Requirements for the background in the experiments

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LHC Machine Induced Backgrounds

- **Introduction and short history**
- **sources, current knowledge**
- **LHC --> HiLumi LHC**
- **requirements -- vacuum**

Aknowledgements :

LBS, secretary Reyes Alemany, previously Alick Macpherson (chaired by me)

Yngve Levinsen, Roderik Bruce, Regina K.Hinzmann ; G. Bregliozzi, Christina Yin Vallgren ; FLUKA team

M. Huhtinen, A. Sbrizzi, et al. ATLAS; M. Guthoff, A. Dabrowski, Sunil Chitra S. Mallows et al. CMS

G. Corti, F. Alessio / LHCb, A. Di Mauro, A. Alici / ALICE

Introduction with bit of history

Machine induced backgrounds have been an issue and at times a performance limitation in many machines

Example : HERA, LEP

Based on this experience and advice from the machine advisory committees :

important to understand / monitor and minimize backgrounds

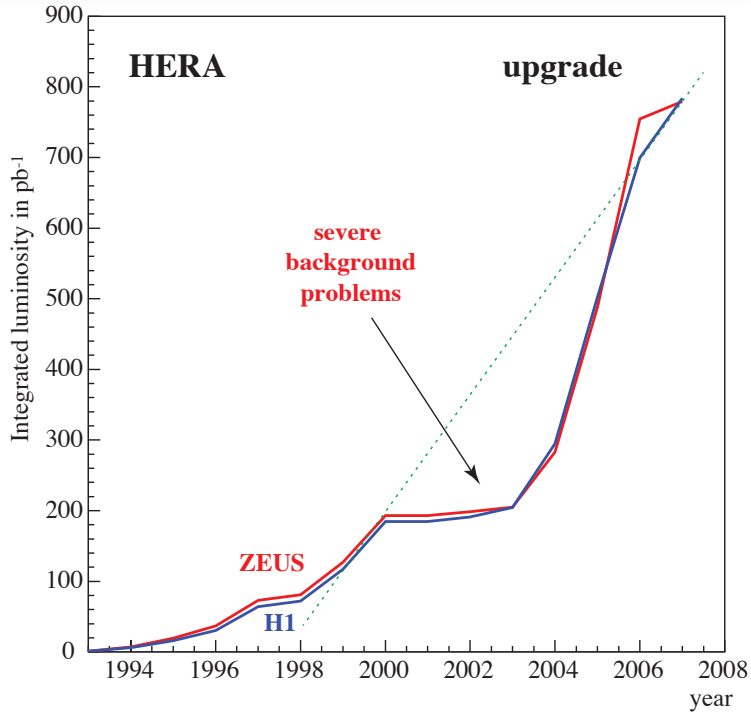
BKG workshop Apr. 2008,

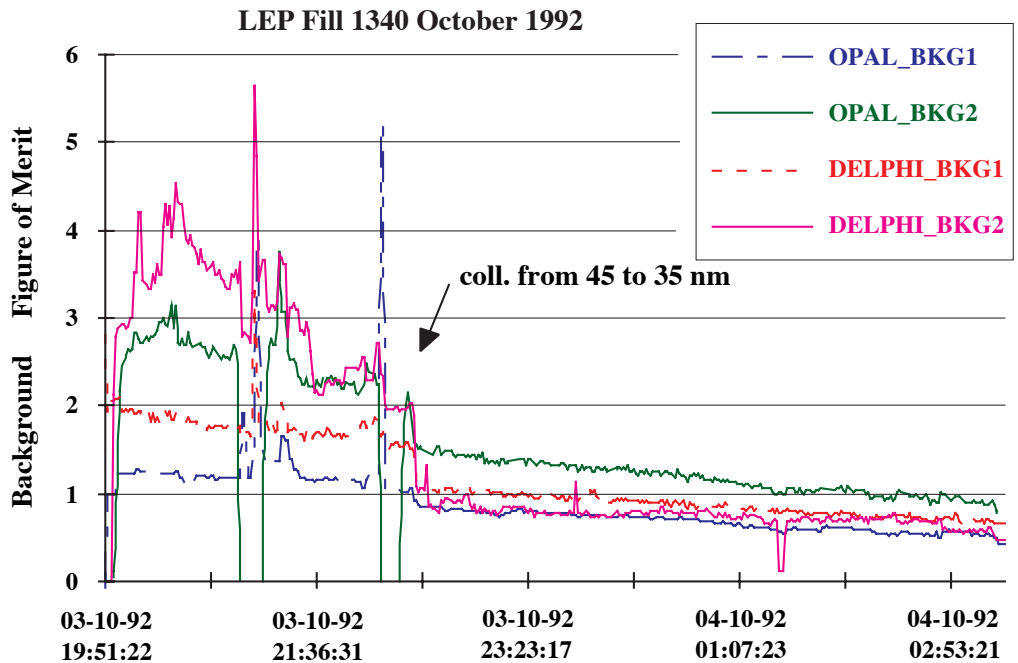
Yellow Report CERN-2009-003

LBS working group

