NLCTA-Note #61

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Subject: Phasing Calculations for Accelerator Sections with Same RF Source.

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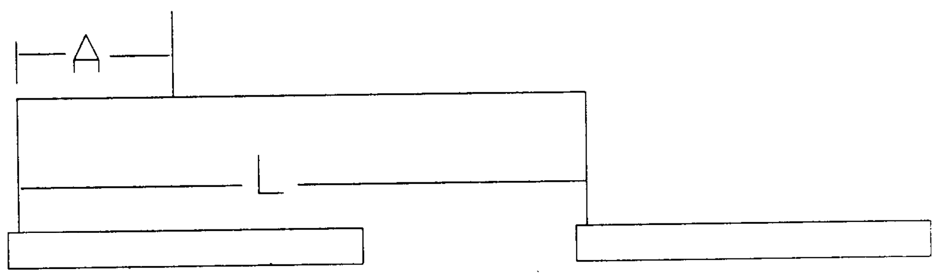
In the NLCTA, more than one accelerator section (two 0.9m injector sections and two or more regular accelerator sections) is fed by a single RF source. The RF phase for accelerator sections needs to be adjusted in order to optimize the energy spectrum and maximize the energy of acceleration. For the injector, two squeeze type phase shifters can make the phase of the second section adjustable within ± 60°. For regular accelerator sections, there will not be any phase adjustable element. Therefore, we have to carefully examine and design the phase length of the RF feed for each accelerator section.

Regular Accelerator Sections



L: distance between two input coupler centers.
A: distance between input coupler center and T center.

Considering the condition of synchronism and the phase change relative to the z-direction for two E-Bends, we can write the equation of RF wave traveling time:

$$\frac{A}{v_p} + \frac{L}{c} = \frac{L - A}{v_p} + nT \quad ,$$

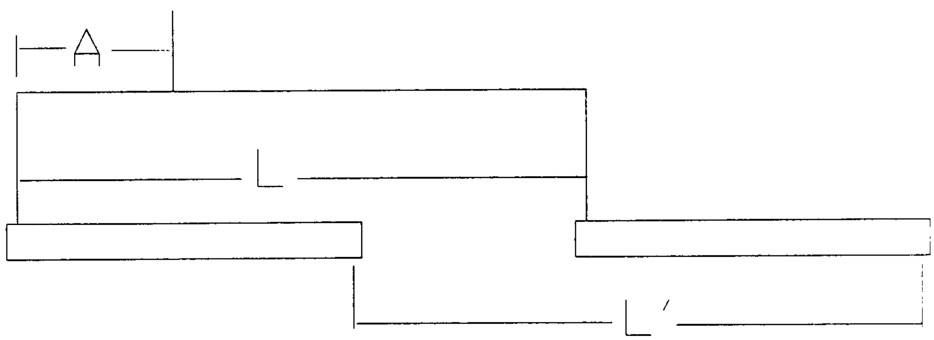
$$A = -\frac{L}{2}\left(\frac{v_p}{c} - 1\right) + n\frac{\lambda_g}{2} \quad ,$$

where υ_p=1.2206c is the phase velocity of the 11424 MHz wave in the WR90 waveguide, λ_g is the guide wave length, and T is RF period.

Based on the preliminary mechanical design, L = 99.182″ and A~ 16.2″. If we choose n=43, we obtain A=16.491″. So A in the mechanical design must be slightly modified to obtain the best phase relationship.

Injector Sections

For the injector, electrons are bunched and accelerated in a low-ß capture section, where they travel with a velocity less than the speed of light. Therefore, their phases change accordingly. To simplify the problem, let's use the condition of synchronism for both output couplers of the accelerator sections. Based on PARMELA simulations, the bunch centroid is located $\Delta\phi$ ahead of the RF crest for the output coupler of the first injector section and it is located approximately at the RF crest for the second injector section.



L: distance between two input coupler centers.
A: distance between input coupler center and T center.
L': distance between two output coupler centers.

We can write the equation for the RF wave traveling time:

$$\frac{A}{v_p} + \frac{(N-1)T}{3} + \frac{L'}{c} = \frac{L-A}{v_p} + \frac{(N-1)T}{3} + nT + (\frac{\Delta\phi}{360})\frac{T}{2} \quad ,$$

$$A = -\frac{L}{2}(\frac{v_p}{c} - 1) - \frac{(L'-L)v_p}{2c} + n\frac{\lambda_g}{2} + \frac{\Delta\phi\lambda_g}{720} \quad ,$$

where N=106 is the total number of cells. One cell is taken out by considering a standing wave in the first half of the input coupler and second half of the output injector.

Our design shows L=79.84", A=21.01" and $\Delta\phi$~7°. The value of L' - L can be calculated based on the lengths of the input coupler, first cell and second cell (ß=0.6, 0.7 and 0.9 respectively). If we choose n=47, the calculated distance A should be 21.01" plus a half guide wave length. This just happens to be out of phase by 180°! We have several ways of fixing the problem. One method is to adjust the positions of the two injector sections. Another method is to insert a spacer of appropriate length, either in the first or second section RF feed. For either solution we have to carefully consider the corrections based on the actual phase shift of each existing microwave component.