SUSY searches at CMS

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On behalf of the **CMS** collaboration

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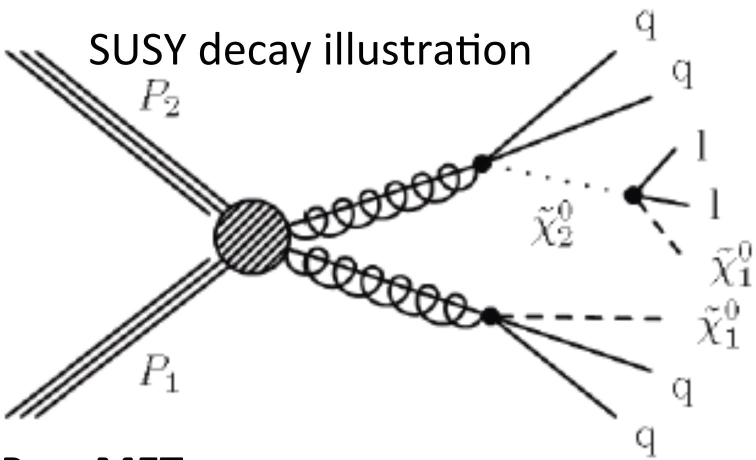
Introduction

Introduction

SUSY decay illustration



2 LSPs ➔**MET**
2 sparticles with decay chains ➔ **many particles**

Channels

- Hadronic
- leptonic (1-lep, 2-lep (OS,SS),tri-leptons …)
- V-Bosons (Z,γ)
- special families (***b***,τ)

Search variables

“classic” or **“ lower level”**:

- MET = missing energy
- HT = Sum of jet P_Ts

“Higher level”:

- M_R,R^2
  - Approximation of Masses diff.
  - + QCD rejection and sensitivity
- M_{T2}
  - new particle (s)transverse Masses
  - + Helps understanding spectra
- α_T
  - QCD event balance
  - + Very strong QCD rejection
- L_P
- **And more**

Introduction

hadronic analysis (α_T,MHT,Razor,M_{T2}):

- Multiple complementary analysis

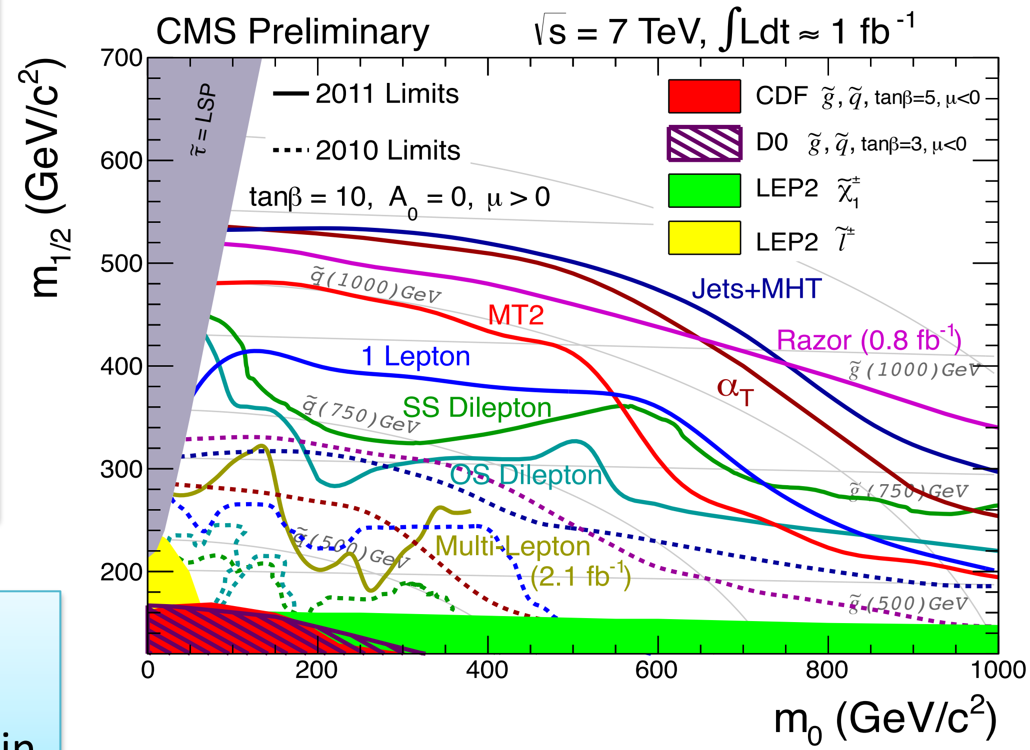
Leptonic analysis:

- Only few channels with complementary analysis, but many channels.

V-Boson analysis (not illustrated in plot):

- Mostly one method per channel

Summer CMSSM



Large number of analysis:

- 27 public results and 11 papers
- + many new 4.7 pb^{-1} results coming in

Had to pick small subset of analysis

Picked Summer/Autumn Results

Hadronic MHT+HT “classic”

Variables:

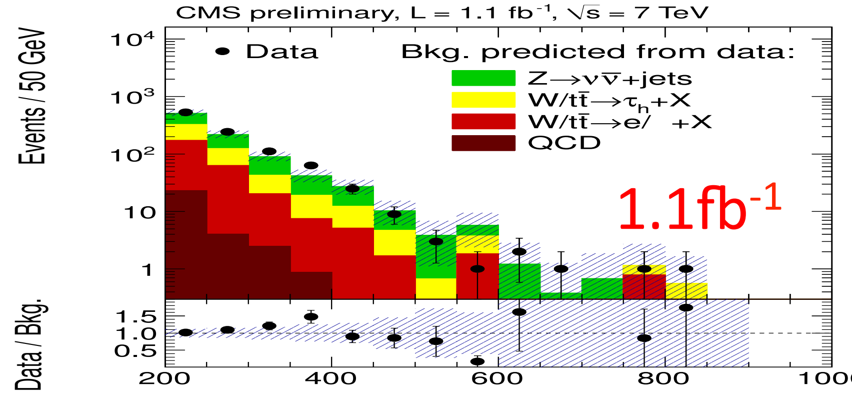
- MHT & HT
- Different HT and MHT thresholds used

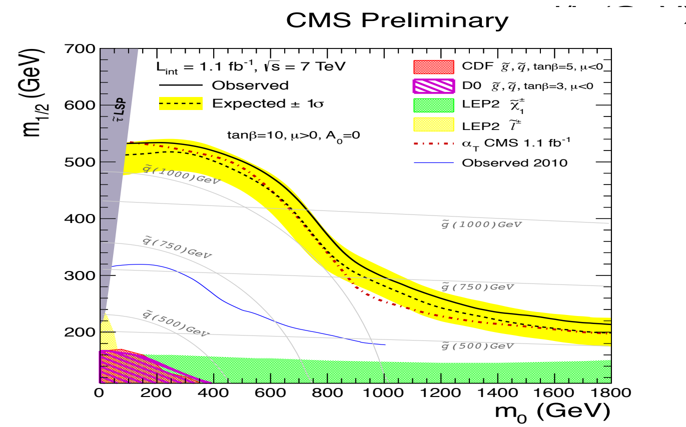
Channels:

- Fully hadronic, >= 3 jets

Background predictions:

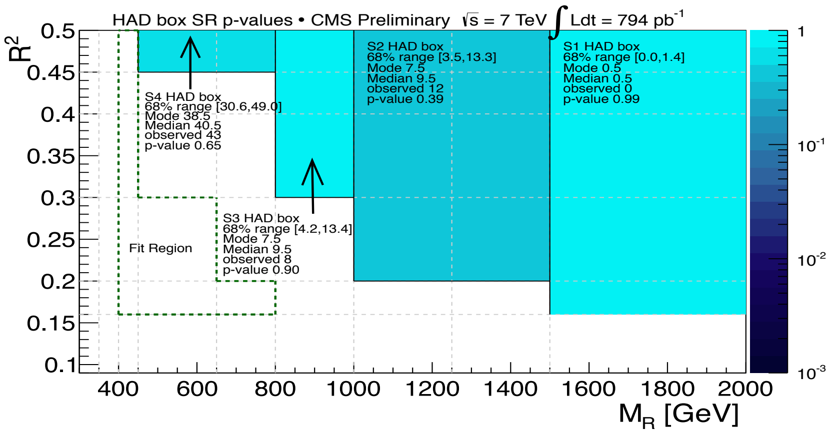
- QCD (most difficult):
  - R&S method
- $Z^0 \rightarrow \nu\nu$ (largest):
  - γ+jet control sample, known γ/Z^0 ratio
  - $Z^0 \rightarrow \ell\ell$ control sample
- W,tt (second largest):
  - One muon control sample for
    - Hadronic taus BKG
    - “Lost” leptons BKG

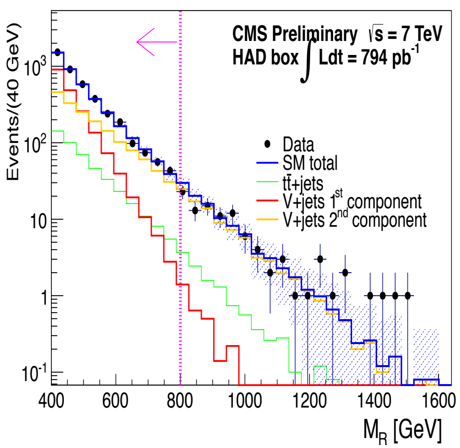


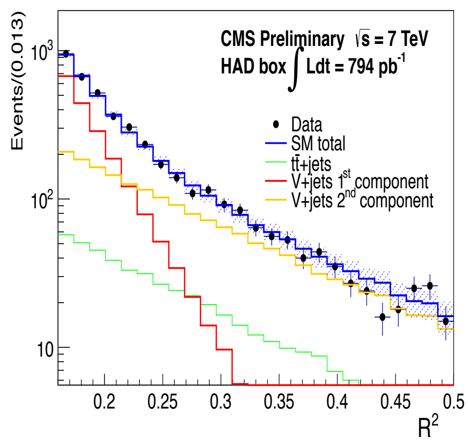


- Each background predicted individually
- Lower level HT and MHT

Razor







Variables:
- M_R, R^2

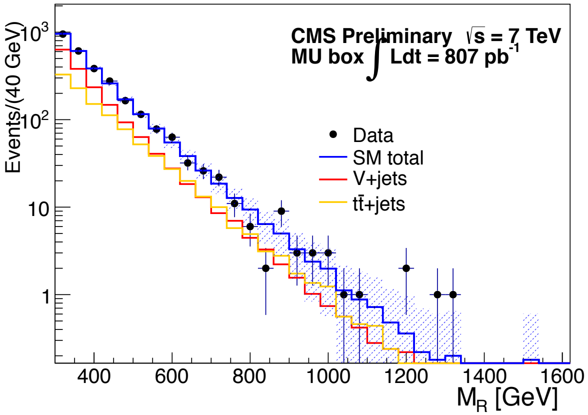
Channels:
- Leptonic and hadronic simultaneously
- >= 2 jets

