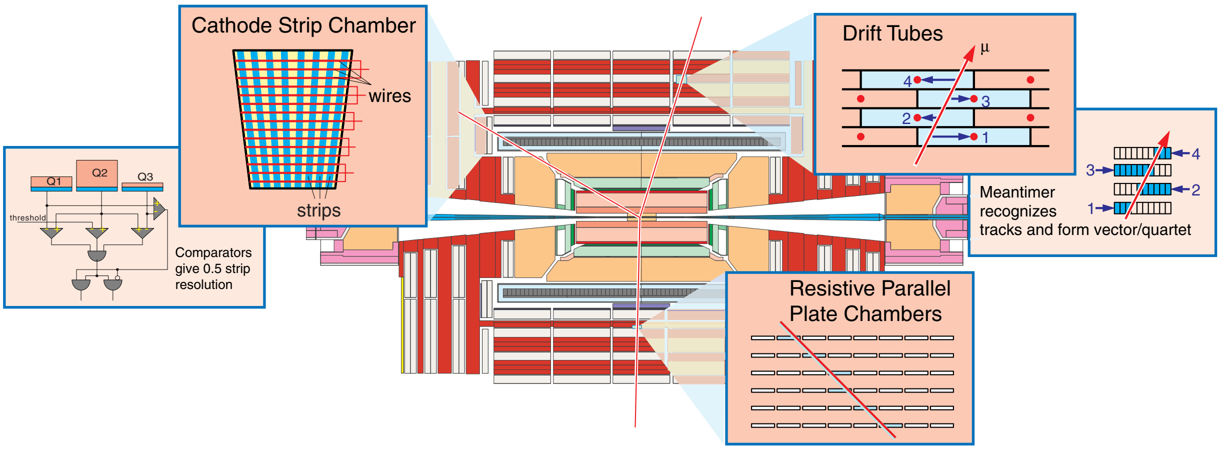
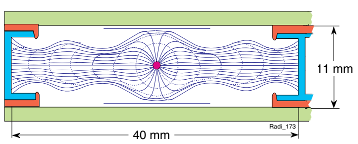
Muon detectors



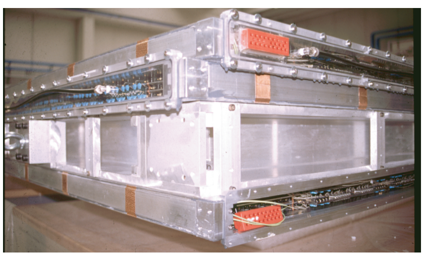
CMS will use three types of gaseous particle detectors for muon identification: Drift Tubes (DT) in the central barrel region, Cathode Strip Chambers (CSC) in the endcap region and Resistive Parallel Plate Chambers (RPC) in both the barrel and endcaps. The DT and CSC detectors are used to obtain a precise measurement of the position and thus the momentum of the muons, whereas the RPC chambers are dedicated to providing fast information for the Level-1 trigger

Drift Tubes

Drift Tubes are used in the Barrel where the Magnetic field is guided and almost fully trapped by the iron plates of the Magnet Yoke. Each tube contains a wire with large pitch (4 cm), and the tubes are arranged in layers. Only the signals from the wires are recorded — resulting in a moderate number of electronic channels needed to read out the detectors. When an ionizing particle passes through the tube, it liberates electrons which move along the field lines to the wire, which is at positive potential. The coordinate on the plane perpendicular to the wire is obtained with high precision from the time taken by the ionization electrons to migrate to the wire. This time (measured with a precision of 1ns), multiplied by the electron drift velocity in the gas, translates to the distance from the wire.



