Search for Supersymmetry in Gauge Mediated Supersymmetry breaking scenarios

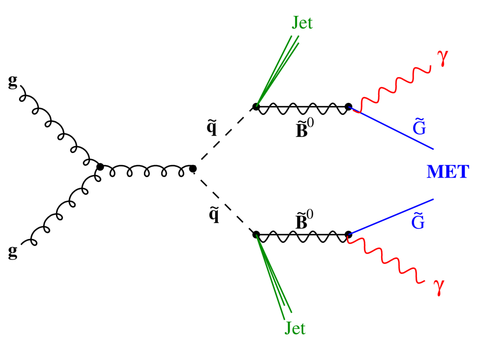
Christian Autermann for the CMS collaboration

I. Phys. Inst. RWTH Aachen, Germany

christian.autermann@cern.ch

Di-Photon and MET inclusive

- Bino-like neutralino $\tilde{\chi} \to \gamma \tilde{G}$
- Strong production



Selection
- Two photons with pT > 40 (25) GeV, |η| < 1.4
- One jet with pT > 25 GeV, |η| < 2.6
- MET > 50 GeV (5 excl. bins)
- Pixel seed veto against electrons
- Tight photon isolation

QCD-background control sample
- Loose but not tight photon isolation

Electroweak (misidentified e) control sample
- Pixel seed

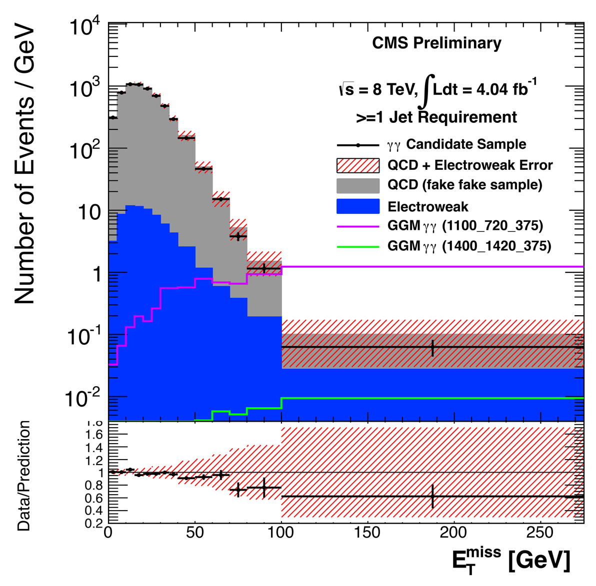


Figure 1: Di-photon MET distribution

Background estimation is extracted purely from data and validated in Monte Carlo simulation.

- Dominant background from QCD and direct γ production modeled using a "fake-fake" control sample with two loosely isolated photon-like jets resembling the photons in the signal. This control sample is weighted and normalized to match the signal MET distribution using the background dominated side-band region MET < 20 GeV.
- The sub-leading EWK background originates from electrons being misidentified as photons. It is modeled using ee and eγ events, properly weighted according to the e→γ misidentification rate measured in data on the Z→ee peak.

The final result is the MET distribution shown in Fig. 1. No significant excess over the Standard Model background expectation is observed, in fact the data is in good agreement with the background-only expectation. The five bins with MET > 50 GeV are used to calculate CLs limits at 95% confidence level using a LHC-style treatment of the nuissance parameters.

GGM cross section limits as well as exclusion contours for strong and electro-weak production for bino- and wino-like neutralinos at 7 TeV with 5 fb^{-1} and at 8 TeV with 4 fb^{-1} in dependence of squark, gluino, neutralino, and chargino masses have been calculated.

In Fig. 3 the combined 7 TeV and 8 TeV exclusion contour corresponding to 9 fb^{-1} for bino-like neutralino production in dependence of the squark and gluino masses is shown.

Single-Photon, Jets, and MET inclusive

Background estimation is extracted purely from data and validated in Monte Carlo simulation.

