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# AGS Stopbands II

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# DISCLAIMER

# AGS Complex Machine Studies

(AGS Studies Report No. 328)

## AGS STOPBANDS II

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|---|---|
| **Study Period:** | May 2, 1995 |
| **Participants:** | M. Blaskiewicz and J.W. Glenn |
| **Reported by:** | M. Blaskiewicz |
| **Machine:** | AGS |
| **Beam:** | Coasting Low Intensity |
| **Tools:** | AGAST - LeCroy |
| **Aim:** | To document effect of sextupoles on stopbands. |

## Data

The effect of current in the horizontal sextupoles on stopband corrections is documented. Corrector settings using DLFSC and SN26 were found that corrected the normal sextupole lines $3Q_H = 26$ and $Q_H + 2Q_V = 26$ as a function of current in the horizontal sextupoles. It was found that the skew sextupole lines $3Q_V = 26$ and $2Q_H + Q_V = 26$ were not affected by the current in the horizontal sextupoles. Figures 1 through 4 show the settings of the ortho counts which simultaneously correct the sine and cosine components of the two normal lines as a function of current in the horizontal sextupoles (IHS) in units of 10 amps. Estimated one sigma error bars are 50 counts. The DLFSC correction was 700 at all times. Note that the vertical scales are different on each plot. Below the plots are the least squares fit values and one standard deviation errors obtained from fitting the function

$$Corr = c0 + c1(IHS/10) + c2(IHS/10)^2, \quad (1)$$

where $Corr$ is SY26, CY26, SX26, or CX26 in counts. The ortho constants on the ring/sn26 page are the current increments in milliamps for an increment of 100 in the corresponding correction. Figure 5. shows the variation in the four quadrupole supplies needed to correct the $2Q_H = 17$ resonance as the current in the horizontal sextupoles is varied. Estimated one sigma error bars are 50 counts = 0.25 amps. The affect of the horizontal sextupoles on the $2Q_V = 17$ resonance was not studied.

## Analysis

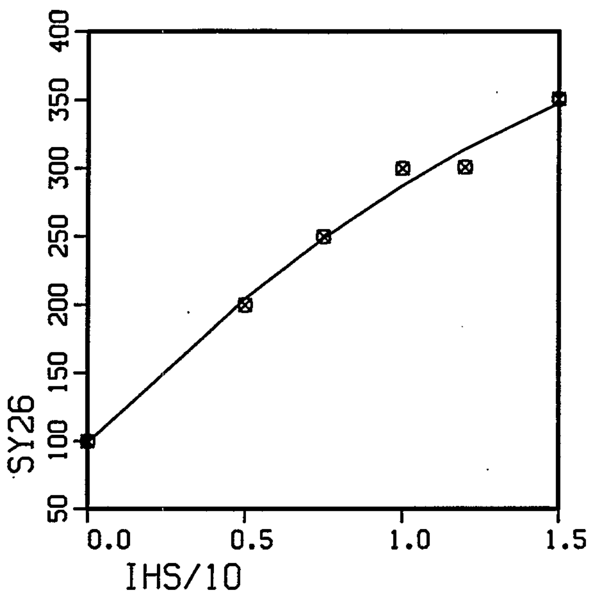
For analysis purposes, consider the stopband driving terms created by the correction currents [1],

$$\kappa(n_x, n_y) = \frac{1}{2\pi(2R)^{N/2}|n_x|!|n_y|!}\int_0^{2\pi} d\theta \beta_x^{|n_x|/2}\beta_y^{|n_y|/2}(-1)^{|n_y|/2+1}K_y^{(N-1)}(\theta) \exp\{i[n_x\mu_x + n_y\mu_y + (P - n_xQ_x - n_yQ_y)\theta]\}. \quad (2)$$

In equation (2) $N = 3$, $P = 26$, $n_x = 3$, and $n_y = 0$ for the $3Q_x = 26$ resonance. For the $Q_x + 2Q_y = 26$ resonance $n_x = 1$ and $n_y = 2$. These resonances are due to the sextupole field

