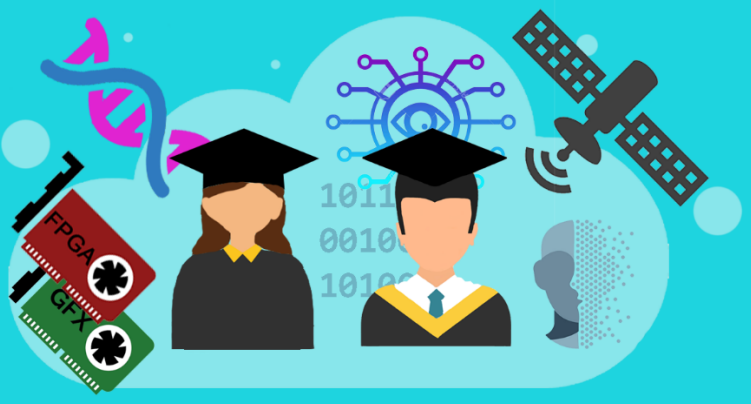
Diploma Thesis

Microproccessors and Digital Systems Laboratory



Massively Parallel Scientific Code Acceleration

At **CERN**, the European Organization for Nuclear Research, physicists probe the fundamental structure of the universe, using instruments of unparalleled magnitude and engineering complexity. CERN's current and future flagship projects such as the LHC Injector Upgrade, the High-Luminosity LHC and the Future Circular Collider, require extensive studies to overcome technological limitations with tight budgetary constraints.

To fulfill these critical requirements, the Beam Longitudinal Dynamics simulation suite (**BLonD**) has been developed since 2014. It features a modular structure that allows the user to focus on different physics phenomena and combine different physics modules according to the study requirements. BLonD is an open-source project that is increasingly gaining popularity among the world's largest accelerator laboratories.

BLonD has been enhanced with a High-Performance, **MPI-over-OpenMP** (HBLonD) and **MPI-over-CUDA** (CuBLonD) implementation. Using advanced computing techniques, such as approximate computing and dynamic load balancing, HBLonD and CuBLonD have demonstrated scalable behavior up-to 32 CPU nodes and 16 GPU nodes.

Despite this optimization effort, the code can still be improved on multiple fronts. At first, parallelizing the **input generation** process will unlock the possibility of running one order of magnitude larger simulations, crucial for increasing the prediction accuracy of the simulator. Furthermore, the computational core BLonD, implemented in C++ and CUDA can be further **optimized and fine-tuned**. An additional requirement is to support not only NVIDIA but also AMD GPUs, therefore the computational core needs to be translated to **OpenCL**. Finally, building and extending the Dynamic Load balancing scheme, an **heterogeneous** simulation platform can be built capable of effectively utilizing different types and models of accelerators and general-purpose processors.

Skills you will learn: The selected candidate will have the chance to work with **real-world**, High-Performance Computing software, and apply cutting edge optimization and parallel computing techniques. Also, they will practice their Python, C++, CUDA and OpenCL programming skills, some of the most used programming languages on their respective domains. Furthermore, Aris, the national **Supercomputing infrastructure** will be used to evaluate the performance and scalability of the BLonD code. Finally, the selected candidate will cooperate closely with an international team of highly skilled scientists that uses and worked on the development of the BLonD code.

Prerequisites: Python, C++, CUDA, Parallel Programming.

Related Material: 1) BLonD website 2) BLonD Github 3) Scale-out BLonD

Contact information: Konstantinos Iliakis, Ph. D candidate, kiliakis@microlab.ntua.gr
Dimitrios Soudris, Professor, dsoudris@microlab.ntua.gr