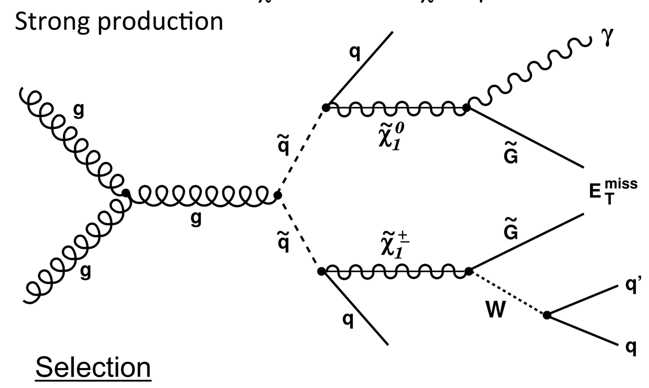
- The dominant background is composed out of direct γ-jet and QCD production. Since the mechanisms responsible for MET, i.e. jet resolution, mismeasurements and detector effects are similar for both components, it is modeled using a control sample with one loosely isolated photon-like jet resembling the photon in the signal. This control sample is weighted as a function of photon-object pT using the background dominated side-band region MET < 100 GeV.
- The sub-leading EWK background are events with one electron failing the pixel seed veto, thus being misidentified as photon. It is modeled using an electron sample weighted by the e→γ misidentification rate.

The third background is initial state radiation in tt, W, or Z production, estimated using Monte Carlo simulation.

The final result is the MET distribution shown in Fig. 2. The observation is in good agreement with the Standard Model expectation. Limits are calculated in a similar way as for the di-photon final state, by combining the six MET bins above 100 GeV as exclusive counting experiments considering the correlation of the systematic uncertainties, where necessary.

In Fig. 4 the combined 7 TeV and 8 TeV exclusion contour corresponding to 9 fb^{-1} for wino-like neutralino production in dependence of the squark and gluino masses is shown.

- Wino-like neutralino $\tilde{\chi} \to W \tilde{G}$ or $\tilde{\chi} \to \gamma \tilde{G}$
- Strong production



Selection
- One photon with pT > 80 GeV, |η| < 1.4
- Two jets with pT > 30 GeV, |η| < 2.6
- HT > 450 GeV (scalar sum of jet pT)
- MET > 100 GeV (6 excl. bins)
- Pixel seed veto against electrons
- Tight photon isolation

QCD-background control sample
Loose but not tight photon isolation

Electroweak (misidentified e) control sample
Pixel seed

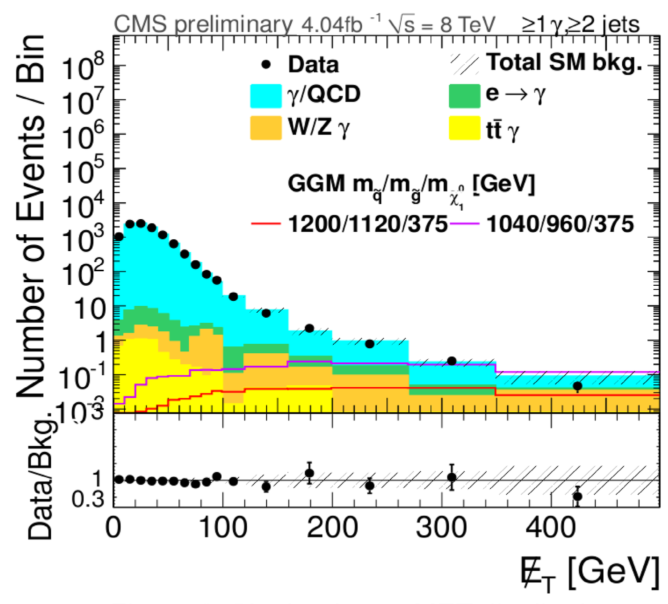


Figure 2: Single-photon MET distribution

References:
8 TeV, 4 fb^{-1}: CMS Physics Analysis Summary SUS-12-018
7 TeV, 5 fb^{-1}: Journal of High Energy Physics 1303 (2013) 111

