Track Triggers for Exotic Signatures at the LHC

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Track Triggers and Exotic Signatures

Currently, it is impossible for the LHC to save all LHC events. The trigger is a system that quickly decides what events must be saved in real time and which to throw away.

Unconventional tracks are the most distinct feature of exotic signatures and currently, it is hard to trigger on them without tracking info. By 2027, the high luminosity LHC will have a track trigger and our goal is to design track triggers for these exotic signatures.

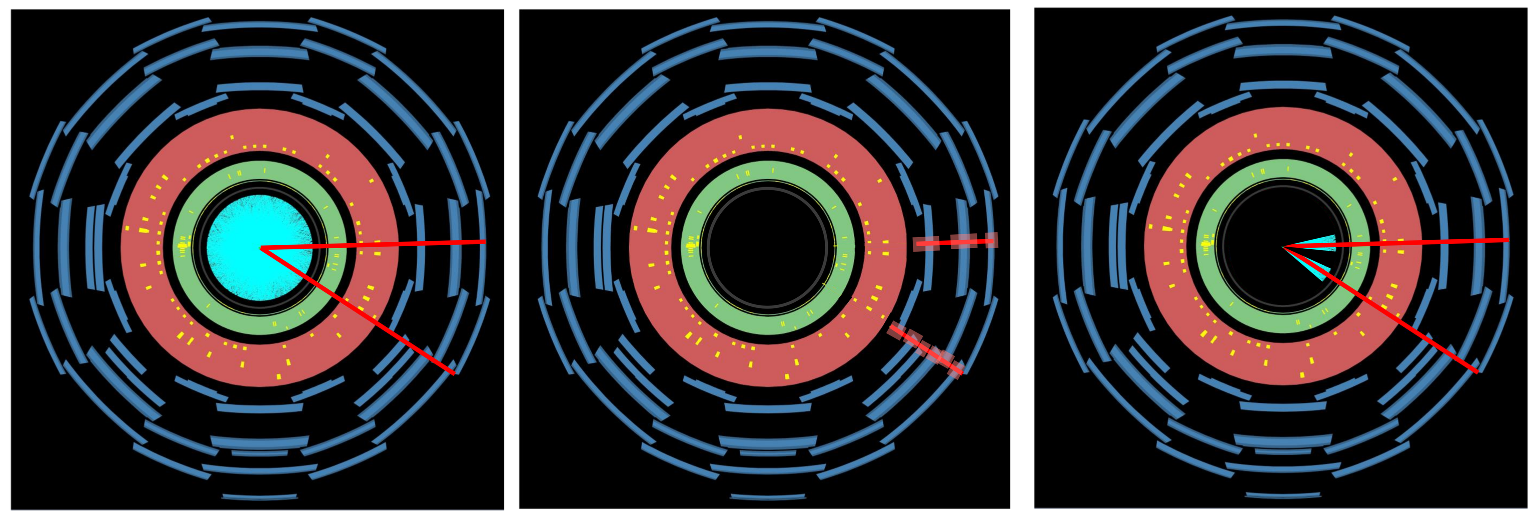


Fig 1: A representation of multiple triggers. The first is a full event reconstruction. The second is a Level 1 (L1) where it is hardware based and has coarse muon and calorimeter information which keeps 1/400 events. The third is a High Level Trigger (HLT) that is software based and adds limited tracking information which allows it to keep 1/100 events

The signatures I am studying, are heavy meta stable charged particles. We want to study efficiencies of different track trigger configurations and identify the most promising ones.

