

LHC Intensity Increase – Check list Proposal

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Motivation and History

- **Check and document each fill** with intensities, dump reasons and stable beams time during the intensity increase (and later cruise).
- Systematically check and document **readiness** for next intensity step of **protection critical systems/elements**.
- **Detect non-conformities**.
- **Delay intensity increase** in case of issues in MP critical system **until resolved** or satisfactory understood.
- 2011: 12x Intensity increase, 3x Scrubbing, 2x cruise
- 2012: 4x Intensity increase, 6x Intensity cruise

LHC intensity cruise – check list

Version 1.4 – 04.04.2012

Bunch pattern / intensity	Mostly 1374/1368 bunches. 50ns_1374_1368_0_1262_144bpi12inj
Start date	21 August 22:52:32 (time of dump)
End date	01 November 20:11:23 (time of dump)
Fill numbers	2992 – 3250 (148 fills)
Comment	This list covers the floating MD, the high beta* and pilot proton-ion run, TS3, MD3 and the 1000m beta* run.

Dump Reason	# of dumps	Comments
QPS	22	
EOF	34	
Cryo	5	
EL Net	8	
RF	4	
PIC	-	
Beam Loss	6	
BLM	3	
Vacuum	7	
PC	10	
Orbit	-	
Feed Back 1 / 2	7 / 1	
Collimators	3	
LBDS	4	
SIS	1	
Access	-	
CO	3	
UFO	4	
BPM IR6	-	
Transverse beam instability	2	
OP / BPM / Water	1 / 2 / 1	
MPS test	8	

Event Timestamp	Fill Number	Beam Energy [MeV]	Intensity B1 [1e10]	Intensity B2 [1e10]	Stable Beams [hours]	Mps Dump Cause	Mps First Detection	Dump Classification	MP Expert comment
01-NOV-12 08.11.23.197653 PM	3250	3999840	19773	19639	4.25	QPS	PIC	QPS trigger	QPS trigger from RQX.L1, HDS discharged correctly, cryogenic conditions were lost and vacuum valves around IP1 closed. Discharge was checked by QPS/MP3 expert. No anomalies found in the post mortem (board A). SEU on board B confirmed indirectly by PM timing error. Clean dump.
01-NOV-12 12.41.55.998107 PM	3249	3999840	14917	14729	15	EOF	OK	Programmed Dump	Clean dump. Abort gap cleaning was turned on ~6mins before the dump, i.e. hardly any losses in IR6. No BLM reached dump threshold during the dump.
31-OCT-12 02.07.41.155306 PM	3245	3999840	0	0	0	MPS test	OK	Programmed Dump	Dry dump without beam.
31-OCT-12 06.27.09.387687 AM	3244	3999840	21239	20691	2.22	QPS	PIC	QPS trigger	Spurious QPS trigger on RQ4.L1, still under investigation. Clean dump. RS: likely to be a SEU, since there was not fault on the protection board
31-OCT-12 12.04.58.907853 AM	3242	3999840	19588	19445	4.46	RF	RF	RF fault	ACSLine4B1: driver fault, Clean dump.
30-OCT-12 02.06.50.708169 PM	3240	3999840	21496	21549	1.46	QPS	PIC	QPS trigger	RQ5.L1 tripped and caused the beam dump at 14:06:50.708 due to QPS. Could be that the redundant board_B. Clean dump.
30-OCT-12 06.24.26.313843 AM	3239	1946280	23561	23678	0	PC	PIC	Power converter fault(s)	Looks like a horizontal orbit oscillation starts for both beam in the H-plane, with amplitudes up to 0.15 mm. No beam losses that is somewhat surprising. Clean dump
30-OCT-12									RCBXV3.R5 and RCBXH3.R5 tripped, likely to be a SEU. Looks like a trip of the V corrector first. Beam dumped before orbit moved. Clean dump, but somewhat higher losses at TCNO as for

Systems / categories

- Magnet powering (MP3)
- Beam and powering interlocks, post mortem
- RF
- Beam instrumentation
- Collimation
- Operation, orbit and feedbacks
- Beam Dump
- Injection
- Heating of Equipment

Proposal for Run2

- Use google tables, to ease exchange and filling.
- Documentation EDMS after finalizing.
- V1: Intensity Increase - check list Run2 V1
- **Feedback** required from system experts, especially on their respective section → scrubbing run, intensity increase, cruise

Check list period		
	Bunch pattern / intensity	
	Start date	
	End data	
	Fill numbers	
	Comment	
	Next intensity	
Non conform points in the following check lists: the intensity increase is put on hold pending a satisfactory understanding / resolution of the issue		

Dump statistics

Dump Reason	# of dumps	Comments
QPS		
EOF		
Cryo		
EL Net		
RF		
PIC		
Beam Loss / BLM / Vacuum		
PC		
Orbit		
Feed Back		
Collimators		
SIS		
Access		
CO		
UFO		
BPM IR6		
Transverse beam instability		
OP		
MPS test		
Exp		

Event Timestamp	Fill #	Intensity B1 [1e10]	Intensity B2 [1e10]	Stable Beams [hours]	Mps Expert Comment

Magnet powering (MP3)	Status	Who	Comments
No magnet quench after beam dump in RQ4.R/L6.			
No unexplained quench of a magnet.			
No problems with loss of QPS_OK for main circuits following injection process.			
No unexplained firing of quench heaters.			

