SCRF Cavity

Avinash Puntambekar

RRCAT

1.3 GHz single-cell SCRF cavity

- Development work on 1.3 GHz single-cell SCRF cavities was initiated during 2007.
- Forming tool drawings, cavity drawings and fabrication specification and niobium material was given by FNAL.
- Development activities carried out at RRCAT ;
  - Die development and Forming of half-cells
  - Design for manufacturing of single-cell cavity
  - Beam tube rolling & parts machining
  - Welding, machining and RF measurement fixture
  - Various testing including mechanical, vacuum leak and RF measurement

1.3 GHz cavities developed at RRCAT

- Electron beam welding work was carried out in collaboration with IUAC, New Delhi at their facility.
- Cavity processing was done jointly by FNAL-ANL.
- 2 K testing was done at VTS facility of FNAL.

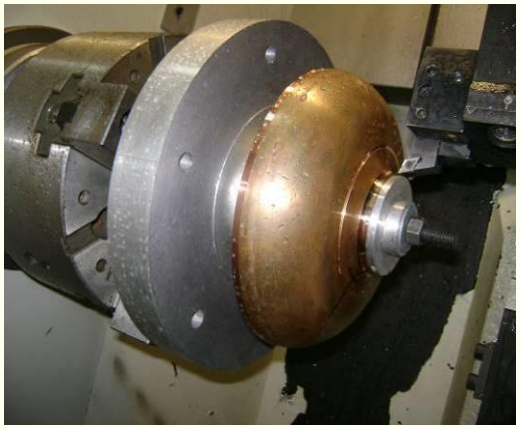
Development of forming tooling

- One set of forming tooling was developed & delivered to Fermilab in December 2008.
- A second set was made and used for making cavity in India.

Long end half-cell forming tooling

Packing & dispatch to Fermilab

Half-cell forming

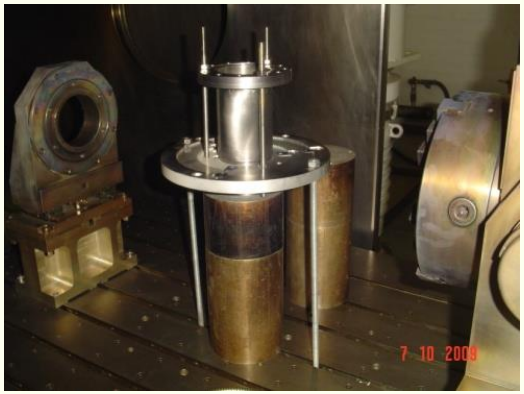


Machining

Inspection

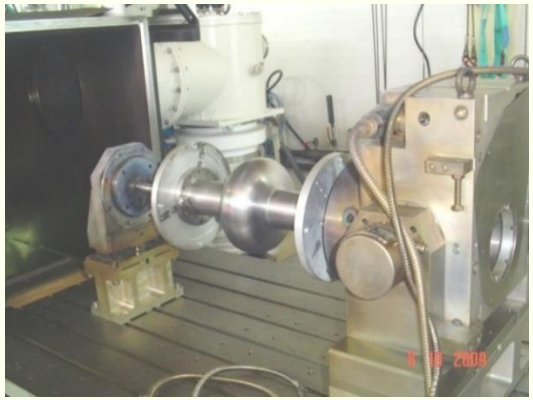
1st formed niobium half-cell

Manufacturing 1.3 GHz single-cell SCRF cavity



Pipe flange welding

Iris welding



Final equator welding

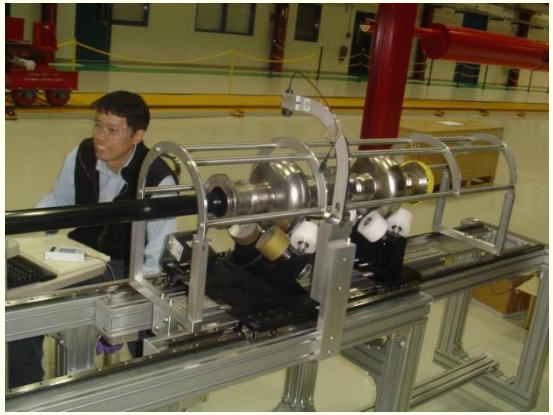
Frequency measurement

Mechanical inspection

Leak testing at 77 K

After all pre-qualification tests the cavities were shipped to FNAL for further processing and testing at 2K for performance evaluation.

