Aperture & Particle Loss Diagnostics

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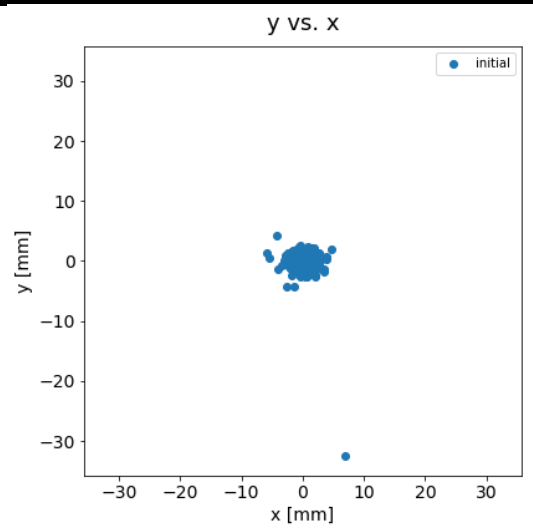
Electron Column Modeling Meeting
February 5, 2019

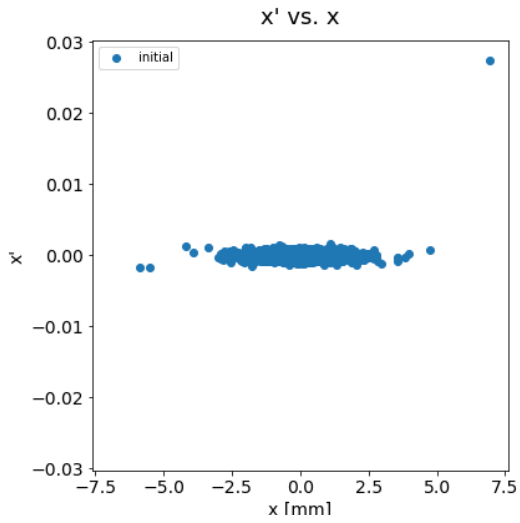
Simulation Parameters

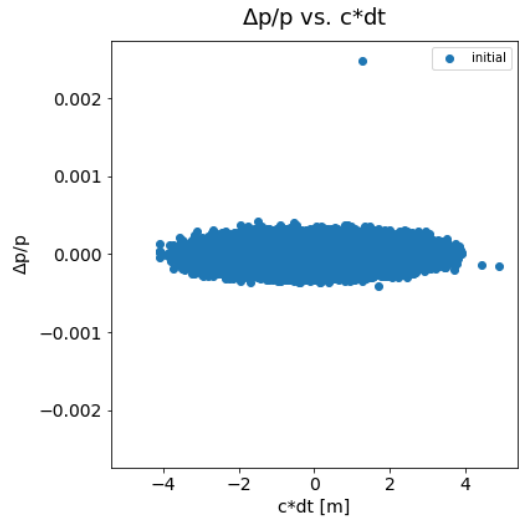
- All cases:
  - 32x32x32 grid
  - 327,680 macroparticles
    - 10 macroparticles per cell
  - RF on – 4th harmonic, 0 lag, 500 V, 5 cm long, 2.18 MHz
  - 72 steps per turn
  - 2.5 cm radius aperture

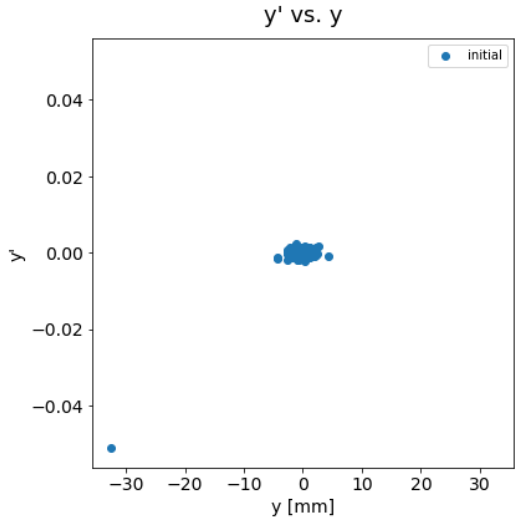
No SC – Initial Distribution

- x_{RMS} = 0.5158 mm
- y_{RMS} = 0.3800 mm
- z_{RMS} = 6.990 cm
- $\varepsilon_{x,RMS}$ = 1.05968e-7
- $\varepsilon_{y,RMS}$ = 1.08266e-7



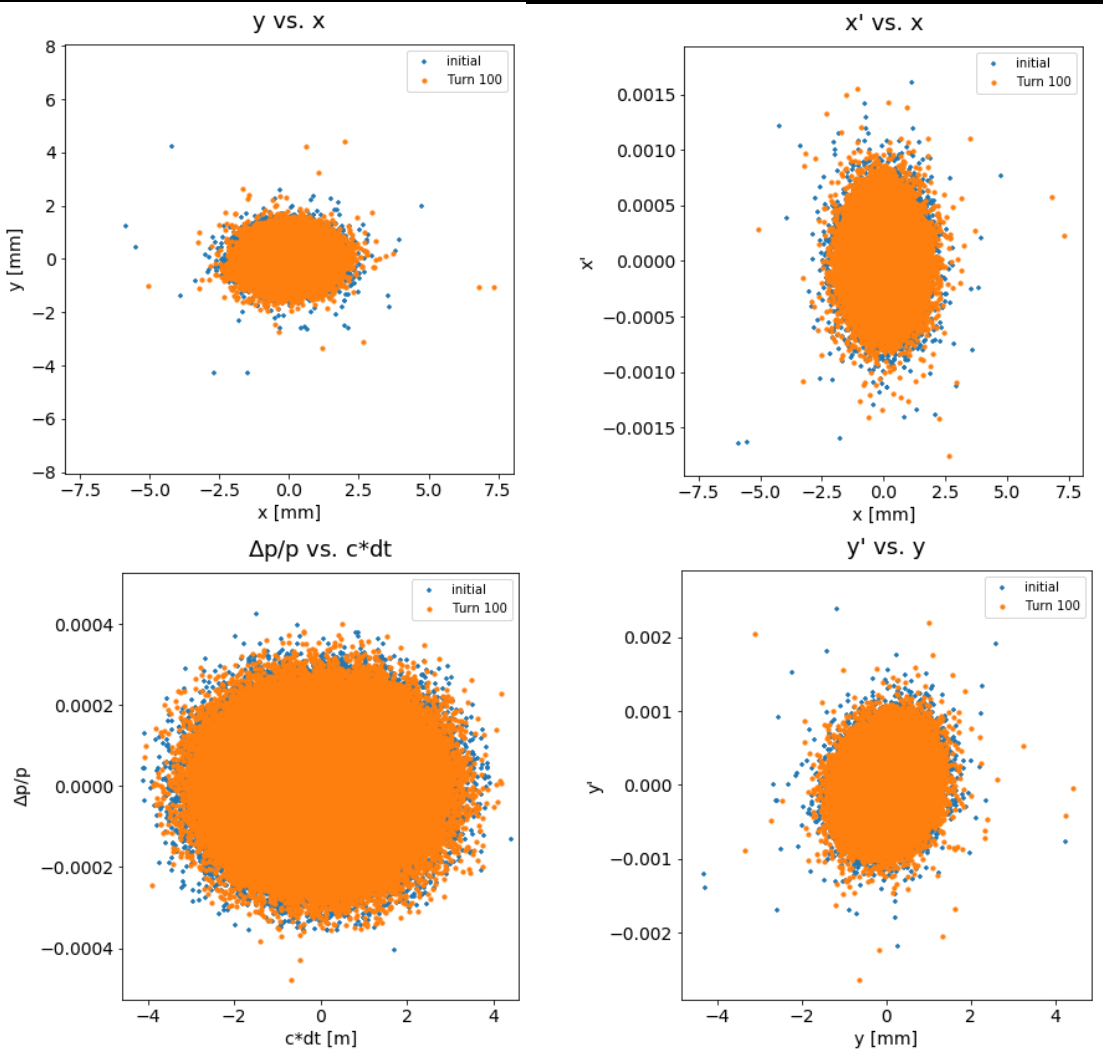






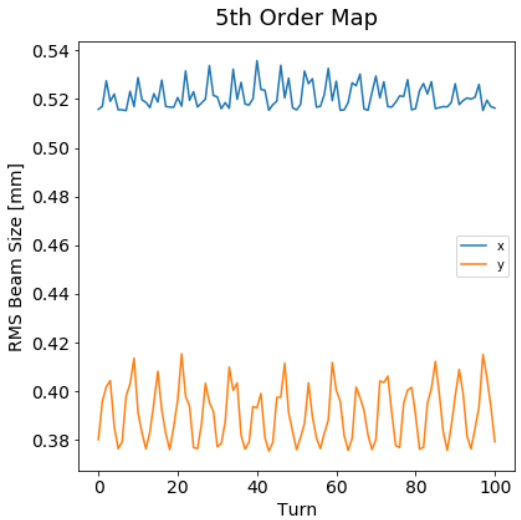
No SC – 100th Turn Distribution

- x_{RMS} = 0.5163 mm
- y_{RMS} = 0.3760 mm
- z_{RMS} = 6.996 cm
- $\varepsilon_{x,RMS}$ = 1.03000e-7
- $\varepsilon_{y,RMS}$ = 1.02488e-7
- Large amplitude particle lost

