A quick look back in time....

Review of MP Workshops 2013/2015

S. Strachinescu, J. Uythoven, C. Wiesner, J. Wenninger, D .Wollmann, M. Zerlauth, for the MPP colleagues and members
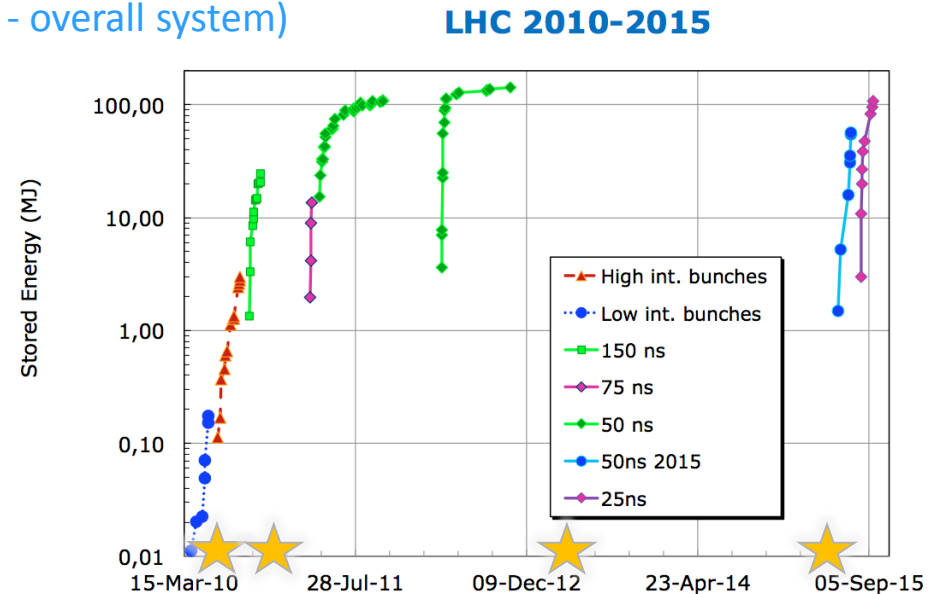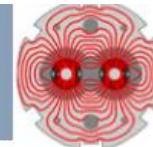
A bit of MP review history

Design phase:

- First design/architecture document ~ 2001
- External Machine Protection review (June 05 - overall system)
- BIC audit summary (Sept 06)
- BIC audit sequel summary (June 09)
- LBDS audit summary (Feb 07)
- LBDS audit sequel summary (June 09)
- BLM audit summary (July 08)
- BLM audit sequel summary (June 09)

During (beam) operation:

- MPS internal review (June 2010)
- Collimation system (several reviews)
- External LHC Machine Protection Review (September 2010 - ready to go beyond 30 MJ?)
- Machine Protection Workshop for linear accelerators (June 2012)
- Machine Protection Workshop (March 2013) - Annecy
- Machine Protection Workshop (June 2015) – Post LS1 re-start @ CERN
- Machine Protection Workshop (June 2019) – Today!

LHC 2010-2015

Legend:
- High int. bunches
- Low int. bunches
- 150 ns
- 75 ns
- 50 ns
- 50ns 2015
- 25ns

Stored Energy (MJ) vs. date (15-Mar-10, 28-Jul-11, 09-Dec-12, 23-Apr-14, 05-Sep-15)

Report from the LHC Machine Protection Review

September, 28th, 2010

Submitted by the LHC Machine Protection Review Committee: Jerry Annala (FNAL), Reinhard Bacher (DESY, Chair), Mei Bai (BNL), Doug Curry (SNS), Stefan Lueders (CERN/IT, Co-Chair), Richard Jacobsson (CERN/PH), Jens Stadlmann (GSI), Dean Still (FNAL), Frank Zimmermann (CERN/BE)

❑ Review provided a detailed snapshot of the MPS state.

❑ 11 recommendations:

  o *No show-stopping item.*

  o *Strong concerns around configuration and sequencing.*

    ➤ *Still with us in 2011…. see talk by L. Ponce.*

  o *All points have been (or will be) addressed.*

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Chammonix 2011 - MPS in 2010 - J. Wenninger

27/1/2011

MPP Workshop 2013

- **11-13 March 2013 in Annecy (2.5 days), 99 (registered) participants**

- **Discuss mid-and longer-term improvements of the MP systems:**
  - Review the current operational experience with MP systems during the first running period (2010-2012).
  - Understanding the planned changes of MP equipment during LS1 and the consequences for operation after LS1.
  - Identifying areas where improvements are required.
  - Ensuring coherence between the different MP systems.
  - Identifying misses.

