

# XVIII CMS Data Analysis School

Jan 14-18, 2019 at the Fermilab LPC



“Run2 Physics”

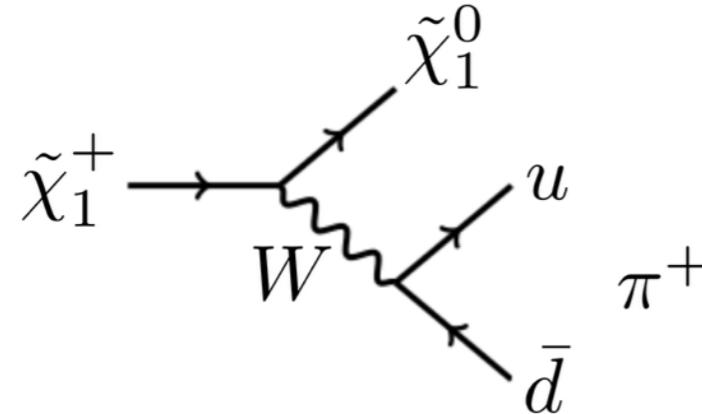


## Long Exercise: search for SUSY with disappearing tracks

Jan 16 2019

Sam Bein, Viktor Kutzner, Sezen Sekmen, Loukas Gouskos, Colin Fallon, Caleb Smith, Zhenbin Wu

