Operational procedure for validation of machine protection functionality for the collimator position survey

1. Introduction

The collimator position interlocking is based on the comparison between the measured jaw positions and collimator gap values against user-defined limit thresholds. If the measured values exceed the interlock thresholds, the collimator survey unit (PRS=Position Readout Survillance) removes the beam beam permit. This document describes how to perform sequences that check the machine protection functionality of the LHC collimators for **discrete limit thresholds**.

Each LHC collimator has 6 **LVDT** (Linear Variable Differential Transformer) sensors for direct jaw position and gap measurements. Each of them can trigger a beam interlock if the measured readout exceed **INNER** or **OUTER limit values**. In total, there are therefore 12 interlocks per collimator that have to be tested in order to validate the machine protection functionality of the PRS unit. In addition, there are **energy-dependent limit functions** (one OUTER limit for each of the gap LDVT, i.e. two additional interlocks per collimator).

An hardware commissioning sequence has been prepared to hit all the possible limits (14 in total). Here, we describe how to run this sequence and how to extract the relevant data.

2. General approach for the MP commissioning procedure

The procedure for the MP check basically consists of three steps:
- Running a commissioning sequence
- Monitoring the status of the collimator input in the BIC
- Extract from the Measurement database the relevant data that document the results

LHC collimators are installed in IP1, 2, 3, 5, 6, 7, 8 and in the TI2 and TI8 transfer lines. They are connected to BIC's for each point, which are also distinguished for beam1 and beam2. In order to have clean signal from the BIC, one should not run in **parallel** commissioning sequences on collimators that are connected to the same BIC. On the other hand, parallel sequences can be run for collimators on different point or in the same point but for different beams.

The results of the performed sequence shall be documented in the **LHC COLL logbook**. In addition, the relevant files (image from logging, CSV text files with the BIC history) shall also be save in dedicated directories in the collimator repository

```
~slops/data/LHC_DATA/OP_DATA/LHCCollimators/MachineProtection/
```

3. Run the commissioning sequence

The sequences for the machine protection check can be run from the *Single Collimator Control* application. The special version at the following web address (and not the one from the LHC console manager) should be used:

http://abwww/ap/next/lhc/lhc-app-collimators

The application "**lhc-app-collimators-launcher.jnlp**" should be run with the JAVAWS (preferably under Linux - no systematic tests were performed on Windows). At start-up, a dialog box asks which hardware group should be used. The group "**LHC COLLIMATORS DRY-RUN**" contains all the collimators. Other hardware groups are available for single IP's as well as for all the collimators used in the various sector tests (for example, there are two groups with all the collimators in IP3 and IP7).

The control applications can be launched at the same time for various collimators within the same hardware group. Multiple selection is done by holding the "Ctrl" key, like usual.

As a first step, before starting the real sequence, one should reset the interlock limits. This is done with the command:

Settings → Set thresholds to HW limits [experts!]

The machine protection sequence is launched from the settings menu:

Settings → Start machine protection sequence [experts!]

The sequence starts immediately after selecting the command above and lasts for about 4 minutes. In the "Jaw positions" plot one will see jaw movements around the average positions of ± 2.5 mm. If the sequence runs smoothly without problem, at the end a "sequence successfully finished" message is displayed in the console of the collimator applications. **start** and **stop times** of the sequence shall be noted on the status advancement table.

Remark: If for any reasons there are problems and the sequence does not start, one should just close the application and report the problem to me. I have had no time yet to optimize the error handling.

Remark: Occasionally the command to reset the thresholds to the hardware limits might fail. One might repeat it a few times. If the problem persists, the exception reported in the console should be reported in the comments. The hardware commissioning sequence should not be performed.

4. Monitoring of the collimator input into the BIC

Before starting the collimator sequence one should start-up the BIC supervision application as well as the "expert view" with all the inputs of the BIC where the collimator under investigation is connected.

Prerequisites to be met before starting the sequence:
- The **COLL#MOT** channel (input 8) must be **ENABLED** and **UN-MASKED.**
- The **COLL#MOT** channel must be **TRUE** (the overall sum signal of the BIC under investigation might be false, though).

