Start-to-end CeC Simulations

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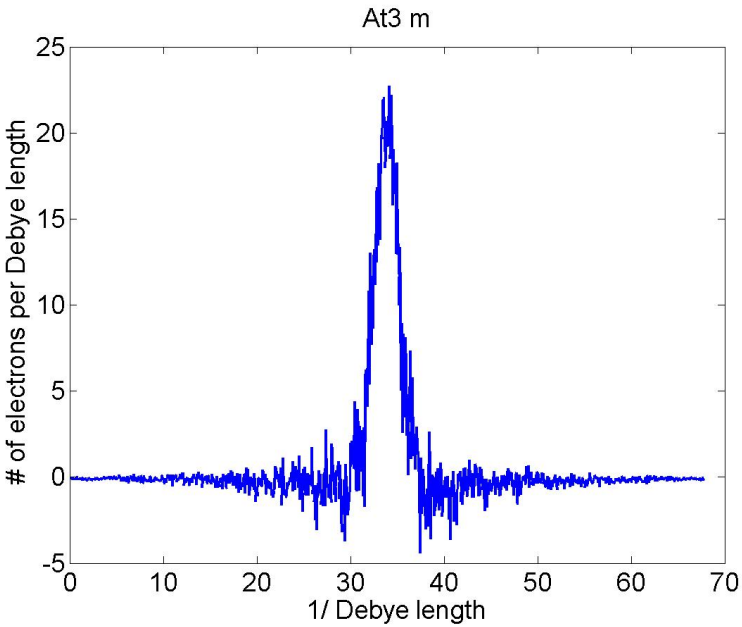
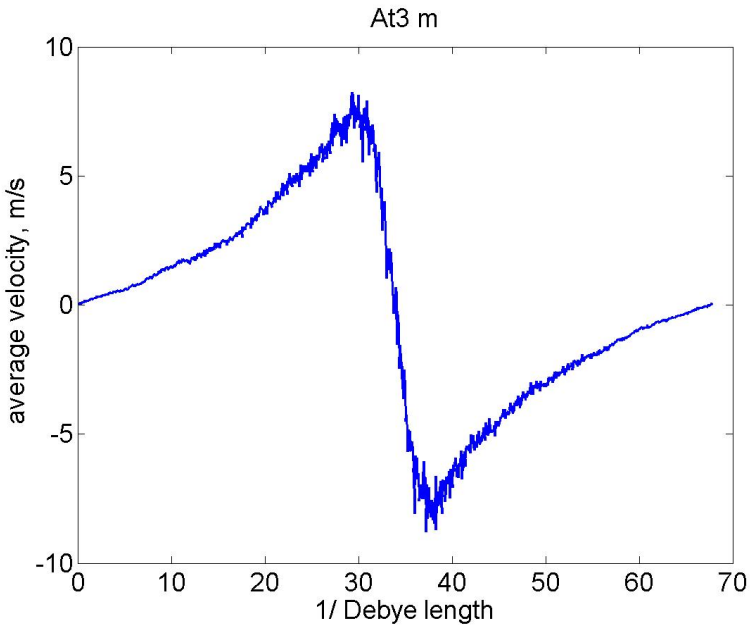
- Let GENESIS generate particles for 400 slices with correct shot noise
- Take 5 slices for modulator simulations (background beam and modulated beam) with quadrupoles
- Replace 5 slices into GENESIS for FEL simulation (background beam and modulated beam)
- Take 5 slices from output of GENESIS as the input of kicker simulation (background beam and modulated beam) with quadrupoles

- Number of real electrons per slice : 2.83e+7
- Number of macro electrons per slice : 1048576
- Number of wiggler period : 188
- Length of each wiggler : 4 cm

