# *SUSY overview at ATLAS*

**High Energy Physics and Quantum Field Theory**

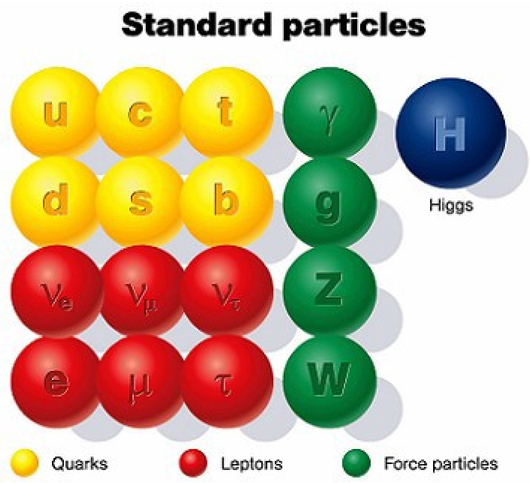
June 23 – June 30, 2013

**Saint Petersburg Area, Russia**

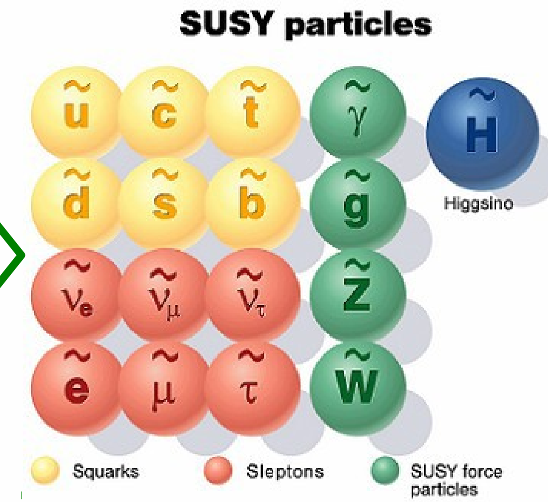
**Khramov Evgeny, JINR**

(on behalf of the ATLAS collaboration)

# Supersymmetry (SUSY)



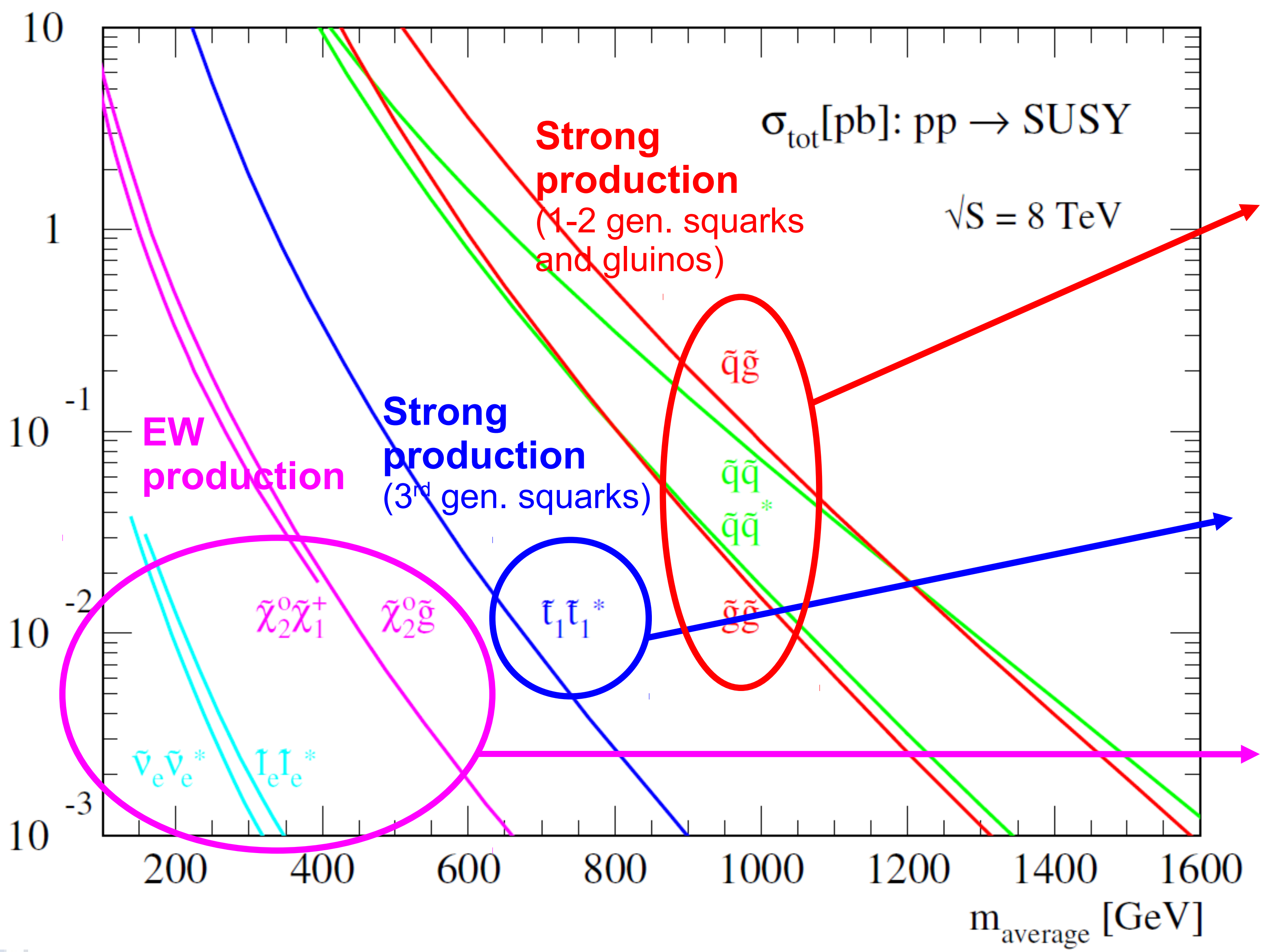

**"Superpartners" to each SM particles (same quantum numbers, but spin differs by ½)**




- if R-parity is conserved ($R=(-1)^{3(B-L)+2S}$ ), SUSY particles are pair produced and the lightest one (LSP) is stable
- Why is SUSY popular? It answers many open questions at once:
  - ✓ allows unification of gauge couplings
  - ✓ provides a solution to the hierarchy problem: the fermion/boson contribution to the Higgs mass cancel
  - ✓ If R-parity is conserved the LSP is stable and is a dark matter candidate

# SUSY search strategies





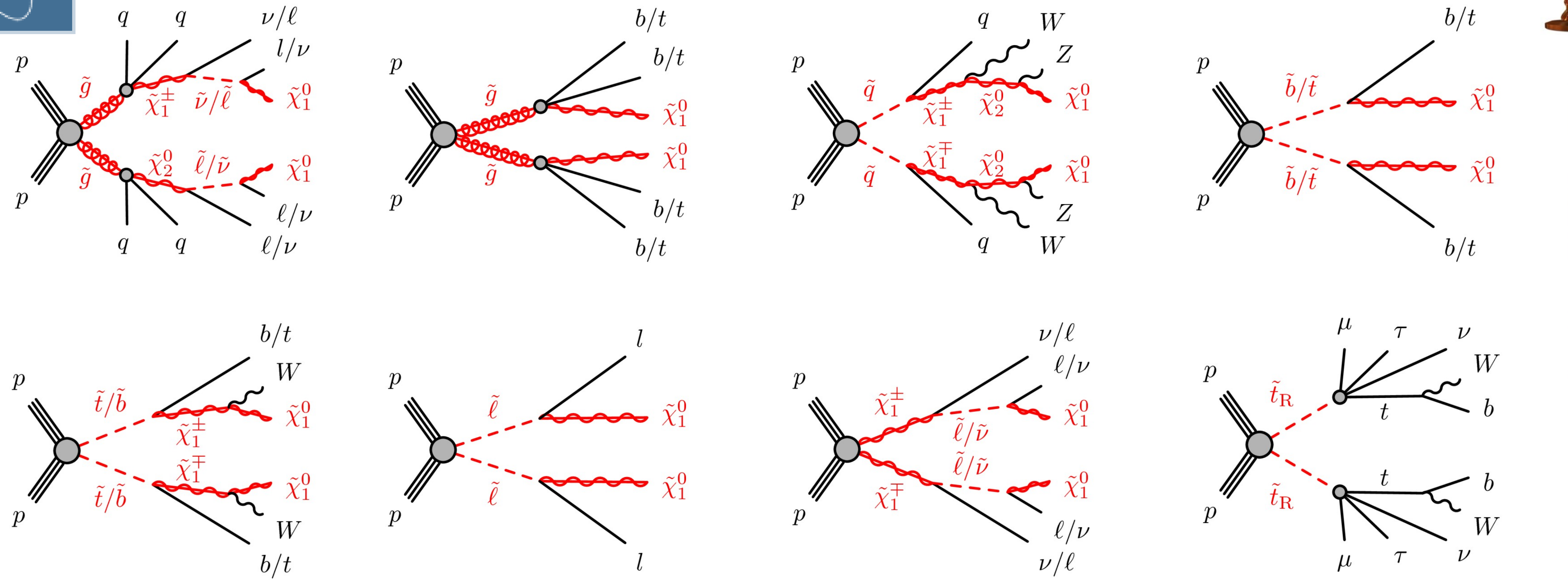

- No-leptons
- Multijet
- 1-lepton
- 2 SS leptons
- Taus
- photons

- No-leptons
- 1-lepton
- 2-leptons

- 2-leptons
- 3-leptons
- 4-leptons

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

# SUSY search strategies




## R-Parity violating searches (RPV)

- LSP: no need to be neutral nor stable.
- LSP decay: possibility to explore new signals, exploit LSP invariant mass and decay properties
- Single Sparticles production is possible
- Not so large $E_T^{miss}$

## R-Parity conserving searches (RPC)

- Neutral Stable LSP
- Sparticles produced in pairs
- Large $E_t^{miss}$
- Long-lived particles



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

# Background estimation

**Standard Model**

Top, multijets
*V*, *VV*, *VVV*, Higgs
& combinations of these

**Reducible backgrounds**

Determined from data
Backgrounds and methods depend on analyses

**Irreducible backgrounds**

*Dominant sources*: normalise MC in data control regions
*Subdominant sources*: MC

**Validation**

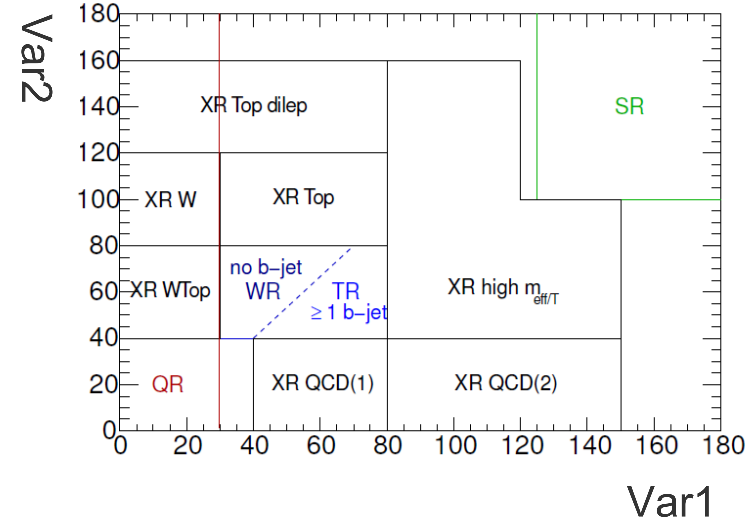
Validation regions used to cross check SM predictions with data

**Signal regions**

**Examples**

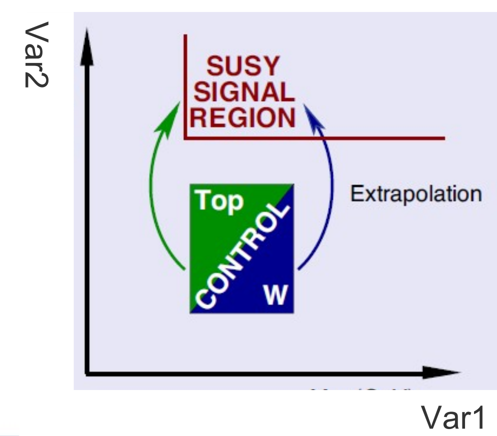
**Fake leptons or heavy-flavour jets determined with "matrix method" in different-purity samples using "real" and "fake" probabilities measured in data.**

**Charge flip rate measured in Z events**



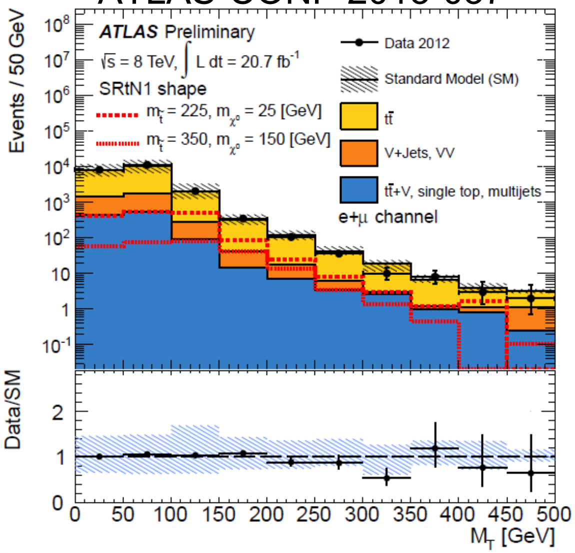

$$C^{j}_{\mathrm{iR}\rightarrow\mathrm{SR}} = \frac{N(MC_j,\mathrm{SR})}{N(MC_j,i\mathrm{R})}$$

$$N^{\mathrm{SR}}_{MC\ pred.,j} = N^{i\mathrm{R}}_{data} \times \frac{N(MC_j,\mathrm{SR})}{N(MC_j,i\mathrm{R})} = N^{i\mathrm{R}}_{data} \times C^{j}_{\mathrm{iR}\rightarrow\mathrm{SR}}$$



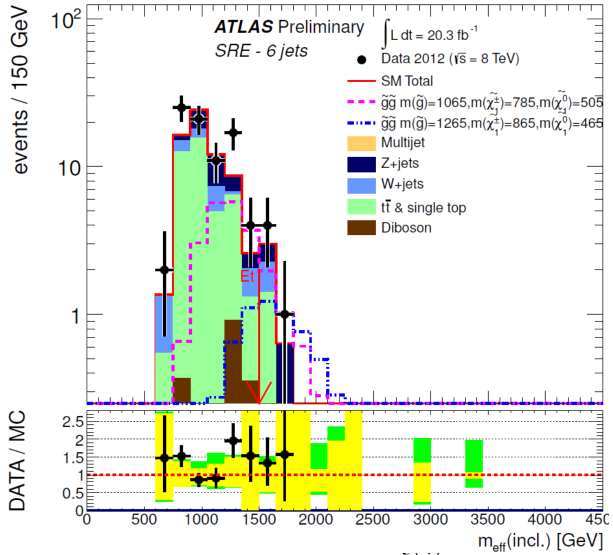
# Common variables

ATLAS-CONF-2013-037



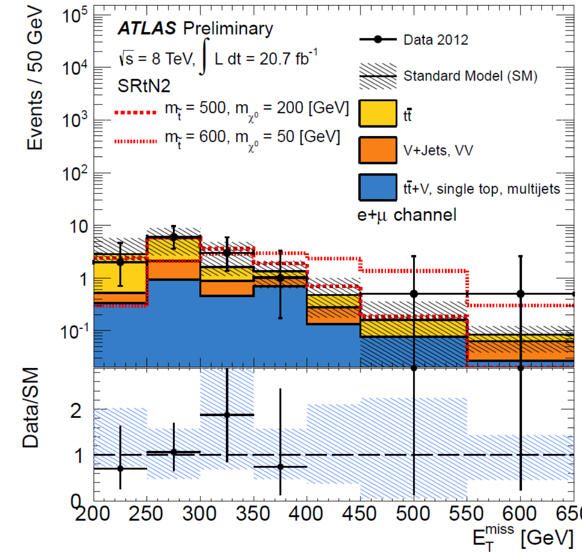

$$m_{\mathrm{T}} = \sqrt{2 \cdot p_T^{\ell} \cdot E_{\mathrm{T}}^{\mathrm{miss}} \cdot (1 - cos(\Delta\phi(\ell, E_{\mathrm{T}}^{\mathrm{miss}}))},$$

