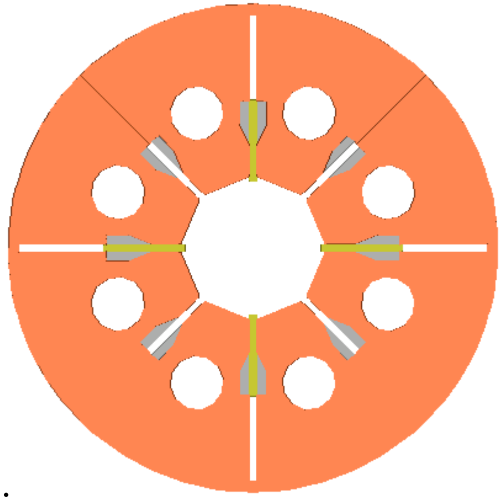
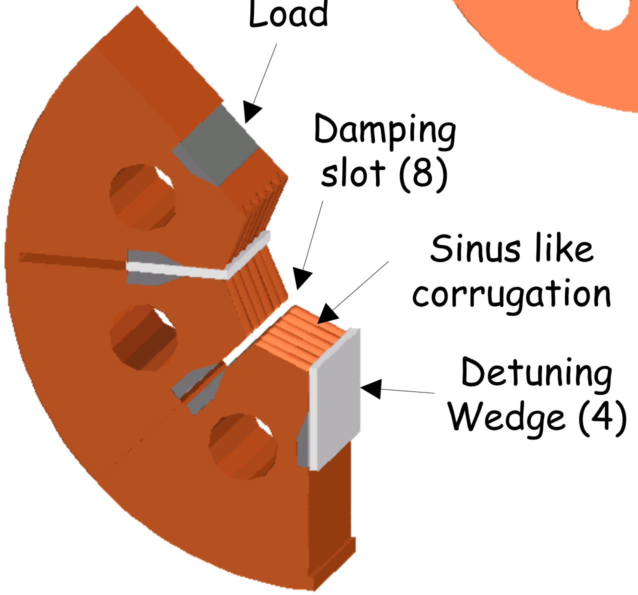
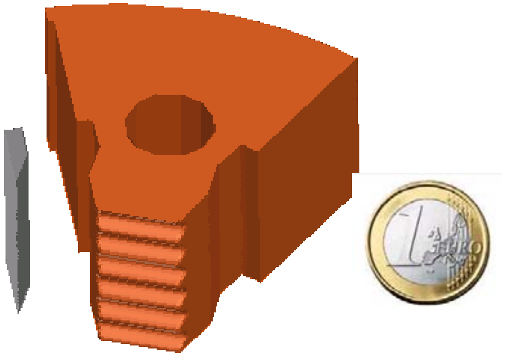
The CLIC PETS
(HFSS & GDFIDL studies)

