Local termination of the power production in the PETS. ON/OFF options and operation.

Igor Syratchev & Alessandro Cappelletti

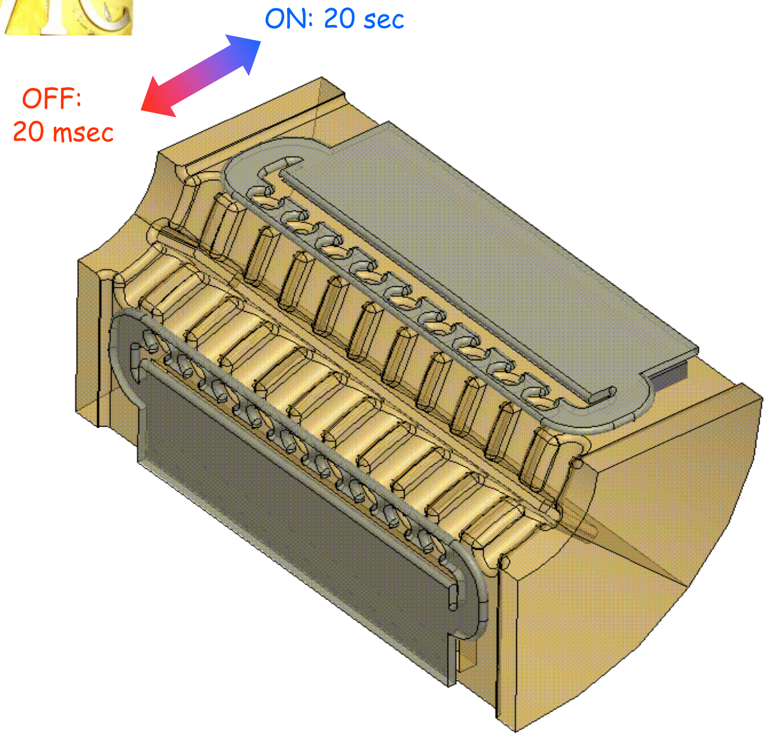
✓ During machine operation the accelerating structure and/or PETS will suffer from the number of RF breakdowns.

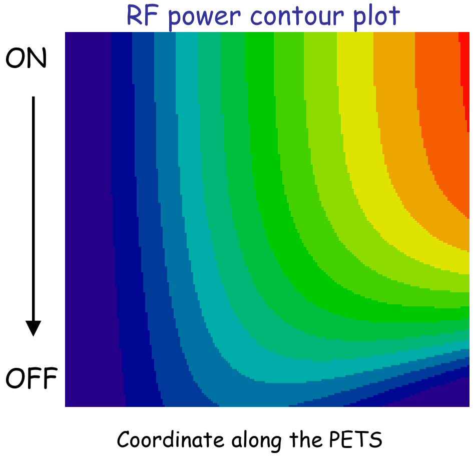
✓ Currently we have a little information about the actual behavior of the structures at a very low (by design: <3×10^{-7} /pulse/meter) breakdown trip rate and so it might be necessary to switch the single structure/PETS OFF and re-process it.

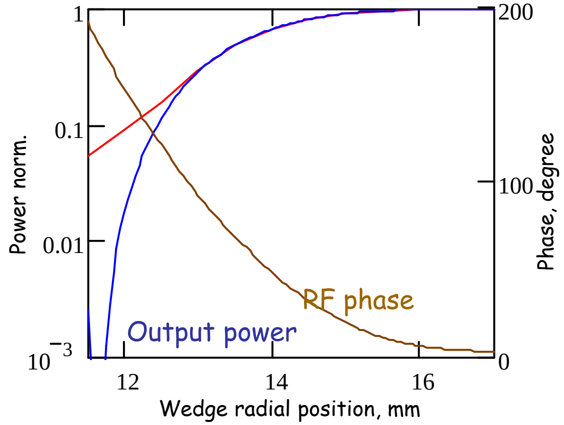
✓ In order to maintain the operation efficiency we want to do the switching OFF very fast – between the pulses (20 msec).

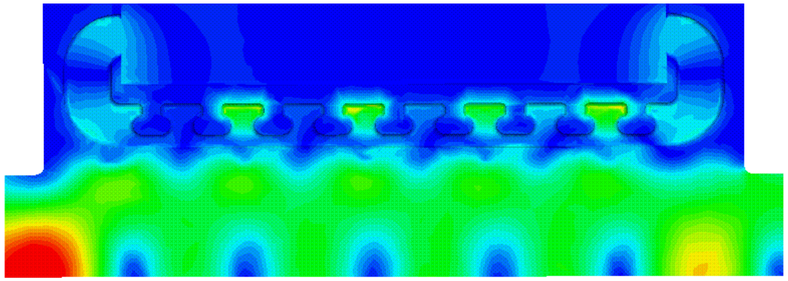
✓ Here we will discuss different possible options and operation regimes of the devices capable to do that.

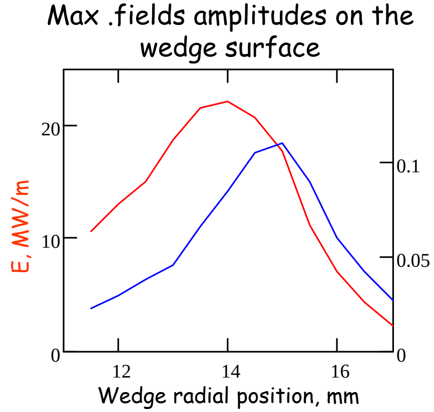
Internal modification of the PETS synchronous frequency (present baseline approach)

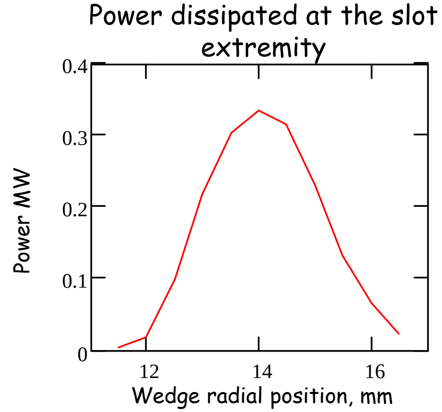


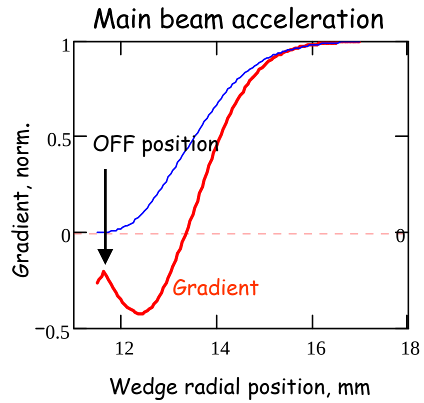












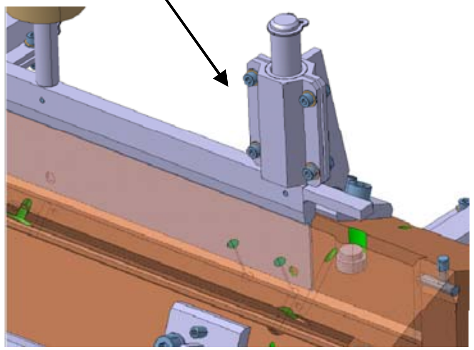
The net RF power generated by the beam at the end of the constant impedance structure will be zero if the structure synchronous frequency is detuned by the amount $\pm 2\beta c/(1-\beta)L$, where β – V_g/c and L - length of the structure. We have found that such a strong detuning can be achieved by inserting four thin wedges through four of the eight damping slots.

