Performance of FBK SiPMs coupled to PETA3 read-out ASIC for PET application

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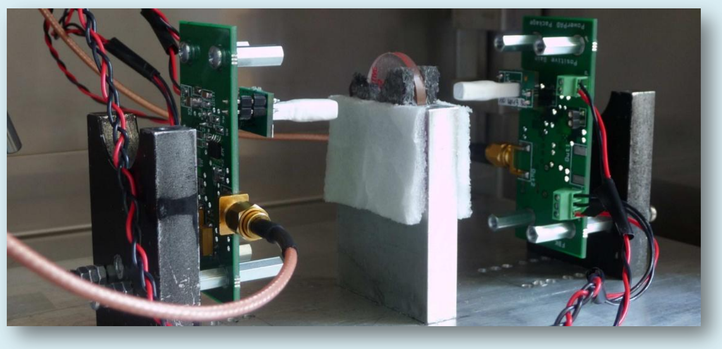
Abstract: In the framework of the HyperImage and Sublima EU projects we are developing a SiPM-based high-performance TOF-PET system to be integrated in a MRI. It has already been shown that single-element FBK SiPMs coupled to LYSO scintillator and read out by an optimized discrete circuit provide excellent energy and timing information. In this paper we demonstrate that a very good performance can be reached also in a system-like configuration. The new set-up is based on the PETA3 read-out ASIC, developed by the University of Heidelberg. The interconnection scheme (ASIC board and connectors to sensor) is identical to the one used in the PET module developed for the above-mentioned projects. The system performance is evaluated by measuring the energy resolution and the coincidence resolving time (CRT) of two single SiPMs coupled to LYSO crystals and read out by two channels of the ASIC. We show that using two scintillator detectors, composed of a 3x3x5mm^3 LYSO crystal coupled to a 3x3mm^2 SiPM, a CRT of about 200ps FWHM can be obtained in this configuration which is very similar to the value obtained in the optimized discrete case.

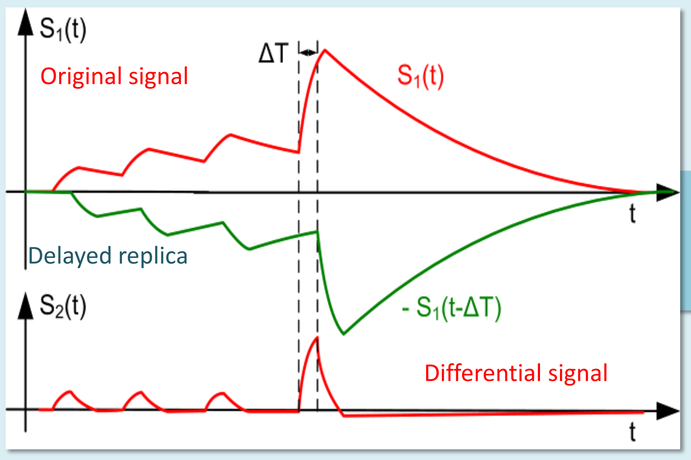
Reference setup with discrete components

Reference setup for CRT and energy characterization



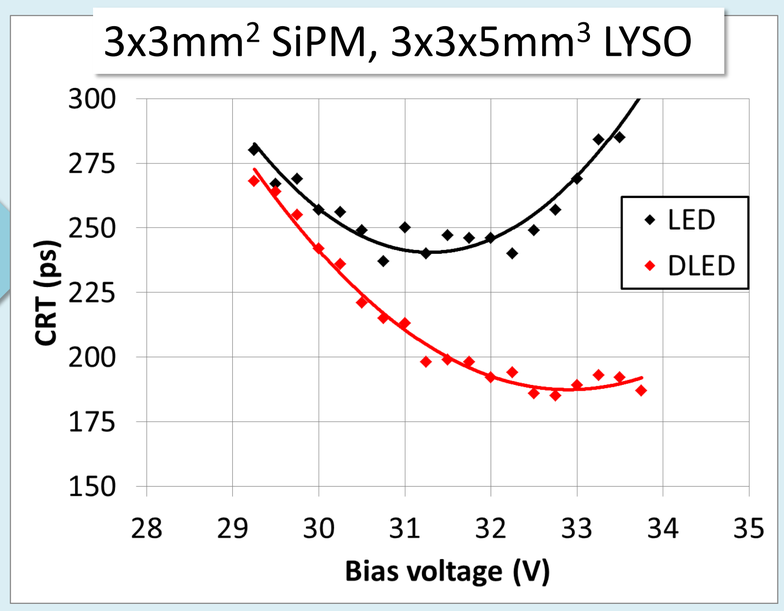
Optimized design to minimize parasitic.
Amplifier's outputs are digitize by an oscilloscope.
Data are analyzed by LabView code.

Signal conditioning



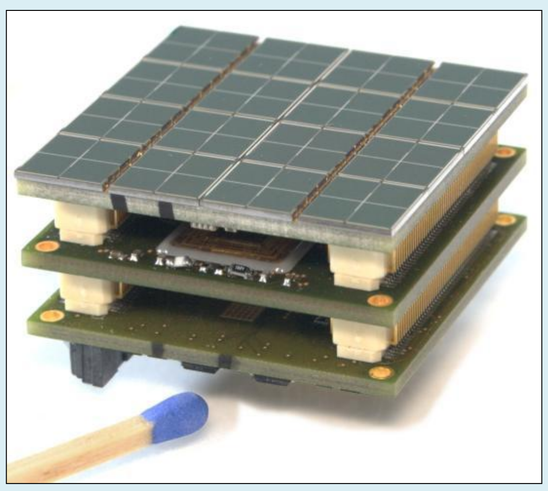
To reduce the baseline fluctuation due to dark noise we implemented DLED technique.

