Title: Photon Counting Cameras for LIDARs, Nuclear Medicine, and Molecular Imaging
Speaker: Edoardo Charbon

Photon counting is not new; it has been used for decades in nuclear medicine and molecular imaging to detect a range of sub-nuclear particles and photons. These particles are generally detected indirectly through scintillators, whereas scintillation emits photons that need to be timed precisely to reconstruct the statistics of the primary photon. Time-resolved single-photon detectors have existed since the 1930s, but it is only in the beginning of the 2000s that solid-state single-photon detectors based on avalanching have become prevalent and are now beginning to be the norm in many imaging applications out of cost, reliability, and accuracy considerations. The evolution from single pixel to multi-pixel photon counters, and the implementation of fully integrated CMOS sensors has accelerated the impact of this technology and expanded the field of applications. One such emerging field is that of 3D imaging and LIDAR, where rangefinding is performed at the pixel level using time-of-flight.

In this talk, I will focus on image sensors based on single-photon avalanche diodes (SPADs) and Geiger-mode avalanche photodiodes (GAPDs) implemented in standard CMOS technologies. After an introduction focused on background concepts and theory, I will discuss basic device physics, avalanche propagation, as well as architectures for fast readout of megapixel image sensors. In this context, I will outline applications involving photon counting cameras, such as the abovementioned LIDAR cameras, positron emission tomography (PET), fluorescence lifetime imaging microscopy (FLIM), as well as emerging SPAD based quantum cryptography tools.

A discussion on technology directions in advanced, deep-submicron technologies and on the emergence of new materials for extended spectra of detection and ultra-high speed of operation will conclude the talk.