Field cross sections and first LCODE sims

John

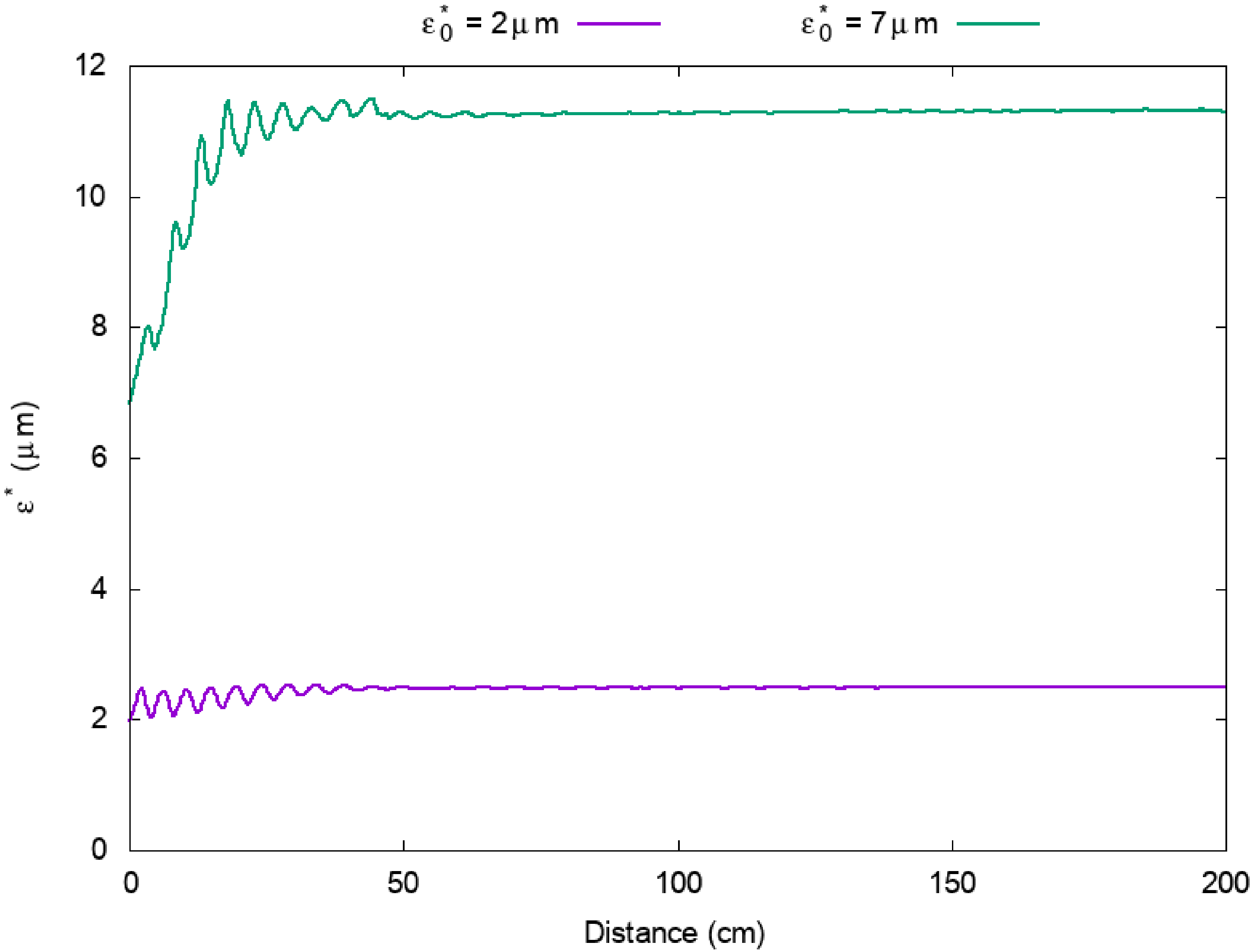
Outline

- New videos of beam/plasma evolution give intuition for emittance blowup

- First results from LCODE simulations
  - Needed for extended parameter scans

- Discussion on which quantities to optimize for

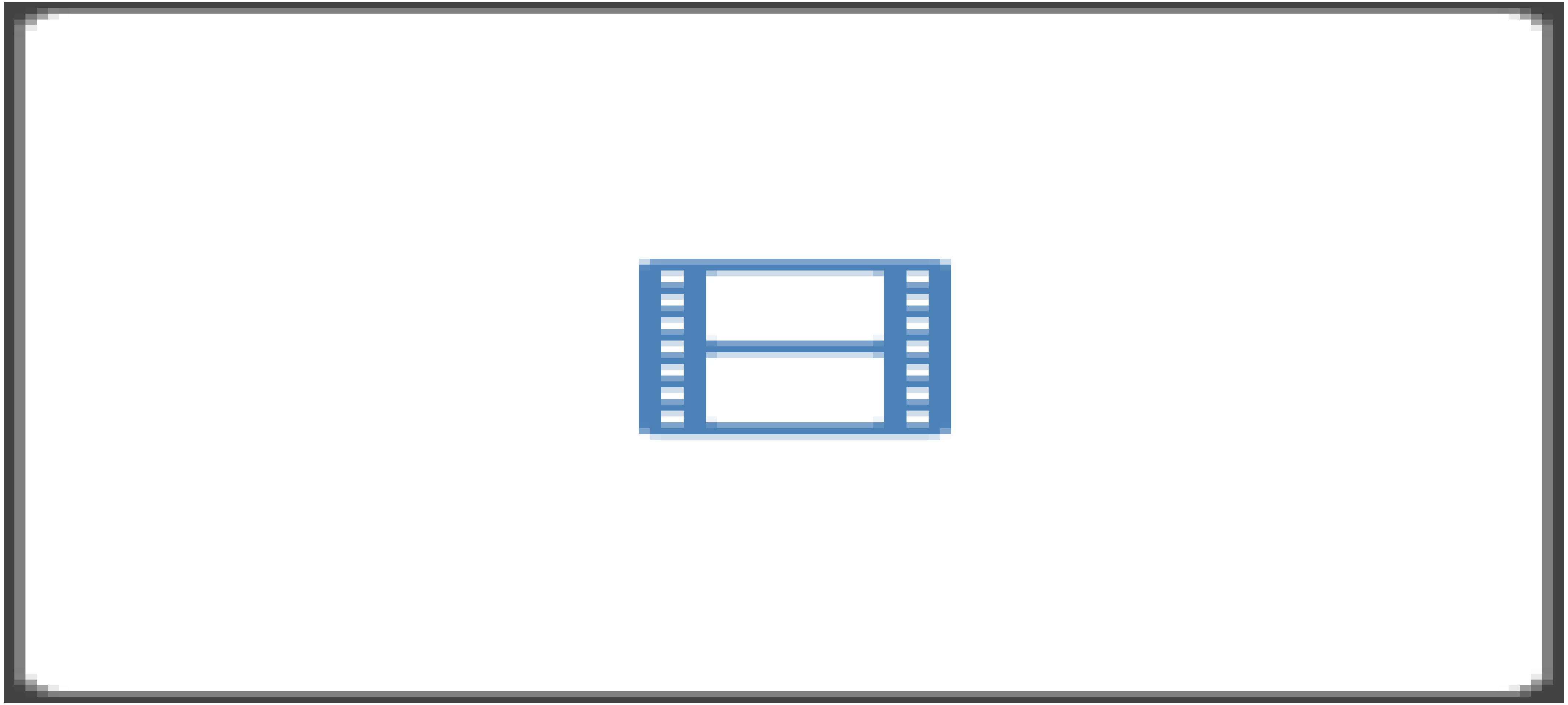
Emittance growth