CLIC PETS views



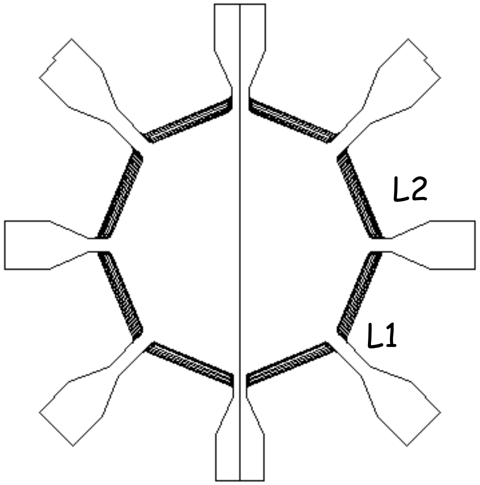




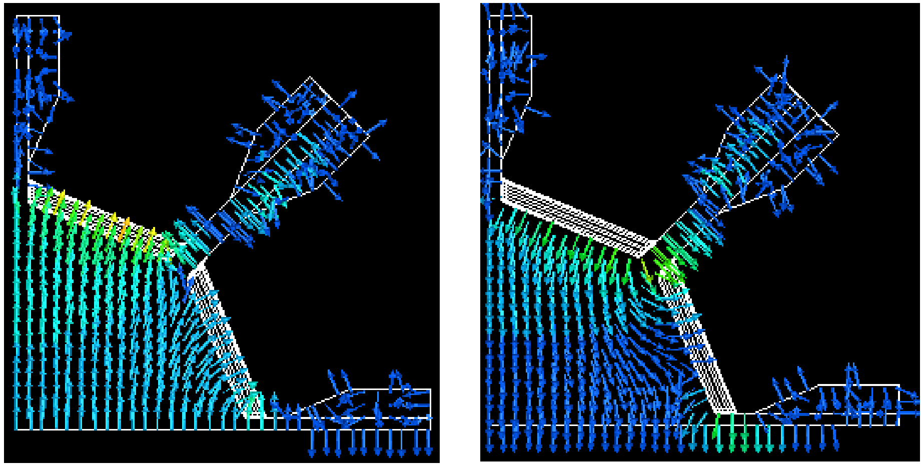
25 mm aperture CLIC PETS parameters:

120^0/cell
L=3.283 mm
2a=25.0 mm
$F_{sync.} = 30.45$ GHz
$\beta_{GR} = 0.8624\ c$
R/Q = 219.3 Ω/m
Depth = 1.222 mm
Structure Length 0.8 m
Cells number: 244
Power: 162(TWS)x4/0.93 = 700 MW
$E_{surf} = 107$ MV/m
Beam current: 167.8 A
+450 MHz detuning gives
power efficiency ~ 90%
The current should be
<u>176.9 A</u>

The CLIC PETS HOM damping performance was first optimized with HFSS. Modifying the depths of 2 pairs of 4 damping slots (L1 and L2), as well as RF loads configuration, the loaded Q-factor of the two transverse modes were minimized and equalized at a fixed phase advance per cell (120^0).



CLIC PETS cross-section



F, GHz Q Loaded

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Mode 2 | ( 3.01948e+01, 3.02335e-01)      4.99384e+01
Mode 3 | ( 3.04850e+01, 4.53984e-01)      3.35787e+01
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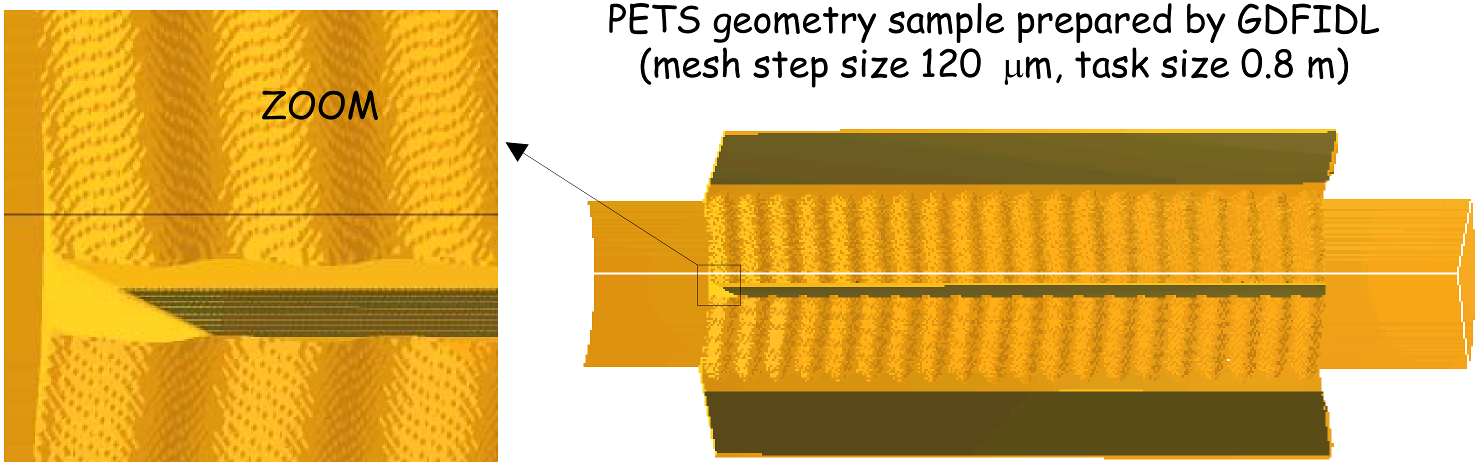
The further detailed studies of the PETS performance with HFSS appeared to be very tricky (because of the heavy damping and very high group velocity). Time domain simulations was the only way to get the precise answers.

