LARP

May 5, 2006

LARP Semi-Annual Progress Report

Editor: S. Peggs

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Executive Summary

This summary provides a snap-shot of the status of the U.S. LHC Accelerator Research Program (LARP), focusing on topics that were prominent at the Collaboration Meeting that was held April 26-28 at LBNL. The main body of this report describes in detail the progress that has been made in the first two quarters of FY06.

Some technical highlights

Subscale Quadrupole SQ02 achieved 97% of its short sample limit after extensive testing at LBNL in October 05, and at FNAL in March 06. Technical Quadrupole TQS01 has just begun testing, and has reached 87% of it short sample limit. This is a great success for the world's first large bore (90 mm) Nb_3Sn magnet. Nonetheless, the cause (or causes) of the shortfall are under investigation.

Simultaneous tune and coupling feedback was demonstrated in RHIC - a world first - thanks to work by physicists and engineers from BNL, CERN and FNAL. This paves the way towards the ultimate goal of chromaticity feedback during snap-back at the beginning of the LHC energy ramp. (See article in the May 2006 CERN Courier.)

IR and Hardware Commissioning

Six people from FNAL and 2 from LBNL have been identified to take part in IR Commissioning (of U.S. built deliverables) and Hardware Commissioning (generic support of LHC installation and commissioning). Peak staffing of 7 people is foreseen in 2007. The start date for a major presence is September 1, 2006. One person, Peter Limon, is already in long term residence at CERN.

Accelerator Systems deliverables

Four items have been identified by LARP and CERN as "hard deliverables", in the sense that they are crucial to LHC performance and that "plan B" is weak or non-existent. These tasks would need special protection in the face of an unforeseen LARP budget shortfall. They are:

- Luminosity Monitors. A review that was held on April 24 2006 noted good progress toward on-time completion.
- Tune Feedback. Excellent recent progress at RHIC. A "Final Design Review" will be held this summer or early fall.
- Beam and Instrumentation Commissioning. Several tentative names are already available, and more are being solicited. A vetting procedure needs to be established soon, in order to ensure excellence in commissioners.
- Rotatable Collimators. We are confident that this longer time scale item is on track, despite a slow start on the first engineering prototype.

Magnet Strategy

The sole goal of the magnet program is to demonstrate long strong quadrupoles using Nb_3Sn technology by 2009. While a single minded focus is currently necessary to maximize the probability of success, nonetheless a modest diversification of the magnet program may begin to be appropriate in 2008. Supporting LHC IR Upgrades will always remain the broad goal.

Gourlay and Peggs contributed as non-European authors to the document "A Strategy for European Accelerator Magnet R&D Aimed at LHC Luminosity Upgrade", which was submitted to the CERN Council. LARP would like to develop closer ties with CARE, building upon todays excellent status of good will and intellectual co-operation.

Better communication with CERN on magnet topics can be fostered in four ways:

1. Broader participation by CERN Magnet Physicists and Engineers at LARP collaboration meetings (none were present at LBNL).
2. Re-tuning the CERN-U.S. Committee meetings that occur at least once per year at CERN.
3. Inviting all members of the CERN-U.S. Committee to be present as observers at the DOE reviews (including the June 12-14 review).
4. Holding regular phone and/or video conferences.

Safety

The safety of U.S. personnel at LHC is an issue of great sensitivity on both sides of the Atlantic. Peter Limon has been named LARP Safety Officer, or GLIMOS, at CERNs suggestion. Safety presentations and discussions will occur at all collaboration meetings. The ability to complete some or all of standard CERN training before an individual leaves the U.S. would help to make (shorter) visits to CERN more efficient.

University involvement

The involvement of U.S. universities could significantly enhance Accelerator Science at the LHC. We are groping towards ways in which the DOE funded labs in LARP can work effectively with the (mostly) NSF funded universities that have appropriate talent and resources. Loose connections are being formed in four potential areas:

1. University of Texas at Austin (Kopp). AC Dipole topics.
2. MIT (Barletta, Milner). Demonstration of Optical Stochastic Cooling at the MIT-Bates ring..
3. National High Field Magnet Laboratory (Larbalestier). Material testing and R&D.
4. Texas A&M (McIntyre). Exotic magnets.

Documentation

Alex Ratti is leading a broadly conceived effort to systematize the set of documents co-written by CERN and LARP that describe the roles and responsibilities, et cetera, of

Accelerator Systems hardware that will be installed and commissioned.

<u>Blue Sky Task Sheets</u>

The "Blue Sky" Task Sheets that are now under preparation for FY07 (and FY08) will proceed though "Grey Sky" editing, before establishing the financial plan that will implemented on October 1. Major potential new tasks that are included in this process will face critical evaluation and prioritization by LARP and CERN committees. Although LARP explicitly maintains an "open door" policy for new tasks, most are rejected or deferred, often in spite of great technical merit, in order to defend existing priorities.

Financial Report

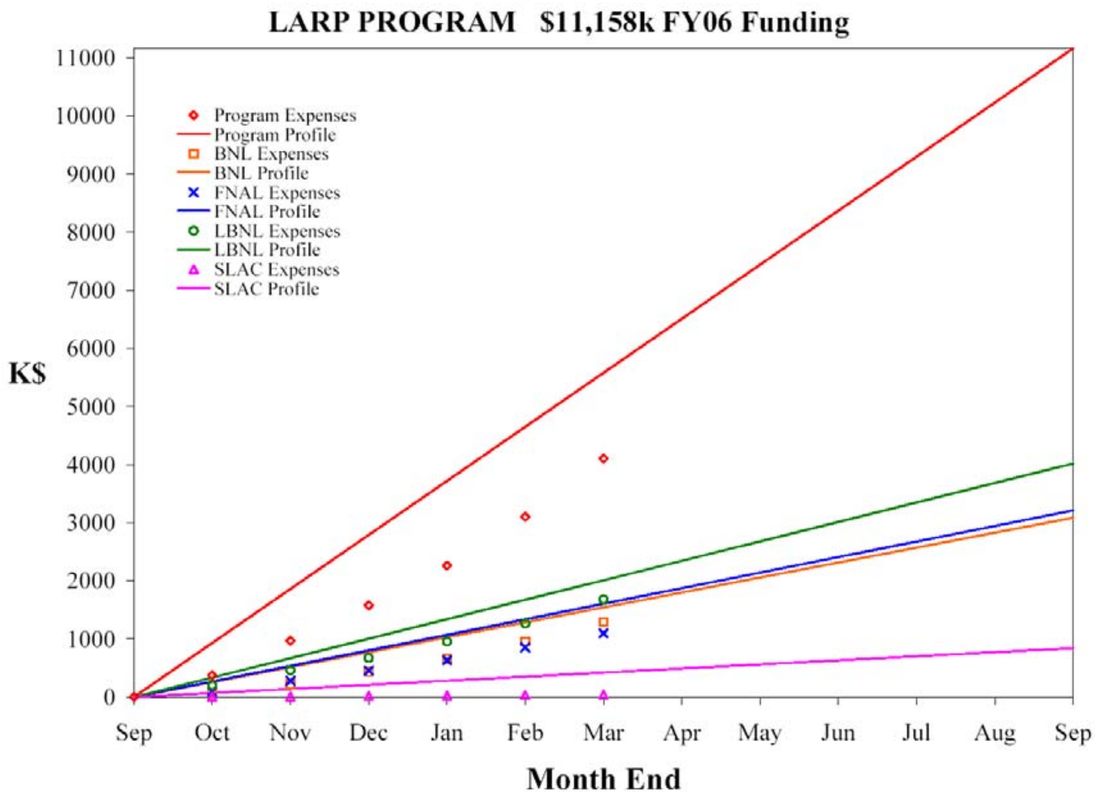
An FY06 budget re-tune was performed at the end of March, in which final allocations were made to the 4 LARP labs according to the Table shown below. Major features in the re-tune from version 2b to 2c included:

- a more accurate redistribution of "Toohig Fellowship" money
- allocation of "Management Contingency" to many tasks, mainly in small allotments
- a temporary decrease in funds to "Rotatable Collimators" at SLAC, reflecting a late start in engineering on the first prototype
- an increase in funding to the "Long Racetrack" activity at BNL

	BNL \$k	**FNAL** \$k	**LBNL** \$k	**SLAC** \$k	**Unallocated** \$k	**Total** \$k
Current allocation	2130	2410	2980	780	2700	11000
Requested allocation	3264	3300	4086	350	0	11000
Requested increment	1134	890	1106	-430	-2700	0

The charts on pages 5 and 6 summarize LARP spending through the end of March 31, the end of the second quarter. The straight line projections on these plots correspond to the version 2b budget, before re-tuning. The spreadsheet on page 7 shows the same data in numerical form (including 2b allocations), while the spreadsheet on page 8 shows the new allocations in 2c.

The spending rate increased significantly from FY05 to FY06, but is now settling down. Because of the "phase lag" in reaching the new burn rate, the mid-year budget re-tune was relatively straightforward and non-controversial. This may not be the case next year, in the middle of FY07.


LARP PROGRAM $11,158k FY06 Funding
Program Expenses
Program Profile
BNL Expenses
BNL Profile
FNAL Expenses
FNAL Profile
LBNL Expenses
LBNL Profile
SLAC Expenses
SLAC Profile
K$
11000
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
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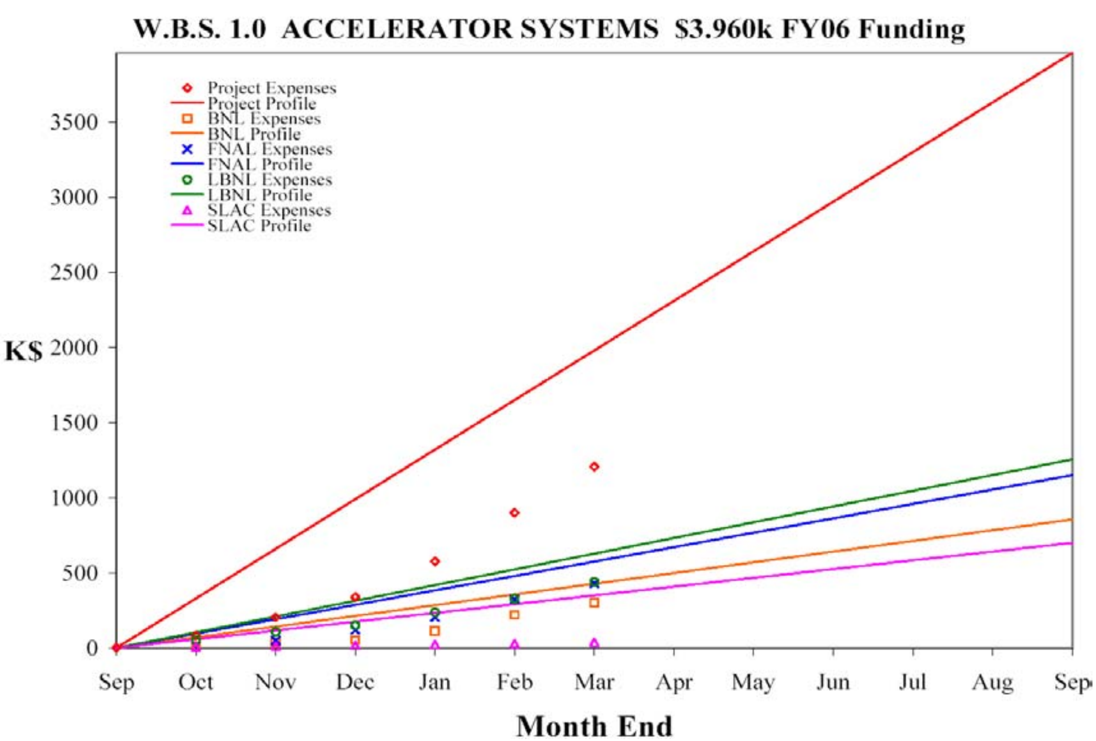
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Month End


W.B.S. 1.0 ACCELERATOR SYSTEMS $3.960k FY06 Funding
Project Expenses
Project Profile
BNL Expenses
BNL Profile
FNAL Expenses
FNAL Profile
LBNL Expenses
LBNL Profile
SLAC Expenses
SLAC Profile
K$
3500
3000
2500
2000
1500
1000
500
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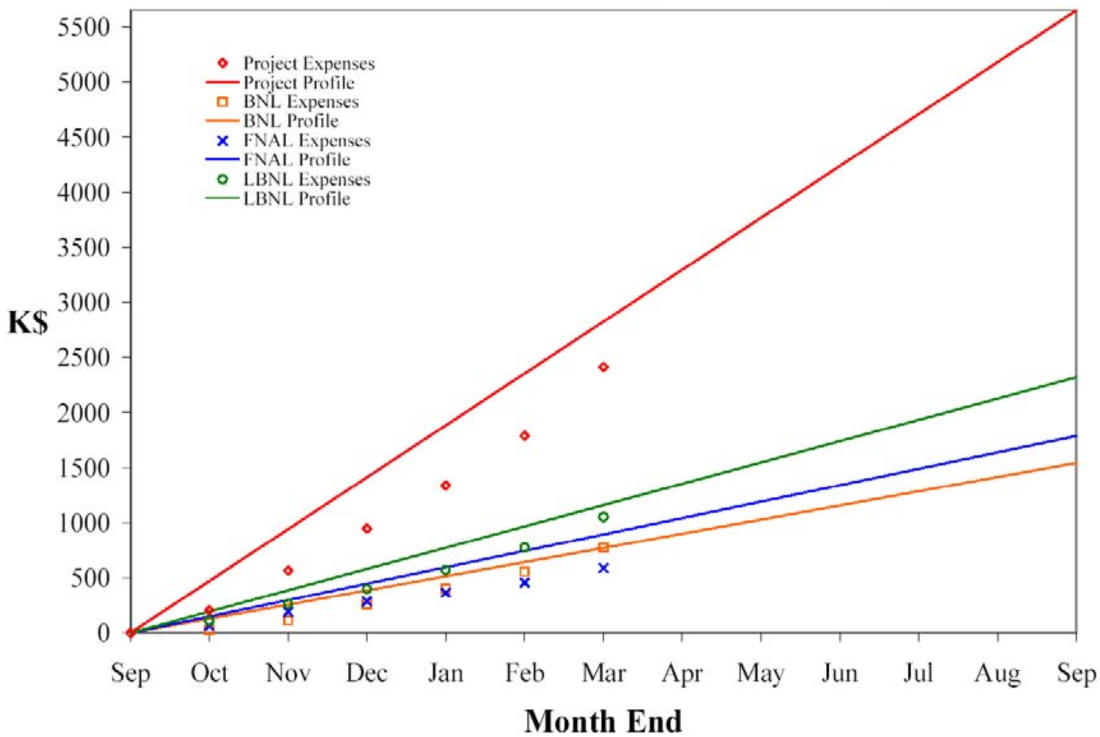
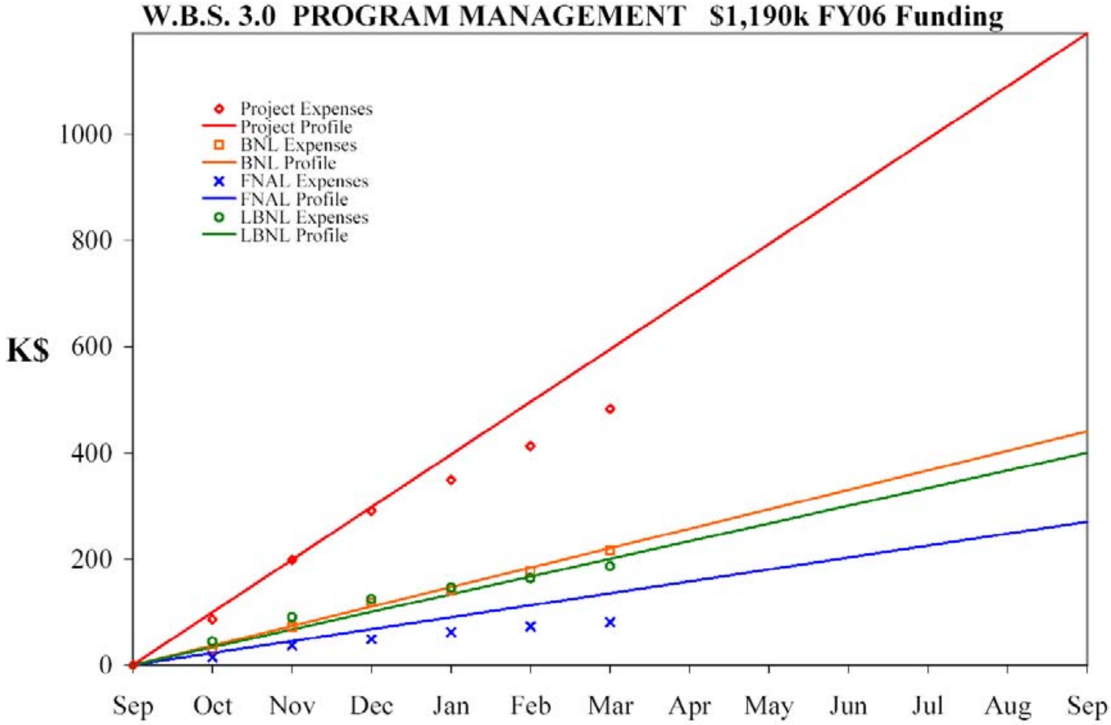
Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep
Month End

