PETS Status and Planning

I. Syratchev

The CLIC Power Extraction and Transfer Structure (PETS) is a low impedance periodically loaded waveguide. It should produce RF power via interaction with high current bunched drive beam, efficiently extract and deliver the power to the CLIC accelerating structure.

Targets and challenges

General:

The decelerating module, consisting of PETS, quadrupoles, BPMs and high power RF networks, must not be longer than the accelerating structure it drives, to ensure maximum effective gradient.

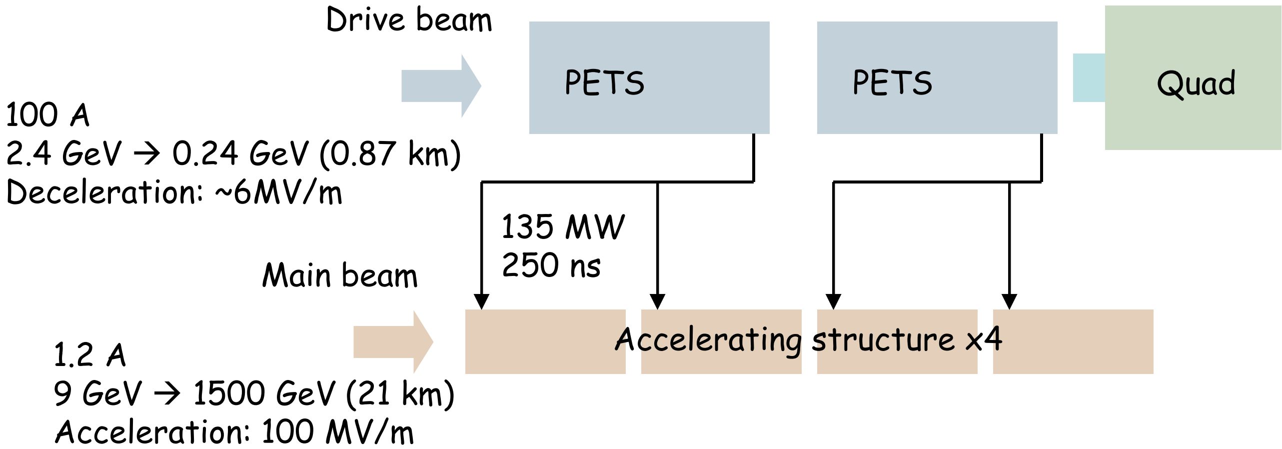
RF power production:

- Generation of high RF power in a presence of high current and HOM heavy damping environment.
- Efficient extraction of the produced RF power from the overmoded RF circuit (diameter ≅ λ).
- Strong request on a possibility to provide local termination of RF power production in a case of breakdown in the accelerating structure or the PETS itself.

Beam dynamics:

- The 90% beam energy spread towards the end of the decelerator sector.
- Very strong damping of the deflecting HOM and strong GODO lattice are vital.
- High current and hence very little beam losses (< 0.1%) should be guarantied.

