Raja Ramanna Centre for Advanced Technology:
Expression of our interest in joining TTC

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RRCAT

INDORE-INDIA

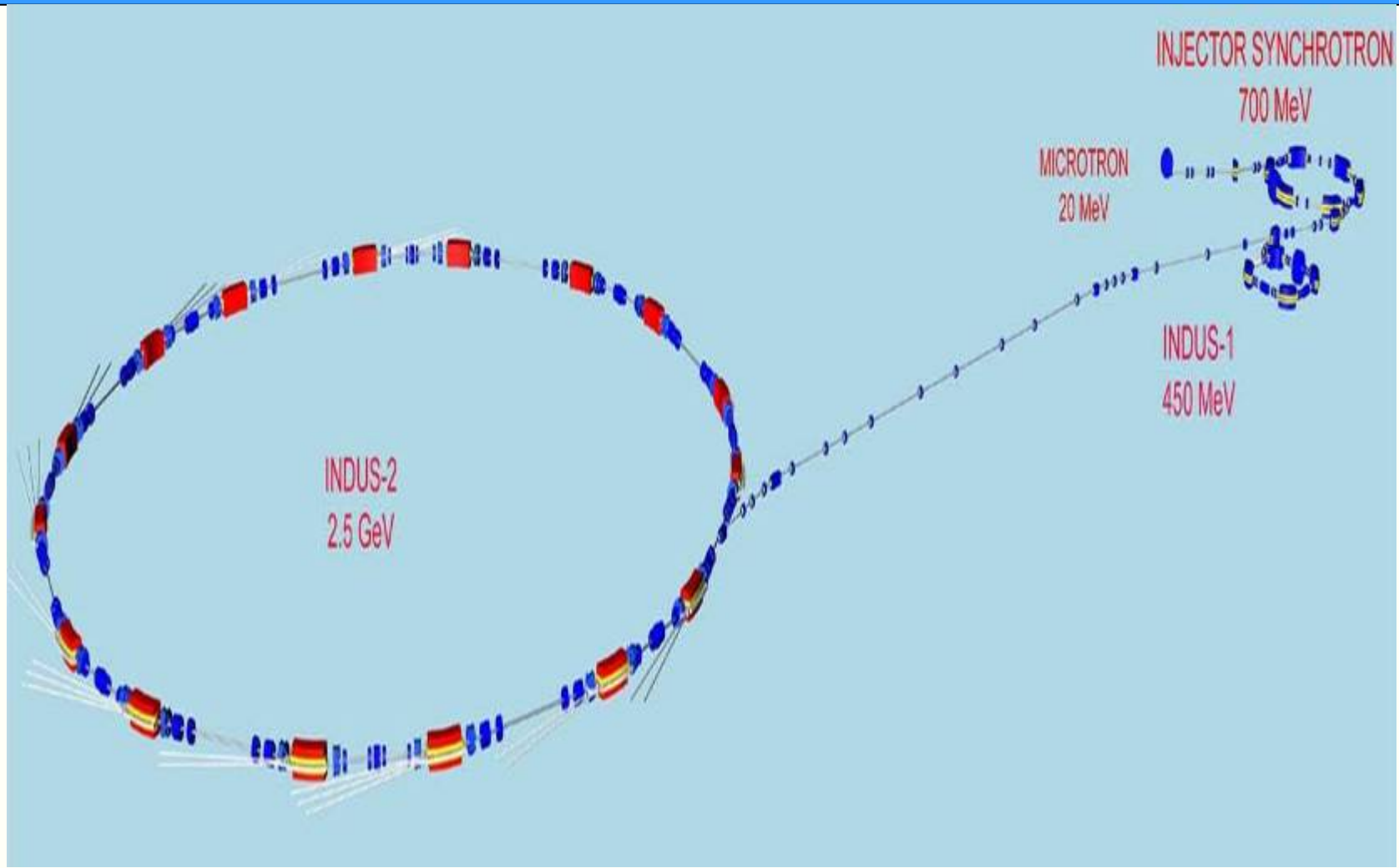
Outline of the talk

- **Present Accelerator Program**
  - **Synchrotron Radiation Source (Indus-I & II)**
  - **Small Accelerators (Irradiation and THz Application)**
  - **Laser Development and Laser Based Electron Acceleration**
- **CERN Collaboration**
  - **LHC (Corrector Magnets, Magnet Stand, Quench Protection System, Magnetic Measurement)**
  - **Linac-4**
  - **CTF3**
- **Indian Future Accelerator Program**
- **SCRF and RF Program at RRCAT**
- **Expression of interest to join TTC**