W.B.S. 2.0 MAGNET R & D $5,650k FY06 Funding



W.B.S. 3.0 PROGRAM MANAGEMENT $1,190k FY06 Funding



		FY2006 LARP Budget		FY06 Funding Allocation					FY Expenses through March 31, 2006					Funding Balance as of March 31, 2006				
				BNL	FNAL	LBNL	SLAC	Total	BNL	FNAL	LBNL	SLAC	Total	BNL	FNAL	LBNL	SLAC	Total
LARP	FNAL	**FY2006 Budget**		3,264.0	3,300.0	4,086.0	350.0	11,000.0										
WBS	WBS	**FY2005 Carry Forward**		27.7	4.3	42.7	63.4	138.1						27.7				
	31	**US LHC Accelerator Research Program**		**3,085.7**	**3,211.3**	**4,017.7**	**843.4**	**11,158.1**	**1291.2**	**1097.1**	**1791.5**	**37.2**	**4217**	**1,794.5**	**2,109.9**	**2,183.5**	**742.8**	**7,030.7**
1	31.1	**Accelerator Systems**		855	1150	1255	700	3960	301.2	428.7	439.9	37.2	1207.0	554	721	815	663	2753
1.1	31.1.1	**Instrumentation**	**Ratti**	345	250	935	0	1530	223.3	127.1	300.3	0.0	651	122	123	635	0	879
1.1.1	31.1.1.1	Phase I																
1.1.1.1	31.1.1.1.1	Tune feedback	Cameron	300	25	0	0	325	*214.7*	*24.8*	*0.0*	*0.0*	240	85.3	0.2	0.0	0.0	85
1.1.1.2	31.1.1.1.2	Luminometer	Byrd	25	0	935	0	960	*8.6*	*0.0*	*300.3*	*0.0*	309	16.4	0.0	634.7	0.0	651
1.1.1.3	31.1.1.1.3	LDM / AGM	Byrd	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
1.1.1.4	31.1.1.1.4	Schottky Monitor	Jansson	20	225	0	0	245	*0.0*	*102.2*	*0.0*	*0.0*	102	20.0	122.8	0.0	0.0	143
1.2	31.1.2	**Commissioning**	**Syphers**	230	620	90	0	940	11.4	202.9	32.3	0.0	247	219	417	58	0	693
1.2.1	31.1.2.1	Phase I																
1.2.1.1	31.1.2.1.1	Beam Commissioning	Harms	150	250	0	0	400	*0.3*	*42.7*	*0.0*	*0.0*	43	149.7	207.3	0.0	0.0	357
1.2.1.2	31.1.2.1.2	Interaction Region Commissioning	Lamm	80	370	90	0	540	*11.1*	*159.5*	*32.3*	*0.0*	203	68.9	210.5	57.7	0.0	337
	31.1.2.1.3	Hardware Commissioning								*0.6*					(0.6)			(1)
1.2.2	31.1.2.2	Accelerator Physics Phase I																
1.2.2.1	31.1.2.2.1	Electron Cloud Phase I	Furman	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
1.2.2.2	31.1.2.2.2	I. R. Regions & Beam-Beam Phase I	Sen	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
1.3	31.1.3	**Collimation**	**Markiewicz**	100	50	0	700	850	46.6	24.1	0.0	37.2	108	53	26	0	663	742
1.3.1	31.1.3.1	Phase I																
1.3.1.1	31.1.3.1.1	Cleaning efficiency studies	Drees	50	0	0	0	50	*5.1*	*0.0*	*0.0*	*0.0*	5	44.9	0.0	0.0	0.0	45
1.3.2	31.1.3.2	Phase II																
1.3.2.1	31.1.3.2.1	Rotating Collimator R&D	Markiewicz	0	20	0	700	720	*0.0*	*1.3*	*0.0*	*37.2*	38	0.0	18.7	0.0	662.8	682
1.3.2.2	31.1.3.2.2	Tertiary collimator study	Mokhov	0	30	0	0	30	*0.0*	*22.8*	*0.0*	*0.0*	23	0.0	7.2	0.0	0.0	7
1.3.2.3	31.1.3.2.3	Irradiation Studies	Simos	50	0	0	0	50	*41.5*	*0.0*	*0.0*	*0.0*	42	8.5	0.0	0.0	0.0	8
1.4	31.1.4	**Accelerator Physics**	**Fischer**	180	230	230	0	640	19.8	74.7	107.3	0.0	202	160	155	123	0	438
1.4.1	31.1.4.1	Studies																
1.4.1.1	31.1.4.1.1	Electron Cloud	Furman	50	0	150	0	200	*19.8*	*0.0*	*61.1*	*0.0*	81	30.2	0.0	88.9	0.0	119
1.4.1.2	31.1.4.1.2	Interaction Regions & Beam-Beam	Sen	0	180	80	0	260	*0.0*	*48.2*	*46.1*	*0.0*	94	0.0	131.8	33.9	0.0	166
1.4.1.3	31.1.4.1.3	Beam-Beam Wires	Sen	130	50	0	0	180	*0.0*	*26.5*	*0.0*	*0.0*	27	130.0	23.5	0.0	0.0	153
2	31.2	**Magnet R&D**		1543	1787	2320	0	5650	773.8	587.8	1165.9	0.0	2527	769	1199	1154	0	3123
2.1	31.2.1	**Design Studies**	**Zlobin**	83	190	105	0	378	29.1	65.8	54.4	0.0	149	54	124	51	0	229
2.1.1	31.2.1.1	Quadrupole																
2.1.1.1	31.2.1.1.1	Shell & Block design comparison	Ferracin	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.1.1.2	31.2.1.1.2	Shell mechanical design study	Ambrosio	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.1.2	31.2.1.2	Separation dipole																
2.1.2.1	31.2.1.2.1	D1 design	Gupta	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.1.2.2	31.2.1.2.2	D1 cooling study	Peterson	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.1.3	31.2.1.3	IR Cryogenics																
2.1.3.1	31.2.1.3.1	Conceptual Design	Rabehl	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.1.3.2	31.2.1.3.2	Inner Triplet Cryo & Heater Trfr.	Rabehl	22	49	0	0	71	*0.0*	*14.2*	*0.0*	*0.0*	14	22.0	34.8	0.0	0.0	57
2.1.3.3	31.2.1.3.3	Radiation Heat Deposition	Mokhov	0	30	0	0	30	*0.0*	*27.0*	*0.0*	*0.0*	27	0.0	3.0	0.0	0.0	3
2.1.4	31.2.1.4	IR Magnets																
2.1.4.1	31.2.1.4.1	HQ Conceptual Design	Sabbi	0	39	62	0	101	*0.0*	*9.7*	*28.0*	*0.0*	38	0.0	29.3	34.0	0.0	63
2.1.4.2	31.2.1.4.2	LQ Conceptual Design	Ambrosio	13	51	43	0	107	*0.0*	*6.4*	*26.5*	*0.0*	33	13.0	44.6	16.5	0.0	74
2.1.4.3	31.2.1.4.3	IR Magnet Study	Gupta	48	21	0	0	69	*29.1*	*8.6*	*0.0*	*0.0*	38	18.9	12.4	0.0	0.0	31
2.2	31.2.2	**Model Magnet R&D**	**Sabbi**	0	1334	1063	0	2397	0.0	431.6	530.9	0.0	963	0	902	532	0	1434
2.2.1	31.2.2.1	Quadrupole																
2.2.1.1	31.2.2.1.1	Technology Quad TQS01	Caspi	0	92	345	0	437	*0.0*	*90.2*	*348.8*	*0.0*	439	0.0	1.8	(3.8)	0.0	(2)
2.2.1.2	31.2.2.1.2	Technology Quad TQC01	Bossert	0	432	161	0	593	*0.0*	*292.0*	*138.5*	*0.0*	430	0.0	140.0	22.5	0.0	163
2.2.1.3	31.2.2.1.3	Technology Quad TQS02	Caspi	0	10	203	0	213	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	10.0	203.0	0.0	213
2.2.1.4	31.2.2.1.4	Technology Quad TQC02	Bossert	0	502	25	0	527	*0.0*	*48.3*	*18.5*	*0.0*	67	0.0	453.7	6.5	0.0	460
2.2.1.5	31.2.2.1.5	Coil/Structure Exchange TQE01	Ferracin	0	37	50	0	87	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	37.0	50.0	0.0	87
2.2.1.6	31.2.2.1.6	Technology Quad TQS03	Caspi	0	108	170	0	278	*0.0*	*0.6*	*25.1*	*0.0*	26	0.0	107.4	144.9	0.0	252
2.2.1.7	31.2.2.1.7	Technology Quad TQC03	Bossert	0	153	109	0	262	*0.0*	*0.5*	*0.0*	*0.0*	1	0.0	152.5	109.0	0.0	261
2.3	31.2.3	**Supporting R&D**	**Ambrosio**	1282	67	504	0	1853	656.4	7.1	350.9	0.0	###	626	60	153	0	839
2.3.1	31.2.3.1	Subscale models																
2.3.1.1	31.2.3.1.1	Small Quad SQ01b test	Feher	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.3.1.2	31.2.3.1.2	Small Quad SQ02 fab & test	Ferracin	0	0	155	0	155	*0.0*	*0.0*	*133.2*	*0.0*	133	0.0	0.0	21.8	0.0	22
2.3.1.3	31.2.3.1.3	Sub-scale dipole test	Schmalzle	0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.3.2	31.2.3.2	Long Magnet Development																
2.3.2.1	31.2.3.2.1	Design & planning		0	0	0	0	0	*0.0*	*0.0*	*0.0*	*0.0*	0	0.0	0.0	0.0	0.0	0
2.3.2.2	31.2.3.2.2	Racetrack Coil Fab. & Test	Schmalzle	1262	32	92	0	1386	*641.7*	*2.8*	*92.7*	*0.0*	737	620.3	29.2	(0.7)	0.0	649
2.3.2.3	31.2.3.2.3	Racetrack Supporting satructure	Ferracin	0	0	222	0	222	*0.0*	*0.0*	*108.0*	*0.0*	108	0.0	0.0	114.0	0.0	114
2.3.3	31.2.3.3	Test Integration																
2.3.3.1	31.2.3.3.1	Testing	Feher	20	35	35	0	90	*14.7*	*4.3*	*17.1*	*0.0*	36	5.3	30.7	17.9	0.0	54
2.4	31.2.4	**Materials**	**Ghosh**	178	196	648	0	1022	88.2	83.4	229.6	0.0	401	90	113	418	0	621
2.4.1	31.2.4.1	Conductor Support																
2.4.1.1	31.2.4.1.1	Strand R&D	Barzi	137	169	41	0	347	*67.5*	*66.0*	*20.3*	*0.0*	154	69.5	103.0	20.7	0.0	193
2.4.1.2	31.2.4.1.2	Cable R&D	Dietderich	41	27	233	0	301	*20.7*	*17.5*	*96.7*	*0.0*	135	20.3	9.5	136.3	0.0	166
2.4.1.3	31.2.4.1.3	Procurement	Ghosh	0	0	374	0	374	*0.0*	*0.0*	*112.6*	*0.0*	113	0.0	0.0	261.4	0.0	261
3	31.3	**Program Management**		440	270	400	80	1190	216.2	80.6	185.7	0.0	483	224	189	214	80	707
3.1	31.3.1	**Administration**																
3.1.1	31.3.1.1	Systems																
3.1.1.1	31.3.1.1.1	Accelerator Systems	Peggs	240	60	60	20	360	*101.7*	*6.6*	*0.0*	*0.0*	108	138.3	53.4	60.0	20.0	272
3.1.1.2	31.3.1.1.2	Magnet R&D	Gourlay	100	110	240	0	450	*104.4*	*59.0*	*148.1*	*0.0*	311	(4.4)	51.0	91.9	0.0	139
3.1.1.3	31.3.1.1.3	Programmatic Travel	Peggs	60	60	60	20	180	*10.1*	*15.0*	*37.6*	*0.0*	63	49.9	45.0	22.4	20.0	137
3.1.1.4	31.3.1.1.4	Toohig Fellowship	Peggs	40	40	40	40	120	*0.0*	*0.0*	*0.0*	*0.0*	0	40.0	40.0	40.0	40.0	160
3.2	31.3.2	**Management Contingency**	Peggs	220	0	0	0	0	0.0	0.0	0.0	0.0	0	220.0	0.0	0.0	0.0	200

LARP FY2006 budget v2c

Mar 31, 2006			Total	Labor+MTSC				Labor				MTSC			
WBS				BNL	FNAL	LBNL	SLAC	BNL	FNAL	LBNL	SLAC	BNL	FNAL	LBNL	SLAC
US LHC Accelerator Research Program			11000	3264	3300	4086	350	2240	2346	2539	240	1024	761	1186	90
1	**Accelerator Systems**	**Shiltsev**	**3684**	**875**	**1200**	**1309**	**300**	**607**	**927**	**962**	**240**	**268**	**273**	**347**	**60**
1.1	**Instrumentation**	**Ratti**	**1635**	**450**	**250**	**935**	**0**								
1.1.1	Phase I														
1.1.1.1	Tune feedback	Cameron	430	405	25			375	17			30	8		
1.1.1.2	Luminometer	Ratti	960	25		935		20		667		5		268	
1.1.1.4	Schottky monitor	Jansson	245	20	225			20	180			0	45		
1.2	**Commissioning**	**Syphers**	**879**	**65**	**670**	**144**	**0**								
1.2.1	Phase I														
1.2.1.1	Beam Commissioning	Harms	335	35	300			20	200			15	100		
1.2.1.2	Interaction Region Commissioning	Lamm	501	30	335	136		22	245	96		8	90	40	
1.2.1.3	Hardware Commissioning	Lamm	43		35	8			25				10	8	
1.3	**Collimation**	**Markiewicz**	**500**	**150**	**50**	**0**	**300**								
1.3.1	Phase I														
1.3.1.1	Cleaning efficiency studies	Drees	50	50				45				5			
1.3.2	Phase II														
1.3.2.1	Rotating Collimator R&D	Markiewicz	320		20		300		20		240				60
1.3.2.2	Tertiary collimator study	Mokhov	30		30				30						
1.3.2.3	Irradiation studies	Simos	100	100				51				49			
1.4	**Accelerator Physics**	**Fischer**	**670**	**210**	**230**	**230**	**0**								
1.4.1	Studies														
1.4.1.1	Electron Cloud	Furman	200	50		150		44		129		6		21	
1.4.1.2	Interaction Regions & Beam-Beam	Sen	260	0	180	80			165	70			15	10	
1.4.1.3	Beam-Beam wires	Sen	210	160	50			10	45			150	5		
2	**Magnet R&D**	**Gourlay**	**5817**	**1696**	**1817**	**2304**		**1168**	**1419**	**1577**		**528**	**375**	**726**	
2.1	**Design Studies**	**Zlobin**	**416**	**99**	**205**	**112**									
2.1.4	IR Magnets														
2.1.4.1	HQ conceptual design	Sabbi	101		39	62			39	62					
2.1.4.2	LQ conceptual design	Ambrosio	130	29	51	50		29	51	50					
2.1.4.3	IR magnet study	Wanderer	69	48	21			48	21						
2.1.3	IR Cryogenics														
2.1.3.2	Inner triplet cryo & heat transfer	Rabehl	71	22	49			20	47			2	2		
2.1.3.3	Radiation heat deposition	Mokhov	45		45				45						
2.2	**Model Magnet R&D**	**Sabbi**	**2397**	**0**	**1334**	**1063**									
2.2.1	Technology Quadrupoles														
2.2.1.1	Technology Quad TQS01	Caspi	437		92	345			70	315			22	30	
2.2.1.2	Technology Quad TQC01	Bossert	593		432	161			362	148			70	13	
2.2.1.3	Technology Quad TQS02	Caspi	213		10	203			10	174				29	
2.2.1.4	Technology Quad TQC02	Bossert	527		502	25			408	20			94	5	
2.2.1.5	Coil/Structure exchange TQE01	Ferracin	87		37	50			27	34			10	16	
2.2.1.6	Technology Quad TQS03	Caspi	278		108	170			38	126			70	44	
2.2.1.7	Technology Quad TQC03	Bossert	262		153	109			77	71			76	37	
2.3	**Supporting R&D**	**Ambrosio**	**1982**	**1419**	**82**	**481**									
2.3.1	Subscale models														
2.3.1.2	Small Quad SQ02 fab & test	Ferracin	155		23	132				109				23	
2.3.2	Long Magnet Development														
2.3.2.2	Racterack coil fab & test	Schmalzle	1515	1399	24	92		897	24	28		502	0	64	
2.3.2.3	Racetrack supporting structure	Ferracin	222			222				144				78	
2.3.3	Test integration														
2.3.3.1	Testing	Feher	90	20	35	35		16	28	30		4	7	5	
2.4	**Materials**	**Ghosh**	**1022**	**178**	**196**	**648**									
2.4.1	Conductor Support														
2.4.1.1	Strand R&D	Barzi	347	137	169	41		118	149	36		19	20	5	
2.4.1.2	Cable R&D	Dietderich	301	41	27	233		40	23	225		1	4	8	
2.4.1.3	Procurement	Ghosh	374			374				5				369	
3	**Program Management**	**Peggs**	**1499**	**693**	**283**	**473**	**50**	**465**	**0**	**0**	**0**	**228**	**113**	**113**	**30**
3.1	**Administration**														
3.1.1	Systems														
3.1.1.1	Accelerator Systems	Shiltsev	500	360	60	60	20	300				60			
3.1.1.2	Magnet R&D	Gourlay	510	100	110	300	0	85				15			
3.1.1.3	Programmatic Travel	Peggs	369	113	113	113	30					113	113	113	30
3.1.1.4	Toohig Fellowship	Peggs	120	120				80				40			
3.2	**Management Contingency**	**Peggs**	**0**												

1 *Accelerator Systems*

Level 1 manager: V.Shiltsev (FNAL)

The Accelerator Systems component of the U.S. LHC Accelerator Research Program continues to address the goals of advancing High-Energy Physics and advancing U.S. accelerator science and technology, while exploiting and building on the strengths and interests of the National Laboratories. In FY06, an Accelerator Physics and LHC Commissioning tasks were separated. Thus, at present, there are four Level 2 tasks in Accelerator Systems: 1.1 “Instrumentation”, led by A.Ratti (LBL); 1.2 “Commissioning” led by M.Syphers (FNAL), 1.3 “Collimation” led by T.Markiewicz (SLAC) and 1.4 “Accelerator Physics” led by W.Fischer (BNL). The U.S. LARP Accelerator Systems FY’06 budget is 3,684,000 USD. At the end of March 2006 it was adjusted (“re-tuned”) to reflect delays in start of the rotating collimator construction at SLAC and small increases in funding for the construction of the tune feedback system at BNL and for continuation of the collimator material irradiation at BNL. Accelerator Systems spending profile shows some delay (~25% of funds spent thru the first 5 months) but it is anticipated that all the funds will be consumed at the end of fiscal year when all four L2 tasks have scheduled increase of activities.

The most notable achievements in the first half of the FY06 were : successful tests of tune and coupling feedback operation at RHIC, completion of the 4.8GHz Schottky design, finalization of the LHC IR and generic hardware commissioning participation plans, approval of construction of the LHC@FNAL remote access room, encouraging results from LHC Phase I material (C-C) irradiation studies, and start of the wire-compensation device construction and beam-beam experiments at RHIC. There were two successful reviews in the first half of FY06: review of the rotation collimators design at SLAC (December 2005) and Luminosity Monitor review at LBL (April 2006). An overview of the different program elements is given in following sections.

Besides approved tasks, there is a healthy list of new proposals, including AC dipole, SuperSyncLite, B-field fluctuation measurement and suppression, crystal assisted collimation, head-on beam-beam compensation with electron lenses, crab cavities for crossing angle compensation at LHC IPs, optical stochastic cooling and 1.5 TeV superferric magnet injector in the LHC tunnel. All these proposals are subject for discussion and evaluation at the coming LARP collaboration meeting (Berkeley, April 26-28, 2006).

1.1 Instrumentation

1.1.1 Phase I

Reporter: A. Ratti

The sudden change in the RHIC schedule had a significant impact on the execution plan of instrumentation activities. The tune feedback in particular had major changes. The luminosity monitor was also impacted, while the Schottky monitor was not affected. As a result there are significant differences from the schedule submitted earlier in the fiscal year. These changes have allowed us to take advantage of the RHIC run, as discussed in the technical section of this report, and to further advance the design of the systems. The changes we have made represent a rearrangement of the milestones for this fiscal year and have not resulted in a delay in the overall schedule, which is to have the LARP instruments available for LHC commissioning.

In general instrumentation had spent 32% of its budget at the end of February, slightly below the projected spending plan. Current planned expenses indicate that we will fully spend our allocated budgets.

Tune feedback: The plan has been heavily rearranged to meet the RHIC schedule. As a result the spending plan is on track with the budgeted expenses, but the milestones are different from those originally planned. After 5 months of activity, the tune feedback group has spent about 50% of the funding allocated for the fiscal year. This is consistent with planned expenses to perform significant experiments during the RHIC run. The delivery of a system for the SPS run has been delayed also because of problems at CERN with the DAB board acquisition system which was needed for this task. These problems have been resolved at CERN, and the support of the SPS installation can now begin.

Luminosity monitor: This task has also been affected by the modified RHIC schedule, but not as much as the tune feedback. Both electrical and mechanical designs have been completed on schedule and the group is ready for the design review scheduled for April 24, 2006. The front end amplifiers have also been completed on time. The group has delayed the start of the production of the systems to have a final design review. This delay is not expected to impact the overall schedule. The Berkeley group has spent only 24% of its budget. Spending levels have increased in recent months due to increased staffing. The increased rate of labor expenses, combined with the fabrication of the complete first article, are projected to spend the remaining budget for the fiscal year.

Schottky monitor: This activity is in line with projected spending and has met its internal milestones. A final design review is planned for June at CERN, as scheduled.

Major progress has been made at CERN and at TRIUMF with the DAB-IV data acquisition boards under development. The boards are now functional, and both BNL and LBL have a VME crate and DAB board from CERN. In order to properly test the boards in the absence of LynxOS licenses, we have decided to follow CERN's suggestion to use a VME-USB interface card that allows for data transfer from the boards. Programming of the Altera Stratizx FPGA can be done using the JTAG connector on board. The Beam

Instrumentation collaboration will hold a one day workshop on DAB-based acquisition system on April 25, with participation from BNL, FNAL, LBNL, CERN and TRIUMF.

Integration with CERN is also improving significantly. In all three activities CERN personnel have participated in activities in the U.S., and LARP personnel have visited CERN to properly plan the respective activities.

1.1.1.1 Tune Feedback

Reporter: P. Cameron

Priorities were rapidly and radically shifted during the past 6 months, as RHIC Run 6 was on, then off, then on again. Initially the focus was on putting together a new VME-based tune measurement system for Run 6. This system was intended to be a BaseBand Q-meter (BBQ), using the CERN-developed Direct Diode Detection Analog Front End (3D AFE). In addition, the number of data acquisition channels was doubled to permit phase-synchronous acquisition of both projections of both betatron eigenmodes in both RHIC rings, for coupling measurement and correction. The efforts halted abruptly with the announcement that Run 6 was cancelled due to lack of funding.

At that point the VME-based approach was abandoned, and focus shifted to implementing the BBQ in the architecture of the CERN Data Acquisition Board (DAB). A BNL LARP collaboration member attended the CARE Workshop on Remote Diagnostics, for the purpose of clarifying the possibilities for remote operations of the tune feedback system during LHC commissioning, and from there traveled to CERN to discuss system boundaries between LARP and CERN as well as system integration issues. These discussions were very helpful. The outcome was that it was agreed that the LARP/CERN boundary will be the VME memory map of the DAB board. LARP responsibility will be for functionality on the gate array side of VME memory, and CERN responsibility for all higher level software on the crate computer side of VME memory. With this, the tune feedback effort moved intensively in the direction of gate array programming. An Altera development system was acquired and programming efforts commenced on that platform, due to lack of availability of a DAB board. These efforts halted abruptly with the announcement that Run 6 was back on due to the generosity and wisdom of Renaissance Technologies.

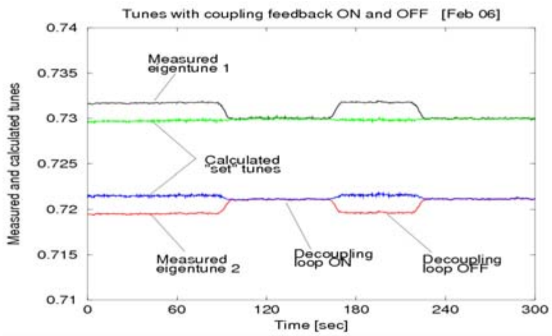


FIGURE 4. Set and Measured Tunes

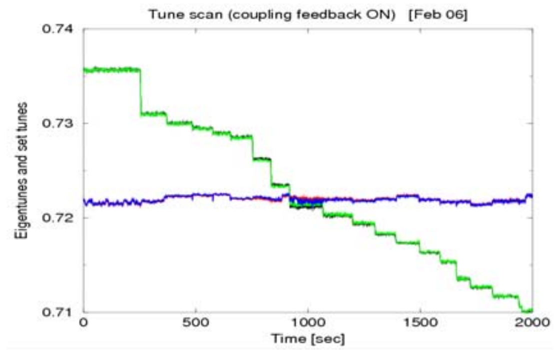


FIGURE 4. Tune Scan

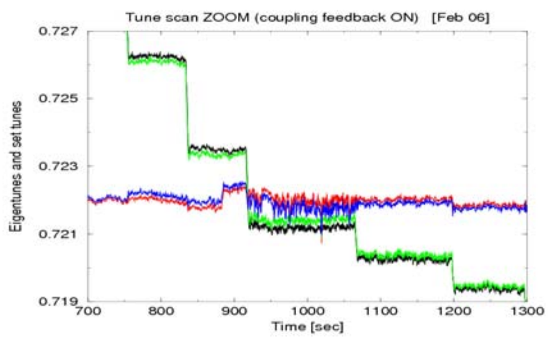


FIGURE 4. Tune Scan Zoom

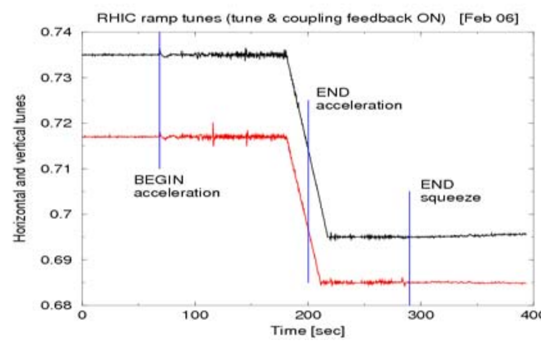


FIGURE 4. Ramp Tunes with Feedback

At that point the VME-based approach was resumed. The system was completed and installed, and was measuring tunes and coupling within minutes of the first bunched beam in RHIC Run 6. Coupling feedback was demonstrated. The first attempt at ramping with simultaneous tune and coupling feedback was successful, and delivered de-coupled beam to full energy. Twelve additional successful feedback ramps were completed during the ramp development phase of Run 6.