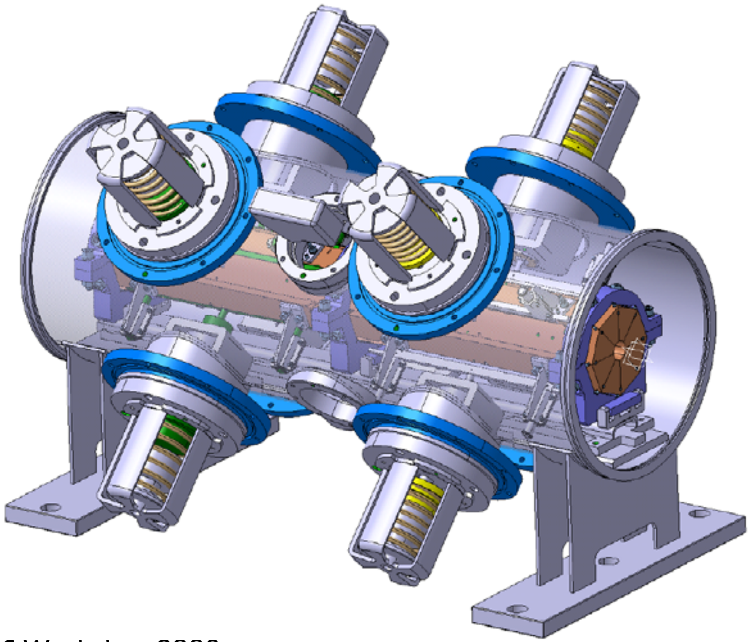
Pets On/Off Prototype

Design, cost, tests

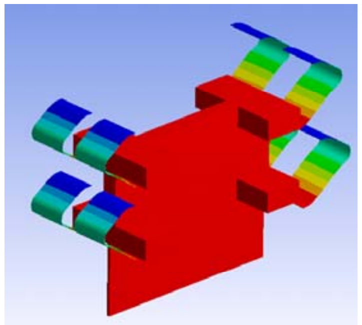
B. Nicquevert, TS/MME – on behalf of the design team

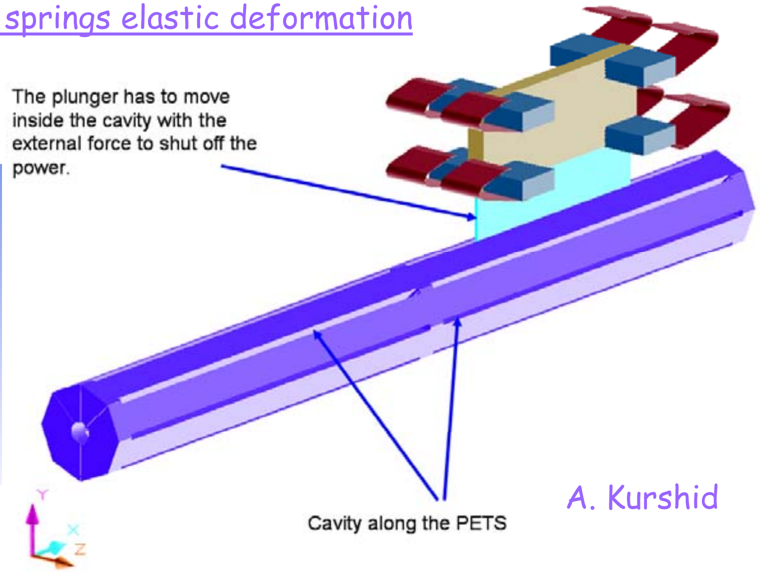
Guiding system with Cu/Be bushings and stainless steel rods,





Guiding system with the springs elastic deformation





A. Kurshid

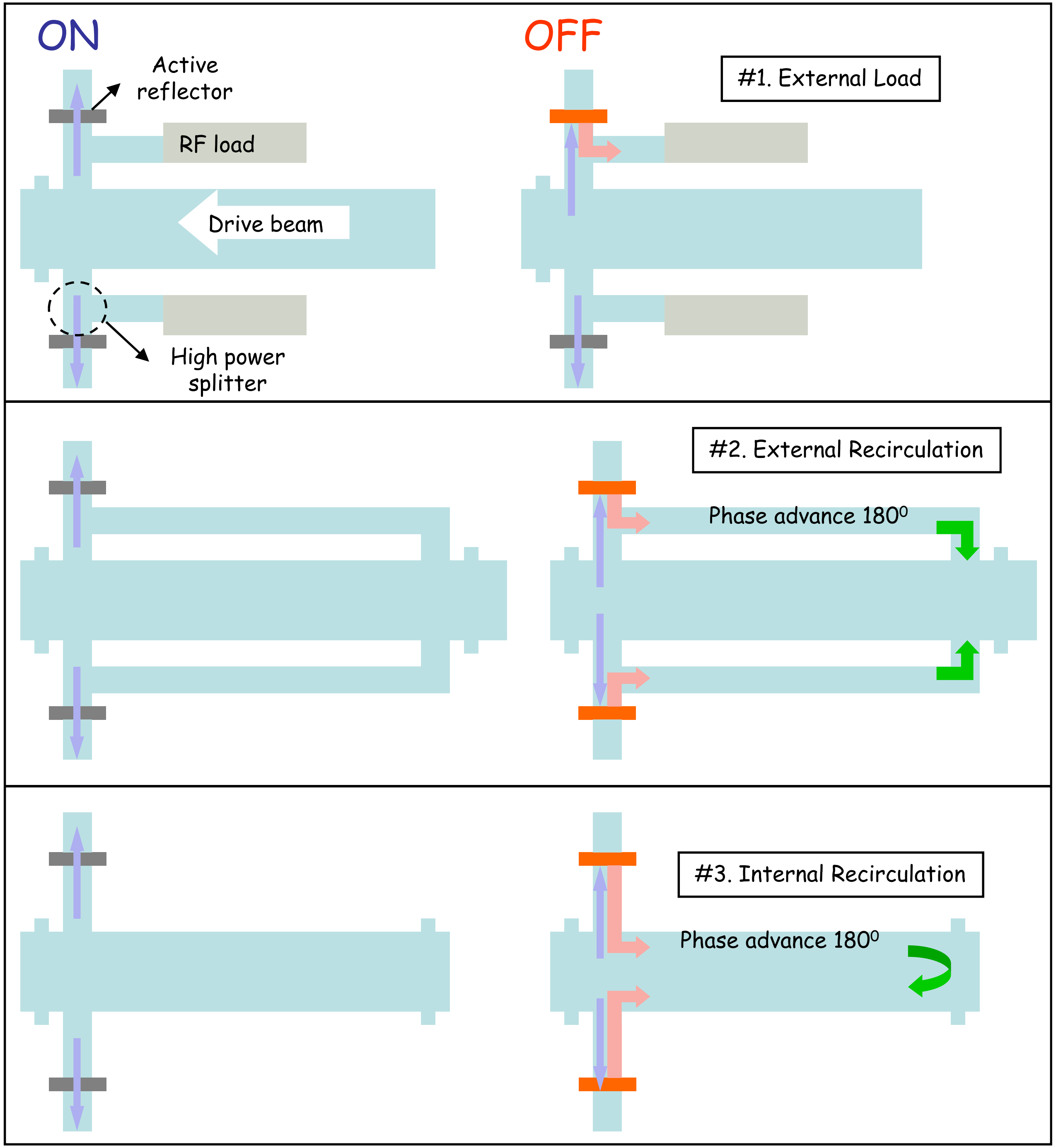
The few preliminary studies for the precise, fast and synchronous movement of the 4 blades in vacuum indicated that this system could become the cost driver for the whole PETS unite.

We are cordially inviting everybody to bring the new technical proposals and to participate in design, construction and testing of the cost-effective and reliable ON/OFF mechanism for PETS !

