international linear collider

ILC-Americas
FY10 Work Package mid-year Progress Reports

Work scope period: 10/1/09 to 3/30/10
Work Package WBS Numbers: 1.10.2 (New Cavity Fabrication), 1.10.4 (EP cavity processing & Vertical testing), 1.10.5 (Cavity Gradient R&D), 1.10.8 (Alternative cavity fabrication R&D), 1.2.1 (Polarized Electron Source Development)

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JLab.

Summary

In the first half of FY10 JLab performed 7 EP cycles out of 15 planned and 16 vertical RF test cycles. (46% and 107% of goals respectively). 9 out of the last 12 9-cell cavities (6 by ACCEL 6 by AES) exceeded the ILC specification on either the first or second-pass processing. This represents a 75% gradient yield at 35 MV/m.

JLab also performed numerous R&D tasks including further studies on large grain material and cavities and surface preparation techniques (including at least 26 single-cell cavity tests), defect analysis and guided repair and alternative fabrication methods including coaxial coupler development and cell forming techniques. The merits of the "inverted insulator" photogun design have been demonstrated at CEBAF, where the new ILC-funded DC high voltage GaAs photoemission gun continues to function reliably at 100kV bias voltage since July 2009. A second inverted gun has been constructed at the JLab Injector Test Cave. Plans are being developed for the longer term to test the installed gun with an ILC-like bunch train.

Work scope period: 10/1/10 to 3/31/10
Work Package WBS Number: 1.10.4
Work Package Title: Cavity EP and vertical testing at JLab
Work Package Leader: Rongli Geng
Laboratory: JLab
Date: 4/28/2010

