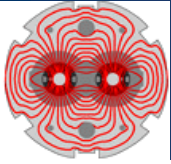


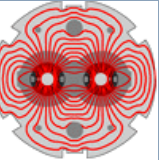
IQC refactoring status

J. Wenninger

Acknowledgements: C. Bracco, W. Bartmann, L. Drosdal (PhD writeup)

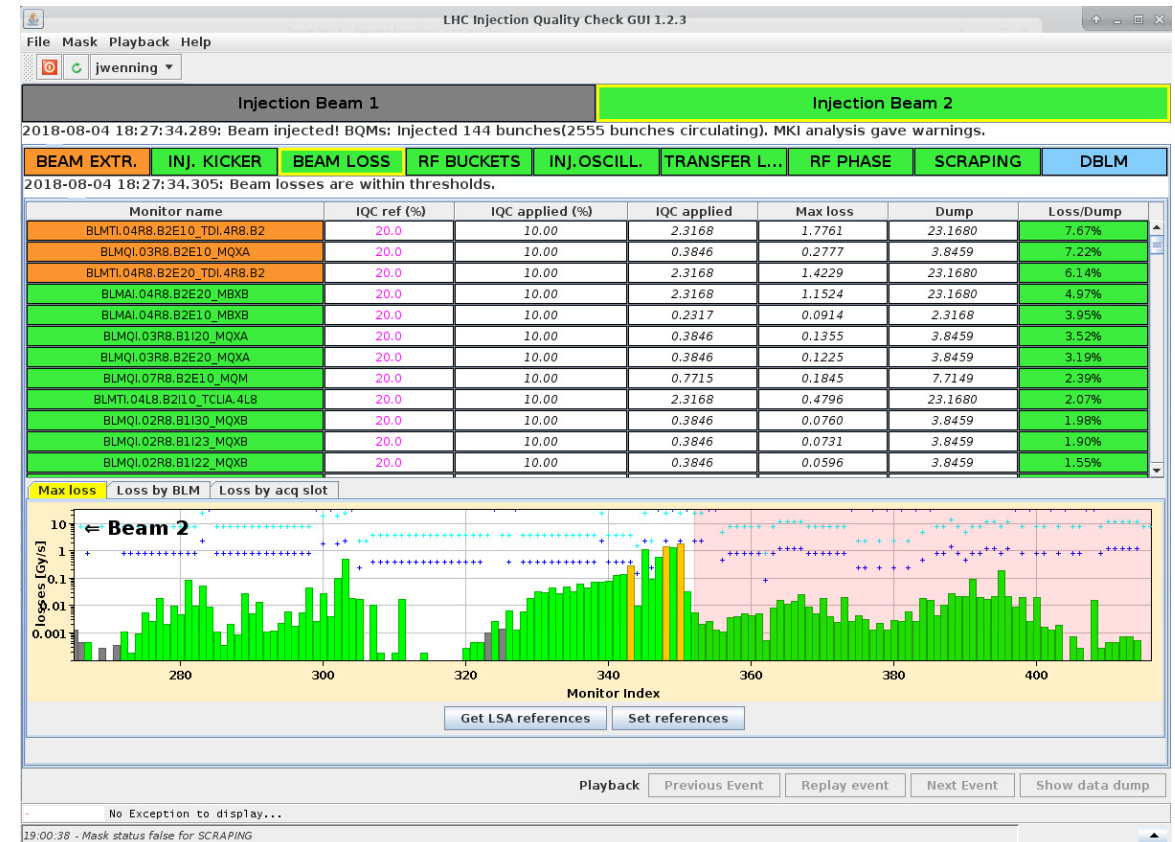


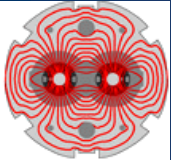
IQC projects



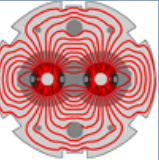
- The OP IQC software consists of two distinct projects:
 - The IQC analysis (<https://gitlab.cern.ch/acc-co/pm/iqc/pm-iqc-user/-/tree/master/lhc-iqc-analysis>),
 - Part of the IQC server,
 - The data analysis should be entirely in this project.
 - The IQC display application (<https://gitlab.cern.ch/acc-co/pm/iqc/pm-iqc-user/-/tree/master/lhc-app-iqc>).
 - The display application used in the CCC on live data or in playback mode (historic events).

- Goal of LS2 work: clean up the code and ensure there is enough internal OP knowledge to adapt it to Run 3 (and to future needs).
 - The code *really* needs some cleaning.
 - Despite a lot of testing on the Run 2 data, some commissioning time with beam will be required.



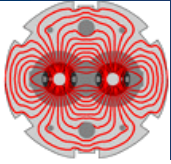


Overview

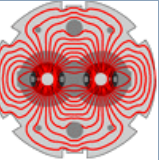


- ❑ General code cleaning (in progress):
 - Proper use of loggers to improve diagnostics,
 - Fixing bugs,
 - A major one was present in the playback GUI (introduced with the diamond BLM module).
 - Moving step by step from ‚FORTRAN/C in a JAVA shell‘ to proper object-oriented JAVA code,
 - Overall poor code structure, improved the worst cases.
 - Re-structuring of LSA IQC settings,
 - Moving hardcoded parameters to new LSA IQC settings,

- ❑ Trying to understand what the code actually does...



Testing and documentation



- ❑ For each module the testing on selected events was consolidate.
 - Analysis modules write local files,
 - Local files can be loaded into single module UI components (eg. BLMs or BPMs only).
 - Work ongoing.
- ❑ In the git path of the IQC analysis, file **INFO.md** is progressively filled with documentation.
 - Can be viewed in a web browser.

