Experimental Particle Physics Group
Gaseous Detectors R&D

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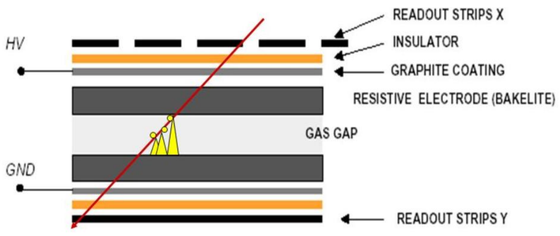
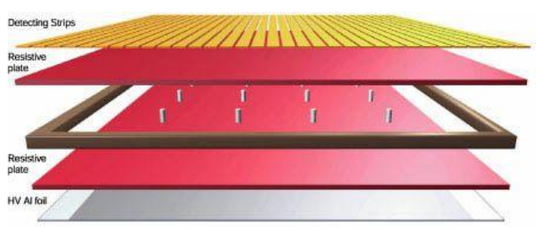
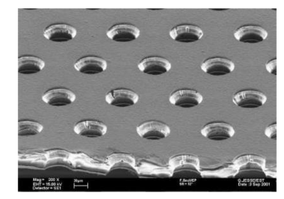
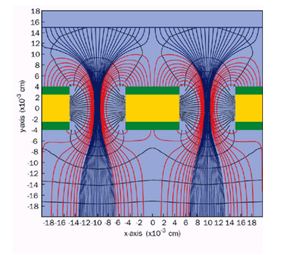
Resistive Plate Chambers **- Resistive Plate Chambers (RPC) are gaseous parallel plate detectors developed in 1981 by R.Santonico and R. Cardarelli. A basic RPC unit consists of two parallel plates made of a material with high resistivity, such as glass or bakelite, separated by a gap of a few millimeters filled with atmospheric-pressure gas. The plates serve as electrodes and are covered with a graphite coating in order to apply an electric field across the gas gap. The passage of a charged particle through the gap initiates a Townsend avalanche, which induces a signal on external read-out strips. RPCs can achieve a good time and space resolution; their relatively simple design and low cost makes them attractive to instrument large areas.**

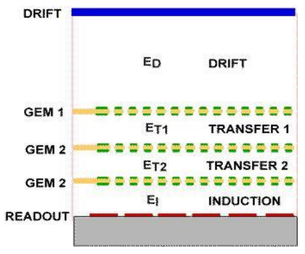




Gas Electron Multipliers **– The Gas Electron Multiplier (GEM) was invented in 1997 by F. Sauli. A GEM consists of a thin, metal-clad polymer foil, chemically pierced by a high density of holes (typically 50 to 100 per mm^2). On application of a potential difference between the two electrodes, electrons released by radiation in the gas on one side of the structure drift into the holes, multiply and transfer to a collection region. Each hole acts as an individual proportional amplifier. The multiplier can be used as detector on its own, or as a preamplifier in a multiple structure which permits to reach large overall gains. GEMs can achieve a very high space resolution, and can operate in a stable manner in harsh, high rate radiation environments.**



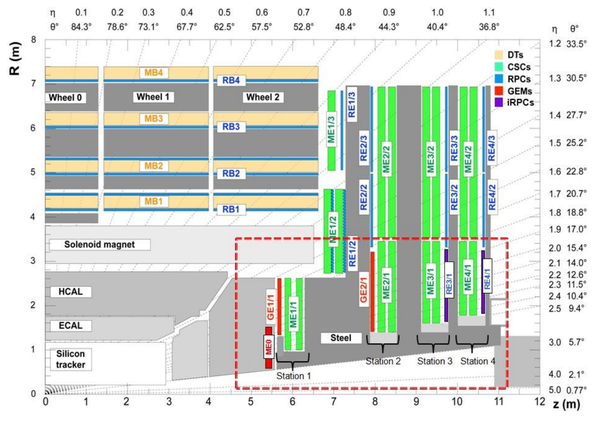




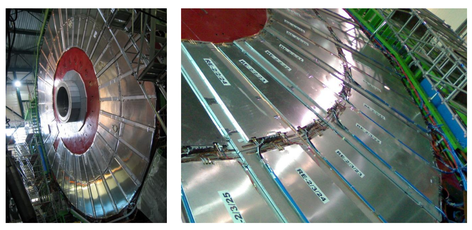
Selected Applications @ UGent

Muon System of the CMS Detector at the CERN LHC **– As the name "Compact Muon Solenoid" suggests, detecting muons is one of CMS's most important tasks. In total there are 1400 muon chambers: 250 drift tubes (DTs) and 540 cathode strip chambers (CSCs) track the particles' positions and provide a trigger, while 610 resistive plate chambers (RPCs) form a redundant trigger system, which quickly decides to keep the acquired muon data or not.**

Facing the High-Luminosity LHC, CMS is planning several muon system upgrades in order to maintain its present high level performance. To increase redundancy and enhance the muon trigger and reconstruction capabilities in the forward region, new muon detectors with high rate capability are being developed. In particular, the muon endcap disks will be extended close to the beamline with new triple-GEMs and RPCs.

