

COMMISSIONING AND EARLY OPERATION – VIEW FROM MACHINE PROTECTION

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Abstract

Before first beam is injected into LHC, the large part of the protection systems that does not require beam for commissioning will already have been formally validated. Some systems require to be commissioned with beam at the start of beam operation. With increasing stored energy, increased performance of some protection systems is required, and also additional systems must be commissioned. It is proposed to define operational stages with limits on the stored beam energy. An increase of the stored energy, either by filling more beam, or by increasing the maximum energy, requires formal validation of the protection systems that are required for the next stage of operation, and an agreement between operation and machine protection experts to go on. The functions of a 'Machine Protection Coordination Team' are proposed.

INTRODUCTION

The Machine Protection System (MPS) has to guarantee the safe operation of the LHC. A not properly working MPS can lead to significant damage of LHC components and long downtime periods [1]. For this

reason commissioning of the MPS needs to be done with great care and the details of the commissioning need to be well defined in advance. The commissioning of the MPS will be a recurring task during the commissioning of the LHC but also after shutdowns and access periods.

Figure 1 gives an overview of the MPS and the systems connected to it. It shows the complexity of the system [2]. To commission such a complex and important systems, a clear strategy and formal procedures are required.

SYSTEMS TO BE COMMISSIONED

The systems to be commissioned can be divided in four groups, each consisting of a number of subsystems.

The first group consists of the core of the system:

- The Beam Interlock System (BIS)
- The LHC Beam Dumping System (LBDS)

The second group consists of the systems connected to the MPS:

- Beam Loss Monitors (BLM)
- Quench Protection and Power Interlock Controllers
- Collimation System
- Etc.

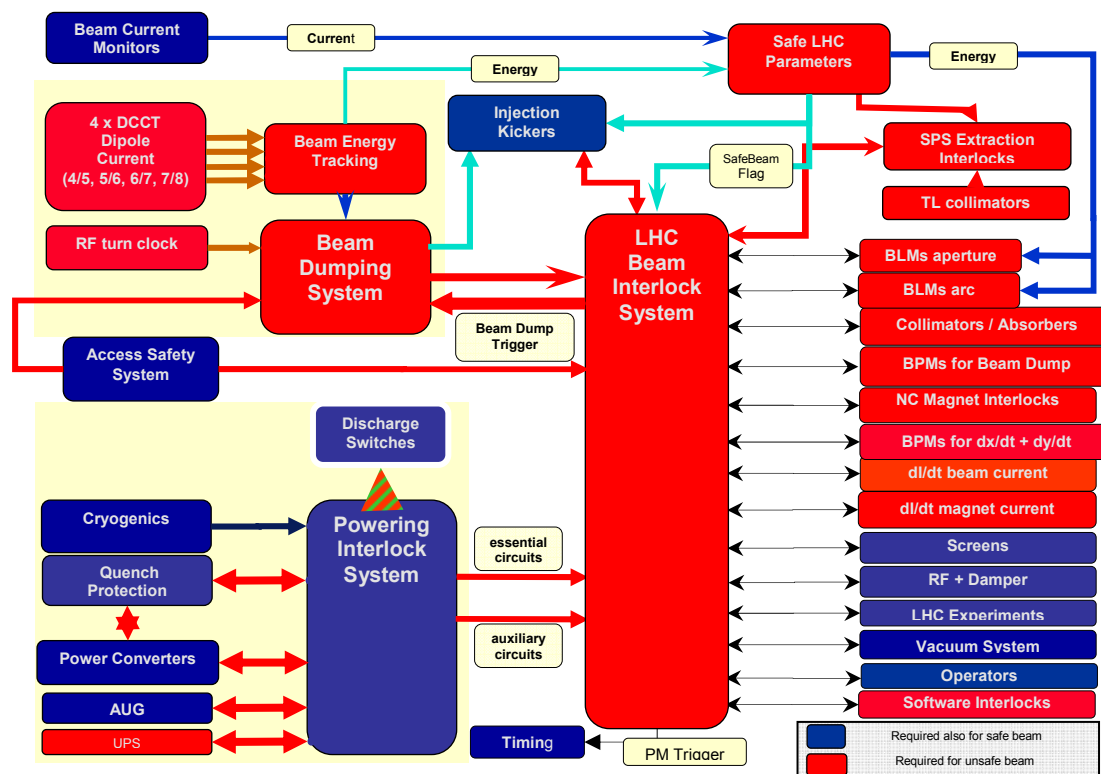


Figure 1: Overview of the Machine protection system and the connected equipment.

