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Temperature Effects of RF Cavity Tuning

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AGS Studies Report

Date: 1 August 1984 Time 1300-1900

Experimenters: W. Frey and J. Woods

Reported by: W. Frey

Subject: Temperature Effects on rf Cavity Tuning.

Observation and Conclusion

There is an apparent short term; 10 to 50 ms, effect on tuning of the rf cavities depending on the initial temperature of the cavity. A CERN paper* indicates that this effect has been noted before, plus additional rf voltage and bias current effects. As a side experiment, a cathode current video amplifier was installed to monitor power amplifier cathode current. This monitor will provide a better indication of proper main-tuning-current/cavity match.

Method and Test Setup

The rf system was run on synthetic sweep. However, since the system had to be available for HEP following the study, there was no attempt to optimize the main tuning servo (MTS) to the synthetic sweep. The synthetic sweep follows the frequency program of the actual beam conditions fairly well, but not exactly. The cavity peak gap volts were held at 3 kV during the entire study. The cavity water temperature, at the input to the cavities, was 78°F ± 2°F. The vernier tuning servo (VTS) current was monitored as an indicator of cavity tuning error from the MTS current. The MTS is driven by the same synthetic sweep as the power amplifiers. While monitoring the VTS current, the temperature of the cavity cooling water was changed. The water temperature was first dropped to 60 ± 2°F, then raised to 82 ± 2°F. Scope photographs were taken of the VTS current of each of the ten power amplifiers at normal, cold, and hot temperatures. Figure 1 illustrates typical vernier currents.

As can be seen by comparing the traces in Figure 1a (82°F) with figures 1b (78°F-normal) and 1c (60°F) the shape and amplitude deviates for the first 60-80 ms (sweep started 100 ms after t_o) after rf drive. The cavity gap volts remained constant at 3 kV during the changes in temperature. The quiesant values of current between pulses and at rf flat top (≈ 4.45 mHz) are unchanged as the temperature is varied.

A video current amplifier was used to monitor power amplifier cathode current during this temperature run. Figure 2a through c illustrate the

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*"The RF Accelerating System for the CERN PS booster", Biglini, et al, IEEE Transactions on Nuclear Science, 3, June 1971.

cathode current as cavity water temperature of 82°F, 78°F, and 60°F respectively. Since the MTS current did not match the synthetic sweep exactly, the tune error results in large current swings due to cavity/cable/ output impedance mismatches. The cavity gap volts were normal, i.e. 3 kV, across the frequency swing and the VTS current was normal, while the cathode current was spiking. This current monitor apparently provides a better indication of MTS current match than either the gap volts or VTS current. When the rf system was returned to HEP operation, the cathode current matched the shape of the gap volts (MTS current matching the frequency sweep). Also note that the shape of the current varies with temperature.

Comment

The cavity cooling system was originally designed to operate at 65°F. However excessive "sweating" of the pipes and cavities during hot, humid weather resulted in the water temperature to be raised to the present 78°F. The only heat input to the cavity cooling water system is the cavity dissipation. During the winter months the ambient temperature will drop and therefore the cavity cooling water temperature will drop. At present there is no provision for raising the temperature of the cavity water. The cavity water temperature will always start at ambient temperature and will increase in temperature until the 78°F where the chillers will cut in and hold at 78 ± 2°F maximum. Thus, this cavity water temperature will cause tuning changes as ambient temperature and duty cycle changes.

Cathode current amplifiers will be installed in all the power amplifiers during the shutdown.

Further studies, with better instrumentation and controls should be planned for the fall/winter run to take quantitive data on the thermal effects on cavity tune.