Present Accelerator Program

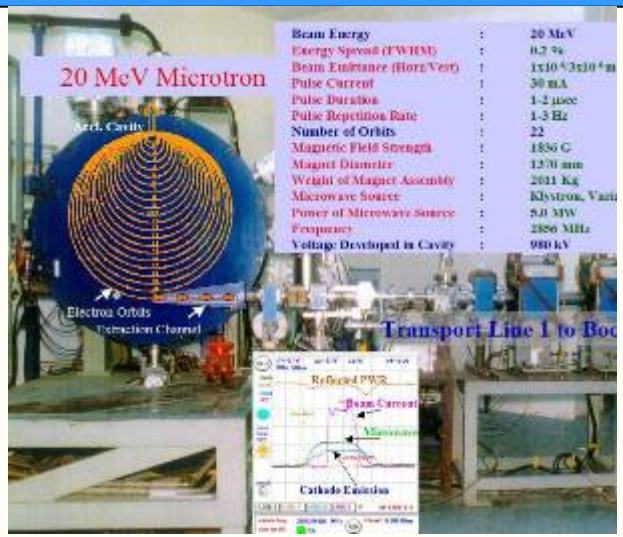
- **RRCAT is the home of India's 1st 2.5 GeV Synchrotron Radiation Source (Indus-II)**
  - **Intense focus on indigenous development & qualification through home based efforts.**
    - **RF Cavities, Magnets, Power Supplies, Vacuum Chambers, Pumps & gauges, Beam Diagnostic, RF drivers, Controls System etc.**
  - **The Indus-II accelerator is under commissioning**
- **750 keV ~ 20 kW DC accelerator**
  - **Polymer grafting**
  - **Medical sterilization**
  - **Surface irradiation of potatoes and seeds**
- **10 MeV, 10 kW Electron Linac**
- **THz Radiation Source**

Schematic View of Indus Complex



Status:Indus-2,~35 mA accumulated, Injection @550MeV, beam energy ramped up to 2.4 GeV.

Indus-I



Injector Microtron

Booster Synchrotron

Indus-1 Storage Ring

Beam Lines of Indus-1

- **Reflectivity – TGM (40 – 100A)**
- **Photo physics – SN (500 – 2000A)**
- **Angle resolved PES – TGM (40 – 1000A)**
- **High resolution VUV Bl–RC (700 – 2000A)**
- **Angle integrated PES – TGM (60 – 1600A)**
- **Photoabsorption (PASS)–PGM (17 – 225A)**

