

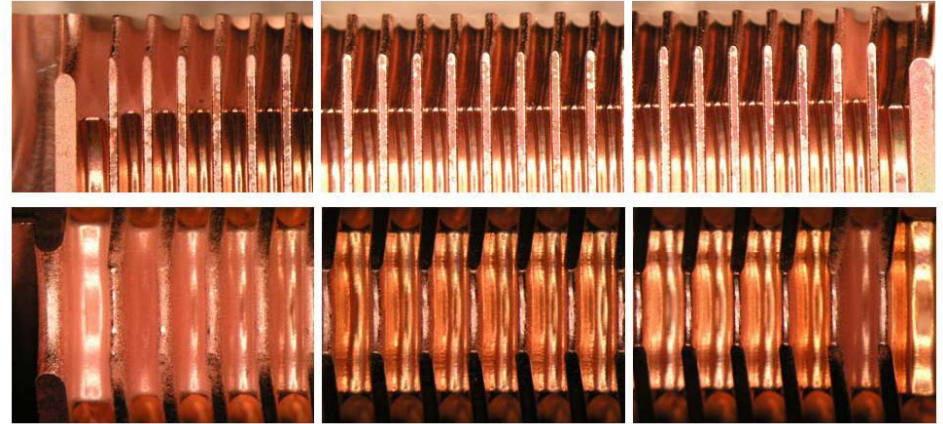
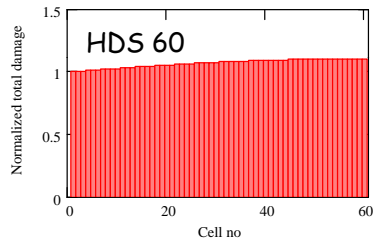
RF Design Options for Quenching Breakdowns

Igor Syratchev, Riccardo Zennaro

Very often we do observe, that after accelerating structure processing the most of the surface modifications take place in a few first cells. Also the number of cells involved is correlated with the group velocity, the less the V_g the fewer cells modified.

As one of the conventional explanation one could expect the statistical distribution of the events in a **chain model**. However with adopted processing strategy (trip rate $\sim 10^{-3}$) the event probability and normalized to that damage distribution is calculated to be very flat.

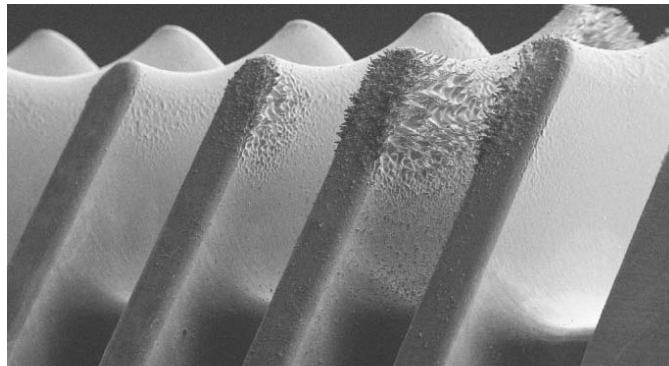
R. Corsini - 14 Nov 2006



P_{INC} →
HDS 60 L

← P_{INC}
HDS 60 S

HDS 11 titanium



What do we certainly know, the breakdown ignition is a very fast process: 0.1 -10 ns. If so, one can propose the main difference between the "first" and "second" cell is **accessible bandwidth**.

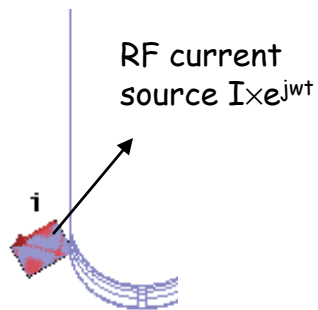
And the lower group velocity the more the difference.

The first cell, if breakdown occurs is loaded by the input coupler/waveguide and is very specific in terms of bandwidth.

