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Time Resolution of Large Area Low Light Level Sensors

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Large area photo-detectors with time resolution of the order of 10 ps for low lights levels, down to the single photon, would bring a revolution in many fields. In medical imaging would enable real time PET, in LIDAR would make possible achieving millimetric spatial resolution requiring no averaging and would have a strong impact in other fields as fluorescence imaging and, of course, in high luminosity experiments in particle physics. Although some Microchannel plate photomultipliers (MCP - PMT) may approximate this performance, a solid-state sensor is often preferred. Silicon Photomultipliers (SiPMs) have been able to replace PMTs in many applications as they have significant advantages in some key aspects: higher Photo Detection Efficiency, robustness and insensitivity to magnetic fields. However, application of SiPMs in large area and fast detectors is an open question as the detector capacitance severely degrades performances: lower signal to noise ratio, worse timing resolution, wider pulse shape and therefore higher pile-up. Neither analog nor digital large area SiPMs achieve a Single Photon Time Resolution below 100 ps. We will discuss how detector segmentation can help in this direction and we will present different techniques, ranging from Application Specific Circuits (ASICs) to a proposal for new generation of hybrid photosensors.

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