**ADDENDUM**

**to a**

**MEMORANDUM OF UNDERSTANDING**

**between the**

**INTERNATIONAL LINEAR COLLIDER**
**GLOBAL DESIGN EFFORT**

**and**

***the Stanford Linear Accelerator Center Laboratory***

**for the period**

**October 1, 2006 to September 30, 2007**



## 1. *Introduction*

This Addendum constitutes the Statement of Work to be performed by SLAC in support of the International Linear Collider (ILC) for the period of October 1, 2006 to September 30, 2007. During this time period it is anticipated that the baseline design for the ILC will be derived under the auspices of the GDE and a reference design report and cost estimate will be started. It is conceivable that during the time period of this Addendum more emphasis and thus more resources may be allocated to the R&D efforts described in this Addendum. Alternatively it is possible that more emphasis will be placed on the reference design report and cost estimate. Such decisions are expected to be made jointly by the GDE and SLAC within the context of the international collaborative R&D program.

The activities detailed in this document falls within the scope of the Memorandum of Understanding (MoU) between the GDE and SLAC dated November 28, 2005. The terms and conditions under which the work will be carried out are found within the MoU and are in force for the duration of time covered by this Addendum.

Work at SLAC for the period covered by this Addendum will primarily involve Accelerator Design of all areas of the machine, R&D on RF Power sources, instrumentation, and controls, and work at facilities such as ATF, ESA, ESB, SMTF, STF and TTF. A detailed description of the work to be performed will be developed by SLAC and the GDE as one of the first FY06 tasks. This description will include a summary of the manpower and costs assigned to each task. Funds at the level of $$$$ for ILC R&D will be established at SLAC in FY06 by transfer from the DOE as recommended by the GDE-Americas Region Director.

## 2. *Statements of Work*

This Section contains the Statements of Work to be done at SLAC during the period of time covered by this Addendum.

Statements of costs and commitments incurred for each work package will be submitted at the end of each fiscal year quarter to the GDE-Americas Regional Office.

Semi-annual technical progress reports for each work package will be submitted at the mid-point and close of the fiscal year to the GDE-Americas Regional Office. These reports will contain descriptions of technical progress, statements of goals for the next reporting period, and indications of long-range plans.

Within two months following the end of the fiscal year, a final technical report for each work package will be submitted, in which the actual work accomplished will be compared with the scope defined in the work package in this MoU.



### 2.1 *Scope of Work*

*Provide a list of the general categories covered by the scope of work for FY06. The categories should be one or more chosen from the following list:*

*1. Program direction and administration*
*2. Accelerator design, including reference design report*
   - *2.1 Management*
   - *2.2 Global systems*
   - *2.3 Electron sources*
   - *2.4 Positron sources*
   - *2.5 Damping rings*
   - *2.6 Bunch compressor*
   - *2.7 Main linacs, including RF systems*
   - *2.8 Beam delivery system*
   - *2.9 Conventional facilities*

*3. Research and development*
   - *3.1 Management*
   - *3.2 Global systems*
   - *3.3 Electron sources*
   - *3.4 Positron sources*
   - *3.5 Damping rings*
   - *3.6 Bunch compressor*
   - *3.7 Main linacs, including RF systems*
   - *3.8 Beam delivery system*
   - *3.9 Conventional facilities*

*4. Engineering, including cost estimates*

*4.1 Management, engineering and technical services*
*4.2 Global systems*
*4.3 Electron sources*
*4.4 Positron sources*
*4.5 Damping rings*
*4.6 Bunch compressor*
*4.7 Main linacs, including RF systems*
*4.8 Beam delivery system*
*4.9 Conventional facilities*

*5. Infrastructure and Test Facilities*

*5.1 Management*
*5.2 Global systems*
*5.3 Electron sources*
*5.4 Positron sources*
*5.5 Damping rings*
*5.6 Bunch compressor*
*5.7 Main linacs, including RF systems*
*5.8 Beam delivery system*



**2.2 *Definition of Work***

*Specific work packages for the period of time covered by this Addendum are defined in this section. These work package definitions should describe in detail the work to be done, giving milestones and deliverables whenever possible. The work packages should be listed by order of their category, as defined by the list given above. Details are provided below.*

**Category 1**

**1.0 SLAC Program Management**

**Description:**
This work package covers the management of the SLAC ILC effort. It includes the program director, office and computing support, ES&H compliance, and travel.

**Motivation:**
None.

**Collaboration with other institutions:**
One of the management tasks is collaboration with other institutions in the GDE as detailed below.

**Milestones and deliverables:**
M&S costs are divided between 310k$ for travel, 60k$ for computing, and 60k$ for office support and 20k$ for ES&H compliance.

**Key personnel:**
Tor Raubenheimer – 95%; Cindy Lowe – 100%; Nick Arias – 100%; Naomi Nagahashi – 70%; Gerry Aarons – 10%; Keith Jobe – 30%; Janice Nelson – 20%; Albe Larsen – 25%

**Total Cost summary for WBS 1.x:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 4.5 FTE | 550 | 307 | 1465 |

**Expectations for FY08 and beyond:**
This work is expected to continue into FY08 and beyond at the same level.

**Category 2.1**

**2.1.1 Accelerator Design Management**

**Description:**
This work package covers the management of the SLAC accelerator design effort.

**Motivation:**
SLAC is contributing to the BCD and RDR designs for the electron and positron sources, damping rings, bunch compressors, main linac optics, beam delivery system, conventional facilities, operations, availability and controls.

**Collaboration with other institutions:**
One of the management tasks is collaboration with other institutions in the GDE as detailed below.



**Milestones and deliverables:**

Dec 05 BCD Document complete
Dec 06 RDR Document complete

**Key personnel:**
Nan Phinney – 100%; Summer Students – 30%

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.3 FTE | | 65 | 240 |

**Expectations for FY08 and beyond:**
This work is expected to continue into FY08 and beyond at the same level.

**Category 2.2**

**2.2.1 Global systems design**

**Description:**
This task includes availability studies, design for operability, design of the Machine Protection and Personnel Protection Systems, and Instrumentation design and specification.

**Motivation:**
The availability studies allow a comparison of various configuration options and specification of the required reliability for various hardware items. As the ILC design is fleshed out, further work will be needed to compare the availability of various options. There will also be more studies with other groups

to determine the best way to solve a specific availability problem. The operability studies will consist of careful examination of how the machine will be operated given how various things can go wrong with the goal of specifying any additional hardware or software that may be needed to ease the commissioning and running. The MPS and PPS/BCS design studies are to develop a sufficiently detailed design to be costable for the TDR.

**Collaboration with other institutions:**

The availability simulation was implemented at SLAC for the USLCTOS and further extended in FY05-06 in collaboration with DESY. DESY is also taking the lead on benchmarking the simulation with HERA data. There is also DESY effort on categorizing failure modes and effects as input to the MPS design. KEK is doing radiation calculations necessary for the PPS/BCS design.

**Milestones and deliverables:**

November 2006: Updated run of the availability simulation with latest parts counts.
November 2006: Complete writing Global systems section of the RDR.



Much of the work will be done in close contact with other groups and the results will show in the documents they write.

**Key personnel:**

Tom Himel 95%, Janice Nelson 55%

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.5 FTE | | $75 | $277 |

**Expectations for FY08 and beyond:**

We expect this type of work to continue into future years gradually going into deeper details of the design.

**2.2.2 Control system design**

Abstract

This category includes coordination and level of effort to define global requirements for controls system architecture for hardware and software to support the RDR and TDR. This effort requires coordination of management level and technical experts from several laboratories.

Project Definition

Provide level of effort to develop specifications, research applications requirements from all Area and Technical Systems, construct the WBS, coordinate cost modeling and estimating, document systems and cost books; write descriptions for RDR and TDR, and archive all backup information.

Initial work in FY07 will focus on the completion of the RDR and costing by November 2006. Beginning in January 2007, work on the Technical Design Report will begin. Although the pace, focus, and milestones of the TDR process will be determined by the GDE, it is anticipated that work beginning in FY07 will consist of two major efforts:

1. Starting from the BCD and RDR, perform a more detailed investigation and definition of the requirements of the Integrated Controls System, and interfaces with the technical systems. This will include:
    - Refining interfaces between the integrated control system and the technical systems.
    - Developing an understanding of unique or special control system requirements.
    - Develop integrated views of the Machine Protection System, Global Timing System, and beam-based feedback systems.

2. Begin work on those areas of the Integrated Control System which must be defined early in the technical design phase so as to provide appropriate information and guidance to the Technical System Groups. Early definition of these globally used resources will help avoid duplication of effort and ensure a smooth integration phase of the entire machine, including:
    - *Definition of site-wide infrastructure and interfaces,* such as networks, timing, real-time video distribution, real-time machine status, computing and storage capabilities.
    - *Definition of the control system "service tier."*
    - *Standardization of the integrating protocol(s) and tools*, to allow easier (and less costly) integration of the technical systems, and to help minimize duplication of effort.
    - *Standardization of control hardware/software where applicable,* to reduce cost, and increase reliability, maintainability and operability.
    - *Definition of Technical System requirements from the control system,* to ensure compatibility and to ensure global requirements are met for data collection, fault analysis, and operations.



Motivation
This work is necessary in order to provide appropriate costing, reference design and technical design for the ILC Integrated Control System.
Collaboration with Other Institutions
This work will leverage the strong collaboration between SLAC, FNAL, and ANL (in the Americas), and institutions in Europe and Asia, including DESY, KEK, University of Oxford, and Daresbury.

Deliverables and Milestones
FY07
- Complete first-cut WBS, cost estimate, Reference Design Report, and supporting documentation by November 2006 (ANL lead).
- Begin developing the Technical Design Report (ANL lead).

Key Personnel
ANL: John Carwardine + staff
FNAL: Margaret Votava + staff
SLAC: Ray Larsen + staff

2.2.2 Cost Summary

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 1.5 FTE | | $75 | $277 |

**Expectation for FY08 and Beyond**

This work will continue throughout FY08 and beyond, with the team developing an increasing level of detail and technical certainty, and completing the Technical Design Report and supporting materials.

### 2.2.3: Installation

**Description:**
This package covers work with Area and technical System managers to develop a complete cost and schedule model for the ILC component fabrication, receiving, acceptance testing, warehousing and installation.

**Motivation**:
This work is a part of GDE for developing an integrated cost and schedule management system for the ILC component installation for the TDR.

**Collaboration with other institutions:**
Collaboration with Asian and European installation co-leader is continued during RDR effort to gather all previous work done in conjunction with installation plan for NLC, GLC and TESLA proposal as well as lessons-learned from LHC installation. Then, with collaboration with Area and Technical System managers to set-up and run data management base for the ILC fabrication and delivery, functional compatibility study, and ultimately leading to an on-site installation process management system.



Table below is "Planning Assumption" for establishing an integrated installation process for the ILC baseline:

| Installation Tasks | Goal | Tools and software |
|---|---|---|
| Fabrication and delivery management | • Real-time tracking on fabrication and delivery status<br>• Managing and optimizing the delivery process | Set-up of the Data Base Software First phase (~$100K) |
| Functional compatibility study | • Checking functional compatibility between sub-systems | Estimate (~$50K ~ $100K) |
| `On-site installation process management | • Visualizing on-site assembly and installation process<br>• Supporting analysis on assembly and installation process<br>• Supporting analysis on site logistics | Common Point Project4D (~$50K ~ $100K) |

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.5 FTE | $100 | $90 | $392 |

## WBS 2.11.1 and 7.1.2: Conventional Facility Design and US Bid to Host Efforts

**Description:**
This package covers work on the development of conceptual design of conventional facilities for the ILC in general as well as all engineering efforts necessary for US to bid to host for American Sample site in Northern Illinois.

**Motivation**:
This work is a part of GDE for developing a complete conceptual design with construction cost and schedule for the ILC conventional facilities in support of RDR and TDR.

**Collaboration with other institutions:**
The SLAC -ILC Conventional Facilities (CF) is working in close collaboration with FNAL on the ILC design and US Bid to Host effort for the American Sample site in Northern Illinois. SLAC is also collaborating with other regional Conventional Facilities group in Asia and Europe on weekly bases toward a uniform approach for the design of non-site specific portion of the ILC conventional facilities.
Table below is "Personnel and M&S Planning Assumption" for SLA-ILC Conventional Facilities for FYO7:



**SLAC- ILC Conventional Facilities In-house Staffing Plan**
**(Entries in Columns Q1-Q4 are Head Counts)**

| WBS | Description | Names | FY 2007 | | | | |
|---|---|---|---|---|---|---|---|
| | | | **Q1** | **Q2** | **Q3** | **Q4** | **FTE (avg.)** |
| **2.2.3** | **Installation** | Asiri | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | | Aarons | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | | Corvin | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| | | *Kim | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| ` **2.11.1** | **Conventional Facility Design** | Asiri | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | | Aarons | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| **7.1.2** | **US Bid to Host Development** | Corvin | 0.75 | 0.75 | 0.75 | 0.75 | 0.75 |
| | | *Kim | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| | | Buhain | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| **Total** | | | **4.5** | **4.5** | **4.5** | **4.5** | **4.5** |
| | | | | | | | **Total #M&S** |
| M&S (in-House) ($000) | | | 10 | 10 | 10 | 10 | 40 |
| M&S (**Contractor Support) ($000) | | | 90 | 90 | 90 | 90 | 360 |
| **Total M&S Cost ($000)** | | | **100** | **100** | **100** | **100** | **400** |

**Notes:**

- General Scope of deliverable in support of TDR:
- Anticipated drawings: General Layout plans; Enclosure plans and Sections for BDS; Electrical; Life Safety ; Fire Protection/ Detection
- Text Section and Studies: Detail description of configuration; Tunnel constructability studies; Ground vibration studies of IP region; Electrical distributions; Environmental geology studies, cost estimate basis and installation schedule

* Jonghoon Kim `status from part time is planned to change to a full time in FY07
** John Cogan is available to work as part time contract employee in FY07 or sooner

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 3.0 FTE | $300 | $195 | $900 |

**Category 2.3**

**2.3.1 Electron Source Design and Cost Estimation**



**Description:**

Source Drive Laser System

This task includes design of the polarized electron source laser system ILC. This laser system will drive the e- source. An identical laser system will be used to generate the electrons to drive the polarized positron source.

Electron Gun and Injector

This task includes design of the polarized electron source gun and injector for the ILC. The focus of the work will be mainly on the injector design and costing (Bunching system and acceleration).

Photocathodes

This task includes design and costing of photocathodes that are used for the ILC polarized electron source. This work will also incorporate associated instrumentation.

**Motivation:**

Source Drive Laser System

The source drive laser system will be used to generate the ILC bunch structure. A laser system that fulfills the source parameters of the ILC design is not commercially available and must be developed for the ILC. A mode-locked oscillator Ti:Sapphire laser oscillator will be used to achieve the 3 MHz repetition rate bunch train with subsequent pulse shaping and amplification. Especially the amplification of the bunch train presents a unique challenge. Design and costing of the system will strongly depend on the associated R&D program.

Electron Gun and Injector

The e-source must deliver electrons at 5 GeV. To accomplish this, detailed simulation of the bunching system, normal conducting and super conducting acceleration are necessary to arrive at a complete design. This work also includes the spin rotation before injection into the damping rings. A significant part of design and costing is the consideration of all necessary subsystem (civil, RF, controls, diagnostics, etc.).

Photocathodes

The photocathode generates the polarized electrons at the source. The ILC baseline design requires an electron polarization of 80 %. The photocathode must generate a charge of 6.4 nC. Previous photocathode design work (pre-ILC era) focused on a different design goals. Photocathode parameters must be re-optimized for ILC conditions. The goal of this effort is the design of appropriate photocathodes and associated equipment.



**Collaboration with other institutions:**
SLAC only.

**Milestones and deliverables:**

Nov 06 RDR Document with design and cost information
End FY07 TDR Draft

**Key personnel:**

Axel Brachmann 50 %
Feng Zhou 25 %
Takashi Maruyama 25 %

Additional required (TDR beginning in FY07):

Systems Engineer/Designer (TBD) 100 %

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.0 FTE | 0 | $100 | $370 |

**Expectations for FY08 and beyond:**

We expect this work to continue in parallel with the R&D program throughout future years. Results from the R&D program will be incorporate into deeper levels of details of the design.

**Category 2.4**

**2.4.1 Positron source**

**Description:**
This package is the design and documentation of an undulator-based positron source for the BCD and RDR, including detailed designs all of the subsystems including the undulator, capture section, pre-acceleration, electron bypass lines, positron transport line, pre-DR collimation and energy compressor.

**Motivation:**
This work is relevant to complete the positron source design for the RDR.



**Collaboration with other institutions:**
SLAC has active collaborations with LLNL, LBNL, ANL, Cornell in the USA and with CCLRC (both Daresbury and Rutherford) and Liverpool University in the UK. The work in the UK is being done under the auspices of EuroTeV. Work on target materials and damage studies are being done in conjunction with LLNL and LBNL. Work on the mechanical design of the positron target is being done with LLNL and Liverpool University. Work on undulator design and prototyping is being done in collaboration with Daresbury and Cornell and groups from ANL and LBNL have indicated interest in this work. Lastly SLAC and ANL are collaborating on calculations for the positron system from upstream of the target to the damping ring.