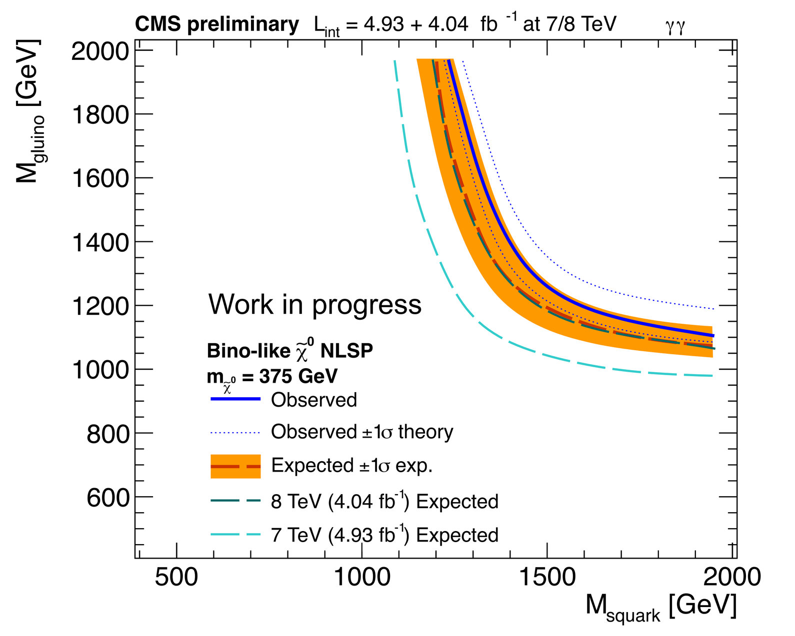


Figure 3: GGM limit for bino-like neutralinos

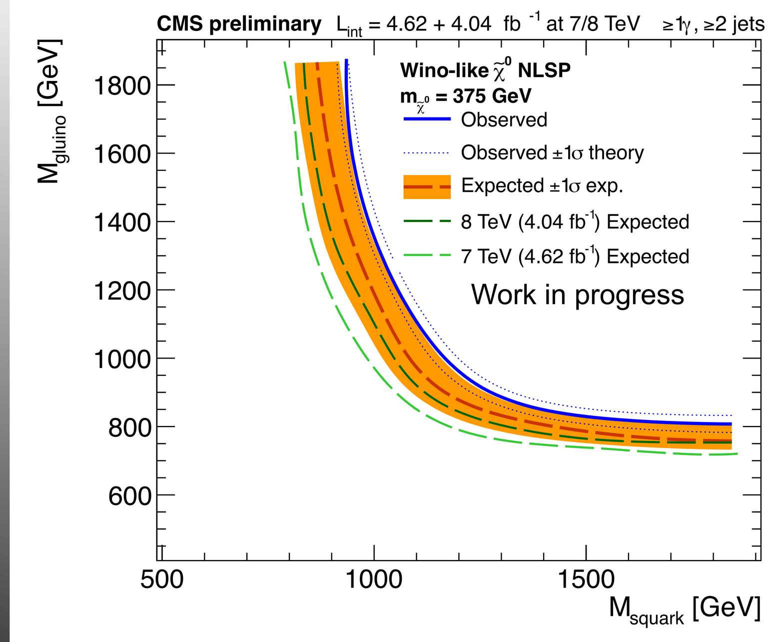


Figure 4: GGM limit for wino-like neutralinos

Figure 5: Limit on squark production in gauge mediated models

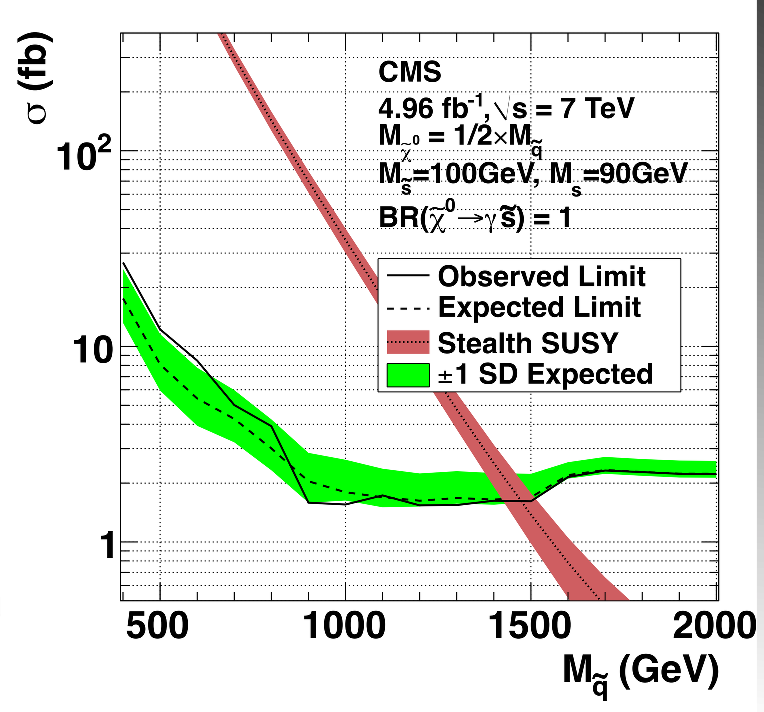
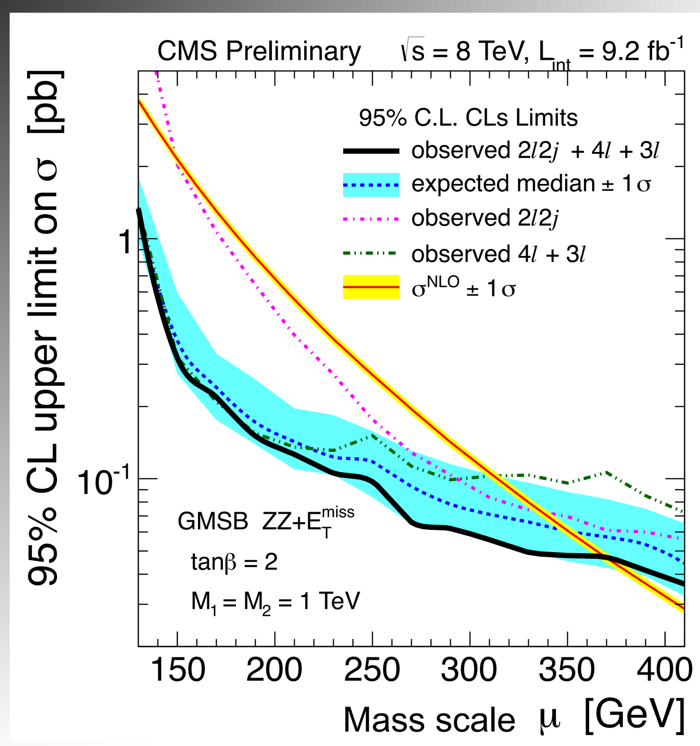


Figure 6: GMSB limit on mass scale μ

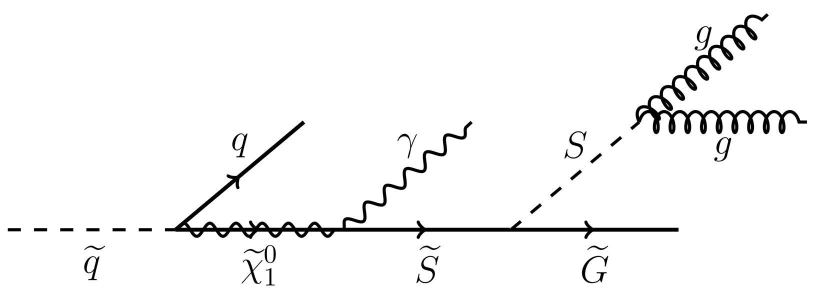


"Stealth SUSY" little MET

7 TeV, 5 fb^{-1}: Phys. Lett. B 719 (2013) 42

Abandoning the large discriminative power of a MET cut requires new techniques to suppress the Standard Model background, but opens sensitivity to a wide range of scenarios:
- extra dimensions
- heavy-flavor compositeness
- little Higgs
- SUSY with R-parity violation, gauge mediated breaking, compressed spectra, and hidden valleys

