III. Physikalisches Institut B

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Dependence of SCT on the Harmonics of the RF Solenoid excitation

2013-09-25| Marcel Rosenthal

Outline

- Influence of longitudinal phase-space to vertical polarization oscillation frequency while using rf solenoid

- Resonance condition and harmonic dependency

- Tracking Results in COSY Infinity compared to simple analytic model based on rotation matrices
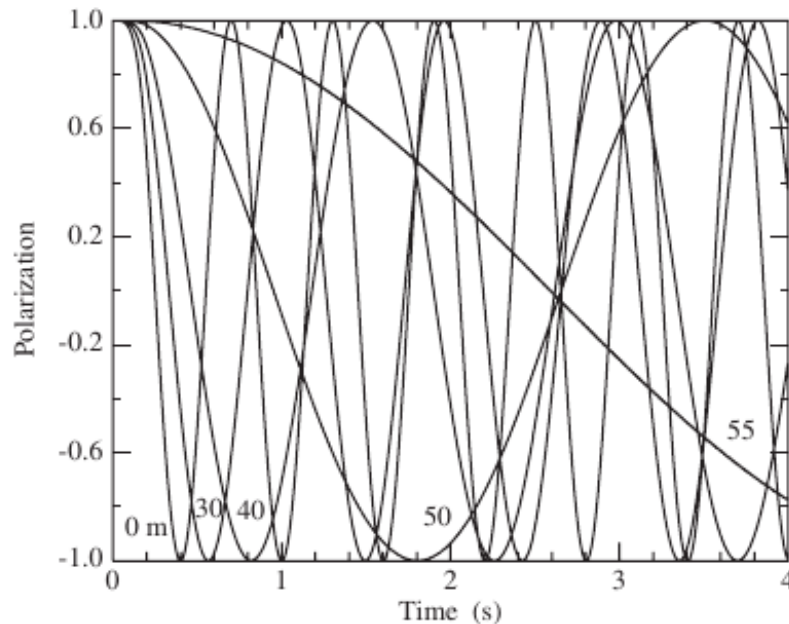
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Reminder

FIG. 13. Sample curves of the change in the vertical polarization as a function of time for different synchrotron amplitudes A. All model calculations were made on resonance. As the synchrotron amplitude gets larger, the oscillation period increases. The curves represent values of $A = 0, 30, 40, 50,$ and 55 m.

- Simulation results shown in 2012 paper:
  "Synchrotron oscillation effects on an rf-solenoid spin resonance"

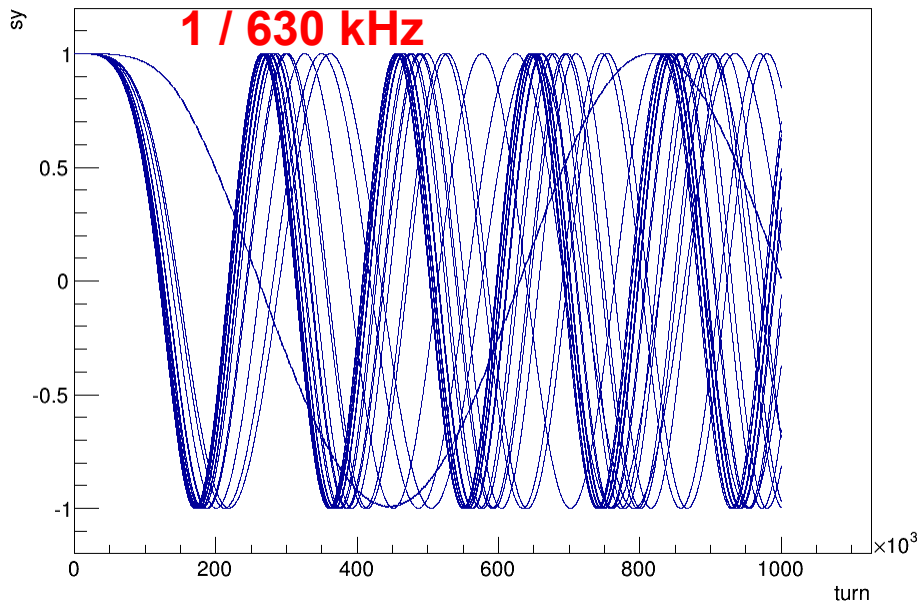- Large synchrotron amplitude corresponds to large max. momentum deviation:

