# LCLS MACHINE PROTECTION SYSTEM HIGH LEVEL INTERFACE IMPROVEMENTS

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## Abstract

The Linac Coherent Light Source (LCLS) is a free electron laser (FEL) facility operating at the SLAC National Accelerator Laboratory (SLAC). The LCLS Machine Protection System (MPS) contains thousands of inputs and hundreds of protection interlocks. Control room operators use a high-level Graphical User Interface (MPSGUI) to view and manage faults [1].

MPSGUI contains a wealth of useful information, from hardware input details to high-level logic flow, but in its first version it was difficult for accelerator operators to take full advantage of this. A recent project has greatly improved the workflow and usability of MPSGUI.

# **INTRODUCTION**

The purpose of the MPS is to prevent damage to beamline components due to beam. The MPS monitors the states of devices throughout the accelerator. If it detects a condition that may lead to damage, it turns off the beam.

MPSGUI, a Java application, is the primary operator interface to the MPS. Operators use it to identify, diagnose, and manage faults. This paper will describe the enhancement provided by this project on MPSGUI.

## **MPSGUI**

The MPS defines its static input and logic configuration in SQLite database files. Real-time state information is hosted by EPICS signals. The MPSGUI uses this combination of static and dynamic data to provide detailed fault and diagnostic information to operators.

The information is distributed in the MPSGUI tabs, accessible at the interface's bottom (Figure 1) [2].

- Summary: displays current rates, current faults, and bypasses
- Faults: details of MPS inputs;
- Logic: details of MPS logic, how inputs translate to rate limits
- Ignore logic: condition under which logic can be ignored
- History: full history of MPS input state changes;
- Recent Faults: last 1000 MPS faults that affected beam (faults that clear quickly, except sub second may not appear here)



Figure 1: MPSGUI summary tab.

# **ENHANCEMENTS**

MPSGUI contains a lot of information available to describe the MPS details but not fully utilized by Operations. In fact, the navigation from High Level GUI down to the logic fault description, hardware level bits related to this fault requires cross-reference and the use of several screens.

The complete requirements list was defined during a series of meetings with control room operators. A task list was made based on MPSGUI's maintenance tickets, user feedback and feasibility balanced with the limited resources of time and budget.

The intent of this project was to solve the following main MPSGUI's issues:

- Hard to find inputs associated with a given piece of logic.
- Missing information in displays.
- Challenging to identify faults that clear quickly.
- Difficult to associate a fault to the related logic details.
- Resolve issues that were discouraging operators from using the GUI.

# Faults History Server

The most important of Operation's requests was the desire to identify fast non-latching recurring faults. This category of faults would appear repeatedly and clear at a very fast rate. Originally, MPSGUI was providing information about "current faults", operated by a separate JAVA thread. The thread was running on the user if launched interface process, increasing the CPU load on the user side. The "current faults" information was not available when launching a new interface, instead was

16th Int. Conf. on Accelerator and Large Experimental Control Systems ISBN: 978-3-95450-193-9

ICALEPCS2017, Barcelona, Spain JACoW Publishing doi:10.18429/JACoW-ICALEPCS2017-THPHA189

populated real-time. An additional server process was nublisher, developed to solve this issue. The server process continuously runs in the background identifying and storing logic faults. The Faults History Server is hosted on a production server where the process increments a PV monitored work. by the alarm system. In rare cases where the server process stops working, the alarm system reports the status to þ Operations to re-start the process. of

The Faults History information is stored into a JSON file. The JSON file contains up to 1000 faults and updates ine. The JSON the contains up to 1000 faults and updates guide using a FIFO methodology. The "Recent Faults" tab add-ed to MPSGUI displays the fault history as shown in Figure 2.

