# DM WG
# Introduction / News

September 4, 2012

# News

**HESS 10 years**

**Some summer papers of interest:**
*Dark Matter Results from 225 Live Days of XENON100 Data*
http://arxiv.org/abs/1207.5988

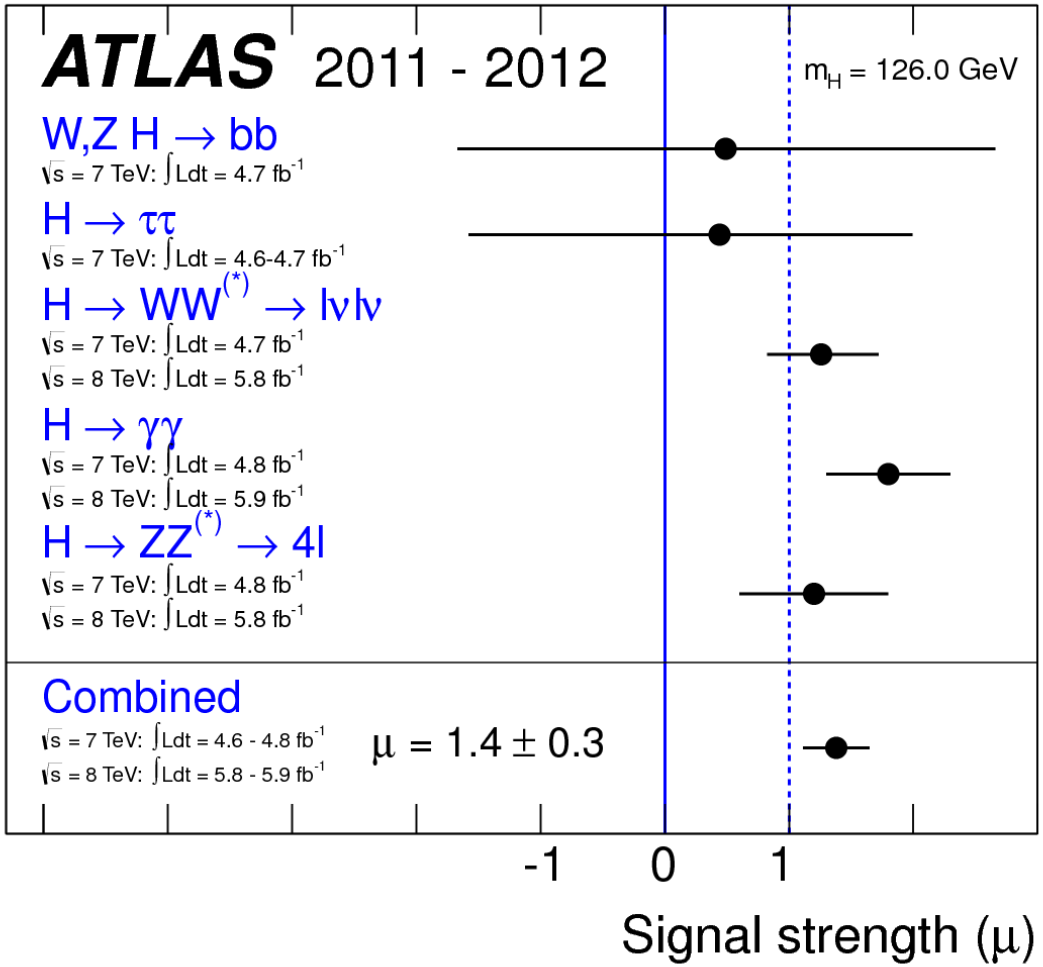
*A new determination of the local dark matter density from the kinematics of K dwarfs*
http://arxiv.org/abs/1206.0015 Plenty of dark matter near the sun.

More suggestions are welcome.

# OKC News

- There will be a new OKC seminar committee
- OKC day preliminary planned for October 17-18 – Outline to be defined
- Need at least one new person post-doc or student to co-chair the dark matter meetings. After discussion with postdocs, this is found to be a good idea to encourage them to take care of the groups.
- **Tonight:** Open Lecture about the Higgs FA2 Jonas Strandberg (KTH)

# Higgs found


ATLAS 2011 - 2012
$m_H$ = 126.0 GeV
W,Z H → bb
√s = 7 TeV: ∫Ldt = 4.7 fb$^{-1}$
H → ττ
√s = 7 TeV: ∫Ldt = 4.6-4.7 fb$^{-1}$
H → WW$^{(*)}$ → lνlν
√s = 7 TeV: ∫Ldt = 4.7 fb$^{-1}$
√s = 8 TeV: ∫Ldt = 5.8 fb$^{-1}$
H → γγ
√s = 7 TeV: ∫Ldt = 4.8 fb$^{-1}$
√s = 8 TeV: ∫Ldt = 5.9 fb$^{-1}$
H → ZZ$^{(*)}$ → 4l
√s = 7 TeV: ∫Ldt = 4.8 fb$^{-1}$
√s = 8 TeV: ∫Ldt = 5.8 fb$^{-1}$
Combined
√s = 7 TeV: ∫Ldt = 4.6 - 4.8 fb$^{-1}$
√s = 8 TeV: ∫Ldt = 5.8 - 5.9 fb$^{-1}$
μ = 1.4 ± 0.3
-1
0
1
Signal strength (μ)

