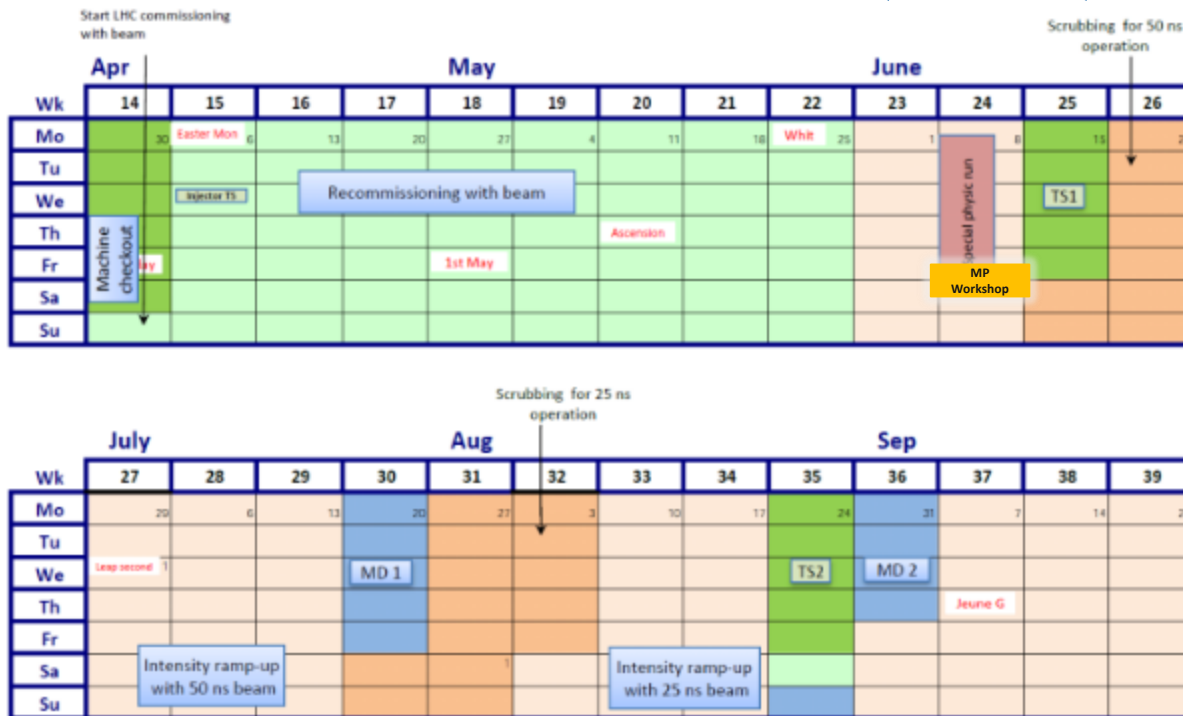




Internal workshop on Machine protection system readiness for MJ beams (post LS1)

Executive Summary

Operation in 2015 Q2/Q3



- Beam commissioning (mostly) finished, Started 2015 operation with special physics run
- Up to TS#1: < 4.5MJ
- 50ns scrubbing: < 12 MJ
- 50ns ramp-up: < 180MJ
- 25ns scrubbing: < 26 MJ
- 25ns ramp-up: ->340MJ

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

Objectives of Workshop

- 1 day workshop @ CERN 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?
 -

Program 1/2

MPP Workshop

Friday, 12 June 2015 from 08:30 to 17:30 (Europe/Zurich)

CERN (864-1-D02)

Description Internal workshop on Machine protection system readiness for MJ beams (post LS1).