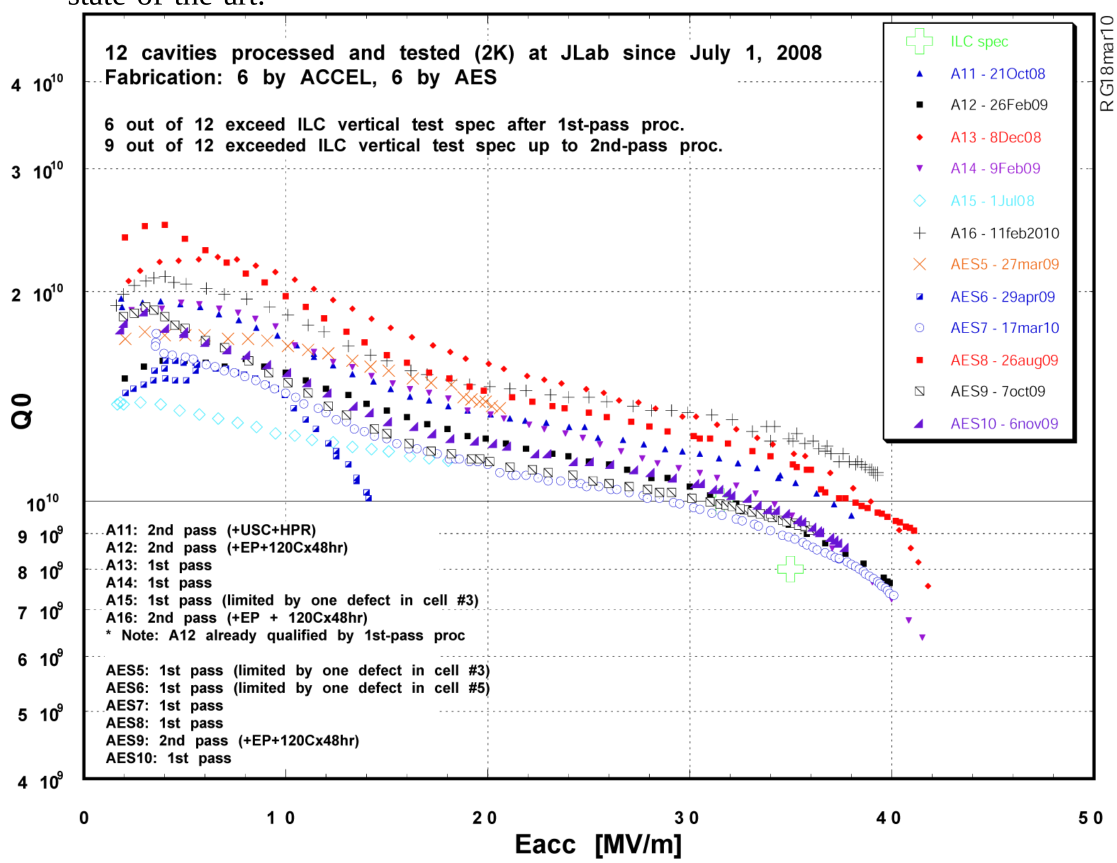
1. Technical progress

FY10 Q1 and Q2 delivered 7 EP cycles and 16 vertical RF test cycles. It represents 46% and 106% of planned EP and vertical test cycles, respectively. We also vacuum furnace heat treated 3 9-cell cavities for Fermilab to assist their ILC effort of testing 9-cell cavities EP processed at RI and ANL.

The shortfall in EP throughput is partly a result of staff turnover and training, partly due to new 9-cell cavity availability (due to delayed delivery) and partly due to EP facility availability (due to unplanned down time and maintenance). However the consistency and quality of results continues to improve.

Two major accomplishments (see graph below):

- Successful completion of processing and testing of all the six 9-cell cavities from the second production batch of the US vendor AES. 4 out of 6 are qualified to pass the ILC spec.
- Successful demonstration of 9 out of 12 9-cell cavities (6 by ACCEL 6 by AES) exceeding ILC specification up to a second-pass processing. This ***75% gradient yield at 35 MV/m*** is the state-of-the-art.



FY10 Q1 also marked a major milestone of the completion of 9-cell high-gradient processing optimization at JLab. JLab optimal 9-cell EP processing has been shown to be repeatable for high gradient performance. JLab 9-cell EP expertise along with associated cleaning and assembly expertise have been successfully transferred to two technicians. JLab optimal EP processing parameters have been adopted by the STF EP facility at KEK. Significantly improved cavity results have been demonstrated recently at KEK. More recently, the joint FNAL/ANL EP facility has started to adopt key JLab optimal EP parameters.

New results are presented at the 2009 Linear Collider Workshop of the Americas (September 29 – October 3, 2009, Albuquerque, New Mexico, USA) and the 2010 Linear Collider Workshop (March 25 – 30, 2010).

2. Goals and plans for FY10 Q3,Q4 and beyond

The planned return of the full-time FNAL technician and increased activity on Jlab's 12 GeV project will provide significant challenges to the project scope for the remaining periods of FY10 and beyond. This will place a premium on coordination and planning of cavity processing activities.

The first production cavities for the CEBAF 12 GeV upgrade project (totally 80 cavities are needed) are expected to arrive at JLab for qualification test. It is expected that the 12 GeV upgrade project will adopt EP as the final surface processing (thanks to the success of the ILC program). This will place a heavy load on the facilities and personnel. In order to mitigate these challenges we are investing in infrastructure improvements to improve the water supply, VTA throughput, critical spares and hardware inventories, new staff training etc. (JLab received ~$900k ARRA fund from Fermilab in November 2009 for throughput improvements). However if the 12 GeV project does adopt EP as the final surface treatment these 80 cavities (all coming from RI) will represent a valuable additional performance dataset.

We will commission the first JLab second sound quench detection system (we received 8 OST's from Cornell in December 2009) and corroborate with JLab "2 of 9" fixed thermometry system. We will commission a Kyoto camera (received on December 2009 on loan from KEK). The combined Cornell OST and KEK Kyoto camera will allow rapid quench detection and optical inspection of defective areas. The obtained data with these tools will be used to drive the decision for second-pass processing. We anticipate a further improved understanding of the nature of gradient-limiting defects in 9-cell cavities. These activities are well matched to the need of ILC gradient R&D in TDP-2, namely to eliminate the yield drop near 20 MV/m.

We will continue to work closely with US industry to feedback cavity information for improved cavity fabrication methods. The first 9-cell cavity made by Niowave-Roark will be processed and tested in FY10 Q3. Based on our successful experience of information feedback to AES (the first US vendor qualified for ILC cavity fabrication), we anticipate further contribution to qualifying the second US vendor.

