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Comments on Studies Report No. 322

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DISCLAIMER

AGS Complex Machine Studies (AGS Studies Report No. 359) Comments on Studies Report No. 322
Study Period: 18 June 1995
Participants: L. Ahrens, C. Whelan, N. Williams, B. Tamminga
Reported by: E. Bleser
Machine: AGs
Beam: 2 Tp protons
Tools:
Aim: This report is the third analysis of the data taken in this study

COMMENTS ON SR 322
E. BLESER
MARCH 28, 1997

SUMMARY

AGS Studies Report 322 (Ahrens et. al., 7/11/95) describes an attempt to measure the center of the high field sextupole string, which should correspond to the central orbit in the AGS. The authors were disappointed with their results, and a subsequent technical note (AGS TN 423, Calvani, 1/12/96) was written which carried out a global fit to the data. The assumption behind carrying out a global fit was that the data were not very precise and that good results could be arrived at by averaging over many points. The present note argues that the data is very precise, but that the AGS is very complex. It will show that when sextupoles are used it is easy to slide into conditions where second order effects are important and simple assumptions do not apply. In particular, these data were taken using only six of the twelve horizontal sextupoles, resulting in a machine that was unusually lumpy and subject to second order effects. The conclusions of this note are that we should operate the AGS in a smooth, well understood regimen, and that further measurements of the sort reported in SR 322 can be taken with great profit, since we have a full modeling capability for understanding them.

DATA

We very briefly recapitulate the results reported in SR 322. Data were taken on the injection front porch for four sextupole settings over a range of frequencies. The four runs were:

RUN	$I_{horizontal}$ Amperes	$I_{vertical}$ Amperes
1	0	-2.7
2	0	-14.9
3	53.2	15.5
4	94	28.5

All twelve vertical sextupoles were powered, but only the six horizontal sextupoles in A, C, E, G, I, and K were used.

The betatron tunes were measured as a function of frequency and are plotted in Figures 1 thru 8, where we have taken the central frequency to be 2.75 MHZ. We show all these plots to make the point that the data points seem to be very precise. For repeated measurements the frequency results seem to repeat to 10 or 20 Hz out of 2.7 MHZ, the tune measurements to 0.001 out of 8.7. Also shown are some polynomial series fits to the data. Beyond showing that the data can be very nicely fit by smooth curves, the fits have no significance. Extrapolating them beyond the range of the data is probably meaningless, and assigning physical meaning to the individual terms is very problematic since the results depend on how many terms are used and in this paper the number of fitted terms has been chosen in a very rough and ready fashion.

ANALYSIS

We assume that the mean central radius of the horizontal sextupole string lies at a certain radius, r_h, and that the mean central radius of the vertical sextupole string lies at a certain value, r_v. Following the horizontal alignment of the AGS nearly a decade ago, we would have predicted these values to agree to a fraction of a millimeter. However with the passage of time, the addition of shielding, and the moving of magnets the disagreement may be large. In this note we shall assume r_h and r_v are different and press ahead.

In our analysis we deal first with Runs 1 and 2. For these runs only the 12 vertical sextupoles were powered and for these runs we define the mean radius of the these sextupoles to be the mean radius of the AGS (this was the design and construction goal, and if it is slightly wrong it does not affect our analysis.) Figure 9 plots Q_h versus frequency. The crossing point in Figure 9 gives the frequency of the beam on the central orbit, 2.7506 MHz. We take the radius of the AGS to be 128.454 meters and find the momentum to be 2.29521 GeV/c. Also from Figure 9 we can determine Q_h for the central orbit. From the vertical data we can get Q_v for the central orbit at this momentum. The inputs to MAD consist of the momentum and the tune quad currents necessary to produce these tunes (close but not identical to the currents recorded for the experiment), and the sextupole currents as recorded by the experimenters. Figures 10 and 11 show the data points and the MAD calculations, which have been fitted to match the tunes at dR equals zero but are otherwise predictions. The qualitative agreement is very good.

Runs 3 and 4 use the 12 vertical sextupoles and in addition the 6 horizontal sextupoles. We carry out an analysis similar to that above, but independent of it and find the mean radius for these 18 magnets to be 2.2 mm inside of that for the 12 magnets. Figures 12 to 15 show the MAD calculations and the data points. The model and the data all show the same tendencies. We no longer have straight lines. The behavior of the AGS is very nonlinear.

