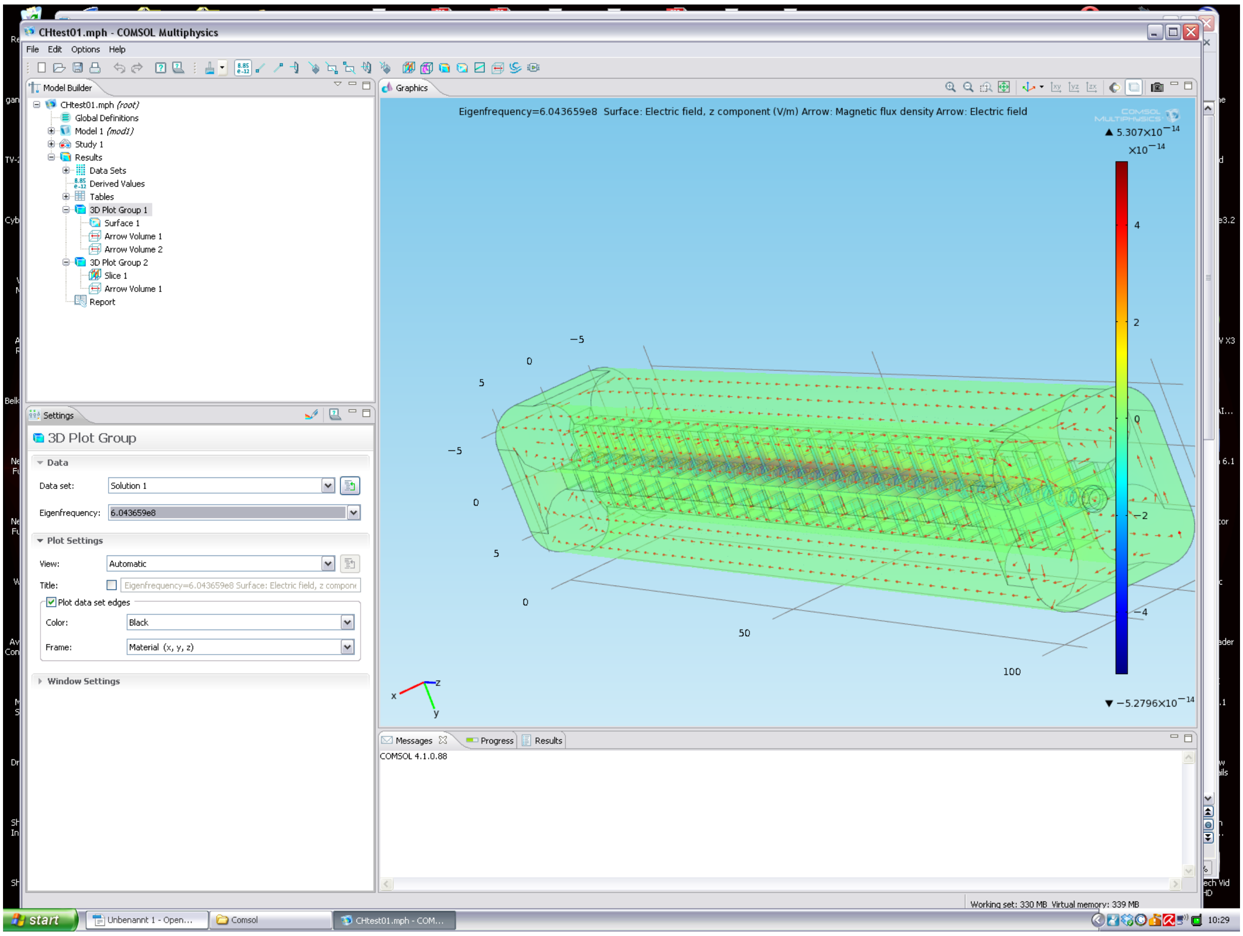
Investigation of the RF properties of a CH structure in COMSOL

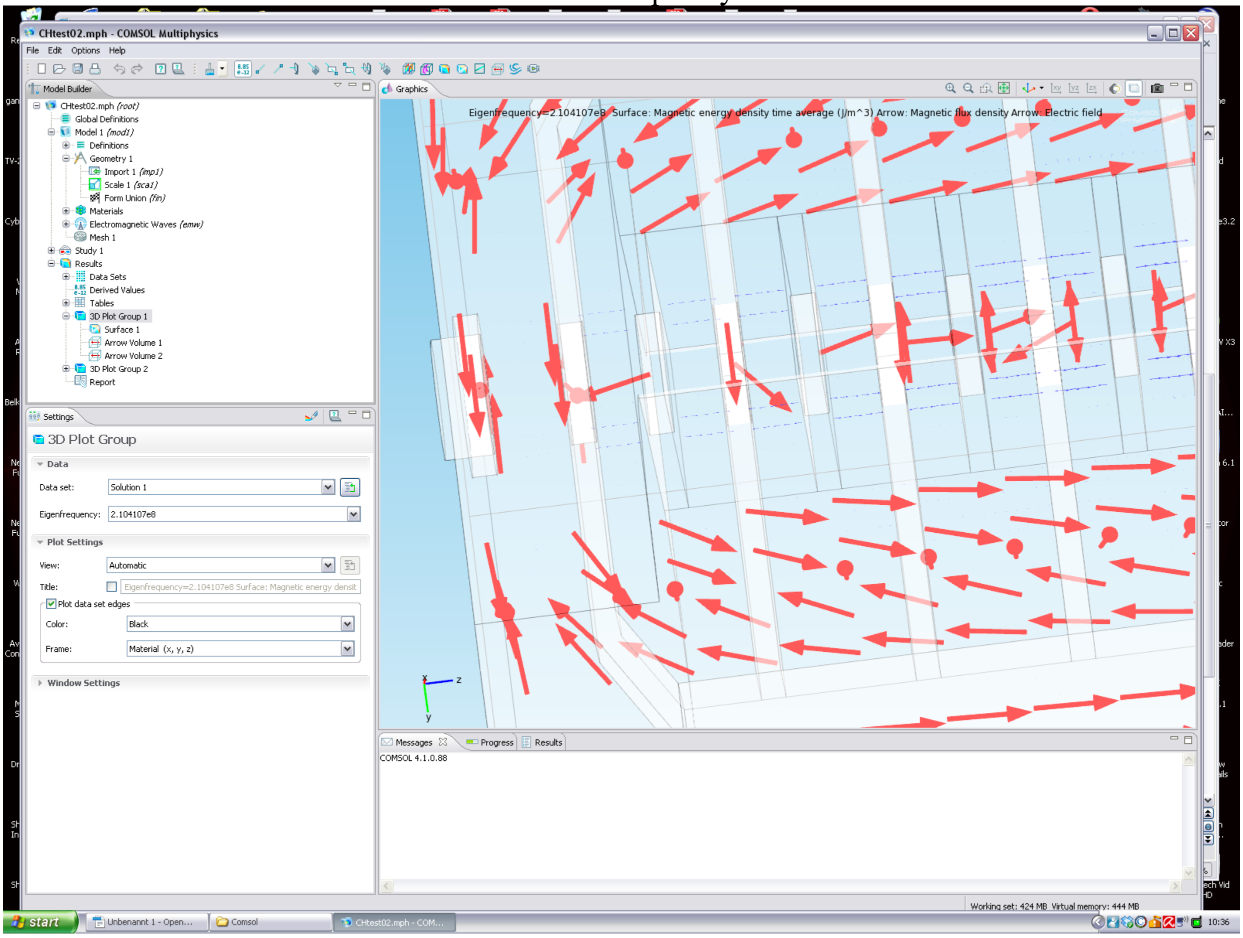
Summary :

