論文の内容の要旨

Search for gluinos in final states with jets and large missing transverse momentum using 36fb^{-1} data observed in the ATLAS detector
（ATLAS検出器で測定された 36fb^{-1} データを用いたジェットと横方向消失運動量を持つ終状態でのグルイーノ探索）

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In elementary particle physics, the last piece of the Standard Model (SM), the Higgs boson, is discovered in 2012 at the Large Hadron Collider ("LHC”). Although the SM explain the particles and their phenomena successfully, it is believed to be a low energy realization of a more general theory. There are serious problems in the SM: the instability of the Higgs mass due to the radiative corrections, no unification between electroweak and strong interactions, and no dark matter candidate.

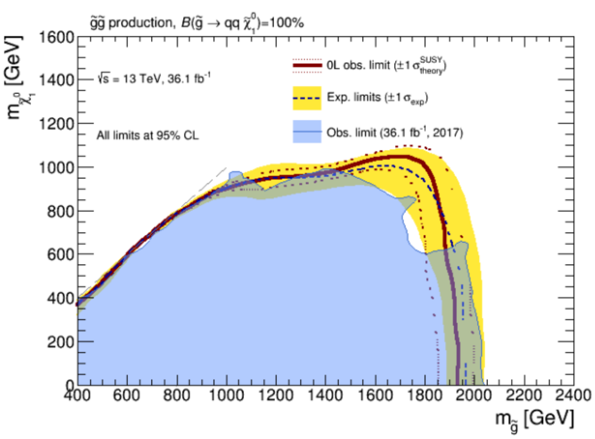
Supersymmetry ("SUSY") is one of very attractive frameworks beyond the SM to resolve them. There are three kinds of the SUSY particles: gaugino, sfermion, and higgsino. They are the superpartner of gauge particles, fermion particles, and the Higgs in the SM, respectively. The electromagnetic, weak, and strong interactions indicates the unification of these three constants at a high energy scale ("GUT scale") if SUSY exists. This is one of the most impressive predictions of the SUSY. Furthermore, this implies the gaugino mass is typically O(1) TeV. On the other hands, the observed Higgs mass indicates the sfermion mass is above 5–10 TeV. This prediction is also consistent with the experimental results related to the flavor mixing and CP violation. Thus, the gauginos are the attractive particles to be searched for in the SUSY particles. Among the gauginos, a gluino has the most potential to be discovered due to its large production cross-section in proton-proton collisions at the LHC.

In this thesis, the gluino is searched in the final states with jets and large missing transverse momentum, in which a lepton (electron or muon) is intentionally vetoed. In the benchmark of this search, the gluino decays to the lightest neutralino $\tilde{\chi}_1^0$ directly (direct decay) or via one chargino (one-step decay). This analysis channel is a so-called golden channel due to its large branching fraction. In Run1 of the LHC until 2012, the gluino is excluded up to ~1.4 TeV if mass difference between the gluino and $\tilde{\chi}_1^0$, $\Delta\mathrm{Mass}(\tilde{g},\tilde{\chi}_1^0)$, is larger than 1.1 TeV. However, for the small $\Delta\mathrm{Mass}(\tilde{g},\tilde{\chi}_1^0)$, the limit on the gluino mass degenerates. The signal mass models with a large $\Delta\mathrm{Mass}(\tilde{g},\tilde{\chi}_1^0)$ (~2TeV) is effectively separated from the SM background since its decay has jets with large momenta originating from the mass difference. However, in the high $\tilde{\chi}_1^0$ mass region, where the $\Delta\mathrm{Mass}(\tilde{g},\tilde{\chi}_1^0)$ is relatively small

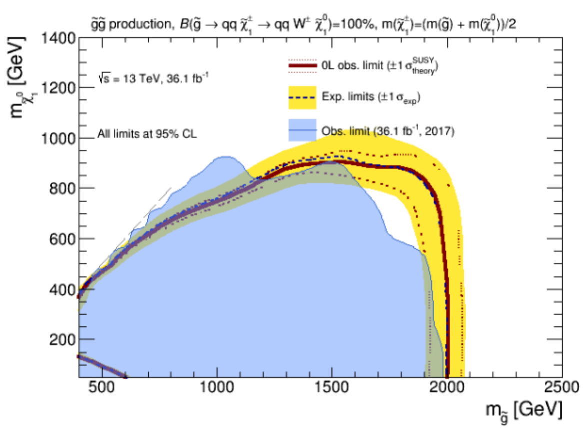
(0.5—1TeV), the jets become soft. This analysis focuses on the high $\tilde{\chi}_1^0$ mass in the gluino search, and new techniques are introduced in order to improve the search for it.

An idea to improve the analysis is quark/gluon separation. In the gluino decay, there are at least four quarks, while the SM background processes has often gluons coming from the shower evolutions. Therefore, quark/gluon separation has potential to improve this search. However, there is a difficulty to take into account all of four jets in the selection comprehensively because quark/gluon separation for one jet is not effective in the current algorithm using the fixed cut on a discriminating variable such as a number of tracks within the jet or a jet width. In addition, it is necessary in the selection of the signal event candidates to take into account the correlation between the discriminating variable and the jet hardness since the variable is strongly correlated with the jet momentum scale. In order to overcome the difficulties, multivariate analysis is introduced in this analysis to make a sophisticated selection taking into account the four jets and the correlations between the variables.

This search is performed using 36.1fb^{-1} data recorded in 2015 and 2016 at the center-of-mass energy $\sqrt{s} = 13$ TeV. There is no significant excess indicating the gluino, and powerful exclusion limits on the gluino and $\tilde{\chi}_1^0$ masses are obtained for gluino direct and one-step decay models. Especially, the high $\tilde{\chi}_1^0$ mass region in the high gluino mass range is more effectively searched than the previous study due to the new techniques. For a signal mass point with high gluino and $\tilde{\chi}_1^0$ masses in the direct decay signal, this analysis makes a gain in the background rejection power by factor 2. The $\tilde{\chi}_1^0$ mass is excluded up to 1 TeV in the gluino mass range of 1.50–1.80 TeV for the gluino direct decay, and excluded up to 0.85 TeV in the gluino mass range of 1.25–1.85 TeV for the gluino one-step decay at 95% confidence level as shown in Figures 1.



(a) Gluino direct decay



(b) Gluino one-step decay

Figure. 1 Observed exclusion limits at 95% confidence level for (a) the gluino direct decay model and (b) the gluino one-step decay model. Red solid lines are the observed exclusion limits. Observed exclusion limits in the previous study using the same data of 36.1fb^{-1} are represented by blue shaded areas.