



Software Interlock System -Real Time Feedbacks

L. Ponce

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⊳ SIS:

- > 2015 tree structure
- Status of interlocks and masks
- Dumps in 2015
- > Tune and Orbit Feedbacks:
 - > Usage in the cycle
 - Status of OFB
 - Status of QFB





Mixed forest: new species introduced for 2015

3 INJECTION PERMITS: exported to injection BICs for TI2 and/or TI8.

- 3 RING PERMITS: exported to ring BICs (SR3 B1/2 and CCR) to abort the beam
- RCBX PERMIT: exported to BIC and PIC
- 2 POWERING_PERMIT: exported to the PIC PVSS system to lock PCs.
- RP PERMIT taken out from RING PERMIT, only announcer
- ABORT GAP CLEANING: exported to abort gap cleaning
- 2 BUILDERs exported to Telegram

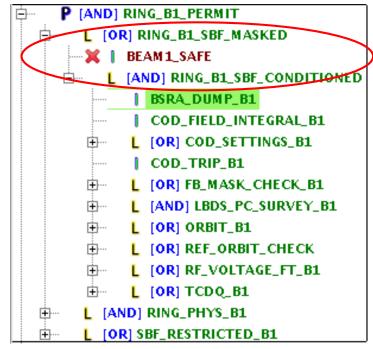
l	Permits Tree								
ĺ	.	P	[AND] ABORT_GAP_CLEANING						
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I	+	P	[AND] POWERING_FPA_PERMITS						
I	.	P	[AND] POWERING_PERMITS						
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I	.	P	[AND] SQUEEZE_FACTOR_BUILDER						
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Interlocks combined by an OR logic
 with the safe beam flag = true
 conditions

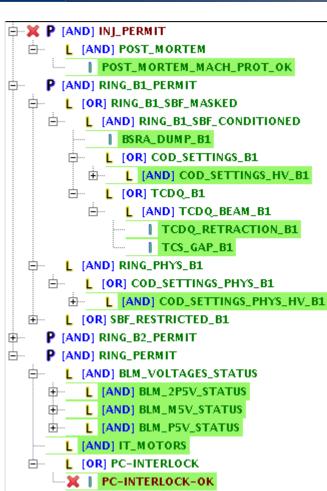
- No new interlocks since end of 2012
- > All branches logic tested.
- > Tolerances for critical parameters back to initial values:
 - > MKI temp and vac interlocks...





Masked interlocks





Several interlocks are still masked, but OK:

- > PM_MACH_PROT_OK (injection permit)
- COD settings in physics
- > TCDQ_BEAM masked for first collisions
- > BSRA dump level
- PC interlock not yet fully commissioned -> masked and COD settings still used (also masked)



Interlocks on and around orbit



- Complex interlocking logic to limit global orbit excursion and catch undetected bumps (COD settings)
- > Tolerances depend on beam modes and ring positions
 - For non-IR region:
 - > \pm 2 mm for injection (2 BPMs trigger)
 - 1 mm for dump in all modes (15 BPMs trigger)
 - > 0.6 mm for dump in stable beams (15 BPMs trigger)
 - In the IR (1+2+5+8): more complex because of specific conditions (VdM, low beta...)
- CODs settings checks is redundant with the PC interlock, will be replaced as soon as PC interlock is validated
 - For injection, tolerance is 15 urad
 - For dump logic, between 12 ad 20 urad, but have to exclude Xing, sep and lumi
 CODs due to large change during cycle
 - Still masked to get more experience





> QPS_OK signal is not reliable for the main circuits (signal flickering)

As it is blocking injection, masked to be efficient for injection

Risk to let it masked after injection and then interlock became useless



LHC SIS GUI	☆ ♪ ∽
File Operation Unlatch all channels Help	
□	
Permits Tree	
• X P [AND] INJ_B1_PERMIT	
P [AND] INJ_B2_PERMIT	
P [AND] INJ_PERMIT	
■ L [AND] BIC_PREOP_CHECKS	
L [AND] BLM_THRESHOLD_TABLE_STATUS	
INJECTION_ENERGY AND] PC-CURRENTS	
L [AND] POST_MORTEM	
E [AND] IPQ-QPS-STATE	
L [AND] RB-QPS-STATE	
RB_A12_QPS_OK	
RB_A23_QPS_OK	
RB_A34_QPS_OK	
RB_A45_QPS_OK	
RB_A67_QFS_OK	
RB_A81_QPS_OK	
L [AND] RCBX-QPS-STATE	
L [AND] RCSOD-RO-QPS-STATE	
I [AND] RD-QPS-STATE	
L [AND] RQ-QPS-STATE	
L [AND] RQT-QPS-STATE	
E [AND] RS-QPS-STATE	
⊞···· L [AND] RU-QPS-STATE ⊡···· L [OR] RF_IN]	
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Expand All Collapse all	
Combined \	
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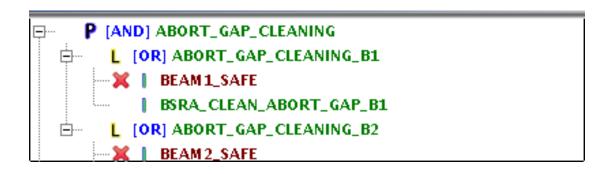
- New interlock introduced to cope with possible failure of the quench loop.
- Logic implemented and tested
- No exporter yet (= no action): to be deployed and tested during TS1

