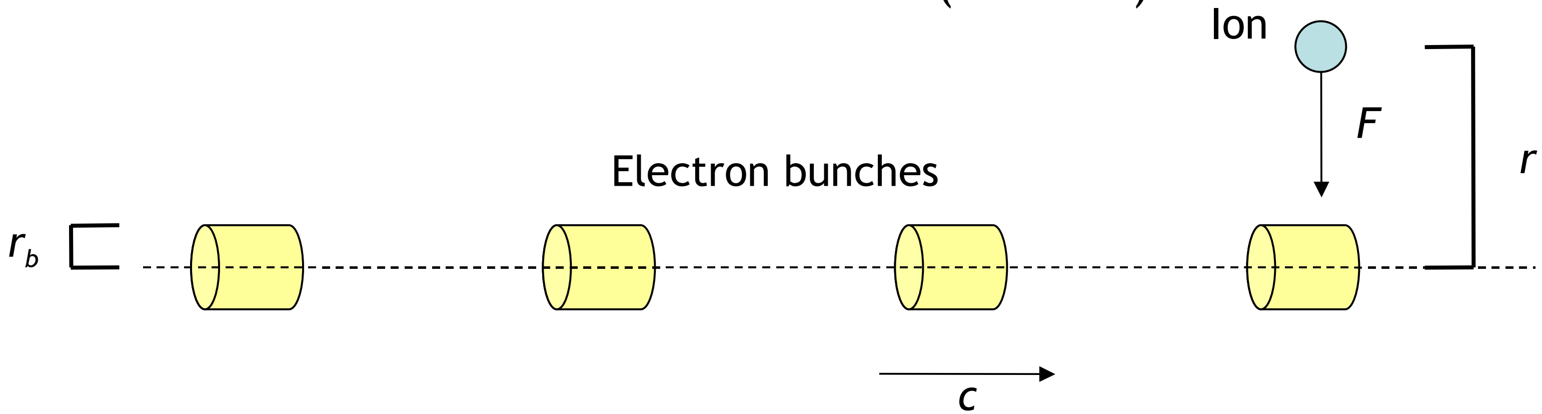
FII Simulation Review

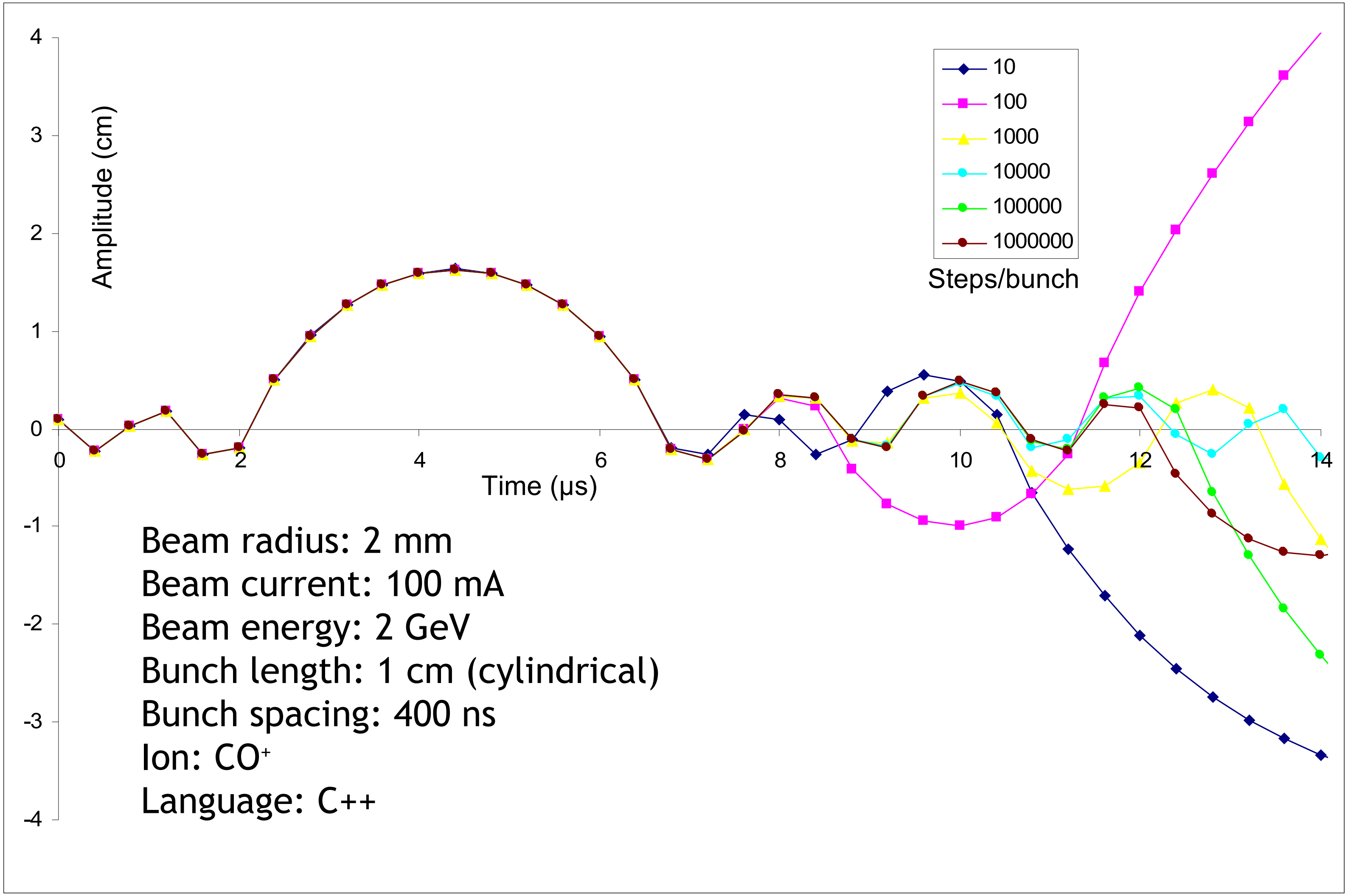
- Simulation assumptions
  - Start ion from rest at some amplitude directly above a bunch
  - Step function radial force/kick
  - No bunch acceleration
- Progress
  - Cylindrical bunched beam simulation (C++/Fortran)
  - Gaussian bunched beam simulation (Fortran)