Friday, 12 June 2015

- | | |
|---------------|--|
| 09:00 - 09:10 | Introduction to the review 10' |
| 09:10 - 09:30 | Collimation system 20'
Speaker: Belen Maria Salvachua Ferrando (CERN) |
| 09:40 - 09:55 | Status of Powering Interlocks 15'
Speaker: Ivan Romera Ramirez (CERN) |
| 10:05 - 10:25 | Beam Interlock System + Safe Machine Parameter System 20'
Speaker: Stephane Gabourin (CERN) |

Collimation and Interlocks

10:35 - 11:00 Coffee Break

- | | |
|---------------|---|
| 11:00 - 11:20 | Beam Dumping System 20'
Speaker: Jan Uythoven (CERN) |
| 11:30 - 11:50 | Injection System 20'
Speaker: Chiara Bracco (CERN) |
| 12:00 - 12:20 | Beam loss monitoring 20'
Speaker: Bernd Dehning (CERN) |

Injection and Dump System + BLMs

12:30 - 14:00 Lunch Break

<https://indico.cern.ch/event/397348/>

Program 2/2

14:00 - 14:20 Beam position monitors (BPMS) +BSRA 20'
Speaker: Thibaut Lefevre (CERN)

14:30 - 14:45 BCT for protection 15'
Speaker: Lars Soby (CERN)

14:55 - 15:05 RF 10'
Speaker: Philippe Baudrenghien (CERN)

15:05 - 15:20 ADT + AG cleaning 15'
Speaker: Wolfgang Hofle (CERN)

Beam Instrumentation + RF/ADT

15:30 - 15:45 Coffee Break

15:45 - 16:05 Software interlock system + Real time FB 20'
Speaker: Laurette Ponce (CERN)

16:15 - 16:30 Post Mortem System 15'
Speaker: Vera Chetvertkova (CERN)

16:40 - 17:00 Experience from operation 2015 20'
Speaker: Jorg Wenninger (CERN)

Operational aspects and Post Mortem

17:10 - 17:30 Summary 20'

<https://indico.cern.ch/event/397348/>

Collimation system (Belen Maria Salvachua)

- No large surprises in cleaning wrt to 2012, loss maps look in general OK, some peaks to be further investigated (possibly related to BLMs?)
- All position and temperature interlocks were checked and validated (>1600 sequences)
- Aperture generally OK for 80cm beta* (allocated 2 sigma margin to MP as endorsed by LMC)
 - min aperture measured 15.7, consistent with assumption of protected aperture in IR1/5 of 15.1 sigma
- Large offset found on TCLA.D6R7 -> **Has been re-aligned in TS1, requires new alignment and validation**
- Need more time to validate new off-momentum loss-map technique, considered a good investment as validation will be (much faster)
 - Need to agree on a (reduced) set of loss-maps after technical stops
- Integrated BPM result very promising, only requiring a few seconds for alignment, but electronics still to be completed
- **Beta * limits remain to be deployed**
- Two issues with temperature interlocks (logic modification proposed), respectively **spike on LVDT (disabled until TS1)**

Powering Interlocks – (Ivan Romera)

- No critical updates during LS1, 5000 tests performed, commissioning completed
- Redundant opening of 13kA EE switches through SIS – to be commissioned in TS1
- Testing of redundant opening of 13kA EE switches (main dipole and quadrupole) through SIS
- QPS_OK toggling – needs to be fixed as blocks too many injections
- Quench heater monitoring – automatic notifications to be re-established
- FMCM commissioning: has been completed, confirming (expected) better resolution due to 6.5TeV operation
- FMCM test at 6.5TeV to be done as well for RMSD?!
- UPS validation for LBDS/QPS/BLM/BPM/... after mitigation actions (EDMS 1505860)
 - Collimators were retracted ? Are they powered by UPS?
- Re-test the ACCESS interlock after TS1

Beam Interlocks & SMP – (Stephane Gabourin)

- **BIS**

- All IST tests have been performed (but with some delay)
- BIC timing misalignment between SPS and LHC timing network of few 10us
- Redundant power supply in IR4 (DIAMON to be re-established)
- CIBDS arming sequence was not working -> Reworked Sequencer arming sequence, no major issue since
 - Hardware revision ongoing for YETS
- SW tools: monitor redundant power supplies of user boxes.. to be made working

