

# INPUT COUPLER DEVELOPMENT FOR SUPERCONDUCTING CAVITY 500kW CW POWER FEED

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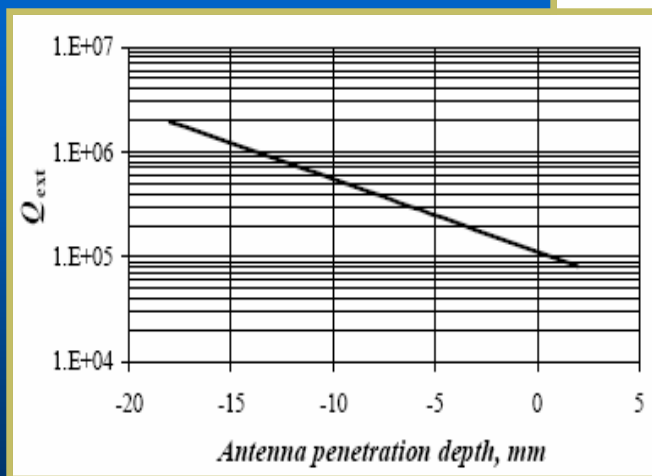
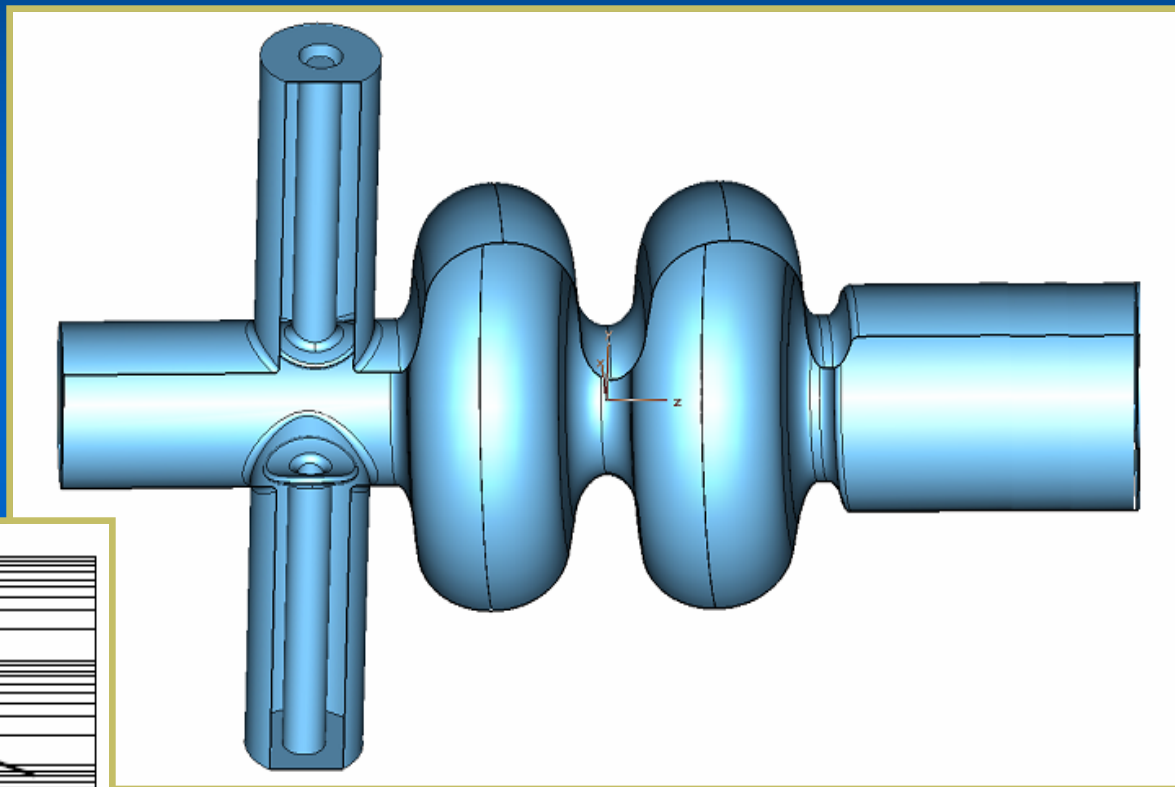
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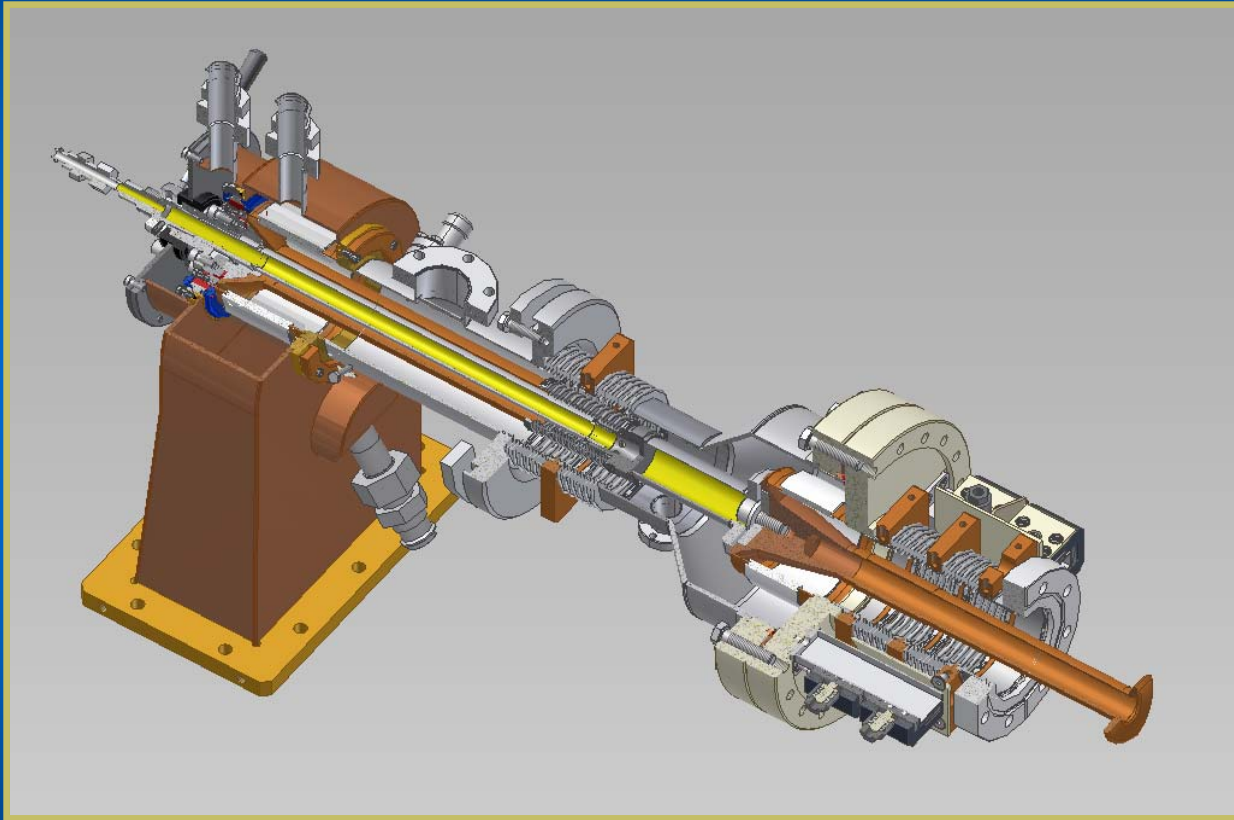


