DAE-DOE:
Discovery Science Collaboration

Shekhar Mishra

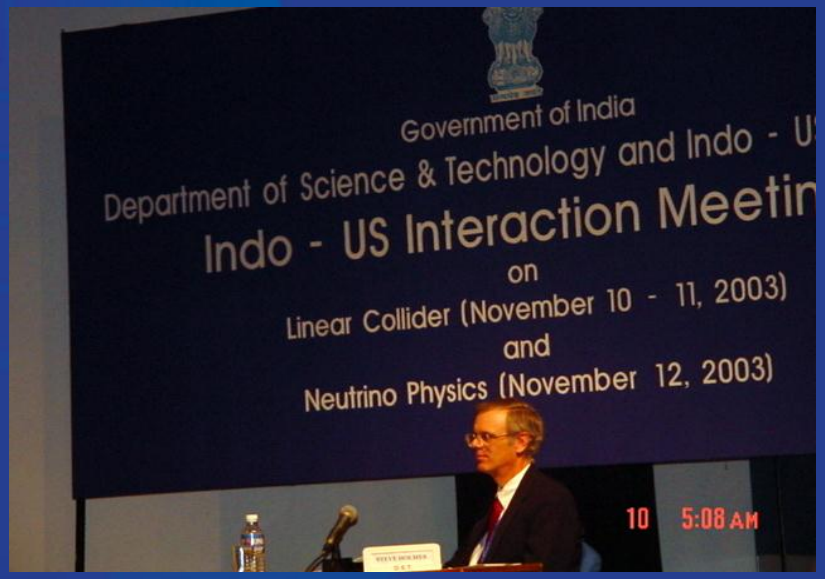
US Technical Coordinator,
Discovery Science Collaboration
Head,
Fermilab Office of International Program

U.S. DEPARTMENT OF ENERGY

Fermilab

2003: Interaction Meeting

- 1st Indo-US Interaction meeting, Nov. 2003, New Delhi.
  - Supported by High level Indian and US government & management
  - 19 US physicists and 70+ Indian Scientists participated.
    - US-India discussed accelerator and neutrino physics collaboration
    - Working group formed to develop collaboration
- Outcome:
  - Indian science management, DOE and Fermilab agreed to develop a new collaboration in Accelerator and Physics



2003-06: Indian and Fermilab scientists visited institutions to understand and evaluate strengths

Fermilab

Guiding Principles

Exciting Science

Training of future scientist

Leapfrog Indian program and Interest

Strengthens India's scientific and Industrial infrastructure

Institutes to Institutes MOU: Jan 2006

Memorandum of Understanding

between

US Universities & Accelerator Laboratories

and

Indian Universities & Accelerator Laboratories

concerning

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

January 9, 2006

The following concur on the terms of the original MOU and outlined in the extension of the Memorandum of Understanding.

Dr. Ratan Kumar Sinha Director, BARC	30-01-2012 Date	Dr. Piermaria Oddone Director, FNAL	1/19/12 Date
Dr. Rakesh Kumar Bhandari Director, VECC	24/3/2012 Date	Dr. Shekhar Mishra Project-X, Co-Chair IIFC Fermilab	1/19/12 Date
Dr. P. D. Gupta Director, RRCAT	30-01-2012 Date		
Prof. Mustansir Barma Director, TIFR	2/3/2012 Date		
Dr. Milan Sanyal Director, SINP	23/3/2012 Date		

2012: IIFC

4.2 **Approvals**

The following concur in the terms of this Memorandum of Understanding:

Piermaria Oddone, Director, FNAL	Vinod C. Sahni, Director, CAT
1/9/05 Date	March 8, 2006 Date
Jonathon Dorfan, Director, SLAC	Bikash Sinha, Director, VECC
1/23/06 Date	March 9, 2006 Date
Christoph Leemann, Director, TJNAJ	Amit Roy, Director, IUAC
1/18/06 Date	March 9, 2006. Date
Maury Tigner, Director, Newman Lab	S. Bhattacharya, Director, TIFR
Date	April 17, 2006 Date
	Srikumar Banerjee S. Banerjee, Director, BARC
Date	March 14, 2006 Date
	Deepak Pental, Vice Chancellor, DU
Date	April 10, 2006 Date

2006-7: Technical Work

- BARC and RRCAT physicists and engineers visited Fermilab to discuss details of technical collaboration.

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"

October 2, 2007

The following concur on the terms of this Memorandum of Understanding:

Dr Vinod C. Sahni,
Director, RRCAT

Oct 2, 2007
Date

Dr. Piermaria Oddone
Director, FNAL

10/2/07
Date

Dr. Shekhar Mishra
Deputy ILC Program Director, FNAL

10/2/07
Date

Focused on Cavity Development and Accelerator Physics

2008: Fermilab ←→ India

Fermilab

Fermi National Accelerator Laboratory
P.O.Box 500 • Batavia, IL• 60510-0500
630-840-3211 FAX 630-840-2900

Director's Office

January 4, 2008
(By E-Mail and Facsimile)

Dr. Anil Kakodkar
Chairman, Atomic Energy Commission of India
Secretary, Department of Atomic Energy
Anushakti Bhavan
CSM Marg
Mumbai – 400001, India

Dear Dr. Kakodkar,

I am very pleased to inform you that accelerator collaboration between Fermilab and Indian Institutions has started with regular visits of Indian scientific staff (RRCAT and BARC) to

Dr. Pier Oddone, in a letter to Dr. Anil Kakodkar, Secretary, DAE invited India to collaborate on High Intensity Proton Accelerator: Project X

I have asked Shekhar Mishra to provide you with additional technical details on the present collaborative efforts, Project-X R&D and its commonality with Indian accelerator programs, when he meets you on Jan 15th.

