Compressor Ring, 2MW

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Outline

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Introduction

Exploring the design for a compressor ring with parameters:

Variable		Value
Beam Power	P	2 MW
Repetition Rate	f	5 Hz
Beam Energy	E	5 or 10 GeV

$$P = fN_pE \Rightarrow$$

$$N_p = \begin{cases} 5.0 \times 10^{14} & (5\text{ GeV}) \\ 2.5 \times 10^{14} & (10\text{ GeV}) \end{cases}$$

! Expect Space Charge to be a main limiting factor

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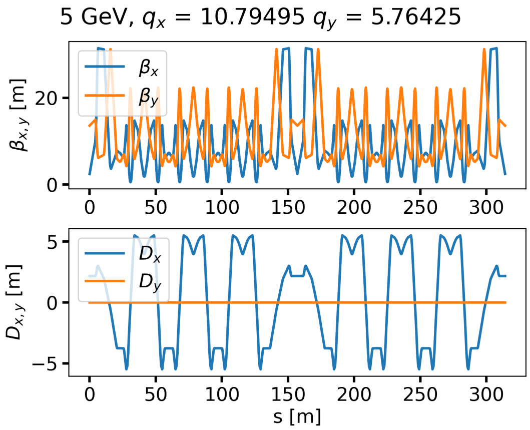
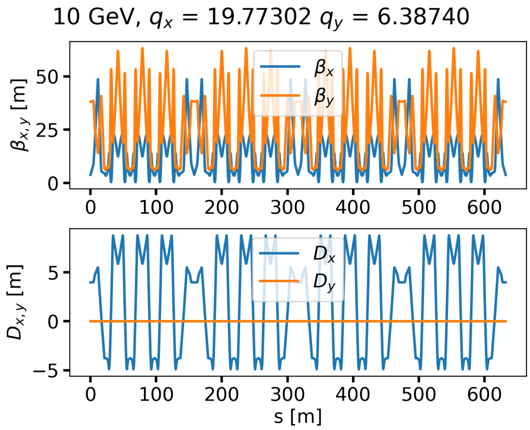
Lattice for SPL from M. Aide

This lattice was designed to provide short proton bunches for a neutrino factory.
Has 150% positive bending magnets and 50% negative bending magnets to reduce dispersion

	injection	extraction
energy spread [%]	± 0.1	±1.7
bunch length [NS]	120	2
r.m.s hor. emittance	1 π mm mrad	
r.m.s. ver. emittance	2 π mm mrad	

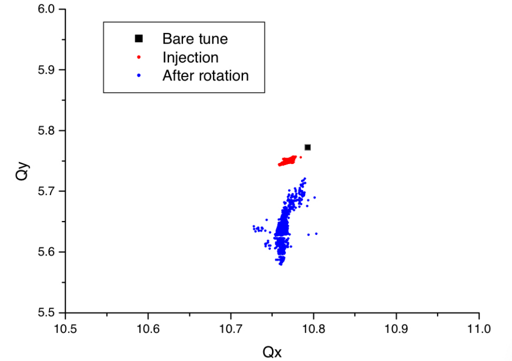




Tune spread from coasting beam

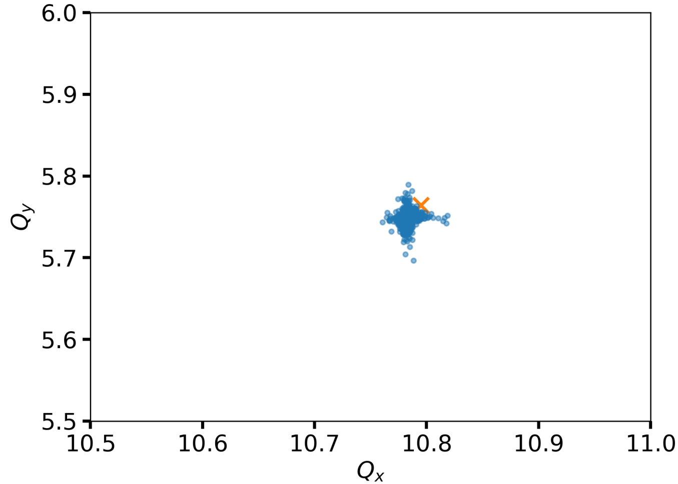
Calculate the tune spread in a coasting beam of equivalent line density.

