**Development of Readout Electronics for the CMS ME0 Muon Detector**

Abhisek Datta on behalf of the CMS Muon Group


---

**Introduction**

**ME0 Detector:**
- In each endcap, arranged in a wide planar ring with inner radius = 0.6 m and outer radius = 1.5 m, centered on beamline
- 6-layer triple Gas Electron Multiplier (GEM) stacks
- Each chamber covering $\Delta \phi = 20^\circ$ and $\Delta \eta = 0.8$ (divided into 8 partitions in $\eta$)
- 384 radial strips in each $\eta$ partition

**Motivation:**
- Improve muon reconstruction at high luminosity (HL-LHC) by supplementing other muon subsystems till luminosity (HL)
- Improve muon reconstruction at high luminosity (HL-LHC)
- ME0 electronics designed to deal with high data rates and be radiation hard

**Time resolution of less than 7.5 ns for fast trigger and control**

---

**ME0 Electronics Overview**

- **Front-end**
  - 128 strips per VFAT plugin card
  - 6 layers per stack
  - 2 OHs per GEB
  - 2 GEBs per layer

- **Back-end**
  - 6 layers per stack
  - 1024 channel chip, reads charges from the sensor
  - 2 OHs per GEB

**Optohybrid and Back-end Electronics**

**Optohybrid** (by UCLA) is the readout interface for 6 VFATs on the ME0 GEB:
- 2 lpGBT chips and 1 VTRX+ transceiver on each OH board
- No FPGA to ensure radiation hardness, data sent to back-end without compression
- Electrical links to VFATs at 320 Mb/s
- High-speed optical links at 10.24 Gb/s for data transmission and at 2.56 Gb/s for trigger and control

**Current Status and Plans:**
- Pre-production boards (using halogen free PCB) produced and successfully tested (reliable optical and electrical links with bit error rate $< 10^{-14}$)
- OH tester board being developed (will enable fast testing of all OH links)

**ATCA based back-end system will be used for ME0** (also for GE2/1 and CSC):
- Has FPGA for online computation and transceivers to interface with VTRX+
- 2 ME0 stacks per card, 18 cards in total
- Supports high DAQ data rate of 700 Gb/s (all raw trigger hits from OH)
- Will perform 6 layer stub finding for trigger

**Current Status and Plans:**
- 2 pre-production boards available and tested with ME0 front-end electronics
- 2 more boards under production

---

**ME0 Electronics Integration**

**Recent Status and Results from ME0 Integration**

- **Front-end Chips and GEM Electronic Board**
  - VFAT3b (by INFN Bari, ULB) is the front-end chip to read out the strips on ME0 (also used in GE1/1, GE2/1):
  - 128 channel chip, reads charges from the sensor
  - Provide tracking and trigger data
  - Time resolution of less than 7.5 ns (with detector)
  - Radiation resistant
  - VFAT3b packaged in a plugin card with protection circuit

**Current Status and Plans:**
- VFAT3b plugin card prototype produced and successfully tested with ME0 GEB and OH
- All wafers for ME0 produced, packaging expected in 2022

**GEB (by PKU)** is fixed to the chamber readout board to which the VFATs are connected:
- Responsible for routing the signals from the VFATs to the OH
- Distributes power to the VFATs and OHs from DC-DC converters (bPOL12V, 3 per GEB)

**Current Status and Plans:**
- Pre-production boards produced and successfully tested
- Future iteration with halogen free PCB, optimized fiber routing and powering configuration

**Figure 1:** Quadrant of CMS experiment highlighting ME0 ($0 < |\eta| < 2.8$)

---

**Contact:** abhisek.datta@cern.ch