# CLIC RF High Power Production Testing Program

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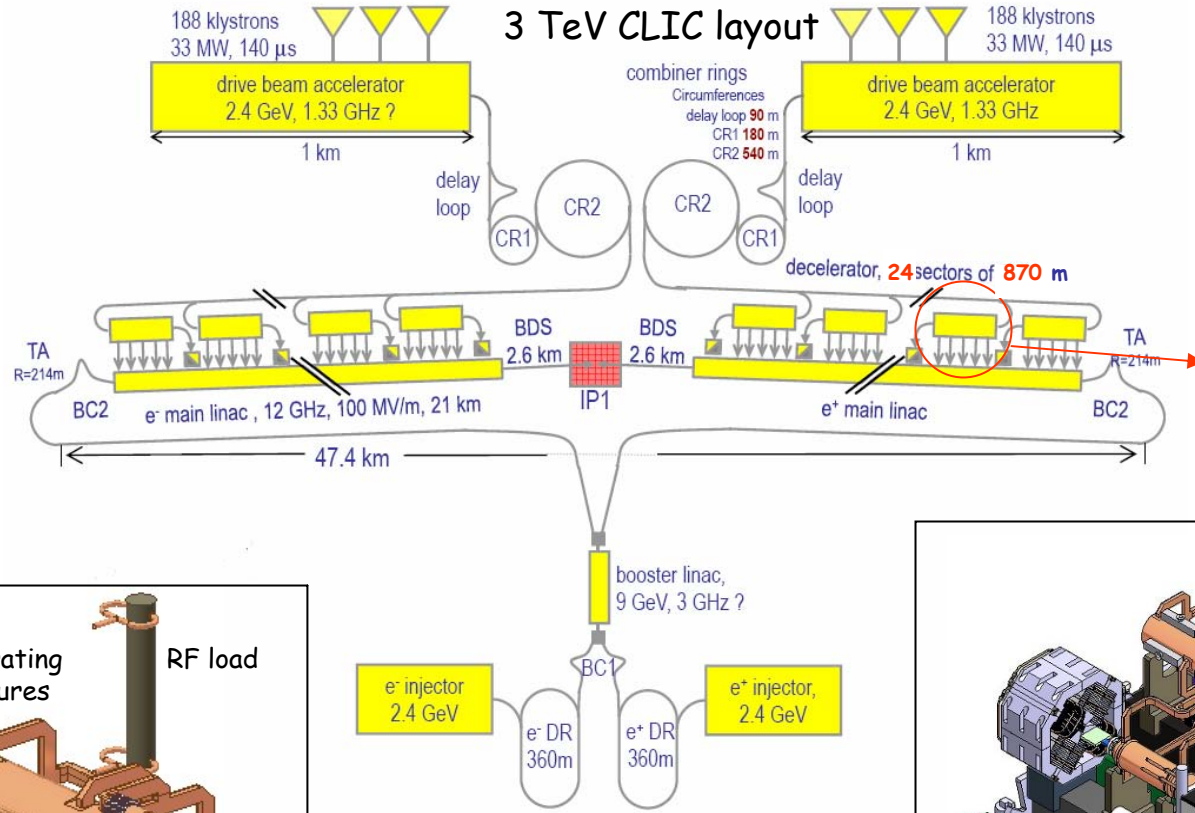
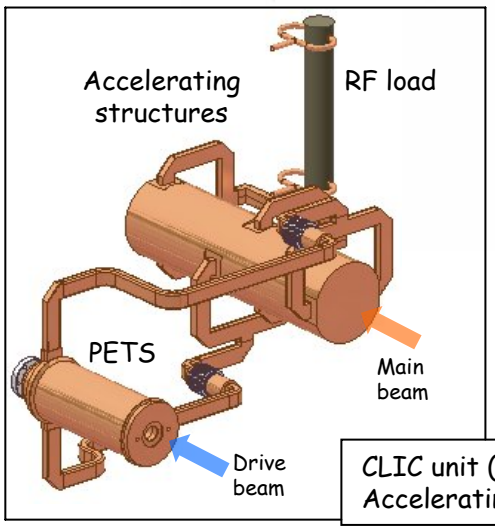
The CLIC Power Extraction and Transfer Structure (PETS) is a passive microwave device in which bunches of the intensive drive beam interact with the low constant impedance of the periodically loaded waveguide and generate RF power for the main linac accelerating structure.

