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## **Innovative thin silicon detectors for beam monitoring in particle therapy**

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**Purpose.** For beam monitoring in particle therapy, silicon detectors could overcome the limitations of ionization chambers. In particular, silicon sensors with internal gain (Ultra Fast Silicon Detectors, UFSDs) provide high signal-to-noise ratio and fast collection times ( $\sim 1$  ns in 50  $\mu$ m thickness).

A segmented sensor could allow discriminating and counting single protons up to high fluxes of therapeutic beams. Moreover, the excellent time resolution suggests using time-of-flight techniques for measuring the proton beam energy.

**Materials and Methods.** Several 50  $\mu$ m thick UFSD prototypes, both single pads or segmented in strips, doped with Boron or Gallium, and with different doping concentrations were fully characterized at the Turin university laboratory and tested on the clinical proton beam of the CNAO particle therapy facility, up to fluxes of  $10^9$  p/s.

Signal-to-noise ratio, pileup probability, internal gain and gain degradation with beam fluence were determined from the offline analysis of the collected waveforms and compared, whenever possible, to the laboratory measurements.

**Conclusions.** UFSDs are found to be a viable option for improving the qualification and the monitoring of a therapeutic proton beams. However, a careful design is necessary to avoid large pileup inefficiencies and early performance degradation