The CMS Collaboration will install trapezoidal Triple-GEM detectors, with dimensions (990x440-220) mm² in the forward region, |η| > 1.6, of the CMS muon spectrometer. Triple-GEM detectors can provide precision tracking and fast trigger information, contributing on one hand to provide missing redundancy in the high-η region and on the other hand to the improvement of the CMS muon trigger.

**Introduction**

**The VFAT3 chip**

- Binary chip
- Programmable shaping time: 25, 50, 100, 250, 500 ns
- Internal calibration
- Direct interface to GBT @ 320 Mbps
- 85 bits to FPGA @ 320 Mbps
- Designed for rate up to 10 kHz/cm²
- L1 latency up to 20 μs

**The GEB**

The GEM Electronics Board (GEB) is a 8-layer PCB which plugs onto the detector and allows the 24 VFAT3s to communicate with a mezzanine, the Opto-Hybrid, which is equipped with an FPGA and GBT chipsets.

**The Opto-Hybrid (OH)**

A FPGA will be placed on the detector Opto-Hybrid (OH) to concentrate the trigger signals from the 24 VFAT3s, to perform zero-suppression and transmit the data to the CSC as well as to the µTCA off-detector electronics. About 216 differential pairs are required to connect the FPGA to the 24 VFAT3 chips. To avoid cables along the detector, the signals are transmitted through 4 160-pin samtec® connectors installed on both GEB and OH. All components are powered through FEAST ASICs [3].

**The µTCA back-end electronics**

The µTCA standard will be used for the back-end electronics. The CTP7 AMC [4], designed for the CMS Calorimeter Trigger upgrade is used to receive the trigger and tracking data from the Triple-GEM detectors, provide local triggering and interface the CMS DAQ. Given the number of optical links available, 12 CTP7 and 1 µTCA crate are enough to read-out the entire GE1/1 system. The AMC13 board [5] is used to interface the Gem readout system to the CMS DAQ.

- Virtex-7 690T FPGA + ZYNQ SoC FPGA with dual ARM Cortex-A9 CPU
- 80 RX and 61 TX GTH I/O links, multi-rate, LHC-synchronous or asynchronous link operation
- Embedded Linux Operating System running on the ZYNQ

**GE1/1 planning and Slice Test**

Before the installation of the final system during LHC Long Shutdown 2 (2019-2020), 10 detectors equipped with the VFAT2 chip [6] (predecessor of VFAT3) have been installed in CMS during the 2017 winter. This prototype step is called Slice Test. End of 2017, these detectors have been fully integrated in the DAQ and DCS (Detector Control System) of CMS. During winter 2018, two detectors have been replaced by detectors equipped with the final electronics version, including the VFAT3.

**GE2/1 and ME0 upgrades**

Beyond GE1/1, CMS plans to install additional layers of Triple-GEM detectors: GE2/1 and ME0. GE2/1 is on the second endcap disk of CMS while ME0 is an extra layer, closer to the beam pipe, that will be installed behind the new High Granularity Calorimeter.

**REFERENCES**