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A Study of Mass Production of Metacrystal Pixels and Arrays

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There is a desire to continue reducing the time resolution of scintillator based detectors without sacrificing the space resolution to further improve the image resolution of current ToF PET scanners. Unfortunately, we have reached a limit of finding one ideal single crystal candidate that can achieve both aims. Current commercial LSO and LYSO crystal detector can offer time resolution near 200 ps at the system level with light yield close to 50K/MeV. Among all known fast decay scintillating crystals, BaF2 stands out with a decay constant of 0.6 ns for its short emission component near 200 nm. However, BaF2 has a lower than LYSO Z (53),density (4.88) and light yield (1,400/MeV) for the fast emission. Deep UV emission can also create serious problem of low photon detection efficiency even for the current state-of-the-art UV-sensitive SiPMs.

The idea of meta-crystal pixels and arrays can offer a solution to overcome this impasse. Meta-crystal pixels consist of interlayers of two kinds of thin crystal plates with different scintillating properties to complement each other, typically one with fast decay and one with high light yield. Given the current knowledge, the combination of BaF2 and LYSO seems to offer the best solution. The goal for the LYSO/BaF2 meta-pixel is to reach 100ps at the system level,a factor of 2 better than that of bulk LYSO.

These meta-crystal pixels will be made with BaF2 and LYSO thin crystal plates of 0.3 mm thick or less. With such large quantity of crystal plates needed even for one single scanner, it is imperative to develop a cost effective manufacturing process to control the cost.

CPI has been involved with other collaborators to optimize the meta-crystal pixel and array design. At the same time, we also start to make the effort to establish a cost-effective mass production process. We will report our preliminary result at this workshop.

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