The University of Windsor

ELEC2250: Physical Electronics

Summer 2020

Lab Five

Carrier Diffusion in a Semiconductor

Friday, July 17, 2020

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Assignment tasks for part one:

1.

(Ex, Ey, Particles): (0, 0, 4)

(Ex, Ey, Particles): (0, 0, 10)

(Ex, Ey, Particles): (0, 0, 20)

(Ex, Ey, Particles): (0, 0, 50)

(Ex, Ey, Particles): (0, 0, 70)

(Ex, Ey, Particles): (0, 0, 100)

Noted Observations: Particle motion is sporadic. The particles' position was a lot more centered in the left half portion of the graph and slowly dispersed as more time was given. The histograms had a random or even spread except for when there were more than 20 particles added.

2.

(Ex, Ey, Particles): (2, 0, 4)

(Ex, Ey, Particles): (3, 0, 10)

(Ex, Ey, Particles): (5, 0, 50)

Noted Observations: Particle motion is polarized to the right. The particles' position tended to move towards the right side of the plane. The histograms had higher carrier concentrations on the right half of the plane.

3.

(Ex, Ey, Particles): (-2, 0, 4)

(Ex, Ey, Particles): (3, 0, 10)

(Ex, Ey, Particles): (5, 0, 50)

Noted Observations: Particle motion is polarized to the left. The particles' position tended to move towards the left side of the plane. The histograms had higher carrier concentrations on the left half of the plane.

4.

(Ex, Ey, Particles): (0, 2, 4)

(Ex, Ey, Particles): (0, 3, 10)

(Ex, Ey, Particles): (0, 5, 50)

Noted Observations: Particle motion is polarized to the upper boundary. The particles' position tended to move towards the top side of the plane. The histograms had higher carrier concentrations closer to the left side when more particles were added but an overall flat trend.

5.

(Ex, Ey, Particles): (0, -2, 4)

(Ex, Ey, Particles): (0, -3, 10)

(Ex, Ey, Particles): (0, -5, 50)

Noted Observations: Particle motion is polarized to the lower boundary. The particles' position tended to move towards the bottom side of the plane. The histograms had higher carrier concentrations closer to the left side when more particles were added but an overall flat trend.

6.

(Ex, Ey, Particles): (2, 2, 4)

(Ex, Ey, Particles): (3, 3, 10)

(Ex, Ey, Particles): (5, 5, 50)

Noted Observations: Particle motion is polarized to the upper-right boundary. The particles' position tended to move towards the upper-right side of the plane. The histograms had overwhelmingly higher carrier concentrations closer on the right half of the plane but when more particles were added it had shifted to the left slightly.

7.

(Ex, Ey, Particles): (-2, -2, 4)

(Ex, Ey, Particles): (-3, -3, 10)

(Ex, Ey, Particles): (-5, -5, 50)

Noted Observations: Particle motion is polarized to the lower-left boundary. The particles' position tended to move towards the lower-left side of the plane. The histograms had overwhelmingly higher carrier concentrations closer on the left half of the plane but when more particles were added it had shifted to the right slightly.

8.

(Ex, Ey, Particles): (2, -2, 4)

(Ex, Ey, Particles): (5, -5, 50)

Noted Observations: Particle motion is polarized to the lower-right boundary. The particles' position tended to move towards the lower-right side of the plane. The histograms had overwhelmingly higher carrier concentrations closer on the right half of the plane but when more particles were added it had shifted to the left slightly.

(Ex, Ey, Particles): (-2, 2, 4)

(Ex, Ey, Particles): (-5, 5, 50)

Noted Observations: Particle motion is polarized to the upper-left boundary. The particles' position tended to move towards the upper-left side of the plane. The histograms had overwhelmingly higher carrier concentrations closer on the left half of the plane but when more particles were added it had shifted to the right slightly.

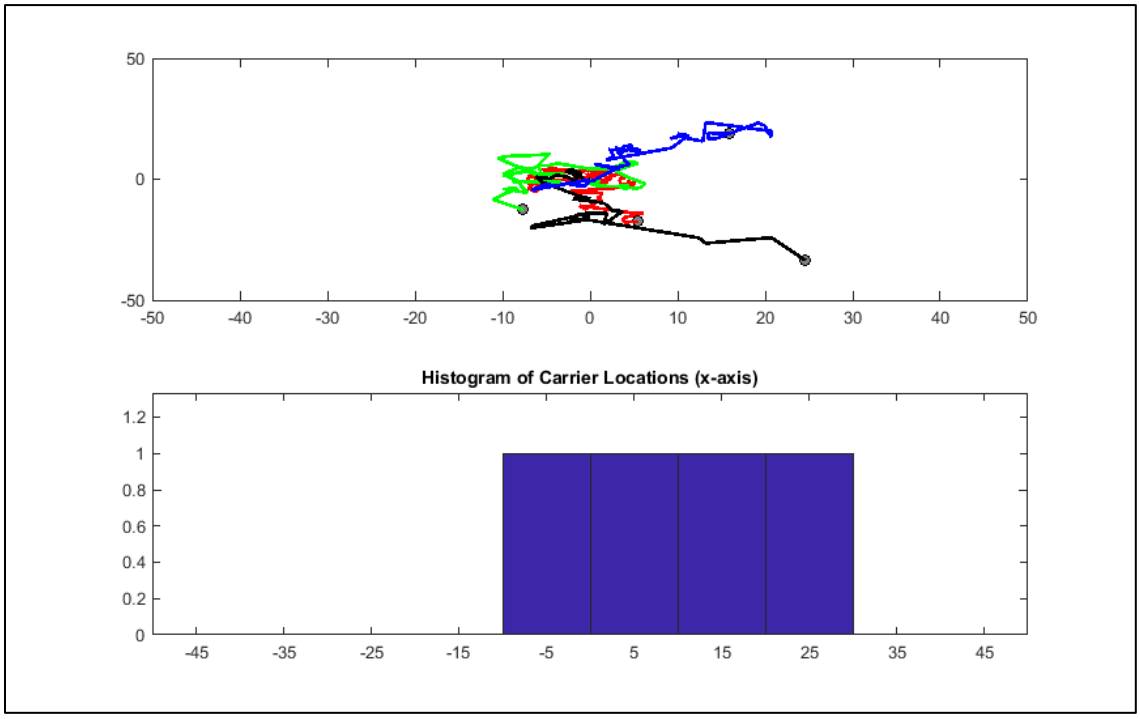
9) Summary of Observations:

Throughout the entirety of the simulation, two factors became clear in deciding what affected the particles' motion, position, and histogram. These two facts were the magnetics fields and the number of particles. When no magnetic field was applied, the particles collided less with one another and their behaviour and were not polarized to one specific point. Once a magnetic field was applied, the particles instantly became polarized to the direction(s) of the prevailing magnetic field. The histograms also reflected this behaviour where the carrier concentrations were higher in the direction the magnetic field was being applied. The number of particles also played a role in the particles' behaviour. When more particles were added, there tended to be more collisions and the particles began to have an increased spread in the histogram. This behaviour was more apparent as the number of particles increased.

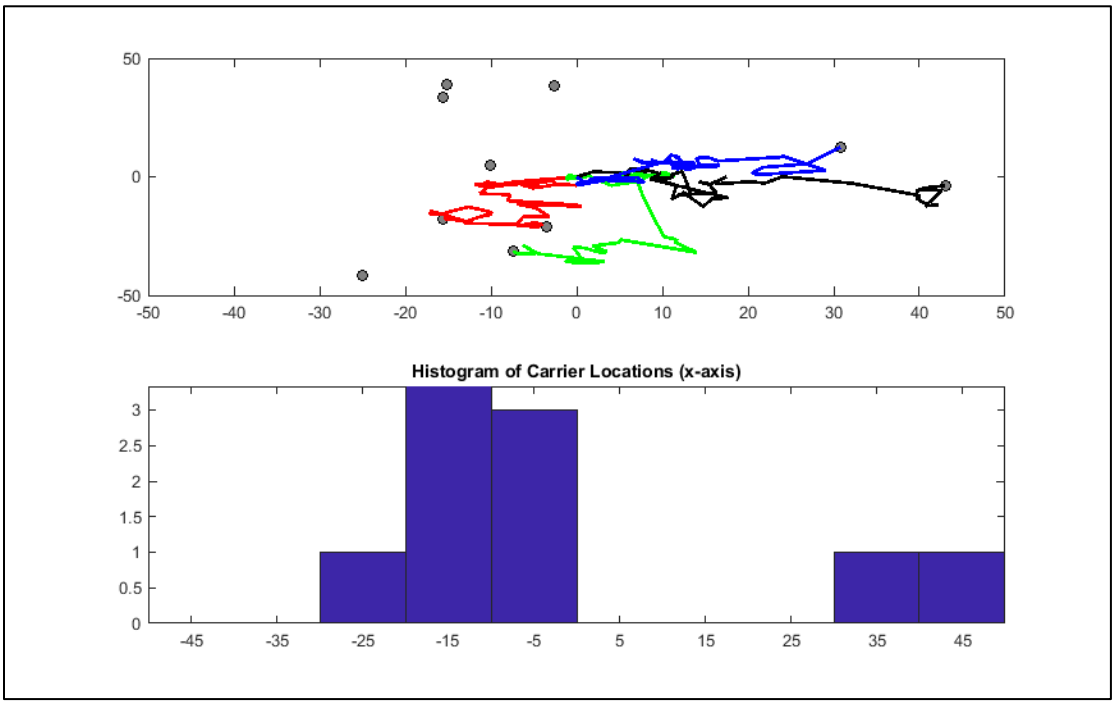
Relevant images for each part are found below

1.

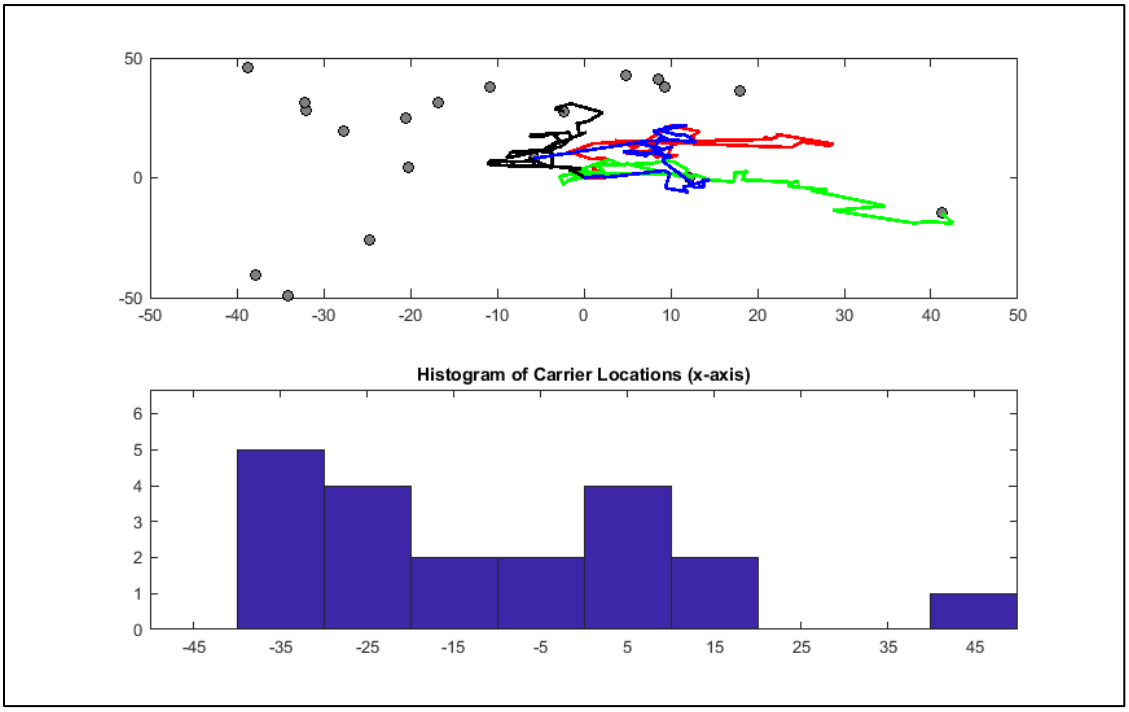
(Ex, Ey, Particles): (0, 0, 4)



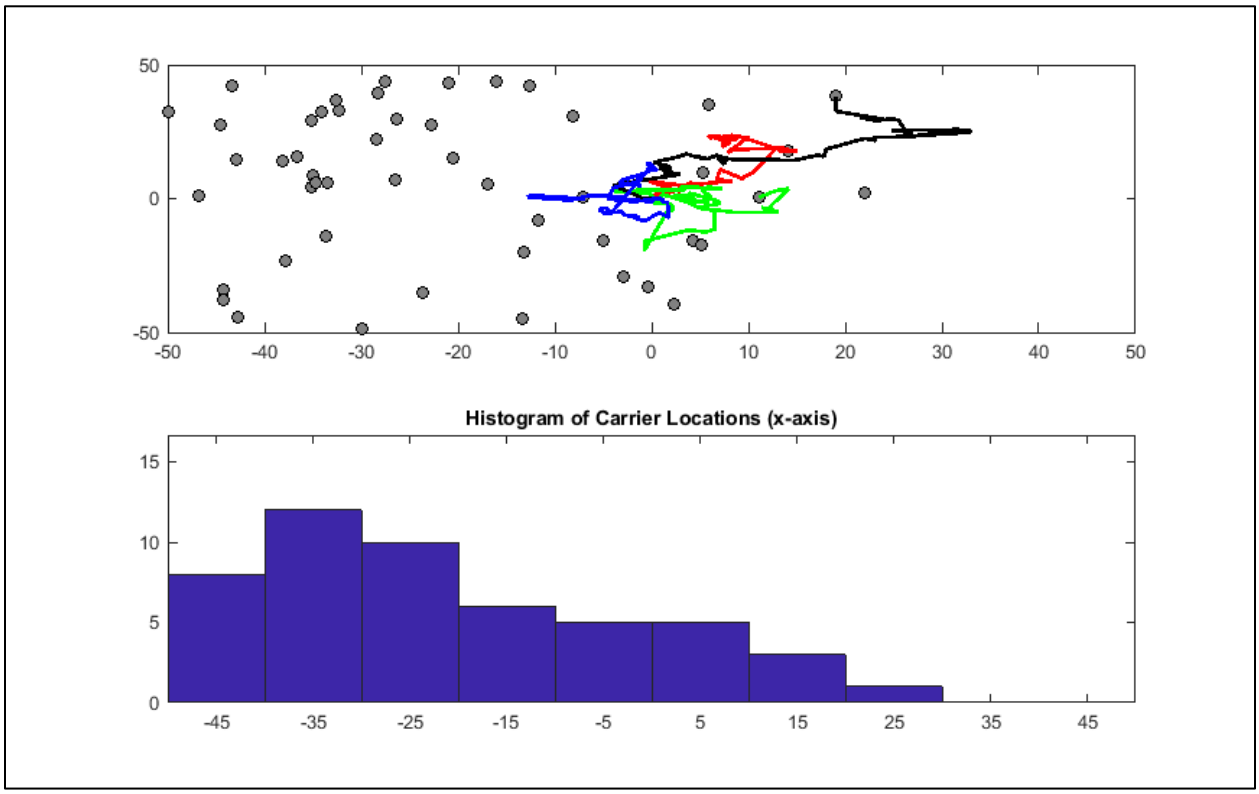
(Ex, Ey, Particles): (0, 0, 10)



