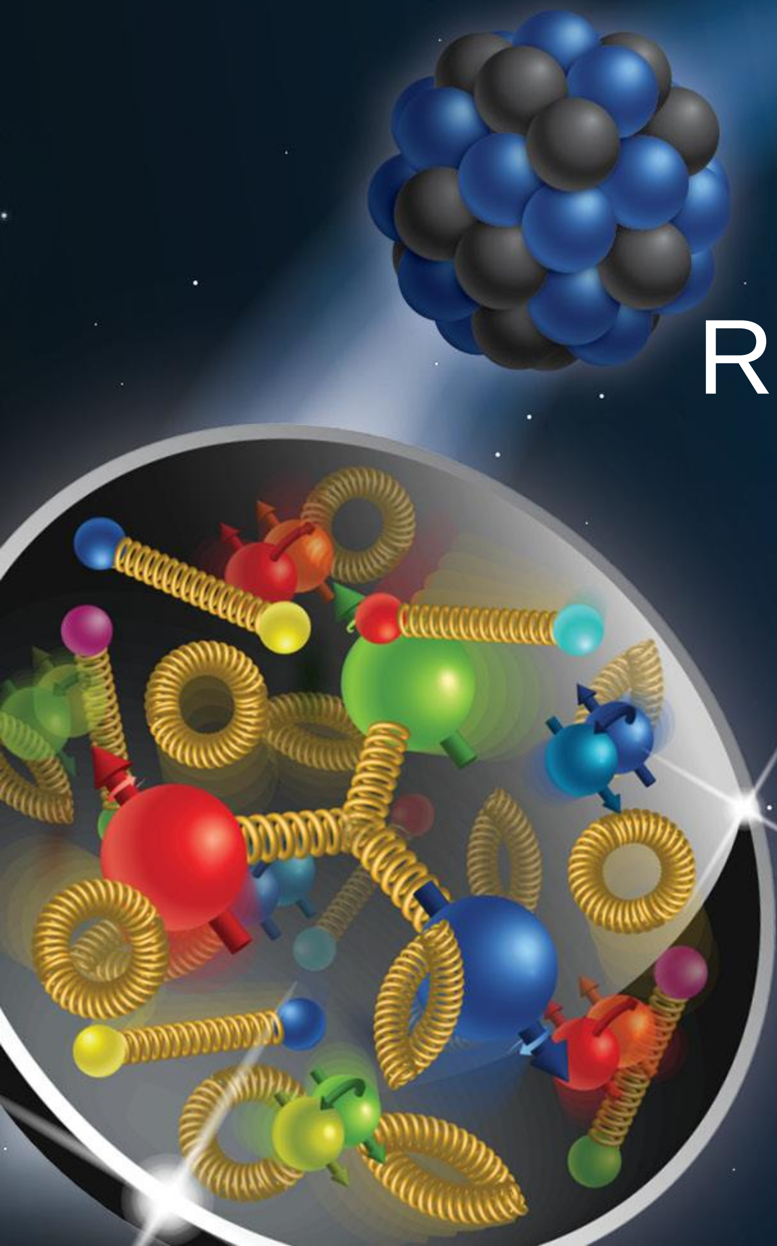


R&D Toward High Power Warm SiC Beam Line HOM Absorbers

Douglas Holmes
February 4, 2020

Electron Ion Collider – EIC at BNL

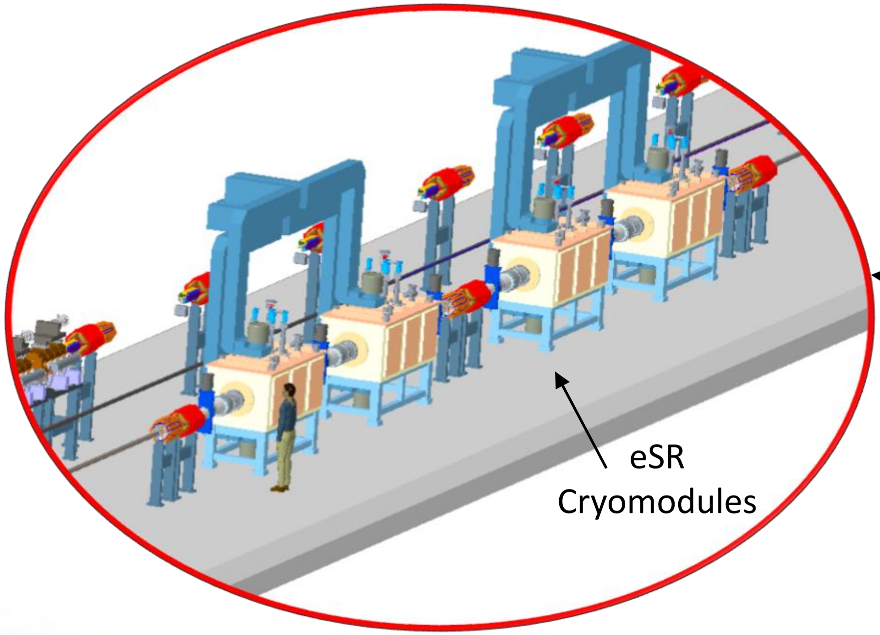
BROOKHAVEN NATIONAL LABORATORY
U.S. DEPARTMENT OF ENERGY | Office of Science

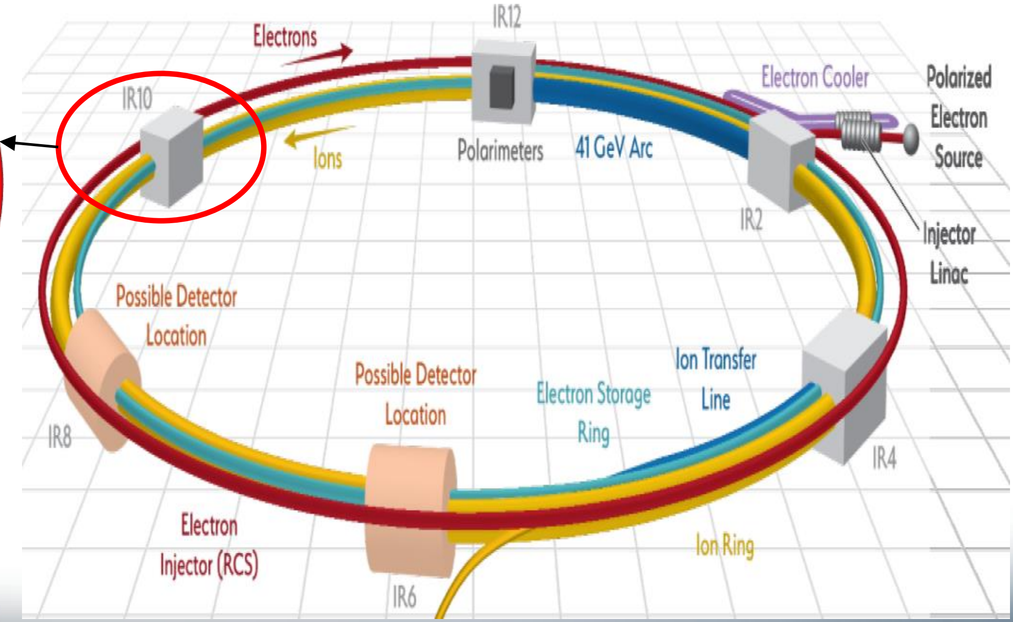
Outline

- BNL EIC electron Storage Ring (eSR) system:
  - operating parameters
  - HOM damping requirements
- eSR SRF cryomodule and Beamline HOM Absorber (BLA) arrangement
- 20 kW Beamline HOM Absorber configuration
- 20 kW Beamline HOM Absorber fabrication progress
- Absorber FEA Details
- Absorber test plans
- Summary

