Feedback from the experiments

-

Cham'11

- First feedback on some observations that were made end of this year will be given, e.g. on beam-gas background, satellite bunches, BCM thresholds. A critical review of 2010 operation will be made (handshake, use of beam modes, operational procedures, etc.), with emphasis on issues and proposals for improvements for 2011 (and further).

Lessons from 2010

- 2010 operation
- Beam diagnostics
- Handshake and data exchange
- Background
- Prospects 2011

ACKNOWLEDGEMENTS

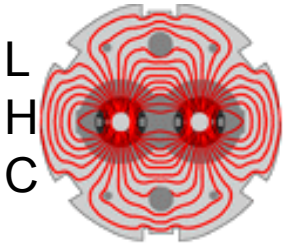
Many thanks all the people who gave me material for this presentation,

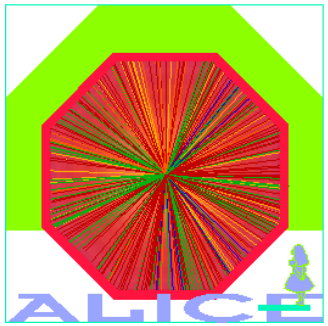
in particular:

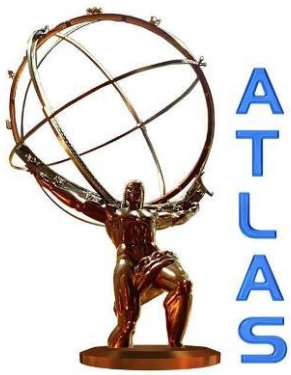
Martin Aleksa, Nicola Bacchetta, Tiziano Camporesi, Mario Deile, Chilo Garabatos, Benedetto Gorini, Richard Jacobsson, Andreas Schopper, and many more.

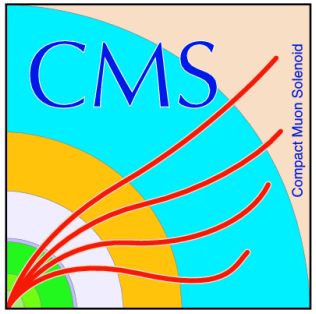
See also

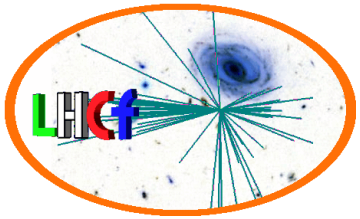
http://indico.cern.ch/conferenceDisplay.py?confId=111076









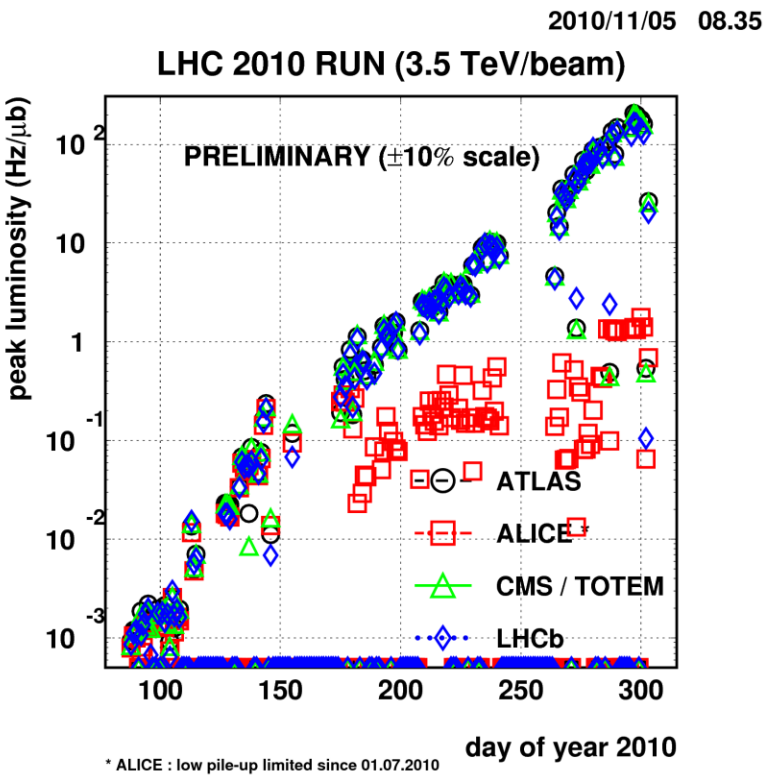


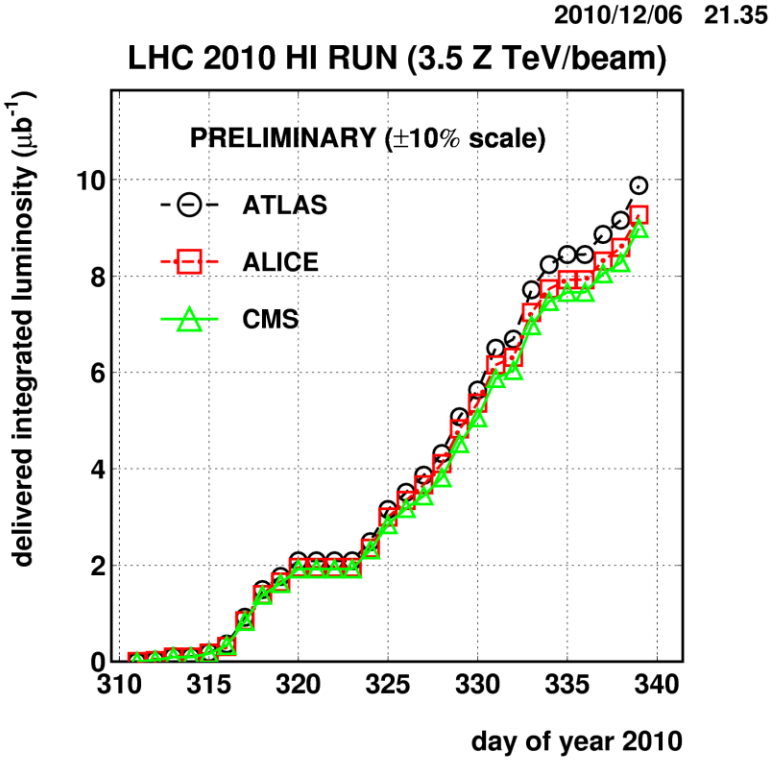
2010 operation

This one is for our friends the HI physicists

Hours spent in stable beams in 2010:

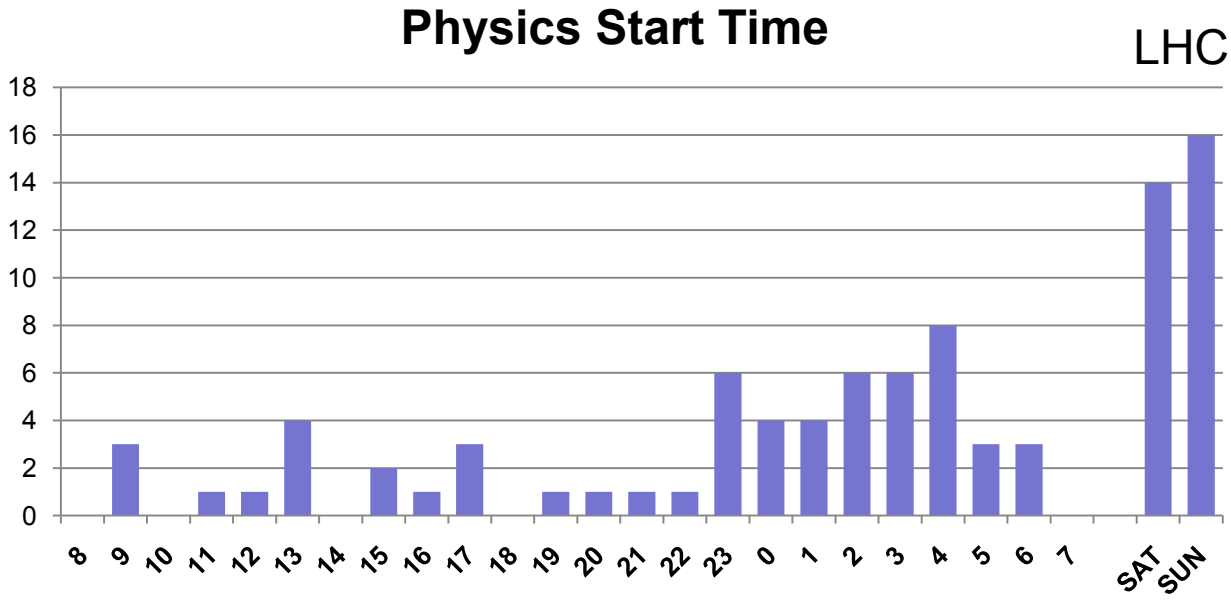
- 851 hours of protons — out of 7 months, 1 apr - 31 oct
- 223 hours of ions — out of 1 month , 8 nov - 6 dec

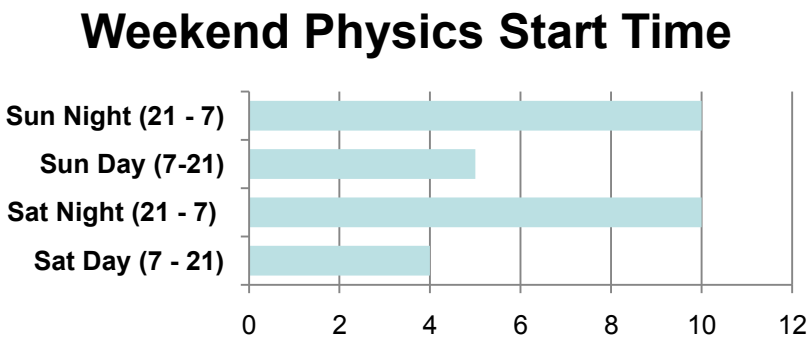




Tough times for the experiments as well

89 (out of 110) proton physics fills





with wildly and rapidly changing conditions (pile-up and lumi)

No problem: 2011 will be different from 2010

Filling the LHC

- **Need very much *much* flexibility!!**
  - LHC is not LEP.
  - LHC = six experiments with widely different scopes!
- Limitations encountered in 2010:
  - (a) Could not switch dynamically nr of booster bunches during LHC filling.
    - Forced to start with <10 bunches. Limited us to 8b trains (no 12b) => loss of collisions, e.g. in 150ns: 3x8b instead of 2x12b
  - (b) Imposing intermediate intensity batch (< ~1e12p) after the probe bunch complicated the construction of physics filling schemes. Sometimes up to 19 injections!
    - In part connected with point (a) above. 8b to start with, hence 8b all the way => no 12b, less collisions.
    - But the intermediate batch also “consumes” one injection, i.e. comes along with a 950ns gap.
  - (c) AGK window: limitation when almost full machine (>300b at 150ns).
    - AGK window length (8us) not matching maximum train length used (~5us with p and ~3.5us with Pb).
  - (d) No low intensity bunches next to the nominal bunches
    - Not really a limitation for ALICE, as the separation leveling worked nicely,
    - But would have been useful for TOTEM

LHC filling: suggested improvements

- Alllow switching dynamically the number of booster bunches during LHC filling.
  - not only after the first SPS batch! Anytime during the filling, such as to match the first one and maintain the 4-fold symmetry in LHC.
- Intermediate batch: is ~1e12 the only solution ?
  - consider 1 “overinjectable” nominal bunch ?
    - no “loss” of 950ns
  - In any case, devise a scheme that works for all filling patterns (75, 50, 25ns…)
- AGK window length matched to the maximum train length that will be used (over a reasonably long period)
  - could be 8us, but could be less
    - 75 ns: 3x24b or 4x24b ?
- Allow keeping probe bunch in, if requested, next to the nominal bunches
  - was already in 2010 done in one special TOTEM fill and in the 50ns fill
    - could one even conceive a train of a few probe bunches ?
  - will allow TOTEM to collect low-pile-up data “parasitically” (still have to commission T1)
    - only as long as there is enough space in the machine (no lumi cost for other expts)

Spectrometer magnets

- **Polarity reversal: important for reducing systematics**
- ALICE/LHCb wish to equalize data in each polarity at every “new set of beam conditions”
  - Typically, one reversal per month. (to be matched with evolving circumstances)
- Can the transparency of reversal be improved ?
  - decouple completely bump closure (compensators) from orbit correctors / crossing scheme
    - ideal goal: make it routine… “flip and go” (no test ramp, etc.)
    - ok for IR8, but problem in IR2 ? (compensation scheme only in one plane… cannot give full closure due to solenoid coupling)
- Define, validate and save two settings of TCTs for IR2
  - not needed for IR8 (?) fixed external angle
- Expts might request some “fields-off” data. How to insert this with minimum impact ?
- NB: in 2011 => ramp LHCb dipole (at least partly) for “bad” polarity
  - note: ramping causes “fatigue” on magnet