# MWS<sup>®</sup> MODEL OF THE TWIN COAXIAL INPUT COUPLER AT 1.3 GHz FOR ERL INJECTOR



The coupler has a variable coupling from  $10^4$  to  $10^5$  dependant of the penetration of the antenna tip into the the cavity beam pipe.

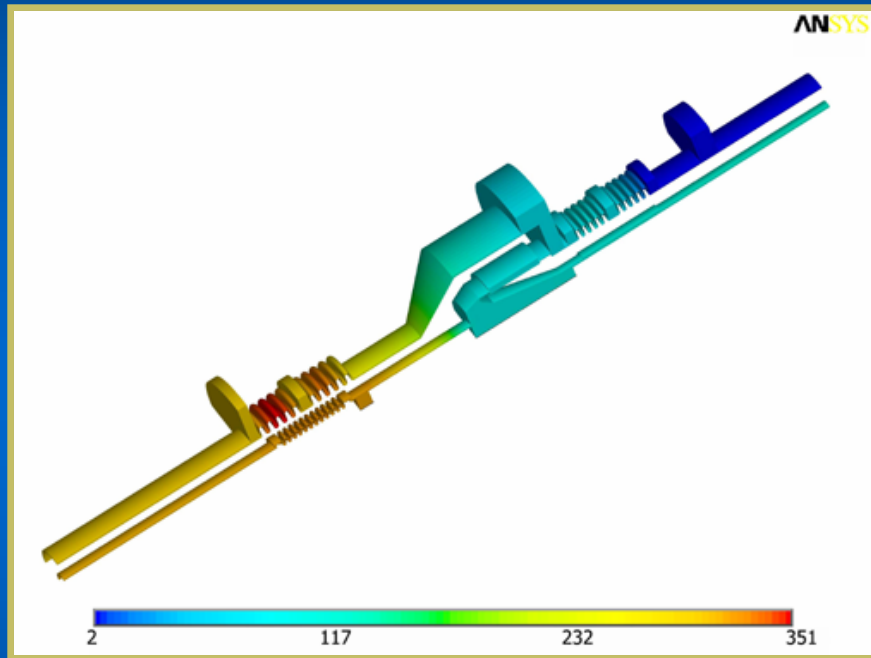
# EXISTING COAXIAL INPUT COUPLER AUTODESK INVENTOR® MODEL



The complete set of technical documentation for coupler production was also made.

# EXISTING COUPLER DESIGN FOR 75 kW CW TRANSFERRED POWER

## Temperature map



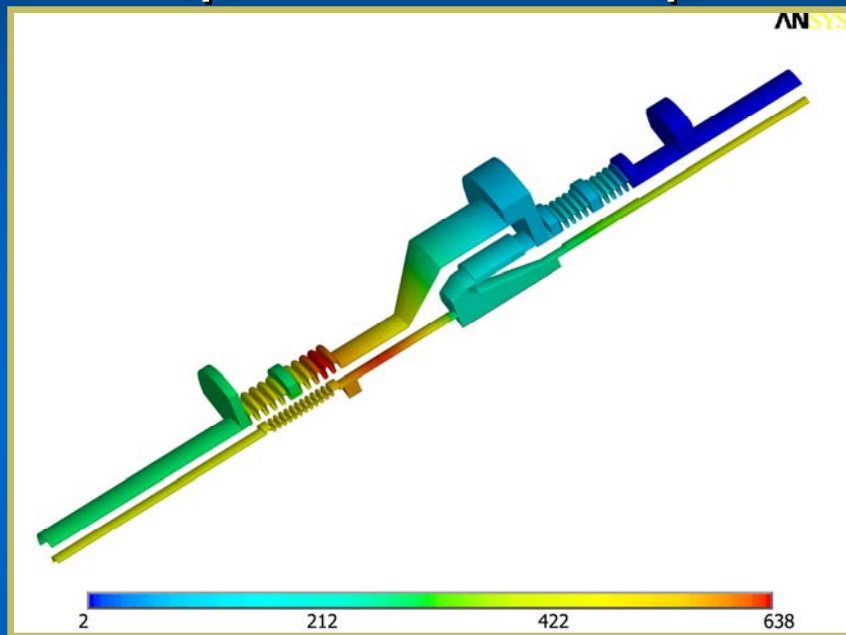
## Heat loads

Helium, 2 K	0.23 W
Helium, 4.2 K	2.4 W
Nitrogen, 80 K	74.6 W

Simulations was done by ANSYS. ANSYS macros custom routines was developed to solve this task. This routines allow to solve coupled electrodynamical – thermal tasks. Material properties temperature dependences were taken into account. Such as resistance, thermal conductivity, specific heat and film coefficient.

