Chapter 1

Introduction

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The TOTEM experiment [1] — small in size compared to the others at the LHC — is dedicated to the measurement of the total proton-proton cross-section with the luminosity-independent method based on the Optical Theorem, which requires a detailed study of the elastic scattering cross-section down to a squared four-momentum transfer of $|t| \sim 10^{-3}\,\mathrm{GeV}^2$ and the measurement of the total inelastic rate. Furthermore, TOTEM's physics programme aims at a deeper understanding of the proton structure by studying elastic scattering with large momentum transfers, and via a comprehensive menu of diffractive processes — partly in cooperation with CMS [2], located at the same interaction point, IP5. Hence the TOTEM collaboration focusses on physics complementary to the programmes of the general-purpose experiments at the LHC, and therefore had to invest heavily in the design of detectors that will be capable of meeting the challenge of triggering and recording events in the very forward region. To perform these measurements, TOTEM requires a good acceptance for particles produced at very small angles with respect to the beam. TOTEM's coverage in the pseudo-rapidity range of $3.1 \leq |\eta| \leq 6.5$ ($\eta = -\ln\tan\frac{\theta}{2}$) on both sides of the interaction point is accomplished by two telescopes for inelastically produced charged particles (figure 1.1), and complemented by detectors in special movable beam-pipe insertions — so-called Roman Pots ("RP") — placed at about 147 m and 220 m from the interaction point, designed to detect leading protons at merely a few mm from the beam centre (figure 1.2).

The telescope closest to the interaction point (T1, centered at $z = 9$ m) consists of Cathode Strip Chambers CSC (section 5.2), while the second one (T2, centered at 13.5 m) exploits Gas Electron Multipliers GEM (section 5.3). The proton detectors in the Roman Pots (chapter 4) are silicon devices designed by TOTEM with the specific objective of reducing the insensitive area at the edge facing the beam to only a few tens of microns. High efficiency up to the physical detector border is an essential feature in view of maximising the experiment's acceptance for protons scattered elastically or diffractively at polar angles down to a few microradians at the IP. To measure protons at the lowest possible emission angles, special beam optics have been conceived to optimise proton detection in terms of acceptance and resolution (chapter 3).

The read-out of all TOTEM subsystems is based on the custom-developed digital VFAT chip with trigger capability (chapter 7). The data acquisition system (chapter 9) is designed to be compatible with the CMS DAQ to make common data taking possible at a later stage.

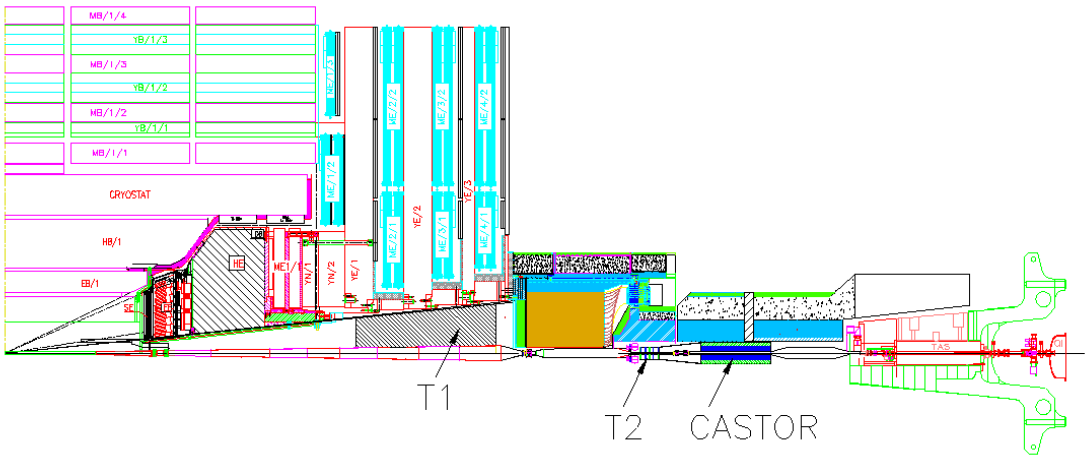

Figure 1.1: The TOTEM forward trackers T1 and T2 embedded in the CMS detector together with the planned CMS forward calorimeter CASTOR.

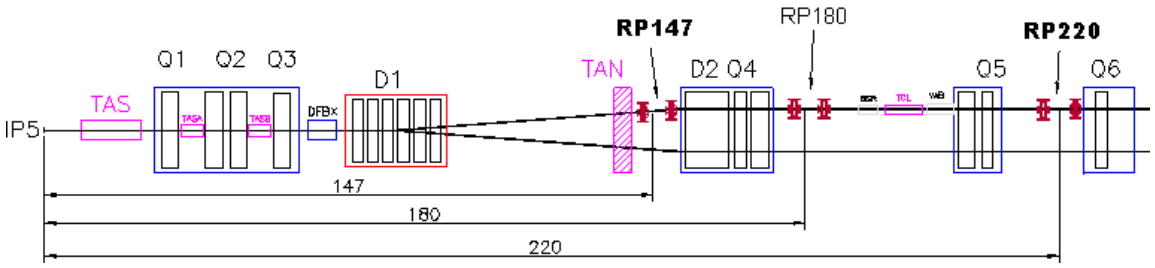

Figure 1.2: The LHC beam line on one side of interaction point IP5 and the TOTEM Roman Pots at distances of about 147 m (RP147) and 220 m (RP220). RP180 at 180 m is another possible location but presently not equipped.

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