Van der Meer scans

- 2010 experience*: Top!
  - very nice collaboration, excellent support
    - ABP, OP, BI, etc.
  - impressive results for first attempts
  - BCTs came under the spotlights!
    - very positive reaction from BI experts

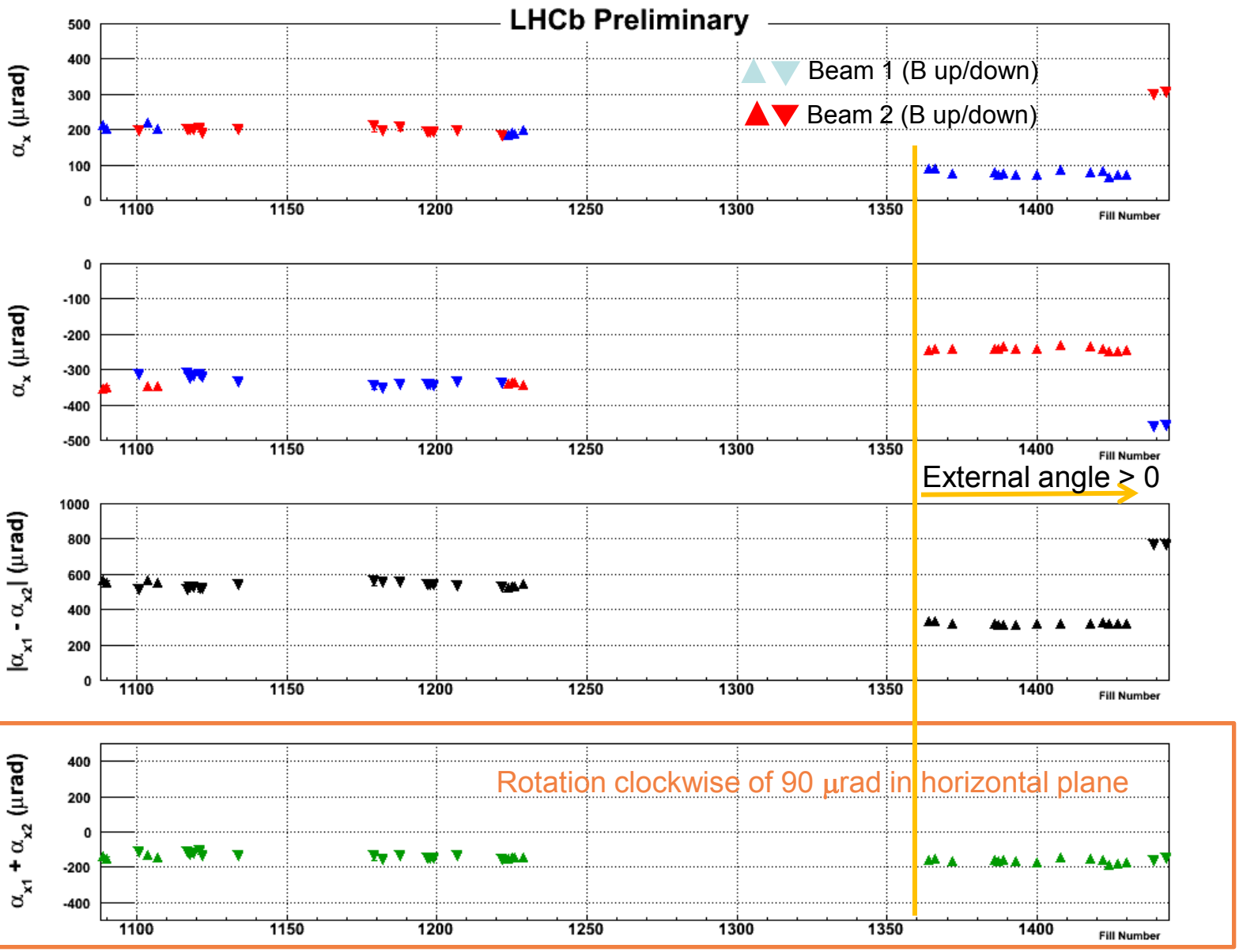
Please, come all to the 13-14 January workshop "LHC lumi days"

- We support the proposal* to have repeated (and rapid) vdm scans at EOF (but only if in stable beams!)
  - to be agreed upon (between machine & the targeted experiment)
  - scans more useful if can go to +/- 3 sigma separation (or more)
  - EOF scans: the faster, the better (should not be 1.5 hour, but minutes)
  - adds valuable information to the luminosity calibration: reproducibility!!
  - however, requires BCTs to work in physics conditions (short spacing)
  - exact conditions & procedure to be defined

* see Simon White's talk

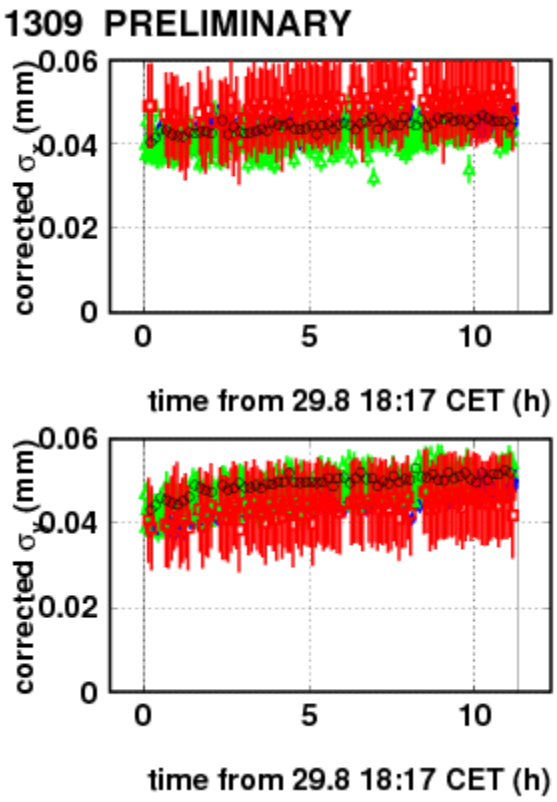
IR crossing angles, a puzzle, not a problem

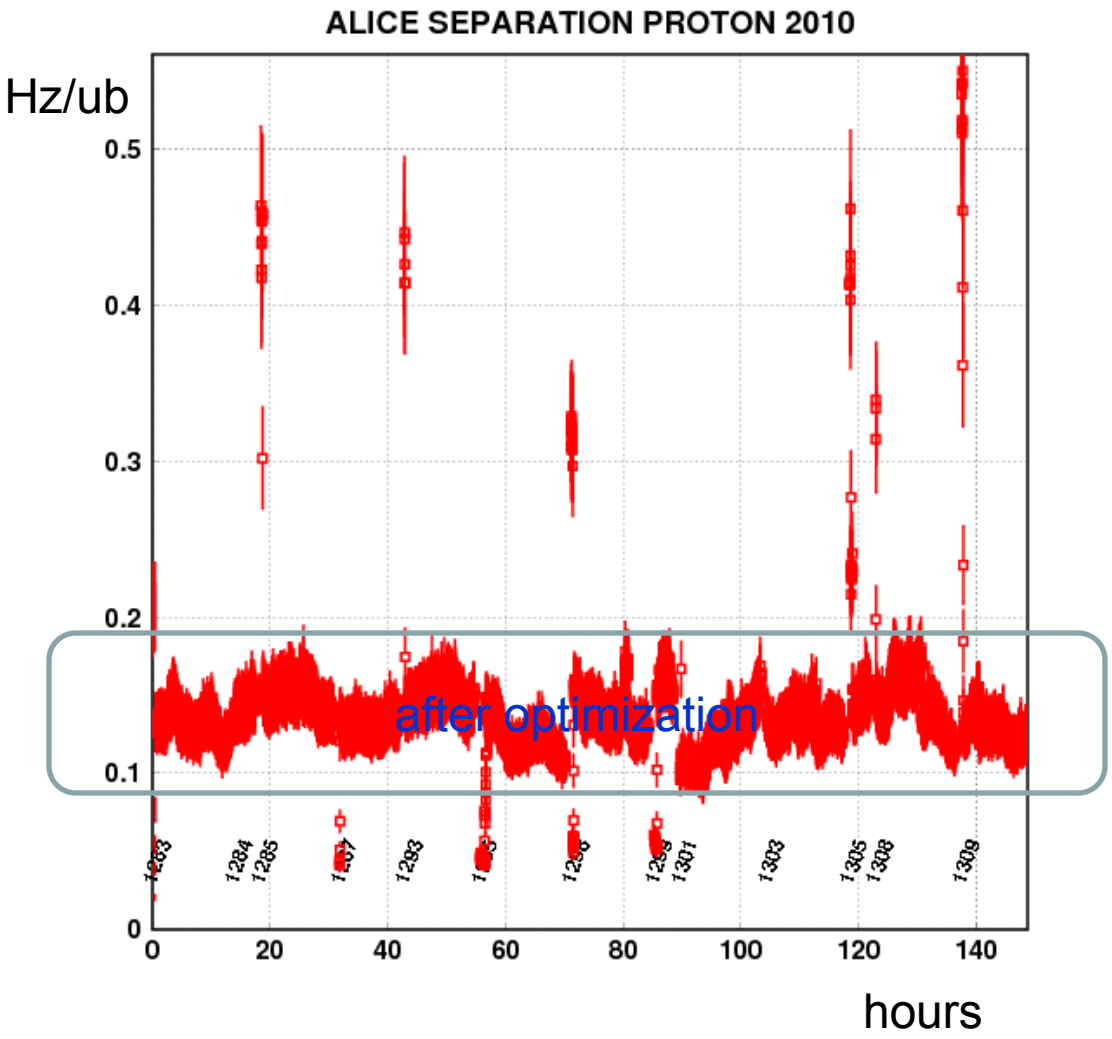
Here LHCb



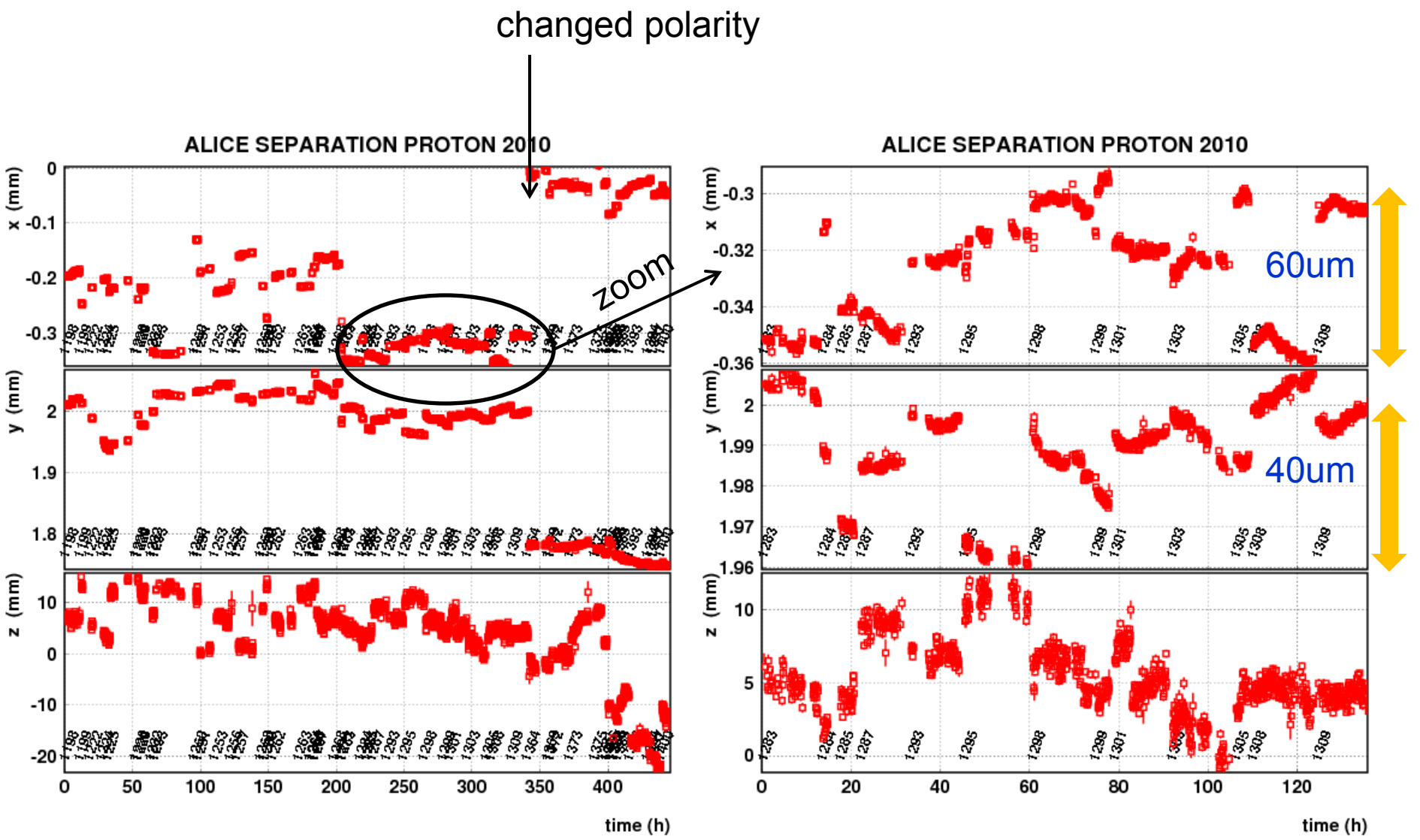
Luminosity leveling by separation

- Used 3 to 3.8 separation in nominal sigma.
- Worked very well
- Nice stable conditions
- Lumi size as in other IPs

