RF REQUIREMENTS FOR A 3 TEV COLLIDER RING

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The purpose of this note is to investigate the possibility of using the existing Tevatron rf system in a large collider ring with injection momentum of 150 GeV/c and final momentum of 3 TeV/c. We are making the assumption that we will need to accelerate 860 proton bunches with 3×10^{11} ppb and 860 pbar bunches with 0.8E11 ppb. The bunch spacing is considered to be 132 nsec or 7 53 MHz bunches for a harmonic number of 6020. The collider ring is assumed to have a gamma-t of 35 and a radius R=5408.8 m resulting to a revolution frequency at injection of 8821.27 Hz.

TEV RF PARAMETERS

The Tev rf consists of a total of 8 cavities (4 for protons and 4 for pbars). A cavity consists of two quarter-wave resonators placed back to back with a coaxial drift tube separating the two accelerating gaps by π radians. Each cavity has a Q of ~7100, a shunt impedance of 1.2 $M\Omega$ and is capable of running cw with a peak accelerating voltage of 360 KV (1.44 MV total from 4 cavities). The rf power is supplied to each cavity by a 200 KW amplifier via a 9-3/16 inch copper transmission line. Cathode drive to the final Eimac Y567B tetrode is provided by a 14 tetrode cascode section. The amplifier and associated equipment reside in an equipment gallery above the beam enclosure. The cavities tune from 53,104,045 Hz at 150 GeV/c to 53,105,048 using a temperature control water system.

VLHC RF REQUIREMENTS

The rf system must in addition to creating bucket area, provide accelerating voltage and deliver energy to the beam. Here we assume that the collider proton and pbar bunches are formed through some form of coalescing in the collider injector and because of that a bucket area of at least 2 eV-sec is required. The accelerating voltage and power depend on the details of the rate of acceleration. In the example considered we assume a modified parabolic ramp with a total acceleration time of 500 sec. The momentum vs. time for that ramp is shown in Figure 1.

The accelerating rf voltage ($V \times \sin \phi_s$) required for the modified parabolic ramp considered is shown in Figure 2. The maximum accelerating voltage or energy gain per turn of 970kV per turn per proton is 1.36×10^{-9} Joules per second per proton or 353 W for 2.58×10^{14} protons (860 bunches$\times 3 \times 10^{11}$ ppb). This is the peak power which must be delivered to the proton beam by the (TeV) rf system. This power is to be delivered by all four cavities, i.e. each cavity must deliver 88.25kW. Assuming that each cavity is running at its maximum voltage of 360kV another 50kW of power is dissipated in each cavity. The total power required per cavity is 138.25kW which is less than the 200kW available from the power amplifier.

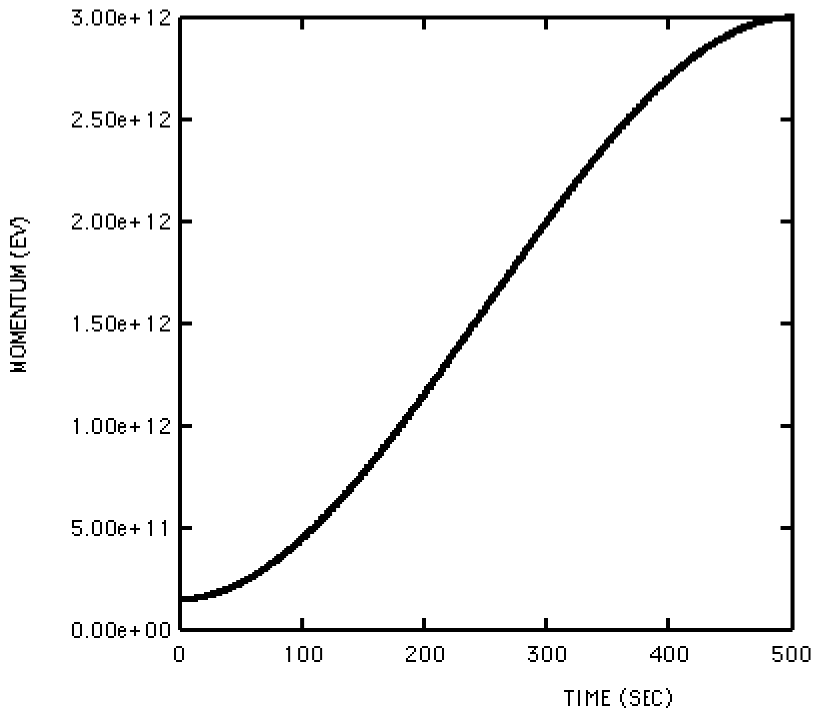

Figure 1: Momentum vs. time for the modified parabolic ramp.

