Progress Report

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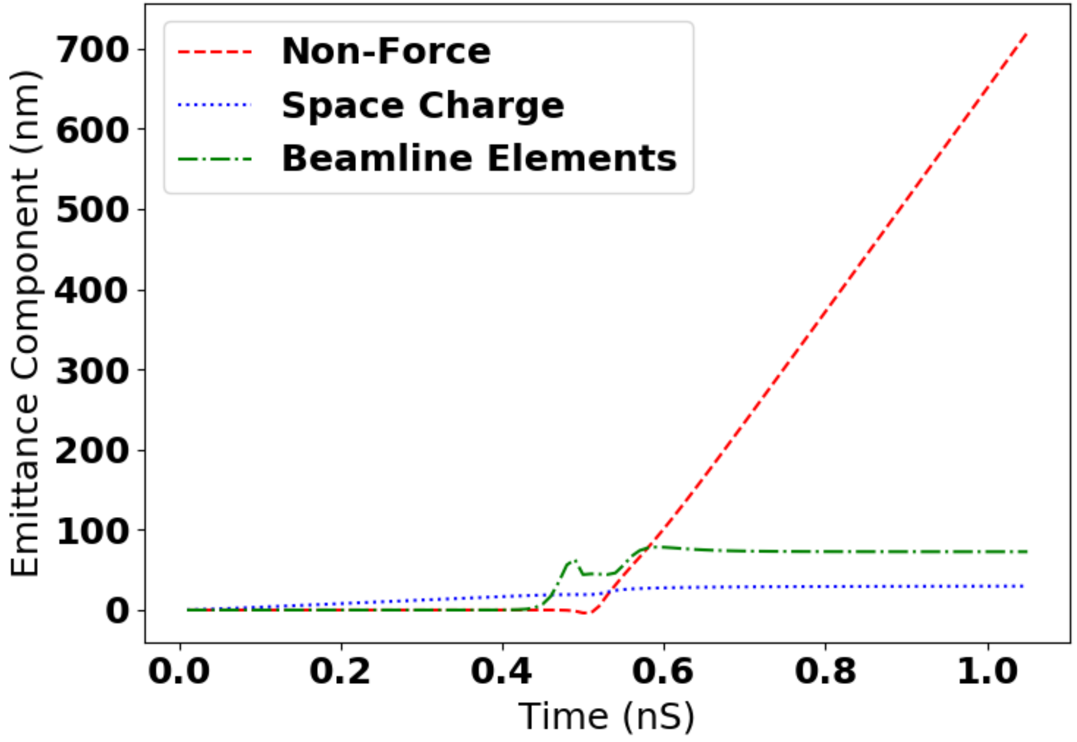
Geometric Aberration + Spacecharge Study

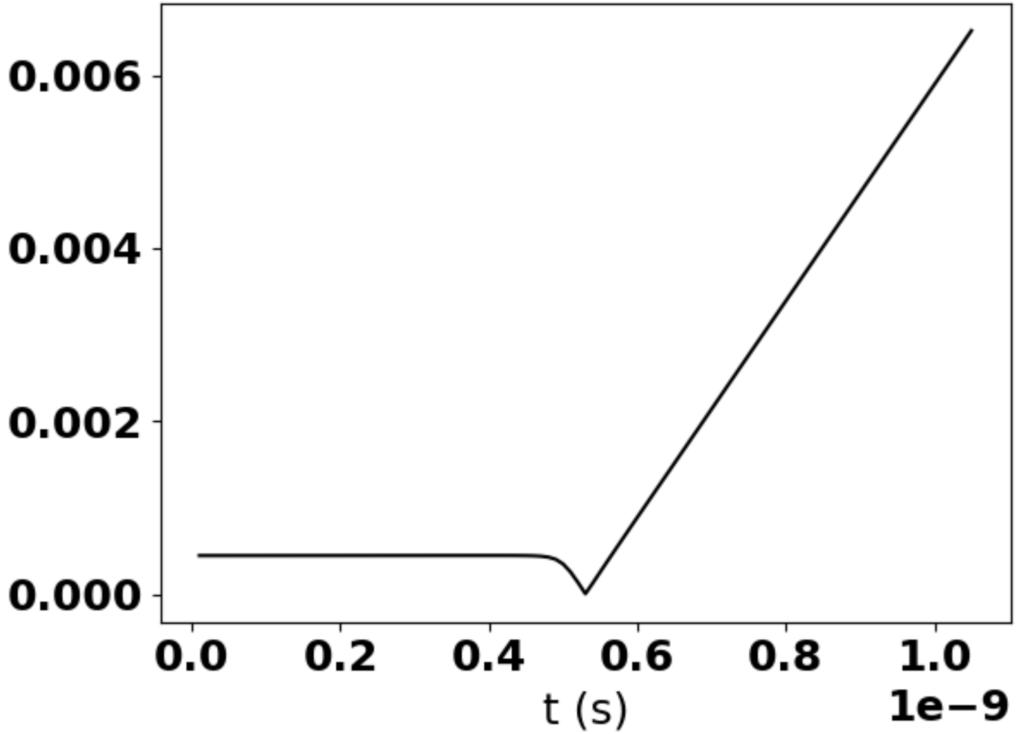
- Simple Test Case: Use emittance component tool to identify geometric aberration emittance growth from a current loop in simulation
- Emittance growth due to spherical aberration agrees within 1%
- Add spacecharge to simulation and see if theoretical emittance growth from geometric aberrations can still be extracted
- To get large charge while keeping energy spread in the beam small enough for GPT3DMesh to function properly, particle energy increased (gamma 1.92 -> 8)

