Spin decoherence in a Frozen Spin lattice, its suppression and effect on the Frequency Domain EDM statistic

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Spin precession essentials

- T-BMT equation
- spin tune and precession axis

Spin tune decoherence

- spin tune expression $\nu_s = \gamma G$
- Phase stability principle
- orbit lengthening
- equilibrium-level momentum shift
- effective gamma γ_{eff}

Sextupole decoherence suppression theory

- orbit length effect
- compaction factor effect

Simulation setup

- beam
- lattice
- tracking parameters
- written data

Spin precession axis effect

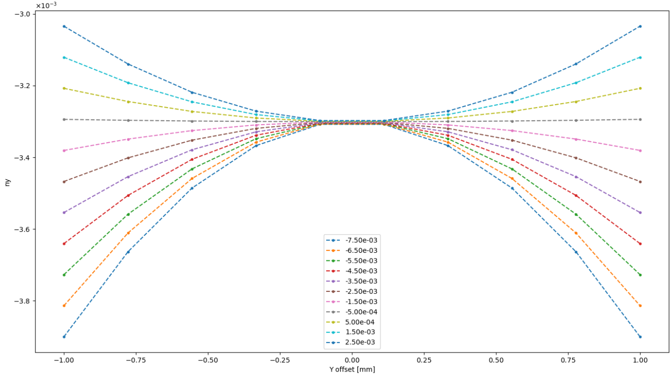


Figure 1: SPA component $\bar{n}_y$ as a function of the vertical beam offset, sextupole gradient value.

SPA: zoom

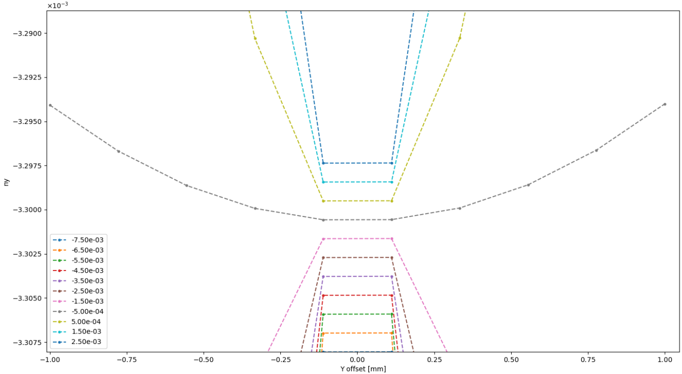


Figure 2: Zoom of Figure 1. SPA component $\bar{n}_y$ (as well as $\bar{n}_x$) is a parabola in the neighborhood of the reference orbit at the optimal GSY value, unlike nu_s, which is **linear**.

Spin tune effect

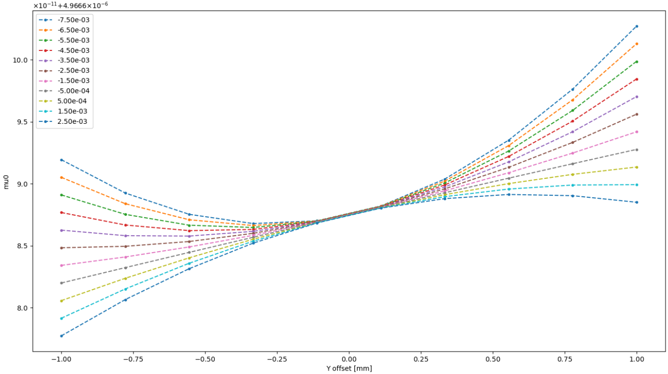


Figure 3: Spin tune ν_s.

Frequency estimate effect

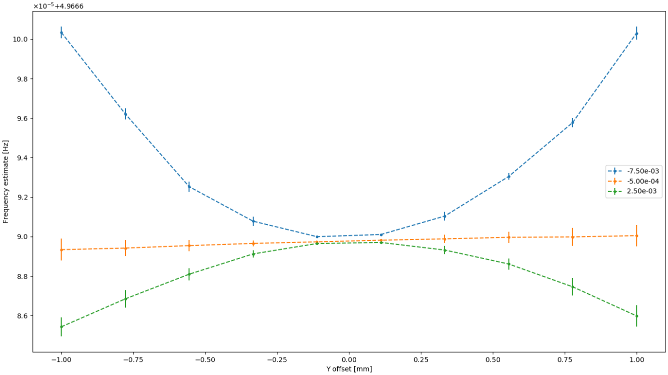


Figure 4: Frequency estimate for the optimal sextupole gradient (orange) and the values at the ends of the searched range.

Frequency estimate: zoom

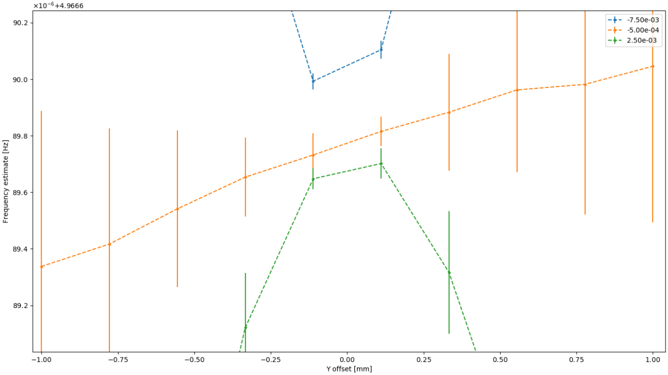


Figure 5: Zoom of Figure 4. Frequency estimate depends on the offset value linearly, like ν_s, and unlike $\bar{n}_y$.

