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Efficient, fast 511-keV γ detection through Cherenkov radiation and ionization: the CaLIPSO detector for PET imaging.

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Positron emission tomography (PET) is a powerful molecular imaging method that plays an increasing role in personalized medicine. Brain PET is especially useful for investigating the molecular dysfunctions associated with neurodegenerative diseases (ND). It contributes to the diagnosis of ND and to the monitoring of the functional changes over the course of ND. For such studies it is important to have a PET scanner with high detection efficiency, high spatial resolution and high time resolution simultaneously. The aim of the CaLIPSO project (French acronym for Liquid Ionization Calorimeter, Scintillation Position Organometallic) is to fulfill these requirements.

Our short term goal is to develop a new efficient and accurate gamma detector optimized for brain PET imaging. We target to achieve an imaging accuracy of 1 mm (FWHM). In order to use this detector in a PET-Scan device, we need to increase at the same time the “imaging efficiency” by a factor 10 compared to HRRT so as to preserve the signal to noise contrast in images*. Excellent time resolution is welcomed as Time Of Flight information leads to very significant gain in image contrast in the image reconstruction.

The 511-keV photon converts in liquid TMBi, by producing a relativistic “primary” electron.

This electron propagates and induces Cherenkov light production. The same primary electron ionizes the detection medium. Both signals will be measured by the CaLIPSO detector.

Achieving an efficient detection and an accurate timing on the low-flux Cherenkov light is a challenge common to all Cherenkov PET detector projects. In this paper, we will present our tests results on the CaLIPSO optical detector prototype. We will show that we achieved efficient detection of the Cherenkov light produced by the 511-keV photo-electron conversion in our detector. In addition, we will present the potential of the technology, for high-resolution timing and thus Time Of Flight imaging using our detailed Monté-Carlo simulation.

Building the prototype of a densely pixelated ionization chamber using liquid TMBi, ie the CaLIPSO ionization detector, is now the priority of the group. The main remaining issue is our ability to reliably purify the liquid from electronegative impurities that trap drifting free electrons. We are now testing several purifying technologies (molecular sieves and getters) in parallel. We will present our latest results.

- See Olga Kochebina abstract.

Summary

For convenience, the summary is enclosed in the pdf attached file.

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