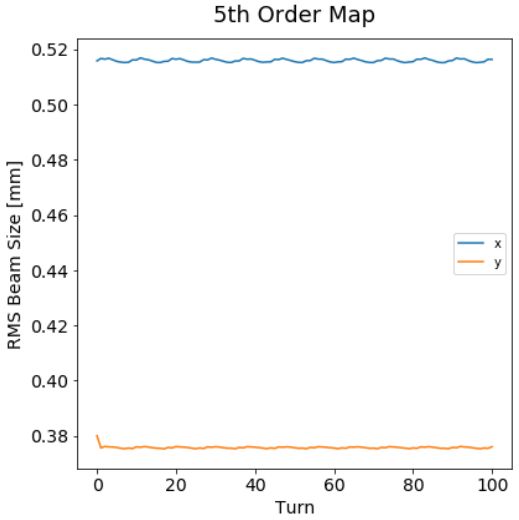


No SC – Beam Size Growth

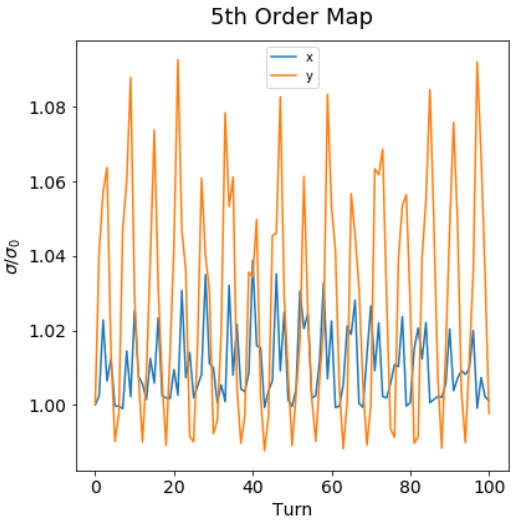
No aperture



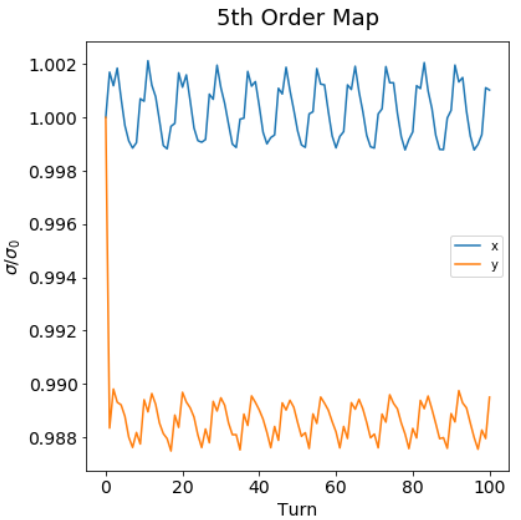
Aperture



No aperture



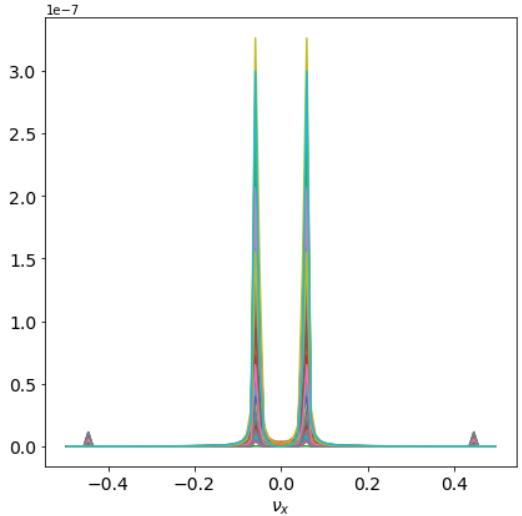
Aperture

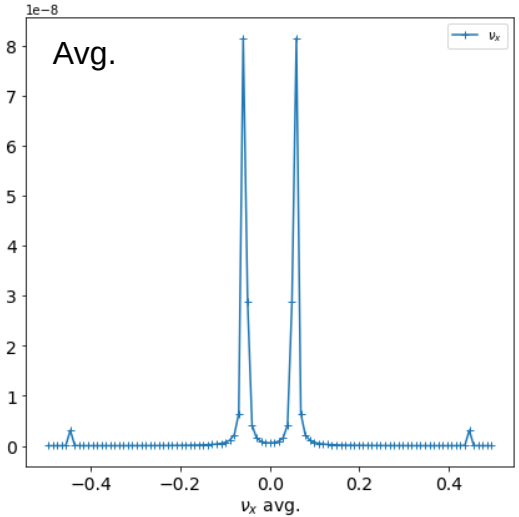


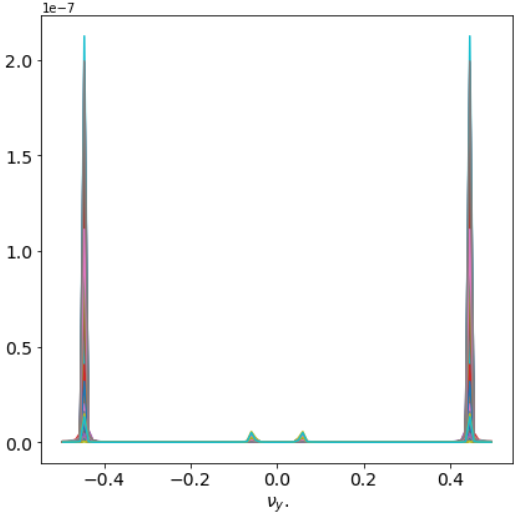
No SC – Tunes

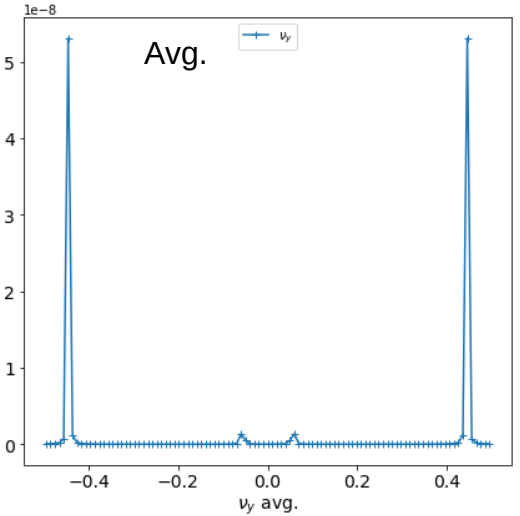
- From Synergia:
- Q_x = 0.0557211361357923 5
- Q_v = 0.555711574399128 1