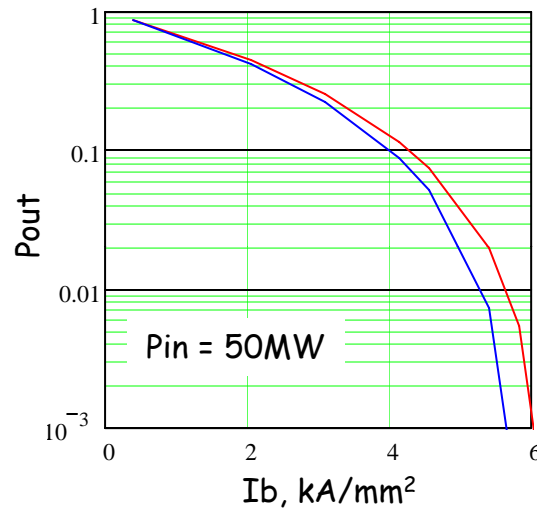
Other words, the first cell can accept "more" energy during breakdown initiation then consequent ones.

Worse to mention that we do not know the exact transient behavior of the breakdown and the structure bandwidth could play important role.

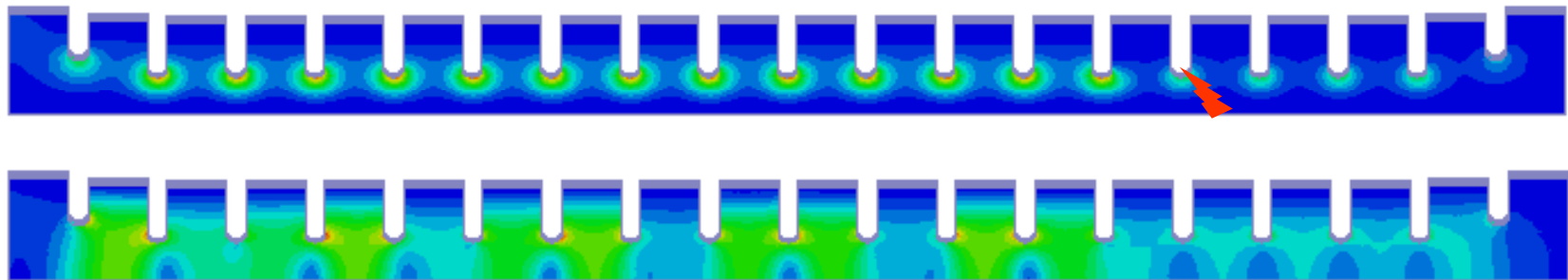
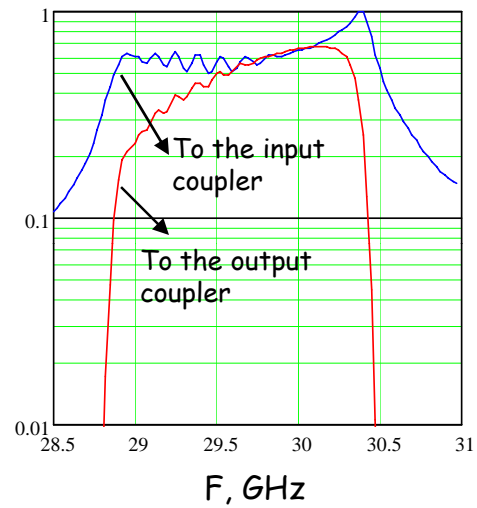
Structure: $2\pi/3$ aperture 3.5 mm ($V_g=4.5\%$)



