Modulator and FEL Simulations
β in FEL
Comparison with δf Method

CeC Simulations

Jun Ma

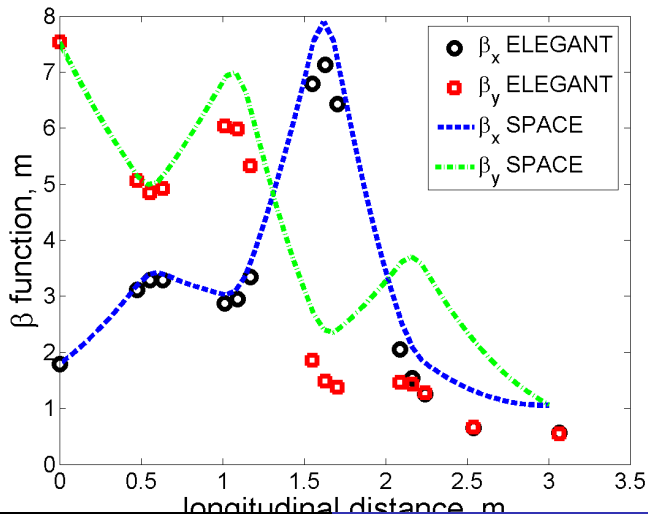Department of Physics and Astronomy
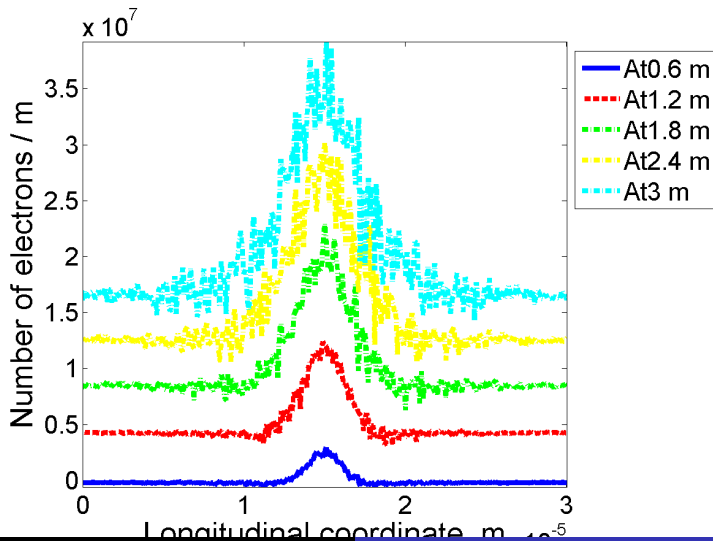Stony Brook University

2017.8.31

Modulator and FEL Simulations
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Modulator

Run one slice in modulator simulations

- slice length $= 3e-5$ m

- Peak current $= 40$ A, use $1e+6$ macro-particles, each represents 20 real particle

- $\varepsilon^* = 3e-6$, $\beta_x = 1.8$ m, $\beta_y = 7.5$ m, $\alpha_x = -1.1$, $\alpha_y = 2.9$
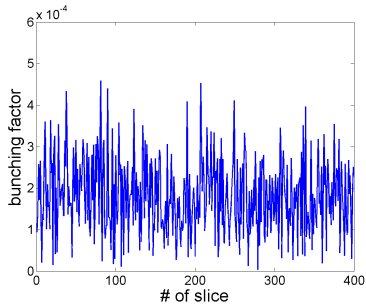
Modulator and FEL Simulations
β in FEL
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β functions in modulator

Modulator and FEL Simulations
β in FEL
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Longitudinal density modulation

Modulator and FEL Simulations
β in FEL
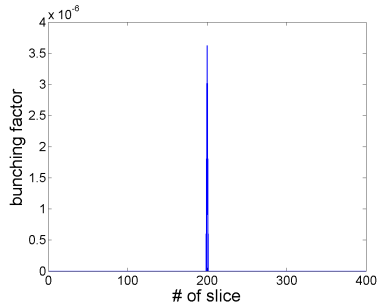Comparison with δf Method

FEL

- Use the beam parameters at the exit of modulator to create 400 slices in GENESIS
- Replace the 200th slice with the results from modulator simulation, run FEL simulation
- $\varepsilon_x^* = $ 3.11e-6, $\varepsilon_y^* = $ 3.15e-6, $\sigma_x = $ 3.3784e-4 m, $\sigma_y = $ 3.4239e-4 m
- $\lambda = $ 3e-5 m, Wiggler Period $= 4$ cm, $N_{wiggler} = 188$, Wiggler Length $= 7.5$ m

