HOW TO ELIMINATE A COPPER COATING AND TO INCREASE AN AVERAGE POWER OF MAIN COUPLER*

S. Kazakov, FNAL, Batavia, IL 60510, USA

Abstract

Idea how to avoid a cooper coating and increase an average power of main coupler by using RF shield is described. RF shield decreases magnetic field at outer wall of coupler, which is connected directly to low temperature superconductive (SC) cavity. Shield has thermal contact with coupler at only one point at 80K, and all RF losses on the shield walls are translated to 80K. Cryogenic losses in the outer wall of a coupler become so small, that there is no need to coat a stainless steel by copper. It decreases a static cryogenic losses as well, simplify technology and promises to make coupler more reliable. More than this, some presented geometries have zero magnetic field around low temperature aria (2K–5K). We can say that coupler "has no dynamic loss" at all.

INTRODUCTION

Main couplers for SC cavities of relatively high average power require special measures to decries a power flow from coupler to low temperature cavity. Among them it is thin copper coating of stainless steel parts. Copper coating is not simple operations and includes several stages. Mechanical and electrical quality of coating does not always satisfy requirements and it causes a malfunction of SC cavity operation. In this paper a new approach is considered, which allows to avoid copper coating and to keep RF cryogenic loss at low level. Calculations show that new couplers have even better thermal properties then coupler with copper coating.

Idea is to use RF shield with good electrical and thermal conductivity which reduces or eliminates fields at coupler stainless steel wall in low temperature aria (2K-5K). At the same tame RF shield has now thermal contact around low temperature, and RF losses are translated to higher temperature (80K) interception.

COUPLERS WITH RF SHIELDING

Simple Sraight Shield

Simple RF shield is presented in Fig. 1. It is an additional copper pipe with thin wall and outer radius slightly less than radius of outer coupler conductor. At one end the copper piper has thermal and electrical contact with stainless tube. Length of copper tube is half of wavelength and it forms slots with the same length. Simulations show that this configuration has no reflection at operating frequency. Maximum fields in slot are the same as in coaxial before and after slot. But in coaxial we have travelling wave and standing wave in slot. By this the RF losses in slot outer wall is twice less then loss in the same wall in coaxial without slot. But real gain can be much more if low temperature area is placed near minimum of magnetic field. In this case the losses in low temperature area, which are most critica, become small. Figure 2 explains this approach. Tables 1 and 2 demonstrate thermal properties of conventional 650 MHz coaxial coupler coated by 10 micron copper and thermal property of coupler with RF shield and without copper coating. One can see that coupler with RF shield has even better thermal characteristics.

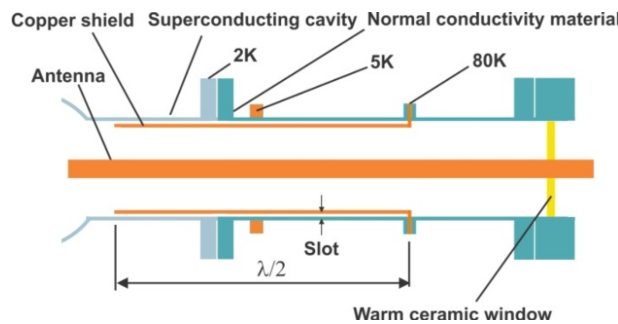

Figure 1: Simple RF shield: l/2λ copper pipe with single mechanical-thermal contact with stainless steel outer pipe.

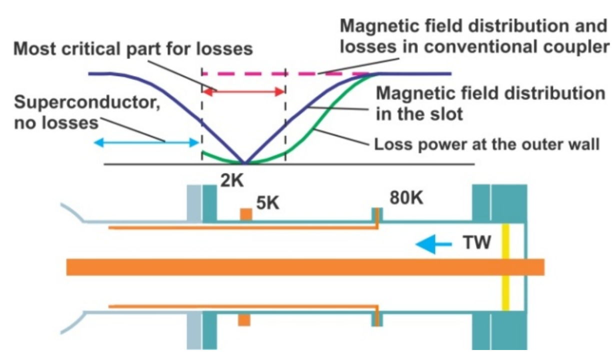

Figure 2: Gain can be much more if low temperature area is placed near minimum of magnetic field.