The results so far are not fully conclusive but show the main characteristics expected of the field patterns for a CH structure. The different simulations performed show the following characteristics for details please load the COMSOL files:

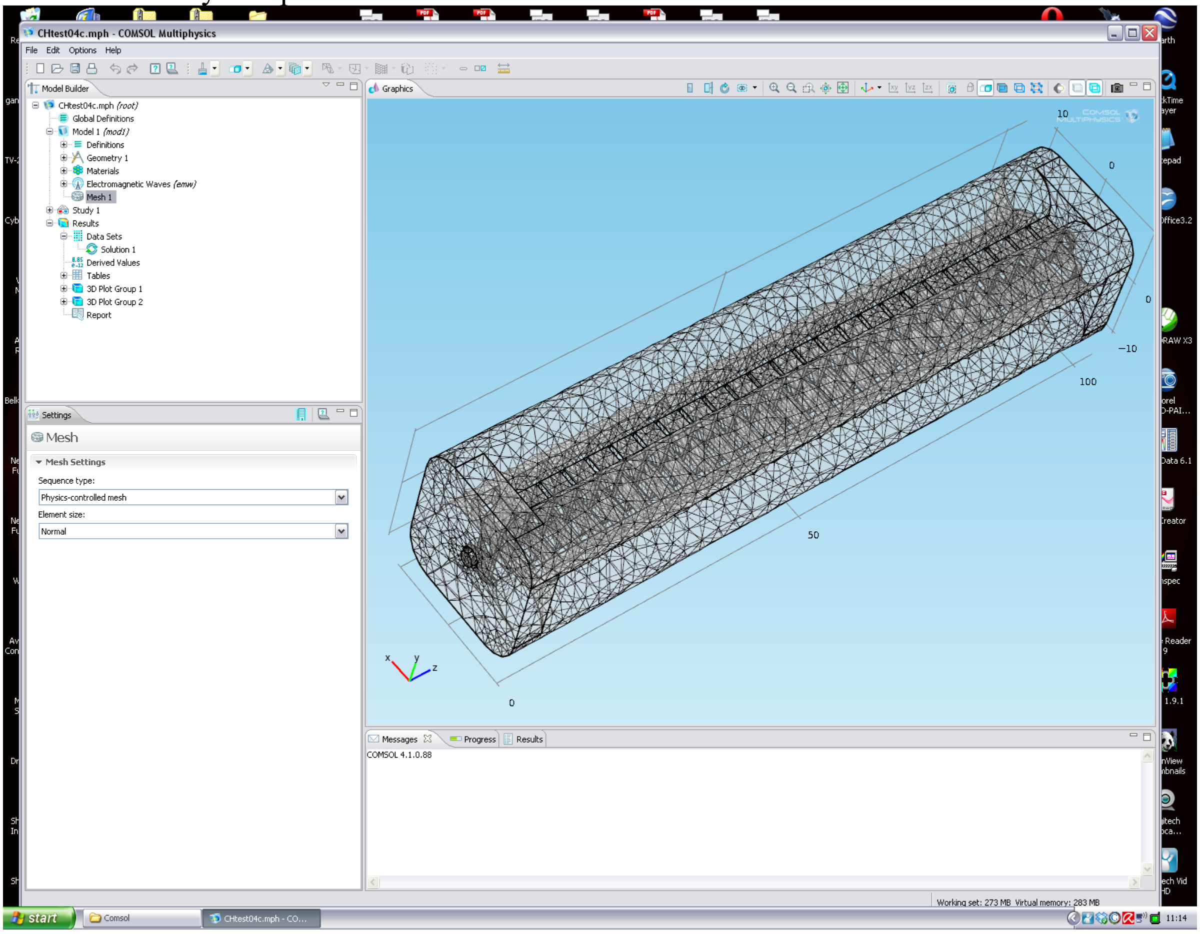
1) model Version 0 – InternalVolume_L2=20_R1=30.sat – gives a resonant frequency for the required RF mode at ~ 600 MHz (Mesh normal MUMPS solver, file : Chtest01). As it can be seen on the picture the electric field is maximum in the middle and much smaller at the ends which indicates detuned end cells.



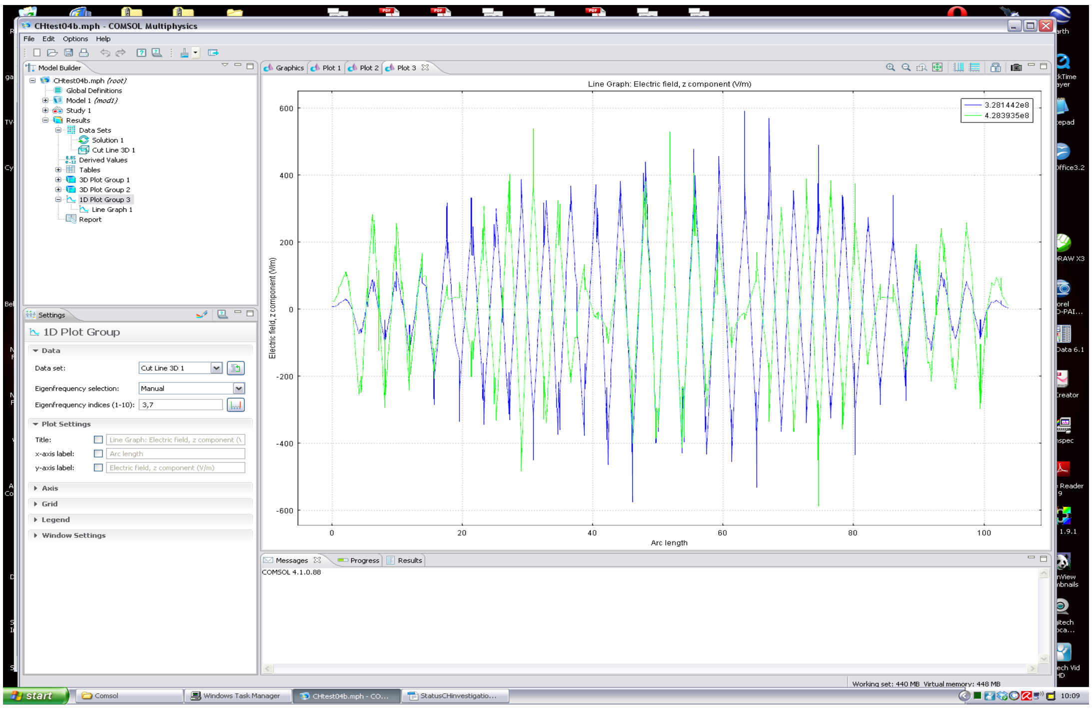
2) model Version 0 – InternalVolume_L2=20_R1=30.sat but transversally scaled by a factor of two to decrease the frequency – gives a resonant frequency for the required RF mode at ~ 210 MHz (Mesh coarser – computer limited - MUMPS solver, file : Chtest02). As it can be seen on the picture the electric field is vanishing in the end cells. Changing the scal from 2 to 1.7 as in file : Chtest03a increases the frequency to ~271 MHz.



