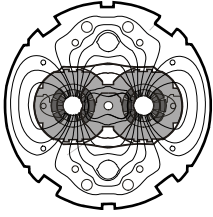


**CERN**  
CH-1211 Geneva 23  
Switzerland



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## software specification

# **SPECIFICATION OF THE DATABASE STRUCTURE AND THE SOFTWARE NEEDED TO CONFIGURE THE BEAM LOSS MONITOR SYSTEM IN THE LHC**

### *Abstract*

The Beam Loss Monitor system is made of about 4000 detectors spread around LHC ring. For each detector a set of operational parameters is prepared. These parameters are stored in databases, modified and send to electronics when needed. This document describes the database structure and software needed to operate Beam Loss Monitor system.

*Prepared by :*

**Mariusz Sapinski,**  
Christos Zamantzas,  
Bernd Dehning,  
Eva Barbara Holzer,  
Laurette Ponce  
[mariusz.sapinski@cern.ch]

*Checked by :*

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## 1. INTRODUCTION

The main purpose of the Beam Loss Monitor (BLM) system is to protect machine components from effects induced by beam particles hitting the walls of the vacuum chamber. The major effect is magnet transition from superconducting to normal state (referred as quench) but at high rates of beam losses the damage of the machine components might occur. For short losses the BLM system is the only one which protects the superconducting magnets against quench what makes it one of the critical elements of the LHC. The majority of the detectors of the BLM system will be ionisation chambers. For regions with very high loss rates, secondary emission monitors (SEM) are foreseen as well.

The BLM system can treat up to 6400 monitors, i.e. the total number of slots in the electronic crates. The number of detectors foreseen for the protection of the LHC elements is about 4000. The system has a direct connection to the Beam Interlock System (BIS) and it will trigger the beam dump if the radiation level is higher than the given threshold. Most of the channels are treated as safety-critical, i.e. the beam will not be allowed to be circulating if they are not working correctly. Additional monitors, referred as mobile monitors, can be used for radiation measurements in any region of the accelerator but will not provide input for the Beam Interlock System. From the machine-protection point of view they are considered as empty slots.

For the system to be functional, a number of parameters need to be loaded on the electronics. The components storing the settings are: CFC cards, timing cards and crates. The parameters can be divided, according to their functionality into two groups. The first group are the parameters used to perform of internal checks of electronics, like checking if the correct equipment and firmware version is being used (serial numbers) or setting up the tests. The second group determines the level of radiation at which the beam dump is triggered.

In total there are almost 400 numerical parameters per monitor plus additional settings per crate and CFC and timing cards. These parameters are stored in CERN databases.

In order to produce the threshold values for the monitors a set of particular configurations, i.e. positions of the monitor with respect to expected loss locations, has been defined. For instance for every Main Quadrupoles (MQ) on the arc the monitors which protect these quadrupoles are placed in the same locations with respect to the magnet elements. For each of these monitors the beam loss position is expected to be localized in a similar distance from the monitor. Therefore, the whole group of monitors will have the same threshold values. Such a group is referred to as a family. It is crucial for the BLM experts to be able to set and tune the BLM threshold values by families.

This document describes the database structure used to store the BLM system settings and it specifies the requirements for the software needed to perform specific operations on these data.

## 2. DATABASE STRUCTURE

There are three databases in which the BLM-system related information are stored.

1. **MTF** (Manufacturing and Test Folders travellers) database,
2. LHC **Layout** database,
3. **LSA** (LHC Software Architecture) database.

The data stored in MTF database concern every element of the system (including the spare elements). This database is foreseen to store information about history of every element, what tests have been performed on it, where it has been installed, etc. The data in Layout database describe the currently installed system configuration. Some information needed to operate BLM system exists in both databases – are doubled (synchronized).

The initial filling of the databases starts with Layout where the slots for the new equipment are created. These slots are then propagated to MTF where the information concerning electronic connectivity is added. This information is propagated back to Layout database. The last step is performed because the information stored in Layout database will be used to set up the BLM system and initially this database does not contain information about electronic connections.