At 5 GeV, this means $5{\cdot}10^{14}$ protons divided over 120 ns before rotation and over 2 ns after rotation

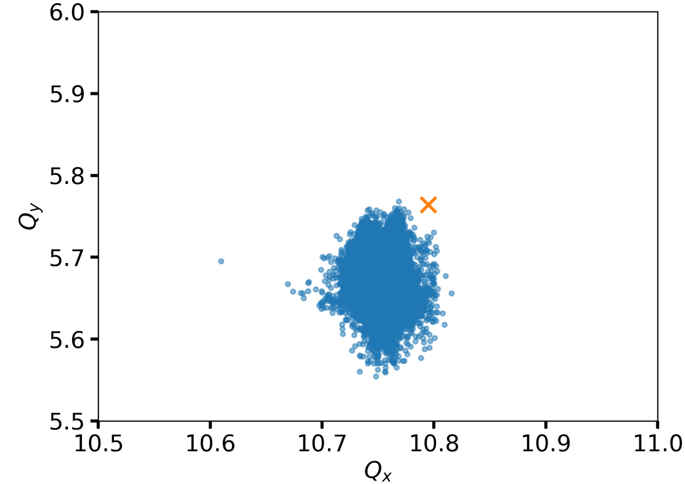


M. Aide in ORBIT

Xsuite: Injection



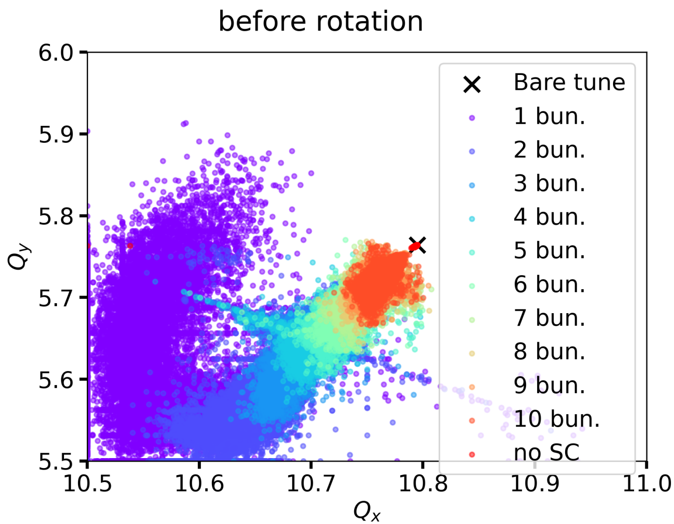
Xsuite: after rotation

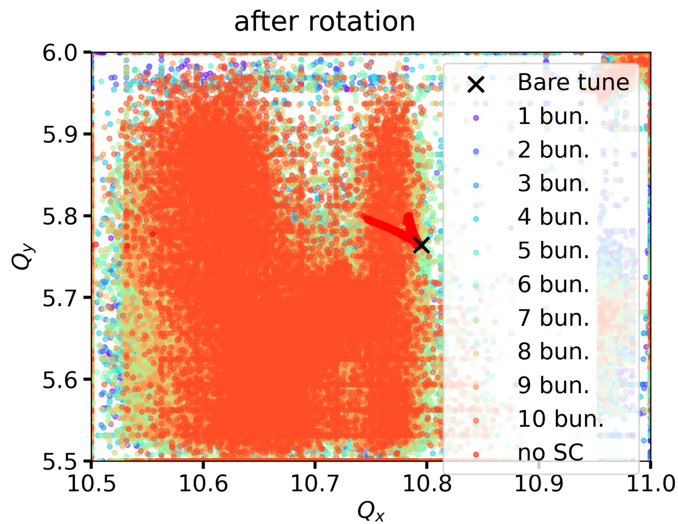


Scan in number of bunches (5GeV)

Space Charge is reduced if the total number of protons (N_p) is divided into several bunches

