LANL Proposal to ILC GDE
for the period
October 1, 2006 to September 30, 2007

Cavity processing
WBS 3.9.3

1. *Abstract*

The Los Alamos National Laboratory (LANL) has existing facilities for superconducting RF (SRF) cavity processing and measurements. These facilities are available to make a significant contribution to the ILC in the future.

This document proposes to re-activate the SRF facilities at LANL and contribute to solve the problems facing SRF cavity community such as the cavity gradient spread. Since LANL has a plan to enhance our Los Alamos Neutron Science Center (LANSCE) accelerator with SRF cavities in the future, the science and technology that will be advanced by this activity will be a mutual benefit to both GDE and LANL.

2. *Statement of Work*

This Section contains the Statement of Work to be performed at LANL. Semi-annual technical progress report for this 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 this work package will be submitted, in which the actual work accomplished will be compared with the scope defined in the work package in this document.

2.1 *Scope of Work*

WBS 3.9: Main Linacs: Cavities and Cryomodules
WBS 3.9.3: Cavity processing
WBS 3.9.3.5 (proposed): Gradient Spread Investigation

Summary:

This work package addresses the current issue of a large data spread in cavity gradient, especially for those that are electro-polished (EP). Presently, we do not know exactly what is causing this large spread. In order to identify the cause, fix the problem(s) and achieve a narrow spread that is acceptable for a large production run, we need to process and measure a number of cavities and statistically analyze the data.

We propose to modify specific equipment in the LANL Superconducting RF Structures Laboratory facilities to accomplish this in a short time in order to find the most effective way to reduce the data spread.

Motivation:
While it has been shown that electro-polished SRF cavities can achieve > 35 MV/m accelerating gradient, the 9-cell cavities processed with EP during the second half of 2005, mostly at DESY facilities, have shown a large gradient spread ($20 \leq E(MV/m) \leq 35$). Since there are a number of causes that could lead to cavity contamination and poor performance, e.g., unsuccessful EP/BCP, chemical residues, insufficient rinsing, particle contamination during the final assembly, etc., identifying the cause or causes of this gradient spread is not an easy task. Probably, statistical analysis of data obtained from a number of cavity processing and measurements will be required to reach a meaningful conclusion. There are not many facilities, however, that can easily perform this task.

LANL has a facility that is capable of doing clean assembly, high-pressure rinsing and vertical tests in one building [1]. If required, we also have a Buffered Chemical Polishing (BCP) facility in another building. We have significant experience with 350 MHz, 700 MHz, 805 MHz and 3 GHz single and multi-cell elliptical and/or spoke SRF cavities. Therefore, we are confident that we will be able to build the capability of processing and measuring 1.3 GHz cavities within 3-6 months.

Considering the size of our existing vertical cryostat (38 inches in diameter and 10 feet deep) at LANL, we will probably be able to test up to eight 9-cell cavities during one cooldown cycle [2]. Eliminating cooldown cycles saves cryogens and significant time, permitting more data to be measured in a given time span than would be the case when a cooldown cycle is required for each cavity tested. For example, a reasonable test rate is two cavities a month when a cryostat is capable of accommodating a single cavity. If the cryostat could handle four cavities simultaneously, we could easily measure 8 cavities per month (four every two weeks), or 96 cavities a year which, together with data from other labs, is sufficient to obtain statistically conclusive results.

The goal of this work package is to modify the LANL facility for testing up to 8 cavities at a time. This will permit LANL to contribute to the testing of a large number of cavities that are necessary for statistical analysis to tackle the gradient data-spread problem.

Work to be performed:
The following are the things to be done to accomplish our goals.

- Clean the class-100 clean room which has had a few power outages in the past 2 years.
- Measure cleanliness of the clean room and confirm that the cleanliness is within the original specification.
- Modify existing RF measurement system for 1.3 GHz cavities.
- Test ultra-pure water system in terms of particles, TOC, etc., to assure that it meets the original specification.
- Modify high-pressure water rinsing system.

- Modify cryostat insert to accommodate up to 8 of 1.3 GHz cavities including vacuum and RF feeding lines.
- Test and complete the RF measurement system using a single- or 9-cell cavity.
- Borrow 4 to 8 cavities depending on availability.
- Test the cavities after a specified high-pressure rinsing (HPR) and assembly procedures and 120 °C baking for 2 days.
- Compare the results with previous results at the lending institution, if the data is available. If the measurements show poorer performance, improve the procedures.
- Electro-polish all the cavities with the same parameter set and test them after specified HPR and assembly procedures and 120 °C baking for 2 days.
- Depending on the results, change EP parameters and iterate the process.
- Other parameters that are worth exploring for the process cost reduction from the viewpoint of industrialization are, but not limited to:
    - HPR pressure and duration
    - Use of pure water instead of using ultra-pure water for rinsing
    - Clean room class and drying procedure
    - Air or vacuum baking at 120 °C baking to cure the high-field Q_0 drop
    - Improved assembly with fewer bolts, washers, nuts, etc.
- In consultation with other experts, determine the optimum process that is good enough for the large scale production runs.

Collaboration with other institutions:
Since LANL will not be involved in the fabrication of the cavities, the cavities that will be treated and tested at LANL will need to be transported to LANL from several institutions such as Cornell, DESY, FNAL, Jlab and KEK. Also, we need to collaborate with institutions that have electro-polishing capability in order to obtain data with electro-polished cavities. Furthermore, there will need to be significant interactions with the institutions from which the cavities will be transported so that the necessary tools and fixtures are manufactured to accommodate the fixturing of the cavities that they provide.

Milestones and deliverables:
January 31, 2007: Build RF measurement system for 1.3 GHz cavities and test several single- and/or 9-cell cavities.
March 31, 2007: Modify the cavity insert, vacuum system and RF feed-throughs to accommodate up to eight 9-cell cavities.
September 30, 2007: Get a statistically-significant data set to analyze the gradient data spread occurring from various cavity treatments and provide appropriate feedback to the various collaborators.

Key personnel: Total 1.75 FTE
Tsuyoshi Tajima (engineer) 50%
Alan Shapiro or Mike Madrid (technician) 50%
Alberto Canabal (student) 50%
Designer (technician) 25%

Cost summary:

Provide a cost estimate for the work. Indicate specifically, in a footnote to the table, the nature and purpose of any single M&S expenditures in excess of $75K.

Labor (K$)	M&S (K$)	Indirect cost (K$)	Total cost (K$)
154	357	230	741

Expectations for FY08 and beyond:

The work will continue to narrow the spread of the cavity performance until it reaches an acceptable level. Then, the focus will be shifted to the investigation into how to simplify various processes to reduce time and cost for processing cavities toward industrialization while maintaining the narrow spread.

References:

[1] J.P. Kelley for the Superconducting RF Team, "Superconducting RF Facilities and Accomplishments at LANSCE," LA-UR-05-0804. http://laacg.lanl.gov/scrflab/SRF%20Laboratory%20Capabilities%20and%20Achievements.pdf

[2] T. Tajima, "LANL Facilities for SRF Cavity Development," Fist ILC Workshop, KEK, Tsukuba, Japan, Nov. 13-15, 2004.