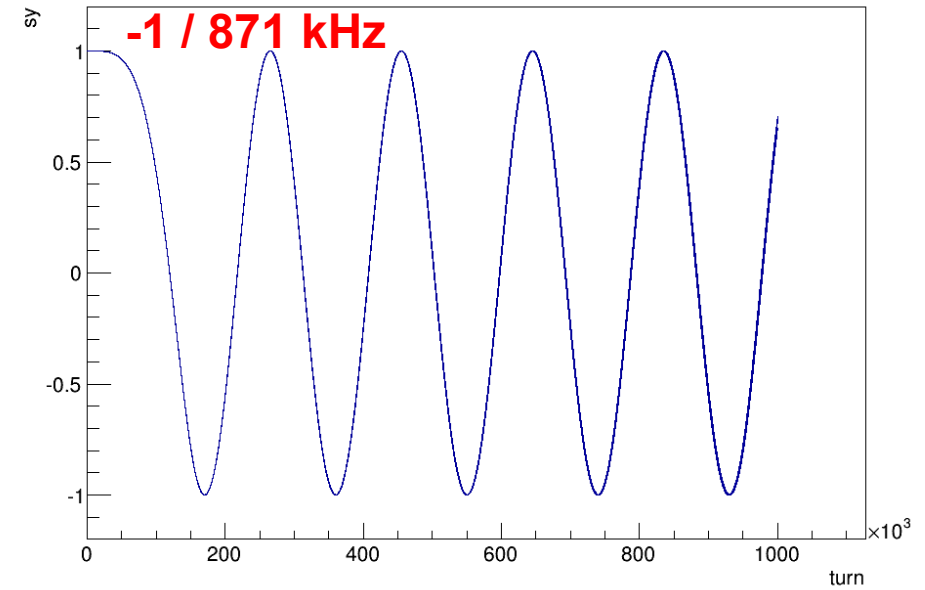- $\frac{\Delta p}{p} = 3.7 \times 10^{-4} \times \frac{A}{15\text{m}}$

50 m → 1.23 ×10⁻³

Comparison of different harmonics
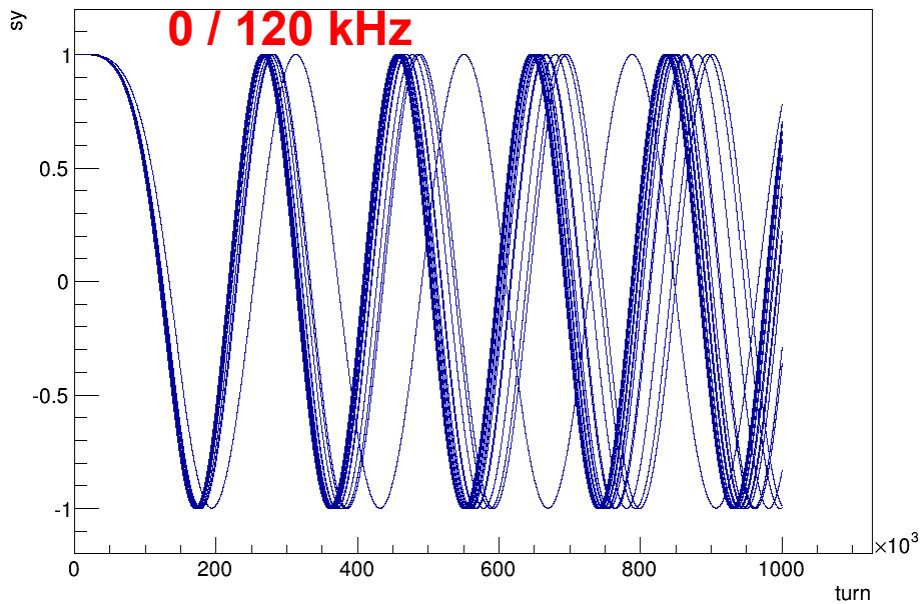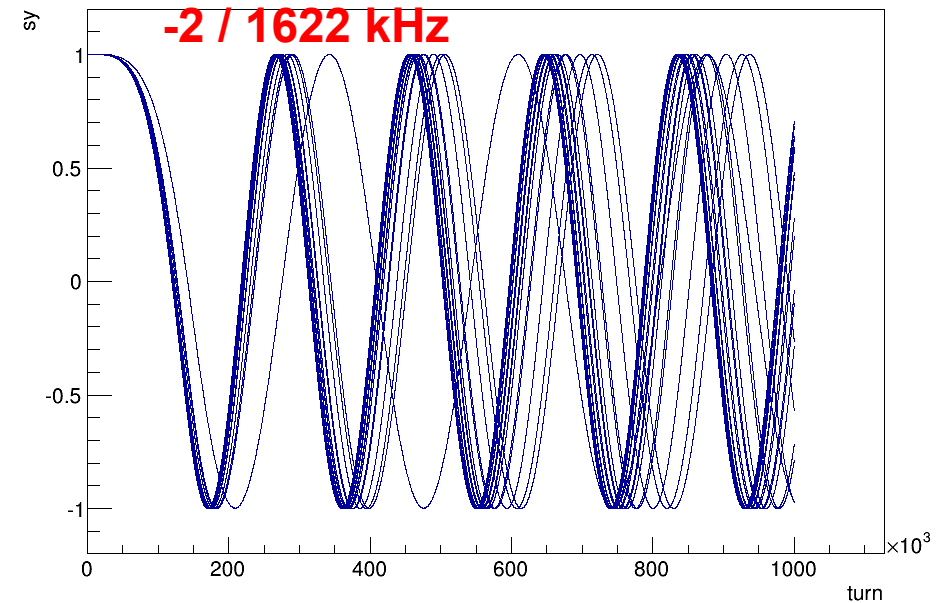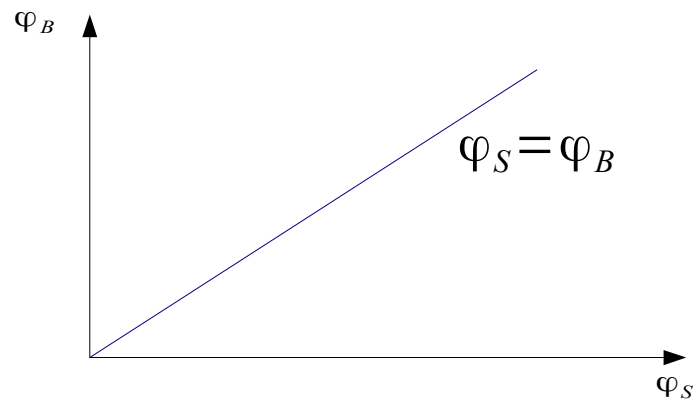
Resonance Condition

