Bunch Lengthening VSR

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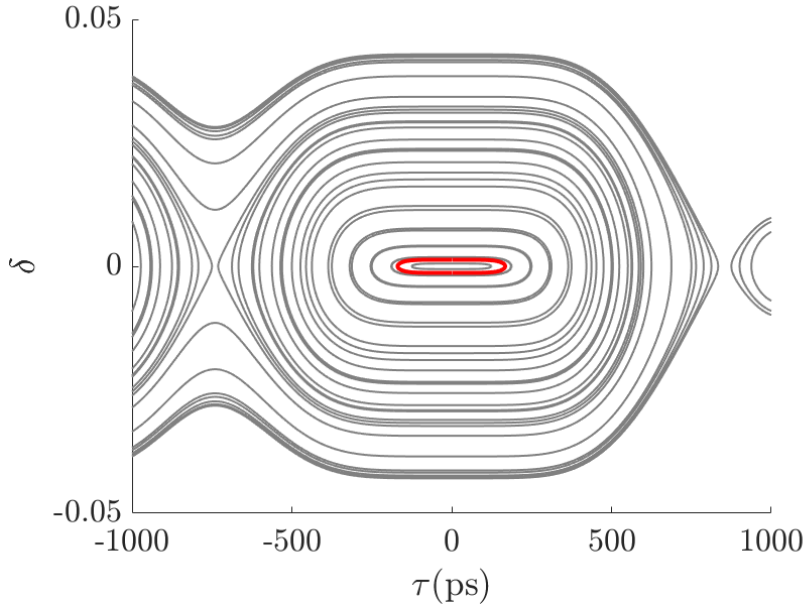
Phase Space Diagram and Particle Tracking

The Hamiltonian satisfying equations of motion is $\mathcal{H}(\tau,\delta)=\frac{1}{2}\eta\delta^2+\frac{eV_1}{2\pi h\beta^2 E}U(\tau)$,

where $U(\tau)=\cos(\omega_{\mathrm{rf}}\tau+\phi_{1\mathrm{s}})-\cos\phi_{1\mathrm{s}}-\frac{r_1}{m_1}[\cos(m_1\omega_{\mathrm{rf}}\tau+\phi_{2\mathrm{s}})-\cos\phi_{2\mathrm{s}}]$

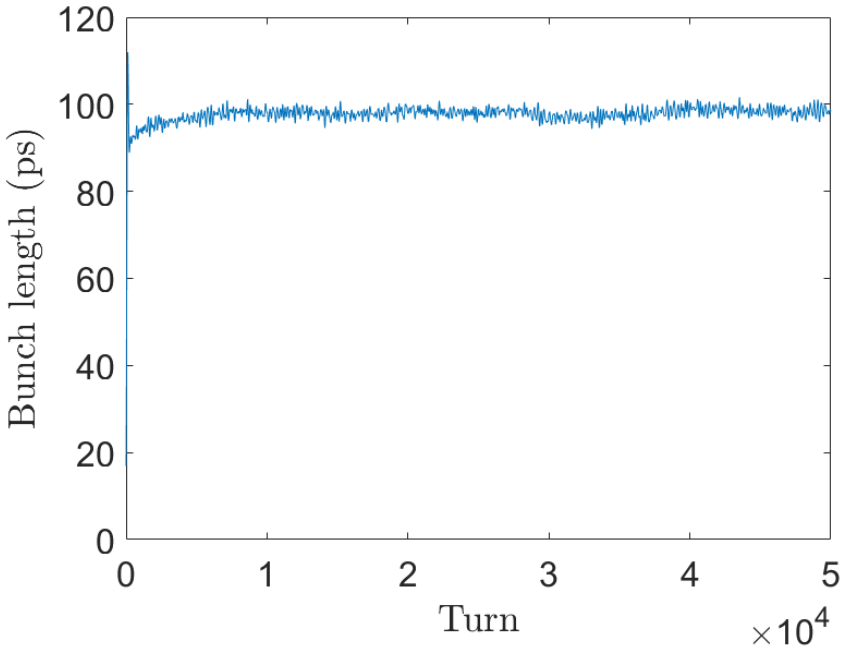
$$-\frac{r_2}{m_2}[\cos(m_2\omega_{\mathrm{rf}}\tau+\phi_{3\mathrm{s}})-\cos\phi_{3\mathrm{s}}]+\omega_{\mathrm{rf}}\tau\sin\phi_{0\mathrm{s}}\ .$$

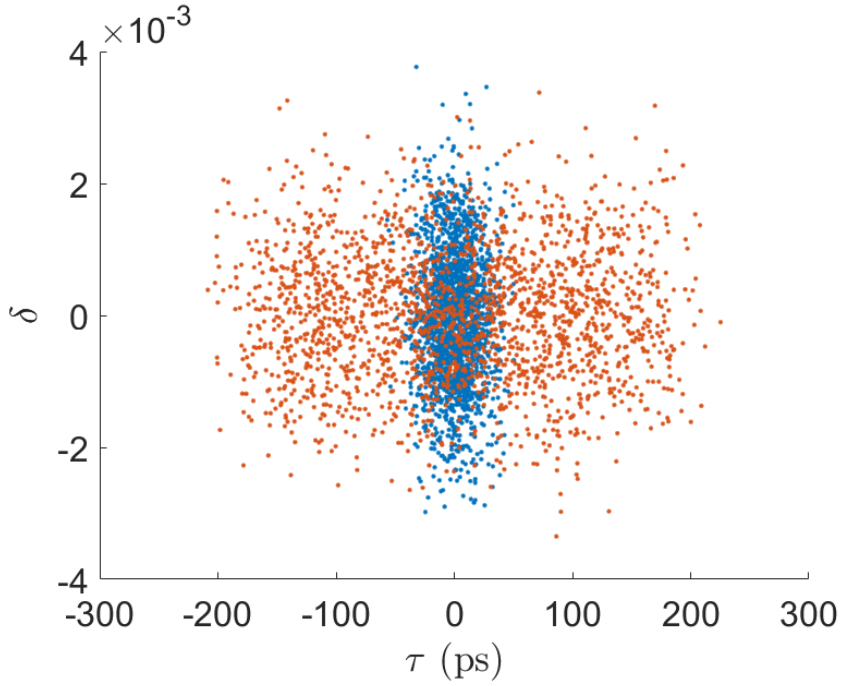
For PLS − II with $m_1=3$ and $m_2=3.5$, BLF @ odd FPs $=5.7$ → Bunch Length $=96$ ps



