ADT

Will the new powers of the ADT make it more ?

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With particular thanks to:

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Topics to address:

- **Will the new powers of the ADT make it more dangerous? Stays the max. power limit the same?**

- Protection of settings

- Mishaps/issues

- Commissioning and validation:

- Configuration of special modes / MDs

- Improved abort gap cleaning possible?
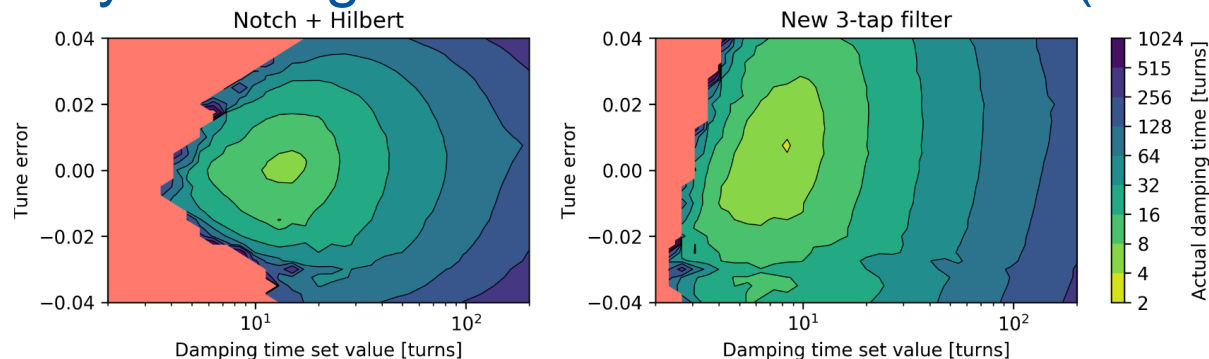
- Impact of operation at 7 TeV

ADT upgrades in LS2

- *Will the new powers of the ADT make it more dangerous? Stays the max. power limit the same?*

- Power system + kickers – **no change**

- Maximum deflection per turn – **no change**
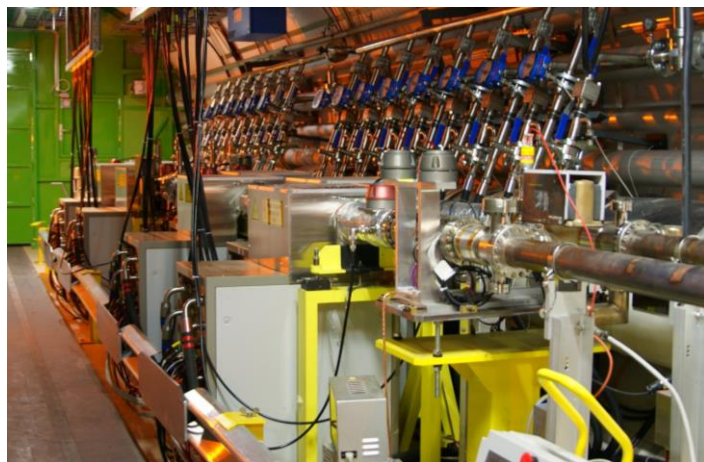
ADT upgrades in LS2

- *Will the new powers of the ADT make it more dangerous? Stays the max. power limit the same?*

- New beam position modules – **no impact**

- Upgrade of the signal processing. **Shorter delay allows for a faster damping.** τ_d ~5 turns demonstrated – equally faster growth in case of a failure (MD4063)

ADT upgrades in LS2

- *Will the new powers of the ADT make it more dangerous? Stays the max. power limit the same?*

- New control software and settings management

- New "active" functionality requested by operation (mainly automated excitation+acquisition) – **potential for mishaps**

ADT upgrades in LS2

- *Stays the max. power limit the same?*
- **Yes it does. But we can use it more efficiently…**

- *Will the new powers of the ADT make it more dangerous?*
- **More users, machines, automated sequences will have access to them…**