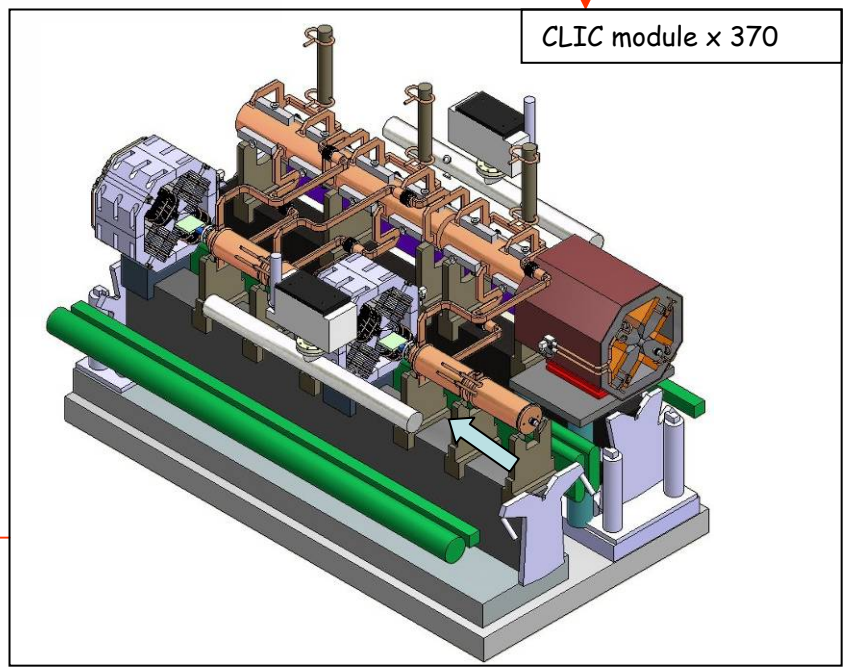



CLIC Decelerator sector x 24

CLIC module x 370




CLIC unit (1 PETS x 2 Accelerating structures) x 4



The demands on the high power production (135 MW) and the needs to transport the 100 A drive beam in a presence of the 90% beam energy spread for about 1 km without losses, makes the PETS design rather unique and the operation very challenging.

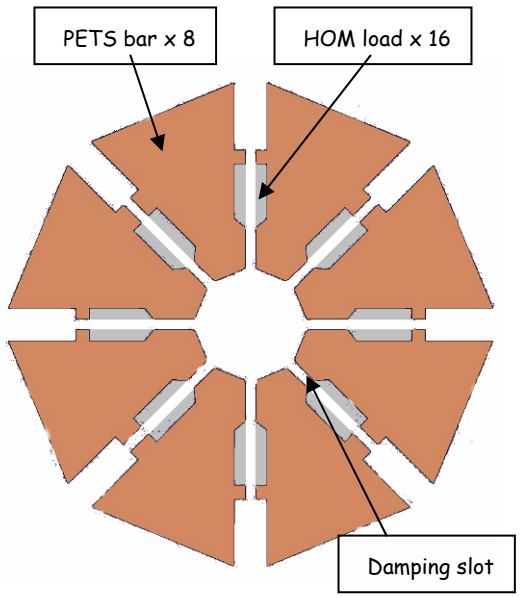
Following the design of the current CLIC accelerating structure [1] in the beginning of 2008, the PETS baseline design was finalized:

- Frequency = 11.9942 GHz
- **Diameter = 23 mm**
- **Active length = 0.213** (34 cells)
- Period = 6.253 mm (90$^0$/cell)
- Iris thickness = 2 mm
- Damping slot width = 2.2 mm
- R/Q = 2222 Ω/m
- V group= 0.459C
- Q = 7200
- **Power = 135 MW**
- E surf. (135 MW)= 56 MV/m
- H surf. (135 MW) = 0.08 MA/m (ΔT max (240 ns, Cu) = 1.8 C$^0$)

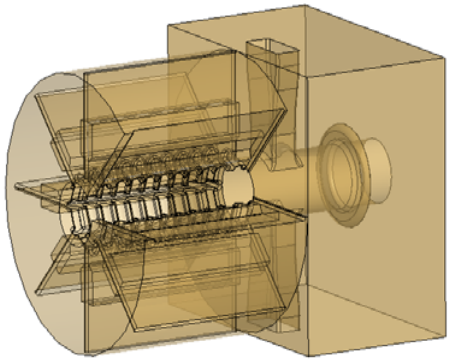
- **Drive beam current = 101 A**
- **Drive beam energy = 2.4→0.24 GeV**
- **Drive beam pulse length = 240 ns**

Each PETS is comprised of eight octants separated by the damping slots [2] . This arrangement follows the need to provide strong damping of the transverse modes

PETS cross-section

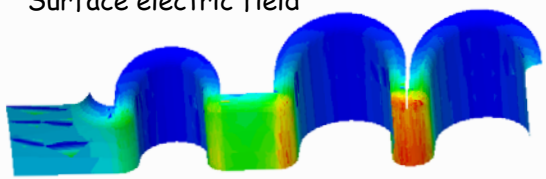



The upstream end of the PETS is equipped with a special matching cell and the output coupler

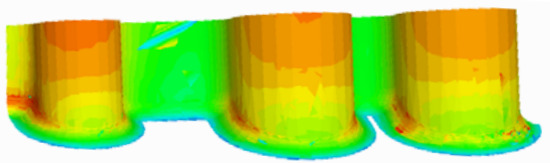


To reduce the surface field concentration in the presence of the damping slot, the special profiling of the iris was introduced.

