Internship Proposal

The search for exotic long-lived particles in ATLAS: illuminating a blind spot of the LHC programme

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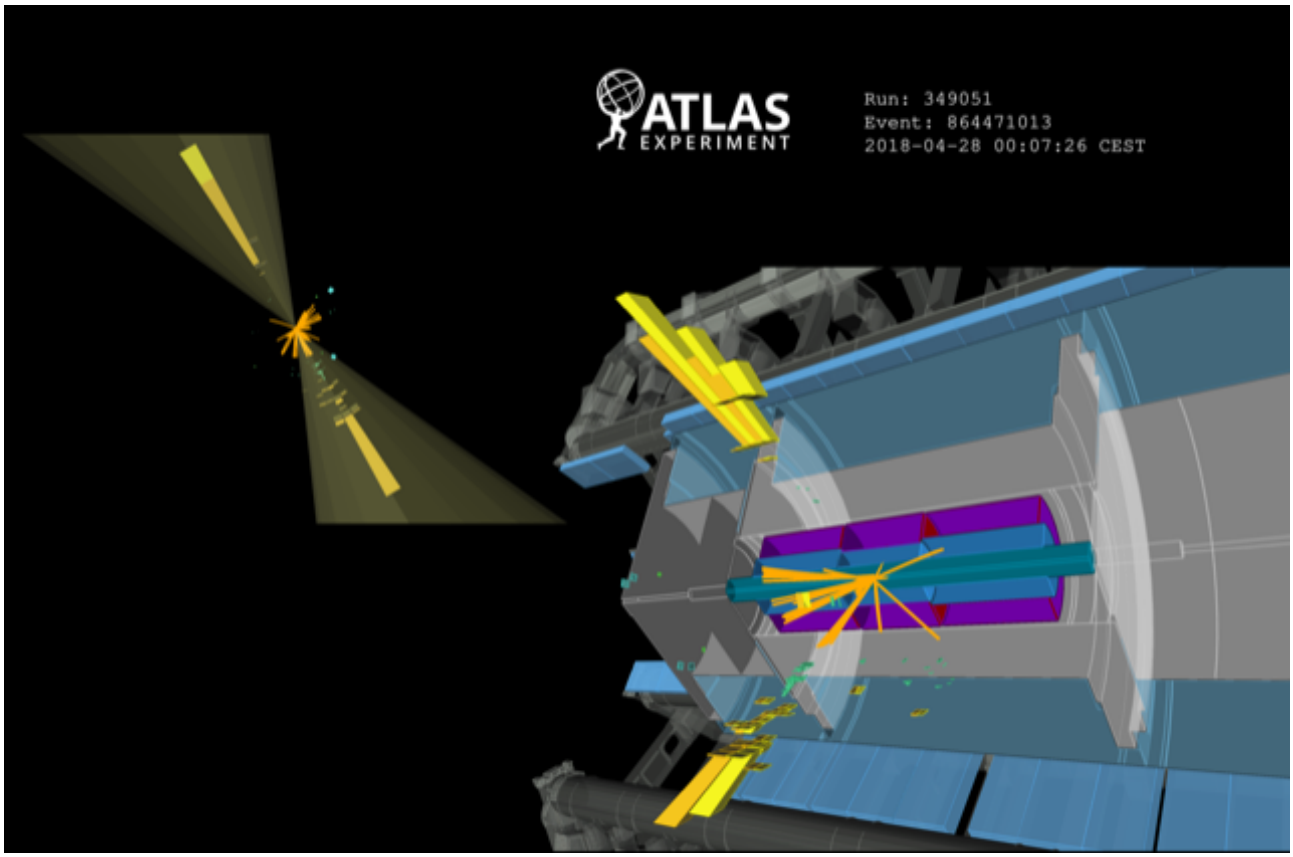

Fig 0: Visualisation of a real ATLAS data event for a candidate long-lived particle signal event leading to two displaced, trackless jets.