Phase Space Diagram and Particle Tracking

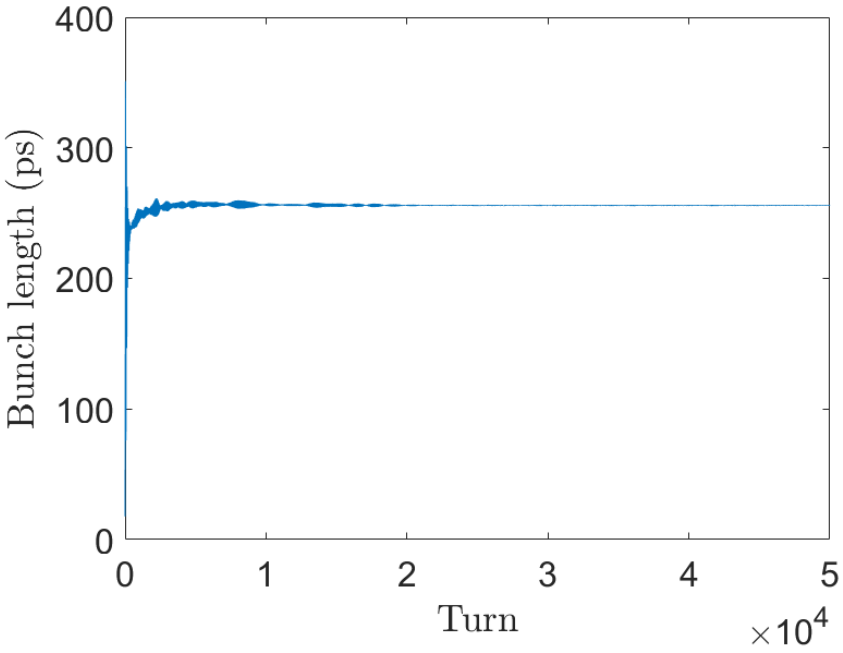
Particle Tracking for *odd* FPs:

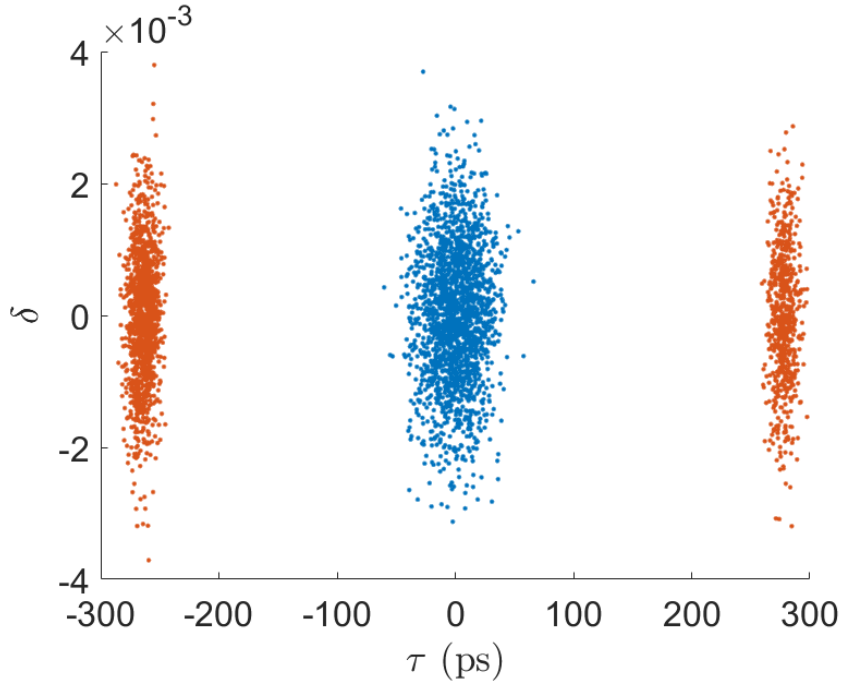




Phase Space Diagram and Particle Tracking

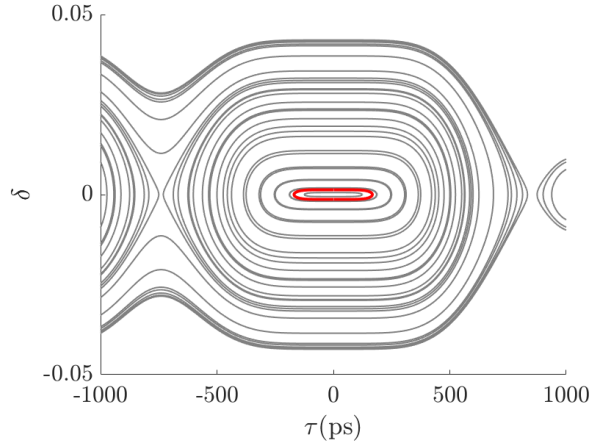
However, Particle Tracking for *even* FPs :

