1 A trigger for disappearing tracks

Project leader: Laura Jeanty
Contact person on organizing committee: Laura Jeanty

ATLAS currently uses a MET trigger at level 1 and HLT in the disappearing track search, which has an efficiency of around 20-30%. If we could identify short tracks already at the HLT level, we could in principle increase the trigger efficiency. However, ATLAS does not have the resources to run full-event tracking at the HLT. Can we use the kinematics of the chargino-charigno or chargino-neutralino system to identify a region of interest in which a short track is likely to be found? If so, we may be able to run some tracking in a small geometric cone at HLT, on some events that pass the L1 MET. How efficiently can we identify the region of interest of a short track based on the L1 jets/MET in the system? How narrow can the region of interest be?

2 Targeting Forward LLPs with Run IV Technology

Project leader: Jared Evans
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Both ATLAS and CMS will install powerful new detector systems for Run IV in the forward region. The High Granularity Timing Detector layer at ATLAS in the pseudorapidity range of 2.4 to 4.0 will have square mm cells with 30 ps timing resolution. The CMS endcap calorimeter in the pseudorapidity range of 1.5 to 3.0 will have unprecedented sensitivity both in spatial resolution, with 52 individually read-out sampling layers, and in timing resolution, where 25 ps resolution is projected, which together allow for 4D shower reconstruction. Although designed with pileup mitigation in mind, the exceptional timing of these detectors, and, in the case of CMS, the finely segmented positioning, provide unique opportunities for long-lived particles. Signatures from light long-lived particles, heavy stable charged particles, SIMPs, displaced jets, emerging jets, quirks, and more can be targeted in new ways with these detectors. This project will examine the new LLP opportunities afforded by these detectors, both in search design and triggering capabilities, and attempt to determine the options which are viable and which could exceed the sensitivities achievable via the existing search strategies.

3 Fine tuning LHCb to increase its sensitivity to LLPs

Project leaders: Xavier Cid Vidal, Yuhsin Tsai
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The special features of LHCb make it quite unique to discovery certain well motivated types of LLPs, in particular those with masses below O(30 GeV), the mass depending on the final state searched for. Examples of this are LLPs from dark sectors decaying to jets or semi-leptonically or dark photons decaying to leptons.

However, we feel that LHCb has been under-studied when it comes to LLP signatures and there is a lot of room to make progress. This involves both not only using the existing data to propose new searches or developing new trigger strategies, but also profiting the planned upgrade(s) to modify slightly certain features of the detector in our favor.

We give two concrete examples to focus in the workshop and that would help to further exploit LHCb for LLP searches.

- Exploiting exclusive charm decays: When searching LLP that decays hadronically, QCD background usually limits the sensitivity, and either hard energy cuts or heavy LLP mass is required to do the search. However, if the search only focus on clean decay channels instead, such as the LHCb B0 $\to D^+D^-$ search (1608.06620) that targets on D-mesons decay into charged tracks, the good D-meson reconstruction and invariant mass measurement allows a much lower background for the $<$ 10 GeV LLP (B0-meson) search. It therefore is interesting to explore different hadronic decay channels from LLP decays, and see if search on more exclusive final states can cover scenarios that is unexplored by the more inclusive search, even with a penalty of BR suppression. Something similar could be conceived for exclusive bottom decays.

- Disappearing tracks: the absence of a magnetic field in the region of the Vertex Locator (the tracking region closest to the interaction point) makes this signature almost impossible to detect at LHCb. One could consider which kind of magnetic field and in which space region could improve the sensitivity to disappearing tracks. Furthermore, the proposal to add tracking stations in the magnet region during the phase II upgrade could also help in this regard.

Apart from these, we would be open to other new bold ideas, that will hopefully arise by gathering a wider audience in the kind of friendly atmosphere foreseen at the workshop.

4 Precision Timing for LLP: Triggers and physics reach

Project leader: Si Xie
Contact person on organizing committee: Zhen Liu, Yangyang Chen

Recent proposals to equip the CMS (`https://cds.cern.ch/record/2296612`) and ATLAS (`https://arxiv.org/abs/1804.00622`) detectors with hermetic precision timing capability for the HL-LHC upgrade motivate new ideas on the application of precision timing on searches for long-lived particles. Time-of-flight measurements with a precision of a few tens of picoseconds can significantly enhance the discovery reach for both charged and neutral long-lived particles, and in specific scenarios uniquely enable the reconstruction of the LLP mass resonance via measurement of its time-of-flight.

To realize the full potential of the new precision timing information for LLP searches, we would like to gather experts in the field to work on the trigger possibilities with precision timing. The aim would be attempting to come up with new trigger strategies complements current trigger system, which mainly aims at selecting hard prompt interactions, in both technical feasibilities and terms of potential physics gains in a broad class of representative models (e.g., `https://arxiv.org/abs/1805.05957`).

5 New subdetectors for enhanced LLP sensitivity

Project leader: Andy Haas
Contact person on organizing committee: David Curtin

The long shutdown before HL-LHC running presents an opportunity to install additional (modest in scale) subdetectors or detector enhancements to one or more LHC experiments, that could significantly enhance the sensitivity to LLPs, either by increasing efficiencies or rejecting backgrounds. (They may also aid other physics object reconstruction at the detectors, as a side-benefit.) One example may be active punch-through veto layers on the outside of a calorimeter, to reduce the main background to displaced decays in the muon system (see `https://arxiv.org/abs/1203.1303`). Another strategy would be to equip the muon system with some simple calorimetry to aid in signal vs background discrimination. We could study the amount and type of shielding / detectors necessary to reject backgrounds sufficiently, and estimate the impact on the sensitivity of the search. We could also consider other new ideas for new (sub)detectors.

6 Explore trigger potential of CMS Tracker Pt-Modules

Project leader: Yuri Gershtein
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The phase 2 upgrade of CMS detector will use silicon tracker hits for the first level trigger decisions. Only the hits in the outer tracker (radii 20-110 cm) consistent with being made by particles with pT>2 GeV will be available. This feature allows for reconstruction of all tracks with pT>2-3 GeV for every proton collision at the HL-LHC. Preliminary studies indicate that displaced track reconstruction (d0 up to 5 cm) is feasible, enabling new trigger strategies, for example, for $h \rightarrow aa \rightarrow 4$ jets, where a is a long-lived scalar. It is very interesting to explore other signatures that could benefit from availability of tracks at L1. Those will have low HT (<300 GeV) and no leptons with pT > 15-20 GeV. Possible examples include rare Higgs decays (exotic, or rare exclusive ones, like phi+gamma), compressed spectra, etc.