Progress Report

Matt Gordon

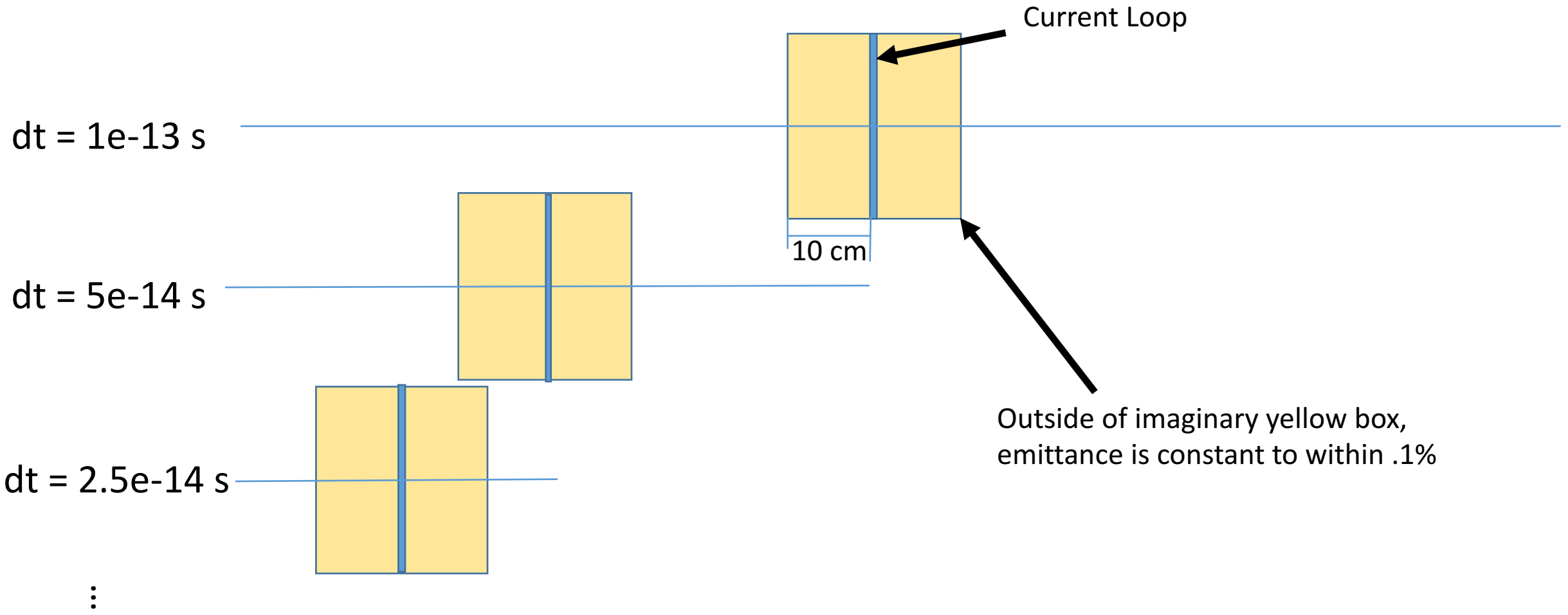
August 17, 2018

Geometric Aberration + Convergence Study

- Simple Test Case: Use emittance component tool to identify geometric aberration emittance growth in current loop
- Found that emittance component wasn’t converging to emittance from GPT
- Test convergence of emittance component algorithm to emittance as well as theoretical geometric emittance growth