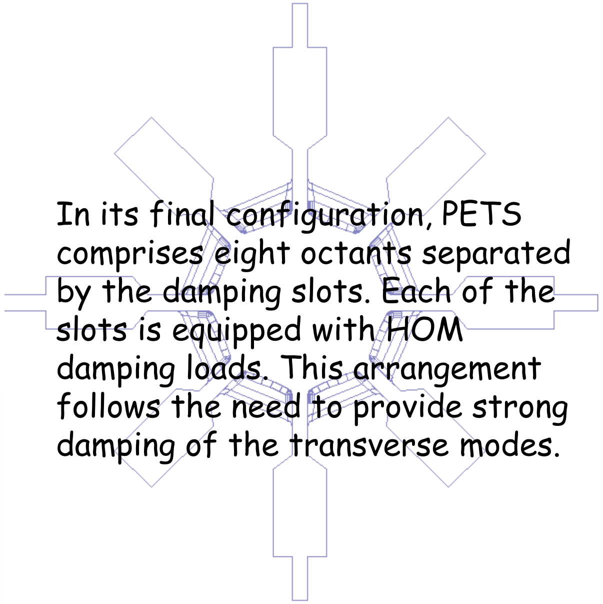
CLIC accelerator unit



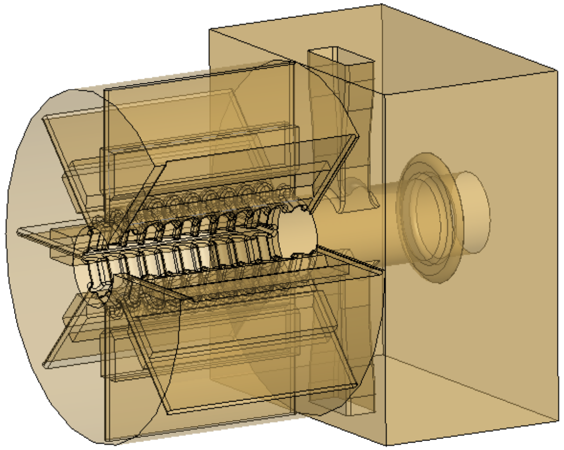
CLIC PETS

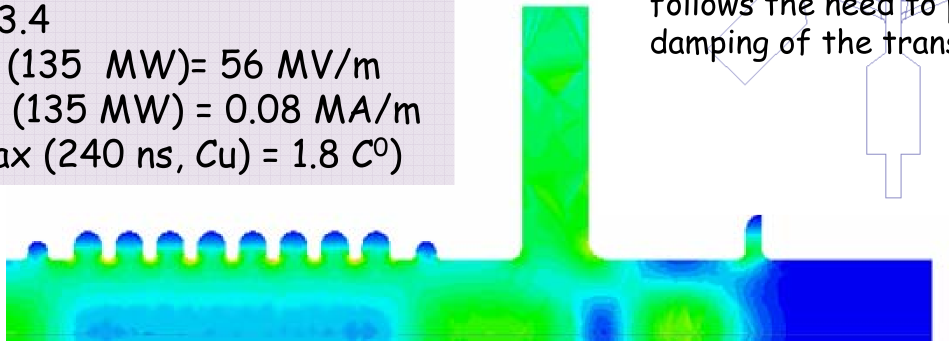
PETS parameters:

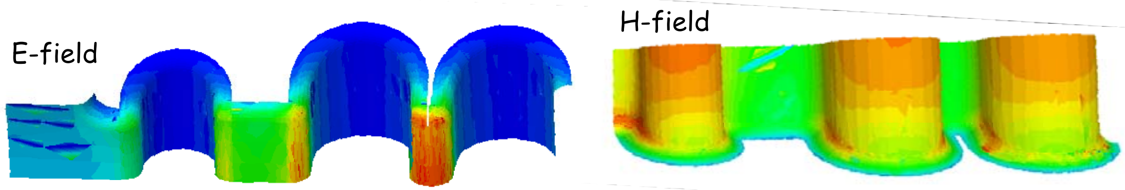
- Frequency = 11.9942 GHz
- Aperture = 23 mm
- Period = 6.253 mm (90^0/cell)
- Iris thickness = 2 mm
- R/Q = 2222 Ω
- V group= 0.459C
- Q = 7200
- P/C = 13.4
- E surf. (135 MW)= 56 MV/m
- H surf. (135 MW) = 0.08 MA/m
  (ΔT max (240 ns, Cu) = 1.8 C^0)



In its final configuration, PETS comprises eight octants separated by the damping slots. Each of the slots is equipped with HOM damping loads. This arrangement follows the need to provide strong damping of the transverse modes.

