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Silicon Photomultipliers: introducing the digital age in low light detection

Single photon sensitivity and photon number resolving capability are enabling features in research and technology development. Quantum information & computing as well as metrology, meteorology, biology, medical physics and security against cyber attacks and nuclear threats are expected to undergo a revolution once low light detection is made easy, reliable and low cost. Single photon detection so far has been mainly associated to photo-multiplier tubes (PMT), the reference instrument since 1934. PMT are certainly a reliable, solid rock technology with decades of improvements and refinements. Their architecture is certainly beautiful but irreducibly complex. Biasing electronics can be sophisticated but the operational voltage necessarily exceeds 1000V. Operation in magnetic fields may be possible but it does not come for free. Last but not least, miniaturisation below a matchbox size is hard to imagine. These figures certainly constrain their integration in apparatus and instruments, with an impact on design and cost.

Silicon PhotoMultipliers (SiPM) stand to PMT like transistors stand to thermoionic valves. In essence, SiPM are an array of p-n junctions operated beyond the breakdown voltage, with every cell in the array ready to trigger an avalanche with 10^6 gain as long as the absorption of a photon generates a charge carrier. With the simplicity and cost of a Silicon sensor, operational voltage not exceeding 100V, magnetic field immunity and miniaturization down to 1 mm^2, SiPM are state-of-the-art sensors, featuring an unprecedented photon number resolving capability and introducing the digital revolution in low light detection. In my talk, I will address the fundamentals of SiPM, identifying the key figures of merit, their measurements and presenting the state of the art and future directions. Moreover, I will consider exemplary applications in nuclear particle detection and dosimetry, homeland security, medical imaging and environmental science.

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