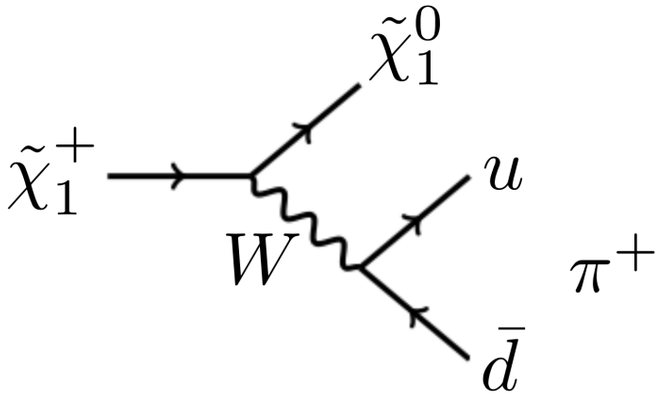
Introduction to the long-lived particles long exercise

Search strategy



- pion: too soft to be reconstructed

mass splitting: $\Delta m = m(\tilde{\chi}_1^{\pm}) - m(\tilde{\chi}_1^0)$

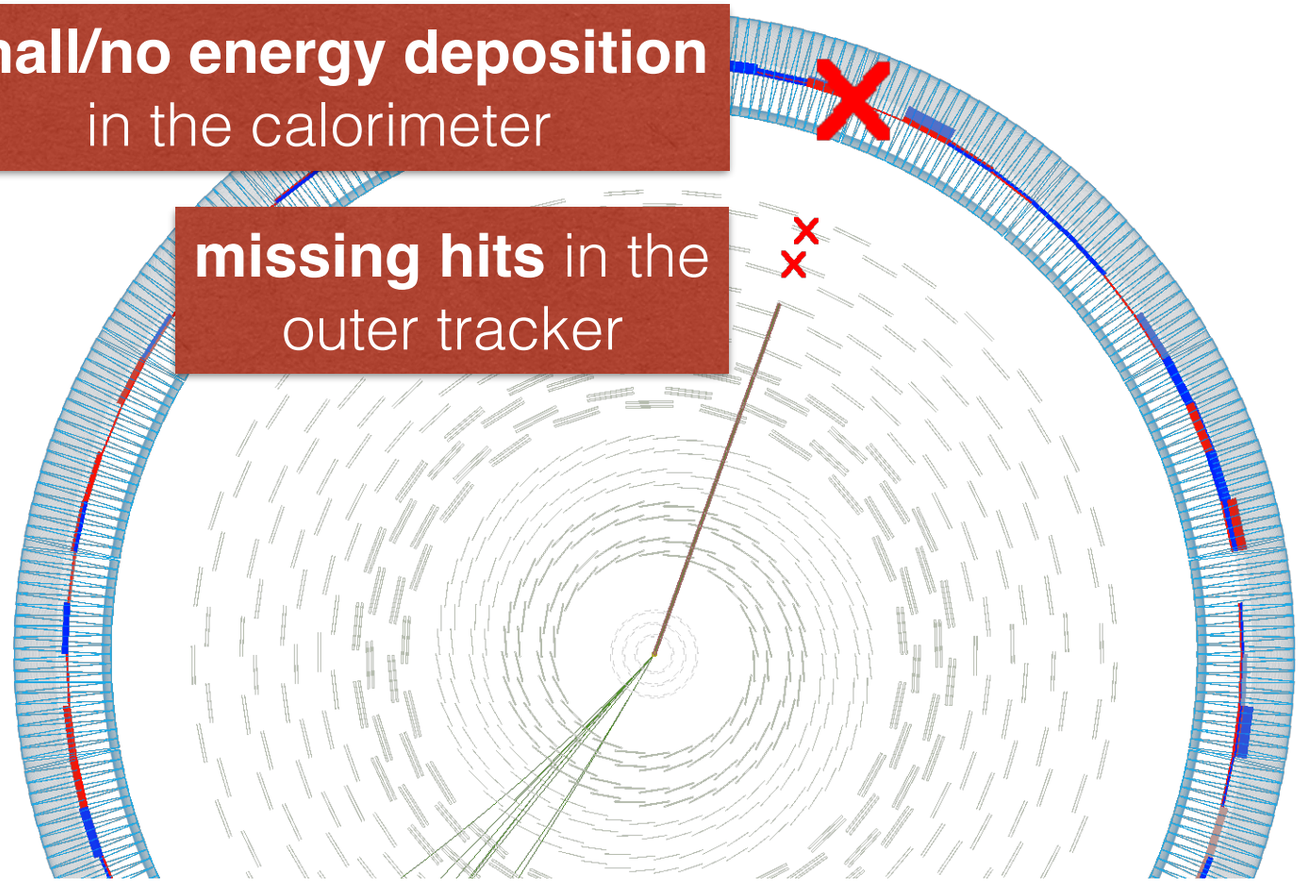
- $m_\pi < \Delta m \lessapprox 200$ MeV: **disappearing track visible in tracker**
- $\Delta m \gtrapprox 200$ MeV: decay before first tracking layer

