October 11, 2010: Final Report of the DRCC

From: Review Committee: Dana Arenius, Arne Freyberger, Allison Lung, Steven Wood,
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To: Dr. Hugh Montgomery
Subject: Directors Review of Cryogenic Capacity

OVERVIEW

The review committee held a series of open meetings with the cryogenic stake holders during the time period March through May. We heard from the Cryogenics Group on the capacity of various refrigerators and transfer lines throughout the JLab site. This was followed up by a series of open meetings discussing the cryogenic needs of Halls A and C, the Free Electron Laser, Halls B and D, the Test Lab and the Accelerator. The customers provided their cryogenic needs during three operating periods (through 6 GeV operations; 12 GeV commissioning; and 12 GeV research era) via spreadsheets provided by the committee. All presentations, public minutes and data sheets are kept on an open web site (*http://www.jlab.org/div_dept/dir_off/ccr/*).

We are submitting this Final Report addressing the specific bullets in your charge and providing the committee's suggested solutions. This report represents a snapshot of an analysis of the data received over the past six months. We anticipate that as new equipment comes on line some factors may change and it may be prudent to re-evaluate the data after 12 GeV operations begin in FY14 to FY16.

Several spreadsheets are attached to this Report which summarizes the cryogenic loads and capacities as a function of time. Three time periods have been defined for this exercise:

- Time Period 1 covers the remaining 6 GeV operations including the 6-month shutdown with 12 GeV installation work (October 2010 through mid-May 2012).
- Time Period 2 covers the 12 GeV major installation and commissioning periods through the start of the 12 GeV research era (mid-May 2012 through the end of FY2015).
- Time Period 3 covers the 12 GeV Research Era (FY2016 and beyond).

Appendix A includes the Accelerator and FEL cryogenic loads and capacities for these time periods. Appendix B includes the cryogenic loads and capacities for the Experimental Halls and Test Lab for these time periods.

Charge to the Review Committee

This Review is to address the totality of the cryogenics on the site. The Committee should examine three aspects: the capacity of the plants; the performance of the transfer lines; the cryogenic loads. It is understood that these are all entangled. The questions to be addressed are as follows:

1. *Loads*

a. *What are the present cryogenic loads?*

The *present* loads for the 6 GeV physics program in the Accelerator, the current FEL program, the magnet and target loads for Halls A, B and C, the magnet coil test loads for Hall D and the CM and cavity test loads in the Test Lab have been enumerated, documented and are well understood. See attached spreadsheets.

b. *What are the planned loads, and when will they require cryogenics?*

The *planned* loads during the next several years and during the 12 GeV operations era for the accelerator, the FEL program, the magnet and target loads for Halls A, B, C and D and the Test Lab are also well documented and understood. See attached spreadsheets..

c. *What possible loads are on the horizon?*

The *possible* new loads on the horizon include target load increases in the Halls (particularly for Hall A's Moller experiment during the 12 GeV program), and for the FEL program if JLamp and or JLamp Ultimate become a reality. In addition consideration has been given to reactivating the cryogenic capability for source development in the Test Lab injector test area. See attached spreadsheets.

2. *Capacity of the plants (CHL1, CHL2, ESR1, ESR2, Hall D, CTF)?*

a. *What is the cooling and refrigeration capacity of each of the plants that are either operating or planned?*

Table 1. Capacity of Refrigeration Plants and Operational Dates

Refrigerator	Operational Date	Capacity @2.1K	Capacity @35K	Liquefaction @4.5K	Capacity @4.2K	Capacity @20K
		W	W	g/s	W	W
CHL#1	Now	4600	12000	10		
CHL#2	Jan 2012	4400	12000	15		
CHL#1&2	Jan 2012	8800	24000	25		
ESR#1	Now			11	1500	
ESR#2	Unknown				4000	5000
CTF#1	Now		1000			
CTF#2	Now			5	700	
CTF#3 (Hall D)	Mar 2012			2	200	
CHL Standby	Now		12000	20	1800	

b. *For the planned plants, what is the expected date when the plant becomes available?*

CHL#2 is part of the 12 GeV Upgrade construction project. It is on track for the start of 12 GeV operations and is expected to be operational in January 2012.