# EXISTING COUPLER DESIGN FOR 250 kW CW TRANSFERRED POWER

## Temperature map



## Heat loads

Helium, 2 K	0.65 W
Helium, 4.2 K	6.6 W
Nitrogen, 80 K	355.0 W

The next stage of this work was to increase transmitted power to 500 kW. The existing coaxial

input coupler design has physical limits. It is seen that the bellows especially the "warm" ones have the excessive temperature. The long bellows having rather thin walls could hardly provide sufficient heat flow and it causes insufficient bellows middle area cooling.

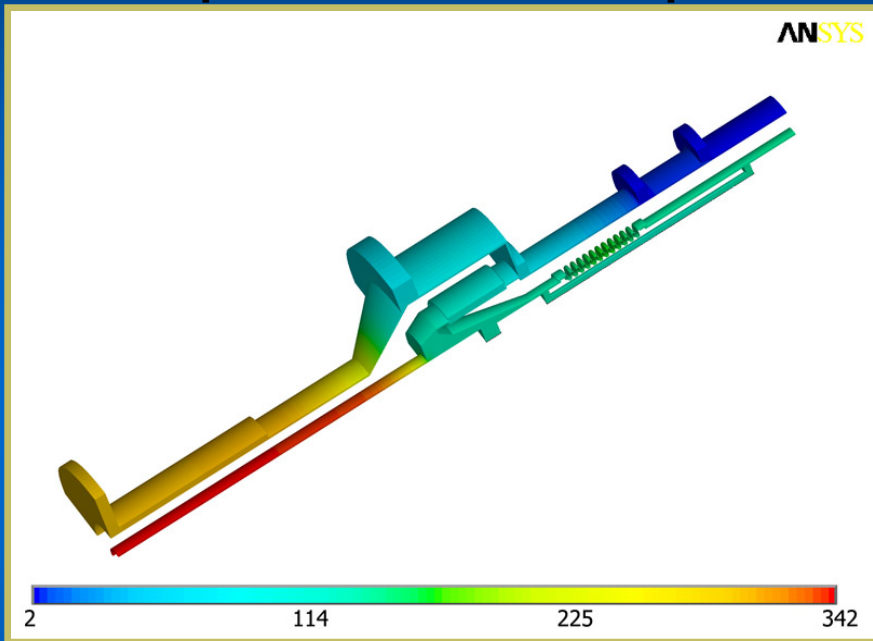
Moreover both the heat conductivity is reduced and the copper resistance increased with temperature growth thus leading to the extra heat generation. At this power level the antenna tip temperature also rises. This could lead to heat flow to cavity cryogenic zone growth due to infrared radiation from antenna tip. Table shows heat loads to different cryogenic zones. The bellows overheating could be avoided by another (third) outer bellows added in design as nitrogen-cooled heat sink. But this leads to more complex design. The antenna tip heating could be diminished by making its shaft solid or at least tube shaped with thick walls. As the side effect this will increase the antenna weight and the extra stress to the ceramics appear.

As the result the maximal transferred power for the existing coupler design is limited to 300 kW.

