

APR07-2007-000384

Abstract for an Invited Paper  
for the APR07 Meeting of  
the American Physical Society

### **Recent Innovations in Simulating Space-Charge-Dominated Ion Beams**

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Driven primarily by the needs of the Heavy Ion Fusion Sciences (HIFS) program, many new capabilities have been added to the Warp code to simulate the broader range of ion beam experiments that are now being carried out. These capabilities have attracted the interest of other programs, such as LHC, ILC, and of private industry, such as Cyberquest. The two thrusts are the innovations are the development of the models used to simulate a rich set of physical processes, such as the presence of electrons and background gas and ions, and improvement of the overall efficiency of the code, for example, by refining time and space only where needed. Some of the innovations that will be discussed include: a suite of models describing electron and ion interactions with walls, gas, etc.; inter- and intraspecies collisions; a new large-timestep particle mover that captures both the drift orbits and the gyroradius correctly; adaptive mesh refinement for electro- and magneto-statics or electromagnetics, and time-centered subcycling with individual particle step sizes based on the local Courant condition; parallelization of all of these methods.