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Simulation of SCT for different Sextupole Settings

2013-09-25| Marcel Rosenthal

Outline

- D0-Optics in COSY
- Chromaticity and Path-lengthening
- Tracking of wide and tall beams to show correlations.

Simulated Optical Parameters

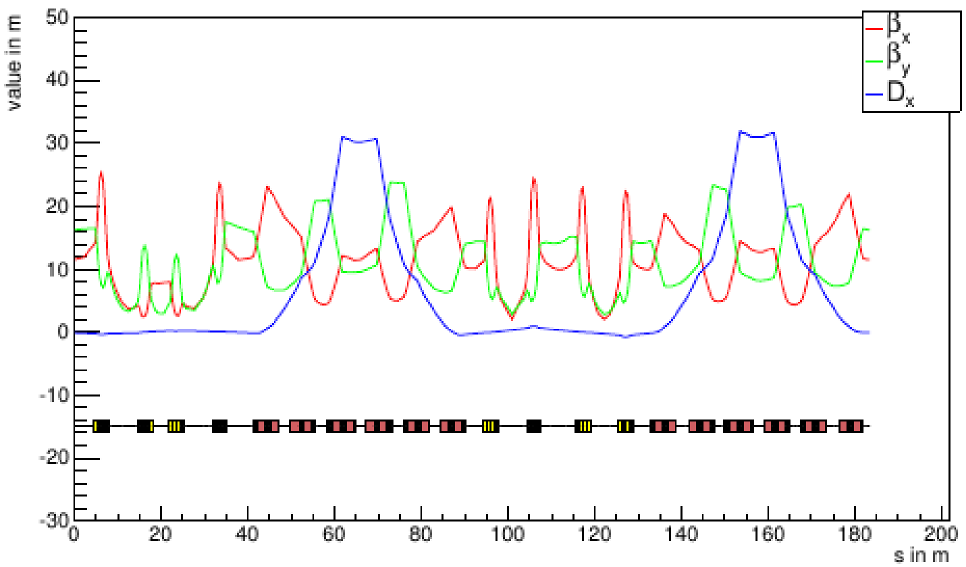

Figure 1.1: Optical accelerator parameters using the "D0Optics"

- Minimized dispersion in straight sections
- Large dispersion in arcs
- Three sextupole families (MXS,MXL,MXG) in the arcs.

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Formalism - Chromaticity

- Natural chromaticity:

$$\xi_x^n = -\frac{1}{4\pi}\oint \beta_x(s)K_x(s)ds$$
$$\xi_y^n = -\frac{1}{4\pi}\oint \beta_y(s)K_y(s)ds$$

- Sextupole induced chromaticity:

$$\xi_x^s = \frac{1}{4\pi}\oint g_s(s)\frac{\beta_x(s)D_x(s)}{B\rho}ds$$
$$\xi_y^s = -\frac{1}{4\pi}\oint g_s(s)\frac{\beta_y(s)D_x(s)}{B\rho}ds$$

Cancellation requires:

$$\xi_x^n + \xi_x^s = -\frac{1}{4\pi}\oint \beta_x(s)K_x(s)ds + \frac{1}{4\pi}\oint K_2(s)\beta_x(s)D_x(s)ds = 0$$
$$\Leftrightarrow \frac{1}{2}\oint K_x(s)\beta_x(s)ds - \frac{1}{2}\oint D_x(s)K_2(s)\beta_x(s)ds = 0$$

Horizontal dispersion and betatron functions at sextupole locations are important

Formalism - Path-lengthening

- Path-lengthening:

$$\Lambda = \Lambda_1 + \Lambda_2 = \oint \frac{u}{\rho} ds + \frac{1}{2} \oint \left(\frac{du}{ds} \right)^2 ds$$

  - linear order canceled by betatron and synchrotron oscillations
  - higher-order contributions i.e. betatron oscillations
  - Also higher order contributions from momentum deviations are very important, but not considered in this talk!

