COMSOL Multiphysics® Application to Open Up a New Way of Cooling Superconducting RF Cavities

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INTRODUCTION: A possibility to cool-down an SRF cavity by a 2W cryo-cooler is investigated. The required values of contact resistance are found.

COMPUTATIONAL METHODS: Superconducting cavity is excited by RF field which causes losses. Eigenmode solver of Radio-Frequency module is used in order to find the power density which is applied in Heat Transfer module for temperature simulation of the cavity.

1-st Generation Design

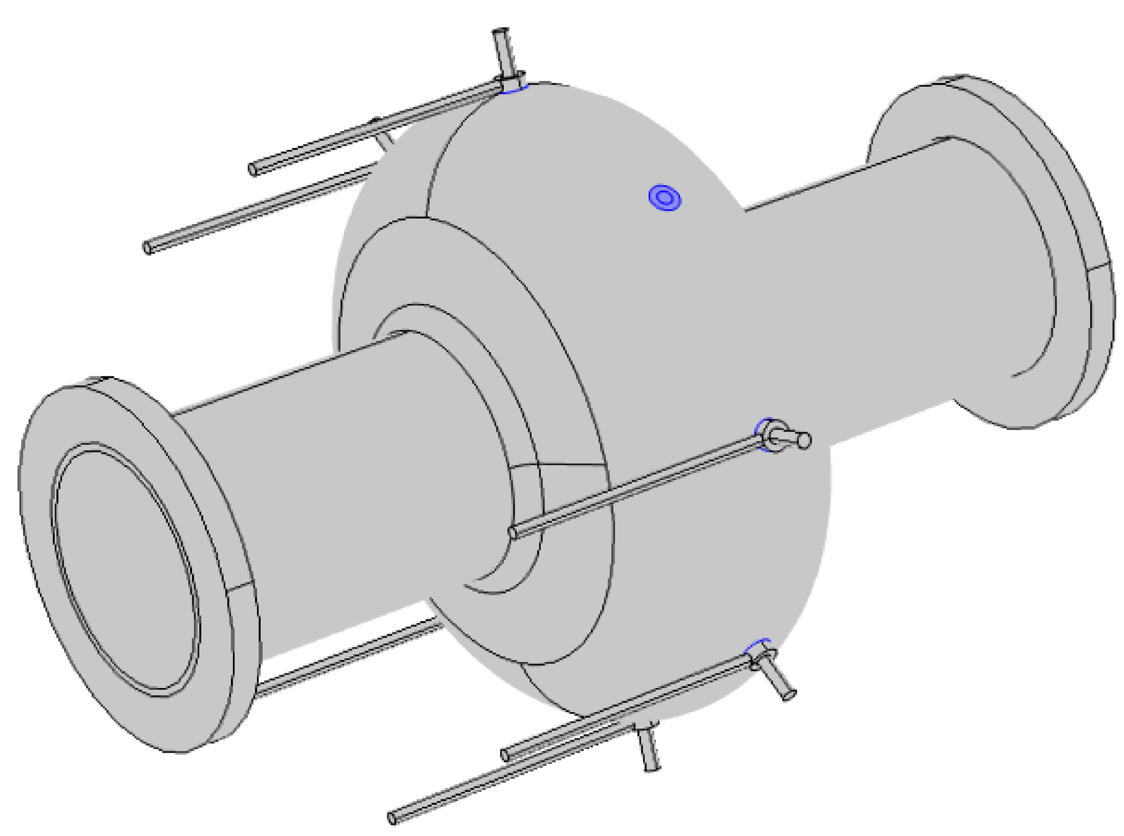

Figure 1. Single cell cavity 3D model with cooling studs on the equator.

