

## FERMILAB'S MECHANICAL DESIGN AND ENGINEERING OF THE 3.9 GHZ, 3RD HARMONIC SRF SYSTEM

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### Abstract

Fermilab has refined the mechanical design of the Superconducting, 3.9 GHz, 3rd Harmonic System over the past two years. This 2 meter long, 4 cavity cryomodule will be installed at DESY's TTF in 2007. Our design is summarized in this paper to include: the development of the 9 cell niobium cavity; the design of the helium vessel, bladetuner, and cryostat; and the HOM and Main Input coupler designs. This paper reflects the current status of our design.

### CRYOMODULE DESIGN

Working closely with DESY personnel, the cryomodule has evolved into the final design. The 3-D design is complete (see Fig. 1) and the 2-D detailing is near completion. The cryomodule design is a combination of DESY's Cryo-1, -2, and -3 designs. This 3<sup>rd</sup> Harmonic module is installed between the TTF Turn-a-round End-can and a type 2 cryomodule. Due to its location and mounting at TTF, the design required an interface to an earlier TTF cryomodule. However, many of the newer design features found in the Cryo-3 design were incorporated wherever possible.

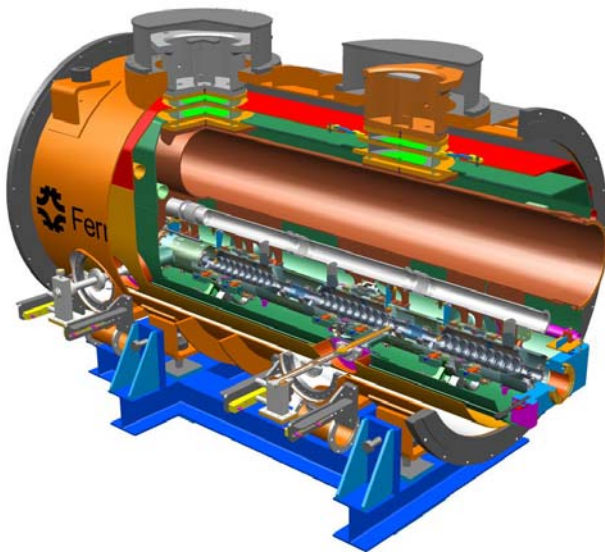


Figure 1: Cryomodule section view.

### CAVITY STRING

Four, 3.9 GHz cavities, four cold main coupler assemblies, two gate valves, helium piping, and interconnect bellows will be assembled, in 2006, into one cavity string inside a class 10 cleanroom. Cavities and helium vessels are being fabricated. Two bladetuners have

been fabricated and tested. HOM couplers are in procurement and will arrive at Fermilab in spring 2006.



Figure 2: Cavity string top.

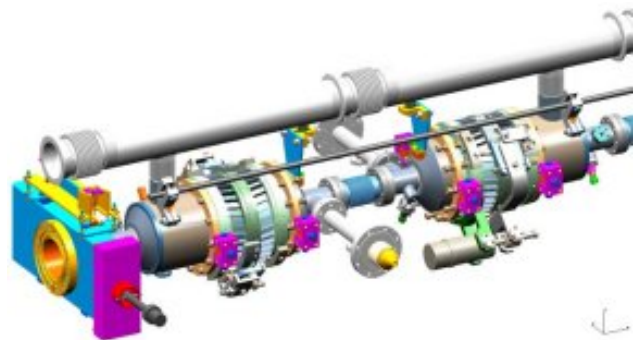


Figure 3: Cavity string isometric.

### Niobium Cavity

This year we suffered a setback when our final equatorial weld on our first 3<sup>rd</sup> Harmonic cavity failed. Attempts to repair the hole created during the final e-beam weld failed as well. We are in the process of cutting out a cavity cell and re-welding a replacement cell. This cavity will be repaired and ready for testing in November 2006. Our second 3<sup>rd</sup> Harmonic cavity is also near completion. JLAB and Fermilab have contracted to produce an additional six cavities.

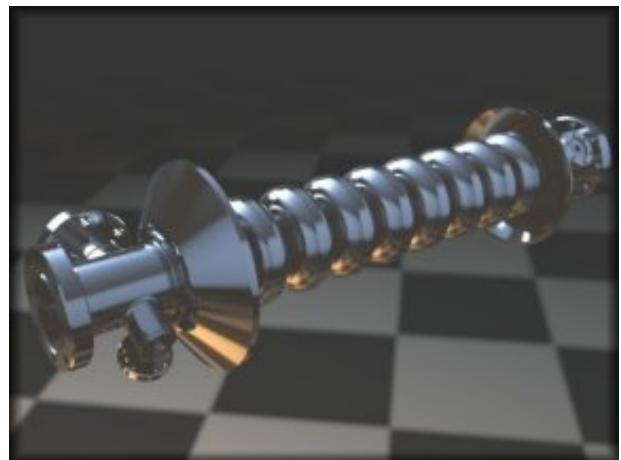


Figure 4: CAD rendered niobium cavity.