Longitudinal modulation

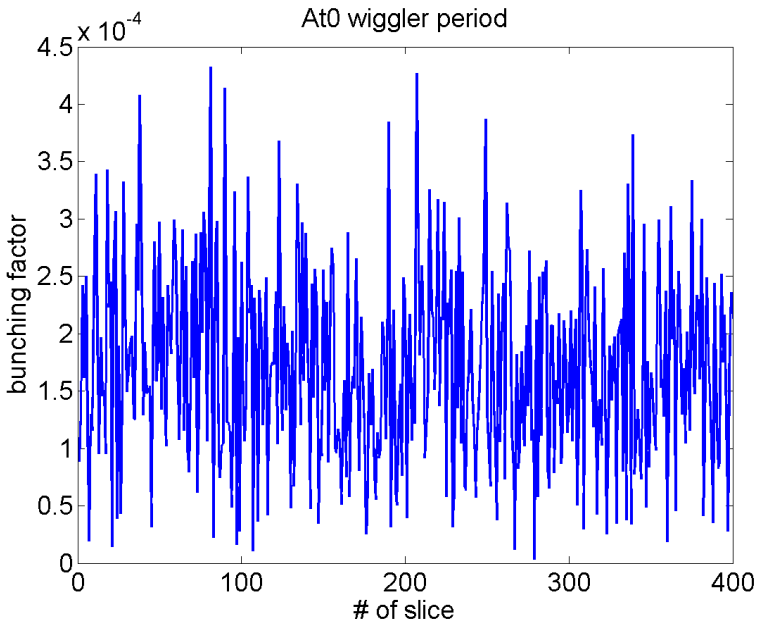


(a) Density

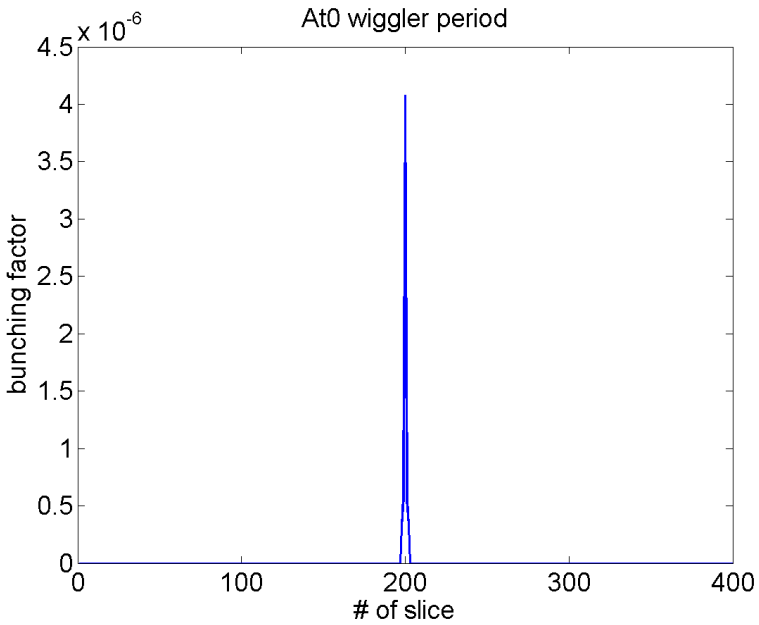


(b) Velocity

Instant bunching factor

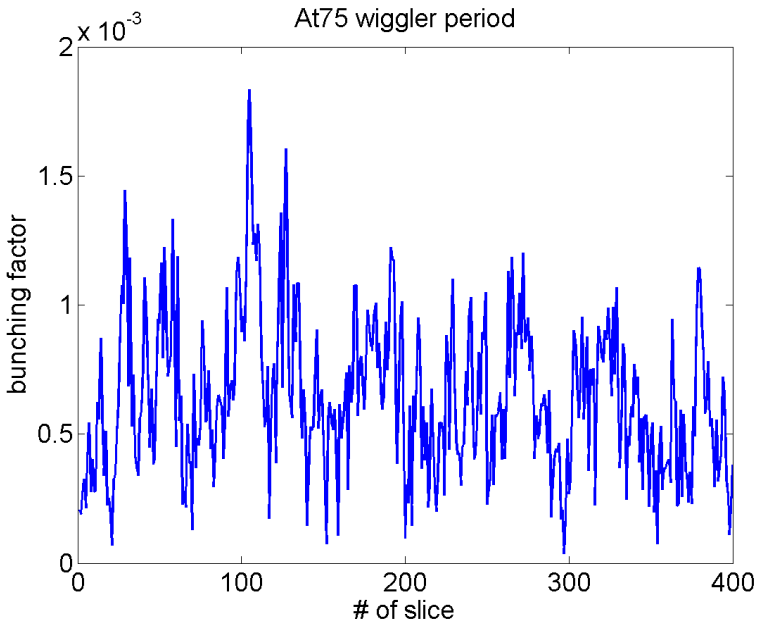


(a) Background

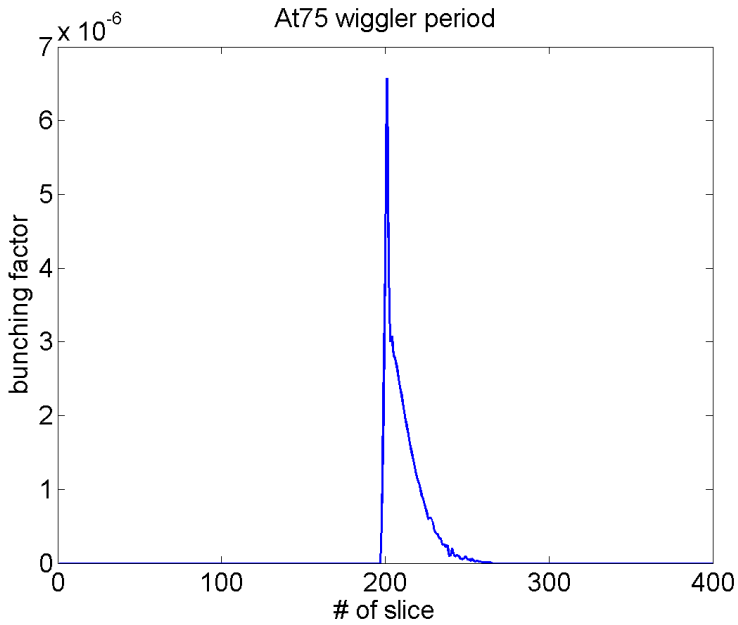


(b) Signal

Instant bunching factor

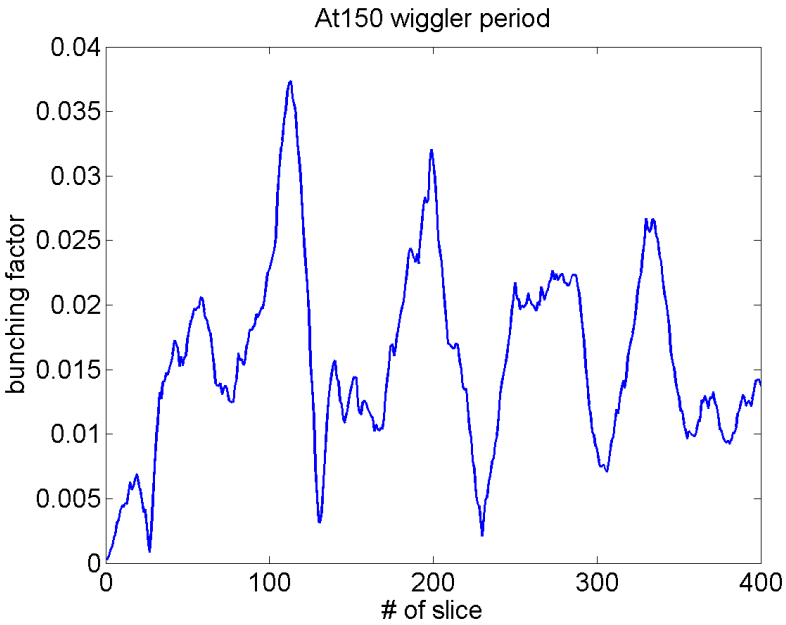


(a) Background

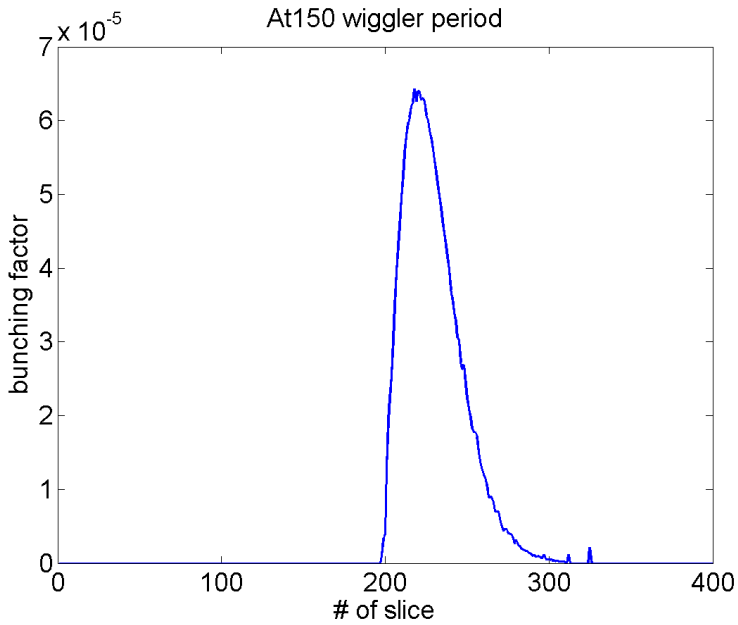


(b) Signal

Instant bunching factor

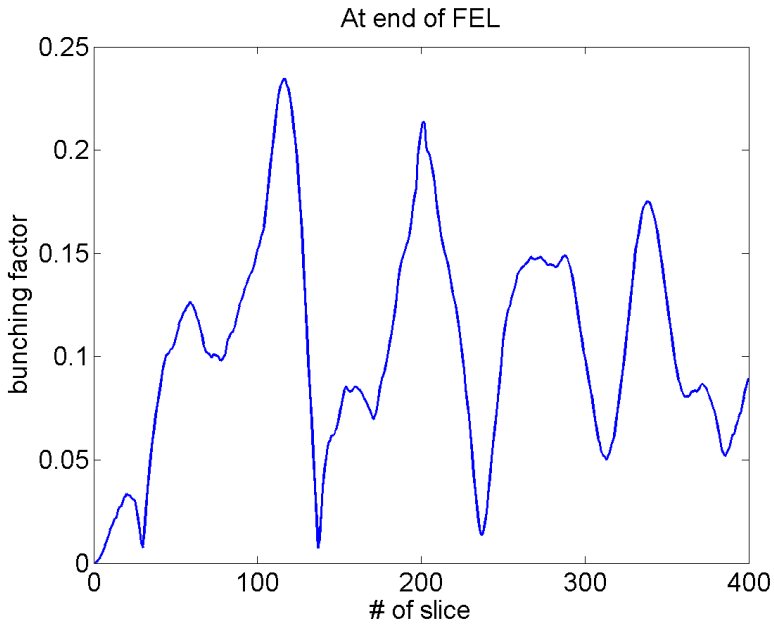


(a) Background

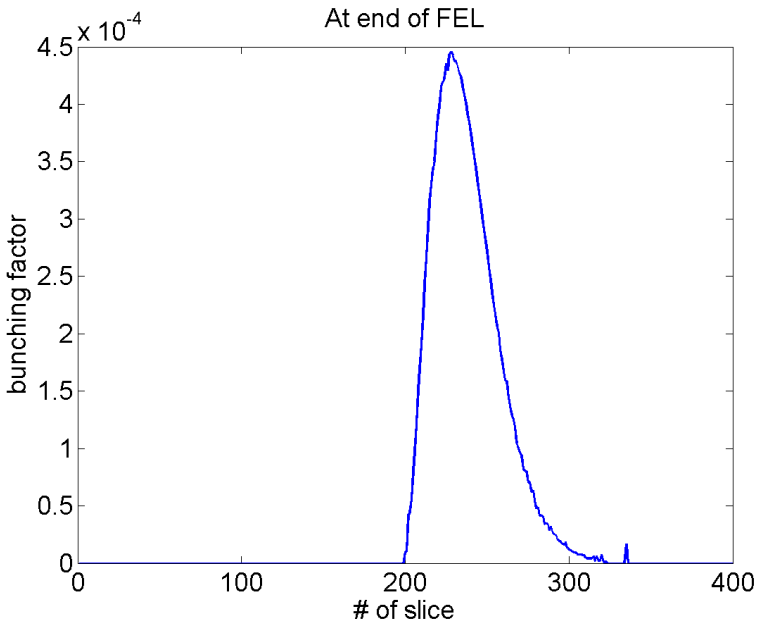


(b) Signal

Instant bunching factor

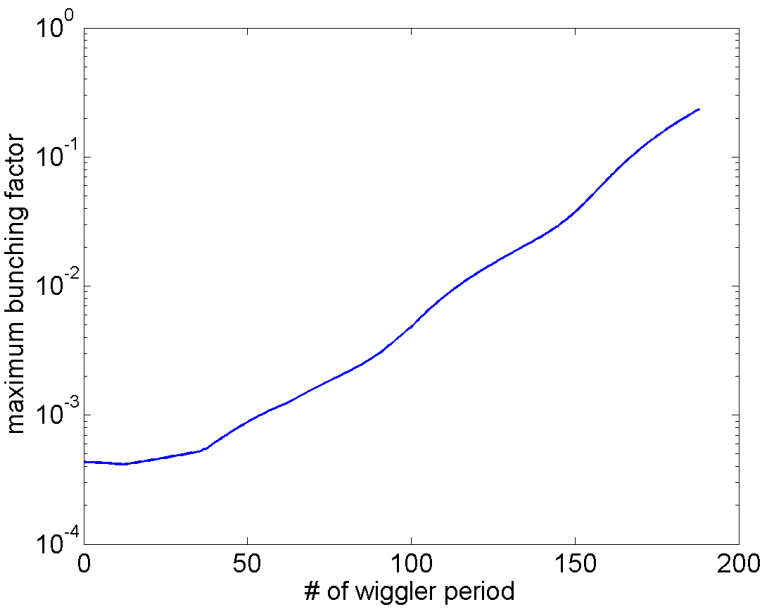


(a) Background

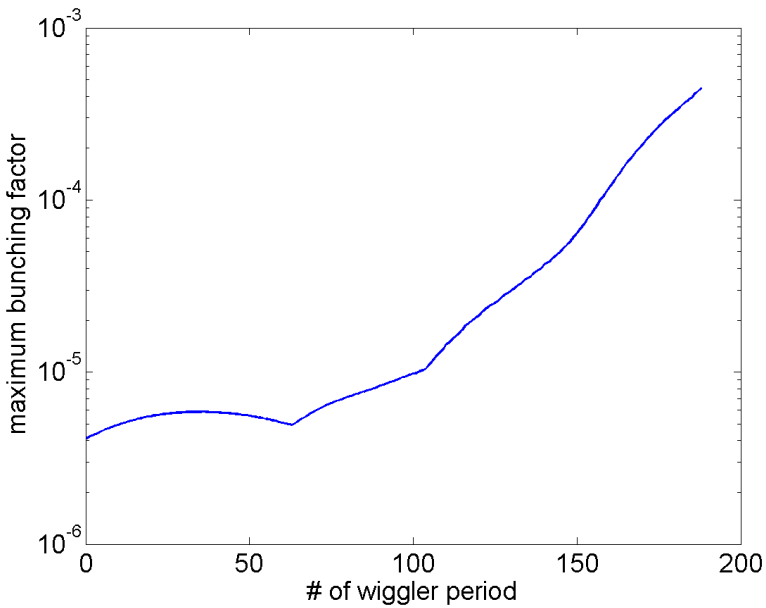


(b) Signal

Bunching factor along time

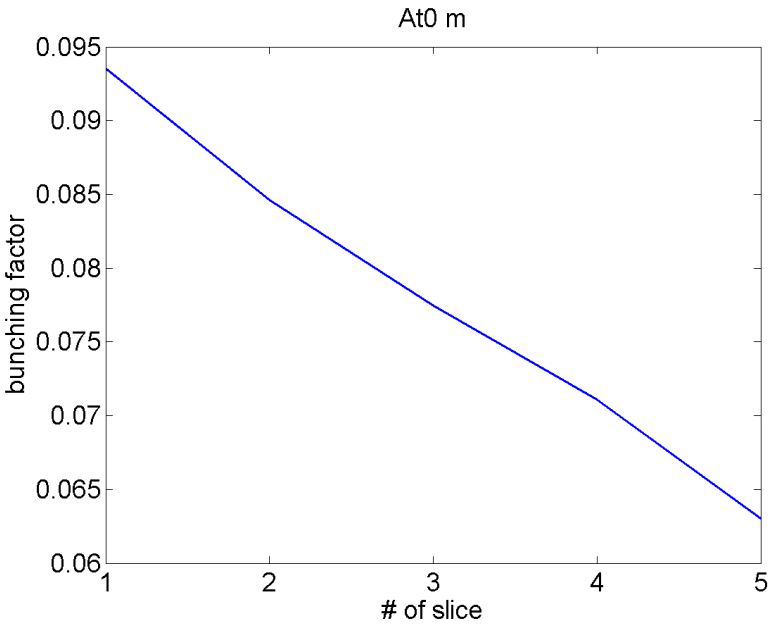


(a) Background

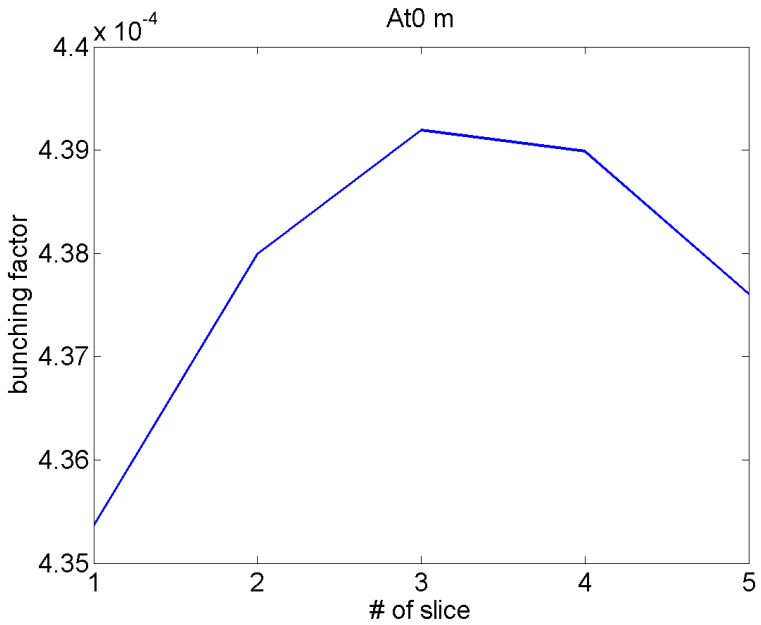


(b) Signal

Instant bunching factor

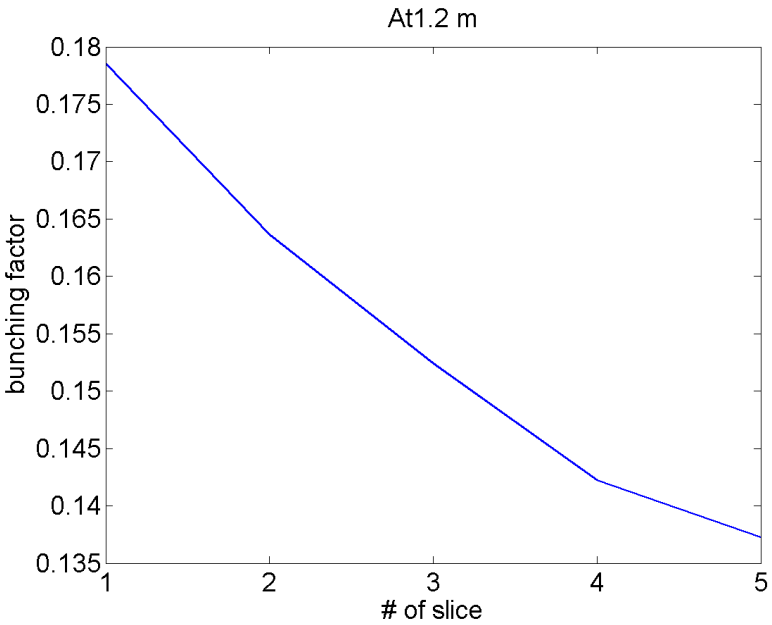


(a) Background

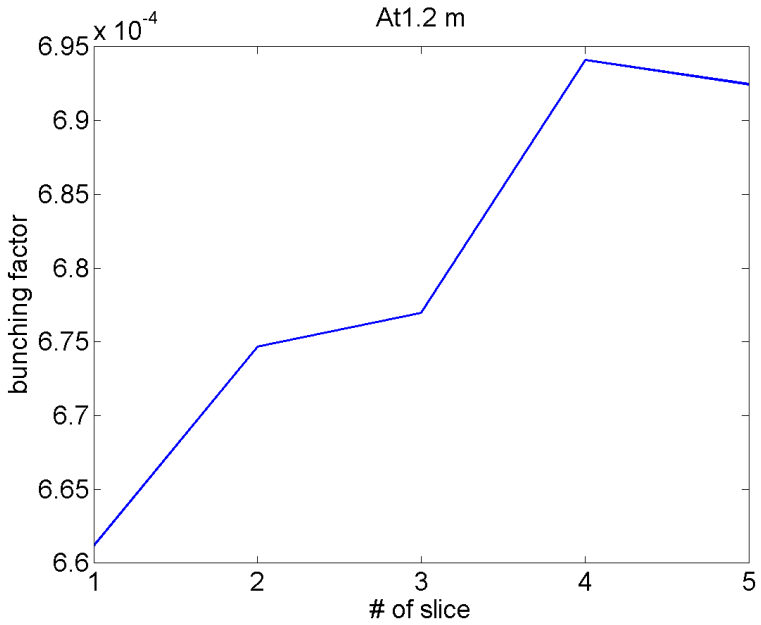


(b) Signal

Instant bunching factor

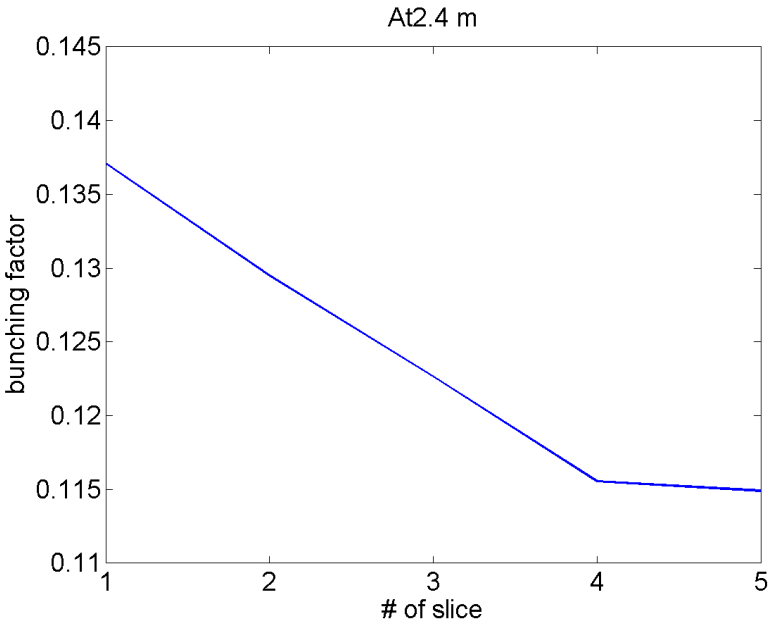


(a) Background

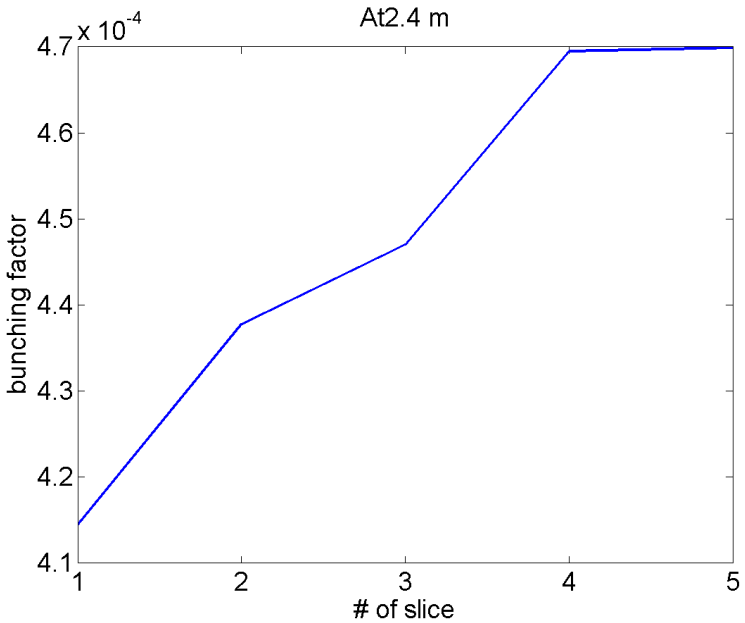


(b) Signal

Instant bunching factor

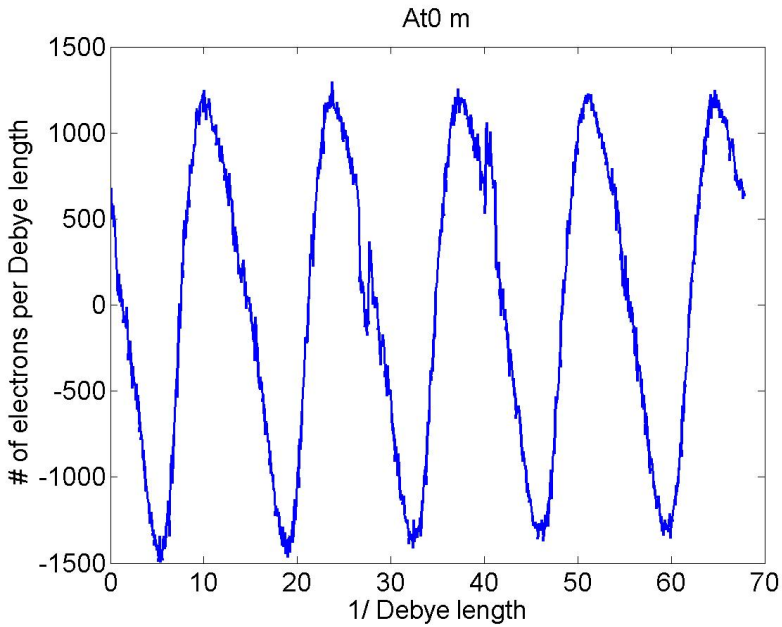


(a) Background

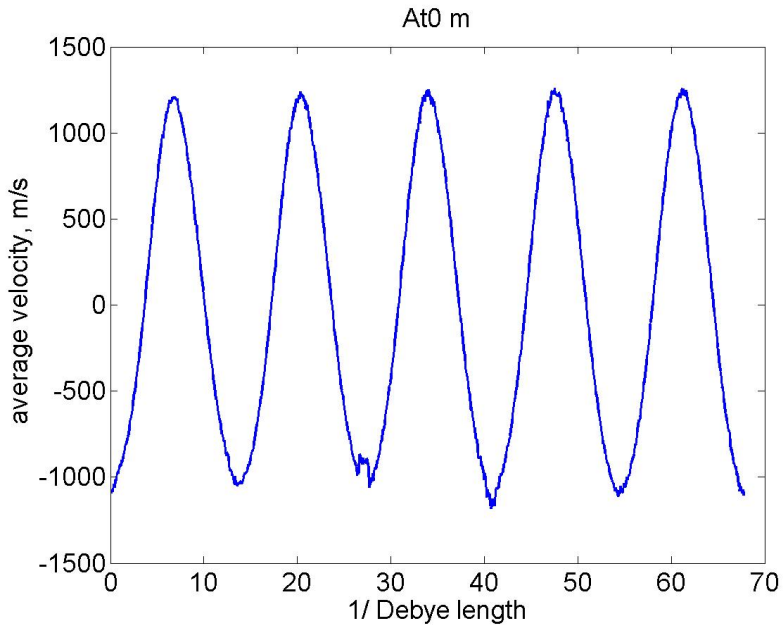


(b) Signal

Longitudinal distribution

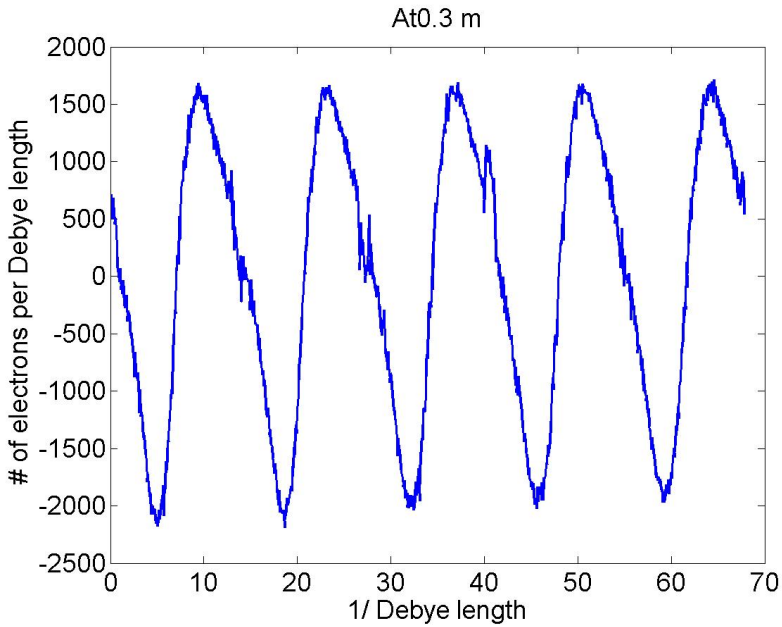


(a) Density



(b) Velocity

Longitudinal distribution



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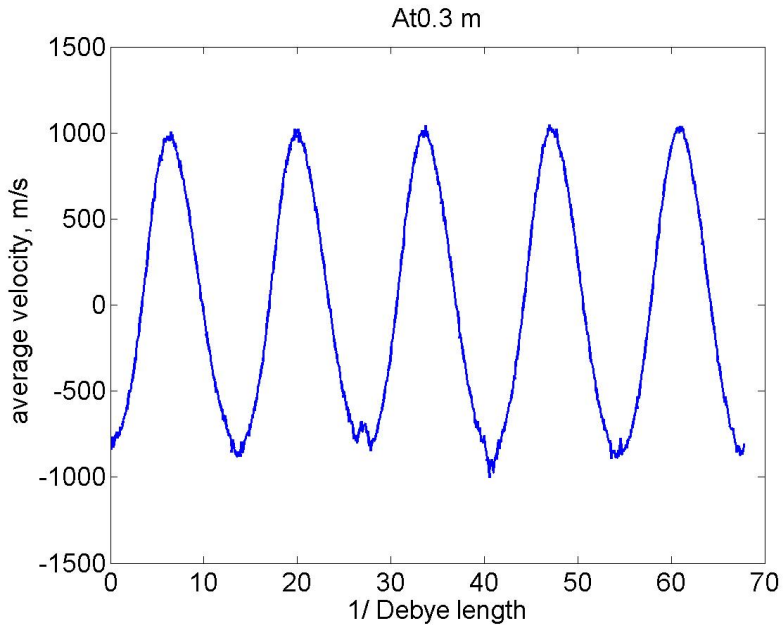
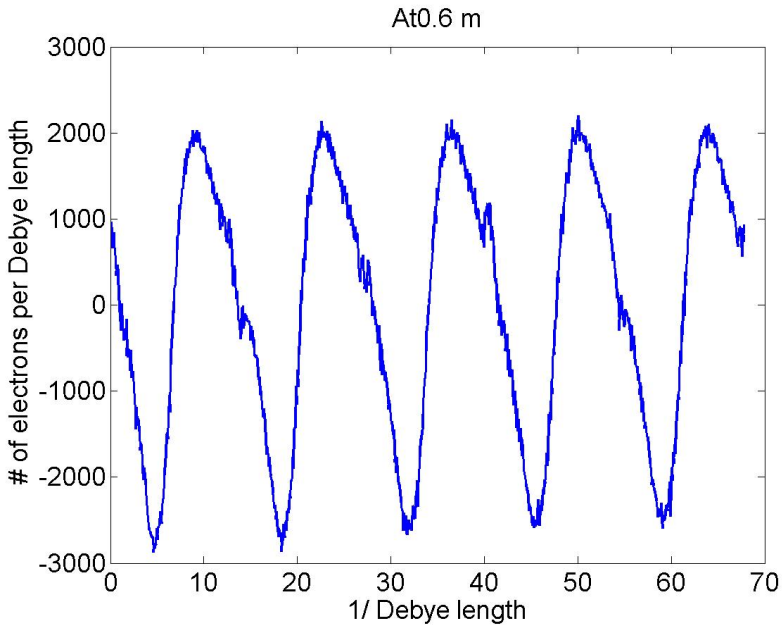
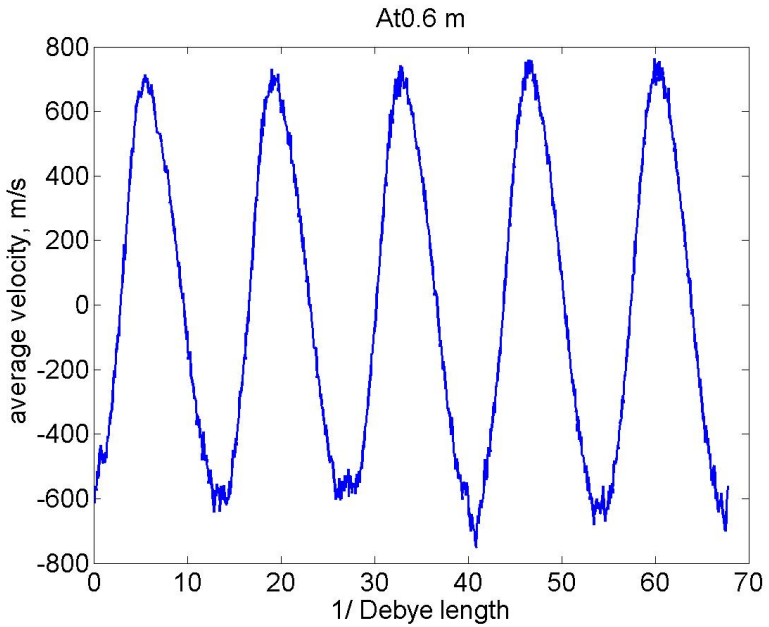


(b) Velocity

Longitudinal distribution

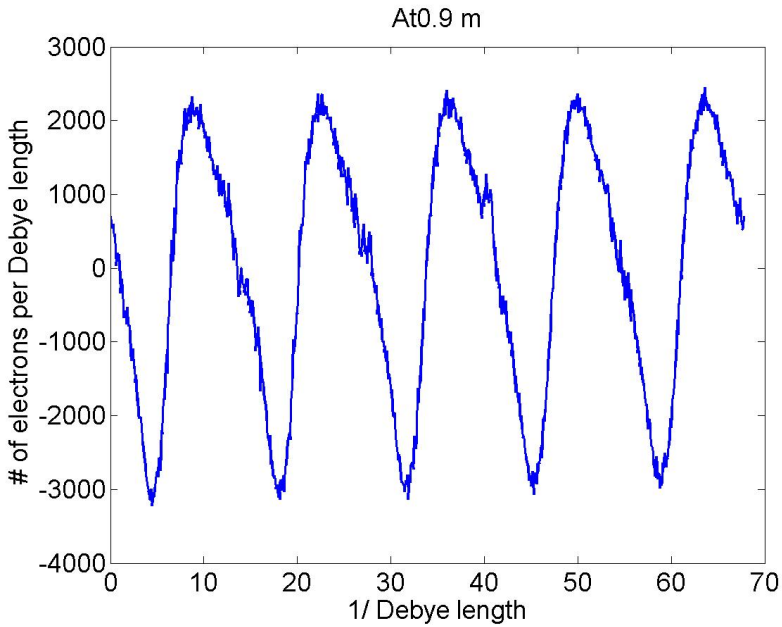


(a) Density



(b) Velocity

Longitudinal distribution



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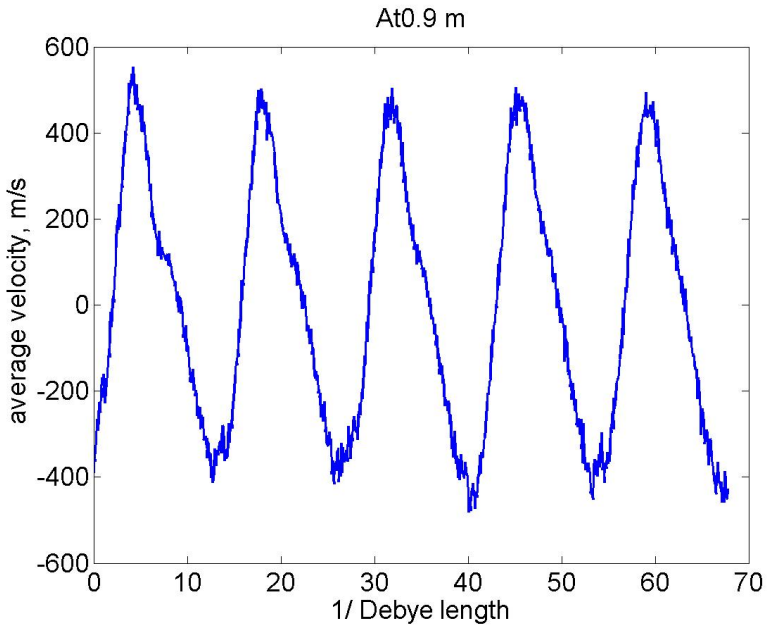
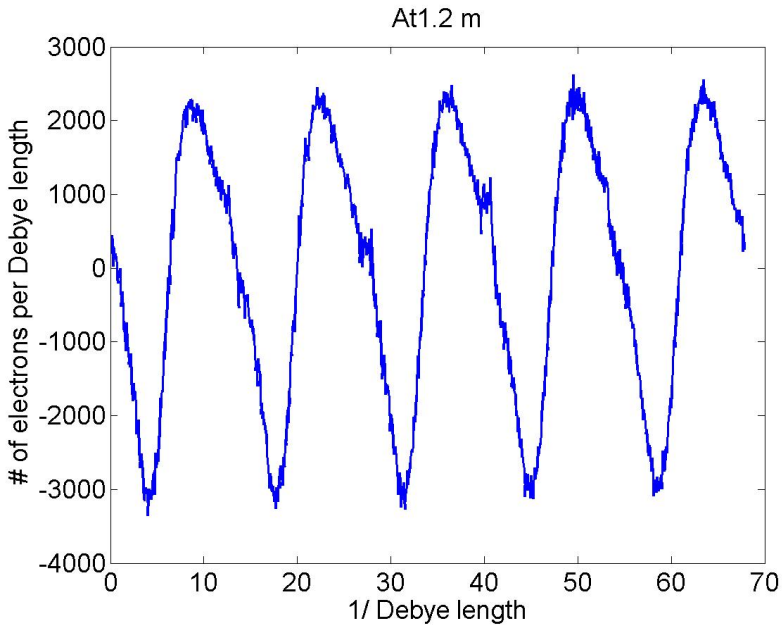


