Different mechanisms and scenarios for the local RF power production switching in a case of single CLIC PETS or accelerating structure failure.

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International Linear Collider
Technical Review Committee

Second Report
2003

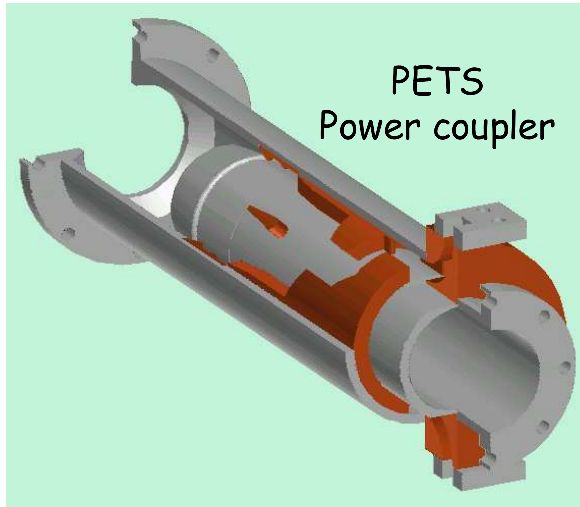
Ranking 1: R&D needed for feasibility demonstration of the machine

The objective of these R&D items is to show that the key machine parameters are not unrealistic. In particular, a proof of existence of the basic critical constituents of the machines should be available upon completion of the Ranking 1 R&D items.

Reliability

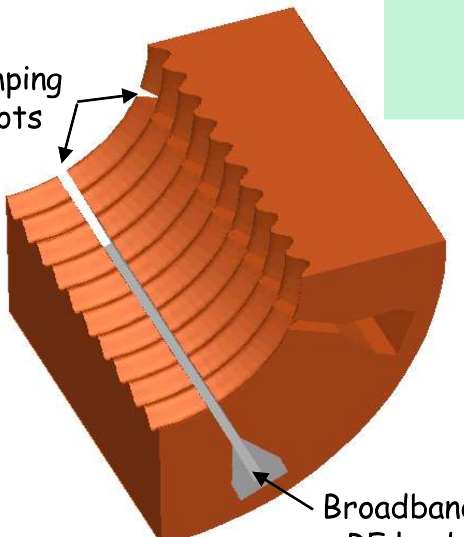
- In the present CLIC design, an entire drive beam section must be turned off on any fault (in particular on any cavity fault). CLIC needs to develop a mechanism to turn off only a few structures in the event of a fault. At the time of writing this report, there is no specific R&D program aimed at that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

CLIC 30 GHz RF structures



Decelerator

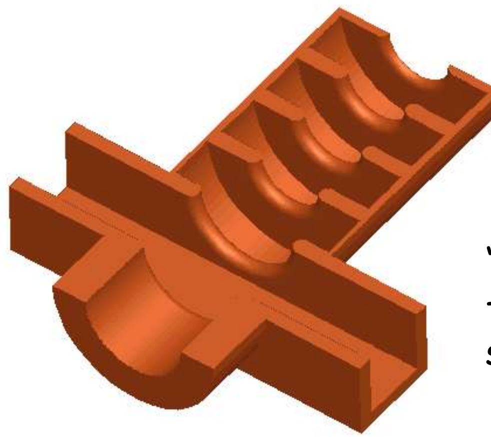
Circularly symmetric PETS for CLIC



Power extracted ~560 MWx130 ns
Max. surface electric field ~ **110 MV/m**
(due-to-slots enchantment included)

