External review of the LHC Machine Protection Systems to prevent beam induce damage

The review will take place on 6 September – 8 September 2010

- An overview of the LHC is given
- The plans for increasing the luminosity and therefore the intensity are presented
- The overall strategy of the LHC machine protection is presented
- The key systems for machine protection and their performance is presented
- The operational experience is discussed

<u>Questions to the reviewers :</u>

- Do you consider the machine protection adequate for increasing the energy stored in the beams up to 30MJoule?
- What could be the main risks?
- Based on experience elsewhere: what is most critical and where have been surprises?

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https://lhc-mp-review.web.cern.ch/lhc-mp-review/

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Questions to the reviewers

- Do you consider the plans for intensity and luminosity increase adequate?
- Do you consider the machine protection adequate for increasing the energy stored in the beams up to 30 MJoule?
- What could be the main risks?
- Based on experience elsewhere: what is most critical and where have been surprises?

Reviewers

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- Richard Jacobsson
- Frank Zimmermann

Review on LHC machine protection, 6 September – 8 September 2010

draft

Monday						
Overview LHC						
09:00		**1**	Meeting of the reviewers		00:30:00	
09:30		**2**	Introduction to the review and mandate	SM	00:15:00	
09:45		**3**	Introduction to LHC	tbc	00:45:00	x
10:30	Coffee					
11:00		**4**	LHC operation and objectives for 2010/2011	ML	00:45:00	x
Overview LHC Machine Protection						
11:45		**5**	Introduction to LHC Machine Protection	RS	01:00:00	x
12:45	Lunch					
14:00		**6**	Operational experience with LHC Machine Protection	tbc	00:45:00	x
LHC Machine Protection Systems						
14:45		**7**	Overview interlocking	BP	00:45:00	x
15:30	Coffee					
16:00		**8**	The role of the collimation system in protecting the aperture	RA et al	01:30:00	x
17:30		**9**	Beam Dumping system, operational experience and validation	BG / JU	00:45:00	x
18:15		**10**	Meeting of the reviewers			

Tuesday						
09:00		**11**	Experience with BLMs	BD ?	01:00:00	x
Single turn failures						
10:00		**12**	Protection at injection	VK / BG / MM	00:45:00	x
10:45	Coffee					
11:15		**13**	Protection when dumping the beam: asynchronous beam dumps, particles in abort gap	JU / BG / MM	00:45:00	x
Interlocking						
12:00		**14**	Fast kick interlocking	JU	00:30:00	x
12:30	Lunch					
14:00		**15**	Magnet powering system and beam dump requests	IR / MZ	00:30:00	x
14:30		**16**	Movable devices	SR	00:30:00	x
15:00	Coffee					
Operational issues						
15:30		**17**	Orbit and feedbacks	JW	01:00:00	x
16:30		**18**	Machine protection and operation	LP	01:00:00	x
17:30			Meeting of the reviewers			

Wednesday (to be defined with the reviewers)					
09:00			Interactive session		
09:45			Interactive session		
10:30	Coffee				
Interactive session (closed session)					
11:00			Interactive session		
13:00	Lunch				
14:00			Executive session		
Conclusions (open session)					
16:00			Recommendations and Conclusions		30

Comments

- Sunday: possibly visit in CCC, to participate to operation and for a demonstration of the tools such as post mortem
- Safety culture – yes for critical systems, less during operation since operational flexibility is required, …
- Extend culture from MP to other systems (such as test procedures, requalification after changes were made, ….)

Question to keep in mind during the presentations

- What can we do in the CCC to make things unsafe (e.g. modifying thresholds, …)?

To be presented in the various talks

- Briefly comment on tests before beam operation

Other comments

- Recommendation from 2005 review – follow-up, done?
- Recommendation from 2010 internal review – follow-up, done?
  - should be included in Machine Protection Introduction, and possibly in the talks
- General commissioning strategy (list of MP tests, test ramps, …)

