# CLIC issue: PETS

1. **Short technical description and corresponding category(ies) of issues :**

| Feasibility | Performance | Cost |
|---|---|---|
| X | X | X |

2. **CLIC nominal parameter issues and comparison with state of the art (in text and/or table):**

| Parameter | Unit | Target value CLIC nominal | Present state of the art | Objective 2010 | Objective 2012 |
|---|---|---|---|---|---|
| Power (including overhead for in-situ reconditioning rf system) | MW | Nominal:<br>CLIC 3.0: 131.5<br>CLIC 0.5: 153<br>Overhead: 145-165? | 160 | 135 | 165 |
| Pulse length with ramp | ns | 240 | 132 | 240 | 240 |
| Breakdown rate | /structure | $10^{-7}$ | Will be known soon | $10^{-7}$ | |
| Pulse shape accuracy for beam loading compensation (really drive beam issue) | % | 0.1 | To be defined | | |
| Short-range wakefield | V/pC/m/mm | 9 | | | |
| Long- range wakefield | V/pC/m/mm | | | | |
| Power adjustment | | On/off/adjust | Under technical design | Slow prototype validation | Fast option validation |

State of the art (achieved performances):

There are two distinct programs of high-power rf tests of the PETS underway – one powered by a klystron (waveguide mode) and the other powered by beam – which taken together allow us to investigate the different performance requirements. Neither test is finished, values indicated in the table are only those achieved so far. It should be specially mentioned, that both PETS are not yet quipped with damping material. The first fully equipped structure will be tested at SLAC beginning 2010.

Klystron-powered test at SLAC:

- 160 MW peak power reached (not yet breakdown limited, mostly out-gassing)
- 132 ns, 80% rectangular pulse
- Breakdown rate not measured yet

- Still conditioning at 60 Hz (about 200 hours of conditioning have been accumulated)

Beam-powered test in TBTS/CTF3

- 30 MW in recirculation mode
- 250 ns total pulse length, 150 ns flattish-top
- Breakdown rate not measured yet (few breakdowns were already observed)
- 24 hours of conditioning at 0.8 Hz have been done (re-starts in June 2009)

The ON/OFF proof of principle prototype device is under mechanical design at CERN. It is planned to be tested at SLAC by the end of 2009.

3. **R&D program presently set-up**:

The PETS R&D program consists of the following technological, experimental and theoretical activities:

- RF design (currently the PETS HOM damping performance is undergoing the improvement)
- Engineering, integration and costing
- Fabrication and manufacture (about 6 companies worldwide are already qualified)
- High-power RF test areas and testing
- Power on/off/adjust technique.

In addition the PETS R&D program is closely integrated with the accelerating structure development program so issues such as high-power RF simulation and experimental studies including breakdown, dark current and pulsed surface heating are covered as well.

For details, please see:

[1] I. Syratchev et. al, 'High Power Testing of X-band CLIC Power Generating structure', Proceedings of PAC 2009, Vancouver, Canada.
[2] I. Syratchev, 'PETS and drive beam development for CLIC', 2nd X-band workshop, December 2008, Daresbury, UK.
[3] I. Syratchev et. al, 'CLIC RF high power production testing program', Proceeding of EPAC 2008, Genoa, Italy.

4. **What performances will realistically be achieved (Target Performances):**
   - **by end 2010**

Operation of at least two more PETS in klystron-driven waveguide mode equipped with damping material (not necessary the final CLIC choice) and possibly different preparation technology (heat treatment for example):

- Minimum 135 MW, up to at maximum165 MW power as a target
- 240 ns pulse length
- a measured breakdown rate in the range of a few times $10^{-7}$ /m
- operation of a few thousand hours after conditioning of at least one of the PETS.

20.8 A beam-powered test of a single PETS (without re-circulation) in the TBTS/CTF3

- 135 MW (with 28 A potentially available in CLEX, the peak power can reach 240 MW)
- 140 ns total pulse length
- A measured breakdown rate in the range of $10^{-4}$ or lower
- Operation of a few hundred hours at 1 Hz

7.4(10) A beam-powered test of a single PETS with external recirculation in TBTS/CTF3

- 135[CLIC nominal](81) MW circulating power, 65(65) MW [CLIC 3.0 nominal] available for accelerating testing
- 250 ns total pulse length, 100(170 – CLIC nominal) ns flattish-top
- A measured breakdown rate in the range of $10^{-4}$ or lower
- Operation of a few hundred hours at 5 Hz
- On/off/adjust will be demonstrated using the external reflection/recirculation system mounted on one of the PETS in TBL.

These tests taken together will constitute the PETS power production feasibility demonstration.

- **by end 2012 (including FP7)**

28 A beam-powered test of at least eight PETS in the TBL/CTF3

- 135 MW per PETS
- 140 ns total pulse length
- A measured breakdown rate per structure in the range of $10^{-4}$ or lower
- Operation of at least one thousand hours at 5 Hz
- Beam measurements to verify wakefield model

- The test module foreseen in the framework of FP7 will not address feasibility issues for the PETS due to low power production capacity.

The ultimate PETS power performance (200 MW?). To follow the results obtained at the earlier stages, with improved design and technology if possible.

This will constitute the first major performance demonstration.

5. **Comments on validation of CLIC parameters issues by comparison with Target Performances:**

PETS RF power ultimate capability will be directly demonstrated by experiments. Wakefields will be calculated (at CERN and at SLAC using different computer codes) and measured/benchmarked in TBL/CTF3. Mechanical tolerances will be measured directly by 3D dimensional control and by using sliding antenna method with low RF power.

6. **Optional: What additional R&D could be set-up to eventually reach the validation of nominal CLIC parameters (estimation of resources and schedule?)**

   - Short term (< end 2009). One FTE is urgently needed to provide the suitable damping material for the CLIC structures (measurements, visiting the companies etc.)
   - Medium term (< end 2010). Three 12 GHz CLIC PETS (incl. damping, cooling, vacuum system accordingly to CLIC layout) equipped with on/off mechanism (without recirculation but tunable reflection) should be built to be ready to be tested at the 12 GHz stand alone power source before 2012.