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The Upgraded Microstrip Silicon Sensor Characterisation Facility of the University of Sheffield

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The ATLAS experiment at the LHC is undergoing a major upgrade to handle the higher collision rate that will be provided by the High-Luminosity LHC. A major component of the ATLAS Phase-II upgrade is the Inner Tracker, an all-silicon detector featuring novel n⁺-in-p microstrip sensors. Miniature sensors implementing this design are tested for their radiation tolerance at the upgraded characterisation facility of the University of Sheffield. After the sensors irradiation, charge collection efficiency and cluster size measurements, taken with the ALiBaVa system utilising β-radiation, quantify their operational robustness. A review of the facility upgrade along with preliminary results is presented.

Summary

The ATLAS detector at the Large Hadron Collider (LHC) at CERN is undergoing a major upgrade to allow it to withstand the higher collision rate that will be delivered by the upgraded High-Luminosity LHC (HL-LHC) 1, which is going to increase the instantaneous luminosity by a factor of 10. The extreme radiation environment requires a replacement of the entire Inner Detector by a new all-silicon tracker consisting of pixel and microstrip sensors, the Inner Tracker (ITk) 2. Fluences of approximately 10ˆ15 1 MeV Neq/cm2 are expected at the inner layer of the strip sensors after about a decade of operation 2. Such a high radiation dose seriously damages the crystal lattice of the microstrip sensor design which is currently used for the ATLAS Semi-Conductor Tracker and comprise of p-strips implanted on n-type silicon bulk (p-in-n). Therefore, for the ITk n+-in-p type sensors are to be used. These sensors are intrinsically more radiation-tolerant and have a number of further virtues: operation capability under partial depletion as there is no radiation-induced type inversion and larger signal generation as they collect electrons with smaller trapping probability than holes. Miniature sensors of the latter design, named ATLAS12 [3], featuring the above advantages are currently under study at the characterisation facility of the University of Sheffield (UoS). The sensors are first irradiated at the Birmingham Irradiation Facility [4] using a 0.5 µA 27 MeV proton beam delivered by an MC40 cyclotron and subsequently transferred, in a cold environment to avoid any annealing, to the UoS for characterisation of their performance. The UoS has been into the business of silicon sensor characterisation the last a few years using the ALiBaVa readout system [5] which is based on an analogue Beetle ASICs clocked at 40 MHz and utilises penetrating β-rays. However, in 2016 the whole facility was upgraded and now features an improved experimental setup in a brand-new cleanroom. A new 90Sr radioactive source and a revised triggering unit, using two plastic scintillators plugged into photomultipliers in coincidence to reduce the number of fake triggers have been implemented. The control of the environmental conditions have been improved using a more powerful fridge, able to reach temperature down to -30 ℃, and N2 gas to retain low levels of humidity. The poster summarises the upgrades and presents commissioning measurements of the new facility. In particular, charge collection efficiency and cluster size measurements, as function of the bias voltage applied and for ATLAS12 sensors irradiated at different fluences, have been conducted. These are compared with un-irradiated sensors to gauge the performance of the irradiated ones and evaluate their potential to withstand the harsh radiation conditions at the HL-LHC. Generally the results found in agreement with the ones from a similar facility at the University of Birmingham [6] and point towards a satisfactory performance of the sensor design.

[3]: Nucl.Instrum.Meth. A765 (2014) 80-90

[4]: Nucl.Instrum.Meth. A796 (2015) 80-84

[5]: DOI: 10.1109/NSSMIC.2008.4775030
[6]: JINST 12 (2017) no.03, C03075

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