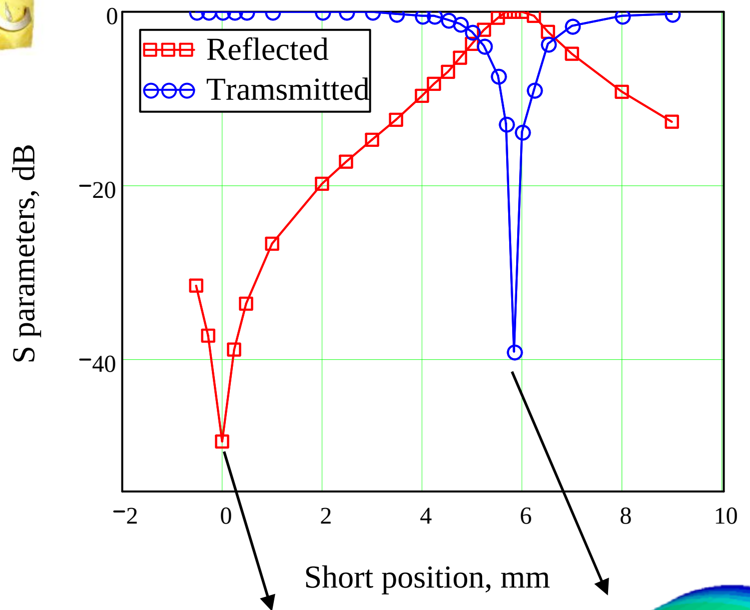
The ON/OF concepts with external active element.

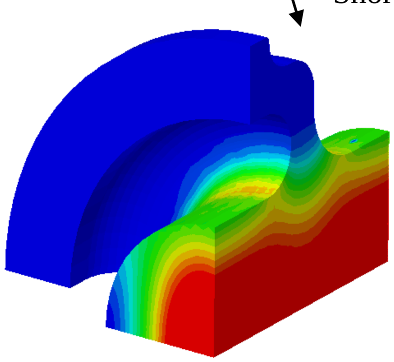
Method#	1	2	3
Minimal # Structure to be switched OFF	1	2	2
The PETS breakdown switching OFF	no	yes*	yes*
Extra hardware:			
- Active reflector (new)	⊗	⊗	⊗
- Splitter (new)	⊗	⊗	-
- Coupler	-	⊗	-
- Load	⊗	-	-
PETS (OFF) operation:			
- Travelling wave	⊗	⊗	-
- Partially standing wave	-	-	⊗
PETS power production:			
- Nominal	⊗	-	-
- Reduced	-	⊗	⊗

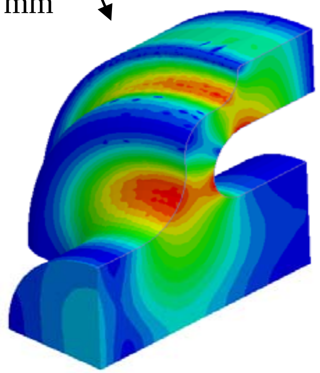
* To be studied/demonstrated!

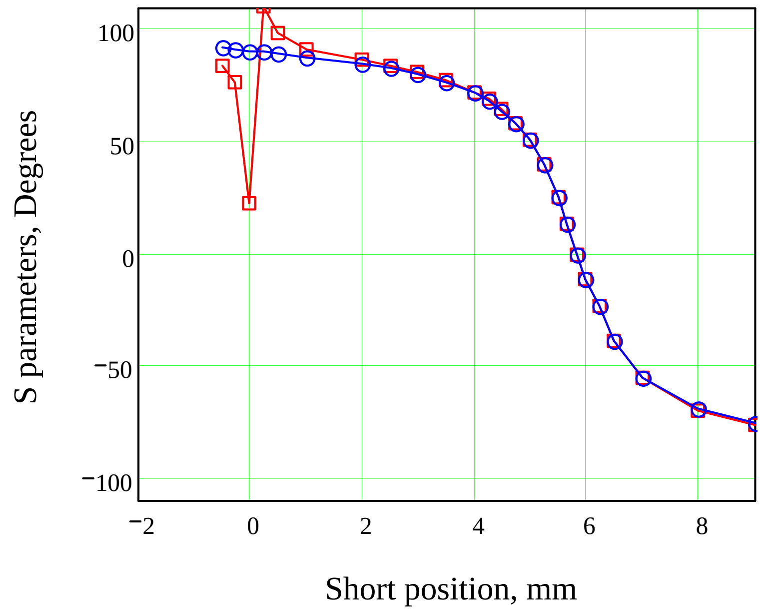


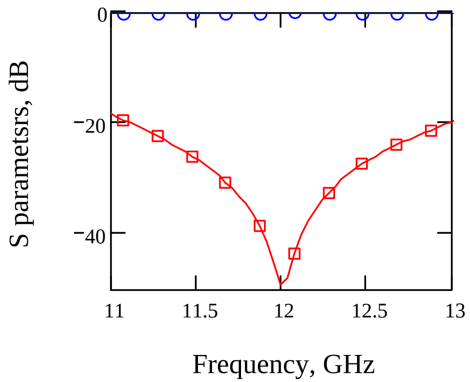
The choke-based tunable reflector concept.

