In the CLIC two beam acceleration scheme the RF power that accelerates the main beam is extracted from a second “drive beam”. The phase (or time) synchronisation between the two beams must be maintained to within 0.2 degrees of 12 GHz (50 fs) to ensure the efficiency of this concept [1,2].

A phase feedforward system with bandwidth above 17.5 MHz [3] is required to reduce the drive beam phase jitter to this level. A prototype of the system is being commissioned at the CLIC test facility CTF3 at CERN to prove its feasibility.

**CTF3 Phase Feedforward System**

- The phase is corrected using two kickers placed prior to the first and last dipoles in the pre-existing chicane in the TL2 transfer line: bunches arriving late are deflected on to shorter paths and bunches arriving early on to longer paths through the chicane.
- Hardware: Three phase monitors and two strip line kickers (INFN/LNF Frascati) [4,5,7], kicker amplifiers and digital processor (JAI, Oxford University) [6,7].
- Latency of the system (including cable lengths) must be less than the 380 ns time of flight between the first monitor and the first kicker.
- Goal: 30 MHz bandwidth correction with 0.2 degrees of 12 GHz resolution.

**Correlation Chicane Optics**

- The correction range for a given transverse kick is proportional to R52, and therefore it should be as large as possible.
- Dispersion must be kept below 2.0 m due to the drive beam energy spread of 1% rms at CTF3 and 10 cm physical aperture.
- Optics used for system commissioning: Dispersion below 1.2 m with R52 of 0.7 m, giving a phase shift of 10 degrees with the maximal 1.2 kV applied to the kickers.
- Response matrix measurements identified large errors in the MADX model of TL2, in particular the strength of quadrupoles reclaimed from the CELSIUS machine and the focusing behaviour of the 7 dipoles in the line.
- The mean position offset between the model and data was reduced from 3.0 ± 0.7 mm to 0.2 ± 0.1 mm by correcting these model parameters.

**Tests of Kickers**

- The first stage amplifier (limited to 345 V out of the design 1.2 kV) was available to vary the path length in the same way as the feedforward system.
- The phase shift per ampere applied to the correctors was calculated to be 13.2 ± 0.2 degrees/A, close to the model prediction of 12.3 degrees/A. This verifies the ability to shift the phase using the TL2 chicane.
- To test the slow feedback the mean beam phase was shifted ±10 degrees by changing the strength of the stretching chicane dipoles in the CTF3 linac.
- The corrector settings were recalculated every 20 pulses based on the mean phase over that time period.

- A mean phase offset of 13.0 ± 2.0 degrees after each phase shift was reduced to -0.2 ± 0.8 degrees after the reaction of the slow phase feedback.

Conclusions

- The phase feedforward prototype at CTF3 is in the final stages of commissioning. It is a significant hardware challenge in terms of the bandwidth and power of the components. The final pieces of hardware will be in place to allow phase feedforward tests to begin in late 2014.
- In preparation, work on the correction chicane optics and MADX model, the development of a slow phase feedback to prevent drifts outside the phase feedback range and tests of the amplifiers and feedforward kickers have been completed successfully.

References:

[1] D. Schulte et al., MOP024, LINAC10;
[4] F. Marcellini et al., WEPEB035, IPAC10;
[5] A. Ghigo et al., TUPCD07, IPAC11;