international linear collider

ILC-Americas
FY06 Work Package
Technical Progress Report

Work scope period: 10/1/05 to 7/1/06

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WBS Number: 1.4
ILC Public Relations — Judy Jackson

1. Technical progress.

During the work scope period, the Fermilab Office of Public Affairs has made significant progress in communication for the International Linear Collider. In collaboration with the Office of Science and the SLAC Office of Public Affairs, we held an R&D Caucus briefing for Congressional Staff on May 8. Also on May 8, again in collaboration with the Office of Science, we launched the HEPAP publication "Discovering the Quantum Universe" and its associated Web site http://interactions.org/quantumuniverse/qu2006/ .

With the help of the Perspectives Group, we met with the Fermilab Community Task Force to obtain community input to the matrix of ILC siting criteria, information which was communicated to the ILC Civil Construction Group. Working further with the Community Task Force, we designed the process for creating the Fermilab ILC Community Board, which we are currently in the midst of convening. We are now forming the Fermilab Community Envoys, a group of 25 Fermilab employees who will interview community members in order to make the appropriate choice of members of the new ILC Community Board. The Envoys will maintain personal links with key members of the community to provide ongoing information about the ILC and to respond to questions and concerns.

The design is nearly complete for a new Fermilab brochure highlighting the role of the ILC in Fermilab's future. Copy for the brochure is nearly complete.

The Fermilab Office of Public Affairs worked with both local and national media, from Science magazine and the New York Times to the Kane County Chronicle on news stories and editorials featuring the ILC.

2. Goals and plans for the remainder of FY06 and beyond

Major goals and plans for the remainder of FY06 include the convening of the ILC Community Task Force in late September or early October, the printing and distribution of a new Fermilab brochure and associated Web site in September, and the publication of the Fermilab ILC Communication Plan in September.

A continuing task of the Fermilab Office of Public Affairs will involve its informal role in coordinating and supporting communication efforts by the LCSGA, the GDE, the InterAction Collaboration, users' groups and others. The Fermilab Office of Public Affairs will support the national Particle Physics Envoy program now being organized by the LCSGA.

WBS Number: 2.5.2
Damping Ring Accelerator Physics Panagiotis Spentzouris

1. **Technical progress.**

During the period 10/1/05 to 2/1/06 the DR Accelerator Physics effort at FNAL was lead by Mike Church. During this period, a study of potential DR related experimental activities was conducted. The results of the study were presented at an FNAL ILC meeting, and a report was written.

During the period 2/1/06 to 7/1/06 we focused on developing the necessary infrastructure for large-scale, multi-physics, simulations of the DR:

1. We used $50k M&S funds to expand our tightly coupled parallel cluster by purchasing twenty-one dual CPU commodity PC's. Twenty of the PC's were used to populate an existing fast networking switch (Myrinet) with existing NICs (thus leveraging FNAL CD resources), and one was added as a head node.

2. We extended our parallel framework, Synergia, to include electrons (and positrons). Synergia allows us to run 3D parallel simulations including multi-particle effects. We began studying the dynamic aperture of the baseline DR lattice and ran simulations, including space charge. We also recently began working closely with the ANL DR design group, in order to coordinate efforts and share resources.

2. **Goals and plans for the remainder of FY06 and beyond**

In the remainder of '06, we will use the 3D parallel code Synergia to study potential emittance growth and halo creation for different operational parameters of the baseline design. For example, we will study how close to different resonances we can run. Three-dimensional, self-consistent space-charge codes, such as Synergia are necessary to study halo generation and emittance dilution. We will continue developing our CSR module, with the objective to add such effects in the model by '07, and repeat a subset of the studies. We will also include realistic wiggler maps and impedance effects, as soon as calculations of the machine's impedance become available. In addition, we will participate in the effort to develop self-consistent electron cloud modeling, including cloud generation and cloud effects on beam dynamics.

WBS Number: 2.7.3
Main Linac Accelerator Physics Nikolay Solyak

1. **Technical progress.**

Fermilab is actively involved in the Main Linac accelerator physics studies. Our accomplishments for the FY06 are as follows:

Static Tuning: Results presented in Snowmass-2005:

After the technology choice decision in Aug. 2004, we started carrying out static tuning simulations on the US ColdLC Technology option Lattice. We know that conventional survey and alignment techniques will not be sufficient to meet the required emittance dilution budget for the ILC and hence new and improved beam based alignment techniques need to be understood. To facilitate that, we compared the performance of the two different beam based steering algorithms: Dispersion Free Steering (DFS) and the Flat (or one-to-one) steering in terms of the emittance dilution. We performed the comparison of the various lattices with different quad configurations in terms of the emittance dilution. We parameterized the emittance dilution as a function of number of quads in the lattice design. In the same line, we also compared the results of the TESLA lattice with the US Cold LC lattice.

After ILC BCD (Work from Dec. 2005 onwards):

Main Linac final realistic lattice design: We are working on finalizing the main linac lattice. It includes working on the specifications of different beamline components, their positions in the linac, specifications of cold and warm drift spaces, matching of the main linac sections with ring-to-main-linac, undulator, and beam delivery system lattices, locations of diagnostic sections, and integrating the final lattice in generalized XSIF or/and MAD format. This lattice will be used as the final main linac lattice for the RDR. Fermilab based simulation program OPTIM, along with MAD have been used for the matching purposes. Deliverables: ML lattice is completed and posted on ILC Wiki page.

Development of New Simulation Package, CHEF, for Low Emittance Transport Simulation: We are working on extending the capability of a Fermilab based simulation package CHEF to the requirements of the ILC low emittance transport (LET) simulation. This code can be used to perform the complete start-to-end static as well as dynamic tuning simulations. To this end, the simulation code has already been benchmarked against other simulation codes in terms of tracking, and work is being going on to add static tuning algorithms in this package.

Modifications in the Simulations Code LIAR: It is envisaged in the ILC BCD that the main linac of the ILC machine will follow the curvature of the earth instead of being laser-straight. Simulation code LIAR did not have the capability to simulate the curved linac system. We worked on the implementation of an arbitrary "dispersion free" element, called GKICK (or geometrical kick), which places beamline elements on the earth curvature by changing the reference trajectory. In LIAR, dispersion could not be used as the initial condition and there was no provision for propagating it through the Linac. We also added this feature. The matched dispersion condition at the beginning of the linac can now be artificially introduced into the initial beam.

Static Tuning: We performed the simulation study of single bunch emittance dilution for the ILC main linac following the earth curvature, and also the implications of curved geometry on the beam based alignment methods, mainly one-to-one and dispersion free steering using the modified LIAR code. We compared the emittance dilution performance of the curved and the laser-straight geometry. We also investigated the sensitivity of these steering algorithms by taking into account the effect of various static misalignments on the emittance dilution performance of the ILC main linac. The contributions of the various sources of emittance dilution, like quadrupole or structure misalignments, structure pitches, quadrupole rotation etc., to the total emittance dilution were also studied. The sensitivity of the emittance dilution for both the steering techniques is compared for the conditions different from the nominal ones. These studies are particularly important as they provide information on the requirement of stringency of a given tolerance, as well as to understand the sensitivity of an algorithm to the various systematic effects. We have investigated the robustness of the DFS algorithm to the failed BPM and correctors. Also, we studied the effect of incoming beam and quadrupole jitter, effect of adding extra BPMs in the Lattice, and dispersion bumps on the emittance dilution performance. We are also working on developing new, and modifying existing, tuning algorithms. Deliverables: Static tuning studies for the ML are completed to the level needed for RDR document.

Simulation Codes comparison: During the Snowmass meeting in August 05, it was observed that there were some disagreements in the results among the various software codes used for the emittance dilution studies. Hence, it was generally felt necessary by the LET community to perform a cross-checking of the various codes. We also participated in these cross-checking studies.

HOM studies: Preliminary results of the multi-bunch emittance dilution studies show that although the effect of random frequency errors in cavities is extremely beneficial, we also need to pay attention to trapped modes in cavities. We are investigating the effect of R/Q and Q_{ext} for a few first pass bands in the real model, Q_{ext} scattering due to cavity imperfections and inter-cavity spacing, and optimizing the design of the HOM coupler.

