# Test Beam Line status

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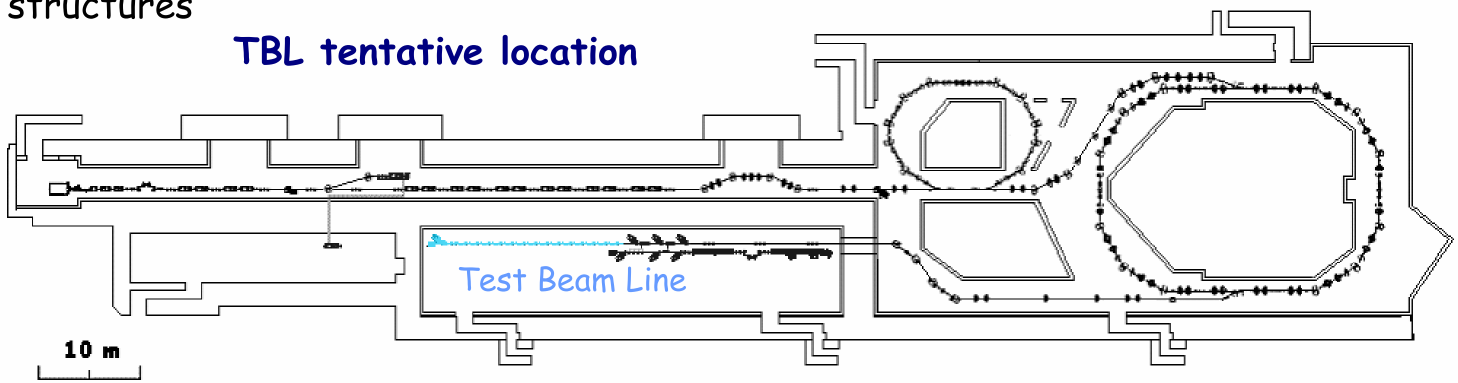
# TBL motivation

Recommended R2 R&D issues for CLIC from the ILC-TRC report

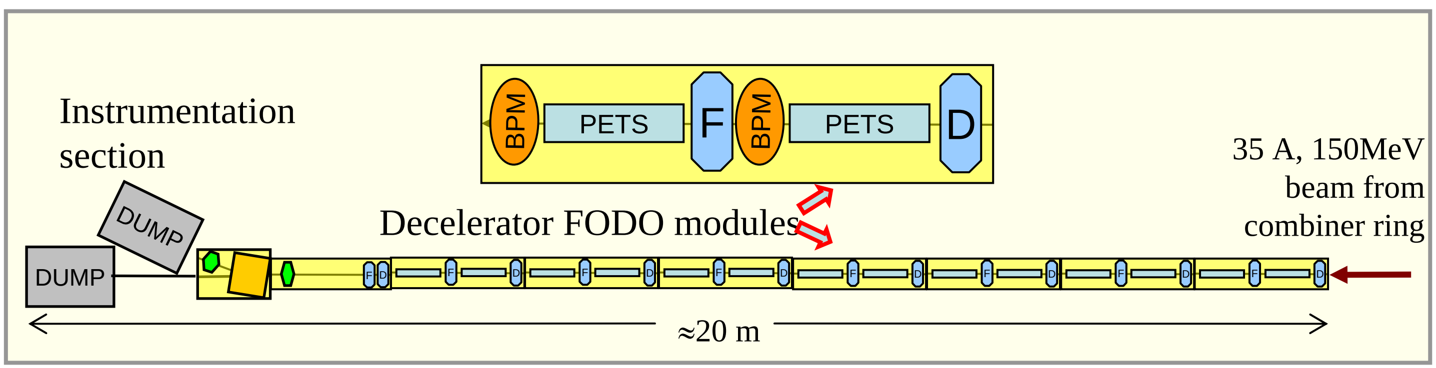
(ILC-TRC=International Linear Collider – Technical Review Committee)

"The very high power of the drive beam and its stability are serious concerns for CLIC. The drive beam stability should be validated, and the drive beam Machine Protection System, which is likely to be a complex system, should be designed to protect the decelerator structures"

**TBL tentative location**




**Design considerations**




D. Schulte and I. Syratchev, 30.11.2005, CTF3 collaboration meeting

**Main concerns for CLIC drive beam decelerators**

- Beam of very high current and damage potential
- Total energy spread of up to 90%
- Considerable transverse wakefields
- Very different from any existing beams

TBL as a scaled model of a CLIC drive beam decelerator allows to test operation and instrumentation for such a decelerator and to benchmark the predictive power of numerical simulation tools !

