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Design and Simulation of High Power Input Coupler for C-ADS LINAC 5-cell Elliptical Cavities

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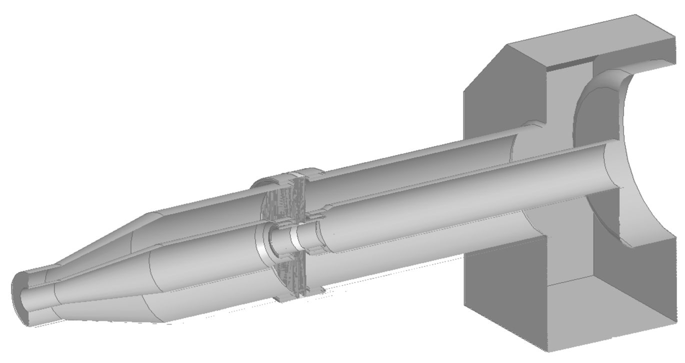
Abstract

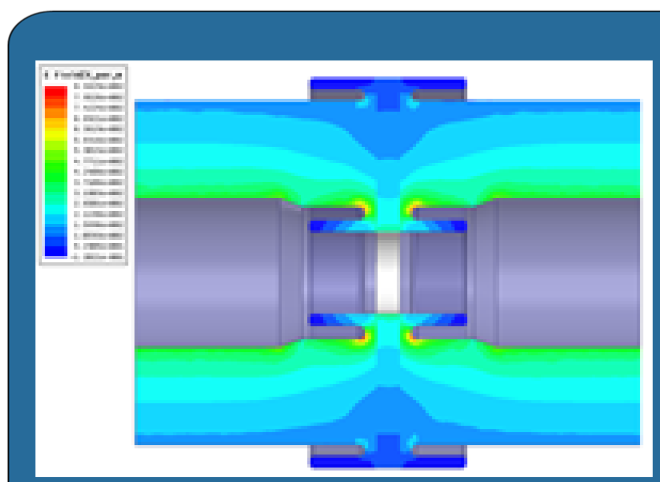
Two 650 MHz elliptical cavity sections (elliptical 063, elliptical 082) are chosen to accelerate medium energy protons for China Accelerator Driven sub-critical System (C-ADS) linac. For each 5-cell cavity, RF power up to 150 kW in CW mode is required to be fed by a fundamental power coupler (FPC). A coaxial type coupler is designed to meet the power and RF coupling requirements. This paper presents the RF design, thermal analysis and multipacting simulations of the coupler for C-ADS 5-cell elliptical cavities.

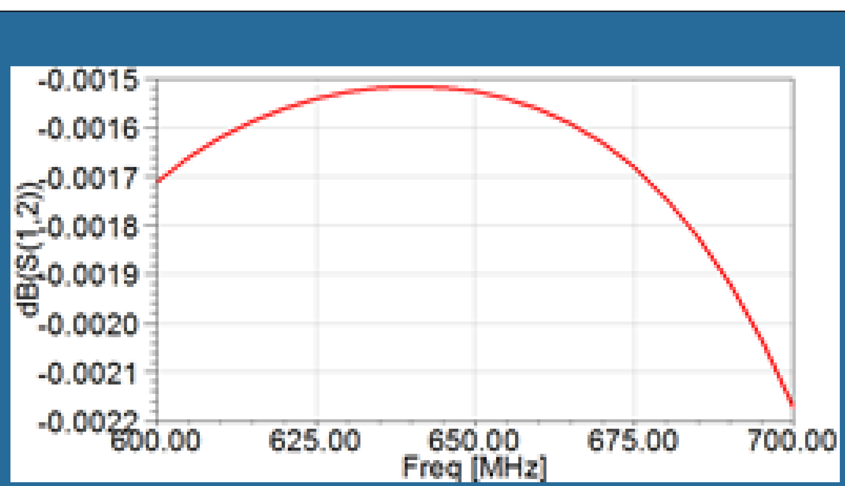
RF structure design

The basic design of the 650 MHz coupler is derived from KEKEB SC couplers. The coupler features a single warm window allowing for clean room assembly of the cold part of coupler to the cavity.

