INR proposal
for design update
of 1300 MHz CW buncher for European X-FEL

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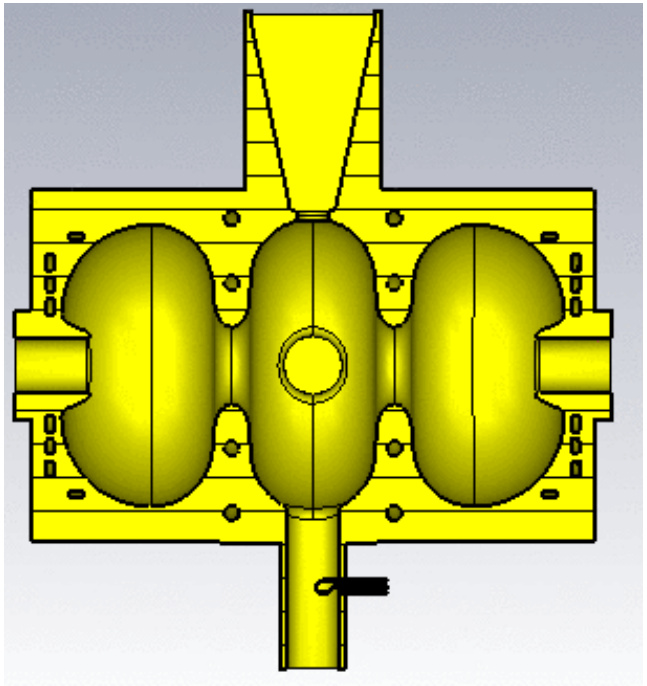
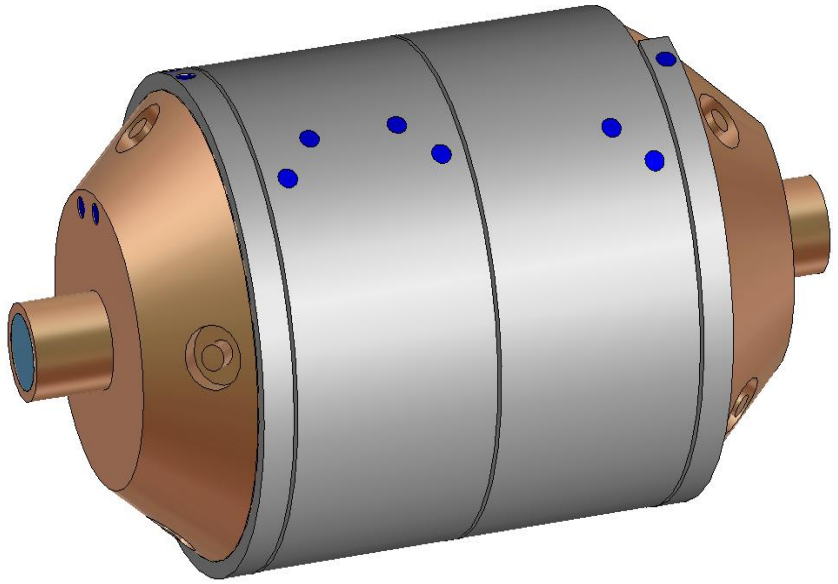
In our INR experience all time we do developments in two turns.
In the first turn we do intelligent service. We touch the problem, clarify relationships, find bottleneck points.
In the second combat turn, after analysis, we modify design, some times very strongly, to fit together contradictory requirements, find counterbalanced solutions, for practical realization.
The first turn, in our opinion, was performed.
This proposal is strongly based on results of previous research!





Leading ideas

1. Three cells – well motivated by SL. Conserved.

2. CW mode but low E-field → circular iris tips. Lower RF losses.

3. Middle cell optimized for higher Q.

4. The first and the third cells are optimized for higher Ze (drift tubes also).

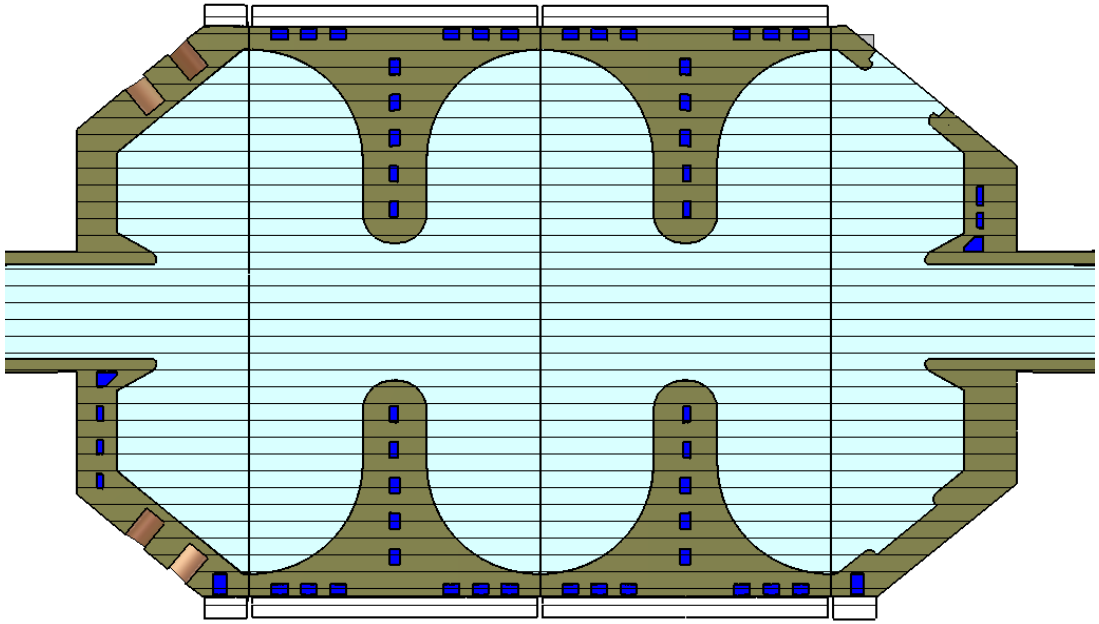
5. Cone part is for equipment – tuners, RF probes (direct, Gun 5 style), RF coupler.

6. Cells are equalized in frequency.

7. Improved RF coupler – smaller coupling slot – much smaller perturbations.

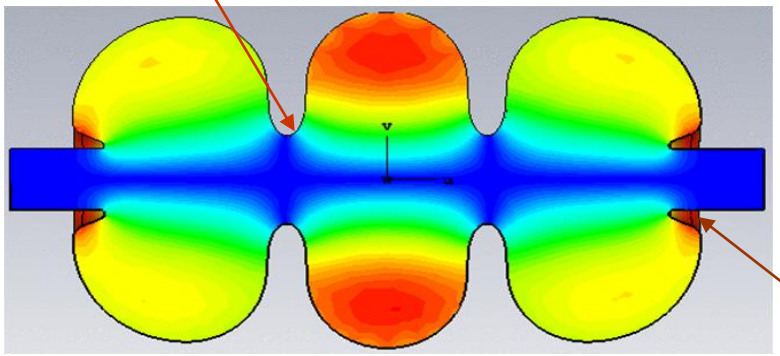
7. Cooling circuit – distributed – Gun 5 style.

