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1 Introduction

This is the introduction.

2 The standard model of particle physics and supersymmetric extensions

This will contain the theory part

3 Experimental setup/ Experiment and ...

3.1 LHC

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3.3 Object reconstruction and particle identification

3.4 Event simulation

4 Measurement of the jet transverse-momentum resolution

bla bla bla

5 A search for highly ionizing, short tracks at the CMS detector

In this chapter a search for highly ionizing, short tracks is presented. The chapter will be structured as follows: In Sec. 5.1 a motivation will be given, followed by an overview of the general search strategy in Sec. 5.2. As the variable $\frac{dE}{dx}$ plays a crucial role in this analysis, a general introduction and different possible parametrizations will be introduced in Sec. 5.3. In this context also the conducted offline calibration of the silicon pixel detector will be explained. After presenting the simulated SM and signal samples which were used in this analysis (Sec. 5.4) the event selection is shown (Sec. 5.5). Then, the various sources of background are charecterized (Sec. 5.6) and the methods to estimate their size are presented (5.7). As a final step an optimization in the search sensitivity was done, which can be found in Sec. 5.8. The chapter concludes by presenting the results of this analysis in Sec. 5.10, and after a short introduction to the statistical methods of limit setting (Sec. 5.9), the results will be interpreted in the context of Supersymmetry (Sec. 5.11).

5.1 Motivation

As it was already pointed out in Chap. 2, Supersymmetry is able to offer solutions to unexplained phenomena in astrophysics and can solve the shortcomings of the Standard Model of particle physics. Unfortunately, due to the unknown mechanism of supersymmetry breaking, the most general parametrization of Supersymmetry introduces over 120 new dimensions which opens up an incredibly huge phenomenalogically rich space, leading to very different possible signature at particle colliders. During the Phase I run at the LHC in 2012, a variety of different seaches, optimized on the hunt for supersymmetry were conducted. At the CMS experiment, taking data from proton-ptoton collsions, a strong focus was put on the search for hints of SUSY in the strong production sector (e.g. []). This led already to a wide exclusion of SUSY space. Therefore, there is the need to focus on more "exotic" sectors, which cannot be easily accessed and require to design searches for very specialized signatures. Among those signatures are SUSY models containing long-lived charginos. There have been already several analyses conducted in CMS which are in principle (even not all were designed to be) sensitive to these models. The excluded space is shown in Fig. 5.1.

- Explain pMMSM (give refenrence)
- Explain what is shown in the plot
- Explain more!

The analysis presented in this chapter is motivated by the possible existence of long-lived charginos, not decaying instantaneously but reaching the detector before their decay. As shown in Sec. **??**, long lifetimes are possible for various reasons. In this analysis the

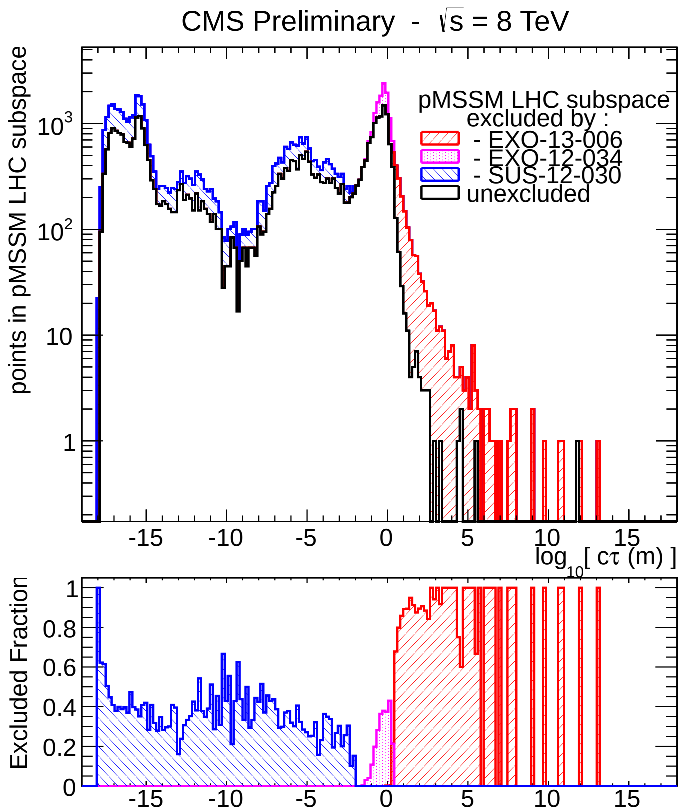

Figure 5.1: Exclusion power of various analyses dependent on chargino lifetime [$c\tau$]. Lower part of the plot shows the excluded fraction. Taken from: https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsEXO12034

focus is put on the possiblity of a lightest chargino ($\chi_1^{\pm}$) which is almost mass degenerate with the lightest neutralino (χ_1^0), leading in this case to long chargino lifetimes because of phase space supression.