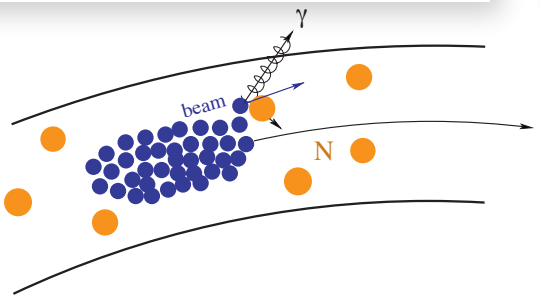
http://cern.ch/lbs started march 2009

next LBS#79 on 21 Nov.





Background sources



1. **Beam gas scattering on residual gas,**
   always present; pressure and intensity dependent
   most relevant: inelastic scattering, straight IR sections + beginning of arcs

2. **Halo - losses by slow drift, on primary, secondary, tertiary collimators ; lifetime and collimation dependent**

3. **Collision related - only there when in collisions**
   "signal" if originating by collisions at the IP + backscatter and out of time afterglow
   non-colliding isolated bunches required for quantitative monitoring
   "collision - cross talk" background generated in collisions by other IPs

Some Refs :

G. Corti, R. Appleby, H. Burkhardt, Y. Levinsen, M. Lieng, V. Talanov, Simulation of Machine Background in the LHCb Experiment: Methodology and Implementation, Proc. 2010 IEEE Conf. Nov. 2010

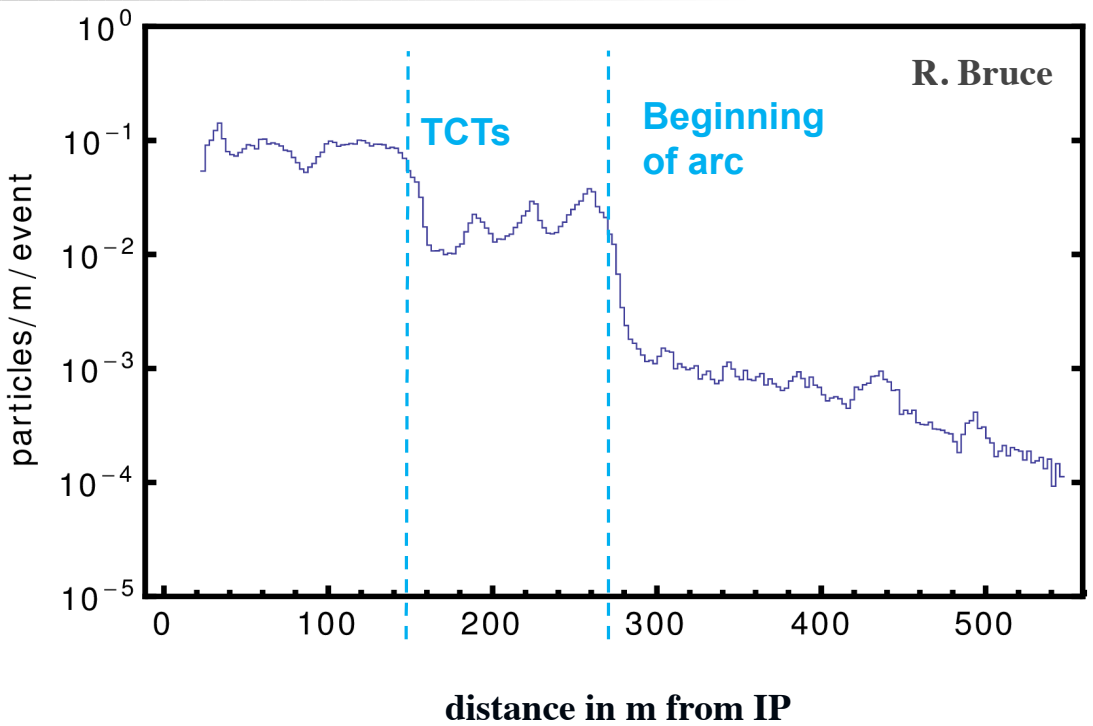
Yngve Levinsen, Machine Induced Experimental Background Conditions in the LHC, PhD thesis, CERN + Oslo university, 9/2012