ATLAS-CONF-2013-047



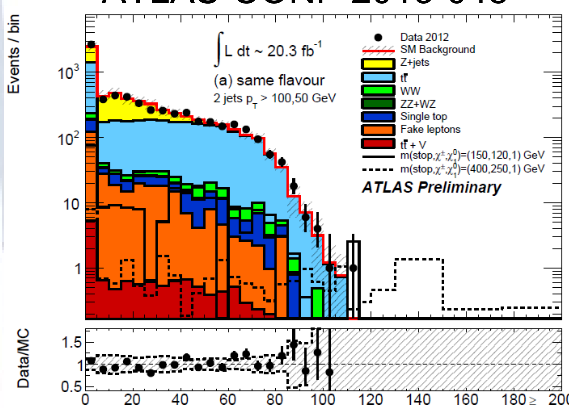

$$m_{\mathrm{eff}} = H_T + E_{\mathrm{T}}^{\mathrm{miss}} = p_T^{\ell} + \sum_{i=1} p_T^{jet_i} + E_{\mathrm{T}}^{\mathrm{miss}}$$

ATLAS-CONF-2013-037




Missing transverse energy

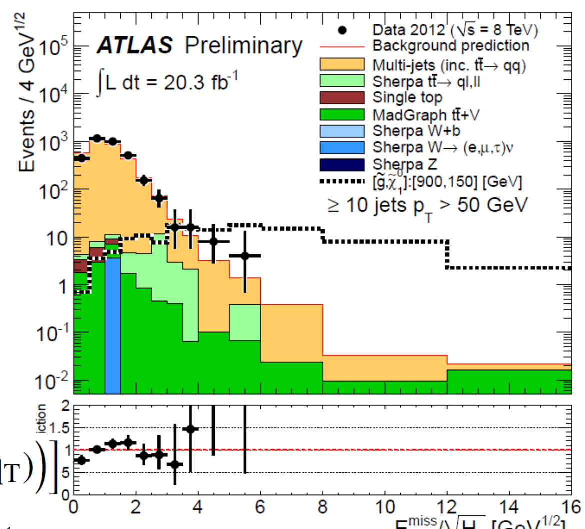
ATLAS-CONF-2013-048




$$m_{\mathrm{T2}} = \min_{\mathbf{q}_{\mathrm{T}}} \left[ \max \left( m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 1}, \mathbf{q}_{\mathrm{T}}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}}) \right) \right]$$

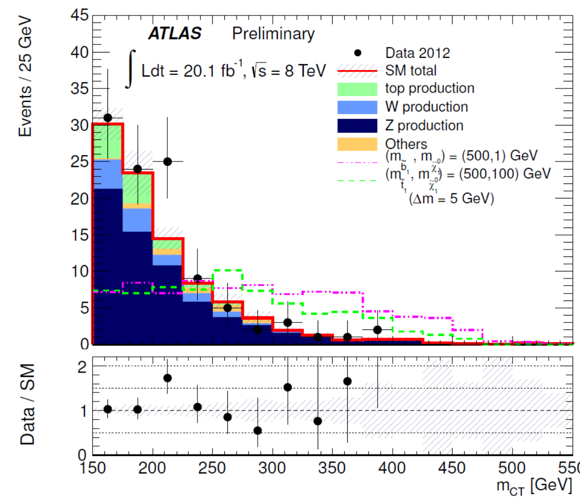
**qt is a component of $p_T^{miss}$ max-ing the "lep, qt" comb. giving the min $m_T$**

ATLAS-CONF-2013-054




$$H_T = p_T^{\ell} + \sum_{i=1}^{3(4)} p_T^{jet_i},$$

ATLAS-CONF-2013-053



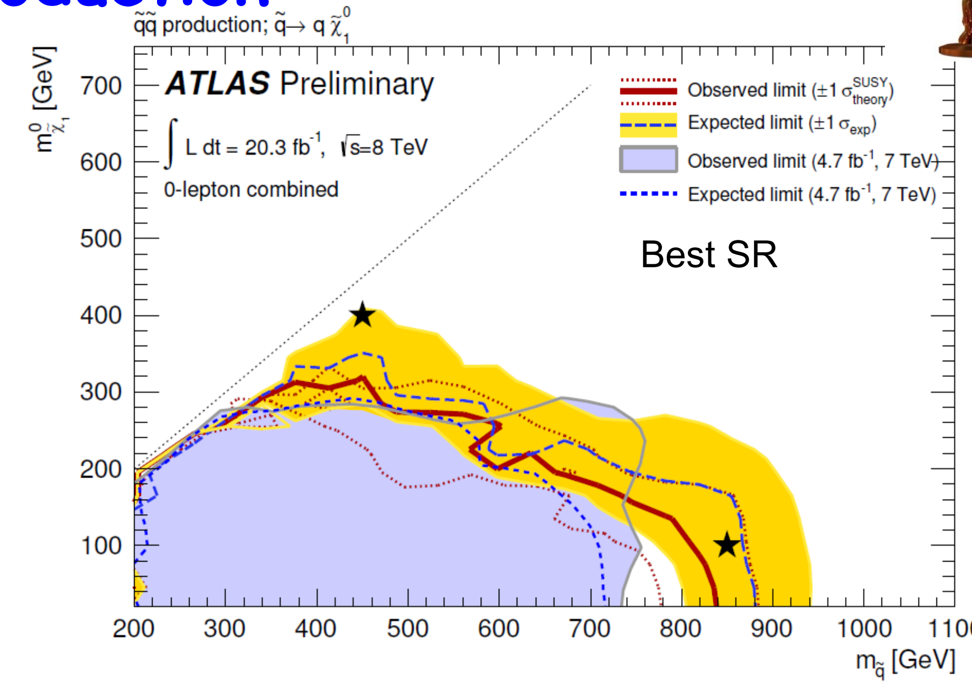

$$m_{\mathrm{CT}}^2(v_1, v_2) = [E_{\mathrm{T}}(v_1) + E_{\mathrm{T}}(v_2)]^2 - [\mathbf{p}_{\mathrm{T}}(v_1) - \mathbf{p}_{\mathrm{T}}(v_2)]^2$$

# Inclusive searches for squark and gluino production

## 0-lepton and 2-6 jets (20.3 fb$^{-1}$)

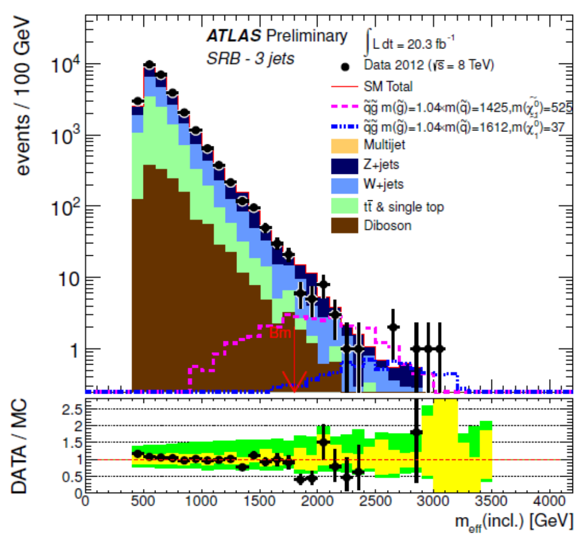
| Requirement | Channel | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A (2-jets) | | B (3-jets) | | C (4-jets) | | D (5-jets) | E (6-jets) | | |
| | L | M | M | T | M | T | – | L | M | T |
| $E_T^{miss}$[GeV] > | 160 | | | | | | | | | |
| $p_T(j_1)$ [GeV] > | 130 | | | | | | | | | |
| $p_T(j_2)$ [GeV] > | 60 | | | | | | | | | |
| $p_T(j_3)$ [GeV] > | – | | 60 | | 60 | | 60 | 60 | | |
| $p_T(j_4)$ [GeV] > | – | | – | | 60 | | 60 | 60 | | |
| $p_T(j_5)$ [GeV] > | – | | – | | – | | 60 | 60 | | |
| $p_T(j_6)$ [GeV] > | – | | – | | – | | – | 60 | | |
| $\Delta\phi(\text{jet}_i, \mathbf{E}_T^{miss})_{min}$ > | 0.4 ($i$ = {1, 2, (3 if $p_T(j_3)$ > 40 GeV)}) | | | | 0.4 ($i$ = {1, 2, 3}), 0.2 ($p_T$ > 40 GeV jets) | | | | | |
| $E_T^{miss}/m_{eff}(Nj)$ > | 0.2 | –[a] | 0.3 | 0.4 | 0.25 | 0.25 | 0.2 | 0.15 | 0.2 | 0.25 |
| $m_{eff}$(incl.) [GeV] > | 1000 | 1600 | 1800 | 2200 | 1200 | 2200 | 1600 | 1000 | 1200 | 1500 |

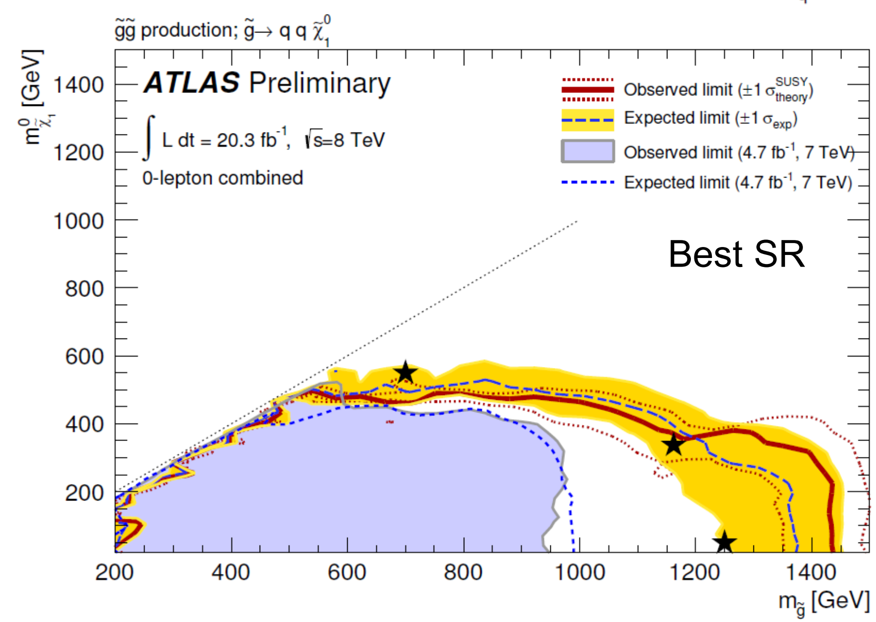
(a) For SR A-medium the cut on $E_T^{miss}/m_{eff}(Nj)$ is replaced by a requirement $E_T^{miss}/\sqrt{H_T}$ > 15 GeV$^{1/2}$.




Backgrounds:

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



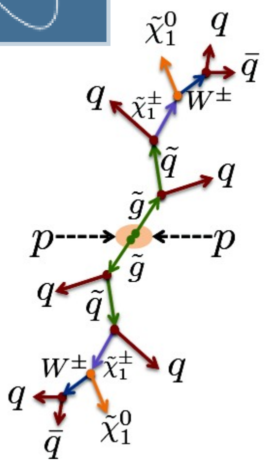




**Data are in agreement with SM expectations in all regions**

**ATLAS-CONF-2013-047**

# Inclusive searches for squark and gluino production

## Large multiplicities (20.3 fb$^{-1}$)

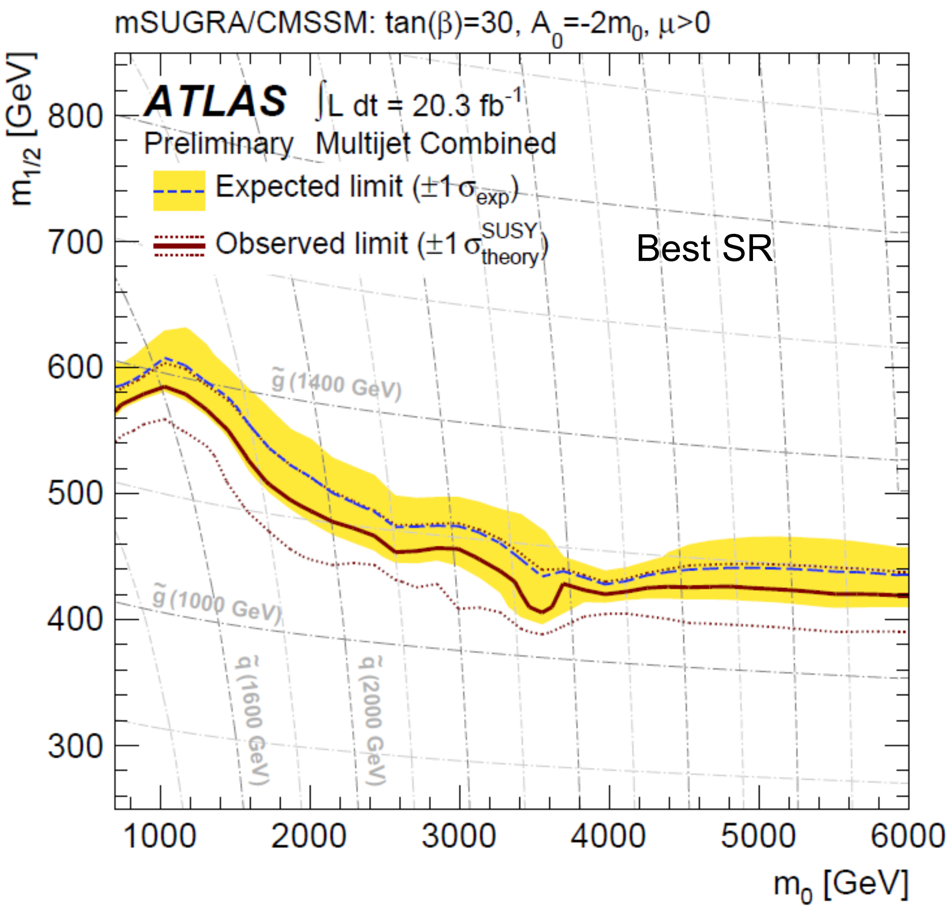



Key observation:
$E_t^{miss}/sqrt(H_T)$ and $M_J^{\Sigma}$

$$M_J^{\Sigma} \equiv \sum_j m_j^{R=1.0}$$

| | Multi-jet + flavour stream | | | | |
|---|---|---|---|---|---|
| Identifier | **8j50** | **9j50** | **≥ 10j50** | **7j80** | **≥ 8j80** |
| Jet $\|\eta\|$ | < 2.0 | | | < 2.0 | |
| Jet $p_T$ | > 50 GeV | | | > 80 GeV | |
| Jet count | = 8 | = 9 | ≥ 10 | = 7 | ≥ 8 |
| $b$-jets ($p_T$ > 40 GeV, $\|\eta\|$ < 2.5) | 0 / 1 / ≥ 2 | 0 / 1 / ≥ 2 | — | 0 / 1 / ≥ 2 | 0 / 1 / ≥ 2 |
| $M_J^{\Sigma}$ [GeV] | — | | | — | |
| $E_T^{miss}/\sqrt{H_T}$ | > 4 GeV$^{1/2}$ | | | > 4 GeV$^{1/2}$ | |

