Simulation of space-charge effects for muon cooling lattices

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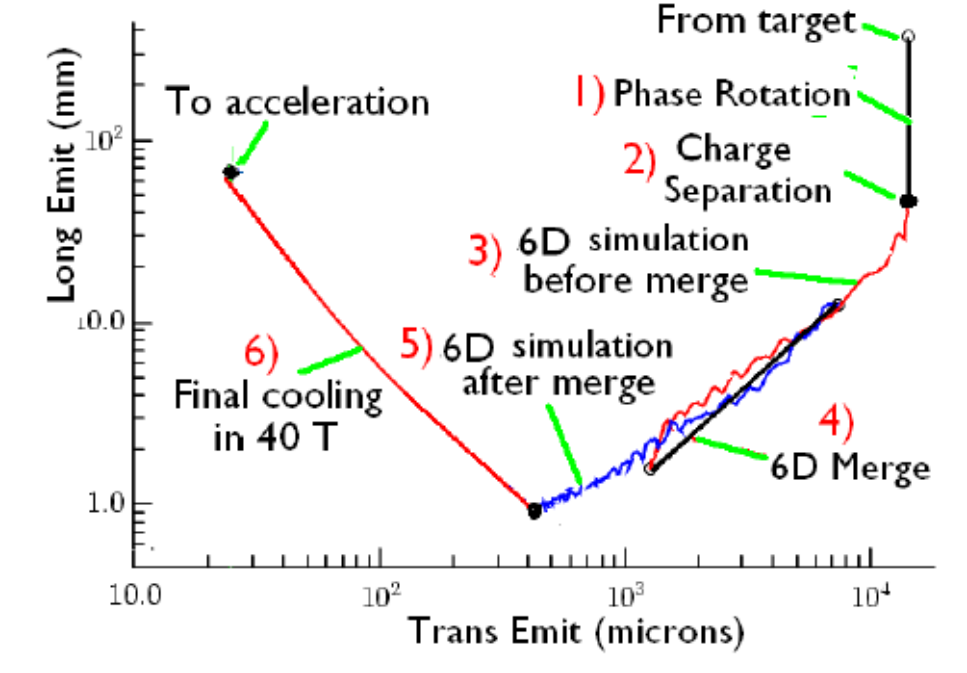
Introduction



- Space-charge can be a issue for the cooling lattices of a muon collider
- Seems to be more harmful at the last 6D cooling stage (see Palmer's talk at the 2011 Muon Collider Workshop)

Simulation Challenges

- Particle-in-cell code WARP has been benchmarked over space-charge experiments at the University of Maryland for more than 10 years
- However challenges arise since WARP has been never used for muon cooling simulations before
- In collaboration with UMD a program is developed to investigate the feasibility of using WARP for muon cooling (Dr. Irving Haber)
- In order to aid and cross-check the WARP simulations the possibility to use PARMELA will be examined (focus of this talk)