- **7 Sessions**
  - MPS operational experience (2018 – 2012) and outlook
  - Injection, Extraction and Beam Dump
  - Beam diagnostics
  - Collimation and movable devices
  - Electrical circuit related protection
  - Operation after LS1
  - Summary session

Executive Summary to 165th LMC

Main actions and follow-ups

System	Action	Comments
Material damage/ failure scenarios	• Review/Update Setup Beam Flag parameters/functions	DONE
	• Study use of collimators with new materials	DONE
	• Update failure cases for asynch beam dump + ion beam damage	DONE
	• Working group to discuss beam induced heating issues	DONE
	• Planning of new test in HighRadMat	DONE
LBDS & injection	• BIS-LBDS retriggering	DONE
	• Scan of MKD waveform with beam	DONE
	• TDE block pressure rise when dumping @ 6.5/7 TeV	DONE
	• TCDQ in BETS, MSI current and TDI gap	DONE
	• TCDIs: virtual beta* and interlocking in SIS	Partially
	• Beam position in TCSG (IR6) interlock from SIS to BIS	tbd
Powering Interlocks/ QPS/Electrical distrib.	• FMCM - dependability analysis and thresholds revision	DONE
	• Extend PC interlocks	DONE

Main actions and follow-ups

| System	Action	Comments
Movable devices	• TCDQ upgrade: new interlocking strategy as ring COLL • How to use Collimators with buttons? • Momentum loss maps with reduced RF frequency change?	DONE DONE DONE
Beam instrumentation	• IR6 BPMs: improved dynamic range and PM buffers • LICs in injection region • DIDT interlock (BCCM) • Reliable/redundant abort Gap Monitoring • Improved reliability of OFB • BLM thresholds for 7TeV and generation via LSA	DONE DONE new development DONE DONE ongoing

Main actions and follow-ups

System	Action	Comments
Software tools and operation	• Tracking of changes in MP systems • XPOC: improve/reduce number of false latching • IQC: improve to require fewer resets • Aperture meter and online model • Facilitating loss-map checks • Mask/SFB consistency check before ramp • Testing of BIS inputs: automatically	SUWG DONE DONE Not really… More tbd More tbd More tbd
MPP/rMPP/ fault tracking	• rMPP piquet phone • MPP <-> MP3 improved interplay • MD documents • Availability Matrix / fault tracking / AWG	DONE More tbd DONE DONE

MPP Workshop 2015

- **12 June 2015 at CERN (1 days), ~ 50 participants**

- **The principle aims of the workshop were to** review and discuss the readiness of vital MP and related equipment systems for high intensity operation.
  - Are the systems operating with nominal parameters?
  - Are there any non-conformities?
  - Any weakness that has been observed so far?
  - New failure modes after LS1 modifications?
  - Were all the commissioning steps performed, and what is still missing?
  - What is the operational experience from the first two months of operation?
  - Diagnostic Data for PM and Logging all available?

- **No dedicated session but talks for all main systems**
  - Collimation
  - Powering Interlocks, Beam Interlocks + SMP
  - Beam dumping and injection systems
  - Beam loss monitoring, Beam position monitors, BCT for protection
  - RF, ADT, AG cleaning
  - Software interlocks and Real Time FBs, Post Mortem System
  - Experience from operation 2015, Summary

Executive Summary to 223rd LMC

Operation in 2015 Q2/Q3
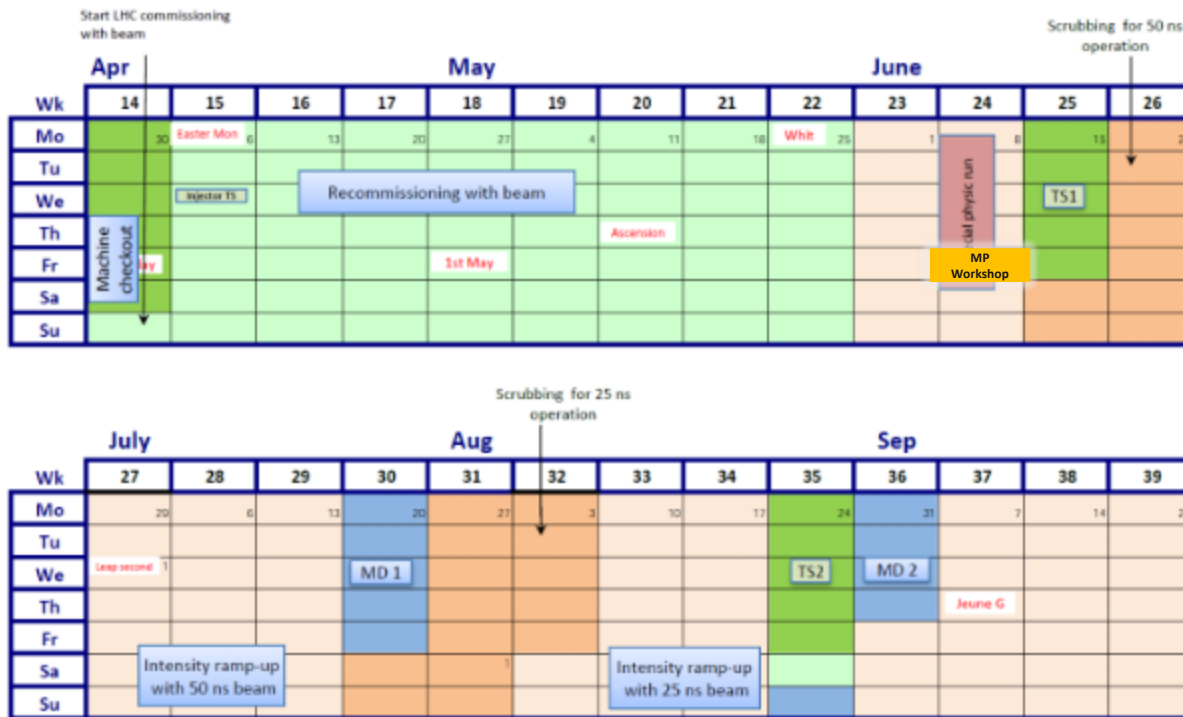
- Beam commissioning (mostly) finished, currently preparing for scrubbing run...
- Up to TS#1: < 4.5MJ
- 50ns scrubbing: < 12 MJ
- 50ns ramp-up: < 180MJ
- 25ns scrubbing: < 24 MJ
- 25ns ramp-up: -> 340MJ