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

Bunching factor in FEL at beginning

(a) Background

(b) Signal

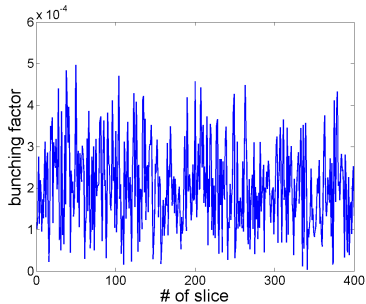Modulator and FEL Simulations
β in FEL
Comparison with δf Method

Bunching factor in FEL at 25 wiggler period

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
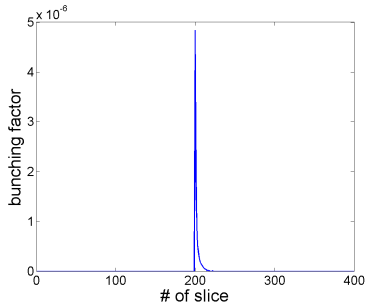
Bunching factor in FEL at 50 wiggler period

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
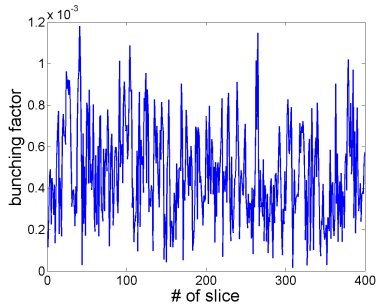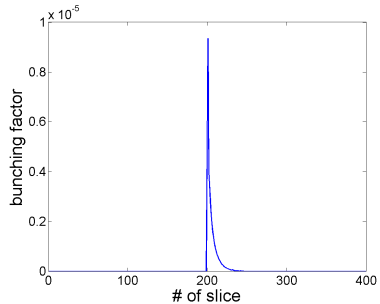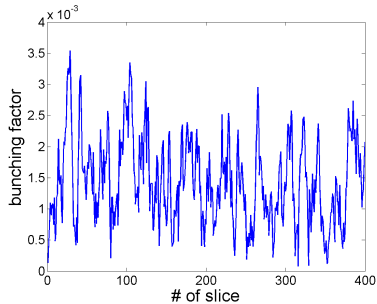
Bunching factor in FEL at 75 wiggler period

(a) Background

(b) Signal

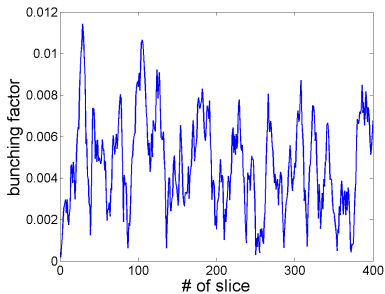Modulator and FEL Simulations
β in FEL
Comparison with δf Method
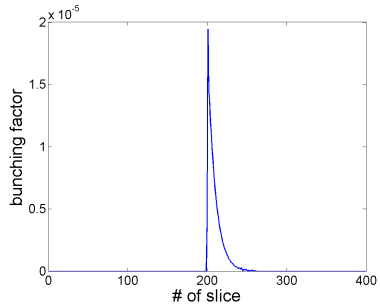
Bunching factor in FEL at 100 wiggler period

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
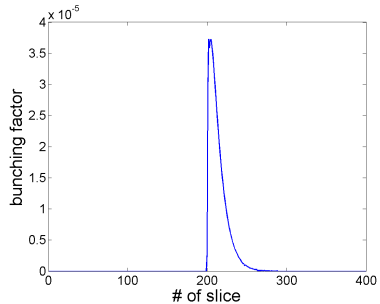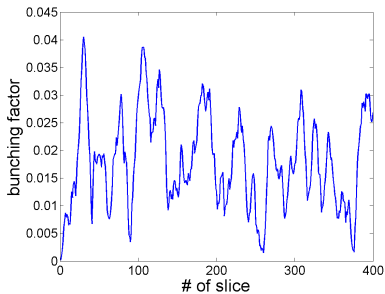
Bunching factor in FEL at 125 wiggler period