CRT: DLED vs LED



Measurement setup with 32-channel PETA3 ASIC

HyperImage PET stack



It composed of a SiPM (by FBK) tile, ASIC (PETA1 chip) tile and interface board.
It proved to be MR compliant.

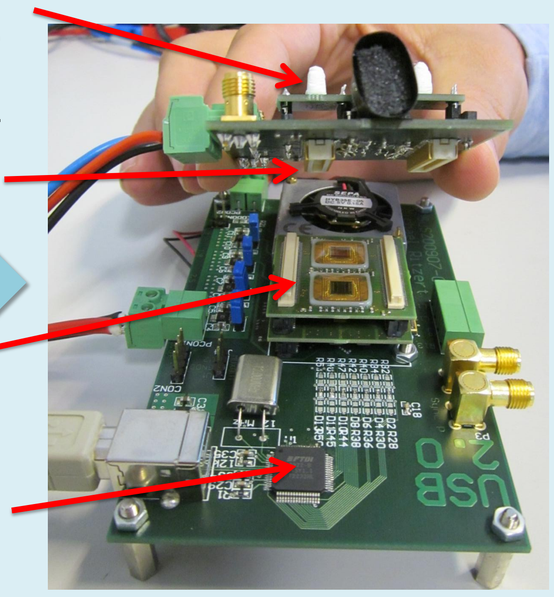
Modified stack to test 2 single channels in coincidence.

2 SiPMs in coincidence

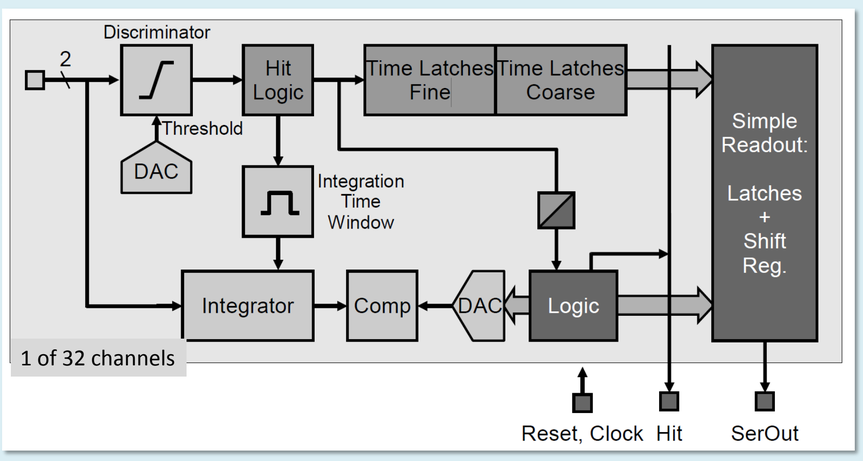
PCB adapter replacing SiPM Tile

PETA3 ASIC chips

control and acquisition board

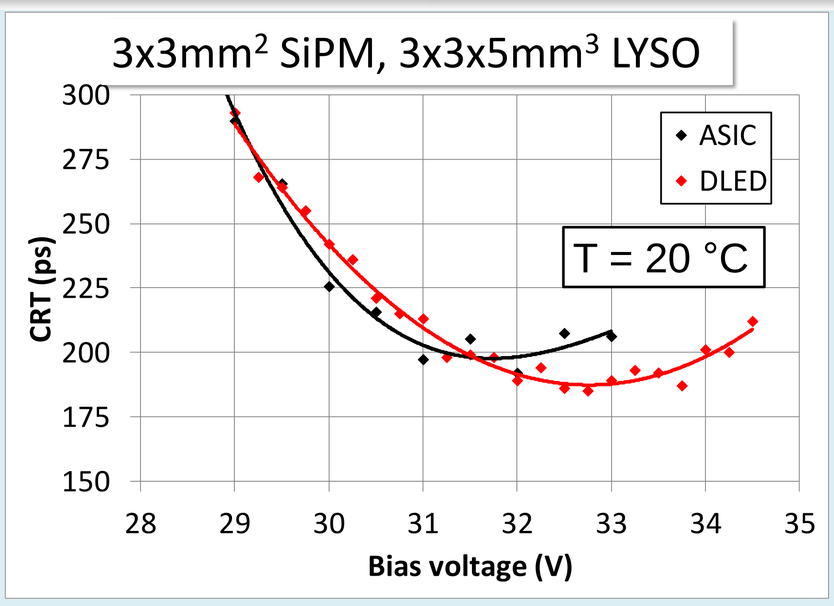


PETA chip block diagram



Important to note is that the SiPM signal is high pass filtered by preamplifier obtaining an attenuation of the baseline fluctuation similar to DLED.

Results: comparison between ASIC and discrete



CRT from PETA3 is very close to what we obtain with our optimized discrete read-out setup which also implements DLED technique.
A timing resolution of **~190ps FWHM is obtained at 5-6 V OV.**

Energy resol. is very similar for both set-ups with a minimum value of 12%

Conclusions

In this contribution we showed energy and timing resolution results obtained with FBK SiPMs combined with PETA3 ASIC developed within HyperImage (FP7 GA #201651) and Sublima (FP7 GA #241711) EU projects.
The results obtained are very important because they show that, in a system-like configuration, we can get energy and timing resolutions that are very close to the values obtained in the optimized bench set-up.
It is worth noting that fully assembled stacks are already working in a pre-clinical PET scanner inserted in a MR allowing for simultaneous acquisition.
Tests in whole-body PET configuration with previous SiPM and ASIC versions already showed reasonable results: dE/E<15% and CRT <500ps.
System upgrade with new components is expected to give much better results, in line to what presented here.

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