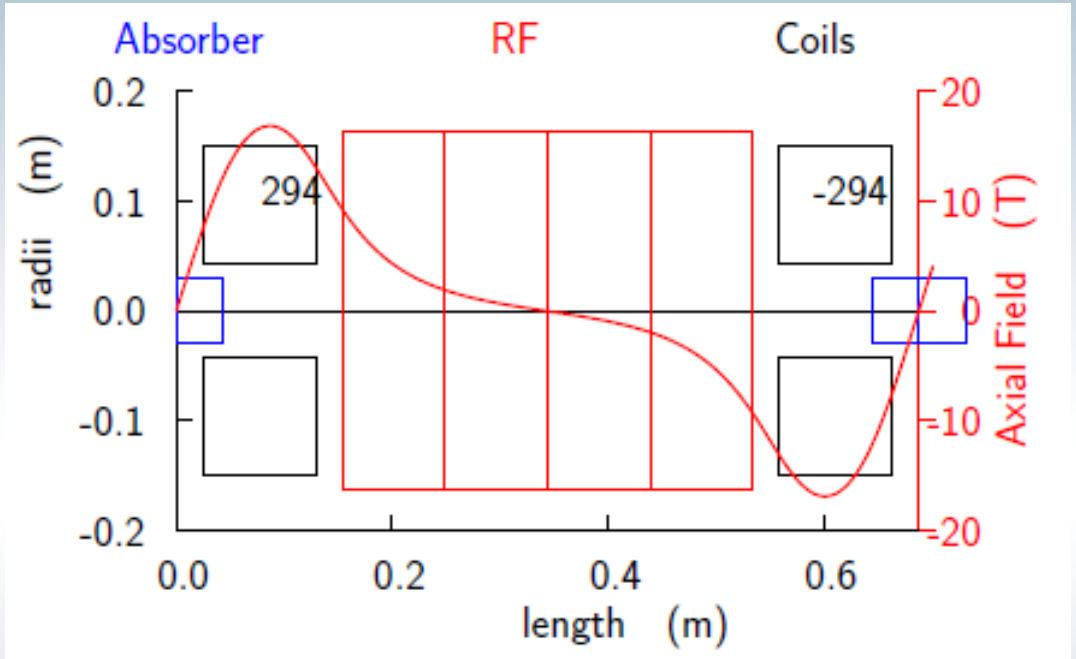
Features of PARMELA

- Integrates macrpoparticle trajectories through the fields in 3D using phase (time) as the independent variable
- Includes acceleration, focusing, space-charge, CSR and wake fields
- Can read 2D and 3D field distributions
- PARMELA has been validated through operating facilities: FNAL A0 Photoinjector, UCLA Neptune facility, LCLS design effort, LANL AFEL, etc

Approach

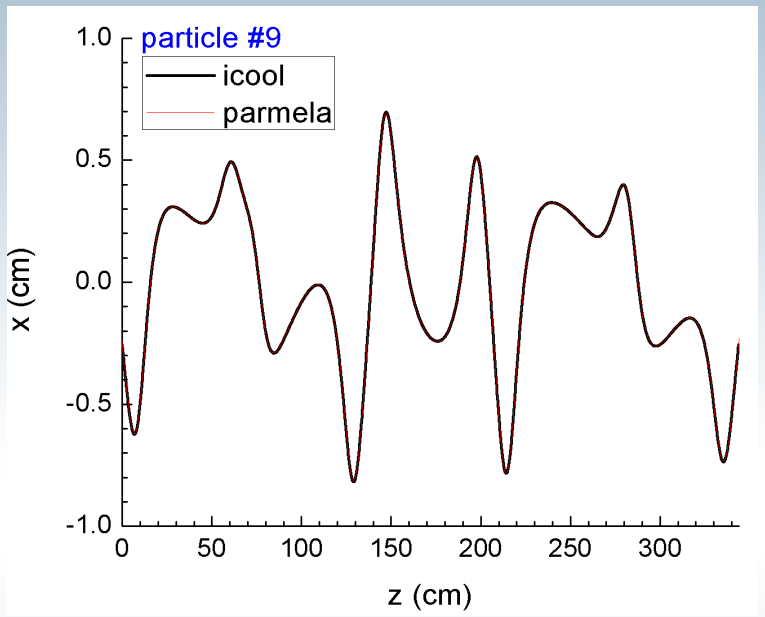
- Steps below apply for both PARMELA and WARP
- Step 1: Simulate a muon cooling lattice and compare with ICOOL (done!)
  - Single particle in a empty lattice (only solenoids)
  - Single particle with rf cavities
  - A beam distribution and compare rms quantities
- Step 2: Add space-charge (next step)
- Step 3: Add absorbers (future step)
- Here I will present some preliminary results with PARMELA

