THE MAX II LATTICE MAGNETS MEASUREMENTS AND CONCLUSIONS

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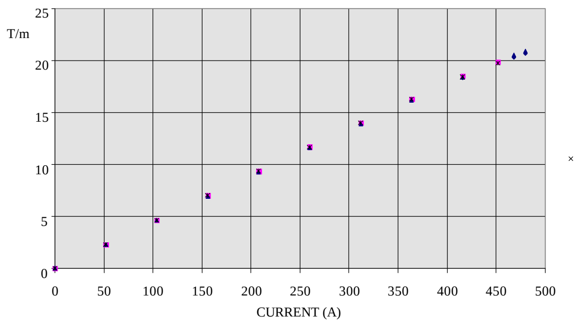
Abstract

The compactness of the MAX ll lattice is partly achieved by integrating the sextupoles in the quadrupoles. Measurements of magnetic fields and length’s for dipoles and quadrupoles with integrated sextupoles are presented and discussed. Conclusions for the chromaticity corrections are made. Measurements on the running machine are given.

1 LATTICE MULTIPOLE ELEMENTS

The MAX II sextupole magnets are integrated in the quadrupoles thus forming multipole magnets of two types. The design of the magnets is given in [1],[2],[3]. The multipoles are measured with Hall probe and a rotating coil apparatus. The Hall probe is used to measure the magnetic length and the gradient at the center of the magnets. The rotating coil measurements gives the relative strength of multipoles up to high order. The relative strength of the integrated gradient is calibrated to the Hall measurements at 240A excitation, yielding an absolute calibration of the coil measurement for all multipoles and all excitations. The extracted gradients as a function of excitation are given in fig 1. In these calibration curves it is assumed that the magnetic length is constant independent of excitation,

Fig. 1 GRADIENTS AS FUNCTION OF EXCITATION



any magnetic length variation with excitation is transferred to the gradients. Figures 2-4 are the Hall probe measurements of the fields in the median plane with poly-fits to the data. The integrated sextupole component is extracted from the rot.coil measurements and calibration is done as described above. During the prototype measurements it was found that the dipole and sexupole must be corrected at higher excitations.

Fig 2 Q250 MEDIAN PLANE

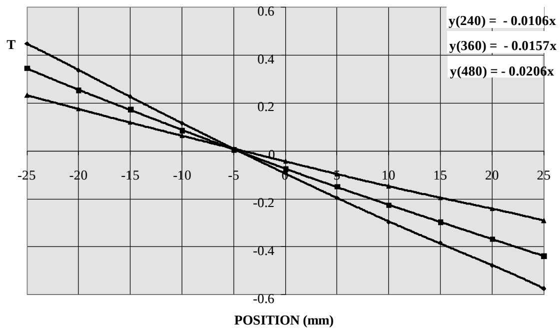


Fig 3 Q180 MEDIAN PLANE

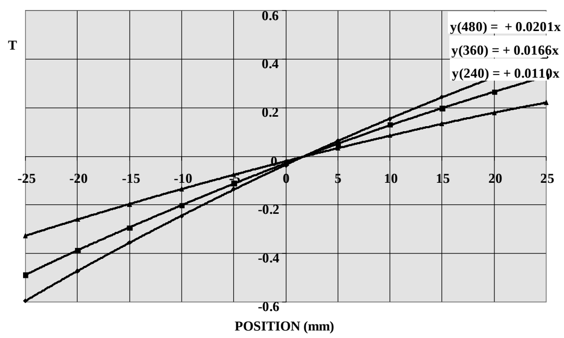
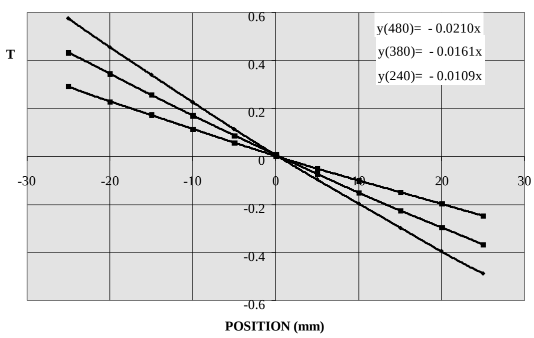


Fig. 4 Q500 MEDIAN PLANE



When measuring the lattice multipole magnets a back leg current is added to adjust the dipole component to a minimum. With this correction it was found that the excitation dependence of the integrated sextupole is closely following that of the integrated gradient.

