

Searches for Squarks and Gluinos at CDF and DØ Detectors

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Abstract. This contribution reports on preliminary measurements of searches for squarks and gluinos at CDF and DØ detectors in $p\bar{p}$ collisions at $\sqrt{s} = 1.96$ TeV using 1 fb^{-1} of data. The analyses are optimised for event topologies with multiple jets and large missing transverse energy in the final state. No excess with respect to the Standard Model predictions is observed and new limits on the gluino and squark masses are extracted in a mSUGRA scenario with R-parity conservation.

1. Introduction

Supersymmetry (SUSY) [1] is one of the most appealing theoretical frameworks to extend the Standard Model (SM). It is based on a new symmetry between bosons and fermions by which every known elementary particle has a superpartner differing by half a unit of spin. mSUGRA [2] is a model which predicts the symmetry breaking via gravitational interactions and requires only five parameters to describe the phenomenology: m_0 , $m_{1/2}$, A_0 , $\tan\beta$ and $\text{sign}(\mu)$. In addition, R-parity (R_P) is introduced to prevent leptonic and baryonic number violation. When R_P is conserved, SUSY particles have to be pair-produced and ultimately decay into the lightest supersymmetric particle (LSP), usually considered the lightest neutralino, which constitutes a valid candidate for cold dark matter. Squarks and gluinos, the superpartners of quarks and gluons respectively, are predicted to be copiously produced in hadron colliders with a characteristic signature of high jet multiplicity and large missing transverse energy (E_T) due to the escaping LSP. The possible presence of these particles in 1 fb^{-1} of Tevatron Run II data has been the object of intensive study at CDF [3] and DØ [4] collaborations.

2. Experimental Strategies and Results

A mSUGRA scenario with $A_0 = 0$, $\text{sign}(\mu) = -1$ and $\tan\beta = 3$ ($\tan\beta = 5$) is assumed by the DØ (CDF) analyses. The different squark and gluino production processes are normalised to next-to-leading order (NLO) using PROSPINO v2 [5]. To avoid dependence on the mixing parameters of the model, 2-to-2 processes involving stops are not considered (CDF also excludes sbottoms) and the rest of the squark masses are considered degenerate. In order to predict the SUSY spectrum at the TeV-scale, CDF uses ISASUGRA 7.74 [6] while DØ uses SUSPECT 3.2 [7] and SDECAY 1.1A [8]. The use of slightly different implementations of the renormalisation group equations translates into a less than $5 \text{ GeV}/c^2$ difference on the computed masses for squarks and gluinos.

The supersymmetric signal must be extracted from large background contributions. One source of background is QCD multijet processes, where the \cancel{E}_T is due to mismeasurements of the jet energy in the calorimeters and the presence of partially instrumented regions. Other important backgrounds are the production of Z and W bosons in association with jets, dibosons and $t\bar{t}$ production, where the missing transverse energy originates from the presence of neutrinos in the final state or the misidentification of jets. In particular, $Z \rightarrow \nu\bar{\nu} + \text{jets}$ constitutes an irreducible background to the supersymmetric signature.

In order to estimate the QCD background, $D\mathcal{O}$ relies on a fit to an exponentially falling shape, based on QCD data at low \cancel{E}_T , and then performs an extrapolation to the very high \cancel{E}_T region. This contribution is found to be negligible after all selection criteria. CDF generates very high statistics MC samples to take into account non-gaussian tails in the \cancel{E}_T distribution and uses the data to check the MC absolute yields. Boson plus jets backgrounds are estimated using ALPGEN+PYTHIA [9][10] where the normalisation is taken from Drell-Yan data. Top and diboson processes are estimated using ALPGEN+PYTHIA ($D\mathcal{O}$) or PYTHIA (CDF) and normalised to NLO theoretical predictions.

Both experiments apply cuts to remove cosmics and beam-related backgrounds and use dedicated selection criteria to reduce the QCD multijets contribution, by requiring a minimum azimuthal distance between jets and \cancel{E}_T directions. Electroweak processes are suppressed using lepton vetoes. Then, cuts on the transverse energy of the jets and on the \cancel{E}_T are optimised in three scenarios depending on the relative masses of squarks and gluinos. When $M_{\tilde{g}} > M_{\tilde{q}}$, the squark production is enhanced and the final state is characterised by dijet events and large missing transverse energy, since the produced squarks tend to decay into a jet and a LSP. When $M_{\tilde{g}} < M_{\tilde{q}}$, the gluino production is more important and final-state topologies are dominated by the presence of at least four jets due to fact that each gluino tends to decay into two jets and a LSP. Finally, when $M_{\tilde{g}} \sim M_{\tilde{q}}$ the predominant final state contains at least three jets. Different cuts on \cancel{E}_T and H_T , defined as the scalar sum of the jet transverse energies, are finally applied varying between 95 and 225 GeV (\cancel{E}_T) and between 280 and 400 GeV (H_T).