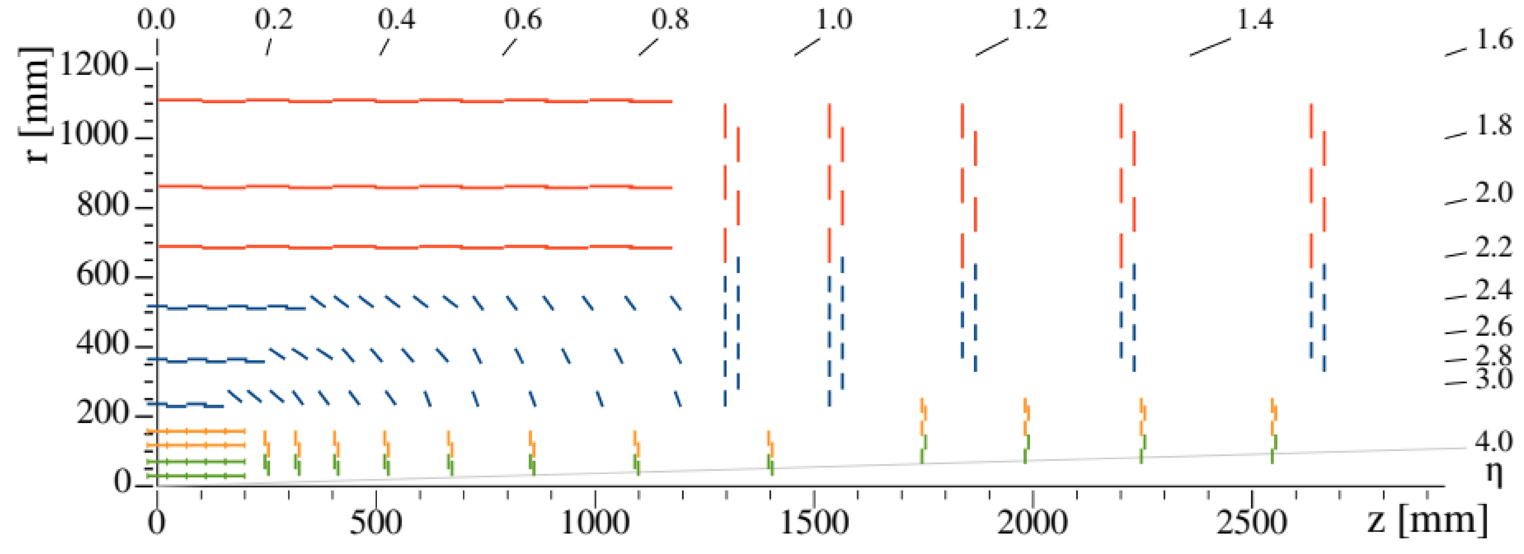