! These bunches need to be recombined before hitting target

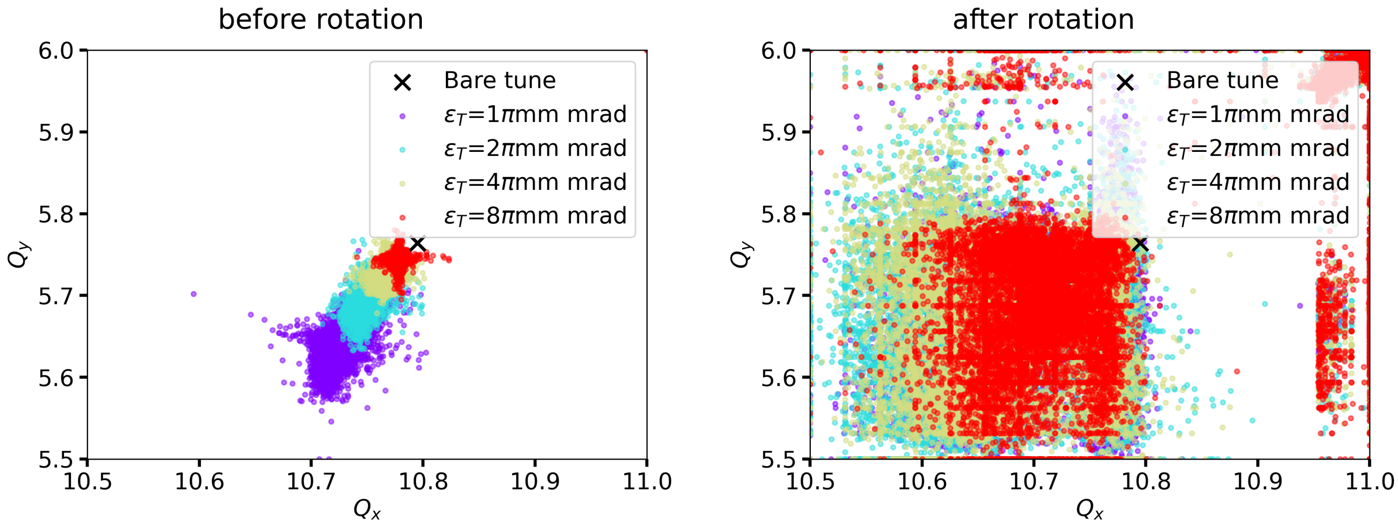




! Not achievable

Increase emittance (5GeV)

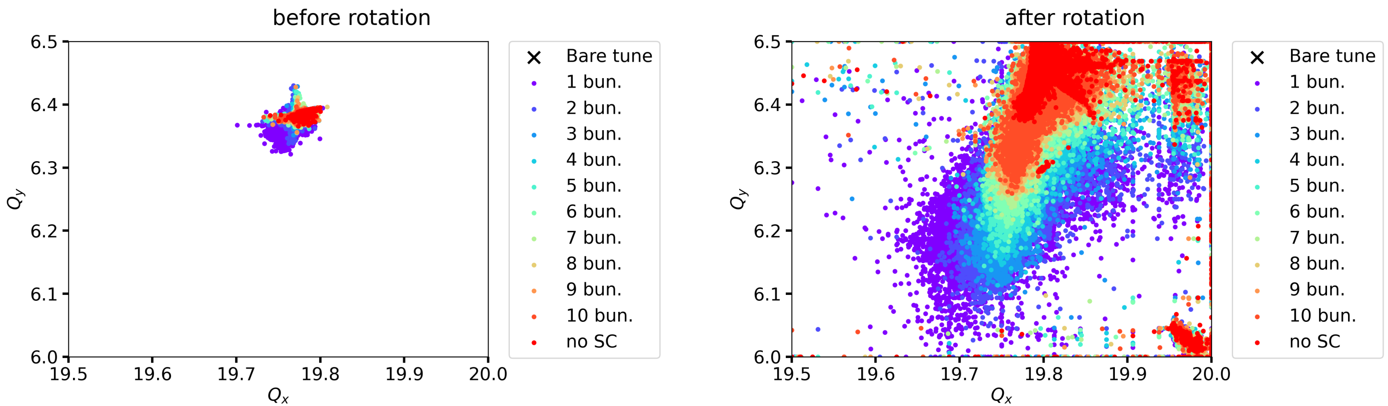
Assume 6 bunches



! Cannot be saved with higher emittance

→ Instead move to 10 GeV

Scan in number of bunches (10 GeV)