- From 100 turn FFT
- Q_x = 0.0594
- Q_v = 0.4455







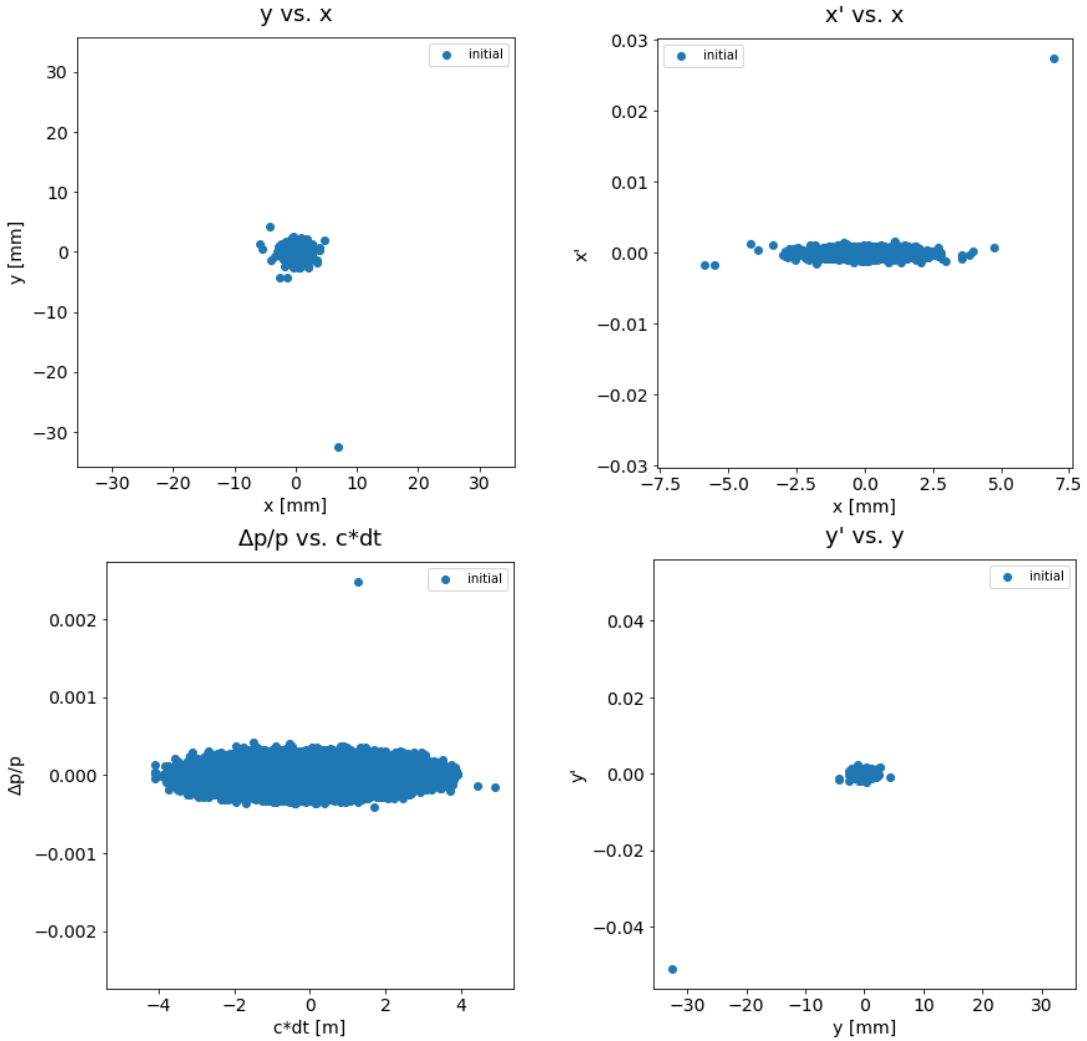


Space Charge Parameters

- 5^{th} order split operator stepper
- 3dopen-hockney solver used

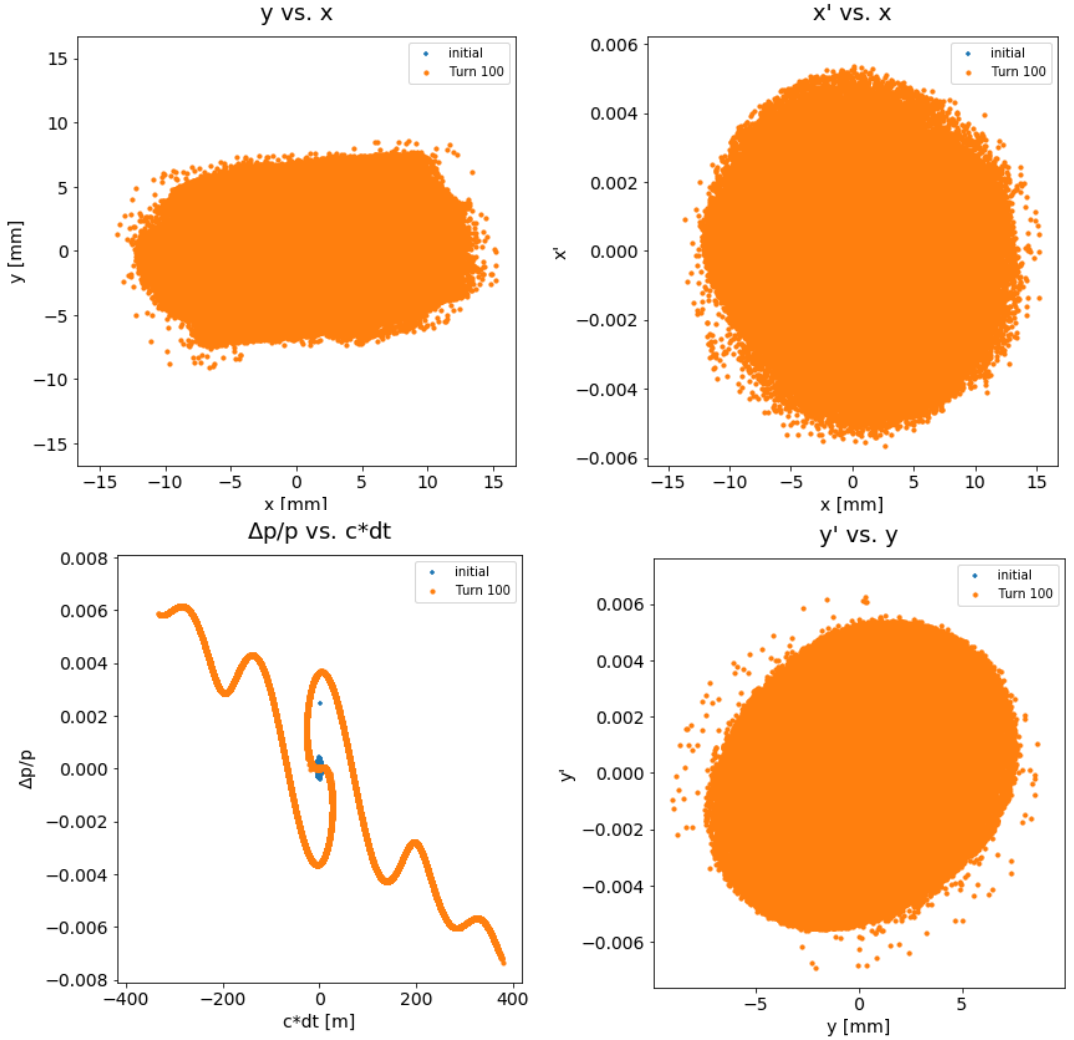
8 μA – Initial Distribution

- X_{RMS} = 0.5158 mm
- Y_{RMS} = 0.3800 mm
- Z_{RMS} = 6.990 cm
- $\varepsilon_{x,RMS}$ = 1.05968e-7
- $\varepsilon_{y,RMS}$ = 1.08266e-7



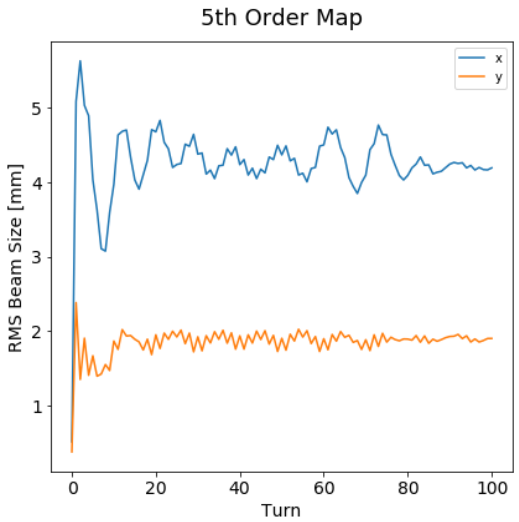
8 μA – 100th Turn Distribution

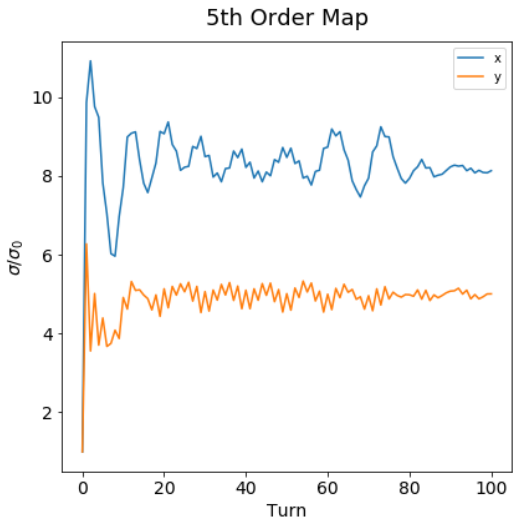
- x_{RMS} = 4.193 mm
- y_{RMS} = 3.800 mm
- z_{RMS} = 8.804 m
- $\varepsilon_{x,RMS}$ = 6.779e-6
- $\varepsilon_{y,RMS}$ = 2.673e-6
- 310,046 particles

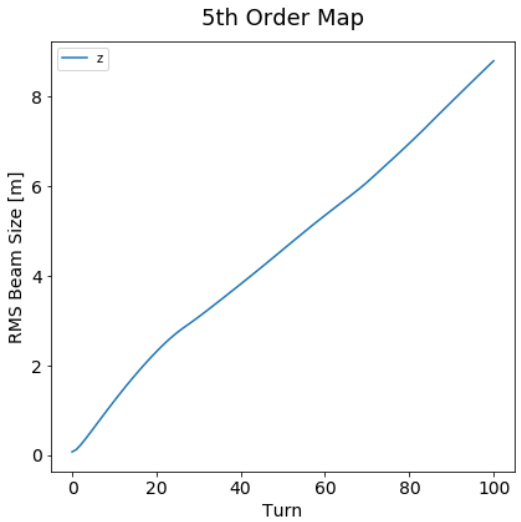


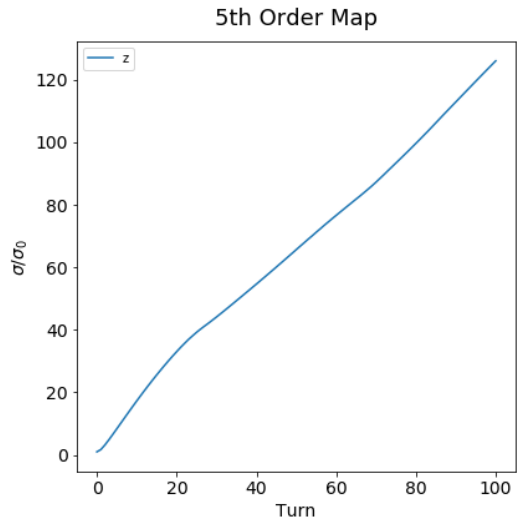
8 μA – Beam Size Growth

- Longitudinal beam size grows much more than transverse – not limited by aperture