Indian Developed Components for Indus-II

Magnet

Vacuum Chamber

Beam profile monitor

Power Supplies

Indus –2 RF Power System

Indus-II

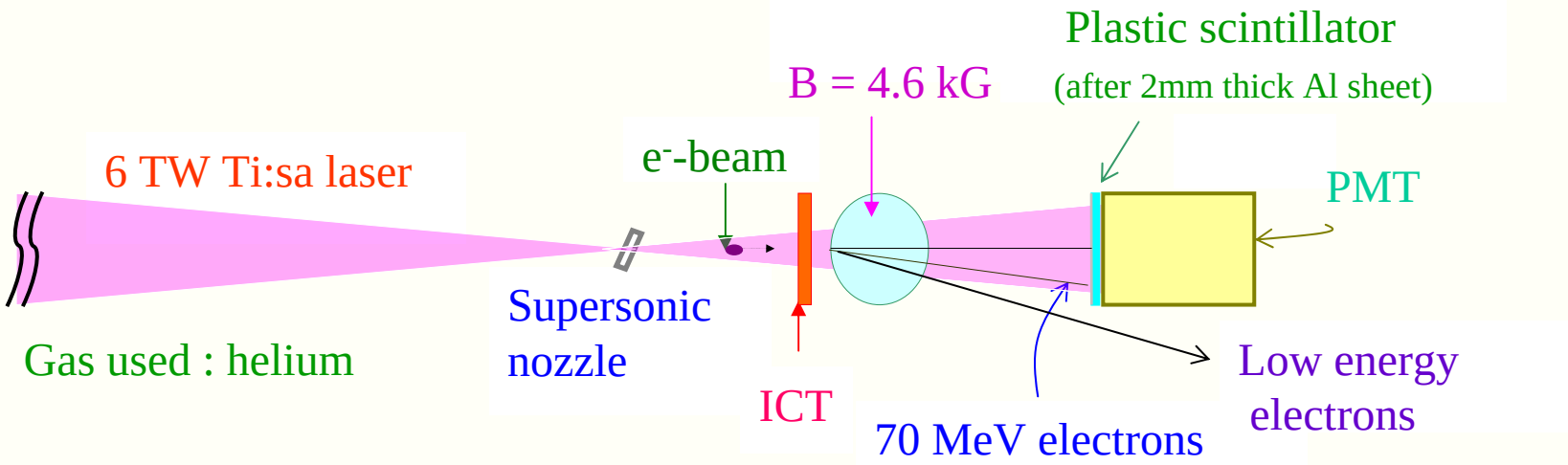
Indus-2 Ring in the Tunnel

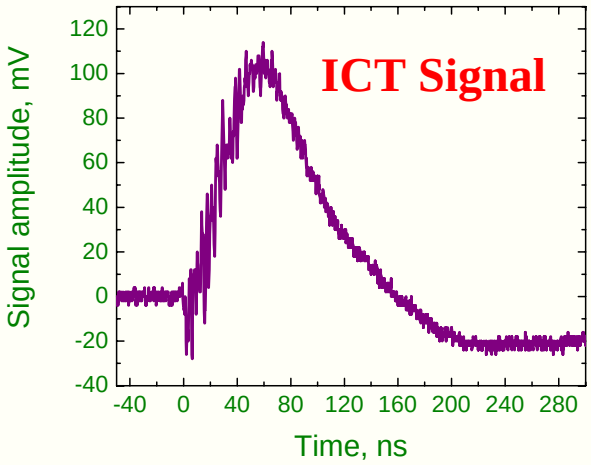
RF Cavities installed in Indus-2 Ring

Long Straight Section LS-6 Assembly

Transport Line-3 Joining on to Indus-2

Laser Based Electron Acceleration





Electron energy > 70 MeV

Total charge: 2.7 nC

No. of electrons ~ 1.7×10^{10}

India HEP Collaboration with CERN

- **Indian scientists have been collaborating at CERN for decades.**
- **Its participation and contribution to LHC has given India an "Observer State" status with CERN.**
  - **Indian in-kind contribution to LHC are valued @ "European costs" of ~44MCHF**
- **India has built accelerator and detector components for CERN**
  - **LHC**
    - **Super-Conducting Corrector Magnets**
    - **LHC Magnet Stand**
    - **LHC Protection System**
    - **Vacuum System**
    - **Cryogenic System**
    - **Engineering Analysis**
    - **Software Development, including Grid Computing**
    - **Support/Alignment**
    - **Magnet Measurement**
  - **CMS**
    - **Silicon Detectors**
    - **Scintillator Detectors**

LHC Contributions

7080 Nos. Magnet Positioning System Jacks

MCS (1146 Units) & MCDO (616 Units)

Magnetic measurements teams- ~100 Man-years

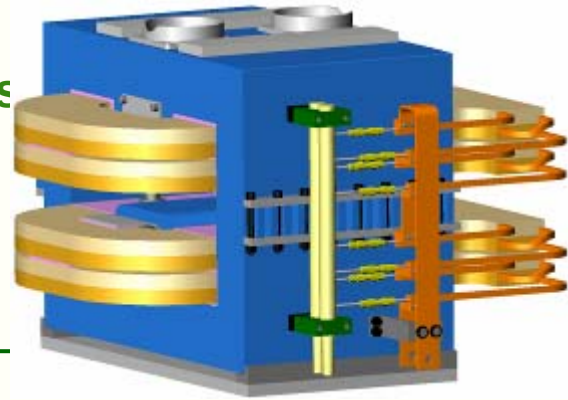
5500 Nos. Quench Heater Power supplies(QHPS)

1435 Nos. Local Protection Units

A part of DAE's contributions installed in LHC Tunnel at CERN

Latest involvement at CERN

- **Encouraged by LHC related success, DAE-CERN initiated cooperation on "Novel Acceleration Technologies"**
- **CERN → India**
  - **Development of Spallation Neutron Source at RRCAT**
  - **Accelerator Driven System at BARC**
- **India → CERN**
  - **SPL, especially LINAC-4, the front end of SPL**
    - **Modulator**
  - **CLIC Test Facility CTF3**
    - **Design of TL-2, Vacuum Chamber and magnets**



Particle Accelerator Technology

TTC Collaboration

SRF and Related Technology

↓

X-FEL
ILC
High Intensity Proton Source
Next Generation Light Source

Indian National Accelerator Plan includes

- Light Source
- High Intensity Proton Source
- Spallation Neutron Source
- Next Generation Light Source
- Research on Advanced Accelerator Concepts