Why GDFIDL?

The filling time of PETS is only about 3 ns, so to get information about HOM damping we need to simulate whole structure (240 cell). Together with big beam aperture and the test beam reasonable length needed (~ 1-2 mm), plus detailed geometry representation, one should deal with meshes of about 5×10^8 grid points. Do not forget the RF loads.
GDFIFL can do it!



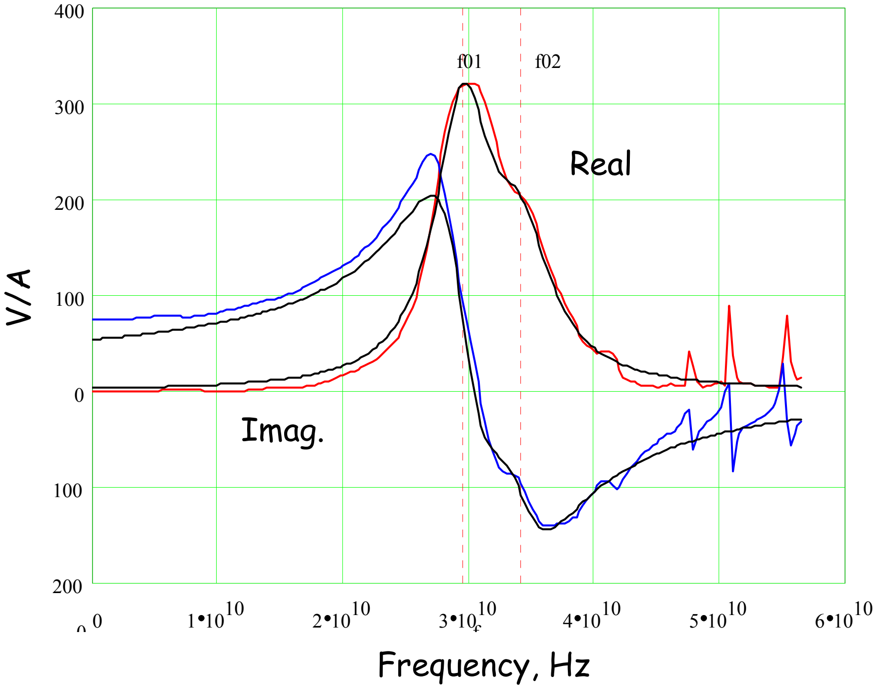
PETS geometry sample prepared by GDFIDL (mesh step size 120 μm, task size 0.8 m)

Easy to use: whole geometry can be imported into GDFIDL using *.stl files, which are prepared elsewhere (directly from HFSS for example).

