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Prolonged signal pulses from silicon strip sensors showing enhanced charge multiplication

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P-type silicon strip sensors will be used as particle detectors in harsh radiation environment, as in the High Luminosity Large Hadron Collider with fluences up to $1 \cdot 10^{16}\ n_{\mathrm{eq}}/\mathrm{cm}^2$. They have been irradiated and annealed to predict their long term performance. Charge multiplication, which appears at high voltages after long annealing times, increases the n charge collection, but also leads to prolonged signals. The edge-transient current technique as well as beta-measurements were used to investigate the origin of these slow pulses. Sensors exhibiting those slow pulses showed a substantial low electric field even beyond the high field region close to the strip implants. Electrons created deep in the sensor are spreading while traveling slowly to the depletion region. All electrons reaching the high field close to the strips get multiplied and create a secondary, new broadend cloud of free holes. These holes move towards the backplane, but experience trapping and a self-screening effect and show a plasma-like behavior. Due to the low field region they introduce a slow and low signal.

The obtained results are supported by simulations and agree well with the observation of a ballistic deficit and an enlarged cluster size observed in charge collection measurement. The conclusion drawn by this study can also be extended to all semiconductor detector exploiting a severe charge multiplication while having low field regions.

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