The screenshot shows a web browser displaying the GitLab page for the file `INFO.md`. The page content includes:

- General information**: This analysis project `lhq-iqc-analysis` is embedded in the IQC PM-style server. A new release of the analysis also requires a new release of the IQC server by R. Gorbonosov.
- To look into the details of each analysis module with the PM gui, launch <http://bewwww.cern.ch/ap/deployments/applications/cern/pm/iqc/pm-iqc-gui/PRO/pmiqc-playback-guijnlp>
- To look at debug output, use the journal option for each module.
- The `lhq-app-iqc` project provides the GUI that displays analysed data or replays old data (with or without analysis).

RF injection phase in IQC

IQC reference for abort gap limits made critical during LS2 : virtual class IQC.PHASERR.ANALYSIS

Scraper in IQC

Situation before LS2

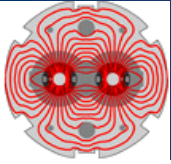
The reference time to evaluate the scraping efficiency is shifted by 340 ms wrt the scraping time in the code, but a look at 2018 data shows that the delay is rather 270 ms. This changes the H/V scraping ratio completely (too much H, too little V). The time tolerance window is 300 ms.

Situation after LS2

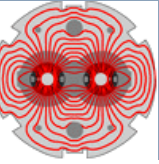
The reference time and tolerance have now a LSA settings in system IQC GENERAL device SPS.SCRAPER.IQC (non multiplexed). The virtual class is IQC.SCRAPING

Settings Management

Source	Parameter Group	Parameter Type	Parameter
Beam Process			
DISCRETE.LHCRING_ADTDSPU_BW_STANDARD	BQMLHC	IQC.DiamondBLM/Setting	SPS.SCRAPER.IQC/Settings
NON_MULTIPLEXED_LHC	CRYSTAL_COLLIMATOR	IQC.SCRAPER/Settings	
ADT-TEST_V1	IQC BPM REF		
DataScrapingSetting_SQUERZE_6.5TeV_ATS_20cm_25cm			



LSA IQC settings



- Many LSA settings for IQC based on virtual FESA classes and devices.
 - Removed obsolete settings,
 - Added new settings for SPS scrapper and diamond BLMs,
 - Made critical all settings that ,should be critical'.
 - Some settings were only partly critical (for example for B1 and not B2 etc),
 - Some looked like work intiated but never completed.
- Reorganized the LSA IQC systems.
 - All system names = ,IQC xxxx'.
 - They are now all next to each other in the settings management app list.

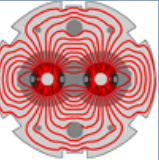
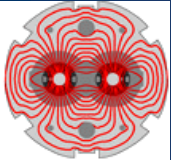
LSA Applications Suite (v 13.9.0)

File Applications Search

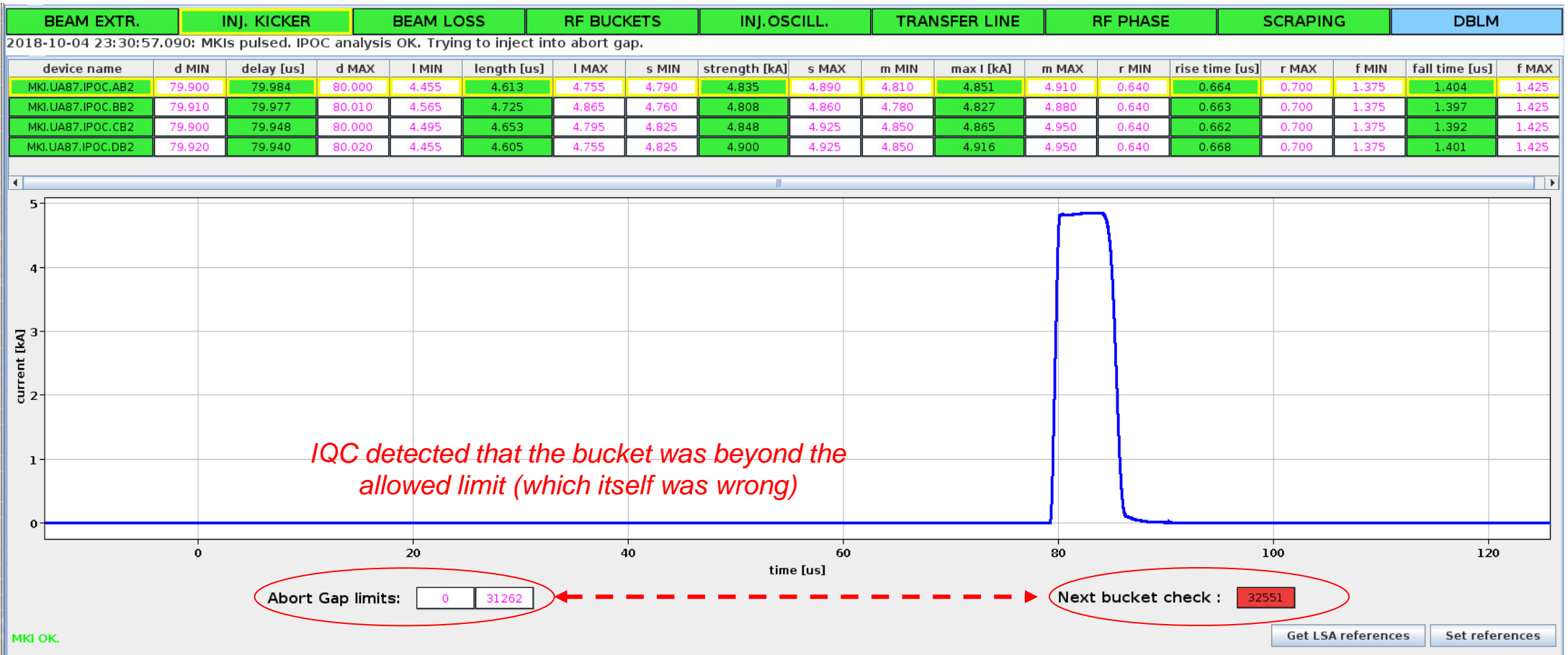
Settings Management x Device Groups Configuration x