2. Goals and plans for the remainder of FY06 and beyond

Fermilab will continue with its efforts in FY07. The goals for FY07 are as follows:

<u>Static tuning</u> – We will continue with our present studies on the static misalignment issues of the ILC main linac. We will keep working on the design of the realistic main linac lattice, carry out the emittance dilution studies, continue with the understanding of steering algorithms in the presence of static misalignments, and participate in setting the tolerances on the various beam-line components. So far, we have been working on simulation codes LIAR and MERLIN to perform most of these simulations. However, we are also working on the development of a robust simulation code, CHEF, for the emittance preservation studies and will continue with this effort. We will also keep working on the wakefield calculations for different RF cavities. We will also address the remaing issues in Dispersion Free Steering, like using RTML to perform DFS in launch region, effect of BPM scale errors and optimization of emittance bumps.

Dynamic tuning – Once the alignment tolerances on the linac components is set (on the basis of static tuning studies), it is important to understand how well those tolerances can be maintained over time in the presence of component vibration and ground motion. We will carry out beam-based feedback (intra-train, train-by-train, interaction point, etc.) studies, which will be essential to maintain the (a) gold orbit established by initial tuning and (b) desired luminosity in the presence of the vibrating components. Based on the various ground motion models, long term stability issues (time scale of hours to months) will also be studied.

Integrated (Start-to-End) simulation – We will carry out full Low-Emittance Transport (LET) studies from the damping ring exit to the interaction point with a particular emphasis on the tuning algorithms, alignment issues, tolerances on beam line elements, and operational concerns. This study is particularly important to understand the final luminosity performance.

MPS design – It is necessary to understand full specifications on the components, procedures, and algorithm logic required for MPS to assure that each bunch can be transported safely to a beam dump without causing hazards (like hitting the non-dump components).

Beam instrumentation issues – We will continue with our efforts to further understand and address the beam instrumentation concerns. For example, the number of diagnostic sections in the linac and the required BPM resolution to achieve the desired emittance budget.

Cold BPM design (0.3um resolution, clean technology) - In ILC linacs, each quad has an associated BPM with resolution 0.3-1um. This is a 78mm aperture BPM working in the cold environment. No existing devices can provide all these requirements. Together with the Beam Instrumentation group, the Accelerator Physics Group will develop a cavity type BPM to fulfill the ILC requirements.

WBS Number: 2.11.1/2.11.2
Conventional Facility Design F. Asiri/V. Kuchler

1. **Technical progress.**

Personnel at SLAC and FNAL work in close conjunction to perform the work described in this Work Package. For that reason, progress reporting for both WBS 2.11.1 (SLAC) and 2.11.2 (FNAL) will be described in this single report.

During FY06, efforts by the SLAC/FNAL ILC Conventional Facilities group were primarily devoted toward two specific milestones. The first milestone was to finalize the Conventional Facilities contribution to the ILC Baseline Configuration Document (BCD). The second milestone is to develop a credible cost estimate for ILC Conventional Facilities that will be incorporated into the overall ILC cost estimate for inclusion into the forthcoming Reference Design Report (RDR).

The Conventional Facilities contribution to the ILC BCD was to include a complete description of the underground enclosures, surface facilities, mechanical and electrical systems, utility distribution and surface infrastructure that comprises the conventional facility design required by the International Linear Collider project. In addition, a sample site for each of the three global regions (Americas, European and Asian) was to be identified and described as part of the ILC BCD. The scheduled completion date for the BCD was December 2005.

Work toward the first milestone began at the Snowmass meeting in August 2006, and was well underway at the beginning of FY06. Direct points of contact for each of the ILC Area Systems were established to identify the criteria needed for the conventional facilities design. As the design was developed, a Work Breakdown Structure (WBS) and WBS Dictionary were also developed. To aid in the identification of the sample sites needed for the BCD, a Site Assessment Matrix was developed. In all cases, the SLAC and FNAL conventional facilities group worked in conjunction with our counterparts in the European and Asian Regions to insure that all work, in all regions, would be completed in a consistent manner. The WBS, WBS Dictionary and the Site Assessment Matrix are all used by each of the three global regions. The Conventional Facilities portion of the ILC BCD, including the identification of the regional sample sites, was completed in December 2005.

The remainder of FY06 was devoted to the development of the cost estimate for the ILC Conventional Facilities, as well as the related text required for inclusion into the ILC RDR. The target date for RDR completion is November 2006.

The SLAC/FNAL Conventional Facilities Group continues to work with the other Regional Teams to complete this work. An intermediate milestone was established that would provide a preliminary, but complete, cost estimate for the ILC Conventional

Facilities based on the BCD and Regional Sample Sites. The scheduled date for this milestone was July 2006. This milestone was met and the Conventional Facilities Cost Estimate was delivered to the ILC Design and Cost Board on schedule.

2. Goals and plans for the remainder of FY06 and beyond

The remainder of FY06 will be devoted to the refinement of the Conventional Facilities cost estimate, across all regions, for eventual inclusion into the ILC RDR. In addition, necessary text will be written to complete the Conventional Facilities portion of the RDR. Refining the cost estimate will include the verification of currently identified criteria, quantities and respective unit costs as well as the investigation of alternative configurations for possible cost savings or other efficiencies. It should be noted that proposed alternatives will, in most cases, affect area and technical systems beyond the Conventional Facilities. These effects will not only result in adjustments to the cost estimate, but will likely affect other aspects of the project that are not as easily quantifiable, such as installation efficiency, machine maintenance, reliability and impacts to other aspects of the baseline configuration. A comprehensive approach to proposed alternatives will require careful attention to all potential impacts. This effort will extend through the end of FY06 and well into the coming fiscal year.

The RDR is currently scheduled for completion in November 2006. However, refinement of the cost estimate and text may continue after the scheduled completion date.

WBS Number: 2.1.2
Reference Design Report Shekhar Mishra

1. Technical Progress.

The Reference Design Report (RDR) will be a key document for defining the scope of the ILC project, the R&D program, and the project cost. Fermilab's objective in these activities is to both secure approval and funding of the ILC as an international project and to develop an Illinois site near or at Fermilab as the preferred site.

Fermilab scientific and engineering staff has been work with the ILC GDE on the development of the Reference Design Report.

The Snowmass workshop (Aug 05) began the definition of the ILC baseline configuration document with the baseline and alternate configuration recommendations. The Working Groups, Global Groups and GDE finalized the Baseline Configuration Document (BCD) in Dec. 2005 at the Frascati Meeting. The ILC baseline configuration is now under Configuration Control Board (CCB) and we are using it to develop the ILC Reference Design Report (RDR) by the end of 2006. The RDR activity is supported by Area System, Technical and Global Groups, R&D, Cost and Schedule and Change Control Boards. Fermilab has key roles in many of these groups and boards. Several members of the Fermilab Staff are working on the technical development of the RDR and also participate in GDE boards that assists in the RDR development.

Fermilab's primary participation is in the Main Linac, Site and Conventional facility, Magnet and cost and schedule development. The details of the design and technical progress made to date are described in other sections of this document. Fermilab is managing cost studies for the Main Linac, Magnet and conventional facility development. These cost studies are also described in the other sections of this document. We are also playing a secondary role in Damping Ring, Beam Delivery System, Controls, Instrumentation and feedback development.

Fermilab is also working on developing a Conceptual design and cost estimation of magnet systems in support of the RDR. We also at the planning stage of working on detailed designs for magnets to better understand parameter space and physical dimensions

2. Goals and plans for the remainder of FY06 and beyond

This work is expected to continue in rest of the FY06 and beyond as development of ILC TDR. We expect that the Reference Design Report activities will slowly transform into the Technical Design Report work. Fermilab's activity in the area is expected to at least double.

WBS Number: 3.9.2
Cavity Fabrication — Michael Foley

1. Technical progress.

The initial ILC cavity fabrication effort began in FY05 using the DESY Tesla TTF design (Type III+) with asymmetric beam tubes. Four Type III+ cavities were purchased from ACCEL and have been delivered. Four additional Type III+ cavities were ordered from AES. The DESY drawings were converted to US standards and transferred to AES. All end groups for these cavities have been successfully completed. A problem with the niobium sheets to be used for forming half-cells has been resolved, and hydroforming of the half-cells is planned for this month. Scheduled completion date for these cavities is January 2007. All of the above cavities are fabricated from fine grain niobium.

In a collaborative effort (FNAL/Jlab MOU Addendum II), Fermilab and Jlab have developed the tooling and infrastructure required to fabricate ILC cavities. Jlab has completed all subassemblies of a prototype cavity for the purpose of fine-tuning the tooling. Jlab is in the process of building two Type IV (symmetric beam tubes) cavities using large grain niobium. These cavities have an estimated completion date of October 2006. Jlab is also scheduled to fabricate two Type III+ cavities using fine grain niobium to be supplied by Fermilab from current stock. Estimated completion date for these cavities is unknown at this time. Jlab has hosted a delegation from Roark (Indianapolis, IN) in a first effort to transfer cavity fabrication technology to US industry.

