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Irradiation Studies of the ATLAS Inner Detector Opto-Electronic Readout System for SLHC

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The readout system of the ATLAS inner detector for SLHC will need to cope with ten time's higher radiation doses than the current ATLAS inner detector readout system. It is an open question of whether the current opto-electronic readout system could be used at SLHC. This is a critical question for the detector design as it will have a major influence on the layout of the readout. We have started to irradiate VCSEL lasers, PIN diodes and optical fibres up to the levels expected at SLHC and are measuring the device-performances. The results of these irradiations tests are summarized.

Summary

Plans are being formulated at CERN for a luminosity upgrade to the Large Hadron Collider (LHC) machine. The LHC upgrade (SLHC) is being designed to increase the luminosity from 1034cm-2s-1 to 1035cm-2s-1. The expected time-scale would be around year 2015. The fluences at the SLHC will be 10 times higher than at LHC. For radii greater than 20 cm the expected fluence is 1015 hadrons/cm2. It is not clear, if the current opto-electronic components of the inner detector readout system are able to cope with this challenging radiation environment of SLHC.
Previous radiation tests have shown that the opto-electronic components (VCSEL lasers, PIN diodes and optical fibres) can survive 10 years of LHC operation. Radiation tests by the ATLAS Pixel detector group have demonstrated that these components can survive fluences and doses up to a factor of two higher than the SCT values.
Therefore there is an open question of whether this type of opto-electronics could be used on the upgraded SCT detector at the SLHC. This is a critical question for the design of this detector as it will have a major influence on the layout of all the readout services and therefore needs to be answered before the detector design can advance very far.
We are presenting the results of irradiation tests of Truelight VCSEL lasers, Centronic PIN-diodes, and SIMM fibres up to SLHC fluences.
Our previous radiation tests have shown that VCSELs and PIN diodes suffer from bulk damage but are insensitive to surface charge effects. These tests have also demonstrated good agreement with the NIEL scaling hypothesis. Hence, the first irradiation tests for SLHC we plan to be perform at the Ljubljana neutron reactor using NIEL scaling as a first step. We intend to confirm these results with other beams in the future.
For the irradiation studies of VCSEL lasers we are planning to have several cycles of irradiation and annealing as we had demonstrated that nearly full recovery of the VCSEL performance can be achieved with injection annealing (i.e. running the VCSELs with a DC current of 10 to 20 mA).
The radiation damage mechanism in fibre is due to creation of "colour centres"in the electronic levels of the molecules. This is then only sensitive to ionising dose, so can be most conveniently studied with a gamma source. We need a high dose rate gamma source and a large area source to give a uniform dose over the sample. A suitable facility is the INER in Taiwan, which we will use to irradiated the fibres up to 100 Mrad. We will determine the induced attenuation of the fibres during irradiation.
We are presenting in this paper the results of the irradiation tests of the VCSEL lasers, PIN diodes and fibres up to SLHC doses and show the performance degradation

of these devices as function of radiation dose.
In the future we intend also to determine SEU cross section of the GOL driver chip and QPLL chip while operating them at 1.6 GBits/sec.

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