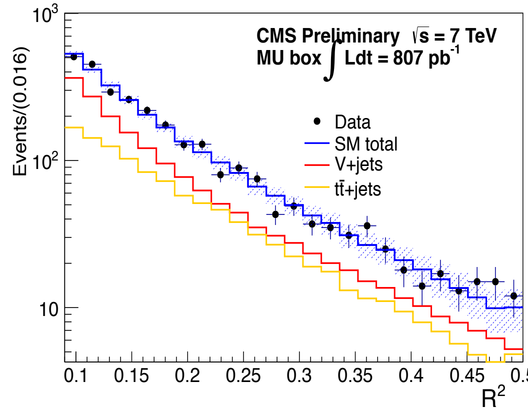
Background prediction:
- 2D fit in M_R, R^2 plane of data in control region to SM parameterization of M_R, R^2 plane
- SM estimate in signal from above fit result

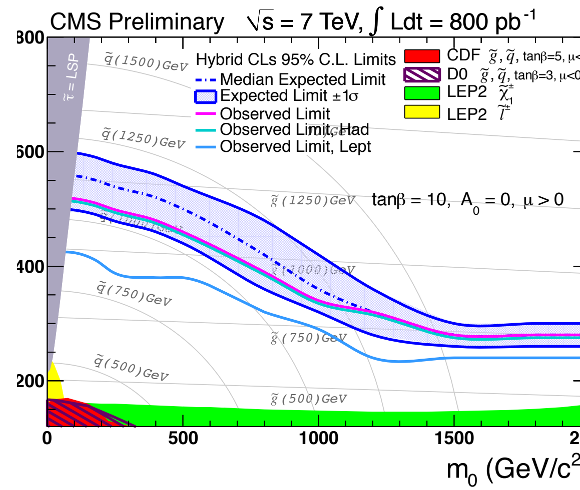
- 7-parameter model in M_R, R^2 plane used for SM to predict (extrapolate) backgrounds
- Higher level observables

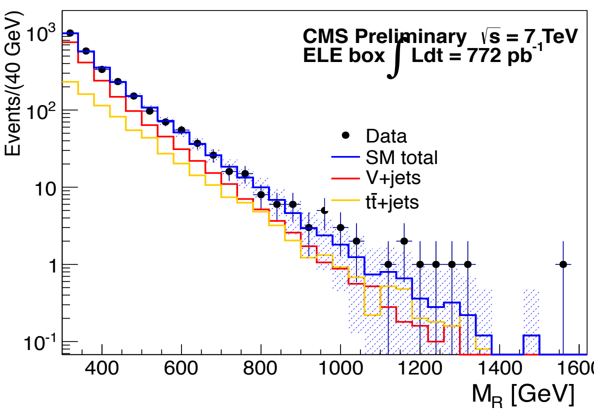
- **Different strategy than "classic" MHT, α_T searches**
- **Searches very complementary!**

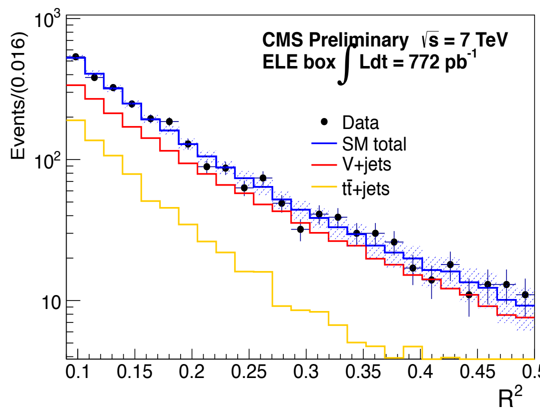
Razor











Analytical BKG prediction:

- Unbinned likelihood used to derive limit

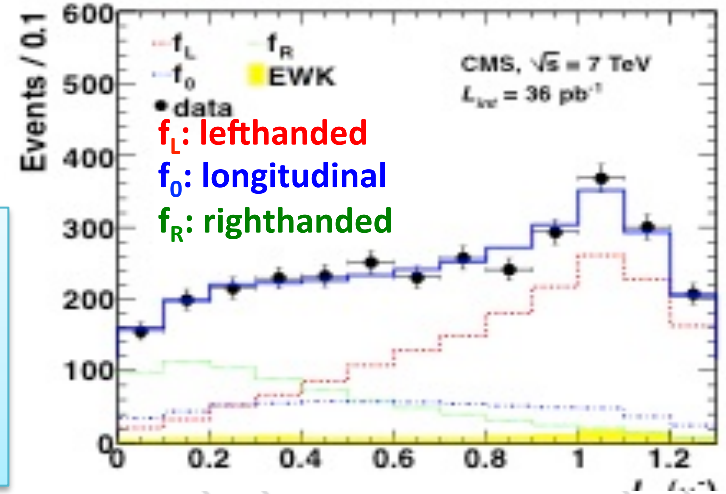
- Same BKG prediction method for different channels
- combination of channels:

  μμ,μ,μ*e*,*e*,hadronic

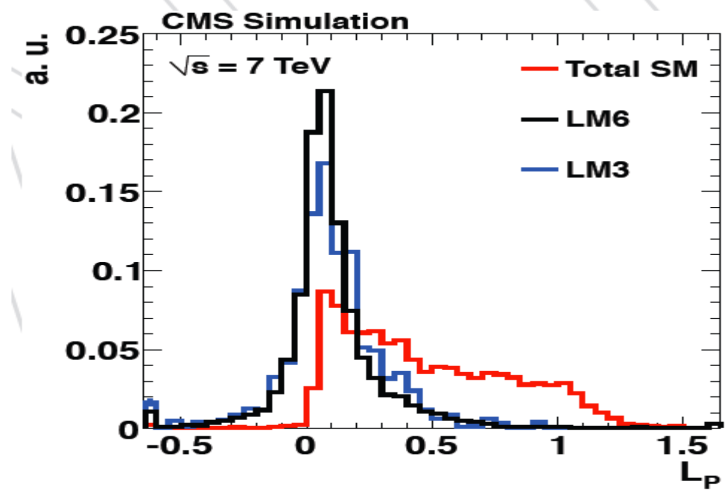
First Winter Results

One leptonic “classic”+ L_P

$$L_P = \frac{\vec{p}_T(\ell)\cdot\vec{p}_T(W)}{|\vec{p}_T(W)|^2}$$



- At large $p_T(W)$: $L_P \sim ½(1+\cos(\theta^*))$; thus polarization variable!
- W polarization measurement in pp and theory paper on W polarization in 2011



SUSY with one lepton: three invisible particles present:

- 2 LSPs (R_P-conservation)
- 1 ν (N_{lepton} conservation)

Therefore:

- Angle between lepton and ME_T bigger in SUSY than in (high-p_T) W+jets events
- In SUSY: lepton may well be softer than ME_T

High LP control region:

- JES uncertainty reduced
- $P_T(W)$ uncert. reduced

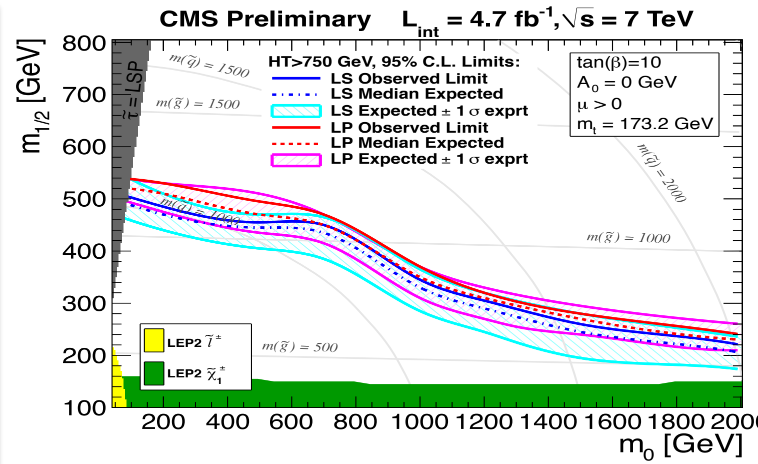
One leptonic “classic”+ LP

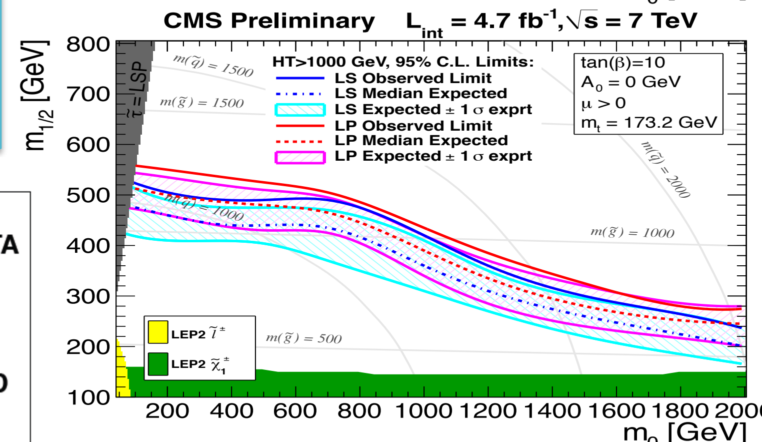
Variables:

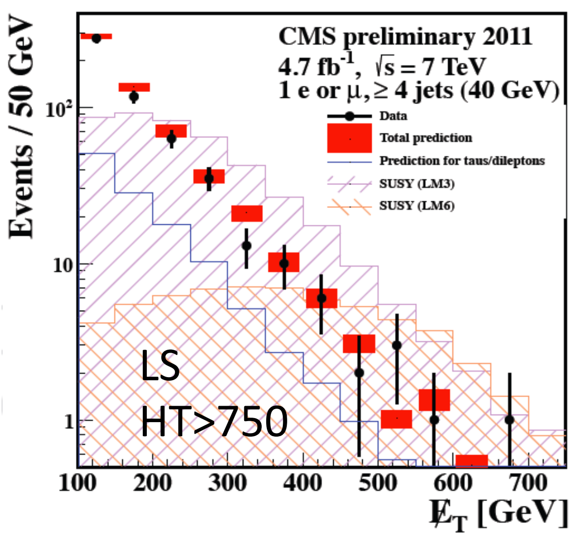
- MET, HT (LS method), **>= 4 jets**
- MET+$P_T(\ell)$, HT, L_P (W-polarization var.), **>= 3jets**