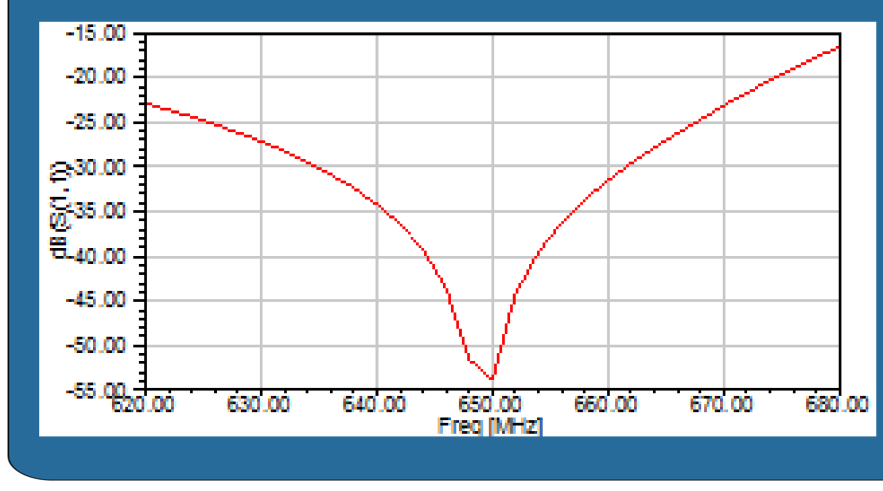
- We scaled the coupler dimension carefully with the HFSS code.
- The coaxial line impedance is 50 Ω.
- 97.6% alumina ceramic was selected to fabricate the RF window.







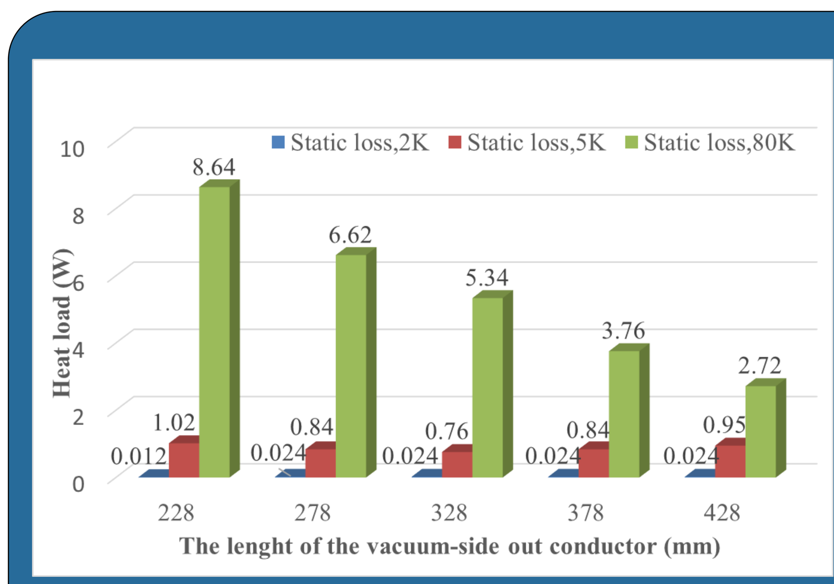
The choke is an impedance-matching structure, meanwhile provides shielding for the window braze joints to reduce the electrical field. As shown in the figures, the electrical field near braze joints is obviously lower because of the choke structure and the window match the impedance well.