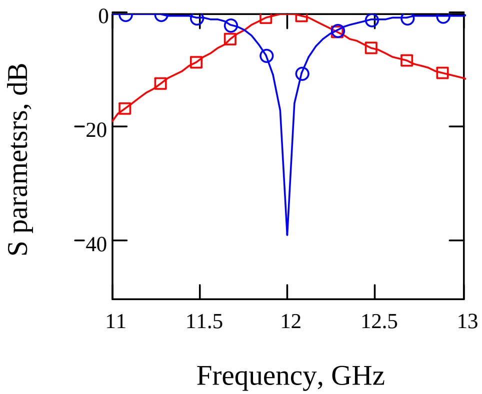


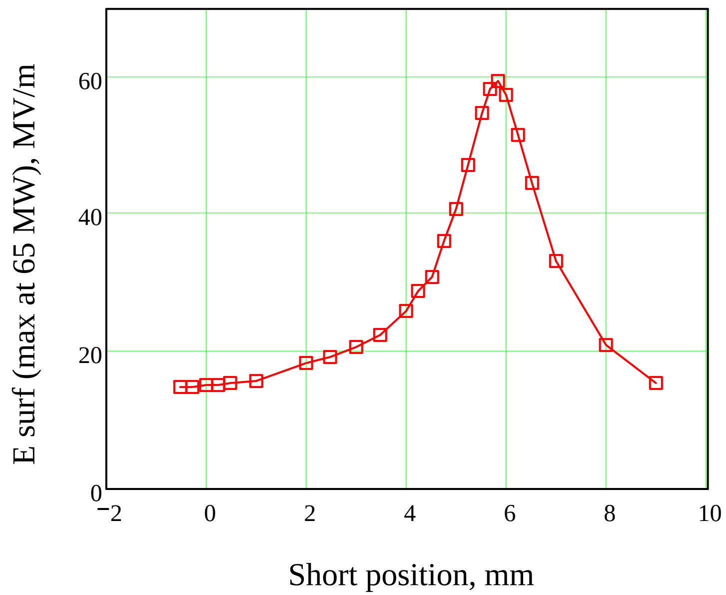




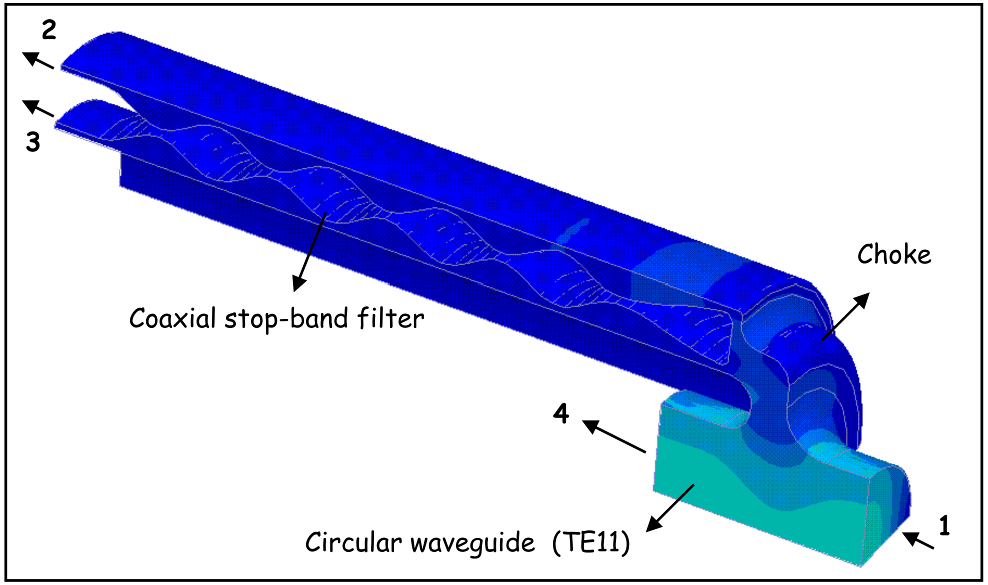


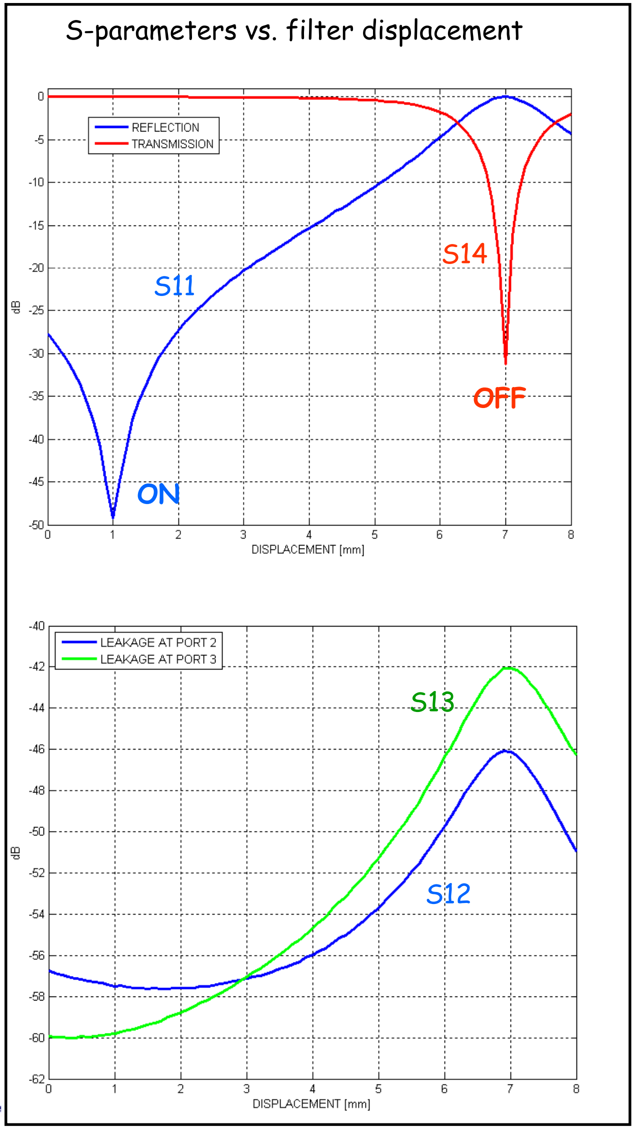


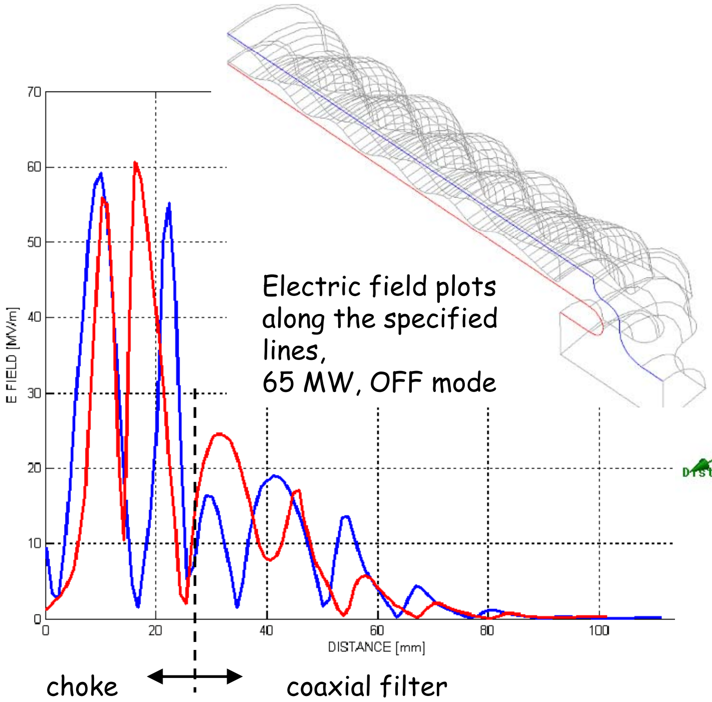


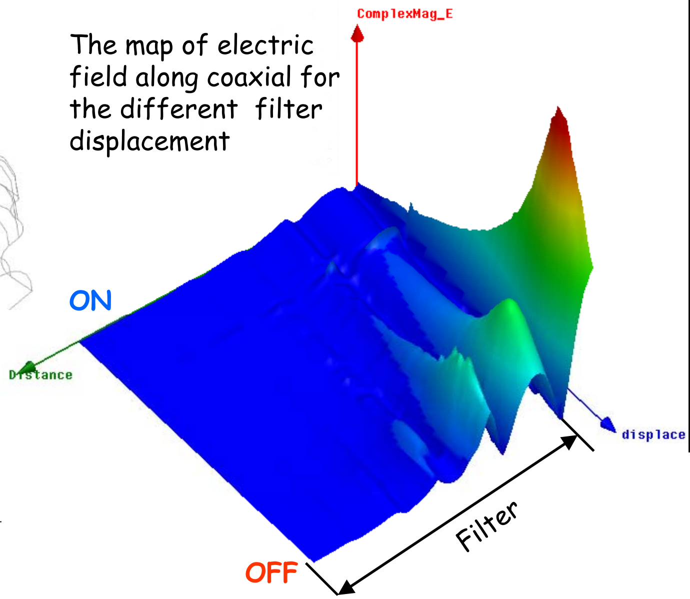


The RF design of the contact-free tunable reflector

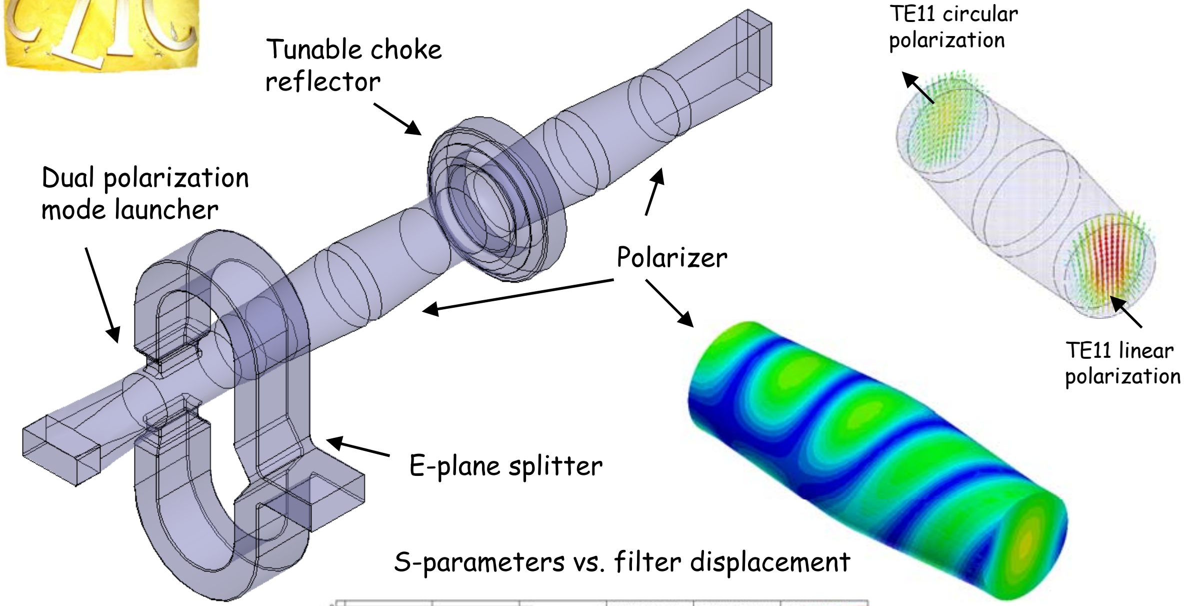




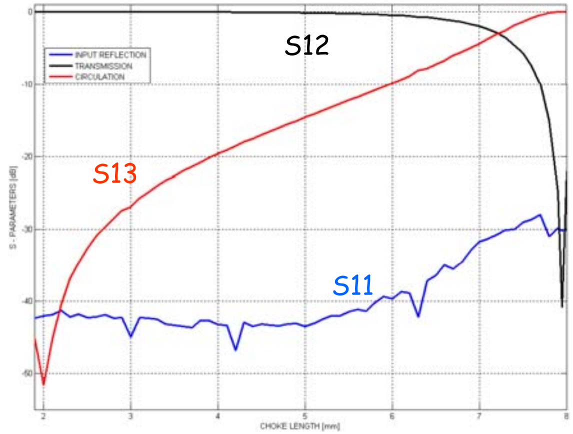


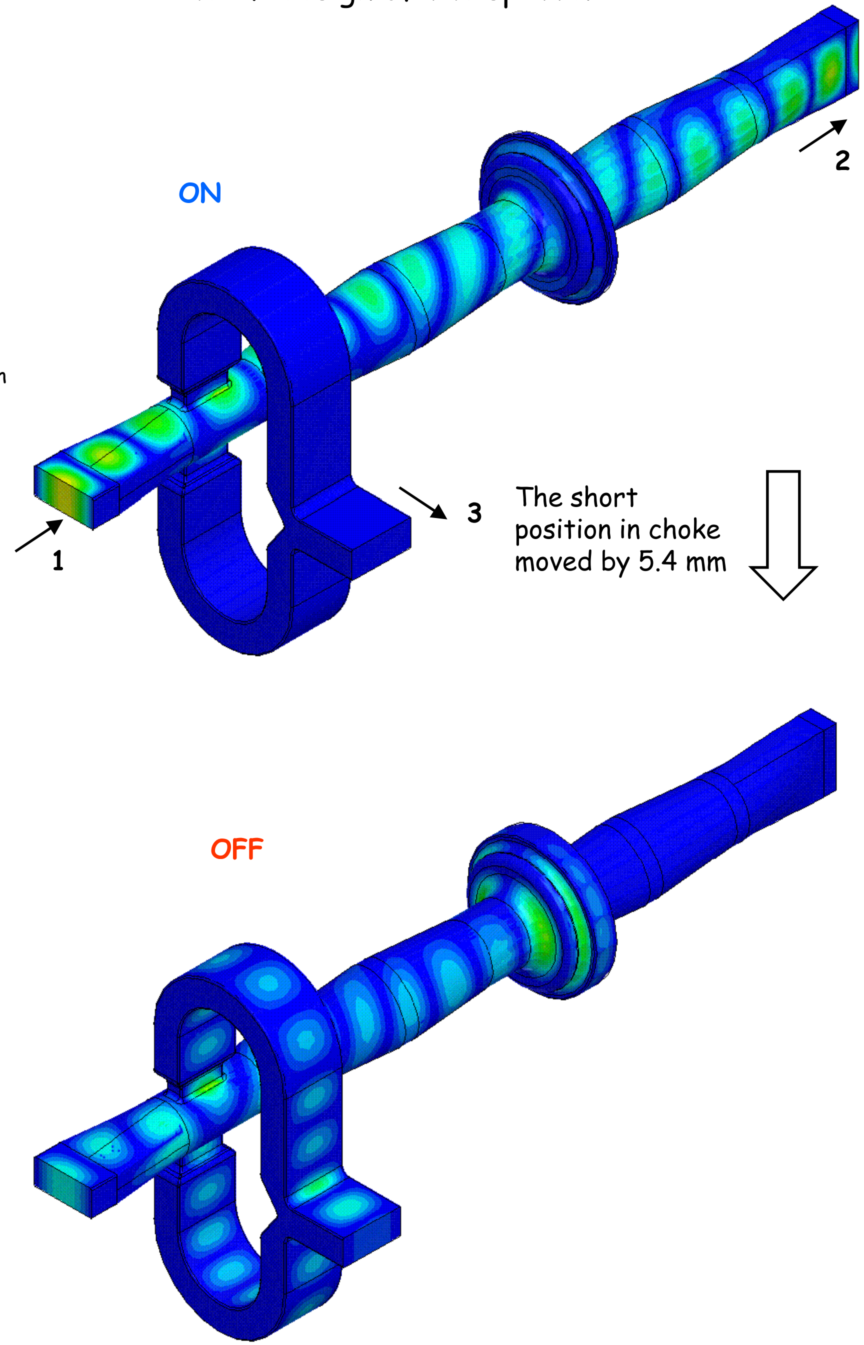


The RF design of the splitter #1



S-parameters vs. filter displacement





- Changing the reflection from choke, the RF power can be gradually switched between the two output channels.
- The circular polarization of the TE11 mode allows for the 30% field reduction in the choke.
- In itself, the device can be used as a compact (29 cm long) high power attenuator/splitter.

- By rotating the polarizer 0^0 -> 45^0 the RF power can be gradually switched between the two output channels.
- In itself, the device can be used as a compact (28 cm long) high power attenuator/splitter.