Accelerator

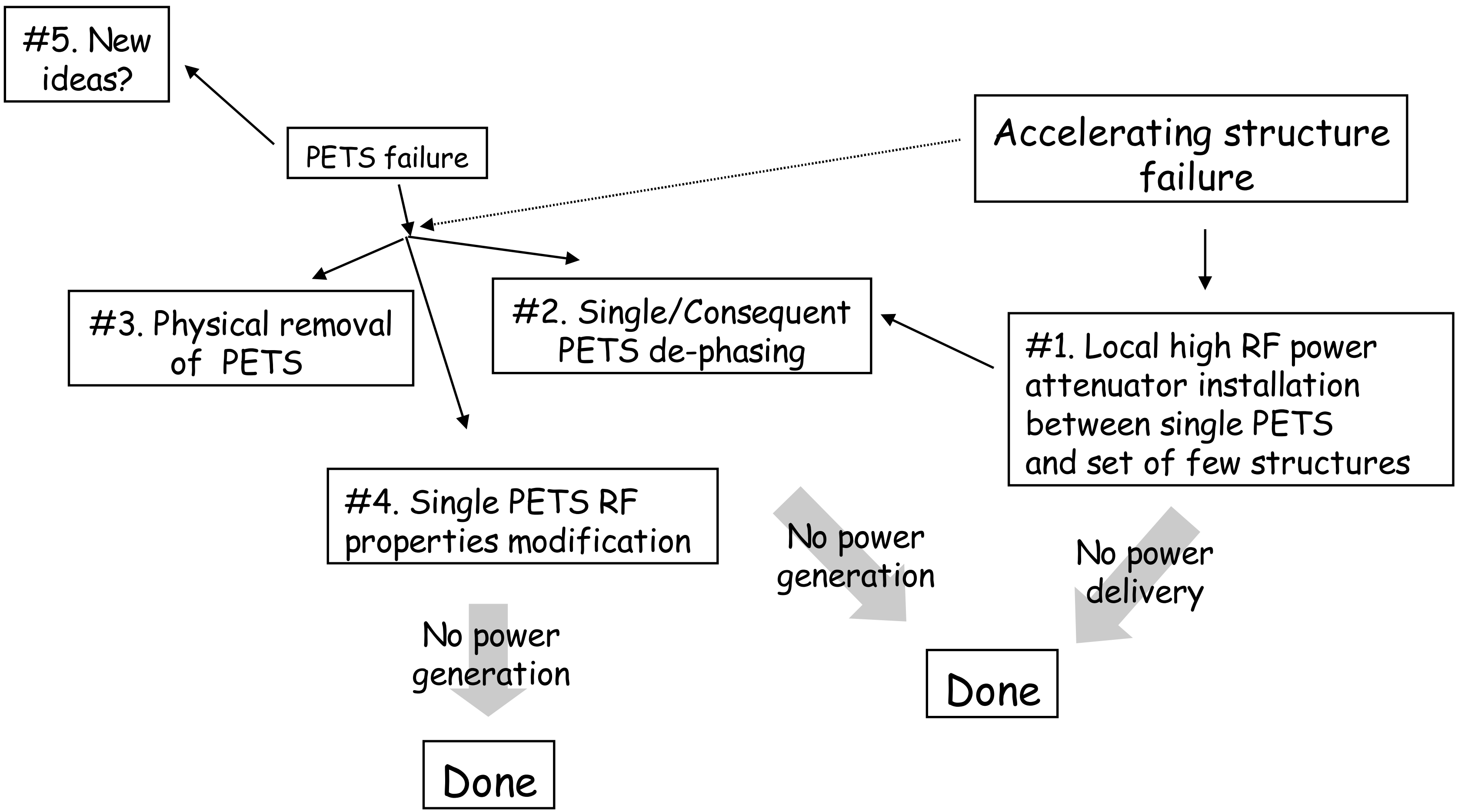
XDS
Single cell



"Electrical" coupler for CLIC accelerating structure

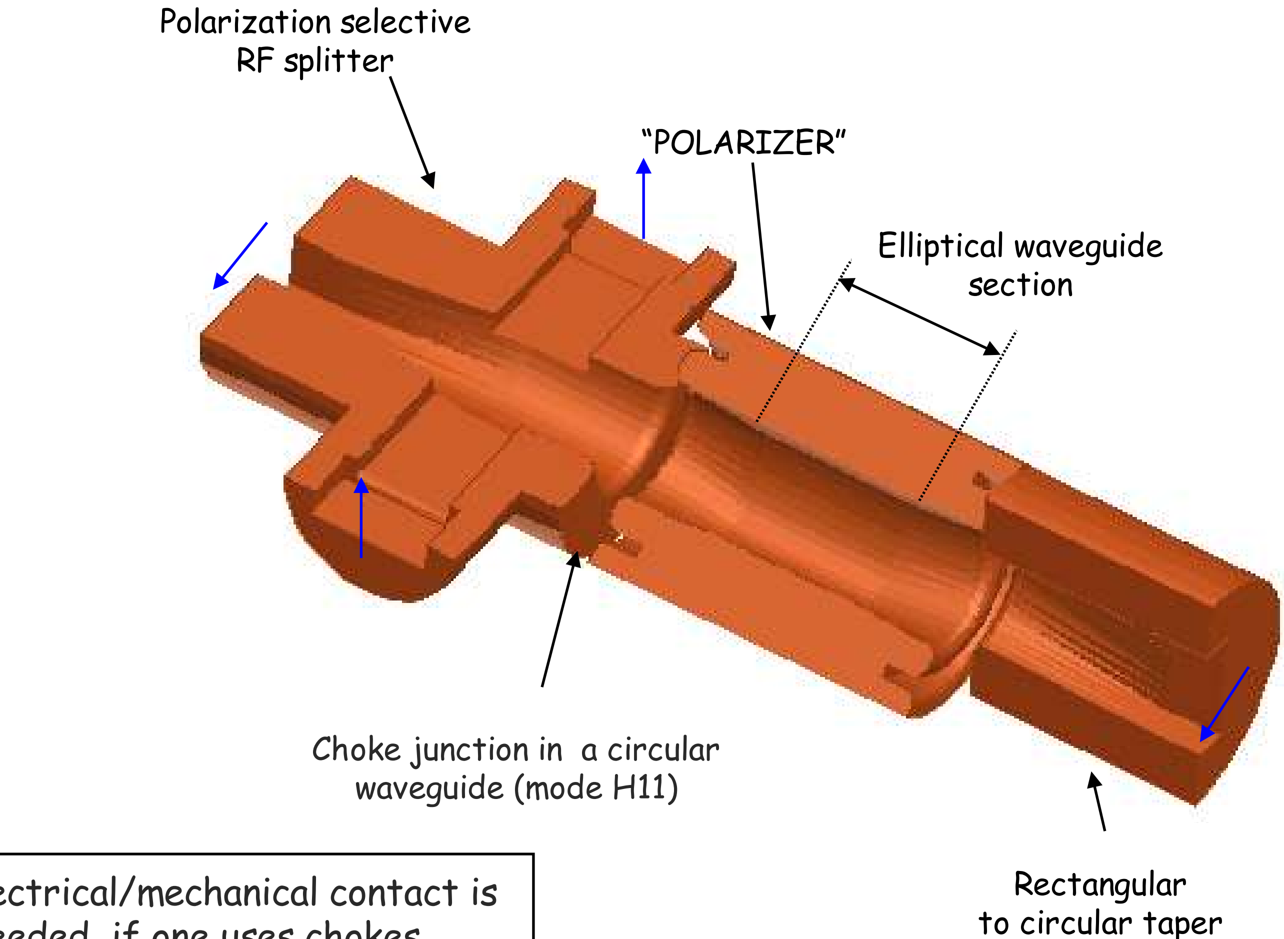
Input Power ~ 130 MWx130 ns
Max. surface electric field ~ **350 MV/m**

How we can possibly manage to do that?



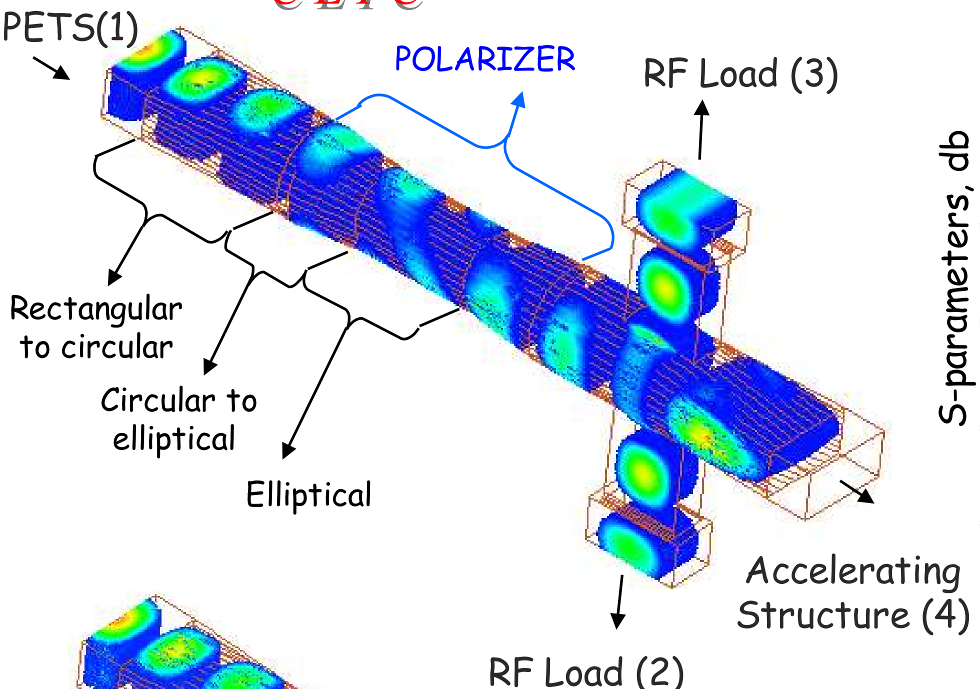
#1. High power RF splitter

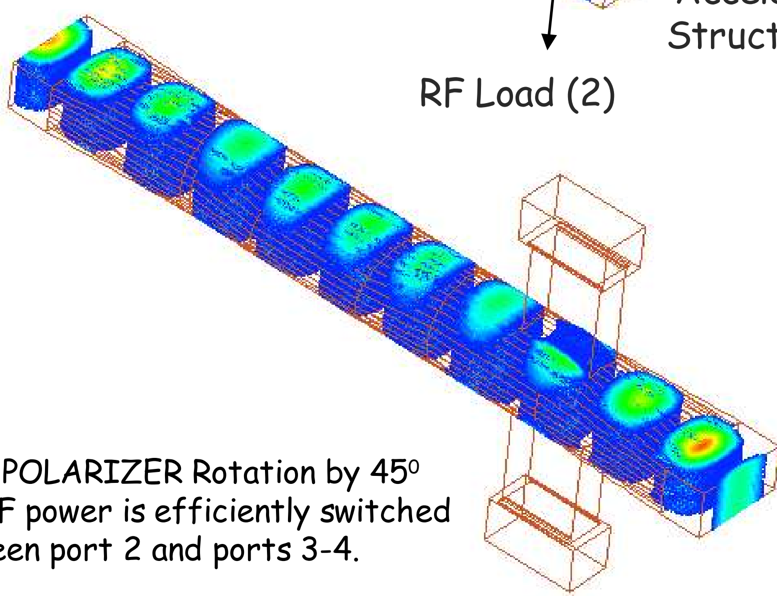
Artistic view of the novel high RF power splitter.