Sincerely,

Piermaria J. Oddone,
Laboratory Director

डॉ. अनिल काकोडकर
Dr. Anil Kakodkar

भारत सरकार
Government of India

अध्यक्ष, परमाणु ऊर्जा आयोग
एवं
सचिव, परमाणु ऊर्जा विभाग
Chairman, Atomic Energy Commission
&
Secretary, Department of Atomic Energy

No. 22 -2008

January 21, 2008

Dear Prof. Oddone,

Thank you for your letter dated January 4, 2008 and very supportive views about the collaboration between Fermilab and Indian Institutions. I am glad that this collaboration is moving so well.

I am also happy to inform you that Dr. Mishra met me as scheduled on January 15, 2008. He apprised me with the details of 'Project X' and its linkage with the R&D required for ILC. I also learnt

Dr. Kakodkar sent a very positive response:

Requesting development of a "Phased Collaboration Plan"

With best regards,

Yours sincerely,

(Anil Kakodkar)
Jan 21, 08

Prof. Piermaria J. Oddone,
Laboratory Director,
Fermi National Accelerator Laboratory,
P.O.Box 500,
Batavia IL 60510-0500, USA

2009: IIFC

- Jan 2009, During the signing of the Addendum MOU III at Indore, Dr. Kakodkar and Dr. Oddone agreed on the
  - Concept of “Total Project Collaboration”
  - Fermilab changed the HIPA design to CW
- Nov 2009, Indian Institutions and Fermilab Collaboration also established an addendum MOU IV to join Neutrino Physics experiments at Fermilab
  - MINOS/MINOS+
  - NOvA
  - LBNE

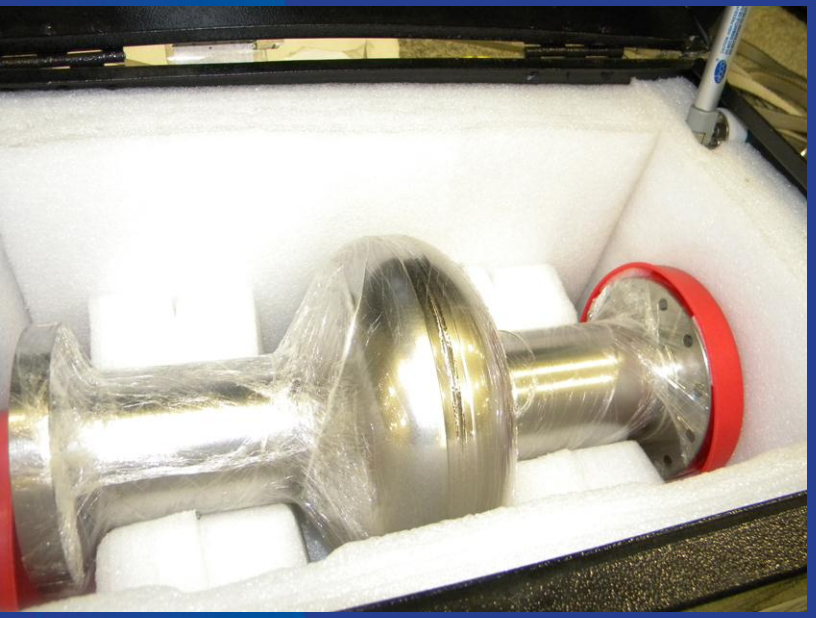
Fermilab

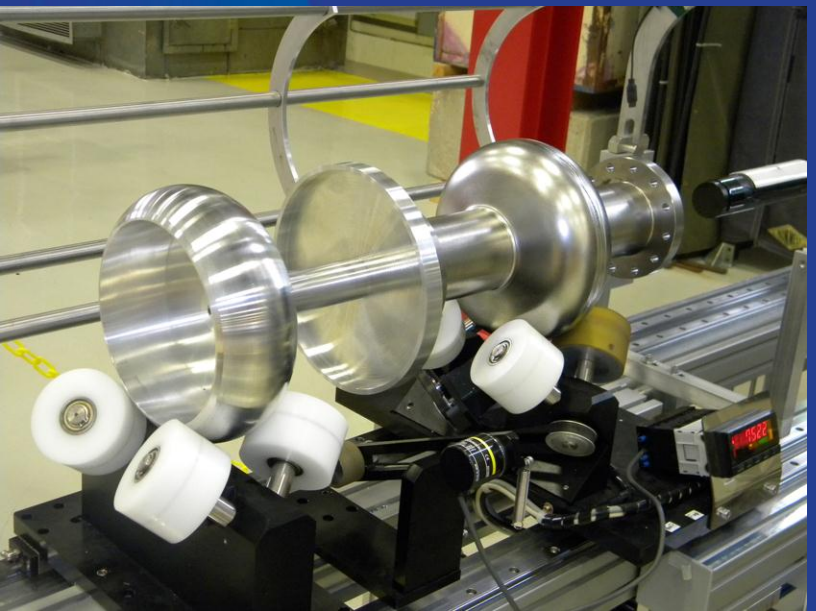
Technical work under MOUs

Covering all aspects of Project X, Indian Accelerators and Fermilab Neutrino Program