Some of the results from those efforts are shown in the accompanying figures. Figure 1 shows set and measured tunes as coupling feedback is turned on, then off, then back on again. Set tunes are calculated from measured values of the eigenmode projections in both planes, and represent what the tunes would be without coupling. When the set tune difference approaches the minimum tune split (as determined by coupling), then the set and measured tunes differ significantly, as in the leftmost portion of figure 1. When coupling is removed by the coupling feedback, then the set and measured tunes are identical. Proof of this is given by scanning the tunes across each other and measuring the minimum tune split. Such a scan was done during the working point study shown in Figure 2. The tunes were decoupled before the tune scan (the upper figure caption is wrong – tune feedback was not on during the scan). Figure 3 shows a zoom of the scan, and verifies that the tunes were indeed decoupled to better than 10^{-3}.

Figure 4 shows tunes during an acceleration ramp with tune and coupling feedback on. The drop in tune near the end of the acceleration ramp follows from the fact that RHIC was running with polarized protons. The working point used during the acceleration ramp was chosen to minimize growth in the emittance of the beam; once the machine was at full energy the working point was shifted to minimize the effect on the protons of depolarizing resonances. Feedback was turned off at the end of the beta squeeze. With the feedback on, the largest departures from the desired tunes were around 10^{-3}, while the rms variation of tune was a few 10^{-4}.

Focus of LARP Tune Feedback efforts is now shifted to three areas. The first is to understand the unexpectedly large phase noise observed with the 3D AFE. The second is to pursue methods of chromaticity measurement, and ultimately chromaticity feedback. And the third is to resume system development on the DAB board.

1.1.1.2 Luminosity monitor

Reporter: A. Ratti

The mechanical design of the detector has been finalized. While the ionization chamber is virtually unchanged from the successful prototype, the housing is a completely new design. This design is a simplification of the previous one, and incorporates features such as modified control of the gas flow through the chamber ensuring that there will be no dead pockets in the areas of highest radiation. The feed through design is also new and takes advantage of fittings available from the commercial vendor of the radiation hard cables used in the system.

The location of the front end electronics has also been revised, thanks to new calculations provided by Nikolai Mokhov. The amplifiers are now a couple of feet from the chamber on the side of the TAN. The expected radiation levels at maximum luminosity are on the order of 100 kRad per year.

The front end electronics has also been defined and is now undergoing final layout. We have adopted a dual channel approach, to allow for a backup channel in case of a random failure of a semiconductor device in the main channel. The baseline grounding scheme has also been defined as a single point ground at the TAN. The analog electronics at the control rack will be optically isolated.

The proposed test of the prototype monitor at RHIC has been accepted. We are expecting to get as many as two shifts of dedicated beam time, of a couple of hours each, in order to bring the beams into collisions at point IP10, which is where the PHOBOS experiment was installed, and where the luminosity monitor is now installed. While the preferred configuration for testing the detector at RHIC is with Au-Au collisions, this run is p-p. We are therefore expecting small signal levels. The present goal for the test is to start developing and understanding of the behavior of the detector in a real collider environment and to start studying backgrounds from hadron collisions.

We also planned for a radiation hardness test. Concentrating on radiation effects on passive components and materials, and with the help of CERN, we have successfully planned an experiment for the upcoming run at the ISOLDE facility ion source at the PS Booster. We prepared two identical kits of parts, including metallized ceramic, resistors and capacitors, and radiation-hard cables. One of these kits will be removed in about three months, while the other will be irradiated until the end of the run in December of 2006.

We also participated in a meeting and a TAN integration workshop at CERN to ensure that all devices planned for the TANs are compatible with each other and can be easily installed and removed without undesired interferences. Besides the luminosity monitor, both Atlas and CMS will have a ZDC installed in the TANs of the respective IPs. In addition the LHCf experiment will be installed in the TANs at IP1.

LBNL will host a design review of the luminosity monitor on Monday, April 24, 2006.

The group has been expanded with the addition of a senior physicist, Howard Matis, and a lead mechanical engineer, Ken Chow.

1.1.1.4 Schottky monitor

Reporter: R.Pasquinelli

The LARP LHC Schottky monitor conceptual design was completed and reviewed at CERN in November 2005. As a result of this review a technical specification document was prepared for the EDMS system.

The detector is designed at a center frequency near 4.8 GHz with a 3 dB bandwidth of 300 MHz. This bandwidth assures the capability to monitor single bunches with 25-nanosecond bunch spacing. This frequency is also within a range to provide small longitudinal impedance Z/n, is below the frequency for Schottky band overlap, and provides adequate physical aperture over the operational dynamic range of the LHC.

All four connections to the pickups will be brought out of the vacuum vessel using matched pairs of SiO2 coaxial cables, which have been deemed acceptable to the CERN vacuum group. A hybrid, limiter, amplifier, and coaxial switches are the only electronics located in the main tunnel on the vacuum vessel. The coaxial switches will be used to inject a test signal on the upstream ports of the pickup for calibration purposes.

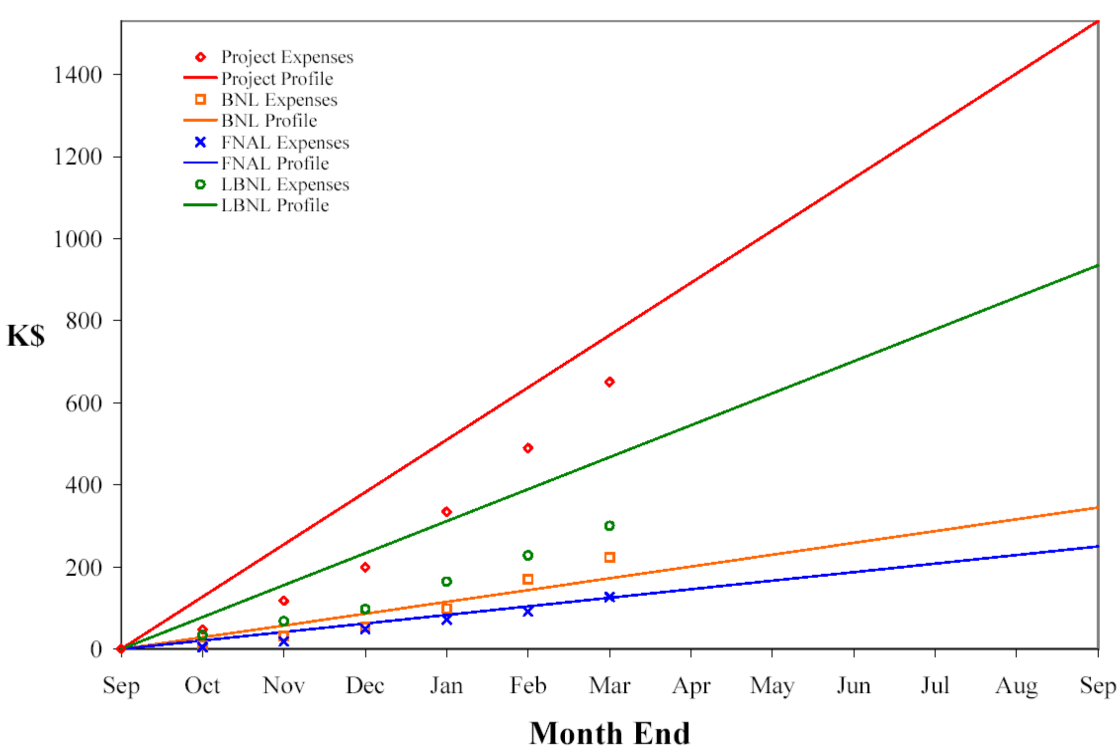
Each pickup will have two gated channels of signal processing. One channel will be dedicated for measuring the average tune of all bunches, while the other channel can be used for special studies on selected bunches. Gating will provide for the best signal to noise ratio for any sequence of bunch loading in the LHC. Gating timing will be made available by CERN from the standard LHC timing module.

A dual down conversion technique will be used to preserve a single sideband signal that contains chromaticity information. The first down conversion is to 45 MHz where a narrowband crystal filter will select a 15 KHz band of Schottky signal, slightly wider than one revolution line. The Local Oscillator (LO) for this down conversion is locked to the 40 MHz reference. A second down conversion will take this signal to base band of DC-80 KHz, where a standard CERN 20-24 bit digitizer (DAB card) will acquire the data. The LO for the second stage will have sufficient frequency agility to allow inspection of a wide band of revolution lines. Fermilab will provide the design of the pickup arrays and vacuum vessels. CERN responsibility will be to procure materials and fabricate the pickups. Fermilab will design and build the analog signal processing and gating hardware from LARP funds; CERN provides the RF reference signals, Local Oscillators (LO), data acquisition, control interfaces, timing channels, and comfort display hardware such as oscilloscope channels. All of this hardware will reside in the service alcove of the LHC tunnel.

The setting, read back, and data acquisition of all Schottky diagnostic related instruments in the service gallery will be controlled via Ethernet. Any local front-end computer shall conform to the CERN VME64x standard. Fermilab will make available the software that was used in the Tevatron Schottky system for reference. All application software for control of the system will be the responsibility of CERN.

The LARP/CERN collaboration is now preparing for the final design review of the system, scheduled for the week of June 19-23, 2006 at CERN.

W.B.S. 1.1 INSTRUMENTATION $1,530k FY06 Funding



1.2 Commissioning

1.2.1 Phase I

1.2.1.1 Beam Commissioning

Reporter: E. Harms

Status

The Beam Commissioning effort ramped up, particularly in the 2nd quarter, as several visits to CERN were made by LARP personnel in January and February, resulting in a nearly continuous presence over a span of several weeks. Visitors to CERN and the main focus of their visits included:

- Suzanne Gysin (Fermilab) – applications software development, particularly in support of the Schottky detector
- Elliott McCrory – applications, potentially to introduce Fermilab's Shot Data Analysis package (SDA) to CERN
- Jean Slaughter – miscellaneous issues especially remote access and administrative matters
- Mike Syphers – attend the Chamonix workshop, meet with CERN staff on commissioning issues
- Elvin Harms – attend the Chamonix workshop, set up a Beam Commissioning Team Account, investigate miscellaneous Beam Commissioning issues and remote access, witness the opening of the new CERN Central Control Center.

Conversely, three members of the CERN Operations group, Lasse Normann, Delphine Jacquet, and Ronaldus Suykerbuyk visited Fermilab in February to experience operation of a superconducting accelerator. This concludes the planned set of visits by CERN staff to the Tevatron.

Some revisions to the budget have occurred due to a reduction in BNL's Beam Commissioning involvement this year, and a desire to marry commissioning to instrumentation via software development. Software support of the Schottky has been seen as a critical area of LARP involvement in the commissioning effort. This work includes a member of Fermilab's Computing Division and has been endorsed by the management of that division.

Regular communication between the principals of the commissioning effort on both sides of the Atlantic continues. The CERN commissioning plan and structure continues to evolve, but specific areas of interest are being solidified and LARP involvement is visible in the CERN plan. As a result of discussion at CERN in January, LARP personnel from both Brookhaven and Fermilab conducted an informal review of the CERN plan for beam commissioning. Results have been forwarded to Roger Bailey with an overall positive view of their organization.

Identification of LARP participants in beam commissioning is becoming helped by the introduction of a “LARP Beam Commissioning Expression of Interest”. So far this web-based form has been distributed to LARP personnel at Fermilab to test its format and usefulness. It has resulted in eight expressions of interest. The audience will be broadened to the LARP community at-large at the collaboration meeting in late April.

Remote access to CERN has taken some significant steps in recent months at Fermilab. While not strictly a LARP activity, this effort involves LARP BC personnel and will provide obvious benefits to the LARP program. The LHC@FNAL committee has been meeting almost weekly since May 2005 to pursue the idea of a remote access center between the U.S. and CERN in support of CMS and LHC efforts. In July 2005 a set of requirements for the center was reviewed and endorsed. Since then, the Fermilab director has given his strong endorsement to this effort. In March, approval was given to proceed with the design of a dedicated facility on the atrium level of Wilson Hall and the Fermilab director is making the necessary funds available. Construction is due to commence this spring with a target completion date of September 2006. A floor plan and view are provided below.

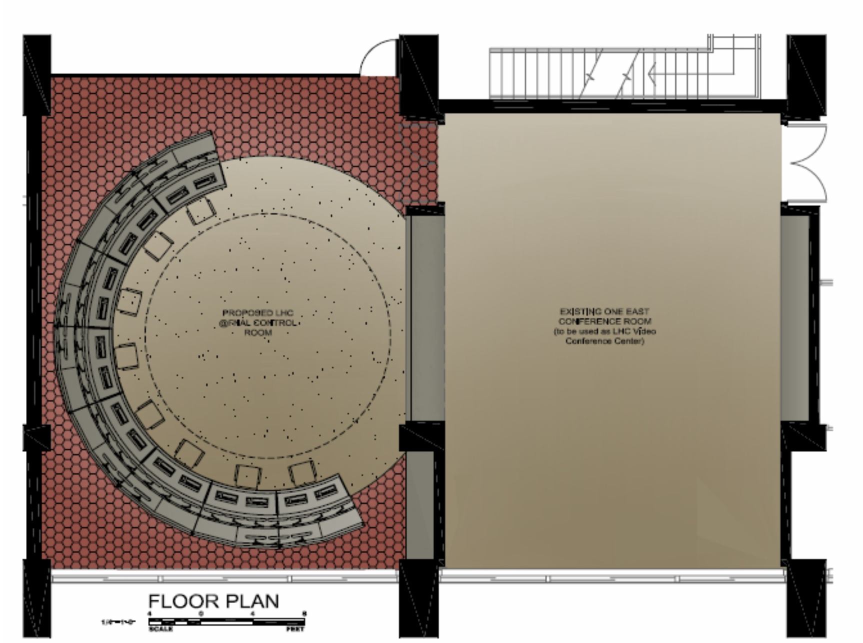


Figure 1.2.1.1-1 Floor Plan of proposed Fermilab LHC and CMS remote access center.

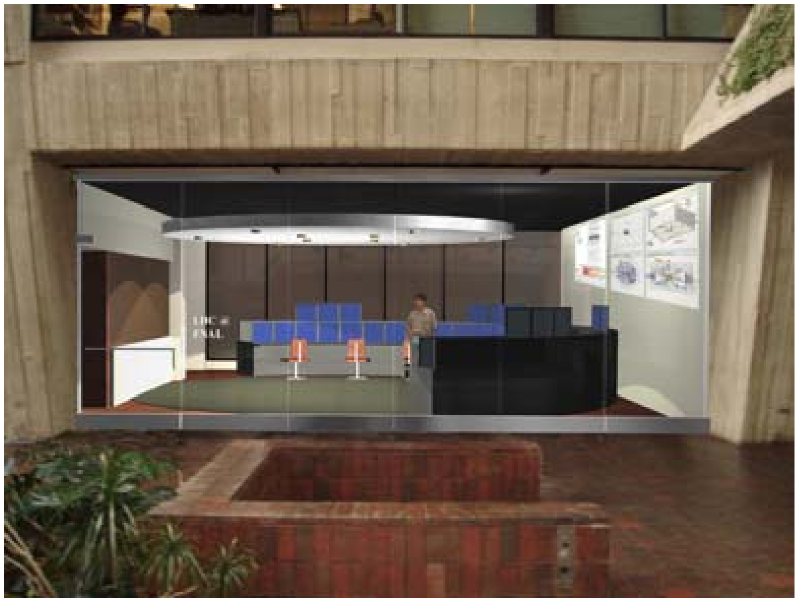


Figure 1.2.1.1-2 Artists conception of proposed Fermilab LHC and CMS remote access center viewed from the Fermilab Atrium.

Report Card

The FY06 task sheet identifies the following milestones

1) January 2006. Participation in Chamonix workshop
2) Ongoing. Short (2-week to 1-month) visits to CERN for face-to-face meetings and training with U.S. and CERN task team members
3) June 2006. Production of a document clearly defining U.S. participants and their duties
4) Summer 2006. LARP presence for SPS start up

In large part, these milestones have been met or are in the process of being met. It is expected that three persons will be at CERN as part of SPS running between now and the end of the fiscal year.

Financial Situation

As stated previously, some Beam Commissioning funds have been reprogrammed in Q2. Brookhaven's share was reduced reflecting reality of its involvement and funds equivalent to up to 0.25 FTE have been made available to support software work for the Schottky detector. This work is perceived as critical to developing a link to CERN for all commissioning efforts. Part of this work will involve developing the necessary tools for generic applications used for beam commissioning.

In general, spending is under budget, but showed an increase in early CY06 consistent with increased travel to CERN. This ramp up is expected to continue through the end of the year.

1.2.1.2 Interaction Region Commissioning

Reporter: M. Lamm

Overview

The primary activities of this task for this reporting period are:

1) Participation in the Installation of the first D1-DFBX-Inner Triplet at CERN

2) Planning for Interaction Region Hardware Installation and Commissioning, including plans for sending U.S. Staff to CERN for IR Commissioning

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Figure 1: In progress installation of first inner triplet in CERN IR 8 R

FNAL Efforts

In November 2005, Peter Limon of Fermilab was assigned to work at CERN as part of the LARP Hardware commissioning effort. Peter joined the CERN AT/MEL group and has been working closely with Ranko Ostojic (AT/MEL) on the installation of the first inner triplet string.

Most of the activity at Fermilab during the first three months of this reporting period centered on preparation for the installation of this first inner triplet string. Regularly scheduled teleconferences were held between CERN (primarily Ranko and

Peter L.) and the participating LARP IR commissioning laboratories. During these meetings we discussed the progress toward transport and installation of the U.S. magnets, procedures for the interconnections, parts status etc. and resolution of problems encountered during the interconnect installation. By the end of CY2005, all of the magnets and the DFBX were delivered to IR8R, and were placed on their jack stands for survey. From their detailed plans were made for LARP oversight of the electrical and mechanical interconnects.

In early January there were a series of 1-2 week planned trips to oversee various aspects of the interconnection. Rodger Bossert and Tom Page spent one week at CERN checking over the interconnect parts lists, and validating the splice procedures. Tom Nicol, Bill Mumper and Jim Rife supervised and provided technology transfer for the electrical interconnect. Mike Lamm provided oversight to the electrical quality assurance tests. During all of this, Peter Limon provided support for these activities.

During the final stages of the mechanical installation, a question was raised about the bellows. There was a concern that these bellows would not be able to withstand the required 25 Bar pressure. Hydrostatic tests were performed at Fermilab, and consequently it was observed that the bellows do squirm at less than 20 Bar. It was determined that the bellows were not adequately supported. On the suggestion of Joseph Rasson and others during our regular teleconference meeting, a support structure was proposed, implemented and successful tested at Fermilab. The solution allows for the retrofitting of bellows already welded in place at this first interconnect.

In addition to the installation, plans continue for the sending of other long term commissioners from Fermilab and LBNL. Three commissioners from Fermilab will start on or about September 1, 2006, with two others planned for CY2007. With members of the local LARP commissioning group including Mike Syphers, Elvin Harms, Jean Slaughter and Mike Lamm, working with the Fermilab employee benefits team, a check list is being developed to help the proposed commissioners get through the necessary practical details associated with this reassignment. The process of filing the paperwork has started for these first three commissioners.

Task Number					Long Task Name	Cost Total Salaries	Cost Total Overhead	Cost Total M&S	Cost Grand Total	Current Month Open Com
31.1.2.1.2					Interaction Region Commissioning	98.598	33.890	27.035	159.523	16.428

The expenses for this first 6 months of FY06 are shown above (in k$). Most of the open commitments are for a “CERN Team account”. Essentially all the M&S is travel related to the installation participation.

LBNL Efforts

Reporter: J. Rasson

During this reporting period LBNL completed the delivery to CERN of all eight cryogenic distribution boxes. Joseph Rasson and Jon Zbasnik completed all CERN required safety training to work inside the tunnel. During this reporting period they made three trips to CERN to oversee the electrical, vacuum and dimensional acceptance tests. All distribution boxes passed the acceptance tests after minor repair of two voltage tap connectors located on the HTS leads.

Distribution box DFBX-G was prepped for installation in IR-8L. Installation in the tunnel between DFBX and the Q3 and D1 proceeded very smoothly and the system passed the vacuum and electrical tests. Now DFBX is ready to be connected to the QRL. DFBX-H is now being prepped for installation in IR-8R and should be transferred into the tunnel during in April 06.

Several additional trips are planned by Joseph Rasson and Jon Zbasnik during FY06 to participate in the installation and commissioning of U.S. delivered hardware. Furthermore, LBNL identified a junior engineer, Fredric Gicquel, to go to CERN for one year starting September 2006. Fredric is a very bright engineer with a Master Degree from Universite de Lyon and he is also a French citizen. Fredric will be working along side Joseph Rasson who is planning to spend 6 months working on the Hardware commissioning at CERN in FY07. Fredric does not have cryogenic experience but he is expected to get it up to speed very quickly once he gets there. In fact he started his cryogenic training at LBNL in March 06 and he expected to continue until he is relocated at CERN where he will receive additional mentoring from Joseph Rasson and Roger Rabehl.

