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LGAD-based detectors for monitoring therapeutic proton beams

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Purpose. Two prototypes for beam monitoring in particle therapy are being developed based on LGAD technology, aiming at improving and enriching the performances of state-of-the-art gas detectors. The results of tests on clinical proton beams are presented.
Methods. A proton counter for online fluence beam monitoring is made of sensors featuring 3.0x0.5 cm^2, 30 strips (150 μm pitch), 50 μm active thickness, readout using 40 dB amplifiers and a 5 Gs/s digitizer. Counting inefficiencies due to signal pile-up are mitigated combining two neighboring strips counts. A 2.7x2.7 cm^2 sensor (146 strips) with dedicated front-end board, readout with FPGAs, will be the final counter at the project end. The second prototype sets two thinned sensors (70 μm total thickness, 11 strips of 2.2 mm^2 area each) in a telescope for measuring the Time of Flight (ToF) and derive the beam energy. The signals are readout through dedicated front-end boards, acquired with a 5Gs/s digitizer and processed with MALTAB. A high-precision positioning system allows changing the sensors relative distance in the telescope with 10 μm precision. The counter prototype was tested at Trento Proton Therapy Center (Italy) at different beam energies with different beam currents, while the ToF prototype was tested at both Trento and CNAO (Pavia, Italy).
Results. The error on the counting efficiency is < 1% up to a proton fluence rate of 1x10^8 Hz/cm^2 and, after pile-up corrections, 5x10^8 Hz/cm^2. A calibration procedure of the telescope prototype allows measuring the beam energy with deviations of a few hundred keV for most of the energies in the clinical range (60-230 MeV), corresponding to less than 1 mm range difference.
Conclusion. Preliminary tests of LGAD sensors segmented in strips demonstrate their capabilities as beam monitors, for both counting and beam energy measurement purposes. Future required developments will be reported.

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