(b) Velocity

Longitudinal distribution



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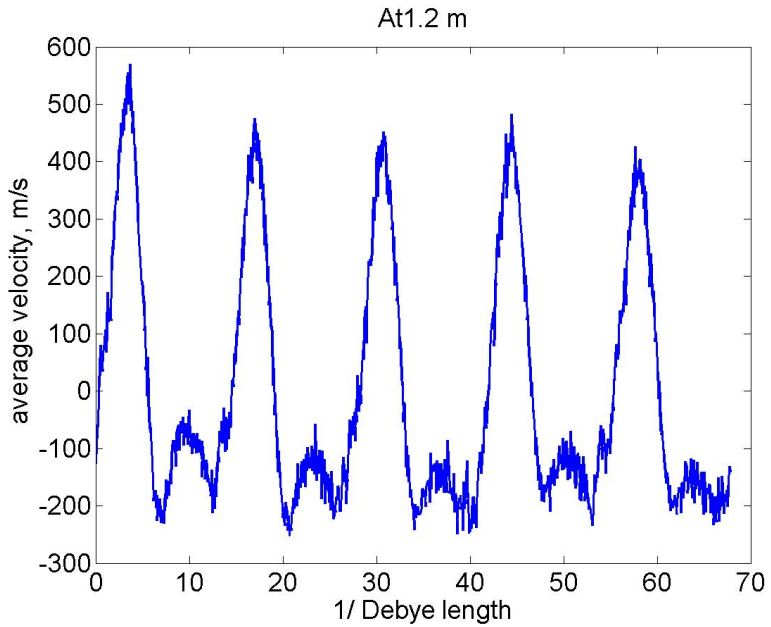
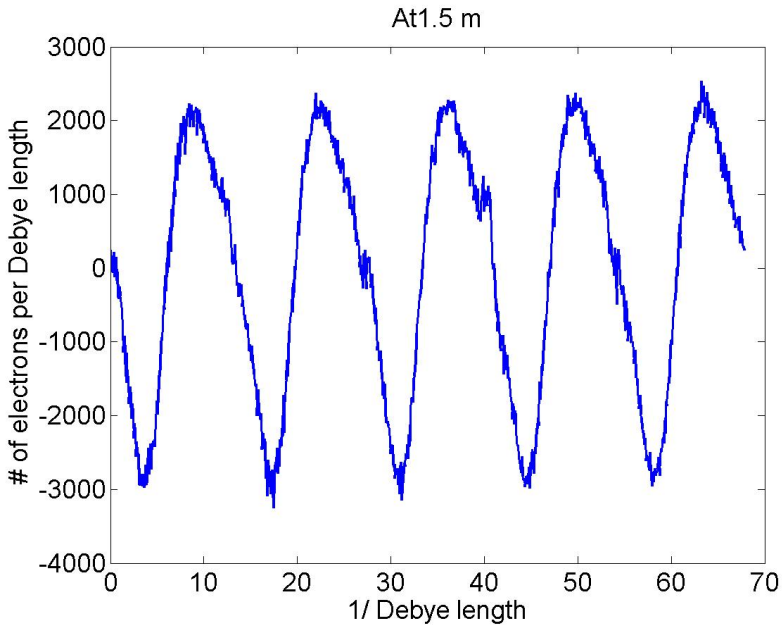
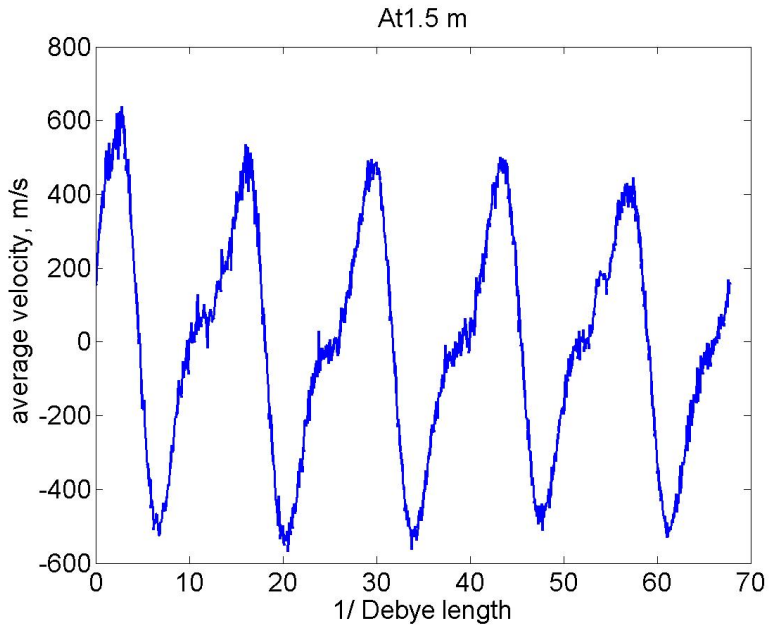


(b) Velocity

Longitudinal distribution

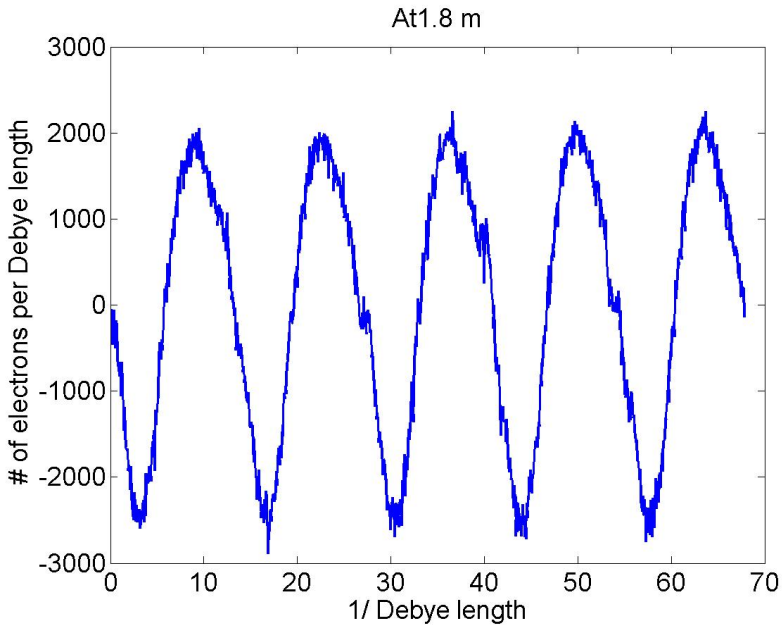


(a) Density

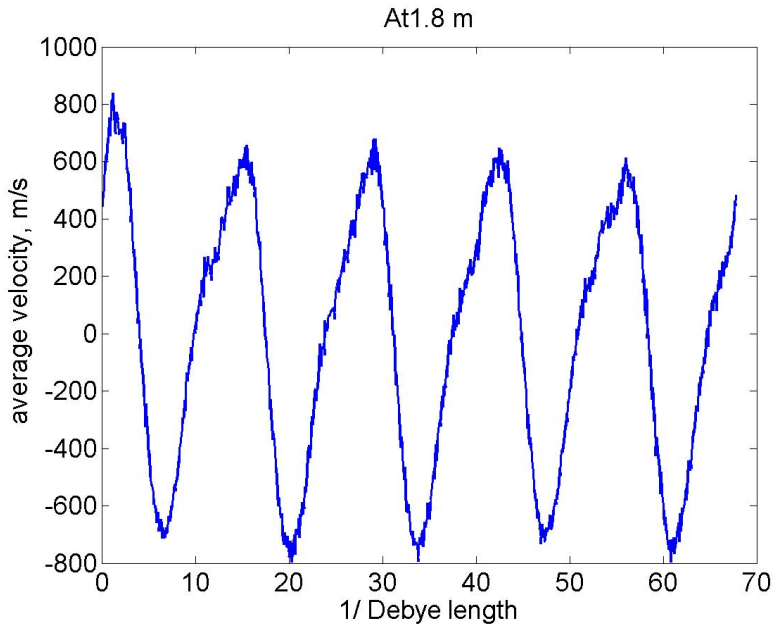


(b) Velocity

Longitudinal distribution

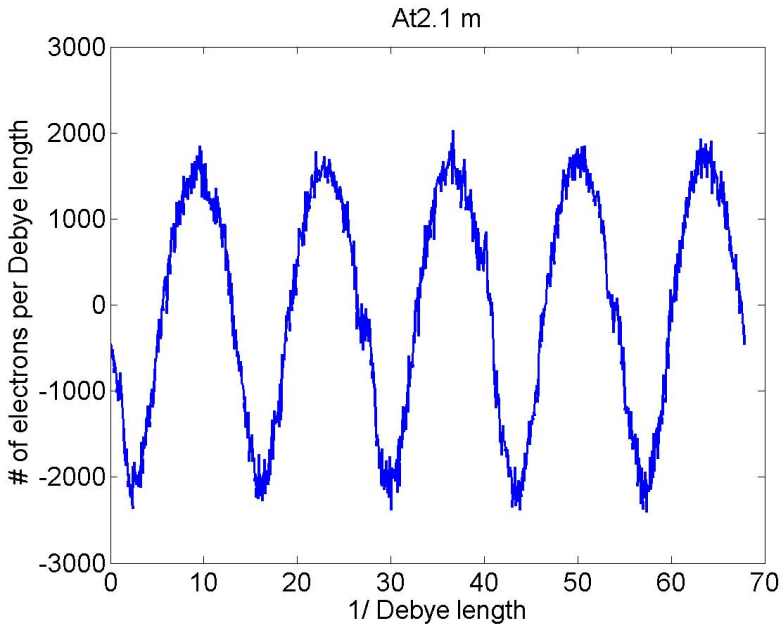


(a) Density

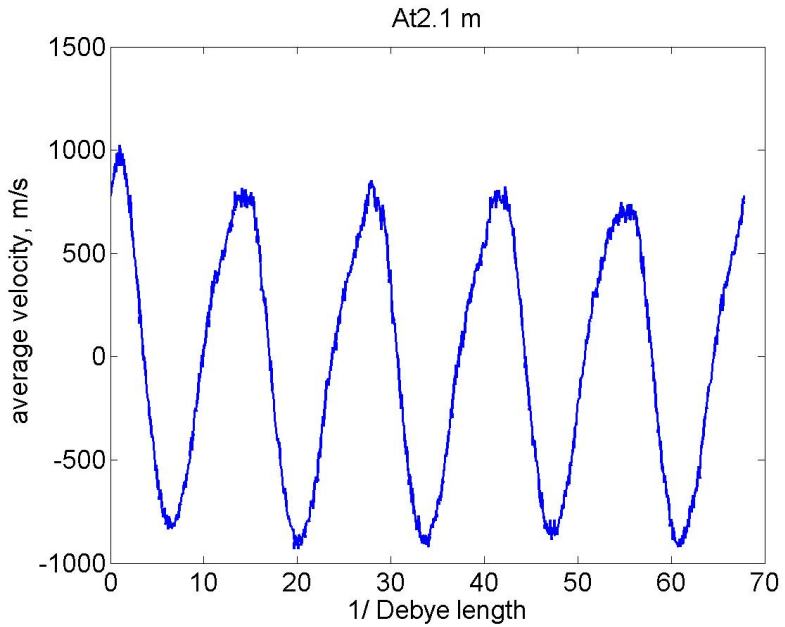


(b) Velocity

Longitudinal distribution

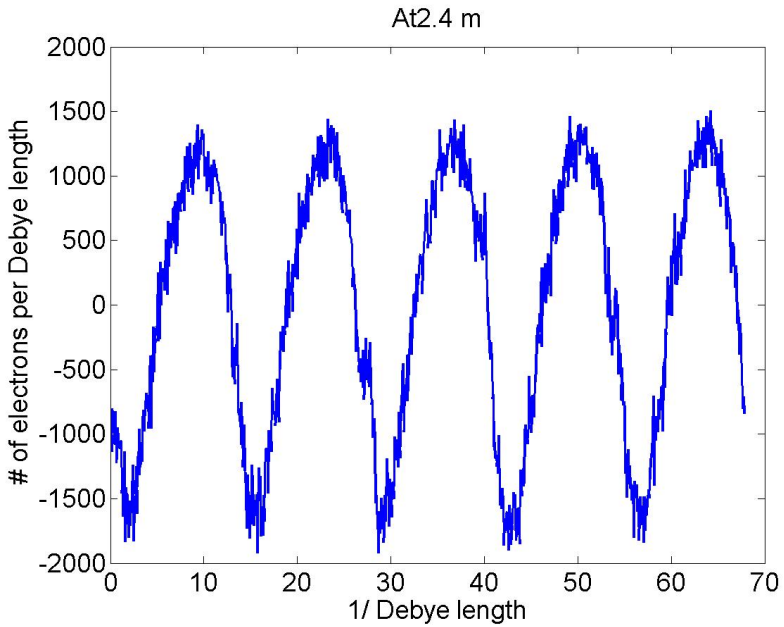


(a) Density

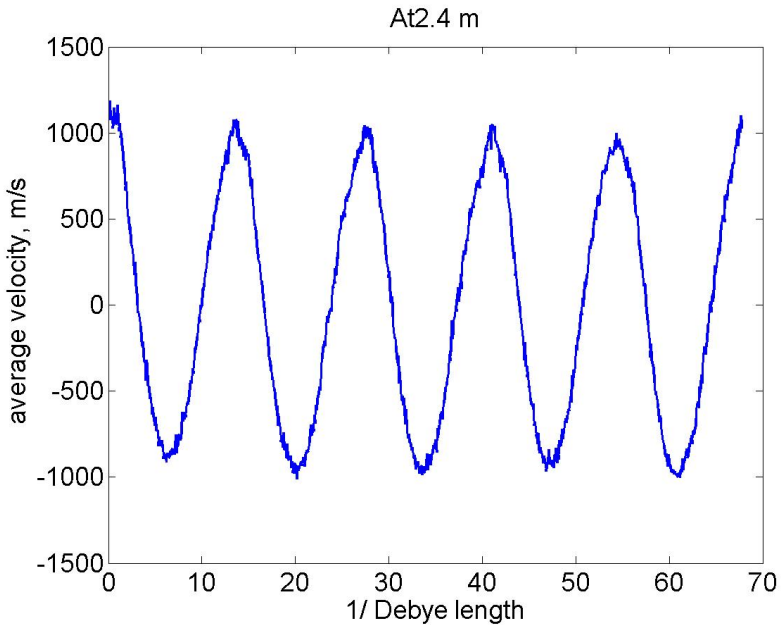


(b) Velocity

Longitudinal distribution



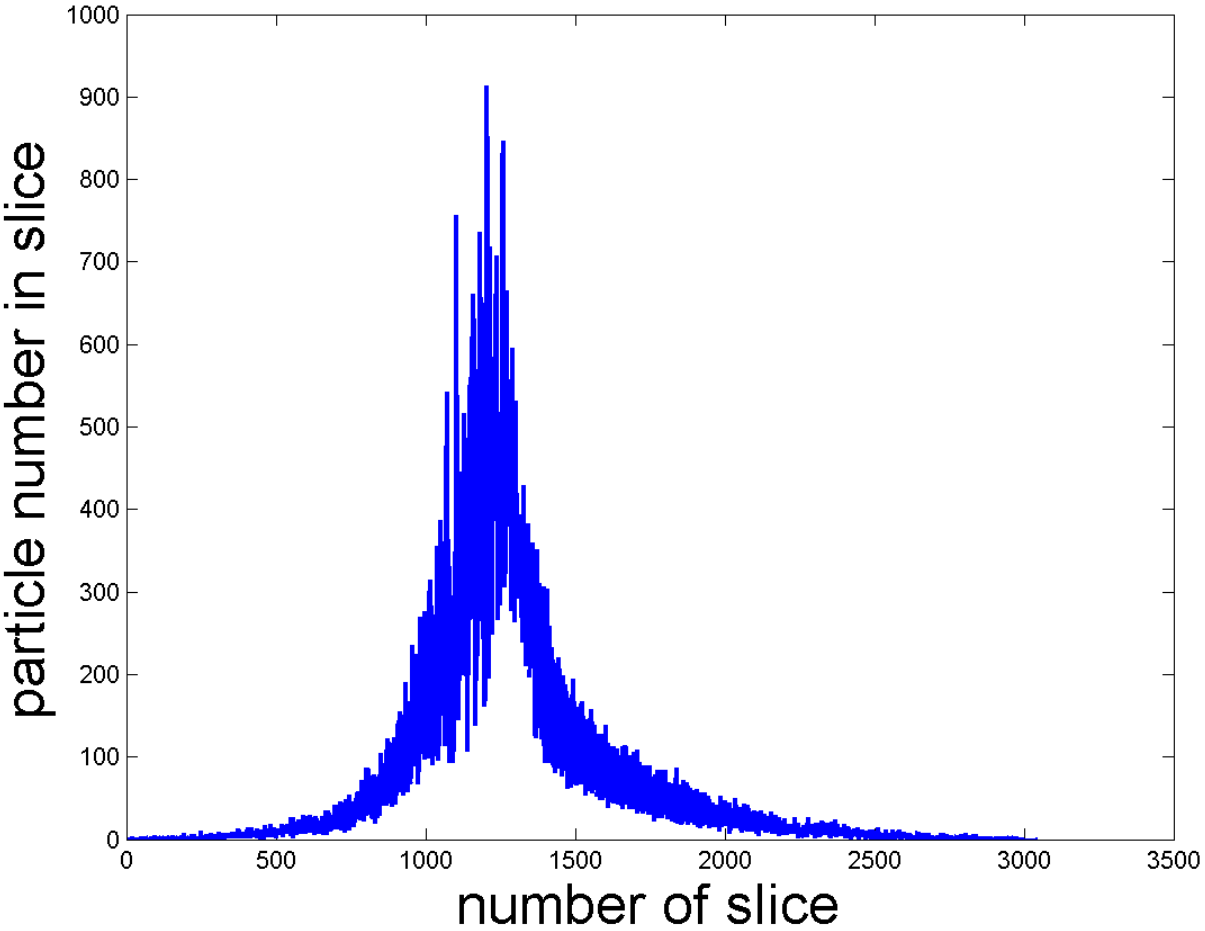
(a) Density



(b) Velocity

Start with distribution from beam dynamics simulation

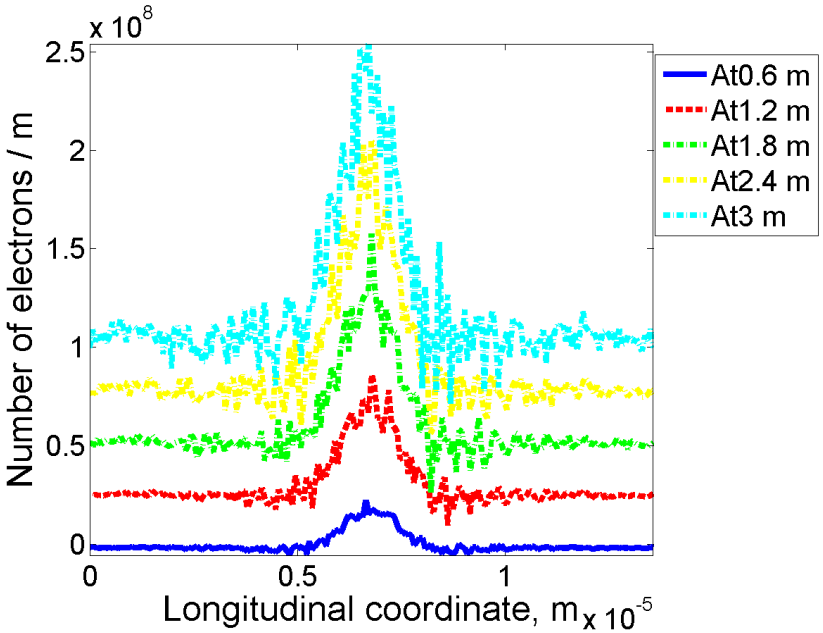
- Total charge is 2 nC, with only 2e+5 macro particles, so each macro particle represents 62500 real electrons
- These 2e+5 particles are distributed in 3000 slices, with each slice containing very few particles (maximum value is 914 for the center slice)
- Up sampling is required


particle number in slice
number of slice
0
100
200
300
400
500
600
700
800
900
1000
0
500
1000
1500
2000
2500
3000
3500

