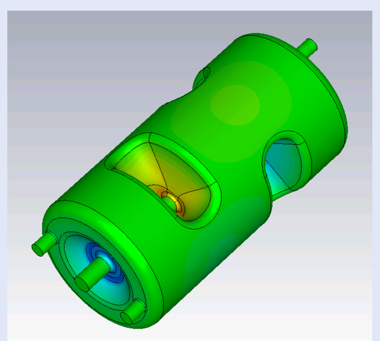
FABRICATION AND MEASUREMENTS OF 500 MHZ SUPERCONDUCTING DOUBLE SPOKE CAVITY*

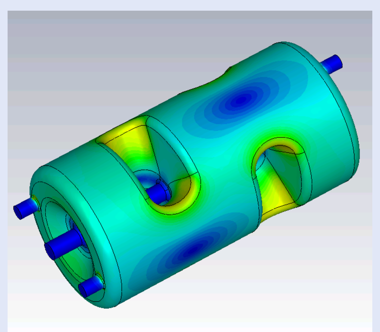
HyeKyoung Park[2,1#], C. S. Hopper[1], J. R. Delayen[1,2],
[1]Center for Accelerator Science, Old Dominion University, Norfolk, VA 23529, USA.
[2]Thomas Jefferson National Accelerator Facility, Newport News, VA 23606, USA.

ABSTRACT

A 500 MHz β_0=1 double spoke cavity has been designed and optimized for a high velocity application such as a compact electron accelerator at the Center for Accelerator Science at Old Dominion University [1] and the fabrication was recently completed at Jefferson Lab. The geometry specific to the double spoke cavity required a variety of tooling and fixtures. Also a number of asymmetric weld joints were expected to make it difficult to maintain minimal geometric deviation from the design. This paper will report the fabrication procedure, resulting tolerance from the design, initial test results and the lessons learned from the first β_0=1 double spoke cavity fabrication.

RF AND GEOMTRIC PROPERTIES [1]


Surface Electric Field

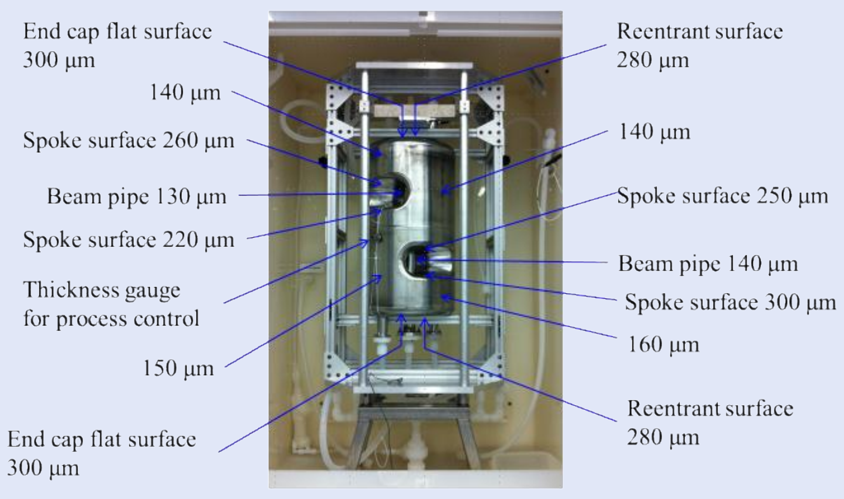

Surface Magnetic Field

Parameter	Value	Units
β_0	1	-
Frequency	500	MHz
Cavity diameter	416	mm
Cavity length	805	mm
Aperture diameter	50	mm
R/Q	675	Ω
$Q{\cdot}R_s$	174	Ω
E_p/E_{acc}*	3.7	-
B_p/E_{acc}*	7.6	mT/(MV/m)
B_p/E_p	2.05	mT/(MV/m)