We will continue 1-cell testing for understanding local defect changes made by chemistry, local treatments. A new graduate student has started working on these subjects. Local electron beam re-melting of AES6 will be pursued (has been delayed due to lack of manpower). We will re-test the first 9-cell cavity (JLab LG#1) treated with local grinding by KEK.

Given the new developments in ILC SCRF, our long-term goal of cavity gradient R&D program will also address the issue of gradient scatter (besides the gradient yield). This leads us into the area of focused material studies tightly associated with cryogenic RF testing of real cavities. We will coordinate with other US teams to form a plan to enhance our on-going program as well as our program beyond 2012.

Work Package 1.10.2, 1.10.5 and 1.10.8
Technical Progress Report
Work scope period: 10/01/08 to 9/30/2009
P. Kneisel

WP 1.10.2 (new cavity fabrication), 1.10.5 (large grain niobium), 1.10.8 (sc joint development)

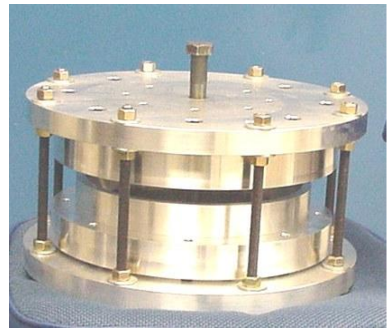
Below the various efforts pursued during the report period are listed:

1. *Qualification of large grain/single crystal niobium (1.10.5)*

- Barrel Polishing investigations with the three single cell cavities fabricated from single crystal niobium in collaboration with DESY (a large crystal had been enlarged to a sheet size, which permitted the deep drawing of ILC half cells) have been pursued. An initial test series with " slow media" (very slow material removal) was followed by a second series with " fast media". Those were recommended by the polishing machine manufacturer, resulting in a removal rate of ~ 3-4 micron/hr.
- During these test series a procedure initially reported by G.Ciovati (SRF 2009) and consisting of a heat treatment at 800C for 2hrs and subsequent high pressure rinsing (no chemical treatment) was reproduced in 4 tests and resulted in very high Q – values, increased values of the gap and accelerating gradient > 25 MV/m limited by the Q-drop. Further investigations will focus on optimizing this procedure with integrated " in situ" baking in the furnace during cool down and it is hoped, that a "streamlining" of the procedures for ILC-type multi-cell cavities can be developed. This would significantly simplify cavity qualification and reduce overall costs.
- During this reporting period we have carried out a total of 26 cavity tests.

2. *Fabrication of two LL/Ichiro 9-cell cavities (1.10.2)*

   Some, but small progress has been made on the fabrication of the two LL/Ichiro-type 9-cell cavities from Tokyo-Denkai and CBMM large grain niobium. For one cavity the dumbbells have been welded, tubes for fabrication of stiffening rings have been made, a tuning fixture for the dumbbells has been designed and fabricated and deep drawing and machining fixtures for the end cells are in fabrication (see pictures). Unfortunately, the fabrication of these cavities is rather slow because of competing activities as already mentioned in the previous yearly report.

Stiffening ring tubes Dumbbell Dumbbell tuning fixture

3. *Development of coaxial coupling scheme for ILC cavities (1.10.8)*

Several more experiments have been made with the coaxial coupling cavity. We have achieved more or less reproducibly high Q-values up to gradients of 6-7 MV/m before the cavities were limited in CW operation by heating. In pulse tests with a duty cycle of 20% gradients up to ~ 11 MV/m were measured. A rough estimation predicts that at 1% duty cycle (ILC/X-FEL operation) fields up to ~ 50 MV/m could be sustained. Future work will concentrate on generating the measurement conditions for pulse measurements with small duty factor, carry out simulation calculations to find out, where the heating occurs during CW operation and make improvements on the flange configuration/material of the superconducting joint.