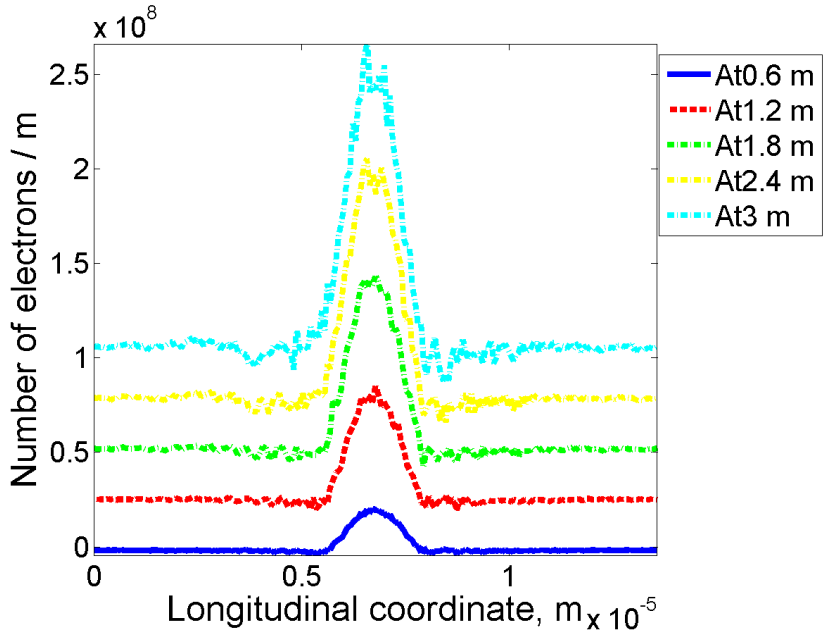
- Up sampling method in GENESIS is not good if we want to increase number of particles by orders
- We calculate beam parameters within each slice and reproduce desired number of particles
- As each slice has different number of particles, GENESIS can not generate initial distribution
- A routine is implemented in our code to generate initial particles from beam parameters
- A special method is used to maintain the real shot noise when we use macro particles

- We use the center slice containing 914 macro particles, with representing number 62500
- We increase number of particles by 1e+2 / 1e+3, with representing number decreased to 625 / 62.5

Longitudinal density modulation



(a) up sampling by 1e+2



(b) up sampling by 1e+3

- Up sampling by 1e+2 gives good results
- For FEL and kicker simulation, we will use 200 slices instead of 1 slice, and up sampling by 1e+3 will be very time consuming
- All following FEL and kicker simulation use up sampling by 1e+2

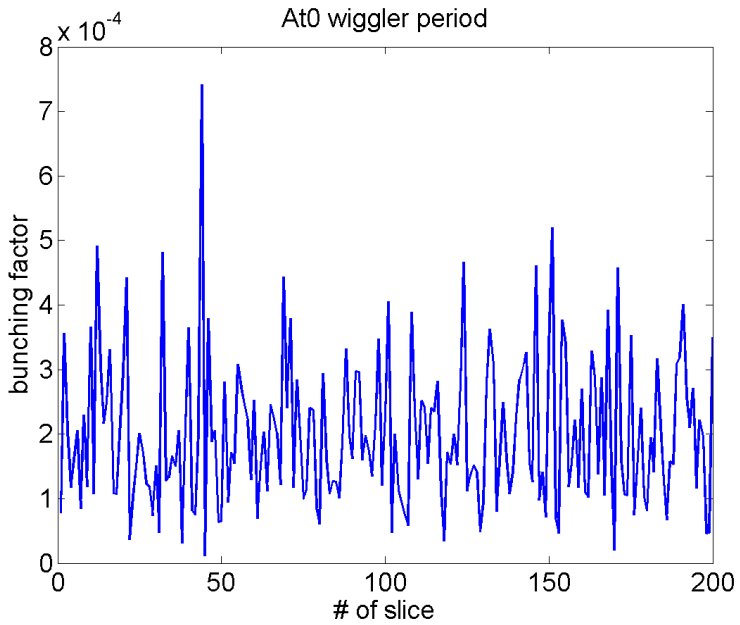
- In previous work, only the center slice passes through modulator, and the other slices don't
- Now, we also let the 200 slices pass through modulator, and use them for FEL simulation

- The 200 slices at entrance of modulator are generated with correct shot noise
- The 200 slices at end of modulator contains too large shot noise
- A possible reason is that, during modulator, particles may go between slices, and affect the bunching factor of those slices

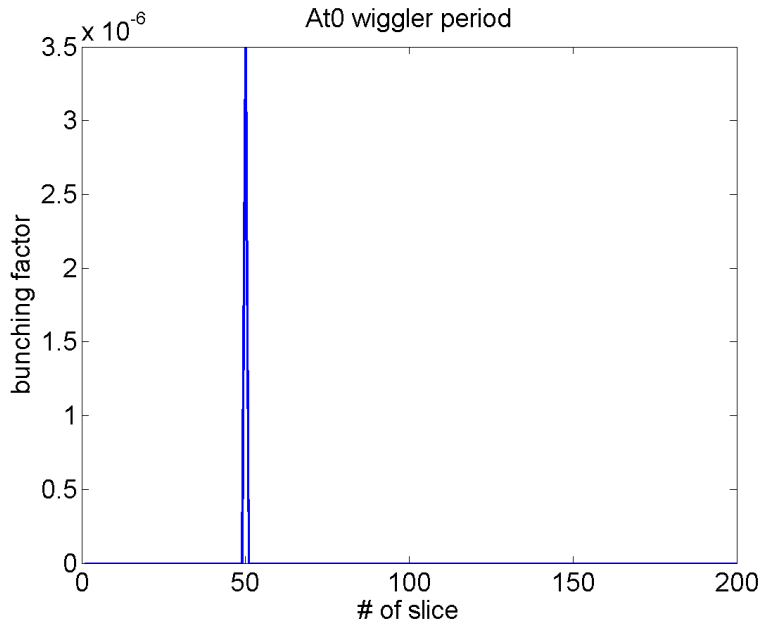
For comparisons, we use three copies of these 200 slices

- 200 slices at the entrance of modulator, with correct shot noise
- 200 slices at the end of modulator, with large shot noise
- Based on the 200 slices at the end of modulator, re-generate them with correct shot noise