Surface electric field

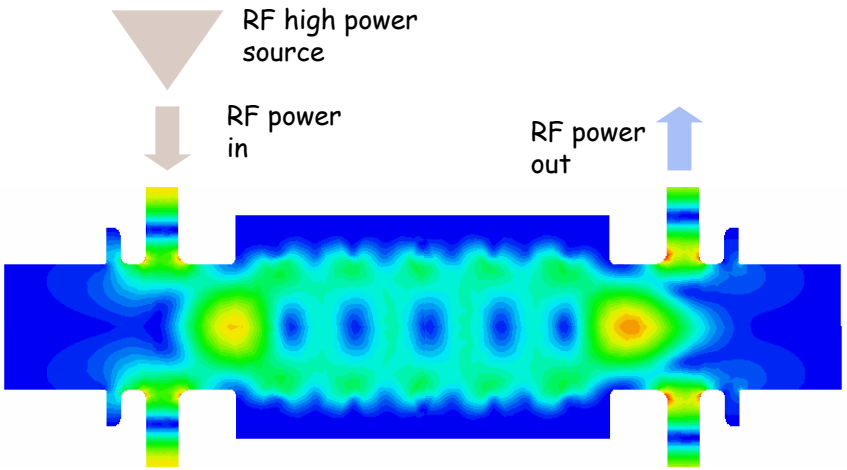


Surface magnetic field



[1] W. Wuensch, "CLIC accelerating structure development ", this conference (THXM01 ).
[2] I. Syratchev et al., "High RF Power Production for CLIC", Proceedings of the PAC 2007, Albuquerque, pp. 2194-2196

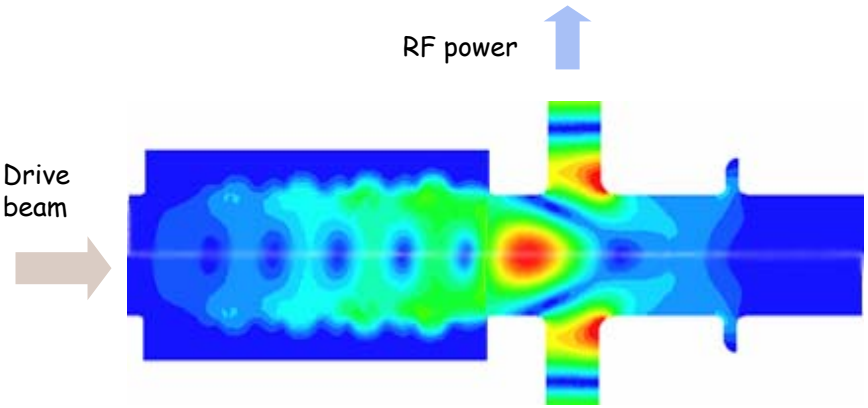
## PETS testing in "waveguide mode" (SLAC)




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

- Access to the very high power levels (300 MW) and nominal CLIC pulse length.
- High repetition rate – 60 Hz.

## PETS power production from the drive beam (CERN)

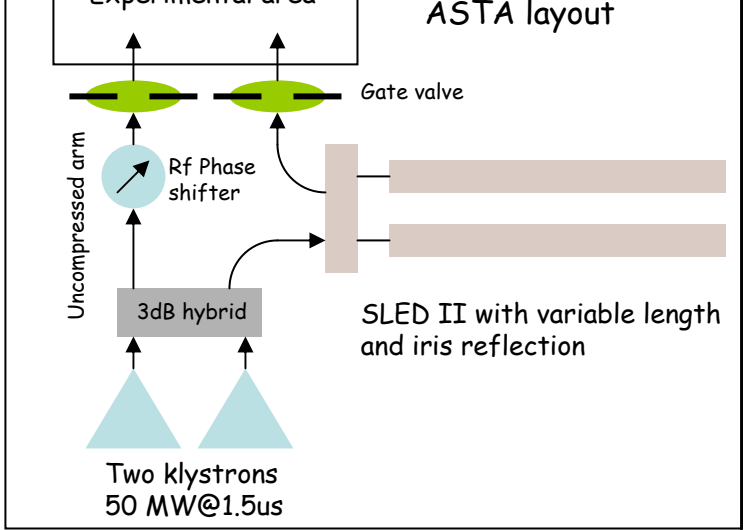



Objective: to demonstrate the reliable production of the nominal CLIC RF power level throughout the deceleration of the drive beam.

# Accelerating Structure Test Area at SLAC

The ASTA pulse compressor with variable delay in delay-lines

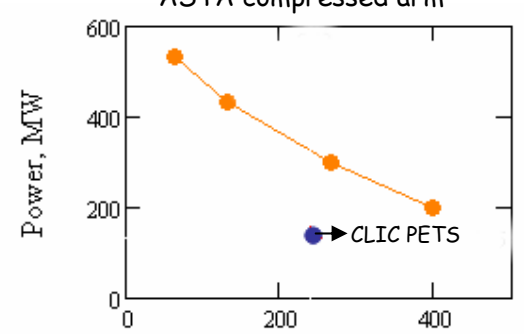
The ASTA pulse compressor with variable iris



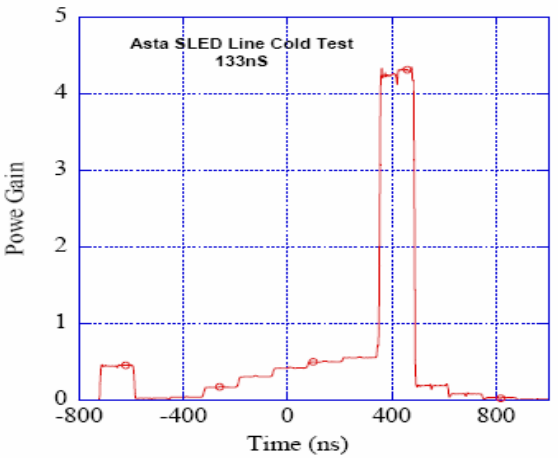

The uncompressed arm has a variable phase shifter and a gate valve

ASTA [1] is a new generation general purpose test stand, which will allow processing the various types of the high power RF equipment at X-band. The facility can provide a very versatile pulse length and power level.

