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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.8.3.1 and 3.8.3.2
Work Package Title: Coupler Development
Work Package Leader: Chris Adolphsen (x.1) and Brian Rusnak (x.2)
Laboratory: SLAC (x.1) and LLNL (x.2)
Date: 8/9/06

1. Technical progress.

During the first three quarters of FY06, progress has been made in a number of areas in developing components for the coupler test stand. Activity in the first quarter was focused on refining the experimental plan and scope, on collecting design information for the TTFIII coupler, and on beginning design work on key components. An overall design concept was configured and an L-band waveguide-to-coaxial transition was designed that would accommodate the SLAC L-band window and the installation of components needed for the tests.

Activity in the second quarter focused on developing a detailed design of the waveguide-to-coax transition as well as designs for the coaxial impedance transitions and component mounting fixtures. As the system design developed, necessary detail was added to include all waveguide interconnect components, mounting fixtures and brackets, and tables.

In the third quarter, fabrication of the waveguide-to-coax transitions started in the SLAC shops. Detailed designs were completed for the impedance transitions and the inner coax connections. This test stand imposed significant constraints on the RF components and how they interconnect. Since the goal of the experiment is to measure gas loads from the RF conditioning process on separate coupler components, it is important that all RF electrical connections be very robust and repeatable to avoid anomalous arcing and heating, which would outgas and interfere with the desired signatures. A further complication is added by the need to reconfigure the experiment multiple times, so both the inner and outer conductor connections must be easily separable, robust, and repeatable. Finally, the inner conductor connections need to ensure that adequate thermal conductivity is maintained between the inner conductor in the component under test and the water cooled thermal sinks in the base of the waveguide-to-coax inner conductors. Commissioning of the test stand without components, a milestone for this period, did not occur due to delays in parts fabrication from competing priorities for resources.

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

The work plan for the remainder of FY06 is to complete the coupler test stand parts and assemble them at the Coupler Test Stand Area in ESB (the RF vacuum windows will be tested first without the waveguide-to-coax section). Also in this time frame, a visit is scheduled with CPI Beverly to discuss in detail the coupler assembly and processing steps a typical TTFIII/XFEL coupler undergoes during manufacture so this can be duplicated for the pieces to be tested.

Commissioning the test stand using a straight, stainless-steel coaxial line should take place by the end of October. Afterwards, additional components will be fabricated at SLAC and purchased from CPI and processed the same way as DESY TTFIII coupler components. They will be used to complete a series of tests on the coaxial components that are suspected of contributing to long conditioning times (RF plating, bellows and windows). After the tests are completed, the data will be analyzed to extract the evolved gas per coupler component feature or plating process. The results will also be compared with multipactoring simulations by the SLAC ACD group to see if such limitations to rf processing can be predicted.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.2.2.1
Work Package Title: Development of a fast kicker For the damping ring injection/extracton
Work Package Leader: Cook
Laboratory: LLNL
Date: 8/15/06

1. **Technical progress.**

Original Milestone and Deliverables:

FY06
Complete fast switch evaluation
Design and build second prototype with upgraded switches
Test new model at ATF

For the past three months (funding was available March 06), we have testing a variety of power MOSFETs and MOSFET gate drive circuits. The objective is to find a combination that will provide the rise/fall time and pulse width performance required for the ILC fast kickers.

MOSFET drivers have been observed to be the limiting component and thereby constrain our ability to measure the short-pulse capabilities of the power MOSFETs. Standard commercial devices are not usually designed to generate very short duration gate drive pulses and their minimum pulse width is often not specified in their data sheets. We began our efforts by evaluating the fastest of the commercial devices. To date we have found that there are several MOSFET drivers that are capable of generating fast switching transitions (rise/fall times) in the power devices. However, none of these drivers have demonstrated the capability of generating the required minimum pulse width. The limitations of these drivers are inherent in their design and are not amenable to enhancements by external circuits or operating conditions.

As a result we have started building our own gate drive circuits. These circuits presently use several of the fastest commercial drivers. We have used these devices in circuit topologies whereby they are individually gated on and off (multiple trigger pulses required). By using multiple devices we can use one device to turn-on the power MOSFET and a separate devices to turn-off the power MOSFET. This method is seen as a way to bypass the minimum pulse widths of the drivers. Our prototype circuits have demonstrated the capability of generating very short duration trigger pulses and, in conjunction with the fastest power MOSFETs, have demonstrated the generation of high voltage (>400V) high current (~ 30A) pulses of pulse duration in the range of 4-9ns (measured as the pulse width at base of pulse). This circuit has been evaluated at burst frequency of 3Mhz for a limited number of pulses (~30 pulses). This circuit needs further testing to evaluate long term stability during the long burst. Perhaps the most important information gathered from these gate driver tests is that the power MOSFETs are indeed capable of generating short duration pulses as required by the ILC pulsers.