### Helium Vessel

The helium vessel (see Fig. 5) has been undergoing small changes over the past two years; mostly for fabrication ease but also to accommodate fixtures used during the acid etching process. The bladetuner was completed one year ago and two prototypes were fabricated and tested with acceptable results. We still plan to make a small change to the motor mount to allow for more heat shield clearance in the cryovessel.

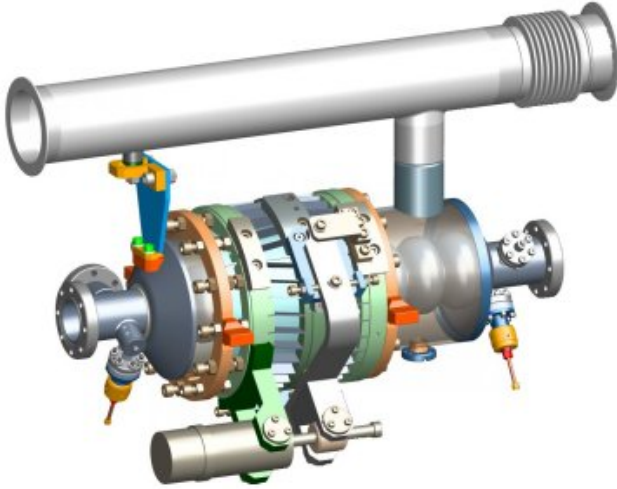


Figure 5: Helium vessel with bladetuner.

### HOM Coupler

The Higher Order Mode coupler was redesigned in 2005. Our engineers worked with industry and performed RF and heat transfer analyses to develop a better design. The new design should be available for testing in January 2006.

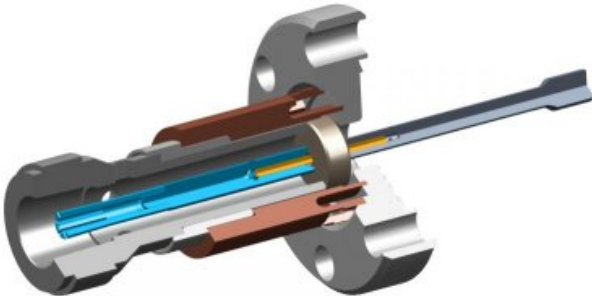


Figure 6: HOM Coupler.

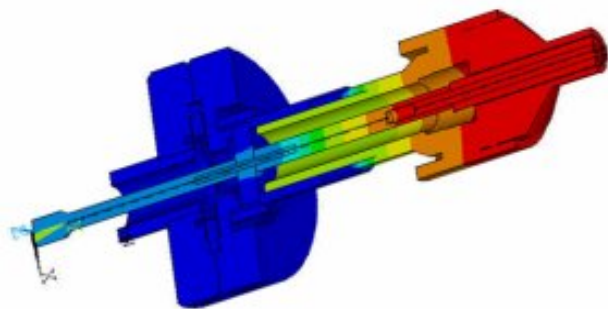


Figure 7: HOM Coupler FEA.

### MAIN INPUT COUPLER

Working directly with CPI near Boston, we have simplified the design of the main input coupler to improve the alignment of the assembly, removed all e-beam welds, and reduced the cost. This coupler is non-biased, non-mechanically adjustable, and utilizes a cylindrical cold window in the cold section and a brazed-in, flat, ceramic window in the warm section. The input power is adjusted to achieve the desired working parameters. We are ordering six couplers with a delivery scheduled for January 2006. A coupler test stand is being designed.

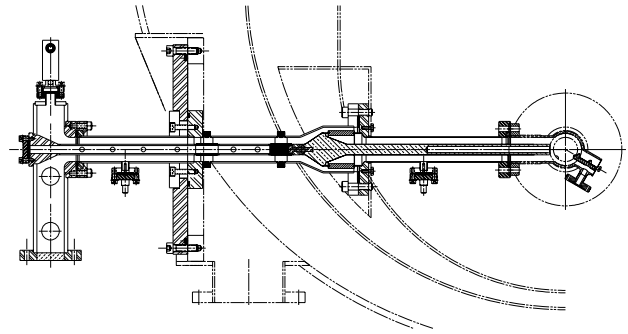


Figure 8: Main Coupler Layout.

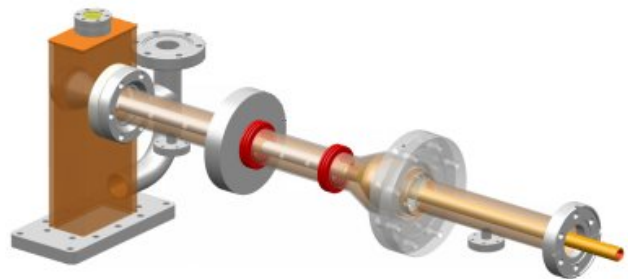


Figure 9: Main Coupler.