Table 1: Conventional coupler. Cryogenic losses at different interception point

RF power,	Power 2K,	Power 5K,	Power 80K,
0 kW	0.029 W	1.63 W	8.90 W
30 kW	0.080 W	1.79 W	9.25 W

*Work supported by DOE
#skazakov@fnal.gov

Table 2: Coupler with simple RF shield, no copper coating. Cryogenic losses at different interception point

RF power ,	Power 2K,	Power 5K,	Power 80K,
0 kW	0.023 W	0.58 W	5.3 W
30 kW	0.053 W	1.37 W	9.59 W

Step-shield

Loss in stainless wall can be reduced significantly if made a slot with step as presented at the Fig. 3. bigger step provide smaller losses. The losses of presented geometry is 50 times less then loss of conventional coupler. The geometry has no reflection at operating frequency and has quite wide passband, Fig. 4. Figure 5 demonstrates distributions of current and losses along surface of outer pipe.

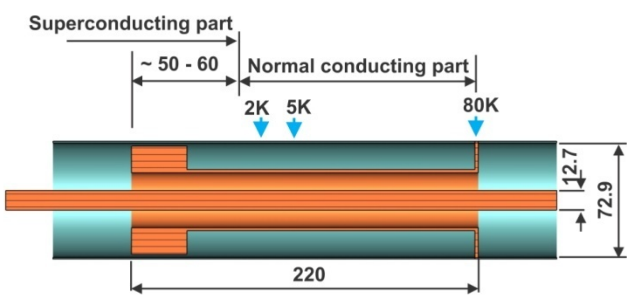

Figure 3: Slot with step-shield. Coupler has 50 times less 2K-5K cryogenic loss then conventional coupler.

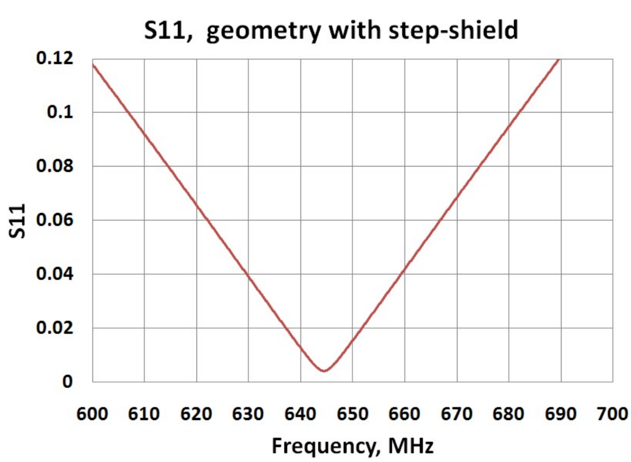

Figure 4: Passband of coupler with step-shield.

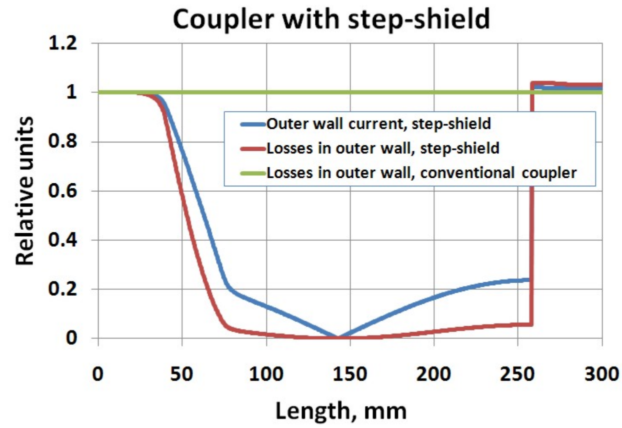

Figure 5: Geometry with step-shield. Distributions of current and losses along surface of outer pipe.

