Feedback on 2017 running conditions

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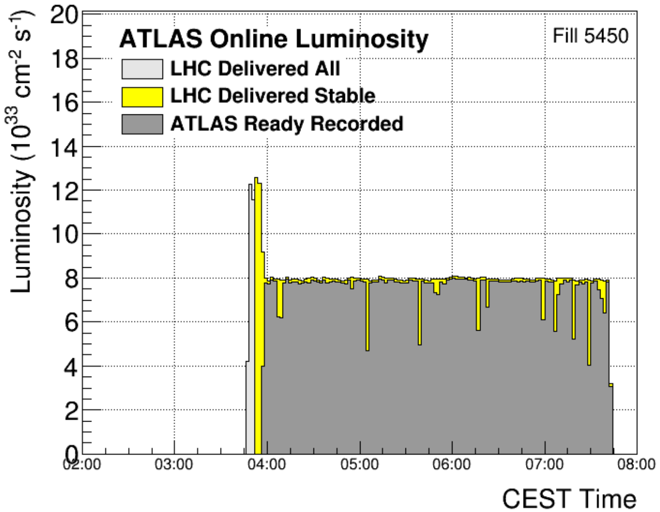
Introduction

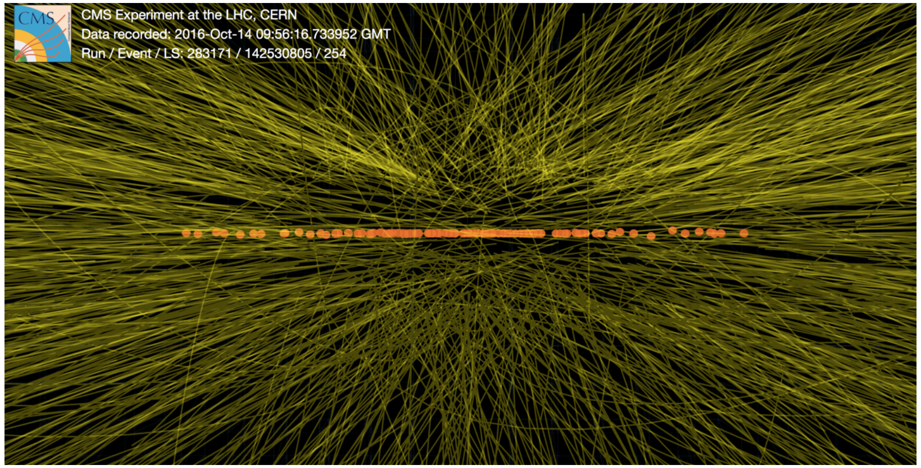
- After a very successful pp run in 2016 we need to start planning the machine configuration for 2017 running
- In 2016 we achieved:
  - a peak luminosity of ~1.4e34 (40% higher than design)
  - ~2200 bunches colliding in IP1/5 (20% less than design)
  - leading to a maximum pileup at the start of fills of ~45 (nearly 2x the design)
- When deciding on the running conditions for 2017 it is important to understand
  - What are the luminosity and pileup limits for ATLAS/CMS in 2017
  - What is the strategy if these limits are exceeded (luminosity levelling)
  - Should we push to increase the number of bunches in the machine at the cost of integrated luminosity
    - BCMS beam with improved emittance limits to 2400b (144b/injection*) compared to nominal injection which has ~2750b (288b/injection)
- ATLAS/CMS both have taskforce/study-group looking into these questions, work in progress final conclusions not available yet
  - Asked for status report at the last LPC meeting which we will report the conclusions on here
  - Will also comment on input from other experiments

* - note this requires the SPS beam dump is replaced in the EYETS which is the plan, but not completely guaranteed

2016 test fills

- In 2016 carried out 2 fills testing luminosity levelling by separation in ATLAS/CMS simultaneously – worked well
  - Considered operational for 2017
  - To work well need well calibrated real-time luminosity from each experiment
- In order to help the experiments assess their performance and limitations at high pileup we carried out a test fill with
  - 3 isolated bunches with pileup of ~100
  - 2x48bunch trains (25ns spacing) with pileup ~50





based on slide from Mike Lamont 17/10 LPC

Possible 2017 parameters

	Nominal 25 ns	BCMS 25 ns
Beta* (1/2/5/8)	0.4/10/0.4/3	0.4/10/0.4/3
Half crossing angle	-185/200/185/-250	-155/200/155/-250
Nb	2748	2460
Nc	2736	2448
Proton per bunch	1.25 e11	1.25 e11
Emittance into SB	3.2	2.3
Bunch length	1.05	1.05
Peak luminosity	~1.41e34	~1.79e34 *
Peak pile-up	~37	~51
Luminosity lifetime	~21	~15
150 days	38 fb^{-1}	40+ fb^{-1}

