# Superconducting Cavity & Infrastructure Development at RRCAT

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# Outline

- Motivation for SCRF cavity R&D Activities
- Major Objective under the Plan Project
- Cavity development
- Infrastructure Facilities planed
- Collaborative Activities under MOU between Indian Institutions & Fermi lab

# Motivation: Link to Major Programs (Domestic and International)

1. **Development of SCRF Science and Technology,** including setting up **of infrastructure facilities for SCRF Cavity for High Energy & High Power Accelerator Applications**
2. **Indian participation in ILC/XFEL/Proton Driver**
3. **Superconducting Materials R & D** for SCRF cavity related research.
4. **Application of SCRF** in development of an infrared source, High Power Proton Accelerator for Spallation Neutron Source etc.

# Project Objective

- Technology development and setting up of an infrastructure for the SCRF cavity fabrication, chemical processing, cleaning, assembly and testing at required accelerating gradient for accelerator applications like SNS, XFEL, ILC etc.
- Establish Cryogenic Infrastructure to operate large systems
- Experimental research in bulk and thin film superconducting materials for SCRF cavities of high gradient and quality factor.

# Development of 1.3 GHz TTF Cavity Forming and Machining Tooling

- **Manufactured and qualified one complete set of forming and machining tooling (Mid half cell, Long end half cell, Short end half cell) for TTF cavity.**

- **One complete set of forming tooling transported to Fermilab.**

- **Developed Niobium grade RRR 300 half cells for 1.3 GHz SC Cavity.**

Forming tooling

Half cell machining

CMM inspection

Formed half cell

# First EB welding trial

## 1.3 GHz Single cell Aluminum Prototype

RRCAT



**Made in collaboration of –**

**RRCAT, Indore – Indian Industry , LTE, Coimbtour**

EBW Machine : 06 kW, 60 kV; Chamber size 0.5 m x 0.45 m x 0.45 m
M/s Techmeta, France

# Half Cell with Beam Pipe of 1.3 GHz Single cell Cavity in Niobium

**Made in collaboration – RRCAT, Indore – IUAC, New Delhi**

EBW Machine : 15kW, 60 kV; Chamber size 2.5 m x 1.0 m x 1.0 m
M/s Techmeta, France

# End Group- Design for Manufacturing

## Objectives:

- Easy manufacturing
- Economy
- Concurrently address the issue of reference alignment
  (HOM coupler head or extended bracket.)

## Approach

- Machining of entire end group from a single cylindrical block.
- Extensive prototyping and testing planned.
- A solid cylinder will be removed from inside by EDM wire cut process.
- This solid part will be used to make other components like form teil housing.

