Main Injector Dipole Magnets Placement in MI62 to MI10.

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In this MI note we describe the placement scheme for the Fermilab Main Injector production dipoles. The placement of the dipoles will start from MI62 in the proton direction going towards MI10. We are reevaluating our dipole placement scheme to uniformly use the early production dipoles in the FMI. These early production dipoles are relatively weaker than the nominal strength. The placement scheme outlined in this MI Note uses 6 out of 35 early production dipoles.

We have produced about 90 long Main Injector Dipoles (IDA's and IDB's) at the time of this calculation. All of these magnets strengths and higher multipoles have been measured at MTF using at least two different probes[1]. During the R&D phase of the FMI dipoles we had decided that the sigma of the dipole strength variation should be less than 10 units. This decision was based on tracking calculations and the available dipole corrector strength. However during the production of FMI dipoles there were some change in the quality of steel that has lead to magnet strength variation in the production dipoles. The shape of the dipole excitation curve changed in the dipoles using Run 4 and higher run number steel[2]. The variations in the strength of these magnets will be discussed elsewhere[3]. This variation has not effected the multipole component of the dipole. Figs 1 and 2 shows the strength variation of the FMI long dipoles with respect to nominal strength. The nominal strength is defined to be the mean strength of a set of 57 long dipole magnets. These 57 long dipole magnets' data includes magnets from IDA028 to IDB047. It is clear from Fig. 1 and 2 that earlier magnets are weaker by about 25 units at high fields. The use of these magnets in the ring randomly will require higher corrector strength than planed. Most of the magnets will be build using steels of quality similar to Run 4 steel. Their strength is expected to be similar to current nominal strength. The first 35 production dipoles are considered to be odd magnets.

In this paper we describe a dipole placement plan for MI62 to MI10. The requirement on the placement is that it should only generate a local bump of less than 2mm, in the closed orbit of the FMI. We know from our earlier calculations that the closed orbit errors due to misalignments are of this order[4]. There are 24 long dipoles (12 each of IDA and IDB) in the MI62 to MI10 section of the FMI. We have 25 and 10 weak IDA's and IDB's respectively. We propose to arrange the dipole magnets such that average dipole strength variations in this small section of the ring is close to zero. Fig. 3 shows the closed orbit error in FMI after the placement of 24 production dipoles. These production dipoles are only placed in the MI62 to MI10 section of the ring. The rest of the ring has perfect dipoles. All the other errors have been turned off to study the effect of dipole strength variation. It is clear from the Fig. 3 that this dipole placement scheme introduces less than 0.3mm closes orbit error, in this section of the ring. The closed orbit ripple produced by this placement scheme around the FMI is less than 0.2 mm. These calculations are performed at 120 GeV.

In Table 1 we present the magnet placement order in FMI. We have used four weak IDA's and two weak IDB's in this section of the ring.

References:-
[1] H. D. Glass et al, MTF Note ####, Flatcoil Measurement
H. D. Glass et al, MTF Note ####, Harmonics Measurement
[2] A. Russel et al, MI Note ####, Summary of steel Property Variation.
[3] C. S. Mishra et al., MI Note ####, Summary of the FMI Production Dipole Strength.
[4] C. S. Mishra, MI Note 0109, "Study of the Alignment Tolerance and Corrector strength in the Fermilab Main Injector lattice".

Table 1

Magnet Placement Table for MI62 to MI10

Magnet Name	AFTER FMI Marker	Relative Strength (In Units) @ 7000 Amps	
IDA035	MI626	5.48	
IDB045	MI626	11.51	
IDA008	MI627	-32.08	IDA
IDB036	MI627	17.83	
IDA044	MI628	8.97	
IDBO13	MI628	-18.59	IDB
IDA031	MI629	9.62	
IDB011	MI629	-8.97	
IDA042	MI630	6.13	
IDB035	MI630	11.50	
IDA014	MI631	-34.17	IDA
IDB037	MI631	17.81	
IDA041	MI632	0.44	
IDB043	MI632	9.70	
IDA010	MI633	-29.89	IDA
IDB034	MI633	14.53	
IDA037	MI634	8.79	
IDB017	MI634	-17.96	IDB
IDA029	MI635	8.56	
IDB012	MI635	-5.62	
IDA038	MI636	6.02	
IDB046	MI636	8.67	
IDA018	MI637	-24.82	IDA
IDB030	MI637	13.00	

