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FERS-5200: a distributed Front-End Readout System for multidetector arrays

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Modern physics experiments usually rely on very big experimental setup where it is possible to find a wide variety of detectors: silicon microstrip trackers, plastic scintillator calorimeters, LAr cryostats readout by a Time Projection Chamber, spectrometers composed of several drift tubes and resistive plate chambers. Moreover, other large and medium scale setups for the search of neutrinos and Astro-particles use thousands of scintillation detectors read out by photomultipliers or SiPMs. Nowadays, waveform digitizers and/or ASIC-based front-end cards are well-established readout electronics to build a reliable system hosting many readout channels. The FERS-5200 is the new CAEN Front-End Readout System, answering the challenging requirement to provide flexibility and cost-effectiveness in the readout of huge detector arrays. FERS-5200 is a distributed and easy-scalable platform integrating the whole readout chain of the experiment, from detector front-end to DAQ. It is based on compact ASIC-based front-end cards integrating A/D conversion and data processing, which can be ideally spread over a large detector volume without drawbacks on the readout performance. Synchronization, event building and DAQ is managed by a single Concentrator board, capable of sustaining thousands of readout channels. Using the appropriate Front-End, the solution perfectly fits a wide range of detectors such as SiPMs, multi-anode PMTs, GEMs, Silicon Strip detectors, Wire Chambers, Gas Tubes, etc, thus matching the requirements of different applications.

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1.Introduction

In the traditional approach to readout systems for physics, the detectors are usually interfaced to close-by Front-End Preamplifiers and long cables bring analog signals to the readout electronics (ADC, TDC, etc.), with A/D conversion, online data processing and communication interfaces concentrated in racks. Given the recent developments in the field of detectors technology, physics experiments are moving in the direction of using large arrays of detectors, to be read out with more compact and more cost-effective electronics. In particular, detectors such as SiPMs, MA-PMTs, GEMs, Silicon Strips, Gas Tubes, etc., are becoming more and more widely used to build huge experimental setups. CAEN, in collaboration with Nuclear Instruments S.r.l.s., has developed a new platform, called FERS-5200, to fit the requirements coming from this type of experiments. FERS-5200 is a distributed and easy-scalable system, where each Front-End unit is a small card that can play different roles such as:

- a traditional analog spectroscopy chain housing 32 or 64 channels with preamplifier, shaper, discriminator, A/D converter
- a digital front-end like a Time-to-digital converter (TDC) or a trigger logic board
- a Switched capacitor array

Each FERS card features also the synchronization capability, local memory and the readout interface. Multiple FERS units can be daisy-chained through a special protocol (TDlink) on optical fiber bringing slow control, readout and synchronization at once. Up to 16 FERS units can be daisy-chained and readout via a single link. Thanks to the Concentrator Board DT5215, hosting 8 TDLinks, it is possible to build a network (FERSnet) consisting of up to 128 FE cards and further extension of the system is possible by synchronizing more than one Concentrator Board (see Fig.1). FERS is designed to be a flexible platform: keeping the same back-end (that is readout architecture and interface), different types of Front-End will be developed to fit a variety of detectors [1]. Typically, the front-end is based on ASIC chips that allow for high channel density and cost-effective integration into small size and low power modules. The first developed unit is the A5202, that uses the CITIROC 1A chip produced by Weeroc SaS for SiPM readout [2]; in the next future there will be a complete line of FERS units using different ASICs or even preamps made of discrete components to match other type of detectors' requirements.

