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Hamlet: High bAndwidth coMmercial digitizer for hostile EnvironmenT

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Hamlet has developed a modular gamma detector that can be operated in a hostile environment. The system is based on a matrix of CsI crystals readout with thermalized SiPM, and a digitizer board designed for the Mu2e electromagnetic calorimeter and customized for this project. Front-end electronics is based on the MUSIC chip, a custom VLSI component developed by the University of Barcelona. The detector is completely modular and up to 20 crystal detectors can be digitized in parallel with a sampling frequency of 200 MHz. Both the detector modules and the digitizer have been qualified against radiation and magnetic field.

Summary (500 words)

Gamma detectors with spectrometric capabilities find applications in many fields, including industry and safety. In specific cases, the instrumentation has to be designed following high reliability criteria and qualified to operate in harsh conditions, which can be made hostile by the presence of high levels of ionizing and non-ionizing radiation as well as magnetic fields. Systems with satisfactory characteristics are not readily available on the market and Hamlet aims to fill such technological gap. Possible end users include the aeronautical industry, and the medical or the accelerator sectors. We recently developed a 20-channel, 200 MHz 12-bit digitizer board for the Mu2e experiment at Fermilab that we qualified to operate up to a Total Ionizing Dose of 12 krad, a neutron fluence of 10E11 n / cm2 @ 1 MeVeq (Si), 1T magnetic field and a 10-4 Torr level of vacuum. We used a modified version of the digitizer as a starting point for the new system and one scintillating crystal as a radiation detector for each digitizer channel. The crystal scintillation light is detected with a matrix of 8 6x6 mm2 silicon photomultiplers produced by Broadcom. A custom front-end chip, produced by ICCUB (a University of Barcelona spin-off) sums, shapes and amplifies the SiPMs signal. We used the same 3x3x18 cm3 Cesium Iodide crystals employed by Mu2e which are particularly suitable for that experiment for their radiation hardness. A custom designed mechanical structure hosts the crystal and the front-end electronics. It has a square section with a side of 3.8 cm, so that modules can be piled to form a 5x4 matrix or positioned as required by the specific application. Each module includes a Peltier cell and a temperature sensor to thermalize the SiPM matrix and maintain a stable gain. SiPM power can be remotely regulated at the percent level. The digitizer can transmit data through several interfaces, like a 5Git/sec optical fiber or a slower but highly reliable CAN serial bus. ADCs are handled by an FPGA from Microsemi (Polarfire 300T). The firmware allows to compress and transmit the digitized pulses above a programmable threshold as raw data over the fiber, as well as estimate and transmit the pulse parameters (pulse height and arrival time) through slower interfaces. The detector, front-end electronic, the modified digitizer and the qualification tests are described.

Primary author: SPINELLA, Franco (Universita & INFN Pisa (IT))

Co-authors: PEDRESCHI, Elena (Universita & INFN Pisa (IT)); Dr TAFFARA, Alessandra (INFN); Prof. CIOLINI, Riccardo (Universita' di Pisa & INFN); DONATI, Simone; GIUSTI, Valerio; MORESCALCHI, Luca (INFN - Pisa); PASCIUTO, Daniele

Presenter: SPINELLA, Franco (Universita & INFN Pisa (IT))

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