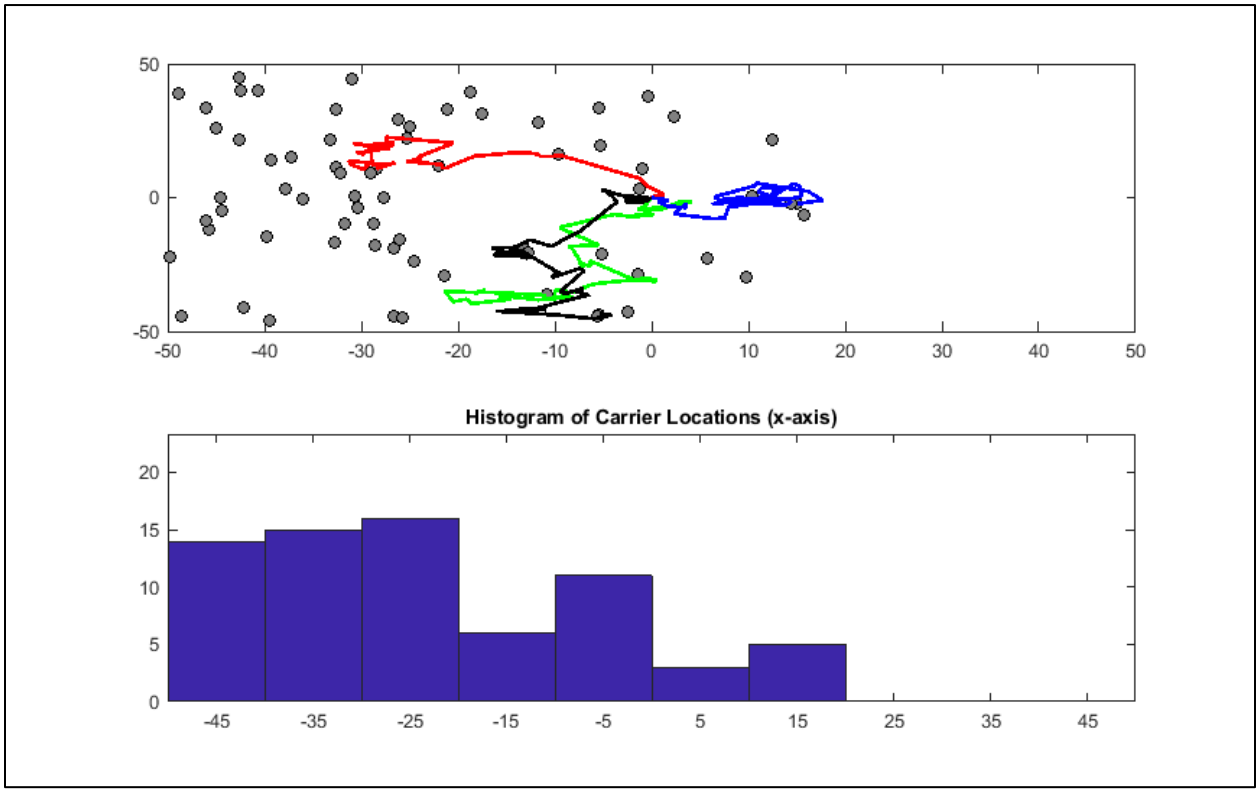
(Ex, Ey, Particles): (0, 0, 20)



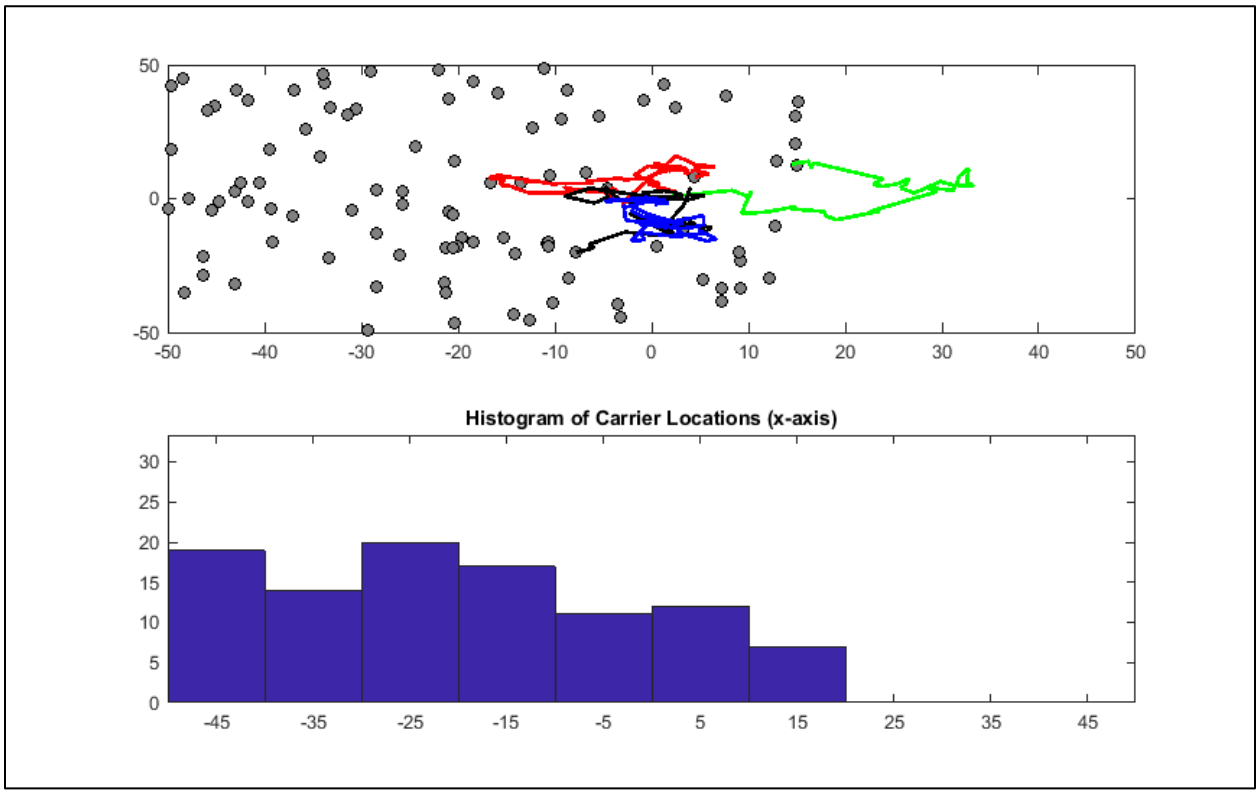
(Ex, Ey, Particles): (0, 0, 50)



(Ex, Ey, Particles): (0, 0, 70)

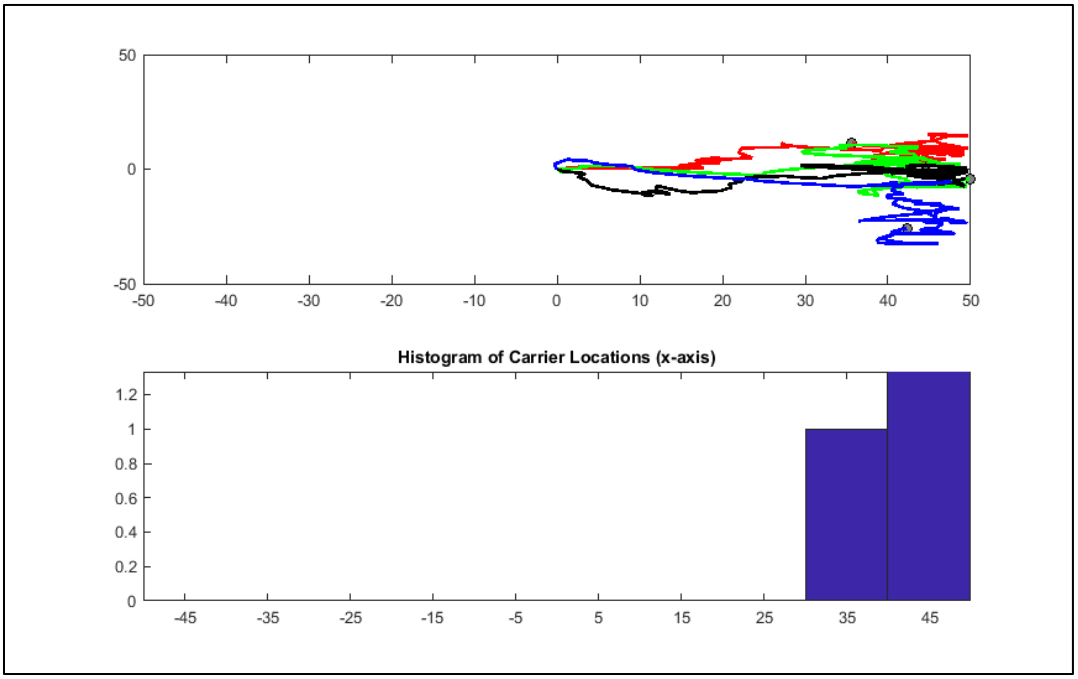


(Ex, Ey, Particles): (0, 0, 100)

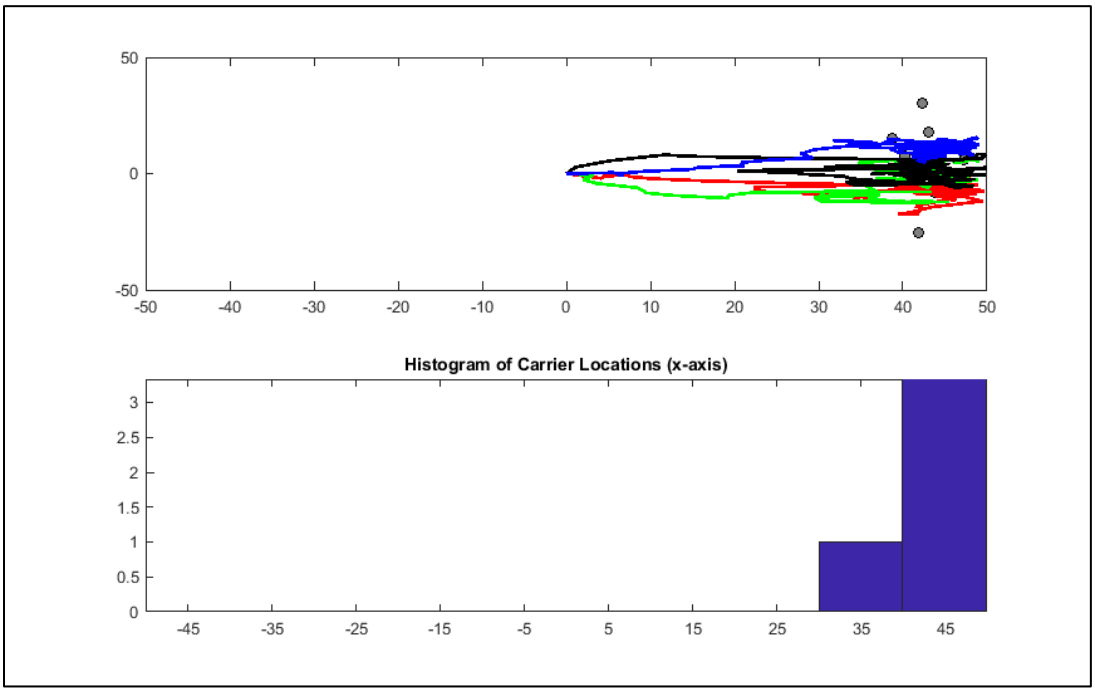


2.

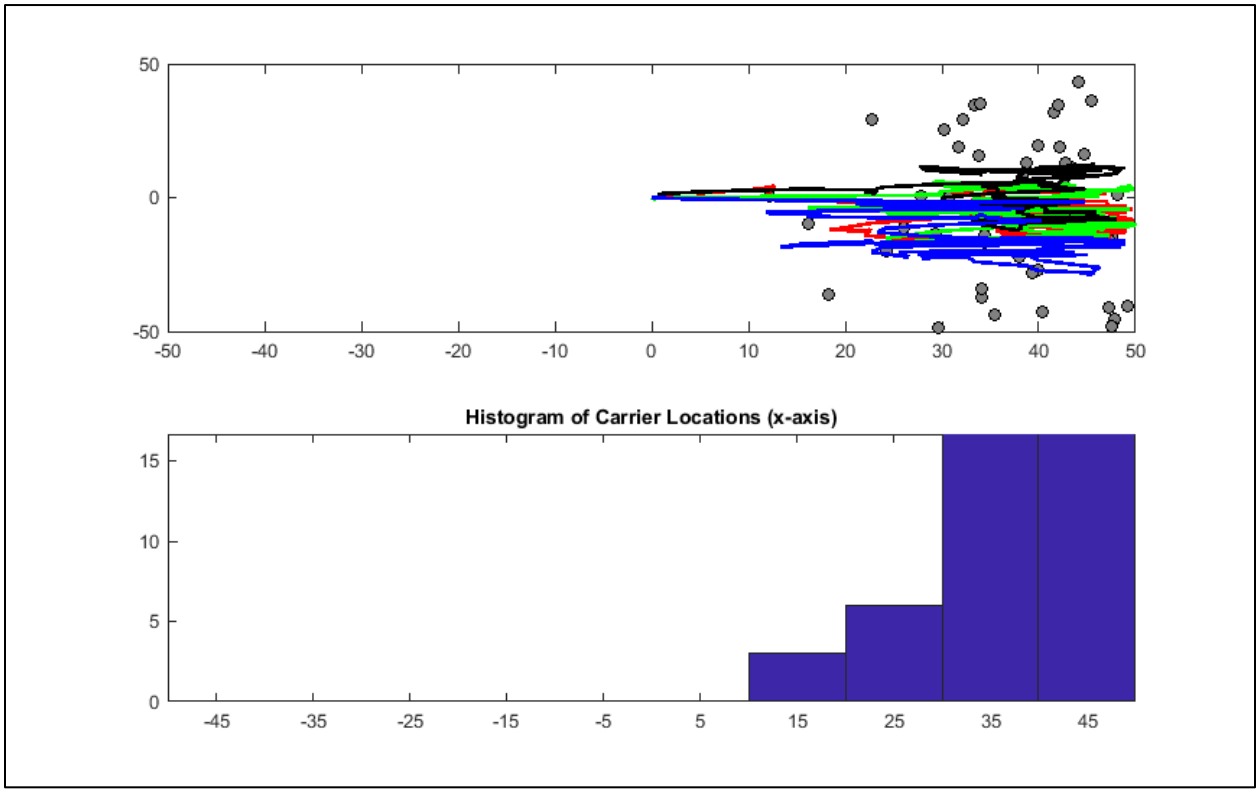
(Ex, Ey, Particles): (2, 0, 4)



(Ex, Ey, Particles): (3, 0, 10)

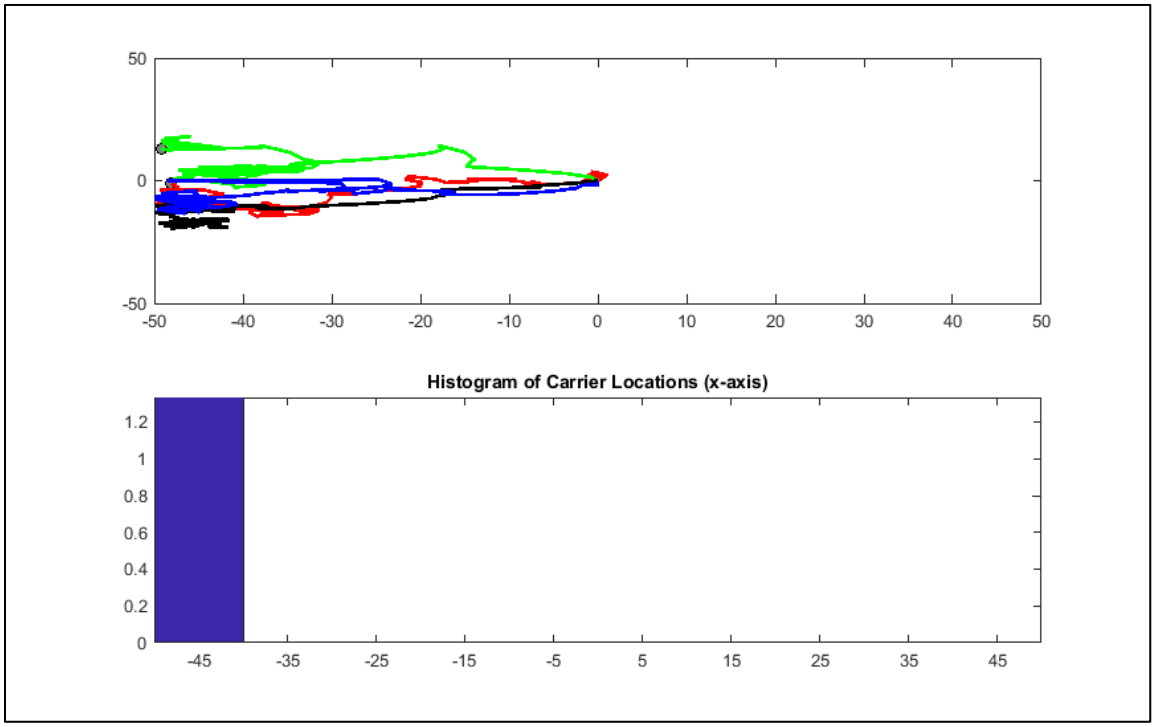


(Ex, Ey, Particles): (5, 0, 50)

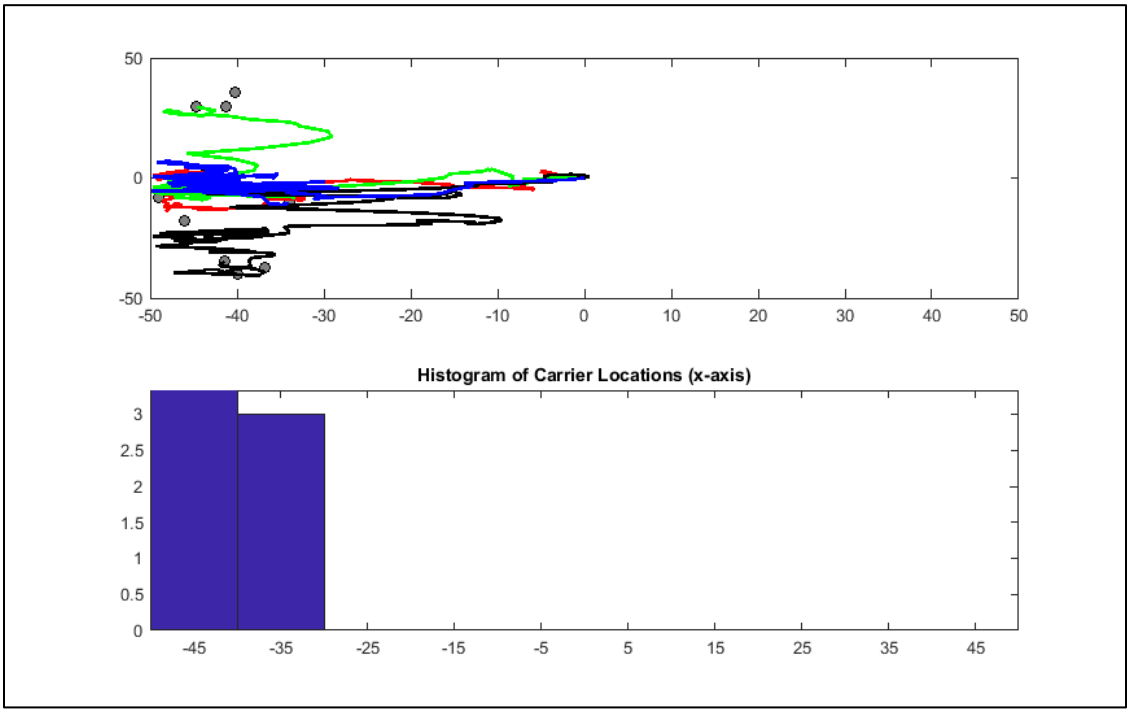


3.