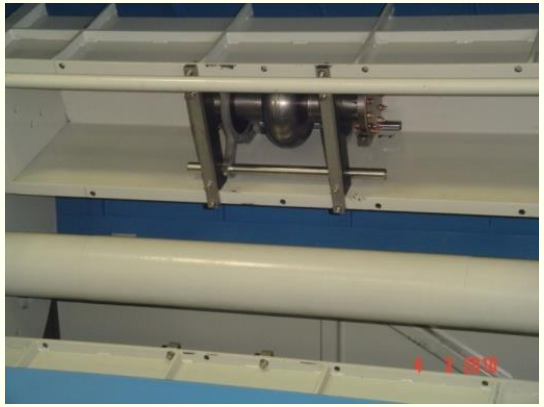
Indian SC Cavity inspection and processing at ANL/FNAL



Optical Inspection @ FNAL

RF Measurement @ FNAL

EP @ ANL



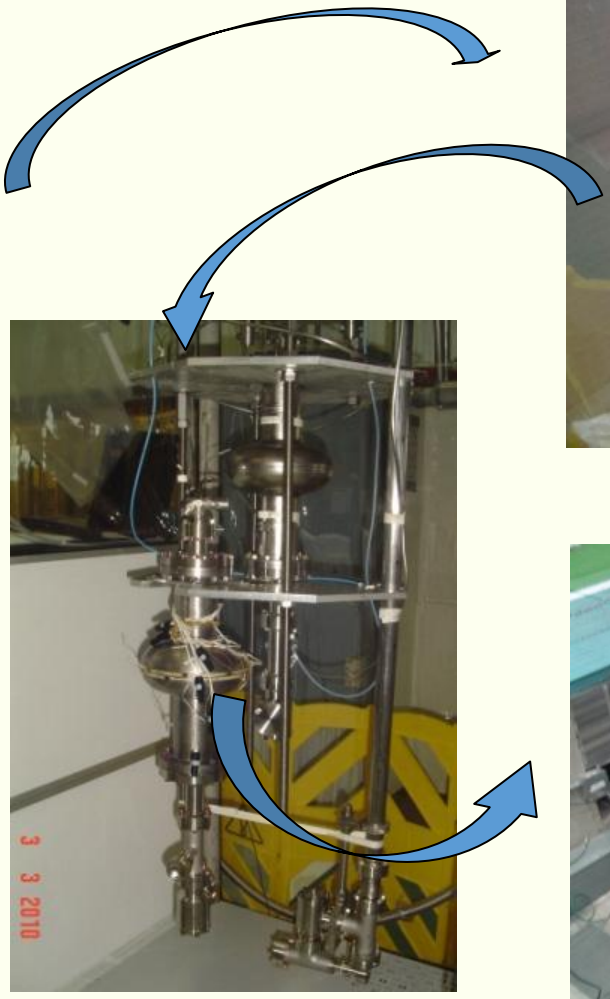
CBP @ FNAL

HPR @ ANL

Cavity assembly in to VTS for 2 K testing at FNAL

Low temp bake

120 C - 48 Hrs



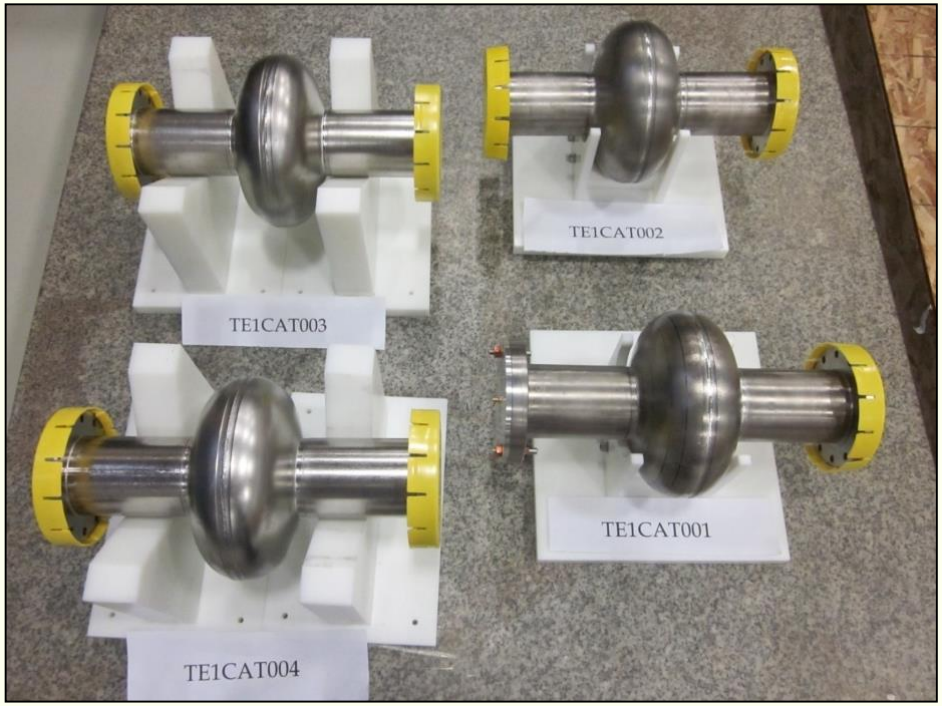