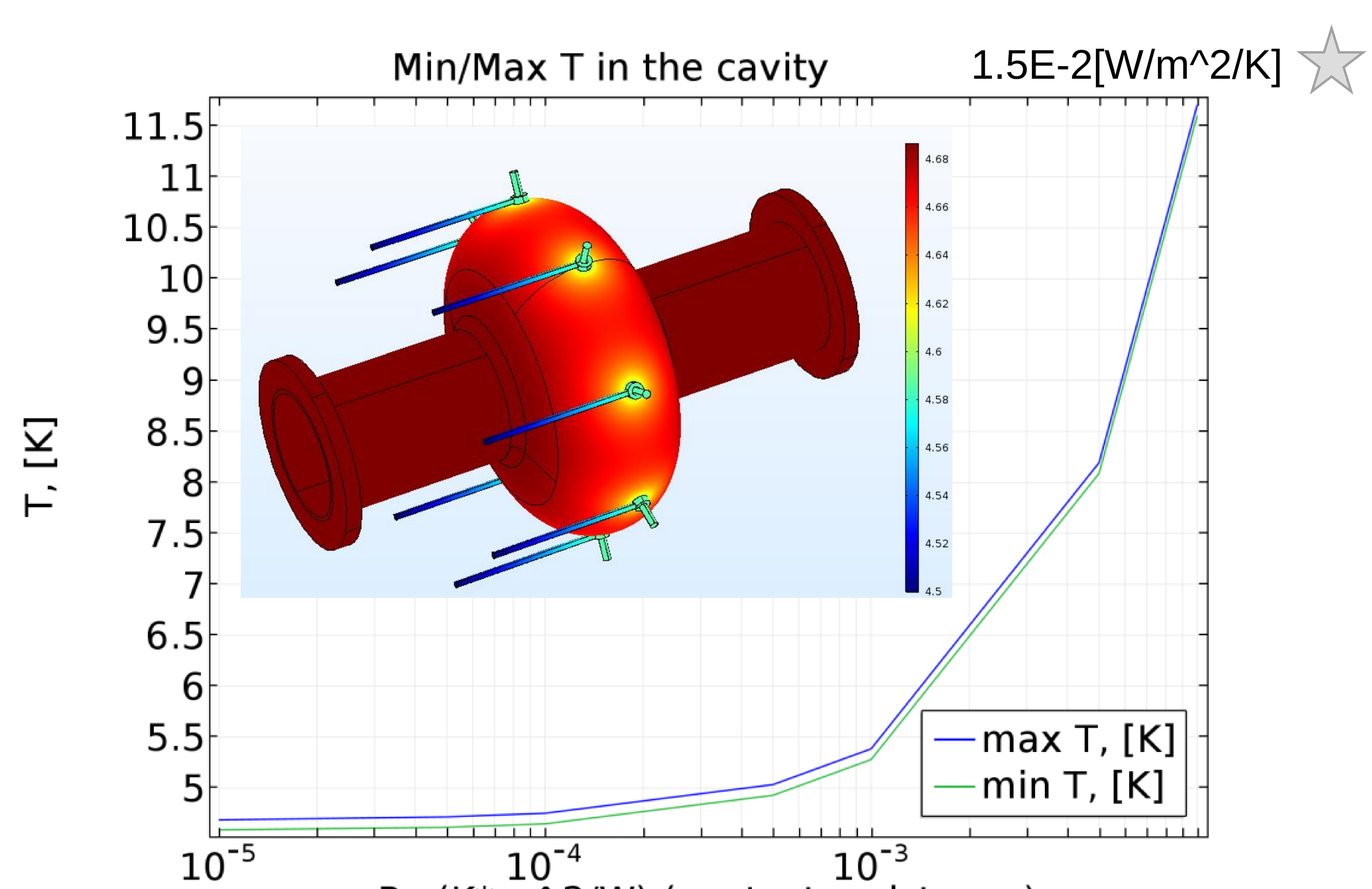

Figure 2. Temperature distribution as a function of contact resistance

2-nd Generation Design

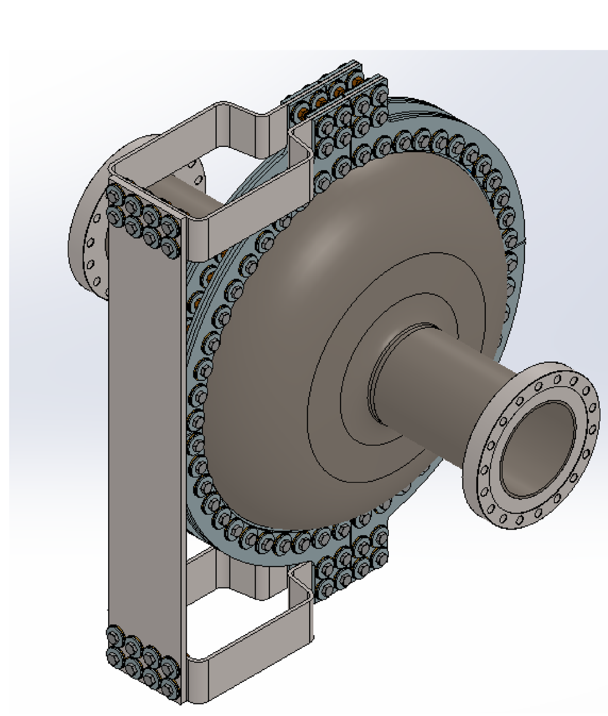

