Positron emission tomography without image reconstruction

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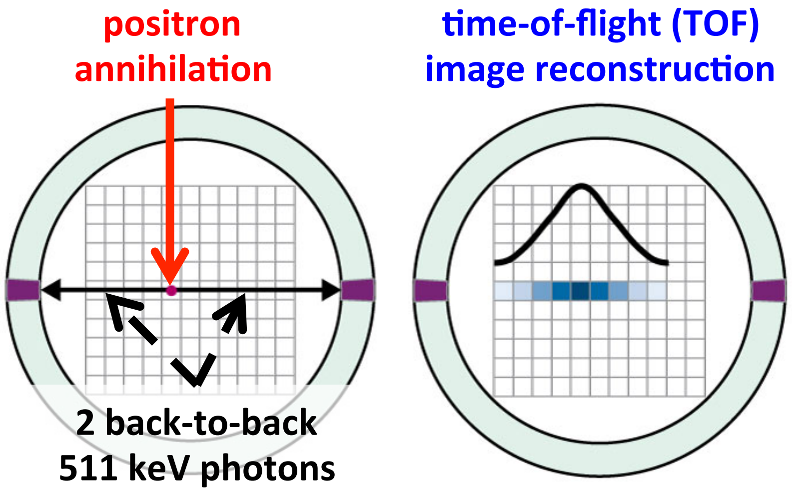


Δx : image positioning resolution)
CRT : coincidence resolving time
c : speed of light

$$\Delta x = c\frac{CRT}{2}$$

Introduction

The use of positron emission tomography (PET) is rapidly increasing due to the development of radiotracers and imaging technology. Concerning the latter, time-of-flight (TOF) information is especially important in improving the image contrast-to-noise ratio.

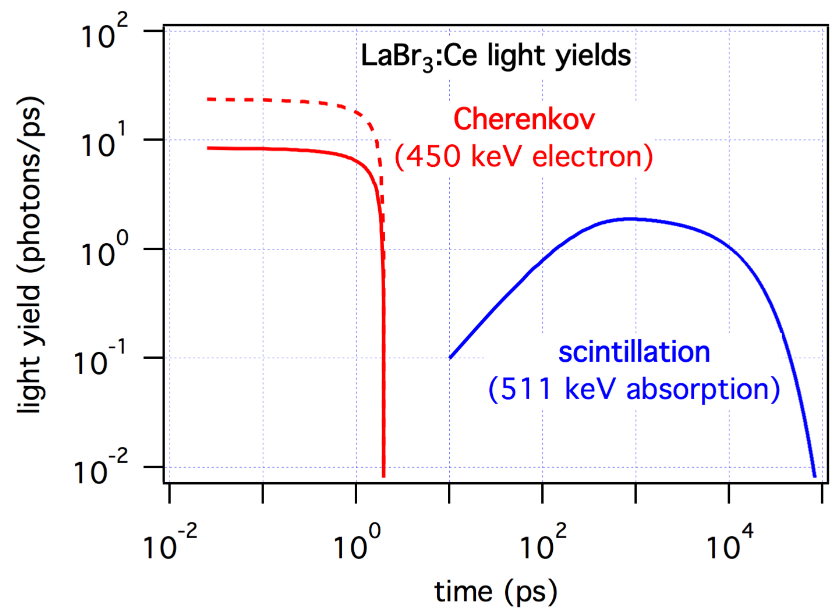
the holy grail of TOF-PET: CRT < 20 ps, Δx < 3 mm:
- image spatial resolution is dominated by factors other than CRT
- **tomographic image reconstruction as is presently needed becomes obsolete**

PET scanners are almost exclusively based on scintillation detectors. Presently, commercially available PET scanners achieve a CRT of about 350 ps, while CRT values somewhat below 100 ps have been achieved for small detectors in the laboratory.

The Idea/Concept: Cherenkov TOF-PET

CRT improves as more photons are detected very soon after the gamma-ray interaction. **The fastest light response of a material to the interaction of gamma rays is Cherenkov light** (see figure). 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. **Steady progress** in the investigation of Cherenkov light for TOF-PET has been reported by others [2-4]. The full realization of this idea will **require improvements in different aspects**:
- scintillators for maximum production of Cherenkov photons
- very fast and efficient UV-sensitive photosensors
- efficient coupling of scintillator and sensor

[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. IEEE Trans. Nucl. Sci. 57(2010)2411-2416
[3] Brunner S.E. et al. IEEE Trans. Nucl. Sci. 61(2014)443-447
[4] Dolenndoec R. et al. Nucl. Instrum. Meth. Phys. Res. A 804(2015)127-131



Light yields (photons/ps) in $LaBr_3$:Ce scintillator material, one of the brightest and fastest scintillators suitable for gamma ray detection. The solid and dashed red lines represent Cherenkov photons in the wavelength range of 600-350 and 600-200 nm. **All Cherenkov light is created before the first scintillation photon !**
Figure: P. Dendooven 2007 (unpublished)

Potential Impact

for positron emission tomography:
- bright but slow scintillators that are useful for TOF-PET
- novel TOF-PET detector concepts and detector materials
- PET without image reconstruction
- cheaper PET imaging

in general:
improved technology for any application where ultrafast and efficient detectors for gamma-ray detection and imaging are needed