TESTING OF 325 MHz COUPLERS AT TEST STAND IN RESONANCE MODE

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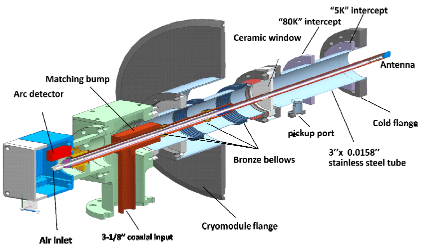
Abstract

Linear accelerator for PIP-II program utilizes two types of 325 MHz Single Spoke resonator cavities, SSR-I and SSR-II. Operating power of SSR-II is about 17 kW. It requires input couplers which can reliably work at power level > 20 kW with full reflection with any reflected phase. Currently only 10 kW RF power supply is available for coupler testing. To increase testing power the special resonance configuration were used. This configuration allows to increase RF power approximately 3 times. The testing scheme and results are discussed in the paper.

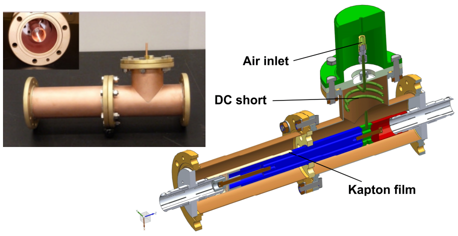
325 MHZ COUPLER



Structure of 325 MHz coupler.

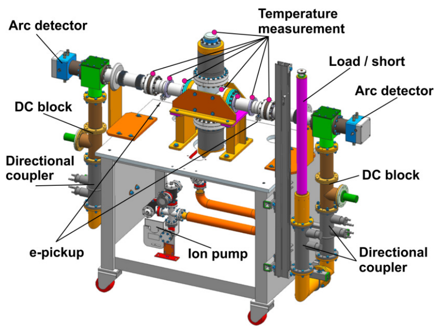
Requirements for 325 MHz coupler: reliable operation at power level > 20 kW, CW with full reflection at any reflected phase.

DC-BLOCK

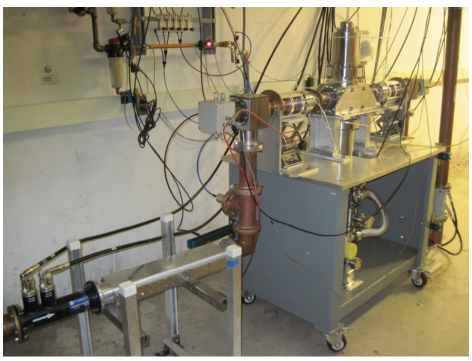


To suppress multipactor in the coupler, high voltage (HV) bias is used. To isolate the coupler input and protect the RF amplifier from HV bias, a DC-block is utilized. The structure of the DC-block is shown Power requirements for the DC-block are similar to coupler power requirements: reliable operation at power level > 20 kW, CW. Two DC-blocks were installed on the test stand and tested simultaneously with two couplers. A HV bias of up to 5 kV was applied during the test.

TEST STAND



Configuration of test stand

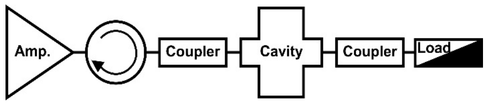


Test stand in test area

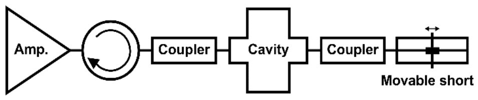
Configuration of the test stand: two couplers are connected to a 6'' stainless steel cavity. Two DC-blocks are attached to the couplers inputs. The movable reflector is connected to the input of the first DC-block. Several directional couplers are used for power measurement and shape monitoring. RF power is measured twice: before and after the reflector. The ratio of these values is the power amplification of this resonance setup.

TEST CONFIGURATIONS

The first stage of coupler testing was performed in two configurations: TW and SW. Power was limited to 10 kW by the amplifier. Due to the long length of 3" heliax needed to go from the amplifier to the test stand only about 8 kW of power was delivered to the couplers. Couplers and DC-blocks were successfully tested in these configurations in the CW regime.

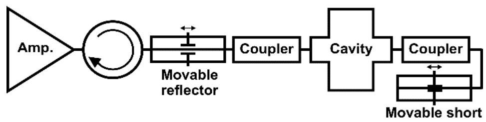


First stage, TW configuration.



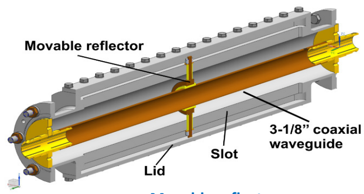
First stage, SW configuration.