The Layout database does not provide history of changes therefore a synchronization of changes in Layout database with MTF will be provided to keep track of the changes in the system.

The LSA database contains the actual settings of the LHC elements. It is used to store the BLM thresholds as well as the other safety-critical settings. It includes also some not safety-critical information which are intended for the Logging data concentrator [cite].

The data concerning the configuration of electronic channels is automatically synchronised from the Layout to the LSA database.

In the Table 1 all the variables stored in databases and used to run the BLM system are summarized. The red field means that information is stored in a given database.

It can be concluded that the information concerning electronic connection of a monitor is stored in Layout database, while operational settings of the system are stored in LSA.

Table 1. List of BLM settings.

Name	Unit	MTF	Layout	LSA
Monitor Type				
Monitor Identifier				
HV Patch				
BJBAP Input				
Tunnel Mini Rack Id.				
LC(offset) w/cable&M-r	pA			
Signal via source w/cable	pA			
BJBAP Cable Number				
AnalogFE:Ra Cr CFC In				
BLECF Identifier				
Opt Link AFE:Cr CFC Out				
OL Patch Tunnel:Ra Pa In				
OLP Surface:Ra Pa SI Out				
OLD Acq:Ra VME SI DAB In				
VME BLETC Id.				
VME CPU Host Name				
VME Crate Id.				
VME Fantray Id.				
VME Power Supply Id.				
VME CPU Id.				
VME BOBR Id.				
VME BLECS Id.				
VME BLETC Serial		n	n	n
VME BLECS Serial		n	n	n
Monitor Function				
Monitor Status				n
VME Fantray Hostname				
DAB card Id.				
Mezzanine card Id.				
CIBU Id.				
FPGA firmware vers(BLETC)				n
FPGA firmware vers(BLECS)				n
Test:10pA/84 sec run.sum	pA			
Test:10pA/84 sec run.sum	pA			
Set voltage:peak-peak	V			
Set frequency	Hz			
Resulting phase	°			
Resulting Gain				
Current signal:peak-peak	pA			
Signal Current	pA			
Threshold/Ch Matrix Test				
ITable User Beam Permit T				
UBP Check BLETC to BLECS				
UBP Check BLECS to CIBU				
Test EMC/40 µs run.sum	pA			
Test EMC/1.3 sec run.sum	pA			
EDMS Procedure				
Modulation 1 Voltage	Volt Bit			n
Modulation 1 Period	Per Bit			n
Modulation 1 Gain minimum				n
Modulation 1 Gain maximum				n
Modulation 1 Phase minimum	°			n
Modulation 1 Phase maximum	°			n
Modulation 2 Voltage	Volt Bit			n
Modulation 2 Period	Per Bit			n
Modulation 2 Gain minimum				n
Modulation 2 Gain maximum				n
Modulation 2 Phase minimum	°			n
Modulation 2 Phase maximum	°			n
Modulation Voltage conversion factor	V/Volt Bit			n
Modulation Period conversion factor	s/Per Bit			n
Modulation Gain conversion factor				n
Modulation Phase conversion factor				n
HV normal operation	HV Bit			n
HV1 - HV2 normal operation	HV Bit			n
HV for Modulation test	HV Bit			n
HV for HVCFC test	HV Bit			n
HV for RDAC reset	HV Bit			n
HV for RGOH reset	HV Bit			n
HV peak for HVCFC test	HV Bit			n
HV peak for RDAC reset	HV Bit			n
HV peak for RGOH reset	HV Bit			n
HV conversion factor	V/HV Bit			n
threshold table (12 values)	BLM bit			
BEAM ENERGY POS				
FAMILY NAME				
CONV FACTOR BLMBIT GY S				
CONV FACTOR GY S AMPS				
MONITOR FACTOR				
LAST MODIFICATION				
LOG RS01				
LOG RS02				
LOG RS03				
LOG RS04				
LOG RS05				
LOG RS06				
LOG RS07				
LOG RS08				
LOG RS09				
LOG RS10				
LOG RS11				
LOG RS12				

