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

This is the author's manuscript

Original Citation:

Availability:
This version is available http://hdl.handle.net/2318/1731929 since 2020-02-27T17:22:38Z

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Authors:

Nicolò Cartiglia – PRESENTING Author 2
Vincenzo Monaco – Author 1-2
Zahra Amadi - Author 5
Andrea Attili – Author 2
Marco Donetti – Author 3
Mohammad Fadavi Mazinani – Author 2
Federico Fausti – Author 2-4
Marco Ferrero – Author 2
Simona Giordanengo – Author 2
Omar Hammad Ali - Author 1-2
Marco Mandurrino – Author 2
Lorenzo Manganaro – Author 1-2
Giovanni Mazza – Author 2
Roberto Sacchi – Author 1-2
Valentina Sola – Author 2
Amedeo Staiano – Author 2
Anna Vignati - Author 2
Roberto Cirio - Senior Author 1-2

(1) Physics Department, Universita’ degli studi di Torino (UniTO), Torino, Italy
(2) Istituto Nazionale di Fisica Nucleare (INFN), Torino, Italy
(3) Centro Nazionale di Adroterapia Oncologica, Pavia, Italy
(4) Politecnico di Torino (PoliTo), Torino, Italy
(5) Faculty of Physics, Yazd University, Yazd, Iran

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.