Resonant HOM Load Made of Resistive Material

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Outline

- Shortcomings of existing absorbers
- Resonant grooves in a lossy waveguide
- Matched pairs of absorbing grooves
- Existing concept of the ERL HOM load
- Possible improvement with resonant grooves

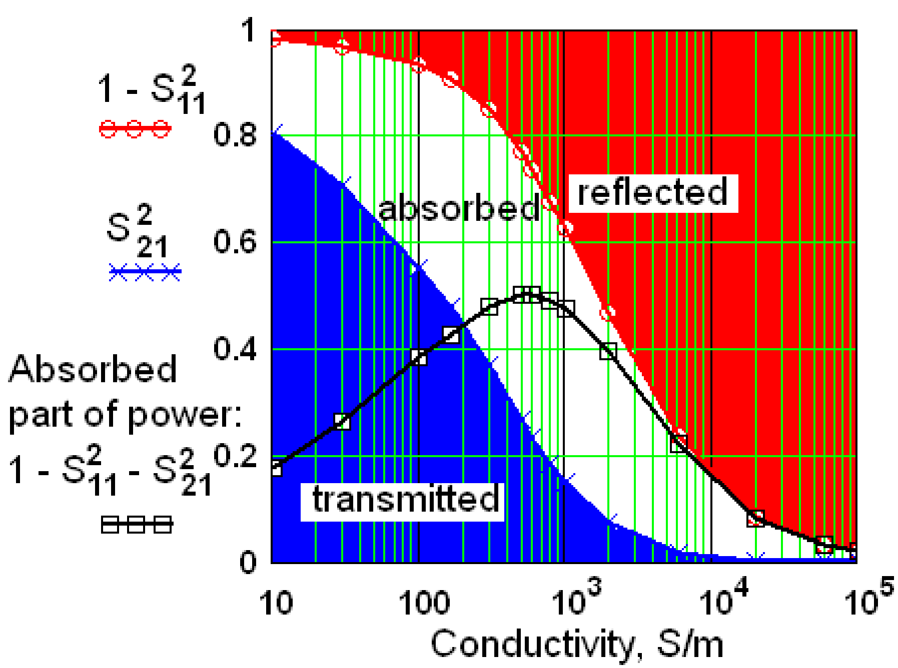
Shortcomings of existing absorbers

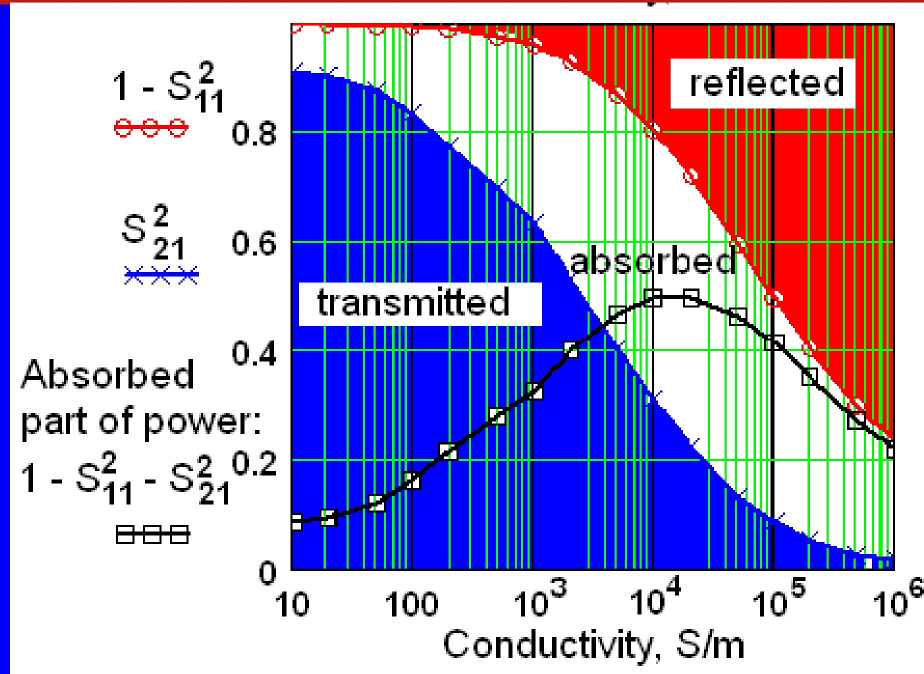
Ferrites and lossy ceramics, used in HOM (higher order mode) loads for superconducting accelerators, have shortcomings such as

- poor batch-to-batch reproducibility of electromagnetic properties (ceralloy),
- extremely low electric conductivity at cryogenic temperatures leading to accumulation of charge on the material surface (ferrites, ERL Injector),
- brittleness, which may cause contamination of the nearby SRF cavities by lossy dust (ferrites, ERL Injector), etc.

A proposal to use a resistive material free of these shortcomings will be presented.

Resonant grooves in a lossy waveguide

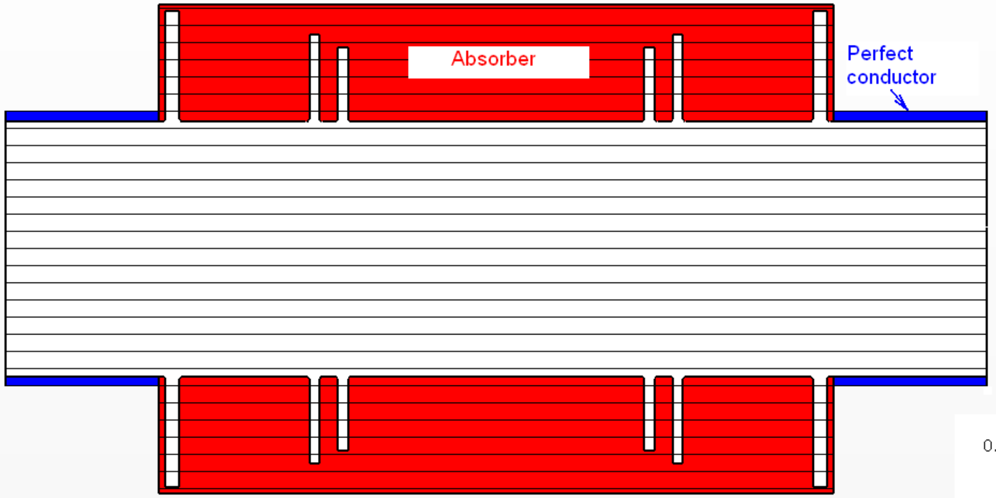




Transmitted, reflected, and absorbed part of RF power in a 10-mm wide (left picture) and in a 4-mm wide resonant groove (choke) made in a round pipe with ID = 78 mm. Frequency of maximal absorption for the given depth changes within 2.3…2.7 GHz.