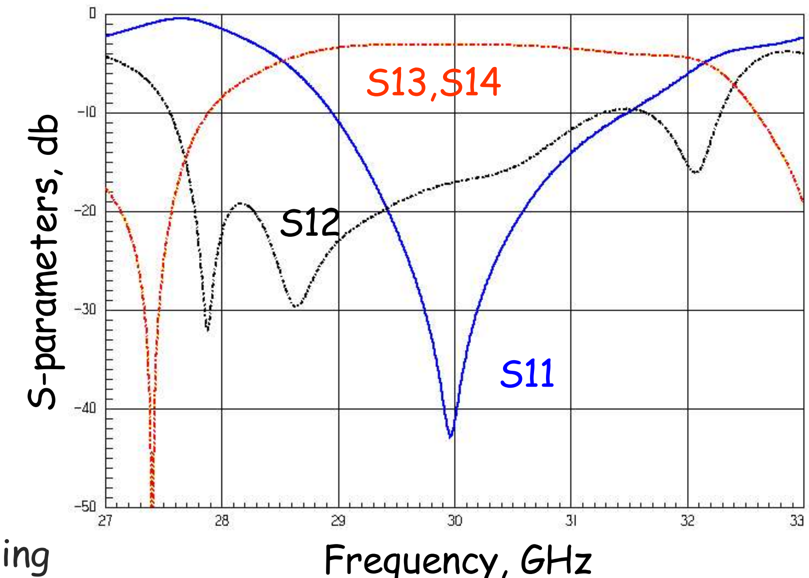


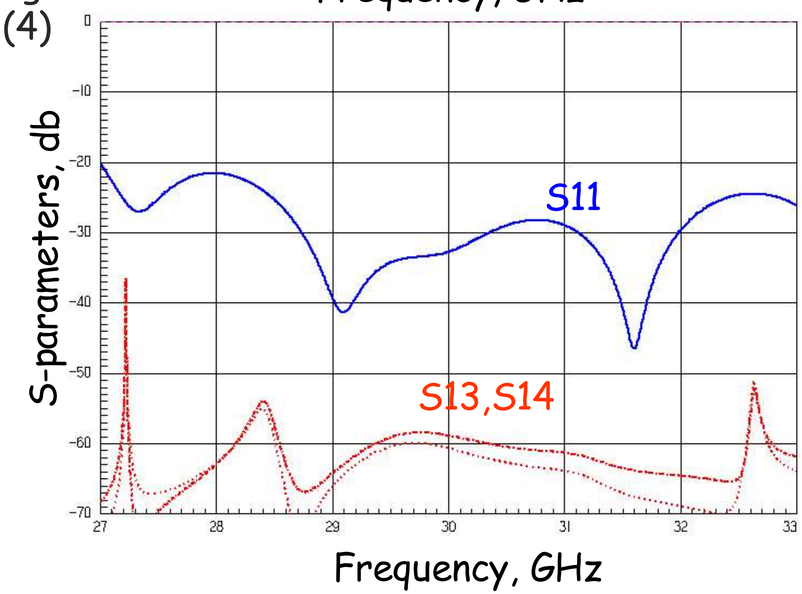
No electrical/mechanical contact is needed, if one uses chokes.

#1. High power RF splitter





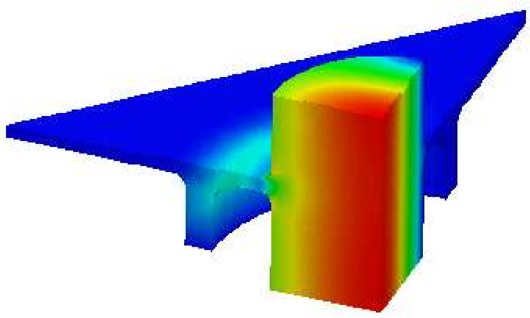




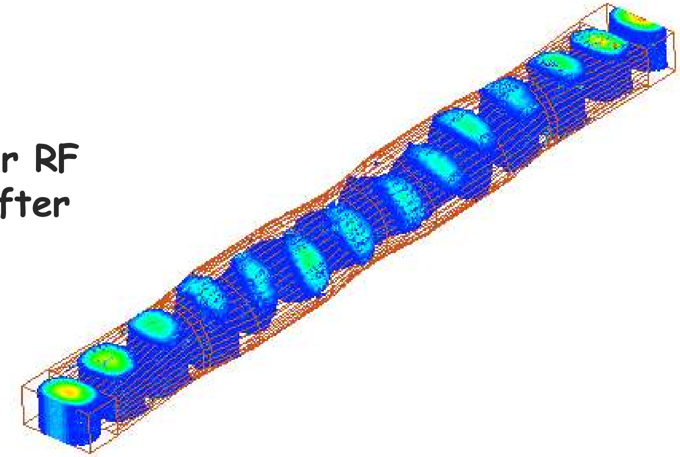
With POLARIZER Rotation by 45^0 the RF power is efficiently switched between port 2 and ports 3-4.

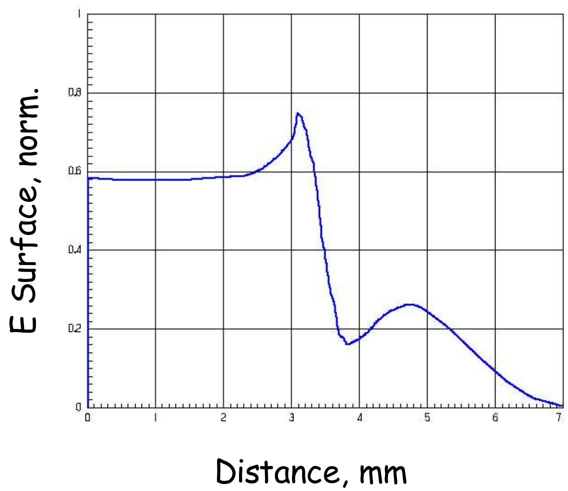
#1. High power RF splitter

Fields plot in choke junction.
Circular waveguide, mode H11

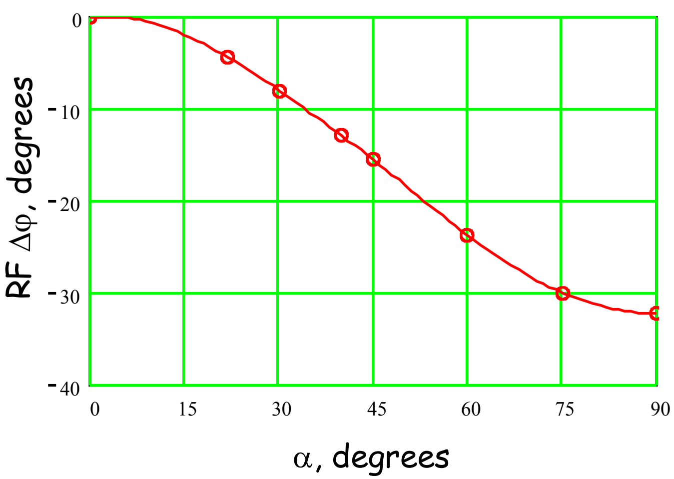


High power RF
Phase shifter





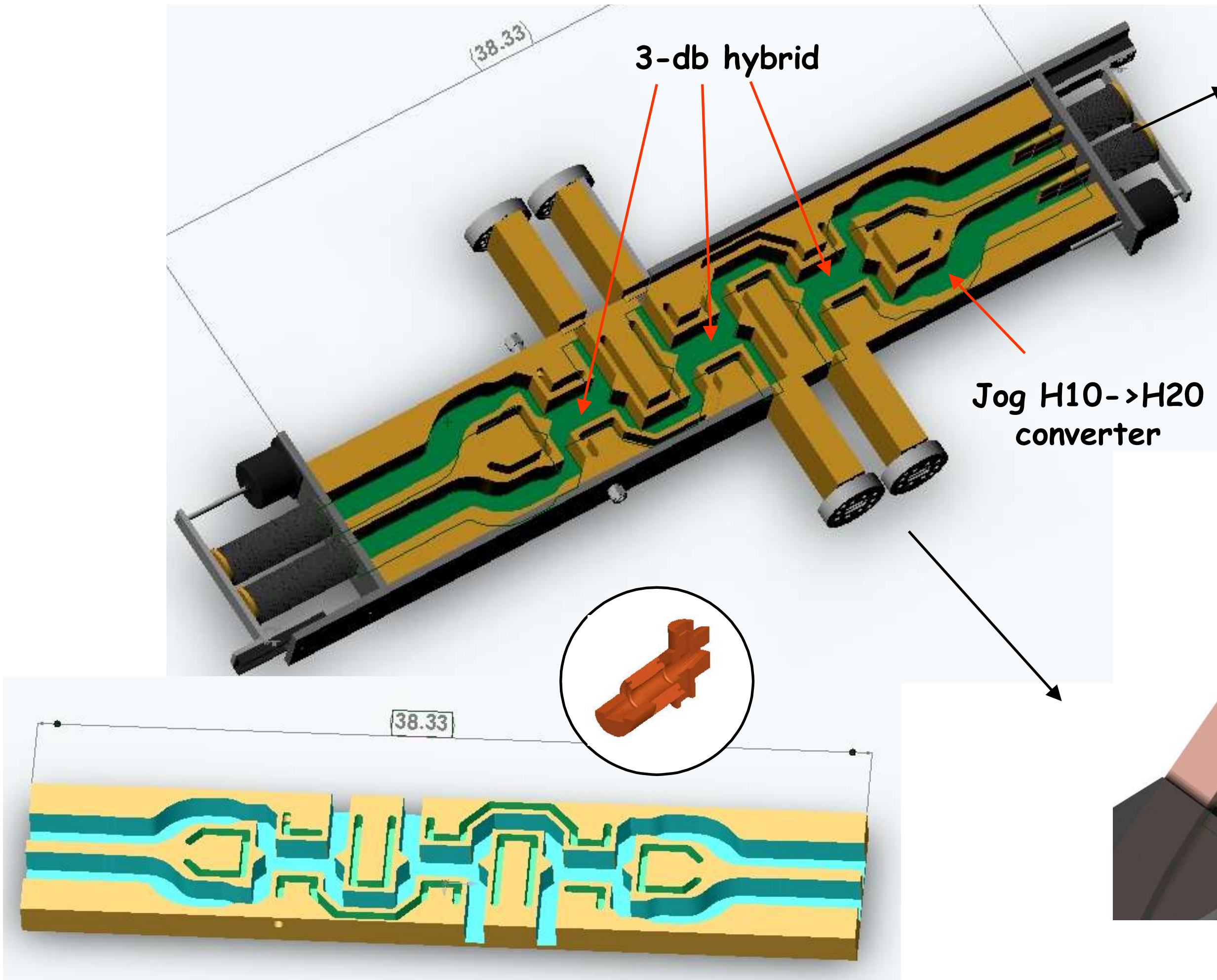
Rotation of two consequent "polarizers" is resulted in additional phase advance due to effective change of electrical length for the different polarizations. Tuning range can be increased with a simple lengthening of the elliptical part of the device