- Solenoid frequency has to match spin precession frequency in horizontal plane:

$$\varphi_S = \arccos\left(\frac{S_x}{\sqrt{(S_x^2 + S_z^2)}}\right)$$

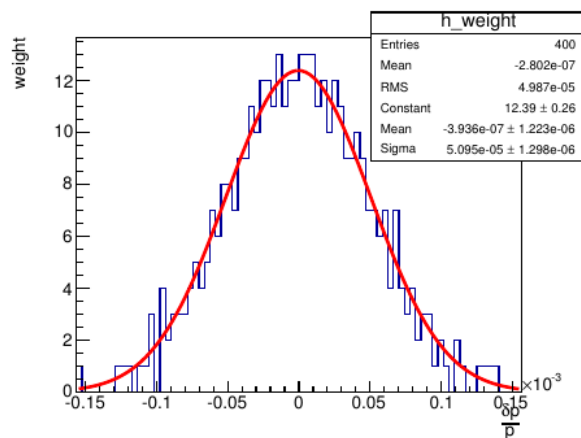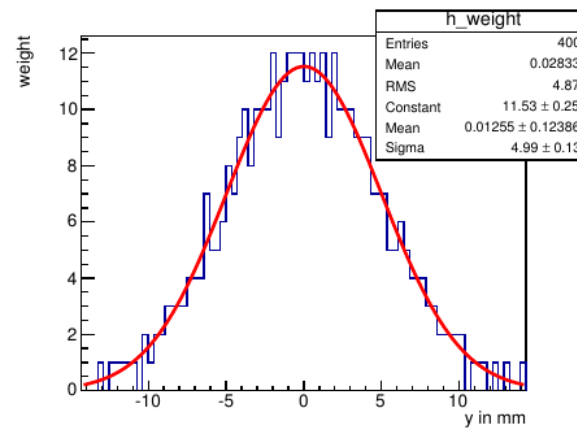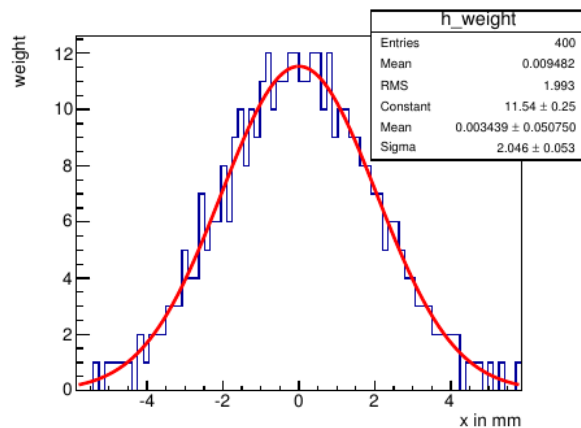$$\varphi_B = \arccos\left(\frac{B_{sol}}{B_{sol,max}}\right)$$

- Synchrotron oscillations lead to a changed time of arrival at solenoid and spin precession frequency.

$$\frac{\Delta\gamma}{\gamma} = \beta^2 \frac{\Delta p}{p}$$

- Changed time of arrival leads to different solenoidal B-Fields (dependent on harmonic of solenoid)