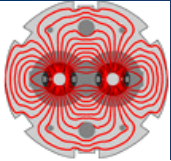
Source	Parameter Group	Parameter Type
DISCRETE_LHCRING_ADTDSPU_BW_STANDA	IQC BLM REF	IQC.BPM.THRESHOLDS/BadBunchAccept
NON_MULTIPLEXED_LHC	IQC BPM REF	IQC.BPM.THRESHOLDS/BadPpmAccept
ADT-TEST_V1	IQC BPM TRANSFER	IQC.BPM.THRESHOLDS/MaxHor
BetaStarLevelling-SQUEEZE-6.5TeV-ATS-30	IQC GENERAL	IQC.BPM.THRESHOLDS/MaxVer
BetaStarLevelling-SQUEEZE-6.5TeV-ATS-30	IQC MKI ABORTGAP	IQC.BPM.THRESHOLDS/P2PHor
BetaStarLevelling-SQUEEZE-6.5TeV-ATS-30	IQC MKI REF	IQC.BPM.THRESHOLDS/P2PVer
CollimatorBP-Parking	IQC PHASEERR REF	IQC.BPM.THRESHOLDS/RmsHor
DISCRETE_LHCRING_ADTBPOS_HIGH		IQC.BPM.THRESHOLDS/RmsVer
DISCRETE_LHCRING_ADTBPOS_NOMINAL		IQC.BPM.TL.REF/TrajectoryBpmRef
DISCRETE_LHCRING_ADTBPOS_PILOT		IQC.DiamondBLM/Settings
DISCRETE_LHCRING_ADTDSPU_BW_ENHANCE		IQC.MKI.ABORTGAP/AbortGapBegin
DISCRETE_LHCRING_ADT_FLATTOP		IQC.MKI.ABORTGAP/AbortGapEnd
DISCRETE_LHCRING_ADT_INJECTION		IQC.MKI/MaxDelay
DISCRETE_LHCRING_INJ_KICKER_EXTEND		IQC.MKI/MaxFalltime
DISCRETE_LHCRING_INJ_KICKER_INTRM		IQC.MKI/MaxLength
DISCRETE_LHCRING_INJ_KICKER_V1		IQC.MKI/MaxMAX
DummyBPforOFB_HalfIntegerTune_V1		IQC.MKI/MaxRisetime
InjectionProtection_BP_2014@0_[START]		IQC.MKI/MaxStrength
InjectionTrim_V1		IQC.MKI/MinDelay
LHC-SIS-REF-INJ-6.37TeV-ATS-Ion-2018_V1		IQC.MKI/MinFalltime
LHC-SIS-REF-PHYSICS-6.37TeV-50cm-240		IQC.MKI/MinLength
LHC-SIS-REF-PHYSICS-6.5TeV-30cm-120s		IQC.MKI/MinMAX
LHC-SIS-REF-RAMP-SQUEEZE-6.37TeV-ATS		IQC.MKI/MinRisetime
LHC-SIS-REF-RAMP_PPLP-SQUEEZE-6.5TeV		IQC.MKI/MinStrength
LHC-SIS-Ref-INJ-6.5TeV-ATS-1m-2017_V1		IQC.PHASEERR.ANALYSIS/InjectionThres
LHC-SIS-Ref-INJ-DESQUEEZE-19m-2016		IQC.SCRAPER/Settings
LHC-SIS-Ref-PHYSICS-6.5TeV-19-24m-20		LHC_BLM/LossType
LHC-SIS-Ref-RAMP-DESQUEEZE-19m-2016		LHC_BLM/ReferencePercentage
PC_INTERLOCK_REF-PHYSICS-6.37TeV-50cm		
PC_INTERLOCK_REF-PHYSICS-6.37TeV-50cm		
PC_INTERLOCK_REF-PHYSICS-6.37TeV-50cm		
PC_INTERLOCK_REF-PHYSICS-6.37TeV-50cm		
PC_INTERLOCK_REF-PHYSICS-6.5TeV-19-24		
PC_INTERLOCK_REF-PHYSICS-6.5TeV-19-24		
PC_INTERLOCK_REF-PHYSICS-6.5TeV-30cm		
PC_INTERLOCK_REF-QCHANGE-6.37TeV-Ion		

Filter

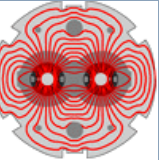


- ❑ Analysis code messy – restructuring to be continued.
 - Fixed / re-activated the check for injection into the abort gap. IQC only catches it once it happened, but still good to sound an alarm !
 - Some GUI font optimization





MKI



- ❑ The error message for injecting into abort gap was there, but the module status was good !
- ❑ The status will be bad again in such a situation in Run 3: we will have to add the update of the IQC settings in the procedure to update abort gap keeper limits...

Event time stamp | Beam

04/08/18 18:21:59.489+000000	1
04/08/18 18:22:36.689+000000	2
04/08/18 18:23:13.889+000000	1
04/08/18 18:23:51.089+000000	2
04/08/18 18:24:28.289+000000	1
04/08/18 18:25:05.489+000000	2
04/08/18 18:25:42.689+000000	1
04/08/18 18:26:19.889+000000	2
04/08/18 18:26:57.089+000000	1
04/08/18 18:27:34.289+000000	2

Beam:

Selected event

IQC event analysed for beam 2 at 2018-08-04 18:27:34.289.
Result: Beam injected! BQMs: Injected 144 bunches(2555 bunches circulating). MKI analysis gave warnings.

