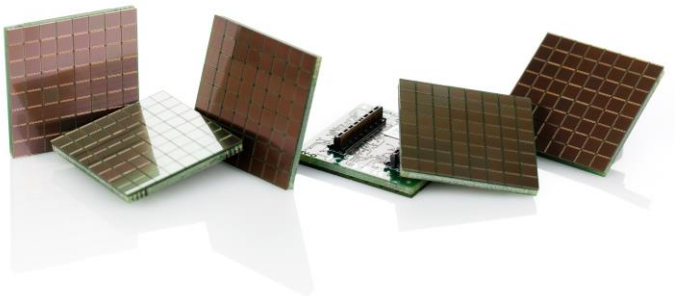
SiPM

Application Note

SiPM – Silicon Photomultiplier

PA3325-WB-0808
Evaluation for Positron Emission Tomography

KETEK



Key Features Overview

- 8 x 8 Array, 3 x 3 mm² Pixel Size
- 3.36 mm Pixel Pitch
- Array Fill Factor 80%, 4-side seamless tileable
- Replacement for PMTs, APDs and PIN Diodes
- Low Voltage Operation (typ. about 30 V)
- Excellent Uniformity of V_{BD} with ± 125 mV

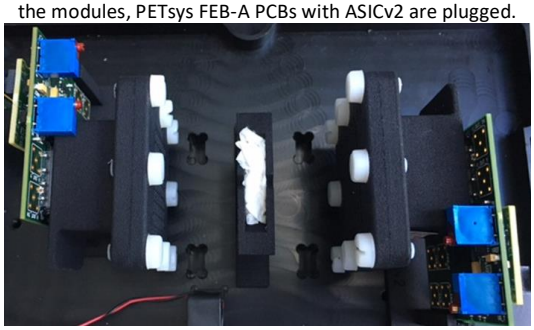
Introduction

Positron Emission Tomography (PET) scanners nowadays have adapted the use of Silicon Photomultipliers (SiPM) as photodetectors. The next generation clinical PET scanners are expected to be based on SiPM technology. Typically, the SiPMs are not used as single devices but combined together in arrays. A typical configuration is with 8 x 8 SiPMs on one array with individual readout of each pixel via the backside of the array. Typical pixel sizes are in the order of a few millimeters. KETEK developed an 8 x 8 SiPM array (PA3325-WB-0808) based on its latest WB Series SiPMs suitable for PET. The array is 4 side tileable and borderless and has a pixel pitch of 3.36 mm. Outer dimensions are 26.84 x 26.84 mm². Each of the 64 pixels consists of a PM3325-WB SiPM (3.0 x 3.0 mm² active area, 3.315 x 3.315 mm² package size, 25 µm microcell pitch). Two of those arrays have been evaluated in coincidence.
As scintillating crystals, LYSO (Lutetium Yttrium Oxyorthosilicate) has been used which is currently the most widely used scintillator for PET. The crystals were arranged in 8 x 8 arrays manufactured by Epic Crystal. Each LYSO crystal had a size of 3.0 x 3.0 x 20.0 mm³ the crystal pitch was 3.36 mm and the used reflector was BaSO4.
To employ the full performance of the SiPMs, highly performant and scalable read out electronics is needed. PETsys Electronics S.A. provides an excellent solution for PET and the KETEK PA3325-WB-0808 array is plug and play compatible to any of their ASICs. Further information and documentation can be found at www.ketek.net and www.petsyselectronics.com.

Materials and Methods

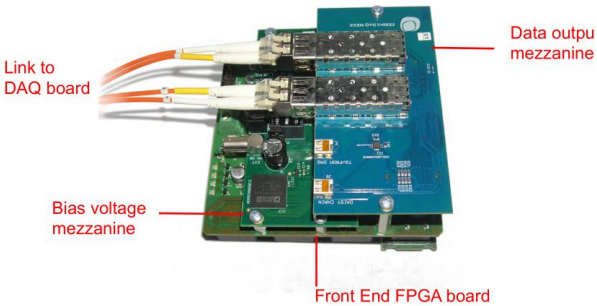
Setup with Two Opposing Modules

Two Modules with SiPM Arrays PA3325-WB-0808 and LYSO crystal blocks mounted in 3D printed black structure. On the backside of the modules, PETsys FEB-A PCBs with ASICv2 are plugged.



Coincidence Time Resolution with LYSO 2 x 2 x 3 mm³ measured with PETsys TOFPET2 ASIC

FEB-A ASIC boards are plugged from below.
Image courtesy of PETsys Electronics.