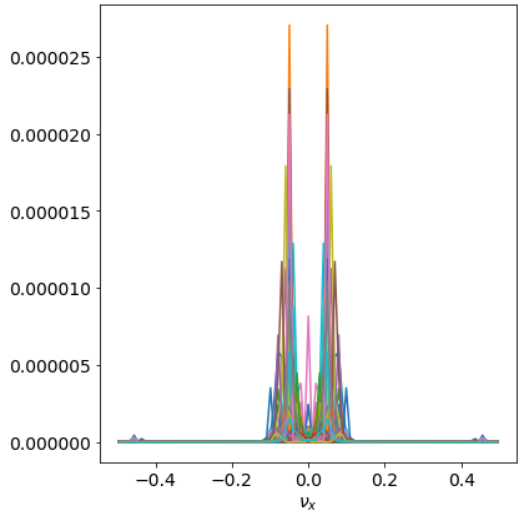


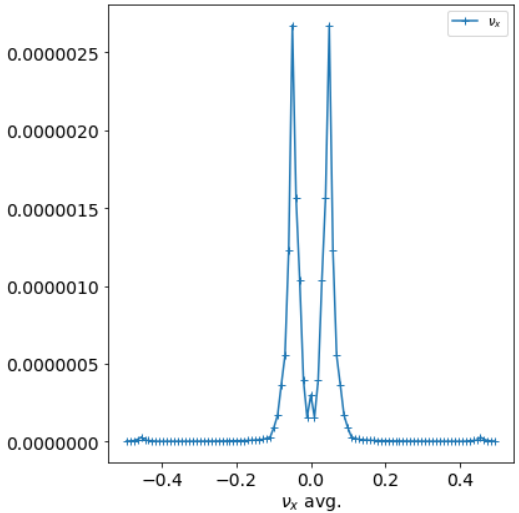


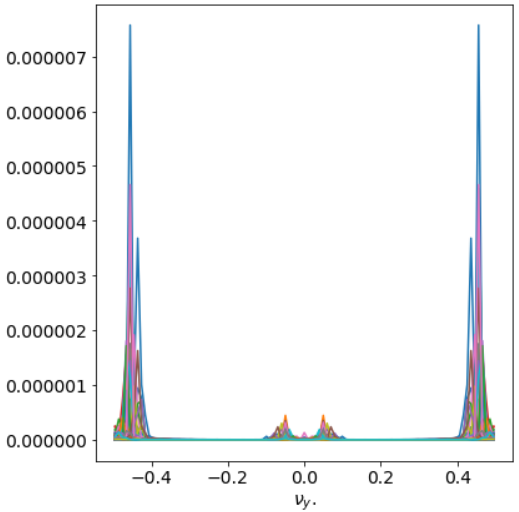
8 μA – Tunes

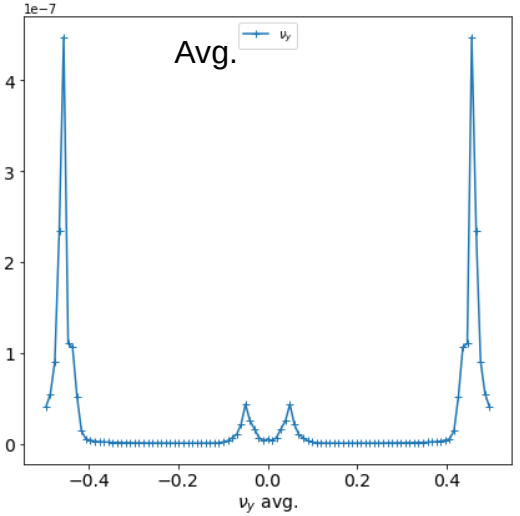
- Undepressed tunes:
- Q_x = 0.0557211361357923 5
- Q_y = 0.555711574399128 1

- DQ = -0.0162



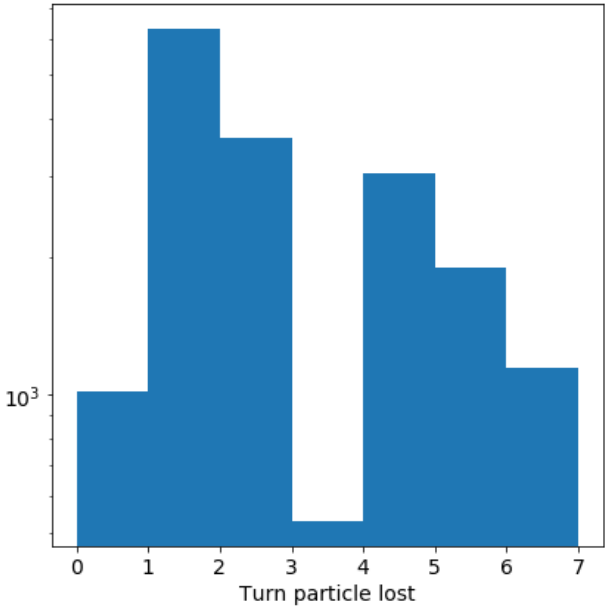


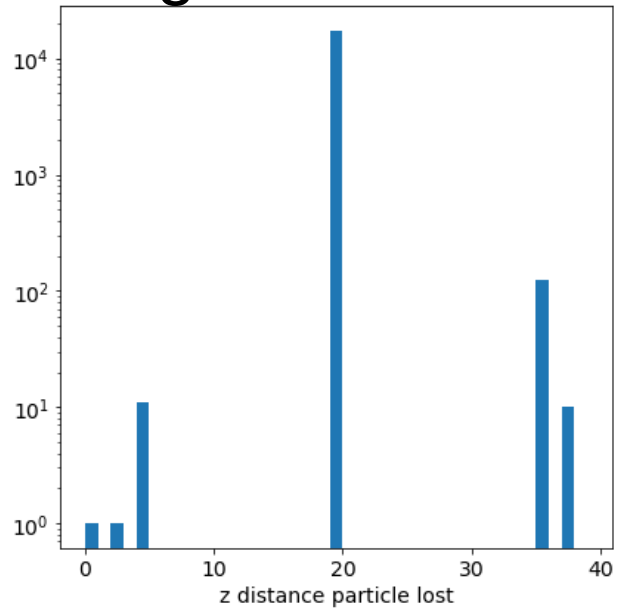




8 μA – Losses

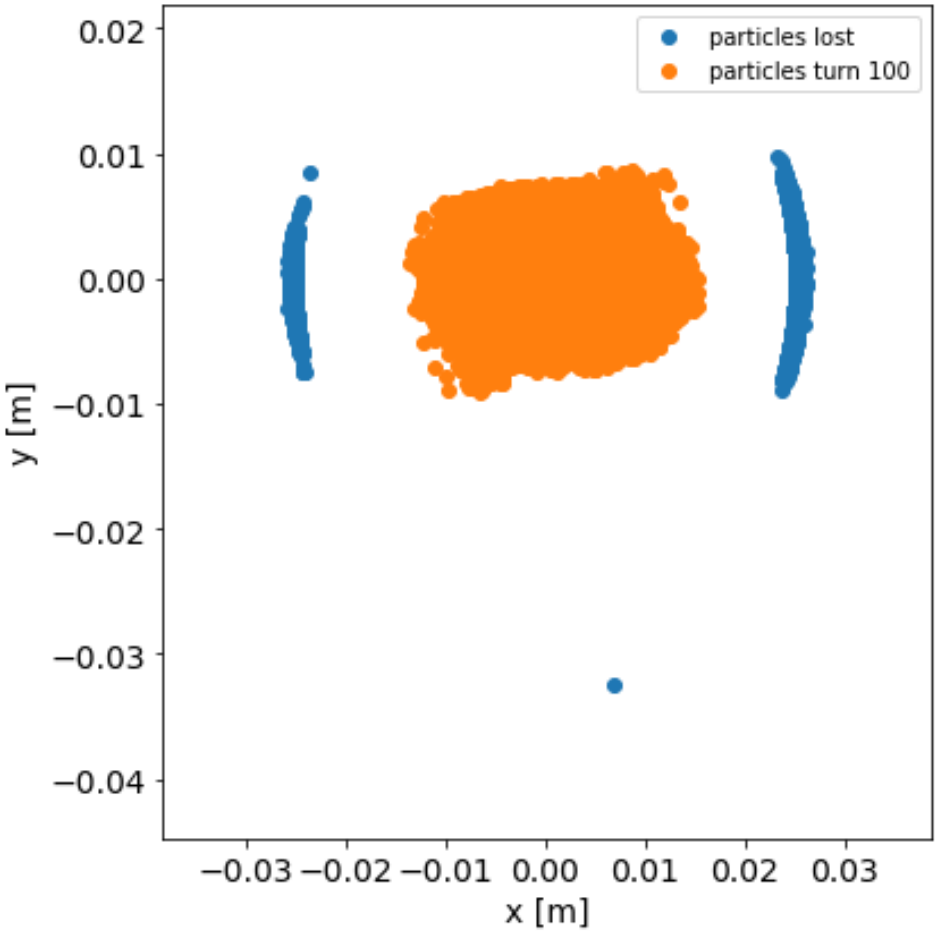
- Most particles lost on second turn
- Most particles lost half way around ring





