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Half Integer Stopband Width of the Booster

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DISCLAIMER

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AGS STUDIES REPORT

Date(s) of Study: 4/14/93 and 4/17/93 **Time(s):**

Beam: 4/14/93: USER1 High B-dot inj. (70 G/ms); 4/17/93: USER3 Low B-dot inj. (30 G/ms); Intensity 10^{12} ppp, 70°-5 turns

Experimenter(s): C. Gardner and Y. Shoji

Reported By: Y. Shoji

Subject: Half Integer Stopband Width of the Booster

I. MOTIVATION

There are two motivations. One is a proposal by Machida (SSC Laboratory) to measure the beta function. Unfortunately, the quadrupole backleg windings in the AGS Booster do not have individually separated power supplies. Therefore, we can only measure the mean beta function. When we use the tune control current as a parameter, the experiment is identical to the measurement of the stopband width of the half-integer resonance.

The other motivation for the study is the mystery of the residual beam loss on the half-integer resonance line. At three resonances in the AGS Booster, 2Qh=9, 2Qv=9, and Qh+Qv=9, even after the optimization of the resonance correction parameters, there still exists considerable beam losses. The strange thing is that they are much larger than the loss on the uncorrected third order resonances (3Qh=14, 3Qv=14, Qh+2Qv=14, and 2Qh+Qv=14). We want to confirm that the half-integer resonances are corrected and that higher order resonances (in particular, the 4th order structure resonances, 4Qh=6x3, 4Qv=6x3, and 2Qh+2Qv=6x3) are for the beam losses.

II. PRINCIPLE

Because the beta function is modulated near the stopband, we expect the ratio of the tune and the unperturbed tune (which is roughly proportional to the tune control quadrupole current) to change.

$$4\pi\ \delta Q = \int \delta K\ \beta\ ds$$

The tune near the stopband is approximated as

$$\cos(2\pi Q) = \cos(2\pi Qo) - (2\pi\Delta Q)^2/8.$$

Here Q and Qo are perturbed and unperturbed tunes. At this time, they correspond to measured tune and set value, respectively. ΔQ is the half-integer resonance stopband width.

III. METHOD

The method used was to change the horizontal tune very slowly and let it cross the horizontal half-integer resonance, 2Qh=9. The trace in the tune space is shown in Figure 1. Next, the horizontal tune charge was measured with the tune meter.

The crossing speed was dQ/dt = 0.004 ms. The beam intensity was 7×10^{11} ppp. The incoherent tune spread from the space charge is estimated to be 0.01. The chromaticities were corrected to zero. The residual coherent tune spread observed on the FFT spectrum of the tune meter was 0.008 (see Figure 2).

The stopband correction strings were turned off. The optimized values were cos9x=600 and sin9x=100. The calculated stopband width from the correction parameters was 0.007. The tune meter measured dR for about 1 ms after the kick. The resolution of the tune meter was 0.001. The fluctuation of the monitored current of the horizontal tune control power supply was $\delta Qh = 0.005$ p-p.

IV. RESULTS

The results of the study performed on April 17 are shown in Figure 3. The stopband width was much smaller than the sensitivity of the measurement. The oscillation of the data points are thought to be from the ripple of the power supplies. The beam was lost before the measured tune had reached to the half integer (see Figure 4). The real tune is thought to be smaller than the measured tune because of the incoherent tune spread by the space charge.

V. DISCUSSION

The calculated stopband width of 2Qv=9 is only a little bit larger than that of 2Qh=9. The half-integer stopband widths are very small and undetectable. If the power supplies in the quadrupole backleg windings were separated, we could hardly detect the modulation of beta functions. The beam loss due to the half-integer stopband is large because the stopband is narrow but very strong.

We have some ways to improve the sensitivity of the measurement, but the required sensitivity to detect the residual stopband width is better than 0.0001. It is almost impossible. We will have to do other kinds of studies to know whether the residual loss is due to the half-integer stopband or not.