**Main concerns for TBL**

- The initial drive beam energy is well below that of the final beam energy in CLIC
- The beam size can not be considered much smaller than the PETS aperture, as it is for CLIC
- The low beam current leads to less coupling to the impedances
- The available length

| TBL tentative parameters comparison with CLIC decelerator | | |
|---|---|---|
| | CLIC | TBL |
| Beam energy GeV | 2.37 | 0.15 |
| Beam current (A) | 176 | 35 |
| Bunch spacing (cm) | 2.0 | 2.0 |
| RMS bunch length (μm) | 400 | 400 |
| RF pulse length (ns) | 70 | 140 |
| Total length (m) | 624 | ~20 |

# What do we really want to benchmark?

The computer codes?

If the codes, then other existing codes can be used to do it better.

or

The models used?

We suggest, that the TBL should be built to verify the model and if this happened, to find an unexpected results. Due to the much lower energy in TBL and the large transverse beam size, we should revise all the component performances, which we believe will not be the case for the CLIC drive beam decelerator.

# What kind of TBL performance would we like to demonstrate?

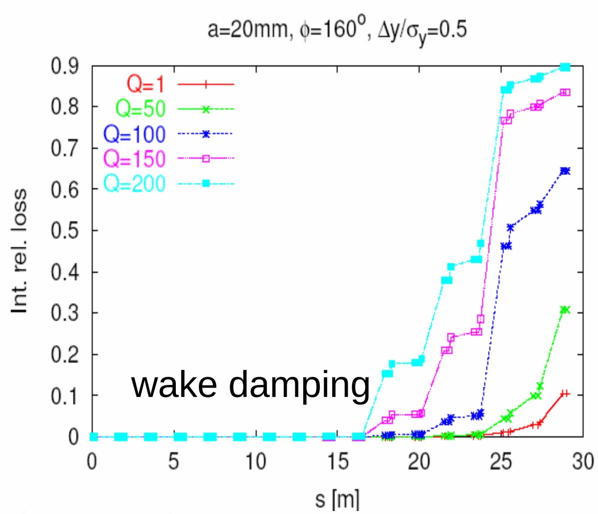
Option #1. The TBL should be predictably unstable at the highest drive beam power and could be brought back to stable operation using available means (beam current and energy, lattice strength, wake damping or decelerator length). Due to the exponential nature of the instability growth, we will need to tune the amplification in a very broad range: from ~1 to 1000.
The extracted beam power will be different for the two regimes of operation.

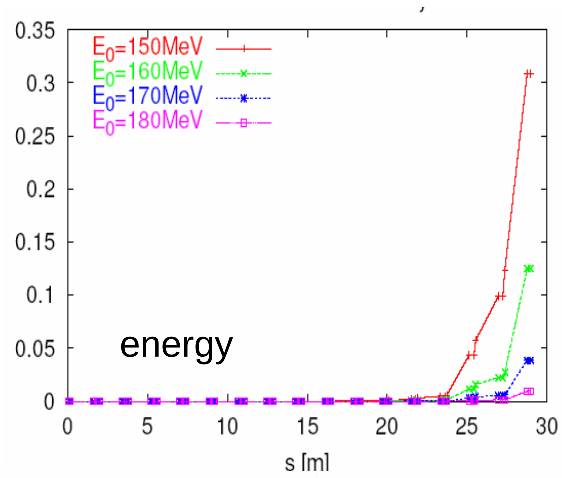
Option #2. We want to verify the wakefield performance of the CLIC PETS.
To do this we will need to provide coherent broad band kickers and BPM's for the drive beam, because we need to be able to control the noise level which should be high enough to provide suitable amplification. Small (~10%) deceleration will be granted. To get higher deceleration the scaled PETS can also be considered.

