HCP Poster Session – 17 November 2011

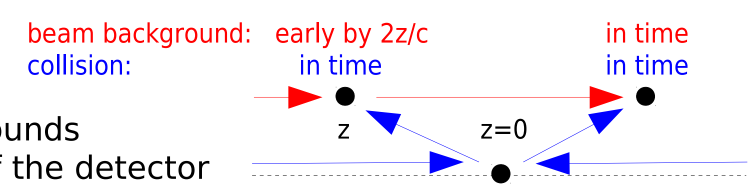
Beam-Induced Backgrounds in the ATLAS Experiment

LHC Beam Structure

- LHC was running at 50 ns bunch-spacing during ***pp* operation** in 2011.
- Each LHC fill has a bunch pattern consisting of different bunch groups:
  - **paired** → bunch in both LHC beams
  - **unpaired isolated / non-isolated** → bunch in only one LHC beam without / with a bunch in the other beam within 75 ns

Beam-Induced Backgrounds

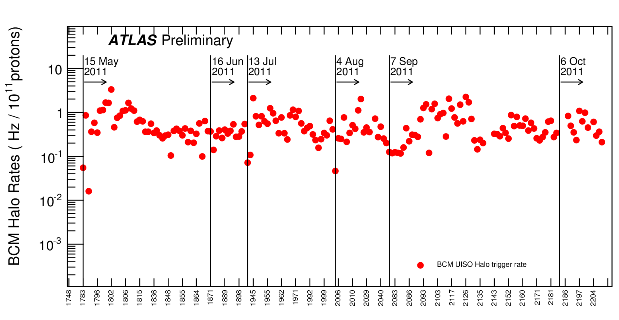
- Beam-induced backgrounds appear in ATLAS due to proton losses upstream of the interaction point.
- Classification of the beam induced backgrounds:
  - **tertiary halo** → protons lost on limiting apertures near the experiment (typically the tertiary collimator located at z = 150 m from the interaction point)
  - **inelastic beam-gas** → inelastic interactions of protons with the residual gas inside the beam-pipe
- The rate of beam-induced backgrounds is proportional to the beam current and depends on the operational conditions of LHC (machine optics, collimator settings, residual gas densities, filling scheme, ...)

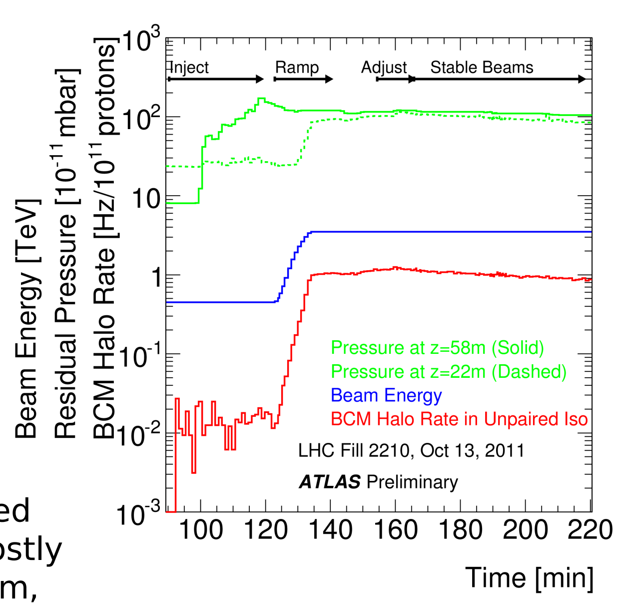


- **Timing signatures**
  - Beam-induced backgrounds travel from one side of the detector to the other.
  - Time-of-flight difference between the potential hits in the sub-detectors located on both sides can be measured.
- Data from unpaired bunches were analysed in order to study general properties of beam-induced backgrounds and monitor their levels.

Beam Conditions Monitor

- Primary purpose of the Beam Conditions Monitor (BCM) is to monitor beam conditions and protect against anomalous beam losses (potential detector damage).
- It is also used to monitor luminosity and beam-induced background.
- Two stations with diamond sensors are located at z = ±184 cm (ct = 6.13 ns) from the interaction point and r = 55 mm.
- BCM trigger is formed by a coincidence of an early hit on one side and an in-time hit on the other side.

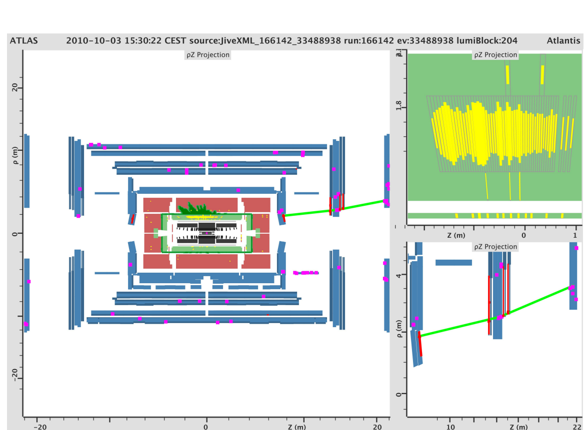




- BCM trigger rate normalised by the number of protons in the machine is stable in 2011.
- During the start of an LHC fill, normalised BCM halo rate measured in unpaired isolated bunches is mostly determined by the pressure at 22 m, which rises during the energy ramp.