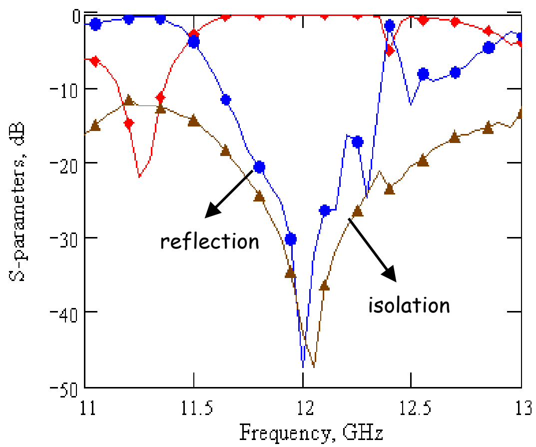


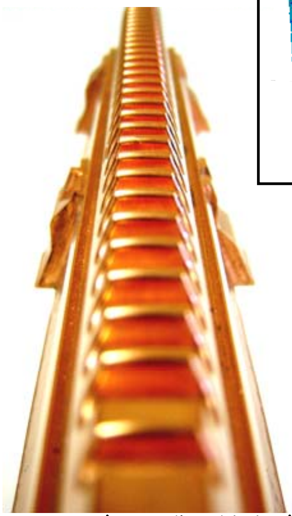


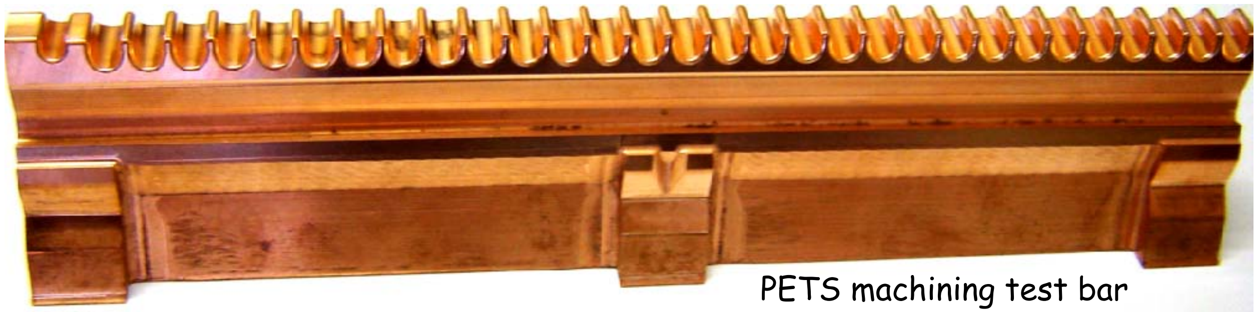


To reduce the surface field concentration in the presence of the damping slot, the special profiling of the iris was adopted.

