LA-UR -89-1574
CONF-890299--10

LA-UR--89-1574

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TITLE: TIME AND FREQUENCY RESPONSE OF BEAM POSITION MONITORS AT THE LOS ALAMOS PROTON STORAGE RING

AUTHOR(S): George R. Swain, MP-14

SUBMITTED TO: Accelerator Design Workshop
Los Alamos National Laboratory
February 20-25, 1989

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

FORM NO 836 R4
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Time and Frequency Response of Beam Position Monitors at the Los Alamos Proton Storage Ring

George R. Swain

Los Alamos National Laboratory, MS H847
Los Alamos, New Mexico 87545

Abstract

A number of beam position monitor (BPM) signals were digitized and recorded for stable and unstable beams in the proton storage ring (PSR) at Los Alamos at the end of the running cycle in October, 1988. This paper describes how this was done and presents some examples of the time and frequency responses obtained.

Introduction

Signals from two types of BPM's were recorded. A BPM using a CERN design used electric pickup elements consisting of helical segments. Signals from the individual segments are amplified and combined to give beam position information. This system has a frequency bandwidth of about 30 MHz. The other type of BPM used stripline pickups, which have a bandwidth of about 800 MHz.[1] Signals from a pair of stripline pickups are fed to a 180-degree power combiner to yield beam position information.

The signals were converted from analog to digital form using a Tektronix RTD 710 Digitizer, and then were shipped using an IOtech MacSCSI488 controller to a Macintosh II computer for recording and processing. The RTD 710 has a maximum sampling rate of once every 5 nanoseconds, which corresponds to a maximum frequency bandwidth of 100 MHz. Other equipment allowed bandpass selection and down conversion in frequency to the zero to 75 MHz band, and a comb filter to suppress multiples of the PSR revolution frequency, as shown in Fig. 1. (In the revised version of the system being implemented in 1989, a MicroVAX-III computer and GPIB interface will be used in place of the Macintosh II and IOtech controller. The MicroVAX will be used for other instrumentation tasks as well.)

Time and Frequency Response

The low-frequency response of the CERN BPM for a stable beam (production conditions) when the comb filter was not used is shown in Fig. 2,