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
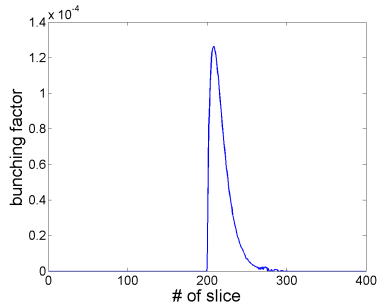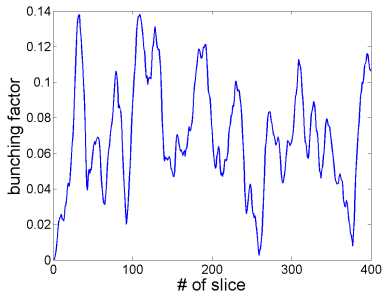
Bunching factor in FEL at 150 wiggler period

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
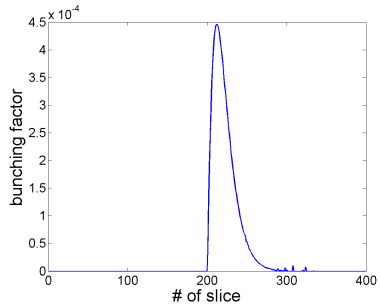
Bunching factor in FEL at 175 wiggler period

(a) Background

(b) Signal

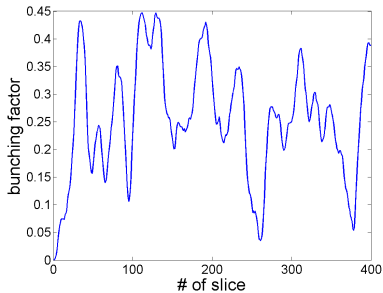Modulator and FEL Simulations
β in FEL
Comparison with δf Method
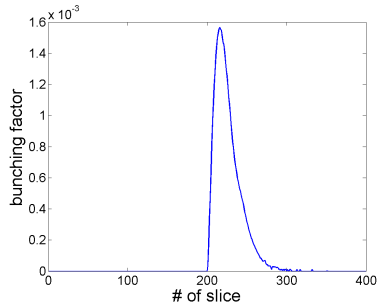
Bunching factor in FEL at end

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
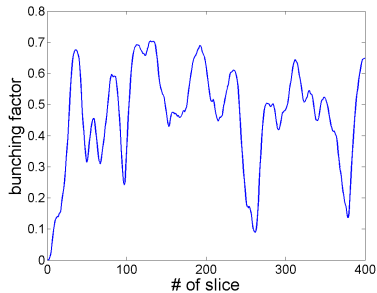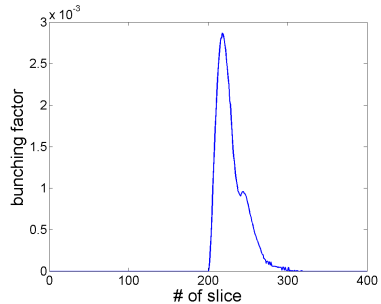
Bunching factor in FEL

(a) Background

(b) Signal

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
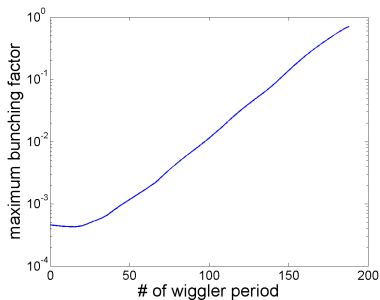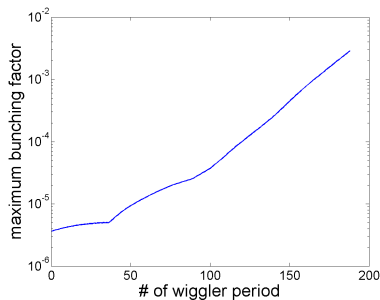
Transverse beam size in FEL