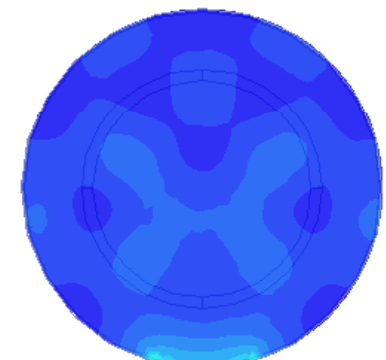
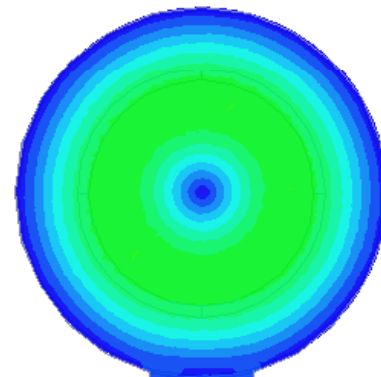
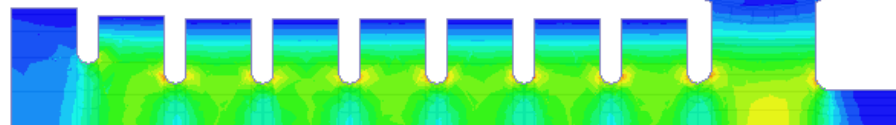
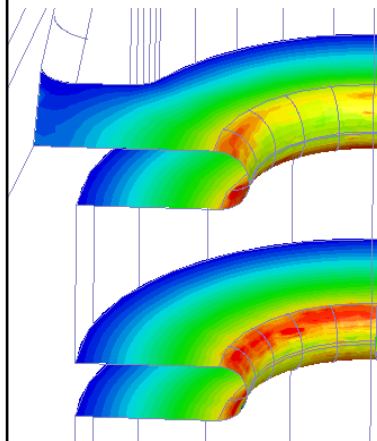
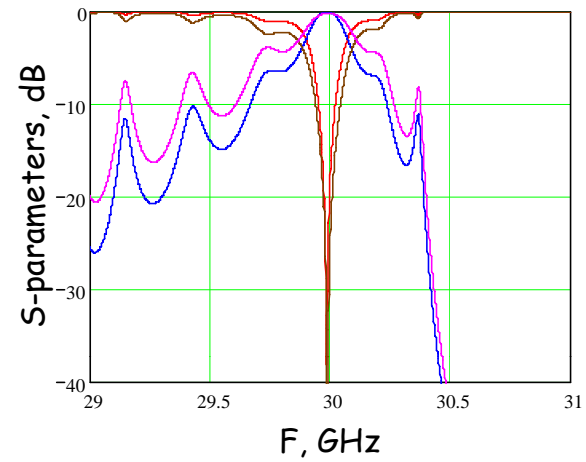
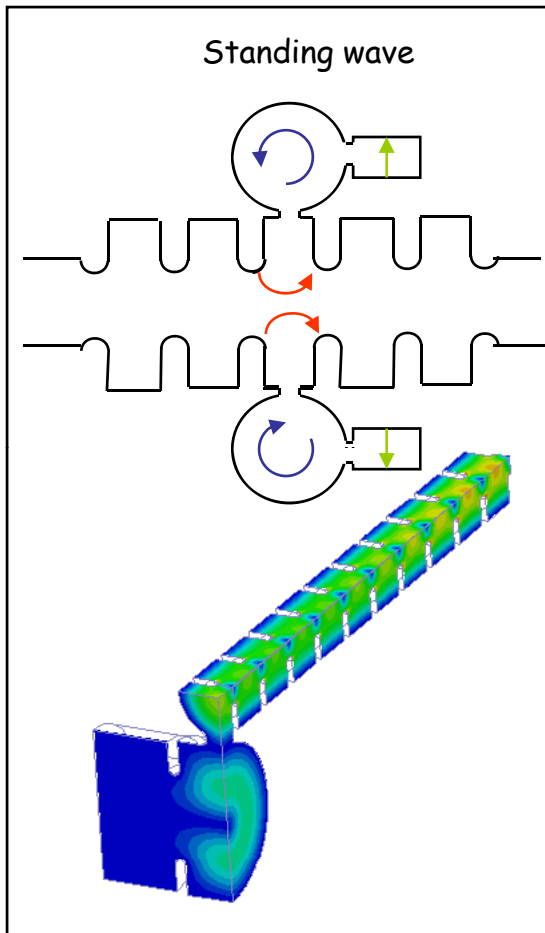
Missing energy plot



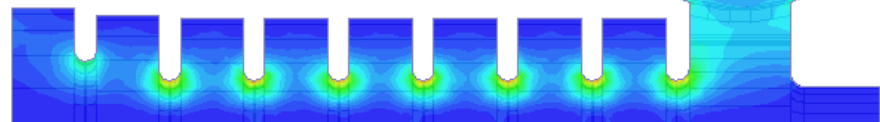
Radiation spectra
(breakdown in cell#1)