# 4. Excess in the di-photon signal?

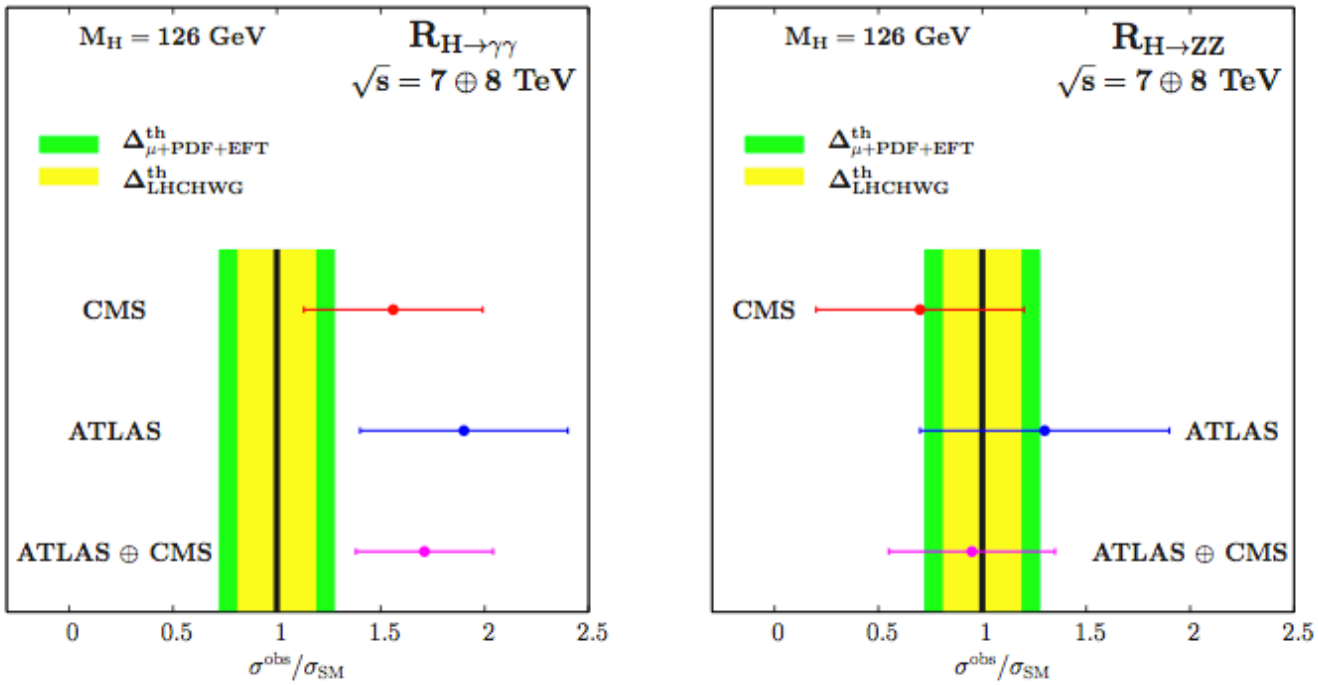
**ATLAS⊕CMS:** $\mathrm{R}_{\gamma\gamma} = 1.71 \pm 0.33\,, \mathrm{R}_{\mathrm{ZZ}} = 0.95 \pm 0.40\,.$

See Christophe for mode details

**It looks like there is a** $\gtrsim 2\sigma$ **excess in the** $\mathrm{H} \to \gamma\gamma$ **channel.**

**Statistical fluctuation, New Physics or maybe QCD uncertainties?**

**Try the later and indeed, only** $\approx 1\sigma$ **excess (Baglio+Godbole+AD).**




**Assume that excess is real and due to SUSY: MSSM nterpretation.**

# 5. Conclusions

**A 125 GeV Higgs provides information on BSM and SUSY in particular:**

- $M_H = 119$ GeV would have been a boring value: everybody OK..
- $M_H = 145$ GeV would be a devastating value: mass extinction..
- $M_H \approx 125$ GeV is Darwinian: (natural) selection among models..

**SUSY spectrum heavy; except maybe for weakly interacting sparticles and also stops $\Rightarrow$ more focus on them in SUSY searches!**

**One has to include other Higgs/SUSY searches in particular:**

- $H/A/H^{\pm}$ searches at the LHC are becoming constraining..
- SUSY searches and flavor constraints are to be taken into account.
- Little room for other Higgs searches at the LHC.
- Need to start thinking bout chngng the benchmark scenrios....

**My personal feeling or bet: maybe the rather optimistic scenario?**

**– a stop and a chargino in 2015: my favorite/best–guess SUSY signal:**

$$pp \to \tilde{t}_1\tilde{t}_1 \to b\chi_1^+\bar{b}\chi_1^- \to b\bar{b}e\mu + \not{E}_T$$

**– following years, search for $gg \to \tilde{t}_1\tilde{t}_1 h$ and measurement of $A_t$...**

# Search for SUSY Weak Production with ATLAS

# Search for SUSY Weak Production with ATLAS

**Search for direct slepton and gaugino production in final states with two leptons and missing transverse momentum with the ATLAS detector in pp collisions at sqrt (s) = 7 TeV**
**http://arxiv.org/abs/1208.2884**

**Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in sqrt(s) = 7 TeV pp collisions with the ATLAS detector**
**http://arxiv.org/abs/1208.3144**

**See also OKC blog**

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# Search for Weak Production with Leptons in ATLAS