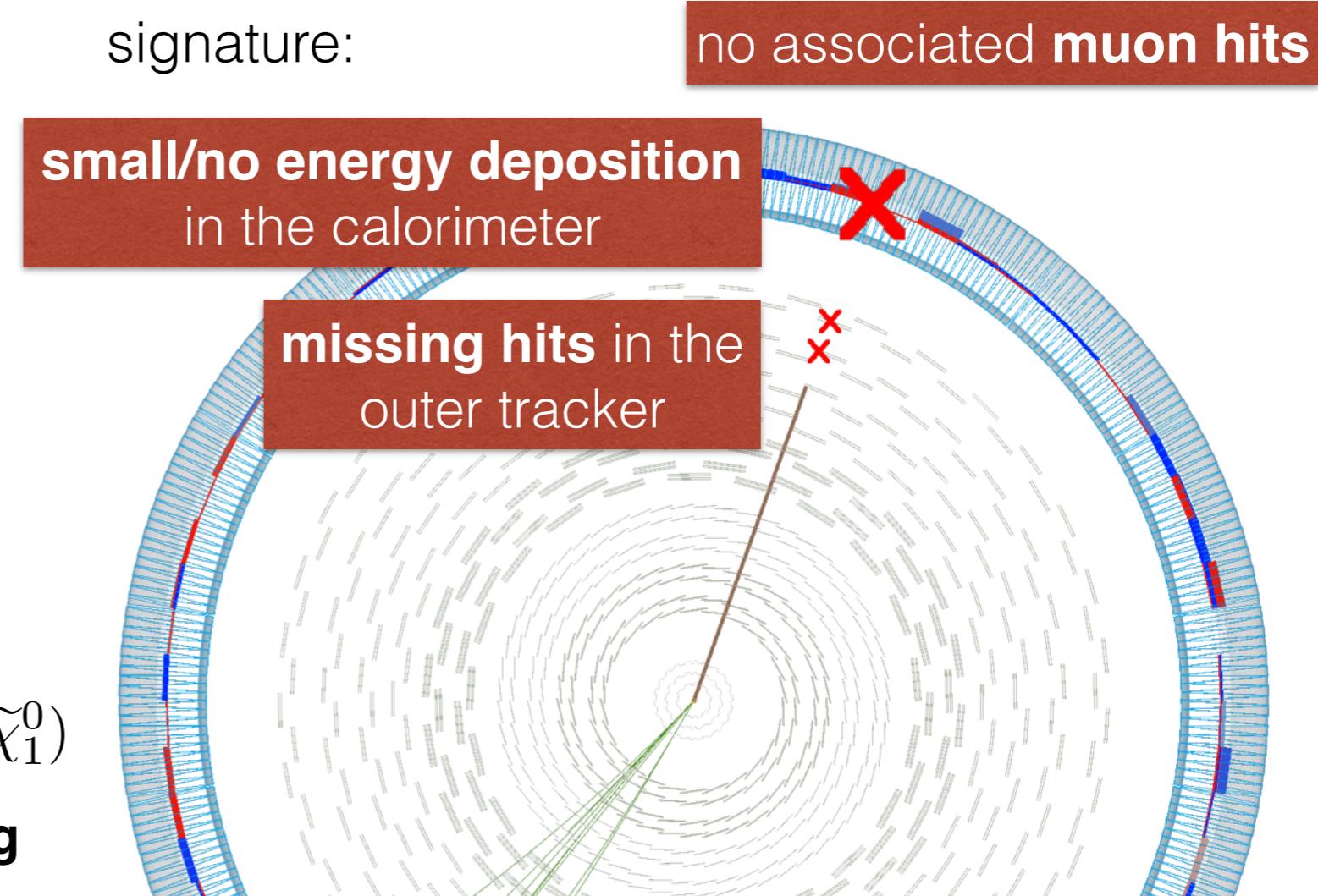
# Search strategy



- pion: too soft to be reconstructed

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

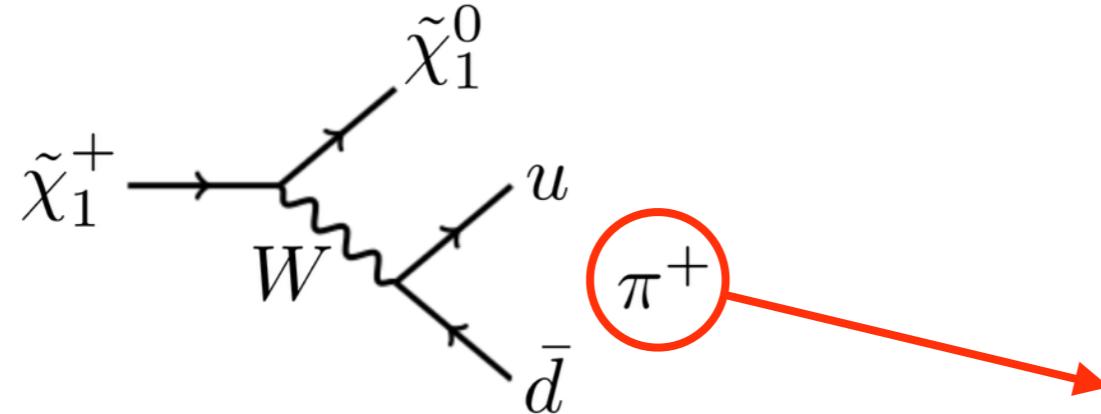
- $m_\pi < \Delta m \lesssim 200$  MeV: **disappearing track visible in tracker**
- $\Delta m \gtrsim 200$  MeV: decay before first tracking layer