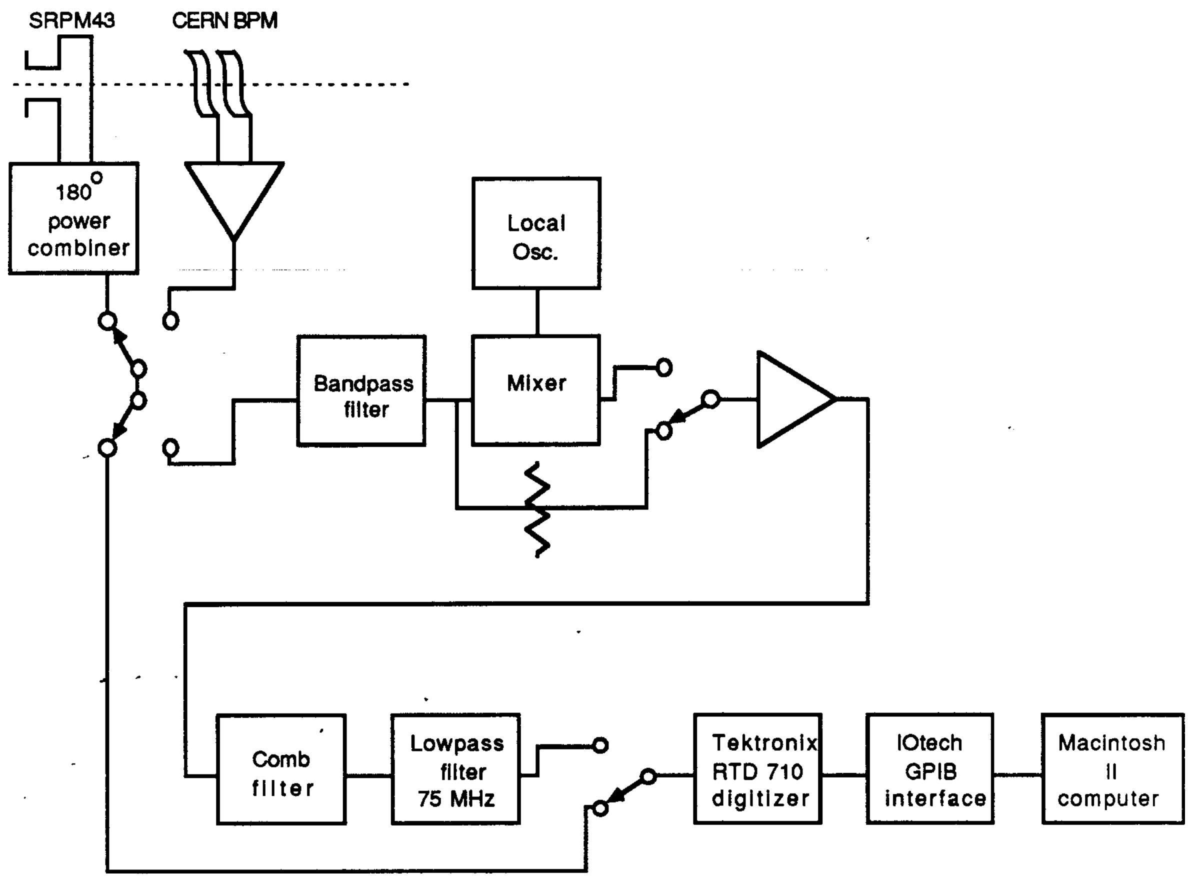

Fig. 1. Schematic diagram of equipment used to process and record BPM signals.

and the response with the comb filter is shown in Fig. 3. Only the PSR revolution frequency, 2.795 MHz, is prominent in Fig. 2, but in Fig. 3, betatron sidebands are clearly seen. The spacing of these sidebands indicates that the fractional tune for the ring was about 0.2.

The signal envelope for the vertical difference signal from a stripline pickup (SRPM43) is shown in Fig. 4. The time range shown, 327.7 μs, is the maximum that the RTD 710 digitizer can record when running at its fastest sample rate, one sample each 5 ns. The data are for the time period near the peak of the instability of an unstable beam, and following the peak. (Time zero on the plot is well after the start of injection of beam into the ring.)

The position signal for a short interval before the peak of the instability is shown in Fig. 5. The pattern is similar enough from turn to turn that one can distinguish three turns of the beam bunch in the 1.1 μs shown.

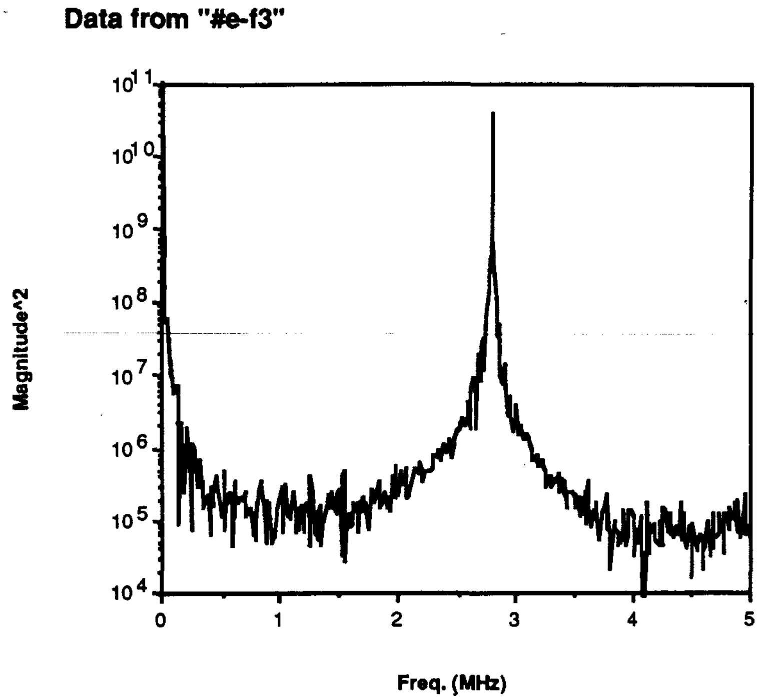

Fig. 2. Power spectrum for CERN BPM horizontal position signal with no comb filter for a stable beam. Vertical scale is in arbitrary units.

