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A novel detector for 4D tracking in particle therapy

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An innovative beam monitor for particle therapy applications was developed to count single protons and carbon ions in clinical beams and was integrated with a Time-to-Digital Converter to measure particles'crossing time.

The detector exploits thin silicon sensors, which show sensitivity to single particles and fast charge collection times allowing to reach large counting rates. A 60 μm thick PiN diode and a 50 μm thick Low Gain Avalanche Diode are used for detecting respectively carbon ions and protons. The sensitive area of both the sensors is 2.7 × 2.7 cm^2, enough to cover the cross section of a pencil beam, and is segmented in 146 strips with 180 μm pitch. The readout is based on the ESA-ABACUS frontend board, developed to house six 24-channel ASICs able to discriminate particle signal pulses in a wide charge range (4-150 fC), with a maximum dead time of about 10 ns. The digital pulses produced by the discriminator are acquired by 3 Kintex7 FPGA boards implementing pulse counters for each channel. Alternatively, the digital pulses of 8 channels are acquired by the CERN picoTDC evaluation board providing the additional time measurements in time bins of 3 ps.

The measurements performed with protons and carbon ion clinical beams at CNAO (Pavia, fig.1) result in beam projections (fig.2) with a FWHM in agreement with measurements performed with gafchromic films. The proton counting efficiency shows a dependence on the beam energy because of geometric and pile-up effects (fig.3), whereas an efficiency above 90 % with lower energy dependence is found for carbon ions. Furthermore, the time measurements with the TDC allowed for the study of the difference of crossing times of consecutive particles in one strip (fig.4) which shows a time structure compatible with the radio-frequency period of the synchrotron.

Collaboration

Role of Submitter

I am the presenter

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