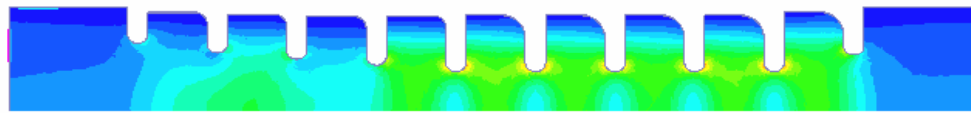
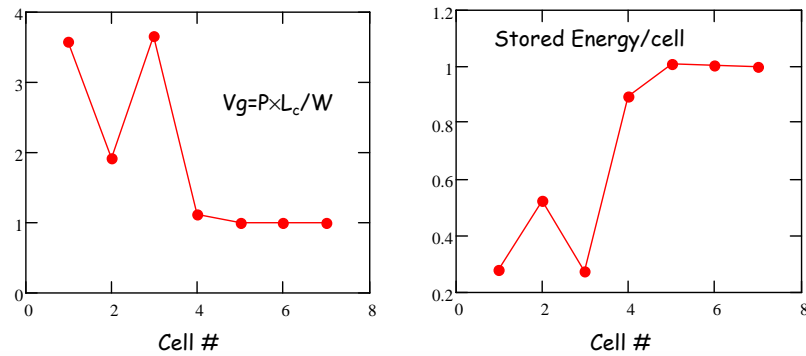
Configuration #1 (breakdown resonant fuse) :
Resonant cavity with reduced electric surface field (HO1) is located between structure and waveguide.



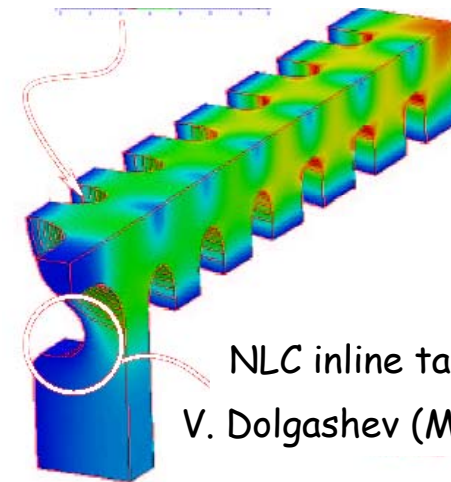
Traveling wave



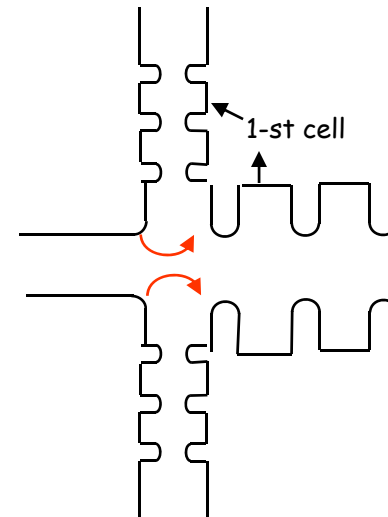
Inline taper with a "speed" bump



H60vg3N input coupler



NLC inline taper
V. Dolgashev (May 2002)



Why speed bump?

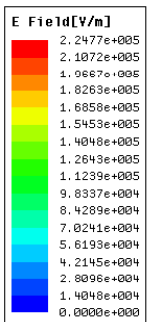
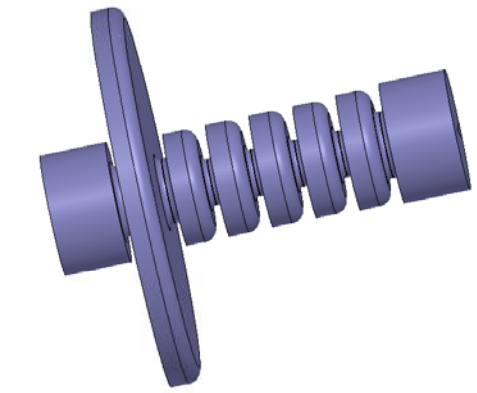


Can we reduce the bandwidth and provide a tapering without increasing the overall length?

