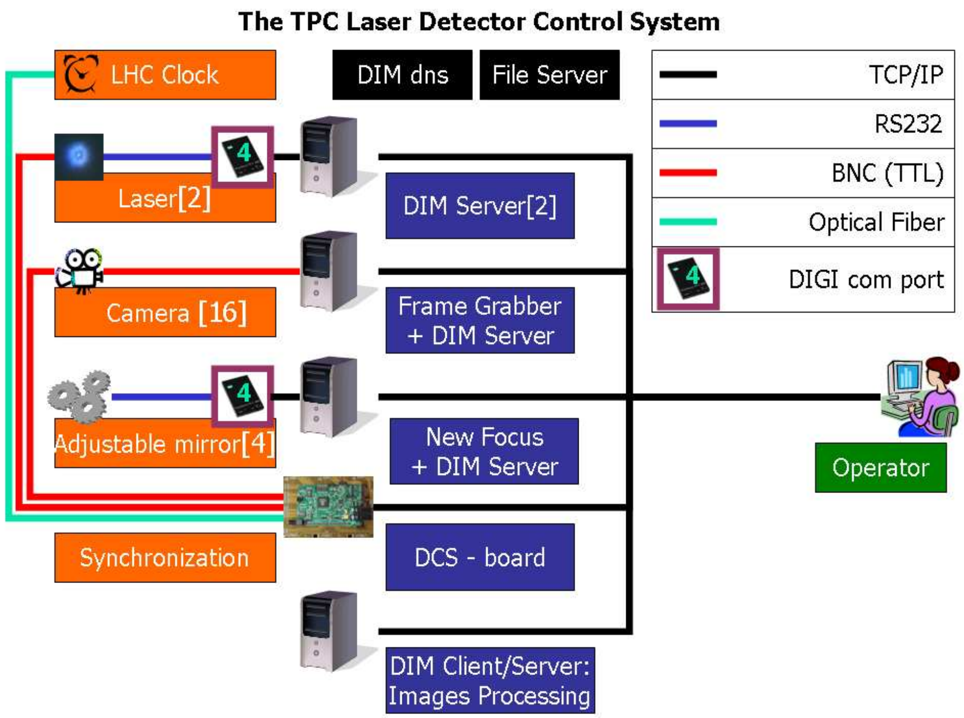

Fig. 3. The overview of the TPC Laser Detector Control System.

Two adjustable mirrors are used to align the laser beam in the guiding system on the TPC endplates. They are controlled by New Focus[7] pico-motors. All pico-motors are controlled by C++ serial port drivers included in a DIM server. The RS232 communication protocol is converted into TCP/IP, with an interface from Digi International[4] company, to be able to control the pico-motors over long distances.

Cameras (up to 16) will monitor the laser beams. At each end cap one camera is placed behind the movable mirror. Two others can be placed at the end of the two 180° bends. Moreover, 12 extra cameras are at the end of each rod. All these cameras will take pictures of the laser beam in order to monitor its intensity and its position. Images are acquired with a frame grabber card (and an extension card) from Imaging Development Systems[8] (IDS), model FALCON-quattro.

An electronic board will synchronize laser pulses and cameras with the LHC clock. This board was developed for the Detector Control System of the TPC and TRD detector in ALICE[1,9].

3. The control system

The TPC laser Detector Control System (Fig. 3) is used to control and monitor the laser beams from the control room while sending pulses through the ALICE TPC. Images of the laser spots recorded by cameras will be processed in order to move adjustable mirrors to align laser beams inside the rods. The DCS board will be configured to synchronize the laser pulse emission and the image capture (by cameras and frame grabber cards) with the LHC clock. All sub-systems are controlled by a common Supervisory Control And Data Acquisition (PVSS, Process Visualization and Steering System[10] from ETM Professional Control company) inside the Joint Controls Project framework[11], giving a stable user interface.

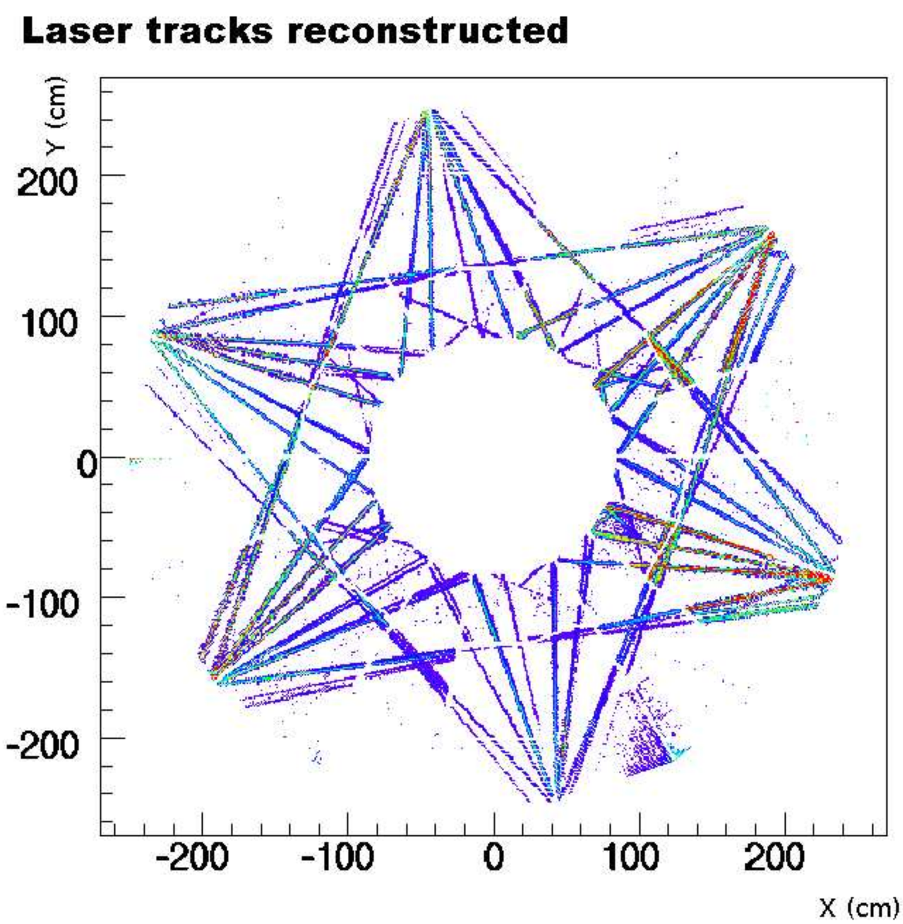

Fig. 4. The laser tracks reconstructed in the side A of the TPC.

4. The data analysis

The TPC reconstruction software was tested and optimized on simulated laser events, where the straight laser tracks in the TPC detector were approximated by high transverse momentum muons emitted from the micro-mirrors, using the AliRoot[12] framework. The reconstruction algorithms of the TPC tracks were used to reconstruct the simulated muons. Last summer, data was recorded in two opposite sectors at the same time during the TPC commissioning. While the data analysis is still going on, preliminary results on the reconstructed laser tracks (Fig. 4) are in agreement with the simulated tracks.

5. Conclusion

The ALICE TPC has been commissioned with both cosmic muon tracks and straight track events generated by the laser system. Further data analysis will make it possible to study and correct for chamber alignment and drift distortion effects before the installation of the TPC in the ALICE experiment. A second laser and the full Detector Control System will be installed in the next months and will be used to monitor and correct distortions for the duration of the ALICE experiment.

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