Resolution Studies of Drift Gases at ATLAS MDT BOS Chambers

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After the luminosity upgrade of the Large Hadron Collider (LHC), an order of magnitude higher background counting rates are expected, mainly gammas and neutrons. To provide a momentum resolution of 10 % at 1 TeV/c transverse muon momentum, single tube resolutions of around 80 μm are envisaged. But at increased background rates the single tube resolution deteriorates due to space charge effects in the slow and nonlinear drift gas mixture (Ar:CO_2 = 93:7 %) [1].
The Garfield [2] simulations in Fig. 1 show, that adding N_2 makes the drift gas about 150 ns faster and more linear. Reducing the percentage of CO_2 one can make the gas even faster.
Two inert gas mixtures (Fig. 3) with linear position-drifttime relations (rt-relations) and maximum drifttimes around 450 ns are promising candidates. These mixtures were tested on their single tube resolutions.

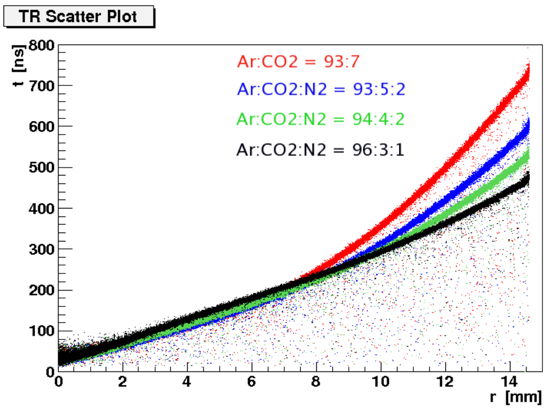

Fig. 1: Impact of N_2 and CO_2 on drift gases from Garfield simulations: the addition of N_2 makes the gas linear and a lower percentage of CO_2 makes the gas faster.

The measurements were performed at the cosmic ray facility in Garching [3]. The setup is shown in Fig. 2.

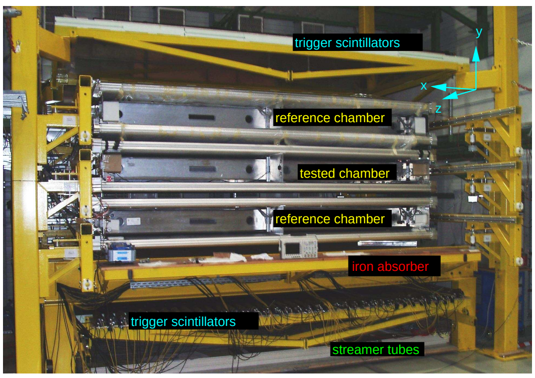

Fig. 2: Cosmic ray facility in Garching

A set of three MDT (Monitored Drift Tube) chambers is enclosed by layers of scintillation counters on the top and bottom to trigger for cosmic muons. The MDT reference chambers were operated at the ATLAS muon spectrometer conditions: 3080 V for the drift field and a gas mixture of 93 % Ar and 7 % CO_2 at 3 bar absolute pressure. Whereas the test chamber was filled with one of the alternative gas mixtures, but the drift field and the pressure was the same. Using a 40 cm thick iron absorber, we selected muons with an energy higher than 600 MeV. The measured drifttime in each drifttube is translated into a driftradius with the help of the rt-relation. So we get a measured driftradius r_{meas} in the test chamber.
The reference chambers provide a highly precise track reconstruction and therefore we get a precise prediction for the driftradius r_{track} in the tubes of the test chamber. The difference between these two values gives the residual res:

$$res = r_{track} - r_{meas}. \quad (1)$$

A Gaussian describes the shape of the residual distribution. The single tube resolution is given by the width σ of this Gaussian. The dependence of the resolution on the radius is shown in Fig. 3.

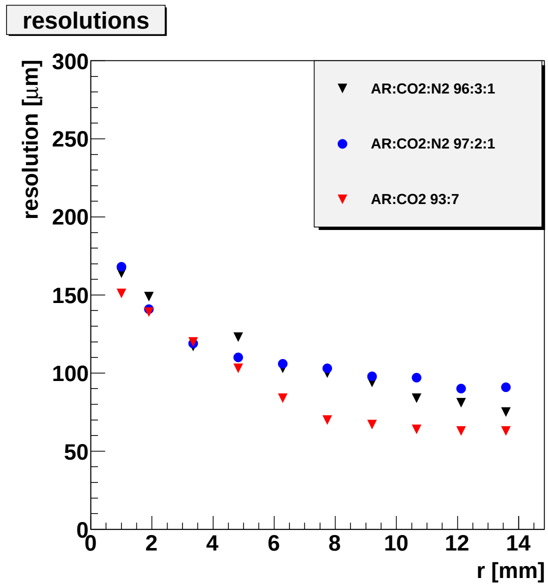

Fig. 3: Single tube resolution of the standard gas (red) and two gas mixtures (black and blue) containing N_2.

The alternative gas mixtures containing N_2 show almost identical resolutions as the present ATLAS gas (in agreement with simulations). The deviations of about 20 μm are due to a not yet optimised rt-relation.

References

[1] M. Deile et al.: Resolution and Efficiency of the ATLAS Muon Drift-Tube Chambers at High Background Rates, Nucl. Instr. and Meth. **A535** (2004) 212
[2] http://garfield.web.cern.ch/garfield/
[3] O. Biebel et al.: A Cosmic Ray Measurement Facility for ATLAS Muon Chambers, arXiv:physics/0307147 (2003)