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PETsys
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PETsys TOFPET2 ASIC

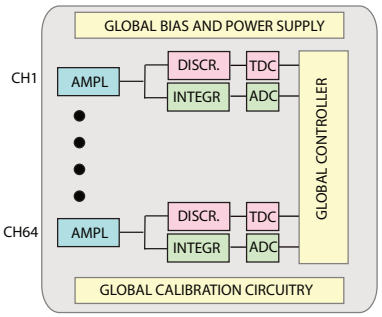

Figure 1:
Simplified block diagram of the TOFPET2 ASIC.

The PETsys High Performance TOFPET2 ASIC is a new 64 channel chip for the readout and digitization of signals from fast photon detectors in applications where a high data rate and fast timing is required. Fig. 1 shows a simplified block diagram of the ASIC.

Each of the 64 channels has a front-end current conveyor followed by two post amplifiers, one for the time branch and one for the energy branch. The time branch uses a low threshold (t_1) for timing and a second threshold (t_2) for rejecting dark counts, avoiding dead-time. The energy branch has a higher threshold (t_E) for validating the event. The t_1 threshold will typically be set at a value corresponding to a few photons. Only events that also pass the energy threshold are digitized. All thresholds are separately configurable for each channel.

There are four Time to Amplitude Converters (TAC) in the timing branch and four Charge Integrators (CI) in the energy branch, allowing a high event rate with negligible dead-time. The charge integration time is configurable up to two microsecond.

The energy of the event can also be obtained from Time Over Threshold (TOT) by using four additional TACs from the Charge Integrations in the energy branch. When charge Integration is selected, ToT is available with clock period resolution. There are two 10-bit Wilkinson ADCs per channel, one for the time branch and one for the energy branch.

Each channel has an embedded counter, incremented each time a signal triggers the low threshold t1. This provides a dark count counter for SiPM characterization.

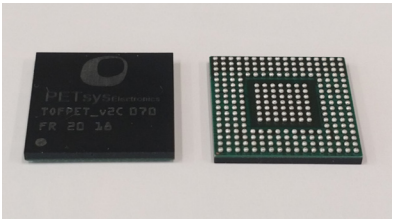

Figure 2:
TOFPET2 ASIC as a BGA package

The ASIC is available as BGA package (Fig. 2). We also provide the complete solution for reading a few 100, a few 1000 or several 10'000 channels. In this readout the ASIC is mounted on the FEB/A board (Fig. 3).

A more extensive performance report is available in reference [1], and a full data sheet is available in the documentation area on our web site.

Main features of the PETsys TOFPET2 ASIC (Version 2c & 2.d).

- Designed in standard CMOS 110 nm technology.
- Version 2.d accepts positive or negative input signals; version 2.c only positive signals.
- Signal amplification and discrimination for each of 64 independent channels.
- Separately configurable t1, t2 and energy thresholds for each channel.
- Rejects dark counts without triggering, allowing to handle large dark counts rates.
- Configurable charge integration time up to two microsecond.
- Quad-buffered TDCs and charge integrators for each channel. The first branch is used for timing measurement. The second branch can either be used for time-over-threshold (ToT) or charge measurement with a Wilkinson ADC.
- Dynamic range: 1500 pC.
- TDC time binning: 30 ps.
- Gain adjustment per channel in the charge branch: 1, 1/2, 1/4, 1/8.
- On-chip charge calibration pulse generator with 6-bit programmable amplitude.
- Main clock frequency: 160-200 MHz.
- Configurable digital data output over 1, 2, or 4 LVDS data links at 2x the main clock frequency and single data rate (SDR) or double data rate (DDR).
- Max output data rate per ASIC: 3.2 Gb/s.
- Max event rate per channel: 500 kevent/s, 80 bits per event.
- Power dissipation per channel: 5 to 8.2 mW, depending on settings.

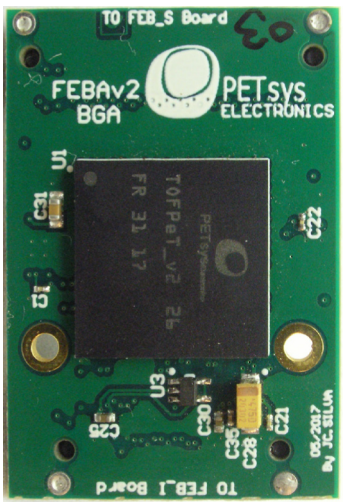

Figure 3:
Front-end board FEB/A with the TOPET2 ASIC in BGA package. The board measures 36x25 mm.

For more information visit our web site www.petsyselectronics.com or contact sales@petsyselectronics.com

[1] Experimental characterisation of the TOFPET2 ASIC, R. Bugalho et al. , 2019 JINST 14 P03029

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Figure 4 :Single Photon Time Resolution.
Single Photon Time Resolution (SPTR) measured with a PLP-10 Picosecond light pulser from Hamamatsu and a Hamamatsu S13361-3050AE-04 MPPC at 7.5 V over-voltage and at 20 °C.

