Minutes of the NLC Collaboration Meeting  
Held at FNAL on November 15-17, 1999

The objectives for this collaborataion meeting included: (i) More Sharply Focus on the program that will proceed during this fiscal year, (ii) Understand the significance of this program in relation to the NLC goals, and (iii) Define the goals for the January Collaboration meeting at SLA. 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 January 31 through February 4, 2000 at SLAC.

Agenda

Monday, November 15
  09:00 - 10:30  Opening Remarks (Mike Witherell)  
                Project Overview (David Burke)  
                Goals for the Meeting (Tom Dombeck)  
                Schedules and Tasking of the Working Groups  
  11:00 - 17:00  Break Out Sessions

Tuesday, November 16
  09:00 - 10:00  Reports from the Working Groups  
  10:15 - 17:00  Break Out Sessions

Wednesday, November 17
  09:00 - 14:30  Working Group Sessions  
  13:30 - 15:00  Close - Out

Working Group Coordinators

Accelerator Physics  Tor Raubenheimer/Mike Syphers  
Main Linac Structures  Chris Adolphsen/Dave Finley  
Conventional Facilities  Jon Ives/Vic Kuchler  
Permanent Magnets  Andy Ringwall/Bill Fowler  
Controls Architecture  Ray Larsen/Paul Czarapata  
Project Coordination  Ted Lavine/Tom Dombeck  
New Topics  Marc Ross/Ralph Pasquinelli

  Final Focus Vibration Feedback;  
  Beam Collimation;  
  Timing Systems;  
  Source Related Issues.
Plenary Presentations During the First Day

Mike Witherell, director of Fermilab, gave the opening remarks. He emphasized the importance of the NLC R&D program for Fermilab and SLAC. He said that the effort mounted to eliminate the restrictive language from the Senate Funding Bill this year showed the commitment to the project on the part of the two laboratory directors. He urged the collaboration to continue its work on the technical, as well as the cost savings, front.

David Burke, the NLC Project Manager, gave a summary of the progress demonstrated recently in the project and the implications of the work that is proposed for this fiscal year. He noted that "Big Projects" have had a rough time winning approval in the government. However, This is not new, as SPEAR had to be submitted three times before winning approval.

Much of the NLC effort at SLAC has focused on cost reduction strategies. A database has been created and is available with the ideas submitted to date. An analysis of the $5.1B cost estimate (no contingency or escalation) for the NLC had 19% in the injectors, 39% in the main Linacs (20% in the rf), 11% in final beam delivery, 17% in global systems and 14% in management. So there is no one large piece to attack to reduce costs. Some of the options under consideration include: (a) optimize on a lower energy, (b) do not provide a direct upgrade route, (c) one IR, (d) lower luminosity, (e) increase risk, (f) use of C-band in the injectors, (g) use of heavily damped rf-structures, (h) improve positron production sources, and (i) improve methods to collimate and stabilize the collisions.

Dave reported progress in the fabrication of a 75MW, 2.67 microsec. pulse length, X-band klystron at SLAC. The longer pulse length will permit doubling the structures driven by one klystron and ultimately is imagined to reduce the overall number of klystrons by 4/7. He reported progress in the use of TGBT-based solid state modulators that will allow 8 klystrons per stack rather than two at present. All of these changes in the rf are estimated to result in a total savings of $0.75B.

Dave put in perspective the proposed R&D effort at Fermilab for this year. First, he compared the heavily damped rf structures (HDS) to the detuned structures (DDS). The HDS would permit tuning of the primary mode, but the DDS allow for the readout of the beam position in each individual cell. The tradeoffs between different precision machining methods have been hard to study due to the low production rate of DDS rf-structures (1/9 months). One objective would be to increase this rate by an order of magnitude so these studies can be done effectively. He also mentioned that one of the hot Accelerator Physics issues was to determine the effect of losing one of the main Linac magnets during operations. The present design reduces this risk by the costly use of a backup power supply on each magnet. Dave said that collimators require large beam spots to reduce damage. It may be possible to design collimators that can be replenished when damaged.

Finally, Dave mentioned certain engineering optimizations to be considered. These include the use of permanent magnets. Also, there may be savings in the vacuum systems by integrating the power supplies with the pumps. He pointed out that the cabling costs alone were estimated to be $0.25B and should be looked at for savings.

