106 MHZ CAVITY FOR IMPROVING COALESCING EFFICIENCY IN THE FERMILAB MAIN RING

J. Dey, I. Kourbanis, D. Wildman, Fermi National Accelerator Laboratory*, P.O Box 500, Batavia, IL. 60510, USA

Abstract

In Fermilab's Main Ring a fast coalescing scheme called "Snap" coalescing[1] has replaced the slower adiabatic coalescing. In Snap coalescing the adiabatic voltage reduction to reduce the dp/p of the bunch has been replaced with a quarter of a synchrotron period rotation in a 53-MHz bucket. A 106 MHz second harmonic cavity has been constructed to help linearize the 53 MHz rotation and reduced the minimum achievable dp/p. The effect of the second harmonic cavity on the 53 MHz rotation and the coalescing efficiency will be described.

I. ESME[2] SIMULATIONS

A series of ESME simulations were done to determine the effect of a second harmonic voltage during the 53 MHz rotation in Snap coalescing. We started with a 0.25 eV-sec bunch matched to a 1 MV, 53 MHz bucket. Then we snapped the voltage down to 60 KV (such that the bucket height equaled the bunch height). Then the bunch was left to rotate for a quarter of a syncrotron period first without a second harmonic and second with different percentages of a second harmonic.

From the simulations we found that a small percentage (20-25%) of a second harmonic was clearly beneficial in reducing the minimum dp/p achieved in the rotation, not only because the second harmonic helped linearize the voltage waveform and eliminated most of the tails, but mainly because the addition of the second harmonic reduced the slope of the voltage i.e. the effective syncrotron period of the small amplitude particles.

In Fig. 1 ESME phase space and θ projection pictures of the 0.25 eV-sec bunch at the end of the 53 MHz rotation without any second harmonic are shown. In Fig. 2 the same ESME pictures are shown but now a 20% second harmonic has been added. The effect of the second harmonic is to more evenly distribute particles towards the edges of the bucket, reducing the tails and the dp/p at the center of the distribution.

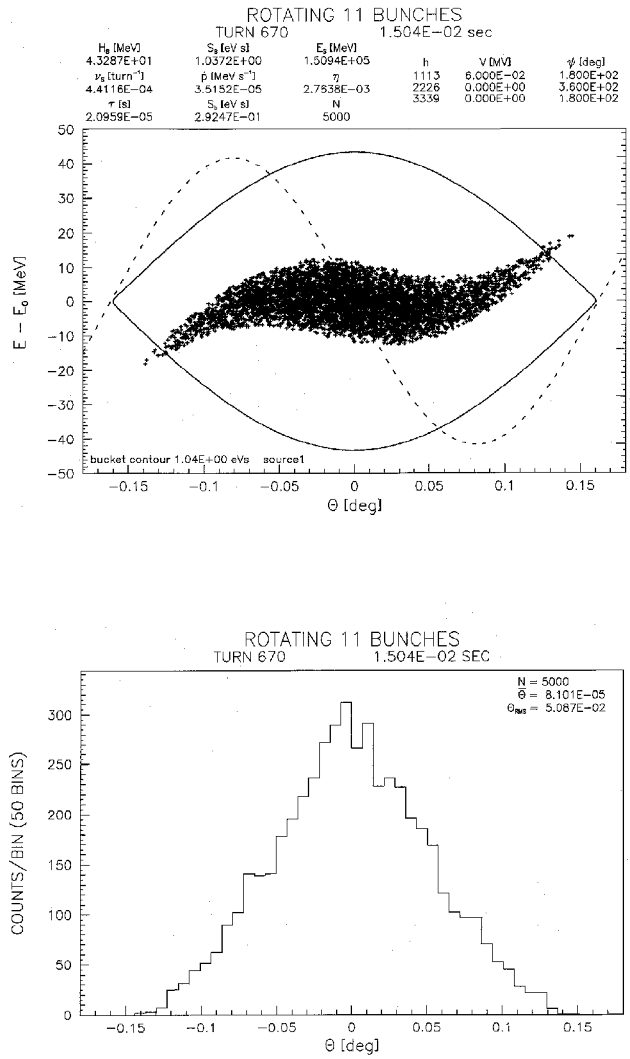

Figure 1: ESME pictures of a 0.25 eV-sec bunch rotated for a quarter of a period in a 53 MHz bucket without second harmonic. Top: Phase space picture. Bottom: θ projection

