The objectives for this collaboration meeting included: (i) Collaboration goals and plans for FY00, (ii) Look at longer-range picture, and (iii) Goals and plans for the November Collaboration meeting at Fermilab. The meeting began with a plenary session, followed by break out sessions of particular working groups. These notes include a brief discussion of the plenary session, a list of the coordinators of the working sessions, and a summary report from each working session. A list of attendees at the plenary session is given at the end.

The next collaboration meeting is scheduled for November 15-17, 1999 at Fermilab.

Plenary Discussion Agenda

1. Project Overview (David Burke)  
2. Report on Physics Circle Line Tours (Slawek Tkaczyk)  
3. Reports from Existing Working Groups  
   Accelerator Physics (Mike Syphers/Tor Raubenheimer)  
   Main Linac Beamline (Chris Adolphsen)  
   Conventional Facilities (Vic Kuchler/John Ives)  
   Project Coordination (Ted Lavine)  
   Special Topics (Marc Ross)  
4. Tasking of Other Working Groups  
   Magnets (incl. Permanent)  
   Power Supplies and Controls  
   A0 Test Facility

Working Group Coordinators

Accelerator Physics        Tor Raubenheimer/Mike Syphers  
Main Linac Beamline       Chris Adolphsen/Tug Arkan  
Conventional Facilities   Jon Ives/Vic Kuchler  
Project Coordination      Ted Lavine/Tom Dombeck  
Magnets                   John Cornuelle/Bill Fowler  
Power Supplies/Controls   Ray Larsen/Paul Czarapata  
Special Topics (inc. A0)  Marc Ross
Plenary Discussions

Slawek Tkaczyk from CDF gave a summary of the objectives and progress of the Circle Line Tours. This effort was created under the leadership of Paul Grannis and Charlie Baltay to investigate the physics potential for a Linear Electron-Positron Collider in the energy range from 0.2 to 3 TeV. Among the many topics of interest are the questions: Higgs physics—is there only one?; How well can a LC study a Higgs in detail?; and, How does LC physics compare with LHC physics?

Slawek said that there were two Circle Line Tour talks presented at FNAL in September (Hinchcliffe and Peskin). It is planned to follow with talks on Higgs physics (Oct. 21), Marciano talk (Nov.), strong coupling and Yukawa coupling physics (Dec.). The next US NLC workshop will be held in March, 2000 at LBL, and the Linear Collider Workshop will meet at FNAL in October, 2000. Other Circle Line Tour activities include the organization of a Journal Club at FNAL.

David Burke, the NLC Project Manager, gave a summary of the objectives for the project during this coming year. One of the primary objectives is to extend development in industry. The hope is to obtain competitive bids on most of the machine components, including the rf-structures. He said that bids had been received for the development work on the klystrons. A primary goal is to increase the pulse width from 1.5 to 2.7 micro-secs, and thus reduce the number of klystrons needed by one-half.

David said that another goal for next year is the testing of the rf-structures currently being fabricated at KEK. It is anticipated that FNAL will take part in the tests at the ATS and NLCTA. This will help provide information for FNAL's effort to industrialize the rf-structure fabrication.

David said that generic studies of tunnels and cut-and-cover concepts of civil construction for the NLC will progress collaboratively between SLAC and FNAL. This work will build on previous work, such as the FNAL site study in 1997, that proposed that the NLC might track along existing power lines in Illinois.

Another goal for next year is to investigate cost reduction strategies. A number of ideas have been presented and these are being tracked relative to the baseline design presented to the Lehman Panel. It is anticipated that FNAL will participate in this effort. A report will be presented at the November collaboration meeting. It is hoped to have a new cost estimate prepared for presentation at the January meeting. The new cost estimate will then be presented in spring, 2000 at a Lab Director's Review.