In the conventional construction area, Dave pointed to cost comparisons between cut-and-cover versus deep boring. Central cooling ideas to maintain tunnel stability are also being studied.
Working Group Reports

Accelerator Physics.
Tor Raubenheimer and Mike Syphers

The three-day meeting was divided into several working sessions. Participants at the discussions included Tor Raubenheimer, Nan Phinney, Peter Tenenbaum, Mike Syphers, Francois Ostiguy, Bill Ng, Leo Michelotti, Bob Noble, John Johnstone, Elliott McCrory, and Court Bohn.

On Monday afternoon, the Accelerator Physics Subgroup met jointly with the subgroup on RF-structures. Details on that discussion can be found in the corresponding section of this report.

On Tuesday, the Accelerator Physics Subgroup met independently to discuss the following issues:

1) Main Linac lattice issues, such as choices of phase advance, sectioning of FODO cell lengths, etc., were discussed -- Fermilab personnel learned details of the choice of certain design parameters.
2) Quad failure -- Syphers presented a first pass analysis of quadrupole failure consequences in the Main Linac. It was assumed for the discussion that the quadrupoles in the linac are grouped in sections and powered off of bulk supplies, with 5% trims (max) used to obtain the proper phase advance per FODO cell. It was shown that a 5 percent change in quadrupole field (i.e., one trim supply turning off) would, in the high energy end of the linac for instance, produce a 25% wave in the amplitude function. For 90 degree cells, this can be corrected by adjusting a trim 180 degrees downstream by the same amount (i.e., turn it off), or by adjusting a trim 360 degrees downstream by the same, but opposite, amount. The latter preserves the total phase advance of the system. For other than 90 degree cells, a "beta bump" using two downstream quadrupoles can be implemented. Syphers will present this method and corresponding simulation results at the next meeting. A quadrupole which is completely turned off will produce a beta wave of amplitude roughly \( \frac{dbeta}{beta} = 25 \). The immediate correction of such a failure using local quadrupoles will be discussed at the next collaboration meeting.
3) LIAR code -- Ostiguy discussed the progress made in obtaining the LIAR simulation code from SLAC and getting it to run on the Beam Physics unix cluster at FNAL. This was successful just in time for the meeting and sample data files from SLAC were run at FNAL.
4) Raubenheimer discussed the general procedure for computing the bandwidth of the main linac and the issues concerning its improvement. Johnstone will be working on this issue for the January meeting.
5) Many general issues regarding wake field calculations, structure tolerances, beam responses, etc. were discussed in the Subgroup meeting.
6) Tuesday afternoon, Tenenbaum delivered the Beams Division Seminar on Beam-based Alignment techniques applied to the NLC design.

Wednesday morning, the group met again to discuss tasks for FY00 and the required level of effort. The FNAL group listed their level of effort and projected the level required by the end of FY00, that is presented in the following table.
FNAL FY00 Accelerator Physics FTE’s:

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FTE: 1.4 2.9 4.2

(Note: a post doc position by 10/00 or earlier is being considered.)

The tasks for FY00 are: 1) Understanding the Main Linac Optics, 2) Understanding emittance Issues, 3) Understanding wake studies, and 4) Miscellaneous accelerator physics. Detailed tasks will be identified by the Winter meeting for each category.

Two other major issues were identified, namely the need for a budget code to which to charge this year's effort (T. Dombeck since has identified such a code), and the need to understand the travel budget constraints. It was noted that to make optimal progress, it is desirable that several people make multi-week/month site visits to the other lab.

Near-term goals for the Winter Collaboration meeting are: 1) Finalize bandwidth improvement investigations, 2) Determine usefulness of “beam bumps” to improve emittance from misalignments, and 3) Initialize study of magnet string and power supply issues.

Goals for the Spring/Summer time frame are: 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 winter meeting will be at SLAC. Video conferences will continue between SLAC and FNAL to discuss accelerator physics issues, and other NLC issues, as needed.
Main Linac Beamline.
Chris Adolphsen, and Tug Arkan

11/15/99 Monday (joint session with Accelerator Physics group)
- Roger Miller – Tradeoffs
  - The discussion began with a video of the fabrication of the SLAC Linac rf-structures.
  - Possible design optimization and tradeoff issues were addressed to lower the overall cost of the structures

- Tor Raubenheimer – Tolerances
  - Alignment and frequency tolerances were explained. Possibility to loosen the sub-micron level tolerances if needed was discussed

- Juwen Wang – RDDS1 Experience to Date and Status
  - Status of the RDDS1 at KEK was given with KEK approach to the structure manufacturing (cell machining, cell bonding etc.)