CTF#3 (Hall D Refrigerator) is currently being used for coil testing in the Test Lab. It will be relocated to Hall D in March 2012 for commissioning and operation of the solenoid magnet.

Additional refrigeration capacity will be required for the proposed research program in Hall A in FY16 and beyond (e.g. the Moller experiment). This capacity could be provided by the ESR#2, which although the refrigerator is designed and the necessary building is under construction, the refrigerator itself is currently unfunded.

3. *Transfer lines*

a. *What is the capacity of each of the transfer lines?*

The *capacity of the transfer lines* in the Accelerator, the current FEL program, the magnet and target loads for Halls A, B and C, the testing loads for Hall D and for the Test Lab have been enumerated, documented and are well understood. See attached spreadsheets.

b. *What are the losses of the existing transfer lines?*

The *losses of the transfer lines* in the Accelerator, the current FEL program, the magnet and target loads for Halls A, B and C, the testing loads for Hall D and for the Test Lab have been enumerated, documented and are well understood. See attached spreadsheets.

c. *What upgrades to existing transfer lines are planned?*

The *upgrades to the transfer lines* in the Accelerator, the current FEL program, the magnet and target loads for Halls A, B, C, and D and for the Test Lab have been enumerated, documented and are well understood. Specifically the valve stems on the 12 GeV cryomodule return valves will be changed to reduce the return line pressure drop. See attached spreadsheets.

d. *What new transfer lines are planned?*

New transfer lines planned include the U tubes for the ten (10) new cryomodules (CMs) in the Accelerator, U tubes for the two (2) new magnets in Halls B, the four (4) new magnets in Hall C, and the one (1) magnet in Hall D.

Should JLamp and/or JLamp Ultimate be funded, a reevaluation of the connecting transfer lines between CHL#2 and the FEL will be required.

Should the injector test area be reactivated for source development, a reevaluation of the impact on test lab operations is warranted. All loads have been enumerated, documented and are understood at this time. See attached spreadsheets.

Table 2. Transfer Line Summary

Transfer Line	Availability	Capability (g/s)	Losses (g/s)	Upgrades
CHL#1 to Linacs	Now / 2012	200	20	Valve stems 2012
CHL#1 to ESR	Now	30	5	
ESR#1 to CTF	Until Summer 2010			Removed for TEDF construction
CHL#2 to FEL	Now / 2012	35	10	None planned; additional capacity would be required for JLamp
ESR#1 to Hall A	Now	10	2	
ESR#1 to Hall B	Now	10	2	Two new magnets 2013
ESR#1 to Hall C	Now	10	2	Five new magnets 2013
CTF#3 to Hall D	August 2012	2	0.5	One new magnet/target 2013
CTF#2 to VTA	February 2011			10 kL Dewar

The current capacity and losses associated with the accelerator transfer lines are acceptable for 6 GeV operations.

For 12 GeV operations, the new cryomodules will require and will construct two sets of U tubes for the primary 2K and the secondary 35K supply and return cooling circuits. In addition, transfer lines are required to connect CHL#2 to the Linac. These loads have been accounted for and are acceptable for 12 GeV machine operations.

The current capacity and loss for the existing FEL transfer line is adequate for the current FEL program; however, if JLamp and/or JLamp Ultimate become a reality, then the transfer line mass flow will increase and the size will become inadequate. This will require re-evaluation of the transfer lines commensurate with the heat loads. It was suggested to introduce the cooling to the proposed JLamp cryomodules similar to what is done on both linacs for the main machine, namely to feed cryogens at the middle and then go in both directions. The committee believes this idea has merit.

Hall B and Hall C are obtaining new superconducting magnets as part of the 12 GeV Upgrade, and will require and construct new U tube transfer lines. The heat loads for these new transfer lines and components should be adequately handled by the current transfer line from ESR#1 to the Halls.

The cryogens available to meet the Hall B target load are adequate for current operations (6 GeV) and for the foreseeable future (12 GeV) operations.