BNL EIC

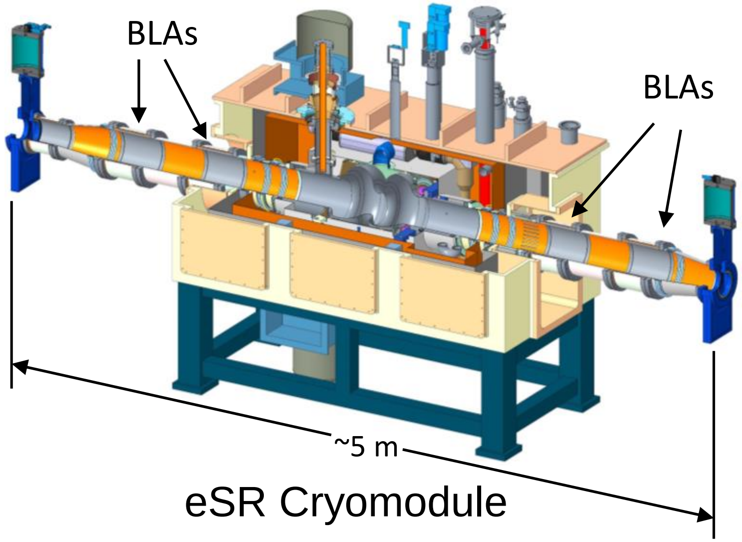
- The BNL Electron-Ion Collider EIC utilizes the existing ion accelerator systems of RHIC
- Will install new electron Rapid Cycling Synchrotron (RCS) Injector and eSR
- eSR beam current: 0.27 to 2.5 A
- eSR beam energy: 5 to 18 GeV
- HOM power: 80 kW HOM power/eSR cavity
- Total of 14 eSR Cavities → >1 MW HOM power



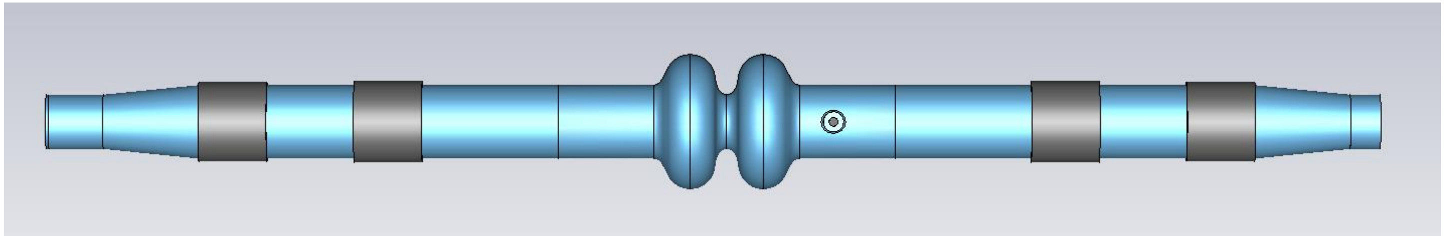


Cryomodule with BLAs

- eSR SRF Cavity: 2-cell, 591 MHz
- BNL EIC requires 3x larger version of the BLAs developed at ANL for the APS upgrade*
- Qty 4 high power BLAs per cavity
- 80 kW HOM power/cavity → 20 kW each BLA
- BLAs at room temperature with water cooling