3) model Version 0 – InternalVolume_L2=20_R1=30.sat but transversally scaled by a factor of 1.5 to decrease the frequency, first investigation of influence of mesh density on RF frequency : Chtest04a = coarser, 4b= coarse, 4c=normal, all higher mesh densities generate a OOM on my computer....



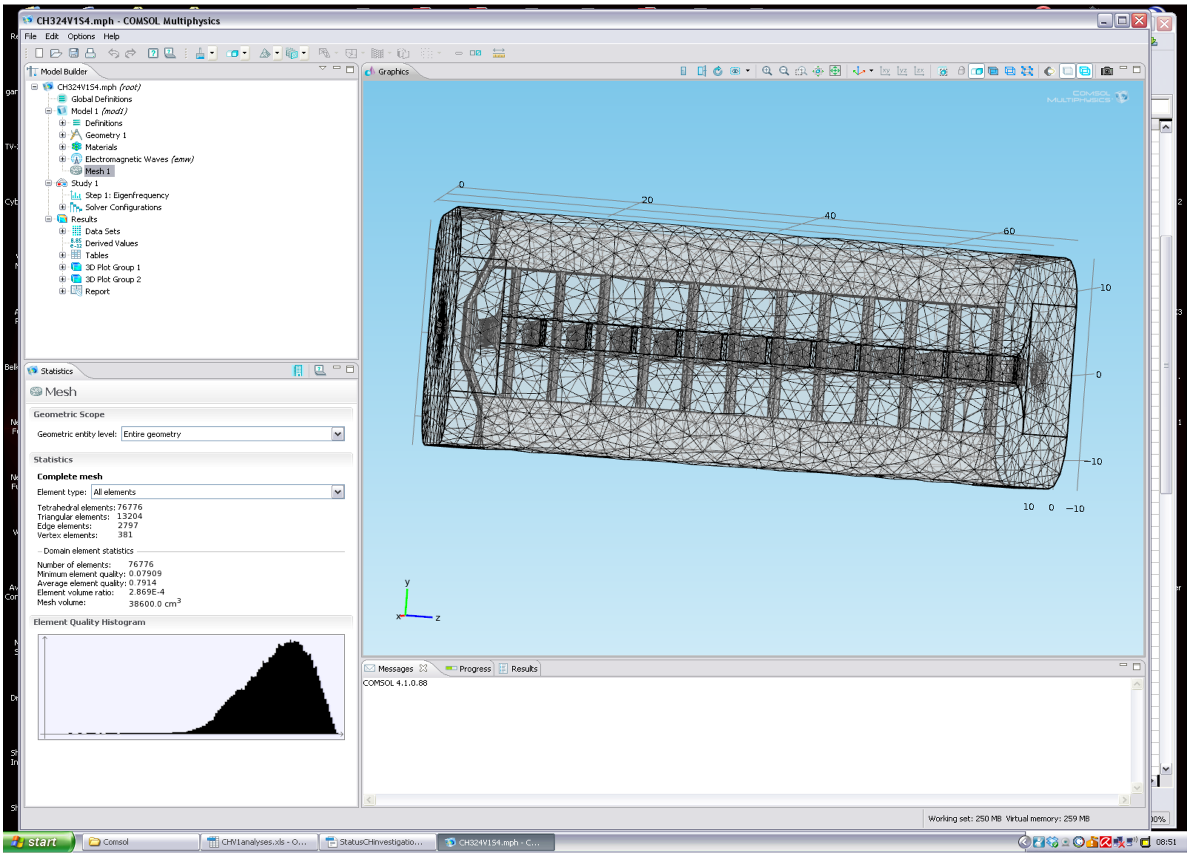
the frequencies calculated vary strongly with the mesh density and the results are inconclusive and further runs with higher mesh density on the server are required (prepared 4c=normal, 4d=fine, 4e = finer, 4f=extra fine).



4) Model Version 1 – InternalVolume_L2=30_R1=60.sat 70cm long. First investigation of influence of mesh density on RF frequency : CH324V1S1 = coarser, S2= coarse, S3=normal, S4= fine, all higher mesh densities generate a OOM on my computer....

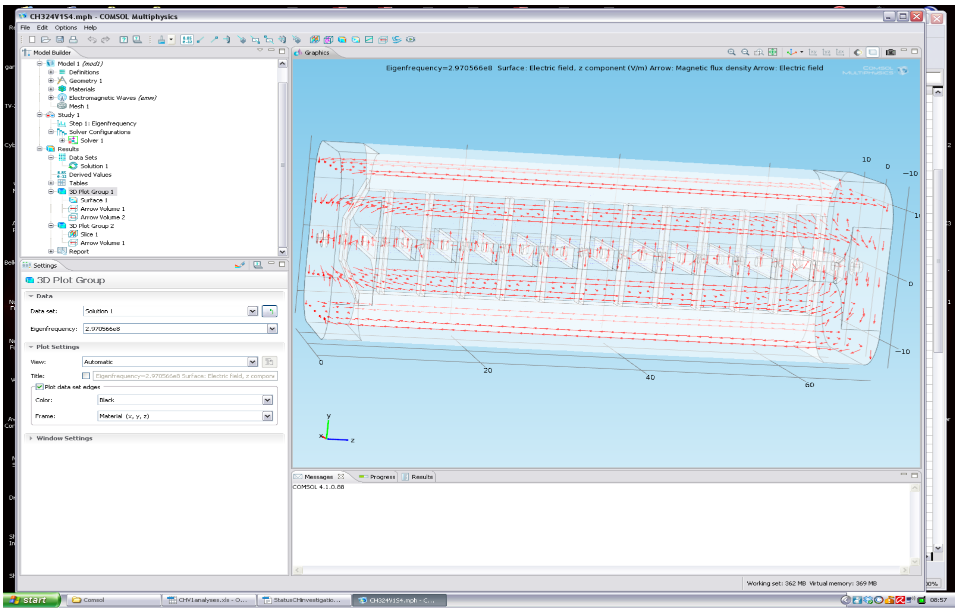
Results for fine mesh:

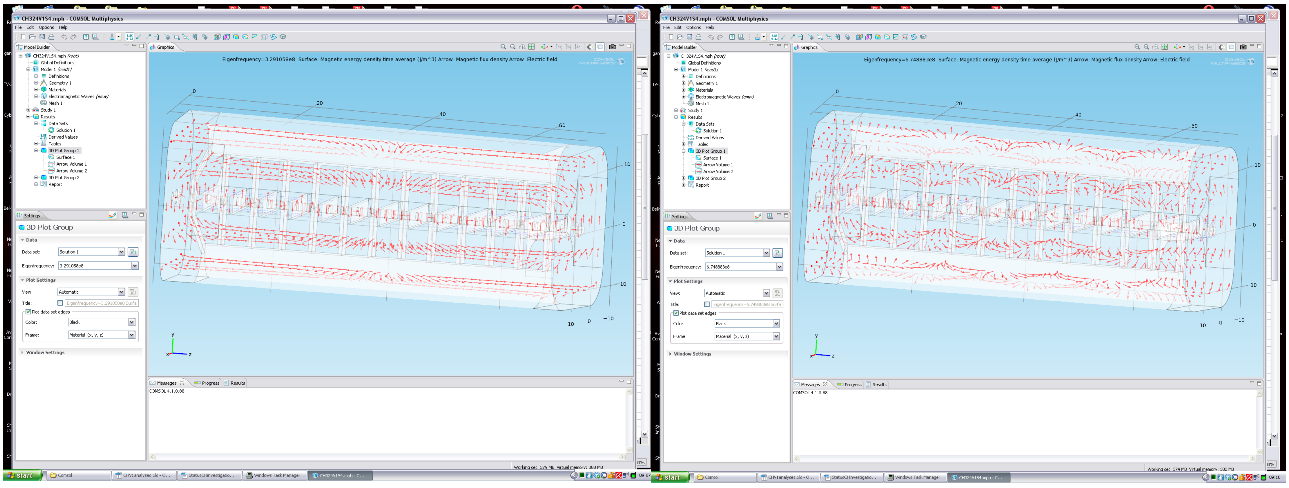
Mesh:



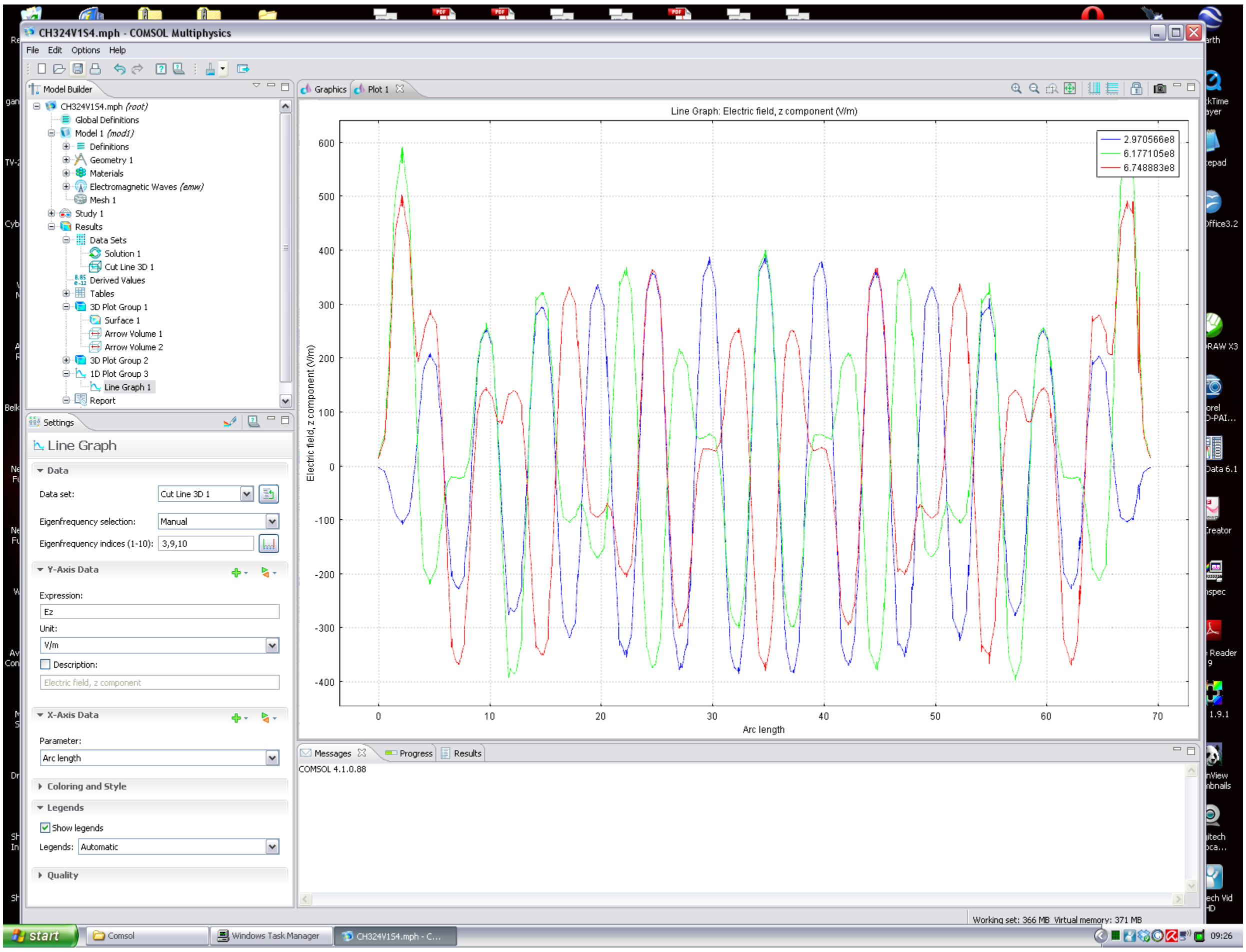
Field distribution:

magnetic field :



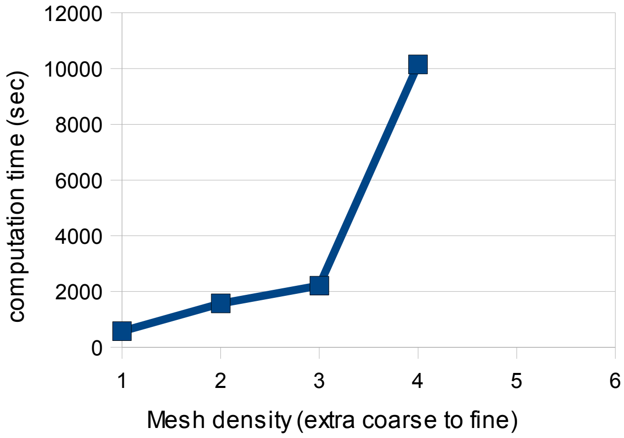


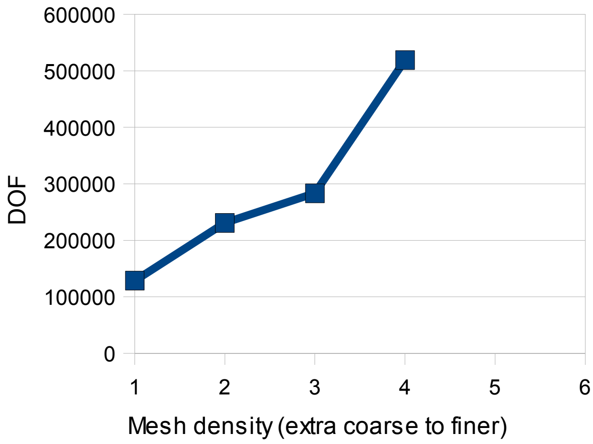
electric field in Z direction (contribution to acceleration)

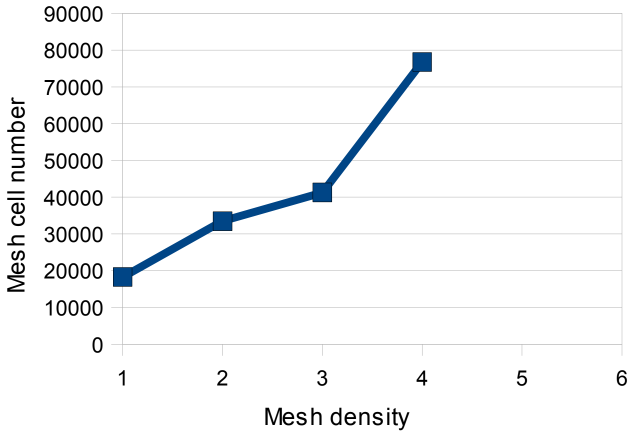


While the blue line (fundamental mode) shows alternating signs in each cell increasing towards the middle the amplitude is quite low. Higher modes (green, red) show a different pattern with a maximum amplitude around the end parts. The maximum amplitude is higher than for the basic mode. This indicates that the two special cells at each end have a different (higher ?) frequency and produce a mode mixing reducing the fundamental mode quality. Therefore we have to tune those two end cells each towards 300 MHz before optimizing main body towards the final frequency.