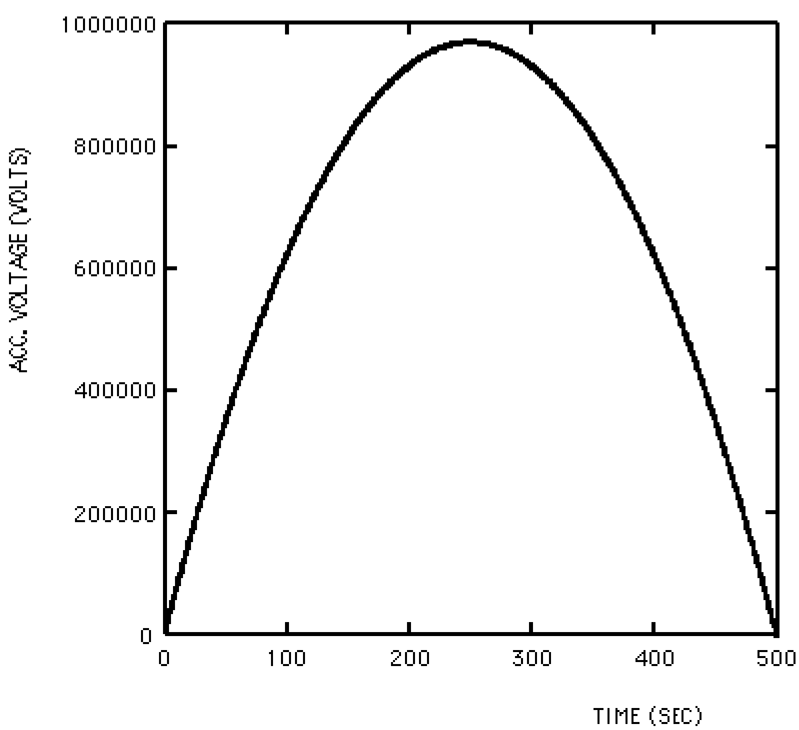

Figure 2: Accelerating voltage vs. time for the parabolic ramp.

Assuming a constant voltage of 1.44MV the bucket area available through the ramp is calculated. The results are plotted in Figure 3. As it can be seen from the figure the bucket area is always larger than the 2 eV-sec required. The synchronous phase angle ϕ_s is also calculated and is plotted in Figure 4.

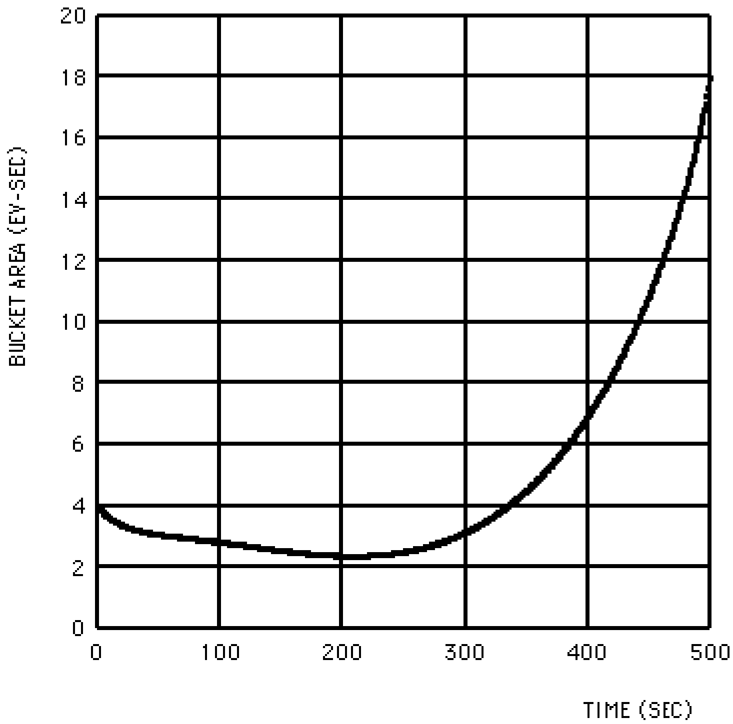

Figure 3: Bucket area vs. time for 1.44 MV rf voltage.

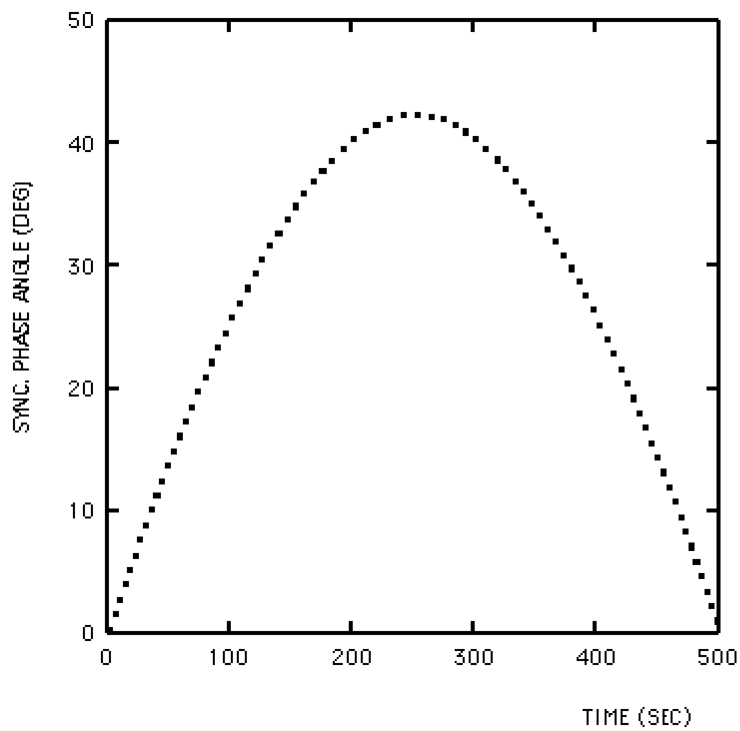

Figure 4: Synchronous phase angle ϕ_s vs. time for 1.44 MV rf voltage.

CONCLUSION

The TeV rf system can be used to accelerate up to 4.4×10^{14} protons (or pbars) in a 3 TeV collider with a 500 sec parabolic ramp, providing a bucket area larger than 2 eV-sec per bunch. Considering the fact that such a collider will be located very deep underground one might consider locating the cavities in a protective room in the tunnel itself. The replacement of the cascode drive section with a solid state amplifier will increase the reliability and will make that placement possible.