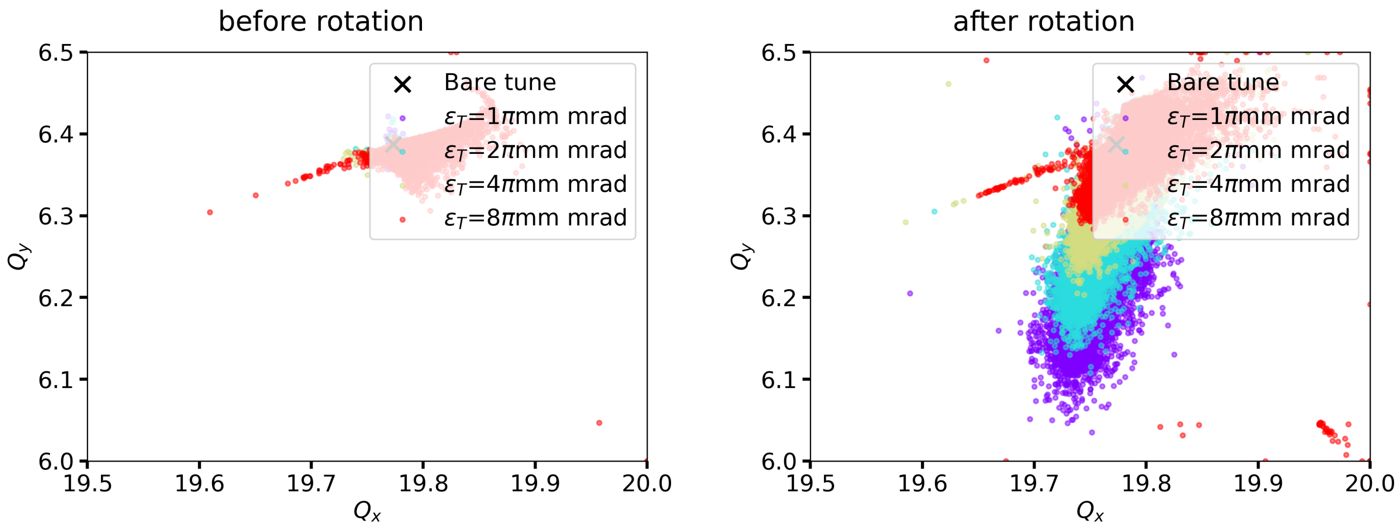


! Also at this energy the tune spread from SC is significant

→ recombination of bunches still needed

scan in emittance (10 GeV)

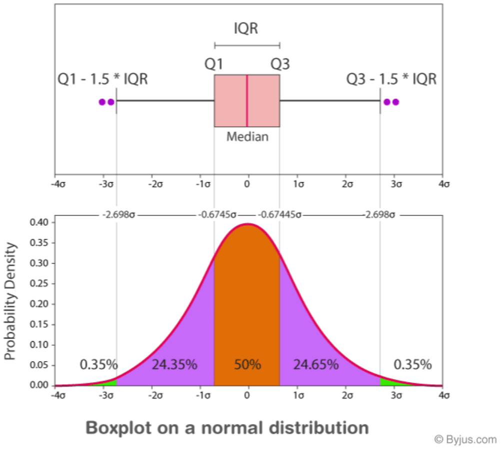
Assume 6 bunches:

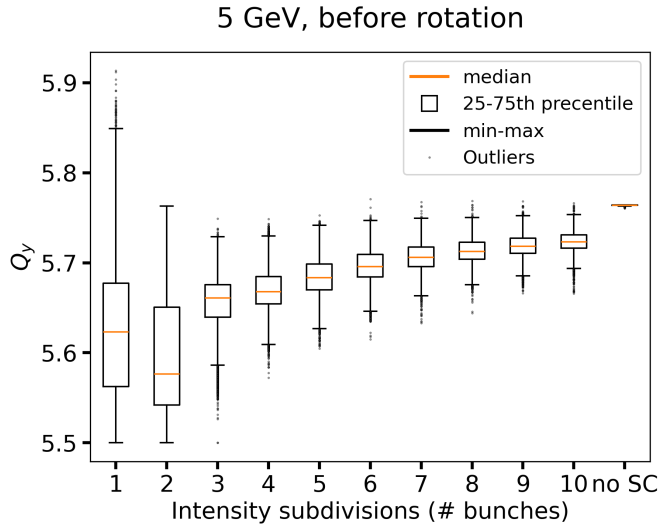


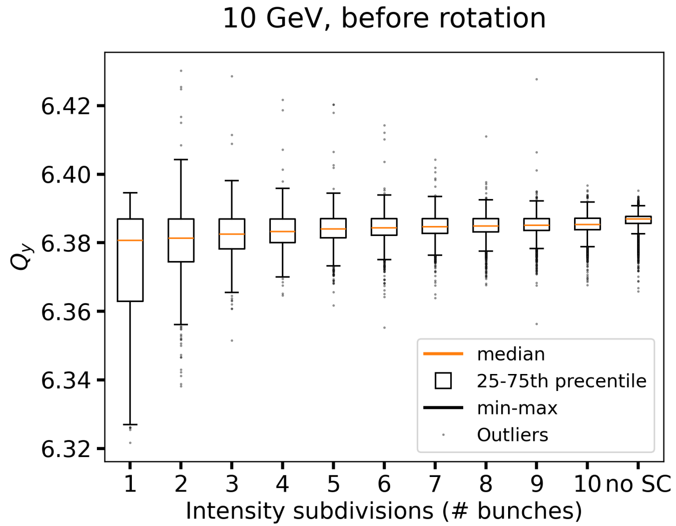
! At this energy and intensity, a change in emittance has a large impact in the tune spread.

Compare 5 GeV to 10 GeV (Q_y)

Before rotation

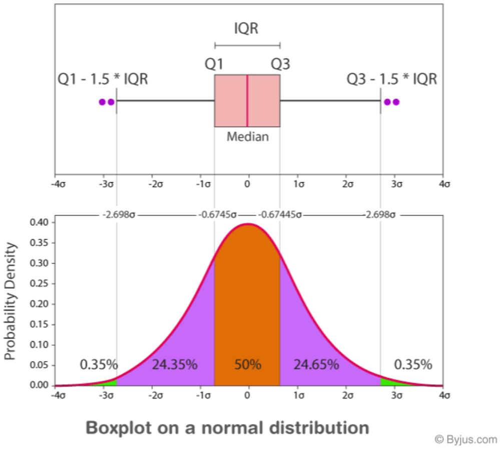


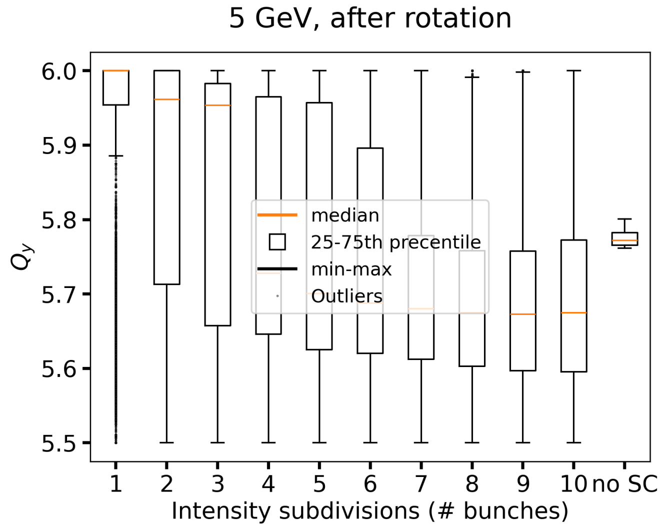


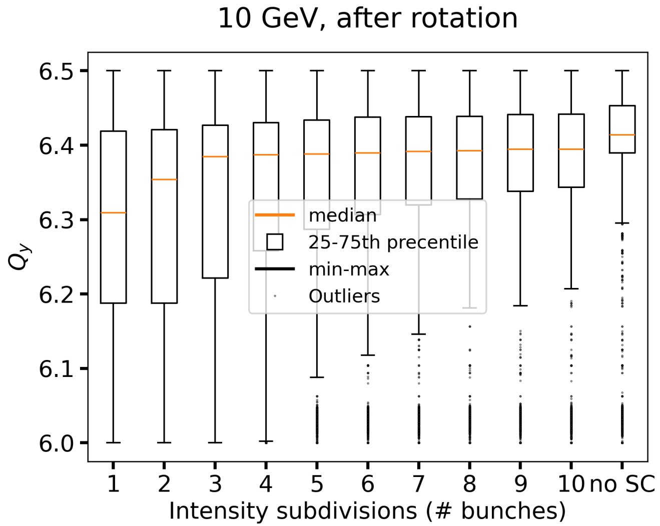


Compare 5 GeV to 10 GeV (Q_y)

After rotation







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Conclusions

- Estimated space charge effects using coasting beams of different densities and emittances.
- 5 GeV seems unattainable at this time from initial estimates of SC induced tune spread
- Also at 10 GeV, several bunches will need to be combined.

→ Go higher in energy?