Main background is multijet production




| | Multi-jet + $M_J^{\Sigma}$ stream | | |
|---|---|---|---|
| Identifier | **≥ 8j50** | **≥ 9j50** | **≥ 10j50** |
| Jet $\|\eta\|$ | < 2.8 | | |
| Jet $p_T$ | > 50 GeV | | |
| Jet count | ≥ 8 | ≥ 9 | ≥ 10 |
| $b$-jets ($p_T$ > 40 GeV, $\|\eta\|$ < 2.5) | — | | |
| $M_J^{\Sigma}$ [GeV] | > 340 and > 420 for each case | | |
| $E_T^{miss}/\sqrt{H_T}$ | > 4 GeV$^{1/2}$ | | |

**Data are in agreement with SM expectations in all regions**



**ATLAS-CONF-2013-054**

# Inclusive searches for squark and gluino production

## 1-lepton searches (20.3 $fb^{-1}$)

### *Soft-lepton SRs:*

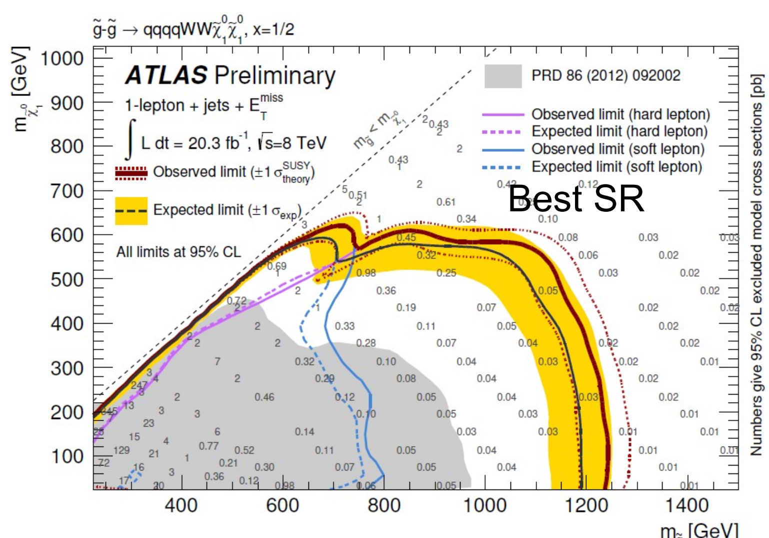
- el/mu: (10-25)/(6-25) Gev
- 0 b-jet + 2mu + ≥ 2 jets
- 1 b-jet + 1lep + ≥ 3 jets
- 2 b-jets + 1lep + ≥ 2 jets
- No b-tag + 1lep + 3-4,≥5 jets

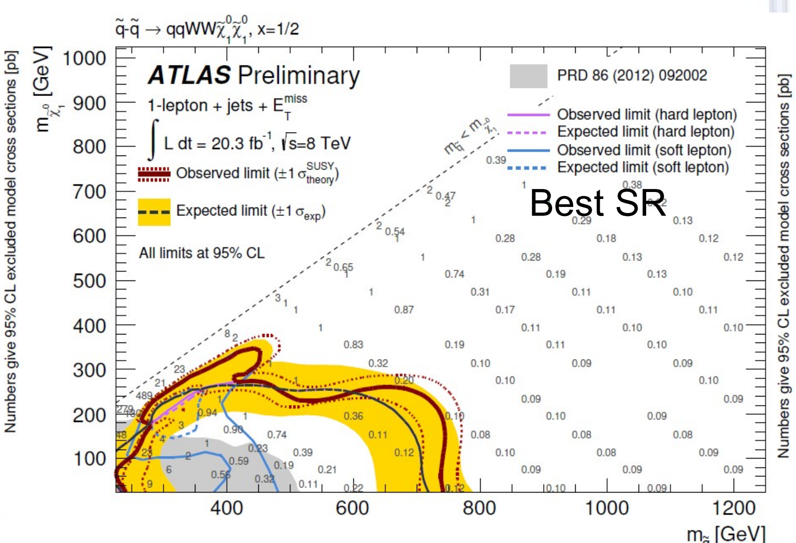
### Hard-lepton SRs

| | 3-jet | 5-jet | 6-jet |
|---|---|---|---|
| $N_\ell$ | 1 (electron or muon) | | |
| $p_T^\ell$(GeV) | > 25 | | |
| $p_T{}^{\text{add. }\ell}$ (GeV) | < 10 | | |
| $N_{\text{jet}}$ | ≥ 3 | ≥ 5 | ≥ 6 |
| $p_T{}^{\text{jet}}$(GeV) | > 80, 80, 30 | > 80, 50, 40, 40, 40 | > 80, 50, 40, 40, 40, 40 |
| $p_T{}^{\text{add. jets}}$( GeV) | – (< 40) | – (< 40) | – |
| $E_T^{\text{miss}}$ (GeV) | >500 (300) | >300 | >350 (250) |
| $m_T$ (GeV) | > 150 | > 200 (150) | > 150 |
| $E_T^{\text{miss}}/m_{\text{eff}}^{\text{excl}}$ | > 0.3 | – | – |
| $m_{\text{eff}}^{\text{incl}}$ (GeV) | > 1400 (800) | | > 600 |

### *Background:*

- ttbar production
- W/Z+jets production
- WW, ZZ, WZ



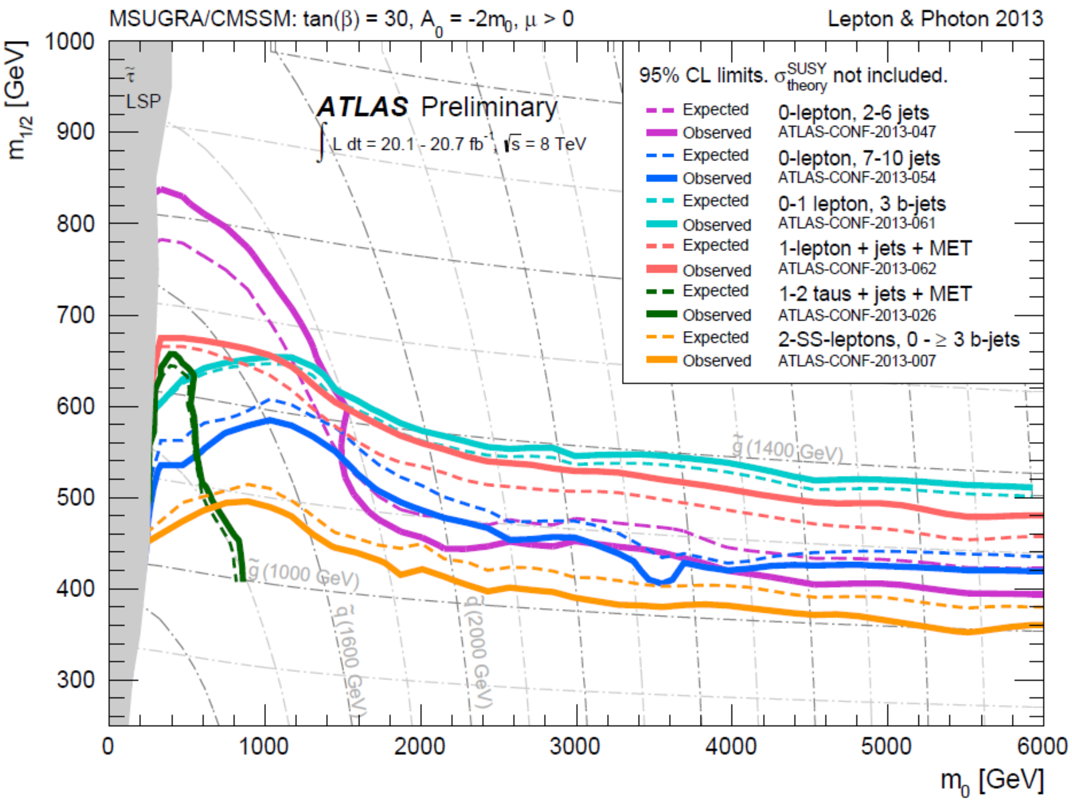



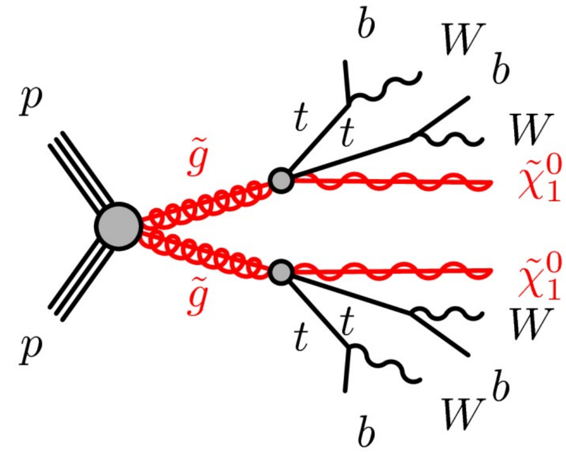

Data are in agreement with SM expectations in all regions

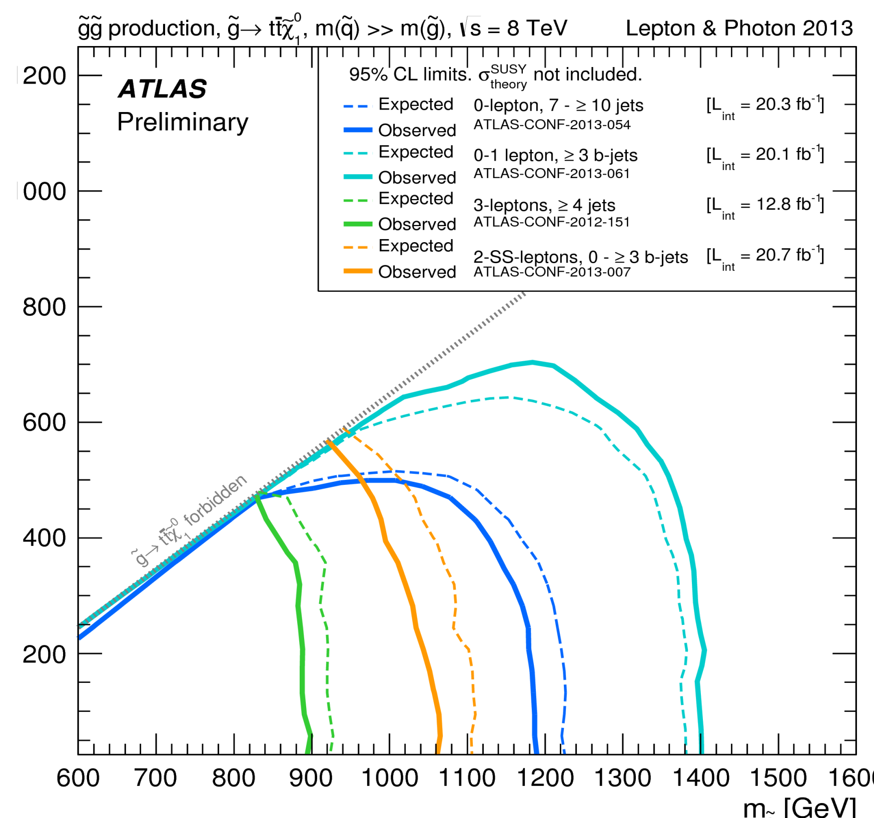
**ATLAS-CONF-2013-062**

# Inclusive searches for squark and gluino production summary





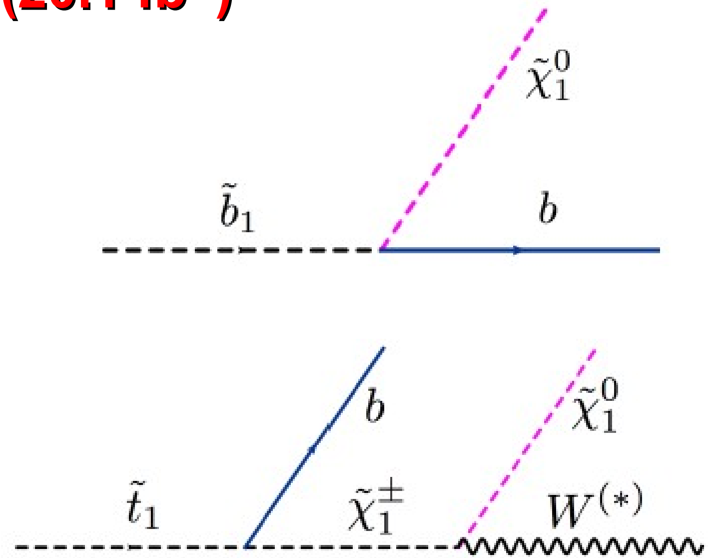




**Gluino masses below ~1.35 TeV excluded for any squark mass**

**Max gluino mass exclusion limit ~1.34 TeV for Gtt model**

# 3rd generation searches

## 0-lepton, b-jets (20.1 fb$^{-1}$)




### *Event selection:*

- Lepton veto
- 2 b-jets
- $E_T^{miss}$

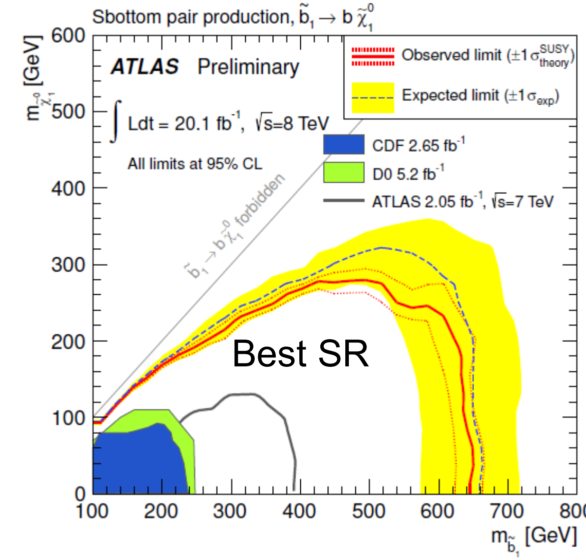
### *Background:*

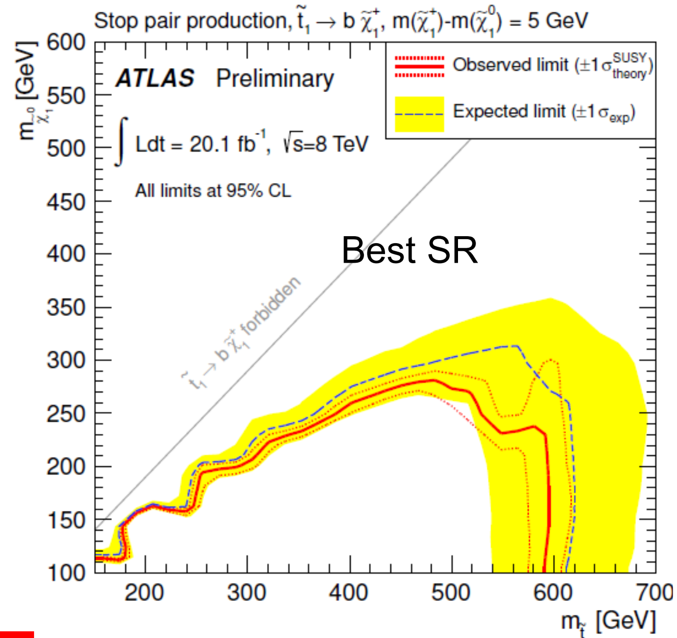
- ttbar production
- W/Z+jets production

