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Characterisation of the MC40 cyclotron irradiation line at the University of Birmingham

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The MC40 cyclotron at the University of Birmingham is routinely involved with proton irradiations for several detector R&D projects. For the majority of these irradiations, a 27 MeV proton beam is delivered at a current of 200 nA, being able to supply fluences of a few 10^{15} n_{eq}/cm^2 in one day. The proton energy at the target and the corresponding hardness factor have been previously determined to be 24 MeV and 2.2, respectively. Following several maintenance works, a revision of the MC40 R&D irradiation line is important to assess the consistency in the performance since the last evaluation.

The two major focuses of the ongoing characterisation of the cyclotron is the dosimetry and an updated measure of the hardness factor. The proton dosimetry is performed using nickel foil and the beam energy incident on the foil is an important parameter given the energy dependant cross-section. To estimate this, a Geant4 simulation of the cyclotron irradiation line was established with the ability to profile the beam energy as it traverses the setup. Beam profile simulations is compared to measurements at the facility with gafchromic film. The hardness factor is determined via measurements of the leakage current in post-irradiated silicon diode structures.

Aside from understanding recent performance, these tests of the cyclotron also serve to better understand a recurring feature in ATLAS inner tracker (ITk) strip sensor test chips irradiated using the cyclotron. Specifically, the interstrip resistance of the interdigitated structures has consistently fallen under the quality assurance specifications. An investigation has been performed with test chips irradiated to fluence points in the range 1 x 10^{14} n_{eq}/cm^2 to 2 x 10^{15} n_{eq}/cm^2 at beam energies of 27 MeV and 20 MeV. The difference in beam energies provides a different TID per unit of proton fluence and the overall ratio of ionising to non-ionising damage delivered to the samples should differ significantly. The measurements of these interdigitated structures allows the interplay between ionising and non-ionising damage to be investigated.

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