Tests of thin Low-Gain Avalanche Detectors for the characterization of therapeutic proton beams.

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Abstract:

Innovative silicon sensors with moderate internal gain (Low Gain Avalanche Detectors, LGAD) are promising devices for monitoring and characterization of therapeutic proton beams, overcoming the limitations of ionization chambers typically used for these purposes. In particular, properly segmented thin LGAD detectors, thanks to their fast charge collection time (1 ns in 50 um thickness) and high signal-to-noise ratio, can be used to discriminate single ions and count the number of beam particles up to the high fluxes used in therapeutic applications and to monitor the beam profile. In addition, the excellent time resolution of LGAD devices optimized for timing applications (Ultra Fast Silicon Detectors, UFSD) allows to measure the beam energy through time-of-flight techniques,

Results of preliminary tests of 50 um thick LGAD pads and UFSD strip detectors with the proton beams of the CNAO hadrontherapy center of Pavia, Italy (proton fluxes up to 10^9 p/s, FWHM 1 cm) are presented. Waveforms collected from two aligned sensors have been analyzed to evaluate their counting and timing properties. Single beam particles are well separated and the fine time structure of the beam is resolved with nanosecond resolution. The detectors have been characterized in terms of time resolution (<50 ps for single crossing), counting linearity, pile-up probability, signal degradation

with the accumulated radiation dose. On the bases of the promising results, dedicated UFSD strip detectors have been produced and custom VLSI readout chips have been designed for therapeutic beam characterization in radiobiological applications.