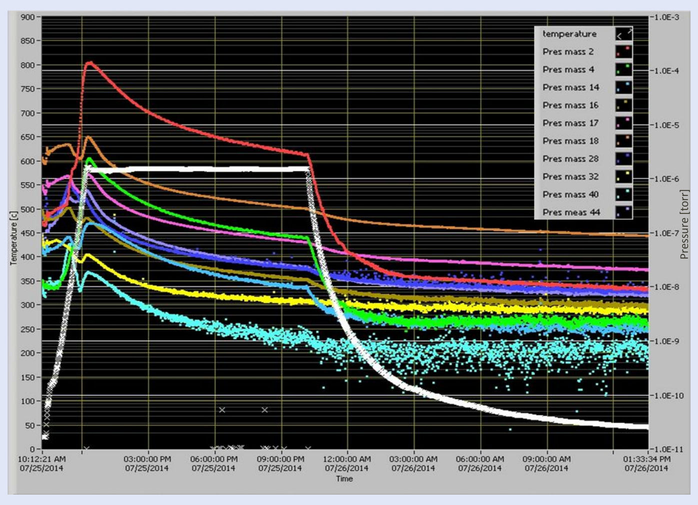
*Reference length $3\beta_0\lambda/2$

CAVITY PROCESSING

1. Bulk 150 micron buffered chemical polish (BCP)
2. Heat treatment at 600 deg C for 10 hours.
3. Light BCP of 10 micron.
4. Ultrasonic degreasing and high pressure rinse (HPR)
5. Cavity assembly in the clean room
6. Bake at 120 deg C for 48 hours.