- General Discussion
  - Physicists and engineers discussed the tolerances and tradeoffs, which can be performed to lower the overall cost of the project. More parametric numerical and experimental studies have to be conducted to study the tolerance sensitivities

11/16/99 Tuesday
- Chris Adolphsen – Gradient Issues
  - Processing of the structures were discussed. Chris showed the surface damages of the iris profile of some cells with 85 MeV/meter power. This phenomenon has to be studied more closely (do we really need sub-micron level surface finish on the iris profile, can we lower the cost without it?)

- RDDS1 Costing Basis – John Cornuelle
  - A preliminary cost comparison and analysis of RF structure manufacturing was presented

- Industrialization of Structures – John Cornuelle
  - SLAC and Fermilab approaches to the mass production of the cells were presented.

- Chris Adolphsen – ASSET Performance of CERN TDS Structure
  - CERN CLIC TDS Structure was presented. Some preliminary data of the ASSET test at SLAC was shown. The introduction of heavily losses to the design has to be studied by SLAC and Fermilab

- Discussion of Potential Task List for Fermilab for FY00
  - John Cornuelle presented a possible menu for Fermilab NLC activities for FY00. A list of potential tasks were defined with FTE, M&S and completion dates. This list is presented at the end of this meeting summary.
11/17/99 Wednesday

- Mike Neubauer – Supports and Mode Mapper
  - Girder and supports to hold the structures were presented.

- Final Report Preparation for Close-Out and Goals for Next Collaboration Meeting
  - Final closeout report was presented and edited. Goals for the next collaboration meeting was discussed

Goals for Next NLC Collaboration Meeting

- Import Omega$_3$ and Tau$_3$ codes to FNAL
- Get drawings of QC fixture to FNAL
- Setup Single Cell QC
- First pass at shunt impedance calculations for HDS
- Prepare HDS summary at SLAC
- Contact CERN regarding collaboration
- Report progress on vendor identification (Cell / Structure)
- Refine schedule and cost
- FNAL perspective on cost
- Discuss progress on RDDS1 and mode mapper parts to be built at FNAL
- Observe RDDS1 brazing, QC at SLAC
List of Fermilab Tasks for NLC RF-Structure Activity

- **Overall Goal:**
  - Complete Understanding of Technology, Schedule and Cost
  - Define Check points, Decision Points and Plans
  - Determine Final Plan by 1/1/03 to Produce Efficient and Economical 5000 Structures in 3 years

- **Cell and Structure Experience (Mechanical and Electrical Group)**
  - KEK
    - Review KEK/IHI RDDS Construction Experience
    - Review Cell Manufacturing Data from KEK NLC Working Group
    - Visit KEK to Observe Structure Bonding and to Obtain Information First-Hand
  - CERN
    - Review of Heavily Damped Structure (HDS) Work at SLAC & CERN

  FTE (man/month) : 1  
  M&S (K$) : 12  
  Completion date : 03/00

- **Cell and Structure Construction (Mechanical & Electrical Group)**
  - RDDS
    - Produce Sample RDDS Cells
    - Produce Sample RDDS Sections

    FTE (man/month) : 3  
    M&S (K$) : 500  
    Completion date : 3/01

  - HDS
    - Produce Sample HDS Cells
    - Produce Sample HDS Section

    FTE (man/month) : 3  
    M&S (K$) : 500  
    Completion date : 6/01

- **Cell and Structure Construction (cont.)**
  - Diffusion Bonding vs. Brazing
    - Evaluate Brazing and Tuning versus Diffusion Bonding

    FTE (man/month) : 3  
    M&S (K$) : 50  
    Completion date : 3/01
- **RF Measurements of Cells/Structures**
  - FTE (man/month) : 6
  - M&S (K$) : 75
  - Completion date : 3/01

- **High Power RF Test RDDS Sample Cells/Sections at SLAC**
- **High Power RF Test HDS Sample Cells/Sections at SLAC**
  - FTE (man/month) : 1
  - M&S (K$) : 2
  - Completion date : FY01

- **Cell and Structure Design**
  - **Cell Design Analysis (Electrical Group)**
    - Establish Heavily Damped Cell and Structure Electrical Design Capability (with CERN?) (Rounded versus Cylinder and Disk Geometry)
    - Perform Shunt Impedance and Q Calculations ($R_{\text{Shunt}}$ and $R_{\text{Shunt}}/Q$)
    - Contrast Relative Performance of HDS and RDDS on Key Accelerator Parameters
    - Contrast Relative Performance of HDS and RDDS on Tolerances (may require additional modeling)
    - Develop Optimization Criteria and Assess Tradeoffs
  