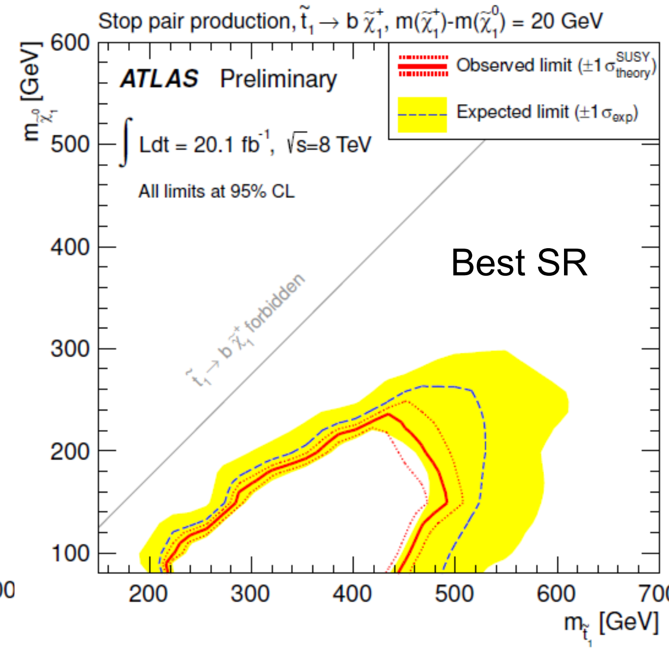
### Signal regions:

SRA: large $\Delta m(\tilde{b}_1, \tilde{\chi}_1^0)$

SRB: small $\Delta m(\tilde{b}_1, \tilde{\chi}_1^0)$



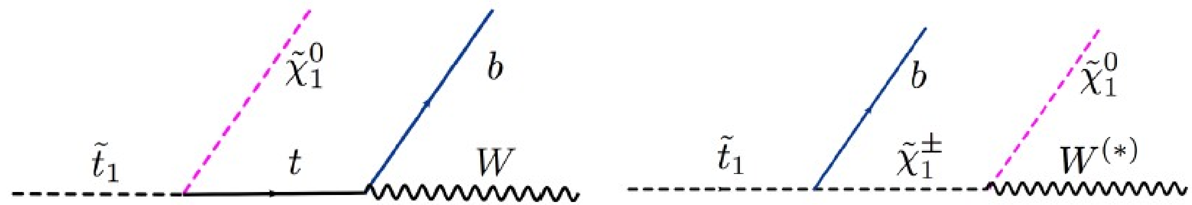

**Data are in agreement with SM expectations in all regions**

**ATLAS-CONF-2013-053**

# 3rd generation searches

## 1lepton, b-jets (20.3 fb-1)

6 SRs: **≥2 b-jets** **≥1 b-jet**




## *Event selection:*

- e/μ $p_T$ > 25 GeV
- ≥4 jets with

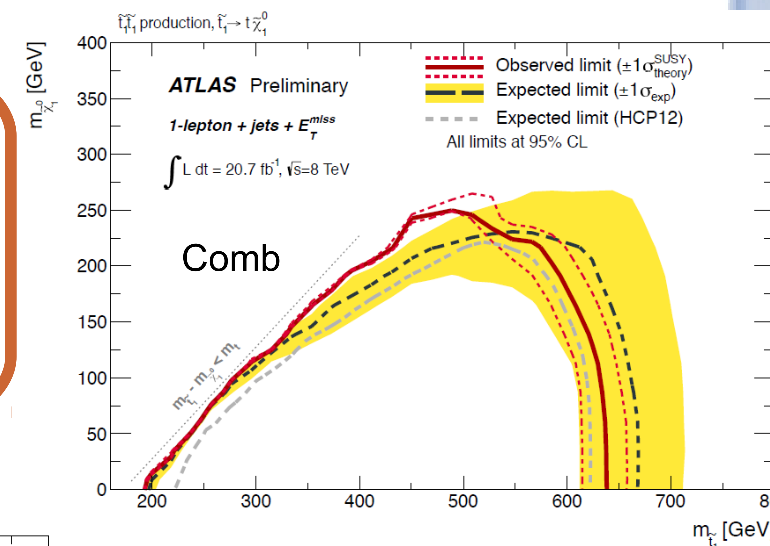
$p_T$ > 80,60,40,25 GeV

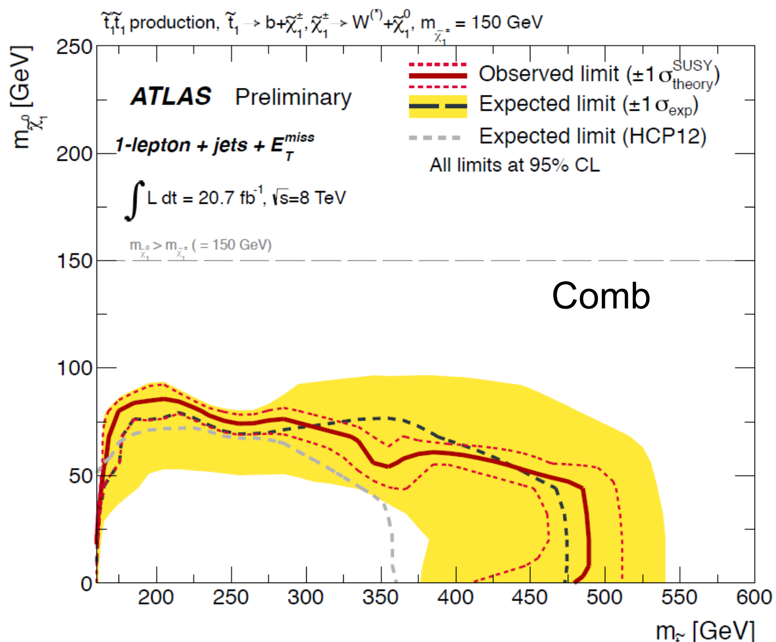
- $E_T^{miss}$ > 80 GeV

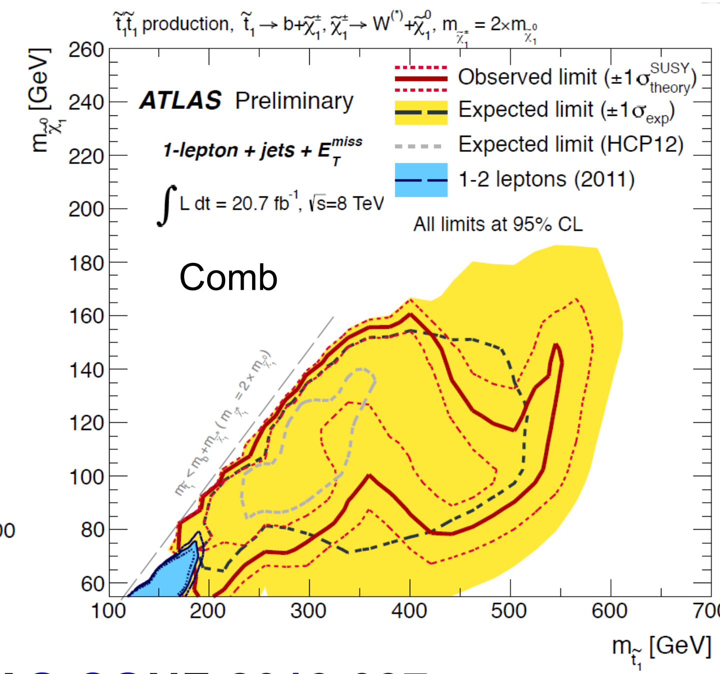
## *Background:*

- ttbar production
- W/Z+jets production
- WW, ZZ, WZ

Data are in agreement with SM expectations in all regions



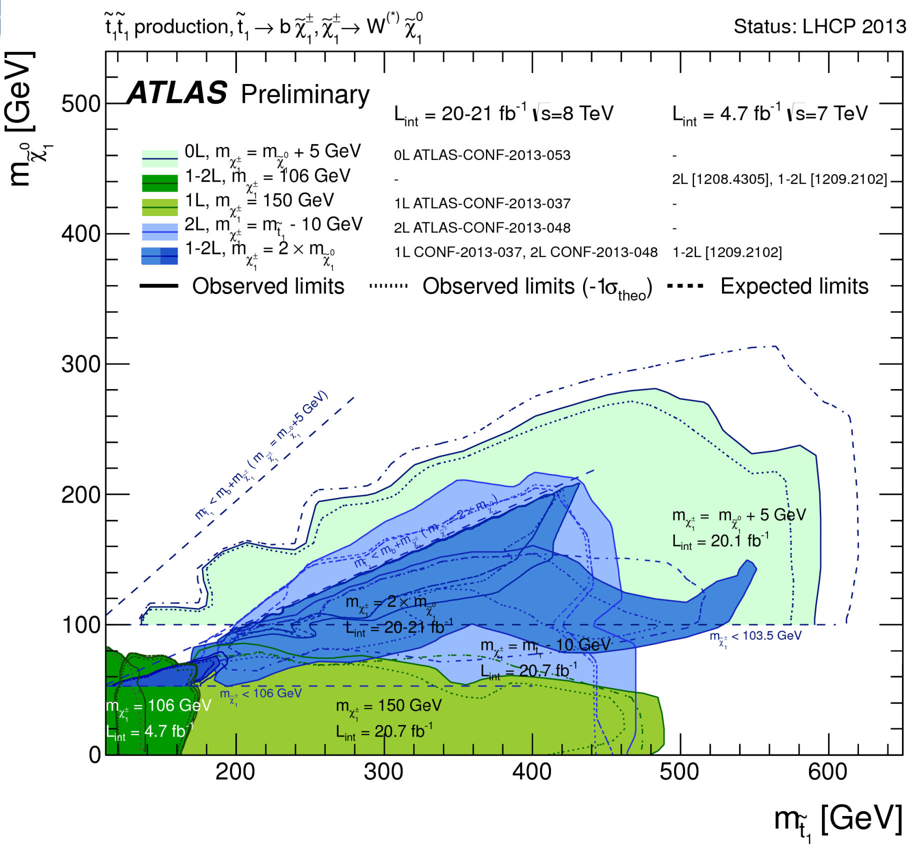



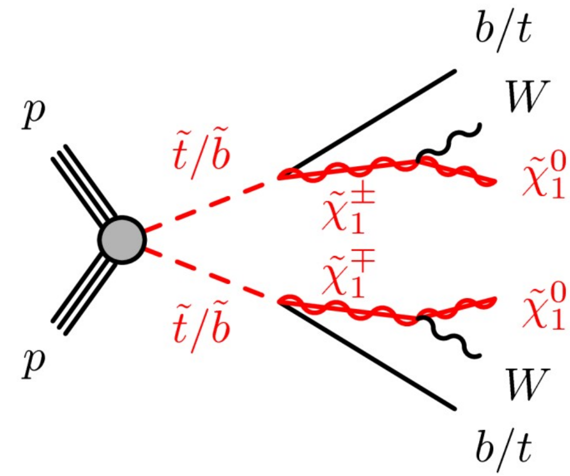



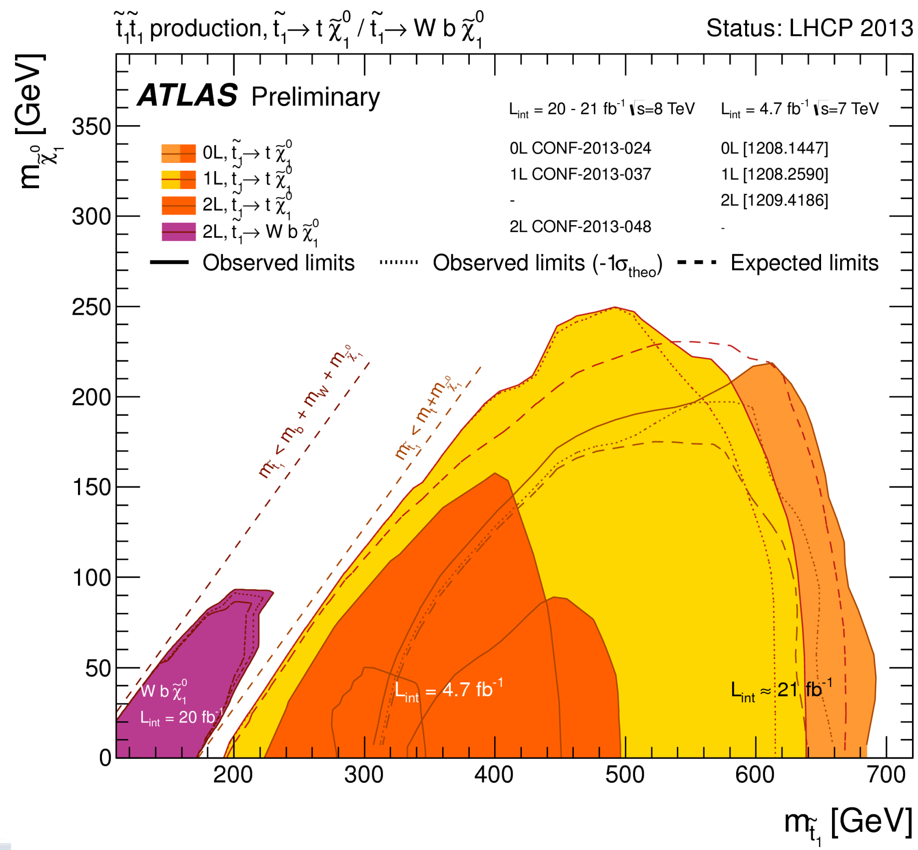

**ATLAS-CONF-2013-037**

# 3rd generation searches summary






**Gluino and light squark masses below ~1.15 and ~1.24 TeV correspondingly are excluded**

**Max stop mass exclusion limit ~660 GeV and sbottom limit ~630 GeV**

# Electroweak production searches

## 2-leptons searches (20.3 fb$^{-1}$)

## Opposite sign analysis (OS)

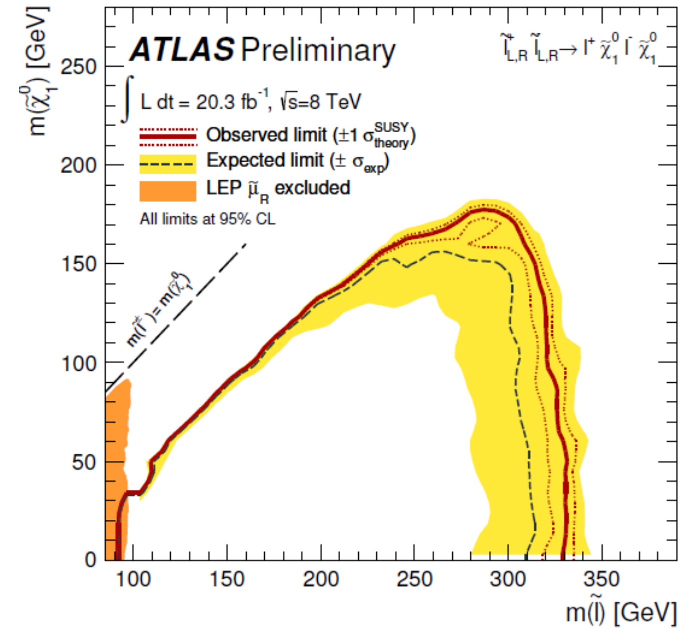
- Background: ttbar, WW, WZ, ZZ
- Discr. variable:

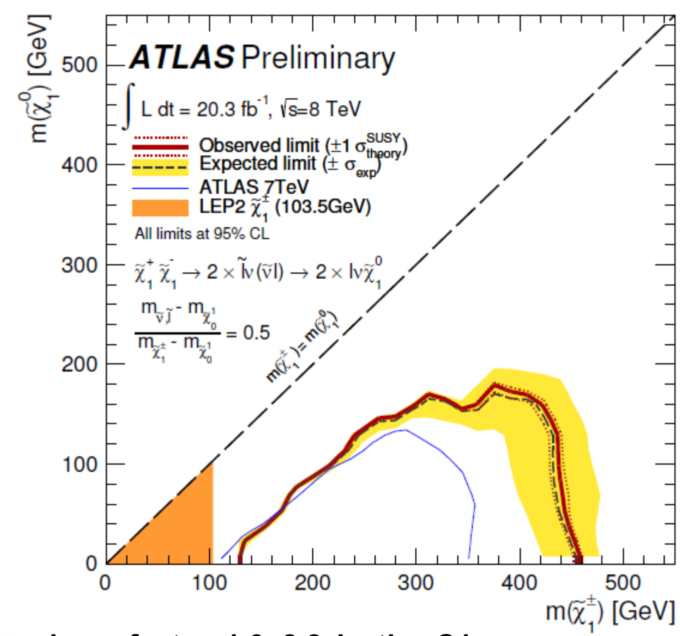
$$m_{T2} = \min_{\mathbf{q}_T}\left[\max\left(m_T(\mathbf{p}_T^{\ell 1}, \mathbf{q}_T), m_T(\mathbf{p}_T^{\ell 2}, \mathbf{p}_T^{\text{miss}} - \mathbf{q}_T)\right)\right]$$

| | SR-$m_{T2,90}$ | SR-$m_{T2,110}$ | SR-$WWa$ | SR-$WWb$ | SR-$WWc$ |
|---|---|---|---|---|---|
| lepton flavour | $e^+e^-$, $\mu^+\mu^-$, $e^\pm\mu^\mp$ | | $e^\pm\mu^\mp$ | | |
| $p_T^{\ell 1}$ | — | | > 35 GeV | | |
| $p_T^{\ell 2}$ | — | | > 20 GeV | | |
| $m_{\ell\ell}$ | $Z$ veto | | < 80 GeV | < 130 GeV | — |
| $p_{T,\ell\ell}$ | — | | > 70 GeV | < 170 GeV | < 190 GeV |
| $\Delta\phi_{\ell\ell}$ | — | | < 1.8 rad | | |
| $E_T^{\text{miss,rel}}$ | > 40 GeV | | > 70 GeV | — | |
| $m_{T2}$ | > 90 GeV | > 110 GeV | — | > 90 GeV | > 100 GeV |

- SR-$m_{T2}$: $\tilde{\ell}^\pm\tilde{\ell}^\mp$ and $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ production
- SR-WW: chargino and neutralino production

  with $\tilde{\chi}_1^\pm \rightarrow W^\pm + \tilde{\chi}_1^0$



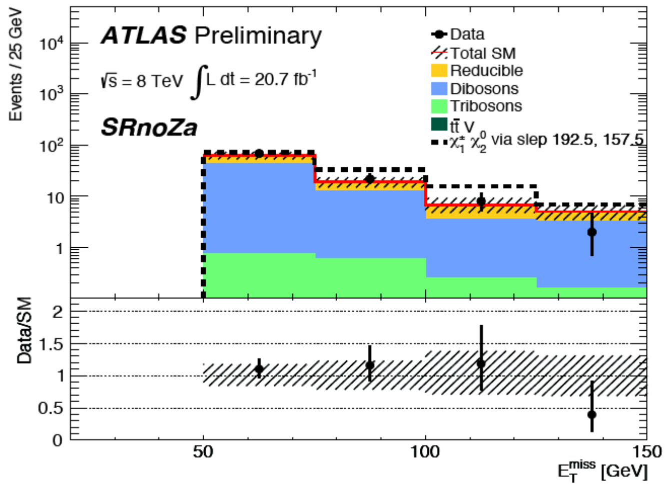




**ATLAS-CONF-2013-049**

**The excluded x-sec is above the model x-sec by a factor 1.9–2.8 in the C1 mass range 100–190 GeV and then degrades to 4.7 when reaching a C1 mass of 250 GeV.**

# Electroweak production searches

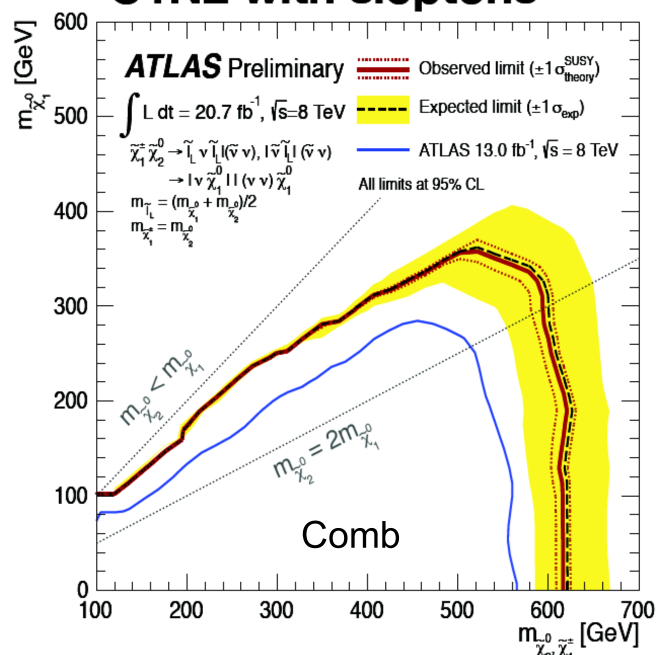
## 3-leptons searches (20.7 fb⁻¹)



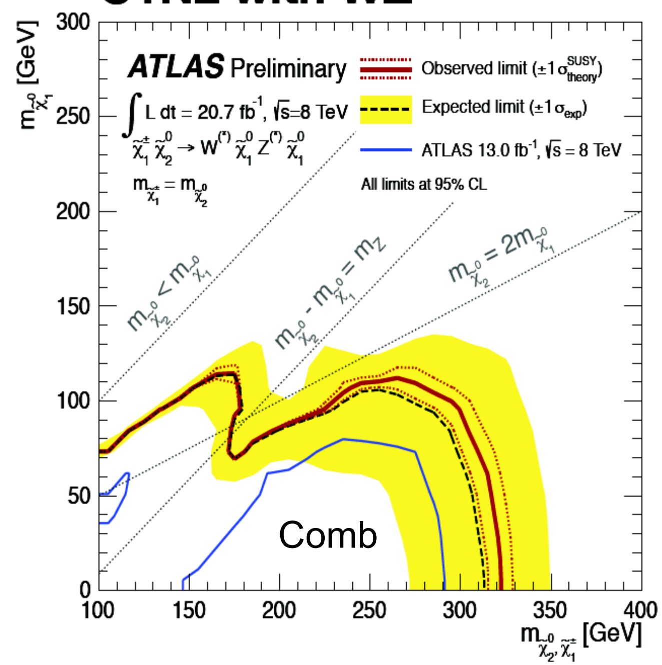

| | Z depleted | | | Z enriched | | |
|---|---|---|---|---|---|---|
| Selection | SRnoZa | SRnoZb | SRnoZc | SRZa | SRZb | SRZc |
| $m_{\mathrm{SFOS}}$ [GeV] | <60 | 60–81.2 | <81.2 or >101.2 | 81.2–101.2 | 81.2–101.2 | 81.2–101.2 |
| $E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV] | >50 | >75 | >75 | 75–120 | 75–120 | >120 |
| $m_{\mathrm{T}}$ [GeV] | – | – | >110 | <110 | >110 | >110 |
| $p_{\mathrm{T}}$ 3$^{\mathrm{rd}}$ $\ell$ [GeV] | >10 | >10 | >30 | >10 | >10 | >10 |
| SR veto | SRnoZc | SRnoZc | – | – | – | – |
| **Target** | Low mass splitting | No-slep off-shell Z | Slepton bulk | WZ-like | No-slep on-shell Z | No-slep bulk |

- Six specialized signal regions targeting **C1N2**
  - Split into Z-veto and Z-request regions
- Background modeling
  - ttbar, s.top, V+jets
  - Di-, tribosons ttbar+V

### C1N2 with sleptons




### C1N2 with WZ

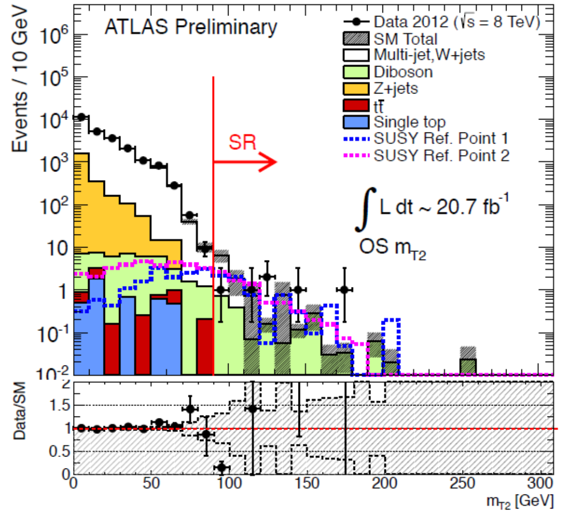


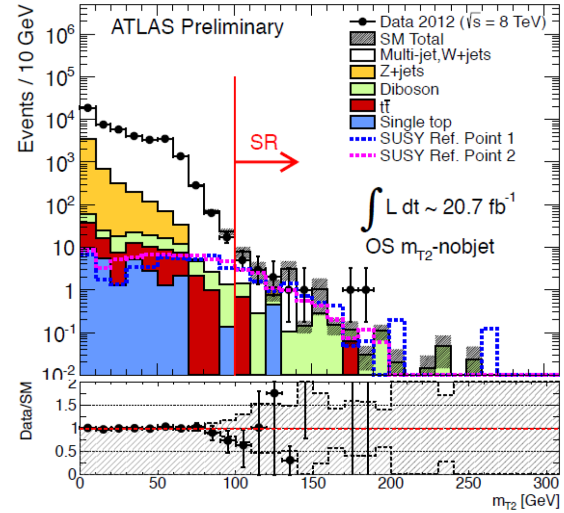

**ATLAS-CONF-2013-035**

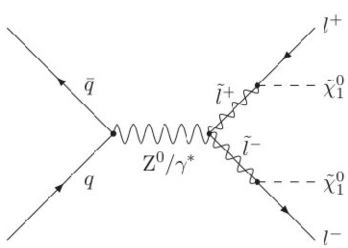
# Electroweak production searches

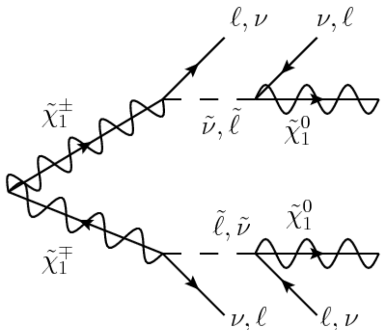
## 2-tau searches (20.7 fb$^{-1}$)

| Signal region | requirements |
|---|---|
| OS $m_{T2}$ | at least 1 OS tau pair<br>jet veto<br>$Z$-veto<br>$E_T^{miss} > 40$ GeV<br>$m_{T2} > 90$ GeV |
| OS $m_{T2}$-nobjet | at least 1 OS tau pair<br>b-jet veto<br>$Z$-veto<br>$E_T^{miss} > 40$ GeV<br>$m_{T2} > 100$ GeV |

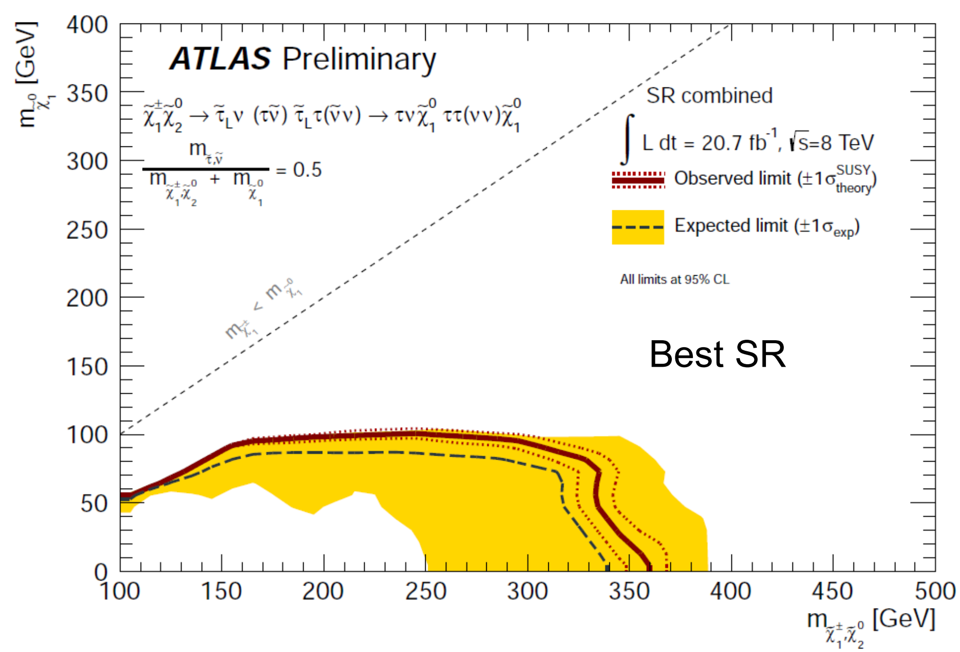




| SM process | SR OS $m_{T2}$ | SR OS $m_{T2}$ -nobjet |
|---|---|---|
| top | 0.2 ± 0.5 ± 0.1 | 1.6 ± 0.8 ± 1.2 |
| $Z$+jets | 0.28 ± 0.26 ± 0.23 | 0.4 ± 0.3 ± 0.3 |
| diboson | 2.2 ± 0.5 ± 0.5 | 2.5 ± 0.5 ± 0.9 |
| multi-jet & $W$+jets | 8.4 ± 2.6 ± 1.4 | 12 ± 3 ± 3 |
| SM total | 11.0 ± 2.7 ± 1.5 | 17 ± 4 ± 3 |
| data | 6 | 14 |




**ATLAS-CONF-2013-028**

SUSY overview at ATLAS, QFTHEP2013

# Electroweak production searches

## 4-leptons searches (20.7 fb$^{-1}$)

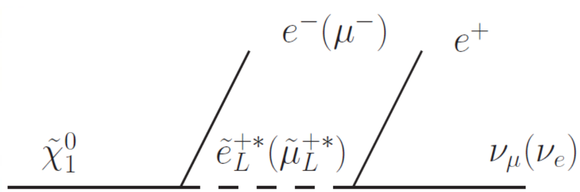
$$R = (-1)^{3(B-L)+2S}$$

| SR | $N(\ell = e,\mu)$ | $N(\tau)$ | $Z$ Candidate | $E_T^{miss}$ [GeV] | | $m_{eff}$ [GeV] | Scenario |
|---|---|---|---|---|---|---|---|
| SR0noZa | ≥4 | ≥0 | extended veto | >50 | | | RPC |
| SR0noZb | ≥4 | ≥0 | extended veto | >75 | or | >600 | RPV |
| SR1noZ | =3 | ≥1 | extended veto | >100 | or | >400 | RPV |
| SR0Z | ≥4 | ≥0 | request | >75 | | | GGM |
| SR1Z | =3 | ≥1 | request | >100 | | | GGM |