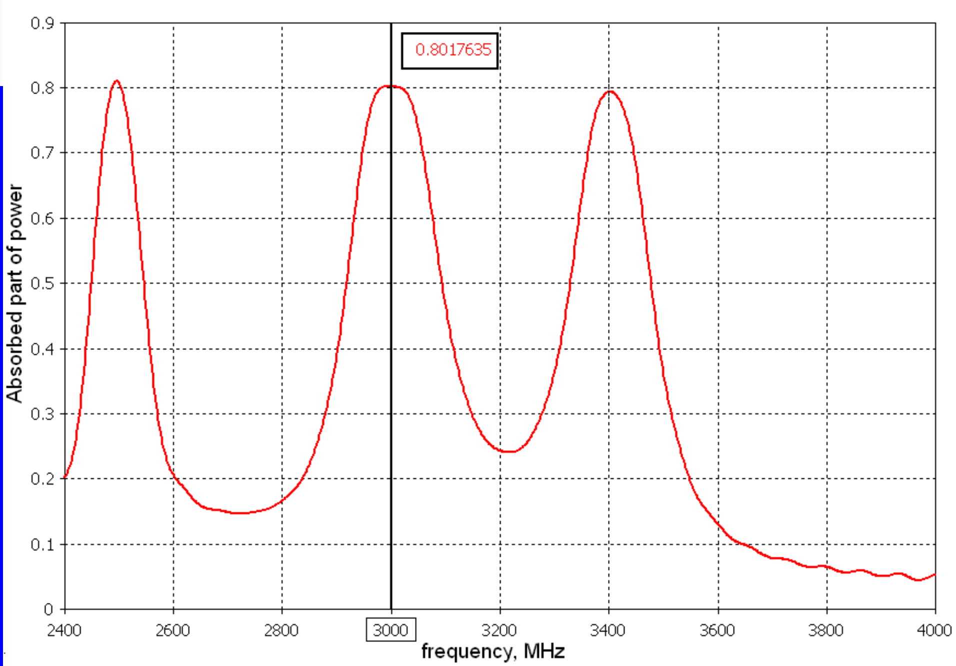
Usually , such a device used at high conductivity to reflect unwanted waves.

Matched groves

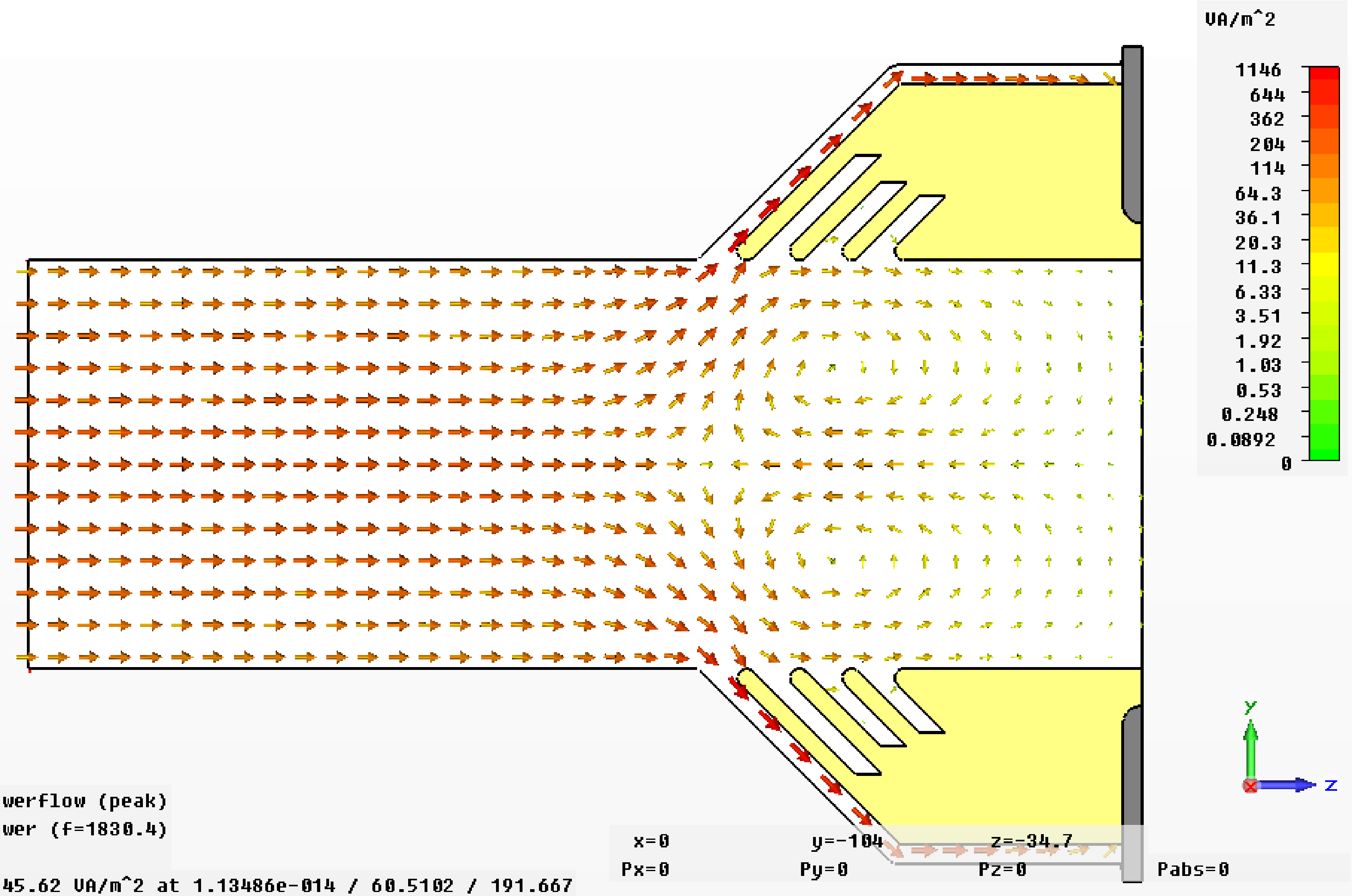


Effectiveness of an absorbing groove can be substantially increased if two or more grooves are tuned to the same frequency. This was used at SLAC [W. Fowkes et al.] to develop a steel RF load for high power. The band-width can be also increased.