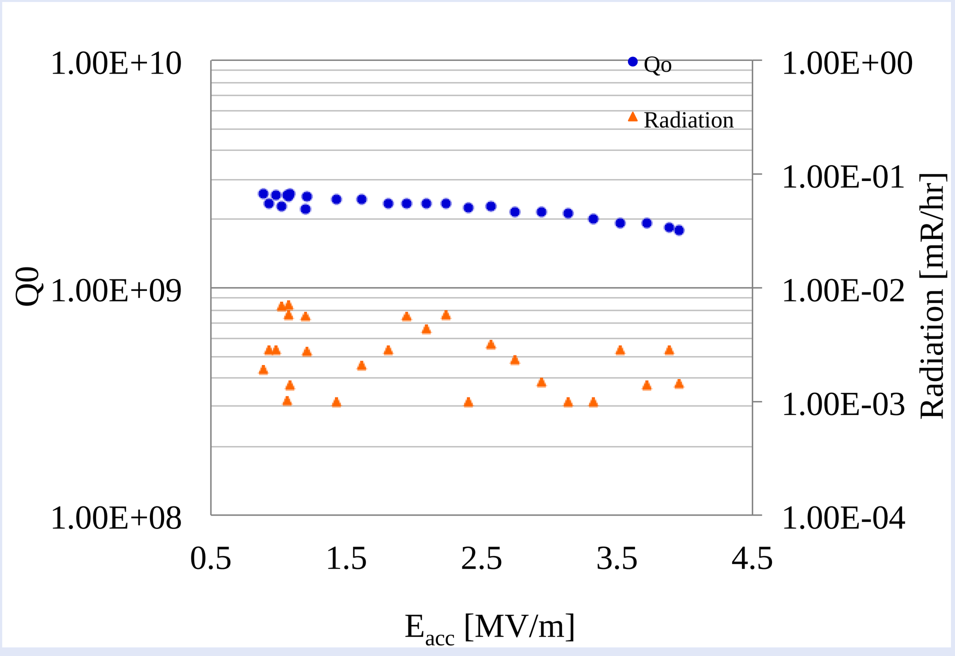


Bulk BCP Removal Results


Heat Treatment Results

RF MEASUREMENTS


Cavity Prepared for Test

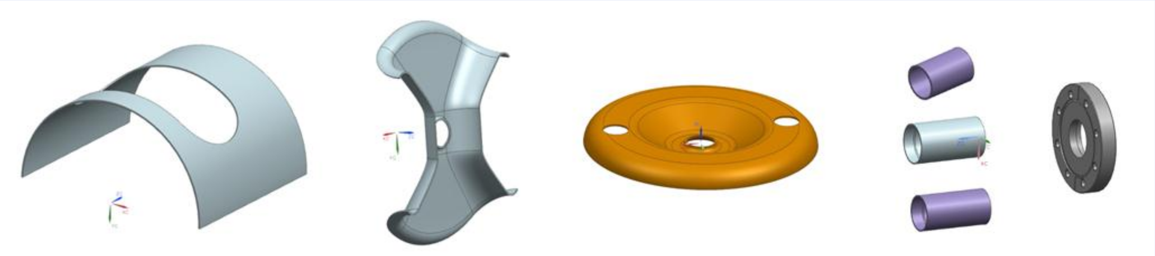


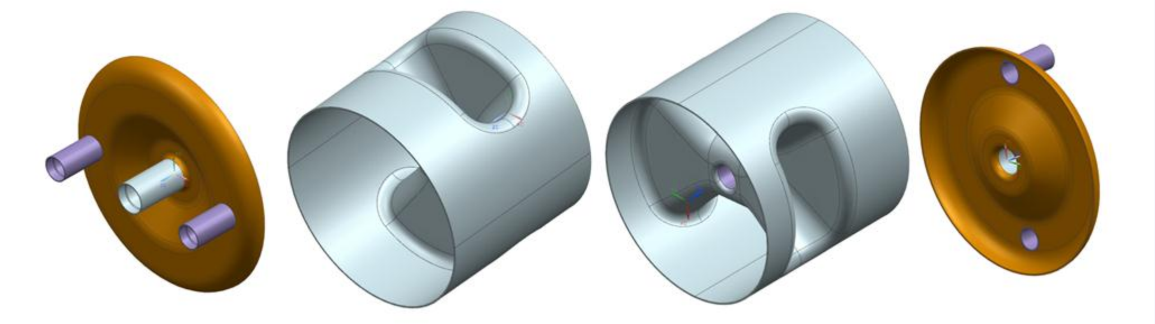
4.3K Test Results

- The measured unloaded quality factor 2.5 ×10⁹ at 4.3K.
- A cold leak prevented 2K test.
- The multipacting observed at the low gradient.
- At about a gradient of 4 MV/m oscillating slow decay of transmitted power was observed and it persisted.

FABRICATION

Fabrication Concept
Divide the cavity into parts to optimize number of forming dies, number of weld joints, and ease of assembly.