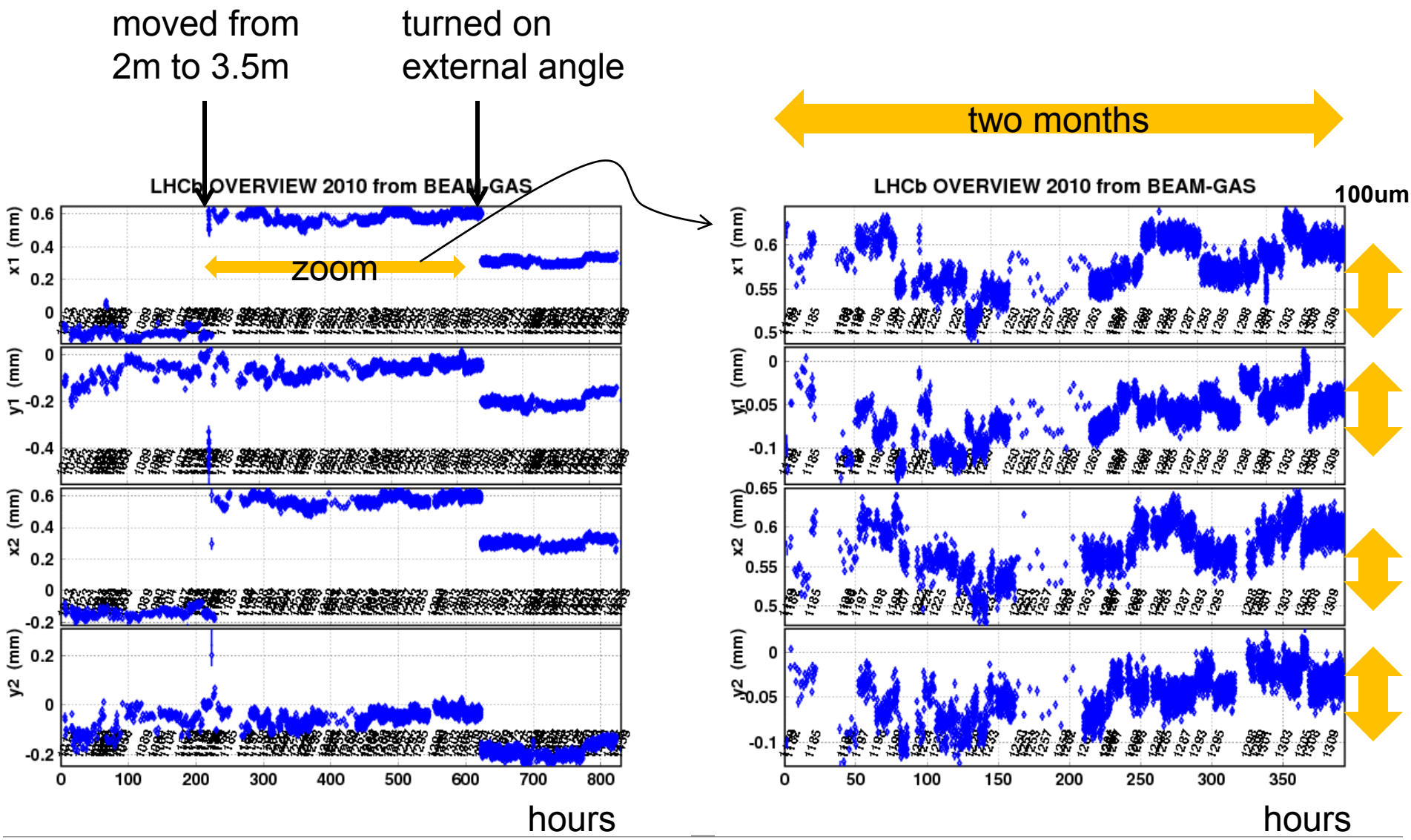




Lumi leveling by separation of beams



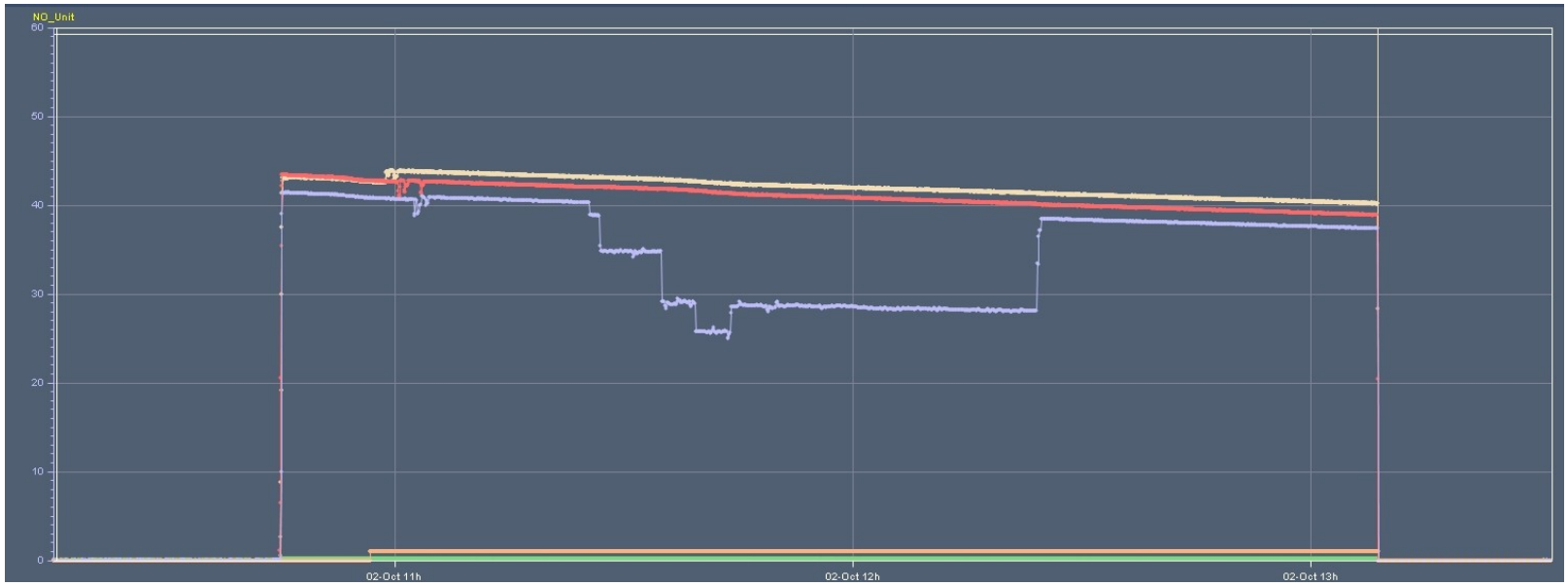
Beams stability at IR from beam-gas imaging (here IR8)



Luminosity leveling by beam separation: test in IP8

- Tested also at IP8 several times during 2010
  - In the steps between trigger configurations
  - Followed bunch behaviour with VELO/BLS and no sign of problems
- Two beam stability tests done
  - 152 bunches x 1E11 @ 150ns up to more than 1 sigma
  - 100 bunches x 0.9E11 @ 50ns up to 6sigma
  - Beam-beam limit yet to be explored…

important for 2011-2012



2011, LHCb case: pictorially

LHCb limited to: (any time during the fill)

1. $L(t) \leq$ 3-5e32 Hz/cm^2 = L_{max}
2. $\mu_{inelas} \leq 2.6$

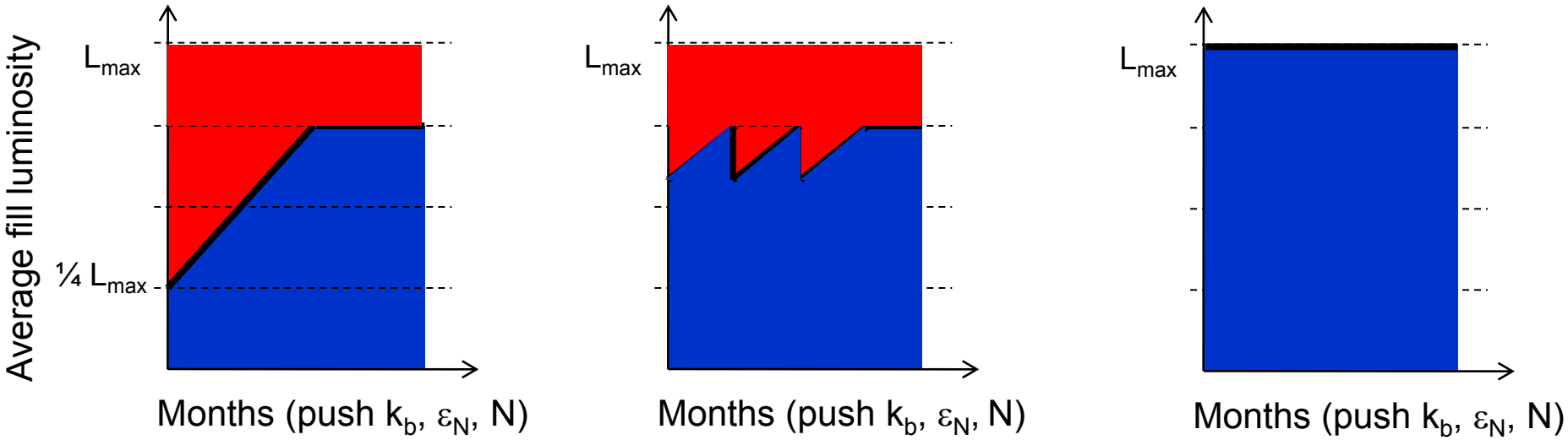
Must be defined for whole of 2011 based on a guess of absolute maximum N^2/ε_N

Three possible scenari:

A) The unacceptable scenario:
- Fixed β^*
- No separation allowed

B) A less bad but not cheap scenario:
- 3 β^* values
- No separation allowed

C) The best scenario:
- Fixed β^*
- With separation leveling



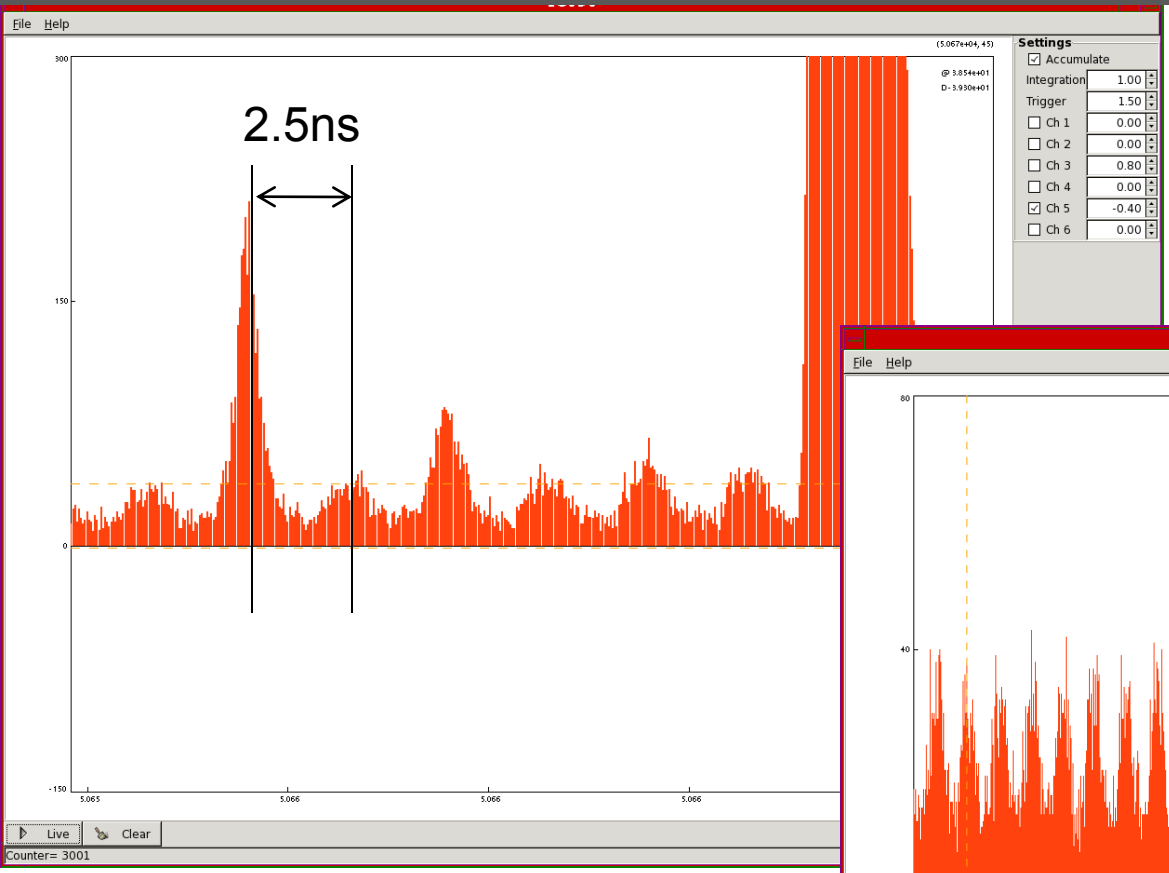
Beam diagnostics

BCTs

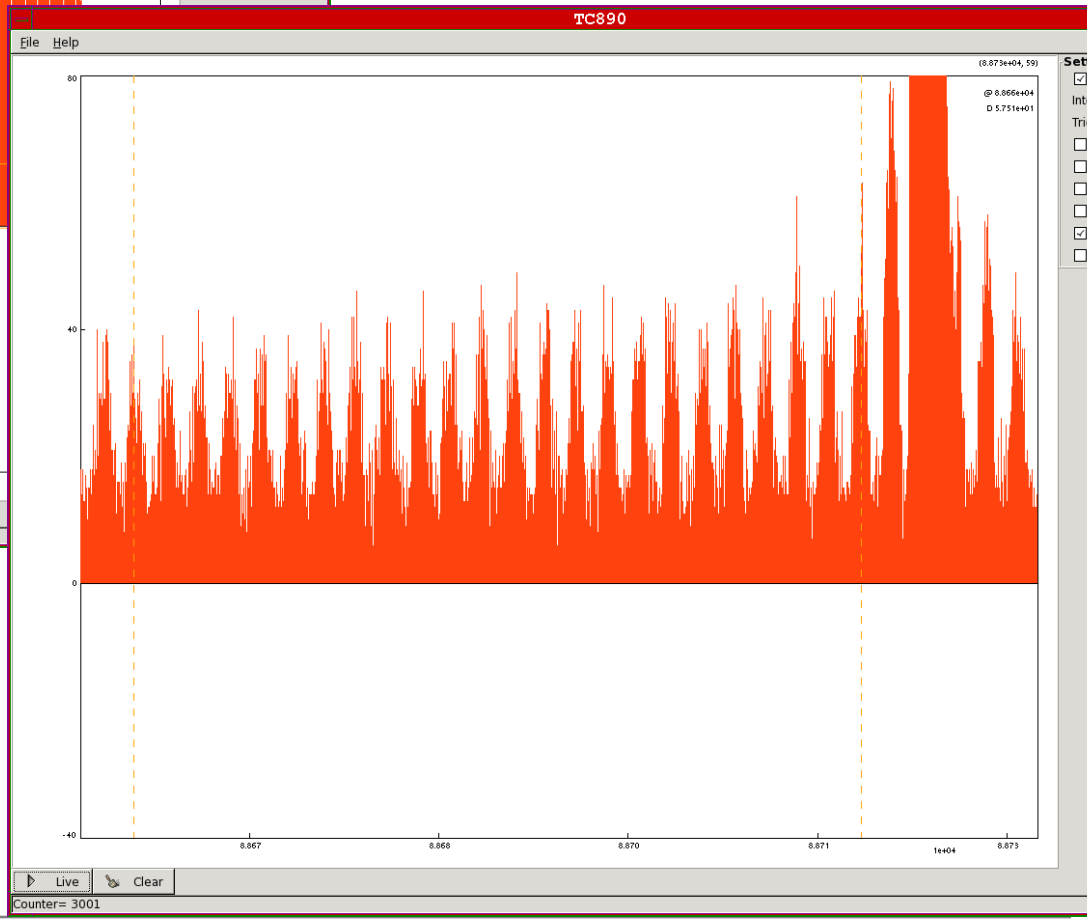
- Vital for precise luminosity calibration

- Issues
  - Bunch length dependence of FBCT
    - systematics on relative bunch populations ?
    - bunch length variations ?
  - LHC pattern dependence of DCCT (150ns)
    - could not make lumi calibration with short spacing !
  - FBCT normalised to DCCT
    - OK , as long as ghost charge under control
    - FBCT linearity is important (if bunch charge spread is important)
  - Ghost charge extracted from expts
    - Longitudinal Density Monitor very welcome!!

Ghost charge by LDM



This is GOLD!

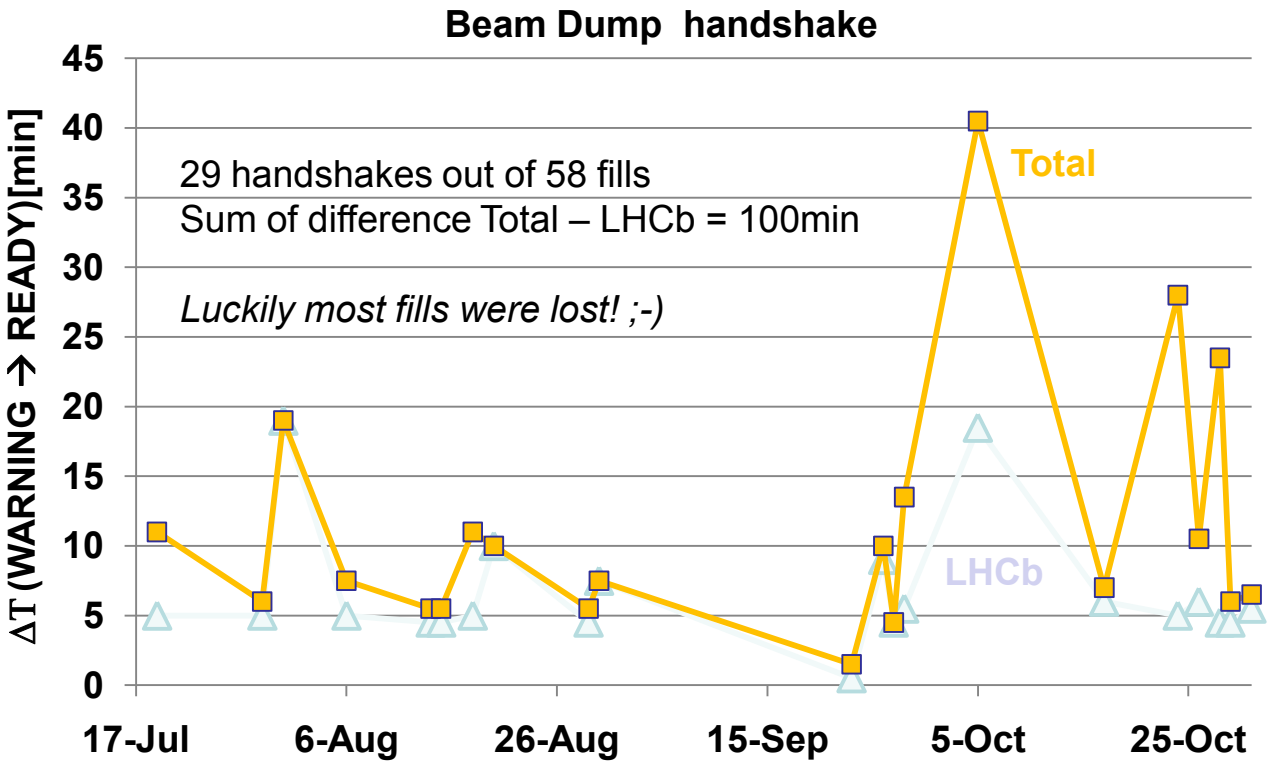


Other important machine measurements

- Transverse emittances
  - Useful for cross check of luminosity and for systematics on precise luminosity calibration
  - Questions
    - Calibration of BSRT ?
      - especially at small emittances
    - WS: up to which intensity can it be used ?
    - BGI calibration (only for ions ? can it be used for protons ?)
- Optics
  - Will be important in 2011 for TOTEM
  - Measurements of beta* and waist position
    - would be nice to have for comparison with lumi calibration
    - not very frequent, … reproducibility, period of validity ?
- But also
  - BLMs near IR, BPMs in the Irs, long emittance, etc.

Handshake and data exchange

End of Fill Procedure



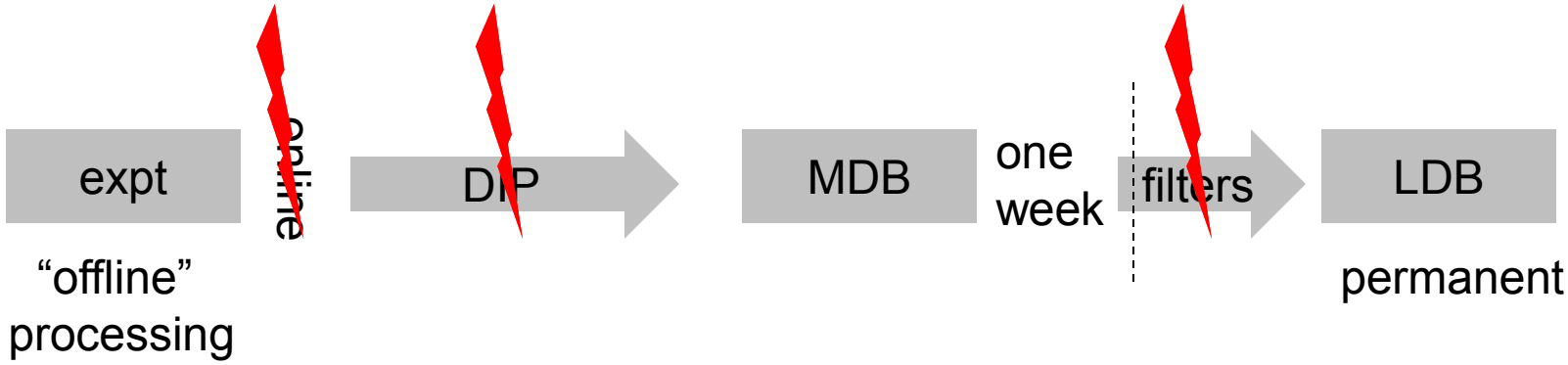
- Modification
  - Movable Device Allowed flag will become “TRUE” also in BEAM DUMP mode
  - Dump handshake remains the same
  - *But we no longer “protect” the VELO by dumping the beam if the VELO is not in garage position when LHC intends to dump the beam….*
  - May still retract VELO but more room for flexibility in software
  - INJECTION and ADJUST logic remains the same obviously

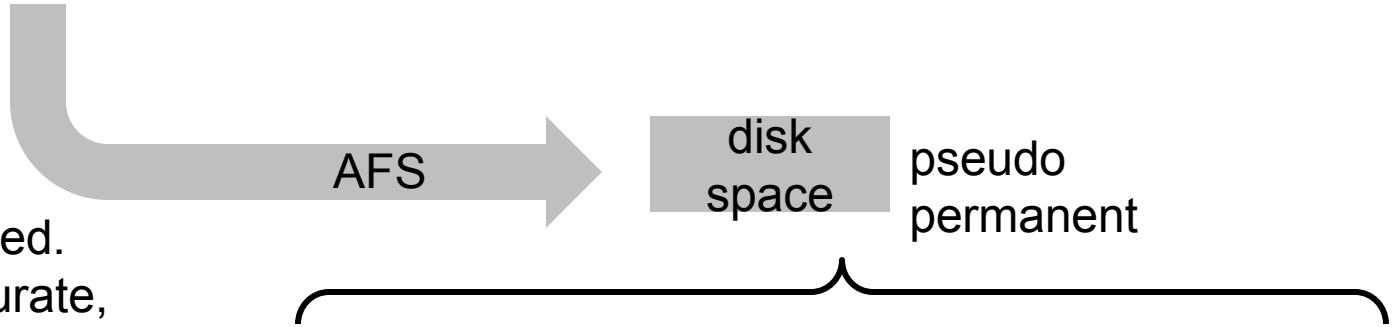
handshake

- documents:
  - **Fixed Display data exchange**
    https://edms.cern.ch/document/1026129/
  - **LHC – EXPERIMENTS HANDSHAKE PROTOCOL OVER DIP**
    https://edms.cern.ch/document/1031913/
  - **POST-MORTEM AND BEAM DUMP DATA ACQUISITION TRIGGERING**
    https://edms.cern.ch/document/886824/
  - **LHC Modes**
    https://edms.cern.ch/document/1070479/

- all up to date ?
- more documents ?