Matched pairs of absorbing grooves for three HOM frequencies and conductivity of 15 kS/m (Cesic)

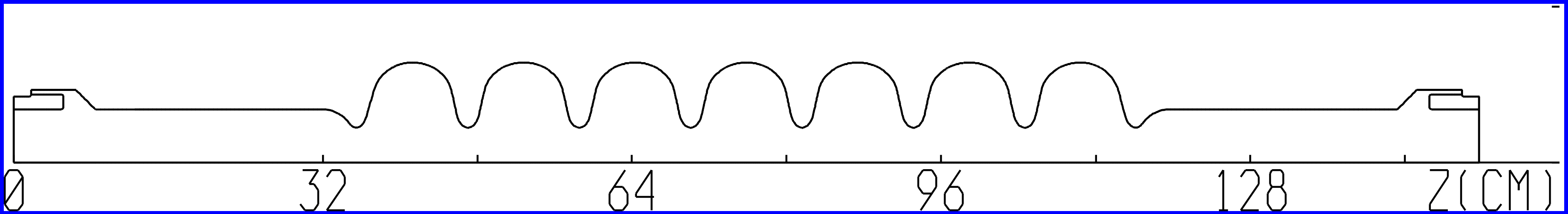


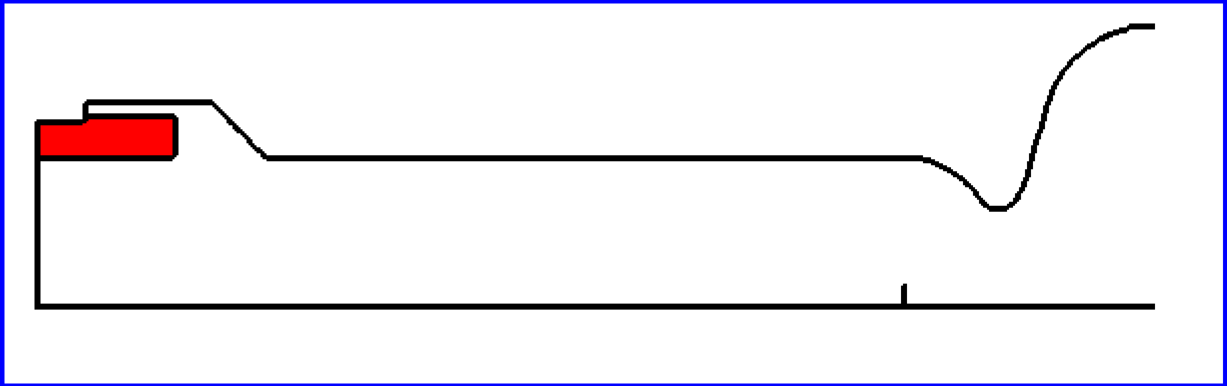
Pointing vector for one of possible designs



Type	Powerflow (peak)
Monitor	power (f=1830.4)
Plane at x	0
Maximum-2d	1145.62 VA/m^2 at 1.13486e-014 / 60.5102 / 191.667
Frequency	1830.4

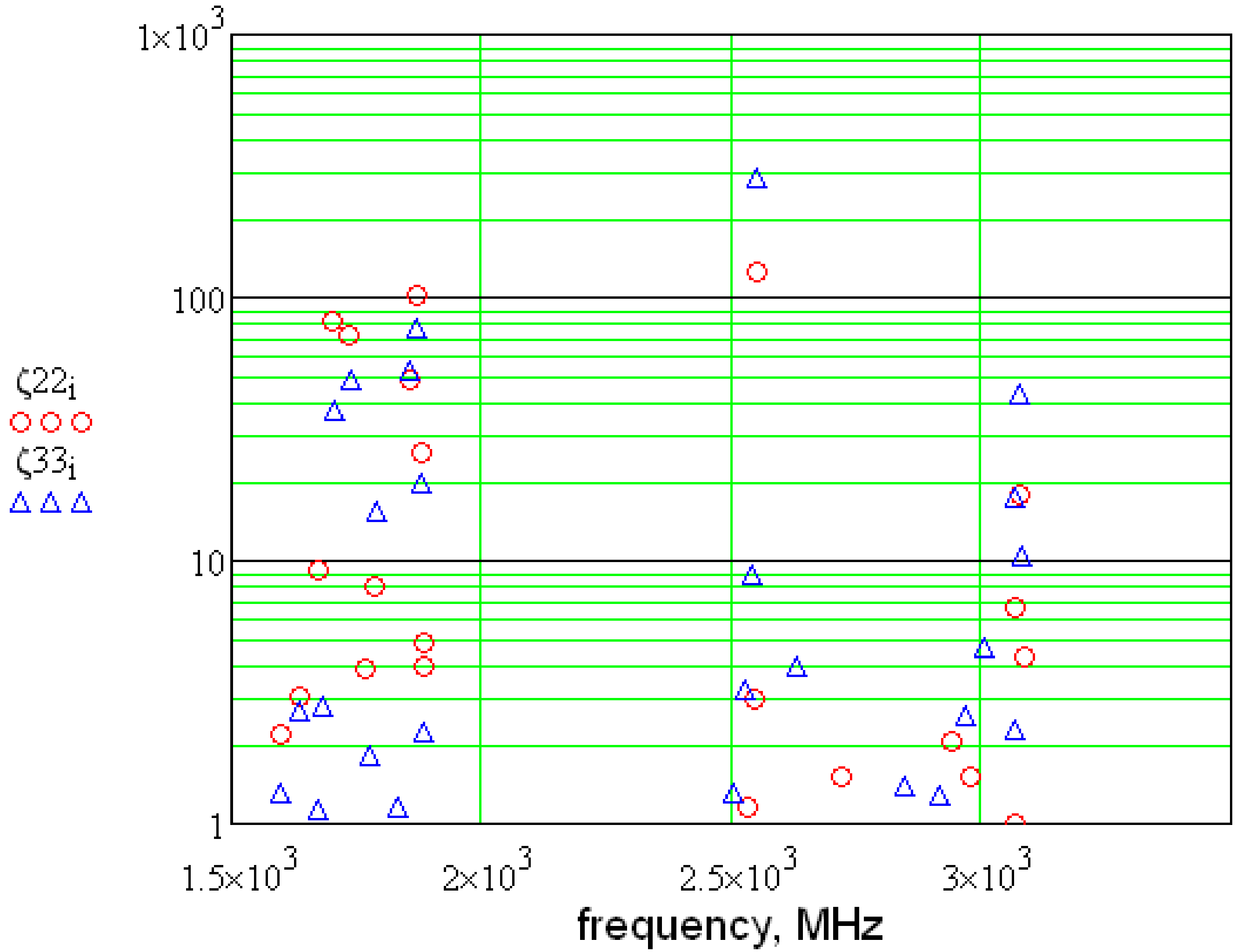
Existing concept of the ERL HOM load





eps = 30 – 20 i

Values of the BBU parameter vs frequency for the existing concept. Two boundary conditions at the ends of the cavity.