Impedances

25 mm PETS impedance by GDFIDL (200 cells) and model

σ=1.77 mm
Δz=0.122 mm
dx=dy=dz

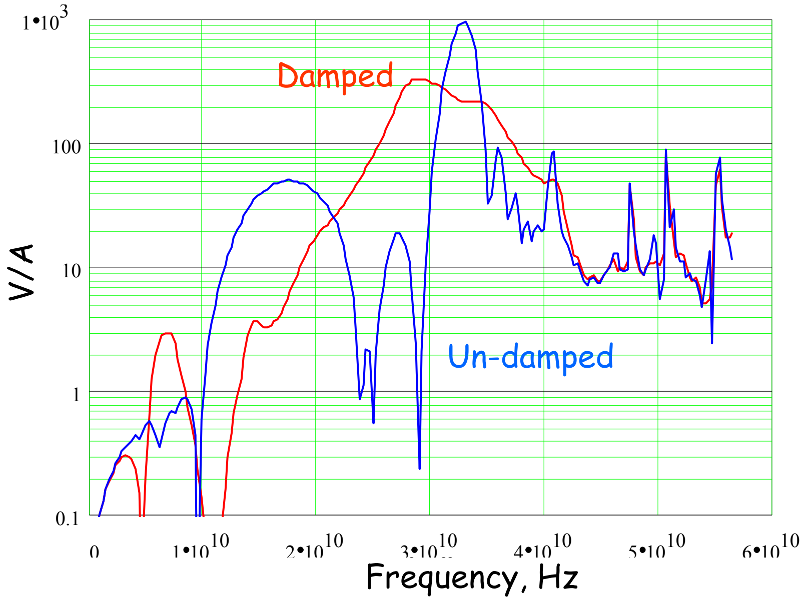


The impedance balance: Z1+Z2 = 1
Fitted parameters:
F1 = 29.55 GHz, Z1 = 0.686
F2 = 34.2 GHz, Z2 = 0.314

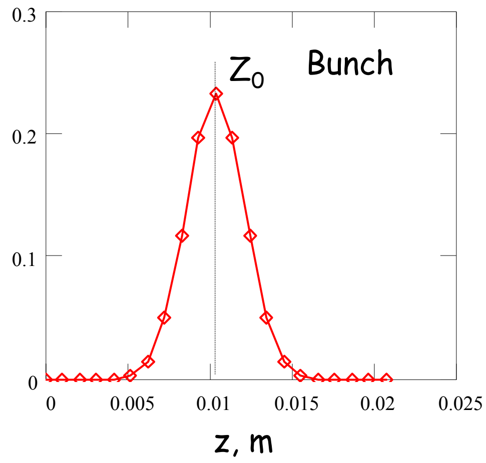
Two modes model,
frequency domain approximation

$$\mathrm{Re}\{Z(\omega)\} = \sum_i \frac{|Z_i|}{1+\left[2Q_i\dfrac{\Delta\omega}{\omega_i}\right]^2}$$

$$\mathrm{Im}\{Z(\omega)\} = \sum_i -\frac{|Z_i|\times 2Q_i\dfrac{\Delta\omega}{\omega_i}}{1+\left[2Q_i\dfrac{\Delta\omega}{\omega_i}\right]^2}$$



Wakes



Z_0=5.857σ

Two modes time domain approximation

Power extraction

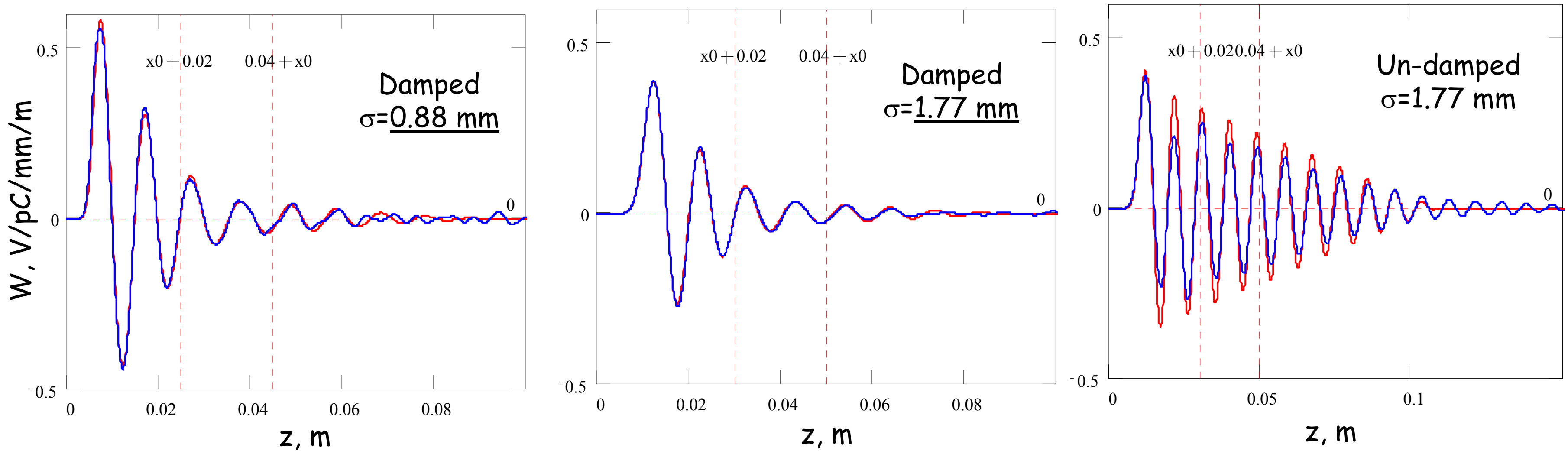
$$q_i = \exp\left\{-0.5\times\left(\frac{z_i - z_0}{\sigma}\right)^2\right\}\times An \qquad \sum_i q_i = 1pC$$

