Supersymmetry Searches

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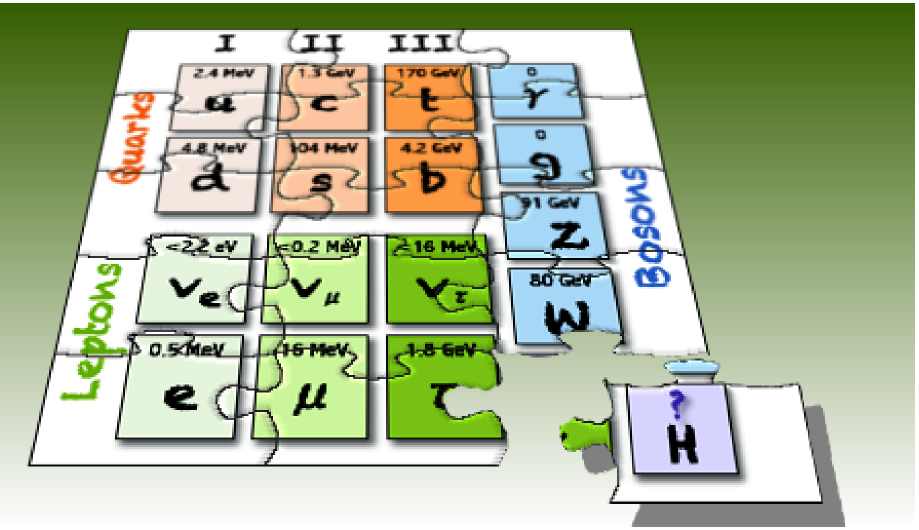
on behalf of CDF, D0, CMS and ATLAS Collaborations

Physics In Collision 2011, Vancouver

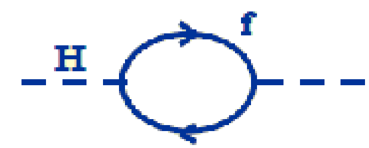
The Standard Model (SM)

No significant deviation found in many years of investigation



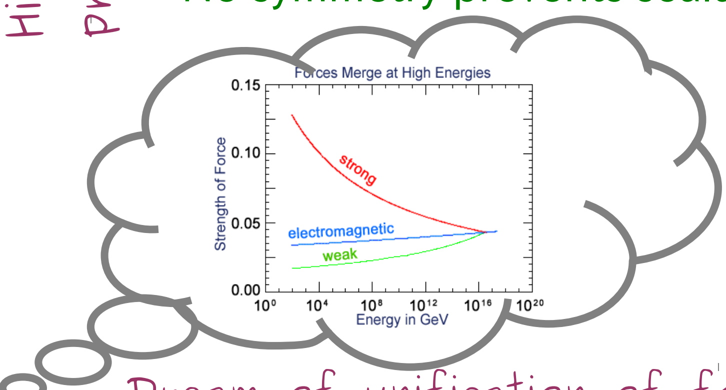
- Matter is made out of fermions:
  - 3 generations of quarks and leptons
- Forces carried by bosons:
  - Electroweak (EWK): g, W, Z
  - Strong: gluon
- Missing piece: origin of masses
  - Higgs particle

However, there are some theoretical problems in the above picture:



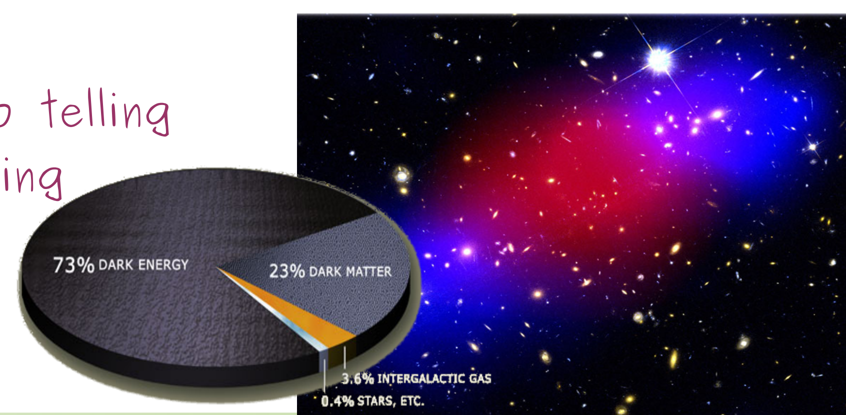
Hierarchy problem

- Higgs mass should be small to preserve unitarity (~<1 TeV)
- If no new physics: $\Lambda \sim \Lambda_{Pl}$ --> why m_W scale << m_{Pl}?
- No symmetry prevents scalars from acquiring mass via radiative corrections: $\delta m_H^2 \sim \Lambda^2 \sim \Lambda_{Pl}^2$



Dream of unification of forces

Universe is also telling us we are missing something...



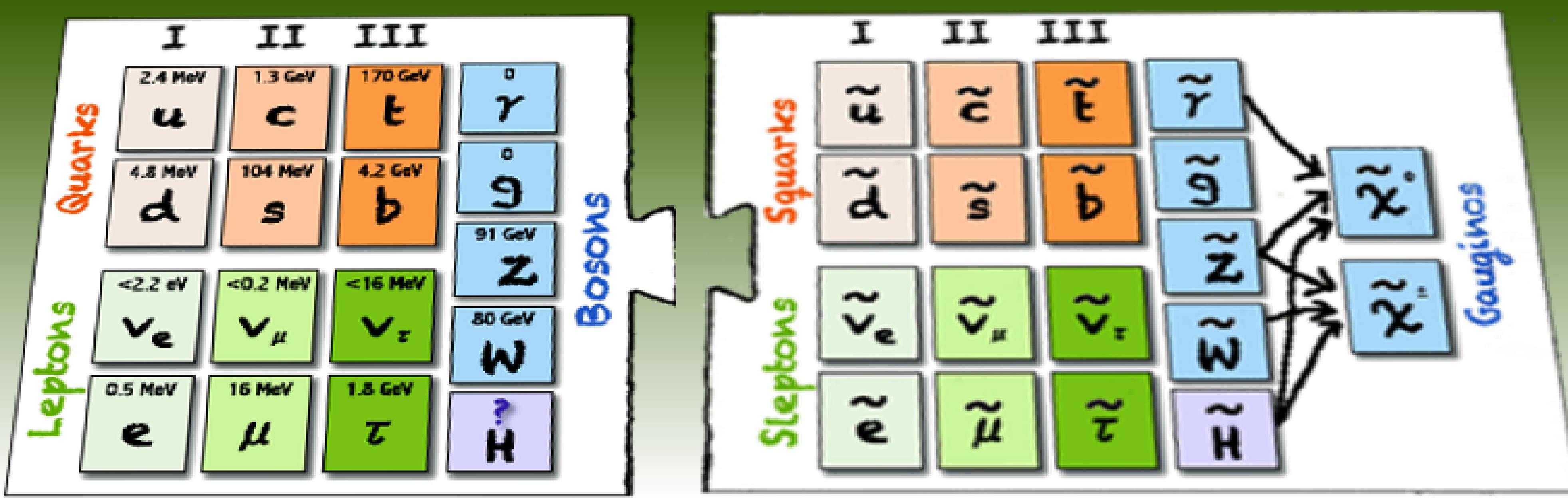
Supersymmetry

- Supersymmetry (SUSY) is a new symmetry between bosons and fermions
  - Every SM particle has a superpartner differing by half a unit of spin
  - Higgs sector extended to 5 Higgs: h, H, A, $H^{\pm}$
- It naturally solves the hierarchy problem
  - Loop contributions cancel
- It could provide solution to other problems
  - Gauge unification
  - Dark matter candidate
  - ...

New issue:

Particles with same mass but different spin are not observed.

SUSY must be broken: mechanism unknown

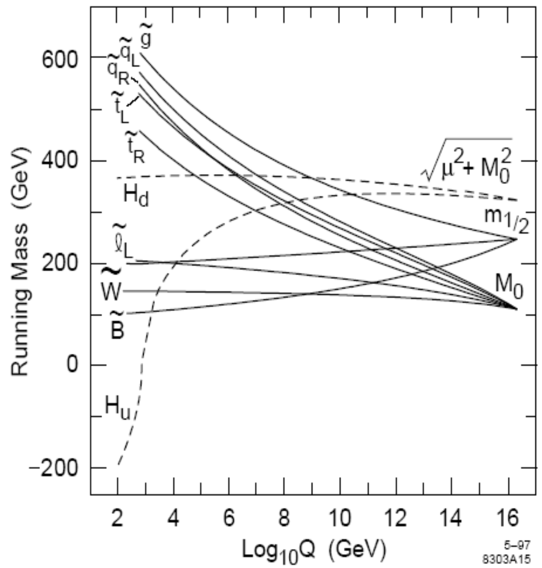


SUSY modelling

- The minimal SUSY extension of the SM (MSSM): 105 new parameters. Need different approaches.

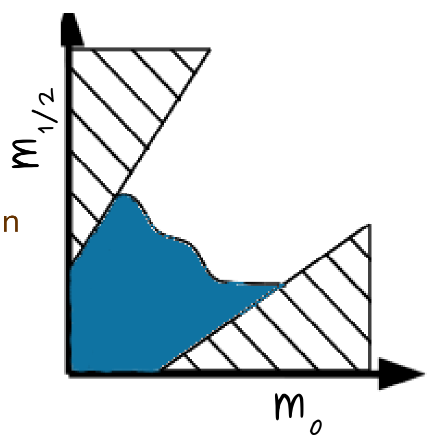
Top-down approach

- Model of SUSY breaking: gravity mediated, gauge mediated...
- Assume GUT scale parameters (few)
- Predict phenomenology at the EWK scale



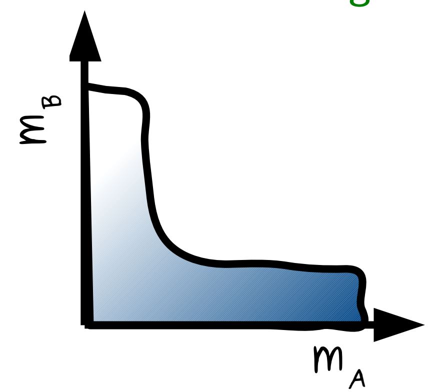
E.g. mSUGRA/CMSSM:

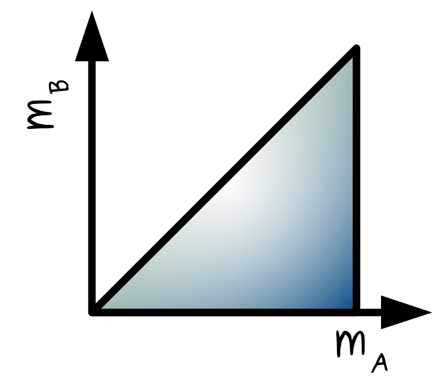
m_0: common scalar mass (GUT)
$m_{1/2}$: common gaugino mass (GUT)
tanβ: Ratio of Higgs vaccum expectation values
A_0: Trilinear coupling
Sign(μ): Higgs mass term



Bottom-up approaches

- Phenomenological models
  - ➔ Assume mass & hierarchy for SUSY particles
- Simplified models:
  - ➔ Assume single decay chain (building block)





Model independent limits

Provide σ · efficiency · acceptance

Expected signatures

General MSSM lagrangian violates leptonic and baryonic numbers in the superpotential

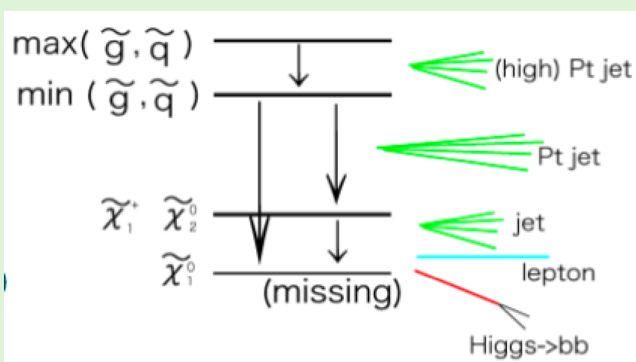
New symmetry postulated: **$R=(-1)^{2S+3(B-L)}$**

Impact on the expected phenomenology

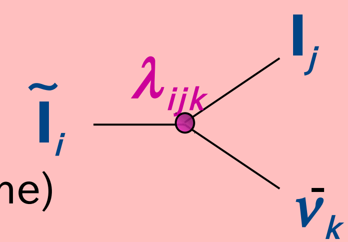
SM: R-parity=+1
SUSY: R-parity=-1

R-parity conservation (RPC)

- SUSY particles created in pairs
- Lightest Supersymmetric Particle (LSP) stable
  - ✔ Missing transverse momentum (EtMiss)
  - ✔ No mass peak expected (tails)
  - ✔ Excellent detector understanding



R-parity violation (RPV)



- The LSP decays
- Some constraints (e.g. proton lifetime)
  - ✔ Exploit invariant masses
  - ✔ EtMiss can also be expected (e.g. neutrinos) but can be relaxed

Other more exotic situations

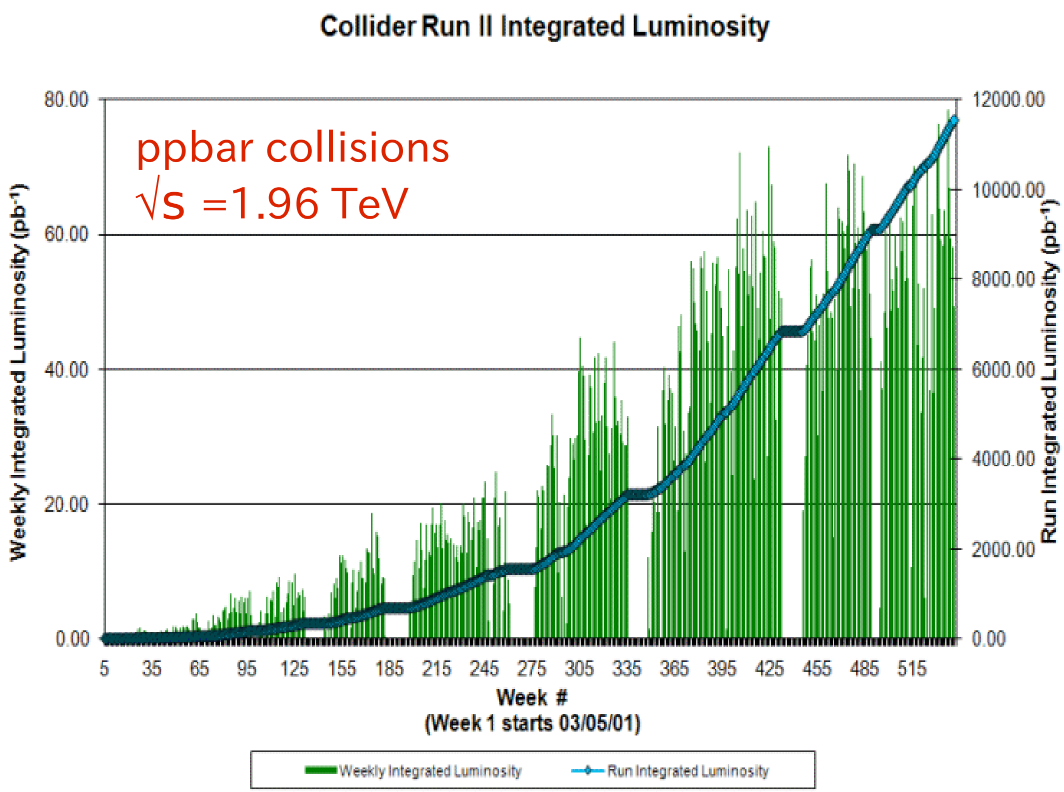
- Depending on the mass splitting/hierarchy
  - ✔ Displaced vertices
  - ✔ Slow moving ionizing particles
  - ✔ Delayed decay
  - ✔ …

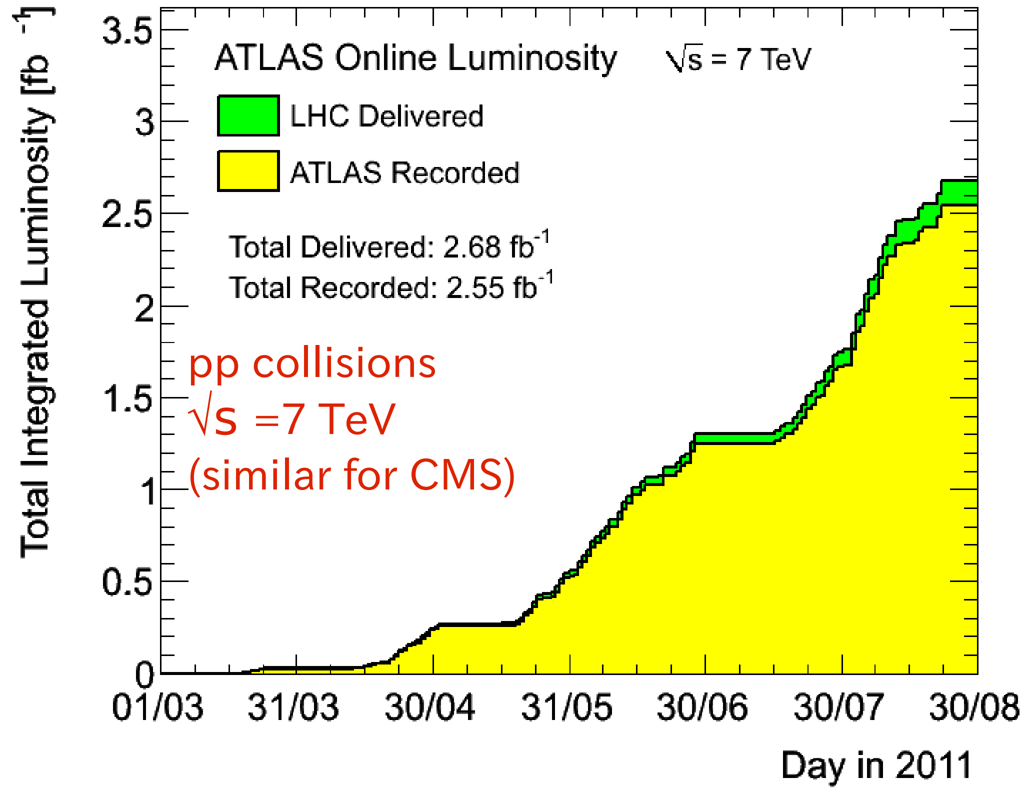
See next talk from S. Rahatlou

Indirect searches (e.g. $B_s \to \mu\mu$)

See backup slides / talks (R. Harr & P. Koppenburg)

Tevatron and LHC performances





Tevatron has been performing very well

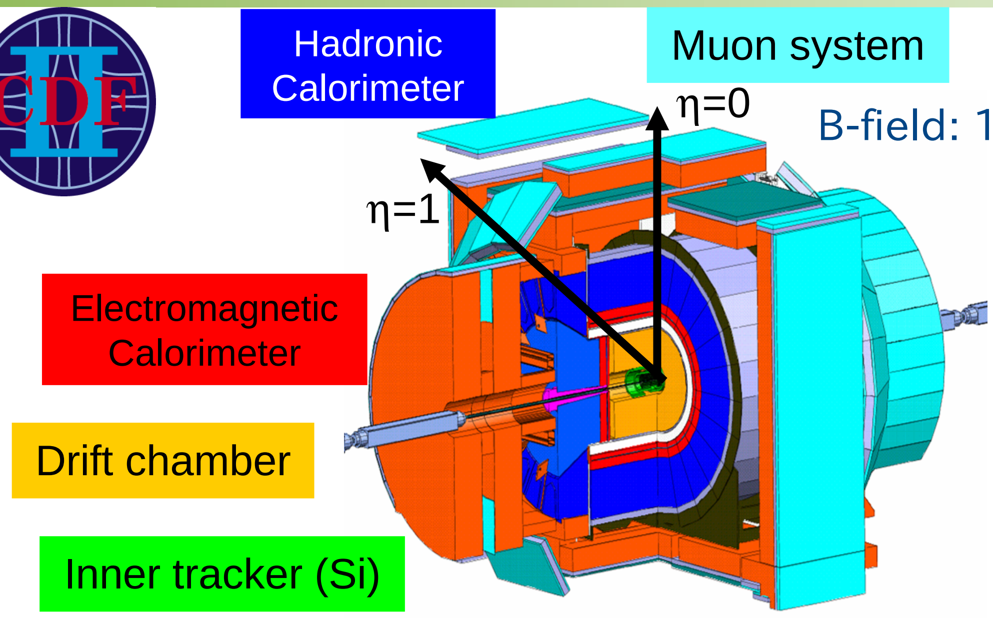
High integrated luminosity delivered, *specially in latest years*.

Big achievements: producing large amounts of antimatter is very challenging

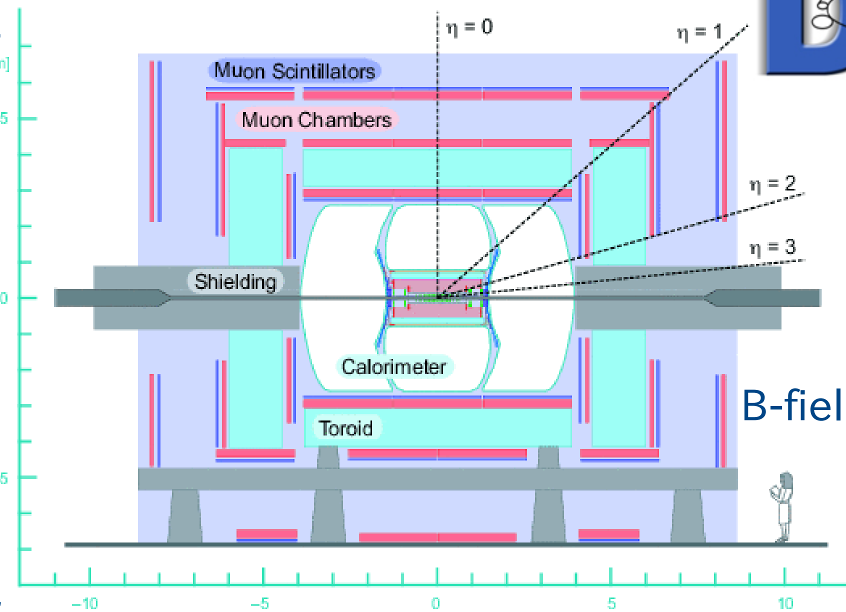
LHC delivered luminosity increasing extremely fast: *last July, SUSY results were only with 70 nb^{-1}!*

Analyses needed to adapt to very rapid changes in a record time: pileup conditions, trigger challenges, new techniques with more data...

Multi-purpose detectors

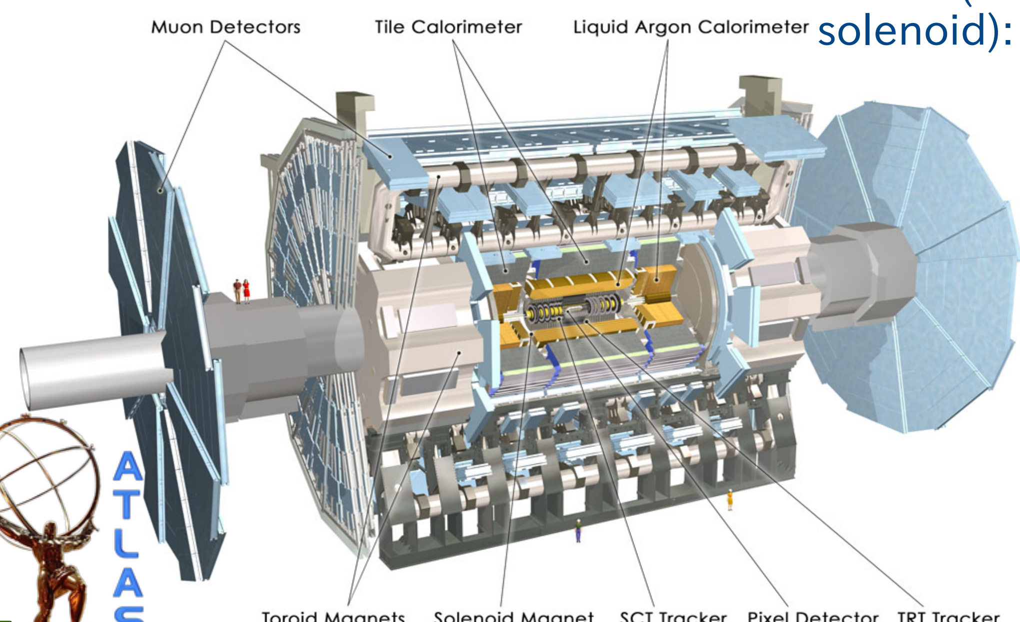


B-field: 1.4 T

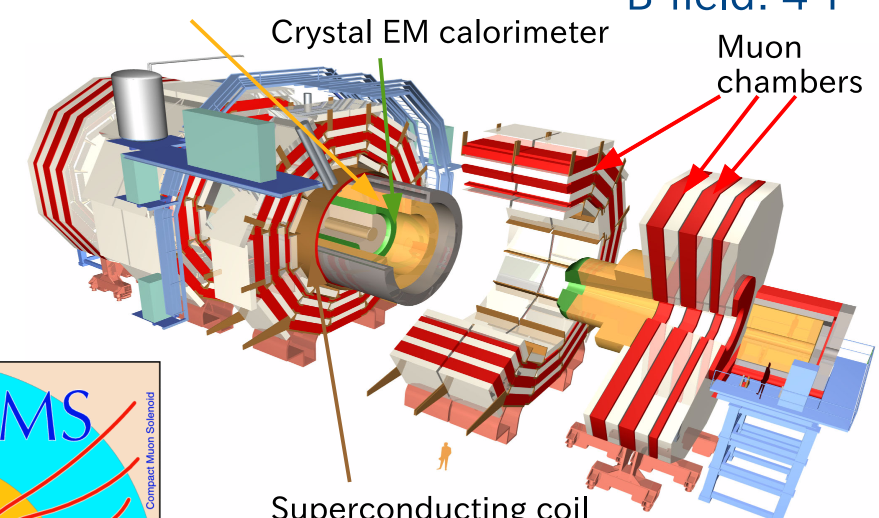


B-field: 1.8 T

B-field (inner solenoid): 2 T

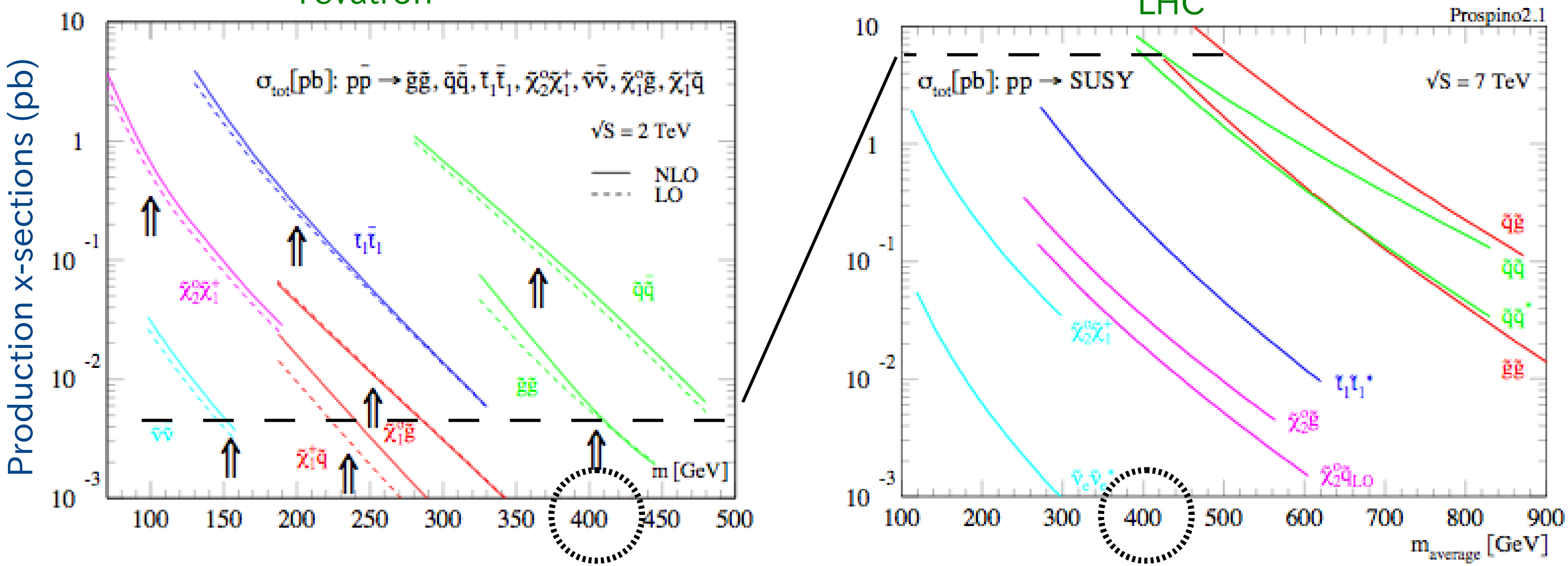


B-field: 4 T



Sensitivity to SUSY

Tevatron   LHC



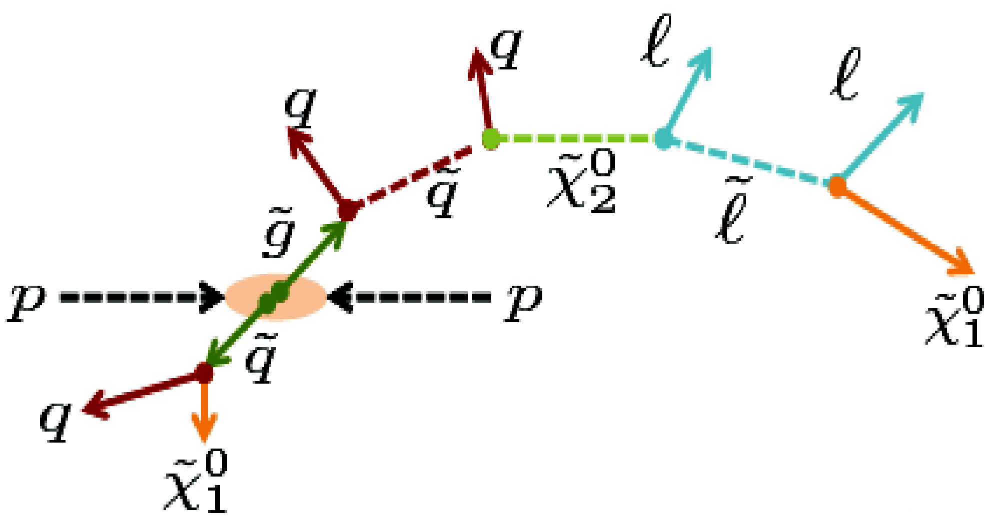
LHC

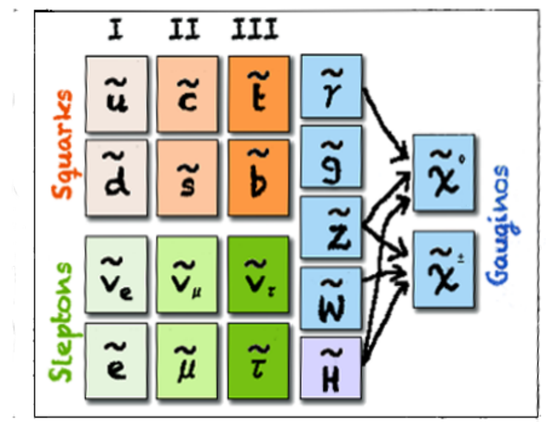
- ✔ Strong production cross-sections > 150 times higher than Tevatron
- ✔ Dominant backgrounds do not increase as much
- ✔ Managed to produce competitive results with just few pb^{-1} in some channels

Tevatron

- ✔ Still competitive in some channels (stop pair production, gaugino production…)
- ✔ Benefit from large datasets and long experience with the detector performance

Outline of analyses





Rich phenomenology:

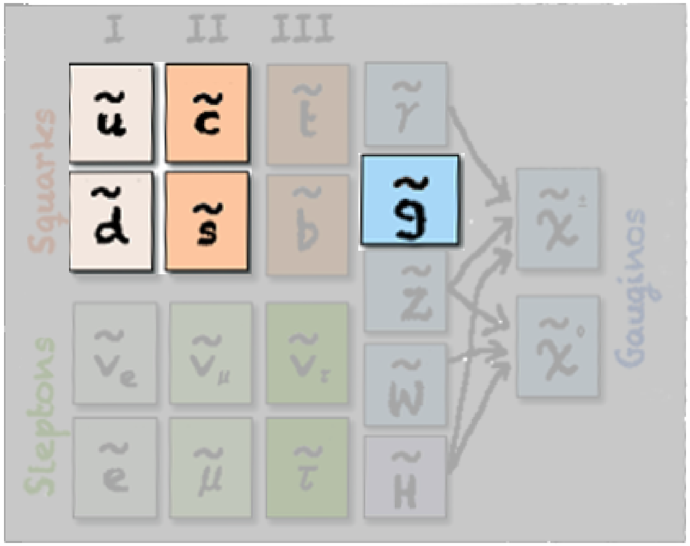
- ✔ short/long cascades
- ✔ with/without leptons
- ✔ Different flavours of jets/leptons
- ✔ Large/small EtMiss (SUSY masses)

R-Parity conserving searches (RPC)

- 0-lepton
- 1-lepton
- 2-leptons
- Multi-leptons
- b-jet searches
- Photon searches