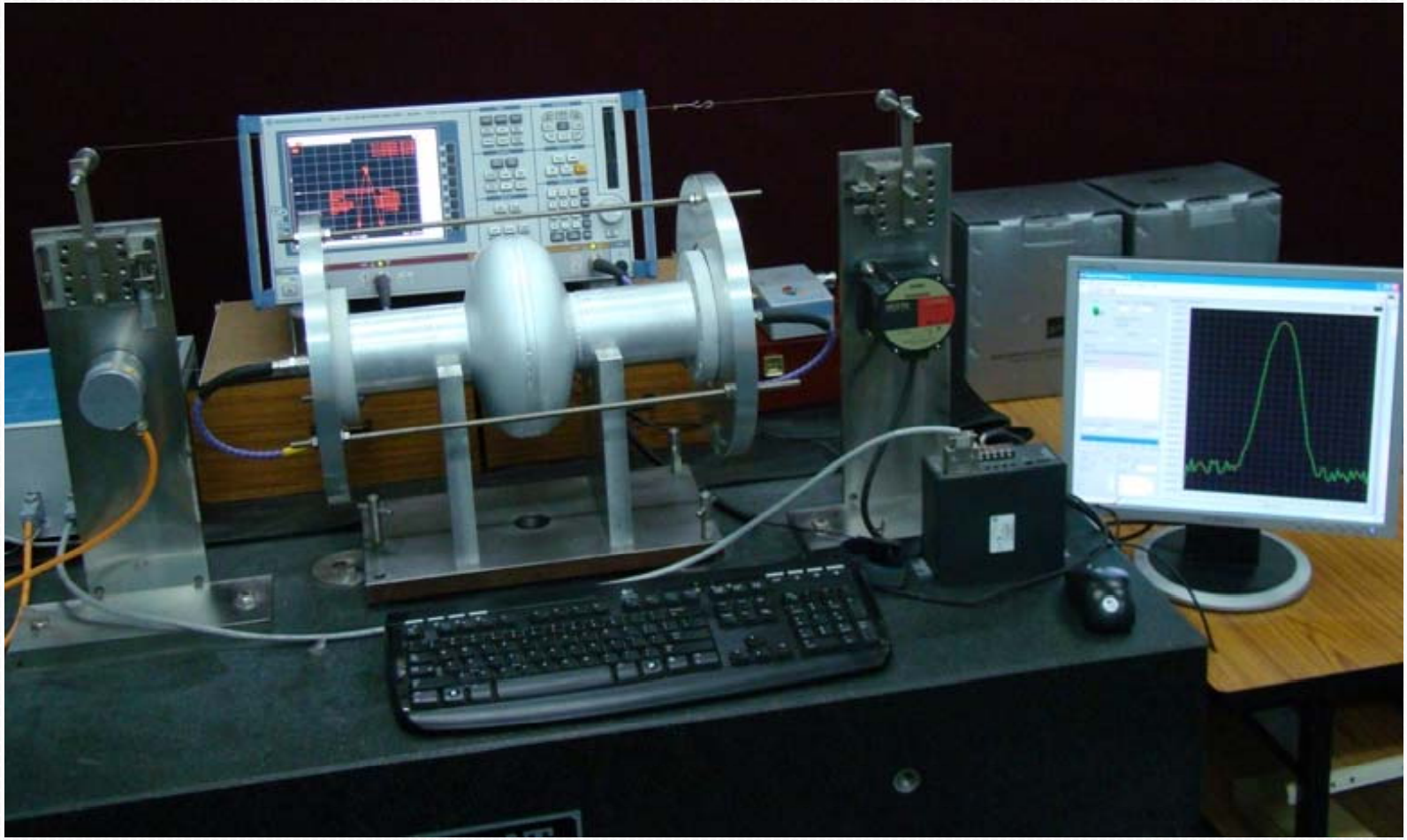
## Status

- Prototypes in Copper and Low RRR niobium block completed.