Individual parts

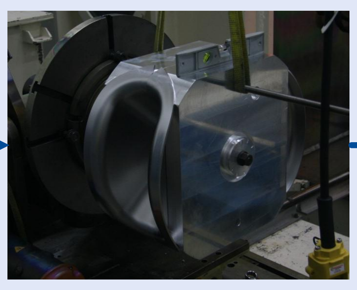

Sub-assemblies

Spoke Assembly


Deep draw forming


Formed spoke half


Side seam trim


Tack weld while fixtured

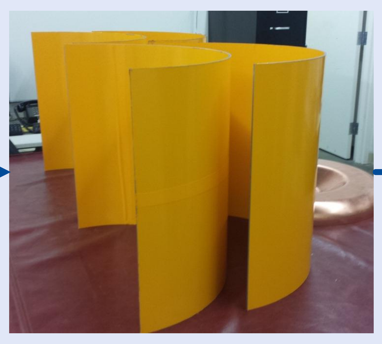

Full penetration weld


Base trim


Finished spoke assembly

Outer Conductor

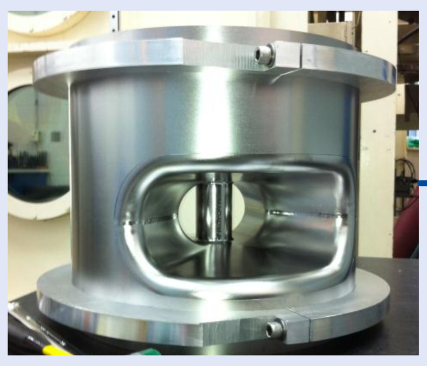

Rolling

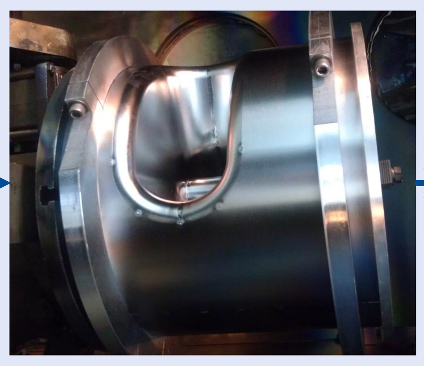

Rolled outer conductor haves

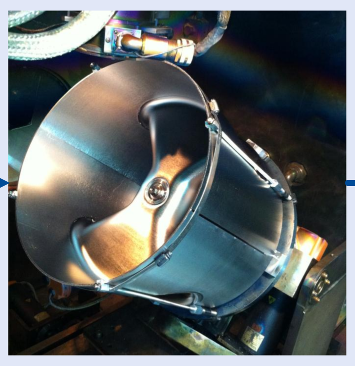

Side seam trim

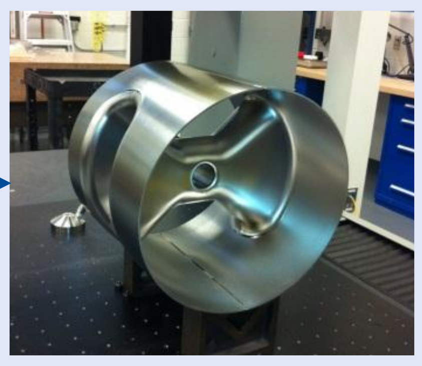
Base opening trim while two halves are fixtured together.

Spoke-Outer Conductor Assembly


Weld fit-up


Tack weld while fixtured


Full penetration weld


Finished assembly

Main Body Assembly

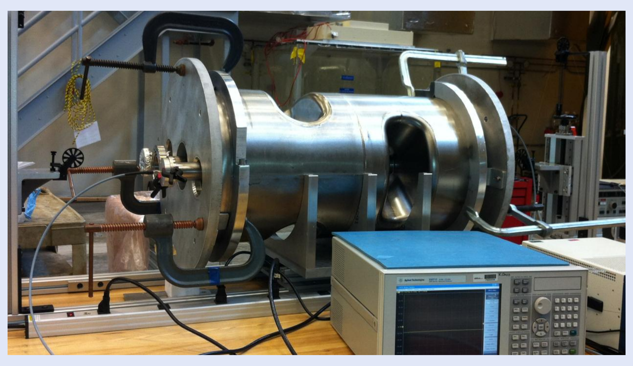

Center seam weld while fixtured

End Cap Assembly

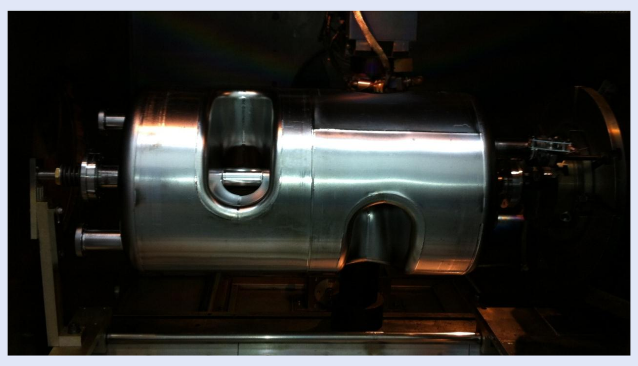

Formed end cap


End cap assembly

Bead Pull before Final Weld



Final Weld



REFERENCE

[1] T. Satogata et al., "Compact Accelerator Design for a Compton Light Source," WEPWA078, IPAC2013, Shanghai, China (2013).
[2] C. S. Hopper et al., "Cryogenic Testing of High-Velocity Spoke Cavities," TUPP109, these proceedings, LINAC2014, Geneva, Switzerland (2014).
[3] C.-K. Ng, et al., "State of the Art in EM Field Computation," THXFI01, EPAC06, Edinburg, Scotland (2006).
[4] C. S. Hopper et al., "Multipacting Analysis of High-Velocity Superconducting Spoke Resonators," MOPB056, LINAC2012, Tel-Aviv, Israel (2012).

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#hkpark@jlab.org

ON GOING EFFORTS AND PLAN

The cavity is being prepared for additional testing. The investigation is planned to find a cause of slow decay (30-40 ms) of the transmitted power. After fixing the cold leak, the cavity will be tested at both 4.2K and 2K. This will allow more accurate residual surface resistance measurements. It is also planned to measure the entire cavity 3D profile with the CMM and to see how the geometrical deviation affects the RF property of the cavity. The results will provide valuable insight how tolerant the spoke cavity is against the fabrication errors and what level of fixturing effort is required during the fabrication.