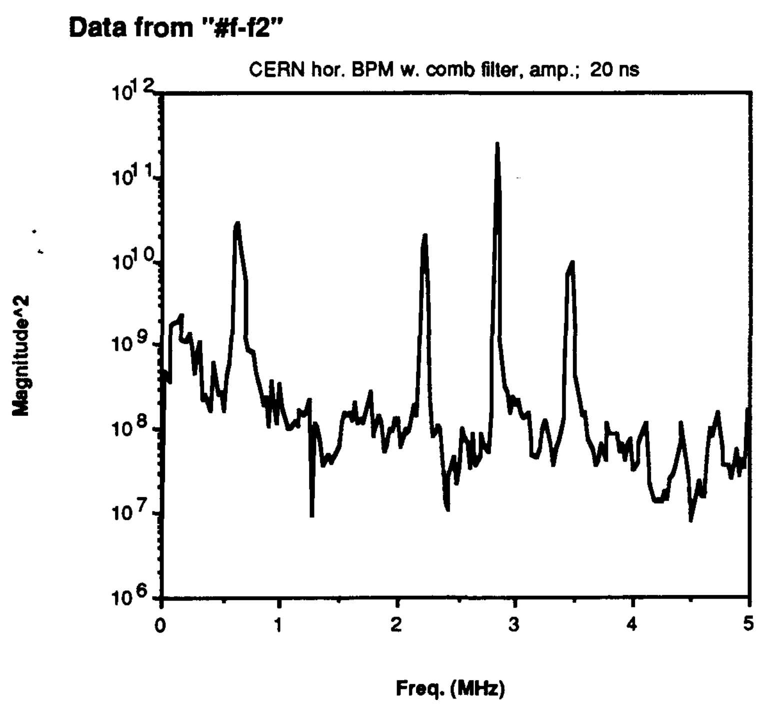

Fig. 3. Power spectrum for CERN BPM with comb filter for a stable beam.

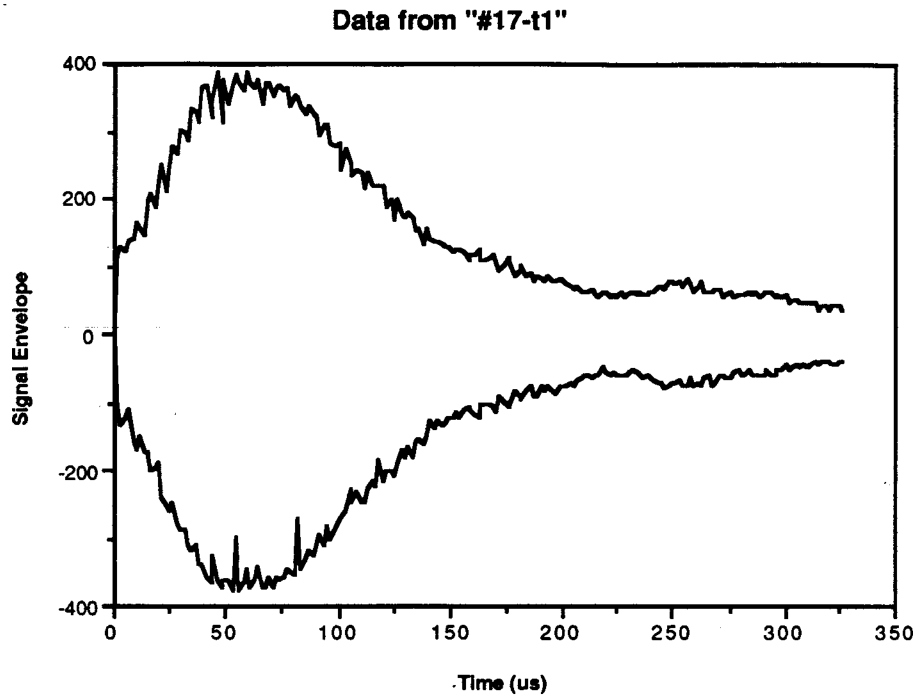

Fig. 4. Signal envelope vs time for stripline pickup SRPM43 vertical difference signal near and following the peak for an unstable beam.