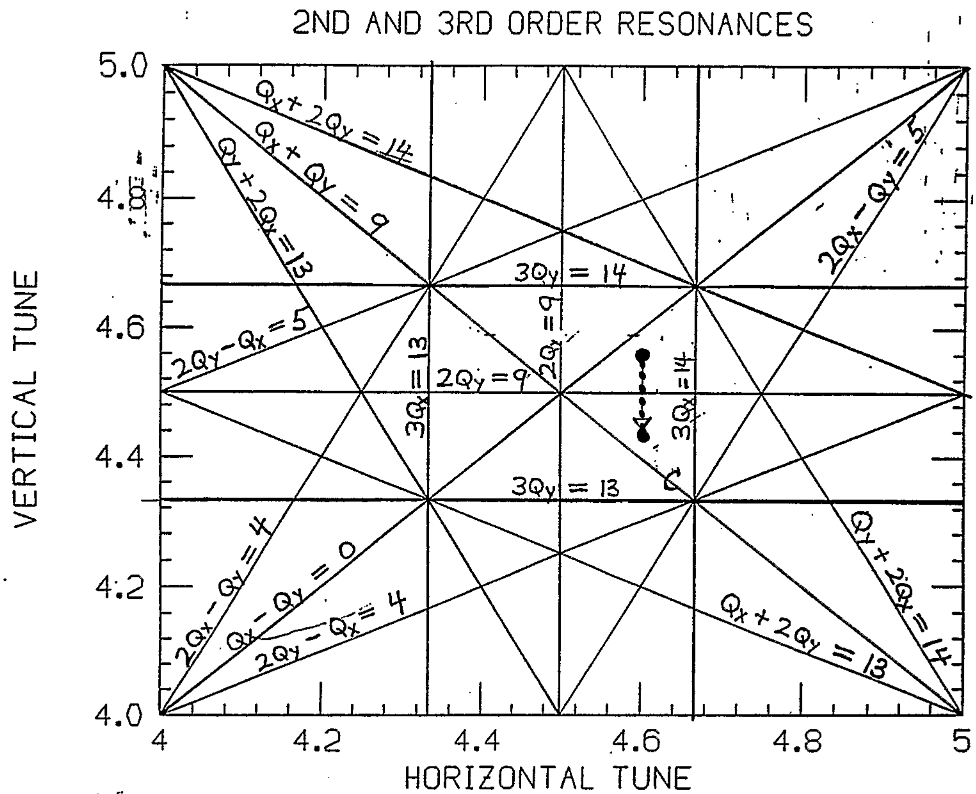

Figure 1. Trace of the moving tunes in a tune space.

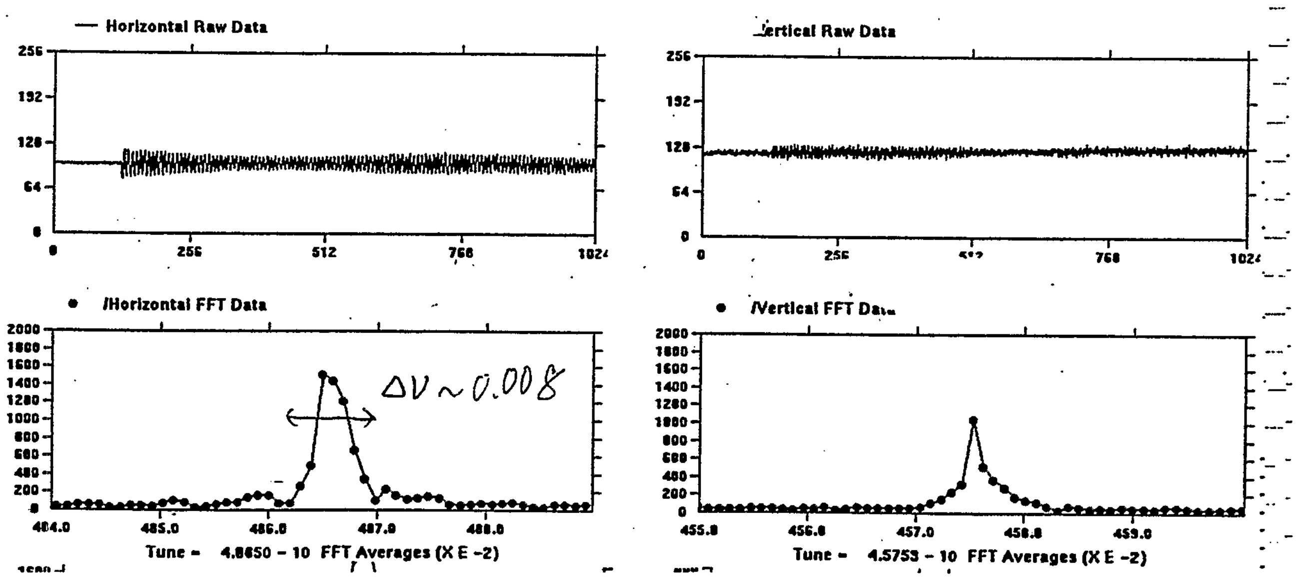

Figure 2. Spread of the betatron frequencies. The chromaticities of both H and V planes are corrected to 0. FFT spectrum are results of several times average.