# SINGLE BELLOWS COUPLER DESIGN FOR 250 kW CW TRANSFERRED POWER

Temperature map

Heat loads

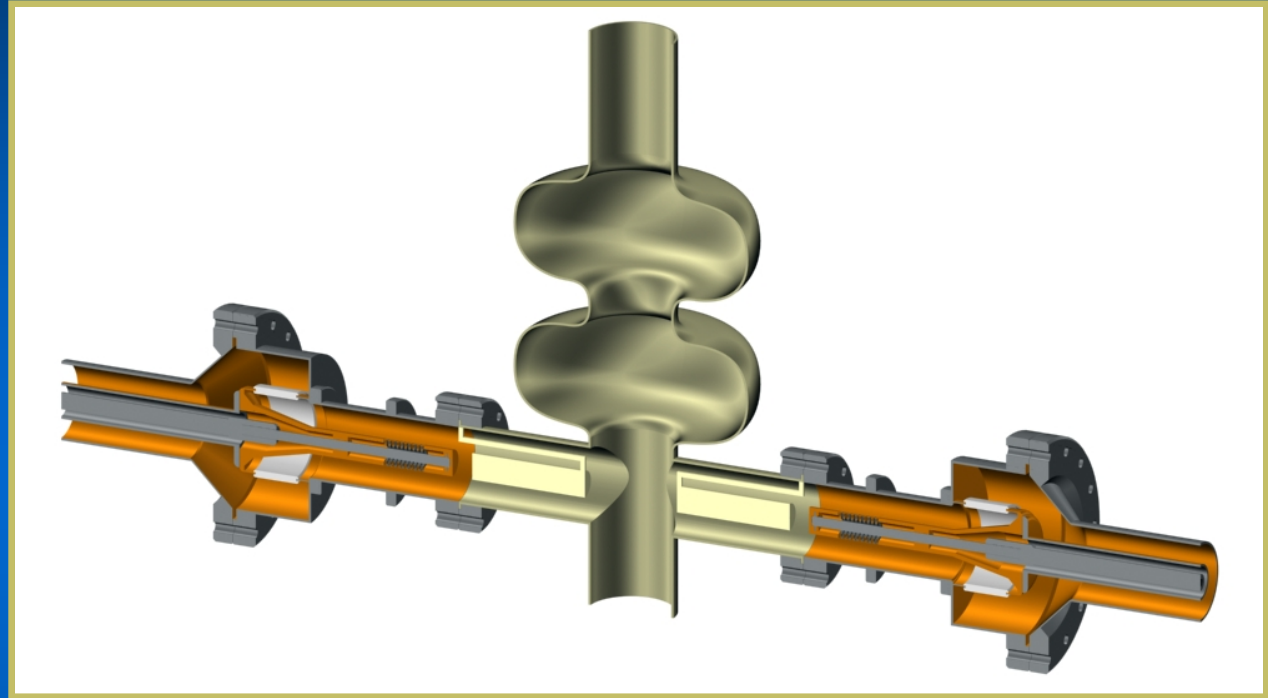


Helium, 2 K	0.55 W
Helium, 4.2 K	9.6 W
Nitrogen, 80 K	178.7 W

With transmitted power increase the bellows became the performance limiting elements. Nevertheless they could not be excluded from the design because the antenna tip must be movable to provide the external quality factor tuning. The single bellows design is proposed as the optimal way to overcome the problems specified.

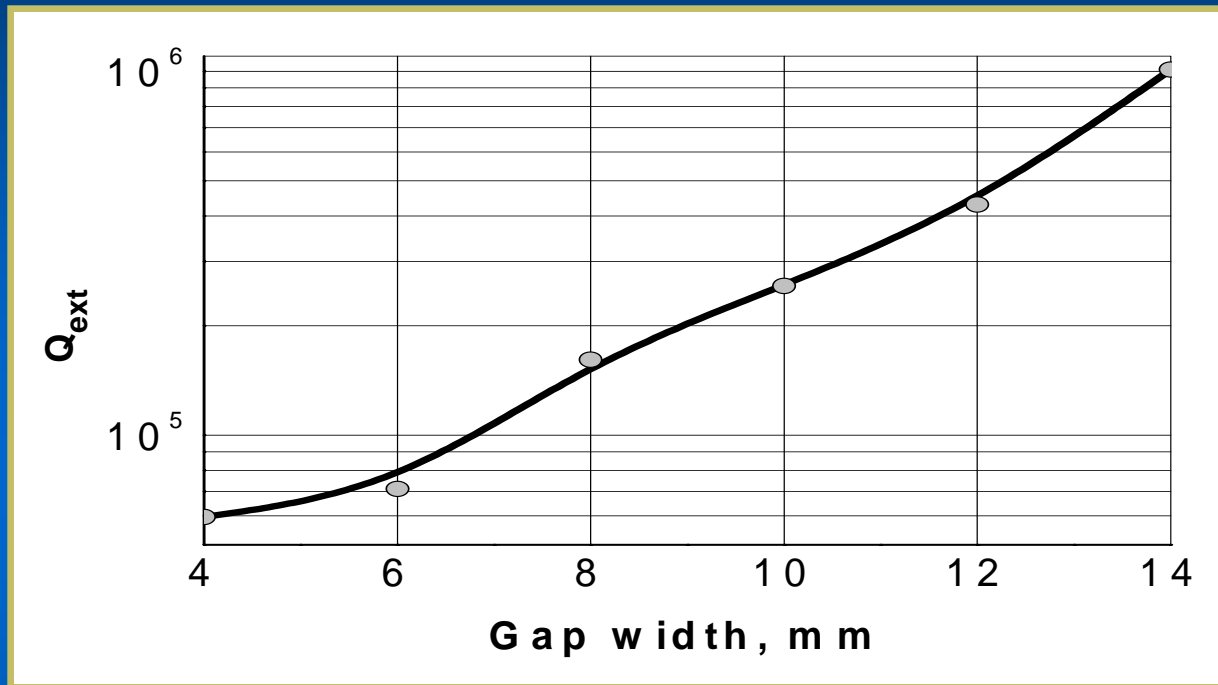
It is based on the similar one evaluated earlier as concept for TESLA coupler. The only bellows is located in inner conductor in "cold" area. This coupler bellows is to be liquid or gas nitrogen cooled during the operation. The other way to decrease bellows temperature is to split it with additional heatsink added in between. Also, as a possible way to decrease bellows heat losses is to use shorter bellows. But there are strict requirements for external quality adjustment and therefore antenna movement range. It must be about 15 mm. To shorten bellows one must reduce antenna movement range. For this antenna design must be changed.