For β of 33cm* (under consideration by machine experts):

Peak luminosity	~1.52e34	~1.91e34 *
Peak pile-up	~40	~56

* = Triplet cooling limit originally thought to be ~1.7e34, but now thought to be significantly higher

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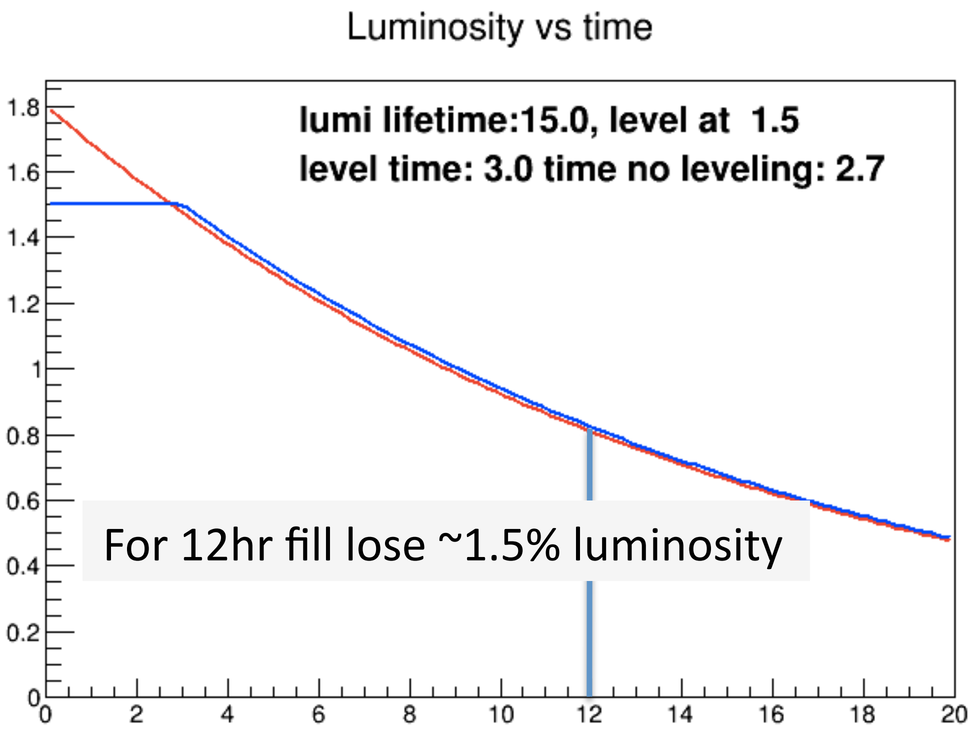
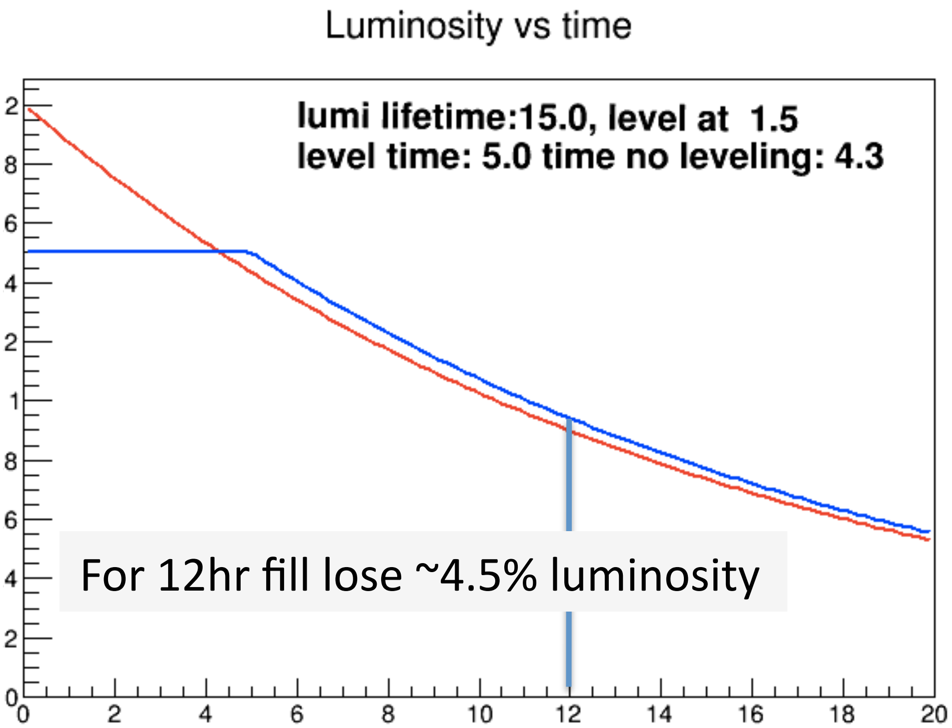
Luminosity levelling

