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## Evidence of multistage charge collection in Si irradiated detectors operated as the monitors of intensive fragmented proton beams

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Charge collection in Si p<sup>+</sup>-n-n<sup>+</sup> detectors was studied in the in situ irradiation test at 1.9 K with intense 23 GeV proton beam fragmented in 400 ms spills in view of detector application as beam loss monitors in the LHC at CERN. The current pulse responses demonstrated a two-stage process of charge collection, in which, in the first stage, the current was induced by holes, and in the second, by electrons arising due to avalanche multiplication produced by holes. The data treatment and the current response shapes simulation for detectors irradiated by  $5 \times 10^{13}$  p/cm<sup>2</sup> yielded a full set of carrier transport characteristics and a signal internal gain. The charge collected in the second phase exposed a threshold in voltage for the signal rise, which verifies evolution of avalanche multiplication as the origin of the second phase and total signal amplification. In Si detector irradiated to  $2.7 \times 10^{14}$  p/cm<sup>2</sup>, a new third stage of charge collection was observed and assigned to avalanche multiplication produced by electrons reaching the n<sup>+</sup> contact and to the following drift of generated holes back to the p<sup>+</sup> contact.

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