SINGLE PASS COLLIDER MEMO

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TITLE: FOCUSING UPGRADE FOR SECTORS 11 THROUGH 19

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Abstract

In order to transport high current, single bunch beams to the SLC positron source for spring 1986 testing, it will be necessary to augment the strength of available focusing in sectors 11 through 19. We have decided to replace the sector doublet type QB quadrupoles with stronger type QE magnets. In conjunction with new Vax controlled power supplies, this sector 11 through 19 doublet lattice can be run at optimal settings for beam energies of several GeV up to the full SLC energy of 32 GeV by sector 19. Installation of the temporary stronger focusing is planned for summer 1985; full SLC FODO array focusing is scheduled for the following summer. This note presents the intermediate solution for sectors 11 through 19. In addition, the sector 10 quadrupole strengths required for matching beams into the doublet array are given.

Introduction

It is necessary to increase the focusing in sectors 11 through 19 so that high current, single bunch beams may be used to test the positron source during the spring of 1986. Since the full SLC FODO lattice (i.e. 8 quadrupoles and BPMs and associated corrector dipoles) is not scheduled for installation until the summer of 1986, it has been decided to upgrade the existing sector doublet lattice. The maximum in β for a series of closely spaced doublets is given as β_{max} :

$$\beta_{max} = \frac{L + [2D(L-D)(1-\cos\Theta)]^{1/2}}{\sin\Theta} \quad (1)$$

wherein D = the separation between quadrupoles and L is the cell length, and Θ is the betatron phase shift per cell. The maximum admittance of such a lattice occurs for $\Theta = 90^\circ$. Required quadrupole strengths are $\int g dl$:

$$\int g dl = 33.356 E \left(\frac{2}{D(L-D)} \right)^{1/2} \text{ kG} \quad (2)$$

with E = the beam energy in GeV. In the present SLAC linac (downstream of sector 10) there is a pair of type QB quadrupoles in each sector drift with a spacing $D=1.80$ m. Since $L = 101.6$ m, $\beta_{max} = 121$ m. This is a factor of about 3 larger than β_{max} in the

SLC FODO lattice, corresponding to a beam size which is 1.7 times larger than in the full SLC. This level of focusing will be sufficient for transport of high intensity bunches to the sector 20 positron source.

Optics and BPMs

From (2) it is seen that $\int gdl = 3.57$ g/GeV for the doublet lattice. With the installation of 50 M klystrons, the beam energy at the end of sector 19 will increase to the SLC level of about 32 GeV. $\int gdl = 114$ kG at this beam energy. Since the maximum strength of QB quadrupoles is 24 kG the existing magnets are too weak for optimum focusing. Type Q2 quadrupoles are to replace QBs in the sector 11 through 19 drift regions. A linac BPM will be included in the upstream quadrupole of the pair. All eight pairs of SLC dipole correctors with their VAX controlled power supplies will be installed in each sector. Presumably the last pair of horizontal and vertical corrector dipoles installed on the 8-D DLWG just upstream of the drift sections will be the only correctors used in the doublet lattice. Table 1 gives the required quadrupole strengths for the cases of a fully accelerated SLC energy beam, and a low energy positron beam. New power supplies are required for the QEs. Table 2 presents the necessary currents.

Sector 10 Solution

It will be necessary to adjust the strengths of quadrupoles in sector 10 in order to match into the doublet lattice. Figure 1 gives the betas along the linac from the beginning of sector 10 to the end of 19. Whereas other solutions which have smaller betas in the matching region have been found, they require a greater number of independent power supplies than the one being adopted. This solution utilizes a QE quadrupole and BPM at the 11-1 11-2 interairder drift and a corrector dipole pair. LI10 QUAD 61 has been turned off. Five individual power supplies, in addition to the sector 10 LGPS, are required to match the beam. Table 3 presents the required field strengths and Table 4 the magnet currents. The SLC energy case is presented along with a 5 GeV coasting beam.

Impact on summer 1986 Installation

Each of the upstream QEs placed in the sector drifts will become part of the full SLC FODO array. In the summer of 1986, the downstream members of the doublets along with their mounting hardware will be relocated to the sector 20 through 30 drift regions. The quadrupole installed at the beginning of sector 11

and the upstream members of the doublets have proper polarities for use in the SLC FODO array. Doublet power supplies will be used after 1986 to power quadrupole singlets. Thus, all the elements required for the doublet upgrade will be reused in the full SLC lattice.