RF pulse @ power in the ASTA compressed arm




Pulse lenght, ns



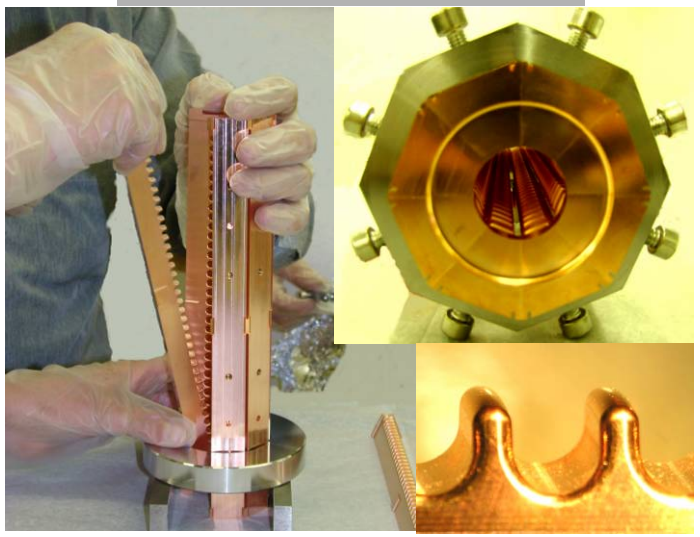

Typical RF pulse envelope in the ASTA compressed arm. The SLED II operates in dual mode regime



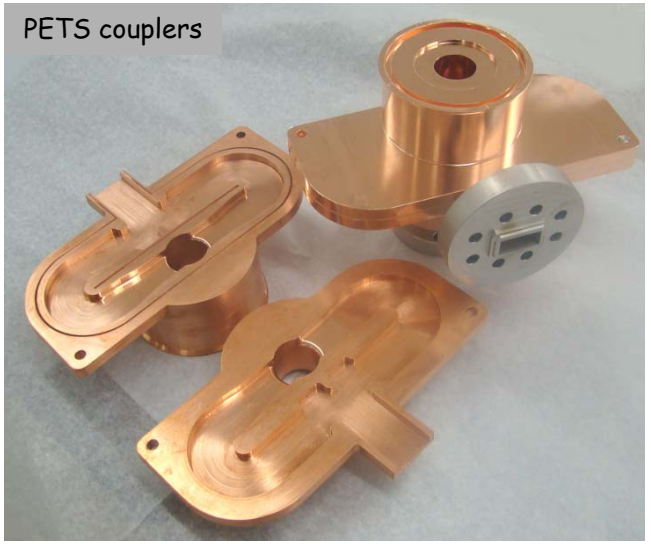
[1] S. Tantawi, "Test Facilities and Component Developments", 2nd Collaboration Meeting on X-Band Accelerator Structure design and TEST program, KEK, Japan, May 2008. Web link: http://indico.cern.ch/conferenceDisplay.py?confId=30911

# 11.424 GHz PETS ( design scaled from the CLIC 12 GHz PETS)

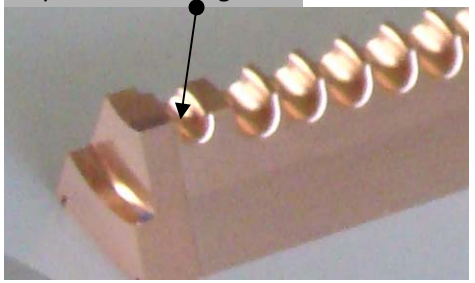
Assembly of the eight PETS bars.