Mounted on the VTS

Cavity connection vacuum & RF

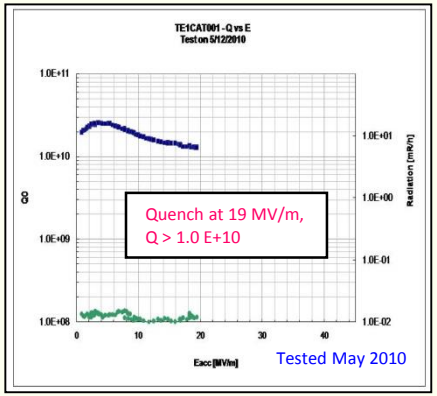
Lowering in to Dewar

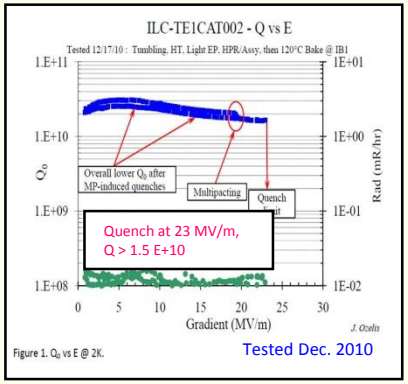
Cold test results of RRCAT 1.3 GHz single-cell cavities

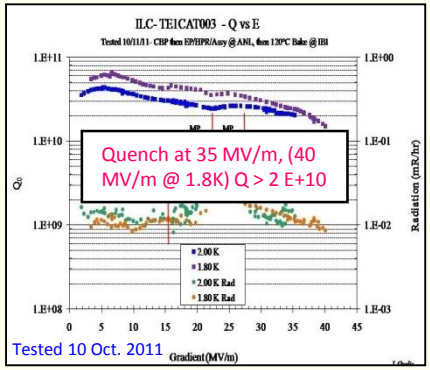
Four 1.3 GHz single-cell SCRF cavities have been fabricated and tested under IIFC during 2009-11.