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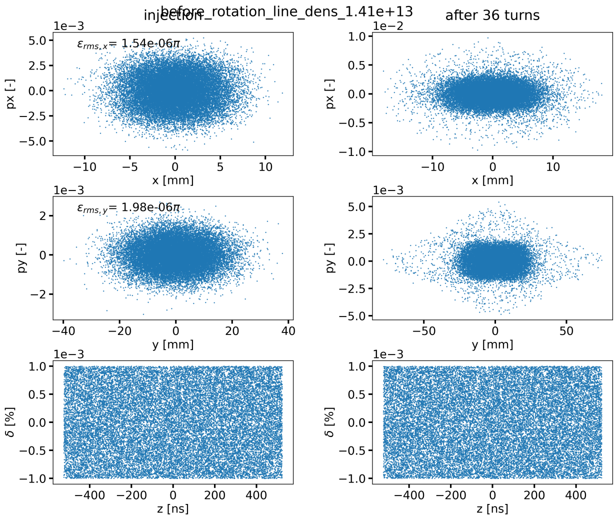
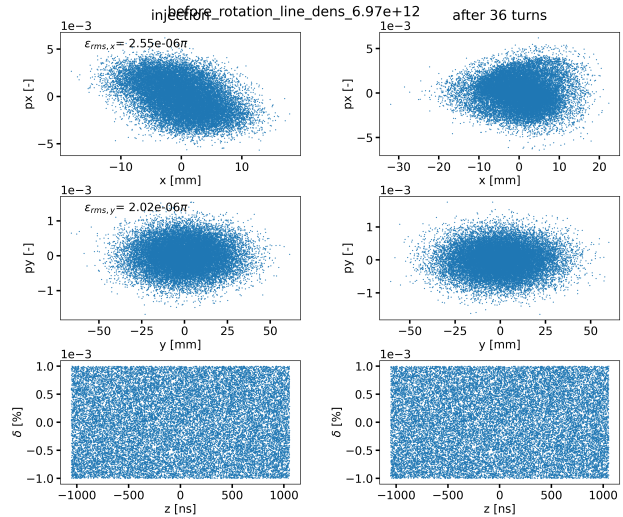
Phase space plots - equivalent coasting beam

before rotation, 1 bunch, 5 GeV



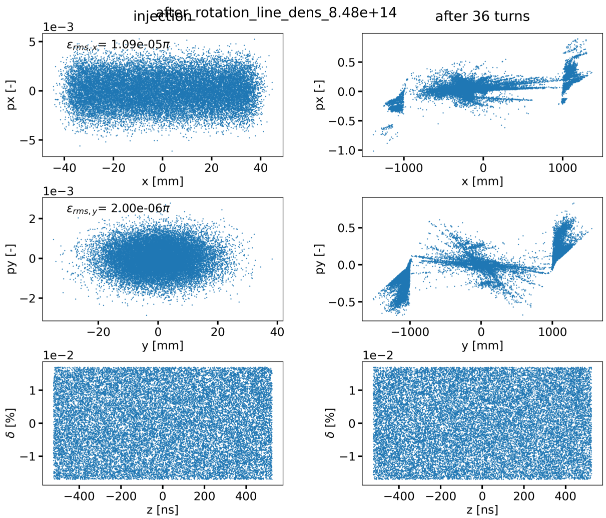
before rotation, 1 bunch, 10 GeV



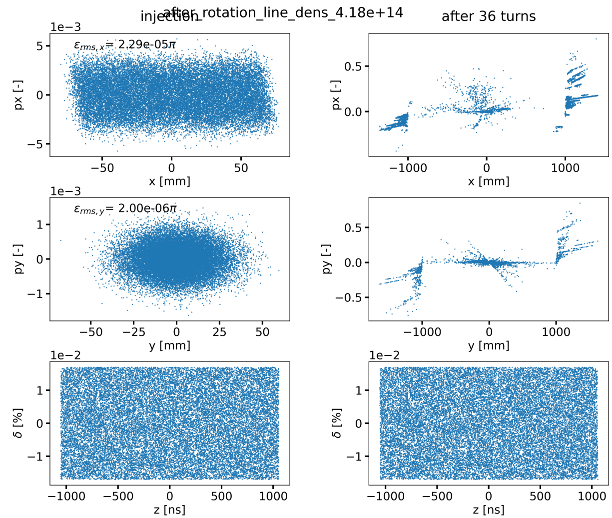
Coasting beam simulations for 36 turns.