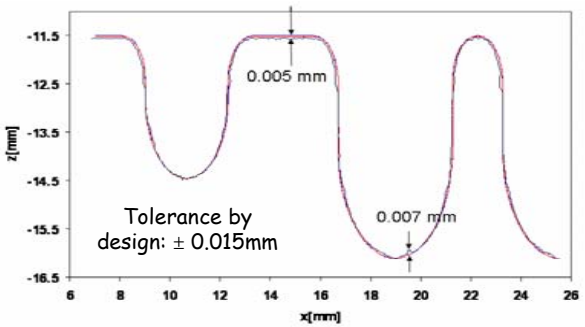
PETS couplers



Special matching cell

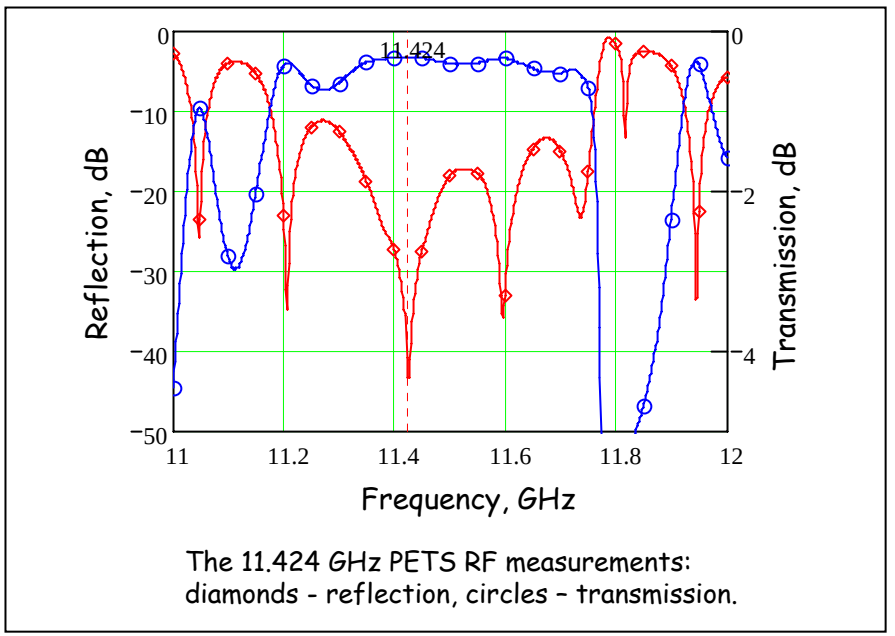


The bars fabricated using high speed milling



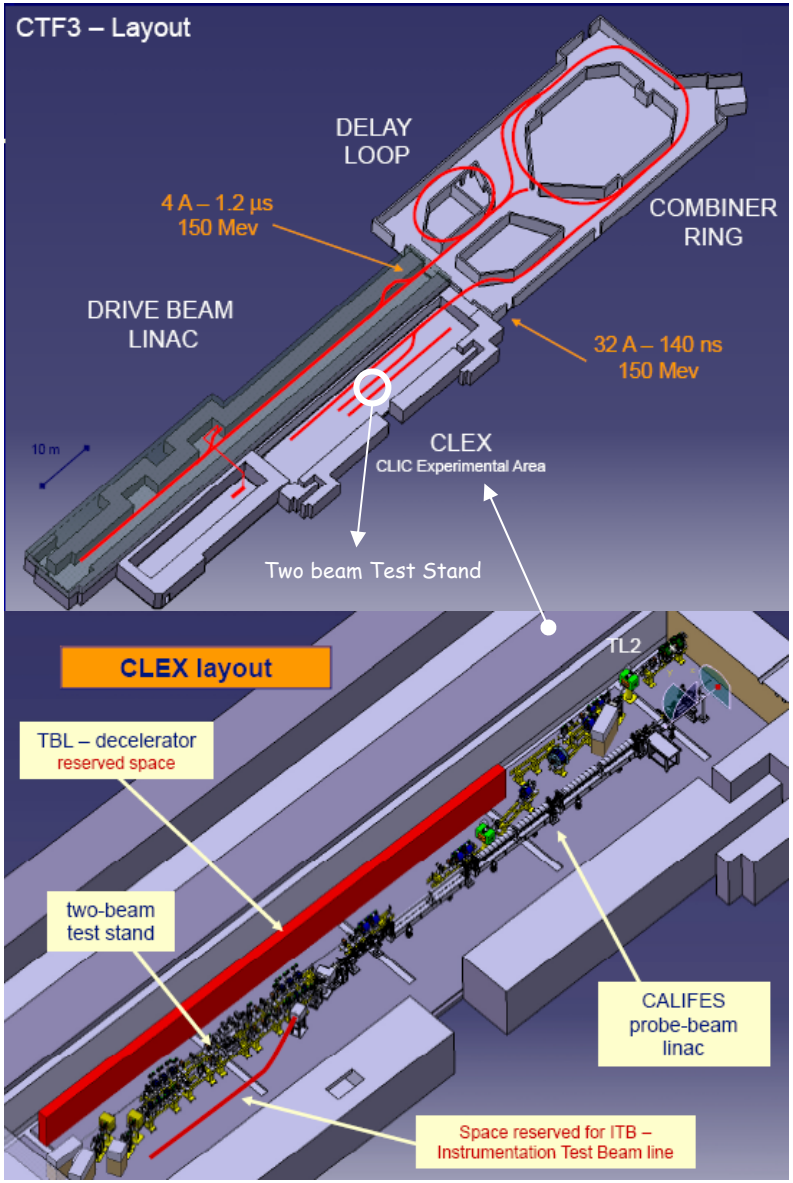

PETS during RF check

PETS before the last EB welding

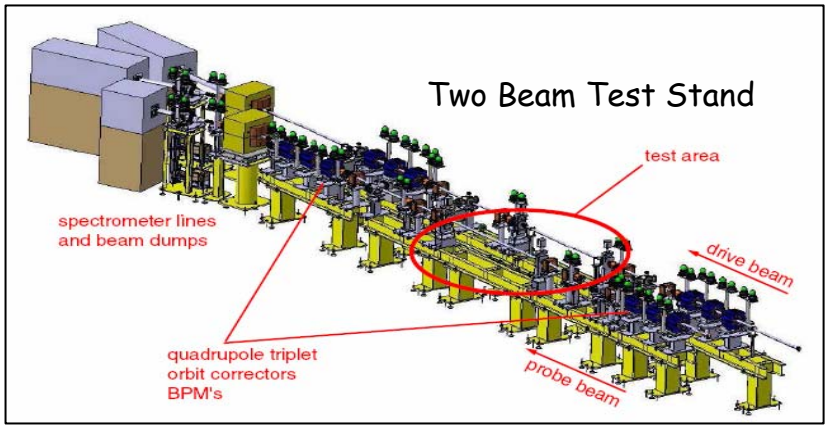


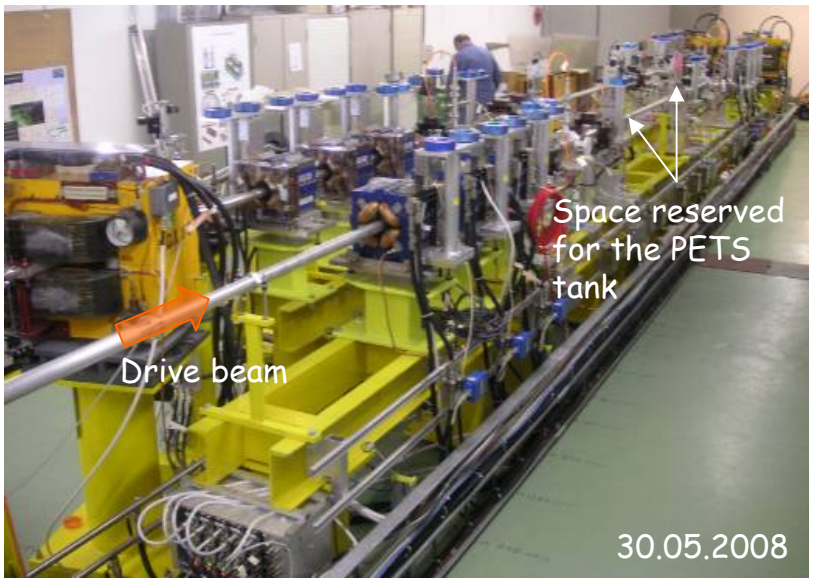

The 11.424 GHz PETS RF measurements:
diamonds - reflection, circles – transmission.

# CLIC Experimental area in CTF3 (CLEX) at CERN




The 12 GHz PETS power production from the drive