Simple toy levelling model (luminosity evolution described by simple exponential)





Loss of luminosity is significantly larger if fill lost early

To use levelling in operation requires reliable and accurate real-time luminosity values from the experiments

ATLAS feedback

Update from Levelling task-force

- From detector, DAQ and HLT considerations we are confident that ATLAS can handle data with a pile-up of up to 60 in 2017. Above 60, problems may start to occur although no concrete sources are identified as of today.
- Increased pile-up puts a strain on offline resources, and very high instantaneous luminosities necessitates increases in the trigger thresholds which in turn affect the physics program of ATLAS.
- We have a credible model for estimating the impact of levelling on the integrated luminosity, and are using this to study the optimal running conditions for ATLAS in 2017.
- If LHC delivers instantaneous luminosities above 2×10^{34} Hz/cm^2, ATLAS has compelling reasons to level at a luminosity of 2×10^{34} Hz/cm^2 from trigger rate considerations at L1. Above 2×10^{34} Hz/cm^2, we would need to change the strategy and not rely on single-lepton triggers anymore as the thresholds would be too high.
- We have not ruled out that levelling slightly below 2×10^{34} Hz/cm^2 could be beneficial to the physics program, in case the gains in trigger threshold settings and efficiencies would significantly outweigh the loss of integrated luminosity. This needs further studies however and there are no conclusions to date.

ATLAS feedback

Update from Levelling task-force

ATLAS considers that there should be equal expected luminosities for the two GPDs.

We ask that known effects leading to differences are compensated for

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Monday, November 21, 2016 ATLAS REPORT AT LPC MEETING - AC, AO 4

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CMS feedback

- Recall: CMS phase-1 upgrade baseline → average <pileup> = 50
  - … with the possibility that it may be higher at beginning of LHC fills
  - See, for example, https://cds.cern.ch/record/1481838?ln=en

- With the planned EYETS activities, all CMS detector systems expect to operate robustly in higher pileup conditions up to at least L=2e34
  - Some adjustments are necessary as luminosities increase to keep data volumes within limits
  - See backup slide for details

- Impact of luminosity increases on L1 trigger thresholds has been evaluated with 2016 configuration
  - Studies of how this affects the CMS physics program are on-going using both simulations and high-pileup fill data
  - A program of optimisation and more sophisticated trigger logic schemes (enabled by recent L1 upgrades) is underway

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CMS feedback

- Impact of high pileup (> 50) on data quality and quality of reconstructed physics objects is not yet complete
  - Expect to have initial conclusions soon
- Consensus principal: lower average pileup conditions, for a given integrated luminosity through LS2 (or LS3), will result in higher quality physics results for CMS

ALICE/LHCb feedback

ALICE and LHCb will run with a very similar setup to 2016.
LHCb are neutral about running with BCMS or nominal injection:

- Filling scheme - neutral regarding (non-)BCMS - pro's and con's:
  - Non-BCMS beams
    - ✓ would allow for 288b/train, so more bunches
    - ✓ would result in increased lifetime, so larger beam/interfill duration ratio
    - ❖ would require longer commissioning time
  - BCMS beam
    - o Hope for 144b/train + fill-up abort gap, to allow +20% colliding bunches in LHCb

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Summary

- ATLAS & CMS have similar requests for running conditions in 2017
- Both want to maximize the integrated luminosity, and therefore would like BCMS injection even with the increased pileup
- Current studies suggest both can handle luminosities up to at least 2e34 and pileup above 50
  - At the moment LHC do not expect to exceed these values
  - If LHC does exceed these it should be possible to level the luminosity with separation in IP1,5 or both
  - Both experiments are studying to see if levelling at lower luminosities could be beneficial for the physics output of the experiment