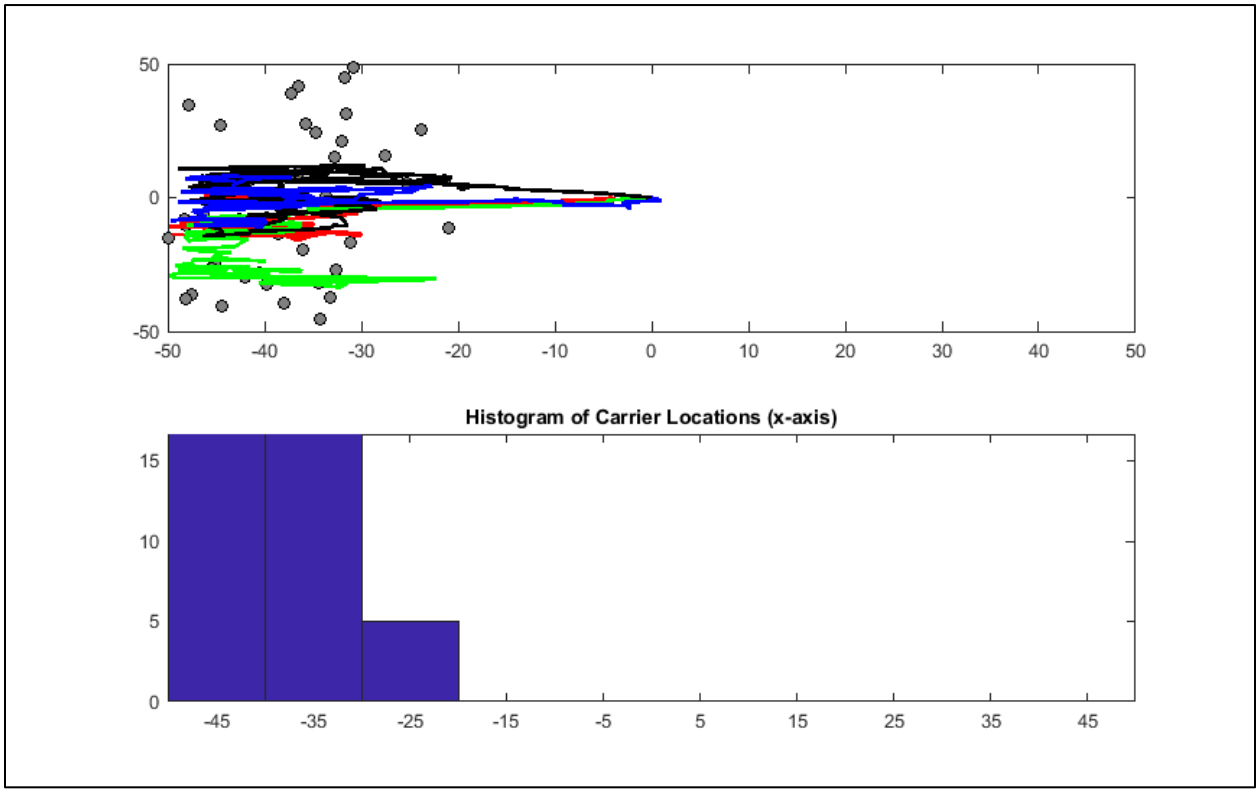
(Ex, Ey, Particles): (-2,0, 4)



(Ex, Ey, Particles): (3, 0, 10)

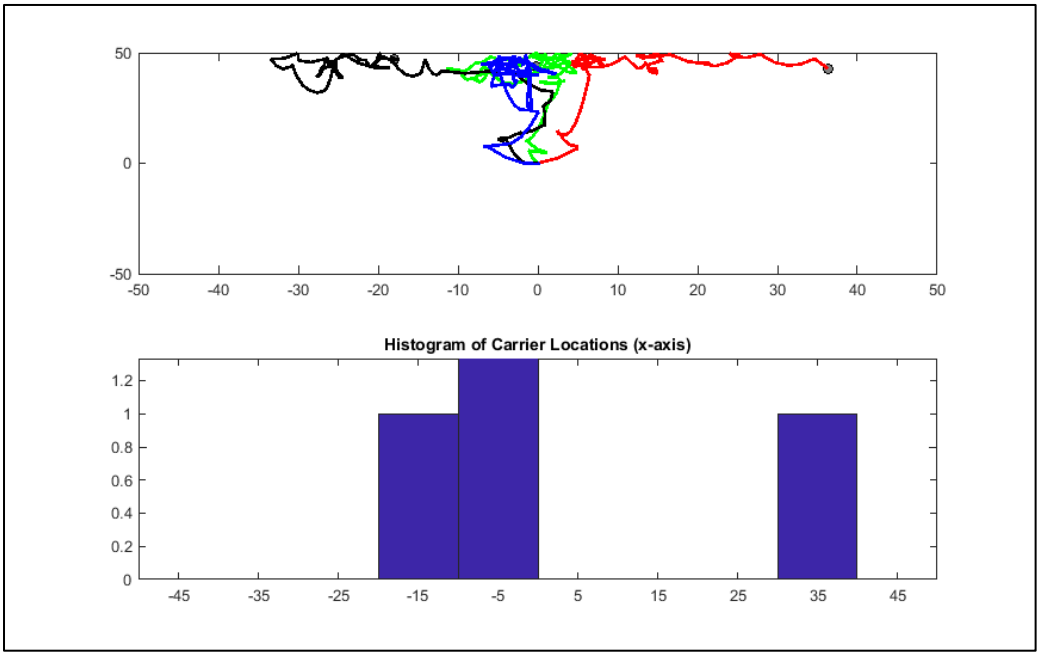


(Ex, Ey, Particles): (5, 0, 50)

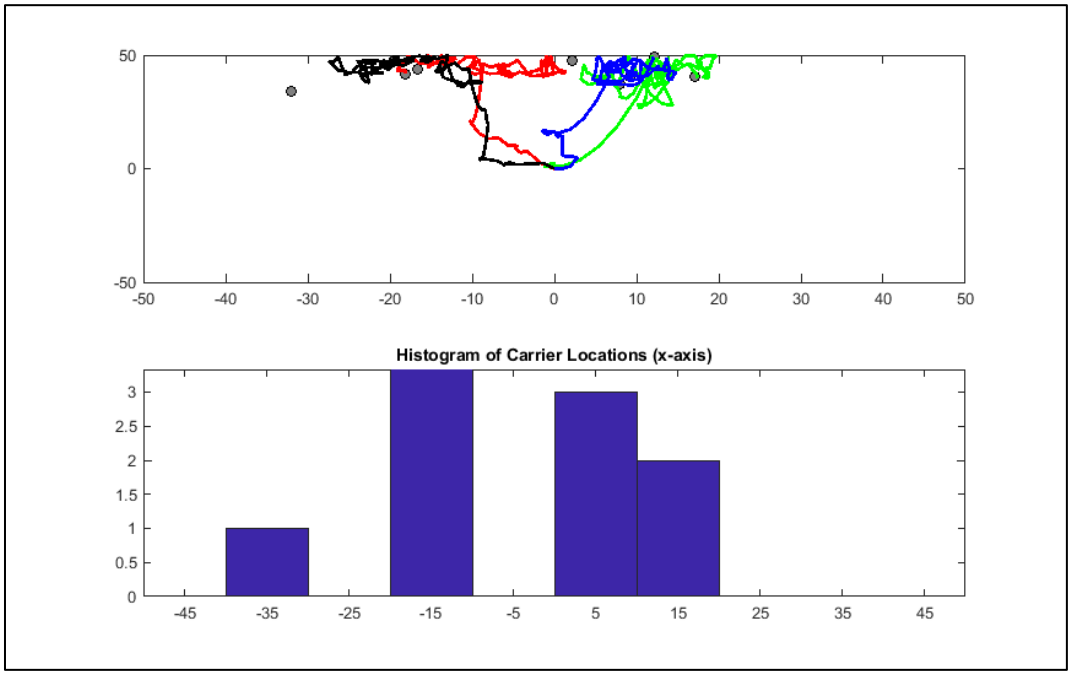


4.

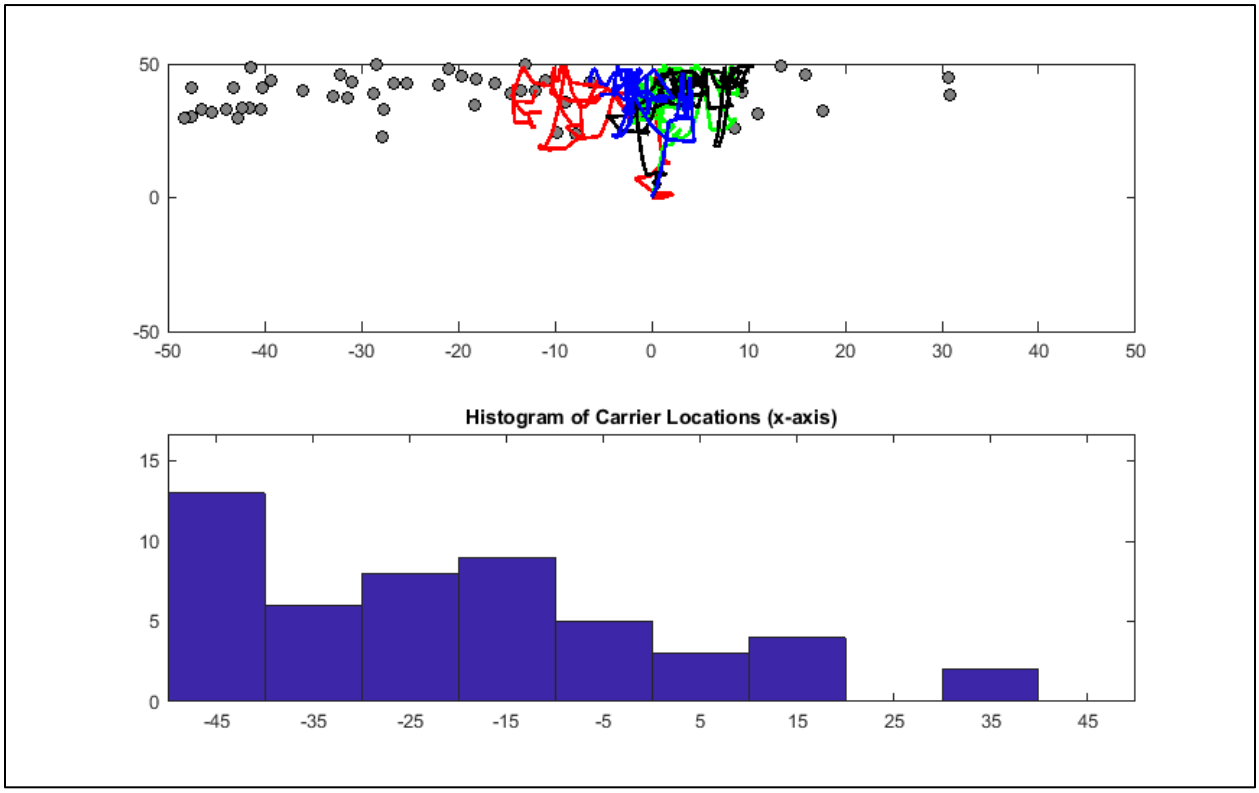
(Ex, Ey, Particles): (0, 2, 4)



(Ex, Ey, Particles): (0, 3, 10)

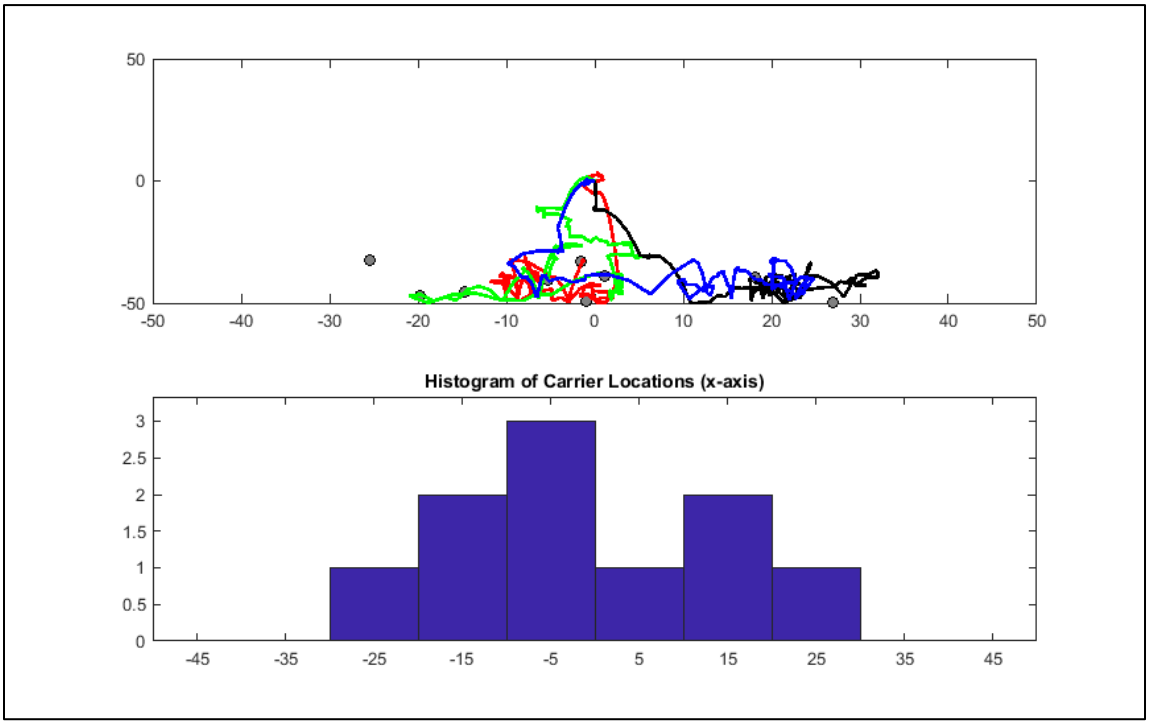


(Ex, Ey, Particles): (0, 5, 50)

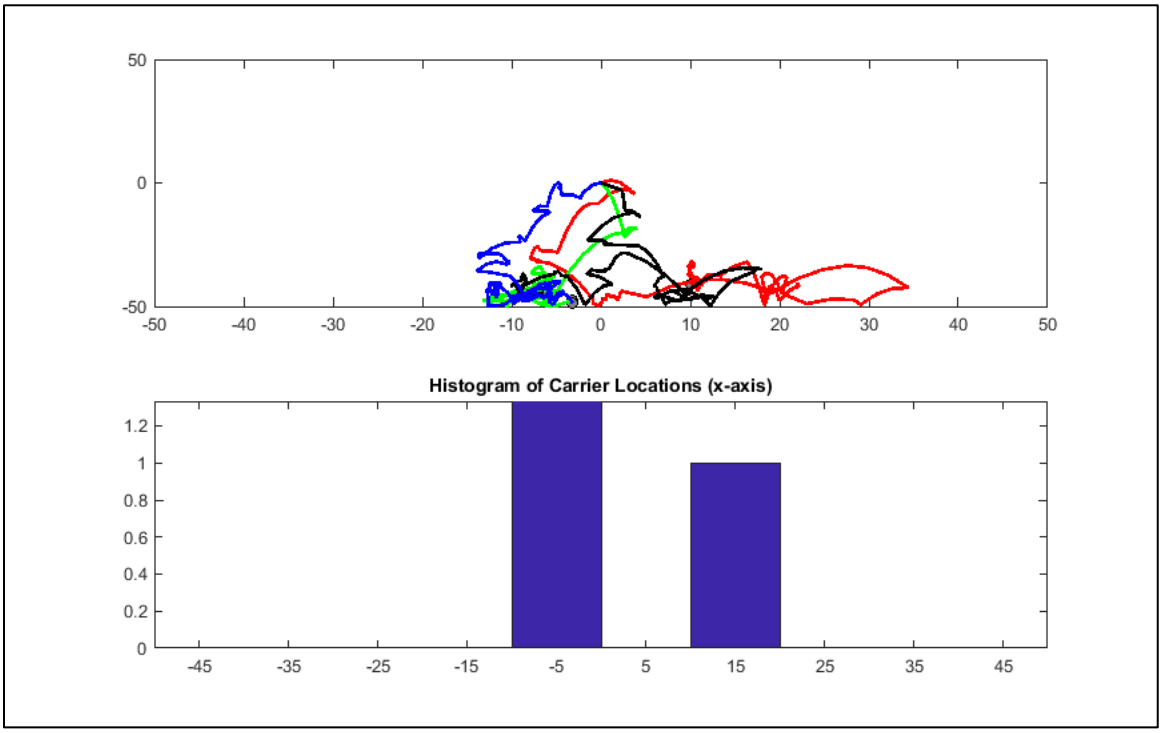


5.