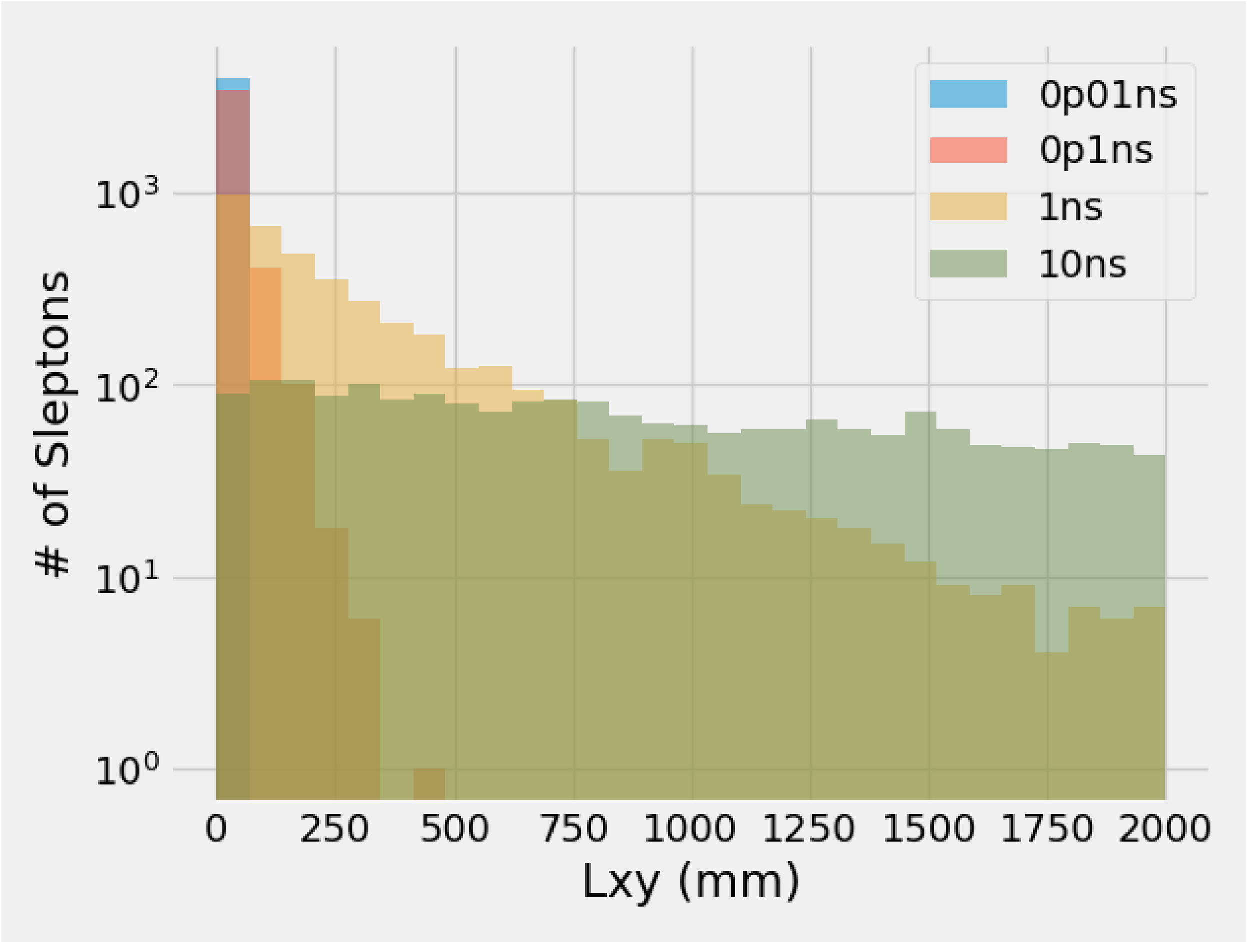


