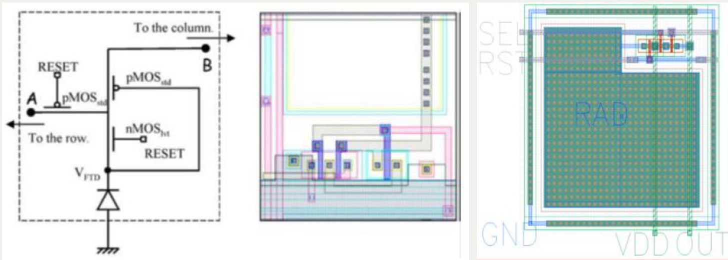
DIPARTIMENTO DI INGEGNERIA
CORSO DI DOTTORATO IN INGEGNERIA INDUSTRIALE E DELL'INFORMAZIONE -
PHD COURSE IN INDUSTRIAL AND INFORMATION ENGINEERING - 34TH CYCLE

Title of the research activity:	**Advanced radiation sensors VLSI design in CMOS technology** Research Field: **Sensors and Electronics** for High Energy Physics, Medical and Space applications. International and National Collaborations: **CERN** (European Organization for Nuclear Research), Geneve (Switzerland); **LFoundry**, Landshut (Germany), **INFN** (Istituto Nazionale di Fisica Nucleare, Italy).
State of the Art:	Monolithic CMOS sensors embed in the same substrate the sensor and its read-out electronics. They are fabricated in commercial, microelectronics-grade foundries. CMOS sensors offer an attractive alternative to standard hybrid pixel and micro-strip detectors to build systems with better performance, higher reliability, and lower cost. The main limitations of the state-of-the art radiation detectors are the **resistance to very high fluences** irradiation and **power dissipation** over relatively large sensing areas.
Short description and objectives of the research activity:	The purpose of the present research is to develop innovative CMOS monolithic pixel detectors that can replace standard hybrid pixel and silicon strip detectors in a wide range of applications such as High Energy Physics experiments, Medical applications as well as Space applications. The proposed development relies on three key elements: – a **sensor fabrication technology** that, starting from the experience gained in the previous research activity within national and international collaborations and projects, will improve in such a way to be suitable for a wide range of applications. – a set of smaller-size **test structures** to investigate relevant issues that can be addressed without full-size prototypes (e.g. radiation resistance, monitoring of the substrate properties, influence of different pixels architectures on charge collection efficiency). – a **versatile and scalable front-end electronics** and architectures, capable to effectively support the development of sensors with realistic size and performances. The CMOS electronics will be common to the different sensor options, that will be explored by changing only the substrate material and/or some step of the production process. All the design improvements and modifications introduced in the process flow will be validated with the help of Technology Computer-Aided Design (TCAD) simulations, relying on process data provided by the foundry. A proper TCAD modeling of the bulk and surface radiation damage effect should also be devised and validated for the selected technology [*Moscatelli-2016*], thus fostering its application for the comparison of different layout/doping profiles aiming at optimizing the radiation resistance of the device in terms of SNR and breakdown effects. Aiming at low power design, alternative pixel front-end architectures will be investigated. In particular, a so-called Weak Inversion Pixel Sensor (WIPS), shown in Fig. 1, exploits a dedicated, yet simple circuitry, based on a pre-charge/evaluation scheme, which allows for

	‘‘sparse’’ access mode and thus for speeding-up the read-out phase [*Passeri-2004*].  Fig. 1: CMOS WIPS scheme: equivalent circuit (left-hand side), corresponding layout (right-hand side)
Bibliography:	[*Passeri-2004*] D. Passeri, P.Placidi, M. Petasecca, P. Ciampolini, G. Matrella, A. Marras, A. Papi, G.M.Bilei, “Design, Fabrication, and Test of CMOS Active-Pixel Radiation Sensors”, IEEE TRANSACTIONS ON NUCLEAR SCIENCE, VOL. 51, NO. 3, JUNE 2004. [*Moscatelli-2016*] F. Moscatelli et al., “Combined Bulk and Surface Radiation Damage Effects at Very High Fluences in Silicon Detectors: Measurements and TCAD Simulations”, IEEE Trans. on Nucl. Sci.63 (5), (2016) 2716-2723.
Scientific coordinator (s)	Daniele PASSERI, Pisana PLACIDI
Contact (s)	Daniele PASSERI: daniele.passeri@unipg.it Ph:+39-075-5853643 http://www.ing.unipg.it/en/component/k2/itemlist/user/73 Pisana PLACIDI: pisana.placidi@unipg.it Ph:+39-075-5853636 http://www.ing.unipg.it/en/component/k2/itemlist/user/74