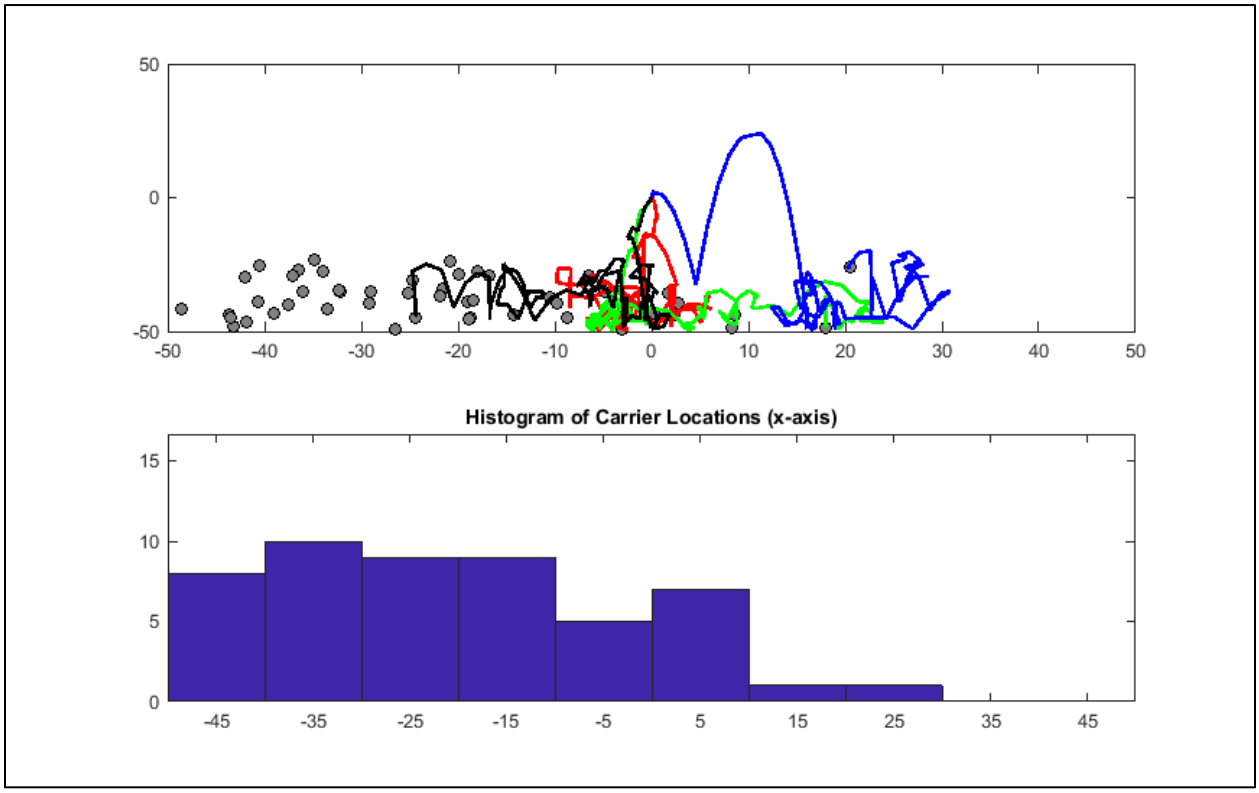
(Ex, Ey, Particles): (0, -2, 4)



(Ex, Ey, Particles): (0, -3, 10)

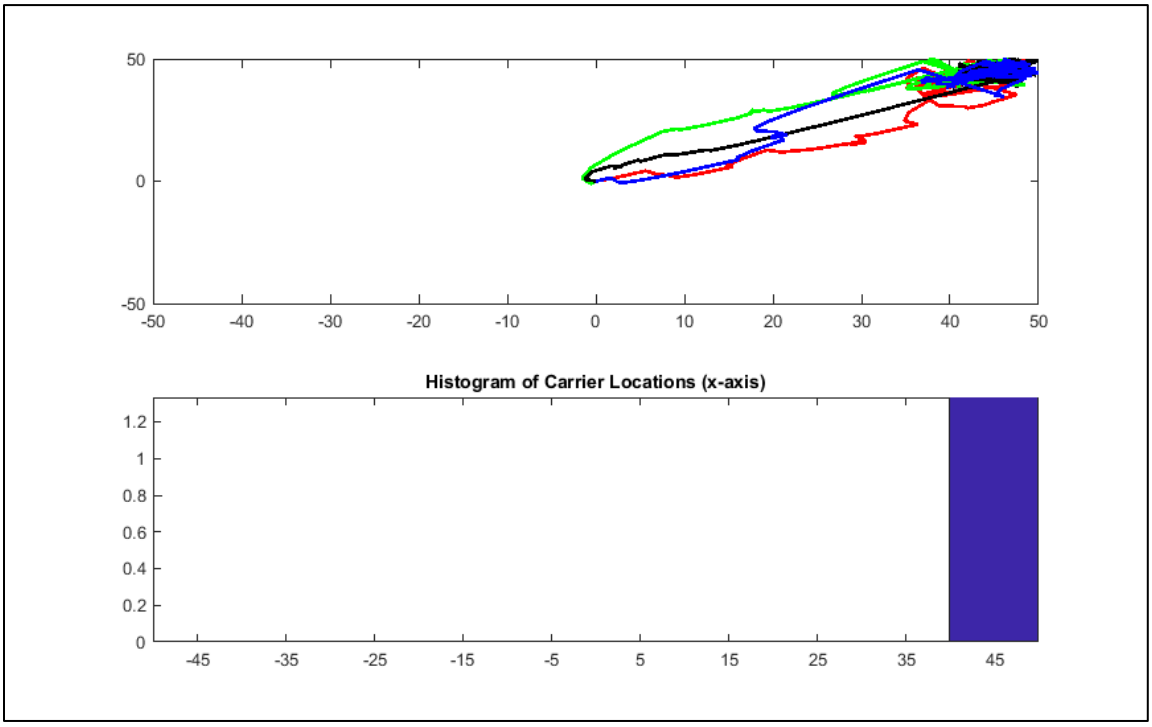


(Ex, Ey, Particles): (0, -5, 50)

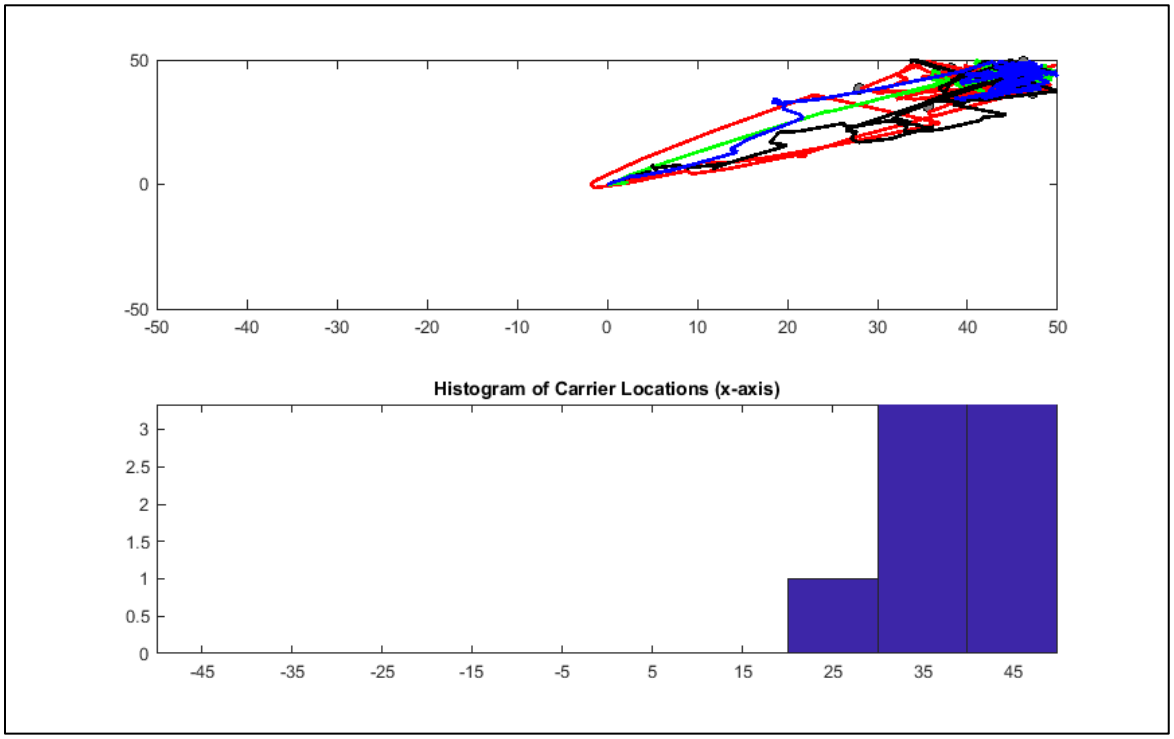


6.

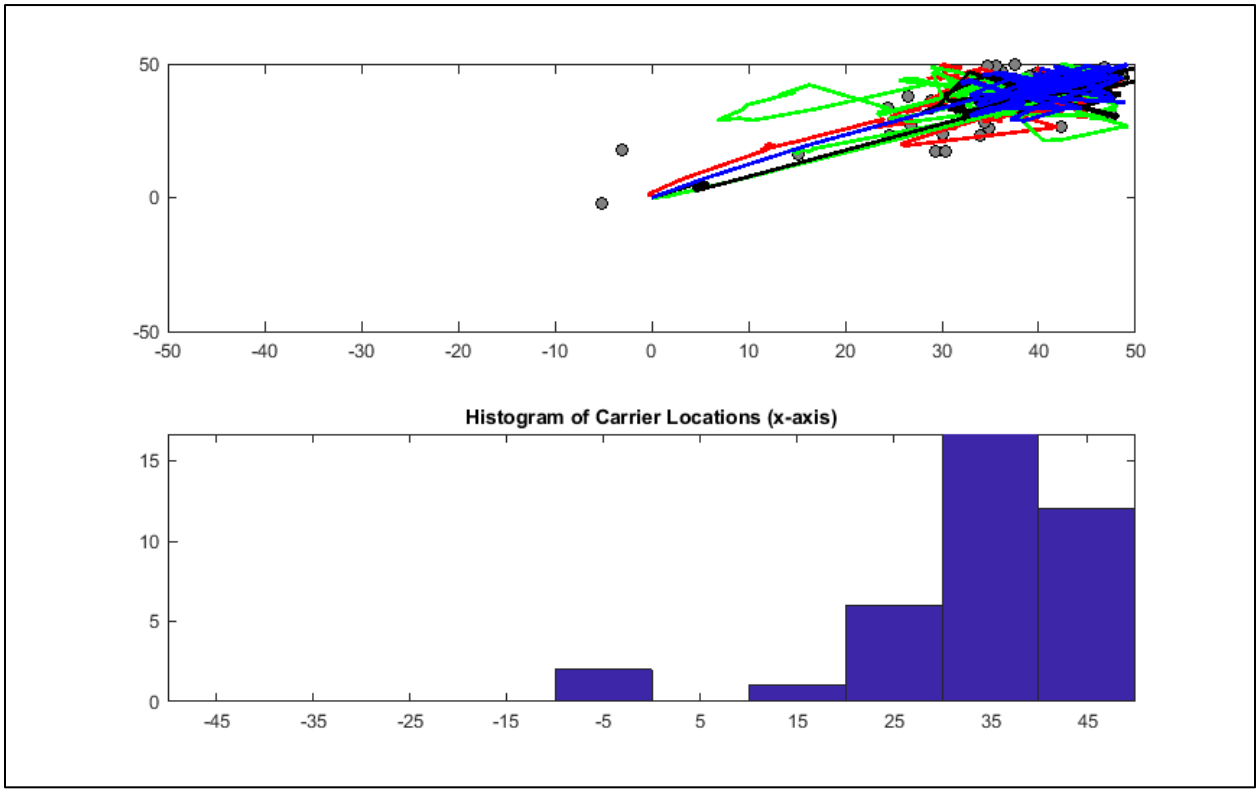
(Ex, Ey, Particles): (2, 2, 4)



(Ex, Ey, Particles): (3, 3, 10)

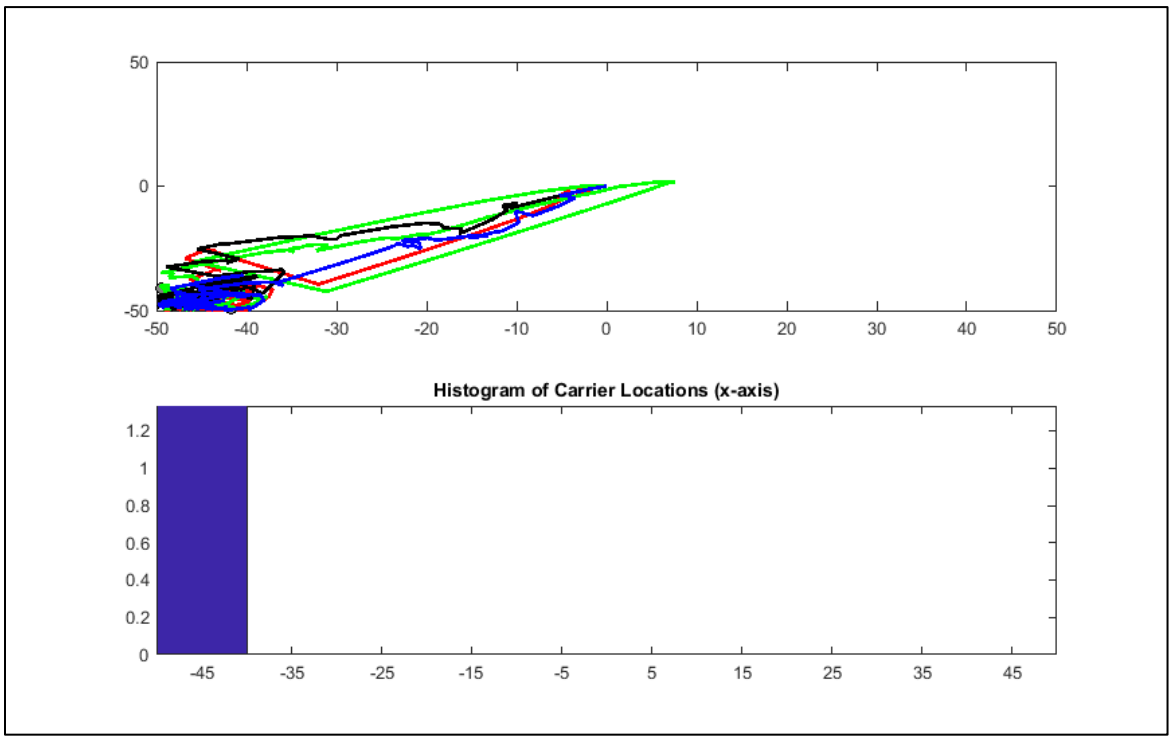


(Ex, Ey, Particles): (5, 5, 50)

