Readout Electronics for a Proton Computed Tomography Apparatus

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The spatial accuracy of proton therapy is presently limited by the uncertainty in stopping power distribution, which is calculated from the photon attenuation coefficients measured by X-ray tomography. The goal of this experiment, supported by INFN (PRoton IMAgin experiment) and MIUR (PRIN 2006), is to develop a proton computed tomography (pCT) apparatus suitable to define electron density maps by measuring the protons energy loss along their path through the tissues. The main problem in pCT is that protons do not move along straight lines across the medium, because of multiple Coulomb scattering. It is thus necessary to determine the most likely path of each proton by measuring its entrance and exit angle, entrance and exit position and residual energy. Our collaboration aims to develop a pCT system by using 4 pairs of silicon single sided microstrip detectors (each with 256 channels and 200 μm pitch) for tracking and a segmented YAG:Ce crystal as calorimeter. The target proton rate is 1MHz, in order to collect data within a time of the order of 1s, suitable to clinical demands. The analog outputs of the readout electronics coupled with the crystal are acquired by a PCI digital oscilloscope and stored within its on-board memory. These signals are used to generate the digital trigger of the system. The trigger forces the acquisition of data from silicon detectors, which are read out by a set of 8 32-channels ASICs, developed within the collaboration. The ASIC includes a charge sensitive amplifier, a shaper and a comparator suitable to produce a digital output. ASIC outputs are latched by the input stage of a FPGA to be sampled at every trigger event. In the first version of the acquisition procedure, calorimeter and tracker data will be transferred from the on-board RAM memories to the PC for data analysis at the end of the measurement session. More sophisticated schemes could be implemented in future versions due to the versatile architecture of the system.