In summary, nineteen type QE quadrupoles, ten BPMs, twenty type 4 corrector dipoles, and fourteen power supplies are required for the doublet upgrade. Additional beam diagnostic devices are being considered and the full complement of SLC dipole correctors for sectors 11 through 19 will be installed.

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Table 1

Doublet Lattice: Sectors 11 to 19, Magnetic Field Requirements

Location	Strength (kG/GeV)	SLC Focus(kG)	SLC Energy ¹ (GeV)	Positron ¹ Focus(kG)	Positron ² Energy(GeV)
11-9 drift	3.57	65.06	18.23	2.14	0.60
12-9 drift	3.57	71.21	19.95	5.00	1.40
13-9 drift	3.57	77.37	21.68	7.85	2.20
14-9 drift	3.57	83.53	23.41	10.71	3.00
15-9 drift	3.57	89.69	25.13	13.56	3.80
16-9 drift	3.57	95.84	26.85	16.42	4.60
17-9 drift	3.57	102.0	28.56	19.28	5.40
18-9 drift	3.57	108.2	30.30	22.13	6.20
19-9 drift	3.57	114.3	32.03	24.99	6.00

(1) $\Delta E = 1.725$ GeV/Sector(2) $\Delta E = 0.800$ GeV/Sector

Table 2

Doublet Lattice: Sectors 11 to 19, Magnet Current Requirements

Location	SLC ¹ Focus(amps)	SLC Energy ² (GeV)	Positron ¹ Focus(amps)	Positron ³ Energy(GeV)
11-9 drift	117.1	18.23	3.9	0.60
12-9 drift	128.2	19.95	9.0	1.40
13-9 drift	139.2	21.68	14.1	2.20
14-9 drift	150.3	23.41	19.3	3.00
15-9 drift	161.4	25.13	24.4	3.80
16-9 drift	172.5	26.85	29.6	4.60
17-9 drift	183.5	28.56	34.7	5.40
18-9 drift	194.6	30.3	39.8	6.20
19-9 drift	205.7	32.03	45.0	6.00

(1) $I_{req'd} = 1.8$ amps/kG = 6.43 amps/GeV of beam energy for type QE quadrupoles.(2) $\Delta E = 1.725$ GeV/Sector(3) $\Delta E = 0.800$ GeV/Sector

Figure 1: β_x and β_y through the sector 10 transition region and in the sector 11 to 19 doublet array.

Table 3

Doublet Lattice: Sector 10 Match, Magnetic Field Requirements

Location	Strength (kG/GeV)	SLC Focus(kG)	SLC Energy ¹ (GeV)	Low E Focus(kG)	Low E Energy(GeV)
QD21, LI10	+3.82	+57.25	14.99	+19.10	5.00
QD31, LI10	-3.82	-58.13	15.21	-19.10	5.00
QD41, LI10	+3.32	+51.19	15.42	+16.60	5.00
QD51, LI10	-1.95	-30.47	15.64	-09.75	5.00
QD61, LI10	+0.00	+0.00	15.85	+0.00	5.00
QD71, LI10	-0.49	-07.86	16.07	-02.45	5.00
QD81, LI10	+2.21	+35.99	16.28	+11.05	5.00
QD91, LI10	-2.02	-33.26	16.50	-10.10	5.00
QD21, LI11	+0.56	+09.38	16.72	+02.80	5.00

(1) $\Delta E = 0.216 \text{ GeV/Station}$

Table 4

Doublet Lattice: Sector 10 Match, Magnetic Field Requirements

Location	SLC ² Focus(amps)	SLC Energy ³ (GeV)	Low E Focus(amps)	Low E Energy(GeV)
QD21, LI10	120.2	14.99	40.1	5.00
QD31, LI10	122.1	15.21	40.1	5.00
QD41, LI10	107.5	15.42	34.9	5.00
QD51, LI10	64.0	15.64	20.5	5.00
QD61, LI10	0.0	15.85	0.0	5.00
QD71, LI10	16.5	16.07	05.1	5.00
QD81, LI10	75.6	16.28	23.2	5.00
QD91, LI10	69.9	16.50	23.2	5.00
QD21, LI11	16.9 ²	16.72	05.0 ²	5.00

(1) $I_{req'd} = 2.1 \text{ amps/kG}$ for LI10 type QC quadrupoles.(2) $I_{req'd} = 1.8 \text{ amps/kG}$ for LI11 type QE quadrupoles.(3) $\Delta E = 1.725 \text{ GeV/Sector}$