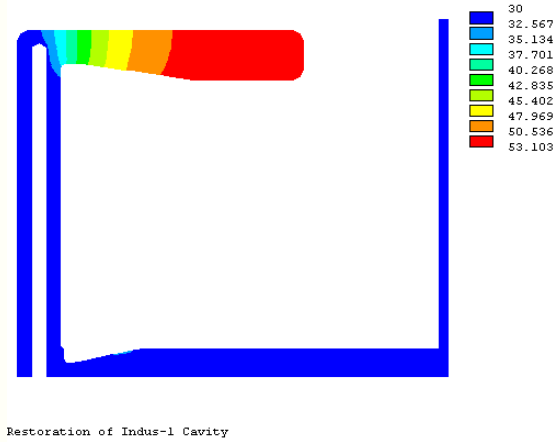
India International Accelerator collaboration

- Large Hadron Collider
- Participating in the design and construction of the advanced accelerator projects such as the ILC, XFEL, High Intensity Proton Accelerator (HIPA) and FAIR,
- Physics studies at the ILC, FAIR etc

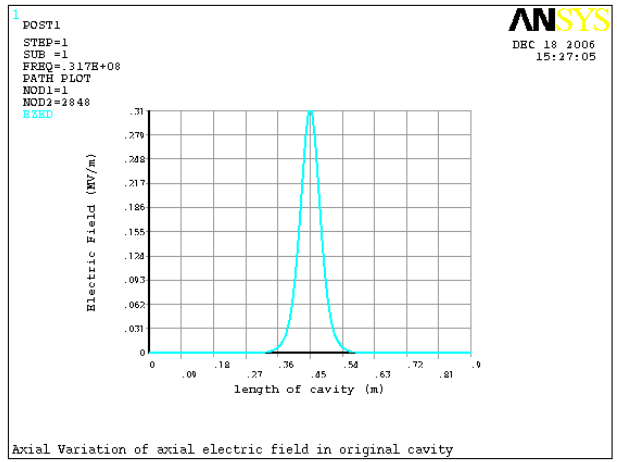
- Collaboration on "SRF and Related Particle Accelerator Technology" will enable development of next generation particle accelerators in India and abroad.
- This collaboration will also educate students, engineers and technicians to use the advanced technologies in universities, laboratories and industry in India.

31.6 MHz RF Cavity for Indus-I

A new cavity under development at RRCAT with tuners and couplers.



Restoration of Indus-1 Cavity

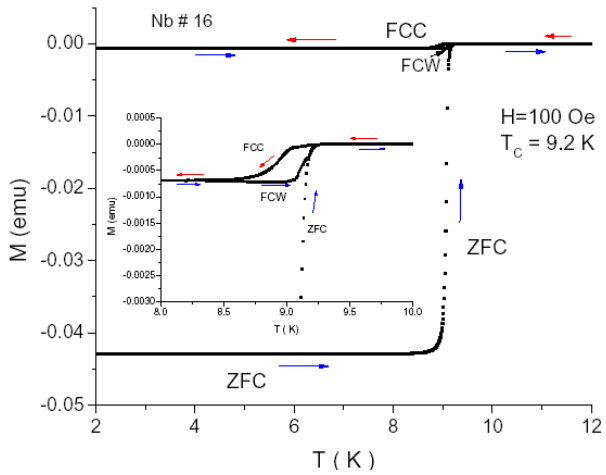


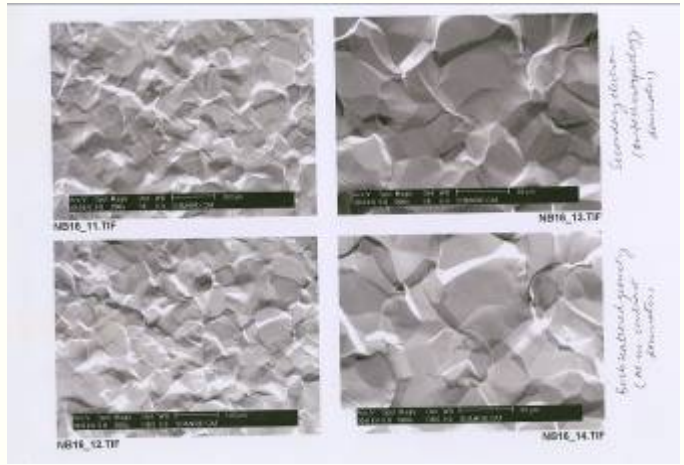
Axial Variation of axial electric field in original cavity