9.58
-40.45
11.51

IDA Dipole Magnet Strength Variation

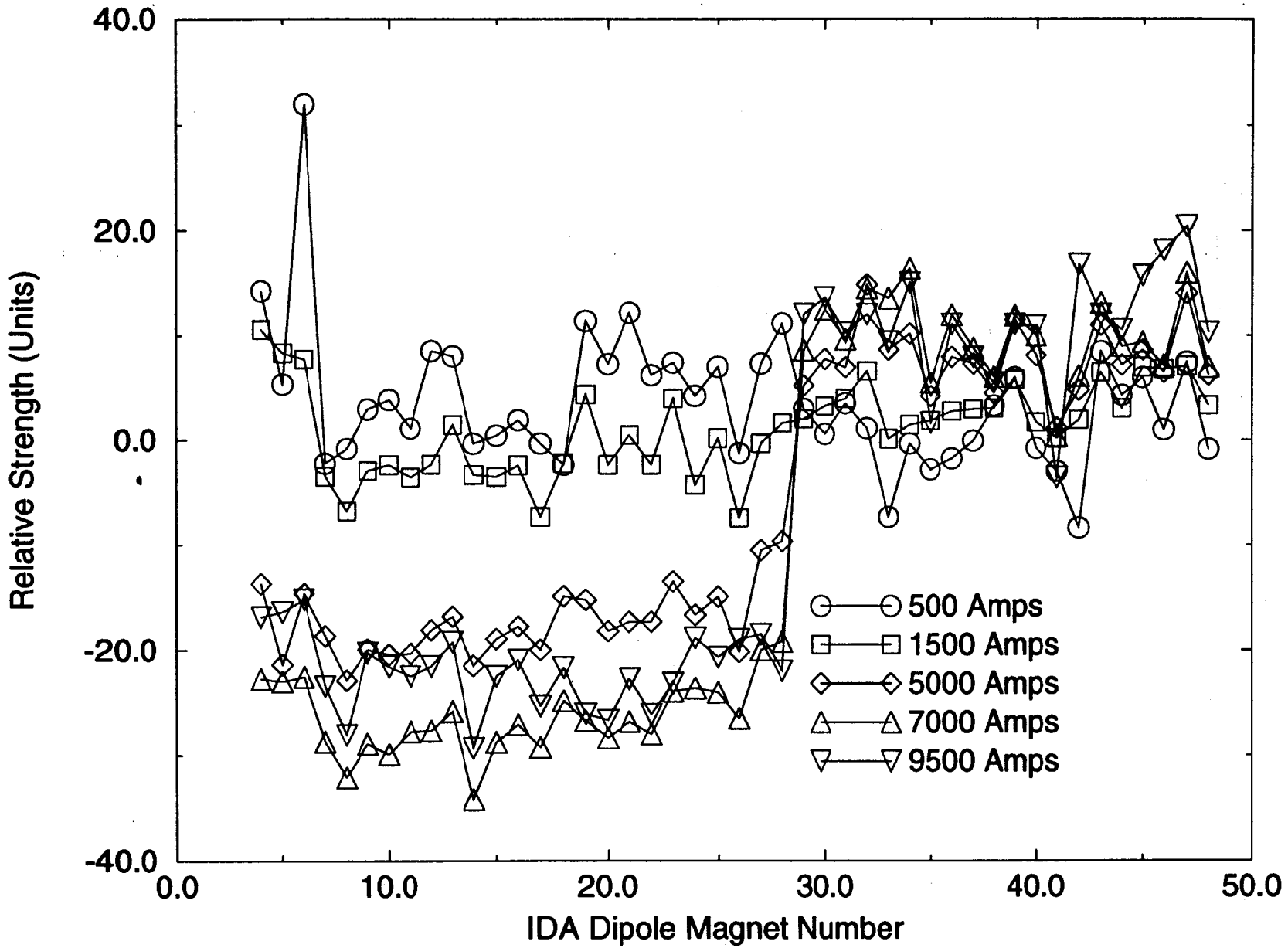