  - FTE (man/month) : 6
  - M&S (K$) : 5
  - Completion date : 8/00

  - **HDS Cell and Structure Design (Mechanical & Electrical)**
    - Perform Heavily-Damped Cell and Structure Electrical & Mechanical Design
  
  - FTE (man/month) : 24
  - M&S (K$) : -
  - Completion date : 3/01

- **Cell and Structure Design (cont.)**
  - **HDS Cell and Structure Fabrication**
    - Visit CERN to Discuss Feasibility of Building a TDS (CLIC Design) Structure at X-Band: CERN Design, FNAL Construction, SLAC High Power Test
  
  - FTE (man/month) : 8
  - M&S (K$) : 500
  - Completion date : 9/01
• Cost Evaluation and Industrialization
  - Industrialization
    - Review Cell Machining Strategies with SLAC, KEK and CERN
    - Contact Candidate Companies for Cell and/or Cell Machine Manufacturing
    - Review Industrialization Approaches; Select Strategy
    - RF and Mechanical QC

  FTE (man/month) : 12
  M&S (K$) : 50
  Completion date : 6/00

  - Cost Evaluation
    - Analyze Cost Estimate Assumptions for RDDS Structure
    - Develop Cost Basis/Cost Model for Heavily-Damped Structure (HDS)
    - Perform Cost Comparison of HDS versus RDDS Structure
    - Obtain Cost per Meter/Watt of All Linac Components
    - Perform Cost Comparison of HDS Main Linac vs. RDDS Main Linac
    - Assess Other Considerations (Reliability, Vacuum) for HDS versus RDDS

  FTE (man/month) : 6
  M&S (K$) : -
  Completion date : 3/00 (preliminary)

• Parts to be built for RDDS1 and Mode Mapper
  - Fermilab will be responsible for the fabrication of the RDDS1 components such as input/output couplers, cooling lines, vacuum components, etc.
  - Fermilab will also be responsible for the fabrication of some parts for the Girder mechanism and Mode Mapper.

  FTE (man/month) :
  M&S (K$) : 200
  Completion date : 5/00
Summary of the Total FTE and M&S Figures for FY00

- **Cell and Structure Experience (Mechanical & Electrical Group)**
  - FTE (man/month) : 1
  - M&S (K$) : 12 (travel)

- **Cell and Structure Construction (Mechanical & Electrical Group)**
  - FTE (man/month) : 16
  - M&S (K$) : 500(RDDS) + 50(bonding R&D)+75(RF QC) = 625

- **HDS Cell and Structure Design (Mechanical & Electrical Group)**
  - FTE (man/month) : 38
  - M&S (K$) : 500 (HDS Fabrication)

- **Cost Evaluation and Industrialization**
  - FTE (man/month) : 18
  - M&S (K$) : 50

Total FTE for FY00 (man/year) : 6
Total M&S for FY00 (K$) : 1,200
Conventional Facilities Subgroup  
Vic Kuchler, Fermilab and Jon Ives, SLAC

Status of Progress

- **FERMILAB COMMITTEE FOR SITE STUDIES (FCSS)**
  Fermilab Committee for Site Studies (FCSS) has been formed and initial meetings have been held. Gathering of existing data has begun. Subcommittees will be formed to concentrate on specific areas to determine where additional data is needed.

- **SITE SELECTION CRITERIA**
  First draft of the NLC Site Selection Criteria has been completed. SLAC Representatives will revise current draft per the Lehman review recommendations for review and concurrence by Fermilab. In addition, information collected by the FCSS will be incorporated into the NLC Site Selection Criteria.

- **FERMILAB SITINGS**
  The FCSS will provide data to the Fermilab Conventional Facilities effort to support both options stated below. These criteria will be revised as decisions are made to complete the CDR 0.4 design iteration.

- **NORTH-SOUTH DEEP TUNNEL**
  Fermilab Conventional Facilities will use the SLAC CD-1 Criteria to develop design options for a North-South deep tunnel orientation.

- **EAST-WEST CUT AND COVER**
  Cut and cover will be considered for the East-West orientation.