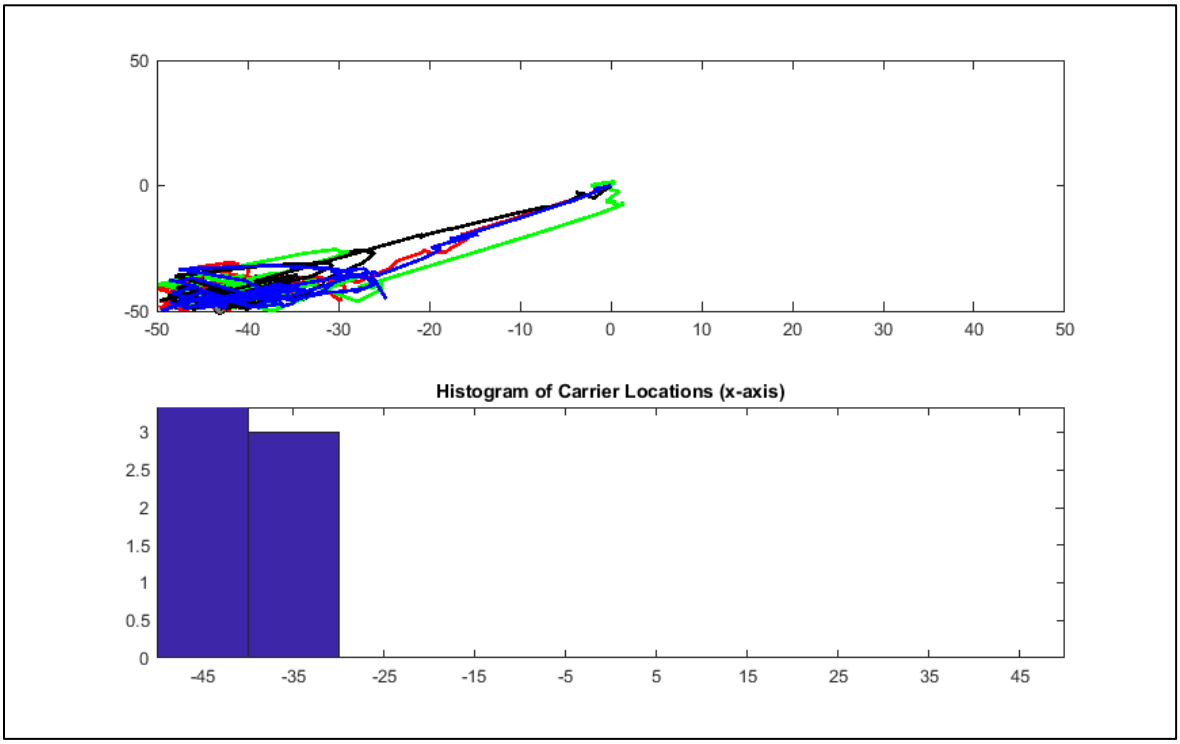


7.

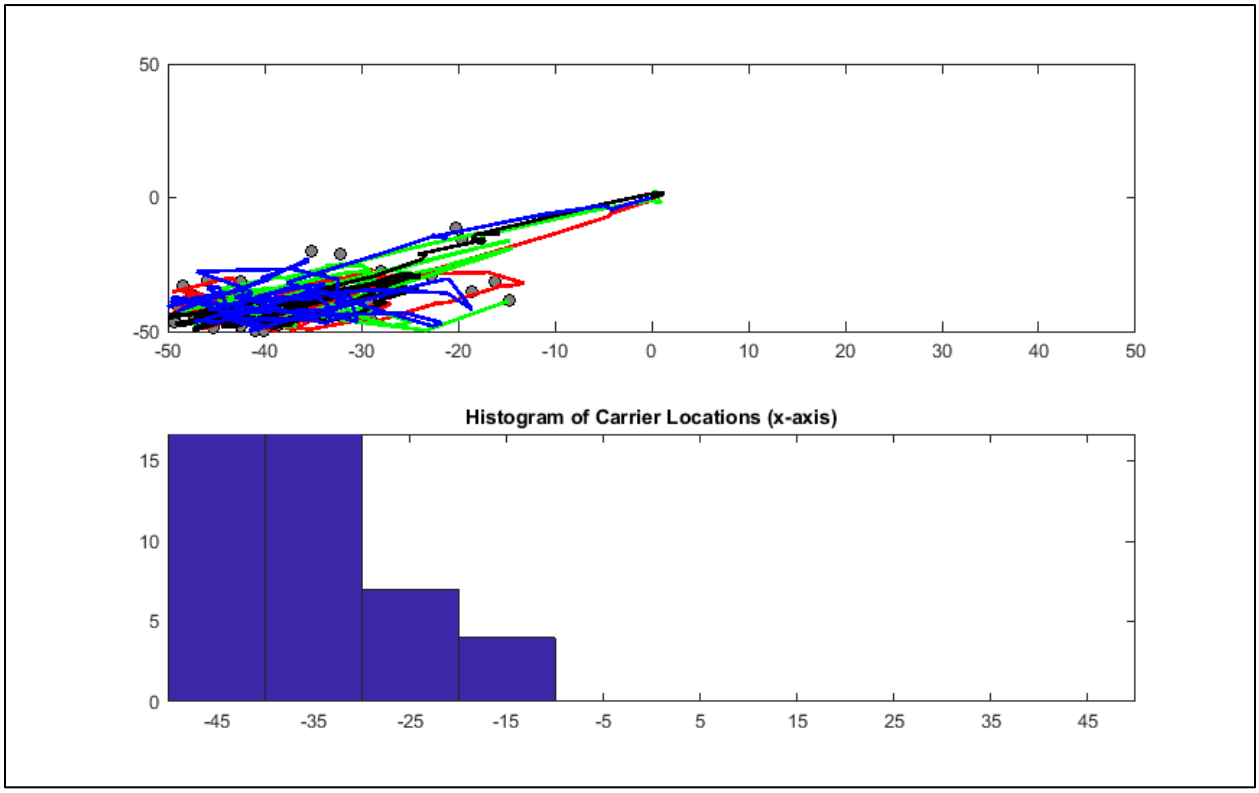
(Ex, Ey, Particles): (-2, -2, 4)



(Ex, Ey, Particles): (-3, -3, 10)

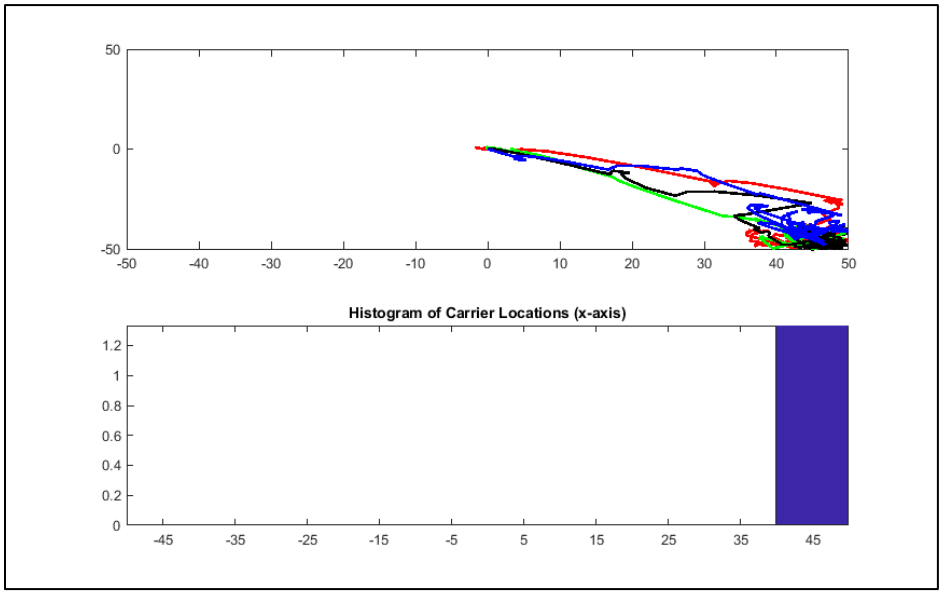


(Ex, Ey, Particles): (-5, -5, 50)

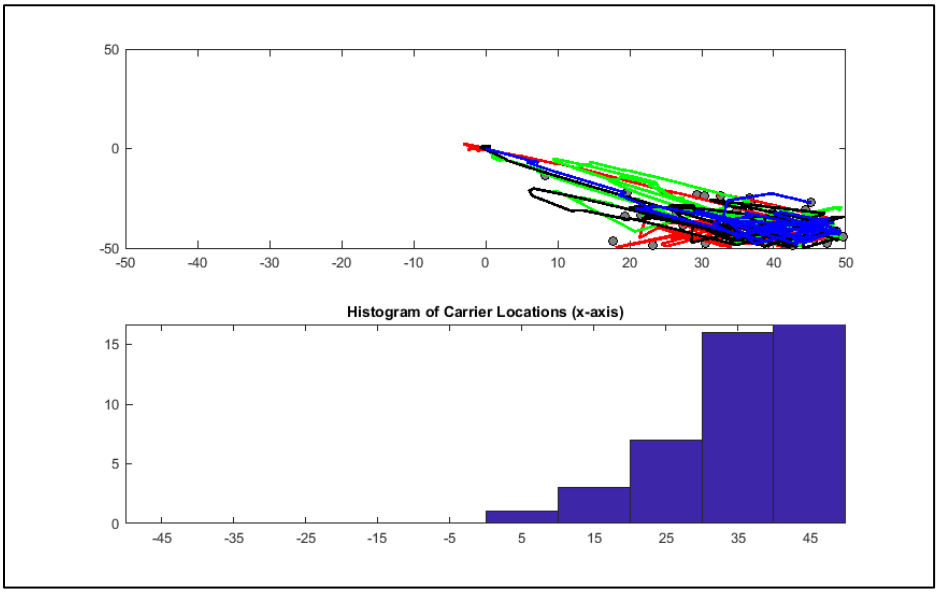


8.

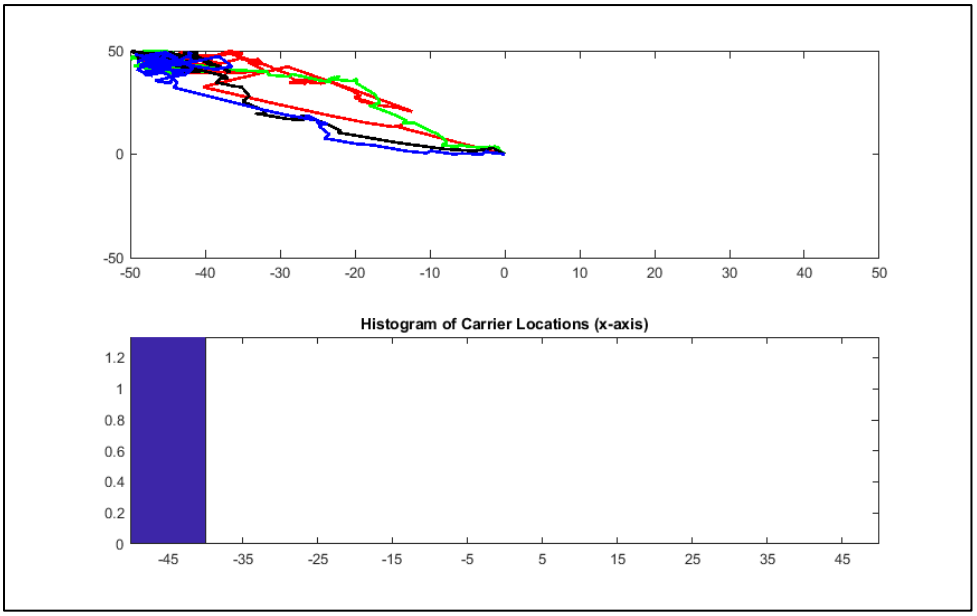
(Ex, Ey, Particles): (2, -2, 4)



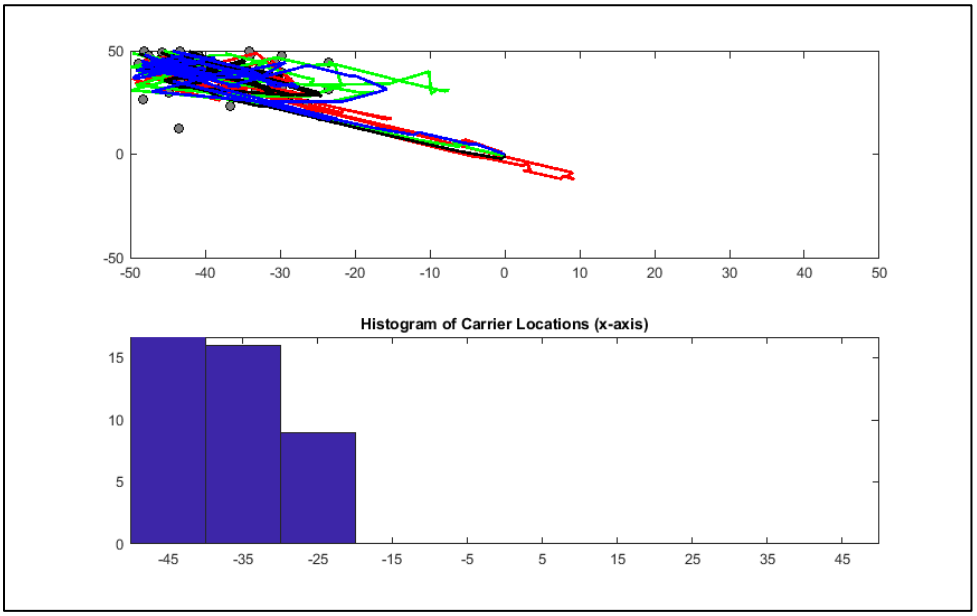
(Ex, Ey, Particles): (5, -5, 50)



(Ex, Ey, Particles): (-2, 2, 4)



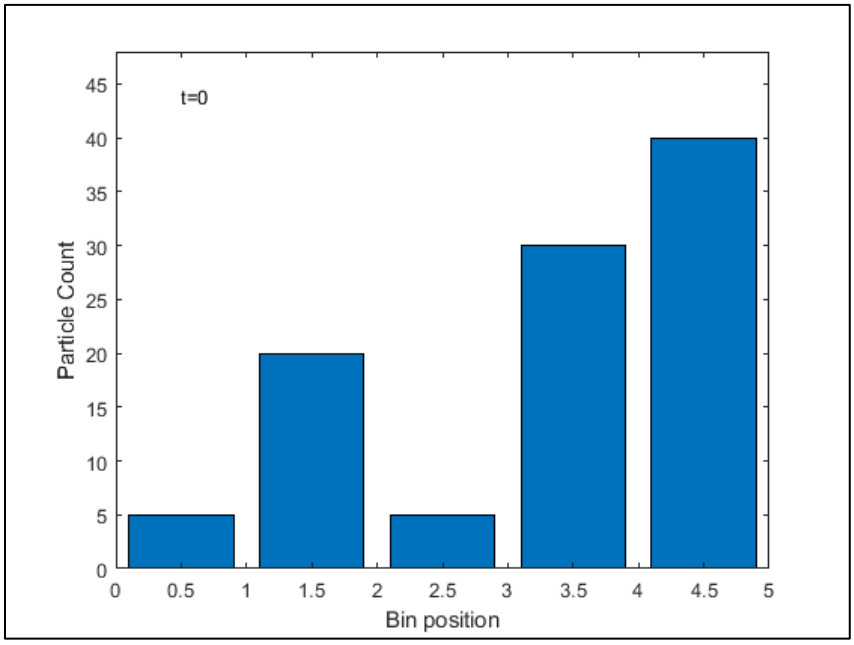
(Ex, Ey, Particles): (-5, 5, 50)