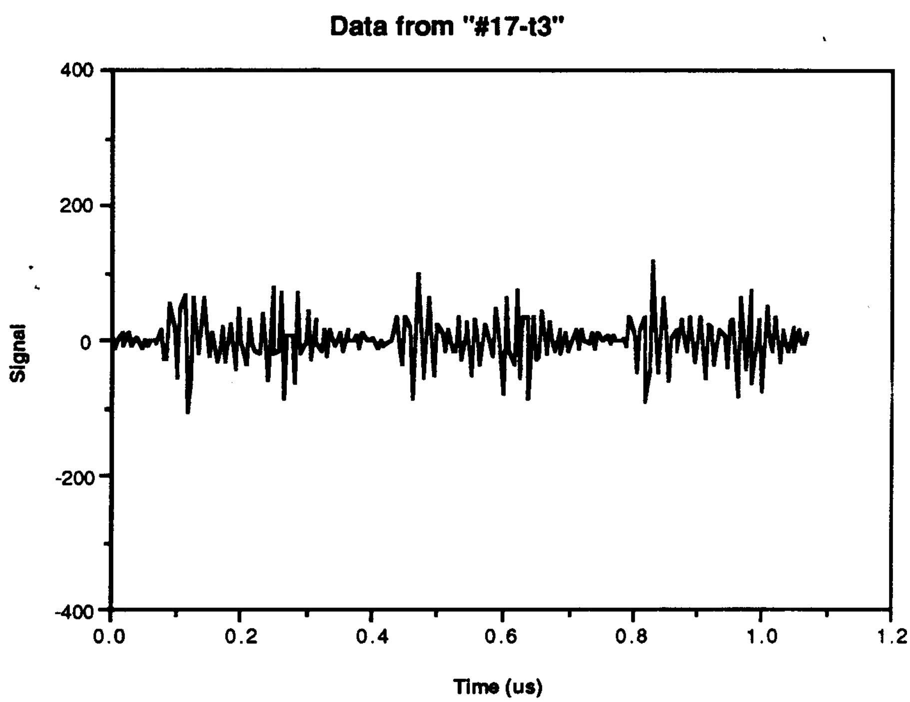

Fig. 5. Time signal for 1.2 microseconds, which is about 3 turns around the ring.

The frequency spectrum for the signal of Fig. 4 is shown in Fig. 6. The comb filter and a low-pass filter were used in the measurement. The comb filter may not have been set correctly for this measurement, as the harmonics of the revolution frequency seem less suppressed at high frequency than they do at low frequency. The cutoff of the low-pass filter can be seen at 80 MHz.

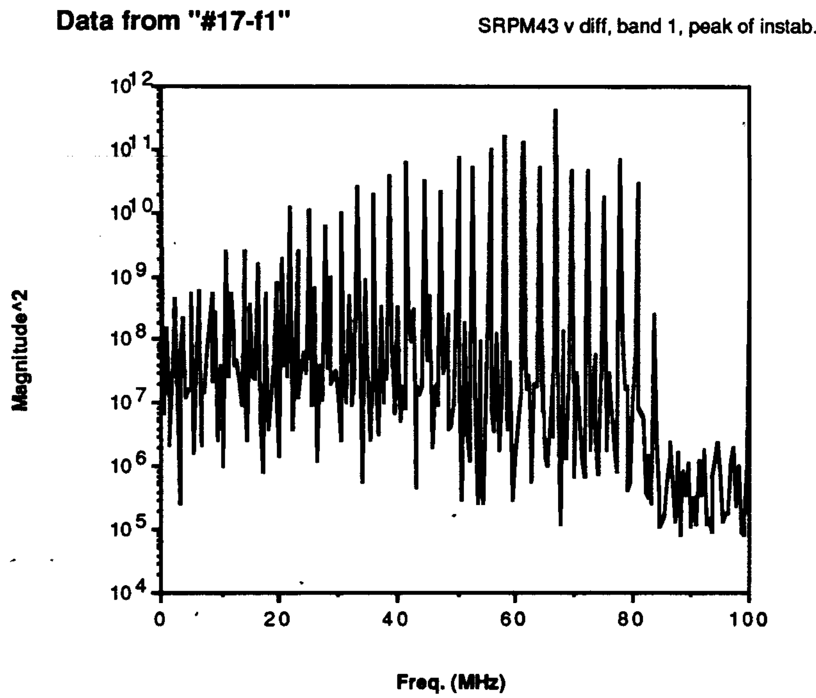

Fig. 6. Power spectrum for the signal shown in Fig. 4.