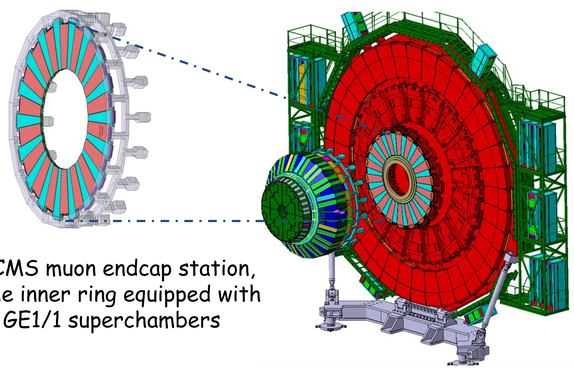


Quandrant of the CMS detector showing present muon system (DT, RPC and CSC) and the locations of the proposed new RPC (blue) and GEM detectors (red) the red box.

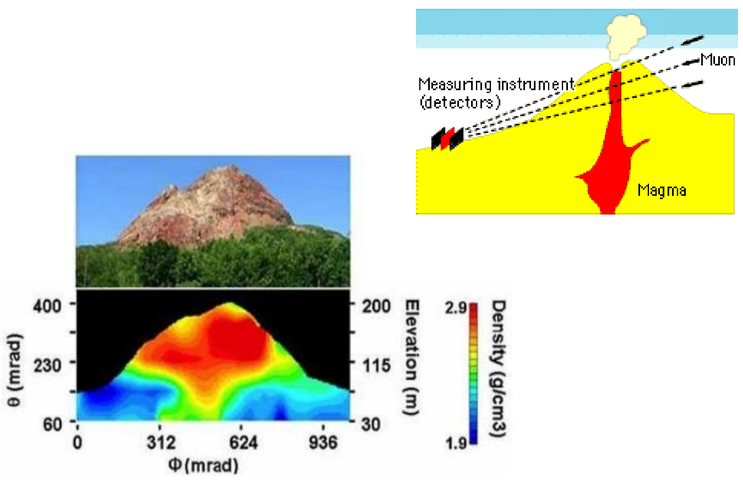


RPCs in the CMS endcap system

GE1/1 prototype after mounting the readout board onto the GEM foil stack



First CMS muon endcap station, with the inner ring equipped with 36 GE1/1 superchambers



Example of muon radiography of volcanoes

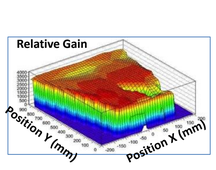
Muon Radiography **– Muon radiography is a technique that uses cosmic ray muons to scan large geological or archeological structures, such as volcanoes and pyramids. As muons are deeply penetrating particles, they are able to cross hundreds of meters of ordinary matter if their energy is sufficiently high. The comparison of the attenuated and the "open-sky" muon flux gives a direct measurement of the matter density crossed. A measurement of the spatial coordinates in a station of 3 or more detectors (such as GEMs or RPCs), together with a precise timestamp, allow reconstructing the muon trajectory and its propagation direction. Counting the number of events, i.e. muon tracks, reconstructed in the detector during a given exposure time, leads to the determination of the muon flux in all directions within the detector acceptance.**

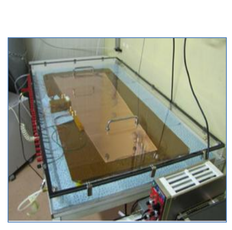
Examples of Thesis Topics

Characterization and quality control of GEMs for CMS

- **CMS recently approved the installation of the so-called GE1/1 station during LHC Long Shutdown 2 (2018-2019): a total of 144 new triple-GEM chambers need to be constructed and quality controlled**
- **Part of the GE1/1 assembly will be done at UGent**

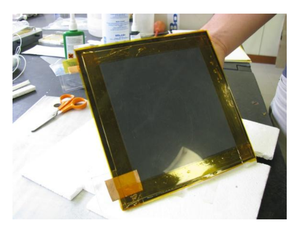
Inspection and cleaning of GEM foils
Discharge, stability and leakage current tests of GEM foils
Precise assembly of the GEM chamber
Verification of completed chamber
Gain uniformity test





Development of a new generation of RPCs for CMS

- **CMS is performing R&D on high rate RPCs for the muon system upgrade**
- **Part of the studies are done at the UGent, e.g. study of new electrodes, eco-friendly RPC gas mixtures …**



A glass RPC prototype developed at UGent

Development of a RPC based telescope for muon radiography

- **A new proposal exists to probe Hellenic tumuli (Greece) using muon radiography**
- **A muon telescope will be constructed using RPCs; several modifications to existing RPC designs need to be studied to produce a low-consumption, autonomous system suitable for outdoor applications**

Tumulus in the Thrace region (diameter of 50m, height 15m)

A scintillator telescope operating on the Soufrière of Guadeloupe