Protection of settings

- Operational settings stored in LSA
- Some loaded by sequencer, some by humans

- Different RBAC roles for different functions
  - RF-EXPERT, RF-ADT-ACDIPOLE, RF-ADT-BLOWUP,
  - MCS-LHC-ADT, MCS-AbortGapCleaner

- **No incidents related to settings protection so far**
- **Few isolated incidents related to humans dealing with those settings**

- Urgent need to relax the above in order to improve automation and flexibility. **Consequences?**

Configuration of special modes / MDs

- Special modes and MDs typically run by experts

- Regularly need to unlock the built in protections and limitations

- Prepare, test and load the special settings

- Experts are normally present during the whole special run, doing the manipulations themselves

Mishaps and issues
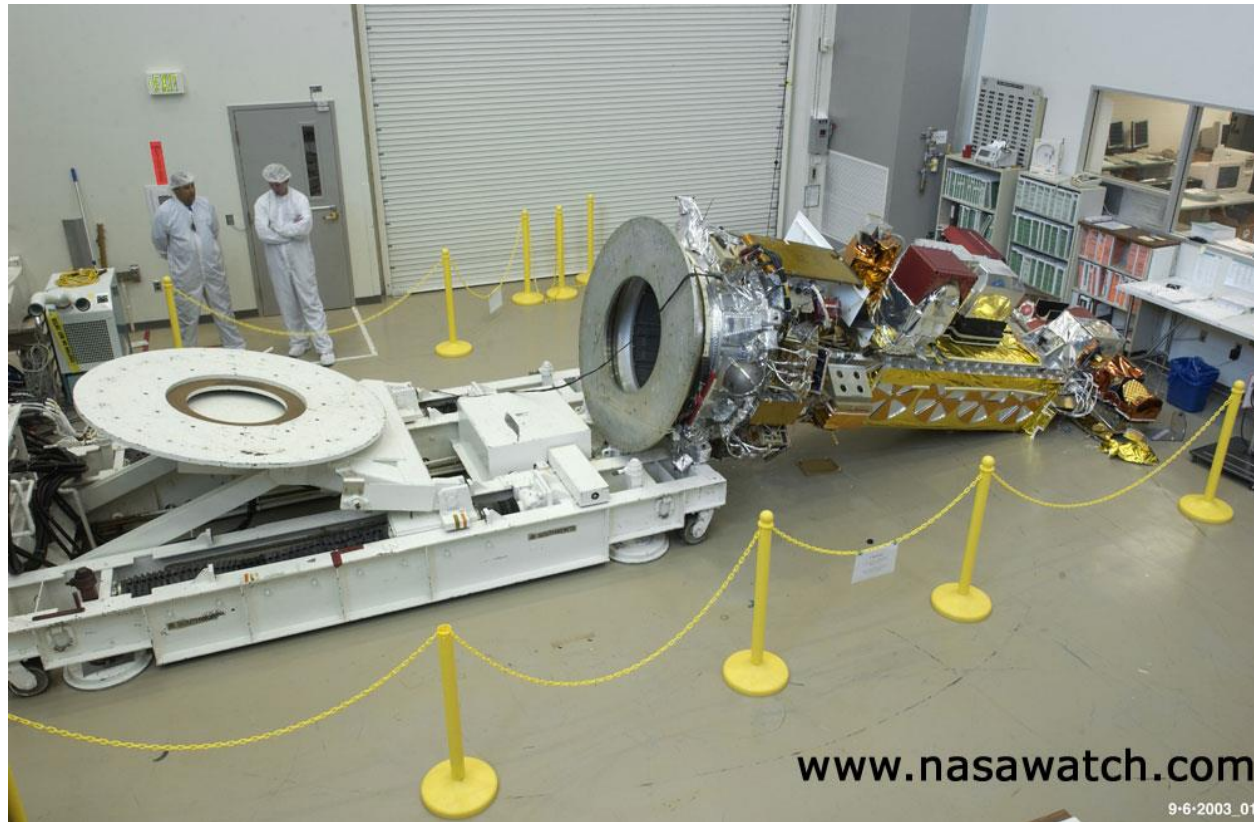
Earth Science Missions Anomaly, Sept. 2003
https://www.nasa.gov/pdf/65776main_noaa_np_mishap.pdf