Results have been reported in PRST (P.Kneisel, J.Sekutowicz; "Update on coaxial coupling scheme for International Linear Collider-type cavities")

WBS 1.10.5
Technical Progress Report
10/1/08 - 9/1/09
Charles Reece & Hui Tian

Task: Basic process research and development in support of improved, reliable performance of SRF cavities for the ILC.

We continued to refine the framework for characterizing cavity surface topography modifications with electropolishing treatments as a function of local conditions. Controlled bench measurements followed by quantitative profilometry continue. Two manuscripts were prepared and submitted for publication. We have retained the involvement of Prof. Stanko Brankovic, University of Houston, an expert in the field of surface modification by electrochemistry. We are building a predictive model of topographic evolution under EP conditions. From the other direction, we have begun a systematic study of the actual surface of cavities that exceed ILC performance requirements in order to establish unambiguously an inventory of topographic features and character which do not inhibit performance so that investigative attention may be well directed at features which do affect performance.

We also plan to acquire an optical 3D profilometry system capable of non-destructive scanning of the interior surfaces of cavities. This should greatly enhance our quantitative understanding of the nature of limiting and non-limiting defects.

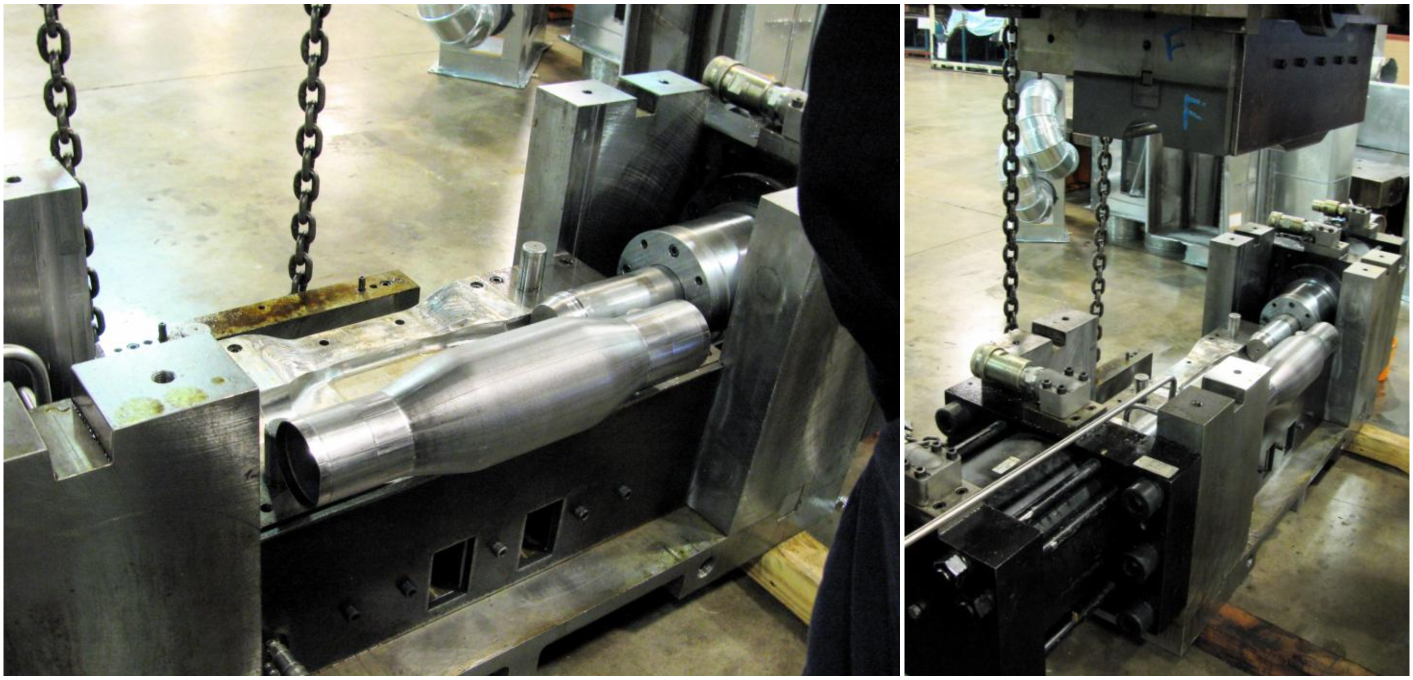
Work package 1.10.8, Alternative Cavity & Cryomodule Component R&D

