

DAE View on IIFC

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Outline

1. Few remarks on our strengths in reactors & accelerators.
2. Long term rationale for our Fermilab collaboration.
3. Summary of IIFC activities @ DAE labs.
4. An update on HIPA activities underway @ RRCAT.
5. Concluding remarks.

What happened during the period of autarchic pursuit of nuclear programme?

Siegfried S. Hecker, after his India visit, said at a **Hearing of the US Senate Committee on Appropriations, Subcommittee on Energy and Water Development, April 30, 2008**

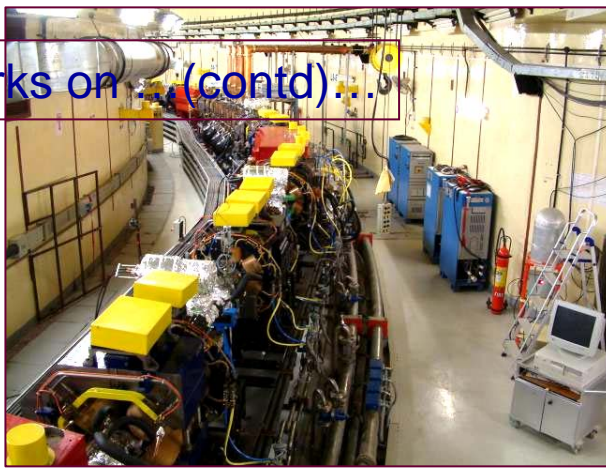
“I found that whereas sanctions slowed progress in nuclear energy, they made India self-sufficient in nuclear technologies and world leaders in fast reactor technologies, while much of the world’s approach to India has been to limit its access to nuclear technology, it may well be that today we limit ourselves by not having full access to India’s nuclear technology developments. Such technical views should help to advise the diplomatic efforts with India.”

What happened during the period of autarchic pursuit of nuclear programme?

“Nuclear technology transfers for power reactors between India and Canada were fairly unidirectional some 40 years ago when they started. Today, however, it is clear that both the Indian and the Canadian designers teams may profit from the other Party’s experience and innovations”

AV Popov, G Marleau and A Olekhnovitch, Ecole Polytechnique de Montreal, Quebec, Canada, “The Third generation of Heavy-Water Moderated Reactors”, 16th Pacific basin Nuclear Conference, Aomori, Japan, Oct 13-18, 2008.

1. Few remarks on ... (contd)...



It has been a great pleasure to visit your facility and to learn about your laboratory and your many skills. The light source INDUS-2 is truly impressive and the spirit of being in command of all aspects of accelerator technology is commendable. The many young people we saw in our tour also tells us that the future will be bright. Your spirit of international collaboration opens up many opportunities for us to work together.

I will now look forward to work on specific areas of collaboration between Fermilab and CAT and together open up new opportunities for the future. A special thanks to your hospitality, especially to Professor Sahu!

Paul Oddone
3/6/06



Precision Magnet Positioning System (PMPS) Jacks

MCS & MCDO

Magnetic measurements teams- ~100 Man-years

To mark DAE's contributions, CERN Gifted a Memento to Director, RRCAT on 20/3/07



Quench Heater Power Supplies(QHPS)