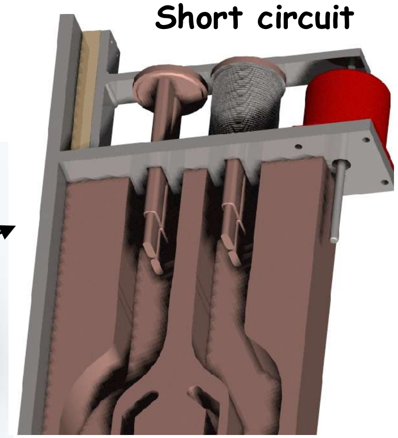
Max. surface field is 75% of that in a standard rectangular waveguide

#1. High power RF splitter

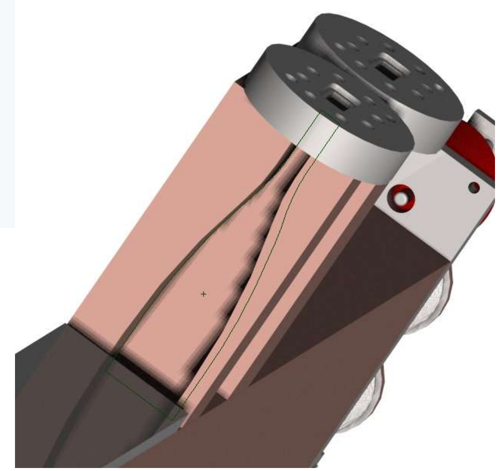
NLC 11.424 GHz High power planar attenuator.
(S. Tantawi)



