Contribution ID: **108** Type: **Poster presentation**

Development of a detector module suitable for Whole body PET with improved timing performance

Tuesday 19 September 2017 10:40 (1 minute)

Most whole body PET scanners today are based on the use of PMT for detecting scintillating light. In recent years, a new solid-state light sensor, the Silicon photomultiplier (SiPM), become available. SiPMs with high gain are intrinsically faster, insensitive to magnetic field, thin, cost effective and the photosensitive area is subdivided in pixels. These characteristics make SiPM a great candidate for whole body PET scanners specially for time of flight applications. Previously, we have developed a detector module based on pixelated LYSO crystal and SiPM photosensor for small animal PET and organ specific PET scanners with depth of interaction (DOI) capabilities to improve the spatial resolution using an innovative method based on the light sharing technique with low complexity and a single side readout [1][2]. However, in whole body PET systems, the most important parameter is timing resolution and the improvement in spatial resolution due to the use of DOI is less important. Previous studies showed that time difference between the signal observed in two detectors for a given positron annihilation depends on DOI of the interaction in case of long crystal. The time difference between an interaction on the near side or the far side of the photodetector is around 200 ps for a 30 mm long crystal. This time difference is significant compared to the coincidence time resolution between two crystals in coincidence about 350 ps FWHM. The aim of this study is developing a detector module based on our newly developed technique in references [1] and [2] where the DOI information is used for improving the time resolution.

The detector module is a matrix of 4x4 or 8x8 LYSO scintillator pixels, each 3x3x20 mm3 and separated by reflective foils. The crystal pixels are in one-to-one coupling to SiPM pixels and readout by PETsys TOFPET2 ASIC with TDC capability (30 ps time binning) [3]. To have light sharing between the pixels, a glass light guide is optically coupled on top (i.e. the side opposite to the SiPM) of the LYSO array and out covered by a reflective foil. The lateral surfaces of the crystal pixels are optically depolished such that the amount of light arriving at the top side will depend on the position of the interaction point along the length of the crystal. Part of the light arriving on the top side will return to the SiPM through the crystals adjacent to the one where the interaction occurred.

Using an electronic collimation set-up and a single reference crystal pixel, the detector module is scanned along its depth. Having the fitting function between the DOI and the mean value of the time difference spectrum for coincidence events between the reference pixel and the module for each pixel of the module, the DOI correction is applied on timing measurements. Moreover, the light arriving on the adjacent SiPM pixels will contribute usefully in the timing measurement. This requires the development of a maximum likelihood based combination of the timing information from different pixels.
We will present the results with this detector module.

References:

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Session Classification: Poster Session 1

Track Classification: P1_applications