**Milestones and deliverables:**

| | |
|---|---|
| Dec 2006 | RDR work completed for the positron source |
| Jan 2007 | Start work on TDR |
| Sep 2007 | Update on ILC positron source improvements |

**Key personnel:**
John Sheppard 100%, Vinod Bharadwaj 100%, Yuri Batygin 100%, Mark Woodley 15%, Zhou 25%, draft/design 50%, Alberto Fasso 10%, Mechanical engineer 25%

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 4.25 FTE | | $212 | $786 |

**Expectations for FY08 and beyond:**

The work in FY08 and beyond includes continued optimization studies and prototyping (with collaborators) directed at reducing the costs of construction and operation as well as improving the operability and availability of the positron system.

**Category 2.5**

**2.5.1 Damping Ring Design**

**Description:**
This package covers SLAC work on the damping ring design, including optics studies, evaluation of dynamic acceptance, space charge effects and classical instabilities, simulations of electron cloud and fast ion instabilities, and design of pre-ring energy and bunch length compressors.

**Motivation:**
A sufficiently detailed lattice of the damping rings along with the specifications of its components for the baseline configuration is vital for validating the achievement of basic requirements of the design and supporting a reliable cost estimate. It also servers a reference point to further optimize the design. Although, this work package does not cover all aspects to the design, it does cover many critical and technically difficult ones.

Many years of experience with PEP-II, SPEAR-3, SLC, and NLC is utilized and applied to the design of the damping ring.



**Collaboration with other institutions:**
This work is part of a collaborative effort with LBNL, Cornell, ANL and FNAL.

**Milestones and deliverables:**

- Complete all optical functions that are necessary for the baseline lattice, such as injection, extraction, RF, tune, wiggler, and coupling bumps.
- Finalize a realistic specification of magnetic errors for all magnets and wigglers in the damping ring to ensure an adequate acceptance and dynamic aperture.
- Develop a solid impedance budget and specify feedback systems to control the conventional instabilities in the damping rings.
- Continue to simulate the effects of electron cloud in the positron ring and specify the essential properties of the vacuum pipe to mitigate the instabilities that caused by the electron cloud.
- Develop a faster and reliable computer program to simulate the fast ion effects in the electron ring and specify a proper vacuum system to control the instability.

Dec 06 RDR Document complete

**Key personnel:**
Yunhai Cai 10%, Mauro Pivi 30%, Lanfa Wang 100%, Sam Heifits 30%, Karl Bane 30%

LBNL – A. Wolski, Cornell – ?, ANL – K.J. Kim, FNAL – ?

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.0 FTE | | $100 | $370 |

**Expectations for FY08 and beyond:**

Optimization of lattices and study of beam dynamics relevant to the damping rings will be an ongoing process as the engineering design proceeds. Many issues expected to be raised during the hardware design requires further refinement of the lattices. The design work will continue at the level of 3 FTE at SLAC in future years.

**Category 2.6**

**2.6.1 Ring to Main Linac Design**



**Description:**

This package includes the detailed design of the bunch compressors, the spin rotators, pre-linac collimation, 180º turnaround, diagnostics, dumps and all other transport lines between the DR and ML.

**Motivation:**

This work is part of developing a complete costed design at an appropriate level of detail and maturity for the TDR.

**Collaboration with other institutions:**

This work is a collaborative effort primarily with Cornell and Fermilab, with some participation of PAL and DESY. In FY2006, Cornell and DESY completed the primary design work on the spin rotator, and Cornell also contributed some emittance preservation studies; Fermilab participated in magnet design and bunch compressor RF stability tolerance studies; PAL continued to advance their short 2-stage bunch compressor design.

M&S request is $100K on for distributed computing,

* $35K - 128-node Matlab Distributed Computing Engine License
* $5K - Distributed Computing Toolbox licenses (~ 5)
* $60K - computer hardware to add to SCS compute farm- will support ~50 AMD opteron CPU's. This would add in to the global pool, we would then bargin for some share of the total pool of >300 cpu's.

This would then allow anybody (who has one of the ~5 dist. Comp. toolbox licenses), to run distributed computing tasks with whatever Matlab products they are licensed for on up to 128 simultaneous nodes.

**Milestones and deliverables:**

Dec 06 Complete static, standalone tuning studies of full RTML
Dec 06 Complete RTML chapter of RDR
Dec 06 Begin static integrated RTML + ML tuning studies

Mar 07 Complete next iteration RTML lattice based on engineering input
Mar 07 Begin dynamic, standalone tuning studies of full RTML
Mar 07 Begin detailed studies of RTML component specifications
Sep 07 Complete dynamic, standalone tuning studies of full RTML

**Key personnel:**
Peter Tenenbaum 60%, Sergei Seletskiy 50%, Woodley 10%

Cornell – D. Sagan, J. Smith; DESY – P. Schmid; FNAL – M. Church, S. Nagaitsev; PAL – E.S. Kim

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.2 FTE | 100 | $75 | $337 |



**Expectations for FY08 and beyond:**
The lattice design and standalone tuning studies of the RTML will be largely completed in FY2007. The studies in support of detailed component specifications will continue into FY2008, as will the integrated simulations of the entire Low Emittance Transport.

**Category 2.7**

**2.7.1 Linac beamline design**

**Description:**
This package covers work on the optics and beam dynamics design for the main linac.

**Motivation:**
This work is part of developing a complete costed design at an appropriate level of detail and maturity for the TDR.

**Collaboration with other institutions:**
The optics work is being done in collaboration with Cornell and FNAL in the US and with CERN and KEK. In FY2006 all institutions studied a number of different techniques for main linac emittance preservation. FNAL took the lead on the detailed optics design work for the BCD, and Cornell played a leading role in the simulation code comparison efforts.

**Milestones and deliverables:**

Dec 06 Complete static, standalone tuning studies of full ML
Dec 06 Begin static integrated RTML + ML tuning studies
Jan 07 Begin dynamic, standalone tuning studies of full ML
Mar 07 Begin studies in support of detailed specifications for TDR

| | |
|---|---|
| Aug 07 | Complete dynamic, standalone tuning studies of full ML |
| Sep 07 | (possible) Begin some site-specific lattice design work |

**Key personnel on Optics:**

Peter Tenenbaum 40%, Sergei Seletskiy 40%, Woodley 20%

Cornell – D. Sagan, J. Smith; FNAL – M. Church, S. Nagaitsev, K. Ranjan; KEK – K. Kubo; CERN – D. Schulte

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.0 FTE | | $50 | $185 |

**Expectations for FY08 and beyond:**

The standalone tuning and emittance preservation studies will be largely completed in FY07. The studies in support of detailed specifications for the TDR will continue into FY08, as will site-specific lattice design work.



## 2.7.2 Linac wakefields

**Abstract**

Study the effects of long-range wakefields in the superconducting linac cavities to verify that these fields will not significantly degrade the low beam emittance. Both the baseline cavities (TESLA shape) and the Low Loss designs will be evaluated. Also, understand the variation in the properties of the modes measured in the TESLA cavities at TTF.

**Project Description**

Using the massively parallel frequency and time domain programs (3-D) that have been developed by the ACD group at SLAC over the past five years,

(1) Study the effect of imperfections/tuning on TESLA cavity wakefields

(2) Calculate mode rotation in the ILC cryomodule and its effect on linac beam dynamics

(3) Improve the HOM damping in the Low Loss cavity design.

In addition, understand the geometric effects that lead to the observed variation in the cavity mode frequencies, external Q's and mode splitting (i.e., the frequency difference of the two mode polarizations), and study how the beam long-range horizontal-to-vertical coupling through the polarized modes can be suppressed.

Work on these topics started in FY06 and significant progress was made in understanding rotating dipole modes through both simulation and analytical analyses. This type of mode (versus one that is linearly polarized) arises from the non-azimuthally symmetric loading from the HOM and Input couplers, but is generally 'washed out' by the effect of non-azimuthally symmetric deformations of the cavity cells, which generate linear polarizations. This work package is to continue this effort in FY07 at roughly the same support level.

**Motivation**

Because of the high Q of the superconducting cavity modes, dipoles modes that are near-resonate with beam have the potential to produce strong, long-range deflecting fields that will degrade the beam emittance. Although the cavities include HOM absorbers to damp the stronger modes, higher frequency trapped modes due to cavity imperfections may still generate significant deflecting fields. Also, cross coupling of the mode excitations (horizontal to vertical) could induce a large absolute beam position jitter in the vertical plane.

**Key Personnel**

Zenghai Li 50%, Liling Xiao 50%, Andreas Kabel 40%, Cho Ng 25%, Ravi Uplenchwar 25%, Kwok Ko 10%
Karl Bane 25%, Genady Stupakov, 25%

**Cost Summary** FY07

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.5 FTE | | $125 | $462 |



**Expectations for FY08 and beyond:**

The work in FY08 will depend on the process made this year, but will likely continue at a similar pace.

**Category 2.8**

**2.10.1 Beam Delivery System design**

**Description:**
This task includes design of all the subsystems of ILC BDS. It also includes "putting it all together", i.e. the integration design work to define requirements and interfaces for various systems and overall design optimization. Finally, it also includes management and coordination of the work on BDS design on international scene.

For the design, in particular, the task includes optics design and development of tuning methods (in collaboration with Daresbury); study of e-cloud, wakes and halo formation (with EUROTEV for the latter); design of collimation system and MDI-wise design (with DESY Zeiten, Daresbury, KEK); design of baseline beam dump and its alternatives (with Daresbury and possibly Fermi or LLNL); design magnets, their supports, muon walls (with LLNL for the latter); design of switchyard kicker and septa (with Triumf); design of IR region optics and solenoid compensation (with BNL); design crab cavity system (with Fermilab and Daresbury); integrated design of polarimetry and energy spectrometers (with ESA international collaboration); design IR and detector shielding and make other radiation safety studies and design optimizations (with Fermilab); IR integrated design and development of the goals for full IR mockup at ESA (with Detector concepts, ESA collaborators); development of specifications and interfaces to BDS instrumentations such as BPMs, laser wires, kickers (with KEK, Oxford, RHUL, Triumf, etc); development of specs for IR MDI instrumentations such as lumi and beamcal (Detector concepts, Eurotev, etc); develop specs for FD motion monitoring (with UBC, Oxford, KEK), etc.

**Motivation:**
BDS design requires meeting the often contradictory requirements from machine and from experiment. Design work is needed to ensure the needed performance.

**Collaboration with other institutions:**
Work is coordinated on the international scene, with collaborators from many labs in the world.

**Milestones and deliverables:**

Sept 07 A fraction of TDR work will be complete

**Key personnel at SLAC:**
A.Seryi, M.Woodley, Y.Nosochkov, C.Spencer, L.Keller, G.White, K.Moffeit, T.Mattison, D.Walz, T.Maruyama, R.Arnold, F.Asiri, C.Corvin, G.Aarons, S.Molloy, S.Smith, S.Seletskiy, P.Bellomo, B.Lam, K.Bane, M.Ross



**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 5.2 FTE | 0 | 260 | 962 |

**Expectations for FY08 and beyond:**
The work will continue gradually shifting from pure design to work on BDS experimental facilities.

**Category 3.1**

**3.1.1 R&D Management**

**Description:**
This work package covers the management of the SLAC R&D effort.

**Motivation:**
SLAC is contributing to the BCD and RDR designs for the electron and positron sources, damping rings, bunch compressors, main linac optics, beam delivery system, conventional facilities, operations, availability and controls.

**Collaboration with other institutions:**
One of the management tasks is collaboration with other institutions in the GDE as detailed below.

**Milestones and deliverables:**

Dec 06 RDR Document complete



**Key personnel:**
Tom Markiewicz – 80%

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.8 FTE | | 40 | 148 |

**Expectations for FY08 and beyond:**
This work is expected to continue into FY08 and beyond at the same level.

**Category 3.2**

**3.2.1 High Availability Power Supplies**

**Abstract**

Availability calculations show that the ILC cannot achieve its target availability without designing all subsystems for High Availability from the outset. This applies especially to the power systems including DC supplies and modulators. The DC supply subsystem alone cannot achieve better than 0.80 without HA design, and for the entire ILC to achieve 0.85 requires that DC power and other subsystems achieve A~0.99. The project proposes to demonstrate technical feasibility with readily-available components and in parallel will develop additional features as needed to reach the availability goal. A demonstration system will be built in collaboration with KEK for ATF2. A second phase of study will demonstrate full HA features as well as cost viability by developing industrial sources.

**Project Description**

The FY07 R&D program includes a component to provide engineering and coordination, supervision of construction and testing of an HA system of 40+ power supplies for ATF2. This system will be modular n/N but will not include redundant bulks or controllers. In parallel we propose to demonstrate a fully engineered HA power supply system capable of meeting the full ILC system availability goal. A detailed analysis by P. Bellomo shows that 4 of 5 redundant hot swappable modules alone can achieve a full ILC system A=0.88; adding the dual Bulk achieves A=0.92; and adding the dual controller yields A~0.99, the remaining limitation due to single-point failure components such as cables and transductors.

The proposed base unit will include n/N redundant hot-swappable switching power supplies, dual redundant bulk and controller, failure detection diagnostics, and auto-failover hardware/software. First a single unit and then a system consisting of four supplies fed from a common bulk will be demonstrated. The top end IOC (Input Output Controller) function with failover software will be built on the Telecom industry ATCA ("Advanced Telecom Computing Architecture") standard platform that is expected to be adopted for the main controls backbone and network systems.

Details of the imbedded diagnostic processor function are described in *3.2.3*.

**Motivation**



Power supply systems are a major limitation to system availability unless designed with high availability performance from the outset. In addition to achieving unprecedented system performance the systems must remain cost-viable.

**Collaborations with Other Institutions**

The power supply development is of interest to the ATF2 and a SLAC-KEK partnership has been proposed for a sizeable demonstration system to evaluate the approach in a real working environment. KEK has modestly supported an early successful prototype but as of this date has not yet committed to the larger system since technically it is not needed for the ATF2.

SLAC proposes a partnership with ANL on the Diagnostic Processor (see below) and has already benefited from a prototype development with Pohang Light Source in 2005-6.

**Key Personnel**

SLAC: P. Bellomo, B. Lam, A. Seryi

KEK: TBD

ANL: John Carwardine (Point of Contact) + staff

FY07 Milestones and Deliverables

<u>Base Program:</u>

- Design, build, test single unit of 4/5 5 KW supply, dual redundant bulk & controller.
- Incorporate diagnostic controller (see 3.2.3).
- Test failover modes with IOC

<u>ATF2 Program:</u>

- Support design, assembly, test, documentation of ATF2 40+ supply system.
- Procure modular supplies, racks, controllers

3.2.1 Cost Summary

SLAC proposes 2 FTE's for Engineering and 85K M&S for the HA full feature system development program, and 0.75 FTE for Engineering and Coordination and 320K M&S for ATF2 development.

The ATF2 effort will occur in the last half of 07 after all purchased equipment is received.

| Institution | Labor (FTE | M&S (K$) | Activity |
|---|---|---|---|
| SLAC | 2.0 | 85 | Engrg. Base HA program |
| SLAC | 0.75 | 320* | Engrg. ATF2 system |
| | | | * May be partially offset by US Japan funds |

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 2.75 FTE | $405 | $198 | $974 |

Expectations for FY08 and beyond



The Base HA program will continue with design, procurement, construction of a 4-unit HA 4/5 system (5KW supplies) with full features including failover software.

The ATF2 system will be tested at SLAC, delivered, installed, tested at KEK, and training conducted for KEK operations and maintenance staff.

Additional efforts will focus on developing vendors in the three ILC Regions for power systems designed to HA design criteria.

### 3.2.2 High Availability Kickers

**Abstract**

Damping Ring Kicker performance is crucial to a compact ring design. The approximate specification is a clean 1 nsec wide pulse with a <3 nsec rise and fall repeating every 150~300 nsec. Initial success in kicking the ATF beam was achieved in late FY05. Work continues at LLNL in FY06 to improve rise and fall and tail-end effects, based on new integrated driver MOSFET power switches. These will be tested on a modified existing prototype in FY06. Design and construction of a full performance unit is planned for 07.

**Project Description**

The major goal is to show feasibility of a prototype via testing at the KEK ATF, and then to move on to a full system design for 10-20 kickers working in tandem.. The current design of an induction modulator balanced output (+/- 10kV) architecture is ideal but the prototype needs improvement for rise & fall time, impedance matching, stability of calibration, and high availability features.

In FY07 a new prototype based on integrated drive power MOSFETs will be designed and constructed along with a timing and calibration system. The unit will be designed for full power and repetition rate performance.

In parallel, simulations of large system operation will begin to determine requirements for timing and amplitude stability. The timing system requires individually remotely adjustable high stability triggers and delays to maintain the precise timing and waveshape with respect to other units in the system.