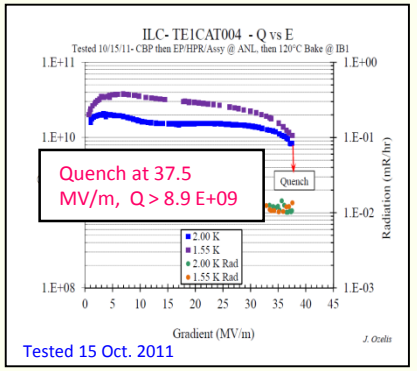


1.3 GHz Single-cell SCRF cavities



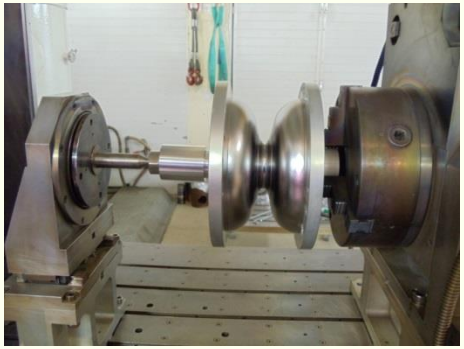






2 K Test results of the 1.3 GHz Single-cell SCRF cavities

Stages of 1.3 GHz Five-cell cavity

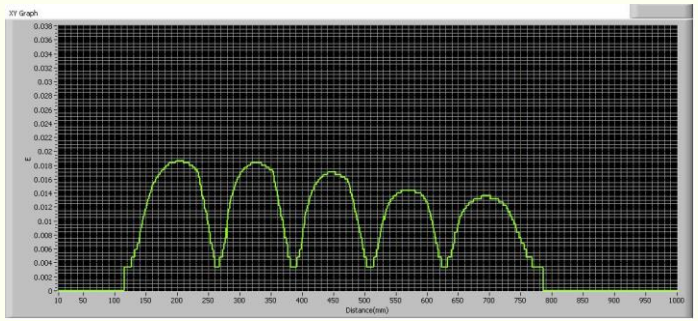


Iris Outside welding

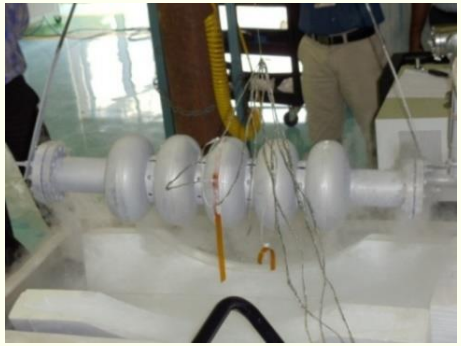
Iris Inside welding

Final mid equator welding

RF testing (Bead pull measurement)



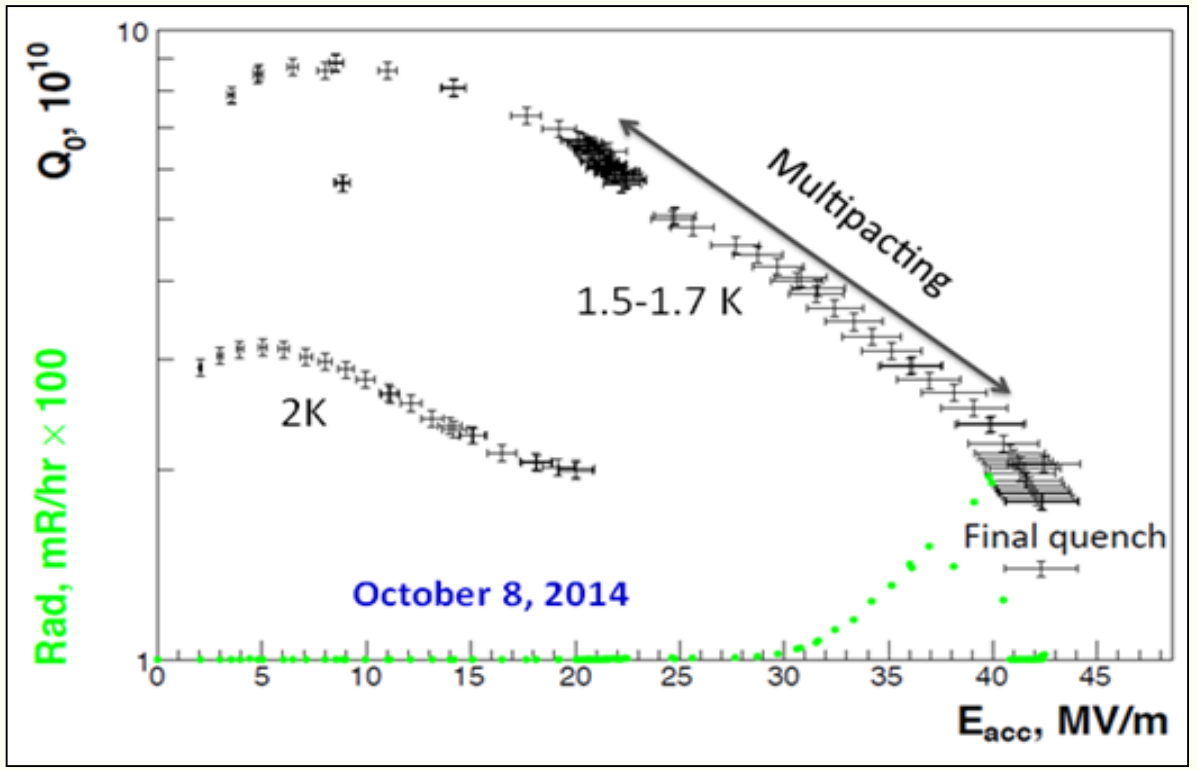
On axis E-field profile
Measured field flatness = 74 %



