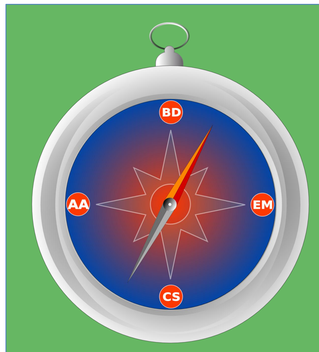
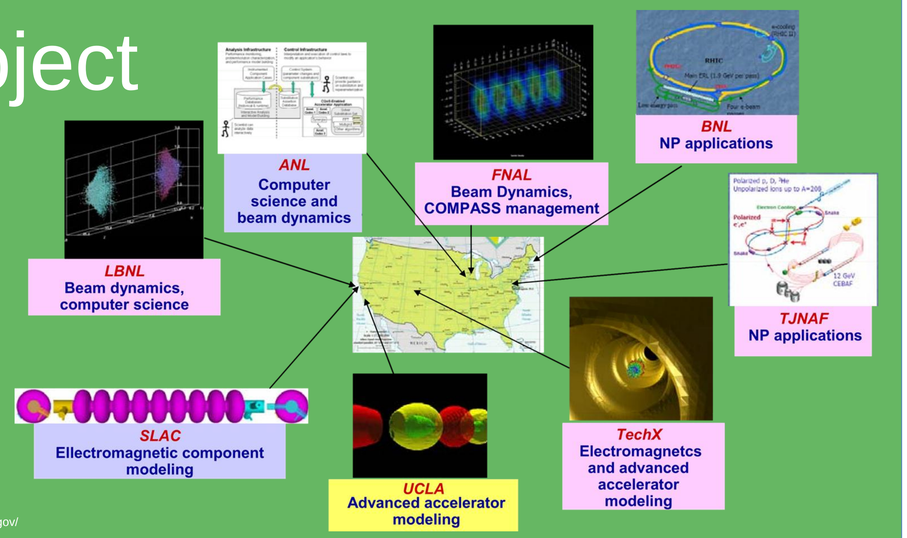
Accelerator Simulation and Parallel Computing



COMPASS – a SciDAC2 Project

Led by Fermilab, the community Petascale for Accelerator Science and Simulation project, funded by the Offices of High Energy Physics, Nuclear Physics, basic Energy Sciences and the Office of Advanced Scientific Computing Research, will develop a comprehensive computational infrastructure for accelerator modeling and optimization.

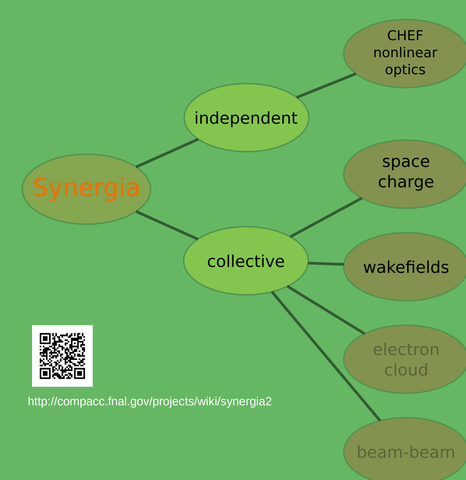
SciDAC
Scientific Discovery through Advanced Computing



https://compass.fnal.gov/

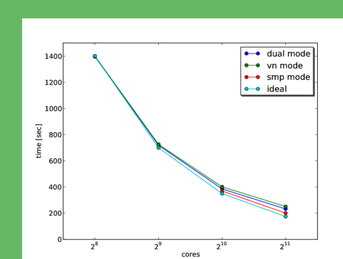
Synergia2

Developed at Fermilab, Synergia2 is a parallel framework for simulation of collective effects in accelerator physics. The code is C++ and Python for optimum performance and flexibility.