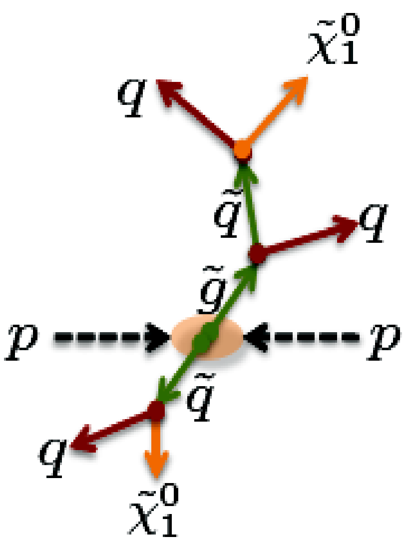
R-Parity violating searches (RPV)

0-lepton searches



- ✔ Strong production of massive particles: jet+EtMiss signature (taus treated as jets)
- ✔ Leptons are vetoed
- ✔ Background control is challenging:

Multijet cross section: ↑↑↑
Efficiency*acceptance: ↓↓↓
} Need data-driven estimations



Different techniques/strategies developed:

$$\begin{cases} H_T = \sum_i^{\text{jets}} |\vec{p}_{T,i}| \\ MHT = -\left|\sum_i^{\text{jets}} \vec{p}_{T,i}\right| \\ m_{eff} = \sum_i^n p_T^{jet,i} + E_T^{miss} \end{cases}$$

MHT or m_{eff} search
Excess at large EtMiss and/or large H_T

Long cascades
Excess at large jet multiplicities

α_T search (L. Randall and D. Tucker-Smith, Phys.Rev.Lett. 101, 221803 (2008))
Exploits information from QCD topologies (dijet or multijet back-to-back)

Razor search (C. Rogan, arXiv:1006.2727)
Associates momentum to the invisible particle after boosting the system back to the centre-of-mass frame ("bump-hunting")

m_{eff} search (1.04 fb^{-1})

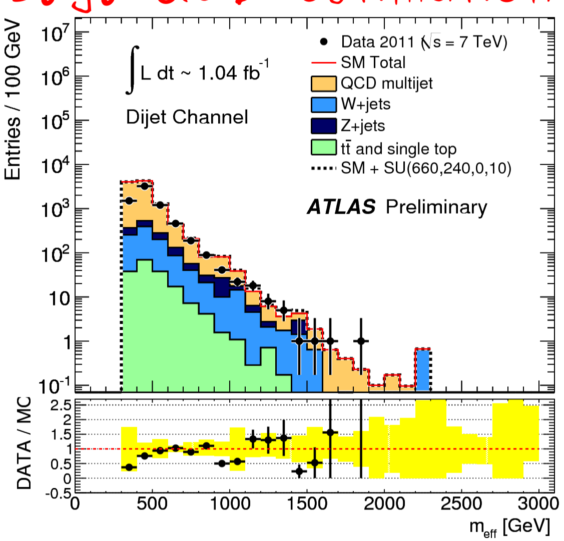
- ✔ QCD multijet impact reduced by the EtMiss, Δϕ (EtMiss,jet) and EtMiss/m_{eff} requirements.
- ✔ 5 different signal regions (SR) defined (maximise sensitivity)
- ✔ 5 dedicated control regions (CR) for each SR (total 25 CR)

Signal Region	≥ 2 jets	≥ 3 jets	≥ 4 jets	High mass
E_T^{miss}	> 130	> 130	> 130	> 130
Leading jet p_T	> 130	> 130	> 130	> 130
Second jet p_T	> 40	> 40	> 40	> 80
Third jet p_T	–	> 40	> 40	> 80
Fourth jet p_T	–	–	> 40	> 80
$\Delta\phi(\text{jet}, E_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
E_T^{miss}/m_{eff}	> 0.3	> 0.25	> 0.25	> 0.2
m_{eff} [GeV]	> 1000	> 1000	> 500/1000	> 1100

Backgrounds:

Multijets
Z(→ νν) + jets
W+jets
ttbar+single top

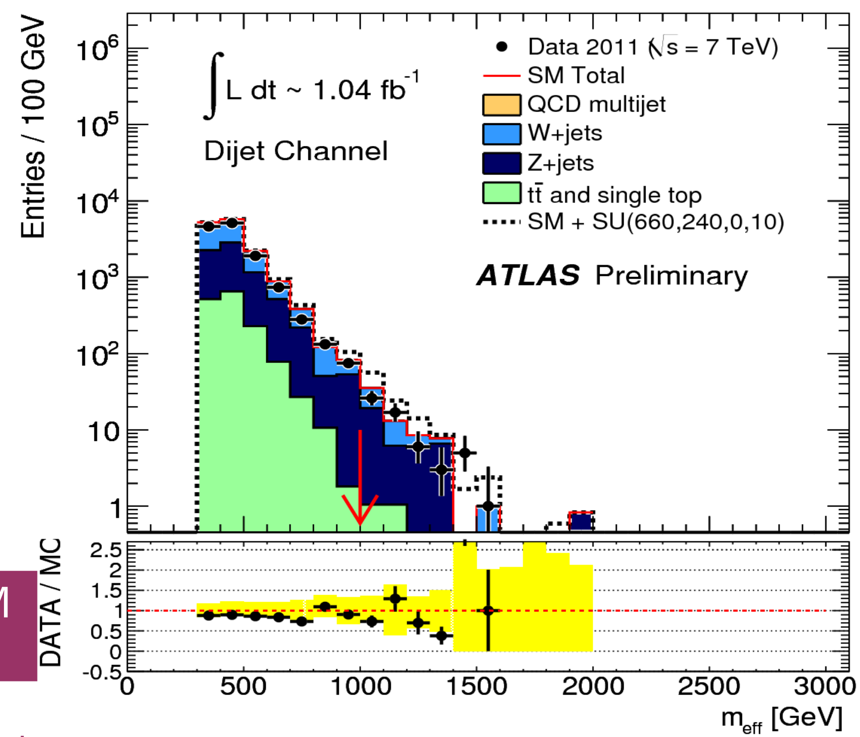
E.g. QCD estimation



- ➢ Pseudo-events by smearing with jet response function
- ➢ Normalise in Δϕ(jet,EtMiss)<0.4

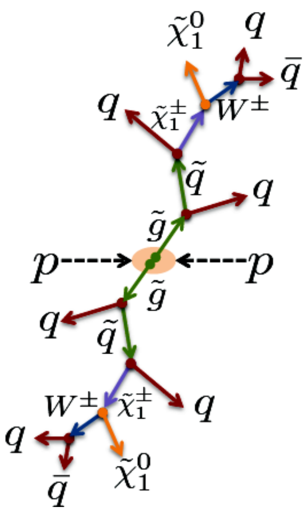
- ✔ Transfer Function (MC): move from CR to SR
- ✔ Likelihood fit: combine all the information and correlation among uncertainties
- ✔ Jet energy scale (~15%) and theoretical uncertainties (~25%) dominate

Data are in agreement with SM expectations in all regions*



*detailed numbers are in the backup slides

Large multiplicities (1.34 fb^{-1})

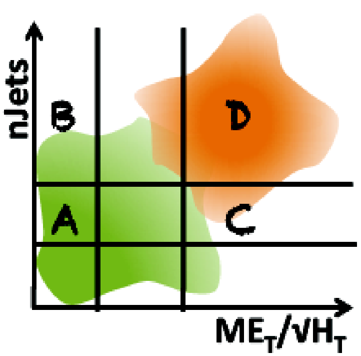


- SUSY cascades can be long: large jet multiplicities with similar energies
- New search directed to >6 jets regions

Maximize trigger capabilities →

Signal region	7j55	8j55	6j80	7j80
Jet p_T	> 55 GeV		> 80 GeV	
Jet $\|\eta\|$	< 2.8			
ΔR_{jj}	> 0.6 for any pair of jets			
Number of jets	≥ 7	≥ 8	≥ 6	≥ 7
$E_T^{miss}/\sqrt{H_T}$	> 3.5 GeV$^{1/2}$			

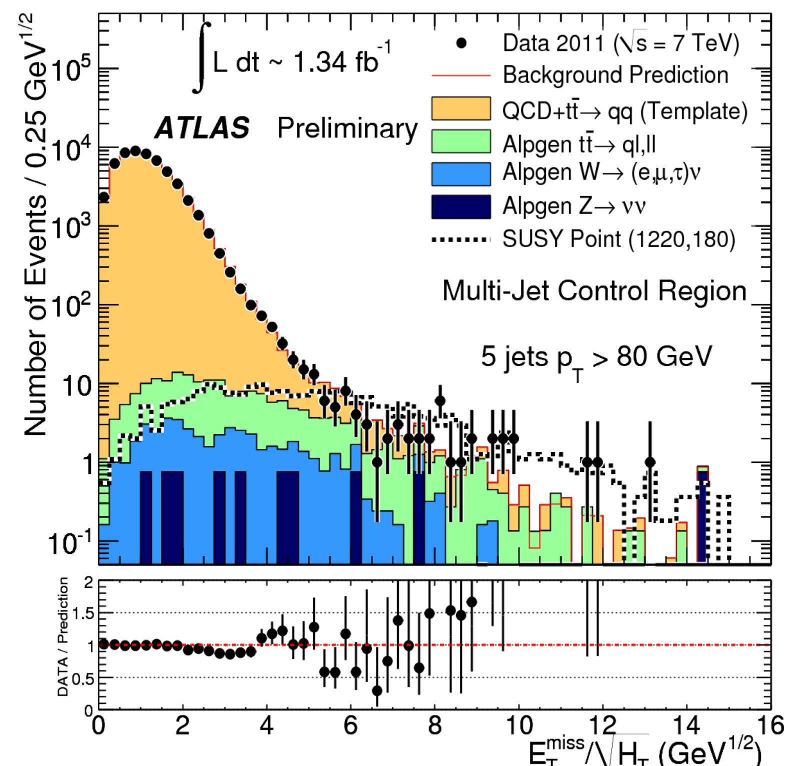
- Main background is multijet production
- Key observation: EtMiss/sqrt(H$_T$) invariant under jet multiplicities →
- Leptonic backgrounds are subdominant: determined with MC in dedicated CRs with lower jet multiplicities and >= 1 muon



Data are in agreement with SM expectations in all regions

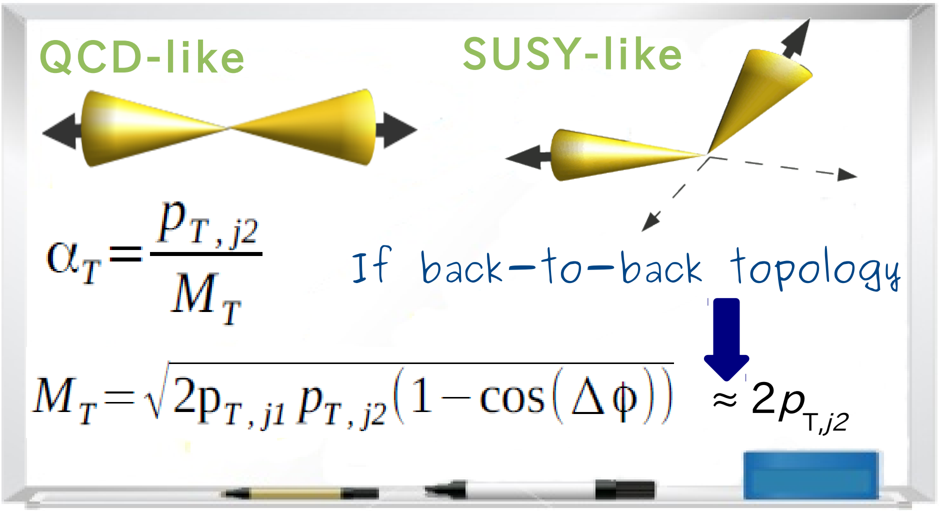
Validated in low EtMiss/√H$_T$ and/or low Njets regions

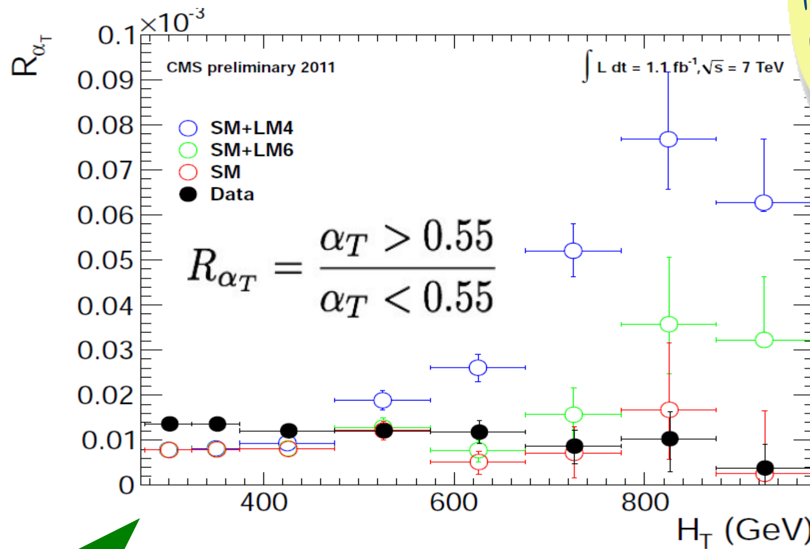
Example: exactly 5 jets with pT>80 GeV with template of exactly 4 jets of pT>80 GeV



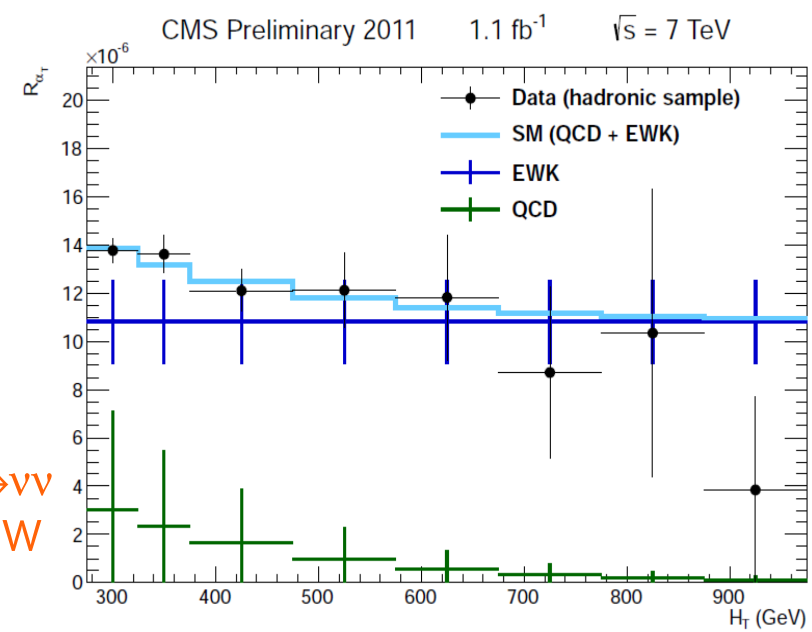
The α_T search (1.1 fb^{-1})

More information:
CMS PAS SUS-11-003





- Two sources of information: flatness of $R_{\alpha T}$ against H_T and also data-driven predictions
- Performed an overall likelihood fit
- Use information from multiple H_T bins



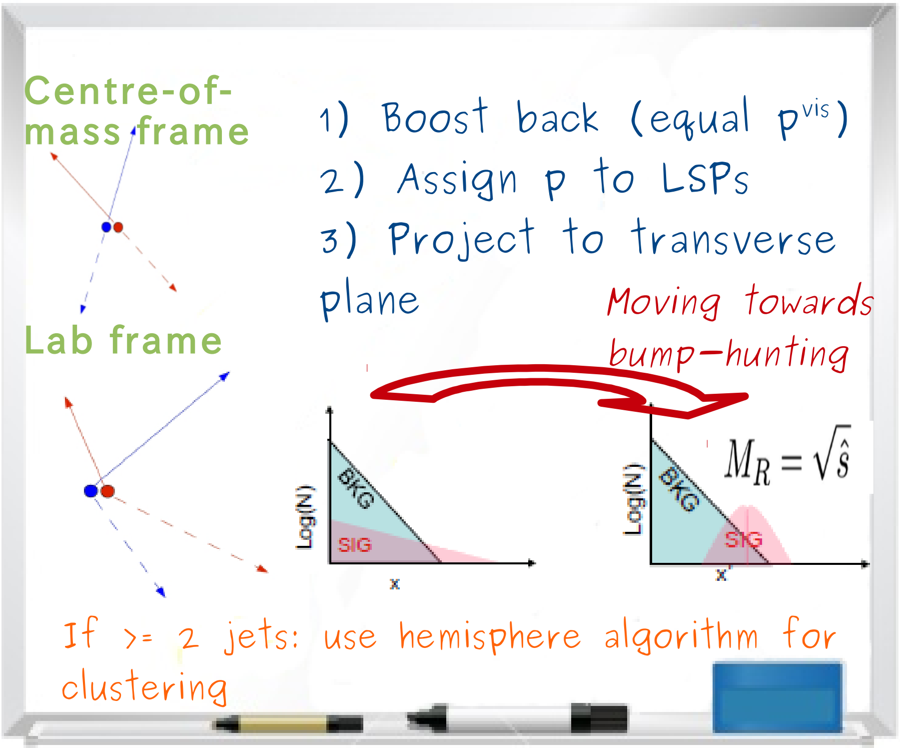
Data are in agreement with SM expectations*

QCD: exponential
EWK (data-driven): $Z \rightarrow \nu\nu$ using γ+jets and ttbar/W using muon CR

*detailed numbers are in the backup slides

Razor search (35 pb^{-1})

More information: arXiv:1107.1279



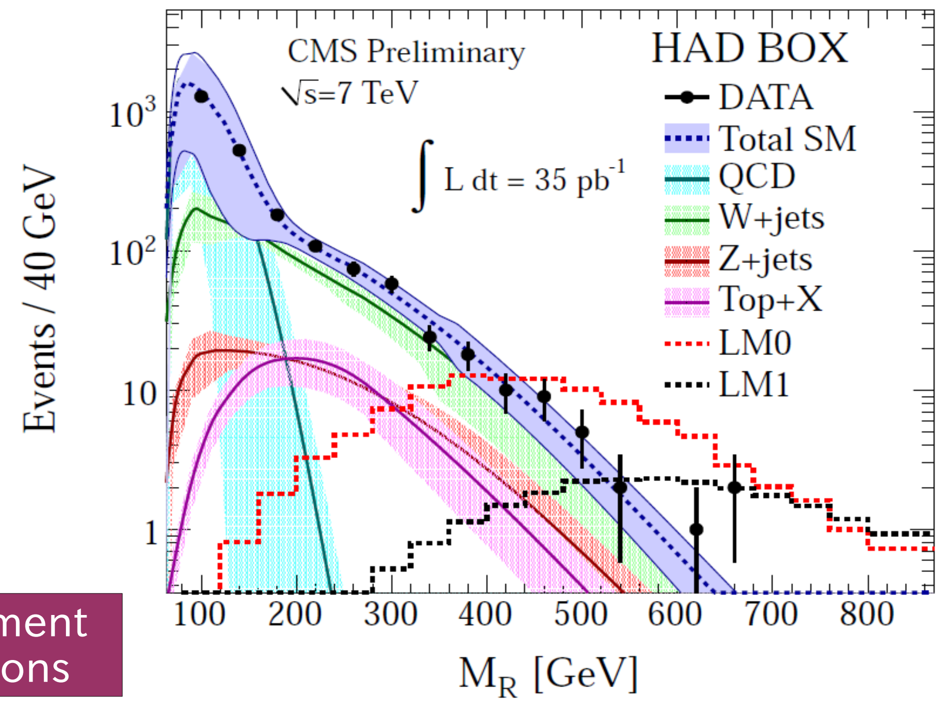
$$M_R = 2\sqrt{\frac{(E_1 \cdot p_{z,2} - E_2 \cdot p_{z,1})^2}{(p_{z,1} - p_{z,2})^2 - (E_1 - E_2)^2}}$$

The transverse quantity (M_{RT}) is also defined. Thus, $R = M_R/M_{RT}$ is dimensionless.

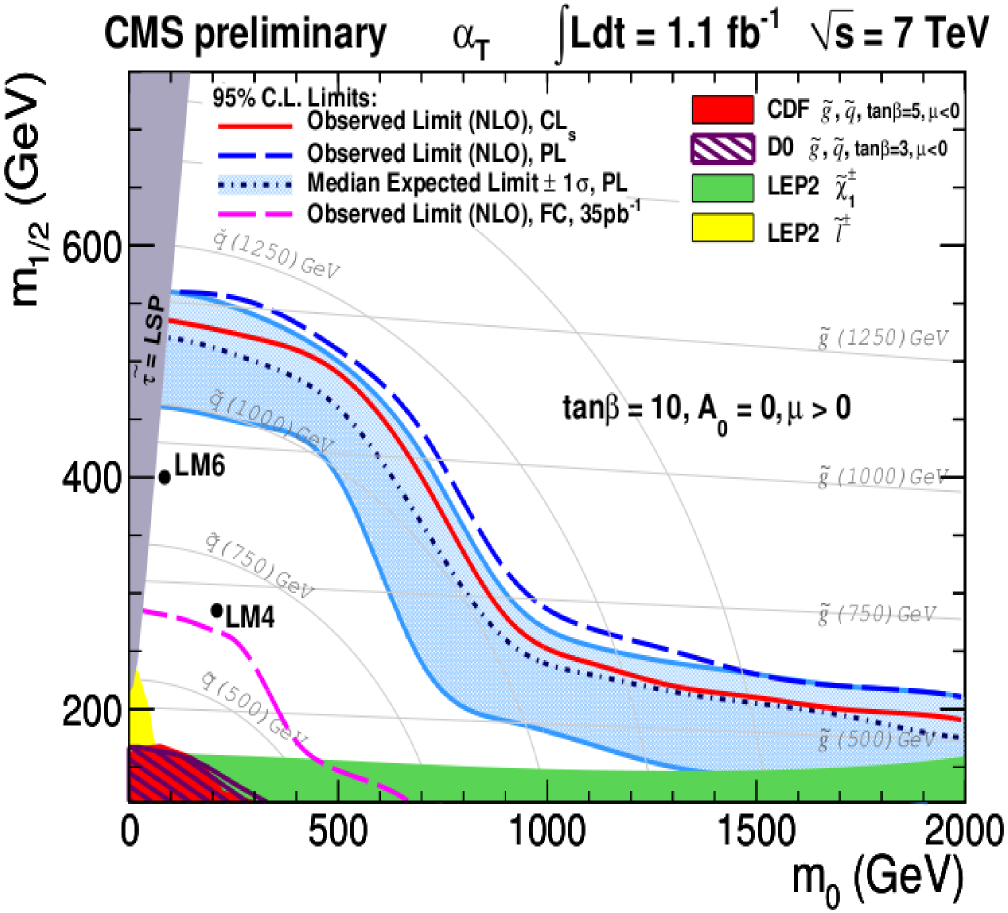
- QCD shape taken from dijets
- Lepton shapes taken from dedicated control regions with leptons
- Fit: 80 < M_R < 400 GeV
- Signal region: R>0.5 and M_R>500 GeV

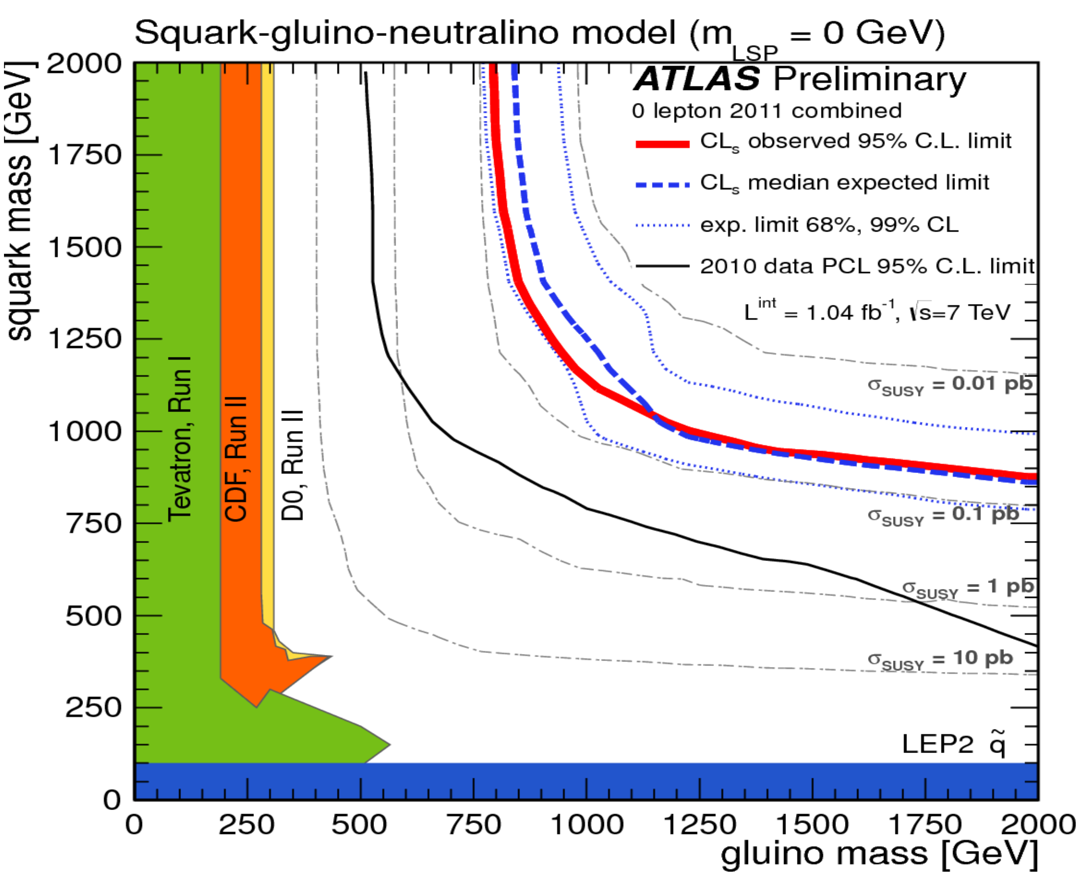
SM exp: 5.5 ± 1.4
Data: 7

Data are in agreement with SM expectations



Interpretation





Results from α_T of CMS exclude squark/gluino masses up to 1.1 TeV for m_0 < 500 GeV (CLs method)

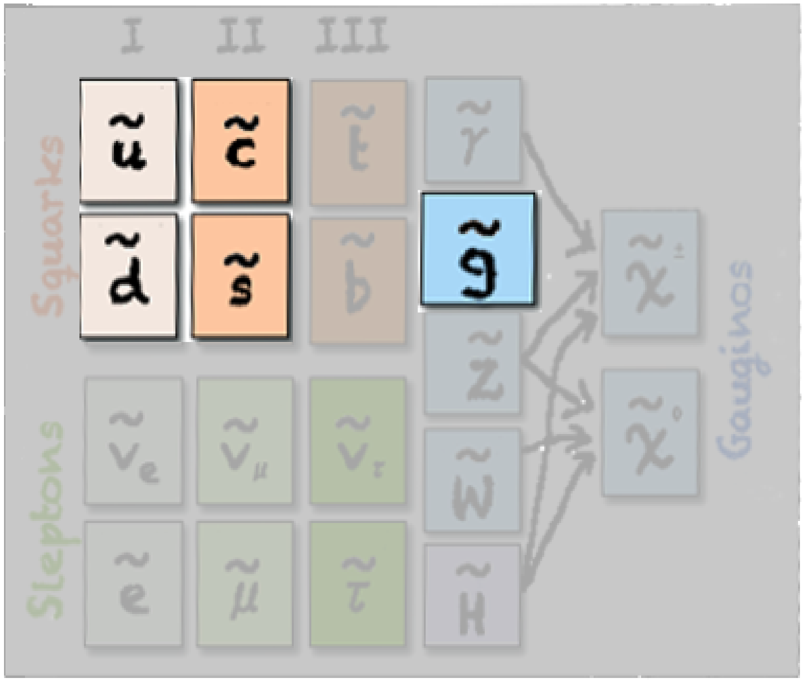
If LSP is massless, squark (gluino) masses below 750 (850) GeV, for less than 2 TeV gluino (squark)

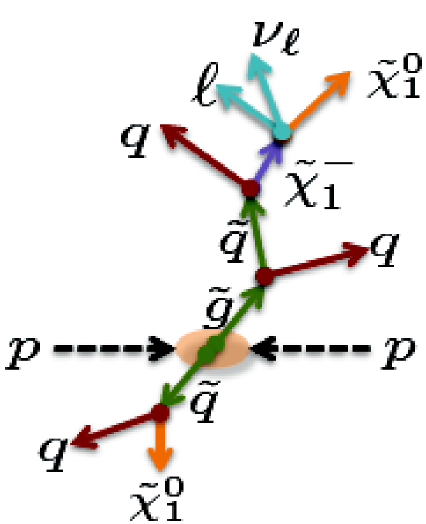
Limits stable up to 200 GeV LSP mass

Both experiments increased the exclusion reach substantially in few months

New 0-lepton MT2 search from CMS not dicussed here (see backup slide for details)

1-lepton searches





LHC: targeting lepton in squark/gluino cascades

Leptons provide extra handles. E.g.:

Matrix Method for QCD

1) Defines "loose" and "tight" leptons
2) Assess efficiency for real and fake leptons
3) Uses data with "loose" to estimate data with "tight"

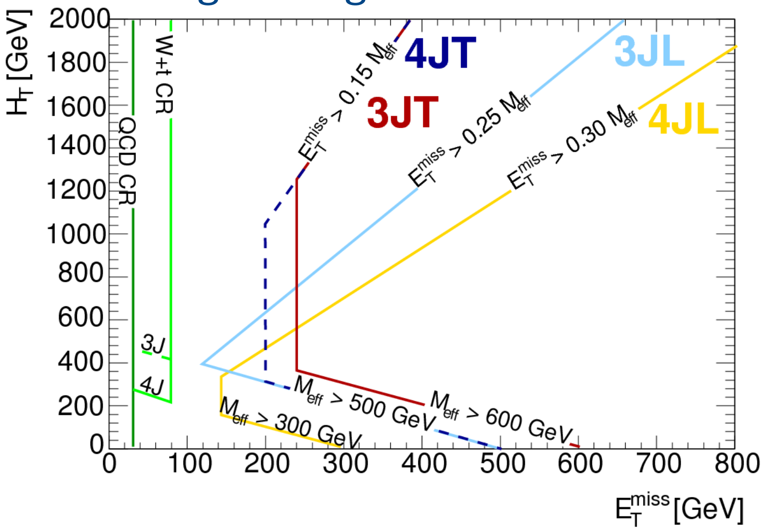
Non-QCD

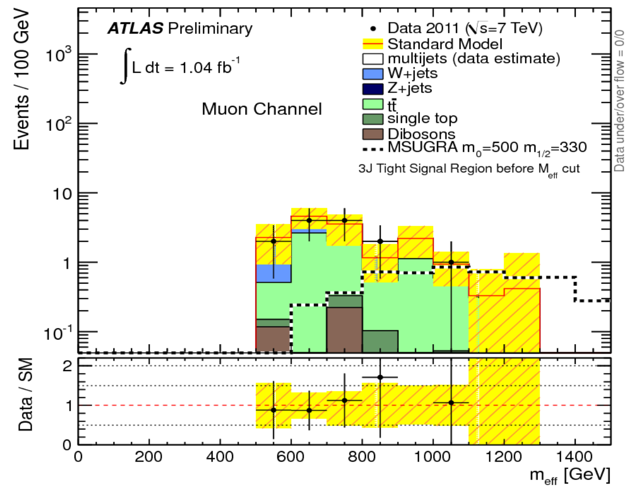
Uses m_T (lepton, EtMiss) to separate signal from background

1-lepton search (1.04 fb^{-1})

Also: see CMS poster on 1-lepton (H. Schettler)

4 Signal Regions defined:

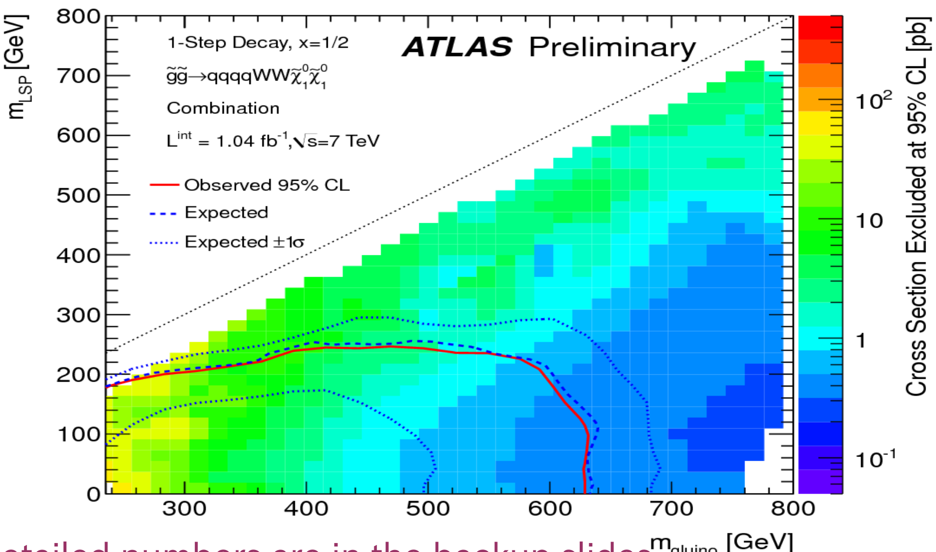




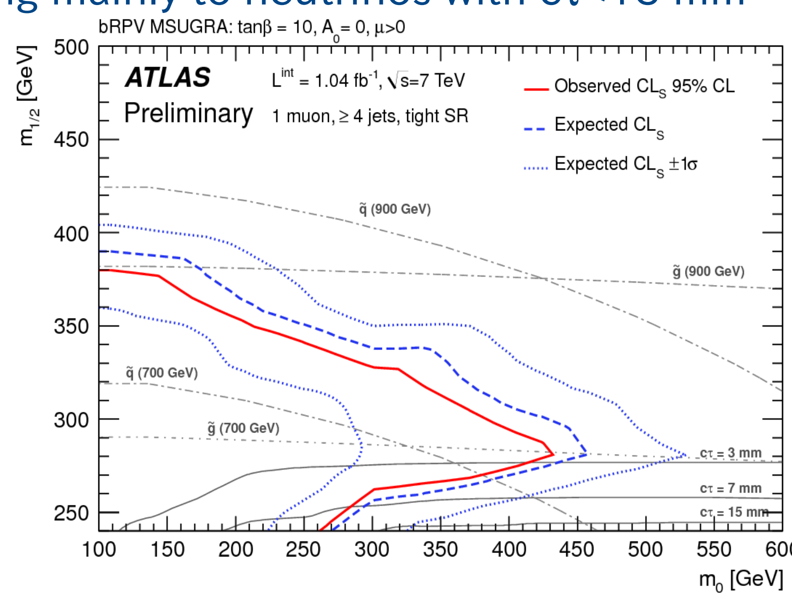
- ✔ Fully/semi data-driven estimations for background
- ✔ Using a combined likelihood fit to estimate the bkg.

