Choosing Corrector Dipoles for ORKA

T. Kobilarcik

04 January 2013
v0.1

Abstract

Errors in beam position due to power supply stability and alignment are calculated. Candidate dipole correctors are tabluated and suitable correctors identified.

1 Overview

Primary beam for ORKA will travel through four tranfer lines: P1, P2, P3 (the "Main Ring Remnant"), and ASector. The primary beam can deviate from the central trajectory for a number of reasons. The two reasons investigated in this paper are stability of the bend buss, and misalignment of quadrupoles. We will only analyse ASector; however, as ASector is an extension of the existing lattice, the analysis is also valid upstream.

2 Mismatch of Central Trajectory Due to Bend Buss Stability

The present design of ASector uses two power sullpies, each powering one-half of the sector. The stability of each power supply is 10^{-4}[1]. If one assumes a worst-case scenario (both power supplies maximully out of tolerance and is opposite directions), the mismatch is 2×10^{-4}.

Figure 1 shows the result of a 2 parts in 10^{-4} mismatch in bend buss strength. We see that the maximum excursion is aproximately 2 mm. Any trim magnets must be able to compensate for at least this much motion.

3 Quadrupole Misalignment

Beamline elements can typically be aligned to 10 $mils$ (1σ)[2]. In order to determine the trim strength, we misalign two consecutive quadrupoles by 20 $mils$

[1] Private communication, Dan Wolff.
[2] Private communication, Jim Volk

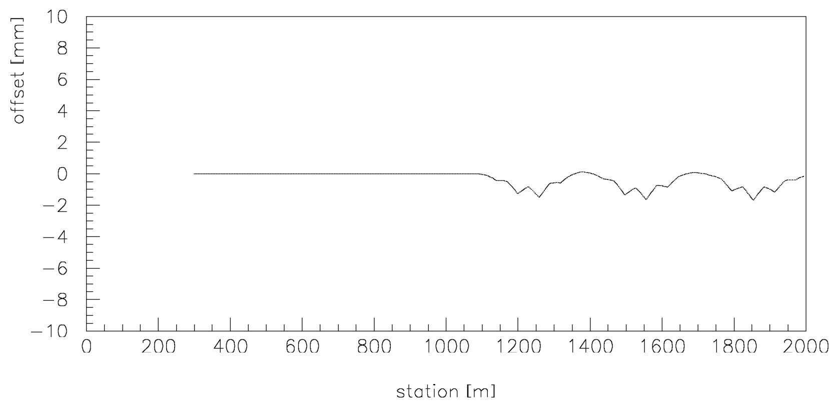

Figure 1: Mismatch of bend buss between P3 and ASector. Mismatch is 2 parts in 10^{-4}.

(2σ) in opposite directions (thereby maximizing the kick), and require that the beam is on-trajectory after exiting the third quadrupole. Recalling that the quadruple gradient is 11.65 T/m, and assuming an impluse aproximation, we find that a 20 *mil* misalignment results in a 19.5 $\mu radian$ kick. Continuing this process yields a 61 $\mu radian$, 2.8 mm offset at the third quadrupole (a TRANSPORT[3] simulation confirms these numbers). In order for the bea to be back on trajectory after the third quadrupole, the upstream two trims must kick the beam by 26 $\mu radians$ and 6 $\mu radians$, respectively.

4 Lattice Corrction

Figure 2 shows the result of an 100 $\mu radian$ vertical kick at after a (horizontally) defocusing magnet. Because the lattice is symetric horizontally and vertically, the same result holds for the horizontal plane. We see that the maximum amplitude is aproximately 10 mm, which simplifies scaling to magnet strengths. (For example, a 20 $\mu radian$ kick is required to compensate for the 2 mm bend-buss mismatch.).

5 Error Budget

To summarize, a mismatch in bend-buss current results in a 2 mm excursions, which can be correected by a 20 $\mu radian$ kick, and a quadrupole misalignment

[3] D.C. Carey, et al., "Third-Order TRANSPORT with MAD Input", Fermliab-Pub-98-310, SLAC-R-530.