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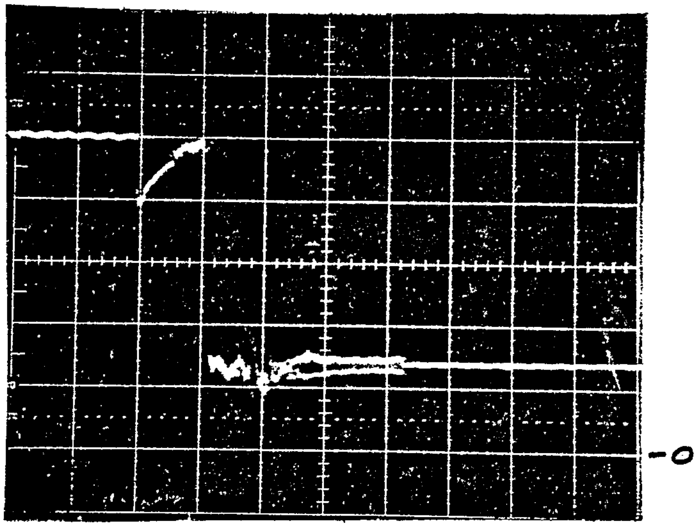
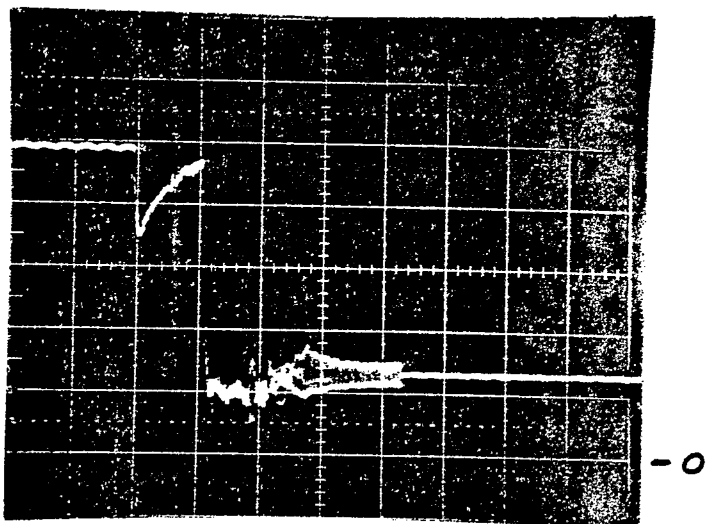
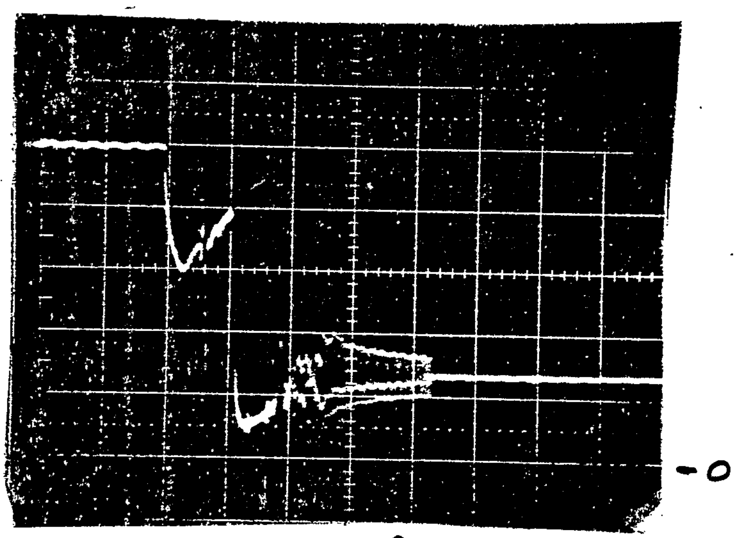
FIGURE 1