$$W_\perp(z) = \sum_{k,i} 2\times k_{\perp i} q_k \sin\left(\omega_i \frac{z-z_k}{c}\right)\exp\left(-\omega_i\frac{z-z_k}{v_i\times 2\times Q_i}\right)\times\left\{1-\frac{z-z_0}{Ls\frac{1-\beta}{\beta}}\right\}$$

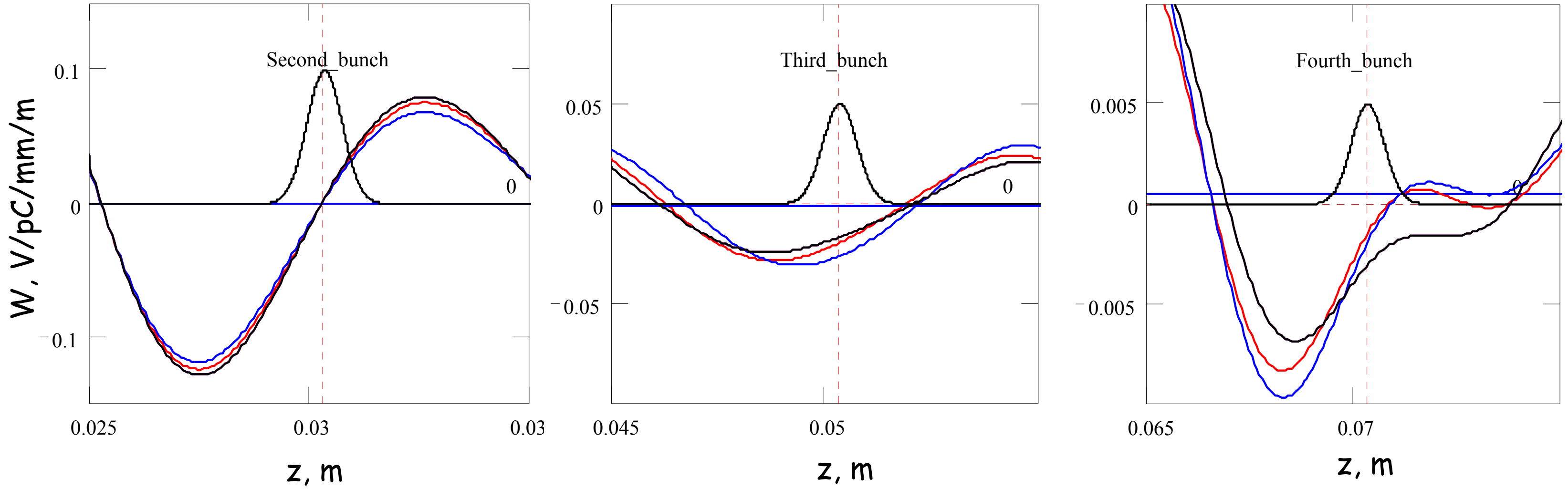
	F, GHz	Q	W, V/pC/mm/m
M1	29.55	8.9(52)	0.54
M2	34.20	9.5(56)	0.26