need to suppress background from

- fake tracks
- tracks from failed lepton reconstruction

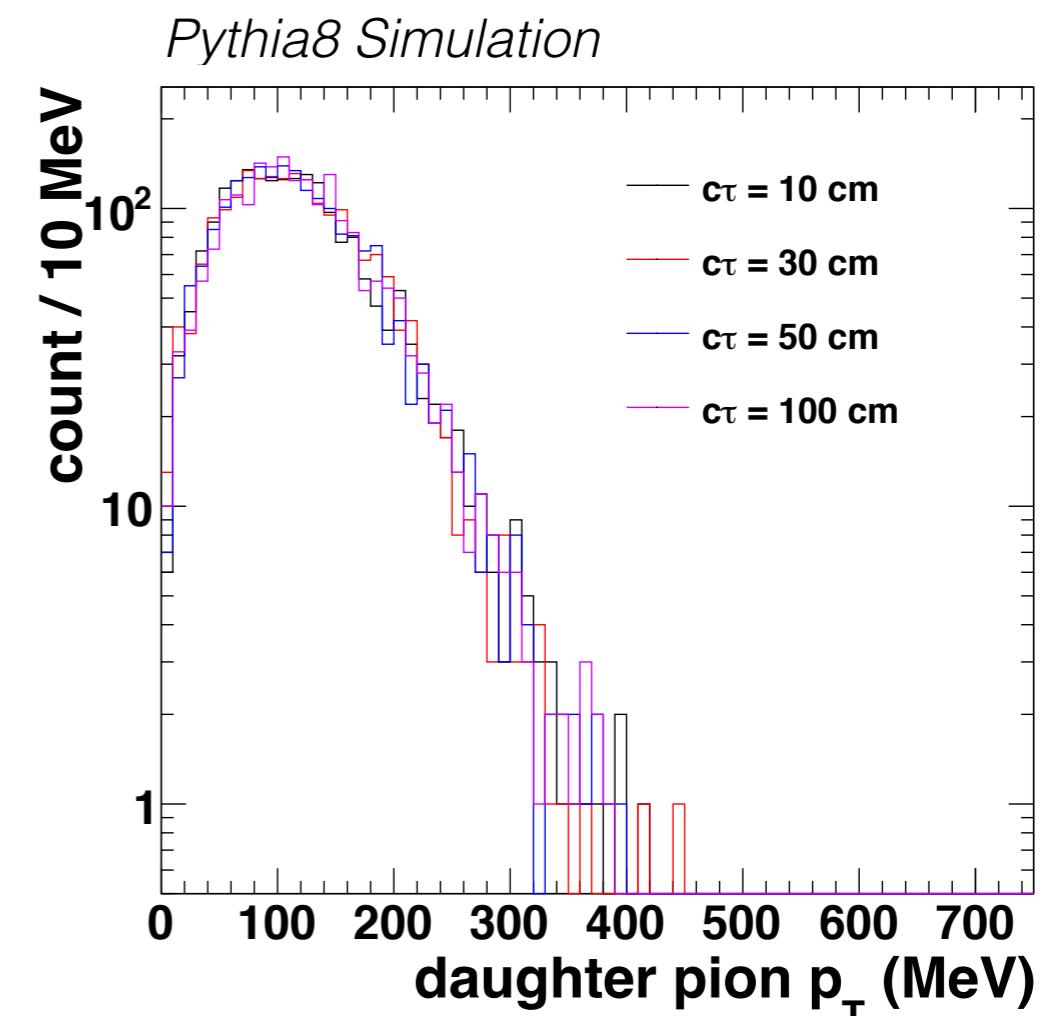
# Search strategy



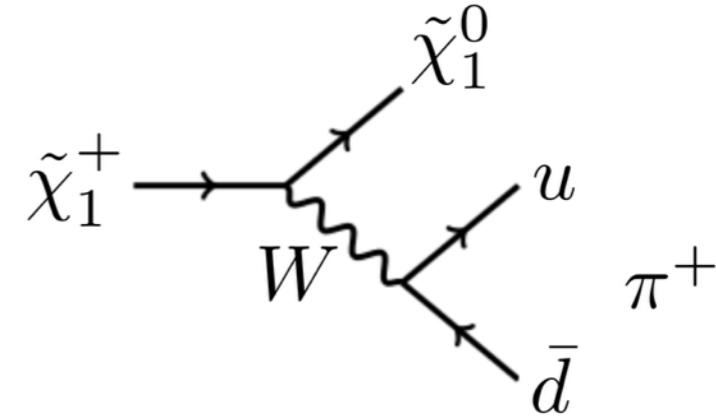
