The Test Beam Line at the CLIC Test Facility 3

Reidar L. Lillestol (with Steffen Doebert, Erik Adli, Guido Sterbini and Maja Olvegaard)
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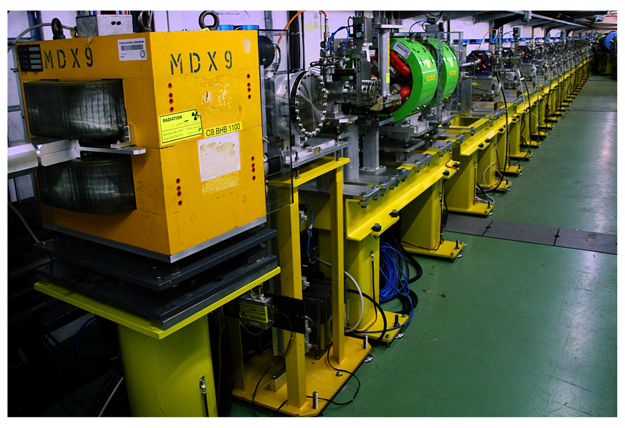
Introduction

- The Compact Linear Collider (CLIC) is a proposed future linear electron-positron collider [1], where the acceleration energy is extracted from a high-intensity electron *drive beam*.
- CLIC Test Facility 3 was set up to verify key technology concepts.
- The Test Beam Line (TBL): 55 % of the beam energy will be extracted in Power Extraction and Transfer Structures (PETS) [2].
  - Stability of a heavily decelerated beam is a CLIC feasibility issue.
  - 8 FODO cells, eventually housing 16 PETS structures.
  - 4 PETS installed and commissioned so far.



Nominal parameters

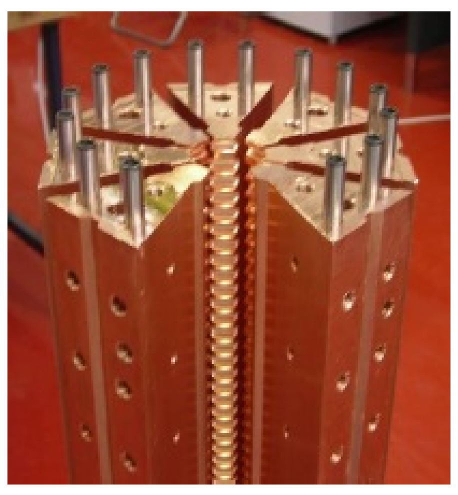
Symbol	Beam parameter	Value	Unit
E_0	Initial beam energy	150	MeV
E_{min}	Minimum final energy	67	MeV
I	Beam current	3.5–28	A
f_b	Bunch frequency	12	GHz
$F(\lambda)$	Charge distribution form factor	0.97	-

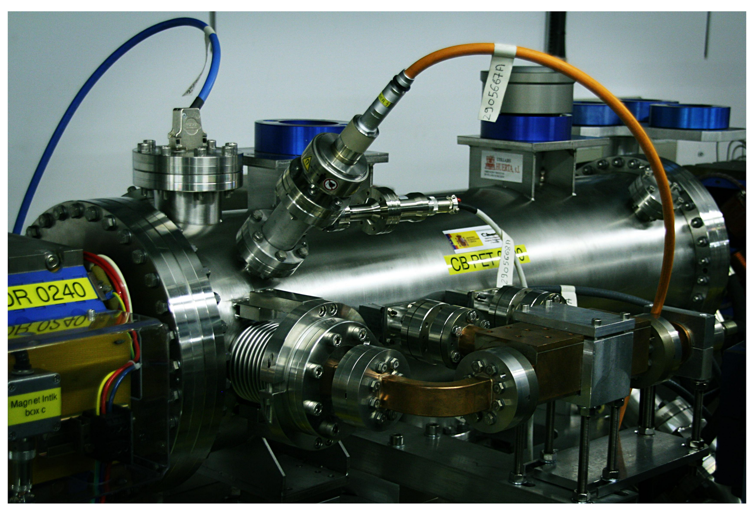
Symbol	PETS parameter	Value	Unit
L	Length	0.8	m
P	Power per PETS	≤ 135	MW
V	Deceleration per PETS	≤ 5.2	MeV
f_{rf}	Fundamental mode frequency	12	GHz
(R'/Q)	Fundamental mode impedance	2222	linac-Ω/m
v_g	Group velocity	$0.46c$	m/s
η_Ω	Ohmic loss factor	0.985	-

Power production in PETS

Power Extraction and Transfer Structure (PETS):

- Passive microwave device, contains a periodically loaded waveguide.
- Drive beam bunches see a strong impedance, and excite preferentially the 12 GHz synchronous mode.
- Power is coupled out at the end of the structure.