⇨ Influence on resonance condition $\varphi_S = \varphi_B$
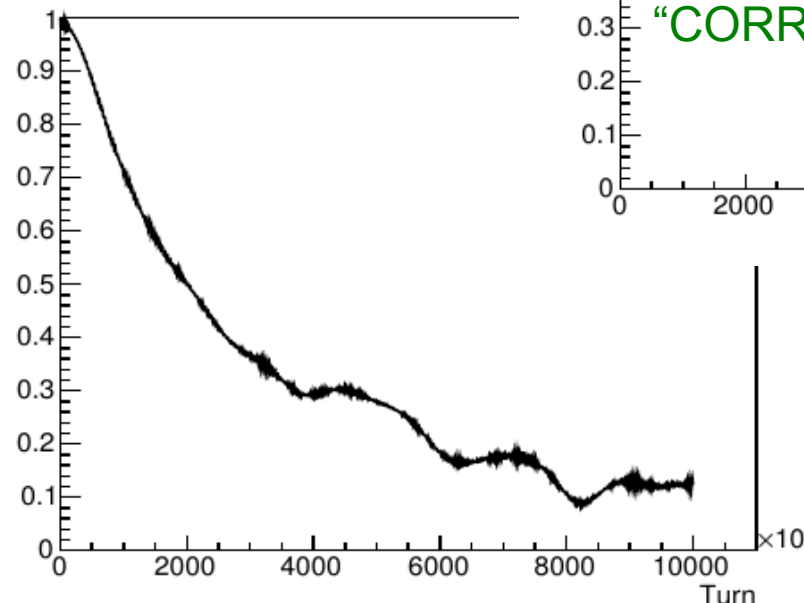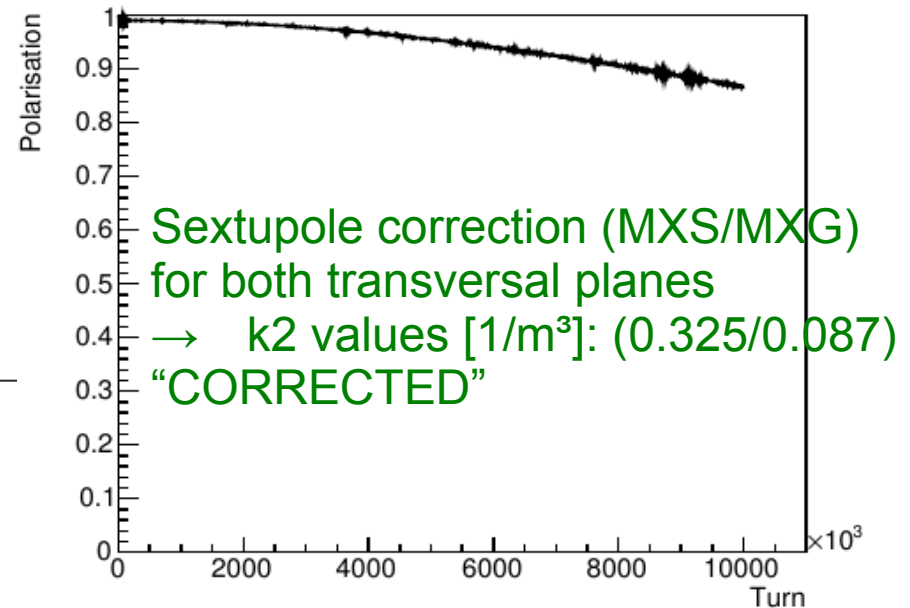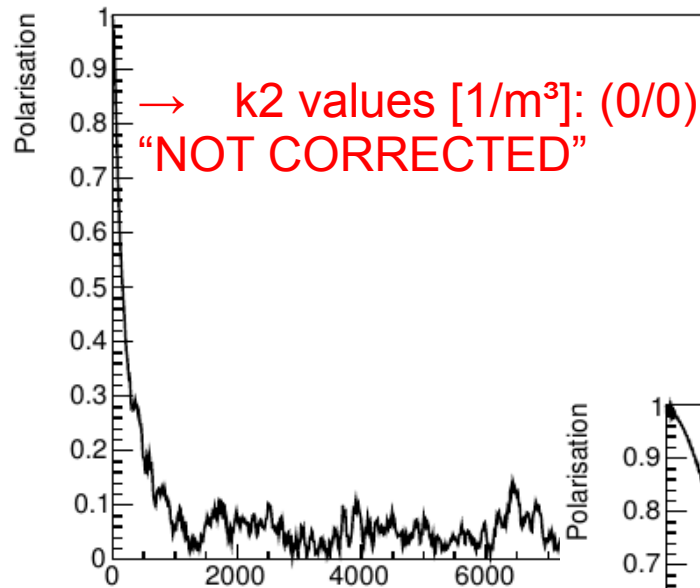
Initial Setup of Beam

- "Ensemble": $\varepsilon_x = 2$ mm mrad, $\varepsilon_y = 8$ mm mrad, $\delta p/p = 10^{-4}$

- 400 particles (deuterons), p=970 MeV/c

- $\beta\gamma = 0.52$

- Gaussian distribution in x, y, and δp/p, other coordinates set to zero.

Polarization lifetime

- Start with initial horizontal polarized beam:

→ k2 values [1/m³]: (0/0)
"NOT CORRECTED"

