Emittance Optimisation in the Drive Beam Recombination Complex at CLIC

Davide Gamba,1,2 Frank Tecker1

1CERN, Geneva, Switzerland; 2JAI, Oxford, United Kingdom

Introduction

CLIC:
- Design of a multi-TeV e+e- linear collider.
- Requires high acceleration gradient.
- Based on two-beam acceleration scheme.
- Besides the two colliding beams, it has two parallel high intensity Drive Beams.
- Current and phase stability of these Drive Beams is crucial for luminosity.

Goal of this work:
- Identify the sources of emittance growth in the Drive Beam Recombination Complex (DBRC) of CLIC, and so spot possible issue to be corrected in the CLIC design.
- Implement a feedback algorithm to correct orbit and dispersion in the DBRC, and to optimise beam parameters in order to improve the Drive Beam recombination quality.

CLIC Test Facility (CTF3):
- Proof-of-principle experiment to study CLIC feasibility.
- Main objectives:
  - Drive Beam production.
  - Drive Beam recombination.
  - RF power production.
  - Two-Beam acceleration.

Simulations

One can define the emittance, \( \epsilon \), of an ensemble of particles in phase-space, \( x \cdot x' \), as the determinant of the covariance matrix:

\[
\epsilon = \text{det}(\Sigma) \quad (1)
\]

By means of Twiss simulations of monochromatic Gaussian beams one can obtain the covariance matrix from the Twiss parameters at any location along a machine.

One can merge many beams, either with different energies or different initial conditions, at one location and calculate the final emittance given by eq. (1).

Linear Feedback Implementation

- Generic implementation in MATLAB®.
- Interfaced with any parameter/observable available in the accelerator control system.
- Able to measure the response matrix based on Regularised Linear Regression.
- It is not needed to excite one actuator at a time.
- It is possible to keep the response matrix updated while correcting.

Experimental Results at CTF3

- Using the developed linear-feedback application.
- Flattening of BPM waveforms signal acting on the buncher klystron phase.
- Each line represents a single 1.2 μs long pulse. Red are shots after correction.
- Vertical orbit correction in the Transfer Line 1 (TL1). Each line represents the orbit averaged over 5 pulses. In black, where present, the target orbit. Red are shots after correction.
- Bunching correction
- Energy flattening
- Orbit correction
- Orbit closure
- Difference between the first and second turn horizontal orbit in the CR. Each line is an average over 10 pulses. The red differences are obtained after minimising the closure on the green-marked BPMs.

Conclusions and Outlooks

DONE:
- Developed software to implement linear feedbacks for parameter optimisation.
- Performed preliminary simulations of emittance growth in the DBRC.
- Proven the ability to control beam orbit, and to correct bunching and energy features along the pulse.

TO DO:
- Prosecute simulations to better characterise the emittance growth sources.
- Implement a Dispersion Matching Steering algorithm.
- Further improve the orbit closure of Delay Loop and Combiner Ring.
- Measure the emittance improvement after the Recombination Complex.