Conceptual design for a diagnostic layer will be incorporated to monitor and keep the system in calibration. High availability strategies for operations and fail-over will be studied.

**Motivation**

Many groups are working on kickers to optimize pulse shape, but overall system problems need attention. Regardless of the final choice the system must be designed around a high availability architecture. An early demonstration of the full system approach critically impacts the damping ring circumference and RF choice.

**Collaborations with Other Institutions**

The SLAC program is a collaboration with LLNL for design and construction and KEK for testing in the ATF.

**Key Personnel**

E. Cook, LLNL (0.5, M&S); C. Burkhart (0.1), J. Olsen (0.1), C. Yee, SLAC (.1); D. McCormick (0.1) T. Naito, KEK

**Milestones and Deliverables**

- Complete testing integrated driver-power MOSFET boards (LLNL)
- Design, build new prototype for full power, 6 MHz repetition rate operation (LLNL)
- Begin design trigger delivery, control and calibration system (SLAC-LLNL)
- Begin simulation model to derive full system specifications (SLAC)
- Test single unit prototype at KEK ATF (LLNL-KEK)



**3.2.2. Cost Summary**

| Institution | Labor (FTE | M&S (K$) | Activity |
|---|---|---|---|
| SLAC (LLNL) | | 275 | LLNL Design labor (200 burdened) & construction (75) |
| SLAC | 0.2 | 10 | Design, prototype timing & calibration |
| SLAC | 0.1 | 10 | Develop, evaluate system simulation model |
| SLAC | 0.1 | | Installation, test at KEK |

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.4 FTE | $295 | $64 | $413 |

**Expectations for FY08 and beyond**

- Complete simulations studies.
- Study other unit models for overall system performance including radiation protection, driver cable time delay stability, temperature control, high availability criteria etc.
- Perform integrated tests with 2-3 kickers in tandem at ATF.
- Down-select kicker technology.

**3.2.3 Diagnostic Processor for Power Systems**

**Abstract**

The Diagnostic Processor is conceived as the key element in the development of the Diagnostic Interlock Layer referred to in the BCD Controls document. A generic diagnostic card designed to monitor internal functions of power devices such as large supplies and modulators was first undertaken in 2005 in collaboration with the Accelerator Department of the Pohang Light Source. This unit has waveform sampling and trigger/timing features for use in pulsed modulators and high power rectifier units in which waveforms are needed for troubleshooting. The card also has slow analog ADC's and DAC's for monitoring slow waveforms down to DC, such as the long pulse in ILC, temperatures, interlock trip signal levels and set-points. The full unit is still under evaluation at Pohang and a performance report is imminent. Meanwhile a second more specific version was undertaken for the Marx modulator under development and the first prototype unit is operational in the first Marx 12KV cell. Now another implementation is needed for the HA modular power supply under development. The goal is a small family of cards with a common communications interface to use in power applications, ultimately to get diagnostic data into the main control room, as well as available to service personnel in the field by a laptop connection to Ethernet.

**Project Description**

1. Continue the support of the Pohang generic card program with M&S funds and matching personnel effort from PLS. Design, build and evaluate second prototype. This card has both fast and slow sampling capabilities and a very wide range of programmable time delays and widths, as well as DC multiplexed inputs for reading temperatures, DC interlock set-points etc. The unit will be tested in a practical application at Pohang and then evaluated in the 2-Pack solid state modulator at SLAC.
2. Continue support of the Marx development. The system consists of up to 16 Diagnostic Controllers, one per Marx cell floating at voltages up to 120KV, and a Ground Station communicating trigger and data information by fiber optic cables. The small 3 by 5 inch card provides local triggers with both a delay control, for output waveform optimization, and width control of the output current pulse to the klystron. Waveform digitizers monitor the charging waveforms as well as the output pulse and pulse rise and fall-times. The ground station link to a higher level applications program will be specified, built and tested. Design a second prototype in conjunction with Marx Design For Manufacture program starting in FY07.
3. Begin development of new Diagnostics Controller for HA Power Supply systems. This unit will provide information to Main Control via the Controls System to manage response to failed units as well as to possibly take action to avoid impending trips that would trip off the entire machine. The feature set will be optimized for modular units of typically a 5-module HA architecture and will have spare inputs for special functions.

**Motivation**

The ILC will contain unprecedented number of modular units in power systems, and it is essential to incorporate an intelligent remote diagnostic system.

**Collaborations with other institutions**

Collaboration will continue with Pohang Light Source for a second-generation prototype.

A new collaboration is proposed with Argonne National Laboratory, APS, for software development of the top level control system for the Marx unit, to start in 06 and complete in Q2 of 07.

Further collaboration with APS is proposed for development of the Power Supply diagnostic controller software system, to begin in 07, and will strongly leverage on the work described in 3.2.4 ("High Availability Control Systems and Standard Instrumentation Modules"), with the diagnostic processor being a demonstration of a redundant EPICS IOC running on ATCA.

**Key Personnel**

SLAC – D. McNair, P. Bellomo, J. Olsen, C. Yee, M. Browne

ANL – J. Carwardine (point of contact) + staff

**Milestones and Deliverables**

1. PLS second generation DP prototype completed and tested Q407
2. ANL Completion of Marx DP controls software Q207
3. SLAC-ANL completion & test HAPS DP first prototype on 4/5 system.

**3.2.3 Cost Summary**

| Institution | Labor (FTEs) | Unburdened M&S (K$) | Activity |
|---|---|---|---|
| SLAC | 1.35 | 50 | Hardware Engrg |
| ANL | 0.25 (ANL) | | Software Engrg |
| PLS | 0.1 (SLAC) | 30 | Prototype 2 support |

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.35 FTE | $50 | $75 | $307 |



**Expectations for FY08 and beyond**

- Assuming Marx system successful, build new full DP system for next generation DFM Marx design
- Explore feasibility of wireless connectivity to Marx cells to possible eliminate fiber connections to HV.
- Develop generic DP cards, hybrid circuits or low power custom chips suitable for major modular power system designs: Modulators, Power Supplies, and Chargers.
- Explore additional applications for DP's in high volume situations, e.g. Vacuum pumps, temperature monitoring of warm structures, etc.
- Major efforts will center on developing vendors to supply Diagnostic Processors for high volume applications.

### 3.2.4 High Availability Control System & Standard Instrument Modules

#### 3.2.4.1 High Availability Controls System

**Abstract**

The Baseline Conceptual Design (BCD) for controls recommends that Controls adopt a High Availability design philosophy in order to achieve overall integrated luminosity goals for ILC. This leads to extensions of classic architectures to eliminate single-point failures of both hardware and software. This work evaluates the cost-benefit of applying various High Availability techniques to address the failure modes. The High Availability techniques will be prototyped across the Applications, Services (middleware), and Real-time tiers of the ILC accelerator control system. This work will require strong interaction with the ILC Commissioning, Operations, and Reliability Group.

**Project Description**

Evaluation of high availability techniques must be informed by a process of identifying potential control system failure modes and their effect on machine performance & luminosity. The work would begin by determining the likelihood, duration, and impact of a variety of failures in the control system and other operational systems, based on experience at existing facilities. Part of the project would involve identifying a useful methodology for doing the failure modes & effects analysis.

High availability techniques for addressing identified failure modes, both administrative and technical, will then be identified. The adoption of a platform such as ATCA ("Advanced Telecom Computing Architecture") (the subject of another proposal) provides one part of a system of highly available hardware and software components. A wide variety of techniques are yet to be identified which can provide high availability through the entire architectural "vertical" of the control system. We will identify options, including administrative controls, software development methodologies, off-the-shelf, and custom frameworks, etc.

In order to ground the above analysis in a concrete implementation, a prototype "vertical" software demonstration will be implemented applying a representative set of techniques to the applications, services, and real-time tiers. This could be done in conjunction with ILCTA specific projects, or on a stand alone demonstration test stand. The performance of the system will be tested through real and/or simulated failures.



Through the above failure mode characterization, solution space analysis, and prototype test stand, a cost-benefit evaluation of the identified high availability techniques and products will be conducted.

This work is coupled with the work described under 3.2.4.2, "High Availability Standard Modules for Instrumentation Systems."

**Motivation**

The technical and geographic scale of the ILC places unprecedented demands on the control system hardware and software for availability and remote diagnosis and troubleshooting. To accomplish the ILC goals of integrated luminosity, the ILC control system must be highly available. High availability is not an easily quantifiable term. Both the bounds of a system that is called highly available and the degree to which its availability is extraordinary must be clearly understood on a case-by-case basis.

Performing this work in FY07 will ensure that decisions about future control system development and control system implementation can be made in a timeframe consistent with the overall ILC schedule.

**Collaborations with other institutions**

A collective understanding of high availability in the context of accelerator control systems has been growing through discussions across many institutions, including SLAC, ANL, FNAL, KEK, and DESY. Efforts and interests amongst the member Laboratories are considered complementary. Discussions with outside organizations such as SAF (Service Availability Forum) and NASA are being pursued as well.

**Key Personnel**

ANL: Claude Saunders + staff

FNAL: Margaret Votava + staff

SLAC: Ray Larsen, Bob Downing (Downing Inc) + staff

**Milestones and Deliverables**

**FY07**

- Identify a methodology and/or supporting tools for conducting and documenting a failure mode analysis of typical accelerator control systems (ANL lead).
- Conduct and document failure modes & effects analysis (SLAC lead).

- Identify and document potential high availability techniques and products, and how they would address failure modes (ANL lead).
- Procure hardware and software necessary to prototype selected techniques, either forming an independent test stand (ANL lead), or integrating equipment with some portion of ILCTA (FNAL lead).
- Leveraging off the work performed under 3.2.4.2 to port EPICS to the ATCA platform, extend EPICS to support redundant IOC databases running on t ATCA processors (ANL lead).
- Develop complete "vertical" demonstration of selected high availability techniques (ANL lead).

**Expectations for FY08 and beyond**

It is anticipated this effort will continue in FY08, with the development of specific recommendations and standards for ILC control system. Specific goals would include completing the cost-benefit analysis which evaluates the identified high availability techniques, and developing an appropriate ILC framework and methodology based on the results of the evaluation.

### 3.2.4.2 High Availability Standard Modules for Instrumentation Systems



**Abstract**

This work package is to investigate the suitability of the ATCA ("Advanced Telecom Computing Architecture") electronics platform as a High Availability compliant standardized electronics platform for the ILC accelerator control system. Both hardware and software suitability and performance must be investigated.

**Project Description**

The ILC Controls Global Systems Group has begun investigations into the new commercial standard modular processor architecture (ATCA) designed for High Availability systems in the range of that required for the ILC. Some of the features that make it attractive as an alternative to more commonly used hardware platforms (VME, VXI, etc) include: redundant power sources and backplane, remote power up/power down of modules, hot swap, module self-identification, a "Shelf Manager" for intelligently managing resources, and high speed point-to-point serial links within the crate for redundancy and higher performance than traditional parallel bus backplanes.

ATCA has many attractive features for the ILC control system, but to date the platform has not been deployed in accelerator controls and instrumentation environments. This work package will continue the initial investigations into prototyping both hardware and software environments, and assess the performance and capabilities of the ATCA platform in accelerator controls and instrumentation applications. Particular areas that require evaluation are: performance of high sensitivity analog & LLRF circuits in an ATCA environment; electronics design/implementation challenges; cabling and connector options for bringing precision analog and RF signals into the ATCA framework. The feasibility of using ATCA with existing accelerator controls frameworks will be evaluated by porting EPICS (as a representative system) to the ATCA environment.

This work is strongly coupled with the work described under 3.2.4.1, "High Availability Control Systems".

**Motivation**

The technical and geographic scale of the ILC places unprecedented demands on the control system hardware and software for availability and remote diagnosis and troubleshooting. It is highly desirable to adopt standard modular electronics platforms for the ILC controls and instrumentation to reduce overall cost of development, deployment, and support. Additionally, backplane bandwidths in the existing

VME/VXI frameworks are likely to be performance limiting in the ILC. The ATCA framework has the potential to address these shortcomings and to provide high availability and remote diagnostic features that could significantly improve ILC accelerator recovery times when failures occur. This task is targeted at evaluating the ATCA platform for accelerator controls and instrumentation applications in the ILC.

**Collaborations with other institutions**

The evaluation of ATCA has already spawned collaborations within the Americans Region. SLAC, ANL, and FNAL have all procured similar ATCA development environments. DESY has also procured ATCA hardware and has a proposal to port LLRF electronics (Simcon 3.1) to the ATCA platform. SLAC has also initiated collaboration with the HEP group at University of Illinois, Urbana Champaign. Efforts and interests amongst the member Laboratories are considered complementary.

**Key Personnel**

SLAC: Ray Larsen, Robert Downing (Downing Inc), UIUC staff

FNAL: Vince Pavlicek, Manfred Wendt + staff

ANL: Claude Saunders + staff



**Milestones and Deliverables FY07**

- Procure test equipment for high frequency digital/analog R&D.
- Prototype a precision instrumentation digitizer for use with beam position monitors. Evaluate analog & digital performance and suitability for precision accelerator instrumentation applications (FNAL lead).
- Prototype representative electronics functions to the AMC mezzanine card, and integrating with the IPMC diagnostic module to assess ease of integration into custom designs and to evaluate the IPMC diagnostic module (SLAC lead). Develop software drivers to utilize and evaluate IPMC capabilities (ANL lead).
- Evaluate cable and connector options for full-size ATCA and AMC mezzanine cards and their suitability for accelerator instrumentation applications with the ATCA framework (SLAC lead).
- Procure a real-time operating system for ATCA CPU modules (ANL lead).
- Port EPICS to the ATCA platform to allow evaluation of the High Availability and "Shelf Management" features in an accelerator control system framework (ANL lead).

### 3.2.4 Cost Summary

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 3.0 FTE | $360* | $204 | 969 |

* includes 1 FTE and $50K M&S to UIUC via SLAC

**Expectations for FY08 and beyond**

It is anticipated this effort will continue in FY08, with the development of specific recommendations and standards for ILC electronic systems. Specific goals would include: evaluating and demonstrating redundancy, fail-over, and self-healing capabilities in the real-time operating system and EPICS controls framework running on ATCA front-end controller(s); evaluating the cost-benefit of using ATCA instead of alternatives such as VME or VXI as the standard platform for the ILC control system.

### 3.2.6 Control Systems

#### 3.2.6.1 High Stability RF Phase Distribution System Development

**Abstract**

This work will develop and implement prototype hardware for distributing a highly stable, high precision 1.3GHz RF phase reference throughout the ILC accelerator complex. The task is separated into two components: phase-stabilized fiber optic links for distribution of phase references over many kilometers from the central timing system to the accelerators; local distribution of the phase reference and timing fiducials to multiple RF stations over a distance of 100's of meters. To meet ILC availability requirements, the phase distribution link systems shall be redundant and have fault detection and automatic fail-over.

**Project Description**

To meet the luminosity goals of the ILC, unprecedented phase stability is required for the RF systems throughout the ILC accelerator complex. Most stringent are the stability requirements of the Ring to Main Linac and Beam Delivery Systems, which require less than 0.1 degree stability at 1.3GHz. This phase stability must be budgeted across multiple subsystems, including the RF power system, LLRF system, RF master oscillator, and phase distribution system. The large geographical scale of the ILC (10's km) places stability requirements on the phase reference distribution system that have not been demonstrated.



Active phase-stabilized distribution systems have been prototyped before with some success, for example at SLAC and at DESY, but the performance requirements of the ILC phase reference distribution system have not been accomplished, even in a laboratory environment. This work package will build on the previous work at SLAC and DESY, and will culminate in a prototype "trench test" demonstration of both long-distance and local phase reference distribution system at the Fermilab ILC Test Accelerator (ILCTA).

There are several candidate approaches for active phase stabilization of the long distribution links, including: frequency-offset optical interferometry, phase shifting via thermal or mechanical fiber stretching, and an optical trombone. These must be evaluated, and a candidate selected for prototyping. Additionally, there are design choices that must be evaluated or tested, including whether or not to chop the RF source at a high rate in order to reduce cross-talk between forward and reflected waves in the long-distance fiber link.

The need for high availability and seamless failover of the RF phase reference presents some important challenges, not just in detecting a failure or "flaky" channel, but also in providing seamless failover to a second (redundant) link such that beam is not lost because of phase jumps between the two links.

Candidate technologies for the short-distance local distribution system include both copper (wired) and fiber optical transmission, phase-stabilized cable with or without active phase stabilization or phase averaging. Again, redundancy must be provided, with seamless failover.

Prototype systems will be evaluated in a laboratory environment and in real accelerator environments on the ILCTA at Fermilab.

**Motivation**

Meeting the LLRF stability specs for the ILC will be extremely challenging. This work package will build on previous development work at other laboratories, evaluate candidate technologies, and prototype a preferred solution that includes redundancy & seamless automatic fail-over.

**Collaborations with other institutions**

Four major US laboratories will collaborate on this work package: FNAL, ANL, SLAC, and LBNL.