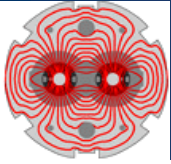
SCRAPING	4.6 % of beam scraped.
RFBUCKET	Beam is in the right buckets. Injected 144 bunches(2555 bunches circuli...
BCTTL	Warning! BCTs give different outcomes!!
DBLM	
RFPHASE	Phase error ok.
BLM	Beam losses are within thresholds.
MKI	MKIs pulsed. IPOC analysis OK. Trying to inject into abort gap.
TL	Transfer line losses are within thresholds. Trajectory ok
FAST	Beam injected.
BPM	Injection oscillations are within thresholds.

Event time stamp	System	Class	Source
04/08/18 18:27:34.291+016475	LHC	MKI_IPOC_IQC	MKI.UA87.IPOC.AB2.Resultipoc
04/08/18 18:27:34.291+016475	LHC	MKI_IPOC_IQC	MKI.UA87.IPOC.BB2.Resultipoc
04/08/18 18:27:34.291+016475	LHC	MKI_IPOC_IQC	MKI.UA87.IPOC.CB2.Resultipoc
04/08/18 18:27:34.291+016475	LHC	MKI_IPOC_IQC	MKI.UA87.IPOC.DB2.Resultipoc
04/08/18 18:27:34.290+000000	LHC	MKI_KICKERSTATUS...	MKI.UA87.GEN.Status
04/08/18 18:27:34.289+000000	LHC	IQC_CONF	BEAM2

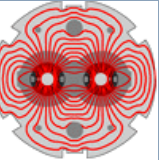
System: Class: Source:

Load selected
Unload all

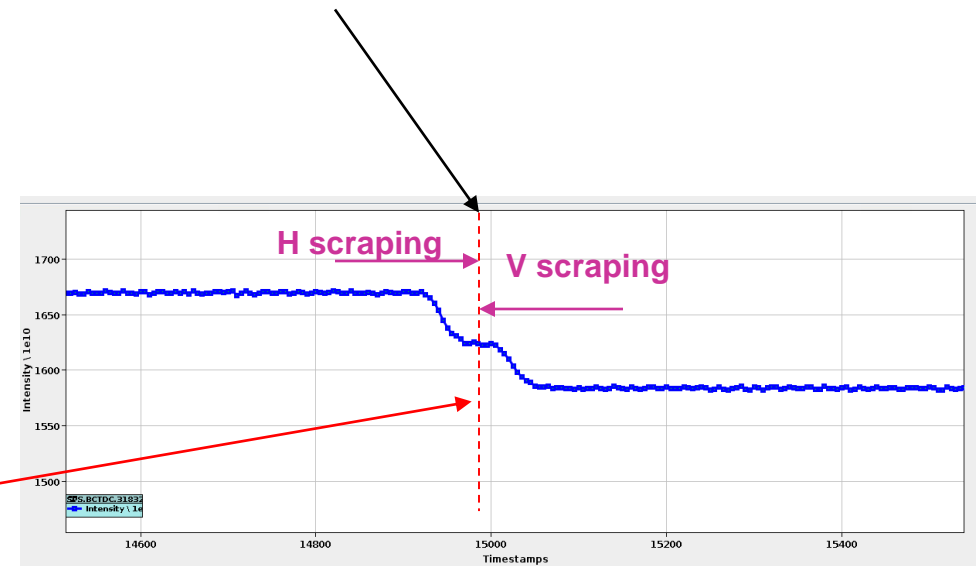
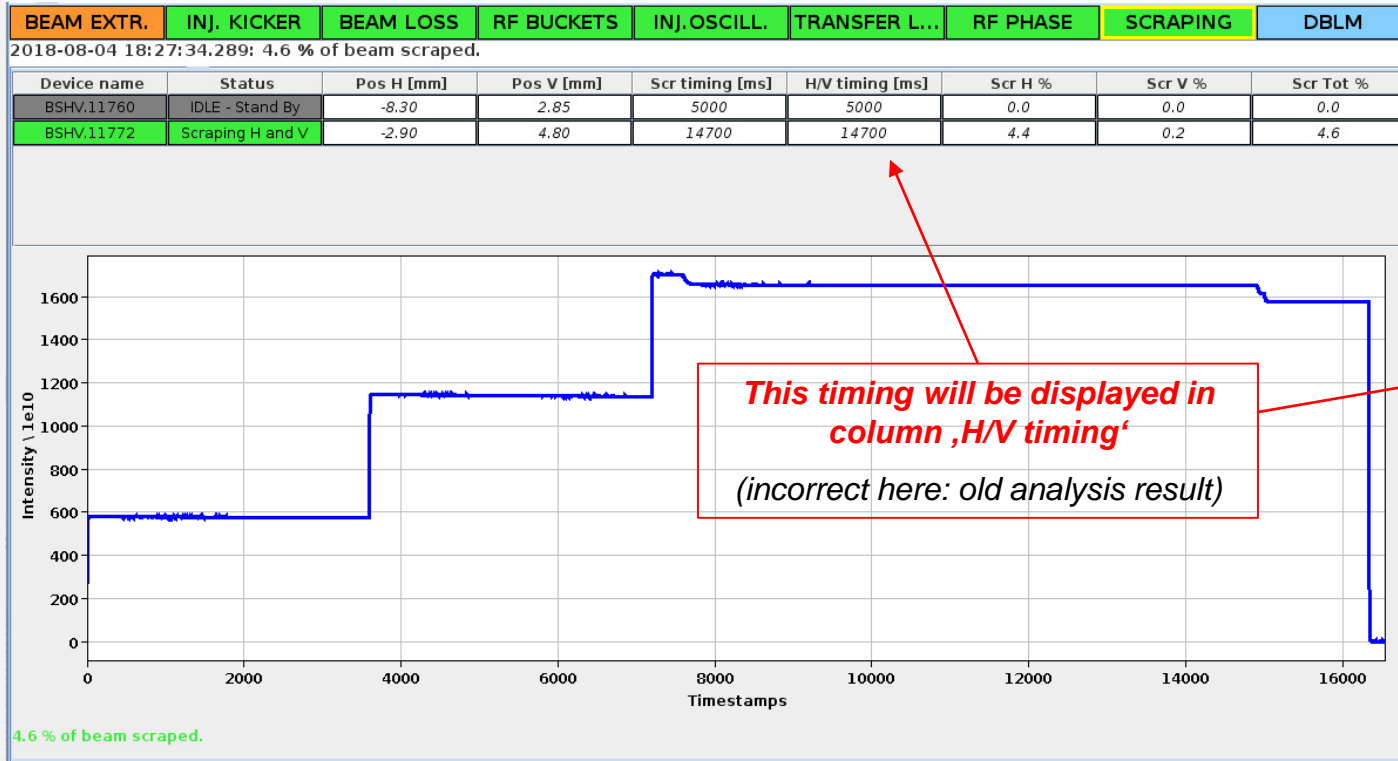
Load Raw Data | Load Result Data | Cancel / Close