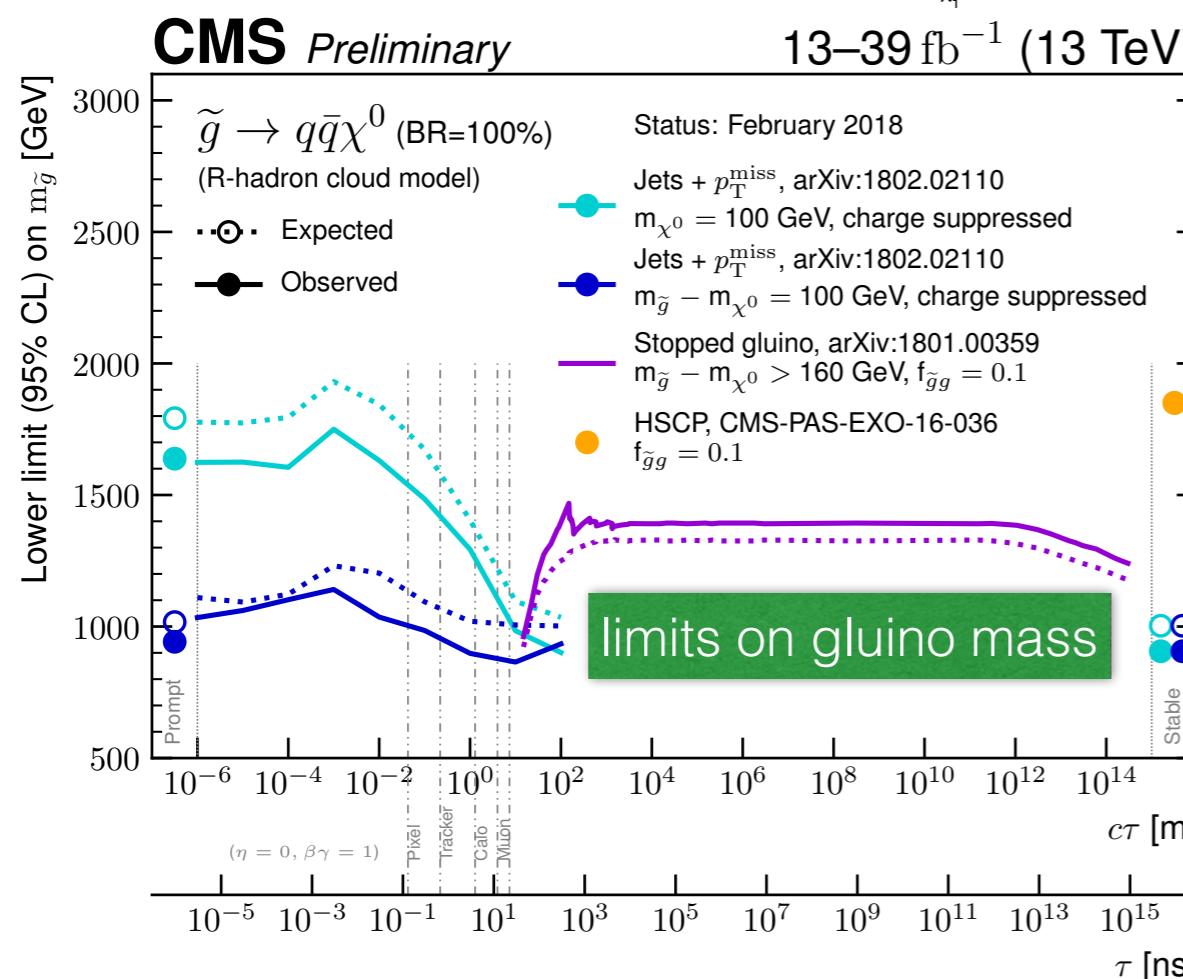
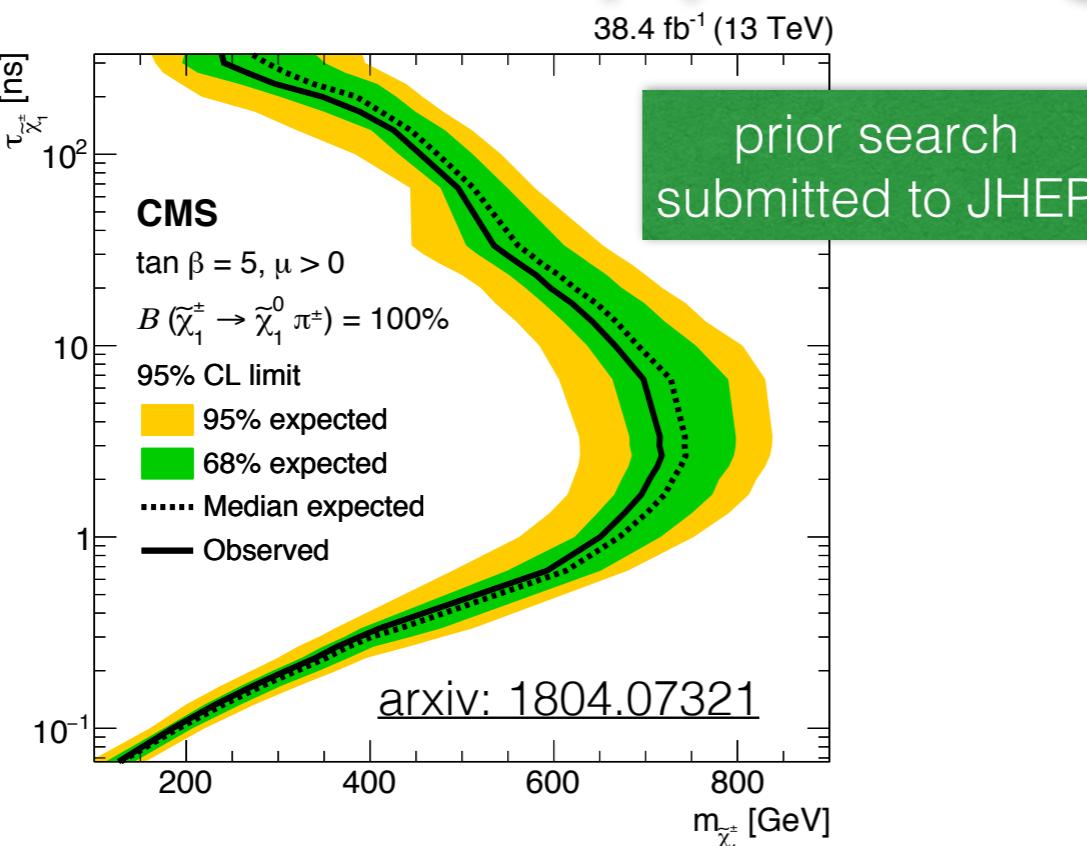
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# Disappearing track signal