- 2 OS leptons +Jets Veto **SR-OSjveto**
  - Reject events with at least one jet $p_T$>30GeV, |η|<2.5, JVF>0.75 **<= This is "Jet-Veto"**
  - ETmiss,rel>100 GeV
  - |mZ-mll|>10 GeV **<= This is Z-veto**

$$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp} \rightarrow (l^{\pm}\nu\tilde{\chi}_1^0) + (l^{\mp}\nu\tilde{\chi}_1^0)$$

$$\tilde{\chi}_2^0\tilde{\chi}_1^0 \rightarrow l^+ \; l^- \; \tilde{\chi}_1^0 \; \tilde{\chi}_1^0$$

$$\tilde{l}\tilde{l} \rightarrow (l\tilde{\chi}_1^0)(l\tilde{\chi}_1^0)$$

- 2 SS leptons +Jets Veto **SR-SSjveto**
  - Jet-Veto
  - ETmiss,rel>100 GeV

$$\tilde{\chi}_2^0\tilde{\chi}_1^+ \rightarrow (ll\tilde{\chi}_1^0) + (l\nu\tilde{\chi}_1^0)$$

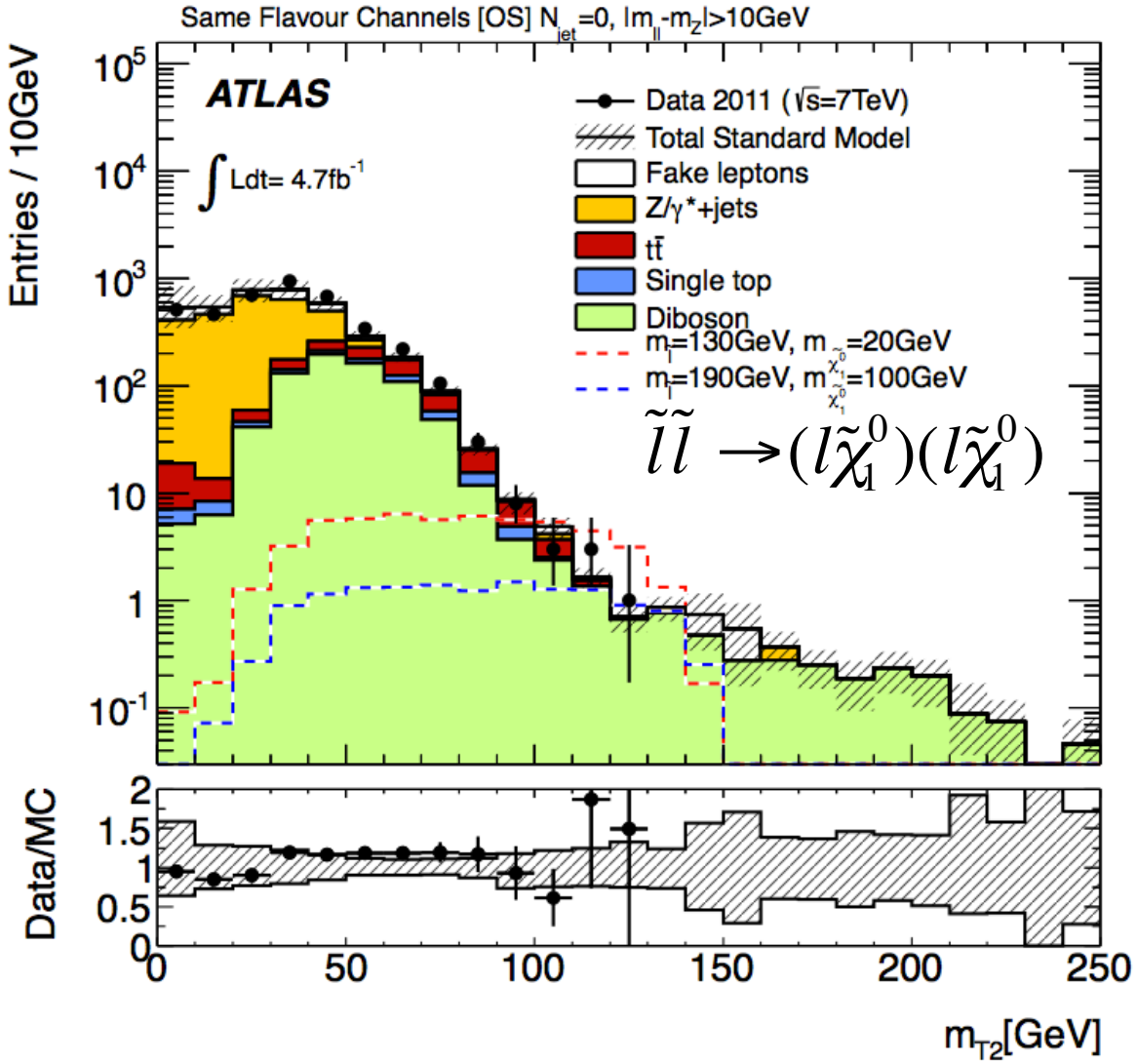
- 2 OS leptons + Jets **SR-2jets**
  - 2 or more jets pT>30 GeV and JVF>0.75
  - Same flavour leptons (from Neutralino 2 decay)
  - mCT top tag veto, b-jet veto, Z veto
  - ETmiss,rel>50 GeV

$$\tilde{\chi}_2^0\tilde{\chi}_i^{\pm,0} \rightarrow (ll\tilde{\chi}_1^0) + (q\bar{q}'\tilde{\chi}_1^0)$$