Budget Report Through March 06:

FY06 Funds	Oct-March expenditures including Travel Lien	Remaining Balance	Total % Spent YTD
90,000	37,289	52,711	41.43%
46000*			

*Additonal FY06 Funding Request

Expected Expenditures During the Remaining of FY06:

Effort planned for hardware commissioning at CERN during the last two quarters of FY06:

Joseph Rasson: 2.5 months
Fredic Gicquel: 0.5 month
Jon Zbasnik: 0.5 month

Estimated Total Cost of Effort: $84,000
Estimated Travel Expense: $20,000

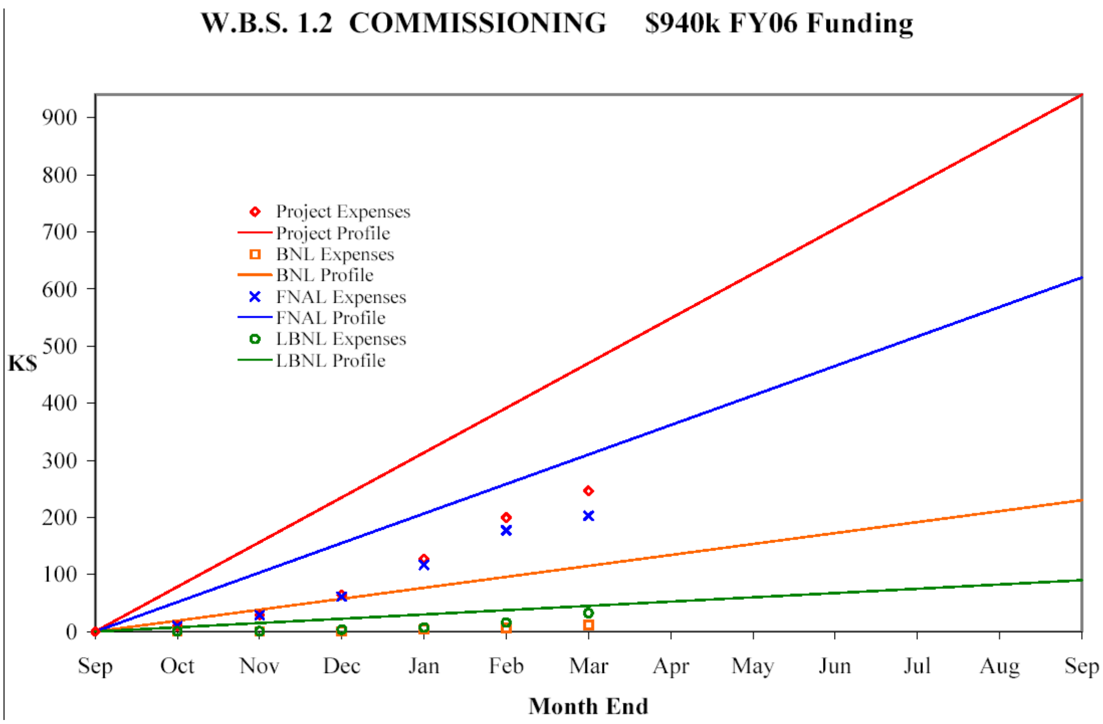
Estimate to Complete FY06: $104,000

BNL Efforts

Reporter: P. Wanderer

J. Cozzolino, the cognizant engineer for the D1 and D3 dipoles, visited LHC for a week at the end of January. He provided technical oversight when the first D1 was connected to a DFBX in the tunnel. Also, he discussed a preliminary design for the repair of the insulation of the leads of the three D3's with R. Ostojic. A final design for this repair was worked out in the following weeks and approved by R. Ostojic. T. Dilgen, senior mechanical technician, visited CERN for two days at the end of March to make this repair on the two D3's at CERN. He also showed LHC staff how to engage and disengage the shipping restraints of the D3 support posts, so that the shipping restraints could be engaged while the magnets are moved into the LHC tunnel.

Budget: $11.1k was charged to this activity for the period. This is 37% of the $30k budget.



1.3 LARP Collimator Program

Accomplishments and spending

Reported by: Thomas W. Markiewicz, SLAC

Program Accomplishments

- Continued design and development of Phase II collimators as pairs of rotate-able copper cylinders.
- Publication of the conceptual design report (CDR) for the first prototype of the rotating collimator (RC1).
- External review of the RC1 CDR and action on the committee's recommendations.
- Visit of CERN staff to BNL to adapt SixTrack to RHIC collimation system
- RHIC loss data were taken that will soon be compared to SixTrack predicted loss maps
- More detailed MARS calculations of Tertiary collimator efficiency
- Equipment to measure the coefficient of thermal expansion (CTE) of irradiated samples was re-commissioned at the BNL Hot-Cell facility. Irradiated samples of 2D Carbon-Carbon, the material in the LHC phase I collimator jaws, were examined for material damage and thermal expansion properties investigated over a wide range of thermal cycles. Post-experimental analysis of the data, normalization of the irradiation in units of displacements per atom (dpa), and correlation of CTE with dpa are underway.
- Preparation of samples of 2D and 3D carbon-carbon composites, as well as samples of copper and GLIDCOP, the materials anticipated for the Phase II rotating collimators, are in progress and expected to be finished in time for the May 2006 run of the BNL BLIP facility.

Expense Report (k$):

	FY Expenses through February 28, 2006				
	BNL	**FNAL**	**LBNL**	**SLAC**	**Total**
Collimation	27.3	21.8	0	29.7	78.8
Phase I					
Cleaning efficiency	*4.1*	*0.0*	*0.0*	*0.0*	4.1
Phase II					
Rotating Collimator R&D	*0.0*	*1.3*	*0.0*	*29.7*	30.9
Tertiary collimator study	*0.0*	*20.6*	*0.0*	*0.0*	20.6
Jaw Material Irradiation Studies	*23.3*	*0.0*	*0.0*	*0.0*	23.3

Task 1.3.1.1: Simulations and tests of Collimation Efficiency at RHIC

Responsible: Angelika Drees, BNL

Scientific Accomplishments this quarter:

Guillaume Robert-Demolaize from CERN visited BNL for 3 weeks after PAC. During that time Angelika Drees and he took some “special” loss data (1 h beam time, 2 times) during scheduled beam experiments with protons. Data was taken at 100 GeV and in one ring only (blue, i.e. clockwise). Loss maps with single collimators were obtained. The newest version of the SixTrack ("colltrack") code was copied over from CERN and compiled; modifications were made to implement the RHIC style collimators (dual plane, single sided). This style collimator is not foreseen by the code as it is and it needs special modifications. A first pass on some simulations was made with a few hundred turns and a varying number of particles (up to a few thousand). The loss maps produced were then compared with the data. However, quantitative comparison was hindered by the necessary debugging required with the new code implementation. Changes to the code, differences between compilers and different ways of implementing the apertures (different from the way this is done at CERN) all need to be better understood before “final” plots can be prepared.

Robert-Demolaize plans to continue to debug the RHIC simulation code at CERN and to produce simulated loss maps which will then be compared with the datasets. It is thought that these comparisons may begin in August or September after his other CERN responsibilities are addressed.

Task 1.3.2.1: Phase II Collimators

Responsible: Thomas W. Markiewicz, SLAC

Status at end of FY2005

The need to wind down the studies of thermal loading (FLUKA), thermal response of the collimator jaw (ANSYS) with the associated choice of material, dimensions and cooling strategy, and collimation efficiency (SIXTRACK) was recognized. To define the parameters of at least the first prototype collimator, a need driven by the LHC schedule and the ultimate milestone of delivering a beam-testable collimator to CERN in early 2008, a Phase II collimator collaboration meeting was held at SLAC on June 15-17, 2005. Ralph Assmann, Allesandro Bertarelli, Mario Santana Leitner and Markus Brugger - all CERN staff - joined the SLAC team at SLAC for these discussions. The major goals of the meeting were to review and clearly define all the LHC constraints in order to make sure any SLAC design would fit in the LHC and to review the technical details of the SLAC design. The talks given can be found at: http://www-project.slac.stanford.edu/ilc/ilcdocs_interface/meetings2/editor/detail_v1.asp?meeting_id=24

As a result of this meeting a baseline design for the first prototype emerged. It was decided to build a device that will fit in the space allotted and that will use Phase I

mechanism to provide jaw adjustment. The cylinder jaws will be prevented from expanding into the beam by the use of appropriate stops and allowed to deflect from 400 up to 1200 microns away from the beam during high energy deposition events. The jaws were specified as 136 mm diameter 75-cm long cylinders with 10-cm tapers at either end. The meeting summary notes can be found at:
http://www-project.slac.stanford.edu/ilc/talks/larp/2005-06-15/Meeting%20notes%206-15-05.pdf

A draft conceptual design report (CDR) for the first rotate-able collimator prototype (RC1) was begun and a draft was available by the end FY 2005.

Scientific Accomplishments in Q1 & Q2 of FY2006:

Work proceeded on the RC1 CDR. The document was reviewed by our CERN colleagues and their suggestions for changes incorporated. LARP management advised that an external review committee should examine our plans before the engineering work turned from design to construction and testing. In preparation for this review a reasonably detailed project plan was developed and incorporated into the document. The design report text can be found at:
http://www-project.slac.stanford.edu/ilc/larp/RC1%20conceptual%20design%20report%20Rev2.pdf
and its set of figures at:
http://www-project.slac.stanford.edu/ilc/larp/RC1%20CDR%20figures%20Rev2%20draft.pdf

The review was held at SLAC on 15 December 2005. The reviewers were Louis Bertolini (LLNL), Alex Makarov (FNAL), and William Turner (LBNL). In addition to the SLAC RC project staff, Ralph Assmann of CERN and several non-involved SLAC engineers attended. The charge to the committee, attendees and talks given are available at:
http://www-project.slac.stanford.edu/ilc/ilcdocs_interface/meetings2/editor/detail_v1.asp?meeting_id=40
and the committee's report at:
http://www-project.slac.stanford.edu/ilc/larp/ReviewersReportFINAL.pdf

The committee's three main recommendations were:

1. To design the jaw support system, rotation and indexing mechanism, and jaw stop before proceeding to the construction and testing of RC1.
2. To analyze the suitability of a jaw consisting of a water-cooled steel cylinder strong back clad with copper.
3. To increase the engineering effort on the project to a minimum of 2 FTEs.

In response, we have:

1. Stopped all thermal analysis and begun the design of the parts mentioned. This work is continuing.

2. Analyzed the bi-metallic cylinder suggested. It's performance was found to be inferior to the baseline copper (or GLIDCOP) material in the CDR.
3. Searched for and hired a full time mechanical engineer and full time designer to join the existing effort.

The work plan outlined in the CDR began with thermal tests of a single jaw. To this end, drawings and parts for short-sample brazing tests have been prepared and the detailed parts required for heating, cooling and measuring the temperature and deflection of the jaw prepared. Files of the mechanical parts of the CERN Phase I collimators have been transmitted to SLAC and are being converted to formats useable by U.S. fabricators. Negotiations to acquire an example of the CERN Phase I support and adjustment mechanism have begun.

Additionally, samples of copper and GLIDCOP have been obtained, machined to the specifications required, and sent to BNL for use in the BLIP irradiation and hot cell measurement facility. They will be among the samples to be irradiated and examined beginning in May 2006, as described in the Task 4 section of this document.

Adjustments to the FY2006 Work Plan and Budget:

The FY06 Task Sheet originally outlined a work plan to two main components:

1. Single jaw thermal test: one jaw with internal helical cooling channels to be thermally loaded for testing the cooling effectiveness and measuring thermal deformations.

2. Full RC1 prototype: a working prototype for bench top testing of the jaw positioning mechanism, supported to simulate operation in all necessary orientations, but not intended for mounting on actual beamline supports with actual beamline, cooling, control and instrumentation connections.

And the following deliverables:

1. Final version of RC1 CDR
2. External review of RC1 CDR
3. Performance report on RC1

Manpower issues and the serialization of the design work recommended by the review committee have resulted in approximately a six month slippage of our schedule. At this point:

1. We plan on completing the single jaw thermal tests and the final design report, including the jaw support, stopper and actuator mechanisms by the end of FY 2006.

2. The fabrication, testing and resulting report of the full two-jawed prototype will be delayed until mid FY07.

As a result we have returned $400k of the FY06 budget to LARP management and will re-budget to account for this delay. As it is expected that CERN will shortly announce an approximately six month delay in the LHC schedule, it is expected that we are still on-track to deliver our beam testable collimator prototype before it is required.

Task 1.3.2.2: Study of Tertiary Collimators at the LHC Experimental Insertions

Responsible: Nikolai Mokhov, FNAL

Scientific Accomplishments this quarter:

1. As agreed at the Port Jeff LARP Collaboration meeting, MARS15 calculations have been performed in IP5 without the TCT tertiary collimators using the same beam halo model as with the collimators in the system. It is shown that heat dissipation in the inner triplet is higher without TCT.

2. The background particle fluxes on the CMS detector are rather sensitive to the TCT parameters and beam halo distribution on them, and can be even higher with the TCTs in. A source term at the entrance to the IP5 collision hall has been calculated and sent to CMS colleagues at CERN to start an iterative process in background minimization.

3. Baseline copper jaws of the TCT collimators have been replaced with tungsten ones, and MARS15 calculations have been performed for this case. Note that all of the above runs are very CPU time-consuming. Better statistics are needed for the tungsten TCTs before drawing reliable conclusions.

4. Fermilab's simulations group is still waiting for "realistic official" beam halo distributions on TCTs promised by CERN collimation group a long time ago.

Task 1.3.2.3: Study of Collimator Material Properties after Irradiation

Responsible: Nikolas Simos, BNL

Following the irradiation exposure of the 2D carbon-carbon composite at the BNL BLIP facility in June of 2005, a series of dedicated activities for post-irradiation analysis of the Phase-I collimator material were initiated at the start of FY06.

Specifically, while the specimens were undergoing a “cooling-off” period in the BNL Hot Lab, the set-up for measurements of the thermal expansion coefficient (property of interest in LHC Phase-I collimator since it controls the jaw movement into the beam that must be maintained below 25 microns) was prepared at the adjacent Hot Lab. Instrument failures due to disassembling and re-assembling of the complex, activated apparatus delayed the start of the actual measurements. Following a successful servicing and re-start of the system, measurements resumed on the irradiated specimens that had cooled-down (radiation-wise) to safe levels. Based on recommendations by the CERN collimator group, new thermal cycling profiles were generated that will reflect conditions anticipated to be experienced by the collimator jaws during normal operations of the LHC. In addition, detailed auto-radiographic measurement was made on the special nickel foils that were part of the irradiation assembly and which would determine the exact beam profile during irradiation. Subsequently, the results of autoradiography were used in the Monte-Carlo analysis performed in an effort to establish the irradiation damage of the 2D CC composite in displacement-per-atom (dpa) units. Analysis of the post-irradiation results generated in the Hot Lab was performed and assessments of the effects of irradiation on the composite used for Phase-I were made.

The different activities associated with Phase-I, their status and results are summarized below:

Material damage due to long exposure: Because of the long exposure of the specimens to the proton beam (peak fluence at ~ 10^{21} protons/cm^2) it was observed that there was serious damage to the structure of this composite. Reported previously was the damage clearly observed on the carbon-carbon specimens that were made normal to the fiber planes (this particular composite, AC-150 made by Tatsuno Company LTD is *a 2D* composite with fibers meshed on parallel planes) and which represents the weakest direction. The damage was in the form of specimen disintegration but only for specimens that were exposed to the peak fluence). Close examination in the Q1 of FY06 of the specimens made along the strong direction revealed damage in the fiber structure (although less severe than what was observed in the weak direction). Again the damage was confined to the specimens, or even the part of the specimen with the highest fluences. It should be pointed out that the exposure the damaged 2D carbon-carbon received is several orders of magnitude greater than what the actual LHC collimator jaws will see during operation. The irradiated material exposed to fewer protons appeared to maintain its structural integrity and showed no signs of damage.

CTE measurements completed for this phase: The experimental evaluation of the thermal expansion properties of the irradiated specimens was performed through a series of tests that included different thermal cycle structure, heating rates, cycle sequence, etc. in order to identify thresholds in the behavior as well as temperature and rate dependence of the changes taking place in the material. The process was very finely controlled and measurements were made at fine steps.

A single cycle (rise and cool-down) would require approximately 4 hours of system operation while for each specimen there were several cycles for each temperature profile and rate. Various sequences of thermal cycling were also applied in an effort to identify the conditions needed for material annealing (or self-healing of irradiation damage). The self-annealing behavior of the composite was a pleasant surprise. It was noted that thermal cycling reverses the damage induced by irradiation. For this composite it became apparent that the damage reversal starts at temperature cycles as low as 200 ^oC. Cycles in different sequences up to 600^o C were applied and showed that the damage progressively is reversed as temperature increases. Representative results are shown in a later section of this report.

A few specimens from the irradiated group and which experienced exposures that is similar to other specimens fully analyzed during this phase were left undisturbed (did not undergo thermal cycling that would result in annealing) for diffusivity/conductivity measurements that is being set to be performed in the second half of FY06. Conductivity studies will be performed using the laser flash method.

Basic Analysis of the CTE measurements:

The detailed post-experiment analysis of the results (CTE conversion/representation, dpa correlation, statistical trends, etc.) is in progress. A PhD student from Stony Brook has joined to assist in the analysis of the large set of data until August. The student will be covered by an LDRD project. The detailed analysis is being assisted by beam profile data and irradiation damage analysis that has been generated for Phase-I studies, specifically

- **Autoradiography Analysis of Special Foils:**

  Proton beam at BNL BLIP started steady but has changed during the 5-week irradiation (especially after switching to 200 MeV protons). As a result the array of specimens was exposed to varying intensities during irradiation. The activation measurements immediately following irradiation, combined with the beam profile, helped identify the irradiation damage experienced by each specimen exposed.

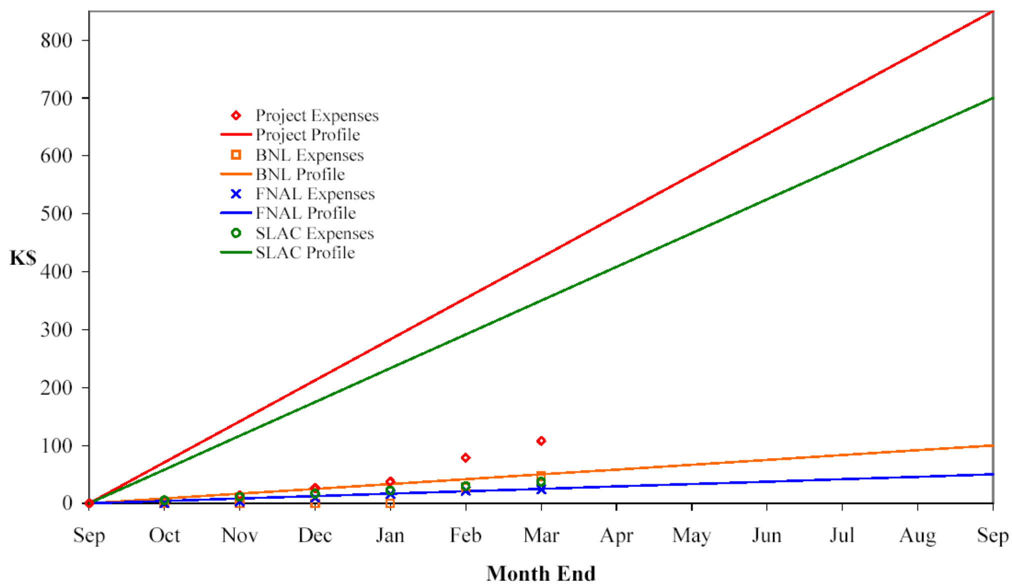
- **Modeling and Analysis Converting Damage to Displacement-per-Atom (dpa) Unitis:**

  A very detailed Monte-Carlo study was performed using the MCNPX transport code and displacement cross sections. Results indicate that the dpa levels at the locations where damage was observed were approximately 0.2 dpa.

For the planned irradiation phase of May 2006 at the BLIP facility, the 2D Carbon-Carbon composite will be tasted alongside and under the same conditions with the 3D Carbon-Carbon. Anticipating similar levels of irradiation exposure as in 2005 it will provide a direct comparison between the different composite grades. More 2D specimens were acquired from the Tatsumo Company and the 3D specimens were also prepared for the upcoming irradiation.

As part of the next irradiation phase, materials for Phase-II were incorporated into the matrix. These are Copper and Glidcop (Cu alloyed with 15% aluminum). Specimens were designed by BNL and information was forwarded to SLAC that is preparing them in the machine shops. The special infrastructure where the specimens will integrate in was designed by BNL and contracted out to the Princeton University Shops where it is being fabricated.

W.B.S. 1.3 COLLIMATION $850k FY06 Funding



1.4 Accelerator Physics

1.4. Budget and spending

Reported by: W. Fischer (BNL)

Funding for accelerator physics activities is primarily for labor costs, with the exception of construction funds for the RHIC long-range beam-beam compensators. Although funds were not used in proportion to the time elapsed during this fiscal year, it is expected that all funds will be used by the end of the fiscal year.

In the Interaction Region and Beam-beam task, labor at FNAL was only used for a post-doc so far. N. Mokhov and T. Sen will charge to this account in the remainder of the year.

In the Electron Cloud task, larger labor charges by M. Furman and J.-L. Vay are planned for the rest of this year.

In the Beam-Beam Wire task, the construction of the compensators at BNL has only recently been started. It is planned to finish the construction in the summer of 2006.