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Backup

CERN

Assessment from each CMS detector group is positive for 2e34 running

Detector	1.8e34	2.0e34
SiPixel	OK (upgraded during EYETS)	OK (upgraded during EYETS)
SiStrip	OK	OK
ECAL	Changes needed, solutions exist (retune ZS threshold, spike killer, etc.).	Changes needed, solutions exist (retune ZS threshold, spike killer, etc).
HCAL	Payload is OK for HB/HF/HO. ZS threshold needs to be tuned for upgraded HE.	Payload is OK for HB/HF/HO. ZS threshold needs to be tuned for upgraded HE.
DT	OK (payload within limitation w/ reduced TDC window)	OK (payload within limitation w/ reduced TDC window)
RPC	OK (Readout chain transmission to data concentrator is bottleneck at some point L>2e34)	OK (Readout chain transmission to data concentrator is bottleneck at some point L>2e34)
CSC	OK (payload within limitation)	OK (payload within limitation)

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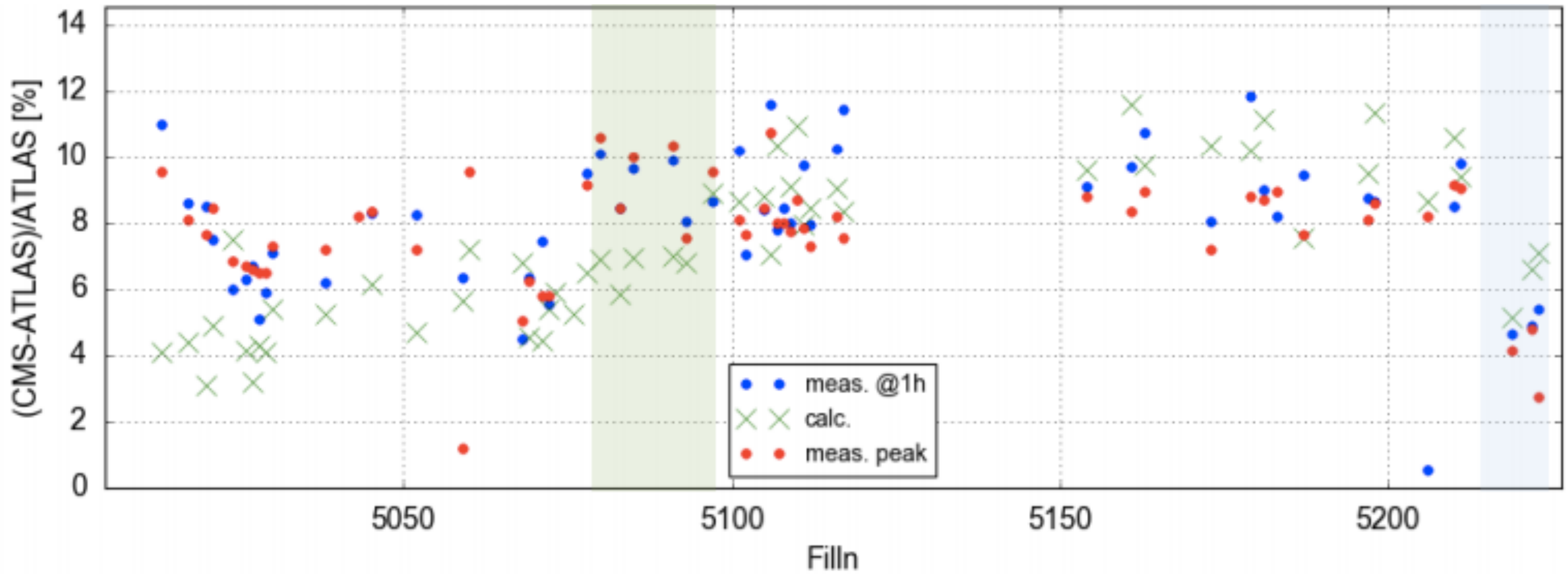
ATLAS/CMS lumi difference

Observed ~7% difference in the luminosity measured in ATLAS and CMS.
Machine studies suggest this could be (partially?) due to the fact that the horizontal emittance is generally larger than the vertical emittance, coupled with the fact the crossing angle is in different planes in IP1/5. Do not have reliable measurements of the emittances for the whole dataset, but in one period calculation from this effect, shows fair agreement with the measured discrepancy.



Can be corrected for by normalising crossing angle by emittance in the same plane.
Preferred by machine as gives better cancelation of beam-beam effects between the two IPs

"Typical" emittances before TS2 (for beam 1 and beam 2)

	Injection	Collision
Horizontal	1.7 um 1.7 um	2.5 um 2.4 um
Vertical	1.5 um 1.4 um	2.0 um 1.7um

ATLAS/CMS lumi difference