Ph.D. in Information Technology
Thesis Defense

March 15th, 2024
at 15:30 pm
Room Beta – building 24

Jacopo QUERCIA – XXXVI Cycle

CDTE AND CDZNTE DETECTORS AND CMOS READOUT ELECTRONICS FOR HIGH ENERGY RESOLUTION X-RAY IMAGERS WITH HIGH PHOTON FLUX CAPABILITIES

Supervisor: Prof. Giuseppe Bertuccio

Abstract:

X-ray image sensors with photon counting and energy resolving capabilities have a great impact in a wide range of fields both in scientific research and industrial contexts. Among them, an emerging X-ray imaging application is non-destructive real-time controls in the food, pharma and recycling industry; requiring the study and development of dedicated high energy resolution and high photon count rate sensors, based on CdTe and CdZnTe detectors with dedicated CMOS front-end electronics. An extensive experimental activity was conducted, coupling CdTe and CdZnTe pixel detectors to research-grade ultra-low noise Charge Sensitive Amplifiers (CSA), to demonstrate state-of-the-art energy resolution at room temperature. A width less than 600 eV FWHM was achieved for the ^{241}Am 59.5 keV line at the optimum peaking time of 1 µs, while also retaining a line width less than 1 keV at a 50 ns peaking time, unlocking spectroscopy-grade energy resolution for this class of detectors also in high input count rate scenarios, higher than 10^6 counts per second on each pixel. However, the system energy resolution performance has been found to be also limited by non-idealities in the detector response, such as the poorer transport properties and the higher fluorescence yield of high atomic number materials. This aspect stimulated the development of a custom simulation toolkit that could reliably predict the detector response simulating both photon energy deposition within the detector volume and signal induction at its electrodes, proposing novel approaches for the simulation of charge cloud broadening under carrier diffusion and electrostatic repulsion effects. Non-stationary gain effects present in pulsed-reset CSA operated in wide dynamic range scenarios were also studied, developing an analytical model that could quantitatively describe
the non-stationary gain induced distortion in charge read-out. Part of the work was also devoted to a technology transfer collaboration with a leading company in real-time defects and contaminants detection, primarily tailored to the food industry, for the development of CMOS Application Specific Integrated Circuits (ASIC) that were ultimately embedded at the core of their inspection technology.

Irisa DEDOLLI – XXXVI Cycle

LOW-NOISE MIXED-SIGNAL INTEGRATED CIRCUITS FOR X- AND GAMMA-RAY SPACE TELESCOPES FOR MULTI-MESSENGER ASTROPHYSICS

Supervisor: Prof. Giuseppe Bertuccio

Abstract:

The studies of X- and γ-ray emissions coming from the deep space is a powerful tool to understand different phenomena in the Universe. The specifications of instruments for the detection of X- and γ-rays on satellites have become more and more challenging over the last decades, in terms of area, number of pixels, noise, and power consumption, in order to satisfy the requirements of new scientific experiments. Besides the availability of high-performance detectors, such as Silicon Drift Detectors (SDD), a read-out ASIC capable of exploiting the detector performance is also required. This thesis focuses on the design and experimental characterization of the next generation low-noise, low-power mixed signals CMOS ASICs for radiation detectors devoted to future Space Missions, in particular, related to projects such as ADAM (Advanced Detector for X-ray Astronomy Missions), THESEUS and HERMES

PhD Committee

Prof. Carlo Ettore Fiorini, Politecnico di Milano
Prof. Alberto Pullia, Università degli Studi di Milano
Prof. Lodovico Ratti, Università di Pavia