Data for two higher frequency bands were also measured (for different, but similar beam pulses). The results of combining the frequency spectra for these data are shown in Fig. 7. In addition to the lines at the harmonics of the revolution frequency, there is a prominent set of betatron lines interspersed with these near 160 MHz. The local oscillator was not set correctly for the higher bands, which meant that the harmonics of the revolution frequency did not fall on the notches of the comb filter. Hence some of the betatron lines near 160 MHz are quite strong. These betatron lines suggest that perhaps the instability is of the e-p type.

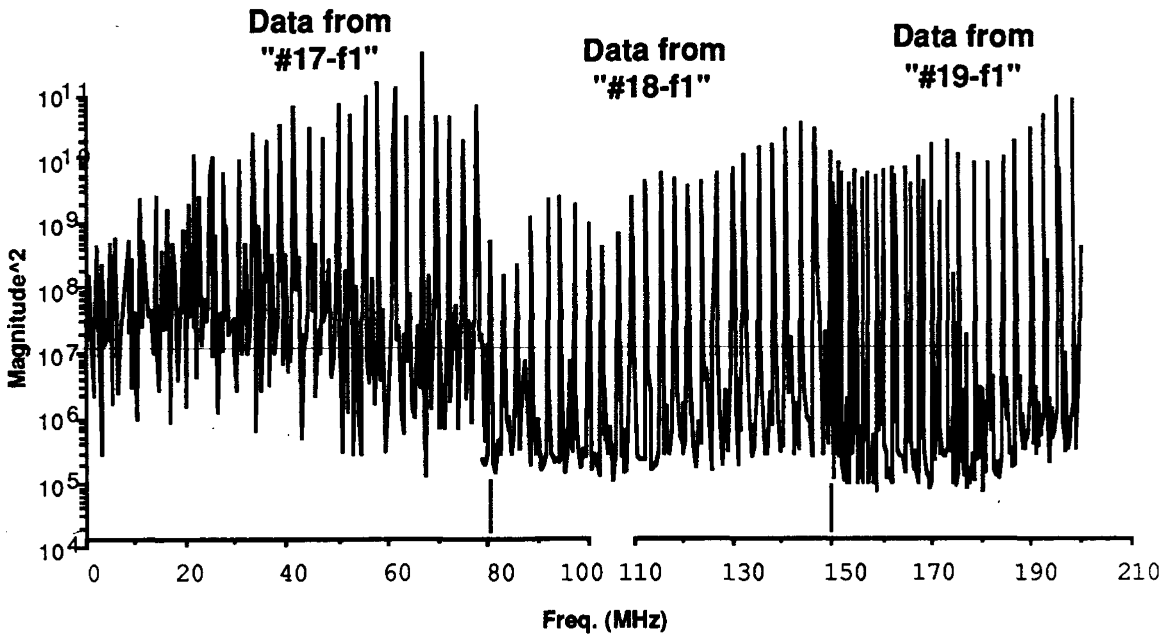

Fig. 7. Composite power spectrum made by combining the results for measurements for three frequency bands.