	FY06 Funding allocation					FY06 expenses through 02/28/06				
	BNL	**FNAL**	**LBNL**	**SLAC**	**Total**	**BNL**	**FNAL**	**LBNL**	**SLAC**	**Total**
Accelerator Physics	**180**	**230**				**15.2**				
Electron Cloud	50	0	150	0	200	15.2	0.0	50.5	0.0	66
IR & Beam-Beam	0	180	80	0	260	0.0	28.4	32.7	0.0	61
Beam-Beam Wires	130	50	0	0	180	0.0	5.4	0.0	0.0	5

1.4.1.1 Electron Cloud

Task leader: M. Furman

Collaborators: V.H. Chaplin (LBNL), P. He (BNL), F. Zimmermann (CERN)

1. Completed updated analysis of e-cloud power deposition on LHC arc dipole at top beam energy by means of simulations with code POSINST. The main variables exercised were: bunch intensity (N_b), bunch spacing (t_b) and peak value of secondary emission yield (d_{max}). Bunch intensity was in the range $4\times10^{10} \leq N_b \leq 16\times10^{10}$; bunch spacing was either 25 or 75 ns; d_{max} was varied in the range $1 \leq d_{max} \leq 2$ (nominal LHC bunch intensity is 16×10^{10}).

Conclusions are:

(a) For t_b = 75 ns, the e-cloud power deposition is well within the available cooling capacity of the cryo system for any reasonable range of parameters.

(b) For t_b = 25 ns, the cryo system available cooling capacity will be adequate if $d_{max} \leq 1.2$ (a bit higher than 1.2 is OK, but definitely needs to be below 1.3).
(c) Secondary electrons produced by the backscattering process (elastically scattered and rediffused) contribute significantly to the power deposition. If these types of electrons are eliminated from the model while true secondaries are increased so as to keep d_{max} fixed, we find good agreement with Zimmermann et al's ECLOUD results. This is as expected, since these latter calculations exclude rediffused electrons. In this truncated-model case the constraints on d_{max} are relaxed (to ~1.3 or slightly higher).

Most of the recent work (~2-3 months) was devoted to assessing the sensitivity of the above-mentioned simulated results to various computational and physical parameters of the model in order to verify their stability. As a byproduct of this (tedious) validation exercise, we concluded the following:

(a) A steady state of the electron cloud density is sensibly reached after one batch passage (72 bunches plus a gap, taking a total of ~2 μs beam time);
(b) The power deposition results are quite insensitive to the photoelectric yield in steady state.
(c) We described a detailed mechanism of the relatively large contribution of the backscattered electrons.
(d) We found an approximate scaling law that relates the e-cloud power deposition to average e-cloud density, and this in turn, to beam intensity and bunch spacing.

2. Almost completed adaptation of POSINST to run in stand-alone mode. This means POSINST will no longer require expensive IMSL library functions, and will instead use the freely available library DCDLIB (or any other equivalent library).

3. A CVS repository has been set up for the public distribution of the POSINST source along with the necessary subprograms (this is still in the testing stages). The public distribution of POSINST is an informal (but serious) commitment we made with CARE.

4. Started adding a "QUICKPIC capability" to the fully self-consistent code WARP/POSINST. This capability allows tracking of the proton beam in an approximate (but much faster, owing to larger time steps for the beam than for the electrons) fashion than the fully self-consistent WARP/POSINST algorithm (same time steps for electrons and protons).

5. Initiated simulations of the RHIC e-cloud build-up in a common-pipe region, with the goal of comparing and calibrating results against expected measurements with the recently installed CERN detectors in IP10. This work is being done mostly by Ping He.

Documentation

Web site: http://mafurman.lbl.gov/ (M. Furman)
Web site: http://ab-abp-rlc.web.cern.ch/ab%2Dabp%2Drlc%2Decloud/ (maintained by F. Zimmermann)
Web site: http://at-div-vac.web.cern.ch/at-div-vac/VACPAGES/ps/Phys&tech/Phys/Ecloud/SEY/SEY_paper.html (maintained by V. Bagelin)

M. A. Furman and V. H. Chaplin, "Update on electron cloud power deposition for the Large Hadron Collider arc dipoles", Phys. Rev. ST Accel. Beams **9**, 034403 (2006).

1.4.1.2 Interaction Region Upgrade and Beam-Beam

Task leader: T. Sen

Collaborators: J. Johnstone (FNAL), J.-P. Koutchouk (CERN), N. Mokhov (FNAL), F. Ruggiero (CERN), F. Zimmermann (CERN)

Interaction Region Upgrade

a) Optics

Investigations of the doublet optics shows a larger luminosity for the same β^*, at the expense of a larger beam-beam tune shift. Under investigation is the use of crossing planes different from the alternating H/V in IP5/IP1 in order to reduce the long-range beam-beam tune shift while preserving the luminosity.

CERN has started a repository of IR upgrade optics scenarios, including the doublet optics developed at FNAL. The idea of using different β^* in the x/y planes is attractive - it happens naturally with the doublets but can also be achieved with triplets using the present "quadrupoles first" scheme. After we pointed out the advantages with different β^*, S. Fartoukh at CERN came up with a triplet optics which achieves the same thing. This would allow a larger separation in the triplet even with the current configuration

A reduction of L* has been proposed for the upgrade. The impact of a smaller L* is currently investigated for both the quadrupole first, and the dipole first options. First indications are that the quadrupole first schemes benefit more from a reduced L*.

Measured flux jumps in R&D Nb_3Sn dipole magnets lead to abrupt changes of multipole content in these magnets. There is concern that these flux jumps could have an adverse impact on the beam, e.g. by changing the chromaticity. Assuming a spurious dispersion of 1cm at the IP and a change in b_3(European) by 1 unit, it was found that the chromaticity changes in the inner triplet are not significant (about 2 units) for both the quadrupole first and dipole first optics. However, changes in higher order harmonics also have an impact on the beam and need to be studied.

b) Energy Deposition

MARS simulations are underway to study the dependence of the peak power deposition and dynamic heat load on critical magnet parameters such as the aperture, thickness of inner absorber and higher Z material for the inner absorber. These simulations assume a quadrupole first optics, as in the baseline. The apertures studied are in the range from 90 to 110 mm, as suggested by the optics designs. Preliminary results for a higher Z material for the inner absorber show that a material such as a Tungsten-Rhenium alloy is helpful in reducing the energy deposition in the magnet to acceptable levels. Scaling laws for the dependence of energy deposition on beam size, quadrupole aperture and length, distance from the IP et cetera are also under investigation. A new post-doc Maura Montville joined the group in April 2006.

c) Beam-beam

Ji Qiang has started simulations of head-on beam-beam effects with elliptical beams - as produced by the doublet optics. He is working on optimizing his 6D code.

Documentation

1.4.1.3 Wire compensation of beam-beam interactions

Task leader: T. Sen (FNAL)

Collaborators: U. Dorda (CERN), W. Fischer (BNL), A. Kabel (SLAC), J.-P. Koutchouk (CERN), J. Qiang (LBNL), V. Ranjbar (FNAL), J. Shi (Kansas University), F. Zimmermann (CERN)

BNL activities

Last year's long-range experiments at the RHIC injection energy were fully analyzed, and reported in an internal BNL note (reference below). In these experiments the beam lifetime of 2 interacting bunches was sensitive to both the vertical separation and the tunes. In addition the beam lifetime and emittance growth time of proton beams in operation were analyzed, and calculations made for a number of effects. This also resulted in an internal BNL note (reference below).

A long-range compensator for RHIC was designed, and construction started. It is planned to install one unit in each of the RHIC rings during the summer 2006 shutdown, in sector 5 next to the Q3 magnet. The RHIC long-range compensators are designed to compensate one long-range beam-beam interaction, for which 3.8A in a 2.5m long wire are needed. The design allows for a current of up to 50A, which gives an integrated strength comparable to what will be needed in the LHC. With such strength, experiments that investigate the onset of increased amplitude diffusion due to long-range beam-beam experiments can be performed. The main design features are documented in an internal BNL note (reference below).

Application of long-range beam-beam compensators in the LHC requires a modulation of the compensator strength. Discussions of pulsed power supply indicate that the LHC requirement pose a significant challenge. At this point it is not clear how the LHC requirements can be implemented.

Initial long-range beam-beam experiments at 100GeV were performed in RHIC. Although the experimental technique is still being developed, it is apparent that the variation of the beam lifetime with the transverse separation is much smaller than at injection. The effect also appears to be less sensitive to the tunes. The experiments are not yet fully analyzed.

A joint LARP-CAD post-doc position has been opened, and an offer has been sent out.

FNAL, KU, LBNL and SLAC

Efforts at the institutions other than BNL concentrated on simulation to reproduce features of the RHIC long-range experiments at injection, and possible predictions of current and future experiments at 100GeV beam energy. A web site, maintained by T. Sen, contains the RHIC lattice and beam parameter information that is shared between all collaborators.

Calculations with BBSIM (V. Ranjbar and T. Sen) included noise to mimic gas scattering, chromaticity sextupoles, and synchrotron oscillations. Beam-beam footprints, dynamic apertures, and diffusion coefficients for sample locations in the beam were calculated for two tunes (0.68,0.69) and (0.72,0.73) for the Blue beam. Analytical functions can be fitted to the obtained diffusion coefficients, which then allow calculating beam lifetimes by solving the diffusion equation numerically. With this approach it is possible to obtain the beam lifetime as a function of the vertical separation, a direct observable in an experiment. Diffusion coefficients increase only gradually as the separation is decreased. Estimates of the lifetime show that the lifetime varies linearly with separation for both sets of tunes.

Simulations by J. Shi did not yet include the effects of rest gas scattering, sextupoles or synchrotron oscillations. These simulations tested the tune dependence, and suggest that operation near the ¼ resonance will enhance the long-range beam-beam effect.

Using a strong-strong code J. Qiang calculated the emittance growth for different vertical separations and tunes. These simulations show enhance emittance growth only for separations smaller than 6σ, and also suggest an enhanced effect at tunes closer to the ¼ resonance.

A. Kabel used the PLIBB code, which provides fully coupled 6-D treatment. The long-range beam-beam interaction is modeled in the weak-strong approximation, and particle loss rates are determined by tracking a 6-D ellipsoidal bunch with Gaussian weighted macroparticles. Preliminary results show that sextupoles are an essential part of the beam dynamics, that the presence of a single parasitic crossing will dramatically decrease beam lifetime, that the lifetime in the presence of a parasitic crossing is not too sensitively dependent on the beam separation in the range of 3.5 to 6σ, and that an optimal (in the sense of the experiment) settings seems to be a separation of 4σ.

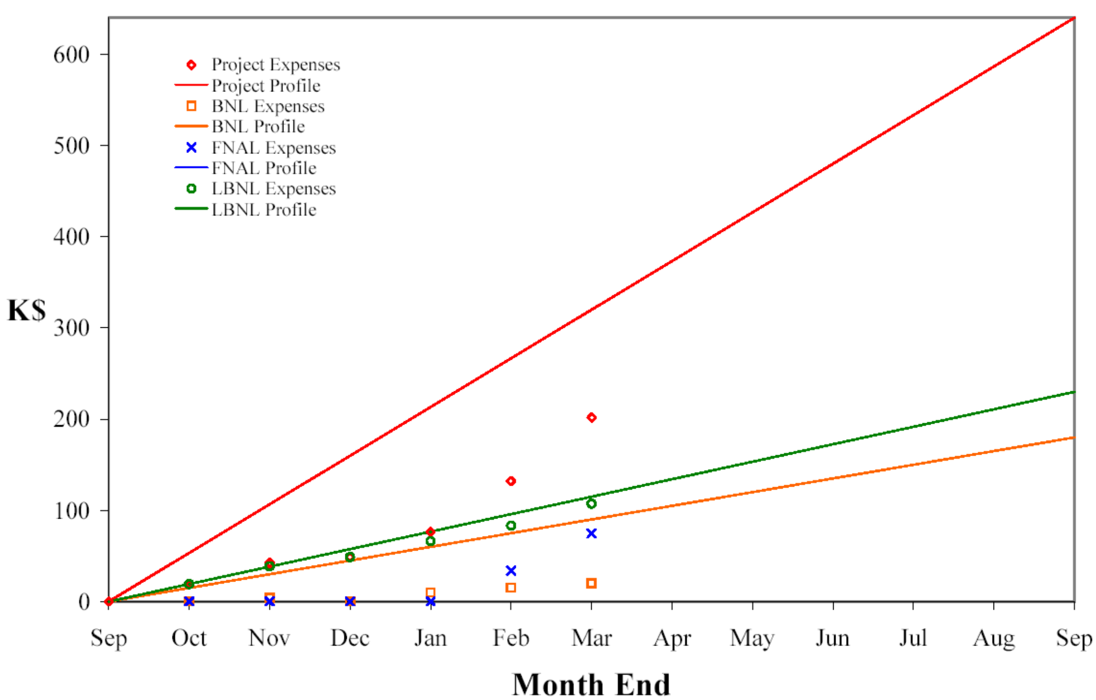
Documentation

Web site: http://www-ap.fnal.gov/~tsen/RHIC/ (maintained by T. Sen)
Web site: http://ab-abp-bbtrack.web.cern.ch/ (maintained by U. Dorda)
Web site: http://cern-ab-bblr.web.cern.ch/ (maintained by F. Zimmermann)

W. Fischer, M. Bai, and M. Harvey, "Beam loss and emittance growth of colliding proton beams during RHIC Run-5", BNL C-A/AP/235 (2006).

W. Fischer, R. Alforque, H.C. Hseuh, B. Lambiase, C.J. Liaw, G. Miglionico, T. Russo, J.-P. Koutchouk, F. Zimmermann, and T. Sen, "Measurement of the long-range beam-beam effect at injection, and design for a compensator in RHIC", BNL C-A/AP/236 (2006).

W.B.S. 1.4 ACCELERATOR PHYSICS $640k FY06 Funding



2 Magnet R&D

2.1 Design Studies

Reporter: A. Zlobin

FY2006-2007 DS work plan is focused on

- supporting the TQ model magnet R&D, data analysis and preparation of critical decisions in FY2007 related to the LARP magnet R&D program
- conceptual design studies of the ultimate gradient quadrupole (HQ)
- mechanical design, parameters and technology of long quadropole (LQ)
- conceptual design studies and radiation analysis of IR magnets, IR cryogenics and heat transfer studies in collaboration with AP group and CERN.

The FY2006 list of acting tasks and task leaders are:

2.1	Design Studies	
2.1.3	IR Cryogenics	
	2.1.3.2 Inner triplet cryo & heat transfer	Roger Rabehl (FNAL)
	2.1.3.3 Radiation heat deposition	Nikolai Mokhov (FNAL)
2.1.4	IR Magnets	
	2.1.4.1 HQ conceptual design	GianLuca Sabbi (LBNL)
	2.1.4.2 LQ conceptual design	Giorgio Ambrosio (FNAL)
	2.1.4.3 IR magnet study	Peter Wanderer* (BNL)

* Peter Wanderer (BNL) replaced in December Ramesh Gupta (BNL) as the 2.1.4.3 Task Leader.

The original FY2006 DS Task budget and its distribution among the participating Labs are presented in Table below (numbers in black color).

Table.

			BNL	FNAL	LBNL	Total
31.2.1	Design Studies	Zlobin	83**+16**	190**+15**	105**+7**	378**+38**
31.2.1.3	IR Cryogenics					
31.2.1.3.2	Inner triplet cryo & heat transfer	Rabehl	22	49	0	71
31.2.1.3.3	Radiation heat deposition	Mokhov	0	30**+15**	0	30**+15**
31.2.1.4	IR Magnets					
31.2.1.4.1	HQ conceptual design	Sabbi	0	39	62	101
31.2.1.4.2	LQ conceptual design	Ambrosio	13**+16**	51	43**+7**	107**+23**
31.2.1.4.3	IR magnet study	Wanderer	48	21	0	69

Budget analysis shows that by the end of February DS tasks spent only $110k out of $378k (~30%). This is mainly due to the slow work start and also partially due to incorrect work charge at the beginning of the year. Some DS works at Fermilab were charged to Fermilab core program since FY2006 tasks are under-funded and it was expected that they will be supported partially by Labs core programs. The situation will be corrected in Q3.

The DS task budget has been reviewed in March by task leaders and Lab coordinators. Roger Rabehl, GianLuca Sabbi and Peter Wanderer confirmed their task budget without any changes. Nikolai Mokhov requested to increase his task budget by $15K to cover the work related to MARS upgrades and to accomplish his FY06 task plan. Giorgio Ambrosio requested to increase his task budget by $23K to cover the expansion of the task scope since design studies related to LR have been added in Q2 to this task. The DS task budget changes are shown in the above table in red color. The DS budget was increased to $416k or by ~10%.

The task progress and results were discussed at DS Working Group video meetings in January, March and April and reported in monthly reports. The current status and plans for FY2006 DS Tasks are reported below by Task Leaders.

2.1.3 IR Cryogenics

2.1.3.2 Inner triplet cryogenics & heat transfer

Task leader: R. Rabehl (FNAL)

Participating laboratories: BNL**,** FNAL

Statement of work: As design studies of 2nd generation IR magnets are performed to investigate possibilities for an LHC luminosity upgrade, the cryogenic system must also be considered. In FY06, analytical studies will be conducted to investigate and compare 2 K inner triplet cryogenic systems and coil temperatures for single-bore quadrupole-first designs. Studies of other IR triplet system designs as well as 4 K cooling systems will begin at a later date. Analytical studies will also be conducted to investigate IR quadrupole cryostat quench protection issues related to stored energy, pipe sizes, and material thicknesses.

FY2006 milestones:

- Establish and document a design temperature profile (Q1)
- Parametric studies of heat transfer in IR quadrupole magnets (Q2)
- Parametric studies of quadrupole-first IR cryo system (Q3)
- Quadrupole cryostat quench protection studies (Q3)
- IR triplet cryostat quench protection studies (Q4)

Status and plans:

A design temperature profile was developed and documented to serve as the basis for the inner triplet cryogenic parametric studies. This design temperature profile is listed in the Table below. A number of factors influenced this temperature profile, such as possible LHC cryogenic system upgrades, known thermal bottlenecks in the existing LHC inner triplets, and the need to maintain the magnet coils in He II.

Table. Design temperature profile for an upgraded LHC interaction region.

Segment	Temperature range [K]	T [mK]
Magnet bore annular space to heat exchanger crossover pipe	2.150-2.000	150
Heat exchanger crossover pipe	2.000-1.950	50
Heat exchanger crossover pipe to heat exchanger (saturated side)	1.950-1.826	124
Pressure drop along the inner triplet heat exchanger	1.826-1.816	10
Pressure drop through the J-T heat exchanger shell	1.816-1.791	25
Pressure drop through piping to the first stage cold compressor	1.791-1.716	75

Typical results of the inner triplet cryogenics parametric studies are shown in the Figure below. The Figure presents a plot of the calculated longitudinal temperature profile of the Q1 non-IP end for a given dynamic heat deposition profile and cold mass parameters (longitudinal cooling channel size, radial cooling channel sizes, beam pipe annulus) chosen to satisfy the design temperature profile.

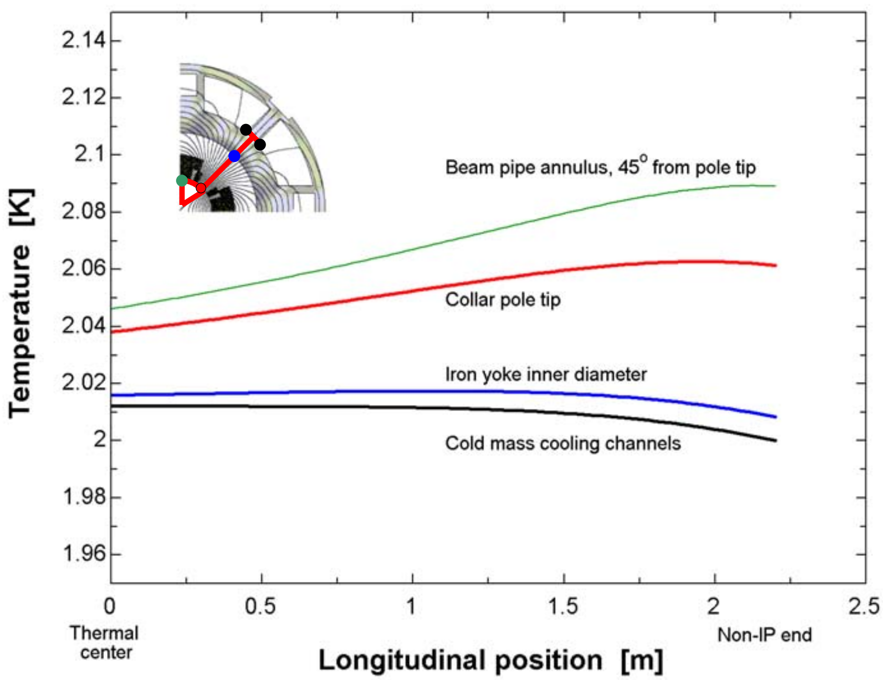
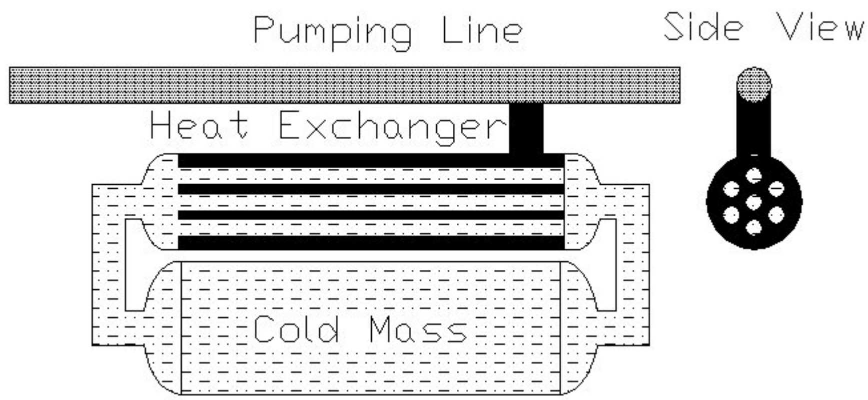


Figure. Calculated longitudinal temperature profile for the A1 non-IP end.