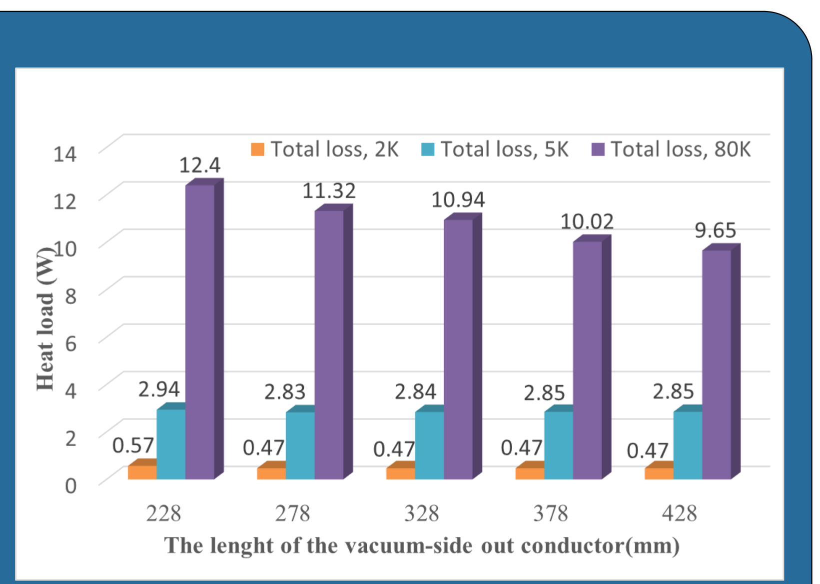


The S11 curver of the integrate coupler. The S11 is smaller than -50 dB at 650 MHz. And the bandwidth is about 40 MHz at S11= -25 dB.

Thermal design

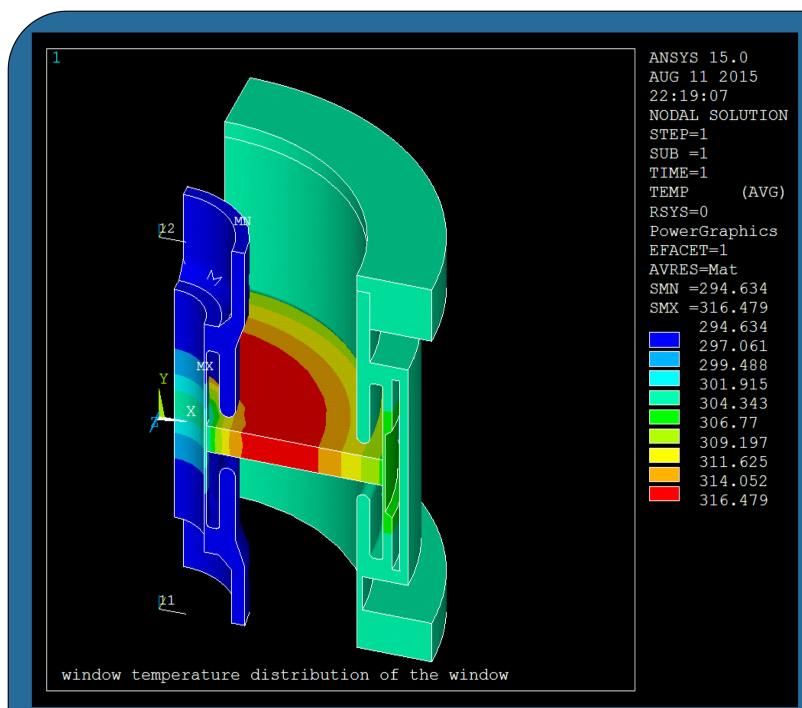
- 5 K helium gas is applied to cool the cold part out conductor.
- The inner conductor of the coupler is a double-wall configuration so as to facilitate water cooling.
- The doorknob is cooling down by room temperature air with two force air cooling tube in its profiles.
- The average dielectric loss of window are handled by the cooling water in the inner conductor and the cooling air flow through the air gap in the out conductor.

