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Temporal Imaging for PET: Coincidence Timing results on 20 mm LYSO crystals

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In this communication we are investigating the timing performance of an original time-based imaging concept within a monolithic scintillator: Temporal imaging. Acquisitions were done with a Phillips DPC digital Si-PM matrix with a delay-time correction map pixel/pixel. By combining the light distribution and the time distribution of the first detected photons, it was possible to recognize photo-electric events from those involving a Compton diffusion. Two criteria are used to make the selection: the symmetry of the light distribution and the presence or not of a secondary light maximum within the characteristic travel time of UV light within the crystal. Only photo-electric events are used for the present version of our software to reconstruct PET coincidence event.
The first step in our processing is to estimate the radius of the undiffused photon cone on the plane of detector by excluding zones where the first photon is detected >800 ps after the first one. The number of detected photons is then at least 100, which ensures the robustness of the statistical estimation of the critical disc filled by the un-scattered UV photons. This radius is proportional to the depth of interaction (Z).
The X-Y position is then estimated using light distribution barycenter. As we use thick high optical index crystals, the time jitter linked to the difference in propagation speed between gamma rays and UV scintillation light becomes important which introduces a big error in the measurement of the coincidence resolution time (CRT) in PET system.
Time of flight (TOF) was measured in PET system using the time based imaging concept. 32x32x20 mm3 monolithic LYSO crystal were used and the full width half maximum (FWHM) of the CRT obtained from raw data was 494 ps. Time correction was used in order to improve the previous result, it consisted of removing time delay introduced by slower propagation of UV light inside the crystal that contributes to deteriorate the CRT. Compensation is done using depth of interaction previously calculated. After this correction, the FWHM of the CRT reached 228 ps.
Taking into account the time information in the localization of the scintillation event is very important, it provides a good CRT measurement in PET system allowing an accurate location of the annihilation event along the line between the two detectors.

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