

MPP Workshop: Injection System

C. Bracco on behalf of ABT

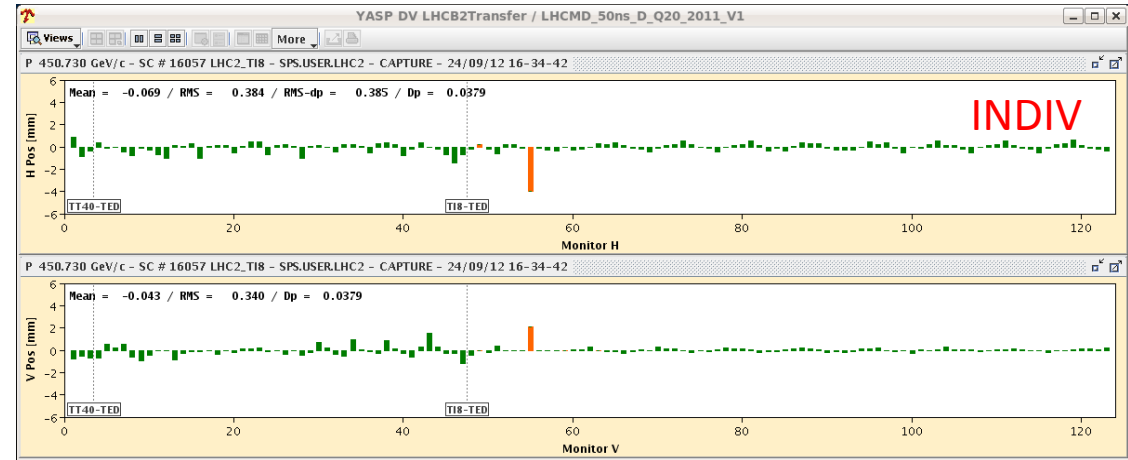
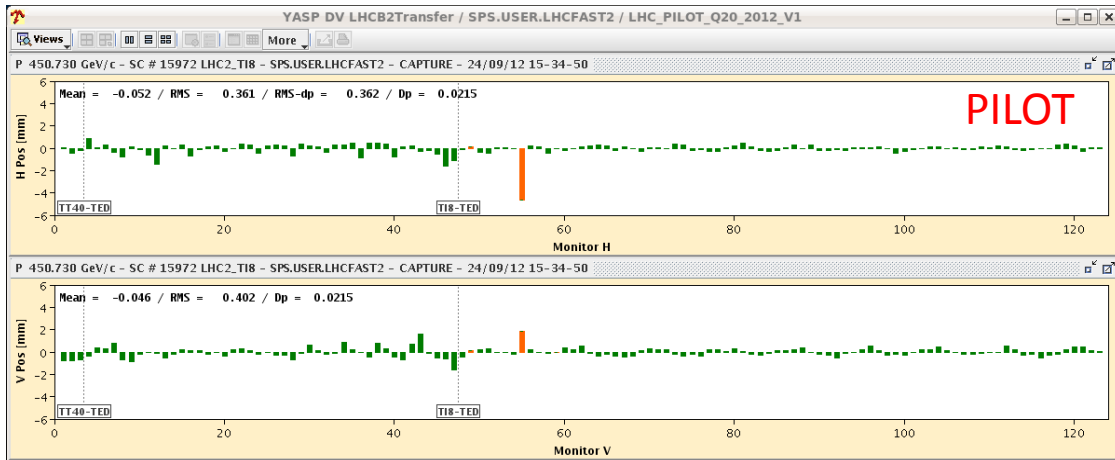
Acknowledgments: STI, ABP, BI,LHC and SPS OP

Outline

- TL steering and IQC
- Injection losses
- LSS6 extraction
- Injection protection collimators (Optics_ID)
- TDI limits
- MKI risetime

TL Steering

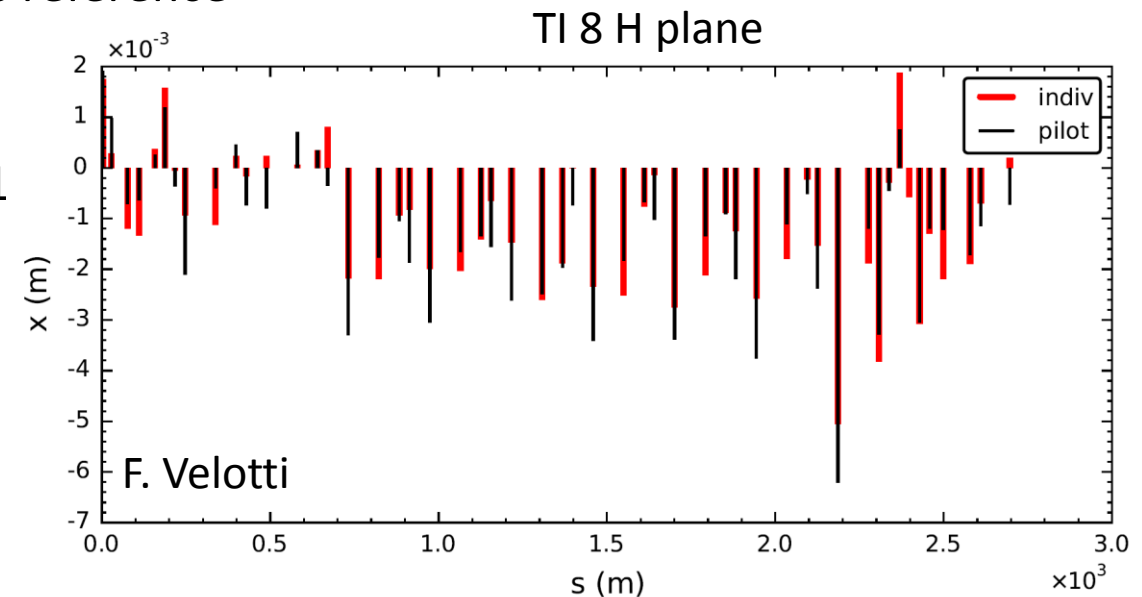
- Known issue: **different trajectories** for **fast-PILOT** and **slow-INDIV/25ns** cycles (slower ramp and different magnetization → “different” extraction)



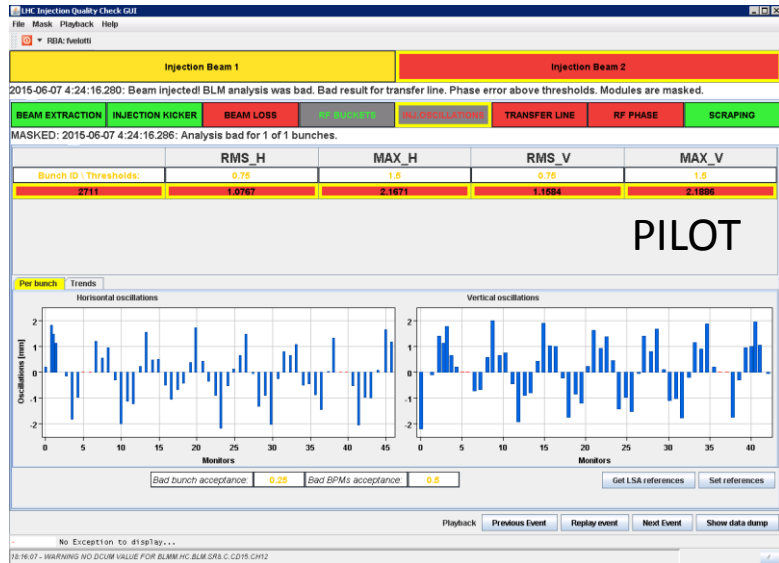
TL Steering

- Known issue: **different trajectories** for **fast-PILOT** and **slow-INDIV/25ns cycles** (slower ramp and different magnetization → “different” extraction)
- **GOLDEN trajectory** defined with **INDIV**
- **TCDI setup and validation** done with **PILOT beam**
- “Bad” trajectory for PILOT beam in operation
- At the beginning of Run 2 the INDIV beam was on the FAST cycle → almost same trajectory and injection oscillations for both beams (only difference due to BPM sensitivity) → **GOLDEN trajectory established with INDIV on FAST** → TCDI setup and validation done with this reference
- Moved to INDIV on SLOW beam process → need to steer back to GOLDEN reference and a larger difference (>1mm) between PILOT and INDIV was observed wrt Run 1

} Check difference in trajectory at TCDI < 0.5 σ



PILOT Beam vs INDIV



Beam 2 Peak to peak injection oscillations:

Pilot H = 3.8 mm

V = 4.1 mm

INDIV H = 1.3 mm

V = 0.6 mm

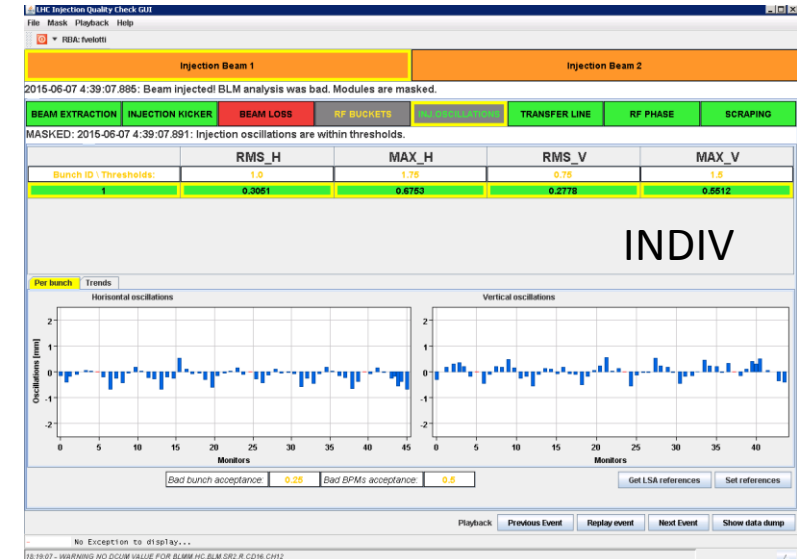
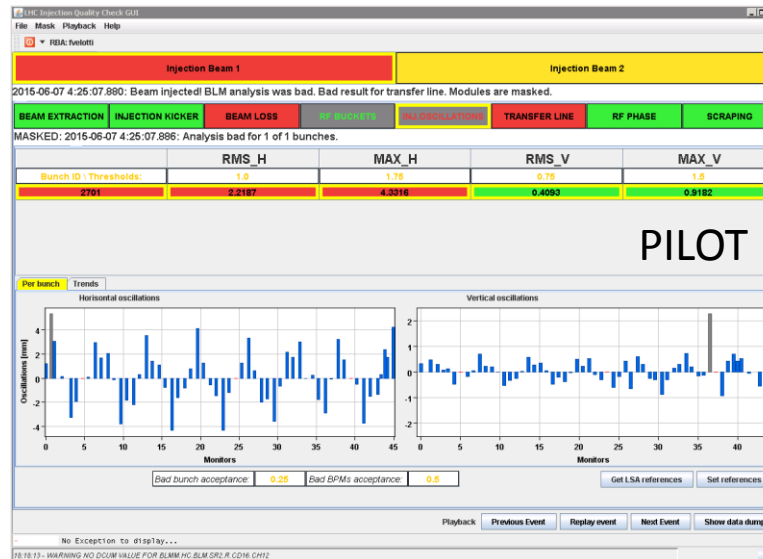
Beam 1 Peak to peak injection oscillations:

Pilot H = 8.4 mm

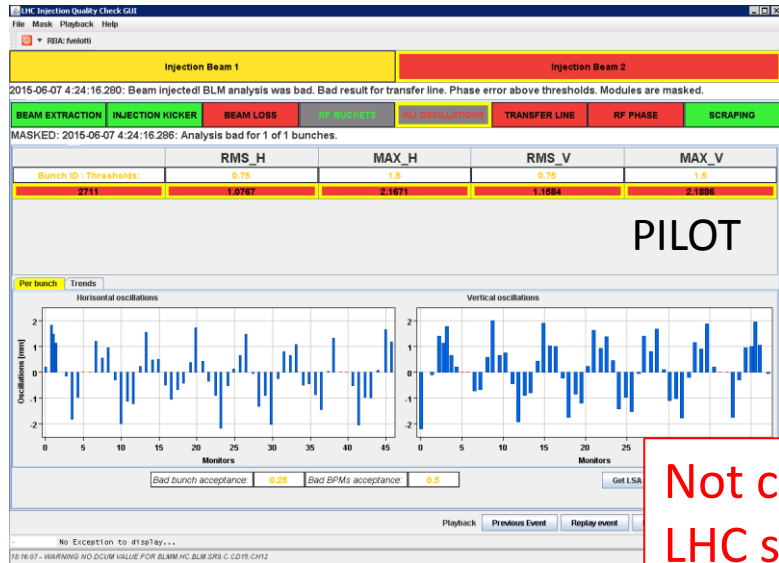
V = 1.6 mm

INDIV H = 1.2 mm

V = 1.2 mm



PILOT Beam vs INDIV



Beam 2 Peak to peak injection oscillations:

Pilot H = 3.8 mm

V = 4.1 mm

INDIV H = 1.3 mm

V = 0.6 mm

Not critical for high intensity injections but LHC setup done with a huge probe beam and IQC always failing.
Possible solution: PILOT on SLOW cycle

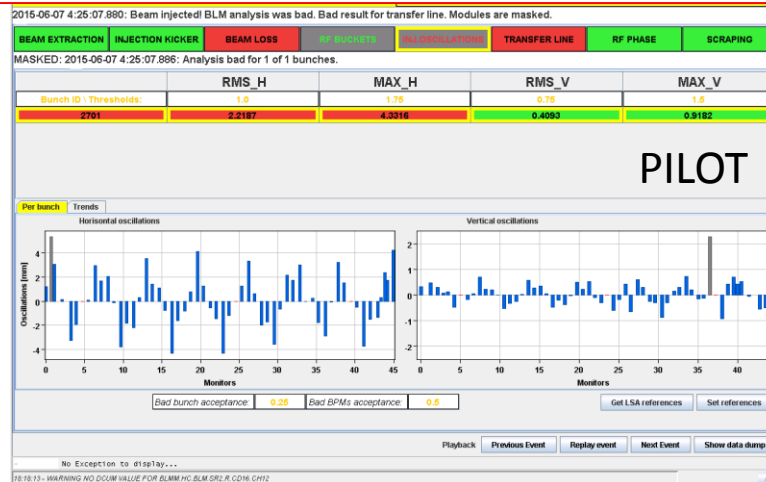
Beam 1 Peak to peak injection oscillations:

Pilot H = 8.4 mm

V = 1.6 mm

INDIV H = 1.2 mm

V = 1.2 mm



6 Bunches Injection Beam 1

LHC Injection Quality Check GUI
 File Mask Playback Help
 RBA: fvelotti

Injection Beam 1 Injection Beam 2

2012-07-20 1:35:33.950: Beam injected! MKI analysis was bad. Bad result for transfer line. Modules are masked.

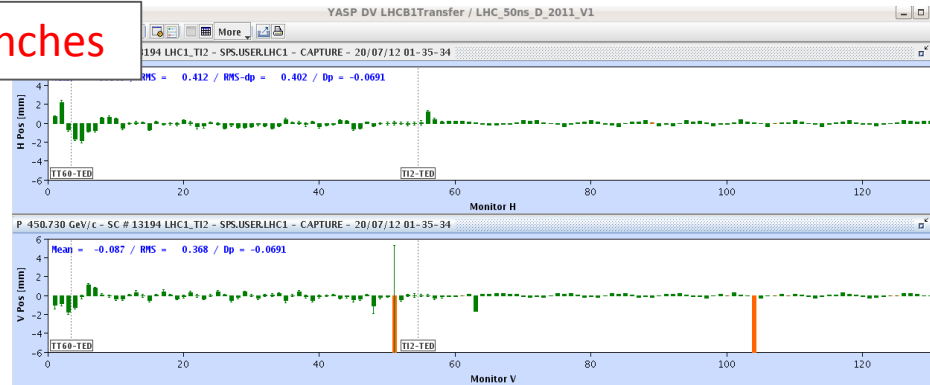
2012-07-20 1:35:33.966: Beam losses are within thresholds. 39 monitors have reference, but are not found in the data.

Monitor name	Max loss	IQC applied	IQC ref	Dump thresh...	Filter factor	Ratio to dump
BLMEI.04L2.B1E10_MBXA	0.0444	0.0965	4.63	2.3168	1.0000	1.92%
BLMQI.03L2.B1E10_MOXA	0.0084	0.0096	0.46	2.3168	1.0000	0.36%
BLMQI.03L2.B2I20_MOXA	0.0057	0.0096	0.46	2.3168	1.0000	0.25%
BLMQI.02L2.B2I30_MOXB	0.0040	0.0096	0.46	2.3168	1.0000	0.17%
BLMQI.02L2.B2I23_MOXB	0.0034	0.0096	0.46	2.3168	1.0000	0.15%
BLMEI.04R2.B1I10_MBRC	0.0043	0.0096	0.46	3.7069	1.0000	0.12%
BLMQI.02L2.B2I22_MOXB	0.0025	0.0096	0.46	2.3168	1.0000	0.11%
BLMQI.02L2.B2I21_MOXB	0.0024	0.0096	0.46	2.3168	1.0000	0.10%
BLMQI.03L2.B1E30_MOXA	0.0021	0.0096	0.46	2.3168	1.0000	0.09%

Max plot Per slot Per BLM

17:27:17 - WARNING NO DCUM VALUE FOR BLMEI.06R3.B1I10_TCLA.6R3.B1

Run 1 - 6 bunches



LHC Injection Quality Check GUI
 File Mask Playback Help
 RBA: fvelotti

Injection Beam 1 Injection Beam 2

2015-05-26 23:18:34.285: Beam injected! BLM analysis was bad. Modules are masked.