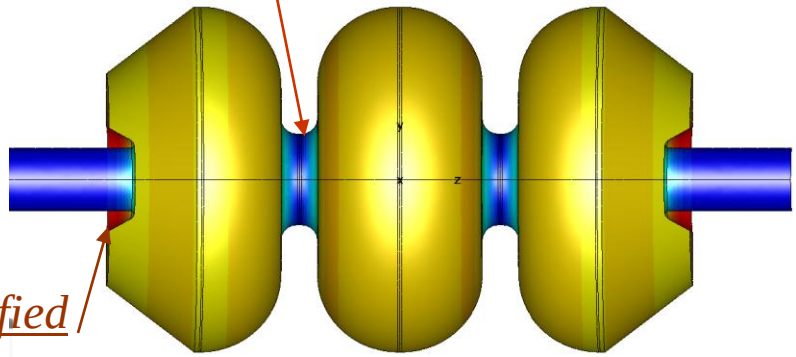
8. Stainless steel jackets – DESY Guns experience, mounting.



RF design

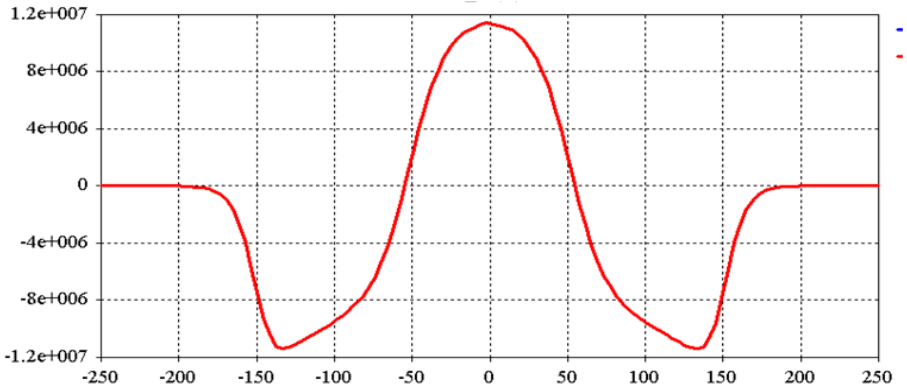
elliptical 24 mm — low field! — circular 20 mm (Gun's)



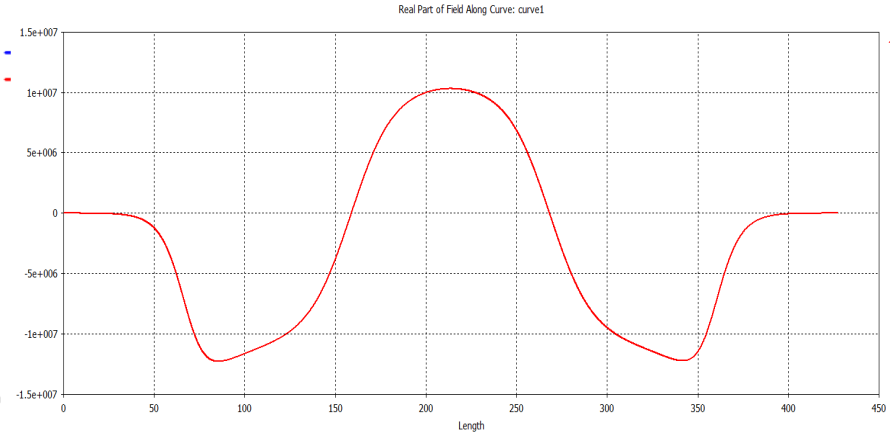


modified

Equalized distribution of H-field



On- axis Electric field profile



For Ueff = 400 Pcst ~13 kW,

Pcst~12 kW

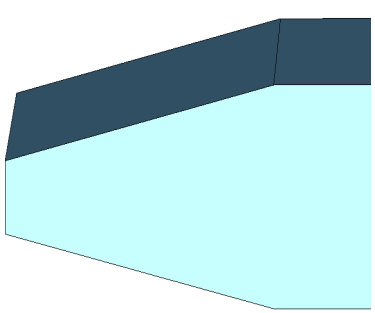
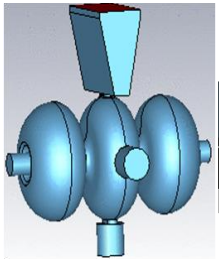
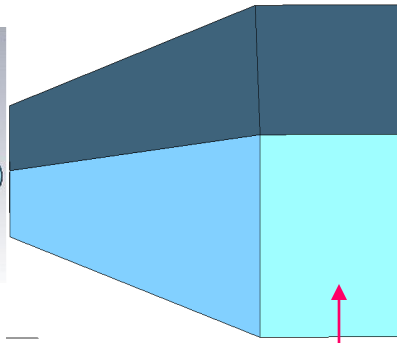
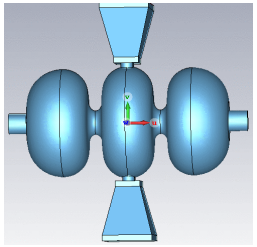
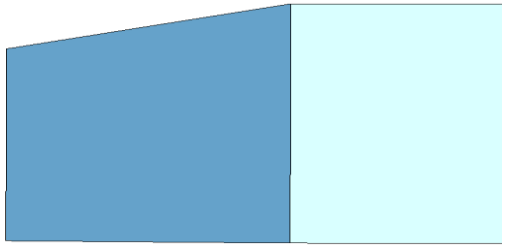
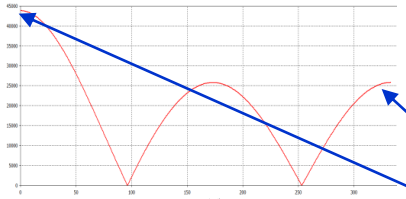
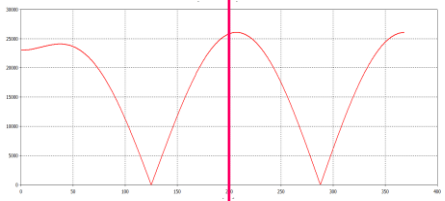
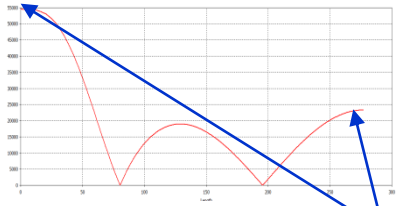
Modes f1= 1293.47 MHz,

f2= 1297.76 MHz, df=2.24 MHz,

f3= 1300.00 MHz

RF coupler

- Central cell is natural for coupler placing, but there is in contradiction with jackets and cooling.
-The structure is only 3 cells, end cell is not prohibited!
- The coupling slot should be as small as possible! WG tapering is required - the method for H field enhancement in TE10 mode at coupling slot from WC side.