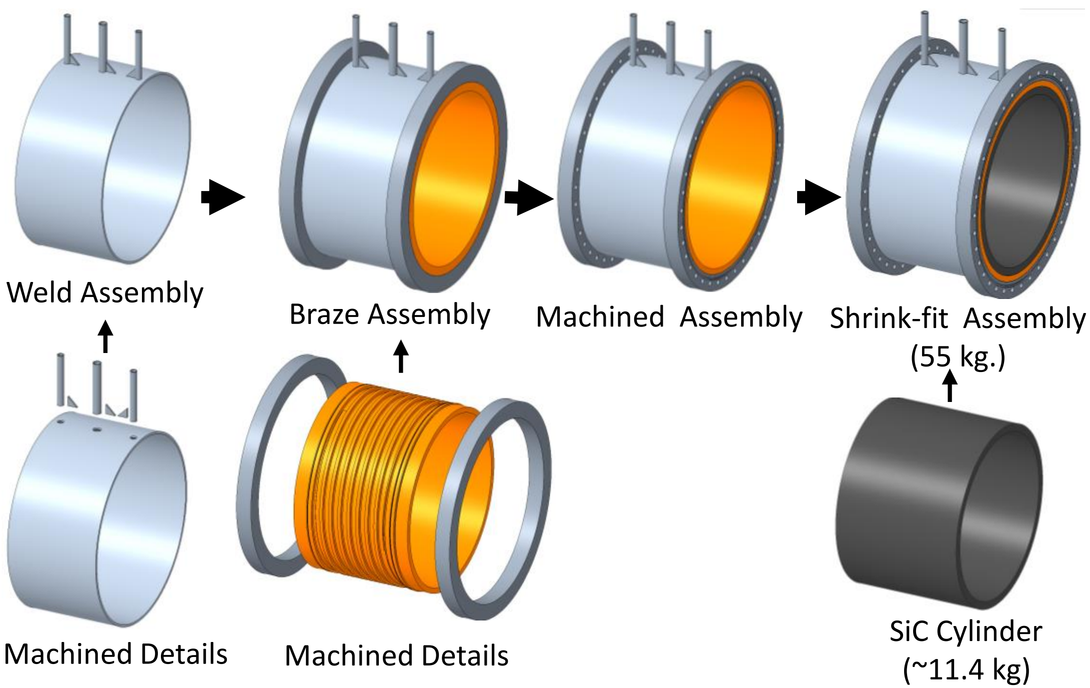
eSR Cryomodule


RF model of the two-cell cavity with the SiC based BLAs**

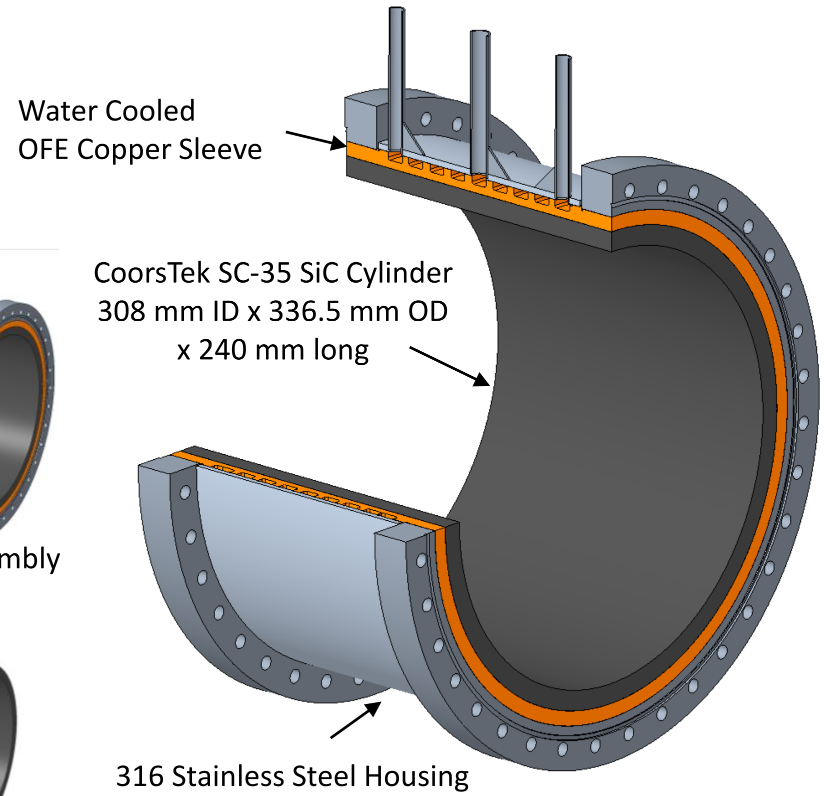
* S.H. Kim, et. al., "Beam Pipe HOM Absorbers in Bunch Lengthening Harmonic Cavity Cryomodule for Advanced Photon Source Upgrade", Collaboration Meeting with BNL, 4/27/2017.
** Philipp Kolb, et. al., "Multicell SRF Cavities for the High Current Electron Storage Ring at eRHIC", 3/30/2018.