Comparing to Theoretical Geometric Aberration Ellipsoid

- GPT emittance growth (68 nm) theoretical growth (44 nm) Spacecharge (charge : emittance growth) (1pC : 30 nm)

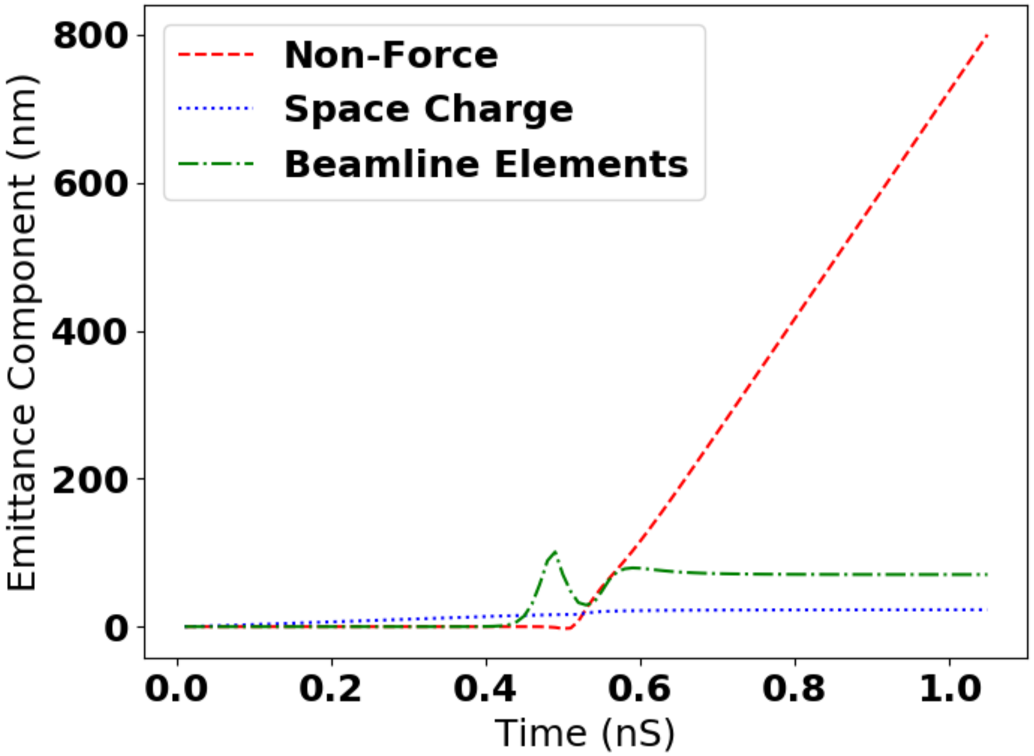


RMS Spot Size in m

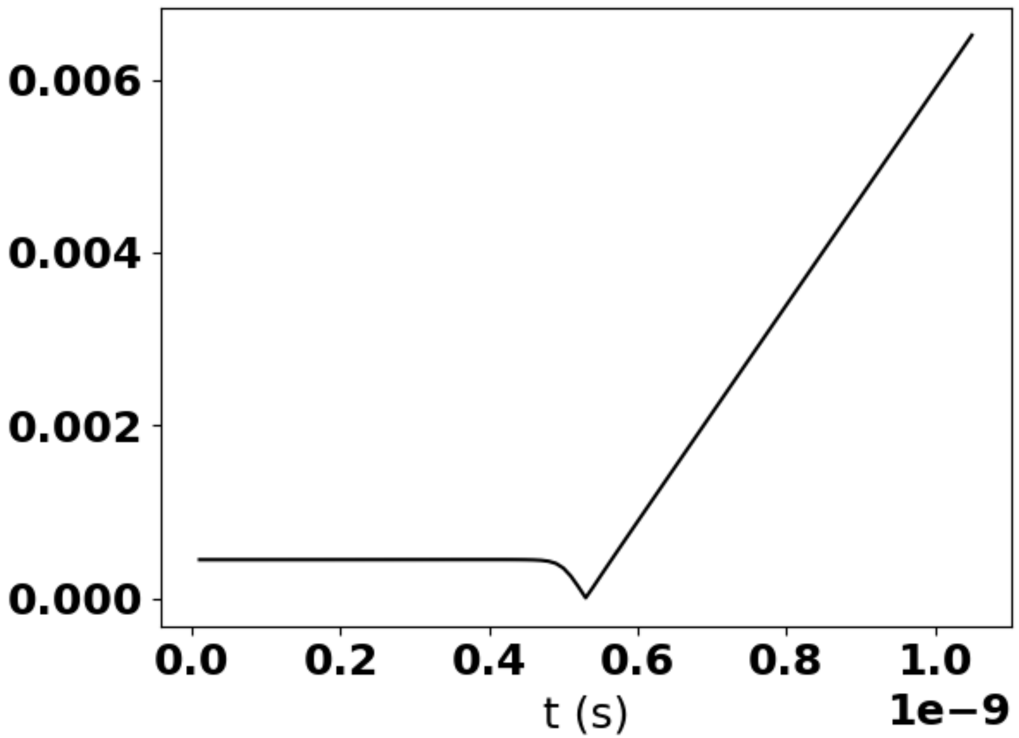


Comparing to Theoretical Geometric Aberration Cylinder

- GPT emittance growth (70 nm) theoretical growth (44 nm) Spacecharge (charge : emittance growth) (1pC : 22 nm)