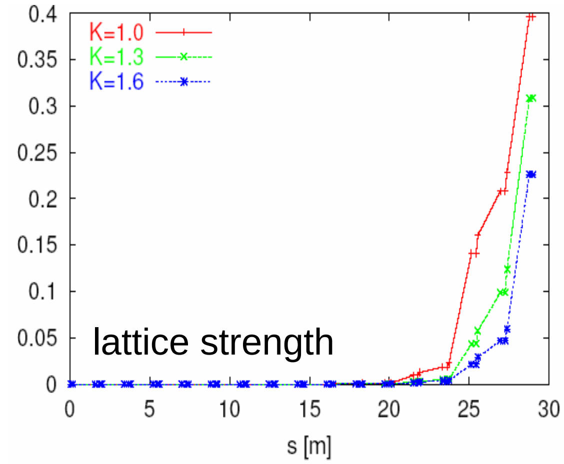
Option #3. The TBL should be able to extract most of the beam power and provide stable operation. This will require special design of the PETS (or the set of different ones) to make it at a restricted length. We suggest that in this case the amplification the wakefields will be comparable or worse than that in CLIC.

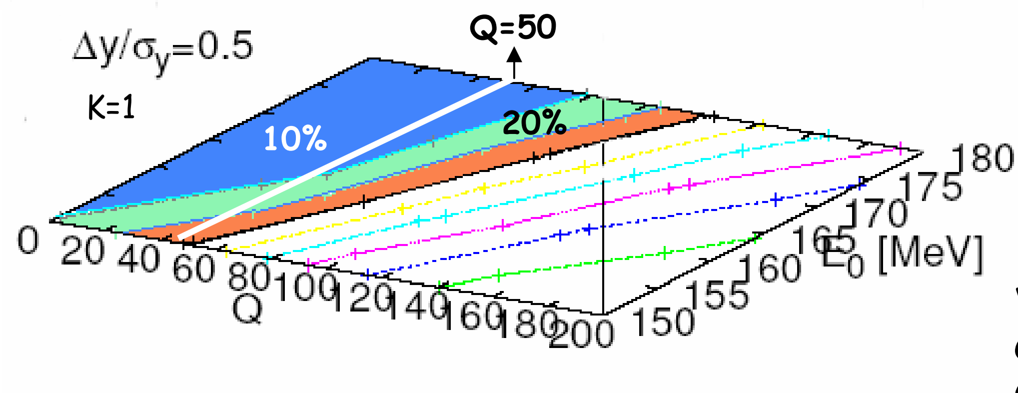
# TBL option #1

Example: TBL made of 16, **2 m long** 20mm aperture structure. Beam power extraction 90% at 150 MeV. (presented at the last CTF3 Collaboration meeting). The simulations have been done for the total beam offset.



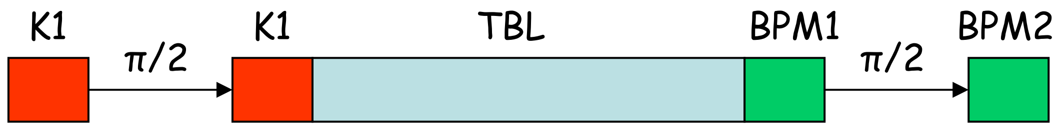




What beam losses can we accept?
Can we build such long structures?
Can we tune the wake damping while operating?
Should we reduce the extraction (linac length)?

The beam energy and lattice strength do not give much room for tuning (all happened in the ~last structure)
The change of beam current seriously affect extraction.

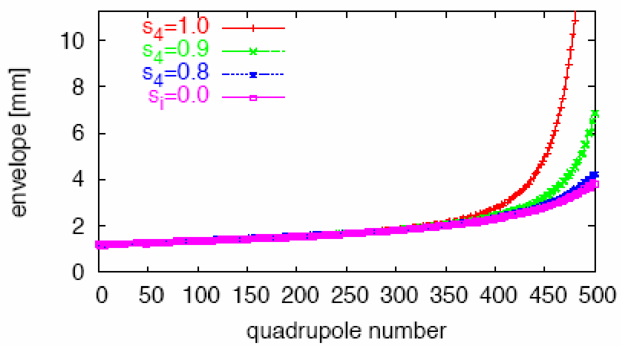
# TBL option #2

For this option one can think to use the broad band (7.5 GHz) resonant kickers and BPMs. This will allow measurement of the wakefield spectra of the whole TBL with high precision and possibly without significant beam losses. (presented at PAC 2005)