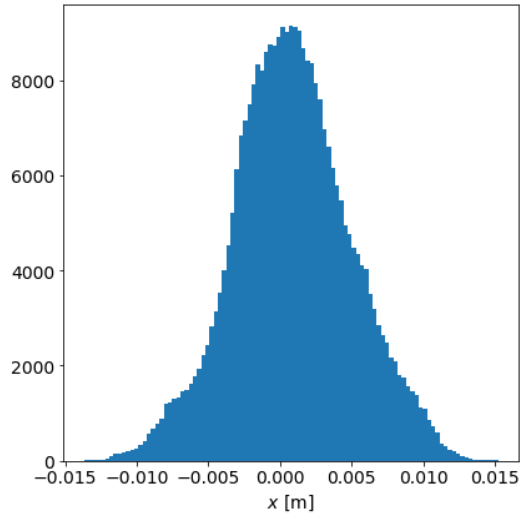
8 μA – Losses

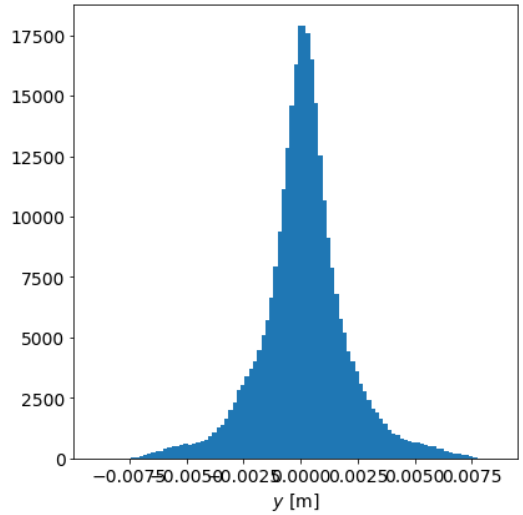
- Losses at aperture clearly seen

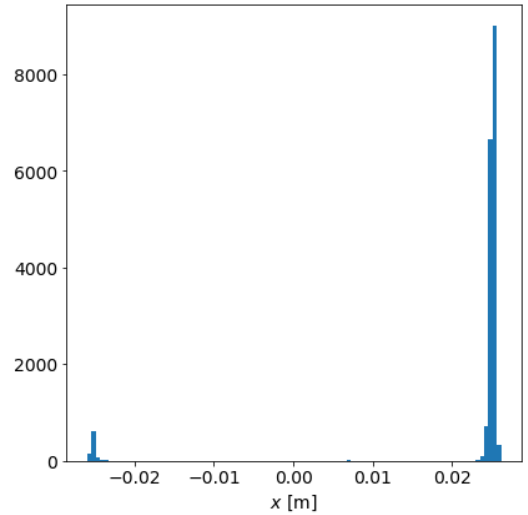


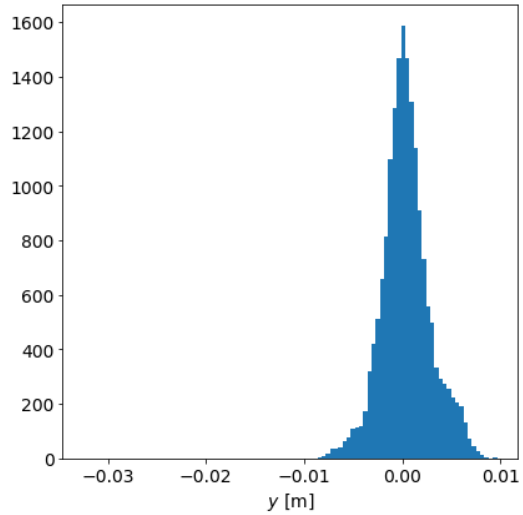
8 μA – Losses

- Top – 100th turn distribution
- Bottom – lost particles
- Plot limits determined by largest & smallest array values
- 17,634 particles lost (5.38%)



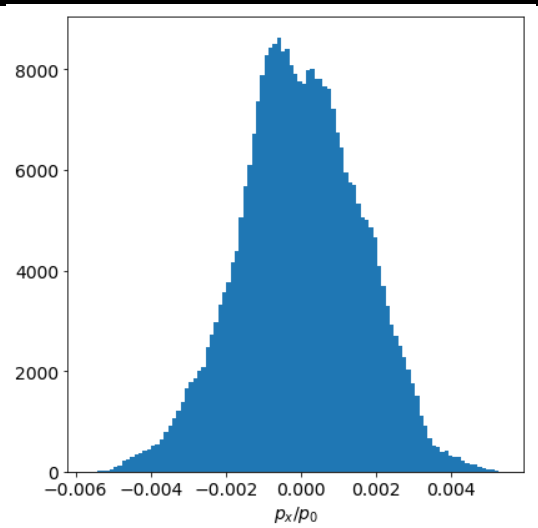


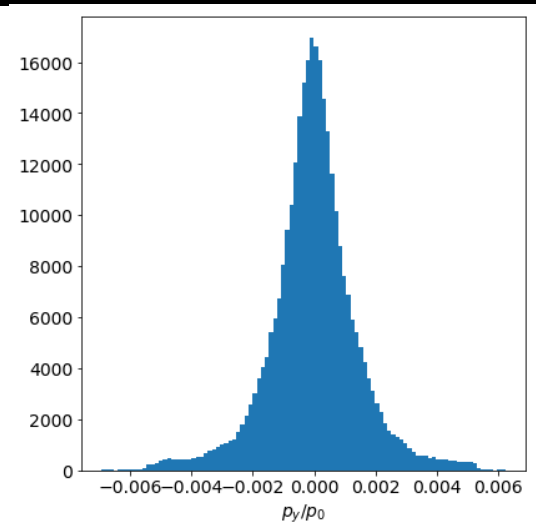


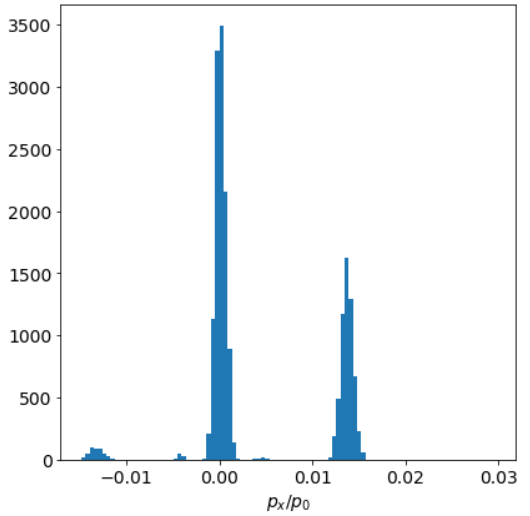


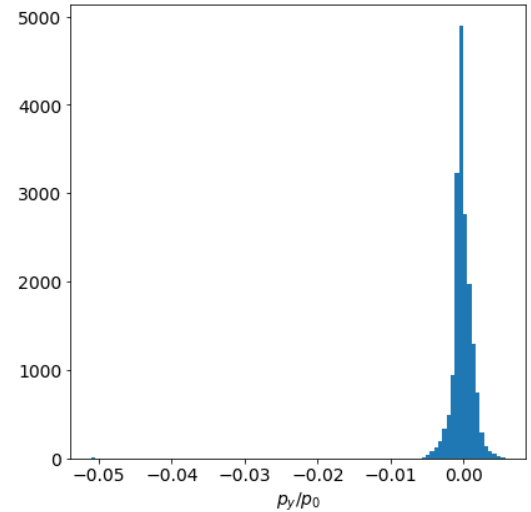
8 μA – Losses

- Top – 100th turn distribution
- Bottom – lost particles
- Plot limits determined by largest & smallest array values



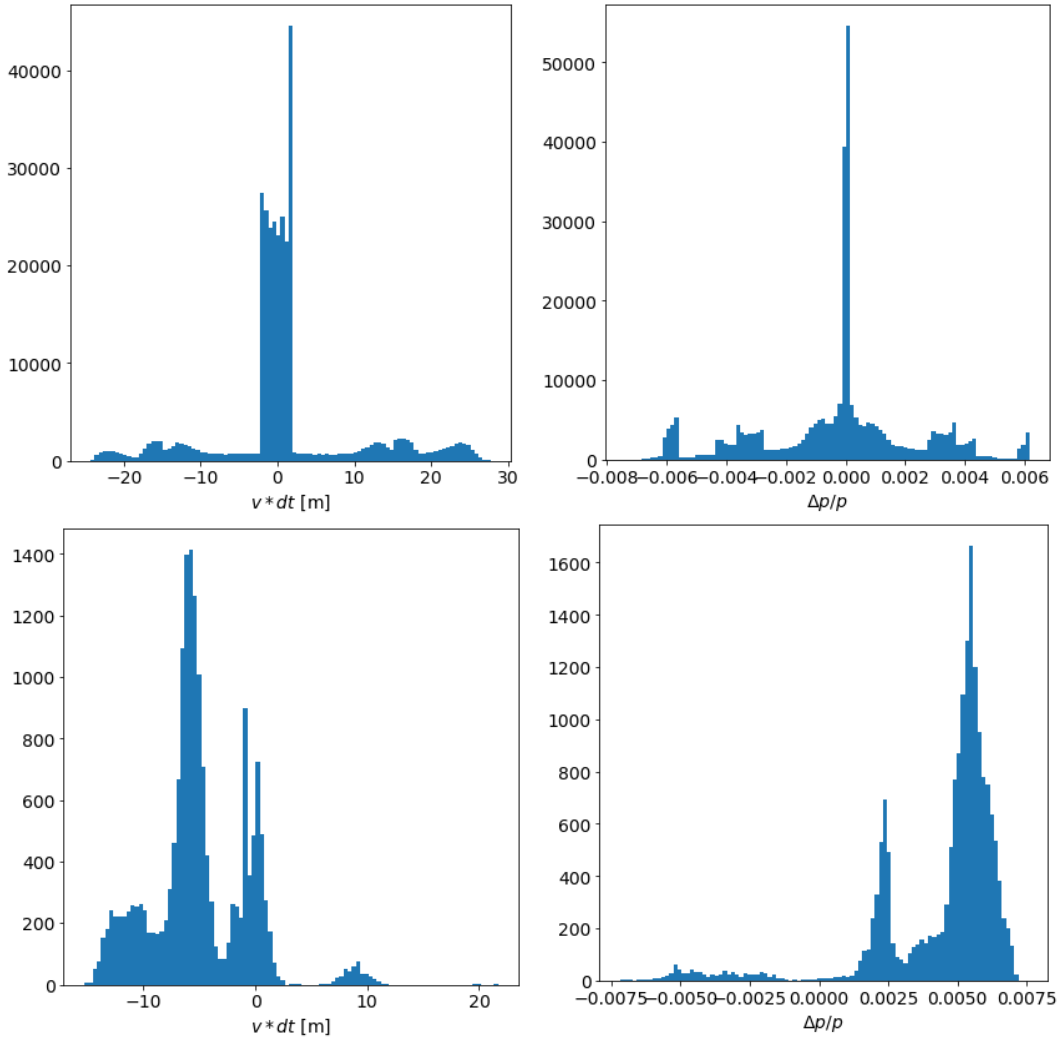






8 μA – Losses

- Top – 100th turn distribution
- Bottom – lost particles
- Plot limits determined by largest & smallest array values
- Horizontal – longitudinal coupling apparent