Testing will continue with this and other circuits in an effort to identify the optimum circuit topology. Based on our experience with inductive adder pulsers, we can reasonably expect to duplicate an individual circuits' performance when it in incorporated into a full scale pulser with the multiple parallel devices and multiple stages as required to scale to the required output voltage and current.

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

Testing and evaluation of in-house custom circuits will continue through FY06. This entails evaluation of prototype and semi-production circuit layouts. Since funding began so late in FY06 (March), we will not be building a full-scale prototype. It is expected that we will have settled on an optimum circuit topology early in FY07 and will begin a design on a pulser capable of meeting ILC requirements. The basis for our design is the proto-type pulser tested at ATF although we will have to incorporate features to allow substantially higher average power and provide adequate cooling.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.4.3
Work Package Title: Positron Source Target Design
Work Package Leader: Piggott
Laboratory: LLNL
Date: 8/15/06

1. **Technical progress.**

Progress completed so far this year can be divided into several components: 1) Mechanical Design of the Target Wheel, 2) Design work for the Adiabatic Matching Device (Positron Focusing Magnet), 3) Radiation Damage of the Target, 4) Activation Studies, and 5) RDR Costing. As the magnetic field of the adiabatic matching device heavily impacts the design of the target wheel we were asked by the GDE area lead to evaluate the engineering feasibility of the AMD and participate in benchmarking experiments for the magnetic force simulation code. These activities were not specifically called out in our deliverables and diverted effort from the analysis of radiation handling issues.

The overall mechanical design of the target wheel moved forward this year. Preliminary drawings and part specifications were prepared and sent to Daresbury Laboratory in the United Kingdom, to begin preparations for prototype testing. Work at LLNL has begun on examining the vibrational properties of the design, as well as further structural modeling. A report on the initial thermal and structural modeling for this work is being prepared.

Preliminary design and simulation work for an adiabatic matching device has been done. Simulations for an immersed target have been completed, resulting in design changes to a rim and spoke wheel design to minimize the rotating motor power. A report has been prepared by David Mayhall on this preliminary work. Also, simulations of permanent magnet tests done at SLAC have been performed, but further simulation and testing is needed to verify the code's accurate prediction of experimental results. Preliminary design calculations and magnetic simulations have been done on a pulsed magnet design similar to the one in *Brechna et al.*.

Brian Wirth of the University of California-Berkeley has prepared a report on his simulation of radiation damage in the target wheel.

A preliminary cost estimate for the RDR costing of target wheel construction was prepared for the Vancouver Conference. However, due to the time and effort needed to prepare this estimate, work with limited funding is just beginning on a study of activation of the target and surrounding materials.

Analysis work has begun on the photon line beam dump, with a preliminary presentation prepared. Conclusions from this work include that the beam spot size at the dump will need to be increased by a factor of $2\,{}^{2}/_{3}$ to allow for a practical beam dump.

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

For the rest of Fiscal Year 2006, work will continue on the mechanical design and activation studies. Work on the AMD will consist primarily of coordination and planning with SLAC to work to conduct experiments next year to provide information on the capability of our magnetic simulations to accurately match experimental data. Coordination and planning will also be done with the Daresbury/Rutherford group regarding construction and testing of experimental prototypes. A low-level effort is beginning to look at radiation activation of the target, peripheral equipment, and cooling fluids. Work on the mechanical design will continue, including documentation of previous analysis, analysis for differing incident beam properties, and vibrational and structural studies of the current design.

A variety of work is scheduled for FY2007, depending on funding and personnel availability. Design work will continue on the target wheel including drawings, and simulations of a variety of effects including vibrational, structural, and thermal loading. Coordination work will continue for experiments at SLAC and Liverpool/Daresbury. AMD designs will need to be evaluated further for a pulsed or immersion type magnet. Also, beam dumps for the electron and photon beams will be evaluated. Physics calculations will be done to investigate shielding requirements, material activation, and radiation damage for the systems being designed. All this work will be coordinated to progress the positron source target design to a final, robust unit.