Data from expts to LHC





can be reprocessed. More accurate, more complete, more reliable

The data sets are not complete, but still give a solid basis.
Go either via this link (for a quick graphical view of selected data):
https://lpc-afs.web.cern.ch/lpc-afs/cgi-bin/webpage.sh
Or, for more direct retrieval, via the AFS directory:
/afs/cern.ch/user/l/lpc/w0/2010/measurements/
This file explains what the data are:
/afs/cern.ch/user/l/lpc/w0/2010/measurements/README.filecontents
Will be continued/improved for 2011 (Colin Barschel's assistance)

Questions to you

- Are the expts publishing the promised values over DIP ?
  - reliably ? how accurate data ? coherent among expts ?
- What else would you like to get from the expts ?
- Feedback (criticism and encouragements) is welcome
  - we'll try to do better in 2011

=> LBS WG or in LPC meetings

Machine data to expts

- Important for the experiments:
  - beam/bunch currents, emittances, longitudinal profile, …
  - near IR: losses, optics, beam positions, angles, collim positions, …
- Formal publication of LHC measurement results
  - e.g. beta* values and waist positions (with validity period as appropriate)
- Experiments care about “improvements” of data interpretation from e.g. new calibrations, more understanding, etc.

  => requested “versioning” of data

  => LDB team made available “virtual variables”
  - allow introduce algorithmic correction to stored data via a new (virtual) variable

thanks to R. Billen, C. Roderick and LDB4DA WG members

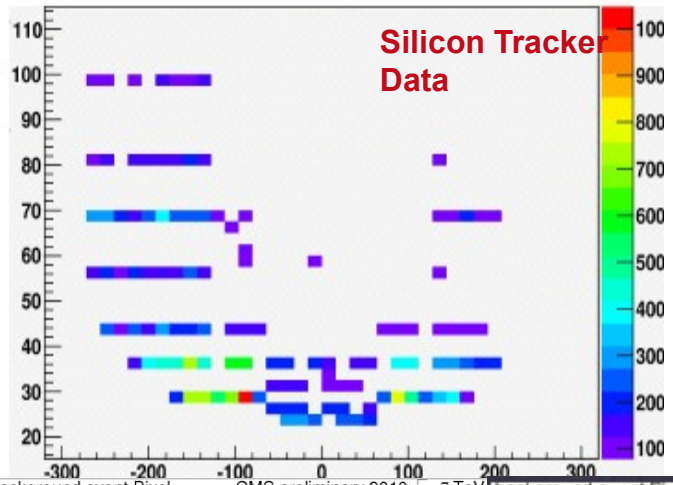
Background

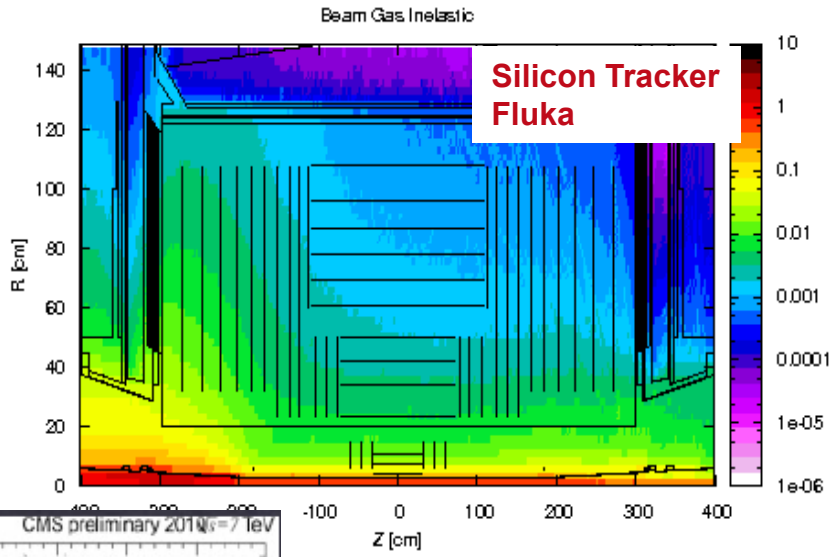
- beam-gas background
- satellite bunches

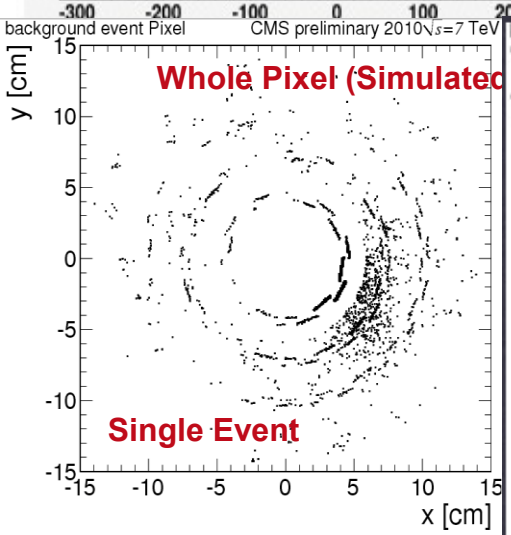
- what levels are acceptable ?

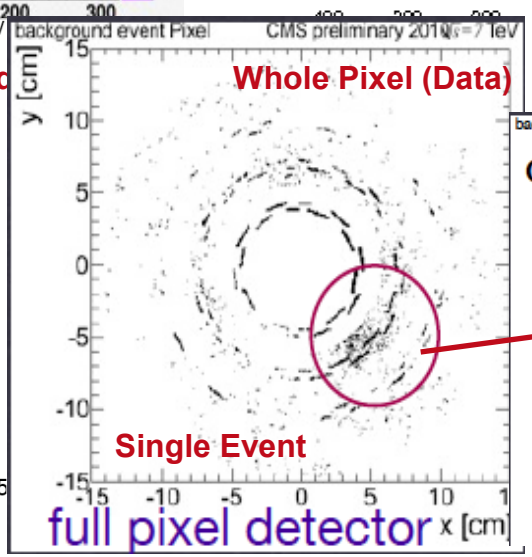
CMS beam-gas bkg

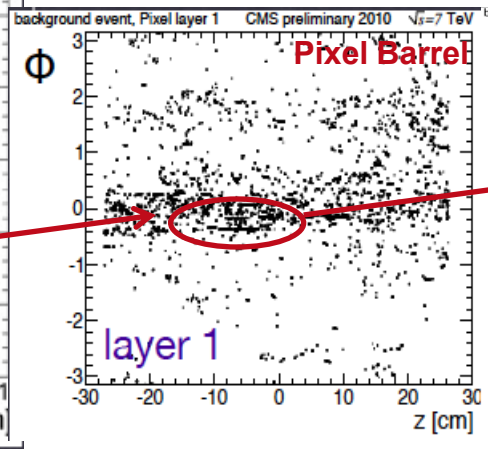
Mostly dominated by beam-gas interactions in the LSS
Well simulated and understood

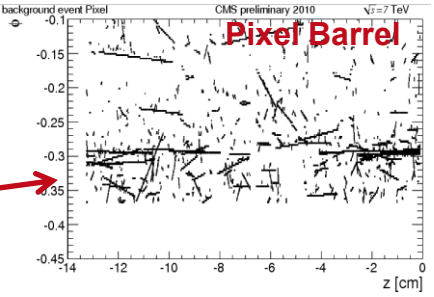






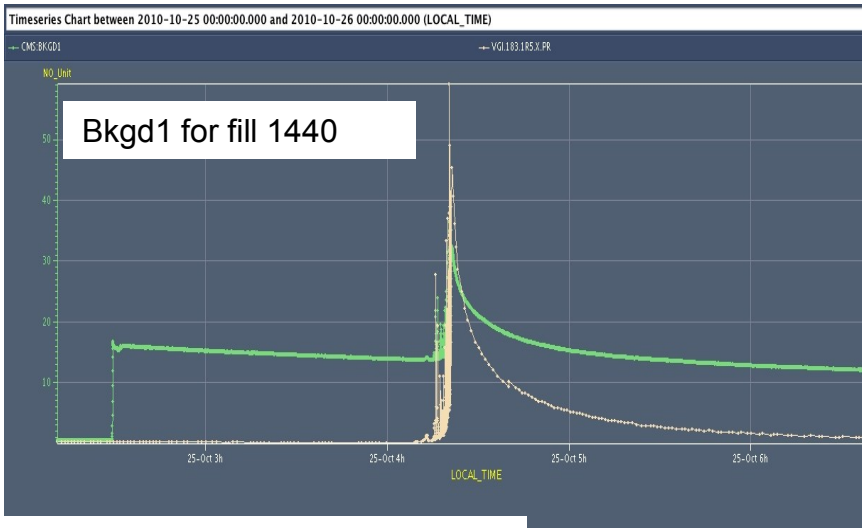


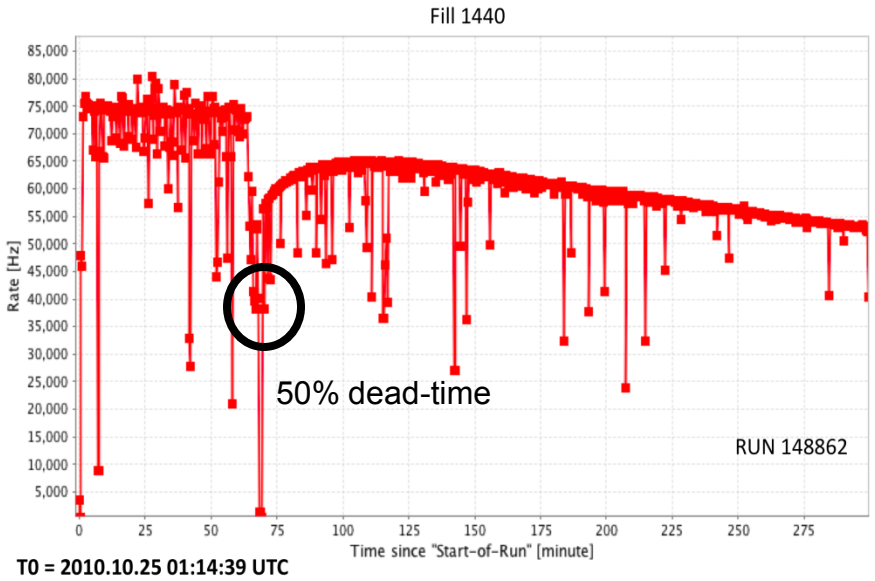


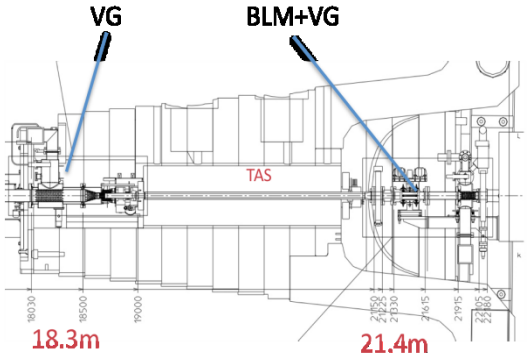


CMS beam-gas bkg

These are large events hitting many pixels along the length of the barrel modules and, if triggered upon, causing the readout to go into a busy state.
We need to keep the dead time below a few percent in order to efficiently take data