Figure 3. Mechanical model of conduction cooled cavity.

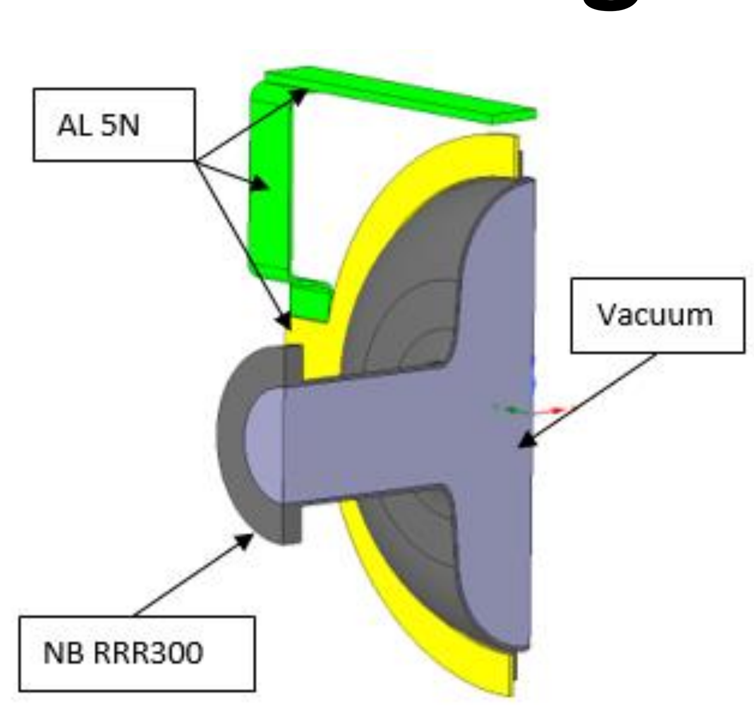

Figure 4. Simplified FEA model of conduction cooled cavity.