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
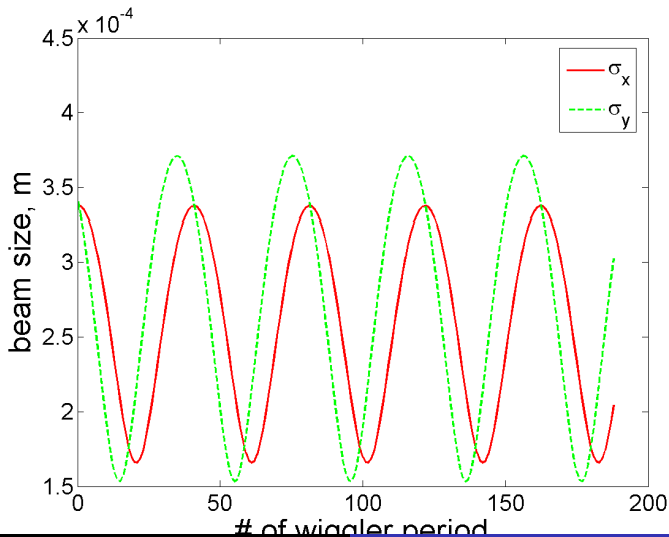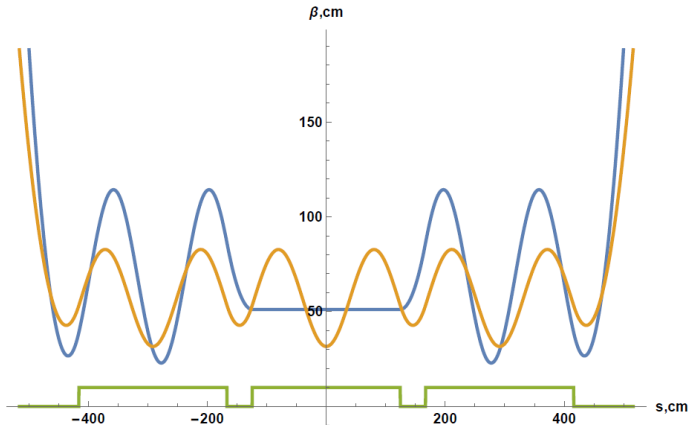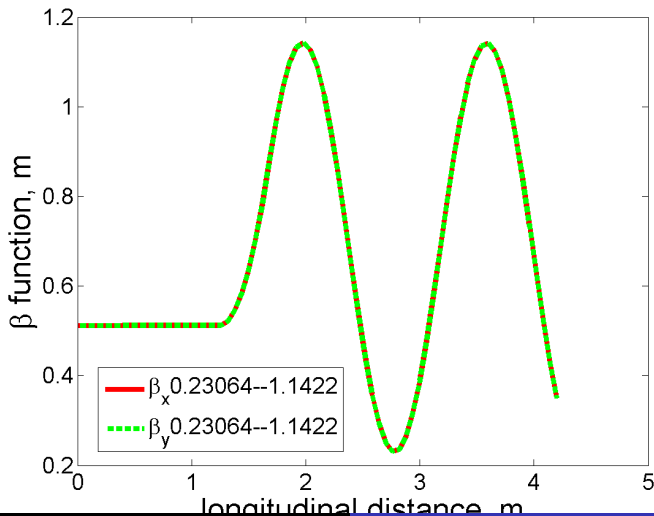
Vladimir's calculation

Fig. 1 Periodic solution for CeC FEL system (yellow) and "matched" beta in the middle wiggler. Periodic solution is much better
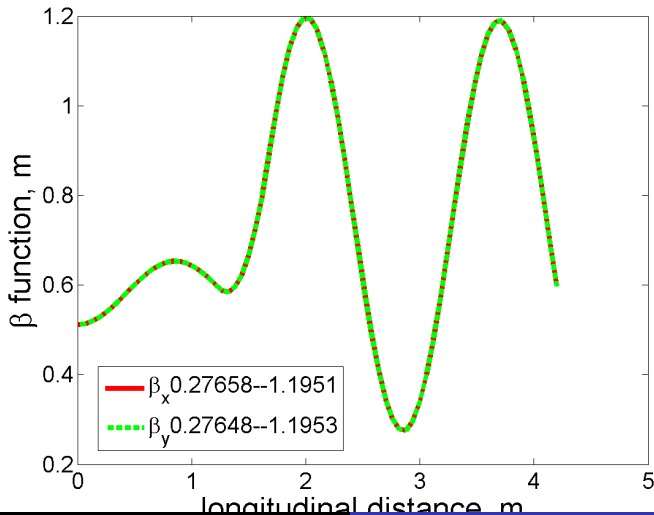
Modulator and FEL Simulations
β in FEL
Comparison with δf Method

FEL simulation

- Simulate the β function changes using SPACE code, including space charge effect

- Use continuous focusing electric field, which provides the equivalent effect as the magnetic fields used in Vladimir's calculation

