## Ph.D. in Information Technology: Thesis Defenses

# July 15th, 2020 Online by Microsoft Teams – at 14.00

#### Marco GIACOMETTI – XXXII Cycle

"Tid Mekii: A Rapid and Quantitative Diagnostic System for Malaria" Advisor: Prof. Marco Sampietro

#### Abstract:

Malaria is a life-threatening parasitic disease killing more than 400 thousands people every year, 61% of which are children aged under 5 years old. The fight against malaria demands billions of USD each year representing an unbearable burden which exasperate the already difficult economic situation of most of the malaria endemic countries. Despite many efforts have been put into the research of antimalarial drugs and prevention methods, the onset of drug resistance and the mosquito habits adaptations risk of putting them in jeopardy. In this ongoing struggle, diagnostic tools represent a fundamental guidance for a prompt and proper treatment of the disease, helping to reduce the mortality rate and counteracting the occurrence of adaptations of the parasite to antimalarials. The panorama of currently diagnostic methods sees three main techniques: microscopy examination, rapid diagnostic test and polymerase chain reaction based diagnosis. Their cost, complexity and time requirements, however, are not always adequate to allow a wide spread to support the constant need.

It is precisely to face this lack that the World Health Organization itself calls for development of low cost, easy to use and reliable new diagnostic techniques. The developed innovative system here presented is aimed to support this request by proposing a panplasmodic, quantitative, easy to use, rapid and potentially low cost diagnostic tools. The name of the project itself, Tid Mekii, the name of the malaria in Cameroon language, highlights its aim and purpose to provide a rapid and valid alternative up to the actual devices and methods while ensuring a low cost to guarantee its wide spread in the poorest endemic countries. The technique relies on the selective magnetophoretic attraction and consequent electrical impedance detection and quantification of malaria infected red blood cells (iRBCs). The tests performed with the device demonstrate its capability of detecting and quantify both hemozoin crystals (HCs), i.e. the malaria pigment, and iRBCs concentrations down to, respectively, 104 HCs/ul and 10 iRBCs/ul in less than 10 minutes. The possibility to perform a follow up of the treatment and discriminating between different stages of the disease has emerged although further dedicated investigations are required to confirm said features. A preclinical validation have been carried out at Hopital Saint Luc of Mbalmayo, Cameroon, Africa on 108

suspected malaria patients. The outcomes of this study show the absence of false negatives (100% sensitivity) but few false positives occurrences (65.5% specificity). However, the high inter-patient differences in blood properties prevented an accurate quantification of the parasitaemia. These results prove the possibility of the developed instrument and technique to become a reliable and useful diagnostic tool up to the task of competing with currently available ones and providing a valid alternative to them.

The idea and the device here presented have been the subject of two social patent applications in which the inventors give up any revenues deriving from its exploitation which should be reinvested for social purposes.

### Idham HAFIZH – XXXII Cycle

"Readout Electronics for High-Rate High-Resolution Energy-Dispersive X-ray Detection System"

#### Advisor: Prof. Carlo Fiorini

#### Abstract:

My doctoral thesis focuses on the preliminary study, design, and characterization of readout electronics, both in circuit-level and system-level, adapted for high-rate high-resolution energydispersive x-ray detection system. X-ray spectroscopy is a technique widely used in applied physics, e.g. X-ray Fluorescence (XRF), X-ray Absorption Spectroscopy (XAS), X-ray Microprobe (µXRF), and many other beamline-enabled X-ray experiments, as well in many industrial instruments, e.g. energy-dispersive system for SEMs, portable XRF analyzers, macro XRF scanner, X-ray diffraction, etc. Therefore, the possible applications could range from fundamental research to cultural heritage analysis, mining and mineralogy measurements, as well as safety, food and pharmaceutical studies. In the past few years, detection module for X-ray spectroscopy based on Silicon Drift Detector (SDD) with a concentric anode, coupled with CMOS monolithic Charge Sensitive Amplifier (CSA), has shown to be very competitive in terms of performances and ease of fabrication. CMOS-based CSA is characterized by high transconductance, when coupled to SDD that has relatively small anode capacitance, it results in excellent noise performance and thus, good energy resolution. The combination is also known to be compatible with high-rate operation, provided several conditions such as small detector unit dimension, low-temperature operation, and fast detector pulse processing system. High-rate operation is essential to some applications, for example, in energydispersive detector in synchrotron beamlines performing experiments such as XRF, XAS, and  $\mu$ XRF. The requirement is driven by the ever-increasing flux of x-ray incident beams in upgraded synchrotron facilities, leading to higher fluorescence flux available for the detector, potentially improving the quality of the acquired data and/or reduce significantly experiment time. The first part of the thesis focuses on this question: can we develop an X-ray spectrometer, adapted for

experiments in synchrotron beamline, that can provide good energy resolution and high throughput capability, with immunity to electrical disturbances typically present in the beamlines?

High-rate spectroscopy can only be realized with SDD-CSA based detection system, only if the following stages provide fast pulse processing. In a system with a limited number of detection channels (< 10 channels), Digital Pulse Processor (DPP) is the most commonly adopted pulse processing solution, thanks to its satisfactory spectroscopic performance, high throughput, and robustness of digital system. On the other hand, when high-density multichannel detection is needed, as in future synchrotron-based experiments, or when the power and/or area constraints apply, Analog Pulse Processor (APP), implemented in an integrated circuit, is still an attractive solution, since it can provide compact and cost-effective solution compared to DPPs. ASIC-based APPs, if exist, with relatively high-throughput capability, appear to be a desirable solution to equip a compact instrument with high-density multichannel readout electronics (50-100 channels) within a reasonable cost and power budget. The second part of the thesis raises these questions: is it conceptually feasible to create an analog pulse processor with throughput capability above 1Mcps output count rate with satisfactory energy resolution and spectrum quality? If yes, can we implement it in ASIC and demonstrate experimentally such performance?

## Martina SAMMARTINI – XXXII Cycle

"High energy resolution X and  $\gamma$ -ray spectroscopic system based on CdTe detector and ultra lownoise and high speed front-end electronics"

Advisor: Prof. Giuiseppe Bertuccio

### Abstract:

In this thesis are reported the results of the research on a spectroscopic system prototype based on a Cadmium Telluride (CdTe) detector coupled to an ultra-low noise and high speed front-end electronics.

The goal is to evaluate the highest spectroscopic performance achievable by the system in order to try to overcome the limits emerged from literature of the last ten years and at the same time to address the issues due to the peculiar physics of the detector.

In the first chapter, the physical properties and the state of the art of CdTe detectors are presented along with an insight on the characteristic "polarization effect". In the second chapter is reported the electrical characterization devoted to evaluating the performance of the detector alone, in order to define the limits of the subsequent spectroscopic characterization of the full system prototype, shown in chapter three. Since the high energetic resolution and the possibility to work with high flux radiation are essential to the final application, the spectroscopic characterization has been focused on finding the optimal working condition to ensure the best energetic resolution at room temperature and moreover the behaviour at short processing times has been studied.

Lastly, in the fourth chapter, the analysis of experimental signals from the detector with a theoretical model has been illustrated, this allowed to extract the transport properties parameters of the charge carriers and also to describe the behaviour in time of the electric field inside the detector, which in turn is remarkable since it provides more information on the detrimental "polarization effect".

PhD Committee Prof. Marco Sampietro, DEIB Prof. Leonardo Abbene, Universita' di Palermo Prof. Gianluigi De Geronimo, University of Michigan