q=100 pC, σ_z=60 um

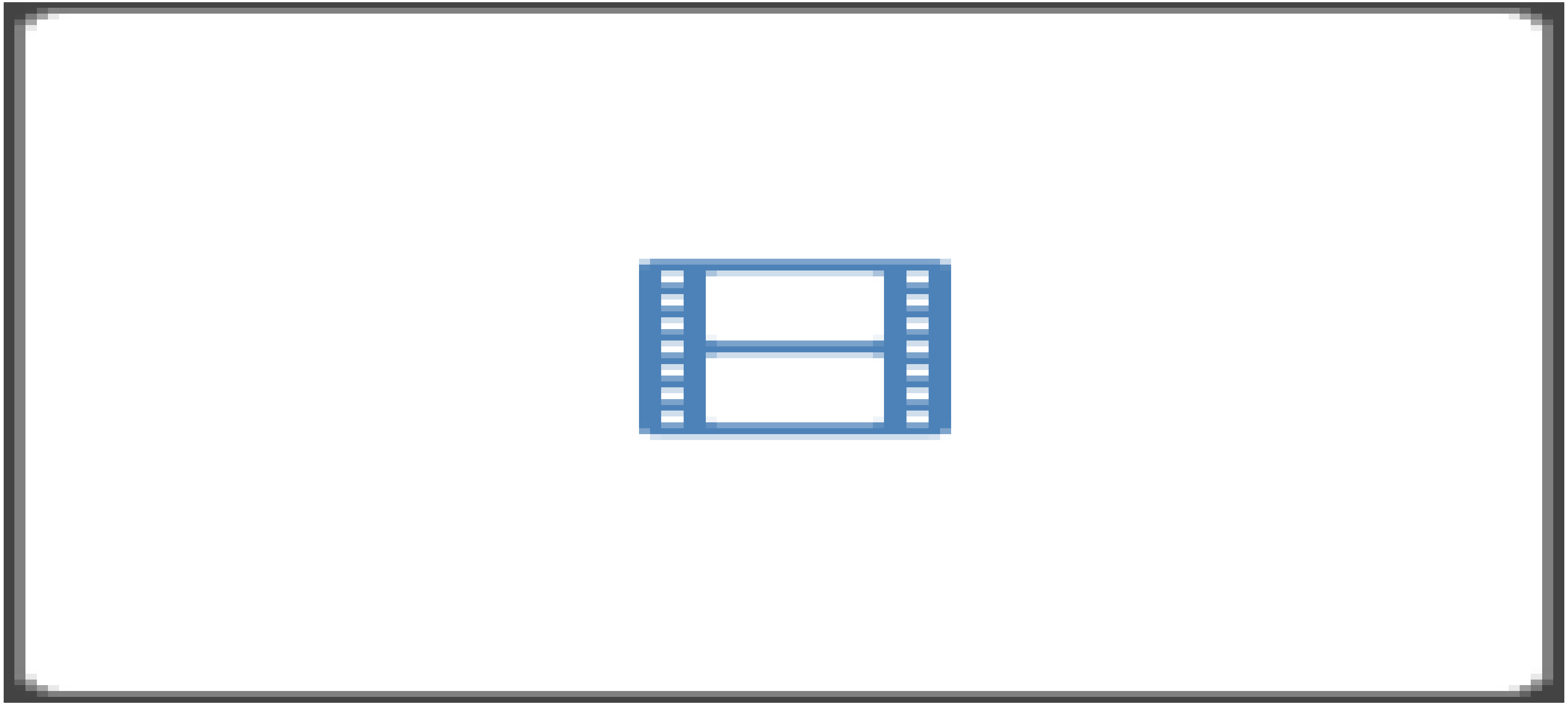
- Higher initial emittance due to scattering leads to rapid emittance increase after injection
- Wider beam takes longer to drive blowout

Emittance growth



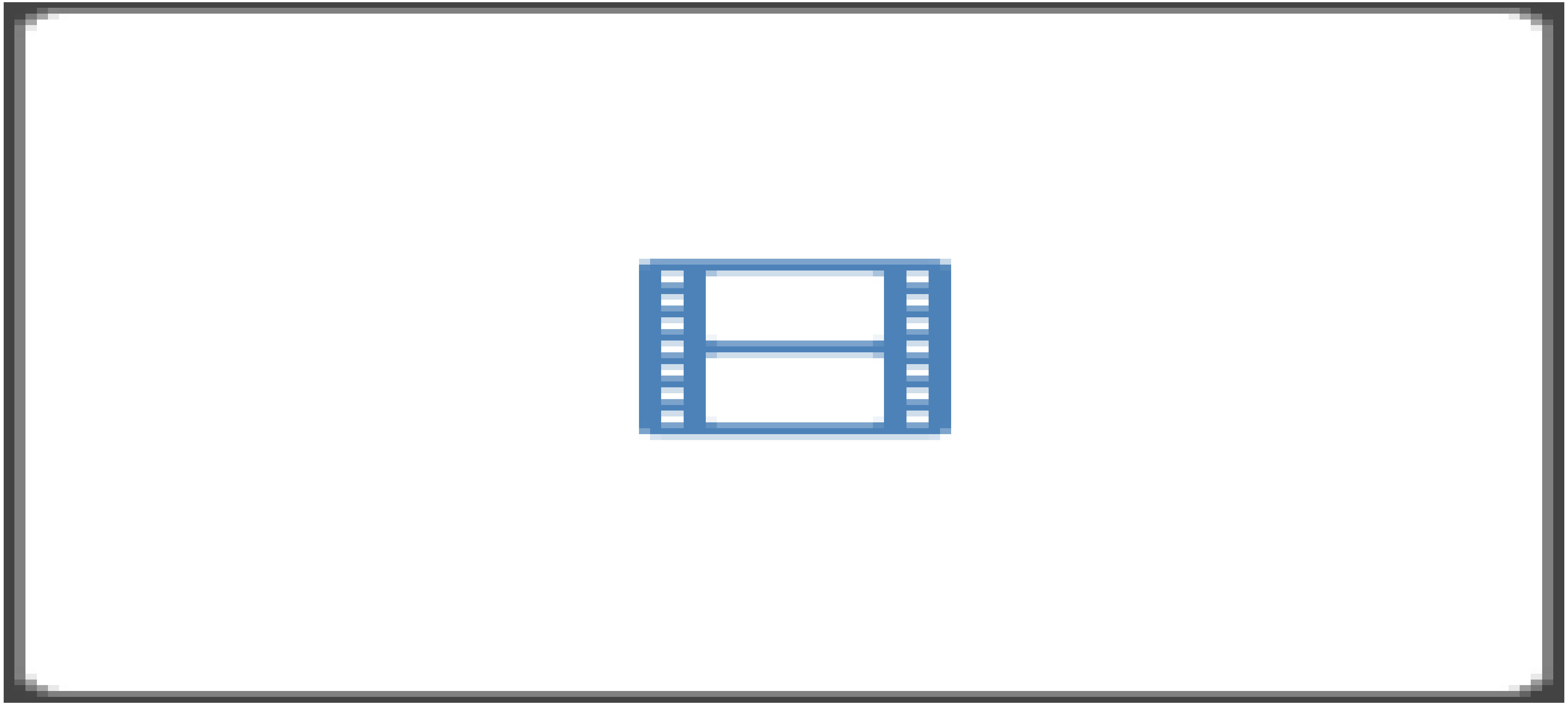
Beam matched to blowout, head oscillates due to mismatch.
Oscillating beam → oscillating wake