Finally, David commented on FY00 budgets. SLAC spent $17M in FY99 on the NLC Project and requested $20.8M for FY00, $17M for SLAC and the remainder at FNAL. It was noted that if the CDR had been approved, its funding would have begun in FY01. Therefore, the FY00 work was still R&D. At the time of this collaboration meeting it appeared that the approved budgets would be very close to the request.
Accelerator Physics.
Tor Raubenheimer and Mike Syphers

During the 3-Day Collaboration meeting of October 4-6, 1999, members of the Beam Physics Department held several discussions with Tor Raubenheimer concerning NLC accelerator physics issues. Discussions were held Monday and Tuesday afternoon, and a video conference between SLAC and FNAL was held Wednesday morning. Major participants at these discussions included Mike Syphers, Francois Ostiguy, Bill Ng, Leo Michelotti, John Johnstone, and Court Bohn. Overall Collaboration discussions were held Tuesday and Wednesday afternoons.

At the time of the meeting, people at Fermilab were attempting to get the code LIAR to run on the Beam Physics Unix cluster. A version of MAD was successfully transferred from SLAC for doing lattice calculations including linac accelerating cavities, and MAD decks were transferred to Fermilab for NLC lattice calculations. SLAC has also provided "trial" LIAR decks for checking the operation of the LIAR code. After a few conversations with Tor and Peter Tenenbaum, LIAR was made operational and the trial decks ran fine.

The following goals were decided upon for near-term accelerator physics effort at Fermilab:

November Collaboration meeting (15-17 Nov 99):
-- Establish fully operational versions of LIAR and MAD (extended) at Fermilab.
-- Begin investigation of improving bandwidth of Main Linac.
-- Begin investigation of correction algorithms for failed quadrupole power supplies.
-- Study use of LIAR code and its output by looking at effect of misaligned accelerating structure(s).

January Collaboration meeting:
-- Finalize bandwidth improvement investigation.
-- Determine usefulness of "beam bumps" to improve emittance from misalignments.
-- Initialize study of magnet string and power supply issues.

May:
-- Begin long-term goal of studying correction algorithms versus tolerances for structure construction, alignment, powering, etc., for minimizing beam emittance, minimizing costs, and maximizing operational performance of the Main Linac.

The November meeting will be held at Fermilab, and the January meeting will be at SLAC. It was agreed that starting in February accelerator physics visits will be held approximately monthly, with the location alternating between each facility. Video conferences will continue between SLAC and FNAL to discuss accelerator physics issues, and other NLC issues, as needed.

Future seminars at Fermilab are being scheduled for SLAC NLC speakers. Peter Tenenbaum will give a talk on November 16 on beam-based alignment, and Paul Emma will visit FNAL in December to discuss the NLC emittance requirements and the Damping Rings.
Main Linac Beamline
John Cornuelle, Chris Adolphsen, and Tug Arkan

Fermilab Attendees in Working Group Sessions:
John Carson, Gregg Kobliska, Tug Arkan, Tom Dombeck, Dave Finley, Tom Jurgens,
Sun Ding, Peter Limon

SLAC Attendees in Working Group Sessions:
John Cornuelle, Chris Adolphsen, Ted Lavine

Monday, October 4, 1999 (from 1 p.m. to 5 p.m.)

Chris Adolphsen from SLAC gave a complete presentation of their activities at SLAC during last years. He presented the project goals, the design parameters, the Main Linac Beamline layout, and the RF systems. He also presented their efforts and work on the RF structures, which are high precision, high-accuracy machined copper disks that are the most important component of the RF system. They require high accuracy machining with micron level tolerances. He showed their efforts at SLAC and also at their collaborators LLNL (California) and KEK at Japan on the high precision machining of these copper cells.

This presentation intended to familiarize Fermilab engineers with the project and its goals. Questions and discussions followed Chris talk for three to four hours. John Carson, Tug Arkan asked questions about the tight tolerances, why they are required, whether they are achievable, and what is the cost to achieve them. Gregg Kobliska asked questions about the cost analysis of these copper disks. John Cornuelle from SLAC answered his questions by showing some cost estimate numbers from different sources such as KEK (Japan), CERN (Switzerland), LLNL (USA). Fermilab engineers also asked about the quality inspection procedure of the high precision machined copper disks. John and Chris showed a couple of transparencies about the QA issues. They showed pictures of their CMM machine at SLAC. They also showed the drawing of a RF testing fixture which is designed by them to measure the frequency characteristic of the machined copper cells. They mentioned that QA is a very critical step towards the success of the Main Linac Beamline. The micron level tolerances have to be checked on the copper cells to assure the proper acceleration of the electron beam in the RF system.

