PhD in: Electrical, Electronics and Communication Engineering

Research Title: Cryogenic photon-detection systems

Funded by	Istituto Nazionale di Fisica Nucleare (INFN)

Supervisor	Angelo Rivetti, Giovanni Mazza

Contact	https://wiki.to.infn.it/doku.php?id=vlsi:home

Context of the research activity	The National Institute for Nuclear Physics (INFN), operating under the ministry of education and research (MIUR), is the Italian research agency in charge of studying the fundamental constituents of matter and the physical laws that govern them. To fulfill its mission, INFN needs to develop novel radiation detectors, based on customized sensors and dedicated front-end electronics. In particular, INFN is at present involved in the design of photo-detection system to be used in the direct detection of dark-matter. To achieve a low back-gound, such devices need to operate at liquid nitrogen temperature. Single photon detection is essential, therefore Geiger-mode silicon sensors will be employed. In the final application, a surface of 20 m2 need to be instrumented. An integral part of the project is the development of a low-noise and low power CMOS front-end electronics optimized to work at cryogenic conditions. Challenges to be addressed are the development of fast and low-power analog front-end electronics and of smart biasing circuits capable of keeping the circuit performance constant over a wide temperature range. In the baseline option, the photo-sensor and its readout electronics will be fabricated on two different chips and mated with wire-bonding or flip-chip techniques. Feasibility studies on monolithic solutions are also planned. This will include the study of a fully CMOS 2D options, with sensors and the front-end electronics realized on the same substrate and of a 3D approach based on wafer-stacking techniques.

Objectives	The primary objective of the research activity is the development of analog front-end electronics for Silicon Photon-Multiplier (SiPM) operating at cryogenic conditions. In a first phase of the project, test structure to evaluate the elementary device performance at liquid nitrogen will be implemented and their characterization will be performed, with the purpose of identifying clear design guidelines. Smart biasing schemes, suitable to guarantee stable circuit performance over a wide temperature range will also be investigated. Following this, a dedicated readout chip will be implemented. Full modules incorporating the sensor and the front-end electronics will be assembled and tested. In a later stage, the possibility of a fully monolithic implementation will be explored. This will entail the device-level simulation of photon-detection sensor in CMOS technologies optimized to work at liquid nitrogen.

Skills and competencies for the development of the activity	The ideal candidate has good knowledge of CMOS analog electronics and a strong interest in developing analog CMOS circuits for fast signal processing and power management. Basic knowledge of standard tools used in analogue integrated circuit design is necessary. In a later stage it might be necessary to acquire familiarity also with device-level simulators.