- 2 OS leptons + Jets **SR-mT2**
  - et veto, Z veto
  - ETmiss,rel>50 GeV

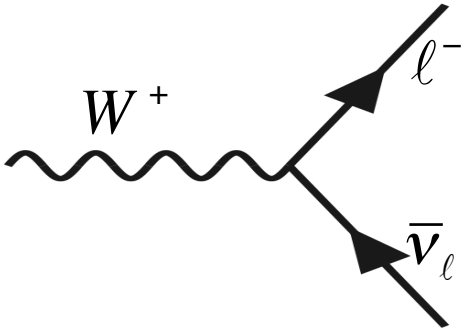
$$\tilde{l}\tilde{l} \rightarrow (l\tilde{\chi}_1^0)(l\tilde{\chi}_1^0)$$

$$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp} \rightarrow (l^{\pm}\nu\tilde{\chi}_1^0) + (l^{\mp}\nu\tilde{\chi}_1^0)$$

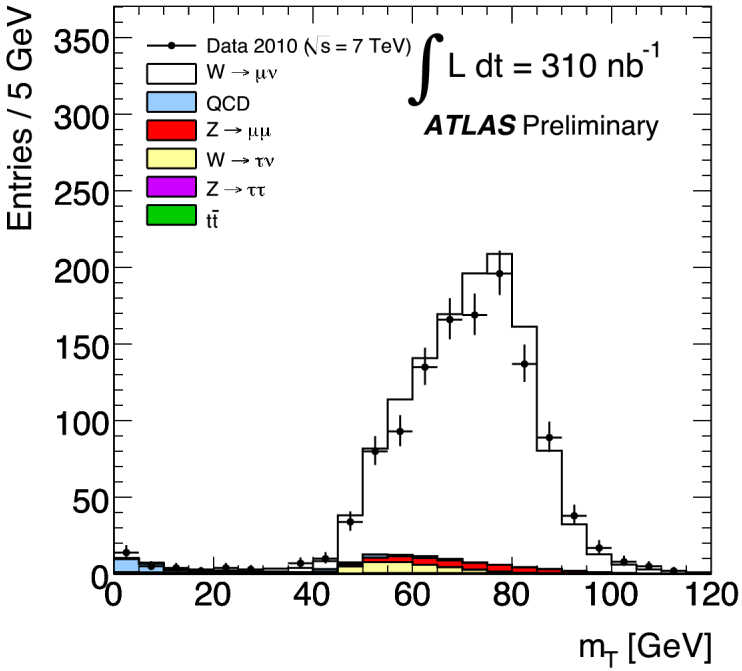

Same Flavour Channels [OS] N_jet=0, |m_ll-m_Z|>10GeV
ATLAS
∫ Ldt= 4.7fb^-1
Data 2011 (√s=7TeV)
Total Standard Model
Fake leptons
Z/γ*+jets
tt̄
Single top
Diboson
m_l̃=130GeV, m_χ̃1^0=20GeV
m_l̃=190GeV, m_χ̃1^0=100GeV
l̃l̃ → (lχ̃1^0)(lχ̃1^0)
Entries / 10GeV
Data/MC
m_T2[GeV]

# $m_T$ and $M_{T2}$

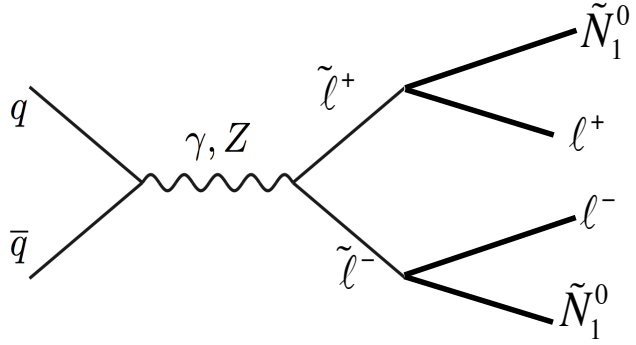
The transverse mass variable $m_T$ was introduced in earlier lectures.



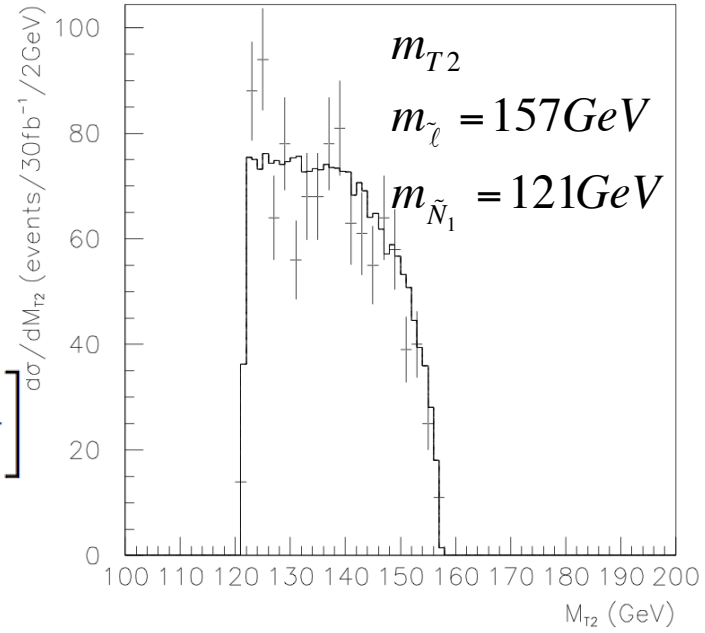

$$m_T = p_T^\ell p_T^\nu \quad (1 - \cos\phi_{\ell\nu})$$
$$= p_T^\ell E_T^{miss} (1 - \cos\phi_{\ell, E_T^{miss}})$$