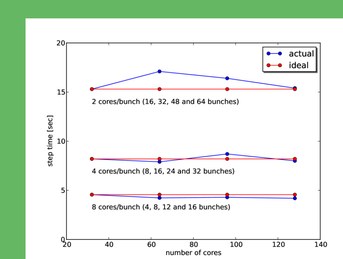


http://compacc.fnal.gov/projects/wiki/synergia2

Existing Synergia2 Pure MPI Implementation



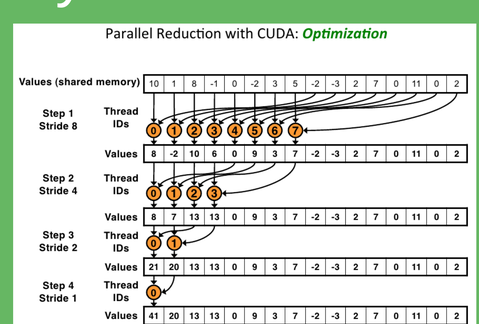
single bunch
strong scaling

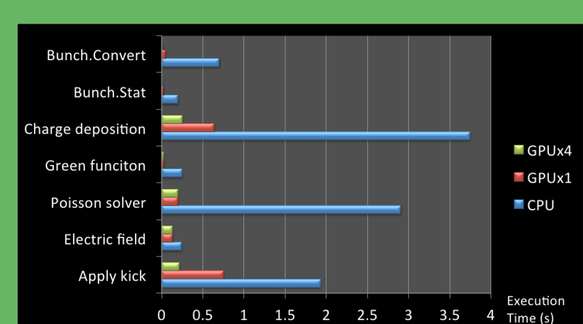


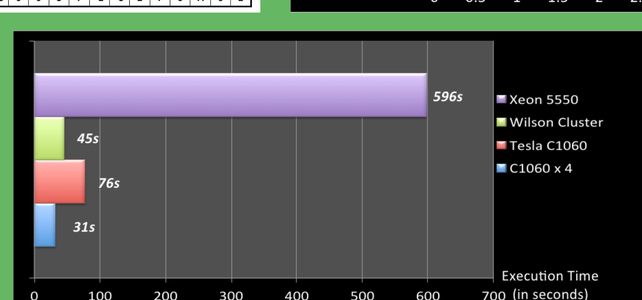
multi-bunch
weak scaling

Preparing Synergia2 for Exascale

Hybrid MPI-CUDA Version Under Development

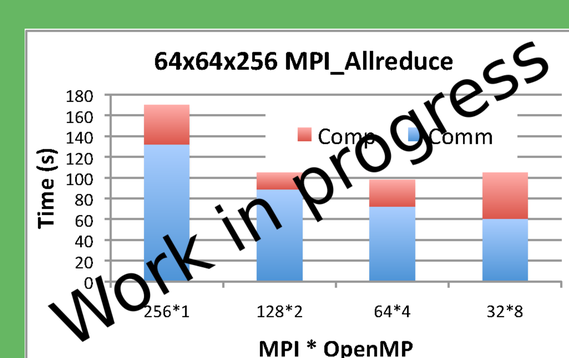






Both approaches utilize communication avoidance for improved scalability in multi-level parallelism

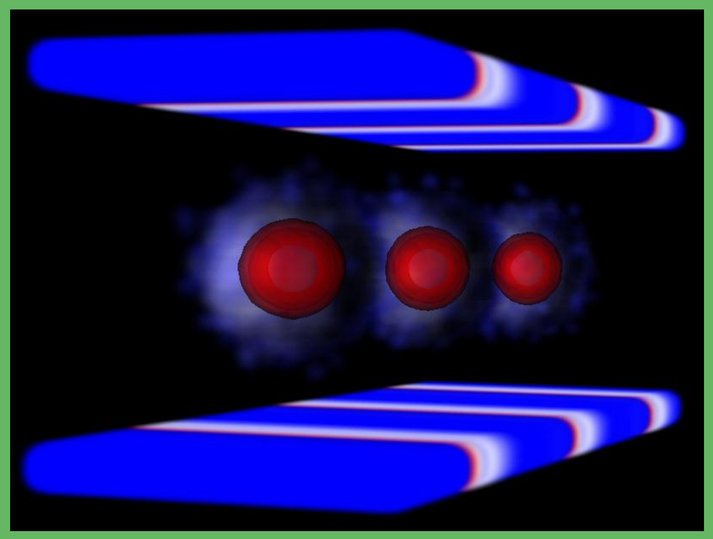
Hybrid MPI-OpenMP Version In Progress



The hybrid MPI-OpenMP version of Synergia2 is a work in progress. The above results display the speedup vs. plain MPI in a preliminary implementation.

Accelerator Simulation at Fermilab

Accelerator simulation at Fermilab advances accelerator science for the HEP program



Wakefields are electromagnetic fields generated in accelerator structures by passing beams. Simulating this effect is crucial for minimizing losses and maximizing efficiency.