beam will be demonstrated in the CTF3. The new CLIC experimental area (CLEX) is now under construction as a part of the CTF3 [1]. Upon completion, the CLEX will be equipped with a number of experiments. One of them is the Two Beam Test Stand (TBTS), where the PETS will be installed [2]

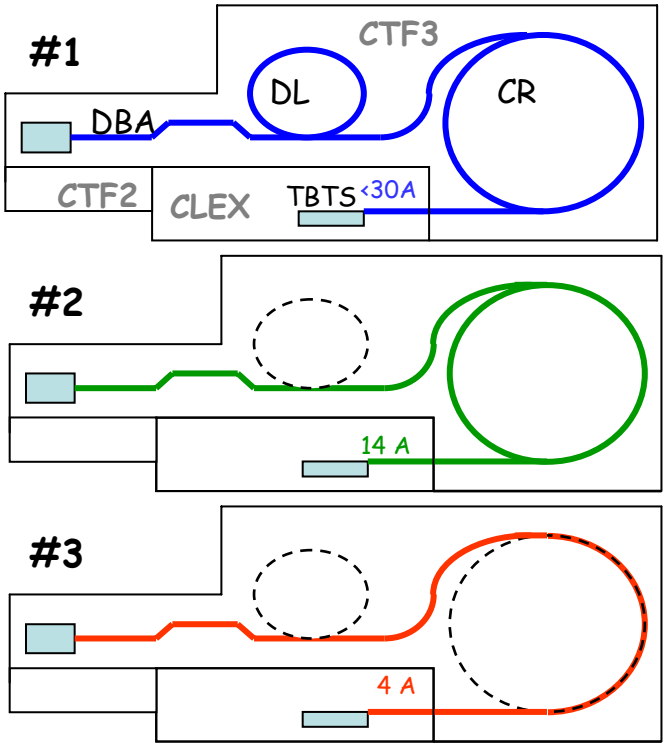





[1] G. Geschonke. "Results from the CLIC Test Facility CTF3 and Update on the CLIC Design", this conference (THYG02 ).
[2] R. Ruber et al., "The CTF3 Two-beam Test-stand", this conference (WEPP139 ).

