# Ph.D. in Information Technology:
# LIU - LOMBARDI
# Thesis Defenses

**DEIB – Room beta – Building 24**
**July 26th, 2017 - 02.00 pm**

Ph.D. presentations and discussions:

**Dr. Chang LIU – XXIX Cycle**
"X-ray Detection System for Advanced Light Sources"
Advisor: Prof. **Andrea Castoldi**

**Abstract:**

The doctorial activities aim at studying novel detection systems for X-ray imaging and X-ray spectroscopy applications at new advanced light sources (i.e. 3$^{rd}$ generation Synchrotrons and Free Electron Lasers, FELs).
Due to the unprecedented brilliance, coherence and time properties, the novel X-ray facilities require large improvements in several key features of the detection systems (e.g. dynamic range, speed, signal-to-noise-ratio) in order to fully exploit their potential. The research effort has been focused to R&D of silicon drift detector (SDD) topologies for both X-ray imaging and X-ray spectroscopy along three lines:
(i) Development of Multi-Linear Silicon Drift Detector for X-ray imaging.
(ii) Development of integrated charge injection devices for precise and on-line calibration of large format X-ray imagers.
(iii) Development of a high resolution X-ray spectroscopy system for Synchrotron ELETTRA Trieste, Italy (INFN ReDSoX/ReDSoX2 experiment & EUROFEL project).

**Dr. Prospero LOMBARDI - XXIX Cycle**
"Wearable Technologies for the Unobtrusive Investigation of Cardiovascular System"
Advisor: Prof. **Franco Zappa**

**Abstract:**

So far, a better understanding of the beat-to- beat dynamics of cardiac and vascular mechanics is advisable. However, novel and unobtrusive wearable sensors and devices are needed for the data collection. In this work two monitoring systems, the MagIC-Space and the Seismote systems, were developed for the investigation of those physiological aspects in the frame of two different research projects. MagIC-Space, the first achievement, is a textile-based system which allowed us to investigate for the first time aspects of sleep physiology in microgravity, including the mechanical behavior of the heart by

seismocardiography (SCG), i.e. the measure of chest vibrations produced by the beating heart. The system was used with success aboard the International Space Station (ISS) for the ecording of sleep data from one astronaut in seven night experiments. The development was based on the enhancement of a previously available prototype (originally measuring the electrocardiogram (ECG) and respiration) and consisted in the re-design of the system 1) to include new sensors and relevant electronics for the additional measure of SCG, body temperature and skin resistance, and 2) to make the hardware compliant with the strict NASA regulations for a safe usage aboard the ISS.
As to the latter issue, specific countermeasures were adopted in the system to reduce the risk of electrical shock, thermal and chemical hazards. Laboratory tests were then carried out to verify the adherence of the system to the requirements and obtain the final NASA approval. In addition, attention was paid to provide the system with automatic recovery procedures from most likely non-fatal failures possibly occurring in the harsh ISS environment.
Seismote, the second achievement, is an architecture which enables a joint assessment of cardiac mechanics and haemodynamics by multi-point SCG and photoplethysmographic (PPG) measures. PPG gives information on the arrival time of the pressure pulse to a peripheral artery and from this signal we may derive information on vascular characteristics. The developed architecture consists of a number of miniaturized sensor nodes, placed on different body sites for multi-point measures, and a hub which collects and stores data from nodes, allows the additional measure of ECG and can be wirelessly connected to a remote device, e.g. a smartphone, for real-time data streaming.
Two versions of the system were realized, one with a wired and one with a custom wireless link between nodes and hub. Notably, the wireless link allows us to connect up to 13 nodes and to collect 52 different signals sampled at 200 Hz.
To realize the wireless architecture, solutions were developed to address the major and open issues of low power data transmission and time synchronization among nodes. A custom protocol was developed since none of available wireless technologies provided the required throughput with the reduced power budged of nodes. The new protocol is roughly 18% more efficient than the recently released Bluetooth Low Energy in terms of up-link data overhead. As to the synchronization, a novel procedure, based on low level timestamp broadcasting, was designed and implemented by means of the custom protocol achieving a small average error of 27.53 µs.