Choke-shield

Field at low temperature area can be eliminated completely if we add second slot which works like a choke. In this case the fields in first slot are exactly zero and there are no losses near low temperature area. All losses are translated to 80K interception. In some approximation we can say that coupler has no dynamic loss.

Static loss is smaller as well because high thermo conductive copper layer on the stainless steel wall is removed. Absence of fields allows reduce static losses even more installing a thermal separation with weak RF requirements (no RF fields). It can be a stainless bellows, for example. Figure 6 demonstrate geometry with choke-shield. Electric and magnetic fields strengths are shown in Fig. 7.

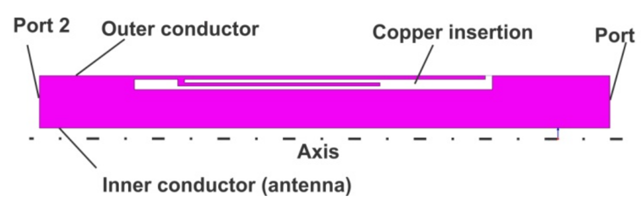

Figure 6: Geometry with choke-shield.

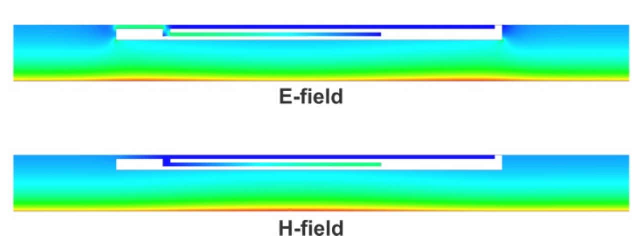

Figure 7: Electric and magnetic fields in geometry with choke-shield.

Multipactor

One of the problem of presented geometries is multipactor in slots. Geometry with choke was modified to shift multipactor threshold beyond of operation power of Project X. Width of choke was increased up to 10mm. Geometry is presented in Fig. 8. Geometries still have wide passbends, Fig, 9. Results of multipactor simulations are presented in Fig. 10 -12. Simulations were carried out using CST code. Fig. 10 shows properties of materiel which was used for calculations. Fig. 11 and 12 demonstrate number of particles vs time for 64 kW and 128 kW input power. According to these results we can expect a multipactor threshold around 100 kW.

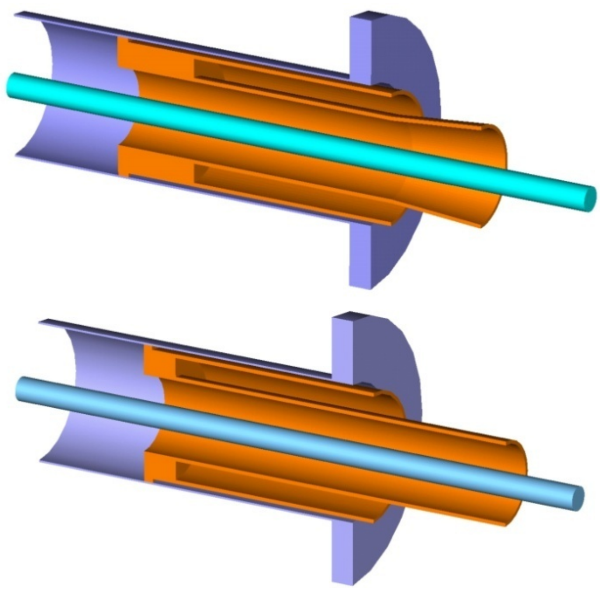

Figure 8: Two geometries with increased width of choke.