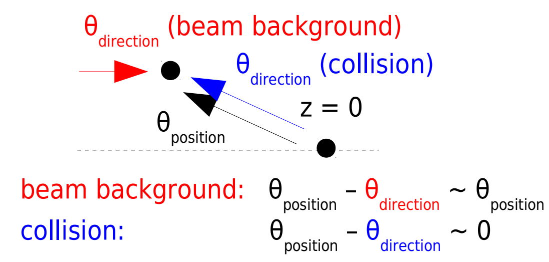
Beam Background Muons

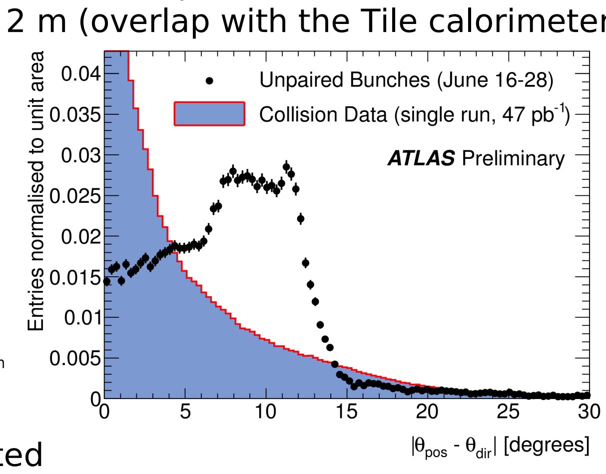
- Beam background muons can be highly energetic (up to several TeV) and can deposit large fraction of their energy in the calorimeters via bremsstrahlung.
- Figure shows an example of a real data event with a beam background muon entering the detector on the left, leaving hits in the muon end-caps, and a calorimeter cluster elongated in the z-direction.



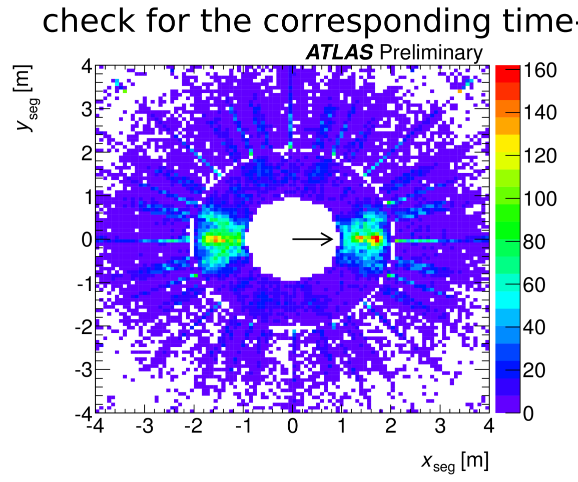
Beam Background Identification

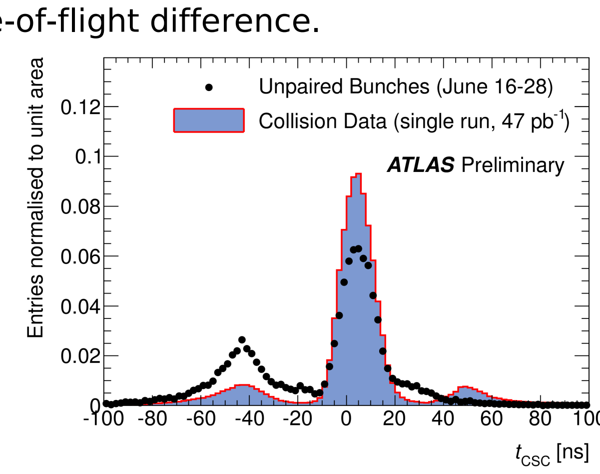
- Identification is based on muon detector and calorimeter information.
  - Cathode Strip Chambers (CSC) are located at z = ±8 m with a radius of 1 < R < 2 m (overlap with the LAr calorimeter).
  - Monitored Drift Tubes (MDT) inner end-cap is located at z = ±8 m with the inner edge starting at R = 2 m (overlap with the Tile calorimeter).
- Beam background muon segments have direction parallel to the beam pipe:





- Beam background is mainly located around the y = 0 plane (see below; the arrow points to the LHC centre).
- Time measurement from the muon system (below right) is used to determine the beam background direction.
- The early peak for beam background is located around t = -50 ns and coincides with the hits from the preceding filled bunch crossing.
- In case there are muon hits on both sides, the time resolution allows to check for the corresponding time-of-flight difference.