Mishaps and issues: Setting the scene

- ADT is a very versatile and powerful device, it is capable to do anything from…

  - … a single kick of a single bunch within a 25ns train without touching the neighbours,
  - … to kicking the whole beam by 2μrad, in phase, for an unlimited amount of time

- A bunch by bunch, turn by turn beam position is available with sub-micron resolution and for unlimited storage time

- Provides real time data analysis, connection to other instruments…

Mishaps and issues: Setting the scene

- Many ideas from the ABP, operation or RF group constantly pour in. New functionalities, new tools, fancy things to try out, would be useful to have stuff…

- As all systems, ADT is also run by people who are capable to get maximum out of the system.

- Always ready, always available, always helpful is the attitude…

- We are expected to be very flexible and "hacky"

- **We always have to respond quickly, often there is no time allocated for thorough testing**

Ingredients for a success?

A recipe for disaster?

Mishaps and issues

- Quench tests at the end of Run I: Four different ways to quench, ADT was involved in three of them

- A method to do an ultra fast excitation was developed (5 turns)

- A method to induce 1MW losses by ADT blow-up was developed

- Preparation and testing took 4-6 weeks

- Great success…

LHC Page1	Fill: 3575	E: 2052 GeV	16-02-13 08:29:03

MACHINE DEVELOPMENT: RAMP DOWN

Energy:	2052 GeV

Post Mortem Information

PM event ID:	Sat Feb 16 08:08:31 CET 2013
PM event category:	PROTECTION_DUMP
PM event classification:	MULTIPLE_SYSTEM_DUMP
PM BIS Analysis result:	First USR_PERMIT change: Ch 5-PIC_UNM: A T -> F on CIB.UA63.L6.B1
PM comment:	Quench test by exciting train of 8 bunches of B2 with ADT.

Mishaps and issues

- MD4063: New signal processing algorithm for ADT

- MD4143: Noise studies with new ADT pickups

- New concept, new firmware, new FESA class, new pickups

- A "brand new" ADT, which needed to be set-up from scratch, completed in <5 hours!

- Preparation and testing took ~4 weeks (MD4063) and ~8 weeks (MD4143)

- Great success…
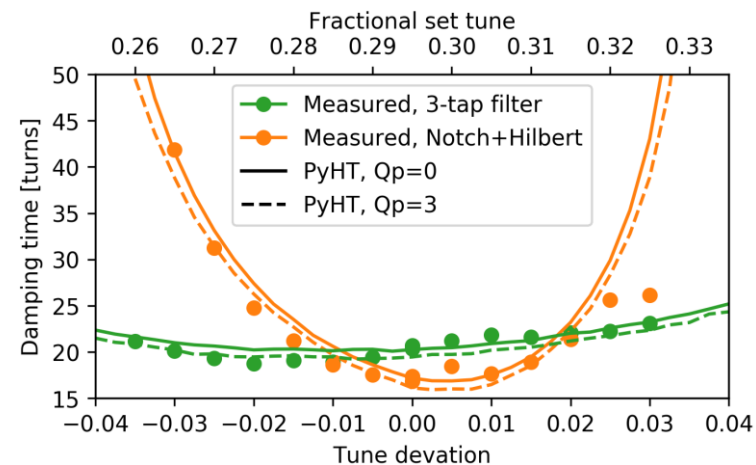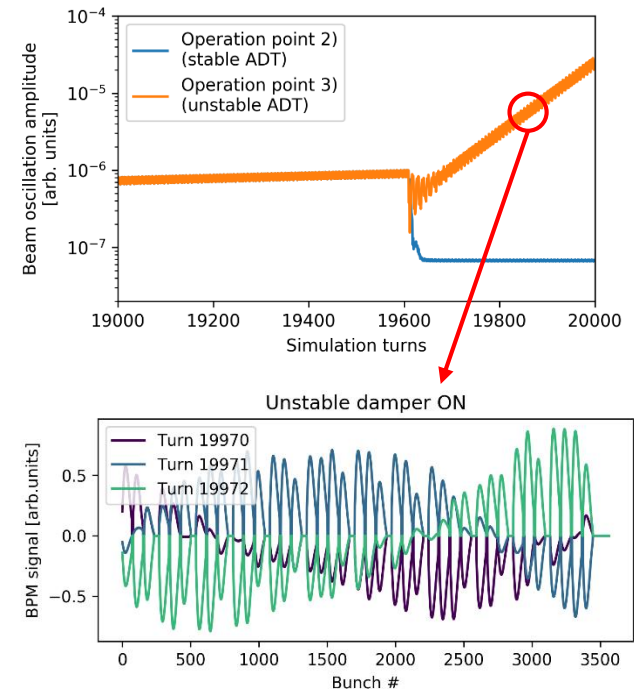
Mishaps and issues