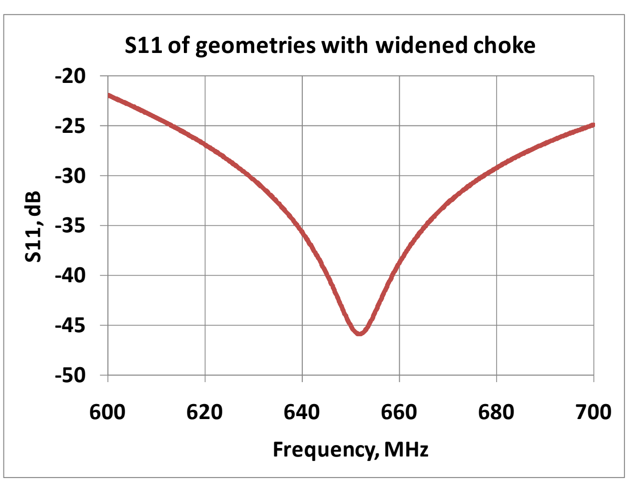

Figure 9: Passband of geometries with widened choke.

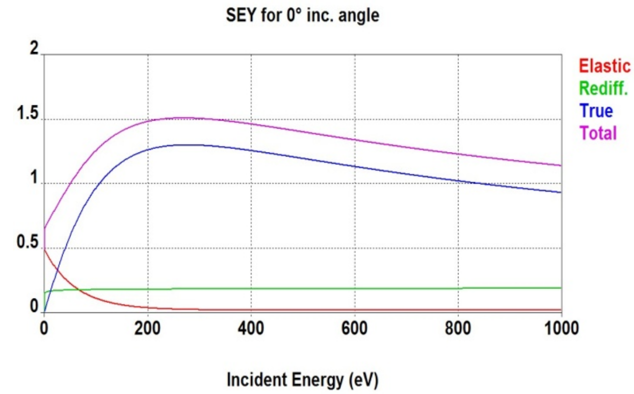

Figure 10: Properties of material with was used in multipactor simulations.

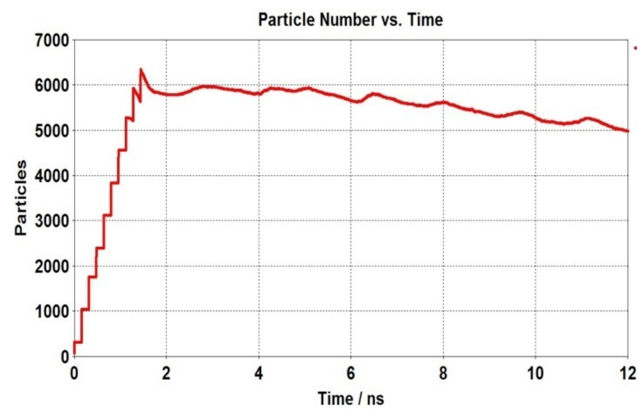

Figure 11: Number of particles vs. tame for 64 kW of RF power. Power is below of multipactor threshold.

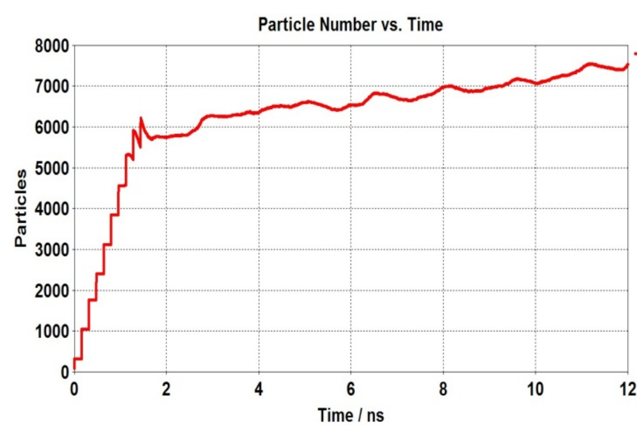

Figure 12: Number of particles vs. tame for 128 kW of RF power. Power is above of multipactor threshold.

ACKNOWLEDGMENTS

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