200 slices at entrance of modulator

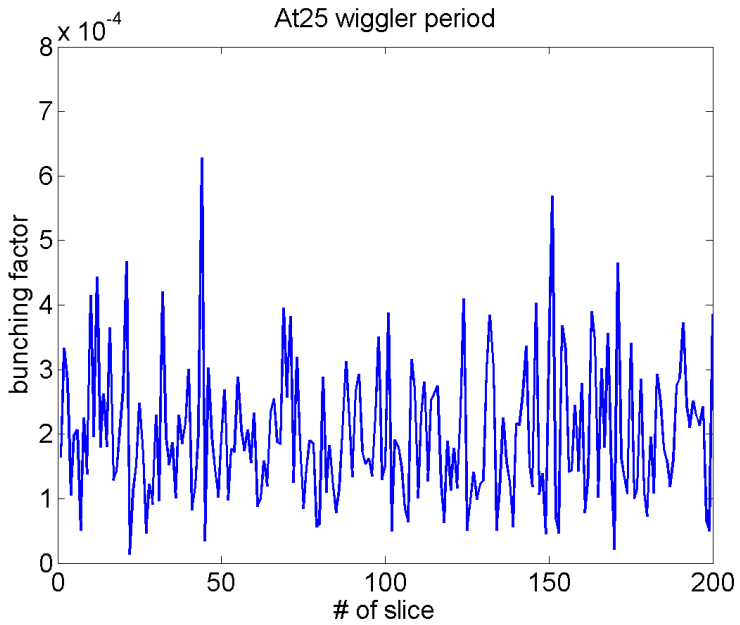


(a) Background

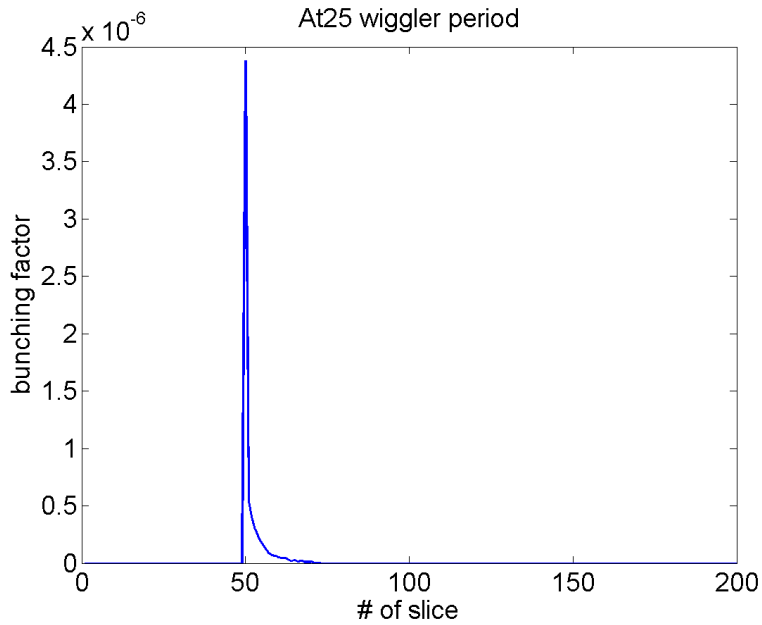


(b) Signal

200 slices at entrance of modulator

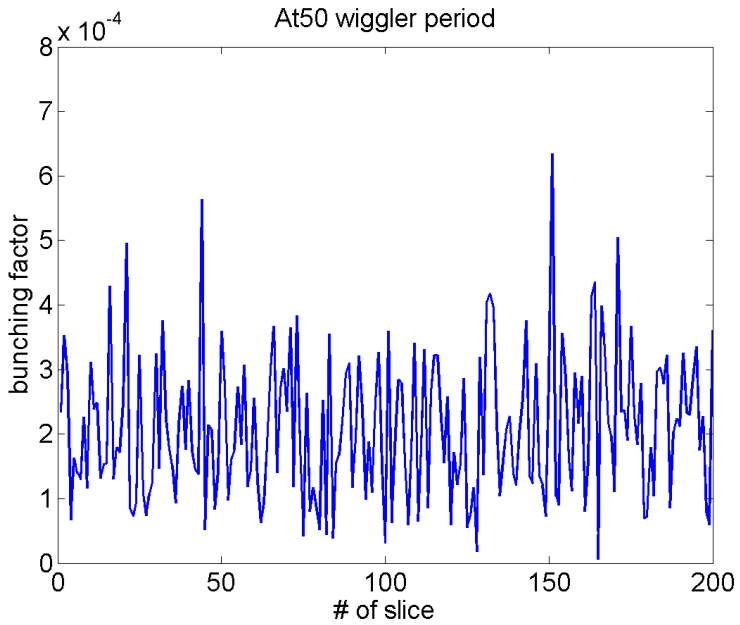


(a) Background

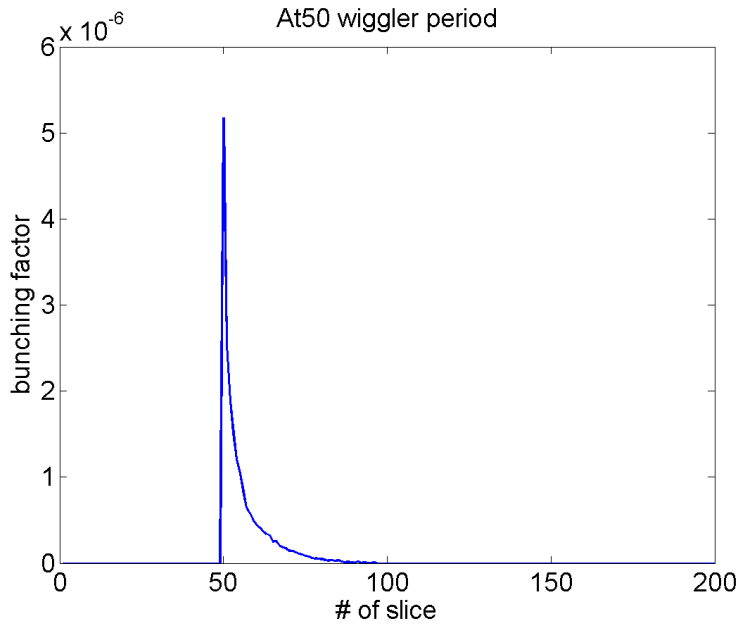


(b) Signal

200 slices at entrance of modulator

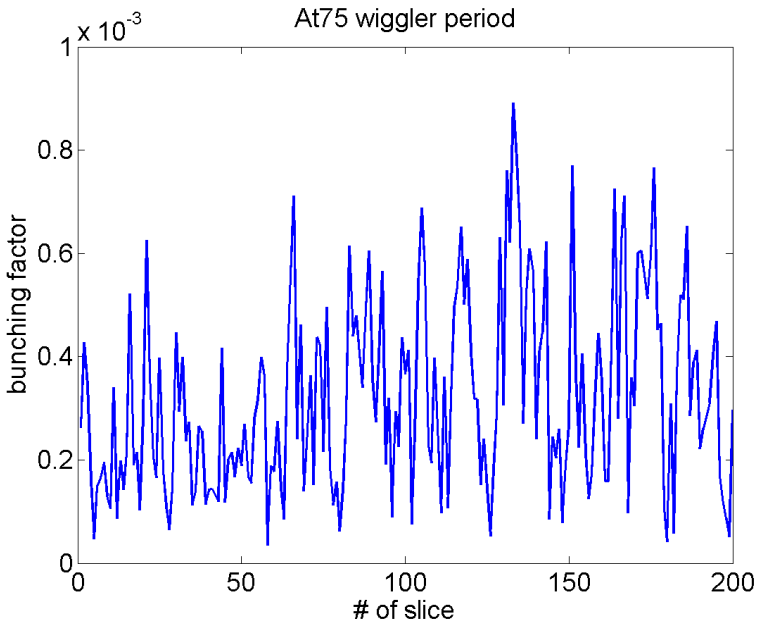


(a) Background

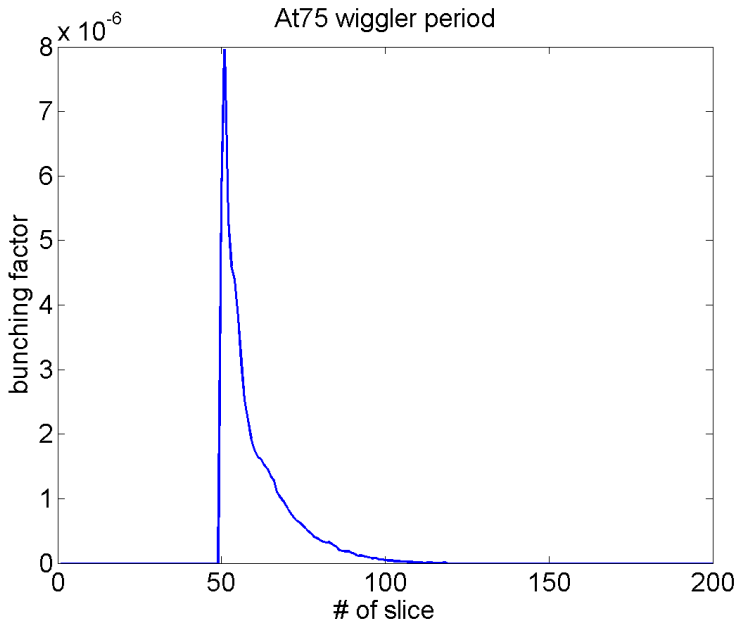


(b) Signal

200 slices at entrance of modulator

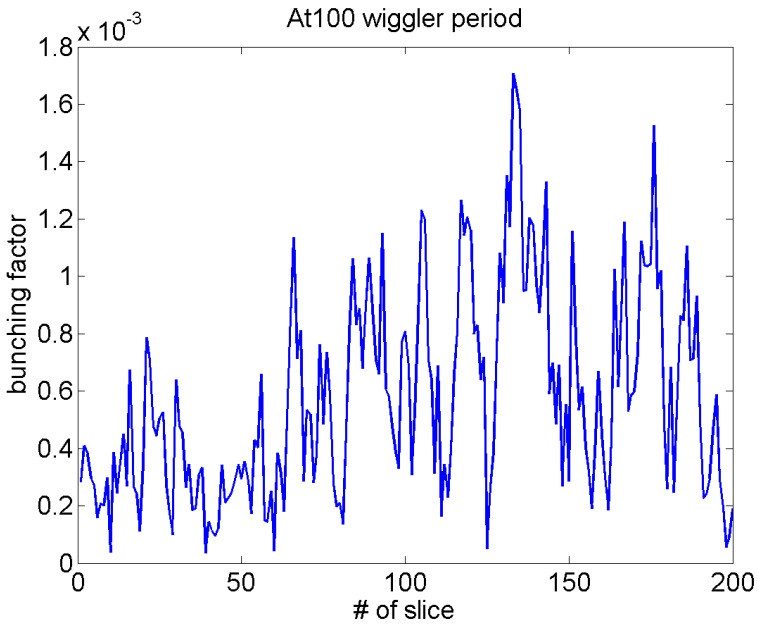


(a) Background

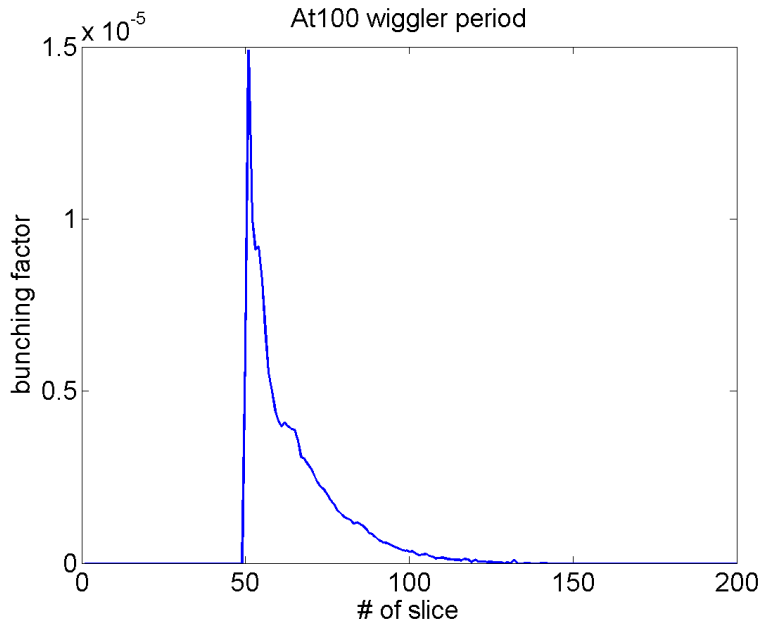


(b) Signal

200 slices at entrance of modulator

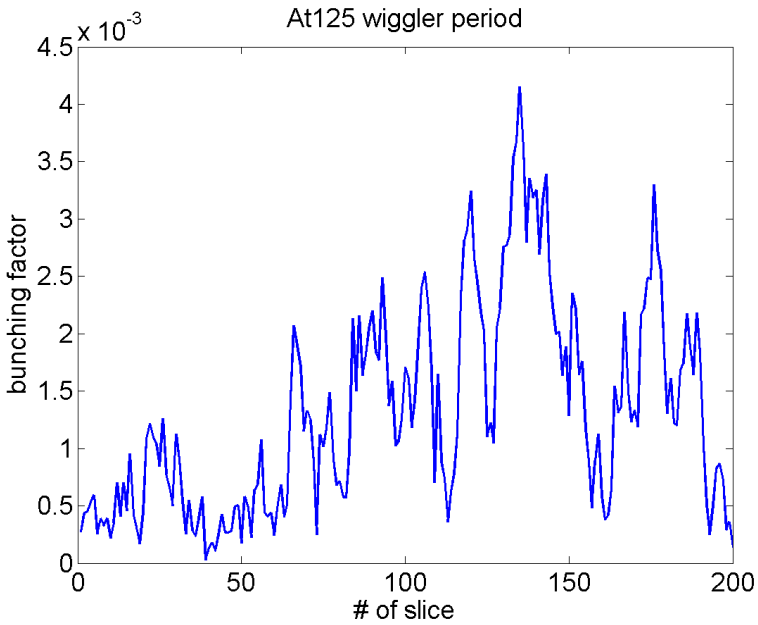


(a) Background

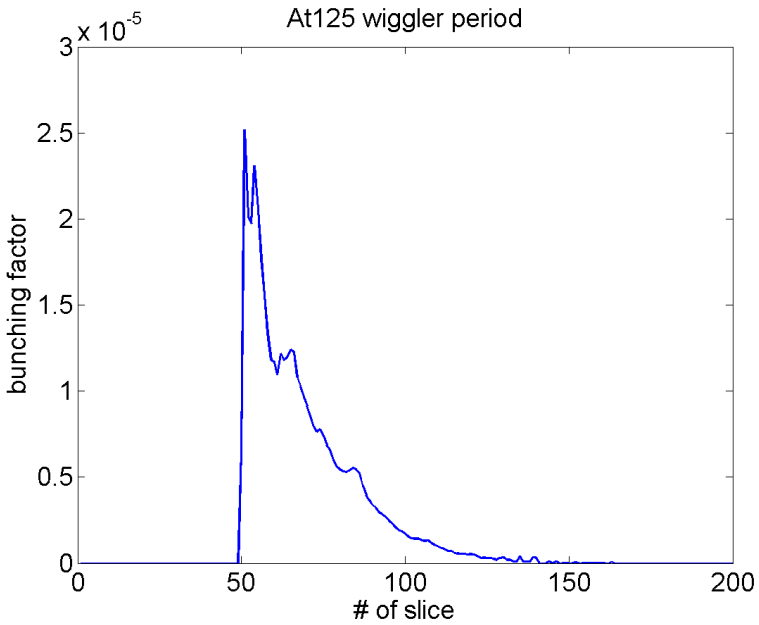


(b) Signal

200 slices at entrance of modulator

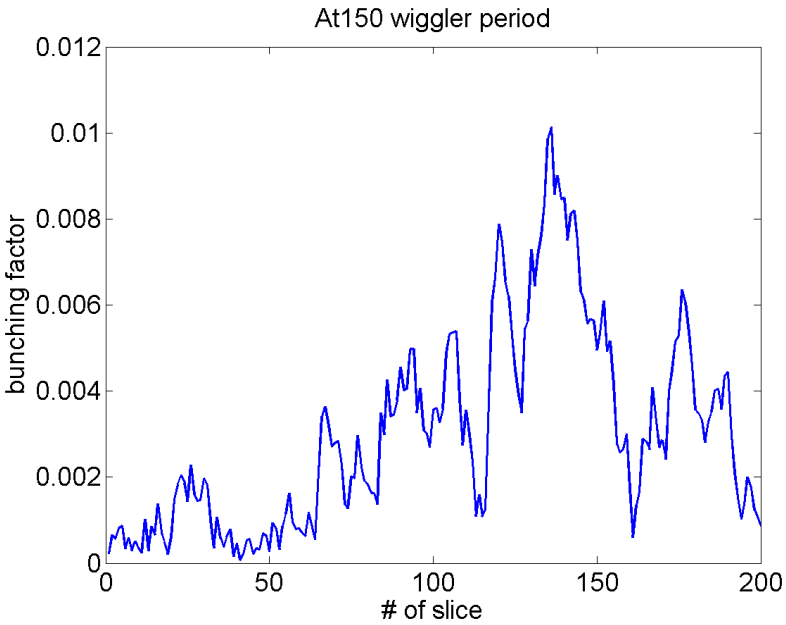


(a) Background

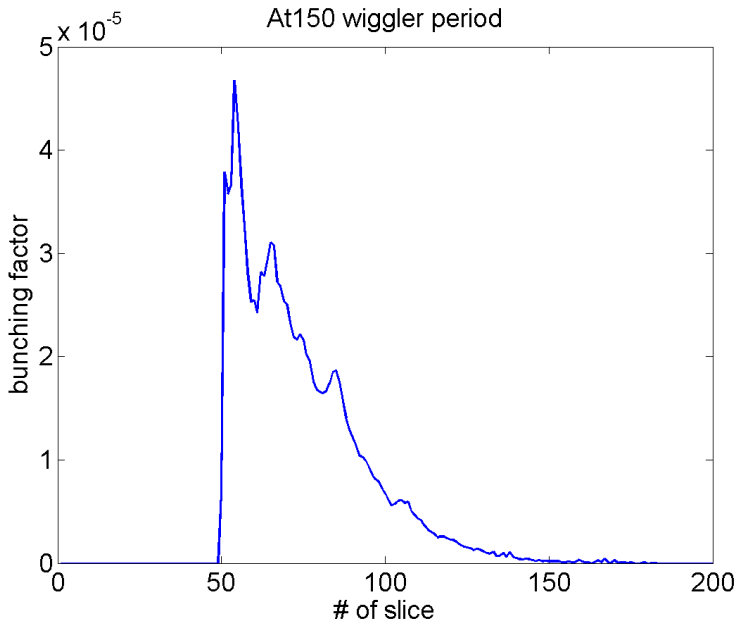


(b) Signal

200 slices at entrance of modulator

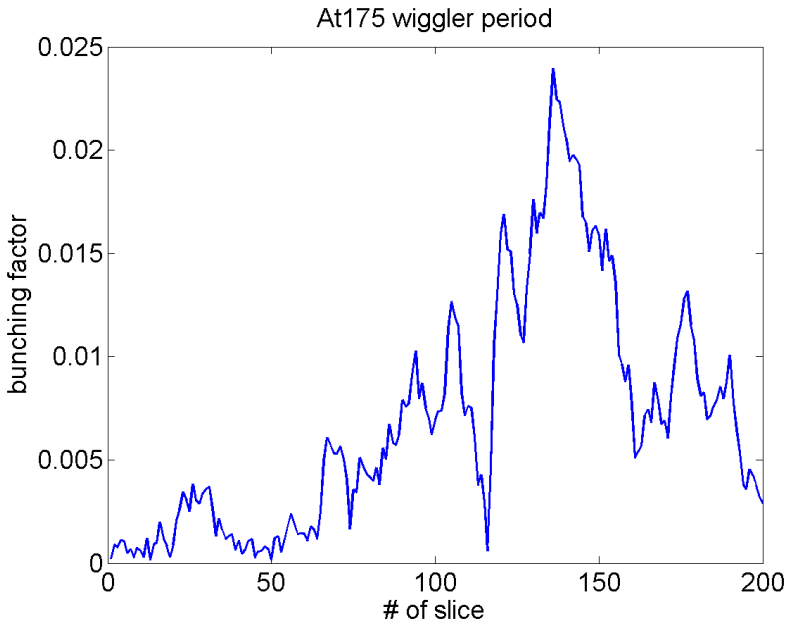


(a) Background

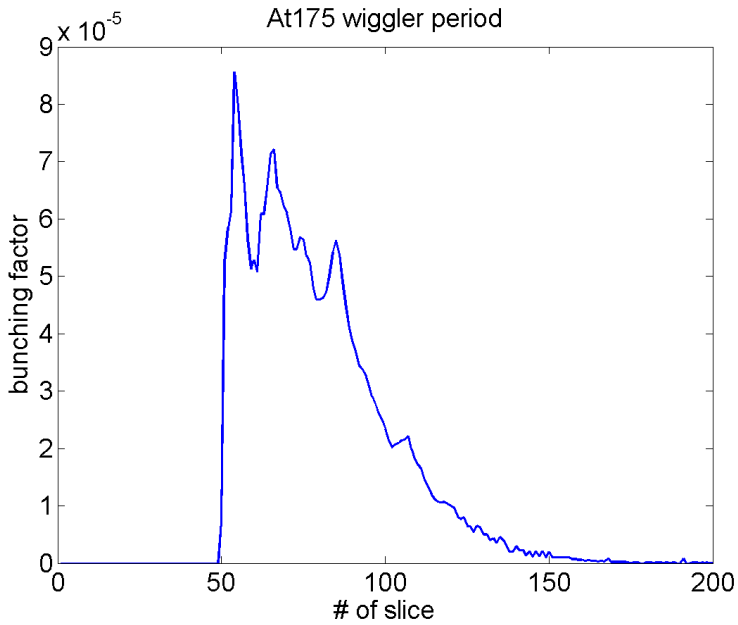


(b) Signal

200 slices at entrance of modulator

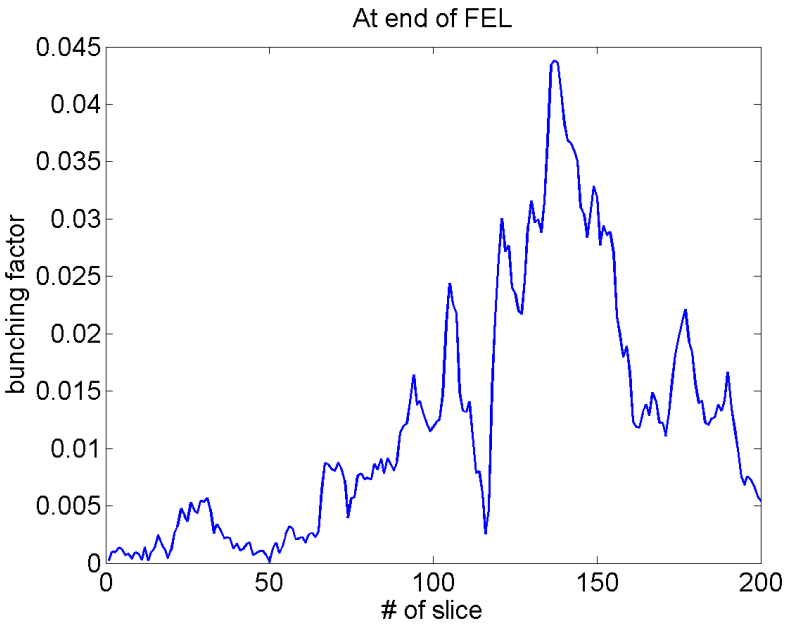


(a) Background

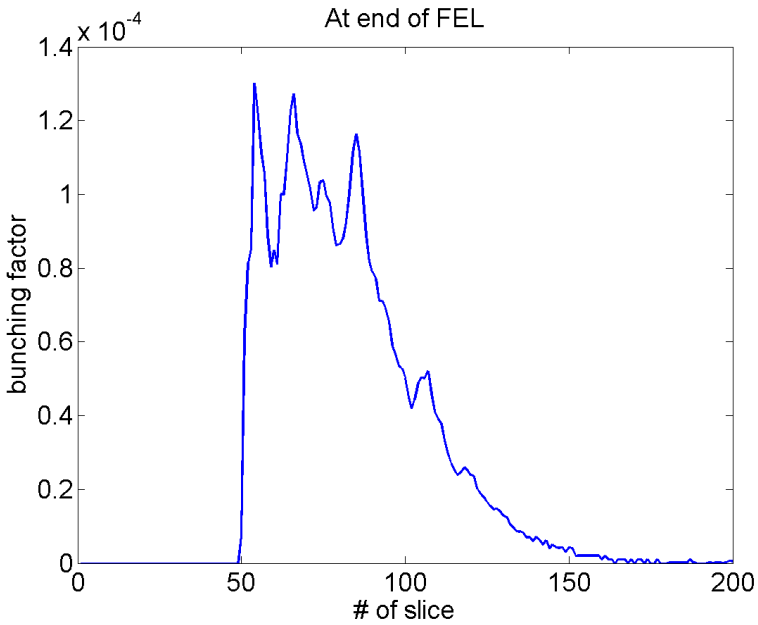


(b) Signal

200 slices at entrance of modulator