R. Rimmer

Work has progressed gradually towards a second round of trials with a US hydroforming vendor. We had a very productive meeting at the vendor during Q2 and discussed the limitations of the previous trials, options going forward and had a tour of their production facilities. The vendor showed us a spare die set that could potentially be modified for full-size 1.3 GHz single cell or possibly 3-cell trials. The die was a test piece to make cylindrical pre-forms for another operation. The test fixture includes a demountable mid-section, that might be modified or replaced, between two rams for material feeding and a hydraulic feed for the hydroforming fluid. The die set can be inserted into a production press for hydroforming trials. The 4000 ton press is needed to hold the die set together while a separate accumulator provides the hydraulic pressure to expand the part. At the time of our visit the vendor was producing tubular beams for vehicle roof sections at the rate of one part every couple of minutes. Two robotic laser cutting machines trimmed the parts to final dimension. Every tenth part was checked for dimensional tolerance. Although the die sets are expensive this is definitely a process that is scalable to large volume production and the unit costs can be very low. We are also evaluating alternatives to spinning for the pre-necking of the tube stock. The vendor is enthusiastic about participating in further trials once we determine the appropriate path.

Working in conjunction with Black Labs, an SBIR partner company, we have acquired some seamless niobium tube with grain structure optimized for hydroforming. Some of this tube was also used at DESY to make seamless three cell sections using the existing process there. The wall thickness uniformity and texture of those parts is encouraging. Several spare sections have been delivered to Jlab and will be processed and tested in the near future. We also plan to test some earlier hydroformed sections from DESY from a different tube stock.

Production 4000 ton hydroforming press.


Hydroforming die set for tubular pre-form. Replaceable insert may be adaptable for cavity tests.

Work Package 1.2.1 : Polarized Electron Gun Development
Mid-Year Report. FY 2010
Matt Poelker

Task: ILC Polarized Electron Gun

The merits of the "inverted insulator" photogun design have been demonstrated at CEBAF, where a new ILC-funded DC high voltage GaAs photoemission gun continues to function reliably at 100kV bias voltage since July 2009. A second inverted gun has been constructed at the JLab Injector Test Cave. It was recently successfully "benchmarked" at 100kV high-voltage and conditioned to 200kV, with beam delivery at this bias voltage expected soon. Field emission at 140kV (the ILC baseline design specification) was consistent with zero, and only ~ 1nA at 200kV (Figure 2). Design modifications to reduce field gradient within the gun, and eliminate this low level of field emission, will be implemented in the coming months.