Exotic long-lived particles (LLPs) occur in many well-motivated extensions to the Standard Model (SM) of particle physics, and could explain the nature of Dark Matter (DM), solve the hierarchy problem, and explain the origin of neutrino masses. However, LLPs could have been missed by the traditional LHC search programme to date due to their non-standard energy deposition patterns, which would often be thrown away as noise by standard reconstruction techniques. LLP signatures could be hiding in the “Blind Spot” of LHC searches! Searches for these unusual signatures could be a novel route to a groundbreaking discovery.

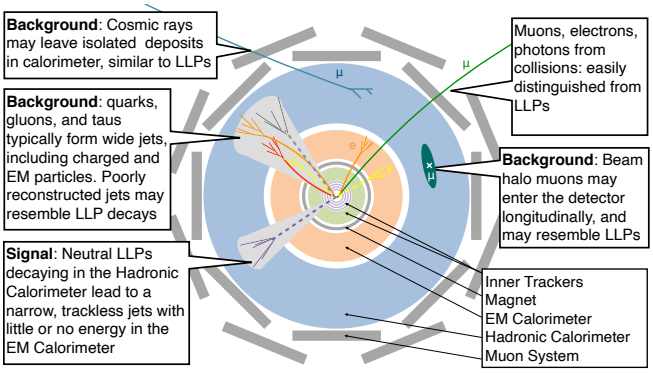

Fig 1: A simplified transverse view of the ATLAS detector showing a LLP decay in the hadronic calorimeter, with example of main backgrounds.

But with unusual signals, come also some unusual backgrounds. As shown in Fig 1, one of the chief backgrounds which LLP searches have to contend with is "beam induced background" (BIB), which is caused by the interactions of the LHC protons with, for example, collimators upstream of the detector. These cause a "halo" of muons travelling in parallel to the beam which can mimic displaced activity: just like long-lived signals. Finding new ways to control this background will be a key challenge in the years to come in order to make progress in the LLP parameter space. Thankfully, new tools are being developed which could help to address this background. The High Granularity Timing Detector (HGTD) upgrade of ATLAS will be a new type of detector, with unprecedented timing resolution in the forward region. The HGTD is one of the LPC ATLAS group's key hardware activities.

The objective of this internship project will be to determine how one could use the HGTD to reject beam-induced background, with the view of designing a new search for LLPs. The first step will be to derive a strategy to match beam-induced background particles to displaced jets or vertices in the forward region, and use the HGTD's timing information to distinguish them from signal hits. From there, we will estimate the proportion of LLP decays which occur in the the HGTD acceptance in a typical benchmark model, and will design a search strategy which could be implemented once the HGTD is installed. We will estimate the lifetime coverage and possible sensitivity of such a search. This information will be extremely valuable to determine the direction of the ATLAS LLP programme, as well as showcase HGTD's capabilities.

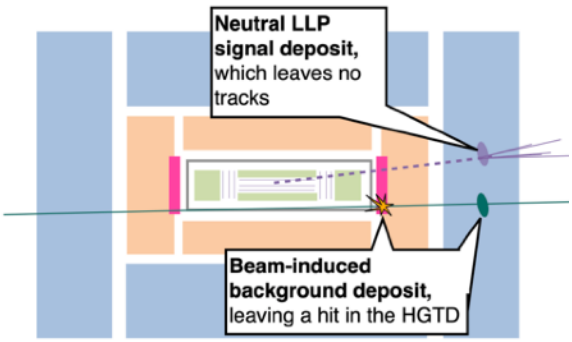

Fig 2: A simplified longitudinal view of the ATLAS detector showing a LLP decay and a BIB deposit, leaving a hit in the HGTD.

Students applying to this internship should have strong skills in python (or other major computing language), a good knowledge of high energy physics, and a willingness to develop and test new ideas.

This project is part of Dr Corpe's plan to open a new avenue of research for LLPs within the LPC ATLAS group. This internship could therefore lead into a PhD in long-lived particles funded directly by Dr. Corpe's Chaire Professeur Junior package.