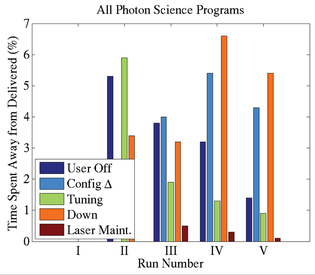
LCLS Availability

B. Allen, A. Brachmann, W. Colocho*, M. Stanek, J. Warren

Introduction

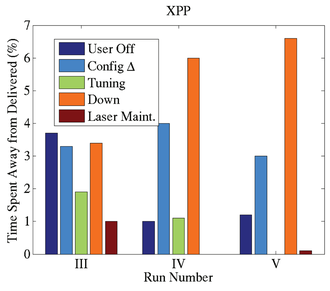
Abstract: The Linac Coherent Light Source at SLAC National Lab is in the middle of its 6th user run. Typically two user experiments are performed in a 5 day block of time. This poster shares availability and reliability data for LCLS. The poster includes MTBF/MTTR tables as well as subsystem availability budget tables and subsystems' reliability performance. A short description of work underway to improve systems' reliability is included.

Availability for LCLS User Programs
RUN V - Nov. to May 2012: 93.1% (95.0% **)
RUN IV - Jun. to Oct. 2011: 91.8%
RUN III - Oct. 2010 to Mar. 2011: 94.8%
RUN II - May 2010 to Sept. 2010: 92.5%
RUN I - Oct. 2009 - Dec. 2009: 92.8%

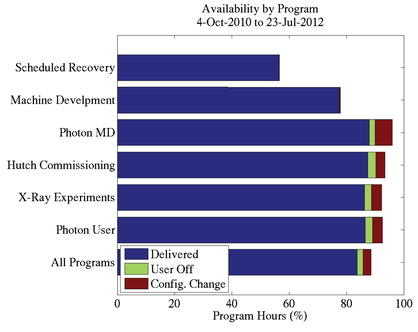


Bar graph shows percentage of scheduled time spent not delivering photons to users. The data is for four different User runs (May 2010 to May 2012).

Note that "User Off" and "Configuration Delta" are counted as available time to users. Tuning, Down and Laser Maintenance are counted as unavailable time.



Availability data is gathered for each of the six LCLS experimental hutches. Since the parameter space requested by users of different hutches varies, we look for possible differences in the availability statistics for each experimental hutch. This is a sample plot for one of the experimental hutches.

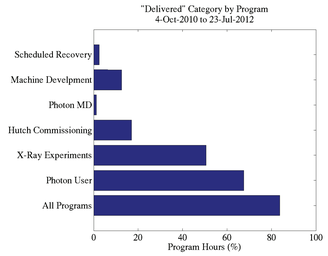


Availability data is kept for all LCLS programs. Photon User programs include X-Ray experiments as well as hutch commissioning. Machine development (MD) programs are divided into electron beam MD, Photon beam MD and scheduled recovery (time spent recovering after a planned maintenance outage).

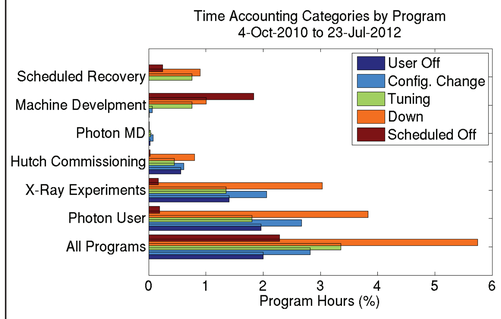
Whenever possible, work that has risk of generating downtime and occurring during scheduled Photon User delivery is shifted (scheduled) to machine development time. This is one of the reasons MD availability is lower.

Time Accounting Categories by Program

Beam time accounting categories include:
"Delivered", "User Off", "Configuration Change", "Tuning" , "Down" and "Scheduled Off".



These two plots show totals for different time accounting categories as well as different programs. The plot on the left shows the "Delivered" category and the one below all the other time accounting categories. The data is normalized to the total number of running hours. The data does not include long scheduled downtime periods but it does include the bi-weekly schedule maintenance shift(s).