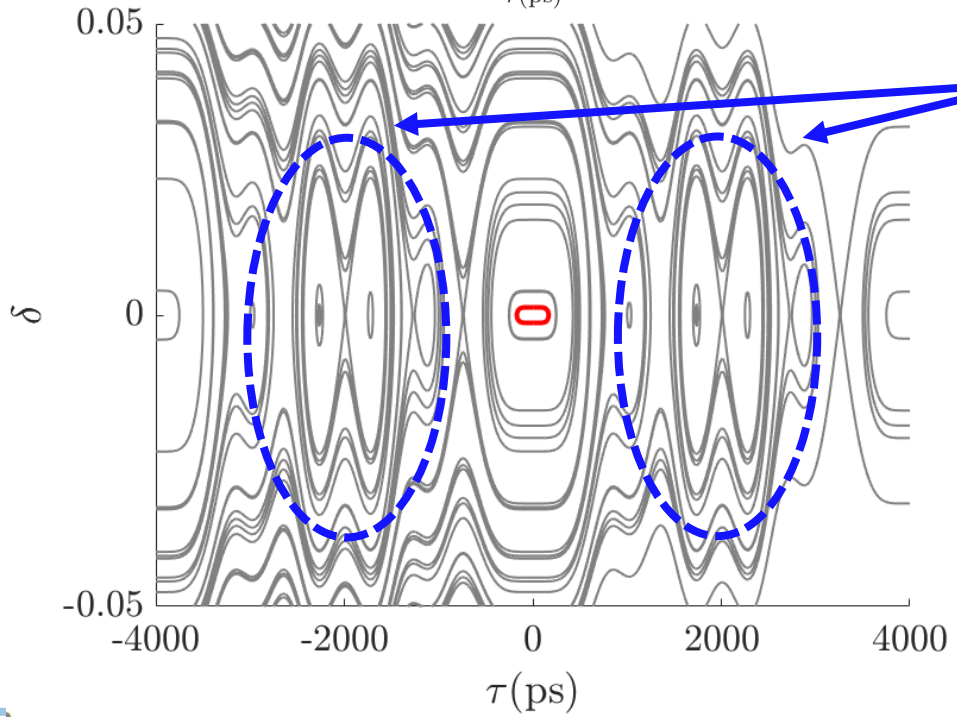




- Bunch must be shorter than natural bunch length = 16.8 ps
- Bunch split?

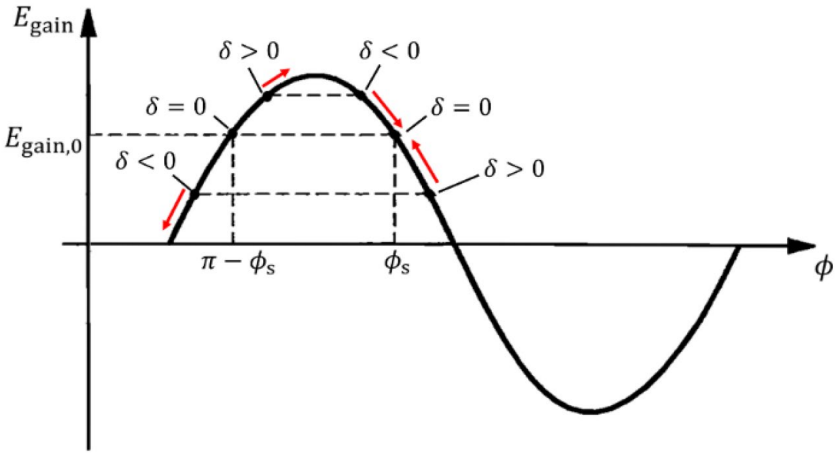
Phase Space Diagram and Particle Tracking

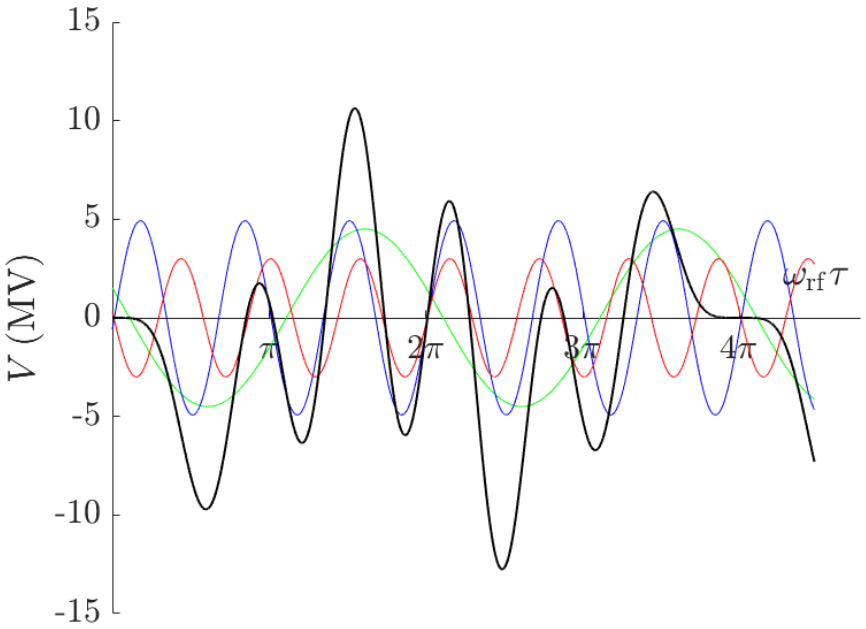




Phase Space Diagram and Particle Tracking

The answer lay in the basic :

