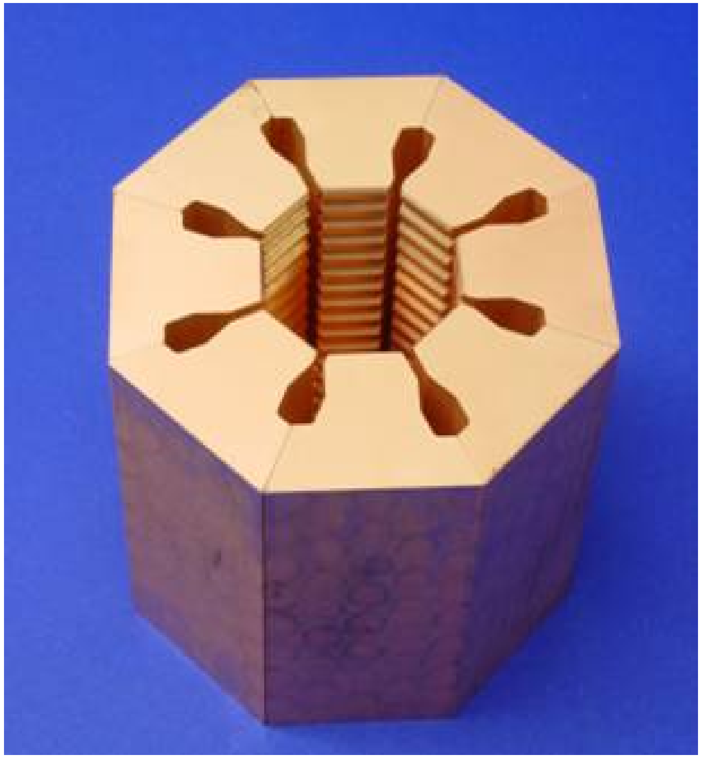
CLIC PETS test program.

I. Syratchev

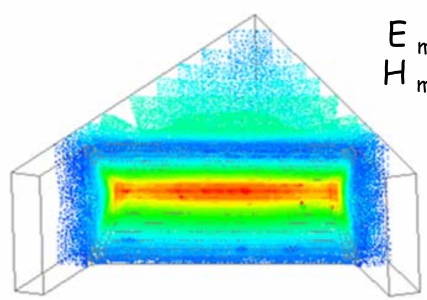
PETS machining prototype



PETS geometry choice is a result of multiple compromises between beam stability along whole decelerator (600 m) and active length of the structure given by main accelerator RF power needs and layout. Surface electric field, power extraction method, HOM damping mechanism and fabrication technology were all evaluated to provide reliable design.

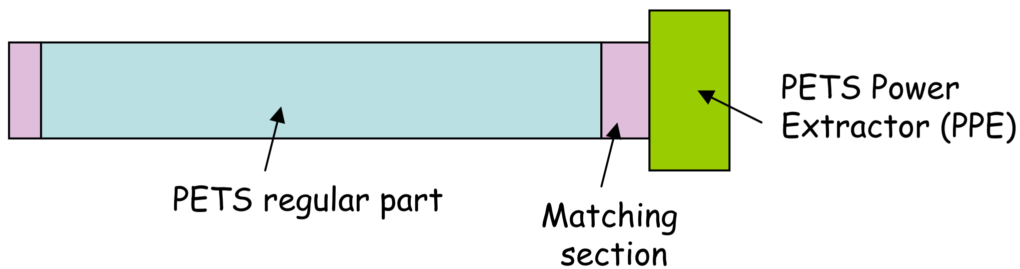
PETS parameters:

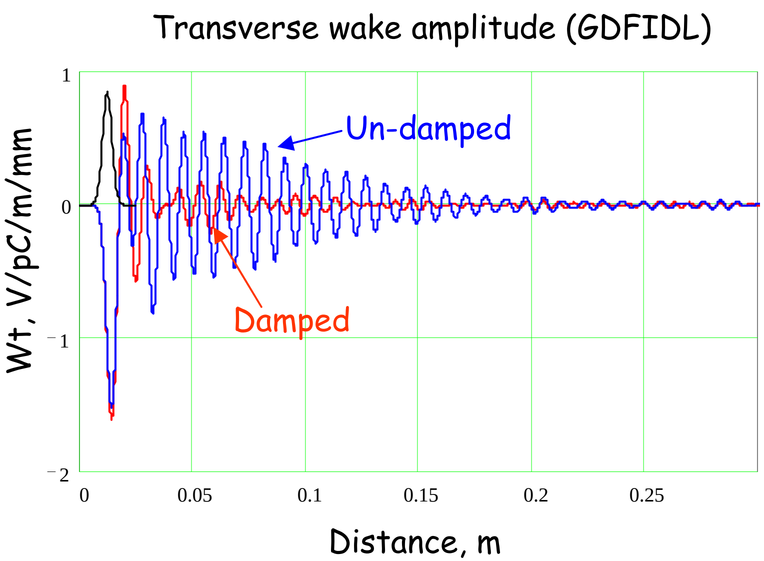
F= 29.9855 GHz
Aperture = 22.5 mm
R/Q = 320.2 Ohm/m
Beta = 0.798 c
$\Delta\varphi$/cell = 140^0
$I_{Drive\ beam}$ = 164 A
RF power = 800 MW
Active length = 0.7 m
Damping slots: 8 x 2 mm