signature:

no associated **muon hits**

small/no energy deposition in the calorimeter

missing hits in the outer tracker

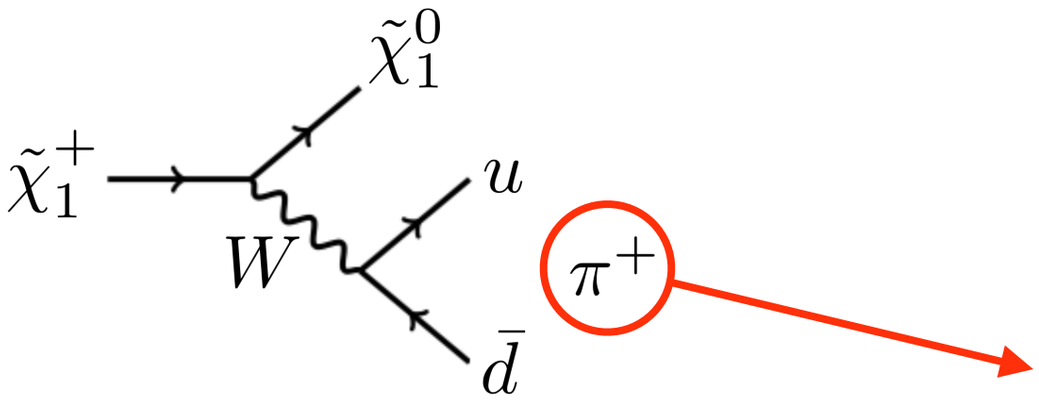


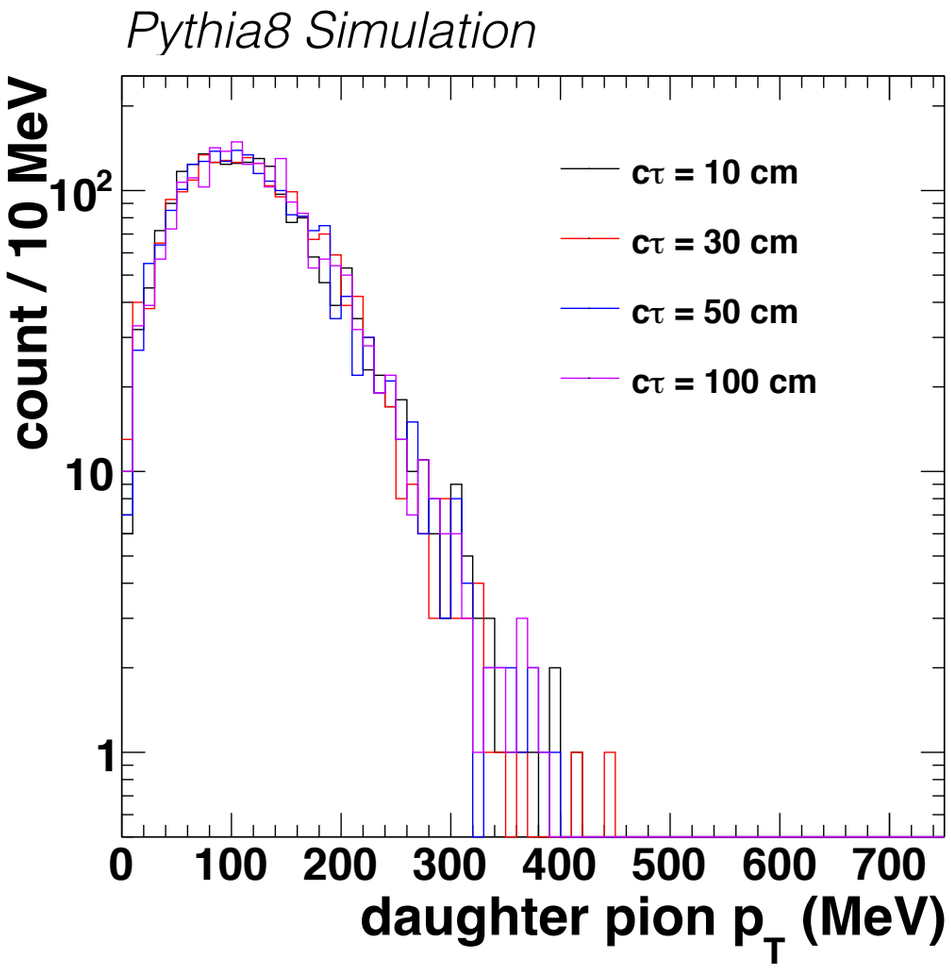
need to suppress background from

- fake tracks
- tracks from failed lepton reconstruction

Illustration: Andrew Hart et al. (OSU)