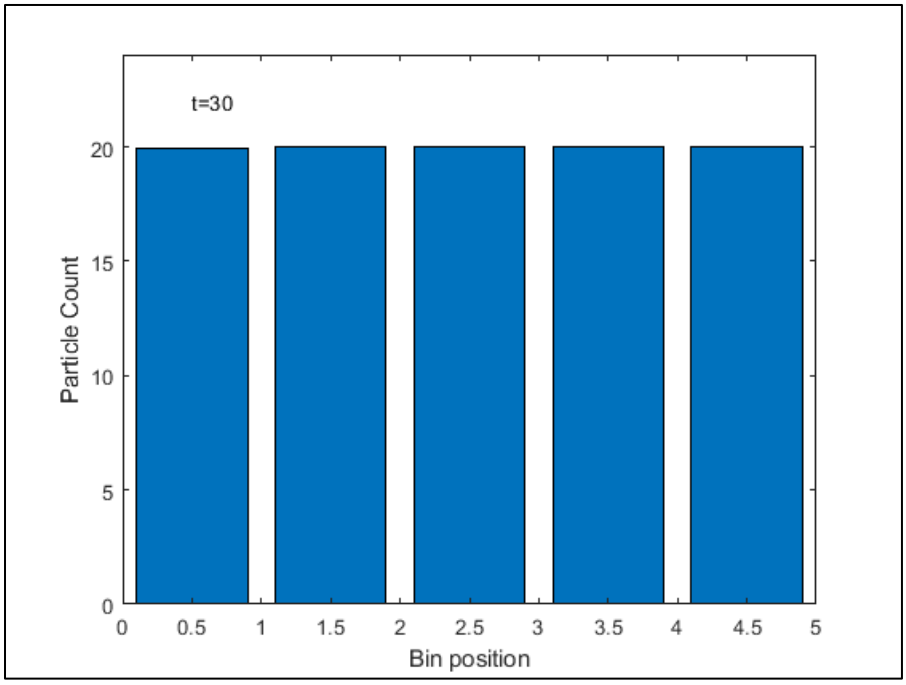
Assignment tasks for part Two:

1. Observations

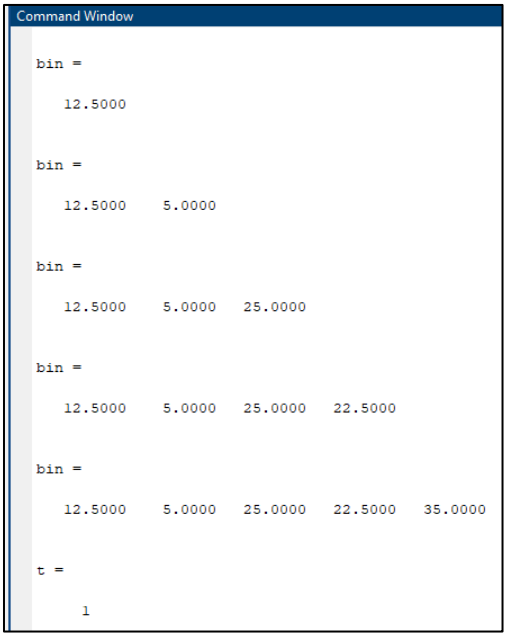
Initial Bin Count



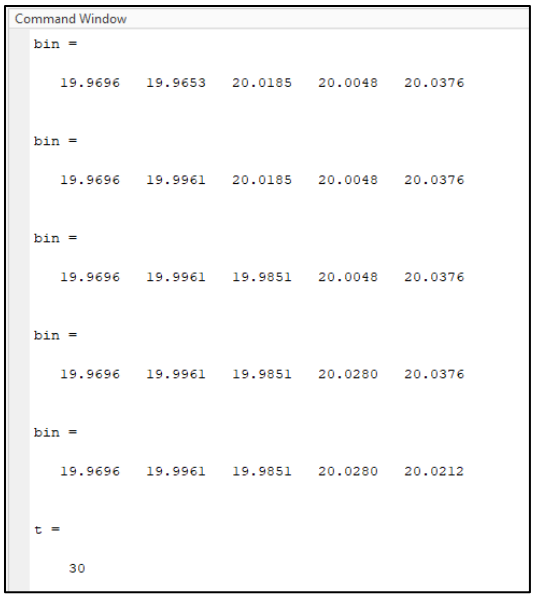
Finalized Bin Count



Command window at t = 1

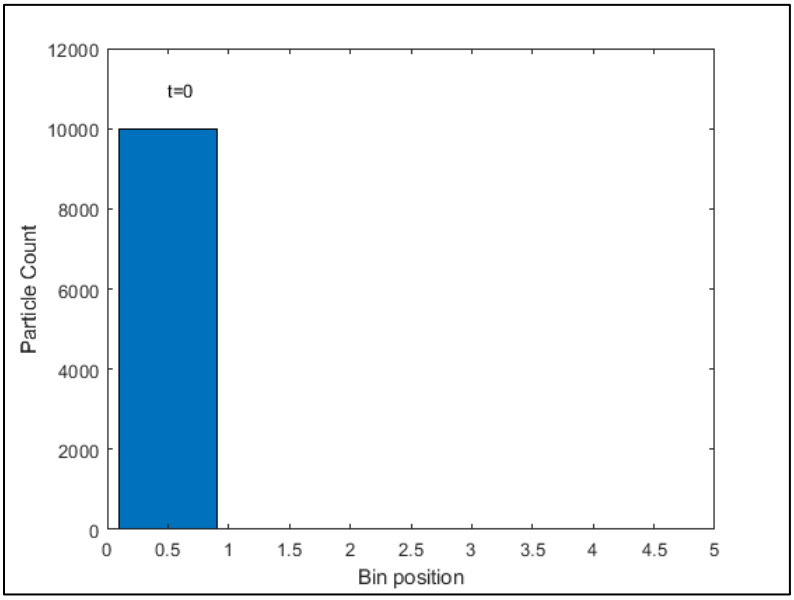


Command window at t = 25

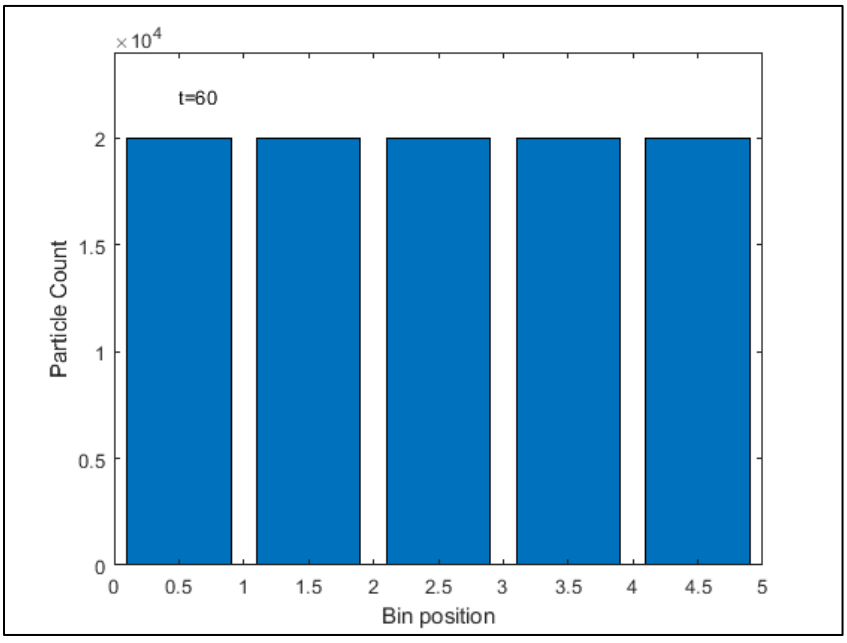


2.

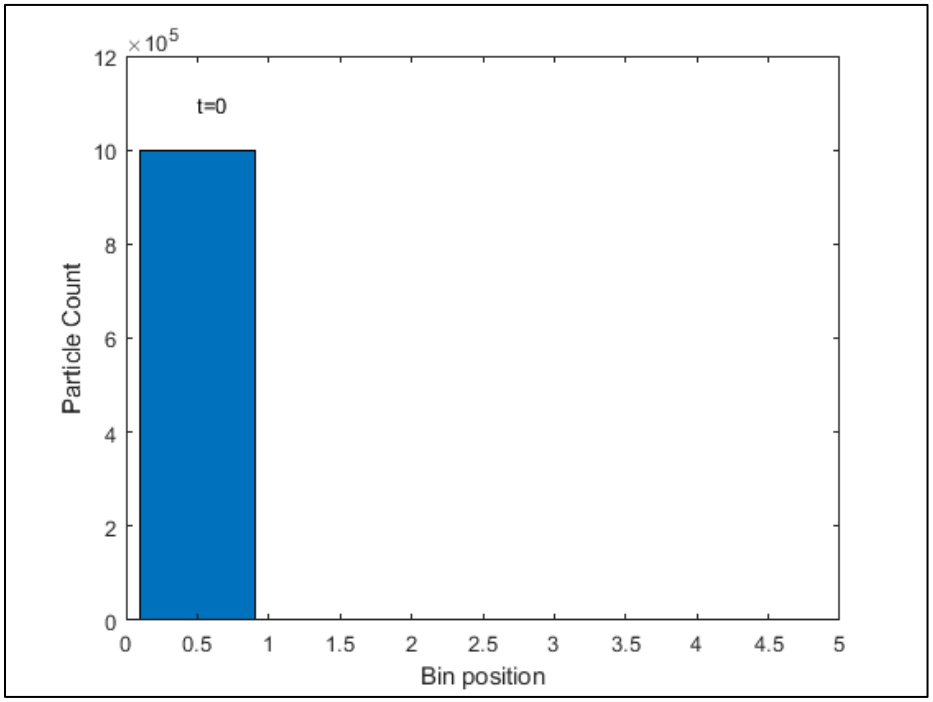
Initial Bin



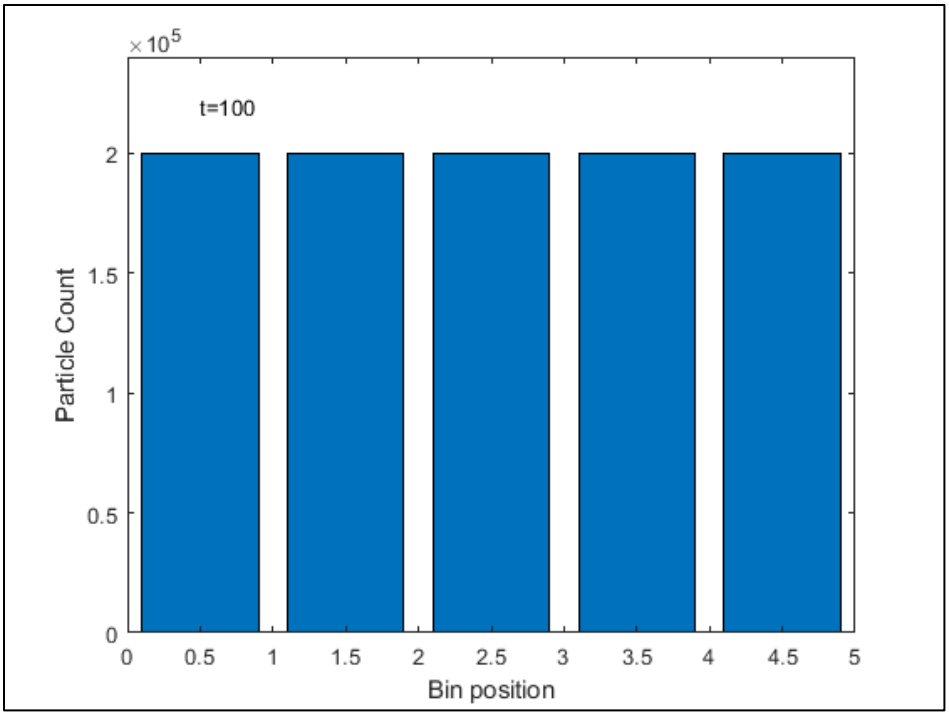
10 000 particles with N set to 60



Initial Bin

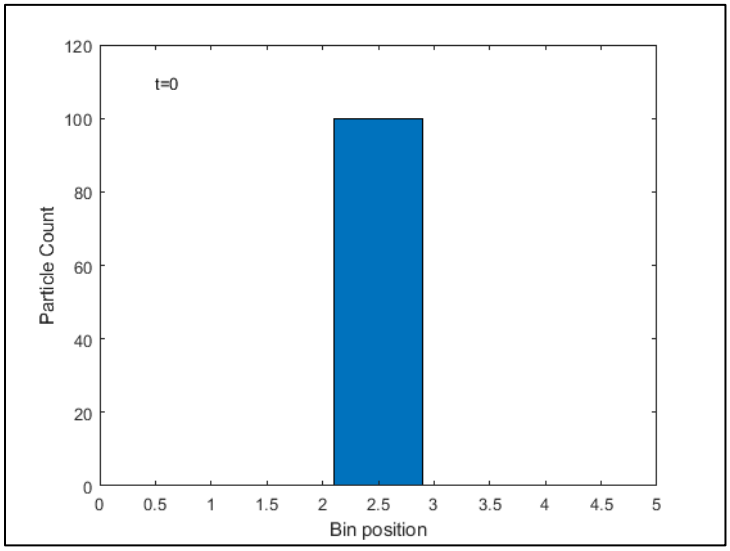


1E6 particles with N set to 100

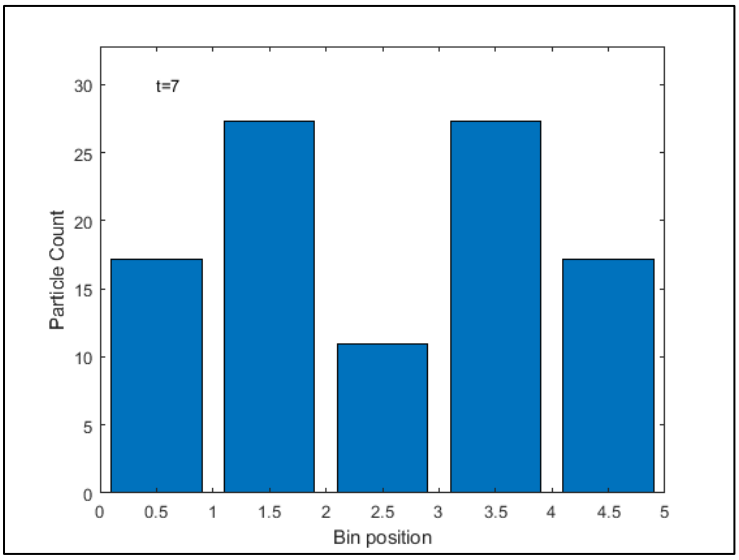


3.

Initialization



Result at t = 7

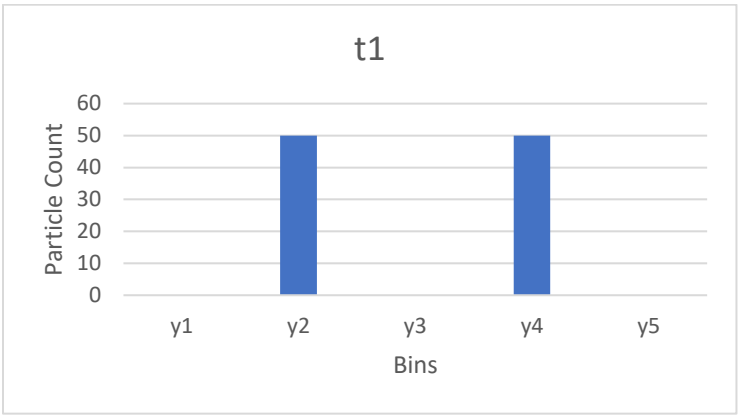


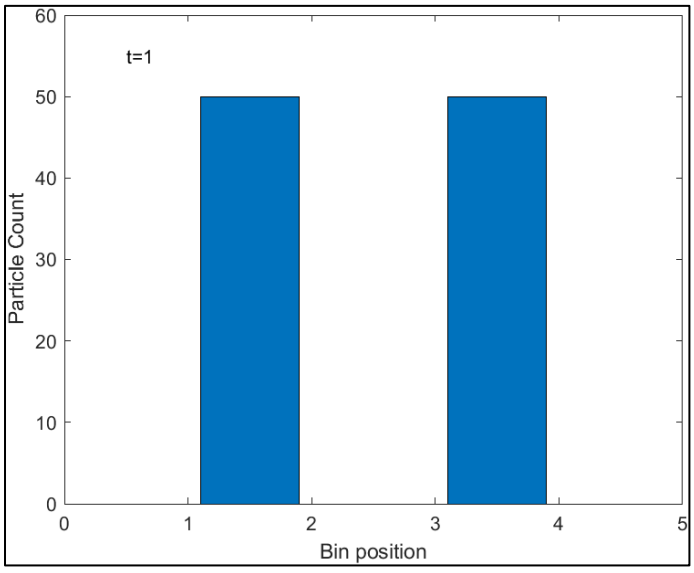
Excel Result

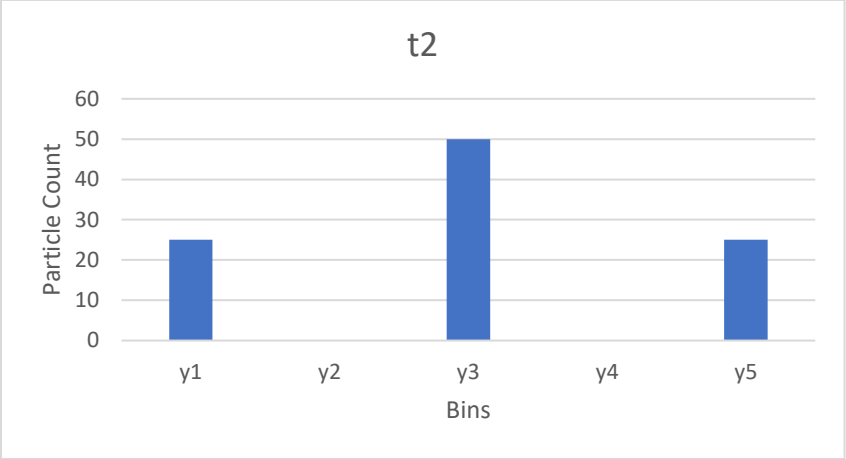
		Time						
		t0	t1	t2	t3	t4	t5	t6	t7
	y1		0	25	12.5	25	15.625	23.4375	17.1875
	y2		50	0	37.5	6.25	31.25	10.9375	27.3438
Bin	y3		0	50	0	37.5	6.25	31.25	10.9375
	y4		50	0	37.5	6.25	31.25	10.9375	27.3438
	y5		0	25	12.5	25	15.625	23.4375	17.1875