We shall make just a few comments on Run 4. The experiment could take data only over a small aperture before losses set in. MAD could find solutions only over a small aperture for this run. Where it could find solutions off the central axis MAD found vastly blown-up beta and dispersion functions as shown in Figures 16 and 17. We shall not discuss this experiment further since it used only six horizontal sextupoles, making it a special case and a particularly egregious one. A future note will attempt to design in detail an experiment useful for the present machine.

CONCLUSION

It should be possible to do a very good experiment of the sort tried in SR 322. Our equipment gives very precise results. The problem with SR 322 is that it had only six horizontal sextupoles available which produced a very lumpy, non-linear machine at high sextupole currents. It should be easier and more to the point to do another experiment than try to sort out the complications of this data.

Figure 1: Qx vs df/f; RUN 1

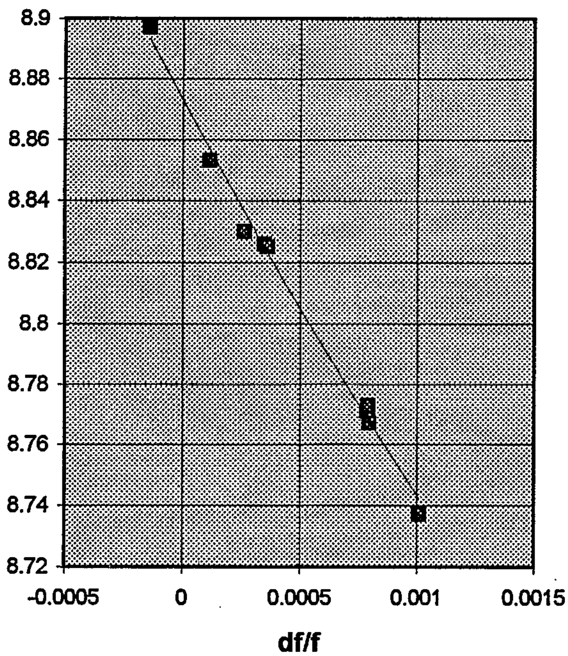