Two detector modules (each 64 SiPM + LYSO pixels) have been assembled, each consisting of a black 3D printed structure, into which the PA3325-WB-0808 SiPM array and the LYSO crystal block are mounted. The structure positions the LYSO exactly above the pixels and presses the LYSO array onto the SiPM array. Between crystal and SiPMs, optical grease (Eljen EJ-550) has been used. Both modules have been directly plugged to the PETsys FEB-A boards with ASICv2. The whole setup has been placed in the light tight evaluation box with Peltier cooling, which is available from PETsys for evaluation purposes. The room temperature has been stabilized to 23°C and the Peltier cooler has been constantly powered with 12 V without additional controlling, resulting in a temperature of approx. 15°C in the box. The data stream from the FEB-A board is then sent to the FEB-Dv2 board, from where the data is transmitted via GBit Ethernet to a computer running CentOS 7 Linux. There the data acquisition and analysis are done with Python, C++, ROOT and Bash. All measurements have been performed with a ^{22}Na source (approx. 500 kBq) which was placed in between the two modules. The breakdown voltage of the SiPMs on PA3325-WB-0808 is 27.0 V and all measurements have been performed at 4 V overvoltage, which showed best performances regarding CTR (Coincidence Time Resolution). Coincidences are all filtered in an energy range of ±2σ of the 511 keV photopeak. For the global CTR between all opposing channels, only channel pairs with at least 100 coincidences have been taken into account. Besides that, no further filtering of events has been applied.

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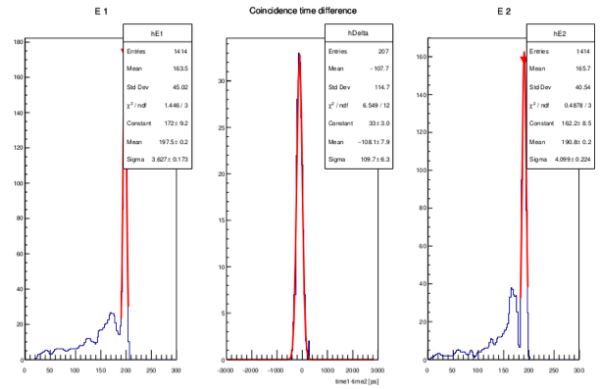
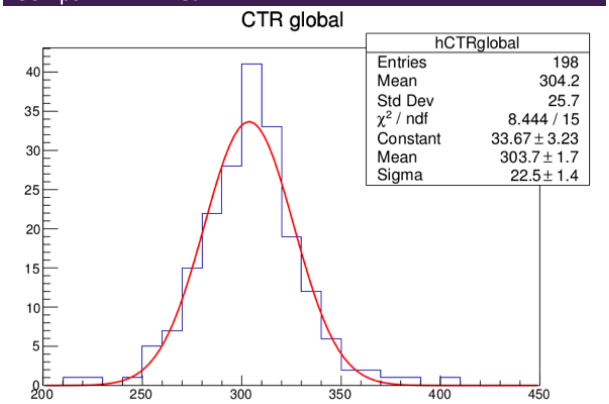
Typical Performance Characteristics

CTR and Energy Spectra of Two Channels
Two Channels, 258 ps FWHM

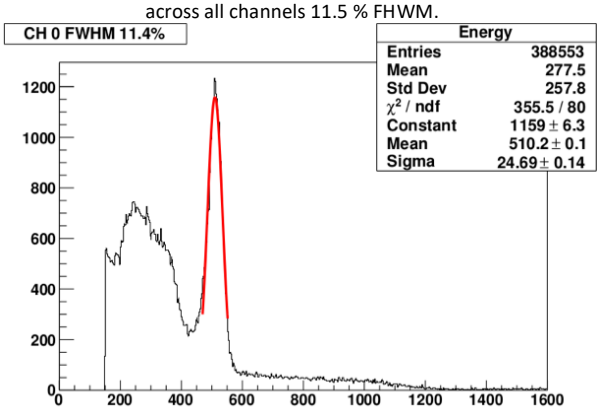


Global CTR distribution of all opposing channels
304 ps FWHM mean



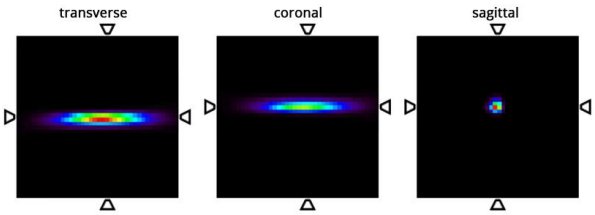
Energy Spectrum
11.4% FWHM at 511 keV

Energy spectrum corrected for saturation, mean energy resolution across all channels 11.5 % FHWM.



MLEM reconstruction of the ^{22}Na point source

Source appears elongated due to missing projections caused by two modules only. Sagittal resolution is 1.5 mm FWHM.



Revision History

Revision and Date	Changes
Rev. 2020-A April 2020	Updated design and layout
Rev. 2016-A January 2016	Initial Release

Important Notice

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