- **FERMILAB BASELINE SCOPE AND COST-JULY/AUGUST FY’00**
  Fermilab Conventional Facilities will work toward a baseline scope and cost model for both Fermilab sites by the July/August, FY ’00 timeframe. This baseline will follow the format of a Project Definition Report.

- **SLAC GEOLOGIC STUDY/REVISED COST**
  In the coming months, SLAC Conventional Facilities will study the geology of representative California sites. When this study is completed, a tunnel configuration will be defined and a revised cost estimate will be prepared for the NLC Conventional Facilities at the California sites.
• CENTRALIZED COOLING STUDIES

The issue of distributed cooling verses central cooling was discussed at length and identified as high priority issue. The Fermilab North-South site option will develop a design concept and cost estimate for centralized cooling.

• INFORMATION EXCHANGE/COMMON WEBSITE

SLAC and Fermilab will work together to establish a means to consistently exchange information on the project. Development of a common website for NLC Conventional Facilities will be explored.

• RESOURCE REQUIREMENTS

Initial funding has been identified for the Fermilab Conventional Facilities effort. A proposal for required resources and funding to support the FY’00 design effort will be developed and submitted.
**Permanents Magnets**
Andy Ringwall and Bill Fowler.

**Attendees in the working group sessions:** Andy Ringwall, Nan Phinney, Dave Burke, Mark Ross, Keith Jobe, Tom Markiewicz, and Ray Larsen (SLAC); Bill Foster, Jim Volk, Tom Nicol, Bruce Brown, Stan Pruss, John Johnstone, and Bill Fowler (FNAL).

**Summary:**

After a review of the possible candidates for replacing the electromagnets in the NLC conceptual design with permanent magnets, the discussion focused on the Main Linac quadrupoles. The most likely design choice is a hybrid of Ferrite with Iron poles. The required adjustment of 20% in the field strength is accomplished by rotating a Nd-Fe-B rare earth magnetic element. Even though there remain questions that this design will meet all of the required specifications, the conclusion was that it looks promising. Studying this design will be the primary focus to be reported at the February collaboration meeting.

Other conclusions reached are: (1) A cooperative program will allow for the strengths of each Laboratory to be utilized. (2) Two identical models will be built so that SLAC can do beam testing while Fermilab can do magnet measurements. Also, this will give information on reproducibility. (3) The objective for the February meeting is to have design drawings for the first prototype, followed by procurement and fabrication.

The detailed permanent magnet presentation is available at the NLC web site

**Motivation**

Permanent magnets (PM) are a technology that is seen as a possible means of reducing cost, simplifying system design, or improving reliability for the NLC. Fermilab has developed an expertise in building hybrid permanent magnets as part of the recycler ring project presently being commission. So permanent magnets are an obvious technology option on which the two labs can collaborate.

**Recycler Ring Magnets/Magnet Options**

General discussions were held about Fermi’s experience with the combined function and quadrupole magnets built for the recycler ring. Topics included:

- Strontium ferrite material properties and block inspection
- Temperature compensation techniques
- Mechanical design and assembly
- Mapping and tuning techniques

The group decided a hybrid PM with a rotating PM corrector element was the lead PM technology option. A hybrid option with a trim coil was presented but rejected due to excessive power dissipation and defeating the goal of reducing power supplies and cable plant for the NLC.
NLC Requirements
The group discussed the requirements for the NLC magnets, centering on the main linac quadrupoles. These magnets are small bore (12 mm) with a 1 T pole tip field. Nearly all NLC quads and sextupoles are on movers and have dedicated BPM's. These magnets will undergo periodic beam based alignment (BBA). The first step in BBA is to determine the offset of the magnet and BPM centers. The magnet strength is varied up to 20% in successive steps each step lasting about a second while orbit fits from upstream and downstream BPM's determine how well centered a particular magnet is with its BPM. The allowed magnetic center shift during this strength variation is tight (<1 micron). The inherent variations in the permanent magnets strengths will contribute to this shift. This requirement could be difficult for PM's (and maybe even for electromagnets).

Technical Issues
Brief technical discussions focused on ways to limit the BBA magnetic center shift. Inspection and sorting of the PM blocks, thermal or magnetic "knock down" of the PM's to a specified value, and adding or subtracting PM material from the finished magnet were all discussed. It was felt that changing the individual pole reluctance by using steel shimming to compensate for the PM strength errors should probably be avoided since the corrector magnet error vectors change as the magnet is rotated. Other sources of center shift error were briefly discussed. The group also decided that the corrector element should be rare earth PM's to avoid demagnetization.