While the collimator sequence is being run, the collimator input will change status several times. More specifically, it must change to FALSE when the measured jaw position hits the interlock limit values. In order to verify this on-line, the operator can start a dedicated monitoring of the relevant properties, as discussed in Section 6. In any case, the sequence is not working as expected if the collimator input stays TRUE and this should be reported.

When the sequence is finished, the operator must take **snapshots of the BIC history buffer** to record the history of change of the collimator input status. This can be done by adding the snapshots into the "LHC COLL" collimator logbook or simply by saving the JPEG image in a dedicated directory (for example by using the program "gimp &", launched from a terminal window). The history buffer should also be exported in **CSV format** (option available in the top-right corner of the history window).

Remark: At the FALSE → TRUE transition of the BIC input status there are often a large number of spurious signals due to the fact that the mechanical relay that closes the loop "bounces" back and forth before closing completely. These signals should be disregarded. However they fill quite a number of entry end therefore several snapshots might be needed to cover the whole collimator sequence.

5. Retrieve the results from the logging/measurement database

After the sequences is completed, the operator must check the validity of the results by extracting from the **Measurement Database** the relevant data for the collimator(s) that has (ve) been tested. In order to facilitate this process, we have pre-defined for each collimator a series of **variable lists** that include all the relevant variables for each position degree of freedom (i.e., for each of the six LVDT sensors that are used for the collimator survey control). These list can be found in the **"Variable list"** tab of **Timber** and are called

COLLIMATOR_MP_CollName_SensorName,

where "SensorName" can be "LU", "LD", "RU", "RD", "GU" or "GD". The variables of each of these 6 lists allow one to check the interlock "IN" and "OUT" - see a few example in the Appendix I.

In order to document the sequence result, for each set of variables one should:
1. Select all the variables in the list.
2. Using the **LOCAL_TIME**, generate a plot over a time range that covers the period when the commissioning sequence was performed.
   Note that for the gaps ("GU" and "GD") one should not plot the "SET_R" variables.
3. "Toggle" the y scales in order to have all the variables displayed on the same scale
4. Zoom in the region where the corresponding degree of freedom was tested (for example, the left upstream corner - "LU" - is the first one of the sequence).
5. Verify that the change of state of the **PRSERROR** variable corresponds with the corresponding change of state of collimator BIC input (TRUE -> FALSE).
6. Export the plot in JPEG format by using the icon in the top-left corner of Timber and add the image into the collimator logbook.

Naming convention for the image: MP_CollName_SensorName. Ex.: For the "TCP.D6R7.B2" six images should be created with the names "MP_TCP-D6R7-B2_LU.jpg", "MP_TCP-D6R7-B2_LD.jpg", ...

6. On-line display with EquipMonitoring tool

It can be very useful to monitor on-line the ongoing sequences. This can be done with the **EquipMonitor** application provided within LSA. This is the same application that is typically used for power converters during the HWC. It is available on the LHCOP CCM or from the LSA application launcher on the web:

http://abwww/ap/dist/lsa/lsa.html

The web link is actually more convenient because it allows one to run in parallel more in-
stances of the application.

One can find the collimators to be monitored within the collimator hardware groups that
were used to startup the collimator control application. The collimator FESA class type is
called "**LHCCollimator_1**" (other possible classes for the TDI's and the TCDQ's are not
discussed here). The relevant variables belong to the "**MeasuredCornerPositions**" prop-
erty. The field are basically the same that are found in the pre-defined logged variables. It
is suggested to generate **two plots** per collimator: one for the **four jaw corners** and one
for the **two collimator gaps**. The required set of variables is shown in the next figure.

Fig. 1: Set of collimator variables for an on-line display of the commissioning sequence
with the LSA EquipMonitoring.

Appendix I: Examples of sequence results from the Measurement database

Two examples of data extracted from the Measurement database, which illustrate the relevant data sets for the verification of the Right-Downstream ("RD") jaw corner and of the Gap-Upstream ("GU") interlocks for the collimator TCSG.4L6.B2.