No athletic jumps or short-cuts, but serious and systematic approach towards 100MJ range

Main actions and follow-ups

System	Action	Comments
COLL	• Beta* limits remain to be deployed • Two issues with temperature interlocks (logic modification proposed), respectively spike on LVDT	DONE ongoing
PIC	• Redundant opening of 13kA EE switches through SIS • QPS_OK toggling + automatic QH discharge monitoring • UPS validation for LBDS/QPS/BLM/BPM/…	DONE DONE After every LS
BIS & SMP	• Logging of data for SMP in decoded way	DONE
Beam Dumping	• Commission direct BLM (small testing procedure required) • Procedure for non-working beam dump (EDMS #1166480) -> Replace last step with loss generation by ADT • XPOC filling pattern still manually edited • Definition of XPOC modules to be safely reset by OP • AG cleaning at 6.5TeV needs to be commissioned – need BSRA + automatic cleaning via SIS	DONE DONE but tbc/updated DONE (AGK) DONE DONE
BLM	• Exchange of HV cables + additional earthing + overvoltage protection • New injection crate firmware ready for deployment but needs quick revalidation, also of new capture buffer/XPOC PM buffer	DONE Validated but never used

Main actions and follow-ups

System	Action	Comments
Injection	• Sunglasses: LIC vs IC • TDI limits: No more than 144b in 1 train, Critical flipping between 25ns and 50ns, changing the length of MKI flat-top • Optics ID for TLs - all done up to distribution over timing. • MKI rise-time too long (1.2us instead of 0.9us); Do MKI waveform scan (sign of injection oscillations in vertical plane); • Injection gap cleaning	DONE DONE Partial DONE DONE
BSRA & BPMS	• BSRA: Zeroing of AG population – beam presence flag is not there with unbunched beam; • BPM IR6: Issue with MCS settings (changing interlock limits). Remove tolerated offset, e.g. allow for certain re-calibration within a given window; • Doublets: Up to 2mm offset and larger errors/fluctuations (1-2mm) depending on the relative bunch intensity	Npt yet addressed? Solved in TS#1 Redesign on-going, doublets not baseline
BCT	• BCCM - Proposal to use it already now with relaxed threshol and enable BIS input after scrubbing run.	new development

Main actions and follow-ups

System	Action	Comments
RF	• Monitoring of HOM is recommended • RF interlocks are existing and should protect the systems	Checklist DONE
ADT and AG cleaning	• Injection gap cleaning- h-plane, to be done before long bunch trains • Abort gap cleaning at 6.5 GeV to be done • For bunch trains 25 ns –set up fine delays • Verify PM (not understood) concurrent use for dump and for head-tail • Can have instability of two bunches in doublets, not been seen…	DONE DONE DONE DONE Still needed?
SIS and FB	• QPS_OK too noisy – injection permit – risk to stay at injection • Redundant 13kA EE switch opening – to be enabled during TS1 • Abort gap cleaning to be activated (cleaning switched on by SIS) – getting info from BSRA; • 15 dumps by SIS – not related to intensity (14 wrong) – being investigated; • OFB: missed some timing events, has been hopefully fixed	DONE DONE DONE DONE DONE
Post Mortem	• Diamond detectors still missing; • Interlock BPMs in IR6	Ongoing Ongoing

Main actions and follow-ups

System	Action	Comments
Experience from OP in 2015	• Daily and careful work on injection has so far been left 'aside': For intensity ramp up steering and monitoring of TL has to become important • Key item for integration are abort gap and injection cleaning; • FBs now stable from controls point of view	Still valid DONE DONE
Tentative plan to come back after LS1	• Add validation of BLM inj crates (dump on closed COLL and enable/disable blinding) + validation of new XPOC buffer – 2 hours in // to TL setup…? ; • Loss maps at injection • Cycle with pilot (+ dump at 6.5TeV, beta * limits,…)	DONE

Conclusion

- MP effort started with the LHC design phase and is in continuous evollution since to adapt to new operating conditions (Jan's following talk), mitigate new failure scenarios and integrate new equipment

- Regular MP workshops are important milestones along the way, allowing to formalise the mid- and long-term follow-up

- Most actions from latest workshops in 2013/2015 successfully completed, some longer-term ones still being adressed

Many thanks for your attention!

Questions?

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