at 800 MW
E_{max} = 135 MV/m
H_{max} =0.22MA/m

PETS architecture

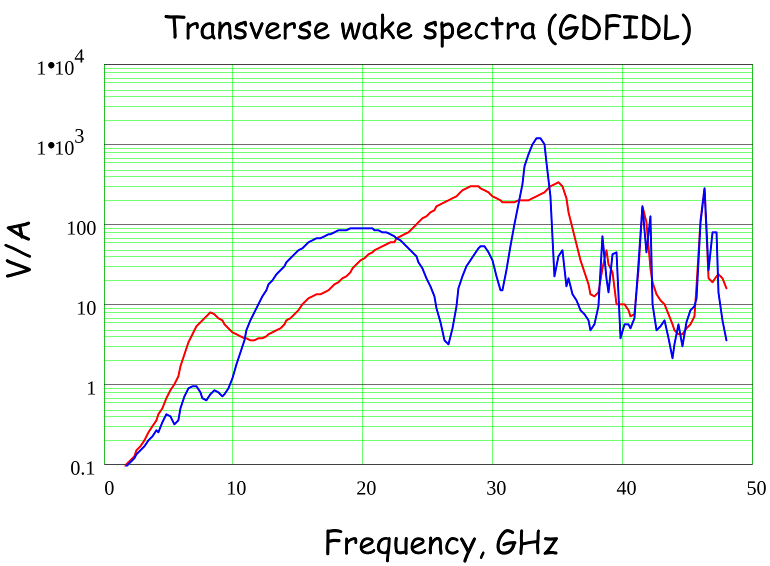


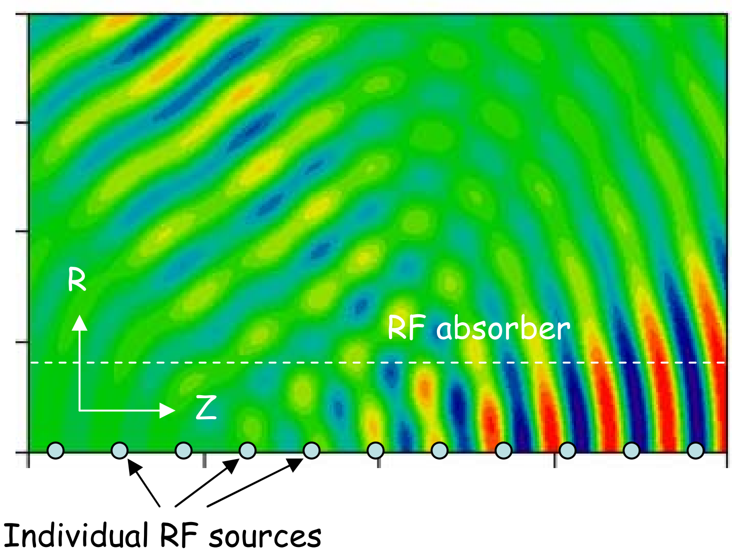


Transverse modes:

	M1	M2
Kt, V/pC/m/mm	0.904	0.473
F, GHz	27.844	34.915
Beta	0.876 C	0.646 C
Q loaded (HFSS)	40	38

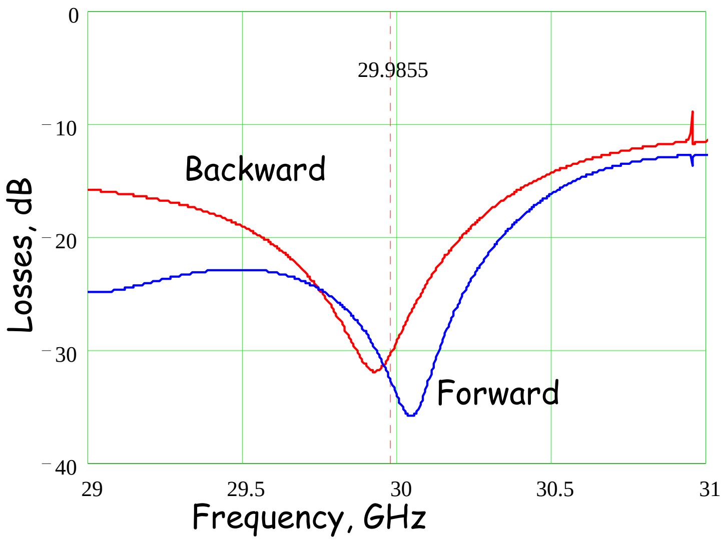
Damping mechanism in PETS can be explained as a coherent radiation into the damping slot of many individual RF sources. The angle of radiation depends on the phase advance and distance between them.