Permits Tree							
Em P [AND] ABORT_GAP_CLEANING							
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🗄 💥 Р [AND] INJ_B2_PERMIT							
🖶 💥 P [AND] INJ_PERMIT							
P [AND] POWERING_FPA_PERMITS							
E [AND] RB_FPA_STATE							
E [OR] RB12_FPA_STATE							
RB12_IN_SIMULATION							
🗱 📔 RB12_LOW_CURRENT							
E [AND] RB12_PIC_STATE							
RB12_PIC_ABORT_OK							
RB12_PIC_DISCHARGE_OK							
E [OR] RB23_FPA_STATE							
E [OR] RB34_FPA_STATE							
□··· L [OR] RB45_FPA_STATE							
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E [OR] RQD34_FPA_STATE							
E [OR] RQD45_FPA_STATE							
\square $[OR] RQD56_FPA_STATE$							
L [OR] RQD78_FPA_STATE							
L [OR] RQD81_FPA_STATE							
□ L [AND] RQF_FPA_STATE							
L [OR] RQF12_FPA_STATE							
L [OR] RQF23_FPA_STATE							
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Image:							
E [OR] RQF56_FPA_STATE							
E [OR] RQF67_FPA_STATE							
L [OR] RQF78_FPA_STATE							
⊡… L [OR] RQF81_FPA_STATE							
P [AND] POWERING_PERMITS							





- Based on Abort Gap monitor, request to activate the cleaning sent by SIS.
- > not commissioned yet:
 - > no signal received,
 - no device to act on.







- > 15 dumps caused by SIS in 2015:
 - > 7 caused by TGM timeout problem
 - > 4 caused by communication problem with BLM crate
 - > 3 due to subscription problems: Safe Beam Flag "blocked" to false without beam in the machine, IT motors surveillance
 - > 1 due to real interlock
 - > IR6 BPM faulty channel triggered the TCS-beam offset interlock

=> Nothing related to intensity





> TGM timeout problem:

- > Telegram signal is lost for long period (up to 25s) on SIS machine,
- Logic programmed such that after a programmed timeout, default energy value is 450GeV -> beam dump at 6.5 TeV by COD settings...
- CO experts working on finding a solution, In the meantime, timeout has been increased and default energy value is set to 6.5 TeV.
- » BLM-SIS communication problem:
 - Some BLM crates (in pt 6 and 7) are becoming unstable, when additional readout are coming (UFO buster, XPOC, IQC..) 1 Hz readout data is blocked and SIS triggered
- > BI experts investigating, in the meantime, UFO buster disabled.



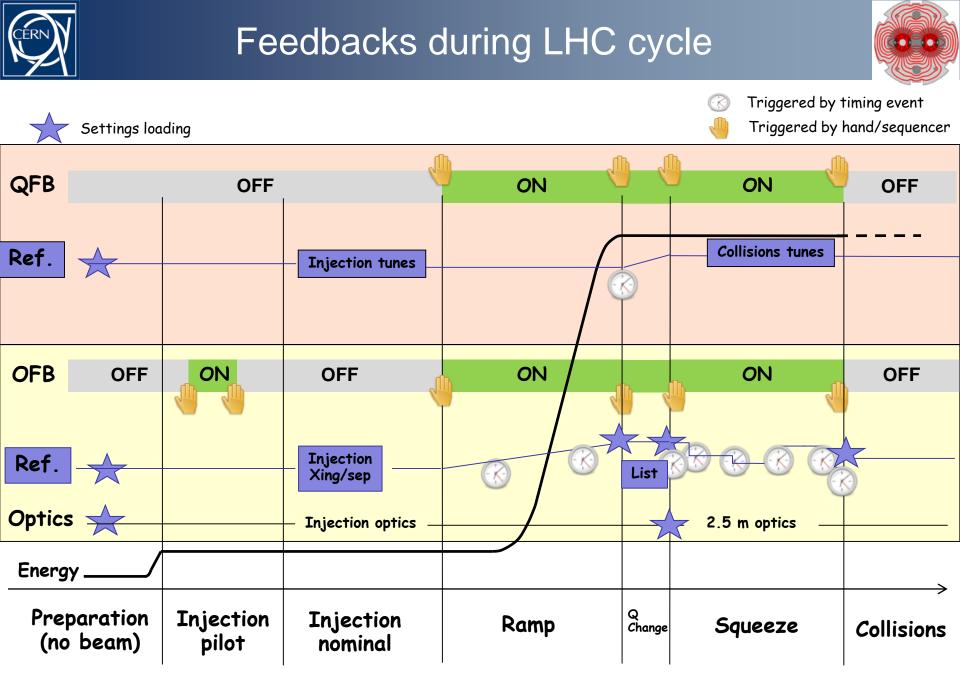


Real Time Feedbacks





- > Major refactoring of BFSU/OFC during LS1:
 - new machines, migration to FESA3, new developers
 - But functionalities not changed for the restart
 - Diagnostics improved
- Functionalities used/needed by operation:
 - On/Off of the FBs via sequencer or application
 - Loading of references and optics (= set to BFSU)
 - Dynamic change of the references (ramp/Qchange/squeeze)
- "Expert" settings becoming operational (set via YASP and stored in LSA):
 - Eigen values, bandwith, gains
 - BPM status
- Both tune and orbit references set in 2 different properties of the BFSU class
 - Critical dependence on BFSU when timing is needed