**Key Personnel**

ANL: Frank Lenkszus + staff

SLAC: Joe Frisch + staff

Fermilab: Vince Pavlicek, Brian Chase + staff

LBNL: John Byrd, L. Doolittle

**Milestones and Deliverables FY07**

- Phase stabilized link (long distance distribution) (ANL lead)
    - Perform preliminary evaluation of candidate technologies.
    - Establish test stand for component evaluation
    - Select and evaluate components.
    - Begin developing a phase reference receiver to evaluate fault detection and seamless fail-over techniques.
- Local phase reference distribution (~250m distances) (LBNL lead)
    - Perform preliminary evaluation of candidate technologies.
    - Establish test stand for component evaluation
    - Select and evaluate components.



**Expectations for FY08 and beyond**

This development will continue during FY08, leading to the installation and evaluation of prototype long-distance and local distribution systems in the Fermilab ILCTA. Specific goals would include:

- Phase stabilized link
    - Prototype the fiber stretcher, using favored technique from preliminary evaluation.
    - Prototype a phase reference receiver. Evaluate fault detection and seamless fail-over techniques.
    - Prototype and evaluate the performance of a complete phase-stabilized link.
    - Install prototype and evaluate in accelerator environment at ILCTA at Fermilab.
- Local phase reference distribution
    - Prototype and evaluate the performance of a local phase distribution system.

Install prototype and evaluate in accelerator environment at ILCTA at Fermilab.

## 3.2.6.2 Control System Framework

**Abstract**

The ILC will place many demands on the control system, and none of the presently-available candidate control system frameworks meet the requirements "out of the box." Since the cost of developing a new control system from scratch would likely be prohibitively high, the Controls Global Group must assess the viability of extending an existing framework to meet the ILC requirements.

This work is to perform a “gap analysis” between the capabilities of known, stable control system frameworks and the specific requirements of the ILC. The gap will be characterized in terms of the work required to modify or extend each framework to meet ILC requirements.

**Project Description**

This work package will assess the various candidate control system frameworks, and perform a gap analysis relative to ILC control system requirements. The goal of a “gap analysis” for controls systems is not necessarily to find the system that offers the minimum “gap”, but rather to inform the larger decision making process which must optimize a larger set of variables. It also provides the basis for developing a work breakdown structure for a detailed costing effort.

The set of ILC control system requirements shall be identified and documented. A candidate set of potential control system frameworks shall then be identified that do not initially violate any of the requirements. Some potential candidates are EPICS, DOOCS, ALMA ACS, Tango, and quite possibly others. Each will be evaluated in turn with respect to the ILC requirements, and potential modifications or extensions proposed in order to meet any shortfall. The proposed modifications or extensions may well also include combining portions of existing frameworks.

This work package will leverage work performed under two other work packages for High Availability Control Systems and High Availability Standard Modules for Instrumentation Systems.



**Motivation**

In order to make an informed choice of framework for the ILC control system, it is necessary to make a fair analysis of the candidate frameworks, and assess their true cost, including costs associating with enhancing the framework. A basic analysis of the options in the context of ILC requirements will prevent any surprises in the later detailed technical design and costing.

**Collaborations with other institutions**

An effective gap analysis will require experience with different control system frameworks. Collectively, the collaborating laboratories have sufficient expertise to make informed assessments of the various candidate systems. Existing collaborative efforts on other controls areas will be brought together to collectively address this work package.

**Key Personnel**

ANL: Claude Saunders + staff

FNAL: Margaret Votava, Jim Patrick + staff

SLAC: Ron Chestnut + staff

DESY: Kay Rehlich

KEK: Kazuro Furukawa

**Milestones and Deliverables**

FY07

- Document ILC control system requirements (ANL lead).
- Identify candidate control system frameworks (ANL lead).
- For each framework, perform and document the gap analysis and any required modifications and/or extensions (ANL lead).

**3.2.6 Cost Summary**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 0.6 FTE | $ | $30 | $111 |

**Expectations for FY08 and beyond**

It is anticipated that this work will allow a decision to be made about the control system framework to be adopted for the ILC. Work in FY08 and beyond will focus on developing enhancements and expansions to the chosen framework to meet the requirements for the ILC control system.

### 3.2.9 Collaboration Tools and Remote Operations

**Abstract**

Effective international collaboration on a large project such as the ILC is a technically demanding problem. There are tools available, but no single tool has been adequate to address the issue of remote operations of an accelerator complex. The goals of this work package are to research and implement collaborative tools that enhance international collaboration and participation in ILC activities, particularly ILC Test Accelerator activities. This work will build on the LHC@FNAL effort at Fermilab and corresponding efforts in Europe to collaborate on LHC machine studies. These collaborative activities have been addressed in the Global Accelerator Network (GAN) community, and in this work package will be addressed in the context of remote operation of ILC test facilities to enhance international collaboration.



**Project Description**

Current efforts to establish remote operations capabilities for the LHC accelerator and experiments have provided experience with available collaboration tools. Similarly, the Fusion Energy Sciences community is preparing for construction and operation of the International Thermonuclear Experimental Reactor (ITER) and is including remote operations in their plans. We have been working with members of this community in studying collaboration tools and network and security issues.

This work package will research concepts that have been developed in the context of GAN, and build on current efforts to design a remote operations center at Fermilab (LHC@FNAL) for the LHC accelerator and CMS experiment. For example, the LHC@FNAL Task Force initiated a three-month evaluation of a commercial web-collaboration tool called WebEx to evaluate its effectiveness for meetings, collaborative work in small groups, and as a means to link control rooms with remote operations centers. At the end of the evaluation period the ILC Controls Group successfully incorporated WebEx in meetings that included participants from the U.S., Europe, and Asia. This work package will evaluate the use of tools for international collaboration and participation in ILC test facilities, and will explore the use of other tools that enhance collaborative efforts.

Requirements for effective international collaboration will be developed, especially with regard to a future ILC operations model that involves multiple control rooms distributed around the globe. We will evaluate tools for role-based access, application and desktop sharing, data acquisition and distribution to international collaborators, and collaborative visualization environments.

**Motivation**

The motivation for this work package is to improve international collaboration and share information in real time.

**Collaboration with Other Institutions**

Effective deployment of collaboration tools and remote operations requires experience with available tools to assess capabilities and identify areas that require future development. Every collaborating ILC institution will eventually work with the tools that have been chosen, and it is essential that the assessment and decision-making process is coordinated with the Global Design Effort across the three regions and across multiple laboratories. For this work package we will work with established ILC controls groups in each region. We plan to work with the GAN community and with the Fusion Energy Sciences (FES) community. We have submitted a joint HEP/FES SciDAC (Scientific Discovery through Advanced Computing) proposal to the Department of Energy.

**Key Personnel**

SLAC: Ray Larsen (point of contact)

FNAL: Erik Gottschalk

ANL: John Carwardine (point of contact)

DESY: Ferdinand Willeke

KEK:

**Milestones and Deliverables**

FY07

- Develop requirements for remote operations of ILC test facilities (FNAL lead).
- Identify, evaluate, and recommend suitable tools for remote operations (FNAL lead).
- Work with international collaborators to develop a model for remote operations (FNAL lead).



**3.2.9 Cost Summary**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.2 FTE | $ | $10 | $37 |

**Expectations for FY08 and beyond**

This work will continue during FY08. Deliverables will include establishing remote operations capabilities for the ILC test facilities at Fermilab.

**Category 3.3**

**3.3.1 R&D Polarized Electron Source**

**Description:**

R&D for the ILC polarized electron source. It includes the source laser system, the polarized electron guns and the injector linac.

**Motivation:**

Laser R&D:

The drive laser system must be developed. This includes the amplification of the pulse train, pulse shaping and development of controls and diagnostics. The laser system must be designed for high reliability

and integrated into an overall control system. The laser technology will be Ti:Sapphire. The main R&D effort will be the amplifier development as such a system has not been developed commercially or at an R&D level.
To support the photocathode R&D program, other laser systems maybe needed to support investigating of alternative materials.

DC-Gun R&D:

Improved HV performance of a polarized DC gun is desirable to modify the bunching section. A first goal is to produce a short enough micro-bunch to allow sub-harmonic bunching at a higher harmonic frequency and thereby increasing the flexibility of bunch train timing with respect to the damping ring injection.
HV performance of a DC gun can be increased by the use of new electrode and insulator materials.

Injector simulations

Continue optimizing the RF and optics simulations for the e- source. Study of beam dynamics issues and investigation of alternative bunching schemes.



**Collaboration with other institutions:**
SLAC

**Milestones and deliverables:**

End of FY07:

Laser R&D: - Complete design of laser pulse train amplification.

DC Gun R&D:
- Experimental results that can be incorporated into improved gun design
- Draft of next generation gun design, including improved loadlock

Injector simulations: Integrated and refined optics design for the injector,
- Alternative bunching system design for higher voltage DC gun operation.

**Key personnel:**

| | | |
|---|---|---|
| Axel Brachmann: | 50 % | (Laser Development) |
| James Clendenin: | 25 % | (Gun Development) |
| Feng Zhou: | 50 % | (DC Gun/Injector) |

Additional required:

Engineer TBD: 50 % (Gun Development)
Engineer TBD: 50 % (Laser Development)

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.0 FTE (Laser R&D) | 400 | | |
| 1.0 FTE (DC-Gun R&D) | 150 | | |
| 0.25 FTE (Simulations) | 0 | | |
| 2.25 FTE (Total) | 550 (Total) | $195 | $1049 |

**Expectations for FY08 and beyond:**

We expect work to continue in FY08 and FY09. The results will be incorporated into the TDR Experimental work will be carried out in SLAC's Injector Test facility.

Laser R&D:

The goal for laser R&D is a fully functional and tested prototype for the ILC electron source laser system.



DC gun R&D

Tests of new electrode and insulator materials will continue beyond FY07. The goal is to design and construct a state of the art DC gun with optimized performance for the ILC.

Injector simulations

Beam transport simulations will continue based on results from laser and Gun R&D.

**3.3.2 R&D Development of Photocathodes**

**Description:**

This R&D program aims to develop photocathode materials for the ILC polarized electron source. Work will take place at SLAC's Cathode Test Facility. Work on GaAs based photocathodes will continue. Emphasis will be placed on increasing polarization, improving robustness and lifetime. Other materials, such as high QE GaN photocathodes will be studied. For FY07 it is planned to upgrade the existing cathode test system.

**Motivation:**

After extensive research in the past several years, the strained-superlattice GaAs-GaAsP photocathode has been developed. This structure is capable of delivering an ILC compatible beam with ~90% polarization. Since the polarized photocathode is independent of the technology choice, the same structure can be used for the ILC. However, since the ILC bunch structure is different from NLC, we should re-evaluate the photocathode parameters for possible improvements. With a valence band splitting of 80 meV, 100% polarization was expected. The peak polarization, in actuality, is still limited to ~90%. We will investigate the source of spin-depolarization. Once we identify the cause of depolarization, we may be able to increase the polarization.

**Collaboration with other institutions:**
SLAC, University of Wisconsin (Richard Prepost)

**Milestones and deliverables:**

End of FY07:

- Experimental results for photocathode designs with increased quantum efficiency and polarization, lifetime and robustness.
- Upgraded cathode test system.
- Design for next generation cathode test system.

First designs for new materials for polarized photocathodes (e.g. GaN)



**Key personnel:**

Takashi Maruyama: 25 %
Katerina Ioakeimidi: 100 %
Engineering/Design(TBD): 100 % (CTS Systems engineering and design)
Robert Kirby: 25 %

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.5 FTE | 200 | $155 | $692 |

**Expectations for FY08 and beyond:**

We expect work to continue in FY08 and FY09. It is planned to expand the laboratory and install a new photocathode test system. This will extend our R&D capabilities. The results will be incorporated into the TDR Experimental work will be carried out in SLAC's Injector Test facility.

## 3.3.3 R&D Polarized RF Gun

**Description:**

R&D for a polarized RF gun for the ILC.

**Motivation:**

Polarized RF-Gun

A polarized RF-Gun can greatly simplify or even eliminate the bunching section of the ILC electron source. Although the damping ring is still necessary, overall requirements will be less severe and reliability can be improved. During FY07, the R&D program for an RF-Gun will consist of the design of a high vacuum RF gun structure and simulation work to investigate electron/ion back-bombardment and secondary electron emission issues.

**Milestones and deliverables:**

RF Gun R&D: - Design of high vacuum structure,
- Simulation results (electron/ion back-bombardment, secondary electron emission)

**Key personnel:**



Brachmann, Clendenin, plus new Physicist 100% (RF Gun)

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.0 FTE | 50 | $57 | $242 |

**Expectations for FY08 and beyond:**

RF Gun R&D

An RF-gun will be constructed and tests of its vacuum performance and subsequent NEA cathode test will be carried out using SLAC's L-band RF source in Endstation B.

**Category 3.4**

**3.4.1 NC Positron Capture Structure**

**Abstract**

Evaluate the performance of a 1.3 GHz, normal-conducting (NC), traveling-wave (TW) structure of the type that would be used in the ILC positron and electron injectors. Such cavities would incur significant rf heating and need to operate at moderately high gradients (9 MV/m) but with high input power (10 MW) to be efficient.

**Project Description**

A 4.3 m long, 50 cell, 3/□ 4, traveling-wave structure with a 46 mm aperture has been designed for the ILC injector accelerators. A half-length prototype (2.2 m, 25 cell) structure will be constructed at SLAC and installed in the NLCTA beamline. It will be powered with a 10 MW klystron using 1 ms pulses at 5

Hz to produce a 9 MV/m accelerator gradient. A single bunch beam with a variable injection time will be accelerated in the cavity to measure the variation of the gradient during the pulse. A portion (~ 0.5 m) of the structure will be surrounded by a solenoid magnet similar in strength to that required for the ILC. This magnet would be the same one used for the SW cavity evaluation in FY06.

**Motivation**

The low energy portions of the ILC injector linacs (< 200 MeV for electrons and < 400 MeV for positron) require normal-conducting structures to allow for solenoidial focusing, and large apertures to accommodate the large beam emittance. Their long pulse operation makes cooling a challenge and the high power may limit the sustainable gradient below the 9 MV/m design value. A half-length prototype should allow verification of the critical performance requirements (i.e., high power and full field) without the additional cost and difficulty of building a full length system.

| **Milestones** | **Date** |
|---|---|
| Complete cavity rf design | Mar 2007 |
| Complete drawing package | Oct 2007 |
| Complete construction | Mar 2008 |
| High power test at NLCTA | June 2008 |



**Key Personnel (in FY07)**

Chris Adolphsen, project leader
J. Wang – 0.1 FTE
G. Bowden – 0.2 FTE
E. Jongewaard – 0.1 FTE
Z. Li – 0.1 FTE

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.9 FTE | 90 | $59 | $270 |

**Expectations for FY08 and beyond:**

The work is expected to be completed in FY07.

### 3.4.2 EDDY Current Heating Experiment

**Status:** The baseline AMD for the ILC positron capture section is a pulsed device similar to the SLC flux concentrator (albeit with a much longer flattop). This choice was made because we do not fully understand the effects of magnetic field on the fast moving metal positron target. The pulsed AMD has a much lower magnetic field at the target and this field is only ON for ~ 1% of the time. This means that the expected eddy current effects are negligible.

**Description:** This R&D project is an experiment design to understand the effects of high magnetic fields on rapidly moving metal targets with experimental parameters close to the ILC parameters and to validate the code that we use to estimate these effects. The experiment will be done in three steps. The first step uses a small permanent magnet and a small spinning copper disk to look for effects (using strain gauges). The second stage is the use a 50 cm to 1 meter diameter disk and higher field. The design of this second stage will be done in conjunction with calculations being dome at LLNL using the MAXWELL suite of simulation codes. This experiment will validate MAXWELL in the range of parameters that are used in the ILC positron source design. Stage three of this experiment will in collaboration with the Liverpool/Daresbury groups to spin the real target prototype in a high magnetic field

**Motivation:** At present we do not have a design for the pulsed AMD. A DC superconducting magnet can be used as an alternative, if the eddy current effects can be handled. The DC magnet has the additional advantage that the target is immersed in the magnetic field and simulations have shown that this will increase the positron yield into the damping rings by ~ 40%.

**Milestones and Deliverables:** At present we are just starting on stage one of the experiment. We expect to design stage two by the summer of 2006 and then build and operate the experiment in FY2007. We expect the experiment to last ~ six months and produce publication quality results by the summer of 2007.

| Benchmarks | Date |
|---|---|
| Design the Stage 2 experiment | Sep 06 |
| Build Stage 2 | Feb 07 |
| Finish Stage 2 data taking | May 07 |
| Design Stage 3 experiment | May 07 |

**Key Personnel:**
Vinod Bharadwaj, (project leader) John Sheppard, Lynn Bentson
Sean Walston, LLNL, Ian Bailey, Liverpool



**Cost Summary (k$):**

| | FY07 | FY08 | Total Project |
|---|---|---|---|
| ED&I (SLAC labor) | 0 | 0 | 0 |
| M&S | 50K | 30K | 80K |
| LBNL/LLNL/BNL funds | 100K | 50K | 150K |

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 0 FTE | 50 | $8 | $58 |

**Category 3.5**

**3.5.1 Electron Cloud Lab Measurements and PEP-II Studies**

**Abstract:**
The electron cloud effect has been identified as one of the main issues in the positron DR. It has high significance and high risk in the Damping Ring Recommendation Summary document prepared in November 2005. To reduce the electron cloud density confidently below the instability threshold, further R&D is needed. If techniques are found that are sufficiently effective at suppressing the electron cloud, a single 6 km, or possibly smaller, ring can be used for the positron damping ring. If electron cloud mitigation techniques are not found that are sufficient for the baseline positron ring (two 6 km rings), then a 17 km ring is a possible alternative.