Two purchase requisitions (PR's) have been issued to solicit bids from industry for fourteen additional Type IV cavities with a projected delivery date of July 2007. The first PR for six cavities was sole sourced to AES. The second PR is open bid. Fermilab will evaluate all positive responses to the second PR based on technical merit, proposed schedule and cost. The eventual order may be split between two vendors. All fourteen cavities will be fabricated using fine grain niobium supplied by the vendors.

2. Goals and plans for the remainder of FY06 and beyond

A PR is in preparation to purchase material required to replenish our stock of fine grain niobium and niobium-titanium. The plan is to maintain a reserve on site sufficient to fabricate approximately twelve ILC cavities. PR's to purchase four large grain niobium ingots are also being prepared.

Fermilab and Jlab will continue collaborative efforts to develop additional US vendors for cavity fabrication.

In FY07 it is expected that PR's will be issued for 24-36 ILC cavities. Possibly half of these cavities may be fabricated from large/single grain niobium, with the remainder constructed from fine grain material. The selected vendors will supply material.

Over the next several years Fermilab will acquire a large pool of ILC cavities. The establishment of a Cavity Fabrication and Processing Facility (CFPF) at Fermilab has been proposed. The CFPF will include capabilities for RF testing, ultrasonic cleaning, chemical (BCP) etching, high pressure rinsing, and electropolishing. It will also include a properly sized and configured electron-beam welding machine. The purpose of the CFPF will be to develop a robust cavity processing methodology with the goal of reliably achieving the highest attainable operating gradients for those cavities. The CFPF will also serve as a site for cavity fabrication R&D (e.g., exploring new cavity shapes, alternative materials, or developing improved construction methods). Knowledge gained will be transferred to US industry to aid in the ILC industrialization effort.

WBS Number: 3.9.2.1

Two Large Grain Cavities P. Kneisel

1. Technical progress.

Monthly progress reports on this work package have been submitted to Helen Edwards as the FNAL representative for the MOU with Jlab.

- All raw cavity parts have been fabricated.
- All dumbbells have been welded with stiffening rings.
- Frequency measurements on the dumbbells are presently being done and subsequently, the dumbbells will be trimmed to the appropriate dimensions and frequency.
- End groups are in fabrication, some weld parameters for some components (e.g. HOM cans) are being developed.
- 30 raw end groups have been ordered from W. C. Heraeus with a delivery in September. Six cans have been loaned from DESY and need to be replaced.
- We anticipate that the fabrication will be completed during September.

2. Goals and plans for the remainder of FY06 and beyond

- The cavities will be tuned, hydrogen degassed, buffered chemical polished, then tested at 2K.
- During BCP, a stirrer for the acid will be used to achieve uniform material removal; this system has been delivered.
- DESY has offered to purchase three helium vessels as a "tag-on" to their presently placed PO; these helium vessels will be delivered soon.
- Helium vessels will be welded onto the 9-cell cavities, followed by an additional cold test.

WBS Number: 3.9.2.1
Fabrication of two TESLA 9-cell cavities from polycrystalline niobium — Peter Kneisel

1. **Technical progress.**

- No funds have been spent on this work package.
- A material list is being put together and the material will be requested from FNAL.
- A tentative schedule (on a best effort basis for the fabrication) is being developed..

2. **Goals and plans for the remainder of FY06 and beyond**

- As priorities at Jlab permit, the two cavities will be fabricated.

WBS Number: 3.9.3
Cavity Processing (BCP) — Allan Rowe

1. **Technical progress.**

A safety review of the Joint Superconducting Surface Processing Facility (SCSPF), located in Bldg. 208, Rm. 101 at Argonne National Laboratory (ANL), was conducted. This review was performed under the auspices of the ANL Physics Division safety office. The scope of the review encompassed the overall operation of the SCSPF as well as operation of the electropolishing (EP) facility located in the ANL chemical processing room. The safety review, begun in January 2006, was formally completed in July 2006. Beneficial occupancy of Bldg. 208, Rm. 101 for chemical processing is pending the implementation of egress related improvements which will be completed in August 2006. This safety review did not include the Fermilab BCP System other than that its operation falls within the general operation requirements of the SCSPF.

Fermilab is developing preliminary safety and procedural documentation for the pending FNAL BCP System safety review to be scheduled following the 1.3 GHz cavity reconfiguration. The documentation presented during the successful ANL safety review will be used as a model for the Fermilab documentation.

A BCP (Buffered Chemical Polishing) system, designed for processing 3.9 GHz cavities, was assembled at ANL in Bldg. 208 Rm. 101. All mechanical and controls modifications requested by the Fermilab BCP System technical review committee were implemented. During the water commissioning phase, several BCP system characteristics were discovered that made processing 3.9 GHz cavities impractical. It was determined that the time required to implement the modifications to the BCP system for 3.9 GHz processing overlapped with the 1.3 GHz cavity processing schedule. Therefore, it was decided that Rm. G150 in Bldg. 203 will remain as the sole BCP processing location for the Fermilab 3.9 GHz cavity program. By forgoing the modifications for 3.9 GHz cavities, reconfiguration of the BCP system for 1.3 GHz processing can begin in earnest.

A large ultra pure water (UPW) plant and distribution system was installed and commissioned as part of the overall SCSPF infrastructure. An unaffiliated analytical laboratory verified the UPW quality met required specifications. The UPW infrastructure services the entire SCSPF including both the ANL and Fermilab chemistry and cleanrooms. ANL also plans to use UPW for high pressure rinsing electropolished resonators.

2. Goals and plans for the remainder of FY06 and beyond

The existing BCP system installed at ANL Bldg. 208, Rm. 101 is not suitable for 1.3 GHz cavity processing. A major reconfiguration that addresses the architectural layout, process controls, cavity manipulation, and operational and safety procedures must be undertaken. This effort began in June 2006 and will continue into FY07.

The reconfigured BCP System will be commissioned with water in the beginning of FY07. Complete system testing with water will be used to verify process controls and operational procedures.

Cavity handling and manipulation occurs through the use of rather complicated hardware, all of which must be designed, developed, and fabricated or purchased. To quicken the pace of this hardware development, Fermilab will consult with other Laboratories (DESY, JLab, Cornell) who have experience handling ILC style cavities. This effort, already underway, will continue into FY07.

A formal safety review of the Fermilab BCP system will be conducted following the water commissioning phase of the reconfigured BCP system. Prior to the safety review, Fermilab must develop significant procedural and safety documentation. The safety review will likely occur in the beginning of calendar year 2007.

Following a successful safety review, ANL Physics Division will grant the approval to perform chemical procedures with the Fermilab BCP system. Fermilab plans to chemically polish both the inside and outside surfaces of 1.3 GHz ILC style cavities soon after approval is granted.

As part of the formal operation of the SCSPF, anyone working on chemical processes must receive formal training in chemical hygiene, emergency and processing procedures, and SCSPF operations. This training will begin in the last quarter of FY06 and continue into FY07.

WBS Number: 3.9.3
Cavity Processing (EP) Cristian Boffo

1. **Technical progress.**

At Fermilab, during the mentioned time period between October 2005 and July 2006, several new activities focused on EP have been started, while ongoing tasks have been pursued further.

The main accomplishment was the establishment of a close collaboration between FNAL, ANL, J-Lab and LANL with the goal of exploring the EP input variables and defining the proper set of working parameters to allow consistent control of the process. This task is still ongoing, mainly at J-Lab where it is possible to perform EP on 9-cell cavities.

Within a wider collaborative effort, during the SMTF (FNAL) and TTC (Frascati) meetings, a preliminary specification document aimed at the standardization of the EP parameters was created. During the STF (KEK) meeting in September 2006 this document shall be further discussed.

A joint ANL/FNAL panel generated a scenario describing the path toward EP industrialization by 2009, which was discussed by the SMTF R&D board and led to the funding of an R&D EP unit to be installed at the ANL/FNAL joint facility. At the moment, while waiting for full operational approval at ANL, the FNAL group is working on the fluid-dynamic optimization of the cathode and is testing a number of components that might simplify the setup.