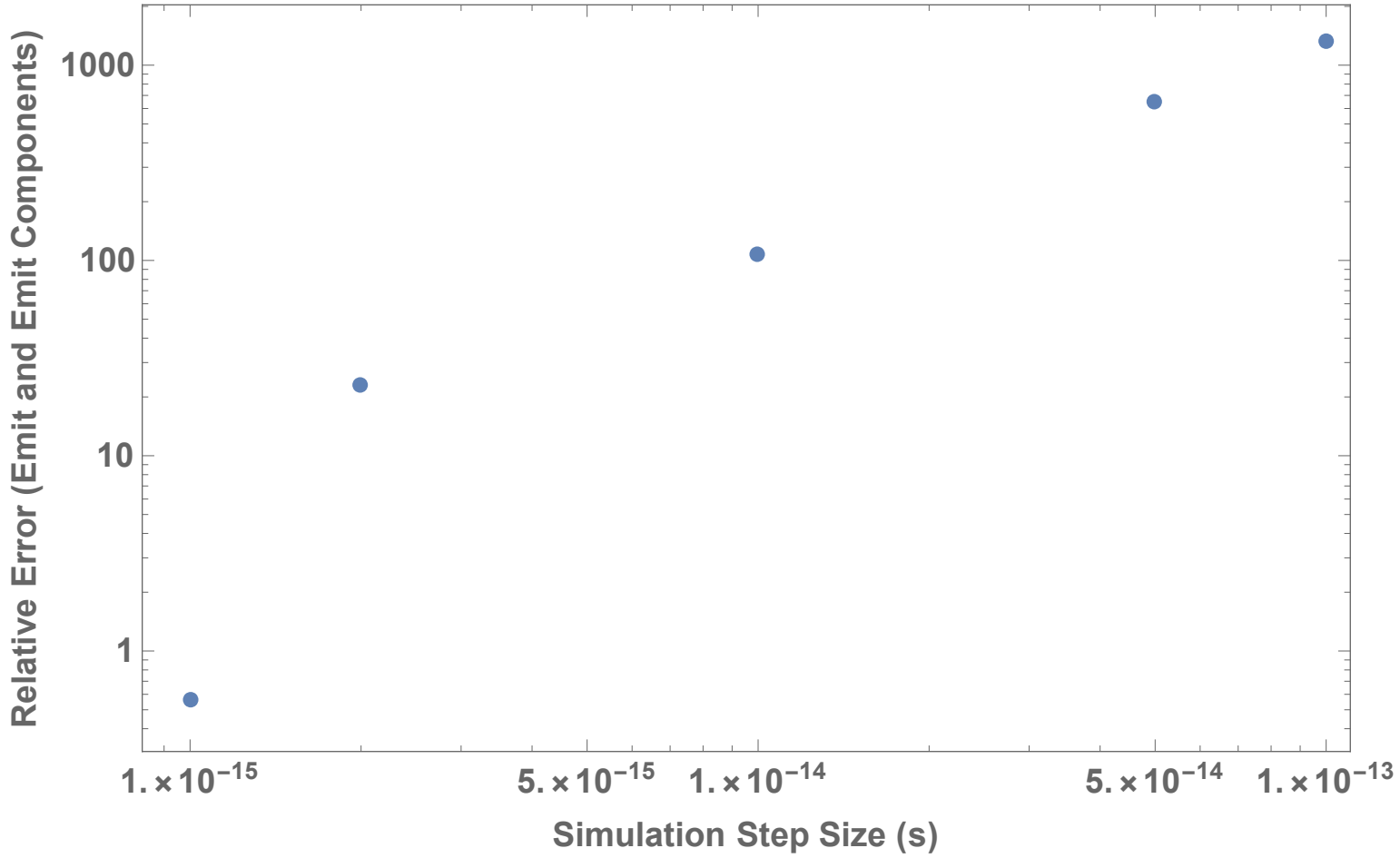
Convergence Test

- Time constraints on simulation runtime mean I can't simply decrease time step, I needed to decrease it in a way to ensure simulation time doesn't grow