Fig. 1

IDB Dipole Magnet Strength Variation

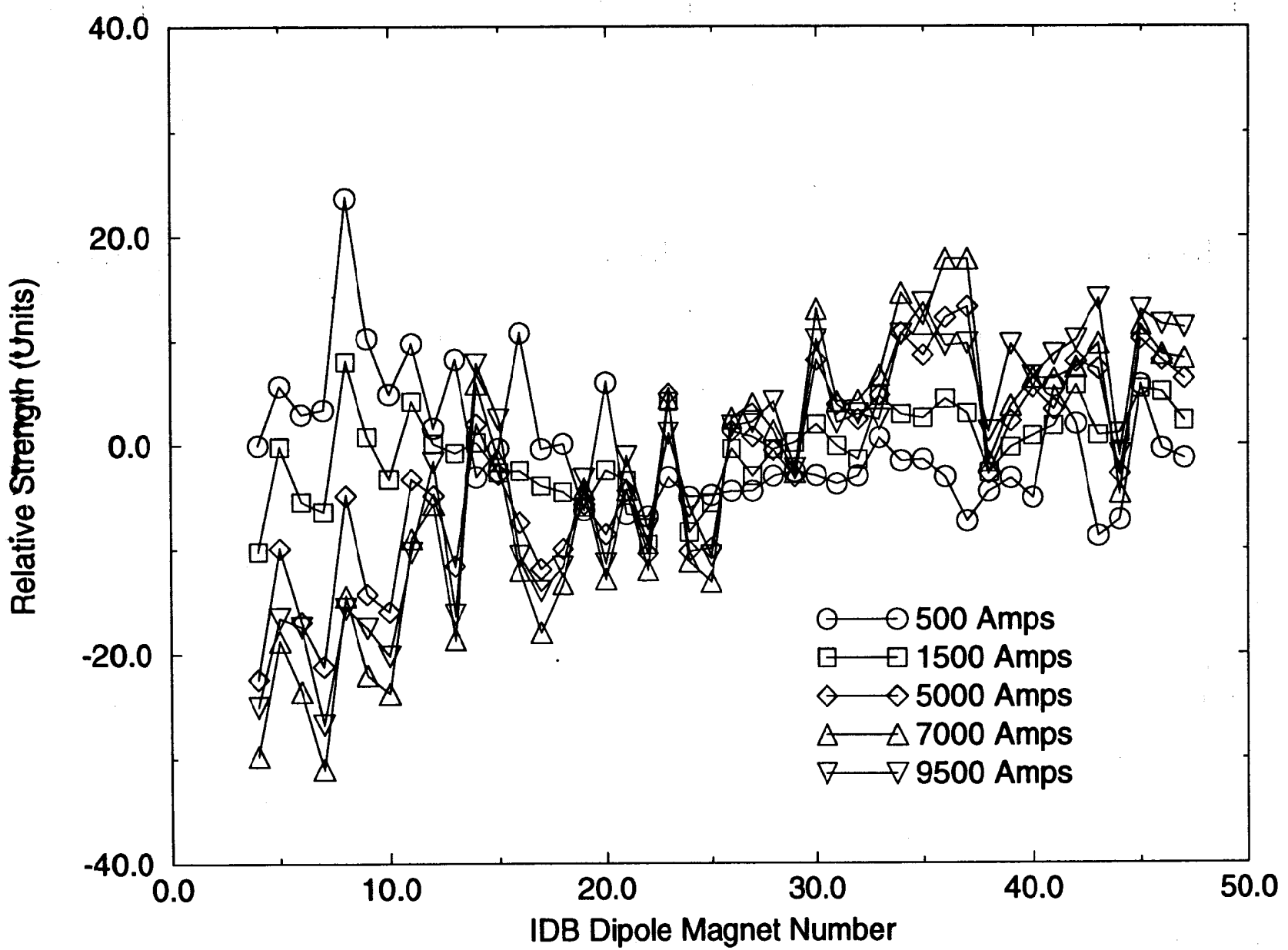

Fig. 2.