A conceptual design of the upgraded magnet heat exchanger was generated and is shown in the Figure below. The heat exchanger is a shell-and-tube design, with the pressurized He II in the tubes and the saturated He II in the shell. Vapor generated is removed via a separate pumping line.



The Q1 milestone was met. A design temperature profile was documented. Significant progress was made toward the Q2 milestones, but the milestones were not met. Extensive work on the parametric studies was completed during Q2. Studies of cold mass parameters (beam pipe annulus, cooling channels, heat exchanger crossover pipe) were completed. Documentation of this work is in progress but not yet completed.

A conceptual design of the magnet heat exchanger was generated but remains to be documented. Because an LHC luminosity upgrade will affect not only the inner triplet but also the entire machine, revised machine heat load estimates are being generated and the impact on the cryogenic system is being studied. Documentation of this work also is in progress but is not yet completed.

Heat exchanger analysis will continue in Q3, leading into studies of the entire inner triplet. Quadrupole quench protection studies are not dependent on the heat exchanger design and can proceed.

As of the end of Q2, FNAL has charged 159 hr to this task (38% of the budget). BNL has charged 32 hr (21% of the budget). Both labs are underspent on this task at the halfway point of this fiscal year. The situation will be improved in Q3 thanks to growing amount of work on this task.

2.1.3.3 Radiation heat deposition

Task leader: N. Mokhov (FNAL)

Statement of work: In FY06, Monte Carlo studies will be conducted to calculate radiation heat deposition rates for the interaction region quadrupoles and separation dipoles in various inner triplet configurations.

FY2006 milestones:

- Calculate radial and azimuthal radiation heat deposition powers for IR quadrupoles
  - as a function of internal absorber thickness (Q1)
  - as a function of midplane spacer size (Q2)

- Calculate radiation heat deposition power for interaction region separation dipoles vs. internal absorber thickness (Q3).
- Calculate longitudinal distribution of radiation heat deposition power for the quadrupole-first inner triplet configuration. (Q4)

Status and plans:

The MARS15 model of the IP5 inner triplet was substantially upgraded to allow a study of the IP-related energy deposition effects in the large-aperture 200 T/m Nb3Sn quadrupoles. This includes the corresponding lattice, quad geometry, layout and fields. Appropriate beam screen and internal absorbers (liners) have been introduced with allowance for variation of the quad aperture and - consistently – internal absorber thickness. Recent changes in the CMS detector inner region and in the machine detector interface have been also implemented into the model.

After thorough testing, the effect of the above model changes in the IR layout on the 90-mm Nb3Sn quadrupole coils was investigated. The maximum effect reaches a factor of 2 in Q1 and up to 30-50% at most other locations. A variation in maximum power densities at the longitudinal peaks (critical regions) is in the range of 10 to 30%. The effect on dynamic heat loads due to the above changes is less than 20%.

With the new MARS15 model, production runs were performed for the 200 T/m Nb3Sn quadrupoles for the coil apertures of 90, 100 and 110 mm with the baseline internal absorbers. It was found that the peak power density in the coils varies with the aperture differently in the different final focus quads. The peak in Q2b (longitudinal maximum at the beta-max location) is significantly higher than the expected quench limit for Nb3Sn at the luminosity of 10^{35}cm^{-2}s^{-1}.

Two possibilities have been studied in detailed simulations, in order to reduce the peak power density in the coils:

(1) increase of the stainless steel inner absorber thickness by 2, 4 and 6 mm possible for the 100 and 110 mm quads;

(2) replacement of stainless steel in the inner absorber by the W75Re25 alloy.

A 6-mm stainless steel absorber does a good job, but using a high-Z absorber looks much more attractive even for smaller apertures and baseline thicknesses: W75Re25 reliably reduces the peak power density to a value below the quench limit, including an appropriate safety margin.

Dynamic heat loads scale with the luminosity, so they exceed 1 kW for the upgrade. They are practically unaffected by all of the above (at least the total heat load) and continue to be the outstanding issue putting constraints on the cooling system capability, the cryoplant capability and the cryosystem cost. It seems that this should be studied in great details in FY07, revisiting the idea of the inner absorber cooling at liquid nitrogen temperatures.

Studies have been launched on the possible advantages of using low-Z insertions (spacers) in the inner coil mid-planes. Results are expected in Q3.

About 86% of the original task budget had been spent by the end of February. The task budget has been increased by 50% to accommodate the remaining task plans for this year.

2.1.4 IR Magnets

2.1.4.1 HQ conceptual design

Task leader: G. Sabbi (LBNL)

Participating laboratories: FNAL, LBNL

Statement of work: The LARP Model Magnet program includes the development of shell-type, high gradient quadrupoles (HQ) with 90 mm aperture and 250 T/m nominal gradient (with >15% margin). The goal of this task is to perform conceptual design studies of such magnets in order to determine their optimal target parameters and features to be implemented during the model magnet R&D phase. The studies will include magnetic, mechanical and quench protection analysis; feedback from the TQ, SQ and LR magnets; results from Nb3Sn strand and cable R&D. Based on these results, the HQ design and R&D plan will be developed. The FY06 design study will concentrate on coil design issues, to allow starting a detailed engineering design of the coil and tooling in FY07. The FY07 design study effort will concentrate on mechanical support issues and further design optimization.

FY2006 milestones:

- HQ design objectives and target parameters; sub-task guidelines (Q1)
- Definition of preliminary conductor and cable parameters (Q1)
- Study and discussion of magnetic and mechanical design options (Q2)
- Magnetic analysis and design of coil ends (Q2)
- Comparison of magnetic design options (Q3)
- Selection of HQ coil design(s) (Q4)
- Mechanical analysis and design of magnet ends (Q4)

Status and plans:

The design study started with a discussion of the basic objectives and plans for the HQ. The task sheet states that HQ will be based on a 90 mm aperture cos2θ coil. However, the LARP technical review (November 2005) recommended that larger apertures and possible alternatives to the cos-theta geometry should be considered as part of the design study. The working group agreed that the basic HQ parameters and coil layout should be clearly explained as part of the HQ task and not treated as assumptions. However, it was determined that although the HQ may ultimately adopt an aperture larger than 90 mm, a reference aperture of 90 mm is adequate for the present purpose of comparing different magnetic and mechanical design options. We believe that the conclusion of this optimization work will still be applicable to design with modestly larger apertures. Therefore, a discussion of the relative benefits and costs of moving to larger apertures can proceed in parallel with a design optimization for 90 mm apertures.

The second step involved defining a preliminary set of conductor and cable parameters for cos2θ geometry with 90 mm aperture, using 2, 3, and 4 layers. These parameters were coordinated with the LARP materials group. For the 4-layer design, the same cable width as for TQ was selected, to enable the use of existing tooling for the inner double-layer. Two options were considered, one with grading and the other without grading. For the 3-layer design, the same total radial envelope for the coil was selected in order to have a consistent comparison with the 4-layer case. For the 2-layer case, however, it was not possible to match the coil radial envelope of the previous cases. A strand diameter of 1 mm was assumed, in order to increase the cable width as much as possible.

The reference strand parameters were also coordinated with the materials group. We started from the measured properties of a recent 54/61 wire (8220). These properties justify using a reference critical current (12 T, 4.2 K) of 3000 A/mm^2, which already includes a small degradation to take into account the effect of cabling. The field dependence is based on 8220 strand measurements. The temperature dependence is based on a parameterization.

A comparison of 2, 3, and 4-layer coil designs from the design and fabrication standpoint was completed. The 2-layer design has the smallest number of parts and fabrication steps. However, in the case of HQ it requires a cable with large aspect ratio, leading to potential difficulties in the design of the end parts and in the coil winding process. The 3-layer design allows to reduce the cable width while maintaining a continuous winding in each quadrant and minimizing the number of joints. However, this option poses some constraints to the design of the third layer, requiring more longitudinal space for the coil ends. This is a disadvantage for short models such as HQ, since the total coil length is limited to less than 1 meter. Finally, although the 4-layer design requires twice as many coils and tooling and fabrication steps as a 2-layer design, it can reach a coil width of about 40 mm while limiting the cable width to 10 mm. It allows a comparatively larger keystone angle, and also allows grading of the outer two layers at small extra cost.

It was therefore decided to concentrate on 4-layer coils for further optimization. Different 4-layer designs were developed, including with and without grading, and one that uses the same inner coil as for the TQ. A common set of assumptions was defined as a basis for a consistent comparison among these options.

The cross-section comparison must take into account fundamental mechanical parameters, such as the stress produced in the coil. A simple comparison of the accumulated Lorentz forces shows differences in the stress patterns that may be exploited to minimize the peak coil stress. However, a comparison with a 2D mechanical analysis using a rigid coil boundary shows that the accumulated Lorentz force is not a good indicator of the actual stresses developing in the coil (due to deflections, friction between layers etc). Therefore, the stress patterns for each proposed cross-section need to be evaluated using ANSYS.

We have completed the Q1 and Q2 milestones (with the exception of the preliminary coil end analysis) and we have made good progress towards a comparison and selection of the magnet cross-section (Q3/Q4 milestones). The magnetic and mechanical analysis of the coil ends will follow the cross-section choice later in the year, and is expected to be finalized in FY07 according to the present task plan.

From the financial standpoint, the March 2006 report shows HQ expenditures at LBNL to be about 45% of the total budget. At Fermilab, the expenses are about 30% of the total budget. This status is consistent with the need to reserve some funding for the magnetic analysis of the coils ends later in the year.

2.1.4.2 LQ conceptual design

Task leader: G. Ambrosio (FNAL)

Participating laboratories: BNL, FNAL, LBNL

Statement of work: The strategic goal demonstration of Nb3Sn technology for the LHC luminosity upgrade will be performed using 4-m long quadrupoles (LQ) based on the TQ model design and technology. The LQ quadrupoles have to provide a field gradient of greater than 230 T/m at 1.9 K in an aperture of 90 mm, with reliable quench performance. The work on LQ will start in FY08 after fabrication and testing series of TQ models and long racetrack coils (LR). The goal of this task is to perform conceptual design studies of LQ quadrupoles in order to determine their optimal design, technology and target parameters. The studies include analysis of data collected during fabrication and test of TQ model magnets (mechanical structure evaluation) and LR racetrack coils; analysis and comparison of Nb3Sn strand and cable parameters; magnetic, mechanical and quench protection analysis and optimization. The proposals for the LQ R&D phase, including LQ design and parameter, baseline technology and cost and schedule, will be based on these studies.

FY2006 milestones:

- Analysis of long coils during heat treatment and cooldown (Q1-Q4)
- Quench protection analysis of LQ based on TQ coils (Q2-Q3)
- Specification of strand and cable parameters for the LQ practice coils and first model to procure in FY2007 (Q4)
- LQ coil conceptual design finalization (Q4)

Status and plans:

In the past months the work for the design of the **Long Racetrack**, originally thought to be a small sub-task of the Long Quadrupole Design Study, has significantly increased. Therefore it was decided to change the LQ task sheet by adding the Long

Racetrack in scope and milestones (a copy of the new task sheet can be found on the LARP web site). The first new milestone is the generation of the LRS01 design report before the end of April. The design report includes conductor, magnetic and mechanical design, quench protection, and long coil fabrication plan. A draft is available on the LARP web site.

The work for the Long Quadrupole design has, up to now, concentrated on the following areas:

Conductor: the Material group is looking at possible conductor designs with different copper-to-non-copper ratio in order to know all possible options (and the possible need of R&D) for the Long Quadrupole.

Insulation: we are exploring the option of fabricating the insulation on the cable, with a thin sleeve that allows much easier application to long cable units. A sample with this kind of insulation, made at NEEW, is used for electrical tests, both before and after transverse pressure application. CTD has developed a new ceramic binder that should replace the present ceramic binder (1008) at significantly lower cost and also shorter procurement time. Qualification tests (compatibility with coil fabrication process, electrical strength, coil sample mechanical properties, thermal conductivity) of cable stacks fabricated with this new binder are underway.

Quench protection: presently we are working on the quench protection of the Long Racetrack. This is useful to fine-tune the simulation codes, collect material properties, and design protection heaters that will be used for the Long Quadrupole.

Magnetic design: a 2D magnetic design was developed with a thick cable insulation (250 microns) and same features of the present TQ design. It will be used together with insulation strength measurement and quench protection analysis in order to evaluate the pros and cons of different cable insulation thickness.

Budget analysis shows slower spending than expected. The following budget modifications have been done. The work for the LR conceptual design was increased to 0.08 FTE at LBNL (+$21.7k). The half of “coil fabrication technology” sub-task was moved to FY07-Q1 in order to wait for feedback from Long Racetrack and Long Mirror coils fabrication (LBNL budget was reduced by $3k). LR quench protection analysis is taking more effort than expected. To accommodate this, the BNL budget was increased by $5.3k. LQ quench protection analysis was moved from LBNL to BNL increasing the BNL budget by $10.6k and reducing the LBNL budget by $11.9k. The total task budget was increased by ~20%.

2.1.4.3 IR magnet study

Task leader: P. Wanderer (BNL)

Participating laboratories: BNL, FNAL, LBNL

Statement of work: The main goal of this task is to perform generic design studies and comparison of different IR magnets for the LHC luminosity upgrade in order to determine their parameter space. A comparison between expected and measured field harmonics in Nb3Sn magnets will also be performed. The goal of this exercise will be to understand the sources of differences, if any, and to create error tables of expected harmonics in future Nb3Sn magnets. In FY2006 the analysis and comparison of

1) IR quads based on shell-type and block-type coils,
2) aperture and field quality limitations for double-aperture IR quads and
3) mechanical analysis of 110 mm IR quads will be completed. Also,
4) field quality analysis in Nb3Sn IR quads will be started and
5) first error tables will be generated and provided for the Accelerator Physics group.

FY2006 Milestones:

- Analysis and comparison of IRQ based on shell-type and block-type coils – Q1
- Analysis of a 110-mm shell-type IR quad with different supporting structures – Q2
- Analysis of aperture and field quality limitations for double-bore IR Quads – Q3
- Field quality analysis and error tables for Nb3Sn IRQ – Q4

Status and plans:

Analysis and comparison of IRQ based on shell-type and block-type coils.

The designs made by Ferracin in FY2005 are on the LARP Web site and available when needed. Comparison of the mechanical and magnetic properties of shell-type and block-type coils was completed in Q1 and the results presented at the Fall 2005 Collaboration Meeting. Ferracin has submitted a written report of this work. Comparison of the effects of radiation on these types of coils has not started due to lack of personnel. It is anticipated that the newly-arrived postdoc will begin work in mid-June. Work will most likely run through the end Q4.

Analysis of a 110-mm shell-type IR quad with different supporting structures.

In March, work was underway on the part of the report with completed models (4 layers glued together, pre-stress introduced by interference at the coil-pole interface), and on the models under development (layers 1&2 separated from layers 3&4, pre-stress introduced by interference on the midplane). The first part of the report should be ready by the end of March; the second part will take more time. One set of models analyzed by the end of Q2. The other will be completed by the end of Q3

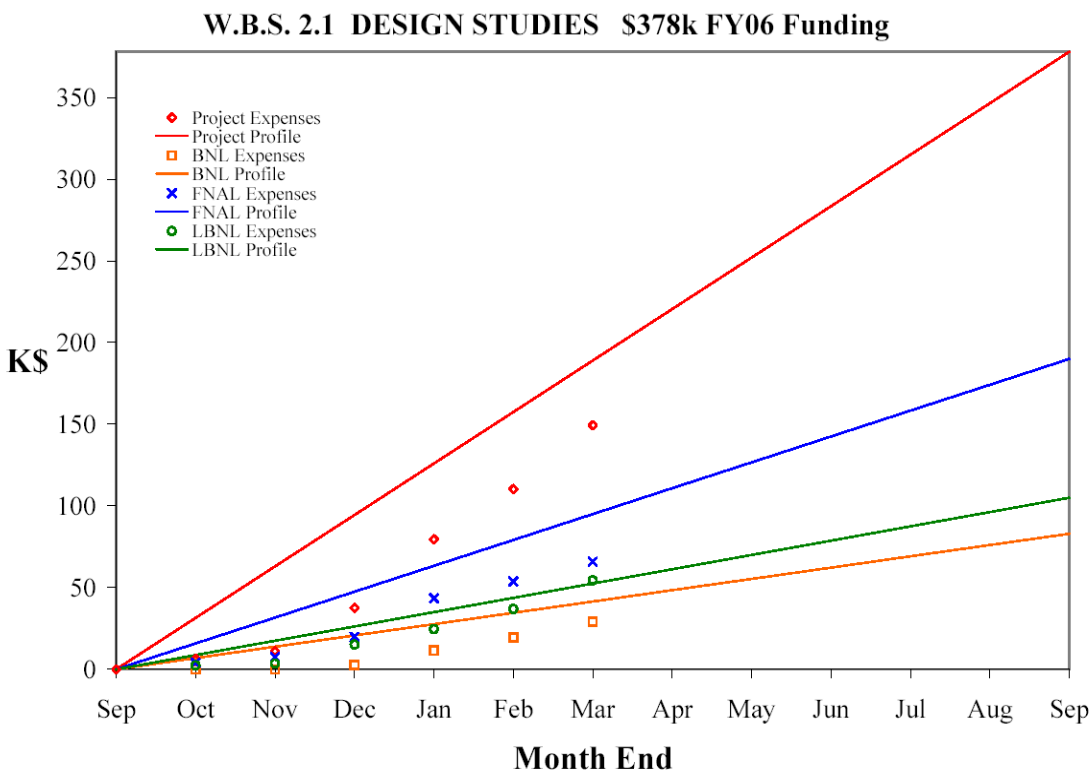
Analysis of aperture and field quality limitations for double-bore IR Quads.

The beam envelopes were analyzed for 2-in-1 quadrupole magnets with the "warm" and "cold" iron yokes. The equivalent dynamic aperture was determined in both cases, assuming the same active correction as in the baseline LHC. The results were presented and discussed at the DS videoconference in April. Work completed by the end of Q2 ahead of schedule.

Field quality analysis and error tables for Nb_3Sn IRQ – Q4.

The work focused on analysis of systematic and random field harmonics calculated in the 90-110 mm Nb3Sn quadrupole magnets and measured in HFDA dipoles and MQXB quadrupoles. Since these magnets have different apertures and reference radii, we are working on determining correct scaling laws for random harmonics. This will help to build error tables as a function of coil aperture. This work is in progress. Completion expected end of Q4, as scheduled.

Financial status of task budget as of 3/31 shows that Fermilab spent $7.9k of $21k (38%) and BNL spent $29.1k of $48k (60%). Work at LBNL is being supported by LBNL core program.



2.2 Model Magnet R&D

Reporters: G. Sabbi, R. Bossert, S. Caspi

2.2.1 Quadrupole

- The manufacture of coils for TQS01 and TQC01 began after completion of the TQ practice coils in FY05. 10 coils - 4 for TQS01, 4 for TQC01, and 2 spares - were wound, cured and measured at Fermilab with LBNL participation. All except the two spares were shipped to LBNL, and reacted and impregnated there. The two spare coils will also be shipped to LBNL for reaction and impregnation.

- Coils TQS-CW-05 through 13 were reacted and potted at LBNL, with FNAL participation. The first 4 coils TQS-CW-05 through 08 were assigned to TQS01 and the second set TQS-CW-09 through 13 (no coil 11) were shipped back to FNAL for use in TQC01.

- The coil manufacturing process was very successful. The decision to have FNAL wind and cure all coils, and LBNL react and impregnate all coils, allowed an optimal use of the program resources, and resulted in a consistent manufacturing process for all coils. In addition, the participation of each Lab in coil manufacturing activities being performed at the other Labs had significant benefits in building collaborative ties and team integration. Coil shipping occurs without damage to the coils. Coils can now be manufactured quickly and efficiently. The last two coils TQS-CW-12, 13 are the best looking coils we have ever made.

- The TQ mechanical review that was held at Fermilab in February 2006 provided very valuable feedback to the program on TQ magnet design, fabrication and testing issues. Several of the recommendations from the review have already been addressed, and others are being implemented.

- Preparations for the fabrication of next two TQ models (TQS02 and TQC02) have started. New cable has been manufactured using RRP conductor. However, tests on the cable indicate possible instabilities, resulting in some uncertainty as to the start date for winding the next series of coils (for TQC02).

- A revision of the model magnet plan and schedule is underway taking into account the experience from TQS01 and TQC01 fabrication, the mechanical model results, the schedule variance, the recommendations of the TQ mechanical review, and the conductor availability and performance issues.

2.2.1.1 Technology Quad TQS01

- The design of TQS01 has been completed, including all coil and structural elements. 2D and 3D magnetic and structural analysis was performed using the computer codes Tosca and ANSYS. Additional structural analysis was carried out with ANSYS to better understand the magnet during assembly cool-down and excitation. The addition of friction to modeling brought about new theories of magnet training.

- The assembly procedure for TQS01 was developed, based on this analysis.

- An assembly and cool-down test of TQS01 was carried out using mechanical coils. Several revisions in hardware and modeling were implemented.

- The 4 coils TQS-CW-05 through 08 were assembled into magnet TQS01. The magnet was pre-stressed and cool-down in stages to 80K. In addition to the strain gauges on the shell and the axial rods, this second mechanical cool-down included strain gauges mounted on the pole piece next to the coil, both in the magnet straight section and in the lead end. This instrumentation provided important additional insight into the mechanical behavior of the magnet and was followed by refined mechanical analysis. The results confirmed that the magnet 4.2K pre-stress levels are sufficiently close to the target values and adequate to proceed with the test.