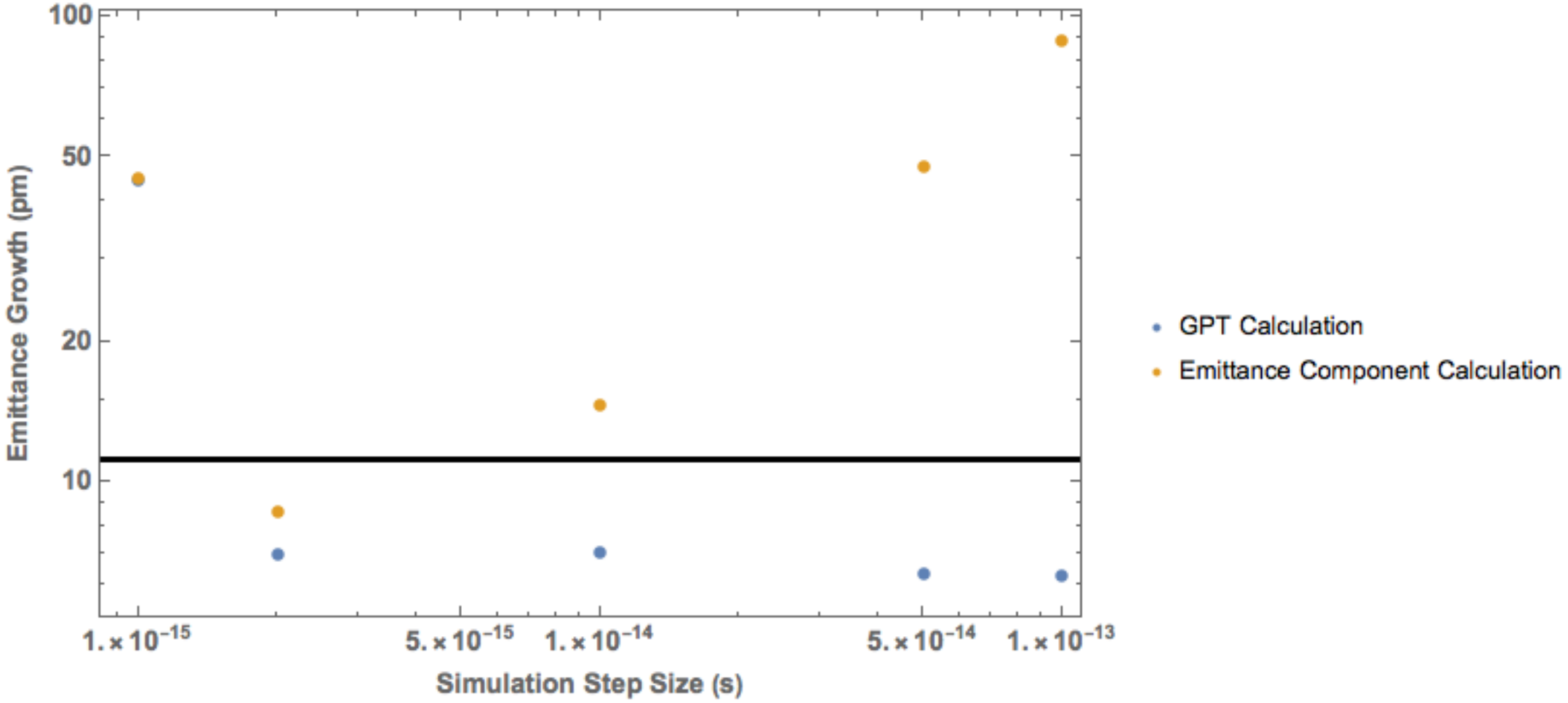
Convergence Test Results

- Emittance Component calculation converges to GPT value within 1% by 1e-15 s step size