Table 1	**Liron**	**Lq**	**Kc**	**S/Qrot**	**LsSc**	**Ls**	**Sc**	**Kn**	**Sn**	**I(500)**
	m	m	T/m	****	T	m	T/m2	m-2	m-3	A
Q180	0.180	0.213	10.8	0.0989	10.44	*****	****	-3.977	-18.05	124.5
Q200	0.200	0.233	10.8	0.1004	11.59	*****	****	-3.977	-18.31	126.4
Q250	0.250	0.283	10.7	0.0504	7.001	0.260	26.90	4.182	9.67	138.1
Q500	0.500	0.533	10.7	0.525	13.73	0.510	26.90	4.182	10.06	146.7

To extract the sextupole (at 240 A excitation) the formula below is used.
Ls*Sc=Srot/qrot*Lq*Kc/Rcoil
Ls is the effective sextupole length
Sc is sextupole strength in center
Srot is magnitude of sextupole in rot coil (arb.units)
Qrot is magnitude of quadrupole in rot coil
Lq is magnetic length of quadrupole from Hall measurements.
Kc is gradient from Hall measurements
Rcoil is rotating coil radius.
In case of the focusing elements QF500 and QF250 there is a possibility to separately extract Ls and Sc as the only difference is the length of the elements (Lq). All results are given in table 1. Note that the values Kn and Sn are the values used in lattice program together with length Liron given in the table.

2 LATTICE DIPOLES

The magnetic properties of the dipoles are extracted with two kind of measurements

1) An array of flip coils measure the entire magnet including end fields. From the measurement the dipole magnetic length is calculated for low and high excitations.(Table 2.)
2) End fields and bulk fields are measured by a Hall probe to deduce the end sextupoles and bulk sextupoles at low and high excitations.

2.1 BULK SEXTUPOLES

The sextupoles in the bulk of the magnet are calculated by polynomial fit to the measured fields. The sextupoles change in sign going from low to high excitation. The results are given in fig. 6,7 and table 3 together with the corresponding sextupole factor “b” used in program dimat. The factor b is corrected for the magnet length used in the program

Table 2.

RESULT OF EFFECTIVE LENGTH MEASUREMENT
Magnetic length at 1.5T is 1055.0 mm +-0.6 rms
Magnetic length at 0.5 T is 1057.4 mm +-0.6 rms
Mechanical length is 1052.4 mm +-0.5 rms

2.2 END SEXTUPOLES

The integrated sextupoles are calculated from a polynomial fit to the measured field ranging from well outside the magnet and 60mm into the faced magnet end. The results are given in fig 5,6 and the table below. The corresponding end curvatures are given.

Fig. 5 DIPOLE END FIELD

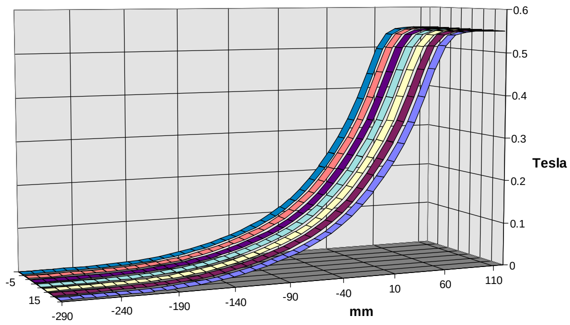


Fig. 6 DIPOLE MEDIAN FIELD (0.5 T)

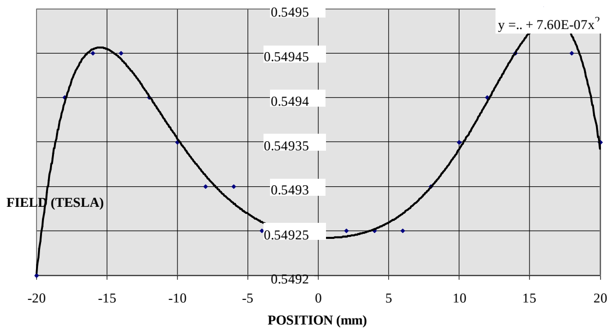


Fig. 7 DIPOLE MEDIAN PLANE FIELD (1.5 T)

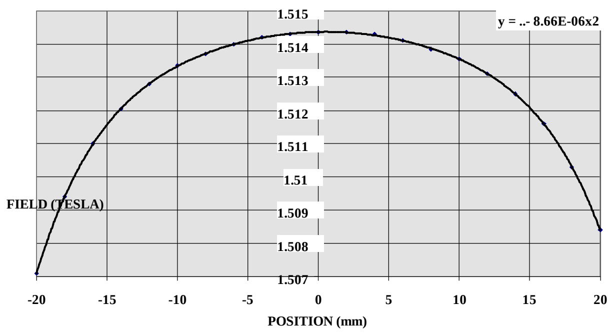


Table 3.