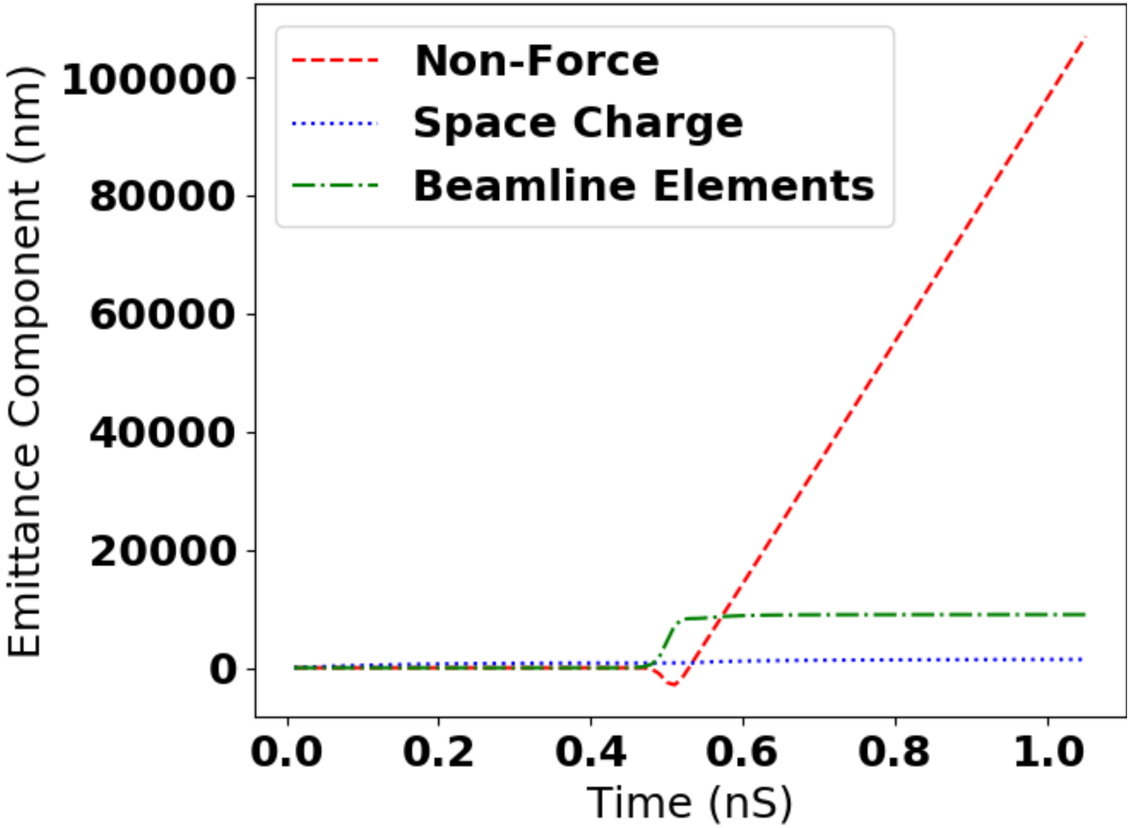


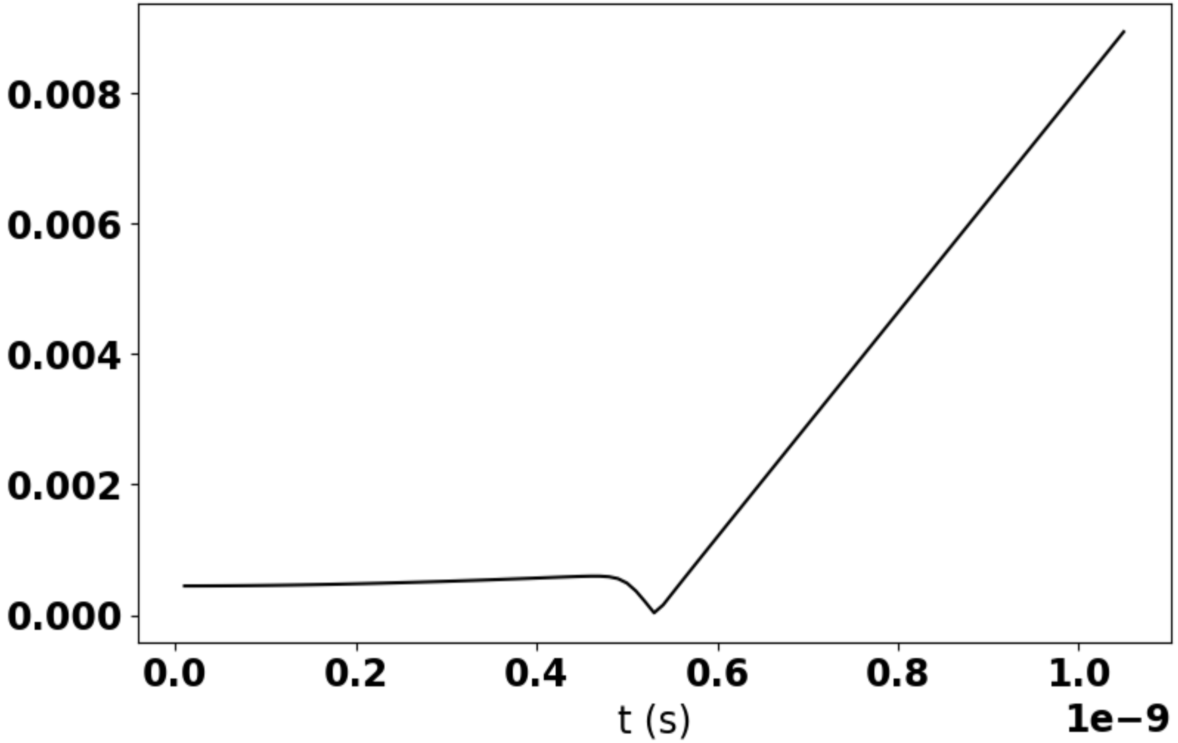
RMS Spot Size in m



Higher Charge leads to problems

- RMS Spot size increases but not large enough to explain geometric emittance growth 9000 nm





Backup

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

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