Sextupole correction (MXS/MXG)
for both transversal planes
→ k2 values [1/m³]: (0.325/0.087)
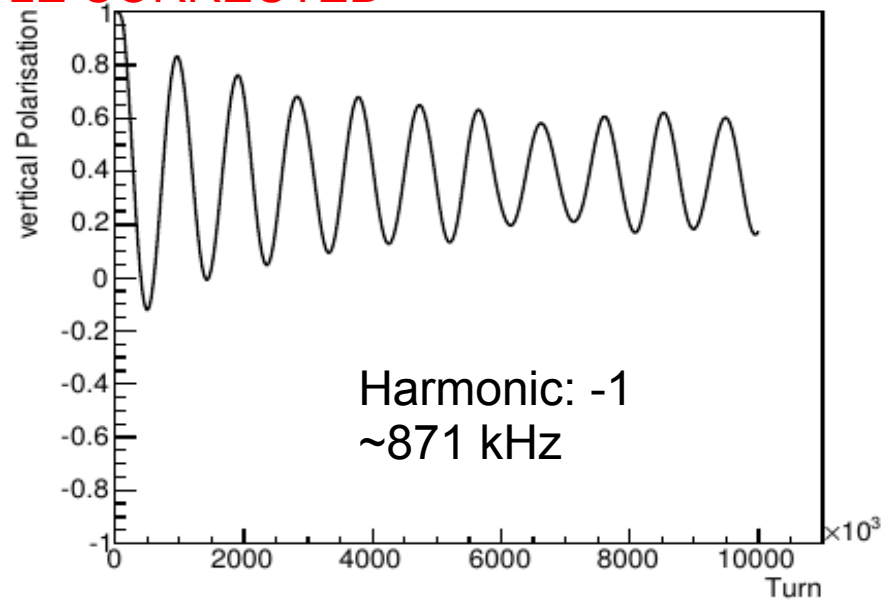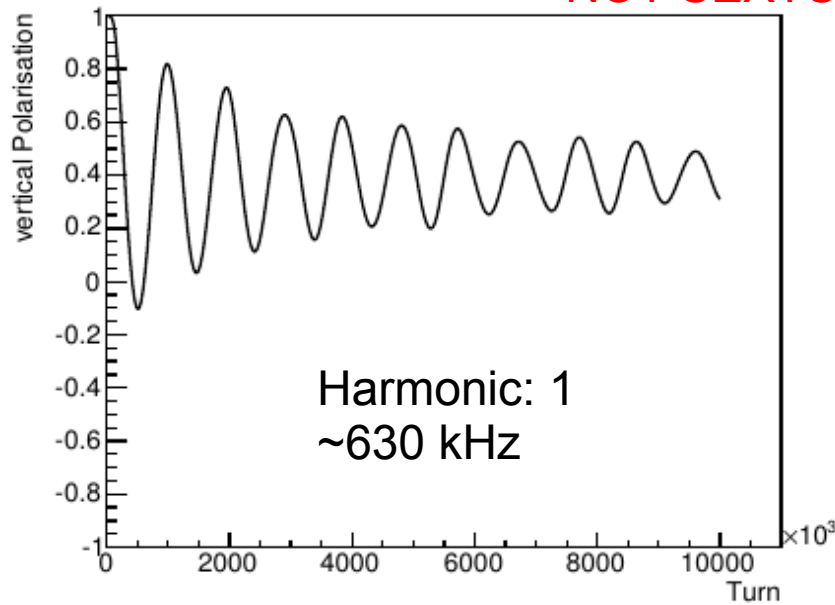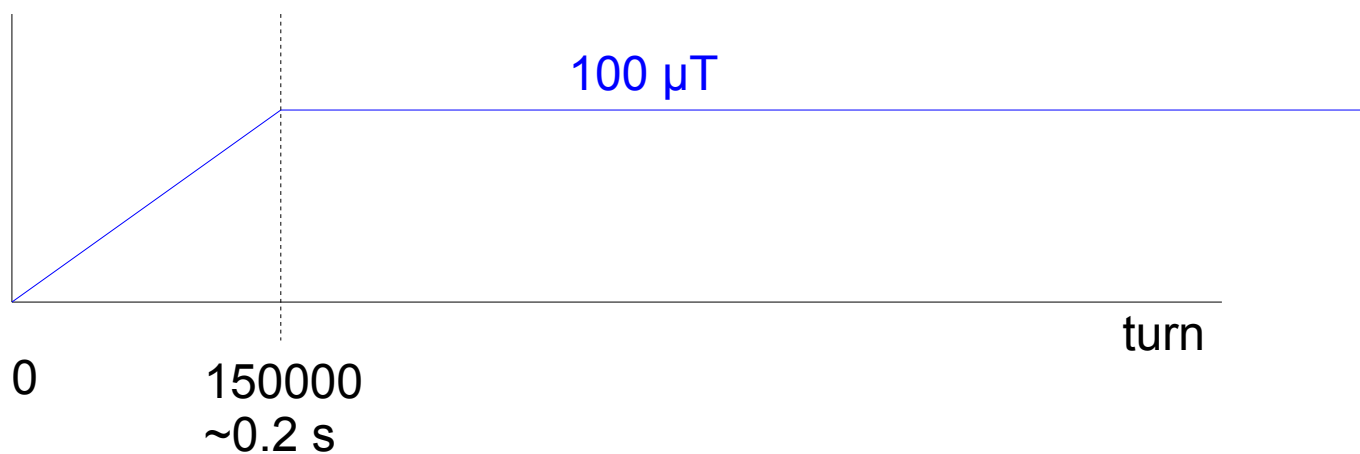"CORRECTED"

10,000,000 turns
~ 13.33 s

→ k2 values [1/m³]: (0.3/0.08) "SEMI CORRECTED"