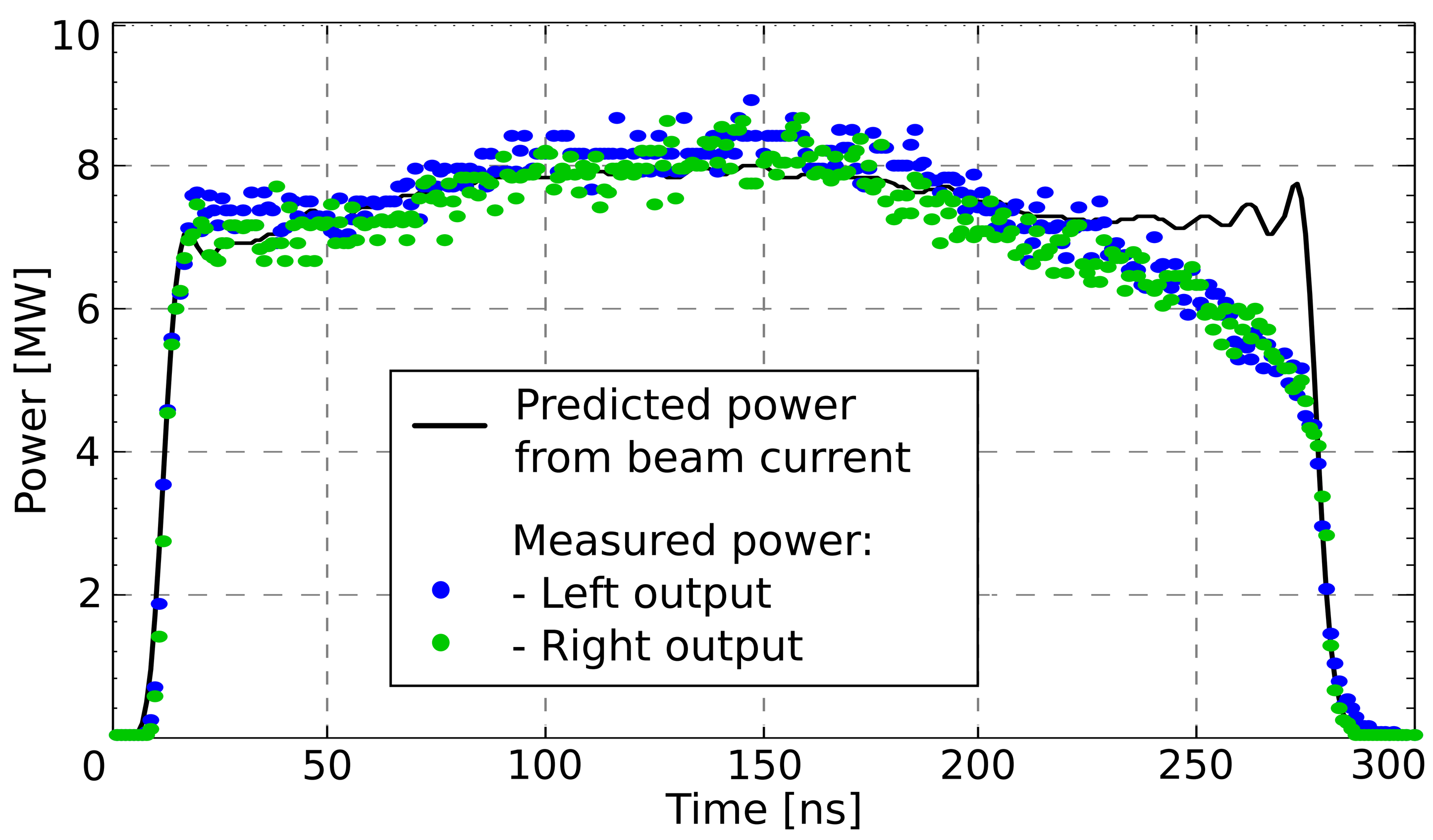




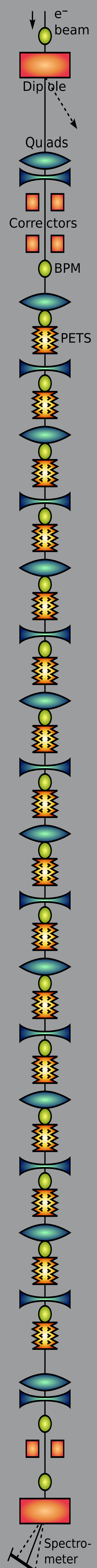
The produced rf power is given by

$$P = \frac{1}{4}(R'/Q)\frac{\omega_{rf}}{v_g}L^2 I^2 F^2(\lambda)\eta_\Omega^2$$

- Beam current I and form factor $F(\lambda)$ may vary along the pulse.
- The other parameters are structure constants.