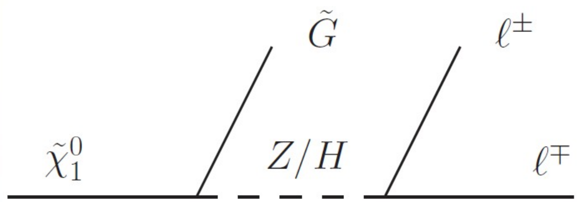
**RPC**

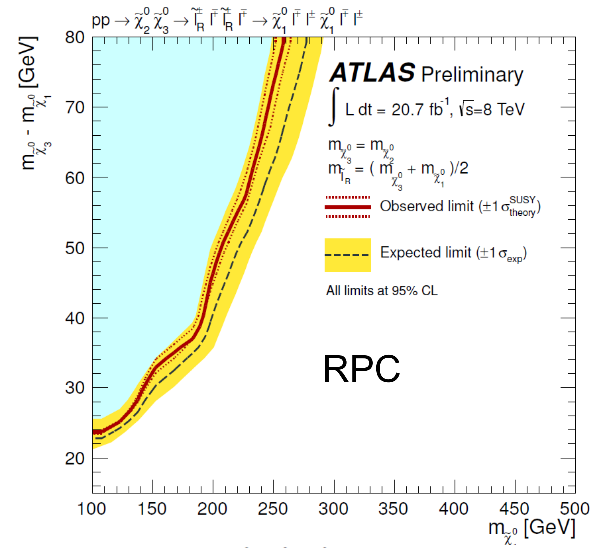
$$\tilde{\chi}^0_{2,3} \rightarrow \ell^{\pm}\tilde{\ell}^{\mp}_R \rightarrow \ell^+\ell^-\tilde{\chi}^0_1$$

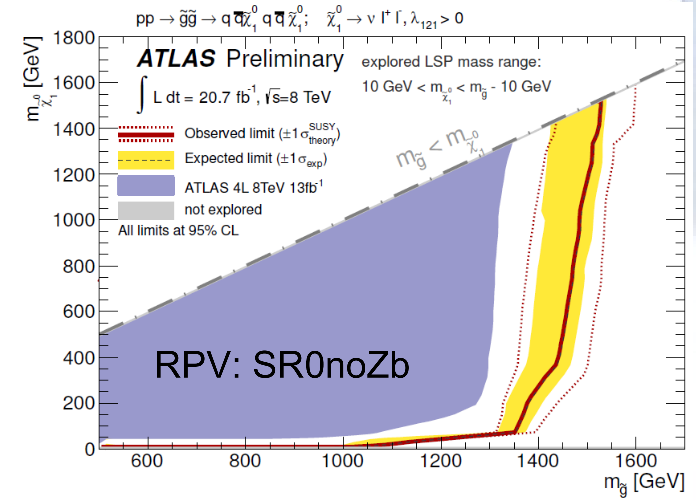
**RPV**




**GGM**

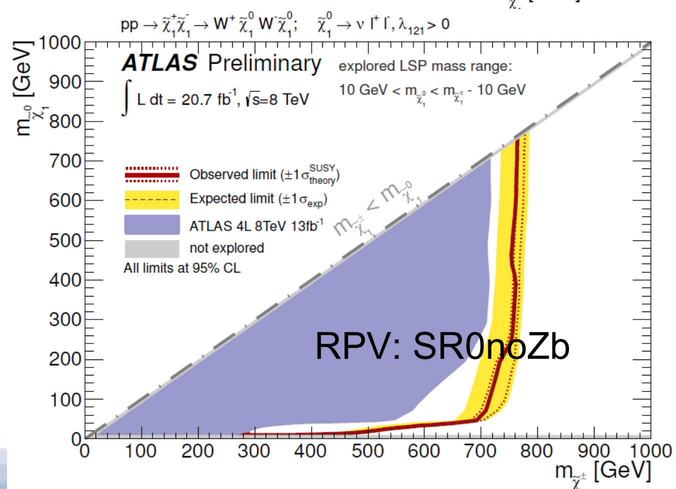


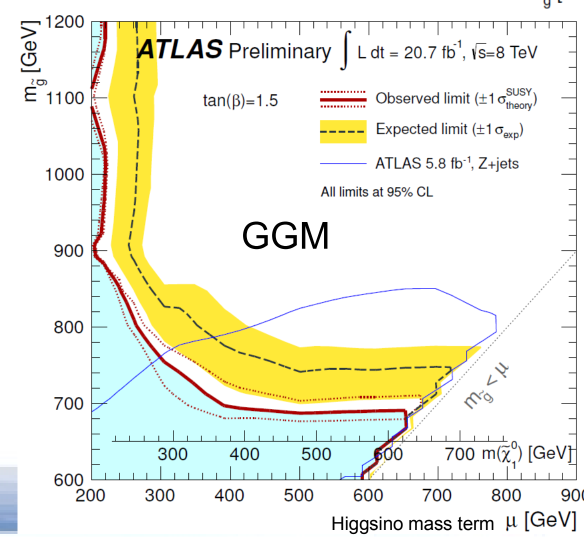




## *Background:*

- ttbar, ttbar+V, ttbar+VV
- Di- and tribosons production



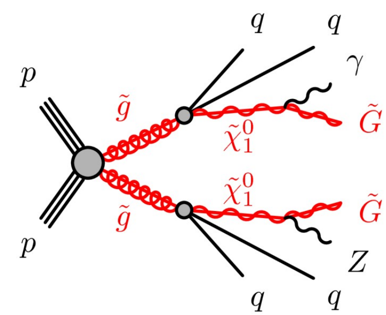

**ATLAS-CONF-2013-036**

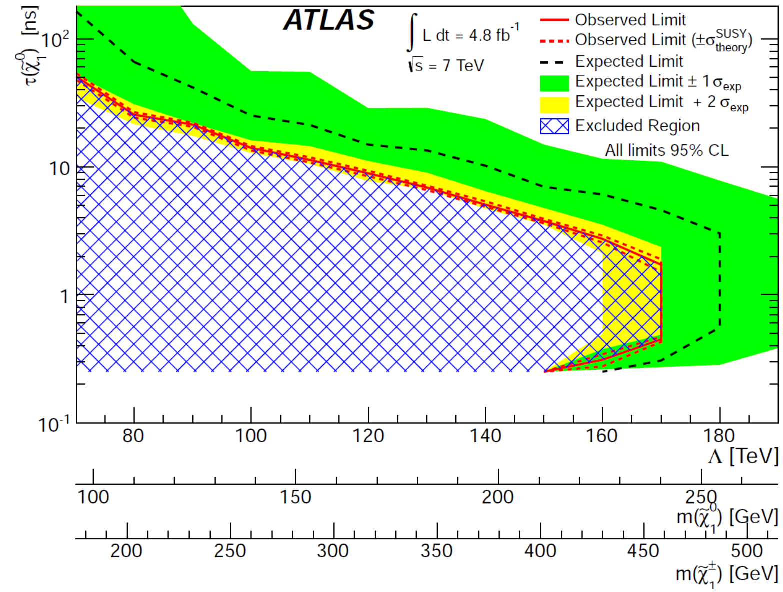
# Long-lived particles searches

## "non-pointing" photons searches (4.8 fb$^{-1}$, 7 TeV)

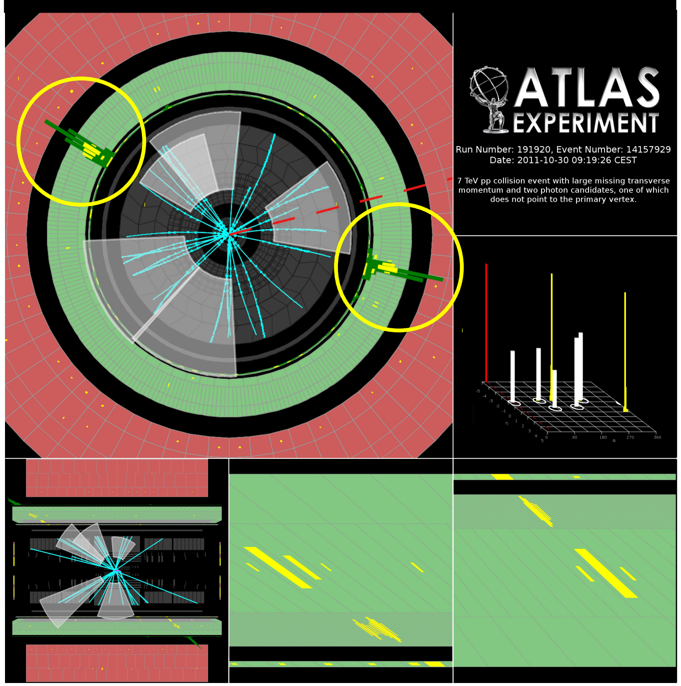
The decay length of the neutralino is a free parameter of the theory.

Gauge Mediated Supersymmetry Breaking (GMSB) models

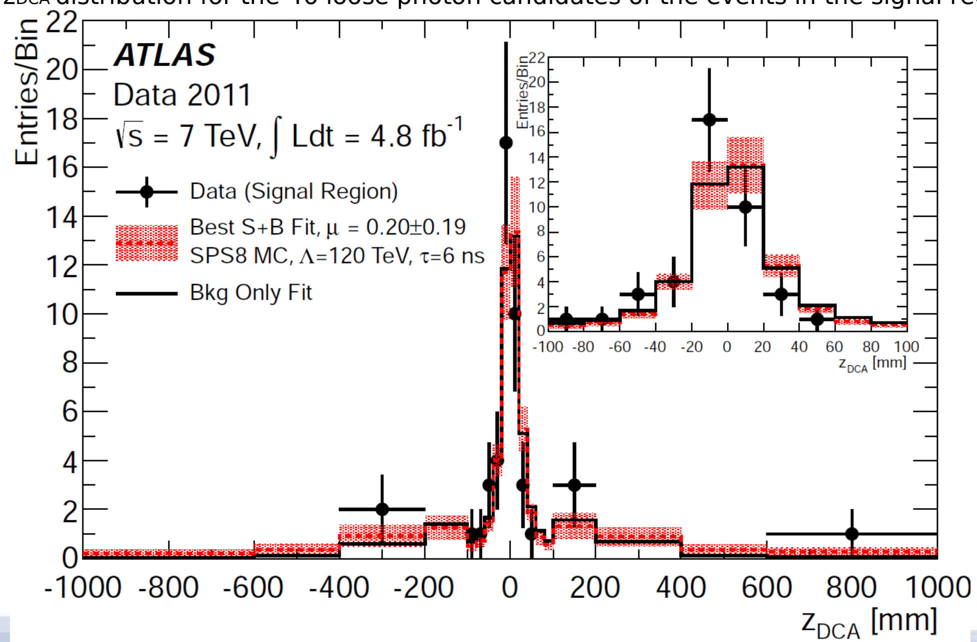



The long-lived NLSP scenario introduces the possibility of a decay photon being produced after a finite delay and with a flight direction that does not point back to the primary vertex (PV) of the event.




The zDCA distribution for the 46 loose photon candidates of the events in the signal region.




ATLAS-CONF-2013-028

# Summary table

**SUSY overview at ATLAS, QFTHEP2013**

## ...S SUSY Searches* - 95% CL Lower Limits

...LP 2013

**ATLAS** Prelimina...

$\int \mathcal{L}\, dt = (4.4 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7,\ 8$ Te...