CLIC PETS without detuning

| Mode | $f$ [GHz] | $w_0$ [V/pCm$^2$] | $Q$ | $\beta$ |
|---|---|---|---|---|
| 1 | 28.216 | 2100 | 45.3 | 0.892 |
| 2 | 35.179 | 900 | 44.7 | 0.643 |
| 3 | 41.680 | 48 | 578 | 0.05 |
| 4 | 46.278 | 163 | 1940 | 0.12 |
| 5 | 4.898 | 20 | 4600 | 0 |

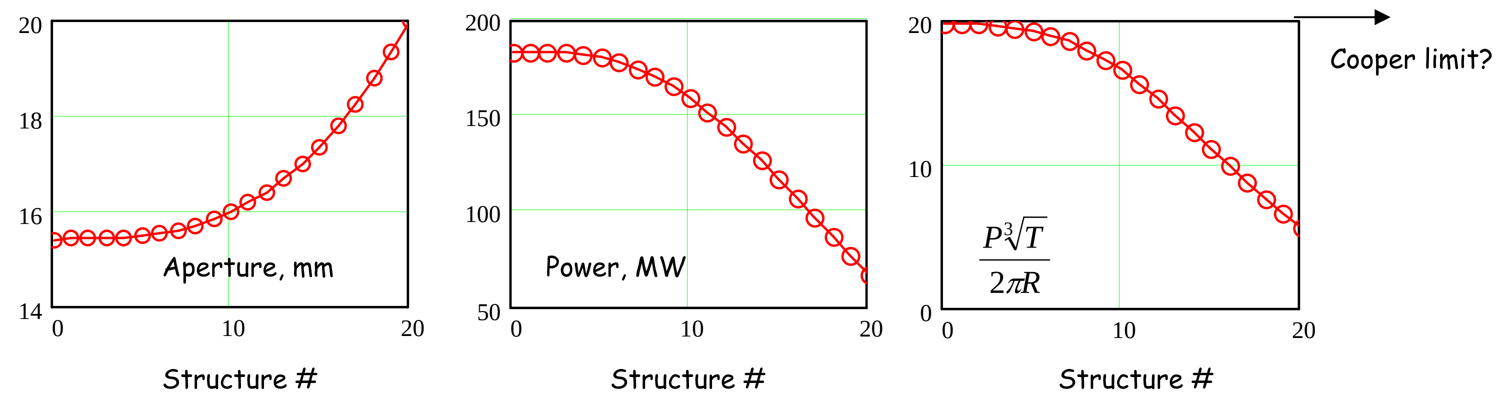



The mode #4 can cause the beam losses in the CLIC drive beam decelerator

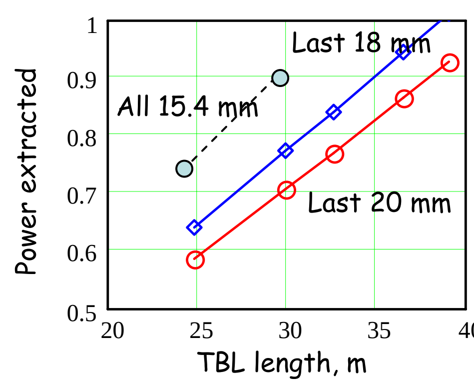
Simulations of the TBL build of 28 CLIC PETS with reduced focusing resulted in a factor of 5 the amplification at the frequency of the dangerous mode . 12% of the beam power is extracted in this case. Potentially, the study of the modes which are sufficiently damped but have rather high kick factors (i.e. modes #1,#2) can be done using CLIC PETS with doubled length.

To extract, at the limited distance, as much power as possible from the drive beam, the small aperture structure is preferable. Following the RF constrains, established for the CLIC accelerating structure, the 15.4 mm should be accepted as the smallest possible for the given mechanical constrain, which will limit the structure length to about 1 m (0.8 m active). To provide the stable transport of the beam, the structures can be built of different types (apertures). For example they can follow the beam envelope, this will bring certain detuning of the transverse modes. Together with heavy damping, the TBL can be design to operate stable. The actual profile should be determined after TBL simulations with PLACET.