The Hall C target load for Q_{Weak} requires extensive modification to accommodate the higher mass flow and cryogenic load. The Hall A SOLID experiment proposed to run during the 12 GeV research program will only increase these requirements. The Committee believes that the target cooling lines for Hall C need to be re-evaluated in light of these higher target powers and resulting higher mass flow requirements. One remedy would be to modify the existing supply and return lines as a supply and add an additional transfer line as a return to accommodate these higher flows.

The heat load associated with Hall A's transfer lines for the 4 K circuit have been traditionally high and have deteriorated over the last ten years. The target heat load projected for the proposed Hall A Moller experiment make the existing transfer line inadequate during the 12 GeV research era. The Committee believes that all transfer lines in Hall A should be re-evaluated and a systematic upgrade be implemented to accommodate the anticipated higher mass flows and loads during the 12 GeV era.

Hall D is planning on new transfer lines as part of the 12 GeV Upgrade installation, so the capacity and losses should be adequate for 12 GeV operations.

The target load for Hall D is to be accommodated by a separate closed cycle refrigerator that is presently planned. Like Hall B, the target loads for Hall D should remain relatively small.

The Test Lab transfer line capacity and losses to the vertical test facility (VTA) and the cryomodule test facility (CTF) are currently adequate.

There are plans in 2011 to install a 10000L Dewar to facilitate operations associated with CM/CTF testing. This is not scheduled until February 2011. This dewar, in addition to an existing 1000G (3800L) dewar, will greatly facilitate this testing in several ways. The new dewar is equipped with an internal condensing coil that reduces the flash losses (now 40%) to much lower values. Additionally, the dewar is equipped with a liquid withdrawal which will greatly facilitate transfers. These improvements will enable CM testing to occur simultaneously with VTA testing at the rate needed for the 12 GeV Upgrade production schedule.

The transfer line currently feeding the CTF from the ESR is to be removed because of interference with the new Technical Engineering Design Facility (TEDF).

There is interest in reopening the injector test cave as a cryogenic source development area. Should this be implemented then the impact on the current test program CTF/VTA need be evaluated.

4. Solutions

Are the planned improvements (new or upgraded cryogenic plants?)

a. Necessary?

All of the planned improvements (CHL#2 and 10000 L Dewar) of the cryogenic plants are necessary.

b. Sufficient?

All of the planned improvements (CHL#2 and 10000 L Dewar) of the cryogenic plants are sufficient.

CHL#2 in the accelerator has sufficient capacity for the 12 GeV Upgrade and possibly for the existing FEL if the estimates of the 12 GeV machine heat loads are accurate. Any increase in the heat load demands for a JLamp or JLamp Ultimate facility can not be met by CHL#2. This will require a new refrigeration source for the FEL or could possibly be handled through scheduling. See attached spread sheets.

CTF#2 in the Test Lab has sufficient capacity to meet the 12 GeV Upgrade schedule provided the additional 10000 L Dewar operates as planned and the flash losses are reduced. During FY16 and beyond, the Test Lab C50 and WFO programs will be impacted if source development becomes a reality. This can be remedied by the planned improvements to CTF#2 (namely a new 2 K heat exchanger) and/or scheduling. See attached spread sheets.

c. Available when required?

As mentioned, there are plans to install an 10000L Dewar in February 2011 to facilitate operations associated with CM/CTF testing. It is anticipated that CM testing will commence then, and could be seriously impacted. This conflict can be remedied by slow cool downs of the CM's, and by scheduling, but if the dewar could be installed sooner this would greatly improve the testing program.

Committee Findings:

- The planned upgrades to the existing JLab cryogenic systems (CHL#2 and the 10000 L Dewar in the Test Lab) are necessary and sufficient to meet the 12 GeV Upgrade needs for both construction and machine operation.
- If the projected heat loads of the 12 GeV accelerator are realistic, then the planned upgrades mentioned above will also be sufficient to operate the current FEL program.
- If a C100 cryomodule would fail, there would not be sufficient cryogenic capacity to operate the 12 GeV machine plus meet the needs of the current FEL program.
- Additional cryogenic capacity will be required in the 12 GeV research era in order to operate the 12 GeV base equipment in Halls B and C as well as the proposed Hall A Moller experiment.