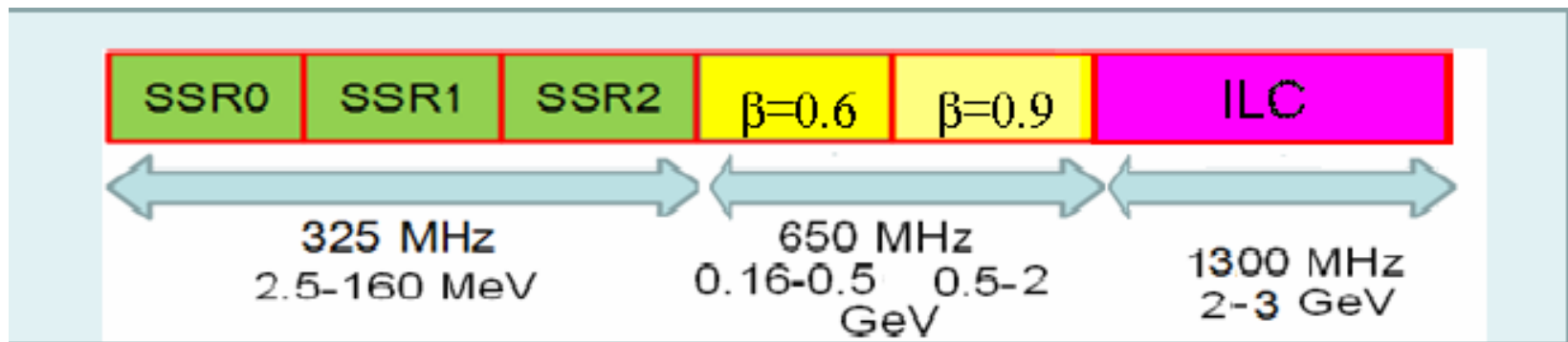
Local Protection Units

DAE's contributions installed in LHC Tunnel at CERN

Inter-twinning of Indian & Fermilab Programs

Building High Power Proton Linacs is of great interest to India for its own present /future R&D programs based on accelerators.

A multi-MW Proton Source for Project-X, is Fermilab's strategy for future development.



Indian Institution Fermilab Collaboration (IIFC)

Key areas of activity

- Work on accelerator physics of high intensity proton linacs.
- Good progress on Niobium SCRF Cavity development & creating test facilities.
- Develop new design to bring down cryo-module (CM) costs.
- Evolve CM designs to handle high power beams.
- Work on Integrated Accelerator Control & Instrumentation System through interaction between groups on both sides.
- Focused dialogue on design of RF system needed for high current proton accelerator.
- Work on physics program & train young Indian scientists/engineers who will contribute to activities in both countries.

Summary of IIFC activities @ BARC

(a) Accelerator physics of high intensity proton linacs.

BARC & Fermilab scientists have started interacting.

(b) Design & Development of Single Spoke Resonators 2

Work has been just initiated.

(c) Design & Development of Cryo Module Test Stand

CDM, BARC & Fermilab engineers are regularly interacting & making progress.

(d) Integrated Accelerator Control & Instrumentation

Work going on in LLRF, protection systems, BPMs & temperature monitoring etc.

(e) Solid state power amplifiers & RF couplers

BARC & Fermilab teams are in touch; 1 & 3 kW systems have been developed.

(f) Development of magnets for MEBT

Discussions on this topic have just started.

Summary of IIFC activities @ RRCAT

(a) Development of 1.3 GHz single cell $\beta=1$ SCRF cavity

4 Nos. of single cell cavities have been built & tested at Fermilab with highest gradient realized in the best cavity approaching 40 MV/m.

(b) Development of 1.3 GHz five cell $\beta=1$ SCRF cavity

1 five cell cavity has been built & is being inspected. It will be shipped soon for processing and tests at 2K at Fermilab.

(c) Making end group for 1.3 GHz nine cell $\beta=1$ cavity

A prototype has been built & is being checked for fabrication conformance.

(d) Development of 650 MHz single cell SCRF cavity

Half cells in Al & Cu have been built & under going conformance checks.

(e) Design of HTS-2 for SCRF cavity evaluation

Essential elements of design have been captured by RRCAT + Fermilab team.

(f) Development of 650 MHz cryomodule

Design of a number of components is done; work on others is in progress.