Now consider the slepton production and decay, there are now **two invisible particles**




$$M_{T2}^2 \equiv \min_{\not{\mathbf{p}}_1 + \not{\mathbf{p}}_2 = \not{\mathbf{p}}_T} \left[ \max \left\{ m_T^2(\mathbf{p}_{Tl^-}, \not{\mathbf{p}}_1), m_T^2(\mathbf{p}_{Tl^+}, \not{\mathbf{p}}_2) \right\} \right]$$

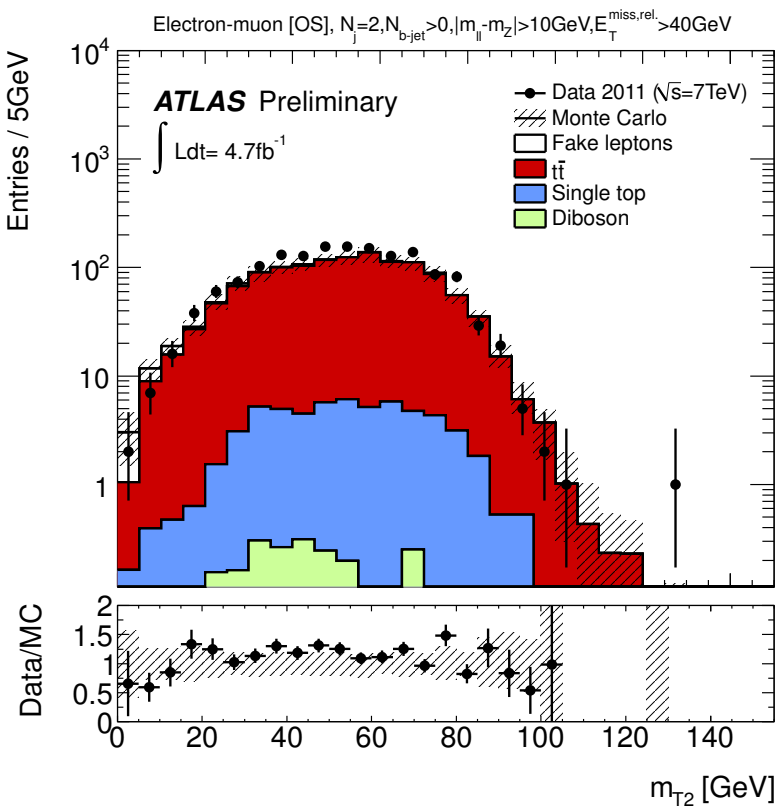



See C.G. Lester and D.J. Summers
http://arxiv.org/abs/hep-ph/9906349v1

# Direct Slepton Search in ATLAS

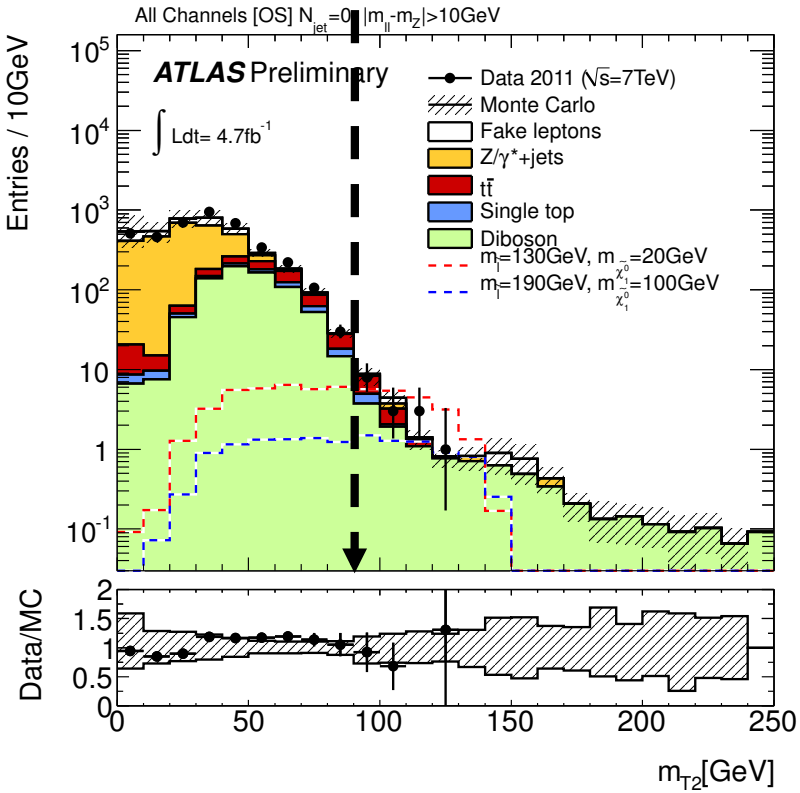
Select ATLAS collision events with $e^+e^-$ and $\mu^+\mu^-$ and exactly no jets and high $E_T^{miss}$.