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

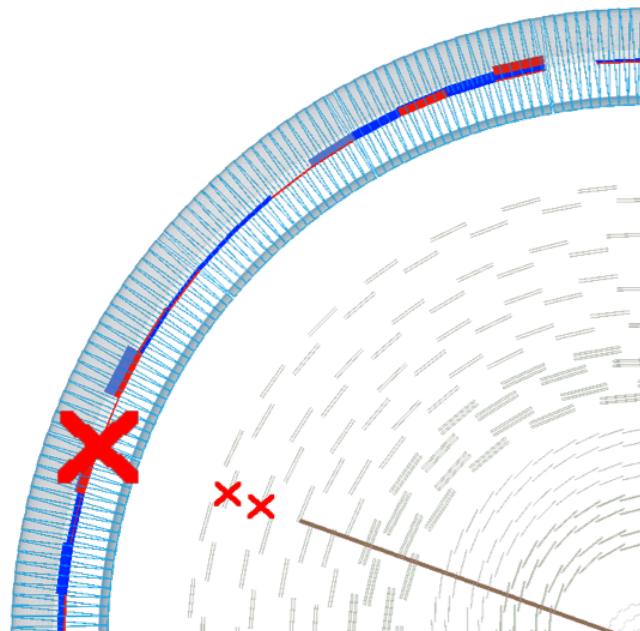
- $m(\tilde{g}) = 1800$  GeV
- $m(\text{chargino}) = 1400$  GeV
- $\Delta m = 180$  MeV
- $c\tau = 10, 30, 50, 100$  cm

include models from pMSSM scan for event selection

# Tagging disappearing tracks

## relevant track properties:

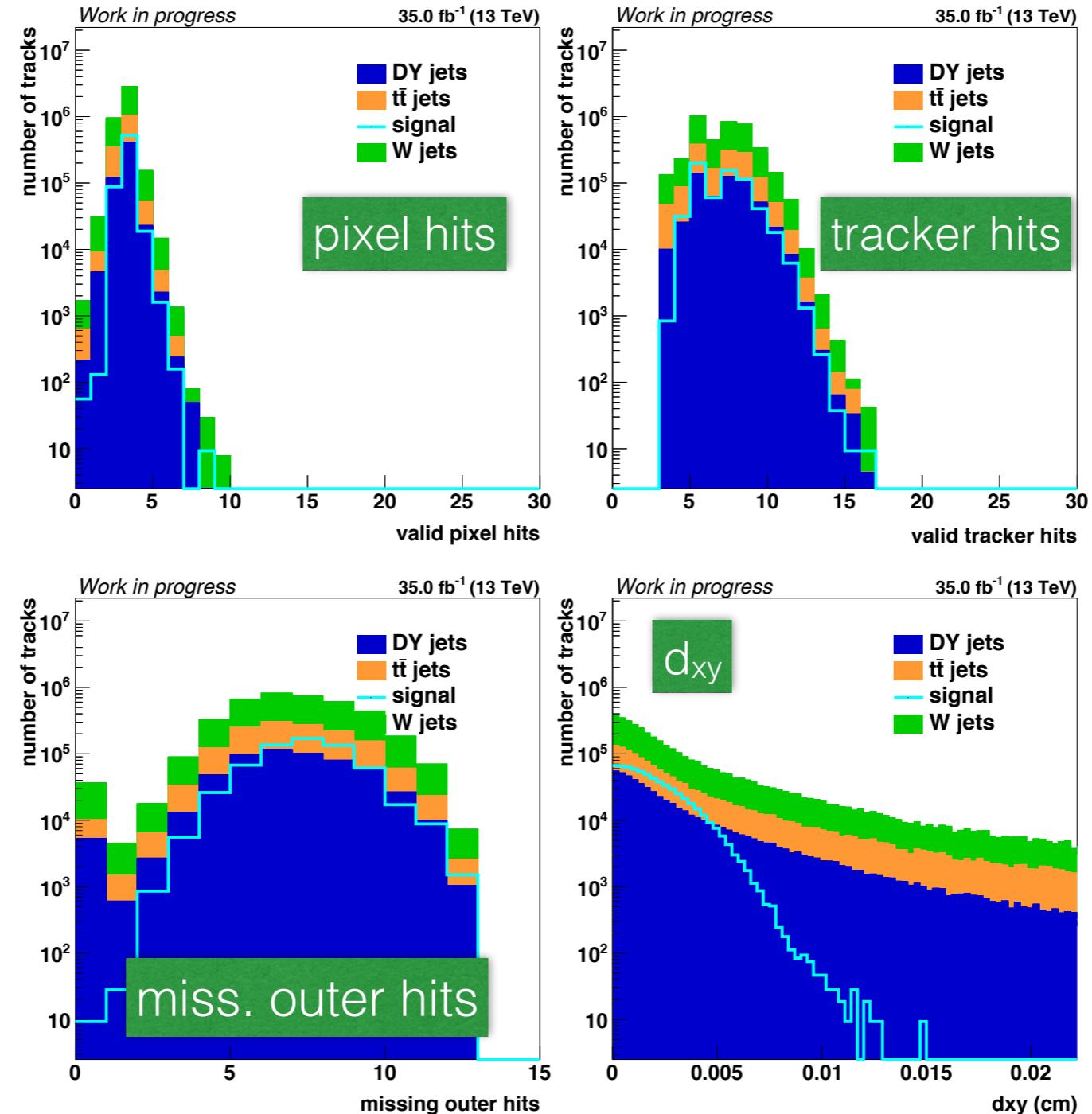
- number of pixel / tracker hits
- missing inner / middle / outer hits
- distance to primary vertex ( $d_{xy}$ ,  $d_z$ )
- $\chi^2 / \text{ndof}$
- $\Delta p_T / p_T^2$
- high purity track quality
- deposited energy in calorimeter within cone of  $\Delta R < 0.5$
- avoid **model dependence** by too tight cuts on  $p_T$ ,  $\eta$ , or isolation