$\max(\zeta 22) = 126.477$

$\max(\zeta 33) = 282.574$

Note:

- **These are dipole modes**
- **They are grouped together into bands**
- **These bands are about 100 MHz wide**
- **If we make a resonant groove, one groove can absorb the whole band**
- **We can make grooves for the most dangerous modes only**

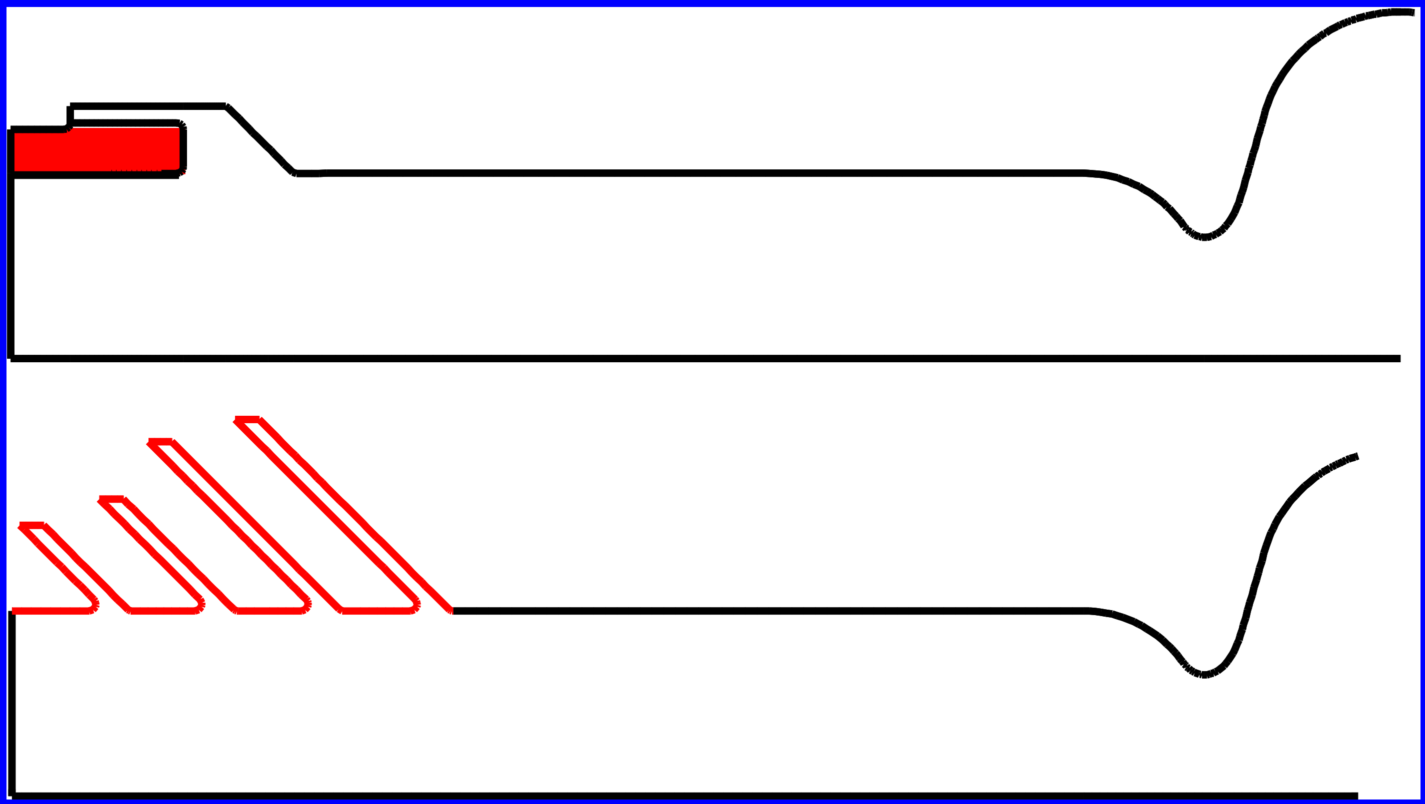
Definitions

- **The BBU parameter is defined as**

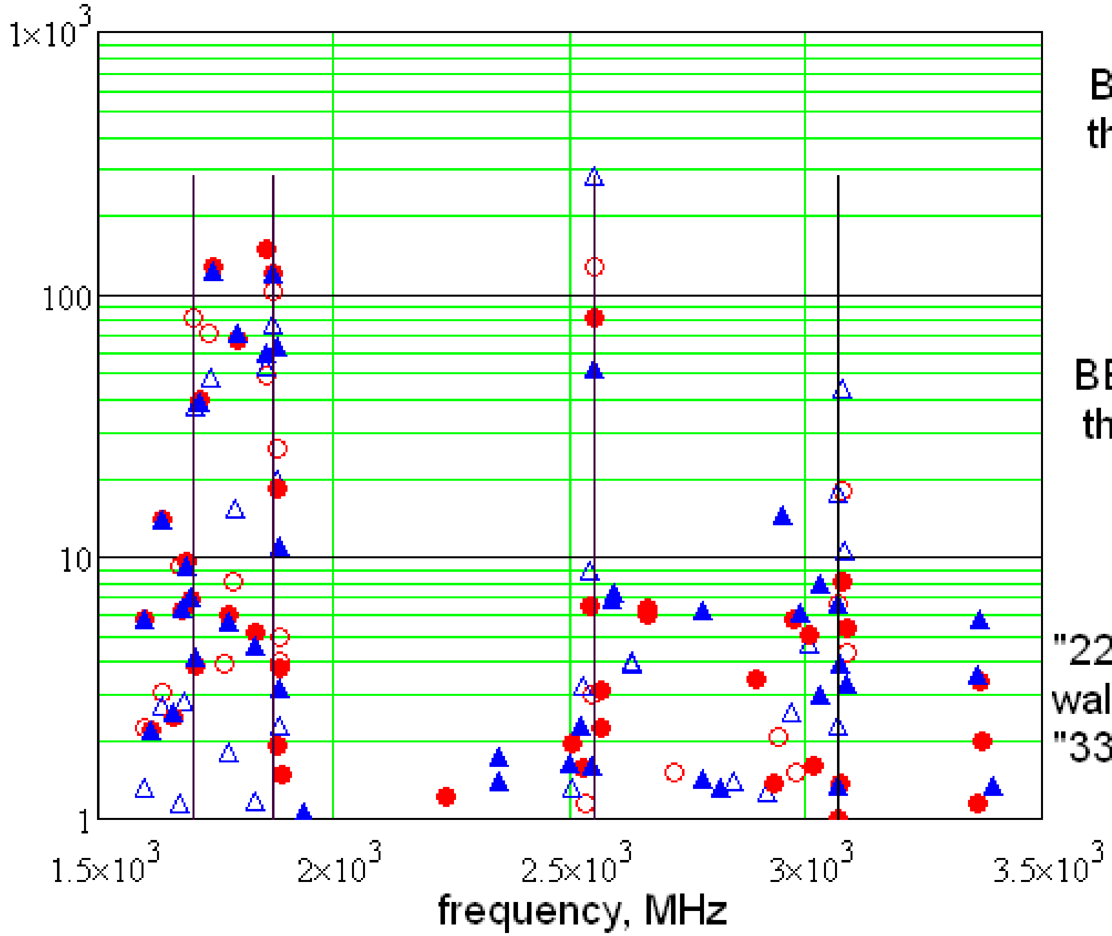
  Dzeta = (R/Q)*sqrt(Q)/f [Ohm/cm^2/GHz]