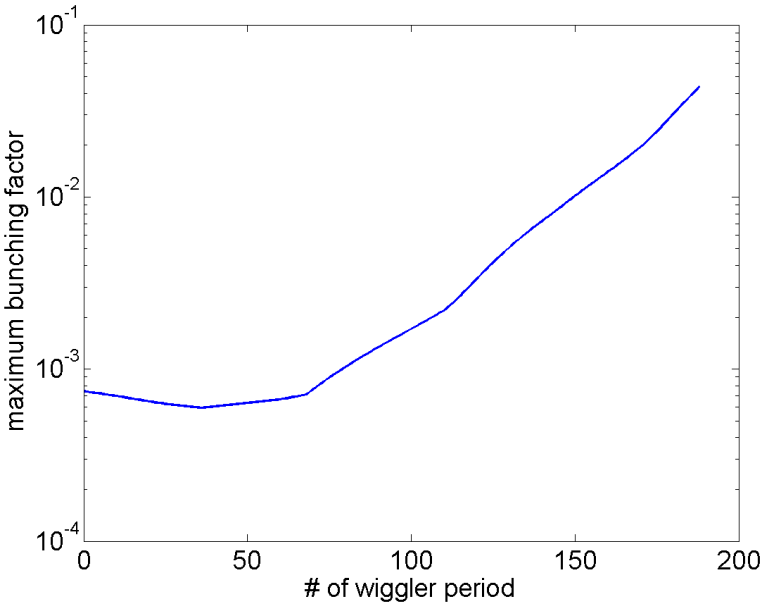


(a) Background

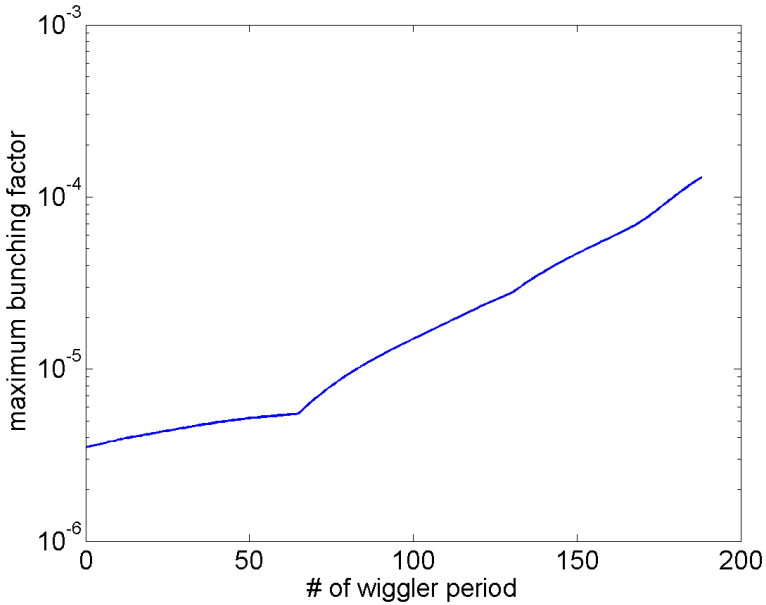


(b) Signal

200 slices at entrance of modulator

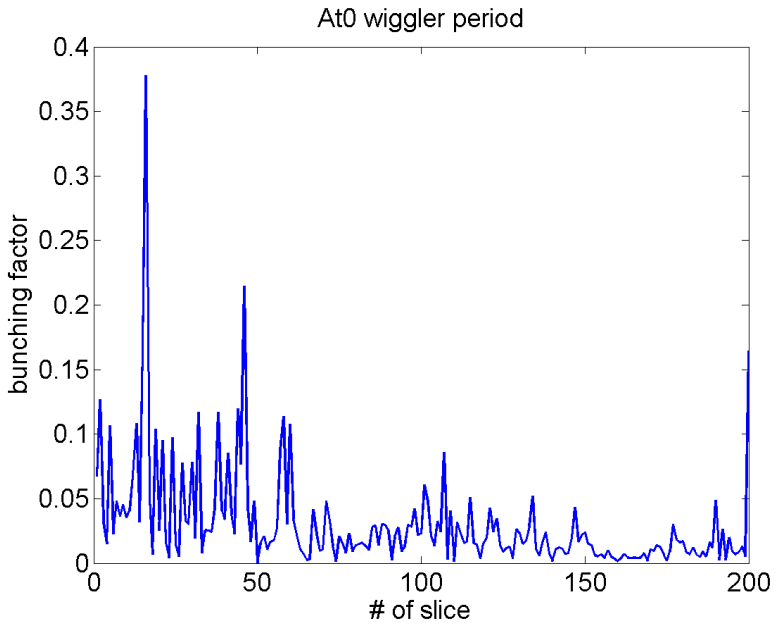


(a) Background

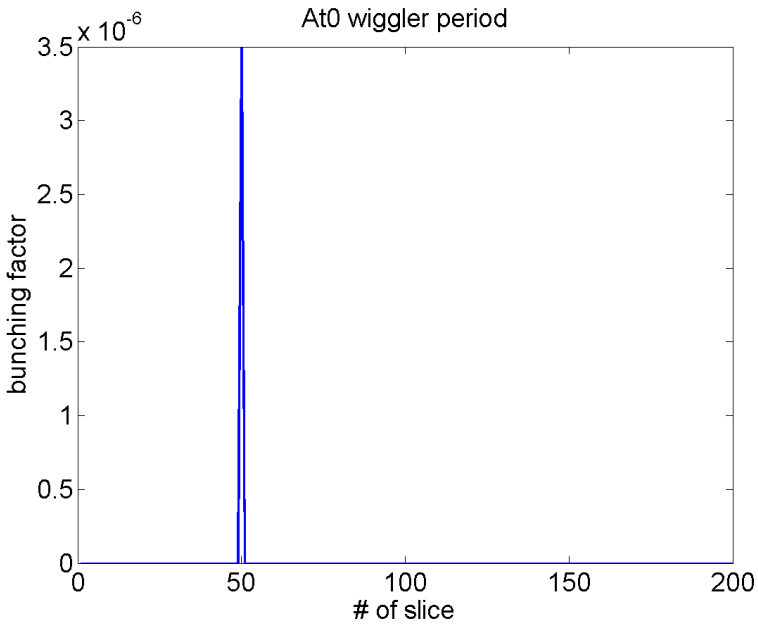


(b) Signal

200 slices at end of modulator, large noise

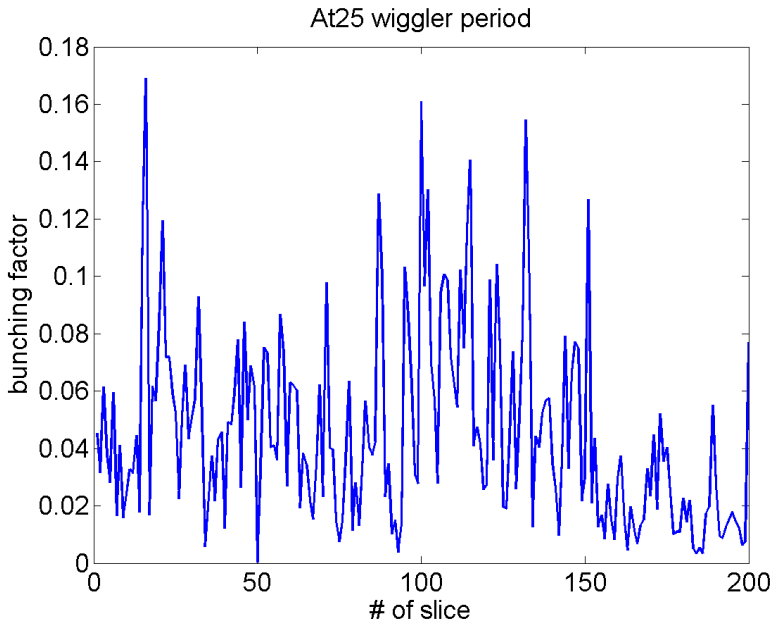


(a) Background

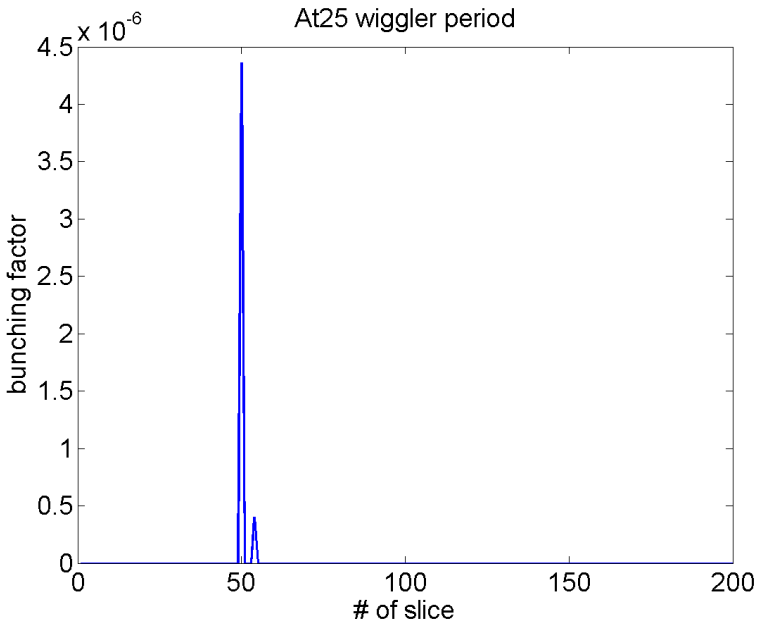


(b) Signal

200 slices at end of modulator, large noise

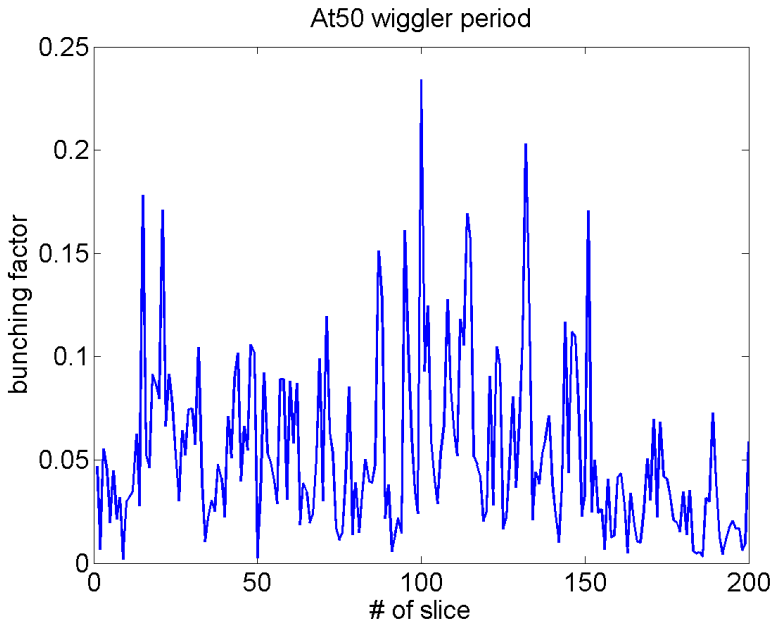


(a) Background

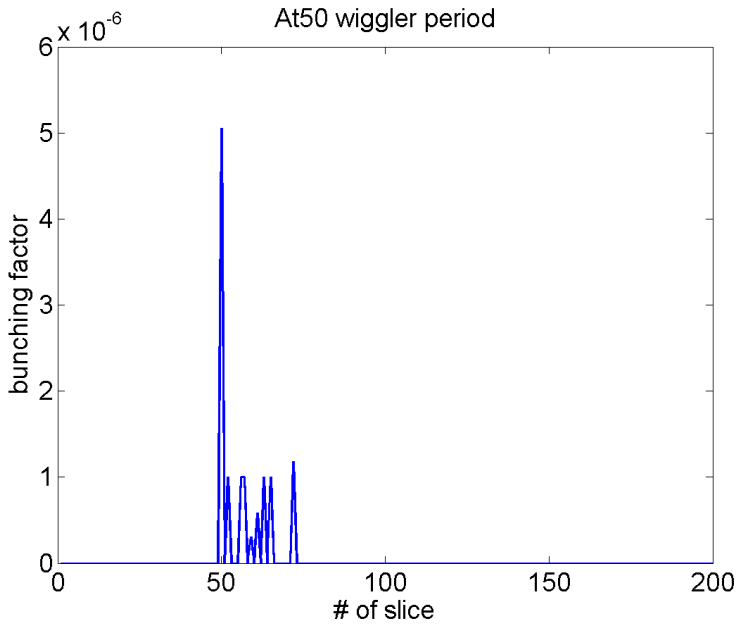


(b) Signal

200 slices at end of modulator, large noise

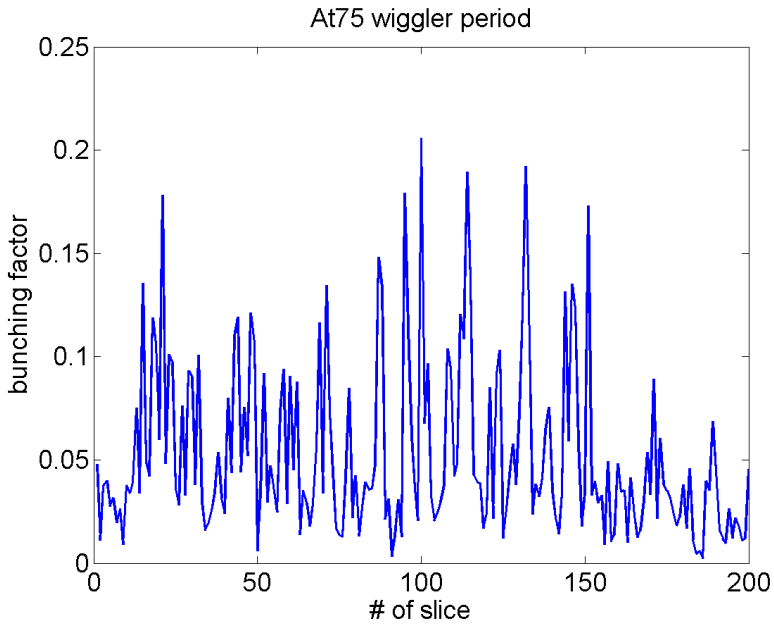


(a) Background

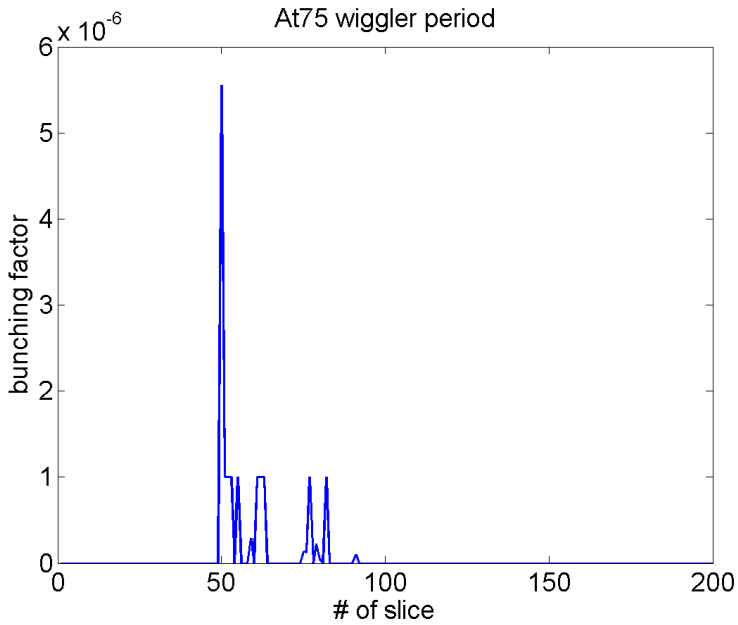


(b) Signal

200 slices at end of modulator, large noise

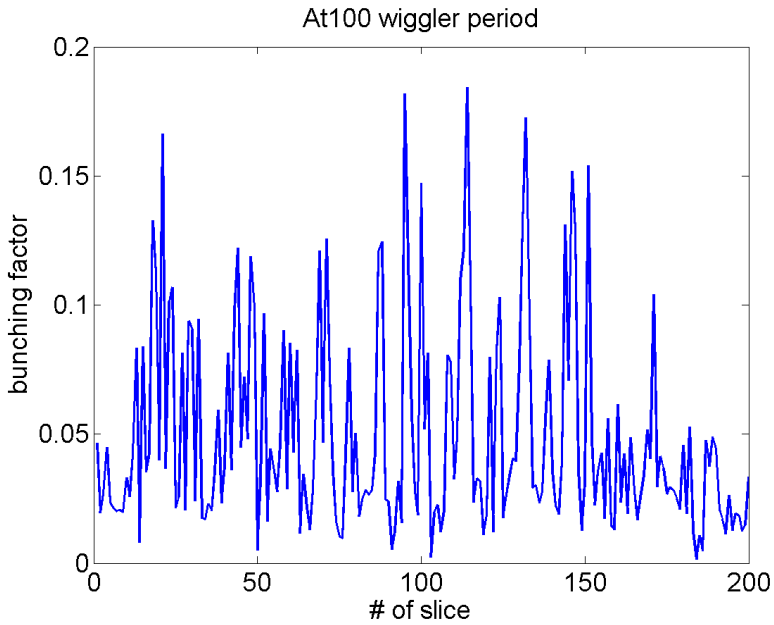


(a) Background

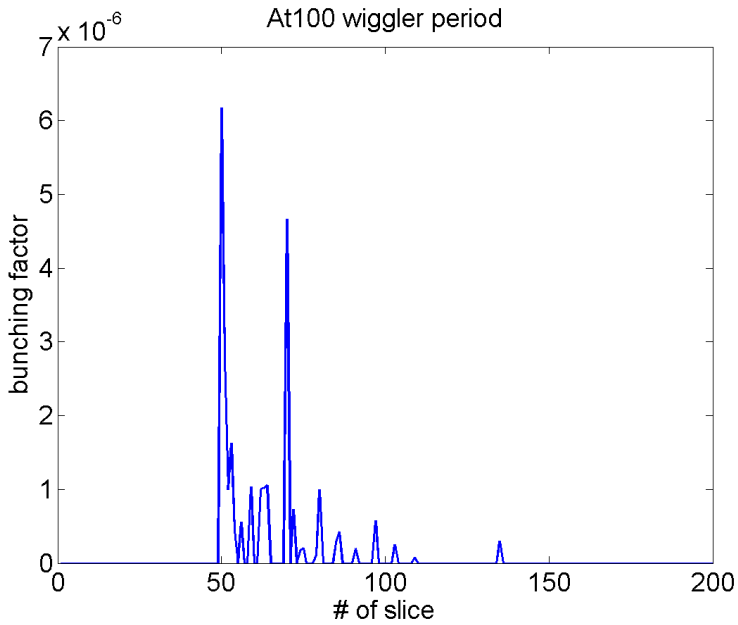


(b) Signal

200 slices at end of modulator, large noise

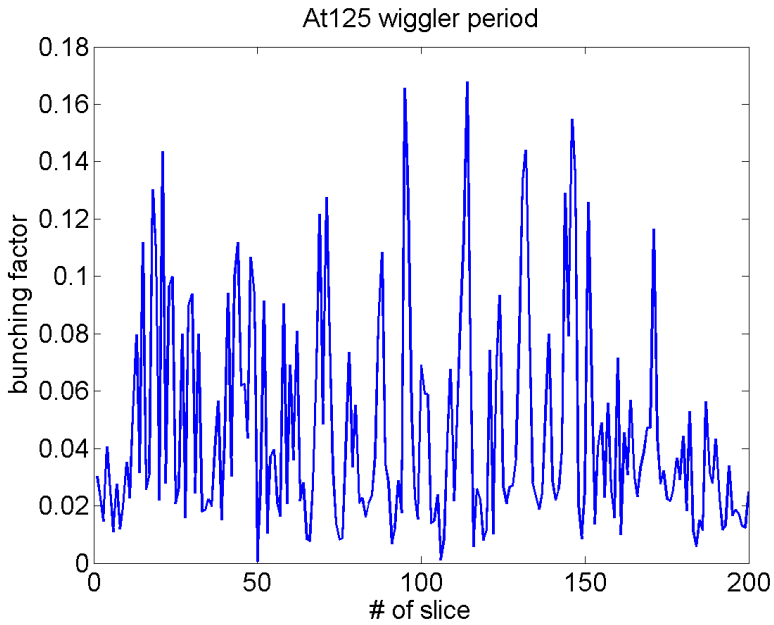


(a) Background

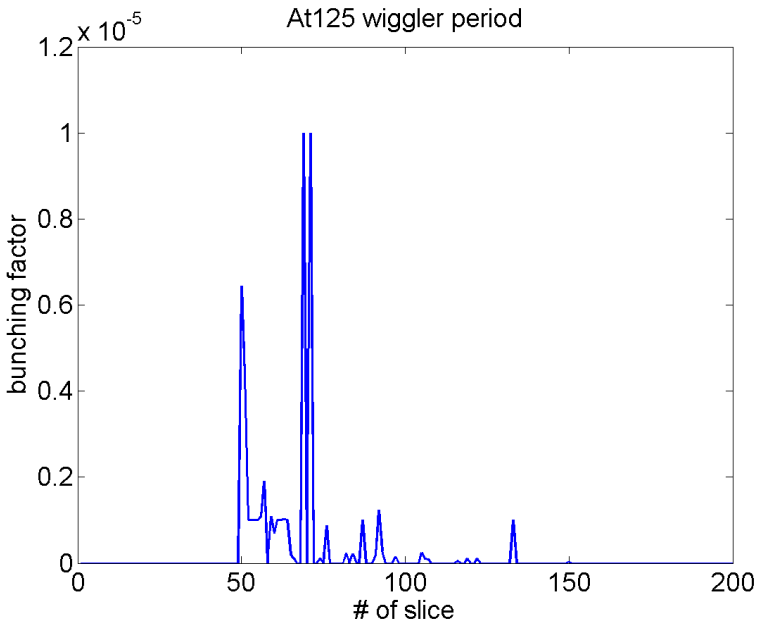


(b) Signal

200 slices at end of modulator, large noise

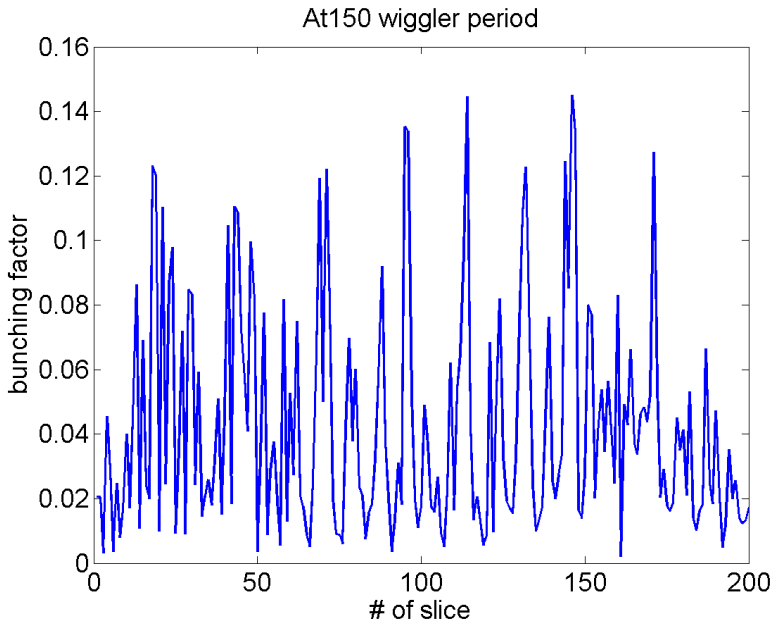


(a) Background

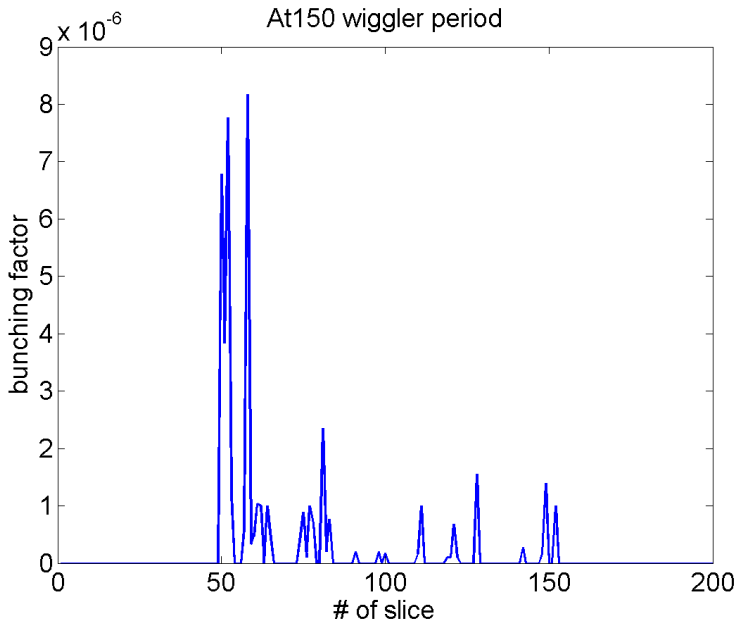


(b) Signal