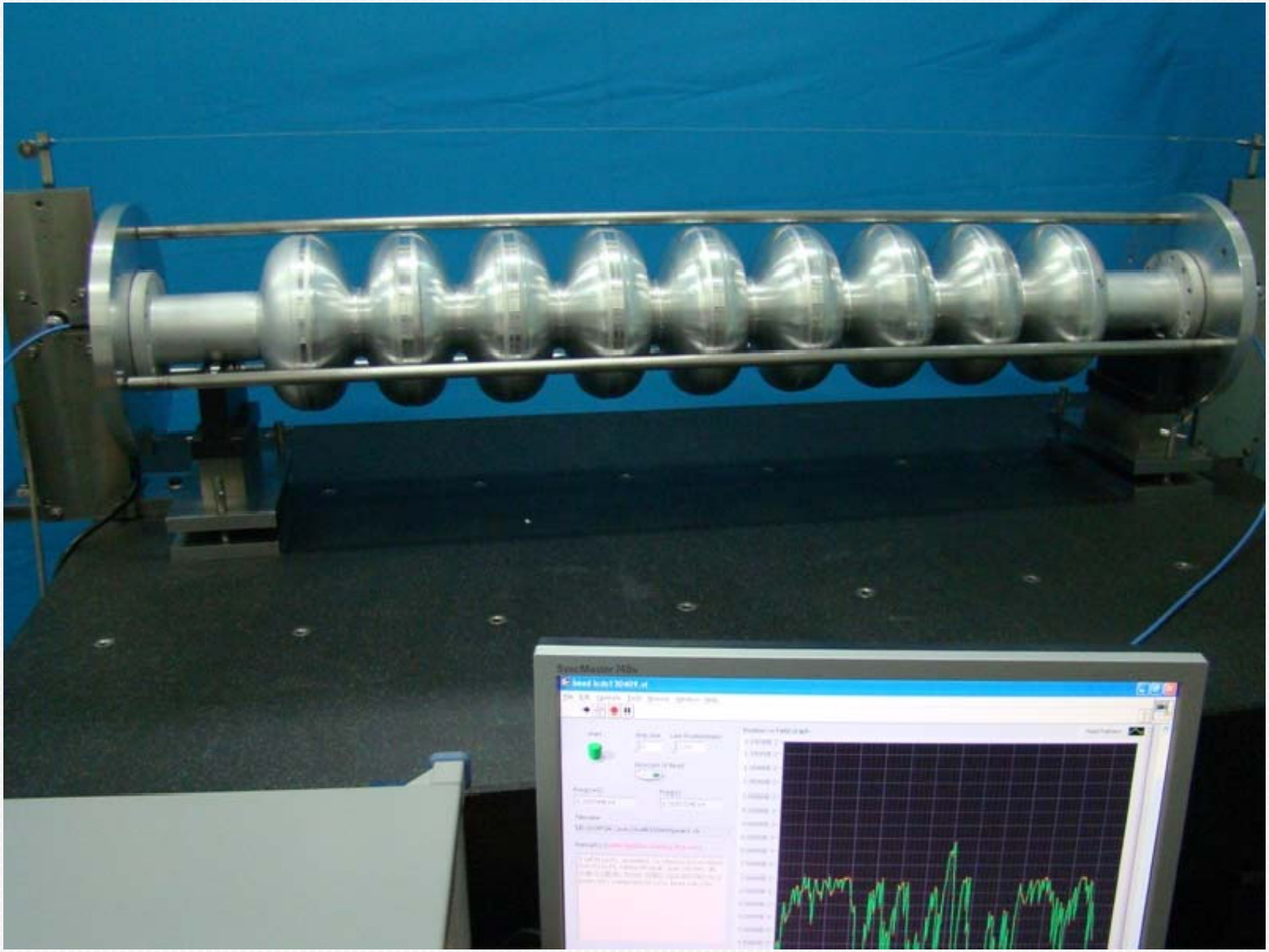
Prototype in Copper

Prototype in Low RRR Nb

# Bead Pull Measurement Setup with Single Cell Cavity

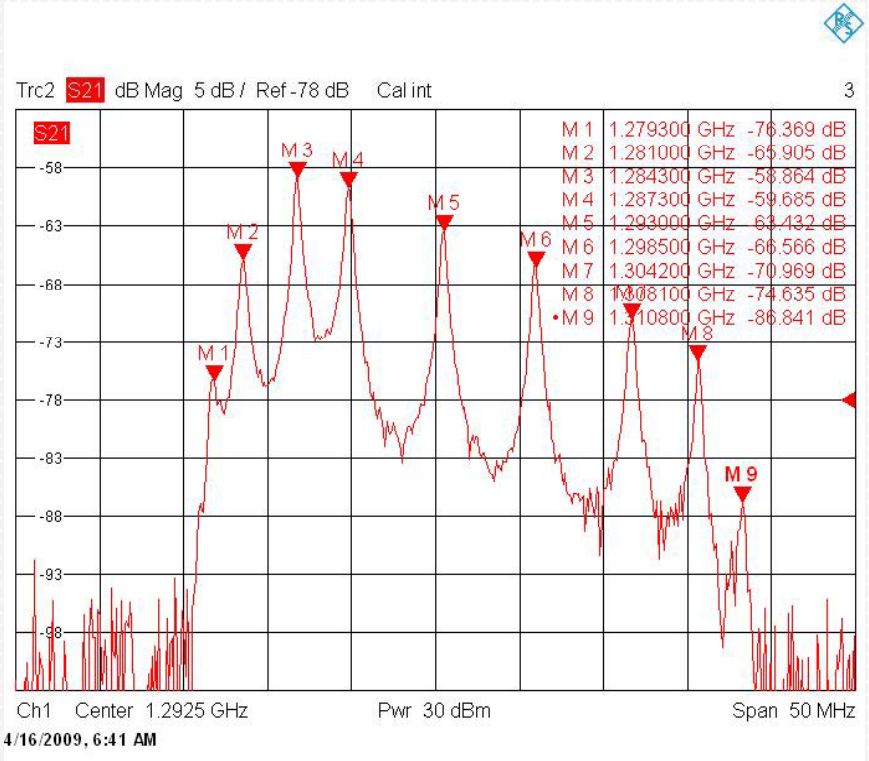


# Assembled 9 Cell Cavity (Al) on Bead Pull Measurement Setup

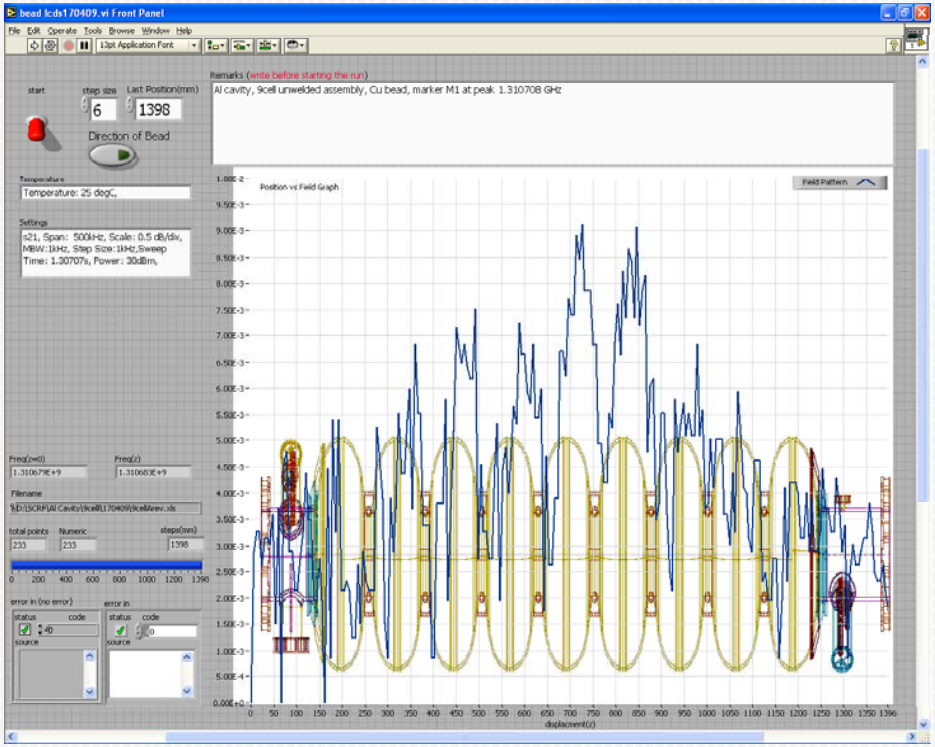