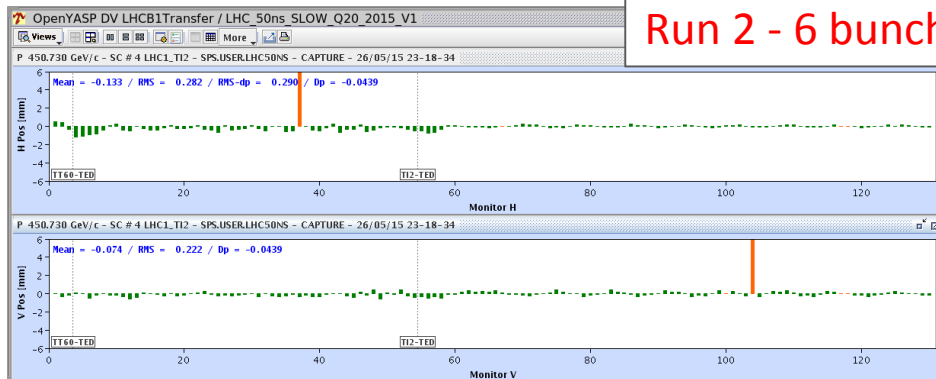
2015-05-26 23:18:34.301: Beam losses above thresholds.

Monitor name	Max loss	IQC applied	IQC ref	Dump thresh...	Filter factor	Ratio to dump
BLMTI.04L2.B1E10_TDI.4L2.B1	0.2463	0.0958	4.6	23.1680	1.0000	1.06%
BLMQI.03L2.B1E10_MOXA	0.0078	0.0096	0.46	2.3168	1.0000	0.34%
BLMTI.04L2.B1E20_TDI.4L2.B1	0.0768	0.0965	4.63	23.1680	1.0000	0.33%
BLMQI.03L2.B2I20_MOXA	0.0059	0.0096	0.46	2.3168	1.0000	0.25%
BLMQI.02L2.B2I30_MOXB	0.0043	0.0096	0.46	2.3168	1.0000	0.18%
BLMTI.04R2.B2E10_TCTPV.4R2.B2	0.0077	0.0194	0.93	4.6336	1.0000	0.17%
BLMEI.04L2.B1E10_MBXA	0.0034	0.0965	4.63	2.3168	1.0000	0.15%
BLMQI.03L2.B1E20_MOXA	0.0028	0.0096	0.46	2.3168	1.0000	0.12%
BLMTI.04L2.B1E10_TCTPV.4L2.B1	0.0139	0.0483	2.32	11.5840	1.0000	0.12%

Max plot Per slot Per BLM

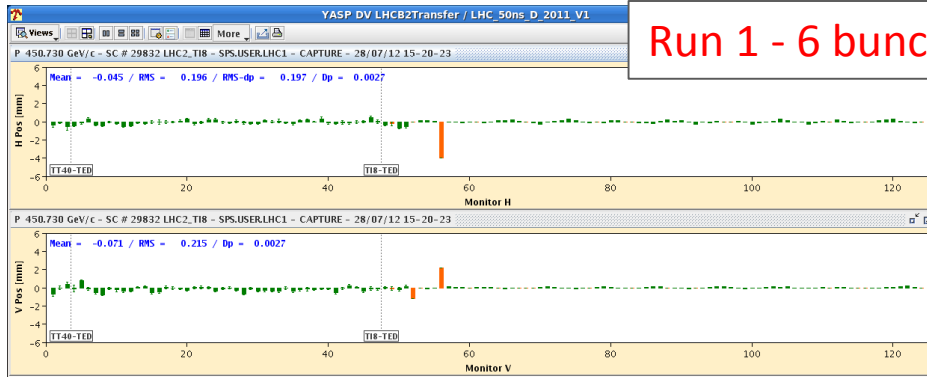
17:29:26 - WARNING NO DCUM VALUE FOR BLMMHC.BLM.SR2.R.CD16.CH12

Run 2 - 6 bunches



6 Bunches Injection Beam 2

Run 1 - 6 bunches



LHC Injection Quality Check GUI

Injection Beam 1 Injection Beam 2

2012-07-28 15:20:23.150: Beam injected! MKI analysis was bad. Bad result for transfer line. Modules are masked.

BEAM EXTRACTION	INJECTION KICKER	BEAM LOSS	RF OSCILLATIONS	INJ. OSCILLATIONS	TRANSFER LINE	RF PHASE	SCRAPING
Green	Green	Green	Grey	Grey	Green	Green	Green

2012-07-28 15:20:23.166: Beam losses are within thresholds. 41 monitors have reference, but are not found in the data.

Monitor name	Max loss	IQC applied	IQC ref	Dump thresh...	Filter factor	Ratio to dump
BLMQI.05R8.B2E10_MQY	0.0035	0.0575	2.76	0.8300	1.0000	0.43%
BLMQI.06L8.B1E30_MQML	0.0028	0.0096	0.46	2.3168	1.0000	0.12%
BLMQI.06L8.B2I10_MQML	0.0021	0.0096	0.46	2.3168	1.0000	0.09%
BLMQI.03R8.B1I20_MQXA	0.0018	0.0096	0.46	2.3168	1.0000	0.08%
BLMQI.03R8.B2E10_MQXA	0.0024	0.0096	0.46	3.7069	1.0000	0.07%
BLMQI.07R8.B2E10_MQM	0.0030	0.0192	0.92	4.5999	8.0000	0.06%
BLMQI.02R8.B1I23_MQXB	0.0011	0.0096	0.46	2.3168	1.0000	0.05%
BLMQI.02R8.B1I30_MQXB	0.0011	0.0096	0.46	2.3168	1.0000	0.05%
BLMQI.03R8.B2E20_MQXA	0.0011	0.0096	0.46	2.3168	1.0000	0.05%

Max plot Per slot Per BLM

0.23%

Successful! The Gy factor was 3.62E-9

Get LSA references Set references Read references from a file Write references to file Slot: 0 Select slot find:

Playback Previous Event Replay event Next Event Show data dump

No Exception to display...

17:42:03 - WARNING NO DCUM VALUE FOR BLMQI.03R8.B1I20_MQ

Not in injection region and unphysical, to be checked!

Injection Beam 2

Monitor name	Max loss	IQC applied	IQC ref	Dump thresh...	Filter factor	Ratio to dump
BLMQI.05R8.B2E10_MQY	23.7240	0.0	0.0	7.7149	1.0000	307.51%
BLMQI.06L8.B1E30_MQML	23.7240	0.0	0.0	7.7149	1.0000	307.51%
BLMQI.06L8.B2I10_MQML	0.0927	0.0	0.0	7.7149	1.0000	1.20%
BLMQI.03R8.B1I20_MQXA	0.0927	0.0	0.0	7.7149	1.0000	1.20%
BLMQI.03R8.B2E10_MQXA	0.0927	0.0	0.0	7.7149	1.0000	1.20%
BLMQI.07R8.B2E10_MQM	0.0927	0.0	0.0	7.7149	1.0000	1.20%
BLMQI.02R8.B1I23_MQXB	0.1177	0.0	0.0	23.1680	1.0000	0.51%
BLMQI.02R8.B1I30_MQXB	0.0241	0.0	0.0	9.2672	1.0000	0.26%
BLMQI.03R8.B2E20_MQXA	0.0083	0.0096	0.46	3.7069	1.0000	0.22%

Max plot Per slot Per BLM

1.20%

No reference for BLM. The Gy factor was 3.62E-9

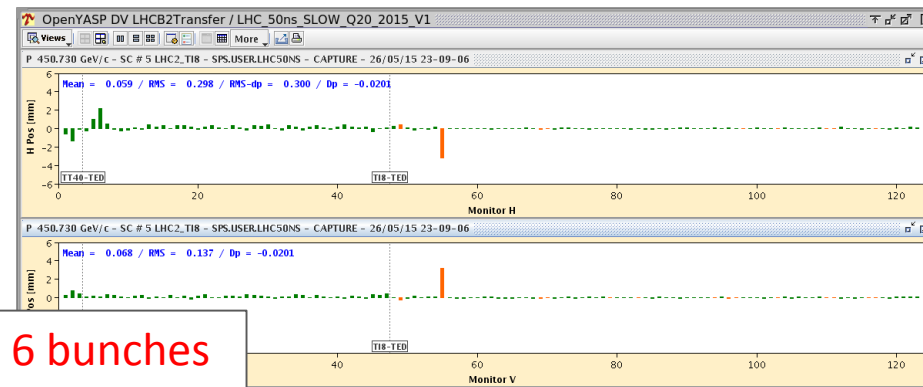
Get LSA references Set references Read references from a file Write references to file Slot: 0 Select slot find:

Playback Previous Event Replay event Next Event

No Exception to display...

