U.S. DEPARTMENT OF ENERGY

FIELD WORK PROPOSAL

1. WORK PROPOSAL NO.: JLAB-HEP-XX	2. REVISION NO.: 1	3. DATE PREPARED: 2/06

4. WORK PROPOSAL TITLE: Understanding, Control, and Elimination of "Dark Current" Sources	5. BUDGET AND REPORTING CODE:

6. WORK PROPOSAL TERM: 10/1/2006 to 3/30/07

7. HEADQUARTERS OFFICE PROGRAM MANAGER: Robin Staffin, Assoc. Dir., HEP (301) 903-3624 hep-tech@science.doe.gov	8. HEADQUARTERS ORGANIZATION: Office of High Energy Physics, SC-20
9. DOE FIELD ELEMENT WORK PROPOSAL REVIEWER: Jim Turi, (757) 269-7146, turi@jlab.org	10. DOE FIELD ELEMENT: Oak Ridge Operations
11. CONTRACT WORK PROPOSAL MANAGER: Swapan Chattopadhyay, (757) 269-7001 swapan@jlab.org	12. CONTRACTOR NAME: Southeastern Universities Research Association, Inc., Thomas Jefferson National Accelerator Facility (Jefferson Lab)

13. Work Proposal Description

Principal Investigators: Charles Reece

Develop a quantitative characterization of contaminants that present "dark current" risks to SRF accelerator cavities. Using existing infrastructure and analysis tools at JLab, perform a systematic assessment of actual sources present and created in the production environment, identify specific mitigation techniques, develop relevant standarized model contaminants, and initiate use of such models for systematic characterization of the effectiveness of various proposed cleaning techniques and the development of optimization strategies for the use of such techniques. The benefit will be increased reliability of production of "dark-current-free" high performance SRF cryomodules and reduced cost by providing an improved basis for process design engineering.Attainment of such is to a successful realization of an ILC.

14. CONTRACTOR WORK PROPOSAL MANAGER	15. OPERATIONS OFFICE REVIEW OFFICIAL
Signature Date	Signature Date

16. DETAIL ATTACHMENTS

______	a. Facility Requirements	______	f. Technical Progress	______	k. Deliverables
______	b. Publications	______	g. Future Accomplishments	______	l. Performance measures/expectations
x	c. Purpose	x	h. Relationships to Other Projects	______	m. ES&H Considerations
x	d. Background	______	i. NEPA Projects	______	n. Human/Animal Subjects
x	e. Approach	______	j. Milestones	______	o. Other (Specify)

WORK PACKAGE REQUIREMENTS FOR OPERATING/EQUIPMENT
OBLIGATIONS AND COSTS

CONTRACTOR NAME:	WORK PROPOSAL #:	REV. #:	DATE PREPARED:
Southeastern Universities Research Association, Inc. Thomas Jefferson National Accelerator Facility (Jefferson Lab)	JLAB-HEP-XX	1	2/06

	FY 2006 Allocated	FY 2007 Target	FY2008 Target	FY 2007 Requirements	FY 2007 Authorized
17. STAFFING (IN STAFF YEARS)					
a. SCIENTIFIC		1.0	0.5		
b. OTHER DIRECT		2.0	1.0		
c. TOTAL DIRECT		3.0	1.5		
18. OPERATING EXPENSE (in thousands)					
a. TOTAL OBLIGATIONS (B/A)		550	220		
b. TOTAL COSTS (B/O)		550	220		
19. EQUIPMENT (in thousands)					
a. EQUIP OBLIGATIONS (B/A)					
b. EQUIPMENT COSTS (B/O)					

20. MILESTONE SCHEDULE (Tasks)	Dates	Proposed $	Authorized $
Establish standarized contamination assessment protocol	02/2007	$200k	
Assess contaminant distributions from hardware assembly	06/2007	$70k	
Evaluate new “standard contaminants”	08/2007	$50k	
Contaminant distributions measured from vacuum system	09/2007	$70k	
Identify improved assembly techniques	09/2007	$105k	
Compare cleaning effectiveness between BCP and EP surfaces and optimize – ultrasonic	10/2007	$110k	
Compare cleaning effectiveness between BCP and EP surfaces and optimize – HPR	03/2008	$165k	

21. REPORTING REQUIREMENTS (Description):

Quarterly budget reports, biannual technical progress reports.

TITLE:	BUDGET AND REPORTING CODE	DATE PREPARED
Understanding, Control, and Elimination of “Dark Current” Sources		2/06
WP NUMBER	CONTRACTOR NAME:	
JLAB-HEP-XX	Southeastern Universities Research Association, Inc., Thomas Jefferson National Accelerator Facility (Jefferson Lab)	

16. c. Purpose

Contamination QA

Contaminants that can cause dark current and degrade cavity performance come from “non-clean” components and from “clean” components that shed by abrasion. Hardware and techniques used for handling, sealing, and evacuating “clean” cavities must be thoroughly characterized with respect to their potential for contributing performance-limiting contaminants during processing, handling, storage, assembly, evacuation, or maintenance.