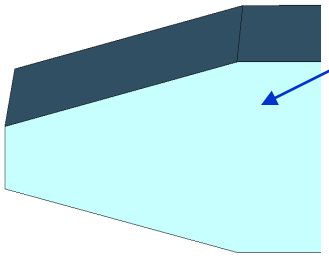
Usual – narrow wall tapering, ratio 1.69,

narrow&wide tapering INR, ratio 2.34

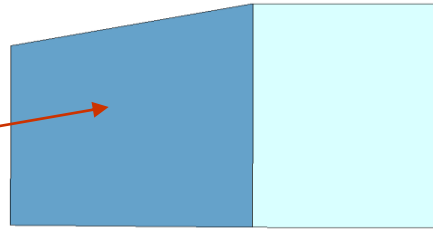
narrow&wide tapering empty WG bad idea 0.88,

Possible candidates

- usual, simpler, lose in results,

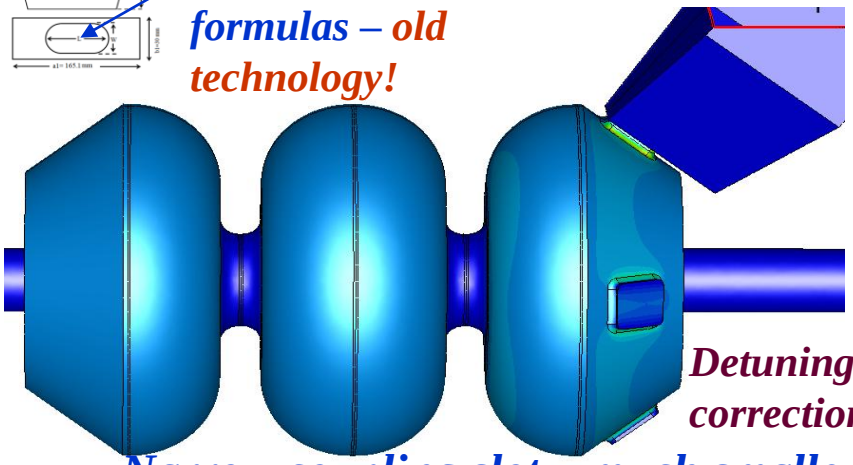


- proposed INR, more complicated in mechanical design, shows better RF results.

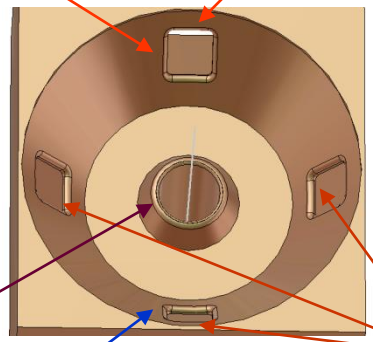


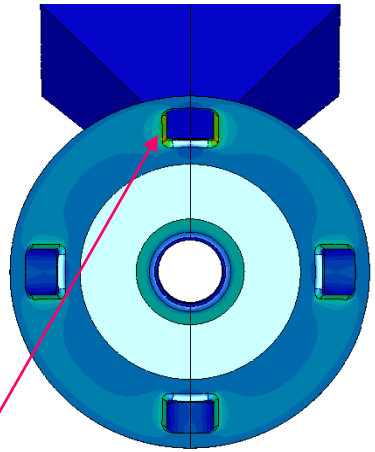
RF coupler results

Oblong slot shape 20x41 mm and Gao formulas – old technology!



29.0 mm *25.75mm*

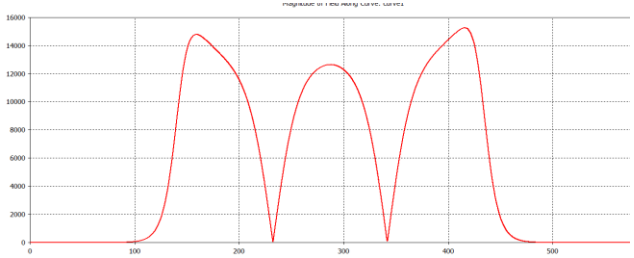


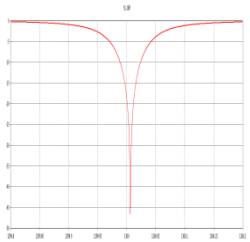


Detuning correction

Preliminary – TBO!!

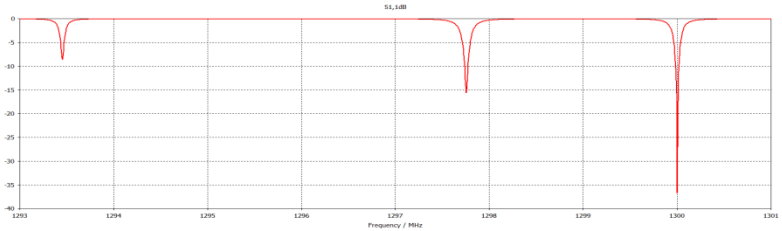
Narrow coupling slot – much smaller field perturbation, hence slot overheating and quad's additions.





Ez(z) distribution – the same.

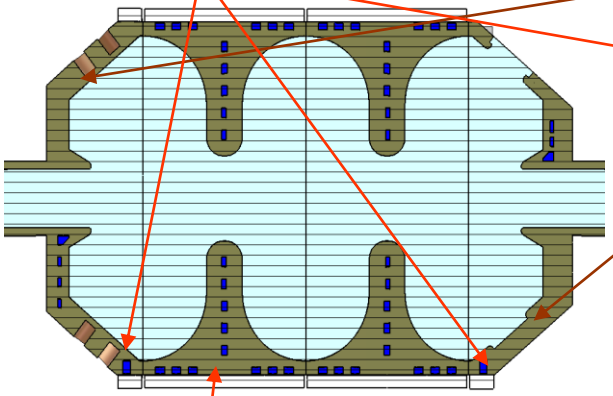
Narrow range matching (for 0.85Q0)

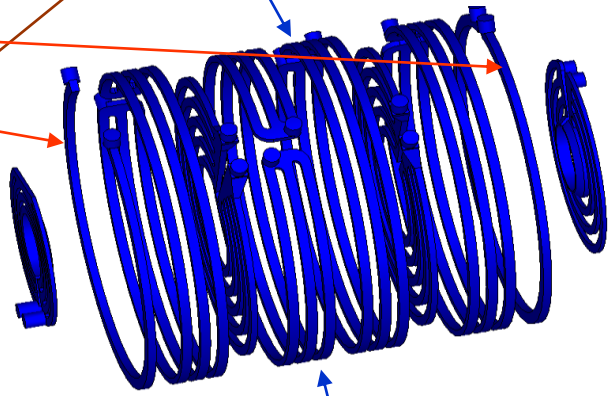


Coupled with all three modes. CW operation!!