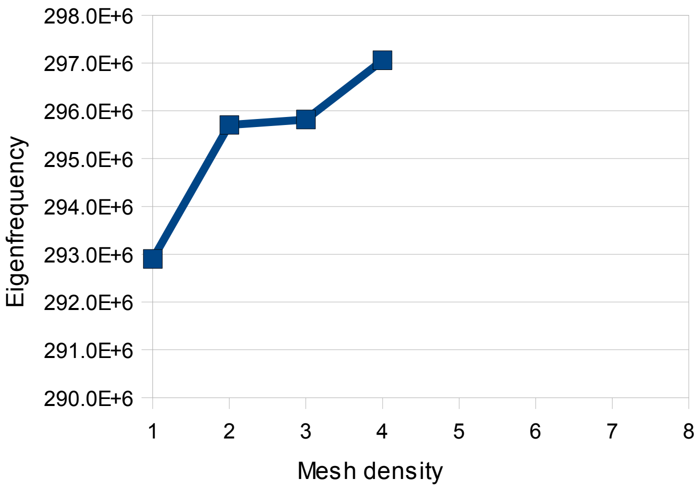
Mesh density and computation time:

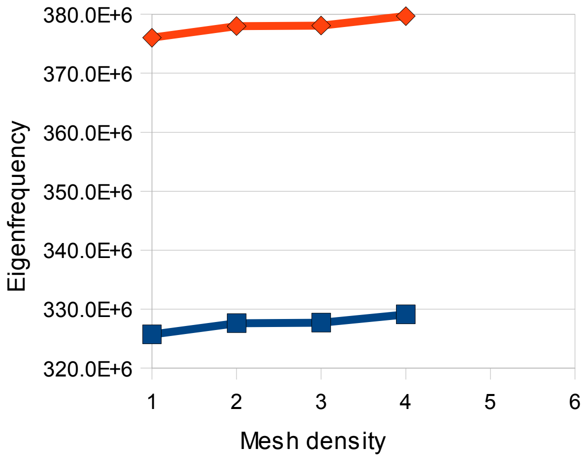


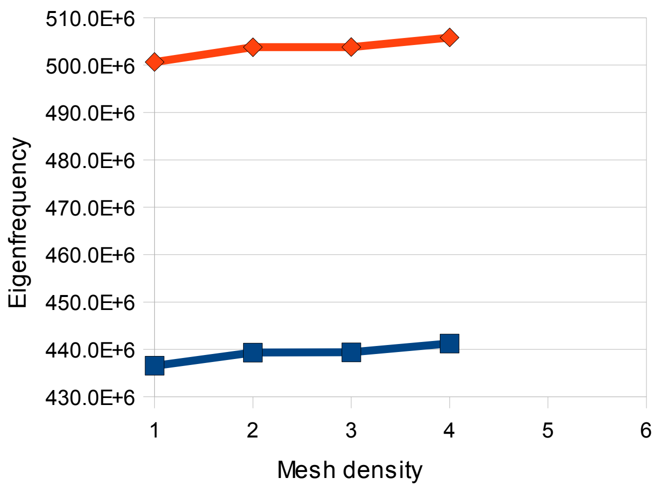




Eigenfrequency :







To do:

1) run V1 simulations with higher mesh on server
2) optimise end cell frequencies to 324 MHz
3) optimize body frequency to 324
4) add tuners, couplers, detailed studies
5) add length increase from cell to cell to accommodate speed increase/acceleration.

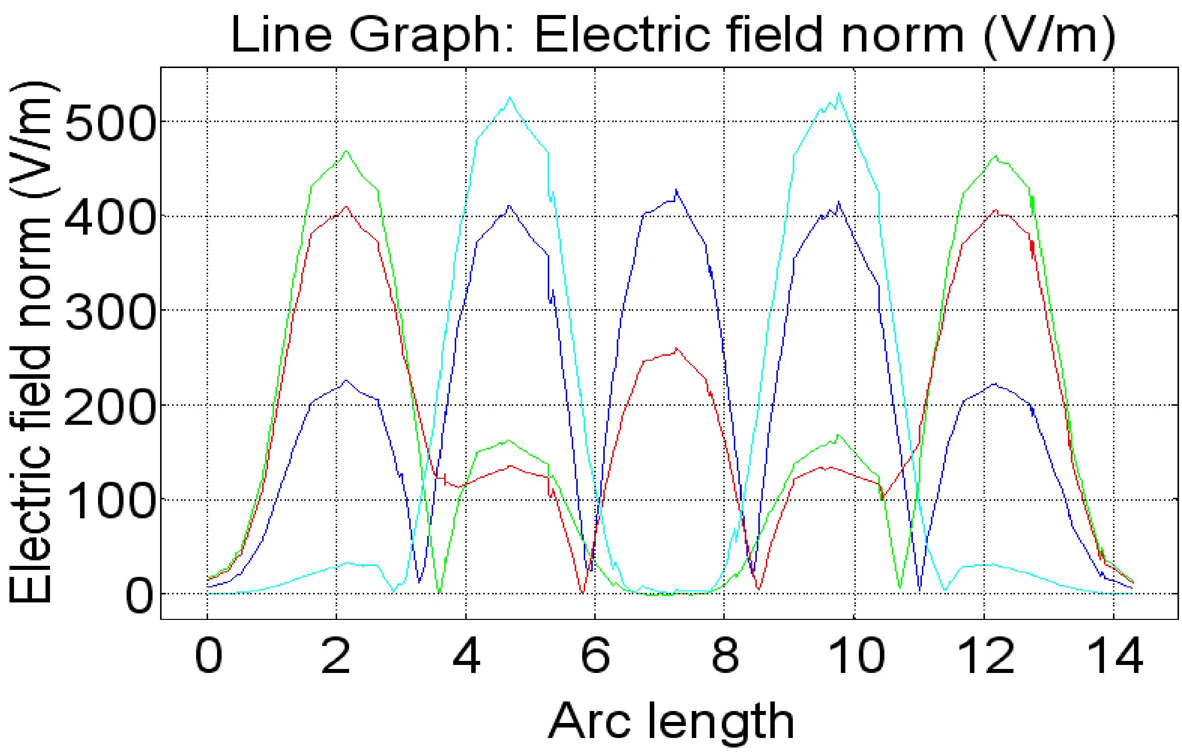
Further work on 2 with 4 models :

A) One model consisting only of the end cells as they are – cut out everything from (behind) the first normal bar the the last normal bar. The model consist only of the endflanges, the two bend bars and one straight bar in each direction. This is the reference for all other investigations/models