Introduction

- Introduction to the review – mandate for the reviewers

Getting to know the LHC – overview

- layout, 8-fold symmetry, insertions, parts with superconducting magnets and normal conducting magnets, optics
- main parameters (number of bunches, intensity, beta function, …)
- aperture and concept of n1, hierarchy of collimators
- injection from SPS

back

LHC Operation

- parameters, what has been achieved, and what should be achieved in the coming year
- parameters related to luminosity: beta function, bunch current, number of bunches, crossing angle, …
- overview of operation (injection, ramp, coast, beam dump)
- lifetime that are usually achieved during stores (very little losses during ramp and squeeze)

back

Overview Machine Protection

- phases during operation and protection (injection, stored beam, dumping of beams)
- single turn failures and risks (injection and beam dump)
- multi-turn failures and risks (circulating beam)

back

Operational experience with machine protection

- diagnostic tools: post mortem, logging, …
- failures, beam losses and beam dumps
- what cause the failure and what captured the failure?
- beam losses that caused a beam dump
- what is understood, what remains to be understood
- background in experiments (should be mentioned that this is not an issue)

back

Overview Machine Protection

- phases during operation and protection (injection, stored beam, dumping of beams)
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back

Overview interlocking

- Beam Interlock System: introduction and users
- interlocks for circulating beam and for extraction/injection
- validation – ensure that it works correctly
- diagnostics, post operational checks
- Safe Machine Parameters: introduction and relevance for protection (distribution of energy, other parameters)
  - beam energy tracking
  - beam intensity (fast and slow), development of beam presence flag from BPM
  - future: squeeze factor

back

The role of the collimation system in protecting the aperture

- introduction into collimation and passive protection for LHC
- collimation of encountered beam losses
- collimation and protection in the experimental IRs
- MP issues from collimation (safety during setup, machine stability, tolerances, ...) and impact from upgrades

- setting up of collimators, hierarchy, tests of cleaning efficiency
- operational experience
- phase coverage in case of failures
- how to ensure coherence between collimator settings and the machine status?

back

Beam Dumping system, operational experience and validation

- Beam Dumping System - design and safety
- energy tracking
- redundancy
- tests with beam
- operational experience
- XPOC

back

Beam Loss Monitors

- concept (running sums, energy dependence, how to define thresholds, ..)
- validation of the system
- experience
- redundancy
- how to ensure that the thresholds are correct?
- quench limit: are we close to it?
- safe changes in firmware

back

Single turn protection: Protection at injection

- interlocking at injection, beam presence flag, beam quality, collimators in transfer lines and in LHC
- experience with injection protection
- beam shaping in SPS
- issues with BLMs during injection
- operational experience
- TL magnets behind collimators

back

Single turn protection: Protection when dumping the beams

- principle (LBDS, collimators, …)
- how to survive an asynchronous beam dump?
- abort gap monitoring and cleaning (status, possible improvements, moving towards a safe system)
- RF interlocks
- operational experience

back

Interlocking: How to avoid fast kicks

- How to make sure that there are no fast kicks on the beam? at injection, during cycle from injection and aperture kicker, from other elements (AC dipole, …)

back

Interlocking: Magnet powering and protection systems

- failures captured at this stage, what dumps the beam (QPS, cryo, thunderstorms, timescales and reaction times,…)
- what are the interlocks?
  - power converter failures
  - FMCM
  - QPS
- enabling / disabling beam dumps for circuits
- orbit correctors (not via PIC) – different strategy
- examples on how fast: normally before the beam in affected
- thunderstorms and other problems in the electrical network

back

Interlocking: Movable elements and interlocking

- what can move into the beam?
- how to prevent it? different type of interlocks (vacuum-switches, collimators-complex interlocks, experiments-stable beam flag + interlocking)
- redundancy: by BLMs
  - example: losses by wire scanners, by collimators or TOTEM touching the beam

back

Issues during operation: Orbit and feedbacks

- How to ensure that the orbit is under control (orbit feedbacks, RF frequency, feedbacks on tune, ... ?)
- performance of BPM and limitations
- risks of a bad orbit
- orbit feedback
- how to avoid closed bumps?
- other feedbacks

back

Issues during operation: Operational dangers

Operational dangers (incl. software such as SIS and Sequencer,...)

- role of software interlocks (SIS), what is captured by SIS?
- role of procedures and the sequencer
- status and development
- other issues

back

Other systems (no presentation)

- Experiments (also TOTEM)
- Transverse damper and protection

Future

- Squeezing factor and position of collimators
- Future developments (2010-11)
  - Fast Beam Current Change Monitor
  - Fast Beam Position Interlock
- Beyond 2011 (maybe not for the review)
  - BLM at injection – mask during injection
  - Abort Gap monitor – make it reliable
  - More use of Beam Position Monitors for beam dumps
  - SPS scraper – is it reliable enough? redundancy?