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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 1.3.1
Work Package Title:Coordination of GDE-wide Damping Ring R&D
Work Package Leader: M. Zisman
Laboratory: LBNL
Date: August 4, 2006

1. Technical progress

From October 2005 through March 2006, Andy Wolski was responsible for this effort. Starting in March, Mike Zisman took responsibility for this work at LBNL. Zisman now serves as U.S. Area System Leader for the Damping Rings, sharing responsibilities globally with Jie Gao (IHEP-China), Susanna Guiducci (LNF), and Andy Wolski (now at Cockcroft Institute).

During the first 6 months the configuration document for the Damping Rings was completed and choices were made for the parameters, including ring circumference, lattice style, RF frequency, and number of positron rings. This document was written up and posted on the damping ring Wiki site (see https://wiki.lepp.cornell.edu/ilc/pub/Public/DampingRings/ConfigStudy/DRConfigRecommend.pdf). A preliminary cost estimate for the damping rings was prepared and turned in to the DCB in preparation for the Vancouver GDE meeting. We are iterating this estimate in an attempt to reduce costs and streamline the configuration. This has involved interactions with the magnet and vacuum groups and discussions about mitigation techniques for the electron cloud instability. A session on electron cloud mitigation was organized at the Vancouver meeting.

In preparation for the RDR activity that will start in FY07, an R&D session was organized by Zisman for the Vancouver meeting. Talks were given by the main institutions involved in Damping Ring R&D activities, including ANL, CERN, Cockcroft

Institute, Cornell, DESY, Fermilab, Frascati, IHEP-China, KEK, LBNL, SLAC, and UIUC.

2. Goals and plans for the remainder of FY06 and beyond

In the remainder of FY06, work will focus on contributing to the RDR write-up and continuing to refine the cost estimate. To this end, we have recently submitted a CCB request to reduce the number of positron damping rings from two to one. This effort will satisfy the remaining milestone for this year.

We plan to hold a Damping Ring R&D meeting, probably at Cornell, in late September. At this meeting we will begin the process of R&D coordination in support of the TDR. The session in Vancouver pointed to many areas of potential overlap among the participating R&D institutions, and the four Area System Leaders will attempt to begin coordination of the work to ensure that there is maximal productivity with minimal duplication of effort. This work will, of course, continue into FY07 and beyond, assuming we still have responsibility for Damping Ring coordination in the "TDR era."

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 1.3.2
Work Package Title:Coordination of Accelerator Effort at LBNL
Work Package Leader: M. Zisman
Laboratory: LBNL
Date: August 4, 2006

1. Technical progress

From October 2005 through March 2006, Andy Wolski was responsible for this effort. Starting in March, Mike Zisman took responsibility for this work at LBNL, with assistance from Christine Celata.

During the first 6 months, cost accounting information for the LBNL effort was provided to the ART manager for Q1 and Q2. Information for Q3 is being collected now and will be passed on shortly.

An R&D planning document for FY06 was prepared. This document details the planned effort for FY06 from LBNL staff. A second document was prepared requesting supplemental funds for FY06. This request was partially funded, with the result that engineering effort for the design of the Damping Ring wiggler vacuum chambers has begun, as has some effort toward the mechanical integration of all Damping Ring systems, e.g., magnets, vacuum, supports, instrumentation.

Preliminary budget requests for FY08 and FY09 were also prepared and submitted to the ILC ART leader. These requests were outlined in a talk prepared for the SLAC meeting in May. After the meeting, Zisman and Mark Palmer from Cornell reviewed all of the Damping Ring R&D proposals and summarized them for ART management.

Effort to coordinate the LBNL work continues on a level-of-effort basis.

2. Goals and plans for the remainder of FY06 and beyond

In the remainder of FY06, work will focus on contributing to the RDR write-up and continuing to refine the cost estimate. Engineering efforts have switched to looking at magnet designs for quadrupoles and sextupoles, in response to a strong request for help from the magnet group.

