

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 II: "SLAC, RRCAT, BARC, IUAC and VECC Collaboration on
ILC RF Power Sources and Beam Dump Design R&D"**

December 3, 2007

1. Introduction

The work detailed in this document falls within the scope of the Memorandum of Understanding (MOU) between US and Indian Institutions dated January 9, 2006. It addresses in some detail three key areas of collaboration: (i) Accelerator for the International Linear Collider (ILC), (ii) Radio Frequency Power (RFP) Acceleration Science and Technology, (iii) Development of Beam dump design and technology for high power beam for ILC. All terms and conditions under which the work will be carried out are found within the main MOU.

This Addendum to the MOU outlines the collaborative accelerator technology R&D that Stanford Linear Accelerator Center (SLAC) and 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 the Indian Institutions in this document) plan to carry out for the development of RFP for the ILC Main Linac, high intensity proton accelerator, and any other accelerator using similar SRF technology. It also outlines collaborative accelerator technology R&D between SLAC and the Indian Institutions on beam dump design.

2. Background

The International Linear Collider is a proposed future international particle accelerator and the highest priority recommendation of the International Committee on Future Accelerators (ICFA). The ILC would create high-energy particle collisions between electrons and positrons. The ILC would provide a tool for scientists to address many of the most compelling questions of the 21st century including questions about dark matter, dark energy, extra dimensions and the fundamental nature of matter, energy, space and time.

Fermilab and SLAC have been exploring the possibility of enhancing and expanding the existing collaboration with Indian Institutions to include accelerator R&D. US and Indian Institutions have held several meetings to discuss the areas of common interest in particle accelerator technologies. The last meeting in this series was held in India during the visit of the directors of Fermilab, SLAC, DESY and ILC-GDE to India in March 2006 followed by visit from DOE. Discussions with the Secretaries of the Department of Atomic Energy and Department of Science and Technology and the Directors of RRCAT, BARC, IUAC and VECC have motivated the development of this Addendum to the MOU.

We have identified several key areas for collaboration that have direct links with the above mentioned activities. The proposed ILC consists of both an electron and a positron source, damping rings to produce beams of small emittance, and two main linacs for the acceleration of each beam to the full energy of 250 GeV. In the final leg, a beam delivery system (BDS) will focus the beams to a tiny spot where a large multi-purpose detector is located to study the outcome of the particle collisions.

The building block of each ILC main linac is called a RF-Unit. The ILC main linac consists of about 560 RF-Units. The "baseline ILC" RF unit specifications can be found on the GDE website <http://www.linearcollider.org/>. Each RF-Unit is fed by one power system, which consists of a modulator that converts AC-power into high voltage and high power to drive a 10 MW klystron that delivers RF power to the superconducting accelerating units called cavities, via room temperature waveguides and couplers.

Development of the ILC RF-Unit could be useful for many other accelerators besides the ILC including high intensity proton accelerators, XFELs, energy recovery linacs, and spallation neutron sources. SLAC and Indian Institutions engaged in the design of the beam dump for the high power beam are also interested in jointly developing these designs.

3. Work to be performed

The goal of this Addendum to the MOU is to describe collaboration on ILC R&D between Indian Institutions and SLAC. SLAC and Indian Institutions will work to jointly develop an ILC beam dump design and prototypes. Indian Institutions, SLAC and Fermilab will jointly develop an ILC RF-Unit. SLAC and Indian Institutions will focus on the RF Power sources while Fermilab and Indian Institutions will focus on the cavities and cryomodules.

Their work will develop on two parallel paths.

1) Indian Institutions will join the international beam dump design team with a scientist or engineer stationed at SLAC for a short time. Subsequent design work will be mainly carried out at Indian Institutions.

2) Indian Institutions will join the international RF distribution system design team with one or more scientists and engineers stationed at SLAC for short periods. Subsequent work on Design for Manufacture of components will be mainly carried out at Indian Institutions and the Indian Institutions will construct components for an ILC RF-Unit, as per mutual agreement, for use at SLAC. This effort may evolve to include work on other aspects of the RF sources in the future.