Data are in agreement with SM expectations*

Interpretation in different simplified models with an intermediate chargino:

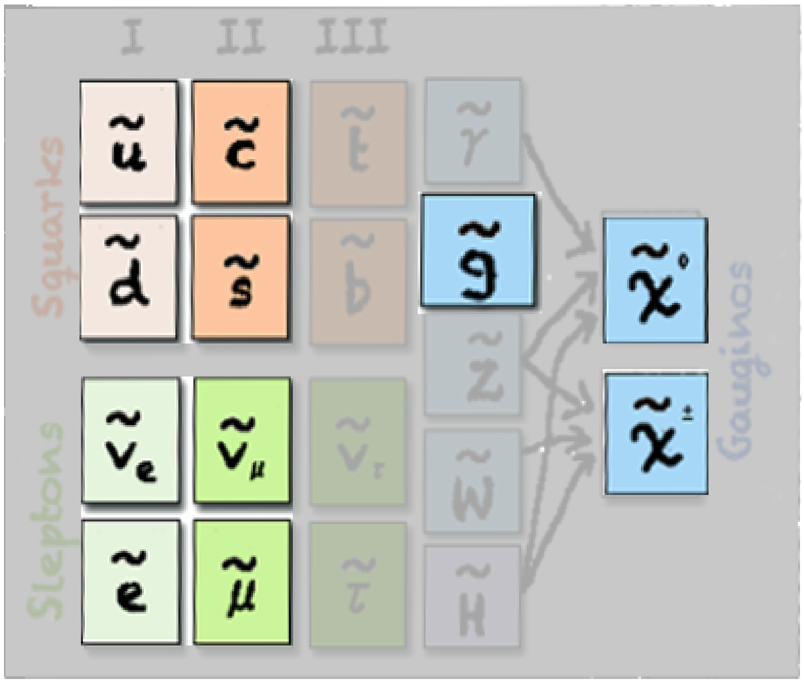


Also in bilinear RPV (Y. Grossman and S. Rakshit, Phys.Rev.D69, 093002 (2004)): model with RPV with neutralino decaying mainly to neutrinos with cτ<15 mm



*detailed numbers are in the backup slides

2-lepton searches



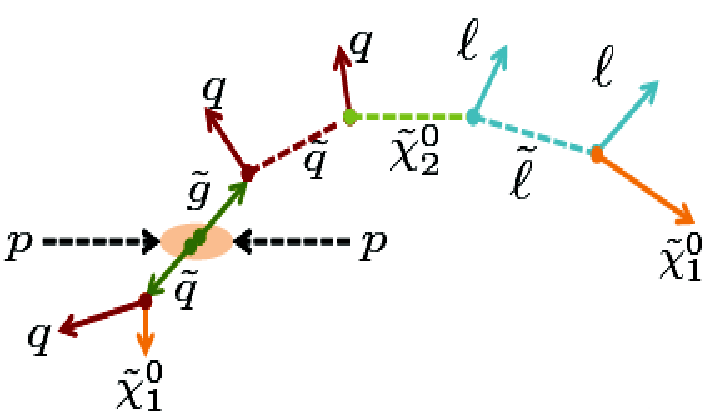
Different cases:

- OS: Opposite Sign leptons
- SS: Same Sign leptons
- OF: Opposite Flavour (e vs μ)
- SF: Same Flavour

} Different combinations exploited (e.g. OSSF)

Big changes in background composition

Sensitivity to different decays

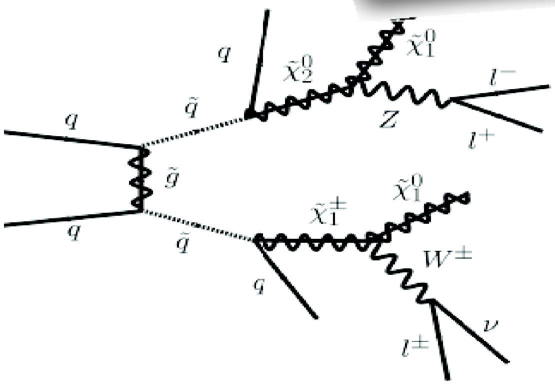


Strategy largely dependent on the mass difference between particles: different lepton p_T

SS dileptons (6.1 fb^{-1})

More information:
CDF/PHYS/EXO/PUBLIC/10464

- ✔ Generic analysis with interpretation on SUSY searches using simplified models (2 jets of p_T >15 GeV)
- ✔ Two production mechanisms: squark-squark and gluino-gluino
- ✔ Sleptons masses set at high values. Chargino and neutralino decay via real/virtual W or Z bosons



MC used to model the different backgrounds:

Real lepton backgrounds: WZ and ZZ productions

Fake lepton backgrounds:

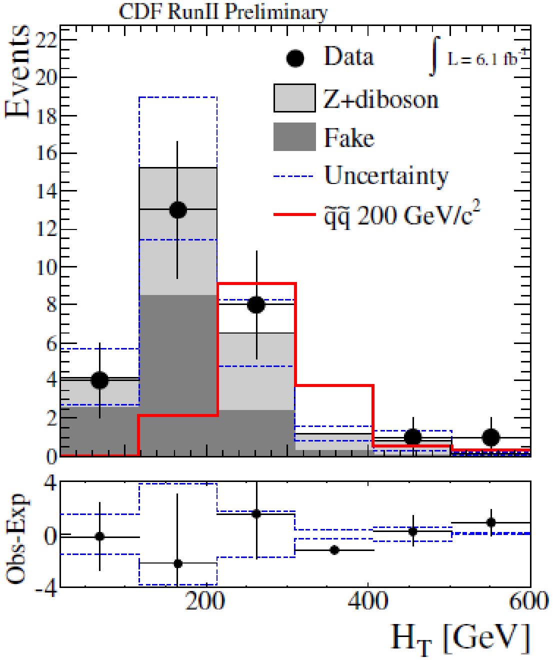
- ➢ W+jets or ttbar (b/c decays semi-leptonically)
- ➢ Conversions: Z/γ*+jets and ttbar

Dominant systematic uncertainty: lepton misidentification

CDF RunII Preliminary $\int \mathcal{L}dt = 6.1\ \text{fb}^{-1}$

Process	Total $\ell\ell$	$\mu\mu$	ee	$e\mu$
$t\bar{t}$	0.1 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.1 ± 0.0
$Z \to \ell\ell$	5.9 ± 1.7	0.0 ± 0.0	4.8 ± 1.6	1.1 ± 0.8
WW, WZ, ZZ	7.2 ± 0.5	1.5 ± 0.2	2.0 ± 0.2	3.7 ± 0.4
$W(\to \ell\nu)\gamma$	0.9 ± 0.7	0.0 ± 0.0	0.5 ± 0.5	0.4 ± 0.4
Fakes	13.8 ± 7.2	3.2 ± 2.4	4.6 ± 2.2	6.0 ± 3.1
Total	28.0 ± 7.5	4.7 ± 2.4	11.9 ± 2.8	11.3 ± 3.3
Data	27	2	16	9

Data are in agreement with SM expectations



2-leptons

SS dileptons (0.98 fb^{-1})

More information: CMS PAS SUS-11-010 and poster (H. Schettler)

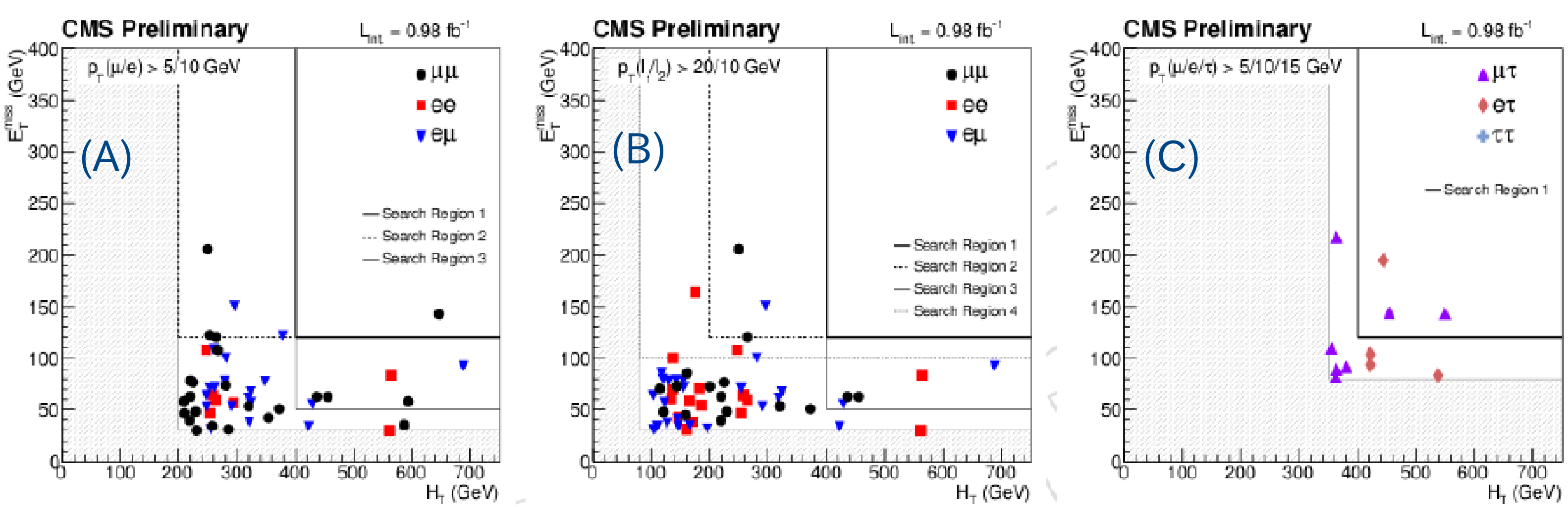
Using different flavour combinations/energy range to cover maximum number of topologies. Trigger exploited for maximum benefit.

Type	p_T lep.	HT	EtMiss	Trigger	Data-driven estimations
Incl. dileptons (A)	↓	↑	↓	2 lep+HT	a) Tight-to-loose ratio in isolation (p_T, η); b) P(iso)*P(EtMiss)
High p_T dileptons (B)	↑	↓	↓	2 lep	Tight-to-loose ratio in isolation (p_T, η)
ττ, τε, τμ dileptons (C)	↓	↑	↑	τ+EtMiss+HT or 2 τ	Tight-to -loose ratio in isolation (p_T, η)

Backgrounds:

- Fakes (e.g. one b-jet from ttbar mis-id as a lepton)
- Charge misrecons.
- QCD fakes (taus)

Misreconstructed charge background: electrons (conversions): measure charge mis-id rate in tracker; taus (3-prong): use Z decays



Different selections considered for each type of search

Data are in agreement with SM expectations*

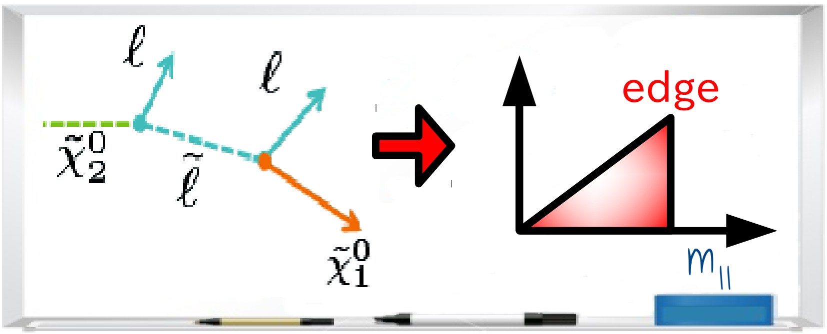
*detailed numbers are in the backup slides

OS dileptons (0.98 fb^{-1})

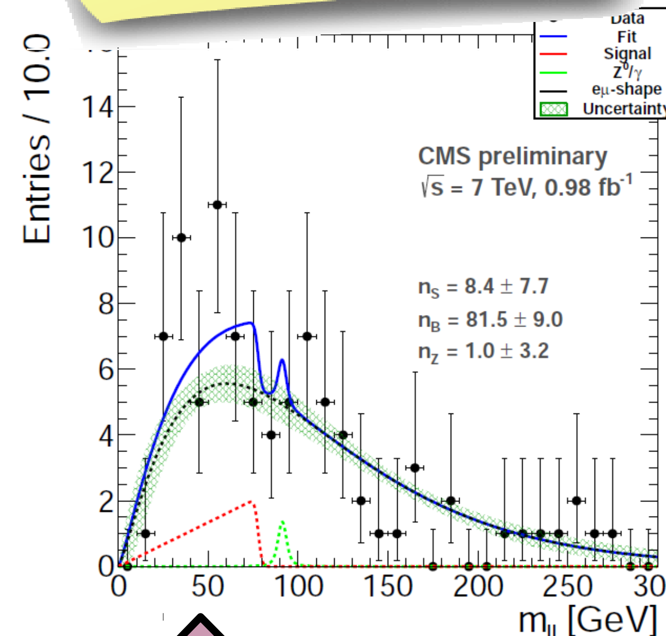
More information: CMS PAS SUS-11-011 and poster (H. Schettler)
(see also CMS PAS SUS-11-019 and backup slides for Z->ll)

Two different cases considered:

1) Kinematic edge (OSSF)



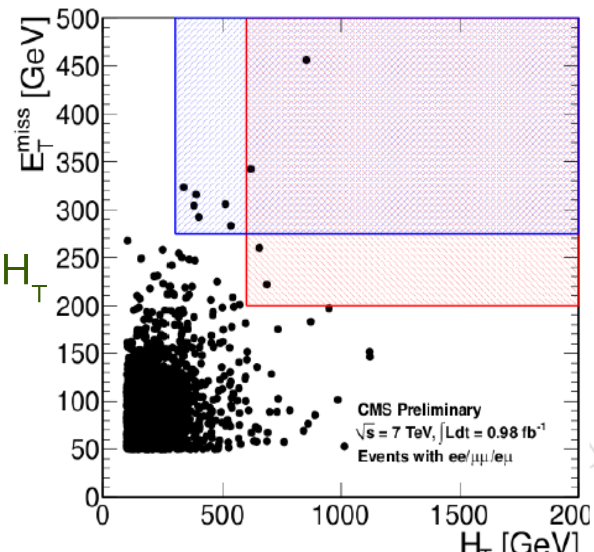
- Sensitive also to low EtMiss or H_T
- Backgrounds: OF $\simeq$ SF (control the shape)
- Use unbinned maximum likelihood fit in a CR (100<H_T<300 GeV) and the SR (H_T>300 GeV)



Data are in agreement with SM expectations

2) Counting experiments

- Two signal regions defined (high EtMiss or H_T)
- 3-methods to estimate bkgs:
  - ➔ Use the soft correlation between H_T and EtMiss/$\sqrt{H_T}$
  - ➔ Model $p_T(\nu\nu)$ using $p_T(ll)$ (driven by W polarization)
  - ➔ Assume OF $\simeq$ SF

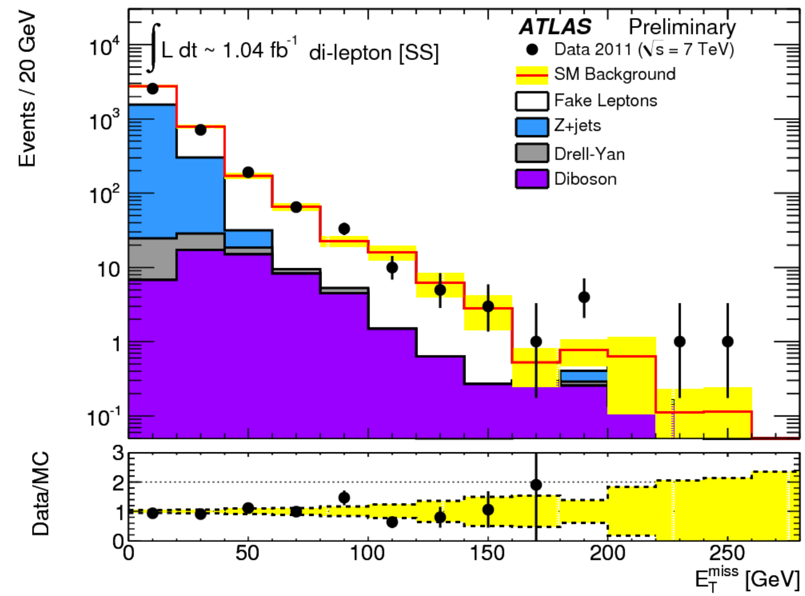


Statistical-only uncert.

High EtMiss:	High H_T:
SM exp: 4.2±1.3	SM exp: 5.1±1.7
Data: 8	Data: 4

2-lepton searches (1 fb^{-1})

- 3 different analyses: OS, SS, OSSF
- Introduced signal regions with no jet requirement but large EtMiss (OS: 250 GeV; SS: 100 GeV; OSSF: 80/250 GeV)
- Data-driven techniques to estimate fakes
- Semi data-driven (MC normalised to dedicated CR) for other contributions



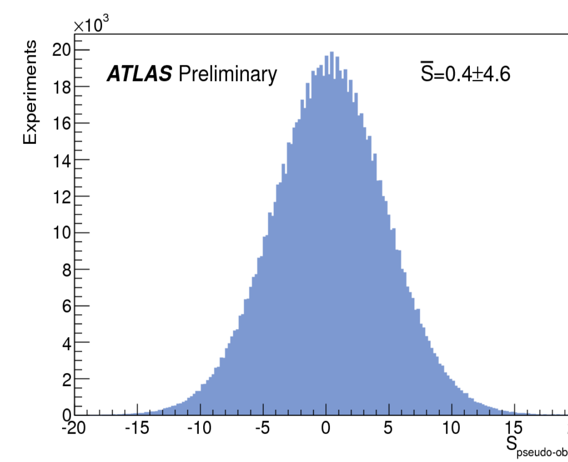
	Background	Obs.	95% C.L.
OS-SR1	15.5 ± 1.2 ± 4.4	13	9.5 fb
OS-SR2	13.0 ± 1.8 ± 4.1	17	15.2 fb
OS-SR3	5.7 ± 1.1 ± 3.5	2	5.0 fb
SS-SR1	32.6 ± 4.4 ± 4.4	25	10.2 fb
SS-SR2	24.9 ± 4.1 ± 6.6	28	20.3 fb

For OSSF, the S variable is defined: measures the excess of SF over OF.

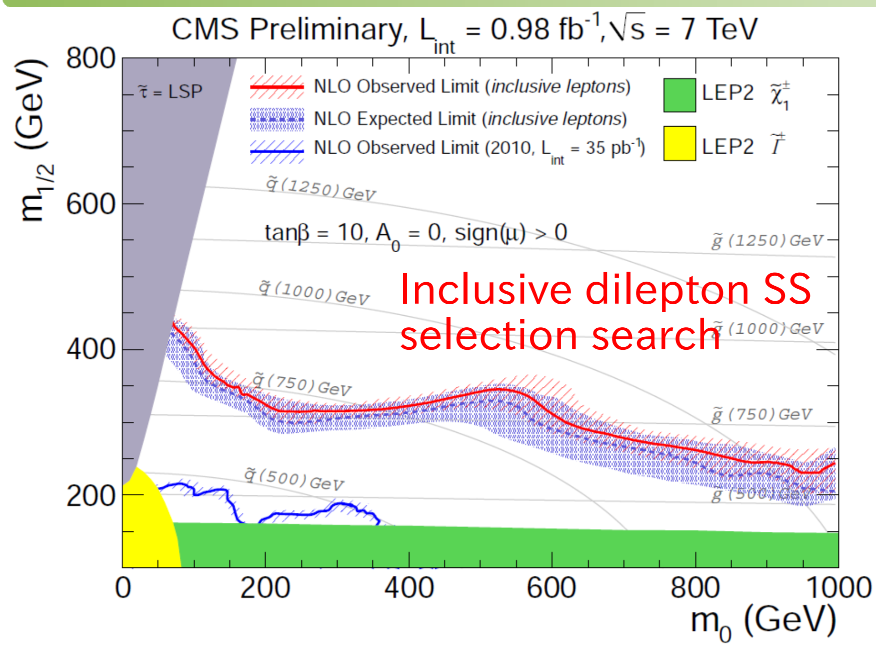
The background-only hypothesis (S_b) is calculated with pseudo-experiments.

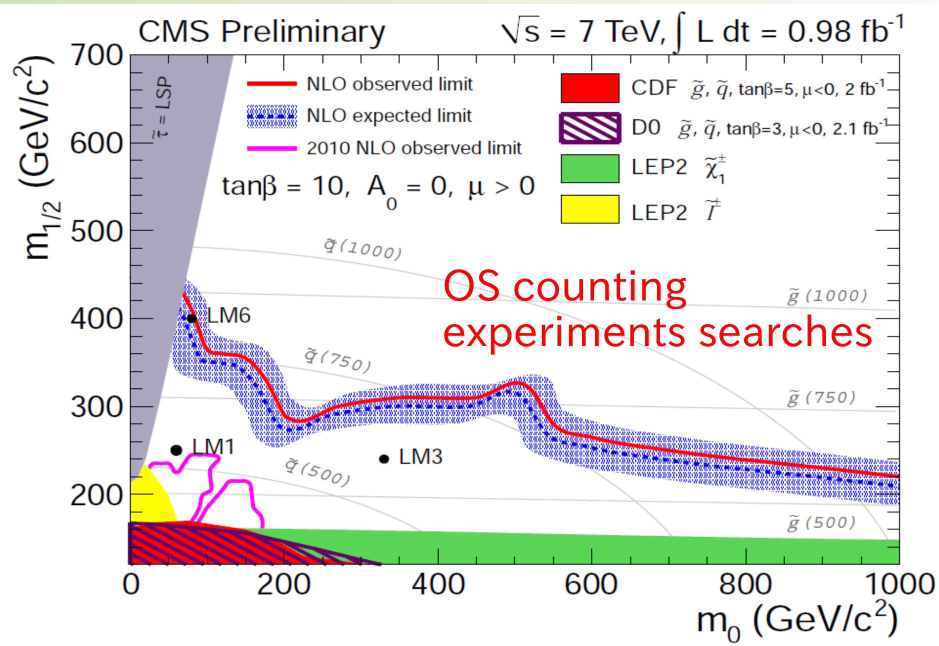
	S_{obs}	$\bar{S}_b$	RMS
FS-SR1	131.6±0.6(sys)	126.5±23.5±17.2	49.9
FS-SR2	142.2±0.6(sys)	70.0±23.2±16.8	49.1
FS-SR3	-3.1±0.0(03)(sys)	0.4±1.2±1.2	4.6

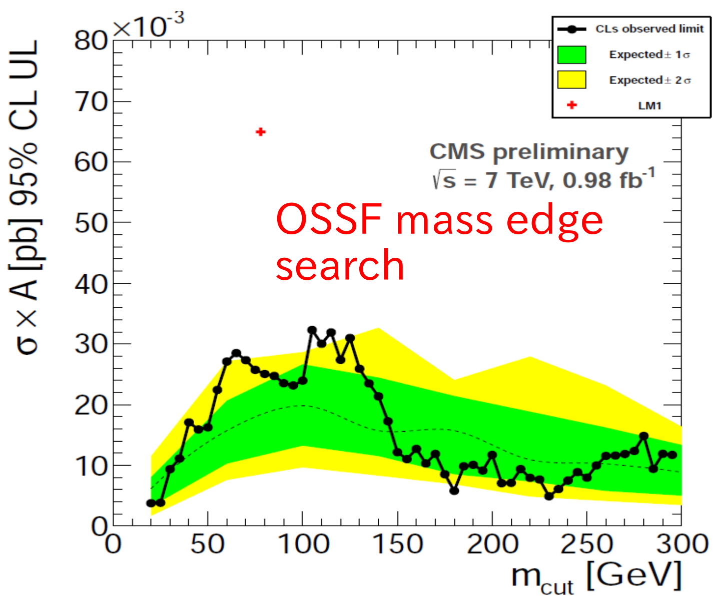
In all cases, data are in agreement with SM expectations

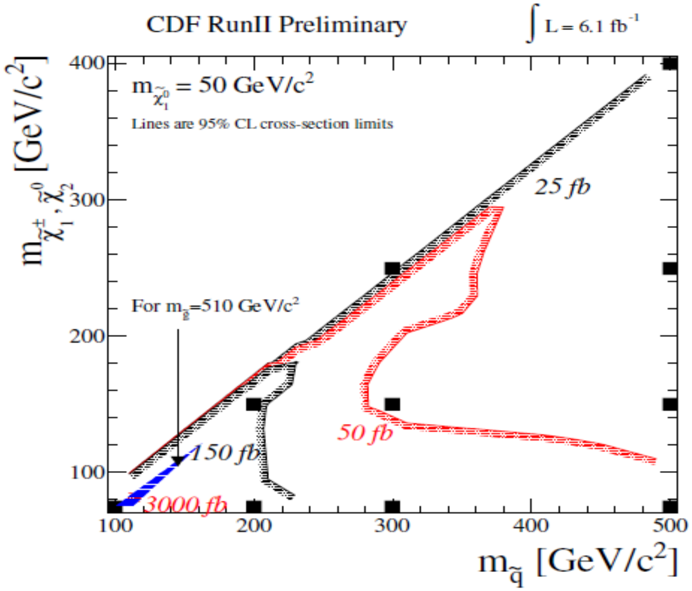


Interpretations



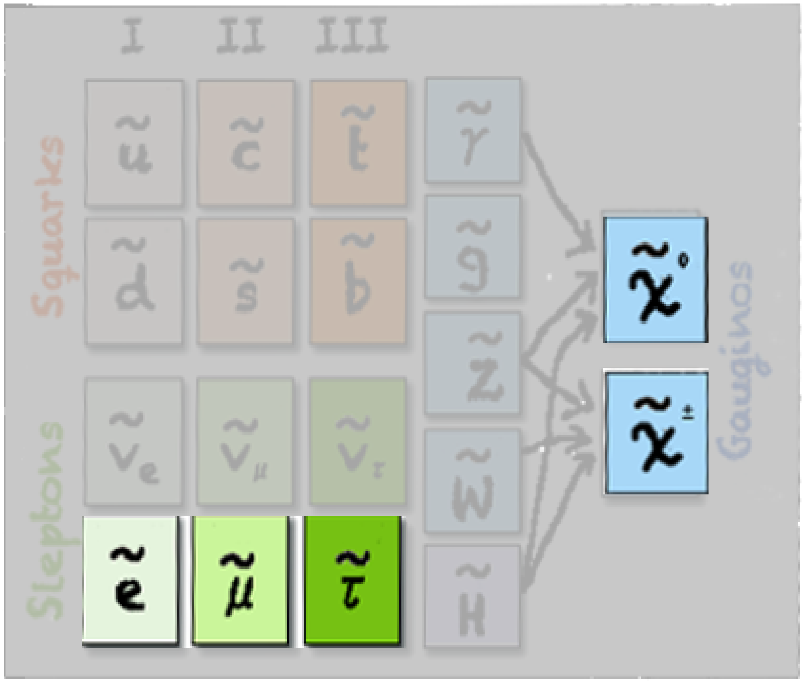


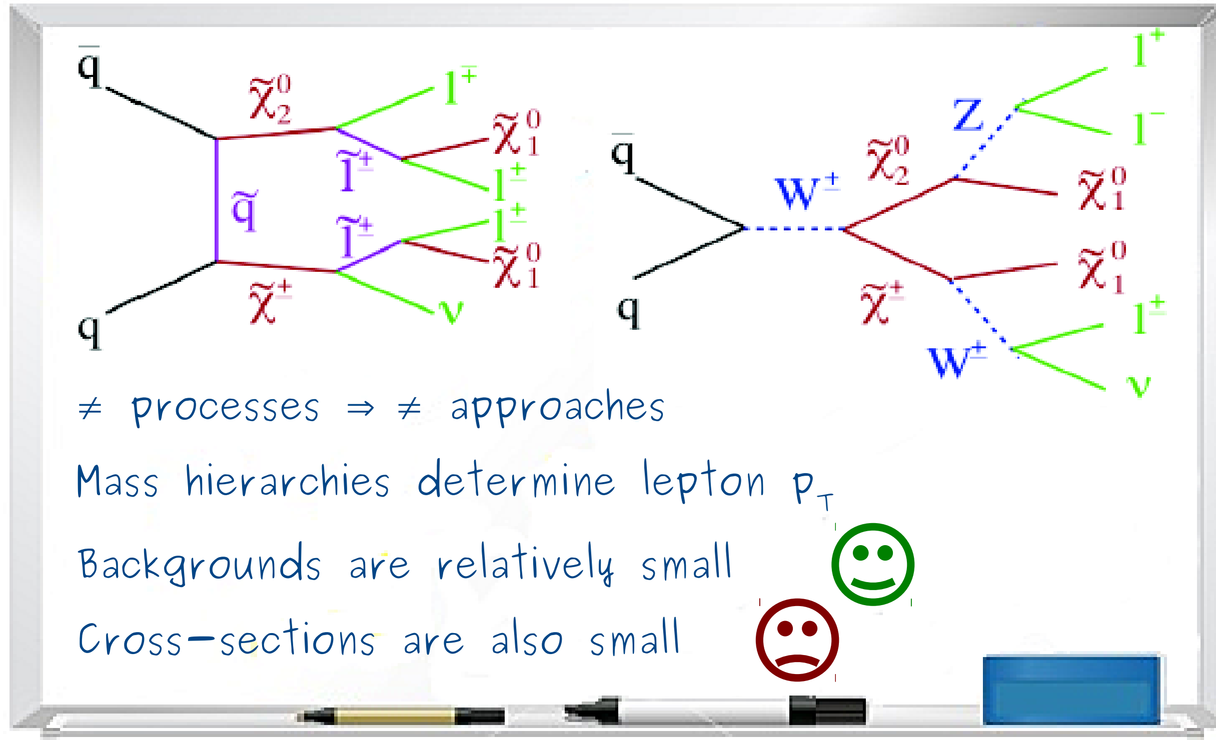




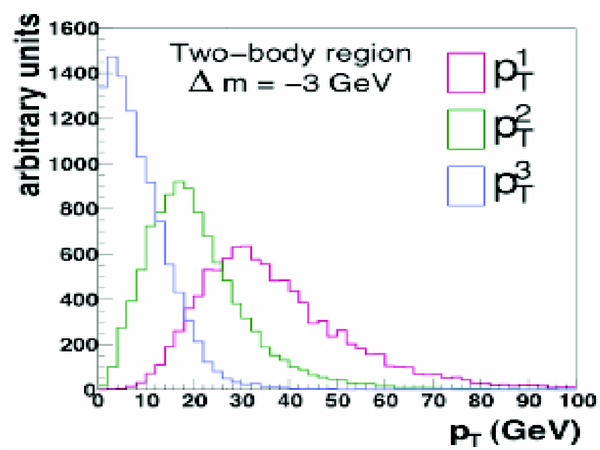
Simplified model limits in SS

Multilepton searches





- ✔ Direct gaugino production: *golden* signature for Tevatron (good S/B)
- ✔ More challenging for the LHC (specially at the beginning but also later due to trigger, pileup…) Currently, only results using trileptons in cascades with strong production.