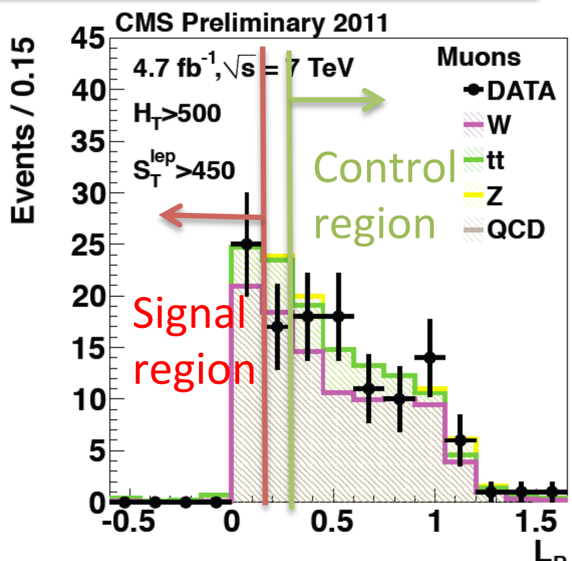
Background prediction:

- W, tt (largest):
  - Control samples high PT(ℓ) (LS) or large L_P (L_P)
- tt-Dileptons in LS (small in L_P):
  - Di-lepton control sample (LS)
- QCD (tiny, but difficult):
  - Sideband methods (cut inversions)









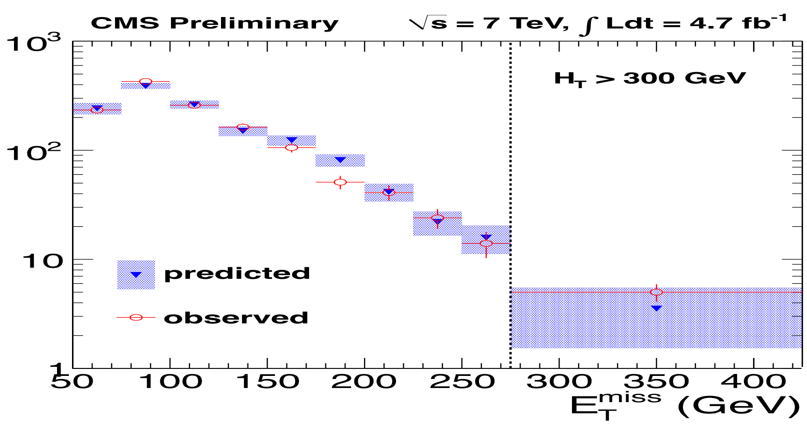
Leading BKG uncertainty is control sample statistic:

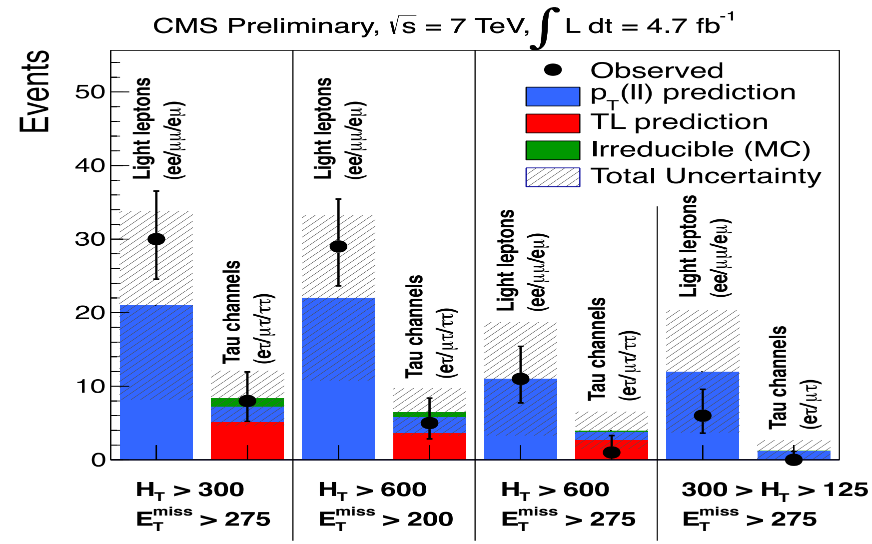
- Uncertainty decreases with $\mathcal{L}$
- improve w.r.t hadronic ones

Di-leptonic OS “classic” + mass edge

PT(ℓℓ) (OS)and LS (single lepton) method:

- The PT(ℓℓ) or PT(ℓ) spectra are used to predict the PT(νν) or PT(ν)





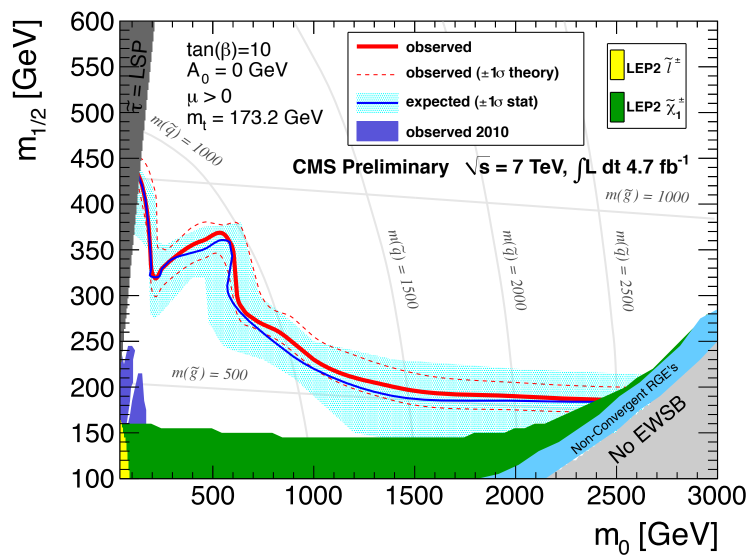
Variables:

- MET, HT
- Mass edge (not shown here)