In order to gain in-house experience on EP, a 1-cell setup has been designed at FNAL. Due to the present limited acid handling capabilities, initially this unit will only be able to electropolish 3.9 GHz cavities, but the design allows a full upgrade to 1.3 GHz, envisioned in 2007. This setup, which incorporates several technological solutions that can be later transferred to the ANL unit, will be operational by the end of August 2006.

In order to introduce Niobium EP to US industry, both local and national companies have been contacted. The initial goal of this activity is to establish a collaborative effort with possible developers of EP units and possible companies that can reliably run the process.

In parallel with the facility activities, a collaboration with Udine University (Italy) has been established and a Laurea student is now applying a numerical approach to the modeling of the EP process. The initial goal of defining the proper system of equations that describe the process has been completed.

Since KEK has achieved the goal gradients with 1-cell cavities where tumbling was adopted as pre-treatment, a pilot small sample tumbling program has been established at FNAL. An experimental device has been designed and shall be operational by the end of this calendar year.

2. Goals and plans for the remainder of FY06 and beyond

Continue the collaboration with the other US institutions. Visit J-Lab and support the ongoing activities. If possible intensify the permanence at J-Lab during FY07.

Discuss the standardization of EP parameter specification document at the KEK STF meeting in September and when in agreement, proceed to the identification of the proper industrial partners capable of producing the unit.

During the end of FY06, the collaboration with ANL shall be strengthened and plans on how to build the newly funded R&D unit shall be identified. Since most of the hardware is already present at ANL, the joint team shall concentrate on integrating the components, designing the control system and completing the setup during FY07.

The 1-cell setup at FNAL shall be operational by the end of August 2006. In parallel, six 1-cell 3.9 GHz cavities produced with material purchased from 2 different suppliers shall become available for testing. This small unit will smoothly integrate with the A0 HPR and vertical testing capabilities, allowing for fast turn-around and testing. The primary goal for FY07 is to keep testing small cavities, allowing collection of useful information to complement the data acquired at J-Lab. At the same time, this unit shall allow testing of additional technical solutions for implementation into the ANL unit. During FY07, this setup shall be scaled up to handle 1.3 GHz 1-cell cavities and support the newly established FNAL 1-cell program.

The effort to introduce US industry to Niobium EP shall continue and will be integrated with the Process Standardization being developed.

The collaboration with Udine University shall continue and possibly a second student shall join in FY07. The goal for the end of this fiscal year is to simulate the EP of 2 parallel plates in a beaker, including the thermal, fluid-dynamic, and electrochemical components of the process. As a further development, and with successive refinements, the modeling shall be extended to a 1-cell cavity during FY07.

The small sample setup for tumbling shall be operational by the end of calendar year 2006. During FY07 several tests shall be performed aiming at the basic understanding of the process and adaptation to the Niobium characteristics. Depending on funding, the setup will be upgraded to 1-cell cavities.

The fundamental understanding of EP and the exploration of new acid mixtures, acid aging and F- concentration control shall be intensified during the end of FY06 and extended through FY07 by increasing the number of small sample tests.

WBS Number: 3.9.3.2
EP Processing at JLab J. Mammosser

1. **Technical progress.**

Monthly progress reports on this work package have been submitted to Helen Edwards as the FNAL representative for the MOU with Jlab.

Adapt Production Tooling to 9 Cell Cavity

- All tooling for processing 9-cell cavity has been completed, several development runs were completed and starting on production runs for first production cavity.
- All tooling for testing a single 9 cell cavity has been completed, a second setup is still needed to meet ILC R&D tight loop planning.

Develop Production Procedures

- Five assemblies and vertical tests have been completed.
- Integrated particulate monitoring and video taping has been completed (reference starting point).
- Started development on improved assembly techniques, which includes monitoring and tooling for hands free assembly.
- Demonstrated that quenches reached on cavities in vertical is multipacting barrier.

Develop EP Procedures

- Investigations on rotation speed, flow rates have been completed.
- Investigations on anode contact point are underway (processing with helium vessel).
- Investigation on HF monitoring has started.
- The system is operational and many improvements have been completed.
- Final electropolish on S35 has been completed.

Process, Qualify & Turnover 8 Cavities to FNAL for String Assembly

- A-7 Bulk electropolish has been completed.

Electropolish Development

- Single cell cavity process cabinet was moved into place.
- Single cell facilities and hardware underway.
- Last four of the five assemblies show no field emission up to multipacting barriers.

2. Goals and plans for the remainder of FY06 and beyond

FY06

- Complete treatment, tuning, processing and vertical testing of A-7 cavity.
- Complete the first flow and thermal model for the Jlab EP process system.
- Complete and implement a prototype HF monitoring cell for the chemical sump.

FY07

- Complete the processing on the 7 nine cell cavities for FNAL.
- Develop procedures and weld helium vessels to all eight cavities.
- Deliver cavities to FNAL.

Jefferson Lab is just getting started with the electropolishing of nine cell cavities and has not yet demonstrated ILC gradients. Therefore, it is most important to determine if the processes and facilities at JLab are capable of meeting the gradient requirements. The focus of FY06 and FY07 is, and will be, to determine what problems will be encountered and to quickly overcome them by adapting processes and procedures as necessary to achieve gradient and Q-value goals as outlined. Throughout this process, an understanding of performance variability at JLab and the parameters that affect it will be the focus of our efforts. This understanding will be approached by several methods as follows:

- Single cell cavity processing and testing focused on reaching high gradients as well as identifying the reason for Q-disease in some cavity tests.
- 9-Cell cavity assembly performance improvement through reduced field emission by applying specialized tooling to reduce assembly errors and particulates.
- Improving process understanding and monitoring with focus on the following:
  - HF loss and its monitoring
  - Better understanding of the chemistry and QC of the electrolyte mixture
  - Reduction of sulfur residues by applying appropriate cleaning methods after electropolish procedures are completed without damaging cavity performance

This work will be carried out in a collaboration of international efforts as well as focused at Jefferson Lab with involvement of local Universities.

WBS Number: 3.9.4
ILC Cryomodule Design — Tom Peterson

1. Technical progress.

DESY type III drawing details were not all converted into Fermilab/US drawing. Due to manpower limitations, it was decided to move ahead with the type IV design effort. We have five contract designers and three senior staff -- Don Mitchell, Youri Orlov, and Chuck Grimm – all working on module design. The total module design effort is currently about 7.5 FTE's.

During the work period, we held two international design meetings. The first was held at CERN on 16 – 17 January 2006. The module workshop agenda and talks are posted at http://indico.cern.ch/sessionDisplay.py?sessionId=0&confId=671
There was agreement regarding technical topics needing attention, but following this meeting, work was delayed in all three regions due to other commitments.

A second international design meeting was held at Fermilab on 13 - 14 July 2006. Much of this second meeting focused on the formats for CAD data exchange among the laboratories. Both INFN-Pisa and Fermilab have IDEAS CAD models of the cryomodule under development, as well as finite element models under development for vibrational studies. Another emphasis, in this July meeting, was on what module test measurements should be done and how to instrument modules. Accelerometers and wire position monitors will be key items in these R&D modules.

We all agreed on the main type IV cryomodule features: closer cavity spacing, 8 cavities per module, magnet/BPM package under the center post, and magnets cooled at 2 K.

2. Goals and plans for the remainder of FY06 and beyond

A meeting will be held at INFN-Pisa in September for the designers and engineers working directly with the CAD model packages. Meanwhile, work will continue in detailing the type IV design. This design effort is likely to go through the third quarter of FY07. The next international design collaboration meeting is tentatively planned for January, 2007, in Milan.

Among the topics which will receive attention as part of this type IV design effort over the next year will be: quadrupole/corrector/BPM package details and supports, magnet current lead and integration into the module, magnetic shielding, inter-cavity connection details, inter-module connection details, tuner details, module instrumentation, module pipe sizing, and module mechanical vibration analyses.

As time permits, there is significant interest among many people to explore a separate quad cryostat for ILC, as opposed to the position within the center of the module.

WBS Number: 3.10.6
Beam Delivery System-Collimators — Nikolai Mokhov

1. Technical progress.

A realistic front-end STRUCT-MARS15-GEANT4 model of the Beam Delivery System (BDS), interaction region and extraction beam line has been created and tested for 2 and 20-mrad crossing angles, and partially for a 14-mrad crossing angle. The model based on the corresponding layouts, includes all the beam elements in that region with their detailed 3-D geometry, materials and magnetic field distributions, collimators and masks, tunnel and the SID collider detector. Detailed simulations have been performed on effects of synchrotron radiation with respect to performance of collimation and extraction systems and on radiation loads to the BDS and extraction components (two Beams-docs). Simulations and benchmarking of results on collimation system performance are done with the BDSIM, MARS15 and STRUCT codes (EPAC paper). Various configurations of absorbers, synchrotron radiation masks, and water and liquid sodium beam dumps in the extraction beam lines have been studied. Comprehensive modeling of BDS-induced backgrounds in the SiD detector with respect to those generated in collisions has been performed for various configurations of the tunnel magnetic spoilers and different time windows of all the SiD sub-detectors (*FN-790)*.

