1. The CMS Muon System and Motivation for its Upgrades

The CMS muon system is composed of three different detector technologies:
- Drift Tubes (DTs)
- Cathode Strip Chambers (CSCs)
- Resistive Plate Chambers (RPCs)

In the current configuration:
- no redundancy in the region 1.6<|η|<2.2
- not instrumented at higher pseudorapidity.

2. Upgrades with MicroPattern Gaseous Detectors (MPGDs)

New proposed stations based on MPGDs:
- the GE1/1 station in the region 1.55<|η|<2.2 [approved]
- the GE2/1 station in the region 1.55<|ŋ|<2.45
- Baseline: two rings of single-layered triple GEM detectors
- Option: micro-Resistive WELL (µ-RWELL) detectors [section 4]
- the MED station in the region 2.03<|ŋ|<2.82
- The first station at |ŋ| > 2.2
- Multi-layered structure
- Baseline: 6 layers of triple-GEM detectors [section 3]
- R&D of interest:
  - Fast Timing Micropattern Detector (FTM) [section 5]

3. The Back to Back GEM detector

- Two independent triple-GEM detectors
- A triple-GEM detector is a stack of three copper-cladded kapton foils covered with holes
- In the Back to Back detector triple-GEMs are positioned with the anodes toward the outside, sharing the same cathode
- GEM foil merged with a readout PCB plane coated with a resistive deposition, with small copper dots in correspondence of each WELL structure on the bottom side of the foil.

A first prototype with dimensions similar to the GE1/1 station has been realized and small active areas of the detector have been tested:
- Measured time resolution: order of 7 ns at gain of 10^4
- Measured efficiency: order of 98% at gain of 10^4

The detector has easier drift vs. readout plane coupling.

Prototype with active area 10x10 cm^2 has been tested:
- Gas gain: up to 10^4
- Time resolution: up to 5 ns (Ar/CO2/CF4, 45/15/40) and 7 ns (Ar/CO2 70/30)
- Efficiency: between 98.5 and 98.1% for a single triple GEM

4. The µ-RWELL detector

A novel detector with Resistive WELL (µ-RWELL) has been designed and tested:
- GEM layers with resistivity coating (i.e. DLC) and covered with holes, the bottom side is “closed” by an insulating material (i.e. kapton)
- At the very bottom of the detector is the readout board
- Every single layer works independently from the other ones.

The detector has easier drift vs. readout plane coupling.

Prototype with µ-RWELL detectors:

- Measured time resolution: 1.7 ns with pion beam and 2.4 ns with muon beam

Above: schematic representation of the amplification stage of a µ-RWELL detector.

5. The FTM detector

- A stack of similar layers:
  - Each one is made of a resistive foil with a high resistivity coating on the top (i.e. DLC) and covered with holes, the bottom side is “closed” by an insulating material (i.e. kapton)
  - At the very bottom of the detector is the readout board
  - Every single layer works independently from the other ones.

- Transparency: Fully resistive foils allow the signal to be inducted on readout also from further amplification layers

- A basic goal of FTM detector (to be verified):
  - using the fastest signals produced, by increasing the number of layers time resolution should improve

Small prototype with two layers has been tested:
- Working principle and detector transparency have been proven
- Measured time resolution: 1.7 ns with pion beam and 2.4 ns with muon beam

Above: schematic representation of the amplification stage of the FTM detector.

References:

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