17:39:05 - WARNING NO DCUM VALUE FOR BLM.HC.BLM.SR8.C.CD15.CH12

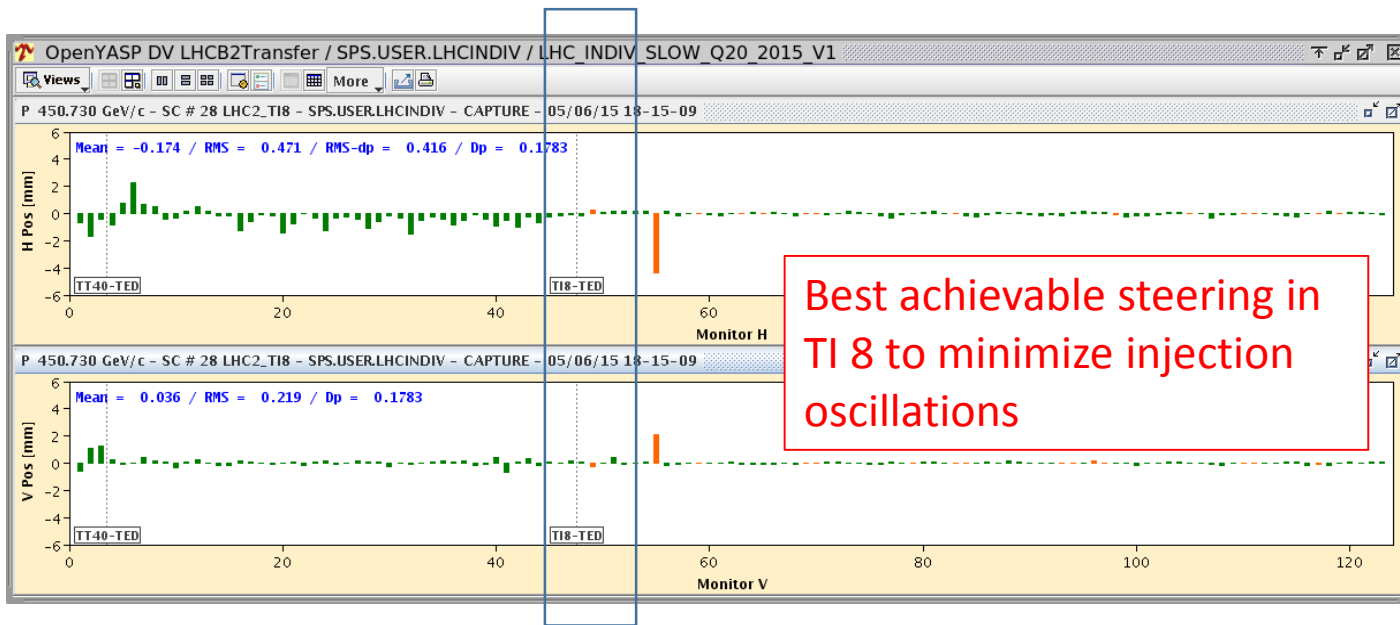
Run 2 - 6 bunches



Bend Repaired in TI8

To be further investigated!!

- From LHCOP logbook 03/06/2015 14:41:
 - SPS: bend repaired in TI8. **RBI in TI8 changed by 4 A***. To be checked next injections.



Best achievable steering in TI 8 to minimize injection oscillations

TL Collimators



* Intervention on Acquisition card to correct a 4 A offset (0.04%) between the DAQ and the Power converters to solve a FEI issue

Injection Losses: LIC vs IC

- Only up to 6 bunches injected → low intensity and statistics!
- Mainly **LIC+Big filters** installed instead of the SEM
- **IC+Small filters** preferred in the injection region in view of possible need to blind most critical BLMs (removing filter!)