Chris Adolphsen showed the difficulties that they and their collaborators encountered during the machining stages of these copper cells. He mentioned that KEK (Japan) engineers achieved the required tolerances within micron level and also they have verified their results with extensive quality inspection such as fancy CMM systems and RF testing fixtures.

Tom Jurgens from Beam Division, Fermilab asked about the Electro-magnetic characteristics of the copper cells and the design issues such as why and how each 206 cells in a RDDS are different in shape from each other. Chris Adolphsen answered his questions.
Second day of the discussions on the RF system was started with an introduction talk from John Cornuelle (SLAC). He showed the design issues and the tolerance levels, and also presented their collaboration with SBIR companies in their region who work on the high precision machining of these copper cells. He explained and showed sample machining criteria proposed by Robertson Precision Machining Inc, which is a SBIR company at California. He explained the machining steps of the copper cells. They start from a scratch copper tube from which they cut the part with rough turning to be +25 microns oversize, then they put in the HOM cavities with rough milling to a +-15 micron accuracy, and finally the iris cavities and surface finish are diamond turned with a single crystal diamond cutter. The final diamond turning step is the most critical of this overall process. It requires 1-micron level tolerance during the iris cavity cutting and surface finish of the cells.

After the John Cornuelle talk, Fermilab Engineers asked technical questions about the machining process, quality inspection process, what kind of tolerances were achieved until now by their collaborators. John and Chris mentioned that it is very critical to keep these tight tolerances because these structures are not tunable so the accuracy of the required design shape plays a very essential role on the performance of the overall RF system of the Main Linac Beamline. Chris stated that 1-micron inaccuracy causes a roughly 1 MHz shift from the desired frequency. A couple of questions were asked about the diffusion bonding and brazing processes that are used to put the cells together to form RDDS structures. Chris showed some pictures from a Japanese company that does the diffusion bonding of the present cells at Japan.

**Conclusion and Decisions:**

John Cornuelle and Chris Adolphsen from SLAC gave talks on their activities for the Main Linac Beamline. At the end of these useful talks and discussions, it is decided that Fermilab Engineers will visit SLAC, LLNL and SBIR companies at California to see the production process on site. It is decided that this will give Fermilab a more realistic view of what kind of progress was achieved at the project until now. The visit was planned for the week starting 10/25. The schedule of the visit will be to spend two days at SLAC to see the overall design and R&D process of the RF structures and their facilities. One-day will be spent at Robertson Precision Inc., a SBIR company, to see their machining centers and their procedure to high precision machine the copper cells. A one-day visit to LLNL is also planned to see their high precision machining facilities.

**Addition to Notes from Chris Adolphsen:**

Several extensive discussion sessions were held between the FNAL Technical Division staff (Gregg Kobliska, John Carson and Tug Arkan) and the SLAC visitors (Chris Adolphsen and John Cornuelle) on the X-Band RF structures for the Main Linac of the NLC. The 500 GeV version of the NLC contains 5000 1.8-m-long structures. Each structure consists of 206 different 61 mm diameter, 8.735 mm thick copper cells that are presently diffusion-bonded together by
IHI in cooperation with KEK. There is currently no post-bonding tuning capability in the cells, so that diameters and flatness are to micron tolerances and surface finishes require optical-quality machining equipment.

The accelerator performance implications of the mechanical requirements were discussed along with the SLAC experiences to date on obtaining parts and building structures. Currently, the first rounded, damped, detuned structure (RDDS1) is being fabricated at KEK where it will be bonded and shipped to SLAC by the start of calendar 2000. The SLAC SBIR activities were outlined, aimed at obtaining low-cost industrial sources of machine tools and copper cells.

Chris Adolphsen also meet with Ralph Pasquinelli to discuss the development work being done at SLAC on the low-level RF systems for the NLC. These include the distribution of timing signals that would be used to generate the X-Band (11.424 GHz) RF, the up-mixing system to modulate the drive RF, the down-mixing system to monitor the RF from the klystrons and structures, and finally, the structure-based beam position monitors (SBPMs) where the structure dipole mode signals are down-mixed and used as guide to position the structures with respect to the beam. Prototype SBPM electronics will be tested in an ASSET run at SLAC next March - Ralph et al. may want to participate in this test.

