international linear collider

Recommendation for Mitigations of the Electron Cloud Effect in the ILC Damping Ring

Working Group Scope Period: FY10 to FY12
On behalf of the Damping Ring Working Group:
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1. Introduction

Electron cloud has been identified as one of the highest priority issues for the ILC Damping Rings. A working group has been set up to evaluate the electron cloud effect and instability and evaluate mitigation solutions for the electron cloud formation.

Working group deliverables include recommendations for the baseline and alternate solutions for the electron cloud mitigation in various regions of the ILC Positron Damping Ring, which is presently assumed to be the 3.2km design. The preliminary mitigation recommendations for the ILC damping rings presented in this report are the result of the working group discussions held during a number of workshops and regular online meetings. The working group met at Cornell University on October 13, 2010, as a satellite meeting to the ECLOUD10 Workshop held on October 8-12. The workshop was devoted to hearing the results of detailed studies of a range of mitigation options that will be summarized in this report and presented in a more detailed report later in 2011. Input from the workshop participants was included in the evaluation.

The studies were carried out over the previous several years by nearly 50 researchers, and the results of the studies form the basis on which the recommendations for the damping rings mitigations have been made. This document represents the executive summary for the preliminary ILC damping rings electron cloud mitigation choices.

The assessments of the significance of the different issues associated with each mitigation item, and the benefits or risks associated with the various options for each item, were based on a systematic ranking scheme. We should emphasize that although our systematic approach allows a "score table" for the various options for each item to be drawn up, our recommendations were reached through structured discussion, and not by

simply adding up the benefit and risk scores for the different options. In addition, a number of items requiring further investigation were identified during the discussions at the Cornell meeting.

2. Drift Region Mitigation Recommendation

TiN is the recommended baseline mitigation for drift regions. TiN has good efficacy and the risks for its implementation are the lowest. Furthermore it has no significant impact on other aspects of the machine performance. NEG coating is recommended as the alternate mitigation since it has somewhat lower mitigation efficacy, but it also has the advantage of providing vacuum pumping in the long straight sections which can decrease the costs of distributed pumping. In addition, solenoids are recommended for inclusion in the baseline design as additional mitigation for the high beam current option ultimately desired for the 3.2km DR design.

3. Dipole Region Mitigation Recommendation

Grooves with TiN coating are the recommended baseline mitigation in the dipoles. In this region, we want to have the greatest possible protection against the electron cloud and grooves have very good efficacy. TiN coating is specified as the alternative mitigation choice. TiN offers good efficacy with reasonable cost, low risk and low impact on machine performance. Although clearing electrodes offer the best effectiveness, use of clearing electrodes in the large number of bend magnets in the damping ring has potentially significant impact on the machine impedance as well as an inherent risk associated with the large number of active components required. At present, these drawbacks make clearing electrodes less attractive for the design. Further R&D may change this assessment.

Our most recent simulations indicate that antechambers are required in the arc regions to minimize the number of photoelectrons produced in dipole fields. This is particularly the case for the high current option in the 3.2km ring design. Thus antechambers are included in the recommendation for the baseline mitigation design.

3. Wigglers Region Mitigation Recommendation

Clearing electrodes deposited *via* thermal spray on copper chambers is the recommended mitigation in the wiggler region. Clearing electrodes offer the best protection in the section that is most critical for electron cloud formation. The impedance and risk issues are less critical than in bends due to the smaller number of chambers involved. We accept these impacts in order to obtain the best efficacy in this region. Grooves with TiN coating are recommended as the alternative mitigation. In particular there are

concerns about the transverse impedance issues with the trajectory of the beam in this region as well as manufacturing challenges of very small grooves. In this case, the alternative option will need considerable additional investigation before it could be implemented.

Antechambers are required in the wiggler regions to remove synchrotron radiation power as well as to minimize the number of photoelectrons produced in wiggler fields. Thus antechambers are included in the recommendation for the baseline mitigation design.

4. Quadrupole Region Mitigation Recommendation

TiN coating is the recommended mitigation in quadrupoles since it offers good efficacy against electron cloud with low risks and low impact on the machine performance. There are concerns about long term build-up of electrons in the quadrupole field that would require extremely effective mitigation. This could be provided by clearing electrodes or grooves but more R&D will be required to validate either option.

5. Acceptable Electron Densities to Achieve the Design Emittance

A particular concern for meeting the emittance specifications of the damping ring is the possibility of emittance growth occurring at electron cloud densities below the threshold for the head-tail instability. Recent simulations and measurements suggest that this effect may be significant and are leading to a re-evaluation of the acceptable electron densities near the beam. While considerable work remains to precisely quantify this issue, initial results suggest that the acceptable cloud densities may need to be lowered by a factor of several. This further increases the need to employ the most effective mitigation techniques possible in each region of the ring.

6. Other Comments

It is important to note that several mitigation methods are under active study at present. For this recommendation, it was felt that coatings such as amorphous and diamond-like carbon, which do show significant promise, have not yet been tested sufficiently in a high synchrotron radiation environment to be included in the baseline or alternate recommendations. Furthermore, high efficacy techniques such as grooves and electrodes could be used more extensively based on the results of further investigation into their manufacture and potential impacts on machine operation.