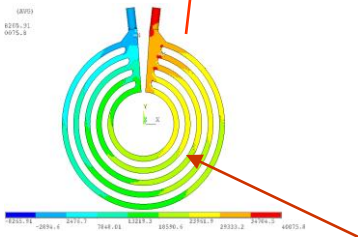
Cooling circuit

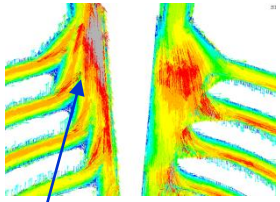
1. Distributed cooling circuit – Gun 5 style.
2. Eight big channels at the distance > 5 mm from RF surface.
3. Natural copper conductivity in conical parts with increased wall thickness.
3. Two intercepting channels.

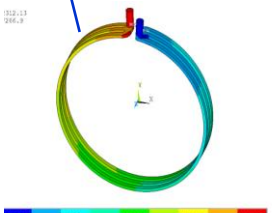




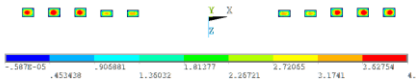
Currently all channels are calibrated (not optimized against vortex) for the same pressure drop 0.4 bar and average flow velocity < 2 m/s. The total water consumption is 1.3 l/s or 4.7 m3/h. Probably, can be reduced (to ~ 3 m3/h) by reducing number of small channels.

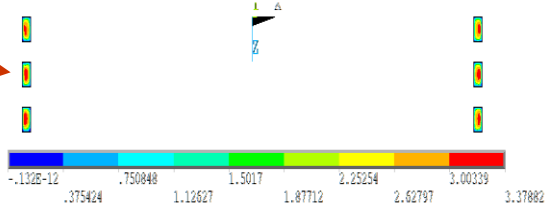






5 or 4 or 3? 3 or 2?

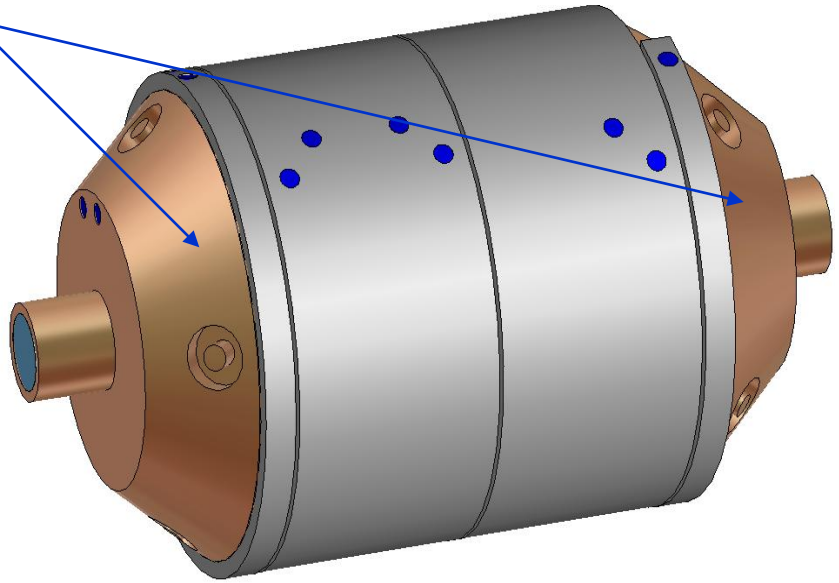


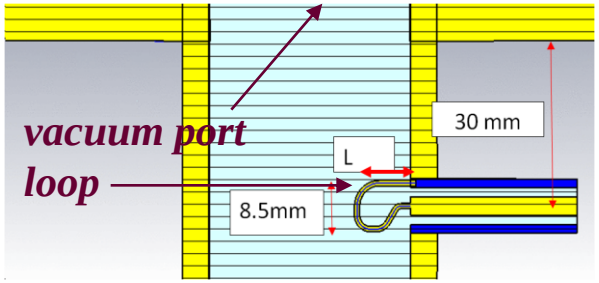


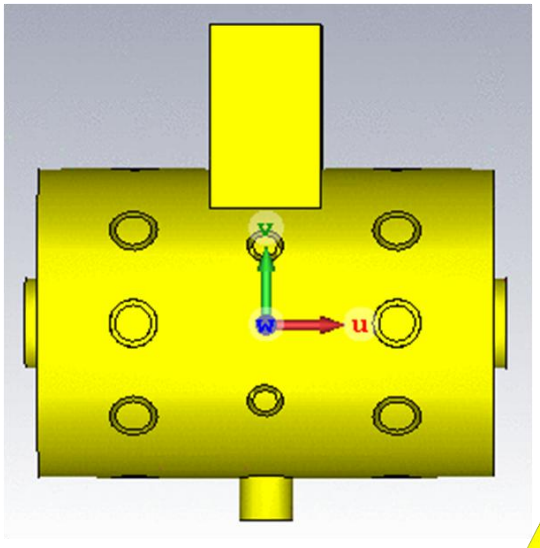
Turbulent flow.

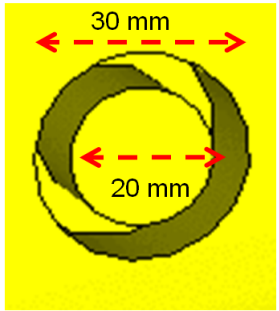
RF probes and RF tuners

Two antenna RF probes – Gun 5 style.
Direct measurements without hesitations.

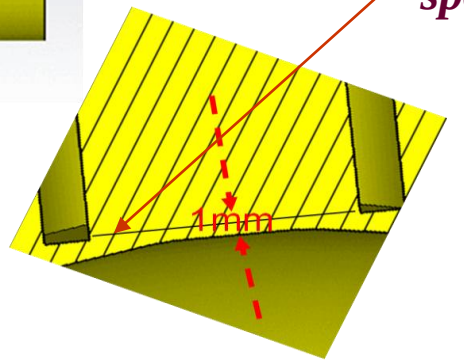




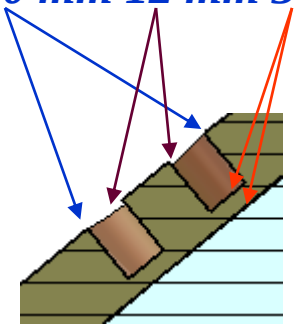




Objection! Plastic deformations! Surface deterioration? Hot spots!