Background prediction:

tt (largest):

- High P_T(ℓℓ) control sample



Also τ-lepton used for search

Di-leptonic SS "classic" + NN

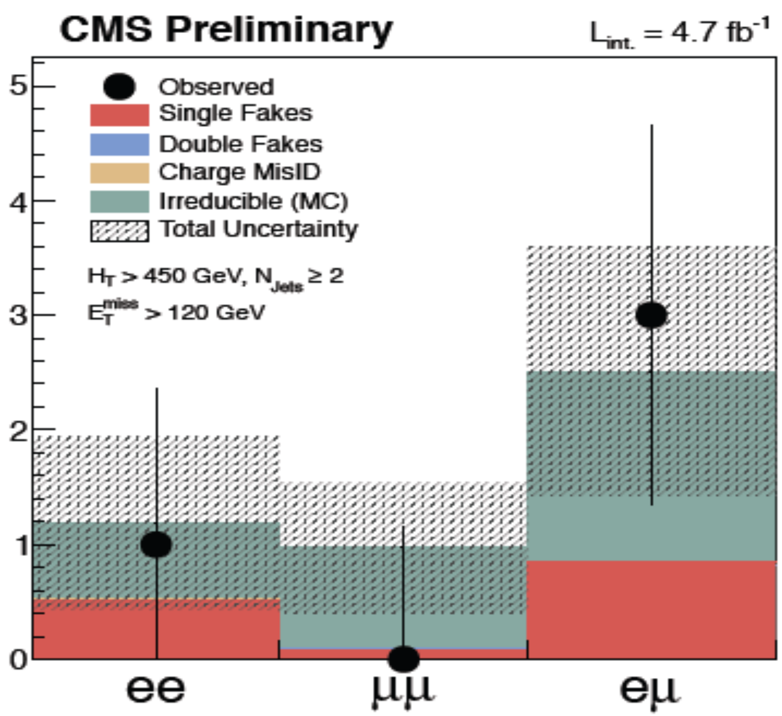
Variables:

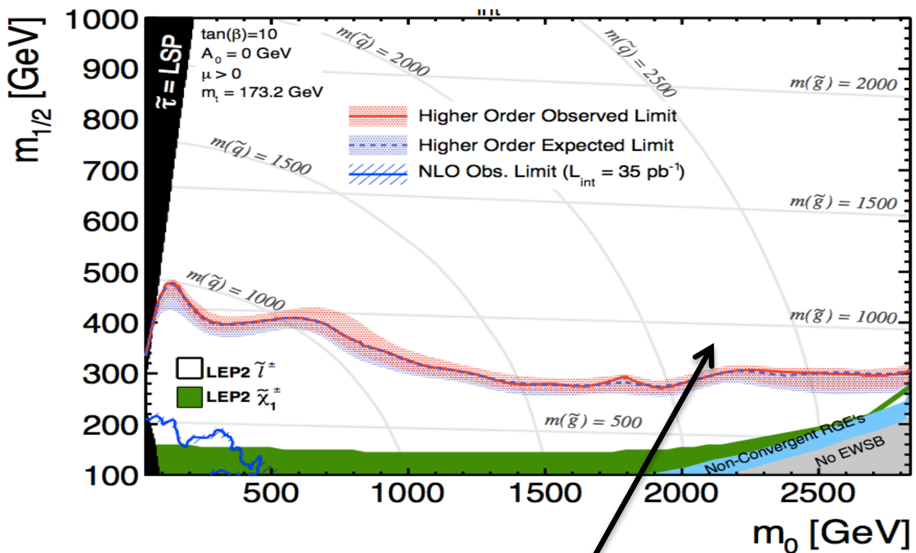
- MET (relatively low)
- NN (not shown here)

Low HT thresholds

Background prediction:

- Fakes are main background:
  - Less isolated control sample



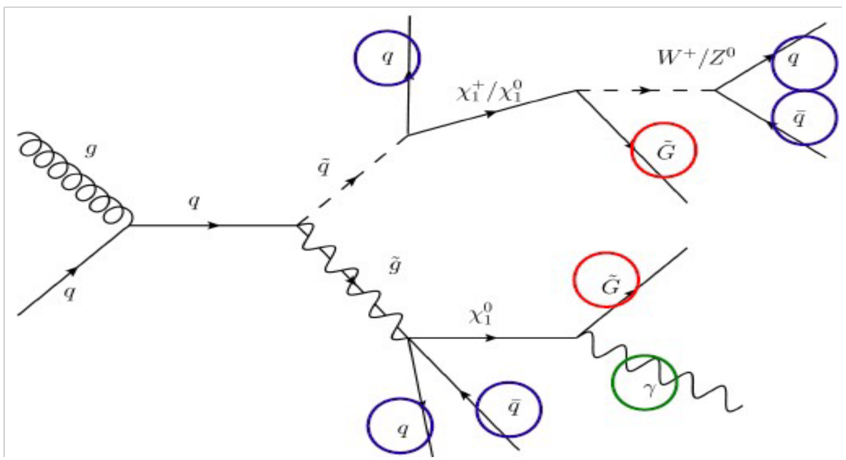


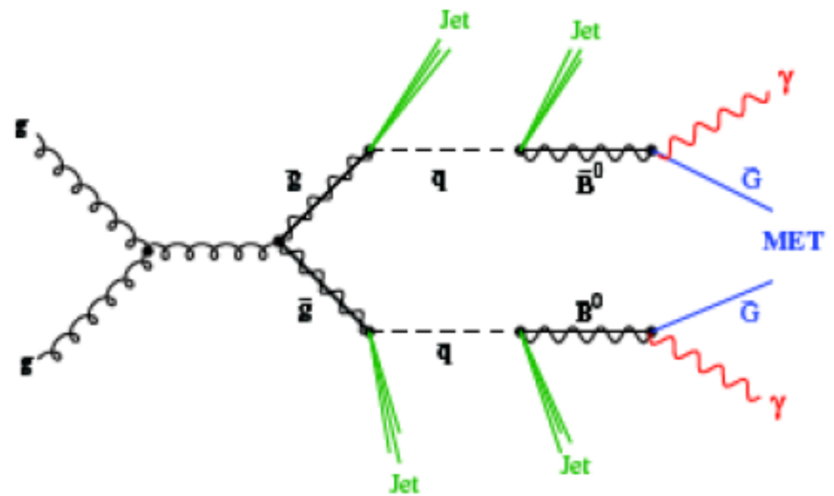
Multilepton searches sensitive at large M_0

- **CMS Searches powerful for low HT&MHT: ZZ&WZ (for Moriond), Z +MET, trilepton, …**

γ + jets + MET “classic”

In General Gauge Mediation (GGM), gravitino is Lightest SUSY Particle (LSP)
● Next to Lightest SUSY Particle (NLSP) is neutralino decaying to gravitino and SM particle





Different gaugino mixing scenarios prefer different V-Bosons (γ,W,Z) in decay:

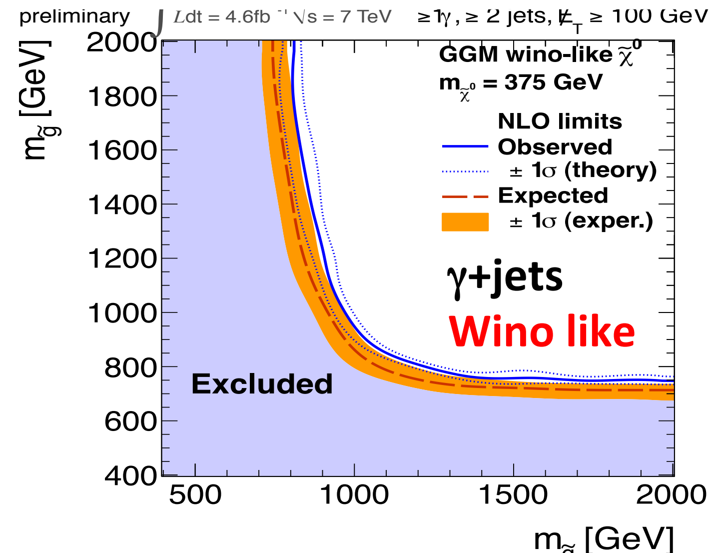
- Bino like neutralino: photon preferred -> di-photon
- Wino like neutralino: W,Z preferred -> single photon, photon + lepton

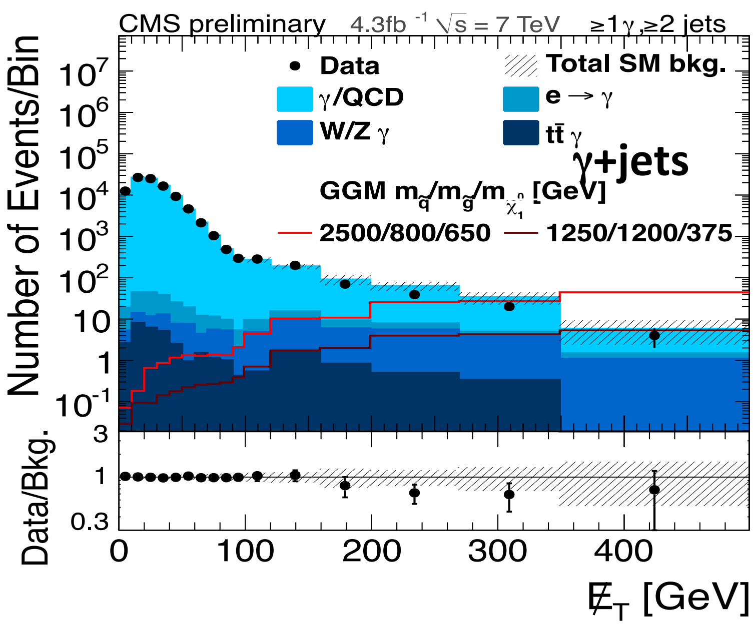
Photon + jet + MET searches have typically very small background

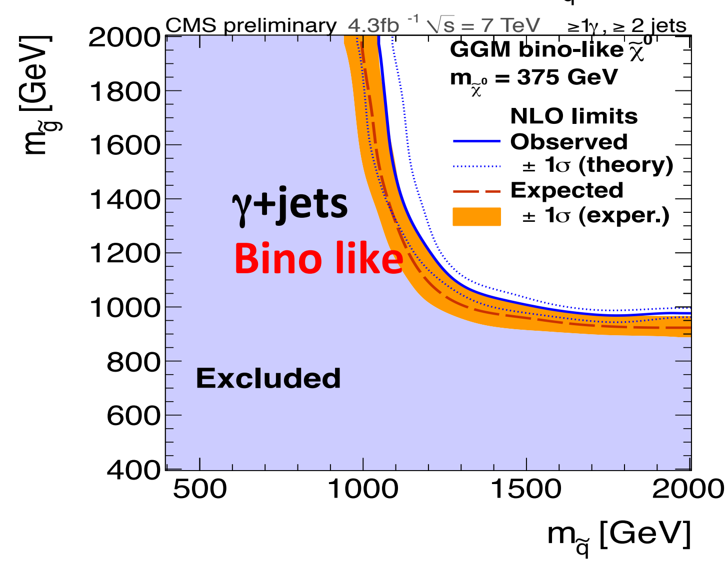
γ + jets + MET

Variables:
- MET, HT

Background prediction (**γ+jets**):
- QCD γ+jet and photon fakes (largest):
  - Multijet control sample
- EWK fake photon from electrons:
  - Electron control sample







