A Gas Monitoring Chamber for the ATLAS Muon Monitored Drift Tube(MDT) System

Song Xie, Florian Ahles, Gregor Herten, Stephanie Zimmermann, Ulrich Landgraf, Wolfgang Mohr

Physikalisches Institut, Albert-Ludwigs Universitaet Freiburg

The ATLAS Muon Spectrometer incorporates MDT precision chambers used for precise track reconstruction. The average resolution of the impact radius of the track of a crossing muon in a tube, which is deduced from the drift time of the ionization via the space-drift time (r-t) relation, will be 80 µm. Since the MDT r-t relation crucially depends on the operating gas mixture, a monitoring chamber was designed and built to continuously check the operating gas mixture by measuring the electron drift velocity spectrum in the operating gas, which is sampled continuously from MDT gas system, over a wide range of electric field strength. In this way quick and precise information can be obtained about any changes and contaminations.

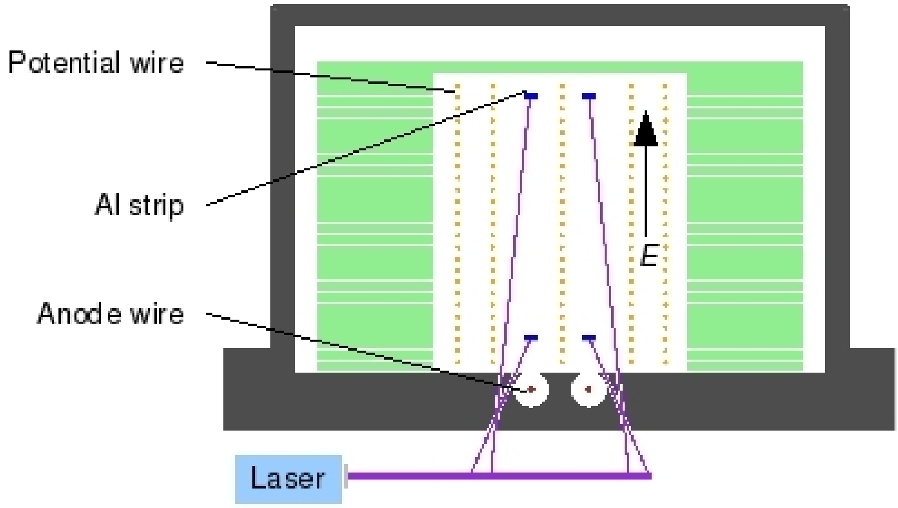

Figure 1: Diagram of Gas Monitoring Chamber

The electric field of the monitoring chamber, which is the drift field for electrons, is provided by a stack of circuit boards with additional potential wires. The distances between adjacent layers are precisely kept by spacers. In this way, a very homogeneous electric field is established.

The electron clusters are produced by shining aluminum cathodes using a UV-laser. Every channel has two aluminum cathodes . One lies near the start point of the drift field, the other closes to the terminal. Two electron clusters are produced simultaneously from the two cathodes separately, and drift towards the terminal, where there is a anode wire made of W-Re(97/3) gold-plated(3% by weight), and produce two signals. the time deference of those two signal indicates the electron drift time between the two aluminum cathodes.

In order to validate the feasibility and optimize the design, a serious simulations based on Garfield and 3D/2D finite element method(FEM) are done, which include mechanics, electrostatics, thermodynamics and computational fluid dynamics(CFD). Garfield is a computer program for the detailed simulation of drift chambers. The Garfield simulation yields electron drift spectrum. The mechanics simulation shows the deformation of components caused by stress. In the thermodynamics simulation considering the heat dissipation caused by distribution resistor a temperature profile of the drift region is plotted. In the electrostatics simulation, the homogeneity of two different designs are compared. Using CFD simulation, the gas flow pattern is optimized.

The drift time resolution of the monitoring chamber is about 0.05%. This value is achieved by continuous measurement of only one channel over three minutes. As a result small changes of the gas mixture, such as 0.5% change of Ar:CO_2 93:7, can be easily detected. By varying electric field strength of the electron drift region, electron drift velocity spectrum corresponding to a variant electric field can be obtained. In such way very small changes and contaminations of the gas can be detected, for instance 0.1% nitrogen in Ar:CO_2 93:7, which mostly indicates leakage of the gas system. Conclusively the precision and fast response of the monitoring chamber satisfy the MDT requirements.

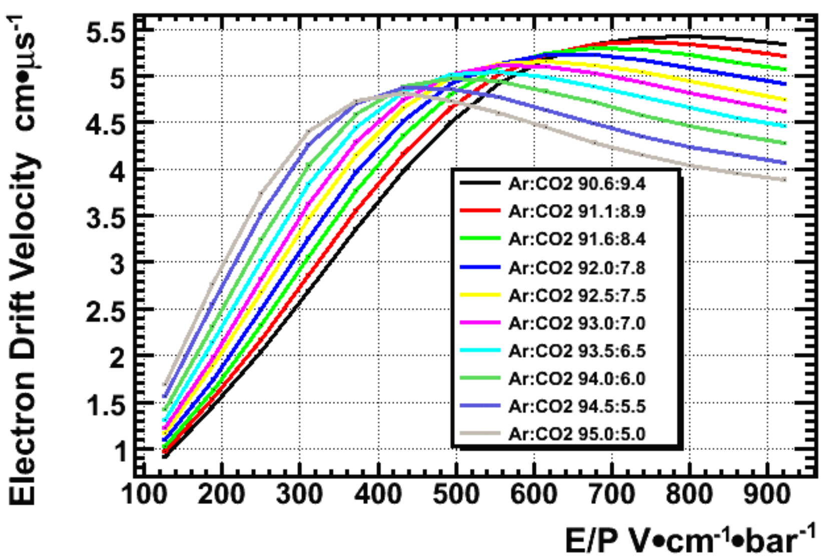

Figure 2: Measured drift velocity spectrum of electron in Ar:CO_2 for about every 0.5% variance of proportion from 90.6:9.4 to 95.0:5.0

Furthermore the construction has to satisfy certain limitations since it is integrated in the ATLAS system. Compounds introducing contamination in to the gas should not be used, such as glue, isolate robber or certain plastics. The size of the chamber is limited also.