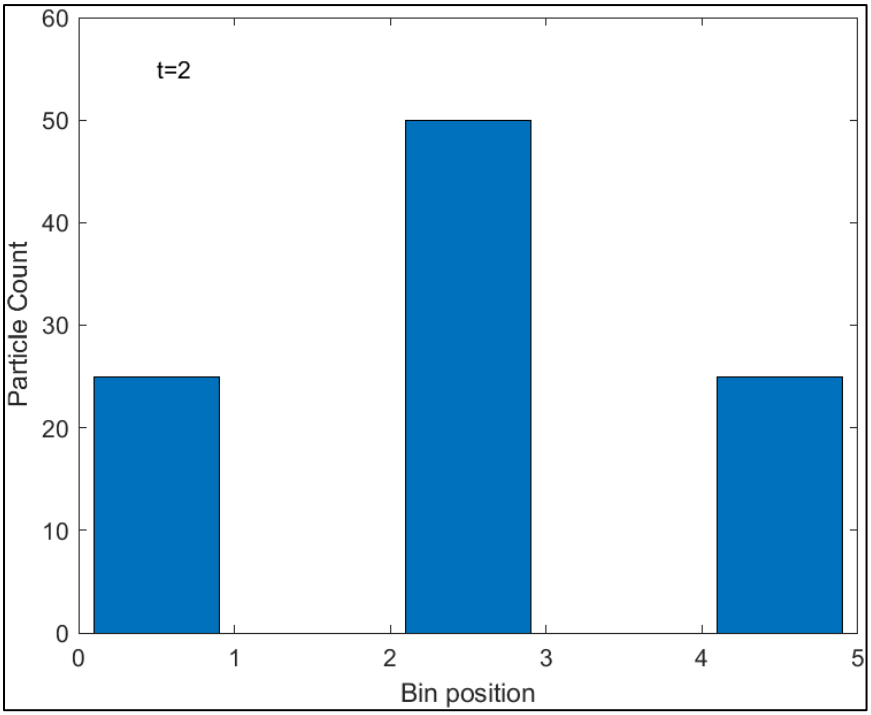
4.

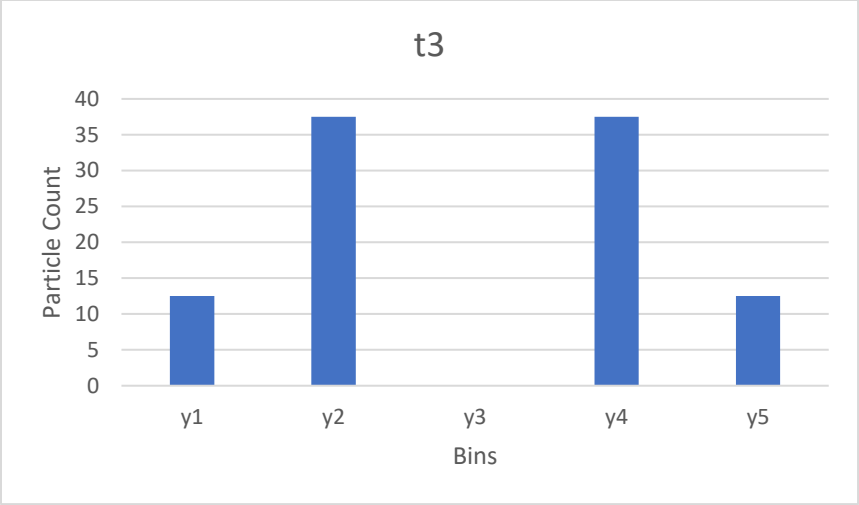
Excel and MATLAB Generated Graphs for Each Time Unit Comparison

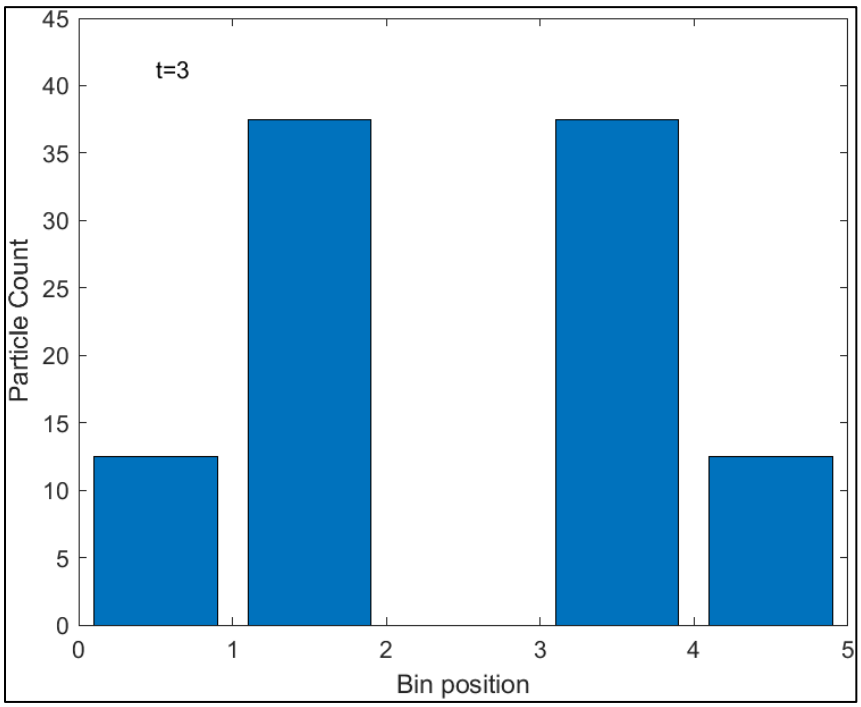


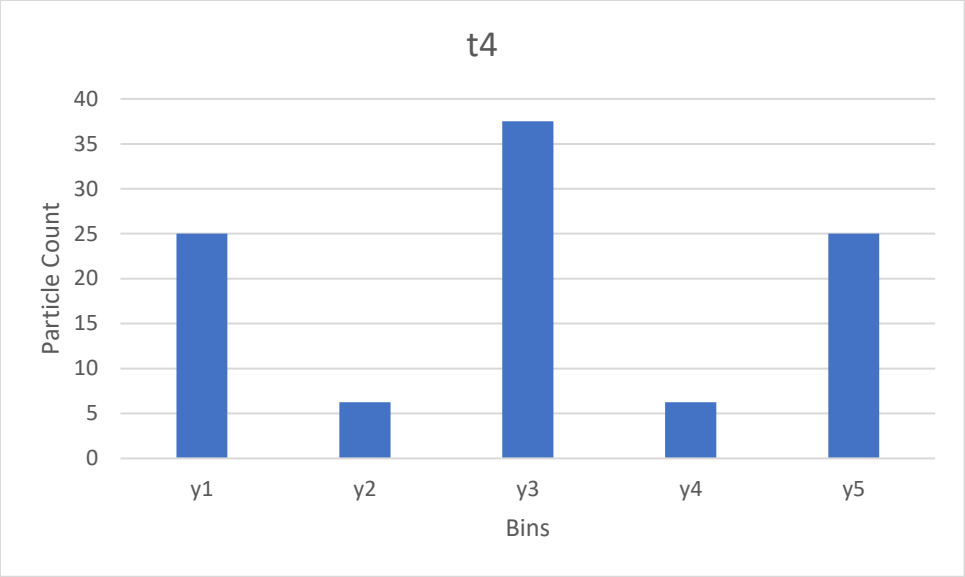


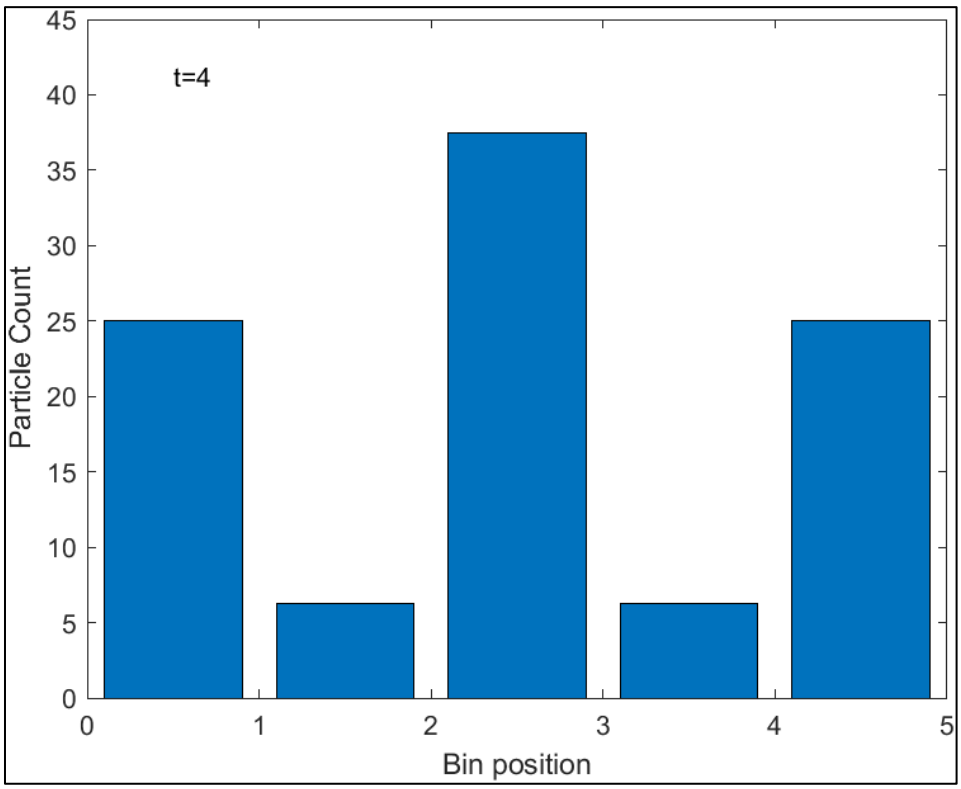

t2
Particle Count
60
50
40
30
20
10
0
y1
y2
y3
y4
y5
Bins

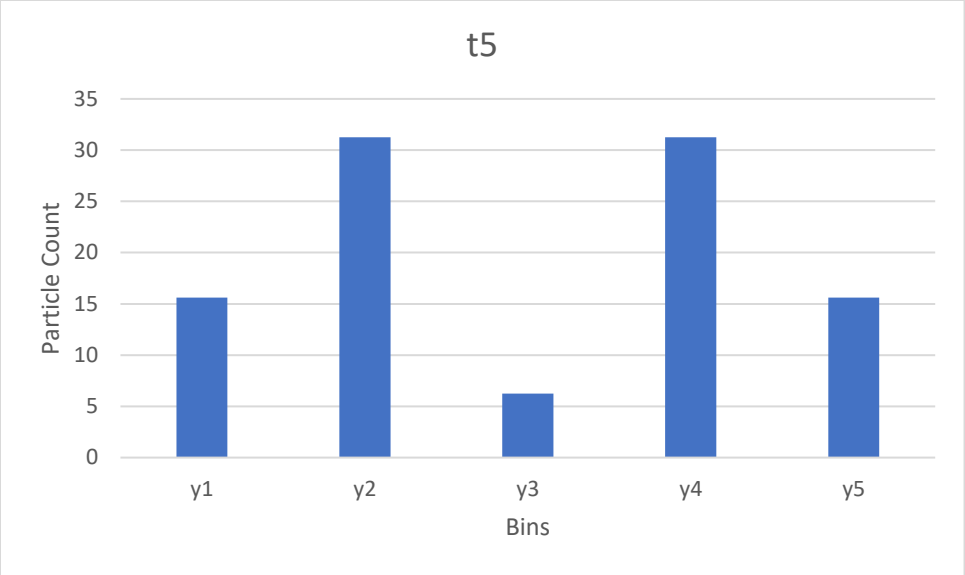

t=2
Particle Count
60
50
40
30
20
10
0
0
1
2
3
4
5
Bin position

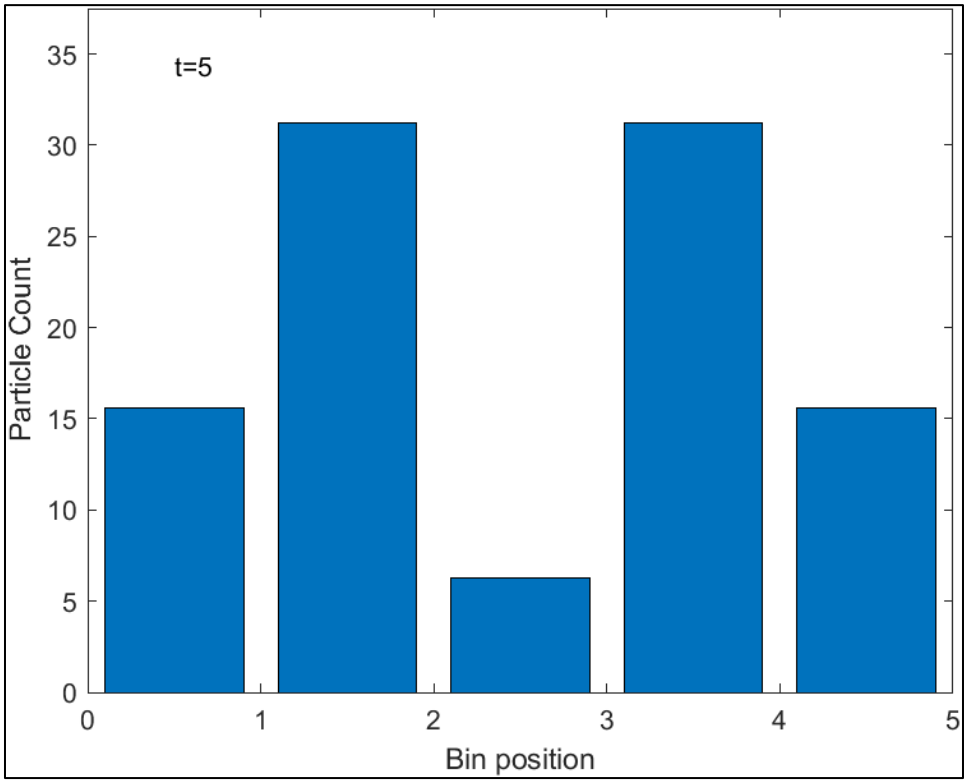

t3
Particle Count
40
35
30
25
20
15
10
5
0
y1
y2
y3
y4
y5
Bins

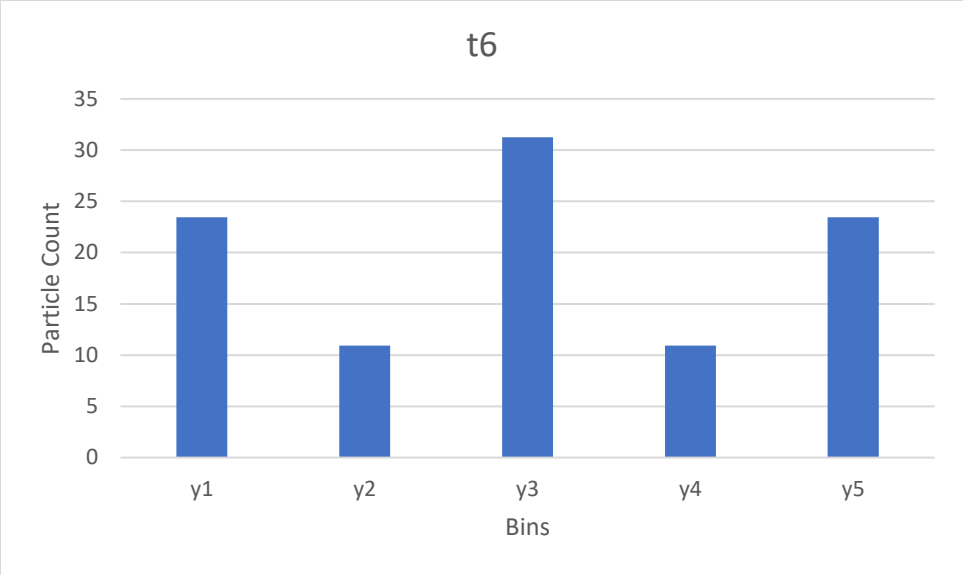

t=3
Particle Count
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
Bin position