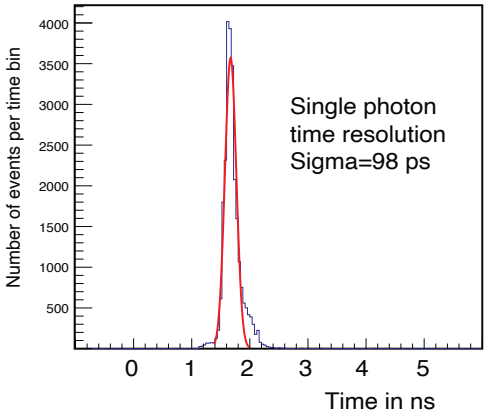


Figure 5: Dark Counts.
Dark count as a function of threshold DAC setting. This measurement was performed with a KETEK-PM3325-WB SiPM at 4 V over-voltage and at 20° C .

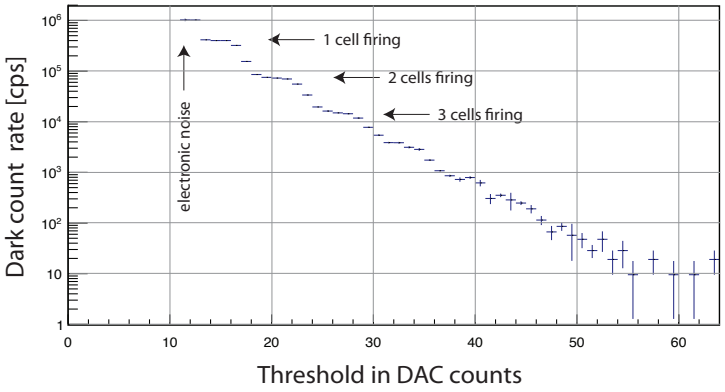


Figure 6: Energy spectrum.
Pulse hight spectrum obtained with a radioactive source of ^{22}Na and with a LYSO crystal of 3x3x5 mm^3 mounted on a KETEK-PM3325-WB SiPM at 4 V over-voltage and at 20° C. The charge signal is integrated in a time window of 350 ns. The energy resolution at 511 keV is 10.5 % . The energy spectrum is corrected for the non-linearity of the SiPM by recording pulse hight spectra with ^{133}Ba, ^{22}Na and ^{137}Cs sources and fitting the relation between ADC counts and gamma energy for the different gamma emissions lines.

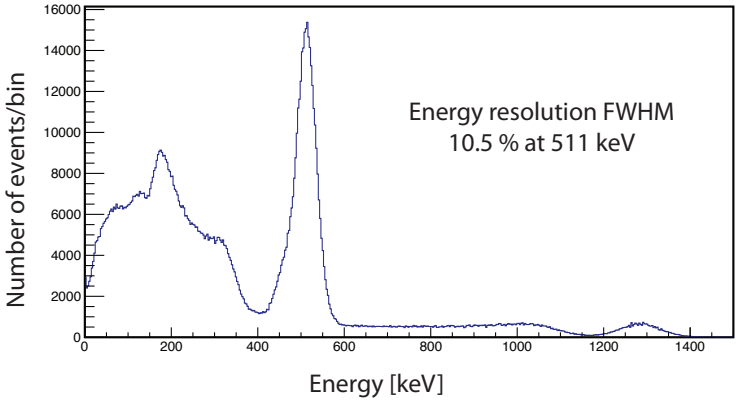
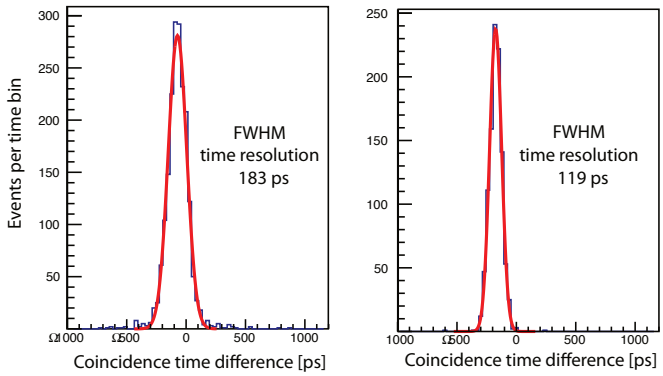


Figure 7: Coincidence Time Resolution.
CTR measured with a 22Na point source and two Hamamatsu S13361-3050AE-04 MPPC arrays. This MPPC array has pixels measuring 3x3 mm with 50 µm cells. Left figure: CTR measured with two 3x3x20 mm^3 LYSO crystals at 15 °C, 4 V over-voltage. Right figure: measured with two 2x2x3 mm^3 LYSO crystals at 15 °C, 3 V over-voltage. The LYSO:Ce crystals used in these measurements were obtained from CPI.



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