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

<table>
<thead>
<tr>
<th>Symbol Beam parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$E_{\text{in}}$</td>
<td>Initial beam energy</td>
<td>150 MeV</td>
</tr>
<tr>
<td>$E_{\text{fin}}$</td>
<td>Minimum final energy</td>
<td>67 MeV</td>
</tr>
<tr>
<td>$I$</td>
<td>Beam current</td>
<td>$3.5-28$ A</td>
</tr>
<tr>
<td>$f_{\text{b}}$</td>
<td>Bunch frequency</td>
<td>$12$ GHz</td>
</tr>
<tr>
<td>$F(\lambda)$</td>
<td>Charge distribution form factor</td>
<td>$0.97$ -</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Symbol PETS parameter</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>$L$</td>
<td>Length</td>
<td>$0.8$ m</td>
</tr>
<tr>
<td>$P$</td>
<td>Power per PETS</td>
<td>$\leq 135$ MW</td>
</tr>
<tr>
<td>$V$</td>
<td>Deceleration per PETS</td>
<td>$\leq 5.2$ MeV</td>
</tr>
<tr>
<td>$f_{\text{rf}}$</td>
<td>Fundamental mode frequency</td>
<td>$12$ GHz</td>
</tr>
<tr>
<td>$(R'/Q)$</td>
<td>Fundamental mode impedance</td>
<td>$2222$ linac-m</td>
</tr>
<tr>
<td>$v_g$</td>
<td>Group velocity</td>
<td>$0.46c$ m/s</td>
</tr>
<tr>
<td>$\eta_{\text{ohmic}}$</td>
<td>Ohmic loss factor</td>
<td>$0.985$ -</td>
</tr>
</tbody>
</table>

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

$$ P = \frac{1}{4} \left( \frac{R' / Q}{v_g} \right)^{f_{\text{rf}}} \left( \frac{L}{\lambda} \right)^2 F(\lambda) \eta_{\text{ohmic}}^2 $$

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

Deceleration

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

$$ V = \frac{LF(\lambda)}{2} \sqrt{\left( \frac{R' / Q}{v_g} \right) \frac{L^2}{\lambda \eta_{\text{ohmic}}}} $$

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.
- $3\sigma$ 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


http://clic-study.org

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