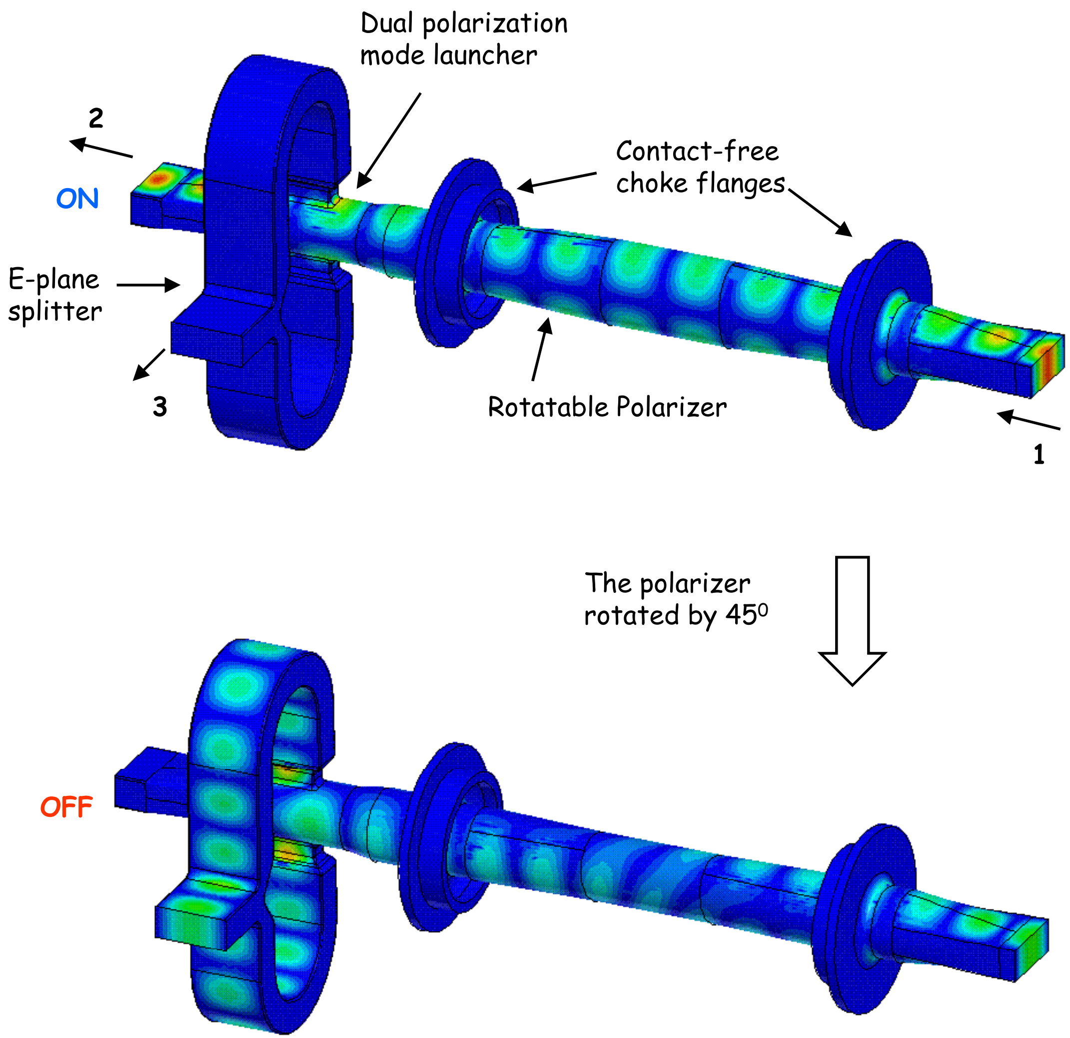
Comparing to the splitter design with the choke reflector, the present design provides:

☺ The more broadband solution both for ON and OFF state.

☺ The RF phase of the spitted signals is independent of the polarizer angular position.

😐 Both designs have similar concentration of the surface electric field: ~ 40 MV/m at the nominal CLIC RF power level (65 MW). However the field level in the choke area is much smaller: ~ 15 MV/m

☹ The mechanical design for the fast 45^0 rotation of the object in vacuum, at a first glance, looks more complicated than the linear movement.



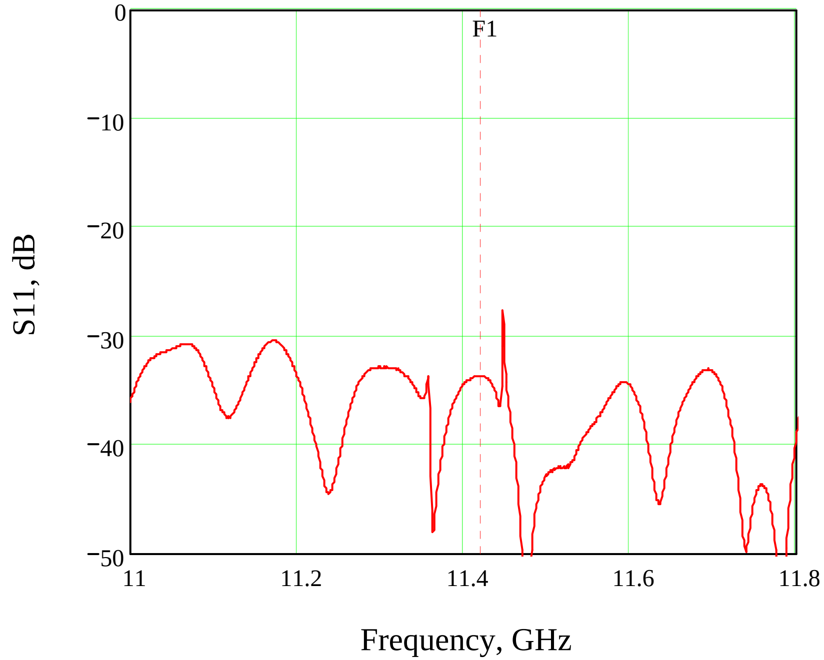
The new RF component development.

1. The choke flange concept allows for the design of the compact tunable RF devices. The first X-band prototype have been build and will be tested soon at SLAC at high RF power level.
2. The RF design of 11.424 GHz tunable choke reflector and polarized power splitters have been finished and are ready for the mechanical design.
3. We are planning to build the first prototype (slow) and test it at SLAC in 2009.

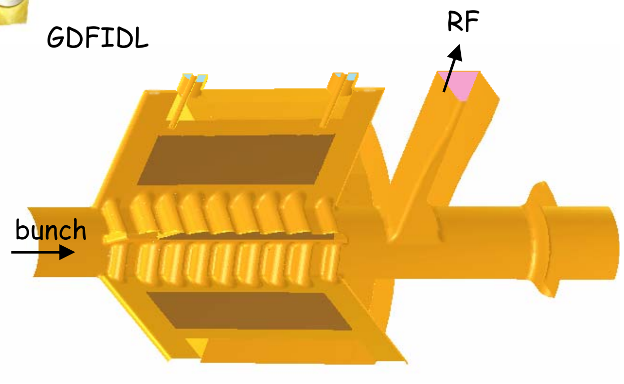
However, there is still a long road to go! We are inviting you to bring the new ideas. One of the promising approach is to develop the fast electronically controlled devices. We have learned from some of you about the progress in a field.

Lets do it…

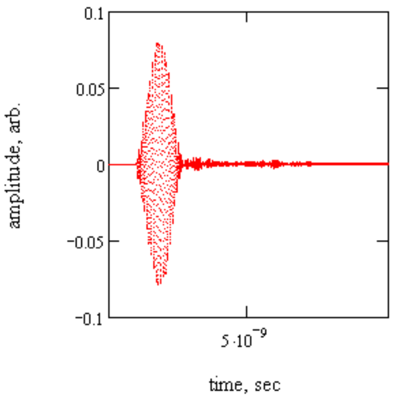
The 11.424 GHz choke mode flange.
To besTed at SLAC.

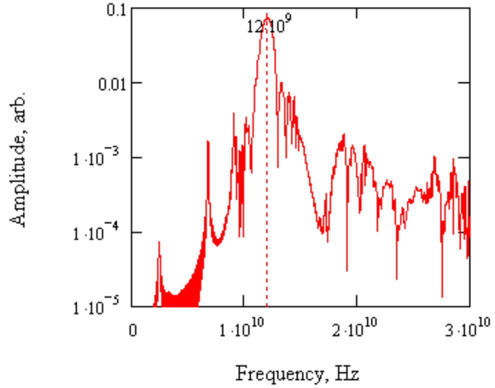


GDFIDL

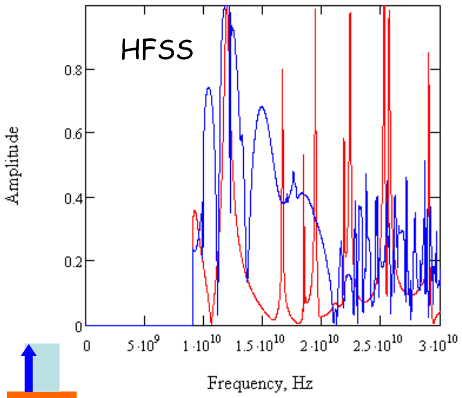


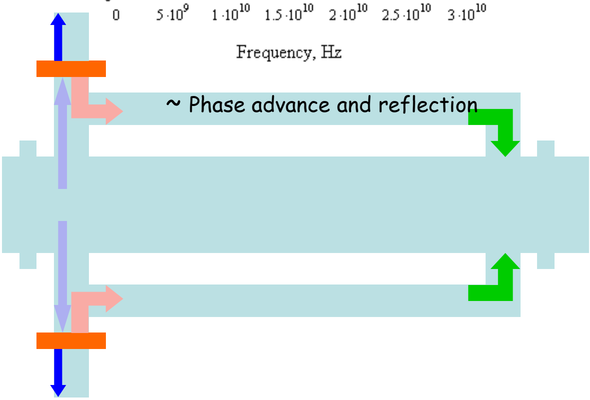
The PETS response for the single bunch excitation