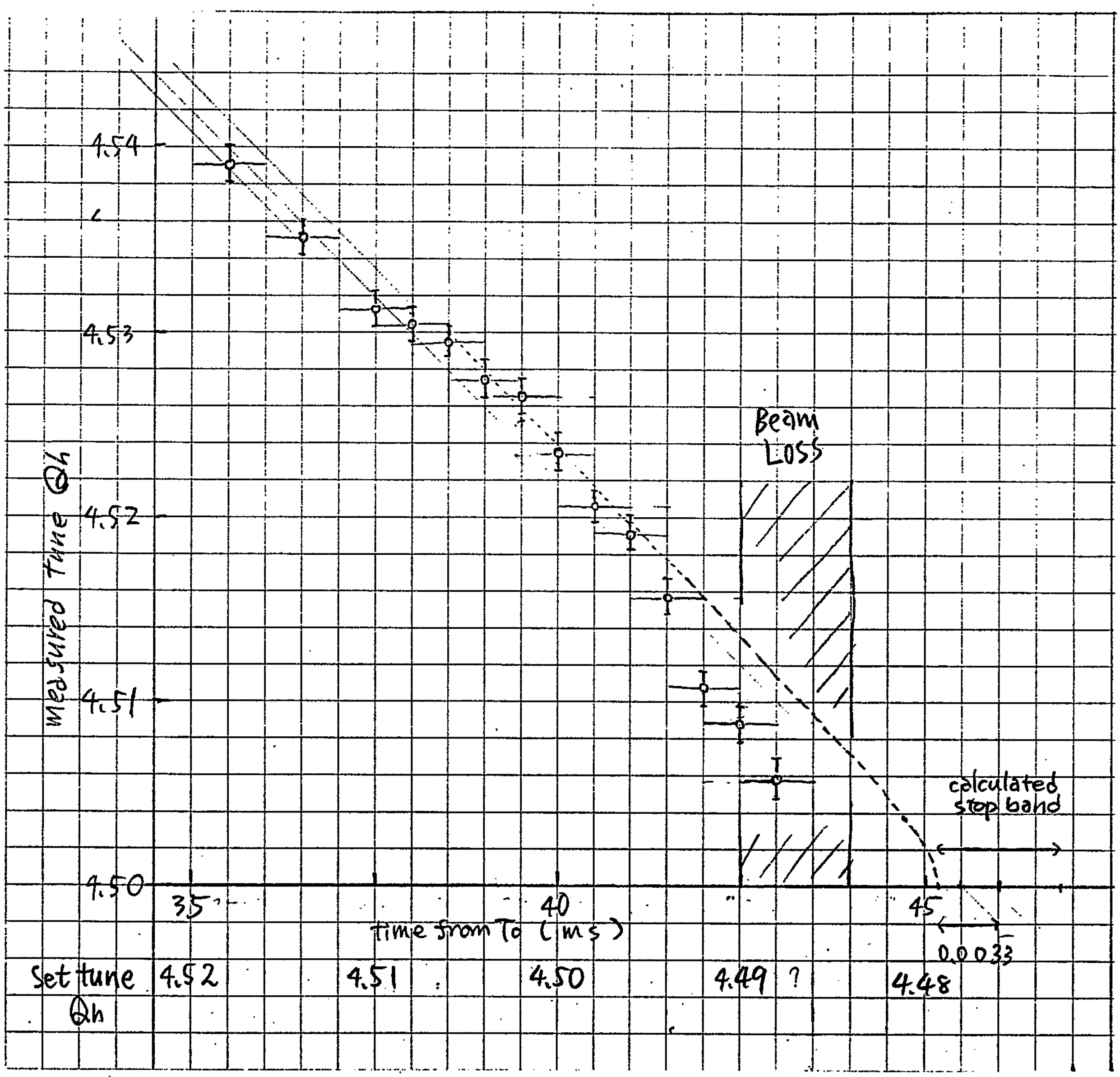

Figure 3. Set tune (Qo) and measured tune (Q).
Horizontal and vertical errors bars of data points are the resolution of time and tune of the tune meter.
Broken line is the tune obtained using Equation (1) with the stopband width $\Delta Q = 0.0066$.

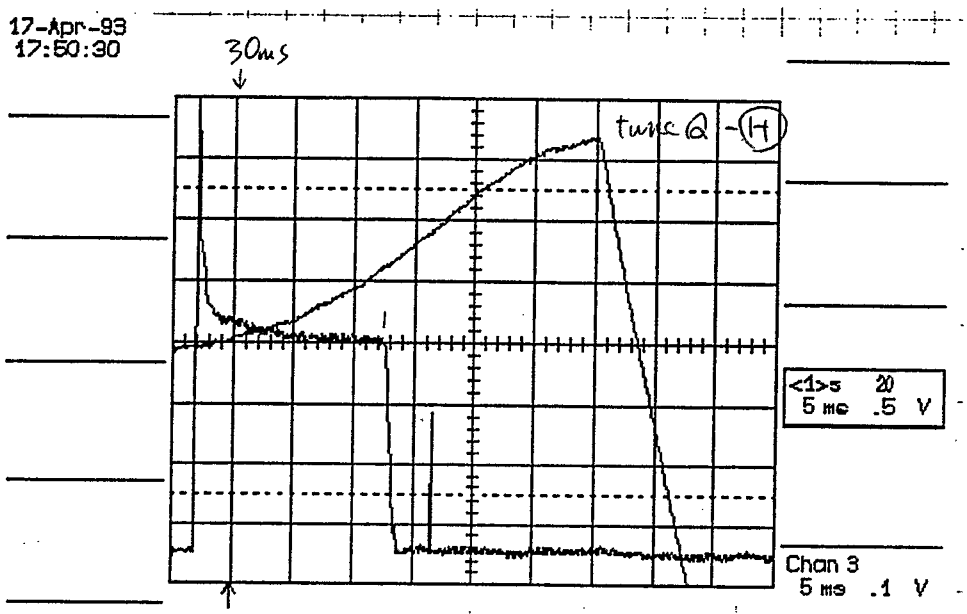

Figure 4. Beam current in the Booster.