Search strategy





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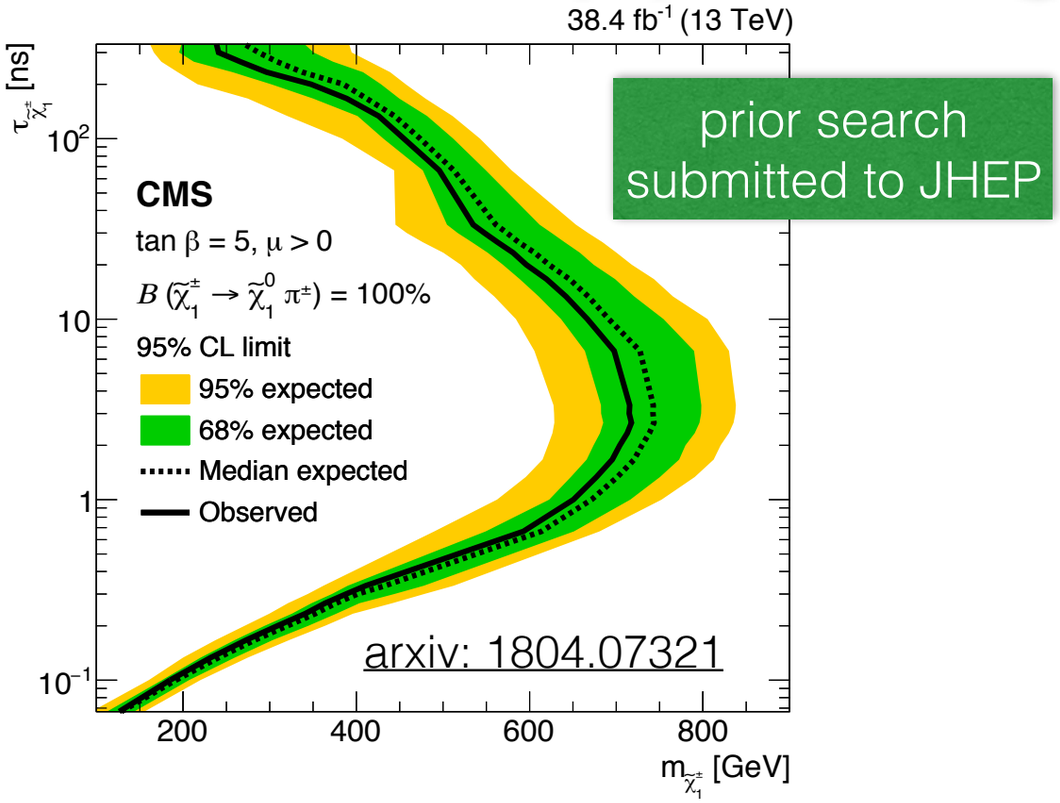
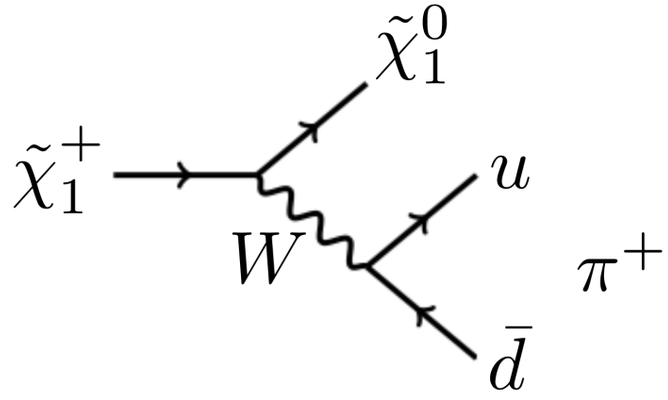
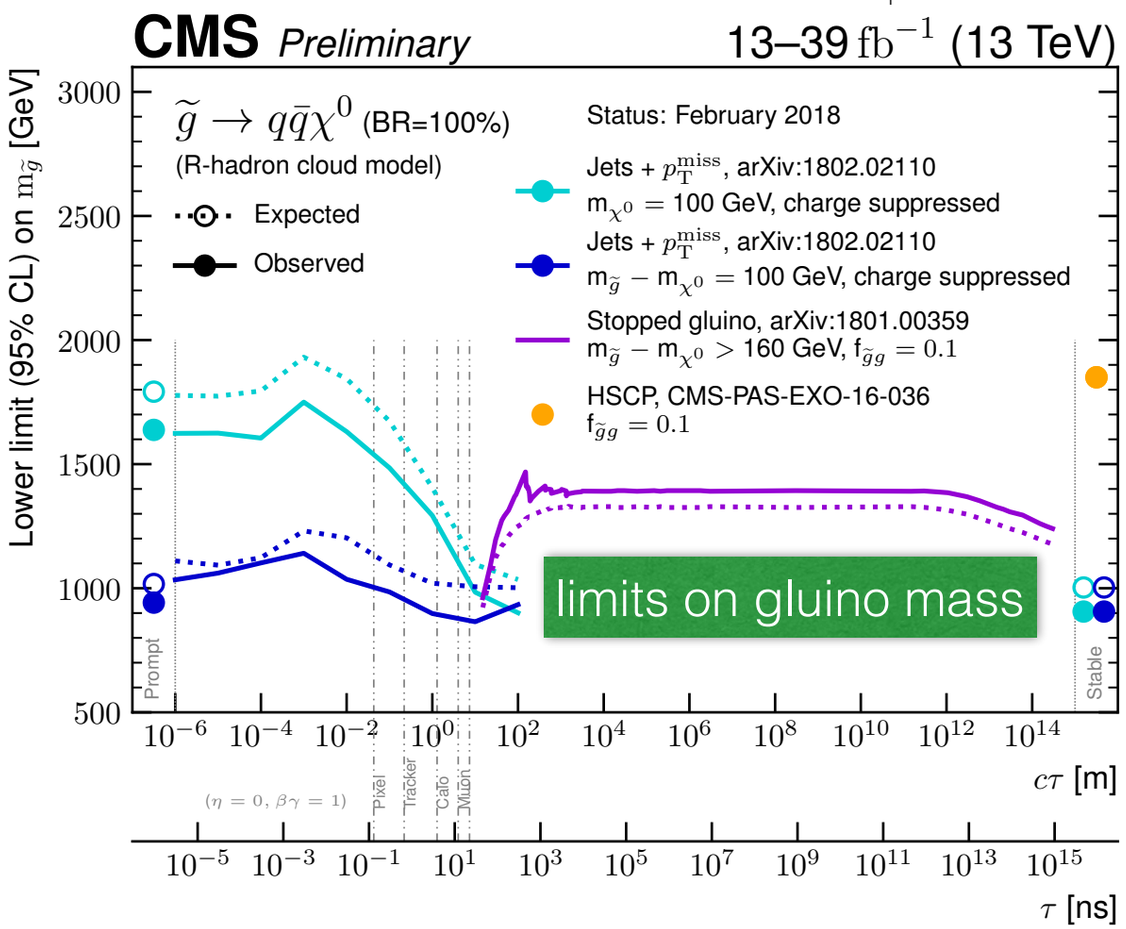
Disappearing track signal



prior search submitted to JHEP



signal generation with Pythia8:
strong chargino production through
$gg \rightarrow \tilde{g}\tilde{g}$