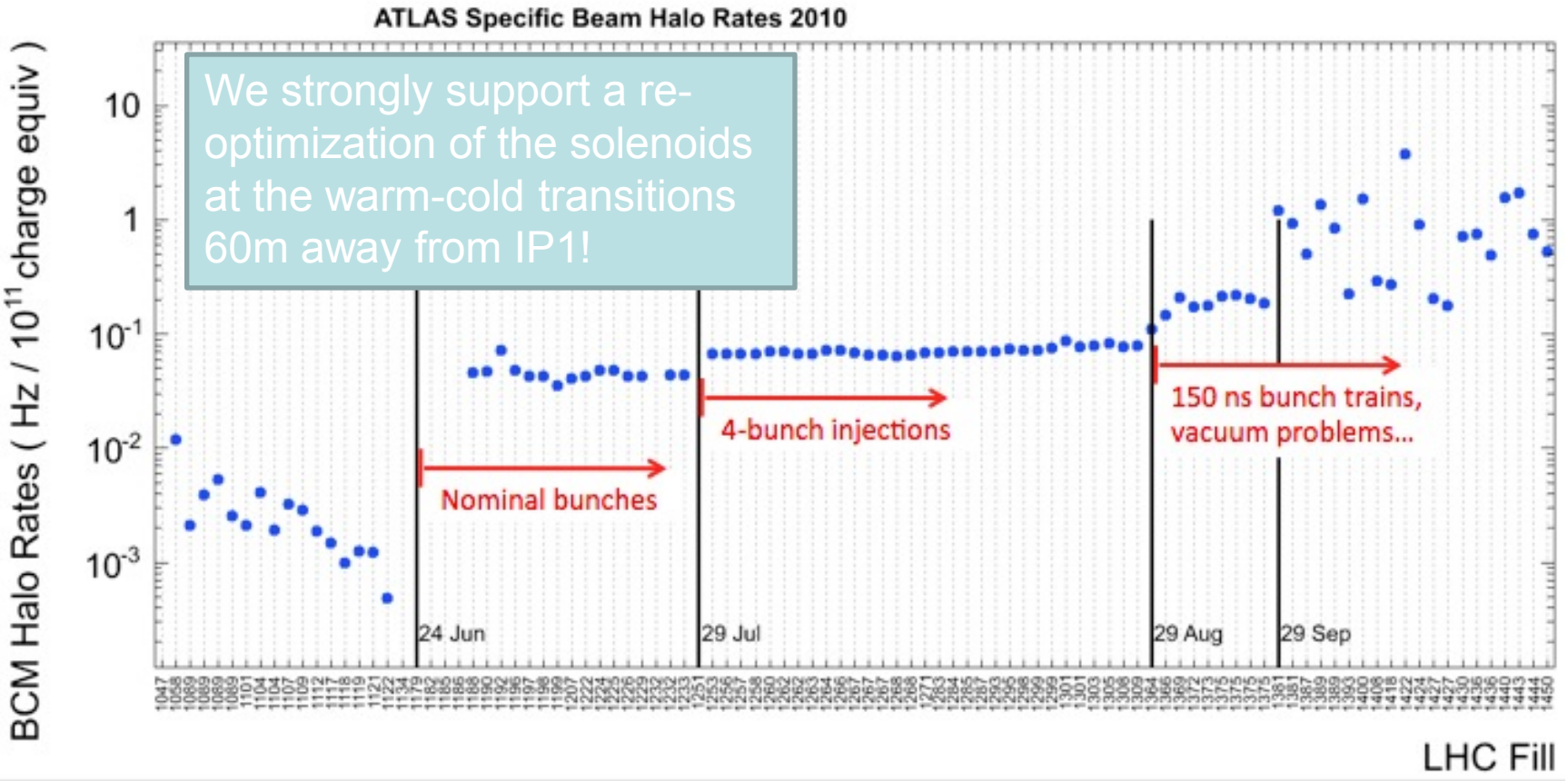




Vacuum spike during fill 1440 at 18.3m on the right of IP5 reached 6E-7 mb causing up to 50% deadtime to data taking

ATLAS: Measured Background Levels

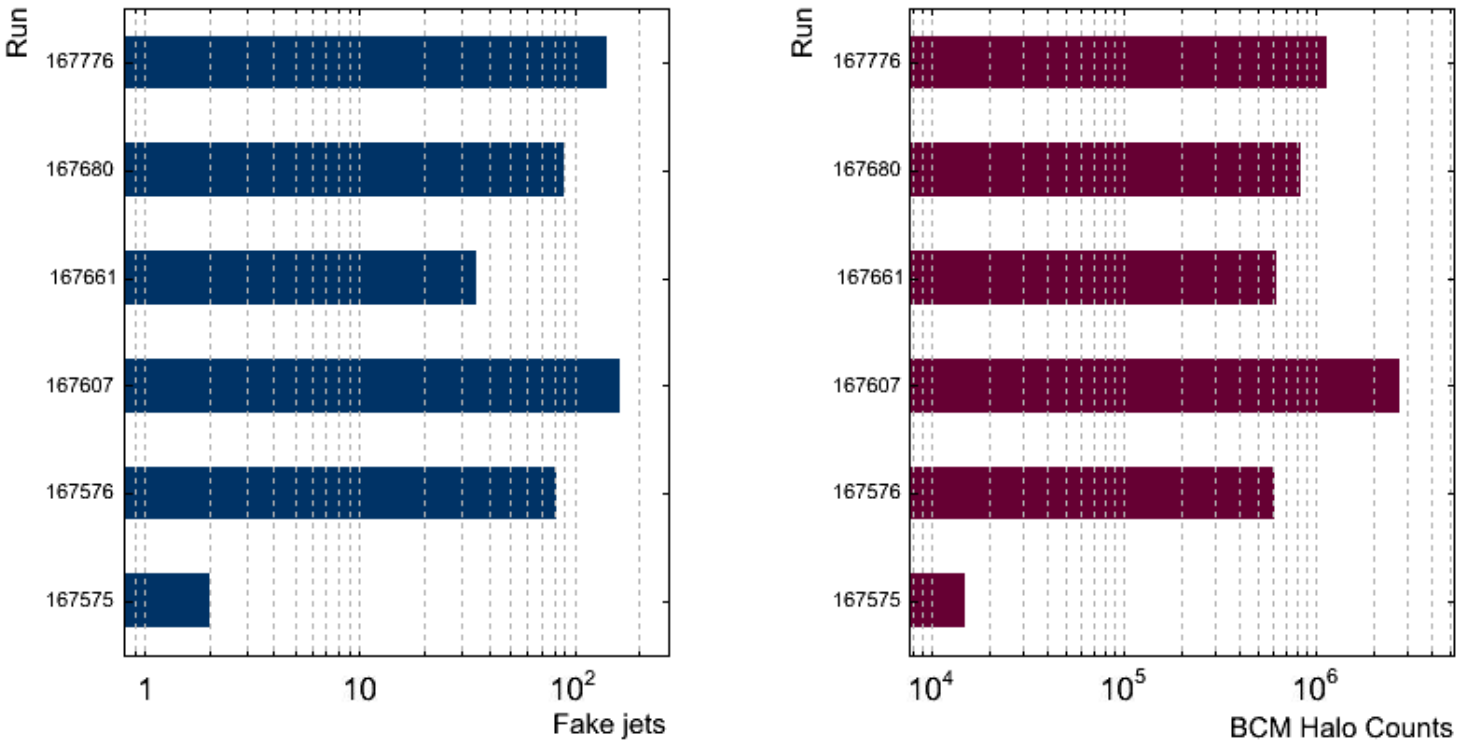
- Use precise timing of Beam Conditions Monitors (BCM) to measure the rate of halo particles crossing horizontally
  - Active area: on each side 4 times 8x8mm^2 inclined by 45 degrees (radius > 55mm, z = ±184cm)
  - Out-of-time coincidences studied (no contribution from collisions)
- Normalize to the total beam current in the machine
- Normalized halo rate increased from O(10-2 Hz) to O(1 Hz) per 10^{11} protons



ATLAS, Correlation: Fake Jets Rate vs Background

- Correlate BCM halo levels to physics analysis background levels
- Choose mono-jet search as an example of a physics analysis sensitive to beam backgrounds
  - Take unpaired bunch data
  - Apply jet cleaning cuts, select on ≥ 1 calorimeter jet > 120 GeV p_T and > 70 GeV of missing E_T
- Compare numbers of fake jets to the numbers of BCM halo counts for the same number of bunches
- Fake jets mostly from beam backgrounds, but some fraction from Cosmics, too
- Good correlation seen, we find that BCM halo rates track the fake jet level well