Spectra of the reflector (red) and the PETS coupler (blue)



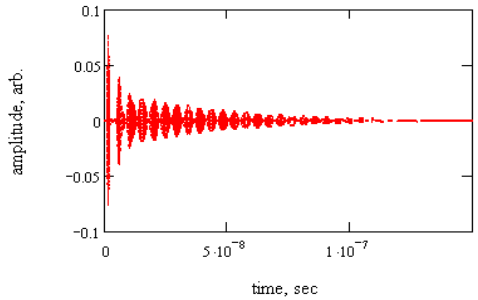


The single bunch response of the system with arbitrary reflection can be now reconstructed:

$$A_{SB}(t)=\sum_{n=0}^{N}\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\infty}B(\omega)\left(R(\omega)C(\omega)^2P(\omega)\right)^n e^{-j\omega t}d\omega$$

Round trip number; Bunch; Reflector; Coupler; PETS

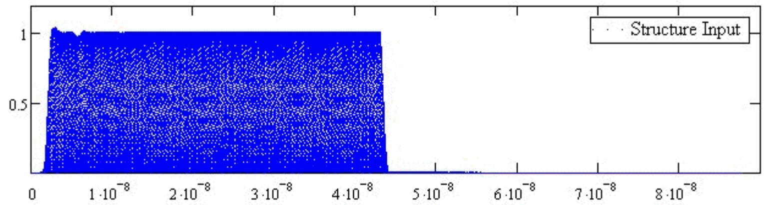
Example: The PETS signal in the OFF state (180 degrees)



The multi-bunch response is simply the sum of the single bunch's ones:

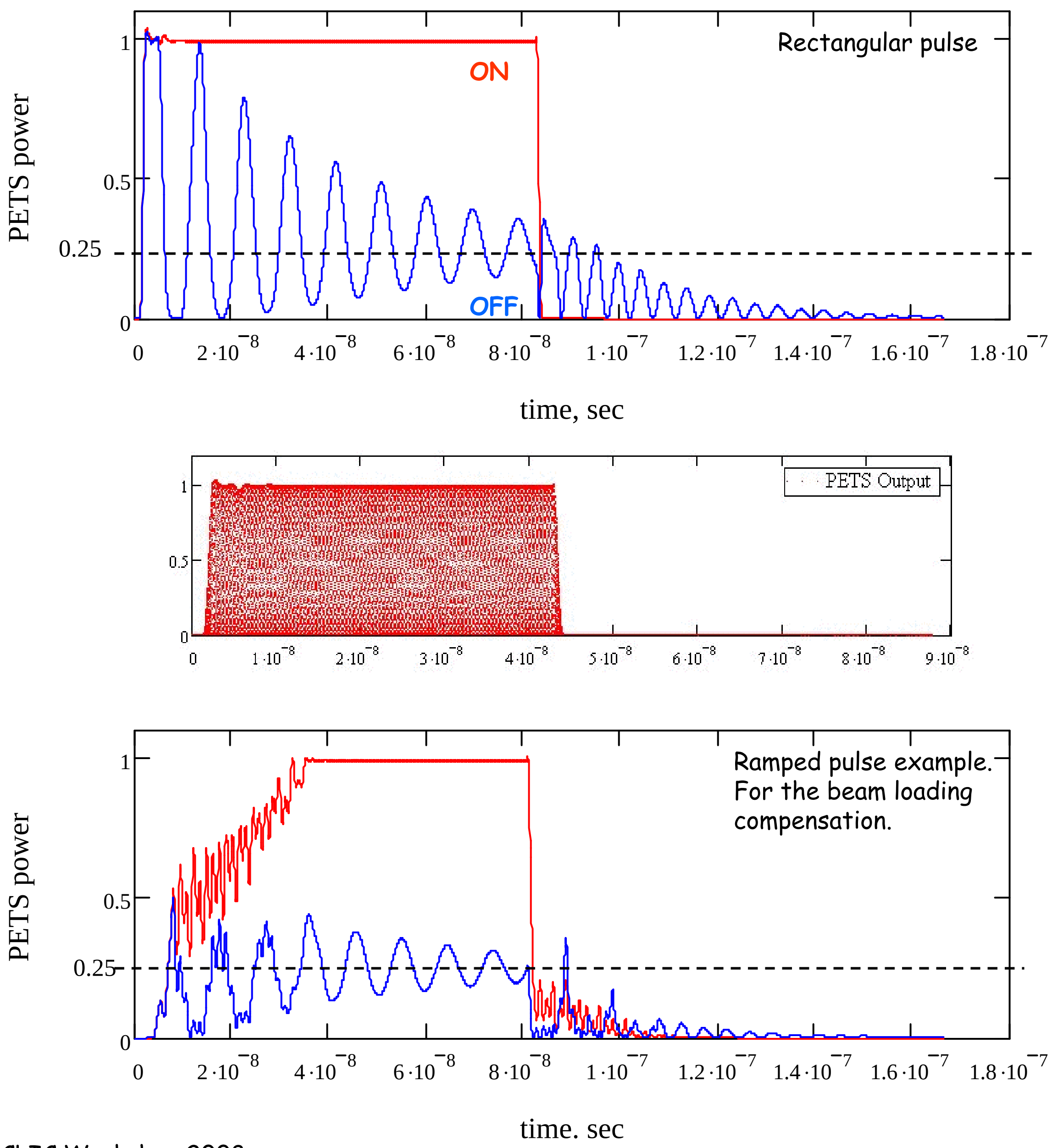
$$A_{MB}(t)=\sum_{m=1}^{M}A_{SB}(t-t_{bs}(m-1))$$

Bunch number; Bunch spacing



With proposed external controls we can guarantee the strong (< -20 dB) suppression of the RF power delivery to the accelerating structure.

