BNL-104086-2014-TECH

AGS.SN210;BNL-104086-2014-IR

RFQ Repetition Rate

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July 1986

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U.S. Department of Energy

USDOE Office of Science (SC)

DISCLAIMER

7/30/86

Number 210

AGS Studies Report

Date(s) 7/17/86 Time(s) ------

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Subject RFQ Repetition Rate

Observations and Conclusion

Introduction

In the past, the RFQ has been operated at the AGS duty cycle only. Since future operation with the booster will require a higher duty cycle, we carried out a study to determine the feasibility of operating the RFQ at an average power compatible with using the booster as an accumulator of polarized protons.

The difficulty which accompanies higher average power operation is the variation of cavity eigenfrequency caused by differential expansion of the internal components compared to the cylindrical body. Only the body is water cooled, so heat dissipated in the vanes must be conducted to the body via flexible contact strips. The temperature gradient which drives this conduction causes the vane tips to move in a complicated way. The vane-tip gap actually closes at the center of the cavity and opens at the ends. In addition, since a relatively low average power and large thermal mass are involved, the time to reach thermal equilibrium is quite long (several hours).

Measurement

A stable rf signal generator (HP-8640) was used to drive the power amplifier chain that excites the RFQ. A phase detector circuit was installed to monitor the cavity phase compared to the phase of the rf drive. On resonance, this phase difference is zero and this signal was used to indicate the resonance frequency. Operating at 5 Hz repetition rate and 700 μs pulse length (0.35% duty factor, 420 W CW power), the generator frequency was manually adjusted at approximately 5 minute intervals, producing the data shown in Figure 1. These data were taken with the three variable tuners at their high frequency extreme and the cooling water temperature regulated to 75 ± 0.1°F. The tuners were then pulled out to the low frequency limit, yielding a frequency swing of 122 kHz. The effect of an individual tuner was determined by holding two tuners fixed and running the third to the high frequency limit. Figure 2 shows frequency versus tuner position.

Discussion

We have determined that the final frequency at 420 W of dissipated power and tuners at mid-range is 201.102 MHz. This is 148 kHz below the Linac frequency. With the variable tuners at maximum frequency, this is still 87 kHz too low.

Some adjustment must be made to the cavity to bring the frequency into the operating range. It is possible to add some small fixed tuners through the various access holes in cavity walls, but each of these can add only a few kilohertz, so this approach is not practical.

