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3D digital SiPM for nEXO

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The Enriched Xenon Observatory (EXO) is a particle physics experiment searching for neutrinoless double-beta decay in xenon-136 with a 200-kg time projection chamber. Efforts are currently being made to enhance the experiment's sensitivity with the development of a 5 tonne-scale detector, the next Enriched Xenon Observatory (nEXO). Major experimental improvements include the use of low noise silicon photomultipliers (SiPM) for the detection of liquid Xenon scintillation light. While the baseline of the experiment is to use SiPM, the Sherbrooke's radiation instrumentation team is proposing a vertically integrated and digitally controlled SiPM that is expected to achieve excellent performances with minimum power dissipation, a critical element to avoid the formation of bubbles in liquid Xenon. Using a digital readout takes advantage of the inherently binary nature of the device, provides fast in-chip processing and significantly lowers the output capacitance of the detector. Moreover, by having the readout electronics under the SiPM, both tiers can be optimally and independently fabricated; a very dense CMOS bottom tier and a dedicated custom SiPM top tier with an improved photosensitive fill factor. This talk presents Sherbrooke's first functional 3D digital SiPM. The motivation of this work was to establish a proof of concept and consequently did not aim at ultimate performance. The work done shows that 3D integration of SPAD arrays on standard CMOS electronics is not significantly affecting the Single Photon Avalanche Diode array performances. Work is underway to develop a 3D integration process with industrial partners to be able to produce the required 4-5 m2 of detectors and to improve sensitivity at 170-180 nm.

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