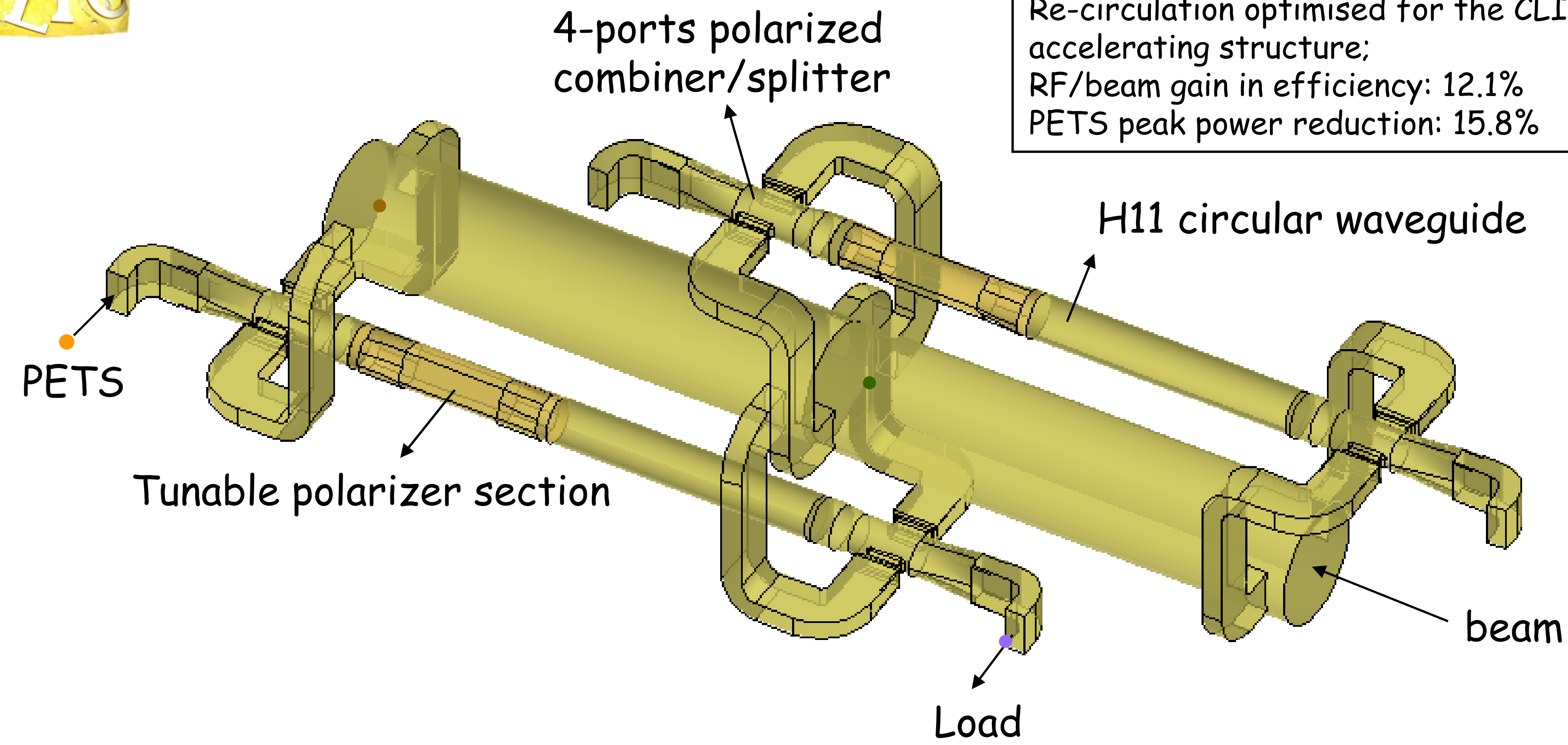
RF pulse envelopes at the PETS output

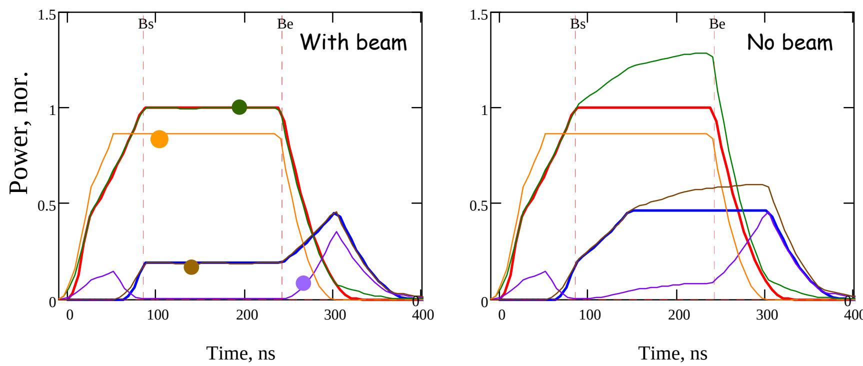


Discussion

1. In a case of the breakdown in PETS the situation is not so obvious. However the RF pulse time structure and 25% saturated power allow to expect the PETS safe behavior. The more studies are needed.
2. The first analyzes of the PETS behavior during the after breakdown consequent pulse with a quarter power can soon be tested at SLAC.
3. The relevant RF high power tests will be done in 2009 using TBTS PETS at a time when the external ON/OFF device will be fabricated and tested.

Re-circulation optimised for the CLIC-G accelerating structure;
RF/beam gain in efficiency: 12.1%
PETS peak power reduction: 15.8%

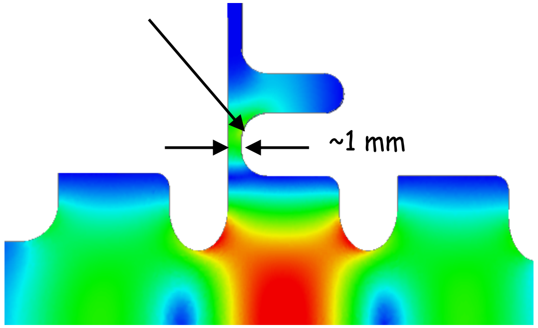




The fabrication and tests of the ON/OFF components for PETS can be a part of the experimental program towards recirculation study in the accelerating structure.

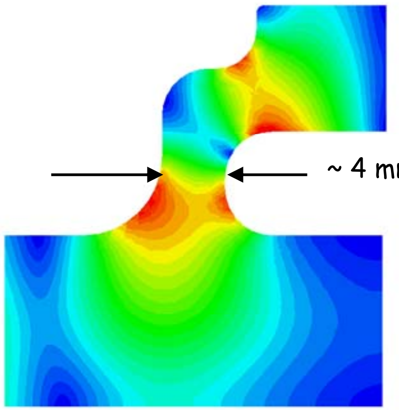
Test results of the X-band standing wave choke mode cavity

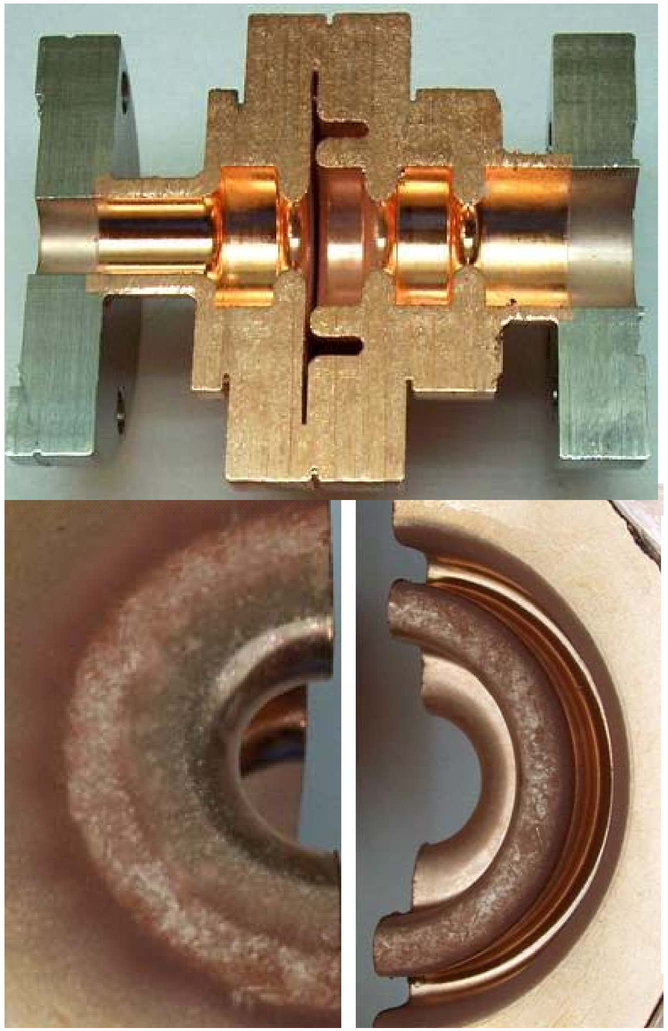
The choke surface was eroded at about 90 MV/m



X-band choke reflector (design)

In the OFF position at the nominal CLIC RF power 65 MW, the max. surface electric field:
- Linear polarization: 60(25) MV/m
- Circular polarization: 42.5(17.7) MV/m





Status of High Gradient Tests of Normal Conducting Single-Cell Structures

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Yasuo Higashi (KEK)

Advanced Accelerator Concepts Workshop 2008, Santa Cruz, CA, July 27 – August 2, 2008.