Thematic CERN School of Computing 2020

Sunday 07 June 2020 - Saturday 13 June 2020

Split, Croatia

Academic programme
The school will focus on the theme of **Efficient Scientific Software for Heterogeneous Architectures**. The complete programme will offer 25 hours of lectures and hands-on exercises, as well as an additional student presentations session, and a special evening lecture.

**Introduction lecture**

**Scientific and computing challenges in fundamental physics**
*by Ivica Puljak (University of Split)* - Big question and challenges in modern science, with emphasis on fundamental physics - Connecting great theoretical ideas and modern experiments to test them - Future challenges in computing: from traditional increase in data throughput, volume and complexity to emerging concepts of quantum computing, machine learning and artificial intelligence

**Track 1: Technologies and Platforms**

4 hours of lectures and 4 hours of hands-on exercises
*by Andrzej Nowak (TIK)* - Introduction to efficient computing - The evolution of computing hardware and what it means in practice - The seven dimensions of performance - Controlling and benchmarking your computer and software - Software that scales with the hardware - Advanced performance tuning in hardware - Hardware evolution and heterogeneity - Accelerators, co-processors, heterogeneity - Memory architectures, hardware caching and NUMA - Compute devices: CPU, GPU, FPGA, ASIC etc. - The role of compilers - Data-oriented design - Hardware vectorization in detail - theory vs. practice - Software design for vectorization and smooth data flow - How can compilers and other tools help? - Summary and future technologies overview - Teaching program summary and wrap-up - Next-generation memory technologies and interconnect - Rack-sized data centres and future computing evolution

**Track 2: Parallel and Optimised Scientific Software**

4 hours of lectures and 4 hours of hands-on exercises

**Track 3: Programming for Heterogeneous Architectures**

4 hours of lectures and 4 hours of hands-on exercises
*by Daniel Campora (Nikhef)* - Scientific computing on heterogeneous architectures - Introduction to heterogeneous architectures and the performance challenge - From general to specialized: Hardware accelerators and applications - Type of workloads ideal for different
accelerators - Trade-offs between multi-core and many-core architectures - Implications of heterogeneous hardware on the design and architecture of scientific software - Embarrassingly parallel scientific applications in HPC and CERN

**Programming for GPUs** - From SIMD to SPMD, a programming model transition - Thread and memory organization - Basic building blocks of a GPU program - Debugging and profiling a GPU application

**Parallel cross-architecture programming** - Data locality, coalesced memory accesses, tiled data processing - Control flow, synchronization, atomics - Other standards: SYCL, HIP, OpenCL - Middleware libraries and cross-architecture compatibility

**Design patterns and best practices** - GPU streams, pipelined memory transfers - Good practices: single precision, branchless, avoid register spilling, convert the problem - Reusable parallel design patterns with real-life applications - Under the hood: Warps, masked execution, floating point rounding

**Additional lectures**

**Student presentations session**

**Special evening lecture**

**Future of the Universe and of Humanity**

*by Ivica Puljak (University of Split)*