Design of an innovative beam monitor for particle therapy for the simultaneous measurement of beam fluence and energy

R. Sacchi[1,2], N.Cartiglia[1], F. Cenna[1], L. Fanola[1,2], M. Ferrero[2], S. Giordanengo[1], F. Marchetto[1], V. Monaco[1,2], A. Vignati[1], M. Varasteh Anvar[1,2], R. Cirio[1,2]

[1] Istituto Nazionale di Fisica Nucleare(INFN), sez. di Torino, Torino, Italy
[2] Department of Physics, University of Torino, Torino, Italy

Purpose: Monitoring the prescribed dose in particle therapy is typically carried out by using parallel plate ionization chambers working in transmission mode. The use of gas detectors has several drawbacks: they need to be calibrated daily against standard dosimeters and their dependence on beam quality factors need to be fully characterized and controlled with high accuracy. A detector capable of single particle counting is proposed which would overcome all these limitations. Combined with a gas ionization chamber, it will allow determining the average particle stopping power, thus providing an effective method for the online verification of the selected particle energy and range.

Methods: Low-Gain Avalanche Detectors (LGADs) are innovative n-in-p silicon sensors with moderate internal charge multiplication occurring in the strong field generated by an additional p+ doping layer implanted at a depth of a few μm in the bulk of the sensor. The increased signal-to-noise ratio allows designing very thin, few tens of micron, segmented LGADs, called Ultra Fast Silicon Detectors (UFSD) optimized for very fast signal, which would be suitable for charged particle counting at high rates.
A prototype UFSD is being designed for this purpose.

Results: Different LGAD diodes have been characterized both in laboratory and beam tests, and the results compared both with those obtained with similar diodes without the gain layer and with a program simulating the signal in the sensors. The signal is found to be enhanced in LGADs, while the leakage current and the noise is not affected by the gain. Possible alternative designs and implementations are also presented and discussed.

Conclusions: Thanks to their excellent counting capabilities, UFSD detectors are a promising technology for future beam monitor devices in hadron-therapy applications. Studies are ongoing to better understand their properties and optimize the design in view of this application.