Figure 2: Qx vs df/f; RUN 2

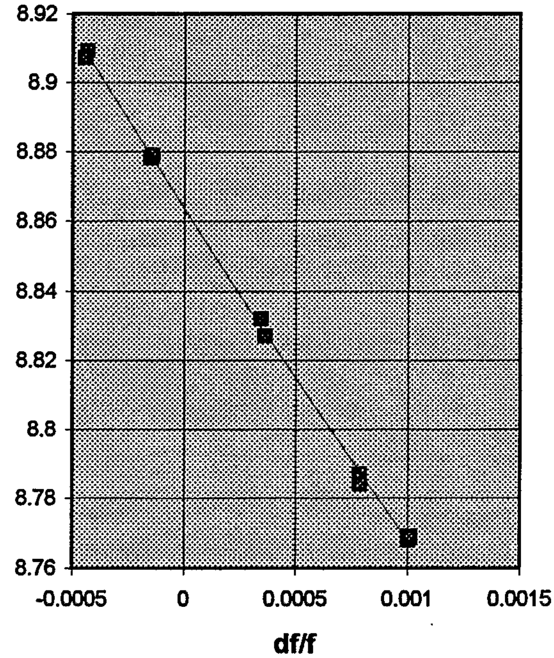


Figure 3: Qx vs df/f; RUN 3

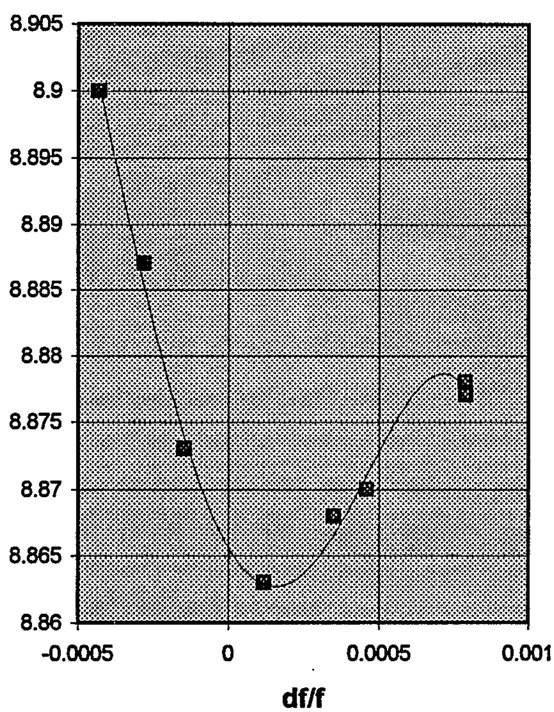


Figure 4: Qx vs df/f; RUN 4

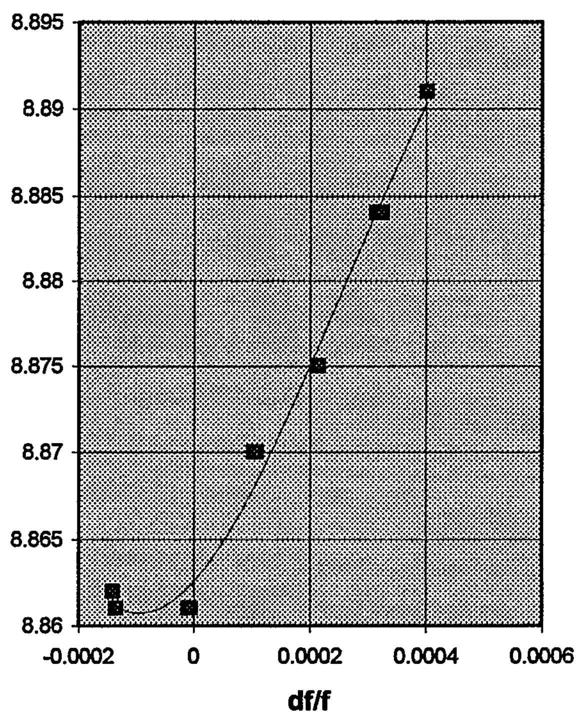


Figure 5: Qy vs df/f; RUN 1

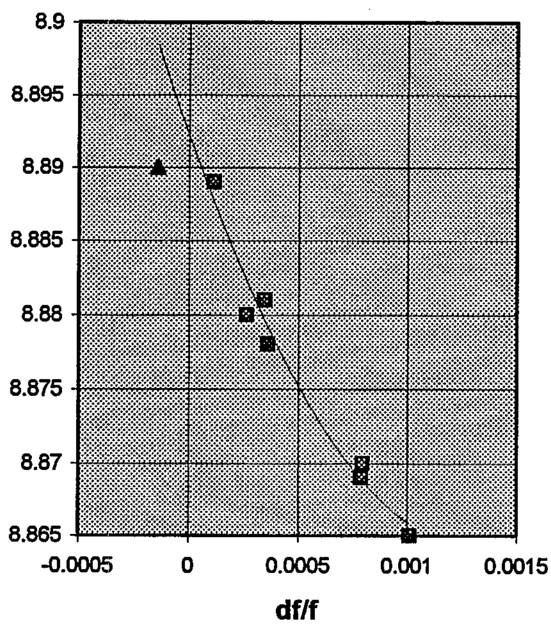


Figure 6: Qy vs df/f; RUN 2

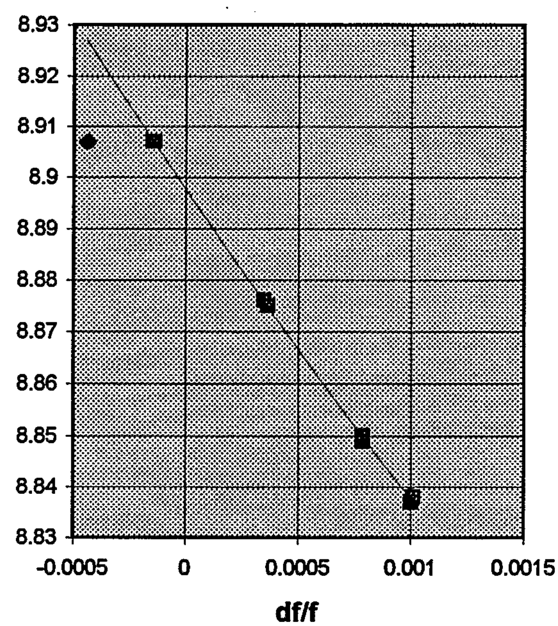