Material R&D at RRCAT

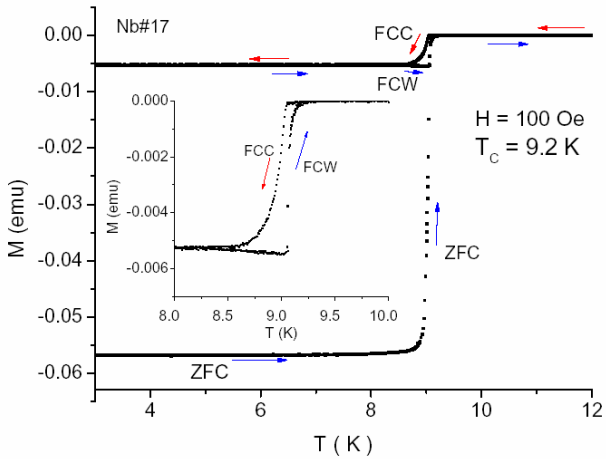
Results on BCP Samples of Nb from Fermilab. (Large Grain Nb from Jlab also studied)

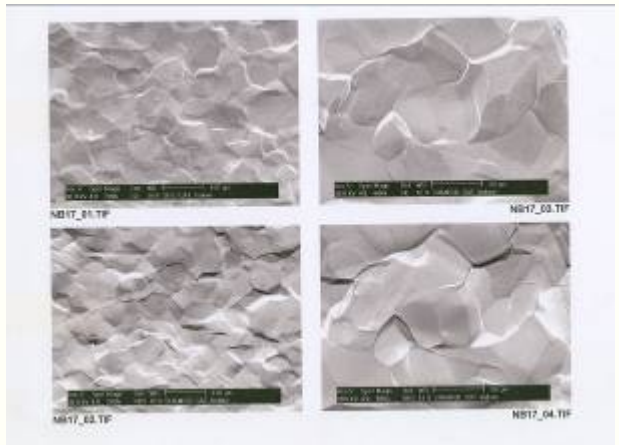
Sample # 16
Avg grain size
~ 30-35 Micron





Sample # 17
Avg grain size
~ 40-45 micron



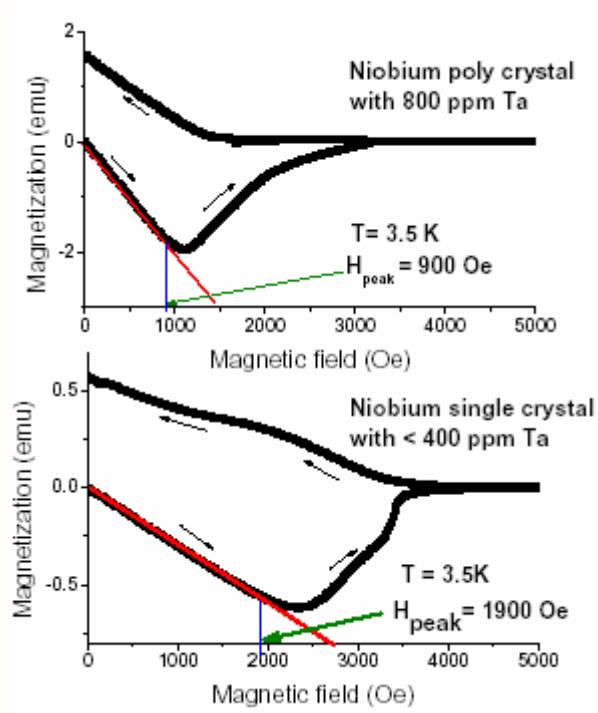


Fundamental limits for SRF Cavity

Peak fields $H_{peak} / E_{acc} = 42$ Oe(MV m^{-1}) $^{-1}$

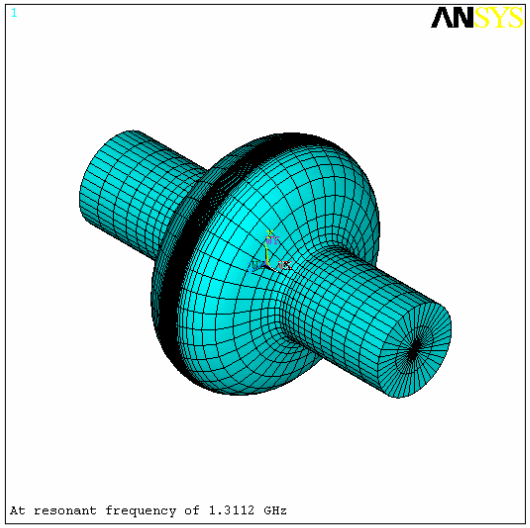
For Niobium, **best $H_{peak} \sim 2.4$ kOe $\Rightarrow$ $E_{acc} \sim 57$ MV m^{-1}**

