Ph.D. in Information Technology
Thesis Defense

March 15th, 2024
at 2:30 p.m.
Room Alpha, Building 24

Ilenia D'ADDA – XXXVI Cycle

DEVELOPMENT OF FRONT-END ELECTRONICS FOR GAMMA RADIATION DETECTORS IN MEDICAL APPLICATIONS

Supervisor: Prof. Carlo Ettore Fiorini

Abstract:

This doctoral project focuses on advancing gamma radiation detection in medical applications, particularly through the development of a prompt gamma camera for real-time range monitoring in hadrontherapy. Hadrontherapy utilizes accelerated charged particles like protons, carbon, or helium ions for precise tumor treatment, offering localized energy deposition while minimizing damage to healthy tissues. Accurate monitoring of the Bragg peak, the point of maximum dose deposition within tissue, is crucial for enhancing precision and reducing safety margins in treatment planning. Prompt gamma rays emitted during ion-beam interactions with target nuclei closely correlate with particle range, making their detection an ideal real-time monitoring strategy. The objective is to develop a 1D real-time prompt gamma detection module featuring an array of SiPMs coupled with a pixelated LYSO scintillator, based on knife-edge collimation with a target spatial resolution of approximately 2mm in determining the dose profile falloff. The unique characteristics of this measurement, including a wide energy range up to 8MeV, significant neutron background, and high input count rate, necessitate tailored detector read-out electronics. The SITH (Spectroscopy Imaging Timing Hadrontherapy) ASIC, a custom 16-channel integrated circuit developed in AMS 0.35 µm CMOS technology, serves as current-read-out front-end for SiPMs. The ASIC measures both energy and time-of-arrival of detected photons, features a low input impedance (<10Ω), high dynamic range (>80dB), and flexibility for coupling with monolithic as well as pixelated scintillation crystals. The envisioned detection module aims for a 64-channel prototype, consisting of an 8x8 pixelated LYSO scintillator, a 64-SiPM array, 4 SITH ASICs, and a FPGA-based DAQ system. The ASIC as well as two scaled-down versions of this prototype were developed, the 16-channel and 32-channel detection modules. Furthermore, an updated version of the 16-channel GAMMA ASIC, designed for the read-out of SiPM arrays coupled with monolithic scintillators used in boron neutron capture therapy (BNCT), was also developed. This version features key modifications and layout adjustments to enhance performance and address previous issues.

PhD Committee

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