CLIC issue: Main Beam Emittance Preservation

1. **Short technical description and corresponding category(ies) of issues :**

Feasibility	Performance	Cost
X	X	

2. **CLIC nominal parameter issues and comparison with state of the art (in text and/or table):**

The required emittances for CLIC are below what has been achieved today. For the damping ring comparison to existing facilities, in particular light sources and damping ring test facilities can be made. For the emittance preservation from the damping ring to the interaction point we rely on simulations. In the future experiments can be carried out at the ATF2 final focus test installation.
The beam physics studies are important for the definition of the hardware performance specifications. In a number of cases the specifications exceed the state of the art.

Damping ring

- Reference lattice designs for the damping ring and pre-damping rings exist.
- Intra-beam scattering contributes strongly to the emittance growth. Currently the estimate of this effect is based on semi-analytic calculations. If these were incorrect the design may be invalid.
- Electron cloud is of great concern. We have the tools to simulate these effects, which have been used for previous versions of the lattice. The main uncertainty of the simulations lies in the modelling of the surface physics of the beampipe.
- Fast-beam ion instability is of concern. We own the necessary simulation tools and used them to determine the required, very good vacuum quality (0.1ntorr) for the previous lattice.
- The design relies strongly on superconducting wigglers. The impact of the wigglers on the beam is simulated but it is not obvious how the results can be experimentally verified, in particular in a IBS dominated regime.
- The beam loading transients in the damping ring are very important. A solution is being developed.
- The extraction kicker stability tolerance is tight (relative stability of a few 10^{-4}). No design exists but investigations are ongoing.
- A number of other issues are important for the damping ring, e.g. low emittance tuning. But we consider them not too far from existing accelerator, in particular light sources. No specific work in ongoing in these areas. Collaboration on experiments of low-emittance tuning at SLS are planned.

RTML

- The design of the most relevant beam lines is ongoing.
- Coherent synchrotron radiation in the main beam bunch compressors has been pointed out to be a serious risk by the TRC2. Simulations have shown that

coherent synchrotron radiation in the bunch compressor is well under control and the process is taken into account in the design.
- Mitigation of static imperfections in the RTML has proven to be difficult in ILC and has not yet been solved to satisfaction. Limited studies are available for CLIC.
- The fast beam ion instability is of concern in the RTML. First estimates of the required very good vacuum level (0.1ntorr) have been performed.

Main linac
- A reference lattice exists. Detailed studies of the impact of the hardware layout are studied continuosly.
- Emittance preservation in the main linac is challenging due to strong wakefields and dispersive effects. Beam-based alignment procedures have been devised to mitigate the impact of static imperfections. Simulations show that these procedures achieve the performance goal.
- The fast beam ion instability can be an issue. In particular it is difficult to achieve a vacuum better than a few ntorr in the main linac as bake out or heat activation seems excluded by the very tight alignment tolerances. A program has been developed and used to estimate the required vacuum level.
- First multi-bunch studies have been performed.
- A conceptual beam orbit feedback exists.
- A solution for the main linac beam loading compensation has been studied for previous parameters. An update to the new parameters is required.

BDS
- A reference lattice exists for CLIC at 3TeV. Minor optimizations in terms of apertures, collimation and final focus optics are still required.
- The lattice at 500GeV needs to be optimised for performance and machine protection.
- The performance of the collimation system is being studied. As part of the work is not done at CERN we do not know when the results will be available.
- The detector solenoid has a strong impact on the beam. Studies are being performed to determine the required compensation and to acceptable field configurations.
- For the beam delivery system a tuning technique has been devised to remove the effect of static imperfections. It does not yet achieve the performance goal but is not too far. 80% of the machines are achieve 80% of the luminosity, the target is that 90% of the machines should achieve 90% of the luminosity.
- Fast beam tuning at the interaction point is of great importance to counteract dynamic effects. It is made difficult by the slow measurement of the luminosity as radiative Bhabhas cannot be detected. A study of the use of faster signals from the beam-beam collision for the tuning is required.

Post collision line
- A reference design exists, which does not include polarization instrumentation.

- Instrumentation of the post collision line is instrumental to be able to tune the luminosity.
- Some studies have been performed to establish the performance of the line with respect to losses.

Integrated studies

- Dynamic effects can be quite important in CLIC. It needs to be counteracted by an integrated feedback system ton control the beam transport from the damping ring to the IP.
- The drive beam phase and amplitude jitter is an important source of dynamic imperfections for the CLIC main beam.

3. **R&D program presently set-up**:

Damping ring

- Review and optimisation of lattice designs.
- Development of a simulation tool for intra-beam scattering is ongoing to verify check the analytic estimates.
- The development of electron cloud mitigation techniques is ongoing world-wide and we participate at a low level (a larger contribution comes form other projects at CERN). The requirements for the vacuum system surface will be studied for the new baseline lattice. Promising carbon coatings, which lower the secondary emission yield, will be tested in CSRTA this summer.
- Vacuum specifications to avoid fast beam-ion instability will be updated for the new baseline design.
- The impact of the wigglers on the beam is being simulated. Also the impact of synchrotron radiation on the wigglers is being studied. A prototype has been built and the field quality is being measured at BINP.
- A solution for the beam loading transients is being worked on.
- Impedance effects are being studied by Daresbury.
- A lattice for 500GeV is being developed.