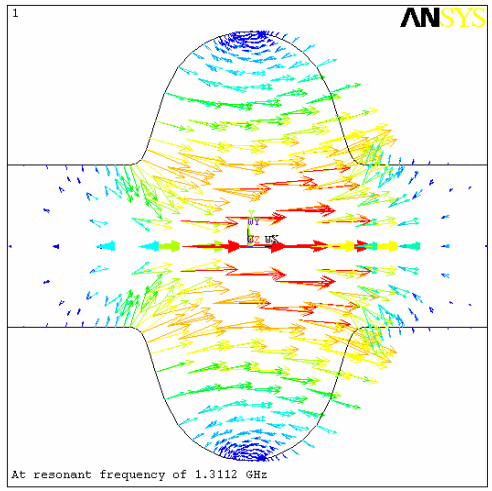
Some test results obtained with the experimental facilities at RRCAT show the importance of the grain size and Ta impurity contents in Niobium on the peak field H(peak).

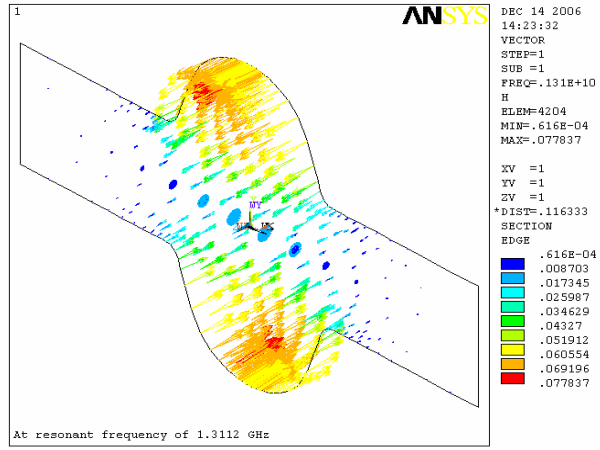


Cavity RF Simulation done at RRCAT

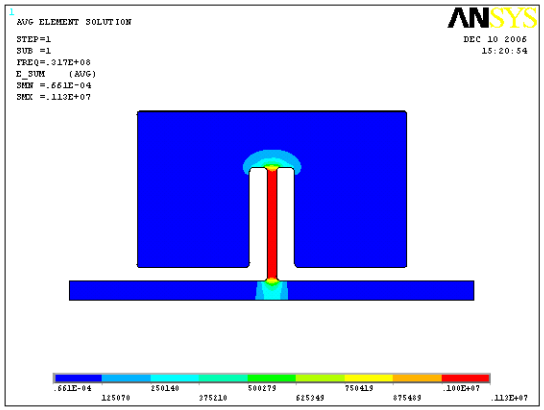
1.3 GHz Cavity

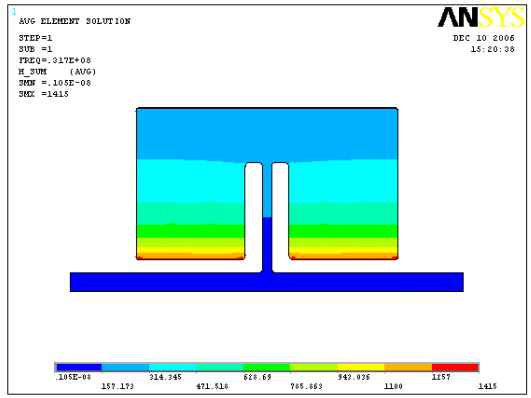


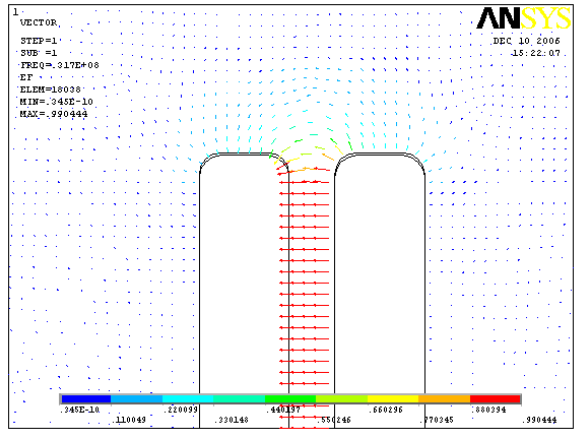




31.6 MHz Indus-1 Cavity







Indian Collaboration Topics

There are several areas where India can start collaboration and make significant contribution to the ILC program