- **SMP**

- New equations for generation of Normal, Restricted and Beam Setup flags
- Flickering of SBF due to noise on BCT-B2 → fixed by filtering (1s → 16s above 500GeV).
- **Firmware upgrade of monitoring part of CISA during TS#1**
- Remove/adapt beta* window opening of currently allowed 0.1m (due to interleaving low/medium/high beta* operation).
- **Logging of data for SMP in decoded way**
- Optics ID transmitted for TL lines but not yet commissioned

Beam Dumping System – (Jan Uythoven)

- One MKD erratic on 4th June, (3/y and beam expected), all worked correctly, rule is to replace a switch, after one erratic
 - reference measurements now taken and have to be compared for any future occurrence
 - Need checklist for switch replacement , the procedure seems effective + was followed twice
- Reference losses TCDS and TCDQ also to be officially written down so can be done by non-specialists
- New and longer TCDQ + BETS
 - Problem with arming / interlocking during commissioning
- MKD waveform rise time to be revalidated (along with AGK) after TS#1 decrease to 925ns
- Outstanding MPS tests:
 - Non-conformity during UPS powering failures – TS#1 Redundant PSU surveillance by SIS
 - Commission direct BLM (small testing procedure is required?) – access needed...
 - Procedure for non-working beam dump (EDMS #1166480) -> Replace last step with loss generation by ADT
 - XPOC filling pattern still manually edited (Delphine)
 - Some XPOC modules can be reset by OP which should not be the case
 - AG cleaning at 6.5TeV needs to be commissioned – need BSRA + Automatic cleaning via SIS
 - Interlocked BPMS – see Thibaut

Injection System (Chiara Bracco)

- Different trajectories for PILOT and INDIV/25ns (different extraction point from the SPS, still below 1mm for run1).
- Possible solution to put pilot on SLOW cycle to allow for proper setup of LHC
- Solved issue in RBI in TI8 (Changing the DAQ and acquisition card), to solve an issue of the FEI, should put back old reference to avoid loosing in IR7
- Sunglasses: LIC vs IC – more statistics when injecting higher intensity -> See BLM
- Extraction issues in LSS6: Convolution of several issues, extraction aperture was the same for both cycles, setup of 25ns cycle not complete, uncaptured beam kicked out by longer risetime of MKE6 wrt to MKE4.
- Orbit drift at extraction points are still not fully understood. BPCE resolution not enough for fine interlock -> Possible mitigation: Interlock through IQC
- Missing: Optics ID for TCDI, all done up to distribution over timing. FESA class not ready to do this (although foreseen)? Would also go into FESA class of LHC collimators. What MP tests would have to be re-done?
- TDI limits: No more than 144b in 1 train, Critical flipping between 25ns and 50ns, changing the length of MKI flat-top + total intensity in SPS?! -> Procedure of Anton
- MKI rise-time too long (1.2us instead of 0.9us) -> TBD during TS1 -> Do MKI waveform scan (sign of injection oscillations in vertical plane)
- Injection gap cleaning

Beam Loss Monitors (Bernd Dehning)

- BLM high voltage issue(s): 2 events 30/09/2014 + this year , losses increase
- Plot shows 12 second of history, fast transition in a few 100ms, jumped by 3 orders of magnitude
 - >1900V measured, cannot come from BLM power converters
 - **Actions (cause still not found): overvoltage protection on tunnel cables -> What will be done?!**
 - **Exchange of HV cables + additional earthing;**
- **New injection crate firmware ready for deployment TODAY – needs quick revalidation, also of new capture buffer/XPOC PM buffer**
- Filter checks still tbc (found 1 missing filter, 6 could not be verified due to small losses).
- **Thresholds and updated:**
 - TS1: IT, IPQ, IPD
 - TS2: collimators, DS-RBs