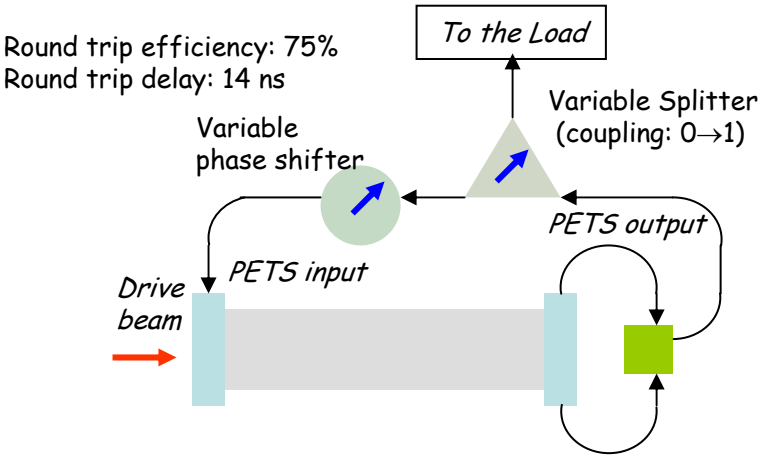
• Different scenarios of the drive beam generation in the CTF3



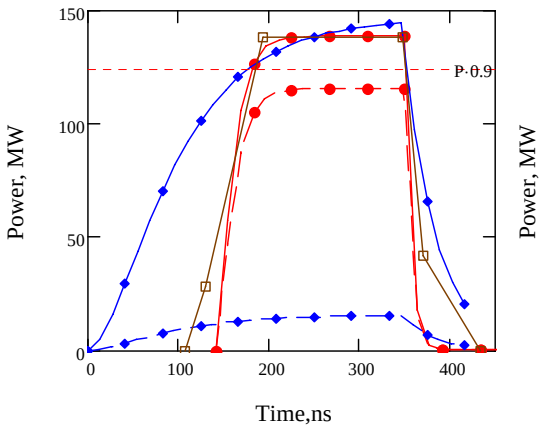

• To compensate for the lack of current, the active TBTS PETS length was significantly increased: from the original 0.215 m to 1 m.

| Operation mode | #1 | #2 | #3 | CLIC |
|---|---|---|---|---|
| Current, A | <30 | 14 | 4 | 101 |
| Pulse length, ns | 140 | <240 | <1200 | 240 |
| Bunch Frequency, GHz | 12 | 12 | 3 | 12 |
| PETS power (12 GHz), MW | <280 | 61 | 5 | 135 |

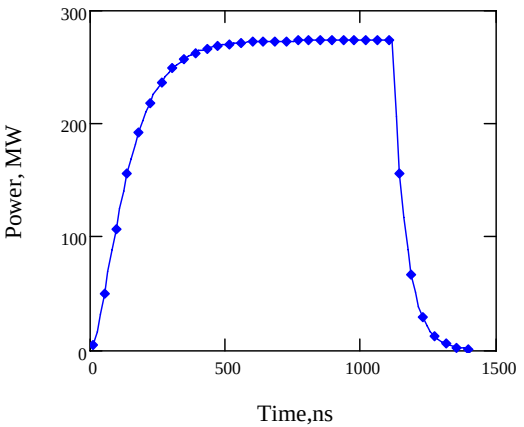
• In order to demonstrate the nominal CLIC power level and pulse length, it was decided to implement a different PETS configuration – PETS with external re-circulation.




Calculated output RF pulse envelops in PETS with re-circulation. Circles – mode 2, diamonds – mode 3, boxes – the CLIC pulse by design. Solid line – PETS output, dashed line – to the load.



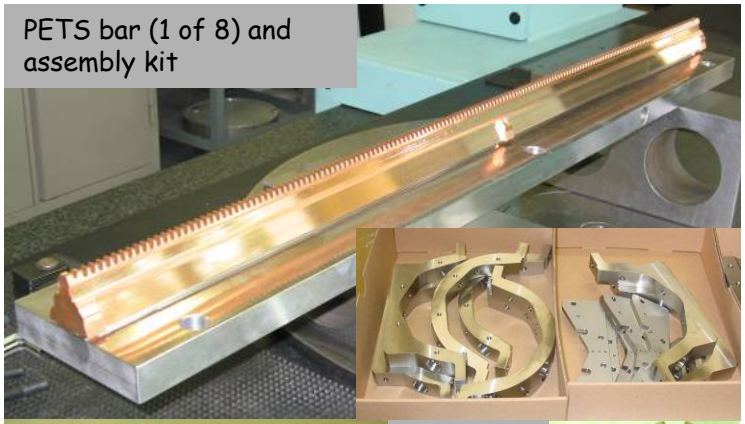

#1. The coupling and pulse length optimized to provide pulsed parameters comparable to the CLIC nominal values.




#2. Full re-circulation (coupling=1) and full pulse length for the mode 3.