Simple Stealth-SUSY model
- Low scale SUSY breaking
- New hidden sector of particles at electroweak scale
- Lightest "visible sector" SUSY particle decays into a lighter "hidden sector" SUSY particle, which subsequently decays into it's Standard Model Partner and the true lightest SUSY particle (LSP); which is here the Gravitino:



Two exclusive signal regions with S_T > 700 GeV and 4 jets or ≥ 5 jets are defined. Further, two control regions are defined: A "jet multiplicity sideband" (JMSB) composed of events with two or three jets and S_T > 600 GeV, and a "ST sideband" composed of events with four or more jets and 600 GeV < S_T < 700 GeV.

The SM expectation is estimated from the data based on the observation that the shape of the S_T spectrum of the SM background is independent of jet multiplicity. The S_T shape is taken from the JMSB and the normalization is taken from the S_T sideband.

The observed S_T spectrum is compared to the Standard Model background expectation in Fig. 7 and good agreement is found.

Limits, calculated in the same way as discussed above, on the stealth SUSY cross section as a function of the squark mass are compared in Fig.5 to the predicted stealth SUSY cross section. The production of squarks with masses <1430 GeV can be excluded by this analysis. SUSY searches based on photons and MET are insensitive to most of the stealth SUSY region excluded by this analysis.

Selection
- Two photons with pT > 40 (25) GeV, |η| < 1.4
- ≥4 Jets with pT > 20 GeV, |η| < 2.4
- MET > 20 GeV
- Pixel seed veto against electrons
- Tight photon isolation
- S_T > 700 GeV (scalar sum of pT of jets, photons, and MET)

The cut on the S_T is optimized for each squark mass under study in order to maximize the sensitivity. The S_T lower thresholds range from 800 GeV to 2400 GeV for squark masses from 400 GeV to 2000 GeV.

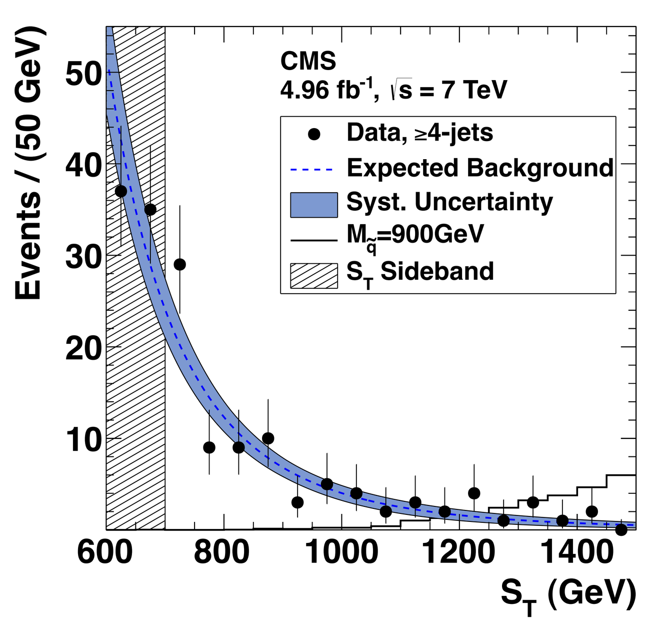


Figure 7: S_T distribution

Four lepton selection
- Four leptons (e, μ, τ) with pT > 10 GeV, |η| < 2.4
- At least one electron or muon with pT > 20 GeV
- At most one hadronically decaying τ
- Hadronically decaying τ must have pT>20 GeV
- Leptons are required to originate from the samevertex and to be isolated
- Veto on inv. Di-lepton mass <12 GeV
- At least one ee or μμ within 15 GeV of the Z mass
- Veto events containing b-tags to suppress tt
- Jets pT > 25 GeV, |η| < 2.5, ΔR(jet, lepton) > 0.4