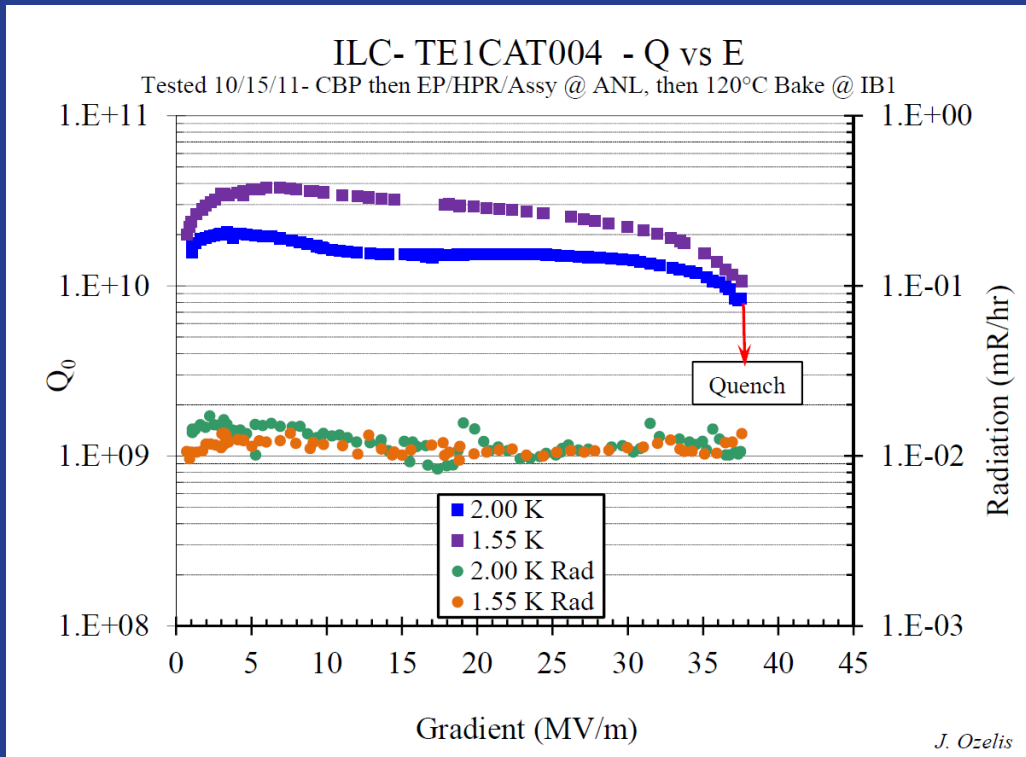
1. "Fermi … ccelerator Techn …
2. "SLAC … nd Beam Dump …
3. "Fermi … Accele …
4. "US and Indian Institutions Collaboration on Neutrino Physics, Related Experiments and Detector Development" (Signed on: Novembe …
5. "Fermilab and Indian Accelerator Laboratorie … High Intensity Proton Accelerator" (Signed on …
6. "Fermilab and Indian Accelerator Laboratorie … High Intensity Proton Accelerator" (Signed on …
7. "Fermilab and Indian Accelerator Laboratorie … or High Intensity Proton Accelerator" (Signed on …
8. "Fermilab and Indian Accelerator Laboratorie … r High Intensity Proton Accelerator" (Signed on …

1.3 GHz Cavity Development





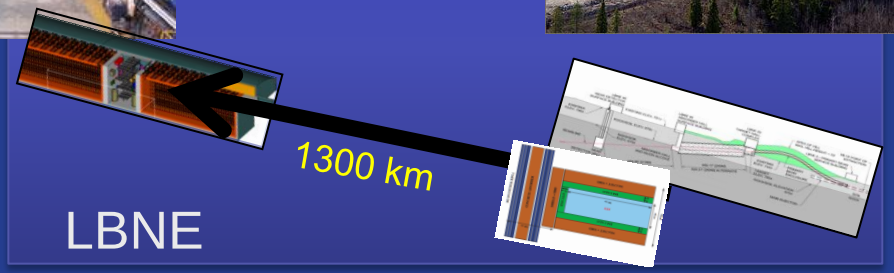
- Fabrication of cavity at RRCAT in collaboration with IUAC
  - Processing and testing at FNAL/ANL

