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Title: Investigation of the CRT performance of a PET scanner based in liquid xe

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Report of referee 1

This paper describes the results from a Monte Carlo simulation of a PET system based on LXe cells instrumented with SiPMs (PETALO), and analyses the coincidence resolving time (CRT) of the 511 keV gammas for this system under the assumption that the spacial resolution is 2 mm (sigma) in both the depth of interaction axis and the perpendicular plane. This study is performed considering the use of VUV sensitive SiPMs that can directly detect xenon scintillation light, and traditional SiPMs coated with a wavelength shifter. It then compares the obtained CRT values with current state-of-the-art PET systems of similar dimensions based on LYSO crystals.

This paper has improved significantly since the previous version. The authors removed the direct comparison with simulations of a similar system based on LYSO crystals, and that made the paper much more clear and easier to follow while still focusing on the essential part of this work. The assumptions made about the PDE of VUV sensitive SiPMs and the decay time of TPB are also clear and consistent throughout the paper now, and the assumptions about the spatial resolution and its meaning (sigma or FWHM) are now clearly stated. Figure 4 and table 1, added in this version, greatly help the reader in understanding the simulated geometry and the assumptions used in the simulation. I therefore recommend that this paper should be published after some minor corrections/comments are answered:

- It’s not clear to me why Rayleigh scattering in LXe is considered in the simulation, but not light absorption by impurities. For a chamber of this size, I would say that absorption by impurities can be more important (depending on the xenon purity, the absorption length can be smaller than the 36 cm considered for Rayleigh scattering). What is the effect in the CRT of the system of introducing absorption by impurities (maybe test an extreme case with an absorption length of 10 cm)? I don’t expect that either process will influence the CRT (as only the first or first few photons are considered), but it doesn’t make sense to me that one process is included but not the other.

- 1st paragraph in section 2.2: ”photoelectric *effect*”

- In eq. 2.7, to make the dependency in the 2 exponentials more clear, the terms in exp(-t/τ_1)/τ_1 and exp(-t/τ_2)/τ_2 can be grouped

- Page 4, the paragraph right after eq. 2.7: ”Figure 2 shows the total intensity of scintillation in LXe for a 511 keV gamma (resulting in...) *for the first 10 ns after the interaction*, according to equation 2.7 (blue dots). *During this initial period,* this distribution is well described...”

- Caption of figure 2: ”Intensity of scintillation in LXe as a function of time *for the first 10 ns following a 511 keV gamma interaction*.”

- Caption of figure 4: ”... where d_g is the distance between the *center of the* LOR..., d_d is the distance between the *center of the* LOR and the emission point of *the* gammas...”

- In figure 4 (and the discussion that follows), is d_g the distance of each interaction point to the center of the LOR, or to the geometrical center of the system? If it’s to the center of the LOR, d_g will be the same for both gammas by definition, and Δd_g will be zero in eqs. 4.1 and 4.2. Figure 4 also needs to be modified accordingly, from ”centre of the LOR” to ”geometrical centre of the system”

- First paragraph of section 4: The GEANT4 version number must have a typo, as I could not find 10.01 in the GEANT4 web site, only 10.0 and 10.1

- Page 8, first paragraph after table 1: ”The gammas interact ... to equation 2.8 *which are propagated* through the material”

- Page 10, below Figure 6: in the estimate of the jitter caused by the DOI correction, although the quoted resolution Δz is 4.7 mm FWHM, the value used in the equation $\delta\Delta t = \Delta z \times n \times 3.3$ ps/mm is clearly σ (2 mm). Using the FWHM value results in a CRT of 26 ps, which will significantly broaden the distribution in figure 7.

- Considering the previous point, was the correct spacial resolution applied to the rest of the study?

- Last paragraph the page 10: "The measurement of the VUV ... PETALO prototype, *to test the validity of this assumption.*"

- Caption of figure 9: "Distribution of the ... in figure 5, the emission spectrum shown in figure 1, *and considering the group velocity described in eq. 4.3.*"

- Caption of figure 12: "... assuming *two* decay times." – same for the caption in figure 13.

- Figure 14: It would be useful to add the curve for the VUV sensitive SiPMs and a PDE of 20% here, for direct comparison.

Report of referee 2

All my comments to the previous version have been correctly answered, so I do not see any reason not to recommend it for publication.

Editor's comments

The readability and clarity of the manuscript has improved significantly. There are still a few issues to be corrected or clarified. The most important in my opinion is inconsistency (FWHM or sigma) in computation of $\delta\Delta t$ in page 10 and in Fig 7 pointed out by one of the reviewer. After reading the footnote in p.8 the reader will assume that $\delta\Delta t$ in p.10 and Fig.7 are FWHM what does not seem to be the case.

I also found that the fact that the position resolution, assumed in the computations, is the average over the cell volume is not clearly stated in the last paragraph of section 3.1 (as you have written – very clearly – in your reply). The keyword *average* should appear in the text. Please, rephrase.

Centre of the LOR in Fig.4 is ambiguous. It is geometrical centre of the setup I believe.

Insets in Figs.12 and 13 are unreadable.

Please, check carefully the list of references – I have noticed a couple of imprecisions as for example (there may be more):

- Ref.5 – J.Jortner, I believe.
- Ref.12 – SiPM
- Ref.34 – Check authors names.