# Frequency & Bead Pull Measurement of 9 Cell Assembled Al Cavity

## Frequency Measurement




## Bead Pull Measurement (screen shot)



# New Facilities Planned at RRCAT

Setting up of SCRF cavity fabrication (120 Ton Hydraulic Press, Facility for Nb machining, EBW Machine etc.),

Chemical & thermal processing facilities (EP/BCP/CBP, HPR & Annealing Furnaces etc.),

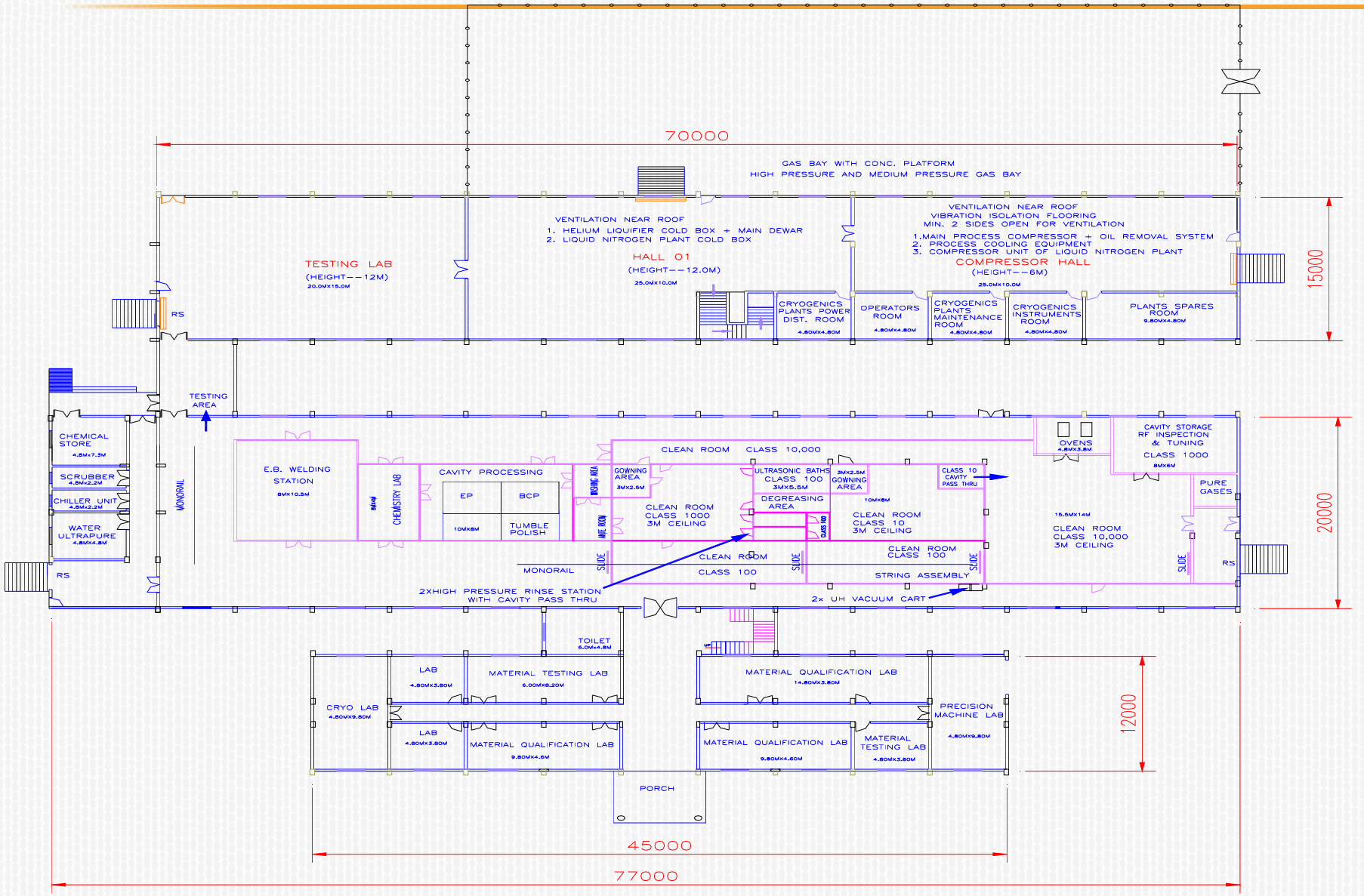
Assembly & testing set up. (Clean-room, Test cryostats, RF sources etc.)