Committee Comments:

- Maintaining the timeline for the installation of the 10000L dewar in the CTF, or even moving it ahead of schedule, will have a positive impact on 12 GeV CM testing.
- Installing transfer lines for the remote fill of the Moller Polarimeter in Hall A would alleviate potential near-term conflicts in the FY11 6 GeV running planned for Halls A and C.
- Due to the increased loads anticipated in the 12 GeV operations era for Halls A and C, improvements in the efficiency of the target transfer lines should be investigated.
- Maintaining the timeline for the fabrication and installation of the 2K heat exchanger for CTF#2 will have a positive impact on the capacity in the Test Lab to handle, the C50 program, and WFO programs.

- The additional cryogenic capacity required to operate halls A, B & C simultaneously (while Hall D is off) during the 12 GeV research era, particularly if one hall is running a high heat load experiment such as Moller or SOLID, could be provided by the envisioned ESR#2.
- The timeline for bringing an ESR#2 online is driven by the out year operating schedule, and would be needed no later than the earliest date that all three existing Halls would be running simultaneously.
- In the event of a C100 cryomodule failure during the 12 GeV research era, possible solutions would include installing a spare cryomodule, delivering reduced beam energy, or increasing the capacity of CHL#1 or CHL#2.
- Given the magnitude of the cryogenic requirements for an FEL JLamp and/or JLamp Ultimate, a thorough review of the cryogenic cooling requirements and the cryogenic resources is warranted prior to JLab commitment to the project.
- A thorough review of the cryogenic cooling requirements, and potential impact on existing Test Lab efforts, should be carried out prior to pursuing source development in the Test Lab.

Committee Recommendations:

- Secure funding and finalize plans for installation of the ESR#2 refrigerator to make it available for the proposed Hall A research program in the 12 GeV era (e.g. Moller and/or SOLID experiments). Depending on out year operations, this could be as early as 2015, but should be no later than 2016.
- Secure funding and finalize plans for construction of a spare C100 cryomodule to permit 12 GeV machine operations in the event of a failure.

APPENDIX A

Accelerator and FEL cryogenic loads and capacities for Time Periods 1, 2, and 3

Time Period 1 has been split into three smaller time periods. Note that the last time slot shows two scenarios for C100 operational during that time.

									2K Load may be a problem			2K Load may be a problem		
						Shield load may be a problem			Shield load may be a problem			Shield load may be a problem		
Accelerator Loads														
Time Period 1			**6 GeV Operations**			**6 GeV Operations**			**6 GeV Operations: Two C100s operational** [1]			**6 GeV Operations: Two C100s installed, warm, not operational** [2]		
			FY11 1st & 2nd Qtr (Start QWeak Run)			FY11 3rd & 4th Qtr (Six-Month Shutdown)			FY12 1st & 2nd Qtr (Last "6 GeV" Running)			FY12 1st & 2nd Qtr (Last "6 GeV" Running)		
			~Oct 2010 thru Apr 2011			**~May 2011 thru Oct 2011**			**~Nov 2011 thru Apr 2012**			**~Nov 2011 thru Apr 2012**		
	Unit Loads													
	2 K	**35K**	**#**	**2K**	**35K**	**#**	**2K**	**35K**	**#**	**2K**	**35K**	**#**	**2K**	**35K**
Static														
Transfer Lines	530	7000	1	530	7000	1	530	7000	1	530	7000	1	530	7000
Original CM's	16	110	42.25	676	4647.5	42.25	676	4647.5	42.25	676	4647.5	42.25	676	4647.5
12GeV CM's	50	250	0	0	0	5	250	500	2	100	500	0	0	0
FEL	370	1310	1	370	1310	1	370	1310	1	370	1310	1	370	1310
Dynamic														
Original CM's	72	0	42.25	2665	0	0	0	0	42.25	2281	0	42.25	2665	0
12GeV CM's	250	50	0	0	0	0	0	0	2	500	100	0	0	0
FEL	295	375	1	295	375	0	0	0	1	295	375	1	295	375
Totals (W)			43.25	4536	13332.5	0	1826	13457.5	45.25	4752	13557.5	43.25	4536	13332.5
			CHL#1	4600	12000	CHL#1	4600	12000	CHL#1	4600	12000	CHL#1	4600	12000
			% Full Load	0.99	1.11	% Full Load	0.40	1.12	% Full Load	1.03	1.13	% Full Load	0.99	1.11

Footnote 1. Two C100s installed and operational. C25/C50 gradient trimmed back to reduce heat load.