Figure 7: Qy vs df/f; RUN 3

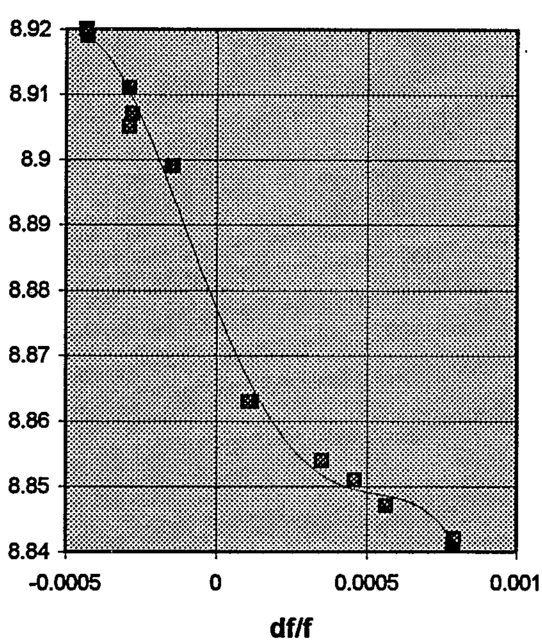


Figure 8: Qy vs df/f; RUN 4

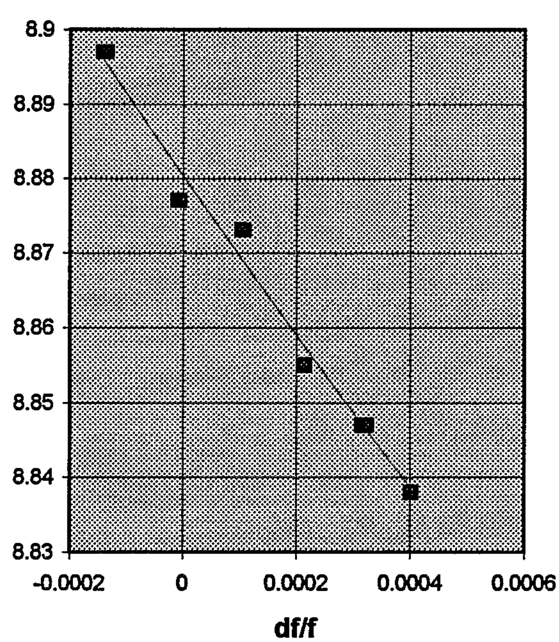


Figure 9: Qx vs df/f; RUNS 1 & 2

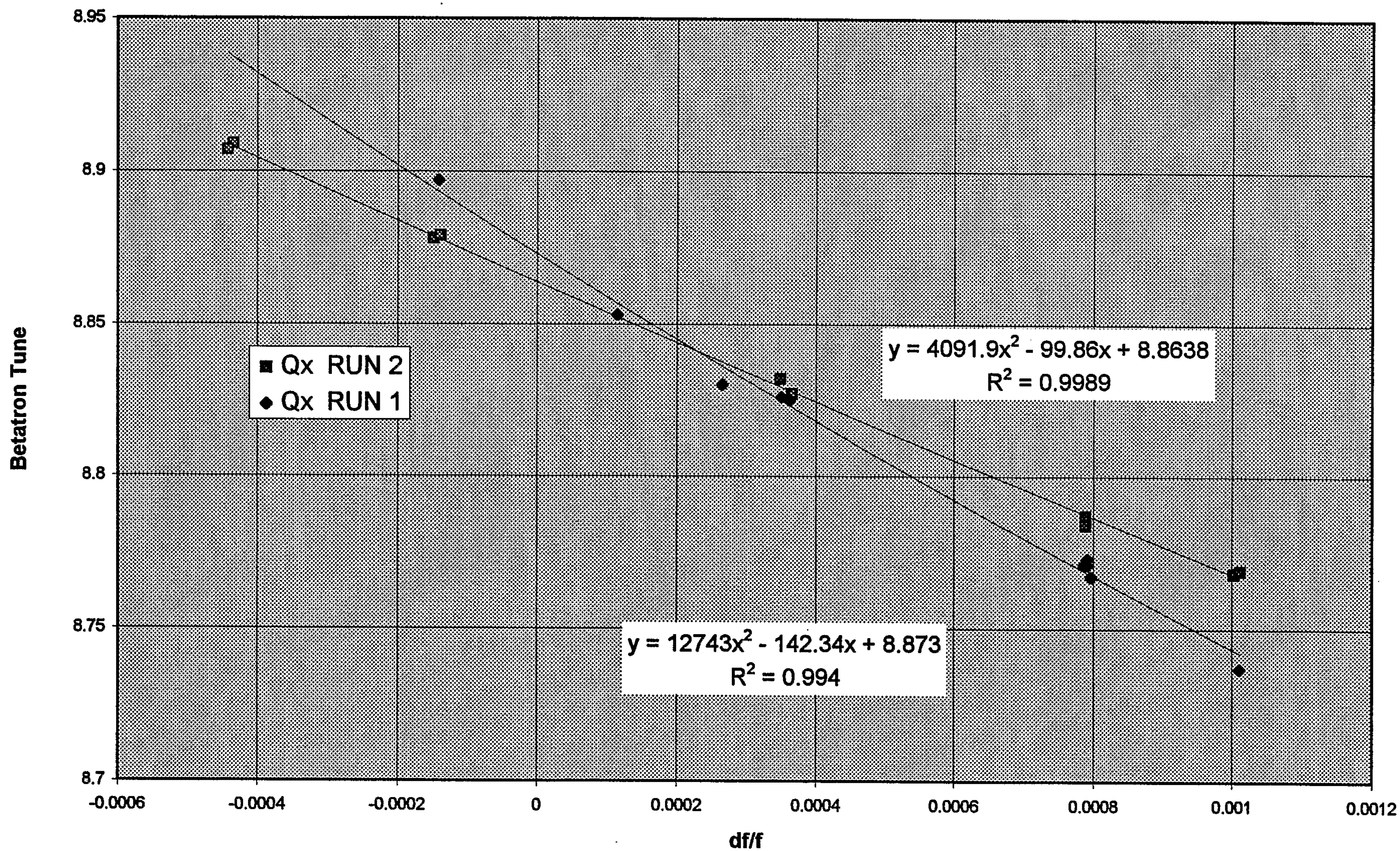


Figure 10: Qx & Qy vs dR; RUN 1

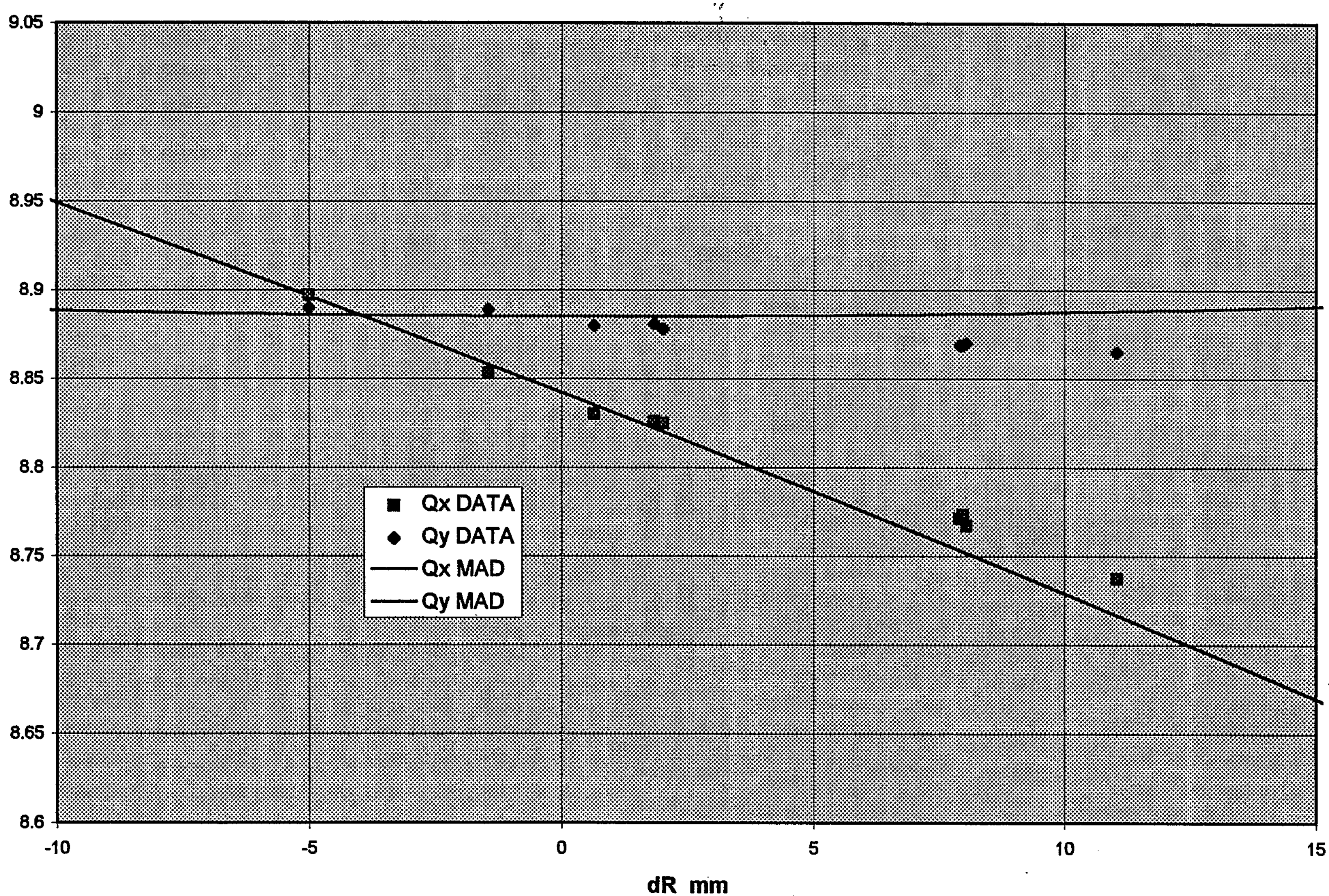
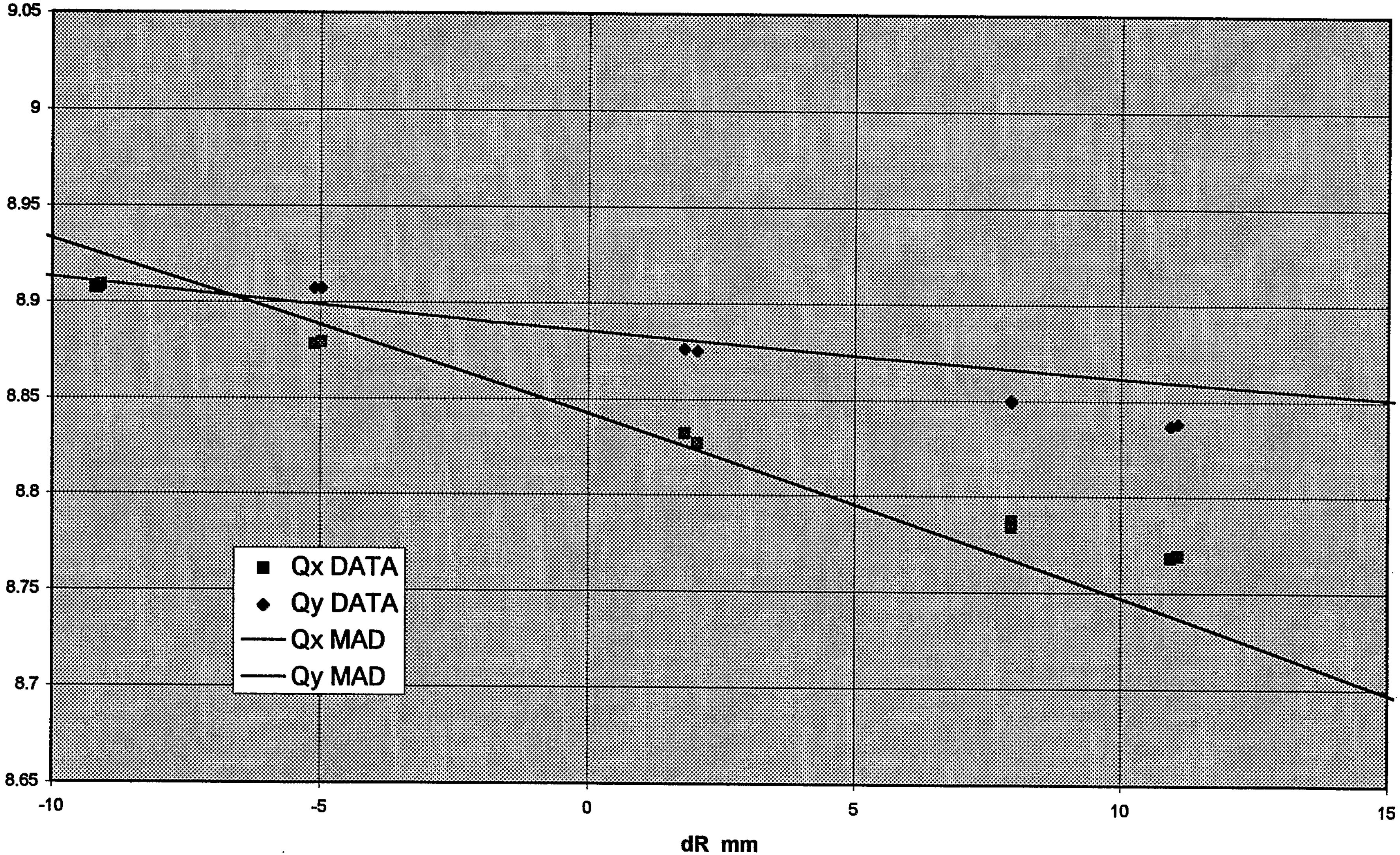


