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Nota di contenuto	Introduction -- The Formation of Electrical Signals in Particle Detectors -- The Statistics of Electron-hole Avalanches in Semiconductors -- Time Resolution and Efficiency of Single-photon Avalanche Diodes -- In-beam Performance of Single-photon Avalanche Diodes.
Sommario/riassunto	Experimental particle physics is a science of many scales. A large number of physical processes spanning energies from meV to TeV must be understood for modern collider experiments to be designed, built, and conducted successfully. This thesis contributes to the understanding of phenomena across this entire dynamic range. The first half of this document studies aspects of low-energy physics that govern the operation of particle detectors, limit their performance, and guide the development of novel instrumentation. To formalise these aspects, classical electrodynamics is used to derive a general description of the formation of electrical signals in detectors, and ideas from quantum mechanics are applied to the study of charge avalanche amplification in semiconductors. These results lead to a comprehensive

analytical characterisation of the time resolution and the efficiency of single-photon avalanche diodes, and isolate the most important design variables. They also reveal the applicability of these devices in precision timing detectors for charged particles, which is experimentally verified in a high-energy hadron beam. Large detector systems at hadron colliders probe fundamental physics at the energy frontier. In the second half, data collected with the ATLAS detector during Run 2 of the Large Hadron Collider are used to measure the cross-section for the production of a Higgs boson together with an electroweak boson as a function of the kinematic scale of the process. This measurement provides the finest granularity available to date for this process. It is highly informative of the structure of interactions beyond the direct kinematic reach of the experiment, and new limits are set on the couplings of such interactions within an effective field theory.