Additionally, radiation studies for SC RF vertical Test Facility were done (*TM-2350)*. A detailed MARS model was built for the ILC Test Area, and beam dumps with their shielding have been designed for an 800-MeV 50-kW electron beam (Technical Memo). A detailed MARS model was built for the main ILC RF structure, and first test runs were performed on radiation loads induced by dark current and beam halo particle loss. Radiation environment in the NIU Beam Diagnostics Lab with its 6-20 MeV microtron for coherent light source has been calculated with the MARS15 code.

2. Goals and plans for the remainder of FY06 and beyond

Complete and document by 09/31/06 optimization studies on handling synchrotron radiation in the BDS and extraction lines for 2 and 20-mrad crossing angles. Launch similar studies for a 14-mrad crossing angle layout aiming at a completion and a report by mid-FY07. Rebuild the STRUCT-MARS15-GEANT4 model of the BDS, interaction region and extraction beam line for a 14-mrad crossing angle layout and implement engineering details of the machine-detector interface, two experimental halls and detectors (first stage by 09/31/06, second stage by 12/31/06). For this new model, perform calculation studies of radiation loads, prompt and residual radiation levels in BDS, IP and extraction line components, and impact on environment and second experimental hall (thorough tests - 09/31/06, modeling – 03/31/07, reports – 06/30/07). For the new model, calculation studies of machine-induced backgrounds in the SiD detector in comparison with those from the IP, with further optimization of the protective measures: tunnel magnetic spoilers, collimators, synchrotron radiation masks, tunnel plug and walls between the experimental halls (thorough tests - 09/31/06, modeling – 06/30/07, reports – 09/30/07). Energy deposition and radiation simulation support for the ILCTA and the main linac design (as needed through FY06 and FY07).

WBS Number: 4.3.1
Magnet Systems: Engineering and Cost Estimation
J. Tompkins

1. **Technical progress.**

Effort was organized and began on this work package roughly halfway through FY2006 in support of the RDR Magnet System Group effort, led by J. Tompkins. A team of magnet design engineers as well as power system and controls experts was assembled from Fermilab, SLAC, and other major laboratories and universities around the world. The primary goal of this work was to develop magnet designs suitable for very preliminary cost estimates as part of the overall ILC cost study. The first steps were to work with Area Leaders to define the requirements for the large number and varieties of magnets needed. Once the requirements were determined, work began on conceptual designs to form the basis for cost estimates. Work carried out at Fermilab during this period included: estimates of magnet designs and costs for the RTML system, the Main Linac, and the Positron Source. Conceptual designs were developed for key components, such as the superconducting quadrupole magnets and correction dipoles in the Main Linac, and the conventional quadrupoles in the positron source transfer line (~1600 magnets). A design package was created for use in obtaining cost estimates from outside vendors. Modifications of the existing LHC quadrupole design were used as a basis for the estimate of superconducting magnets in the BDS 2 mrad beam line final focus region. Fermilab personnel also worked on developing the controls system quench protection requirements for superconducting magnets as well as instrumentation and controls interfaces for conventional and superconducting magnets.

Fermilab scientists and engineers participated in numerous ILC meetings and workshops in carrying out this work, including Magnet Systems Group meetings at SLAC and Fermilab, and the ILC Meeting at the Vancouver Linear Collider Workshop in July. In addition, weekly teleconferences have been held since June to discuss ongoing efforts. Despite the very compressed schedule and limited resources, a nearly complete, very preliminary, estimate of the magnet system cost was assembled for the Vancouver meeting. Importantly, this work revealed technical difficulties and associated higher equipment and operating costs in some areas.

2. Goals and plans for the remainder of FY06 and beyond

The goals for the remainder of FY06 are to complete the preliminary cost estimate and to review it for completeness and consistency, given the very short time in which it was developed. The number of magnet designs or “styles” will be reviewed across the different Area Systems along with the cost estimates to ensure that consistent design and cost methods have been employed. Estimates for a small selection of larger quantity magnets will be obtained from industry for purposes of comparison to internal estimates and to get feedback on cost drivers (e.g., specifications) as well as savings on large quantity orders.

The task of writing the magnet portions of the RDR is beginning and will continue beyond the end of FY06.

Effort will begin on detailed design of the Main Linac superconducting quadrupole and associate dipole and skew quadrupole correctors. This effort will continue beyond the end of FY06 with prototype development occurring in FY07, if sufficient funding is available.

Effort will continue on the design of the e^+ source transfer line, low gradient, large bore quadrupoles with the intent of building a prototype in FY07 if resources are available.

Precision measurements of quadrupole axes are critical to determining magnetic field stability. Fermilab plans to develop an improved stretched wire measurement system with thermal and vibration damping, based on its long experience with axis measurements for the LHC quadrupole program and precision measurements of quadrupole axis stability for NLC final focus permanent magnets.

Finally, extremely low fringe fields from quadrupoles near superconducting RF cavities are required to avoid degrading cavity performance. Procurement of magnetoresistive sensors and development of a very low field measurement system for initial studies at room temperatures is planned as part of the FY07 program.

WBS Number: 4.10.1
Industrial Studies: Engineering and Cost Estimation
P. A. Pfund

1. **Technical progress.**

A contract was placed with Advanced Energy Systems (AES) to lead a team of Linear Collider of America (LCFoA) companies to conduct an industrial study. The goal of this study was to define the cost to construct the first RF unit and production lots of 250 and 750 RF Units of the ILC main linac. An RF Unit is defined as a total of 24 superconducting cavities within 3 cryomodules powered by a common RF system. The center cryomodule contains a magnetic element that provides beam-focusing and steering correction.

The study will include detailed costs of all major components and subsystems by WBS, along with a schedule showing critical paths of the construction program. It is assumed that a facility capable of providing the equipment and space for superconducting cavity processing and integration, as well as checkout of the RF Units, will be available at a location near the ILC site. The cost of the setup and operation of this facility is not part of this study.

The study will included the cost of the superconducting cavities and processing (Buffered Chemical Processing, Electro Polishing, High Pressure Water Rinsing, Radio Frequency Testing), helium vessels, cavity tuners, magnetic shields, required cryomodule instrumentation, beamline string support systems, thermal shields, vacuum vessels, cryomodule support stands, internal cryogen piping, and major RF system components (such as the couplers), RF distribution, circulators, klystrons, modulators and low level RF.

The industrial team members will generate component and subsystem cost estimates in each of their areas of responsibility via internal estimating methods and, where appropriate, by solicitation of US manufacturers that have had previous experience in this technical area. The team members will develop component fabrication plans only to the level necessary to enable them to estimate the manufacturing cost of their respective components and provide appropriate quotations. The costs associated with acquisition and set up of new equipment (i.e. e-beam welders, BCP systems, etc.) for high rate production is not included. Tooling for integration and assembly of the RF units is also not included, since it is assumed that this is part of the government furnished facility. Each solicited manufacturer will be asked to provide quotations for the number of components in a single ILC RF Unit and budgetary quotations for the quantities associated with up to 250 and 750 RF Units. Each manufacturer will be given the opportunity to provide input on cost reduction ideas, utilize learning curves to extrapolate low quantity costs to full ILC quantities where applicable, and utilize their expertise to validate vendor quotations.

2. **Goals and plans for the remainder of FY06 and beyond**

During the remainder of FY06, we will meet with the AES team for a technical kick-off, where we will establish that the industrial team has adequate information with which to begin and conduct their study. Upon completion of the kick-off, the AES team will have six months to complete the study. By 9/30/06 they will have provided us with two monthly status reports describing, progress, the next month's plans and highlights of any issues. With each monthly report, they will provide a current draft of their costing spreadsheet. This will enable us to have preliminary snapshots in time of the detail and development of their cost estimates.

