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The Effect of radiation on the spatial resolution of a novel proton range detector for use in proton Computed Tomography

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Dr Tony Price, Prof Stuart Green, Dr Spyros Manolopoulos, Prof David Parker on behalf of the PRaVDA Consortium

The recent expansion in particle based radiotherapy worldwide is coupled with an increased demand for research in the area to improve cancer treatments. The goal of the Proton Radiotherapy Verification and Dosimetry Applications (PRaVDA) Consortium is to develop a solid state device with the capability of monitoring the particle beam during patient treatment together with a capability to perform proton Computed Tomography (pCT) scans of the patient.

In order to acquire a pCT scan the residual energy of each individual proton must be measured. PRaVDA have designed a device which uses large scale CMOS sensors to track the protons and measure their range after the patient. Previous attempts at measuring the residual range of the protons using scintillators have been hampered by the requirement to have a low proton current in the device. The technology choice for the PRaVDA device means it will be able to acquire data at an increased proton beam current.

The maximum possible proton current is set by the devices ability to distinguish between individual protons. The device's performance is expected to degrade with radiation damage. Hence there is a requirement for large area pixelated CMOS detectors which are resistant to radiation damage. The THORe sensor is a test CMOS chip with various radiation resistant architectures. Here we will present results on its performance following irradiations at different dose levels with 36 MeV protons from the Scanditronix MC40 cyclotron at the University of Birmingham. The device ageing with increasing levels of radiation damage will be evaluated by measuring the modulation transfer function (MTF), noise power spectrum (NPS), and signal to noise ratio measurements. The result of the THORe sensor irradiations will influence the design of PRAVDA's CMOS sensor. Moreover, because THORe contains a similar architecture to the one envisaged for PRAVDA's sensor, it will be possible to estimate the maximum beam current that could be detected in the PRaVDA range telescope before the onset of track ambiguities and similar issues that could affect the device's performance at high rates and thus impact on the quality of the pCT scan.

Primary author: Dr PRICE, Tony (University of Birmingham)

Co-authors: Prof. PARKER, David (University of Birmingham); Dr MANOLOPOULOS, Spyros (University Hospital Coventry); Prof. GREEN, Stuart (University Hospital Birmingham)

Presenter: Dr PRICE, Tony (University of Birmingham)

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