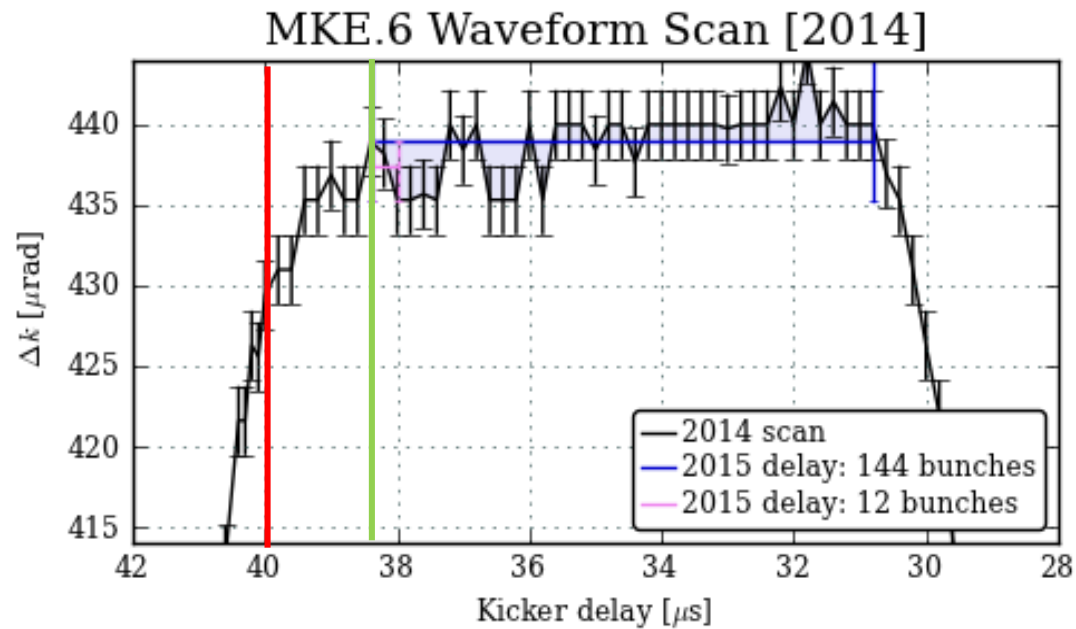
Before LS1

After LS1

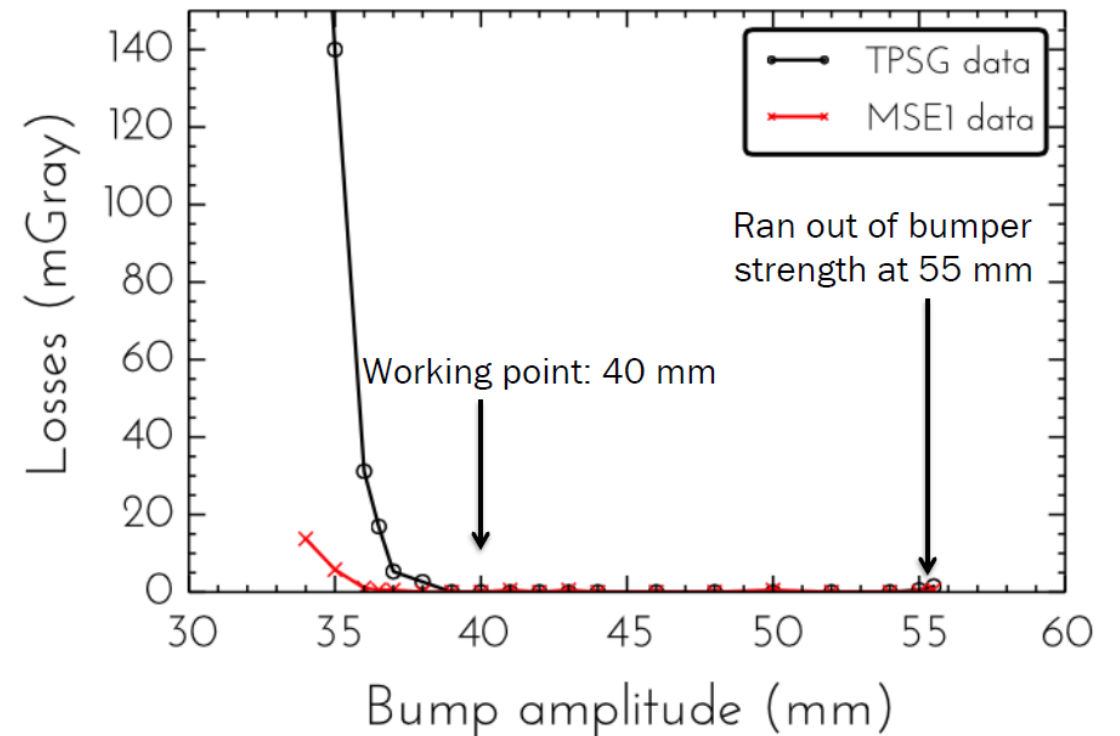
BLMQI.A9L2	BLMQI.08L2.B2I30_MQML	UJ22	HCBLM_I001-05003083	IC	HCBLM_I001-05003083	BJBAP.C8L2_1	BJBAP.C8L2	U	1	Not Installed			3022.6704	BLMQI.08L2.B2I30_MQML	no	1	IC+SF	BJBAP.C8L2	
BLMQI.F8L2	BLMQI.08L2.B1E10_MQML	UJ22	HCBLM_I001-05003060	IC	HCBLM_I001-05003060	BJBAP.C8L2_2	BJBAP.C8L2	U	1	Installed	small	2200	150	3025.7604	BLMQI.08L2.B1E10_MQML	blind	1	IC+SF	BJBAP.B8L2, rename
BLMQI.E8L2	BLMQI.08L2.B2I20_MQML	UJ22	HCBLM_I001-05003956	IC	HCBLM_I001-05003956	BJBAP.C8L2_3	BJBAP.C8L2	U	1	Not Installed			3027.0434	BLMQI.08L2.B2I20_MQML	no	1	IC+SF	BJBAP.C8L2	
BLMQI.D8L2	BLMQI.08L2.B1E20_MQML	UJ22	HCBLM_I001-05003006	IC	HCBLM_I001-05003006	BJBAP.C8L2_4	BJBAP.C8L2	U	1	Installed	small	2200	150	3028.2434	BLMQI.08L2.B1E20_MQML	blind	1	IC+SF	BJBAP.B8L2, rename
BLMQL.A8L2	BLMQL.08L2.B2I10_MQML	UJ22		0.4 LIC		BJBAP.C8L2_5	BJBAP.C8L2	U	1	Not Installed			3030.4154	BLMQL.08L2.B2I10_MQML	no	1	LIC	BJBAP.C8L2	
BLMQI.B8L2	BLMQI.08L2.B1E30_MQML	UJ22	HCBLM_I001-05003333	IC	HCBLM_I001-05003333	BJBAP.C8L2_6	BJBAP.C8L2	U	1	Installed	small	2200	150	3032.9154	BLMQI.08L2.B1E30_MQML	blind	1	IC+SF	BJBAP.B8L2, rename
BLMEI.F8L2	BLMEI.08L2.B2I23_MBA	UJ22	HCBLM_I001-05003936	IC	HCBLM_I001-05003936	BJBAP.A8L2_1	BJBAP.A8L2	U	1	Not Installed			3035.0854	BLMEI.08L2.B2I23_MBA	no	1	IC	BJBAP.A8L2	
BLMES.F8L2	BLMES.08L2.B2I23_MBA	UJ22	HCBLM_S001-05000337	SEM	HCBLM_S001-05000337	BJSAP.B8L2_1	BJSAP.B8L2	M	0	Not Installed			3035.0854	BLMEL.08L2.B2I23_MBA	no	0	LIC+BF	BJBAP.A8L2	
BLMEI.E8L2	BLMEI.08L2.B2I22_MBA	UJ22	HCBLM_I001-05003094	IC	HCBLM_I001-05003094	BJBAP.A8L2_2	BJBAP.A8L2	U	1	Not Installed			3038.7354	BLMEI.08L2.B2I22_MBA	no	1	IC	BJBAP.A8L2	
BLMES.E8L2	BLMES.08L2.B2I22_MBA	UJ22	HCBLM_S001-05000232	SEM	HCBLM_S001-05000232	BJSAP.B8L2_2	BJSAP.B8L2	M	0	Not Installed			3038.7354	BLMEL.08L2.B2I22_MBA	blind	0	LIC+BF	BJBAP.B8L2, rename	
BLMEI.D8L2	BLMEI.08L2.B2I21_MBA	UJ22	HCBLM_I001-05003948	IC	HCBLM_I001-05003948	BJBAP.A8L2_3	BJBAP.A8L2	U	1	Not Installed			3042.1754	BLMEI.08L2.B2I21_MBA	no	1	IC	BJBAP.A8L2	
BLMES.D8L2	BLMES.08L2.B2I21_MBA	UJ22	HCBLM_S001-05000327	SEM	HCBLM_S001-05000327	BJSAP.B8L2_3	BJSAP.B8L2	M	0	Not Installed			3042.1754	BLMEL.08L2.B2I21_MBA	blind	0	LIC+BF	BJBAP.B8L2, rename	
BLMEI.C8L2	BLMEI.08L2.B2I30_MBB	UJ22	HCBLM_I001-05003082	IC	HCBLM_I001-05003082	BJBAP.A8L2_4	BJBAP.A8L2	U	1	Not Installed			3046.0354	BLMEI.08L2.B2I30_MBB	no	1	IC	BJBAP.A8L2	
BLMES.C8L2	BLMES.08L2.B2I30_MBB	UJ22	HCBLM_S001-05000235	SEM	HCBLM_S001-05000235	BJSAP.B8L2_4	BJSAP.B8L2	M	0	Not Installed			3046.0354	BLMEL.08L2.B2I30_MBB	blind	0	LIC+BF	BJBAP.B8L2, rename	
BLMEI.B8L2	BLMEI.08L2.B2I22_MBB	UJ23	HCBLM_I001-05003931	IC	HCBLM_I001-05003931	BJBAP.A8L2_5	BJBAP.A8L2	U	1	Not Installed			3051.4954	BLMEI.08L2.B2I22_MBB	no	1	IC	BJBAP.A8L2	
BLMES.B8L2	BLMES.08L2.B2I22_MBB	UJ23	HCBLM_S001-05000354	SEM	HCBLM_S001-05000354	BJSAP.B8L2_5	BJSAP.B8L2	M	0	Not Installed			3051.4954	BLMEL.08L2.B2I22_MBB	blind	0	LIC+BF	BJBAP.B8L2, rename	
BLMEI.A8L2	BLMEI.08L2.B2I21_MBB	UJ23	HCBLM_I001-05003426	IC	HCBLM_I001-05003426	BJBAP.A8L2_6	BJBAP.A8L2	U	1	Not Installed			3056.6954	BLMEI.08L2.B2I21_MBB	no	1	IC	BJBAP.A8L2	
BLMES.A8L2	BLMES.08L2.B2I21_MBB	UJ23	HCBLM_S001-05000303	SEM	HCBLM_S001-05000303	BJSAP.B8L2_6	BJSAP.B8L2	M	0	Not Installed			3056.6954	BLMEL.08L2.B2I21_MBB	blind	0	LIC+BF	BJBAP.B8L2, rename	
BLMQI.A8L2	BLMQI.07L2.B2I30_MQM	UJ23	HCBLM_I001-05003986	IC	HCBLM_I001-05003986	BJBAP.A7L2_1	BJBAP.A7L2	M	1	Not Installed			3061.6954	BLMQI.07L2.B2I30_MQM	no	1	IC	BJBAP.A7L2	
BLMQI.F7L2	BLMQI.07L2.B1E10_MQM	RH23	HCBLM_I001-05003057	IC	HCBLM_I001-05003057	BJBAP.A7L2_2	BJBAP.A7L2	M	1	Installed	small	2200	150	3064.8254	BLMQI.07L2.B1E10_MQM	no	1	IC+SF	BJBAP.A7L2
BLMQI.E7L2	BLMQI.07L2.B2I20_MQM	RH23	HCBLM_I001-05003942	IC	HCBLM_I001-05003942	BJBAP.A7L2_3	BJBAP.A7L2	M	1	Not Installed			3067.2489	BLMQI.07L2.B2I20_MQM	no	1	IC	BJBAP.A7L2	
BLMQI.D7L2	BLMQI.07L2.B1E20_MQM	RH23	HCBLM_I001-05003034	IC	HCBLM_I001-05003034	BJBAP.A7L2_4	BJBAP.A7L2	M	1	Installed	small	2200	150	3068.4489	move to MB interconnect cell 8	no	1	IC+SF	BJBAP.A7L2
BLMQI.C7L2	BLMQI.07L2.B2I10_MQM	RH23	HCBLM_I001-05003363	IC	HCBLM_I001-05003363	BJBAP.A7L2_5	BJBAP.A7L2	M	1	Not Installed			3071.8154	BLMQI.07L2.B2I10_MQM	no	1	IC	BJBAP.A7L2	
BLMQI.B7L2	BLMQI.07L2.B1E30_MQM	RH23	HCBLM_I001-05003038	IC	HCBLM_I001-05003038	BJBAP.A7L2_6	BJBAP.A7L2	M	1	Installed	small	2200	150	3075.3654	BLMQI.07L2.B1E30_MQM	blind	1	IC+SF	BJBAP.A6L2

Extraction Issues in LSS6

- High losses when extracting HiRadMat beam (12 bunches)
- Found out:
 - **Not optimum delay** between Beam and MKE pulse (40 instead of 38.5 μs) \rightarrow corrected
 - **Drift of the orbit** at the extraction point by 2.5 mm \rightarrow corrected and extraction bump from 40 mm to 42 mm

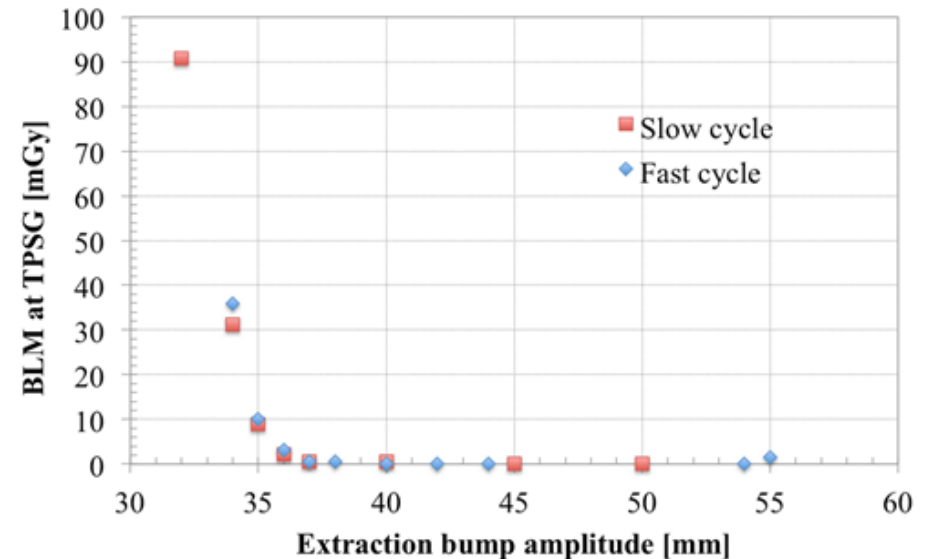


Proposed delay 38.5 μs



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 - **Not optimum delay** between Beam and MKE pulse (40 instead of 38.5 μs) \rightarrow corrected
 - **Drift of the orbit** at the extraction point by 2.5 mm \rightarrow corrected and extraction bump from 40 mm to 42 mm
- This did not solve the extraction problem and we realised that losses were only present for nominal bunch on LHC25ns cycle but not on PILOT cycle
 - Measure extraction aperture for both cycles \rightarrow no difference
 - Measured MKE delay for both cycles \rightarrow no difference



