

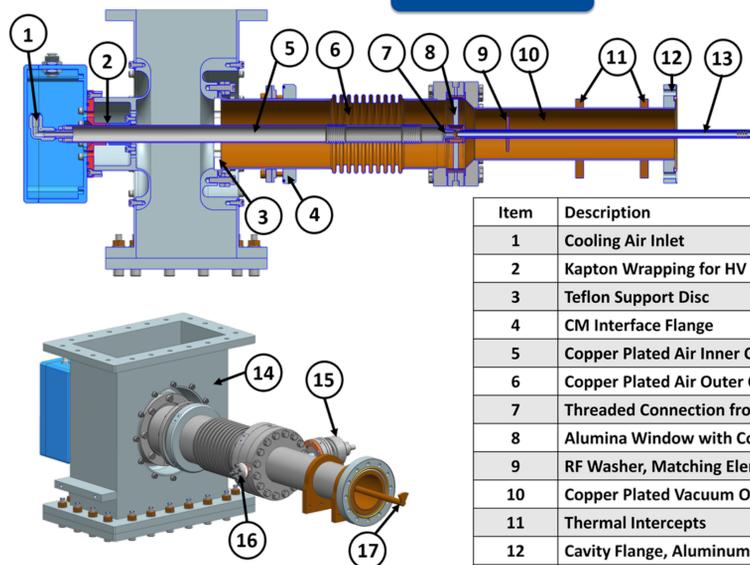
Design, Manufacturing, Assembly, Testing, and Lessons Learned of the Prototype 650 MHz Couplers*

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INTRODUCTION

The prototype High Beta 650 MHz (pHB650) couplers will provide radio frequency input to the superconducting accelerating cavities housed within the pHB650 cryomodule, which is part of the PIP-II Project. Six pHB650 couplers are used in the pHB650 CM string. Eight pHB650 couplers with three additional vacuum sides were procured. These pHB650 couplers are predated by 'proof of concept' 650 couplers, which validated the overall design and testing regime.

DESIGN

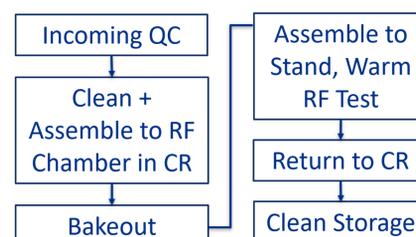


| Item | Description |
|------|------------------------------------------------|
| 1 | Cooling Air Inlet |
| 2 | Kapton Wrapping for HV Isolation |
| 3 | Teflon Support Disc |
| 4 | CM Interface Flange |
| 5 | Copper Plated Air Inner Conductor (IC) |
| 6 | Copper Plated Air Outer Conductor (OC) |
| 7 | Threaded Connection from IC to Antenna |
| 8 | Alumina Window with Copper Sleeves |
| 9 | RF Washer, Matching Element |
| 10 | Copper Plated Vacuum Outer Conductor |
| 11 | Thermal Intercepts |
| 12 | Cavity Flange, Aluminum Hex Seal |
| 13 | Copper Antenna with Stainless Steel Inner Tube |
| 14 | Aluminum Waveguide |
| 15 | Cold Cathode (Vacuum) Gauge |
| 16 | Electron Probe |
| 17 | 'Goose Foot' Shaped Antenna Tip |

MANUFACTURING, INSPECTION, ASSEMBLY



MANUFACTURING LIFE CYCLE



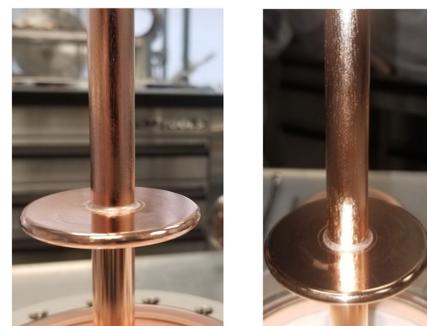
FERMI LAB LIFE CYCLE

Manufacturing Lessons Learned

- Detailed specifications and frequent vendor visitation are essential for error prevention
- Brazing quality greatly benefits from vendor optimization of joint designs
- Only solid copper stock should be used for fabrication of the primary antenna tube
- The antenna design must be modified to allow thermal expansion during brazing or buckling will occur
- Temperature ramp during 400° C vacuum bake of plated components with bellows should be slow to prevent overheating