SPS scraping

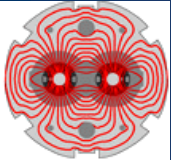


- Simple module and UI, overall OK except: the **delay settings to identify H and V scraping** were **hardcoded** and unfortunately **incorrect** (for 2018).
 - Fine delay to be set with respect to scraper timing to identify the two scraper actions (H and V).
 - Hardcoded delay is now a setting in LSA to ease tuning.

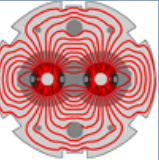


In this case scraping H & V both around 2.2%, but old analysis claimed ~ only H scraping as the timing for analysis was incorrect.

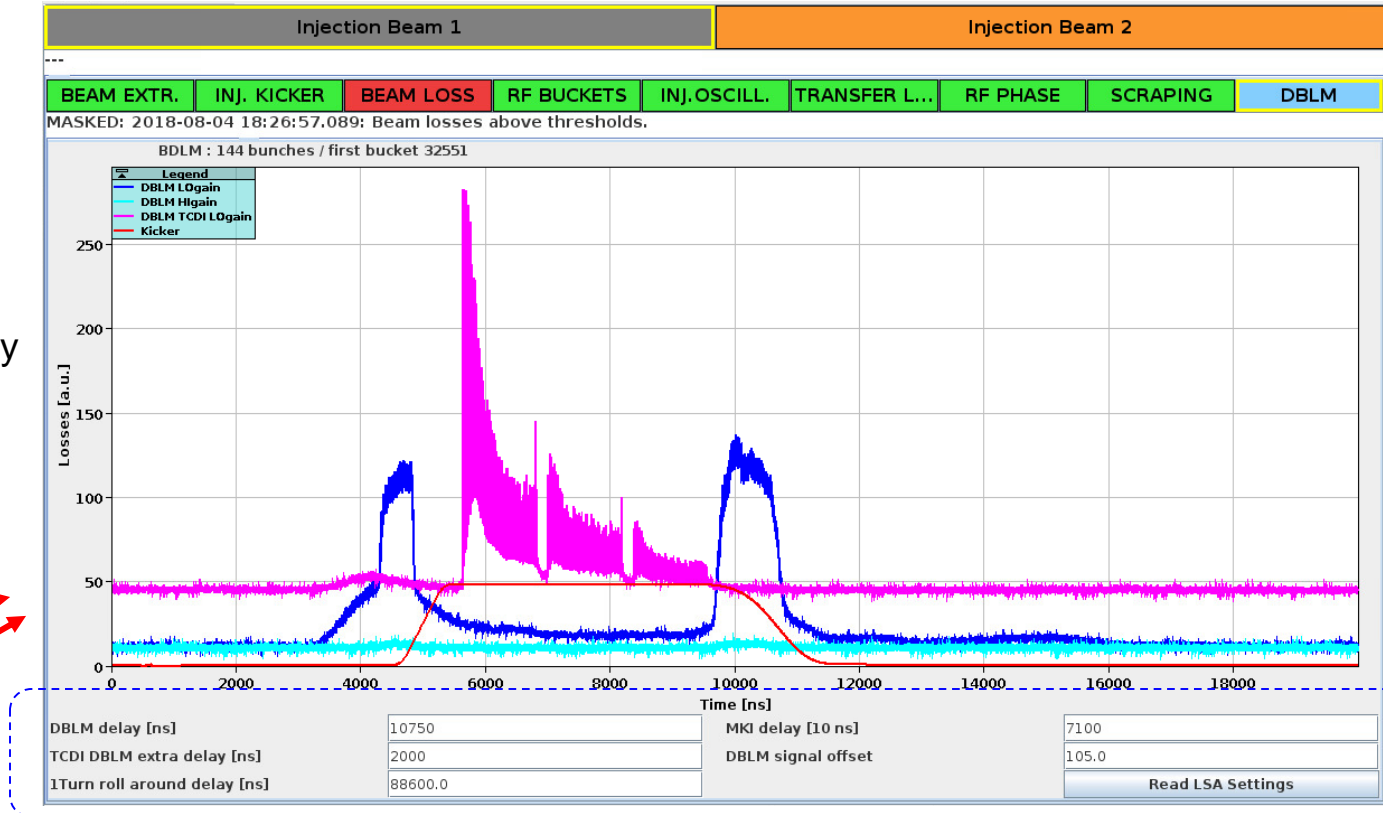
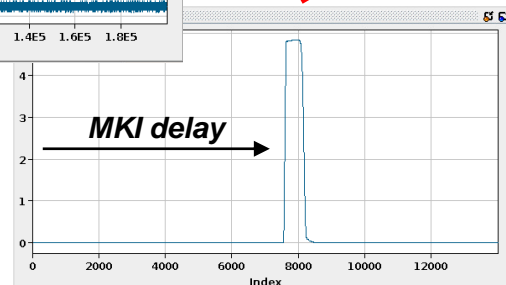
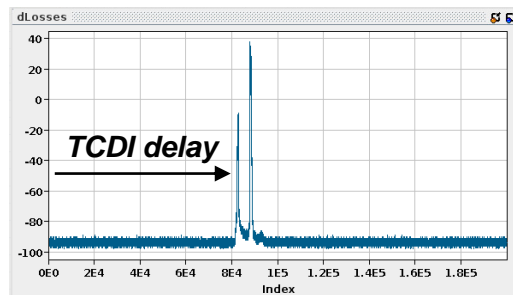
Scr H %	Scr V %
0.0	0.0
4.4	0.2