In order for the FNAL RF group to learn more about what SLAC has done and where they could get involved, Ralph, Ding Sun and Dave McGinnis will visit SLAC on Nov. 3-5. Chris Adolphsen, Ray Larsen and Marc Ross will schedule presentations of the SLAC R&D and plans for the low-level RF systems, and will arrange meetings with the people working on these systems.
Conventional Facilities Subgroup
Vic Kuchler, Fermilab and Jon Ives, SLAC

Discussions
Five alternative tunnel configurations, and their pro's and con's were discussed:

- Cut and Cover
- Shallow bored tunnel
- Deep - two parallel tunnels
- Deep - elliptical tunnel with shielding wall
- Deep - single tunnel with mined caverns for klystron galleries

Top-level parameters for conventional facilities were discussed to convey basic requirements for the conventional facilities design, e.g., land area, power, water, population loading, stability requirements, micro-seismicity and vibration, design life, reliability requirements, etc.

Mechanical systems were discussed to identify the basic types of systems involved, heat loads and design requirements. The present design concept is based on a "distributed" cooling system, with an independent cooling system for each main linac sector, for example. Analysis of an alternative concept for a "centralized" cooling system was discussed, for use in deep tunnel configurations or as a less costly alternative in shallow configurations.

Site selection criteria were discussed, including the recommendation of the Lehman Review to consolidate those criteria evaluated on the basis of comparative cost into a single item, thereby reducing the number of criteria substantially.

Documentation provided:
- WBS structure, cost estimates and quantities (outputs from "Success" by U. S. Cost)
- Paper on proposed content of CDR
- Paper on Baseline Cost Model Description
- Site Selection Criteria Document, and comparison of two Illinois and three California sites.
- URLs for NLC Conventional Facilities web site
- Drawings, sketches and summaries of heat loads and flow rates for mechanical systems

Scope of Potential Work
Beam-line housings - injector, main linac and beam delivery housings, plus interaction region facilities.
Campus Facilities (will be unique for Fermilab because of substantial reuse of existing facilities).
Site development work (will be unique for Fermilab sites).

Immediate goals
Obtain guidance from the two lab directors and DOE for activities relating to characterizing the range of conditions likely to be encountered at representative sites in Illinois and California. Note: because of the strong influence on cost of such site characteristics as geology and topography, this type of work is essential...
in order to develop concepts for tunnel configurations, identify opportunities for cost reduction and develop realistic estimates of cost.

Establish communication links and the means for routine exchange of information via web sites, etc.

Collaborate on development of concepts for cost reduction.

Collaborate on development of a common set of design criteria for eventual use by the Architect-Engineer/Construction Manager in designing the NLC conventional facilities. (These common design criteria will be supplemented by additional design criteria that are site-specific, e.g., climate and weather, seismic design considerations, etc.)

Near-Term Action Items
Establish points of contact for SLAC & Fermilab (completed: principal points of contact will be Vic Kuchler, Fermilab and Jon Ives, SLAC).

Identify key Fermilab people who should visit SLAC to meet counterparts and gather information (in process: Ed Crumpley visited SLAC in August and Vic Kuchler in September; Jon Ives visited Fermilab in October.)

Fermilab evaluate present Site Selection Criteria document and collaborate with SLAC on revision per Lehman Review recommendations (by November)

Through a newly-appointed Siting Committee to be chaired by Vic Kuchler, Fermilab will gather and evaluate previous studies relating to siting at Fermilab. A status report of this effort will be presented at the NLC Collaboration meeting in mid-November.

Fermilab review, revise and expand as necessary the site comparison information for the two Illinois sites (by November)

Fermilab review and update previous work on a concept design for a centralized cooling system for the NLC. A status report of this effort will be presented at the NLC Collaboration Meeting in mid-November.

