DRAFT: Task B (simulation studies) of ILC Simulation

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Description of each task is based on
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RTML-1

Initial Goals of the Study

- The study will focus on the emittance tuning requirements of the Ring to Main Linac (RTML). The goal of the first phase of the study is to demonstrate that the RTML's emittance preservation goals can be achieved: the goal is to limit growth in the normalized vertical emittance to 4 nm.rad with 90% confidence, using standard assumptions of misalignment and component errors. It is preferred that multiple paths to achieve the emittance goal are demonstrated. Techniques that can achieve the necessary emittance without resorting to bumps are preferred to techniques which require bumps.
- A prerequisite to performing the tuning studies is to develop a set of simulation code benchmarks which can be used to validate, or at least cross-check, the multiple simulation codes which will be used for this set of studies. The benchmarks must include the key physics features of the RTML: misaligned quadrupoles, sector bends, and RF cavities; pitched RF cavities; quadrupole errors in the spin rotator section; transverse wakefields of uncompressed bunches; momentum compaction.

Essential Features of the Study

- Full and accurate lattices, including vertically-curved or laser-straight segments, and geometry matching between them
- A set of standard misalignments and errors which is considered appropriate by the relevant technical experts
- The expected beam distribution from the extraction of the DR, including the correct bunch length, energy spread, and any non-Gaussian features; both the nominal and low-charge, short-final-bunch cases should be studied
- Long-range wakefields, including any expected rogue modes or mode-rotation wakes

RTML-2

Later Goals of the Study

- Once the basic study has reached a conclusion, the next steps will be: to include BPM and corrector "hard failures" in the study (failed BPMs and correctors known to have failed); to use an initial set of misalignments which include the expected long-wavelength distortions of the tunnel (if this was not included in the initial set of studies). The studies will be used to set specifications and tolerances on many parameters of the main linac, for example determining the actual requirements on initial alignment. The exact dimensions of this last part of the study will be determined later based on experience from the initial portions of the study and demands from the various area, technical, and global experts.
- In parallel with the above, incorporate dynamic features into the tuning model. These features include: ground motion and component vibration based on the accepted model; 5 Hz, feedbacks, 3 MHz feedbacks, "train-straightener" feedbacks, and feed-forward; bunch-by-bunch and train-by-train beam jitter.

Deliverables

- The key deliverable is a "white paper" summarizing the results of the study, which is to be available at the time of the Engineering Design Report (ie, in early FY10). Additionally, the algorithms must be documented and made publicly available in some form, whether as source code or as a fully-developed technical note on the algorithms; this will allow other users to develop studies which take the tuning algorithms as a starting point. Additionally, datasets representing the misalignments and corrector settings for a number of "seeds," which can be loaded into other simulation programs for simulation of a misaligned, corrected beamline. These datasets, in ASCII format, would be stored on a central web server for use by any ILC LET person who wishes to use them. Finally, the data files needed for the benchmarking of RTML simulation codes, and the results from the codes which have passed the benchmark, must be made available for general use.

ML Dynamic tuning

Goals of the Study

- The study will focus on main linac emittance tuning and preservation in the presence of dynamical effects. It should incorporate the following refinements:
- The ground motion and vibration model for the ILC
- Time-dependent errors in the magnet settings, RF power, and BPM performance
- 5 Hz feedbacks, 3 MHz feedbacks, and train-straightener feedbacks
- Resteering or continual steering models
- Initial beam jitter, both train-to-train and intra-train, which is expected from the results of the RTML dynamic study
- The study will quantify the degradation in the initial tuning due to dynamic effects, determine the optimum mitigation of the dynamic effects, set specifications, tolerances, and limits on dynamical effects, and determine the necessary procedures and equipment to maintain optimum emittance performance of the main linac over time.

(Note: do we need to develop benchmarks for this part of the overall study? If so, what should they be?)

Deliverables

The key deliverable is a "white paper" summarizing the results of the study, which is to be available at the time of the Engineering Design Report (ie, in early FY10). Additionally, the algorithms must be documented and made publicly available in some form, whether as source code or as a fully-developed technical note on the algorithms; this will allow other users to develop studies which take the tuning algorithms as a starting point.

BDS

Goals of the Study

- The study will focus on the luminosity tuning requirements of the Beam Delivery System (BDS). The goal of the first phase of the study is to demonstrate that [the BDS's emittance preservation goals can be achieved: the goal is to limit growth in the normalized vertical emittance to 6 nm.rad with 90% confidence,] [the designed luminosity can be achieved with 90% confidence,] using standard assumptions about the initial alignment of components and the accuracy of electromagnetic fields in the devices.

  The key physical issues to be studied include:
  - The typical misalignments, rotations, and strength errors of beamline devices
  - Crab cavity effects, including wakefields, phase and amplitude errors, and xy rotation errors
  - Wakefields, including both collimators and the vacuum chamber itself
  - Dynamic effects: ground motion, technical noise (especially on the final doublet and detector), train-by-train and intra-train feedbacks
  - Beam-beam effects
- A prerequisite to performing the tuning studies is to develop a set of simulation code benchmarks which can be used to validate, or at least cross-check, the multiple simulation codes which will be used for this set of studies. The benchmarks must include the key physics features of the BDS, as outlined above.