Use $m_{T2} > 90$ GeV to remove the *tt*, *WW*, *WZ*, *ZZ* backgrounds




*In control region dominated by production of top-quark pairs*

$m_{T2} > 90$ GeV




*In the Signal Region*

## Backgrounds

**Single and double top quark production**

remove with a veto on central jets

$Z/\gamma^*, ZW, ZZ$

Veto on two leptons with Z mass

**WW production**

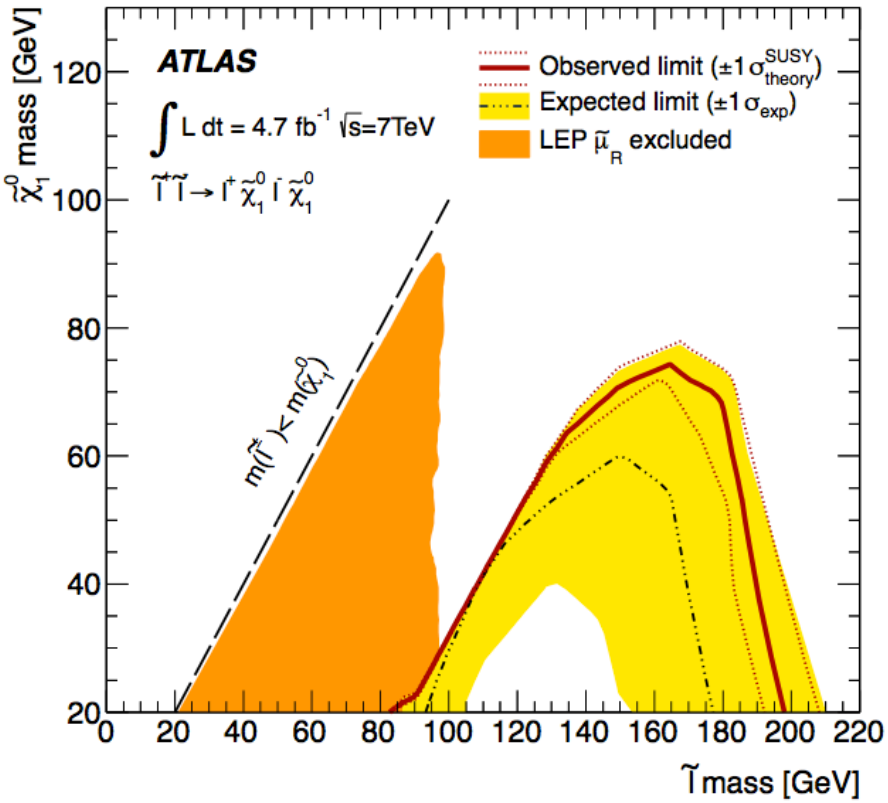
Removed with $m_{T2}$

**Fake leptons**

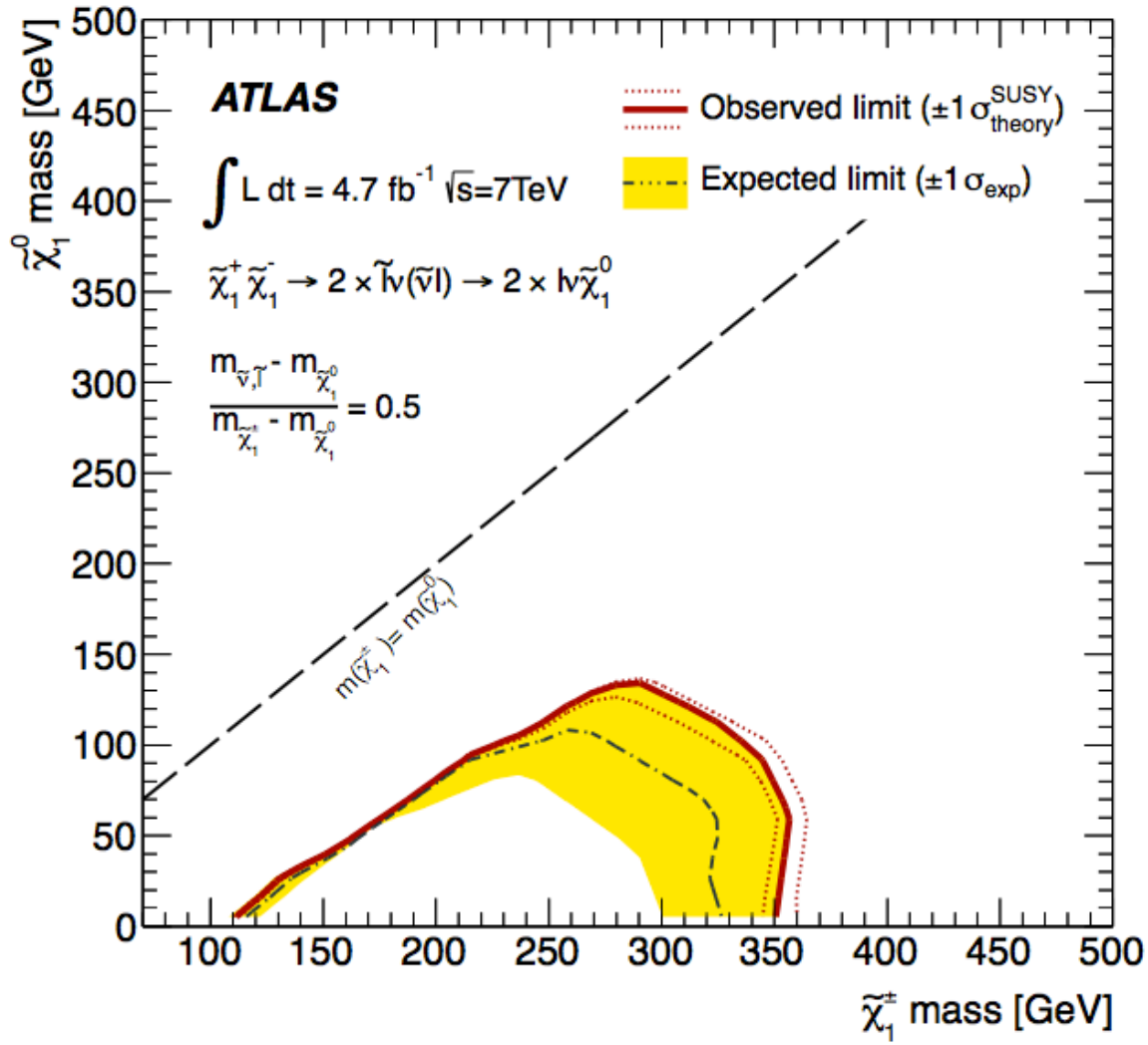
Removed with lepton isolation

| | SF |
|---|---|
| Z+X | $6.8 \pm 1.7 \pm 2.1$ |
| $WW$ | $5.8 \pm 0.4 \pm 0.9$ |
| $t\bar{t}$, single top | $6.8 \pm 1.8 \pm 2.3$ |
| Fake leptons | $1.0 \pm 0.6 \pm 0.6$ |
| Total | $20.4 \pm 2.6 \pm 3.9$ |
| Data | 15 |
| $\sigma_{\text{vis}}^{\text{obs(exp)}}$ (fb) | 2.0 (2.7) |