Fermilab define proposed course of action and collaborate with SLAC counterparts on an overall joint plan of action (January)
Project Coordination
Ted Lavine and Tom Dombeck

Discussions were held with Harlan Dick from the Beams Division Financial Office concerning a mutual FNAL/SLAC reporting system to DOE. DOE has been requested that all NLC R&D expenditures (salaries, M&S and G&A) be reported through a new B&R code. Harlan described FNAL practices, which were found to be in general concurrence with those at SLAC. It was agreed that FNAL would attempt to provide one account number for each WBS element in which FNAL is engaged. It would be left to Lavine and Dombeck to decide which WBS elements this applied to. SLAC has not used the WBS for their own reporting purposes, but they are planning to do so this year.

Internal to FNAL, the expenditures for each division (Technical, FESS, PPD, and Beams) would be reported to Harlan each month. Project reporting would then be made via an EXCEL spreadsheet from Harlan to the appropriate person at SLAC.

Discussions continued with Ted Williams, a project planner in Beams Division. Lavine said that there were four people at SLAC involved in the project planning office for the NLC, using the tools SUCCESS, Primevera Project Planner, and COBRA. Ted Williams described what was used in the Main Injector Project at FNAL. This was a $230M project with 200 tasks that had a team of four project planners. Microsoft Project was used for planning purposes, but EXCEL spreadsheets were used for cost and schedule estimating. He described the Mini-Boone Project and stated that for this $15M project there were three project planners working on it now.

As a goal for the November meeting it was hoped that Lavine and Dombeck would have a first draft of a WBS structure incorporating FNAL into the NLC project. Also, it was hoped that a project planner would be assigned to the FNAL NLC effort. This person would take part in the decisions being made at SLAC on the NLC project programs.
Magnets
John Cornuelle and Bill Fowler

Talks were presented by both SLAC and FNAL on the question of the use of permanent magnets in place of electromagnets for the NLC. This effort was aimed at assessing whether a cost savings could be achieved by incorporating permanent magnets in the overall machine design.

Nan Phinney of SLAC forwarded a study document that examined the various places permanent magnets could be inserted in place of electromagnets. Andy Ringwall of SLAC presented a Terminology Definition Sheet, a Specifications Table for each of the permanent magnet candidates, and other relevant material. A video conference was held to clarify the NLC requirements, including tolerances, and the need for variability in the field strengths.

FNAL investigated the cost of a sample dipole magnet with a gap of one by two inches, a field of 0.6 T, and using Ferrite or SmCo. The estimated cost of the Ferrite was about one-half that of the SmCo. Since FNAL has extensive experience using Ferrite for the Recycler, it appears that FNAL might concentrate on Ferrite designs.

The next step is to select one or two examples from the Ringwall Specifications Table for the development of a design. Models could be constructed and tested to show the capability of meeting the specifications. To aid in the selection of the best candidate, SLAC will develop a rough cost estimate that they believe is appropriate for each of the Table entries.
Power Supplies and Controls
R. Larsen and P. Czarapata

1. DC Power Systems

Fermilab has indicated an interest to assume a lead role for DC power systems. Presumably this means for the entire accelerator complex and not just the main linacs. The proposed date of commencement is March 00.

Larsen had discussions with Paul Czarapata and Dan Wolff reviewed the work accomplished since Lehman and the work in progress, namely the optimization of magnet systems using string and booster models. The work also intersects with tunnel models and radiation hard design options.

The conclusion was that for the plans to begin with a serious effort in March 00, after the magnet modeling itself has become more settled, Paul and Dan will need to begin to plan the human resources in order to have people available by that time. The department is extremely heavily loaded and appears to be struggling to meet current demands from not only NLC but also current projects and other proposed new initiatives. It appears that they need a clearer prioritization of the proposed NLC work.

As a preparation for March, we will begin a regular correspondence of meeting minutes for DC power systems so Fermilab can track the ongoing work. Dialing up meeting notes on the NLC web page can cover some of this. Larsen will follow up.

2. Controls

Controls topics are not officially in the Fermilab NLC plan for FY00. However, an information exchange will be beneficial for the future. Larsen proposes that Czarapata appoint a person in his department who can track developments, again using web page meeting information, occasional summary reports and reviews, and contacts through future working meetings. It is important that Fermilab be connected to the effort for future applications when systems under Fermilab’s responsibility begin interacting with Controls.