- ➤ QFB:
 - Loosing the peak, coupling too large (automatic off), fake noise peaks...
 - Interference with transverse damper: time is needed top optimize the settings
- > OFB:
 - Missed timing events to change references: critical in the ramp
- Dependence on FBs can be reduced with feed-forward of the real-time trims into the PC functions (for next fills).
 - High(er) survival probability when FBs switch off.





- The SVD matrix should in principle be recomputed for each optics:
 - Quite long process: Take between 1 and 2 minutes
- Dynamic change of the optics during the squeeze is implemented, never used in nominal operation:
 - Reduced list of optics to avoid crash of BFSU
 - Never tried the re-computation with feedback ON
 - Re-computation time versus squeeze segment length?
- Only used for squeeze in a discrete mode:
 - FB stopped, optics recomputed and sleep time before switching ON again
- CONTRACT CONTRACT
 - SWITCH ORBIT AND ENERGY FB OFF
 - calc ALL optics for the squeeze
 - set active optic 2734 (2.5m)
 - ARM REF ORBITS FOR THE SQUEEZE
 - SET ACTIVE ORBIT INDEX 0
 - SLEEP 5S
 - SWITCH ON ORBIT AND ENERGY FEEDBACKS





- Needed during ramp and squeeze, following PC functions
- Settings stored in LSA and tasks executed by sequencer
- Linear interpolation between actual settings and requested settings over a time set by the task (*timeConstant*)
 - BFSU is not playing a function
- Changes triggered by timing events send to BFSU.
- Mechanics for tune feedback:
- All timing events for given BP are generated in the dynamic timing table which is played at the same time as the:
 - 11 events sent for the squeeze to 80 cm

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- Traced back to a configuration problem of the O/S in the processing of interrupts: 2 timing events were sen too close
- Several mitigation methods put in place after the events:
 - Configuration of the BFSU machine corrected
 - Introduced a delay between the timing event to changed the optics and the one to trigger the change of reference
 - > No more missing event observed since few weeks.

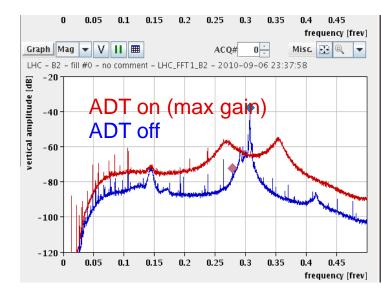
MTG tables	SELECTED MTG TABLE DETAILS								
rampdown injection	TABLE NAME (no sp	ace)	optics_orbit_changes						
BLM_capture_test	START EVENT		HX.START-TBL-CT (33) - Start table(s) Set start Event						
optics_orbit_changes									
precycle Injection_Bl	RUN COUNT		-1						
· -	EVENT NAME	PAYLOA	D	OFFSET (ms)	EVENT DESCRIPTION				
	HX.FBOREF-CT	1		0	Start Orbit Feedback reference change				
	HX.SIS-SSQU-CT	283		0	Start SQUEEZE for PC intlck				
	нх.ортір-ст	2727		500	Optics Identifier				
	HX.FBOREF-CT	2		65000	Start Orbit Feedback reference change				
	нх.ортір-ст	2770		65500	Optics Identifier				
	HX.FBOREF-CT	3		108000	Start Orbit Feedback reference change				
	LIV ORTO CT	3769		109500	Optics Identifier				





- Not a feedback issue, but efficient tune feedback need good tune measurement quality
- 2 different problems: Saturation and S/N ratio
 - Saturation = peak disappearing
 - Fixed in 2012: Device sensitivity adapted for high bunch intensity (2 different devices for pilot and nominal bunches
 - Saturation observed during LHCf physics, to be checked during TS
 - Bad S/N ratio: multiple peaks
 - BBQ vs ADT settings
 - + co-existence with abort gap cleaning?

=> In 2012, after feed-forward during commissioning phase, Tune Feedback left OFF during squeeze and if stopping in the ramp.







- SIS logic ready for intensity ramp-up, but still controls problem to be consolidated.
- Feedbacks are crucial for operation
- Worked very well most of the time with some exceptions when dynamic change of references is needed:
 - Gymnastics with the sequencer tasks
 - Consolidated during commissioning, working well now
- > Need a bit of beam time to optimize settings