- A document was developed relating the TQS01 instrumentation and expected measurements to the model objectives and the R&D issues being explored, following a recommendation from the TQ mechanical review.

2.2.1.2 Technology Quad TQC01

- Several mechanical models for TQC01 were built to understand the details of the TQC structure. Coil preload evolution during the collaring process, and during the yoke and skin welding process, needed to be understood and compared to data from analysis. The size of the coil mid-plane shims and collar-yoke shims also needed to be established. Measurements were taken from strain gauges and capacitor gauges mounted in various places within the structure. Collar and yoke deflection measurements were also taken.

- Mechanical model work took longer than expected. Some anomalous measurements with practice coils indicated that side-to-side variations existed within the individual coil structure, causing additional measurements of the coil cross section to be taken.

- Detailed measurements of the practice coils are taking place, in order to understand the coil internal structure. Initial measurements indicate that the placement of components within the cross section is uniform and consistent within about 50 microns. Nevertheless, TQC will use “full round” collars that eliminate the pole “tab” on the outer coil, until a complete understanding of the internal structure is developed.

- Mechanical model measurements are now nearly complete, with coil shims and manufacturing processes using the “full round” collars established.

- All four TQC01 coils are now complete, with construction of the magnet ready to begin. Construction is expected to take about 6 weeks. The magnet test is expected to take place in June 2006.

Schedule variance and budget status

- With respect to the milestones indicated in the last revision of the TQS01 and TQC01 task sheets (Rev. 3, October 20, 2005), the schedule variance as of March 31, 2006 is as follows:

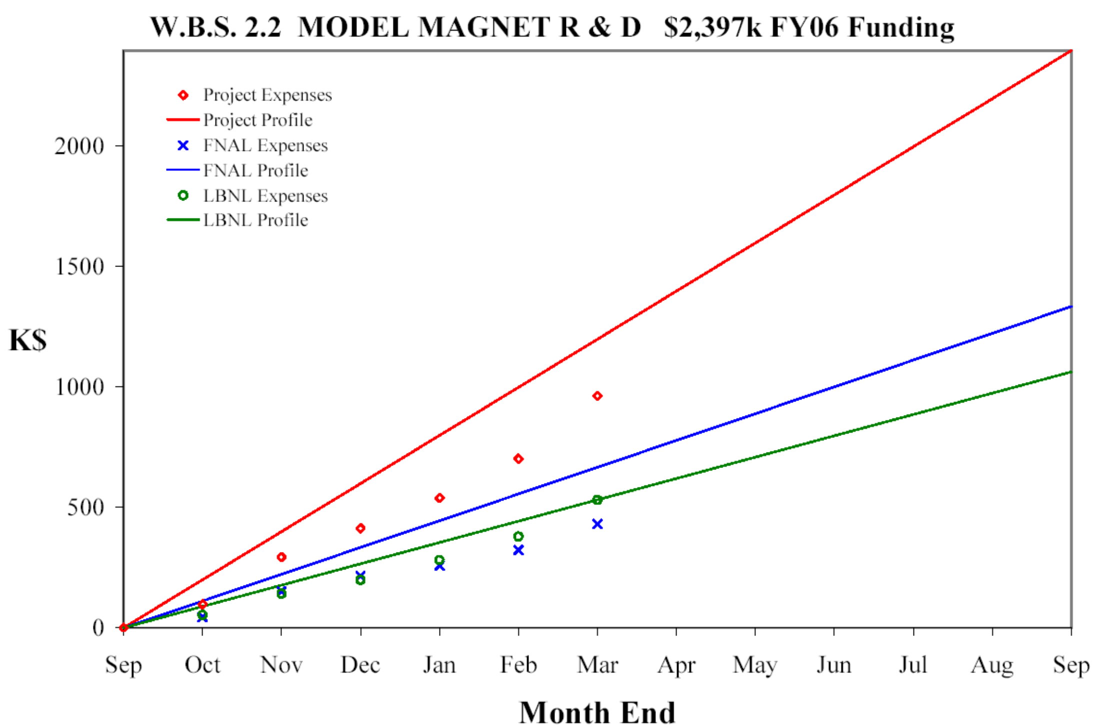
  - TQS01 coil fabrication: +2 month
  - TQS01 mechanical model: +3 month
  - TQC01 coil fabrication: +1 month
  - TQC01 mechanical model: +4 month

  These variances show that additional time and effort is required for

  (a) coil fabrication, and more significantly for
  (b) mechanical analysis and for
  (c) mechanical model fabrication, test and analysis,

  with respect to what was planned at the beginning of the fiscal year. This experience will be taken into account in revising the model magnet R&D plan for the remainder of this year and for next year.

- The model magnet R&D spending rates at the two Laboratories are approximately linear in time and consistent with the total budget allocation for the year. However, based on the higher than expected effort required to complete several of the TQC01 and TQS01 sub-tasks, a request to transfer funds from each of TQS03/TQC03 into TQS01/TQC01 was granted. Progress on TQS03/TQC03 in FY06 will therefore be less than initially planned, consistent with the schedule delays in completion of TQS01 and TQC01. The total model magnet R&D budget at each Lab for FY06 did not change.


W.B.S. 2.2 MODEL MAGNET R & D $2,397k FY06 Funding
Project Expenses
Project Profile
FNAL Expenses
FNAL Profile
LBNL Expenses
LBNL Profile
K$
0
500
1000
1500
2000
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month End

2.3 Supporting R&D

Reporter: G. Ambrosio

The FY2006-2007 SRD work plan is focused on

- Long magnet development by the fabrication and test of long racetrack coils which will be tested in a long supporting structure pre-loaded using bladders and keys
- Subscale models: fabrication and test of a small quad (SQ02) under different end pre-loads

The FY2006 list of acting tasks and task leaders are:

2.3.1 Subscale models

2.3.1.2	Small Quad SQ02 fab & test	Ferracin

2.3.2 Long Magnet Development

2.3.2.2	Racterack coil fab & test	Schmalzle
2.3.2.3	Racetrack supporting structure	Ferracin

The original FY2006 SRD Task budget and its distribution among the participating Labs are presented in Table below (numbers in black color).

			FY2006			
			BNL	FNAL	LBNL	Total
2.3	**Supporting R&D**	**Ambrosio**	1399	47	446	1892
2.3.1	Subscale models					
2.3.1.2	Small Quad SQ02 fab & test	Ferracin		+ 23	155 - 23	155
2.3.2	Long Magnet Development					
2.3.2.2	Racetrack coil fab & test	Schmalzle	1262 + 137	32 - 8	92	1515
2.3.2.3	Racetrack supporting structure	Ferracin			222	222

Budget analysis shows a good agreement between SRD actual expenses and projected expenses at the end of February, but also a parabolic growth. At the end of February LBNL expenses were above the projected expenses. This can be explained by the fact that both SRD tasks at LBNL should be almost completed within FY06-Q3. (SQ02 2^{nd} test has been completed and only analysis is left; Fabrication of parts for SRS01 has been completed, and support for technology transfer to BNL almost competed; Racetrack Supporting Structure should be completed in July with the delivery and the test of the Supporting Structure at BNL.) In addition, some work for the Long Racetrack design was charged to SRD instead of to the LQ Design Study. This is going to be corrected in the next months.

The SRD budget was reviewed in March and the following modifications were introduced (shown in red in the table):

- SQ02: $23k from LBNL to FNAL for SQ02b test
- Racetrack Coil Fab & test: +$137k to BNL for oven costs higher than budgeted, a few things not in the baseline, and adjustments between budgeted and actual costs.
- Racetrack Coil Fab & test: -$8k to FNAL: some trips planned in FY06 for technology transfer moved to FY07 because of the delay in oven procurement at BNL.

2.3.1 *Subscale models*

2.3.1.2 *Small Quad SQ02 fab & test*

Task leader: P. Ferracin (LBNL)

Participating laboratories: LBNL, FNAL

Task status report: work performed in Q1 and Q2

1. Test of SQ02 at "medium" axial pre-load (at LBNL)
    a. Training at 4.3 K
    b. Ramp-rate studies

        c. Quench propagation studies (spot-heater triggered quenches)
2. Analysis of SQ02 test results
    a. Quench locations
    b. Comparison with finite element predictions
3. Reassembly at "high" axial preload (SQ02b)
4. Test of SQ02b (at FNAL)
    a. Training at 4.3 K
    b. Ramp-rate studies
    c. Training at 1.8 K
    d. Temperature-dependence studies
    e. Magnetic measurements

Results are available on the LARP web site at:
https://dms.uslarp.org/MagnetRD/SupportingRD/SubscaleModels/SmallQuadSQ02FabTest/

Plans for Q3-Q4

1. Analysis of SQ02b test results
2. If additional funds are available, otherwise in FY07
    a. Reassembly at "low" axial preload (SQ02c)
        i. Training at 4.3 K
    b. Analysis of SQ02c test results

2.3.2 Long Magnet Development

The work for Long Magnet Development in FY06 consists of two SRD tasks and a topic (Long Racetrack design) under the LQ Design Study task, all of them tightly connected.

We hold weekly meetings (video or phone) and generate weekly reports by the task leaders, in order to facilitate the exchange of information and the development of these SRD tasks in the most effective collaborative way.

Minutes of the weekly meeting and supporting documents can be found on the LARP web site at:
https://dms.uslarp.org/MagnetRD/SupportingRD/LongMagnetDevelopment/meetings/

The LRS01 Design Report (in progress) can be found on the LARP web site in:
https://dms.uslarp.org/MagnetRD/SupportingRD/LongMagnetDevelopment/

2.3.2.2 Racetrack Coil Fab & Test

Task leader: J. Schmalzle (BNL)

Participating laboratories: BNL, LBNL, FNAL

Work performed in Q1 and Q2 for the SRS01 (small racetrack to complete technology transfer):

1. Practice coil wound and impregnated.
2. Ten stack measurement fixture modified to measure SR cable.
3. Retort fabricated and installed in oven for reaction in argon atmosphere.
4. 2 coils wound, reacted, impregnated.
5. Coils assembled into LBL support structure.

Work performed in Q1 and Q2 for the LRS01 (first Long Racetrack):

1. 4m oven specification written.
2. Oven purchase order placed with L&L.
3. Winding machine platform, shuttle and clamping system designed, drawings created and released to the shop for fabrication.
4. Reaction tooling designed, drawings created and released to the shop for fabrication.
5. Impregnation tooling designed, drawings created.
6. Reaction fixture lifting tooling designed, drawings created and released to the shop for fabrication.
7. Coil lifting tooling designed, drawings created and released to the shop for fabrication.
8. Support structure lifting tooling designed, drawings created.
9. Coil parts designed, drawings created and released to the shop for fabrication.
10. Cable re-spooling line designed, detail drawing creation started.

Weekly reports and other documents regarding this task can be found on the LARP web site at:
https://dms.uslarp.org/MagnetRD/SupportingRD/LongMagnetDevelopment/RacterackCoilFabTest/

2.3.2.3 Racetrack Supporting Structure

Task leader: P. Ferracin (LBNL)

Participating laboratories: LBNL

Task status report: work performed in Q1 and Q2

1. 2D and 3D mechanical and magnetic analysis
2. Engineering design (drawings) and procurement of
    f. Aluminum shell (under fabrication)

g. Iron yokes (under fabrication)
h. Iron pads (under fabrication)
i. Aluminum dummy coils (fabricated)

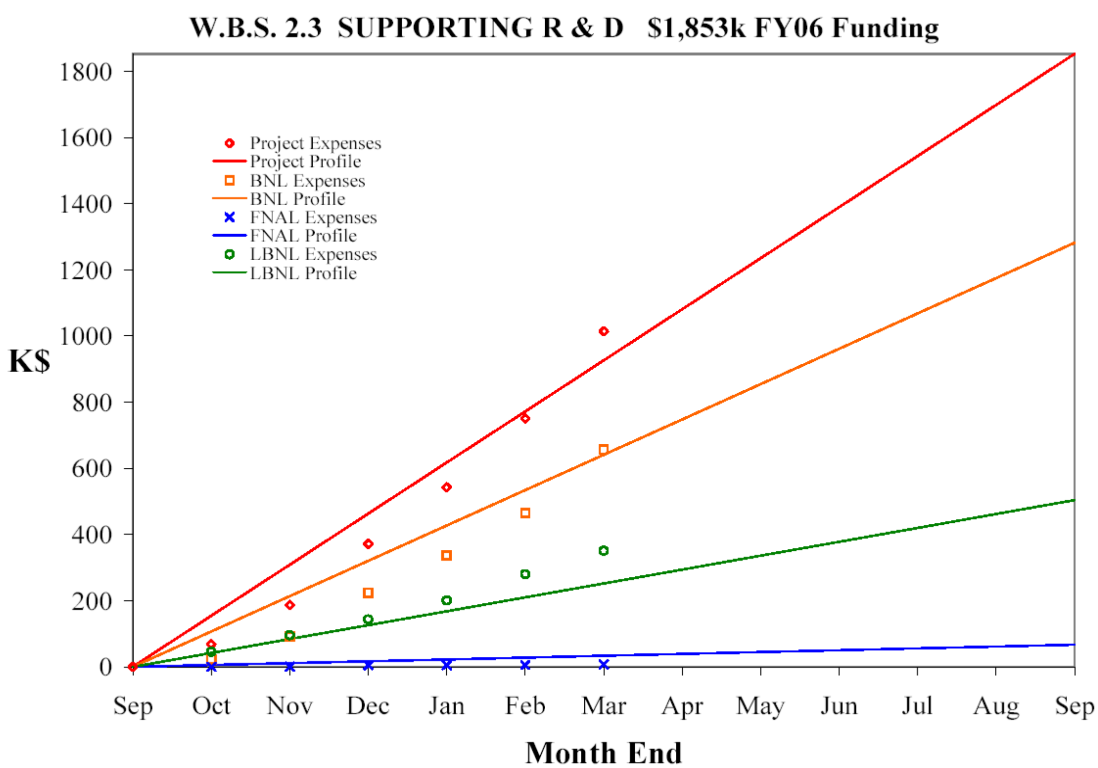
3. Procurement of tie rods, shims, keys, and hardware (under fabrication)
4. Definition of the assembly procedure
5. Definition of the test

j. Pressure sensitive film implementation
k. Strain gauge locations on the aluminum shell

Plans for Q3-Q4

5. Procurements of components required for the assembly (beam, pistons, etc)
6. Instrumentation of the aluminum shell with strain gauges
7. Inspection of the support structure components
8. Assembly
9. Test of the structure
10. Disassembly
11. Inspection of the pressure sensitive films
12. Shipment of the structure to BNL.

Weekly reports and other documents regarding this task can be found on the LARP web site at:
https://dms.uslarp.org/MagnetRD/SupportingRD/LongMagnetDevelopment/RacetrackSupportingStructure/



2.4 Materials R&D

Reporter: A. Ghosh

During the last six months certain key decisions were made regarding strands for the LARP magnets, beyond the initial TQ-magnets which use old MJR strand. Using strand from Oxford's RRP billet 8220 (which was available from the CDP inventory), the materials group established that strands of the 54/61 design can meet the low-field stability requirement of 1000 A for the 0.7mm diameter strand, with the appropriate reaction. Additional tests using a TQ-prototype cable given the optimized heat-treatment showed that the cable has adequate stability for use in TQ magnets. It was therefore decided that RRP strand of the 54/61 design would be the "workhorse" strand for LARP magnets.

The first test of this strand in a magnet will be that of the short race-track dipole SRS01 which will be tested shortly at BNL.

The materials group has also provided cables for several magnets that are being (or will soon be) fabricated. It has also provided testing of strands both round and extracted as "witness" samples for coil reactions.

An outstanding issue that is being addressed is that of strand testing procedures of extracted strands at the three laboratories. During the next quarter, tests are planned to compare critical current measurements of extracted strands reacted in the same furnace and measured at the three labs.

2.4.1.1 Strand R&D

Reporter: A.Ghosh

Summary

BNL, FNAL and LBNL have been testing virgin strands and extracted strands in support of the magnet programs - primarily SQ, SR and TQ magnets. SQ02, TQS01 and TQC01 use strands of the MJR-type. SRS01 is fabricated from a 20-strand rectangular cable using RRP strand. In addition, strands from the CDP inventory were also tested, mostly the RRP strands of different stacking designs which are of interest for LARP. Several tests were also done to accurately determine the RRR of the strands tested. Most of the initial reactions were made at 650-665^{o}C of different durations. Results from these tests prompted further reactions at a lower temperature of 635^{o}C to improve the observed stability current at low fields.

Tests of RRP-8220 wire samples were done to determine the effect of reaction time/temperature on the critical current I_c, the stability current I_s and the RRR. A report of these tests is available on the LARP web-site.
https://dms.uslarp.org/MagnetRD/Materials/ConductorSupport/StrandRD/file.2006-04-13.6854652407/file_view

Figure 1 shows the behavior of I_c and RRR as a function of reaction temperature, Fig. 2 shows the stability current as a function of RRR, and Fig. 3 shows the self-field quench current of the prototype cable as measured by FNAL. The minimum quench current in this test is greater than 15kA.

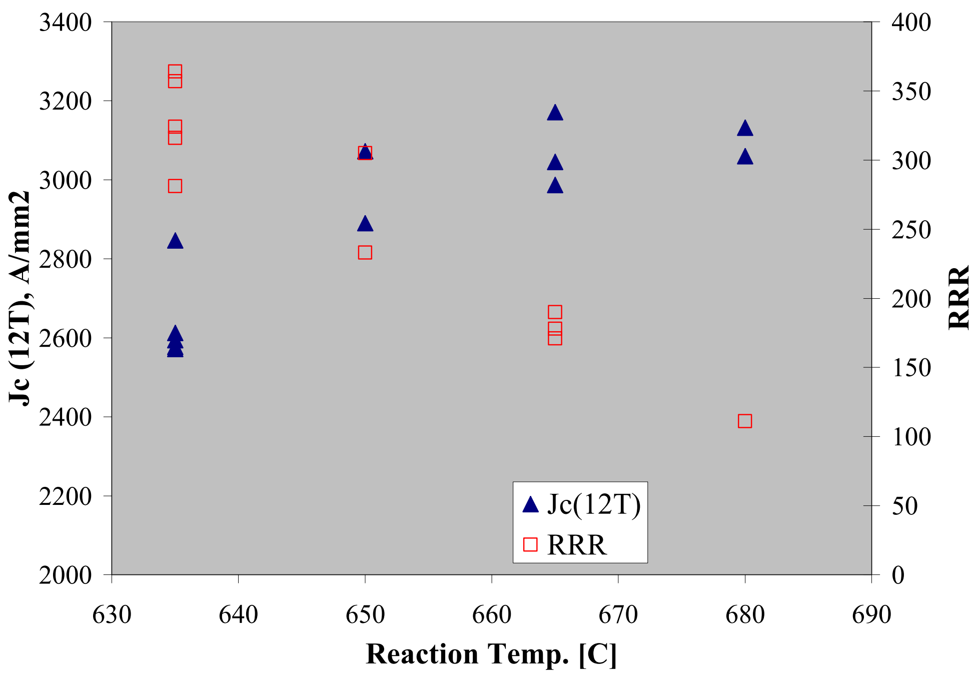


Fig. 1. Critical current density and RRR for RRP-8220 strand

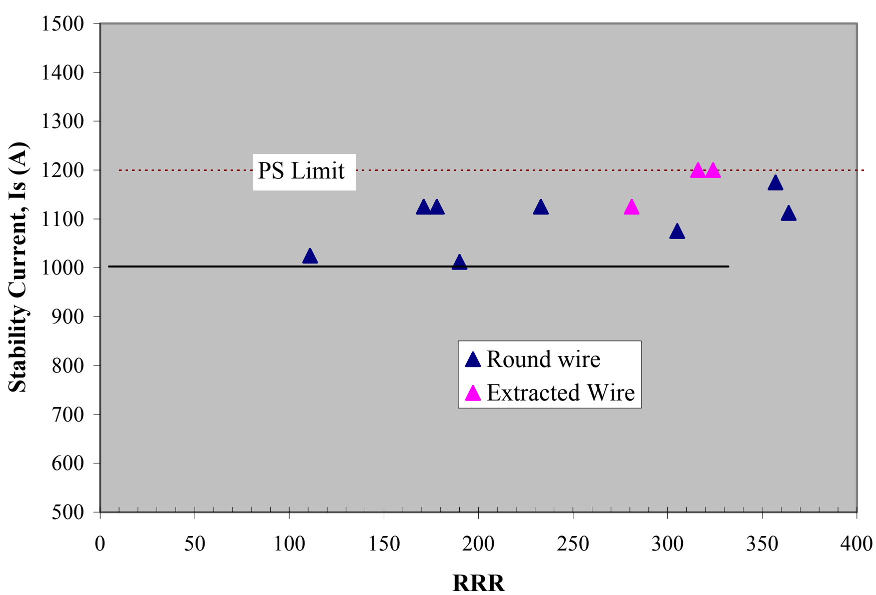


Fig. 2. Stability current as a function of RRR for RRP-8220 strand

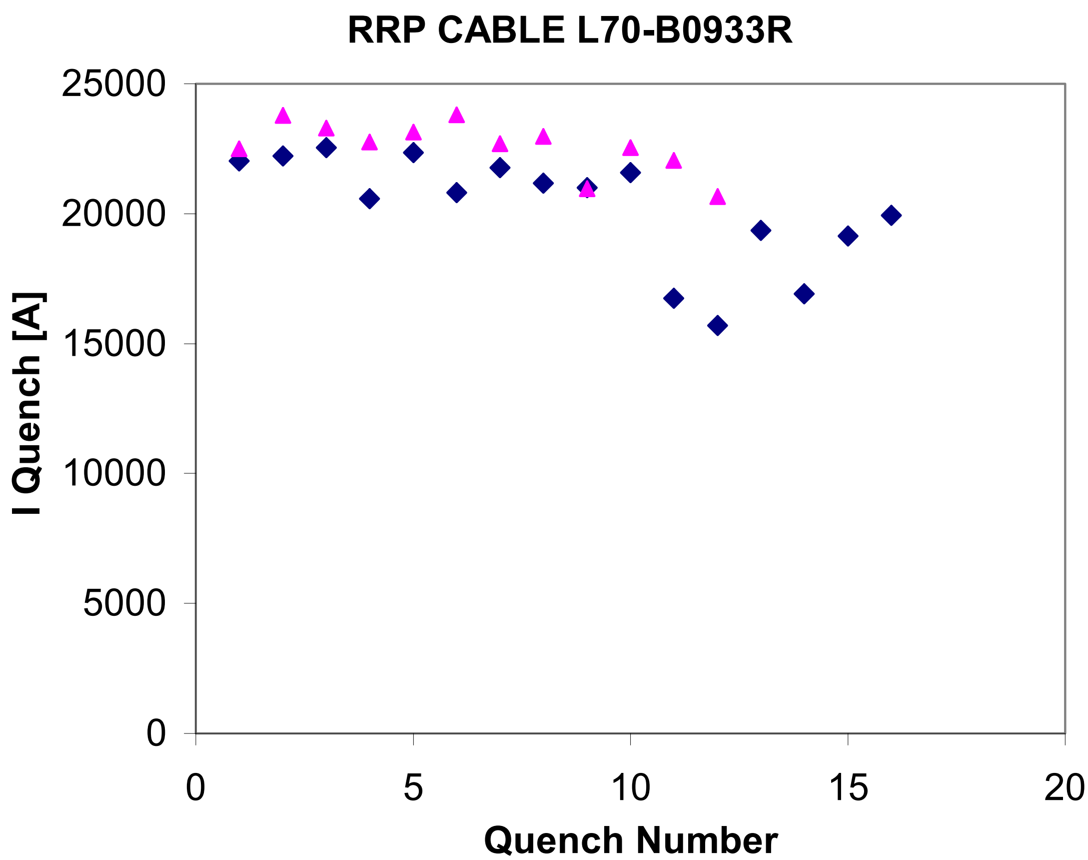


Fig. 3. Transformer test of prototype TQ-cable using RRP-8220 strand (**FNAL**).