- End od fill MD3291: Reduced ADT bandwidth for low-noise operation in physics

- No dedicated machine time granted to do a low intensity test prior the MD. **Be prepared for the call**

- Preparation: ½ day to compute new filter coefficients

- Full testing in the lab would require a couple of days

Mishaps and issues

- First few attempts: Can you come to the CCC, we may get time in 1 hour (carried on for 2 months)

- Next attempt: We finally got the time, can you load the settings? Yes, but I am at the Vienna airport. No problem, just load them.

- Did not dump. But very uncontrolled conditions, no conclusive results…

- Next attempt: **End of fill, everyone in the CCC, load the coefficients, increase the gain, instant dump.**

Mishaps and issues

- Post mortem of the MD:
  - Required days were finally spent in the lab – the digital filter coefficient normalization was found not to be optimal for this kind of operation
  - Another 2 weeks spent by simulations, which precisely predicted the observed behavior

- Next test was successful

- Lessons learned:
  - **If tests require time to prepare, it is not possible to be flexible and responsive.**
  - **Unorganized end-of-fill MDs penalize tests which require thorough preparation.**

Mishaps and issues

- Fall 2018, 16L2 MD:

Dear Daniel,

… I was wondering if you or **someone from your team is available** during these times or could help **prepare the ADT settings for the bunch blow-up.**

For details I have attached the MD procedure, but in short, the MD will consist of two parts, one fill with 852b and a second with 1812b. For both fills we want to excite the following RF buckets:

Then, as an end-of-fill for the 1812 fill, about ~1 hour before the end of the MD slot, we want to further excite the following RF buckets:
b1&2, hor: 2481-5641, 13161-16321, 23841-27201
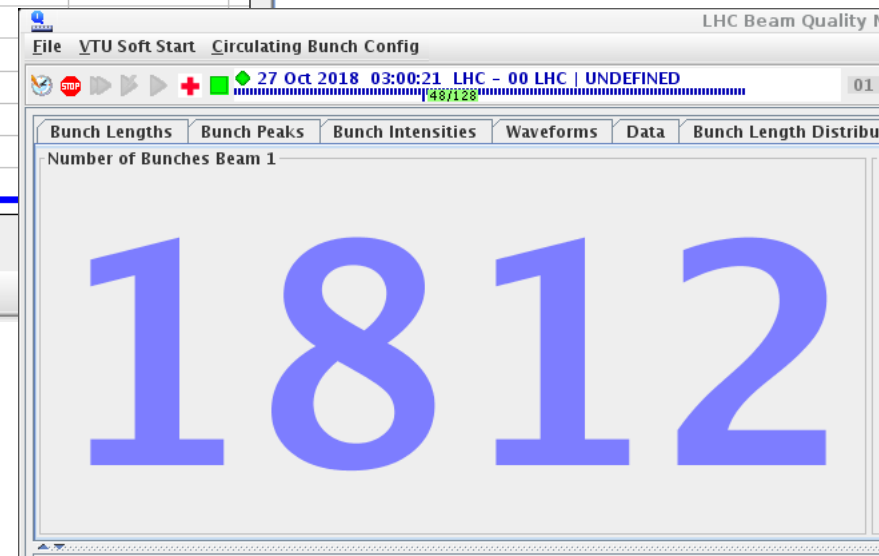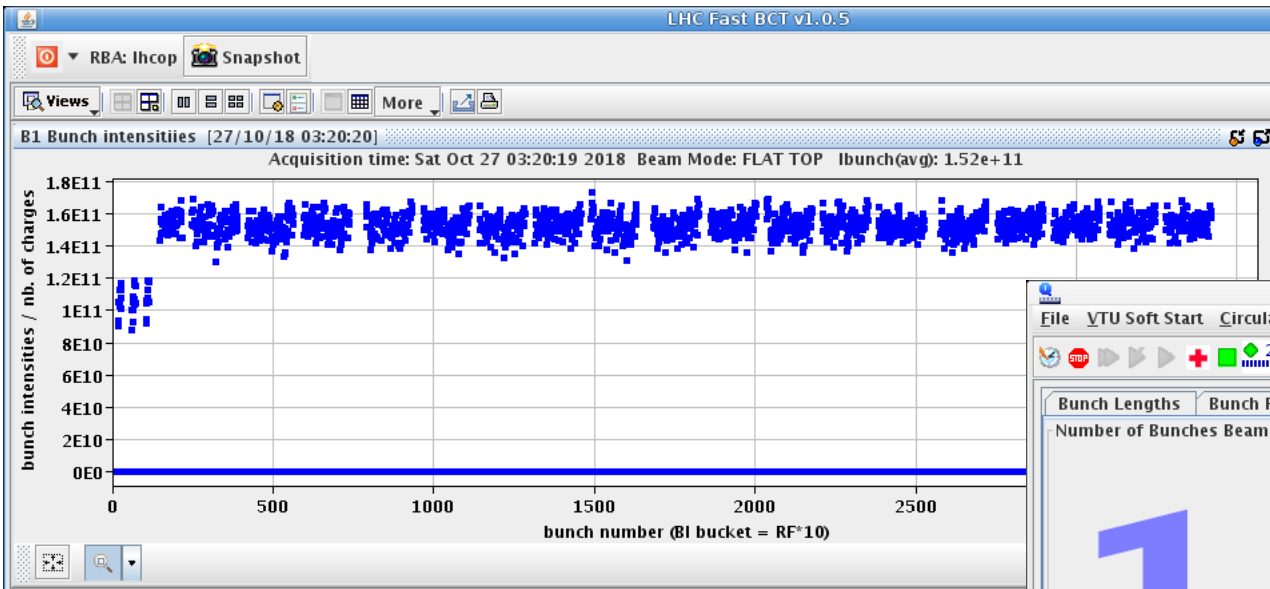b1&2, ver: 9681-12841, 20361-23521, 31041-34201
Total 1152 bunches per beam

In all cases, the goal is ~2 times the emittance (but not more than 4 μm.rad)

Thank you very much in advance!

Mishaps and issues

- 16L2 MD: The machine was filled and ramped (in the middle of the night)

Mishaps and issues

- 16L2 MD: Starting the tests

| 04:49 | BI | starting blow-up for UFO studies with B1H. |

| 04:49 | 1 | Global Post Mortem Event

Event Timestamp: 27/10/18 04:49:10.936
Fill Number: 7366
Accelerator / beam mode: MACHINE DEVELOPMENT / ADJUST
Energy: 6499080 [MeV]
Intensity B1/B2: 26159 / 26872 [e^10 charges]
Event Category / Classification: PROTECTION_DUMP / MULTIPLE_SYSTEM_DUMP
First BIC input Triggered: First USR_PERMIT change: Ch 11-BLM_MSK: B T -> F on CIB.SR7.S7.B2 |

| 04:49 | 1 | Global Post Mortem Event Confirmation

Dump Classification: Beam Loss
Operator / Comment: mschauma / Beam losses in 655ms running sum at TCSG.A4R7.B2 during ADT excitation (B1H) for UFO studies of MD3246 with 1812b. |

| 04:50 | BI | Dumped on first ADT excitation B1H. |

Mishaps and issues

- 16L2 MD: Debrief

- *"We have started the blow-up on all bunches simultaneously, because there was no sufficient time to do it in small pieces (e.g. train-by-train)"*