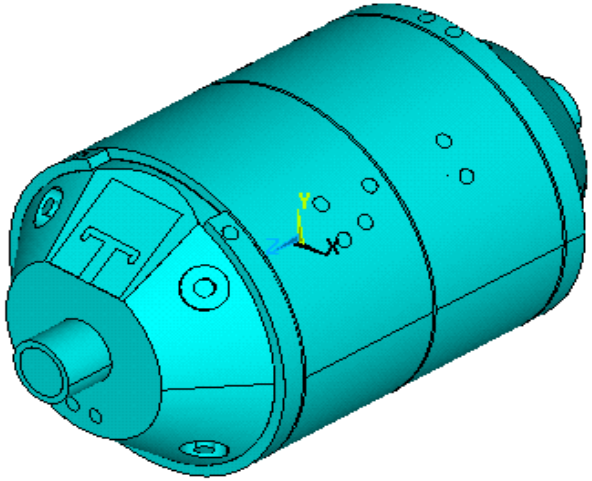


40 mm 12 mm 3 mm

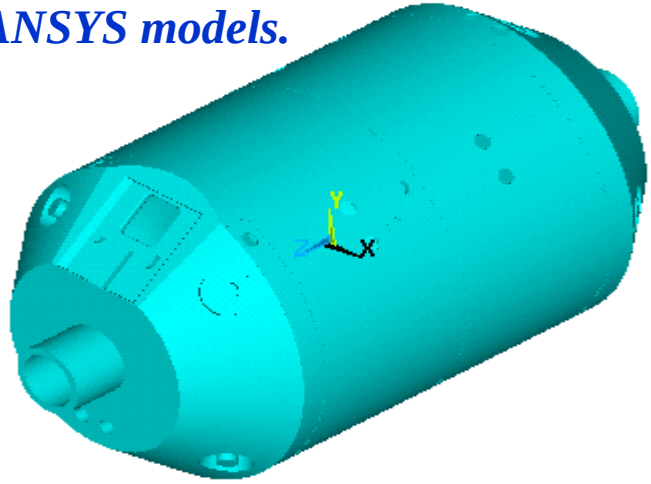


Old release ANSYS 14 is used, DESY should have it. According ANSOFT policy, there is no technical support, but license works.

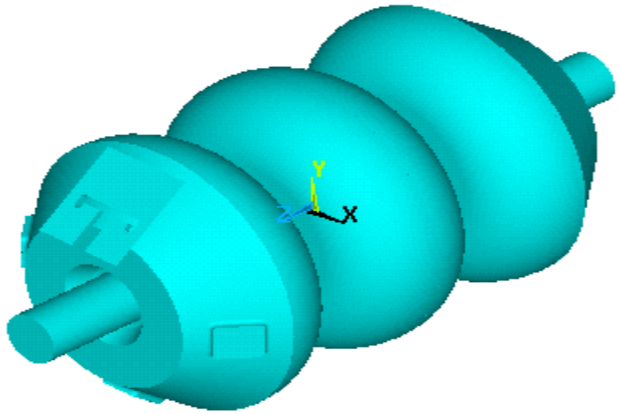
ANSYS models.