Chaotic Ion Motion

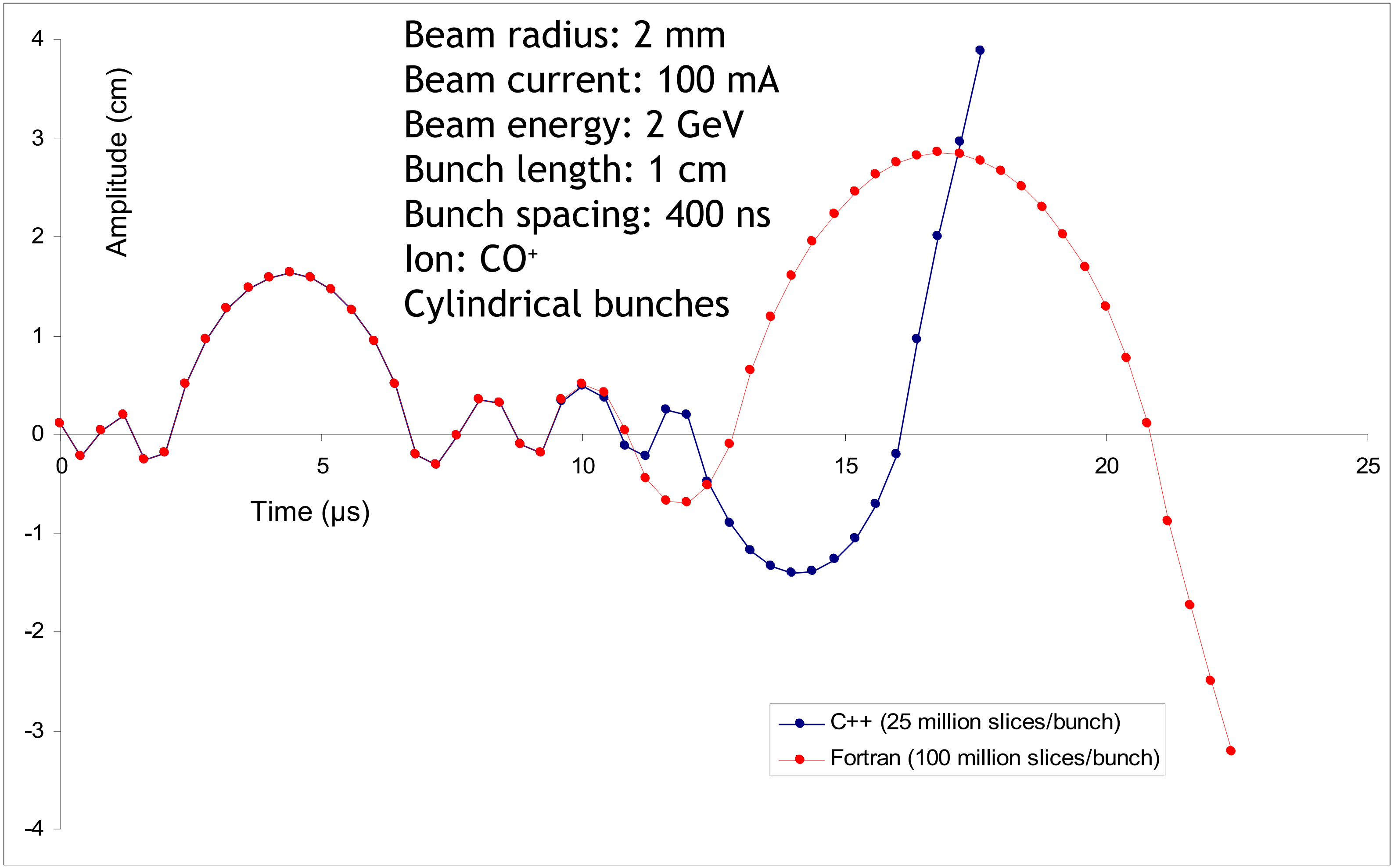
- At border between stable oscillation and immediate ejection, the ion's motion is chaotic
  - Velocity deviations cause position deviations, which lead to different ion paths
- Velocity deviations caused by roundoff error
- Many slices per bunch required for path convergence
  - 25 million slices/bunch for C++, 100 million for Fortran

Ion Paths



Beam radius: 2 mm
Beam current: 100 mA
Beam energy: 2 GeV
Bunch length: 1 cm (cylindrical)
Bunch spacing: 400 ns
Ion: CO^+
Language: C++

C++/Fortran Path Comparison



Gaussian Bunches

- Fortran simulation written using Gaussian charge distribution
- Used Bmad `bbi_kick` subroutine for transverse bunch slices
- Vertical kick calculation

$$kick_y = \Delta v = \frac{r_p c N}{2\pi (\sigma_x + \sigma_y) A} k_y$$

r_p: classical proton radius

N: particles per slice

A: ion mass (amu)

k_y: `bbi_kick` return parameter

Ion Frequency Comparison

- σ_x = 2 mm, σ_y = 2 mm, σ_z = 9 mm, 14 ns bunch spacing, 10^{10} e^-/bunch
- CO^+ oscillation frequency (small amplitudes)
  - Gaussian bunches: 275 kHz
  - Cylindrical bunches (using centroid density): 309 kHz
  - Solid beam (using centroid density): 306 kHz
- H^+ oscillation frequency (small amplitudes)
  - Gaussian bunches: 1.506 MHz
  - Cylindrical bunches: 1.698 MHz
  - Solid beam: 1.619 MHz
- Next step: compare frequencies at large amplitudes