Investigation of RF solenoidal "kick"
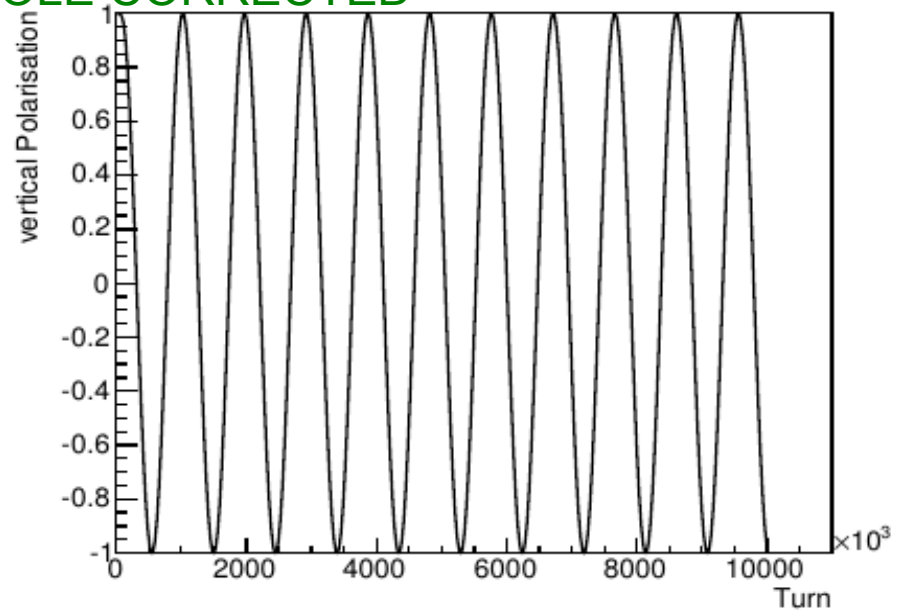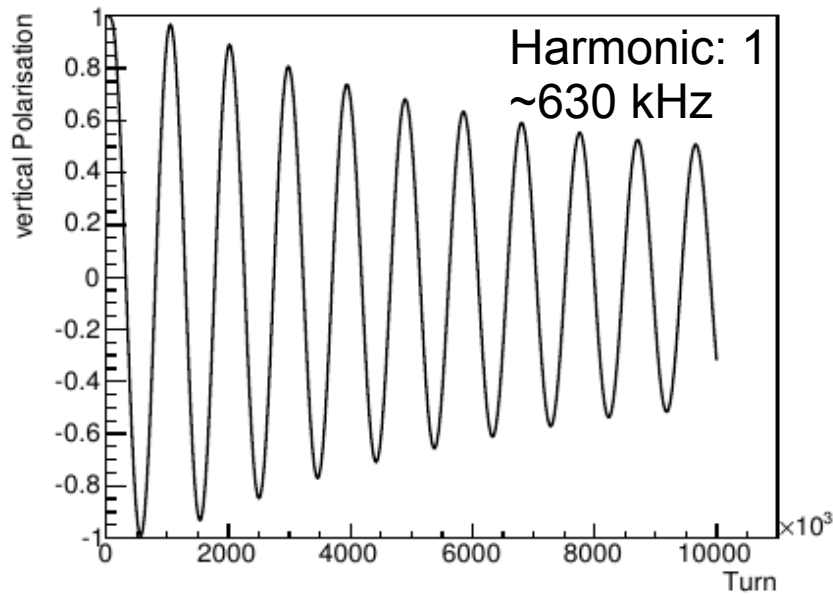
NOT SEXTUPOLE CORRECTED

Harmonic: 1
~630 kHz

Harmonic: -1
~871 kHz

Max. B-Field
RF-Solenoid

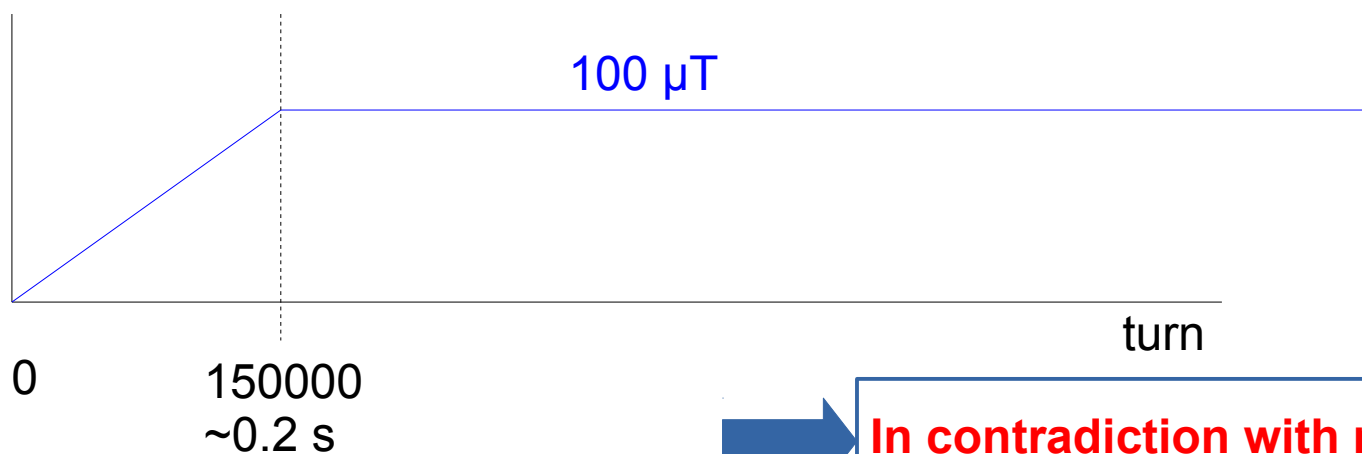100 µT

turn

0

150000
~0.2 s

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Investigation of RF solenoidal "kick"