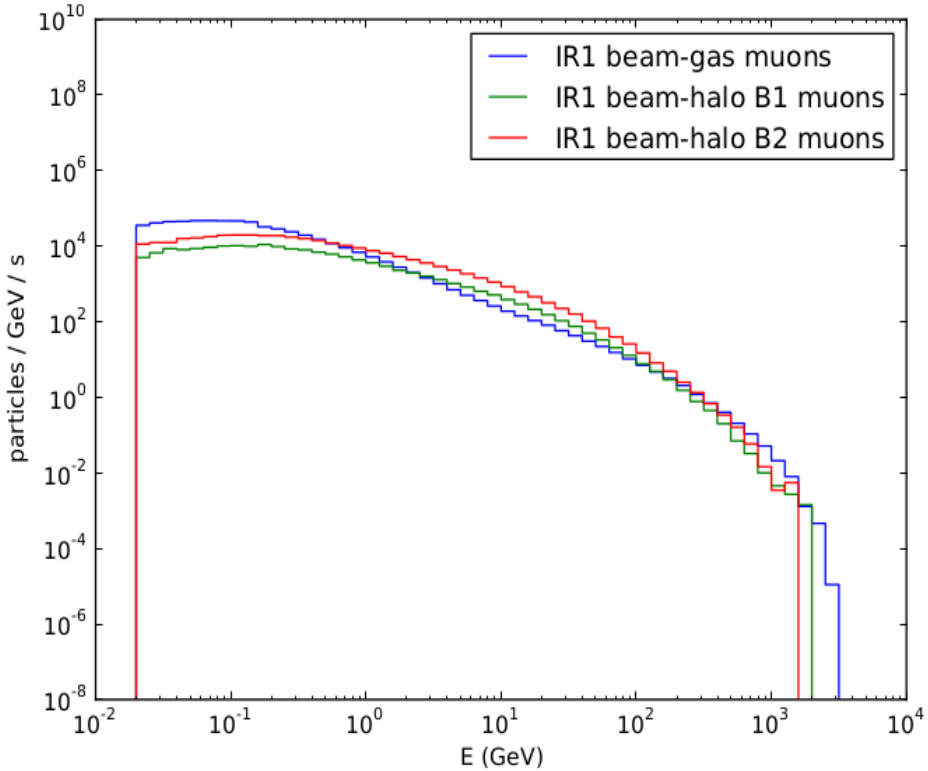
R. Bruce et al., *Sources of machine-induced background in the ATLAS and CMS detectors at the CERN Large Hadron Collider*, *NIM* A 729 (2013) 825–840

R. Alemany et al., *Run 2 experiments background information sent to LHC*, June 2015, EDMS#1513755

Early simulations, Run I

presentations by Yngve Levinsen LBS#29, Roderik Bruce, LBS#37 18/06/2012





Background muons, energy spectrum

Beam-gas backgrounds generally dominate, generated over several hundred meters from IP

Followed by halo-background, of similar importance in the muon background component

Early observation : high signal + afterglow
hard to distinguish signal & background

slide shown by Mika Huhtinen / ATLAS at Lumi Days 2011

Background

Types of background potentially affecting the luminosity measurement

Beam gas & beam halo

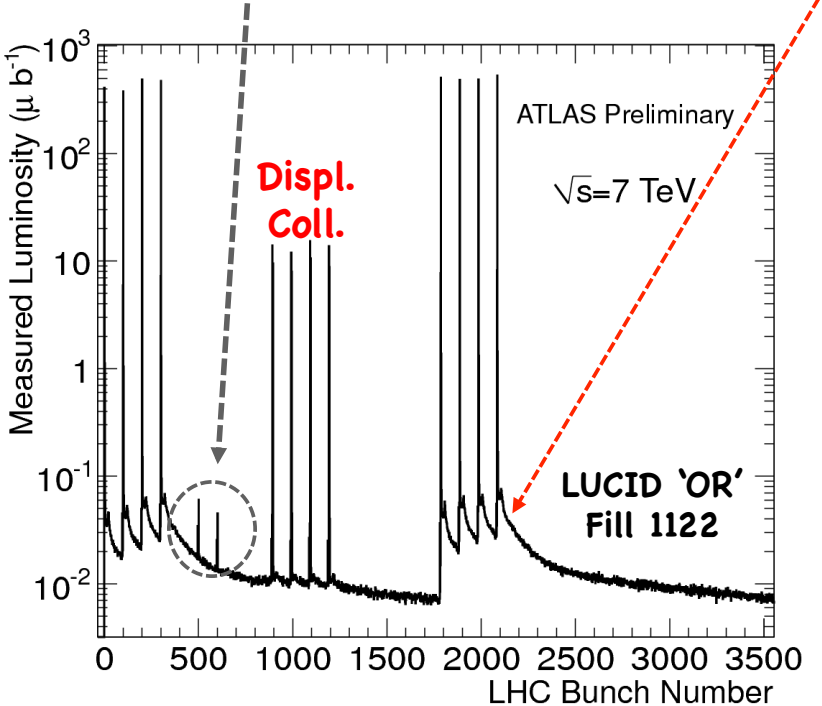
'AND' less sensitive than 'OR'