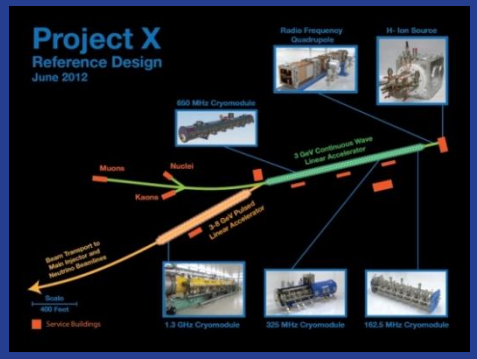


Indian Institutions at Fermilab

Before 2006

Now





University of Delhi · Panjab University · tifr · BARC · IGCAR · IUAC · Fermilab

Indian Institute of Technology, Guwahati · Saha Institute of Nuclear Physics, Calcutta · Cochin University of Science and Technology · Harish-Chandra Research Institute, Allahabad · The Institute of Mathematical Sciences · University of Hyderabad · Manipal, Inspired by Life

IIFC – Accelerator 2010

Banerjee: Discovery Science

- Dr. Banerjee in May 2010, requested DOE for a “Road Map” for the Fermilab Collaboration.
- He charged the IIFC to prepare a plan that would expand the accelerator collaboration to include physics collaboration with Fermilab.
  - The program should be rich in Physics
  - Indian contribution should be significant and DAE-DST Ownership
  - Contribution should have synergy with interest and expertise in India
  - Development of Indian manpower, laboratory and industrial infrastructure
- The collaboration has developed such a program and was submitted to DAE in 2011.

DOE-DAE Implementing Agreement

IMPLEMENTING AGREEMENT

BETWEEN

THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA

AND

THE DEPARTMENT OF ATOMIC ENERGY

OF THE REPUBLIC OF INDIA

FOR COOPERATION

IN THE AREA OF ACCELERATOR AND PARTICLE DETECTOR

AND DEVELOPMENT FOR DISCOVERY SCIENCE

दिल्ली में दिनांक 19.07.2011 को अंग्रेजी एवं हिन्दी भाषाओं में, दो-दो प्रतियाँ (दोनों भाषाओं के प्रलेख समान रूप से प्रामाणिक) हस्ताक्षरित।

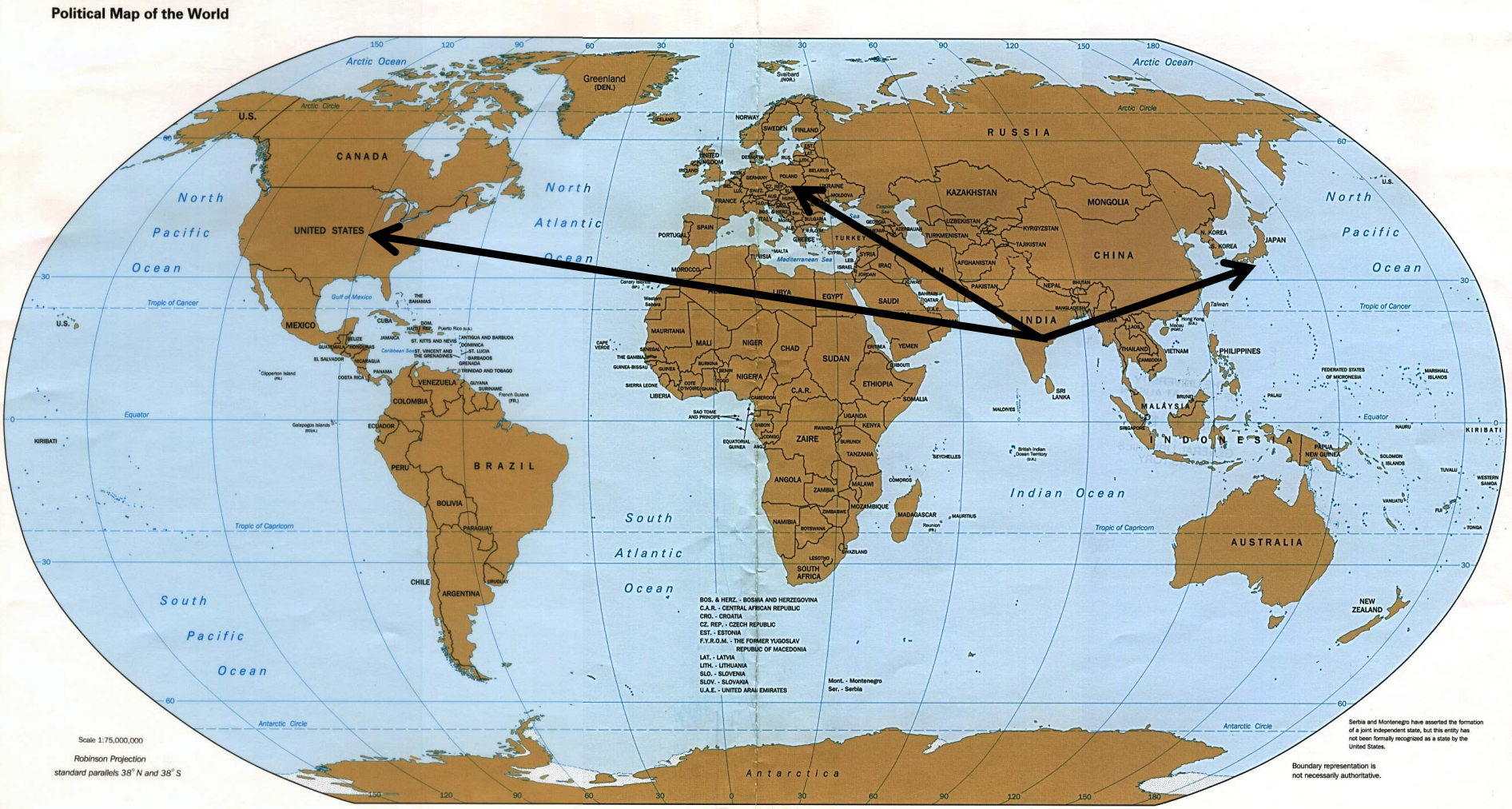
संयुक्त राज्य अमेरिका के ऊर्जा विभाग की ओर से