Footnote 2. Two C100s installed, not operational so they are warm and detuned.

Accelerator Loads								
Time Period 2					12 GeV Commissioning/Initial Ops			
					(May 2013 thru June 2015)			
	Unit Loads		North Linac			South Linac		
	2 K	35K		2K	35K	#	2K	35K
Static								
Transfer Lines	530	7000	0.57	302.1	3990	0.43	227.9	3010
Original CM's	16	110	22.25	356	2447.5	20	320	2200
12GeV CM's	50	250	5	250	1250	5	250	1250
TL Bayonets				75			75	
FEL	370	1310				1	370	1310
Dynamic								
Original CM's	72	0	22.25	1602	0	20	1440	0
12GeV CM's	250	50	5	1250	250	5	1250	250
FEL	295	375				1	295	375
Totals (W)			27.25	3835.1	7937.5	26	4227.9	8395
						FEL 2K heat load acceptable		
						JLamp 2K heat load too large		
			CHL #1	4400	12000	CHL #2	4400	12000
			% Full Load	0.87	0.66	% Full Load	0.96	0.70

Accelerator Loads

Time Period 3

					12 GeV Operations Era (Oct 2015 and beyond)			
	Unit Loads		North Linac			South Linac		
	2 K	35K	#	2K	35K	#	2K	35K
Static								
Transfer Lines	530	7000	0.57	302.1	3990	0.43	227.9	3010
Original CM's	16	110	22.25	356.0	2447.5	20	320	2200
12GeV CM's	50	250	5	250.0	1250	5	250	1250
TL Bayonets				75.0			75	
FEL	370	1310				1	370	1310
Dynamic								
Original CM's	72	0	22.25	1602.0	0	20	1440	0
12GeV CM's	250	50	5	1250.0	250	5	1250	250
FEL	295	375				1	295	375
Totals (W)			27.25	3835.1	7937.5	26	4227.9	8395
						FEL 2K heat load acceptable		
						JLamp 2K heat load too large		
			CHL #1	4400	12000	CHL #2	4400	12000
			% Full Load	0.87	0.66	% Full Load	0.96	0.70

APPENDIX B:

Experimental Hall and Test Lab cryogenic loads and capacities for Time Periods 1.

		TIME PERIOD 1: 6 GeV Operations ; Six-Month Shutdown [12 GeV Installation] ; 6 GeV Operations									
Time Period 1	**Customer**	**# CM's**	**2K Heat Load (W)**	**35K Heat Load (W)**	**Liquefaction Load (L/wk)**	**4K Heat Load (W)**	**Liquefaction Load (g/s)**	**80K Heat Load (W)**	**20K Heat Load (W)**	**Experiment (or Task)**	**Customer**
FY 11: ~ 1st & 2nd Qtr [Start QWeak Run]											
(Oct 2010 - Apr 2011)											
Loads	Hall C / QWeak					40		0	2300	QWeak running	Hall C / Qweak [1]
	Hall A					460	3.29	870	600	DVCS/D threshold/SRC	Hall A [2]
	Hall B					180	1.60	100	10	??	Hall B
	A+B+C					**680**	**4.89**	**970**	**2910**		
	Hall D Solenoid					50	0.20	100		Testing coils in Test Lab?	Hall D Solenoid
	Test Lab	1.00	75	100	11585					12 GeV CM testing & CTF	Test Lab
	FEL	3.25	665	1685						??	FEL
	Accelerator	42.25	3871	11648						Running QWeak + ?	Accelerator
	FEL+Accel	**45.5**	**4536**	**13333**							
											injector
Supplies	CHL#1	45.50	4600	12000			10.00				Compare to FEL+Accel
	ESR#1					750	5.5	970	3273		Compare to A+B+C [3]
	CTF#1			900.00							Test Lab
	CTF#2				12096	0		0			Test Lab
	CTF#3					50	0.20				Test Lab
Result / Solution			ok	scheduling	ok	ok	ok	ok	ok		**Total**

Footnote 1: Hall C/Qweak 20K heat load assumes 150 µA beam.