Figure 11: Qx & Qy vs dR; RUN 2



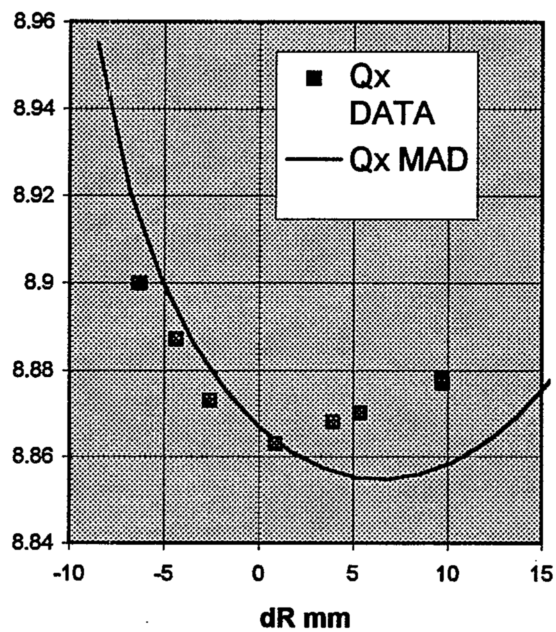


Figure 12: Qx vs dR; RUN 3

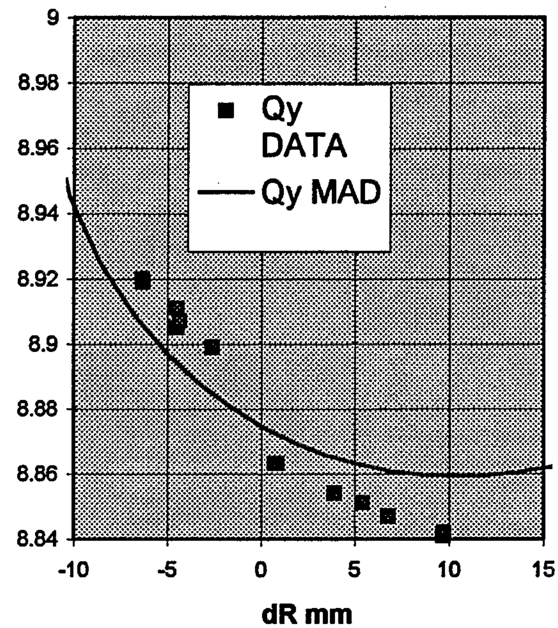


Figure 13: Qy vs dR; RUN 3

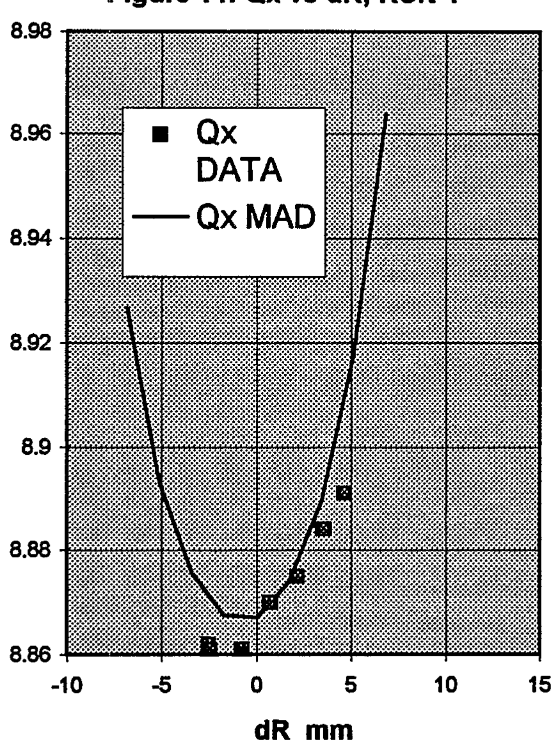


Figure 14: Qx vs dR; RUN 4