# LOOP-CAPACITIVE COUPLER CONCEPTUAL DESIGN



External quality factor value is adjusted by capacitive gap between inner conductor and antenna tip variation. The most preferable way is to use superconducting antenna. It can be made of bulk niobium, or niobium plated stainless steel. This leads to considerable reduction of heat loads to helium area. The overall inner conductor length is reduced by antenna tip separation. So the heat flow to nitrogen cryogenic zone and ceramic window mechanical stress will be reduced.

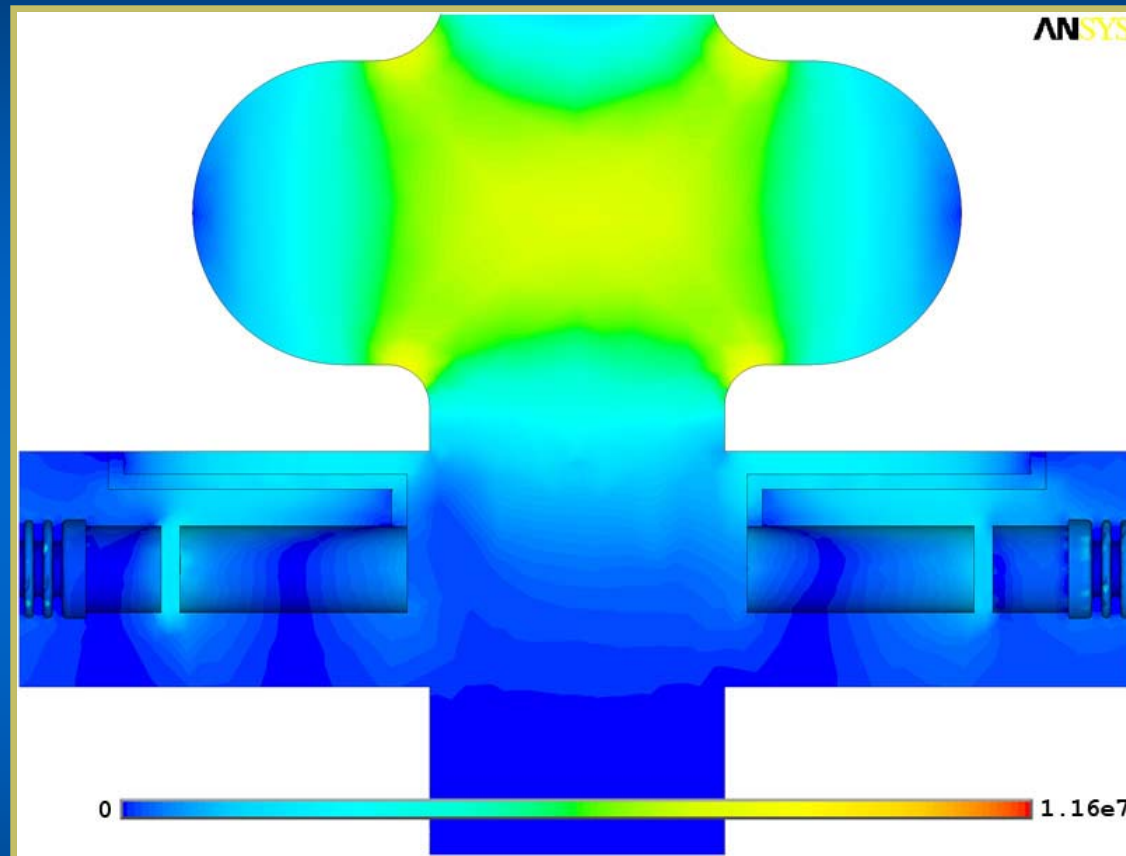
# DEPENDENCE OF $Q_{EXT}$ OF A TWIN COUPLER ON THE GAP WIDTH



The coupler electrodynamical simulation and optimization were done using HFSS code. The external quality factor dependence on gap width is presented on picture. As it could be seen