| | Model | $e, \mu, \tau, \gamma$ | Jets | $E_T^{miss}$ | $\int \mathcal{L}\, dt[\mathrm{fb}^{-1}]$ | | Mass limit | | Reference |
|---|---|---|---|---|---|---|---|---|---|
| Inclusive Searches | MSUGRA/CMSSM | 1 $e, \mu$ | 3-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.2 TeV | any $m(\tilde{q})$ | ATLAS-CONF-2013-062 |
| | MSUGRA/CMSSM | 0 | 7-10 jets | Yes | 20.3 | $\tilde{g}$ | 1.1 TeV | any $m(\tilde{q})$ | ATLAS-CONF-2013-054 |
| | $\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 20.3 | $\tilde{q}$ | 740 GeV | $m(\tilde{\chi}_1^0)$=0 GeV | ATLAS-CONF-2013-047 |
| | $\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$ | 0 | 2-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.3 TeV | $m(\tilde{\chi}_1^0)$=0 GeV | ATLAS-CONF-2013-047 |
| | $\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^\pm \to qqW^\pm\tilde{\chi}_1^0$ | 1 $e, \mu$ | 3-6 jets | Yes | 20.3 | $\tilde{g}$ | 1.18 TeV | $m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)$=0.5($m(\tilde{\chi}_1^0)$+$m(\tilde{g})$) | ATLAS-CONF-2013-062 |
| | $\tilde{g}\tilde{g}\to qqqq\ell\ell(\ell\ell)\tilde{\chi}_1^0\tilde{\chi}_1^0$ | 2 $e, \mu$ (SS) | 3 jets | Yes | 20.7 | $\tilde{g}$ | 1.1 TeV | $m(\tilde{\chi}_1^0)$<650 GeV | ATLAS-CONF-2013-007 |
| | GMSB ($\tilde{\ell}$ NLSP) | 2 $e, \mu$ | 2-4 jets | Yes | 4.7 | $\tilde{g}$ | 1.24 TeV | $\tan\beta$<15 | 1208.4688 |
| | GMSB ($\tilde{\ell}$ NLSP) | 1-2 $\tau$ | 0-2 jets | Yes | 20.7 | $\tilde{g}$ | 1.4 TeV | $\tan\beta$>18 | ATLAS-CONF-2013-026 |
| | GGM (bino NLSP) | 2 $\gamma$ | 0 | Yes | 4.8 | $\tilde{g}$ | 1.07 TeV | $m(\tilde{\chi}_1^0)$>50 GeV | 1209.0753 |
| | GGM (wino NLSP) | 1 $e, \mu + \gamma$ | 0 | Yes | 4.8 | $\tilde{g}$ | 619 GeV | $m(\tilde{\chi}_1^0)$>50 GeV | ATLAS-CONF-2012-144 |
| | GGM (higgsino-bino NLSP) | $\gamma$ | 1 $b$ | Yes | 4.8 | $\tilde{g}$ | 900 GeV | $m(\tilde{\chi}_1^0)$>220 GeV | 1211.1167 |
| | GGM (higgsino NLSP) | 2 $e, \mu$ ($Z$) | 0-3 jets | Yes | 5.8 | $\tilde{g}$ | 690 GeV | $m(\tilde{H})$>200 GeV | ATLAS-CONF-2012-152 |
| | Gravitino LSP | 0 | mono-jet | Yes | 10.5 | $F^{1/2}$ scale | 645 GeV | $m(\tilde{g})$>$10^{-4}$ eV | ATLAS-CONF-2012-147 |
| $3^{rd}$ gen. $\tilde{g}$ med. | $\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$ | 0 | 3 $b$ | Yes | 20.1 | $\tilde{g}$ | 1.2 TeV | $m(\tilde{\chi}_1^0)$<600 GeV | ATLAS-CONF-2013-061 |
| | $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$ | 0 | 7-10 jets | Yes | 20.3 | $\tilde{g}$ | 1.14 TeV | $m(\tilde{\chi}_1^0)$ <200 GeV | ATLAS-CONF-2013-054 |
| | $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$ | 0-1 $e, \mu$ | 3 $b$ | Yes | 20.1 | $\tilde{g}$ | 1.34 TeV | $m(\tilde{\chi}_1^0)$<400 GeV | ATLAS-CONF-2013-061 |
| | $\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$ | 0-1 $e, \mu$ | 3 $b$ | Yes | 20.1 | $\tilde{g}$ | 1.3 TeV | $m(\tilde{\chi}_1^0)$<300 GeV | ATLAS-CONF-2013-061 |
| $3^{rd}$ gen. squarks direct production | $\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}_1^0$ | 0 | 2 $b$ | Yes | 20.1 | $\tilde{b}_1$ | 100-630 GeV | $m(\tilde{\chi}_1^0)$<100 GeV | ATLAS-CONF-2013-053 |
| | $\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^\pm$ | 2 $e, \mu$ (SS) | 0-3 $b$ | Yes | 20.7 | $\tilde{b}_1$ | 430 GeV | $m(\tilde{\chi}_1^\pm)$=2 $m(\tilde{\chi}_1^0)$ | ATLAS-CONF-2013-007 |
| | $\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 1-2 $e, \mu$ | 1-2 $b$ | Yes | 4.7 | $\tilde{t}_1$ | 167 GeV | $m(\tilde{\chi}_1^0)$=55 GeV | 1208.4305, 1209.2102 |
| | $\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$ | 2 $e, \mu$ | 0-2 jets | Yes | 20.3 | $\tilde{t}_1$ | 220 GeV | $m(\tilde{\chi}_1^0)$ =$m(\tilde{t}_1)$-$m(W)$-50 GeV, $m(\tilde{t}_1)$<<$m(\tilde{\chi}_1^\pm)$ | ATLAS-CONF-2013-048 |
| | $\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 2 $e, \mu$ | 0-2 jets | Yes | 20.3 | $\tilde{t}_1$ | 150-440 GeV | $m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{t}_1)$-$m(\tilde{\chi}_1^\pm)$=10 GeV | ATLAS-CONF-2013-048 |
| | $\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$ | 0 | 2 $b$ | Yes | 20.1 | $\tilde{t}_1$ | 150-580 GeV | $m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^0)$=5 GeV | ATLAS-CONF-2013-053 |
| | $\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$ | 1 $e, \mu$ | 1 $b$ | Yes | 20.7 | $\tilde{t}_1$ | 200-610 GeV | $m(\tilde{\chi}_1^0)$=0 GeV | ATLAS-CONF-2013-037 |
| | $\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$ | 0 | 2 $b$ | Yes | 20.5 | $\tilde{t}_1$ | 320-660 GeV | $m(\tilde{\chi}_1^0)$=0 GeV | ATLAS-CONF-2013-024 |
| | $\tilde{t}_1\tilde{t}_1$(natural GMSB) | 2 $e, \mu$ ($Z$) | 1 $b$ | Yes | 20.7 | $\tilde{t}_1$ | 500 GeV | $m(\tilde{\chi}_1^0)$>150 GeV | ATLAS-CONF-2013-025 |
| | $\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1 + Z$ | 3 $e, \mu$ ($Z$) | 1 $b$ | Yes | 20.7 | $\tilde{t}_2$ | 520 GeV | $m(\tilde{t}_1)$=$m(\tilde{\chi}_1^0)$+180 GeV | ATLAS-CONF-2013-025 |
| EW direct | $\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$ | 2 $e, \mu$ | 0 | Yes | 20.3 | $\tilde{\ell}$ | 85-315 GeV | $m(\tilde{\chi}_1^0)$=0 GeV | ATLAS-CONF-2013-049 |
| | $\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$ | 2 $e, \mu$ | 0 | Yes | 20.3 | $\tilde{\chi}_1^\pm$ | 125-450 GeV | $m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$) | ATLAS-CONF-2013-049 |
| | $\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$ | 2 $\tau$ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm$ | 180-330 GeV | $m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$) | ATLAS-CONF-2013-028 |
| | $\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$ | 3 $e, \mu$ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ | 600 GeV | $m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})$=0.5($m(\tilde{\chi}_1^\pm)$+$m(\tilde{\chi}_1^0)$) | ATLAS-CONF-2013-035 |
| | $\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W^*\tilde{\chi}_1^0 Z^*\tilde{\chi}_1^0$ | 3 $e, \mu$ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ | 315 GeV | $m(\tilde{\chi}_1^\pm)$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled | ATLAS-CONF-2013-035 |
| Long-lived particles | Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^\pm$ | 0 | 1 jet | Yes | 4.7 | $\tilde{\chi}_1^\pm$ | 220 GeV | 1<$\tau(\tilde{\chi}_1^\pm)$<10 ns | 1210.2852 |
| | Stable, stopped $\tilde{g}$ R-hadron | 0 | 1-5 jets | Yes | 22.9 | $\tilde{g}$ | 857 GeV | $m(\tilde{\chi}_1^0)$=100 GeV, 10 $\mu$s<$\tau(\tilde{g})$<100 s | ATLAS-CONF-2013-057 |
| | GMSB, stable $\tilde{\tau}$ | 1-2 $\mu$ | 0 | - | 15.9 | $\tilde{\tau}$ | 385 GeV | 5<$\tan\beta$<50 | ATLAS-CONF-2013-058 |
| | Direct $\tilde{\tau}\tilde{\tau}$ prod., stable $\tilde{\tau}$ or $\tilde{\ell}$ | 1-2 $\mu$ | 0 | - | 15.9 | $\tilde{\tau}$ | 395 GeV | $m(\tilde{\tau})$=$m(\tilde{\ell})$ | ATLAS-CONF-2013-058 |
| | GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$ | 2 $\gamma$ | 0 | Yes | 4.7 | $\tilde{\chi}_1^0$ | 230 GeV | 0.4<$\tau(\tilde{\chi}_1^0)$<2 ns | 1304.6310 |
| | $\tilde{\chi}_1^0\to qq\mu$ (RPV) | 1 $\mu$ | 0 | Yes | 4.4 | $\tilde{q}$ | 700 GeV | 1 mm<$c\tau$<1 m, $\tilde{g}$ decoupled | 1210.7451 |
| RPV | LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e + \mu$ | 2 $e, \mu$ | 0 | - | 4.6 | $\tilde{\nu}_\tau$ | 1.61 TeV | $\lambda'_{311}$=0.10, $\lambda_{132}$=0.05 | 1212.1272 |
| | LFV $pp\to\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\to e(\mu) + \tau$ | 1 $e, \mu + \tau$ | 0 | - | 4.6 | $\tilde{\nu}_\tau$ | 1.1 TeV | $\lambda'_{311}$=0.10, $\lambda_{1(2)33}$=0.05 | 1212.1272 |
| | Bilinear RPV CMSSM | 1 $e, \mu$ | 7 jets | Yes | 4.7 | $\tilde{q}, \tilde{g}$ | 1.2 TeV | $m(\tilde{q})$=$m(\tilde{g})$, $c\tau_{LSP}$<1 mm | ATLAS-CONF-2012-140 |
| | $\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$ | 4 $e, \mu$ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm$ | 760 GeV | $m(\tilde{\chi}_1^0)$>300 GeV, $\lambda_{121}$>0 | ATLAS-CONF-2013-036 |
| | $\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$ | 3 $e, \mu + \tau$ | 0 | Yes | 20.7 | $\tilde{\chi}_1^\pm$ | 350 GeV | $m(\tilde{\chi}_1^0)$>80 GeV, $\lambda_{133}$>0 | ATLAS-CONF-2013-036 |
| | $\tilde{g}\to qqq$ | 0 | 6 jets | - | 4.6 | $\tilde{g}$ | 666 GeV | | 1210.4813 |
| | $\tilde{g}\to\tilde{t}_1 t$, $\tilde{t}_1\to bs$ | 2 $e, \mu$ (SS) | 0-3 $b$ | Yes | 20.7 | $\tilde{g}$ | 880 GeV | | ATLAS-CONF-2013-007 |
| Other | Scalar gluon | 0 | 4 jets | - | 4.6 | sgluon | 100-287 GeV | incl. limit from 1110.2693 | 1210.4826 |
| | WIMP interaction (D5, Dirac $\chi$) | 0 | mono-jet | Yes | 10.5 | $M^*$ scale | 704 GeV | $m(\chi)$<80 GeV, limit of<687 GeV for D8 | ATLAS-CONF-2012-147 |

Mass scale [TeV] (axis: $10^{-1}$, 1)

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1$\sigma$ theoretical signal cross section uncertainty.

# Summary and perspective



**No discovery yet**

**Motivations for SUSY still strong, many analyses in progress to full data sets.**

**Searches are physics mode oriented, very large number of final states analyzed (Presented limits valid within a specific simplified or constrained model)**

**New window opens in 2015 with 14 TeV collision energy!**
**Preparation of 14 TeV analyses ongoing!**

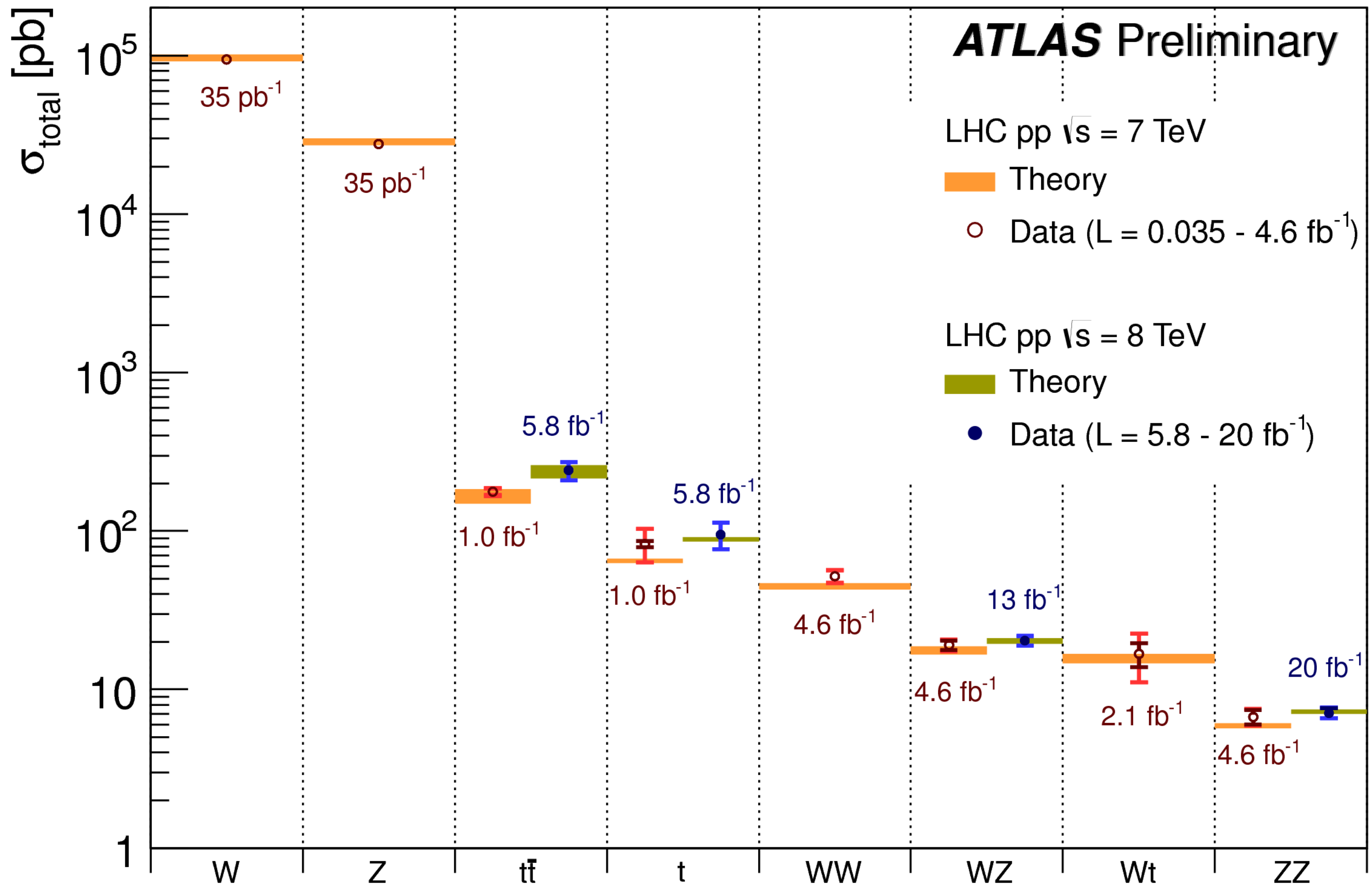


https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults

# Thank you!

# Backup slides

# Standard Model Cross-Sections




**$M_H$ = 125.5 GeV (ATLAS-CONF-2013-014)**

# ATLAS Detector

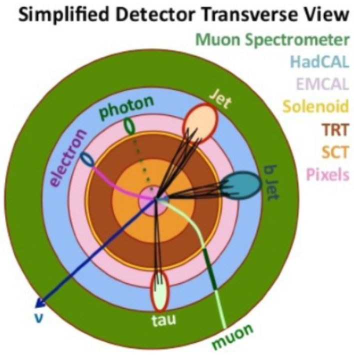
ATLAS superimposed to the 5 floors of building 40

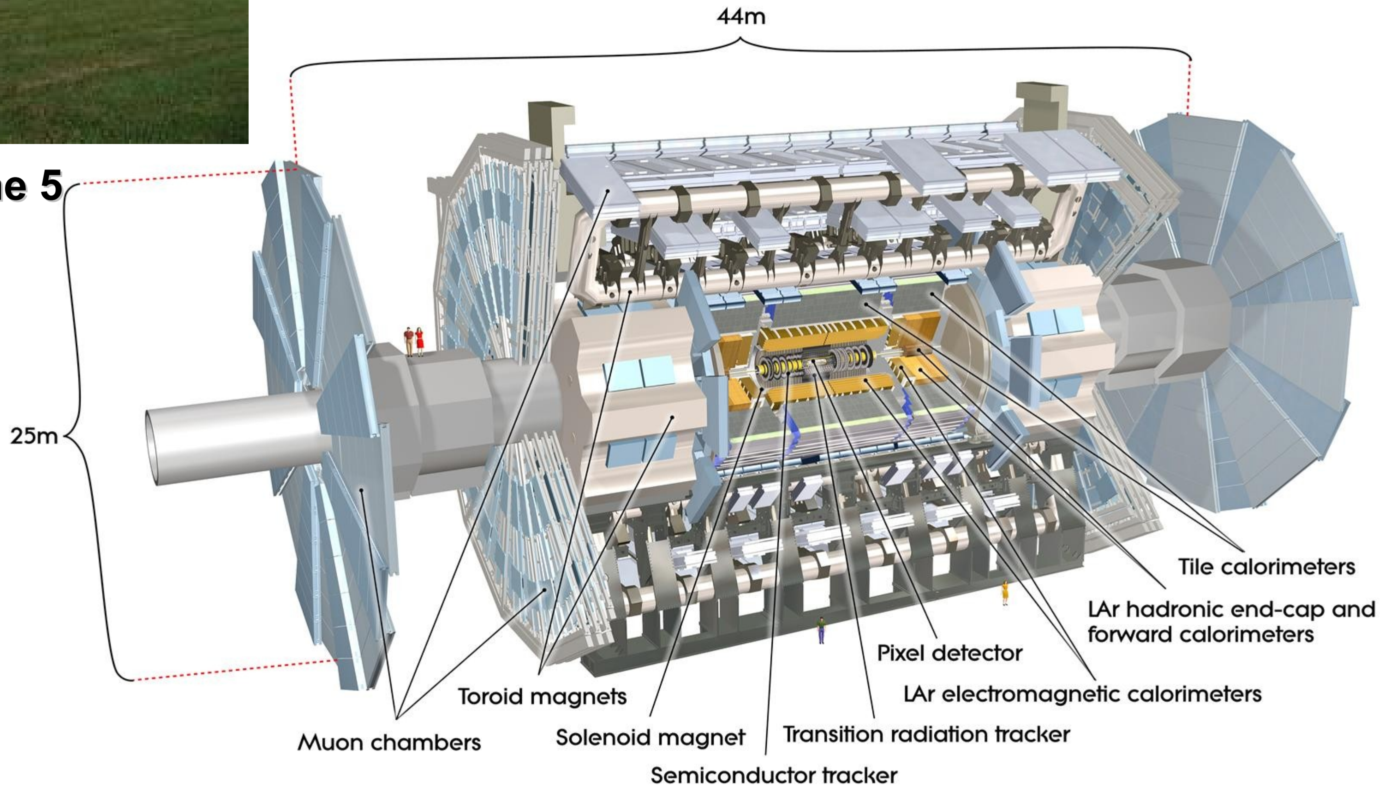
**Excellent resolution for jets, electrons, photons, muons and missing $E_T$**

