RF Power production at CTF3

- 30 GHz power production
- 12 GHz power production in the Two Beam Test Stand (TBTS)
- 12 GHz power using the Test Beam Line (TBL)
- 12 GHz stand alone power source
Rf power production with CTF3

Drive Beam Injector
- 16 structures - 3 GHz - 7 MV/m

Drive Beam Accelerator
- 4 A - 1.2 μs
- 1.5 GHz, 150 MeV

X 2 Delay Loop

X 4 Combiner Ring

Probe Beam Injector
- 30 A - 140 ns
- 12 GHz, 150 MeV

30 GHz Test stand
- 65 MW, 100 ns

Two Beam Test stand 12 GHz
- 200 MW, 140 ns
- TBL, 16*150 MW, 140 ns

Stand alone 12 GHz test stand in CTF2, 50 MW klystron + pulse compressor
30 GHz Power Production

Up to 60 MW for testing

36% Power lost in ‘Translation’

Up to 100 MW out of PETS
Automatic conditioning

Pulse to pulse data acquisition for history and waveforms for trips
# Automatic conditioning, strategy and interlocks

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<th>Number events</th>
<th>Pulse length</th>
<th>Stepping Motor</th>
<th>Wait</th>
<th>Threshold</th>
<th>Enable Threshold</th>
<th>Incid. Power Threshold</th>
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# Programmable trip detection method and switch on procedure
The 12 GHz PETS

\[ P = I^2L^2F_b^2\omega_0 \frac{R/Q}{V_g 4} \]

E max (135 MW)=56 MV/m

H max (135 MW)=0.08 MA/m

One of the eight PETS bars
PETS high power test in the TBTS

Different drive beams generated in the CTF3

<table>
<thead>
<tr>
<th>Operation mode</th>
<th>#1</th>
<th>#2</th>
<th>#3</th>
<th>CLIC</th>
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<tbody>
<tr>
<td>Current, A</td>
<td>&lt;30 A</td>
<td>14 A</td>
<td>4 A</td>
<td>101</td>
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<td>Pulse length, ns</td>
<td>140 ns</td>
<td>&lt;240 ns</td>
<td>&lt;1200 ns</td>
<td>240</td>
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<tr>
<td>Bunch Frequency, GHz</td>
<td>12 GHz</td>
<td>12 GHz</td>
<td>3 GHz</td>
<td>12</td>
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<tr>
<td>PETS power (12 GHz), MW</td>
<td>&lt;280 MW</td>
<td>61 MW</td>
<td>5 MW</td>
<td>135</td>
</tr>
</tbody>
</table>

Round trip efficiency: 75%
Round trip delay: 22 ns

Variable Splitter (coupling: 0→1)
Variable phase shifter

Expected PETS power production with re-circulation. The calculation followed the measured performance of all the components

I. Syratchev
Variable high power RF power splitter

Variable high power RF phase shifter

Fully equipped 1 m long TBTS PETS

Two Beam Test Stand (TBTS)

Drive beam

PETS tank with re-circulation RF circuit installed in TBTS test area (October 2008)

I. Syratchev
PETS processing history in 2008

Conditioned to about 30 MW, 150 ns flat top
High power test, first results

\[ P_{\text{mod}} = c^2 P_{\text{meas}} = (0.78)^2 P_{\text{meas}} \]

(bunch length 2.8 mm rms)

E. Adli
Objective: to understand the limiting factors for the PETS ultimate performance

What matters is the output section!

I. Syratchev
- High energy spread beam transport, low losses (Bench mark simulations)
- RF Power Production, Stability (End Energy <50%, 2.4 GW of RF power)
- Alignment
  - Active Quad alignment with movers (Test procedures for BBA, DFS)
  - 100 microns pre-alignment for PETS
- Drive Beam Stability, Wake fields (no direct measurement of the wake fields)
- ‘Realistic’ show case of a CLIC decelerator
- Industrialization of complicated RF components
TBL cell
Happy Team after finishing the first tank
Prototype module installed in April 2009

BPM, IFC, UPC, LAPP

Quad Mover, CIEMAT

PETS-tank, CIEMAT

Quad, BINP

BPM, IFC, UPC, LAPP
Organize and launch production of at least 7 more PETS with our collaborations to be commissioned with beam in 2010.