Comparing the measured power and the measured beam current gives an indication of the form factor (and therefore the bunch length).



Deceleration

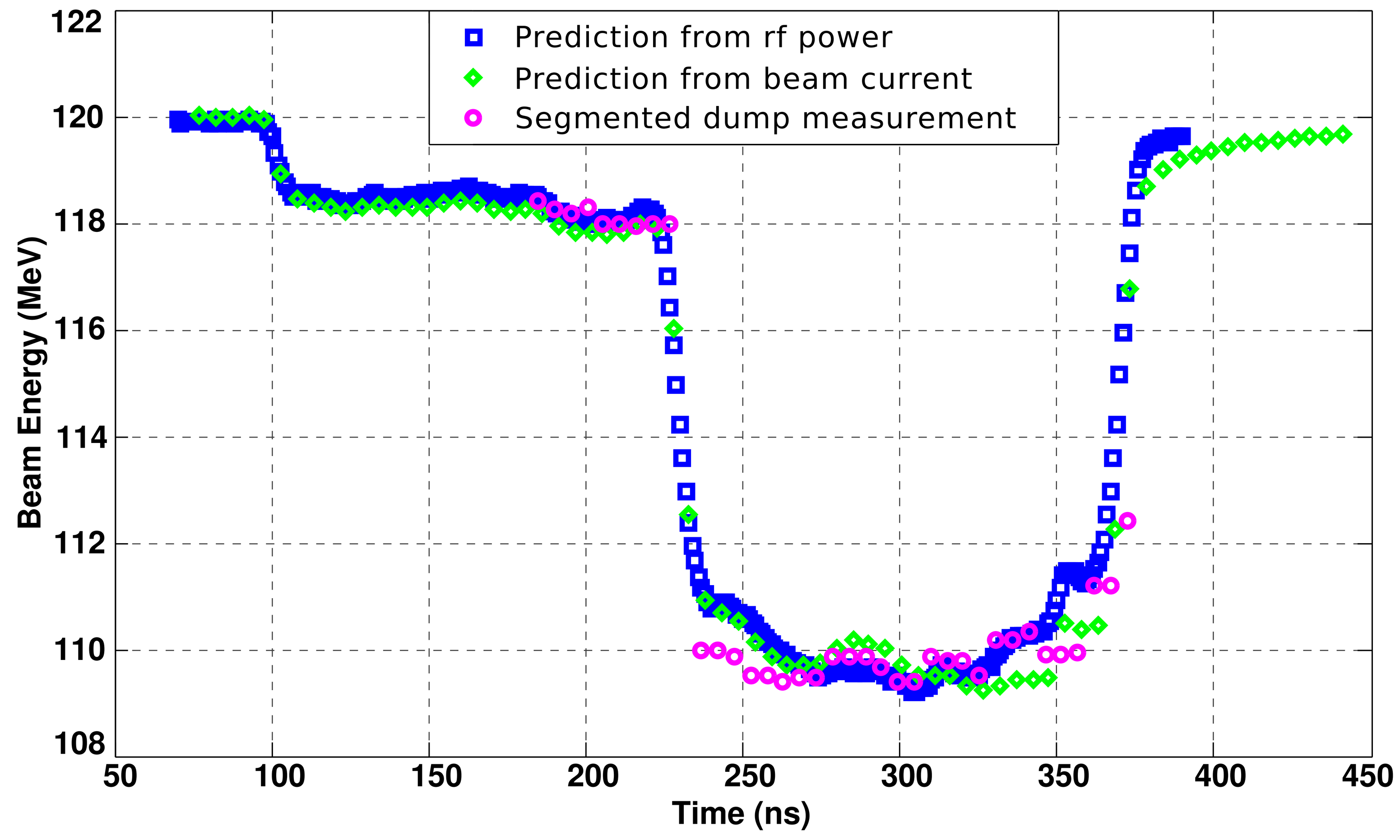
Energy is extracted from the drive beam, and the deceleration experienced by the steady state part of the beam pulse is

$$V = \frac{LF(\lambda)}{2}\sqrt{\frac{(R'/Q)\omega_{rf}}{v_g}P}$$

The deceleration can be

- Predicted from rf power measurements.
- Predicted from the beam current.
- Measured directly in the spectrometer.

Plot: Energy along the pulse (pulse preceded by satellites due to a non-optimized beam).