Diamond BLMs

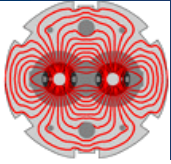


- Diamond analysis only consists in re-aligning the dBLM and MKI data to overlap in the display.
 - This simple ,analysis‘ is actually **performed in the GUI and not in the analysis** – which is not ideal...
- The raw data must be corrected for acquisition delays wrt triggers (beam dependent):
 - Fixed delay for MKI,
 - Fixed delay + first bucket *2.5 ns for dBLMs,
 - Extra offset for TCDI dBLMs,
 - Trigger ,roll-around‘ delay (when trigger jumps back by one turn) – **missing so far**, explained why some late injection did not show dBLM data.
- The delays were hardcoded, moved to LSA.

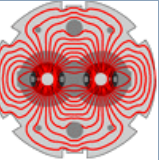


,analysis‘ settings (from LSA)

(can be edited in the GUI for tuning)



BLMs

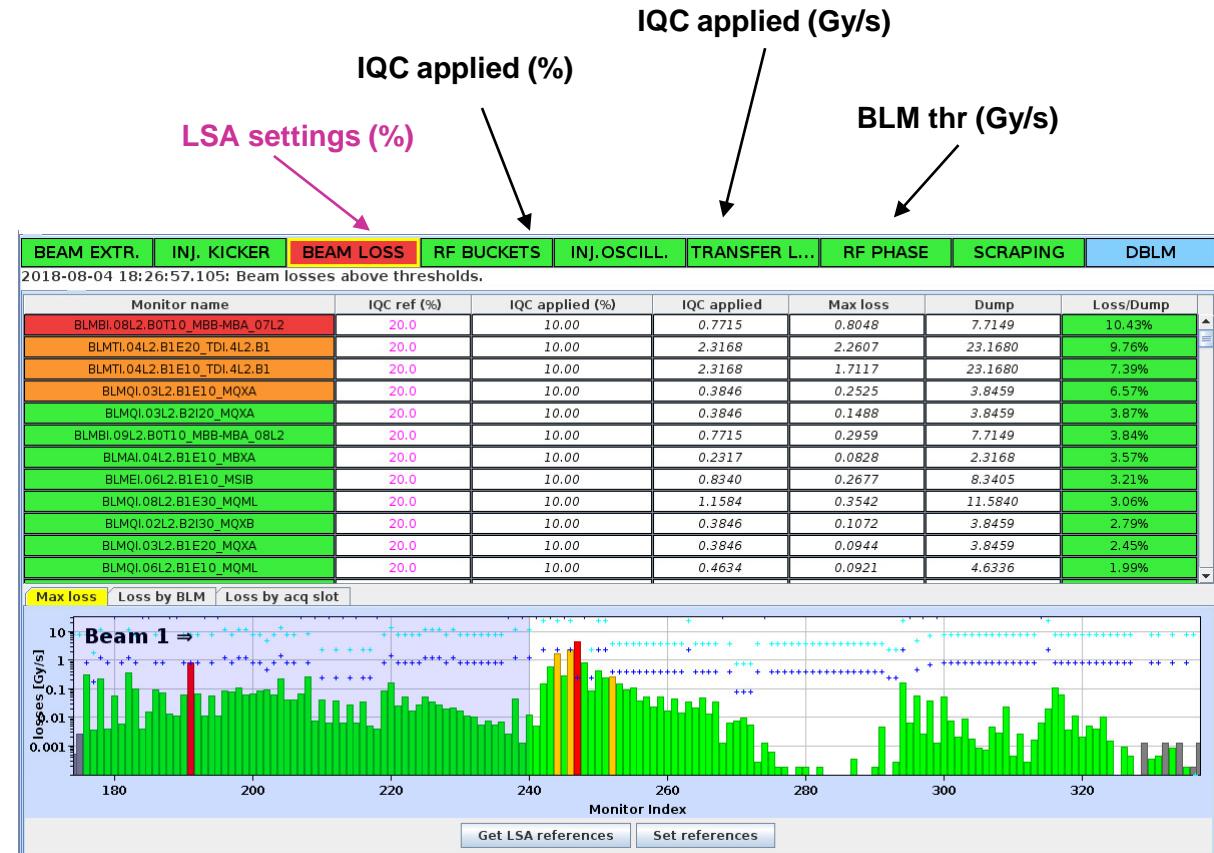


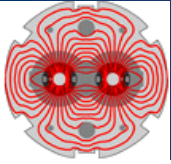
□ The BLM analysis cleaning was already initiated in 2018, continued in LS2.