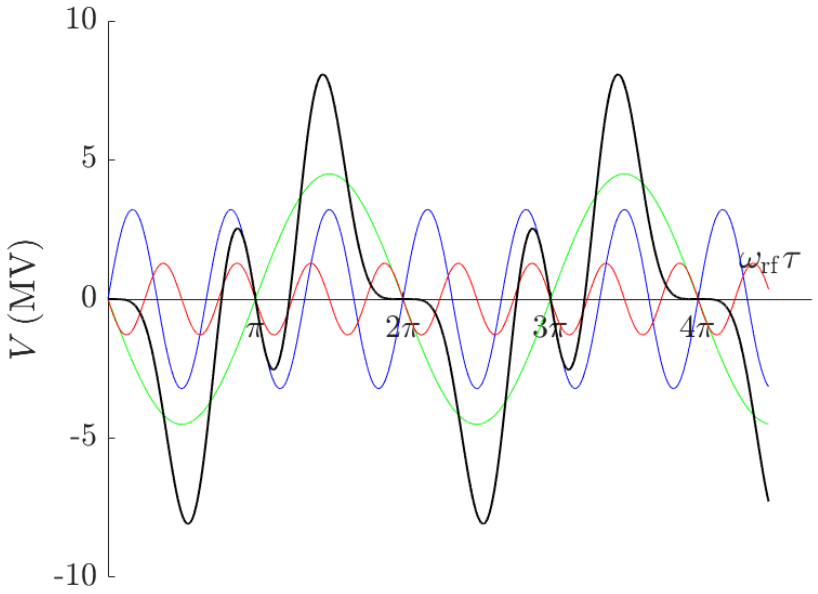


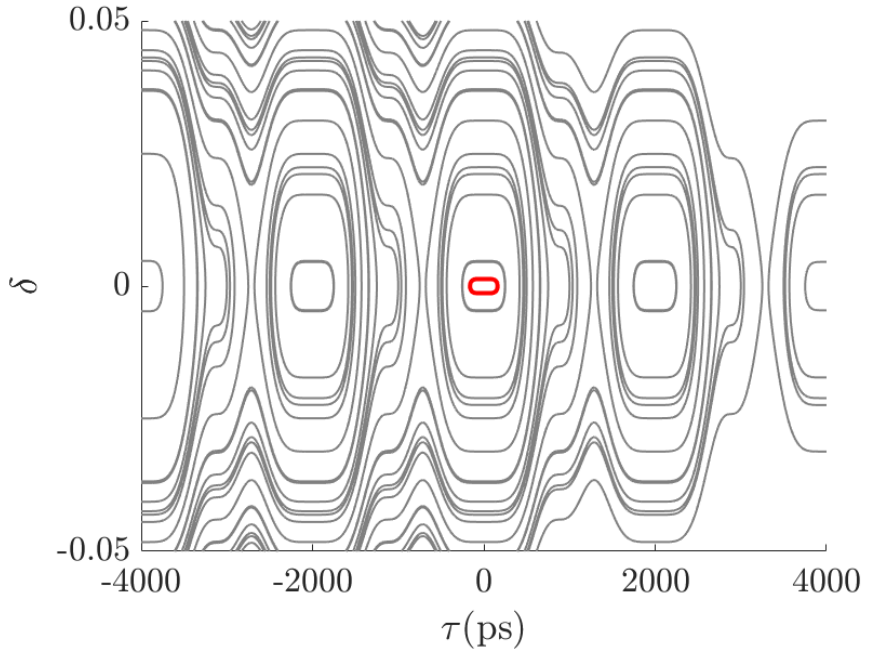


$\Rightarrow$ *Maybe* high positive voltage gradient at $\omega_{\text{rf}}\tau = 2\pi$ splits the bunch

Phase Space Diagram and Particle Tracking

What about integer harmonic cavities? e. g. $m_1 = 3, m_2 = 4$:



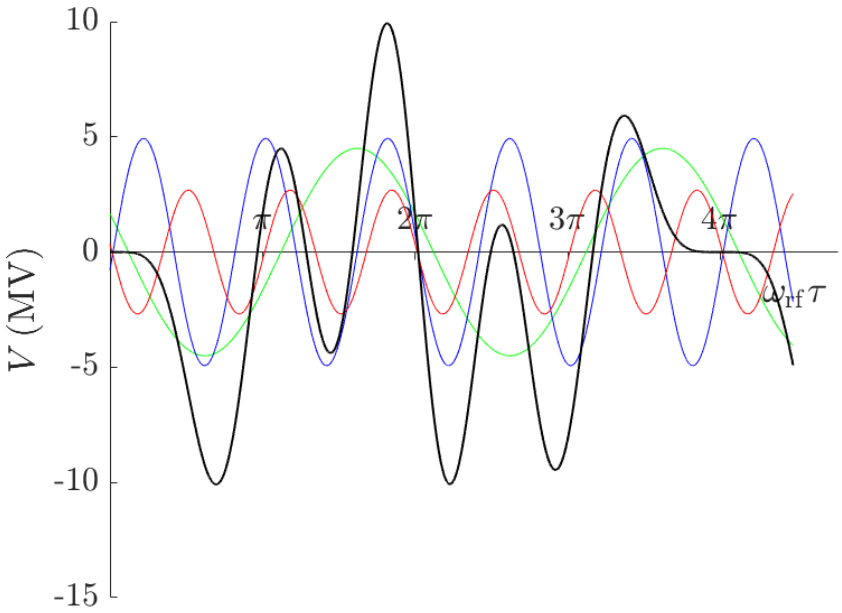


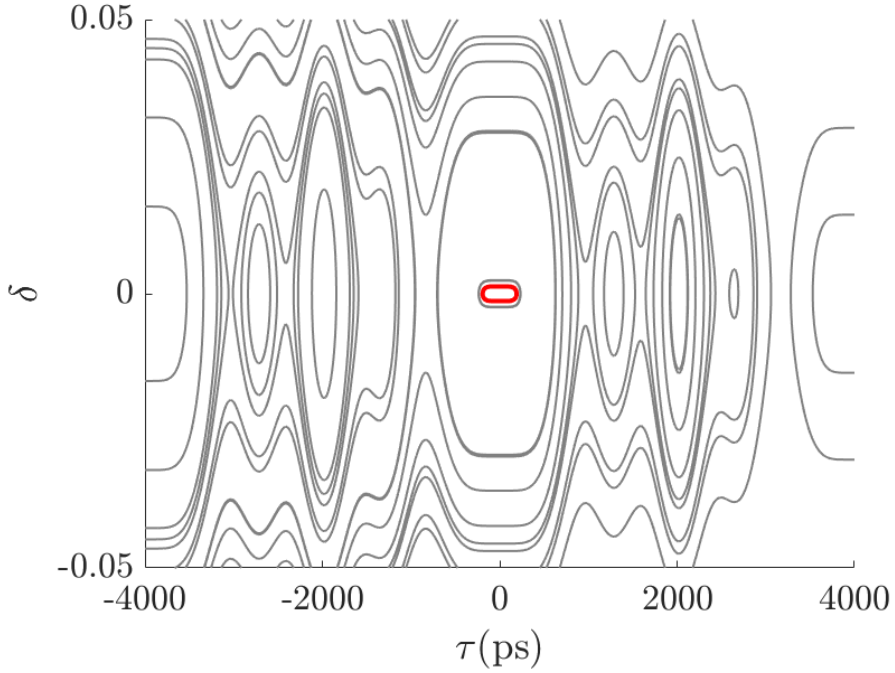
⇒ Should we abandon the Bunch Lengthening VSR concept?