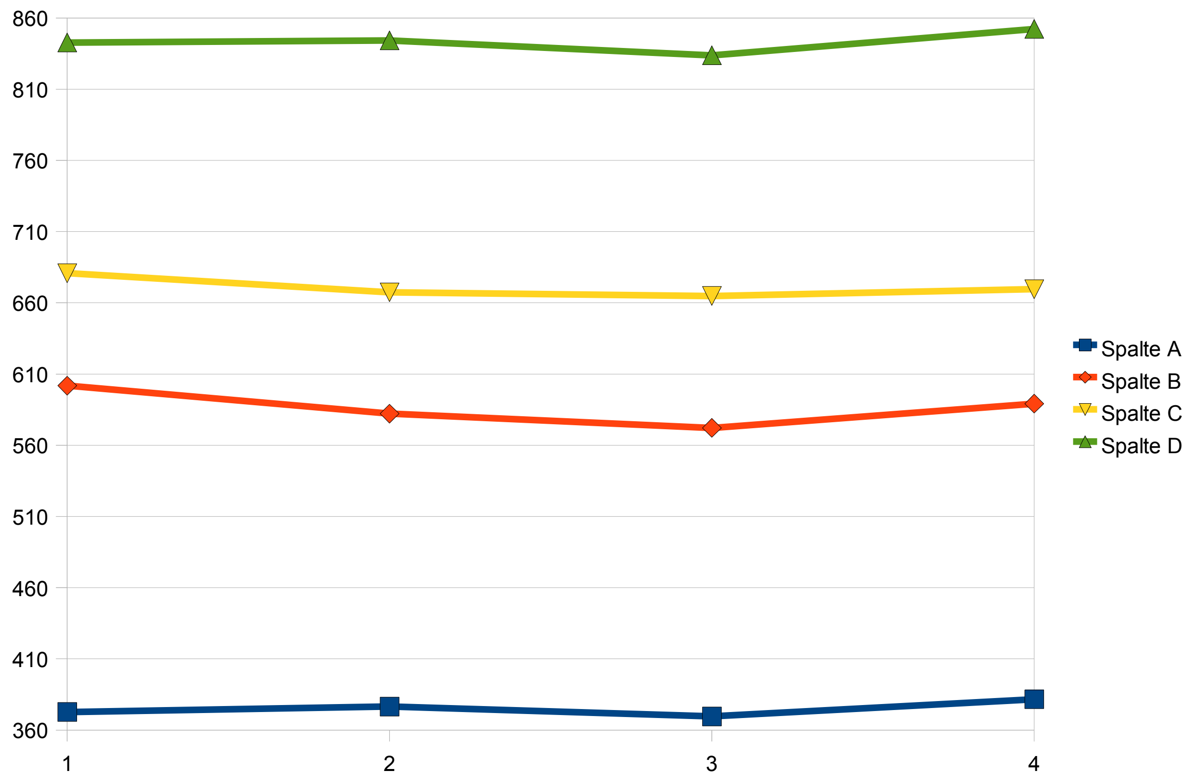
B) Like cell A) but reduce the length of the two endcells by 5 mm (move endplate towards bend electrodes)

C) like B) but also introduce ears to the bend cells (see sketch) (4 mm wide
D)like C) but inverse remove the "ear material" from the model.......

All calculations performed with "normal" meshing.....



Electric field distribution of the 4 interesting modes for model A), but all models show the same behaviour with slightly different frequencies for those modes and different amplitude ratios. Mode 1 (dark blue) is a mixed mode similar to the ones we observe in the long models. Mode 2&3 (green, red) are also mixed modes but the amplitude is prominent in the first gap = larger contribution of endcells. The Forth mode (light blue) is a pure mode (nearly) for the second (distorted) cell. This let's us disentangle the 2 cells by tuning first this cell to 324 and then get the endcell right.



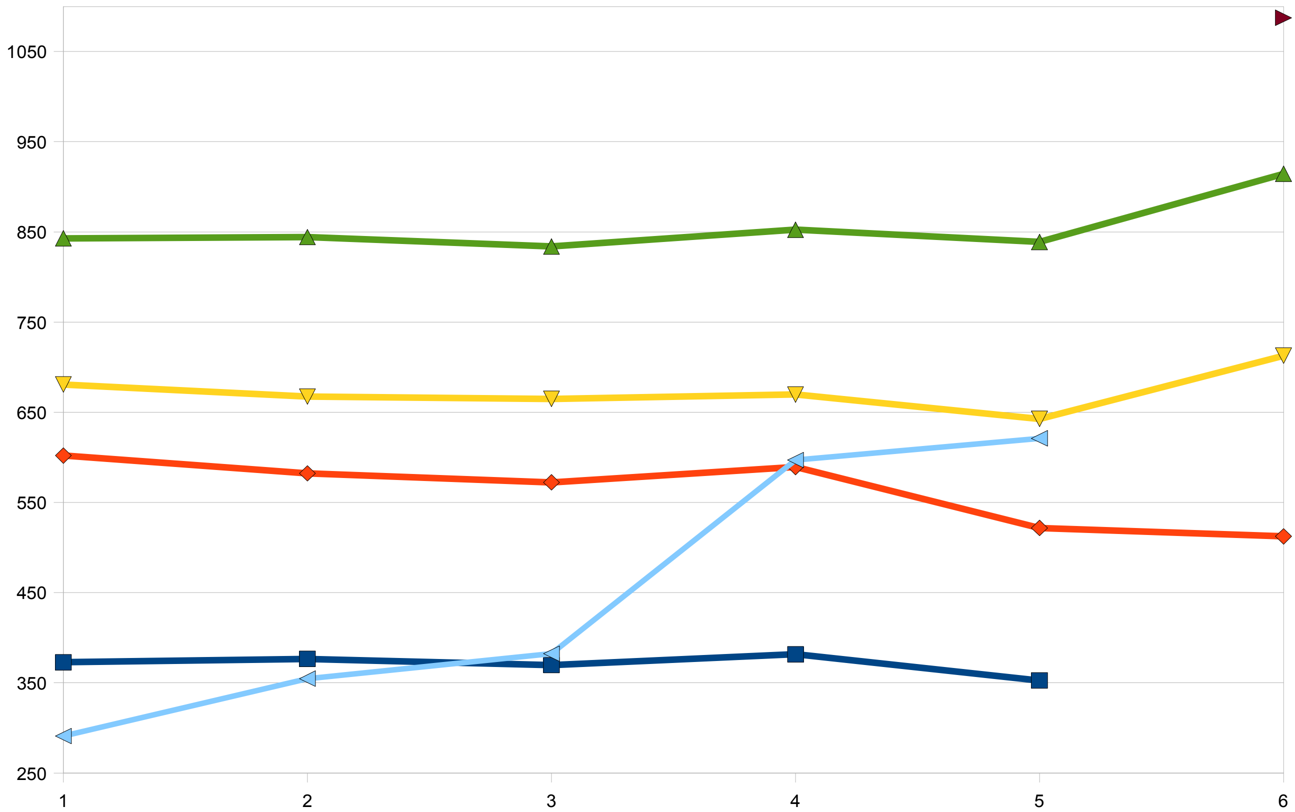
While the endcell length did increase the frequency of the first and 4th mode only little but the modes 2&3 were reduced strongly this effect could be increased. Adding ears (capacity) hat the right effect in terms of frequency but was far to small (11 MHz of 500 MHz) – we have to increase the ears and also work on the conductance (current path). These changes will form the new baseline. To tackle also the end cell with more speed I suggest that we try to breed a 324 frequency.....