Vacuum leak qualification at 77 K

VTS test results of 1.3 GHz Five-cell SCRF cavity

1.3 GHz five-cell cavity on vertical test stand at Fermilab

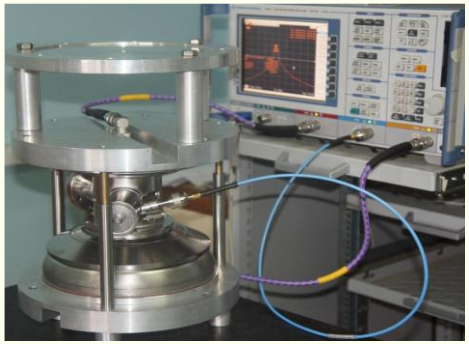


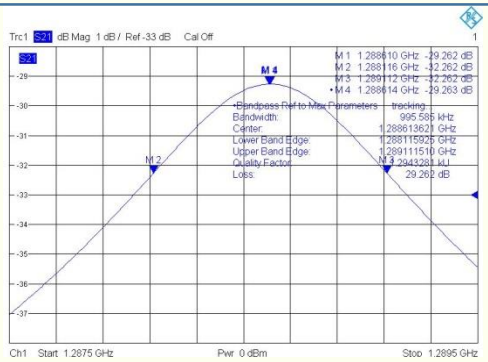
Q vs E_{acc} plot for TE5CAT006

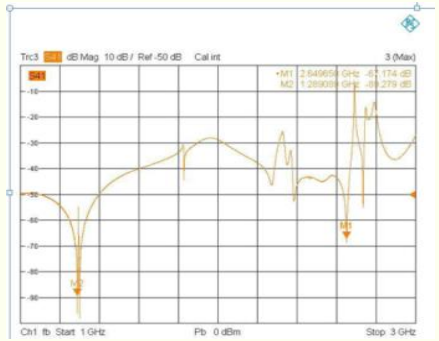
The 1.3 GHz five-cell cavity was tested during October 2014.
The cavity achieved accelerating gradient of 20.3 MV/m at 2 K and 42 MV/m at 1.5-1.7 K with Q_0 of 2 x 10^{10}

1.3 GHz End Group

1.3 GHz long and short end group





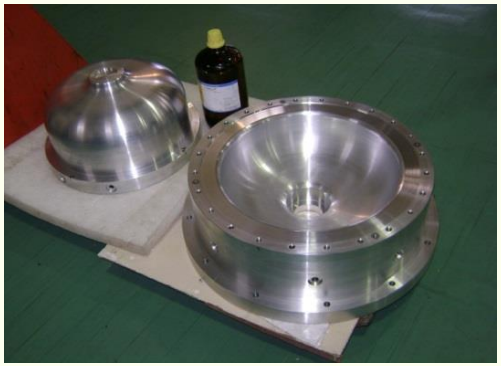


RF testing and qualification

The Antenna for the end group RF measurement was supplied by Fermilab.

Useful guidance and discussion were held with Fermilab for RF qualification of End Groups.