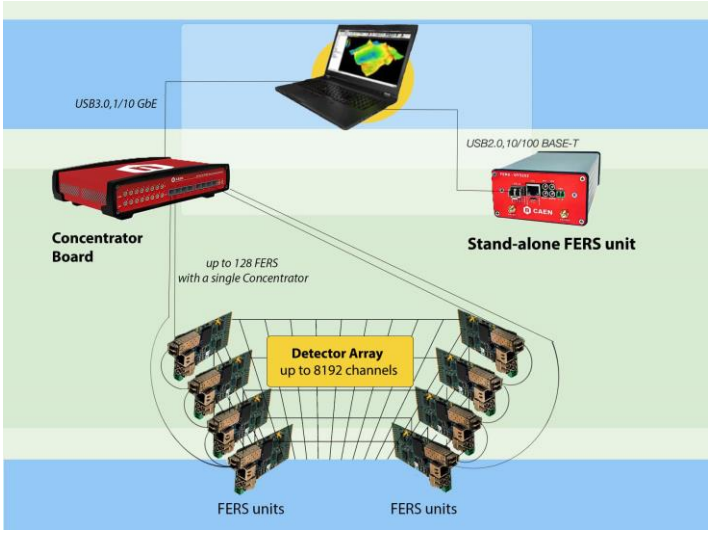

Figure 1: FERS-5200 tree network

1.1 Architecture of the Front-End

FERS-5200 is designed to be tailored for different specific detectors and applications. The Front-End is a compact card (nearly 15 x 6 cm) hosting the analog Front-End, ADC and/or TDC, FPGA, I/Os, communication interfaces and, in some cases, the detector bias power supply. In most cases the analog Front-End is based on ASICs, to optimize channel density and cost-effectiveness of the solution. One FERS unit can be used stand alone, mainly for evaluation and basic applications, or in a network. For large readout systems, a flexible and scalable network of units (FERSnet) can be created by means of the high speed optical link called TDlink, that allows up to 16 FERS units to be connected in daisy chain (ring), providing data readout, synchronization between the units and broadcasting of commands, such as triggers, time resets, etc.

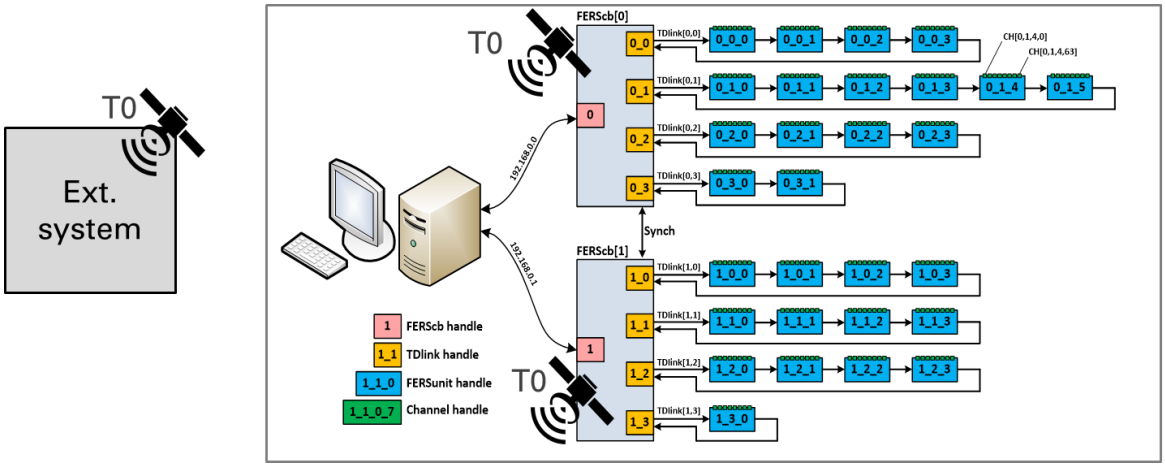

Figure 2: the FERSnet: each Concentrator Board (FERScb) is able to readout 16 FERS units per TDlink, for a total of 128 cards. Multiple Concentrator Boards can be synchronized and the overall system can be synchronized with an external system through GPS.

The architecture of the FERS unit will be the common infrastructure to provide an easy integration of different analog Front-Ends, either ASICs, either discrete components (see Fig. 3). In this way a complete line of FERS units will be available, making FERS-5200 a platform covering the main types of experimental setups and applications in the field of nuclear and particle physics. The first FERS units is the A5202 (or DT5202 in boxed version for stand-alone use) which is a 64-channel board for SiPM readout based on the CITIROC1A ASIC by Weeroc SaS.