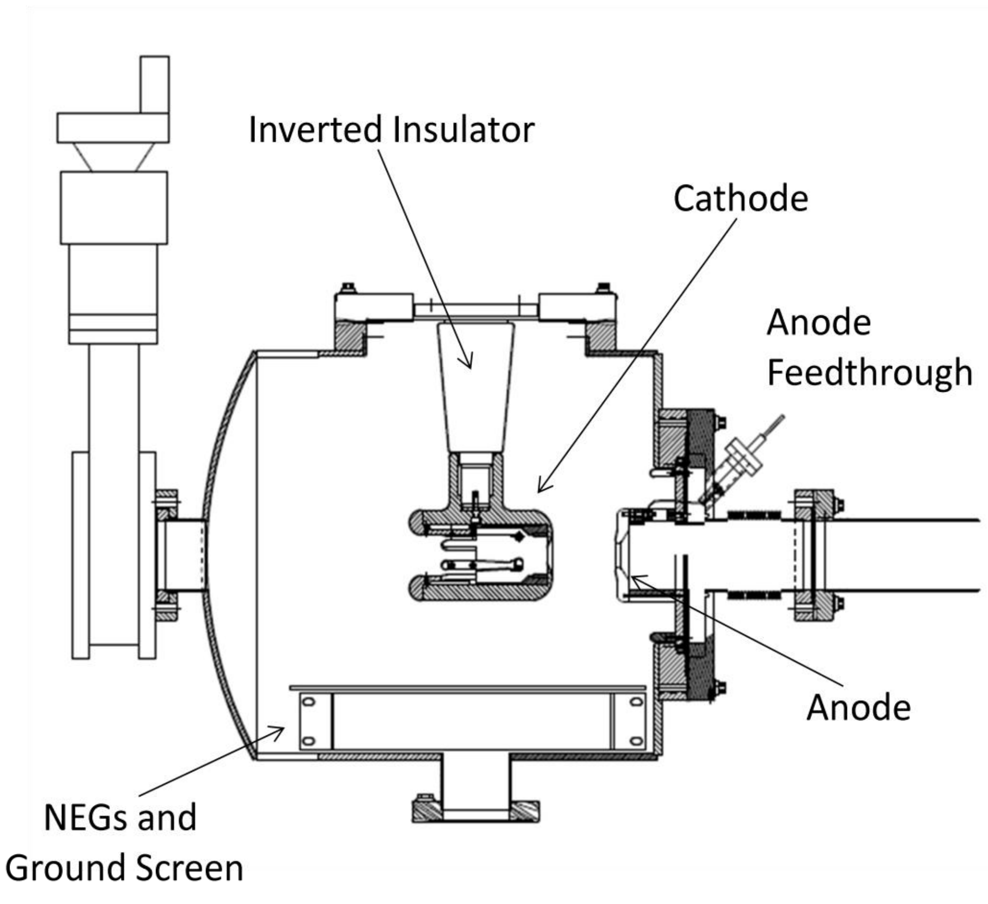


Figure 1: Diagram of the inverted gun with compact tapered insulator that extends into the gun vacuum vessel. For scale, the top flange is 10" diameter