(a) 82°F



(b) 78°F



(c) 60°F

STATION BC

$V_{GAP} = 3KV$

LEVEL 3 = 350

$t_0 + 1$

VERT = 20 A/DIV

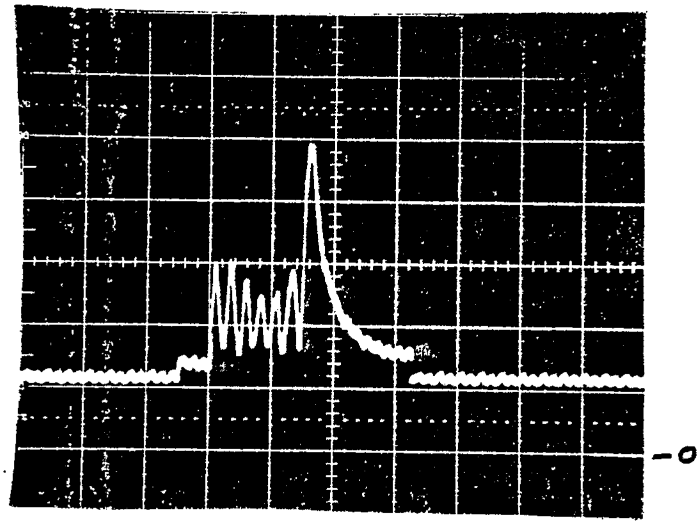
HORIZ = 50 ms/DIV

FIGURE 2

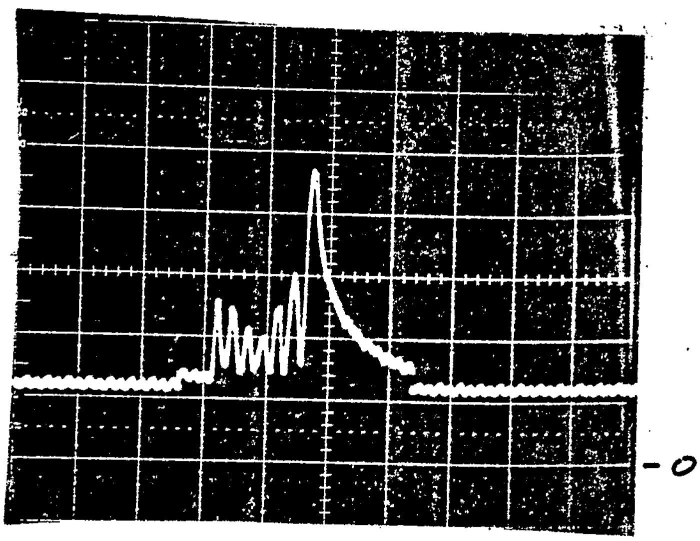
STATION KL

i_{CATH} LEFT TUBE

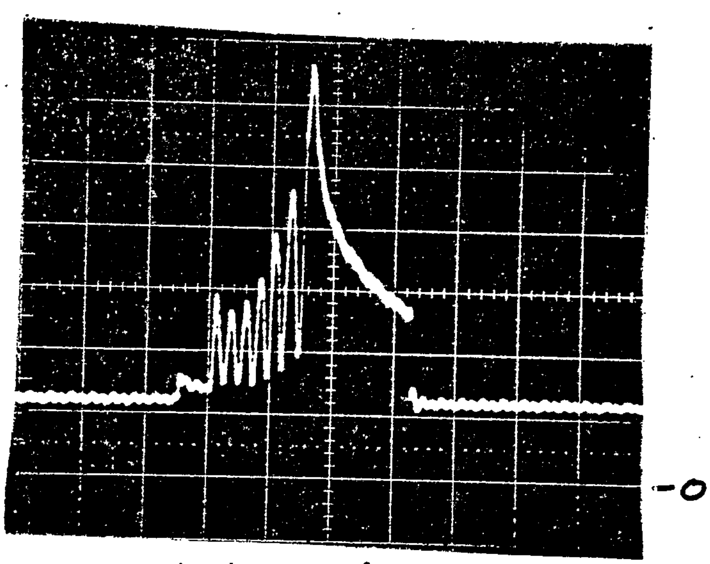
VERT = 2A/DIV
HORIZ = 100 mS/DIV



(a) 82°F



(b) 78°F



(c) 60°F