- Code overhaul to ease changes,
- Cleaning of the obsolete LSA settings, remaining:
 - Fraction of BLM threshold to use for IQC,
 - Flag to define if IQC threshold scales with # of bunches.
- Completion of LSA settings,
- **Preparation for new BLMs (IR7 for B1, IR6 for B1+2).**
 - **LSA settings ready,**
 - **Changes to concentrator with CO.**

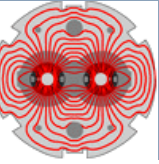
□ GUI changes.

- Table only contains BLMs used for IQC,
- More table columns to clarify what threshold is used,
- Some improvements in plots.
- Work in progress.





BPMs



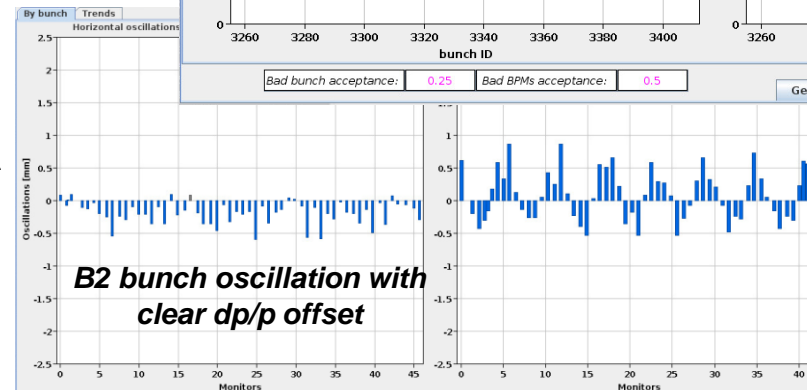
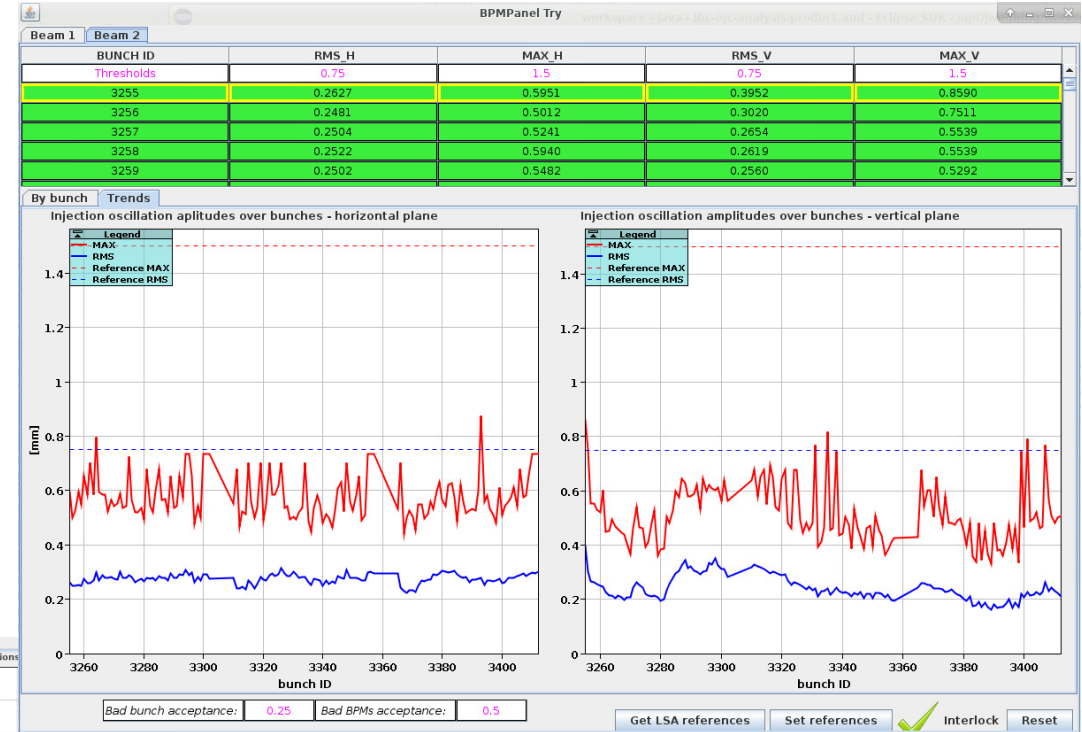
□ Analysis code refactoring into smaller classes –a nice

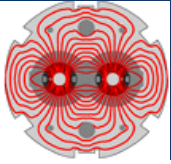
□ Improvements:

- Logic for H & V planes separated and simplified.
 - Before a bad H status would disqualify the V plane (and vice-versa).
- Added the ,REMOVED_OP' status bit to tag a BPM as bad.
 - Improved the rms/max results, eliminated some outliers.

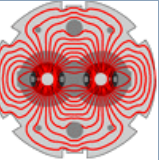
□ On the plate:

- Oscillation fits with hardcoded phase advances (!!), and without normalizing the positions with $\sqrt{\beta}$.
 - Fits incorrect, and not used at all. Will be removed.
- **Fit the dp/p offset of injected beam.**
 - **Requires LSA optics and improved oscillation fits etc. TBD.**
 - Reuse fits implemented in YASP.
 - Could set a warning on dp/p offset.