3rd lepton can be very soft

Trileptons in D0 (2.3 fb^{-1})

More information: Phys. Lett. B 680, 34 (2009) ArXiv:0901.0646V1

4 ≠ channels considered:

- eel
- μμl
- eμl

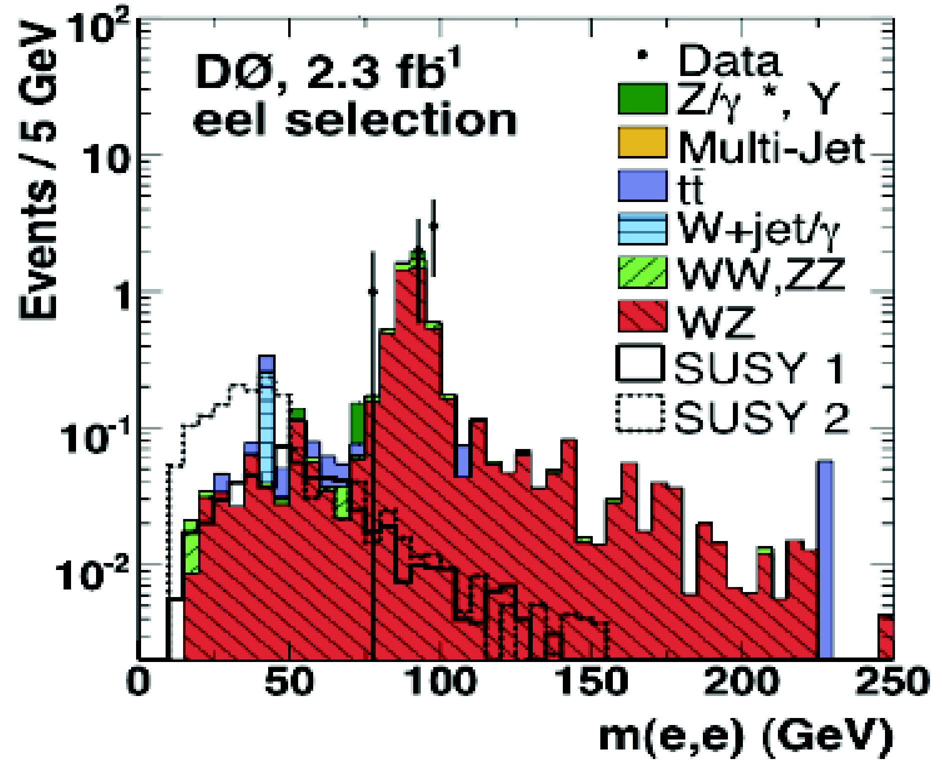
} Low and high pT selections for each

μτ: μτl and μττ

'l' is an isolated track

Triggers determine how low in p_T for leading leptons:

2-l triggers: pT> (12, 8) GeV
1-μ trigger (τ-case): pT>15 GeV



- ✔ Different dominating backgrounds depending on the signature: Z/γ*, W… Dibosons are irreducible.
- ✔ Background reduction with a very extensive set of kinematic cuts: invariant mass, EtMiss significance, mT, HT, Δϕ, pT balancing…

Low p_T and m_T selection:	High p_T selection:
SM exp: 5.4±0.4±0.4	SM exp: 3.3±0.3±0.3
Data: 9	Data: 4

No significant deviation from SM expectations

Trileptons in CDF (5.8 fb^{-1})

More information:
CDF/PUB/EXOTIC/PUBLIC/10636

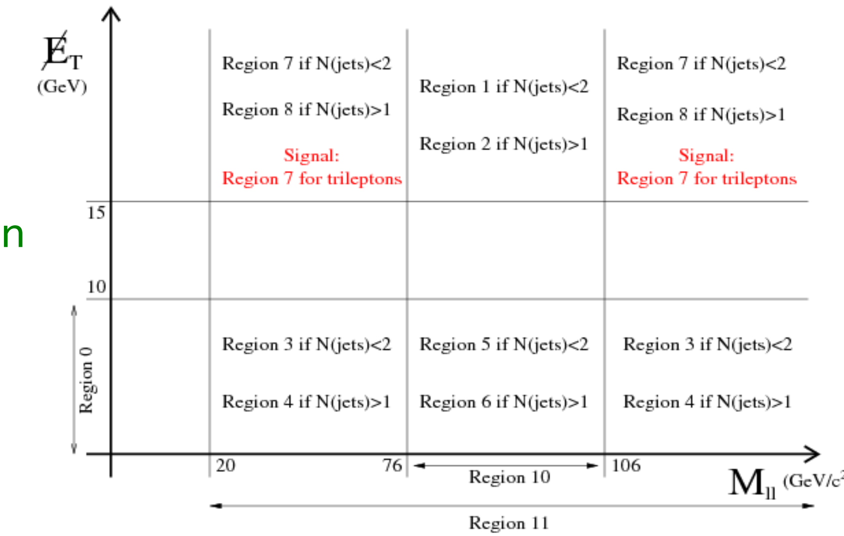
8 ≠ exclusive channels considered:

eel, μμl } l ≡ e, μ, τ, track

p_T ranges between 5 and 20 GeV

- 24 dilepton control regions
- 40 trilepton control regions

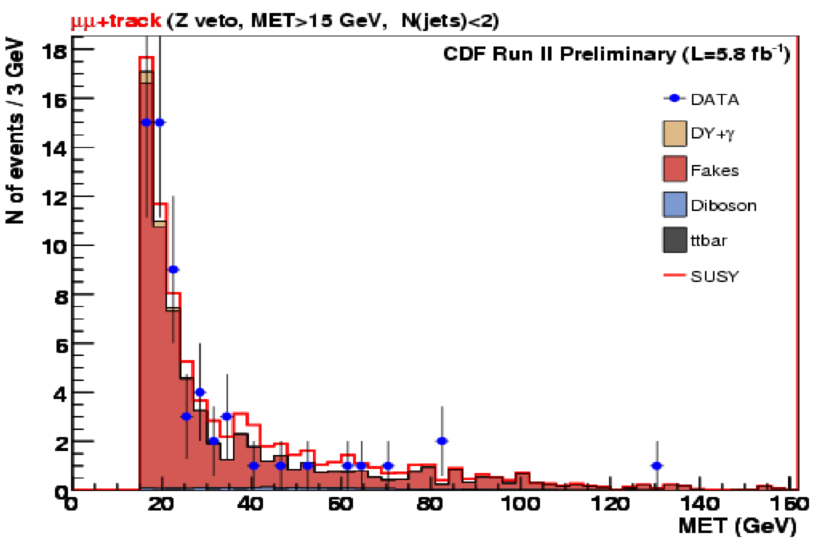
Defined using m_{ll}, EtMiss and N_{Jets}



- Backgrounds:

2-lepton regions: Drell-Yan, jet fake (e.g. W→lν+jets), diboson

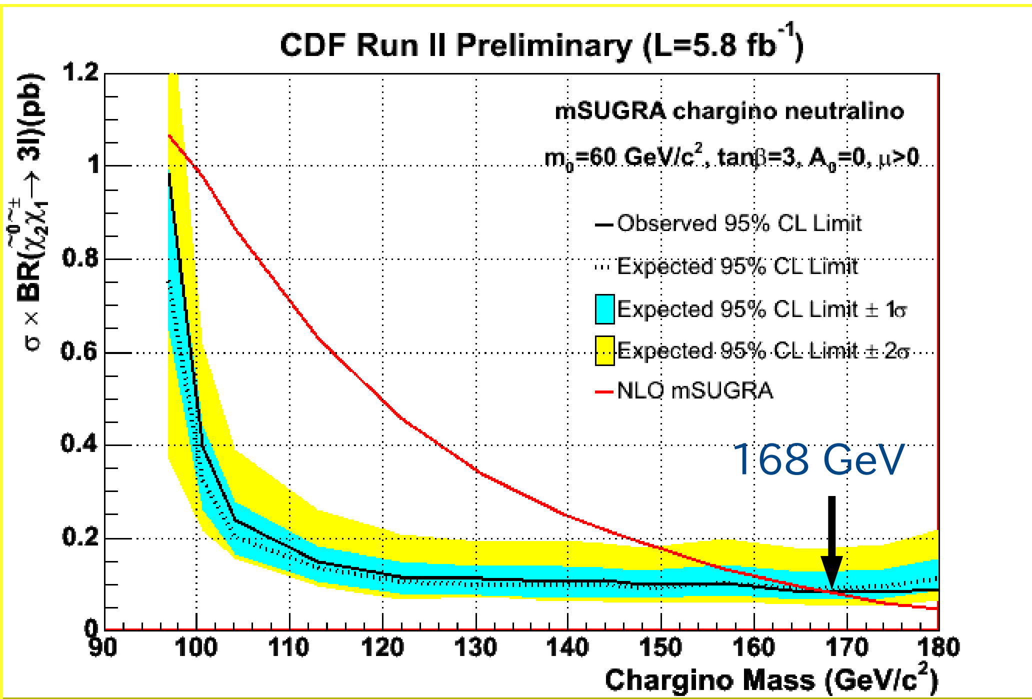
3-lepton regions: Drell-Yan with converted γ or with jet fake

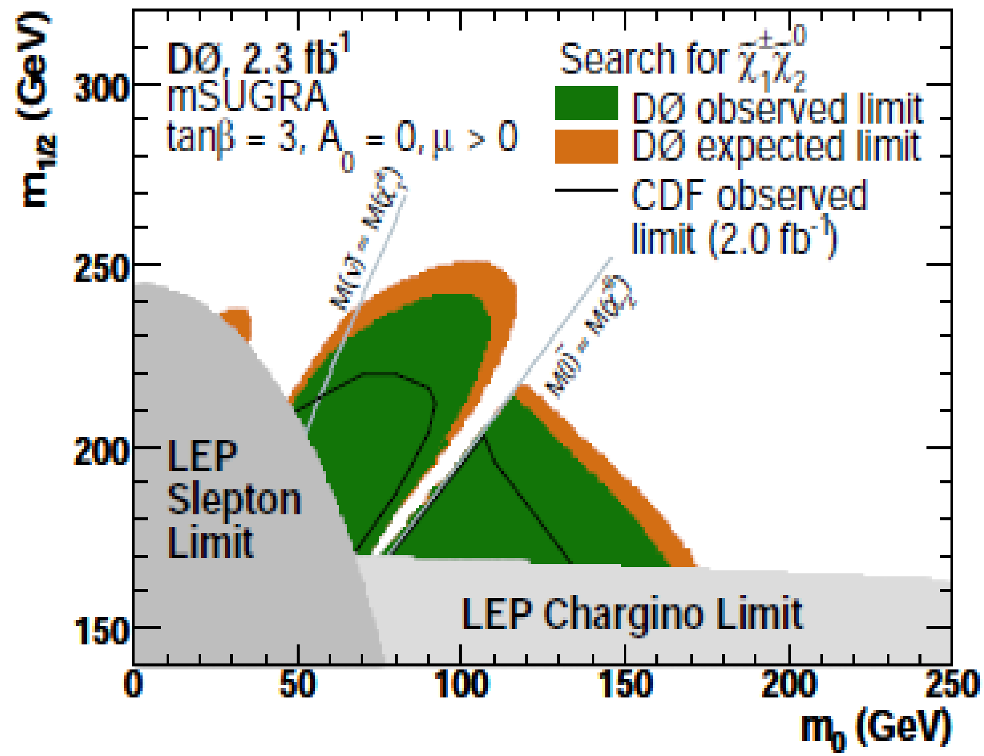


Optimized Trilepton Yields for Benchmark			
Channel	SM background	SUSY signal	Observation
ee+lepton	1.5 ± 0.4	8.0 ± 0.8	**3**
ee+track	11.6 ± 1.7	7.6 ± 0.8	**13**
$\mu\mu$+lepton	0.5 ± 0.1	6.7 ± 0.7	**0**
$\mu\mu$+track	3.6 ± 1.0	6.2 ± 0.6	**3**

No significant deviation from SM expectations

Interpretation





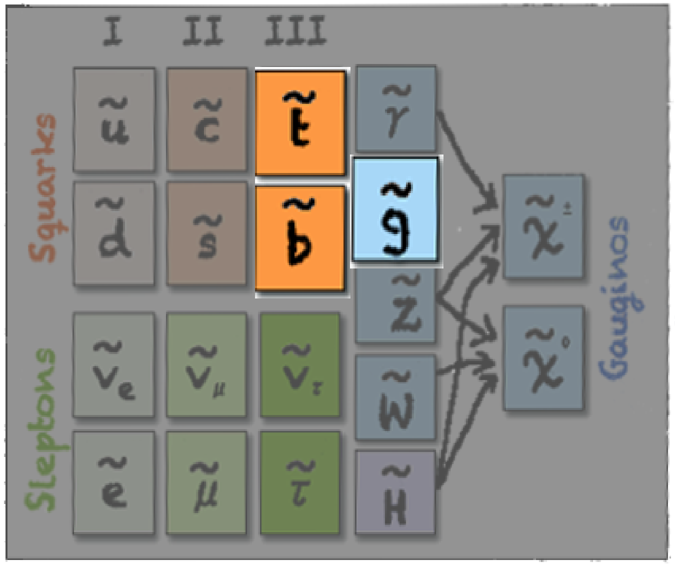
Null results interpreted in mSUGRA model with fix m_0=60 GeV and vary $m_{1/2}$ (related to chargino mass)

Model independent limits of σxBR(lll) above 0.1 fb

D0 has also competitive results .

The gap is created due to too low p_T lepton in degenerate slepton-LSP transition. This can be recovered with 2-lepton Same Sign interpretation.

Searches with b-jets



3rd generation: potential important role (mixing)

Mixing between $\tilde{q}_L$ and $\tilde{q}_R$:

$$m^2(\tilde{t}_{1,2}) = \frac{1}{2}\left[m^2(\tilde{t}_R) + m^2(\tilde{t}_L)\right] \mp \frac{1}{2}\sqrt{\left[m^2(\tilde{t}_R) - m^2(\tilde{t}_L)\right]^2 + 4m^2(t)\left[A_t - \mu\tan\beta\right]^2}$$

mixing term

Top mass and $\mu\tan\beta$ can amplify the mixing
stop mass: could be significantly lower
Similar effect in sbottom and stau (less pronounced)

Low stop also motivated by naturalness arguments:

$m(\tilde{t}) \sim <$ 500 GeV (to avoid too much fine-tuning)

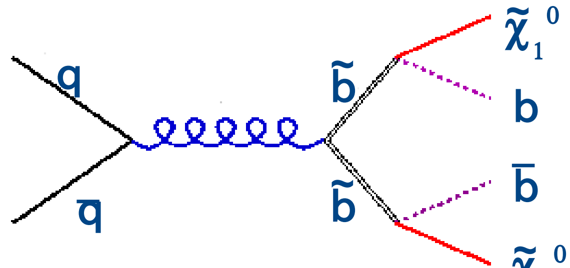
Experiments search for direct stop or sbottom pair production or via gluino decay (SUSY decay chain)

e.g. gluino->$b\tilde{b}/t\tilde{t}$

Sbottom-pair production

Sbottom naturally decays to $b+\tilde{\chi}_1^0$ or to $t+\tilde{\chi}_1^-$

Usually assumed, for kinematic reasons



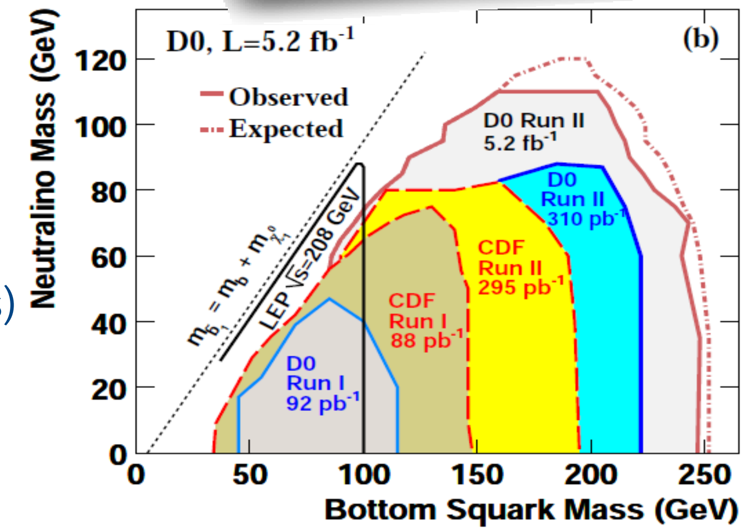
2 b–jets and EtMiss

More information:
D0: Phys. Lett. B 693, 95 (2010)
CDF: Phys. Rev. Lett. 105, 081802 (2010)

D0 (5.2 fb^{-1})

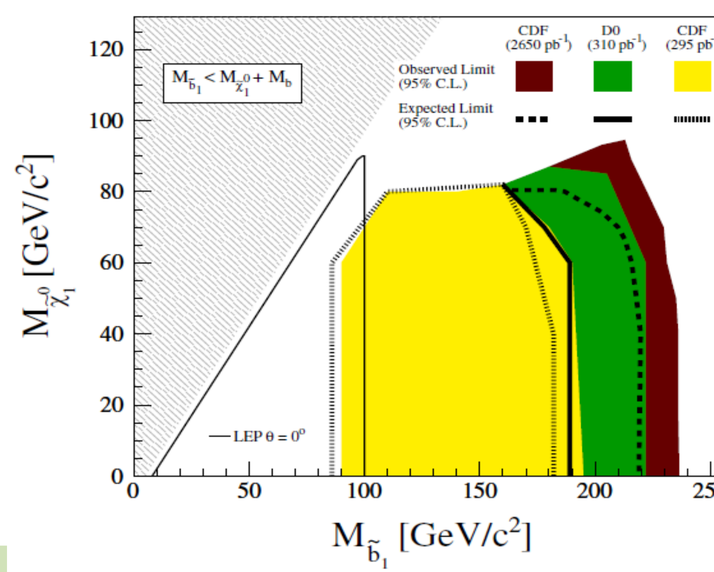
- ✔ Veto leptons (also taus)
- ✔ Reduce multijets with $\Delta\phi$ cuts (jets vs EtMiss or EtMiss vs PtMiss)
- ✔ Two b-jets required: tagging at 70% (50%) w/light-mistag at 6.5% (0.5%)
- ✔ X_{jj} variable (p_T jet1 + p_T jet2)/H_T (protect against top)
- ✔ 2 scenarios considered: low and high $\Delta M(\tilde{b}, \tilde{\chi}_1^0)$

Xjj>0.75 and low EtMiss/H_T:	Xjj>0.9 and large EtMiss/H_T:
SM exp: 971±152	SM exp: 6.9±1.7
Data: 901	Data: 7



CDF: Similar analysis (2.65 fb^{-1}). Requiring >=1 b-tag and loose and tight selections using EtMiss and H_T as main variables

Loose selection:	Tight selection:
SM exp: 133.8±26.4	SM exp: 47.6±8.8
Data: 139	Data: 38



Gluino-mediated $\tilde{b}$ (0.83 fb^{-1})

More information: ATLAS-CONF-2011-098 and poster (B. Butler)

Gluino decays to sbottom or stop in 2 or 3-bodies:

On-shell or off-shell

$\tilde{g} \to b\tilde{b}$ / $\tilde{g} \to \tilde{t}t$

$\tilde{g} \to tb\tilde{\chi}_1^-$ / $\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ / $\tilde{g} \to b\bar{b}\tilde{\chi}_1^0$

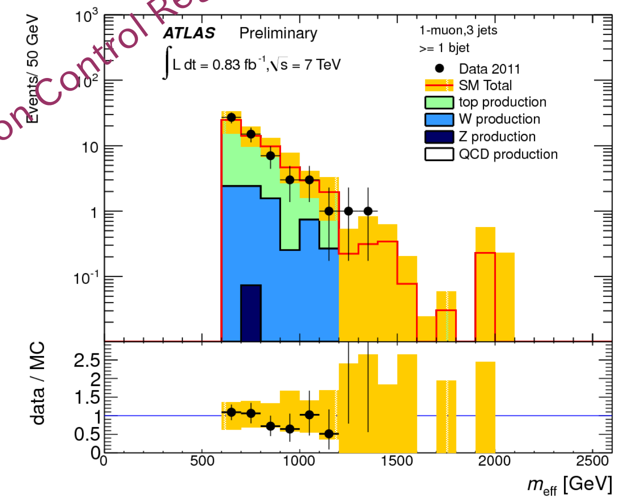
Gluino cross-section is larger: preferred production at the LHC

4 b-jets and EtMiss

4 signal regions defined:

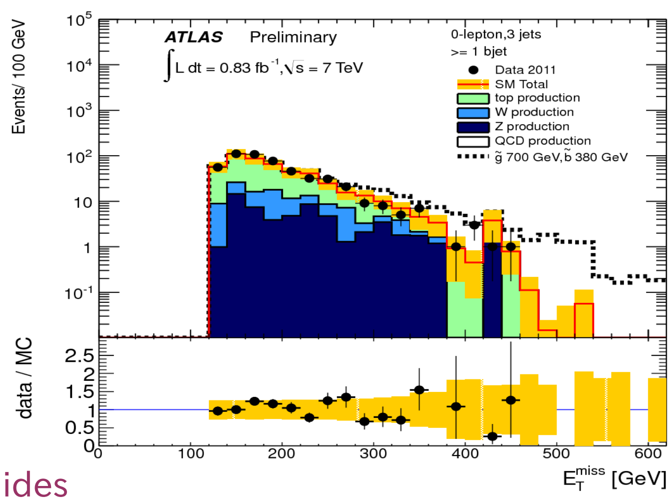
- 3JA: ≥1 b-jet, m_{eff}>500 GeV
- 3JB: ≥1 b-jet, m_{eff}>700 GeV
- 3JC: ≥2 b-jet, m_{eff}>500 GeV
- 3JD: ≥2 b-jet, m_{eff}>700 GeV

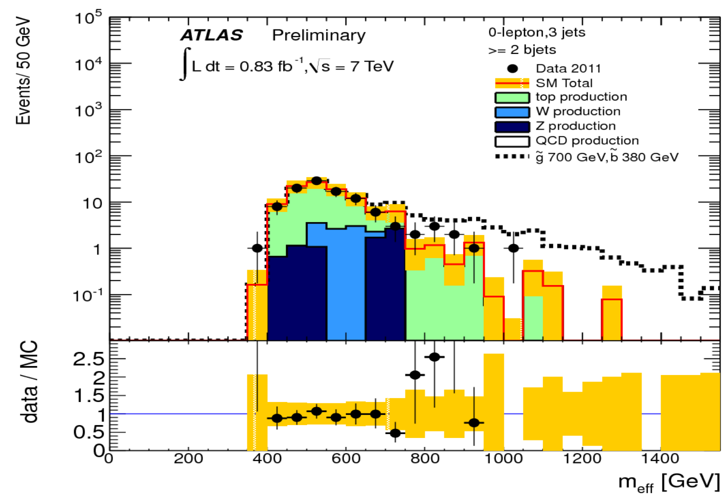
1 muon Control Region



- ✔ Lepton veto, 3 high p_T (100, 50, 50) GeV jets, significantly large EtMiss and jets not close to the EtMiss direction
- ✔ QCD fully data-driven: jet smearing technique (validation at low Δϕ(jet,EtMiss) region)
- ➢ W(bb), Z(bb), top... estimated using MC (validation using data-driven estimations)

No significant deviation from SM expectations*

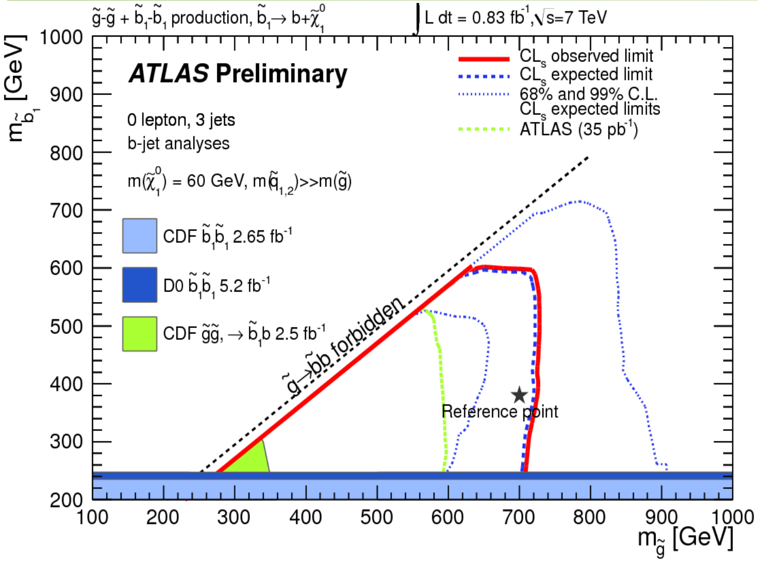




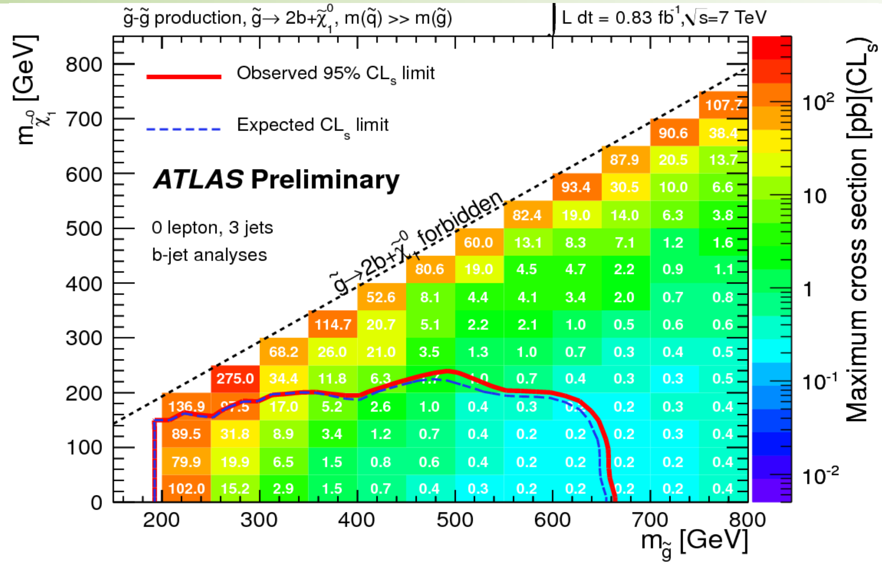
*detailed numbers are in the backup slides

$\tilde{g}$-mediated $\tilde{b}$: interpretation

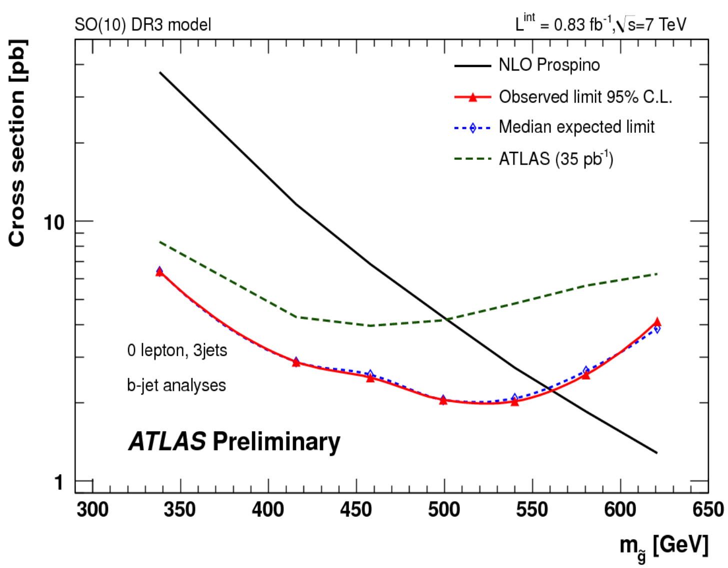
More information:
ATLAS-CONF-2011-098
CMS-PAS-SUS-11-005



Gluino mediated interpretation in an on-shell sbottom (other SUSY particles at larger scale)



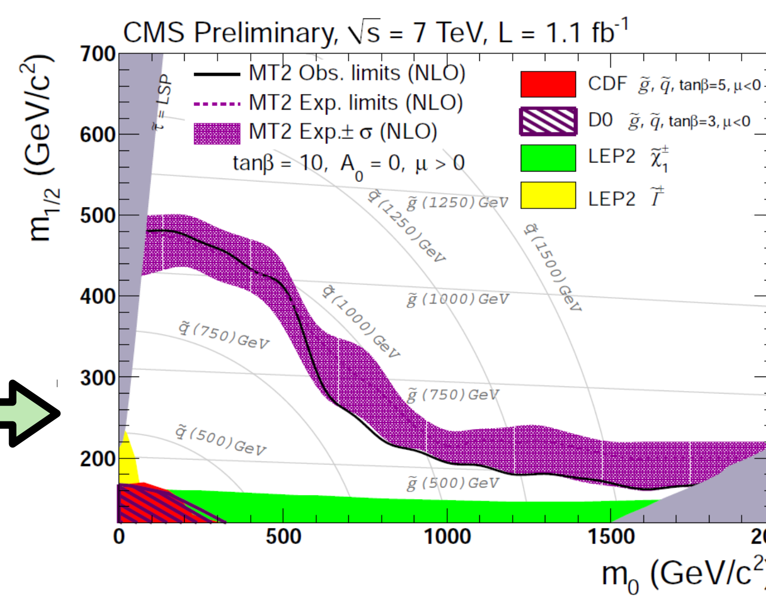
Gluino mediated interpretation with off-shell sbottom ($m(\tilde{b})>m(\tilde{g})$): 3-body decay



Interpretation in some theoretical scenarios:

SO(10) DR3 mode

MT2 analysis from CMS (see backup slides) with one b-jet. No excess observed. Interpretation in mSUGRA tanβ=10

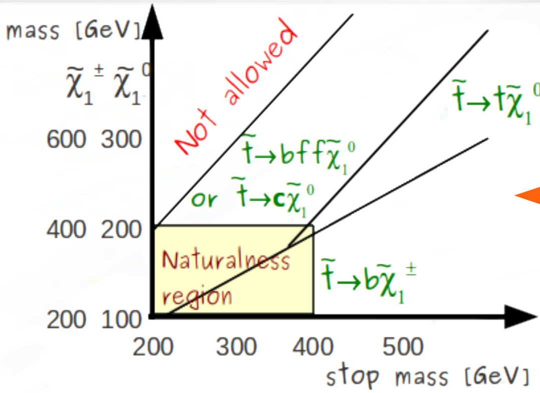


Stop-pair production (5.4 fb^{-1})

Stop decays depending on $\tilde{\chi}^{\pm}/\tilde{\chi}^{0}$ masses, sleptons...

