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Novel techniques for high density channel γ measurements based on SiPM

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The use of Application Specific Integrated Circuits (ASIC) is drastically increasing in nuclear and particle physics for applications that require a large number of acquisition channels, keeping the system compact with small power consumption. This work aims to explore the possibility to use the ASIC based Citiroc-1A chip, integrated in the CAEN A5202 Fers-5200 board, to acquire γ energy spectra from scintillator detectors, like Caesium Iodine (CsI), Cerium-doped Lutetium Yttrium Orthosilicate (LYSO(Ce)), and Bismuth Germanate (BGO), coupled with SiPMs. Future plans are in progress to perform measurements with faster crystals like Lanthanum Bromide (LaBr3) and Cerium Bromide (CeBr3). ASIC chips with higher shaping time than Citiroc-1A and different pulse processing were already successfully used for γ spectroscopy. This would be the first time that Citiroc-1A chip, which has a maximum shaping time of 87.5 ns, is used for γ spectroscopy measurements.

The A5202 board is an all-in-one system optimized to work with signals coming from SiPM, it has a total of 64 channels, provided by two Citiroc-1A chips, however the number of acquisition channels can be easily extended by synchronizing up to 128 boards through optical connections, or TDlink. The bias voltage for the SiPMs is provided by a power supply incorporated in the A5202 for all the channels, which can be finely tuned channel by channel through a DAC. The board can work in four different configurations: in spectroscopy mode (SM) the Citiroc-1A performs the classical pulse height analysis (PHA) to build energy spectra, in counting mode (CM) all the channels self trigger and the events recorded are counted inside a time interval, in timing mode (TM) the pulse time of arrival is saved in a timestamp. Finally, in spectroscopy and timing mode (STM), both the SM and TM operating configurations are active. The triggers coming from Citiroc-1A are sent to the FPGA for logical combination of the 64 channels or for timing measurement purposes with a time resolution of 500 ps. Energy spectra are built in the charge section: two preamplifiers, one with higher gain (HG) and the other with lower gain (LG) are available. The preamplification stage is followed by a slow RC-CR2 amplifier, connected to both the HG and LG preamplifiers of each channel. The available peaking times range from a minimum of 12.5 ns to a maximum of 87.5 ns, with a pitch of 12.5 ns. Finally, the shaped signal is sent to a peak sensing system which detects the maximum value and builds the energy spectrum. The peak sensing workflow consists of three phases: at first it is in the off phase, upon the arrival of a trigger the peak detector switches on and turns to the peak sensing phase to memorize the maximum value of the incoming pulse. This second phase is held until the arrival of the rising edge of a hold signal, after which the system turns to the hold phase and disconnects from the slow shaper to ensure that no other value is memorized. When the falling edge of the hold signal arrives, the peak detector goes back to the off phase.

We performed preliminary measurements with a 6x6x15mm LYSO crystal coupled with a single 6x6 mm2 SiPM and a 22Na radioactive source. We built the energy spectra with the same setup using a digitizer (DT5720A) that performs charge integration, obtaining results comparable with the A5202. Measurements with other detectors and radioactive sources are still ongoing. This high flexibility on the number of channels, combined with the ability to properly perform gamma spectroscopy with resolution compliant with the literature and with a complementary system, could be an interesting solution for experimental setups requiring a large number of acquisition lines.

In-person participation

Yes

Primary authors: SALTARELLI, Alessandro (Istituto Nazionale di Fisica Nucleare); MATTONE, Cristina (CAEN SpA); PERRI, Marco (Istituto Nazionale di Fisica Nucleare); TINTORI, Carlo; Dr NINCI, Daniele (CAEN SpA); VENARUZZO, Massimo (CAEN SpA); Dr CORBO, Matteo (CAEN SpA); GAROSI, PAOLA (CAEN SPA); Mr VENTURINI, Yuri (CAEN SpA)

Presenter: PERRI, Marco (Istituto Nazionale di Fisica Nucleare)

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