Contribution ID: **68** Type: **not specified**

Positron emission tomography without image reconstruction

Time-of-flight positron emission tomography (TOF-PET) has been a main driver for the steady improvement, in recent years, of the timing performance of scintillation-based gamma-ray detectors. PET image quality will benefit from improvements in coincidence resolving time (CRT) down to a value of about 20 ps. At this point, tomographic image reconstruction as is presently needed will actually become obsolete. Presently, commercially available PET scanners achieve a CRT of about 350 ps FWHM, while CRT values somewhat below 100 ps have been achieved for small detectors in the laboratory.

Basically, detector timing improves if more photons are detected very soon after the gamma-ray interaction. An especially interesting idea is to use Cherenkov light for fast timing as it is the fastest light response of a material to the interaction of gamma rays. However, the number of Cherenkov photons is very small, causing other detector properties such as energy resolution, and potentially position resolution, to suffer. A combination of the use of Cherenkov light for timing and scintillation light for other purposes was therefore proposed [1]: improved PET imaging performance may be obtained by decoupling the timing from other information, e.g. allowing TOF-PET using slow scintillators. In recent years, steady progress in the investigation of Cherenkov light for TOF-PET has been reported [2-4]. The full realisation of this idea will require improvements in different aspects: scintillators modified for maximum production of Cherenkov photons, very fast and efficient UV-sensitive photosensors and the coupling of the two. An important requirement in these developments is that the detector efficiency does not suffer.

The improved technology will be useful in any application where ultrafast and efficient detectors for gamma-ray detection and imaging are needed.

[1] Dendooven P.G., "Time-of-flight positron emission tomography using Cerenkov radiation", patent no. WO/2010/085139, filed 26 January 2009, issued 29 July 2010

[2] Lecoq P. et al. "Factors influencing time resolution of scintillators and ways to improve them"IEEE Trans. Nucl. Sci. 57(2010)2411-2416

[3] Brunner S.E. et al. "Studies on the Cherenkov effect for improved time resolution of TOF-PET"IEEE Trans. Nucl. Sci. 61(2014)443-447

[4] Dolenec R. et al. "Cherenkov TOF PET with silicon photomultipliers"Nucl. Instrum. Meth. Phys. Res. A 804(2015)127-131

Summary

TOF-PET, Cherenkov, scintillator, timing

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