BLA R&D

Work performed with BNL Laboratory Directed Research and Development (LDRD) funds to fabricate three high power 308mm ID BLAs



High Power BLA Build Sequence



High Power BLA Assembly

Fabrication Progress

- Final machining of first high power BLA is finished
  - Will fit SiC in machined assembly in near future.
- Two more high power BLAs ready for final braze

High Power BLA Components

Diamond Tool
Machine Finish

Final Machined Assembly

Shrink Fit FEA Details

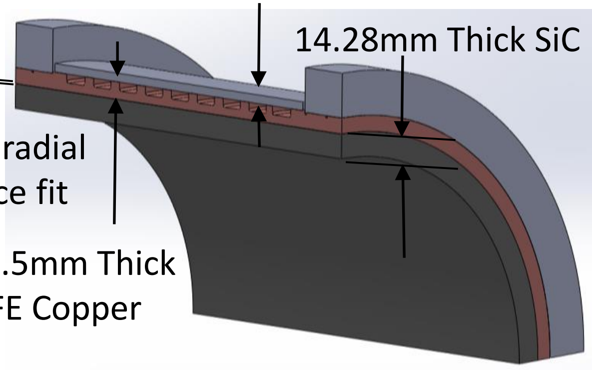
20 °C

4.4mm Thick S. Steel

14.28mm Thick SiC

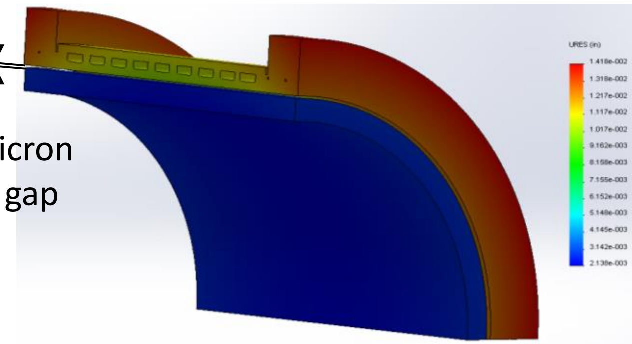
60 micron radial interference fit

11.5mm Thick OFE Copper

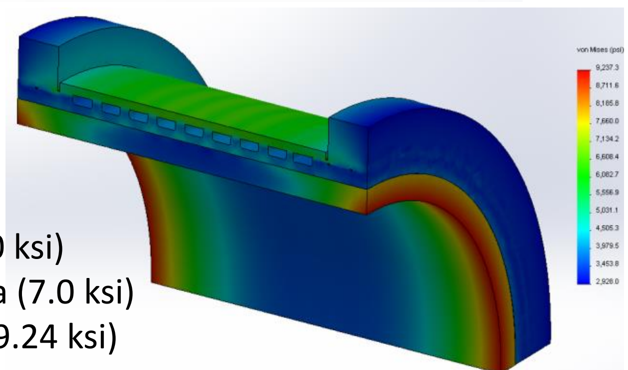


100 °C

130 micron radial gap

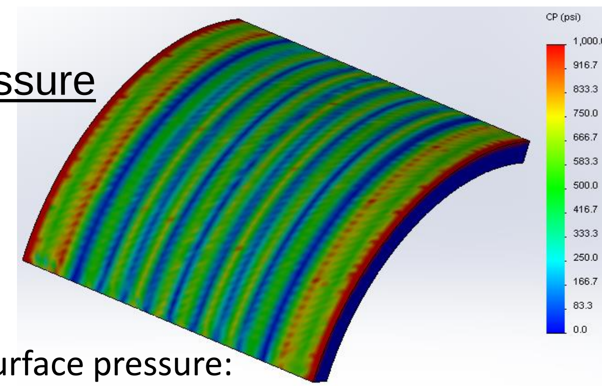


Shrink-Fit Stress



Max Stress:
Cu = 48.3 MPa (7.0 ksi)
S. Steel = 48.3 MPa (7.0 ksi)
SiC = 63.7.3 MPa (9.24 ksi)