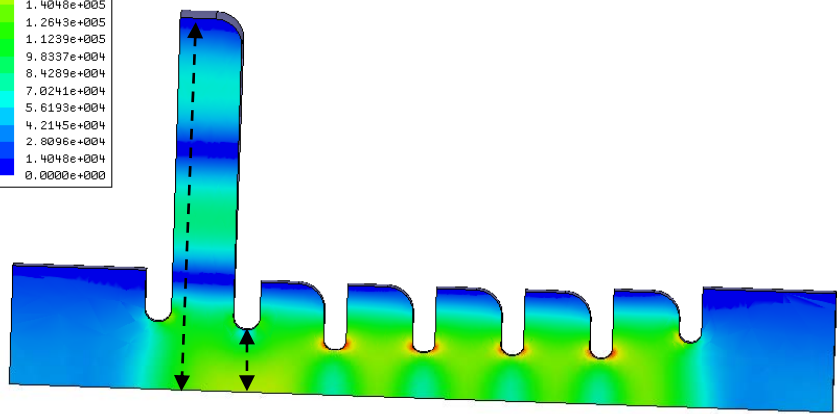


We can try by reducing v_g in the matching cell

Speed bump (TM₀₃)

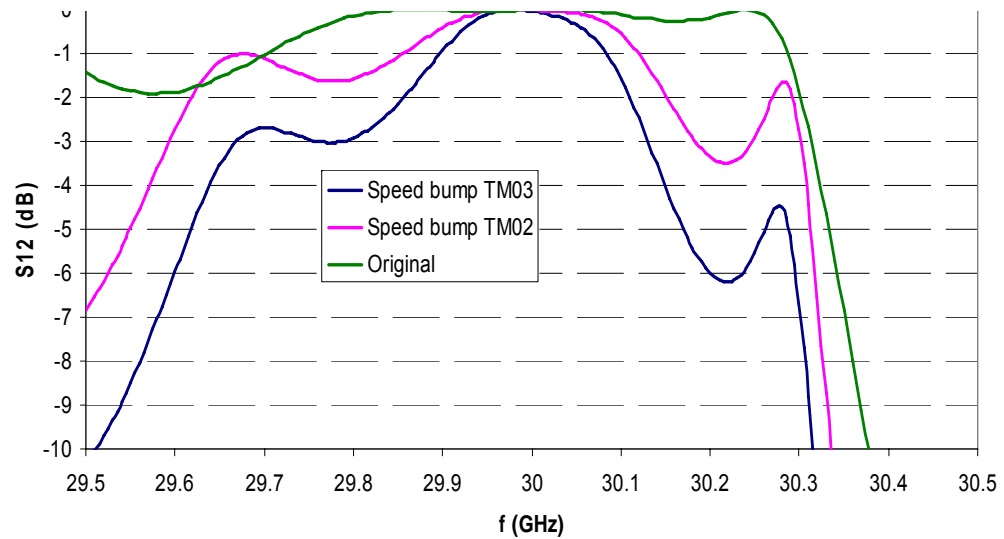
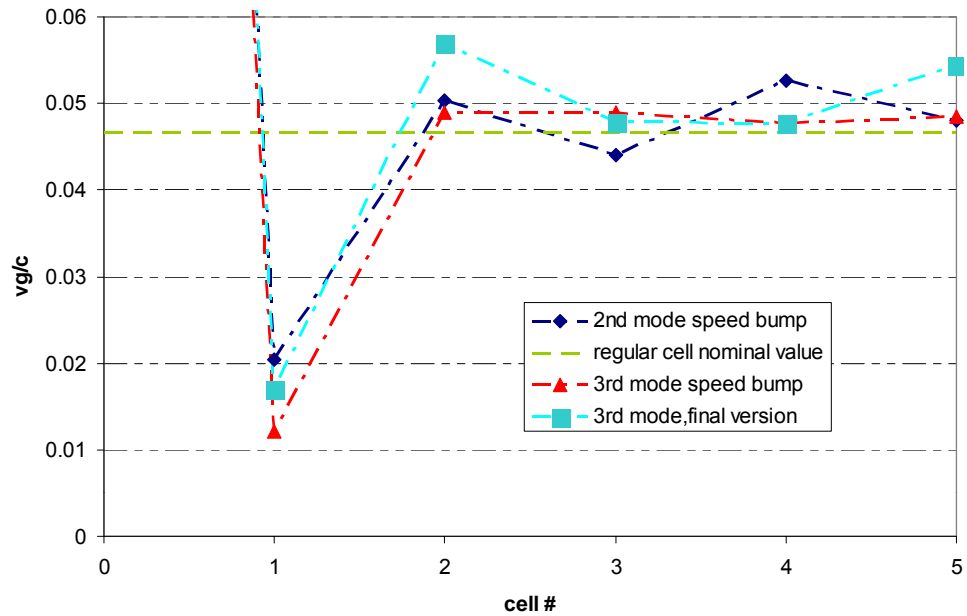