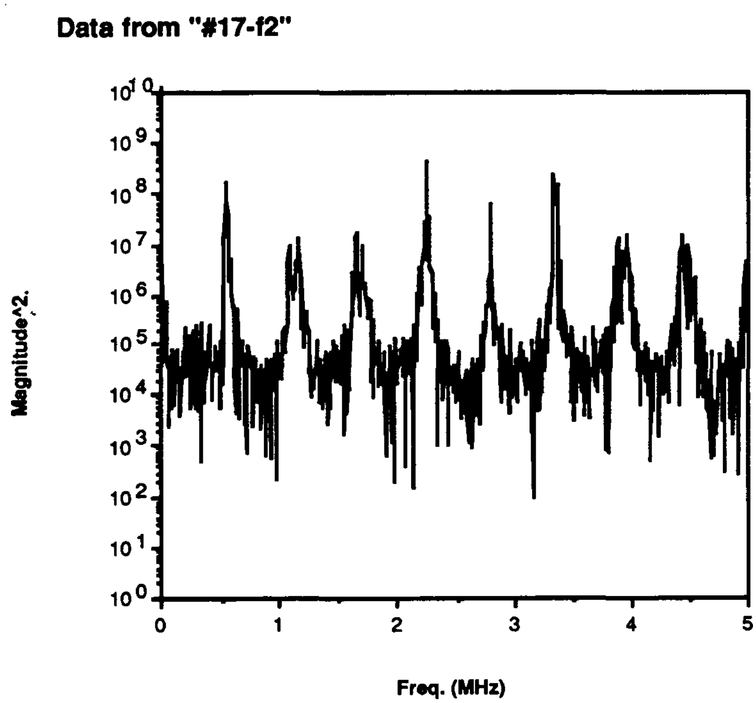

Fig. 8. Low-frequency segment of power spectra for the signal shown in Fig. 4 (unstable beam).

Examination of the portion of the frequency spectrum near the revolution frequency, 2.795 MHz (see Fig. 8), reveals not only betatron lines (indicating a fractional tune of about 0.2), but a set of quadrupole lines. (Compare Fig. 8 with Fig. 3.)

It was desired to see if the quadrupole lines grew in strength as the instability developed. The signal for the time region before the peak of the instability (obtained in a different measurement) is shown in Fig. 9. (Injection starts near time zero on this plot.)

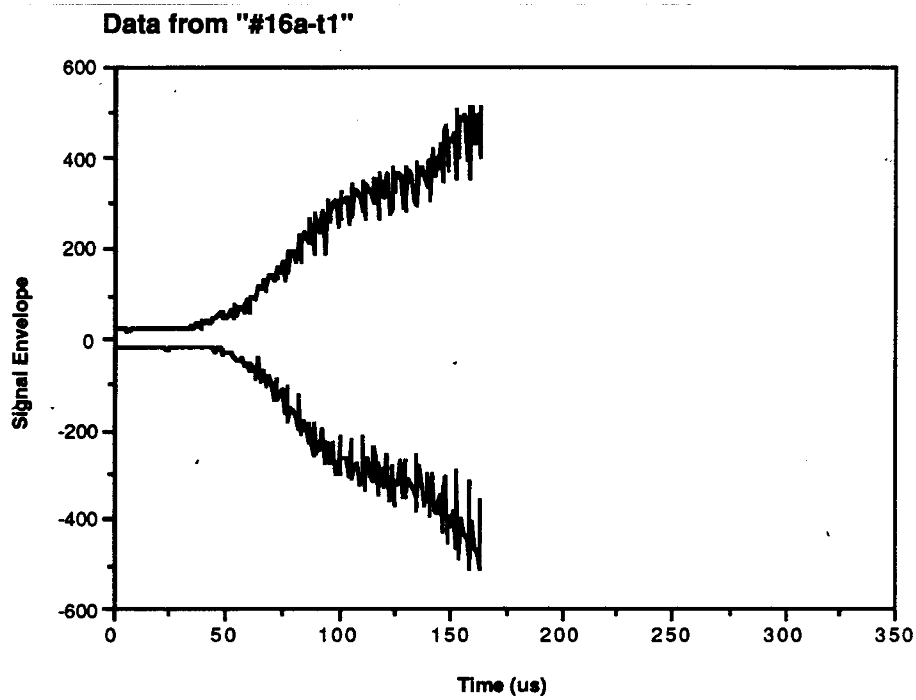

Fig. 9. Signal envelope before the peak for an unstable beam using SRPM43 vertical difference output.

The frequency spectra for different time ranges within the time range shown in Fig. 9 are plotted in Fig. 10. Only a peak at the revolution frequency is evident for the first interval. In the next interval, 50-90 μs, betatron lines appear, and in the last two intervals, there is at least the suggestion of quadrupole lines as well.