Emittance growth



Beam matched to blowout, head oscillates due to mismatch.
Oscillating beam → oscillating wake → oscillating fields

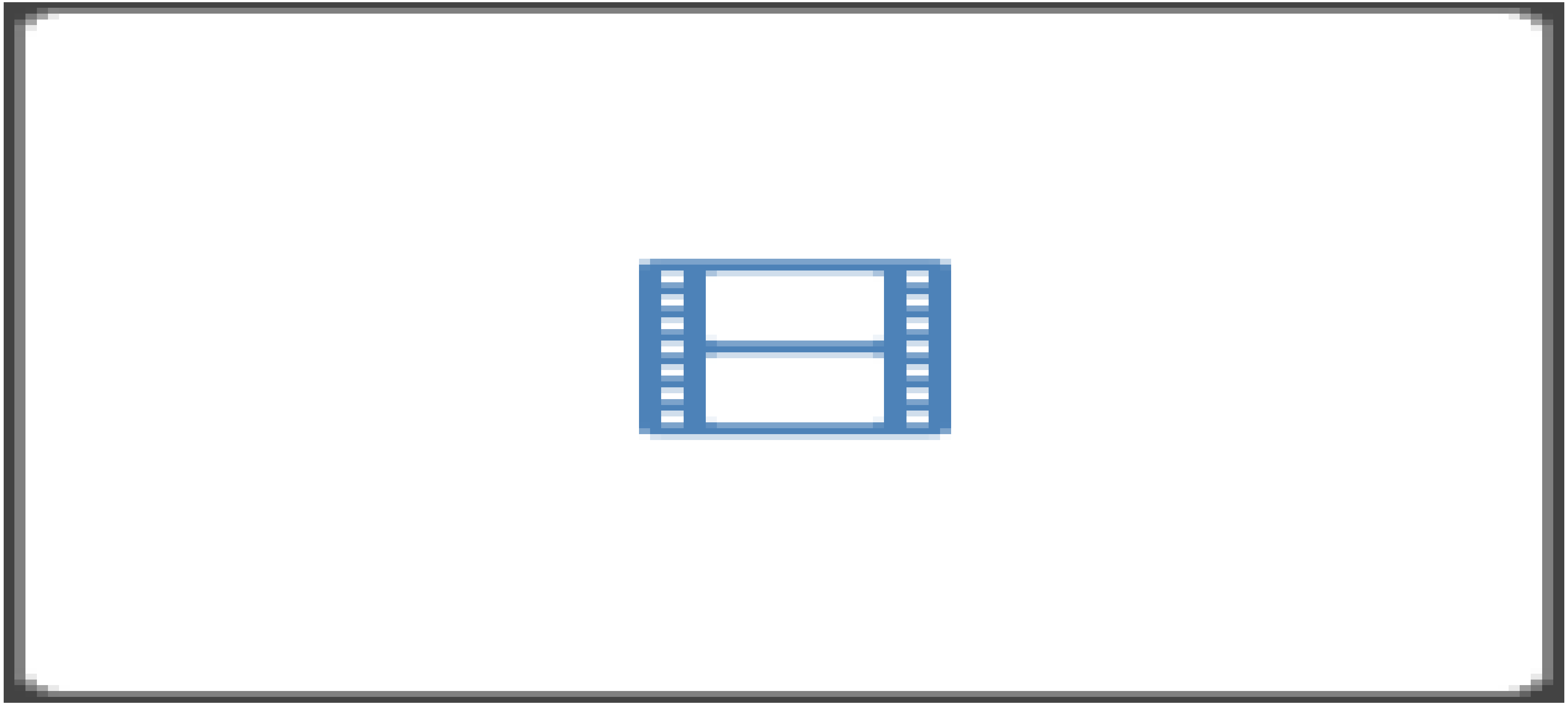
Emittance growth



Fields close to axis are near linear, so slice emittance is conserved

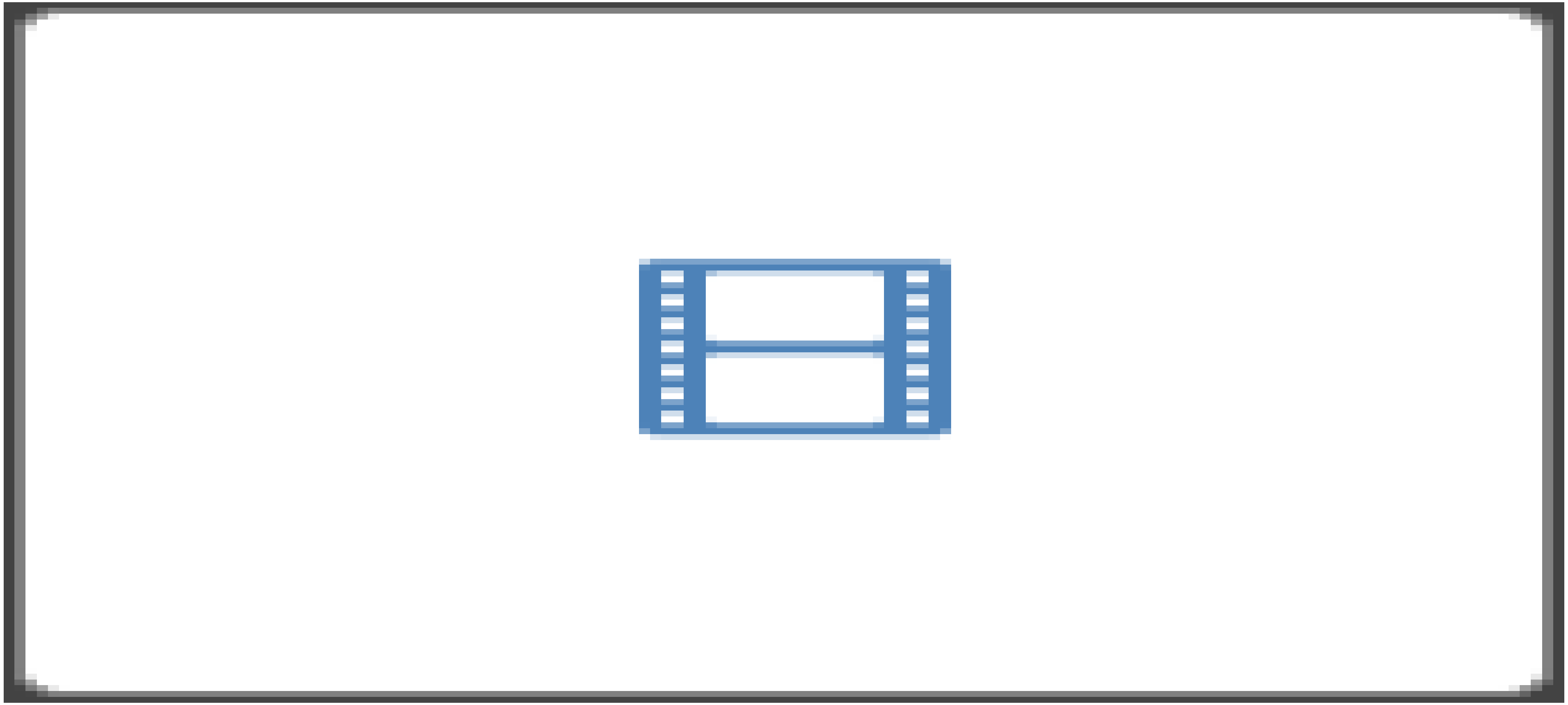
Projected emittance increases as slices dephase