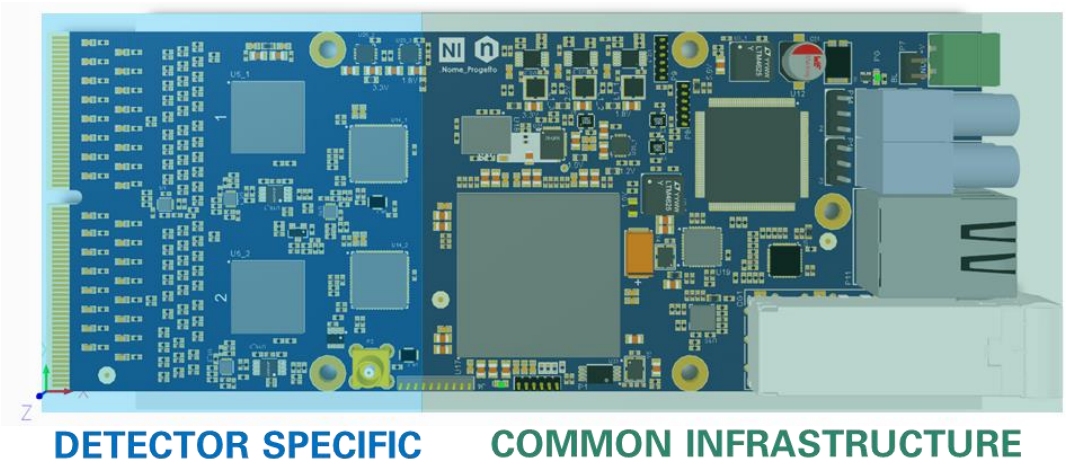

Figure 3: General view of a FERS unit, where the detector specific part and the common infrastructure are highlighted.

2. Measurements with A5202 and SiPMs

In the following we present the results obtained measuring the output of a Hamamatsu S13361 series 64-channel SiPM matrix using the A5202, running it in Spectroscopy and ToT mode. The SiPM matrix was connected to the A5202 using the A5251 MPPC adapter compatible with the Hamamatsu pinout. The matrix was biased at about 55 V.

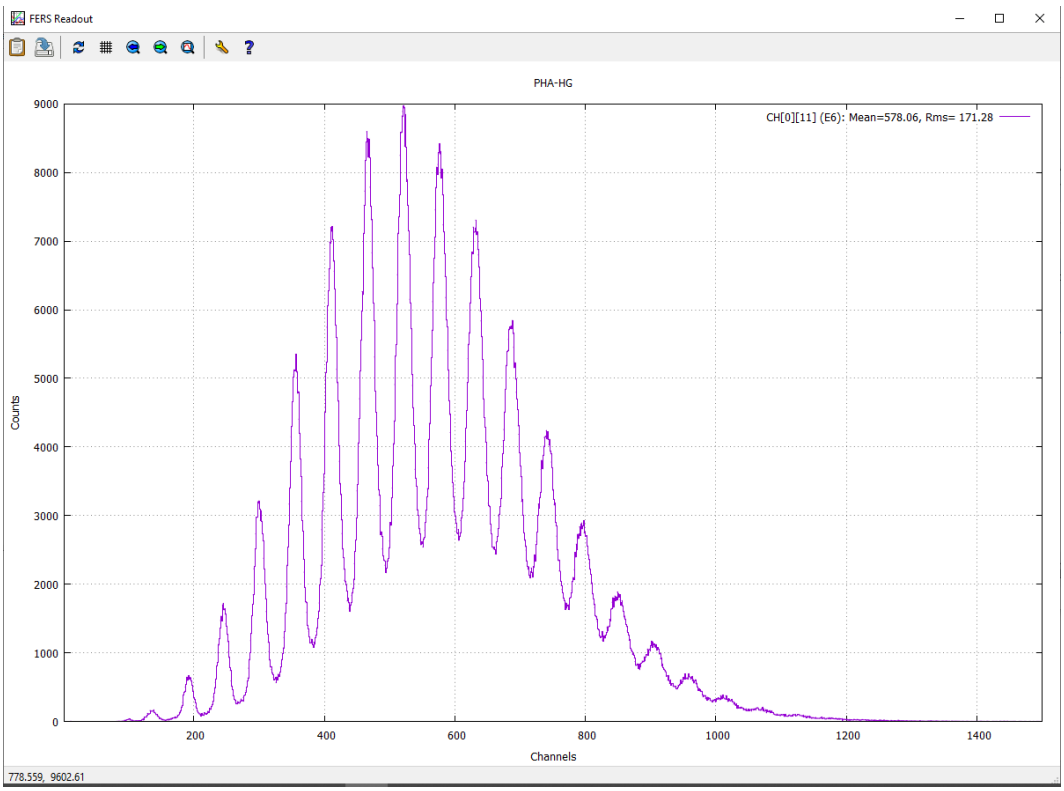

Figure 4: SiPM pulse height spectrum with the clearly visible photopeaks.