We are continuing to search for a suitable replacement for Andy Wolski. Until such time as one is identified, Zisman will maintain his responsibility for supervising this effort.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 2.5.3
Work Package Title: Damping Ring Injection & Extraction Beamline Design & Characterization
Work Package Leader: M. Zisman
Laboratory: LBNL
Date: 08/09/2006

1. Technical progress

For both lines a basic design exists based on the OCS injection/extraction straight. No detailed studies of tolerances, required instrumentation and correction devices have yet been done.

Injection:
Transfer lines for the current DR lattice have been designed. They are matched to the beamlines from the sources (electrons and positrons).

Extraction:
To respond quickly to layout changes the following elements have been designed:

- Extraction from the ring, with additional bending to cancel dispersion from the kickers and septa
- A Double Bend Achromat (DBA) cell with the same total bending angle as the extraction section, including its kickers and septa
- FODO cells for transport
- A matching section into the RTML (not yet finalized)

All cells have the same Twiss parameters at the ends where they need to be connected to each other.

The simplest layout with the end of the line being parallel to the extraction straight in the ring would just be the extraction, a DBA cell and the matching section. More complicated variants to adapt to layout changes are easily accommodated by our modular design.

The current layout requires about 90 m of separation, which can be achieved by adding one or two extra DBA cells after the extraction, then some FODO cells, and then two or three DBA cells to bend parallel to the ring straight section before beginning the matching section.

2. Goals and plans for the remainder of FY06 and beyond

a. Design abort line. (This is a deliverable.)
b. Study emittance dilution in the extraction line.
c. Tracking studies for the injection and extraction lines to study tolerances, consequences of kicker faults, etc.
d. Define required magnet and alignment tolerances, instrumentation and correction devices.
e. Work with Tom Mattison on his proposed redesign of the injection/extraction straight, including tracking studies to assess its impact on the damping ring dynamic aperture.

The majority of these tasks will continue into FY07, assuming adequate funding is made available.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 2.5.4
Work Package Title: Damping Ring Beam Dynamics: Dynamic Aperture
Work Package Leader: M. Zisman (acting)
Laboratory: LBNL
Date: 08/09/2006

1. Technical progress

Tracking Studies:
Tracking studies with different physical apertures in the wiggler magnets were performed for seven different lattices to determine the required aperture.

IBS:
Modified versions of the OCS lattice were produced that use fewer wiggler magnets. A new code was written in Matlab to calculate the effect of IBS on the achieved emittances. Calculations were done on different lattices to study the effect on the positron damping ring and to find out if the electron damping ring could get by with significantly fewer wiggler magnets.

2. Goals and plans for the remainder of FY06 and beyond

Tracking Studies:
Participate in tracking studies for the damping rings with emphasis on injection and extraction issues. The goal is to test performance including realistic sources of errors (field strength, field quality, and alignment).

IBS:
Calculate emittance growth for finalized lattices, including all errors.

Other beam dynamics issues:
Study orbit correction and optimization schemes for the damping rings and injection/extraction lines. These studies will assess required corrector strengths, required alignment tolerances, and required bpm locations and performance.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 2.5.5
Work Package Title: Damping Ring Beam Dynamics: Collective Effects
Work Package Leader: M. Zisman
Laboratory: LBNL
Date: Aug. 5, 2006