650 MHz (β=0.9) Single-cell SCRF cavity

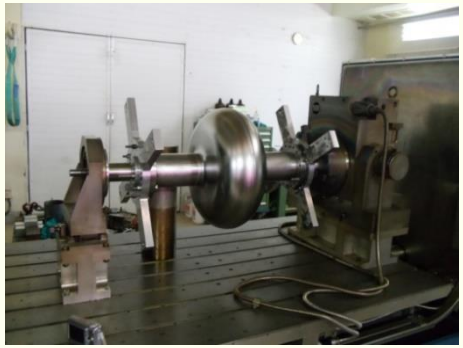


Half cell forming die & punch set

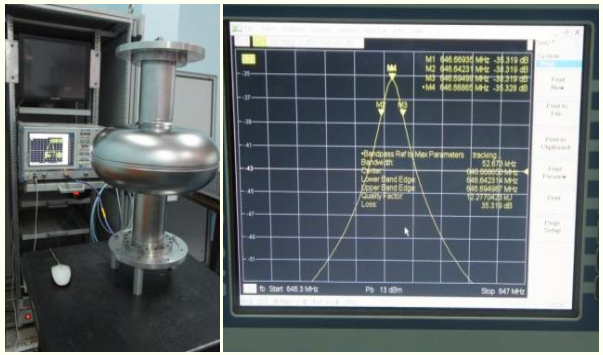
Formed Half cells
(Aluminum, Copper, Niobium)

Half-cell machining

Profile inspection



Cavity fabrication

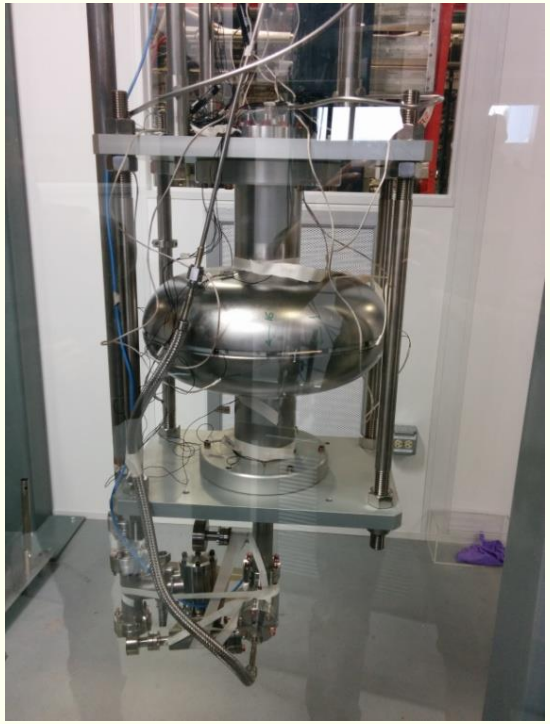


RF testing

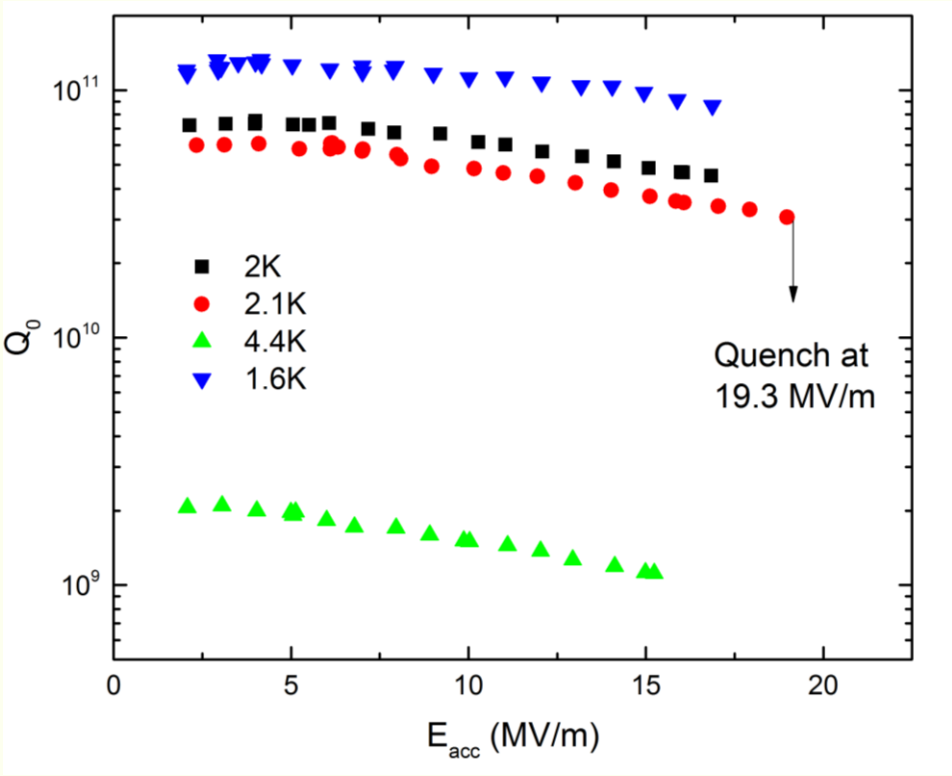
VTS test result of the first Indian 650 MHz (β=0.9) single-cell SCRF cavity