In this respect, to reduce the electron cloud in magnetic field regions is important. Possible cures in bends and wiggler regions such as rectangular micro-fins and clearing electrodes although very promising need further R&D studies and a full demonstration.

The simulation effort and benchmarking between different codes is continuing. Self consistent simulation codes are also being developed. SLAC has an extensive R&D program simulating cloud buildup and its effect on the circulating beam and studying a number of possible remedies to reduce the secondary electron yield below that required.

**Project Description:**

The program is to reduce and stabilize the surface secondary electron yield (SEY) below the threshold for the onset of the electron cloud in the damping ring. The requirement from simulations is an SEY<1.2.

- Project 1: Build prototype chambers with mm fins (grooves) for installation in PEP-II.
- Project 2: Build a dedicated chamber for installation in the PEP-II to test effect of e- and photon conditioning on SEY.
- Project 3: Build dedicated chambers to test clearing electrodes technique for installation in PEP-II. This test will require a new dedicated chicane of 4 (2) bends for installation PEP-II.
- Laboratory measurements of the SEY in a dedicated existing set-up.
- Developing new material alloys.
- Fabrication of samples with rectangular fins with tens of μm size.
- Fabrication of dipole chambers with rectangular fins with tens of μm size.
- Collaboration with Frascati for installation of dedicated electron cloud diagnostic and TiN coating of the wiggler chamber in the Dafne positron ring.
- Measurements of electron trapping mechanism in a quadrupole field: collaboration with LANL for installation of dedicated electron cloud diagnostic in a PSR quadrupole.



**Motivation:**

In the beam pipe of the Damping Ring (DR) of a linear collider, an electron cloud may be produced by ionization of residual gas or photoelectrons and develop by the secondary emission process. For the ILC positron damping ring, the development of the electron cloud must be suppressed. Coupling between the electrons and the circulating beam can cause collective effects as coupled-bunch instabilities, coherent single-bunch instabilities or incoherent tune spreads that may lead to increased emittance, beam blow-up and ultimately to beam losses directly affecting the collider luminosity. Many of the electron cloud effects have been evaluated by simulations. Actions to suppress the electron cloud are required for the ILC positron damping ring.

**Project status:**

Project 1: Installation of SEY test chamber in PEP-II LER planned for summer downtime.

Project 2: Installation of 4 test chambers w/wo fins mm size in PEP-II LER planned for summer downtime.

Project 3: Optimized the clearing electrode design and experiment layout. Planned installation of clearing electrode chambers in PEP-II LER in summer downtime 2007.

The first micro-fins OFHC Cu samples have been manufactured by photo-etching technique in Apr06. Surface analysis studies ongoing.

Collaboration with Frascati: coating the existing wiggler chambers of the Dafne positron ring.

Collaboration with LANL: ongoing measuring electron trapping mechanism in quadrupole field.

**Milestones and Deliverables:**

| Milestones | Date |
|---|---|
| Project 1. Fabrication of the prototype fins (mm size) chambers 06/06 | |
| fins chamber installation in PEP-II | Summer shtdwn 06 |
| Project 2. Fabrication of SEY test chamber | Done |
| Chamber installation in PEP-II | Summer shtdwn 06 |
| Fabrication of micro-fins OFHC Cu samples by photo-etching | Done |

Measure SEY of micro-fin samples 2007
Project 3: Fabrication of clearing electrode chamber 06/07
Installation of clearing electrode chambers in PEP-II Summer 2007
Measure electron trapping in quadrupole filed PSR LANL Summer 06
Installation of electron cloud diagnostic in Dafne ring Summer shtdwn 06

**Collaboration with other institutions:**
This work is in collaboration with:PEP-II – J. Seeman and N. Kurita, Cockroft Institute - A. Wolski, LANL - R. Macek, Frascati – S. Guiducci, C. Vaccarezza.

**Key Personnel:**
M. Pivi 40%, R. Kirby 25%, G. Collet 25%, B. McKee 10%, M. Munro 50%, designer 50%.

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.0 FTE | 240 | 158 | 646 |



According to FY07 funding availability the project will be given the following priority:
1. Project 1: Fins chambers: Installation and measurements 30 k$
2. Project 2: SEY test chamber: Installation and measurements 45 k$
3. Project 3: Clearing electrode chambers tests. Fabrication to installation 130 k$
4. Other laboratories. Novel material alloy manufacturing 15 k$
5. Micro-fins. Sample fabrication and measurements 20 k$
6. Micro-fins. SEY measurements in B field, FY08

**Comments**
In magnetic field regions, conventional remedies as external solenoids are not effective. Simulations show clearing electrodes and rectangular micro-fins are viable ways to reduce the electron cloud density well below the instability threshold.

**Expectations for FY08 and beyond:**
Studies will continue as needed to support the TDR.

**Category 3.8**

**3.8.1 Modulators**
**3.8.1.1 Evaluate First Marx Prototype**

**Abstract**
The Marx Modulator is the Alternate Baseline Design for the BCD Bouncer Modulator. The first Marx prototype is scheduled for lab demonstration by the end of 2006. In early 2007, it will be fitted for service as a test station in one of the new L-Band test stands in End Station B (ESB).

**Project Description**

Assuming successful fabrication of the first Marx prototype by the end of FY06, the modulator will be first evaluated in Building 15 to establish few-hundred-hour-level reliability, and then it will be turned over to an engineering group for assembly into an enclosure with an internal air-water heat exchanger system and moved to ESB (along with its 12 kV DC charger source that operates from 480V). Its total power consumption under full load will be 150 kW. In ESB, the unit will be integrated with power, water, controls, fire and electrical safety systems, tested into a water load to verify reliability at the few thousand hour level. It will also be used to drive L-band klystrons as they become available.

**Motivation**

The present Baseline Conceptual Design (BCD) modulator has not had major reliability problems, but it can be improved to reduce size, weight and cost while increasing reliability and energy efficiency significantly. The present design has a very large and heavy oil-filled transformer driven by a 10 kV switched capacitor circuit, with the droop compensated by a "bouncer" circuit. There are losses in the transformer and switches since all switching is done at the high current low voltage end. These can be reduced in a Marx design which has no transformer and all switching at the lower load current that directly feeds the klystron. This design results in a significantly lower cost, lower size and weight, higher efficiency and higher reliability due to redundancy features.



| Milestones | Date |
|---|---|
| Complete Marx lab testing: | Dec 2006 |
| Assembly into enclosure in B15 | Jan 2007 |
| Retest in B15 & move to ESB | Feb 2007 |
| Operate over 2000 hours at ESB | Sept 2007 |

**Key Personnel**

SLAC Power Conversion: G. Leyh (0.1), P. Blum (0.1), R. Cassel (0.2) = 0.4 FTE

C. Burkhart (0.2), M. Nguyen (0.2), D. Anderson (0.1), D. Moreno (0.1) = 0.6 FTE

SLAC Controls: TBD - 0.2 FTE

ILC: C. Adolphsen (0.1), R. Swent (0.1) = 0.2 FTE

LLNL Mech Eng: C. Brooksby - 0.1 FTE

**Cost Summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.4 FTE | 120 | 88 | 397 |

**Expectations for FY08 and beyond:**

???

**3.8.1.2 Marx Design-For-Manufacture (DFM) Modulator**

**Abstract**

Assuming success with the Marx prototype, the Marx engineering design team will immediately begin a second-generation DFM design to incorporate the lessons learned from the first design and prepare a package for commercial production. Some physical changes are needed to optimize tunnel installation and servicing. This strategy supports a fast buildup of test capacity for L-Band sources.

**Project Description**

The FY07 goal is to complete the DFM design and order parts for two units in preparation for FY08 construction. The fabrication of these modulators would be contingent on a formal down-select to the Marx for the ILC Baseline Conceptual Design. In early FY08, the two units would be assembled in-house, but with the circuit board subassemblies and loading, which is the bulk of the cost, let to commercial vendors. This strategy is in preparation for letting bids for three completely commercial units to at least two vendors in FY08.

**Motivation**

If the first Marx is successful, this program provides the source drive power for future klystron and device testing at SLAC and elsewhere. The two DFM units would serve to benchmark the costs for commercially built units and to verify that such units can achieve the reliability required for the ILC.

**Key Personnel (FY07 Fraction)**



SLAC Power Conversion: G. Leyh (0.8), P. Blum (0.8), R. Cassel (0.1), C. Burkhart (0.2), M. Nguyen (0.3), D. Anderson (0.1), D. Moreno (0.1) = 2.4 FTE

SLAC Controls: Software – 0.3 FTE

LLNL Mechanical: C. Brooksby - 0.4 FTE

**Milestones**

| | |
|---|---|
| Complete DFM Electronic Subassembly Design | June 2007 |
| Complete Mechanical Assembly design | July 2007 |
| Place orders for all long-lead components | August 2007 |
| Place orders for all remaining parts | Oct 2007 |
| Complete assembly of two DFM modulators | March 2008 |

| **Cost Summary** | FY07 | FY08 | Total Project |
|---|---|---|---|
| SLAC labor (FTE's) | 3.1 | 1.5 | 4.5 |
| Shop and M&S (k$) | 300 | 200 | 500 |
| LLNL labor (FTE's) | 0.4 | 0.2 | 0.6 |

**Cost Summary:**

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 3.1 FTE | 300 | 200 | 918 |

**Expectations for FY08 and beyond:**

???

### 3.8.1.3 Evaluate DTI Modulator

**Abstract**

A SBIR-funded direct-switch modulator (135 kV, 166 A, 1.5 msec, 10 Hz) from Diversified Technologies Inc. (DTI) will be sent to SLAC in FY07 to be evaluated. This modulator uses a multiplier circuit to produce full voltage, which is then applied by a direct solid-state switching element to the klystron. As in the Marx design, the pulse transformer is avoided, and as in the ILC baseline design, droop is compensated with a bouncer circuit. The goal is to run the modulator into a water load for a minimum of a few thousand hours to assess its reliability. In FY08 and beyond, this modulator would be used for testing ILC prototype 5 MW and 10 MW klystrons.

**Project Description**

The first unit is under development and due to be delivered to SLAC at the end of 2006 for installation in a test stand in ESB. The facilities costs associated with the test stand are covered under a separate proposal. The costs listed below cover power and water connections, timing system, PLC-based interlocks, EPICS interface, installation, safety evaluation and remediation, and operations oversight.



**Motivation**

This modulator design likely provides cost savings relative to the ILC baseline design from having eliminated the large transformer. DTI built such a modulator without the bouncer circuit for CPI, which has used it for several years for klystron testing. However, this modulator approach does not have the modularity and operational flexibility afforded by the Marx design. As such, it is more likely to be a fall-back solution if the Marx approach does not prove feasible. Regardless, it should provide a 'free' station for klystron evaluation.

| Milestones | Date |
|---|---|
| Receive the modulator from DTI | Dec 2006 |
| Ready for operation after safety evaluation and interlock checks | March 2007 |
| Operated 2000 hours into a water load | August 2007 |

**Key Personnel**

Chris Adolphsen, project leader – 0.1 FTE
Richard Swent – 0.1 FTE
Bobby McKee – 0.1 FTE
Dick Cassel (0.1), M. Nguyen (0.1), D. Anderson (0.1) = 0.3 FTE
TBD (Experimental) – 0.2 FTE

**Cost Summary** FY07

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.8 FTE | 80 | 52 | 240 |

### 3.8.2 Prototype Linac Quad and BPM Tests II

**Abstract**

Based on the FY06 test results of a prototype SC quad and linac BPMs, iterate their designs to meet the BCD requirements, and to be amenable to large scale production. This work would be done in collaboration with FNAL, and would take advantage of the beam and SC quad test facilities developed at SLAC in FY06.

**Project Description**

The prototype SC linac quadrupole magnet (cos(2θ) design) that will be tested in FY06 was not designed for large scale production, and may not meet the tight requirements on magnetic center stability for the ILC (this requirement was not considered when the magnet was built several years ago). The FNAL ILC magnet group is currently refining the specs for the linac SC quads, and are in a good position to design a more realistic prototype (e.g., superferric quads may be used in the first half of the linac). This magnet would be built in FY07 at FNAL and then measured using the existing warm-bore cryostat and high-resolution, rotating-coil system at SLAC. In the meantime, the first prototype would be installed in the SLAC ESA beamline where quad shunting tests would be done using the high resolution BPMs there.

The BPM program would be a follow-on to the development effort started in FY06 to produce an ILC linac cavity BPM that (1) meets the 300 nm single bunch resolution goal, (2) can be high-pressure rinsed so it does not contaminate nearby ultra-clean cavities when installed in a cryomodule, and (3) will operate reliably at cryogenic temperatures (2K). In the FY06 program, a triplet of S-band (2.9 GHz) cavity bpms will be beam tested at ESA to evaluate the resolution achievable in a slotted-waveguide cavity design that has a low Q (~ 600) to allow clean bunch-to-bunch signal separation in the ILC. These BPMs were made with an aperture size about half of the nominal value for the ILC since this made testing this design concept simpler, and it would be advantageous to adopt this aperture size for the ILC. If the tests go well and there is no broad consensus to reduce the large linac aperture (80 mm), we would build a triplet of full aperture, L-band (1.5 GHz) versions of this design in FY07.



These BPMs would also be tested with beam in ESA (funding for this test is covered under an instrumentation proposal). The BPMs would be made compatible with operation in the ILC linacs, which requires damping the lower-order modes and using materials suitable for the cryogenic environment. Cold tests of the BPMs would be done in a He Dewar and cleanliness evaluations performed to show that they meet ILC requirements. Eventually they could be installed in a cryomodule at FNAL or DESY for full integration tests.

To be specific, the costs below cover (1) the construction of another prototype ILC linac quad at FNAL and its testing with a rotating coil at SLAC, (2) the installation of the first prototype quad in the ESA beamline and quad shunting tests using existing BPMs and (3) construction of a triplet of full aperture, cryomodule-ready BPMs of the design tested in FY06.

**Motivation**

To preserve the small emittances in the ILC linacs will require beam-based alignment of the quadrupole magnets. The simplest technique proposed for this purpose requires that the alignment of the magnetic center of each quad be first measured relative to the electrical center of the nearby bpm. This involves changing the quad strength (shunting) and recording the resulting beam kick. To achieve the desired accuracy, the quad center cannot move by more than about 5 microns when the field strength is changed. Thus we want to verify that the field center is stable to this level in an ILC-like quad, which nominally has a large aperture (78 mm diameter) so may be prone to distortion when the magnetic forces are varied. For the quad alignment procedure, we also want to show that stable, high resolution (micron level) beam position measurements are achievable with the large aperture cavity bpms that are required in the linacs (DESY has had limited success with their TTF bpms). Such quad and bpm performance demonstrations are probably all that can be done experimentally to test the quad alignment procedure without having at least 100 m of beamline and low emittance beams. Other beam-based alignment methods are less local in their correction and so are even harder to evaluate in a meaningful way without a large-scale linac.

| **Milestones** | **Date** |
|---|---|
| Specify SC quad design | Sept 2006 |
| Begin construction at FNAL | Jan 2007 |
| Ship to SLAC | June 2007 |
| Test at SLAC Magnetic Measurement Facility | Aug 2007 |
| Install first prototype in ESA | Jan 2007 |
| Do quad shunting tests | Mar 2007 |
| Complete design and drawings for BPM triplet | Jan 2007 |
| Complete fabrication | April 2007 |

**Key Personnel**

Chris Adolphsen, project leader – 0.1 FTE
Gordon Bowden – 0.2 FTE
Pearson Shop – 0.8 FTE
Eunjoo Thompson (0.2), Tom Weber (0.2) and Cherril Spencer (0.2) = 0.6 FTE
Beam Physicist = 0.2 FTE
FNAL collaborators. J. Tompkins and V. Kashikhin and M. Wendt



| **Cost Summary** | FY07 |
|---|---|
| SLAC labor (FTE) | 1.9 |
| Shop and M&S (k$) | 455 |

**Cost summary:**

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 1.9 FTE | 455 | 163 | 875 |

**Expectations for FY08 and beyond:**
The work described here should be completed in FY08.

## 3.8.5 Klystrons
### 3.8.5.1 Sheet Beam Klystron Development

**Abstract**

This proposal is to develop a Sheet Beam Klystron (SBK) as a alternative to round-beam designs for the ILC. This tube is likely to be less expensive than the ILC baseline Multiple Beam Klystron (MBK) due to its planar geometry and its reduced parts count, and it is likely to have a longer cathode lifetime due to its lower beam current density.