- Under the assumption of bilateral symmetry, only simulate the right half of the FEL section
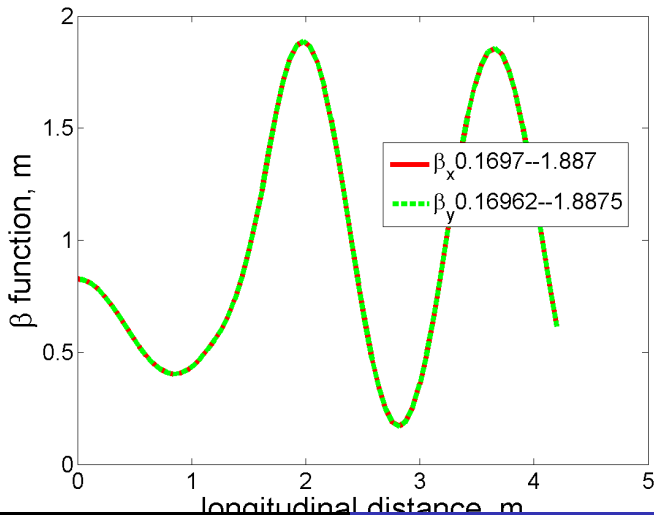
Modulator and FEL Simulations
β in FEL
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β in FEL, β=0.5117m at center, space charge turned off

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.5117m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.8m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.7m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.6m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.5m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.4m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.3m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