HFSS simulations

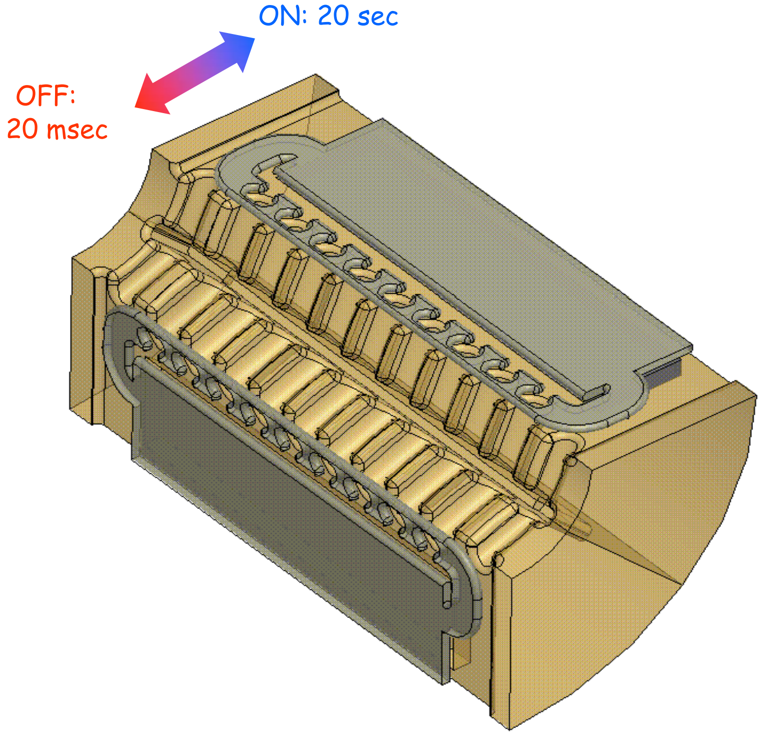


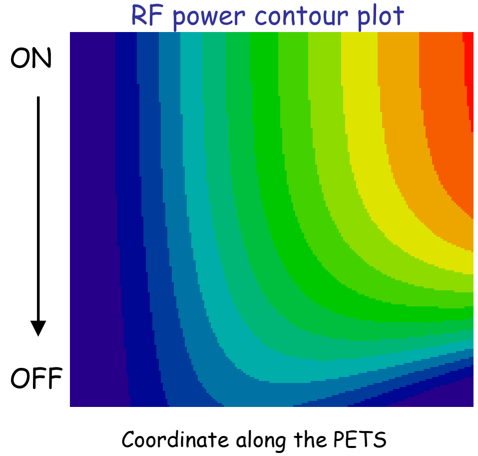


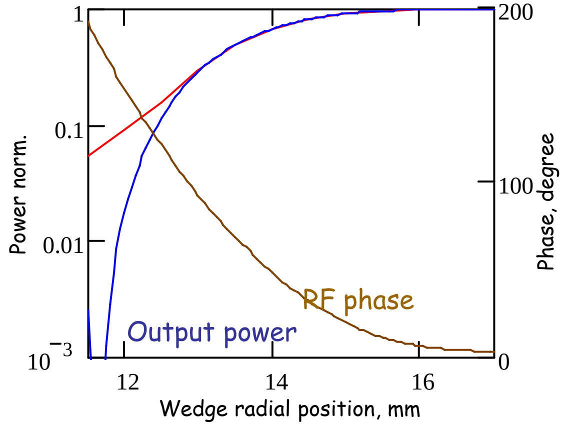


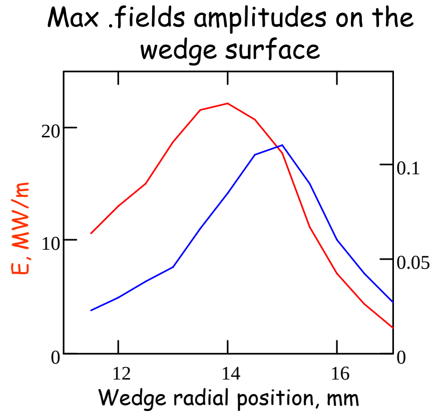
PETS machining test bar

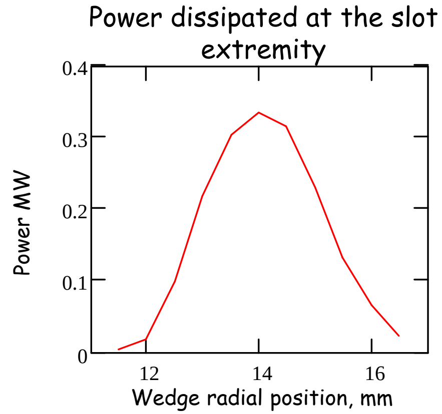
Local termination of the RF power production in the PETS (Petsonov)

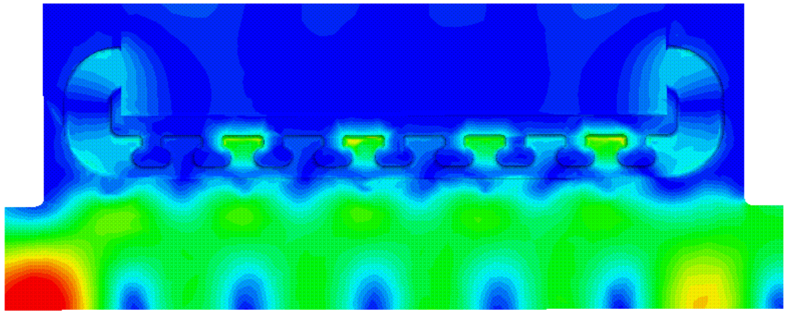


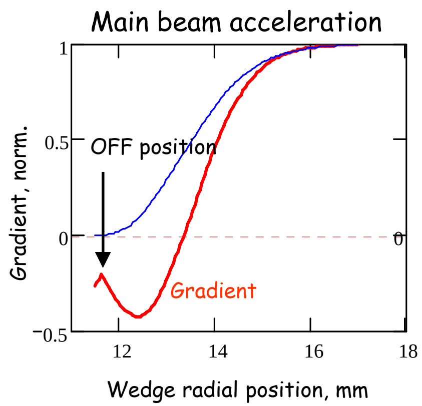












The net RF power generated by the beam at the end of the constant impedance trucsture will be zero if the structure synchronous frequency is detuned by amount $\pm\beta c/(1-\beta)L$, where β – V_g/c and L - length of the structure. We have found that such a strong detuning can be achieved by inserting four thin wedges through four of the eight damping slots.