1. Technical progress

The main focus of our work for this period has been space charge. In the early part of the year we completed investigations of direct space-charge effects for the damping ring lattices considered for the baseline configuration studies. We shared coordination of the global task force charged with these studies. Space charge had early on been recognized as potentially harmful for the DRs because of the unusual combination of small emittances and large ring circumference. We looked at space charge as a factor for driving, or moving the working point close to, resonances. We used a model based upon the weak-strong approximation of beam dynamics that neglected radiation effects. We employed computational tools specifically developed for this task. Cross validation of results with those obtained elsewhere were generally satisfactory. Our findings, which showed that the "dogbone" lattices could be quite vulnerable to space charge, were instrumental in making the baseline configuration choice for a ring lattice with intermediate circumference. After the baseline configuration decision, we continued studies of space-charge effects from a different point of view. It had been suggested that, even far from resonance conditions, space-charge forces in a non-ideal lattice could alter the equilibrium vertical emittance as determined by radiation emission (e.g., by modifying the effective x/y coupling). We have constructed a beam-envelope model to account for both space-charge and radiation effects and applied it to the current damping ring lattice design. We found that indeed the predicted effect could be present, but should be of no concern given the present design parameters. The effect could be relevant for the dog-bone lattices, but this has yet to be specifically investigated.

Regarding the study of single-bunch microwave instability, it was agreed earlier this year that a more focused effort should start only after a reasonably detailed

layout of the machine components, along with numerical impedance models of those components, becomes available. In the meantime, we have made more progress in developing a code for the analysis of the linearized Vlasov equation, to be used for the determination of the instability threshold in addition to other methods already in our tool-box.

We have started to develop a method for the integrated simulation of radiation effects and intrabeam scattering (IBS) using tracking of the beam envelopes. This calculation will be more time consuming than, but should improve on the accuracy of, current methods for estimating equilibrium emittances in a coupled lattice. Moreover, our method will make it possible to monitor the emittance evolution during the damping process. Our approach would also allow a seamless inclusion of space-charge effects, though this may be of limited interest for the present baseline configuration where space-charge is a non-critical issue.

2. Goals and plans for the remainder of FY06 and beyond

In the remaining part of the year, we plan to contribute to a proposed effort to benchmark the presently available codes and methods for studying the microwave instability. This exercise is important to gain confidence in the work that we will be doing for the damping rings. We also hope to settle some still unanswered questions concerning accuracy and reliability of some of the methods in use. By the end of FY06 we expect to have already made significant contributions to this effort using the variety of tools that we have developed. However, we expect work on this issue to continue well into next fiscal year.

We plan to complete an estimate of the equilibrium emittance in the presence of IBS, including monitoring of emittance evolution through the damping cycle using the method of beam-envelope tracking. This will be done for the current DR lattice with small coupling errors. Delivery of first results using this method during FY06 is contingent on successful resolution of some technical problems.

For next year we plan to:

- Devote considerable time to simulations of the e-cloud instability. The first step is a 3D calculation of electron-cloud build-up in the wigglers. Depending on the resources available, other goals will include modeling of e-cloud buildup in other lattice elements, a self-consistent calculation of e-cloud induced instabilities, and modeling of the technical devices (clearing electrodes, microgrooves) that have been proposed as remedies to the e-cloud build-up. There is increased emphasis on proposed remedies due to the recent configuration change request to eliminate one of the two positron damping rings. We are well positioned to carry out accurate simulations of proposed remedies.

- Complete our contribution to the code benchmarking effort for the microwave instability and start estimating the instability thresholds for the DRs as impedance models for DR components become available. We are also committed to carrying out calculations for the KEK ATF ring as soon as the existing information concerning its impedance is made available by the KEK staff.

- Complete coding for the integrated simulations of radiation and IBS effects and calculation of emittance evolution from injection to extraction.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.2.5
Work Package Title: Development of the Universal Accelerator Parser
Work Package Leader: M. Zisman (acting)
Laboratory: Lawrence Berkeley National Laboratory
Date: 08/10/06

1. Technical progress

Over this period, significant development has been made on the Universal Accelerator Parser library. Many of the core components of the code have been designed and/or implemented, including core data structures, and code translation routines. Among the core modules implemented are classes for building and modifying a lattice, exception handling, and handling for I/O operations. We have written parsers for reading a MAD or Accelerator Markup Language (AML) input file and constructing an identical UAP model that can be modified or translated to another lattice format. The code constructs a proper AML data structure following the AML draft specification. We developed a flexible translation system for specifying "vocabulary" and "structural" conversions from a source data structure to a proper AML data structure. The translation system should make constructing translators for a variety of accelerator languages a straightforward process. Additionally, we built a simple project MAD2AML, which reads in a MAD input deck and generates an AML file. We have written Application Program Interface documentation to expedite the integration of the library into existing programs as well as to further international collaboration on the code.