The main source of systematic uncertainty comes from the 3% uncertainty on the jet energy scale. This translates into a 10% and 20% uncertainty on the signal and background predictions, respectively. Other sources of systematic uncertainty are initial- and final-state radiation (ISR/FSR) (6%), renormalisation scale and PDF uncertainties (15 – 50% on the signal cross-section estimation depending on the signal mass point) and luminosity (6%).

No significant deviation from SM predictions is found by CDF or $D\mathcal{O}$ in any of the studied regions and new exclusion limits are calculated (see Fig. 1). In the case of CDF, the systematic uncertainties on the NLO cross sections are included in the 95% C.L. bayesian limit calculation. In the $D\mathcal{O}$ case, these uncertainties are not included in the limit calculation but the mass limits are conservatively quoted at the lower edge of the theoretical predictions including systematics. Both experiments exclude cross-sections of the order of 0.1-0.2 pb, which corresponds to gluino masses below 280 GeV/ c^2 and squark masses below 370 GeV/ c^2 . In the region where both masses are comparable, the limit is extended to 385 GeV/ c^2 . In Fig. 2, limits are also expressed in terms of m_0 and $m_{1/2}$. The Tevatron results extend previous results from LEP at low values of m_0 and $m_{1/2}$.

3. Summary and Conclusions

CDF and $D\mathcal{O}$ found no evidence for gluino or squark production with multiple jets and large missing transverse energy topologies based on about 1 fb⁻¹ of data. As a result, the preliminary exclusion limits in the gluino-squark mass plane have been significantly expanded, excluding gluino (squark) masses below 280 GeV/ c^2 (370 GeV/ c^2) which translate into improved limits at low values of m_0 and $m_{1/2}$.

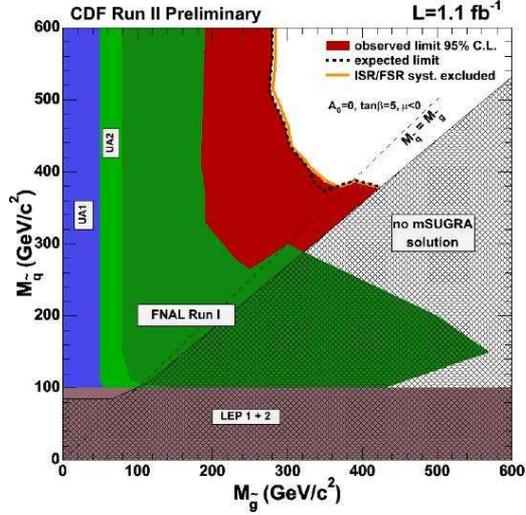


Figure 1. CDF observed (red) and expected (dashed-line) exclusion limits at 95% C.L. in the squark-gluino mass plane. Results without ISR/FSR uncertainties are also shown. Excluded regions from previous experiments are labelled in the figure together with the non-mSUGRA solution (dashed) region.

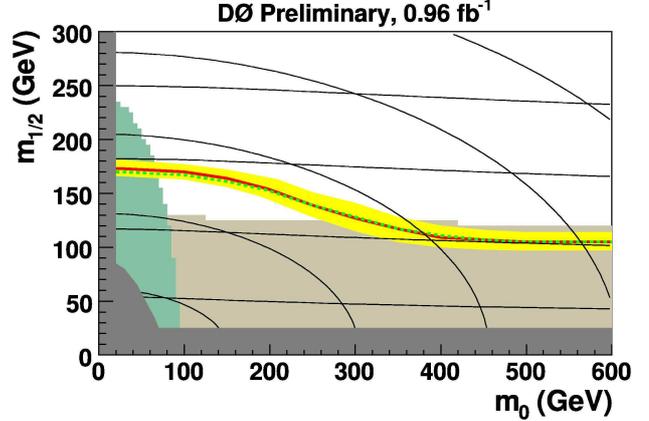


Figure 2. DØ limits in the m_0 - $m_{1/2}$ plane. The solid (dashed) line is the excluded observed (expected) region for central theoretical uncertainties. The yellow band shows the effect of the theoretical uncertainties. There is no mSUGRA solution in the grey region. The beige (green) regions are excluded by LEP2 chargino (slepton) searches.

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