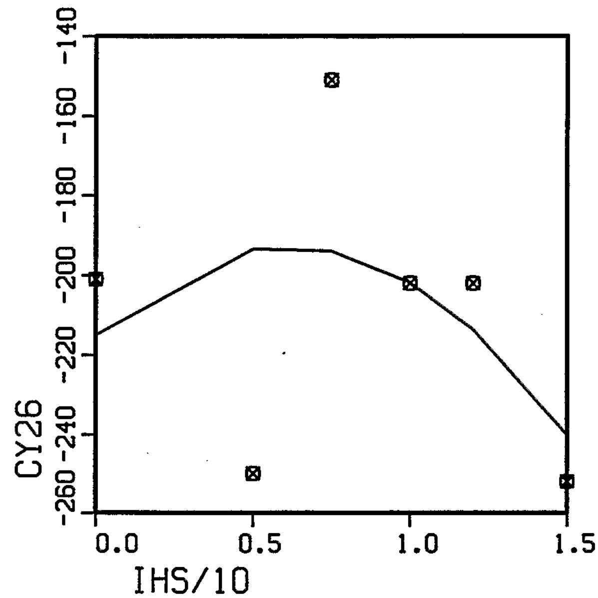
$$K_y^{(2)}(\theta) = \frac{R^2}{(B\rho)}\frac{\partial^2 B_y}{\partial x^2}. \quad (3)$$

The goal of the analysis is to find lattice errors using the measured values of $\kappa$. In particular the strong dependence of SX26 and CX26 on $IHS^2$ needs to be understood. At this point in time the only situation I know of which would lead to a nearly quadratic dependence of correction on the current in the sextupoles involves a closed orbit which is badly offset in some of the sextupoles. For a 5cm offset in one horizontal sextupole, MAD calculations predict a variation in the $3Q_x = 26$ stopband strength which matches the data. The predicted variation in the $2Q_y + Q_x = 26$ stopband is about a factor of 15 smaller than the measure variation. Given that the measured variation in the second case is an order of magnitude smaller than the variation in the $3Q_x = 26$ case, and the model is imperfect, the disagreement is not too worrisome. The best locations for the offset sextupole are in B, E, H, and K with a difference between calculated and measure phases $\sim 20°$. Additionally, one needs to consider the changes in the correction of the $2Q_x = 17$ resonance with $n_x = 2$, $P = 17$, $N = 2$. For an orbit offset of 5cm in a single sextupole the integrated quadrupole strength is 33Gauss/Amp. For the quadrupoles in the correction strings the integrated quadrupole strength is 41Gauss/Amp. An order of magnitude estimate for the change in quadrupole correction current with current in the sextupoles is $\Delta I_Q 41 N_Q = \Delta I_S 33$ where $N_Q \sim 8$ is the effective number of quadrupoles used in the correction. For $\Delta I_S = 6$Amps the predicted value is $\Delta I_Q = 0.5$Amp while the measured value is $\Delta I_Q \sim 3$Amps. A more careful accounting of the phase and $\beta$ weighted averages shows that the observed variation in the $2Q_x = 17$ stopband is only twice as large as that predicted by the model.




| c0 | c1 | c2 |
|---|---|---|
| 99 | 233 | -45 |
| dc0 | dc1 | dc2 |
| 11 | 30 | 19 |

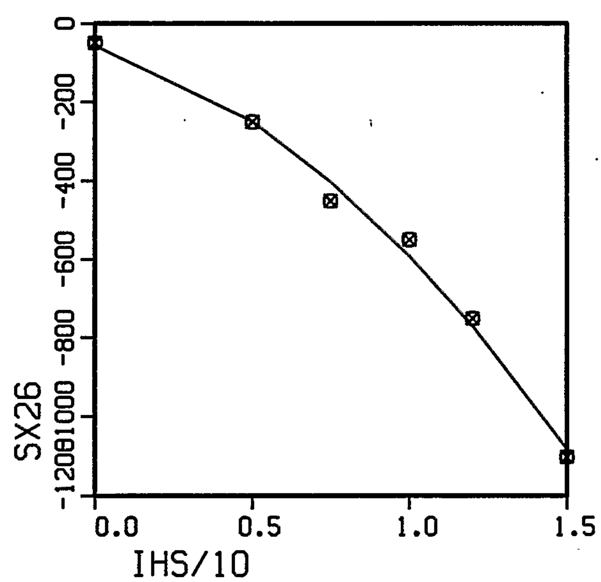
Figure 1: SY26 correction .vs. IHS/10, weighted rms = 11




| c0 | c1 | c2 |
|---|---|---|
| -214 | 73 | -60 |
| dc0 | dc1 | dc2 |
| 41 | 117 | 75 |