2. Goals and plans for the remainder of FY06 and beyond

The following is a list of items that remain to be done:

- Implement expression evaluation and beam line expansion routines for an AML-structured tree
- Improve AML compatibility

  Improve support for reading, writing and translating AML lattice files to other lattice formats.
- Write user guide
- Implement support for beam dynamics simulation codes, such as MERLIN and BMAD
- Algorithmic analysis and optimization of code

  Analysis needs to be performed to determine the complexity of library routines, in terms of running time, memory usage, and I/O utilization. Based on the algorithm analysis, routines can be optimized appropriately.
- Validation of code

  The UAP code needs to undergo a process of quality assurance. The code needs to be assessed and purged of potential security vulnerabilities, as well as validated to ensure reliable results.

During the remainder of FY06, we hope to implement expression evaluation and beam line expansion routines, provide better support for AML lattice files, and begin work on a user guide. Future work includes support for the beam dynamics simulation code MERLIN, algorithmic analysis, optimization, and validation of the library.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.5.3
Work Package Title: Damping Ring Studies at LBNL-ALS
Work Package Leader: J. Byrd
Laboratory: LBNL
Date: 08/15/06

1. Technical progress

The fast ion instability is a potentially limiting effect on the performance of the ILC electron damping ring. The present theories and models have not been rigorously tested in the regime of the damping rings, leading to significant uncertainty in the predictions. The LBNL-ALS has the ability to operate in a low-emittance regime where fast-ion effects are expected to occur, together with the diagnostics and instrumentation needed to make detailed studies of these effects.

We have made progress in development of multibunch diagnostics. This includes development of a bunch-by-bunch diagnostic that allows recording of a BPM signal from individual bunches at a 500 MHz rate over 20,000 turns. The system also permits gating of the transverse feedback system, which allows periodic modulation of the feedback gain (typically on/off) and will therefore allow measurements of transverse growth rates.

2. Goals and plans for the remainder of FY06 and beyond

Plans for the remainder of FY06 are to test the system under nominal ALS conditions to measure growth rates of conventional HOM-driven instabilities. Time permitting, we will test the system with the ALS low-emittance lattice and begin looking for ion-instabilities. This program will continue into FY07 with more detailed measurements of growth rates and investigation of possible mitigation techniques, e.g., very fast feedback systems.

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FY06 Work Package Technical Progress Report

Work scope period: 4/1/06 to 7/1/06
Work Package WBS Number: 4.2.1
Work Package Title: Vacuum System Engineering and Cost Estimation
Work Package Leader: R. Schlueter
Laboratory: LBNL
Date: 08/09/2006

1. Technical progress

During this work period, a preliminary conceptual design was produced for the damping ring wiggler straight section vacuum system, encompassing wiggler and quadrupole sections. This formed the basis for an initial cost estimate presented at the Vancouver Linear Collider Workshop. The wiggler chamber is a machined and welded aluminum unit designed as a warm bore insert that is mechanically decoupled from the wiggler and cryogenic system. A NEG pumping system and photon absorber are incorporated in antechambers. Integral cooling is incorporated to minimize distortion of the chamber and thermal load on the wiggler cryostat during NEG regeneration. A surface coating will be used to minimize secondary electron yield in the beam duct. For the purpose of the initial cost estimate, NEG coating is assumed.

The quadrupole chamber is welded aluminum, also incorporating NEG coating for secondary electron yield reduction. Bellows, a BPM assembly, and an ion pump are incorporated. The quadrupole chamber is completely shadowed by the wiggler chamber photon absorbers, and so is not subjected to a high synchrotron radiation heat load.

