Adjustable Power Coupler for NICA HWR Cavities

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Introduction

Current results on input power coupler development for Half-Wave superconducting accelerating cavity proposed for Nuclotron-based Ion Collider fAcility (NICA) collider injector upgrade are discussed. Two coupler designs are considered, first one is a low-power coupler for cavity tests and the second one is a high-power operational coupler. Both devices are of coaxial type with capacitive coupling; high-power coupler utilizes single ceramic vacuum window. NICA is designed to accelerate different types of ions. Due to the variable intensity of ion sources, beam current will vary in wide range. In order to ensure efficient acceleration, power coupler must be highly adjustable in terms of coupling coefficient. This introduces excessive mechanical stress in the ceramic RF window due to the bellows deformation. In order to mitigate this effect bellows were substituted with sliding contacts. This paper discusses new coupler design and its electrical, mechanical and thermal properties.

Power coupler model

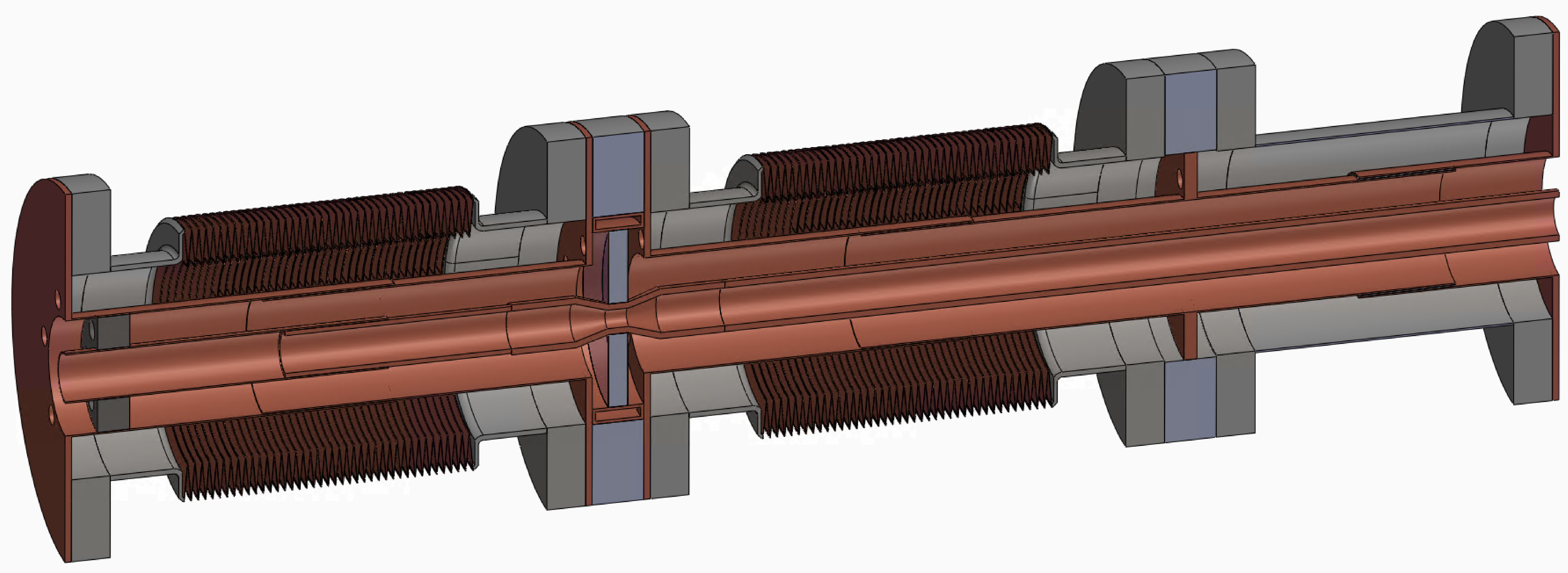

Fig. 1: Power coupler model

Power coupler model was developed. According to the specifications it must be optimally coupled in beam current range $[0, 10]\, mA$, which corresponds to $1.5\, cm$ antenna immersion tuning range. Conventional coupler layouts were discarded due to the excessive mechanical stress caused by a central conductor bellows. In order to remove this stress, EM shields and sliding contacts were introduced to the design.