Approach: parallel fabrication at CIEMAT and CERN using multiples vendors

CDR demonstration measurement milestones at the end of 2010

Complete TBL with 16 PETS in 2011

Full demonstration of drive beam decelerator end of 2011

> 2012 use TBL as a 12 GHz power source, rf conditioning with beam (up to 16 testing slots would be possible)
16 PETS

$E_0 = 150$ MeV

$I = 28$ A

Energy extraction: 56%

2.2 GW of rf power
Stand alone 12 GHZ test stand with independent bunker (CTF2) and option to use the power synchronized with beam in CTF3 50 MW klystron form SLAC, pulse compressor from the beginning

K. Schirm, F. Peauger
Modulator

Status: ordered
Pulse Compressor: Gycom

Two modes (H01+H02) mode mixing taper

TE_{01} + TE_{02}

3-dB coupler

Courtesy: I. Syratchev

Status: ordered
Goal is to be operational in Summer 2010
30 GHz power source will stop operating at the end of this year.
We basically finished our testing program at 30 GHz.

TBTS will come online in fall with a first 12 GHz structure test and two beam acceleration experiments. It will be challenging to operate at the beginning.

TBL should produce power soon and is effectively a test for PETS but the power will be used only after 2012 for accelerating structure testing.

The 12 GHz klystron based test stand should be available in summer 2010 and is considered as the new work horse for CLIC structure testing. We are already thinking of a klystron based structure testing plant with of the order of 10 testing slots.

Conclusion
Up to 2010: CLIC feasibility testing, rely on collaboration with SLAC and KEK at 11.4 GHz

2011 -2012: ~ 6 structure tests/year at 12 GHz, stand alone test stand + a few in the TBTS

2013 -2016: In case we enter into the TDR phase
TBL as power source
Klystron base structure testing plant
Goal: ~ 50 structure tests/year
TBL beam dynamics

Beam envelope along the lattice:

3-σ beam envelope along lattice (adiabatic effects alone)

Energy distribution of the beam:

Beam energy after lattice: $1m \sim 3$ ns

Energy distribution of a bunch (steady-state):

Steady state bunch energy profile
HOM damping in PETS
1. With proposed scheme we can guarantee the strong (< -20 dB) suppression of the RF power delivery to the accelerating structure.

2. In a case of the breakdown in PETS the RF pulse time structure and 25% saturated power allow to expect the PETS safe behavior.

The choke-based reflector concept.
The short position in choke moved by 5.4 mm

PETS ON/OFF

ON

OFF

Coaxial stop-band filter

Circular waveguide (TEH1)
Conditioning history

![Graphs showing conditioning history](image-url)
The PETS are large aperture, high-group velocity and overmoded periodic structures. In its final configuration, PETS comprises eight octants separated by 2.2 mm wide damping slots.
Installation of prototype beam line completed, waiting for beam
(3 Quads on movers, 3 BPM’s and 1 PETS tank with undamped PETS)

Beam line without PETS tanks will be finished this fall

Prototyping:

- PETS tank: engineered and manufactured by CIEMAT
  (low level measurements performed and accepted)

- BPM’s: smaller version of CTF3 type BPM, made by IFC Valencia
  Electronics from UPC Barcelona and LAPP Annecy
  (basic tests with beam done)

- Quads: Designed at CERN and manufactured by BINP Russia

- Quad-Movers: engineered and manufactured by CIEMAT
  (tests demonstrated the micron level accuracy)
Produce nominal 28 A beam and nominal CLIC power (135 MW) with at least 8 PETS and 100% transmission (120 MeV from CTF3). This corresponds to 35% power extraction.

- Beam based quad alignment with movers to optimize transmission and transverse beam parameters.
- Detailed energy and energy spread measurements to verify deceleration.
- Streak camera measurements before and after TBL.
- Monitor rf power production stability, amplitude and phase (% level in amplitude, 1 degree in phase).
- Measure beam properties and compare with simulations.
- Controlled misalignment of quads, measure effect?
- Controlled beam offset in PETS, measure effect?