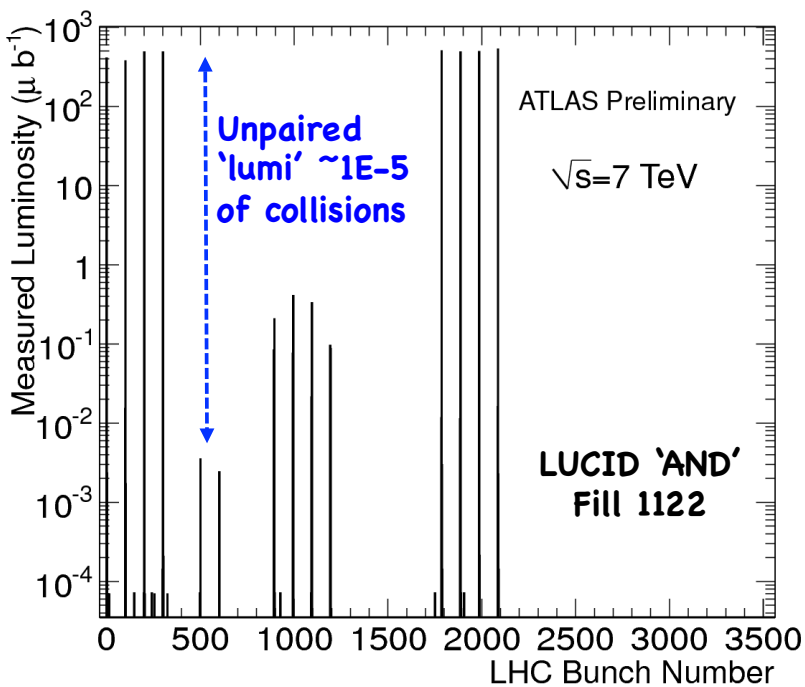
Easy to monitor with unpaired bunches

'Afterglow' (= long lived radiation)