Cryogenic infrastructure, (Bigger Liquid He Plant, Liquid N2 Plant and Accessories for Larger Cryogen & Gas Handling Systems etc.)

Experimental facilities for superconducting materials research. Add to presently available (magnetic, electrical & thermal conductivity measurements)

Facility to support cavity design, fabrication & processing (UTM, CMM, SIMS, Eddy Current Scanner etc.)

# Building Plan for SCRF Cavity R&D



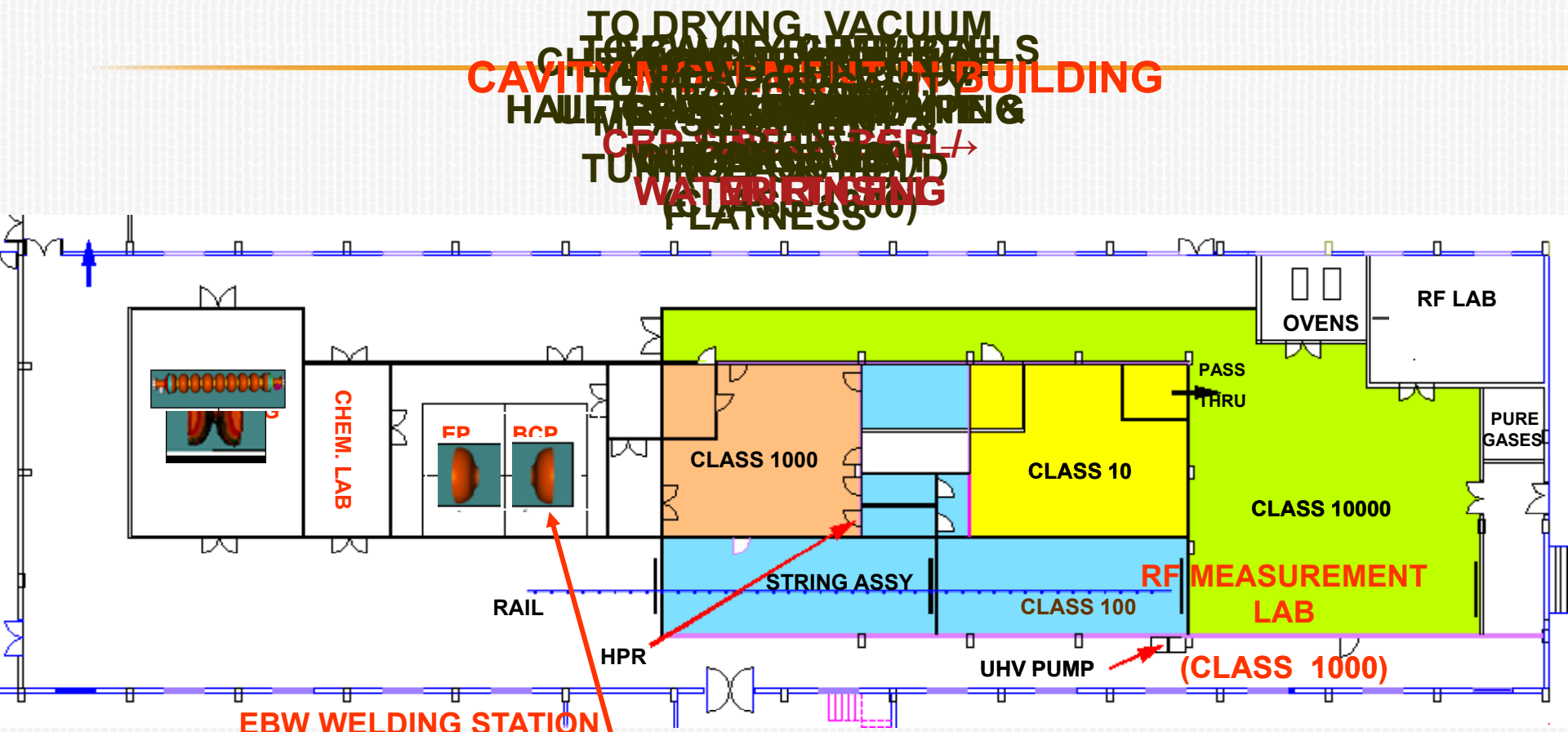
# Proposed Clean Rooms

- A set of 4 clean rooms are planed as a part of Superconducting cavity processing and assembly facility.
- Clean rooms will be as per FS-209E/ISO standard
  - Class 10000 General assembly area,
  - Class 1000 Ante Clean room and
  - Assembly clean room divided in Class 100 and Class 10.

  The division between class 100 and class 10 area will be with plexiglas panel divider from ceiling, as short as possible to permit easy access between the adjoining areas of class 100 and class 10.
- The sizes indicated for the clean rooms are tentative.
- Federal Standard FS-209E/ ISO classification system or equivalent will be used for the clean room class specifications.

# CLEAN ROOM FACILITY

RRCAT




| Proposed Clean Room Facility | |
|---|---|
| Class-10 | 80 sq m |
| Class-100 | 120 sq m |
| Class-1000 | 130 sq m |
| Class-10,000 | 230 sq m |

# Clean Room Area

Modular Clean Area
Size = 6 m x 4 m
HEPA & ULPA FFU = 12
Assembly and measurement Area