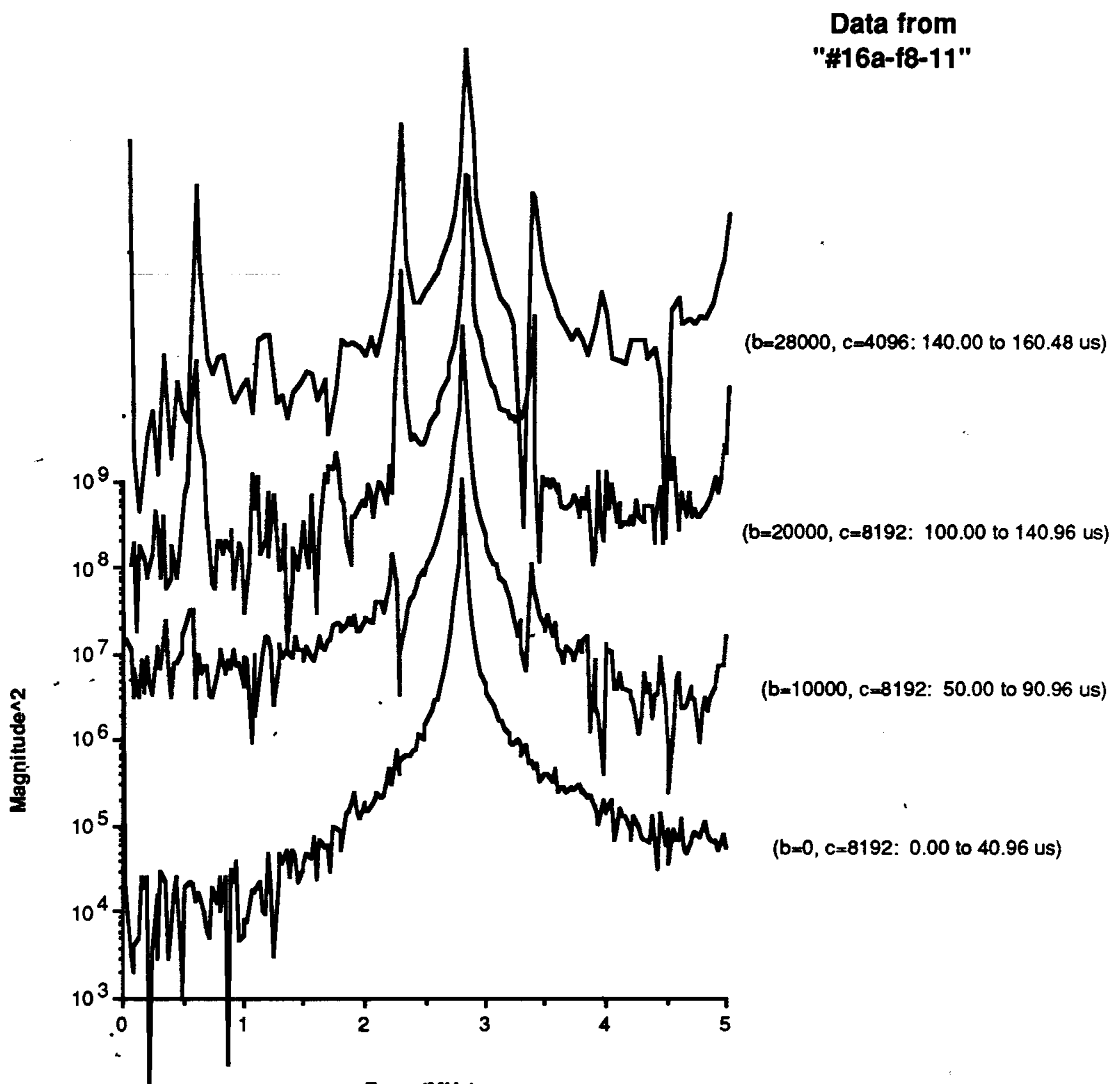

Fig. 10. A series of power spectra for different time intervals for the signal of an unstable beam shown in Fig. 9. The spectrum for the earliest time interval is at the bottom of the figure, and for the latest, at the top.

References

[1] R. E. Shafer, G. Swain, H. A. Thiessen, R. Macek, G. Mackenzie, and W. Rawnsley, "Beam Position Monitor Upgrade for the Los Alamos Proton Storage Ring," submitted for publication in the Proceedings of the 1989 Particle Accelerator Conference, Chicago IL, March 20-23, 1989. (Los Alamos National Laboratory preprint LA-UR-89-1406.)