Abstract

Each ILC’s main linear accelerating cavity, superconducting cavity, is supplied with both fundamental and higher order mode couplers. The configuration of these rf couplers results in an asymmetrical field which gives rise to both an rf kick being applied to the beam and a transverse wake-field. These results can seriously dilute the emittance of the particles beams. Detailed circuit model represent the cavity excluded the couplers are shown in order to assess the loss parameters of cavity. Wake fields of cavity are simulated by using ECHO software benchmarking with ABCI software. The electromagnetic (e.m.) fields are simulated in the vicinity of the cavities in order to assess the impact on the beam dynamics.

Introduction

The ILC main lines consist of approximately 16,000 TESLA 9-cell design superconducting of cavities [1] as shown in Figure 1. A TESLA 9-cell cavity consists of 7 identical mid-cells and 2 tuning end cells. Here we present the initial framework in which we have developed a double chain circuit model for these cavities.

Wake Fields of Cavity by ECHO and ABCI

An ultra-relativistic charge particle beams excite wake fields, these wake fields may be decomposed into a short range (within the vicinity of the bunch) and a long range. Here we calculate the proximity or short range wake fields. We simulate wake fields on three different types of accelerating cavities: TESLA, ICHIRO, and RE-ENTRANT as shown in Figure 6. The comparison between ECHO 2D [4] and ABCI [5] results on the longitudinal loss factor ($k_z$) and the transverse loss factor ($k_x$) are shown in Table 1. There are consistent, less than 5%, difference between these two solvers.

Table 1: Comparison of loss factors between 2 solvers on 3 accelerating cavities.

<table>
<thead>
<tr>
<th>Cavity</th>
<th>$k_z$ (ECHO)</th>
<th>$k_z$ (ABCI)</th>
<th>$k_x$ (ECHO)</th>
<th>$k_x$ (ABCI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TESLA</td>
<td>0.1 mm</td>
<td>9.89</td>
<td>10.04</td>
<td>1.52</td>
</tr>
<tr>
<td></td>
<td>0.05 mm</td>
<td>18.36</td>
<td>18.52</td>
<td>0.87</td>
</tr>
<tr>
<td></td>
<td>0.05 mm</td>
<td>28.14</td>
<td>28.26</td>
<td>0.43</td>
</tr>
<tr>
<td>ICHIRO</td>
<td>0.1 mm</td>
<td>12.89</td>
<td>13.03</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>0.05 mm</td>
<td>21.17</td>
<td>21.30</td>
<td>0.61</td>
</tr>
</tbody>
</table>

Figure 2: Eigensystem matrix of a double chain circuit model.

$\alpha = 1$ mm  $\alpha = 0.7$ mm  $\alpha = 0.3$ mm

Figure 3: Comparison of the results obtained from the validation of the double chain circuit model with a 9-identical TESLA mid cell shapes structure.

Fields in Cavity with Fundamental mode coupler

The inclusion of couplers breaks the cavity symmetry and this affects the transverse fields in the vicinity of couplers. Here we present e.m. fields with the inclusion of the TTF-III type fundamental mode power coupler. The simulation were performed with CST MWS [6] using eigenmode solution. This TTF-III coupler is positioned 45 mm from the end cell and has 9 mm penetration. The simulation were performed with two different boundary conditions at the end of the coupler in order to construct travelling wave solution from two standing wave solutions [7] as illustrated in Figure 7. Figure 8 shows the fields along the cavity axis from two boundary conditions at the end of the coupler; electric short (PEC) and magnetic short (PMC). A sufficiently large mesh density is required to resolve the small perturbations for the fields in the vicinity of the coupler.

RF Coupler Kicks

We construct the travelling wave from two standing wave solutions as the equation below. The coupler kick, $k_c$, is defined as a ratio of the change in the transverse momentum to the change in the longitudinal momentum, [7].

$$k_c = \left( \frac{\Delta p_y}{\Delta \omega_z} \right) = \left( \frac{\Delta \omega_z}{\Delta p_y} \right)$$

The rf coupler kick is given by:

$$k_c = \left( \frac{\Delta p_y}{\Delta \omega_z} \right) = \left( \frac{\Delta \omega_z}{\Delta p_y} \right)$$

Figure 9: TTF-III power coupler a) cutaway view b) assembly unit.

In the simulations performed on the TTF-III type coupler as shown in Figure 9, the coupler was assumed to be perfectly matched, so the fields are purely incoming in this instance. The rf coupler kick factor is:

$$k_c = (19.74 + 91.03) \times 10^{-7}$$

Figure 10: E.M. fields along the cavity axis between 2 boundary conditions at the coupler end a) PEC b) PMC.

Discussion

The double chain circuit model provides a reasonable model of sc TESLA-like cavities. The kick factors and mode frequencies are well represented after suitable parameterizations. This model lends itself to the construction of a double chain circuit model with a 9-identical TESLA 9-cell structure without the couplers based on the circuit model of [2].

Acknowledgements

We have benefited from discussions at the weekly Manchester electromodynamics and wakefields meetings held at Cockcroft Institute, where these results were first presented. We would like to thank Dr. Igor Zagorodnov for providing permission to use ECHO 2D code.

References


CERN Accelerator School, CAS 2008, Frascati, Italy, 2nd-14th November 2008

*Nawin.Juntong@postgrad.manchester.ac.uk