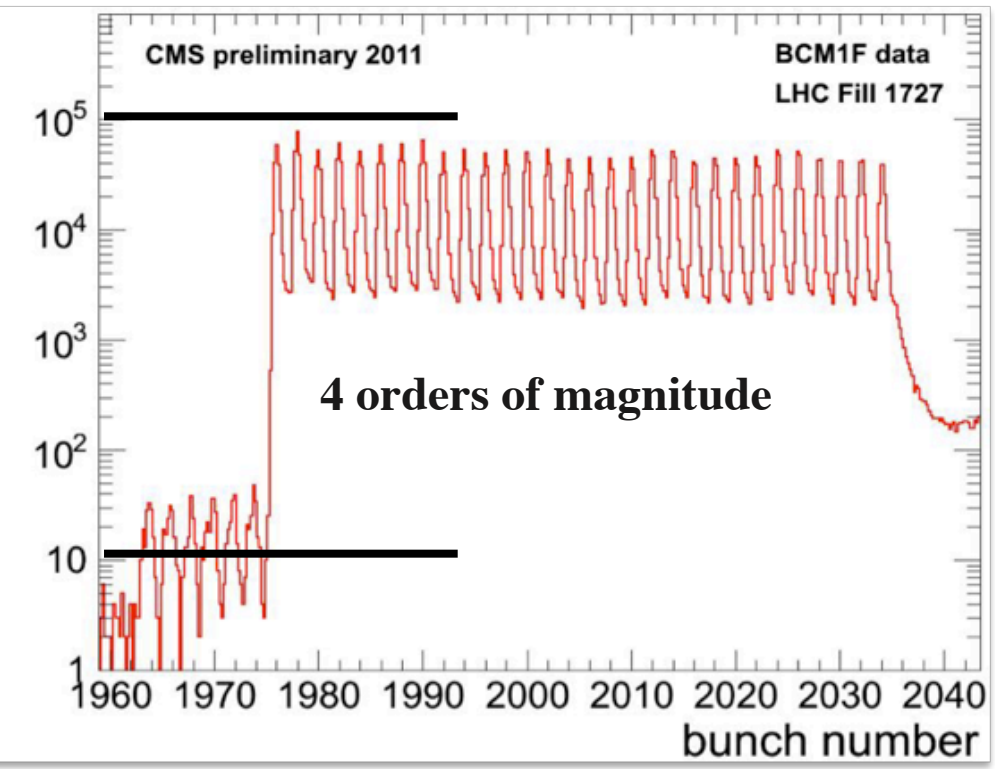
'AND' almost insensitive

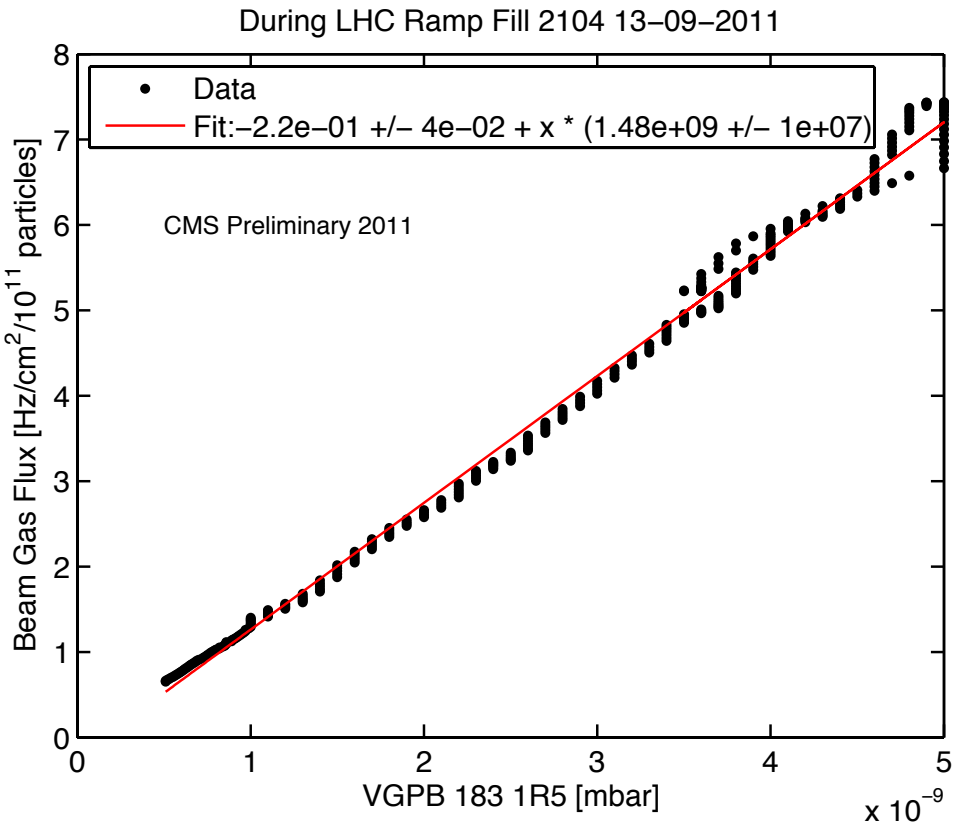
In 'OR'-mode makes a BCID-aware (bunch-by-bunch) analysis compulsory





