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AUTHOR(S) NAME(S) & EMAIL(S): maria giuseppina bisogni (bisogni@pi.infn.it)
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PU = Public N/A IN THE INFIERI CONTEXT
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Abstract:

In the context of Positron Emission Tomography (PET), the Medical Physics group of the University of Pisa, achieved studies on the feasibility of a L1 trigger for in-beam PET.

Work description:

The "in-beam PET" project aims at the development of instruments and techniques for the monitoring of the dose delivered to a patient during an hadron-therapy treatment so as to improve the quality assessment of the therapy itself.
The key characteristic of the in-beam PET system with respect to standard PET instrumentation is its superior capability of operating at high single photon rates without incurring in detection paralization. To this aim fast data acquisition technology and smart coincidence sorting algorithms based on FPGA as developed in the INFIERI framework play a key role in the project.

The project aims at the construction of a dual-head, modularized acquisition system for in-beam monitoring, based on custom ASICs for L1 trigger and signal processing. The system features two planar panels positioned laterally to the patient each 10 cm x 20 cm wide. Each panel will be made by 2 x 4 detection modules (Figure 1,a). Each module is composed of a pixelated LFS scintillator matrix 16 x 16 pixels, 3 mm x 3 mm crystals, pitch 3.125mm, for a total sensitive area of 5 cm x 5 cm. Four arrays of SiPM (8 x 8 pixels) are coupled one-to-one to each LFS matrix (Figure 1,b). Data acquisition will be accomplished with a distributed processing tree made of:

-A front-end level consisting of 4 ASICs for L1 trigger and the biasing circuitry

-A read-out and pre-processing level, implemented by distributed low-end FPGAs, one per module

-A data collection and discrimination level, based on a centralized high-end FPGA

-A host system for data storage and analysis.

A schematic diagram of the overall acquisition architecture is reported in Figure 1, a. The front-end ASICs will manage 64 SiPM channels each and will provide the fundamental characteristics of each incoming high-energy photon to the FPGA onboard (Figure 1, c).

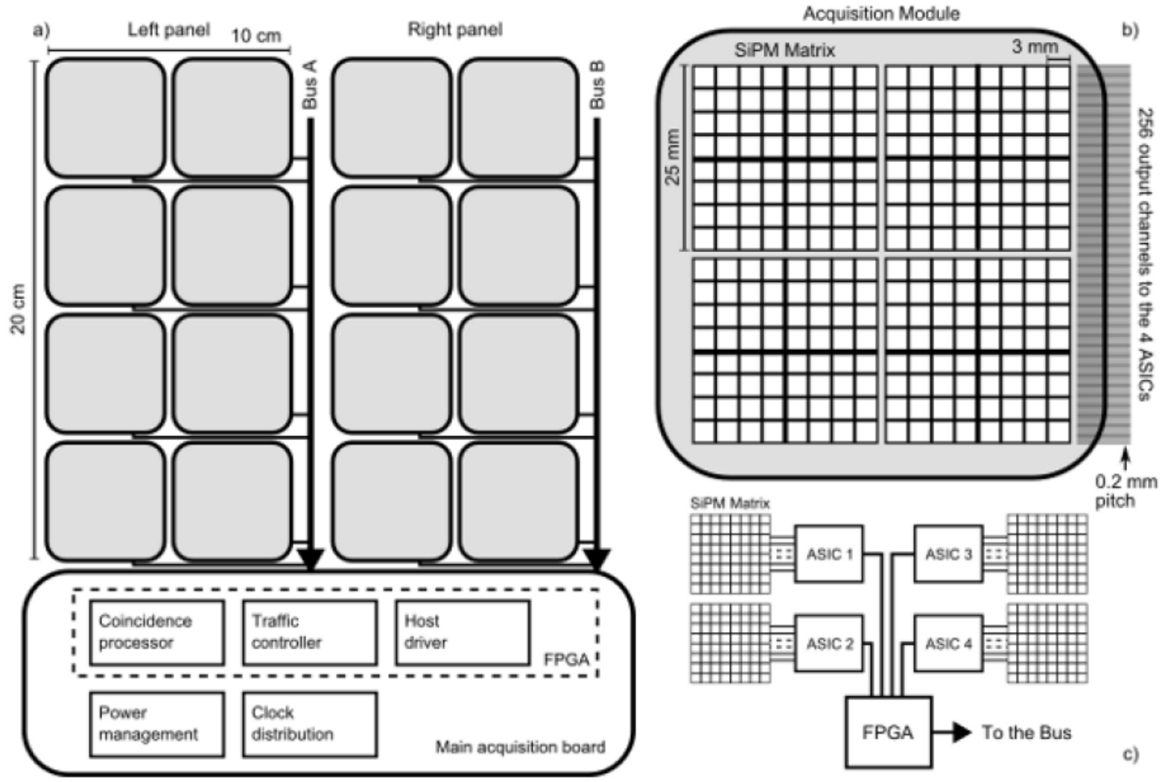

Figure 1 Simplified scheme of the PET architecture. a) Overall system connections including the modular detector plates (10 cm x 20 cm) and the main acquisition board. b) Geometrical diagram of the acquisition module. The module measures 5 cm x 5 cm. c) Main interconnections within the acquisition module.

In order to be able to sustain high input photon rates it is important to optimize the data bandwidth usage between the detector modules, the main acquisition board and the host server. It is therefore important to extract as much information as possible at the earliest acquisition stages and carry on only the useful data through the acquisition chain. This includes photon time to digital conversion (TDC), pixel identification and energy correction, which will performed by the FPGAs distributed among the detector modules.

Characterization data are produced for every single photon and transmitted to the central FPGA for coincidence discrimination. Considering that the input single rate will be of the order of million photons per detector plate (output data rate 1 MHz per detection module) and that a typical event data packet is of 12 bytes (6 for the timestamp, 2 for the energy and 2 for the pixel identifier, 2 bytes are free) the estimated data throughput at each bus is of the order of 12 megabytes per second, which is well below the limits of commercial quality components.