Ageing studies on small-strip Thin Gap Chambers for the New Small Wheel

The ATLAS Detector Upgrade

The LHC will deliver beams to the ATLAS detector with a center of mass energy of 13-14 TeV and instantaneous luminosities up to $7 \times 10^{34}$ cm$^{-2}$s$^{-1}$. The end-cap detectors in the small wheel will be replaced during the Phase-1 upgrade (2019-2020). The New Small Wheels (NSWs) will give tracking resolution better than 100 µm/plane and an angular resolution of 1 mrad at the trigger level. The implications of the NSWs for muon reconstruction and triggering are:

- Momentum resolution better than 15% for muons with $p_T \sim 1$ TeV. The performance will not degrade for higher background rates.
- Significant rejection of fake muons originating from the activation of material in the end-cap toroid. The NSWs will allow to maintain similar $p_T$ trigger thresholds to Run 2 while having higher background rates.

Small-strip Thin Gap Chambers

The small-strip Thin Gap Chambers (sTGCs) will be used with MicroMegas (MM) detectors in the NSW. The sTGCs are gaseous wire chambers with two cathode planes at a distance of 1.4 mm from the wire plane. The sTGC chambers uses a mixture of 45% n-pentane and 55% CO$_2$ and will operate at a voltage of 2.8 kV.

Test stand setup

A prototype sTGC chambers measuring 10 cm x 20 cm was used to test the signal quality after a total accumulated charge of more than 10 C/cm. This radiation dose is equivalent to more than 150 LHC years.

A gas mixture of 45% n-pentane and 55% CO$_2$ was made by bubbling CO$_2$ through liquid n-pentane in a bubbler held at 17 C. The CO$_2$ flow rate was controlled and three flow rates were studied. The potential between the wire and cathode planes was set to 3 kV. A 10 mCi Strontium-90 beta source was placed on top of a collimator, irradiating a total of 5 anode wires and inducing a current of ~3.7 µA.

The signal from the anode wires was directly read out and integrated in a time window of 40 ns.

The ageing effect would manifest as a decrease in the integrated charge. In order to account for changes of the integrated charge due to environmental effects, the temperature and pressure were monitored. In addition to reduce humidity the chamber was enclosed within an air-tight vessel with a constant flow of nitrogen gas.

Ageing phenomenon

Long term radiation exposure can cause a degradation of a gaseous detectors performance. Ionization produces free radicals which eventually recombine with the original molecules. These molecules can deposit on the electrode surfaces and can cause a modification of the electric field, excessive currents and sparking. Collectively these effects would manifest as a decrease in the integrated charge from a decrease in the gas gain. This process is known as ageing.

The ATLAS muon end-cap detectors are expected to be exposed to 1 C/cm$^2$ of accumulated charge during the 15 years of operation in Run 3 and beyond. Therefore it is important to study the long term effects of radiation exposure on sTGC detectors.

Results

No signs of ageing were found in any of the three different flow rates.

- Gas flow rates of 10.0, 5.0 and 2.5 cc/min were tested
- Integrated charge was found to be constant as a function of time, up to 4500 h of data taking for the 2.5 cc/min run!
- Chemical analysis of the irradiated wires shows deposits of carbon and oxygen enriched molecules adhered to the anode wires.

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