  and is reversely proportional to the maximal current in the ERL (M. Liepe, N. Valles).

Regular load vs resonant load - geometry



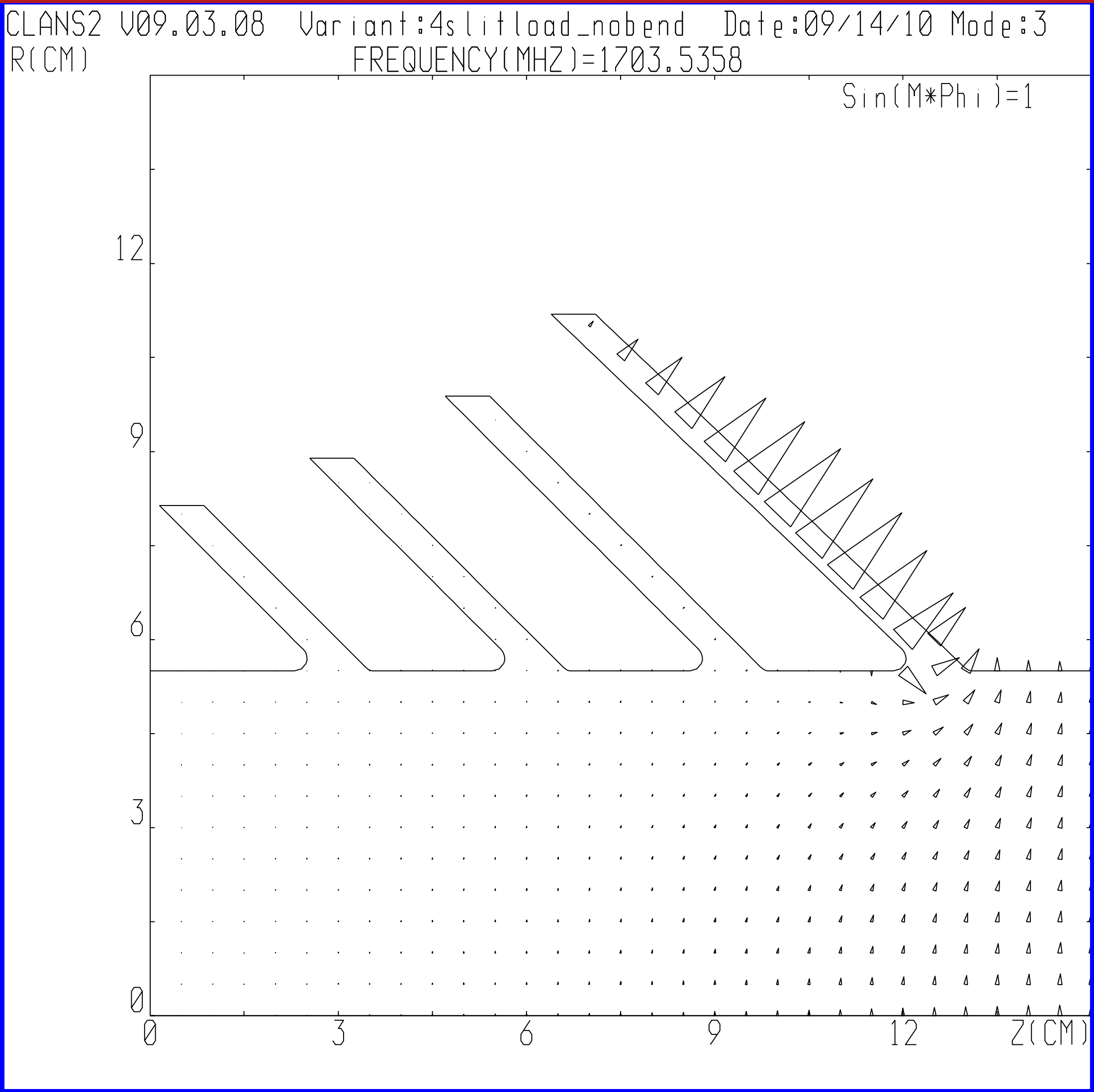
Resonant vs regular load BBU parameter



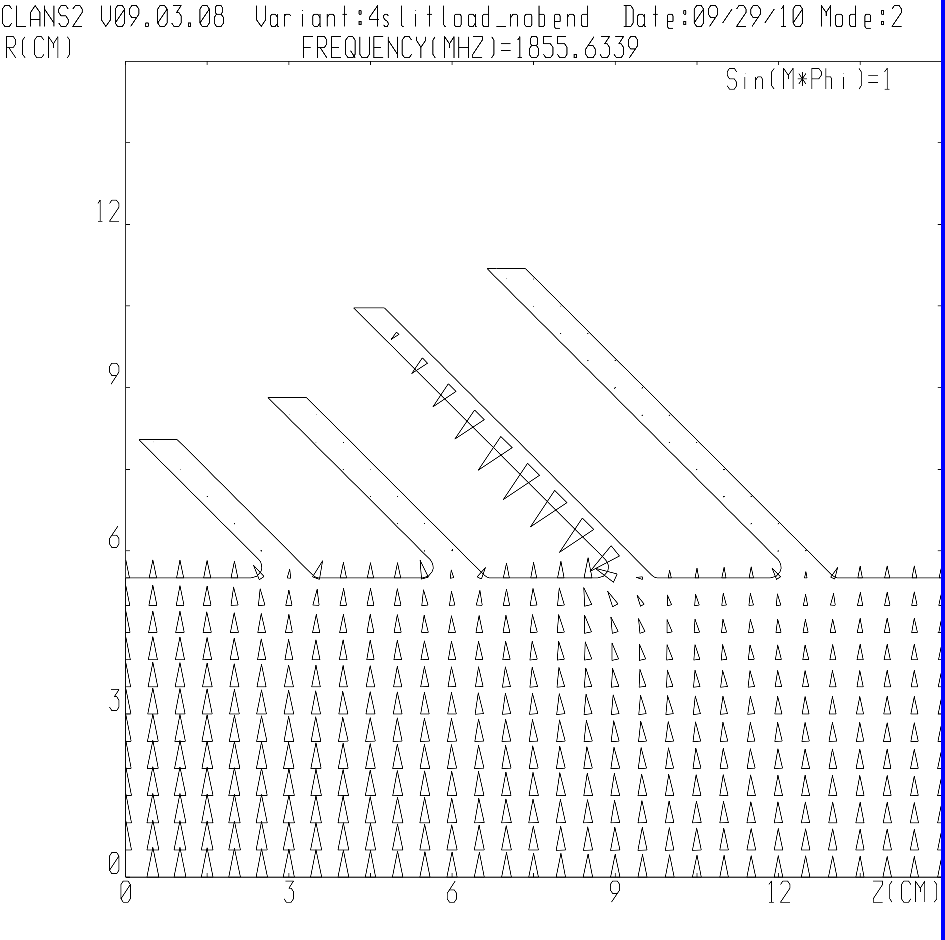