Phase space plots - $\epsilon_H = 1\pi$ mm mrad, $\epsilon_V = 2\pi$ mm mrad

after rotation, 1 bunch, 5 GeV



after rotation, 1 bunch, 10 GeV



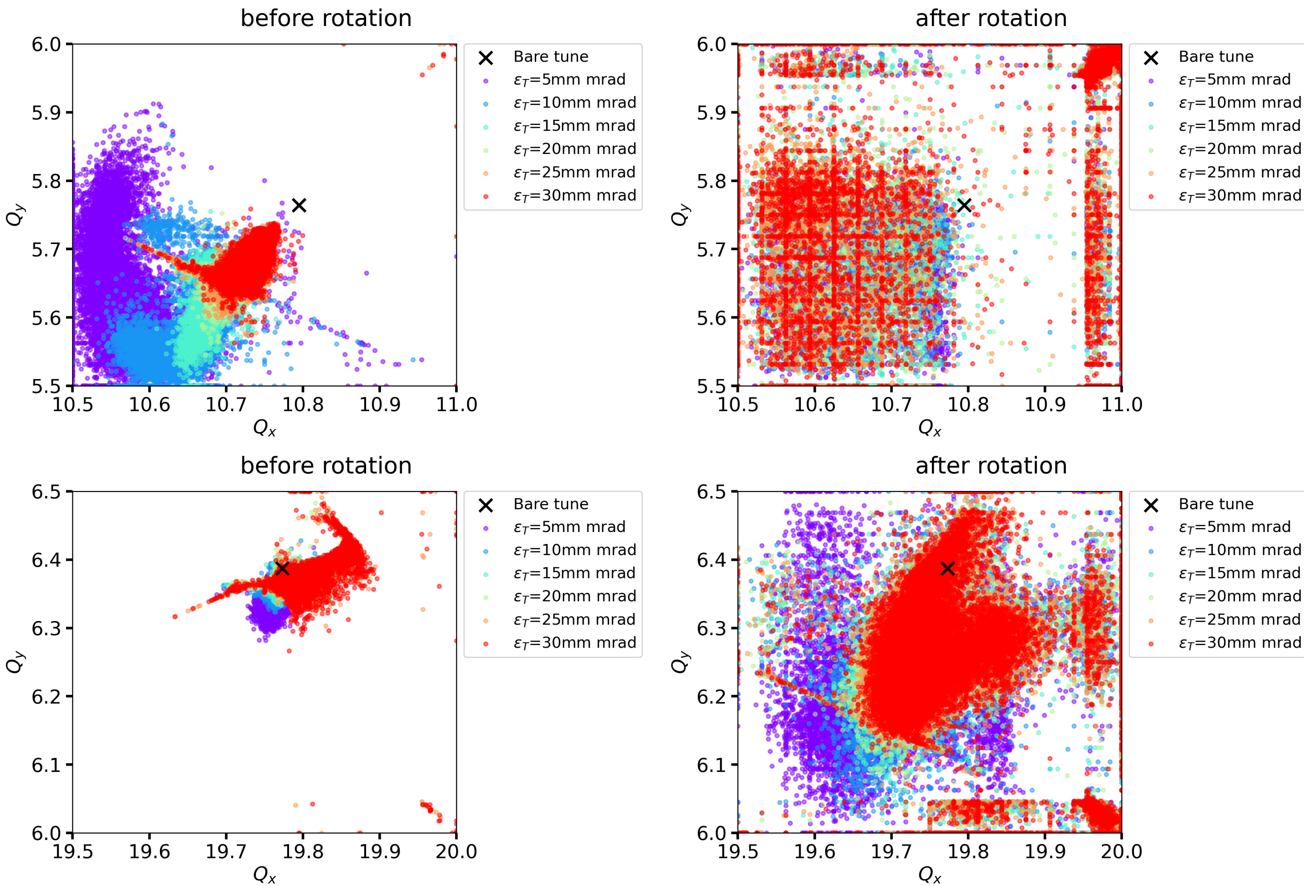
Coasting beam simulations for 36 turns.