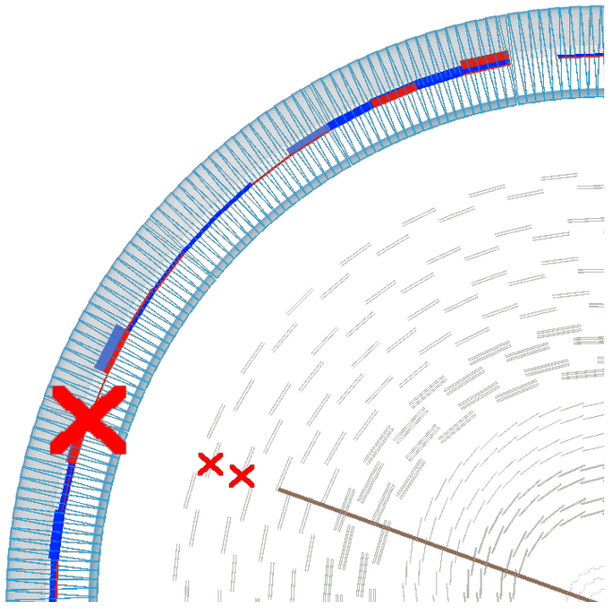


limits on gluino mass

- m($\tilde{g}$) = 1800 GeV
- m(chargino) = 1400 GeV
- Δm = 180 MeV
- cτ = 10, 30, 50, 100 cm

include models from pMSSM scan for event selection

Tagging disappearing tracks



relevant track properties:

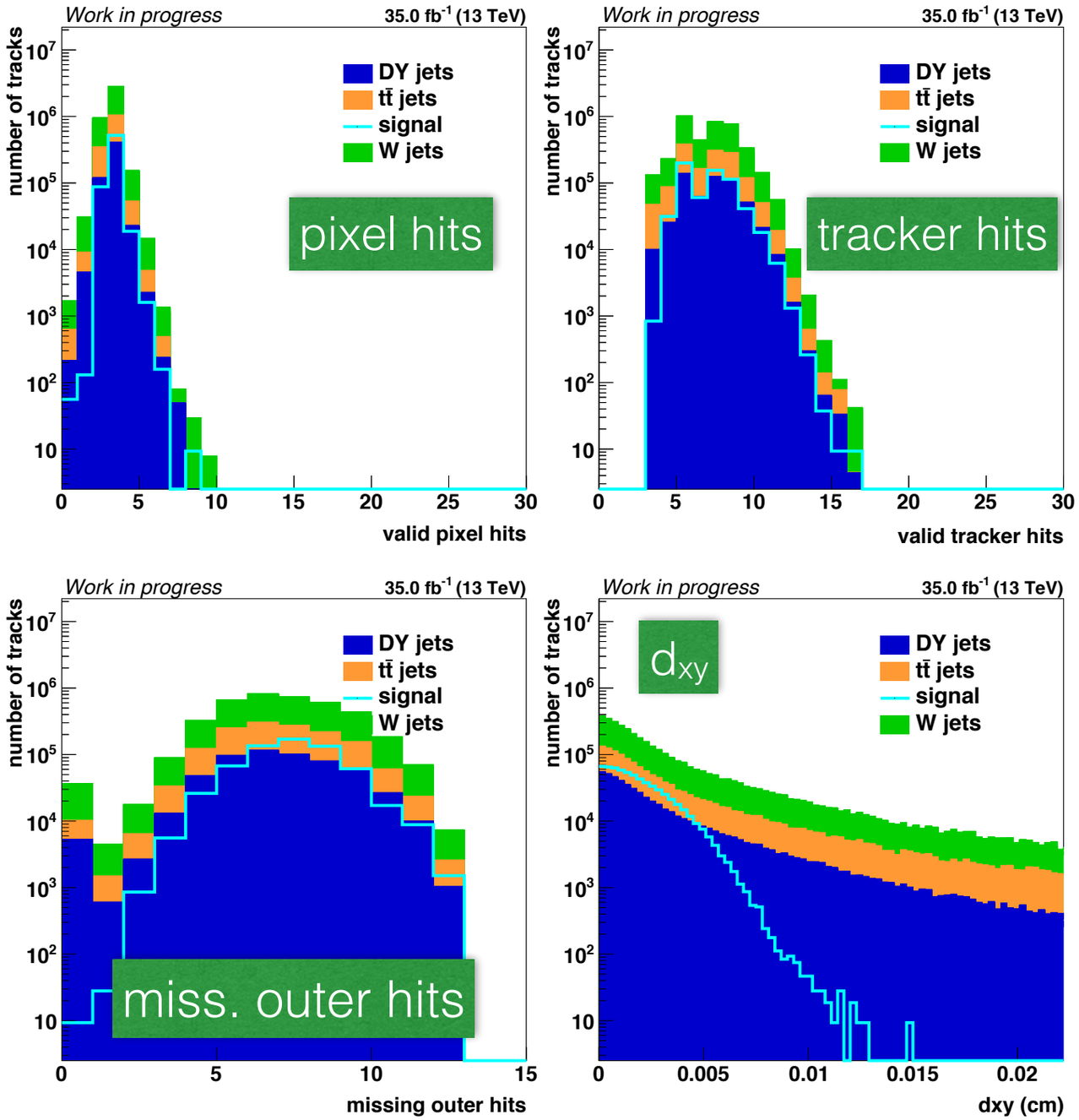
- number of pixel / tracker hits
- missing inner / middle / outer hits
- distance to primary vertex (d_{xy}, d_z)
- χ^2 / ndof
- $\Delta p_T / p_T^2$
- high purity track quality
- deposited energy in calorimeter within cone of $\Delta R < 0.5$