END SEXTUPOL	T/m2*m	NORM(m-2)	CURV(m-1)
At 0.5 T	-0.37	-0.22	1.4
At 1.5 T	-2.9	-0.58	3.7
BULK SEXTUPOL	*T/m2*	*NORM(m-3)*	*b=r2*B"/2B*
At 0.5 T	0.76	0.46	15.0
At 1.5 T	-8.7	1.74	-57.0

Fig. 8 INTEGRATED DIPOLE END FIELD (0.5 T)

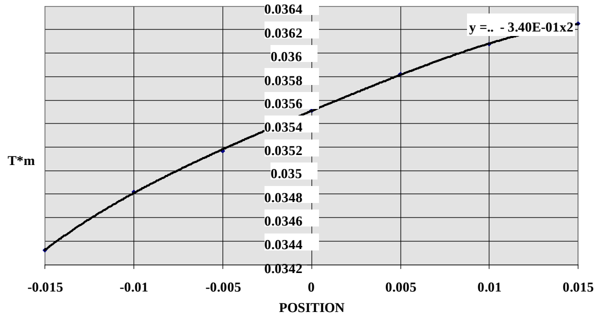
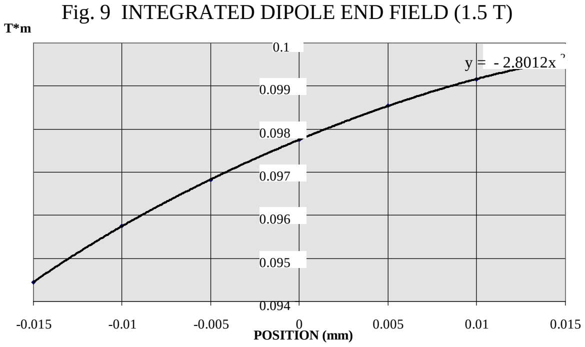


Fig. 9 INTEGRATED DIPOLE END FIELD (1.5 T)



3 LATTICE RESULTS AND CONCLUSIONS

The extracted sextupoles from the measurements have been transferred to the lattice program and the chromaticities are calculated with the following results. By a 10% increase of the defocusing sextupoles (increase of back-leg current) at injection energy and by a 5% decrease of the same sextupole at storage energy We will get the desired values. The problem of correcting the chromaticity was evident when we analyzed the first prototype magnet which resulted in adding the backleg windings to all the quadrupoles.

3.1 CHROMATICITY CORRECTIONS

The evaluation of the magnetic properties of the MAX II lattice magnets has shown that the sextupole strength must be corrected to achieve positive chromaticities in both planes. The lattice quadrupoles have all an backleg winding connected in series for the five different groups. When correcting the sextupoles an dipole component shows up that induce closed orbit errors. Due to the periodic nature of this error it can be handled by proper adjustments. The dipole to sextupole dependence picked up by the rotating coil for different backleg currents is found in fig. 10. The simulation of the chromaticity correcting procedure was made in program dimat. As an example a change of DQD1 and DQD2 by 6% give a chromaticity of +4 in both planes. The induced dipoles corresponds to a magnetic center shift of 0.3 mm. By slightly changing the relative strength of the backleg and finally correcting the energy(frequency) the closed orbit errors are reduced below 0.1mm.

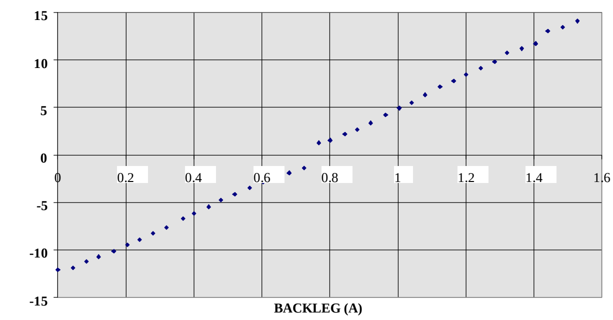
3.2 *COMMISSIONING RESULTS*

During the commissioning of the Max II ring we have gained a lot of experiences in correcting chromaticities. The ring was started up on a horizontal tune that differed one unit from the design value thus giving a quit different chromatic situation. It was found that even in this case it was possible to correct chromaticities to a slightly positive value in both planes. The procedure for correcting was as follows.

1) Keeping the tunes constant the relative strength of the defocusing quads (two families) are balanced to give the best situation.
2) The backleg currents are set to give the desired chromaticities.
3) The frequency is tuned to give the correct mean position.
4) The final closed orbit deviations are corrected with the orbit correctors.

When running on the design tunes at 500MeV we measure small positive chromaticities in both planes without using the backlegs.

REL.UNITS*100 Fig. 10 DIPOLE/SEXTUPOLE(rot coil)



4 REFERENCES

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[3] M. Eriksson Novel techniques used in MAX II This Conference