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FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.7.1.2
Work Package Title: Mechanical engineering of a MARX generator modulator prototype
Work Package Leader: Cook
Laboratory: LLNL
Date: 8/15/06

1. Technical progress.

Milestone and Deliverable:

Mechanical design of a high power resistor stack for testing
Mechanical design of a full Marx modulator

This year, the mechanical design for the MARX resistive load has been finished and the drawing package completed. The drawing package includes detail drawings for fabrication parts, assembly drawings, and a parts list for commercially available components. All components were ordered and are currently in-house. The MARX load is in the process of being assembled at SLAC.

An enclosure designed to provide physical isolation from the high voltage components has also been designed. This grounded enclosure features clear panels with a wire safety mesh that provides personnel protection while allowing visual observation of the prototype MARX during operation. Since the MARX is cooled by a closed-loop air circulation system, the enclosure needs to be almost air-tight. The doors allow access to both sides of the MARX high voltage modules thereby providing maintenance access and, for the protection of personnel, are interlocked to the safety system. Additionally, an automatic HV grounding switch that closes when doors are opened or interlocks broken has been designed and incorporated into the enclosure to ensure personnel safety. The enclosure design is finished and parts have been ordered. The grounding switch is in the final stages of review.

A typical MARX exhibits voltage droop as the capacitors discharge. The SLAC MARX compensates for this droop by adding sections during the pulse. These sections are charged to different voltages and are designed to reduce the output ripple to <1%. This level of voltage regulation may not be sufficient so an additional voltage regulation method is being designed at LLNL. The LLNL circuit is designed to work with the present SLAC MARX hardware and will provide more precise digital regulation on the order of to ~ .05% by switching resistance into and out of the MARX output circuit with high voltage IGBTs (Insulated Gate Bipolar Transistors). We have designed the circuit, procured the components and are presently having other parts fabricated.

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

For the remainder of FY06, LLNL will continue to provide mechanical design support to SLAC MARX effort. This includes coordination with SLAC to finish the assembly of the resistive load and the enclosure. The digital regulation circuit will also be assembled and delivered to SLAC for testing.

The FY07 effort will be focused on design for manufacturability for all MARX mechanical hardware with the objectives of reducing fabrication and material costs, simplifying design, improving assembly, and streamlining maintenance actions.

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ILC-Americas
FY06 Work Package Technical Progress Report

Work scope period: 10/1/05 to 7/1/06
Work Package WBS Number: 3.8.3
Work Package Title: Development of a Nanometer Resolution BPM System
Work Package Leader: Gronberg
Laboratory: LLNL
Date: 8/15/06

1. **Technical progress.**

Original Milestone and Deliverables:
FY06
Dec 05: Completion and characterization of a carbon fiber metrology frame
Jan 06: Installation of the frame at KEK
Mar 06: Data taking at KEK
Aug 06: Final analysis

The carbon fibre metrology frame construction was completed in the first quarter. The frame was subjected to a modal vibration analysis which showed that its fundamental mode was at a frequency above the range where excitation from ambient vibration would be a problem. Initial testing showed that the struts which hold the nanogrid sensors needed to be tightly clamped to the frame in order to reduce the motion at the end of the strut to the design value.

The Nanogrid sensor system along with its data acquisition system were bench tested at LLNL. Modification of the PC bus backplane was needed in order to get the entire system of 9 nanogrids operational. Operation of the nanogrid in a test jig showed resolution of a few nanometers, most likely limited by the test jig.

In January the full system was installed at the ATF and interfaced with the ATF data acquisition system.

In April the system had its first data run. No significant correlation was observed between the nanogrid measurement of BPM position and the measured beam position. This is consistent with an analysis of the BPM signal size and noise which concluded that the BPM readout electronics were the limiting factor for system resolution. A reproducible system resolution of <20 nm was observed. These initial results were presented at EPAC. Subsequent analysis of the data showed anomalies in the nanogrid readout which were diagnosed as problems on the nanogrid readout boards. The boards will be dismounted for repair and new data will be taken in FY07.

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

During analysis of the nanogrid data it was observed that two of the nanogrids were producing anomalous readouts. They will be dismounted and returned to LLNL for analysis and repair.

In FY07 the NanoBPM system will be used for a series of tests on stabilization of extended systems at the nanometer level for the ATF2 project. The problem nanogrids will be repaired and reinstalled. Beam data will be taken and the correlation of the beam position with nanogrid determined position will analyzed. This will allow short term motion and long term thermal drift of the system to be removed. LLNL will participate in operations at the ATF in support of this program.