OFFICIAL ABSTRACT and CERTIFICATION

Depth of Interaction Improvement due to Directional Control of Scintillator Light

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Positron emission tomography (PET) uses radioactive tracers to localize disease manifestation in the body by mapping the gamma rays the tracers emit. PET scans are essentially maps of the varying levels of radiation inside the body in real space and time. Arrays of crystals called scintillators detect the position of the gamma ray ' s interaction—this point of interaction is different from the gamma ray ' s point of entry in that it is where the ray converts its energy into visible light. The interaction coordinates of the rays are uncertain without an accurate depth of interaction (DOI) value—a better accuracy, or resolution, of which allows for precise image reconstruction. Low DOI resolution leads to low spatial resolution as inaccurate positioning of the gamma events causes distortion of the final image. The pattern of visible light shared changes in accordance with the DOI. This light distribution is dependent on the path the light takes throughout the crystal. A portion of the light undergoes total internal reflection (TIR). Surface roughening can decrease TIR. Uniform depolishing, or roughening, is a process that involves mechanically or chemically treating the crystal ' s outer surfaces so they are no longer smooth. Here, a combination of polished and roughened sides are used in conjunction with a uniform light guide on top of the scintillator array improve DOI resolution at all module locations by optimizing the amount of TIR. Roughening the surface ensures light is scattered at a random angle, thus decreasing TIR. These light sharing patterns that are a function of DOI can be used to predict energy, timing, and spatial resolutions—all critical parameters of PET efficiency—of different PET modules. Varying the ratio of polished to roughened surfaces on Monte Carlo simulated scintillator sidewalls resulted in a wider range of light sharing values—this can be extrapolated to better DOI resolution. Simulated flood histograms showed improved crystal separation due to increased light output. Additionally, as a result of favorable surface roughening, the light sharing is more confined.

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