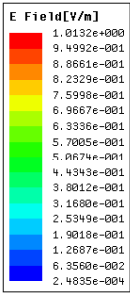
R=14.398 mm



R_{iris}= 2.428 mm

Iris_thickness= 1mm

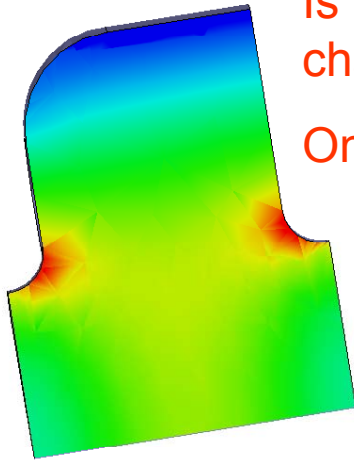




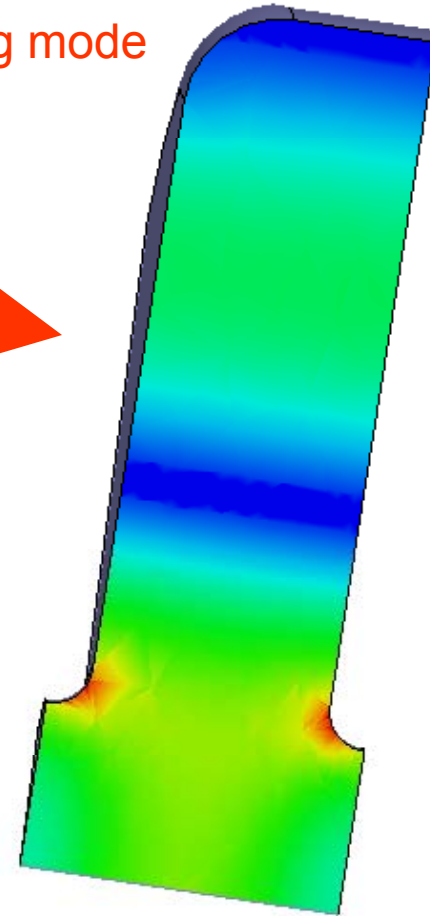
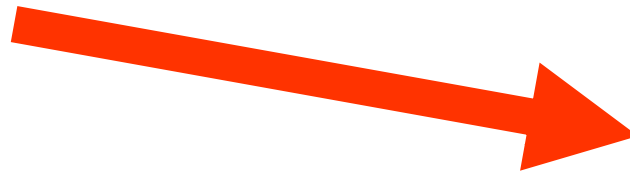
TM₀₂ structure

Is it possible to change some global parameter without changing local field distribution?

Only by changing the propagating mode



TM₀₁ regular cell "reference"