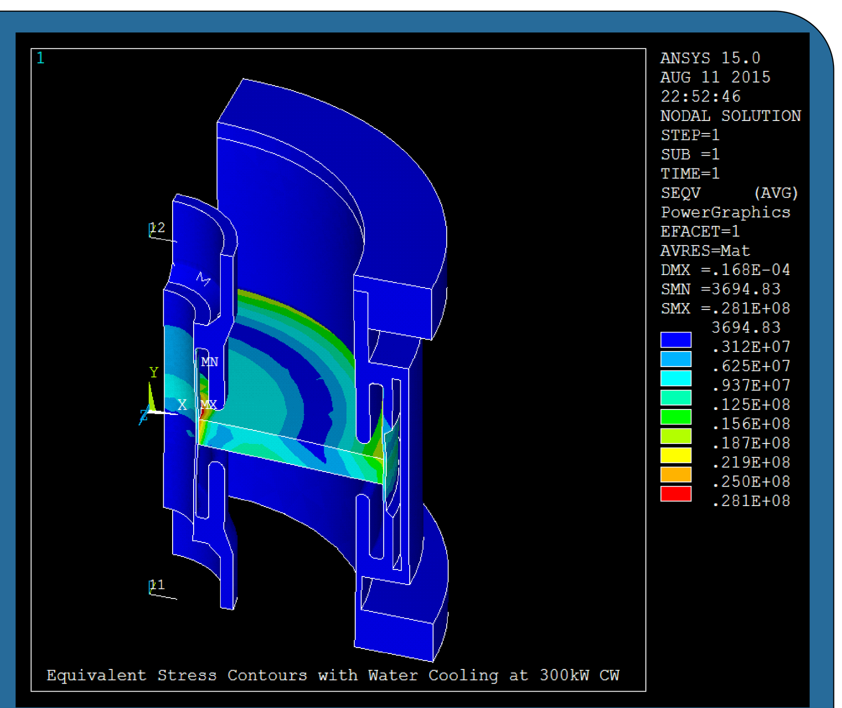




The simulation shows that the heat loads to 2 K flange and 5 K are too high for the Cryostat heat loss controlling. The heat load to 2 K flange and 5 K anchor are mainly consist of the dynamic heat loss, and it could not be minished by extend the vacuum-side out conductor.

We came to the conclusion that **anchors are incapable to control the heat load to reasonable level**. Aiming to minimize the heat transferring to the cavity beam pipe, we select the helium gas to cool the cold part out conductor.





Thermal and mechanical stress analysis were performed for the window under 300 kW RF power using the ANSYS code.

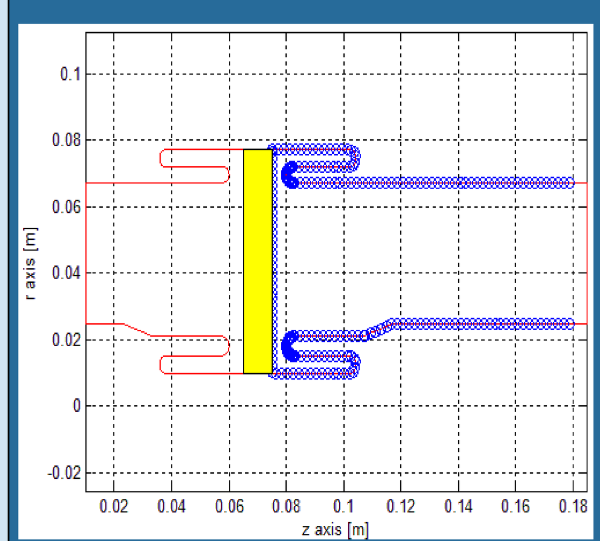
The left figure shows the temperature contour of the RF window at 300 kW, CW. The inner conductor cooling water temperature is 20℃ and so is the window cooling air temperature.

The maximum temperature is 43℃. The maximum stress from the heat load and the ambient pressure is about 28 MPa, nearly one tenth of the tensile strength of ceramic.