**Project Description**

Two prototype SBK's will be designed, fabricated and tested at SLAC. This effort will benefit from work that the Klystron Department has done to develop a small W-band SBK. The beam will have an 40:1 aspect ratio and will utilize permanent magnets for focusing. Aside from the novel beam architecture, rectangular cavities, and absence of a large solenoid and power supply, the device will essentially be a plug-in replacement for the existing multi-beam devices currently under consideration for the ILC. Much work has been performed over the past 3 years in perfecting 3-dimensional simulation efforts using recently developed software packages for modeling of the gun, beam transport and rf power formation and extraction. Upgrades in the parallel computing platform allow for faster turnaround in the design synthesis process.

The first prototype will be tested in the Fall of 2007. The design of a second version will be started earlier to incorporate the lessons learned from the fabrication and QC of parts for the first SBK. In this way, the development of this tube concept will be accelerated. At present, the basic design work has been completed for the first prototype and simulations of the rf and beam transport are ongoing.

**Motivation**

The current class of high-power rf sources for the ILC utilize linear-beam klystrons with one or more round beams. A multi-beam approach has been pursued by several companies in Europe, Asia and the United States due to the high power requirements and desire for good efficiency at relatively low voltages (however, none of the prototypes have been tested long enough or have survived long enough to be considered successes). When comparing these designs to an equivalent SBK approach one finds a plethora of parts, a large solenoid, and limitations due to cathode currents. Perhaps something may be done to address the latter two items but the parts count issue (i.e., cost and reliability) is unmistakably in favor of the SBK vacuum-envelope. Successful development of an SBK prototype may very well usher in a whole new class of microwave sources. With the single beam and large surface area, a higher average power operation becomes possible than is currently held to be the limit. The large surface area of the cathode reduces the current density (thermal requirement) and hence will produce a longer lifetime. The low parts count further reduces the number of joining operations and increases tube yields.



| **Milestones** | **Date** |
|---|---|
| Complet DC beam transport design | Nov 2005 |
| Complete rf beam transport design | June 2006 |
| Complete gun electrode design | July 2006 |
| Complete mechanical layout and electrical design | Aug 2006 |
| Bake-out of first prototype | Aug 2007 |
| Bake-out of second prototype | Jan 2008 |
| Evaluation of both tubes complete | April 2008 |

**Key Personnel**

Daryl Sprehn, project leader
Erik Jongewaard and Chris Pearson (SLAC engineers)

-

| **Cost Summary** | FY06* | FY07 | FY08 | Total Project |
|---|---|---|---|---|
| Klystron Dept Labor (FTEs) | 2.0 | 6.0 | 1.9 | 9.9 |
| Shop and M&S (k$) | 0 | 440 | 125 | 565 |

* The FY06 design work is supported at SLAC with non-ILC funds

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 6.0 FTE | 440 | 366 | 1616 |

**3.8.5.2 L-Band Klystron Acquisitions**

**Abstract**

SLAC is preparing to lead the ILC Americas effort to develop a viable, cost efficient rf source for the ILC linacs. To speed up the development of a robust klystron, SLAC proposes to buy two next-generation 10 MW multi-beam klystrons (MBK), and to contract a tube company to design and manufacture a 5 MW, high efficiency, single-beam klystron (to be adopted for the ILC if the MBK's do not prove feasible).

**Motivation/Project Description**

Currently there is not a 10 MW, high-efficiency klystron design that has proven to be robust. Thus it is imperative that the ILC work to develop one in the next few years. Given the high cost and the 1-2 year turnaround time per design iteration, this will require a multi-prong approach to be effective. Currently Thales is fairly saturated providing tubes to DESY (four tubes are on order, two of which may be modified to improve performance). At SLAC, we propose to contract CPI and Toshiba (in collaboration with KEK) to build improved versions of their multi-beam klystrons (each company has built one but neither tube has been fully qualified), These tubes would be evaluated using the three modulator test stands that will be available at End Station B (at SLAC) in FY07. One of these tubes would eventually be shipped to FNAL (probably in FY09) to power up to three cryomodules at 35 MV/m.

Another approach to a high-efficiency 10 MW source is a sheet-beam klystron. A separate proposal has been submitted to develop such a tube at SLAC. A more conservative route for the ILC would be to use the commercially available 5 MW, single-beam tubes that been have shown to be robust from over 30 years of service. However, their 42% efficiency is significantly lower than the 65% goal that has been achieved with the MBKs. Thus we propose to contract a tube company to design and build a higher efficiency, 5 MW, single-beam tube. Hopefully this will be done without significantly increasing the gun voltage so the present style modulators could be used.

The estimated cost for each of these three klystrons is about 900 k$ (the 5 MW tube cost includes the design effort), and it is expected that the tubes would be delivered in about a year and half after the contracts are approved. These purchases would be managed with the support the Klystron Department at SLAC and the RF groups at KEK and FNAL (Chris Adolphsen would be the contact person).

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.0 FTE | 2700 | 455 | 3290 |

**3.8.6 RF Distribution**
**3.8.6.1 Optimized RF Distribution System**

**Abstract**

This proposal is to develop a more efficient and less costly rf distribution system for the ILC linacs, and to provide two 8-cavity rf distribution systems for FNAL cryomodules in FY07. Four changes to the baseline design are being considered, and the new parts would be first tested at SLAC with an L-band source before being incorporated in the systems sent to FNAL.

**Project Description**

The proposed changes to the baseline rf distribution system are described in the section below. The variable tap-off system would be developed first and then used to produce an 8-cavity distribution system for the first cryomodule to be tested at FNAL in Summer 2007. This system would have four variable tap-offs feeding four pairs of cavities through 3 dB hybrids. Each feed from the hybrid would have the same elements as in the baseline design (i.e., circulator, 3-stub tuner and directional coupler). With this configuration, the power going to each cavity pair could be adjusted, and the cavities would be fully isolated. This system would also allow tests of operation with the circulators removed to verify that imperfect hybrid isolation and load matching would not adversely affect operation (however beam could not be accelerated in this mode of operation due to the choice of cavity spacing in the TTF3 cryomodules – the TTF4 design would allow beam operation as well). The second 8-cavity system would be similar but use a simpler phase shifter than the 3-stub tuner, and many of the flanges may be eliminated and the waveguides welded together instead. Tests of these two systems should provide enough operational experience to decide whether to include circulators in the next system, which would be for a TTF4 cryomodule.

**Motivation**



The rf distribution systems at TTF are built from off-the-shelf parts that are not necessarily cost optimal for this application. For the TESLA TDR, a similar, but more compact layout was proposed, and its cost estimated to be comparable to that of the modulator. The ILC baseline choice is essentially that in the TDR, which is even less optimal in this case due to the fairly large variations in the assumed maximum cavity operating gradients (~ 5 %  rms). That is, the relative power delivered to the cavities in this rf distribution system is fixed, so the worst cavity will limit the operating gradients of the others, and hence the rf source capacity will not be fully utilized. Thus it would be advantageous to have some control of the relative power going to the cavities, which would likely yield savings of a few percent of the linac cost. Also, other parts of the system can be simplified for additional cost savings. To this end, we outline below four changes that we want develop and incorporate into the design.

The circulators in the TDR design (one per cavity) are a big cost item (~ 35% of total distribution system). To eliminate them, the cavities would be powered in pairs using 3 dB hybrids, which would still isolate the cavities, but would allow some power (< 1%) to return to the klystron in the event a rf fault in a single cavity/coupler (which should be benign as the rf drive would be immediately shut-off, as would be done even if the klystron was fully isolated). A second change would be to develop a variable tap-off system to feed the cavity pairs. This would involve having rotatable, polarized TE11 circular waveguide sections between the couplers. Their orientation would be adjusted (one time only) after the relative cavity performance was measured. The relative power in the three main waveguide feeds would also be adjustable, but hybrid-like splitters would be used in this case. Another cost cutting measure is to replace the 3-stub tuner with a mechanical squeeze type phase shifter that would adjusted once the system is setup, and should not require further changes. Finally, we want to develop a means of welding the waveguide together in place to eliminate the flanges and improve reliability.

| **Milestones** | **Date** |
|---|---|
| Complete rf design of tap-offs and phase shifter | Sept 2006 |
| Order standard parts for the two systems | Sept 2006 |
| Build and test tap-off and phase shifter | Feb 2007 |
| Build system of  4 tap-offs / hybrids and 8 three-stub tuners | April 2007 |
| Assemble first rf distribution system at FNAL | May 2007 |
| Build system of 4 tap-offs / hybrids and 8 phase shifters | July 2007 |
| Assemble second rf distribution system at FNAL | Sept 2007 |

**Key Personnel**

Chris Adolphsen, project leader – 0.1 FTE
Chris Nantista (RF Designer) – 0.2 FTE
Gordon Bowden (Mech Engineer) – 0.2 FTE
TBD (Production Engineer) – 0.3 FTE
TDB (RF Engineer) – 0.7 FTE
Bobby McKee – 0.3 FTE
Richard Swent – 0.1 FTE

**Cost Summary:**

| | FY07 |
|---|---|
| SLAC Labor (FTE's) | 1.9 |
| Shop and M&S (k$) | 920 |

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.9 FTE | 920 | 233 | 1409 |



**3.8.6.2 Coupler Improvement Effort**

**Abstract**

The TTF-3 coupler design being pursued for the XFEL project has a number of deficiencies that will make its implementation on the ILC costly (about 16 thousand are required). It is complicated and expensive to build and it is time consuming to condition. Information obtained on conditioning from the coupler component testing work being performed this fiscal year will be combined with cost evaluations to come up with an improved power coupler design for the ILC that would be lower cost and easier to build and condition. Two couplers will be designed, built, and tested over the next year.

**Project Description**

The present TTF-3 design will evaluated and modified to improve its conditioning time and lower its manufacturing cost. By understanding what aspects of the design contribute most significantly to lengthy conditioning times, these features will be re-engineered within the constraints imposed by the cryomodule. Likewise, a thorough evaluation of the design from a cost-to-manufacture standpoint will be done to identify major cost drivers, either in the form of overly demanding mechanical assemblies or excessively complex preparation and processing steps. The highest-cost aspects of the TTF-3 coupler will also be addressed to produce a second-generation design that is an improvement over the original.

**Motivation**

To achieve a reliable, robust, and cost-effective engineering design of any technical component, iterating on the design and making improvements based on increased understanding is key. While the present TTF-3 coupler design is the baseline for the XFEL project now underway and will benefit from iteration for this project, the extent of the design iteration performed to satisfy the XFEL requirements will likely fall short of the more demanding improvements needed for the ILC. Scaling the implementation of this design to the ILC will thereby result in excessive cost, due to the complexity of the coupler assembly, and due to the excessive time it will take to properly condition the couplers before they can be installed and used. By improving aspects of the design beyond the XFEL work to reduce the shortcomings, appreciable cost savings for the ILC should be realized.

| **Milestones** | **Date** |
|---|---|
| Perform cost and fabrication analysis | Jan 2007 |
| Develop conceptual design for improved coupler | Feb 2007 |
| Develop detailed design | Apr 2007 |
| Receive two couplers | Aug 2007 |
| Test on L-Band test stand at SLAC | Sep 2007 |

**Key Personnel**

Chris Adolphsen, project leader – 0.1 FTE
Brian Rusnak (LLNL-SRF Engineering)
Klystron Department – 1.3 FTE

| **Cost Summary:** | FY07 |
|---|---|
| SLAC labor (FTE's) | 1.4 |
| Shop and M&S (k$) | 100 |
| LLNL labor (FTE's) | 0.3 |



| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 1.4 FTE | 100 | 85 | 374 |

### 3.8.6.3 Coupler Acquisition and Processing

**Abstract**

Work with vendors to acquire the couplers required for the cavities to be tested at FNAL in the next several years. The coupler parts would be assembled at SLAC and rf processed using the L-band facility in ESB. Pairs of sealed couplers would then be shipped to FNAL.

**Project Description**

SLAC would take the lead on the specification and acquisition of eight TTF3 power couplers per year for the cryomodules being assembled at FNAL. The couplers would be purchased from industry and delivered to SLAC, where they would be inspected, cleaned, assembled in a Class 100 clean room, and rf conditioned. The rf processing step will provide insight into the limiting mechanisms that contribute to the long conditioning times observed by Orsay and DESY. After conditioning, the couplers would be sealed, evacuated, and shipped to FNAL for installation of their cryomodules. The costs below assume the use existing class 1000 clean rooms at SLAC and the purchase of a small class 100 clean room. Parts for the couplers delivered in FY08 and FY09 would be ordered in FY07 and FY08, respectively.

**Motivation**

By taking a lead role in the acquisition and initial rf processing of the couplers needed by FNAL for their cryomodule integration objectives at ILCTA, SLAC can not only gain detailed insight into the limitations of the TTF3 coupler design, but also accelerate FNAL progress by using the installed rf power capability at SLAC to deliver cryomodule-ready couplers. By cleaning and handling the couplers under clean room conditions, SLAC personnel will gain valuable experience in this technology that is crucial to ILC. This will also serve as a process demonstration model and provide information on what will be required for the ILC industrialization process.

| **Milestones** | **Date** |
|---|---|
| Order long lead items for cleaning, assembly and test facilities | Oct 2006 |
| Order 16 TTF3-style couplers from industry | Oct 2006 |
| Complete cleaning, assembly and test facilities | March 2007 |
| Deliver 8 processed couplers to FNAL | July 2007 |
| Deliver 8 processed couplers to FNAL | Jan 2008 |
| Deliver 8 processed couplers to FNAL | Jan 2009 |

**Key Personnel (FY07)**

Chris Adolphsen, project leader – 0.1 FTE
Brian Rusnak (LLNL-SRF Engineering) – 0.3 FTE
TBD (Production engineer) – 0.7 FTE
TDB (RF Engineer) – 0.3 FTE



| **Cost Summary** | FY07 | FY08 | FY09 | Total Project |
|---|---|---|---|---|
| SLAC labor (FTE's) | 1.4 | 0.7 | 0.7 | 2.8 |
| Shop and M&S (k$) | 700 | 250 | 50 | 1000 |
| LLNL labor (FTE's) | 0.3 | 0.2 | 0.2 | 0.7 |

**Cost summary:**

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 1.4 FTE | 700 | 175 | 1064 |

**Expectations for FY07 and beyond:**
The work described here will be completed in FY06.

**4.2.5 BDS cavity, vacuum, instrumentation, magnet system engineering & cost estimate and crab cavity design**

**Description:**

A) This task includes engineering aspects of design and cost estimation of several subsystems of ILC BDS. In particular, engineering design of vacuum chamber, deflecting cavities, instrumentation system, warm magnets and supports are included.

Systems NOT included in this task as their engineering design for BDS assumed to be covered in other WBS: IR engineering (4.3.4); collimation and dumps (4.10.2)

B) The crab cavity design is one of particular tasks singled out from BDS design task. It involves optimization of the electromagnetic design of crab cavity by the Advanced Computing Division.

In particular, the work involves

(1) Determine the ILC deflection cavity requirements based on beam dynamics considerations

(2) Improve the CKM design (more effective LOM, SOM, HOM couplers) to meet these requirements using parallel frequency and time domain modeling.



**Motivation:**

A) Integration of the design, with engineering constraints taken into account, is important for BDS performance.

B) BDS relies on crab cavities to rotate the bunch before collision. The baseline design of crab cavities is superconducting 3.9GHz. Accurate design of the high, low and same order mode couplers is needed to prevent unwanted influence on the beam from various modes.

**Collaboration with other institutions:**

A) Work will be coordinated via RDR organization.

B) The work is closely coordinated with Fermilab, where preparation for fabrication of crab cavity are ongoing and with Daresbury and other UK universities, where the work on the simulations and development of phase stabilization system is ongoing.

**Milestones and deliverables:**

A) Sept 07 A conceptual engineering design of the above mentioned systems to be completed.

B) Sept 07 Design of cavity should be complete and cavity should be fabricated (fabrication plans should be described in Fermilab proposal)

**Key personnel:**

A) Interface to BDS design group 0.2, New Engineer 0.6, New Designer 0.6

B) Zenghai Li 50%, Liling Xiao 50%, Cho Ng 25%, Ravi Uplenchwar 25%, Kwok Ko 10% – Total 1.6 FTE

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 3.0 FTE | 0 | 155 | 555 |

**Expectations for FY08 and beyond:**
The work will escalate in FY08.

**4.3.2 Positron system engineering and cost estimation**

Missing

**4.3.4 BDS IR system engineering and cost estimation**

**Description:**
This task includes engineering design and cost estimation for the Interaction Region of BDS.

**Motivation:**
The IR design requires particular attention as integration of many subsystems such as vacuum, magnets, instrumentation, etc., should be done. Design work is needed to ensure constructability, optimal design and operational performance of the system.

**Collaboration with other institutions:**
Work is coordinated on the international scene, with collaborators from many labs in the world.