β=0.87

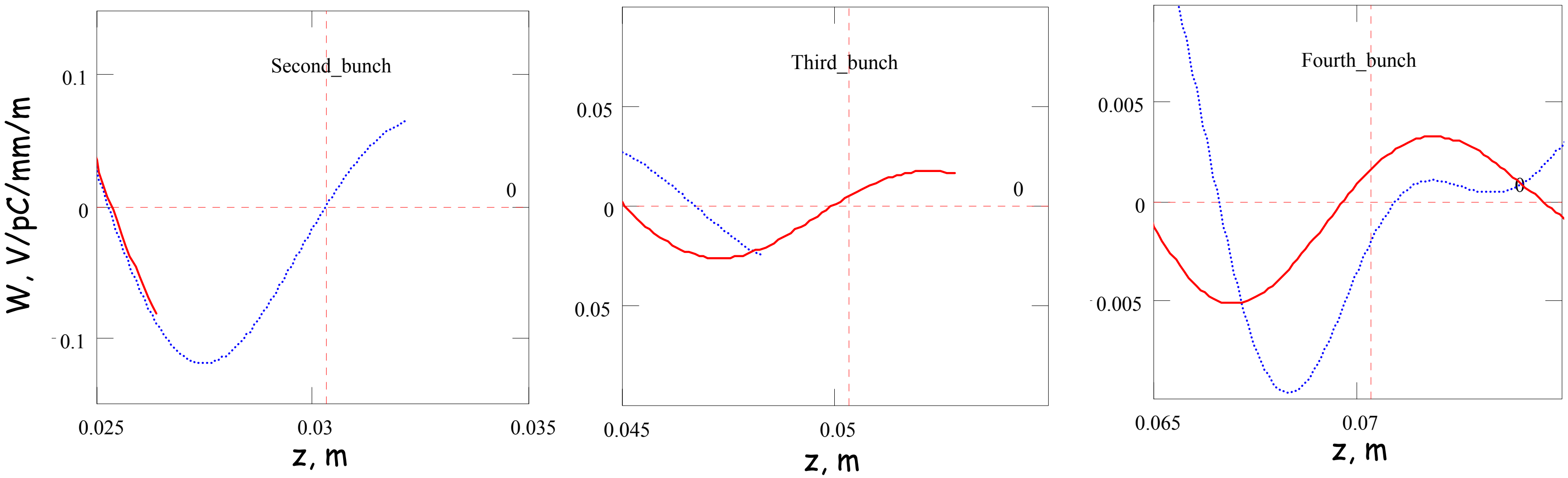
	F, GHz	Q	k, V/pC/mm/m
M0	32.90	10000	0.78



The effect of the damping slots depth modification (GDFIDL)



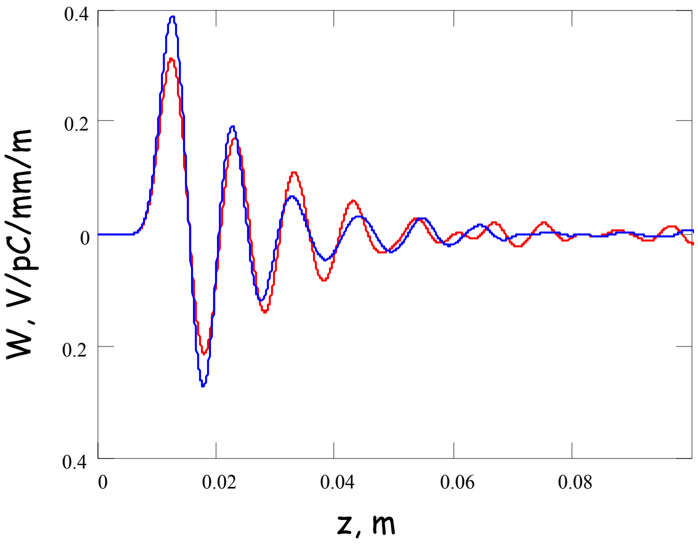
Single mode model (solid line) comparison to GDFIDL results (broken line). The model was tuned to provide close to GDFIDLE wake amplitude at a position of the second bunch.

