Contribution ID: **107** Type: **Oral**

Ultra Fast Strip silicon detectors for beam monitoring in proton therapy

Tuesday 26 February 2019 17:10 (20 minutes)

Purpose
Due to their extra advantages, solid state silicon detectors were initially used in nuclear and particle physics experiments and rapidly gained widespread applications in many different fields (space, medical, etc.). High detection precision, radiation resistance and very good time resolution are their main advantages that overcome many limitations of alternative gas detecting systems.
Low Gain Avalanche Detectors (LGAD) exploit the enhanced signal obtained through an extra doping layer in the conventional p/n junction of the silicon diode, to produce low thicknesses sensors (50μm) which have a faster charge collection (˜1 ns) and an improved time resolution of few 10's of ps under reversed bias voltage (Ultra Fast Silicon Detectors - UFSD) and are well suited for particle counting at high rates (100 MHz with efficiency > 99% in the current prototypes)

UFSDs are under study and development to be applied in particle therapy with two applications in mind: counting the particles delivered to a patient in a therapeutic beam and measuring the beam particle's energy through time-of-flight methods.
Methods
Two different designs of strip detectors have been developed at the Italian National Institute of Nuclear Physics (INFN) of Torino (Italy) in collaboration with the Bruno Kessler Foundation (FBK) of Trento, Italy, where the sensors were produced.
The first was optimized for high rate counting and was produced in two geometries: segmented in 20 short strips (length=15mm; pitch=200μm) or 30 longer strips (length=30mm; pitch=146 μm). The sensors will be read out with new version of TERA chip which was designed and developed at Turin university microelectronics lab to reach fast counting with rates up to 100MHz /channel.
Dedicated pile-up mitigation algorithms are under study and will be implemented in the FPGA where the logical pulses in output for the readout ASIC are collecting for real-time counting and analysis.
The second design was optimized, through a simulation with Geant4, in order to maximize the efficiency of coincidences for single protons passing two thinned sensors aligned to the beam, allowing to measure precisely the time of flight and hence the beam particle's energy. This led to a design with a square shape segmented in 8 strips (length=4mm; pitch=590μm).
Results
Strips sensors were characterized in the laboratory through laser test and I(V) curve studies and were also tested with therapeutic proton beams, with energy ranging from 62 to 227 MeV. Beam test results were obtained analyzing the waveforms collected using a digitizer.
The pileup inefficiency was measured by varying the beam flux and comparing the measured number of protons with the charge collected in a pinpoint dosimeter. The correction methods proposed were found operate up to an average count rate of 40 MHz, where the initial 30% counts loss was reduced to 8%.
The new UFSD sensors designed for energy measurement have not been tested on beam yet. However, Energy measurements using UFSD pads showed possibility to estimate beam energy using time of flight techniques with a statistical error as small as 0.4% at the highest beam energy and detectors at about 1m distance.
Conclusions
Based on the preliminary results, UFSDs are found to be promising for beam qualification and monitoring in Particle Therapy. The aim of this contribution is to report results of lab and beam tests using UFSD strip sensors with a therapeutic proton beam.

Primary authors: Ms BABENKO, Zhanna (Physics Department of the University and INFN, Torino, Italy); BOSCARDIN, Maurizio (FBK Trento); CARTIGLIA, Nicolo (Universita e INFN Torino (IT)); DONETTI, Marco (Fondazione CNAO); Dr FAUSTI, Federico (INFN Torino (IT)); FERRERO, Marco (Universita e INFN Torino (IT)); FICORELLA, Francesco (FBK); GIORDANENGO, Simona (Istituto Nazionale di Fisica Nucleare); HAMMAD ALI, Omar (INFN - National Institute for Nuclear Physics); MANDURRINO, Marco (INFN); Prof. MAS MILIAN, Felix (Universidade Estadual de Santa Cruz, Brasil); MONACO, Vincenzo (Universita e INFN Torino (IT)); Dr PATERNOSTER, Giovanni (FBK); SACCHI, Roberto (Universita e INFN (IT)); Ms SHAKARAMI, Zahra (Physics Department of the University and INFN, Torino, Italy); SOLA, Valentina (Universita e INFN Torino (IT)); STAIANO, Amedeo (Universita e INFN Torino (IT)); VIGNATI, Anna (INFN - National Institute for Nuclear Physics); CIRIO, Roberto (Universita e INFN Torino (IT))

Presenter: HAMMAD ALI, Omar (INFN - National Institute for Nuclear Physics)

Session Classification: Session 7: LGAD (1)