**Milestones and deliverables:**

Sept 07 A conceptual integrated design of IR region will be complete

**Key personnel at SLAC:**
Interface from BDS design group, new engineer 1, new designer 1

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.5 FTE | 0 | 125 | 462 |

**Expectations for FY08 and beyond:**
The work will continue and expand, also branching to engineering design of IR prototype to be built at ESA.

**4.8.2 Dumps & Collimators Engineering and Cost Estimation**

**Description:**
This task includes design of the dumps and collimators of all areas of the ILC.

**Motivation:**
High power main dumps and devices to protect the machine and detector from high intensity and high power beam are required throughout the ILC and particularly in the beam delivery system. A particularly difficult part of the dump is the window, which needs to be prototyped and beam tested. For the collimators, survivability of the spoilers is a question which requires beamtests.

**Collaboration with other institutions:**
Work will be coordinated through the ILC RDR matrix.

**Milestones and deliverables:**

Nov 07 RDR Document with design and cost information. Design of the beam dump window prototype will be ready for manufacturing and beam tests in 2008. Design of survivable spoilers will be ready and prototypes will be manufactured for beam tests at ESA in late 2007 or beginning of 2008.



**Key personnel:**
Tom Markiewicz 20%, Eric Doyle 20%, Unspecified Designer 20%; new engineer 50%, interface to BDS design group 20%, Interface to ESA group 20%.

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.5 FTE | 100 | 90 | 392 |

**Expectations for FY08 and beyond:**
We expect this type of work to continue into future years gradually going into deeper details of the design, beam tests of window in 2008 and beam tests of spoiler survivability in late 2007-2008, as well as development of beam dump window robotic replacements in 2009.

## Category 5.1

### 5.1.1 ILC Beam Test Facility Coordination

**Abstract:** Beam testing is critical for mitigating technical risk associated with ILC. Several beam test facilities are available, notably ATF and TTF, but also including SNS, 'A0', various storage rings and ESA. A host of technical and logistical issues makes it difficult to start new projects at these facilities, mostly resulting from a lack of dedicated hosting staff that have the time and expertise to deal with potential users. We propose a small group that will work to match RD efforts with appropriate opportunities so as to maximize successful testing at the test facilities.

**Project Description:** This is a proposal to form a small group of ILC experts who would strive to match the capabilities of the test facility infrastructure with the needs of the RD program. This group would have experience operating the systems at the facility and would have developed working relationships with the appropriate experts. The group would have no direct authority but would participate and facilitate participation in test facility operation, as needed by the host organization and the ILC RD effort.

**Motivation:** The ILC RD effort is intended to be proposal – driven and prioritized by an oversight board with multi-regional representation. An important task for the RD board is the assessment of beam testing time required for each RD task in order to mitigate ILC technical risk and maximize the knowledge gained in the process.



Also, many of the ILC design staff developed operational skills at SLC or similar HEP accelerators. The staff need continued connection with an operating machine in order to appreciate the practical aspects of SCRF and ultra-low emittance operation. Newly recruited students have a similar need.

**Milestones and Deliverables:**. This group would write an annual report listing critical test beam facility usage issues for review by the host collaboration (e.g. ATF and TTF) and the ILC RD board.

| Benchmarks | Date |
|---|---|
| First report | April 2007 |

**Key Personnel:**
Marc Ross, team leader
Helen Edwards, co-team leader (to be confirmed)
**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 2.0 FTE | 60 | 109 | 439 |

## Category 5.5 Damping Ring Test Facilities

### 5.5.1.1 ATF Beam Dynamics and Instrumentation Studies

**Abstract:** The study program at ATF is focused on development of the ILC low emittance source and development of precision beam instrumentation for position and profile measurements.

**Project Description:** There are eight ongoing projects: 1) ultra-high resolution cavity BPMs, 2) emission of coherent synchrotron radiation, 3) laser-based beam profile monitors (laserwire), 4) fast (including multi-bunch) feedback, 5) optical stabilization, 6) generation of low emittance beams using precision

BPMs and correction procedures, 7) development of fast pulse kickers and 8) stabilization of residual synchrotron motion. Items 1), 6) and 7) are collaborative efforts directed by (or substantially involving) SLAC. Separate proposal sheets describe those efforts.

**Motivation:** The projects listed have been identified in the TRC and the Damping Ring RD task list as important RD tasks. ATF is a unique test facility that provides ready access to ILC quality beams. The SLAC ILC group has more than 10 years experience working closely with the ATF and we provide both technical and logistical leadership to the teams working on the projects listed. Each of these tasks involves one or more graduate or post-doctoral students, for a total of around 25 (includes 30% Asian students).

**Milestones and Deliverables:**. Each of the projects listed has a funding and deliverable timeline established by the ILC, supporting funding agencies and the ATF operational schedule. By the end of 2007, ATF must be ready to deliver beam for ATF2. Items 1), 3), 6), 7) and 8) address that. Improvements and studies integrated with ATF2 will continue in 2008 and 9.

| Benchmarks | Date |
|---|---|
| Deliver beam for ATF2 | January 2008 |

**Key Personnel:**
Marc Ross, project leader
Junji Urakawa, KEK, ATF Manager

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.4 FTE | 90 | 33 | 177 |

JFY 2005 US-Japan will provide some of the funds needed for this project. The above total includes travel and accommodation at KEK, estimated at 60K/year.

### 5.5.1.2 ATF Multi-bunch feedback

**Abstract:** Longitudinal coupled bunch instabilities have been observed at ATF. The purpose of this project is build and install a digital damper system, similar to that in use at PEP.

**Project Description:** The purpose this project is to damp longitudinal coupled bunch instabilities in the ATF storage ring, to gain experience with this sort of feedback and to determine the limits of coupled bunch stabilization in a high current, ultra-low emittance damping ring. The components of the project include a longitudinal kicker structure, a broad-band 100W amplifier and a digital receiver / processor system.

**Motivation:** Stabilization of the high current damping ring beam has been identified as an important task in the Damping Ring RD task list . ATF is the ideal place to study these effects because of the flexible extraction / injection systems and the achieved ultra-low emittance. We also expect to require stable multi-bunch 'ILC-like' beam for ATF2 studies. This sort of system has been demonstrated at high current light sources. With this project, we will be testing and gaining experience with the recently developed SLAC 'G-proto' high speed processor system.

**Milestones and Deliverables:**. There are 2 stages in the project, 1) development and testing of the kicker 'structure' and 2) integration of the G-proto and kicker structure at ATF. We expect to use a kicker designed at INFN.

| Benchmarks | Date |
|---|---|
| Kicker cold tested | November 2006 |
| System installation at ATF | March 2007 |

**Key Personnel:**
Dimitry Teytelman, project leader (Deputy Marc Ross)
Takashi Naito, KEK, kicker systems leader

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.3 FTE | 80 | 27 | 147 |

JFY 2006 US-Japan may provide some of the funds needed for this project.

### 5.5.1.3 ATF Ring BPM Electronics



**Abstract:** This project involves the replacement of the electronic signal processing equipment used for the ATF damping ring BPMs. The present 'single-pass' system will be replaced with one which can be used to average data from many ring turns, resulting in more than 10x improvement in resolution (to 100nm) and a similar improvement in offset control. The multi-turn system includes a CW calibration system for controlling offsets and gain errors. Such a system will be crucial in damping rings and future storage rings where offset 'jumps' and drifts are a serious cause of poor performance.

**Project Description:** The project goal is to apply digital receiver technology to all 100 ATF damping ring BPMs. This will result in 100 nm (multi-pass) resolution for emittance and beam dynamics studies and ~1 um offset stability. We expect this system will be needed for ATF2. Full system completion is at the end of JFY 2007. 1/2 the system will be in place at the end of JFY 2006.

**Motivation:** With this system, the ATF should be able to achieve 1 pm-rad vertical emittance through improved coupling and spurious vertical dispersion correction. This will be important for the ATF2 project and instrumentation tests in the extraction line. The present vertical emittance, as seen in the extraction line, is about 20 pm-rad.

**Milestones and Deliverables:**. Each channel (4 per BPM) consists of a coupler/calibration printed circuit card, a receiver /downmix printed circuit card and a high speed digital receiver. JFY05 costs cover design and prototype work on the printed circuit boards. The software to control the digital receiver is in use at SPEAR III and was tested at ATF in June 2004. A large scale system test was completed in February 2006 The system will be delivered by March 31, 2007. A pilot system consisting of all required infrastructure for about 10% of the ATF ring BPMs is in place.

| Benchmarks | Date |
|---|---|
| Large scale system test | February 24, 2006 |
| Half completion | December 15, 2006 |
| Full system delivery | March 31, 2007 |

**Key Personnel:**
Marc Ross, project leader
Masao Kuriki, KEK, co-project manager

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.1 FTE | 20 | 8 | 41 |

US-Japan will provide some of the funds needed for this project. Some of the JFY2006 funding is included in the USFY2006 column.

## Category 5.8 Linac test facilities

### 5.8.1 L-Band Facilities in ESB

**Abstract**

In FY07, two new L-band stations will be installed in ESB (these are in addition to the SNS-modulator station that was built in FY06). This work package covers the facilities cost for maintaining the existing station and the the additional facilities for the two new stations, which would be used initally to evaluate a Marx and DTI modulator. The modulators in all three stations would support testing of 5 MW and 10 MW klystrons starting in FY08.



**Project Description**

For the two new stations, provide working space with an elevated floor and cable trays, AC power distribution, cooling water, equipment racks and secondary containment tanks. A oil-filled tank would also be built that would hold two L-band klystrons and two full power water loads. For the existing station, this work package would fund ongoing maintenance.

| Milestones | Date |
|---|---|
| Clean out floor space | June 2006 |
| Install water and power | September 2006 |
| Install elevated floor and cable trays | November 2006 |
| Install equipment racks | February 2007 |

**Key Personnel**

Rich Swent, project leader – 0.5 FTE in FY07
Fred Asiri – 0.2 FTE in FY07
Bobby McKee – 0.5 FTE in FY07
John Wray – 0.5 FTE in FY07

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 1.7 FTE | 85 | 98 | 412 |

**Expectations for FY08 and beyond:**

The work described here will.

### Category 5.8.2 ILCTA-FNAL

## 5.8.2.3 ILCTA Linac Cavity BPM

**Abstract:** Cyrogenically compatible, cleanable cavity BPMs are required for the ILC. This project include the development and testing of such cavities with their readout electronics with ultimate installation in the ILCTA facility at Fermilab. This project will be done in collaboration with Fermilab.

**Project Description:** The FY07 program we propose is a follow-on to development effort started in FY06 to produce an ILC linac cavity BPM that (1) meets the 300 nm single bunch resolution goal, (2) can be high-pressure rinsed so they do not contaminate nearby ultra-clean cavities when installed in the cryomodules, and (3) will operate reliably at cryogenic temperatures (2K). In the FY06 program, a triplet of S-band (2.9 GHz) cavity bpms will beam tested at ESA to evaluate the resolution achievable in a slotted-waveguide cavity design that has a low Q (~ 600) to allow clean bunch-to-bunch signal separation in the ILC. These BPMs were made with an aperture size about half of the nominal value for the ILC since this made testing this design concept simpler, and it would be advantageous to adopt this aperture size for the ILC. If the tests go well and there is no broad consensus to reduce the large linac aperture (80 mm), we propose to build a triplet of full aperture, L-band (1.5 GHz) versions of this design in FY07. They would be tested in ESA and used along with the S-band triplet to verify quad shunting performance of a SC quadrupole (the quad tests are covered under a separate proposal). The BPMs would be made compatible with operation in the ILC linac, which requires damping the lower-order modes and paying attention to the materials used. Cold tests of the BPMs would be done in a He Dewar and cleanliness evaluations performed to show that they meet ILC requirements. Eventually, they would be installed in a cryomodule at FNAL or DESY for full integration tests.



**Motivation:** TTF does not have a cryomodule cavity BPM capable of meeting ILC baseline specifications. With what we have learned about cavity BPMs at ATF, we are ready to develop and test an L-band device that meets the mechanical, stability and electronic performance requirements.

**Milestones and Deliverables:**. Two S-band scale models are presently in the final stages of fabrication. Electronics and expertise from LBL will be used for the initial tests, scheduled for May 2006. The L band version will be tested in February 2007 with specifically developed electronics. Cryogenic tests will also be done in FY07. Installation and testing at ILCTA will be done in FY08.

| Benchmarks | Date |
|---|---|
| Initial beam test in ESA | May 2006 |
| Cold beam test in ESA | Summer 2007 |
| Installation in ILCTA | Summer 2008 |

**Key Personnel:**
Marc Ross, project leader, electronics and data acquisition
Chris Adolphsen, Project Leader, mechanical and RF
Manfred Wendt, co-project leader, Fermilab

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.7 FTE | 110 | 51 | 256 |

## 5.8.2.4 FNAL Test facility Instrumentation and LLRF Controls Collaboration

**Abstract:** The FNAL ILC group have plans for three cryogenic cavity test stands, vertical, horizontal and ILCTA (cryomodule). Much of the controls effort is expected to include deployment of the 'EPICS'

toolbox, currently in use at SLAC for L-band and X-band operation. SLAC staff will work with the Fermilab controls group to commission these systems.

**Project Description:** The controls effort for the test stands is substantial and, while centered at FNAL, will require additional resources. Through negotiation with S. Nagaitsev and M. Votava, leaders of the test stand and associated controls project, respectively, we will arrange for direct SLAC participation in the hardware, software and operation of these critical systems.

Beginning in 2008, we expect the rate of PEPII upgrades to slow, freeing expertise on critical LLRF processes, such as fast digital control, feedforward and feedback.

**Motivation:** It is expected that SLAC will contribute strongly, perhaps lead, the RF source ILC linac work. The group here must therefore become closely involved with the SCRF development work at FNAL. There will be no large scale development of SCRF at SLAC.

**Milestones and Deliverables:**. The test stand projects at FNAL are in the advanced planning stage and our milestones and deliverables will be closely connected to that plan. At present, we have not assigned responsibilities for the SLAC group involvement.

Benchmarks Date

To be planned – April 10, 2006.

**Key Personnel:**
Janice Nelson, Key liaison with FNAL LLRF controls



**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.7 FTE | 110 | 51 | 256 |

**5.8.2.5 Control Systems Support for ILCTA**

**Abstract**

The FNAL ILC group has plans for three cryogenic cavity test stands, vertical, horizontal and ILCTA (cryomodule). Much of the controls effort is expected to include deployment of the 'EPICS' toolbox, currently in use at several DOE facilities, including SLAC for L-band and X-band operation, and ANL at the Advanced Photon Source.

Fermilab has primary responsibility for implementing control systems for the three test stands (described in a different work package). This work package provides additional resources from SLAC and ANL to support the primary efforts.

**Project Description**

The controls effort for the test stands is substantial and, while centered at FNAL, will require additional resources.

Through negotiation with S. Nagaitsev and M. Votava, leaders of the test stand and associated controls project, respectively, we will arrange for direct SLAC participation in the hardware, software and operation of these critical systems.

Argonne will provide expertise with high level application development, and with EPICS core software. Specific tasks are still being identified, but are anticipated to include developing EPICS applications, database applications, and high level scripting for running experiments, and collecting & analyzing data.

**Motivation**

The Fermilab ILCTA program is critical to the R&D efforts on the ILC. Successful and timely deployment of the accelerator control systems will be essential to meeting the project goals. This work package will allow Fermilab to utilize expertise from SLAC and ANL, especially in EPICS, to supplement the expertise already on site at Fermilab, to meet the aggressive test stand installation schedule. This in turn will help to strengthen collaborative efforts on ILC controls efforts overall.

It is expected that SLAC will contribute strongly, perhaps lead, the RF source ILC linac work. The group here must therefore become closely involved with the SCRF development work at FNAL. There will be no large scale development of SCRF at SLAC.

**Collaborations with other institutions**

This work package is inherently collaborative, involving staff from Fermilab (with primary responsibility for the ILCTA control system), SLAC, and ANL.

**Key Personnel**

ANL: Claude Saunders + staff.

FNAL: Margaret Votava, Sergei Nagaitsev + staff

SLAC: Janice Nelson +staff

**Milestones and Deliverables**

The test stand projects at FNAL are in the advanced planning stage and our milestones and deliverables will be closely connected to that plan. (FNAL lead)

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.6 FTE | 90 | 43 | 214 |

**Expectations for FY08 and beyond**

It is anticipated that this collaborative support for ILCTA controls will continue through FY08. Beginning in 2008, we expect the rate of PEPII upgrades to slow, freeing expertise on critical LLRF processes, such as fast digital control, feed-forward and feedback.

### 5.8.5 Superconducting RF Cavity HOM BPM Project for the TTF VUV-FEL

**Abstract:** Use of HOM BPMs in ILC has been recommended but not accepted. Initial testing of the concept has proved 3 micron resolution and has been very useful for TTF operations. Production was finished November 8, 2005. Further work is needed to integrate the system into the TTF controls and to test HOM BPM performance.