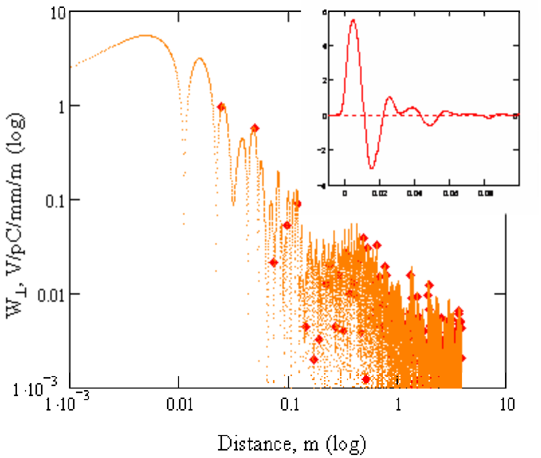
Wake expression for the structure with high group velocity and finite length:

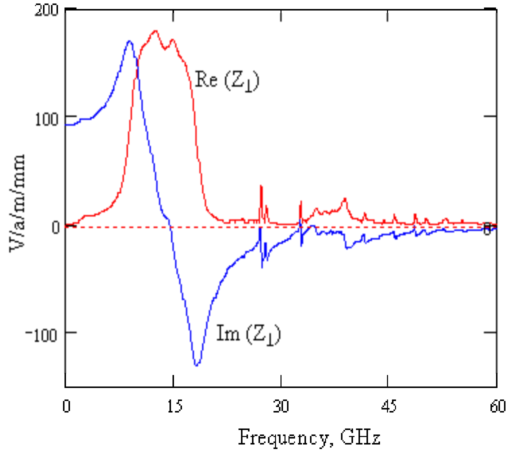
$$W(z) = 2q \times K \sin\left(\frac{\omega z}{c}\right) e^{-\frac{\omega z}{2Q(1-\beta)c}} \times \left\{1 - \frac{\beta z}{L(1-\beta)}\right\}$$

$$W(z) = 0, \quad z > L\frac{1-\beta}{\beta}$$

In the presence of the longitudinal slots, the transverse mode field pattern is dramatically distorted so that a considerable amount of the energy is now stored in the slots. The new, TEM-like nature of the mode significantly increases the group velocity, in our case from 0.42*c* to almost 0.7*c*. The proper choice of the load configuration with respect to the material properties makes it possible to couple the slot mode to a number of the heavily loaded modes in dielectric. This gives a tool to construct the broad wakefields impedance.

The transverse wakepotential simulations in a complete PETS geometry were done with GDFIDL:





HOM damping and beam stability issues

The computer code PLACET was used to analyze the beam dynamic along the decelerator in the presence of strong deceleration and calculated wakefields. The results of the simulation clearly indicate that the suppression of the transverse wakefields obtained, is strong enough to guarantee the beam transportation without losses:

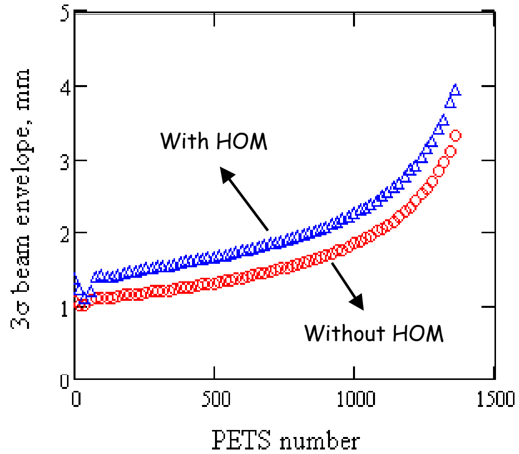
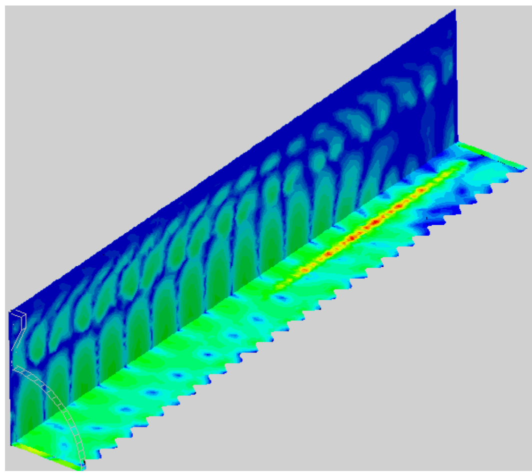
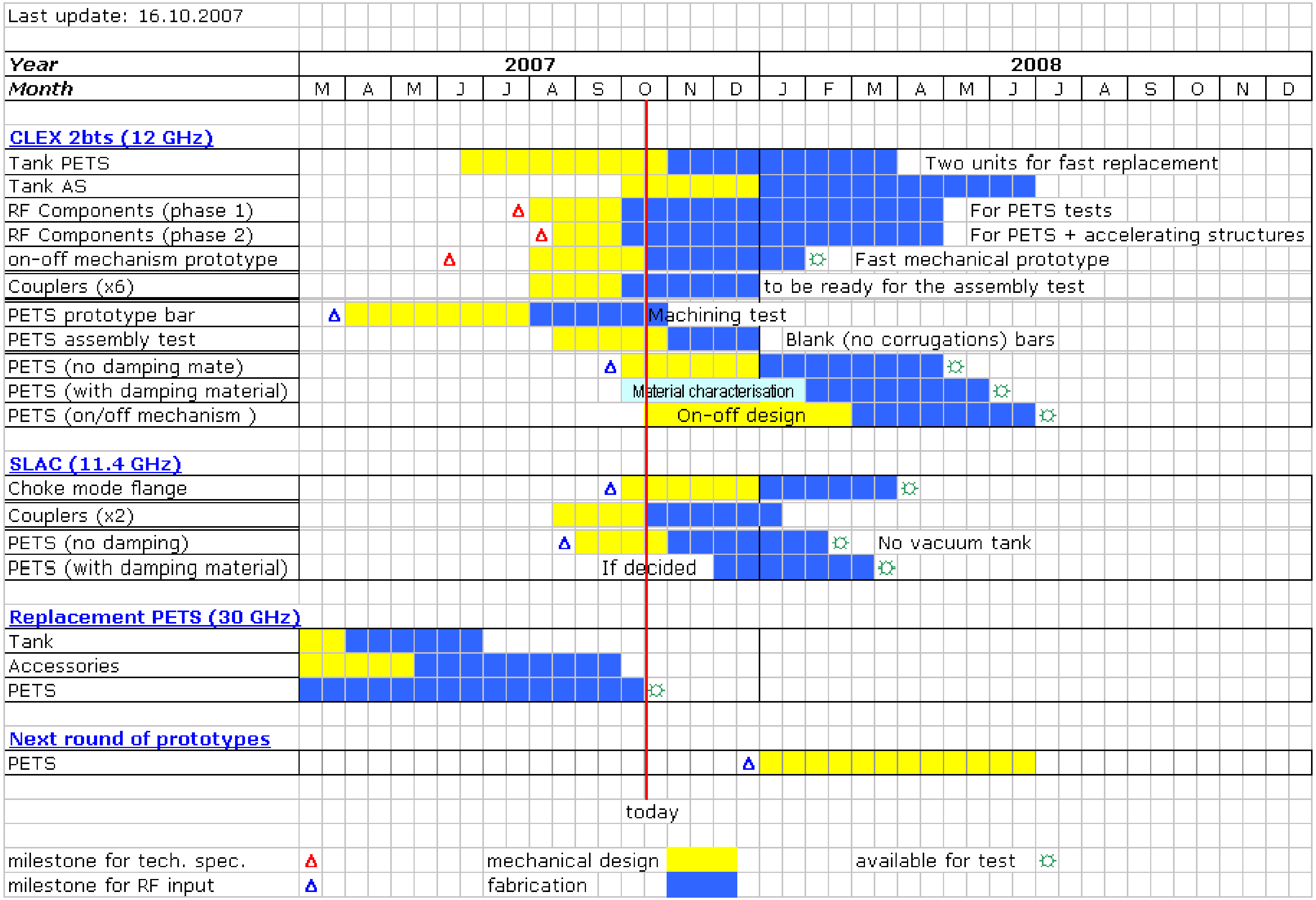


Illustration (HFSS) of the transverse mode damping mechanism



PETS high RF power testing program



(* TBL program is not included)

The Pets development crew (CERN)

Khurshid Alam
Claude Achard
Bruno Favrat
Valeri Ferapontov
Luca Gentini
Bertrand Nicquevert
Germana Riddone
Thomas Sahner
Mauro Taborelli
Igor Syratchev