This activity proposes to yield

1. Characterization of actual contaminants that present field emission (dark current) risks to SRF cavities when present techniques are employed.
2. Screening criteria by which materials and handling techniques will be selected to minimize generation of contaminating particulates from formerly “clean” materials – keeping cavities clean.
3. Identification of suitable contamination “standards” to aid characterization and design of maximally effective cleaning techniques.
4. Initial use of the standard contaminants to assess the relative effectiveness of potential surface cleaning protocols.

16. d. Background

The phenomenon of "dark current" is a major concern for the superconducting cavities in the ILC. Dark current is an electron current that flows in the superconducting linac from sources within the cavities themselves, rather than being injected from an external source, as is the main beam. Dark current arises from particulates randomly distributed over the interior surfaces of the cavities that emit electrons when subjected to high electric fields. Dark current does not contribute to luminosity, but does reduce the efficiency of acceleration, increases heat loads at 2K and is the primary source of background radiation in the accelerator itself, causing radiation damage to components. Understanding and control, leading to elimination of the sources of dark current is the subject of this proposal.

JLab is in a unique position to promptly undertake this task due to the availability of powerful analytic tools in close proximity to on-going cryomodule assembly activities already working with 2nd-generation disciplined production techniques.

JLab has a scanning field emission microscope (SFEM) integrated with an SEM with EDS analysis[i], a field emission viewer (FEViewer) system, and a fully equipped surface science lab for pursuing any correlation of surface morphology with susceptibility to contaminant adhesion.[ii]

16. e. Approach

A.

Develop standard qualification tests relevant to SRF application for observing particulates generated from the materials present in the cleanroom and beamline vacuum space. This extends the work reported by Bonin and Reschke,[iii] using new tools to establish a qualification protocol.

- Disciplined use of airborne and in-line particle counters to sense migration of particulates within the assembly cleanroom.
- “Watch-plate” tests with analysis in FEViewer, Scanning Field Emission Microscope (SFEM), SEM/EDS, and laser surface scanners.

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[i] T. Wang, C. E. Reece, and R. M. Sundelin, “Direct Current Scanning Field Emission Microscope Integrated with Existing Scanning Electron Microscope” Rev. Sci. Instrum. **73** 3215 (2002).

[ii] http://srf.jlab.org/SurfaceScienceLab.htm

[iii] Bonin et al. “Field Emission Studies at Saclay”, 6th SRF Workshop, CEBAF, 1993, p. 1033; and D. Reschke, "New Aspects of Quality Control during Preparation of TTF 1.3 GHz cavities", 9th SRF Workshop, Los Alamos, p. 159.

B:

Using standardized methods, characterize the particulates generated by well-defined “representative” actions with “typical” components associated with cavity preparation and assembly.[iv] The objective is to determine the size and material distribution of particulates generated by these actions in order to better inform the efforts to avoid the contaminants and to remove them.

- Screw assembly and tightening
- Conflat flange assembly
- Flat-on-flat like-material rubbing
- Valve actuation
- External impact generation
- Bleed-up and pump-down of completed beamline assemblies
- Nearby human activity

C:

Establish objective and quantitative evaluation criteria for activities and techniques that present contamination risks to clean cavities. Identify principal vulnerabilities and develop improvement strategies. Propagate both the evaluation criteria and accumulating technique guidance to the community.

D:

Based on results from **B**, identify three or four candidates for reproducible “standard” contaminants (most likely, metal powders).

- Identify commercial sources of such materials.
- Develop standardized contamination methods using the powders.
- Evaluate such materials with respect to their similarity to “found” contaminants with respect to field emission properties.

E:

Develop and implement systematic evaluation of the effectiveness of various cleaning techniques applied to representative Nb (BCP, EP, etc.) and other surfaces after controlled exposure to the standardized contaminants.

- Enhanced sensitivity to the effectiveness of proposed cleaning techniques is obtained by the deliberate enhancement of the contaminant density.
- Ultrasonic - Megasonic
- Removal efficiency of HPR as a function of various nozzle, flow, and geometrical factors. This should dove-tail with the HPR nozzle optimization studies of P. Michelato, INFN Milan.[v]
- IPA cleaning.

16. h. Relationships to Other Projects

Contaminants are commonly accepted as presenting risks to the performance of high-gradient SRF cavities. Qualitative strategies have been deployed to control such contamination sources and to implement cleaning methods. The international community lacks a quantitative assessment standard with which to characterize the risks and the remedies. This work will seek to establish a common metric for identifying risk sources for dark current and to begin providing guidance to the ILC community on specific risk reduction strategies.

[iv] This extends the work of A.Matheisen, D. Reschke; "Control of Particle Contamination with Liquid and Air particle Counters during Preparation of the TTF 1.3 GHz Resonators", LNL-INFN 133/98, p. 640 to better understand the size distribution of contaminants produced.

[v] See presentation TTCM, LNF Dec. 2005