Proper choice of harmonic cavities

If we choose $\boldsymbol{m_1 = 2.5}$ and $\boldsymbol{m_2 = 3}$, then BLF @ odd FPs $= 6.5$

→ Bunch Length @ odd FPs $= 108.8$ ps

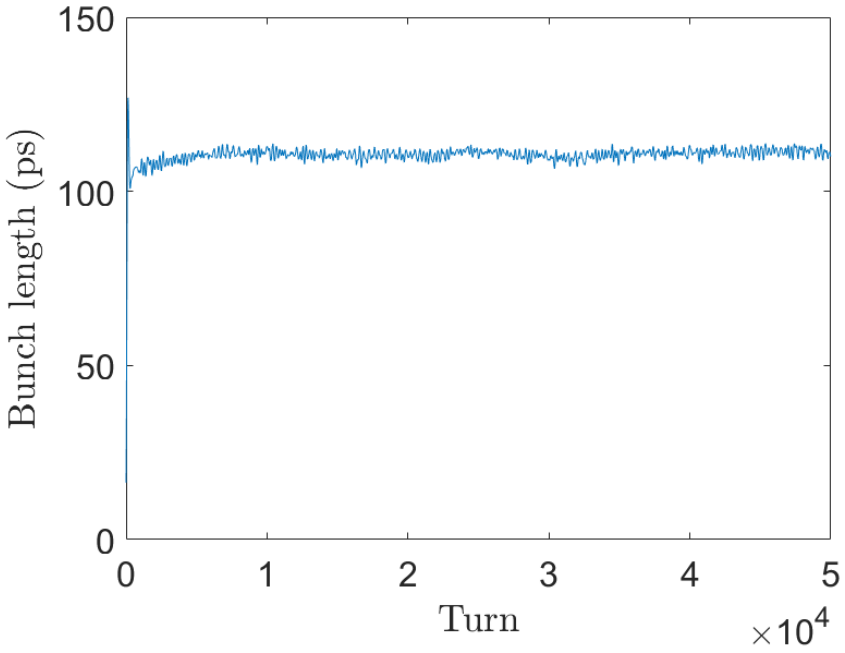


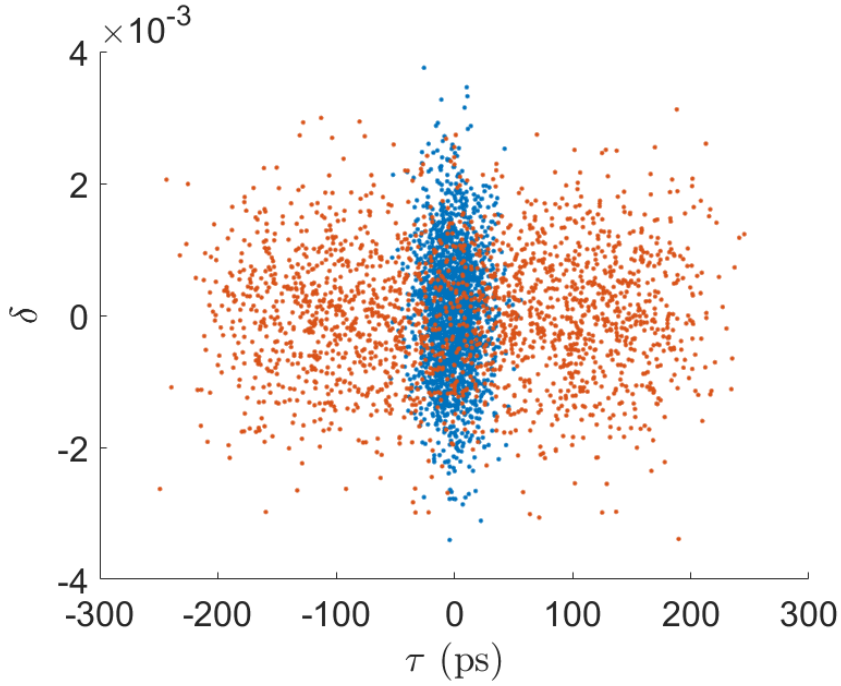


- *No bunch splitting at even FPs*!

Proper choice of harmonic cavities

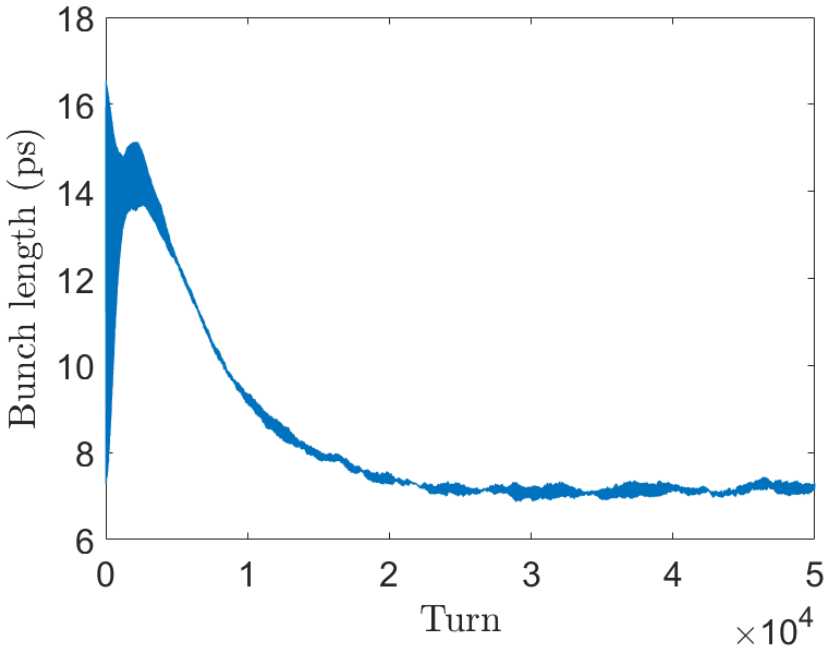
Particle Tracking for *odd* FPs:

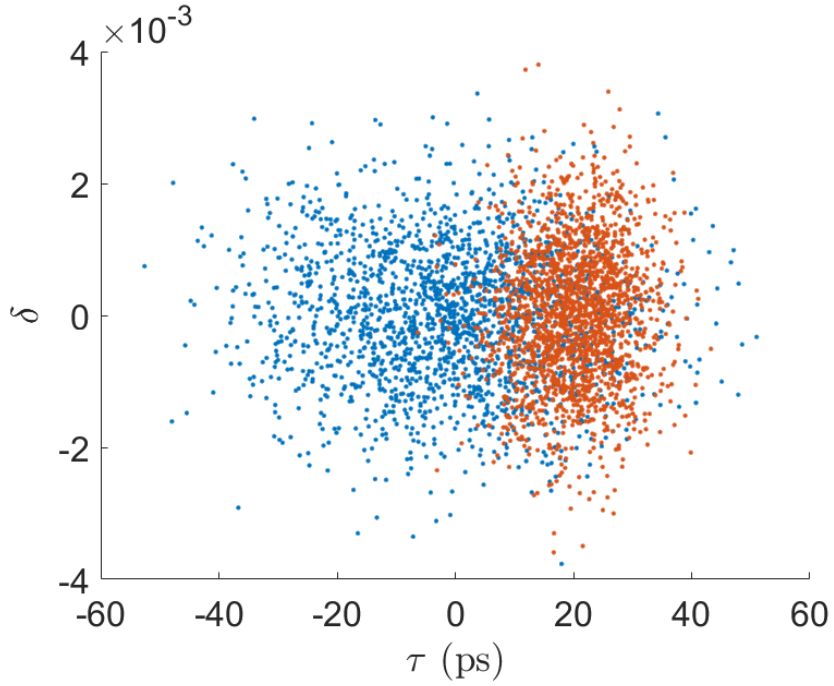




Proper choice of harmonic cavities

Particle Tracking for *even* FPs :





- Bunch length at even FPs = 7.1 ps

Proper choice of harmonic cavities

BESSY chose $m_1 = 3$ and $m_2 = 3.5$ to avoid following problems :

- If $m_1 = 2$ and $m_2 = 2.5$, the cavities become larger at the same V' and might not longer fit into one straight section or would require operation at an unreasonably high accelerating field.
- If $m_1 = 4$ and $m_2 = 4.5$, the structure become smaller and raises the concern of increased excitation of HOMs, leading to beam instabilities.

Thus, $m_1 = 2.5$ and $m_2 = 3$ might be an only solution for Bunch Lengthening VSR if we have to include 3HC in harmonic cavities.

Bunch Shortening VSR

Recall)

Choose $\phi_{1s} = \phi_{2s} = \phi_{3s} = 0$,

Even fixed points :

$$V' = \frac{2\pi h}{c}(f_0 V_0 + f_1 V_1 + f_2 V_2)$$

Odd fixed points at $f_1 V_1 + f_2 V_2 = 0$:

$$V' = \frac{2\pi h}{c} f_0 V_0, \qquad \left|\frac{V_1}{V_2}\right| = \frac{f_2}{f_1}$$

Revise)

Choose $\phi_{1s} = \pi$,

Even fixed points :

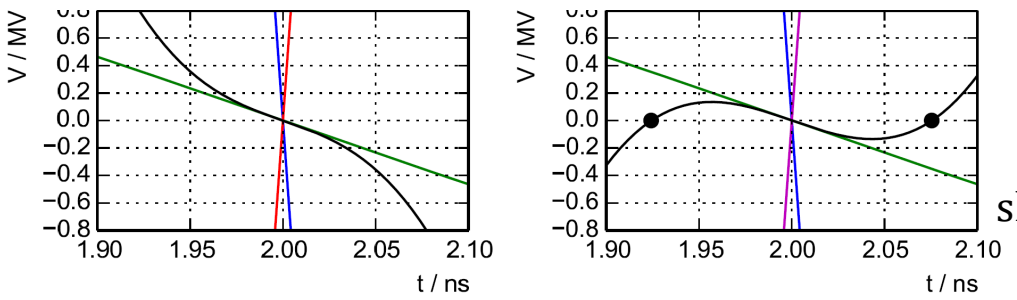
$$V' = \frac{2\pi h}{c}(-f_0 V_0 + f_1 V_1 \cos\phi_{2s} + f_2 V_2 \cos\phi_{3s})$$

Odd fixed points at $f_1 V_1 \cos\phi_{2s} + f_2 V_2 \cos\phi_{3s} = 0$, :

$$V' = -\frac{2\pi h}{c} f_0 V_0, \qquad \frac{V_1}{V_2} = -\frac{f_2 \cos\phi_{3s}}{f_1 \cos\phi_{2s}}$$

Choose $\phi_{2s} = \phi_{3s} = \pi$: $\frac{V_1}{V_2} = -\frac{f_2}{f_1}$

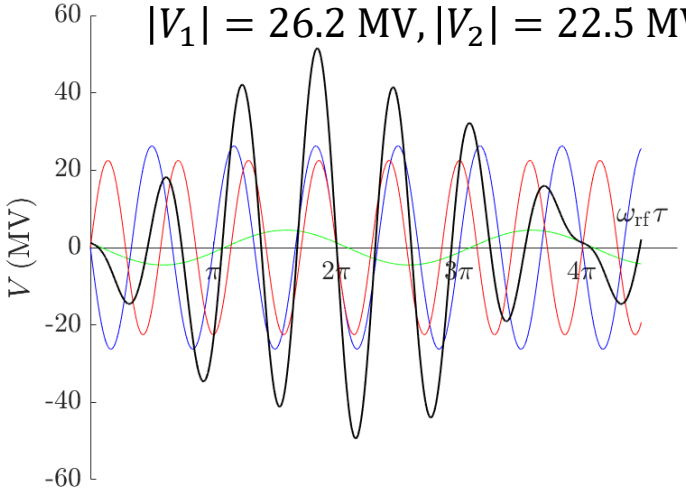
Also,

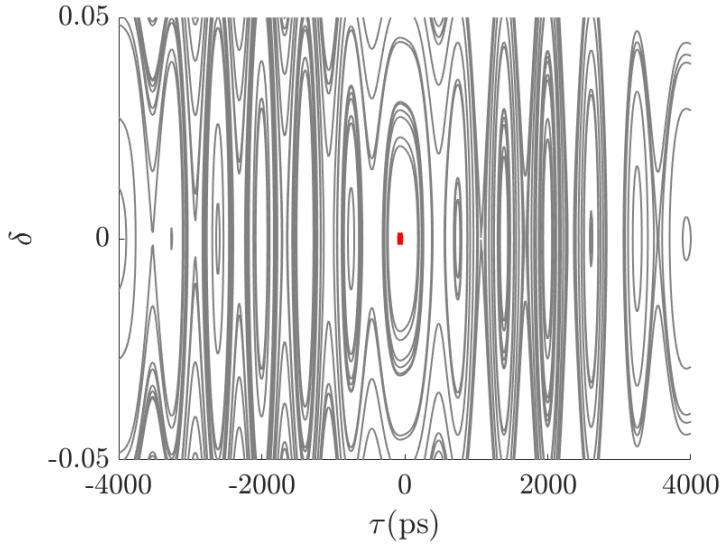


should be avoided.