Emittance growth – bonus round



Re: Francesco’s question
here’s a video showing 10 um initial offset

Emittance growth



Worth noting that similar (but much smaller) oscillations also occur for 2μm initial emittance

LCODE

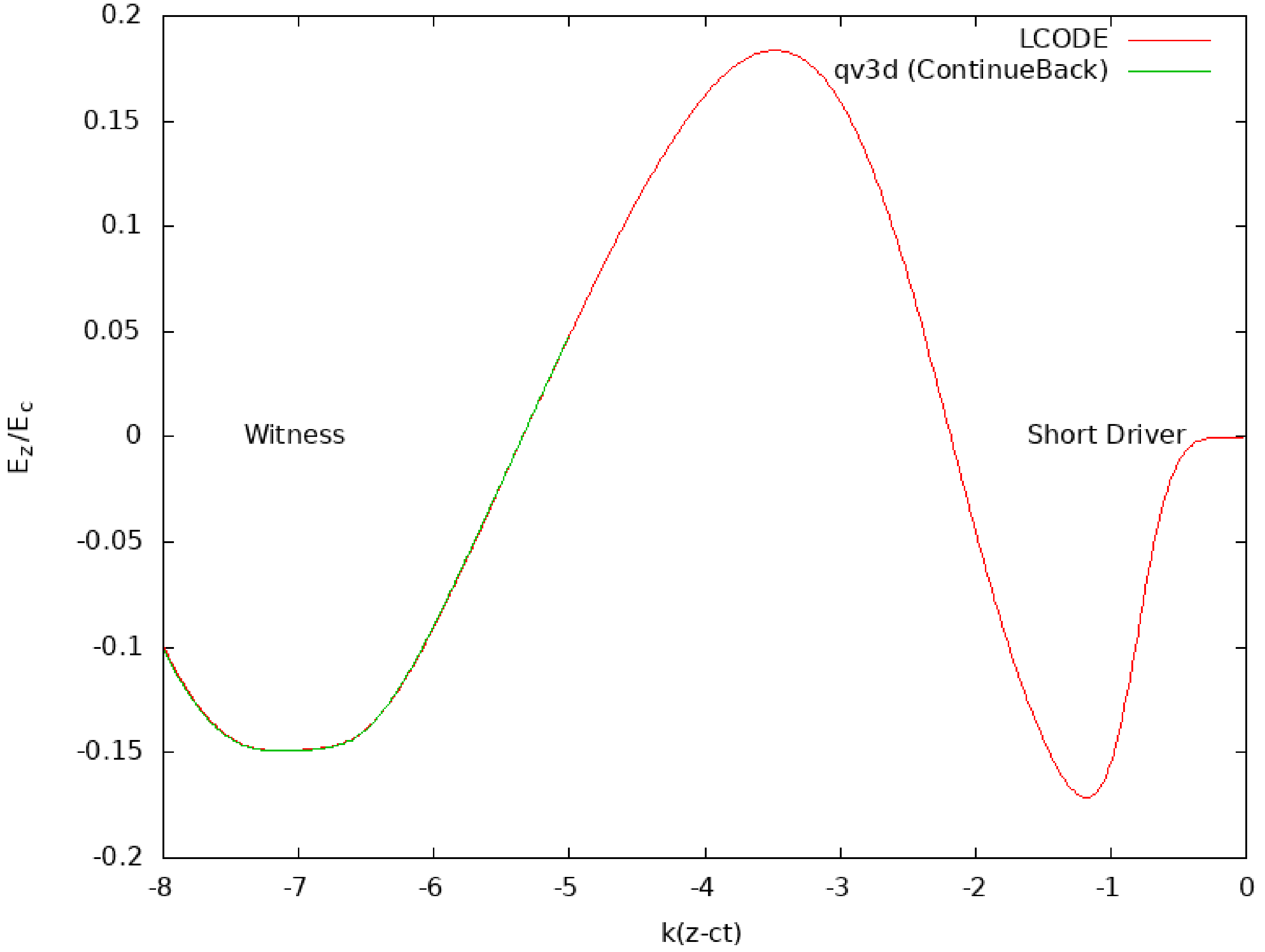
Many parameter sets require 3D modelling