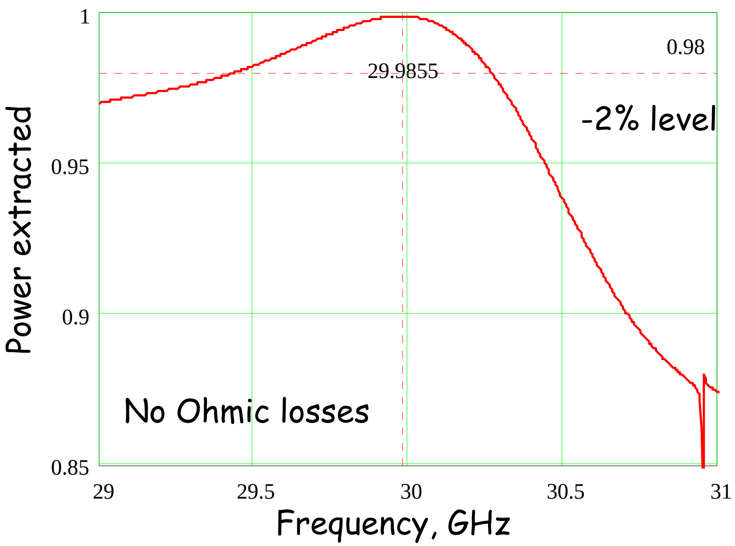


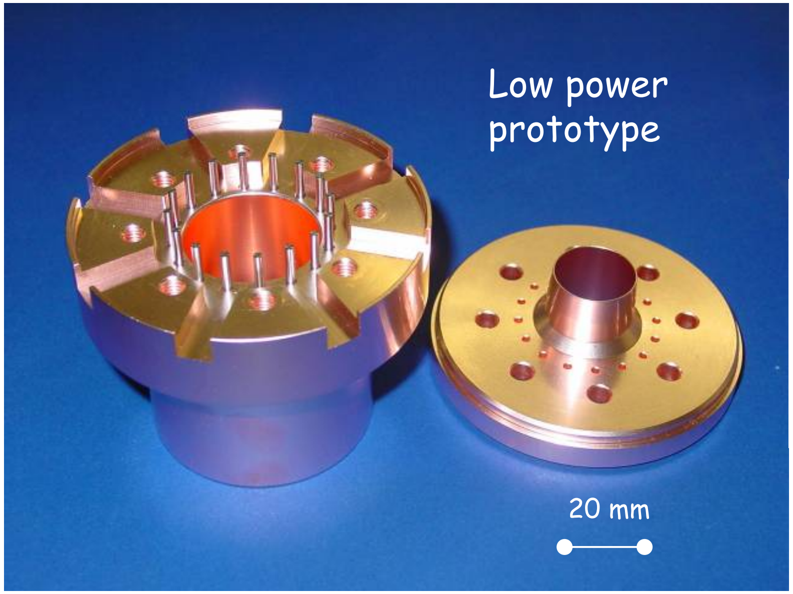


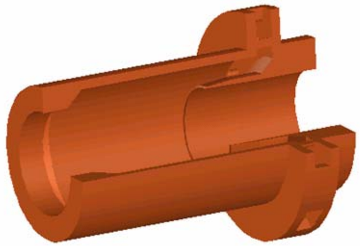
PETS 30 GHz 8 cannel quasi-optical RF power extractor