Footnote 2: Hall A 20K heat load is worst case and occurs for limited times. More typical load for this period is 360W.

Footnote 3: ESR assumptions - ESR, without CHL supplement, can provide 1500 W of 4K load cooling, 4500 W or 20K load cooling, or 11g/s of liquefaction. Or any combinination assuming that 1g/s of liquefaction is equivalent to 136W of 4K load cooling or 409 W of 20K load cooling. After losses, the CHL transfer of 10 g/s is assumed to provide 8 g/s of liquefaction, 8*136=1088 of 4K load cooling or 3272 W of 20K cooling.

Time Period 1	Customer	# CM's	2K Heat Load (W)	35K Heat Load (W)	Liquefaction Load (L/wk)	4K Heat Load (W)	Liquefaction Load (g/s)	80K Heat Load (W)	20K Heat Load (W)	Experiment (or Task)	Customer
FY 11: ~3rd & 4th Qtr [Six-month Shutdown]											
(May 2011 - Oct 2011)											
Loads	Hall C									??	Hall C
	Hall A									??	Hall A
	Hall B									??	Hall B
	Hall D Solenoid					50				??	Hall D Solenoid
	Test Lab	1.00	75	100	11585					12 GeV CM testing & ??	Test Lab
	FEL									??	FEL
	Accelerator - 12GeV CMs									12 GeV CM commissioning?	Accelerator - 12GeV CMs
	Accelerator - Injector									Injector Tests?	Accelerator - Injector
Supplies	CHL#1	0.00	0	0							CHL#1
	ESR#1					0	0.00	0	0		ESR#1
	CTF#1										Test Lab
	CTF#2				1841	0		0			Test Lab
	CTF#3					50	0.00				Test Lab
Result / Solution			ok	ok	10 kL Dewar	ok	ok	ok	ok		**Total**

Time Period 1	Customer	# CM's	2K Heat Load (W)	35K Heat Load (W)	Liquefaction Load (L/wk)	4K Heat Load (W)	Liquefaction Load (g/s)	80K Heat Load (W)	20K Heat Load (W)	Experiment (or Task)	Customer
FY 12: ~1st & 2nd Qtr **[Continue Qweak Run]**											
(Nov 2011 - Apr 2012)											
Loads	Hall C / QWeak					40		0	2300	QWeak running	Hall C / QWeak
	Hall A					460	3.99		1.5 W @1 K	g2p/Gep	Hall A [1]
	Hall B					180	1.6			??	Hall B
	A+B+C					**680**	**5.6**	**0**	**2300**		
	Hall D Solenoid					100	0.2			??	Hall D Solenoid
	Hall D Refrigerator					100	0.2			Relocation? Commissioning?	Hall D Refrigerator
	Test Lab	1.00	75	100	11585					12 GeV CM testing & ??	Test Lab
	FEL		665	1685						Down	FEL
	Accelerator - 12GeV CMs	2	600	600						??	Accelerator - 12GeV CMs
	Accelerator - Ops	42.25	3163	11648						Running QWeak + ?	Accelerator - Ops
	FEL+Accel	**44.25**	**4428**	**13933**							
Supplies	CHL#1	44.25	4600	12000			10.00				Compare to FEL+Accel
	ESR#1					20	0	0	3273		Compare to A+B+C
	CTF#1			900							Test Lab
	CTF#2	1.00	75		12096			0			Test Lab
	CTF#3					50	0.3				Test Lab
Result / Solution			ok	scheduling	ok	ok	ok	ok	ok		**Total**

Footnote 1: Hall A requires a greater liquefaction load for the polarized target, but will have no 20K target load.

Experimental Hall and Test Lab cryogenic loads and capacities for Time Period 2.