The third group consists of the related hardware systems:

- Safe Beam Parameters
- Beam Presence Flag

The fourth group consists of the related software systems:

- Post Mortem system
- Management of Critical Settings (MCS)
- Software Interlock System (SIS)
- Sequencer

STAGES IN COMMISSIONING

Without Beam

The commissioning of the MPS and the connected equipment starts with tests in the laboratory, followed by equipment tests in the machine. This is followed by the hardware commissioning, where the equipment is tested under normal operating conditions and the interface between the different systems has to be tested. A maximum of functions should be tested without beam: the individual equipment and their interface but also the Post Mortem system, sequencer, Safe Beam Parameters etc., even if they can only be partially tested without beam.

With Beam

Many systems, like the BLMs, the collimators and the LBDS will also need to be commissioned with beam. The tests will consist of individual system tests and tests of the interface between the systems. These tests will need to be repeated at the different stages of the LHC commissioning and can depend on:

- The beam intensity
- The beam energy
- The different operational states, like optics (squeeze), polarities of the magnets of the experiments or proton – ion operation.

DEFINITION OF THE STAGES

The different stages of commissioning can be defined according on the increasing risk during the operational period or according to the operation state of the machine which has not been checked before. After the commissioning of a certain stage, the operation should be declared safe *for the given conditions (intensity, energy, state)*. Operation outside these conditions should not be allowed.

The 'jump' to the next stage should be small enough so that the commissioning process itself is safe. Several systems might move into the next stage together, but only one should be commissioned at a time.

The systems can be classified in two groups: the system which only need to be commissioned once and are either 'on' or 'off'. These systems can already be commissioned at an earlier stage than formally required. This is in contrast with the systems that need to be retested at several instances to check there behavior under the different beam conditions. They will need to re-commissioned at each stage defined for this system.

The definition of the stages needed for Machine Protection commissioning will need to be more refined than the ones defined for the LHC commissioning [3]. A general overview of different stages and the systems which are required for these stages are given in [4]. This will need to be further refined for the actual MPS commissioning plan.

To simultaneously commission all the different systems requires a complex description of the different stages and the machine protection elements required. For the main systems, the logical order of commissioning for the same stage seems to be: first the commissioning of the injection system, followed by the LBDS, the other systems (as required for diagnostics), the BLM system and last the collimation system.

The different stages might not follow in a 'linear order' like always increasing beam intensity. As an example: it might well be possible that injection has already been commissioned up to higher intensities, followed by the first energy ramp which will need to be done with a pilot beam.

FORMAL TEST PROCEDURES

The tests to be performed during the commissioning of the MPS should be established and agreed upon well before the tests will be made. If the test results are negative (the conditions are not met) the operation of the LHC should not be allowed to move to the next stage. This can be tests either with or without beam. Similar procedures as already in place for the LHC hardware commissioning could be used.

Formal MPS test procedures should already be used in 2006 for the commissioning of the following beam operations:

- CNGS operation with nominal intensity
- TI 8 operation with high(er) intensity
- TT40 operation with high intensity LHC type beams (collimator tests)
- Sector test (low intensity, but important to check functionality and to establish procedures).

MACHINE PROTECTION COORDINATION TEAM

The creation of a Machine Protection Coordination Team (MPCT) is proposed. This team would have the following tasks:

- Definition of the different stages of the commissioning of the MPS. This should be done in collaboration with the Operation group and the equipment experts.
- Definition of the details of the different tests to be performed for the different types of equipment to go from one stage to the next. This is likely to be a dynamic specification, which can change during the LHC operational period.
- Declaration of whether a protection system is commissioned for a specific stage.

- Participation in the commissioning of the MPS.
- Consultation in the case of non-standard situations. If certain pre-defined conditions are not met, the MPCT can be consulted if and under which conditions LHC operation can continue. This should avoid and rushed 'over night' decision making.

The MPCT could consist of a small team of machine protection experts (4 – 6 persons), always available on short notice. If required, a contact person can be assigned to be one duty for a period of one week at a time. The MPCT can be contacted by the Machine Coordinator, EiCs etc. They can also bring any potential dangers, not foreseen, to the attention of the operations team and will closely follow the machine operation. They will contact other MPS specialists if required.

CONCLUSIONS

The commissioning of the Machine Protection System will take place in stages. The different stages and the formal acceptance tests will need to be clearly defined and agreed upon before LHC beam operation starts. The commissioning should already start with tests without beam and during the hardware commissioning period, followed by the many different stages with beam. These stages can be different for the different equipment types and will depend on beam intensity, beam energy and machine state.

The creation of a Machine Protection Coordination Team is proposed. Its task will be to formalize the above procedures and validate tests. It will consist of a small team of experts, available for consultation on short notice.

ACKNOWLEDGEMENTS

This paper is the result of fruitful discussions within the Machine Protection Working Group.

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