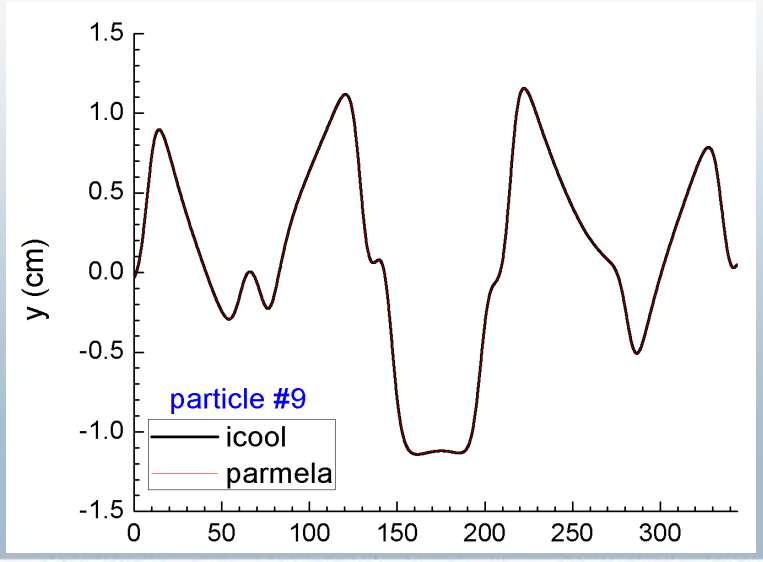
Final 6D RFOFO

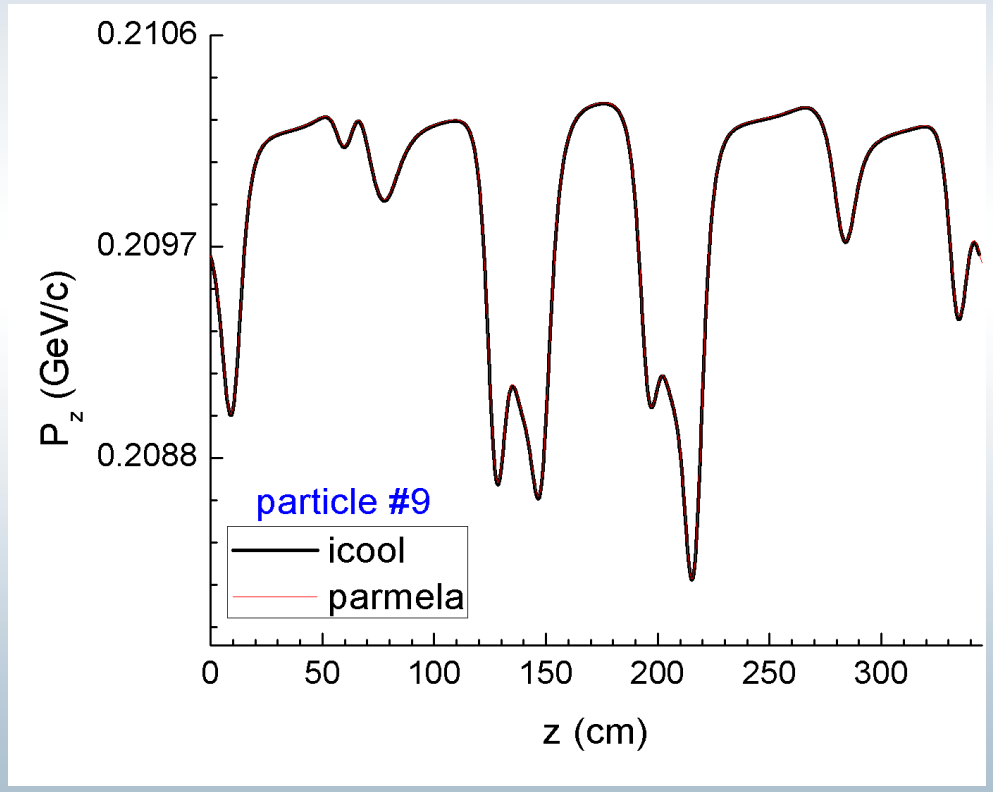


- 67 cells, each 0.6875 m long
- Each cell has four 805 MHz cavities with a 15 MV/m axial peak field.
- Minimum beta is 2.8 cm and mean momentum is 200 MeV/c

