SPIN@USPAS Summer 2021
Graduate "Polarization in MultiGeV RLAs " Homework

HOME WORK 2

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The purpose of this homework is to demonstrate the interplay between the spin tune and the betatron tune in a RLA machine. Due date is June 18, 2021. Grading is on a scale of 0 to 20 points, points per question are given in the writeup below.

We will explore the case of the Stanford Linear Collider (SLC) which was a machine designed to collide polarized electron and unpolarized positrons , around 45.6 GeV each to produce polarized Z_0 bosons.

In 1992, during the commissioning of the detectors for SLC, it was observed that the longitudinal polarization of the electron beam at the interaction point was much smaller than predicted even after accounting and compensating for the precession in the arc by using the spin rotators in the damping ring. Figure 1 is a schematic of this machine layout.

1/ **3 Pts** After being produced, the beams are stored in damping rings where their emittance is reduced. They are then accelerated in a linac to around 50 GeV and brought into collision at the interaction point by means of collider arcs. The electron spin precession is compensated for by rotators located in the damping ring.

These arcs are periodic structures made up of cells with the specifications shown in figure 2 below. They provide a phase advance of 108 degrees (tune of 0.3) and ten such cells form an achromat which advances the betatron phases by exactly 6π.

Construct a simple zgoubi model of one cell using the 'MULTIPOL' element for 50 GeV. For the purpose of this exercise, we will ignore the sextupole terms which are there for chromatic corrections in order to ensure a design momentum aperture of 0.5%.

2/**6 Pts** Assemble 10 cells together to form an achromat, scale it to an incoming beam energy of 45.64 GeV Hints:

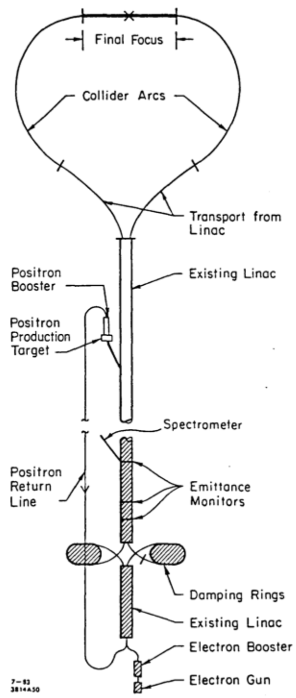
- use the 'INCLUDE' feature of zgoubi to make another file using the cell constructed in 1/
- use the SCALING feature of zgoubi as well as the incoming reference momentum in 'OBJET' to rescale at 45.64 GeV

3/**6 Pts** Inject spin longitudinally and show that the vertical spin starts building up in the presence of a vertical orbit error. You should be able to reproduce figure 3 by shifting the incoming orbit vertically 0.05cm. Verify that for zero orbit errors, there is no such vertical spin buildup.

4/**5 Pts** What is the cause of the orbit buildup ? What happens if you rescale the incoming beam energy to 40 GeV ?

Rev 9/1/84

Figure 1.2.1 Schematic Layout of SLAC Linear Collider



1–6

Figure 1: Stanford Linear Collider layout

TABLE I

Dipole Field in KGauss	B_{y0}	$= 5.96976$
Bending Radius in Meters	ρ	$=279.378$
Field Index	n_f	$=-32847.5$
	n_d	$=+32848.5$
Field Gradient KG/cm at Equil. Orbit	g_{av}	$=7.0189$
Sextupole Terms:	B_s	$=1/2g'x^2$
in focusing magnet:		
	$\frac{e_F}{\rho}$	$=+0.0013579\ mm^{-2}$
	g'	$=-1.629\ kG/cm^2$
in defocusing magnet:		
	$\frac{e_D}{\rho}$	$=-0.0022748\ mm^{-2}$
	g'	$=-2.702\ kG/cm^2$
Eff. Arc Length of	L_b	$=2.50300$ m
Magnet ℓ	L_g	$=2.48565$ m
	iron L	$=2.47935$ m
1/2 cell arc length		2.596201936 m
Total Arc Cell Length		5.192402112 m
		=17.03544 feet
12 Cell Bend Angle		0.513323348°

Figure 2: Design specifications for a periodic cell in the SLC arc

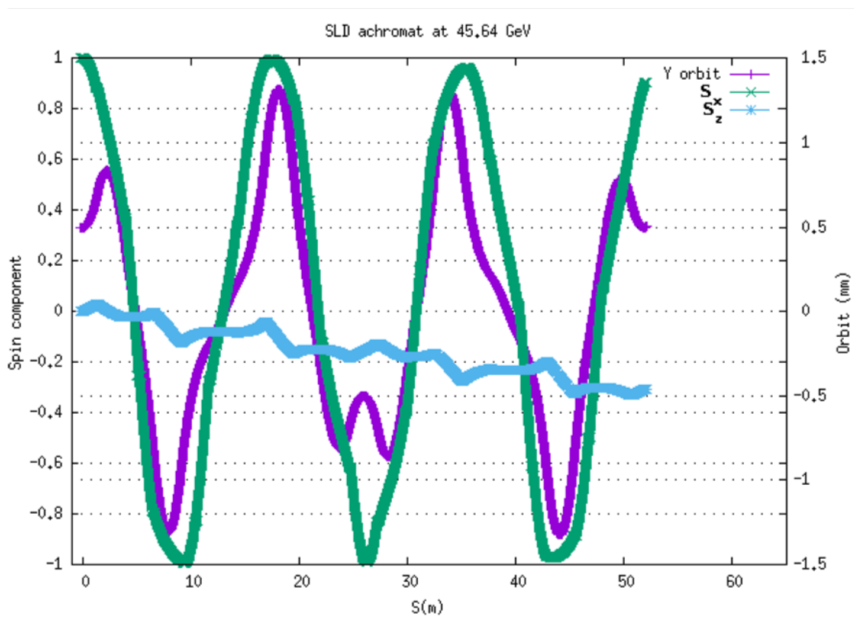


Figure 3: Vertical spin buildup in a SLC achromat at 45.64 GeV