It is expected that this addendum will evolve and undergo revision based on initial results. Further work will be carried out under subsequent Addenda.

4. Scope of Work in CY08-09

We propose to start with relatively small projects, utilizing current Indian technical strength and progressively develop more complex hardware. It is expected that Indian physicists and engineers will visit SLAC to develop technical expertise.

1) The full scope of work for the international beam dump design team includes the physics & engineering design of the ILC 17 MW beam dump and its subsystems, including the 1.5m diameter and 6.5m length, 10atm water vessel, three loop water system with catalytic recombiner and filters, shielding, double window and the mechanism of its remote exchange. Design may also include the beam sweepers that raster the beam on the window and doughnut collimators that protect the dump window. The needed R&D may include building a prototype of the windows and performing irradiation tests, and possibly prototyping the front-end of the window remote exchange mechanism.

The contribution of Indian Institutions will begin with an engineer stationed at SLAC for a period of two to three months to gain familiarity with the project and determine

which aspects of the design and prototyping are best suited to be carried out later at Indian Institutions. These aspects of the design will then be continued in India.

2) For the RF distribution, Indian Institutions will have a few scientists and engineers stationed at SLAC for short periods to gain familiarity with the RF components, such as High Power Circulators, Low Power Loads and Variable TapOffs. Subsequent work on Design for Manufacture of components will be carried out at Indian Institutions in collaboration with Indian industry. Based on discussions with SLAC, the Indian Institutions will construct components for an ILC RF-Unit, as per mutual agreement.

5. Schedule and Review

The detailed schedule of this work will be finalized in a meeting between Dr. Shekhar Mishra, Fermilab, Dr. Tor Raubenheimer, SLAC and Dr. Vinod C. Sahni, RRCAT in December 2007. The schedule and progress on both sides will be jointly reviewed every six months. Both groups agree to report and evaluate progress at individual laboratory reviews by their respective funding agencies. An initial schedule for the scope of work outlined in section 4 will be added as a supplement to this Addendum to the MOU.

6. Funding

SLAC and the Indian Institutions agree that SLAC will establish an ILC-India account and fund it to support the local expenses of Indian scientists and engineers invited to visit SLAC under this Addendum. Indian Institutions will provide the Indian scientists and engineers with salary, travel expenses to SLAC, and medical insurance. Initially, SLAC agrees to support up to 3 Indian visitors per year for a period of up to 3 months each.

Indian Institutions agree to collaborate on hardware designs and to fabricate hardware components for SLAC to be used in the ILC R&D. All labor, materials and components available in India will be supplied by the Indian Institutions. SLAC will provide materials and technical components that are not available in India. For each hardware component fabricated in India, Indian Institutions and SLAC will, by mutual agreement, set a dollar value on the contribution from Indian Institutions. SLAC will increment the ILC-India account by an amount equal to 50% of this agreed upon value. All components fabricated by Indian Institutions under this agreement will be delivered to SLAC for use by SLAC in collaborative R&D.

For travel to India, Indian Institutions will provide visiting SLAC scientists and engineers with local accommodation when possible at the laboratory site. The cost of travel of SLAC staff to India will be covered by SLAC.

7 Management and Approval:

The work under this MOU will be jointly managed by Dr. Shekhar Mishra, Fermilab, USA and Dr. Vinod C. Sahni, RRCAT, DAE, India, who will coordinate on behalf of all MoU partner institutions in their respective countries and serve as a single point of contact.

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

Dr Vinod C. Sahni,
Director, RRCAT

Date

Prof. Persis Drell
Director, SLAC

Date

Prof. Tor Raubenheimer
Accelerator Research Division Head, SLAC

Date

Dr. Shekhar Mishra
Deputy ILC Program Director, FNAL

Date