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PETALO: Time-of-Flight PET with liquid xenon

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Liquid xenon has several attractive features, which make it suitable for applications to nuclear medicine, such as high scintillation yield and fast scintillation decay time. Moreover, being a continuous medium with a uniform response, liquid xenon allows one to avoid most of the geometrical distortions of conventional detectors based on scintillating crystals. In this paper, we describe how these properties have motivated the development of a novel concept for positron emission tomography scanners with Time-Of-Flight measurement, which combines a liquid xenon scintillating volume and silicon photomultipliers for the readout. A first Monte Carlo investigation has pointed out that this technology would provide an excellent intrinsic time resolution, down to 70 ps, which makes it possible to measure the Time-Of-Flight with high efficiency. Also, the transparency of liquid xenon to UV and blue wavelengths opens the possibility of exploiting both scintillation and Cherenkov light for a high-sensitivity positron emission tomography scanner with Time-Of-Flight capabilities. Monte Carlo simulations point to a time resolution of 30-50 ps obtained using Cherenkov light. A first prototype is being built to demonstrate the high energy, spatial and time resolution of this concept, using a ring of 30 cm of internal diameter and a depth of 3 cm instrumented with VUV–sensitive silicon photomultipliers.

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