8 mA – Initial Distribution

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- y_{RMS} = 0.3800 mm
- z_{RMS} = 6.990 cm
- $\varepsilon_{x,RMS}$ = 1.05968e-7
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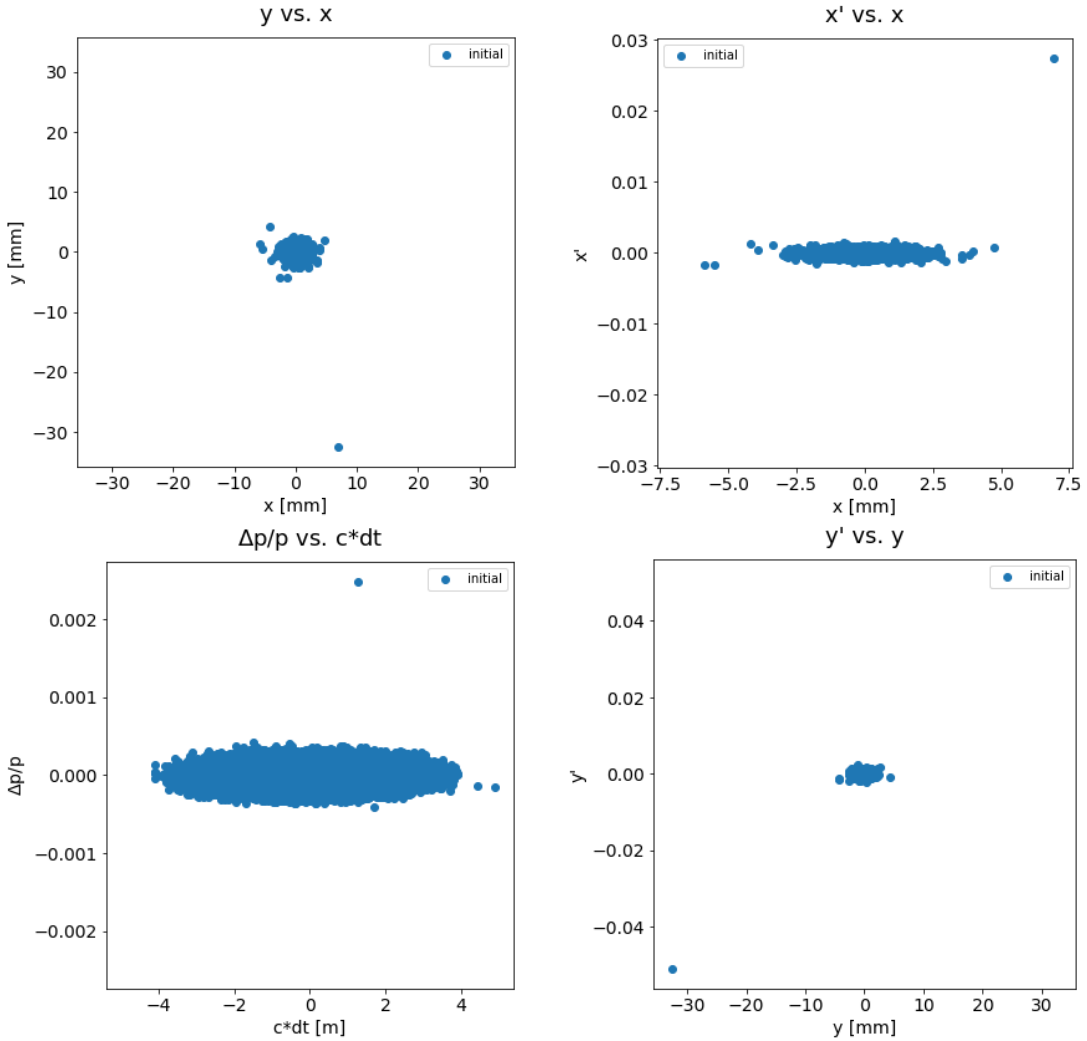
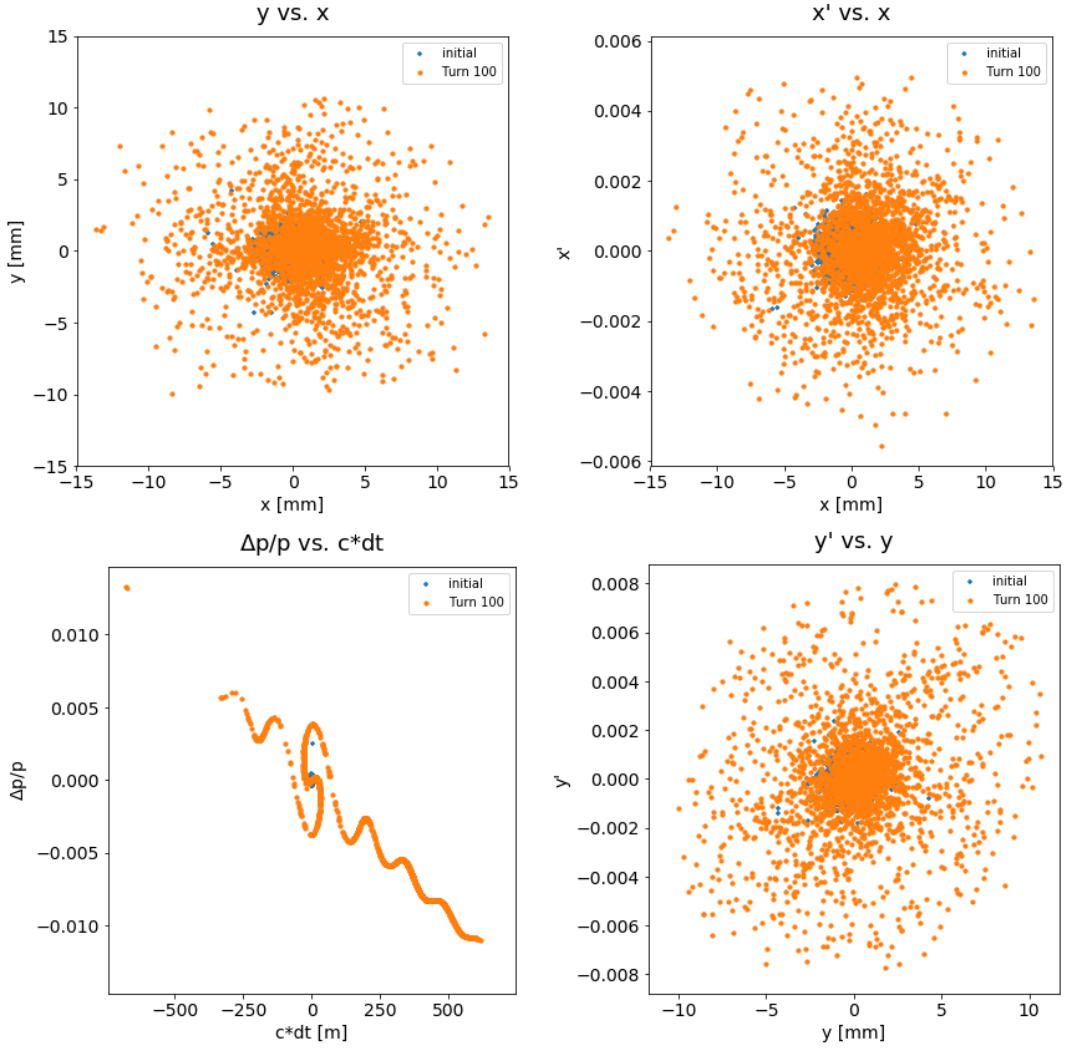


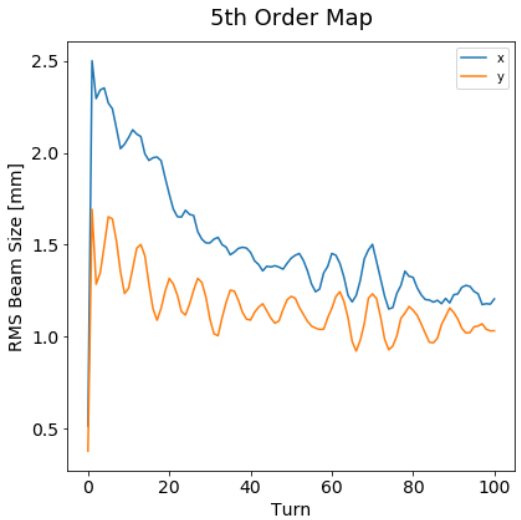
8 mA – 100th Turn Distribution

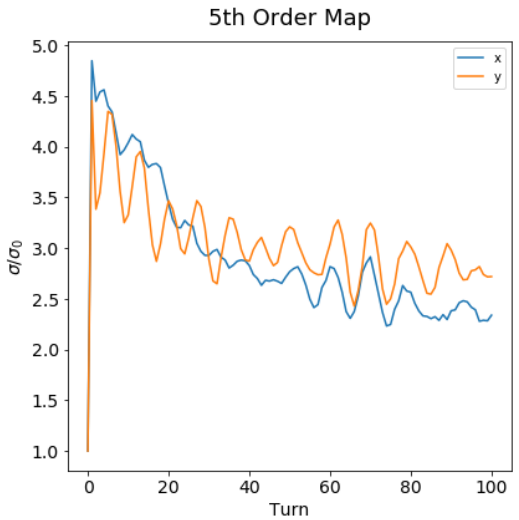
- x_{RMS} = 1.206 mm
- y_{RMS} = 1.033 mm
- z_{RMS} = 7.848 m
- $\varepsilon_{x,RMS}$ = 5.805e-7
- $\varepsilon_{y,RMS}$ = 8.054e-7
- 20,480 particles

