Contribution ID: **300** Type: **Poster**

Exploiting Charge Multiplication in Silicon Detectors for the HL-LHC

A number of measurements have recently reported a type of gain effect in silicon detectors for particle physics. This effect manifests itself in signal levels that significantly exceed expectations and in some cases even the signal charge generated by a passing MIP. The excess charge is seen in particular for heavily irradiated sensors operated at very high bias voltages. It is believed that this effect (termed "charge multiplication") originates from a local avalanche effect in the high field regions of the sensor. The charge multiplication could potentially be very beneficial within the silicon tracking systems for LHC detector upgrades, as it could at least partially compensate the severe radiation-induced signal loss of the silicon sensors. In this context we have measured the collected charge for a set of miniature silicon strip sensors of various sensor designs, and after irradiation to HL-LHC fluences. One aim of the study was to identify detector parameters that would enhance the effect. In this way, one could design detectors optimized for charge multiplication.

Another aim was to evaluate the long-term evolution of the charge multiplication effect. This is intended to test operation under realistic LHC conditions, such as exposure to extreme bias voltages for many days, bias voltage cycling, and running at very low temperature.

In our presentation, we will report on the findings from our charge multiplication study, including the design parameters that we believe enhance the measured signal. In addition, will comment on the feasibility of exploiting the charge multiplication effect in the Phase-2 LHC tracking detector upgrades.

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Track Classification: Sensors: 1b) Semiconductor Detectors