भारत गणराज्य के परमाणु ऊर्जा विभाग की ओर से

Discovery Science: The United States' Department of Energy and India's Department of Atomic Energy signed an Implementing Agreement on Discovery Science that provides the framework for India's participation in the next generation particle accelerator facility at Fermilab.

http://www.state.gov/r/pa/prs/ps/2011/07/168740.htm

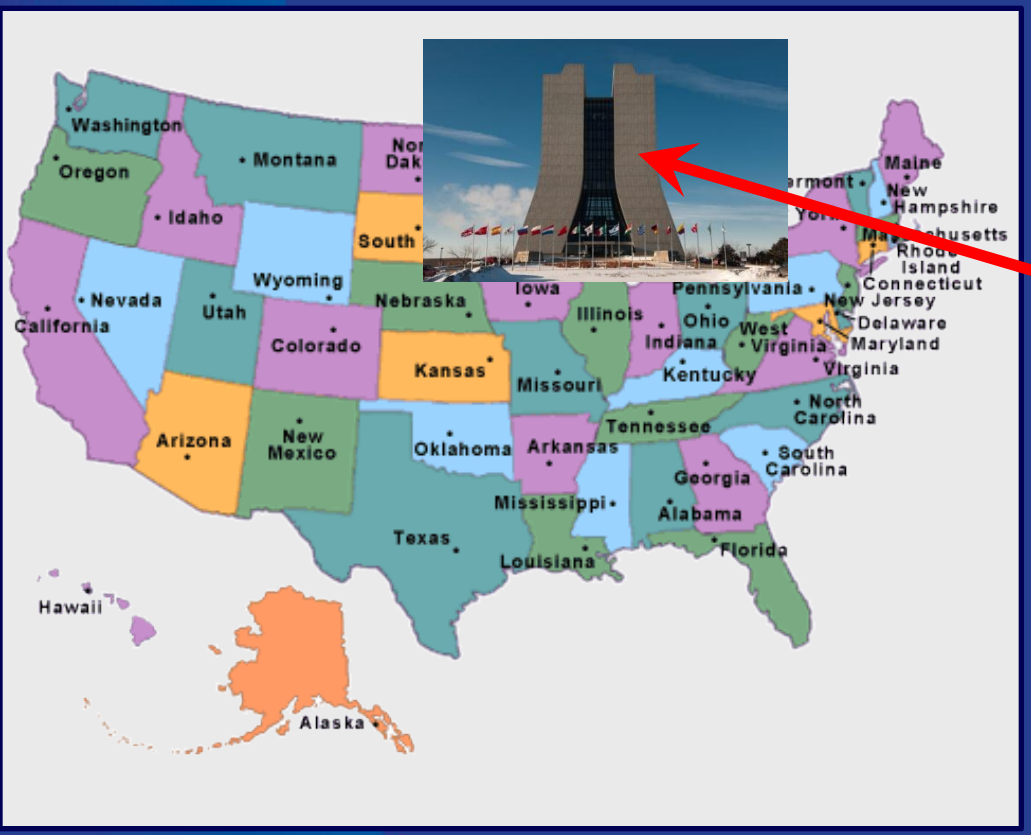
India and the HEP/NP World



Indian Institutions Collaborates with International Laboratories

Fermilab

The New Frontier: India-Fermilab



Indian Institutions and Fermilab Collaboration is jointly building infrastructure, accelerator and physics program(s) in India and at Fermilab for the programs of vital interest to both countries.

Fermilab

India International Collaboration

Physical Sciences

- Large Hadron Collider (Switzerland)
- Facility for Antiproton and Ion Research (Germany)
- Laser Interferometer Gravitational Wave (India)
- Square Kilometer Array (Australia, S. Africa)
- Thirty Meter Telescope (USA)
- Solar Energy Development (India)
- Discovery Science Collaboration(US-India)
  - Project X (Fermilab, USA)
  - Long Baseline Neutrino Experiment (Fermilab, USA)
  - Nuclear Energy Accelerator (BARC, India)
  - Spallation Neutron Source (RRCAT, India)
  - Material Science (IGCAR, India; Fermilab)

Discovery Science is the only "Total Project Collaboration"