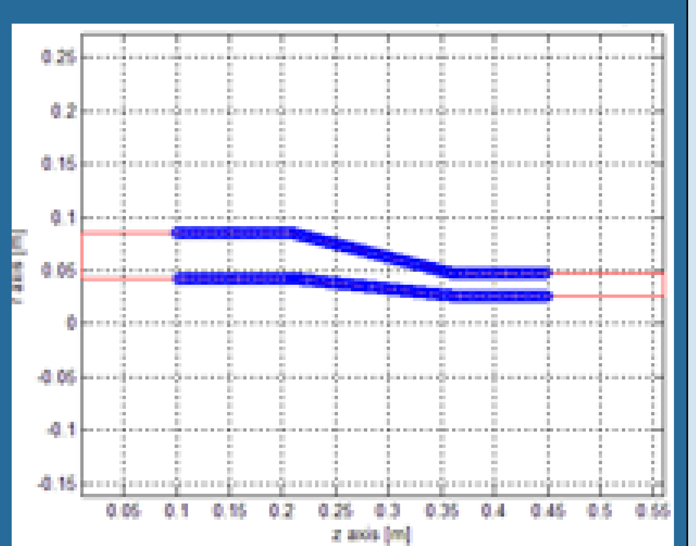
Multipacting simulation

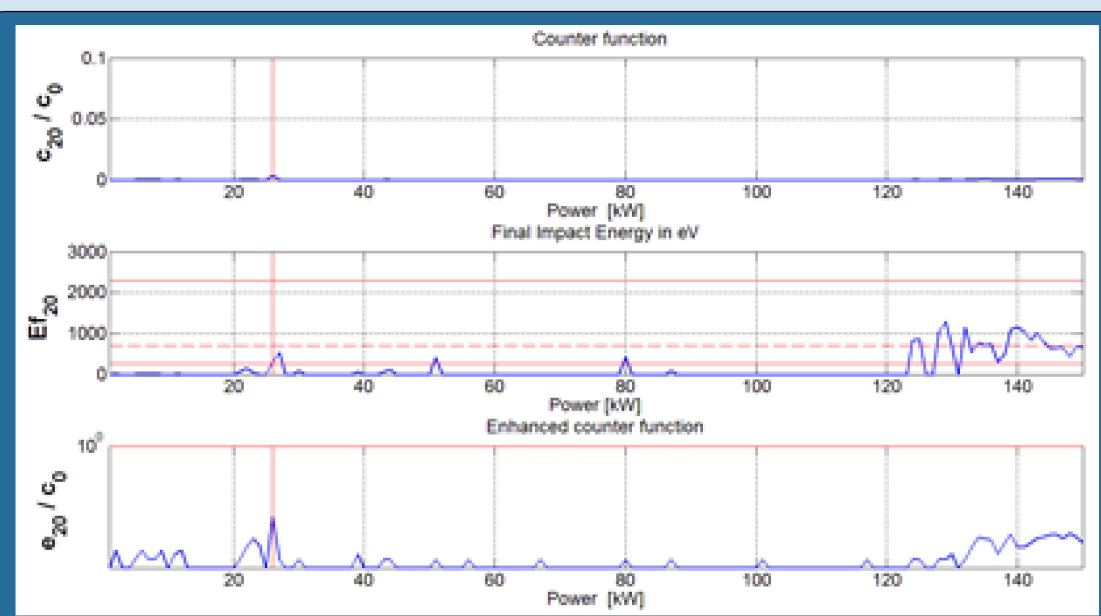
Multipacting is a serious problem for coupler operation. It is important to know whether multipacting would happen at the operation power level or not.

Simulations results indicate that there is no multipactor barrier under 150 kW for the 650 MHz coupler.



The window (left) and coaxial line (right) geometries for multipacting simulation. The blue dots are initial electrons.





From the top to the bottom, the electron counter, the average impact energy of the last impact in eV and the enhanced electron counter in the coax line with a taper for a standing wave.

After 20 times of impacts, nearly all of the free electrons were disappeared and the number of all electrons was less than initial electrons at all power levels below 150 kW which means **there is no multipacting in the coaxial line for a standing wave.**

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