Figure 2: CY26 correction .vs. IHS/10, weighted rms = 43

The factor of two discrepancy does not seem too serious. As the $2Q_x = 17$ resonance is approached any errors will cause large excursions in $\beta_x$. The stopband strength will be due to both the gradient at the sextupole as well as the $\beta$ and phase weighted averages in *i.e.* the combined function magnets at all locations around the ring. I expect that the correction strings would create just as severe a $\beta$ function modulation as the offset in the sextupole but have no proof. Additionally, a 5cm offset is very large indeed. Smaller offsets in several sextupoles would also do the job but the phases would have to be right. The relative size of the sextupole and quadrupole stopbands might change as well.

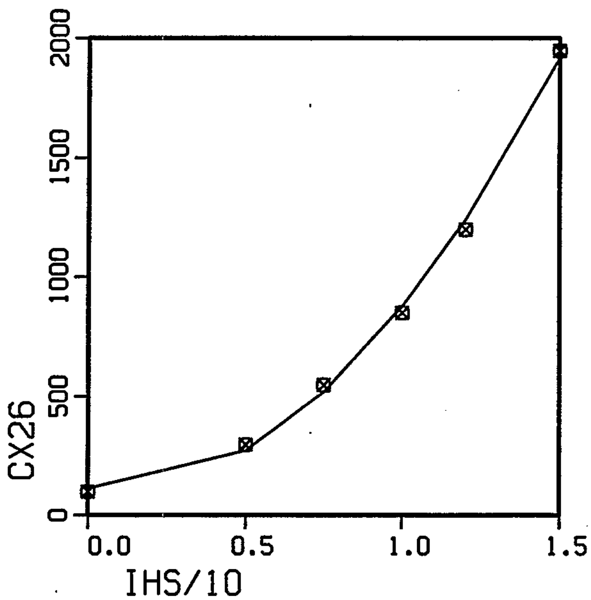



| c0 | c1 | c2 |
|---|---|---|
| -57 | -236 | -299 |
| dc0 | dc1 | dc2 |
| 39 | 110 | 71 |

Figure 3: SX26 correction .vs. IHS/10, weighted rms = 40

# References

[1] G. Guignard, CERN 78-11 1978.




| c0 | c1 | c2 |
|---|---|---|
| 111 | -118 | 882 |
| dc0 | dc1 | dc2 |
| 39 | 110 | 70 |

Figure 4: CX26 correction .vs. IHS/10, weighted rms = 40

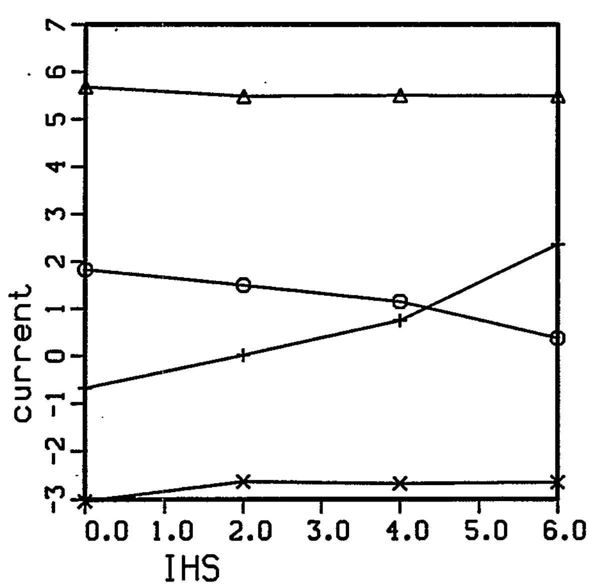



Figure 5: QN17 currents .vs. IHS, $\triangle$=QVF, $\bigcirc$=QVC, +=QHC, $\times$ = QHF.