We conclude from these results that the new generation of 54/61 strands from OST have the capability of high Jc as well as a lower tendency of Sn-contamination, compared to the billets produced in 2003 and 2004. It appears that reacting at a lower temperature of 635-650 C for 48hrs still produces a Jc > 2600 A/mm2 at 12T with no contamination of the inter-filament copper as shown by the high RRR > 300. The stability current for these wires is greater than 1000 A. This genre of strand is deemed suitable for the immediate needs of the LARP magnets, based on these and on subsequent measurements of the cable at FNAL,

The following reports summarizing the testing of witness strands and cables are available on the LARP website:

1. Witness Sample Test Results for SQ-02 (LBNL), Practice Coils 1-3 (FNAL) and Practice Coils 2-4 (LBNL).
2. Witness Sample Test Results for SRS01.

I. BNL Activity:

Measurements at BNL are usually done on Ti-Al-V alloy barrels. However, samples are reacted on stainless steel grooved barrels and then transferred to the Ti-alloy barrel. All reactions are in vacuum in the large oven at the Magnet Division or in the small tube-furnace in the Material Science Dept. Witness samples from the various coil reactions at different labs are usually done in a retort in flowing argon gas.

During the first two quarters of FY 2006, 62 strand samples were measured at BNL. These included samples reacted as witnesses for coil reactions which included round as well as extracted strands from the cables that were used to wind the coils. A summary of the strands tested and the test results are available on the LARP web-site. Note that BNL's maximum current for Ic is 1500A, and that for stability current is 1200A.

https://dms.uslarp.org/MagnetRD/Materials/ConductorSupport/StrandRD/folder.2005-11-22.1371415180/

II. FNAL Activity:

FNAL was very active during the first half of FY06. A total of 58 strands were tested, including witness samples from coil-reactions at LBNL, FNAL, BNL, and samples from RRP billets 8220, 8647 and 7933. FNAL has documented most of the relevant information in reports that summarize test results for various witness sample tests. These are available on the LARP web-site:
https://dms.uslarp.org/MagnetRD/Materials/ConductorSupport/StrandRD/

In particular the reports document all the relevant strand tests including extracted strand, and provide short sample limits for the magnets. The test procedures that were used are also documented on the website TD-05-046.

A difference in Ic of as much as 10% is observed in comparing extracted strand data from FNAL and BNL. FNAL has been comparing test procedures using end-splices and restraining wire movement by using Stycast. A series of round-robin tests between the three labs is planned during the next quarter. Extracted samples will be taken from Cable B0939R, and all of them will be reacted at BNL.

FNAL is also conducting tests of rolled strands, in order to evaluate the tendency of the deformation of the newer RRP strands to cause filament merging of distorted sub-elements, and the effect on magnetization and low-field stability.

III. LBNL Activity

LBNL is in the process of improving the strand test station, and hence has done only a very limited number of strand tests ~- about 10 samples. However, the RRR of 16 samples which were reacted as witness samples were tested to check that the RRR of the TQ-coils is adequate to ensure adequate strand stability.

WORK IN PROGRESS AND FUTURE STEPS

Heat treatment optimization cycles that provide good Ic, Is and RRR are being performed with RRP material, in order to establish a suitable heat treatment schedule for the next series of TQ magnets. Witness samples from the SRS and extracted strand from new TQ cables will be used to further study the effect of time/temperature on the stability and critical current of round and extracted strands.

2.4.1.2 Cable R&D

Reporter: A.Ghosh

2.4.1.2.1 Cable fabrication

Cabling at LBNL has been proceeding on a schedule commensurate with requirements for coil winding. LBNL has been using the new RRP strand to fabricate rectangular and keystone cables during the last six months. These cables are being insulated using a fiberglass sleeve treated with palmitic acid as a sizing agent. The recent TQ-cables are still being evaluated for cabling degradation.

I. LBNL Activity.

CABLES FABRICATED AT LBNL

Cable TYPE	CABLE ID	STRAND	MAGNET	Cable Designation	Date / Manufacture
L7O	B0933	RRP	TQ	Prototype	10/5/2005
S3O	B0935	RRP	SQ	Production	10/28/2005
L7O	B0936	RRP	TQ	Prototype	11/10/2005
L7O	B0939	RRP	TQ	Production	3/9/2006
L7O	B0940	RRP	TQ	Production	3/20/2006

L70-B0933R

The objective of this cabling run was to manufacture a short length of TQ cable using the new RRP 8220 wire to evaluate the effect of cabling on strand properties. 26m of this cable was made and used for the short sample measurements reported in the strand section.

LARP SRS Cable

The cable for the first short racetrack SRS magnet was fabricated in October 2005 **(S3O-B0935R).** 86m of insulated cable was delivered to BNL for coil winding that took place during this quarter.

Sections of cable 935R were mounted for metallographic examination. Microscopy revealed an internal scratch on the wire caused by a burred edge on the mandrel. It was observed that a strand at the edge of the cable had a small scratch on its interior edge. Two short sections of cable - one from each end - were opened to observe the interior, and to better determine the nature of the scratch. There are two conclusions:

1. The scratch is visible at both ends. Therefore, it must be present along the whole length of the cable.

2. The scratch does not penetrate to the level of the sub-elements.

The Cu matrix was removed with nitric acid and the sub-elements in the region of scratch were inspected, in order to confirm that the sub-elements were not damaged. No damaged or scratch sub-elements were found in either section.

L70-B0936

A short 18 m length of cable was produced using RRP strand with a larger keystone angle of 1.2 degrees. This was done to study the effect of varying the keystone angle and the number of strands.

L70-B0939R

The cable for the next series of magnets TQC-02 was made in March 2006, using the nominal parameters of the TQ cable. Cable was fabricated from RRP-8220-2 and 8220-3. Cabling went very well. The first-pass had cabling tension fluctuations of +/- 10 lbs. 263 m of insulated cable (4 Unit lengths) were shipped to FNAL for coil winding.

L70-B0940R

This cable used wire from billet RRP-8647 spools 1,2 and 3. Cabling went very well. First-pass cabling tension was maintained at 105+/- 5 lbs. 128.8m of finished cable (2 UL) were shipped to FNAL on 3/28/06.

II. FNAL Effort

The following work was done to qualify the cabling machine at FNAL to fabricate cable for the LARP program.

About 50 m of 27-strand cable and 50 m of 28-strand cable were obtained in a first rectangular pass using 0.7 mm hard Cu (NEEW A101). Sizes (thickness and width) were recorded in each case. The following four cases were used in a search to establish the appropriate thickness (thin and thick edge) to be used to obtain a 10.08 mm wide cable (size of groove) during the pass to keystone the cable:

1* 27-strand, 1.3 degree
2* 27-strand, 0.9 degree
3* 28-strand, 1.3 degree
4* 27-strand, 0.9 degree

Two lengths of the 28-strand cable, ~14 degree of lay angle (one of a dozen meters, and one of half a dozen meters), each with a slightly different thickness, were shipped to LBNL to be measured. The distributions of width, thickness and angle as obtained at LBNL will be compared with FNAL measurements (also marked at several points on cables).

About 120 meters of 27-strand cable of 0.7 mm strands of Alloy68 from NEEW were fabricated in one single pass by mounting the sizing fixture and the keystone rollers in series. The keystone angle was 0.9 degree. This cable was used to explore sizes and lay angles.

MID-THICKNESS Study: A thicker cable (27 strands of 0.7 mm Alloy68, 14.5 degree lay, 0.9 degree keystone), narrower than nominal, was produced and measured in several points. A thinner cable with nominal width (same parameters as above) was produced and measured in several points.

LAY ANGLES: The lay angle was reduced as much as possible to determine the minimum angle that could be used. Then some experimentation with sizes was made as in the case of the 14.5 angle. A cable was made with average thickness ~1.26 mm, and a thinner cable was made with nominal width.

The grooved rollers used to keystone the cable of 10.08 mm width were ground with a 0.062 in radius.

2.4.1.2.2 Cable Test

So far there have been no measurements of cables at high fields. A plan to set-up a test facility at BNL has been shelved for lack of funds from the core-program. LARP so far has not committed funds for high field cable test. The facility at the NHMFL is a possible site for making limited tests. Another is the FRESCA facility at CERN. Both of these options will be discussed at the next April collaboration meeting. The efficiency of extracted strand tests as a means of predicting cable performance is being evaluated. The procedures for testing extracted strands are currently under review.

I. FNAL Activity

The program has relied on FNAL transformer test to establish the low-field stability of the cable during the last two quarters. The cable samples were mostly reacted along with the coils for TQ and SRS magnets. Below are tables of the cables that were tested, and their test results.

CABLE TESTS

HEAT TREATMENT	Cable ID	Impregnation
SQ-02, LBNL	926R (SQ)	Y
“	“	N
PC-13, FNAL	928R-B (TQ)	Y
“	“	N
PC-24, LBNL	928R-B (TQ)	N
“	932R-A (TQ)	N
“	933R (TQ)	N
“	“	N
SRS-C01 (HT-038), BNL	935R (SRS)	Y
“	“	N

WITNESS CABLES TEST RESULTS

HEAT TREATMENT	Cable ID	Impregnation	Cable Ave. I_q, A	Cable Min. I_q, A	Ave. I_q/strand, A	Min. I_q/strand, A
SQ-02 at LBNL	926R (SQ)	Y	18362	17965	918	898
“	“	N	18874	17846	943	892
PC-1&3 at FNAL	928R-B (TQ)	Y	19836	18827	734	697
“	“	N	19706	18593	729	688
PC-2&4 at LBNL	928R-B (TQ)	N	20391	19773	755	732
“	932R-A (TQ)	N	23472	22981	869	851
“	933R (TQ)	N	22581	20569	836	762
“	“	N	20114	15740	745	583
SRS01-C01	935R(SRS)	N	18693	17560	935	878
“	“	Y	18070 [a]	16119 [a]	904 [a]	806 [a]
SRS01-C02	“					

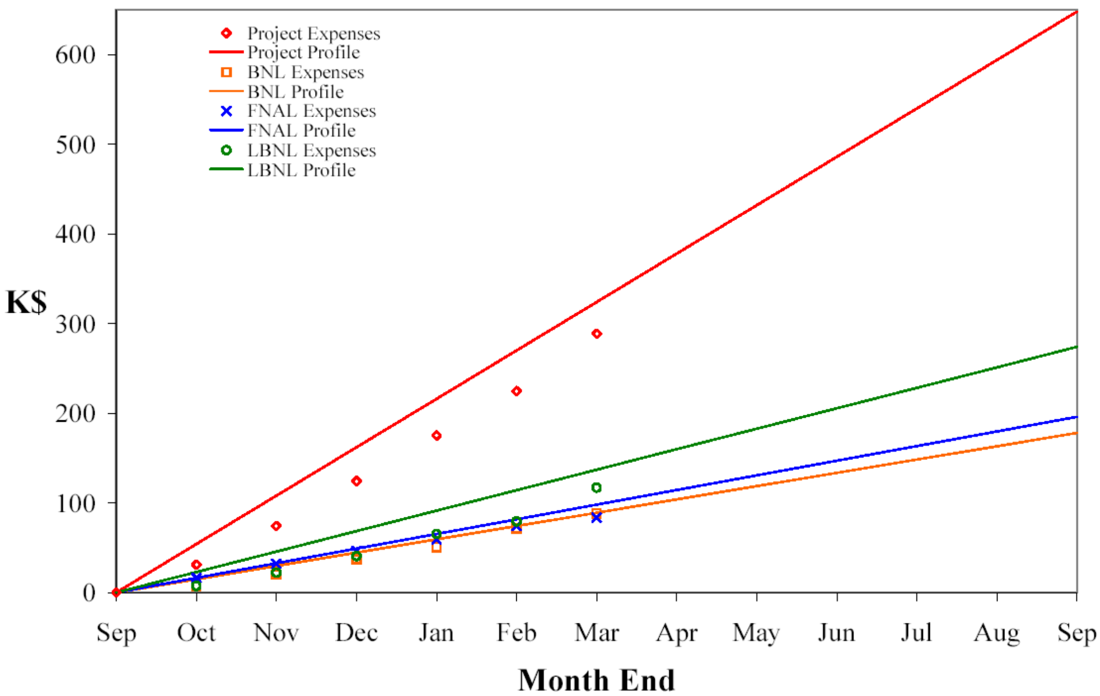
[a] Values not corrected yet for drift

Low field performance is measured on both strands and cables. Cables at self-field appear to quench at currents that are systematically lower than in strands. The prediction on magnet stability performance improves with test statistics. The present data indicate that the cables fabricated so far have adequate stability so that magnets will not be limited by the low-field instability inherent in the strands.

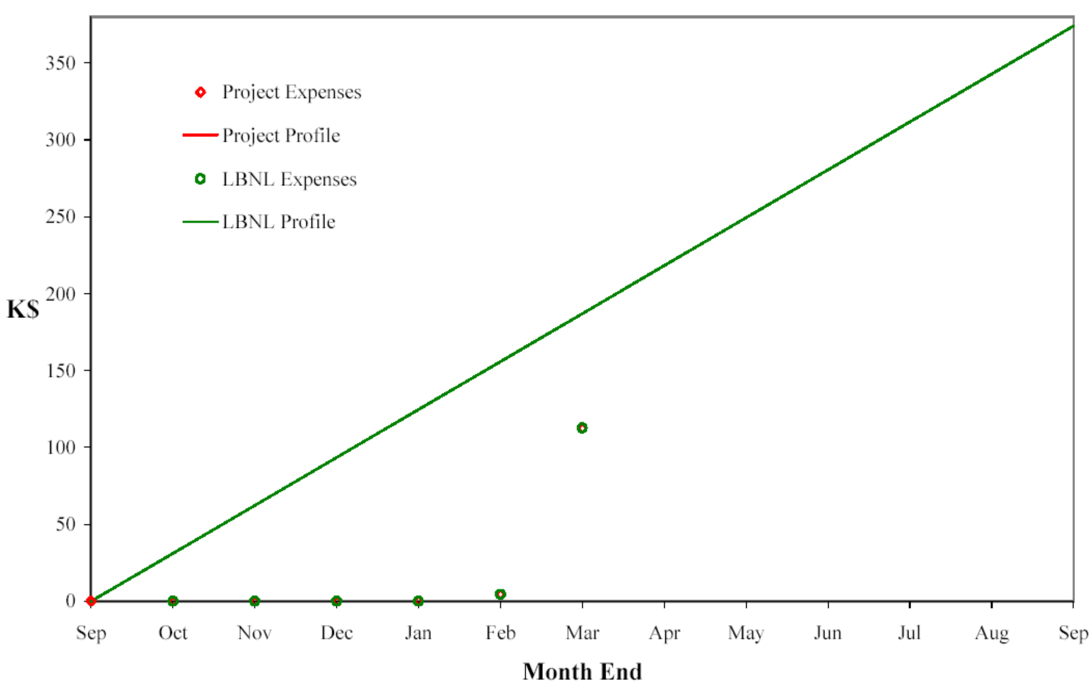
II. BNL Activity

A pair of cable samples from B0933R was reacted at BNL during an SRS coil reaction, and then impregnated and tested at applied fields up to 7T. This proved not to be successful. In lieu of testing cable samples, BNL has been testing many extracted strands from a cable sample to establish statistical variation in I_c and I_s.

W.B.S. 2.4.1.1 and 2.4.1.2 MATERIALS STRAND & CABLE R&D $274k FY06 Funding



W.B.S. 2.4.1.3 MATERIALS: PROCUREMENT $374k FY06 Funding



2.4.1.3 Strand Procurement
Reporter: A.Ghosh

A specification for magnet strands, Spec. No. LARP-MAG-M-8001-RevB, was released for procurement in October 2005, as shown below.

Main parameters of the strand

Process	Ternary RRP Nb_3Sn
Strand Diameter, mm	0.7 ± .003
Jc(12 T) at 4.2 K, A/mm^2	≥ 2400
D_{eff}, μm (based on billet design)	< 70
I_S, A	> 1000 A
Cu-fraction, %	47 ± 2
RRR (after full reaction)	≥ 100
Twist Pitch, mm	14 ± 2
Twist Direction	right-hand screw
Minimum Piece length, m	350
High temperature HT duration, h	≥ 48

A visit to Oxford-Instrument Superconducting Technology (OST) at Cartaret was made in FY06 Q1, to discuss the strand requirement for LARP and to get an update on the R&D that OST is conducting for the Conductor Development Program. LARP placed orders in FY06 for about 270 kg of finished wire during this period. The vendor took exception to the I_s specification, since that is not routinely measured in industry. It was agreed that this exception does not materially affect the strand property, based on experience gained from tests on billet 8220. Since the I_c requirement is fairly conservative, I_s condition can be met by lowering the reaction temperature. LARP will test every billet and cable to qualify the conductor for use in magnets.

Table of LARP and CDP orders to OST

Order Date	Ship Date	Adjusted Ship Date	Quantity	Completed	PO	Program	Billets
	4/1/2006	at LBNL	30			CDP	8220
2/28/2005	11/30/2005	at LBNL	70		6720228	CDP	8647, 8648
8/29/2005	3/31/2006	5/15/2006	30	21	6802116	CDP	8817
"	"	7/15/2006	60		"		
			190			**CDP**	
11/7/2005	7/2/2006	3/30/2006	90	37.4	6803608	LARP	8781
				16.1			8817
				36.5			8857
1/20/2006	9/6/2006	9/6/2006	90		6804489	LARP	
2/23/2006	11/30/2006		90			LARP	
TBD	TBD		30		TBD	LARP	
			300			**LARP**	

90 kg has already been delivered to LBNL under the LARP orders, and 70kg under the CDP order. The Table below shows the present status of the LARP and CDP orders. All strands are of the RRP-54/61 design. The delivery dates as shown are the standard time that OST reserves after order is placed. We expect some of the delivery to be ahead of schedule.

Project Expenditures

Reporter: A. Ghosh

Report through June30, 2005:

Costs reported, as available, by Laboratory for individual activities for FY06.

WBS		**FY Expenses through March 31, 2006**					**Funding Balance as of March 31, 2006**				
		BNL	**FNAL**	**LBNL**	**SLAC**	**Total**	**BNL**	**FNAL**	**LBNL**	**SLAC**	**Total**
2.4	**Materials**	71.4	74.1	83.7	0	229	107	122	20	0	21
2.4.1	Conductor Support										
2.4.1.1	Strand R&D	*57.0*	*57.0*	*16.6*	*0.0*	131	80.0	112	24.4	0	216
2.4.1.2	Cable R&D	*14.4*	*17.2*	*62.7*	*0.0*	94	26.6	9.8	170.3	0	207
2.4.1.3	Procurement	*0*	*0*	*336.1*	*0*	336.1	0	0	37.9	0	37.9

Strand and cable testing charges to LARP are not consistent with the actual number of samples tested, at both BNL and FNAL. A significant portion of the cost is being provided by the core-programs, was assumed at the start of FY06. The actual estimated cost (just for testing) during the last six months is ~ 127 k$ (BNL) and ~ 140k$ (FNAL). This does not include the labor and other cost for reacting the test samples. That compares with 71k$ for BNL and 74k$ charged by FNAL. Charges for cabling seem to be under-reported by LBNL in the amount of ~ 18k$. In procurement, ~ 38k$ has yet to be committed for FY06.