**Project Description:** The purpose of this project is to build, test and commission signal processing electronics for the higher order mode signals from all 5 cryomodules in the TTF VUV-FEL.
The TTF VUV – FEL HOM BPM system consists of one single-line (TE111-6, 1701 MHz nom.) heterodyne receiver and a 14 bit 100MHz waveform digitizer for each HOM coupler (total of 80 couplers at present). The processing electronics was installed November 8, 2005. Software integration is ongoing and includes self calibration, multi-bunch operation and tracking of the cavity positions and response functions. A future project will be for the development of ILCTA and XFEL HOM electronics.

**Motivation:** With this system, each of the TTF cavity HOM signals is received and analyzed to obtain beam position information. We expect the resolution to be about 1 micron for single bunch beam and have achieved 3 microns with strong protective attenuators installed. We expect offsets to be determined to 100um or better. For ILC and the XFEL, this technique will be used to test cryomodule construction precision.

**Milestones and Deliverables:**. The system was delivered November 8, 2005. SLAC is presently developing calibration, multi-bunch and testing algorithms.

| Benchmarks | Date |
|---|---|
| Software integration (online calibration and position display) | May 1, 2006 |
| Multi-bunch operation | November 1, 2006 |
| Cavity offsets | May 1, 2006 |

**Key Personnel:**
MCR, project leader
Nicoleta Baboi, DESY, co-project manager

**Cost Summary (k$):**

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 0.1 FTE | 15 | 7 | 36 |

Saclay provides help for this project. Contingency is low because much of the work is complete.

## Category 5.8 Beam Delivery Test facilities

### 5.10.1 Design and fabrication of ATF2 magnets

**Description:**
Design, fabricate, and measure ATF2 final doublet magnets (quadrupoles and sextupoles) and dipole bending magnets.

**Motivation:**
A final focus test facility at KEK, the ATF2, will allow studying the BDS related issues such as optics tuning, developments of instrumentation, achieving and maintaining nanometer scale beam. This facility is being built internationally, with contribution from all regions. It was agreed that, as part of the contribution to ATF2, SLAC will develop and produce the bending magnets and final doublet magnets for ATF2.

**Collaboration with other institutions:**
Work is well coordinated with international collaborators.

**Milestones and deliverables:**

Sept 07 At the end of FY07 all the magnets should be constructed, delivered to KEK, necessary acceptance tests performed

**Key personnel:**
C. Spencer, Designer

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.3 FTE | 200 | 45 | 285 |

**Expectations for FY08 and beyond:**
This particular work will be finished in 2007.

### 5.10.3 ATF2 optics and operation



**Abstract:** The ATF2 beamline will be constructed from new and reused components from each of the 3 regions. Testing, qualification and review will be required to ensure the system functions properly and is ready for operation per plan. This proposal involves field testing, initial beam tests, development of operations procedures and analysis of the results.

**Project Description:** This project will support the testing of installed cavity BPMs, magnet movers, magnet power supplies and general instrumentation for ATF2. It includes measurements of system stability and transient response. It also supports test implementation of tuning procedures and instrumentation data acquisition systems. This project is complete when ATF2 operation begins, now expected in mid-2008.

**Motivation:** ATF2 is intended to provide very small (35nm) and stable (2nm) beam spots at its 'IP'. In order to ensure this will succeed, system testing at a variety of levels is required, especially of IP area components. The stability of the IP system is thought to have had a big effect on FFTB measurements.

**Collaboration with other institutions:**
Work is well coordinated with international collaborators.

**Milestones and deliverables:**

Sept 07 At the end of FY07 most of hardware for ATF2 will be constructed and necessary acceptance tests and preparation for installation will be completed

**Key personnel:**
ATF2 design and operation team

**Cost summary:**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| 2.0 FTE | 20 | 103 | 393 |

**Expectations for FY08 and beyond:**

In 2008 the work will focus on ATF2 commissioning and achieving desired performance.

### 5.10.4 ATF2 Cavity BPM Electronics

**Abstract:** The ATF2 cavity BPM system is in the final design stage. Cavities were be produced by the Pohang group and tested with prototype SLAC electronics at ATF in December 2005. The production signal processing and data acquisition system will be delivered June 5, 2006.

**Project Description:** The purpose of this project is to build, test and commission signal processing electronics for 35 ATF2 cavity beam position monitors. The cavities are similar to those in use in the existing ATF extraction line, and the electronics design is based on the proven system used with those BPMs. The ATF2 Q-BPM system consists of 35 RF cavity BPMs, each with a 2 channel (x,y) heterodyne receiver and a 2 channel, 14 bit, 119 MHz waveform digitizer. SLAC is responsible for the production, testing, qualification and installation of the signal processing electronics from the heterodyne receiver to the final digitized signal.



**Motivation:** With this system, each ATF2 cavity BPM (Q-BPM) will be fully instrumented for calibration and operation. The BPM resolution will be better than 100 nm at nominal ATF single bunch current over a dynamic range of more than 1 mm. The system will also operate with multi-bunch trains with the same resolution, although this operational mode has not been experimentally verified. We expect this system to be ‘first pulse ready’, meaning that it will provide valid readings on the first beam pulse at the start of initial commissioning.

**Milestones and Deliverables:**. The system will be delivered June 5, 2006. Because actual beam testing using the final cavities will await the delivery and installation of the cavities, final testing will be later. The prototype cycle was completed by December 1, 2005.

| Benchmarks | Date |
|---|---|
| Prototype complete | Dec 05 |
| Delivery ATF | Jun 06 |

**Key Personnel:**

Marc Ross, project leader

Yosuke Honda, KEK, co-project manager

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.3 FTE | 20 | 18 | 78 |

### 5.10.5 ATF2 Magnet Movers

**Abstract:** FFTB demonstrated that the key to precision beamline optics is a good magnet mover system. With this project we retrieve and revitalize the FFTB mover system, test and prepare it for ATF2 operation.

**Project Description:** There are 30+ cam-follower movers in use at the SLAC FFTB which will be surplus following the termination of FFTB operation April 10, 2006. We plan to remove, clean, test and ship these to KEK for use in the ATF2 project. We will also participate in the on-site testing and installation activities, scheduled for late 2007. All mover related equipment will be recovered, including cables, supports and electronics.

**Motivation:** FFTB operation and tuning was enabled through the use of precision movers. Such mover systems will be a key part of the ILC DR, BC and BDS and we would like to deploy them in a precision beamline in order to better understand engineering requirements.

**Milestones and Deliverables:**. The movers will be removed from FFTB April 10, 2006. Testing and shipment will be complete August 1, 2006

| Benchmarks | Date |
|---|---|
| Deliver mover systems to KEK | August 2006 |
| Install and in-situ test | November 2007 |

**Key Personnel:**
Marc Ross, project leader
Junji Urakawa, KEK, ATF2 Manager



**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.1 FTE | 30 | 9 | 53 |

JFY 2006 US-Japan will provide some of the funds needed for this project.

### 5.10.6 ATF2 S-band and IP Cavity BPM Electronics

**Abstract:** In addition to the large set of C-band cavity QBPMs needed for ATF2, there is a need for 3 large aperture S-band BPMs and a system of IP BPMs. The latter provide key results for ATF2 phase 1.

**Project Description:** The S-band BPM system will be (for the most part) installed in the final doublet. These systems will be subject to careful engineering analysis for stability and vibration. The IP system is a very unusual system that will be installed at the ATF2 IP. The latter system will have to have nanometer scale resolution in order to prove ATF2 goals. The SLAC group will develop electronics and software for both of these systems. SLAC will also provide the cavity for the S – band system.

**Motivation:** There are two parts to the project and the motivation for each is different. The S-band BPMs must be tightly integrated with the final doublet and we expect this project provide experience with this engineering task. The IP BPMs will be the focus of the ATF2 effort and must be carefully proven before use.

**Milestones and Deliverables:**. The S-band BPM system must be ready for installation in ATF2 in late 2007. Electronics development for that system will begin in early 2007. The IP BPM cold test hardware fabrication is now underway at KEK. Beam tests will begin in late 2006. Since nanometer resolution is expected, we think the testing of the device may take more than one year.

| Benchmarks | Date |
|---|---|
| Deliver S-band BPM system | December 2007 |
| Begin beam tests of IP BPM system | December 2006 |
| Install IP BPM system | March 2008 |

**Key Personnel:**
Marc Ross, project leader
Junji Urakawa, KEK, ATF Manager

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.3 FTE | 80 | 27 | 147 |

**5.10.7 ATF2 ESA / LCLS Bunch Length Monitor**

**Abstract:** ILC will have a 2 kinds of bunch length monitors, one based on transverse deflecting cavities and another based on broad – band microwave pickups. This project is for the development of the latter and includes installations of such a monitor in ESA and LCLS BC1.

**Project Description:** The high precision broad band pickup consists of a simple ceramic beamline gap and a sequence of extremely high frequency diode or pyroelectric detectors. These systems have been tested (including tests at SLC) and are very robust, simple and inexpensive. In this project, two such devices will be installed at SLAC, one in End Station A, where there is easy access (but no accurate reference system for comparison) and the other at the output of LCLS BC1, where access is more difficult but a reference system is accessible. The LCLS unit will have a dynamic range of 50 to 400 microns, cleanly covering the range of ILC bunch lengths.



**Motivation:** Precision, inexpensive bunch length monitors are in strong demand at several accelerator projects, including ILC and LCLS. With this project, we test and deliver two such monitors.

**Milestones and Deliverables:** The first of the two monitors was completed in ESA in late 2005 and tested successfully in early January 2006. The LCLS bunch length monitor will be delivered in November 2006 and tested throughout 2007. Upon completion of the testing, we may also propose a monitor for LCLS BC2, with much shorter bunch capabilities.

| Benchmarks | Date |
|---|---|
| Upgrade and retest ESA BLM | May 15, 2006 |
| Installation of LCLS BC1 BLM | November 2006 |
| Acceptance of LCLS BC1 BLM | November 2007 |

**Key Personnel:**
Marc Ross, project leader
Juhao Wu, LCLS physicist

**Cost Summary (k$):**

| Labor (K$) | M&S (K$) | Indirect cost (K$) | Total cost (K$) |
|---|---|---|---|
| 0.9 FTE | 100* | 60 | 281 |

*Funding for the FY06-FY08 project will be supported in part through LCLS.

**5.8.2 ESA Facility Beam Studies**

**Abstract:** The SLAC Linac can deliver a high-energy beam with ILC parameters for bunch charge and bunch length to End Station A. We plan to use this facility to test prototype components of the Beam Delivery System and Interaction Region. The first experiments will study collimator wakefields and energy spectrometers. We also plan an interaction region mockup to investigate effects from backgrounds and beam-induced electromagnetic interference.

**Project Description:** The ESA program is described in a recent PAC paper available at the ILC-ESA website, http://www-project.slac.stanford.edu/ilc/testfac/ESA/esa.html.

**ESA PROGRAMS, existing and planned, in FY07-09**

1. **T-474**: bpm energy spectrometer -- **FY06-08** (underway)
    i. Prototype for ILC bpm energy spectrometer; investigate performance and systematics issues for achieving <100ppm accuracy
2. **T-475**: synchrotron stripe energy spectrometer -- **FY06-08** (underway)
    i. Prototype for ILC synchrotron stripe spectrometer; in a common 4-magnet chicane as T-474. Investigate performance and systematics issues for achieving <100ppm accuracy.
3. **T-480**: collimator wakefields -- **FY06-07** (underway)
    i. Determine optimal geometry and materials for ILC collimators
    ii. Compare experiment and theory so emittance dilution effects are known.
4. **T-BPM tests**: **FY06-08** (first test underway)
    i. First test is with ILC Linac bpm prototypes, for FY06 tests
    ii. Two 50" drift sections are available for future bpm tests
5. **T-FONT**: -- **FY06-07** (test beam proposal soon for July '06 test)
    i. Test how robust IP bpms needed to keep beams in collision are against large flux of low energy e+e- backgrounds; simulate this environment with a secondary spray beam with relevant flux density in energy range 2-5 GeV.
6. **T-EMI**: -- **FY06-07** (underway)
    i. characterize EMI along beamline
    ii. Measure EMI at frequencies up to 2.5GHz near different beamline features
    iii. Measure dependence on bunch charge and bunch length
    iv. In FY06, using 2 calibrated antennas, one from GLAST EMI tests for frequencies up to 330 MHz and a 2$^{nd}$ commercial one being acquired for frequencies up to 2.5GHz. Using a 2.5GHz 4-channel oscilloscope.
7. **T-bunchlength**: -- **FY06-07** (described in 5.10.7)
    i. Tests with 100GHz diode detectors underway in FY06; of interest to both ILC and LCLS
    ii. bunch length diagnostics for LCLS (planning in progress)
    iii. ILC bunch length diag. w/ Smith-Purcell radiation (Doucas at U. Oxford) – plans in progress for FY07
    iv. ILC bunch length diagn. w/ electro-optics (Gillespie at Dundee) – possibility for FY07 or FY08
8. **T-Linac quad package FY07-08** (possibility)
    i. (cold quad + correctors + bpms)
    ii. beam stability measurements—is magnetic center of quad stable enough for ILC operation? Look at deflection of beam
    iii. (under discussion with Adolphsen)
9. **T-Spoiler Damage** (FY08 possibility)
    i. Requires <20-micron spotsizes; will need to add additional quads in ESA
10. **T-LCLS**

   i. FY07: test operation with 5-15 GeV beams, 0.2-3nC bunch charge. Verify BCS, MPS ok. Check A-line diagnostics at low bunch charge. Measure LCLS energy spread
   ii. FY08: test pulsed BSY operation for compatibility of 10Hz ESA beam with LCLS operation
   iii. FY09: rebuild A-line with TME lattice? Would give much superior beam capability than SABER can provide. >10x better transverse emittance and >10x better longitudinal emittance. Potentially achieve <5-micron bunch lengths with <0.1% energy spread and <10-micron spotsizes, for a variety of physics programs (ultrafast science, plasma physics, ILC tests)

11. **T-IR Mockup** >= FY09
   i. Mockup of ILC IR within +-5 meters in z and +-~25cm radially

**PPS replacement needed to run ESA beyond FY08!**
(this is why most experiments shown above only run thru FY08; most could continue into ILC era especially if ILC is on fast track for construction start in FY10-11. Will want to test actual hardware that will be committed to the ILC, in time period FY10-15 and beyond.)



**Motivation:** This program involves both machine and detector physicists, reflecting the close connections in design and performance between the accelerator and experiment. Primary areas of study are collimation, backgrounds, precision energy measurements. It also plays an important role for the test beam program considered by the Worldwide Study on Detector test beams. SLAC's End Station A can be an important test beam facility for ILC and provide a test bed for advanced beam instrumentation, such as BPMs and bunch length diagnostics.

**Project Status:** There was a 5-day commissioning run Jan. 4-9 and two experimental runs from April 24 - May 8 and from July 7-19. The major parts of these tests in 2006 are for T-480 and T-474, and also for initial tests of T-FONT. Wakefields kicks will be measured from 8 sets of collimators provided by the UK for T-480. For T-474, 10 rf bpms at 4 stations (two doublets and two triplets spaced over 70 meters) are being commissioned. Seven of these bpms are existing SLAC Linac bpms and there is one new bpm triplet that is an ILC Linac protototype. These bpms are also used to measure kick angles for T-480. New processors will be used for all the bpms. The energy spectrometer tests, T-474 and T-475, are planned to include a common 4-magnet chicane and a wiggler magnet. The 2006 tests include bpm stations at pre-chicane, mid-chicane and post-chicane locations. The magnets will be added in FY07, where it is initially planned to use existing magnets available from SPEAR.

**FY05-06 Milestones and Deliverables:**

Benchmarks Date

**Key Personnel:**
Mike Woods 50% (SLAC) and Ray Arnold 50% (SLAC), project leaders.
Steven Molloy (SLAC) and Nigel Watson (U. of Birmingham, UK), PIs for collimator wakefield test T-480.
Mike Hildreth (U. of Notre Dame), Stewart Boogert (Royal Holloway University, UK), co-PIs for BPM energy spectrometer test T-474.
Eric Torrence (U. of Oregon), PI for Synchrotron Stripe Energy spectrometer test T-475.
Other SLAC support: postdoc 35%, Carsten Hast 40% (End Station A Facility Manager), Zen Szalata 25% (ESA DAQ)

**Cost summary:**

| **Labor (K$)** | **M&S (K$)** | **Indirect cost (K$)** | **Total cost (K$)** |
|---|---|---|---|
| 3.0 | 200 | 150 | 785 |

Notes:

1. Major costs for FY07 are preparing the 4-magnet chicane for T-474 and the wiggler Magnet for T-475. There are also costs associated with additional bpms, movers and an interferometer system for T-474 and the detector system for T-475.
2. T-480 infrastructure is all in place. Anticipate costs associated with testing new new collimators to be provided by UK.
3. In the next 6 months we will be determining the viability for running ESA past FY08 into the PEP-II era. If this becomes a project goal, then we need to replace the existing PPS system, whose project price is currently estimated at $500K. We should then consider beginning an AIP for this in FY07.
4. The contract for R. Arnold expires July 31, 2007. We should plan a 2-year extension of this.



**Expectations for FY08 and beyond:**

The work described here will continue in FY08 at the same level.