"22" stands for magnetic wall boundary conditions, "33" - for electric wall.

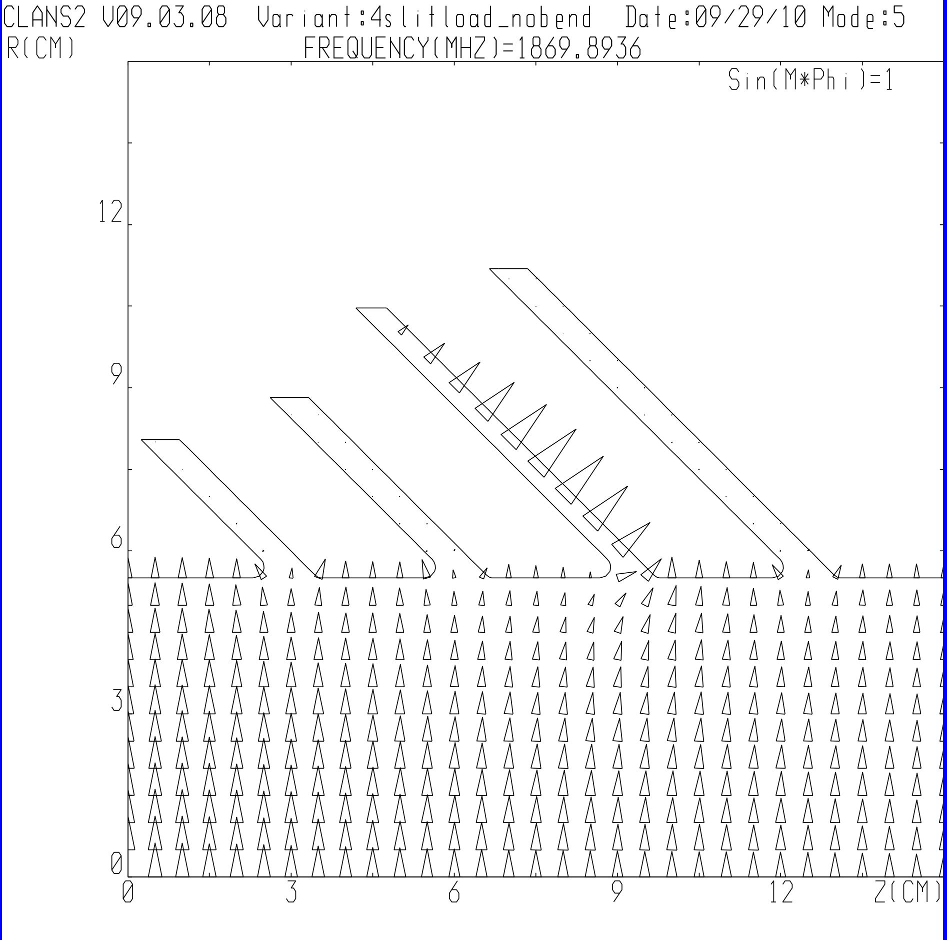
Resonant absorption at 2550 MHz and 3100 MHz makes the maximal value of dzeta below 100 and 10, respectively. The regular load has max dzeta ~ 280.