US-India Strategic Dialogue

SCIENCE & TECHNOLOGY DIALOGUE, WASHINGTON, DC ///

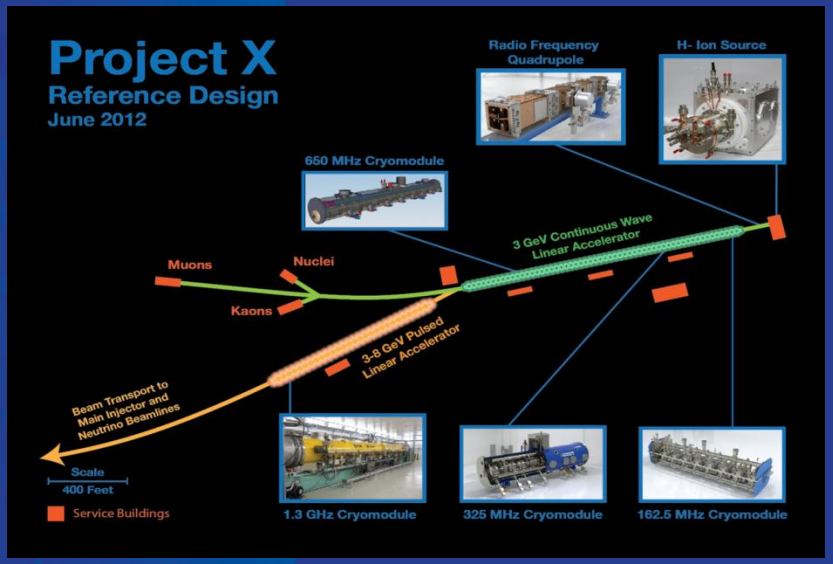
MEET THE CATALYST

June 11, 2012

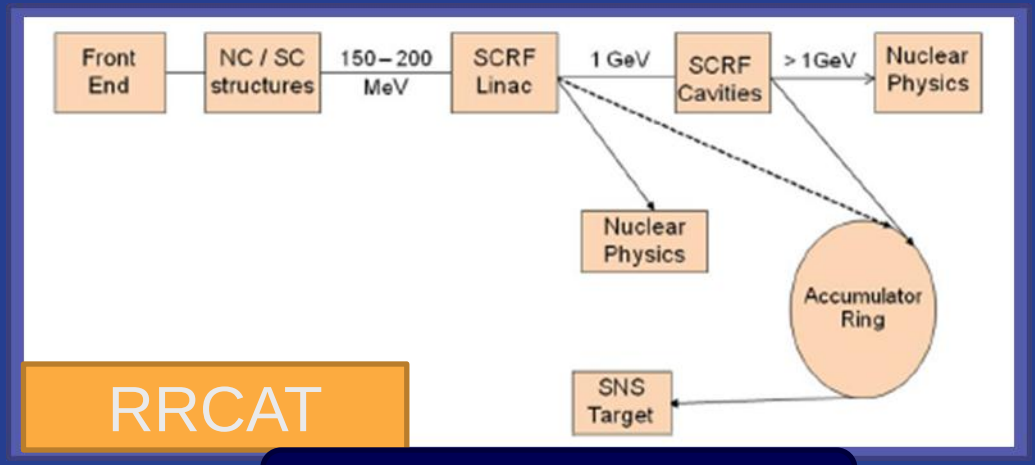
At the end, the Joint Commission recommended several new directions of cooperation including research in the areas of high energy particle physics and gravitational wave detection under the 'Discovery Science Agreement' between Department of Atomic Energy and U.S. DOE. In Basic and Applied sciences — materials research, computer sciences and neurosciences have been identified as potential areas of future engagement.

Project X and Physics Program are No 1 deliverables to the Joint Coordination Meeting