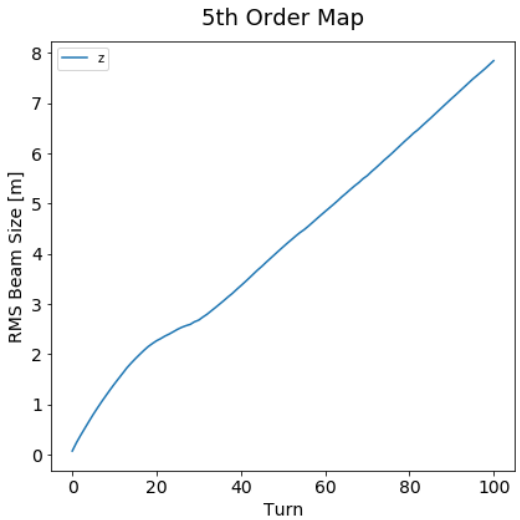


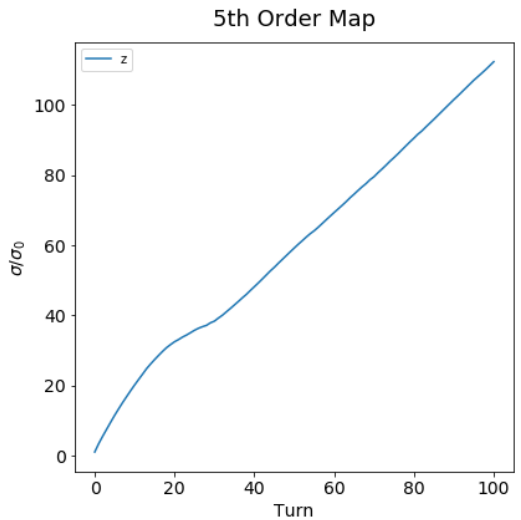
8 mA – Beam Size Growth

- So many particles lost, transverse beam size settles down to smaller than 8 μA case
- Longitudinal beam size similar in both cases



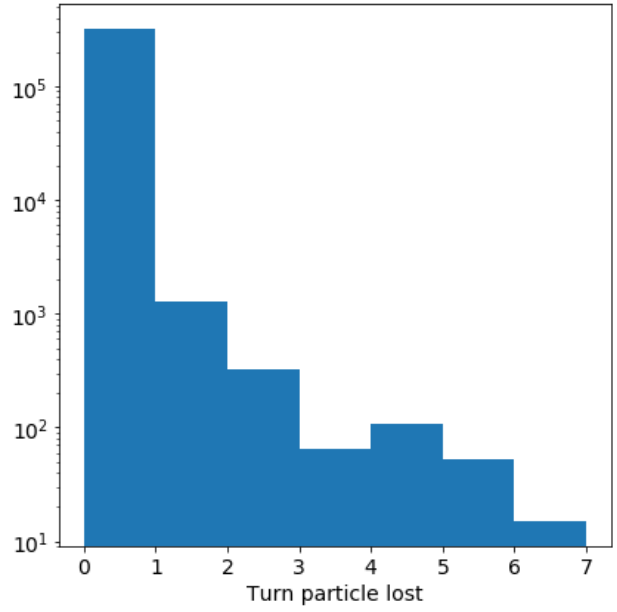


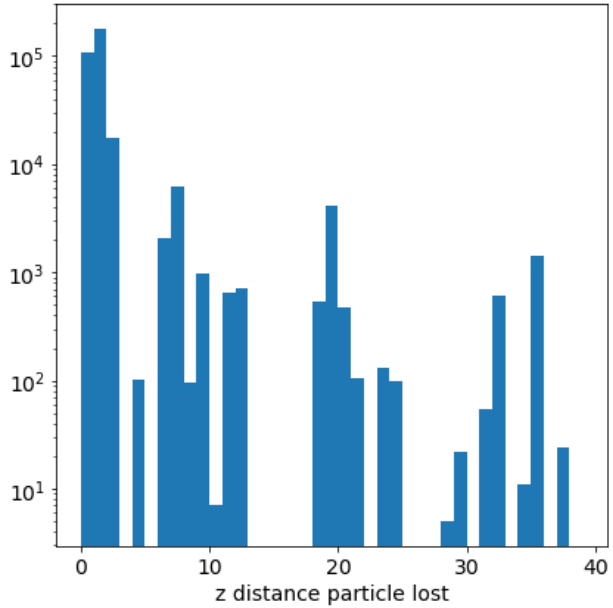




8 mA – Losses

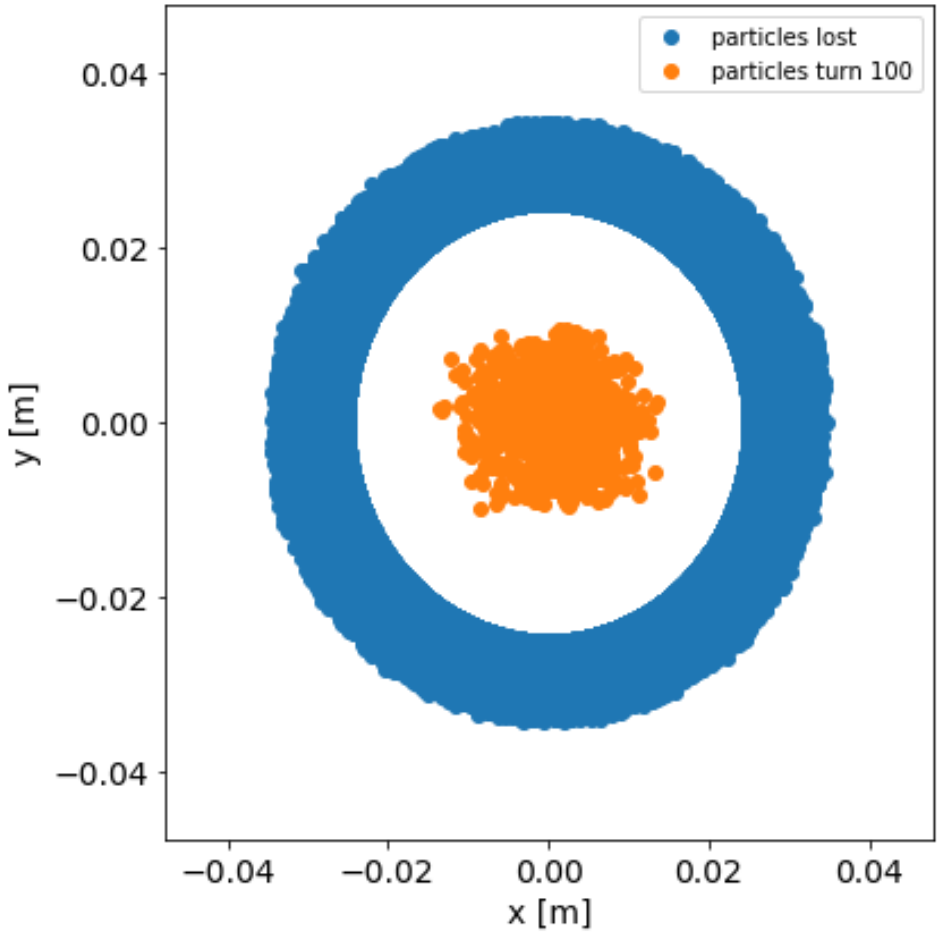
- Most particles lost on first turn
- Most particles lost in first few meters