# (Some) tracking variables

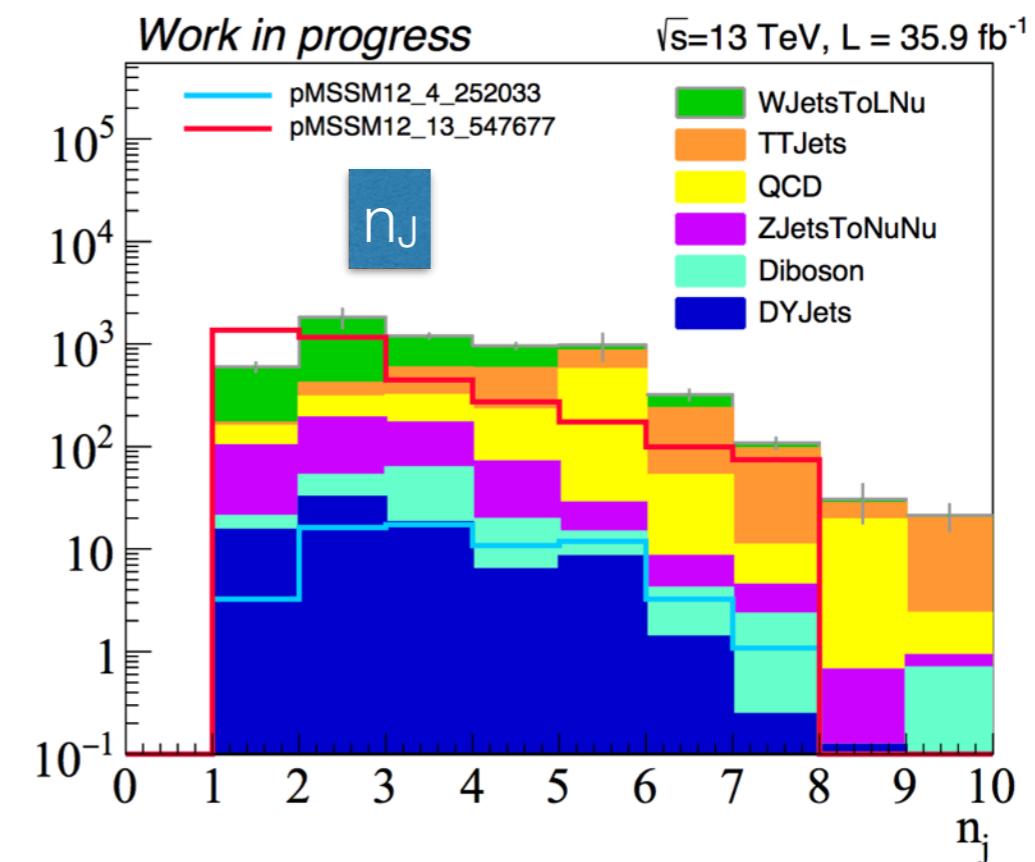
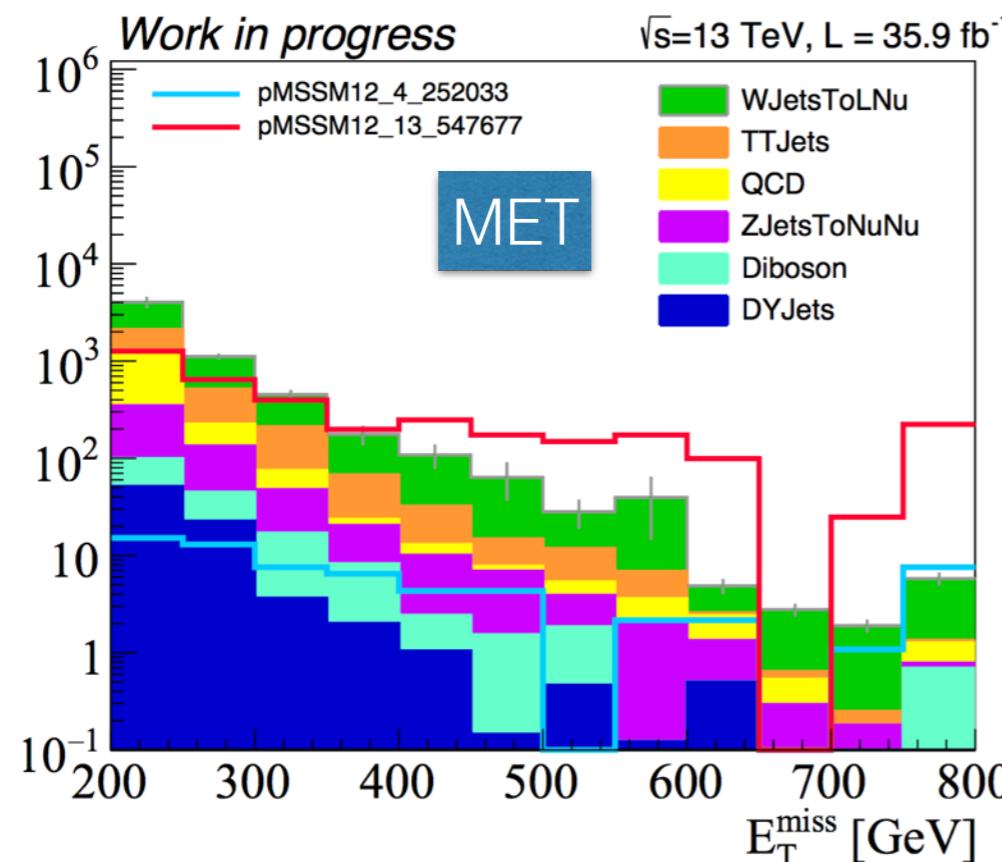
track variables after applying a basic preselection including  
**a reconstructed lepton veto & no missing inner hits:**