- Transverse offsets
- Elliptical beams

Life is short, and the ice-caps are melting

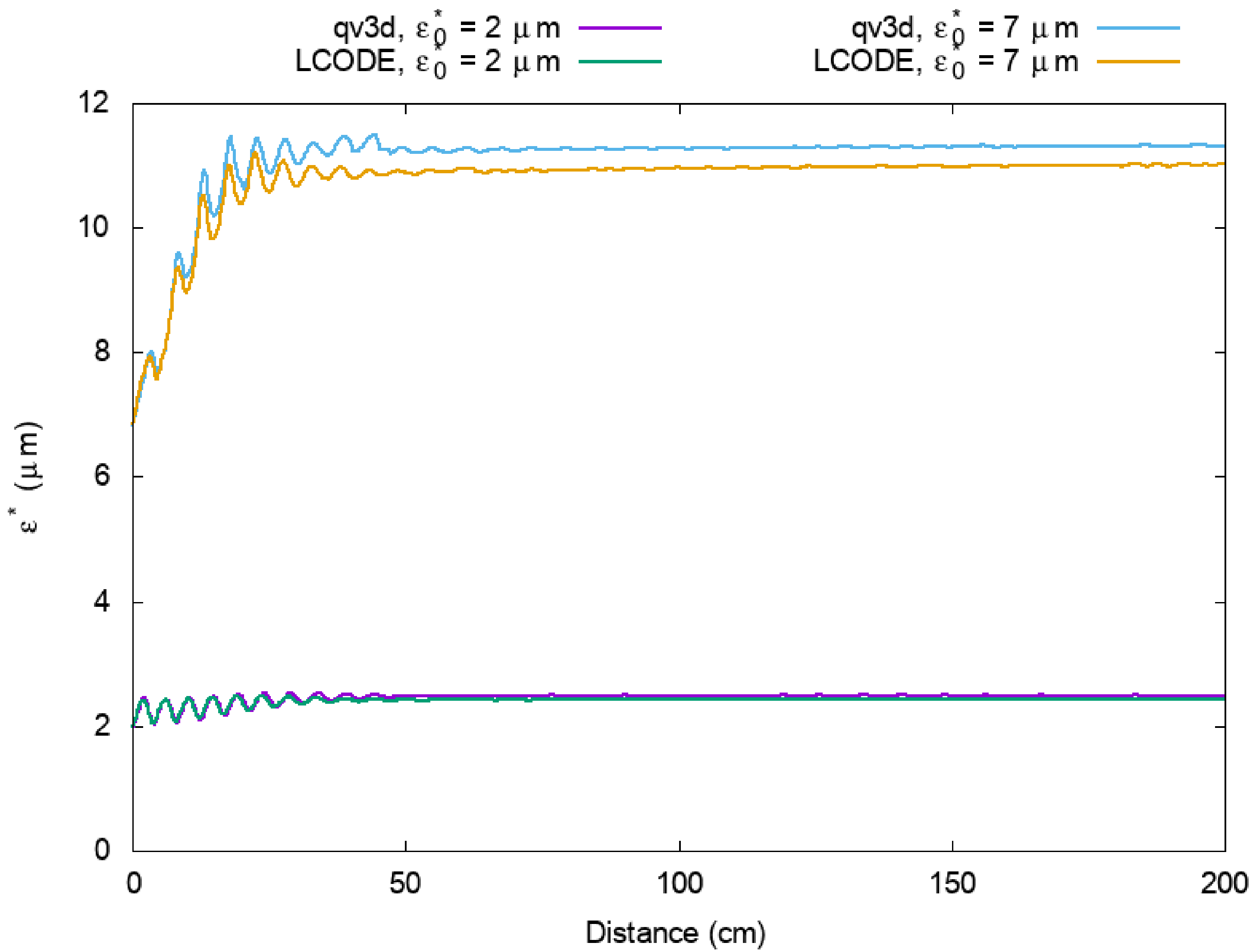
- If you can use a quasistatic code, you should
- If you can use a 2D geometry, you should

Benchmarking



- Excellent agreement
- Like, really

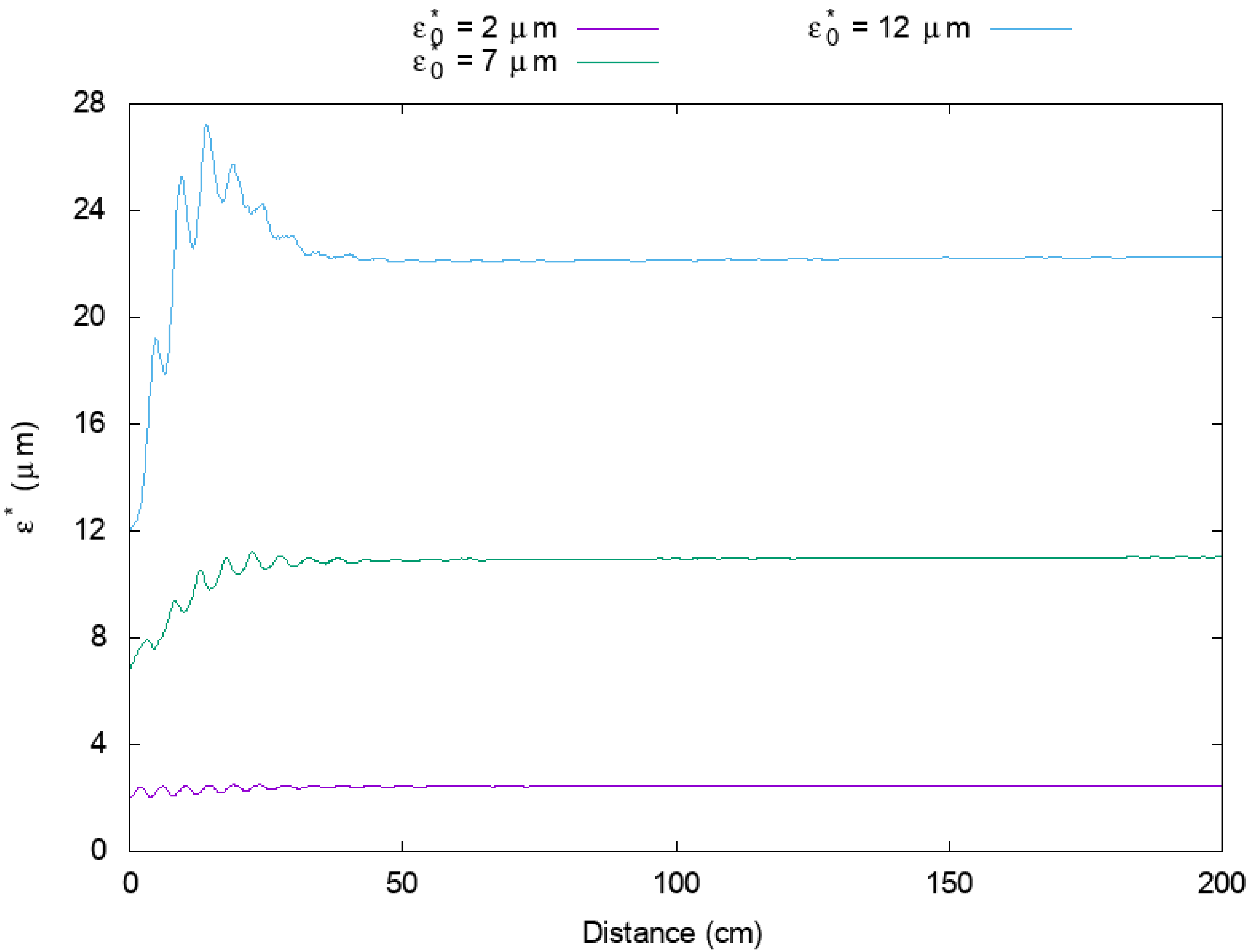
Benchmarking



q=100 pC, σ_z=60 um

- Again, excellent agreement
- LCODE gives slightly less emittance growth,
  - better sampling of the phase space
  - Fewer instability modes

