Contribution ID: **805** Type: **Poster**

Investigations on the radiation damage of the LHCb VELO: a full review

The LHCb Vertex Locator (VELO) is a silicon micro-strip detector operating extremely close to the LHC proton beams. During nominal data-taking the innermost active strips are as close as ˜8 mm to the beams.
This proximity makes the LHCb VELO
an ideal laboratory to study radiation damage effects in silicon detectors.

The analysis of charge collection efficiency (CCE) data showed that there is a correlation of cluster finding efficiency (CFE) with the distance of strip to a second metal layer routing line. The detectors are constructed with two metal layers to cover the R/ϕ strips and route the signal to the front-end chips.
A loss of signal amplitude is observed with a dependency on the distance to the routing lines. Using the Perugia n-type bulk model and the
Peltola surface damage model it is shown that up to 60\% of the charge is collected by routing lines. This is caused by trapping of the otherwise mobile electron accumulation layer at the oxide-silicon interface, causing the shielding effect on the routing lines to be reduced. The observed drop in CFE can be explained by the angular dependence of charge loss to the second metal layer. The efficiency drop as function of track radius and angle is reproduced combining 2D and 3D TCAD simulations.

A complete review of the whole history of the LHCb VELO radiation damage studies will be presented with results of run 1 and 2, as well as comparisons to TCAD simulations.

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Session Classification: Poster Session A

Track Classification: Semiconductor Detectors