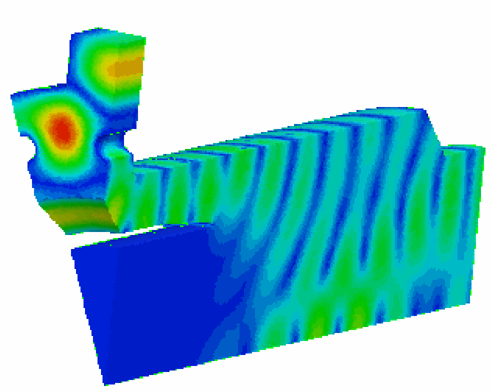
HFSS simulations



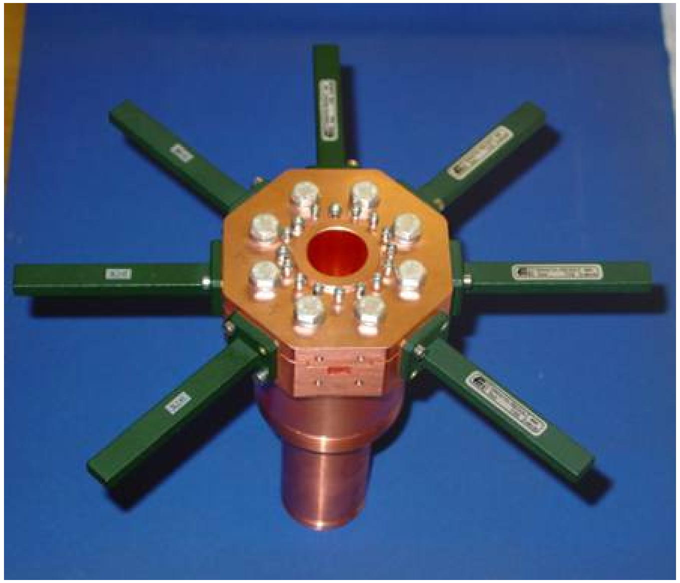




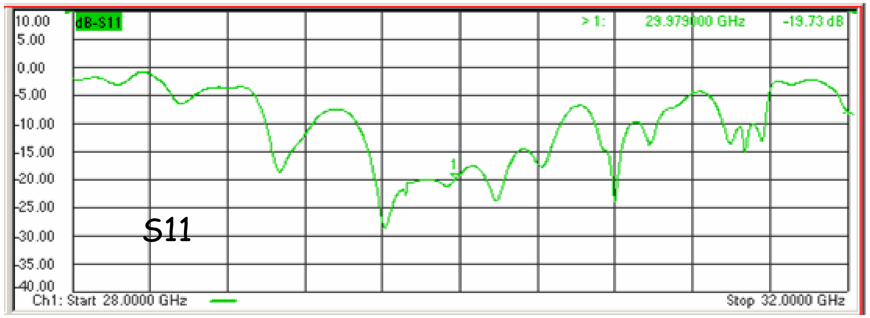


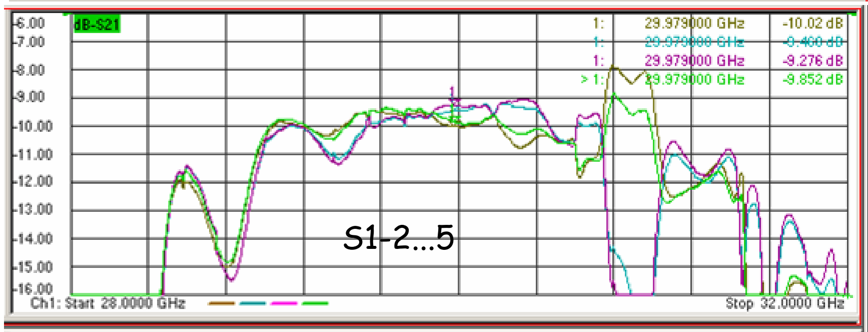


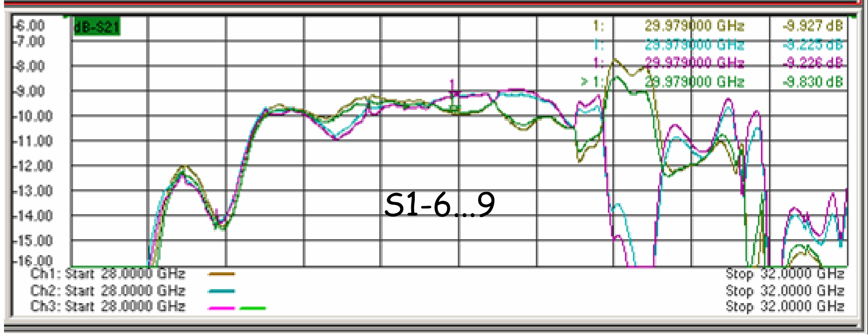
E_{max}: 88 MV/m at 800 MW



Prototype low power RF measurements







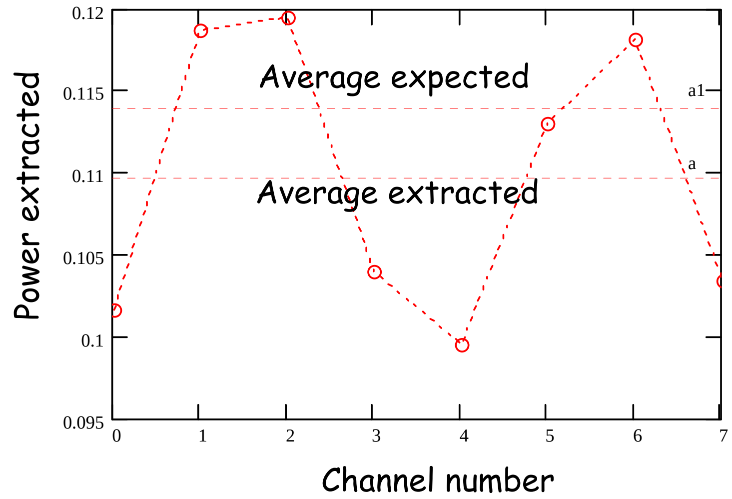
Power budget per channel:

Reflection — E01 mode launcher — Matching transformer

$$P^{Expected}_{cannel} = (1-0.011)\times 10^{\frac{-0.36}{10}} \times 10^{\frac{-0.02}{10}} \times 0.125 = 0.113$$

$$Power^{Measured}_{channel} = 0.11$$

Efficiency: **97.0 %**



International Linear Collider
Technical Review Committee

Second Report

2003

Reliability — Ranking 1

- In the present CLIC design, an entire drive beam section must be turned off on any fault (in particular on any cavity fault). CLIC needs to develop a mechanism to turn off only a few structures in the event of a fault. At the time of writing this report, there is no specific R&D program aimed at that objective but possible schemes are being studied.

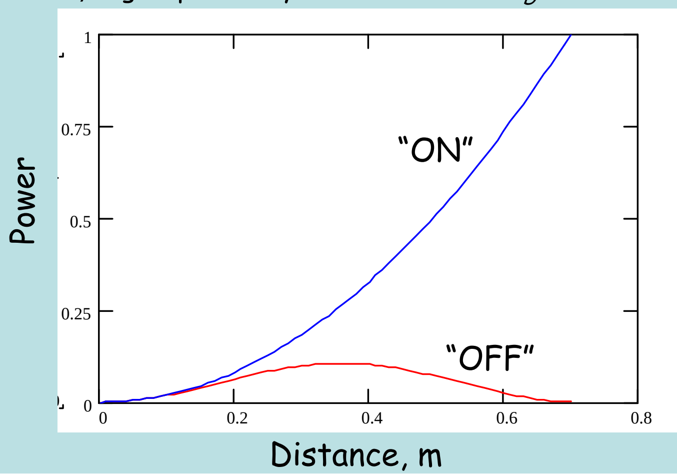
In detuned accelerating structure without losses, the field distribution along the structure can be expressed as:

$$E(z) \approx \int_{o}^{z} \cos\left(\frac{\omega_D - \omega_0}{2C} \times \frac{1-\beta}{\beta} z\right) dz$$