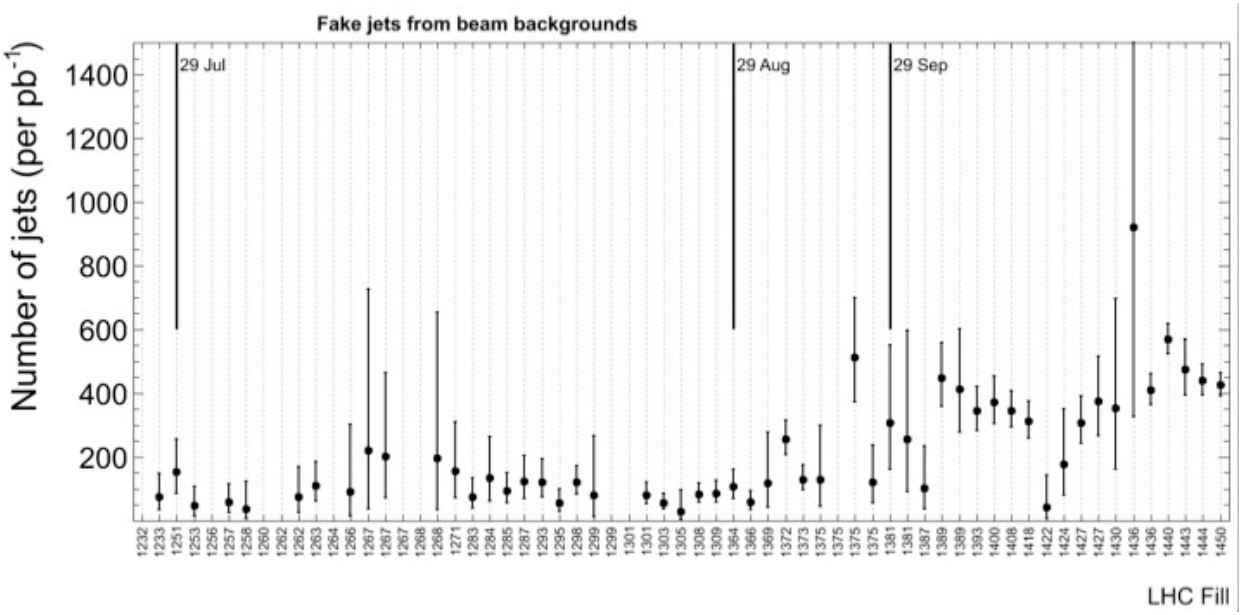
Running period 25 – 29 October 2010



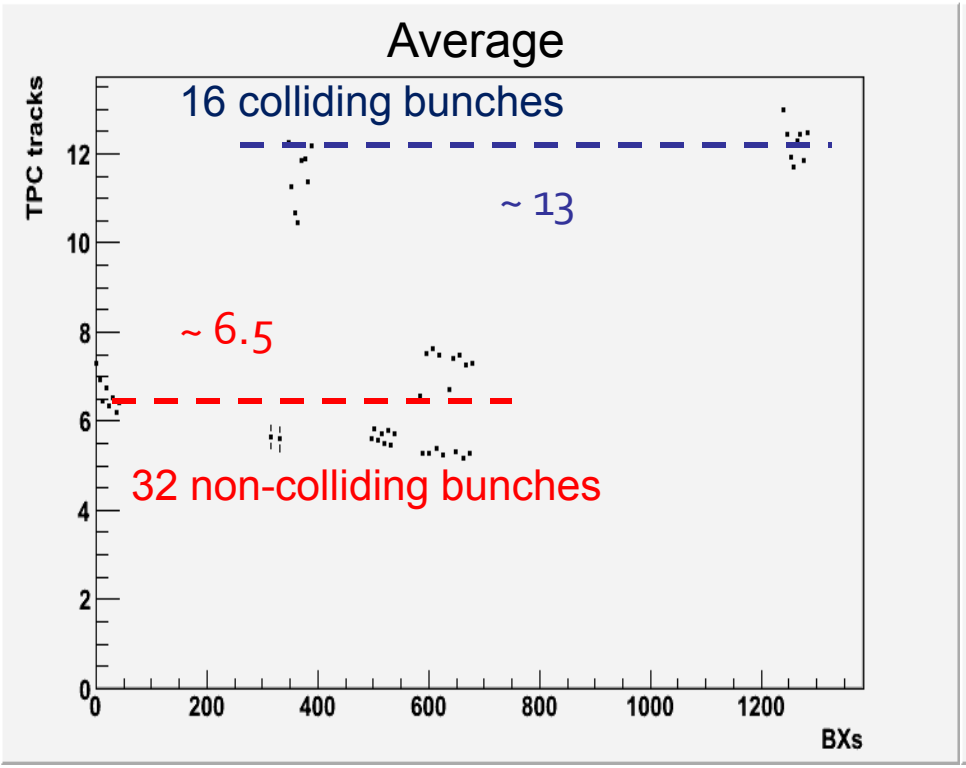
ATLAS Fake Jet Rate

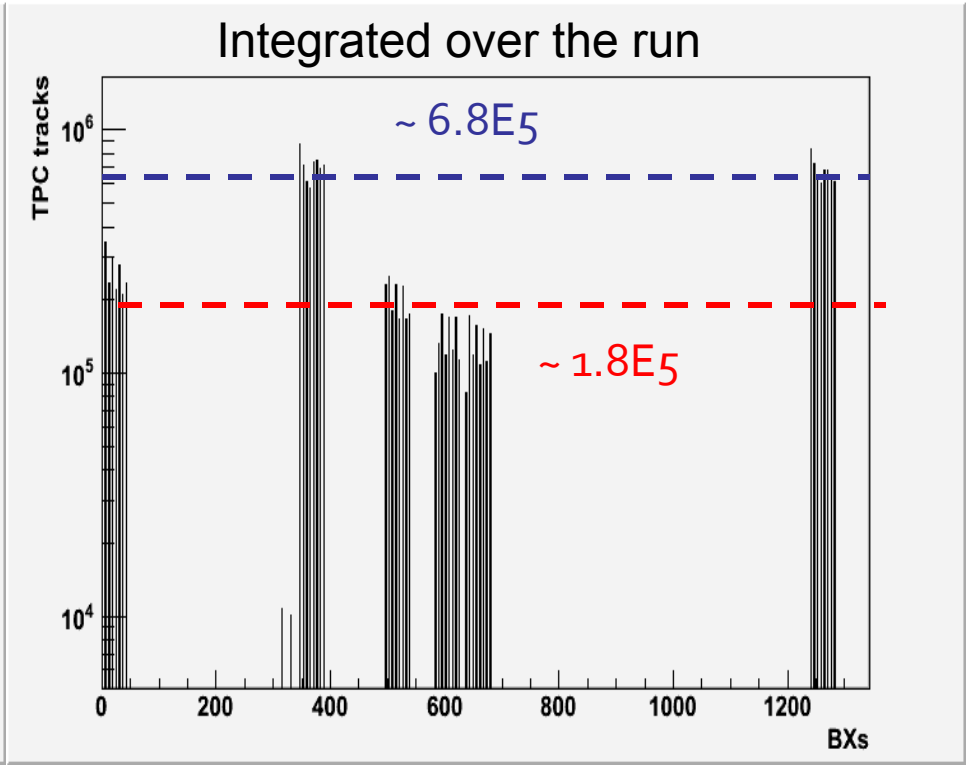
- Convert our estimate for fake jets from unpaired to paired crossings, and divide by the delivered integrated luminosity
  - See hundreds of fake jets from beam backgrounds per pb^{-1}
- Additional analysis cuts achieve typically background rejection factors of 50 – 1000 depending on the analysis. Clearly, analyses can always be improved, and more advanced rejection techniques can be developed
- At the current stage, such fake jets are 2nd most important background for mono-jet searches (Z->vv+jets is the 1st background)
  - Ultimately, such backgrounds limit our physics sensitivity in mono- and di-jet search channels

Summary fake jets: ATLAS has shown to be able to take data independently of the background level. However, for a part of the ATLAS physics program it is extremely important that the level of fake jets is brought to the absolute minimum. The investigations show a linear correlation between the background level and the amount of fake jets.



ALICE: TPC track multiplicity



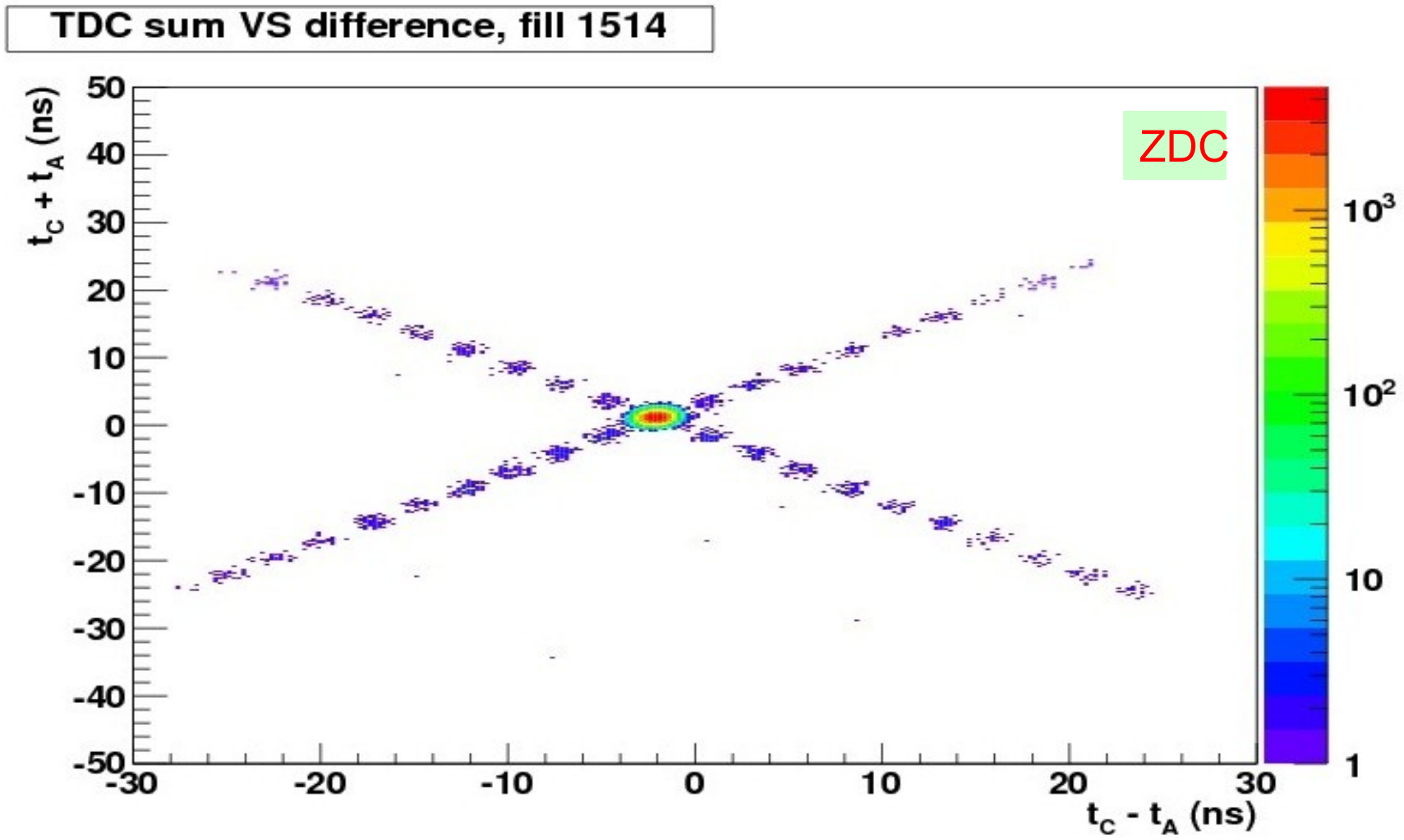


(6.5 · 0.5)/13 → 25%

1.8E5/6.8E5 → 26%

25% of MB collisions are actually beam-gas collisions in fill 1400, with pressure few 10^{-8}
In addition, beam-gas collisions result in extra data storage space
So pressure should be well below 10^{-8} mbar

ALICE: satellite bunches (here, ions)



Same argument (data contamination, storage space): say <5% of total charge is tolerable

bkg summary

- Hard to give precise limits on beam-gas bkg and satellite bunches
  - not a cliff
  - smoothly degrading conditions for physics
- Most sensitive to beam-gas bkg: probably ALICE and the fwd Expts
  - not LHCb
- Very approximately:
  - Fraction in non-nominal buckets < 5% of beam
    - Special: for some runs (vdM) must have less, and well measured, ghost charge => it should not introduce more than ~0.5% uncertainty on the individual bunch currents
  - Pressure in IRs in the e-9 mbar range is probably OK

to be seen…

Prospects 2011

General

- Experiments welcome 75 ns as starting point for 2011
  - all the way to 936b, then only move to 50ns
  - no loss in luminosity, easier for triggers/DAQs
- Welcome 4 TeV, of course
- Wish maximum integrated luminosity,of course
  - NB: LHCb no longer following ATLAS/CMS
- Maintain non-colliding bunches (at least 1 per beam and IP)
  - at start of train (hence, not affected afterglow)

<u>2011 Specials</u>:

- VdM scans => special fill with optimized conditions
  - low nr of bunches, low bunch intensity ? injection beta* ? $\alpha = 0$?
- sqrt(s)=2.76TeV
- Special TOTEM + ALFA
  - TOTEM: 12 more pots, T1 installed
  - ALFA: a few pots equiped

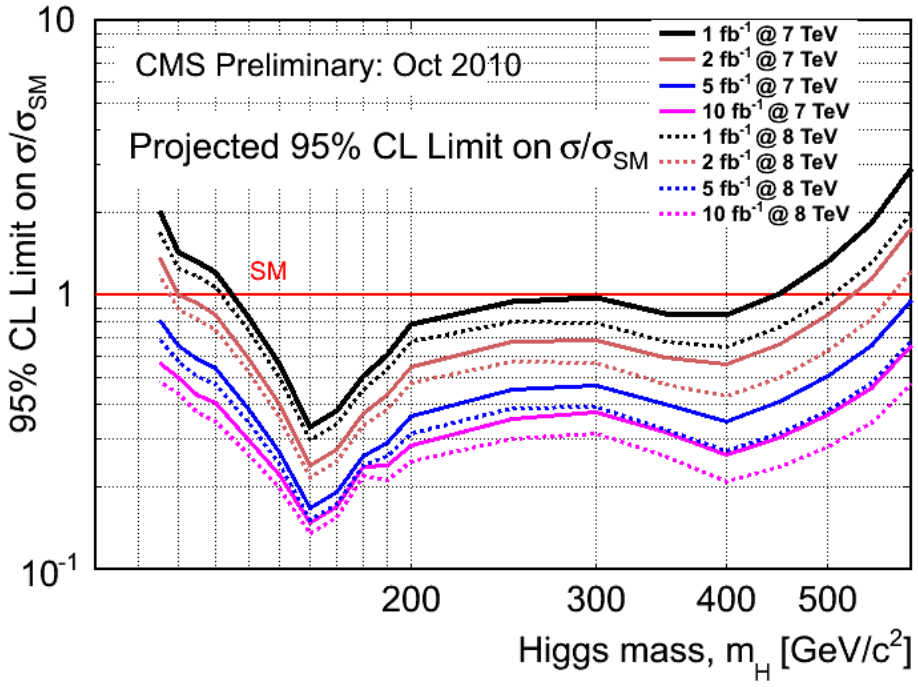
CMS preliminary projections Higgs

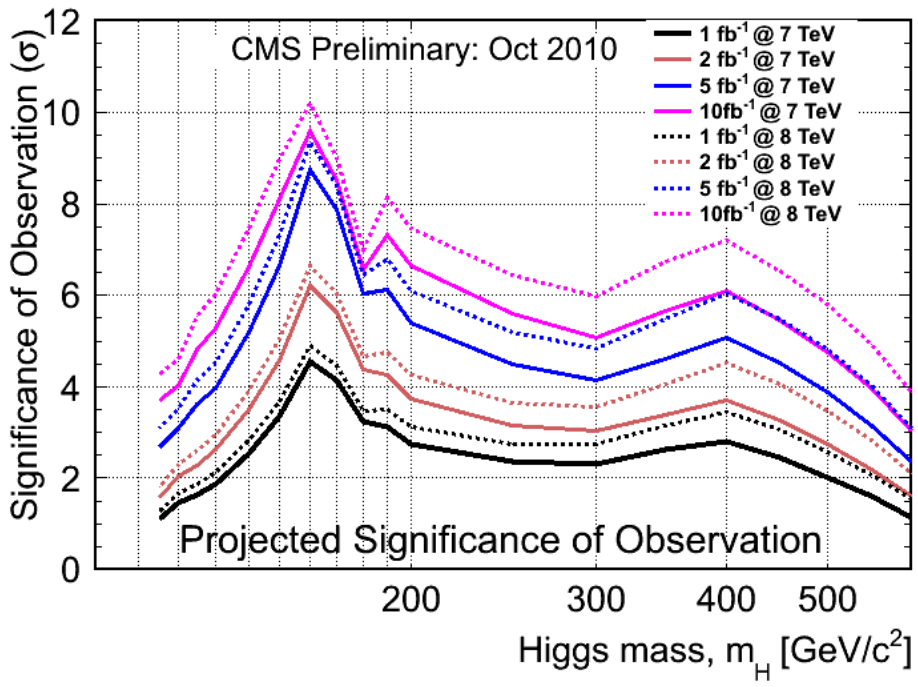
5 to 10 fb^{-1} of accumulated lumi become very interesting