Summary of IIFC activities @ VECC, Kolkata

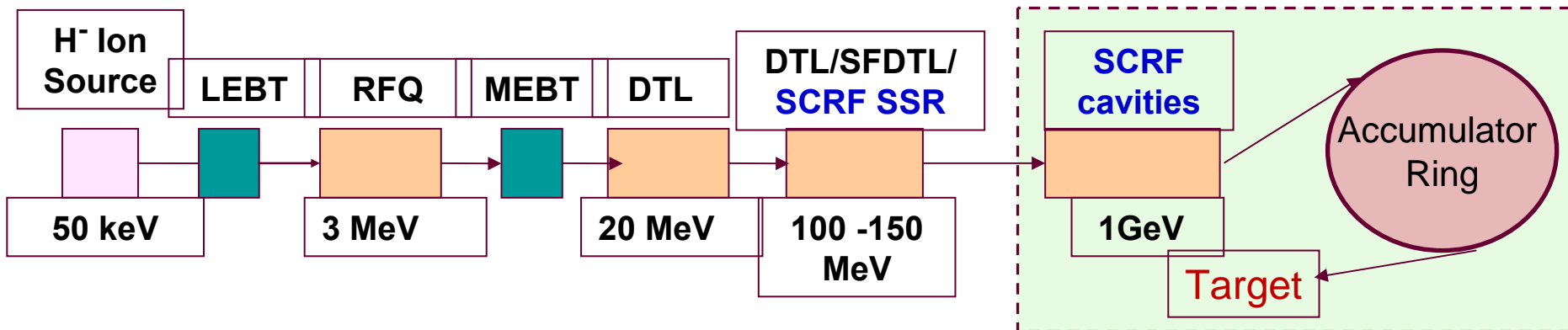
Ongoing programs: (a) Development of 5 cell, 650 MHz, $\beta=0.61$ SCRF cavity & (b) Work on cryomodule for SSR1

Present status of these activities:

- ▶ **EM design and analysis, Structural analysis, Mechanical modal analysis of the 5-cell 650 MHz, $\beta=0.61$, SCRF cavity has been carried out.**
- ▶ **Fabrication of die has been done and deep drawing trial of aluminum half-cell is in progress by local vendor.**
- ▶ **After successful completion of aluminum prototype, fabrication of Niobium cavity will start.**
- ▶ **600 x 600 x 4 mm. Nb sheet (RRR > 300) already procured from ATI Wah Chang.**
- ▶ **Electron Beam Welding of Nb Half Cells will be carried out at IUAC, New Delhi (MOU already signed!)**
- ▶ **For SSR1, Strong Back temperature distribution (3D analysis) has been carried out. Waiting to start fabrication of SS jacketing for SSR1 (Final version of Drawing yet to be received)**

An Update Relating to Work Under Way at RRCAT Towards Indian High Intensity Superconducting Proton Linac

RRCAT has program to develop ~ 1GeV H⁻ accelerator for a Spallation Neutron Source. It will augment our reactor neutron based multi-disciplinary research in condensed matter physics, material sciences, chemistry, biology etc.

