The experience of the ATLAS muon spectrometer shows that drift-tube chambers provide highly reliable precision muon tracking over large areas. The ATLAS muon chambers are exposed to unprecedentedly high background of photons and neutrons induced by the proton collisions. Still higher background rates are expected at future high-energy and high-luminosity colliders beyond HL-LHC. Drift-tube detectors with 15 mm tube diameter (30 mm in ATLAS) and improved readout electronics optimized for high rate operation have been developed for such conditions. Several full-scale chambers have been constructed with unprecedentedly high sense wire positioning accuracy of better than 10 micron. The chamber design and assembly methods have been optimized for large-scale production, reducing considerably cost and construction time while maintaining the high mechanical accuracy and reliability. Tests at the Gamma Irradiation Facility at CERN showed that the rate capability of sMDT chamber is improved by more than an order of magnitude compared to the ATLAS chambers as space charge effects are strongly suppressed and operation with minimal electronics dead time becomes possible. In order to further increase the high rate performance, the read-out electronics has been improved.

**Abstract**

The experience of the ATLAS muon spectrometer shows that drift-tube chambers provide highly reliable precision muon tracking over large areas. The ATLAS muon chambers are exposed to unprecedentedly high background of photons and neutrons induced by the proton collisions. Still higher background rates are expected at future high-energy and high-luminosity colliders beyond HL-LHC. Drift-tube detectors with 15 mm tube diameter (30 mm in ATLAS) and improved readout electronics optimized for high rate operation have been developed for such conditions. Several full-scale chambers have been constructed with unprecedentedly high sense wire positioning accuracy of better than 10 micron. The chamber design and assembly methods have been optimized for large-scale production, reducing considerably cost and construction time while maintaining the high mechanical accuracy and reliability. Tests at the Gamma Irradiation Facility at CERN showed that the rate capability of sMDT chamber is improved by more than an order of magnitude compared to the ATLAS chambers as space charge effects are strongly suppressed and operation with minimal electronics dead time becomes possible. In order to further increase the high rate performance, the read-out electronics has been improved.

**Limitation of Present sMDT Read-Out Electronics**

- Bipolar shaping used to guarantee baseline stability at high rates
- Disadvantage: long overshoot at the end of each signal
  ⇒ Effectively higher threshold and increased dead time for subsequent hits
- Want to operate with short dead time to maintain high efficiency at high rates
  ⇒ strong influence of undershoot

**Solution: Shaping Circuit With Baseline Restoration**

- High bandwidth (700 MHz) transimpedance amplifier (PreAmp)
- Discrete bipolar shaping circuit (2 filter stages) with baseline restoration (BLR)

**Application of Baseline Restoration on sMDT Muon and Gamma Pulses**

- Due to the discrete circuit, the amplified signal before and after the signal shaping can be measured in parallel
- Baseline restoration leads to a clear suppression of the bipolar undershoot
- The diode used in the baseline restorer causes a slightly smaller pulse amplitude compared to shaping without baseline restoration

**sMDT Design**

- sMDT chamber design and assembly procedures optimized for mass production
- Simple and cheap drift tube design with high reliability
- Special plastic materials selected to prevent outgassing and cracking
- Industrial standard Al tubes
- Wire positioning accuracy better than 10 μm

**sMDT Chamber Construction**

- Semi-automated drift-tube production and chamber assembly take place in a air-conditioned clean room
- Automated testing of tube leakage rate, leakage current and wire tension
- 2 sMDT chambers already installed in the ATLAS detector
- Additional 12 (16) sMDT chambers under construction until 2016 (2018)

**Bibliography**