— 1 fb^{-1}
— 2 fb^{-1}
— 5 fb^{-1}
— 10 fb^{-1}
@ 7 TeV

--- 1 fb^{-1}
--- 2 fb^{-1}
--- 5 fb^{-1}
--- 10 fb^{-1}
@ 8 TeV

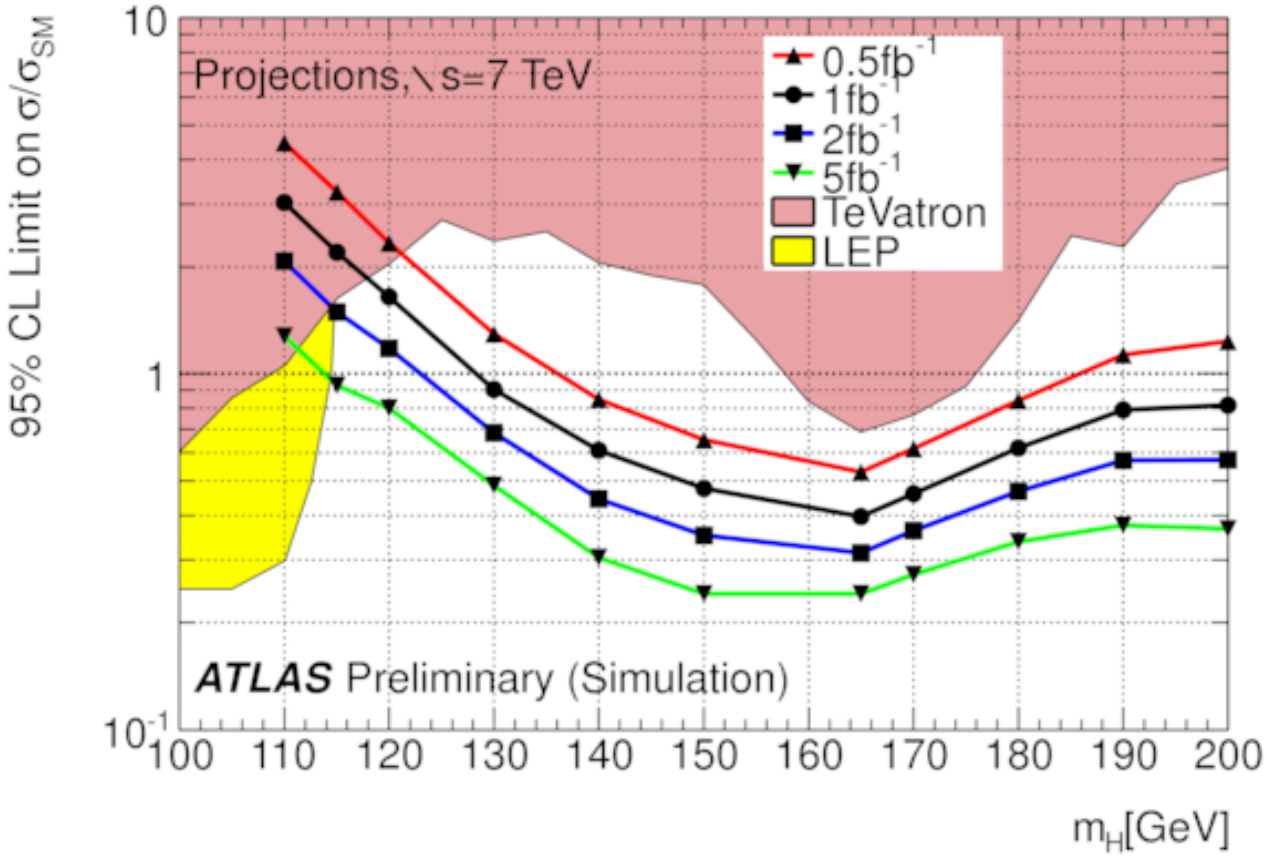
With 5 fb^{-1} can exclude or have 3 σ evidence from 114 to 600 GeV





2010

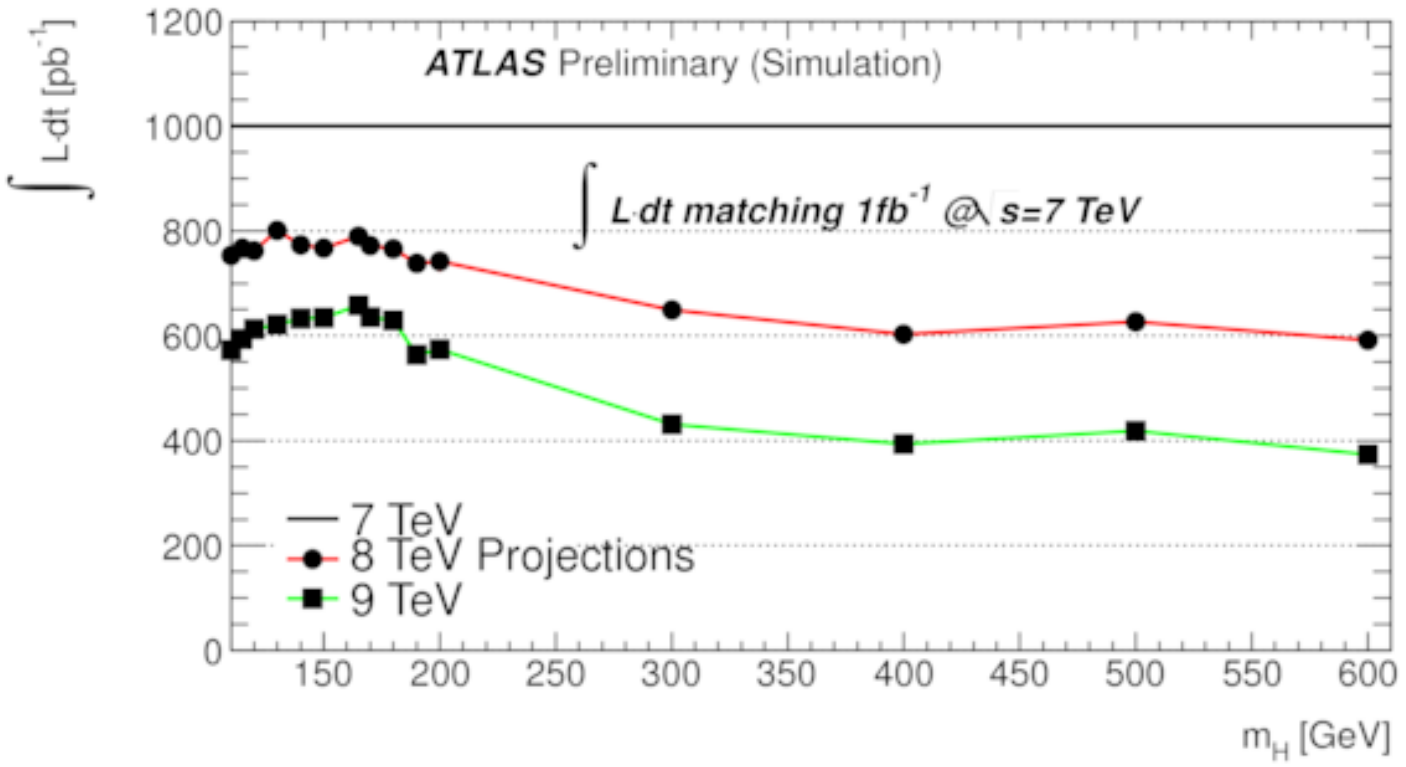
ATLAS preliminary projections Higgs



- $5fb^{-1}$ enough to close gap with LEP at 7 TeV
- Expected 3σ observation from 123 to 550 GeV with ATLAS estimates from a very conservative analysis at 7TeV

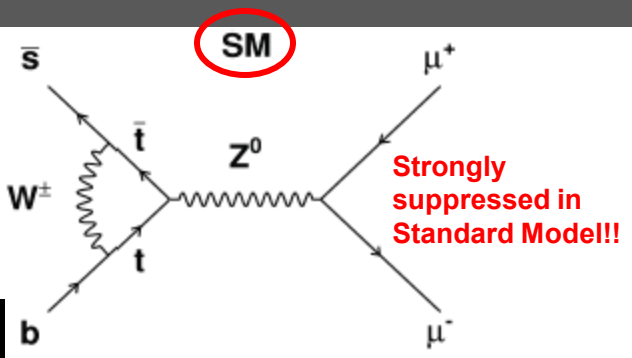
ATLAS preliminary projections Higgs

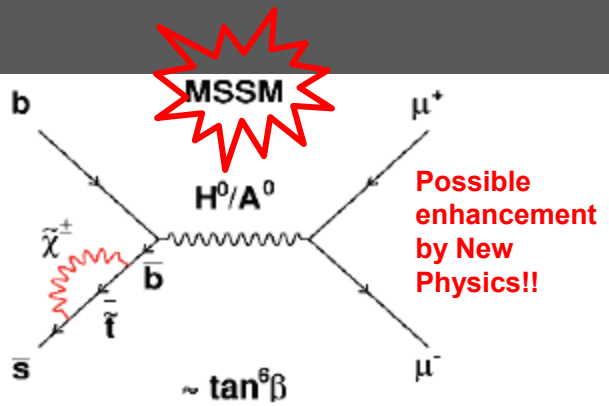
- Compare integrated luminosity at 8 or 9 TeV which gives same median sensitivity as 1 fb^{-1} at 7 TeV
- At 8 TeV, require 20% less integrated luminosity



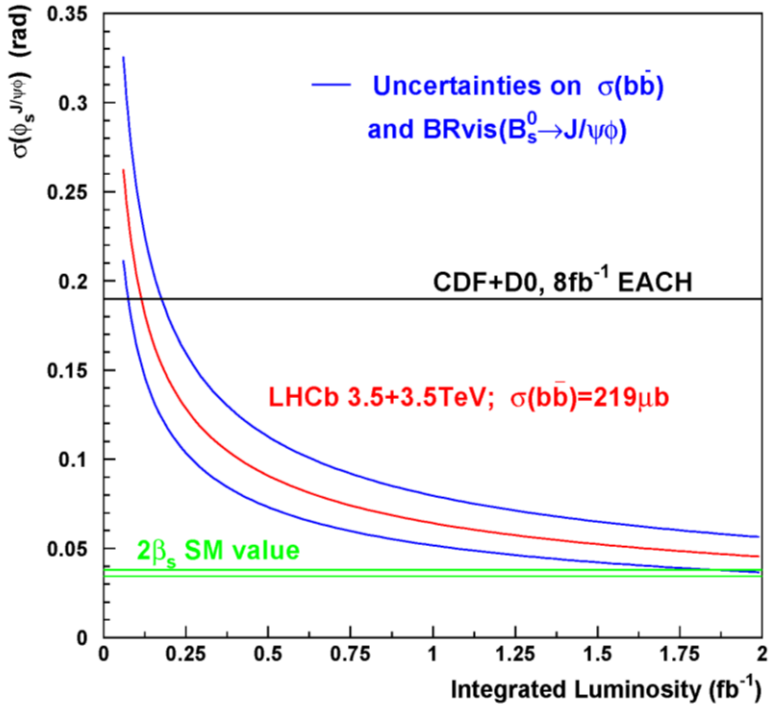
But Higgs is not everything

- Beauty also counts
- LHCb expectations for $B_s \rightarrow \mu\,\mu$ (FCNC)





And the B_s equivalent of the "B_d CKM angle (from B factories)"



MANY THANKS

FOR THE EXCELLENT COLLABORATION

AND

THE FANTASTIC PERFORMANCE