Mishaps and issues

- 16L2 MD: Epilogue

| FAULTS						
#	Group	Fault	Element	Description	Begin	End	Duration
1	Transverse Damper > Hardware	VOID	ADTExcitation	B1H ADT excitation during MD caused beam loss	2018-10-27 04:49:10	2018-10-27 04:50:29	0:01:19

*&$!)%@#!~@$@#$#**###!!!

Mishaps and issues

- 16L2 MD:

- Preparation took ~1 hour – new excitation window
- No special testing, blow-up is a standard operation used daily…

- During the MD: switch to the "expert" mode and unlock all excitation limits

- Lesson learned: **Machine protection colleagues… Who guards the guardians???**

Commissioning and validation:

- *Validations to be performed after firmware or HW changes*

- **Two stage validation:**
  - The new firmware is always thoroughly tested in the laboratory
  - When deployed in the machine, a full dedicated test with few bunches is always run (check the signals, synchronization, measure transfer functions with beam…)
  - Excitation checked without and with circulating beam, oscilloscope on the deflection plates
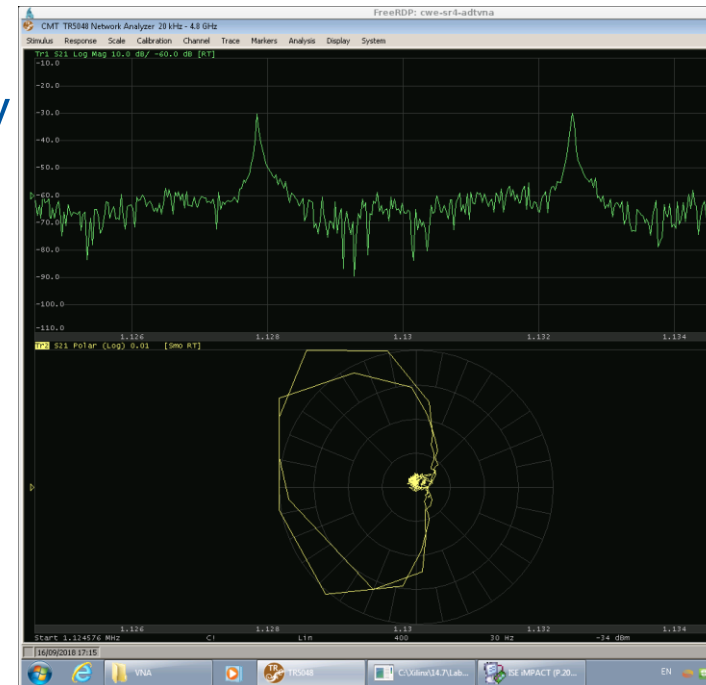
Commissioning and validation:

- *Validations in case of special functionalities for MDs*

- Properly planned MDs: the same validations are done as for firmware changes. Takes a lot of time, therefore no flexibility.

- Ad-hoc MDs: *(Hi! there might be a slot in one hour time, can you come to CCC?)* Equal amount of time is required. So either the MD is not granted because we will not be ready, or there is minimal, if any testing…

Commissioning and validation:

- Required commissioning after LS2

- ADT will be significantly altered during LS2:
  - New beam position modules
  - Re-built firmware
  - Cleaned-up FESA and software
  - Changes at high level control (LSA, sequences)

- ADT will need to be re-commissioned "as new" after LS2

Improved abort gap cleaning possible?

- What needs to be improved?

Impact of operation at 7 TeV

- There is not much difference between the operation at 6.5 and 7 TeV

Thank you for your attention