Spatial Resolution of ATLAS Muon Drift Tubes with Neutron Background Radiation

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Neutrons and photons will comprise a substantial background contribution to the measurement of the ATLAS muon spectrometer. In a dedicated setup, see Fig. 1, the impact of neutron radiation on the resolution of monitored drift tube (MDT) chambers was investigated. At the tandem laboratory the tracks of cosmic muons in a MDT-chamber are compared to track predictions from silicon-strip-detectors at presence of varied fluxes of 11 MeV neutrons. The experimental setup used drift tubes and readout electronics of the same kind as used in the ATLAS muon spectrometer.

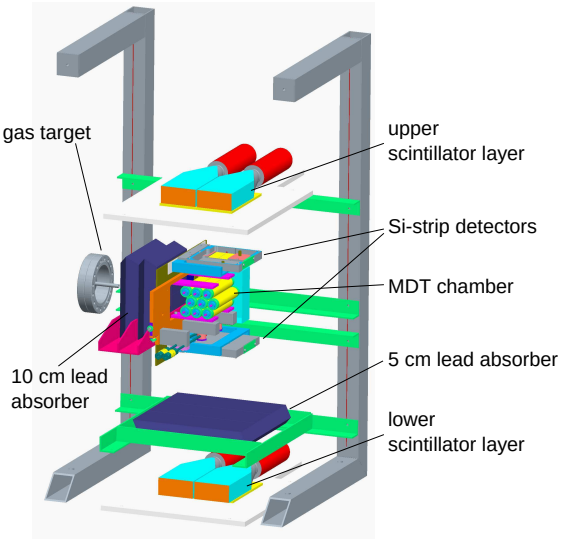

Fig. 1: Setup for resolution study of MDT chamber under neutron irradiation

Five centimeters of lead absorbers were used to suppress the cosmic muon flux with energies less than about 100 MeV. Higher energy muons were triggered by a coincidence of scintillating detectors. The position of a cosmic muon was reconstructed by two silicon strip detectors (Fig. 1) located close to the MDT chamber with strips adjusted parallel to the tubes at a precision of about 10 μm.

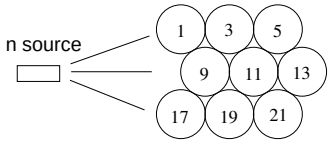

Fig. 2: Illumination of drift tubes by neutrons from the gas target.

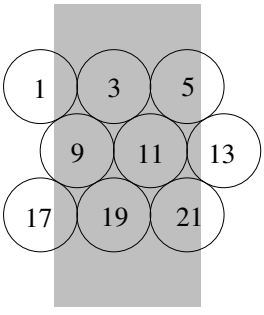

Fig. 3: Acceptance of the silicon strip telescope for cosmic muons.

The nine tubes' MDT chamber with about 15 cm length was irradiated by neutrons of about 11 MeV. Neutrons were produced using the reaction $^{11}\mathrm{B} + {}^{1}\mathrm{H} \rightarrow {}^{11}\mathrm{C} + n$ in inverse kinematics. A 60 MeV boron beam hits on hydrogen gas which was kept in a gas target at 3 bars. The neutrons passed through 10 cm of lead absorber to suppress the background from photons out of the gas target (Fig. 1, 2).

The average neutron flux in the tubes of the MDT chamber ranged from 4.4 to 16.0 kHz/cm^2. This flux corresponds to about 1 to 10 times the expected flux of neutrons with energies of at least 10 MeV in the barrel part of the ATLAS muon spectrometer for LHC conditions after a tenfold luminosity upgrade (SLHC). Some regions of the endcap part of the ATLAS muon spectrometer are expected to suffer even higher neutron fluxes.

During the one week measurement period several studies of neutron induced background on the MDT chamber were performed, including a measurement of the sensitivity of the chamber to neutron background [1]. Data on the resolution degradation could be collected over roughly two days. Although the small acceptance to cosmic muons because of the silicon strip detectors (Fig. 3) limited the statistics, a measurement of the degradation of spatial resolution due to the neutron irradiation was possible for five of the nine MDT tubes, Fig. 4. The width of the bands of the space-drifttime relation respresents the spatial resolution of each tube. Those five tubes showed effects of up to three standard deviations. The spread in the degradation of the spacial resolution is partly due to the different illumination of the tubes and possibly also due to temperature variation during the measurement period.

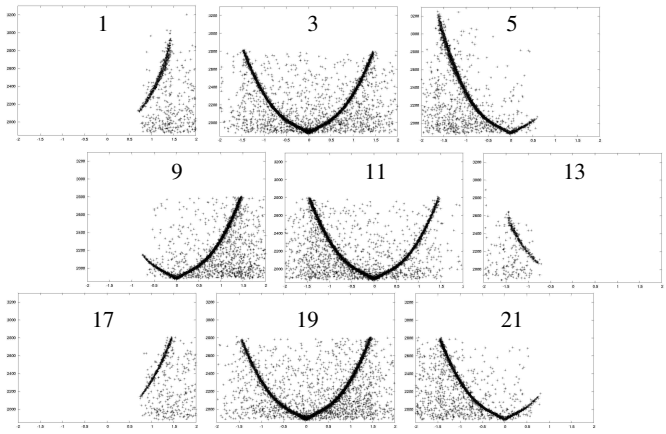

Fig. 4: Relation of Space (horizontal axis) vs. Drifttime (vertical axis) from cosmic muons for drift tubes inside the silicon strip detector acceptance (cf. Fig. 3).

A statistical analysis of all data was performed to determine an upper limit on the degradation of the resolution. The quadratic contribution due to neutron irradiation to the spatial resolution of a single tube is less than 54 μm at 95% confidence level. So, the resolution of a single tube degrades from the nominal 100 μm to about 114 μm due to neutron irratiation with fluxes of up to 16 kHz/cm^2.

References

[1] T. Müller *et al.*: this annual report 89