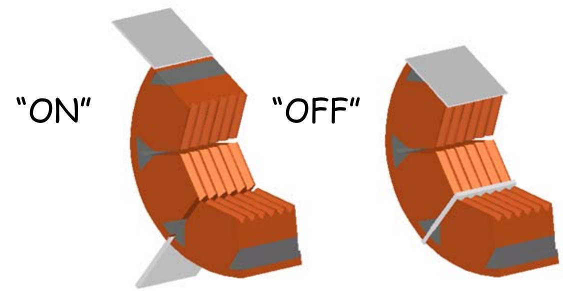
If we need to avoid power production at the end of the structure, than the detuning should be sufficient if:

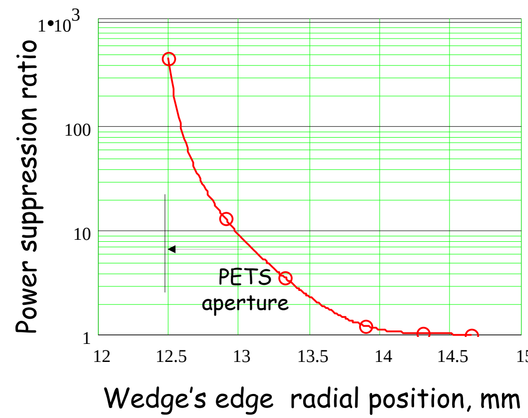
$$F_D = F_0 \pm \frac{\beta \times C}{(1-\beta) \times L}$$

Where F_D is a new detuned synchronous frequency, L – length of the structure and β - group velocity. For CLIC PETS F_D = 31.69 GHz:



By insertion of 4 (1.8 mm thick) wedges through the damping slots, sufficient PETS synchronous frequency detuning can be achieved.





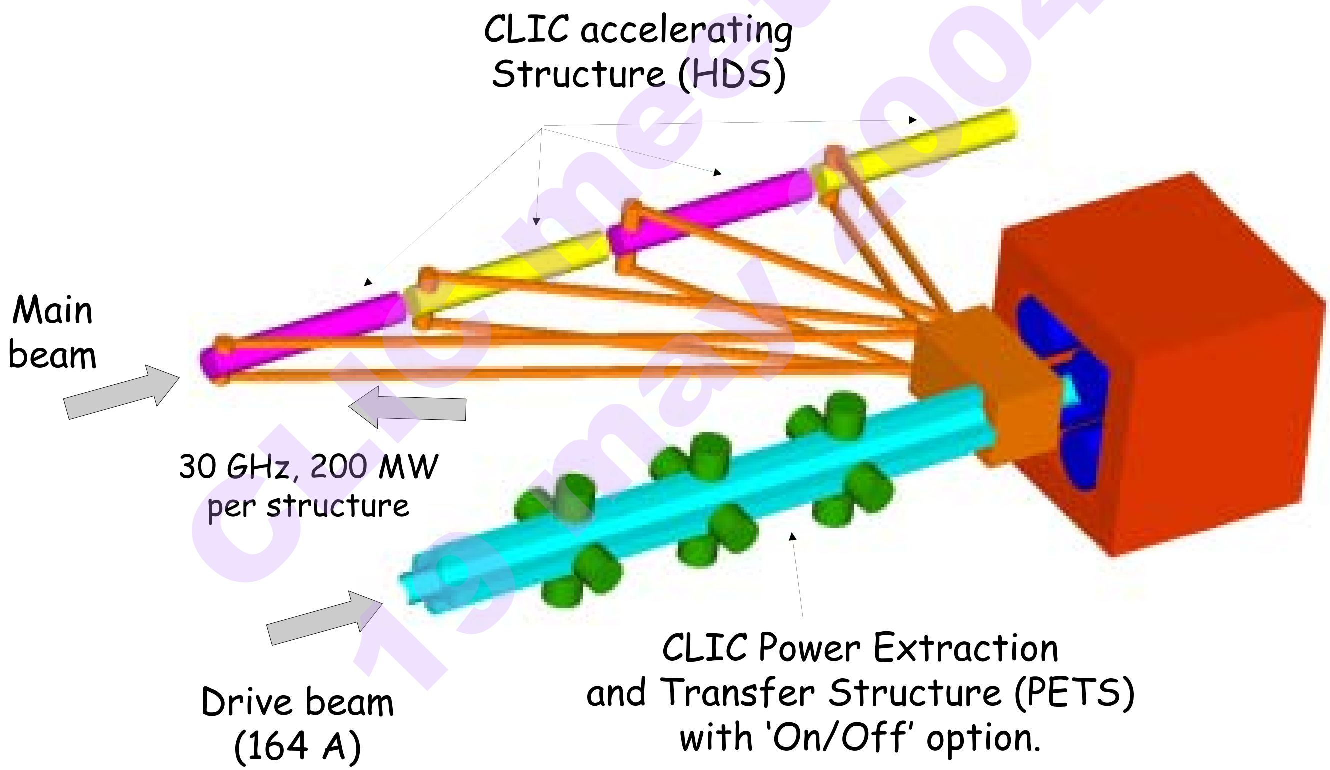
The detailed study of possibility to provide variable attenuation and mechanical layout of the de-tuner are under way.