Extraction Issues in LSS6

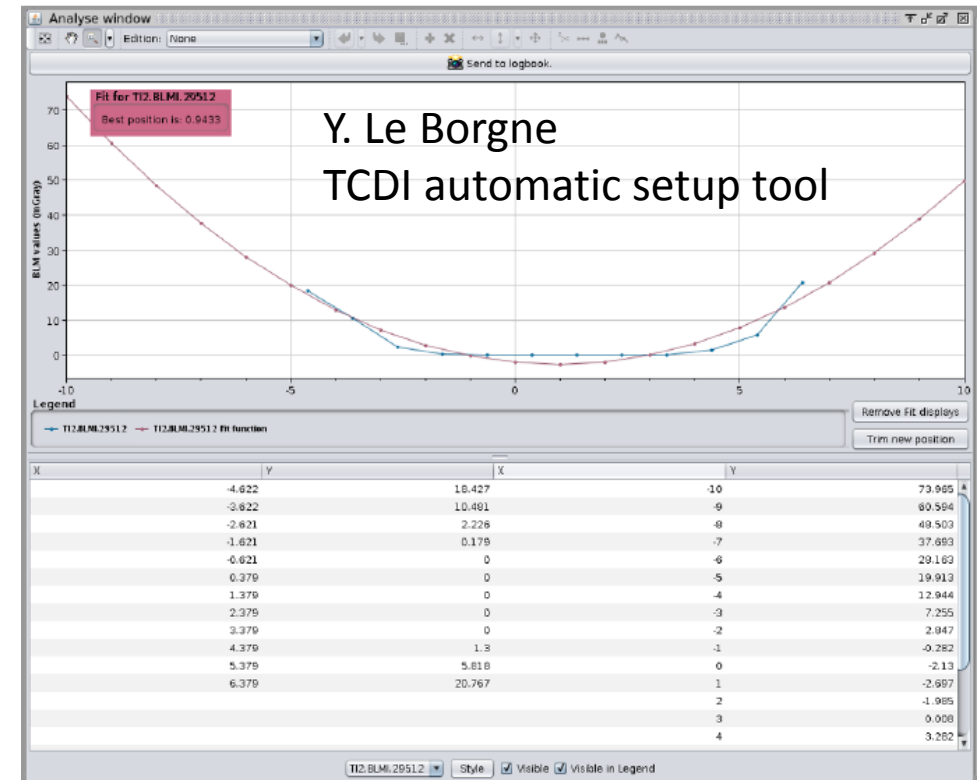
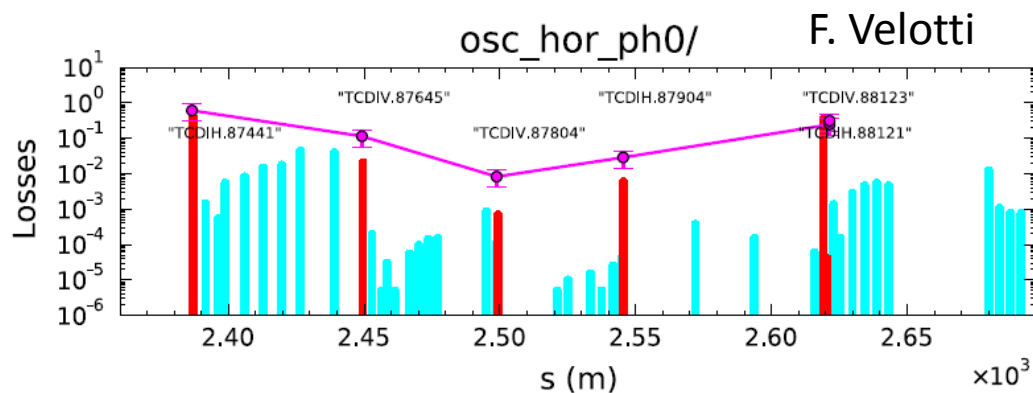
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 - **Drift of the orbit** at the extraction point by 2.5 mm → corrected and extraction bump from 40 mm to 42 mm
- This did not solve the extraction problem and we realised that losses were only present for nominal bunch on LHC25ns cycle but not on PILOT cycle
 - Measure extraction aperture for both cycles → no difference
 - Measured MKE delay for both cycles → no difference
- Found out that main problems:
 - LHC25ns was not fully set up: uncaptured beam kicked out by longer rise time of MKE6 wrt MKE4 → corrected
 - The MKP generators not properly adjusted and 250 ns rise time not yet possible → not possible to extract 4 batches on the LSS6 flattop waveform (too short: 8 μs) → possible to increase MKE6 flattop during Xmas stop (also in view of 80 bunches and BCMS)
 - HiRadMat beam-MKE synchronization → corrected

Extraction Issues in LSS6

- High losses when extracting HiRadMat beam (12 bunches)
 - Found out:
 - Not optimum delay between Beam and MKE pulse (40 instead of 38.5 μ s) → corrected
 - **Drift of the orbit** at the extraction point by 2.5 mm → corrected and extraction bump from 40 mm to 42 mm
 - This did not solve the extraction problem and we realised that losses were only present for nominal bunch on LHC25ns cycle but not on PILOT cycle
 - Measure extraction aperture for both cycles → no difference
 - Measured MKE delay for both cycles → no difference
 - Found out that main problems:
 - LHC25ns was not fully set up: uncaptured beam kick corrected
 - The MKP generators not properly adjusted and 250 bunches extract 4 batches on the LSS6 flattop waveform (too low) during Xmas stop (also in view of 80 bunches and BC) → corrected
 - HiRadMat beam-MKE synchronization → corrected
- **Orbit drifts at extraction point are still a non fully understood issue → strong impact on TL stability (BPCE resolution not enough for fine interlock)**
 - **Possible solution: beam position at BPCE extrapolated from SPS orbit in IQC → monitor orbit drift and improve TL and injection diagnostics in case of problems**

Injection Protection Collimators

- TDI, TCLIA/B and TCDI are **set up** and **fully validated**
- Now **straightforward procedures** for setup and validation
- Effective time (**PROVIDED BEAM AVAILABILITY**) reduced from 1 shift per TL down to 3 hours
- “Position” and “Energy” **dump thresholds set up to:**
 - TDI and TCLIA/B: position $\pm 0.25\sigma$, gap $+1\sigma$
 - TCDI: position $\pm 0.5\sigma$, gap $+1\sigma$
- TDI **BETS interlock** thresholds set to gap $\pm 1.5\sigma$



Optics ID for TCDI

- Aim: check the **TL optics** and verify that **TCDI settings** are correct for that optics
- Proposed to adapt β^* interlock used for the ring collimators:
 - All/some **TL quad currents** defined as **critical settings** in LSA **V**
 - Associate a **unique ID** **V**
 - Distribute it through timing system **V**
 - Define TCDI thresholds and specifications **X**
 - Control implementation **X**

The FESA class has to be modified: a new "Active_IP" has to be added which checks the OIDI2/8 telegram instead of the BSTAR1/2/5/8 telegram → impact on ring collimators → repeat MP checks also for them!
Not ready to be implemented in TS1

The screenshot shows the 'Timing editor' interface with the 'TELEGRAM MONITORING' tab selected. The interface includes a 'SET TELEGRAM GROUPS' section on the left with a dropdown menu set to 'SECTACC' and a 'set' button. Below that is a 'SEND AN EVENT' section with a 'Select Event' dropdown and a 'SEND' button. At the bottom, there are buttons for 'send START TABLE event with payload' and 'Send inj forewarning event in test mode'. The main area displays a table of telegram data:

GROUP	DESCRIPTION	VALUE
AMODE	Machine mode	PROTPHYS
BKNI	Next injection RF bucket	29991
BMODE	What the LHC is doing	SETUP
BPNM	Basic Period Number	26812
BSTAR1	Squezing factors: 16bits, res=0,01 m/bit	559
BSTAR2	Squezing factors: 16bits, res=0,01 m/bit	1000
BSTAR5	Squezing factors: 16bits, res=0,01 m/bit	501
BSTAR8	Squezing factors: 16bits, res=0,01 m/bit	1000
ENG	Beam energy (x120 Mev)	59.28
FILLN	Fill number	3848
FREE28	Not used	0
FREE29	Not used	0
INT1	Beam intensity - Ring 1 (x10E10 charges)	0
INT2	Beam intensity - Ring 2 (x10E10 charges)	0
LVELIR	Leveling: Luminosity adjustment	
NIBIN	Next injected bunch intensity	150
NIBNCH	Next injected number of bunches	4
NIBSP	Next injected bunch spacing	0
NIPTY	Next injected particle type	1
OIDI2	Optic ID for TI2	2087
OIDI8	Optic ID for TI8	2088
OMODE	Operational mode	
OPTID	Beam optics identifier	2728
PARTY1	Ring 1: Particle type	PROTON
PARTY2	Ring 2: Particle type	PROTON
PP60A	Power permit 60 Amps	ARC12 ARC23 ARC34 ARC45 ARC56 ARC67 ARC78 A
RNGI	Next injection ring	RING_1
SECTACC	Sector access	
SMP	Safe machine parameters - Ring 1 and 2	SAFE1 SAFE2
SPCON	Specific conditions	
USER	LHC user	LHC

Missing Optics ID Critical for High Intensity?