And many more good SUSY analysis

For a complete list and updates please visit:

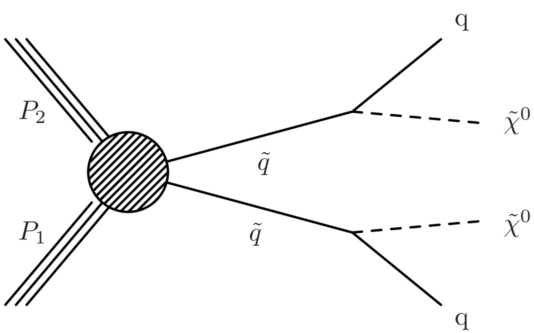
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

No excesses found in any analysis

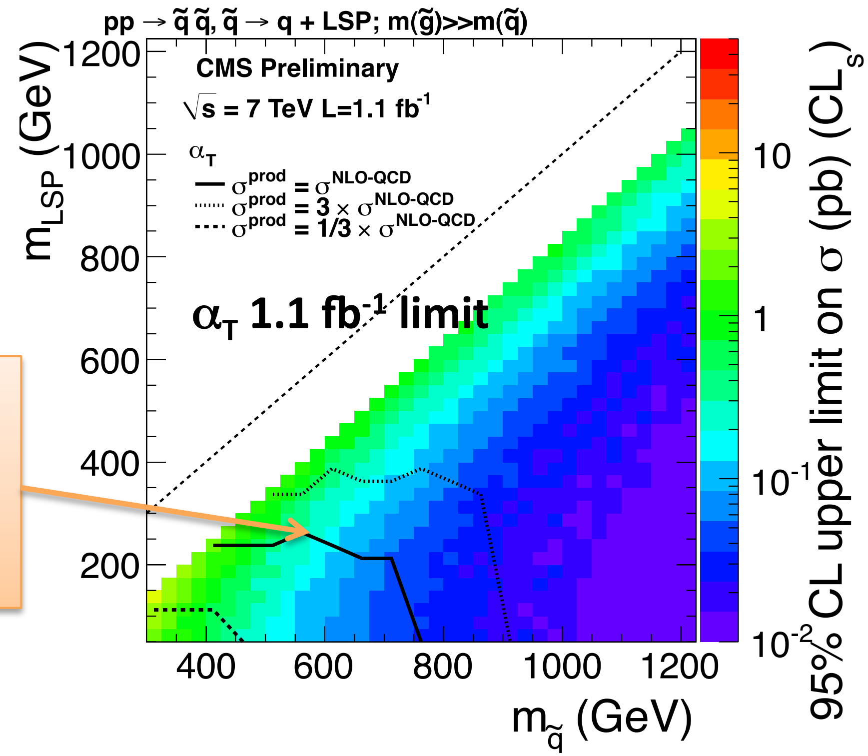
"Compressed" SUSY

CMSSM:
- Wide spectra and much MET

Simplified Models:
- Variable sparticle spectra, allowing low MET SUSY



Squark mass close to LSP mass ➔ few MET



- SMS constraint on squark masses less stringent than CMSSM
- Almost all analysis presented limits on SMS and CMMSM
- Compressed spectra can lead to missing out SUSY

SUSY “*trends*”

The “natural” SUSY solution of the hierarchy (fine-tuning) problem is one motivation for SUSY:

- A “light” scalar (squark) needed to cancel fermion Higgs-mass terms.
- Large difference of the fermion (SM) mass to scalar SUSY particle mass, replaces “fine-tuning” problem of SM by a “tuning” problem with SUSY

From RGE and from max-mixing the 3rd generation of squarks is likely the lightest

- Stop is a favored candidate to solve fine-tuning problem
- Exclusion of light stop “***hot***” topic

- Much increased activities in adding b-tagging to **more** analysis
  - MHT+HT b-tagged, One-leptonic b-tagged, Razor b-tagged, …
  - Completely new custom analysis introduced

Summary

Many analysis presented results:

- No excess observed
- CMSSM squark to > 1250 GeV and gluons to >750 GeV (from preliminary results)

New analysis added w.r.t. summer:

- Less inclusive analysis, e.g. ZZ,ZW,…
- More detailed analysis, e.g. NN.

Current developments:

- Special searches for 3rd generation searches

- In the process of precision determination of the luminosity collected by CMS in 2011, a slight time-dependent calibration drift was found in the calorimeter used as a luminometer
- To remedy this, we developed an independent luminosity determination using stable and precise pixel tracker
- Preliminary result presented at the LHC Luminosity Days suggests an upward change in the estimated luminosity for 2011 by ~6%, i.e. slightly outside the 1σ-band of our original estimate of the luminosity uncertainty
  - The corresponding change for the low-luminosity part of the run (2011A), which is the basis of our new and published precision measurements, is ~3.5%, well within the quoted systematics
- We are finalizing determination of the new luminosity measurement, with significantly better precision
- The anticipated change has a very minor effect on our preliminary results and no visible change in published limits
- Instability does not affect the 2010 luminosity determination, as it only affects high-luminosity running