Tevatron has sensitivity to masses < top. Given LEP constraints, preference is:

$\tilde{t}\bar{\tilde{t}} \to (be\tilde{\nu})(\bar{b}\mu\tilde{\nu})$



Example of mSUGRA with sleptons decoupled

More information:
Phys. Lett. B 693, 95 (2010)
(ArXiv:1005.2222v3)
See also interesting studies from CDF: Phys.Lett. B 665, 1 (2008)
and Phys.Rev.Lett. 104, 251801 (2010)

- Exactly 1 electron and 1 muon (opposite charge)
- Dominant background is $Z\to\tau\tau$, dibosons and dileptonic top
- MC is used to model backgrounds except for multijets (matrix method to estimate it)
- Discriminant: linear combination of different variables

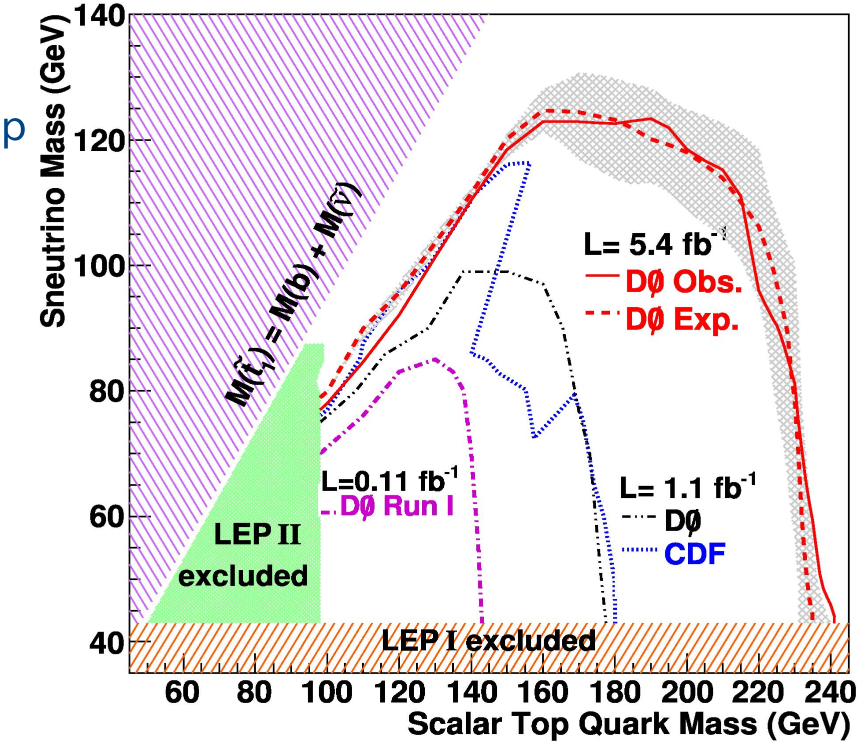
Two selections: for low ΔM and large ΔM

Low ΔM: SM: 785±57 Data: 776

Large ΔM: SM: 513±37 Data: 472

Data is found to be in agreement with MC:

If $m(\tilde{\nu})$<110 -> $m(\tilde{t})$>210 GeV or have a ΔM < 30 GeV



Gluino-mediated $\tilde{t}$ (1.03 fb^{-1})

More information:
ATL-COM-2011-130
and poster (A. Barr)

Searching for:

1) $\tilde{g} \to t\tilde{t}$ with:
   - a) $\tilde{t} \to b\tilde{\chi}_1^{\pm}$
   - b) $\tilde{t} \to t\tilde{\chi}_1^{0}$

2) $\tilde{g} \to t\bar{t}\tilde{\chi}_1^{0}$

Backgrounds:

- QCD: data-driven (matrix method)
- Non-QCD: normalization at low m_T and extrapolation using transfer function (MC-based)

Selection:

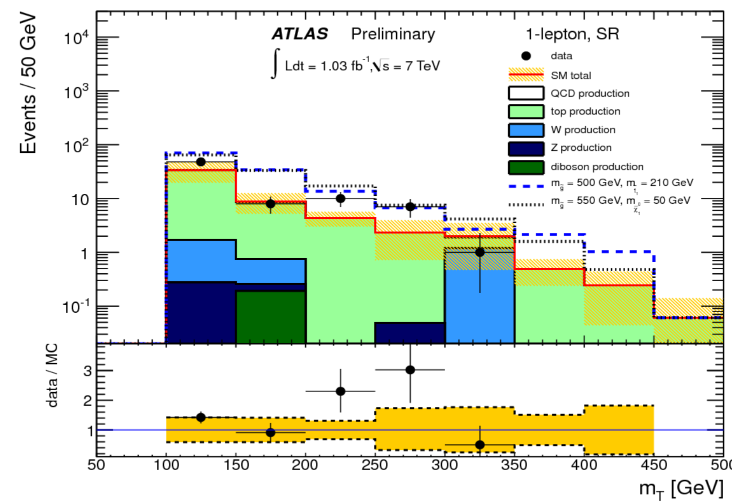
4 jets and 1 lepton, >=1 b-jet

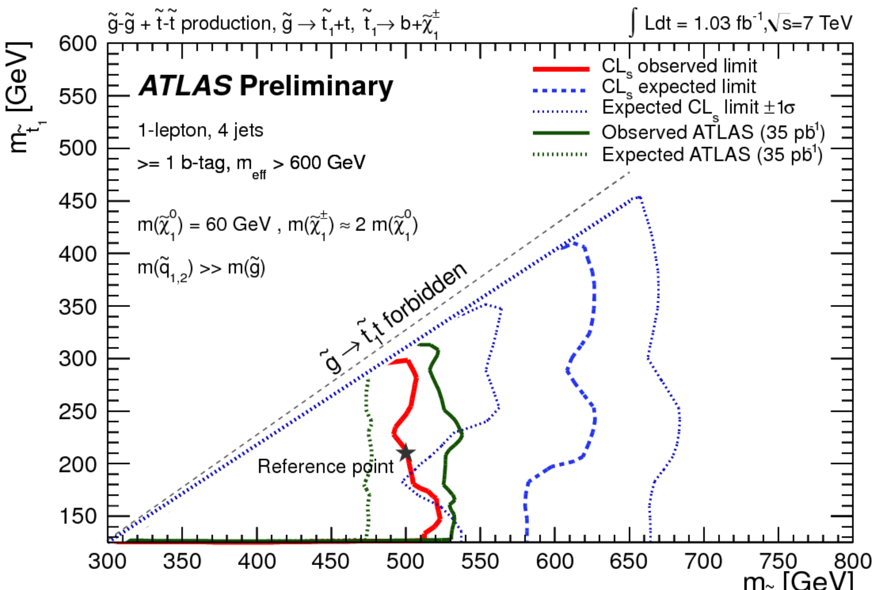
EtMiss>80 GeV
m_T>100 GeV
m_{eff}>600 GeV

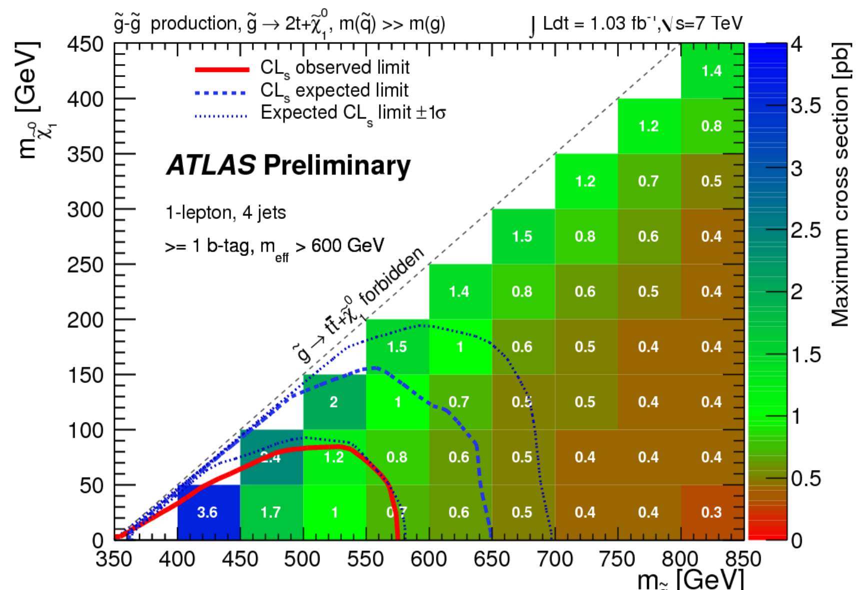
SM exp: 54.9±13.6
Data: 74

No significant deviation from SM expectations

(Up-fluctuation of 1.2 σ)

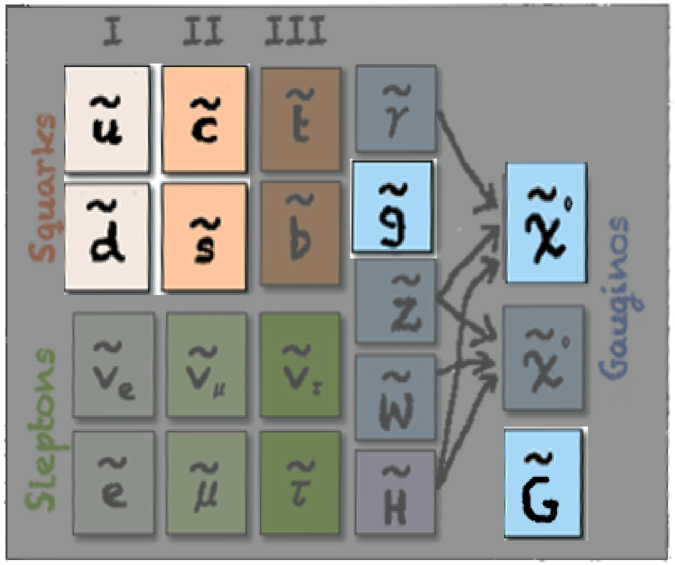






Excluding processes with σ>46 fb

Photons + EtMiss



Photonic final states: | * SUSY partner of U(1) gauge boson

GMSB: SUSY masses from SM *gauge interactions* and proportional to breaking scale Λ.

Gravitino ($\tilde{G}$) is the LSP and NLSP is mostly the $\tilde{\chi}^0_1$

(bino*) $\tilde{\chi}^0_1 \rightarrow \gamma \tilde{G}$ ➡ $\gamma\gamma$+EtMiss final state

Main bkgs (EtMiss and fakes):

1) QCD/instrumental ($\gamma\gamma, \gamma$+j, jj)
2) EWK/genuine ($\gamma + W \rightarrow e\nu$)

} data-driven

3) Irreducible: $(Z \rightarrow \nu\nu) + \gamma\gamma$ and $(W \rightarrow l\nu) + \gamma\gamma$

Tevatron GMSB (SPS8 scenario): assuming gaugino mass unification @ GUT scale: gaugino pair production dominates

LHC GGM: General Gauge Mediation model: No constraints on squark/gluino masses
SPS8: already getting sensitive to this model

Background estimation -> similar strategies: example taken from ATLAS in next slide

Background estimations

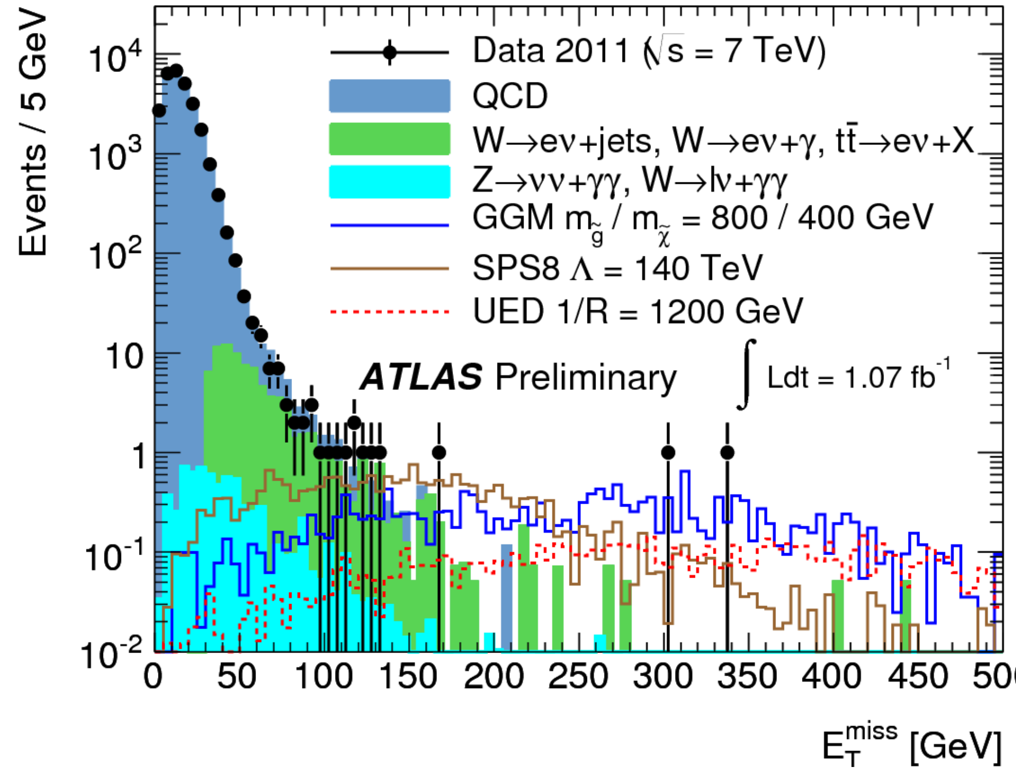
Selection: 2 photons with E_T > 25 GeV

QCD/Instrumental

1) γ+jet: require one γ failing tight id.

2) jet+jet: select Z→ee with invariant mass and similar kinematics (EtMiss not dominated by EM objects)

3) Normalisation: EtMiss<20 GeV



Electroweak/Genuine

1) Determine probability for an 'e' to be mis-identified as a 'γ': use Z→ee

P(e-γ)~5-17%

2) Select "e-γ" and rescale by probability

3) Subract QCD/instrumental shape (normalised at EtMiss<20 GeV)

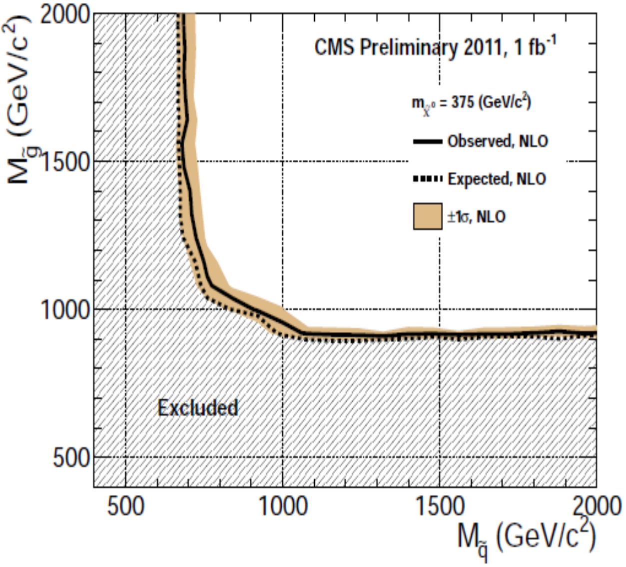
Other backgrounds (irreducible): used MC

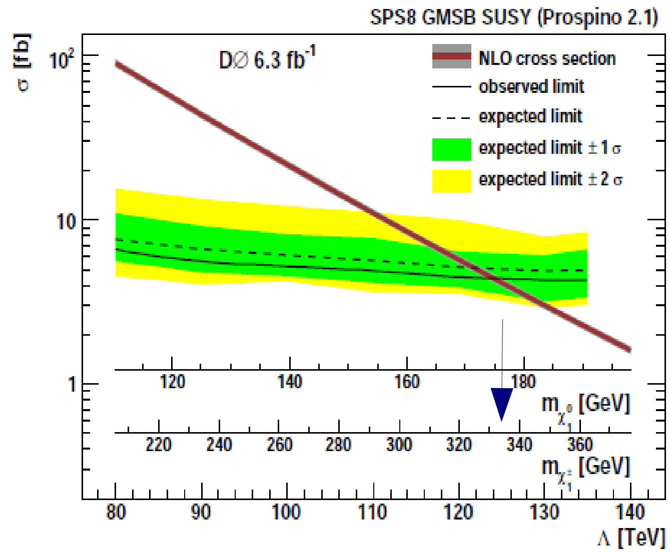
E_T^{miss} range [GeV]	Data events	Predicted background events Total	QCD	$W/t\bar{t}(\to e\nu)+X$	Irreducible
0 - 20	20881	-	-	-	-
20 - 50	6304	5968 ± 29	5951 ± 28	13.3 ± 8.1	3.6 ± 0.3
50 - 75	86	87.1 ± 3.3	60.9 ± 2.8	25.2 ± 1.7	1.0 ± 0.2
75 - 100	11	14.7 ± 1.2	6.7 ± 0.9	7.4 ± 0.8	0.52 ± 0.10
100 - 125	6	4.9 ± 0.7	1.6 ± 0.4	3.0 ± 0.5	0.32 ± 0.08
> 125	5	4.1 ± 0.6	0.8 ± 0.3	3.1 ± 0.5	0.23 ± 0.05

No significant deviation from SM expectations

Results and interpretation

D0: Phys.Rev.Lett. 105, 221802 (2010) (ArXiv: 1008.2133v1)
CDF: Phys.Rev.Lett. 104, 011801 (2010) (ArXiv:0910.3606)
CMS: PAS SUS 11-09 (including also a single γ analysis)





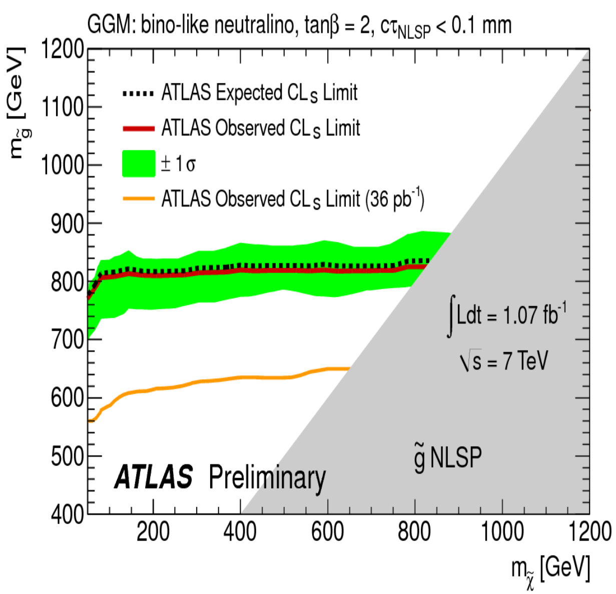
No excess in any experiment

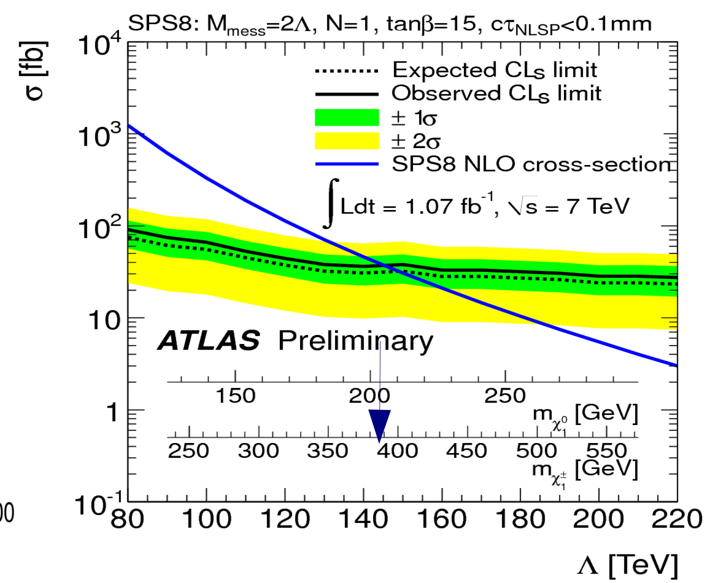
D0 (6.3 fb^{-1}): SPS8 GMSB model

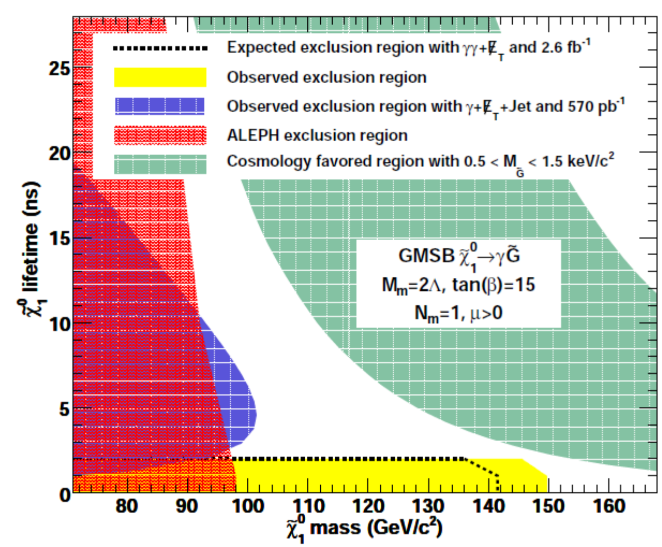
CDF (2.6 fb^{-1}): SPS8 (plane of NLSP lifetime)

CMS (1.14 fb^{-1}): GGM in sq-gl plane

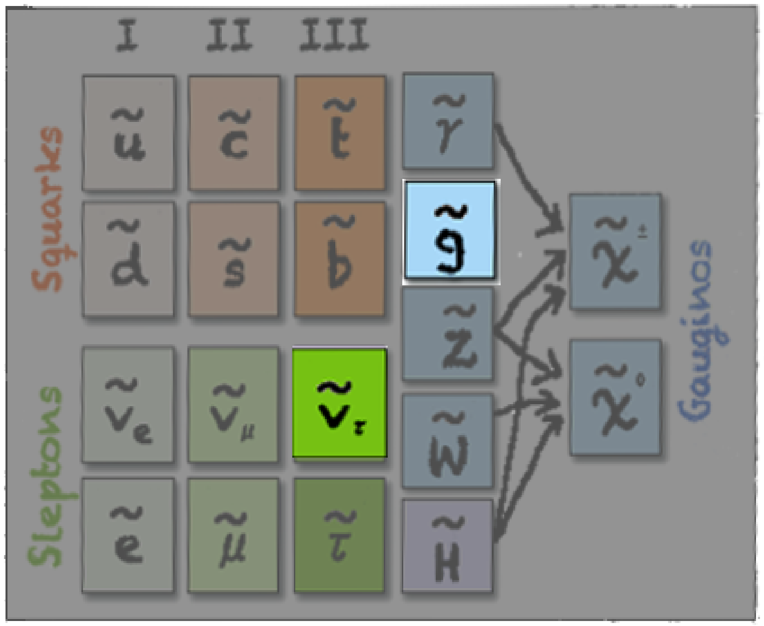
ATLAS (1.07 pb^{-1}): GGM (gluino vs LSP) and SPS8 *(first time at the LHC)*



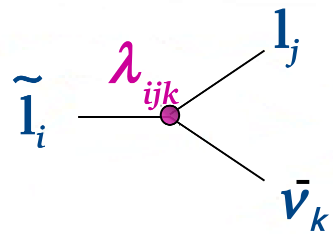




RPV searches



RPV:



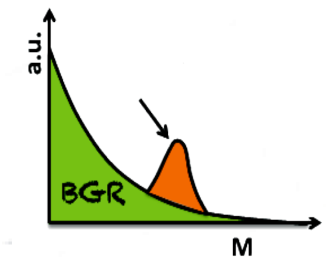
$\lambda_{ijk}\hat{L}_i\hat{L}_j\hat{E}_k + \lambda'_{ijk}\hat{L}_i\hat{Q}_j\hat{D}_k$

Experiments usually assume only λ'_{311} and $\lambda_{312} \neq 0$

(experimentally less constrained)

$\tilde{\nu}_\tau$ -> $e\mu$

Another possibility explored is a gluino decay to jets (λ_{uds} term)



Main backgrounds (for tau sneutrino):

1) SM processes with eμ final states:
Z/γ*->ττ, ttbar, single top, WW, WZ, ZZ

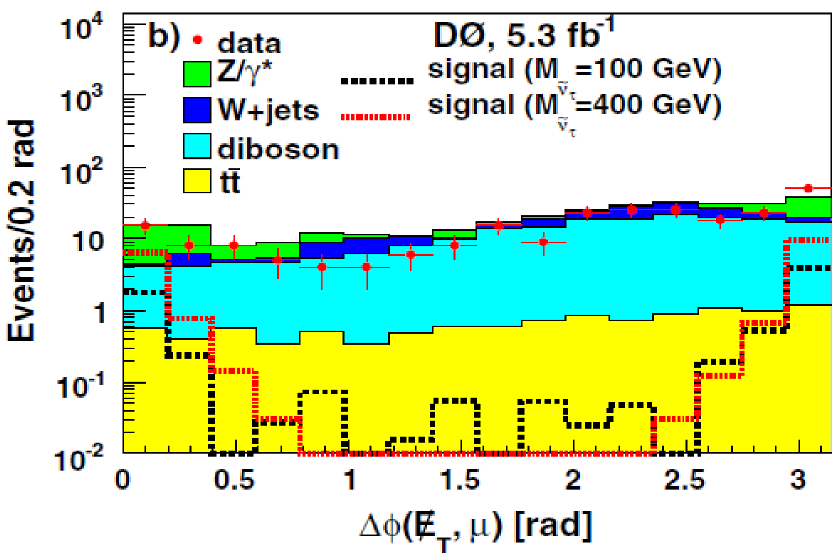
2) Instrumental backgrounds (lepton from mis-identified or from conversions): W/Z+γ/jets, QCD

More information about RPV:
R. Barbier et al., Phys. Rep. 420, 1 (2005)
(arXiv:hep-ph/0406039)

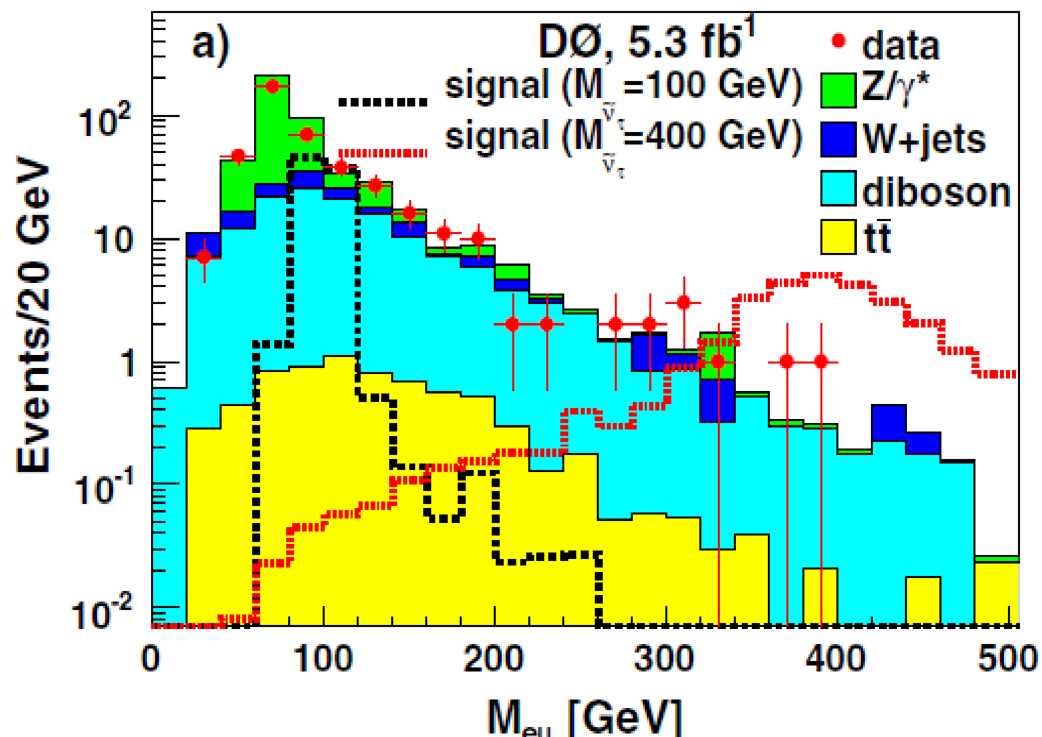
RPV scalar tau neutrino (5.3 fb^{-1})

- Exactly 1 electron and 1 muon (no charge requirement)
- Used Neural Network to distinguish electrons from jets.
- No EtMiss expected but could appear from limited muon resolution: remove events if 0.7 < Δφ(μ,EtMiss) < 2.3

More information:
PRL 105, 191802 (2010)
See also CDF analysis with eμ, μτ and eτ (1 fb^{-1}):
Phys. Rev. Lett. 105, 191801 (2010)



Process	Number of events
Drell-Yan (Z/γ^*)	254 ± 26
Diboson (WW, WZ, ZZ)	116 ± 12
$t\bar{t}$	5.8 ± 1.0
W + jets	34.1 ± 5.9
Total background	410 ± 38
Data	414

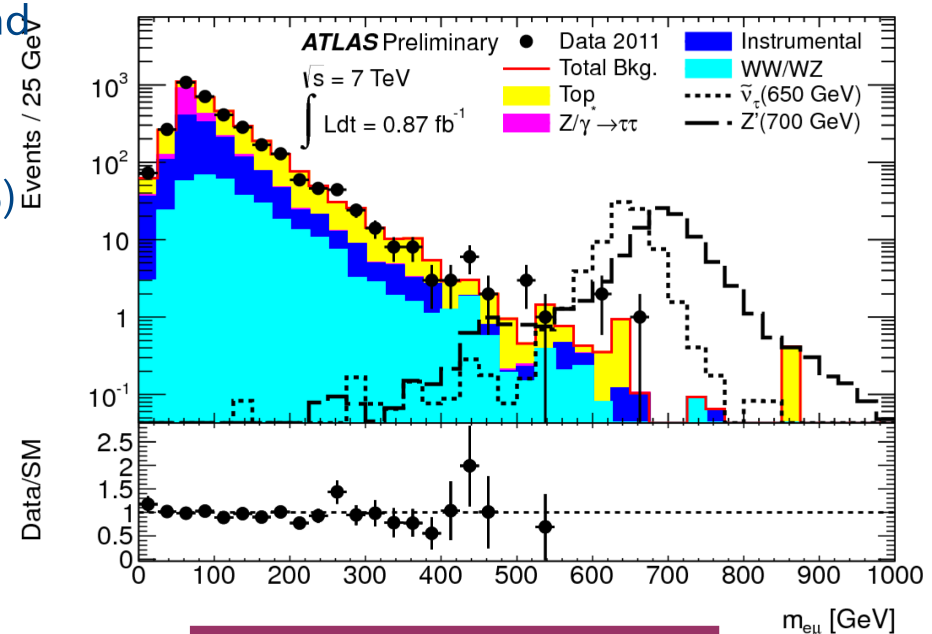


No significant deviation from SM expectations

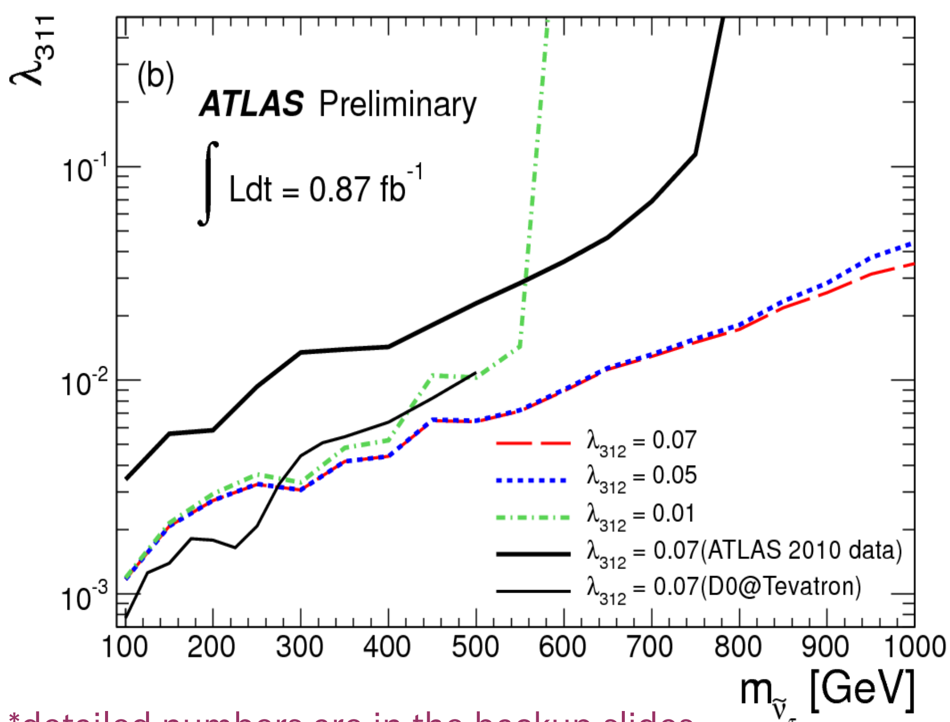
RPV scalar tau neutrino (0.87 fb^{-1})

More information:
ATLAS-CONF-2011-109

- ✔ Exactly 1 electron and 1 muon (opposite sign)
- ✔ SM processes with eμ or photons estimated with MC
- ✔ Instrumental bkg with 4x4 matrix method: loose/tight (isolation) and determine probabilities for real (Z->ll) and fakes (QCD region)
- ✔ Main systematics come from the probability of loose quality non-prompt muon passing tight criteria (~10.5%)



No significant deviation from SM expectations*



Coupling λ'_{311} above lines is excluded (each coloured line is a different λ_{312})

ATLAS limits expand mass ranges beyond D0

D0 still competitive in low stau neutrino mass range

*detailed numbers are in the backup slides

3-jet resonances

More information:
CDF: Phys.Rev.Lett. 107, 042001 (2011)
CMS: ArXiv:1107.3084 (acc. by PRL)

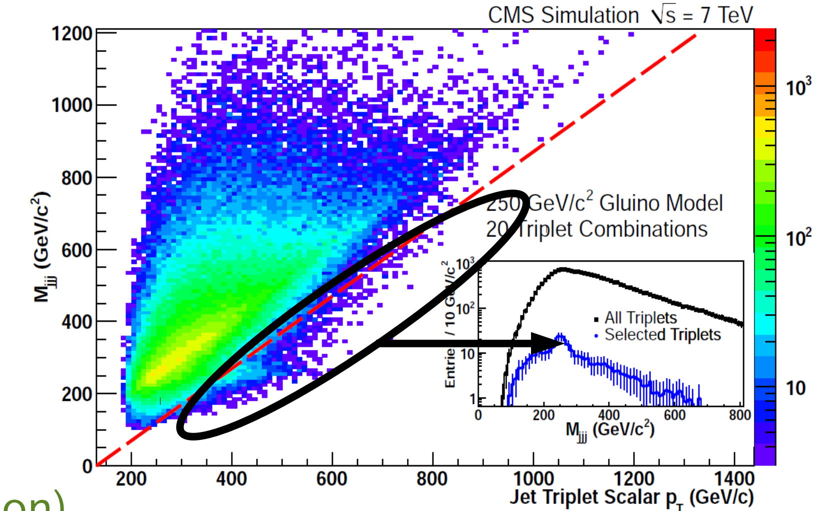
- Search for gluino/squark production, with gluino decaying to 3 jets (two 3-jet resonance)
- CDF (3.2 fb^{-1}) and CMS (35 pb^{-1}) complementary: different mass ranges (77-240 GeV vs 200-500 GeV)
- Main background is QCD multijet production and wrong combinatorics (in CDF also ttbar)

6 jets final state: 20 combinations (jet triplets).