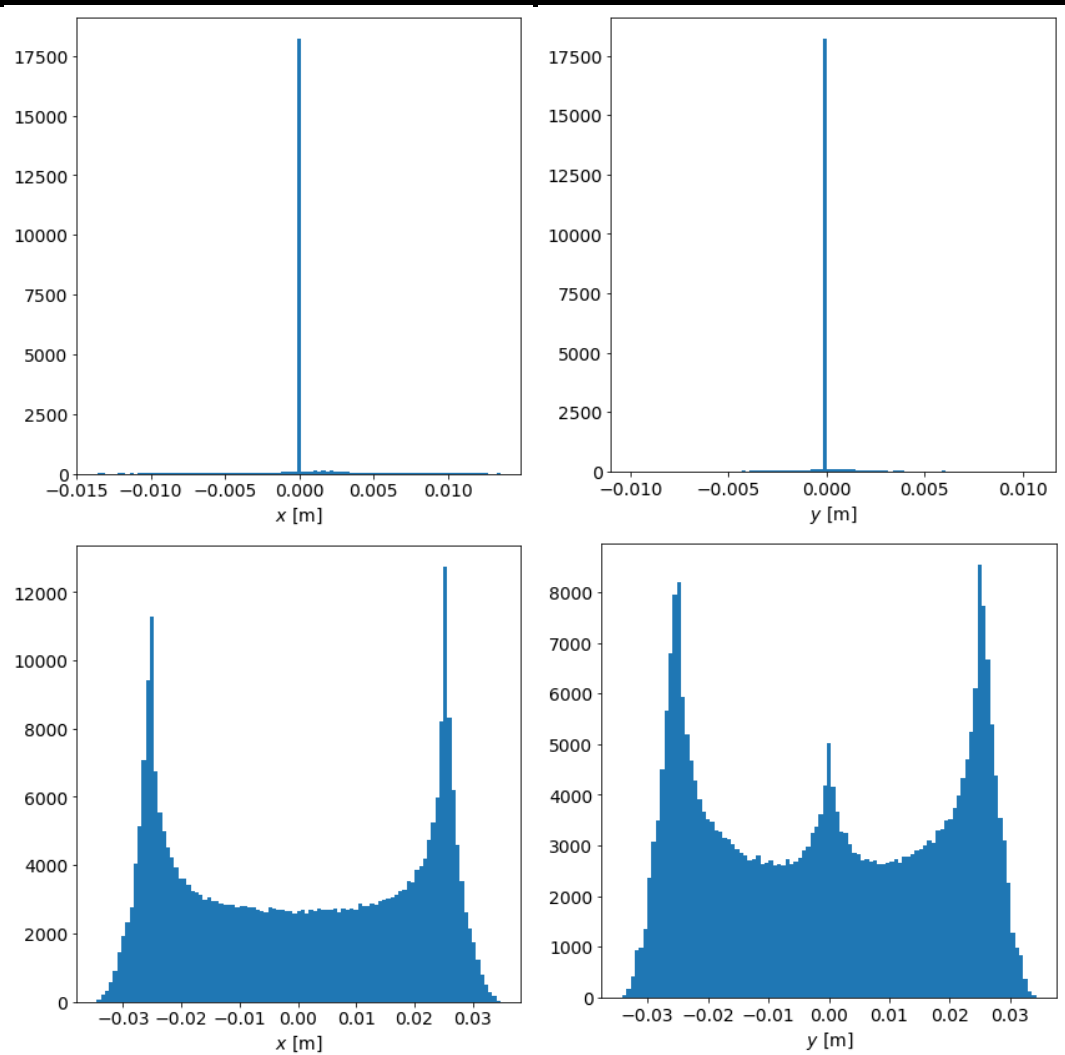
8 mA – Losses

- Only core of beam remains



8 mA – Losses

- Top – 100th turn distribution
- Bottom – lost particles
- Plot limits determined by largest & smallest array values
- 325,290 particles lost (99.27%)
- Particle loss not entirely due to aperture anymore



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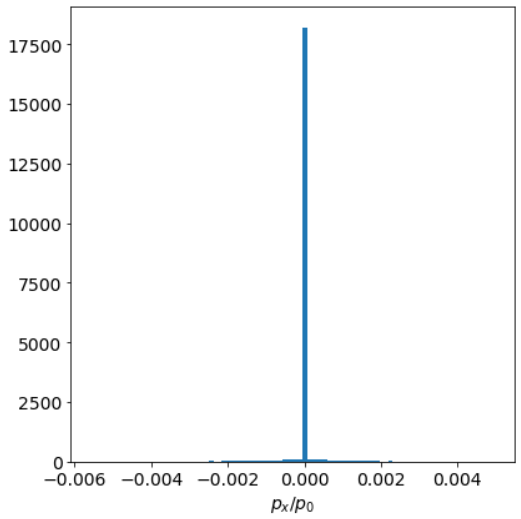

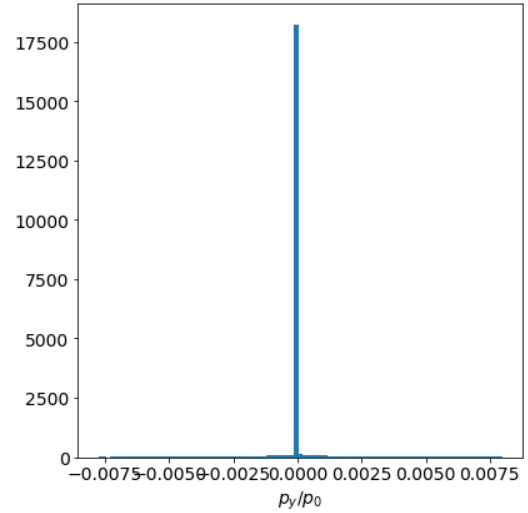

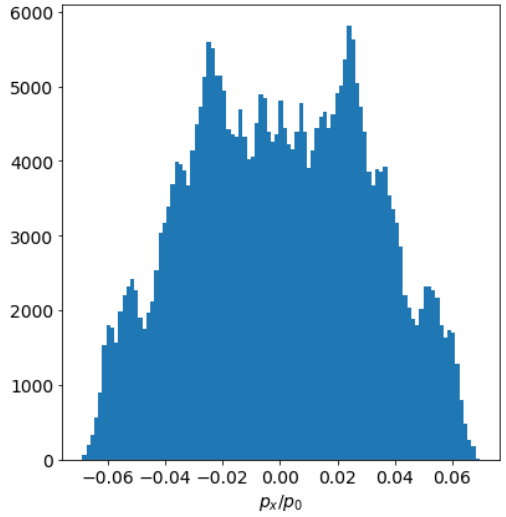

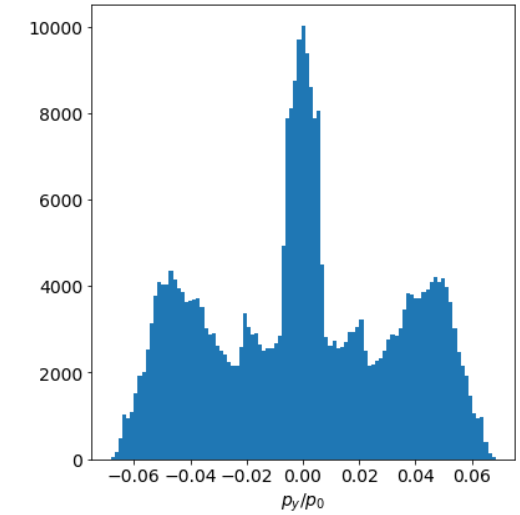

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- Bottom – lost particles
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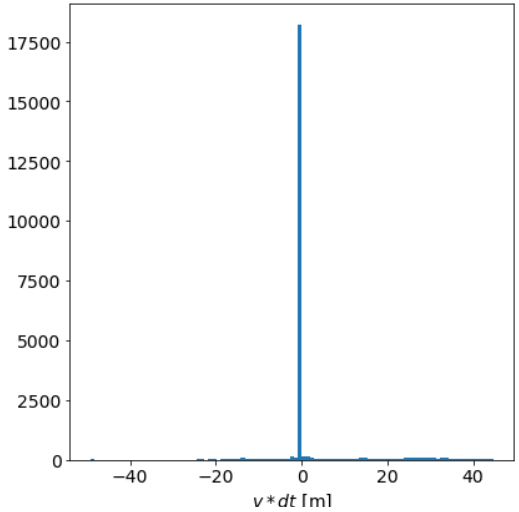

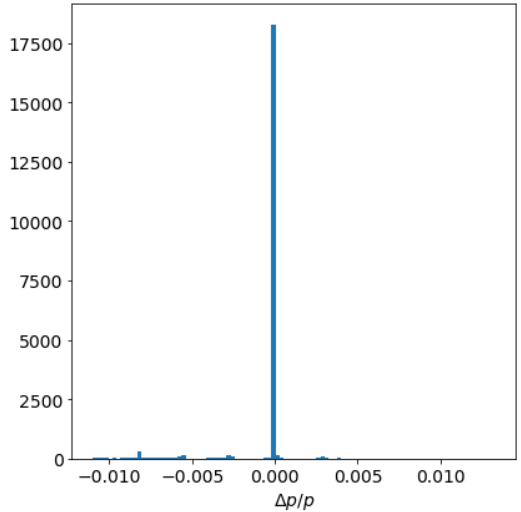

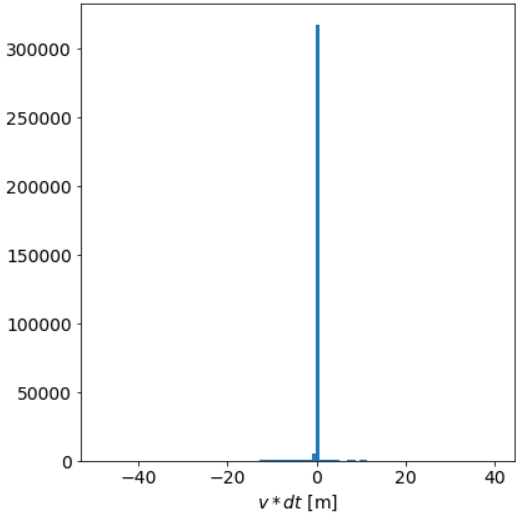

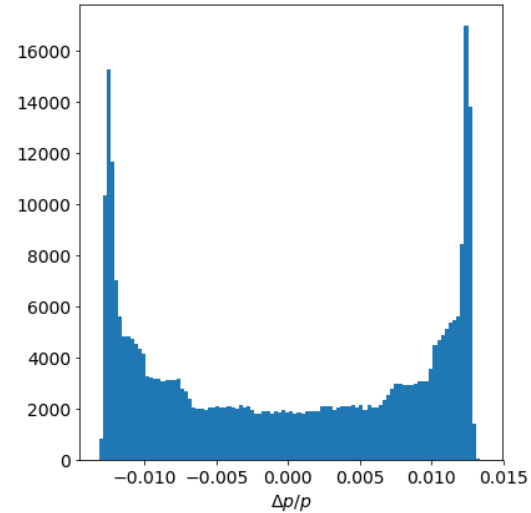

Comments

- Space charge seems to be working okay
- It would be interesting to run the 8 mA beam through Warp to see if the Electron Column reduces losses on subsequent turns
- Time to turn on sextupoles?