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REQUIREMENT FOR THE AGS BOOSTER CORRECTION ELEMENTS

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by

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This note is intended to give approximate requirements for the correction elements to correct chromaticity, and up to third order resonance stopbands, and to introduce appropriate tune spread for the Landau damping.

CHROMATICITY SEXTUPOLES

The chromaticity sextupoles are located at 1, 7 for the horizontal, and location 2, 4 for the vertical in every super periodes. We intend to correct the chromaticity to 1 GeV($B\rho$ --5.66). Beyond this point, we believe only the partial correction would be sufficient to controll the tune spread. The sextupole created by the eddy current in the vacuume chamber is estimated to be .12 T/m^2. [1] And the lattice calculation gives the chromaticity generated by those sextupoles are

$$\Delta\nu_H \cong 9.39\,\frac{2.15}{B\rho} + 4.3\,\frac{B''_H\,l}{2B\rho} + 2.08\,\frac{B''_V\,l}{2B\rho}$$

$$\Delta\nu_V \cong -8.26\,\frac{2.15}{B\rho} - 1.61\,\frac{B''_H\,l}{2B\rho} - 5.46\,\frac{B''_V\,l}{2B\rho}$$

which should cancel both horizontal and vertical natural chromaticities -4.808 and -5.138 respectivly. At 1 GeV, required the sextupole strengthes are

- 1.761 T/m^2.m for vertical set

1.123 T/m^2.m for horizontal set.

For example, if we assume 10 cm long magnets, the pole tip field at the radius of 3.25 inches is 1.2 k-gauss for the vertical set and less for the horizontal set.

We may be able to incorporate the correction for the random

sextupole error in these sets of the sextupoles.

OCTUPOLE FOR THE LANDAU DAMPING

If one assumes damping time of 200 turns, the required tune spread is .005. The tune spread caused by the octupoles are given by[2)]

$$\Delta \nu_y = \frac{3\beta_y k l}{4\pi B\rho}\left(\frac{y_o^2}{4} - \frac{x_o^2}{2}\right)$$

$$\Delta \nu_H = \frac{3\beta_x k l}{4\pi B\rho}\left(\frac{x_o^2}{4} - \frac{y_o^2}{2}\right)$$

where $k = B'''/6B$

l = length of the octupole

x_o, y_o = peak betatron amplitude at octpole

β_x, β_y = betatron function at octupole

The locations where we may place the octupoles have the betatron functions of

near F quad. $\beta_x = 10.7$ $\beta_y = 4.8$

near D quad. $\beta_x = 4.8$ $\beta_y = 10.7$

If we install 12 each of horizontal and vertical octupoles, the field requirement is 22.7 $T/m^3.m$ at 1 GeV. which gives pole tip field of approximately 1.3 K-gauss at 3.25" for 10cm long magnet.

CORRECTION DIPOLES

The correction dipoles are needed to correct 5 theta harmonics at the injection energy, and to correct vertical 3 theta harmonic polarization resonance at $B\rho = 4.2$.

i) **Vertical** -- The major sources of the errors are quadrupole survey error of .1mm r.m.s. and dipole roll of .2 mrad. r.m.s. which are;

Quad. 119 gauss-cm

Dipole 147 gauss-cm

The probable in-phase component of them is given by;

$$[119^2 \times 48 + 147^2 \times 36]^{1/2} \simeq 1210 \text{ gauss-cm}$$

If we place 42 correction elements(6 locations may be physically impossible to place the elements), half of which are in-phase and requires about 60 gauss-cm which would be trivial to make.

ii) **Horizontal**--We do not have complete analysis of the dipole random errors, however we may refere to similar SPS magnet analysis.[2] The random error for the typical dipole is 4×10^{-4} r.m.s. and similar analysis gives horizontal correction requirement of about 1000 gauss-cm (--50 gauss-cm each).

RANDOM QUADRUPOLE

Corrections are needed for the 9th and possiblly 10th harmonic quadrupole error. Again using CERN SPS analysis which gives;

low field	7×10^{-4}
mid field	3×10^{-4}

the total in-phase error is estimated to be

at injection	30 gauss
at 1 GeV	41 gauss

which is translated to be (for 42 correction elements) about 2 gauss. For 10cm long magnet the field is 2 gauss at 10 cm radius.

SKEW QUADRUPOLE

Skew quadrupoles are needed to correct 0 theta coupling resonance. The field roll of the quadrupoles can be as big as .5 mrad. which gives effective in-phase component of about 21 gauss. The required strength of the skew quadrupoles are about one half of the correction quadrupoles.

RANDOM SEXTUPOLES

The 14th and possiblly 13th and 15th harmonic should be corrected. The major random sextupole errors are from the eddy current (10^{-2}) and the chromaticity sextupole error (10^{-3}), which amounts to total in-phase component of 190 gauss/m^2.m. For forty two 10 cm long magnet, field required is about 1 gauss at 10 cm radius.

SKEW SEXTUPOLES

The major source of the skew sextupole errors are from the roll of the dipoles and it's vacuume chambers, and from the roll of the chromaticity sextupoles. Both of which can be as large as 5 x 10^{-4} and total in-phase error is about 85 gauss/m^2.m that is about a half of the correction sextupole requirement.

REFERENCES

1) G. Morgan and S kahn Booster Tech note 4

2) The SPS Correction Elements Working Group CERN/Lab.II-DI-PA, 1972.