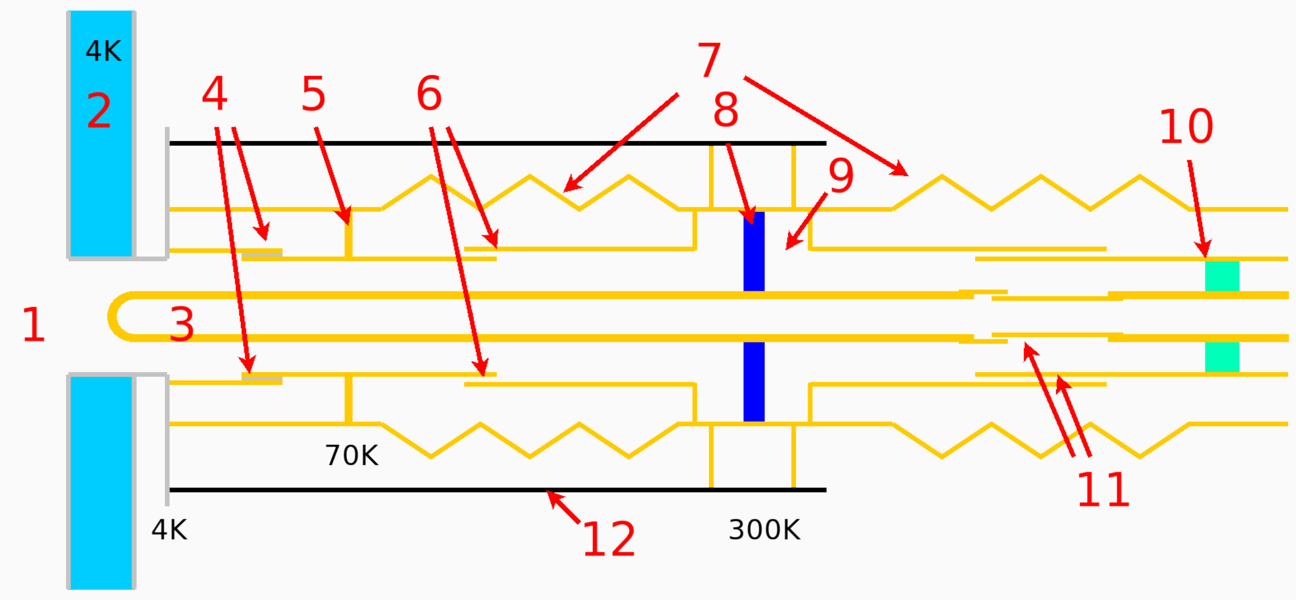

Fig. 2: Power coupler scheme

1. Cavity internal space
2. Liquid helium
3. Antenna
4. 4.2 K — 70 K outer conductor gap
5. Support bar
6. Vacuum part sliding contacts
7. Bellows
8. RF window
9. Barrel
10. Air part sliding contacts
11. Teflon support
12. Guide beams

Thermal load

Originally, EM shields were introduced to lower thermal load in PIP-II project. Vacuum gap between 4 K and 70 K line cuts insulates these lines but makes assembly harder. Introducing a sleeve helps to keep outer conductors centered. Steel it a good choice of material due to low thermal conductivity on low temperatures. Cylindrical sleeve was used in calculations. Further experiments with sleeve geometry may improve performance.

Cooling line	Load, W steel sleeve	Load, W vacuum gap
	Static load	
4.2	1.05	0.45
70	6.5	7.1
	Dynamic load	
4.2	0.21	0.52
70	2.3	2.3

