OVERVIEW OF THE PROJECT

High energy resolution X-ray detector read-out integrated circuits with amplitude and time measurement

The aim of the project is research towards new techniques for the design of fast, ultra-low noise multichannel read-out front-ends dedicated to radiation imaging systems using X-ray. This project works will be focused on improving the energy resolution and keeping the high intensity of incident radiation. These techniques and devices are the very up-to-date and important research topic of many scientific institutes and companies worldwide. The main trend is reaching very high X-ray spectroscopy resolution as a result of low equivalent noise charge. It is important for wide application in medical imaging, material science or X-ray fluorescence holography, and also new drug development, crystallography including more-recently COVID-19 research ("The Complicated Story of Antibodies in COVID-19" 2020). Achieving this goal is even more difficult when adding high input count rates. Meeting both requirements leads to the development of new techniques ranging beyond known techniques of noise reduction but also reaching for "digitally assisted analog circuits", event-based processing, time-based analog-to-digital conversion or finally system-level approach and co-design of the system, as a whole. In spectroscopic applications, the parameters uniformity (between all read-out channels) is crucial to successfully distinguish between spectral lines of radiation and requires careful design taking into account mismatch correction and calibration for proper operation of the read-out system.

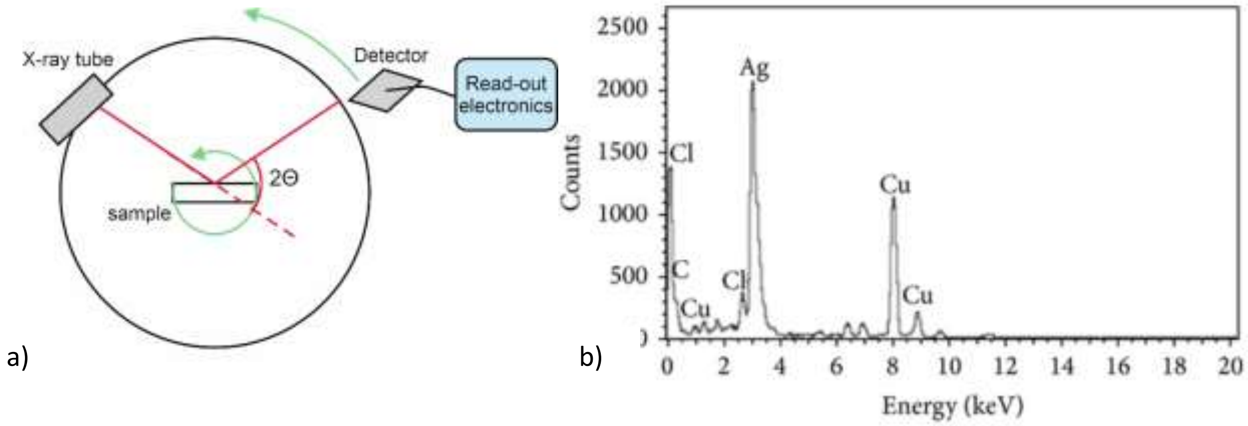

Figure 1 a) Principle of X-ray spectroscopy, b) example of energy-dispersive X-ray spectroscopy (EDS) analysis (Singh, Sahu, and Thangaraj 2014).

Basing on simulation works towards the electronics optimization (using Cadence Virtuoso tools), a prototype multichannel (8 to 16 channels) Application Specific Integrated Circuit will be designed, fabricated and tested. Tests will be performed for functional verification, charge-sharing effects investigation and noise performance. The tests can be performed using a well-focused femtosecond laser, tests with synchrotron beam, radiation sources and X-rays of various energies.

The research objective is to develop a front-end architecture for silicon microstrip sensors read-out for X-ray spectroscopy, crystallography and radiation imaging (enhanced colour imaging thanks to novel energy digitization method). Increasing the energy resolution by the noise performance improvement, requires a novel approach, system-level oriented design and careful off-chip noise contributions analysis. Providing better noise performance is challenging while ensuring high input count-rate and processing speed of the read-out system and taking into account limitations such as low power consumption and limited channel area. The possibility to improve spectroscopic parameters of the system like higher spatial resolution will be investigated, by implementation of the methods for the charge-sharing effects handling or digitally assisted analog circuits techniques and novel approach to time measurements.