Correct combination:

$$M_{jjj} < \sum_{i=1}^{3} |p_T|_i - \Delta,$$

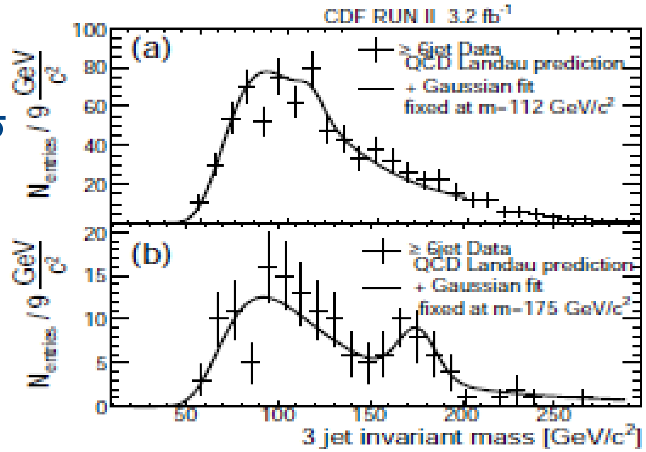
Optimized (gluino mass explored)

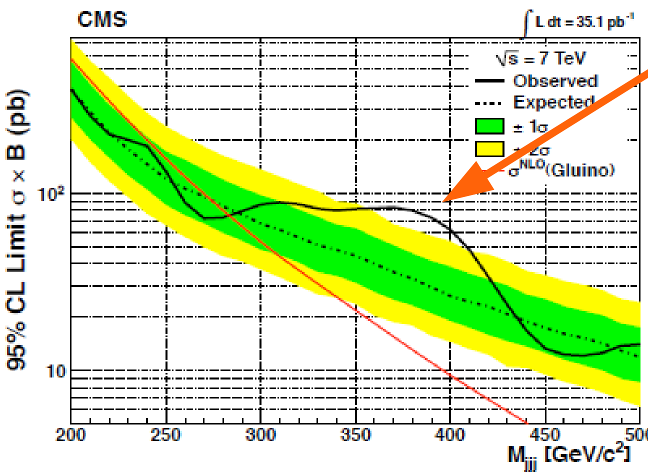


Background-only hypothesis using Nj=4 and rescaling.

Validations: predict Nj=5 and Nj>=6 (w/o kinematic condition)

CDF finds 2σ deviation around the top mass





1.9 σ deviation at 380 GeV

CDF excludes gluinos below 144 GeV (155 GeV if degenerate squarks)

CMS excludes gluino masses between 200 and 280 GeV

* Inspired by discussions at the EPS 2011 conference

Looking forward...*

- ✗ Many different searches and no sign of SUSY
- ✗ Most probable SUSY scenarios (from EWK precision tests) already excluded...

} Is SUSY really there?

> *"It is not time to desperate yet...*
> *...but maybe it is time for depression already"*
> G. Altarelli

SUSY: estabilisation of EWK sector (highest virtue)

In MSSM: radiative corrections bring Higgs mass above LEP constraints.

No fine-tunning -> stop mass should be small:

$$\delta m_H^2 \simeq -\frac{3y_t^2}{8\pi^2}\left(m_{Q_3}^2 + m_{U_3}^2 + |A_t|^2\right)\ln\left(\frac{M}{m_{\tilde{t}}}\right)$$

→ Mass of the messenger particle of the SUSY breaking

But also gluinos should be relatively light (radiative corrections): $\delta m_{\tilde{t}}^2 \simeq \frac{8\alpha_s}{3\pi} M_3^2 \ln\left(\frac{\Lambda_M}{m_{\tilde{t}}}\right)$ ➡ $M_3 \lesssim 1.5\text{TeV}\left(\frac{3}{\log\left(\Lambda_M/m_{\tilde{t}}\right)}\right)$

Scenarios for naturalness:

1) Heavy squarks, intermediate gluino, light stop and gauginos

2) Compressed light spectrum. SUSY breaking should then be at low scales (RGE tends to open the spectrum).

Both still possible...

Conclusions

- All multi-purpose experiments at colliders searching for SUSY in many different final states
- Developed different analyses techniques and approaches to maximize sensitivity: Tevatron and the LHC are complementary machines at this stage.
- Unfortunately, no indication of SUSY particles has been found.
- More details on the analyses presented and others that there was no time to cover:

  http://www-cdf.fnal.gov/physics/exotic/exotic.html

  http://www-d0.fnal.gov/d0_publications/d0_pubs_list_runII_bytopic.html#np

  https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

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

More data on tape, more ideas to cover different final states, refined techniques...

The search has not finished, yet. In some cases, it has just started...

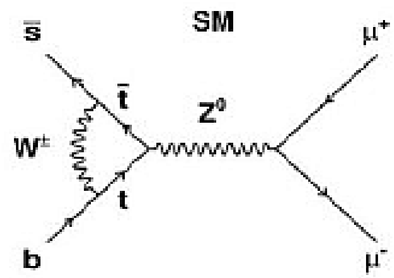
BACKUPS

$B_s \to \mu\mu$

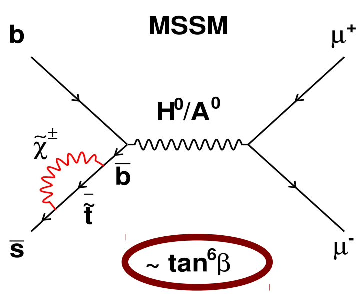
More information:
CDF: ArXiv:1107.2304
CMS/LHCb: CMS-PAS-BPH-11-019

Very rare process in SM:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-)_{\rm SM} = (3.2 \pm 0.2) \times 10^{-9}$$



In MSSM, the process can be enhanced with the contribution of new diagrams:



$$BR(B_s \to \mu^+\mu^-) \propto \tan^6\beta / m_A^4$$

Newest result from CDF (some small excess between 2 and 3 sigma):

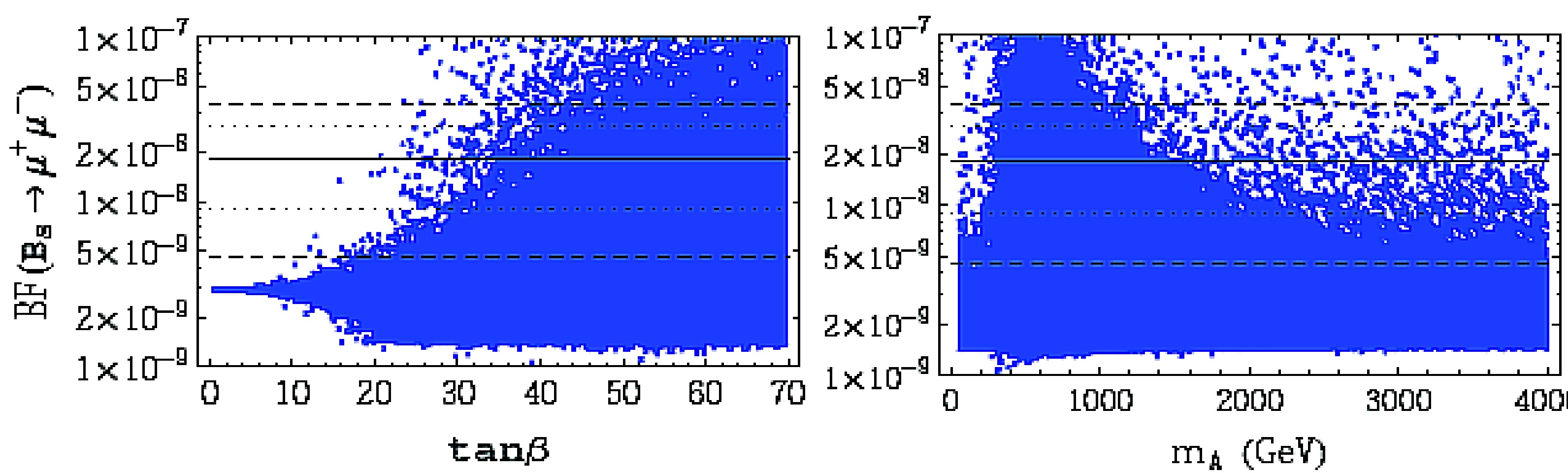
$$BR = 1.8^{+1.1}_{-0.9} \times 10^{-8}$$

Newest result from LHCb and CMS combination:

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 1.08 \times 10^{-8} \text{ at } 95\,\%\text{ CL},$$
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) < 0.90 \times 10^{-8} \text{ at } 90\,\%\text{ CL},$$

New results constrain some MSSM scenarios (without further assumptions rather than experimental bounds)

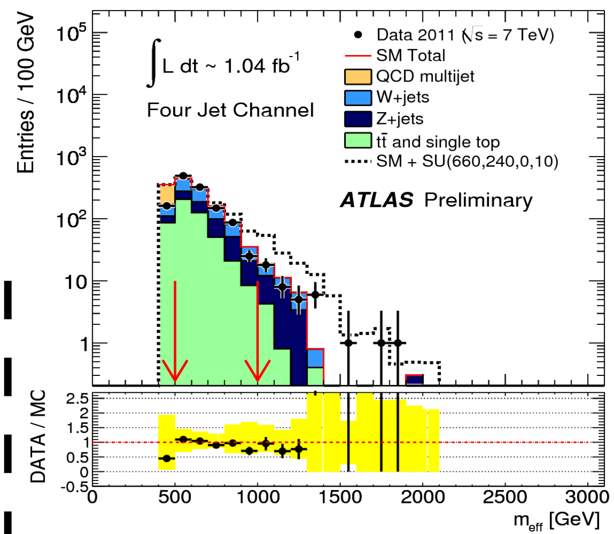
D. Hooper, C. Kelso, ArXiv: hep-ph/107.3858



m_{eff} search: bkg determination

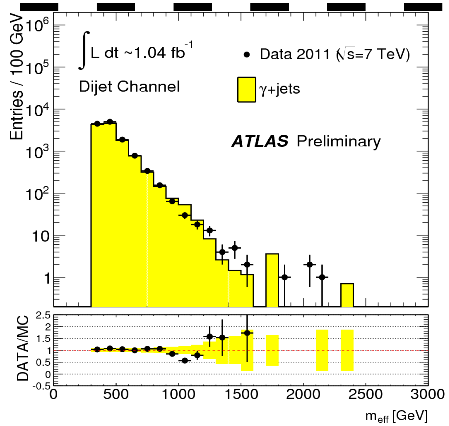
Process	Signal Region				
	≥ 2-jet	≥ 3-jet	≥ 4-jet, m_{eff} > 500 GeV	≥ 4-jet, m_{eff} > 1000 GeV	High mass
Z/γ+jets	32.5 ± 2.6 ± 6.8	25.8 ± 2.6 ± 4.9	208 ± 9 ± 37	16.2 ± 2.1 ± 3.6	3.3 ± 1.0 ± 1.3
W+jets	26.2 ± 3.9 ± 6.7	22.7 ± 3.5 ± 5.8	367 ± 30 ± 126	12.7 ± 2.1 ± 4.7	2.2 ± 0.9 ± 1.2
$t\bar{t}$+ Single Top	3.4 ± 1.5 ± 1.6	5.6 ± 2.0 ± 2.2	375 ± 37 ± 74	3.7 ± 1.2 ± 2.0	5.6 ± 1.7 ± 2.1
QCD jets	0.22 ± 0.06 ± 0.24	0.92 ± 0.12 ± 0.46	34 ± 2 ± 29	0.74 ± 0.14 ± 0.51	2.10 ± 0.37 ± 0.83
Total	62.3 ± 4.3 ± 9.2	55 ± 3.8 ± 7.3	984 ± 39 ± 145	33.4 ± 2.9 ± 6.3	13.2 ± 1.9 ± 2.6
Data	58	59	1118	40	18

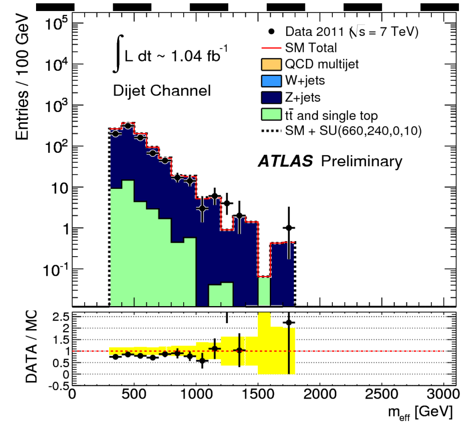
Results



$Z \rightarrow \nu\nu$

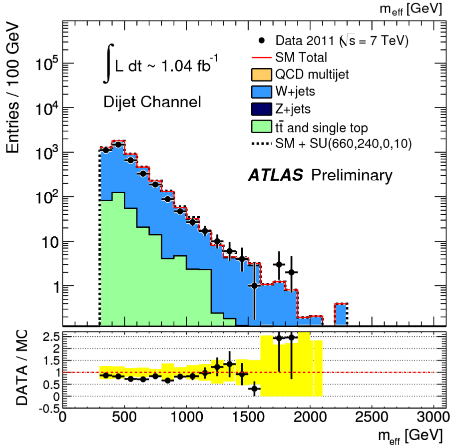
- Dominant Z background
- Use Z->ee(μμ) / γ + jets
- Replace the boson by EtMiss in both cases

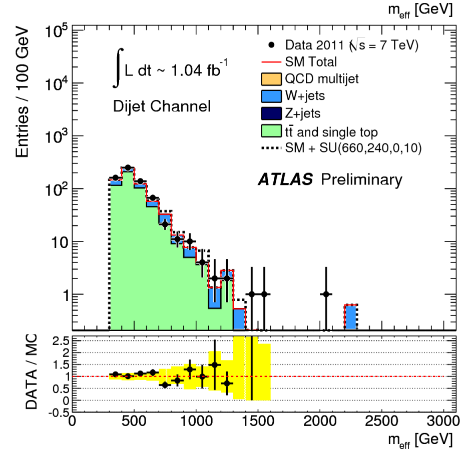




W/ttbar

- Select events with one lepton
- Apply 30<m_T<100 GeV
- <1 b-tag jet: enhance W
  >=1 b-tag jet: enhance top



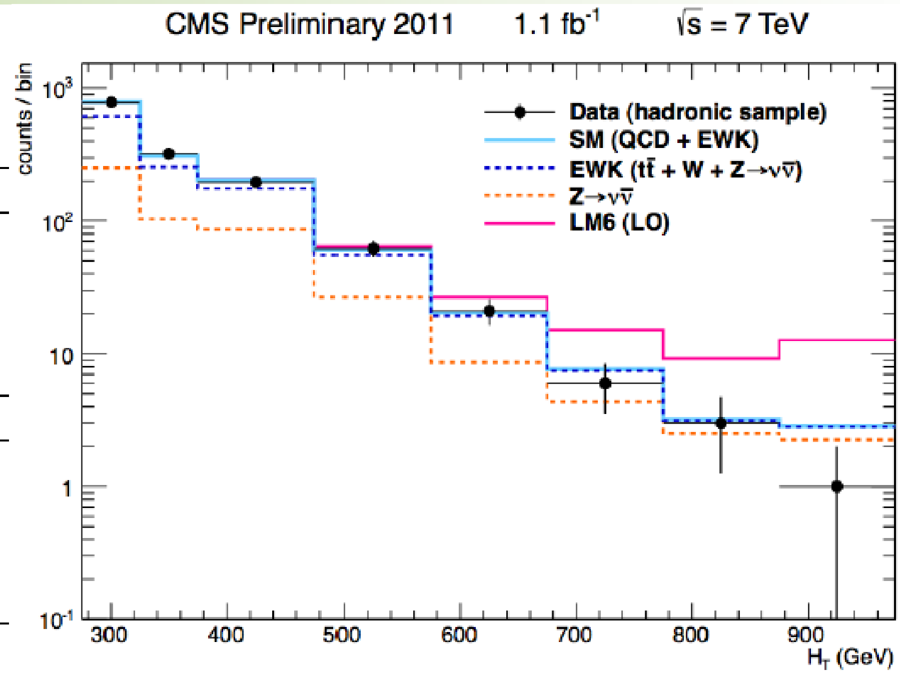


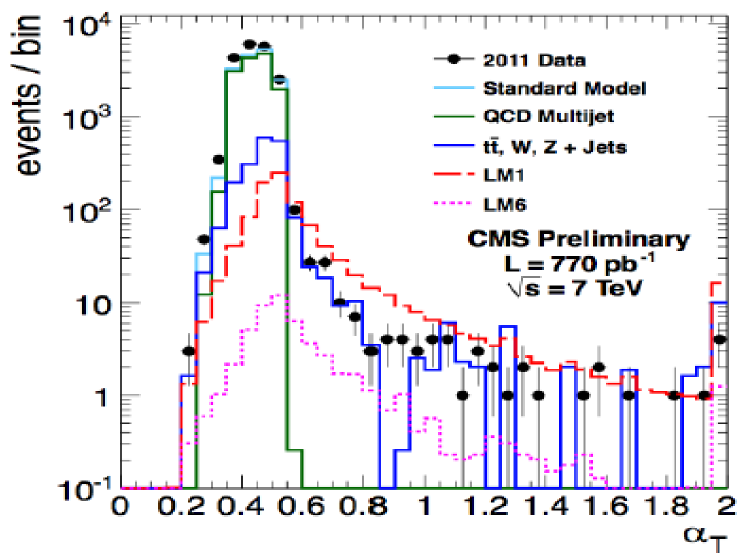
Background estimations

The α_T search (1.1 fb^{-1})

Table 2: Muon sample predictions with 1.1fb^{-1}. Errors quoted on predictions correspond to statistical errors and an additional conservative systematic uncertainty of 30%, as used in the previous analysis.

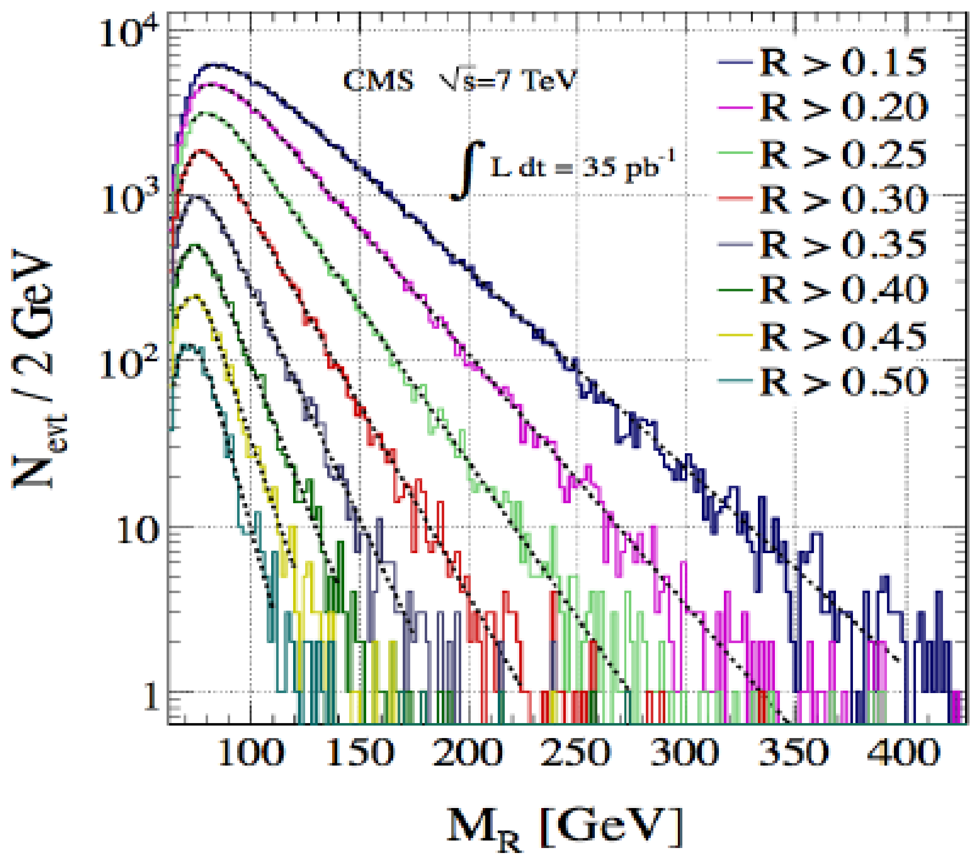
H_T Bin (GeV)	275–325	325–375	375–475	475–575
MC W + $t\bar{t}$	$463.0 \pm 16.0_{stat}$	$171.2 \pm 9.5_{stat}$	$116.3 \pm 8.3_{stat}$	$43.7 \pm 5.1_{stat}$
MC μ+ jets	$407.5 \pm 14.5_{stat}$	$179.1 \pm 9.6_{stat}$	$131.6 \pm 8.8_{stat}$	$48.7 \pm 5.5_{stat}$
MC Ratio	1.14	0.96	0.90	0.90
Data μ+ jets	389	156	113	39
W + $t\bar{t}$ Prediction	$442.0 \pm 22.4_{stat} \pm 132.6_{syst}$	$149.1 \pm 11.9_{stat} \pm 44.7_{syst}$	$101.9 \pm 9.6_{stat} \pm 30.6_{syst}$	$35.2 \pm 5.6_{stat} \pm 10.6_{syst}$
H_T Bin (GeV)	575–675	675–775	775–875	875–∞
MC W + $t\bar{t}$	$17.5 \pm 3.2_{stat}$	$5.1 \pm 1.8_{stat}$	$1.1 \pm 0.7_{stat}$	$1.8 \pm 1.0_{stat}$
MC μ+ jets	$13.3 \pm 2.9_{stat}$	$8.0 \pm 2.3_{stat}$	$3.2 \pm 1.4_{stat}$	$0.9 \pm 0.7_{stat}$
MC Ratio	0.90	0.90	0.90	0.90
Data μ+ jets	17	5	0	0
W + $t\bar{t}$ Prediction	$15.3 \pm 3.7_{stat} \pm 4.6_{syst}$	$4.5 \pm 2.0_{stat} \pm 1.4_{syst}$	$0.0 \pm 1.0_{stat}$	$0.0 \pm 1.0_{stat}$

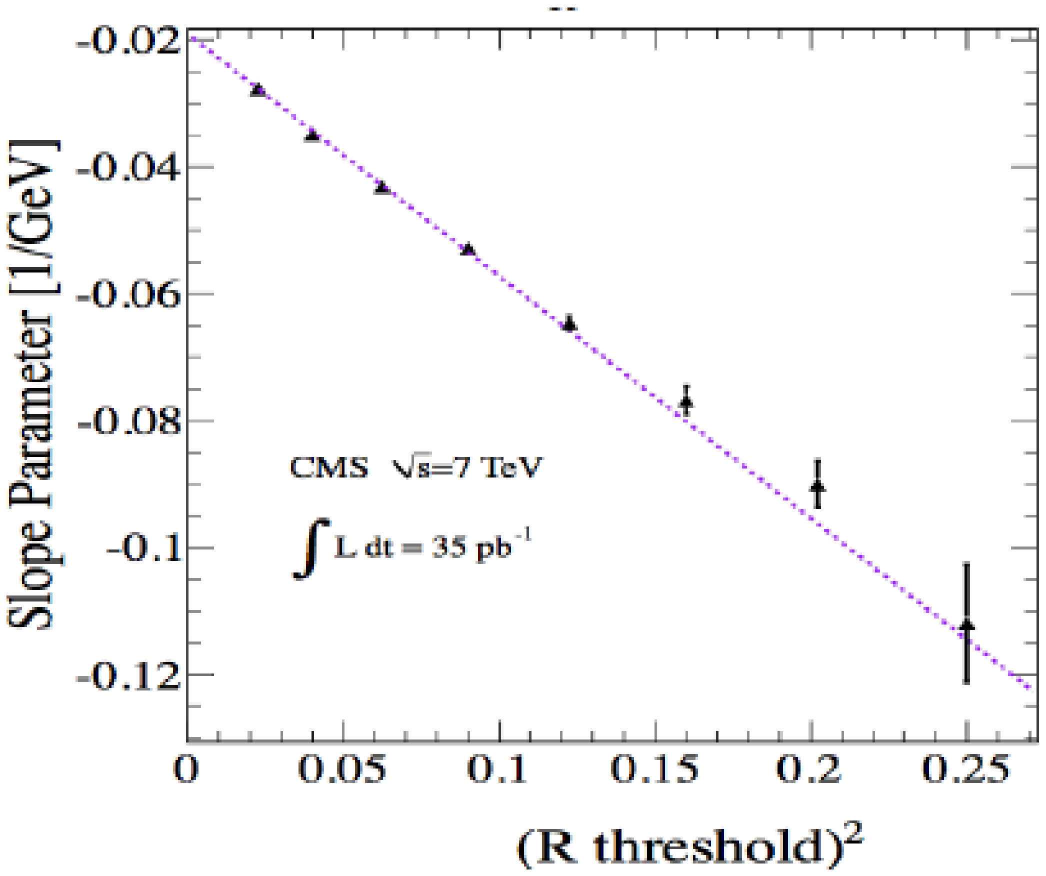




Razor

C. Rogan, ArXiv: 1006.2727





MT2 (1.1 fb^{-1})

CMS: PAS SUS-11-005

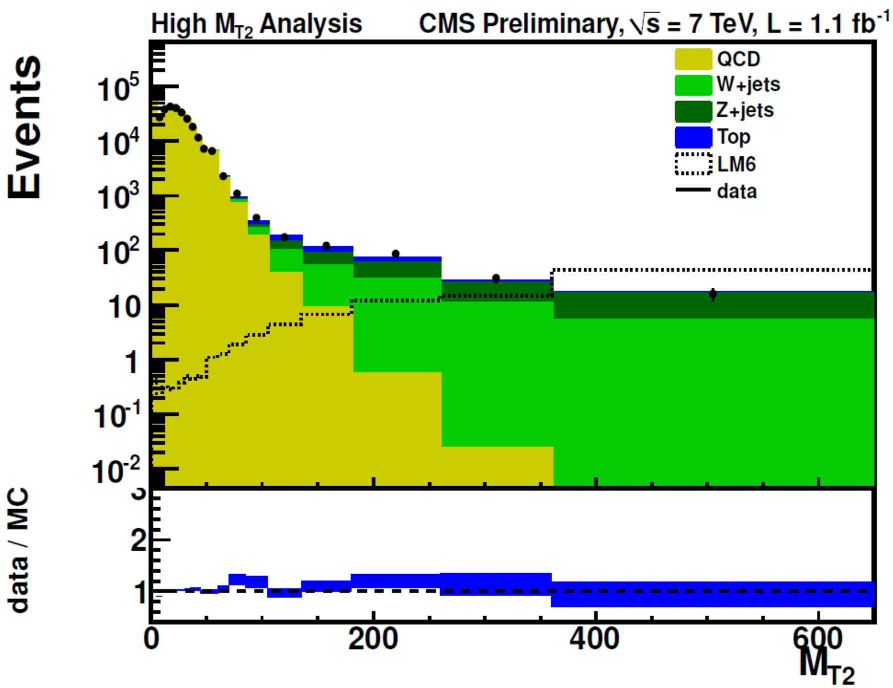
MT2 is defined as: $$M_{T2}(m_\chi) = \min_{p_T^{\chi(1)}+p_T^{\chi(2)}=p_T^{miss}} \left[\max\left(m_T^{(1)}, m_T^{(2)}\right)\right], \quad (m_T^{(i)})^2 = (m^{vis(i)})^2 + m_\chi^2 + 2\left(E_T^{vis(i)}E_T^{\chi(i)} - \vec{p}_T^{\,vis(i)} \cdot \vec{p}_T^{\,\chi(i)}\right)$$

If back-to-back topology: small MT2
If parallel topology (visible): large MT2

When more than 2-jets, hemisphere algorithm

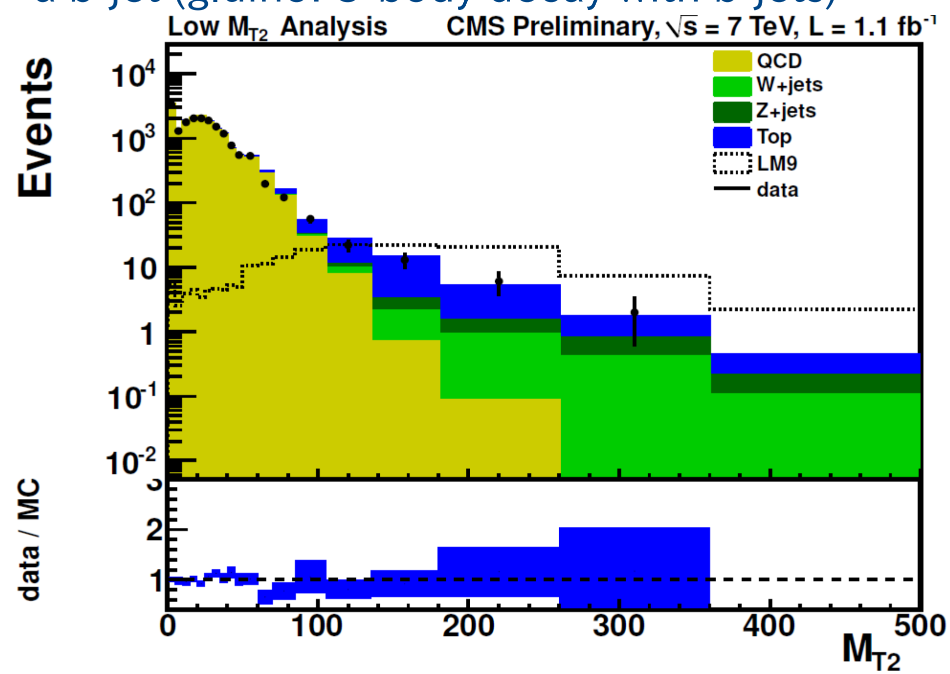
High MT2

- Aiming at large squarks and gluinos (e.g. low m_0 in mSUGRA)
- Requiring 3 jets and large MT2 (above 400 GeV)



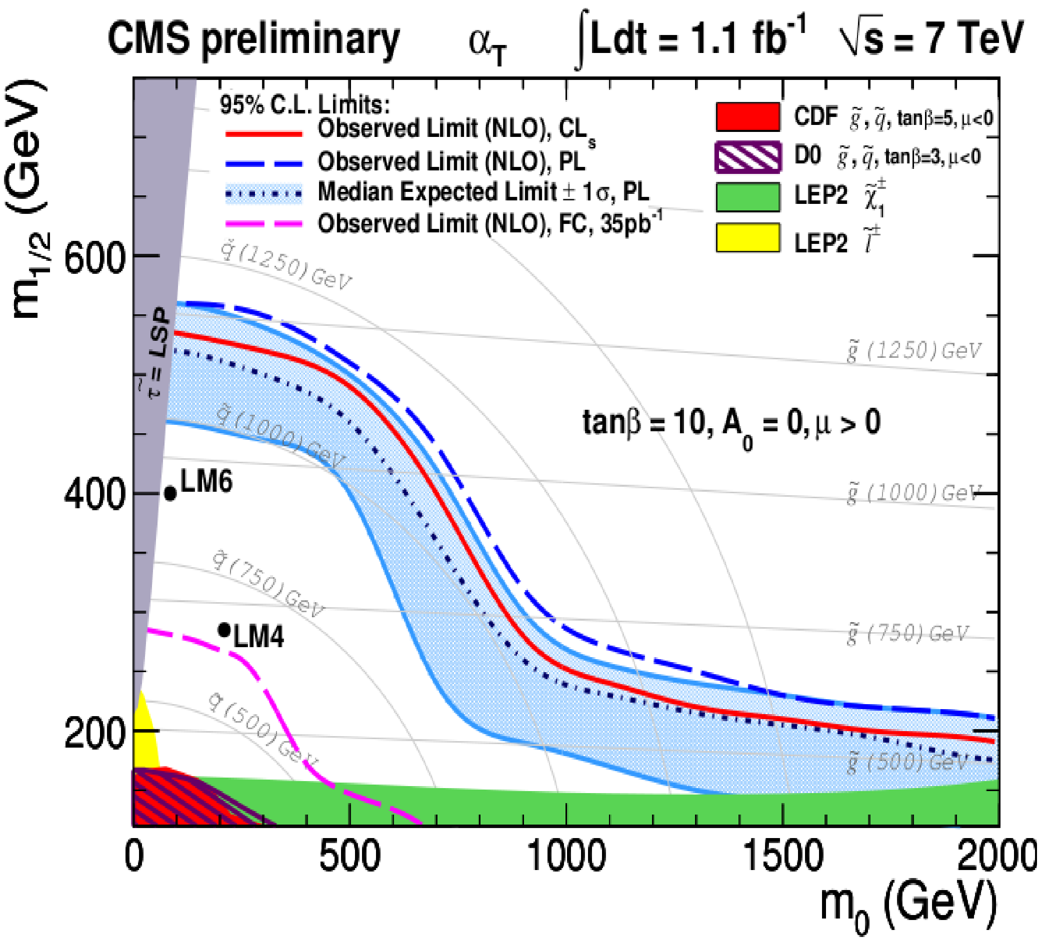
Low MT2

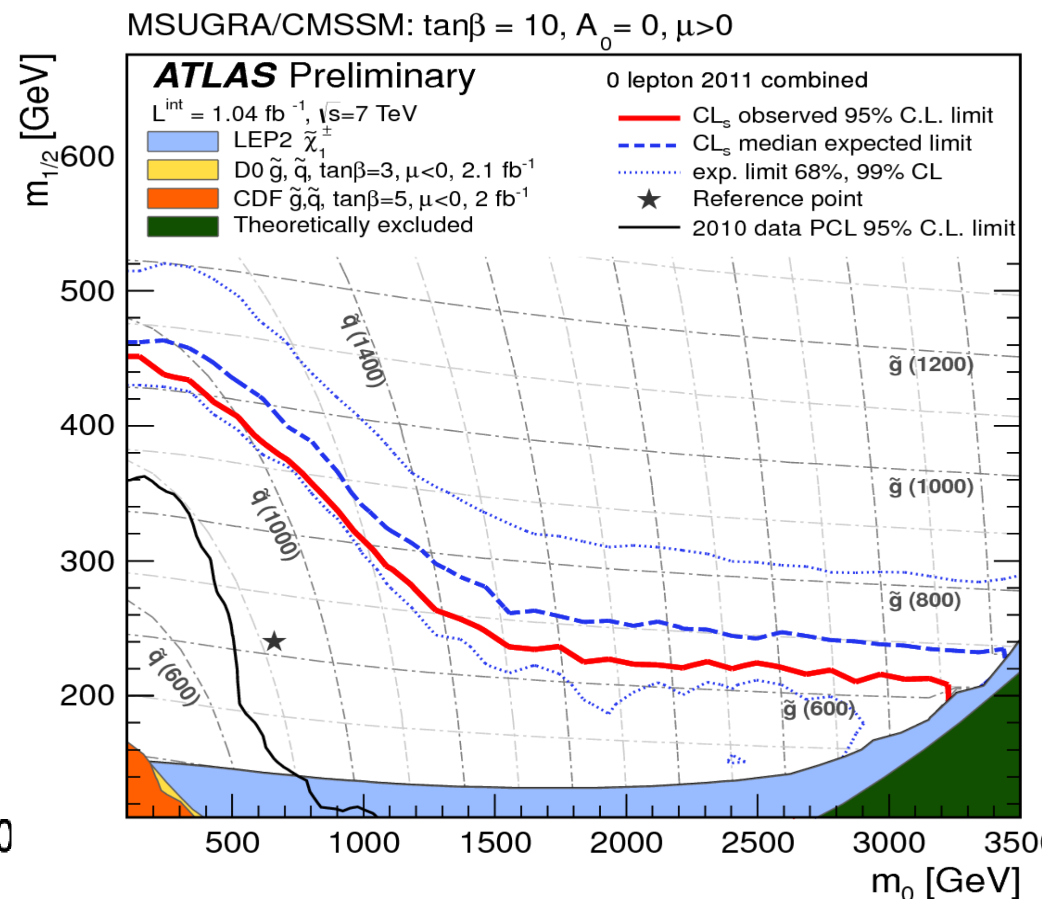
- Aiming at large squark and small gluino masses (e.g. large m_0 in mSUGRA)
- Requiring large HT (650 GeV), 4 jets and at least a b-jet (gluino: 3-body decay with b-jets)