Example ($a(n)=a_0+\Delta a x n^3/N^3$): 20 structures, 0.8 m long, total extraction 65 %, pulse length 140 ns



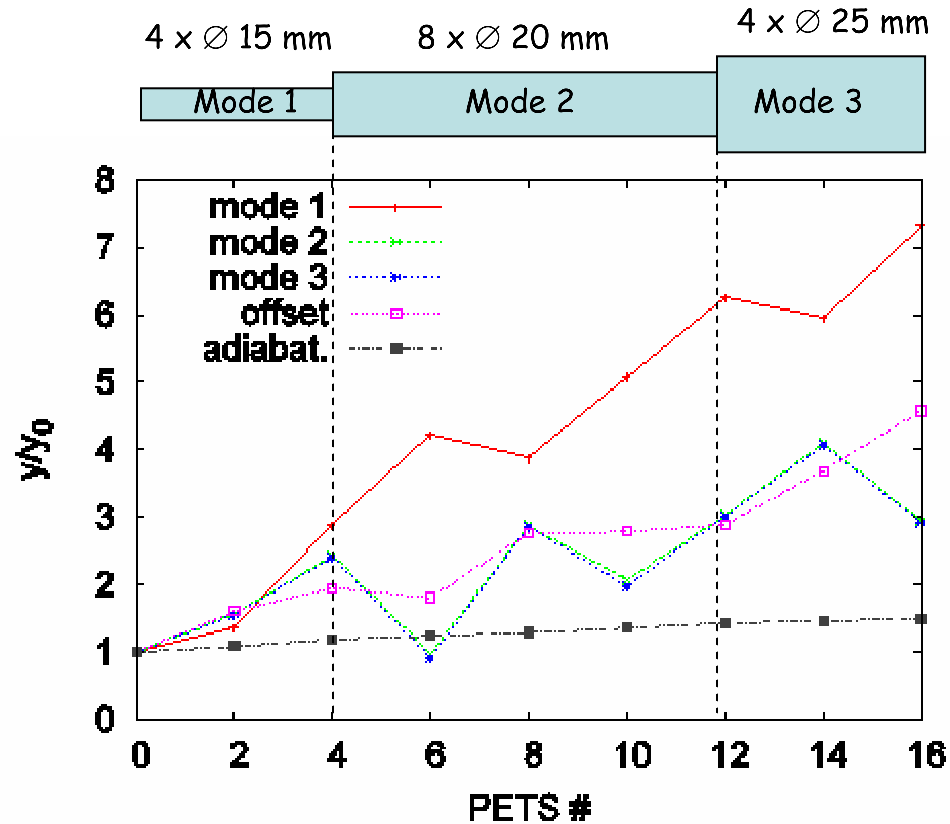

The 1.3 m physical length for single PETS including the quad and BMP have been scaled from the CLIC design. Thus, the total deceleration will be scaled with a number of structures.




Note, if the structure length were to be a free parameter, than for the constant aperture TBL, the total length ~30 m will be optimal to extract 90% power.

# TBL option #3

Example: TBL made of 16 1.0 m long structures.
Deceleration 55%.




PLACET was recently modified to accept multi-modes, multi-structures analysis. The TBL was analyzed in approximation for the single transverse mode and artificial damping (Q=50).

For this configuration we can expect stable operation (no beam losses) and relatively high beam power extraction.

Here we take a risk that the spectrum of the transverse beam jitter does not contain the frequencies equal to the transverse mode frequencies of the individual structure.

# Next steps

| | |
|---|---|
| Now! | ➢ We should agree on the TBL configuration |
| summer 2006 | ➢ The detailed study of the PETS with different apertures should be done (incl. Gdfidl). A new power coupler should be designed if needed.<br><br>➢ Beam dynamic simulation will follow |
| summer 2007 | ➢ TBL full design<br><br>➢ PETS prototype (or prototypes) followed by serial production |
| | ➢ TBL has to be operational for spring 2008 |