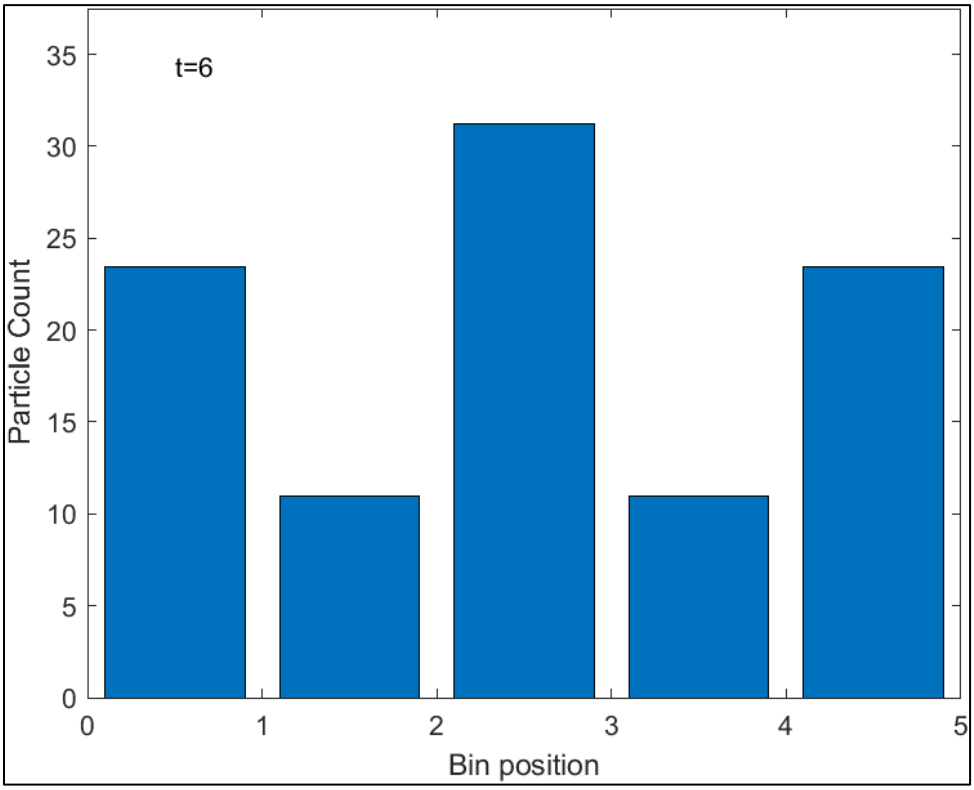

t4
Particle Count
40
35
30
25
20
15
10
5
0
y1
y2
y3
y4
y5
Bins

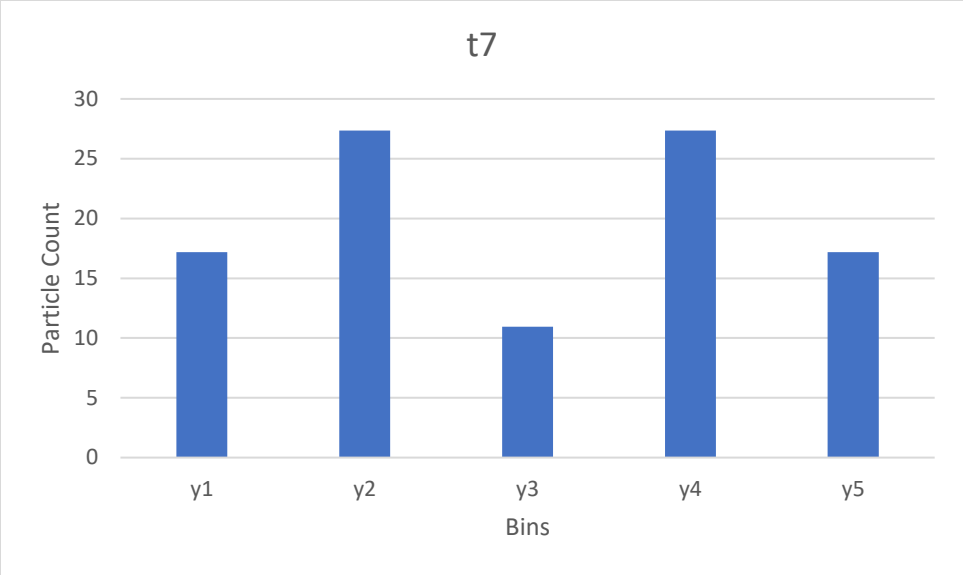

t=4
Particle Count
45
40
35
30
25
20
15
10
5
0
0
1
2
3
4
5
Bin position

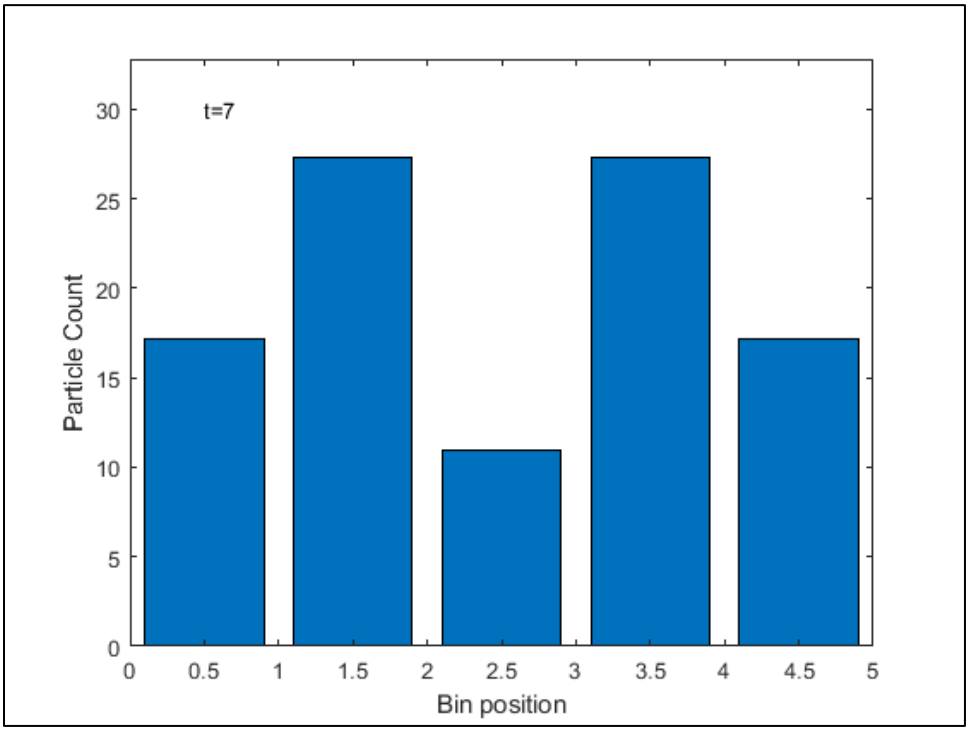

t5
35
30
25
20
15
10
5
0
Particle Count
y1
y2
y3
y4
y5
Bins


t=5
35
30
25
20
15
10
5
0
Particle Count
0
1
2
3
4
5
Bin position


t6
35
30
25
20
15
10
5
0
Particle Count
y1
y2
y3
y4
y5
Bins


t=6
35
30
25
20
15
10
5
0
Particle Count
0
1
2
3
4
5
Bin position

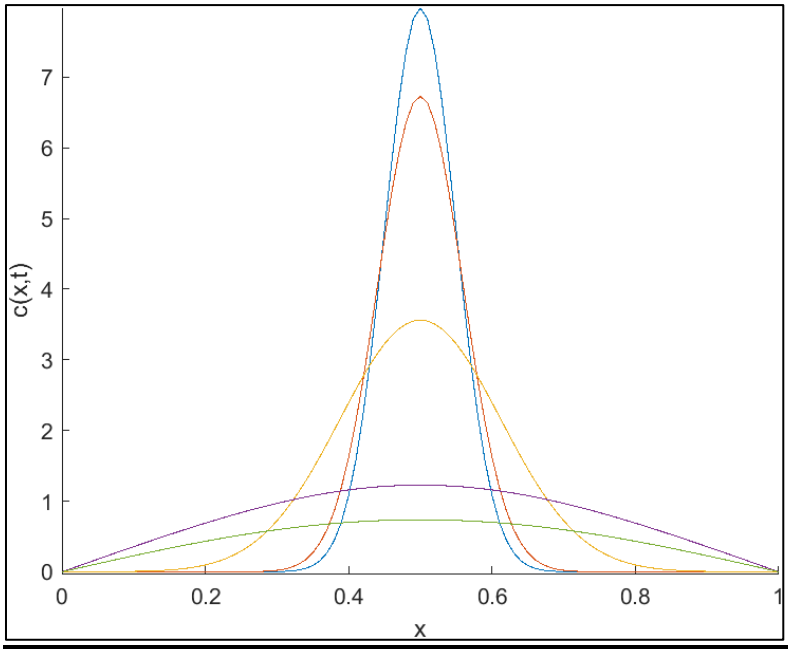




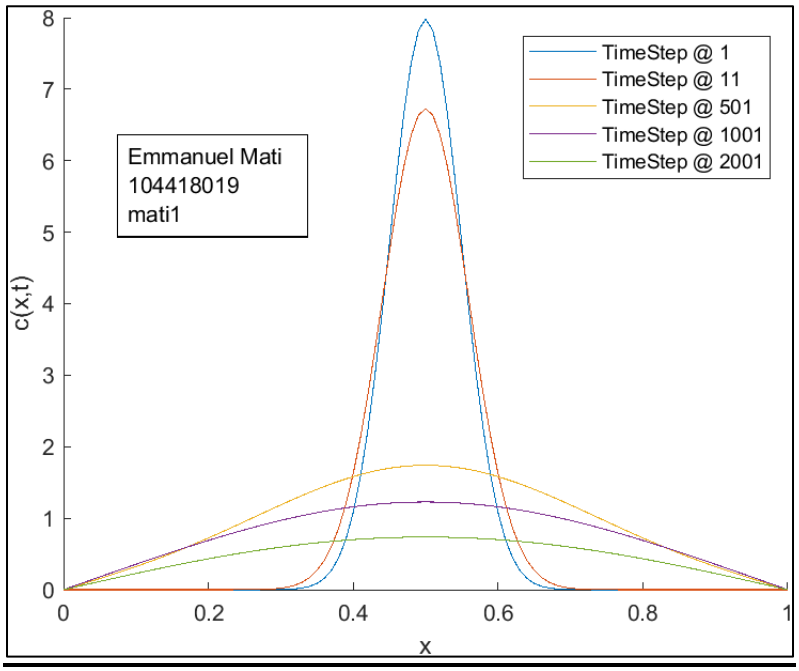
After comparing the MATLAB generated graphs and Excel Generated graphs for each time unit. It can be observed that they are the exact same. This occurs because the excel graphs are using the same values as MATLAB to graph each time unit.

Assignment tasks for part Three:

Original default for reference Graph



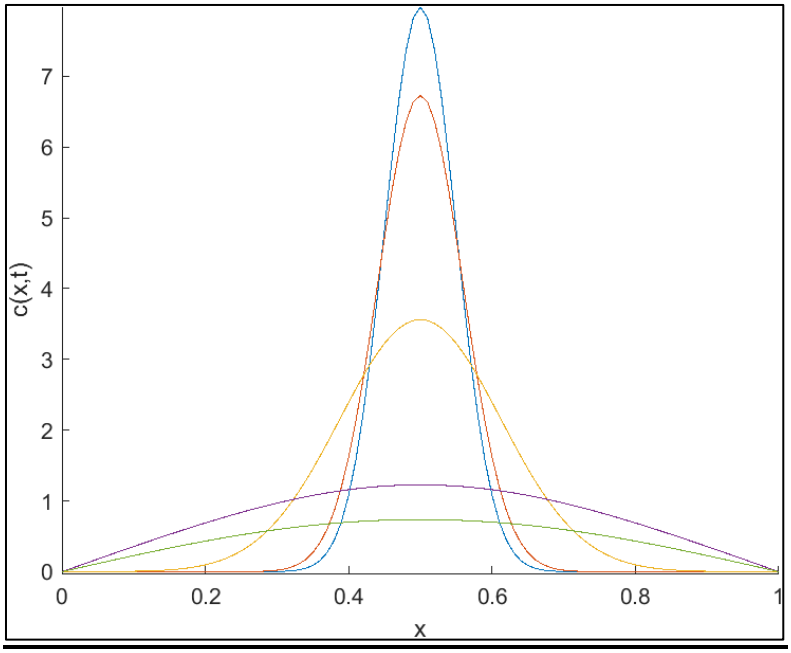
Changed timestep 101 to 501



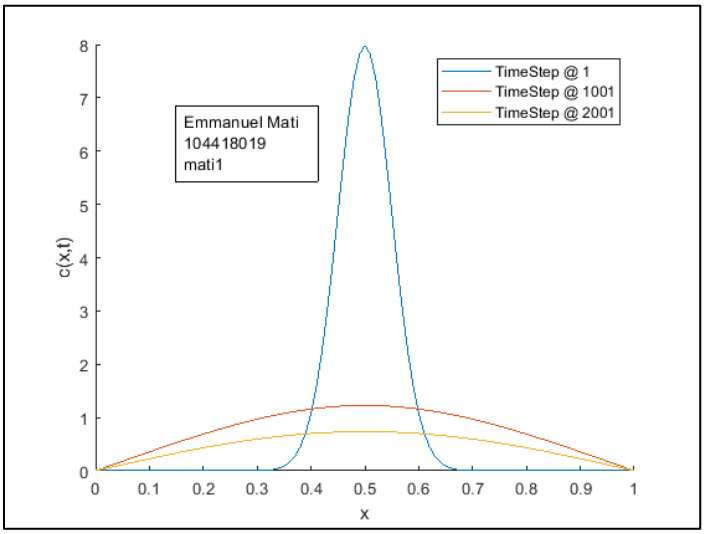
We can observe that as the timestep increases, the c(x, t) values decreases. This can be seen when you pay attention to the yellow line.

2.

Original default for reference Graph



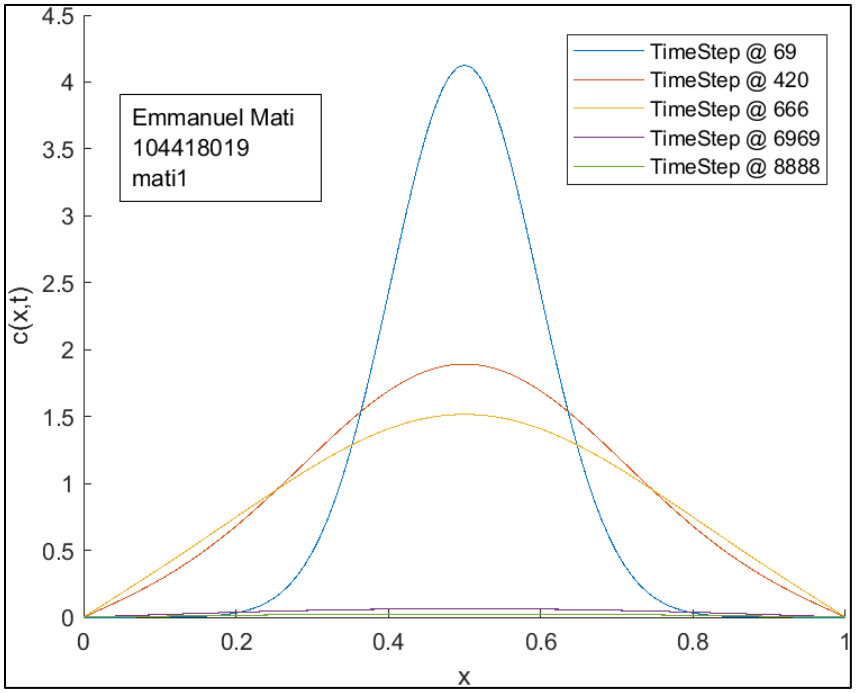
Changing the total number of time steps to 3 with values 1, 1001, and 2001 respectively



It can be observed that changing the total number of time steps from the default of 5 to 3 did not have any affect on how the graph appeared. Instead, it just removed two of the original timesteps.

3.

Timesteps changed to 69, 420, 666, 6969, and 8888 respectively



Essentially, higher time step values display smaller c(x,t) values. Additionally, very large time step values began to loose amplitude to the point that they look like they are touching zero.