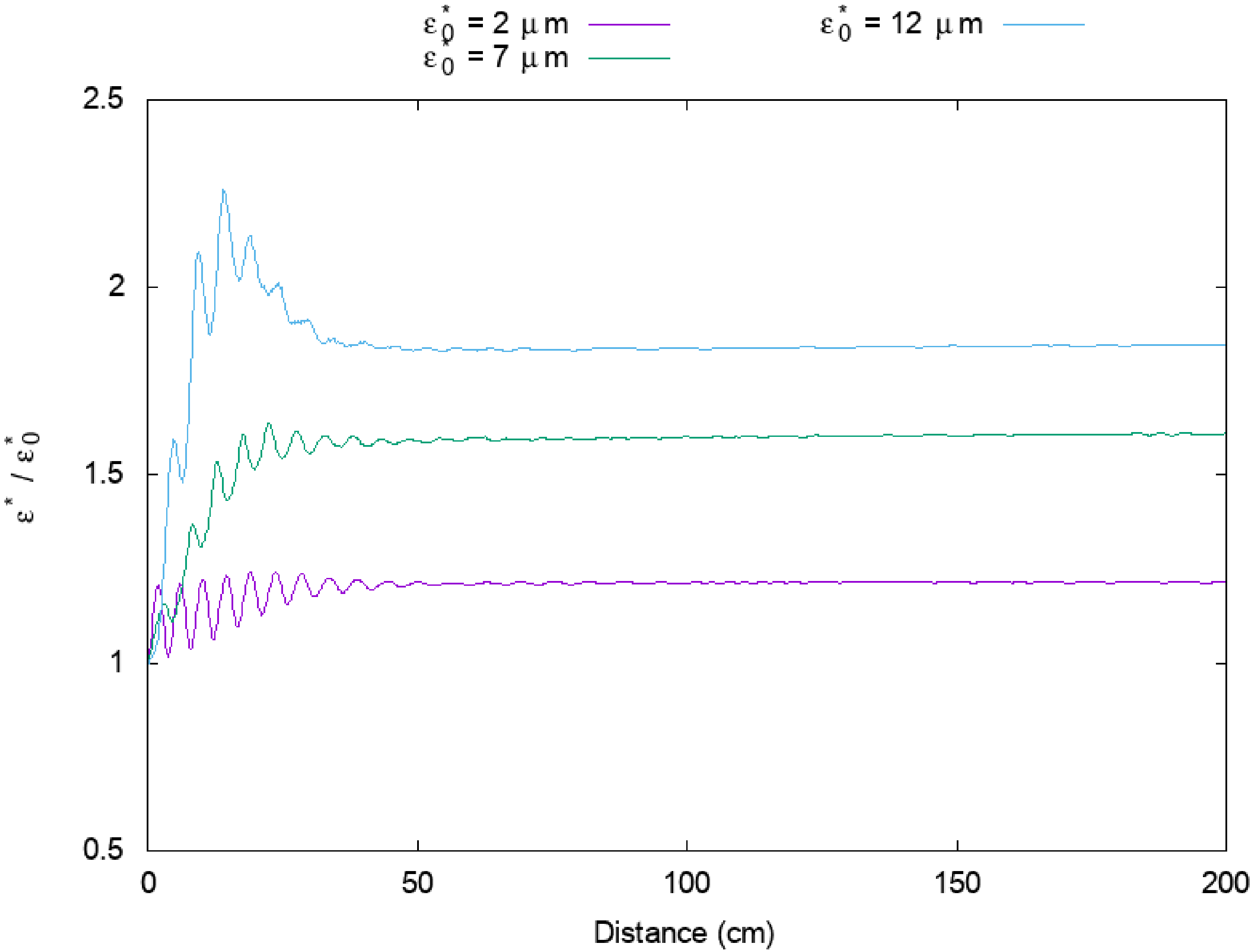
Emittance growth



q=100 pC, σ_z=60 um

- Emittance always grows
- Larger emittance at injection leads to larger emittance growth

Emittance growth



- Emittance always grows
- Larger emittance at injection leads to larger emittance growth
- Relative emittance growth (final/initial) also grows

q=100 pC, σ_z=60 um

Emittance growth

Slice emittance is ~ conserved

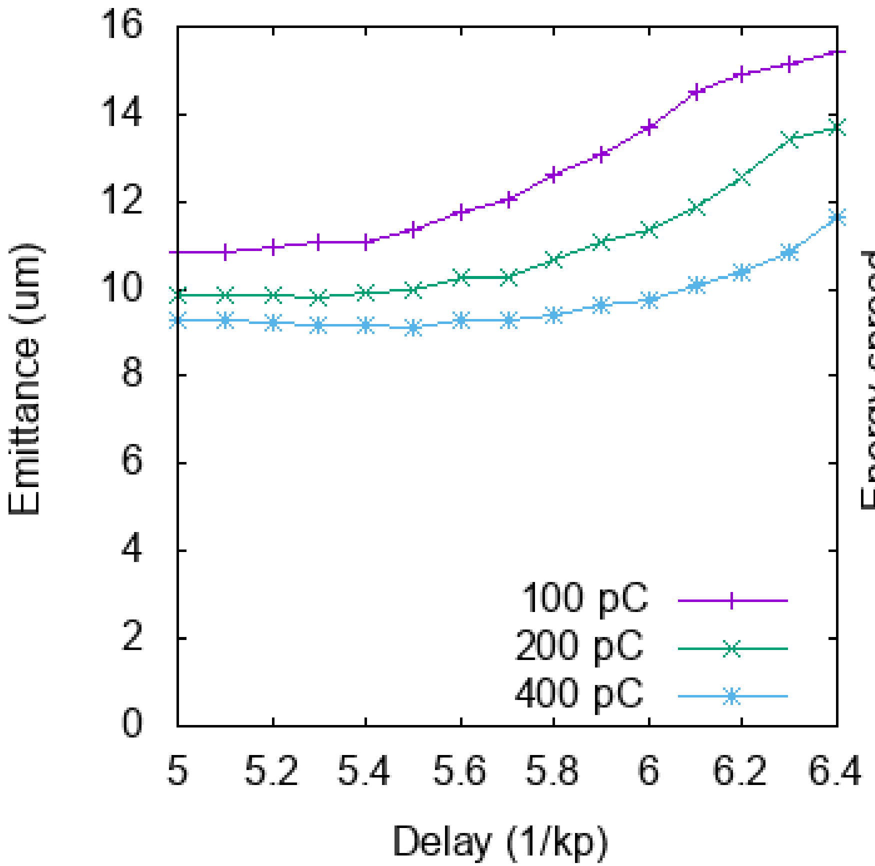
As slices dephase, projected emittance increases