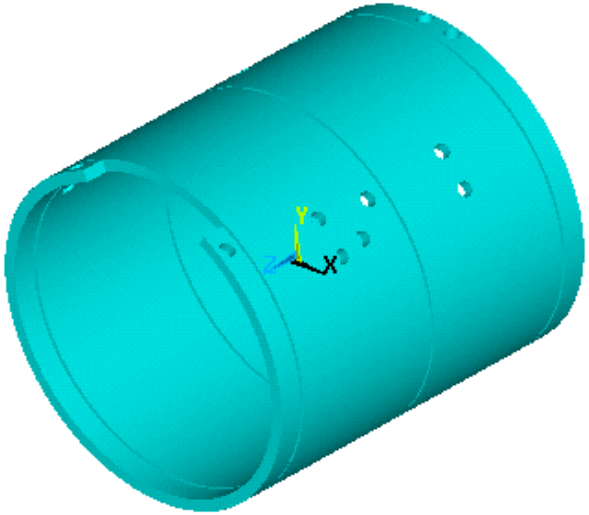
Total model



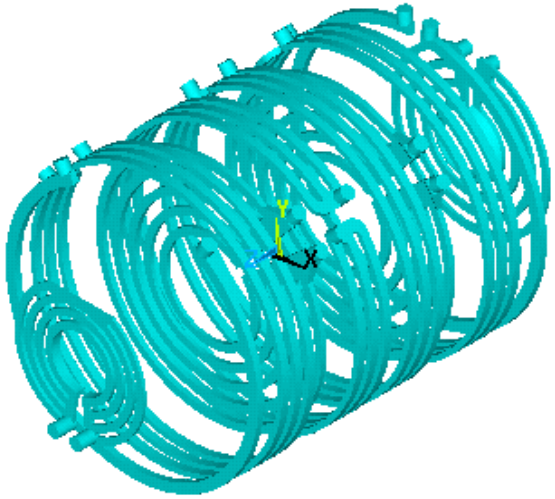
Copper body



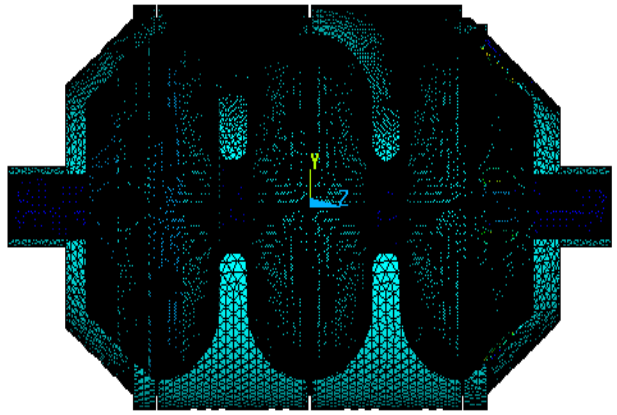
RF volume



Jackets

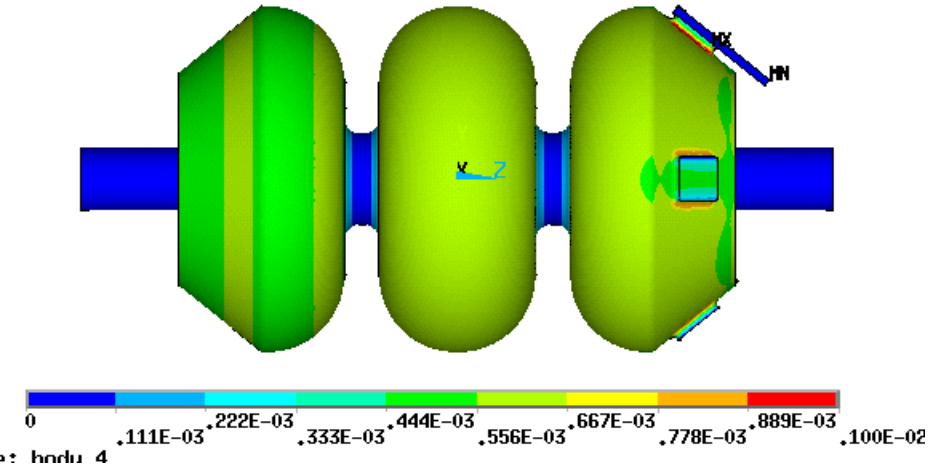


Cooling channels

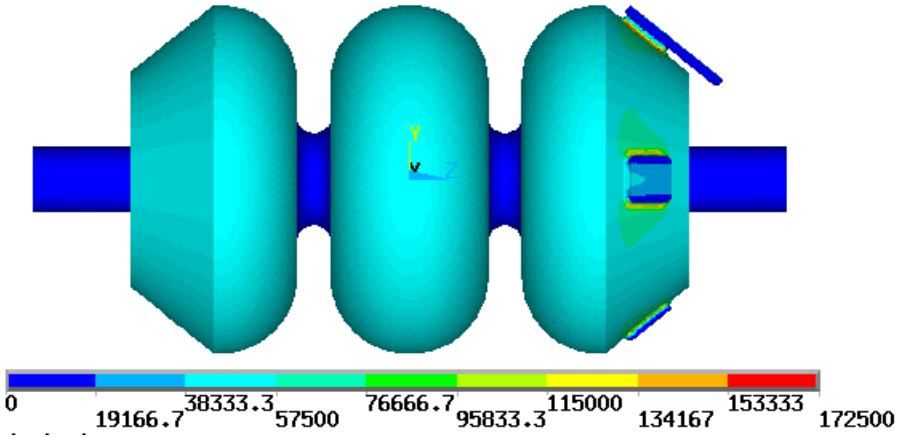


Mesh (15 000 000 points, 10 000 000 elements, average size)

ANSYS RF results (preliminary)

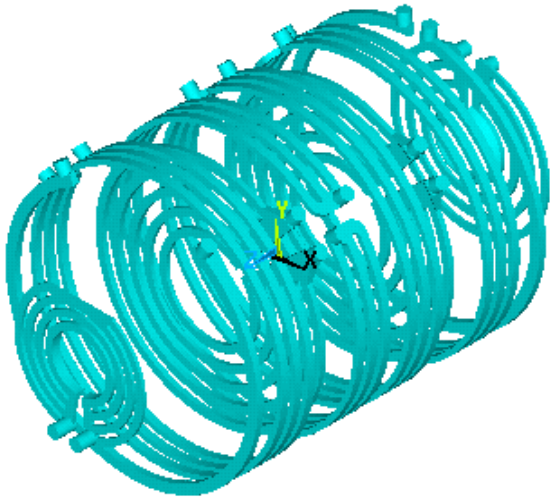


H field distribution



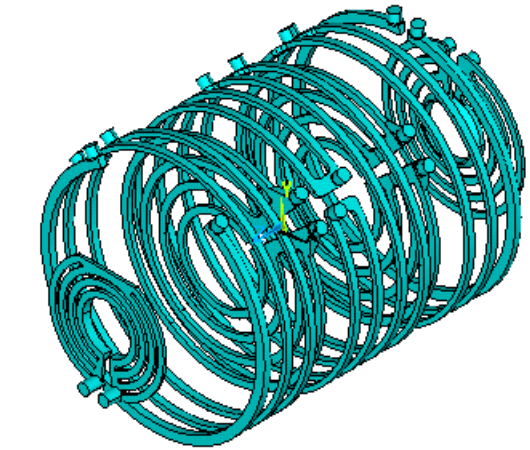
Distribution of RF losses.

Two options of cooling circuit

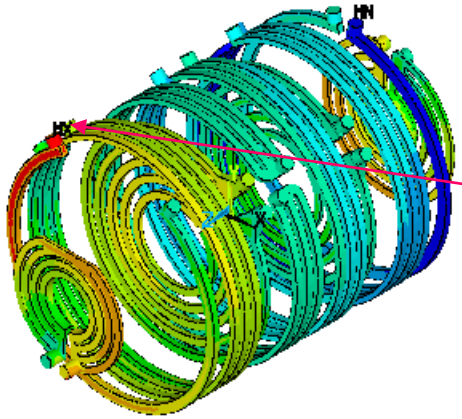


Three subchannels in outer channels and five subchannels in irises

Flow rate 1.29 l/sec or 4.65 m^3/h



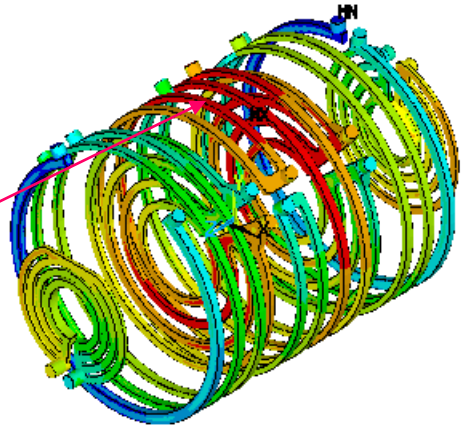
Two subchannels in outer channels and four subchannels in irises
Enlarged intersecting channel.
Flow rate 1.12 l/sec or 4.03 m^3/h



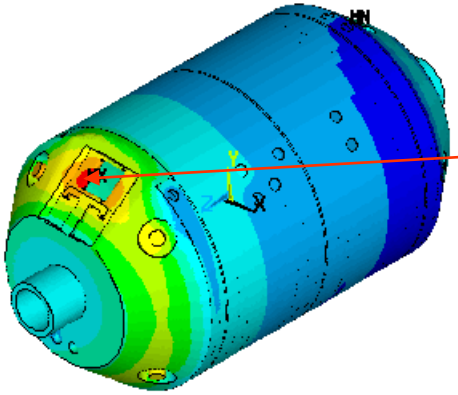
dTmax=

4.66 C^o

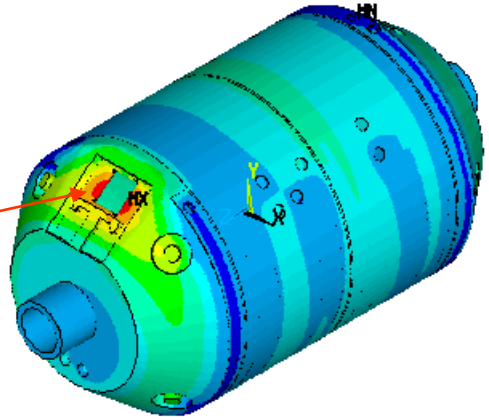
3.9 C^o



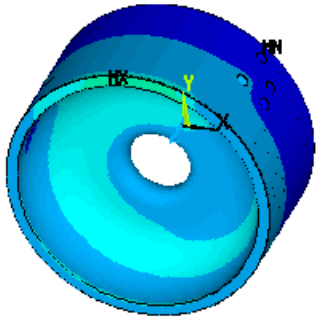
ANSYS results for temperature.