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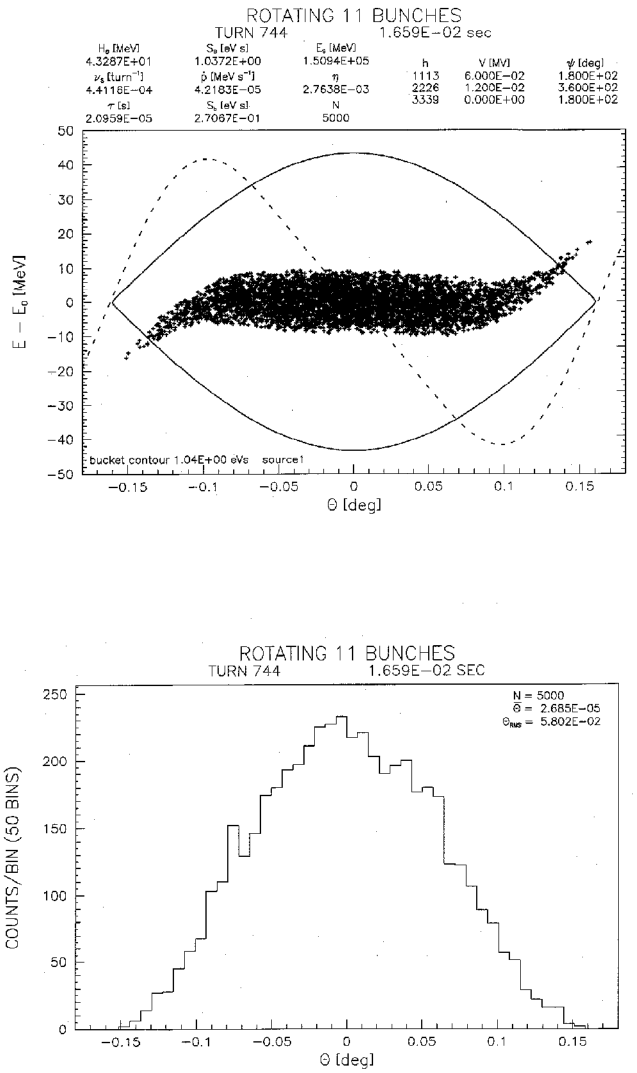

Figure 2: ESME pictures of a 0.25 eV-sec bunch rotated for a quarter of a period in a 53 MHz bucket with 20% second harmonic. Top: Phase space picture. Bottom: θ projection.

II. THE 106 MHZ CAVITY

The second harmonic cavity is a quarter of a wavelength type with a fixed frequency of 106.2 MHz made out of OFHC copper. The physical dimensions of the cavity are shown in Fig. 3.

The design of the cavity minimizes the transient beam loading by having an R/Q=9, ten times smaller than the R/Q of the regular 53 MHz cavities. The shunt impedance of the cavity is $R_S = 45K\Omega$, and it is powered by a 5 KW solid state amplifier for a variable voltage of 0-15 KV. The cavity has a Q of 5100, corresponding to a bandwidth Δf of 21 KHz. To keep the temperature of the cavity constant the cavity is water cooled with 95^o water.

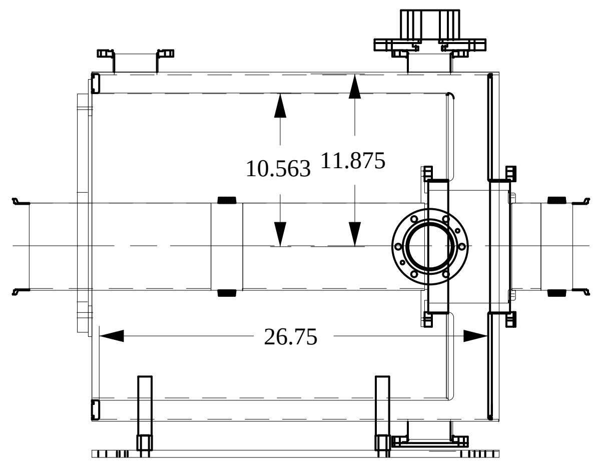

Figure 3: Schematic of the second harmonic cavity.

