Ph.D. in Information Technology:

Butt, Parsani, Schembari, Zou and Ragaglia Final Dissertations

DEIB Alfa Beta

February 25th, 2016

10.00 am

First Ph.D. presentation and discussion:

Arslan Dawood BUTT – XXVIII Cycle

"Silicon Drift Detector Arrays for X- and Gamma-Ray Detection Applications"

Supervisor: Prof. **Carlo E. Fiorini**

Abstract:

This Doctoral activity aims at the study and development of X- and gamma-ray detection systems based on Silicon Drift Detectors (SDDs) for diverse applications in the field of radiation detection instrumentation.

Silicon Drift Detectors, invented by E. Gatti and P. Rehak in 1983 are now widely used detectors for applications demanding low-noise, high-rate soft X-ray detection solutions. In addition, SDDs have also proved to be useful for scintillator readout to perform gamma-ray spectroscopy and imaging. This dissertation deals with the study, design, development and characterization of prototype detection systems based on Monolithic SDD arrays and complementary system mechanics for nuclear physics research and gamma-ray astronomy applications. Among these, X-ray application includes primarily the upgrade of SIDDHARTA experiment, which aims at detection of X-ray emissions of exotic atoms for study of strong nuclear interactions. Another application thoroughly described in this work is a European Space Agency (ESA) supported feasibility study to evaluate the use of SDD arrays to readout large LaBr3:Ce scintillators for planetary gamma-ray observations. In addition, position sensitivity of this SDD+ LaBr3:Ce gamma-camera alongside spectroscopy has been investigated for a possible reduction of Doppler Broadening Effect in the scope of an Instituto Nazionale di Fisica Nucleare (INFN) supported study.

Second Ph.D. presentation and discussion:

Tommaso PARSANI – XXVIII Cycle

“Femtoscope ARray for COrrelation and Spectroscopy (FARCOS): Silicon Detector Layers Response Mapping and Highdynamic Range VLSI Front-End Design”

Supervisor: Prof. **Chiara Guazzoni**

Abstract:

FARCOS (Femtoscope ARay for COrrelation and Spectroscopy) is a novel detection system based on Double Sided Silicon Strip Detectors (DSSSD) with a high degree of segmentation and CsI(Tl) scintillators. It features high angular and energy resolution and it is able to reconstruct the particles momentum at high precision for different physical cases in heavy-ion collision nuclear physics experiments at intermediate energies (10-100MeV/u). The main goal of the system is to achieve a full particle identification and correlation by exploiting, together with the standard identification techniques (ΔE-E, ToF), Pulse Shape Analysis (PSA) techniques both on the CsI(Tl) signals and, more ambitiously, on the DSSSD. The research activity consists of the development and the characterization of the frontend electronics to be coupled to the DSSSD detectors.

The silicon detectors characterization has been performed by investigating the fundamental physical parameters (dark currents and capacitances, studied as a function of the applied bias and of the frequency) and by performing a detailed amplitude and position detectors response mapping exploiting the monochromatic pulsed ion beams available at the INFN-LaBeC facility (Firenze). Special attention is given to the impact of inter-strip beam incidence on the shape of the induced signals, among the main causes that can greatly spoil the overall identification capabilities. In order to better study the interstrip response we performed a deep characterization using an infrared pulsed laser at different wavelengths.

The obtained results has been used as design specification for the development of a multichannel CMOS VLSI frontend. The circuit, based on Charge PreAmplifier (CPA) topology, is able to amplify both the signal polarities of the signals coming from the DSSSDs without significant amplitude and shape distortion, thus allowing PSA. To cope different experimental scenarios we implemented also a selectable gain feature, with corresponding energy ranges of 90 MeV to 500 MeV. The circuit has been produced in an 8-channel and in a 16-channel version with the AMS C35M4B3 technology. The qualification of the circuit, both stand-alone and coupled to the detectors, has shown a response fully compatible with the experimental requirements. The VLSI frontend is implemented on a 32-channel PCB able to carry out the signals of one side of the silicon detectors and the analog output signals are delivered to the digitizers, located outside the vacuum chamber wherein FARCOS operates, by dedicated line-drivers.