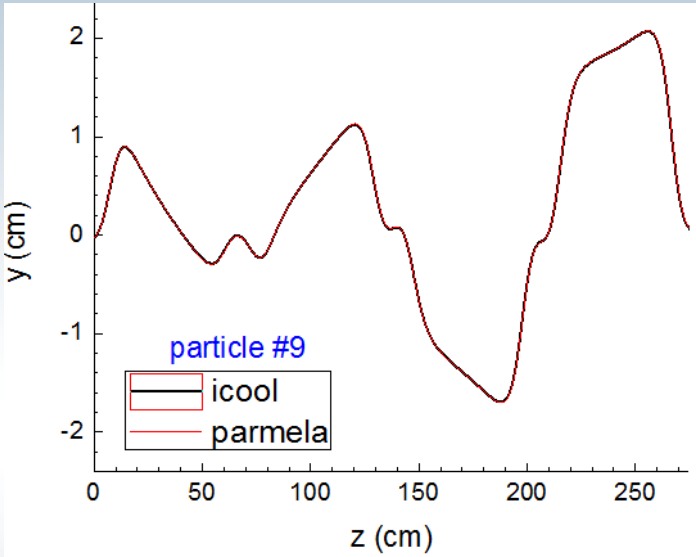
Single particle in a empty lattice

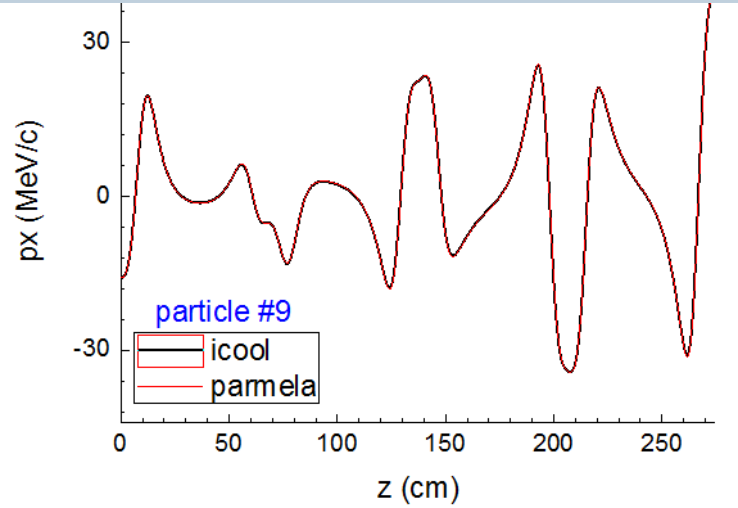


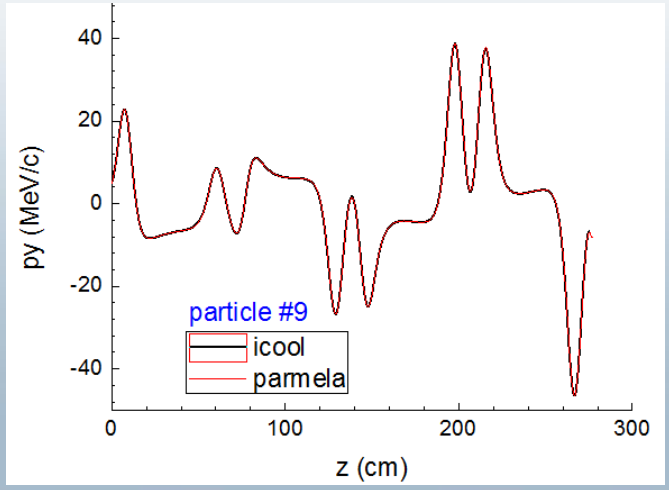


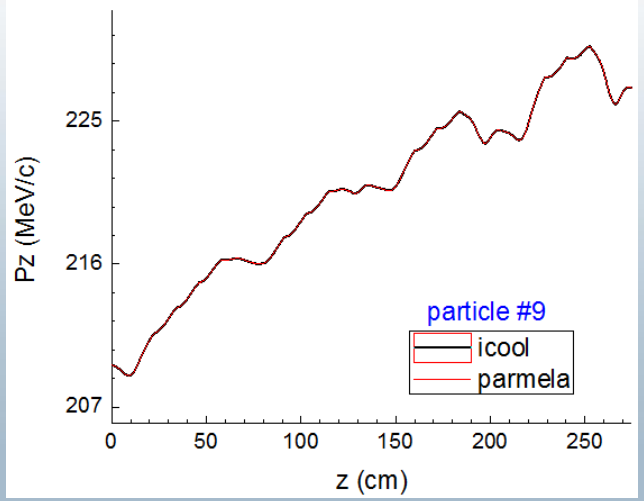


Single particle in a lattice with rf cavities

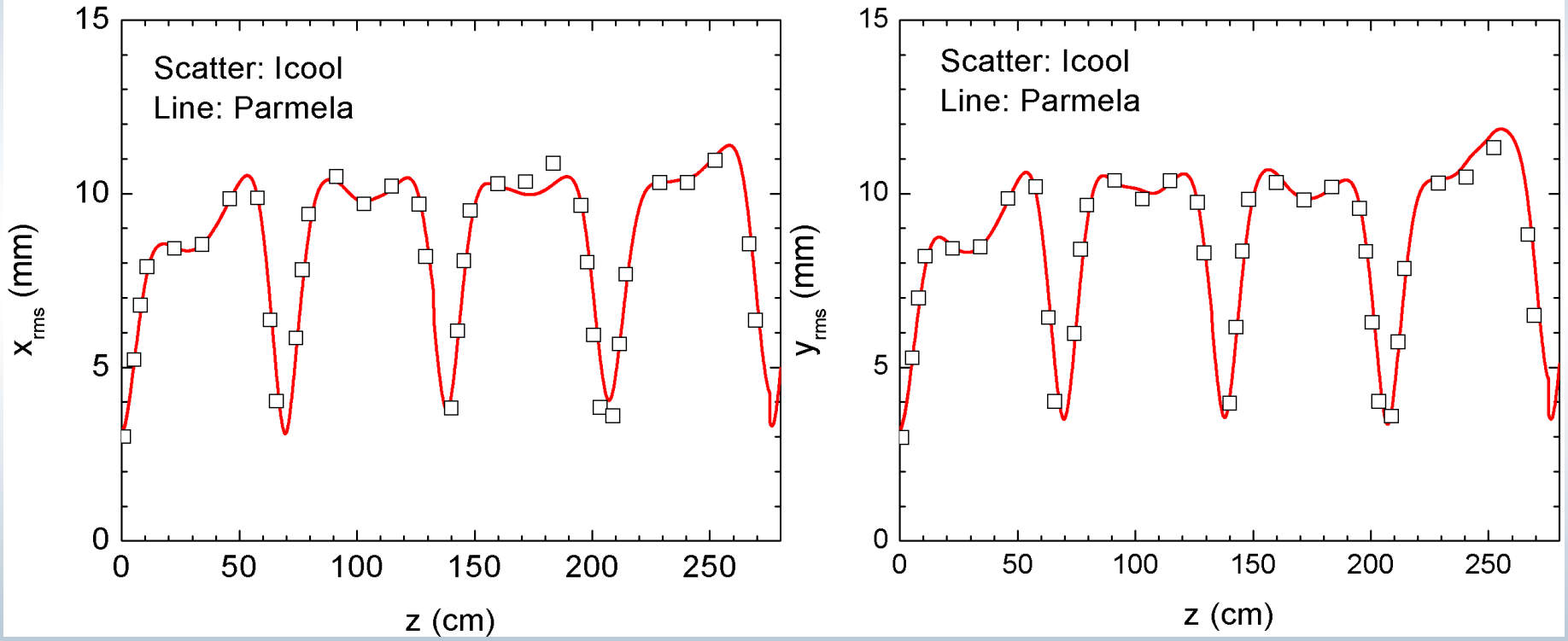








Tracking a beam distribution



Summary and next steps

- We found good agreement between PARMELA and ICOOL (no absorbers, no SC)
- This gives the green light for adding space-charge in PARMELA.
- The plan is to start space-charge simulations this month.
- Compare PARMELA and WARP results with each other and with theory
- Add absorbers