RTML

- The design of the most relevant beam lines is ongoing, including the effect of coherent synchrotron radiation.
- An exploration of the most important mitigation of static imperfections in the RTML is planned.
- A simplified model of the dynamic imperfections and feedback in the RTML will be made for the integrated studies.
- A lattice for 500GeV is being developed.

Main linac

- Detailed studies of the impact of the hardware layout are studied continuosly.

- Simulations are continued of the emittance preservation in the main linac to investigate the impact of hardware details and follow the improved modelling of the survey performance.
- Tolerances will be studied for 500GeV.
- The fast beam ion instability will be investigated for the 500GeV linac.
- Multi-bunch effects are being included in the simulations.
- Studies are ongoing to demonstrate the robustness of the orbit feedback design.
- Studies are being launched to model the transverse jitter of the quadrupoles.

BDS

- Minor optimizations in terms of apertures, collimation and final focus optics will be performed.
- The lattice at 500GeV will be optimised for performance and machine protection issues will be studied.
- The performance of the collimation system is being studied. As part of the work is not done at CERN we do not know when the results will be available.
- Studies are being performed to determine the impact of the detector solenoid field on luminosity and to determine the required compensation and acceptable field configurations.
- A further improvement of the beam-based alignment and tuning methods will be attempted.
- A conceptual orbit feedback is going to be developed.
- A study will be performed of a tuning strategy using the faster signals from the beam-beam collision for the luminosity tuning.

Post collision line

- Studies will be performed to verify the performance of this design. In particular with respect to losses and the instrumentation potential. As this will be done by new members of the study, the work programme needs to be defined with them.

Integrated studies

- A conceptual integrated feedback system will be developed for the beam transport from the damping ring to the IP. It will address the orbit and phase feedback. The RTML will be included in a simplified fashion.
- A simplified model will be developed of the drive beam longitudinal dynamics to determine the specifications for the drive beam injector and RF stability.

4. **What performances will realistically be achieved (Target Performances):**
   - **by end 2010**

Damping ring

- Updated reference lattice designs for the damping ring and pre-damping rings at 3TeV and 500GeV.

- Simulations confirming the damping ring performance in presence of intra-beam scattering.
- Simulations defining the requirement beam pipe surface properties to suppress electron cloud. The results of the world-wide collaboration on electron cloud suppression.
- Updated vacuum specifications to suppress the fast beam-ion instability.
- Prototype wigglers will be available.
- Simulations showing that the heat load in the wigglers is acceptable.
- A solution for the RF system including the beam loading compensation.

RTML

- Baseline lattices for the most important components with the exception of the spin rotator at 3TeV and 500GeV.
- A simplified model of the dynamic imperfections and feedback in the RTML for the integrated studies. Tolerances for dynamic imperfections (magnet jitter, dynamic magnetic fields).
- Assessment of the most important static imperfections in the RTML.
- Updated vacuum requirements for the RTML.

Main linac

- Lattice designs for 3TeV and 500GeV.
- Updated emittance preservation studies of the impact of the hardware performance at 3TeV and 500GeV.
- A robust orbit feedback design.
- A study of the beam loading compensation scheme.

BDS

- Updated reference lattice exists for CLIC at 3TeV.
- A lattice at 500GeV needs to be optimised for performance and machine protection.
- Studies establishing the performance of the collimation system.
- Studies establishing that the detector solenoid and shielding are acceptable.
- A tuning technique that removes the effect of static imperfections.
- A conceptual orbit feedback.
- A study of a tuning strategy that uses fast signals from the beam-beam collision.

Post collision line

- A baseline design.
- Studies of the performance of the baseline design, in particular with respect to losses and the instrumentation potential. As this will be done by new members of the study, the work programme needs to be defined with them.

Integrated studies

- A conceptual integrated feedback system will be developed for the beam transport from the damping ring to the IP. It will address the orbit and phase feedback. The RTML will be included in a simplified fashion.
- Studies evaluating the performance of the integrated feedback using the model provided by the stabilisation working group.
- A simplified integrated model of the longitudinal drive beam effects.

➢ **by end 2012 (including FP7)**

The beam physics programme after 2010 will essentially focus on more indepth studies of the different effects mentioned above.

BDS

- Test of the CLIC beam-based alignment scheme at ATF2. While the beam size that can be reached in ATF2 is 20nm, much larger than the 1nm for CLIC, ATF2 will serve as a test bed for the chromaticity suppression and the system tuning algorithms.

5. **Comments on validation of CLIC parameters issues by comparison with Target Performances:**

6. **Optional: What additional R&D could be set-up to eventually reach the validation of nominal CLIC parameters (estimation of resources and schedule?)**