H20 short tunable
Short circuit

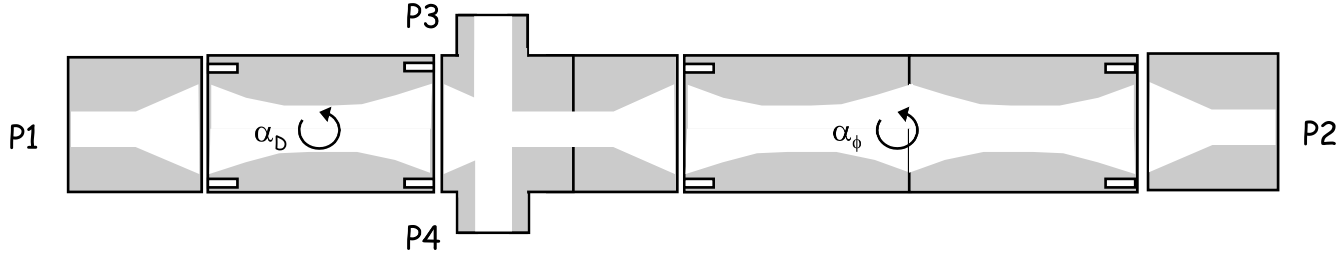


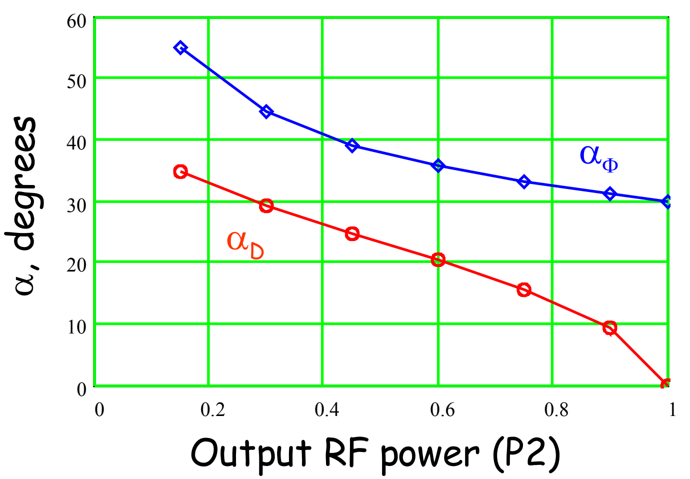
WG height taper



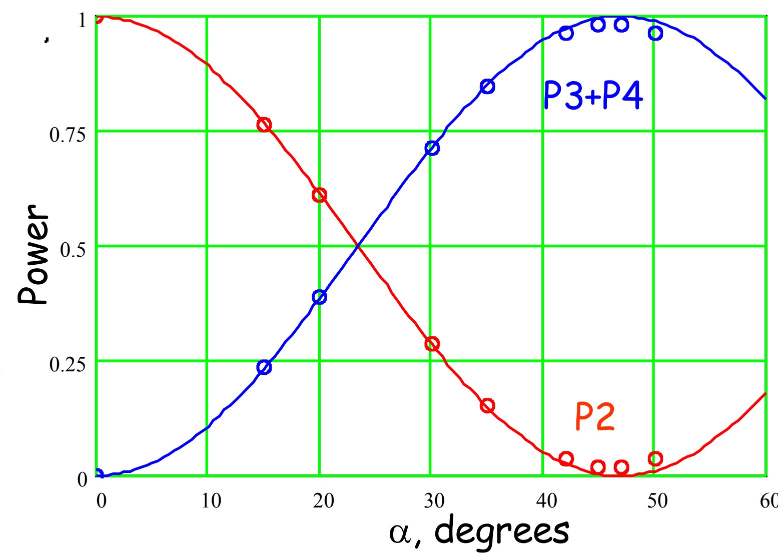
#1. High power RF splitter

Sketch of the high RF power attenuator with constant output RF phase





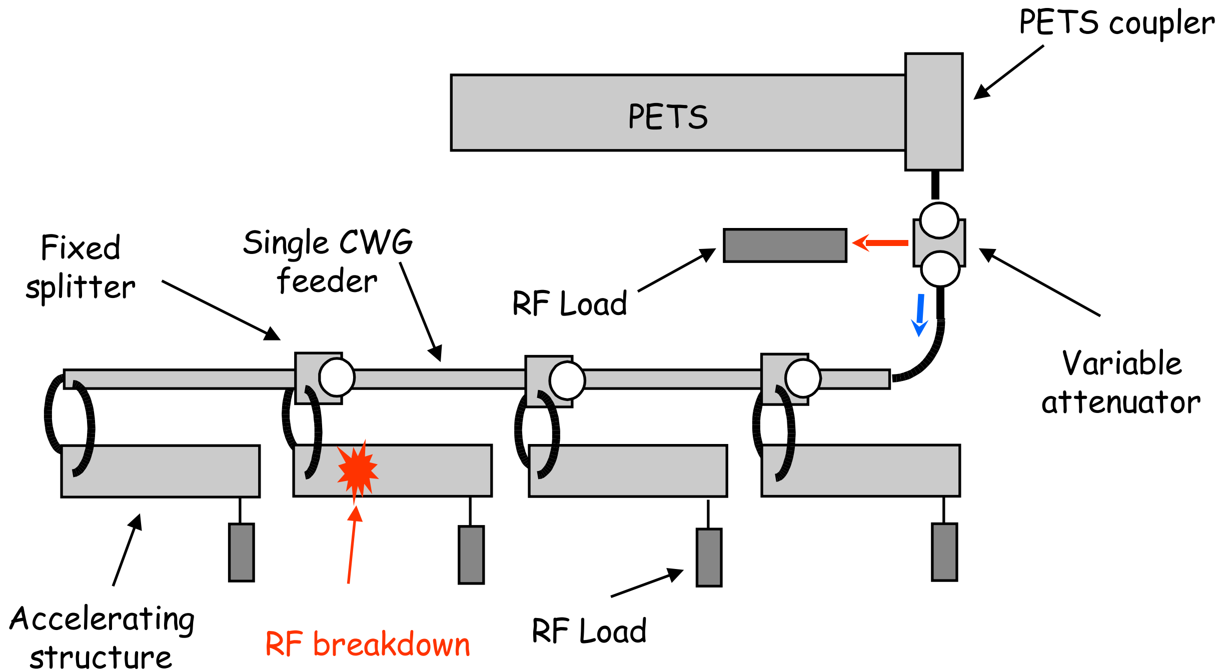
Rotation angles for the splitter and RF phase shifter vs. power attenuation for the constant output RF phase.



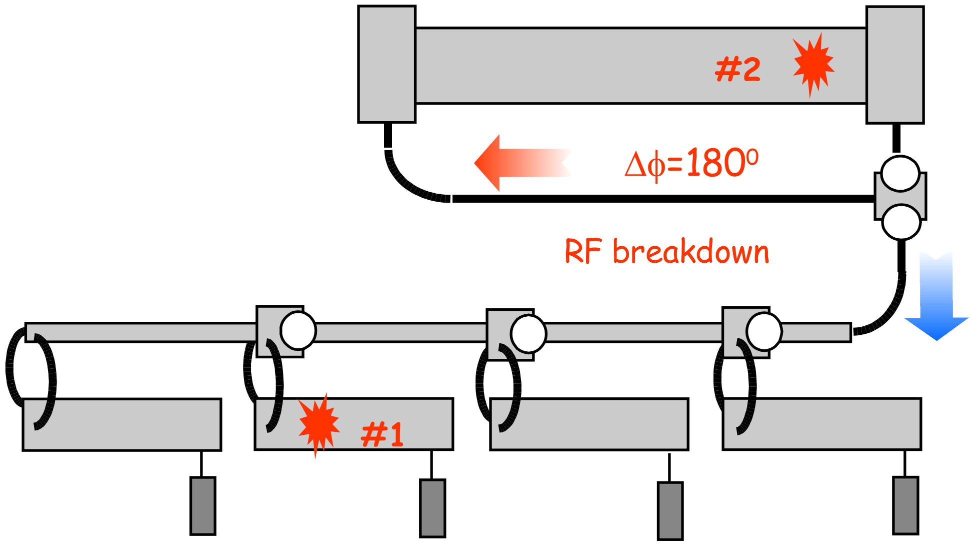
RF power budget of the splitter vs. Rotation angle.

#1. High power RF splitter

CLIC accelerator unit layout with local termination of the RF power delivery



CLIC accelerator unit layout with local termination of the RF power generation



Discussion:

#1. We know that serious breakdown "eats" practically all RF power.

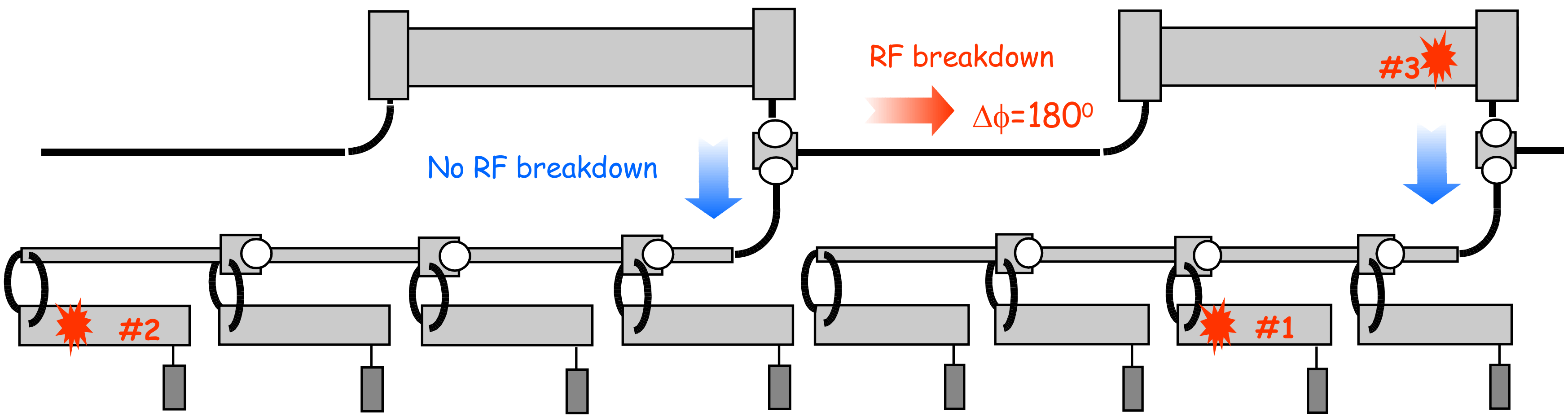
#2. With re-circulation the output/input power has periodical beating.

#3. Strong fields at the input of PETS are induced.

#4. Two PETS couplers per one power station are needed.

#1,2. High power RF splitter and 2 PETS de-phasing

CLIC accelerator unit layout with local termination of the RF power generation

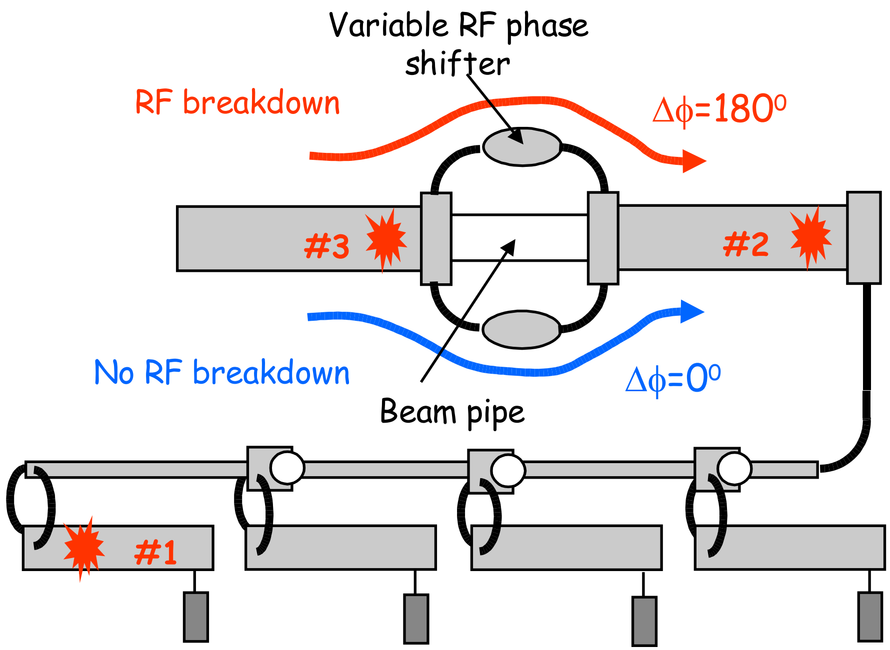


Discussion:

#1. Two power stations should be sacrificed in a case of any single breakdown.
#2. Upstream PETS is needed – no measure to cancel breakdown in #1 PETS.
#3. Strong fields at the input of downstream PETS are induced.
#4. Two PETS couplers per one power station.

