Resolution and Efficiency of Drift-Tubes for the ATLAS Muon-Spectrometer at High γ-Ray Background

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1. Introduction

In the ATLAS Muon-Spectrometer drift-tube chambers will provide the precision tracking. They will have to be operated in a high radiation background environment. The maximum expected background count rate is 60 kHz per tube or 100 Hz cm^{-2}. To allow for a safety factor, a stable operation and a single tube resolution better than 100 μm are desired at rates of up to five times the expectation.

The effect of high gamma radiation in ATLAS drift-tubes was studied using a 662 keV γ-source (^{137}Cs) in conjunction with a 100 GeV muon beam at the Gamma-Irradiation-Facility at CERN. The source can supply background rates up to 1 kHz cm^{-2}. The detector-telescope ODYSSEUS [1] consisting of silicon-strip detectors provided a reference impact point of the muon trajectory with a precision of 20 μm.

2. Single Tube resolution

The single tube resolution is determined from a Gauss-fit to the distribution of the difference between the drift radius measured in the tubes (r_{drift}) and the impact radius prediction from the silicon-telescope (r_{STEL}). The upper curve in figure 1 shows the measured resolution as a function of the background irradiation rates. The degradation of the resolution with increasing irradiation is due to the fluctuations of the space charge created by the γ-hits. The resolution is for every irradiation worse than 100 μm.

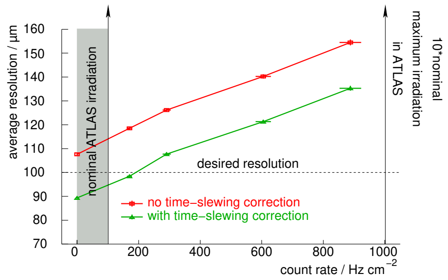

Fig. 1: Single tube resolution versus background irradiation rate

The resolution can be improved by a correction on time slewing effects. Besides a drift-time measurement, the readout electronics of the drift tubes also provides the pulse height of the signal. In figure 2 the difference between r_{drift} and r_{STEL} is plotted versus the inverted pulse height for a 1 mm wide slices in r_{STEL}. A clear correlation, originating from the finite slope of the leading edge of the drift tube signal, can be seen. By fitting parabolas to these distributions, a correction to the drift-radius measurement depending on the pulse height and the impact radius can be calculated. The lower curve in figure 1 shows the resolution with this correction. This time slewing correction improves the resolution by about 15 μm for all investgated background irradiations. The resolution remains better than 100 μm at up to two times the highest expected background irradiation in the ATLAS.

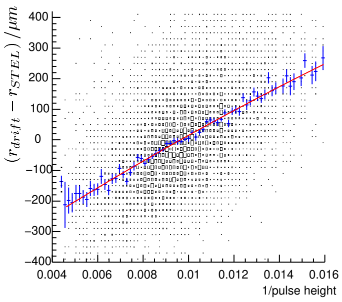

Fig. 2: Correlation between the deviation of the measured drift radius from the impact radius and the pulse height

3. The 3-σ-Efficiency

The 3-σ-efficiency is calculated as the ratio of the number of hits in a tube with a deviation of r_{drift} from r_{STEL} of less than three times the single tube resolution, and the number of tracks crossing the tube (figure 3). The efficiency of less than 100 % at no irradiation, and its degradation with higher γ-ray background is due to a deadtime, which is built into the electronics to eliminate multiple hits from a single track. The muon hit can therefore be masked by preceding δ-rays and γ-hits. The prediction from this dead-time model agrees with the measured data up to background irradiations of five times the expectation in ATLAS.

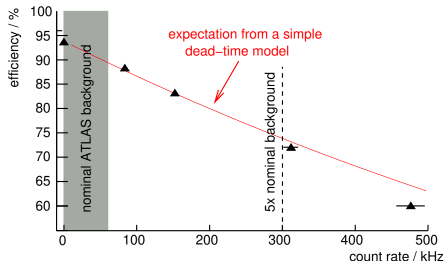

Fig. 3: 3-σ-Efficiency versus background irradiation

References

[1] M. Deile J. Dubbert N. Hessey A. Staude *ODYSSEUS - a Silicon Testescope for Test Beam Experiments* ATL-COM-MUON-99-015 **1999** (ATLAS internal note)

[2] J. Dubbert S. Horvat O. Kortner H. Kroha A. Manz S. Mohrdieck-Möck F. Rauscher R. Richter A. Staude W. Stiller *Resolution and Efficiency of Monitored Drift-Tube Chambers with Final Read-out Electronics at High Background Rates* ATL-COM-MUON-2003-036 **2003** (ATLAS internal note)