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The radiation induced attenuation of specific single-mode and multi-mode optical fibres below -20℃ exposed to full HL-LHC doses at a dose rate of 1 kGy/hr

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The Versatile Link (VL) project is developing a high-speed optical link for the HL-LHC. 850 nm VCSELs are more radiation-hard than 1310 nm EELs. Previous tests on multimode fibres at -25℃ at 27 kGy/hr showed unacceptable radiation induced absorption. We have developed a CO2 cooling system which will be used in late June to irradiate cold fibres at low dose rates (1 kGy/hr) to the full HL-LHC dose (300 kGy). These results will determine the viability of an 850nm VL solution with fibres within the cold volume.

Summary 500 words

The Versatile Link (VL) is a collaborative project between ATLAS and CMS. It is designing high-speed optical links for use at HL-LHC, for which the radiation levels will be an order of magnitude higher than at LHC. The VL is being developed in two flavours to operate at either 850 nm or 1310 nm. The 850 nm version uses VCSELs for the optical source, whereas the 1310 nm version uses EEL (although new long-wavelength VCSELs are also being investigated). The main advantage of the 850 nm version is the superior radiation tolerance of the VCSELs compared to the EELs (or the 1310 nm VCSELs). However, Radiation Induced Attenuation (RIA) in the fibre is greater at 850 nm than at 1310 nm, hence the need to develop solutions for both wavelengths.

Suitable candidate fibres for both multimode (MM) operating at 850 nm and singlemode (SM) operating at 1310 nm have been identified and irradiated to beyond the full HL-LHC dose with excellent results for the RIA, enabling these fibres to be qualified for warm operation. However, fibres inside the tracking detectors at HL-LHC will have to operated cold (around -25℃). Earlier research has indicated that the RIA for fibres can be very significantly enhanced at these low temperatures because of the reduction in the thermally induced annealing.

We have previously tested the SM and MM fibres that passed the warm RIA test, at cold temperatures. Two candidates for SM fibre showed very little RIA up to the full HL-LHC dose of 300 kGy(Si), and can be considered as qualified for operation inside the cold volume of a tracker at HL-LHC. Both of the MM fibres (and one of the SM fibres) which passed the warm RIA tests showed unacceptably large values of RIA for cold operation. However, we have previously performed cold RIA tests to lower total doses, which have indicated that there is a very significant dose rate dependence. The dose rate used for these earlier tests (27 kGy(Si)/hour) was orders of magnitude higher than that expected at HL-LHC. Therefore it is quite possible that the fibres that failed the cold operation, high dose rate test, might pass a test at a lower dose rate.

We have developed our CO2 blow-off cooling system so that it can now run for a period of 13 days. This will allow us to perform a lower dose rate study at RITA, a gamma irradiation facility at SCK. The dose rate will be around 1 kGy(Si)/hour and the run will be long enough to achieve the full HL-LHC dose. These tests will be carried out at the end of June. These important results will be presented to the workshop and will determine the viability of an 850nm VL solution with fibres within the cold volume of an inner tracker at HL-LHC.

Primary author: Mr HALL, David (University of Oxford)

Co-authors: Dr WEIDBERG, Anthony (University of Oxford); Dr HUFFMAN, Todd (University of Oxford)

Presenter: Mr HALL, David (University of Oxford)

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