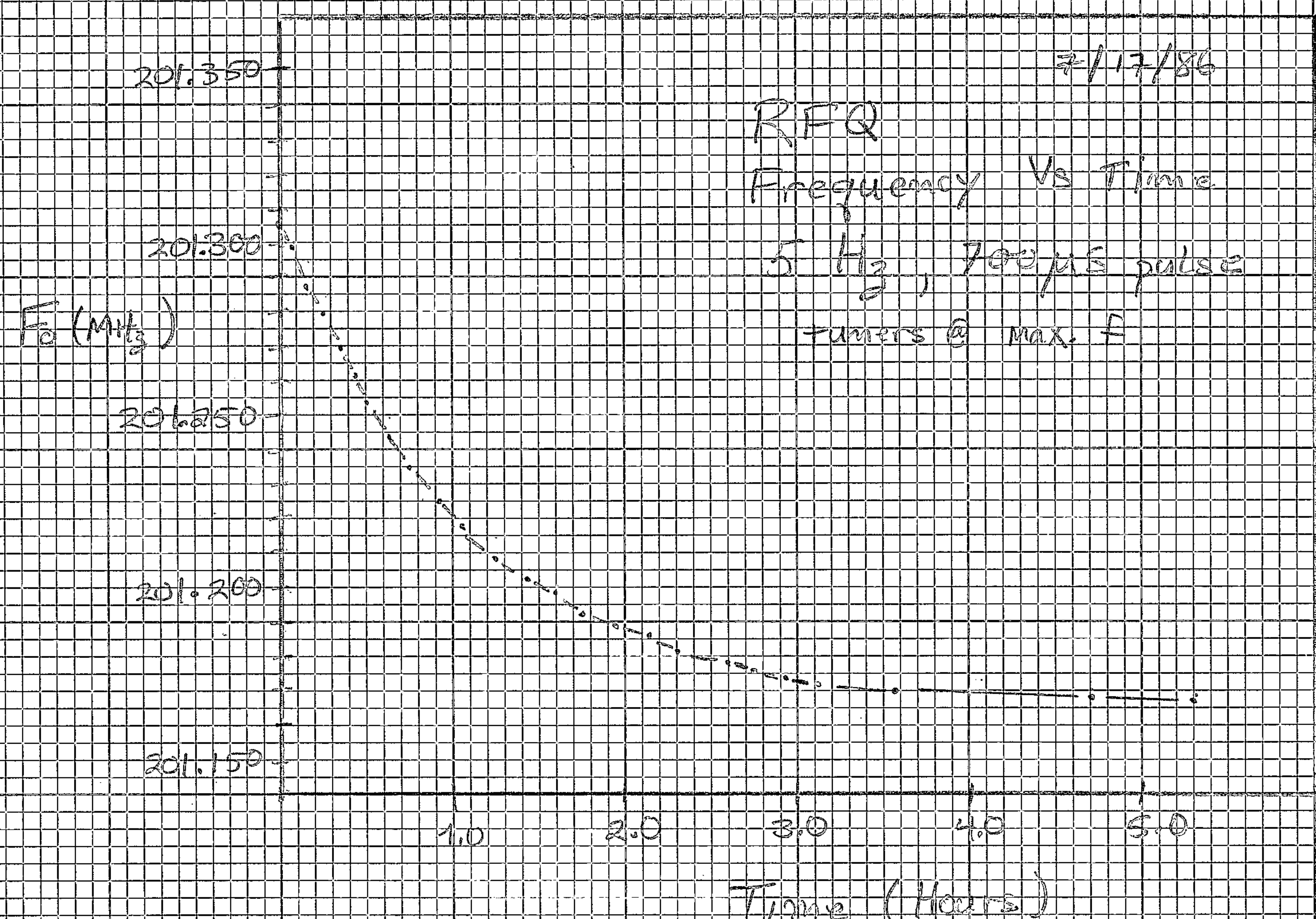
The only other alternative is to adjust the end-cell capacitors which are internal to the cavity. These capacitors serve the dual purpose of determining the frequency of the RFQ and also balancing the fields in the four quadrants. This is not the type of adjustment that should be attempted on-line. Although straightforward, it requires disassembly of the cavity and set up of instrumentation to map the fields. The appropriate time to do this adjustment is when the RFQ is moved to the off-line test stand for high current experiments.

Conclusion

The resonance frequency of the RFQ at a dissipated power level commensurate with 10 Hz repetition rate has been measured and found to be out of range for use with the 200 MeV Linac. A straightforward internal adjustment will be made when the RFQ is moved off-line to bring the frequency into range. The limited range of the variable tuners, however, implies that all future operation must be done at 10 Hz repetition rate, even if not all cycles are filled with beam.

mvh

Figure 1.


7/17/86
RFQ
Frequency Vs Time
5 Hz, 700 μS pulse
tuners @ max. F
Fo (MHz)
201.350
201.300
201.250
201.200
201.150
1.0
2.0
3.0
4.0
5.0
Time (Hours)