### **3. HISTORY OF CHANGES**

The MTF database is able to keep a history of changes in order to provide a tool for tracking the element changes. The Layout database has no built-in history record management therefore all the changes in Layout are propagated back to MTF. This is important for the operational phase when changes will be made only in Layout database (note that this is not true in the cases where those changes concern equipment replacements or additions. For example, if a new BLECF card is introduced then a new record must be created in MTF).

The history of the parameters stored in LSA is managed in two ways. History of monitor factors is followed by mechanisms build in the trim application while a change of any other parameter (except of Logging flags) affects the MASTER table and in this case a snapshot of the current situation in the database is made. A procedure to reconstruct the state of the database from snapshot and trim history will be defined.

### **4. STRUCTURE IN LAYOUT DATABASE**

(information about tables from Pascal)

## 5. STRUCTURE IN LSA

The parameters are stored in LSA database in a specific structure, illustrated in the Figure 1.

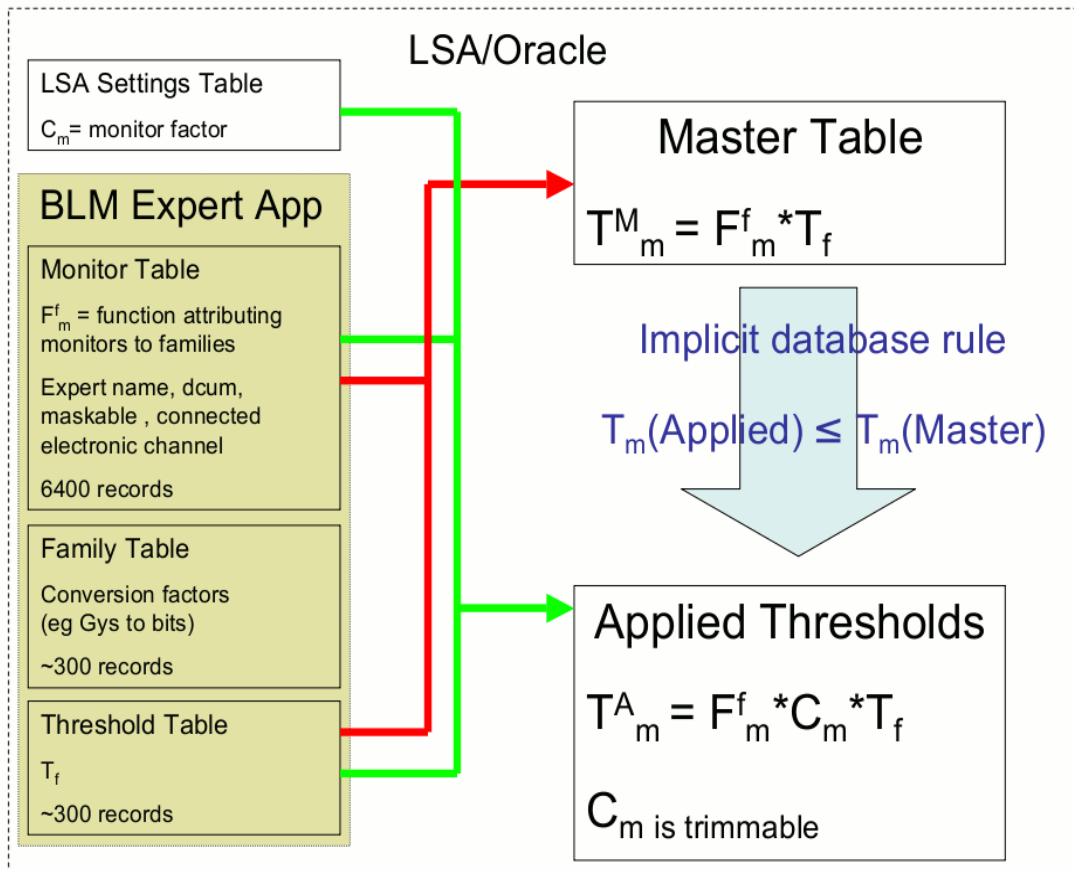


Figure 1: Structure of LSA tables.