SEXTUPOLE CORRECTED

Harmonic: -1
~871 kHz

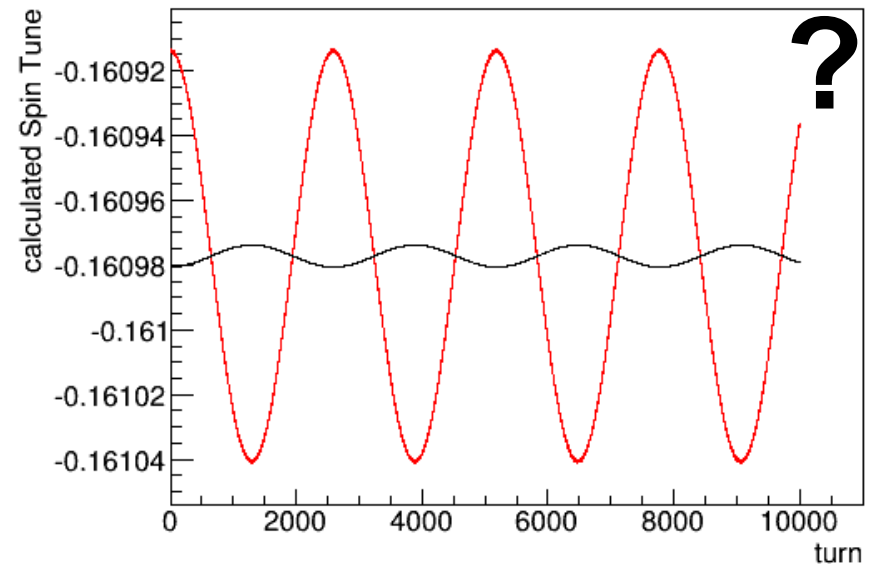Harmonic: 1
~630 kHz

Max. B-Field
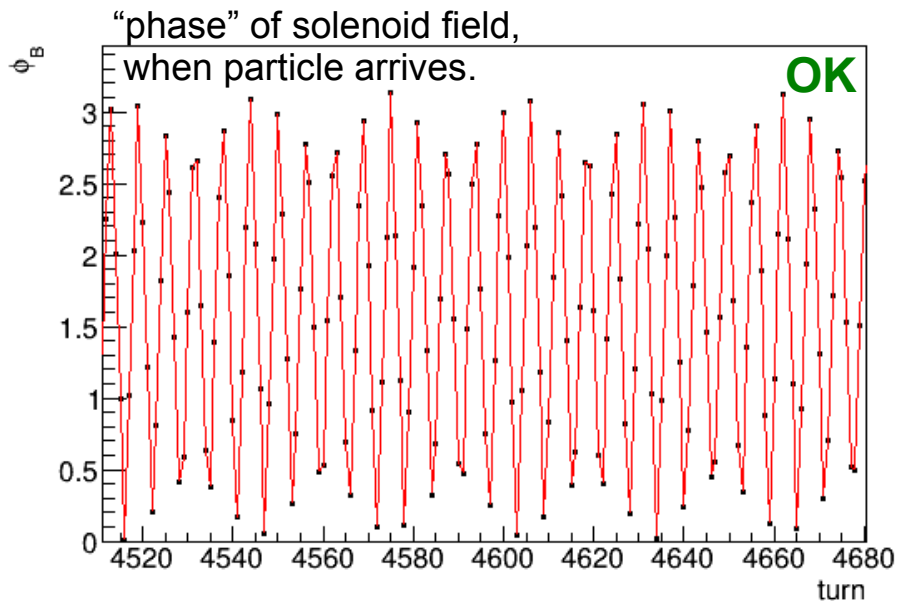RF-Solenoid

100 µT

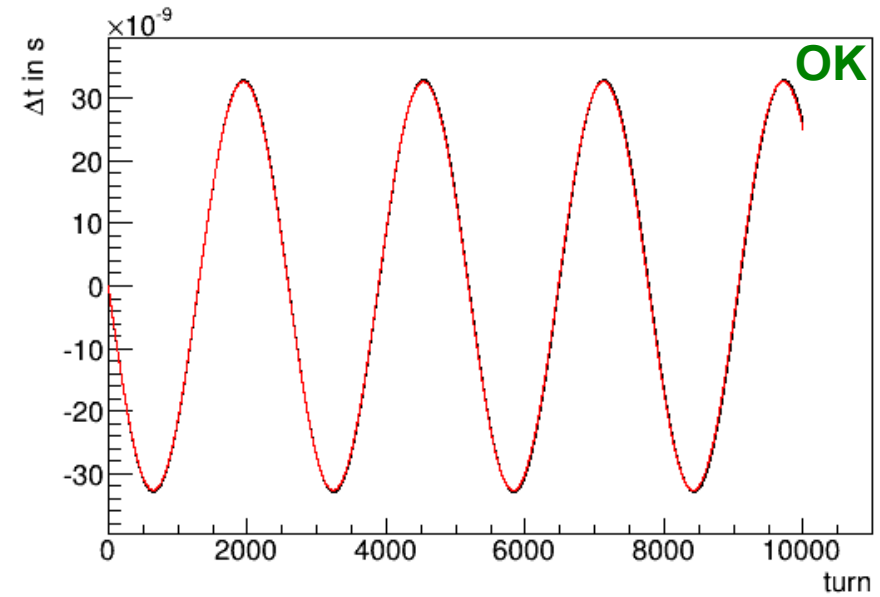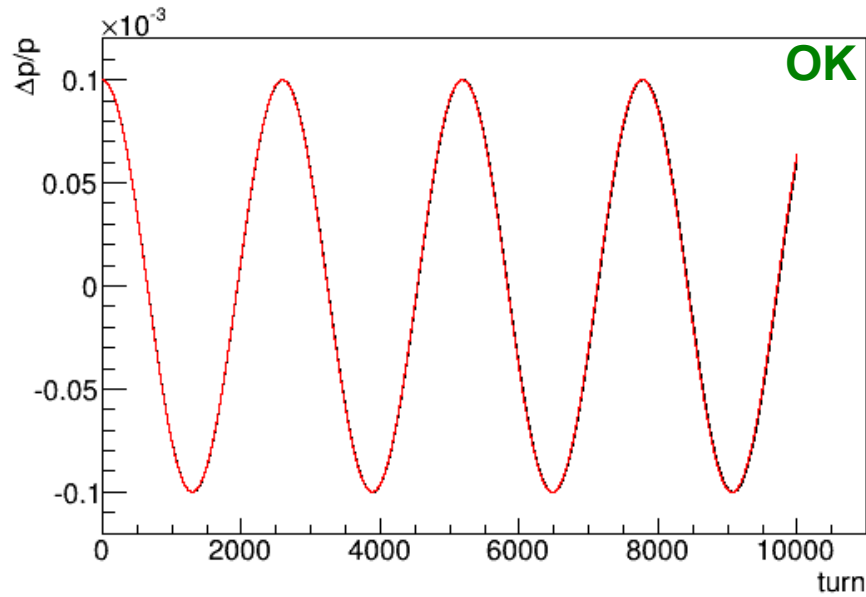turn
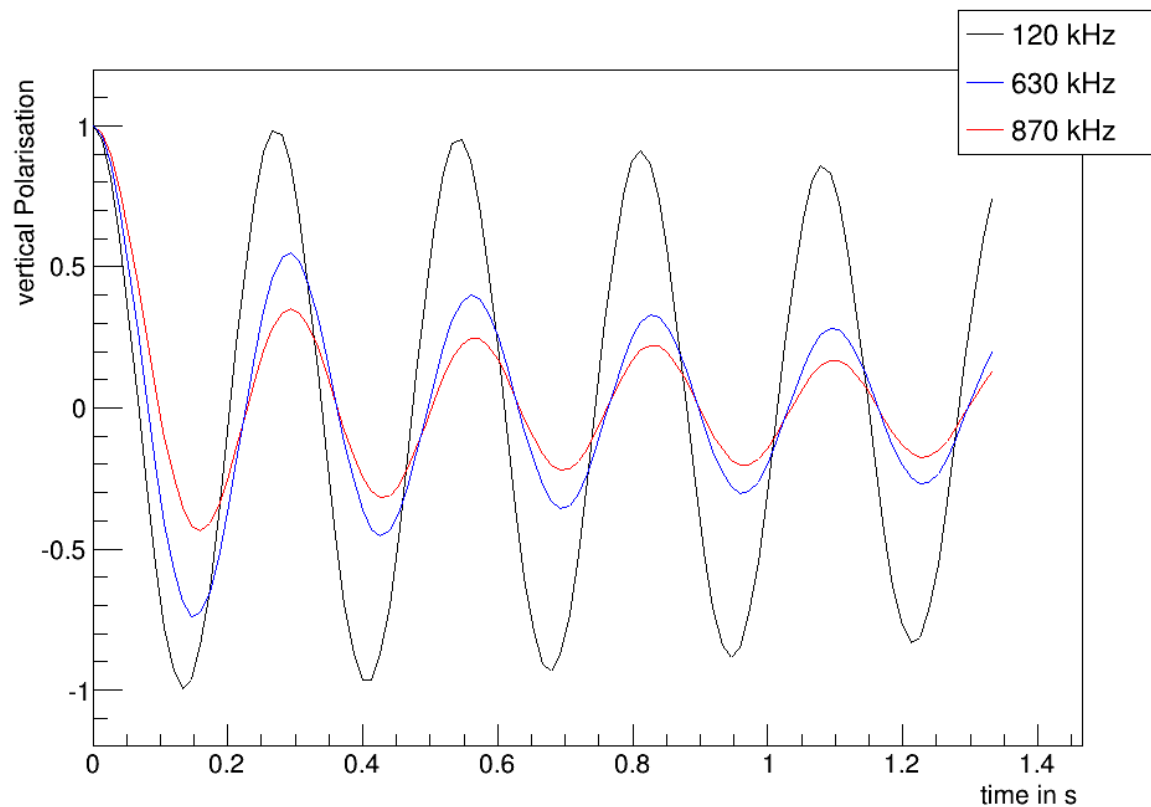
0   150000
     ~0.2 s

In contradiction with measurements!

Black: Analytic Calculations based on simple rotation matrices
Red: COSY Infinity

deuteron, 970 MeV/c, COSY lattice (in COSY Infinity)

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Different Harmonics in Analytic Model

- Analytic model based on rotation matrices.

- Only spin tune changes induced by momentum deviation to linear order are considered.

- Qualitative agreement with measurements from EDM and JEDI beamtime.

Summary

- Polarization lifetime dependency on rf solenoid harmonics exists in COSY Infinity model and analytic model.

- Hint for possible issue in spin tracking and negative G values:

  - Plan: Clearify, if there is a problem. Write a small report about it and communicate with Michigan, how to rule it out together.

- For reference particle simple kick approach to model the RF solenoid in COSY Infinity agrees with non-lattice analytic model.

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