No excess found with respect to SM predictions

Interpretation: mSUGRA



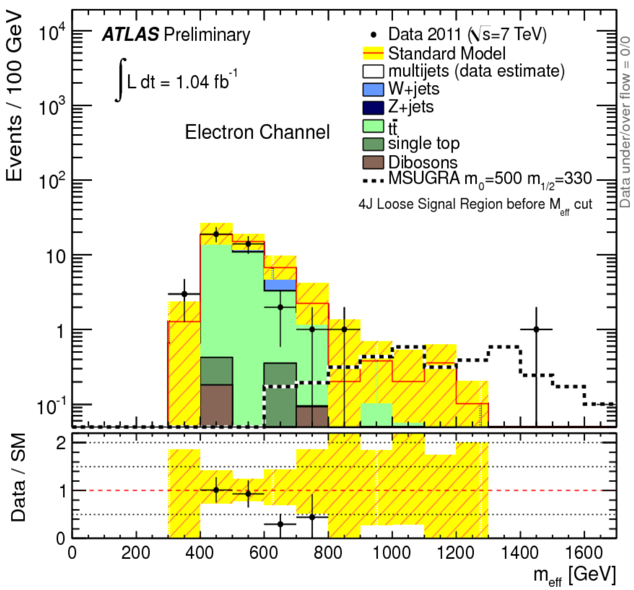


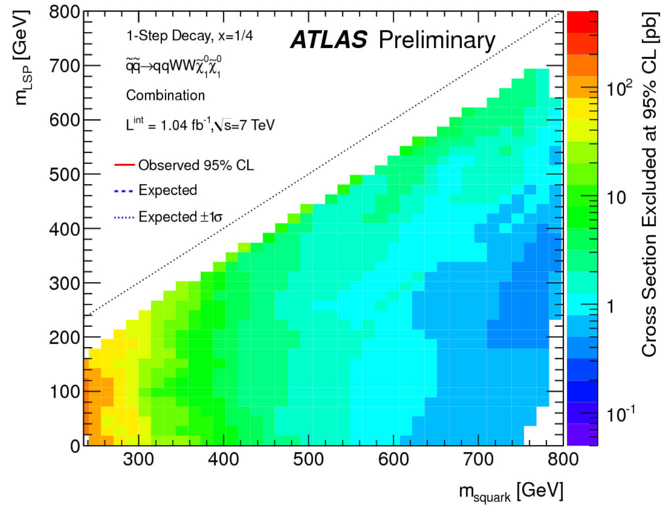
Results from α_T of CMS exclude squark/gluino masses up to 1.1 TeV for m_0 < 500 GeV (CLs method)

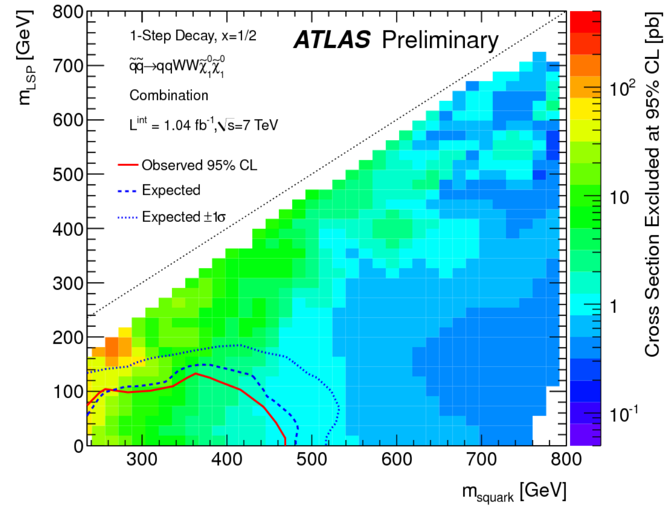
ATLAS excludes gluino/squark masses ~<1 TeV/950 GeV for m_0 < 500 GeV (CLs method)

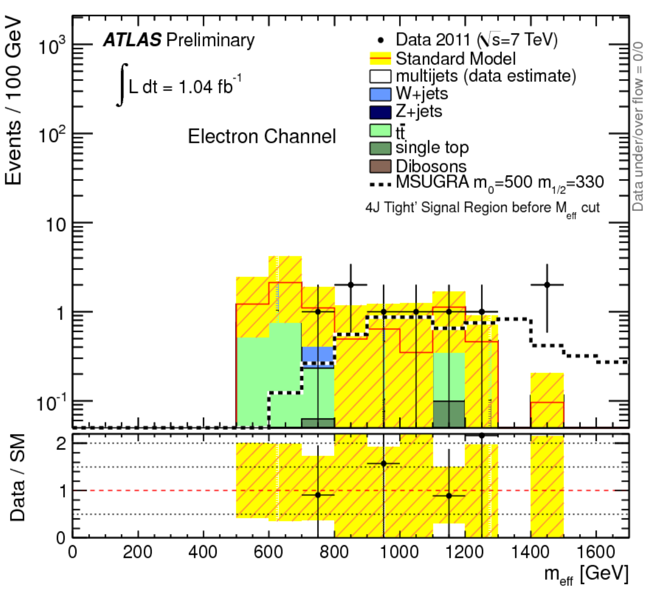
Both experiments increased the exclusion reach substantially in few months

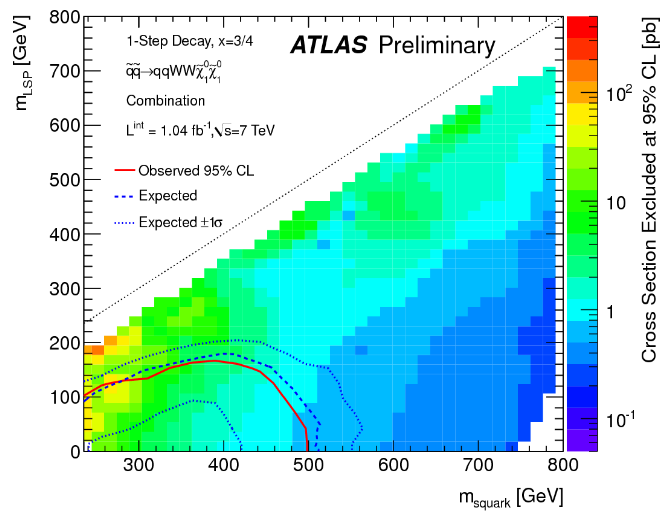
1-lepton analysis (1.1 fb^{-1})

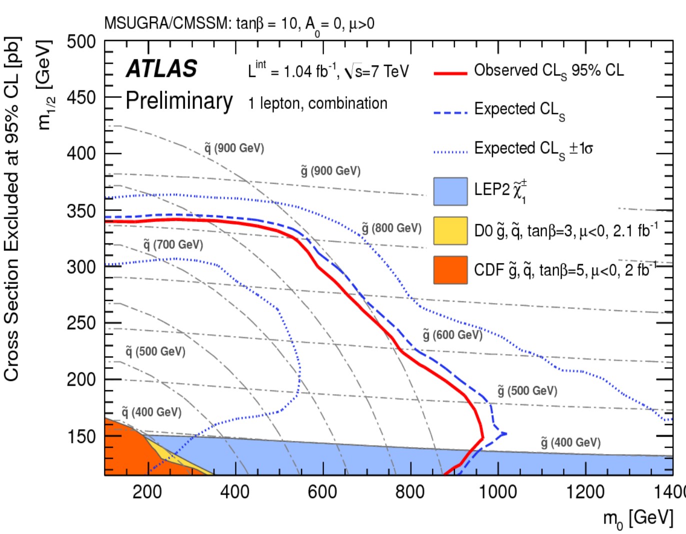




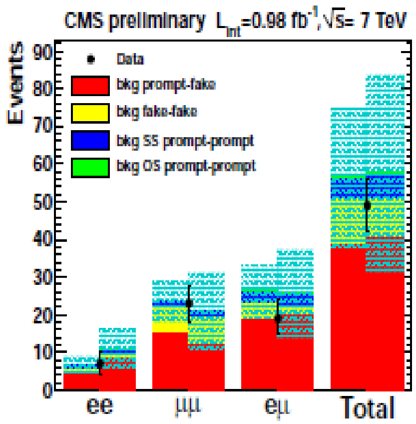


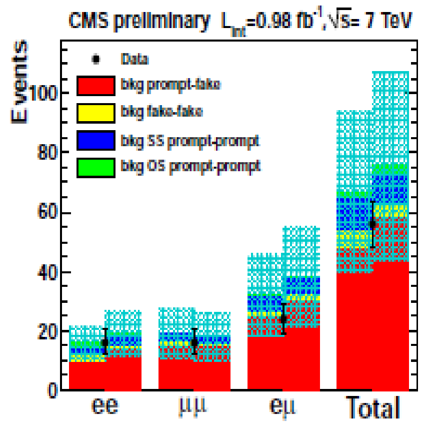






2-leptons SS (Results)





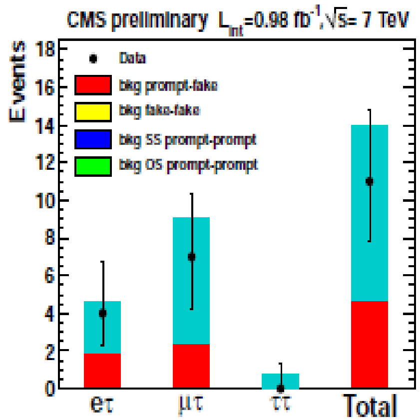


Figure 3: Summary of background predictions and observed yields in the baseline the *inclusive* (left), *high-*p_T (right), and τ *dilepton* (bottom) selections. For the *inclusive* the results of method (B) are compared with those from method (A1) in the left and ri

Signal regions

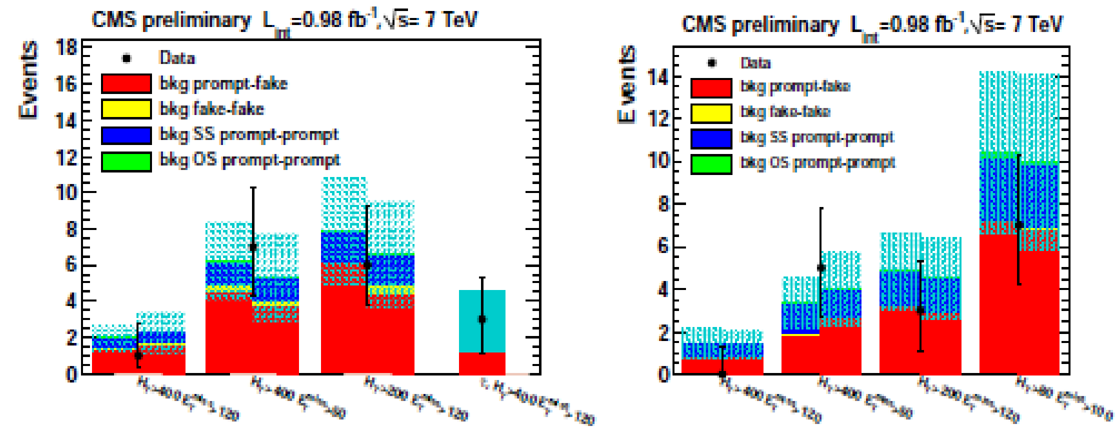


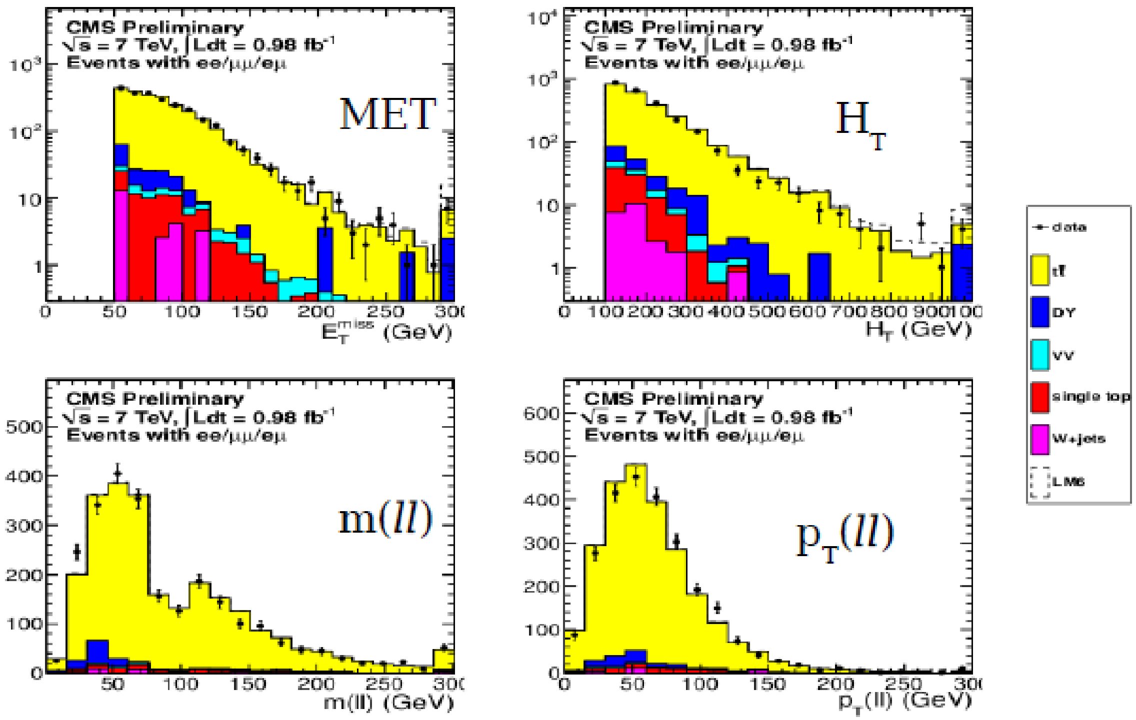
Figure 4: Summary of background predictions and observed yields in the search regions for the *inclusive* and τ (left), and *high-*p_T *dilepton* (right) selections. For the *inclusive* selections, the results of method (B) are compared with those from method (A1) in the left and right bar for each channel, respectively. For the *high-*p_T selections, the results of method (A2) are compared with those from method (A1) in the left and right bar for each channel, respectively. Predictions for events with one and two fakes (prompt-fake and fake-fake), contributions from simulated backgrounds (SS prompt-prompt), and those from events with a lepton charge misreconstruction (OS prompt-prompt) are reported separately.

2-leptons OS (0.98 fb^{-1})

Some distributions after baseline selection:

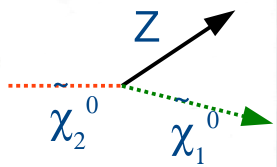
Baseline selection:

- Two isolated leptons (e, μ): one with p_T > 20 GeV, other with p_T > 10 GeV
- At least 2 jets with p_T > 30 and |η| < 3.0, MET > 30 GeV, H_T > 100 GeV
- Veto same-flavor pairs in Z mass window (76, 106) and m_{ll} < 12 GeV



OS dileptons in Z→ll (0.98 fb^{-1})

SUSY likely to be connected to EWK sector



Backgrounds for Z->l+l- small at large EtMiss: instrumental or OSSF ttbar

More information:
CMS PAS SUS-11-017
See also searches:
CMS PAS SUS-11-012
CDF/PHYS/EXO/PUBLIC/9791

Two signal regions defined:

- 3 jets (pT>30 GeV)
- $|m_{ll}-m_Z| < 20$ GeV
- EtMiss > 100 or > 200 GeV (loose and tight)

Two fully data-driven methods used:

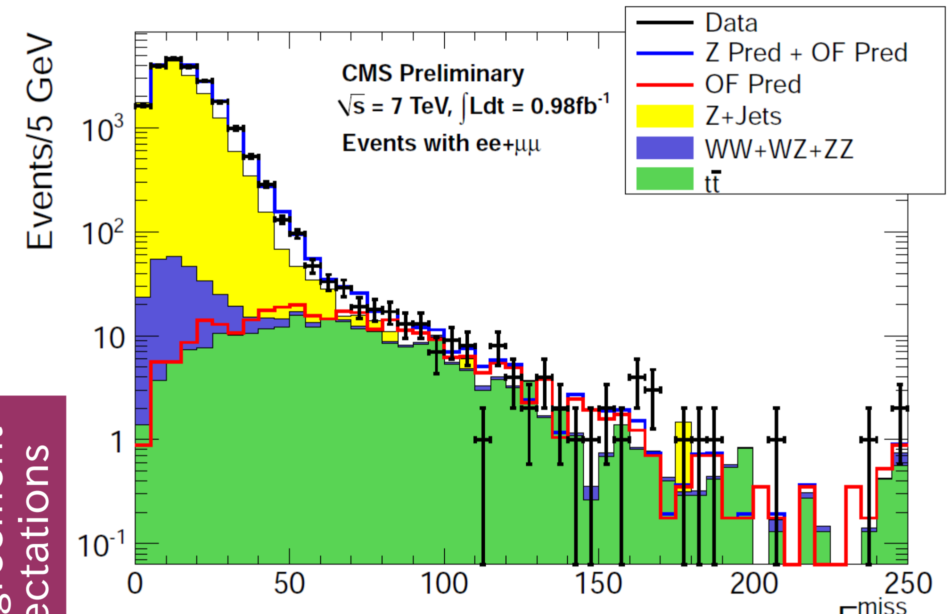
Instrumental EtMiss

Use of EtMiss templates coming from γ+jets (very similar topology)
Checked in two different CRs

Ttbar OSSF (+minor bkgs like WW and DY)

1) In ttbar: yield of eμ = yield of ee+μμ
2) Correct by μ/e selection efficiencies (using Z->μμ and Z->ee in data)
(evaluated with MC)

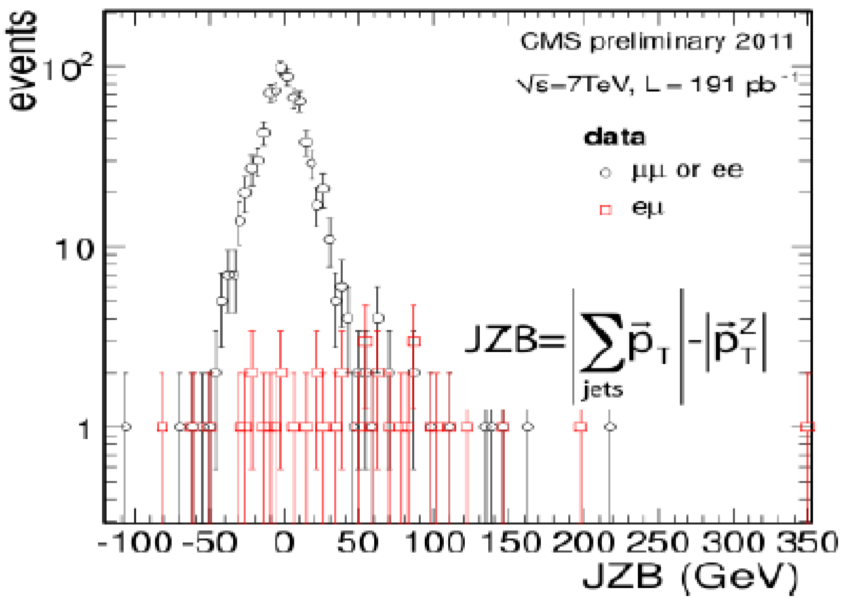
Data are in agreement with SM expectations



	$E_T^{miss} > 100$ GeV	$E_T^{miss} > 200$ GeV
Z Pred	$5.1 \pm 1.0 \pm 0.8$	$0.09 \pm 0.04 \pm 0.01$
$t\bar{t}$ Pred	$50.6 \pm 2.8 \pm 4.6$	$3.2 \pm 0.7 \pm 0.3$
Prediction	$55.7 \pm 3.0 \pm 4.6$	$3.3 \pm 0.7 \pm 0.3$
Data	**57 (25,32)**	**4 (1,3)**
UL	20	5.9

2-l OS with Z suppression (0.19fb^{-1})

More information:
CMS PAS SUS-11-012



Analysis 1

JZB for Z assumed symmetric around 0, JZB of top taken from eμ pairs. Signal would be a tail on the positive side after eμ subtraction.

Region	Observed events	Background prediction	MC expectation
$JZB > 50$ GeV	20	$24 \pm 6(\text{stat}) \pm 1.4(\text{peak})^{+1.2}_{-2.4}(\text{sys})$	16.0 ± 1.2 (MC stat)
$JZB > 100$ GeV	6	$8 \pm 4(\text{stat}) \pm 0.1(\text{peak})^{+0.4}_{-0.8}(\text{sys})$	3.6 ± 0.4 (MC stat)

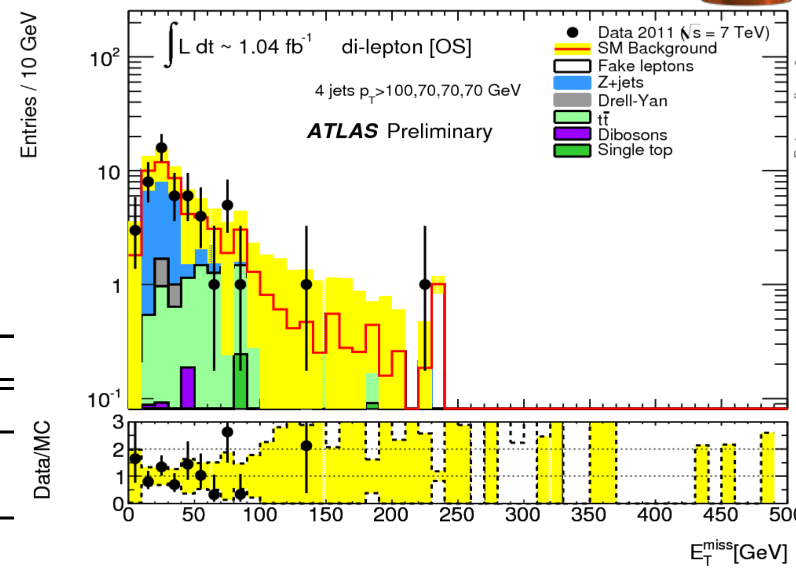
2-lepton: results and definitions

Signal Region	OS-SR1	OS-SR2	OS-SR3
E_T^{miss} [GeV]	250	220	100
Leading jet p_T [GeV]	-	80	100
Second jet p_T [GeV]	-	40	70
Third jet p_T [GeV]	-	40	70
Fourth jet p_T [GeV]	-	-	70

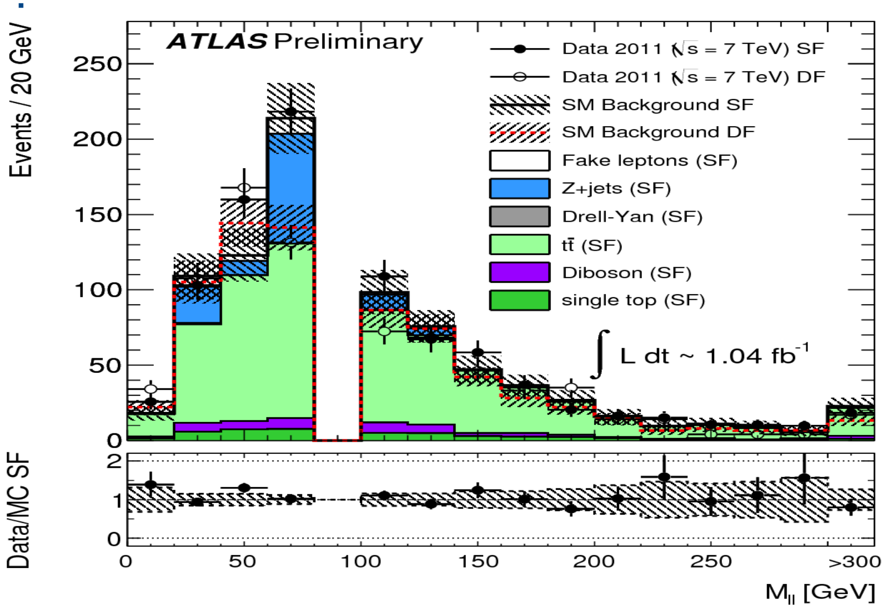
Signal Region	SS-SR1	SS-SR2
E_T^{miss} [GeV]	100	80
Leading jet p_T [GeV]	-	50
Second jet p_T [GeV]	-	50

Signal Region	FS-SR1	FS-SR2	FS-SR3
E_T^{miss} [GeV]	80	80	250
Number jets	≥ 2	-	-
m_{ll} veto [GeV]	-	80-100	-

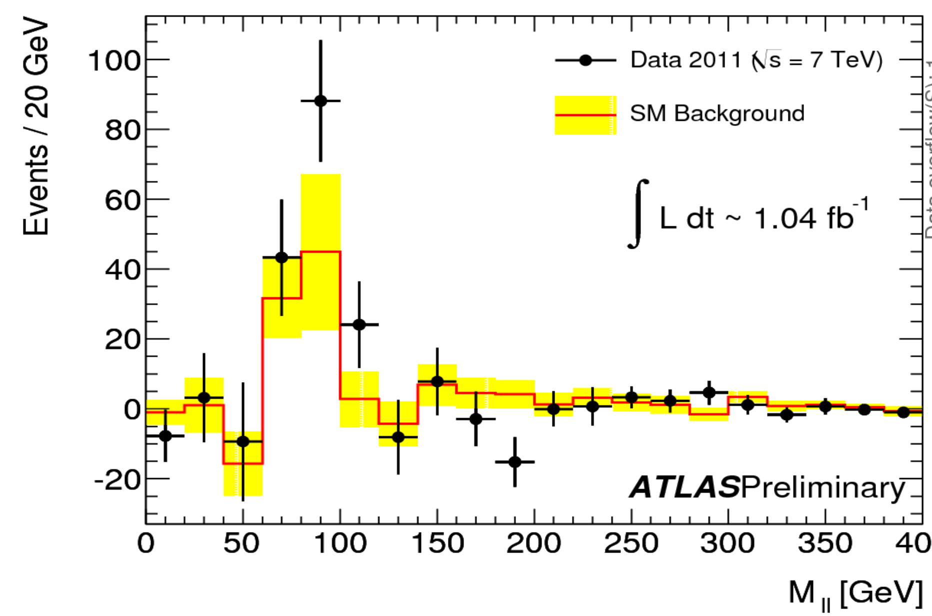
OS:



SF:

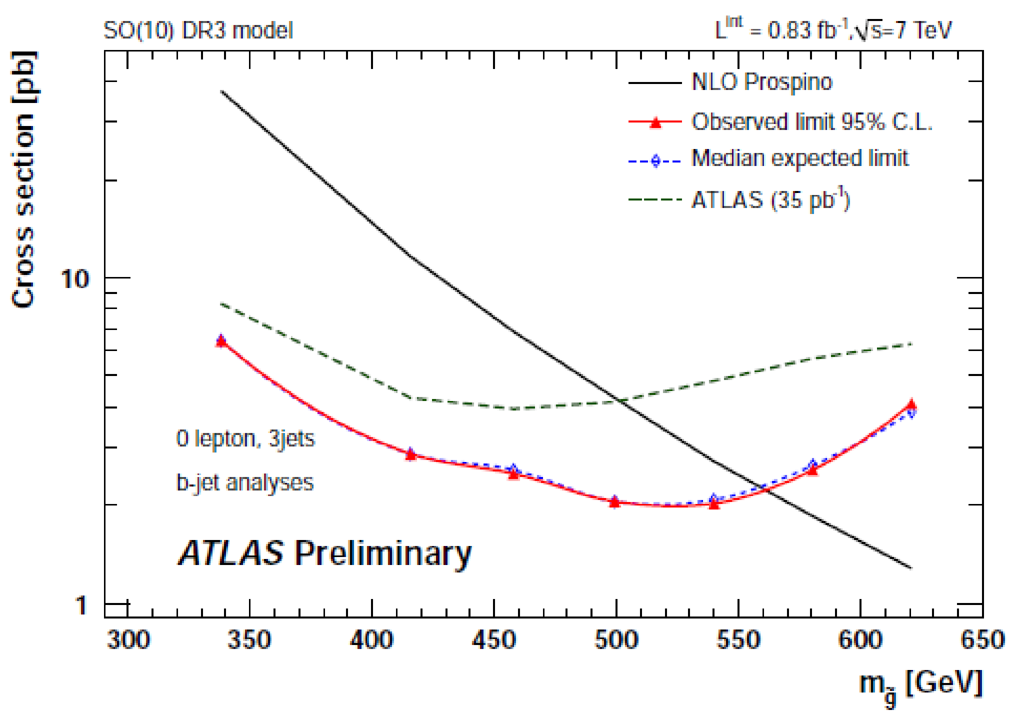


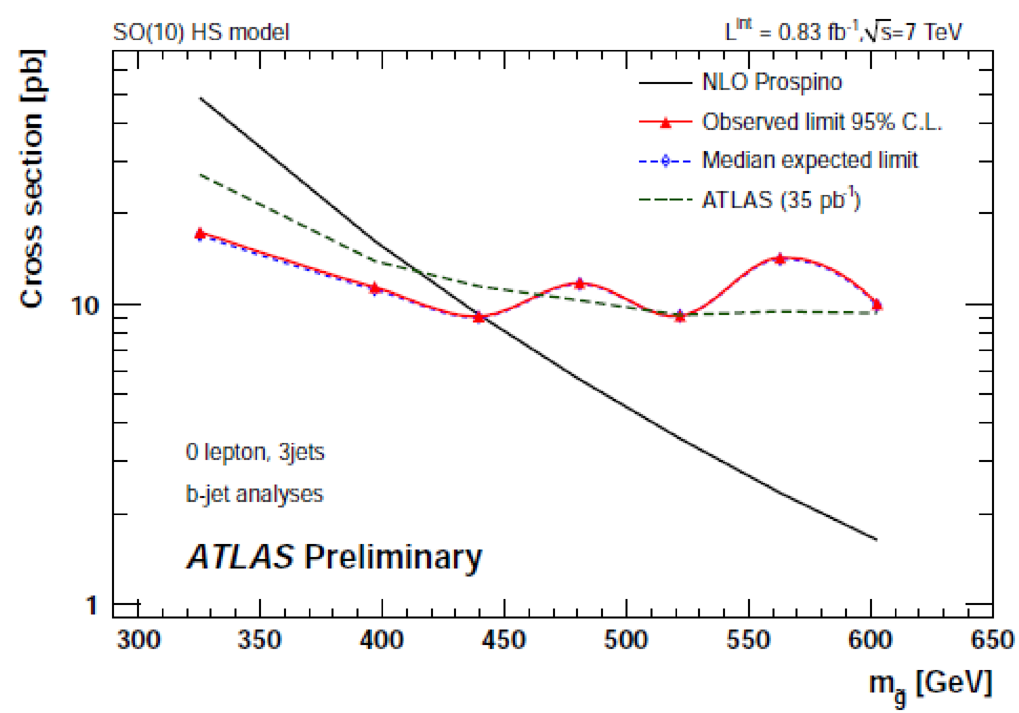
OSSF:



Gluino-mediated sbottom

Sig. Reg.	Data (0.83 fb^{-1})	Top	W/Z	QCD	Total
3JA (1 btag m_{eff} >500 GeV)	361	221^{+82}_{-68}	121 ± 61	15 ± 7	356^{+103}_{-92}
3JB (1 btag m_{eff} >700 GeV)	63	37^{+15}_{-12}	31 ± 19	1.9 ± 0.9	70^{+24}_{-22}
3JC (2 btag m_{eff} >500 GeV)	76	55^{+25}_{-22}	20 ± 12	3.6 ± 1.8	79^{+28}_{-25}
3JD (2 btag m_{eff} >700 GeV)	12	$7.8^{+3.5}_{-2.9}$	5 ± 4	0.5 ± 0.3	$13.0^{+5.6}_{-5.2}$