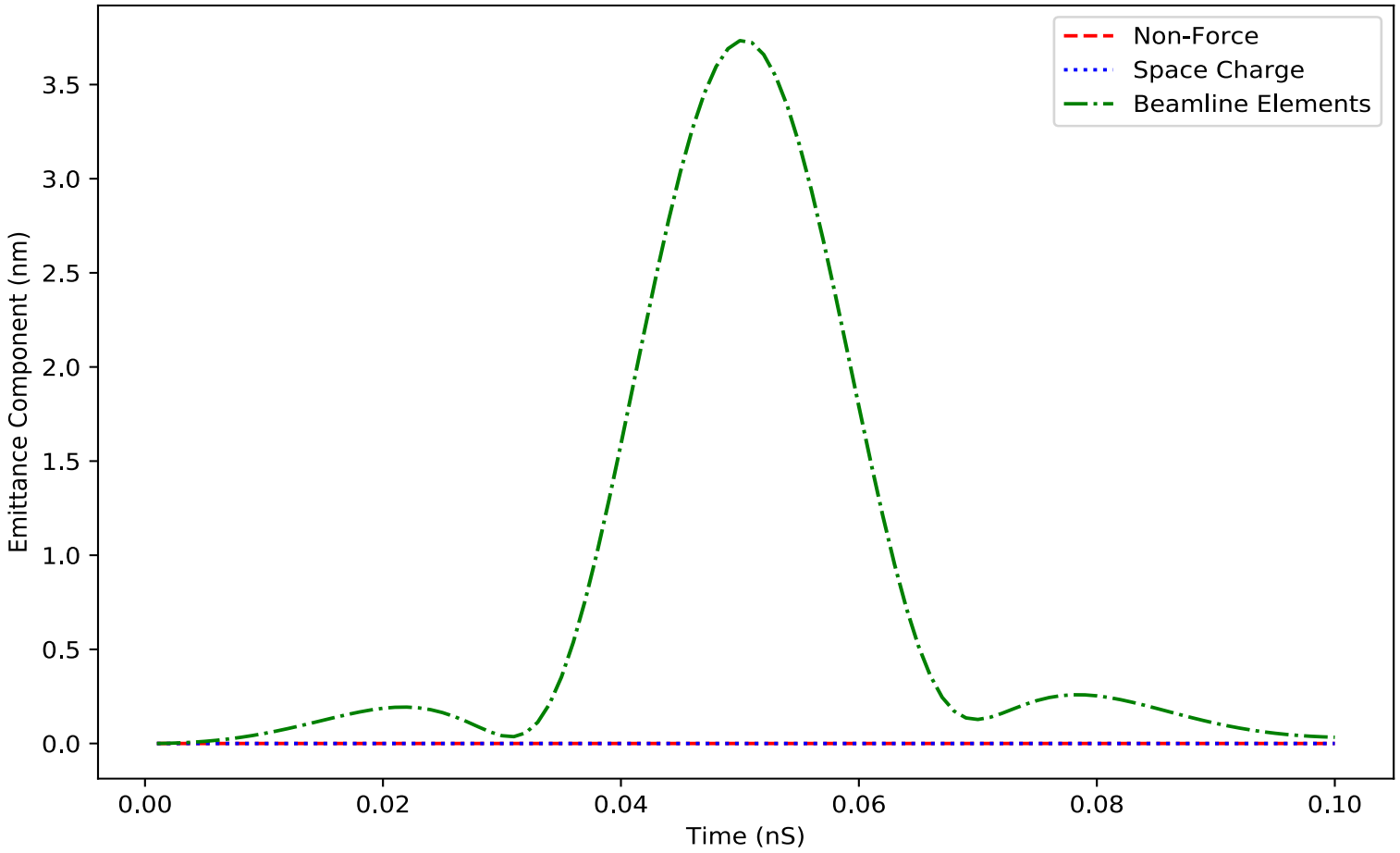
Comparing to Theoretical Geometric Aberration

