

## Simulations of Plasma Based Accelerators

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Plasma based accelerator technology, supported by the extreme accelerating fields driven by the interaction of high-intensity laser and particle beams with plasmas, has matured significantly, promising the development of a new generation of plasma based accelerators, capable of delivering high quality electron/ion beams for multiple applications. These developments have relied heavily on numerical modeling for the understanding of the underlying physics and identification of optimal regimes. Given the highly-nonlinear processes occurring in these scenarios, the tool of choice for numerical modeling has been fully relativistic particle-in-cell codes. However, the computational requirements of these algorithms for detailed full scale 3D modeling of these scenarios require efficient use of state-of-the-art Petascale supercomputing systems throughout the full simulation. This requires not only efficient, multi-scale, simulation algorithms, but also matching these algorithms to the computing hardware, ensuring both good parallel scalability to hundreds of thousands of computing cores, and high floating point efficiency at the single core level. We discuss the new developments that address these issues, focusing on different algorithms that allow for separating the laser / target spatial and temporal scales, allowing for longer interaction lengths, for electron wakefield acceleration, and for over-critical laser interaction scenarios, for ion acceleration, and also on numerical developments that range from multi-dimensional dynamic load balancing and hybrid distributed / shared memory parallelism to the vectorization of the PIC algorithm. Illustrations of these developments will be given for electron and ion plasma based accelerators.

**Primary author:** Prof. FONSECA, Ricardo (ISCTE - IUL)

**Presenter:** Prof. FONSECA, Ricardo (ISCTE - IUL)

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