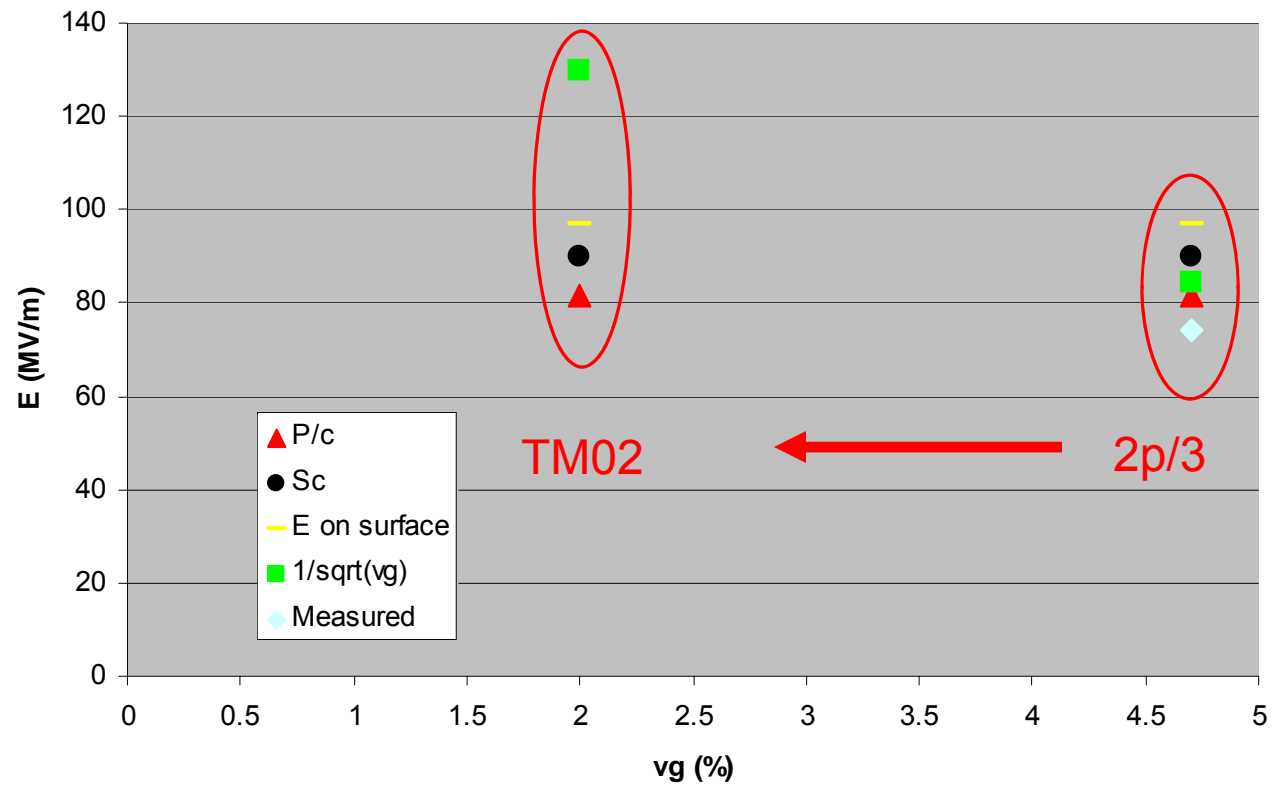
TM₀₂ regular cell

- Same phase advance
- Same P/c
- Same aperture and iris shape
- Same field configuration in the iris region

but

- Different group velocity: 4.7% & 2%
- Different R/Q: 29 kΩ/m & 12 kΩ/m

TM₀₂ structure



Predicted gradients for the test structures calculated for different parameters (normalized to the experimental results of T53 for b.d.r.=10⁻⁶ and pulse length=100 ns)

Conclusions

- ✓ Experimental results shows a correlation between RF damage and group velocity
- ✓ This correlation could be explained in terms of accessible bandwidth
- ✓ The speed bump structure should inhibit the large breakdown damage in the first cells
- ✓ The TM02 structure should provide indications on the correlation between the gradient at a given b.d. rate and the group velocity

Extra slides....just in case

The test matrix (all structures in disks)

In red: 11.4 GHz new structures

In blue: 30 GHz new structures (scaled values for a and d)

