Test of spatial resolution and trigger efficiency of a combined Thin Gap and Fast Drift Tube Chambers for high-luminosity LHC upgrades

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The forthcoming upgrade of LHC to super-LHC will increase the expected background rate in the forward region of the ATLAS Muon Spectrometer by approximately one order of magnitude. Some of the present Muon Spectrometer components will fail to cope with these high rates and will have to be replaced. The higher rate of photons and minimum ionizing particles should be matched by a comparable increase in the rate capability of the various detector components. The results of a test of a device consisting of Thin Gap Chambers (TGC) and a fast drift tube chamber (DT) using the 180 GeV/c muons at the SPS-H8 muon beam at CERN are presented. The aim of the test was to study the combined TGC-DT system as tracking and triggering device in the ATLAS muon spectrometer after high-luminosity upgrades of the LHC.

Two TGC quadruplets of $1.2 \times 0.5\ m^2$ size, containing four sensitive gaps, with a single gap providing pad, strip and wire readout were used for the test. The four gaps fit within a total thickness of 50 mm. A schematic view of the TGC with wire, strip and pad readout is shown in Fig. 1. A single gap position resolution of 70 μm was achieved with the TGC chambers using a Time-over-Threshold method, and an angular resolution between the two quadruplets of 0.4 mrad for 1.6 m distance between them (dominated by multiple scattering).

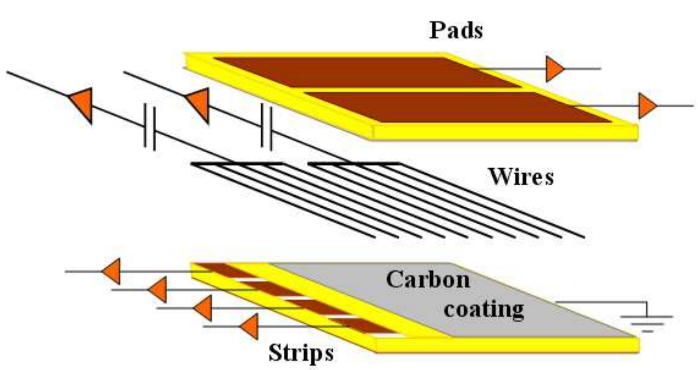

Figure 1: Schematic view of the TGC.

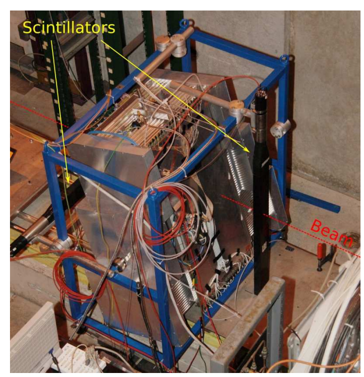

Figure 2: Prototype of a 15 mm drift tube chamber in the 180 GeV muon beam line at CERN.

The drift tube chamber consist of 2 times 8 layers of aluminium tubes with 15 mm diameter compared to the 30 mm drift tube diameter of the current Muon Drift Tube (MDT) chambers in ATLAS. With the shorter maximum drift time of 200 ns for the thinner tubes, compared to about 700 ns for the 30 mm tubes and the smaller tube cross section, the background occupancy is reduced by a factor of 7. At the same time the excellent spatial resolution of 40 μm per chamber is retained up to high counting rates. The larger number of drift tube layers fitting in the same detector volume offers improved redundancy and tracking efficiency.

Signal coincidences from the TGC pads were used to provide the trigger for the combined TGC-DT device, where the DT chamber was placed in between the two TGC quadruplets. The setup of the DT is shown in Figure 2. The efficiency of the TGC pads as a triggering device was measured to be better than 99%. The analysis of the recorded data shows a very good correlation between the TGC and DT track position and inclination. The correlation beteen the angle measured by the TGC and the angle measured by the DT is shown in Figure 3 (left). The correlation between the track hit position measurements is shown in Figure 3 (right). In both cases a very clear correlation is seen. The distribution of the difference between the TGC and DT measured angles is shown in Figure 4. The width of the distribution is less than 0.4 mrad, indicating that the angular resolution of each of the devices is better than this value.

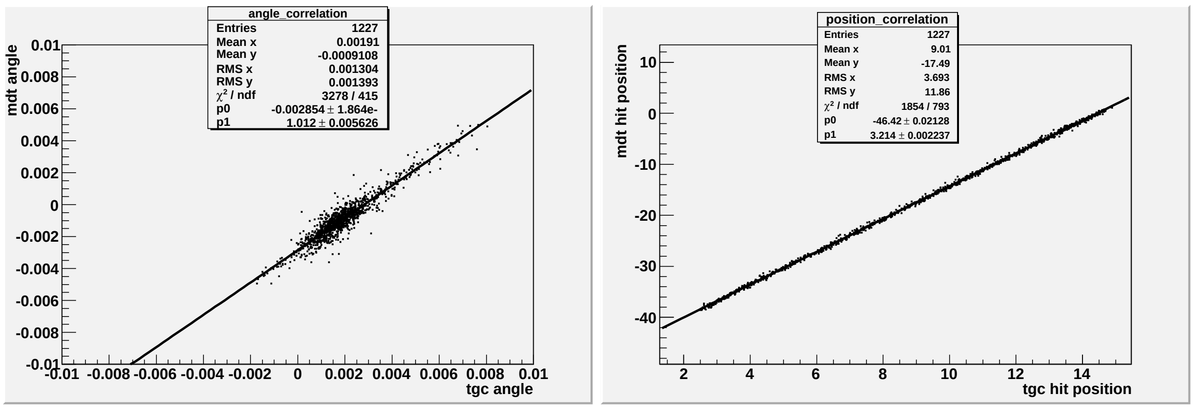

Figure 3: The correlation beteen the angle measured by the TGC and the angle measured by the DT (left); The correlation beteen the track hit position measurements (right).

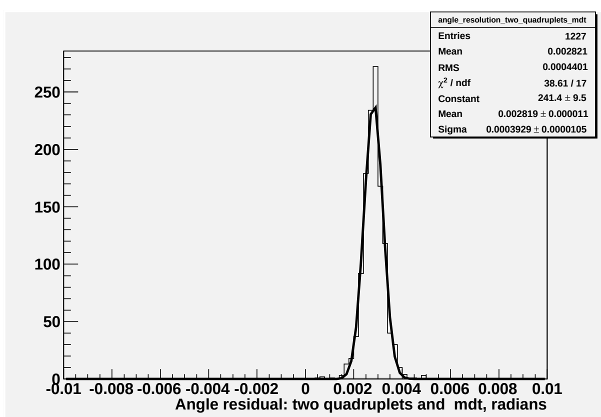

Figure 4: The distribution of the difference between the TGC and DT measured angles.