The following further models have been investigated

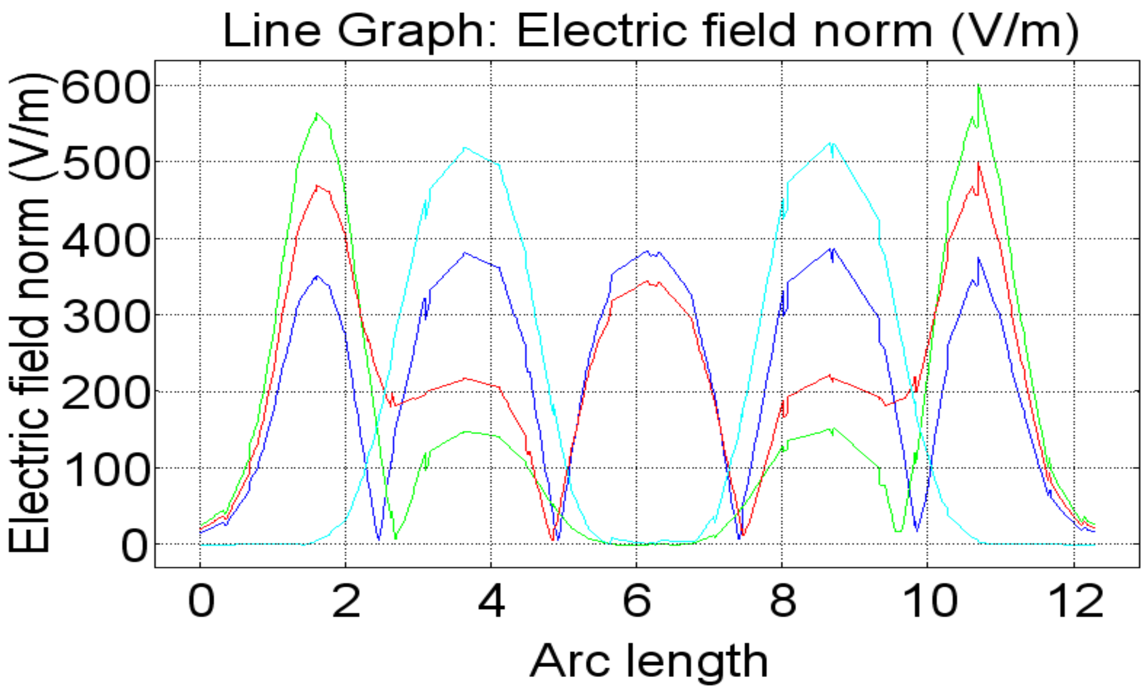
E) - will be new baseline with changes tothe bend stems, reduced End cell length by another 5 mm, replaced the ears from model C by circular ears of radius 50 mm.

F) Like E) but make the endcell such that the 4 circles got to the endflange – thus we reduce the size of the endcell volume dramatically – I assume that this will drive the frequency up... therefore we need another model.....

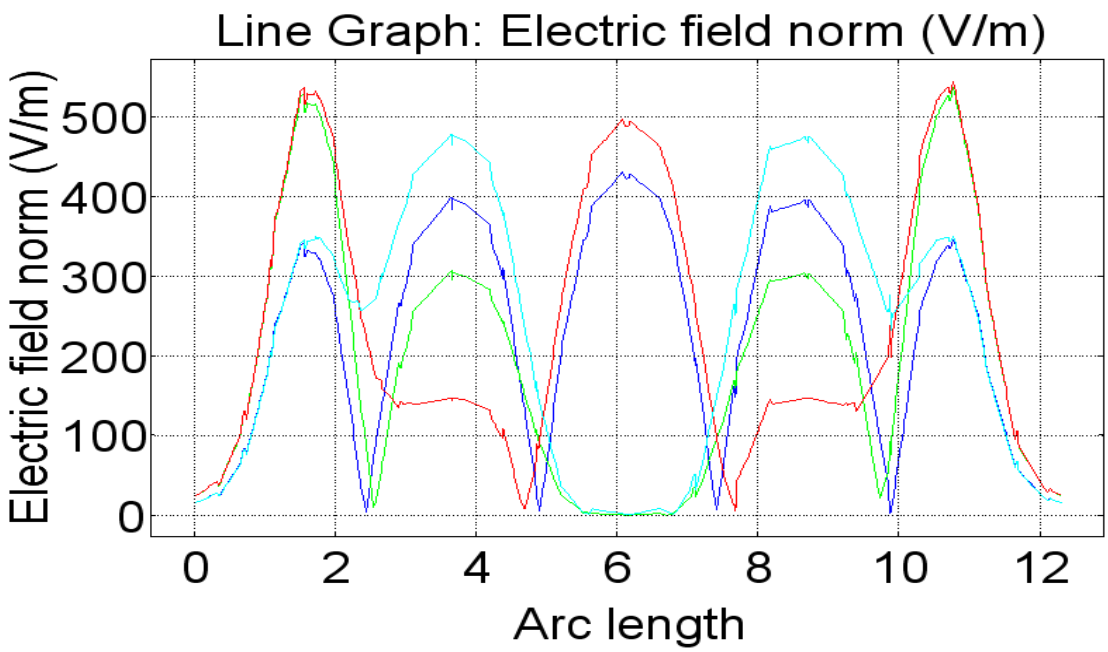
G) like E) but change the endcell to represent a cylinder with the length as in E), but a radius of 300 mm (so the end cell will be quite a bit larger than the diagonal of the CH, the size of the radius is r ~ what we would use for a pillbox to get to 324 HMz.... (there we would need 35.41 cm radius but the additional complication in the geometry ….) for the new models the following mode frequencies have been found :



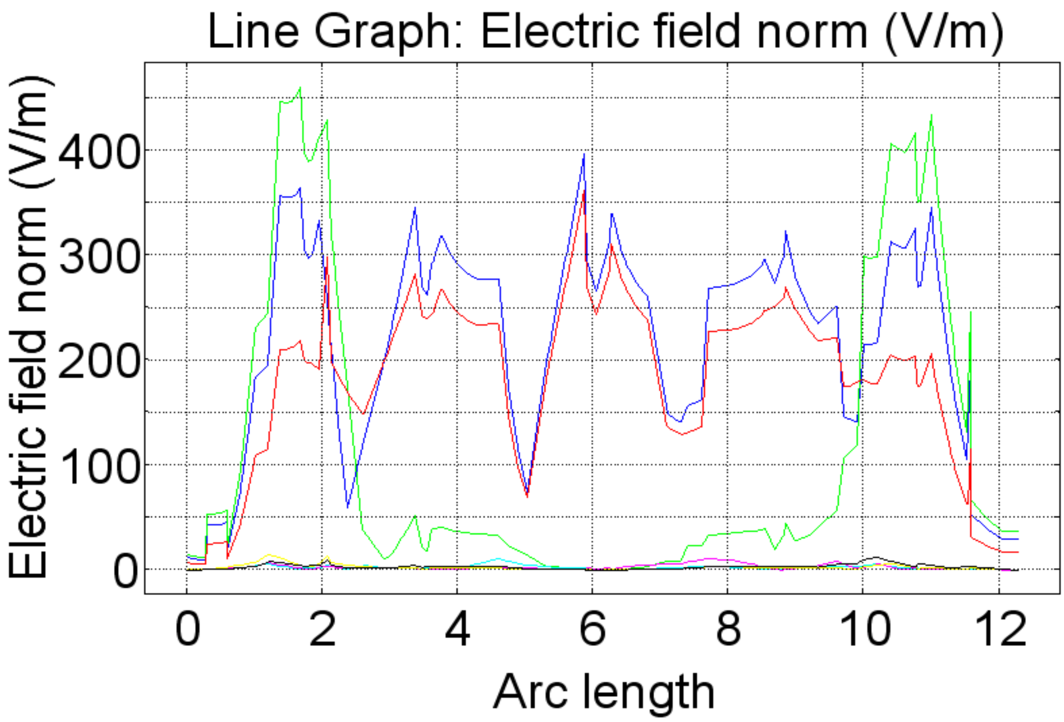
The base mode dropped by 20 MHz and the mode 2 by 80 MHz and 3 by 38 MHz but 4 only by 4 compared to example A – old baseline. So the changes have mainly influenced the end cell to get towards 324 while the second couldn't benefit from the changes. If compared in the field distribution with the model A the main changes are obvious. A much flatter distribution of the fundamental model.Model F shows an very different behaviour. Not surprisingly removing the space at the ends suppresses the basic mode we want for acceleration, we also see a slight depression of the second mode which was hoped to be larger.... The model G is drawn in light blue (this time the X – numbers refer to the mode). The modes shown are all not related to the fundamental mode we are looking for, but as shown later mode 2 is a pure mode only at the end cells at 354 MHz.