Background measured, correlation with pressure, Run I





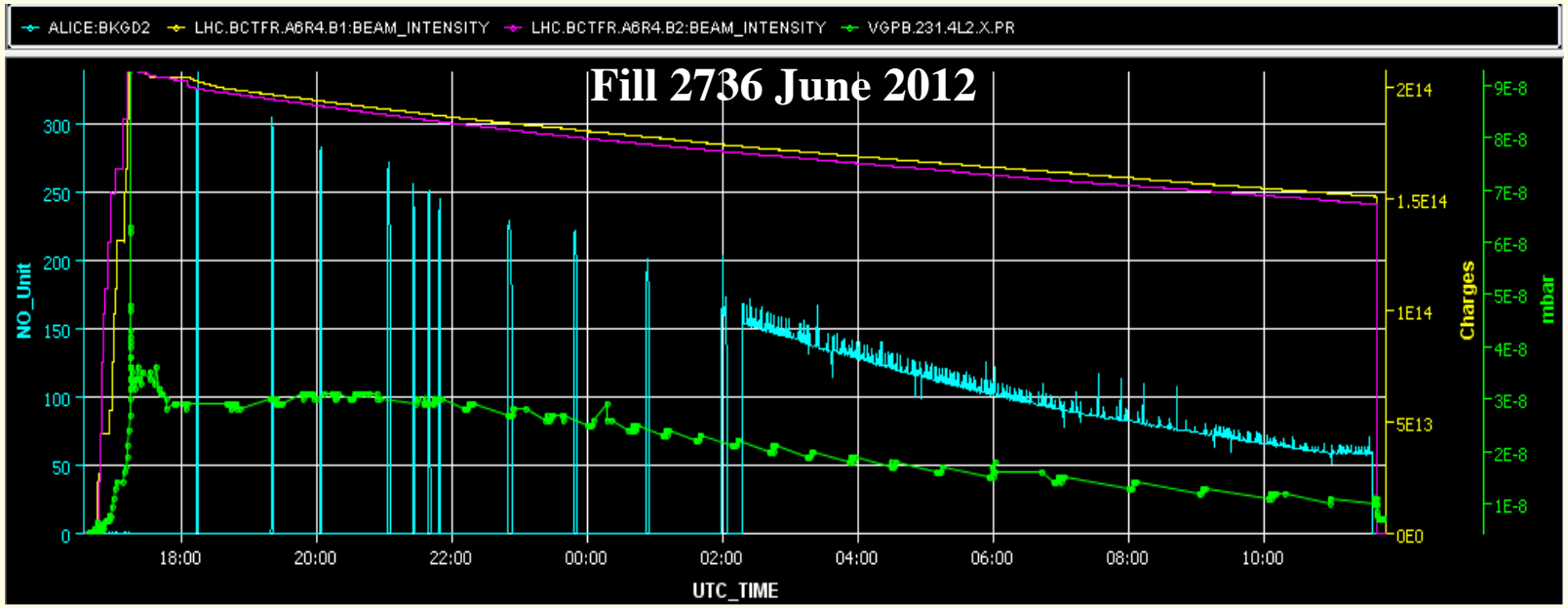
CMS Presentation, Anne Dabrowski, LBS#50, November 2013

Issues, efforts

ALICE background issues RUN I pp, related to heating of the TDI at injection

want P < 5×10-9 mbar, cannot ramp up gaseous detectors P > 2-3 ×10-8 mbar

lost part of the pp running in 2012



Improved a bit when changing order of injection from Sept. 2012 Reported in LBS#43

LS1 : TDI vacuum upgrade and sectorization, NEG coating of ID800 chambers in LSS2 and RF inserts

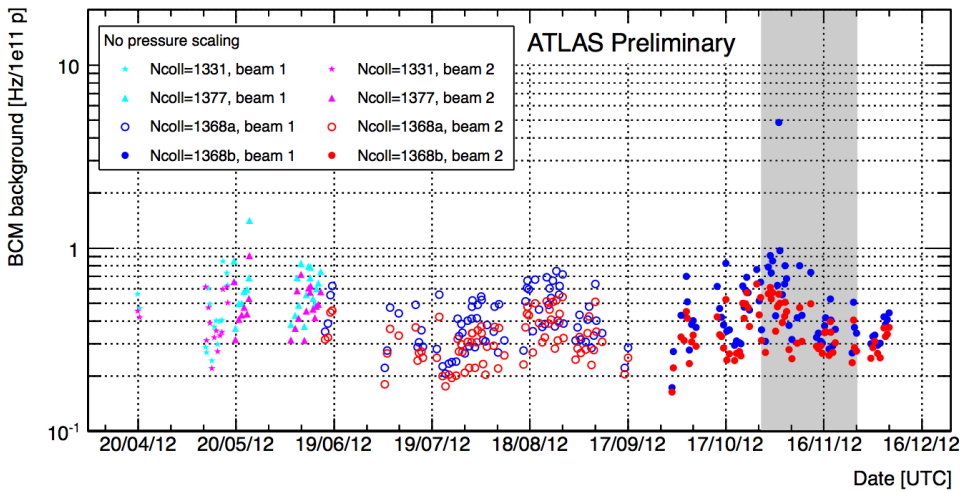
-----> much better in RUN 2 so far , typically P < 3×10-9 mbar

