THE DIGITAL PLASMA LAB: HOW SUPERCOMPUTERS AID IN THE DEVELOPMENT OF NOVEL PARTICLE ACCELERATORS

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PIConGPU

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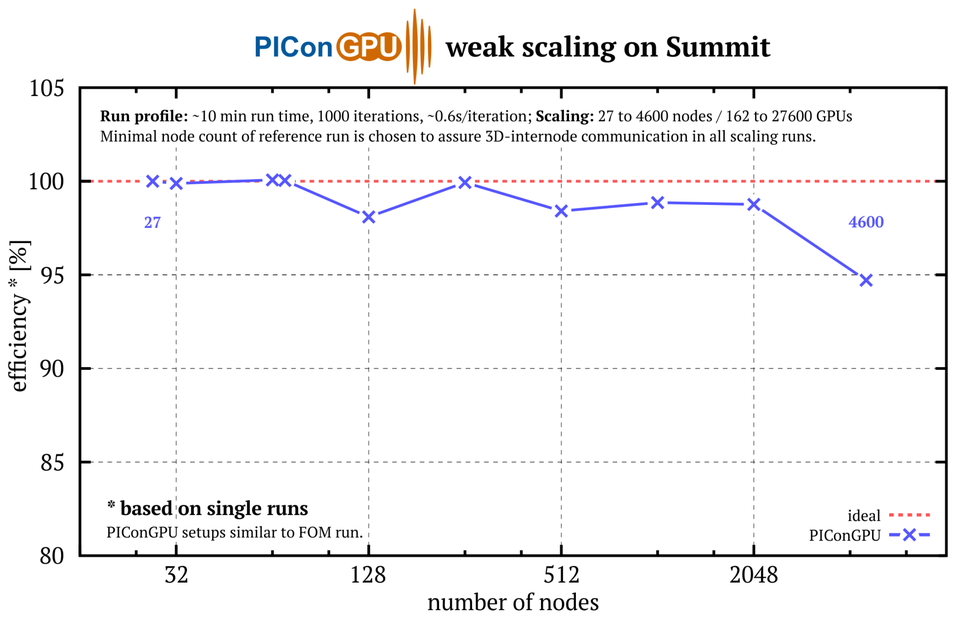
SIMULATING RELATIVISTIC PLASMAS WITH PIConGPU

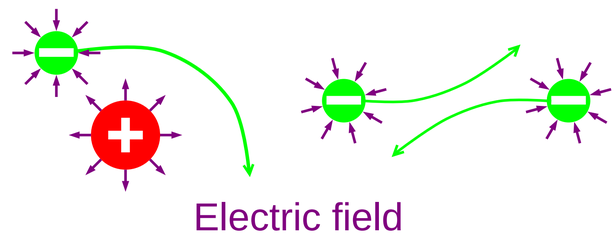
https://github.com/ComputationalRadiationPhysics/picongpu
https://picongpu.readthedocs.io

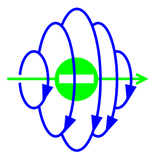
PIConGPU is an open source, fully relativistic, 3D3V, manycore performance portable particle-in-cell code achieving highest performance even on the largest available computing systems.

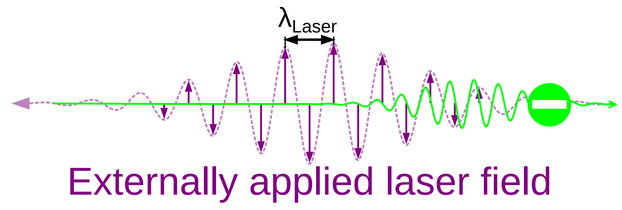


PLASMA DYNAMICS

Particle trajectories are influenced by electric and magnetic fields which originate from electrons, ions, their movement, or are applied externally.