Electric field distribution of the 4 interesting modes for model E). Mode 1 (dark blue) is a mixed mode is much flatter now. Mode 2&3 (green, red) are also mixed modes but the amplitude is prominent in the first gap = larger contribution of endcells. The Forth mode (light blue) is a pure mode (nearly) for the second (distorted) cell. This let's us disentangle the 2 cells by tuning first this cell to 324 and then get the endcell right.



Electric field distribution of the 4 interesting modes for model F). Mode- dark blue is a mixed mode at 1 GHz – the last of the modes now. Mode 2&3 (green, red) are also mixed modes but the amplitude is prominent in the first gap = larger contribution of endcells. The Forth mode (light blue) is a pure mode (nearly) for the second (distorted) cell. This let's us disentangle the 2 cells by tuning first this cell to 324 and then get the endcell right.

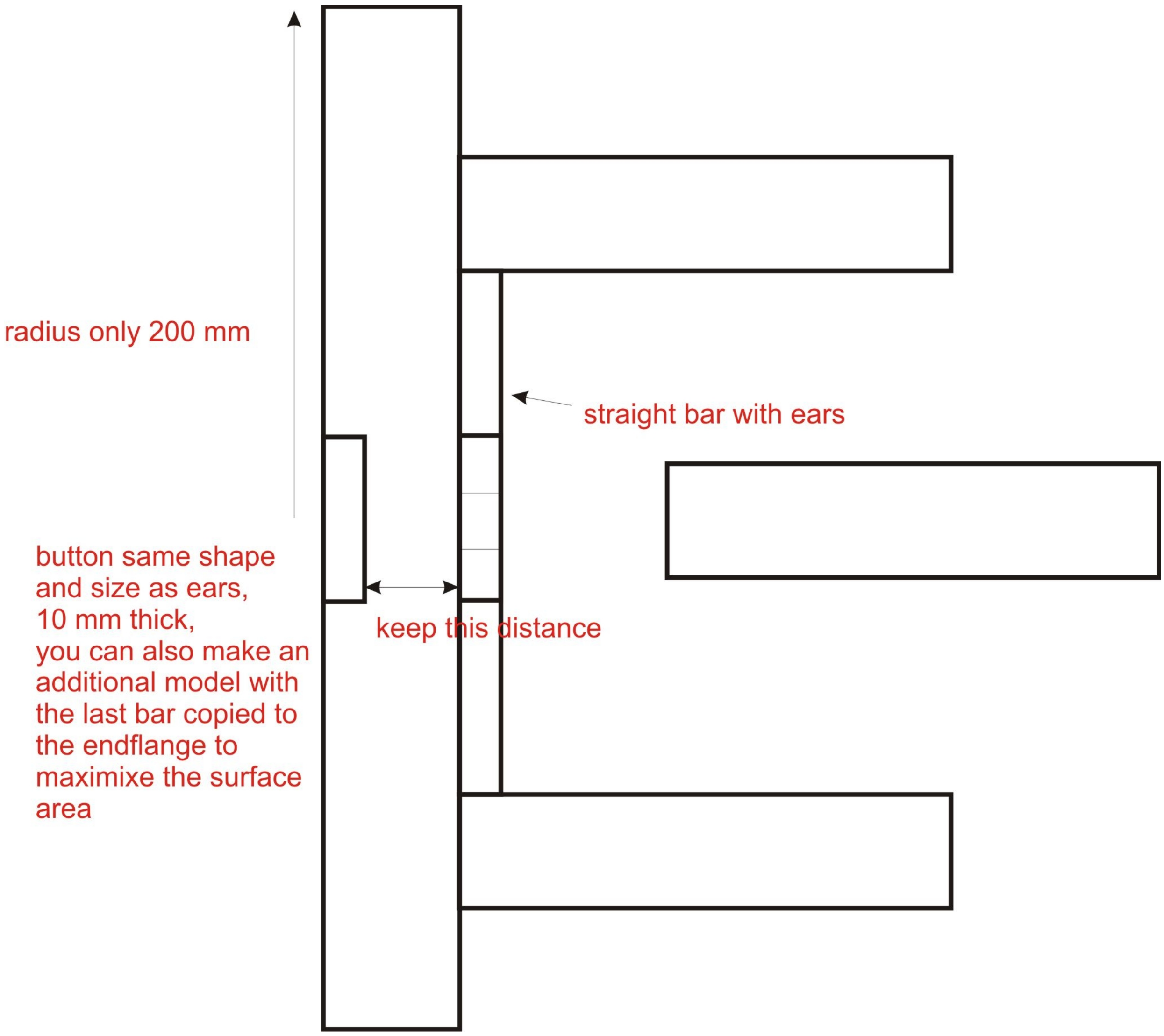


Electric field distribution of the 4 interesting modes for model G). Mode 1 (dark blue) is a mixed mode similar is much flatter now. Mode 2&3 (green, red) are also mixed modes but the amplitude is prominent in the first gap = larger contribution of endcells. The Forth mode (light blue) is a pure mode (nearly) for the second (distorted) cell. This let's us disentangle the 2 cells by tuning first this cell to 324 and then get the endcell right.

To continue with 2 we need one further model :

This model is based on the model E but with changes from F and G in variations included.

1) to increase the capacitance in the second cell we change the round ears : the radius is now only 40 mm but the centre of the circle is at the edge of the bar. …. so at the entre of the bar it is 30 + 40 + 40 mm wide.
2) We take the change in model F, but instead of making the rounded bit longer to the end flange we make it exactly such that the last bar could be straight – and we make the last bar also straight. A small gap is now between the end flange and the end of the 60 mm circle holes.
3) We modify the end flange from model G – according to this sketch..... (reduce radius, optimize the capacitance between endwall and the stem, allow more flux for magnetic field (basic mode)


radius only 200 mm
straight bar with ears
button same shape
and size as ears,
10 mm thick,
you can also make an
additional model with
the last bar copied to
the endflange to
maximixe the surface
area
keep this distance