- TCDI settings (aperture) depend on the TL optics
- In the past when changing from Q26 to Q20 optics it was not caught that the optics change was affecting the region where TL collimators are → one TCDI with gap larger than 5σ → poorer protection
- Now **system setup, validated and reference defined** → **protection for injection of high intensity beam is granted** (other checks are performed and prevent extraction if magnet currents are wrong).
- Still important to implement this interlock in view of **future possible optics changes**. When? TS or Xmas stop? It has to be defined **which MP checks** have to **be repeated**: all? Only β^* ? For **all ring collimators or a sample?**

TDI Limits

- TDI hBN block cannot withstand temperatures higher than 450 °C (B_2O_3 reactant melting temperature) → limit the maximum number of bunches which can hit the TDI (maximum allowed temperature = 400 °C)

Beam type	Bunch/Doublet intensity	Emittance ($\mu\text{m rad}$)	Bunch/Doublet spacing (nsec)	Bunches/Doublets per batch	1 batch	2 batches	3 batches	4 batches
Standard 25 nsec	1.20E+11	2.6	25	72	72 (1.8 usec) 206 deg C	144 (3.8 usec) 352 deg C	216 (5.8 usec) 483 deg C	288 (7.8 usec) 606 deg C
BCMS	1.30E+11	1.3	25	48	48 (1.2 usec) 239 deg C	96 (2.6 usec) 408 deg C	144 (4.0 usec) 560 deg C	
50 nsec	1.20E+11	1.5	50	36	36 (1.8 usec) 160 deg C	72 (3.8 usec) 277 deg C	108 (5.8 usec) 378 deg C	144 (7.8 usec) 473 deg C
Doublet(*)	1.60E+11	4	25	72	72 (1.8 usec) 212 deg C	144 (3.8 usec) 363 deg C		

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TDI Limits

- TDI hBN block cannot withstand temperatures higher than 450 °C (B_2O_3 reactant melting temperature) → limit the maximum number of bunches which can hit the TDI (maximum allowed temperature = 400 °C)
- Consequences:
 - **Limit** number of **injected bunches**
 - **Increase** number of **injection**
 - **Limit maximum number of circulating bunches** (maximum reachable with 25 ns beam: 2448 instead of 2736, B. Gorini LMC 13/05/2015)
- How to insure that no more than 144 bunches hit the TDI when operating with 25 ns beam?
 - **Reduce length** of **injection kicker** to 3.8 μ s (erratic on circulating beam)
 - **Reduce length** of the **SPS flat-bottom of LHC cycle**
- A new TDI with graphite instead of hBN will be installed during the next Xmas stop.

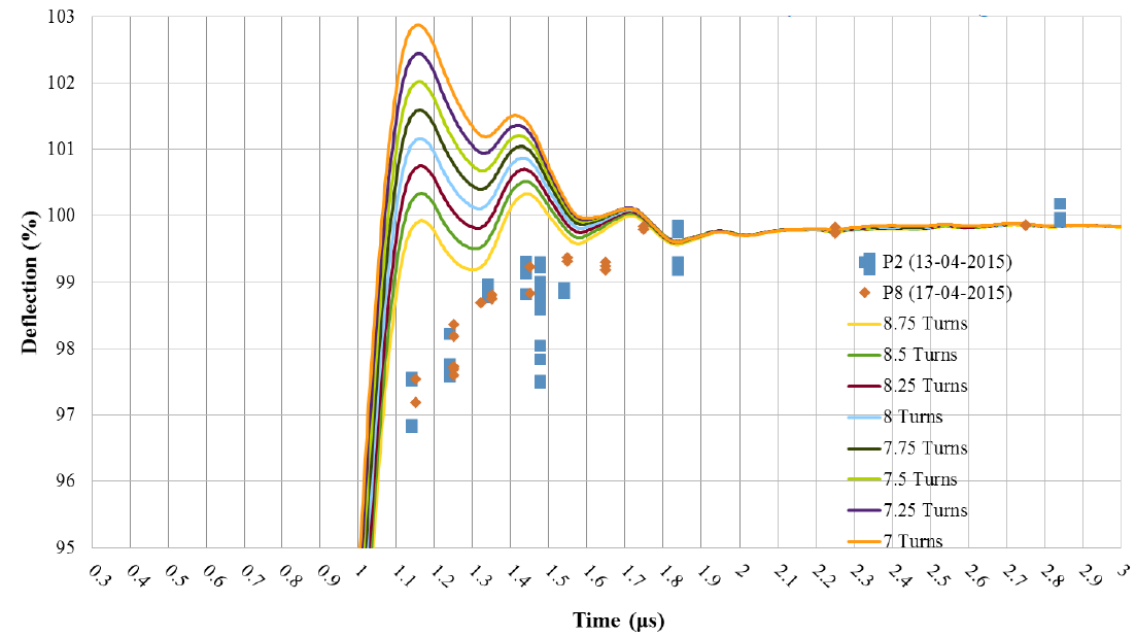
TDI Limits

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**Critical topic: flip
between 25 ns and 50 ns
configuration!**

MKI Waveform

- Measured an **MKI rise time**, both in IR2 and IR8, **longer than nominal** ($1.2\ \mu\text{s}$ instead of $0.9\ \mu\text{s}$) and thus a shorter flattop (possible to adjust)
- The **number of the MS end turns** were **increased** in April 2010 from 8.25 to 8.75 to **reduce the overshoot**
- Wrt to LS1 the **TMR resistance is reduced** and the **number of screen conductors increased** → undershoot
- New calculations were done taking into account all these effects and the **optimum number of MS end turns calculated** (7.25)
- This change will be implemented during TS1
- A new waveform scan will have to be performed



Summary

- Large difference between PILOT and INDIV/25ns → **bad trajectories** and **injection oscillations** for **PILOT** (used to set up the LHC): **Not critical for MP** but **not ideal for operation**. Proposal: put **PILOT** on **SLOW cycle**
- **Injection losses** of the **same order of Run 1** (only 6 bunches injected!). Still too low intensity to draw conclusions about LIC and need of BLM blinding.
- **Large trajectory drift in H plane** after fixing a DAQ problem for **TI 8 bends**. **Not critical for MP**, no increase in injection losses (but losses appearing in IR7) and possible to steer on injection oscillations. **Not reassuring for operation**: GOLDEN reference could be no more valid if this happens again!
- **Orbit drifts** of few mm affect the **SPS extraction** point and have a big **impact on TL stability**. **Not critical for MP** but **frequent steering** is expected to be needed. Proposal: monitor losses and orbit drifts in IQC to improve diagnostics (possible future interlock on next extraction)
- All injection **protection collimators set up and validated**. **Optics_ID** for TCDI **not yet in place** (need to modify FESA class and revalidation also for ring collimators). **Not critical for MP** since needed only in case of optics change.
- **TDI hBN block** fragility **limits the number of injected** (and circulating) **bunches**. **Critical for MP** since an adequate **strategy** has to be put in place **to insure the correct flip between 25 ns and 50 ns settings** (MKI pulse and SPS flat-bottom length)
- **MKI rise time** will be restored to its **nominal value after TS1**, to be checked with measurements.

Ready to start with high intensity beams with some care!

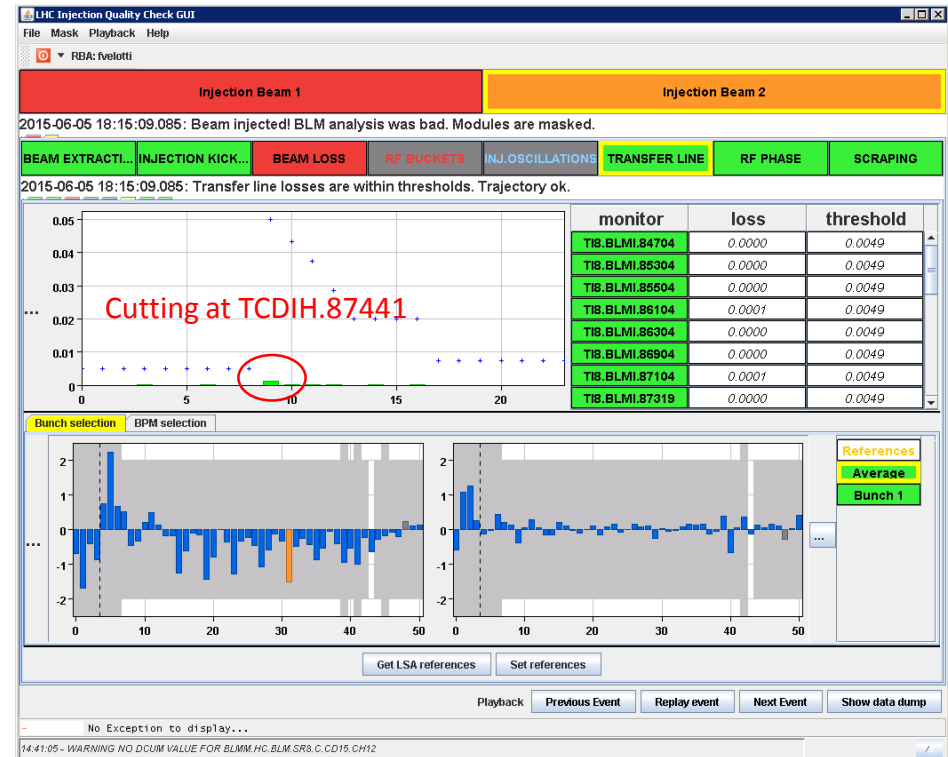
Thanks a lot for your attention!