COMPASS
The Community Petascale Project for Accelerator Science and Simulation

A SciDAC2 project led from Fermilab

SciDAC
Scientific Discovery through Advanced Computing

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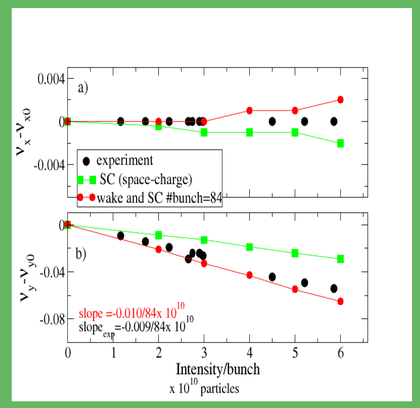
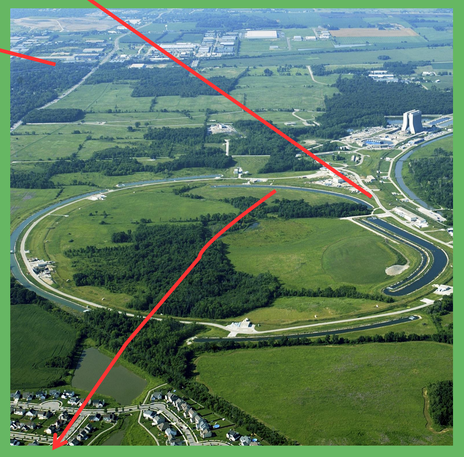
Synergia multi-physics simulations of the Fermilab Booster include nonlinear optics, space charge and wakefields



MINOS and Nova neutrinos to Soudan mine and Ash River (MN)

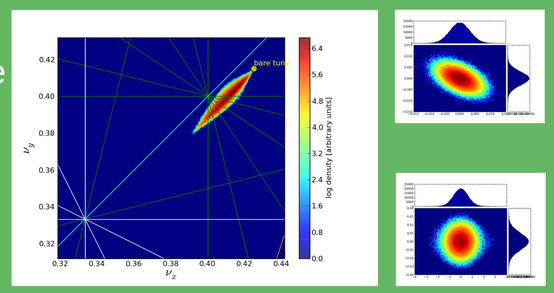
LBNE neutrinos to DUSEL (SD)



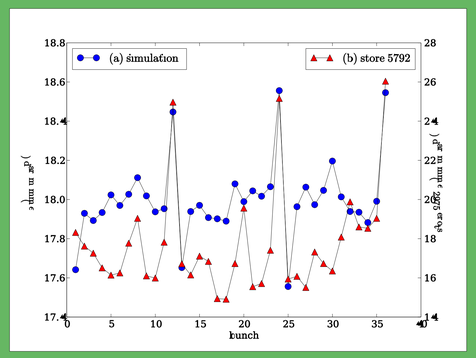
The Fermilab Main Injector will be the workhorse of the Project-X high-energy, high-intensity physics program

Space charge is the electromagnetic repulsion among the particles in a beam bunch. Its effects increase as intensity increases.

Synergia multi-physics simulations of the Fermilab Main Injector include nonlinear optics and space charge.

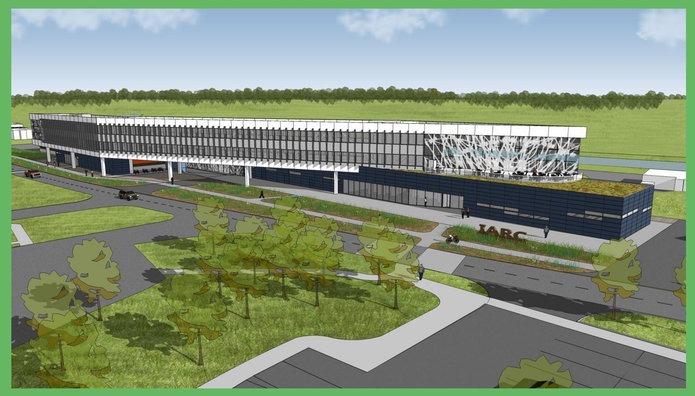


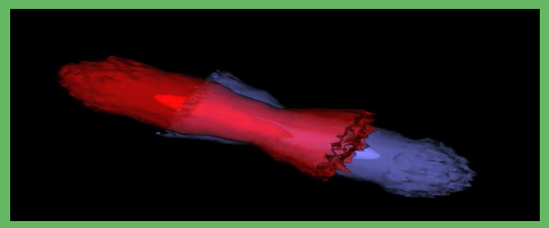
Beam-beam effects arise from the electromagnetic interactions between colliding bunches



Beam-beam simulations from the SciDAC Breakthrough presentation showing comparison of simulation results with Tevatron data

Illinois Accelerator Research Center



At IARC, scientists and engineers from Fermilab, Argonne and Illinois universities will work with industrial partners to research and develop breakthroughs in accelerator science

Fully 3-D multiple beam dynamics processes simulation of the Fermilab Tevatron:
A SciDAC Breakthrough