PhD in Electrical, Electronics and Communication Engineering

Research Title: 4D Tracking Sensor Systems

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Supervisor	Angelo Rivetti (rivetti@to.infn.it), Manuel Rolo (darochar@to.infn.it) Michele Goano (michele.goano@polito.it)

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 fulfil its mission, INFN needs to develop novel radiation detectors, based on customised sensors and dedicated front-end electronics. It has been recently recognised that sensors capable of identifying simultaneously the impact point of a particle with excellent spatial (a few micrometers) and time resolution (100 ps or better) would be of great interest in future experiments at particle accelerators. An adeguate number of layers of such devices allows to identify unambiguously the particle trajectory in space and time, which justifies the name “4D-tracking sensors” used for them. The ideal 4D sensor would be a matrix of pixels, in which each sensing element has an area of 100 um x 100 um or smaller and is mated to a dedicated readout unit encompassing in the same area the key functions of amplification, amplitude, time measurement and data buffering. To achieve the best possible time resolution a careful co-design of the sensor and its front-end electronic is essential. The amount of signal processing that must be embedded in the pixel calls for the use of a very dense integrated circuit technology. The design of the readout chip will thus assume as baseline the 28 nm CMOS node. Exploratory work in a 16 nm FinFET process is also planned. The research work will be carried-out in the context of national and international collaborations, involving other research units of INFN and italian Universities as well as major international laboratories, such as CERN.

Objectives	The research activity will pursue three main objectives. The ambitious timing performance can only be achieved by a careful co-design of the sensor and its front-end electronics. In particular, it is essential to design the sensor with a topology that minimises the timing jitter induced by statistical fluctuations in the signal generation process. A second goal is the development and characterisation of analog building blocks in a 28 nm CMOS technology. Such blocks include, but are not limited to, very front-end amplifiers with leakage compensation circuitry, auto-zeroing comparators and ultra-low power time-to-digital converters. The design of a complete readout system will then be pursued. The demonstrator ASIC will incorporate a matrix of 32 x 32 or 64 x 64 pixels, ideally with 50 um pitch. The ASIC will then be mated to one or more sensor prototypes to build a demonstrator of an advanced 4D tracking systems. Additionally, the key building blocks will be also prototyped in a 16 nm FinFET process and uses as test vehicles to assess the advantages and issues of using such an advanced process in the implementation of readout electronics for radiation sensors.

Skills and competencies for the development of the activity	The ideal candidate combines a good attitude to team activity with the capacity of working autonomously to identify novel solutions. Basic knowledge of advanced CMOS technology nodes is required. In a first phase, the student will be involved in analog integrated circuit design in 28 nm CMOS. Good computer skills are thus essential. The knowledge of state of the art professional software for analog circuit design, simulation and layout is a plus.