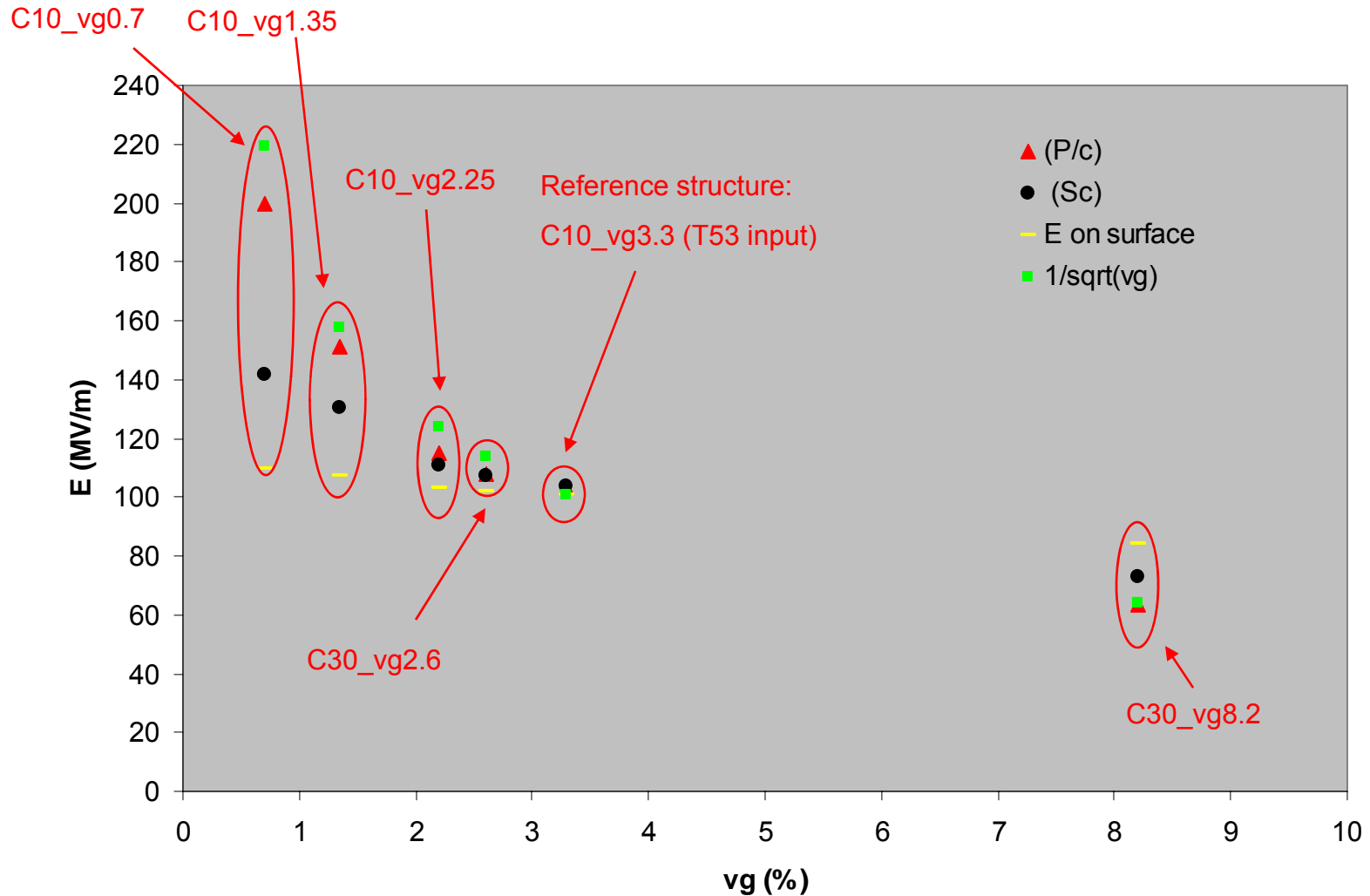
d [mm]	2.79	2.13	2.00	1.66	1.37	1.25
a [mm]						
2.53				Vg: 0.7%		CLIC_vg1 output 1.0%
2.85				T53 output 1.0%		
3.0				Vg: 1.25%		
3.87	Vg: 2.25%	30 GHz $2\pi/3$ $\approx 2.6\%$		T53 input Vg: 3.3%		
3.89*	(*)					
4.38		30 GHz $2\pi/3$ 4.7%				
5.00		30 GHz $\pi/2$ 7.4%			30 GHz $2\pi/3$ 8.2%	

Direct comparison of variation of d

Direct comparison of variation of P/c

Direct Test for a relatively large group velocity

The test matrix



Predicted gradients for the test structures calculated for different parameters (normalized to the experimental results of T53 for b.d.r.= 10^{-6} and pulse length=100 ns)