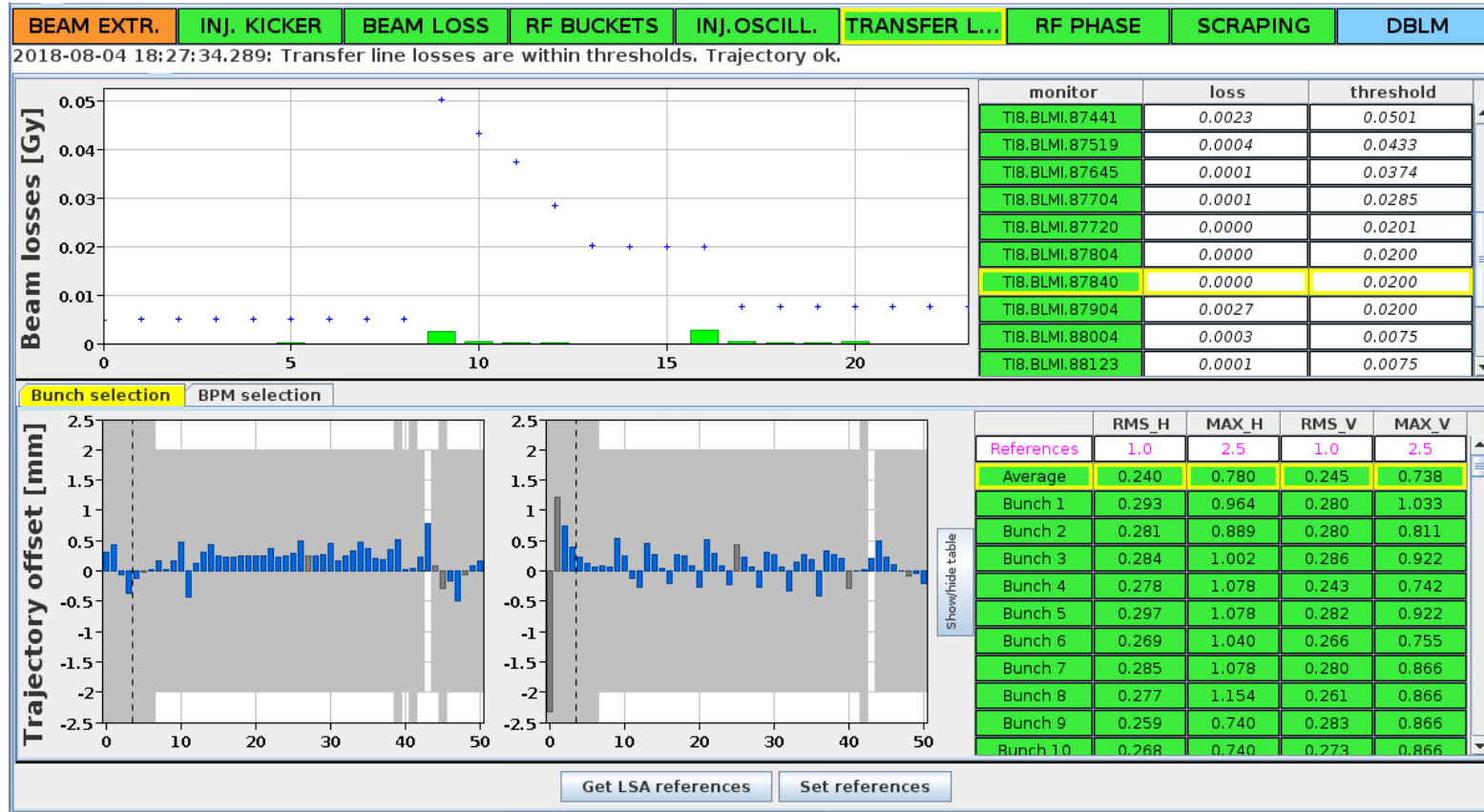




TL BLMs and BPMs

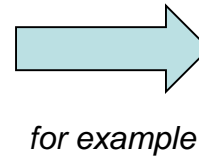


- A lot of code cleaning in the TL BPM part, BLM part ok as trivial (just get data and display).
 - Removed TL oscialtion fits with hardcoded phase advances which were anyhow not used.

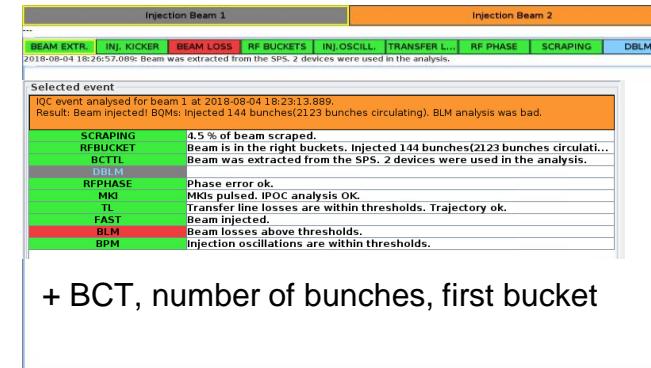


Outlook

- ❑ IQC code analyzed, repaired and refactored.
 - A complete re-design could be worthwhile, not possible during LS2. But current consolidation will help in the future. Documentation setup within the SW project.
 - IQC settings cleaned and improved.
- ❑ GUI work in progress, playback UI fixed.
 - Propose to remove quasi-empty BCT UI → replace by an overview UI.



for example



- ❑ Proposal to add a determination of dp/p at injection from the trajectory to complete the future RF determination from tomography.
- ❑ Changes of FESA classes (version, FESA2 →3 etc) to be carefully checked to maintain as much as possible backward compatibility.
- ❑ Currently the IQC code is no longer releasable because BE-CO removed the RDA2 libraries unilaterally and the PM/IQC framework still links the RDA2 libraries.