- Using an infinitesimal distortions model:

$$\Lambda_{2,d} + \Lambda_{2,s} = \frac{1}{2} \oint K(s) u^2 ds - \frac{1}{2} \oint D(s) K_2(s) u^2 ds = 0$$

Conditions for chromaticity and path-lengthening cancellation are exactly the same, if $u^2 \sim \beta$

Sextupole contribution

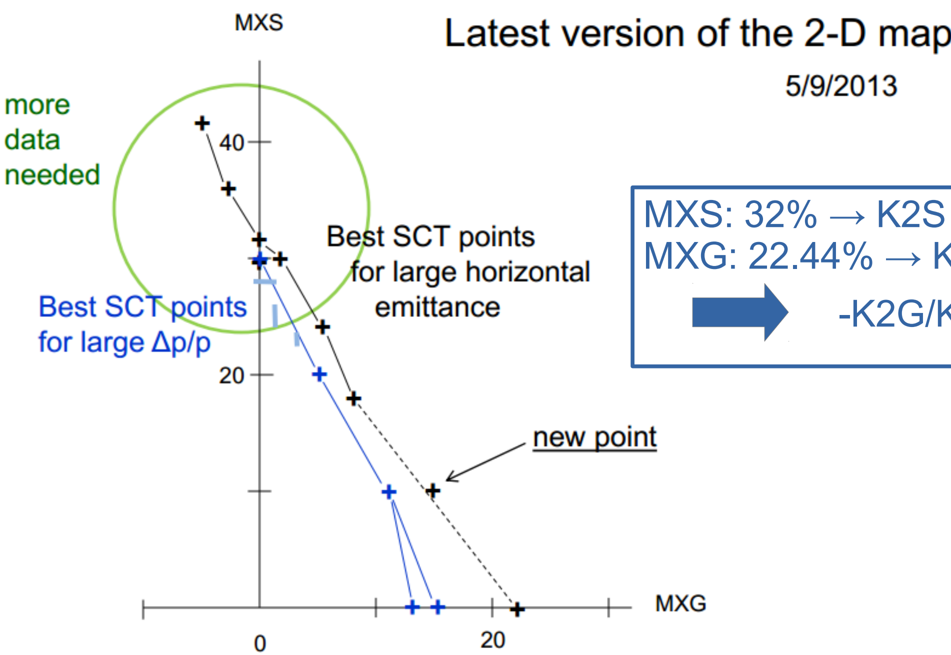
Simulation of optical parameters

- Calculate proportionality for a set of two sextupole familiy strengths, where chromaticity should stay constant:

$$\xi_x^s = \frac{1}{4\pi}\oint g_s(s)\frac{\beta_x(s)D_x(s)}{B\rho}ds$$

$$\xi_y^s = -\frac{1}{4\pi}\oint g_s(s)\frac{\beta_y(s)D_x(s)}{B\rho}ds$$

EDM Beamtime August/September 2013



MXS: 32% → K2S = 6.304 m⁻³
MXG: 22.44% → K2G = 2.1595 m⁻³

-K2G/K2S = -0.343

$$\frac{K2Lx}{K2Sx} = -\frac{\sum_{i,MXS}[\beta_x(s_i)D_x(s_i)L(s_i)]}{\sum_{i,MXL}[\beta_x(s_i)D_x(s_i)L(s_i)]} = -0.827$$

$$\frac{K2Ly}{K2Sy} = -0.151$$

$$\frac{K2Gx}{K2Sx} = -0.275$$

$$\frac{K2Gy}{K2Sy} = -0.340$$

$$\frac{K2Gx}{K2Lx} = -0.332$$

$$\frac{K2Gy}{K2Ly} = -2.247$$

Tracking results:

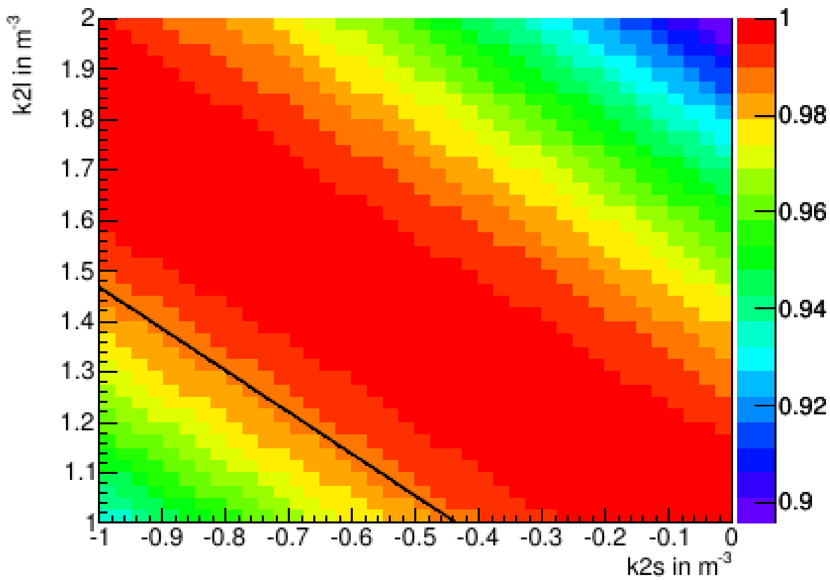


Figure 1.2: wide beam, remaining polarization

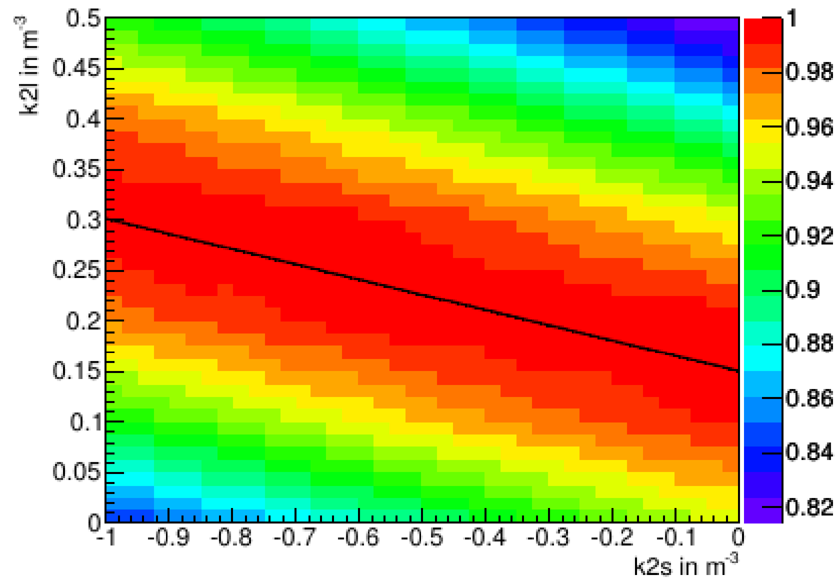


Figure 1.3: tall beam, remaining polarization

- Simulated 1-dimensional beams in x- or y-direction (wide / tall) and track for 20000 turns.
- Black lines indicate calculate proportionality factor between these lines with arbitrary vertical offset.

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Results for MXL/MXG and MXS/MXG