A mode from the lowest dipole band

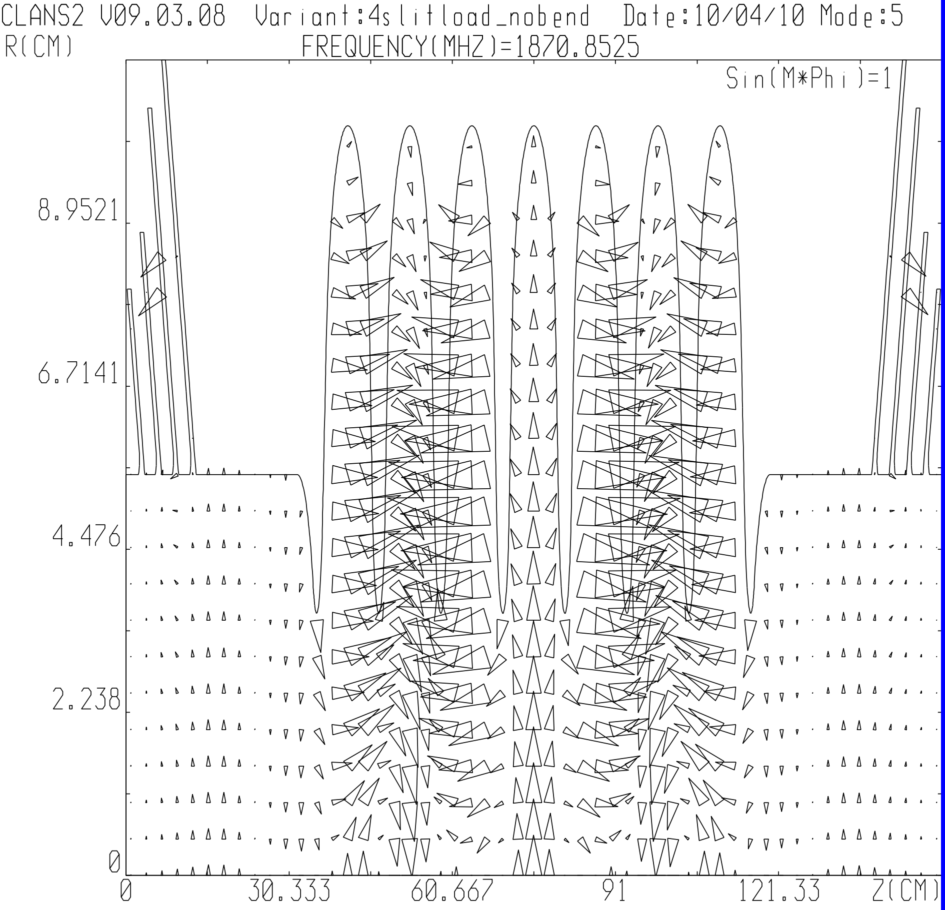


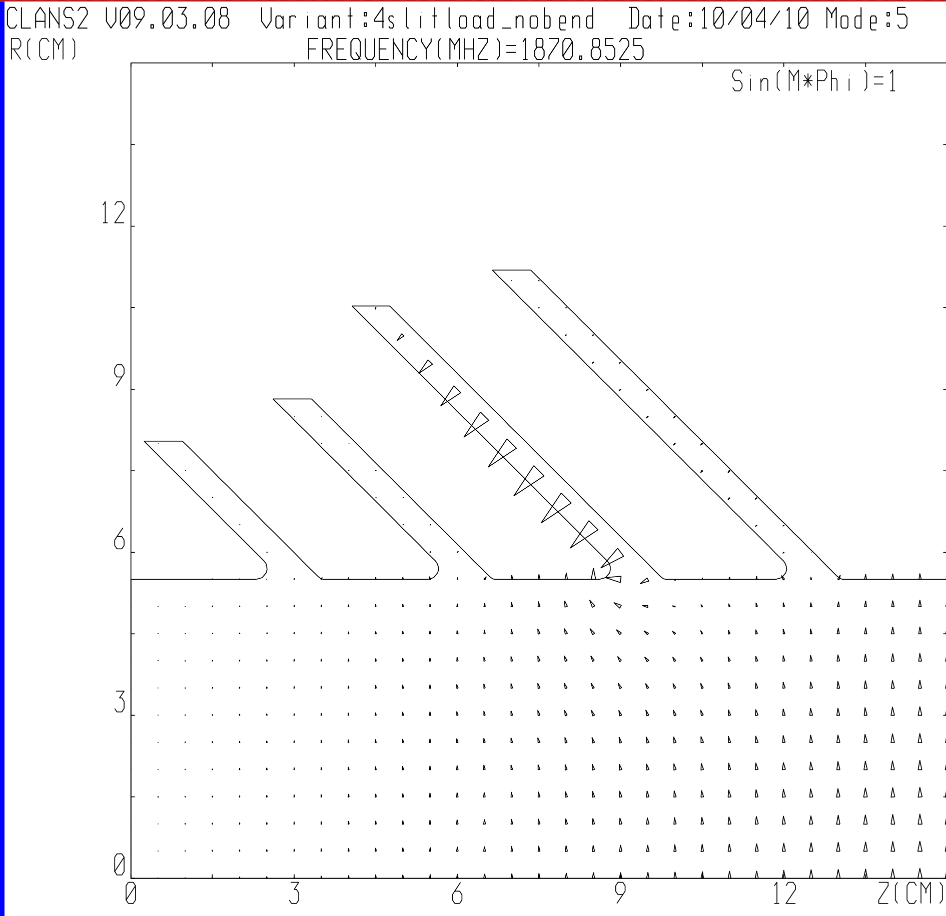
Two modes from the second dipole band





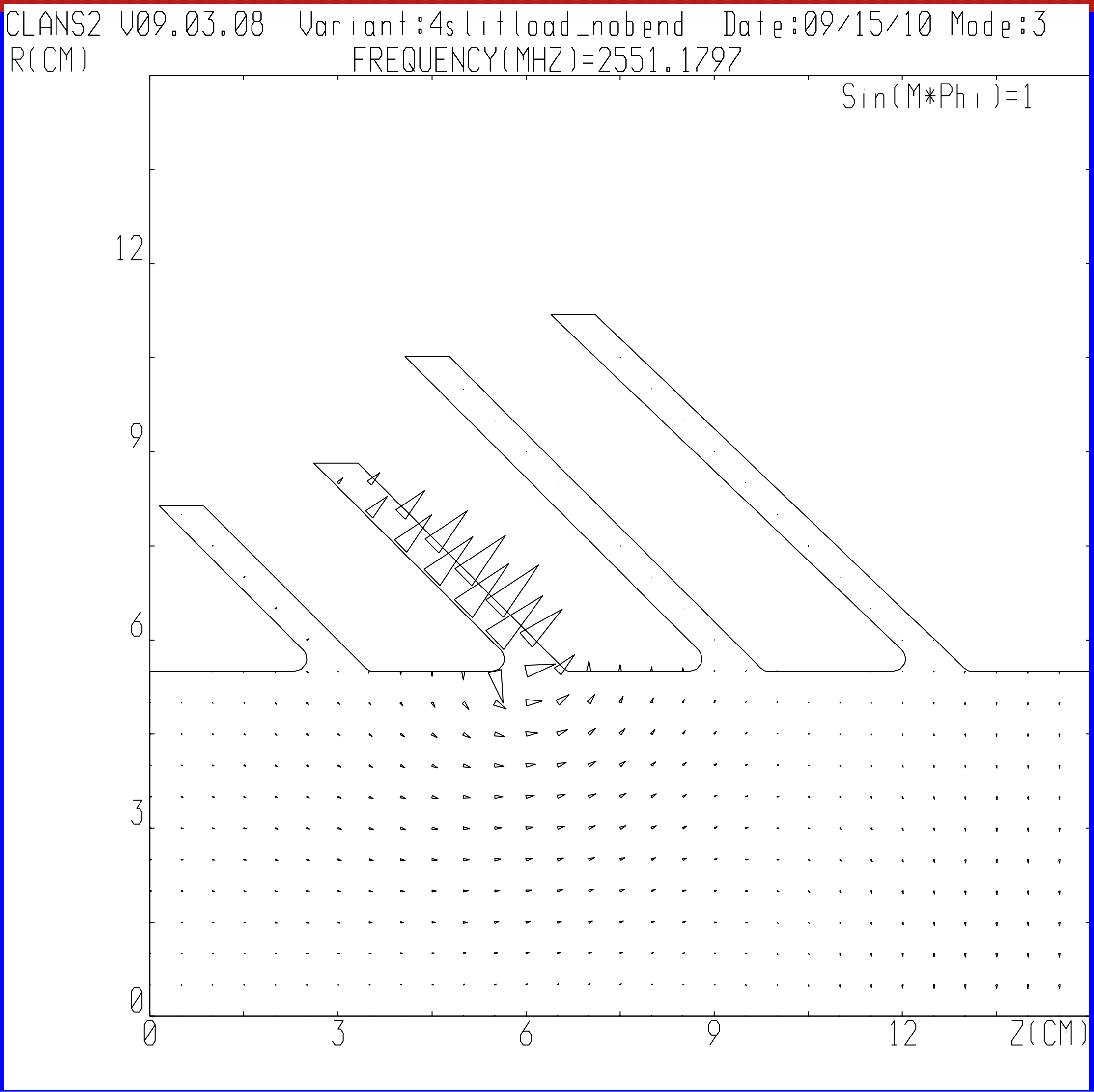
The whole picture of the mode 1870 and its resonance in the slit