SiC/ Copper Contact Pressure



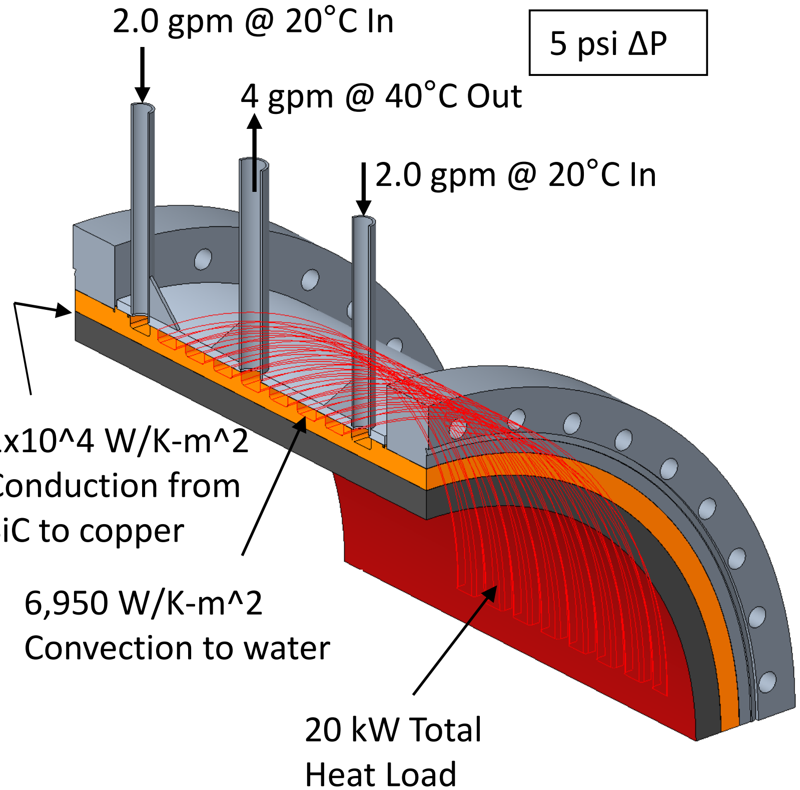
Surface pressure:
100 to 1,000 psi

Material properties:
Annealed Cu yield ≈ 34.5 Mpa (5.0 ksi)
Stainless Steel yield = 207 MPa (30.0 ksi)
SC-35 compressive strength = 676 MPa (98.0 ksi)

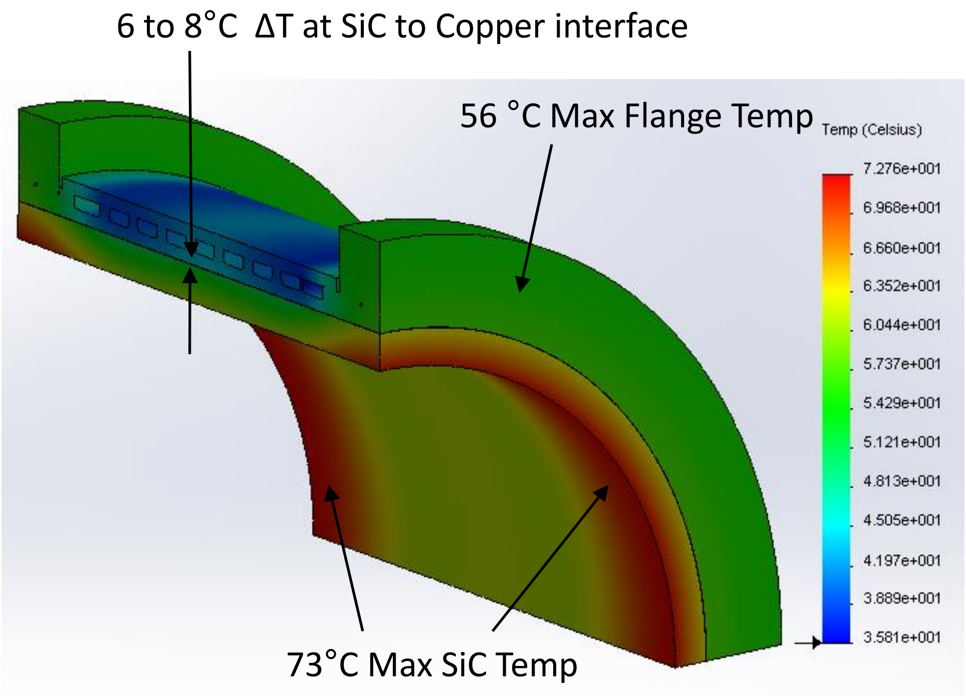
- Local yielding in Cu is acceptable
- Stainless Steel & SiC stress is low
- SiC to Cu heat transfer is dependent on contact pressure

