

SPIN MOTION PERTURBATION EFFECT ON THE EDM STATISTIC IN THE FREQUENCY DOMAIN METHOD

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INTRODUCTION

The Frequency Domain method of search for the EDM of a particle consists in measuring the combined MDM+EDM spin precession frequency in two situations: beam circulating clockwise (direct), and counter-clockwise (time-reversed). When these frequencies are added up, the MDM effect cancels, leaving only the EDM in the final statistic.

The frequency in question is estimated by fitting a sine function to polarimetry data. However, variation of the spin precession angular velocity vector introduces a mismatch between the constant-parameter sinusoidal model and measurement data.

Model specification errors are prone to introducing biases into parameter estimates. The purpose of this work is to analyze the effect of spin motion perturbation on the EDM statistic.

PROBLEM STATEMENT

Solution of the T-BMT equation for the vertical spin-vector component:

$$s_y(n_{turn}) = \sqrt{(\bar{n}_y \bar{n}_z)^2 + \bar{n}_x^2} \cdot \sin(2\pi\nu_s \cdot n_{turn} + \delta). \quad (1)$$

Here

- the *invariant spin axis* \bar{n} defines the orientation of the spin precession angular velocity vector;
- *spin tune* ν_s defines the magnitude of the vector.

Significant variation of \bar{n} and/or ν_s can lead to model specification error.

SIMULATION

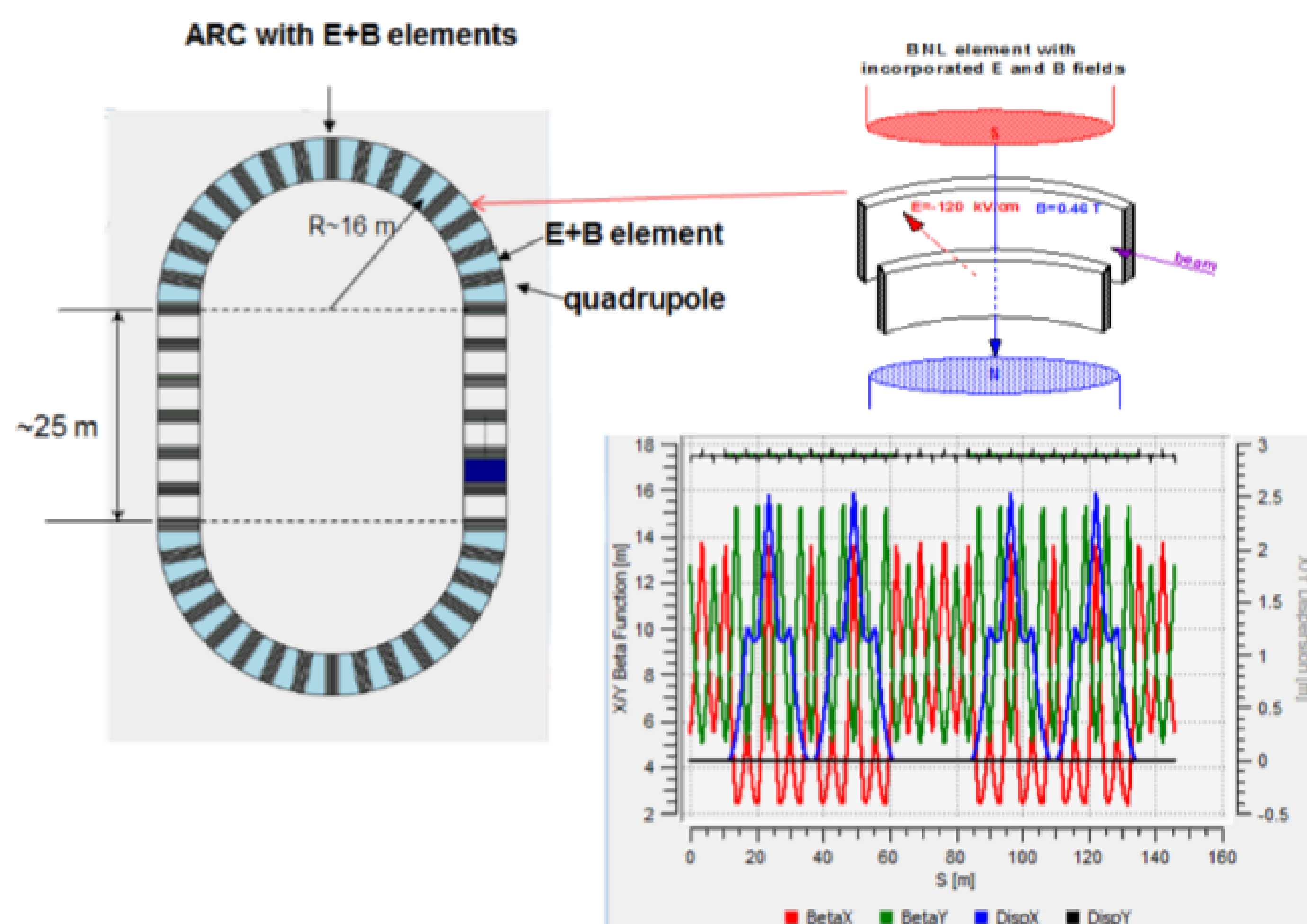


Figure 1: Imperfect Frozen Spin lattice in which sextupole spin decoherence suppression is implemented

Machine imperfections

- rotations of E+B spin rotator elements about the optic axis by $\alpha \sim N(\mu_i, 3 \cdot 10^{-4})$ degrees;;
- $\mu_i \in [-1.5 \cdot 10^{-4}, +2.5 \cdot 10^{-4}]$ degrees
- μ_i simulates the application of a Spin Wheel.

Particle

- 0.3 mm offset from the reference orbit — vertical plane betatron oscillations;
- injection kinetic energy slightly off Frozen Spin;
- small \bar{n}_x value — increased sensitivity to perturbations.

ANALYSIS

Three data series

TRK S_y^{trk} data generated by the COSY INFINITY TR command;

GEN S_y^{gen} data computed from equation (1) with \bar{n} , ν_s the TSS command output;

IDL S_y^{idl} as in GEN, but $\bar{n} = \langle \bar{n}(t) \rangle$, $\nu_s = \langle \nu_s(t) \rangle$.

What was done

- Compared model (1)'s goodness-of-fit with respect to S_y^{trk} , S_y^{gen} , S_y^{idl} ,
- checked ϵ_1 and ϵ_2 's standard deviation behavior against $\sigma[\bar{n}]$ behavior.

CONCLUSIONS