On the left part of the Figure 1 there are four tables. The LSA setting table is a table where the monitor factors are declared as LSA parameters. The three other tables are called Monitor, Family and Threshold table are used to produce the MASTER table.

The LSA structure chosen uses data staging. That is, the tables presented in Figure 1 exist as STAGE tables and as FINAL tables. The STAGE tables are foreseen to load new parameters and perform consistency tests on them before sending them to the FINAL tables where they become accessible by the electronics. There is a special procedure defined in order to commit changes made in the STAGE tables to the FINAL tables.

The names used for the tables in LSA are:

- Monitor table: **STAGE\_BLM\_MONITOR** and **LSA\_BLM\_MONITOR**
- Family table: **STAGE\_BLM\_FAMILIES** and **LSA\_BLM\_FAMILIES**



– Threshold table: **STAGE\_BLM\_FAMILY\_THRESHOLDS** and **LSA\_BLM\_FAMILY\_THRESHOLDS**

The contents of the staging tables is presented in Figure 2.



Figure 2. Structure of staging tables

All 6400 channels are defined in the **Monitor table**. Naturally these channels are divided into 3 groups: normal monitors – connected to Beam Interlock System, "mobile" monitors, used for measurements and not connected to BIS and empty slots. From safety point of view mobile monitors and empty slots are the same therefore they look the same in the LSA structure described above. For technical reasons (in order to inform concentrator to log data from mobile monitors), an additional table (called Mobile table, not presented in Figure 1) is created where a non-generic name is attributed to channels where mobile monitors are connected. This way, when a mobile monitor is connected/disconnected, no change is made in safety-critical LSA tables.

Additional table in LSA contains values of the integration times (**LSA\_BLM\_RS\_TIMES**).

## 6. USE CASES

There are different situations in which intervention in the parameter structure of the BLM system will be needed. Here these situations are described together with procedures needed to perform changes.

The interventions are of two types:

- Hardware change, typically change of electronics (exchange of CFC card, switching monitor to another channel, etc.)
- Change of threshold settings

<b>Nr</b>	<b>action</b>	<b>Master Table</b>	<b>Fields affected in other tables</b>
1	disable/remove monitor	Affected	Monitor: connected
2	adding a monitor	Affected	Monitor: monitor_name monitor_exp_name connected family_name
3	change of monitor location or electronic channel	Affected	Goes via Layout Monitor: dcum crate_name crate_card_idx crate_card_chan_idx blecf_id
4	Change of monitor factor (Cm)	Only Applied table	LSA Parameter table - trim
5	Change family Master Thresholds (Tf)	Affected	family_thresholds: 12 integration times (32 records will be touched)
6	Deleting a family	Affected	Remove records from: Monitor, Family and Family_Thresholds tables
7	Creating a family	Affected	After deleting a family
8	Splitting existing family without threshold change	Affected	Actually operations 6 and 7 must be performed in order to split family
9	Adding mobile monitor	not affected	Only Mobile table affected

## 7. SOFTWARE

A program or a set of programs able to perform tasks (use cases) mentioned in the previous chapter should be created.

The possible software tasks have been divided into three programs, although in the future more or less programs with similar functionality can be created.

The first kind is LSA trim application, working with LSA parameters which are monitor factors (Cm in Figure 1). The second kind is LSA-expert application which main purpose will be setting the threshold table. The third kind of application will change other system parameters in case of changes in electronic channels. It is called here Layout-expert application because it should principally operate on Layout database, although it may probably also operate on LSA.