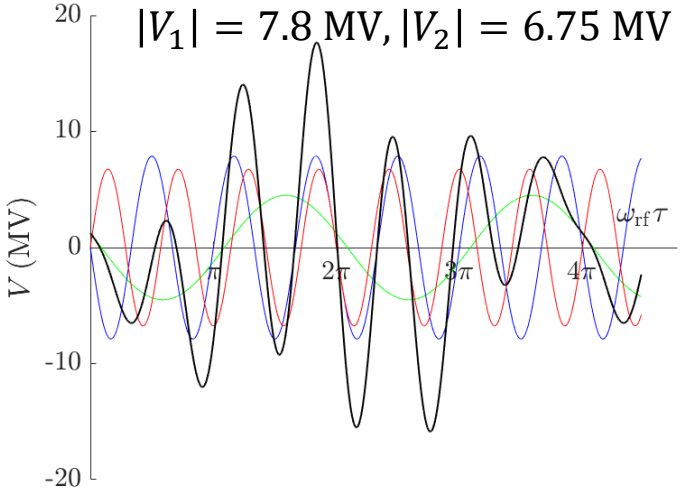
Bunch Shortening VSR

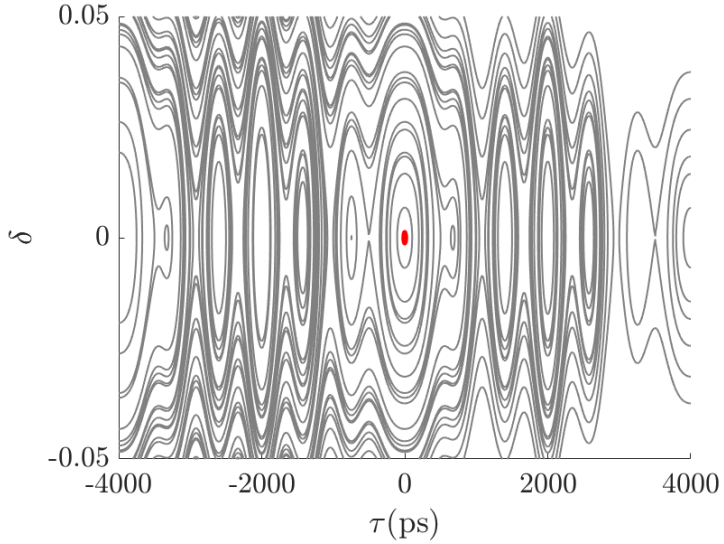
$|V_1| = 26.2$ MV, $|V_2| = 22.5$ MV : SC case





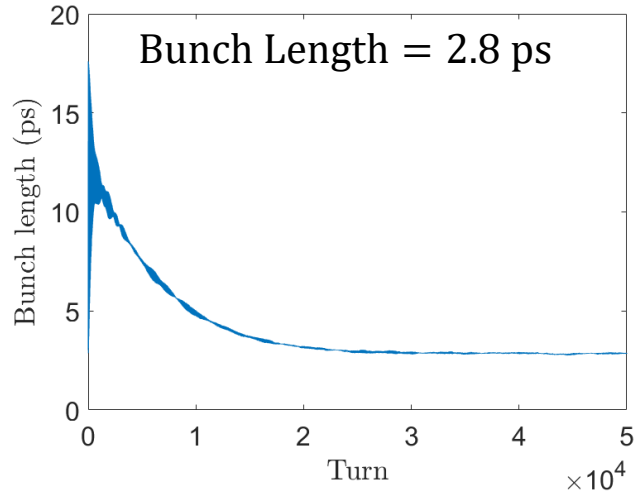
$|V_1| = 7.8$ MV, $|V_2| = 6.75$ MV : NC case