- GPT emittance converging to 7-9 pm, theoretical prediction 11pb



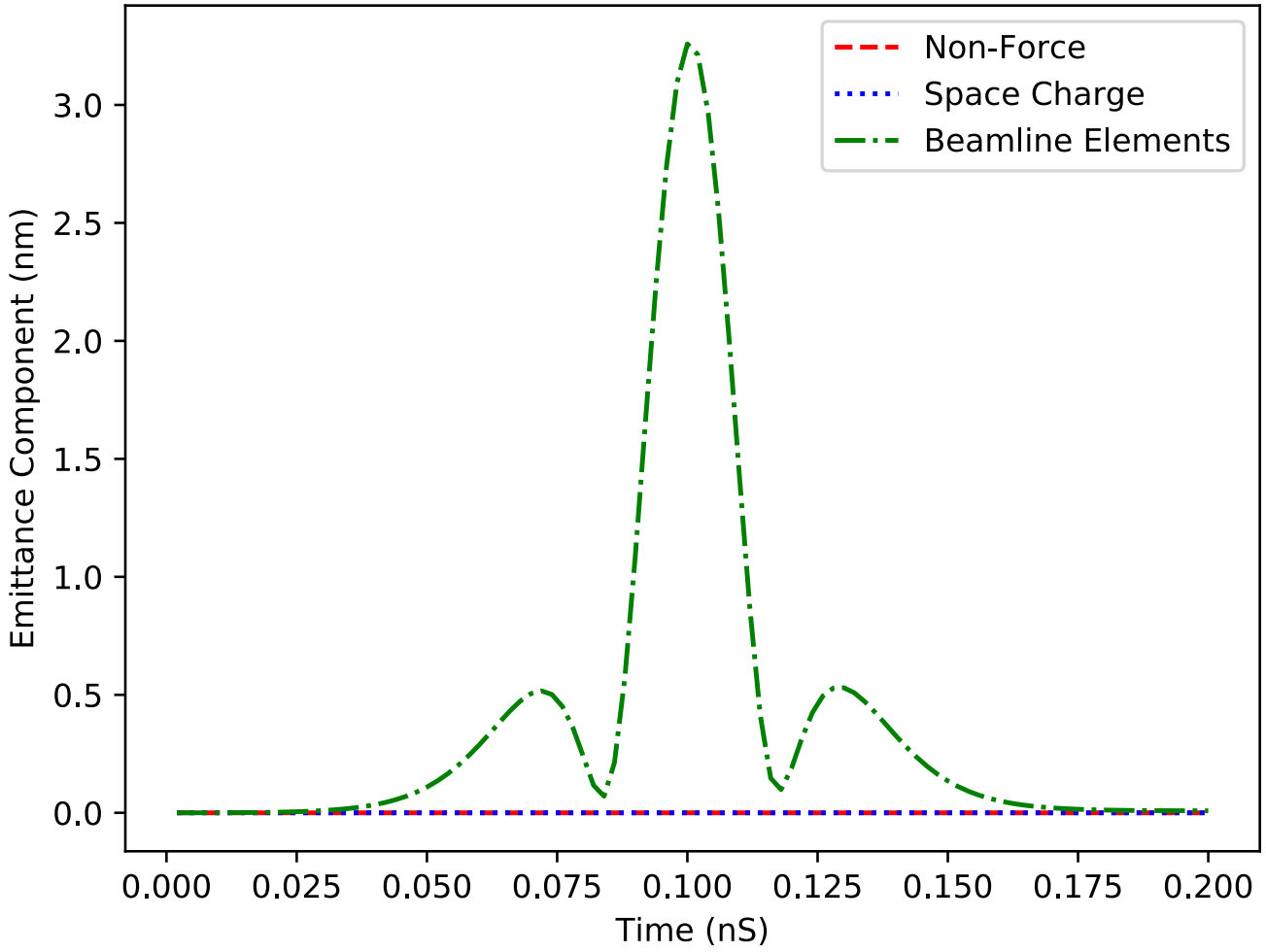
1e-15 Test Case Emittance

- Simulation ends before effect of current loop is negligible



Backup

2e-15 Test Case



Spherical Aberration Calculation

- Using simple current loop, calculating emittance growth due to spherical aberration from:
  Kumar, Vinit & Phadte, Deepraj & Bhai Patidar, Chirag. (2011). A simple formula for emittance growth due to spherical aberration in a solenoid lens.

- The emittance growth of a azimuthally symmetric beam due to a solenoid in the thin lens approximation is simply related to the geometry of the solenoid and the beam

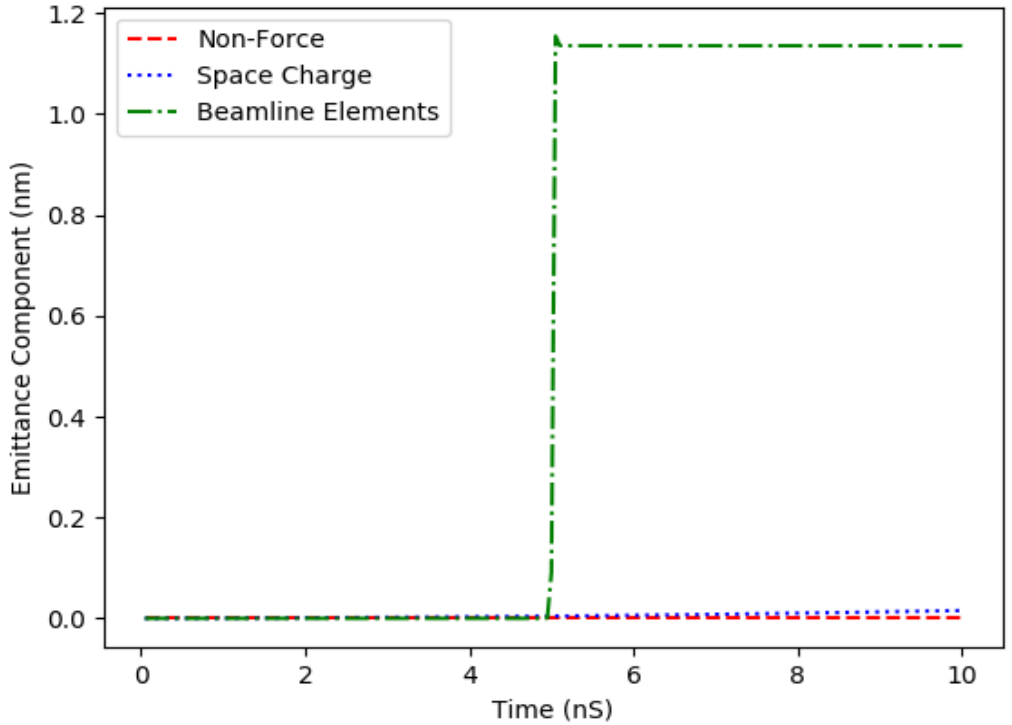
$$\varepsilon_{x\,y} = \frac{R^4}{2\sqrt{6}\,f_0}\sqrt{\frac{C_1^{\,2}}{12} + \frac{C_1 C_2}{5}R^2 + \frac{C_2^{\,2}}{8}R^4}$$