Assembly Lessons Learned

- QC tooling for clean separation of the antenna and vacuum outer conductor is beneficial



BRAZE QUALITY AND STRIATIONS

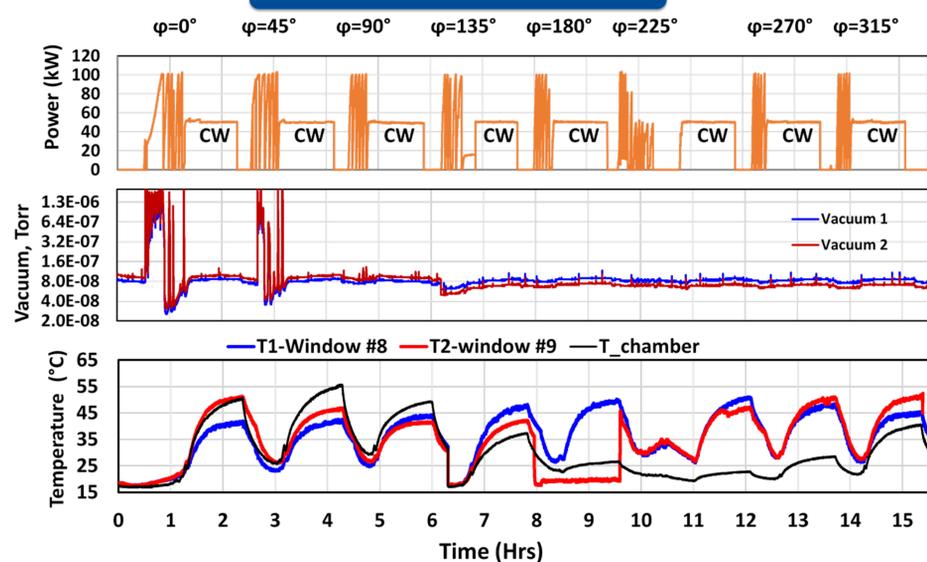


PLATING OXIDATION

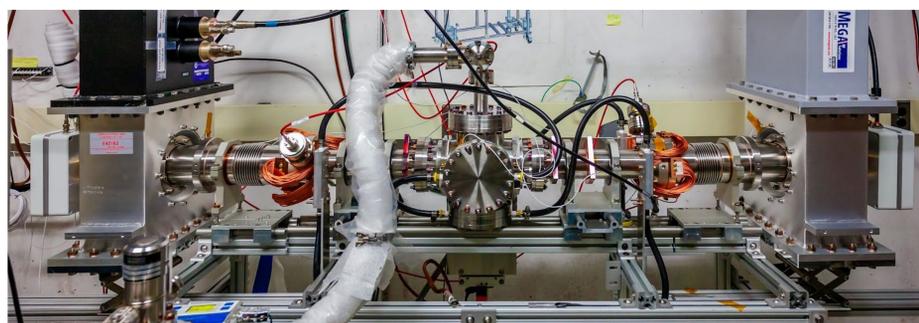


COUPLER ASSEMBLY TO RF CHAMBER

RF TESTING AND RESULTS



COUPLERS 8 & 9 RF TESTING RESULTS



RF TEST STAND

SUMMARY

- All pHB650 Couplers tested have been qualified for use on SRF Cavities without major incident even though COVID-19 prevented visits to the vendor from Fermilab
- Procurement, Manufacturing, QC, Cleaning, Assembly, and Testing have all provided valuable experiences which will positively influence the Design and Specifications of the Production 650 MHz Coupler along with other PIP-II couplers.

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