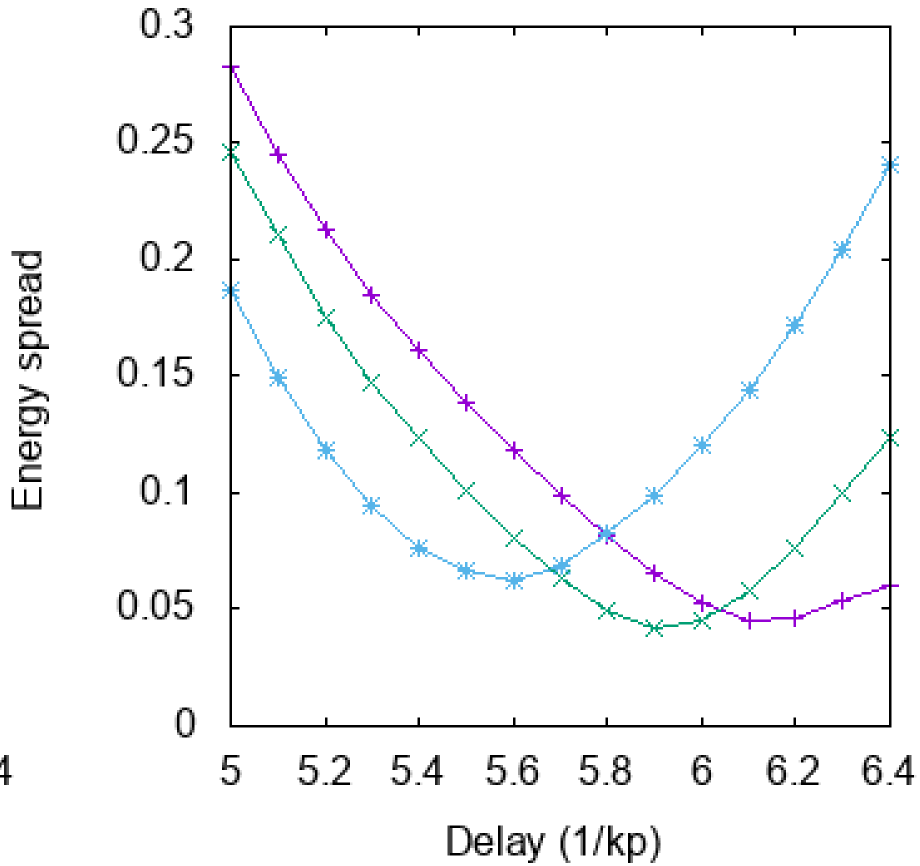
- Consider a series of elipses at different angles

Higher emittance gives larger emittance growth

- Slice field varies more → slices dephase faster
- Lower focussing fields give “longer” elipses

