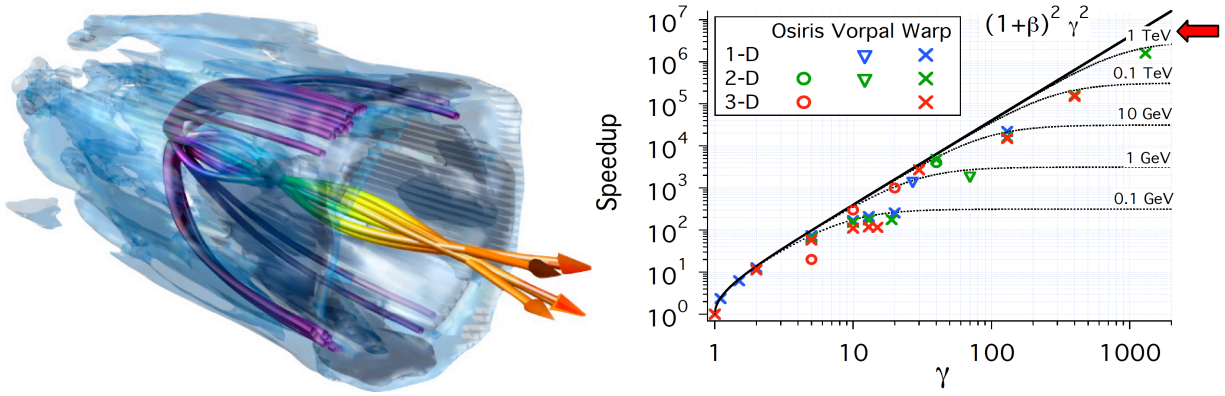
“Boosting” plasma accelerator simulations

Investigator(s): Bruhwiler D.L., Cary J.R., Cormier-Michel E., Cowan B.M. (Tech-X), Fonseca, R.A. (IST, Portugal), Geddes C.G.R. (LBNL), Lu W. (UCLA), Martins, S.F. (IST, Portugal), Mori, W.B. (UCLA), Silva, L.O. (IST, Portugal), Tsung, F.S., (UCLA), Vay, J.-L. (LBNL)

Simulation tools developed by the SciDAC Compass project are using a technique exploiting Einstein's theory of special relativity to speed up some calculations dramatically. The project develops and maintains a suite of simulation tools that are optimized for modeling compact accelerator stages using plasma wave ‘wakefields’ driven by lasers or particle beams, which provide accelerating gradients more than 1000 times higher than current technology. These simulation tools now run efficiently on over 100,000 processors on national leadership class facilities, and are used to explore accelerator designs for future experiments not yet feasible in laboratories. Such simulations were at or beyond the capacity of even the present worlds largest computers until it was demonstrated recently that dramatic speed ups were possible by carrying out the simulations in a Lorentz boosted frame, a frame moving with a velocity near or at that of the wakefield which accelerates the particles. A numerical instability which limited previous speed ups has been controlled recently, allowing speed ups in the 10^2 to 10^6 range under appropriate condition. This novel technique is being used to optimize the laser and plasma conditions for 10 GeV and beyond class laser wakefield stages.

Reference(s): J.-L. Vay, *Phys. Rev. Lett.* **98** (2007); S. F. Martins et al, *Nature Phys.* **6** (2010); D. Bruhwiler et al, AIP Proc. (2008); J.-L. Vay et al, *submitted to J. Comput. Phys.*

For more information: www.compass.fnal.gov



(left) Three-dimensional rendering from an Osiris simulation of a laser wakefield accelerator stage in a Lorentz boosted frame with self-trapping (arrows); (right) Examples of speed ups including a 1 million times speed up for a 1 TeV stage with no self-trapping.