international linear collider

ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 2.4.2
Work Package Title: End-to-end simulation of positron source-und to DR
Work Package Leader: Wei Gai
Laboratory: ANL
Date: August 15, 2006

1. Technical progress.

During this period, we have developed a numerical model of the helical-undulator-based photon source using the Monte Carlo method. We explored a wide range of parameters including undulator length, drift distance between collimator and undulator, collimator iris and drive electron beam profiles. Detailed correlations between these parameters were found.

The milestones and accomplishments were:

1. *Conduct detailed end-to-end beam dynamic simulations and multivariate optimization from the photon production and collimation at the undulator to the polarized positron production at the target and to the damping ring for different ILC positron designs. Provide the necessary input parameters to the ILC positron source collaboration for baseline considerations and provide particle phase space to the damping ring design teams.*

By extensive simulation of the ILC baseline positron source, we found that the majority of the captured positrons are produced by photons from 2^{nd}-4^{th} harmonics, the contribution from the 1^{st} harmonic being less than 15% of total captured positrons. We have also found that the undulator period λ is more critical to the yield of positrons than the parameter K; For K=1, the final yield of positrons drops more than 40% when the period increases from 1cm to 1.3cm. For a fixed undulator period, on the other hand, the yield drops only ~20% when K decreased from 1 to 0.8. Our simulation work led to important conclusions for the ILC baseline design: a)undulator length should be >200m in order to achieve yield at 1.5 with 60% polarization; b) Photon drift length > 500m and beam spot size ~3mm in order to achieve optimum yield.

2. *Conduct detailed studies on the positron separation and collimation at 250 MeV before injecting into a 5-GeV linac. Detailed magnets requirements and beamline design will be given. We will also investigate phase manipulation schemes that compress and collimate the positron beam for the damping ring input.*

We have completed a conceptual design of optics to separate the positrons, gamma rays and electrons at the end of e+ normal conducting linac. The tools we used here were PARMELA and Trace3D. The separation optic consists of a chicane for momentum selection, a linac for longitudinal phase space rotation, a bunch compressing chicane, a transverse emittance collimator and several beam matching quadrupole sets. PARMELA simulation showed that there will be an insertion loss of about 20% on the positron yield.

3. Perform initial design of the keep-alive positron source. Determine the drive beam energy and intensity based on the requirement from the GDE.

We have found that enough positrons satisfying the requirements of the keep-alive source can be produced with a 300MeV e- beam hitting on a four radiation length tungsten target. Since the keep-alive positron source need not be polarized, a microwave-gun-type positron source configuration can be used to provide enough positrons with a much simplified magnet configuration.

4. *Investigate various schemes for the AMD solenoid, such as Bitter magnet, conventional, and superconducting coils. Examine the capturing efficiency as a function of the AMD magnetic field parameters. Produce a final design of the tapered solenoid, and perform a detailed engineering study, including cooling implementation and a power supply.*

We have investigated the normal conducting DC magnet and ng flux concentrator. The DC magnet was found to be difficult to operate due to its huge energy consumption. However the DC magnet can be for the keep alive source due to its low magnetic field. For an alternative configuration of the normal-conducting pulsed flux concentrator AMD, we have developed a circuit model to design the flux concentrator type AMD. The agreement between the simulation results and the measured data in the literature confirmed the validity of our circuit model. Currently an AMD has been designed using the flux concentrator principle which satisfies the ILC polarized positron requirement.

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

During the year FY2007, we will continue to perform the following tasks as we did in FY 2006:

1) Continued optimization of the undulator parameters. We will investigate the photon spectrum as a function of the helical undulator parameters, such as K, B and drive beam energy. This will provide the necessary input parameters for the ILC damping ring design team.

2). Optimization of the beam capturing device and preaccelerator. Optimize the design of the keepalive positron source parameters, such as target material, thickness, energy selection and so on.

3). Design of the adiabatic matching device. Investigate various schemes for the AMD solenoid, such as the pulsed flux concentrator magnet, conventional and superconducting coils. We will examine the capturing efficiency as function of the AMD magnetic field parameters. We will have a final design of the tapered solenoid and perform a detailed engineering study including cooling implementation and power supply requirements.

In addition, we will study the following tasks during the year FY2007:

1). Construct a prototype AMD solenoid, with engineered cooling and test it with a power supply.

2). Perform photon collimator simulation, calculate its background radiation and its impact on the undulator.

3). Perform radiation background calculation and its impact on accelerator components.

During the year FY2008:

The majority of the work outlined in FY 2007 will be extended in FY08. In addition to the tasks outlined in FY07, we will perform hardware design and experimental demonstration of the positron source components, such as the solenoid, and the photon-collimation. We will also perform detailed studies on the radiation target for the keep alive source

ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 2.5.6
Work Package Title: Damping Ring Characterization and Optimization
Work Package Leader: Louis Emery
Laboratory: Argonne National Laboratory
Date: August 8th, 2006

1. **Technical progress.**

First phase milestone (10/1/05 - 12/31/05)

Characterized the dynamic aperture of seven reference lattices. Tracked realistic particle distributions in the seven lattices with multipole errors and synchrotron radiation effects. Also scaled the particle distribution in three dimensions for estimating the dynamic aperture limitation. The results was provided to the damping ring working group at the CERN DR baseline workshop in Nov 2005 for deciding on baseline design.

Second phase milestone (various periods)

(10/1/05 - 12/31/05)

Added a model of transverse space charge effects into elegant, which is available publicly (http://www.aps.anl.gov/Accelerator_Systems_Division/Operations_Analysis/manuals/elegant_ver16.0/elegant.html).

(1/1/06-4/1/06)

Worked on damping ring baseline lattice design. Based on the requirement from the baseline recommendation document, a new lattice (OSC2 listed in https://wiki.lepp.cornell.edu/ilc/bin/viewfile/Public/DampingRings/WebHome?rev=1;filename=ocs2.xsif) was worked out, and posted on the web for others to examine and to start their work on subsystems and cost estimates. The major change and progress are: larger momentum compaction factor and the injection section. The momentum compaction factor is 2.5 times that of the original OCS DR design. The concept of distributing kicks along some ring optics makes injection with weak-but-fast strip-line kickers possible. Dynamic aperture was re-optimized for OCS2. The dynamic aperture now is much larger than OCS, which is about 3 times the size of the injection positron beam.

4/1/06-7/1/06

The OCS2 design has ten straight sections with eight of them for RF/Wiggler. Upon the pressure of reducing rf system cost, a new lattice OCS6 (https://wiki.lepp.cornell.edu/ilc/pub/Public/DampingRings/WebHome/OCS6.xsif) was generated with six straight sections with four of them for RF/wiggler sections. The dynamic aperture is reduced to about 60% of that of OCS2, but still larger than the original OCS. We are continuing work on the dynamic aperture optimization. A modified OCS6 with more spacing between wiggler magnets had been designed and posted on the web.

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

Work plan for remainder of 2006 with milestones and deliverables

Develop similar OCS6-type lattices with varied momentum compaction in order to study instability limits vs rf system costs.

Explore the use harmonic sextupoles (sextupoles in dispersion-free straight sections) for compensating nonlinearities of the two sextupole families in the arcs.

Continuation of the work in 2007

The modification of the lattice will continue on an as-need basis, as subsystems cost are determined. Lattice updates will be put in the ILC DR WIKI page.