The primary technical challenge was to develop a photon absorber to handle the intense synchrotron radiation power from the upstream wigglers. The current design uses a rectangular, hollow, water-cooled copper tube. Peak power densities are 3 W/mm^2.

LBNL vacuum system work has involved collaboration with complementary vacuum system work at ASTeC and the wiggler design effort at Cornell.

The following milestone, which was part of the original proposed work package has been met:

9/30/06: Contribute to the RDR vacuum system design and cost estimate.

2. Goals and plans for the remainder of FY06 and beyond

Work through the end of FY06 will include refinement of the initial cost estimate, and a written contribution to the RDR.

Work in FY07 will focus on developing a more detailed vacuum system design, with particular emphasis on issues related to the suggested elimination of a second positron damping ring. In particular, we will look at incorporation of clearing electrodes in the wiggler chamber, and incorporation of suitable surface coatings for minimizing secondary electron yield. If time and resources permit, we will begin to examine the vacuum chamber requirements in the injection and extraction straight sections.

Collaboration with ASTeC regarding vacuum system design, and with Cornell regarding the wiggler interface, will continue.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 4/1/06 to 7/1/06
Work Package WBS Number: 4.2.2
Work Package Title: Damping Rings Mechanical and Vacuum Systems Integration
Work Package Leader: R. Schlueter
Laboratory: LBNL
Date: 08/08/2006

1. Technical progress

We have completed mechanical layouts of the latest damping ring lattice design. We have developed magnetic designs for the damping ring quadrupoles and sextupoles. We have compiled and specified the quantities and locations of magnet support systems, vacuum chambers and their support systems, diagnostics such as BPMs, scrapers and kickers, instrumentation, valves and bellows.

We have supplied RDR cost estimates to area leaders for the quadrupoles and sextupoles as well as support systems for all magnets.

The following milestone, which was part of the original proposed work package has been met:

9/30/2006: Contributions to RDR mechanical system design and cost estimate.

2. Goals and plans for the remainder of FY06 and beyond

7/1/06 to 9/31/06:
We intend to continue honing magnetic designs for the damping ring quadrupoles and sextupoles. We will continue to gather information on the quantities and locations of magnet support systems, vacuum chambers and support systems, diagnostics, such as bpms, scrapers, and kickers, instrumentation, valves and bellows. We will continue to refine cost estimates as appropriate for the RDR. This will include the injection and extraction lines when their designs have been specified.

FY07:
We will develop a conceptual design for damping ring mechanical systems, including a layout of major magnets, vacuum system, and instrumentation components. Special attention will be devoted to the mechanical system design implications of installing a single vs. a double positron damping ring. In particular, the concept of providing a flexible design that will allow installation of either option will be adopted. We will continue to collaborate with ASTeC regarding the vacuum system design, ANL regarding the lattice design and SLAC and Oxford regarding survey and alignment.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 5.5.2
Work Package Title: Development of Injection/Extraction Kickers at KEK-ATF
Work Package Leader: John Byrd
Laboratory: LBNL
Date: 08/09/2006

1. Technical progress

Through June 2006 we carried out the calculations of the main parameters for a stripline kicker able to satisfy the requirements for bunch extraction in the ATF ring, with low residual values of the deflecting field. We calculated stripline length, coverage angle and spacing, and number of kicking modules necessary to achieve the 5 mrad deflection angle in a manner compatible with the available space in the ring. The kicker shunt impedance, peak and average power dissipation, and required voltage were also calculated.

We performed computer simulations, both 2D and 3D, using the Microwave Studio EM simulation software suite to obtain a characteristic impedance of 50 Ω for the electrodes (which minimizes reflections), and initiated a study of the time transients in a kicker module design that includes beam pipe tapers, using both ideal and more realistic pulse shapes. This activity has allowed us to identify the main challenges and the critical aspects in the kicker design.