- **Development of one complete ILC RF Unit**
- **Accelerator Physics**
- **Design and Drafting of ILC Cryomodule**
- **Positron Production Target R&D**
- **Fabrication of Tuner and coupler**
- **High power Marx Modulator, Sheet Beam Klystron**
- **Cryogenic distribution**
- **R&D: Laser Welding, Surface treatment of Niobium, Beam tube for Damping Ring**
- **Magnet: Damping Ring, Beam Delivery System**
- **Controls: Software and Hardware**
- **Infrastructure: Electron Beam Welding**
- **High Intensity Proton Accelerator Front End development**
- **Detector R&D: Silicon, Electronics**

MOU with Fermilab

ADDENDUM

to the

Memorandum of Understanding

between

US Universities & Accelerator Laboratories

and

Indian Universities & Accelerator Laboratories

concerning

Collaboration on R&D for Accelerator Physics and High Energy Physics Projects

Addendum I: "Fermilab, RRCAT, BARC, IUAC and VECC Collaboration on ILC Main Linac SRF Accelerator Technology R&D"

March 15, 2007

1. Introduction

The work detailed in this document falls within the scope of the Memorandum of Understanding (MOU) between US and Indian institutes dated January 9, 2006. It addresses in some detail the four key areas of collaboration mentioned in the main MoU. These are (i) Accelerator for the International Liner Collider (ILC), (ii) Superconducting Radio Frequency (SRF) Acceleration science and technology, including setting up test facilities and a high current proton driver , (iii) General Accelerator Science and Technologies, including conventional and free electron lasers and (iv) Superconducting Materials R&D for SRF acceleration related work. All terms and conditions under which the work will be carried out are found within the main MOU.

This MOU outlines the collaborative accelerator technology R&D that Fermilab, Raja Ramanna Center of Advanced Technologies (RRCAT), Bhabha Atomic Research Center (BARC), Variable Energy Cyclotron Center (VECC) and Inter University Accelerator Center (IUAC) (referred as Indian Institutes in this document) plan to carry out for the development of SRF cavities and cryomodules for the ILC, high intensity proton accelerator and any other accelerator using similar SRF technology. It is our understanding that Stanford Linear Accelerator Center (SLAC) will be developing Radio Frequency Modulator collaboration MOU with RRCAT and BARC. Indian Institutions

Goals:

1. Develop Cavity Fabrication tooling
2. Fabrication of 1-Cell TESLA Shape cavity
3. Fabrication of 9-Cell ILC Cavity (TESLA Shape)
4. Fabrication of an ILC Tuner
5. Collaboration on the design of the ILC Cavity and Cryomodule
6. Design and construction of cryogenic components for ILCTA@Fermilab

Goal and Resources

- **RRCAT has plans to build SRF accelerating structures**
  - **Proton accelerator in India.**
  - **It is also interested in participating in the R&D of the Main Linac for the International Linear Collider**