--- ALICE can run from beginning of pp fills; reported on 17 Oct. in LBS#78

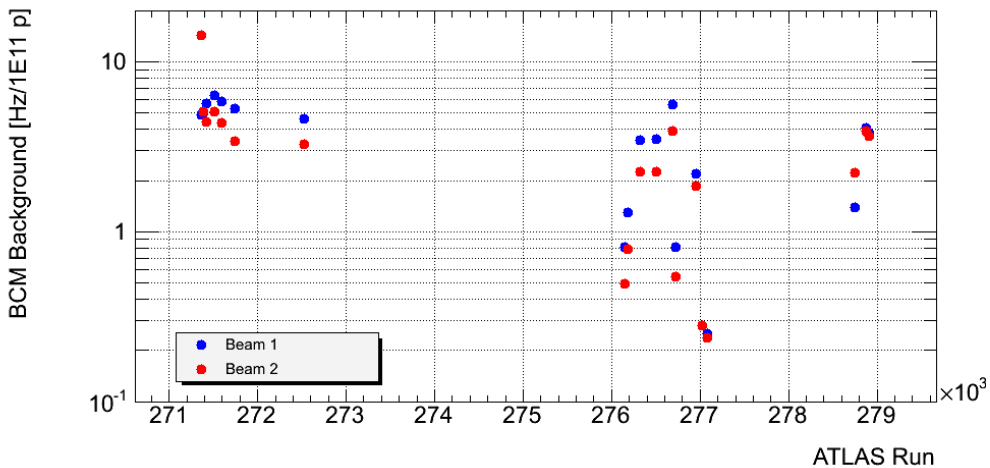
RUN2, general increase and more dynamic

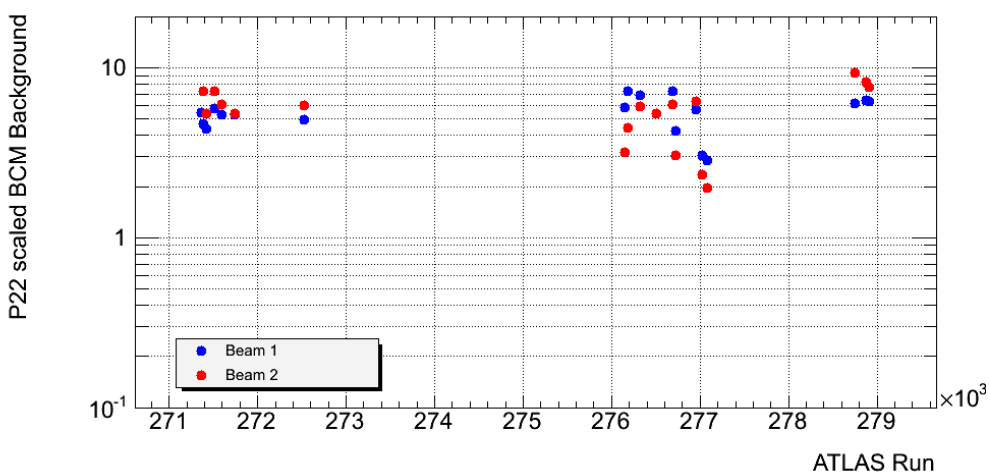
LBS#67 14/9/2015, here ATLAS, reported by Mika Huhtinen

Run 1 (2012)



Run 2 (so far, early runs missing)





In Run 1 the (fill-averaged) rates were around 0.4 Hz/1E11p

In Run 2 we observe 2-5 Hz/1E11p !

Inconclusive if vacuum improves and background drops as run 2 progresses since many recent fills with low intensity vdM etc and now in intensity ramp-up.