Third Ph.D. presentation and discussion:

Filippo SCHEMBARI – XXVIII Cycle

"Development and Characterization of a Low Noise Multichannel Readout ASIC for X and γ-Ray Spectroscopy Applications"

Supervisor: Prof. **Carlo E. Fiorini**

Abstract:

When dealing with X and γ-ray spectroscopy, nuclear physics experiments and medical imaging applications, the main focus is undoubtedly optimizing the energy resolution of the overall detection system. X and γ-ray integrated readout front-ends often present significant differences both in terms of processing times, gains, multiplexing protocols and inner architectures. Depending on the application, X-ray front-ends might favor shorter shaping times, higher gains and fast sequential multiplexing or sparsification, while γ-ray electronics based on monolithic crystal scintillators exploits longer shaping times, lowers gains and different multiplexing protocols. In addition, most of the readout front-ends designed so far do not provide any analog-to-digital (A/D) conversion of output signals, making the data transmission to the external DAQ more susceptible to electromagnetic interference. With the aim of merging all the aforementioned peculiarities, thus paving the way towards a more general-purpose approach, this dissertation presents the design of SFERA, a fully programmable readout ASIC in principle suitable for both X-ray and γ-ray detection modules, able to perform on-chip data digitization. The reference detector for the implementation and characterization that followed is the SDD (both single and arrayed) because of its excellent noise performance in the typical range 0.2 to 30 keV and also representing a competitive alternative to conventional detectors employed in γ-ray modules (PMTs, SiPMs, PIN diodes). Project specifications and relevant implementation details are addressed, moving further to the experimental characterization of both spectroscopic and high-throughput performance. Finally, the embedded 12-bit SAR ADC is described and conclusions are drawn.

Fourth Ph.D. presentation and discussion:

Yu ZOU – XXVIII Cycle

"SPAD Imagers and Systems for 2D Imaging and 3D Ranging"

Supervisor: Prof. **Franco Zappa**

Abstract:

The aim of this thesis work is to develop CMOS SPAD image sensor and 3D vision system based on indirect time-of-flight techniques for safety and security applications.

The thesis presents the innovative -BackSPAD sensor chip, exploiting backside illumination of a silicon-on-insulator (SOI) wafer containing custom single-photon avalanche diodes (SPADs), flipped upside down and wafer-bonded on a standard 0.35 μm CMOS wafer integrating the analog front-end circuit, in-pixel digital processing and readout electronics. Two major improvements are achieved: higher pixel density and fill-factor, since these detectors are placed on the top of the corresponding smart-pixel electronics, instead of being placed side-by-side (as in planar structures); enhanced spectral sensitivity in the near-infrared, up to 1 μm wavelength, thanks to thicker active volume within the SOI detector wafer and to the backside illumination of the active area.

Then, the thesis presents an optical 3D ranging system for automotive applications able to provide centimeter depth resolution over a 40° × 20° field-of-view up to 45 m with just 1.5 W of active illumination at 808 nm. The imager is based on a previously designed CMOS array chip of 64×32 pixels, with a Single-Photon Avalanche Diode (SPAD) able to perform lock-in time-of-flight calculation of individual single photons emitted by an illuminator and detected back by the camera. Thanks to the new firmware and software developed in thesis, the detection range is able to extend to 45m with large field-of-view, which is never reported in literature

DEIB Conference Room

February 25th, 2016

2.30 pm

First Ph.D. presentation and discussion:

Matteo RAGAGLIA – XXVIII Cycle

"Towards a Safe Interaction Between Humans and Industrial Robots Through Perception Algorithms and Control Strategies"

Supervisor: Prof. **Paolo Rocco**

Abstract:

In the past few years the need for more flexibility in industrial production has implied, in the field of industrial robotics, a growing attention towards the possibility of making humans work directly in touch with robots. As a matter of fact, it is today a common opinion that Human-Robot Interaction (HRI) represents the key factor that will facilitate industrial robots to spread in Small and Medium sized Enterprises (SMEs). Nevertheless, HRI introduces a series of safety issues which are uncommon in industrial settings where physical separation between robot and human workspaces is typically enforced. In order to achieve safe and efficient HRI, this thesis was developed around two main goals: x) enhance the perception capabilities of a typical control system of an industrial robot by integrating information coming from different exteroceptive sensors, like for instance RGB and depth cameras; x) develop reactive control strategies and trajectory generation algorithms that not only rely on the information acquired by these sensors, but that also guarantee human workers' safety by satisfying safety standards and regulations.