β in FEL, β=0.35m at center, with space charge

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
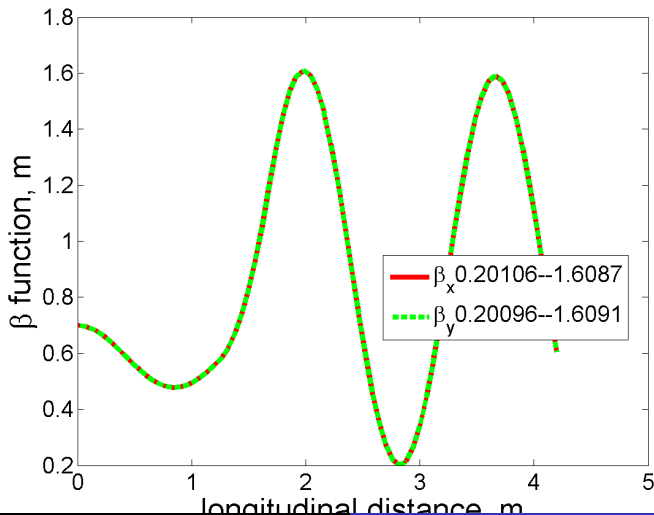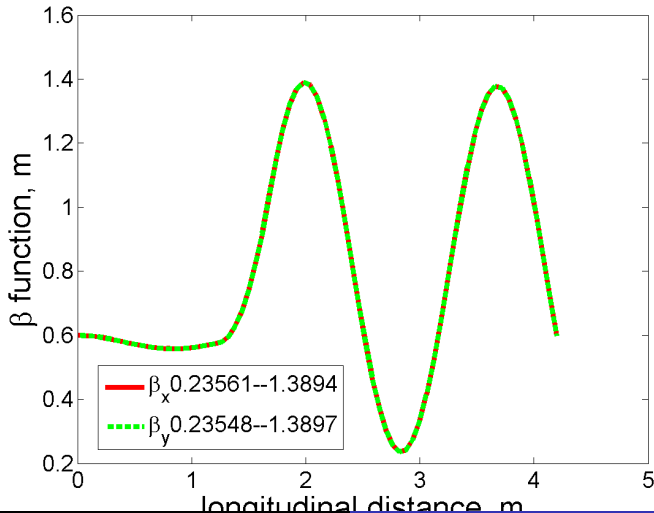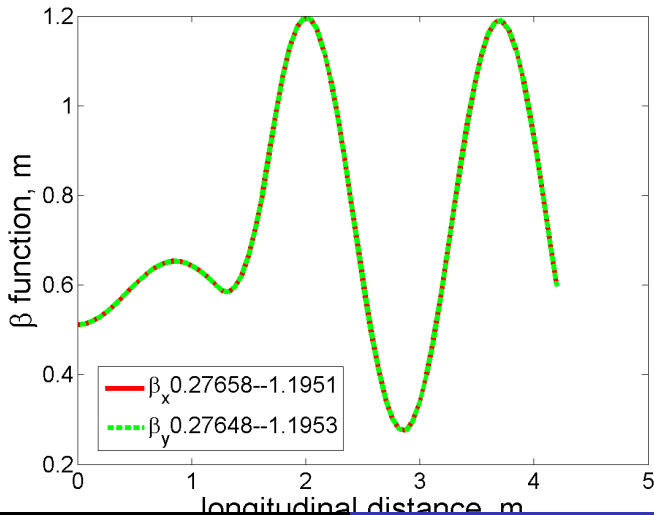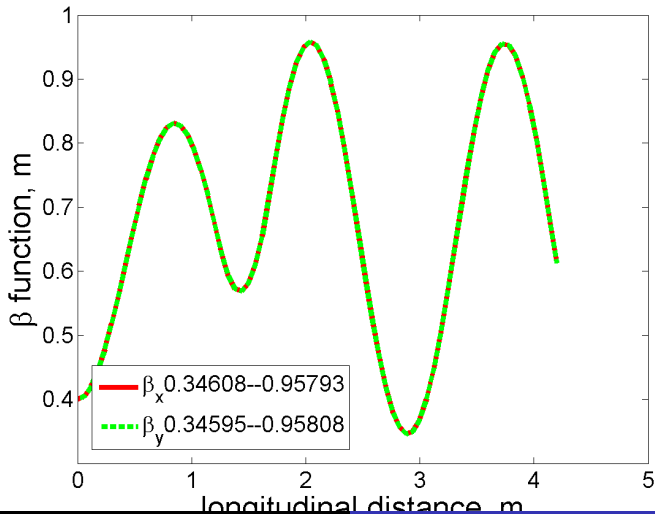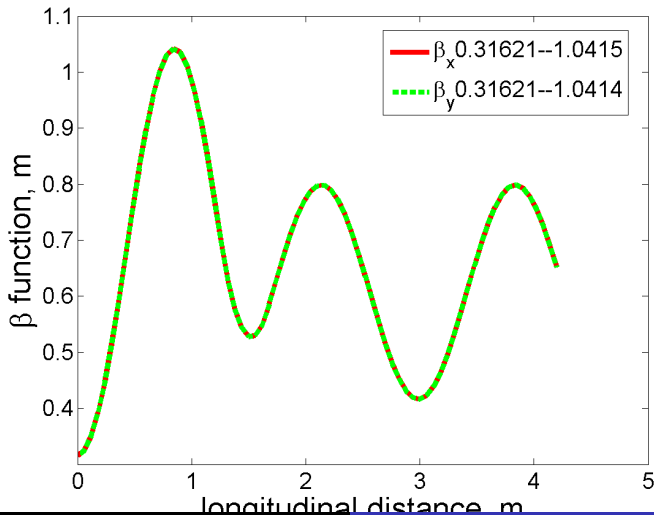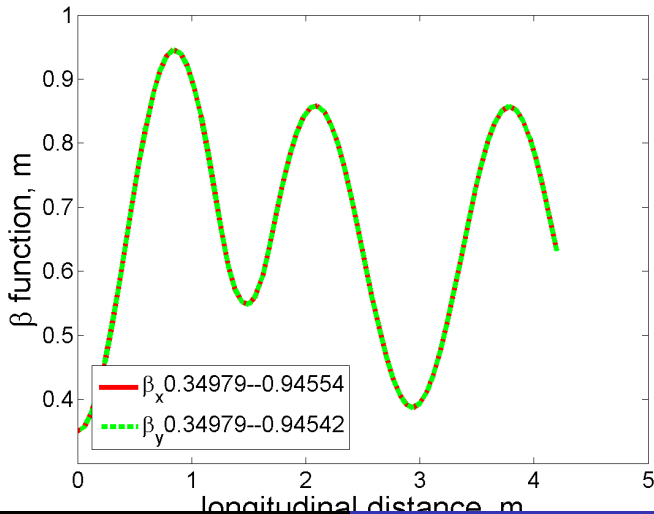
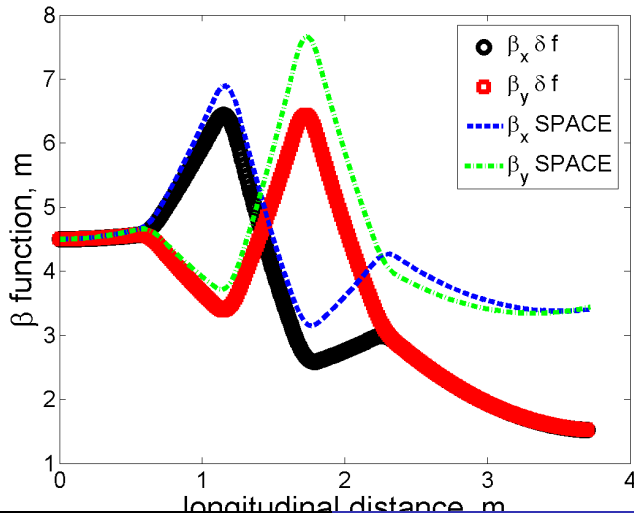# Settings in δf simulations