#2. Single PETS de-phasing

CLIC accelerator unit layout with local termination of the RF power generation

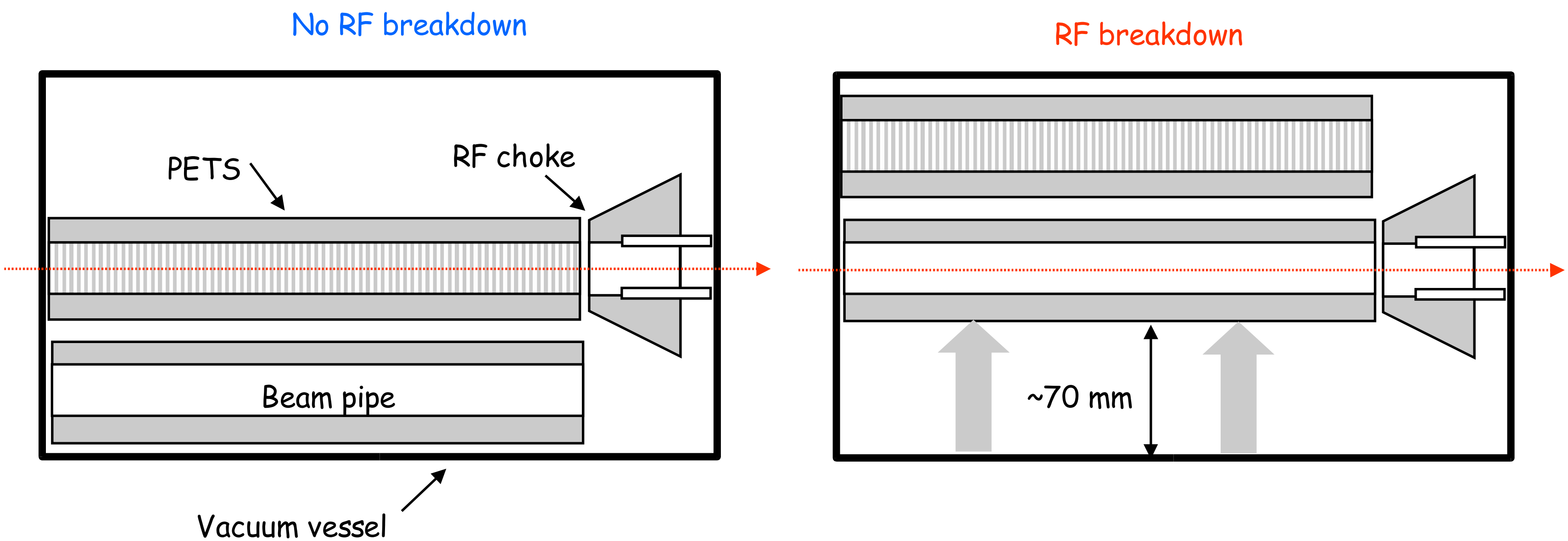


Discussion:

#1. Three PETS couplers per one power station plus dedicated variable RF phase shifters (-> inefficiency and complication).

#2. Upstream half-part of PETS is not protected.

#3. Physical removal of PETS



Discussion:

#1. Alignment (on/off)?

#2. Choke in over-moded waveguide. By itself it could be the place where the breakdown is most likely probable. Mode conversion and transverse kick danger.

#3. Low frequency trapped modes in a beam pipe (need to be damped?)

#4. Single PETS RF properties modification

PETS power production modeling

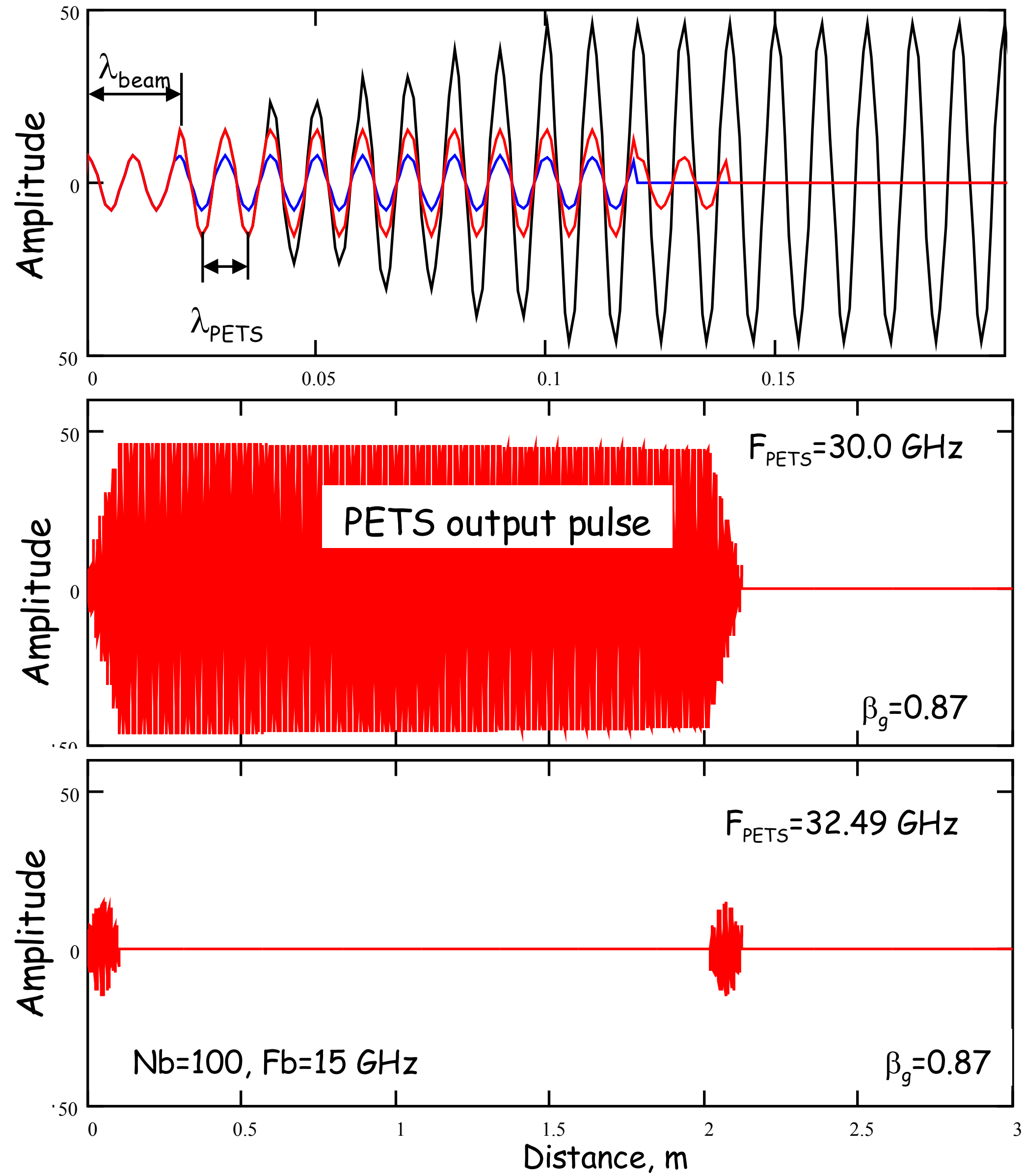
Single bunch wake:

$$E_b(z) = \cos\left(2\pi \frac{z}{\lambda_{PETS}}\right)\frac{1}{1-\beta_g}$$

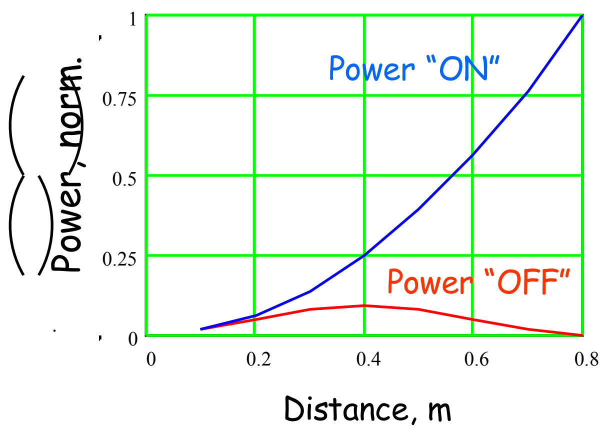
$$E_b(z) = 0, \quad z < 0;\ z > \frac{L_{PETS}(1-\beta_g)}{\beta_g}$$