The group identified that the temperature tolerance of the NLC tunnel needed to be clarified for the temperature compensator design.

Jim Volk completed a preliminary model of a hybrid quad with rotating corrector element (Nd-Fe-B) for the 0.5Q12.75 magnet. This corrector could modulate the pole tip field by 50%.

Cost Issues
The group decided that not enough information was available at hand for a one to one cost comparison. It was noted that PM's open up opportunities for other systems to reduce cost, particularly with conventional facilities.

Future Plans
It was decided that the group should work toward a preliminary design for a prototype at the next collaboration meeting. The goal would be to build two prototypes with one possibly being tested with beam at SLAC. Many things needed to occur to achieve this. A clarification of the requirements by SLAC and adequate resource allocation were discussed as a first step.

A realistic cost comparison of PM's against electromagnets will be presented at the next meeting.

Other candidates for PM's would be developed as time permitted.
Bill Fowler's Additional Comments:

This is not a big ticket item, so why should work be done on it. The answers are: (a) Fermilab has just completed the Recycler and the 8 GeV beam line, gaining much experience with Ferrite Permanent Magnets. Therefore, it seems desirable to capitalize on this experience. (b) The scope is small enough that it does not require a full time drafting staff. (c) Will help in starting up cooperative efforts towards the NLC. (d) This appears that it will produce cost savings for the NLC and probably carries less risk than the CDR design. (e) Low cost high-precision Permanent Magnet adjustable quadrupoles probably have other applications.
Controls Architecture
Ray Larsen and Paul Czarapata.

Attendees: P. Czarapata, S. Lackey, K. Cahill, D. Johnson, B. Hendricks, C. Briegel, M. Shea, J. Smedinghoff, and E. McCrory (FNAL); R. Larsen and N. Phinney (SLAC); and P. Schoessow (ANL).

An initial exploratory meeting between SLAC-NLC and the Fermilab Controls group was held on Tuesday November 16th for about 2-1/2 hours, continuing on Wednesday the 17th for another 1-1/2 hours before breaking to prepare a closeout summary.

The meetings discussed two main topics:

1. Opportunities for collaboration on goals of mutual interest to Fermilab and the NLC.
2. Discussion of a "Global Controls" concept being advanced by a group of Lab Directors as a way to encourage collaboration of major labs on large new accelerators that are beyond the scope of a single Lab.

1. Opportunities for Collaboration:

Paul Czarapata pointed out that to date there has been no discussion of implementing formal collaboration in the field of Controls. Larsen had been lobbying for a contact person at least on the premise that controls issues will arise out of the ongoing work and we need a way to deal with at the very least interface issues. The following discussions were an attempt to explore issues and concepts.

Ray Larsen gave an overview of the proposed NLC Control System following the overheads of Mark Crane et al that were presented to Lehman in May 99. This talk concentrated on the hardware architecture, based on a centralized computer farm with fast serial fiber links to remote areas of the machine, along with a local nodal concept where single or grouped hardware devices could be serviced by fast local processors (if required), and copper or fiber fast serial links. Timing, Low Level RF, BPMs and Machine Protection pose special bandwidth or timing precision issues. The relative estimated costs of both hardware and software were discussed. NLC web page references were given to access these and other talks of interest to the Controls group.

Nan Phinney discussed the bandwidth requirements of not only handling the expected large number of feedback loops required to stabilize the beam, but also the concept of collecting all available machine data for later off-line analysis by machine design engineers and physicists. This leads to an additional requirement for deep storage of aggregate machine data, which will prove invaluable in the ongoing work of characterizing, calibrating and updating the machine to obtain maximum possible performance over the lifetime of the machine.

In the discussion, the group explored areas of mutual interest. Fermilab is upgrading its control system with an implementation of NT machines running JAVA. The EPICS system is being studied by both groups; Fermilab is learning from the Argonne APS experience. The recent ICALEPS conference was discussed as a rich source of information. LHC at CERN, RHIC, TJNAL all offer recent examples of software initiatives for study. CDEV, EPICS and JCOPS initiatives or collaborations are all of interest to both groups.
Possible ways of developing an ongoing dialogue on these topics where we have common interests was also discussed. Such a discussion would benefit both parties irrespective of future formal collaboration on the NLC. Tools are websites, video conferences and email discussion or information groups. We agreed to study this further.

