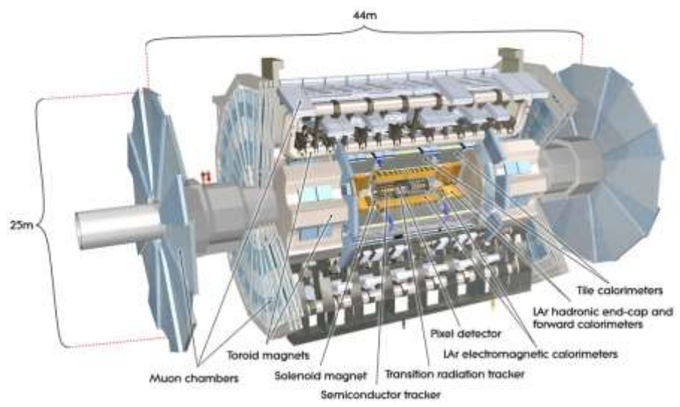
The characterisation of non-collision background events in the ATLAS detector during LHC Run 2 data-taking.

LHCP 2021, 7-12 June

Introduction & Motivation

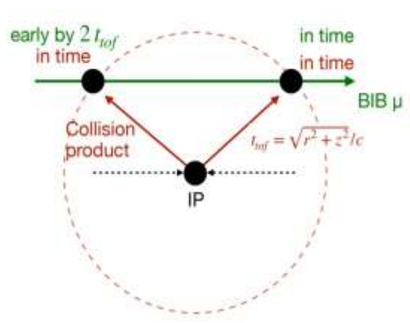


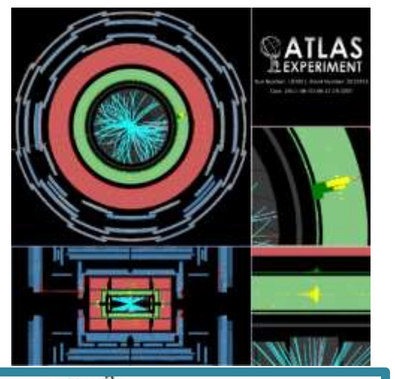
Unconventional new-physics signals may have signatures similar to events originating from cosmic rays, beam gas interactions and interactions of beam halo with LHC collimators. Especially when overlapping with a physics event, these collisions can be a non-negligible source of background. The performances of the beam halo tagging methods, developed during Run 1 and Run 2 data-taking to identify events coming from beam-induced background are evaluated.

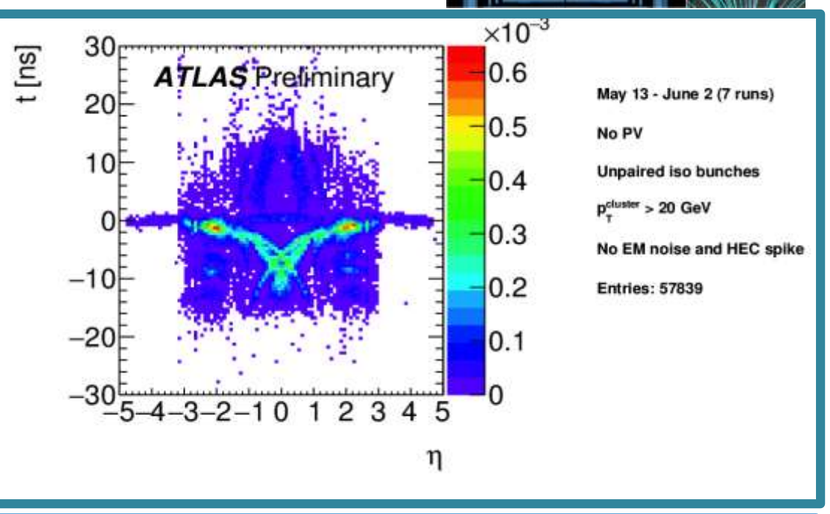
Three main sources of NCB:

- **Beam halo:** protons with high transverse amplitude hitting tertiary collimators (TCT)
- **Beam gas:** small-angle deflections of the protons originated by elastic beam-gas scattering (adds to TCT loss) or inelastic hits of protons with residual gas molecules
- **Cosmic rays:** predominantly muons travelling downward due to atmospheric cosmic-rays showers