To continue testing at higher power levels, the resonance configuration was used. For this purpose the reflector was designed.



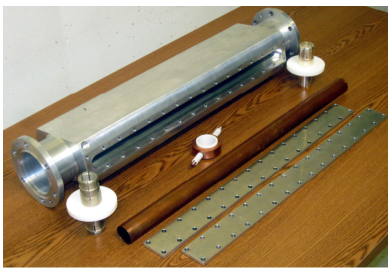
Second stage, resonance configuration.

In this configuration the movable short was replaced by the set of coaxial waveguides with different length and a shortening plate at the end of each waveguide. The position of movable reflector was adjusted for each shortening waveguide to get the maximum power amplification.



Movable reflector.

This reflector is based on 3-1/8'' coaxial waveguide with a movable reflecting element, which can move a distance slightly more than half of the wavelength. Measured reflection coefficient is ~ 0.63 (-3.95 dB). This allows us to get power amplification of ~ 4 times and means that the couplers can be tested at power level ~ 30 kW, CW.



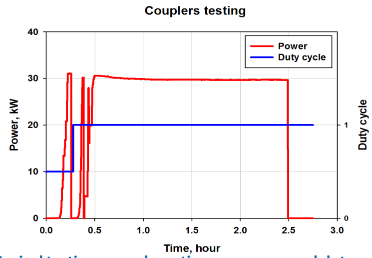
WEAK POINTS

Several weak points in DC-block and the coupler were identified during the tests in the resonance configuration. First, the RF breakdowns were detected between the DC-block copper coil (DC short, Fig. 2) and the outer conductor. To avoid the breakdowns, the coil was placed inside a heat-shrinkable plastic tube. After that no evidence of breakdowns was detected at these points.

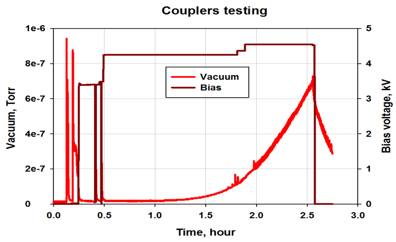
We then found that the number of kapton layers on the DC-block capacitors and couplers capacitors was insufficient. We found that after ~ 15 min at maximum power and HV bias one of the capacitors would fail. The initial number of DC-block kapton layers was 3 while the number of coupler layers was 2. The thickness of the kapton film was 25 micron. We increased the number of layers to 5 for both cases. After that the devices worked without breakdowns at maximum RF power and HV bias up to 5 kV.

PROCEDURE OF TESTING

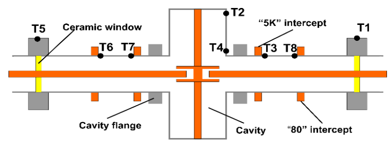
For each position of shortening waveguide the conditioning started in pulse mode with duty cycle 0.5 and pulse length 0.5s. Power was gradually increased up to the maximum. Multipactor was observed at some levels of power. The multipactor was conditioned keeping pressure level less than 2.5E-6 Torr. After reaching maximum power the HV bias was applied to suppress multipactor completely. After that we transitioned to CW mode. RF power was gradually increased again, from minimum to maximum level. After reaching maximum, the system was left for two hours. If no trip occurred the test was considered a success and the length of shortening waveguide was changed. This testing procedure was repeated starting from the pulse mode. We performed a total of four runs with different shorting waveguides.



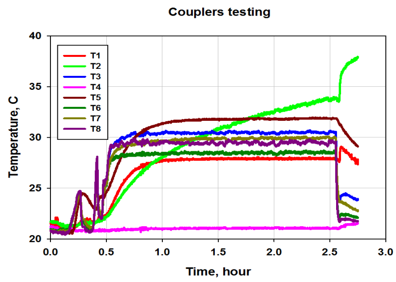
Typical testing procedure: time vs. power and duty cycle.



Typical testing procedure: time vs. vacuum and bias voltage.



Points of temperature measurements.



Typical testing procedure: time vs. temperature.

In addition, one coupler was tested with a cold superconducting spoke cavity SSR1 installed in a test cryomodule. The cavity achieved nominal voltage of 2 MV. Since the coupling was not optimal, the necessary RF power applied to the cavity through the coupler exceeded optimal power several times and reached ~ 10 kW, CW. Signs of multipactor were observed at a RF power level ~ 7 kW: "dark" current coming from cavity was observed. After applying HV bias this dark current vanished.

CONCLUSION

The resonance configuration installed at the coupler test stand allowed us to test couplers and DC-blocks at power level about 3 times greater than the power of the RF source. After some modifications, the couplers and DC-blocks demonstrated the ability to work at power level ~ 30 kW, CW and full reflection with arbitrary phase.