Fig 2: Sketch of one quarter of the tracker layout in r-z view. The Inner Tracker green lines correspond to pixel modules made out of readout chips and the yellow lines to pixel modules with four redout chips. In the Outer Tracker, the blue lines are a double layer formed of one layer of pixel and one layer of strips. The red layer is formed of two layers of silicon strips

Simulation of Heavy Stable Charged Particles

We used MadGraph to simulate long lived particles. MadGraph is a Monte Carlo event generator. We studied long lived particles with masses from 100 – 600 GeV and lifetimes varying from 0.01ns to stable. From there, we study potential track trigger selections based off of CMS's design.



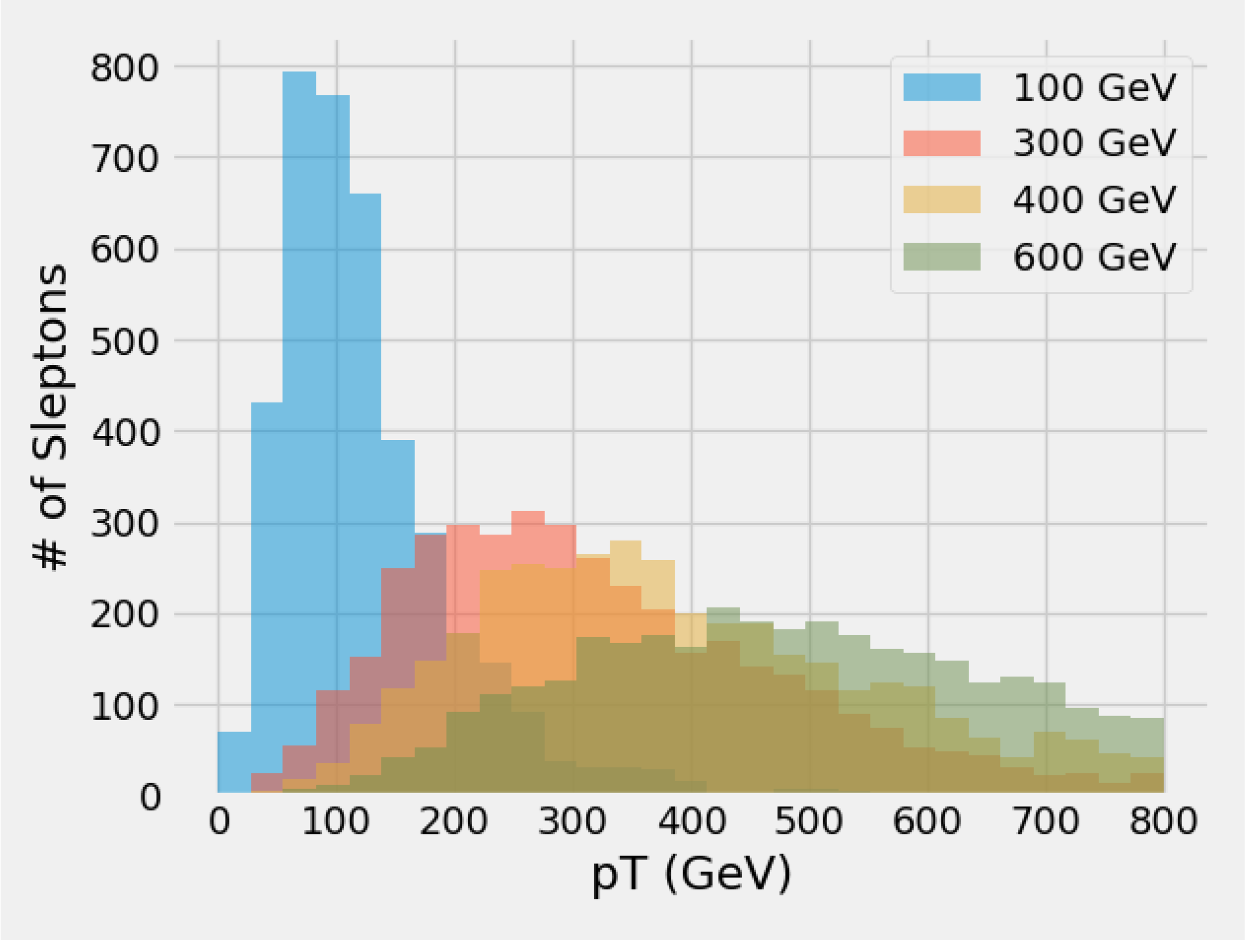


Fig 3: A plot representing sleptons of different lifetimes. Each slepton is recorded in how far they travel, with the shortest lifetime not traveling far away from the track trigger and the highest lifetime, having more traveling further

Fig 4: A plot representing sleptons and their momentum, with low mass having numerous sleptons at low momentum and higher masses having a more evenly distributed momentum