Test coupler

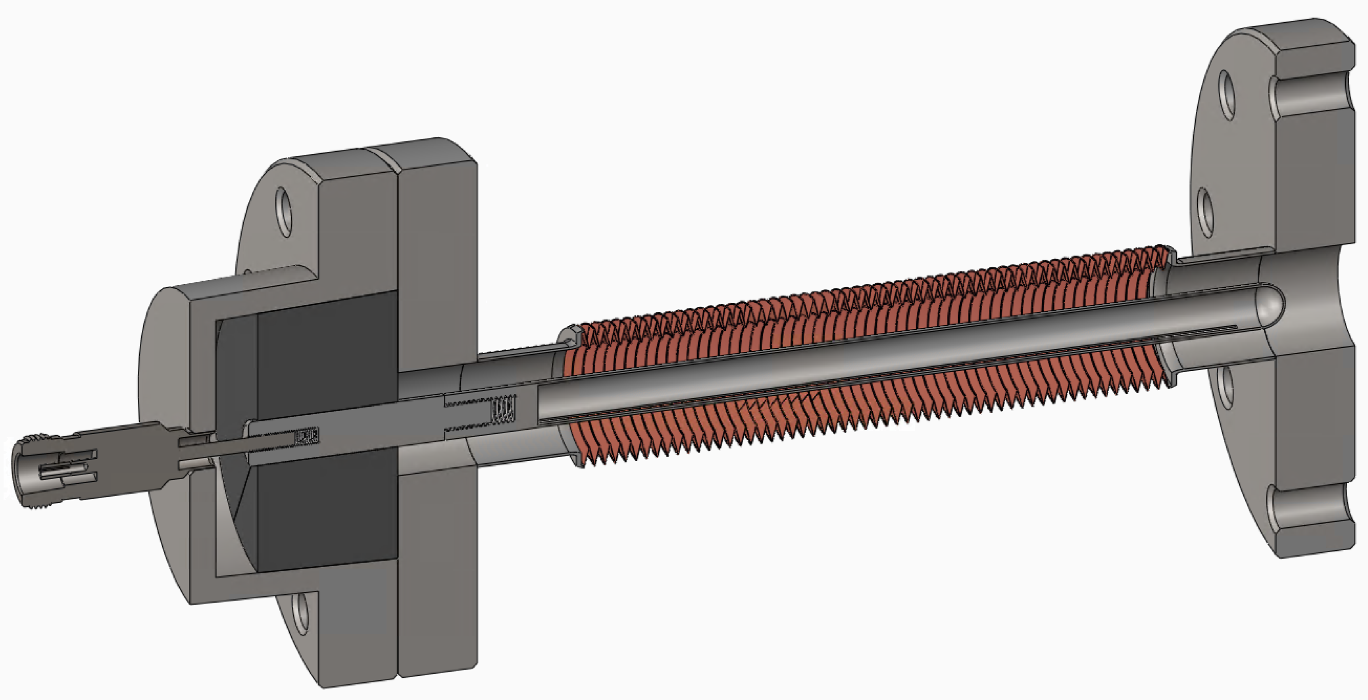

Fig. 3: Test coupler model

Test coupler was developed for cavity vertical tests. It uses N-type connector as an interface, provides a wide antenna immersion tuning range. Shapal-M was used as an antenna support material.