### 7.1 LSA TRIM APPLICATION

#### 7.1.1 WHAT THE SOFTWARE SHOULD DO

The first task of LSA trim application is changing the values of monitor factor. The trim mechanisms provide history of changes. There should be 2 modes of trimming. In the default mode a group of monitors should be trimmed together. Initially this group will correspond to BLM family, but a flexibility to define a group from any monitors should be kept. In order to make this feature work, a new table, containing monitor grouping, must be added in LSA. In this case the trim application should also take care about management of this table, that is creating, populating and deleting lines of this table.

In the second mode it should be possible to trim one single monitor. In this case a special flag should be stored in trim history saying that a monitor has been treated in a non-standard way. (this might be a specific string in the comment to trim action)

#### 7.1.2 SOFTWARE INPUT

The input should be a new value of monitor factor or a shift or factor relative to present value.

By default the monitor factor should be set to recommended value (for instance 0.3). This default value should define suggested trim level. For convenience it should be the same for all monitors.

#### 7.1.3 PERFORMANCE

The trim software should allow to trim a group of monitors or a single monitor in a time between LHC fills.

#### 7.1.4 ATTRIBUTES

The trim should be allowed only when beam permit flag is off. The trimming procedure should not change the beam permit flag.

The trim application should be protected by RBAC (Role-Based Access) protocol [1].

## 7.2 LSA EXPERT APPLICATION

This application manages BLM families and sets the values of the thresholds in LSA tables.

### 7.2.1 WHAT THE SOFTWARE SHOULD DO

The program should do:

- produce a table of thresholds (32x12),
- generate a list of monitors in a family based on SQL query performed on monitor expert name,
- create new family,
- delete a family,
- disable/enable a monitor (only in emergency case when Layout database is not accessible),
- produce some kind of status containing a statistical information (list families with numbers of monitors in them),
- read the existing threshold tables and visualize them.

### 7.2.2 SOFTWARE INPUT

The program input is:

- the SQL query (executed on expert name),
- the method (set of parametrizations) to expand a seed into a table,
- the family seed (one number, in Gy, obtained from Geant4/FLUKA simulations)

### 7.2.3 PERFORMANCE

Expert LSA application is not foreseen to be used during the operation, therefore the important changes in the system structure are not time-critical. The only time-critical function might be disabling a monitor, which in some cases could be done between the fills.

### 7.2.4 ATTRIBUTES

This application can only be used by expert. The access to LSA tables is password-protected.

The changes in the master table can be made only if the beam permit flag is off (although the play with stage tables should be allowed? - beam permit check on LSA level?).

## 7.3 LAYOUT EXPERT APPLICATION

This application manages the electronic structure of the BLM system.

### 7.3.1 WHAT THE SOFTWARE SHOULD DO

The software should allow to make changes in electronic channel of every monitor. The typical examples are

- exchange CFC card (serial number propagated to LSA),
- connect a BLM to different channel on the same or different CFC card (channel Number and slot number propagated to LSA).

During the normal operation the layout expert application should perform changes in the Layout database. Consecutively the changes should be automatically propagated to LSA. Although in case when Layout database is not accessible for any reason the program should allow to make changes directly to LSA in order to allow normal LHC operation. Changes made in this way should be back-propagated to Layout database when possible.

### 7.3.2 PERFORMANCE

It should be possible to make this changes in half day (including hardware intervention).

### 7.3.3 ATTRIBUTES

The access to the software should be restricted (password protected?) to the BLM group experts.

The automatic propagation of changes in layout into LSA database should be allowed only when beam permit flag is off.

## 8. REFERENCES

[1]. Role-Based Access Control for the Accelerator Control System at CERN, S.Gysin, A.D. Petrov, P.Charrue, W.Gajewski, V.Kain, K.Kostro, G. Kruk, S. Page, M. Peryt proceedings of ICALEPCS 2007