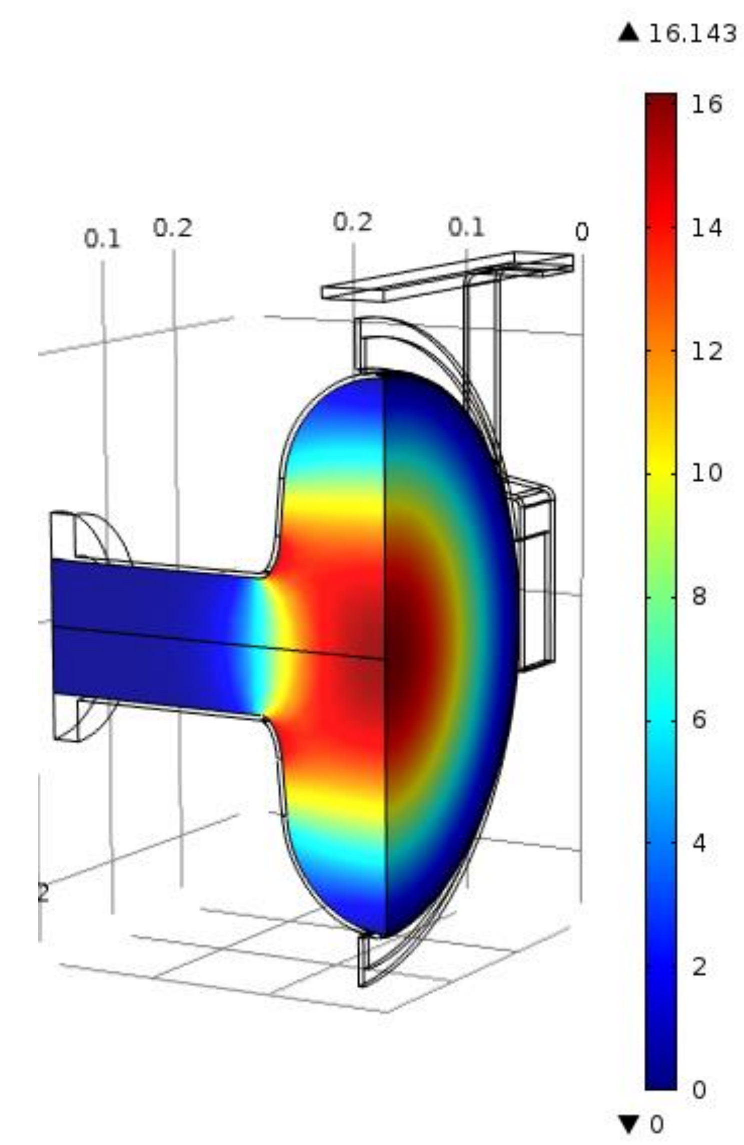

Figure 5. E field distribution

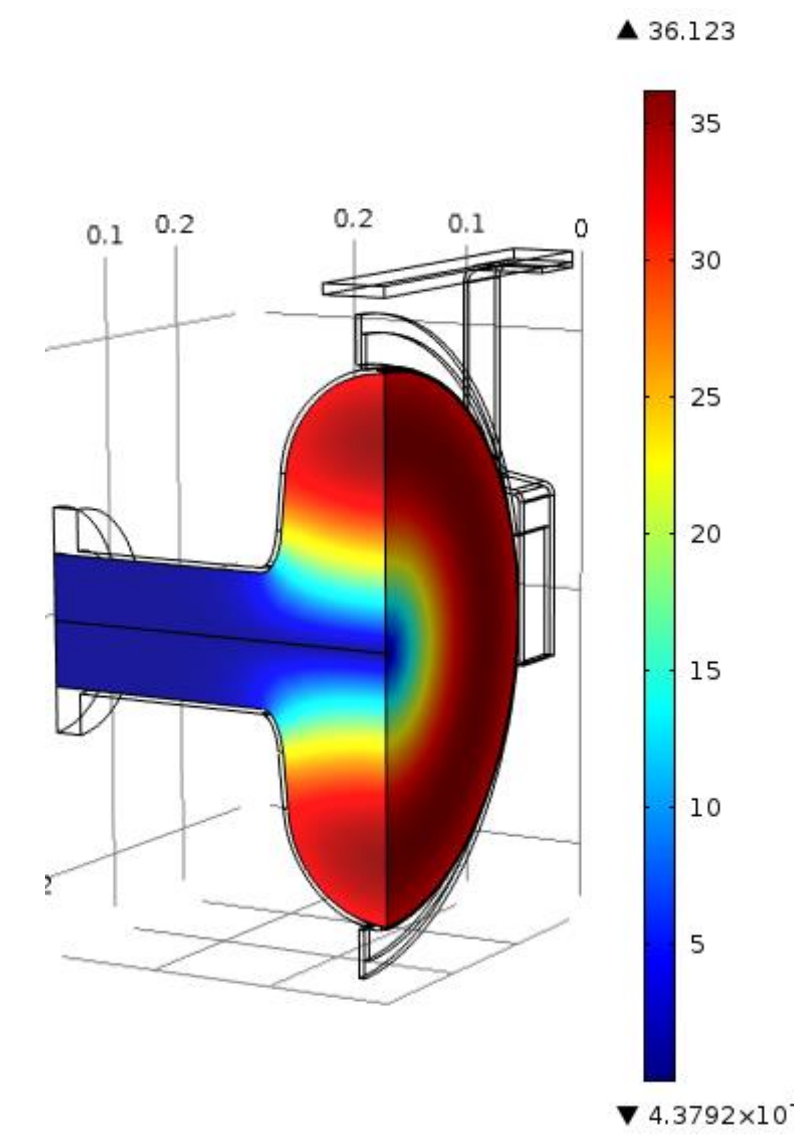

Figure 6. B field distribution

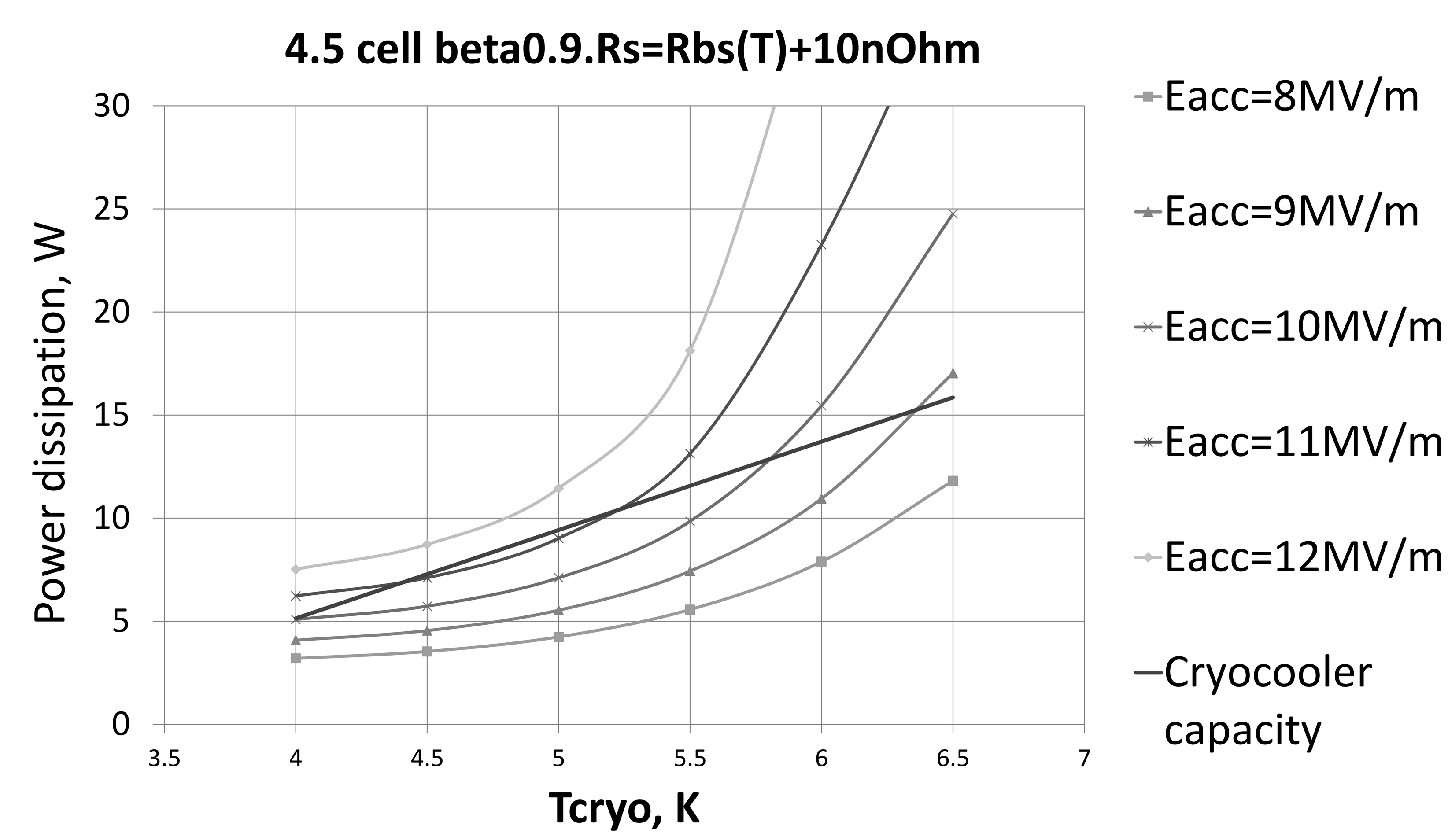

Figure 7. Dissipated power in 4.5cell beta 0.9 cavity and cryocooler capacity as a function of temperature.

CONCLUSIONS: The maximum value of thermal contact resistance of Rc=1.5E-2[m2K/W] was not sufficient to cool down an SRF cavity. A new design (2-nd generation) was proposed which showed much better performance. Contact resistance was reduced 2 orders of magnitude. COMSOL Multiphysics simulations were performed to find stable operation regimes (see fig. 7). The simulations conform very well with experimental results. These finding opened a way for industrial application of SRF.