BSRA and BPMS (Thibaut Lefevre)

BSRA

- Calibrated in May, many issues solved
- PMT gate protection – operator needs to re-enable PMT
- Zeroing of AG population – beam presence flag is not there with unbunched beam
 - Can use another flag from the BIS?
- HV regulation loop to be adjusted for B2
- Threshold need to be set

IR6 BPM

- Modified system, improved processing of interlock data
- All bunches 154 turns, better dynamic range, high sensitivity for scrubbing run
- Issues: integrator mezzanine broken, faulty RF filter => should be fixed before continuing
- SW/FW issues: discrepancy and calculated by FE, capture buffer issues
- Some communication issues.... new FESA release will cure it
- Issue with MCS settings (changing interlock limits). Now solved, release in TS1
- Calibration procedure to be reviewed -> 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
- -> Mix both nominal and doublet bunches to validate injection (trust in nominal) -> Should not wait too long to try

BCTs for protection (Lars Soby)

DCCTs

- System B for Beam 2 has more noise: fixed by filtering (increasing integration window >500GeV)
- Important to have **DECODED SMP data** in Logging
- SBF reliability: not a high SIL system
- Some short term improvement are being done, e.g. scaling factor hard coded
- **Long term solutions: different solutions, e.g. FPGA with direct links to be defined! specification needed**

BCCM

- System A and B (A operational)
- New FESA class not yet operational (frequent crashes)
- New BCTs promising
- Looks good from the operational experience for the first weeks...
- All thresholds are still independent of energy....
- **Proposal to use it already now with relaxed threshold, enable BIS input after scrubbing run.**

RF (Philippe Baudrenghien)

- Klystron trips, beam passes in empty cavity which is not acceptable since the beam induces (mostly reflected power (up to several 100 kW)
- Klystron trips: 560 kW can get into load, in this case dump beams in three turns
- Transients are acceptable
- Beam excited HOM, dedicated couplers are required, 500, 535, 779, 1184, 1238 MHz, designed for 1 kW -> power and temperature are monitored and interlocked
- Power extracted scales with beam current
- No problems with 50ns, not fully known for 25ns and for different bunch patterns
- **Monitoring of HOM is recommended**
- **RF interlocks are existing and should protect the systems**

ADT and AG cleaning (Wolfgang Hoefle)

- Many changes were done during LS1
- Some interlocks on HW (e.g. to protect the amplifier)
- Some voltage induced from beam (to be watched for 25ns beam)
- Abort gap cleaning: tests were done
- 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
- Other commissioning steps: setting switches, flat frequency response, scrubbing doublet setting-up, then readiness for doublet beams: should be ok
- Can have instability of two bunches in doublets, not been seen...
- High intensity – damage of HW is not excluded

SIS and Real time FB (Laurette)

- New SIS interlock tree, with 3 different Powering branches
- 1 branch is conditioned by the SBF inside the SIS
- All logic branches tested, remains to be enabled:
 - PM_mach_pro – ok can be unmasked, BSRA and CODs
 - PC interlock needs commissioning, takes over from the SIS-COD interlock
 - Orbit is active, COD interlock still masked
 - 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
- FB: Major refactoring towards BFSU/OFC during LS1 (new machines, migration to FESA3, new developers), but similar functionality
- Orbit, complex process, change reference during ramp
- OFB: missed some timing events, has been hopefully fixed
- Feed-forward would avoid tune feedback (preferred solution)
- More experience with bunch trains is needed

Post Mortem (Vera Chetverkova)

- Most post mortem modules existed before
- Have been commissioned during early part of run, a few bugs...
- Safe for injection => Flag into SIS, should be ok now
- Powering PM server being built up: automated event analysis for quenches,...
- Quench heaters after discharge is being tested.... after TS1 should be operational
- **Still tbd:**
 - Diamond detectors still missing
 - interlock BPMs in IR6
 - time for BCT is not correct, collimator time stamps
 - event classification, review dump classification.....
- MPE-MS-SW team et al will follow up the non-conformities

