Search for Supersymmetry in Final States with a Single Lepton, B-jets and Missing Transverse Energy at CMS

Abstract

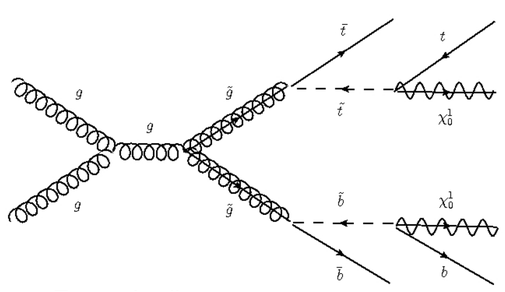
Motivated by supersymmetric models with light top and bottom squarks, a search for supersymmetry in final states with a single lepton, b-jets and missing transverse energy is performed. The analysis is based on data recorded at the CMS experiment in proton-proton collisions at a center of mass energy of 7 TeV during 2011, corresponding to an integrated luminosity of 4.96/fb. Results are interpreted in the context of the Constrained Minimal Supersymmetric Standard Model and a heavy flavor simplified model.

Altan Cakir[1], Francesco Costanza[1], Dean Horton[1], Dirk Krücker[1], Isabell Melzer-Pellmann[1], Niklas Pietsch[2], Elias Ron[1], Özgür Sahin[1], Hannes Schettler[2], Peter Schleper[2], Matthias Stein[1]

[1]Deutsches Elektronen-Synchrotron DESY
[2]University of Hamburg

Supersymmetry

Supersymmetry (SUSY) predicts that for each Standard Model (SM) particle there exists a partner particle (sparticle) with identical gauge quantum numbers, but a spin differing by 1/2. Assuming R parity conservation, sparticles are produced in pairs and their decay chains terminate with the lightest supersymmetric particle (LSP), which is stable.
In several SUSY scenarios top and bottom squarks are lighter than the squarks of the 1st and 2nd generation, which may result in an excess of events with a large multiplicity of 3rd generation quarks.



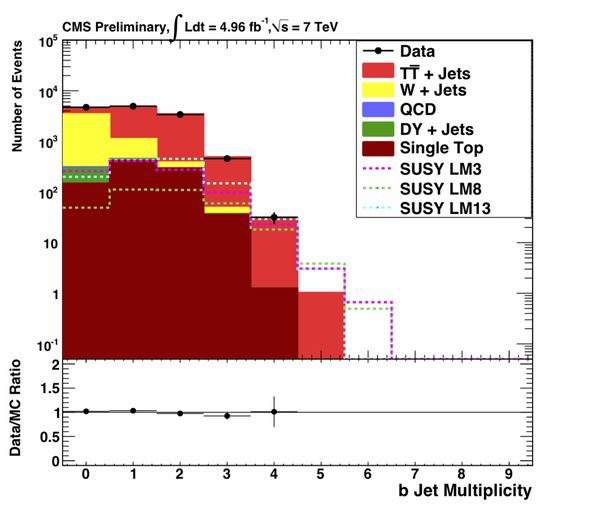
Example diagram

Signature

- Large jet and b-jet multiplicity
- Missing transverse energy from two stable LSPs
- Lepton from leptonically decaying top quark or two- or three-body decay of neutralino or chargino

Event Selection

Selection criteria	Object definition
1 lepton	Isolated muon or electron with p_T > 20 GeV, |η| < 2.1 and |η| < 2.5, resp.
Veto on 2nd lepton	Muon or electron fulfilling looser criteria
≥ 4 jets	Jets with p_T > 40 and |η| < 2.4 reconstructed with the anti-k_T algorithm from particle flow objects
HT > 375 GeV	Scalar sum of the p_T of all selected jets
E_T^{miss} > 60 GeV	Vectorial sum of the p_T of all particle flow objects
1, 2 or ≥ 3 b-jets	Selected jets with 2 tracks with impact parameter significance ≥ 3.3 (track counting algorithm)



B-jet multiplicity after event selection w/o b-jet requirement.

