MICE RF Cavity Measurements

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July 8, 2010
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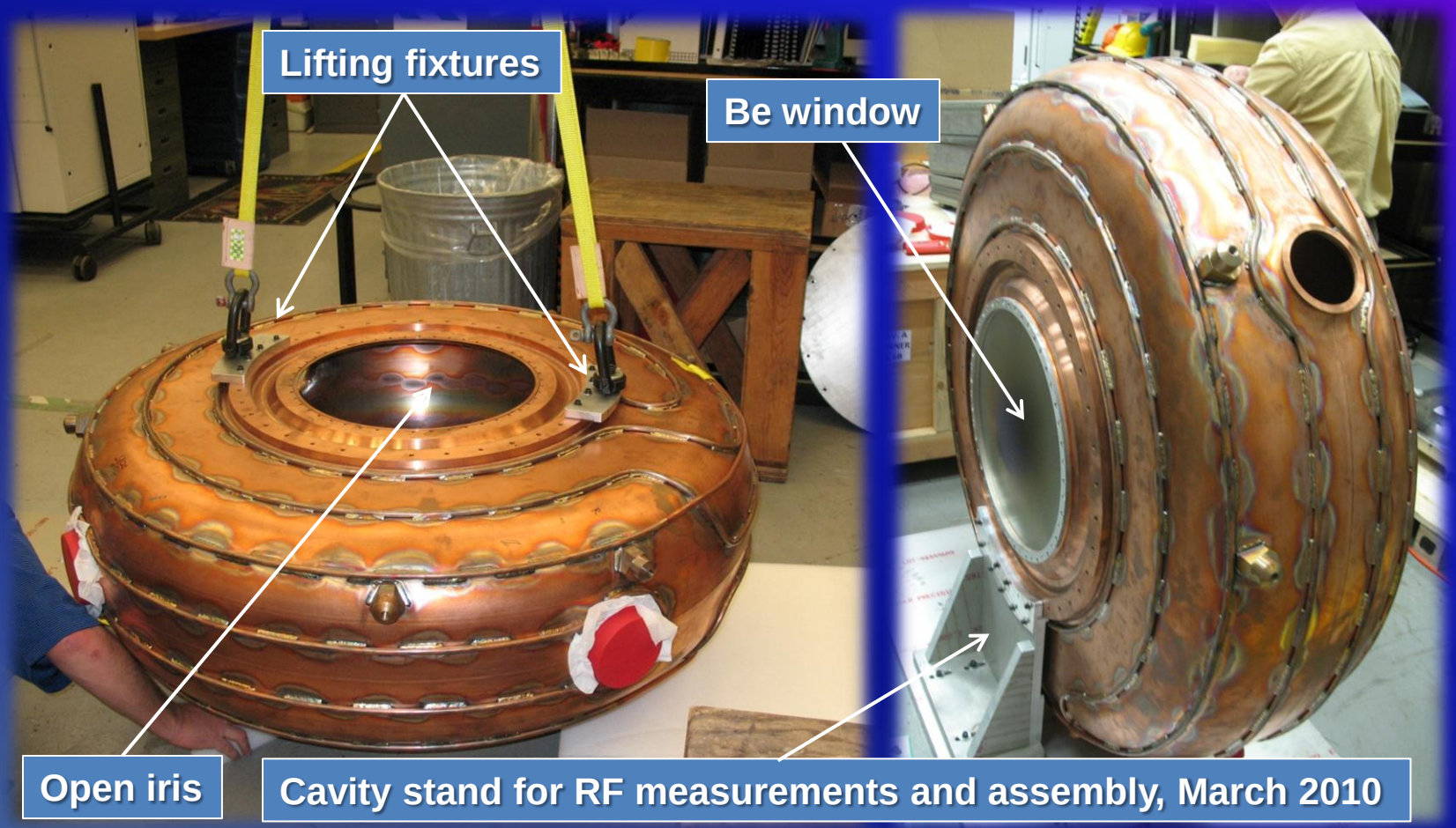
Summary

- Cavity fabrication status
  - The first five MICE RF cavity bodies are at LBNL (received in December of 2009)
  - The second five MICE RF cavities expect to arrive at LBNL in September of 2010
- Cavity measurements
  - Completion of CMM and low power RF measurements of the first five MICE cavities
- Auxiliary components of the cavity
  - Three completed Be windows at LBNL now, 11 windows have been ordered and expect to receive the remaining eight in next two months.
  - RF coupler fabrication in progress & purchase order of 10 ceramic RF windows in process
  - Progress on RFCC module, RF tuner design, prototype and tests (Virsotek's talk)
- Near term plans