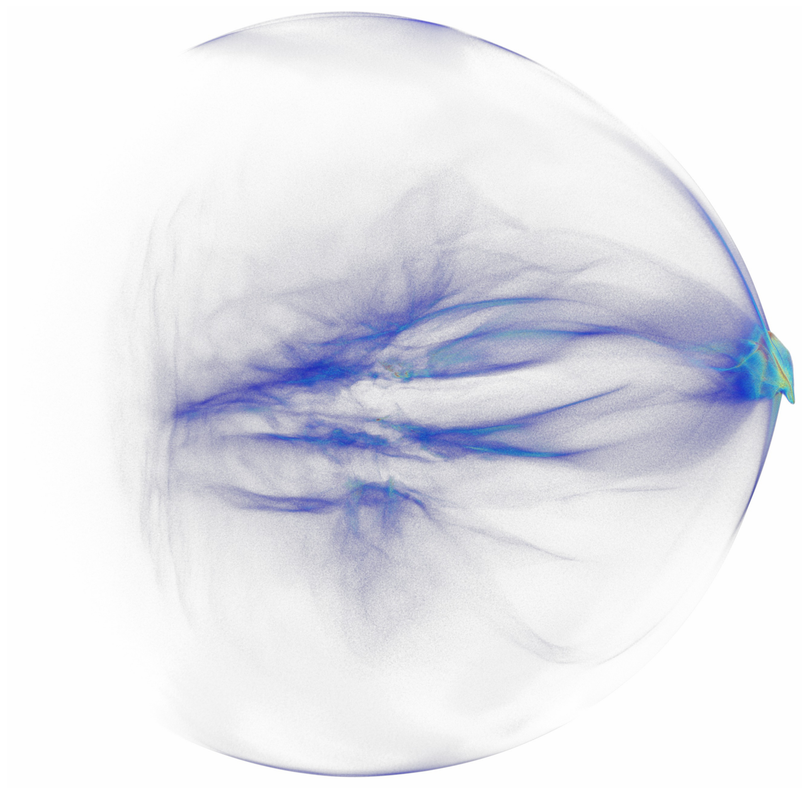


EXPLORING NOVEL CONCEPTS OF LASER PLASMA ACCELERATORS

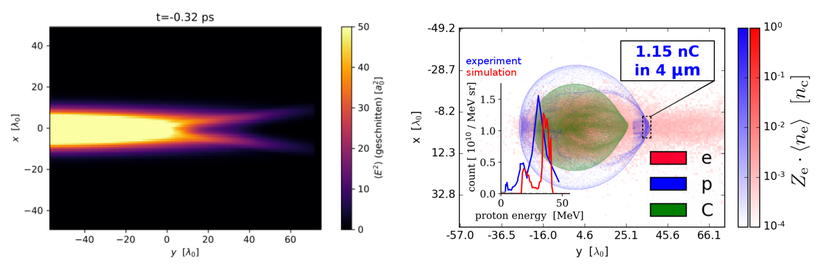
Realizing acceleration of clean proton bunches with almost no low-energetic background from levitating 1µm diameter plastic spheres positioned in the focus of a petawatt laser pulse is one topic we recently investigated [1] on Titan, a former #1 of the TOP500 supercomputers. Another research project concerns circumventing the dephasing and depletion limits of laser-wakefield based electron bunch acceleration within the TWEAC geometry [2] which we will investigate on Frontier, one of the world's first exascale systems scheduled for delivery in late 2021.

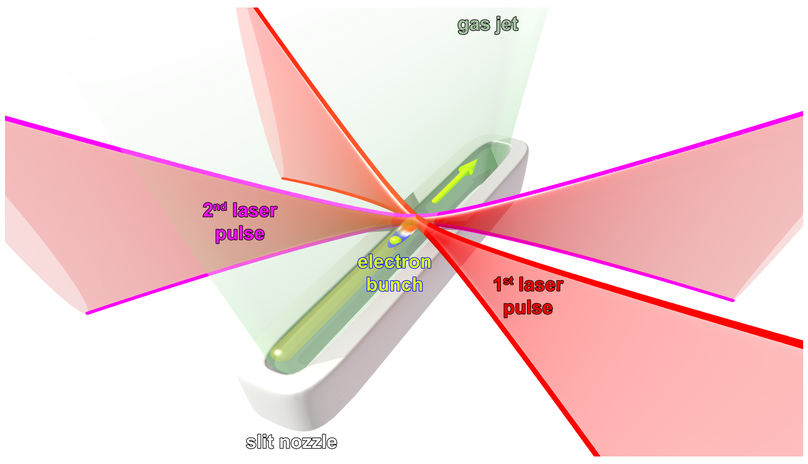
[1] Hilz, P., Ostermayr, T.M., Huebl, A. et al. **Isolated proton bunch acceleration by a petawatt laser pulse**. Nat Commun 9, 423 (2018). *https://doi.org/10.1038/s41467-017-02663-1*

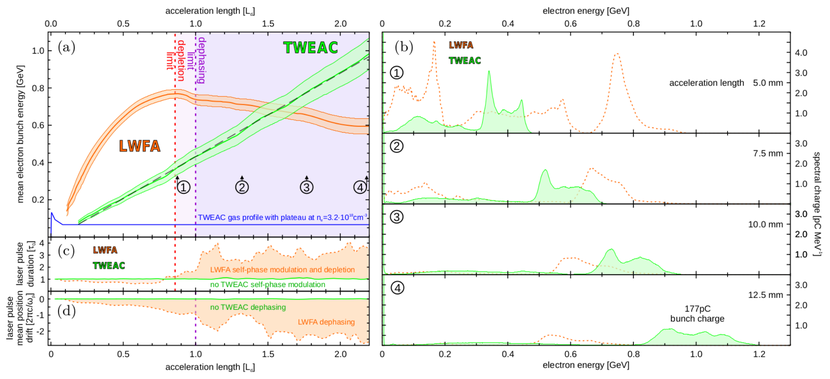
[2] Debus, A., Pausch, R., Huebl, A. et al. **Circumventing the Dephasing and Depletion Limits of Laser-Wakefield Acceleration**. Phys. Rev. X 9, 031044 (2019). *https://doi.org/10.1103/PhysRevX.9.031044*



Collimated, monoenergetic proton bunches of high charge are accelerated on milliimeters by irradiating micrometer diameter plastic spheres with high power laser pulses.







With laser wakefield acceleration in a TWEAC geometry, electron beams with energies beyond 10GeV can be generated on millimeter distances since it circumvents pervasive limitations of existing accelerator concepts.

MODELING RELATIVISTIC PLASMAS

Modern particle-in-cell methods subdivide the computational domain in smaller domains, i.e. cells. Fields and particle movements are calculated for each cell allowing parallelisation.