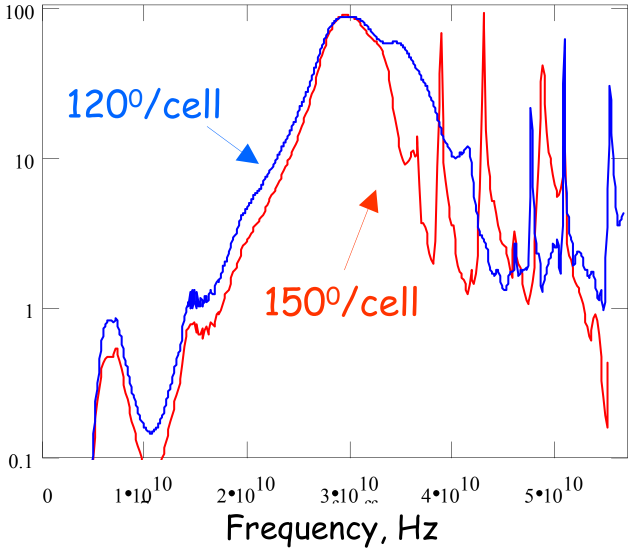


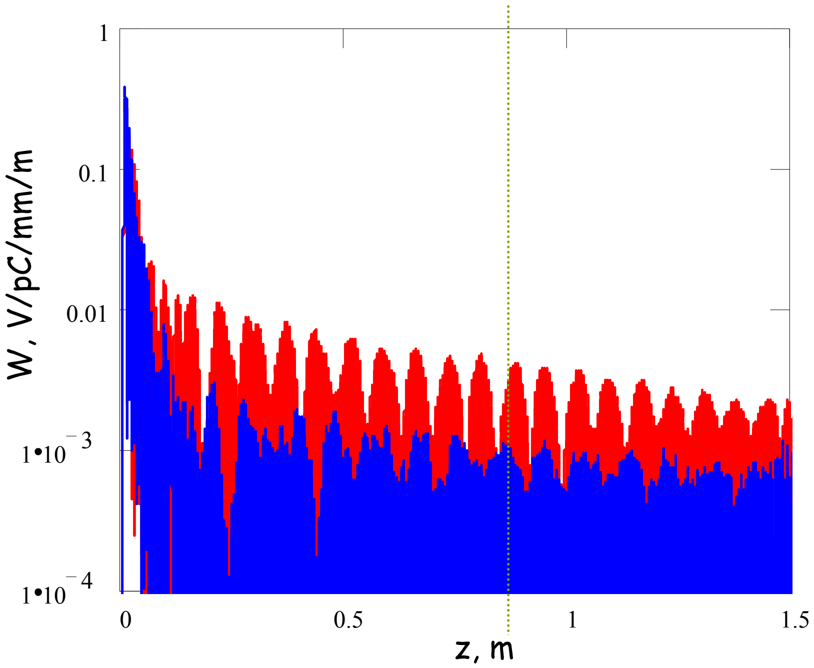
120^0 phase advance per cell versus 150^0

Decelerating mode:

120^0/cell	150^0/cell
$\beta = 0.8624\ c$	$\beta = 0.802\ c$
R/Q = 219.3 Ω/m	R/Q = 215.3 Ω/m







Summary

#1. The PETS simulations with GDFIDL confirmed validity of the developed method for the transverse modes damping.
#2. Two-modes transverse wake representation requires more studies of the drive beam dynamic in the CLIC decelerator.
#3. After the design revision of the PETS output coupler, the whole PETS assembly will be studied with GDFIDL.