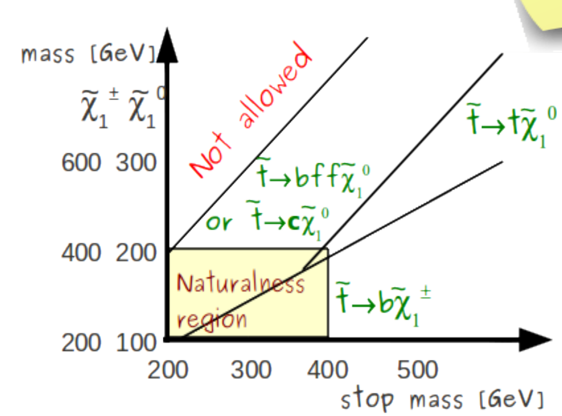


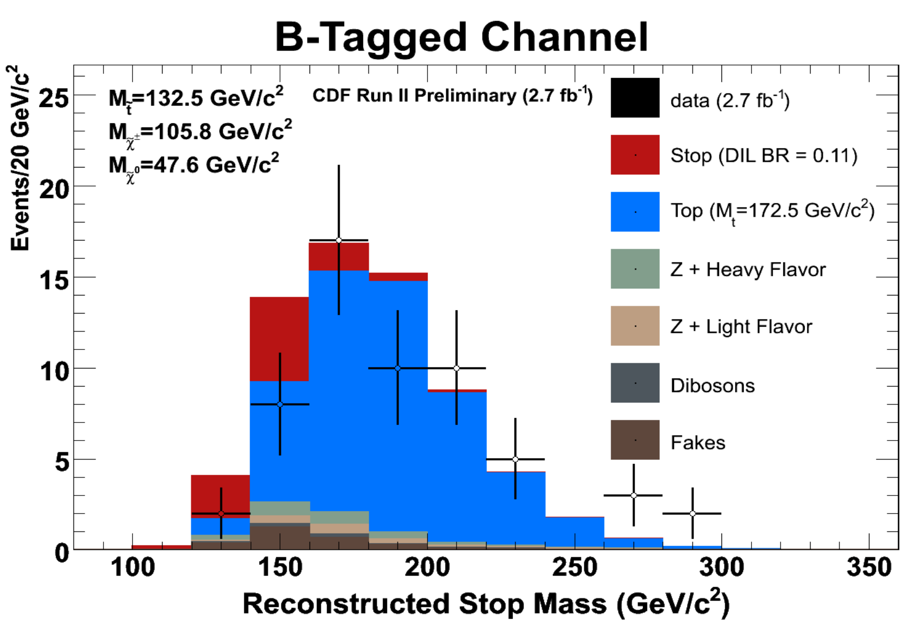
Stop to b+chargino (2.7 fb^{-1})

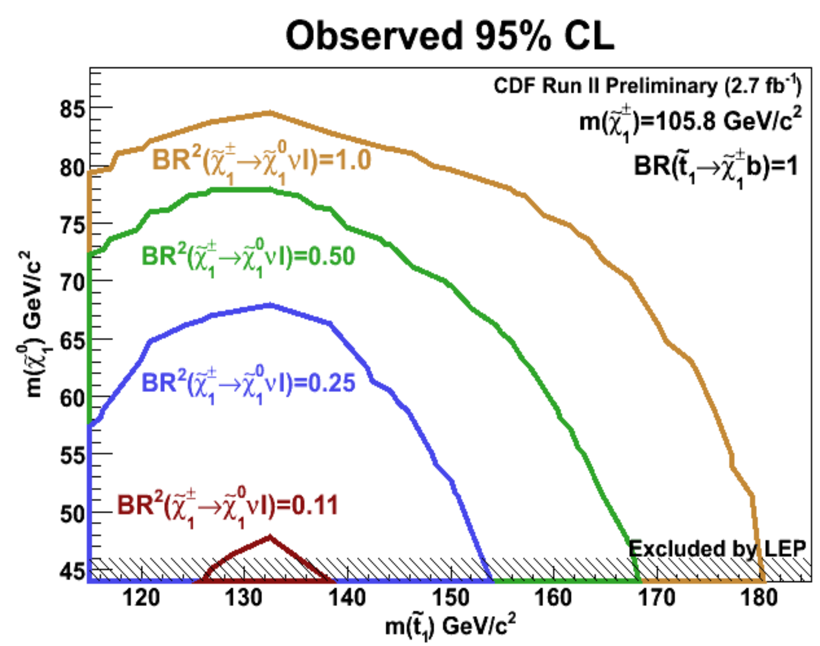
More information: Phys.Rev.Lett. 104, 251801 (2010)

$$\tilde{t}_1 \rightarrow b\tilde{\chi}_1^{\pm} \rightarrow b\tilde{\chi}_1^0 W^{\pm(*)} \rightarrow b\tilde{\chi}_1^0 l\nu$$

- Stop has lower mass than the top and chargino is in between
- Signal topology depends on mass difference between stop and chargino
- Signature: EtMiss + 2 OS leptons + 2 b-jets (0 or >= 1 b-tag)
- Reconstruct stop mass with kinematic fit (main background is ttbar production)



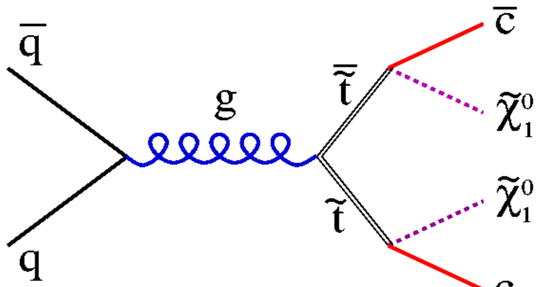




Limits provided also for 125.8 GeV chargino mass

Stop to charm (2.6 fb^{-1})

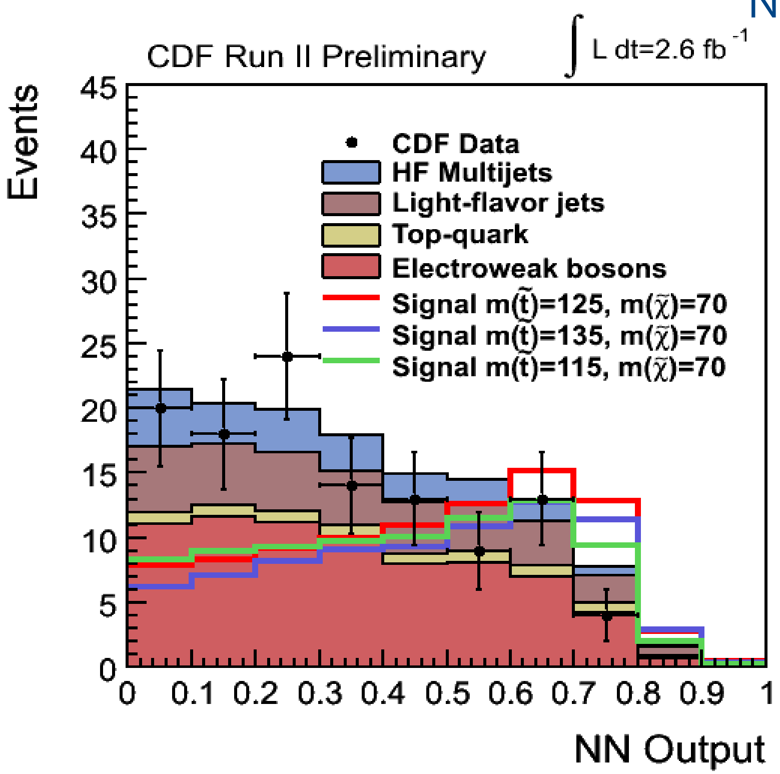
More information: CDF PUB NOTE 9834

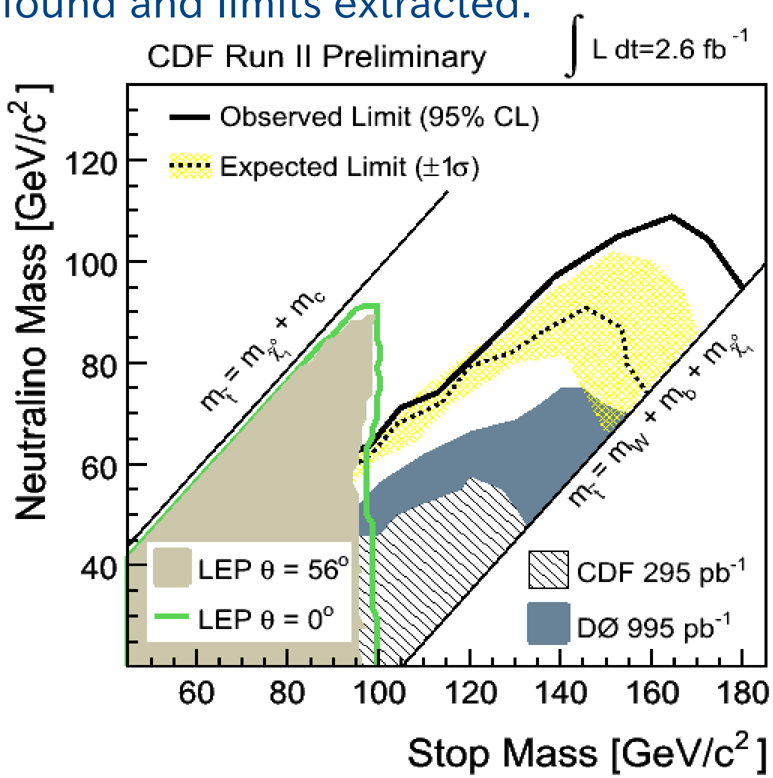


2 jets and EtMiss
Several angular and kinematic variables introduced inside a Neural-Network (NN) in order to perform the final optimisation.

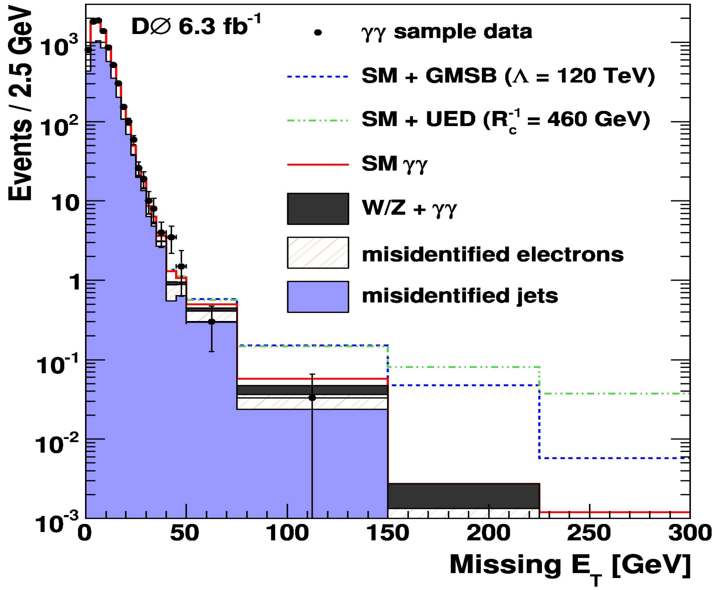
Finally, a 2D NN is used to exploit the charm information (CHAOS algorithm)

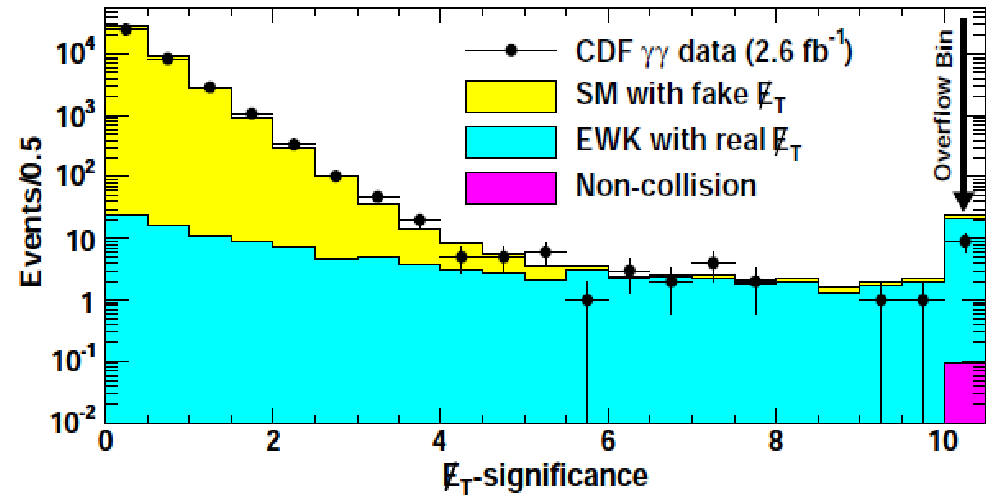
No excess from SM found and limits extracted.

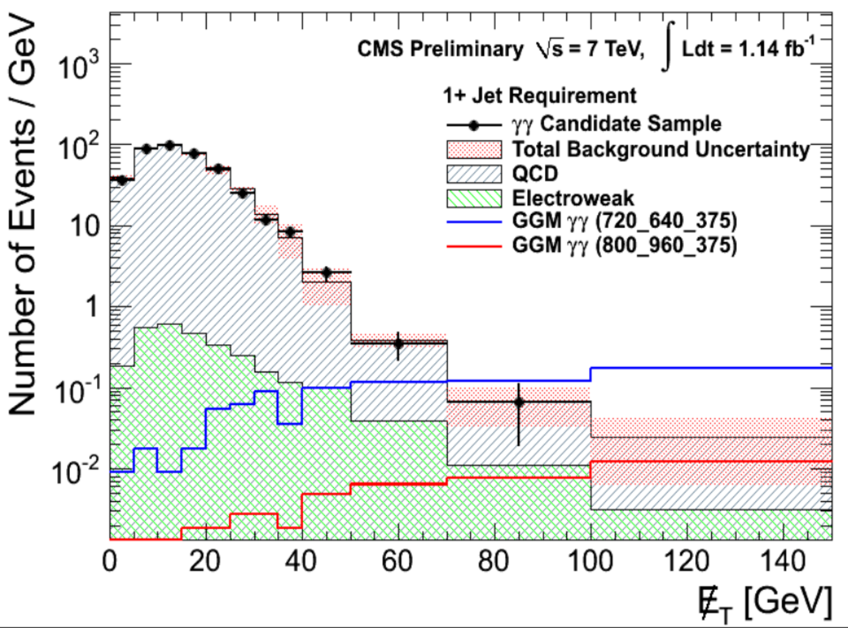


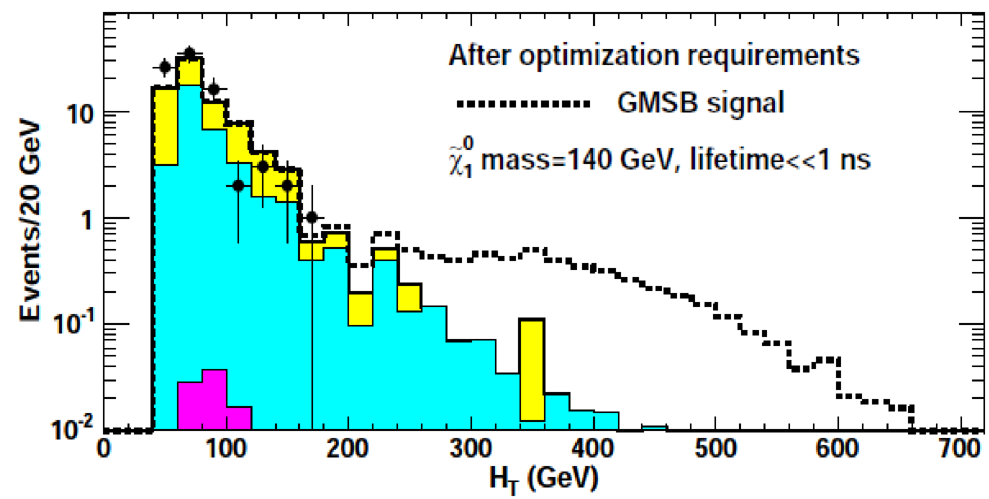


Photon+EtMiss results





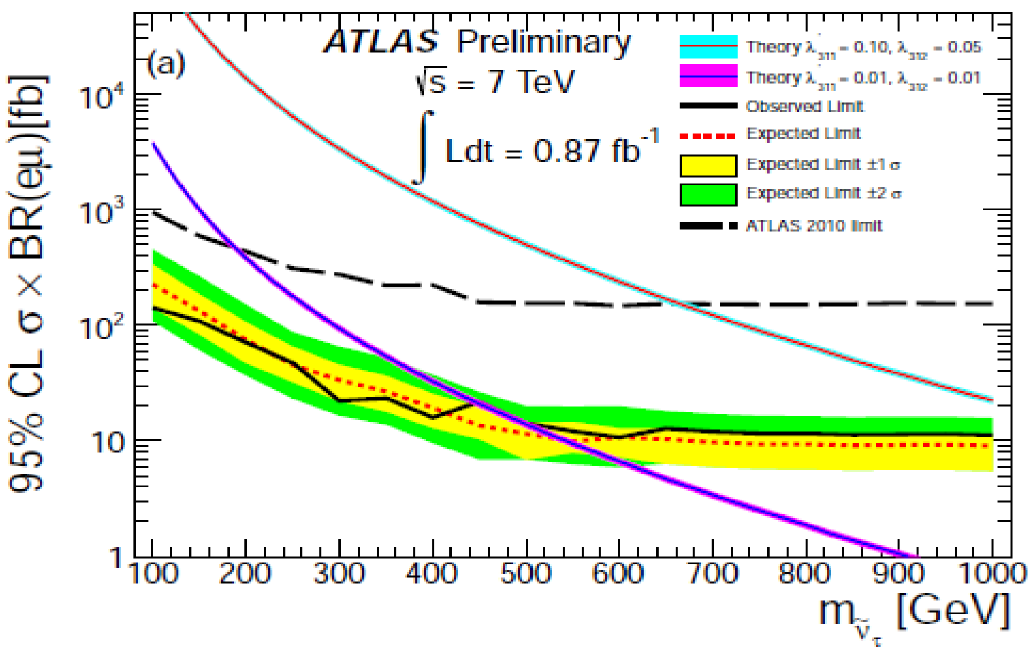




RPV stau neutrino (0.87 fb^{-1})

Process	Number of events
$Z/\gamma^* \to \tau\tau$	614 ± 53
$t\bar{t}$	1281 ± 168
WW	318 ± 24
Single top	125 ± 17
WZ	18.2 ± 1.9
$W/Z + \gamma$	67 ± 11
Jet instrumental background	984 ± 105
Total background	3408 ± 230
Data	3338

$m_{e\mu}$	Data	SM prediction
> 200 GeV	224	236 ± 21
> 250 GeV	119	111 ± 11
> 300 GeV	51	55 ± 6
> 350 GeV	29	30 ± 4
> 400 GeV	18	14.2 ± 2.2
> 450 GeV	9	8.2 ± 1.5
> 500 GeV	7	5.3 ± 1.1
> 550 GeV	3	3.4 ± 0.8
> 600 GeV	3	2.2 ± 0.7
> 650 GeV	1	0.9 ± 0.4
> 700 GeV	0	0.8 ± 0.4



3-jet resonances

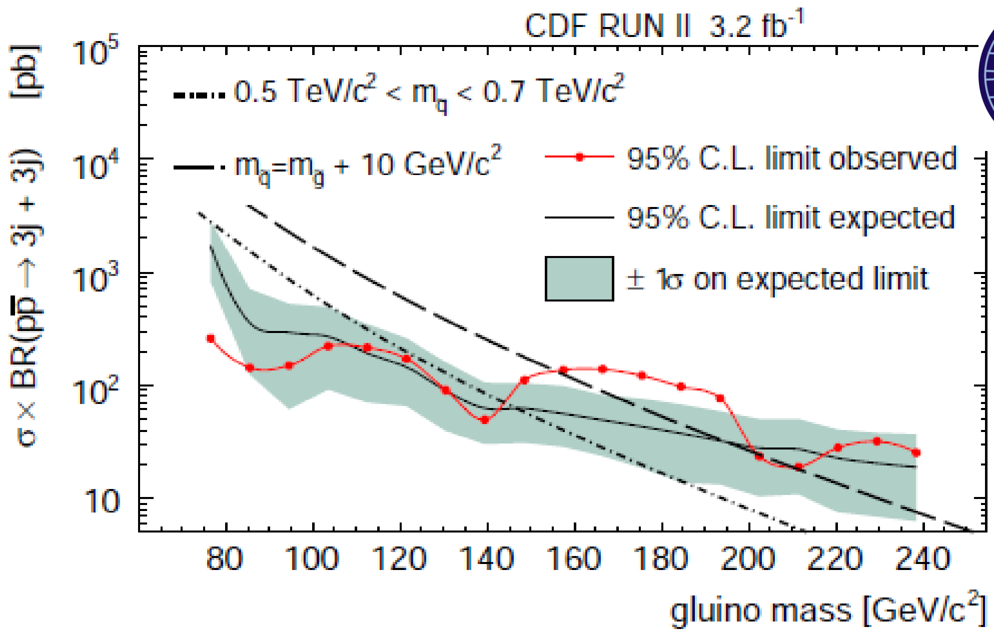
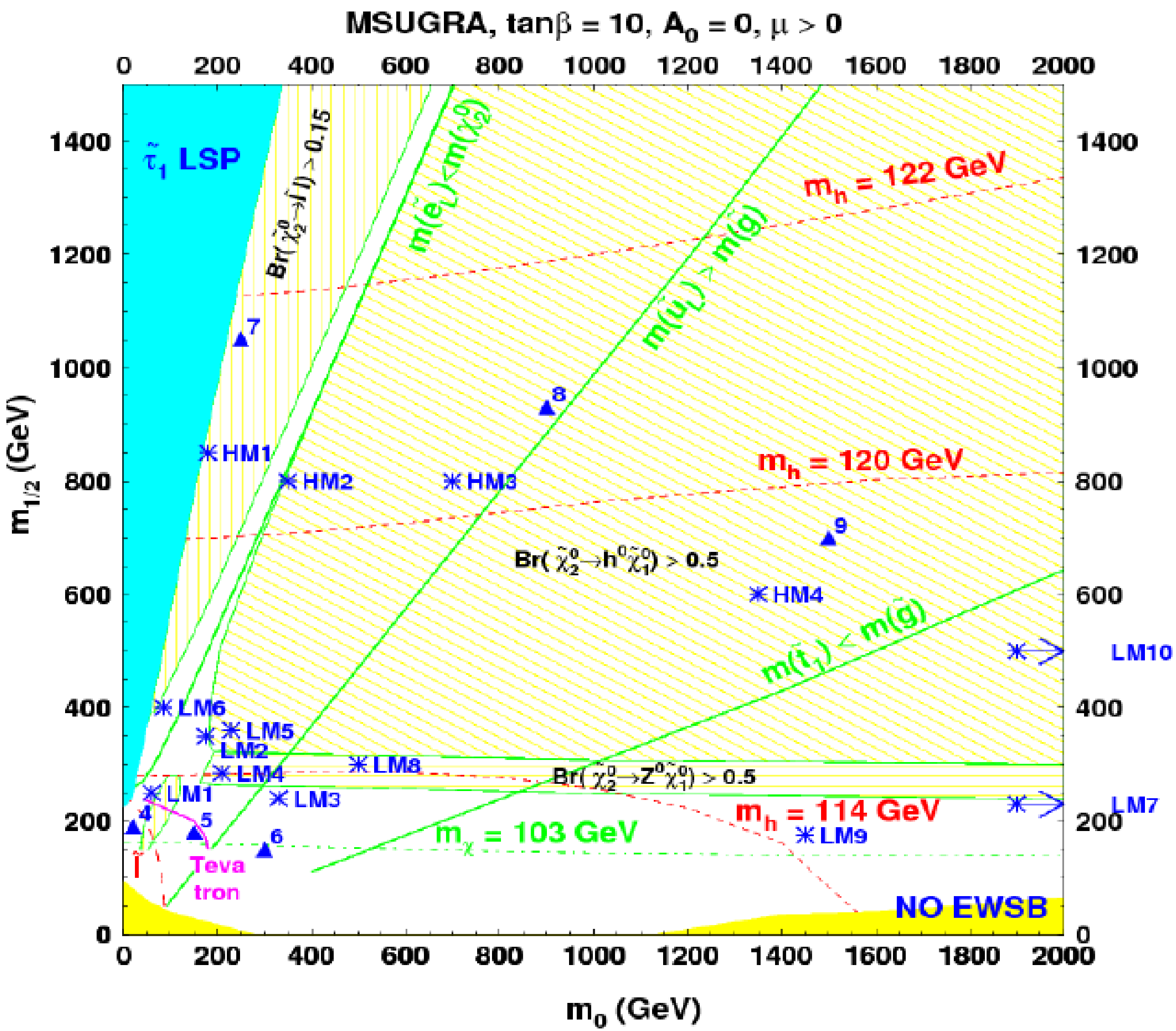


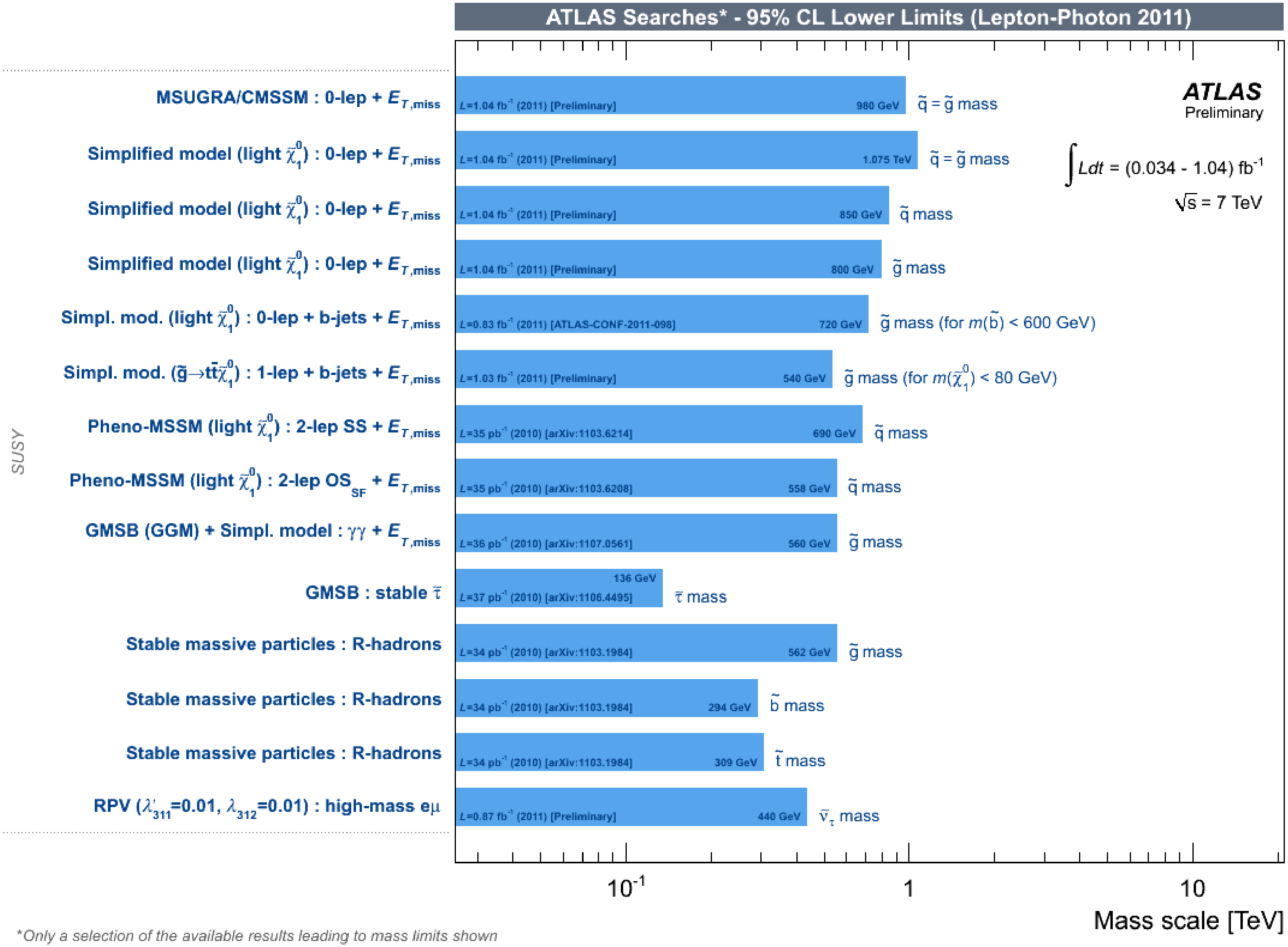
Table 1: Observed and expected 95% CL upper limits on the cross section times branching ratio for the pair production of gluinos with masses (M_{jjj}) ranging from 200 to 500 GeV$/c^2$.

M_{jjj} (GeV$/c^2$)	Observed (pb)	Expected (pb)	M_{jjj} (GeV$/c^2$)	Observed (pb)	Expected (pb)
200	383	387	360	82	40
210	273	287	370	83	36
220	214	219	380	80	33
230	200	178	390	73	29
240	184	146	400	62	26
250	132	120	410	48	24
260	88	106	420	34	23
270	72	96	430	24	21
280	73	84	440	17	19
290	79	76	450	13	17
300	86	67	460	12	16
310	89	62	470	12	15
320	87	56	480	13	14
330	82	51	490	14	13
340	80	48	500	14	12
350	82	45			

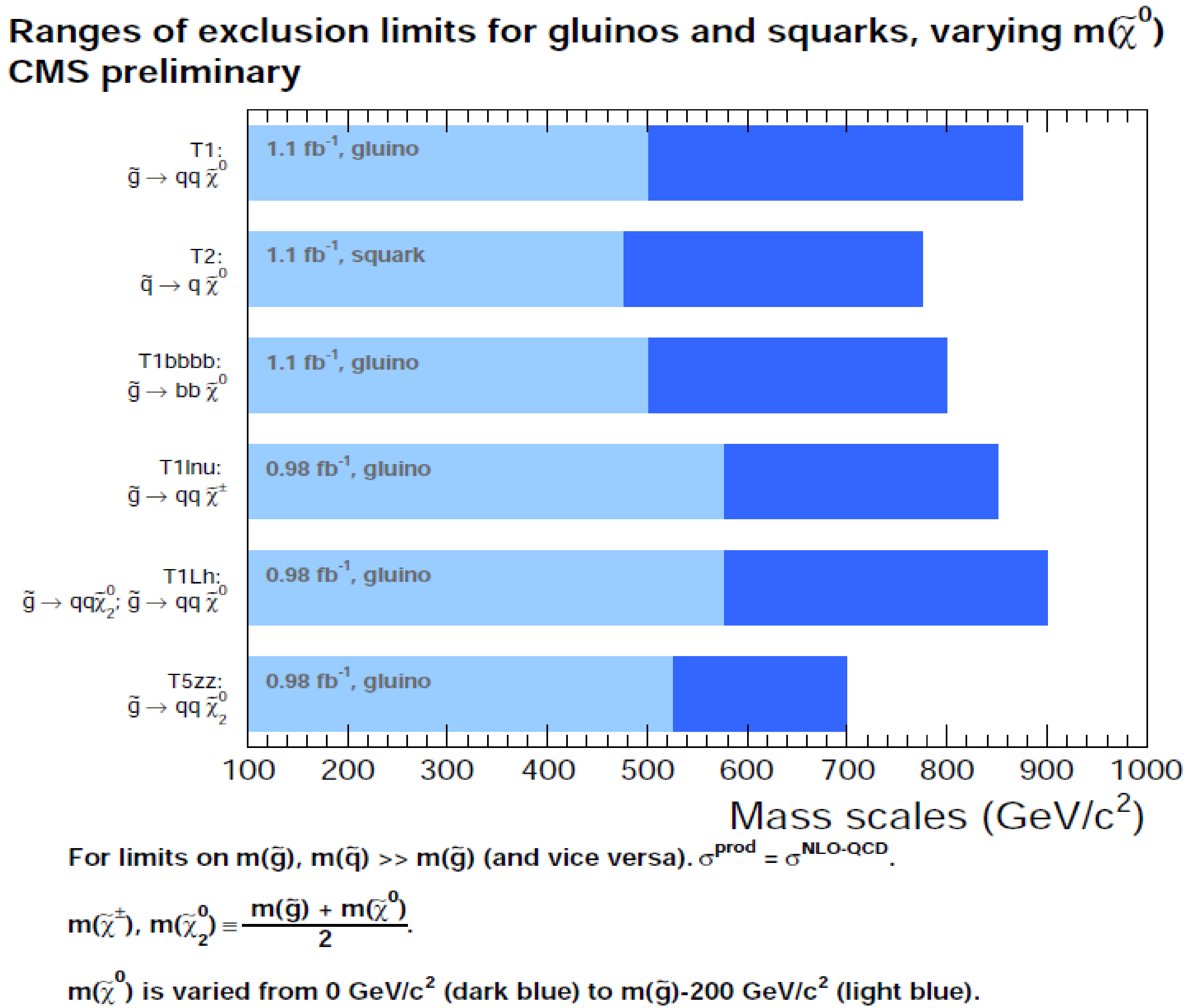
CMS benchmark points



ATLAS summary of searches



CMS summary of searches



CMS limits in mSUGRA