The study is expected to be completed in the second quarter of FY07. Their final report is expected to include:

- Estimated labor and material costs by WBS.
- Commentary as appropriate to explain the above costing information, including cost model characteristics such as QC overhead, process efficiencies and expected rework.
- Identification of key suppliers with a summary of their respective cost proposals.
- An overall project plan with a rough staffing profile keyed to schedule requirements.
- Top-level requirements for government furnished support facilities for processing, testing, and assembly.

WBS Number: 4.10.2
Industrial Studies: Civil Design Vic Kuchler

1. **Technical progress.**

During FY06, the verification of unit costs for underground construction was identified as a topic appropriate for investigation by independent private sector consultants. The Conventional Facilities Group worked with the Linear Collider Forum of the Americas (LCFOA) to identify a firm with the experience necessary to complete this review. Unit costs for underground construction had been developed initially through a combination of in-house experience and supporting consultant input. This study would provide an independent "second opinion" based only on the experience of the newly selected consulting firm, with the benefit of previously collected data. This unit costs requested would be based on specifically defined underground construction activities required by the ILC Project including: cost per unit length of excavated tunnel for various tunnel diameters using tunnel boring machines, shaft construction, general underground excavation, tunnel invert installation, cross tunnel penetrations and personnel access enclosures. In an effort to maintain global consistency, the definitions for underground construction activities and respective unit costs were also used in consulting agreements developed in the European and Asian Regions for similar unit costs.

The current status of this effort is as follows. The initial Request for Proposal was sent through the LCFOA to the Parsons Consulting Group in July 2006. A proposal was received and after a brief period of negotiation, a final proposal was developed and accepted. Contract signing is expected to be complete in mid-August, 2006. A draft report is due to Fermilab in November 2006 with a final report due in January 2007. Although it is anticipated that additional topics for independent consultant review will be forthcoming, none are planned at this time.

2. Goals and plans for the remainder of FY06 and beyond

As stated above, the contract for services to provide the independent development of unit costs for specific underground construction activities is expected to be signed in August 2006. Work will continue into FY07 with completion expected in January 2007.

WBS Number: 5.8.3
RF Power — Sergei Nagaitsev

1. Technical progress.

RF power (1.3 GHz) at Fermilab is needed in the following areas: Horizontal Test Stand (HTS) at Meson Detector Building (MDB), Vertical Test Stand (VTS) at IB1 and at beam test facility at New Muon building.

At MDB – installed a rebuilt Phillips YK-1240 Klystron (300 kW) and the entire distribution system for CC2. The Klystron was tested on a dummy load and on CC2. It produced 287 kW at required operating parameters. This same setup will be used to RF power the HTS. Presently, Fermilab has 3 rebuilt (with 2 operating) YK-1240 Klystrons. Three low-power modulators are in the final stages of assembly -- one is already complete, two more to be finished in Aug 2006.

High-power Klystrons: Presently have TH2104C (1 y.o.) operating the RF gun at A0. A used 2104U is an operational spare for the gun. The power and efficiency of this Klystron is lower, thus there is a need to buy another 2104C. One solenoid for 2104C (or U) has been received, and one is already in use at A0.

High-power modulators: waiting for SLAC to receive new HV parts to complete two HV switches. All Fermilab components have been received. One modulator is being assembled at MDB for HINS. A second modulator is scheduled to be delivered to New Muon Lab in Nov. 2006.

2. Goals and plans for the remainder of FY06 and beyond

Since the HTS Dewar was just received in July, 2006, no work on RF distribution has been done. The detailed RF layout and distribution work will start in Aug 2006. We plan to finish and commission it in Nov 2006. The third low-power YK-1240 Klystron will be tested and conditioned when CC2 cryostat is open for tuner motor repair.

In FY07 we plan to buy two 500-kW klystrons for the Horizontal test stand and a spare (or to run a Capture cavity). Also, in FY07 we plan to buy a 5-MW TH2104C Klystron to power either the RF gun or the first CM.

We will complete 2 low-power modulators in Aug 2006.

In FY07 we will buy one – 500 W SS driver for MBK, two-three – 200 W drivers for 2104C, and several 100W for low-power klystrons.

In FY07 we will buy a pulse transformer and parts for the high-power modulator, assemble one more 1-ms 10-MW modulator, and get two more HV switches from SLAC.

For the VTS, the RF system design review will take place in August 2006, with the design finalized before the end of FY06. The VTS RF system will be assembled and commissioned in FY07.

For the test at Fermilab's New Muon building in the summer of 2007, an RF gun, capture cavity, and the first cryo module will be installed. Fermilab will provide the RF power sources for the RF gun, capture cavity, and first cryo module. An existing 5 MWatt klystron and new full pulse length modulator (to be delivered to New Muon in November 2006) will be used for the gun and a 300 KW klystron and modulator will be used for the capture cavity. Fermilab provides all interlocks and controls for these systems and the wave guide to connect to the RF distribution waveguide. Fermilab intends to place the order for a 5 MW klystron on October 1, 2006 and to build an additional bouncer type, full pulse width, modulator in FY 2007. This second 5 MW system will be used for initial testing of the first cryo module.

By Summer 2007, SLAC is to provide the RF distribution hardware for distributing RF to cryo module 1, containing eight 9-cell cavities. Higher Order Mode couplers (HOM) are an integral part of the cavity structure. Fermilab will need to supply the external terminations for these couplers. The initial concept is to utilize the SLAC (Nantista) rotational variable coupler design with hybrids, loads, and tuners. SLAC intends to high power test this system at SLAC by January/February 2007. SLAC will provide circulators with this first distribution system. Dual directional couplers at each of the cavity inputs will also be included to monitor power flow. Should the rotational coupler design not meet specification, SLAC will provide the fixed coupler, circulator design that is currently in the ILC base line.

WBS Number: 5.8.4
LLRF Controls Ruben Carcagno

1. Technical progress.

The motivation for WBS 5.8.4 (LLRF Controls) is to develop LLRF systems for ILCTA and work towards an ILC LLRF system. FY06 milestones and deliverables in the original work package are the design and fabrication of the LLRF system for the Horizontal Test Stand (HTS) in the Meson Test Area (ILCTA_MDB) by May 2006.

All milestones and deliverables have been met: A LLRF system was delivered ahead of schedule for ILCTA_MDB commissioning using the Capture Cavity 2 (CC2), and the system is ready to support the HTS when needed.

The current LLRF system delivered to ILCTA_MDB is based on the latest DESY FPGA-based LLRF controller VME card, Simcon 3.1. This LLRF system successfully supported the first CC2 test on March 2006, and it is a result of a strong collaboration with DESY which started in FY2005 and continued into FY2006. The LLRF system was first fully tested and fine-tuned using Fermilab's Capture Cavity 1 (CC1) in the A0 photoinjector area, so there was high confidence about the performance of this system to support ILCTA_MDB commissioning with CC2. Other components delivered to ILCTA_MDB associated with the LLRF system include: a new Fermilab designed and built programmable multi-frequency, low-noise Master Oscillator (MO); a new Fermilab designed and built Downconverter and Vector Modulator; and a Fermilab built fast piezo tuner assembly instrumented with a novel method developed at Fermilab to continuously monitor piezo preload forces together with the associated electronics to monitor and control this device.

In parallel, a second LLRF system based on a modified SNS LLRF system for 1.3 GHz operation was also developed in collaboration with the SNS LLRF team and was ready as a contingency for ILCTA_MDB. This modified SNS system was also tested with the A0 photoinjector CC1. The approach of having two independent systems tested under realistic conditions with a 9-cell cavity prior to delivery to ILCTA_MDB minimized project risks and assured availability of the LLRF system when needed.

The LLRF Controls work at Fermilab is performed as a collaborative effort among divisions and other laboratories and institutions. Details of this organization are described in the document "ILC Fermilab R&D - LLRF Controls R&D Program" issued on January 19, 2006. Further details on Fermilab plans to deliver ILCTA LLRF systems can be found in the document "ILC Fermilab R&D – ILCTA LLRF Short-Term Development Project" issued on February 24, 2006.

As part of our collaborative efforts, a 3-day LLRF workshop was held at Fermilab in February 2006. This workshop included over 50 of the most active researchers in the LLRF field from around the world. In addition, five Fermilab staff members traveled to DESY for a week to participate in a LLRF software workshop and to work on collaborative projects with the DESY LLRF group. Fermilab maintains weekly LLRF videoconferencing meetings with DESY, UPenn, KEK, ANL, and SLAC collaborators.

