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The FastIC ASIC: A Fast Integrated Circuit for the readout of Fast Detectors with Intrinsic Amplification

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Many applications can benefit from detectors which have the ability of detecting low light intensities with precise timing. Some examples are Time of Flight Positron Emission Tomography (ToF-PET), High Energy Physics experiments (e.g. RICH detectors), Fluorescence Lifetime Imaging Microscopy (FLIM), Light Detection and Ranging (LIDAR) or Quantum Communications.

The FastIC Application Specific Integrated Circuit (ASIC) is an 8 channel chip to readout the signal from fast detectors with intrinsic amplification, like Micro Channel Plates (MCP), Photomultiplier Tubes (PMT) or Silicon Photomultipliers (SiPM). The chip was developed in an standard CMOS 65nm technology. The ASIC includes an input stage that can be configured to process the signal from positive or negative polarity detectors with a linear energy measurement and a dynamic range from a few microamperes to ~20 mA (in the negative polarity stage) and to ~25 mA (in the positive polarity).

The input stage generates replicas (in current mode) of the input signal that are fed in three different paths. The *Time* path provides an accurate measurement of the particle time of arrival using a precise leading edge discriminator. The *Energy* path generates a digital pulse at its output whose duration is directly proportional to the input signal amplitude. The third path is for *Trigger* purposes and might be used to set its threshold above the first photoelectron, allowing to ignore dark count events from the detector . The *Cluster Trigger* adds the trigger signal from multiple channels before discrimination. This is useful to trigger on detectors in which the signal is shared by different channels (e.g. PET detectors based on monolithic crystals). The chip provides the interface between detectors and Time-to-Digital Converters (TDCs).

The power consumption of the full channel is 12 mW with default settings, although in some applications, the user might choose to use only the Time path and in this case the power consumption of the channel reduces to ~6 mW . The power consumption of the input stage is 3 mW.
A first series of measurements was performed with several photodetectors and standard scintillators.
A HPK photomultiplier R5900 producing, according to the manufacturer datasheet, pulses with ~5 ns FWHM duration and 330 ps FWHM transit time spread, was tested using a red-light laser. The measured time jitter was ~340 ps FWHM after Time Walk Correction (TWC). This time jitter corresponds to the time uncertainty of detecting tens of photons. These results show that the FastIC electronics does not degrade the system time response.

The Single Photon Time Resolution (SPTR) was measured to be 176 ± 3 ps FWHM (including laser, sensor and electronics contribution) when using the light from a blue laser and a 3x3 mm^2 SiPM HPK S13360-3050CS at 10.6 V over-voltage. When the FastIC is connected to new SiPM technology HD-NUV Low Field (3.2 × 3.12 mm^2, 40 µm cell) from FBK, the SPTR decreased to 151 ± 3 ps.

The chip was also used to read out the signal generated in a pair of identical LSO:Ce:Ca 0.2% scintillators (2 × 2 × 3 mm^3) coupled to SiPM devices, in a setup to record 511keV coincident gamma photons. The results showed a Coincidence Time Resolution (CTR) of 94 ± 2 ps and 76 ± 2 ps FWHM with HPK and FBK SiPMs respectively. First measurements with the FastIC chip confirm its ability to detect scintillating light (e.g., LSO and BGO) and prompt light emission (e.g. using Cherenkov radiators like TlCl and PbF_2).

In this contribution, further results on ASIC characteristics will be presented.

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