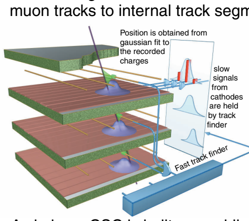
A DT layer is put together gluing to an aluminium plate a set of parallel aluminium I beams. The wires are stretched, held by appropriate end plugs, and the layer is closed by another aluminium plate. Groups of four layers are grown in this way on a precision table. Copper strips are previously glued to the Al plates in front of the wire to better shape the electrostatic field. A full-size final prototype of a DT chamber is shown below. The chamber is 2m x 2.5m in size. The largest DT chambers to be used in CMS will have dimensions of 4m x 2.5m in size.



Cathode Strip Chambers

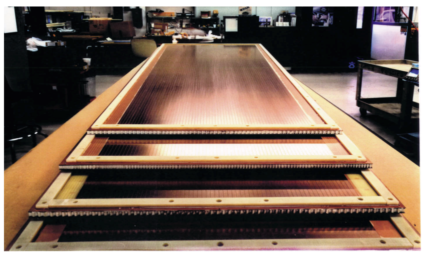
Cathode Strip Chambers are used in the Endcap regions where the magnetic field is very intense (up to several Tesla) and very inhomogeneous. CSCs are multiwire proportional chambers in which one cathode plane is segmented intro strips running across wires. An avalanche developed on a wire induces a charge on several strips of the cathode plane. In a CSC plane two coordinates per plane are made available by the simultaneous and independent detection of the signal induced by the same track on the wires and on the strips. The wires give the radial coordinate whereas the strips measure ϕ.

In addition to providing precise space and time information, the closely spaced wires make the CSC a fast detector suitable for triggering. CSC modules containing six layers provide both a robust pattern recognition for rejection of non-muon backgrounds and also efficient matching of external muon tracks to internal track segments.



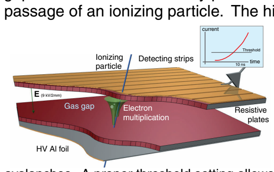
Artist scheme of a CSC chamber, with a sketch of the mechanism of signal detection. The electrons are collected by the wire, whereas a cloud of positive ions moving away from the wire of the wire and toward the cathode induces a current on the cathode strips perpendicular to the

A six-layer CSC is built assembling together 7 Honeycomb panels. Three of them support two wire planes each, one on each face of the plate, wired at the same time as shown in the photograph below. The other four plates have the etched strip. The two inner plates have strips on both faces, whereas the two outer plates (closing the chamber) have strips on only one face.



Resistive Parallel plate Chambers

Resistive Parallel plate Chambers are fast gaseous detectors whose information is at the base of the triggering process. RPCs combine a good spatial re-solution with a time resolution of 1 ns, comparable to that of scintillators. The RPC is a parallel plate counter with the two electrodes made of very high resistivity plastic material. This allows the construction and operation of very large and thin detectors that can operate at a high rate and with a high gas gain without Resistive Parallel plate Chambers are fast gaseous detectors whose information is at the base of the triggering process. RPCs combine a good spatial re-solution with a time resolution of 1 ns, comparable to that of scintillators. The RPC is a parallel plate counter with the two electrodes made of very high resistivity plastic material. This allows the construction and operation of very large and thin detectors that can operate at a high rate and with a high gas gain without developing streamers or catastrophic sparks. The high gain and thin gap result in a small but very precise delay for the time of passage of an ionizing particle. The high resistivity electro-



The electric field inside a RPC is uniform. Electrons made free by the ionizing particle near the cathode generate a larger number of secondary electrons (exponential multiplication). The detected signal is the cumulalive effect of all the avalanches. A proper threshold setting allows the detection of a signal dominated by the electrons generated near the cathode. The threshold setting determines to a large extent the time delay of the pulse, the time resolution and also the efficiency. With a proper choice of the resistivity and plate thickness, the rate capability can reach several thousand Hertz per cm^2.

The drawing shows the simplicity of an RPC detector: one of the two resistive plates holds a glued array of small 2mm thick spacers having a typical pitch of 10 cm. Also glued on the plate is the border that will guarantee the chamber tightness. The second plate is then placed on top and the detector is completed.