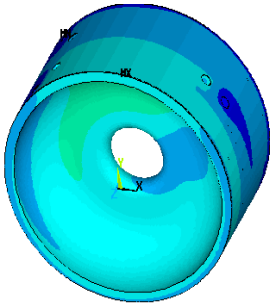


dTmax=
14.93 Co
13.85 Co

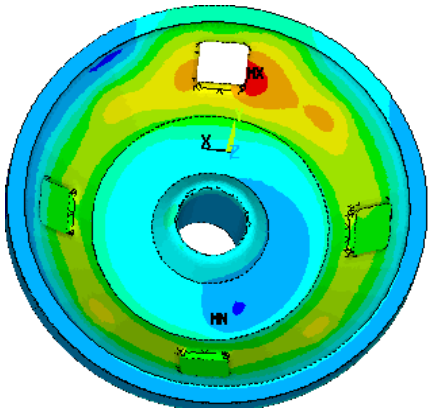


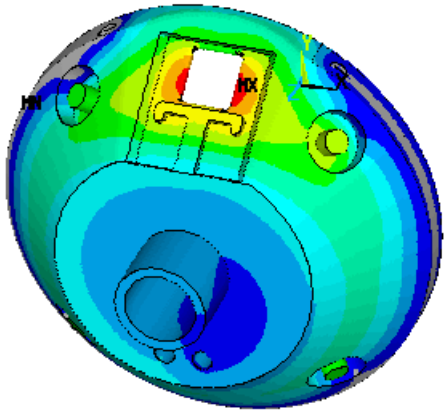
Temperature distribution at outer surface of copper body





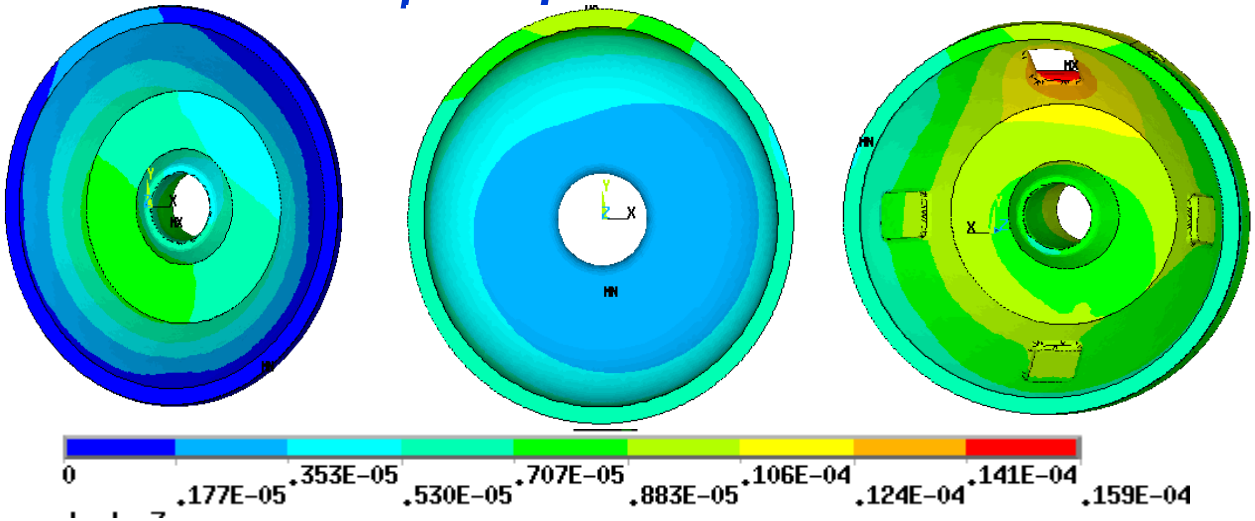
Temperature at irises – well cooled.





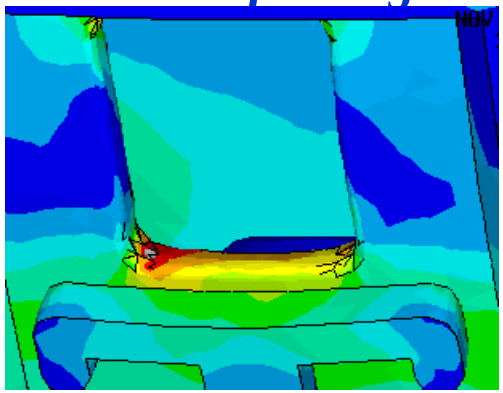
Hot spots are at slot end naturally.
But Tmax~14 Cº, is ***not bad.***
Drift tubes are cold.

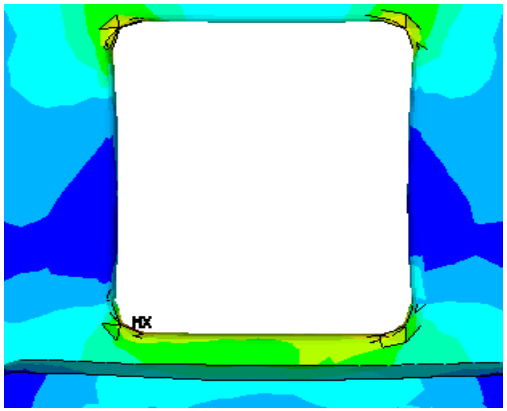
ANSYS results for displacements and stress.



With practical cooling circuit displacements all time have no rotational symmetry.

Stress. Max ~70 MPa – corner of SS jacket,
copper body – max 28 MPa – mainly slot shape sequence. Can be reduced, but leads to chain of changes.





Induced frequency shift is -856 Hz and -791 Hz. Not expected – too small, but why not? Cold design with complicated displacements.