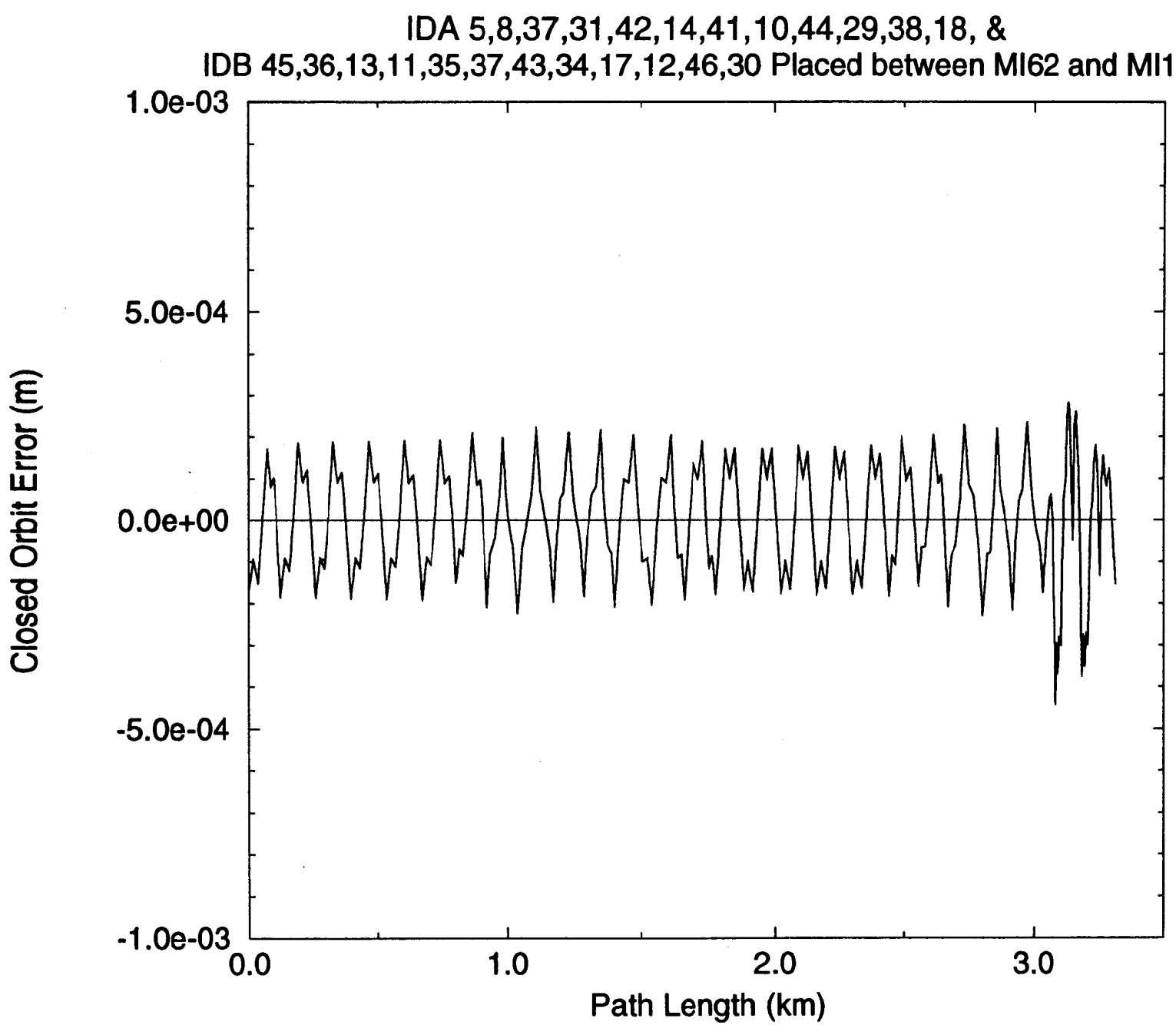
IDA 5,8,37,31,42,14,41,10,44,29,38,18, &
IDB 45,36,13,11,35,37,43,34,17,12,46,30 Placed between MI62 and MI10
1.0e-03
5.0e-04
0.0e+00
-5.0e-04
-1.0e-03
Closed Orbit Error (m)
0.0
1.0
2.0
3.0
Path Length (km)

Fig. 3.