RF window ceramics

Alumina

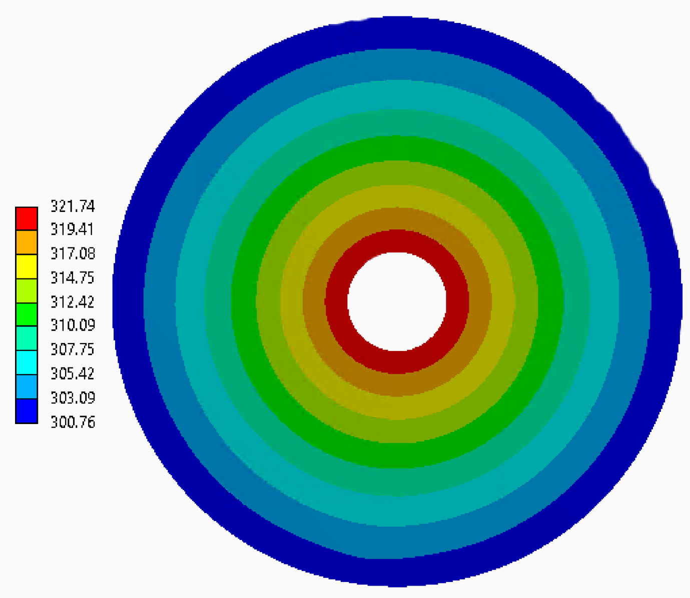

Fig. 4: Temperature

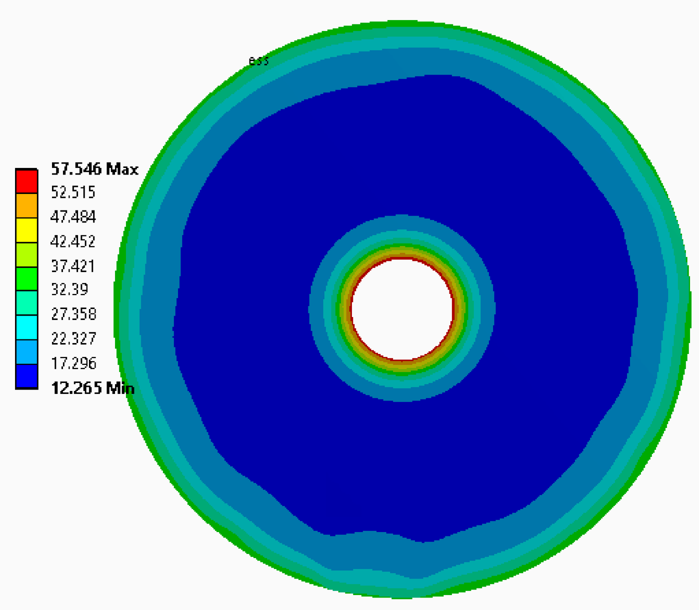

Fig. 5: Stress

Beryllium

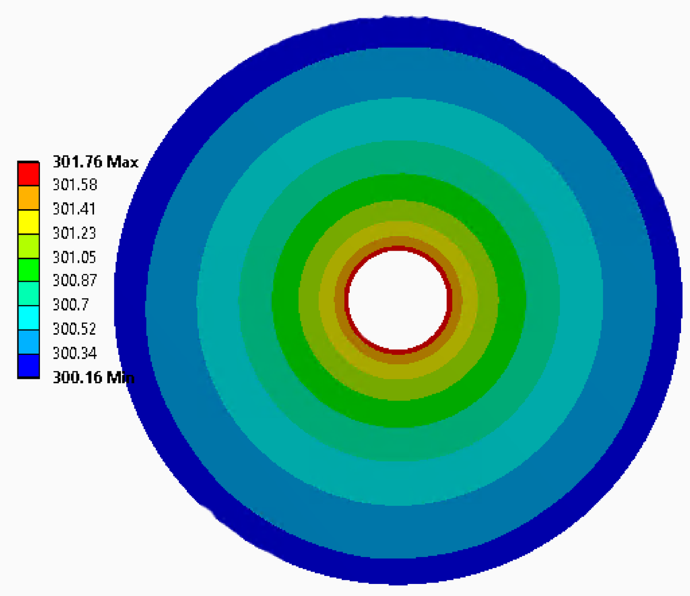

Fig. 6: Temperature

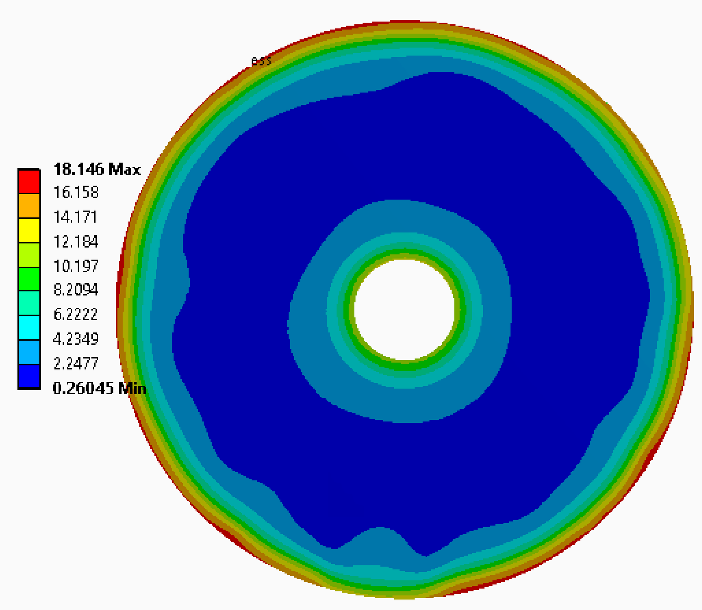

Fig. 7: Stress

Conventionally alumina is used as a material for the coupler RF windows. RF windows with alumina and beryllium ceramics were modeled and compared. Superior heat transfer properties and low losses make beryllium an excellent RF window matherial. Under 13 kW of transmitted power it heats up only by one degree. In these conditions, safety margin for the alumina ceramic window is 3. It is 6 for the beryllium window. However, beryllium is a toxic material and must be handled with extreme caution.

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