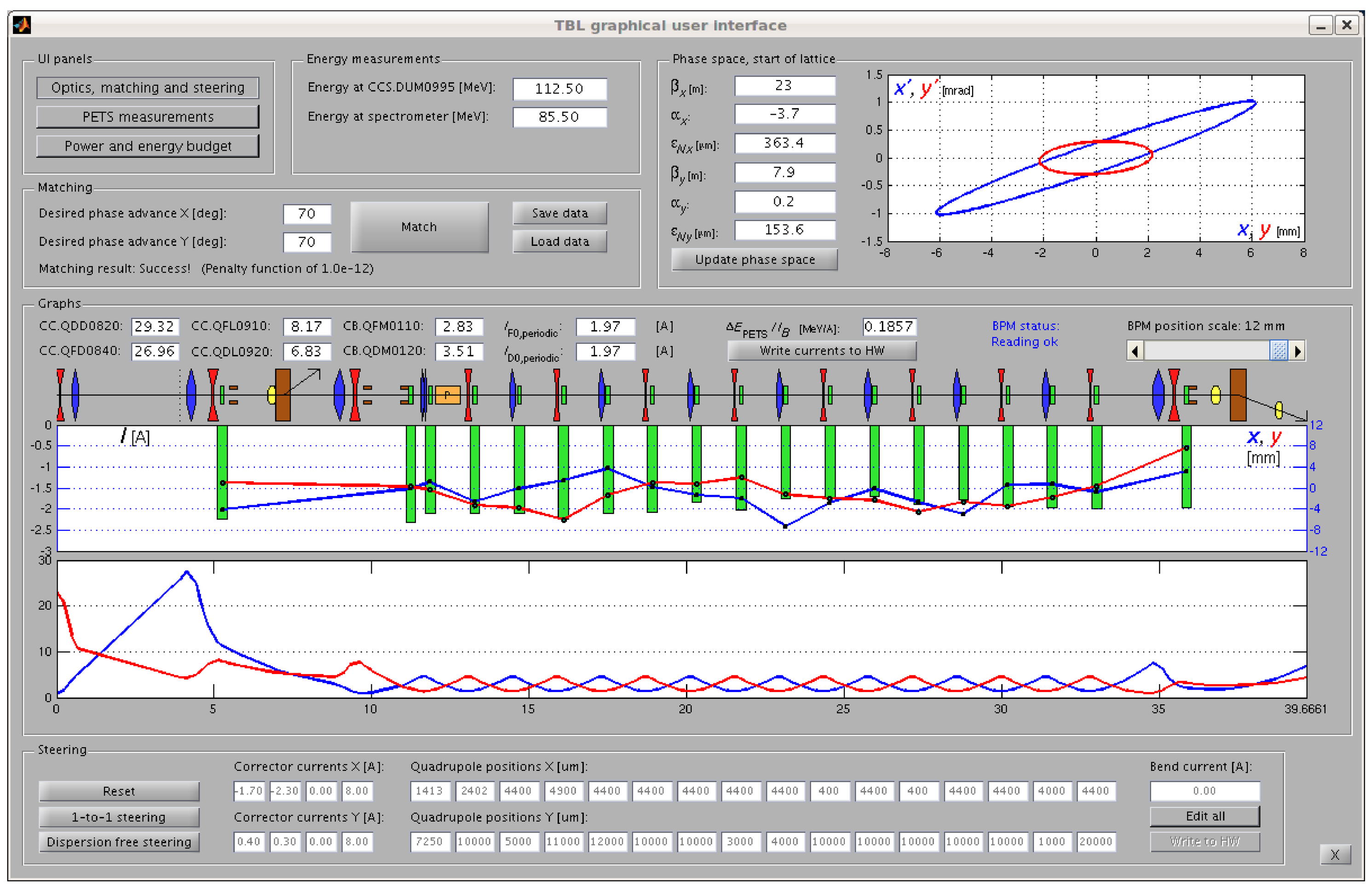
Deceleration features:

- Large energy spread.
- Lattice must be scaled to the most decelerated particles.
- 3σ envelope fills 2/3 of the aperture at the end.

Graphical User Interface

Dedicated GUI for operation and experiments

- BPM and phase space displays.
- Optics matching via interface to Mad-X.
- Automatic 1-to-1 steering via interface to Placet.



- Another operation mode for PETS experiments.
- Another operation mode for deceleration estimations.

Conclusions and outlook

The TBL has been commissioned with 4 PETS, and power production and beam deceleration is behaving as expected. 4 additional PETS are currently being installed, and 4 more will be installed in December 2011.

References

[1] G. Guignard (ed.), *A 3 TeV e+e- Linear Collider based on CLIC Technology*, CERN, 2000

[2] E. Adli, *A Study of the Beam Physics in the CLIC Drive Beam Decelerator*, PhD thesis, University of Oslo, 2009

[3] R. L. Lillestol, *Power production experiments at the Test Beam Line in the CLIC Test Facility 3*, MSc thesis, Norwegian University of Science and Technology, 2010