				y fast faults may not appear!			
Dete	Name	State	Min Fate	Cun RF Permit	Case-insensitive Nech Shutter	Fiter Brick	
01/14113134	MPS Deam Permit: EXP2K	Nat Permitted	0102			0.812	
01/1411:31:26	MPS Beam Permit: BVKIK	Not Permitted	0 Hz			0 H2	
01/14113118	MPS Beam Permit, BINIK	Nat Permitted	0 H2			0 H2	
01/141131:10	MPS Beam Permit, BVNAK	Nat Permitted	0 Hz			0 Hz	
01/141131.04	Stopper XRT SS Position	Moving	0 H2	0 H2	0 Hz	0 H2	
01/141131.04	Cil Configuration 4 Summary	fashed	0 Hz	0 Hz	O Hiz	0.82	
01/14112418	MPS Beam Permit: BINIK	Nat Permitted	0 Hz	**	**	0 HZ	
01/141123:44	MPS Deam Permit, BINIK	Not Permitted	012		**	0 #2	
01/1411:09:31 P	IC Rav Overge Thresholds: U	Over High Threshold	910	0 Hz	0 HZ	0.82	
01/141035:20	Stopper XRT 55 Peakon	Houng	0 H2	0 H2	0 H2	0.82	
01/14 10:23.46	Stopper XXT 55 Postion	Horng	0 H2	0 Hz	O HQ	0.82	
01/14 10:18:30	Stapper XHT SS Position	Moung	0 H2	0 H2	0 HZ	0.42	
01/14/00/17 40	NUCCESSION OF STREET	Monte	0 Hz	0 Hz	0.84	0.84	_
01 / 14 09 14 16	WES from Premie Billik	ByFass b	010			0.87	
01/14/09/11/45	Stepper XRT SS Position	Open it ims LogicTab Working	010	0.162	0.142	0.82	
01/14/09/11/27	TD11 Perition	Noving	0 Hz	0 Hz	0 Hz		
01/14/09/10/53	TD11 Peoton	Houng	010	0 HZ	0 H2		
01/14/09/10/53	Hechanical Shatter Position	Noving	0 Hz	0 Hz		OWE	
01/14/09:09:53	TD11 Position	Moving	0 Hz	0 Hz	0 Hz		
01 / 14 09:07:18	<b>Hechanical Shafter Position</b>	Horing	0 Hz	0 Hz		0 H2	
01/14/09:05:43	MPS Beam Permit: BXARK	Not Permitted	0 Hz			0.82	
01 / 14 09:02:24	MPS Beam Permit: BINIK	Nut Pormitted	0 H2			0 #2	
01/14/08/40:19	MPS Deam Permit DINIK	Net Permitted	0.142			0.812	
01/14/08:46:17	IG2 Ekaptortic Stopper Pocition	Houng	0 Hz	0 Hz	0 Hz	0 HZ	
01/14/08/33/23	TD11 Position	Moving	012	0 H2	O HZ		
01/14/08/31:44	OTR-Q Pesition	Moving	0 Hz	0 Hz	0 Hz	0.82	
01/14/08/31:40	OTRH2 Position	н	10 H2	10 Hz	20 Hz	10 Hz	
01/14/08/31/36	OTR-Q Position	Moving	0 Hz	0 Hz	0 Hz	0 Hz	
01/14/08/31/34	195 Beam Permit: Mechanical	Nat Permitted	0 Hz		0 Hz		
01/14/08/31/22	OTR-Q Position	Moving	010	0 H2	0 H2	0.82	
	OTTO I FARMER	Ph I	10 MZ	20 HR	30 Hz	10 Hz	
01/14/08/31:16							
01 / 14 08:31:16 01 / 14 08:31:12	OTR-Q Pesition	Noving	0 H2	0 Hz	0 Hz	0 #2	

Figure 2: MPSGUI recent faults tab.

Another new tab's feature is the context menu to bypass or to show details for the selected piece of logic.

#### Logic Input Information Accessibility

BY 3.0 licence (© 2017). The MPS's logic is displayed into MPSGUI's logic tab, it contains details how inputs translate to rate limits.

The information provided was incomplete and required to cross-reference multiple displays in order to map the hardware input to high-level logic. A table appear while erms of clicking on one of the listed logic, containing sensitive information and the link to the link node information.

The additional search feature by fault name is very useful for troubleshooting and identifying a fault occurrence. Prior to this search feature becoming available, it was not possible to easily find a fault in a Logic tab unless knowing the exact name.