2. Global Controls Model

This model sees a remote collaborator user who bought, designed and built a major system in the machine, being able to own a remote control room and actually operate the accelerator. Different groups around the globe would cover various shifts on a 24 hour a day basis. The model is one small piece of a large, complex puzzle that we must solve to make the building of such large machines even possible: No one lab or nation can afford a machine of the scale of the NLC, a message that comes through to NLC from recent budget machinations with the U.S. Congress.

Questions are:

Can we do this technically?
How do we collaboratively design, support and operate it?
Can we do a demonstration experiment?

The group spent several hours on the questions. The immediate observation of several people was that there are already living examples of machines being built collaboratively and being operated remotely. Various physics experiments, diagnostic systems, and actual remote setup of a controls terminal can be cited as examples. There seemed to be unanimity that the purely technical problems of actually operating the machine from afar were not particularly difficult.

Collaboration issues in designing and building are more difficult, but again examples exist: LHC at CERN, LHC detectors being built at Fermi and BNL, the ITER (International Experimental Tokamak Reactor for fusion), international space station, NASA space programs, the Astronomy community, Boeing 777, and other examples are relevant. The methods of managing such projects are continuing to develop and improve with time.

Regarding demonstration experiments, it is hard to think of a meaningful one that would explore some of the difficult issues. Technically it a basic demo seems almost trivial, while to actually build a machine and an international collaborator infrastructure is very challenging. It has been reported that the KEK Director has charged the ATF (Accelerator Test Facility) group to mount a demonstration with SLAC. The group was asked to write a brief note on the examples they know about so we can explore them more fully if desired.

In summary, the group seemed agreed that the main issues in the Global Controls model are primarily managerial, sociological and political, and secondarily technical.

The Coordinators comment that if such a study is to become in integral part of the NLC CDR as part of a thrust toward early development of fully participating international partners, then NLC management needs to provide guidance on specific goals to be met by demonstration models along the timeline leading to CDR.
Project Coordination
Ted Lavine and Tom Dombeck

On the issue of budget tracking and reporting for the R&D Program, important agreements were reached with Harlan Dick and Pat Lesiak who will be reporting Fermilab's effort to SLAC. Fermilab's October costs have been reported to SLAC.

On the issues of integrated budget-schedule planning for both the R&D program and the future construction project, much discussion and work have been accomplished at SLAC during the past year. However, it was recognized that both labs must work together on important decisions. This process has begun with productive, but preliminary, discussions within Fermilab planner, Ted Williams. It is hoped he will continue as part of FY2000 R&D program.
On a recent visit to SLAC by Ralph Pasquinelli and Ding Sun, four “New Topics” for Fermilab’s participation in the NLC collaboration were selected from a larger number of accelerator design problems. It is believed that FNAL can make a significant contribution on all of the challenges presented, but due to limited resources and budget, it was decided to concentrate on these four critical areas. A steering committee will be formed at Fermilab to provide guidance and direction of FNAL’s contribution to the collaboration. What follows is a summary of the break out meetings held at Fermilab on November 16 and 17.

Fermilab Technical Division has decided to contribute to accelerator structure fabrication. While this is mainly a mechanical and industrialization effort, there is a need for microwave engineering to assure quality control of the accelerator structures. In addition, a specialized test fixture, known as a mode mapper, must be fabricated to aid in the measurements associated with the distribution of the high power microwave signals between klystrons and accelerator structures. The RFI department of the Beams Division can supply the fractional FTE to support this microwave engineering effort. This engineer would need to spend some time at SLAC in an effort to understand the requirements and what has been built to date. On the topic of accelerator structures, the CERN damped structure could be a viable candidate for the NLC. As little is known about the structure’s history and performance, an investigation by microwave engineers at Fermilab should be initiated should this alternative be pursued.

The RF frequency reference distribution system was also sited as both critical to accelerator performance and an area where Fermilab has expertise. While SLAC is pursuing several options to solve the distribution problem, experience at Fermilab may have a simpler technique for implementation in the NLC. A series of teleconferences should be planned between now and the collaboration meeting that is tentatively planned for February 2000. A small group at FNAL could review in detail the effort to date at SLAC. The Fermilab plan for RF distribution can then be formulated with preliminary ideas presented at the collaboration meeting.