Beam, powering interlocks and post mortem	Status	Who	Comments
No unexplained IPOC failure in Post Mortem for FMCM.			
No unexplained IPOC failure in Post Mortem for PIC.			
No unexplained IPOC failure in Post Mortem for BIC.			
No unexplained false beam dump from beam interlock system.			
No unexplained abort of the previous fills by magnet powering system.			
No unexplained abort of the previous fills by FMCM.			
No failure of BIS pre-operational check.			
No unexplained PM event with intensities > 8 nominal bunches			
No unexplained PM event above 450 GeV.			
UFO occurrences.			

RF	Status	Who	Comments
Check klystron forward power during ramp, all klystrons. Report peak demanded power for each.			
Check transient beam loading compensation and corresponding klystron power in physics (previous fill). Set Point module acquisition. All cavities.			
Check Temperature and Power levels in all HOMs during the previous intensity fills (Timber or RF application).			

Beam Instrumentation	Status	Who	Comments
BLM Internal sanity checks results must be true.			
Rise time (10 to 90%) of fast losses must be larger than 200 us.			
No unexplained BLM check failures.			
BLM system modification (ECRs) have to be agreed on, EDMS: notified persons signature is needed.			
No nonconformities in the energy transmission to the BLM crates.			
BSRA functioning and abort gap population always properly monitored			

Collimation	Status	Who	Comments
Valid set of betatron loss maps (hor/ver at Inj., flat top, squeezed separated, colliding) done in last 3 months.			
Valid set of off-momentum loss maps (pos./neg. at Inj., flat top, squeezed separated, colliding) done in last 3 months.			
Loss maps for re-qualification after technical stop did not show unexpected losses distributions.			
No observation of abnormal cleaning efficiency.			
No observation of abnormal passive protection.			
Collimators at agreed positions during cycle.			
Correct LSA positions, thresholds, limits, warning levels.			
No unexplained beam dumps due to collimators.			
No beam dumps from collimator temperatures.			

Operation, orbit and feedbacks	Status	Who	Comments
OFB operational status / no anomalies.			
QFB operational status / no anomalies.			
Global orbit in tolerance in stable beams (< 0.2 mm rms).			
Orbit IR3/IR7 collimators within ± 0.2 mm in stable beams.			
Check that orbit is correctly measured.			
Orbit at TCTs in tolerance in stable beams (≤ 1 sigma in IR1/5, ≤ 3 sigma in IR2/8).			

Beam dump	Status	Who	Comments
Asynchronous dumps understood? Protection worked correctly?			
Parasitic asynchronous dump data show no loss of protection.			
BPM IP6 (interlock BPM) during first beam with higher intensity and different bunch pattern.			
No positioning errors on TCSG/TCDQ.			
No settings or thresholds mistakes/wrong sequences/unexplained faults on TCSG/TCDQ.			
Loss leakage to TCTs below 0.5% of losses at TCDQ during beam dumps.			
No unexplained MKD, MKB kicker, TSU or BETS faults.			
No potentially dangerous XPOC or IPOC failure on MKD or MKB.			
No unexplained synchronization problem with TSU.			
Pressure and temperature rise in TDE block within tolerances.			
Requalification passed OK at 450 GeV and 6.5 TeV with pilot in case of any important component exchange.			

Injection	Status	Who	Comments
Injection protection devices at agreed positions during cycle.			
Correct LSA positions, thresholds, limits, warning levels.			
Injection oscillations within tolerance for all injections.			
No unexplained large beam loss on TCDIs.			
Expected losses for the beam to be injected at least 30 % below threshold level.			
Line has been re-steered successfully if losses have been to high.			
No issues in injection procedure, settings or tolerances.			
Orbit in injection region in tolerance wrt reference (tolerance <0.5 mm).			
Resetting of TL trajectories, TCDIs and optics done when needed.			
No increased rate of MKI flashovers.			
No increased rate of MKI switch erratics or missing.			
No unexplained MKI vacuum or temperature activity.			
No machine-protection related injection system hardware failures.			

Heating of Equipment	Status	Who	Comments
Heating of ALFA			
Heating of BSRT			
Heating of TCP_B6L7			
Heating of TCTVB			
Heating of MKI			
Heating of TDI			
Heating of beam screen			
No unexplained heating of other equipment observed.			
Variation of bunch length within the usual range.			
Variation of beam spectrum within the usual range.			
No additional non-conformities in vacuum observed (RF-fingers, etc.)			