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Fast and Efficient Optical Cherenkov Detector for PET

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Positron emission tomography (PET) is a nuclear imaging technique widely used in oncology. Decay of the tracer emits positrons, which annihilate in the nearby tissue. Two gamma quanta with the energy 511 keV are produced by positron annihilation and allow one to reconstruct the annihilation vertex and distribution of the tracer activity in the body of the patient. The time-of-flight (TOF) technique allows one to improve the signal-to-noise ratio in full body scans and therefore the image quality, or, alternatively, to reduce the dose injected, keeping the same image quality. This technique measures the difference in time between the two annihilation photons in addition to their position. In this thesis we propose to develop an innovative detector using the Cherenkov photons produced by electrons from the photo-ionization conversions of 511 keV gamma. We expect to reach a time resolution better than 150 p. We propose to study two configurations. The first uses the heavy crystal as a Cherenkov radiator, the second uses the heavy liquid radiator. In both configuration the photo-multiplier optimized for the detection of the Cherenkov light will be used. The Ph.D. study will consist in the detectors simulation with Geant4 software, development of the detector concept, construction and commissioning of the mechanical and electronics part of the detectors. The final step will be the characterization and optimization of the detector performances and extrapolation of the developed technology to the “clinical size”PET detector.

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