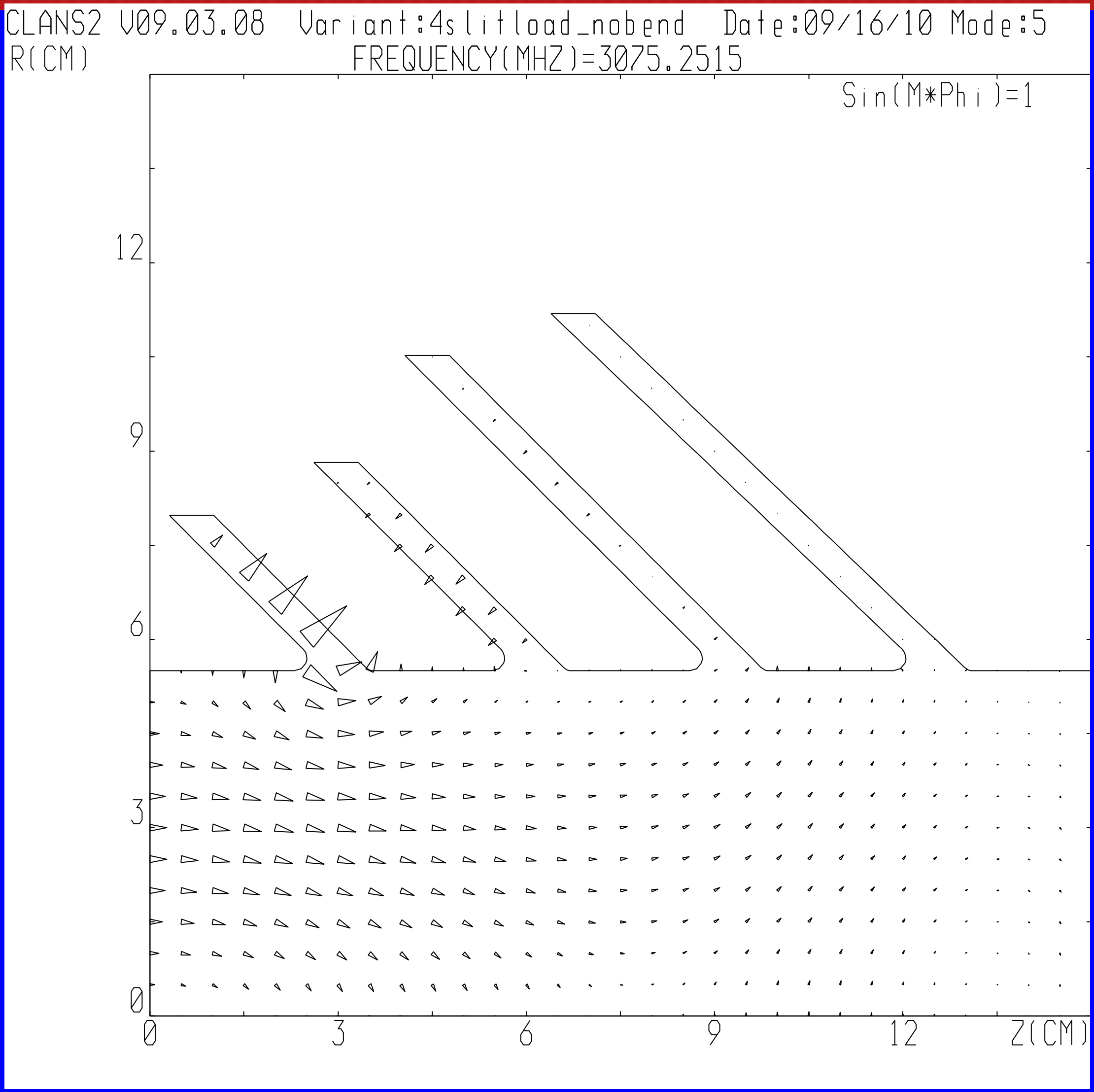


Q = 5417

Mode 2551 MHz



Mode 3075 MHz



Final remarks

- This is a preliminary optimization only. Many geometric parameters of the resonant grooves can be tuned: position, width, length, angle of slope.
- For compactness, the grooves can be bended. This will also decrease interaction with wakefields.
- The resonant load can be made of metal, e.g. St. Steel 430 has $\mu = 11$ and $\sigma = 1.12$ MS/m, -> equiv. $\sigma = 0.102$ MS/m,
  The grooves in this case will be narrower than in the presented example (with 15 kS/m) but you can make more grooves.
- One groove will absorb not at one frequency but at multiple frequencies too.
- Two parts of the load can be asymmetric to broaden the band of absorption.