Background/pressure seems about constant, but more scatter than in 2012

Also seen RUN2 : background fluctuations - correlated with triplet temperature

Localized pressure bump tests

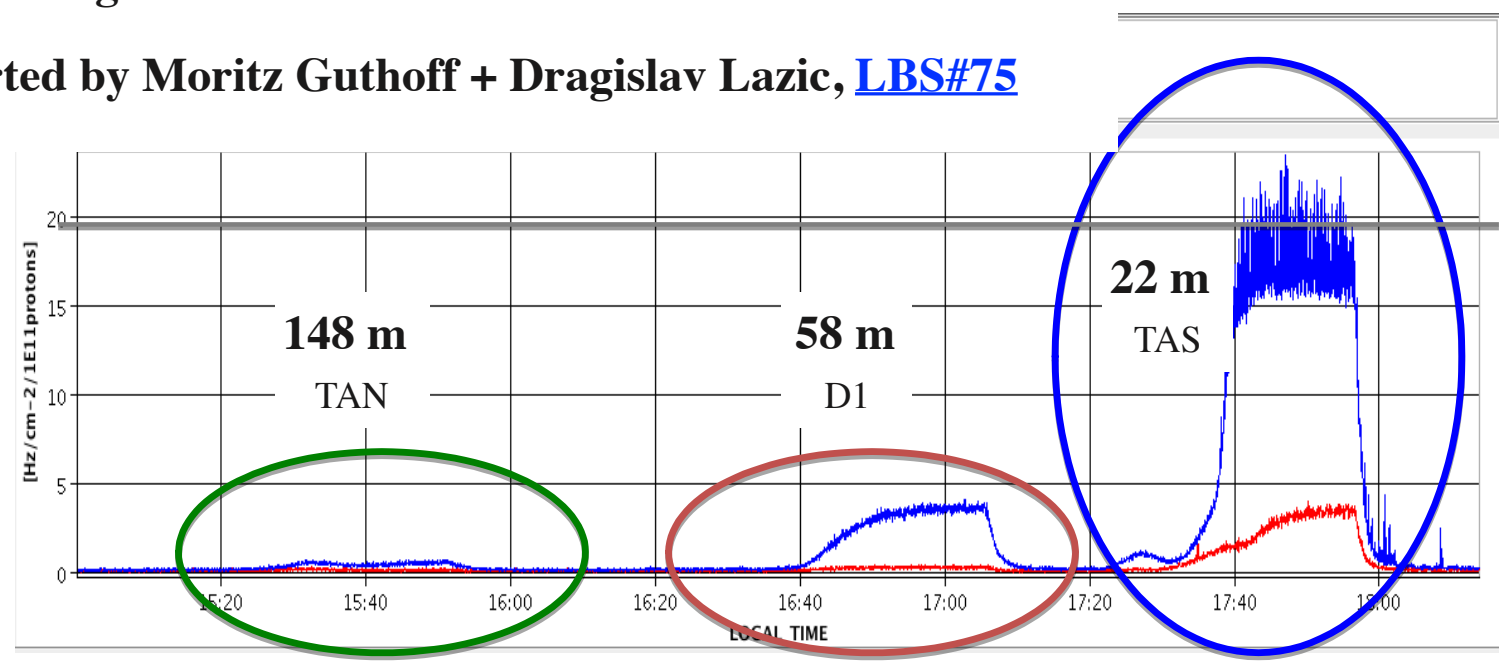
At reduced intensity -- during intensity ramp-up; MD1224 EDMS#1683784 R. Alemany et al.

Local vacuum bumps (NEG heating) --- measure backgrounds in experiments

9-10 May, 11 June, 25 Sep. (ATLAS)

CMS backgrounds at Pixel detector

reported by Moritz Guthoff + Dragislav Lazic, LBS#75



Fitting background vs pressure, determine "efficiency" factors vs position

for ATLAS ~0.8 @ 22m, 0.025 @ 58 m, 0.027 @ 150 m for BCM, Pixel

fake jets, muons, matching section

Beam gas collisions further downstream @ 150 m contribute less to background rates as seen by the BCM and Pixel detectors in the central region around the beam pipe.

But :

Far beam-gas important for backgrounds at larger radius, seen as “fake jets”, clearly observed in recent bump tests

Tend to increase trigger rates and dead time + some impact on data quality

Currently further studied and analyzed, including impact of TCTs, impact on detector muons, elastic beam-gas ...

---> Both local vacuum close to IP and vacuum in matching section important

Concluding remarks, Vacuum requirements

RUN2 backgrounds generally increased and more dynamic than RUN1, but well acceptable

ALICE - improved thanks to vacuum upgrade in LSS2 during LS1

Expect further increase for HiLumi -- more intensity, detectors more exposed (TAXS)

increased halo component for tighter collimation / lower β*

still expect to be dominated by Beam Gas BKG ~ #protons × residual Pressure

Rough spec. : aim P < few 10-9 mbar (ALICE 5e-9 scaled to HiLumi)

very important for the experiments that vacuum quality as best as (reasonably) possible

encourage all affordable C-coating (ecloud minimization) and pumping upgrades

with emphasis on long straight sections including matching section and beginning of arcs,

avoid / monitor any local heating (kickers, TDIs)