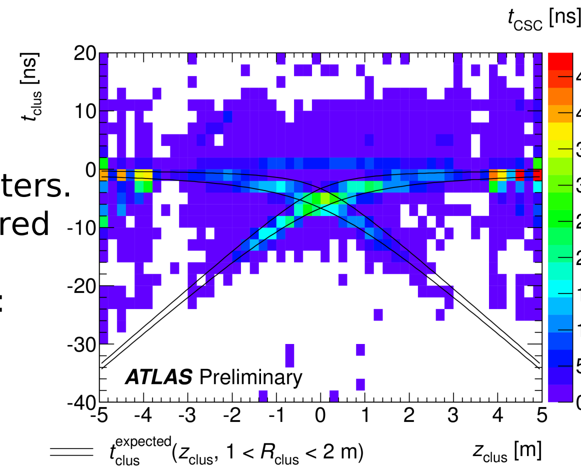




- Beam halo muons are not bent in the azimuthal direction by the magnets. → Muon segments can be matched with calorimeter clusters.
- Time of the cluster can be compared with the expected value for a particle traversing the detector:

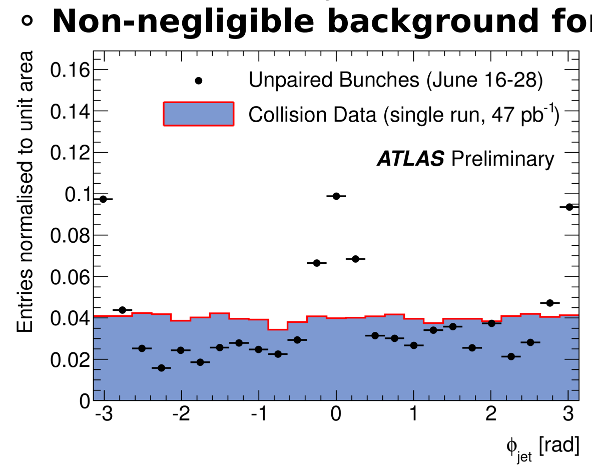
$$t^{expected}_{clus} = -1/c\left(\pm z_{clus} + \sqrt{z^2_{clus} + R^2_{clus}}\right)$$

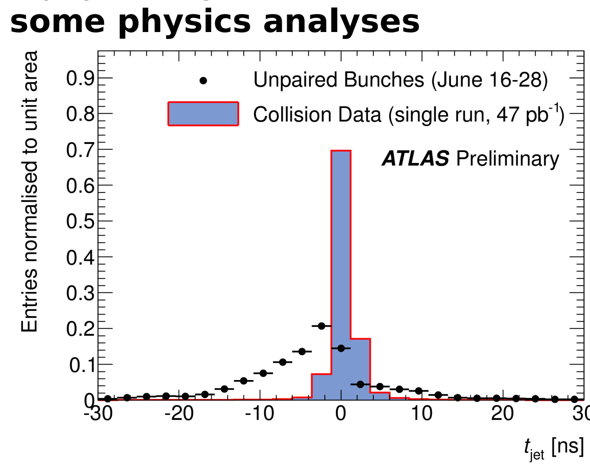
- For more details, see ATLAS-CONF-2011-137



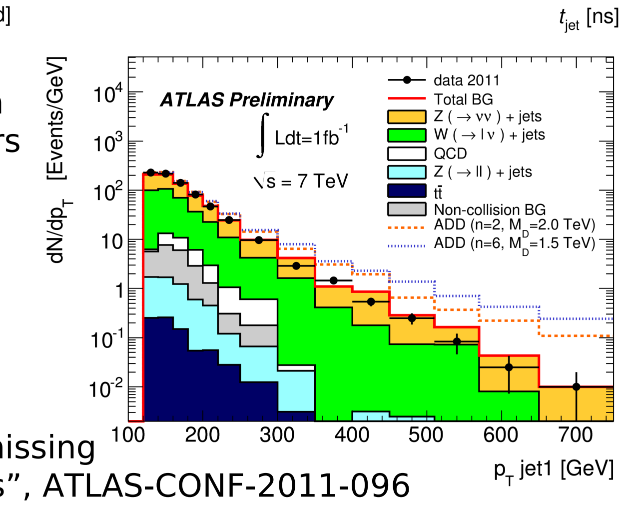
Fake Jets

- Energy depositions by beam background muon bremsstrahlung can be reconstructed as jets and lead to high missing transverse momentum.
- Events with fake jets can mimic new physics signals (SUSY, exotics, ...)
- **Non-negligible background for some physics analyses**





- Fake jets are characterised by: the azimuthal structure of beam backgrounds, early time, clusters in a single calorimeter layer, no tracks pointing to a jet, ...
- Identification methods based on the combination of muon and calorimeter measurements (position and timing) can serve as a **fake jet cleaning tool**.
- It is used in the "monojet plus missing transverse momentum searches", ATLAS-CONF-2011-096



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