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The TOTEM detector at LHC

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ABSTRACT

The TOTEM experiment, small in size compared to the others at the LHC, is dedicated to the measurement of the total proton–proton cross-sections with a luminosity-independent method and to the study of elastic and diffractive scattering at the LHC. To achieve optimum forward coverage for charged particles emitted by the pp collisions in the IP5 interaction point, two tracking telescopes, T1 and T2, will be installed on each side in the pseudo-rapidity region between 3.1 and 6.5, and Roman Pot stations will be placed at distances of 147 and 220 m from IP5. The telescope closest to the interaction point (T1, centred at z=9 m) consists of Cathode Strip Chambers (CSC), while the second one (T2, centred at 13.5 m), makes use of Gas Electron Multipliers (GEM). The proton detectors in the Roman Pots are silicon devices designed by TOTEM with the specific objective of reducing down to a few tens of microns the insensitive area at the edge. High efficiency as close as possible to the physical detector boundary is an essential feature. It maximizes the experimental acceptance for protons scattered elastically or interactively at polar angles down to a few micro-radians at IP5. To measure protons at the lowest possible emission angles, special beam optics have been conceived to optimize proton detection in terms of acceptance and resolution. The read-out of all TOTEM subsystems is based on the custom-developed digital VFAT chip with trigger capability.

1. Introduction

The Totem Experiment will measure the total pp cross-section and study elastic scattering and diffractive dissociation at LHC [1,2]. The experimental apparatus is placed symmetrically with respect to the Interaction Point 5 (IP5) and the CMS experiment. Two tracking telescopes, T1 and T2, will measure the inelastic interactions in the forward region covering an adequate acceptance over a rapidity interval of $3.1 \leq \eta \leq 6.5$, with T1 placed between two conical surfaces, the beam pipe and the inner envelope of the flux return yoke of the CMS end-cap, at a distance between 7.5 and 10.5 m from the IP5, and T2 installed in the

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forward shielding of CMS, between the vacuum chamber and the inner shielding of the HF calorimeter. The measurement of $d\sigma_{el}/dt$ down to $-t = 10^{-3}\,\mathrm{GeV}^2$ is accomplished by silicon detectors placed in Roman Pots located at 147 and 220 m from IP5. Since the beam of the LHC is rather thin, with a 10 σ envelope of about 1 mm at large β^* values, the detectors in the Roman Pot must have a very small dead zone at the mechanical edge facing the beam. In the following paragraphs, the single detectors will be described and their status revised.

2. The inelastic telescopes T1 and T2

The T1 and T2 telescopes will be employed to trigger and partially reconstruct inelastic events. Together they must provide a fully inclusive trigger for diffractive events and enable the reconstruction of the vertex of an event, in order to disentangle beam–beam events from the background. Each Telescope is made of two arms, symmetrically placed with respect to IP5.

Each arm of T1 is composed of five planes of Cathode Strip Chambers, with six chambers per plane covering roughly a region of 60° in φ. It is split in two halves and mounted on two different supports. A picture of one half of a T1 arm is shown in Fig. 1.

In each chamber, the readout strips of the two cathode planes are oriented $\pm 60^\circ$ with respect to the anode wires. This allows the measurement of three coordinates for each particle track, which significantly helps in resolving multiple events. To improve pattern recognition, the planes are rotated at 3° with respect to one another.

The production of the CSCs with its readout cards and the support structure has been completed and qualified and the system is under test for data taking with cosmic rays. T1 will be inserted in the CMS end-caps in September 2009.

The T2 telescopes are made of triple Gas Electron Multipliers (GEM) [3]. GEMs are gas-filled detectors that have the advantageous decoupling of the charge amplification structure from the charge collection and readout structure. Furthermore, they combine good spatial resolution with very high rate capability and a good resistance to radiation. The two arms of the T2 telescope are placed, on each side, at 13.5 m away from the IP5. Each arm is made of two sets of 10 aligned detector planes with almost semicircular shape, mounted on each side of the vacuum pipe. To avoid efficiency losses on the boundaries, the angular coverage of each half plane is more than 180°. The readout of these half planes made of triple GEMs has two separate layers with different patterns: one with 256 concentric rings, 80 μm wide and with a pitch of 400 μm, providing the radial coordinates of traversing tracks with a good precision, and the other, with a matrix of 1650 pads varying in size from $2 \times 2\,\mathrm{mm}^2$ to $7 \times 7\,\mathrm{mm}^2$, used for triggering. A GEM chamber is shown in Fig. 2.

Both arms of T2 have been installed in their final placement. A picture of one T2 arm during the installation, right before the insertion in the CMS HF calorimeter, is shown in Fig. 3.

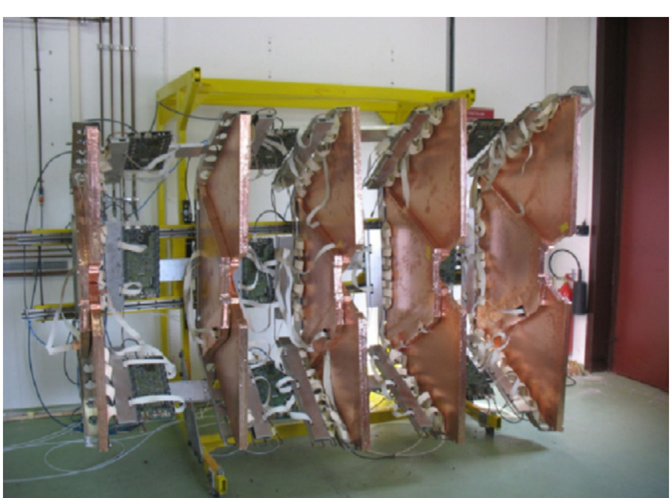

Fig. 1. One quarter of the T1 Telescope mounted on its support structure.

Fig. 2. GEM chamber assembled with its horseshoe shaped readout card.

Fig. 3. One arm of the T2 Telescope just before the insertion in the CMS HF calorimeter.