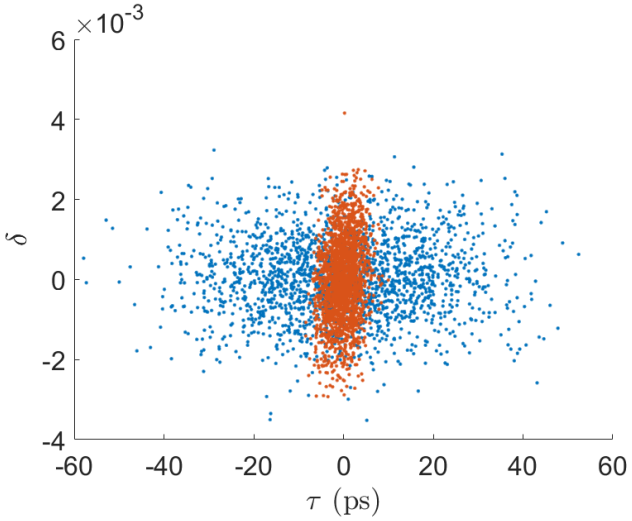


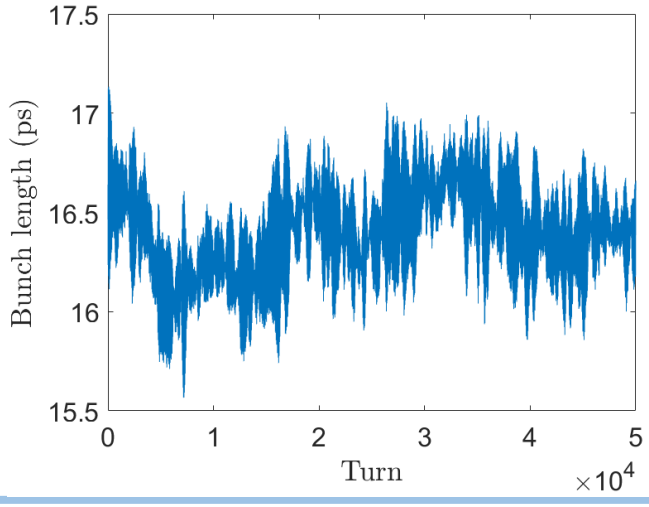
Bunch Shortening VSR

For SC case,

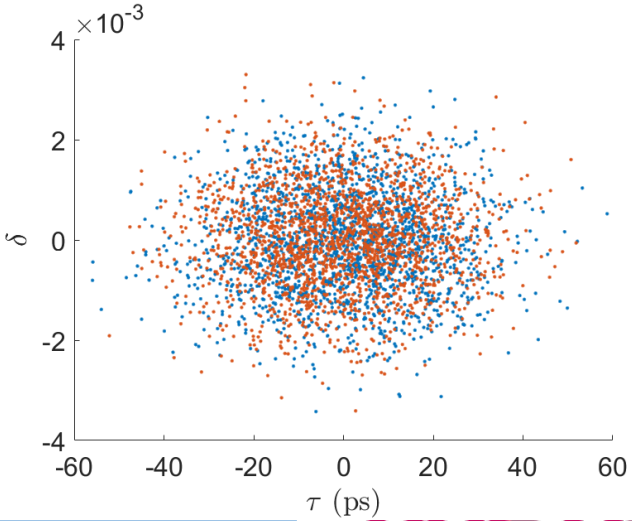


even FPs



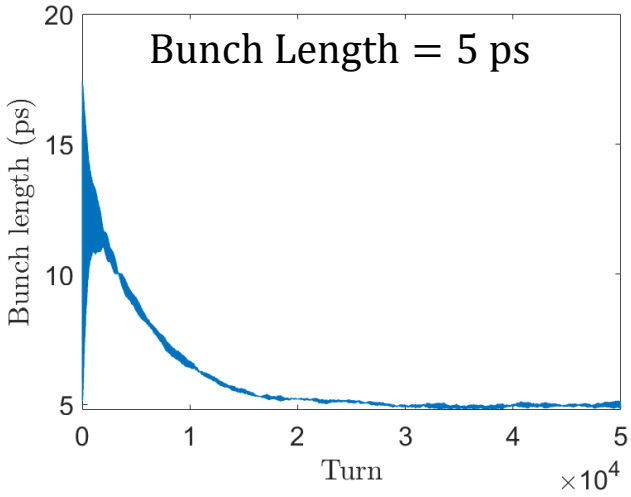


odd FPs

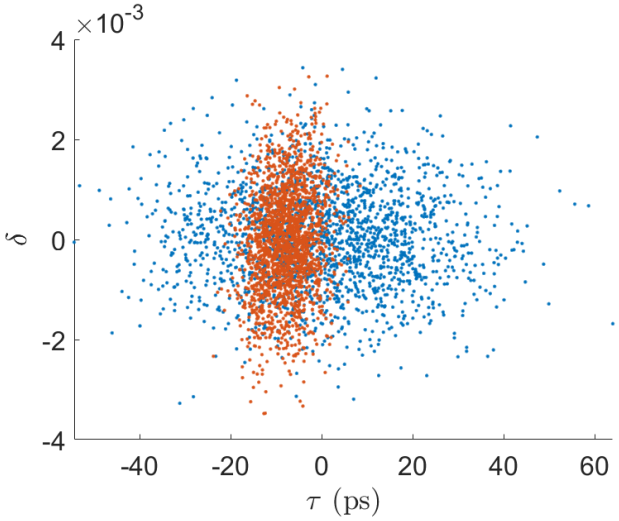


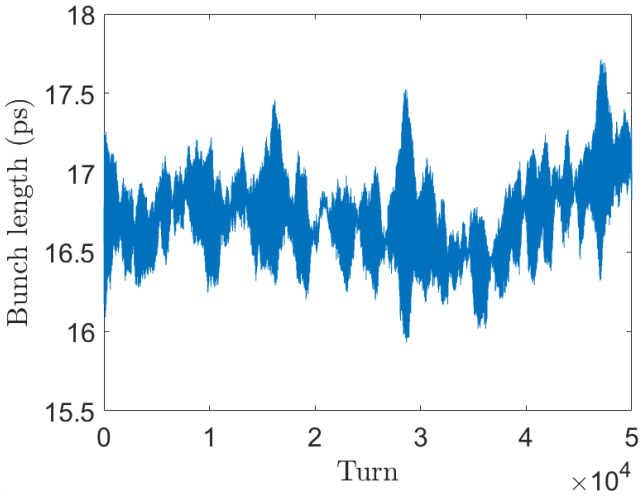
Bunch Shortening VSR

For NC case,

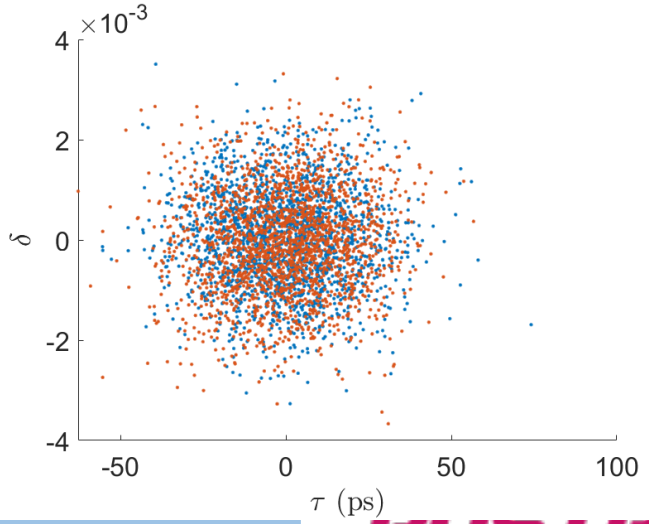


even FPs





odd FPs



Conclusion

Type	m_1	m_2	BLF (Long)	BLF (Short)	
Long Bunch VSR	2.5	3	6.5	0.44	
Short Bunch VSR	3	3.5	1	SC	0.17
				NC	0.30