Preparation for RF measurements

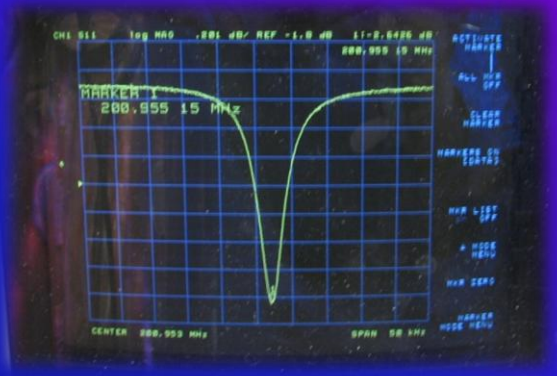


RF measurements

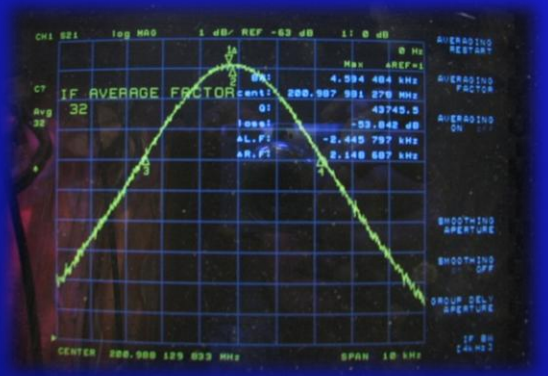
Two curved Be windows (#1 and #2) used as references for all the cavity measurements; require minimum three measurements to determine cavity body frequency

Installation of Be windows for RF measurements, March 2010

RF Measurement Setup, Results

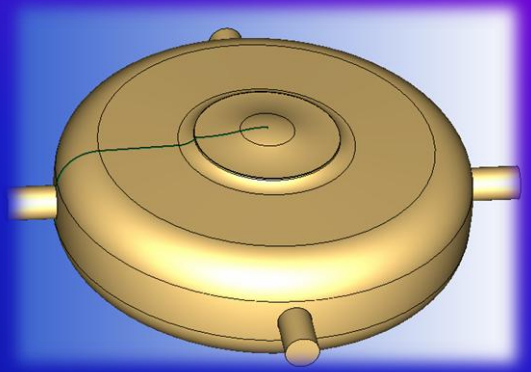


S_{11} measurements



S_{21} measurements

MICE Cavity Design Parameters



- The cavity design parameters
  - Frequency: 201.25 MHz
  - $\beta = 0.87$
  - Shunt impedance (VT^2/P): ~ 22 MΩ/m
  - Quality factor (Q_0): ~ 53,500
  - Be window diameter and thickness: 42-cm and 0.38-mm
- Nominal parameters for MICE and cooling channels in a neutrino factory
  - 8 MV/m (~16 MV/m) peak accelerating field
  - Peak input RF power: 1 MW (~4.6 MW) per cavity
  - Average power dissipation per cavity: 1 kW (~8.4 kW)
  - Average power dissipation per Be window: 12 watts (~100 watts)

Measurement Results

- The first five MICE cavities have been measured in three different window configurations using Be windows #1 and #2 (reference windows)

Cavity #	1	2	3	4	5 (spare)*
Freq. (MHz)	201.084	200.888	201.247	200.740	201.707

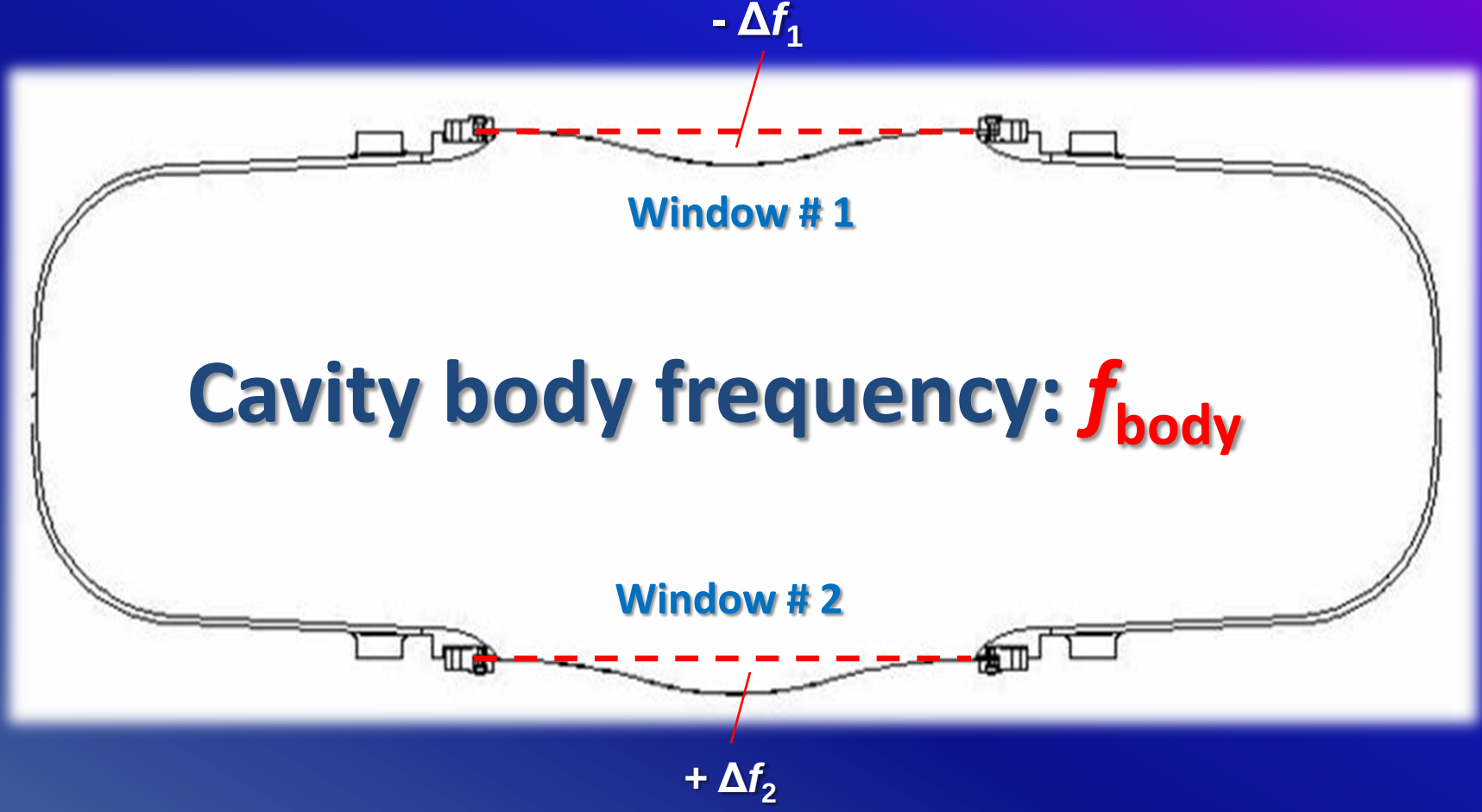
*no water cooling tube brazed to the cavity body