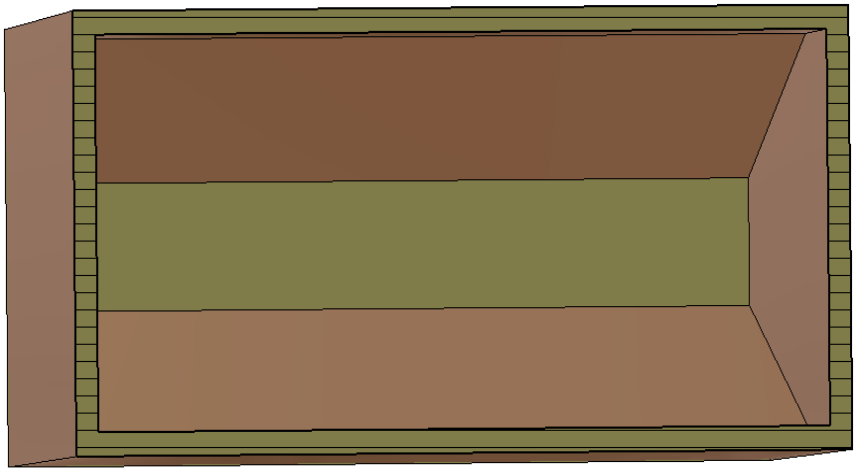
SUMMARY

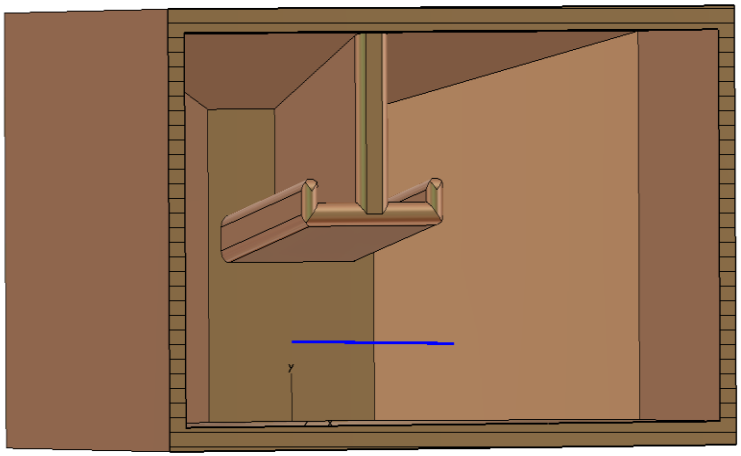
I will not criticize the results of the previous consideration. It were nesessary to understand problems and relationships.
But the first pancake is always lumpy and the first attempt is usually far from the final solution. As a result of critical analysis, we propose more balanced solution that includes the elements most suitable for the given task.
This proposal contains physical ideas and based on these ideas, this option will always override competitors in terms of a set of parameters.
This proposal is not completed and some points are open – multipactoring, quad addition compensation, tolerances, channels optimization and probably something else.
We suggest this proposal for further development in frame of collaboration. It is also the chance to learn our advanced technology of simulations and developments.
Details I have to discuss with Frank and Houjun.
Presentation on PITZ collaboration meeting?

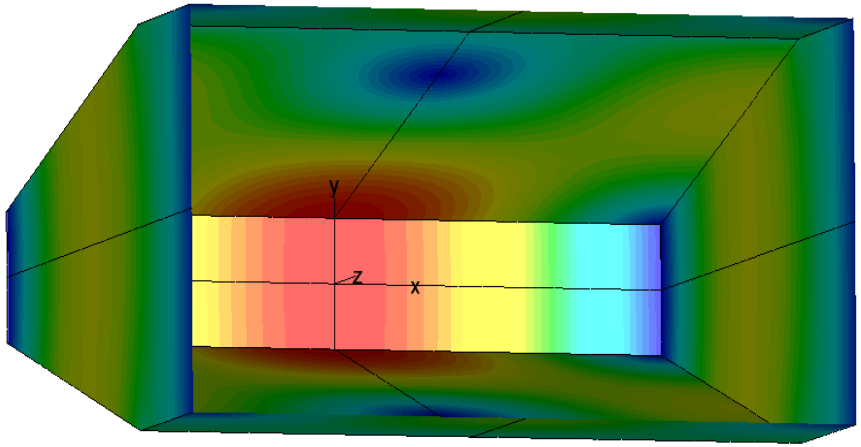
Valentin Paramonov,

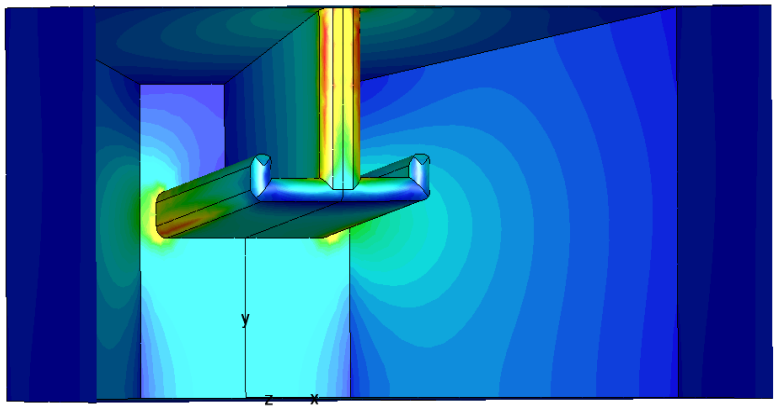
INR, Moscow, Russia

Why the WG tapering in both directions wors well in INR propsal?





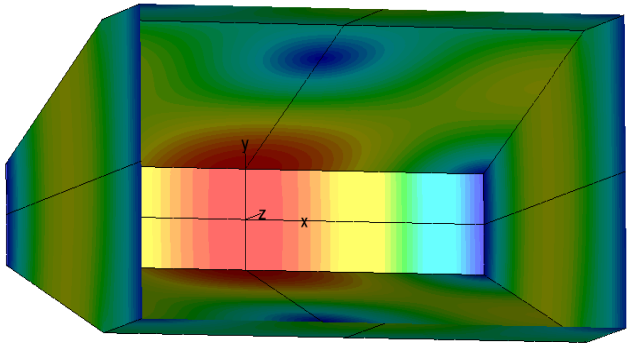


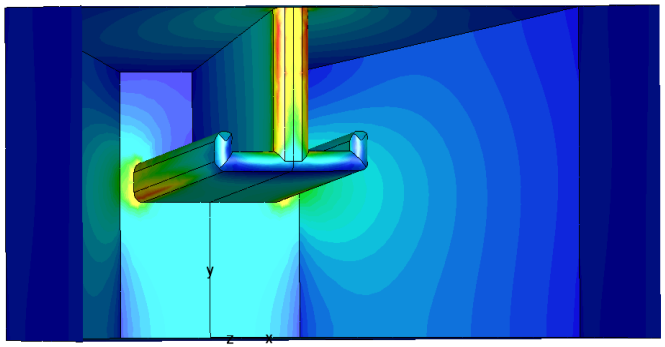


Because we keep the local cut off frequency constant.

There was my attempt to explain, why tapering in two directions in hollow WG results in field reduction.

Possible options of WG coupler.





Option 1	*Option 2*
a) simpler in construction	*more complicated, two steps . of brazing,*
..	
b) tolarances - similar for both options	
c) essentially lower field enhan cement	*higher field enhancement*
d) cooling problem –	*abcent for both options*
e) bigger slot opening	*smaller slot opening*
f) much stronger overheating of slot edges	*smaller overheating of slots*
g) bigger filed perturbation	*smaller field perturvation*
h) space conflict wit 4 tuners	*allows 4 tuners*
i) not comfortable for 3 cells	*higher performances for 3 cells*
j) reasonable for 2 cells	*exdtra for 2 cells*
k) something else?	