# Precision Drift Tube Chambers at High Background Rates for the ATLAS detector at the Super-LHC.

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The ATLAS detector is one of the two general purpose detectors at the Large Hadron Collider (LHC) at CERN. One of the most challenging aspects of the ATLAS experiment is the measurement of muon momenta with very high precision. The ATLAS muon detector is equipped with three layers of tracking chambers in a magnetic field of 3–6 Tm bending power generated by a superconducting air-core magnet system. Over most of the pseudo-rapidity range, measurements of the track sagitta are provided by precision drift tube detectors, the Monitored Drift Tube (MDT) chambers [1]. The ATLAS muon spectrometer has to withstand high radiation background mainly caused by low-energy neutrons leaking out of the calorimeter and $\gamma$ particles emitted from nuclei excited by the low energy neutrons. At the LHC, Monte-Carlo simulations predict background counting rates of about 10 $cm^{-2}s^{-1}$ in the barrel part, and of up to 100 $cm^{-2}s^{-1}$ in the end-caps [2]. The muon chambers are designed to cope with the expected background rates including an uncertainty factor (5). At the Super-LHC, the high luminosity upgrade of the LHC, ten times higher counting rates may be encountered if the background rate scales with the accelerator luminosity.

The ATLAS MDT chambers consist of 2 triple or quadruple layers of aluminum drift tubes. The tubes are filled with a gas mixture of Argon and $CO_2$ in the ratio 93:7 at an absolute pressure of 3 bars. The outer diameter of the tubes is 29.970 mm. A 50 $\mu$m diameter gold-plated tungsten-rhenium wire is placed at the center. The tube wall thickness is 0.4 mm. The drift tubes are operated at 3080 V, corresponding to a 2 x $10^4$ gas gain. The MDT chambers are known to suffer from high background counting rates by a degradation of the spatial resolution due to space-charge fluctuations, and by a degradation of the muon detection efficiency due to dead time effects leading to a loss of muon hits [3, 4]. These effects can be compensated by reducing the diameter of the pressurized aluminum drift tubes from 30 mm to 15 mm, mainly due to a more linear space-to-time relationship and to a faster response of the gas for drift radiuses smaller than 7.5 mm [5]. Moreover, a more linear space-time relationship entices a lesser dependency on environmental parameters, such as temperature, magnetic field, gas pressure and background radiation, than in the current design. Additional advantages of the reduction of the tube diameter from its present value of 30 mm to 15 mm are: more tubes can be packed into the same volume; and a smaller background count rate per tube due to less conversions taking place in a smaller tube wall surface at the same background particle flux. A first detector prototype equipped with drift tubes with reduced diameter was successfully tested in a low-rate cosmic-ray test stand [5].

The possibility to improve the muon detection efficiency at the Super-LHC by reducing the diameter of the drift tubes from 30 mm to 15 mm has now been investigated in a high rate radiation environment in the Gamma Irradiation Facility (GIF) at CERN, where a cosmic ray test stand has been setup. The setup consists of a layer of 6 prototype drift tubes with 15 mm diameter and 1 m length, and two chambers equipped with two triple layers of 8 standard MDT drift tubes with 30 mm diameter and 50 m length, who serve as reference detectors (see Fig. 1). All parameters of the prototype drift tubes except for the radius are unchanged with respect to the current design. In order to obtain the same electric field as in the current MDT tubes for distances from the wire smaller than 7.5 mm, the operating voltage is set to 2760 V. This allows us to use the standard ATLAS MDT readout electronics. The trigger on cosmic muons is given by two layers of scintillation counters. The GIF has a $^{137}$Cs source with an activity of 590 GBq emitting 662 keV photons which simulate well the photon background in ATLAS.

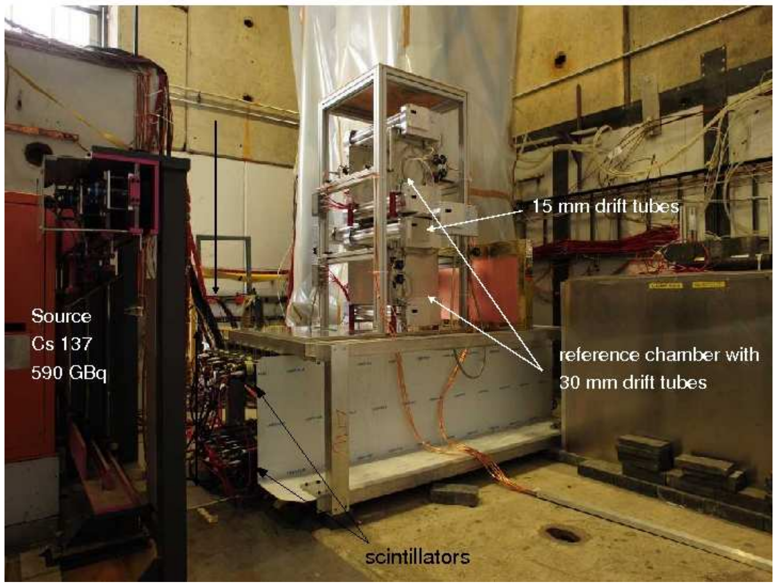


Figure 1: The cosmic ray setup at the GIF.

We report on the performances of the prototype drift-tube detector with thin-walled aluminum tubes of 15 mm diameter in the GIF environment, and we compare the experimental results with simulations.

# References


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