PETS output signal:

$$E_{out} = \sum_{i=1}^{Nb} E_b(z - i \times \lambda_{beam})$$



RF power profiles along PETS



#4. Single PETS RF properties modification

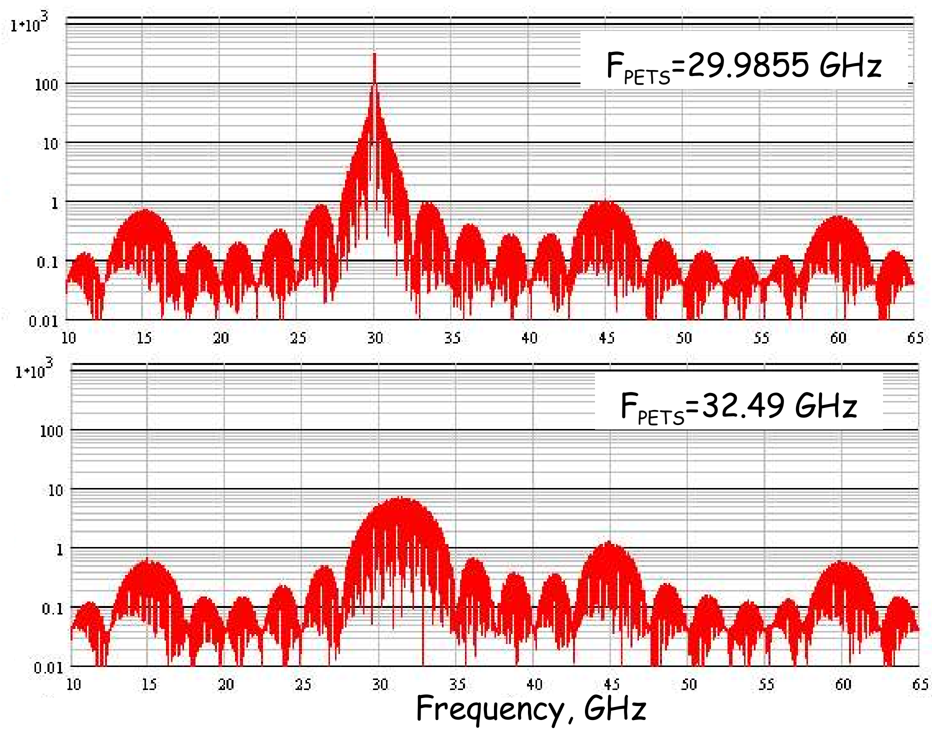
Statement:

The RF properties of the CLIC PETS should not be modified with any lump elements (tunable chokes and etc.), to avoid any mode conversion and high transverse impedances introduction. This should be done adiabatic.

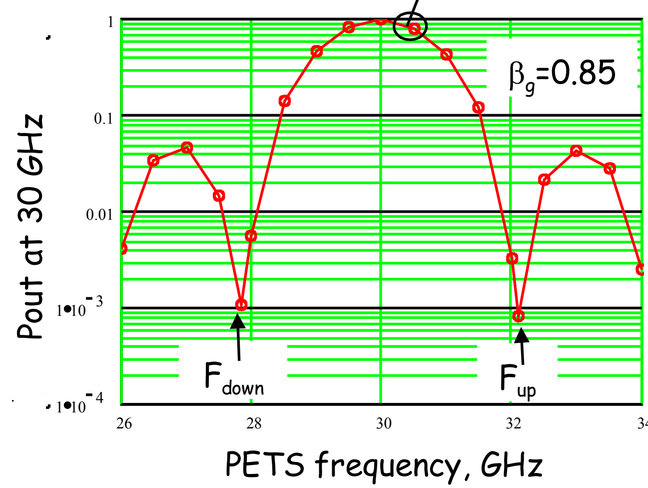
We are here – 30.45 GHz (Daniel)

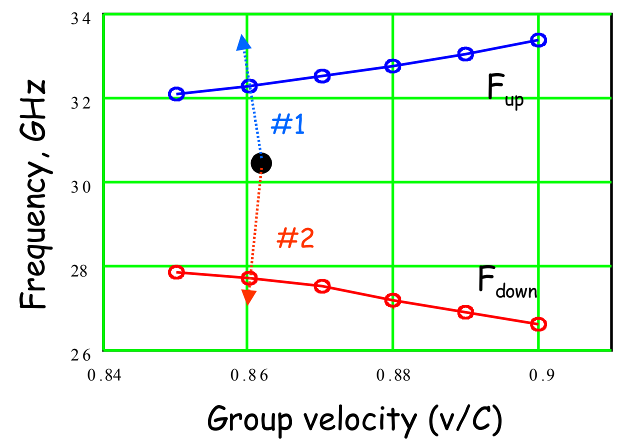
The generated RF power can be significantly reduced if we can find the way to change PETS synchronous frequency

Spectra of the RF pulses generated by 15 GHz drive beam



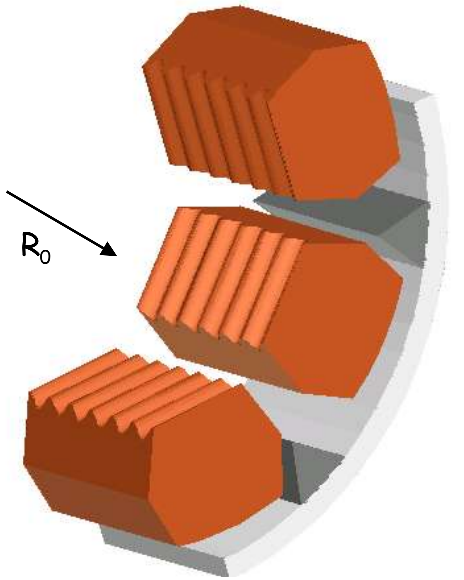
30 GHz RF power vs. PETS de-tuning



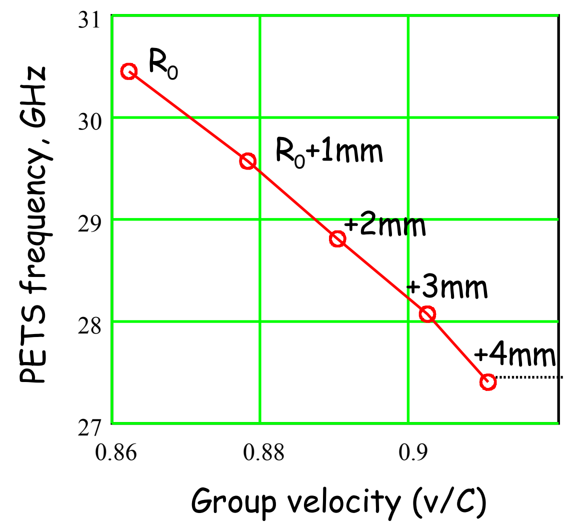


#4. Single PETS RF properties modification

Modified PETS geometry with a pull/push option.

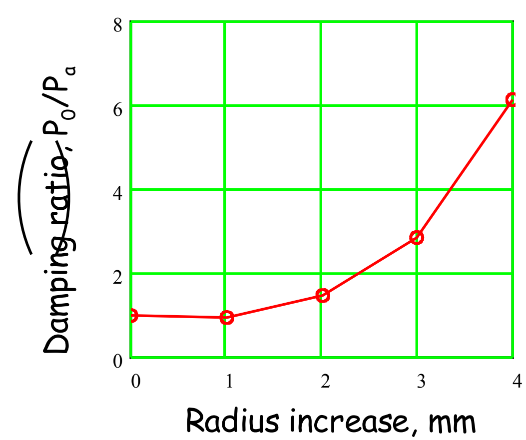


PETS parameters vs. aperture increase



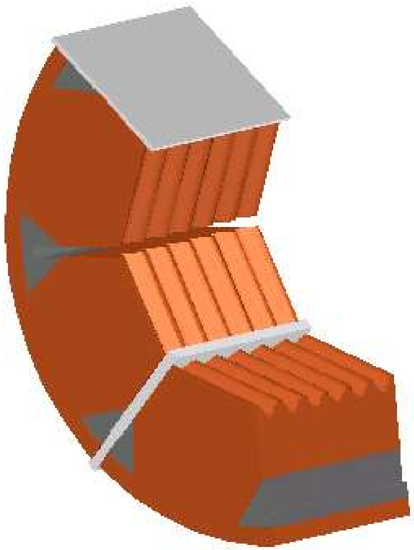
Limit due to the damping slot opening. $F_{cr.}$ comes closer to 30 GHz.