Experience from OP in 2015 (Jorg Wenninger)

- Started operation with experience of run1
- 60 days from first injection to stable beams (maybe leaving some things aside), less enthusiasm (care for the detail) as people worked on many // things
- Often parallel commissioning threads require different 'task combinations'
- Need another 2-3 weeks of regular operation (not scrubbing) as all shift crews should have seen all phases of cycle
- No evident stoppers for increasing intensity
- **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**
- Decay of persistent current, first time observed orbit decay (snapback) – not a problem -> Orbit FB
- Need to understand orbit drifts up to $\pm 0.2\text{mm}$ (origin around IR8 triplet?!)
- Key item for integration are **abort gap and injection cleaning**
- **FBs now stable from controls point of view**
- **Octupoles and ADT almost at full strength -> Not a problem for MPS**

Conclusion

- In general, looks good, e.g. efficient protection against training quenches – beam dump without beam movement
- No major show-stopper for intensity ramp up, but many (minor) issues still to be followed up
- Very important to have intensity ramp up
- Need to clarify remaining injection commissioning and intensity ramp-up ahead of scrubbing run t
- Thanks to all speakers, co-organisers and Stefanie

Tentative plan to come back from TS#1

Cryo should be ready Fri. evening (pt.4 ?)				Point 4 - cavity conditioning can start when? In principle cavities filled Thursday evening			
WS vacuum giving the foreseen delay							
Friday	N			Powering tests ramping the MSI to nominal and verifying that we are in the tolerance in the BETS explorer Precycle(s)	Should come in under the shadow of recovery elsewhere	Mirko	
Saturday	TBD	2 hours	450 GeV	TL verification	T18 dipole issue - correct knobs... schedule the SPS extraction to check the current in the last bend of T18 for Friday 23:00. LHC P8 closed	(Wolfgang&Chiara)	
		8 hours	450 GeV	MKI risetime		ABT	
		1 hour	450 GeV	AGK checks	After the PFN modifications	Etienne	
		2 hours	450 GeV	BPMS checks with bumps (12 b)	BPMS - new FESA release	Jan/BI	
		1 hour	450 GeV	TCLA at injection	aperture bump tbc		
		2 hours	Flat-top	Ramp for TCLA	Nominal		
		1 hour	Flat-top	Realign TCLA	set-up at flat-top	Stefano and team	
		1 hour	Collide	ALICE vertical IP displacement and TCT set-up	collision beam process		
		1 hour	450 GeV	FBCT re-phasing circulating nominal bunch in b	Call David Belohrad		
Sunday	M	6 hours	450 GeV	Injection gap cleaning		Gerd, Delphine on M over the weekend	
		En passant	450 GeV	Abort gap cleaning tests (should work)	Check BLMs in IQC with and without injection and abort gap cleaning		
				OMC request for 40 cm!	Settings available?	Possible SF	
				If time gentle 24b injection - pre-scrubbing			

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,...)

Program after TS#1 continued

	OMC request for 40 cm!	Settings available?	Possible SF
	If time gentle 24b injection - pre-scrubbing		
Specific preparation for scrubbing	set-up for trains as part of the process - including damper setup injection of 144 bunches 25 ns will need to be set up in the beginning of the scrubbing run. check solenoids off, dipoles on vacuum interlock levels emittance measurements	inc. MKI at 450 GeV - should be OK	
Before 50 ns ramp-up	Roman pots set-up BSRT calibration on flat-top Full cycle	Loss maps as required	Push until after scrubbing - to be combined with RP set-up
NOTE	UPS tests during TS1 - e.g. LBDS FMCM FESA class modifications FESA class - access powering interlocks BLM modifications in IR6 - overvoltage protection etc. re-enable UFO buster triggers Foresee doublet commissioning before 2nd scrubbing run	EOF when available	