III. EXPERIMENTAL RESULTS

A picture of a bunch obtained with an HP-54720A 8 Gs/sec scope at the end of the 53 MHz rotation with the 106 MHz cavity off andwith 20% second harmonic is shown in Fig. 4. The beam profiles agree with the simulations. The rms. spread of the beam profile with 20% second harmonic is 15% larger than the rms. spread of the beam profile without second harmonic.

Since in coalescing the phase spread is turned into momentum spread and vice versa, the bunches rotated first with 20% second harmonic had a narrower phase spread at the end of coalescing by 25%, indicating that the dp/p at the rotation with a second harmonic was 25% smaller than the dp/p achieved without a second harmonic.

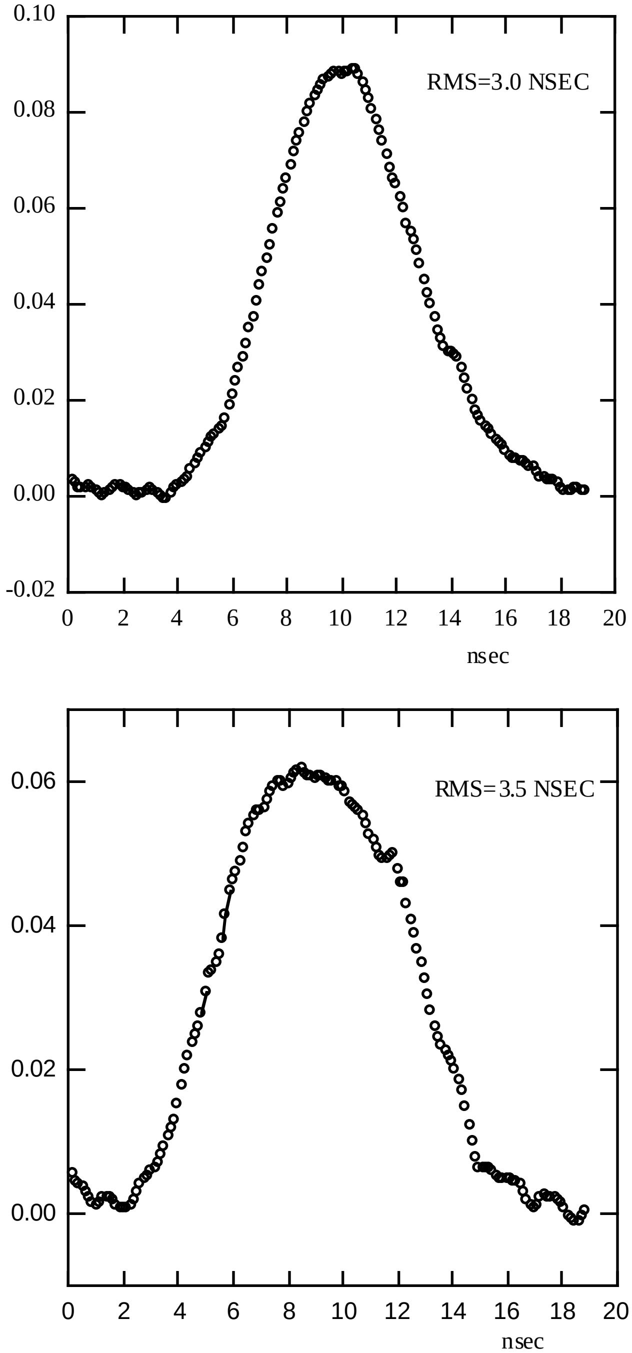

Figure 4: Beam profiles at the end of the 53 MHz rotation. Top: No second harmonic. Bottom: With 20% second harmonic.

IV. CONCLUSION

A second harmonic (106 MHz) cavity has helped us to reduce the minimum dp/p achieved during the 53 MHz rotation in Snap coalescing by 25% and increase the Snap coalescing efficiency by 10%.

VI. REFERENCES

[1] "Performance and Comparison of Different Coalescing Schemes Used in the Fermilab Main Ring", I. Kourbanis, G.P. Jackson, and X. Lu. Proc. of the 1993 Particle Accelerator Conf. 3799 (1993).

[2] "Users Guide to ESME v. 7.1", S. Stahl and J. MacLachlan, Fermilab internal note TM-1650 (2/90).