Work package 5

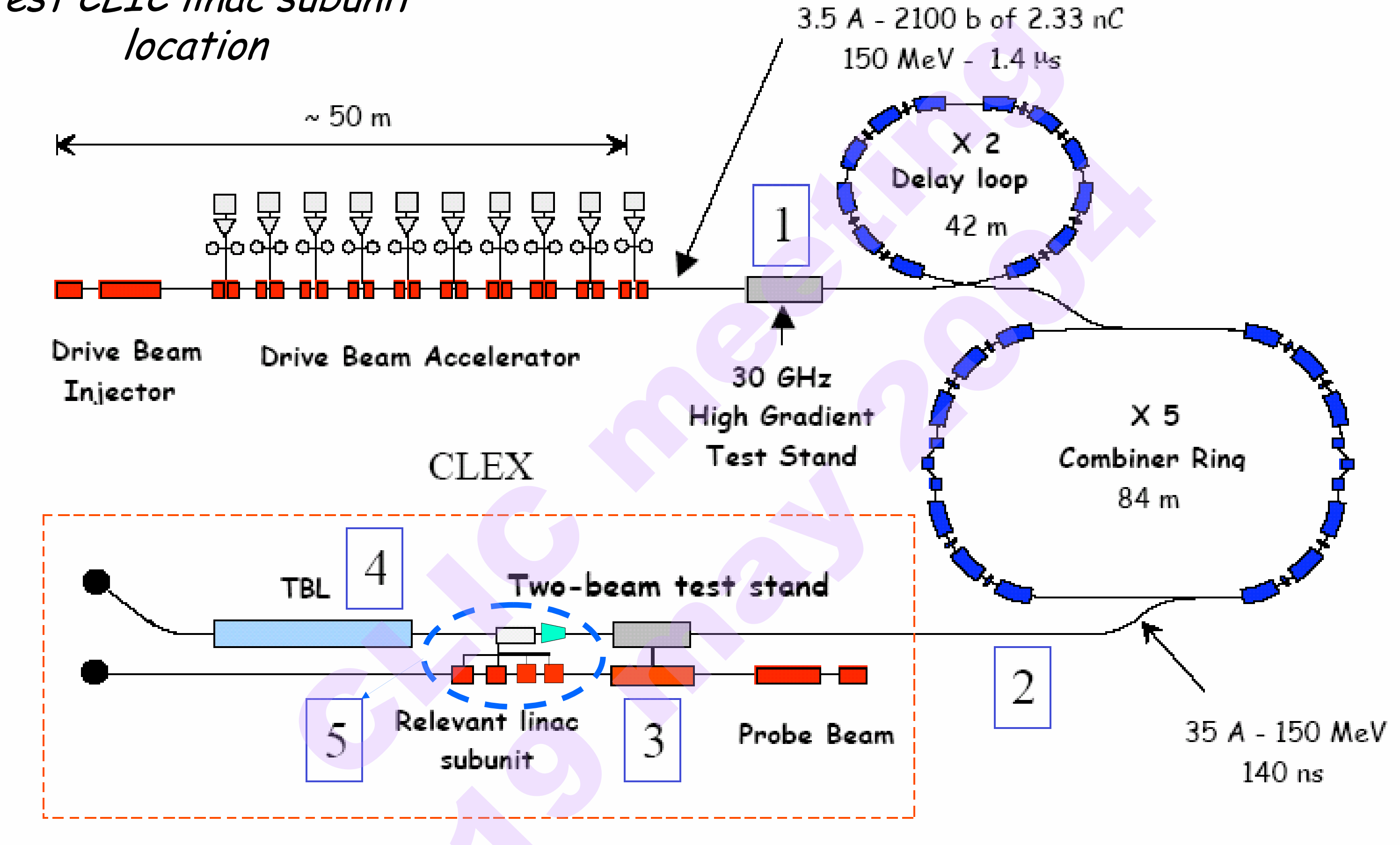
Motivation

The International Linear Collider Technical Review Committee has listed “the test of a CLIC relevant linac subunit“ as a **Ranking 2** task for CLIC study.

CLIC linac subunit layout:

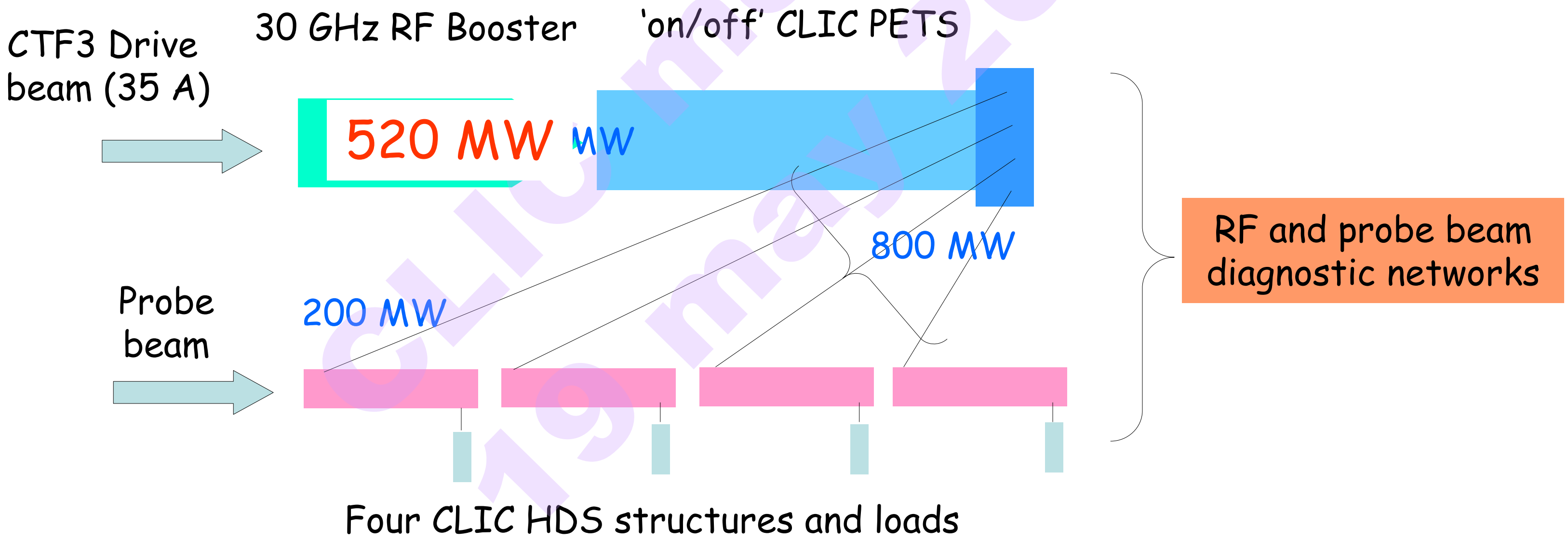


Test CLIC linac subunit location



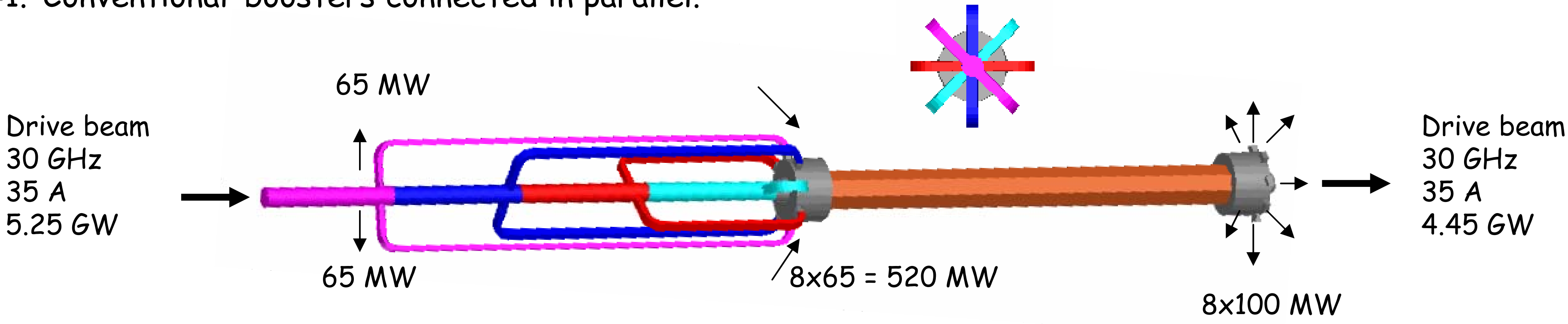
Work package description

The requirement is for a fully-equipped test facility to enable the testing of a CLIC linac sub unit consisting of one CLIC PETS with 'on/off' option and 4 HDS structures with the nominal CLIC 30 GHz RF power and pulse length. Since the CTF3 drive beam is only 35 A instead of the 164 A CLIC beam, it will be necessary to use a RF power booster to "prime" the CLIC PETS to produce the full power.

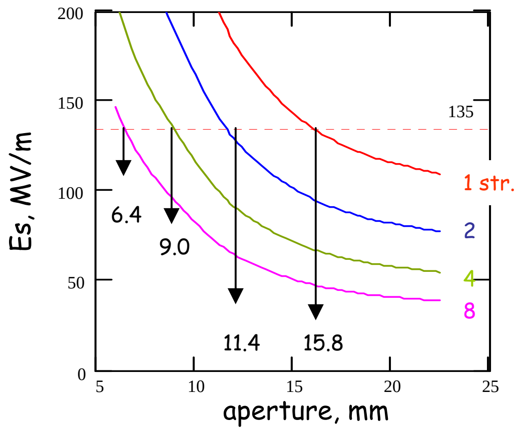


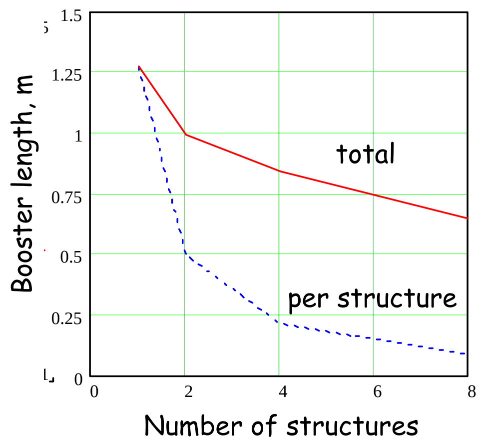
Basic consideration:
The surface electric field in booster should not exceed the corresponding values in CLIC PETS.
The same could be true for the RF power density.