R&D efforts towards a system capable of meeting the ILC LLRF requirements continue vigorously at Fermilab. Further LLRF development is needed in areas such as technical performance, reliability, ease of use, tight integration with the control system, and cost reduction. Fermilab's R&D efforts include noise characterization of Simcon 3.1 boards, board redesign and manufacturing to improve noise characteristics, FPGA firmware developments towards higher Intermediate Frequency (IF) capabilities, and control system integration with DOOCS and EPICS. With the rapid advance of commercially available FPGA-based electronic boards and higher level FPGA programming languages, Fermilab is also exploring their use and suitability for LLRF control applications. A board developed by industry (Lyrtech) has been purchased together with the associated software (Matlab/Simulink/Sysgen) for high-level FPGA programming. In addition, work has also started on prototyping a 32-channel in-house controller card optimized for an ILC RF Unit (Klystron plus three Cryomodules) to explore lower cost and higher density technology. One of our collaborators (University of Pennsylvania) is involved in the development of an ILC RF unit simulator, including a real-time version of this simulator which is expected to be quite useful for LLRF system developments.

2. Goals and plans for the remainder of FY06 and beyond

For the remainder of FY06, Fermilab plans to continue working on developments associated with LLRF hardware, firmware programming, and controls interface.

In the hardware development area, Fermilab plans to complete the Simcon 3.1 board redesign to improve its noise characteristics and start manufacturing a prototype to validate design improvements. This activity will continue into FY07 with the manufacturing of several Simcon 3.1 improved boards to populate ILCTA as needed with LLRF boards and spares.

In the firmware programming development area, Fermilab plans to make progress towards a higher Intermediate Frequency (IF) LLRF controller. The current version of the LLRF controller Simcon 3.1 operates with a rather low IF of 250 KHz. There has been recognition from some time that it would be better to increase this IF frequency to reduce the latency in the LLRF control loop and improve its performance. However, implementation of this higher IF requires substantial changes to the FPGA firmware. This activity is expected to continue into FY07, and delivery of this higher IF LLRF controller firmware will constitute a significant upgrade to Simcon 3.1 that is expected to benefit all members of our LLRF collaboration.

In the controls interface development area, until a decision is made of which control system (DOOCS or EPICS) will be adopted for ILCTA, Fermilab plans to support both control system interfaces to Simcon 3.1 and work on interfaces that can be easily changed from one system to another. Efforts toward LLRF automation, exception handling, and piezo control integration are expected to increase in FY07 as more funding and resources become available.

In addition to efforts related to improvements related to Simcon 3.1, Fermilab plans to integrate firmware and controls interface developments into commercially available hardware to explore the performance of electronic components produced by industry. In parallel, work on the in-house 32-channel LLRF controller optimized for an ILC RF Unit which started in FY06 will continue in FY07. We also plan to continue supporting UPenn's efforts to develop an ILC RF unit real-time simulator.

There are several ILCTA LLRF deliverables anticipated for FY07:

- LLRF systems for the beam source and for the first 8-cavity ILC cryomodule at ILCTA_NML
- LLRF systems for the Vertical and Horizontal Test Facilities (VTS and HTS) at ILCTA_IB2
- Upgrades to the ILCTA_MDB LLRF system delivered in FY06

WBS Number: 5.9.1
Cavity Horizontal Test Stand — Andy Hocker

1. **Technical progress.**

At the beginning of the work scope period, the cryostat for the ILCTA_MDB Horizontal Test Stand was under design. This design was completed and the package sent out for bid. The construction contract was awarded to PHPK in Columbus, OH, and the completed cryostat was shipped from PHPK to FNAL on 12-JUL-2006. Instrumentation for the cryostat has also been procured and assembled.

A shielding block cave for the Horizontal Test Stand has been constructed in the Meson Detector Building (MDB). Cryogenic transfer lines servicing this cave have been built, and the "feed can" interface between the MDB cryogenic system and the cryostat is in place. The MDB cryogenic system has been built, commissioned and used to successfully cool A0 Capture Cavity II (in a separate shielding cave) to 1.8 K.

A high-power, 1.3 GHz, RF system consisting of a modulator, charging supply, and 300 kW klystron has been installed and commissioned in MDB and has been used to power Capture Cavity II to a peak gradient of 31.3 MV/m. A low-level RF system based on the

DESY SIMCON design has been deployed at MDB and has been successfully run in closed-loop mode in order to maintain a constant flat-top accelerating gradient.

A controls/display system based on EPICS has been developed for the MDB cryogenic system and has begun to be developed for RF controls.

2. **Goals and plans for the remainder of FY06 and beyond**

The main goal for FY06 is to have the HTS fully commissioned and ready to accept a dressed cavity by the end of September. The cryostat will be installed in the ILCTA_MDB cave in the beginning of August and connections to the MDB cryogenic system will begin. All interior piping should be completed in approximately 1 month, as well as dressing of the cryostat with its instrumentation. After that, approximately one month of leak checking, debugging, and commissioning will take place. As the RF system is already in place for Capture Cavity II, very little will need to be done in this area outside of running cables to a different cave.

For FY07, ILCTA_MDB will be fully operational. It is anticipated that testing the first dressed cavity will take approximately six weeks due to an initial learning curve, but that the turnaround time should steadily decrease to something like 10 days for subsequent cavities. During FY07, ILCTA_MDB will test six 3.9 GHz accelerating-mode cavities for the DESY VUV-FEL, and as many 1.3 GHz ILC cavities as possible, depending on their production schedule.

WBS Number: 5.9.2
Cavity Vertical Test Stand — Camille Ginsburg

1. **Technical progress.**

The Fermilab Cavity Vertical Test Stand (VTS) will be used to test single, bare 1.3 GHz 9-cell SRF cavities. During the work scope period of 10/1/05 – 7/1/06, the VTS project scope was defined and construction began. The subtasks in which significant progress was made in FY06 are the cryostat design, RF system design, cryogenic capacity studies, radiation shielding design, and civil construction.

The cryostat design is based on a Fermilab design for the DESY Tesla Test Facility vertical test stands, with some updates from experience at DESY. The primary improvement to the design was the addition of a phase separator, to provide a better quality of liquid helium to the cryostat. The Process & Instrumentation Diagram was completed in May 2006. A design and procurement readiness review took place in May during which the review committee assessed the technical design of the cryostat and its readiness for the procurement and fabrication process. The completed cryostat design drawings, which incorporated the recommendations from the review committee and bid evaluation criteria, were sent to the Procurement department in July 2006.

The RF system design is based on that of the Jefferson Lab vertical test stands, modified for 1.3 GHz operation. A 500 W CW RF amplifier will be used to excite the cavities. The procurement of non-design-specific and long-lead-time equipment has begun.

A systematic study of the cryogenic capacity for VTS has been performed, and the capacity was determined to be 125 W at 2 K. This cryogenic capacity is sufficient to measure Q vs. T down to about 1.5 K, and measure Q vs. E up to at least 35 MV/m at 2 K, for typical cavities.

The radiation shielding design was completed in April 2006 and satisfies the requirement that IB1 be maintained as a Controlled Area: x-rays, photo-produced neutrons, and tritiation of the ground water were considered. Data from the DESY/TTF vertical test stands were used to estimate the expected x-ray flux. The shielding consists of three parts: a plug internal to the dewar, a movable shielding lid, and the concrete walls of the pit. The tritium production rate in the surrounding groundwater will be negligible. The shielding design has been reviewed and approved by Fermilab ES&H.

Because the vertical cavity pit walls are an integral part of the radiation shielding design, the final civil construction detail drawings were finalized after the radiation shielding design was complete. The civil construction, consisting of a shaft, recessed area for top plate instrumentation, and cryogenic piping and instrumentation cabling trenches, began June 23 and was completed on July 26.

The completed milestones from the original work package description are the new cryostat design, the vertical cavity pit, and the beginning of test stand component procurement.

2. Goals and plans for the remainder of FY06 and beyond

The subtasks in which significant progress is expected for the remainder of FY06 are the cryostat procurement, completion of design for cavity suspension and magnetic shielding components associated with the cryostat, and RF system design and assembly. In September, vendor bids for the cryostat fabrication and assembly will be received and reviewed, and immediately thereafter, the contract awarded. Remaining components associated with the cryostat which will be designed during FY06 are the cryostat top plate and the magnetic shielding mechanical design. Procurement will begin on these items as well. The RF system design review will take place in August 2006, with the design finalized before the end of FY06.

The milestones for the remainder of FY06 are the awarding of the cryostat contract, the completion of the magnetic shielding design, and the completion of the RF system design.