- Average center frequency of the cavity body (#1 to #4) = 200.990 MHz; frequency variations among the cavities ± 254 kHz (within our expectations)
- Q measurements of the first five MICE cavities:

  42,000 – 44, 600 (~ 80% of the design Q)

  (S_{21} measurements using 2 probes with all ports terminated)

Measurement Data Analysis



Analysis of the Measurements

- Additional RF measurements to study frequency shifts due to each RF port
  - Frequency shift of one RF port (from open to short) :

    ~ +11 kHz/port (S_{11} measurements)
- Preliminary analysis
  - Definition of a cavity body frequency (approximately equivalent to the iris terminated by flat metal sheet/window, $f$body
  - Assuming the curved Be windows introduce frequency shifts of $+\Delta f_1$ (out) by window #1 and $-\Delta f_2$ (in) by window #2 and neglecting higher order frequency shifts due to local field changes by the curved window, therefore:

    Measured frequency ≈ $f_{body} \pm \Delta f_1 \pm \Delta f_2$
  - The "±" depends on Be window configurations (curved-in or -out of the cavity body)
  - Require three measurements to determine f_{body}, Δf_1 and Δf_2

Data Analysis (cont'd)

- Curved Be windows
  - Measured three windows so far

Window	#1	#2	#3
Frequency (MHz)	0.691	0.591	0.659

  - Frequency shifts from curved-in and curved-out are different
  - For a given window configuration, the cavity frequency can be predicted within less than 20 kHz using the formulae and measured frequencies of the cavity body and the windows
- Conclusions:
  - Profiles of the two windows must be different (~ 100 kHz or less)
  - Cavity frequency variation within ± 254 kHz
  - Be windows can be used as additional tuning knobs, find best pairs to match with cavities

Near Term Plans

- Low power RF measurements
  - The 2nd batch of five MICE cavities
  - Find center (average) frequency of all (8) MICE cavities
  - Tune cavity a center frequency, in combination with best pair of Be windows predicted by the formula
- Cavity fabrication and assembly
  - Modified port extruding technique at Applied Fusion
    - Better control of local temperature using torch
    - Ports: more consistent, less sagging and good finish
    - Oxidation: argon purge during extruding process
  - Be windows, tuners, RF couplers, RF windows and vacuum vessels
- Post-processing
  - Electro-polishing and cleaning
    - Identified a local company (San Francisco Bay Areas)

Near Term Plans (cont'd)

- **Production of the second batch of five MICE cavities at Applied Fusion**
  - Nose rings
  - Port extruding and flanges
  - Braze water cooling tubes
- **Modified extruding technique**
  - Experimented using the test cavity
  - Need argon gas purge to prevent oxidation of cavity surface
  - Measure oxidation layer thickness

Near Term Plans (cont'd)

– EP: vendor visit

Advanced Electropolishing Technologies

398 Railroad Ct.,

Milpitas CA 95035

- The inside surface of each cavity needs to be electro-polished
- Electro-polish tank dimensions: 12' Long x 5' Wide x 6' Deep
- EP test using the test cavity