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Upgrade of the ATLAS Monitored Drift Tube Detector for the SLHC

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The upgrade of the LHC towards higher luminosity needs to be matched by an upgrade of the detector performance. In the case of the ATLAS Monitored Drift Tube (MDT) detectors, higher luminosity will result in increased neutron and gamma background rates leading to a reduction of spatial resolution and tracking efficiency as well as to an increase of the required readout bandwidth. In the regions of highest background rates (forward region) a modified detector and readout concept will probably be necessary to maintain tracking efficiency and to limit the data volume due to background hits. We will present an overview of the upgrade options for the MDT chambers and their readout electronics.

Summary

The muon spectrometer forms the outer shell of the ATLAS experiment and is designed to measure the momentum of muon tracks with high accuracy. It is instrumented with precision tracking chambers, the monitored drift tube chambers (MDT), which consist of layers of drift tubes with tube diameters of 30 mm, using Ar/CO2 (93/7) at 3 bar as drift gas.
A serious problem for MDT chamber operation, already at nominal LHC luminosity, is the presence of high neutron and gamma radiation levels in the experimental hall creating Compton electrons in the tube walls and extra ionization in the tubes. This background hit rate largely exceeds the one expected from muon tracks. In the forward region of the detector (eta > 1.5) the hit rates due to neutron background go up to 300 kHz/tube, while rates in the barrel region (eta <
1) are an order of magnitude lower. High hit rates in the tubes lead to ccumulation of space charge in the gas volume degrading position resolution. They also mask hits from subsequent muon tracks, reducing detection efficiency and, finally, pose problems to the readout bandwidth which is designed for up to about 400 kHz per tube. Beyond this value a certain fraction of hits will have to be suppressed to limit readout latency.
These problems will aggravate with an upgrade of the LHC luminosity beyond the nominal value of 1034 cm-2 s-1, and a replacement of the present readout electronics will have to be envisaged. For a redesign of the electronics the main technical issues are: (a) efficiency, signal processing and dead time at the frontend, (b) storage capacity and data transmission speed between TDC and on-chamber processor, (c) bandwidth for data transmission speed to the readout drivers (ROD's) and (d) radiation tolerance of the on-chamber components.
In the forward region (eta > 1.5), where about 15% of the MDT are located, the replacement of the electronics may not be sufficient, and a detector type with higher rate capabilities will have to be selected to limit the degradation of resolution and efficiency. A feasible option for this upgrade would be MDT chambers with smaller tube diameter. The hit rate recorded by a 15 mm diameter
drift tube is only about one tenth of the presently used 30 mm tube due to the combination of reduced tube size and higher drift velocity in the Ar/CO2 gas. The smaller size will also allow to increase the number of tube layers per detector volume, increasing the number of coordinate measurements along the track. We will present first test results of this tube type and discuss some aspects of MDT chamber construction from small tubes.
Depending on the neutron rates actually observed at LHC (present predictions are uncertain by a factor of 5) and on the definitive radiation shielding for the SLHC, a smaller or larger fraction of the MDT chambers will have to be replaced by chambers of the new design. Assuming a fraction of 15 −20 %, construction of about 150 −200 chambers would have to be foreseen. We will present a preliminary estimate for the resources needed for an upgrade program of the
MDT.

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