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The Light-Trap: A novel concept for a large SiPM-based pixel

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Several applications in particle physics, high-energy astrophysics or medical imaging require the detection of nanosecond pulses, typically performed with photomultiplier tubes or silicon photomultipliers (SiPMs). SiPMs offer several benefits, such as compactness, low voltage operation and potentially better detection efficiency and time resolution. Their limited physical area (they are rarely commercially available in sizes larger than 6×6 mm^2) remains however as the main limitation to produce large pixels for large detectors. We propose to solve this issue by building a Light-Trap[[1]], a low-cost pixel consisting on a SiPM attached to a PMMA disk doped with a wavelength shifter (WLS). Light in a given wavelength band is absorbed by the WLS, re-emitted isotropically and trapped inside the disk volume until it reaches the SiPM. Light outside the WLS absorbing band is rejected. As a result, the pixel collects photons over a much larger area than standard SiPMs, while being sensitive only in a desired wavelength range. The cost of building a large pixel is significantly reduced, at the expense of losing some efficiency. We introduce the Light-trap principles and present results from laboratory measurements performed with a proof-of-concept (PoC) pixel. The PoC pixel uses a 3×3 mm^2 SiPM collecting light only in the 300-400 nm band, covering an area $\sim$20 times larger than that of the same SiPM itself. Its measured trapping efficiency for 375 nm is $\sim$30\%, i. e., collects the same amount of light than 6 SiPMs like the one used to build the PoC pixel. We will also discuss results from Monte Carlo simulations and potential improvements that could significantly boost the trapping efficiency of the Light-Trap.

References

1 D. Guberman, J. Cortina, J. E. Ward, et al., NIM-A, **923**, 19 (2019)

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