Our results have been summarized in a paper presented at EPAC06 (S. De Santis, A. Wolski, and M. Ross, "Design of a Fast Extraction Kicker For the Accelerator Test Facility") in line with the deliverables outlined in the 2006 Addendum to the Memorandum of Understanding (March 06: Physics design for single-bunch fast extraction kicker).

2. Goals and plans for the remainder of FY06 and beyond

By the end of FY06 we intend to produce a complete EM modeling of the kicker, which includes both high-order-mode analysis and longitudinal impedance calculations. Based on these, we will also try to reduce the challenging requirements on the pulsers. We will therefore investigate: reducing the electrode distance, which lowers the required voltage but increases the kicker's longitudinal impedance; increasing the electrode length, which reduces the peak power but increases the decay time; and using constant-impedance tapered electrodes, an approach that has been successfully demonstrated at DAΦNE, with parameters not too different from those needed for the ATF.

The document may also contain calculations for a lower-performing version of the kicker (compatible with an increased bunch spacing of 5.8 ns), depending on the achievability of the final kicker constraints.

Deliverable end of FY06: Comprehensive EM modeling, possibly including a 5.8 ns bunch spacing option, if required.

For FY07, we plan to participate in the construction and bench testing of a kicker cold test model, and eventually of the kicker itself, assuming that the required resources are allocated to the project.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 5.5.3
Work Package Title: Studies of Beam Dynamics at KEK-ATF
Work Package Leader: M. Zisman (acting)
Laboratory: LBNL
Date: 08/09/2006

1. Technical progress

In December 2006, after the replacement of the in-vacuum window in the ATF synchrotron light diagnostic beamline for better transmission at infrared wavelengths, we borrowed an infrared bolometer from the ALS and measured the bunch emission in the 1 mm to 50 μm wavelength range. The object of this measurement was: 1) to confirm CSR emission, due to mismatch between injected and equilibrium bunch length, and 2) to experimentally verify the CSR instability threshold, as calculated by J. Wu *et al*. Having improved our data-taking capabilities compared with our first measurements in April 2005, we were able to take a large quantity of data, under different conditions, which required extensive analysis. Unfortunately, due to operational constraints, the ATF was only able to reach bunch current intensities well below the theoretical CSR instability threshold, so it was not possible to investigate point 2).

As far as point 1) is concerned, our new data pointed out that the signal corresponding to the bunch injection is caused by incoherent emission. Unexpectedly, we also recorded a signal emitted by the stored beam at the shorter wavelength end of our instrument response. On the basis of the data in our possession, it has not yet been possible to assess the true nature of this signal.

Our results through June 2006 have been reported in a paper presented at EPAC06 (S. De Santis, A. Aryshev, T. Naito, J. Urakawa, M. Ross, “Coherent Synchrotron Radiation Studies at the Accelerator Test Facility”).

2. Goals and plans for the remainder of FY06 and beyond

As far as the CSR instability threshold is concerned, it is now apparent that reaching the required bunch current at the ATF requires extensive machine retuning. It is not presently clear whether the ATF staff has sufficient interest in this goal. Should a suitable time for this experiment be identified, we see no problem in bringing a bolometer to the ATF once again and performing the necessary measurements, especially now that the logistical challenges involved (LN_2 and LHe cooling, in particular) are well in hand.

In an effort to rule out an abnormal response of our bolometer being responsible for generating the stored beam signal, we will carry out measurements at the ALS in the same wavelength range, with similar bunch repetition rates. It is possible, of course, that new measurements at the ATF could be required, perhaps using a more sensitive bolometer. Again, we see no problem in doing so if there is sufficient interest.

Plans for FY07: LBNL will continue to be involved in beam dynamics studies at the KEK-ATF, in line with what was expressed in the 2006 Addendum to the Memorandum of Understanding.