3. Communications and Front End Architectures

Larsen had an off-line discussion with Ed Barsotti, who runs a collaboration on electronics standards work on behalf of Fermilab, with a team of support people. They primarily support detector work through the development of wide-band data architectures, communications protocols and hardware.

Barsotti and his team are heavily involved in the new architectures and moreover have a strong ongoing collaboration with industry, including chip manufacturers, processor board manufacturers and serial communications IO manufacturers. They are tracking industry’s push for integrated packaging, powering, and cooling systems based on high-volume, low-cost, high-speed processor chips and serial links. Their own R&D includes architectures for high density
chip support, including on-board DC-DC converters to support the new super high density processor and programmable chips that operate on voltages down to 0.8 volts. They also are working with other labs, in particular with some people involved in LHC detectors, and have design responsibilities involving high radiation tolerant vertex (pixel) detectors along with radiation tolerant fiber optics communication links out of the detector.

Larsen reviewed Fermilab’s new role in NLC. In the Controls systems it is desired to eliminate the traditional crates and backplanes from the NLC controls architecture in favor of stand alone front end modules interconnected with picosecond stability serial fiber optics timing and Rf clocking, and separate high bandwidth robust noise immune protocol data links. There is potential to involve a broader group of former standards bearers from the physics communities to support future lab-initiated R&D in both controls and detector electronics.

There is potential significant benefit to NLC by a more formal collaboration with this group, and Barsotti is interested. In future, they can be a resource for specific NLC R&D tasks for specialized front end architectures, especially fast serial links and support hardware and firmware; and interfaces with higher level control systems and software utilizing the newest industrial standards. The definitions of these systems impact our choices of overall controls hardware and software systems. The existing industry collaborations play well into our desire to involve industry early in all phases of development of the NLC, and to position the project for a smooth transition into competitively bid commercial solutions to all our major subsystems.

We Propose that a meeting be organized with Ed Barsotti and his supervisor, Matthias Kasemann, to develop a collaboration proposal over the next few months for this work.
Notes on the Use of the A0 Facility for NLC
Marc Ross and Don Edwards

Marc Ross visited A0. After a tour through the hardware, he, Helen Edwards, and other Fermilab personnel engaged in a discussions of topics in which the A0 facility may contribute to NLC. Two meetings were set up for the following day. In the morning, Marc met with Mike Fitch concerning the laser modifications that would be needed to shift the wavelength for to work with gallium arsinide cathodes. In the afternoon, a larger group met to talk about other aspects of the polarization subject. It was agreed that there is potential applications for A0 in several NLC efforts, especially those involving photo-cathode development.

It was agreed to discuss A0 further at the November collaboration meeting.
Special Topics
Marc Ross

The most important result of the special topics/RD discussions was the agreement of Ralph Pasquinelli, Dave McGinnis and Ding Sun to visit SLAC in early November. The dates of their visit will be Nov 3-5. The SLAC-NLC group will prepare a series of presentations for them that will cover the RD plans as laid out in May for the Lehman Panel. The presentations will cover timing system, low level RF, vibration feedback, collimation/MPS, and instrumentation issues.
SLAC Participants:
Chris Adolphsen
David Burke
John Cornuelle
Jon Ives
Ray Larsen
Ted Lavine
Tor Raubenheimer
Marc Ross

FNAL Participants:
Tug Arkan
Court Bohn
Bruce Brown
John Carson
Harlan Dick
Tom Dombeck
Helen Edwards
Don Edwards
David Finley
Bill Fowler
Dave Harding
Steve Holmes
John Johnstone
Tom Jurgens
Gregg Kobliska
Andreas Kronfeld
Vic Kuchler
Moyses Kuchnir
Peter Limon
John Marriner
Leo Michelotti
King Ng
Francois Ostiguy
Adam Para
Ralph Pasquinelli
Mike Syphers
Slawek Tkaczyk
James Volk
Ted Williams

Others:
Paul Schoesson (ANL)
Nobu Toge (KEK)