the external quality factor ten times variation is achieved with 10 mm gap width change rather 15 mm in existing design. So the bellows could be made 30 percent shorter. The latter value could be lowered with antenna of modified shape.



# COUPLER TO CAVITY TRANSITION ELECTRIC FIELD DISTRIBUTION

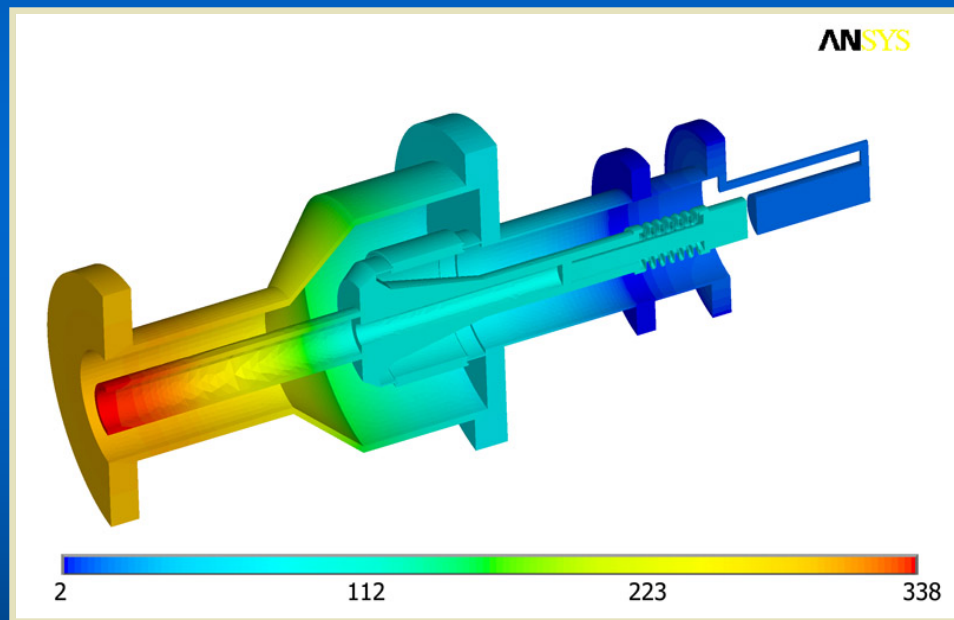


Picture shows the electric fields distribution in coupler to cavity transition area. Field strength in antenna part could be lowered by the holder shape optimization. The design with holder connected directly to cavity instead of the flange is possible.

# LOOP-CAPACITIVE COUPLER FOR 250 kW CW TRANSFERRED POWER

Temperature map

Heat loads



Helium, 2 K	0.79 W
Helium, 4.2 K	10.6 W
Nitrogen, 80 K	119.8 W

This design is very promising for further development.