In Figure 3, the blue rectangle is showing the related g a In Figure 3, the blue rectangle is showing the related ⇒ information bottom and the related display to link node's display. The same feature is available for the "ignore logic" tab. THPHA189

The same feature is available for the "ignore logic" tab.



Figure 3: MPSGUI logic tab.

## Freeze History Tab

The MPSGUI History tab was updating at a very fast rate. Many MPS changes occur very quickly making difficult to use the History tab, continuously updating.

Added a "freeze" button which allows users to control the GUI and stop receiving updates to the list of input state changes, Figure 4.

Time	Message	
1459.49	EUK_LTUI_EUS-45_L035_1_L THREHOLD (hanged from 0 to 1	
14.59.49	EUX_LTV1_EUX46_L005_1_L_THYEEHOLD charged from 1 to 0	
1459.49	824,1793,82545,1055,1,1,154854015 changed from 9 to 1	
14.53:49	BDM.LTV1.BD545.L005.1.1,TH4EEH0LD changed from 1 to 0	
14.50.40	BUM_LTU1_BUT545_L005L1_1_TTHREE/GLD (hanged from 0 to 1	
1459:49	804.1783.80545.1055.1.1.7H485H0L5 changed from 1 to 0	
14.50.40	824,1191,82545,1005,1,1,194324062 charged from 0 to 1	
1459:49	RUM_LTW1_RUPS45_L005_1_L_THEREHOLD changed from 1 to 0	
1450.43	PKX,870,71,10SLTHRSH0UD thanged from 1 to 0	
145037	BUM_LTB1_P62_TEST_1_H TH#ESH0.00 charges from 1 to 0	
145036	FIOR_85Y0_75_L00560H THREEH0LD changed from 1 to 0	
145036	FKH, ESY0, 78A, LOSSON THRESHOLD charged from 1 to 0	
145036	Fick_8510_76_LOSSLTW82540LD charged from 1 to 0	
145036	MUNDOLCOMPLI2 STATE charged from 1 to 0	
14.50.36	TC251L1 STATE charged from 1 to 0	
145036	Beam rate sher POCHES CEL, changed from 0 HZ to 120 HZ	
145036	MFS, N20, 200, HSHT1, OUT FALST charged from 0 to 1	
145036	Beam rate after BNDK changed from 120 HZ to 0 HZ	
145036	MFLN20_200_MGHTL_NFAULT charged from 1 to 0	
145036	FXX,829,16,10380H THREEDD charged from 1 to 0	
145035	RIM_IND1_1321_L095_10_LTHR5H0.D competition 1 to 0	
14:50:35	FICH, BSY0, 67, L0536CH THRBHOLD charged from 1 to 0	
1410.15	PICH_BDYD_67_LOSSH THREEHOLD changes from 1 to 0	
145035	FOX.3010.788.L00560H THREHOLD changed from 1 to 0	
14.50.35	POX, 80Y0, 45 (L0056OH THREEHOLD changed from 1 to 0	
145035	Beam rate after BrNX changed from 0 H2 to 320 H2	
1450.35	MPS. N20. 200 MGHT LIN FAULT charged from 0 to 1	
145035	EUH_UND1_021_L005_10_J_TH#ESH06D charged from 1 to 0	
145035	PICSLTUL-HB0.L00566H THREPHOLD charged from 1 to 0	
14.50.25	BMI, JMD1, 1221, JJD5, 10, LTHREHOLD charged from 1 to 0	
145035	Ream rate after MECKANICAL SHITTER changed from 0 H2 to 120 H2	
1#5025	MK MON THE MART IN AN IT REPORTED IN A	

Figure 4: MPSGUI history tab.

#### CONCLUSION

The new features now allow operators to quickly identify MPS faults and diagnose problems. The troubleshooting time has been reduced, increasing the uptime for FEL delivery to user experiments. The MPS Logic Faults History server, in particular, has had a strong positive impact, allowing users to access days of recent fault history with freshly launched GUI instances.

#### ACKNOWLEDGEMENT

Acknowledgement to Sonya Hoobler for her guidance and support; to the SLAC operators for the teamwork to write the project requirements.

### REFERENCES

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