Expression of Interest:
R&D on Precision Drift-Tube Detectors for Very High Background Rates at SLHC

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1 MDT chambers at very high background rates

Already at the LHC design luminosity of $10^{34}/\mathrm{cm}^2$ s, the ATLAS muon chambers have to cope with unprecedentedly high neutron and γ ray background rates of up to 500 Hz/cm^2 in the forward regions of the inner and middle endcap layers. At a high-luminosity upgrade of the LHC, the background rates are expected to increase by up to an order of magnitude.

It has been demonstrated [1-3] that the Monitored Drift Tube (MDT) chambers, in combination with the trigger chambers, provide robust and efficient pattern-recognition in high-background environment. However, for the very high occupancies of the drift tubes to be expected at SLHC in the forward regions of the muon spectrometer, the muon reconstruction efficiency of the present detectors will deteriorate significantly [4-6] compromising the physics goals.

In the highest-background regions covered by MDT chambers in the endcaps of the muon spectrometer, the detection efficiency of individual drift tubes of 30 mm diameter will decrease from 94% at the nominal background rate of 100 Hz/cm^2 to 50% at 10 times the nominal background rate (corresponding to 30% occupancy) for the standard deadtime setting of the readout electronics of 800 ns. For the minimum deadtime setting of 200 ns, the drift tube efficiency degrades only to 70% [3], but higher readout bandwidth is required. Consequently, the muon reconstruction efficiency in these regions of the spectrometer would decrease from about 97% to 65% or 88%, respectively.

An obvious possibility to increase the efficiency of the drift-tube chambers while retaining their good pattern recognition capabilities is to reduce the diameter of the tubes. Not only will the occupancy be reduced proportional to the maximum drift time, but also the number of tube layers fitting in the same available volume can be increased. A simple estimate using the space-to-drift time relationship of the MDT chambers shows that by reducing the tube diameter from presently 30 mm to 15 mm, for example, the maximum drift time and, therefore, the occupancy will be reduced by a factor of about 200 ns/700 ns $\approx$ 0.3.

The number of tube layers in a chamber could be doubled improving pattern recognition efficiency and chamber resolution. The effect of space charge fluctuations which deteriorate the drift-tube resolution at high rates mainly for larger drift radii > 7.5 mm [4-6] is significantly reduced. At 10 times the nominal background rate, the drift tube resolution is about 120 µm for

30 mm and 140 μm for 15 mm diameter tubes at equivalent operating conditions [5, 6]. The small degradation of the drift tube resolution for smaller tube diameter can be compensated by a larger number of tube layers per chamber such that the average chamber resolution remains essentially unchanged.

2 R&D program

We propose an R&D program towards faster precision drift-tube chambers with smaller tube diameter and a larger number of tube layers for the high-background regions of the ATLAS muon spectrometer at SLHC. We plan to start with the investigation of detectors with 15 mm diameter drift tubes. The drift-tube properties will be studied with the standard gas mixture $Ar:CO_2$ (93:7) and with possible alternative drift gases. With the standard gas mixture, the high voltage resulting in the same gas gain of $2 \cdot 10^4$ is only slightly lower for 15 mm than for 30 mm diameter tubes, 2760 V instead of 3080 V.

The main challenge for the chamber design is a robust scheme with good HV stability for the gas, signal and ground connections to the drift tubes in a 4 times denser package than before and for up to 2 times 8 tube layers. New front-end electronics boards will have to be developed.

We intend to build a prototype chamber for a test at high rates in the new Gamma Irradiation Facility at CERN in 2008. The test will first be performed with the present ASD and mezzanine cards. Development of new readout electronics optimized for higher rates is also envisaged (see also [7]) and will be tested with a prototype chamber in the next step.

References

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