200 slices at end of modulator, large noise

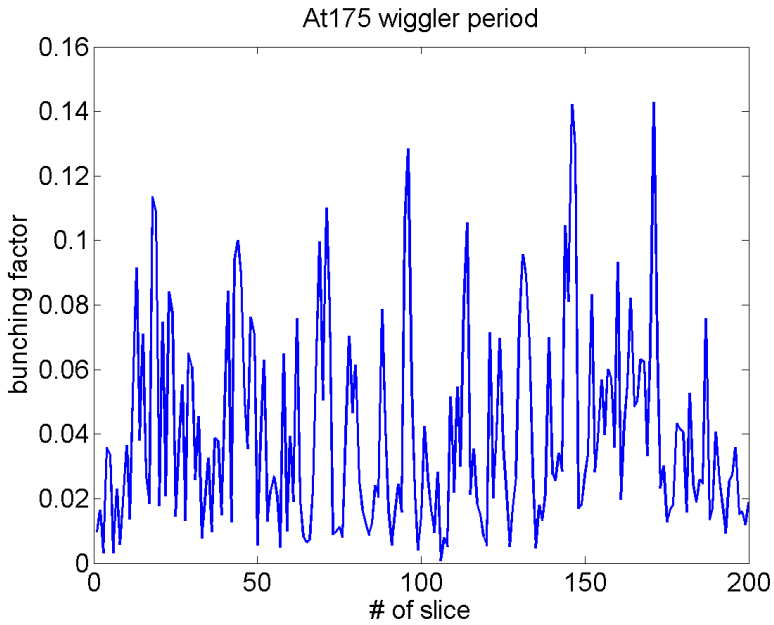


(a) Background

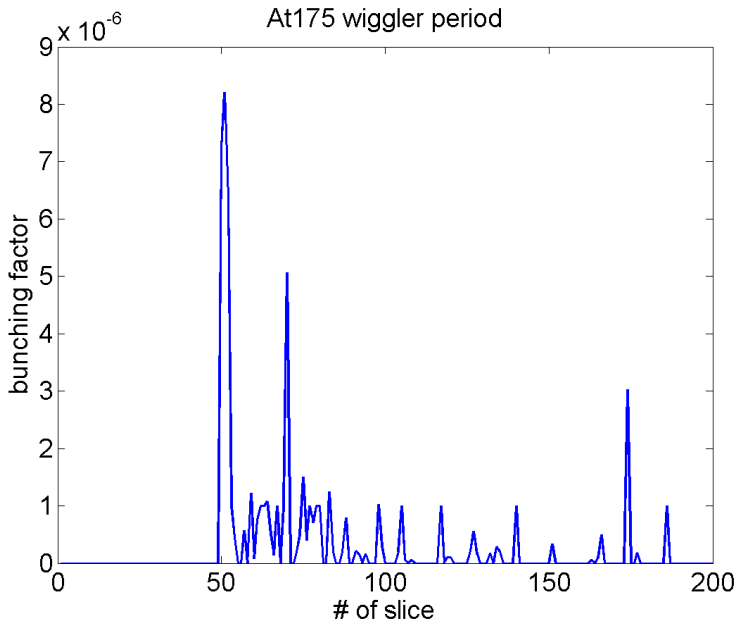


(b) Signal

200 slices at end of modulator, large noise

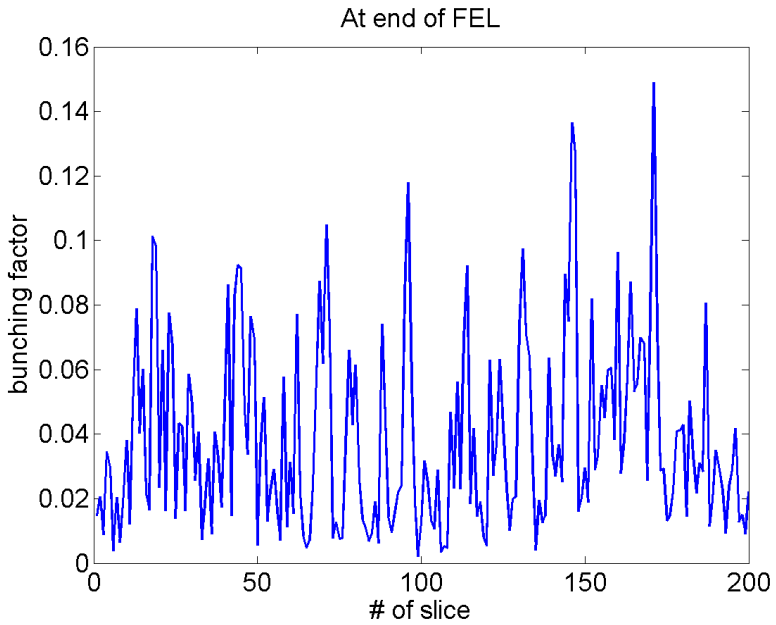


(a) Background

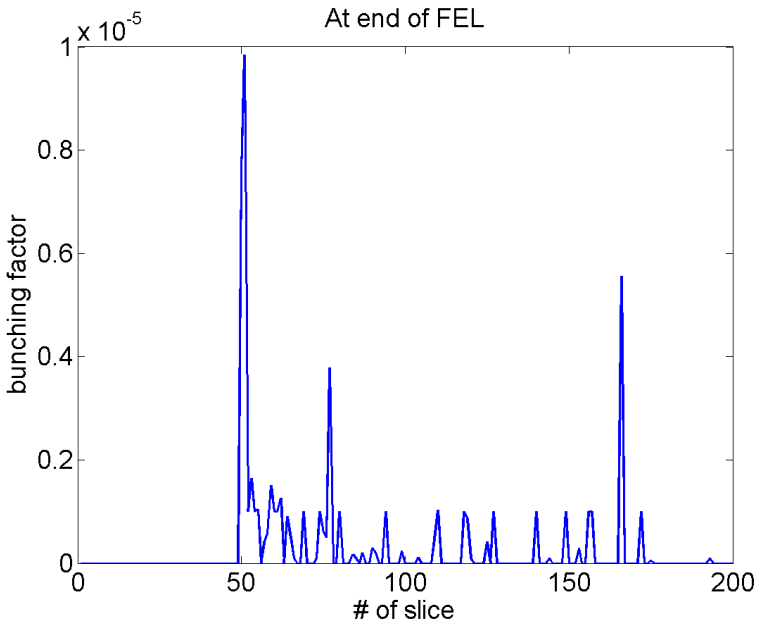


(b) Signal

200 slices at end of modulator, large noise

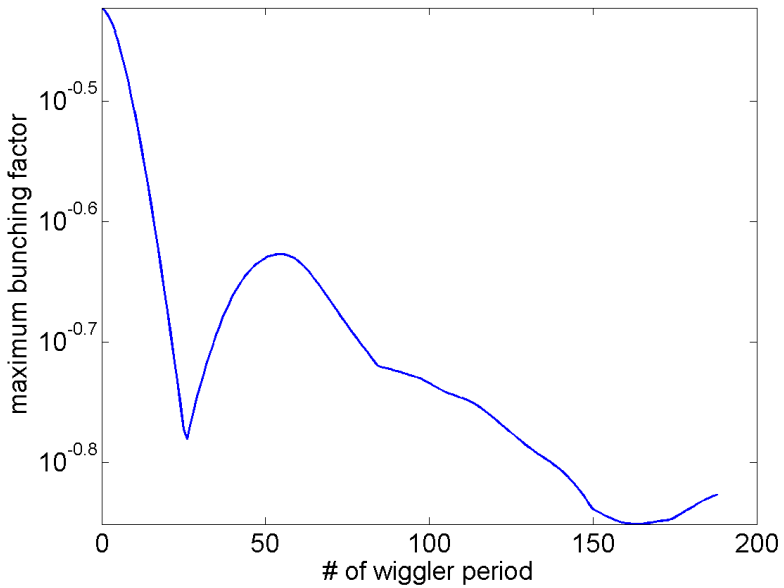


(a) Background

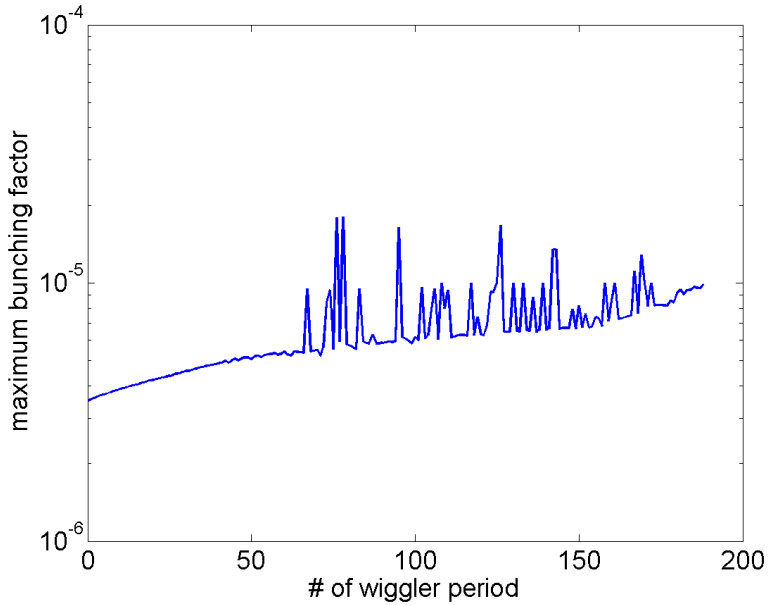


(b) Signal

200 slices at end of modulator, large noise

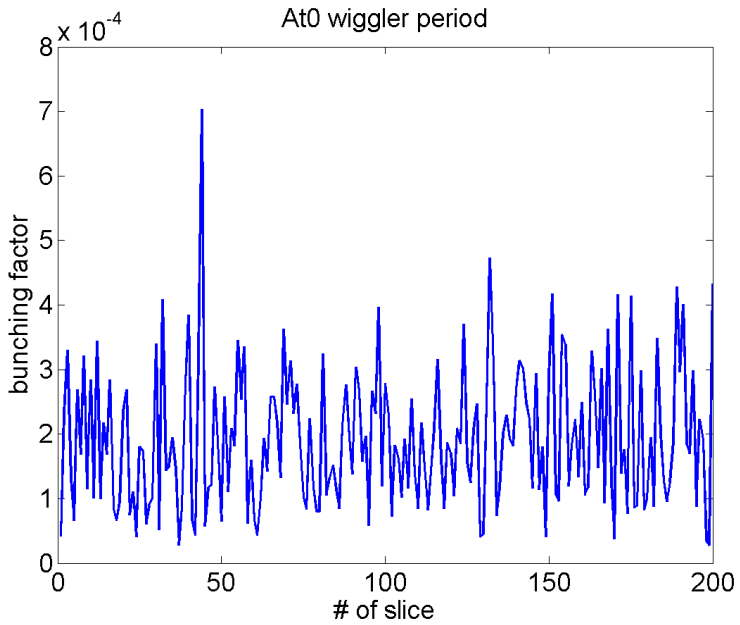


(a) Background

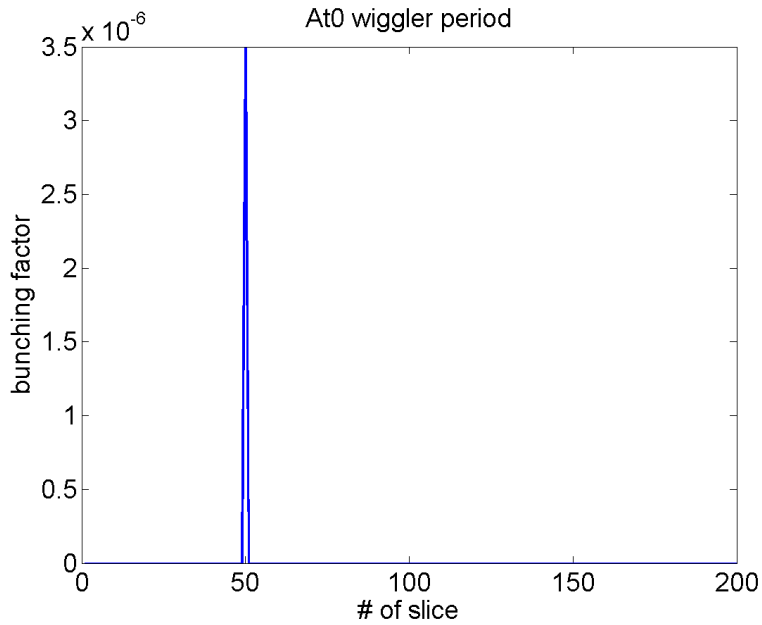


(b) Signal

200 slices at end of modulator, correct noise

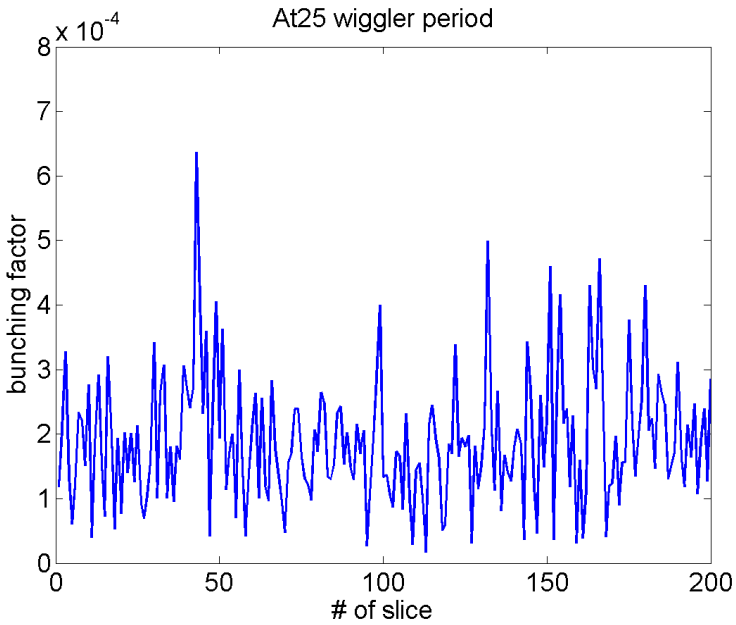


(a) Background

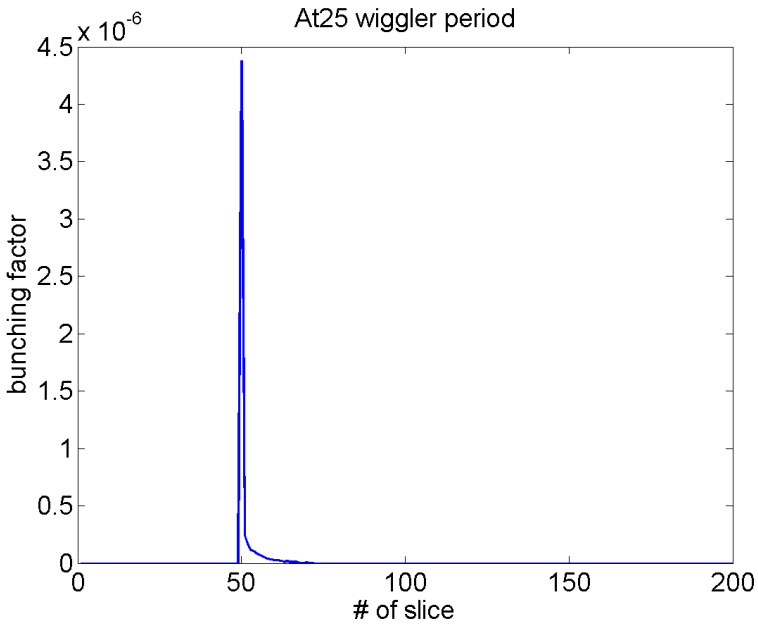


(b) Signal

200 slices at end of modulator, correct noise

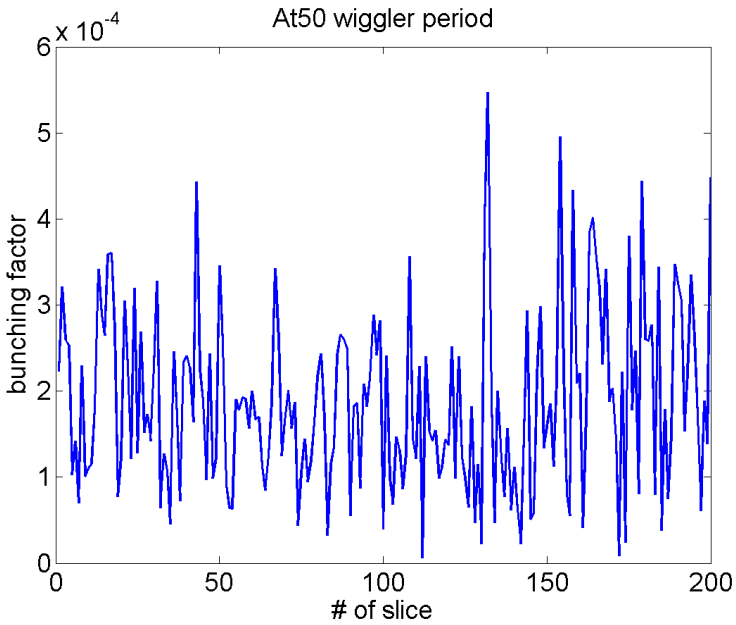


(a) Background

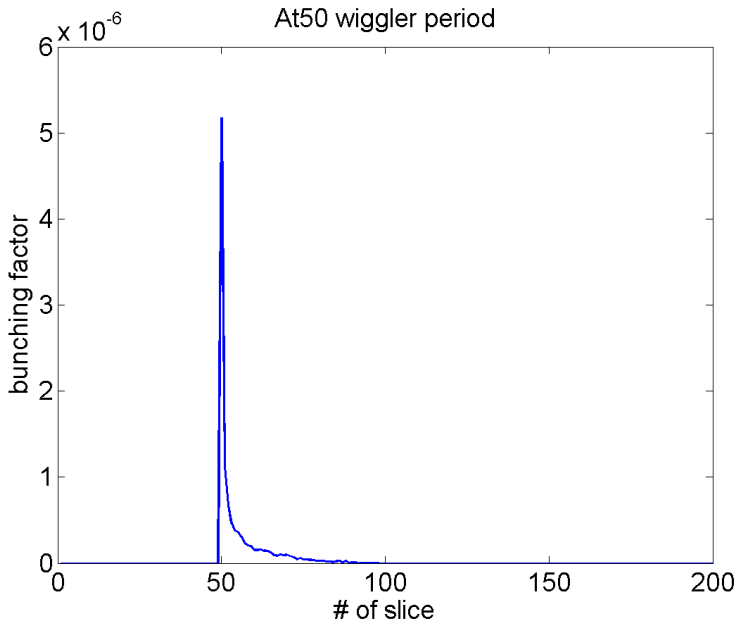


(b) Signal

200 slices at end of modulator, correct noise

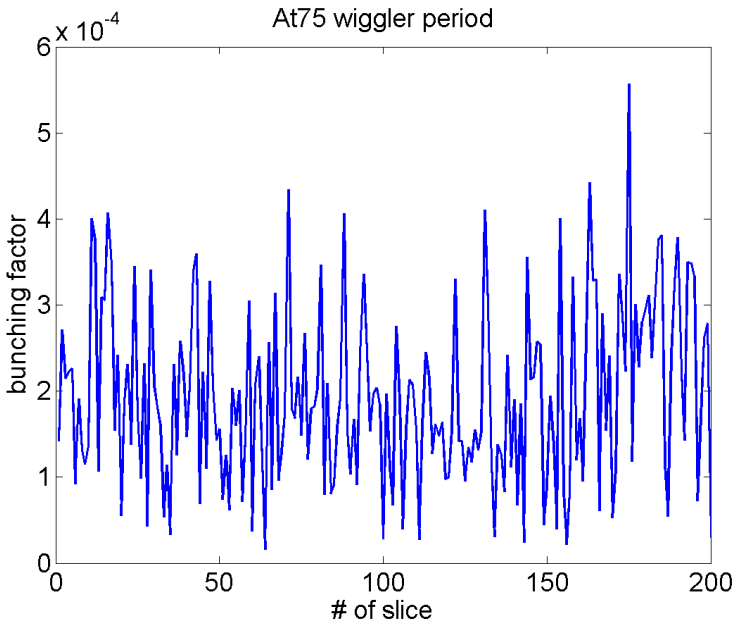


(a) Background

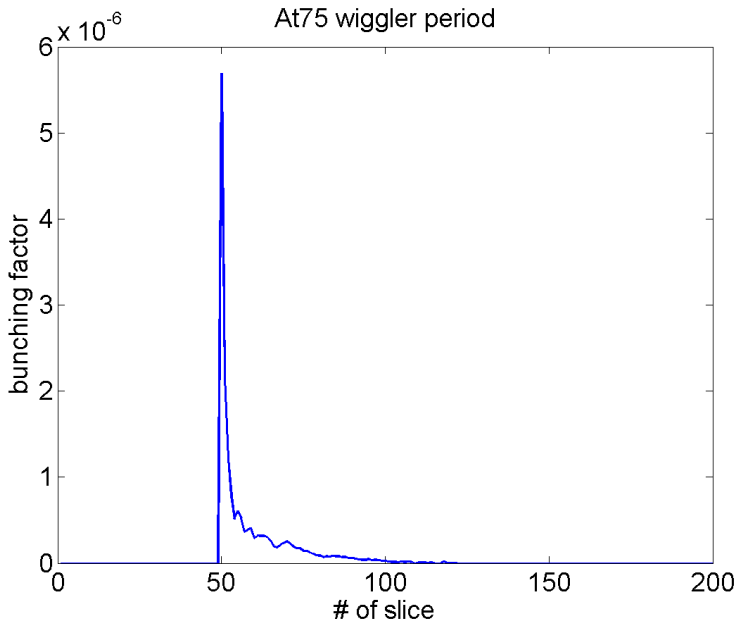


(b) Signal

200 slices at end of modulator, correct noise

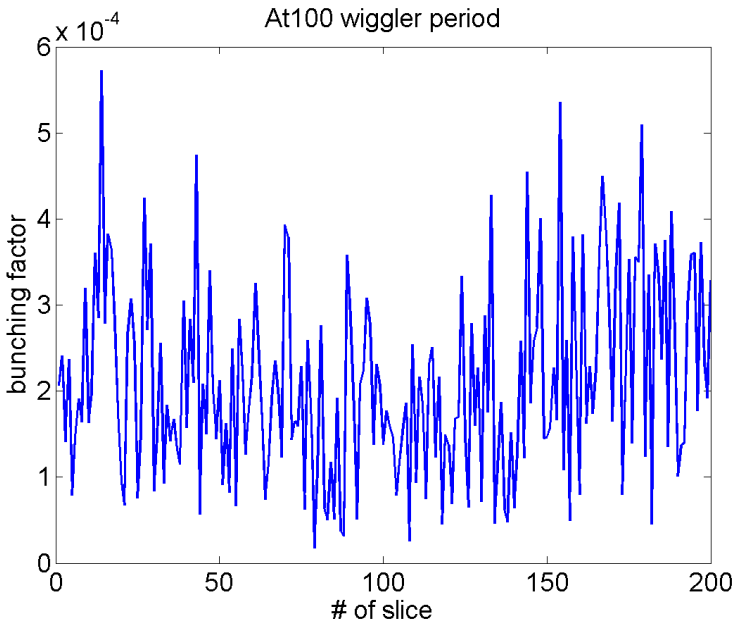


(a) Background

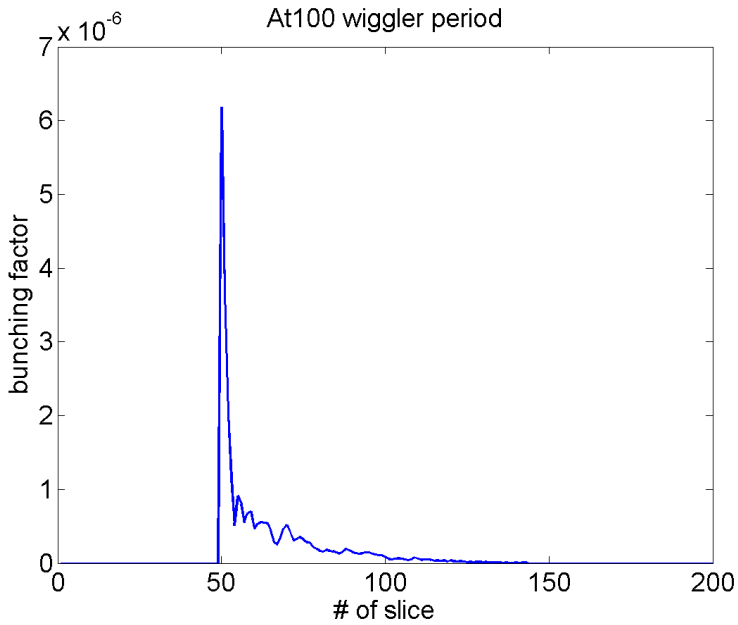