The collimation requirements for the NLC are stringent. SLAC is presently building a consumable scraper that could provide the required collimation, but requires as much as six kilometers of drift space between the main linacs. Such a scraper would expect to have a year lifetime due to several errant beam pulses per day. All scraping scenarios require beam proximity of microns. At these short distances from the beam, damage to such a collimator could also be induced by large beam image currents via $I^2R$ losses. Fermilab should concentrate on the design of a continuously renewable collimator surface. Such a device would allow tighter scraping tolerance and could lead to substantially reduced drift space between the main linacs, a major cost saving. This project is mostly mechanical engineering and could be supported by the Beams Division Mechanical Support Department. Here again, a series of teleconferences should be held to examine in more detail the effort to date. Presentation of brainstorming ideas for a renewable surface collimator would be the goal for the next collaboration meeting.

The last new topic is one of final focus vibration feedback. Ground motion due to a variety of sources has been measured at SLAC in the frequency range of DC to 100 Hz. It is believed that most of the ground vibration below one Hz could be handled by some form of pulse to pulse beam feedback. The range of 1-100 Hz is dominated by “cultural” noise and would require active feedback damping on the final focus quadrupoles. The range of motion is on the
order of 100 microns with 1-5 nanometer resolution. While measurements of ground motion
with this sensitivity have been performed, it is not clear that active feedback on massive elements
is well understood. This project requires participation by both mechanical and electrical
engineers. While Fermilab has limited experience in this field, there is an interest in the
problem. A number of ground motion problems have been observed and corrected at the
Tevatron, albeit at the micron not nanometer resolution. A goal for the February 2000
collaboration meeting would be for Fermilab to have a more detailed understanding of the
problem. The need for a fast kicker to keep beams in collision is closely related to this topic.
Some discussion centered on this 20 nanosecond delay fast feedback system, but the analysis to
date is only contains one data point. Fermilab could also contribute to understanding the strong
focusing effect the colliding beams have on each other. Before engineering of such a fast kicker
system could begin, the fundamental effects of beam beam interactions must be better
understood. The pay off for such a fast kicker system may reduce the resolution requirements of
the vibration feedback system and result in substantial cost savings.

Marc Ross Additions:

Moyses Kushnir met with Marc Ross and John Corlett of LBNL to discuss a bunch
length monitor capable of measuring short bunch lengths. The device has also been described by
a group at TESLA. It is based on a Josephson junction array that functions as a high
bandwidth optical spectrum analyzer; that is, a coherent radiation (millimeter wave) spectrum
could be derived for each machine pulse (certainly fast compared to a mechanical spectrum analyzer).
The minimum bunch length observable depends on the type of superconductor used in the junctions
and ranges from just under a millimeter for niobium to around 100 microns for high temperature
superconductor. Shorter bunches generate shorter wavelength light that can break up the
Cooper pairs in the superconductor.

Since the coherent radiation is fairly broadband, and contains some energy in the short wavelength
region, one might question how much short wave radiation is required before the junction array
begins to behave differently. Moyses said that he would look into this.

We briefly discussed the advantages that such a device has in comparison to other bunch length
monitors (streak camera and coherent radiation Michelson interferometers). It's advantage lies in
its fast response time (when compared with the latter) and in the possibility of short (<1mm) bunch
(when compared to a streak camera) monitoring. Arrays of niobium junctions (16x16) are available
commercially from Hypres; some RD is required to make an array out of high temperature
superconductor material. None of the coherent radiation devices readily allow bunch shape
measurements of asymmetric bunches. This remains an outstanding problem. The NLC linac will
have asymmetric bunches about 100 microns rms.
SLAC Attendees:
Chris Adolphsen
David Burke
John Cornuelle
Clay Corvin
Jon Ives
Keith Jobe
Ray Larsen
Ted Lavine
Tom Markiewicz
Roger Miller
Mike Neubauer
Nan Phinney
Tor Raubenheimer
Andy Ringwall
Marc Ross
Javier Sevilla
Peter Tenenbaum
Juwen Wang

FNAL Attendees:
Tug Arkan
Court Bohn
John Carson
Champion
Brian Chase
Paul Czarapata
Harlan Dick
Tom Dombeck
Alexander Drozhdin
David Finley
Bill Fowler
Peter Garbincius
Steve Holmes
John Johnstone
Vic Kuchler
Moyses Kuchnir
Sharon Lackey
Fritz Lange
Elliott McCrory
Frank Nezrick

LLNL Attendees:
Jeff Klingman
Karl Van Bibber

Ralph Pasquinelli
John Reid

LBL Attendee:
Bill Barletta
John Corlett

Nicolai Solyak
Ding Sun
Jim Volk
Jim Zagel

ANL Attendees:
Wei Gai
Paul Schoessow