Thermal FEA Details

FEA Input



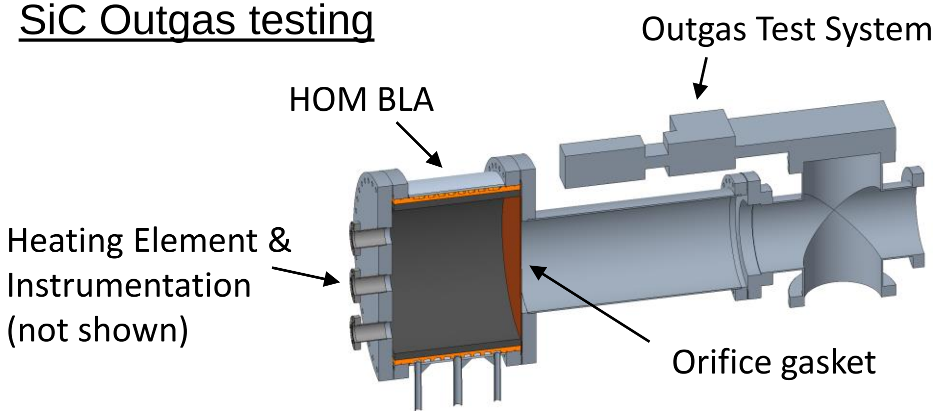
BLA Thermal Profile



SiC to Cu contact pressure Increases with increased heat load, reducing ΔT at SiC-Cu interface