# 120 T – HYDRAULIC PRESS

RRCAT

## CAPACITY

MAIN RAM : 120 TONS

MAIN RAM STROKE : 400 MM

DIE CUSHIONING: 40 TONS

DIE CUSHINING STROKE: 200 MM

CLAMPING : 20 TONS

DAYLIGHT : 600 MM

BOLSTER PLATE SIZE : 900MM X 900 MM

## Machine Installed:

March 2009

Forming of Al Half Cells

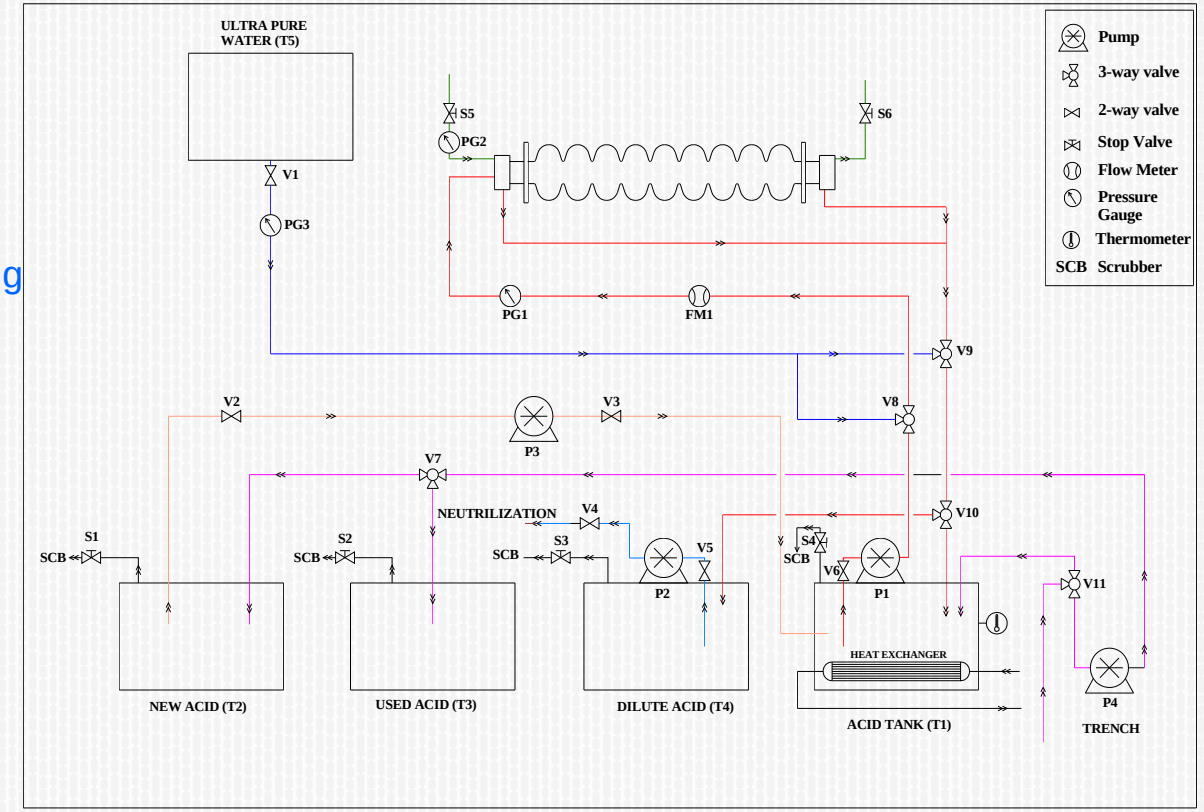
# Proposed EBW Machine

Major Specifications

- Electron Gun– 15 kW – 70 kV,
- Welding chamber Suitable for a job size: 1300 mm (L) x 1000 mm (W) x 1000 mm (H) with two suitable pumps for vacuum ~$1x10^{-7}$ mbar and run out platform.
- Y axis, by the Electron Gun, 200 mm travel, CNC controlled.
- X axis, by the worktable, 1300 mm travel, CNC controlled.
- CNC Rotary Manipulator with tail stock
- Motorized Tilting system, 0° to 90°
- General Control System with CNC

# Plan for EP Setup

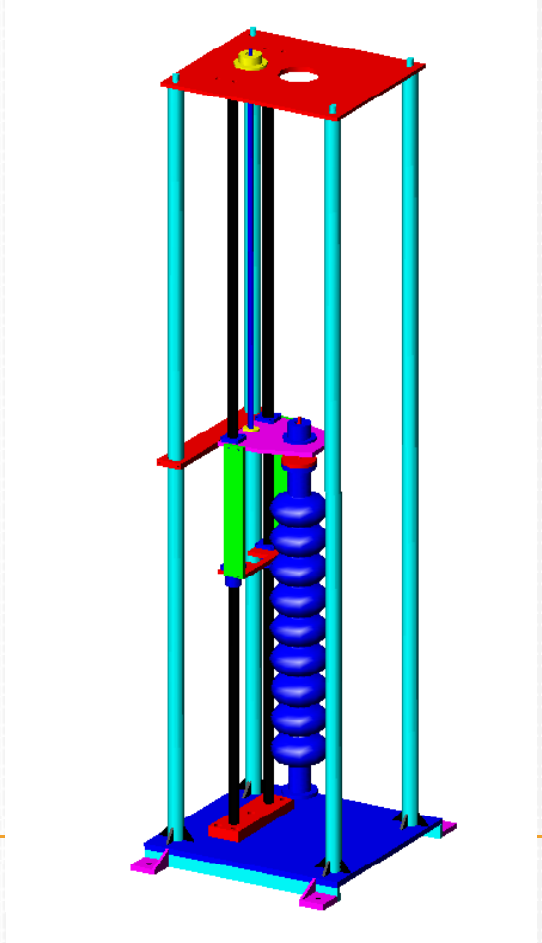
- Electro polishing Bench (Single cell / Multi cell)
- Acid Storage, refrigerator and handling system
- Heat Exchanger for EP solution
- Scrubber Unit (Acid fumes from EP)
- Chemistry Lab support for EP,BCP
- Used Acid and affluent Collection & neutralization
- PLC Control Power supply ( 0-25 V, 1000 A)



# High Pressure Rinsing Stand

## Features:

- Cavity Rotational speed: 10-100 RPM
- Vertical Stroke: 1300 mm
- Vertical movement speed: 300 mm/min
- Ultra-pure water jet pressure: 80 – 100 bar
- Structure made of SS304
- Installed in Class 100 clean room