→ **Very good agreement between data and simulated events**

Background Estimation from Data

The main background after the event selection with b-jet requirement originates from $t\bar{t}$ events. For these $Y_{MET} = E_T^{miss}/\sqrt{H_T}$ and H_T are only slightly correlated, which allows one to estimate the background using a factorization method:

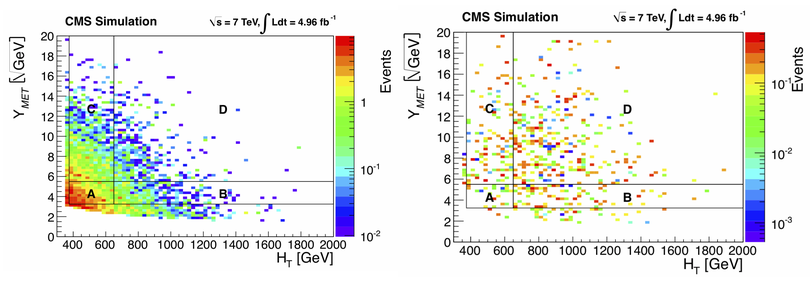
- **Define signal-enriched region D at large values of Y_{MET} and H_T and control regions A, B and C:**

Region	H_T / GeV	Y_{MET} / √GeV
A	375 < H_T < 650	3.25 < Y_{MET} < 5.5
B	H_T > 650	3.25 < Y_{MET} < 5.5
C	375 < H_T < 650	Y_{MET} > 5.5
D	H_T > 650	Y_{MET} > 5.5

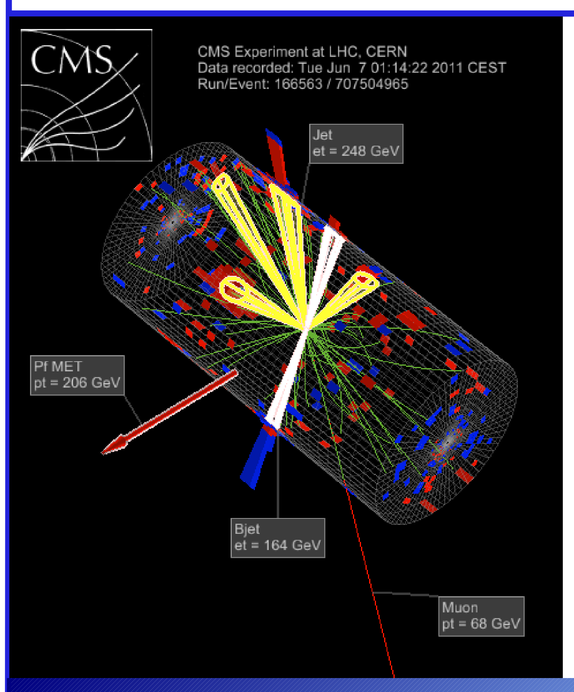
- **Calculate expected number of background events in region D from control regions:**

$$\kappa \frac{N_A}{N_C} = \frac{N_D}{N_B} \Rightarrow N_D = \kappa\, N_B \frac{N_A}{N_C}$$

- where the correlation between Y_{MET} and H_T is taken into account by the factor κ = 1.20 ± 0.04 estimated from simulated events.



Y_{MET} vs. H_T for the SM background (left) and the cMSSM low mass signal point LM8.



Event in signal region D:

- 1 muon
- 6 jets with p_T > 40
- 2 jets tagged as b-jet (white cones)
- H_T = 793 GeV
- E_T^{miss} = 206 GeV
- Y_{MET} = 7.3

Systematic Uncertainties

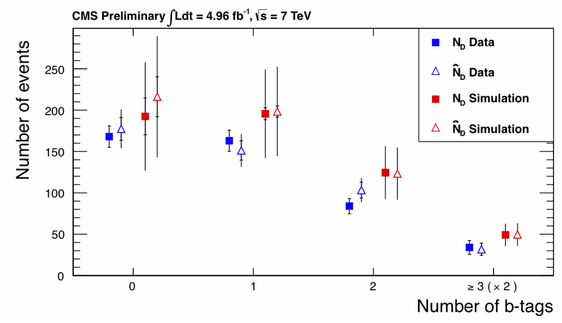
- **Systematic uncertainties on data prediction mostly cancel out** (only contributions > 1% given) **:**