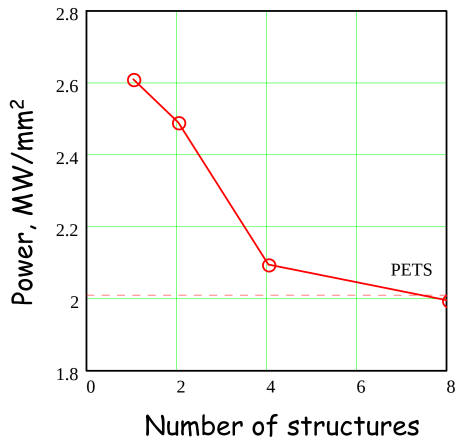
#1. 'Conventional' boosters connected in parallel.

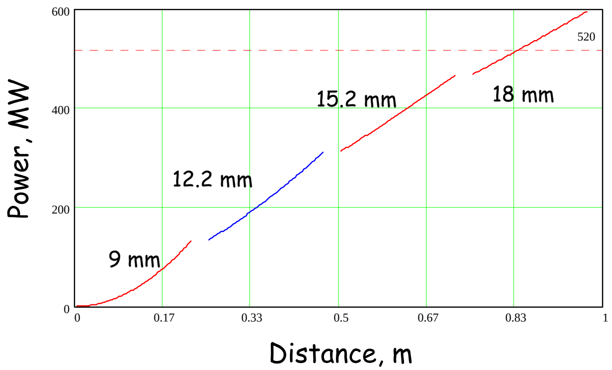


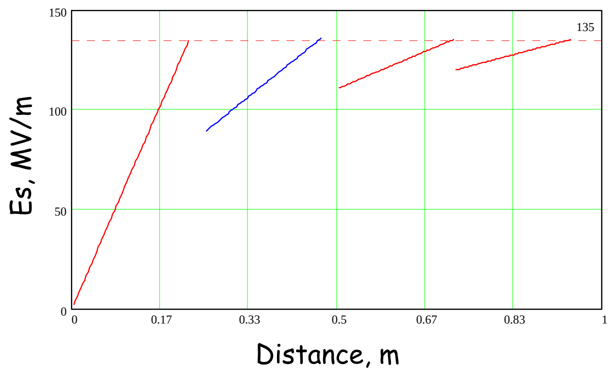
As a 'conventional' booster, 9 mm PETS can be used. It will deliver 130 MW from drive beam of 35 A at a length of 22 cm (66 cells). A 130 MV/m surface electric field in a booster is comparable to the CLIC PETS value – 135 MV/m at about the same power density ~ $2 MW/mm^2$. The total booster length is about 1.0 m (couplers are included). With that the longest waveguide line (WR32) of 80 cm have 92% efficiency.
All the components for such a booster and x8 combiner are exist and were partially tested.

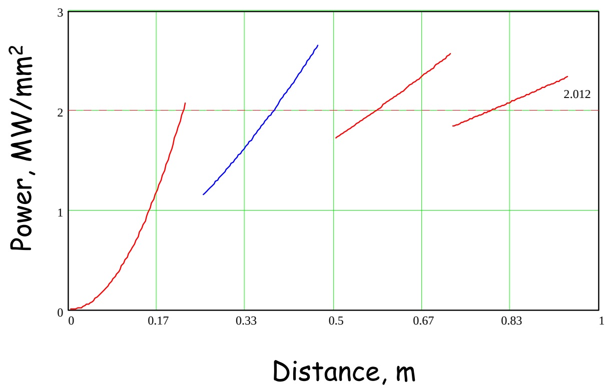




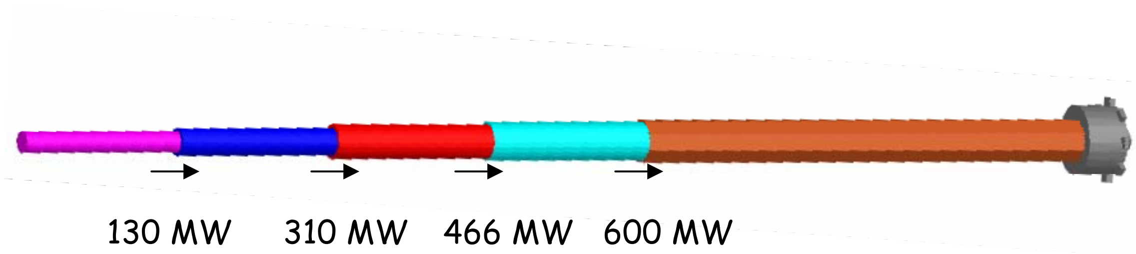








#2. Series of boosters with increasing aperture.



As an example, 4 different structures with identical length equal to that was used in scheme#1 (66 cells) were studied while keeping E_{surf} below 135 MW/m in each of them. Even 600 MW appeared to be possible.
Very careful design of between-structures spacer is needed, both to keep good matching and RF-to-beam phasing, because now the beam and RF use the same channel.