A chargino can be produced via chargino pair production through a photon or a Z boson exchange. The chargino decays then via a virtual W boson to the lightest neutralino and fermion. This process is illustrated in the Feynman diagram showed in fig. 5.2. Other possible production channels are the exchange of a supersymmetric Higgs boson or via a t-channel squark exchange. The corresponding Feynman diagrams for main production channels are shown in Fig. 5.3. Another possibility of chargino production is the chargino neutralino production channel. On tree level, there exists the s-channel W boson exchange or the t-channel squark exchange, see Fig. 5.4 for the Feynman diagrams.

5.2 General search strategy

- No detection of low momentum fermions possible (fermion pt plot?)
- Show event displays and sketch for pion decyay!
- Detection via ISR

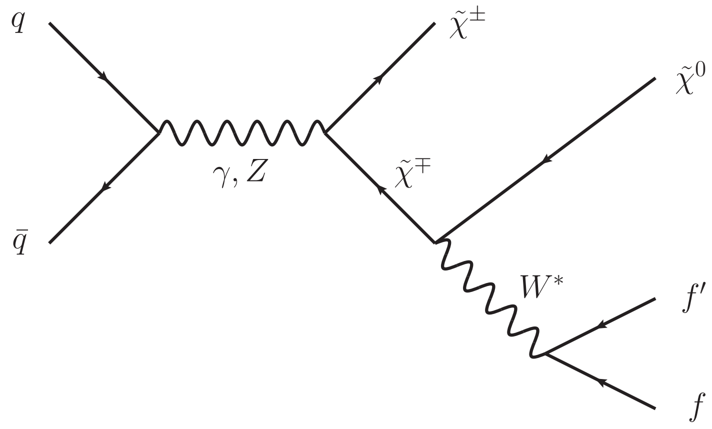

Figure 5.2: Feynman diagram showing a possible production mechanism and the decay channel of a chargino.

- Event selection by ISR jet and MET
- Detection of track (possibly short and disappearing and highly ionizing, not reconstructed as muon)
- Short and highly ionizing track → inclusion of pixel tracker information

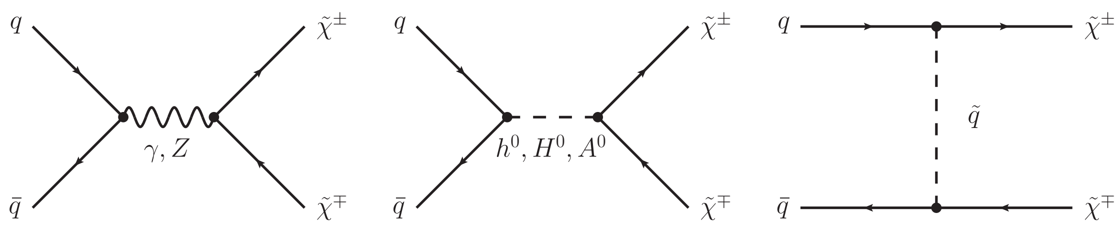

Figure 5.3: Main tree level diagrams for chargino pair production.

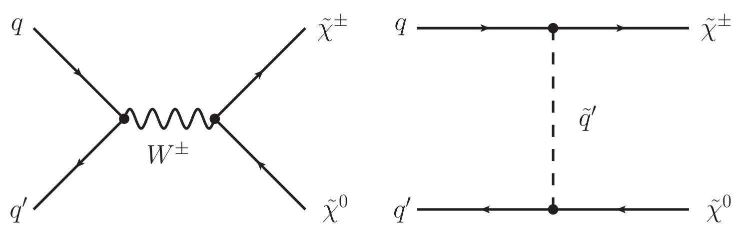

Figure 5.4: Main tree level diagrams for chargino neutralino production.