The 650 MHz (β=0.9) single-cell SCRF cavity was tested during January 2014.

The cavity has achieved E_{acc} 19.3 MV/m with $Q_0 > 4x10^{10}$ at 2K.



Cavity VTS mounting



Q_0 vs E_{acc} plot of 650 MHz Cavity

HB 650 SCRF Cavity R&D Phase for Annex-1 Deliverables

- In order to make progress in the timely manner during R&D phase, a lists of initial inputs required from FNAL has been prepared.
- The requested information is categories in three sub categories.
  - Cavity engineering design
  - High purity niobium and other materials
  - Cavity manufacturing and inspection

HB 650 Cavity Engineering Design

Inputs required from FNAL

- Approved Functional Requirement Specification (FRS)
  - Version dated June 2013 available.
- Technical Requirement Specification (TRS)
- Cavity design reports and documents on 650 MHz five-cell cavities designed at FNAL.
- Engineering design parameters and review procedure
- Design validation methodology with prototyping
- Various interfacing subsystems affecting cavity engineering design and how to address them
- Cavity design codes and applicable standards
- Present design status of End Group, Stiffening ring, Transition spool
  - Three design of end group under consideration to be finalised

HB 650 cavity Niobium and other materials

Inputs required from FNAL

- Material specification and acceptance criteria
  - Latest and approval material specification giving electrical, mechanical and chemical properties
- Material qualification-
  - Material acceptance procedure adopted by FNAL
    - 100%, Random sample, Batch qualification ?
  - Tests performed at FNAL with details of test set up /equipment for testing
    - Eddy current scan for 4 mm thickness sheets etc ?
- Final size with tolerances on critical items
  - Nb sheets for Half-Cells, Stiffening Rings
  - Nb disk/ Rod for EG parts
  - Nb-Ti for Transition spool and End Flanges

HB 650 Five-cell Cavity manufacturing

Inputs required from FNAL

- Cavity Fabrication Specification
  - Specifications made for vendors received on 21 Feb. 2015. To be jointly discussed, finalized and approved.
- Sharing of Fermilab experience of manufacturing and testing of 650 MHz (β=0.9) five-cell SCRF cavities
  - Fabrication flow sheets including end group, dumb-bells and final equator welding
  - Design and drawings of various tooling and fixtures for cavity fabrication like forming dies, machining, welding fixtures, handlings and RF measurement fixtures
  - Quality control report (inspection data) of industry made cavities on various testes like mechanical inspection, RF measurement, leak testing etc. on intermediate sub assemblies and final cavity
  - Inspection reports of FNAL made 650 MHz (β=0.9) five-cell cavities
- SCRF cavity "Traveler" to be made during fabrication, processing and testing to be sent to Fermilab along with cavities

HB 650 cavity R&D phase activities - discussions

- HB 650 single-cell cavity
  - Cavity fabrication has been taken up with RRCAT drawing.
  - The drawing approval through team center route to be completed.

- HB 650 five-cell cavity
  - It will be required to finalise and approve the five cell cavity design including Stiffening ring location, end group and interface to He vessel before start of cutting Niobium.

Thanks