Measurements and identification strategies for non-collision backgrounds in the ATLAS experiment

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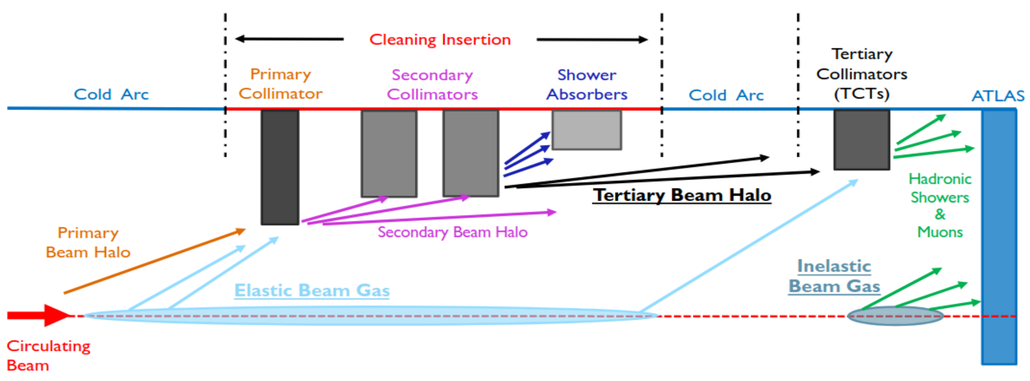
Introduction and motivation

Unconventional new-physics signals, such as hadronically decaying neutral long-lived particles (LLP), produced and decaying within the detector volume may result in displaced jets which resemble fake jets from beam induced background or cosmic background.

Non-collision backgrounds

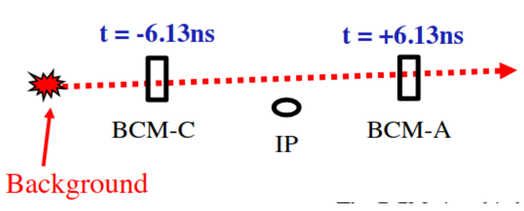
Main sources of NCB:

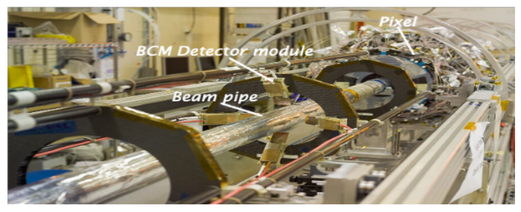
- Elastic beam-gas scattering around the ring.
- Inelastic beam-gas events in the LHC long straight sections (LSS) or the adjacent arc.
- Beam losses on limiting apertures, coming predominantly from losses on the TCTs, which in the normal optics are the smallest apertures in the vicinity of ATLAS.
- Cosmic-induced backgrounds are predominantly caused by energetic muons from cosmic-ray showers traversing the detector from top to bottom.



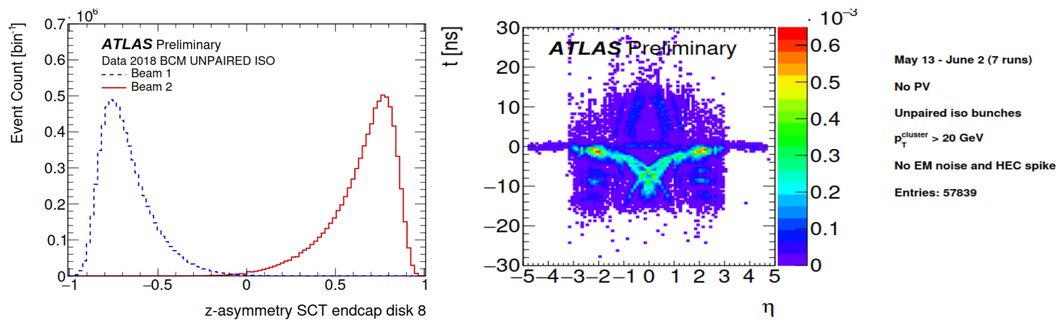
Beam Condition Monitor

- Beam Condition Monitor sub-detector is used to monitor luminosity and Beam Induced Backgrounds levels. It consists of two detector stations with four diamond modules each.
- BCM trigger is formed by a coincidence of an early hit on one side and an in-time hit on the other side.





Identification of background in inner detector and calorimeter

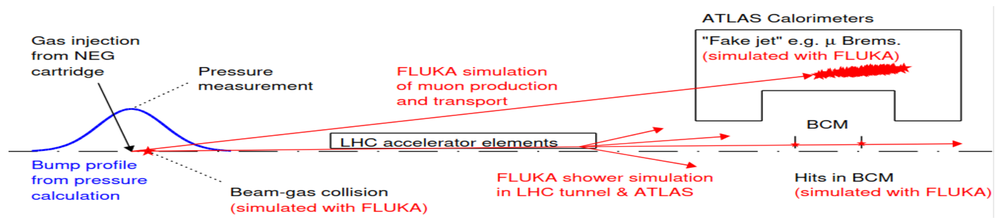


The z-asymmetry quantifies the difference in in-time hits between the downstream and upstream endcaps.