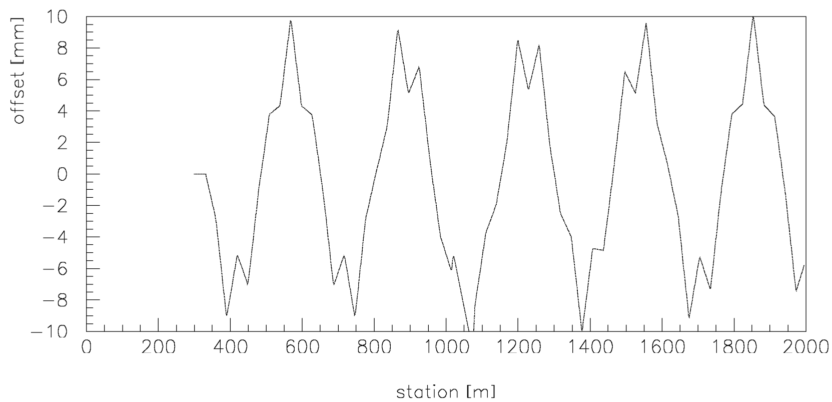

Figure 2: Result of a 100 $\mu radian$ vertical kick at F21 location propageted along P3 and ASector lines to ORKA target.

can be corrected by a 26 $\mu radian$ kick. The errors are uncorrelated, so the bend strengths must be added linearly, resulting in a bend requirement of 46 $\mu radian$. Note that the vertical plane is not affected by a bend-buss mismatch; thus, the vertical plane requires only a 26 $\mu radian$ kick.

Table 1 lists various trim magnets proposed for use in the ORKA beam line.

6 Other Cosiderations

Using round, as opposed to rectanglur, beam pipe would reduce cost. Three inch diameter beam pipe would be apropriae for ASector. Requiring a three inch (minimum) gap rules out several correctors.

One further notes that a sufficient number of Main Injector style correctors do not exist – they would have to be manufactures.

7 Conclusion

We rule out Main Ring correctors due to their small gap; FMI correctors due to their non-existance; and PEP correctors due to their lack of strength. We conclude that LEP correctors are the choice.

Horizontal Correctors	HDC Main Ring	MCH LEP	MCHB LEP	IDH FMI	HERH PEP	HCORR PEP	units
BL/I	0.003397	0.013030	0.004200	0.006000	.	.	[T·m/A]
I_{max}	10.3	2.5	9.0	15.0	12.0	12.0	[A]
$\int B(I_{max})\,\mathrm{d}l$	0.03499	0.03258	0.03780	0.09000	0.01533	0.01026	[T·m]
$\Delta\theta$	87.4	81.4	94.4	224.8	38.3	25.6	[μrad]
inductance	.	23.	2.11	.	.	.	[H]
resistance	.	10.2	1.09	.	.	.	[Ohm]
gap	1.928	4.016	4.016	2.000	2.905	4.500	[in.]
δx	8.7	8.1	9.4	22.5	3.8	2.6	[mm]
Vertical Correctors	VDC Main Ring	MCV LEP	MCVB LEP	IDV FMI	HERV PEP	VCORR PEP	units
BL/I	0.002199	0.008553	0.003457	0.002400	.	.	[T·m/A]
I_{max}	10.3	2.5	7.5	15.0	12.0	12.0	[A]
$\int B(I_{max})\,\mathrm{d}l$	0.02265	0.02138	0.02600	0.03600	0.00897	0.01026	[T·m]
$\Delta\theta$	56.6	53.4	65.0	89.9	22.4	25.6	[μrad]
inductance	.	21.8	2.75	.	.	.	[H]
resistance	.	9.25	1.48	.	.	.	[Ohm]
gap	2.416	7.835	7.835	5.000	5.250	4.500	[in.]
δx	7.5	5.3	6.5	9.0	2.2	2.6	[mm]

Table 1: Comparison of trim magnet types.