Accelerator: DAE-DOE-Fermilab



Basic Science

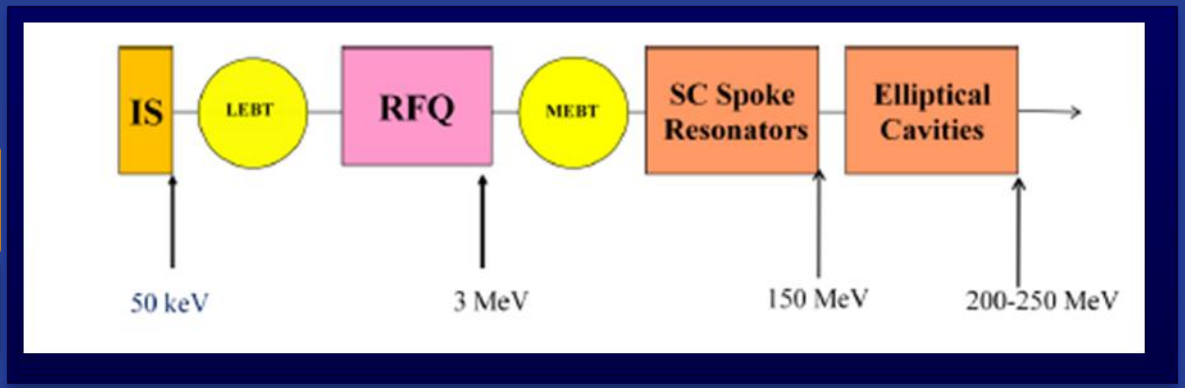


RRCAT

Material Science

BARC

Energy and Medical



In the 12th and 13th plan of India

Fermilab

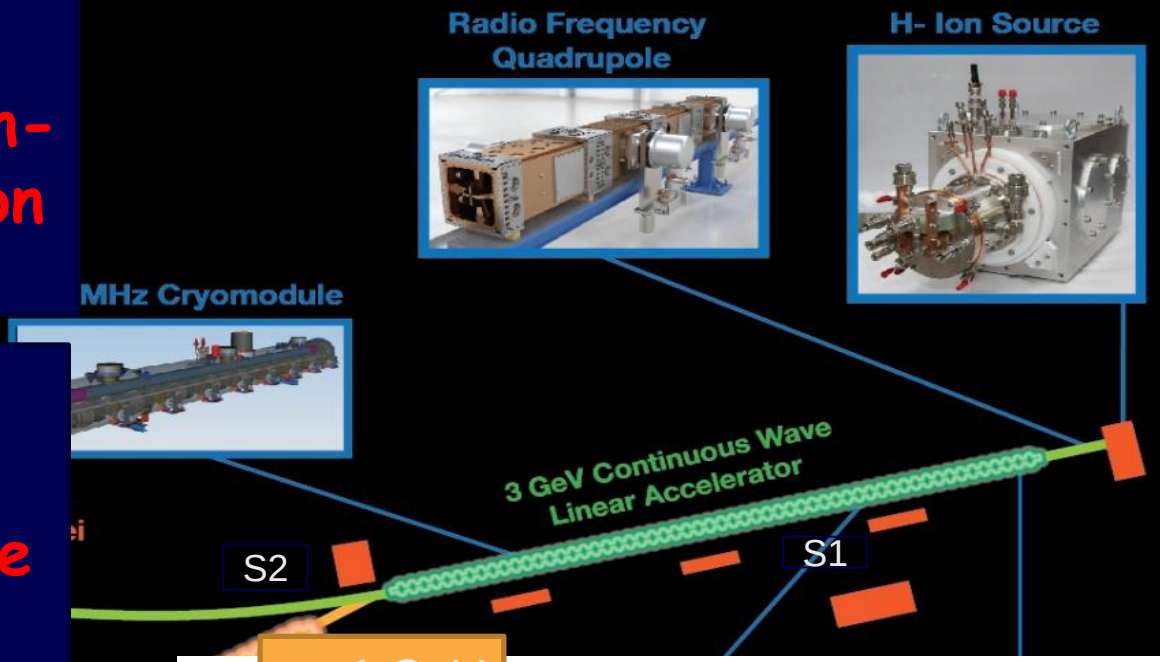
Project X and Its Physics Program

S1&2:

Next generation muon-to-electron conversion experiment

S1&2:

$K^+ \rightarrow \pi^+\nu\nu$: >1000 events, Precision rate and form factor



Stage 1-3:

Neutrino Physics:

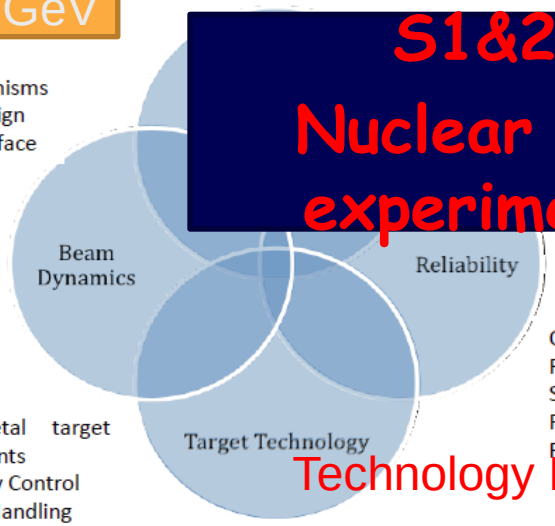
- **Mass Hierarchy**
- **CP violation**
- **Precision measurement**

1 GeV

Beam Quality
Beam Loss Mechanisms
Fault Tolerant Design
Beam-Target Interface

S1&2:

Nuclear edm experiments



Component-level Reliability
System-level Reliability
Rapid-fault recovery
Fault tolerance

Liquid-metal target components
Chemistry Control
Remote Handling
Windowless Design

Technology Demonstration Facility

Neutrino Physics Program

- Fermilab and the Indian Institutions within the “Discovery Science” collaboration are jointly working on Neutrino physics program.
  - Focus on neutrino physics (MINOS, NOυA, LBNE)
  - Joint development of detector and associated technologies

Lots of documents to DAE/DST

Inter University Centre in Physical Sciences[#]

Arun K Grover

Addresses all the mandates given to the collaboration by Secretary, DAE, DST and DOE

US Technical

USA

(# Joint proposal by the Indian Institutions and Fermilab)

Panjab University, Chandigarh
Phone - +91-172-2534463 (O)
Email: vipin@pu.ac.in

LBNE Near Detector Building

LBNE-India proposal to the Government of India could fund the LBNE Near Detector

What does it takes to be No 1

From: Hanson, Paul (CONTR) <Paul.Hanson@ch.doe.gov> Sent: Thu 9/27/2012 3:49 PM
To: C. Shekhar Mishra
Cc:
Subject: Travel history
Message | Shekhar Travel abbreviated.xlsx (16 KB)

Shekhar,

Here's the spreadsheet you asked for. Very impressive! According to the foreign travel system, in the last 5 years (Sept 07 to Sept 12) you've been on 33 trips to 96 destinations!! I excluded the descriptions of each trip because it made the spreadsheet extremely hard to read. Now you can show your family where you've been.