Results

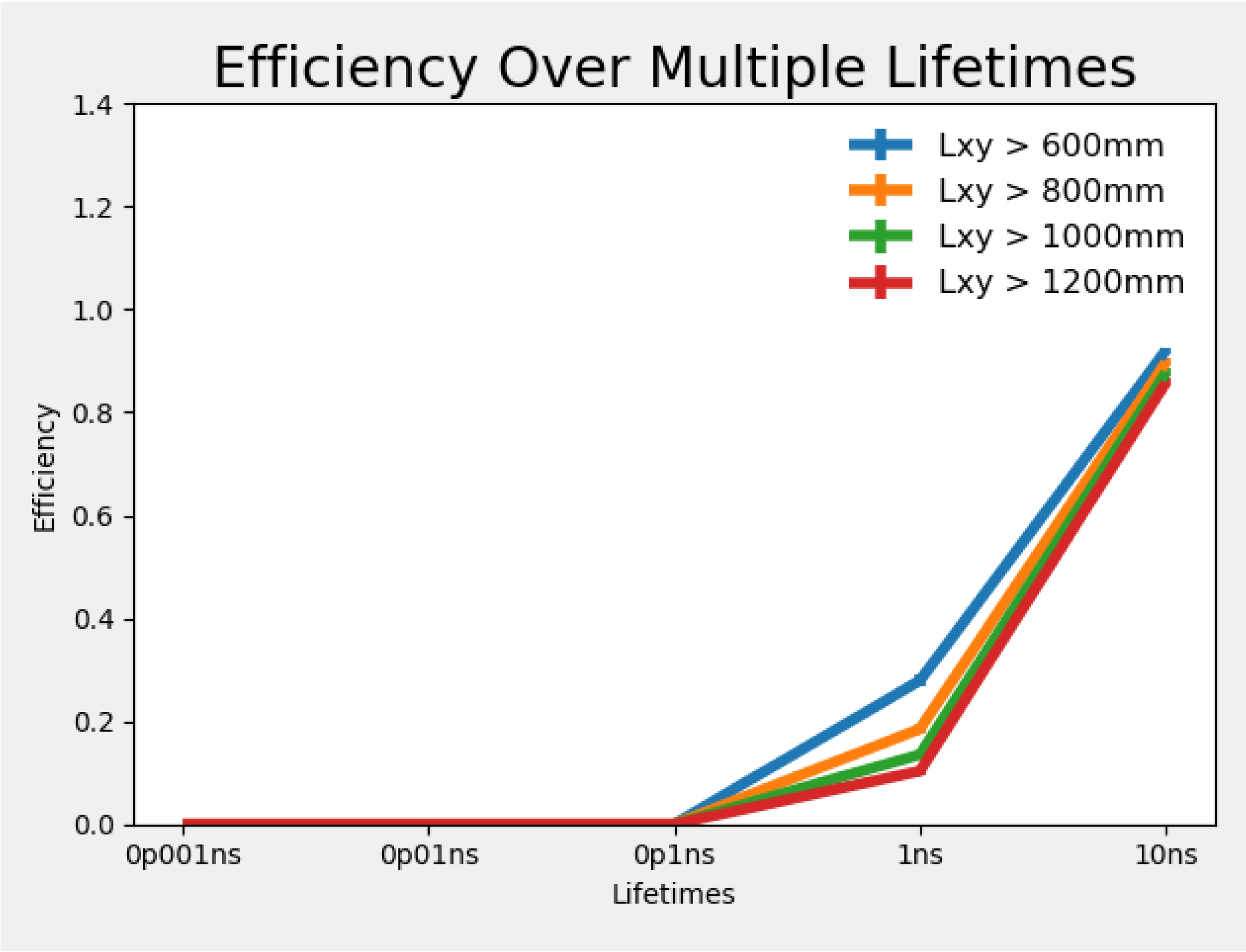


Fig 5: A plot representing how many sleptons for each event pass through each cut under certain conditions. Efficiency goes up to 100% with higher lifetime sleptons having the highest efficiency.

Running the simulations, we can see that the properties of the long-lived particles follow what we assume from them. If we reduce the number of layers required per track, this is equivalent to reducing the minimum Lxy that we require, there is an improvement of a factor of 4x for 1ns and 10ns lifetimes.

Future Steps

For the future, we plan to use tracking delay to find long lived particles since they will move and decay slower than other particles, along with looking for more promising strategies for track trigger configurations. We plan to use full CMS simulation to then study the exotic signatures and backgrounds.

Acknowledgements

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