# Plans for Enhancement of Cryogenics Infrastructure

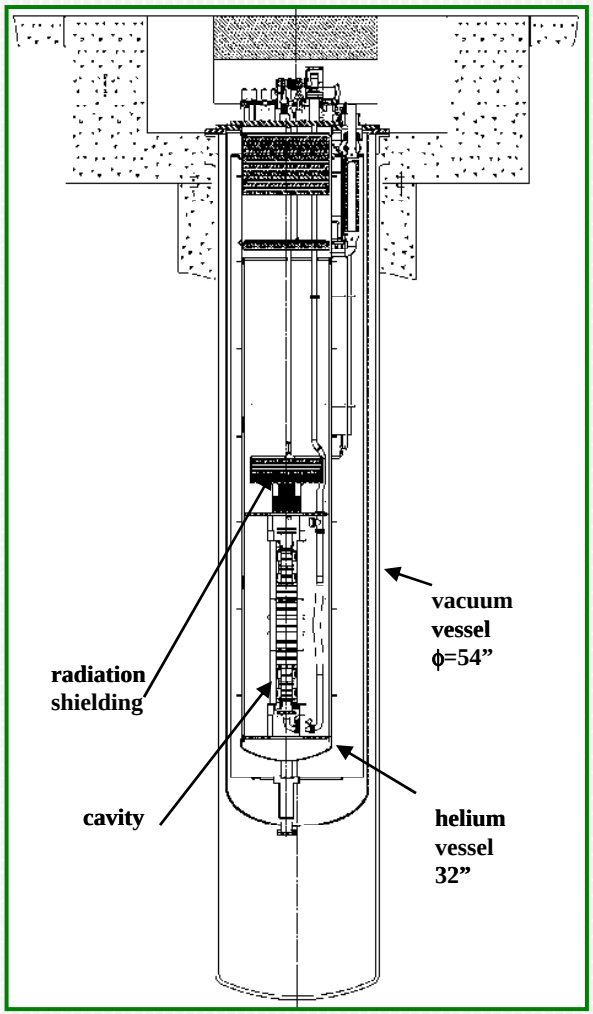
- Development of infrastructure required for
  - Saturated bath type vertical Test Cryostats: 2 K (For Sensor calibrations, RRR measurements etc.)
  - Vertical Cryostat for testing SCRF Cavities: 2 K
- Development of Horizontal Test stand for high power testing of SCRF Cavities at 2K.
- Development of Cryomodules

Augmentation of present facility of liquid Helium and Liquid Nitrogen production to

Approx. 200 lit/hr LHe with 10,000 L storage capacity

Approx. 400 lit/hr of Liquid Nitrogen.

# Development of VTS-2 in collaboration with FNAL

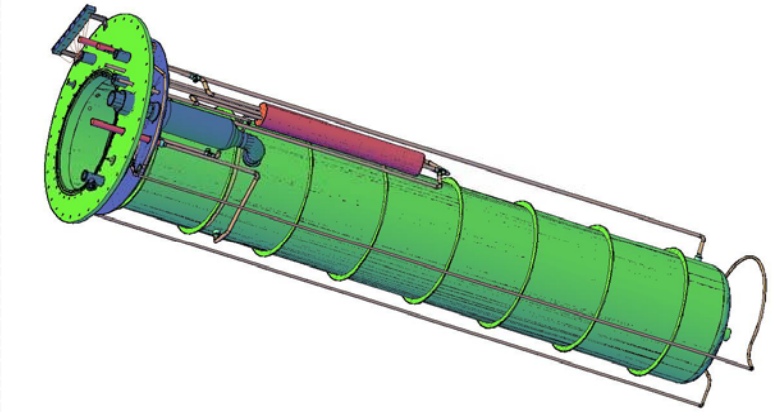



- Single & 9-cell Tesla-style cavities (2 – 6 cavities)
- Single Spoke Resonator cavity 325 MHz
- Triple Spoke Resonator Cavity 325 MHz
  - Measure Q vs. T ($T_{min}$~1.5 K)
  - Measure Q vs. $E_{acc}$ at 2 K
- cryogenic capacity ~250 W at 2 K
- Magnetically shielded cryostat
  - External (room-temperature) Amumetal® (80% Ni alloy) and internal Cryoperm 10® magnetic shield, designed to attenuate field to <0.01 G at cavity
- Radiation shielding to maintain “Controlled Area” status
  - < 5 mrem in an hour immediately outside the shielding

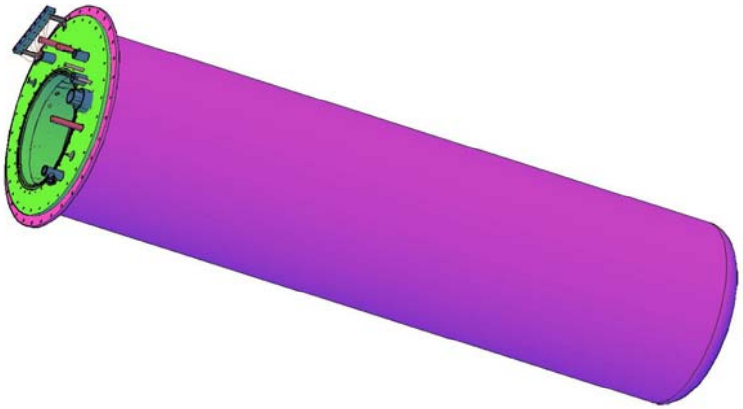
# VTS-2 Development

- Design study of 32” bore VTS-2
  - Engineering design of
    - LHe, Vessel, 80 K shield, Top Flange,
    - internal & external magnetic shield
    - Vacuum Vessel (54” OD)
    - JT Heat Exchanger
- Design & Fabrication of VTS-2 at Indian Industry
- Evaluation of VTS-2 at RRCAT

LHe Vessel of VTS-2



Assembly of VTS-2



Thank You