LCLS User Programs Run IV
Total Hours Down and Availability for 01-Jun-2011 to 31-Oct-2011

System	Hours	Availability	Goal (%)	Budget (hours)	Budget - Actual
Power Supplies	30.3	98.24	99.77	4	-26.3
Magnets	0	100	99.95	0.9	0.9
RF	10.7	99.38	99.44	9.6	-1.1
Vacuum	3.6	99.79	99.95	0.9	-2.7
Utilities	60.4	96.49	99.84	2.8	-57.6
Guns & lasers	28.7	98.33	99.64	6.2	-22.5
Controls	18.4	98.93	98.66	23.1	4.7
Non-Radiation Safety	0.8	99.95	99.95	0.9	0.1
Alignment	0	100	99.95	0.9	0.9
Other	3.5	99.8	99.93	1.2	-2.3
Unassigned	0.2	99.99	99.95	0.9	0.7
Photon Controls	6.8	99.61	99.95	0.9	-5.9

Systems' goals were established by calculating a given systems past availability performance and scaling this performance for a goal to achieve 97% hardware availability. This leaves a 2% margin for tuning and an overall availability goal of 95%.

LCLS User Programs Run V
Total Hours Down and Availability for 01-Nov-2011 to 31-May-2012

System	Hours	Availability	Goal (%)	Budget (hours)	Budget - Actual
Power Supplies	11.1	99.48	99.77	4.9	-6.2
Magnets	0	100	99.95	1.1	1.1
RF	7	99.67	99.44	11.9	4.9
Vacuum	3.3	99.84	99.95	1.1	-2.2
Utilities	84.1	96.04	99.84	3.4	-80.7
Guns & lasers	21.7	98.98	99.64	7.6	-14.1
Controls	13.4	99.37	98.66	28.4	15
Non-Radiation Safety	0	100	99.95	1.1	1.1
Alignment	0	100	99.95	1.1	1.1
Other	4.9	99.77	99.93	1.5	-3.4
Unassigned	0.1	100	99.95	1.1	1
Photon Controls	5.5	99.74	99.95	1.1	-4.4

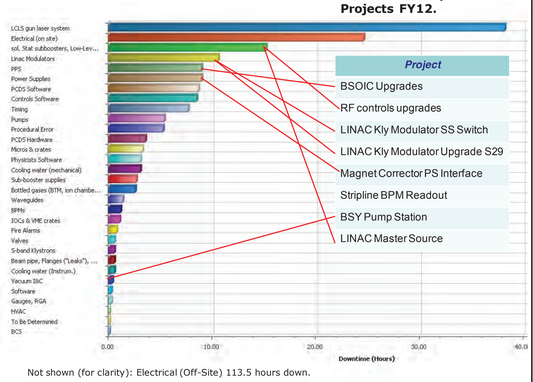
Mean Time Between Failures and Mean Time to Repair for LCLS User Runs.

	RUN IV		RUN V	
System	MTBF (Days)	MTTR (Hours)	MTBF (Days)	MTTR (Hours)
1.3 Power supplies	71.7	0.8	88	8.2
1.6 Linac Modulators	3.7	1.5	17.7	0.4
1.7 Subbooster supplies	23.9	0.5	88.3	1.1
3.1 S-band Klystrons	35.9	0.2	88.4	0.2
3.3 Hi-power Subboosters	71.7	0.5		
3.6 sol. Stat subboosters, Low-Level RF	23.8	3.2	29.4	1.9
3.7 Waveguides	35.9	0.2	44.2	0.6
4.1 Pumps	23.9	1	29.4	0.8
4.2 Gauges, RGA	71.8	0.1	88.4	0.2
4.3 Valves			44.2	0.3
4.4 Beam pipe, Flanges ("Leaks"), Stoppers	35.9	0.2	88.4	0.2
5.1 Electrical (on site)	14.2	4.5	44.1	1
5.2 Electrical (off-site)	11.7	5.9	12.2	11.2
5.3 Cooling water (mechanical)			29.4	1
5.4 Cooling water (Instrum.)	71.8	0.1	44.2	0.2
5.6 Bottled gases (BTM, ion chambers,??)	35.8	1.3		
5.9 HVAC			88.4	0.1
6.1 LCLS Gun	71.4	8		
6.2 LCLS gun laser system	2.6	0.8	5.1	1.3
7.1.1 Micros & Camac crates	11.9	0.3	44.2	0.9
7.1.2 IOCs & VME crates	23.9	0.4		
7.1.3 Timing	11.9	0.9	29.4	0.7
7.1.4 Vacuum I&C	35.9	0.2	88.4	0.1
7.1.8 BPMs	17.9	0.3		
7.1.15 MPS	71.8	0.2		
7.3.1 BCS			88.4	0.1
7.3.2 PPS	71.6	3	17.6	1.2
7.4.1 Controls Software	10.2	0.7	8.8	0.3
8.1 Fire Alarm	71.7	0.8		
10.1 Procedural Error	17.9	0.5	22.1	0.9
10.2 Physicists Software	71.7	1.7	22.1	0.3
11.2 To Be Determined	71.8	0.2	88.4	0.1
12.1 PCDS Hardware	35.9	0.6	22.1	0.6