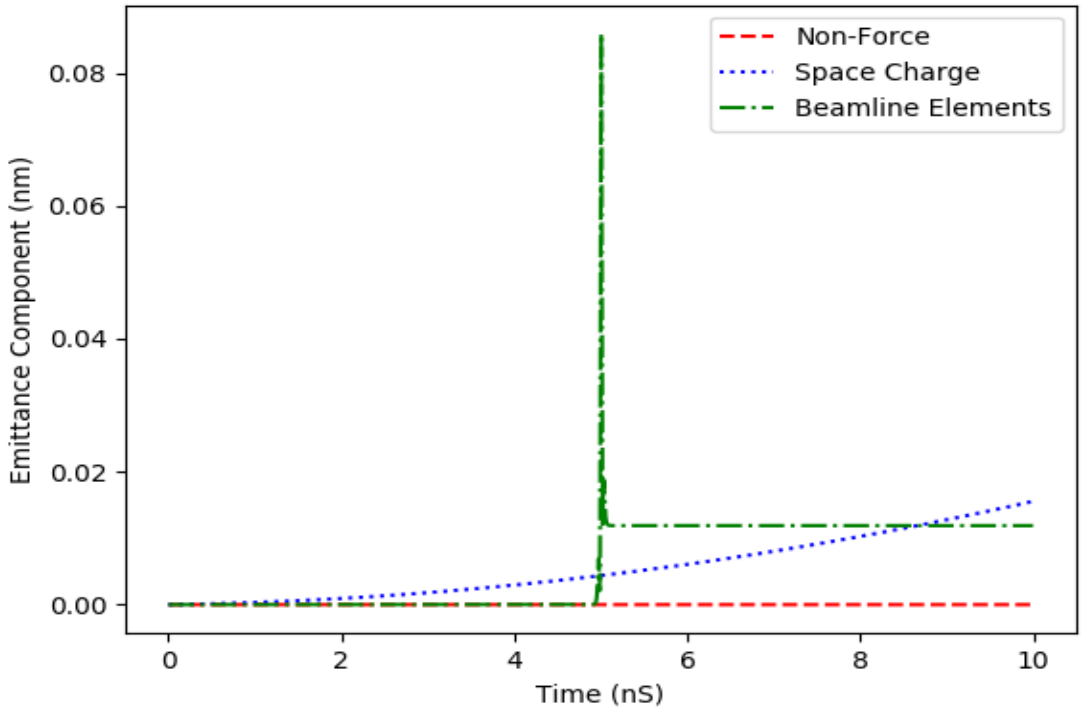
- Where C1 and C2 are reductions of the focal length due to the 3rd and 5th order spherical aberrations respectively

$$C_1 = \frac{1}{2}\frac{\int_{-\infty}^{+\infty}\{B'(z)\}^2\,dz}{\int_{-\infty}^{+\infty}B^{\,2}(z)\,dz},\quad C_2 = \frac{5}{64}\frac{\int_{-\infty}^{+\infty}\{B''(z)\}^2\,dz}{\int_{-\infty}^{+\infty}B^{\,2}(z)\,dz}.$$

Time Step Convergence

- Tested in case where emittance growth should be negligible (10^-15)Trouble converging in reasonable time step run time (~1 hours)





Comparing Emittance Component to Emittance (~10 hour run time)

- Expected emittance growth from spherical aberration (2*10^-10 m)
- Doesn't seem to line