# 12 GHz PETS hardware and RF components status to-date.

PETS bar (1 of 8) and assembly kit





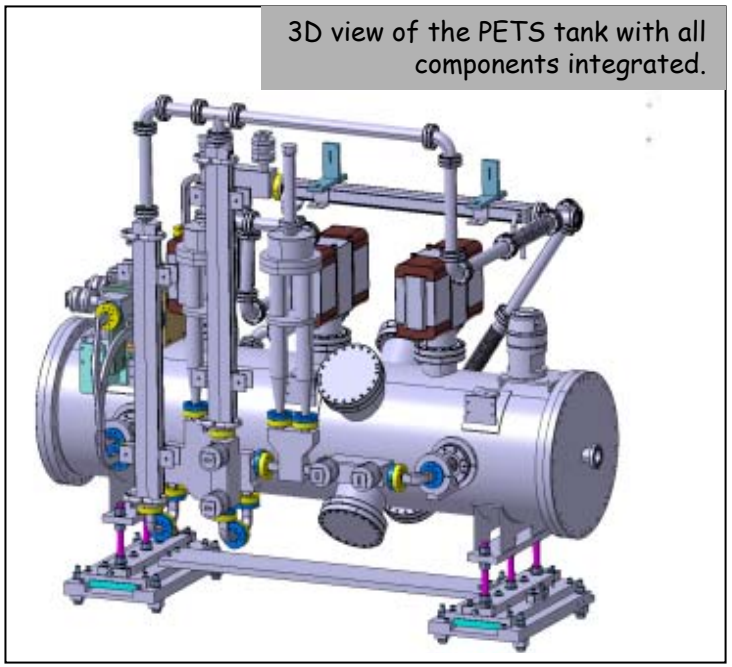
PETS couplers

Cooling channels

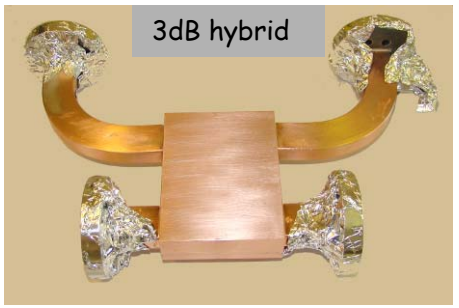

PETS vacuum tank

Variable high power RF power splitter

3D view of the PETS tank with all components integrated.



Directional coupler

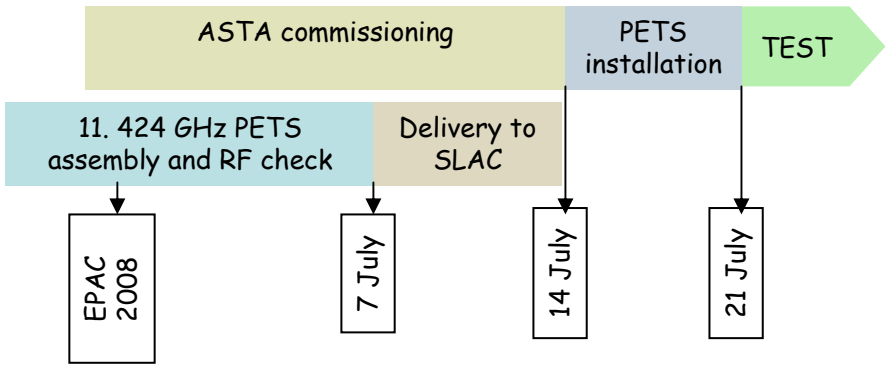


3dB hybrid

Parts of the dry stainless steel high power RF load

# PETS'es installation and testing schedule in 2008

## At SLAC



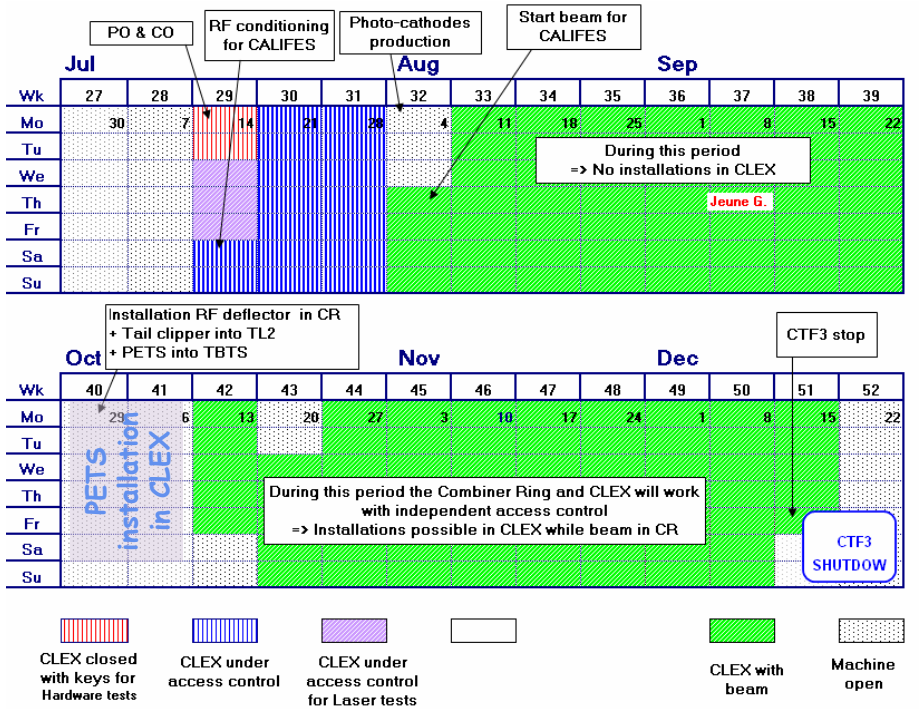

## CONCLUSION

In the year 2008, an intense PETS testing program will be implemented. The target is to demonstrate the full performance of the PETS operation.

- First, to get the results as soon as possible and to understand the limiting factors for the PETS ultimate performance, the PETS will be connected to a high power source and tested in a "waveguide" mode at SLAC, starting in July 2008.
- The nominal PETS power production from the dive beam will be demonstrated at CERN. The first experiments will start in October 2008.

## At CERN

### CTF3 schedule




### PETS schedule