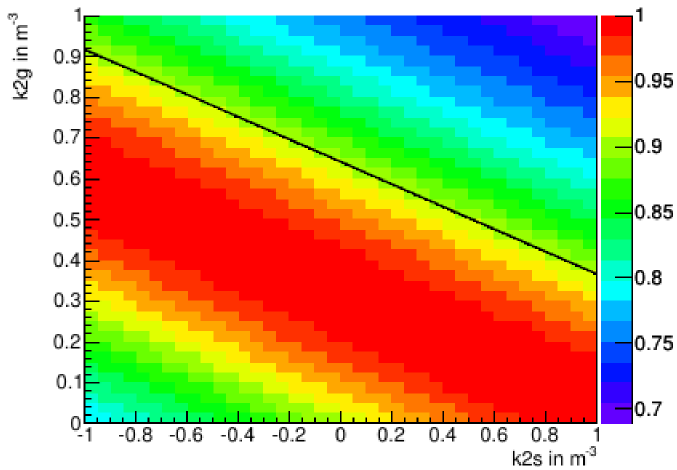

Figure 1.4: wide beam, remaining polarization

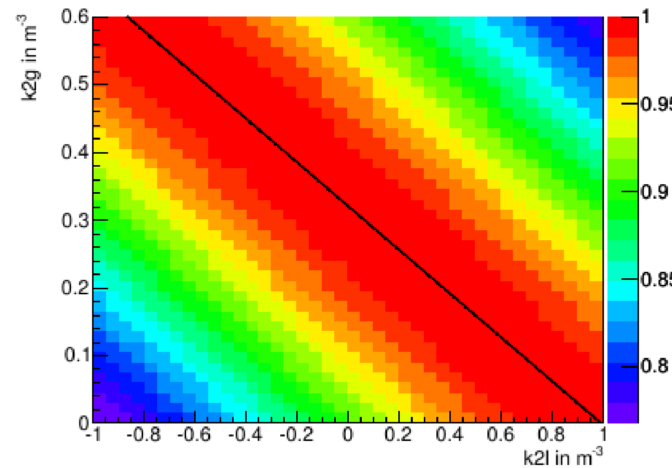

Figure 1.6: wide beam, remaining polarization

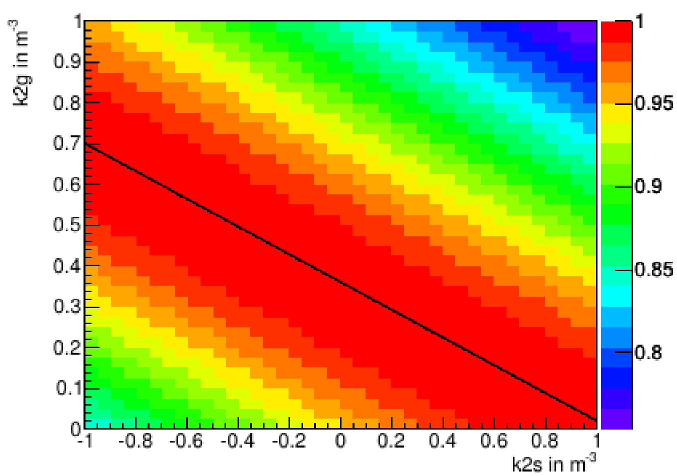

Figure 1.5: tall beam, remaining polarization

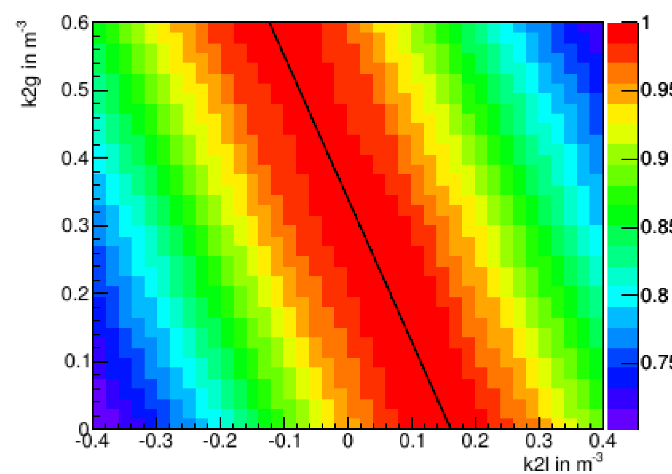

Figure 1.7: tall beam, remaining polarization

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Summary

- Change of location of maximum polarization lifetime in simulations for wide and tall beams coincides with calculated proportionality factor for same chromaticity.
- But: chromaticity not zero in simulation
- Realistic beam (transversal and longitudinal distributions) has a mixture of all kinds of contributions.

➡ Intelligent setup of higher-order multipoles is required to maximize the spin coherence time.