Two lepton and two jet selection
- Two leptons (ee, μμ) with pT > 20 GeV, invariant mass within 10 GeV of the Z-mass
- No third lepton
- Two jets with pT > 30 GeV, invariant mass within 20 GeV of the Z-mass

E_T^{miss} (GeV)	Data	Total Bkg	$Z\gamma^*$	Rare SM	$t\bar{t}$ and Fake	WZ	ZZ
OSSF1, 0 τ							
0–30	0	3.94 ± 0.32 ± 1.32	2.15 ± 0.26 ± 1.16	0.10 ± 0.03 ± 0.05	0.02 ± 0.01 ± 0.00	0.03 ± 0.01 ± 0.01	1.64 ± 0.19 ± 0.64
30–50	1	0.71 ± 0.10 ± 0.18	0.07 ± 0.04 ± 0.04	0.07 ± 0.02 ± 0.04	0.02 ± 0.01 ± 0.00	0.03 ± 0.01 ± 0.01	0.51 ± 0.09 ± 0.17
50–100	1	0.74 ± 0.09 ± 0.17	0.00 ± 0.00 ± 0.00	0.24 ± 0.04 ± 0.13	0.03 ± 0.01 ± 0.00	0.03 ± 0.01 ± 0.01	0.44 ± 0.08 ± 0.11
> 100	0	0.36 ± 0.04 ± 0.12	0.00 ± 0.00 ± 0.00	0.22 ± 0.04 ± 0.12	0.01 ± 0.01 ± 0.00	0.02 ± 0.01 ± 0.01	0.11 ± 0.02 ± 0.03
OSSF1, 1 τ							
0–30	13	11.33 ± 0.51 ± 2.44	0.75 ± 0.34 ± 0.29	0.18 ± 0.04 ± 0.10	1.09 ± 0.24 ± 0.14	0.74 ± 0.05 ± 0.21	8.57 ± 0.29 ± 2.40
30–50	4	5.50 ± 0.20 ± 0.73	0.00 ± 0.00 ± 0.00	0.06 ± 0.01 ± 0.03	0.98 ± 0.05 ± 0.05	1.00 ± 0.06 ± 0.29	3.45 ± 0.18 ± 0.67
50–100	6	4.93 ± 0.17 ± 0.55	0.00 ± 0.00 ± 0.00	0.19 ± 0.05 ± 0.10	1.18 ± 0.06 ± 0.06	1.16 ± 0.06 ± 0.33	2.39 ± 0.14 ± 0.42
> 100	1	1.62 ± 0.09 ± 0.19	0.00 ± 0.00 ± 0.00	0.21 ± 0.04 ± 0.11	0.37 ± 0.03 ± 0.02	0.32 ± 0.03 ± 0.09	0.72 ± 0.07 ± 0.12
OSSF2, 0 τ							
0–30	69	68.52 ± 1.04 ± 20.18	0.08 ± 0.04 ± 0.04	0.33 ± 0.02 ± 0.18	0.01 ± 0.01 ± 0.00	0.01 ± 0.01 ± 0.00	68.09 ± 1.04 ± 20.18
30–50	9	9.31 ± 0.32 ± 3.08	0.10 ± 0.06 ± 0.05	0.21 ± 0.03 ± 0.12	0.01 ± 0.00 ± 0.00	0.01 ± 0.01 ± 0.00	8.98 ± 0.31 ± 3.08
50–100	1	1.67 ± 0.14 ± 0.56	0.00 ± 0.00 ± 0.00	0.32 ± 0.04 ± 0.17	0.01 ± 0.01 ± 0.00	0.02 ± 0.01 ± 0.01	1.31 ± 0.13 ± 0.54
> 100	0	0.31 ± 0.03 ± 0.12	0.00 ± 0.00 ± 0.00	0.21 ± 0.03 ± 0.11	0.00 ± 0.00 ± 0.00	0.00 ± 0.00 ± 0.00	0.09 ± 0.01 ± 0.04

Table 1: Observed and expected events yields for exclusive channels of the four lepton final state.

