Ph.D. in Information Technology
Thesis Defenses

February 1st, 2022
at 9:30
Room Beta and online by Teams

Luca BUONANNO – XXXIV Cycle

Gamma-Ray Spectroscopy and Imaging with SiPMs Readout of Scintillators: Front-End Electronics and Position Sensitivity Algorithms

Supervisor: Prof. **Carlo Fiorini**

Abstract:

Gamma radiation detectors for both spectroscopy and imaging find application in various fields, such as nuclear physics experiments, gamma-ray astronomy, nuclear medicine, molecular imaging, and homeland security. Remarkably, the instrumentation design often benefits of technological transfer from one field to another, with a strong push in technological development driven by the demanding requirements of fundamental research. The collection of papers presented in this thesis largely focuses on a detection module developed in a joint project with INFN, within the context of GAMMA experiment, which couples a 3"×3" cylindrical, Ce+Sr codoped LaBr3 scintillation crystal to a large array of silicon photomultipliers, targeting the superseding of PMT-based spectroscopy modules for medium and high energy gamma radiation detection. The main results results presented in the thesis are the SiPM-based module capability of detecting single photons when pulsed with an external laser, and the achieved 2.6% energy resolution and sub-cm resolution planar position sensitivity at the 662keV gamma-ray energy, when coupling the SiPM array to the thick 3"×3" LaBr3 crystal. The discussion encompasses the front-end ASIC design, the machine-learning algorithms for position sensitivity characterization, and applications of the developed module in environmental monitoring and particle therapy.

Vincenzo Loris SICARI – XXXIV Cycle

Developments, commissioning and upgrade of the FARCOS frontend electronics

Supervisor: Prof. **Chiara Guazzoni**

Abstract:

In nuclear physics the study of heavy-ion collision at intermediate energies (10-100MeV/u) is the only means available to investigate the properties of nuclear matters under extreme condition and, thus, to better understand the Equation of State (EOS) of nuclear matter.

This is fundamental for the study of the properties of stable and unstable (radioactive) nuclei and for the study of the properties of compact astrophysical objects such as neutron stars, core-collapsing supernovae and black-holes formation.

The large variety of particles and fragments produced in a single collision and their reciprocal correlation event by event allows quantitative understanding of the reaction dynamics and probing space-time properties of emitting sources. Several experimental techniques and the corresponding detection systems have been developed in order to find the answers to the remaining open issue (space-time dynamics of the produced fragments, their thermal properties, internal temperature or spin, etc).

The FARCOS system is positioned in this field, with its most promising application in particle-particle collision studies, particularly within the heavy-ion collision nuclear physics experiments. This extended abstract of my PhD thesis as collection of papers shows the work done for the development, commissioning and upgrade of this novel detection system called FARCOS (Femstoscopy Array for COrrelation and Spectroscopy) which is a compact, modular and versatile telescope array made of Double Sided Silicon Strip Detectors and CsI(Tl) scintillators. During these years, the study, meticulous qualifications and various experiments have led to the development of a detection system with an increased energy and spatial resolution, wide solid angle coverage and unique capability to perform pulse shape identification techniques, even in the first detection stage, make it a promising investigation tool for many physical cases.

Gianlorenzo UTICA – XXXIV Cycle

Development of X-Ray Spectroscopy Instrumentation for Synchrotron Applications Based on Silicon Drift Detector

Supervisor: Prof. **Carlo FIORINI**

Abstract:

Fluorescence spectrometers support researchers for a wide range of applications in the field of biology, cultural heritage, medicine, and many more. Some of them make use of intense X-ray sources, such as synchrotron radiation, to investigate the properties of specimens by studying the fluorescence emission spectra of the latter. Therefore, efficient and high-count rate capable energy-dispersive X-ray fluorescence spectrometers are needed. The synchrotron radiation sources are an exceptional and rather unparalleled source in terms of performances. Synchrotron facilities around the world are continuously growing in brilliance and thus driving the development of X-ray detection systems able to cope with the demanding requirements in terms of high-count rate.

Nowadays, multichannel X-ray fluorescence detectors for synchrotron applications are highly widespread. However, most multichannel detection systems are usually obtained combining single-element Silicon Drift Detectors (SDDs). The main drawback of such an approach is the large dead area among elements. Therefore, an emerging trend in development of SDD-based spectrometers is moving toward a monolithic configuration which allows to minimize source-detector distance and to increase solid angle coverage.

The major core of this dissertation is the study of monolithic SDD arrays, with different wafer thicknesses, as an alternative solution with respect to configurations employing arrays of single-element SDDs. In this context, ARDESIA project started aiming at developing multichannel SDD-based spectrometers for synchrotron applications. The strategy followed in ARDESIA developments is to employ large multichannel monolithic SDD arrays coupled to custom designed 4-channel CUBE preamplifiers. A new 16-channel spectrometer with thicker substrates have been designed, developed, and commissioned to gain in both maximum count rate and detection efficiency at higher energy range. Measurements have been carried with ARDESIA spectrometers in three different synchrotron beamlines at the ESRF in Grenoble and at PETRA in Hamburg. Finally, two new cutting-edge developments have been launched and investigated: the development and the characterization of first prototypes of hybrid detectors where the preamplifier is bump-bonded to the SDD, and the preliminary study of a new spectrometer, named ASCANIO, designed in back scattering configuration.

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