DR Deliverable 3: Report on impact of wiggler dynamics on DR dynamic aperture

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Abstract

This paper describes the accomplishment of the 3rd deliverable of the Damping Ring (DR) Work Package.

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1. Introduction

The Deliverable of the WGLRDYN task of the EUROTeV work package WP3 – Damping Ring is the following: Report on impact of wiggler dynamics on DR dynamic aperture.

In February 2005, the "WIGGLE 2005 mini-workshop on wiggler optimisation for emittance tuning" was held at LNF. This workshop was very helpful to build tools for simulations and to review different wiggler magnet designs and technologies. In the same workshop, a comparison of wiggler models with beam measurements at DAΦNE (tune shift with amplitude, beam decoherence) was presented, as well as wiggler modelling and modifications performed on the eight wigglers installed in DAΦNE [1, 2, 3].
The 1st EUROTeV Scientific Meeting was held at RHUL, UK, from 20 to 23 June 2005, For the Damping Ring the objective of this meeting was to detail the scope and planning of the Work Package [4], in order to coordinate the EUROTeV activity with the international collaboration for the ILC. A summary of the WIGGLE05 workshop was presented at this meeting [5].

After the meeting the international scenario changed with the 2nd ILC Workshop at Snowmass and the formation of the Global Design Effort (GDE) (August 2005). At the Snowmass GDE meeting, each working group made a recommendation for the ILC Baseline Configuration (BC) to be used for the reference design and cost estimate. For the damping rings the choice of layout (dog-bone, circular or racetrack ring) and circumference (17, 6 or 3 km) needed a lot of work to evaluate the pros and cons of the many issues [6]. Task forces have been charged to study the key issues, one was dedicated to the acceptance issue with the following objectives: determine dynamic aperture and injection efficiency of the seven proposed lattices including linear and nonlinear wiggler effects. A meeting was held at CERN in November in order to finalise the BC recommendation. The EUROTeV participants were actively involved in this process.

After the BC recommendation, the Damping Ring WP3 needs a redefinition of the detailed plan with respect to the report of the RHUL workshop, in order to focus on the R&D activity that is considered first priority by the GDE. Three of the WP3 tasks, ECLOUD, LETS and RFSEP focus on critical issues concerning the recommendations for the ILC DR baseline. In particular, the ECLOUD task is centred on a critical issue that requires the most R&D to assure adequate performances, and the RFSEP task is focused on fast kickers, considered a very high priority. The WGLRDYN activity has lower priority and therefore within WP3 more resources have been dedicated to the other three tasks.

The work done for the BC recommendation is described in a Document [7]. The effect of the wiggler on the DR DA has been studied in a very exhaustive way by different investigators at the global level. They used different models and codes that were in good agreement between them. The Dynamic Aperture for the seven different lattices considered was calculated on and off energy, with and without errors, and the study was supported by frequency map analysis.
A specific study of the wiggler aperture needed for the required injection efficiency was also performed. The comparison was done for different wiggler models: and ideal wiggler with infinitely large poles, the CESR type superconducting wiggler [8] and the TESLA TDR permanent magnet wiggler [9].
The modified CESR-c wiggler model is sufficiently close to the ideal nonlinear wiggler model that, for the lattices tracked using both models, there are no significant differences in the results. The CESR type wiggler has been recommended as baseline since the requirements

for field quality and aperture have been demonstrated and the power consumption is low.

As a consequence the WGLRDYN activity continued on the optimization and modelling of normal-conducting electromagnetic (DAFNE wiggler) and permanent magnet wigglers (TESLA type). These type of wigglers were considered as an alternative configuration for the ILC DR provided that designs with acceptable costs could be developed, that meet specifications for aperture and field quality.

2. Wiggler Field Optimization and Modelling

A collaboration with the Yerevan Physics Institute has been implemented in order to study the possibility to achieve a larger aperture and a better field quality with respect to the TESLA permanent magnet wiggler design. In 2006, the YerPhI Institute has provided different sets of wiggler field maps optimizing the field quality for permanent magnet wigglers with different values of the magnet gap [refs.]. These field maps have been analyzed in order to calculate the trajectory and the nonlinear terms that affect the beam dynamics [10, 11, 12, 13].

In 2007 the work was dedicated at the reduction of the effects on beam dynamics of the non-linearities of the electromagnetic wigglers of the DAΦNE main rings. A method to reduce the integrated odd multipoles (the even ones tend to vanish for the periodicity of the magnet) by alternatively displacing the magnetic axis of the poles to compensate the integrated odd multipoles in each half-period of the wiggler has been found. In order to check the effectiveness of this approach, tracking studies have been performed. Tracking results have been used to tune the MAD model of the wiggler. This results have been presented at the "ILCDR07 LNF" workshop and at PAC07 [14, 15].

The same modeling and tracking studies performed for the DAΦNE wiggler have been done for the Large Aperture Permanent Magnet Wiggler field provided by YerPhI Institute in 2006 [16]. The aperture of this magnet is still rather small for the ILC positron damping ring but would be sufficient for the electron damping ring and it could be considered as an alternative solution for the wigglers of the electron damping ring.

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