Controlled Electron-Beam Injection into Plasma Waves for Tailored Betatron-Radiation Generation

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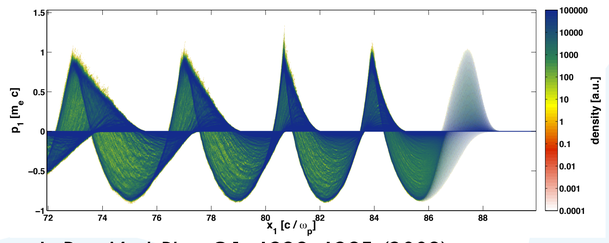
Laser-driven plasma acceleration

Laser-driven plasma acceleration[1] is a novel acceleration technique for charged particles.

- Proposed by Tajima and Dawson[2] in 1979
- Provides extreme electric fields >10 GV/m
- Allows orders of magnitude larger energy gain than in conventional accelerators for given acceleration length
- Beam quality and stability improved significantly over the last decades
- Possible technology candidate for affordable and compact future particle colliders and light sources



[1]Esarey et al., *Rev. Mod. Phys.* **81**, 1229–1285 (2009)
[2]Tajima, T., and J. M. Dawson, *Phys. Rev. Lett.* **43**, 267 (1979)

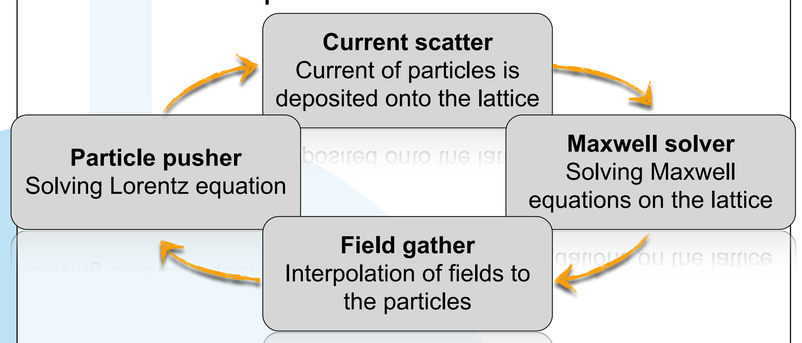
Particle-in-cell code OSIRIS

Particle In Cell (PIC) simulations

Processes in plasma acceleration are highly nonlinear and not easily probed experimentally. Simulations are thus the only feasible way to understand the physical phenomena in detail.

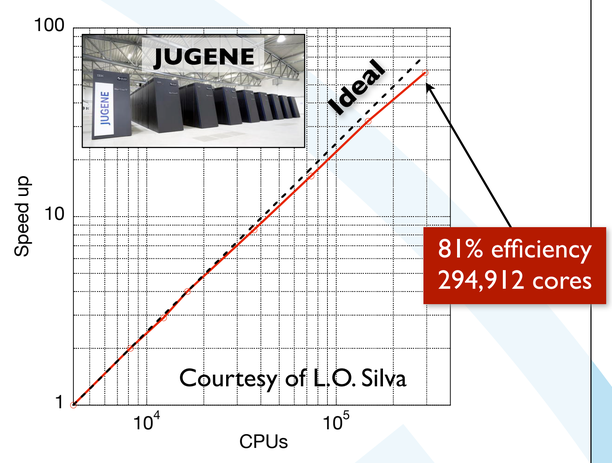
PIC main loop:

Macroparticles in PIC simulations have continuous positions and momenta.



This particle-mesh technique makes the full electrodynamic treatment of a large number (10^6-10^{12}) of charged (macro-) particles in their self-consistent fields computationally feasible.

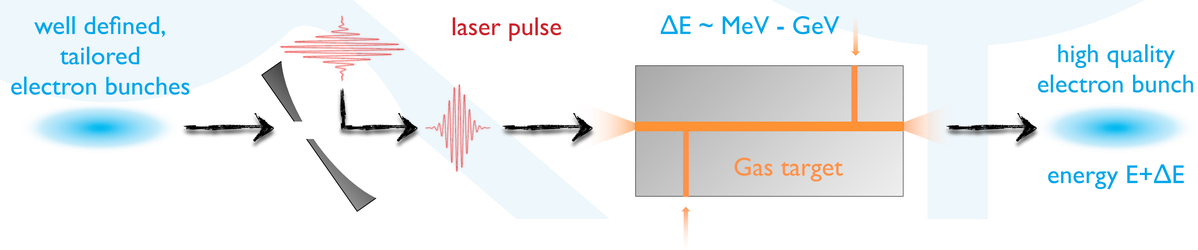
Osiris[3] is a three dimensional, relativistic PIC code, developed at GoLP, Instituto Superior Técnico, Lisbon and UCLA to model plasma accelerators. The code, written in Fortran 90, is highly parallelized and has shown excellent scalability in tests on various supercomputing platforms.



[3]Fonseca et al., *LNCS* **2331**, 342 (2002)

Controlled electron-beam injection into plasma waves

Laser wakefield experiments so far utilized mechanisms that trapped background plasma electrons in the accelerating phase of the plasma wave. However, these injection techniques provide only limited control over the trapping process. Injection of well defined, pre-accelerated electron bunches into plasma wakefields offers a new degree of control over the injection process.



Simulations performed at JUGENE serve not only as a preparation for external injection experiments which will be conducted at DESY in the future, but also serve as in-depth analysis of different effects that can only be studied via external injection like induced emission of betatron radiation, emittance growth or bunch compression.