- $\varepsilon_x^* = \varepsilon_y^* =$ 5e-6

- $\beta_x = \beta_y =$ 4.5 m

- $\alpha_x = \alpha_y = 0$

- γ=42.66

- Energy Spread $=$ 1e-3

- Peak Current $=$ 100 A

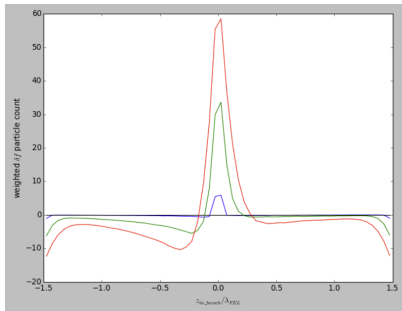Modulator and FEL Simulations
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Comparison of β, space charge turned off in SPACE

Modulator and FEL Simulations
β in FEL
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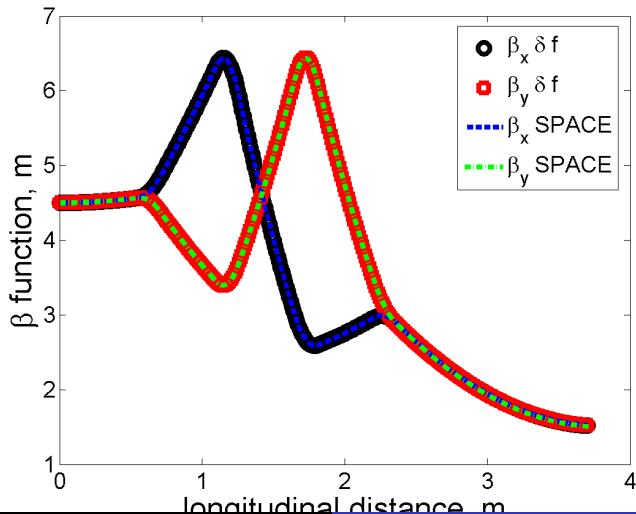
Comparison of β, space charge turned on in SPACE

Modulator and FEL Simulations
β in FEL
Comparison with δf Method

Comparison of longitudinal density modulation

(a) δf

(b) SPACE

Modulator and FEL Simulations
β in FEL
Comparison with δf Method
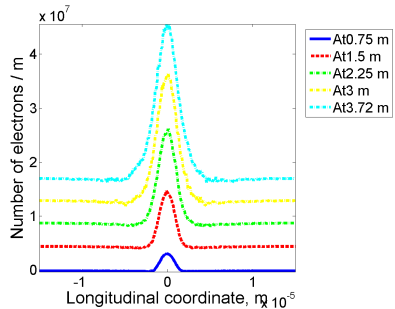
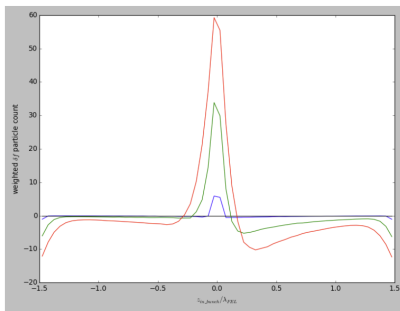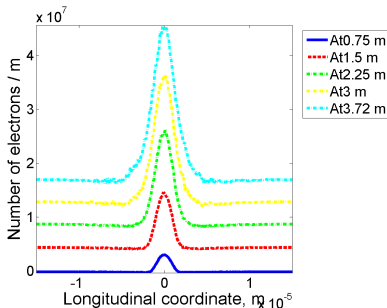# Comparison of longitudinal density modulation, flipping quadrupole field

(a) δf

(b) SPACE