Deliverables

- The key deliverable is a "white paper" summarizing the results of the study, which is to be available at the time of the Engineering Design Report (ie, in early FY10). Additionally, the algorithms must be documented and made publicly available in some form, whether as source code or as a fully-developed technical note on the algorithms; this will allow other users to develop studies which take the tuning algorithms as a starting point. Additionally, datasets representing the misalignments and corrector settings for a number of "seeds," which can be loaded into other simulation programs for simulation of a misaligned, corrected beamline. These datasets, in ASCII format, would be stored on a central web server for use by any ILC LET person who wishes to use them. Finally, the data files needed for the benchmarking of BDS simulation codes, and the results from the codes which have passed the benchmark, must be made available for general use.

Feedback/Feedforward simulation

Goals of the Study

Deliverables

Start to End simulation

Goals of the Study

This study will integrate the RTML, Main Linac, and BDS simulations into a common framework and produce direct estimates of the ILC luminosity (rather than indirect estimators such as the emittance). As such, it will incorporate the static tuning algorithms of each area, the dynamic effects and feedbacks, and the beam-beam interactions necessary to achieve a fully-realistic luminosity estimate. As a secondary goal, the study will produce estimations of the unwanted beam-beam induced byproducts (ie, backgrounds or lost beam power in various forms).

In the event that the integrated simulations predict a luminosity which is lower than what is expected from the emittance-preservation studies, the efforts will be directed towards understanding the discrepancy and increasing the luminosity.

Deliverables

The key deliverable is a "white paper" summarizing the results of the study, which is to be available at the time of the Engineering Design Report (ie, in early FY10). Additionally, the algorithms must be documented and made publicly available in some form, whether as source code or as a fully-developed technical note on the algorithms; this will allow other users to develop studies which take the tuning algorithms as a starting point. Additionally, datasets representing the misalignments and corrector settings for a number of "seeds," which can be loaded into other simulation programs for simulation of a misaligned, corrected beamline. These datasets, in ASCII format, would be stored on a central web server for use by any ILC LET person who wishes to use them.

Code development-1

Goals of the Project:

- The goal of the Simulation Code Development project will be to produce a beam dynamics simulation code which is suitable for use in LET Start to End (S2E) simulations: simulations which incorporate the RTML, main linac, BDS, and collision point. Optimally, simulations of the extraction line should be supported as well.

The physics simulation requirements of an S2E code are as follows:

- Standard beam dynamics issues: drifts, bends, quads, sextupoles, octupoles, thin-lens multipoles, solenoids, dipole correctors, including errors and misalignments; bend magnet errors and rotations must be correctly treated, ie, a bend with a strength error produces an error in the beam trajectory as well as in the dispersion.
- Accelerating cavities: acceleration, focusing from fringe fields, single bunch transverse and longitudinal wakefields, long-range wakefields including mode-rotation wakes, pitched-cavity aberrations.
- Interaction region: crab cavity including collective and multi-bunch effects, IR solenoid overlapping IR beamline magnets, beam-beam effects (luminosity enhancement, disruption of the outgoing beams, crossing angle, arrival time error, kink instability).
- Capacity to incorporate the ground motion model.
- Capacity to incorporate intra-train feedbacks, train-to-train feedbacks, train-straightener feedbacks, and feed-forwards.
- Two-beamline simulation: appropriate incorporation of misalignments and errors which are correlated between the e- and e+ beamline such as bunch compressor phase errors, crab cavity errors, ground motion effects over the full site, IR girder and solenoid field error / alignment effects.
- BPM resolution limits, scale factor errors, electrical and mechanical offsets, rotations.
- Other appropriate instrumentation: profile monitors of various forms, bunch length and arrival-phase monitoring.
- The S2E codes should be developed in such a way as to maximize their use of parallel processing and grid computing capabilities of the national laboratories.

Code development-2

- Optimally, the S2E codes should explicitly incorporate book-keeping tools for managing common girders, RF sources, power supplies, and other fixed relationships between beamline elements.

  In addition to the actual simulation codes, the S2E effort must develop a set of benchmarks which can be used by prospective codes. The benchmarks incorporate the benchmarks used by the RTML, ML, and BDS studies, and any additional benchmarks which are needed to verify the correct functioning of additional features in the S2E code.

  Deliverables

  The deliverables of the project are the following:

- The simulation package itself: source code, exectuables, and any makefiles or other construction tools needed to build the executables from the source.
- Documentation adequate to allow a modestly-experienced simulation guru to run the code.
- Documentation of the results of benchmarking studies.
- Ideally all of the above should be made available on a public web server, and everything should be placed under some form of version control.

QUESTION: It may not be a good idea to develop one single code in the world. I (K.K.) guess there is a project to make such a code in the US. Other regions may have different code(s)? However, every accelerator facility seems to have one standard code for simulation and operation. (It may be wrong.) ??????? So, ILC should have one?