## *Direct Slepton Limit with ATLAS*

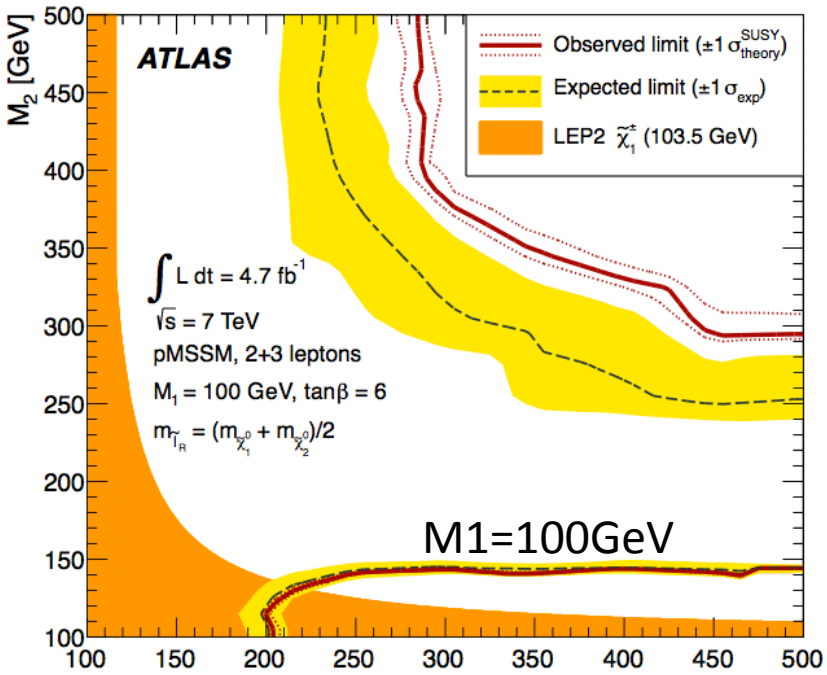


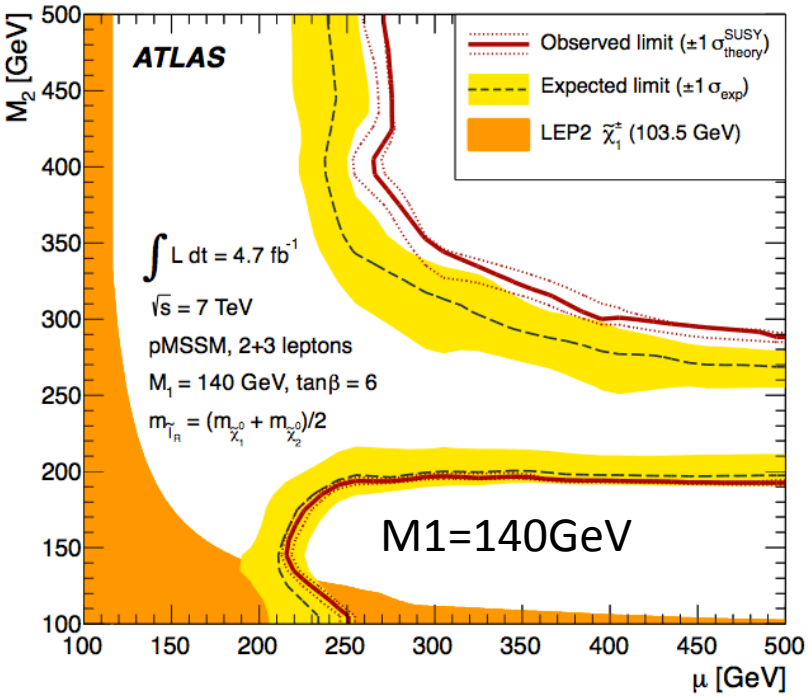
# Chargino Pair Production

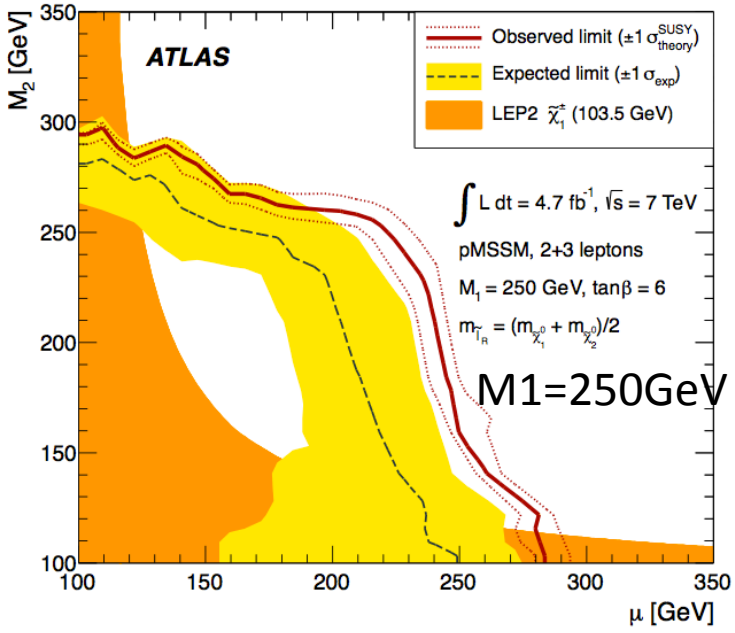


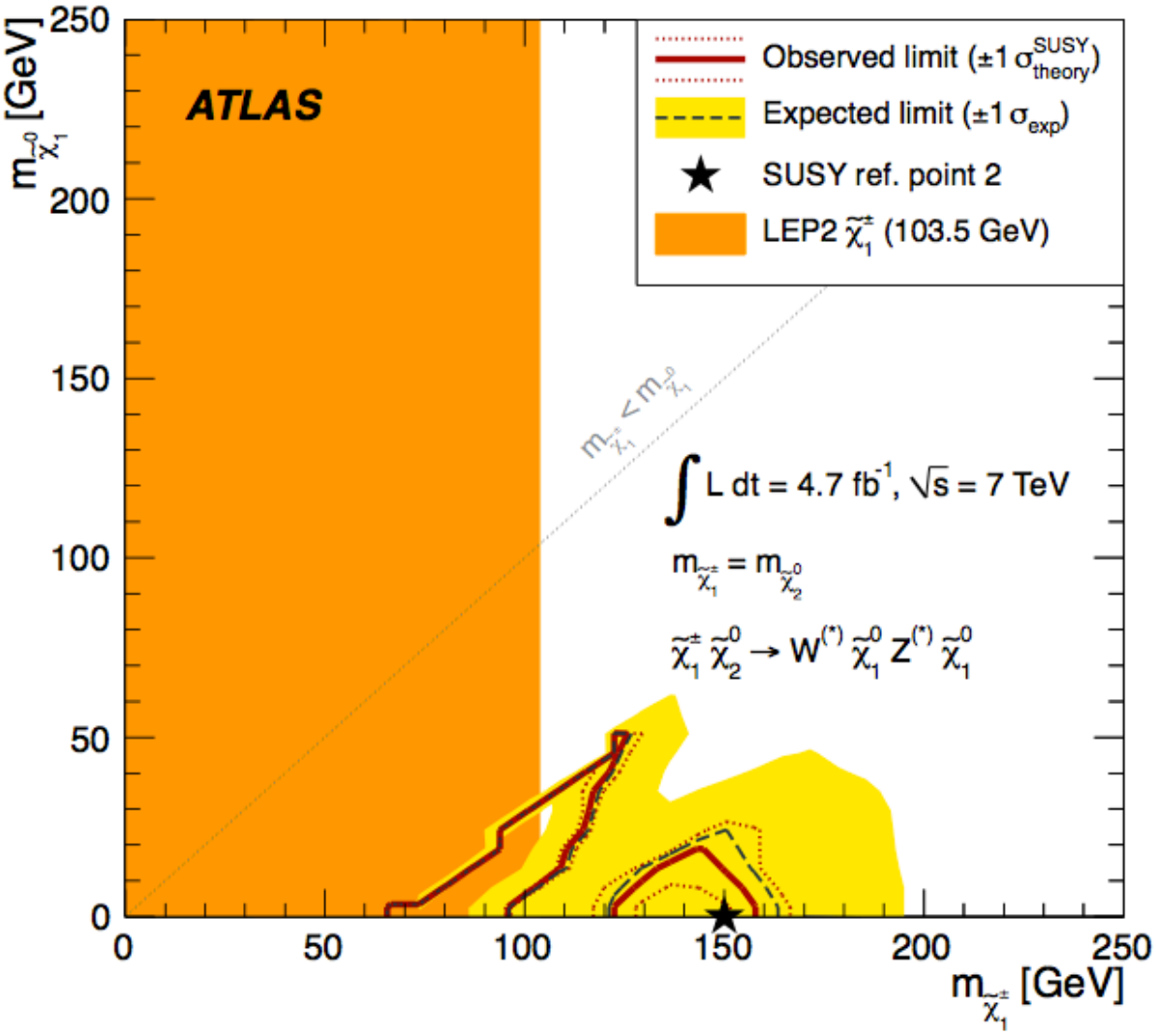

$$\tilde{\chi}_1^{\pm}\tilde{\chi}_1^{\mp} \rightarrow (l^{\pm}\nu\tilde{\chi}_1^0) + (l^{\mp}\nu\tilde{\chi}_1^0)$$

# pMSSM Limits 2+3 leptons combined – Intermediate slepton scenario






- Much weaker limits w/o intermediate sleptons
- Similar results from CMS
- Used so far only 5fb-1
- Additional signal regions under development
- Make limits as model dependent as possible