ST+SPA structure

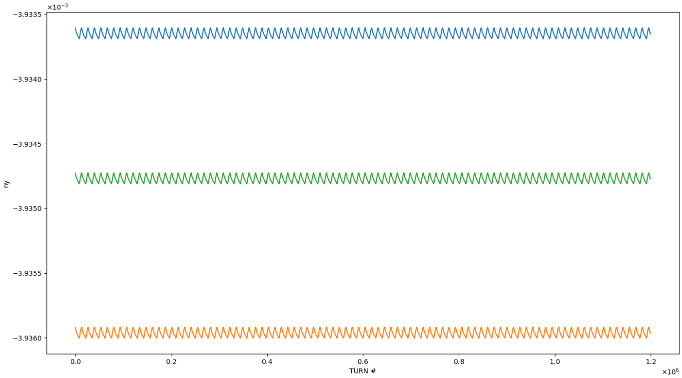


Figure 6: SPA component $\bar{n}_y$ for **particles** with offsets: [1.02749, 1.02937, 1.02840] mm. We observe small rapid oscillations about an average level. This average level changes parabolically with the vertical offset (Figure 8 below). The rapid oscillations are due to betatron motion (Figures 10, and 12).

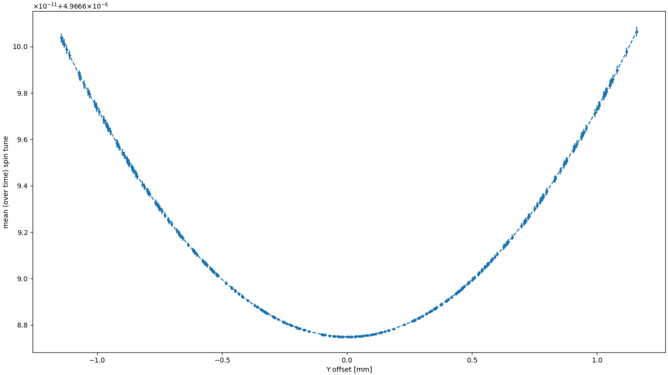


Figure 7: Mean level of spin tune as a function of beam offset

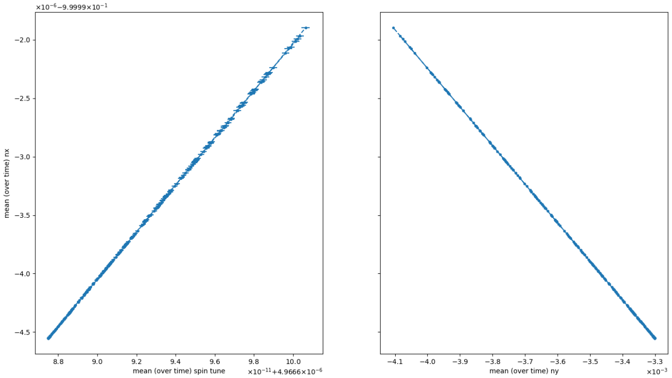
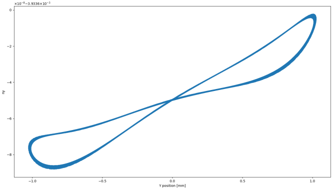
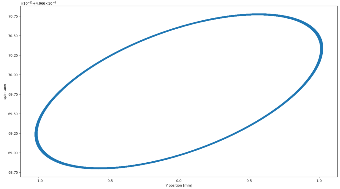


Figure 8: Mean SPA and ST levels versus each other. Observe strong correlation.

Vertical betatron motion dependence



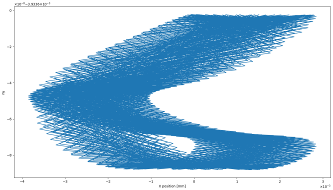
a: SPA component $\bar{n}_y$ as a function of the vertical particle position.



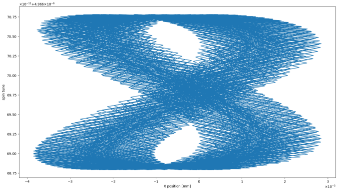
b: Spin tune ν_s as a function of the vertical particle position.

Figure 10: Particle spin precession frequency depending on its vertical position. The observed non-functionality of the parameters on the y-position os due to the dependence on the x-position as well, which also oscillates at a small amplitude (Figure 12).

Horizontal betatron motion dependence



a: SPA component $\bar{n}_y$ as a function of the horizontal particle position.



b: Spin tune ν_s as a function of the horizontal particle position.

Figure 12: Particle spin precession frequency as a function of itsd radial position.