Industrial Application

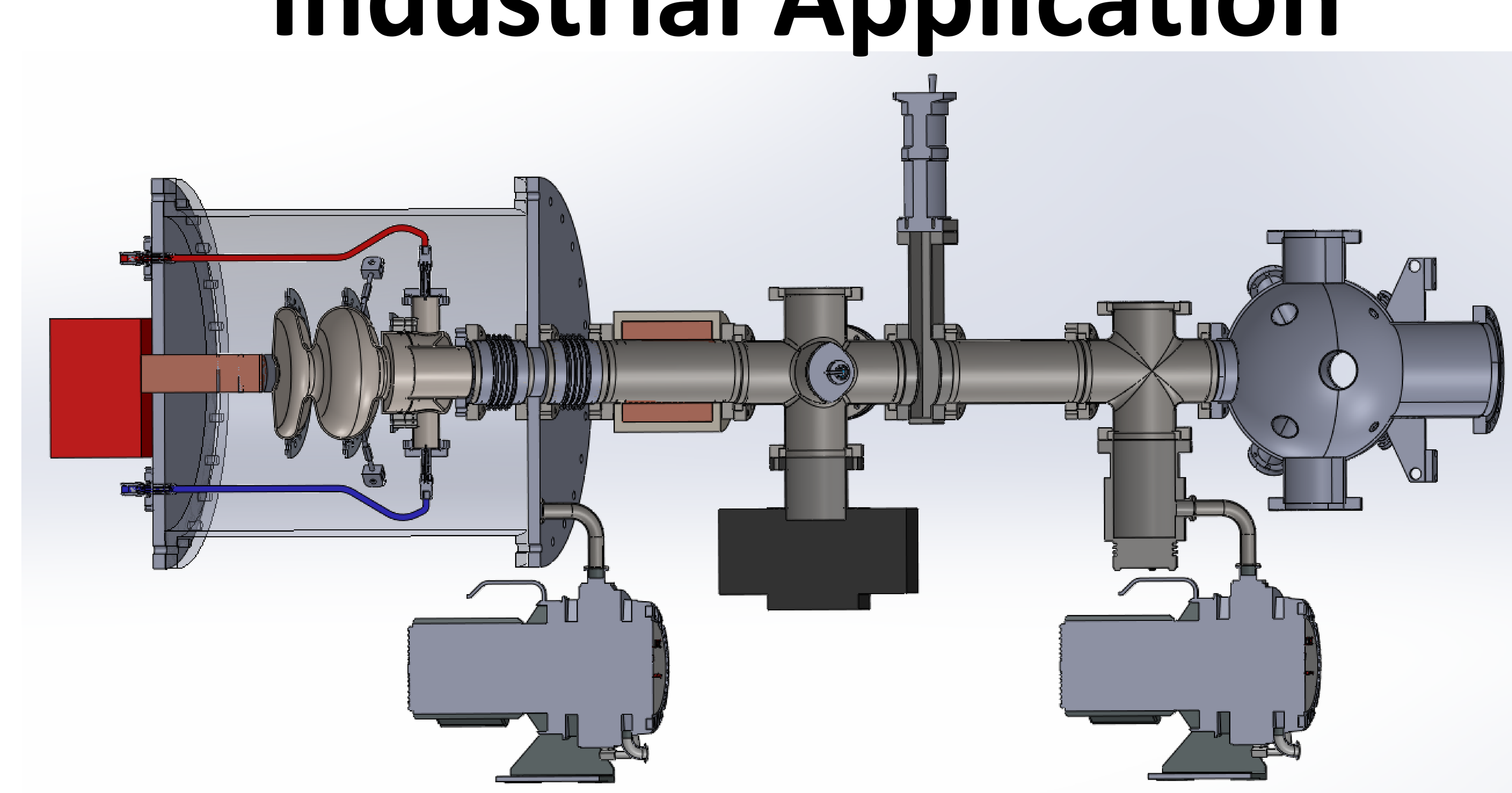

Figure 8. Current Euclid Beamlabs project: Conduction cooled SRF gun for UED/UEM, **phase II grant by DOE #DE-SC0018621**

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