TIME PERIOD 2: 12 GeV Commissioning -mid May 2012 (end of 6 GeV operations) through the start of 12 GeV Research Era (end of FY 15).

Note: 12 Month Installation (May 2012-May 2013)

Time Period 2	Customer	# CM's	2K Heat Load (W)	35K Heat Load (W)	Liquefaction Load (L/wk)	4K Heat Load (W)	Liquefaction Load (g/s)	80K Heat Load (W)	20K Heat Load (W)	Experiment (or Task)	Customer
12 GeV Commissioning: mid May 2012 (end of 6GeV operations) through the start of 12 GeV Research era (end FY 15)											
(May 2013 - Sept 2015)											
Loads	Hall C					334	3.19	597	820	Hall C Commissioning	Hall C
	Hall A					460	3.29	1000	1200	Gep	Hall A
	Hall B					230	2.2	2100		Hall B Commissioning	Hall B
	A+B+C					**1024**	**8.68**	**3697**	**2020**		
	Hall D					100	0.2			Hall D Commissioning	Hall D
	Test Lab	1.00		110	31566					C50 CM testing & ??	Test Lab
	FEL	3.25	665	1685						110 MeV	FEL
	North Linac Accelerator	27.25	3835	7938						Accelerator - 12GeV	North Linac Accelerator
	South Linac Accelerator	25.00	3563	6710						Accelerator - Ops	South Linac Accelerator
	SL+FEL	**28.25**	**4228**	**8395**							
Supplies	CHL#1	27.25	4400	12000			10.00				NL
	CHL#2	28.25	4400	12000			15.00				SL+FEL+ESR
	ESR#1					1000	7.0	3697	2045		A+B+C [1]
	CTF#1			890							Test Lab
	CTF#2	1.00	0		24192			0			Test Lab
	CTF#3					150	0.5				Hall D
Result / Solution			ok	ok	scheduling	scheduling	scheduling	ok	ok		**Total**

Footnote 1: Operating halls A, B, and C simultaneously will require coolant from the CHL-ESR transfer line and scheduling so that high power targets are not simultaneously in use in Halls A and C.

Experimental Hall and Test Lab cryogenic loads and capacities for Time Period 3.

TIME PERIOD 3: 12 GeV Research FY16 and Beyond											
Time Period 3	**Customer**	**# CM's**	**2K Heat Load (W)**	**35K Heat Load (W)**	**Liquefaction Load (L/wk)**	**4K Heat Load (W)**	**Liquefaction Load (g/s)**	**80K Heat Load (W)**	**20K Heat Load (W)**	**Experiment (or Task)**	**Customer**
12 GeV Research FY16 Beyond											
(Oct 2015 - Beyond)											
	Hall C					334	3.19	930	800		Hall C
	Hall A					40	0.01		5200	Moller	Hall A
	Hall B					230	2.2	1800		CLAS 12	Hall B
	A+B+C					**604**	**5.4**	**2730**	**6000**		
	Hall D					100	0.2			GlueX	Hall D
	Test Lab	1.00	75	100	31566					C50 CM testing & ??	Test Lab
JLamp	FEL	5.25	1230	2915						300 Mev	FEL JLamp
	North Linac Accelerator	27.5	3835	7938						12 GeV	North Linac - Accel
	South Linac Accelerator	25.00	3563	6710						12 GeV	South Linac - Accel
	SL+FEL	**30.25**	**4793**	**9625**							
	CHL#1	27.50	4400	12000			10.00				NL
	CHL#2	30.25	4400	12000							SL+FEL+ESR
	ESR#1					750	5.5	2730	3250	Physics	A+B+C [1]
unfunded	ESR#2								5000	Moller	A+B+C [1]
Test Lab	CTF#1			900							CTF#1
Test Lab	CTF#2	1.00	75		24192			0			CTF#2
Hall D	CTF#3					150	1				CTF#3
Result / Solution			ok	ok	scheduling	ok	ok	ok	scheduling		**Total**

Footnote 1: Running halls A,B & C requires ESR#2, and supplementing ESR with CHL flow.