Ph.D. in Information Technology
Thesis Defenses

February 2nd, 2022
at 10:00
Room Beta and online by Zoom

Matteo GUGIATTI – XXXIV Cycle

Development of a Large-matrix SDD-based Radiation Detector for Beta-decay Spectroscopy in Neutrino Physics

Supervisor: Prof. **Carlo Fiorini**

Abstract:

Several theories outside the Standard Model (SM) propose the existence of new kinds of neutrinos, called sterile neutrinos, that would interact only via gravitational forces. If their mass were in the keV range, they would be promising dark matter candidates, answering a series of unresolved questions in astroparticle physics and cosmology. The TRISTAN project aims at searching for a sterile neutrino signature by measuring with unprecedented accuracy the whole tritium beta-decay spectrum. To achieve this, the current KATRIN (Karlsruhe Tritium Neutrino Experiment) apparatus will be extended with a new multi-pixel Silicon Drift Detector (SDD) system. In this context, the present thesis focuses on the design, development, and characterisation of a monolithic 166-pixel SDD-based detection module for the TRISTAN project. Since the SDD technology is usually widely adopted in X-ray spectroscopy applications, its employment in detecting electrons must be validated. Moreover, in the development and tuning of such a large detector, several challenges have to be addressed. The 166-pixel SDD matrix is the building block for the final detection system of the TRISTAN project, which will comprise twenty-one identical matrices, constituting an array with a total of 3486 cells. The detector and its readout electronics must comply with stringent requirements for their operation in high vacuum and strong magnetic field conditions for an extended period of time. Firstly, the validity of the SDD technology in electron detection applications has been experimentally assessed with a single-pixel device mounted in an electron scanning microscope (SEM). Secondly, the development of the multi-pixel TRISTAN prototypes has been subdivided into three milestones, with an increasing number of cells: 12, 47, and 166 pixels.

Pietro KING – XXXIV Cycle

Development of a multi-channel analog pulse processing and data acquisition system for the TRISTAN detector

Supervisor: Prof. **Carlo Fiorini**

Abstract:

The aim of this thesis is the design, development and characterization of the Analog Pulse Processing and Data Acquisition (APP-DAQ) system for the detector readout of the TRISTAN project. Its experimental target is the search of sterile neutrino in the keV-scale, a promising dark matter candidate. To reach this goal, it envisions the operation of 21 detection modules each equipped with a monolithic array of 166-pixel Silicon Drift Detectors exploiting the existing KATRIN (KArlsruhe TRItium Neutrino) apparatus.

In this framework, the APP-DAQ platform Kerberos and its Data Concentrator Athena were developed. The first is aimed to provide a simple and low-cost multi-channel readout solution in the early phase of the TRISTAN detector development. It is based on three 16-channel programmable analog pulse processor front-end ASICs (SFERA), three high linearity ADCs, and an FPGA. The platform is able to acquire data from up to 48 pixels in parallel, providing also different readout and multiplexing strategies.

Instead, Athena is designed to increase the capabilities of Kerberos, connecting up to 4 of them, reaching the parallel readout of 192 pixels at the same time. Athena platform acts as global trigger and event builder constructed for the readout of the final 166-pixel detector module for TRISTAN. It is based on a Zynq Ultrascale+ MPSoC, exploiting both the FPGA and microprocessor functions. The systems hereby presented demonstrate that the use of an analog ASIC-based solution instead of a Digital Pulse Processor, represents a viable and scalable processing system at the price of slightly limited versatility and count rate capability, especially for applications with large number of channels or more stringent power consumption constraints.

PhD Committee

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