Emittance scan, 1 bunch

No bunch recombination, all power contained in one bunch

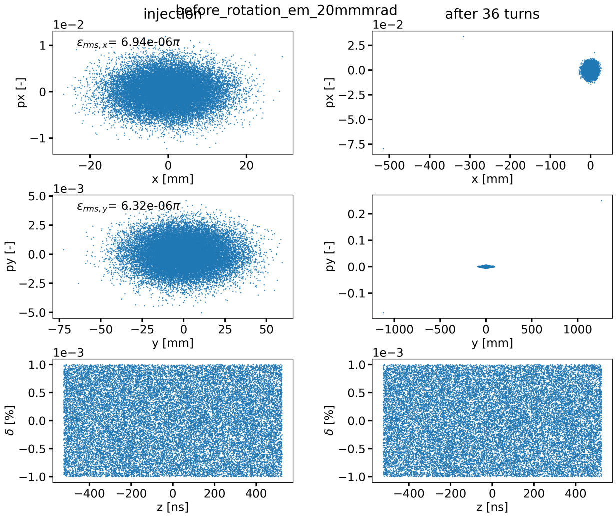
5 GeV

10 GeV

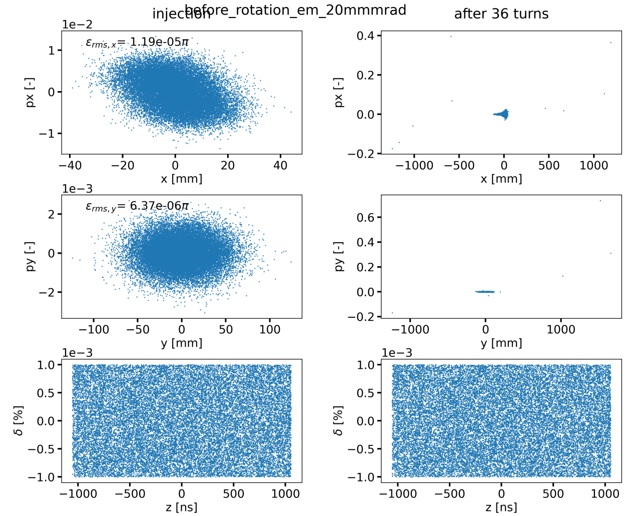


Phase space plots - $\epsilon_H = \epsilon_V = 20$ mm mrad

before rotation, 1 bunch, 5 GeV

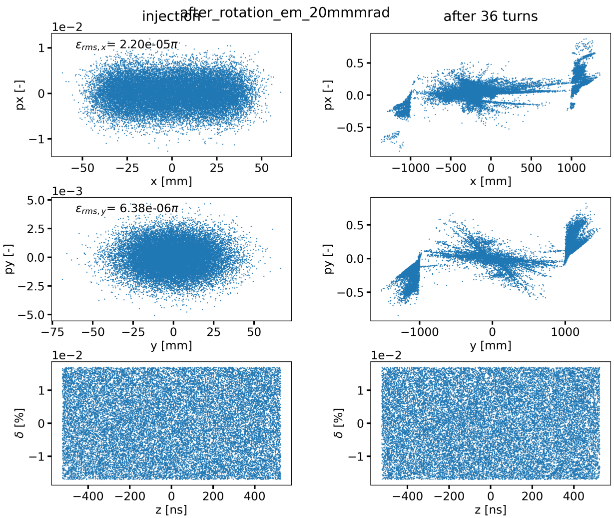


before rotation, 1 bunch, 10 GeV

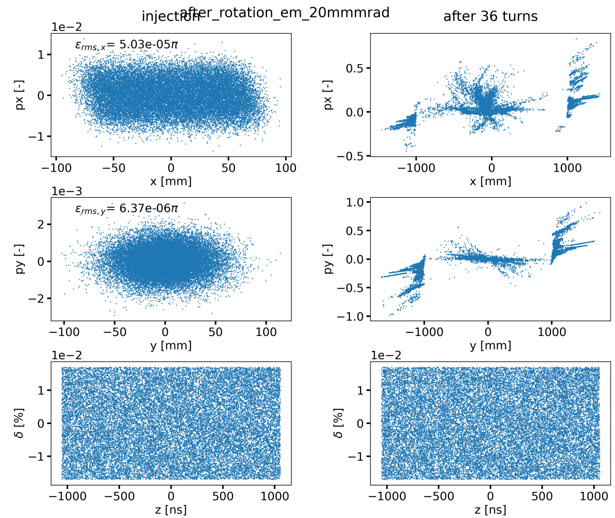


Phase space plots - $\epsilon_H = \epsilon_V = 20$ mm mrad

after rotation, 1 bunch, 5 GeV



after rotation, 1 bunch, 10 GeV



Coasting beam simulations for 36 turns.