- avoid **model dependence** by too tight cuts on p_T, η, or isolation

(Some) tracking variables

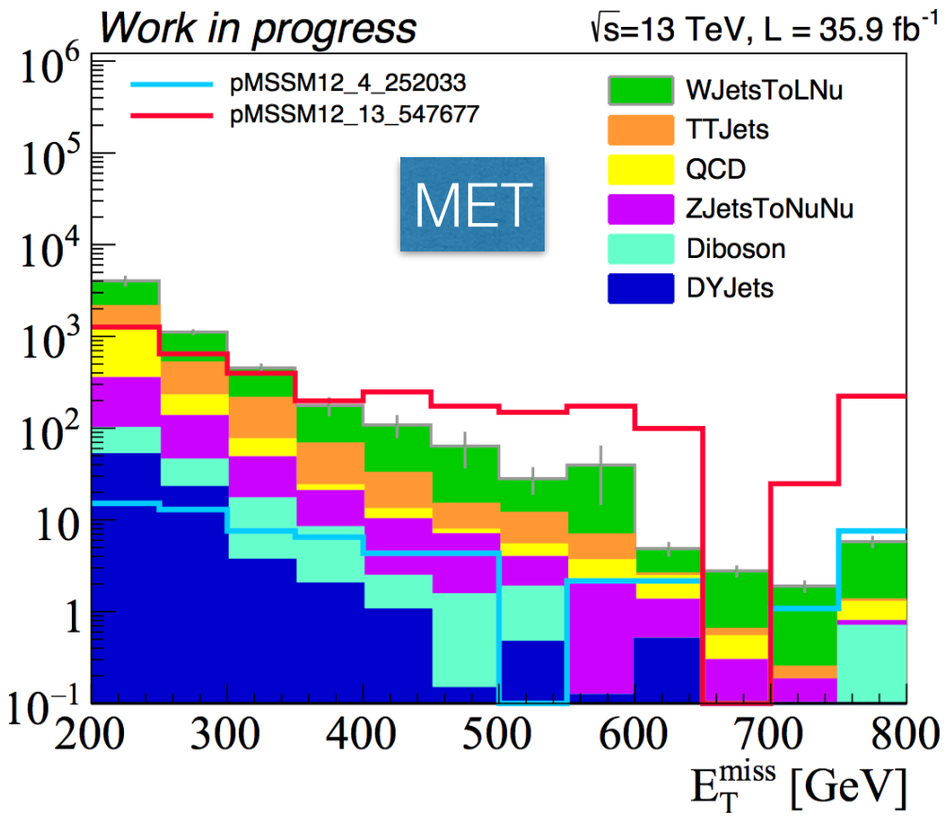
track variables after applying a basic preselection including a **reconstructed lepton veto & no missing inner hits**:

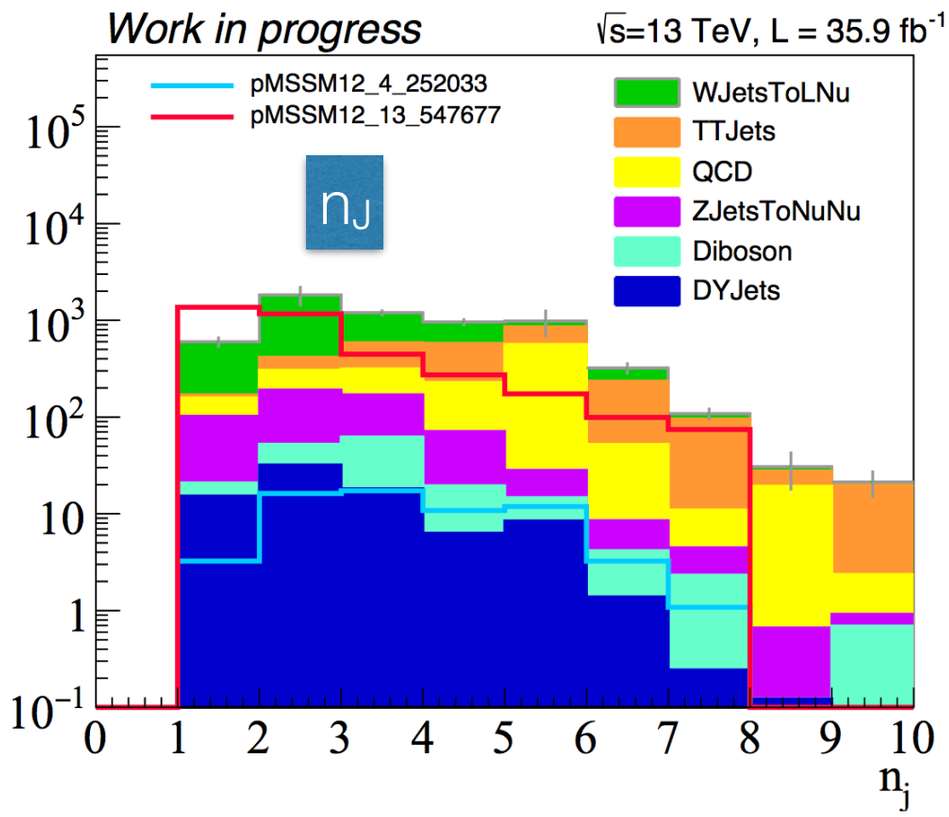
medium tracks, signal scaled to 100 pb



Event topology

- use **disappearing track tag** for event selection
- look at **event topology** variables