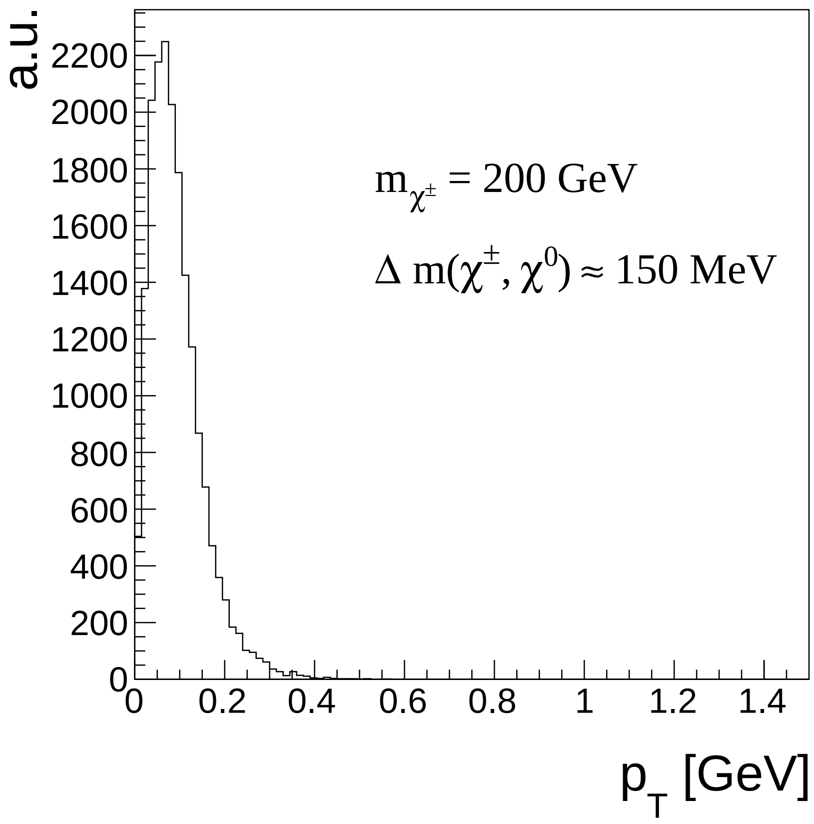

Figure 5.5: Transverse momentum distribution of pions coming from chargino decay into a neutralino with a mass gap of 150 MeV.

5.2.1 Comparison to existing searches

- HSCP
- Disappearing track
- No cut on Nhits
- Muon veto + inclusion of dE/dx

5.3 (Improved) dE/dx measurement of short tracks

5.3.1 Measuring dE/dx

- The variable dE/dx: General introdution, Bethe-Bloch,
- Asymmetric Smirnov Discriminator

5.3.2 Gain calibration of the silicon pixel tracker

5.3.3 Asymmetric Smirnov discriminator

5.3.4 Efficiency improvements

5.4 Simulated samples

5.4.1 SM samples

5.4.2 Signal samples

5.5 Event selection

5.5.1 Datasets and triggers

- Datasets and triggers used in the analysis
- signal samples generated with Madgraph and pythia
- They are decayed in Geant to only pions. Around ten different lifetimes were simulated
- For other lifetimes: lifetime reweighting is done PLOT
- For five diffenrent masses (100-500 GeV)

5.5.2 Preselection

- Motivate different selection cuts
- Reference DT search for most of them

5.5.3 Main discriminating variables

- dE/dx
- pt
- Show some MC signal bkg comparioson plots (only Wjets?)

5.6 Sources of backgrounds

- Background consist of particles which make high energy deposits and are high pt
- In general: Low background search

5.6.1 Fake tracks

- Definition of fake tracks
- How can they fake the signal

5.6.2 Muons

- How can muons fake the signal

5.6.3 Pions

- How can pions fake the signal

5.6.4 Electrons

- How can electrons fake the signal

5.7 Background estimation methods

5.7.1 Fake background

5.7.2 Leptonic background

5.7.3 Systematic uncertainties

5.8 Optimization of search sensitivity

- Show plots
- show table
- Include NlostOuter here, too

5.9 Statistical Methods/ Limit setting

5.10 Results

- Data cutflowtable
- Tables with results
- One plot (4 bins: Prediction and data)

5.11 Interpretation

5.11.1 Systematic uncertainties of simulated signal samples

5.11.2 Exclusion limits

- 1-d limits
- 2-d limits

6 Conclusions

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