Emittance growth

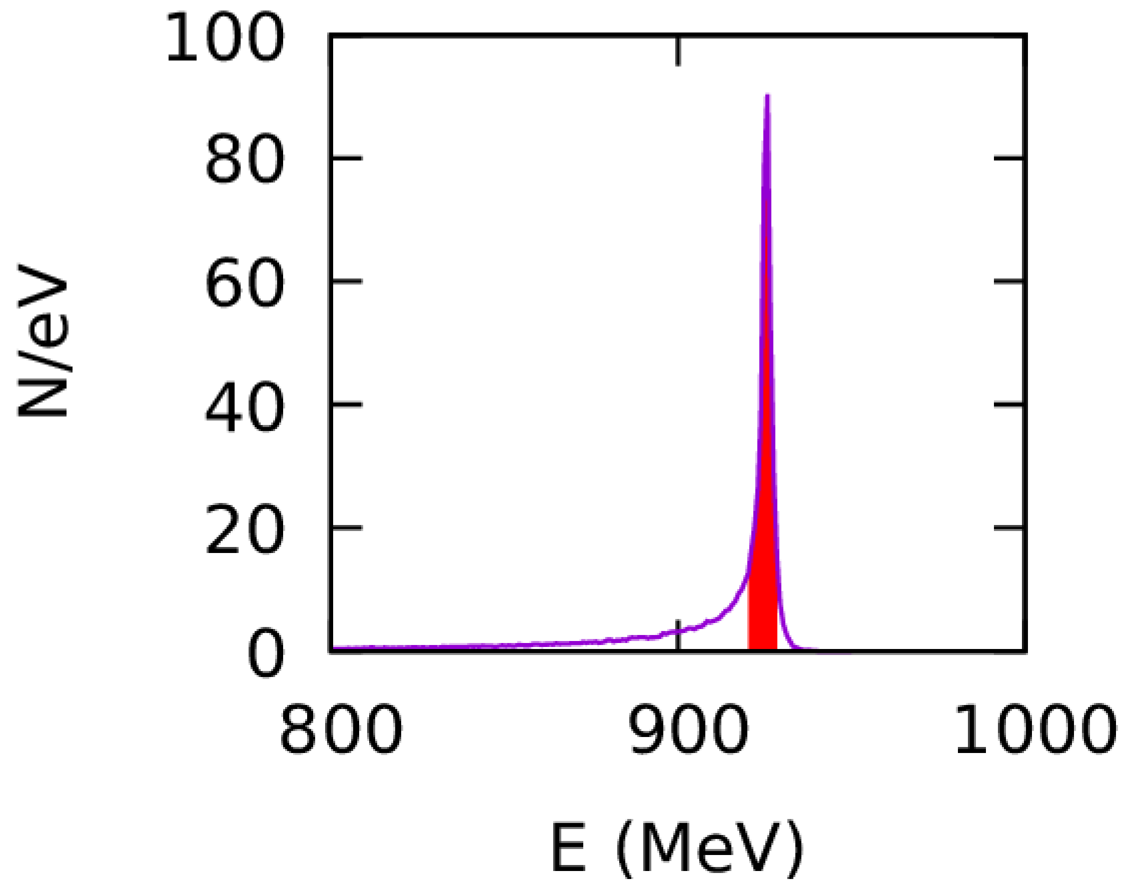




$\epsilon^*_0 = 8\ \mu m$
$z = 1$ m

Increasing charge reduces emittance growth
… but increases energy spread

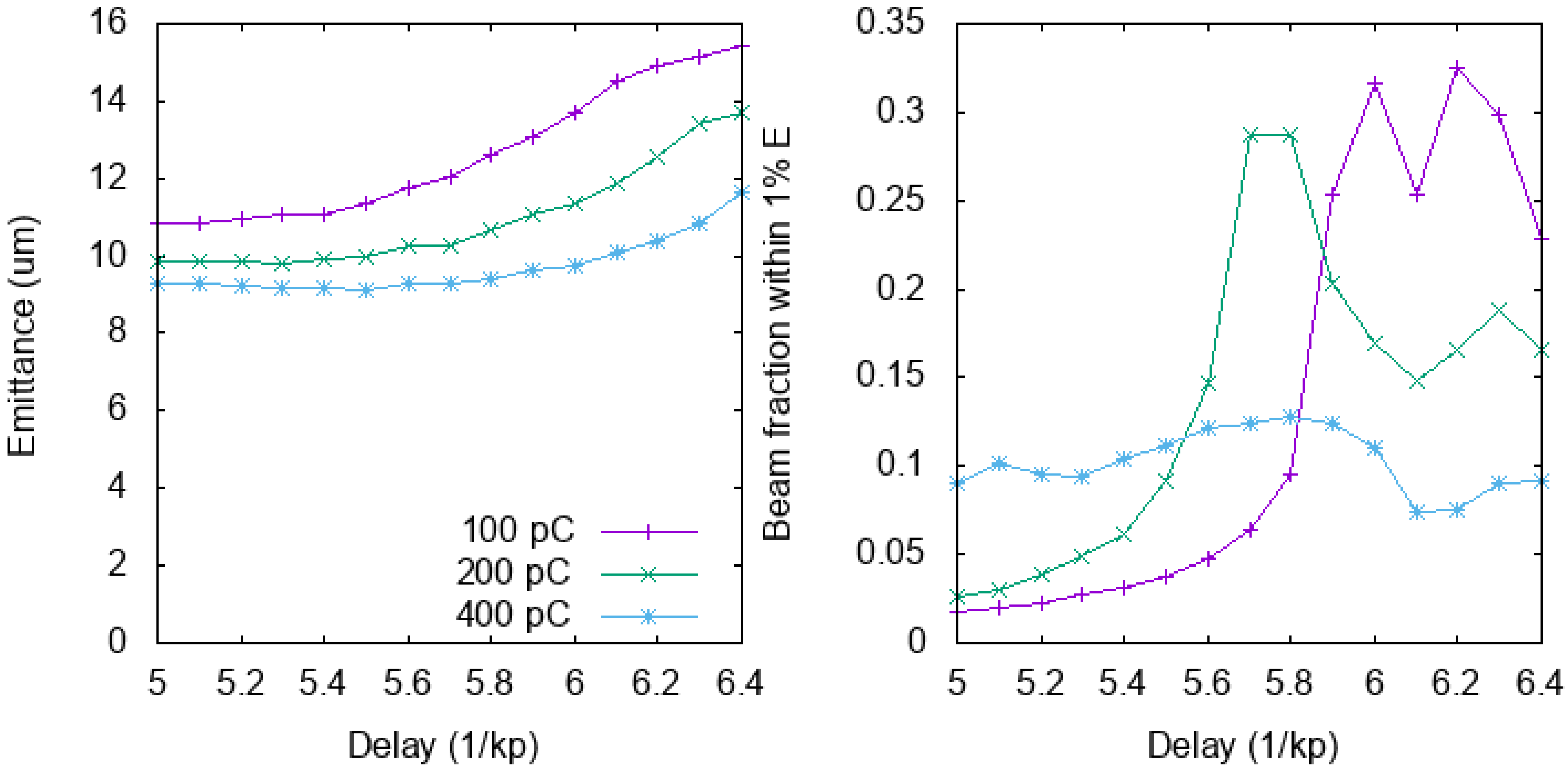
Emittance growth



ϵ^*_0 = 8 μm

RMS energy spread perhaps doesn’t describe a “quasimonoenergetic” well

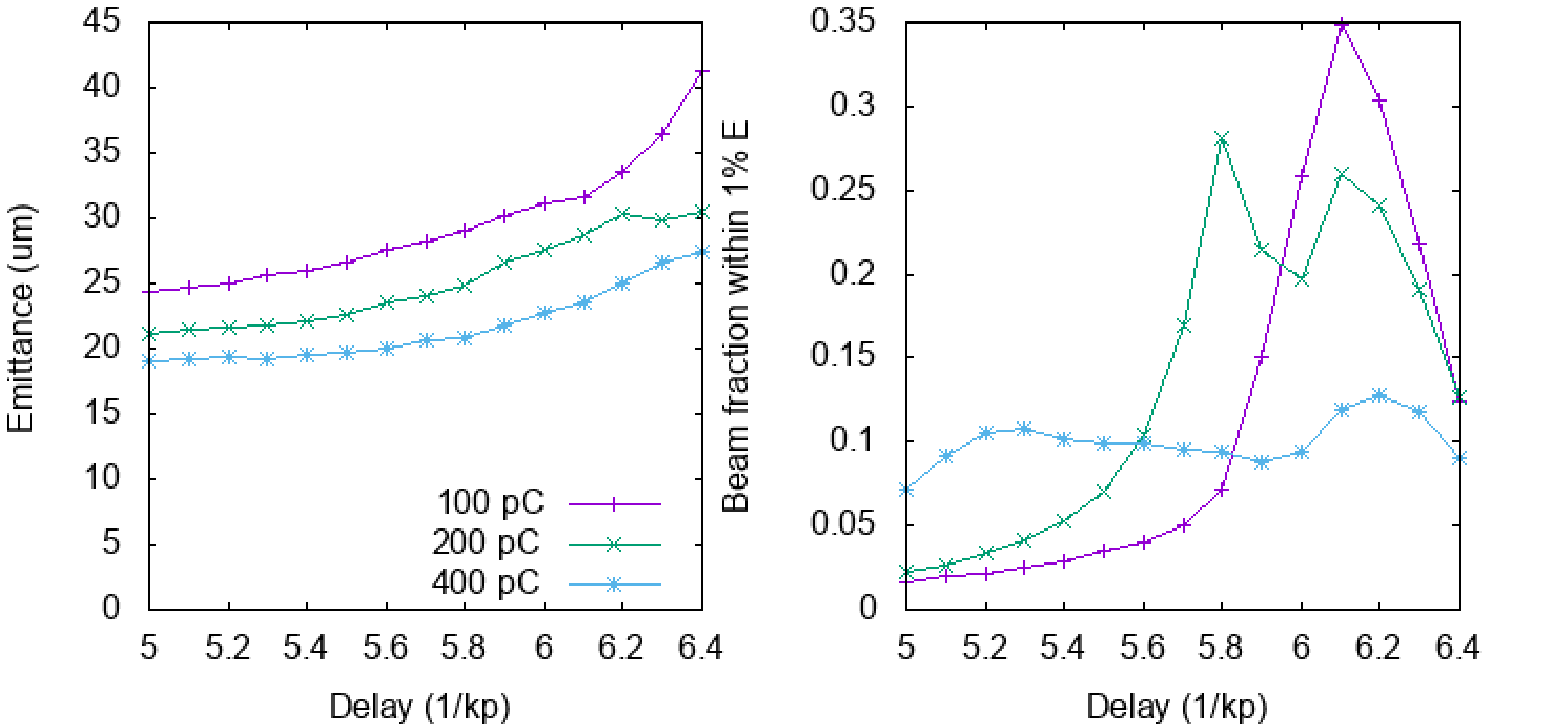
Emittance growth



$\epsilon^*_0 = 8\ \mu m$
$z = 1$ m

Fraction of beam within 1% energy spread decreases drastically for high charge

Emittance growth



$\epsilon^*_0 = 16\ \mu m$

$z = 1\ m$

Tradeoff will be different for different initial emittance

Larger parameter scans will be useful here

Summary

LCODE simulations give excellent agreement with qv3d

- Significant time investment, but already paying dividends

Even if a blowout isn't formed, larger fields give a tighter bunch which limits growth of the projected emittance (rounder elipses)

Positive tip – we can minimize emittance growth and we can minimize energy spread, but scans are still required to work out how best to do both at once