V/R,
Paul

Hanson, Paul (CC

30 trips in last five years to India.

Listening to both sides

Keep focus on the directives and goals

Meeting the deadlines

Anticipating what the policy maker would like

Summary

- Fermilab along with its US and Indian collaboration is making significant R&D, infrastructure and industrial progress that could lead to
  - The Neutrino and Material Science Experiment
  - Project X construction at Fermilab.
  - Construction of two vital accelerators in India
  - Training of next generation of scientists
- We have set the foundation of a very strong technical collaboration with Indian Institutions.
  - US-DOE and Indian DAE are working to finalize two project Annexes for the funding of Fermilab and Indian-DAE programs
  - Support of all collaborating institutions for this unique collaboration is very strong
  - Working with DOE/DAE-DST in making developing the next stage of this program.

Thanks to All who helped



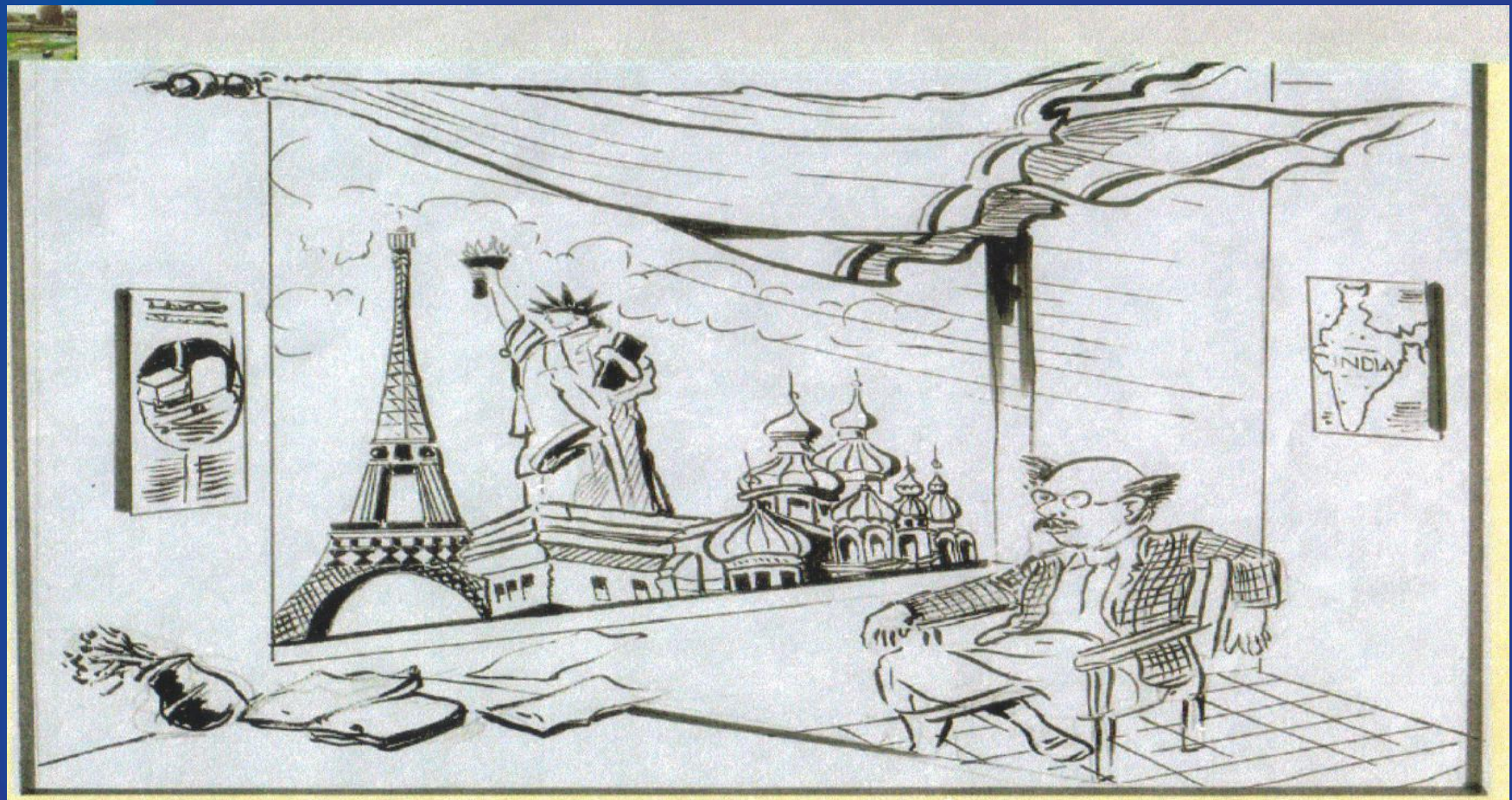









Wind of Change



I do not want my house to be walled in on all sides and my windows to be stuffed. I want the cultures of all the lands to be blown about my house as freely as possible. But I refuse to be blown off my feet by any.

- Mahatma Gandhi