The “banana plots” shows the distribution of the time of the leading calorimeter clusters vs. pseudorapidity, in events from unpaired isolated bunches, without any primary vertex.

Pressure bump test

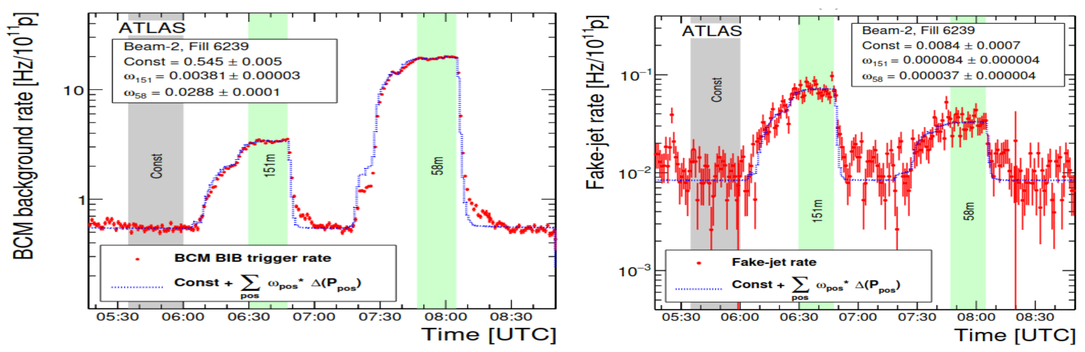
- Series of dedicated pressure bump tests was performed during LHC Run 2 in order to quantify the sensitivity of ATLAS to beam-gas events at various well-defined locations .
- Non-evaporable getter (NEG) cartridges were heated such that some of the gas they had absorbed was re-injected into the LHC beam vacuum.



Background measurements

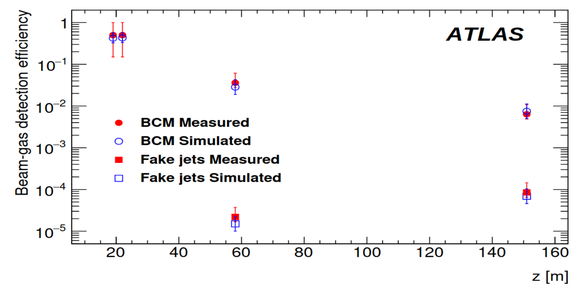
The observed background B is parameterised as $B = C + \omega(z_i)\Delta P(z_i)$.

- $\omega(z_i) = \frac{\Delta B}{\Delta P(z_i)}$.
- $\Delta P(z_i)$ is the change of local pressures reported by vacuum gauges at locations z_i where i refers to the four pressure bump locations.
- C is the pedestal BIB level from beam-halo losses and from beam-gas interactions in the absence of the pressure bump with minor contribution for fake jets.



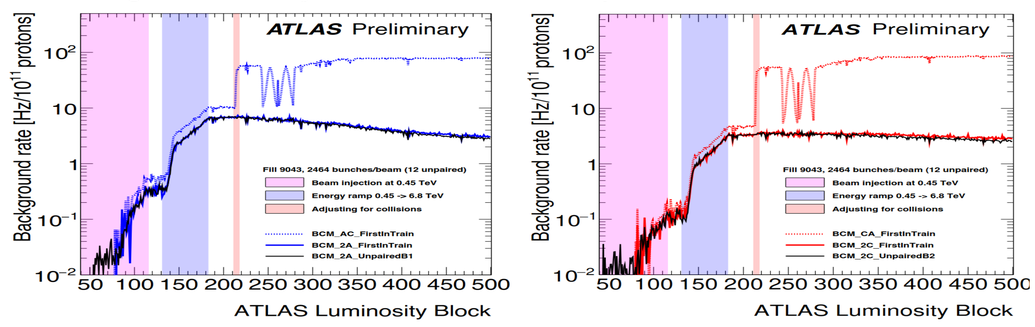
Data in the shaded regions are used to determine the parameters C and $\omega(z_i)$ needed to produce the dotted blue histogram for BCM and fake jets.

The efficiency summary plot illustrates the opposite trends of the two BIB rates as a function of z.



Run 3 improvements in background measurement

The old algorithms ’AC’(’CA’) for the Beam 1(2) were based on an early hit on one side and an ”in-time” hit on the other. These were found to have an overwhelming luminosity contamination in paired bunches.



The new algorithms 2A’ and ’2C’ with two early hits enable a beam background measurement on some paired bunches of colliding trains grouped in the ’First In Train’ bunch group.

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