TL Comparison

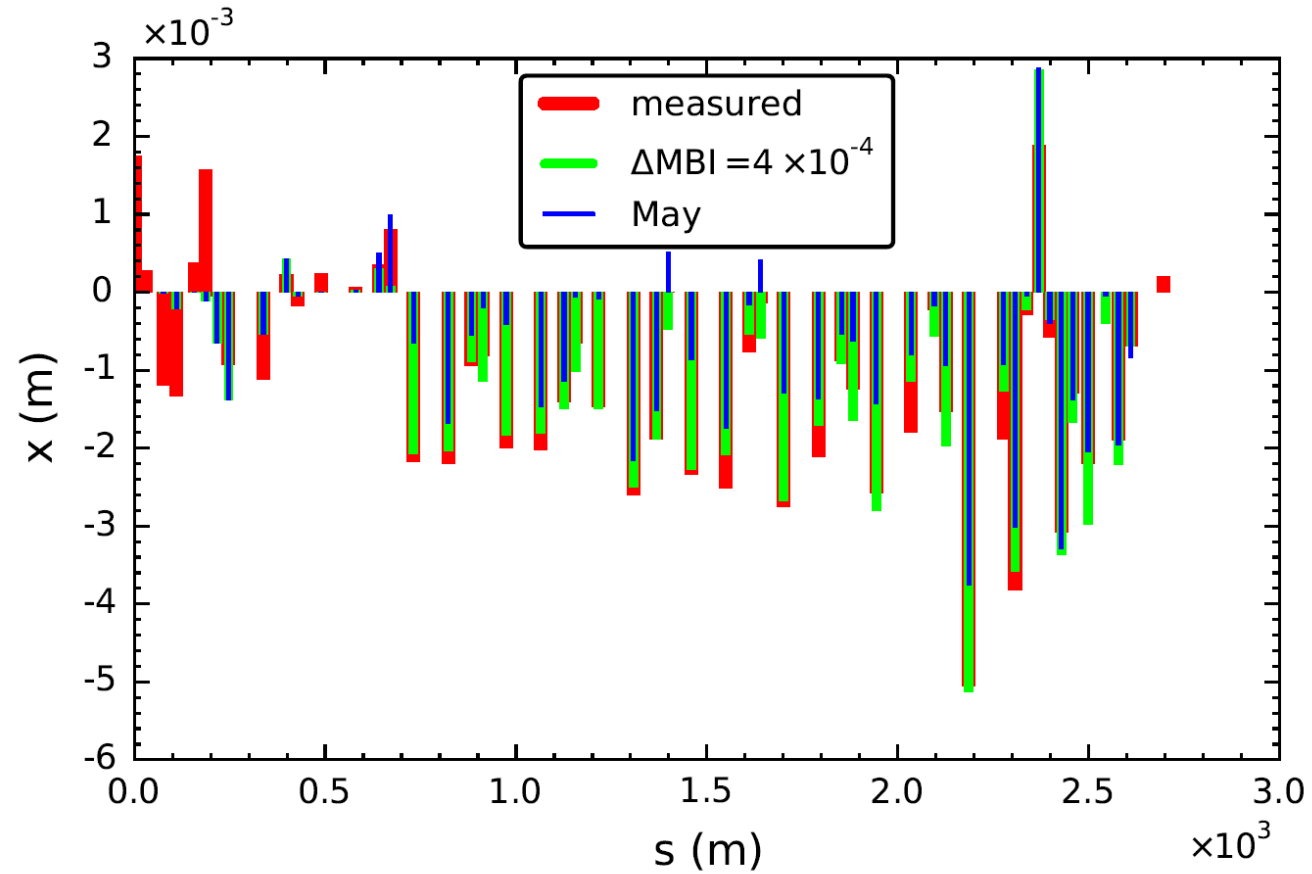
Before RBI change



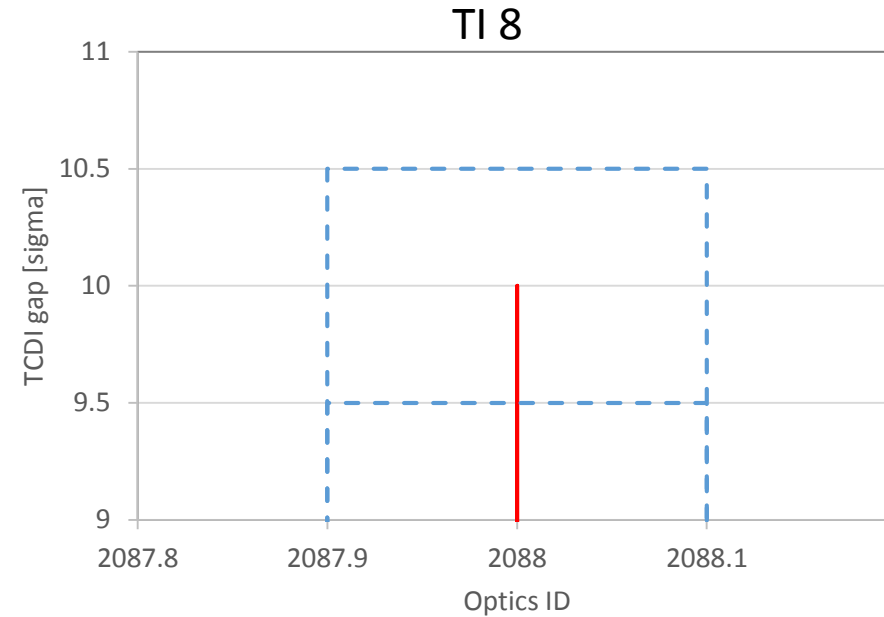
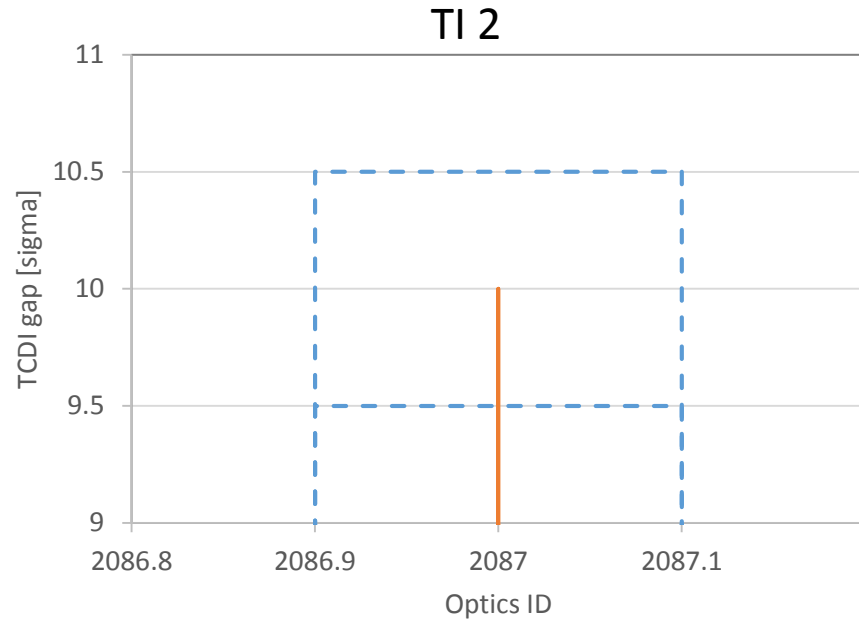
After RBI change



Real 4 A Current Change?



Proposal for TCDI Threshold Tables



Optics_ID	GU_IN [mm]	GD_IN [mm]	GU_OUT [mm]	GD_OUT [mm]
2086.9	9.5	9.5	10.5	10.5
2087	9.5	9.5	10.5	10.5
2087.1	9.5	9.5	10.5	10.5

Optics_ID	GU_IN [mm]	GD_IN [mm]	GU_OUT [mm]	GD_OUT [mm]
2087.9	9.5	9.5	10.5	10.5
2088	9.5	9.5	10.5	10.5
2088.1	9.5	9.5	10.5	10.5

For simplicity it is assumed $1 \sigma = 1 \text{ mm}$ (thresholds = gap $\pm 0.5 \sigma$)