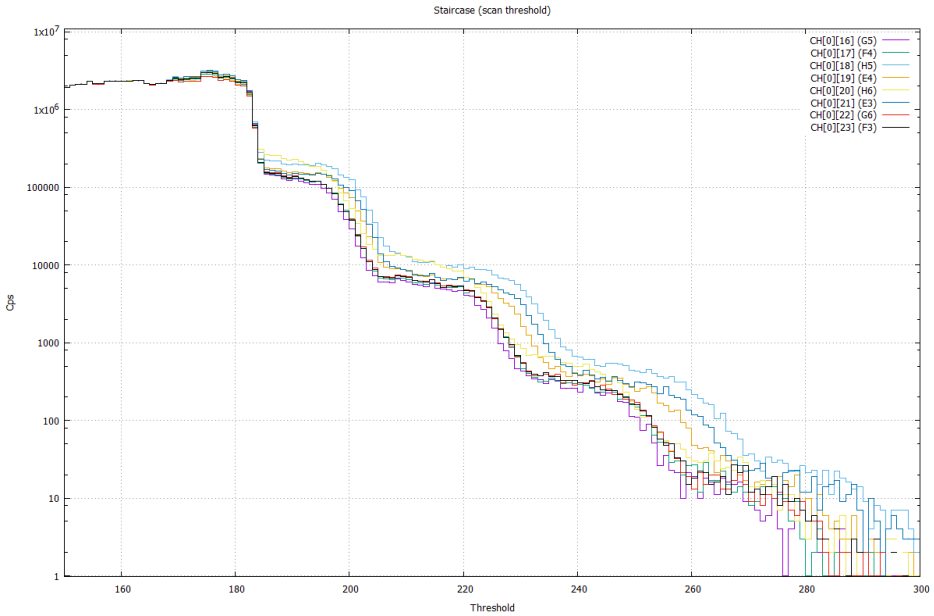

Figure 5:Example for the trend of the number of events triggered as a function of the threshold (SiPM staircase).

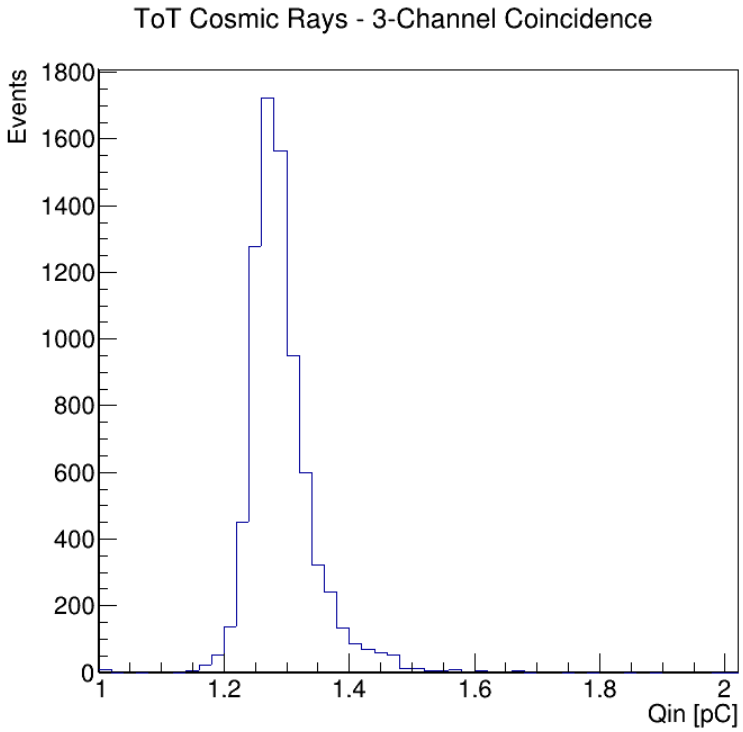

Figure 6: Landau distribution of cosmic rays acquired in ToT mode, using single 4.8 cm x 4.8 cm x 1 cm plastic scintillators, each one coupled to a Hamamatsu S13360-6050CS SiPM

References

[1] CAEN SpA, FERS-5200 webpage: https://www.caen.it/subfamilies/fers-5200/

[2] Weeroc SaS, CITIROC datasheet, https://www.weeroc.com/my-weeroc/download-center/citiroc-1a/16-citiroc1a-datasheet-v2-5