論文 / 著書情報
Article / Book Information

題目(和文)	LHC-ATLAS検出器における重心系エネルギー13 TeV陽子陽子衝突データによるぼやけた二次崩壊点を用いた長寿命超対称性粒子の探索
Title(English)	Search for long-lived supersymmetric particles using fuzzy displaced vertices in pp collision at $\sqrt{s}$ = 13 TeV with the LHC-ATLAS detector
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Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

The Standard Model (SM) of particle physics describes the elementary particles and the interactions between them. Most of the observation and measurement results agree with the prediction from the SM with great accuracy. However, there are several problems that the SM cannot explain, such as dark matter and the fine tuning problem of the Higgs boson mass. Many theories beyond the SM are proposed to solve those problems. One of the most famous and comprehensive theories is the Supersymmetry (SUSY). This thesis focuses on bino-wino co-annihilation scenario among various SUSY scenarios, which is especially motivated by the observed dark matter relic density. In this model, the mass difference between the lightest neutralino $\tilde{\chi}_1^0$ and the second lightest neutralino $\tilde{\chi}_2^0$ prefers to be $O(10)$ GeV. Depending on the unknown parameters, $\tilde{\chi}_2^0$ may have a decay length measurable in the collider experiments.

This thesis presents the search for the pair production of $\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$ using 137 fb^{-1} of proton-proton (pp) collision data at $\sqrt{s}$ = 13 TeV collected by the ATLAS detector in the LHC. This thesis assumes that $\tilde{\chi}_1^{\pm}$ decays promptly via off-shell W-boson (W^*) and $\tilde{\chi}_2^0$ has a lifetime of $O(10^{-2})$-$O(1)$ ns and decays via off-shell Higgs boson (h^*). The target process is $pp \to \tilde{\chi}_1^{\pm}\tilde{\chi}_2^0$, $\tilde{\chi}_1^{\pm} \to \tilde{\chi}_1^0 W^*(\to ff')$, $\tilde{\chi}_2^0 \to \tilde{\chi}_1^0 h^*(\to b\bar{b})$, where f and f' are fermions and $b\bar{b}$ is a b-quark pair. This process was searched using the missing transverse momentum made by $\tilde{\chi}_1^0$ and an unconventional signature made by long-lived $\tilde{\chi}_2^0$.

When a long-lived neutral particle decays in the tracking detector and its decay includes multiple charged particles, a secondary vertex far from the collision point, called a displaced vertex (DV), can be reconstructed from charged particle tracks. Since the SM does not contain any long-lived heavy particles, DVs with a high invariant mass are a very distinctive signature in searching for a new long-lived particle.

Since the ATLAS detector is not designed to search for long-lived particles, the DV analysis is challenging and needs some special reconstruction techniques. In addition, the search for the target signal events in this thesis has an additional difficulty: Since the $\tilde{\chi}_2^0$ decay includes b-quarks, not all the tracks originating from the decay of the long-lived particle intersect at one point due to the decay length of the b-hadrons which is up to a few mm. The standard method for reconstructing DVs used in ATLAS cannot efficiently reconstruct DVs in such a case. Therefore, a new method for DV reconstruction suitable for such decays has been developed to compensate for the disadvantage of the standard method. Using this new method, the efficiency with which target signal events have DVs with high track multiplicity and high invariant mass increased by a factor of 2–6. The analysis method using DVs reconstructed by this new method was then established.

Although no long-lived heavy particle exists in the SM, the background events from the SM process can have "fake DVs" with a high invariant mass from the experimental and algorithmic effects. More fake DVs are reconstructed with the new DV method in exchange for increased signal selection efficiency. In order to reduce those signal-like fake DVs, the characteristics of the tracks in DV of the signal events and major background events were compared using simulated samples, and the selection criteria for the tracks in DV were optimized. Those track-level selections decreased the number of fake DVs with a high track multiplicity and high invariant mass to 1/100 or less while keeping approximately half the signal events. The signal region (SR) was required to have a missing transverse momentum larger than 150 GeV and at least one DV reconstructed with five or more tracks and an invariant mass larger than 10 GeV after these DV-track selections. The number of background events in the SR was estimated using a data-driven method. A new estimation method using the correlations between the existence of the DV and the other variables was developed. After validating the validity of the estimation, the data in the SR were unblinded. Three events were observed, while the estimated number of background events was 0.81±0.49. The excess from the expected number of background events was equivalent to 1.59σ, and the upper and exclusion limits were set based on the result. The $\tilde{\chi}_2^0$ mass up to 650 GeV is excluded at a 95% confidence level for the case when $\tilde{\chi}_2^0$ lifetime is 0.03 ns, and the mass splitting between $\tilde{\chi}_2^0$ and $\tilde{\chi}_1^0$ is 50 GeV. This search gives the first search results for the model that this thesis focuses on in the LHC experiments.

備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).

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