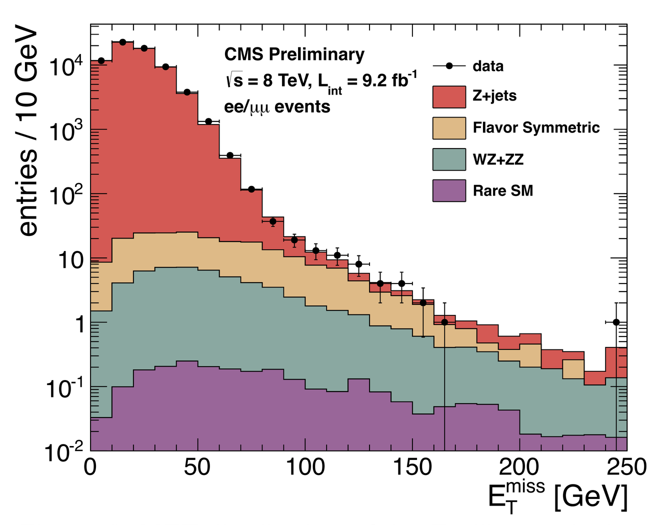
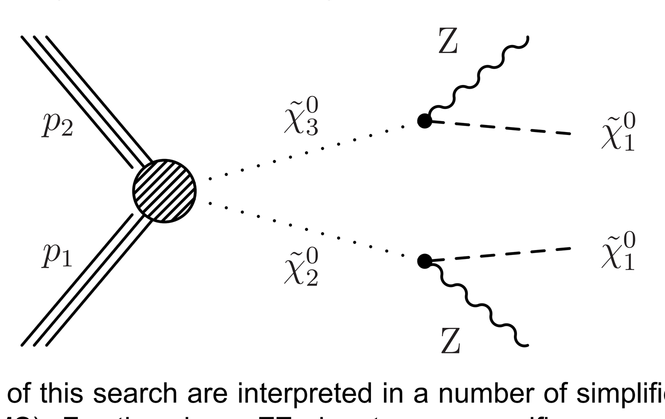


Figure 8: MET distribution of the Z+dijet analysis

Electroweak production

8 TeV, 9.2 fb^{-1}: CMS Physics Analysis Summary SUS-12-022

- Electroweak production of charginos, neutralinos, and sleptons
- Generally little hadronic activity



The results of this search are interpreted in a number of simplified model spectra (SMS). For the above ZZ signature, a specific gauge-mediated supersymmetry breaking (GMSB) Z-enriched higgsino model is considered, that enhances the ZZ + MET final state.

Four lepton analysis
The primary non-reducible background from ZZ is estimated from Monte Carlo simulation with corrections. Fake and non-prompt leptons may arise. These are modeled using data sideband regions with non-isolated leptons.

Two lepton and two jet analysis
Eight signal regions in exclusive bins of MET between zero and > 200 GeV are defined. The Z+jets background is suppressed in the high MET bins and further reduced by the invariant di-lepton and di-jet mass cuts. The dominant background to this search is tt, which is reduced by a factor of ten by applying a b-tag veto. The remaining tt, WW, and single-top background is characterized by an equal rate of ee + μμ versus eμ. This flavor symmetric background is evaluated on a eμ sample. The remaining non-flavor symmetric background like WZ is taken from Monte Carlo simulation and is found to be negligible.

Results
In Fig. 6 the CLs limit obtained by the combination of the four lepton and the two lepton plus two jet analyses on the GMSB cross section versus the mass scale μ is shown. The mass scale μ is a measure for the degenerate gaugino masses. The branching fraction to the ZZ + E_T final state varies from 100% at μ = 130 GeV to 85% at μ = 410 GeV.

Prepared for:

HEP 2013
Stockholm
18-24 July 2013

More information available at:

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Federal Ministry of Education and Research