Empty fields indicate that the given subsystem had zero downtime during that run.

LCLS downtime (hours) for Users' runs IV and V.

Accelerator Improvement Projects FY12.

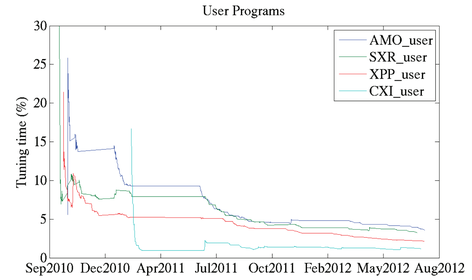


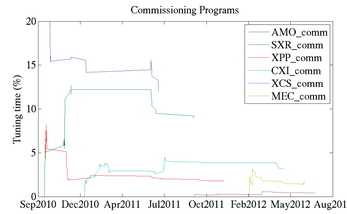
Not shown (for clarity): Electrical (Off-Site) 113.5 hours down.

Planned Accelerator Improvement Projects. (A. Brachmann)

Project	Planned Completion
Stripline BPM Upgrade	FY13
BSY Pump Station Upgrade	FY13
Injector Source Laser Upgrade	FY13
Linac Klystron Modulator Upgrade S28&27	FY13
Klystron Solenoid Power Supply Upgrade	FY13
Magnet Cable System Upgrade	FY13
MCOR Voltage Monitor	FY13
BCS Hardware Upgrade	FY14
Linac PPS	FY15
MCC Computer Server Upgrade	FY17
Planning Project	FY13

Tuning Improvements:





Dedicated time for tuning is not considered as time available to Users. LCLS Operations work on reducing tuning time as well as finding ways to tune that are not invasive to the experiments. Clear understanding of Users' expectations on machine performance are also a factor. Due to various technical reasons, soft X-Rays configurations require more tuning time (AMO and SXR).

Conclusions

LCLS hardware reliability data has been presented. Other factors like time spent on configuration changes and tuning also affect the machine's availability. Given that different experimental hutches have different Free Electron Laser parameter space requirements, care should be taken when considering tuning availability expectations.

LCLS accelerator improvement projects underway should help improve machine availability. Tuning time reduction is always an operational goal. Other areas that may require attention are configuration change time and user off time.

At present, the "User Off" category includes experimental apparatus downtime as well as experimental configuration change and any other reason(s) X-Ray users decide to close the hutch stoppers. Better tracking of reasons that require "User Off" are needed to be able to optimize this time when the photon beam is available but users are not able to use it.

**A major source of machine downtime during runs IV and V were two separate power outages (off site electrical distribution). Some of the schedule programs during the run V outage were re-scheduled; so a second availability number can be calculated taking into account this compensation time.
These type of outages were not included in the availability projections and budget used for goal setting. Work is underway to allow for a separate backup power distribution line.

Acknowledgments

* This work was performed in support of the LCLS project at SLAC. Presented at the Workshop on Accelerator Operations held at SLAC National Laboratory, Aug 6 – Aug 10, 2012
• Many thanks to LCLS Operations group as well as the Accelerator Department Maintenance Office. They are in charge of keeping track of program downtime data. Daily Operations' reports keep track of downtime data. The CATER trouble reporting database is used to keep track of each system's downtime.
• A. Brachmann manages the LCLS Accelerator Improvement Projects. Including the difficult task of resource allocation and prioritization.