medium tracks,  
 signal scaled to 100 pb



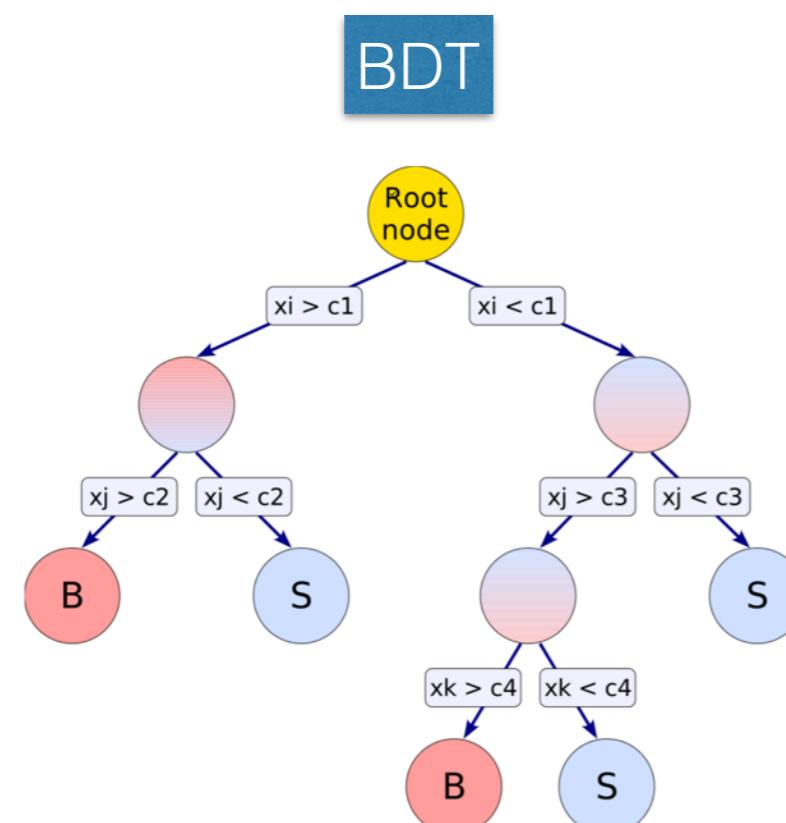
# Event topology

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



# Optimization methods

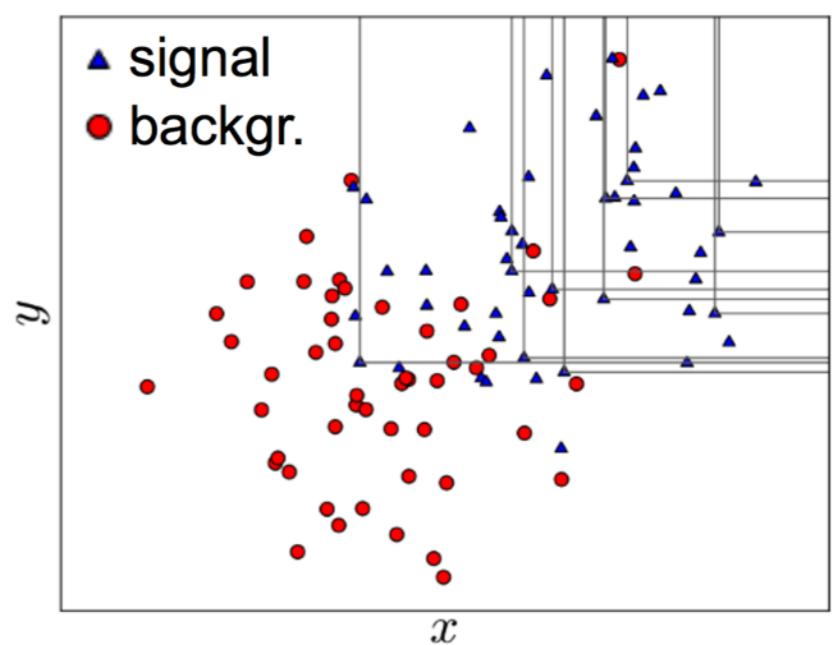
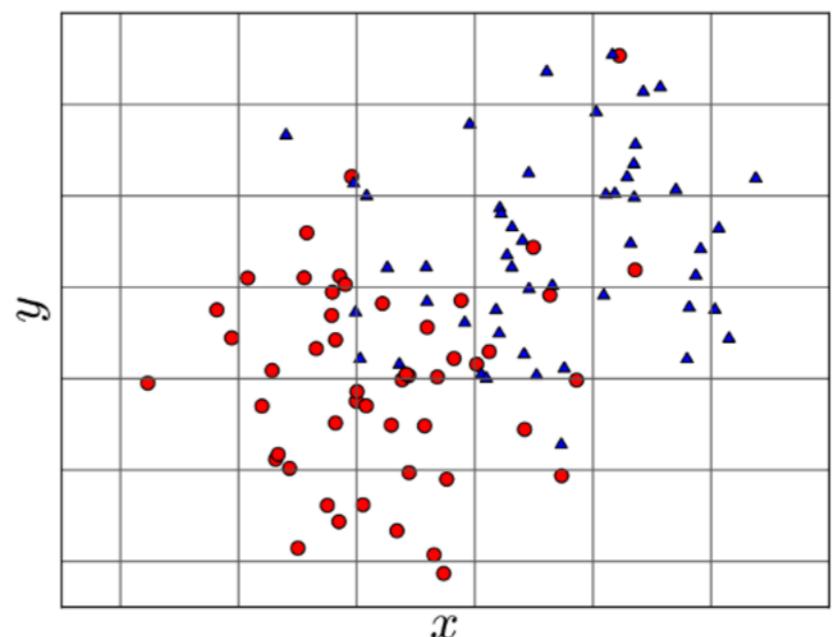
- **random grid search (RGS)**: find optimal cuts via importance sampling, focus on signal-like regions rather than entire phase space
- **boosted decision tree (BDT)** using TMVA



both methods:

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

random grid search



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>

The screenshot shows the GitHub repository page for 'LongLivedSusy / cmsdas'. The repository has 118 commits, 1 branch, 0 releases, and 1 contributor. The latest commit was 2816a21, 2 days ago. The repository description is: 'No description, website, or topics provided.' The README.md file contains the following content:

## CMSDAS @ FNAL 2019

Welcome to the 2019 FNAL CMSDAS exercise on disappearing tracks! This long exercise will walk students through a number of steps needed to set up and implement a search for new physics at CMS. Enjoy :)

If you're doing teh exercise at the school, please send an email to me so I can sign you up for Mattermost ([samuel.bein@gmail.com](mailto:samuel.bein@gmail.com))

<https://mattermost.web.cern.ch/cmsdaslpc2019/channels/shorttrackteam>

Note about the samples: This exercise is built largely on pre-made ntuples, and is thus mostly independent of CMSSW. The code that generated the ntuples is contained in the repo: <https://github.com/longlivedsusy/treemaker>