(b) Signal

200 slices at end of modulator, correct noise

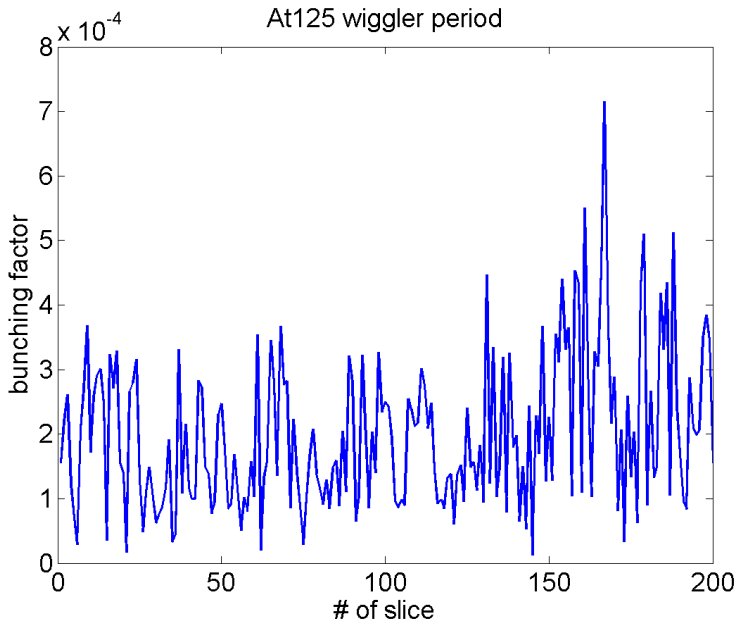


(a) Background

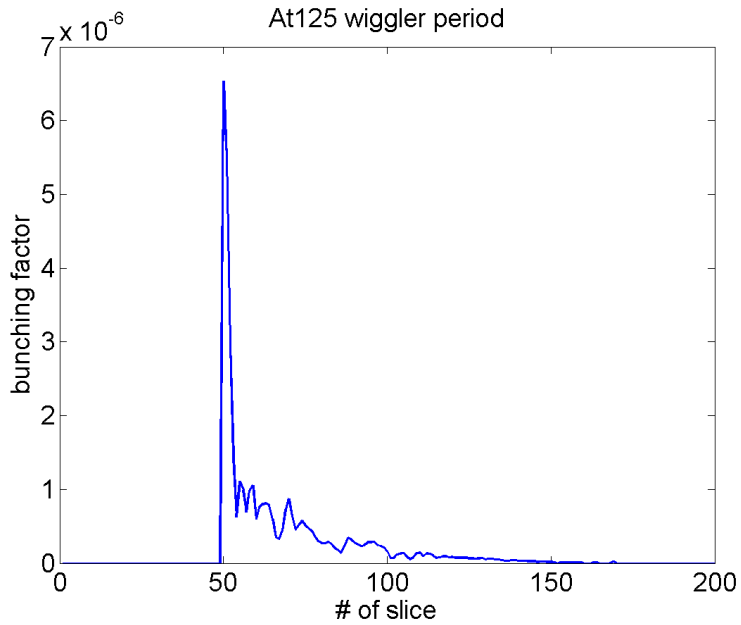


(b) Signal

200 slices at end of modulator, correct noise

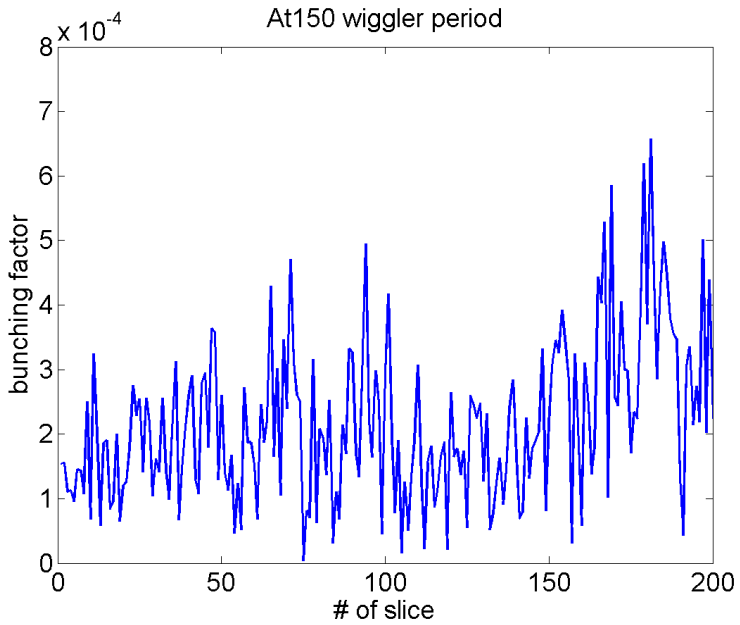


(a) Background

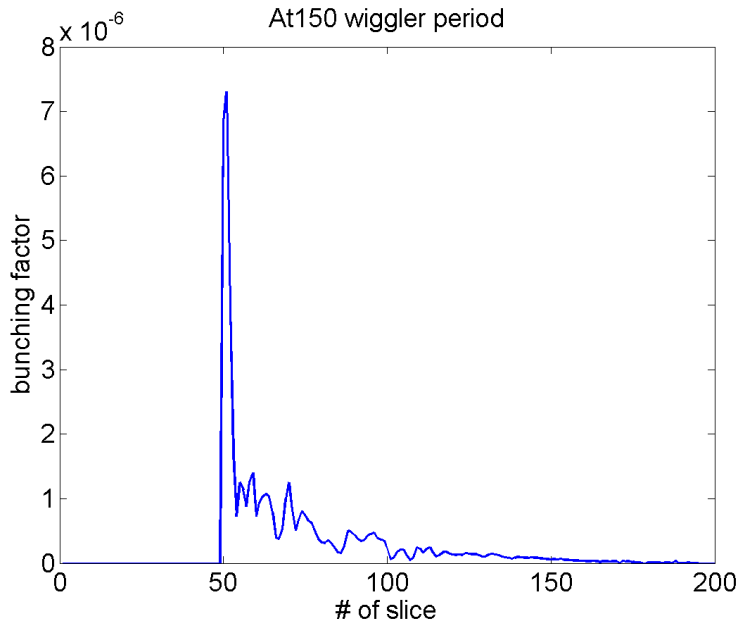


(b) Signal

200 slices at end of modulator, correct noise

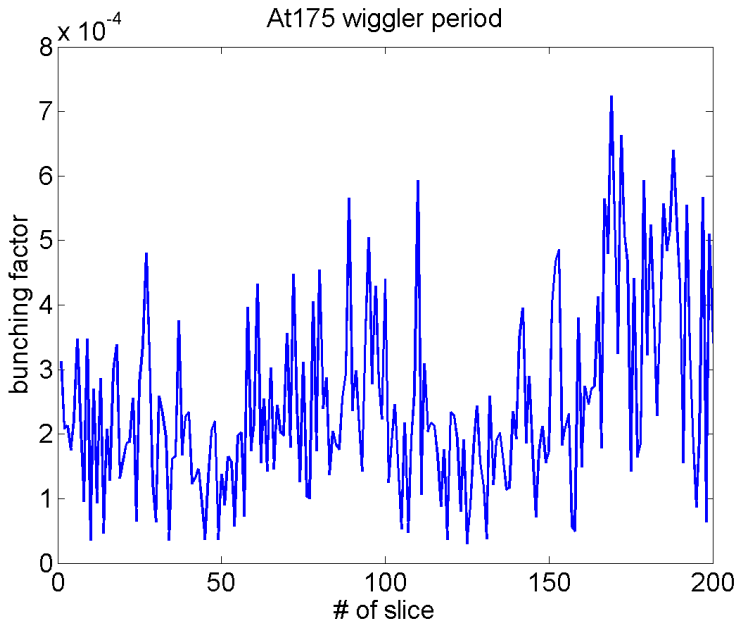


(a) Background

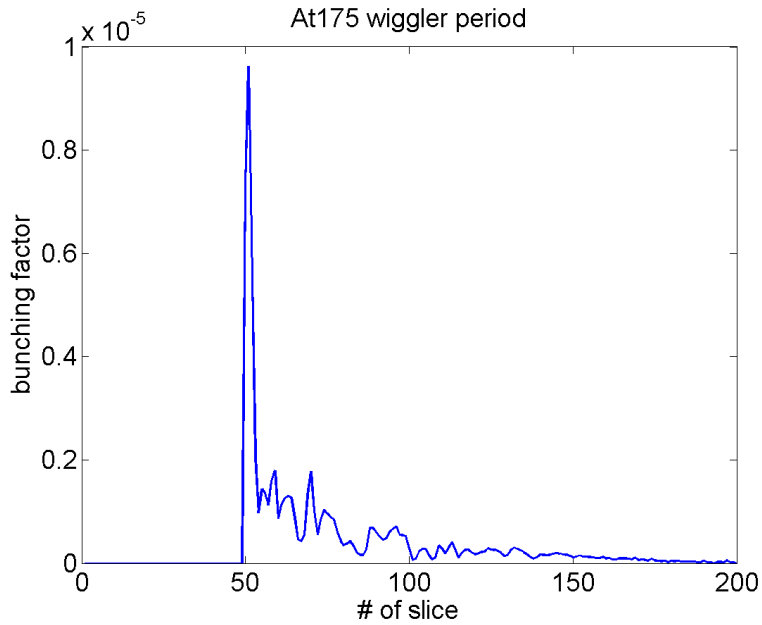


(b) Signal

200 slices at end of modulator, correct noise

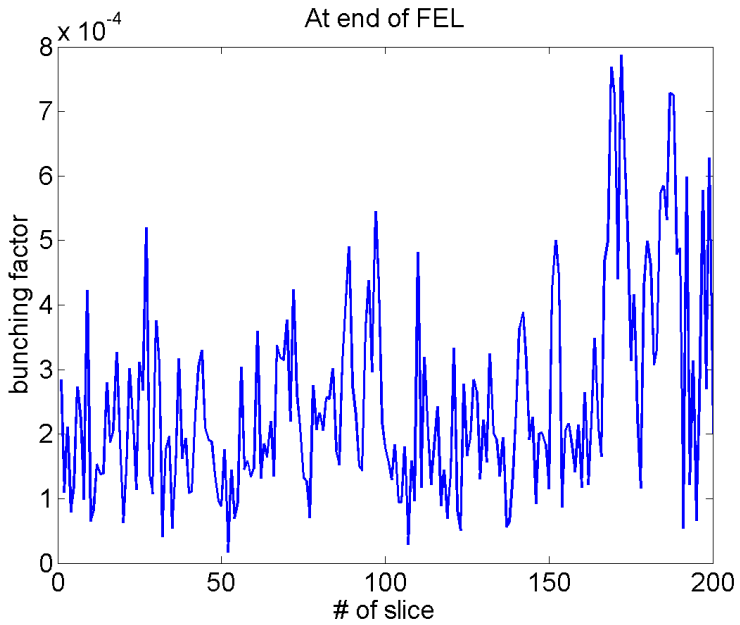


(a) Background

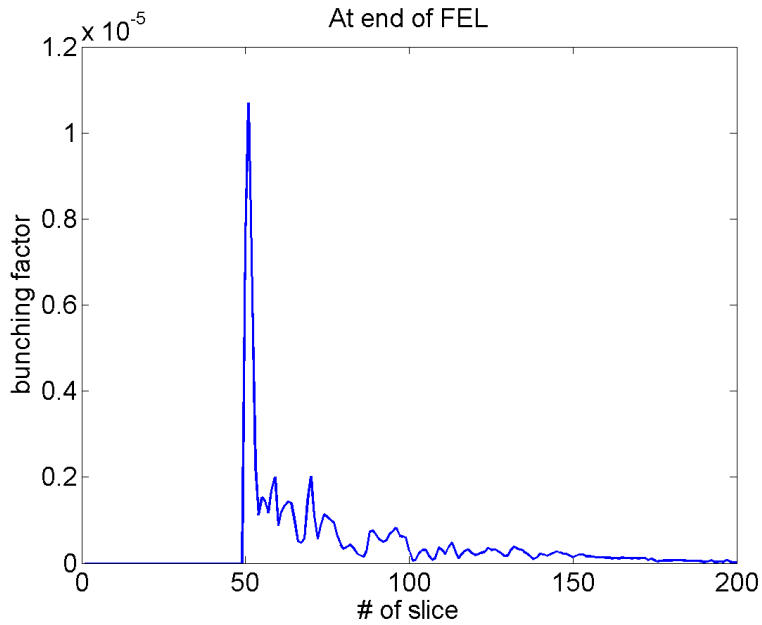


(b) Signal

200 slices at end of modulator, correct noise

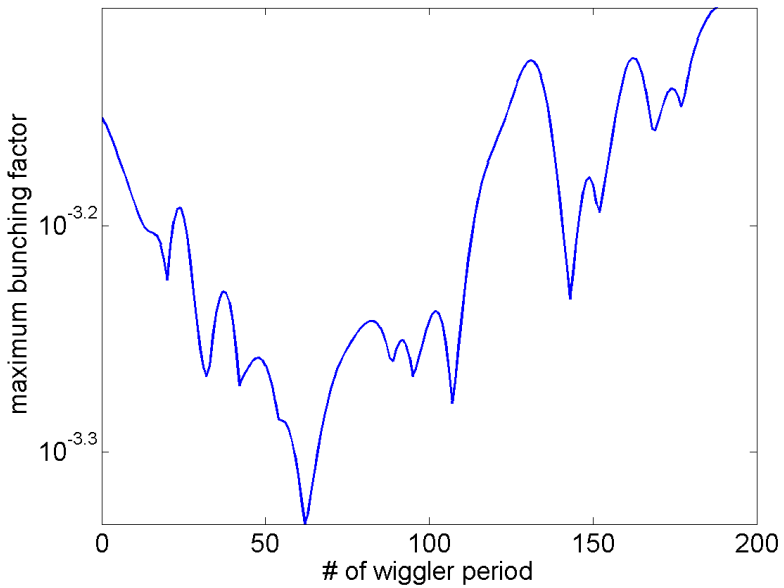


(a) Background

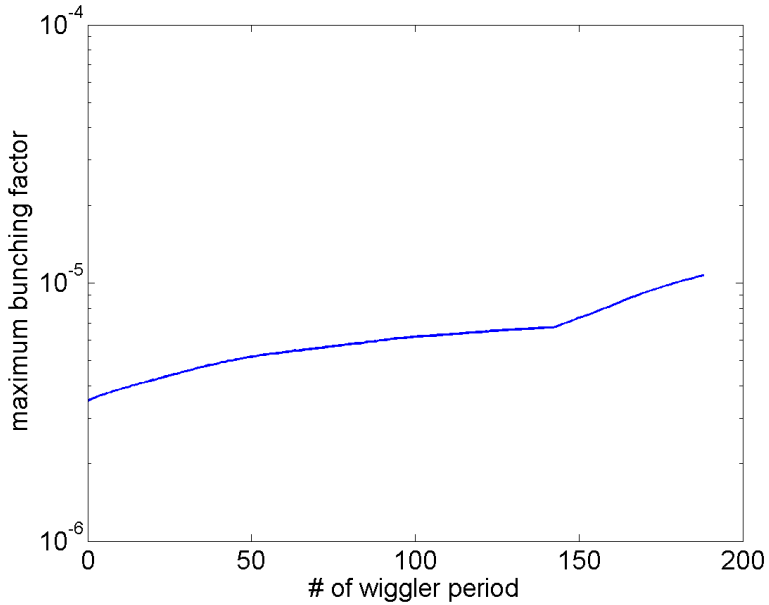


(b) Signal

200 slices at end of modulator, correct noise

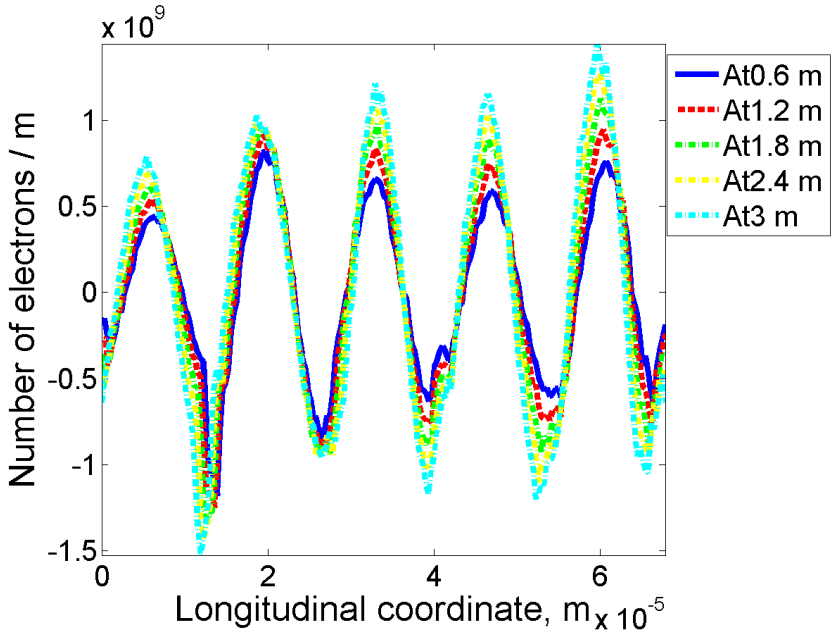


(a) Background

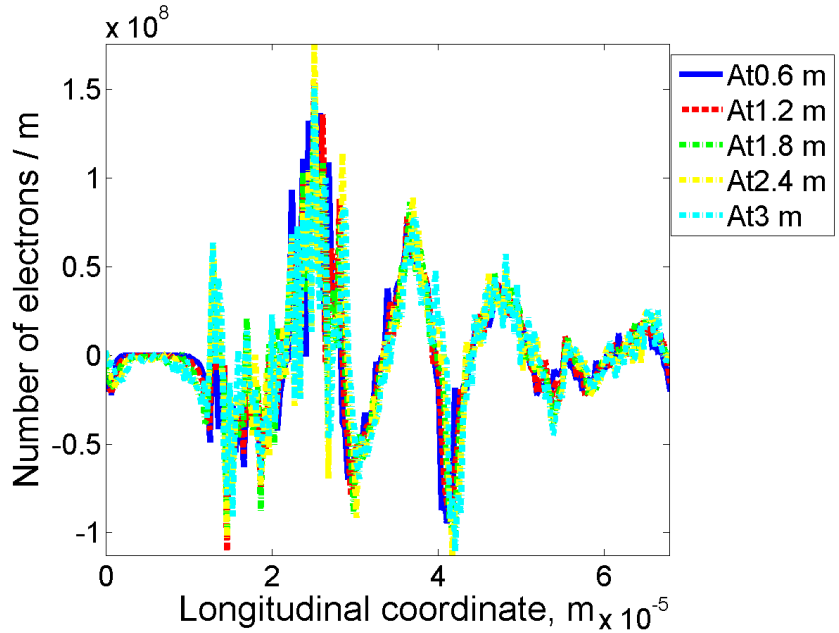


(b) Signal

Longitudinal density distribution



(a) 200 slice at entrance of modulator



(b) 200 slice at end of modulator

Beam parameters at entrance and end of modulator

Parameter	At entrance	At end
α_x	-2	16
α_y	-2	-30
energy spread	1.5e-4	1e-3