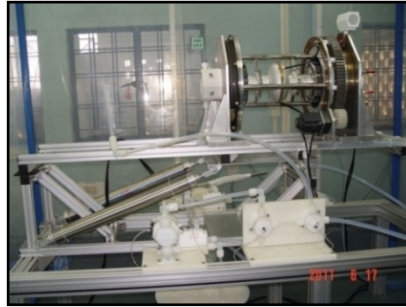


Schematic of 1 GeV proton linac for SNS

Infrastructure for SCRF Cavity Fabrication and Processing



Cavity forming facility



Electro-polishing setup



Centrifugal barrel polishing machine



High pressure rinsing Set up

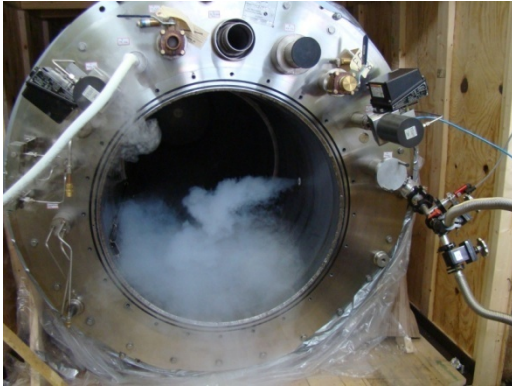


SCRF Cavity manufacturing hall



Test and measurement facilities building

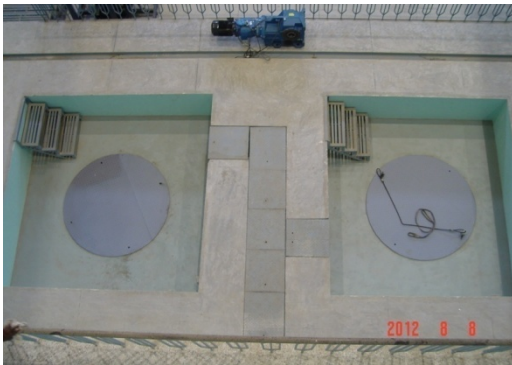
Development of VTS Facility



Cold Shock Testing



External Magnetic Shield segment under fabrication



VTS Pit



500W 1.3 GHz RF System



Cavity Insert

Development of RF Components

Several RF components such as power combiners, directional couplers, dummy loads etc have already been developed and tested for 505.8 / 650 MHz operation



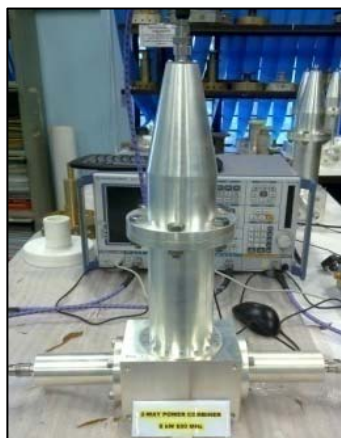
20 W Low Power Driver



200 W Amplifier Module



Coaxial Transitions



2-way 15 kW Power Combiner



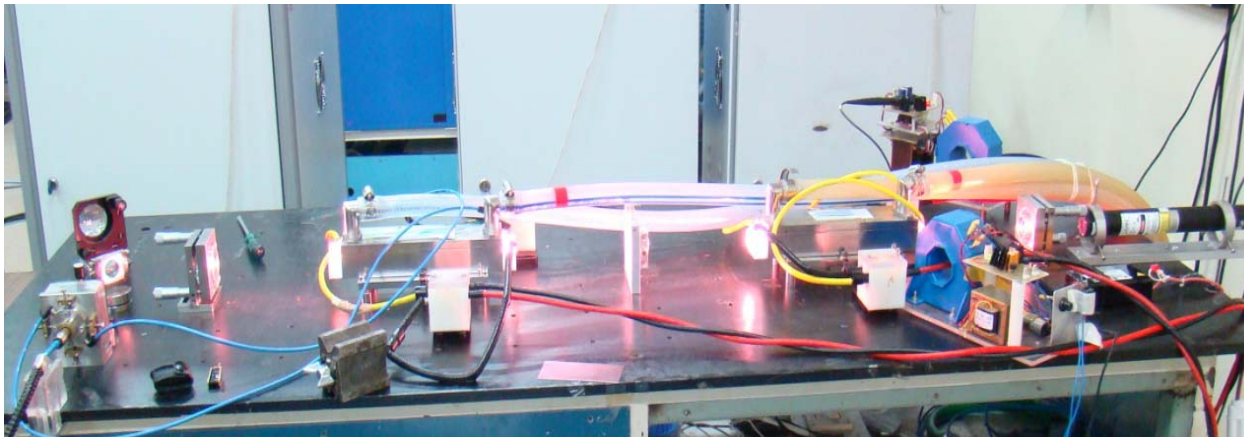
4 kW & 1 kW Coaxial Directional Couplers



30 kW RF Dummy Load

Laser Welding Technology for SRF Cavity Fabrication

20 kW Nd:YAG fiber-coupled laser



Prototype 3.9 GHz SCRF
Nb cavity



Prototype 1.3GHz cavity Nb
half cells welded



9-cell copper cavity

Concluding Remarks

As H⁻ accelerator based “Discovery Science” program in India & US has huge overlap, clearly, DAE labs & Fermilab will both gain significantly by joining hands for building & using high intensity proton accelerators.

Many people on each side have right experience that will enrich the other side & working together will be helpful.

In this context, I would be more than happy to help forge strong partnership of DAE scientists & engineers with their counterparts in Fermilab.

Thank You