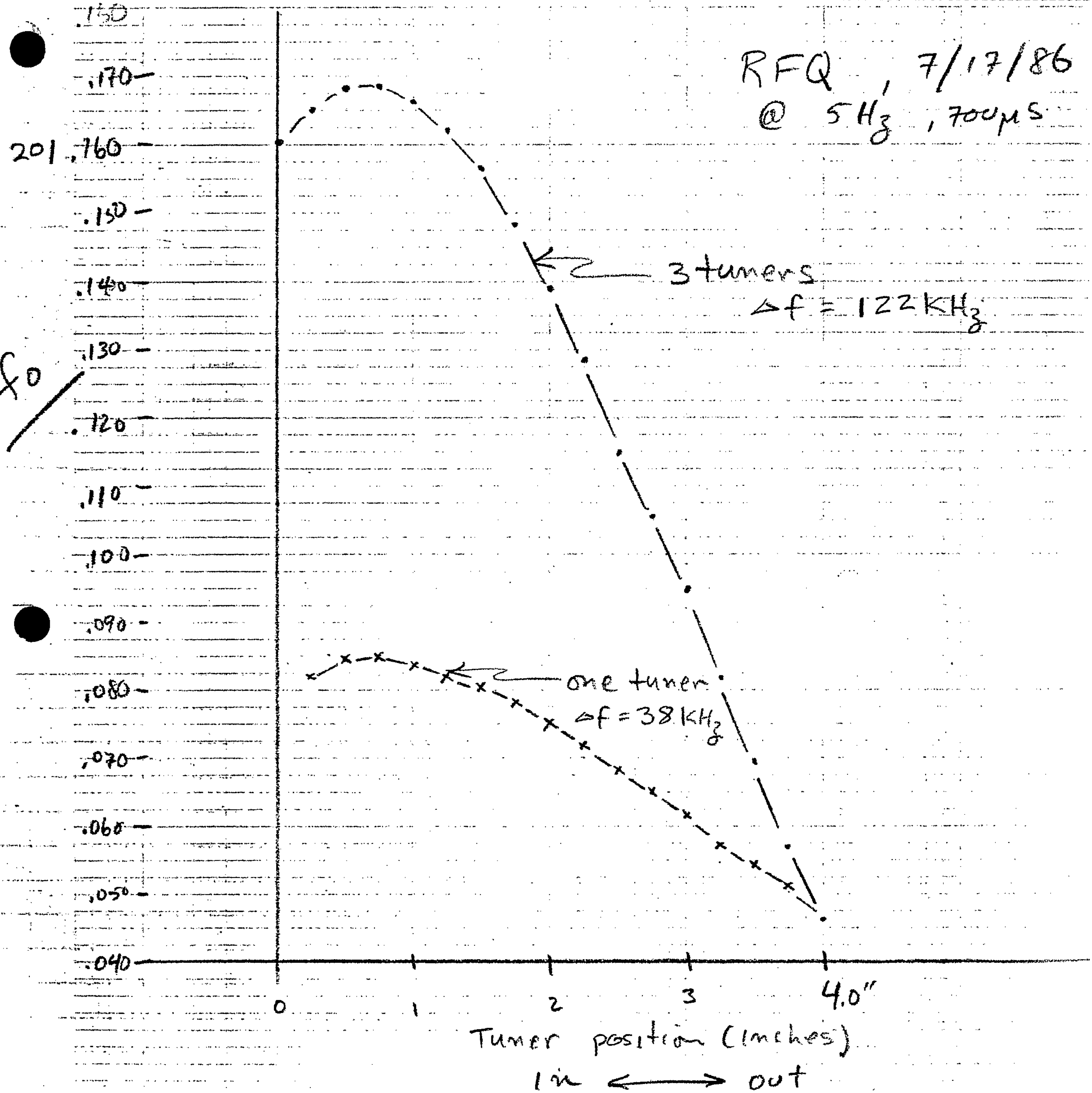

RFQ, 7/17/86
@ 5 Hz, 700μs
3 tuners
Δf = 122 KHz
one tuner
Δf = 38 KHz
fo
201.760
.180
.170
.150
.140
.130
.120
.110
.100
.090
.080
.070
.060
.050
.040
0
1
2
3
4.0"
Tuner position (inches)
in ⟷ out

Figure 2.