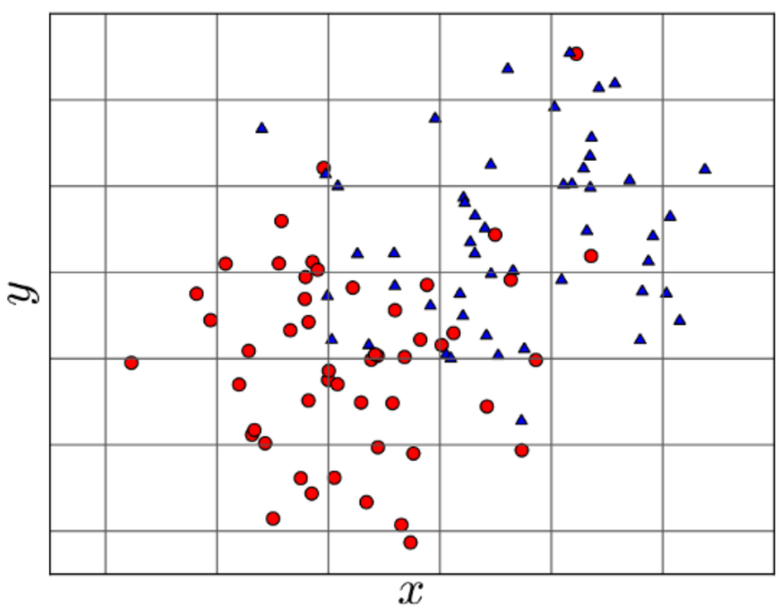




Optimization methods

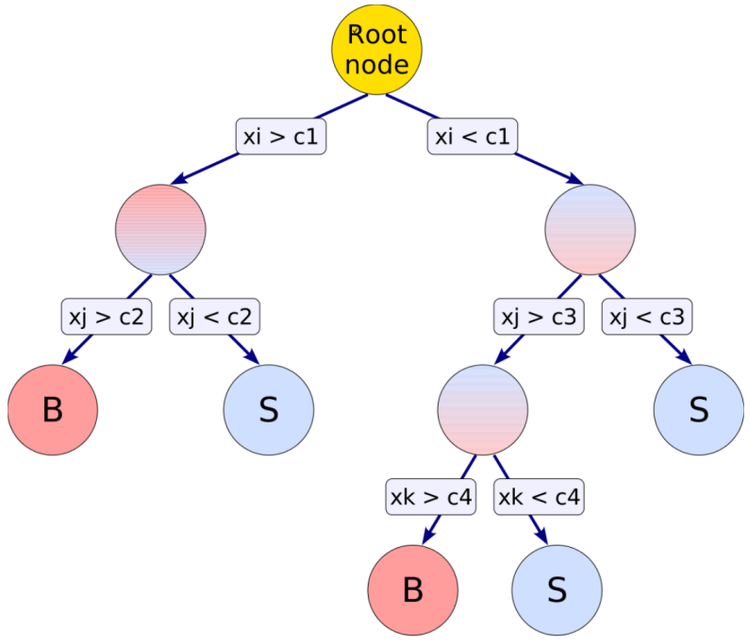
- **random grid search (RGS)**: find optimal cuts via importance sampling, focus on signal-like regions rather than entire phase space
- **boosted decision tree (BDT)** using TMVA

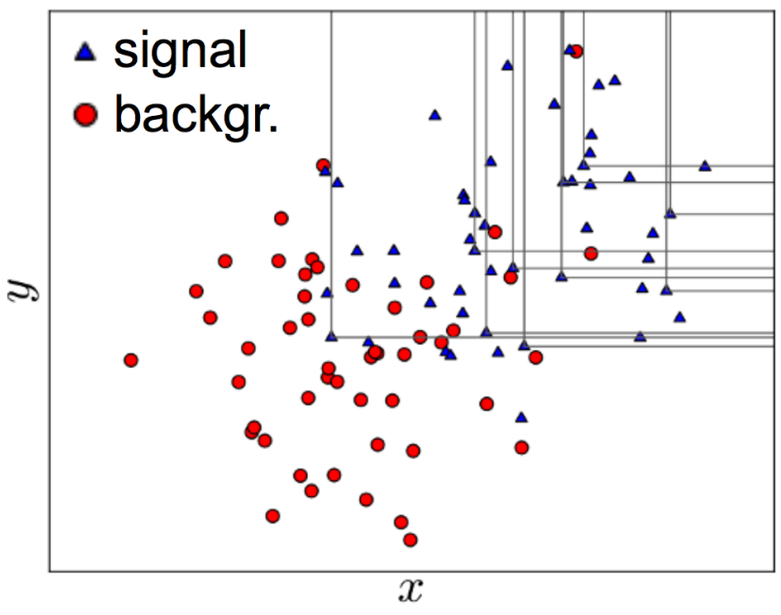
random grid search



arxiv: 1706.09907

BDT





both methods:

select best cuts by maximizing significance $s/\sqrt{s+b}$

BDT illustration by Böser, Fink, Röcker (KIT)

Today's exercise

today:

- take a closer look at tracking variables
- construct disappearing track tag using a BDT
- define signal regions with RGS for event selection

tomorrow:

- background estimation methods for
  - prompt background
  - fake track background
- systematic uncertainties, derivation of expected limit

Today's exercise

- start here: **https://github.com/ShortTrackSusy/cmsdas**

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sbein Update README.md Latest commit 750df4d 3 hours ago

tools	update	6 hours ago
track-tag	changed tmva bg samples	3 days ago
Kappa.root	added a decoy kappa. please don't overwrite	2 days ago
README.md	Update README.md	3 hours ago

README.md

CMSDAS @ DESY 2018

Welcome to the 2018 DESY CMSDAS exercise on disappearing tracks! This long exercise will walk students through a number of steps needed to set up and implement an search for new physics at CMS. Enjoy!

Introduction

Long-lived (LL) charged particles are featured in many models of physics beyond the standard model, e.g., hidden valley theories. In particular, R-parity conserving SUSY models with a wino-like LSP usually feature charginos with proper decay lengths between 1 nm and several meters, after which point the chargino would decay into a neutralino and a very soft pion or lepton. SUSY models with a light higgsino but with particularly heavy bino and wino parameters can also give rise to charginos with similar lifetimes. The known particles do not have similar lifetimes, so the potential signal events are quite distinct from the standard model background.