Part I

The CMS GEM Project

In the upcoming years, several upgrades of the LHC and its injection chain are planned with the aim of increasing the performance of the machine (see Section **??**). The next upgrade, LS2, is currently set to take place in 2019 and will increase the instanteneous luminosity of the LHC to 2×10^{34} cm^{-2} s^{-1} for the 2020-2022 run. In 2023, the LHC Phase 1 will end with a total integrated luminosity of around 300 fb^{-1} and LS3 will start and allow to prepare the systems for the so called high-luminosity LHC (HL-LHC) or LHC Phase 2. The HL-LHC will restart mid-2015 with an instantenuous luminosity of 5×10^{34} cm^{-2} s^{-1}.

The muon spectrometer of CMS must be able to cope with the HL-LHC program. It was originally designed to be a hermetric and redundant system relying on the DTs, CSCs, and RPCs to provide efficient muon detection, indentification, and triggering. The DTs are installed in the barrel and cover a region of $|\eta| < 1.2$, and the CSCs are located in the endcaps between $1.0 < |\eta| < 2.4$. Additionnaly, the RPCs provide redudancy in both the barrel and the endcaps but were not instrumented in the $|\eta| > 1.6$ region due to concerns about their tolerance to high particle fluxes.

Moreover, studies have shown that the triggering efficiency of the muon system of CMS will be drasticly affected by the increase in luminosity and reduce the physics performance by limiting the parameter phase-space that can be studied.

To tackle these challenges, the CMS GEM collaboration [1] will install during LS2 a set of muon detectors that use the Gas Electron Multiplier (GEM) technology in the $1.6 < |\eta| < 2.2$ region left vacant by the RPCs. The objectif is to improve the L1 trigger efficiency in combination with the CSCs. To this end, a new DAQ system has to be designed based on the Micro Telecommunications Computing Architecture (microTCA, MTCA, or μTCA) standard [2]. Small scale systems have been studied during test beam campaigns and the full system will be tested during the YETS-2016, where a slice test consisting of the installation of four GEM chambers equipped with their electronics will be take place in CMS.

This part focusses on the CMS GEM upgrade project and the developments of the author with respect to the DAQ system design. Chapter **??** provides an overview of the GEM technology and the status of the project. It brushes the evolution of the chamber design and the different generations of GEM detectors that have been developped, and covers the performances of the detectors. The architecture of the DAQ system is explained in details in Chapter **??** describing each component of the system and their integration in the global CMS DAQ system. Chapter **??** focusses on the test beam campaings that took place in November 2014 and 2015 and helped to qualify the system providing results on the chamber performance. Following the test beams, modifications have been done to the electronics in order to prepare for the slice test. Chapter **??** reviews the architecture that will be installed during the YETS-2016 and the developments done by the author. Finally, Chapter **??** details the work performed on the qualification and callibration of the front-end electronics used in the GEM project.