Beam Halo Identification Methods In The Calorimeter



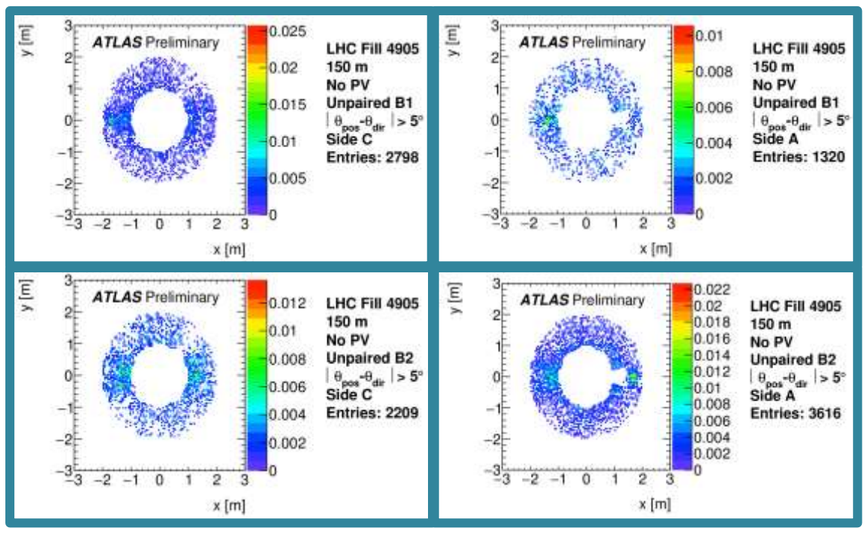




✓ The "banana plots" shows the distribution of the time of the leading calorimeter clusters vs. pseudorapidity, in events from unpaired isolated bunches, without any primary vertex and passing a trigger requiring a jet with p_T > 12 GeV in unpaired isolated bunches.
✓ The cut on the leading cluster p_T is 20 GeV.
✓ The distributions for each run are normalized by the duration of the run in seconds, and the plot represents the average over all the runs.

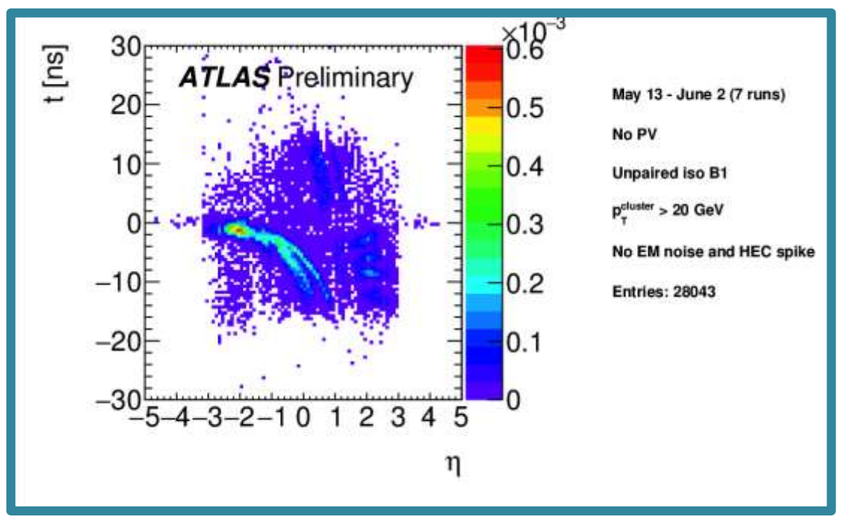
BIB in the tracking system

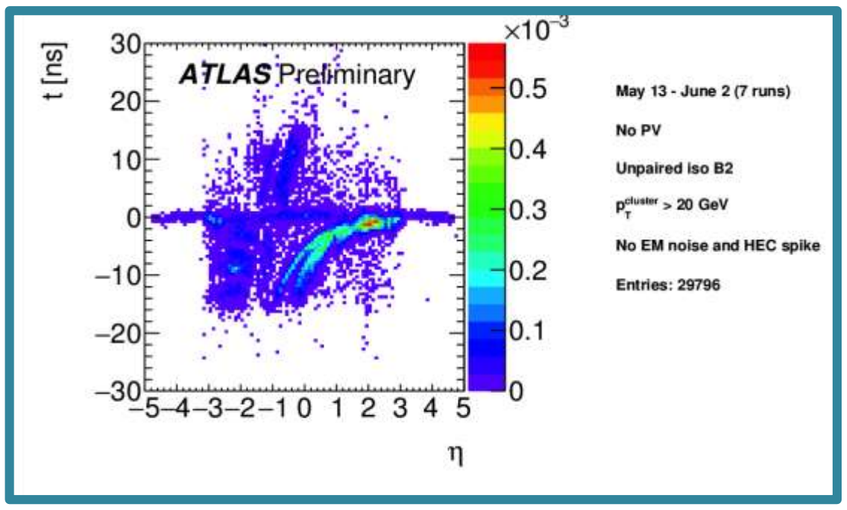
Spatial distributions of CSC muon segments