PETS detuning concept #1

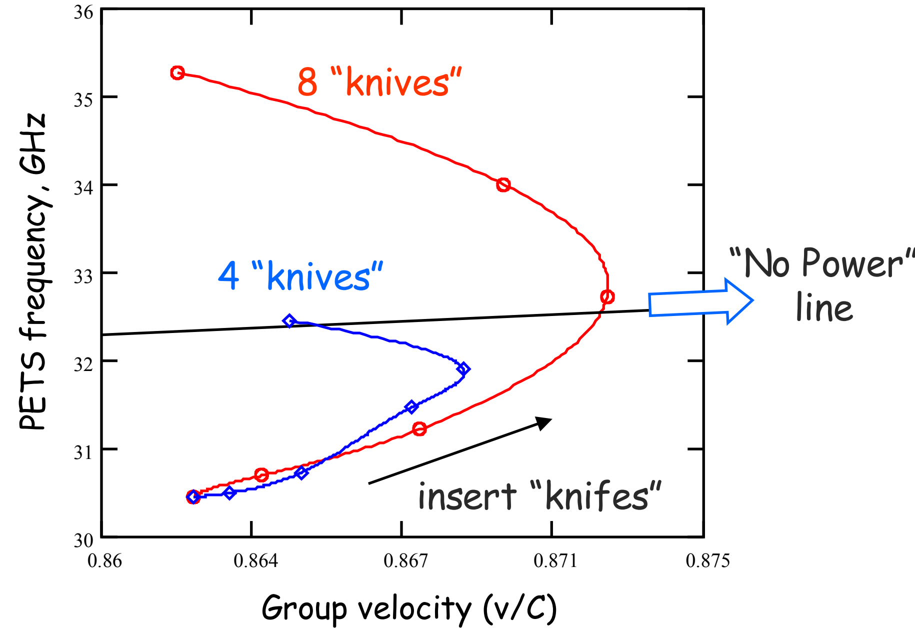


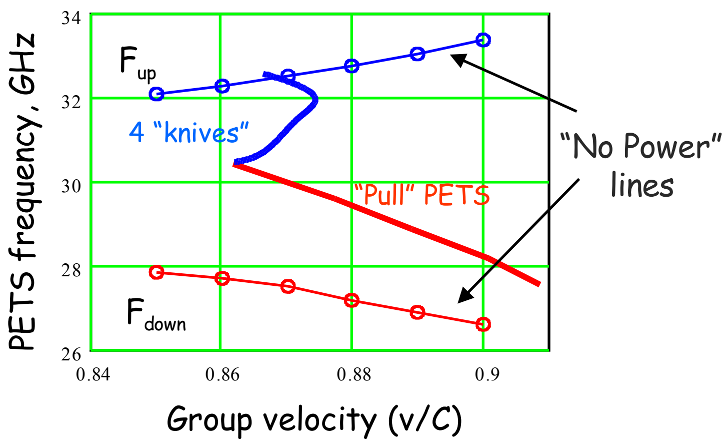
#4. Single PETS RF properties modification

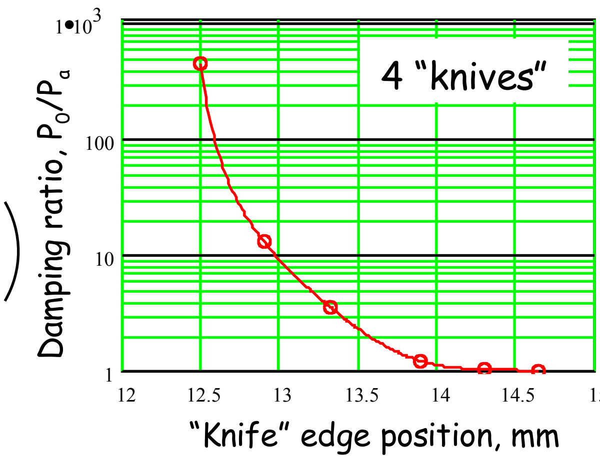
PETS detuning concept #2



PETS parameters vs. "knife" position



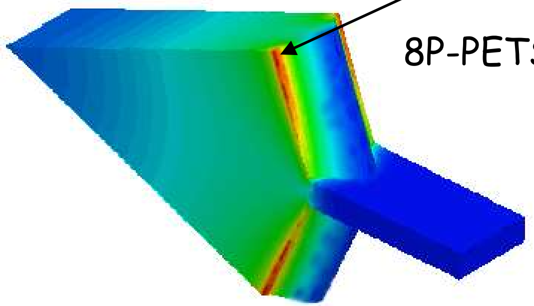




For 560 MW:

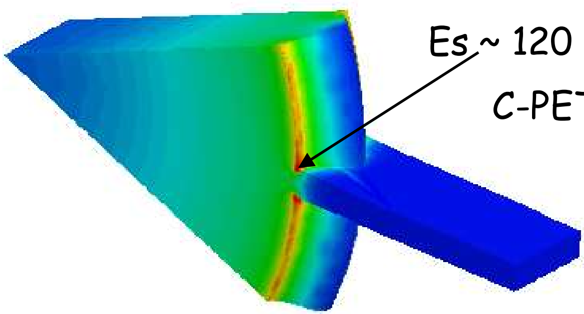
"8-petals" PETS versus "Circularly-symmetric" PETS

Es ~ 100 MV/m

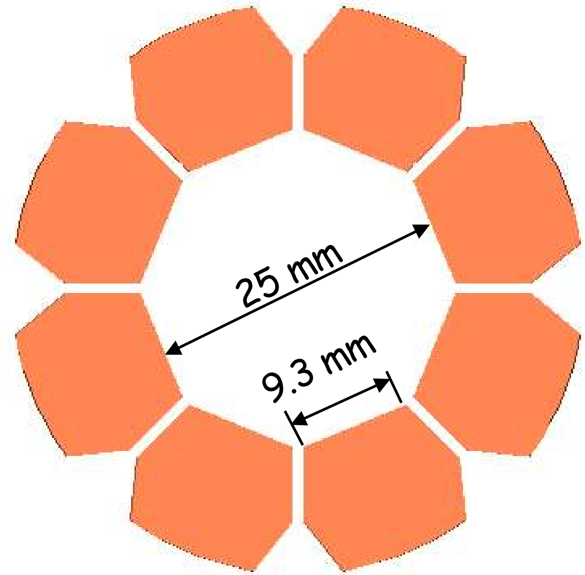


8P-PETS

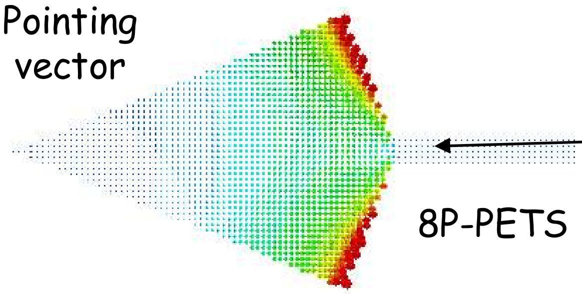
Es ~ 120 MV/m



C-PETS



Pointing vector



8P-PETS

"8-petals" PETS;
#1. Reduced max. surface electric field
#2. Each "petal" should be machined from single rod.
#3. The same damping technique as for the C-PETS
#4. Better field pattern for RF power extractor, natural 8-th symmetry - no needs for "diffractor"

Summary

#1. Even the accelerating structure failure looks more probable, we can not ignore the chances of PETS RF breakdown.

#2. Following the few preliminary discussions and my personal opinion the best candidate will be "4-knives" PETS option.

#3. The detailed study of "8-petal" PETS to complete technical design for the damping slots and new loads configuration should be done (already started).

#4. The developed RF power attenuator and RF phase shifter by themselves are very useful components that can be used even in CTF#3 30 GHz high power operation.