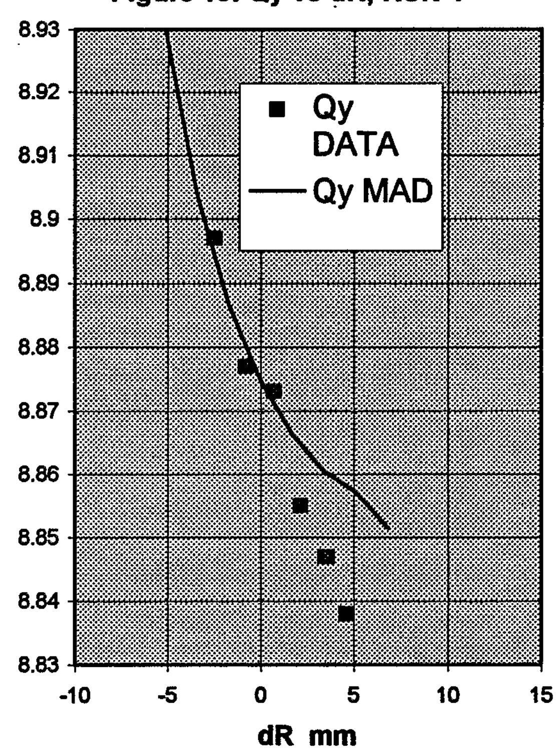


Figure 15: Qy vs dR; RUN 4

Figure 16
BETA FUNCTIONS
RUN 4 with and without sextupoles
dR = +6.8 mm

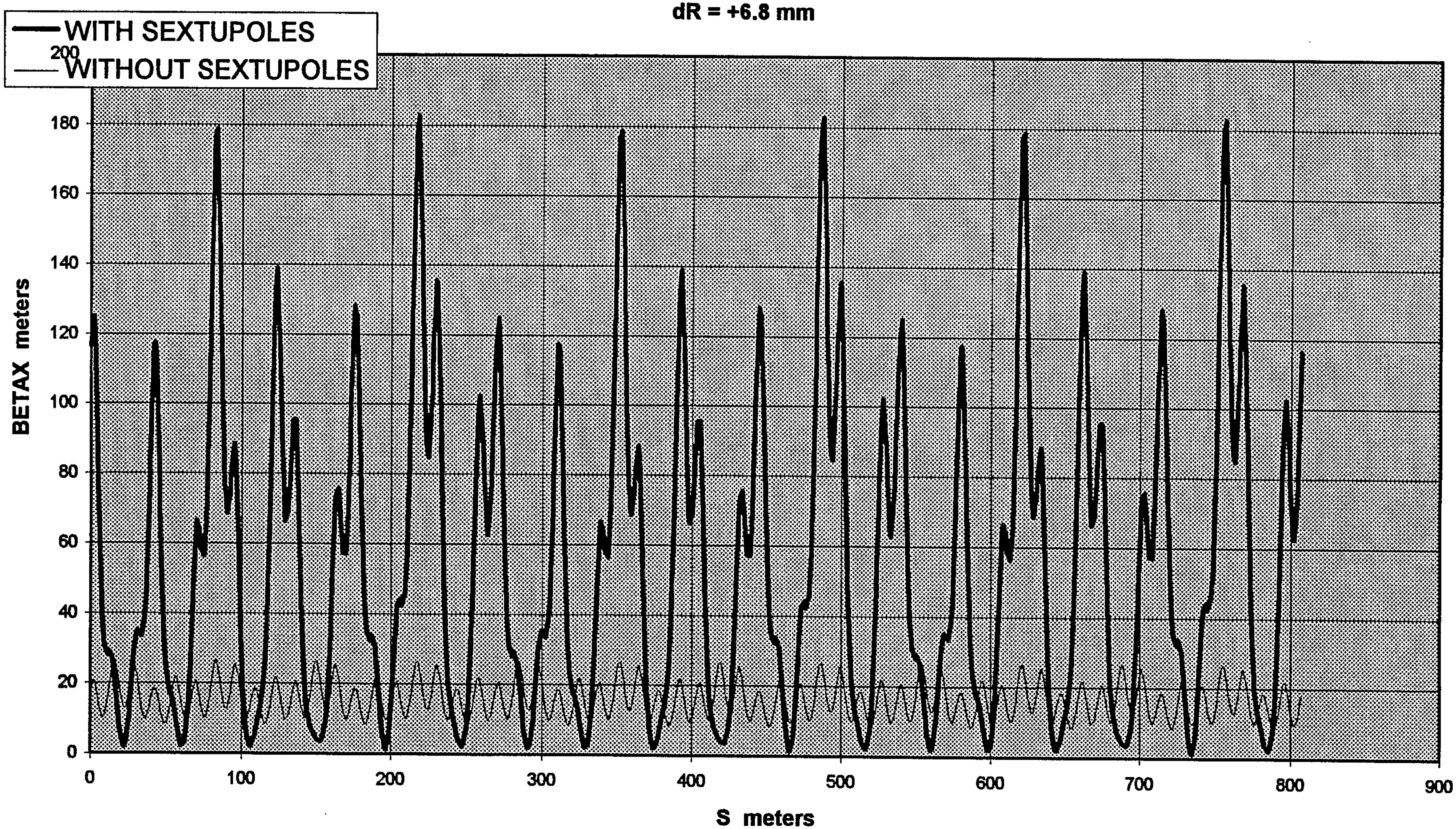


Figure 17
X(CO)
RUN 4 with and without sextupoles
dR = 6.8 mm