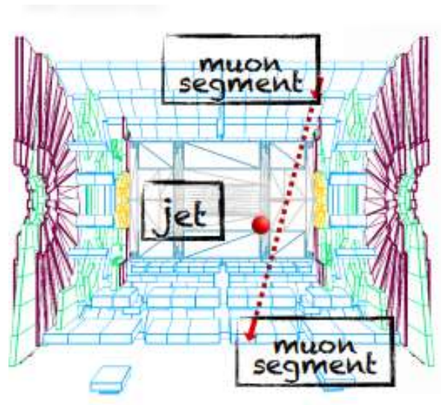
✓ The figure above shows a space distributions of CSC muon segments during an LHC fill, when the beam pipe pressure was increased at 150 m from the interaction point.
✓ The plots show the distributions of muon segments from CSC End Cap C, while the bottom row shows the distributions for CSC End Cap A.
✓ The Events without any primary vertex are selected and a cut on the difference between the polar position and the polar direction of the muon segment is applied in order to select muon candidates going in a direction parallel to the beam-pipe.
✓The distributions are normalized by the duration of the luminosity block interval when the pressure was stable.

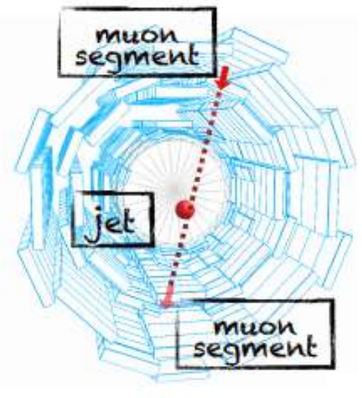
Eta versus time distribution of leading calorimeter clusters



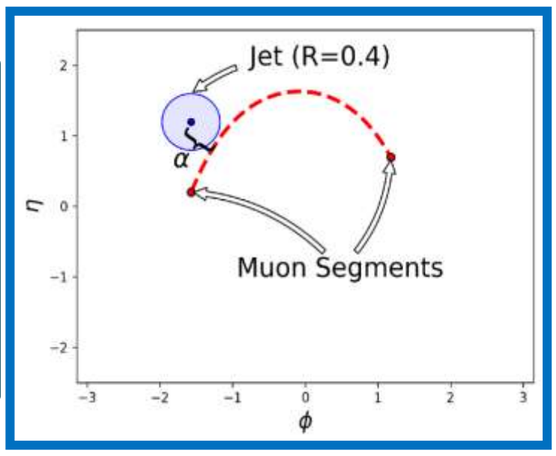


Cosmic-ray muons in the calorimeter and muon system





α is indicated as the smallest spatial distance between the jet and the muon segment connection



✓ A cosmic muon traverses the detector from top to bottom passing through the calorimeter and inducing a jet.
✓ The two clusters of muon segments and the jet can be connected by a line which curved due to the influence of the magnetic field on the muon trajectory.

Conclusion

The term non-collision backgrounds (NCB) refers to signals seen in the ATLAS detector which have not been produced by standard collisions of the LHC beams. The studies are based on :

✓Offline studies of NCB events and monitoring tool to ensure good data quality.
✓The events are an important background source for searches with displaced objects.

References

•**arXiv:2104.03050 :** *A search for the decays of stopped long-lived particles at √s=13 TeV with the ATLAS detector*
•**arXiv:1603.09202 :** *Beam-induced and cosmic-ray backgrounds observed in the ATLAS detector during the LHC 2012 proton-proton running period*

Zakaria CHADI (On behalf of the ATLAS collaboration)
Faculty of sciences - University Hassan II of Casablanca