Uncertainty	Δκ (1 b-jet)	Δκ (2 b-jets)	Δκ (≥ 3 b-jets)
Jet energy scale	± 2.2 %	± 1.4 %	± 4.0 %
Jet energy res.	± 1.7 %	± 1.8 %	± 5.5 %
Lepton pT	± 1.5 %	± 0.7 %	± 1.2 %
Cross-sections	± 1.0 %	± 2.0 %	± 1.4 %

- **The correlation between Y_{MET} and H_T is cross-checked in data in the exclusive 0 b-jet channel**

→ An additional uncertainty of 10% is applied on κ

Results



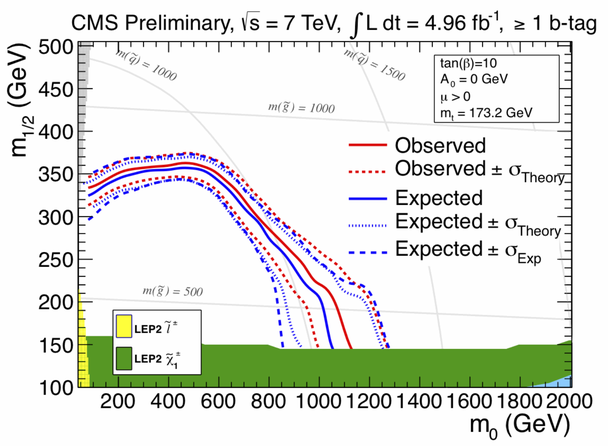
- Number of simulated and predicted simulated events agree well → **Test on simulated events closes**
- Agreement between data and prediction from data within uncertainties → **No excess observed**

Interpretation

95% CL limits are set upon the parameters of the Constrained Supersymmetric Standard Model (cMSSM) and a heavy flavor simplified model using the CLs technique.

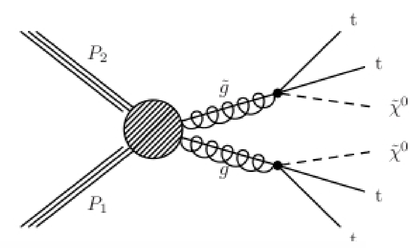
cMSSM

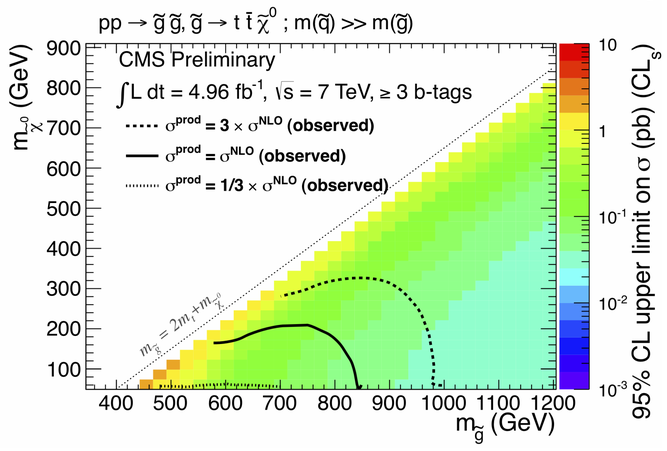
- tanß=10, A_0 = 0 and μ > 0
- ≥1-bjet



Simplified model "T1tttt"

- ≥ 3 b-jets





Summary & Outlook

A search for SUSY with light 3rd generation squarks has been performed on data collected by the CMS experiment in proton-proton collisions at a center-of-mass energy of 7 TeV, corresponding to an integrated luminosity of 4.96/fb. No deviation from the SM has been found. Limits upon the parameters of the cMSSM and a simplified model have been set.
Defining signal regions at larger values of Y_{MET} and H_T might increase the sensitivity of this analysis (work in progress).

Reference: CMS PAS SUS-11-028

niklas.pietsch@desy.de