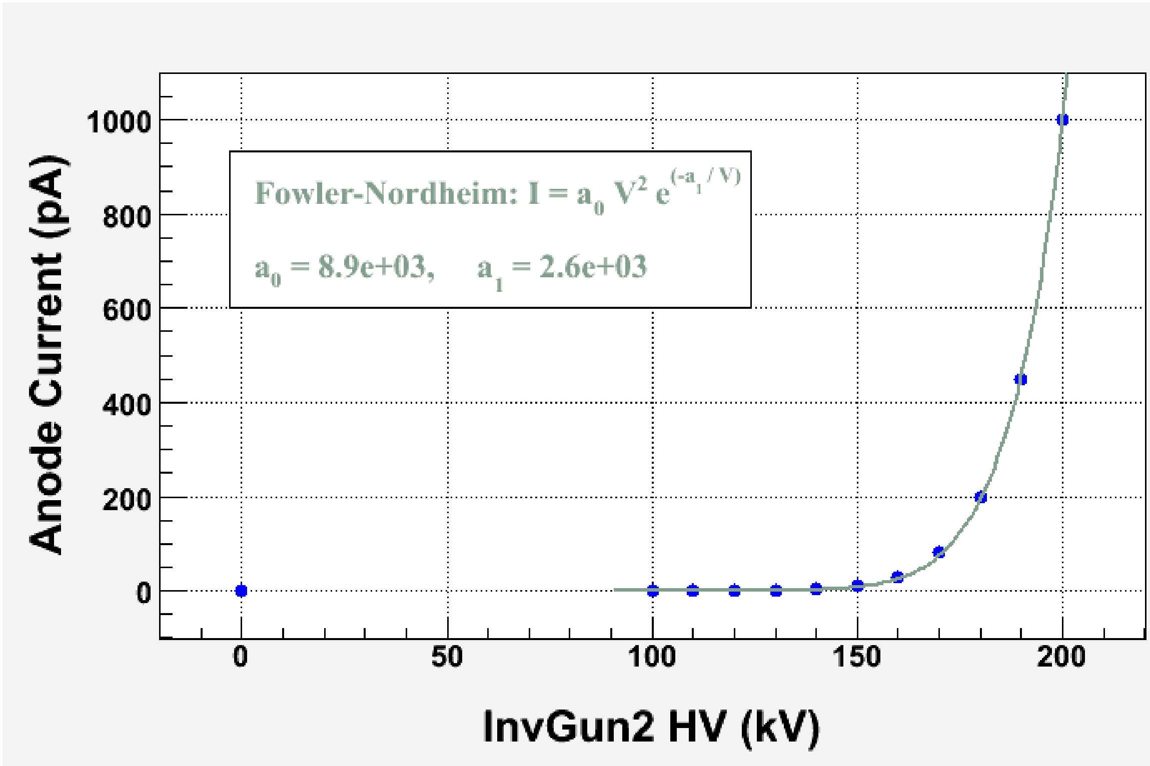


Figure 2: Field emission from the cathode electrode of Inverted Gun #2 as a function of gun bias voltage, measured at the anode electrode. Reliable DC high voltage photoguns exhibit zero field emission. The ILC baseline design calls for gun bias voltage at 140kV, but higher bias voltages are desirable to improve photoinjector beam quality.

Appendix A: JLab FY10 mid-year Financial summary

FY10 2Q costs and commitments for ILC program (cumulative, burdened)

Work package		Work package leader	FY09 Open Commitments (K$)	FY09 Carryover to FY10 (K$)	FY10 budget (K$)	FY10 Funds Avail (K$)	Labor (FTE)	FY10 2Q cost Direct labor (SWF) (K$)	FY10 2Q cost Direct M&S (K$)	FY10 2Q cost Indirect labor (K$)	FY10 2Q cost Indirect M&S (K$)	FY10 2Q cost Total (K$)	FY10 2Q Open commitments (K$)	Unobligated
1.2	Electron Source	Matt Poelker	$3.83	$8.80	$361.50	$370.30	0.01	$0.86	$43.96	$0.32	$16.26	$61.40	$15.23	$293.66
1.8	Global Systems	Dana Arenius	$-	$49.68	$45.20	$94.88	0.00	$-	$-	$-	$-	$-	$-	$94.88
1.10	Cavity & Cryomodule	Bob Rimmer etc.	$45.77	$753.07	$1,745.24	$2,498.31	2.67	$278.28	$167.42	$101.68	$61.18	$610.61	$118.16	$1,769.54
		Total	$49.60	$811.55	$2,151.94	$2,963.49	2.68	$279.14	$211.38	$102.00	$77.44	$672.02	$133.39	$2,158.09

1.10 projects:

	FY09 Open Commitments	FY09 Carryover to FY10	FY10 budget	FY10 Funds Avail	Labor (FTE)	Direct labor	Direct M&S	Indirect labor	Indirect M&S	Total	Open commitments
LCMGMT	0.00		129.10		0.27	43.06	9.46	15.93	3.50	71.95	24.26
LC005	0.00		204.40		0.21	30.18	6.10	11.17	2.26	49.71	0.00
LC006	22.36		83.90		0.00	0.06	8.34	0.02	3.08	11.51	13.70
LC007	9.86		114.10		0.40	30.71	32.98	11.36	12.20	87.26	32.99
LC008	13.27		912.44		1.24	126.18	82.12	46.69	30.38	285.36	20.41
LCFLD	0.29		215.20		0.52	44.32	2.91	16.40	1.08	64.70	26.79
LC1CLL	0.00		86.10		0.04	3.78	25.51	1.40	9.44	40.13	0.00
	45.77	753.07	1745.24		2.67	278.28	167.42	101.68	61.18	610.61	118.16

Appendix B: JLab proposed FY10 task list

JLab code	ILC WBS	Task		FY10 request
LCGUN	1.2.1	Electron Source R&D (DC gun development (MP)		400
	1.8	Cryogenic systems (DA)		50
LCMGMT	1.10.1	Cavity Coordination & Management		100
LC005	1.10.2	New Cavity Fabrication (PK)		125
LC008	1.10.4	30 EP cycles Cavity Processing & Vertical Testing (RG)		1000
	1.10.5	Cavity Gradient R&D		400
LCFLD		cleaning and surface prep R&D (CR)	200	
LC1CLL		off-line EP development (RG)	100	
LC005		large grain studies (PK)	100	
LC006	1.10.8	Alt. Cavity & module Component R&D (BR)		100
			total	2175
			SRF total	1725