### INFRASTRUCTURE

#### Manufacturing

Fermilab purchases pure, RRR 300, Nb sheet from industry, cut disks via wire EDM, and stamp, coin, and machine them into cells. Prior to forming, the disks are inspected for imperfections and inclusions with an eddy current scanner (see Fig. 9) donated to Fermilab by JLAB. E-beam welding (see Fig. 10) is performed near FNAL at Sciaky, Inc. We are exploring alternate facilities as well.



Figure 9: E-current scan.

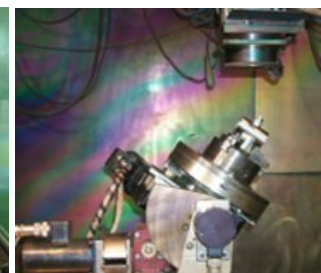


Figure 10: E-beam welding.

In parallel, JLAB is collaborating with Fermilab to produce 4 cavities plus spares. RF and profile measurements of cells as well as field flatness tuning are all performed on-site.

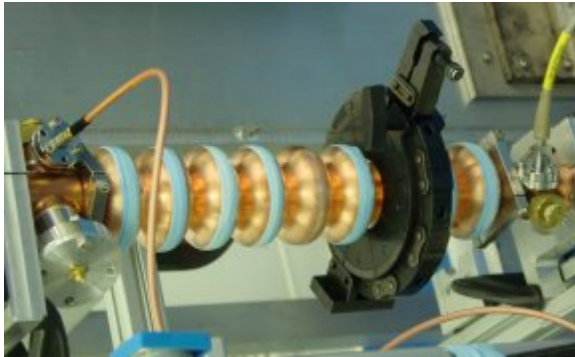


Figure 11: Cell tuning.

### Processing

Fermilab's vacuum bake facility (1000 °C) is used for annealing and H<sub>2</sub> removal. Currently, JLAB's BCP facility is utilized for the acid etching of complete cavities. We have constructed a BCP facility at ANL in collaboration with Argonne which will be operational in 2005. High pressure rinsing with 18MΩ H<sub>2</sub>O in a Class 10 clean room is conducted on-site.

### Facilities

Fermilab is in the process of creating a clean room facility for cavity string assembly and high pressure rinsing. We are also constructing a facility for cryomodule assembly. Fermilab's Horizontal Test Vessel will be operational in 2006 for both 3.9 GHz and 1.3 GHz cavity testing. These facilities will be operational in 2006.

## VERTICAL TESTING

Currently, our test apparatus is being retrofit (see Fig. 12) to accommodate a 9-cell cavity. One year of cavity vertical testing (see Fig. 13) has proven to be quite successful for our three cell cavity. Results without electro-polishing indicate that our cavity design and processing will yield cavities that perform above the design specifications.

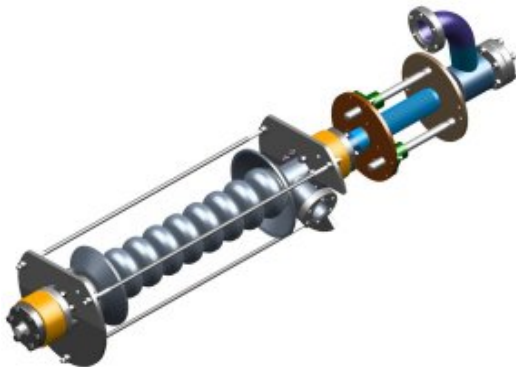


Figure 12: 9-Cell vertical test fixture.



Figure 13: 3-Cell vertical testing.

## WEB-ACCESSIBLE PROJECT DATA

### Project Data

Throughout the entire design and engineering process, the project data is organized and tracked within Microsoft Excel and can be viewed via the internet [1]. The current and easily viewed design intent is shared and discussed between collaborators from around the world. Within this database are CGM, JPEG, ASCII, PDF, DOC, JT, and VRML files as well as complete bill of materials for all assemblies. Material cost quotations, FEA reports, and general layouts are also viewable.

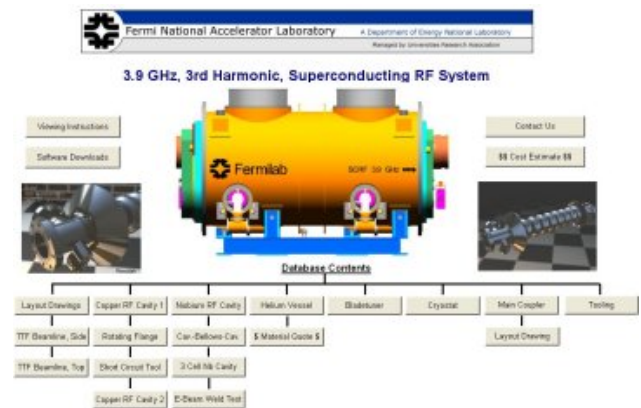


Figure 14: Web accessible database.

### EDMS Data with DESY

We have recently reached a milestone by linking DESY and Fermilab's CAD data via DESY's electronic data management system (EDMS). This is the proving ground that institutes can, in real time, collaborate with each other with live, CAD data that is viewable from the web. We are hopeful that the ILC will adopt this system.

## REFERENCES

- [1] <http://www-td.fnal.gov/lc/sc/lc.html>