In FY07, the radiation shielding lid mechanical design and motion control system will be completed, parts procured, and the system assembled. The RF system assembly and commissioning will be completed. Personnel safety interlocks for the RF power and shielding lid will be designed, procured, and installed. The cryostat top plate will be fabricated "in-house." In addition, a portable clean room for top plate assembly will be designed and procured. The complete cryostat, including magnetic shielding and top plate, will be installed in March 2007, and commissioning begun.

Once the baseline VTS is complete, its functionality will be extended. The diagnostic instrumentation will be expanded, beginning with the design of a quench-location detection system. This activity will continue into FY08.

The milestones for FY07 are the completion and installation of the radiation shielding lid, RF system, cryostat and top plate, the connection of VTS to the IB1 cryogenic system, and the installation of personnel safety interlocks. The primary deliverable for FY07 is a complete, commissioned, and operational VTS.

WBS Number: 5.9.3
Cryogenics for Test Stands Jay Theilacker

1. **Technical progress.**

Major cryogenic accomplishments took place during the work scope period. In October 2005, the Cryogenic Test Facility (CTF) sent 4.5K helium to the Meson Detector Building (MDB). Since the Capture Cavity II (CCII) was not available as a load, a temporary dummy load was installed in order to tune control loops for stable operation. Warm return flow from the MDB was returned to the CTF after passing through the newly installed and commissioned purifier compressor and existing purifier.

During the winter of 2005/06, the large helium vacuum pumping skid to be used to cool the loads down to 1.8 K was installed and the appropriate safety documentation was prepared for the required system safety review. The pumping system was commissioned in May 2006.

Capture Cavity II was cooled to 4.5 K for initial commissioning of the RF system and for cavity performance verification in January 2006. CCI was cooled down to 1.8 K in June 2006 using the vacuum pumping system.

Transfer lines were extended in the spring of 2006 to feed cryogens to the cave which will support the Horizontal Test Stand (HTS). The feed box and low pressure pumping lines were fitted in place using a mock-up, since the horizontal test cryostat was not available. Cryogenic controls for the distribution and horizontal test cryostat were installed. They now wait for the cryostat to arrive in order to complete the final tie-in.

The cryogenic controls for CTF and CCII utilized ACNET as the user interface and for many of the required controls functions (alarms, fast time plots, data logging and system graphics). A decision had previously been made to use EPICS as the higher level controls system. Effort has been made to duplicate the cryogenic graphics displays from ACNET to EPICS.

Operational support for cryogenics to the MDB continues. Considerable progress has been made to understand the system operation and to begin automating processes, such as pump-down of CCII to 1.8 K.

All cryogenic milestones for the MDB systems have been attained.

2. Goals and plans for the remainder of FY06 and beyond

A major milestone for the beginning of FY07 will be the cool down and commissioning of the horizontal test cryostat. The schedule for the cool down is not dictated by the cryogenic system tie-in or the horizontal test cryostat installation, but by cavity production leading to a dressed cavity available for testing.

Conversion of the higher level cryogenic controls to EPICS will take place the remainder of FY06 and FY07. Training of the key Cryogenic Department personnel in the use of EPICS is taking place in August 2006. The goal is to move all higher level controls requirements for the cryogenic system to EPICS by the end of FY07 and to work with the Controls Department to ensure that development or implementation of the required EPICS controls services takes place.

The majority of the cryogenic effort in FY07 will be applied toward cryogenic operations and migration of cryogenic controls from ACNET to EPICS.

Budget Rich Stanek

The financial summary (attached to the technical report) is compiled using data from the end of July 2006 accounting reports not the 3rd Quarter numbers. The July data was used because it was available at the time of the report and represents the most accurate financial status. In addition, the report incorporates the latest revision of the GDE funding distribution as agreed to by Fermilab and the ILC Americas Regional Director.

The financial information is presented in two ways. The standard ILC Americas report uses "Cost" information and shows "Open Commitments". This gives a statement of the actual cost of the project to date and an expectation as to what will be costed (given the existing orders and contracts). It does not indicate what is "in the pipeline" with respect to purchase requisitions. We have added in information on "Requisitions in Process" which creates a more forward looking view of the financial status of the project and helps the reviewer to anticipate how the Fiscal Year will end. The combination of the two reporting methods into one table allows a full picture of the financial situation. This financial data is displayed in the ILC Americas WBS format for easy incorporation into an overall ILC Americas report and with a filter for FNAL tasks only.

A brief summary of the FY06 financial data (after removing the ILC School and GDE Common Fund data) is as follows:

For direct M&S, including both Obligations and Reqs in Process, indicates that if all requisitions in the queue are placed, the remaining funding available in FY06 would be ~746K (out of an overall budget of 6730K). The big ticket items (left to commit) include orders associated with Cavity Fabrication and Cavity Processing. Task leaders for all WBS elements are well aware of the budget situation and in most cases have presented formal plans to obligate the remaining funds this Fiscal Year (example RF Power – finish modulator work and LLRF – design and parts for LLRF controls). The actual "costed" part of the M&S direct budget totals only 2090K out of the same 6730K, indicating that many of the orders have not yet resulted in full invoicing. As expected the combination of open commitments and cost is equal to obligations. There appears to be no problem with obligating the full M&S FY06 funding in accordance with the revised ILC Americas work packages. Management Reserve will be used to supplement those areas where M&S costs are running high and the work must continue at the same pace.

For direct SWF, obligations are the same as costs. The total direct SWF budget is 3631K. Using the July numbers yields a remaining SWF of ~ 433K. However, there is another ~202K of SWF that will be moved off of these WBS elements and onto Infrastructure task numbers in order to abide with the provisions of the latest ILC Americas MOU and its associated funding distribution. These charges were mistakenly made to ILC Americas tasks and will be corrected in the next monthly report. In general, incorrect SWF charges have occurred on tasks that have a shared responsibility between ILC and Infrastructure and we are working to correct this problem. The total remaining SWF budget is therefore ~ 635K. This appears to be adequate for the level of effort defined by the work packages in the remaining two months of the Fiscal Year.

WBS 1.2 Program Management R. Kephart, S Mishra

Progress

The Fermilab ILC program office was reorganized in FY06**.** The ILC R&D effort is now managed from the Fermilab Directorate. The motivation of central ILC Program management at Fermilab is to make the most efficient use of Fermilab ILC resources throughout the laboratory. The organization is a matrix management scheme with the Technical and Accelerator Divisions managing most of the accelerator R&D activities. The Computing Division will be responsible for various ILC-related computing, control, and simulation activities. The Particle Physics Division is mainly responsible for ILC Physics and Detector. The ILC program office is also responsible for all SCRF R&D and infrastructure development at FNAL allowing for overall coordination of this activity lab wide.

The ILC Program Director's office is the point of contact for the GDE, regional ILC collaborations (TTC, SMTF, SFT, ATF-II etc.) and institutions collaborating with Fermilab on the ILC. The ILC Program Director's office is responsible for developing collaborations with other institutions described in the GDE MOU. These collaborations are managed under bi-lateral MOU's between Fermilab and the collaborating institutes. At present Fermilab is has or is developing bi-lateral MOU's with DESY, KEK, SLAC, TJNL, Cornell, INFN, LANL, MSU, UPenn, UIUC, NIU, IIT. Fermilab is also member of the TESLA Technology Collaboration (TTC). FNAL is constructing a 3.9 GHz cryomodule for DESY as part of its work on TTC and DESY in turn will supply parts to assemble a 1.3 GHz TTF cryomodule. Both activities, while not supported with ILC funds, benefit the ILC. . The ILC program office has begun to organize a regional team on the US Bid to Host ILC at Fermilab and is working to create political and financial support for an ILC sited in Illinois. The first tangible progress is a commitment from the State of Illinois to construct the Illinois Accelerator Research Center, a $35 M building on the FNAL site whose focus is SCRF testing, industrialization, and education.

Fermilab ILC management office has established the financial tools to track the ILC and SCRF R&D programs. We developed a full WBS and the machinery to track expenditures, requistions in process, SWF spending and technical progress at FNAL. We use these tools for reporting to American Region Team. We have task leaders of every WBS code in place who accept responsibility for the technical and financial goals of the task.

Goals and plans for the remainder of FY06 and beyond

The goals for the rest of the year and FY07 are to continue the ILC program begun in FY06, expand our capabilities in SCRF and machine physics, continue and expand detector development including improvements to the FNAL test beams, and initiate the Technical Design of a site specific ILC. We will also continue and expand our community outreach efforts and work to build political support for an ILC at FNAL.