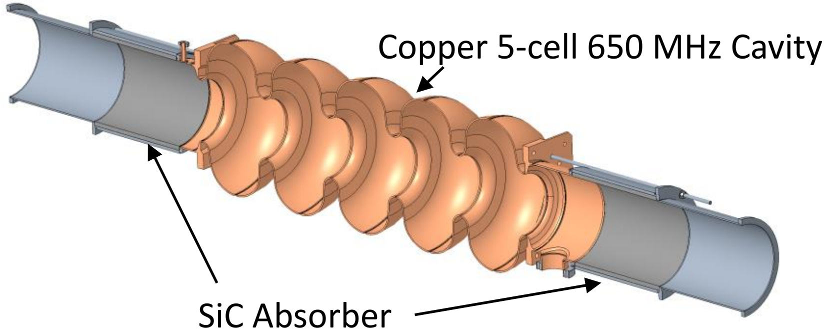
BLA Test Plan

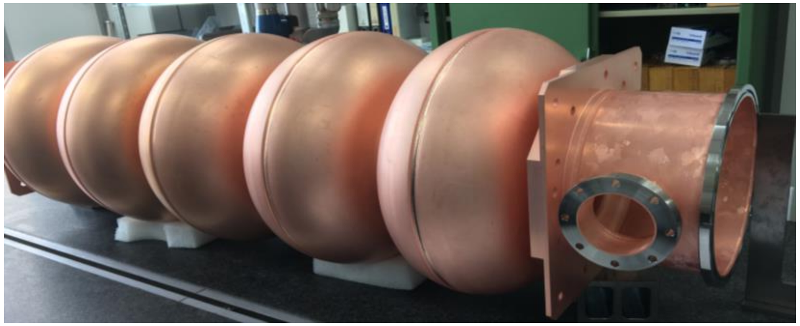
SiC Outgas testing



Outgas Test System

Low power testing with copper 5-cell cavity

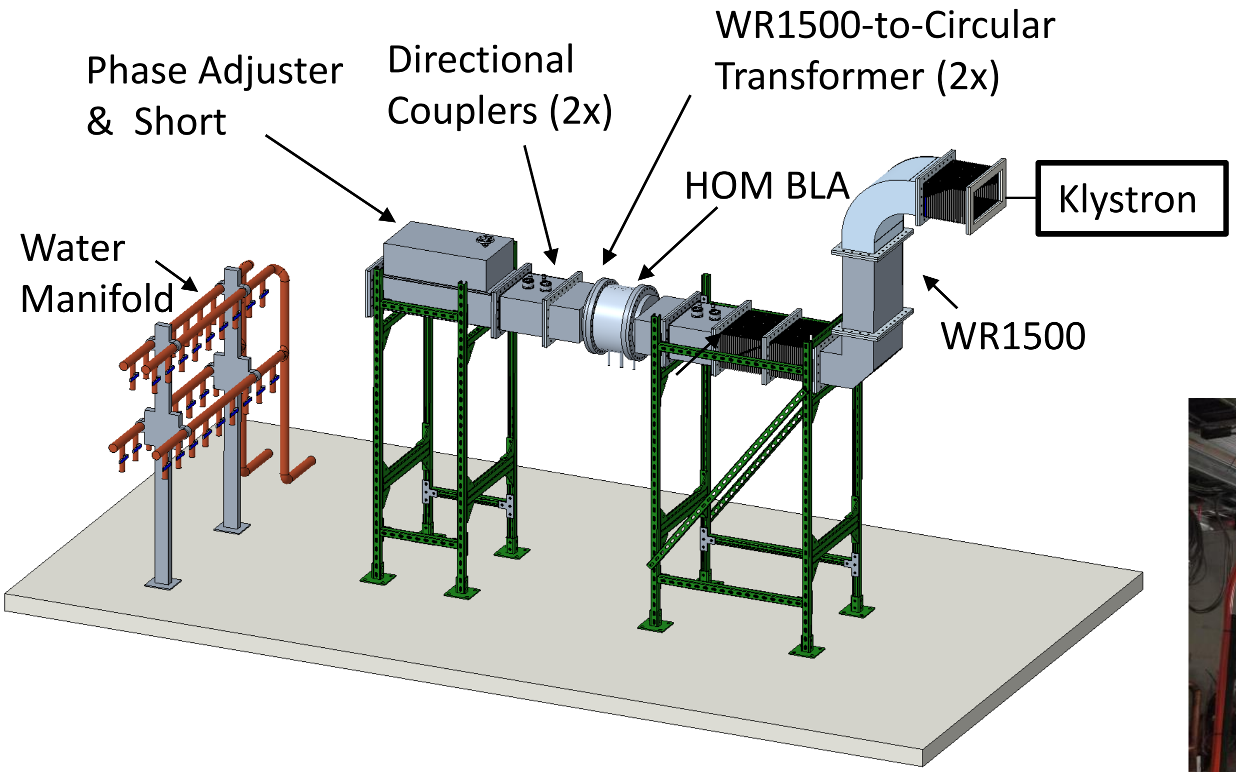




Copper 5-cell 650 MHz Cavity

BLA Test Plan

High Power testing (with MW 704 MHz klystron)



WR1500-to-Circular Transformers

Plan to monitor directional coupler power, coolant water flow rate/temperature, component temperature

High Power Test Facility
with Waveguide Tuner
(See W. Xu's presentation for details)

Summary

- First article HOM BLA manufacture is near finished
  - No major fabrication issues to note.
  - Final fitting of first SiC cylinder to machined assembly soon.
- Fabrication of 3 Φ308 mm BLAs will conclude in March, 2020
- Outgassing and RF testing to begin in the spring of 2020
- I look forward to future updates as our work progresses.

Thank you for listening!

Acknowledgements:

ANL: M. Kelly

BNL: M. Calderaro, Z. Conway, J. Genco, A. Hubert,
G. McIntyre, S. Seberg, K. Smith, D. Weiss, W. Xu, A. Zaltsman

FRIB: S.H. Kim

TRIUMF: P. Kolb