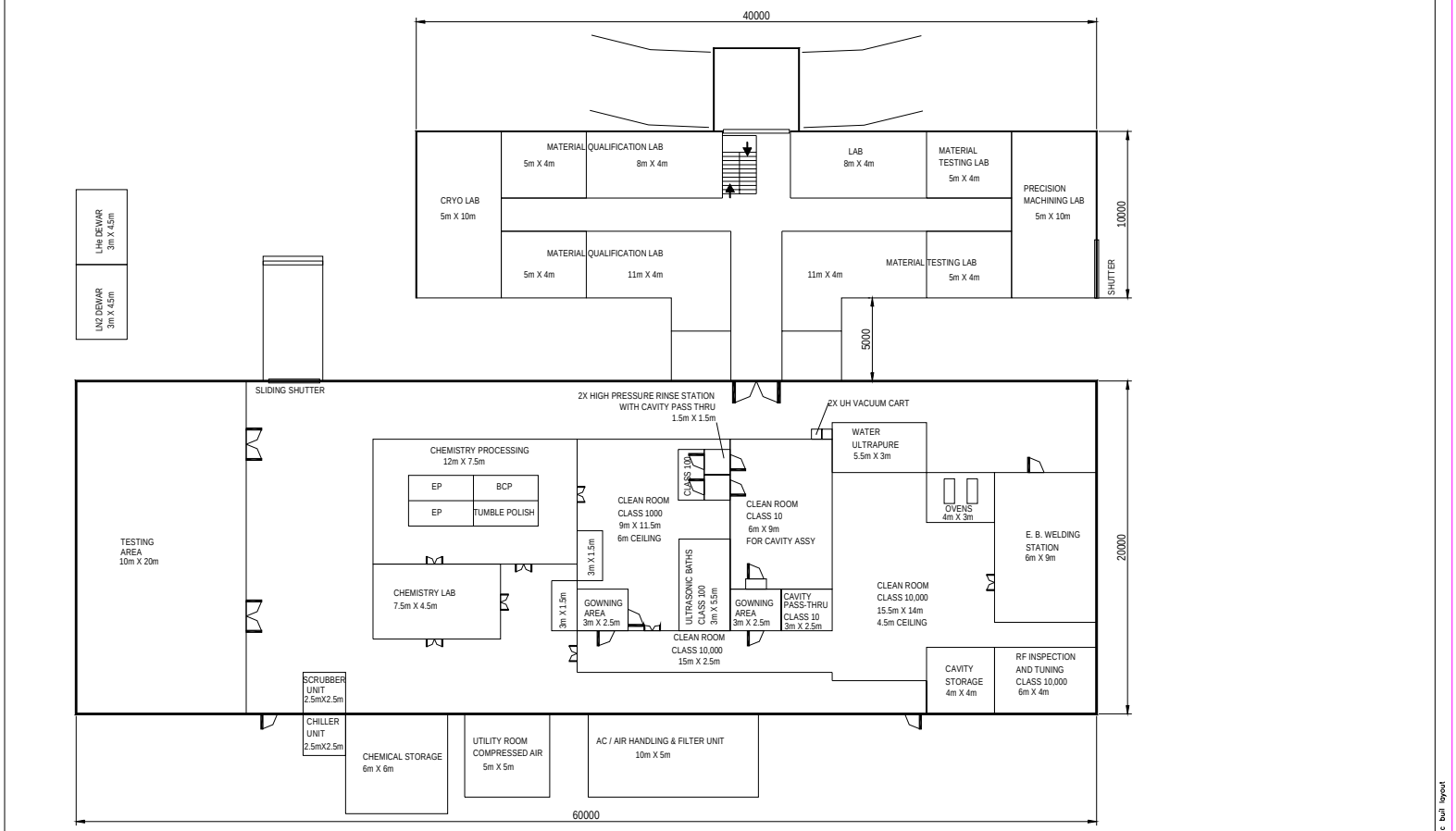
- **Man Power resource for these activities**

Physicists	-	6
Mechanical Engineers	-	12
Electronic Engineers	-	10
Design draftsman	-	10

Proposed SRF Infrastructure

- **RRCAT has proposed to build significant infrastructure to Fabricate, Process and Test SRF cavities**
  - **1200 sq meter building**
  - **Cavity Fabrication infrastructure including Electron Beam Welding Machine**
  - **Material Qualification Facility (Eddy Current Scanner, RRR, Surface Characterization, SIMS, Photo Emission Analyzer and SEM)**
  - **Vacuum Annealing Furnace up to 1400°C**
  - **Clean Room (Processing and Assembly)**
  - **Chemical Processing (EP, BCP, Mechanical Polishing)**
  - **High Pressure Rinse and Ultra Pure Water System**
  - **He liquefire 35 l/hr to be upgraded to 100 l/hr (LHe storage dewar ~ 5000 liter)**
  - **Vertical and Horizontal test facility for Cavity**
  - **Underground tunnel to build ~50 MeV Linac**
  - **Computing (ANSYS) and CAD Facilities (NX-4)**

SRF Cavity Development Building



BUILDING LAYOUT FOR PROPOSED INFRASTRUCTURE FACILITY FOR SCRF CAVITY DEVELOPMENT AT RRCAT, INDORE.

GOVERNMENT OF INDIA
RAJA RAMANNA CENTRE FOR ADVANCED TECHNOLOGY
ACCELERATOR PROGRAMME
TITLE: BUILDING LAYOUT FOR SCRF CAVITY DEVELOPMENT
DESD: S.C. JOSHI — DATE — CECK — DATE — SCALE
DRN: B.OMKAR — DATE: 03/04/07 — APPD — DATE
ORGANISING SECTION/GROUP: PROTON ACCELERATOR GROUP
DRG No. RRCAT/PLVT/SCRF/07/01 — SHEET 1 OF 1
File Location :-bdra/s c joshi/s c buil layout

Request to Join TTC

- **RRCAT has considerable expertise in accelerator technology development**
  - **Indus and other accelerator**
  - **LHC, Linac-4 and CLIC**
  - **SRF material and Cavity and Cryomodule R&D**
- **Indian national program calls for Indian Accelerator laboratories to play major role in both national and international accelerator projects.**
- **RRCAT plans to install significant SRF infrastructure for**
  - **Indian Proton Accelerator**
  - **Indian Light Source**
  - **International Linear Collider**
- **RRCAT request to become a member of TTC to collaborate on the development of these international accelerators while building Indian Accelerator.**