**Excellent vertex reconstruction**

**~ 4π coverage in solid angle**

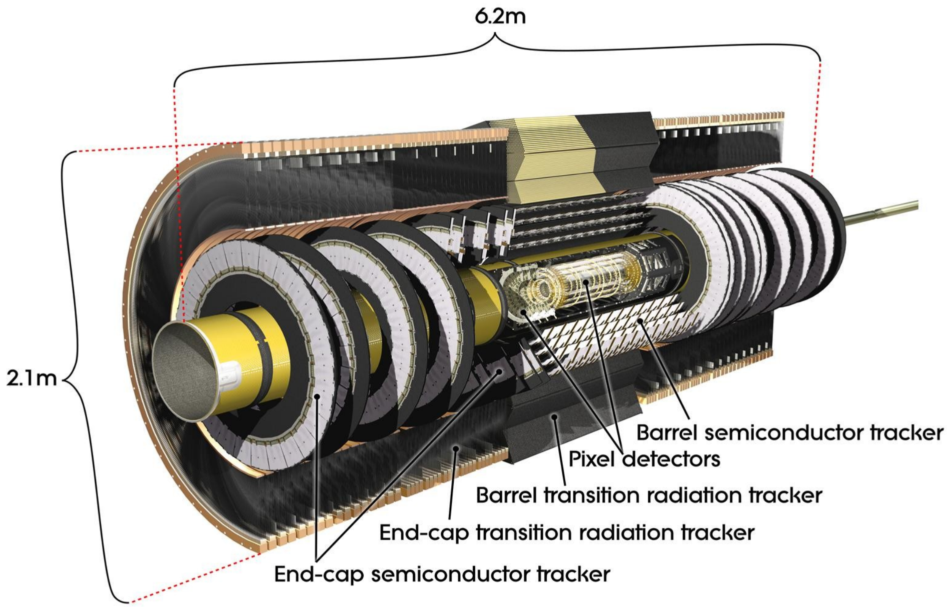
**7000 T**

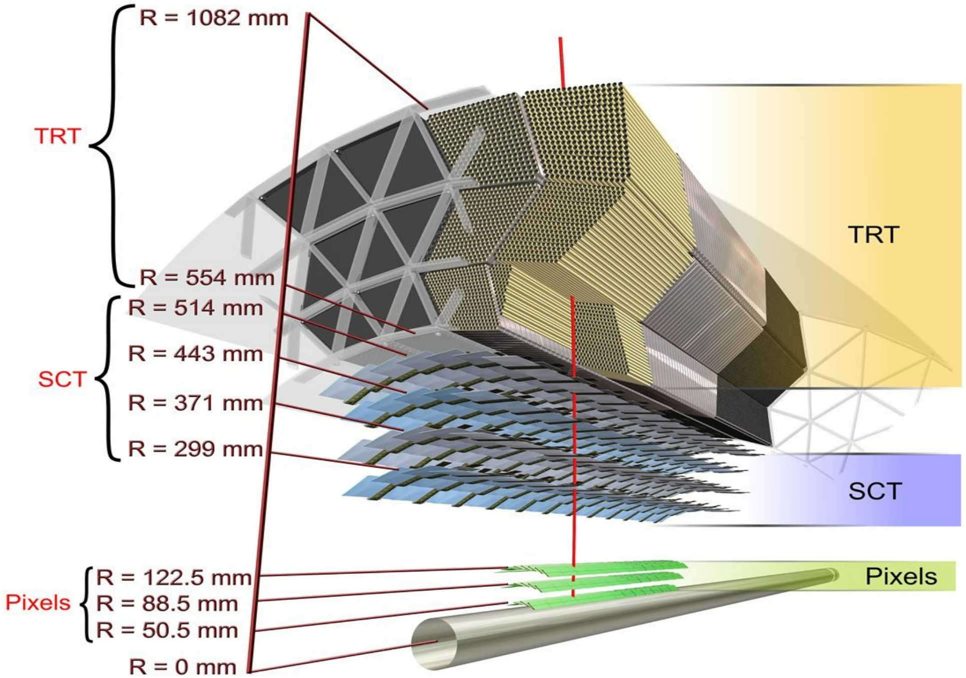


# Inner Detector (tracker)

Covers |η|<2.5 in a solenoidal magnetic field of 2T




Silicon pixels (**Pixel**): 0.8 $10^8$ channels
Silicon strips (**SCT**) : 6 $10^6$ channels
Transition Radiation Tracker (**TRT**) :
straw tubes (Xe), 4 $10^5$ channels
e/π separation

$$\sigma/p_T \sim 5\times10^{-4}\, p_T \oplus 0.01$$

**Pixel: each pixel is 50 μm wide in Rφ and 300 μm long. At R=4cm -- "B-layer" (good vertexing)**

**SCT: 4 double layers of silicon strips. Each double layer consists of strips aligned in the azimuthal direction and strips rotated by a 40 mrad stereo angle with respect to the first set. The strips have an 80 μm pitch and are 12 cm long.**

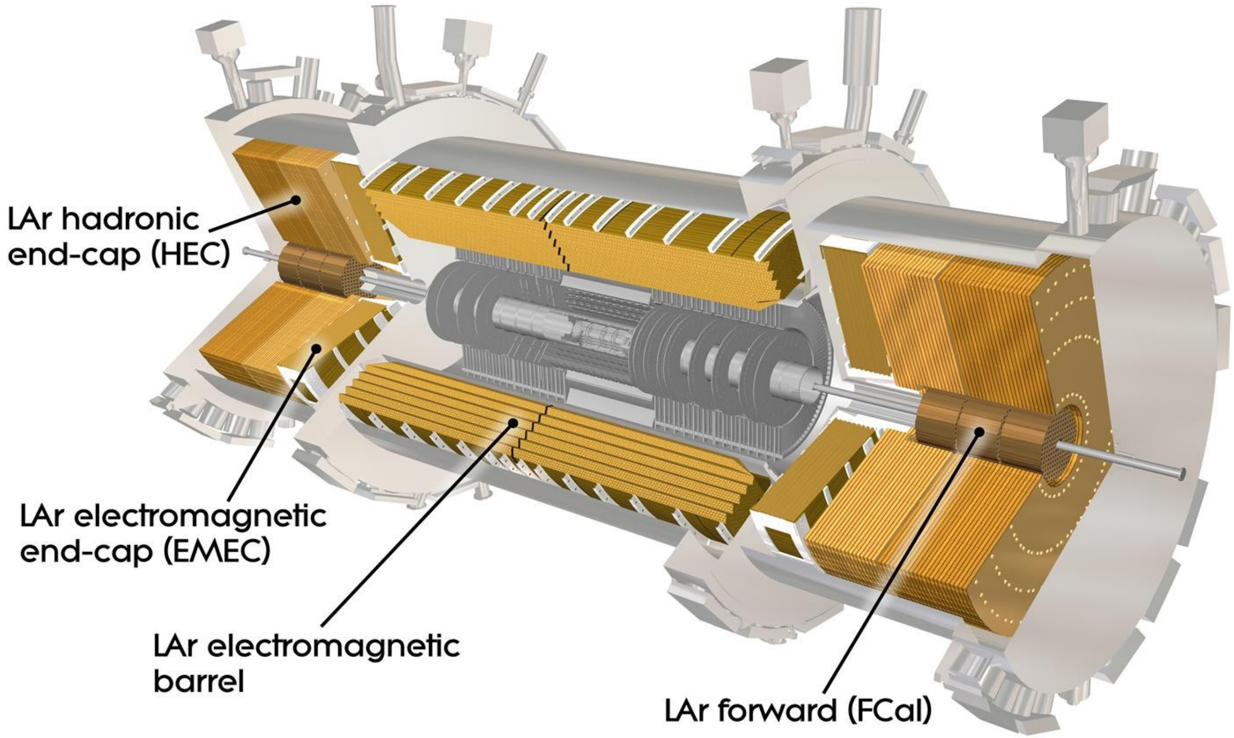
**TRT: consists of ~36 layers of 4 mm diameter straw tubes with resolutions ~200 μm**


25

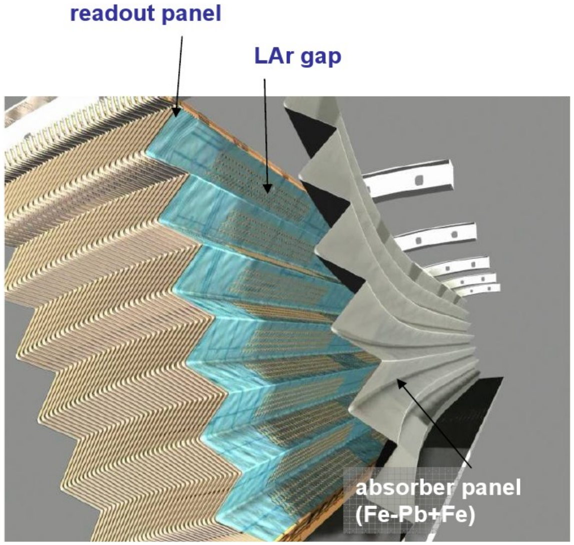
# LAr EM Calorimeter

**Barrel coverage |η|<3.2**

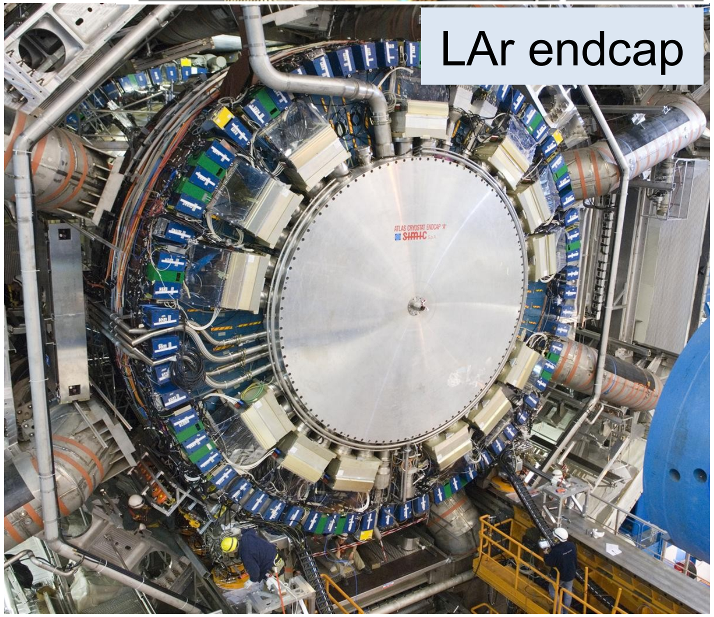
**Total coverage |η|<4.9**




High granularity accordion geometry




**Outer radius of 2.25 m and half-length 6.65 m**

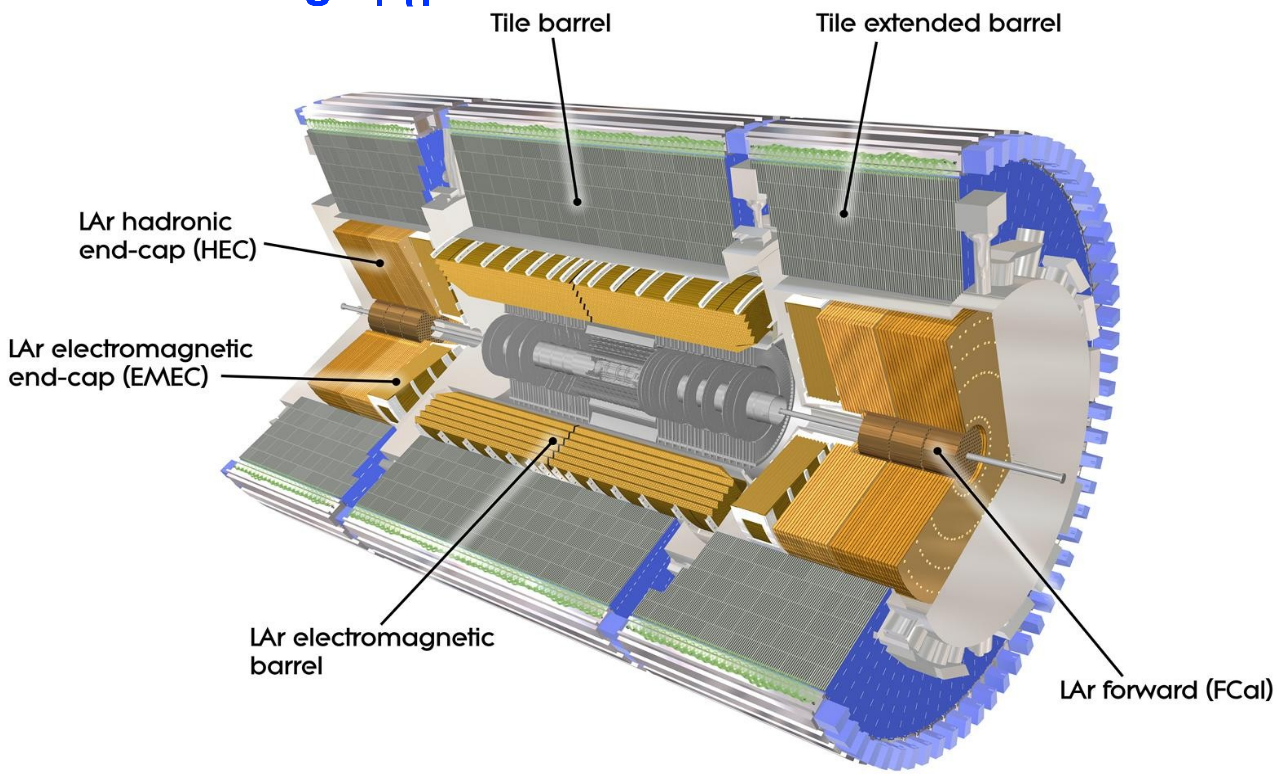


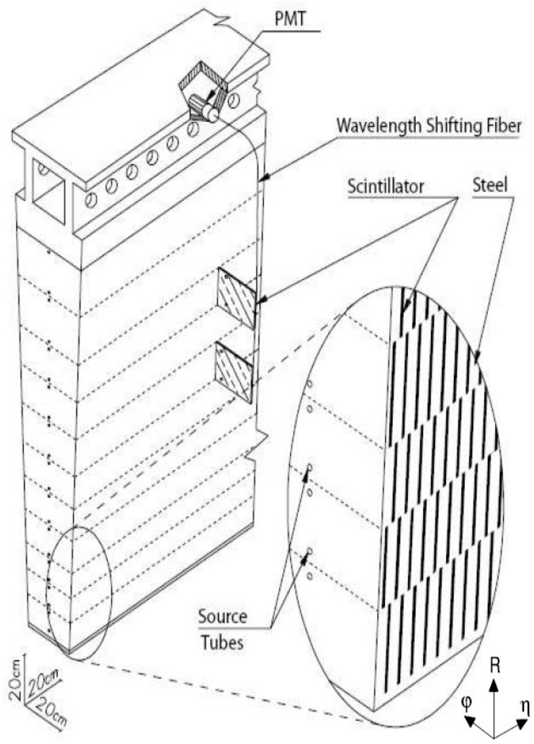

**Electromagnetic Calorimeter**
Barrel,Endcap: Lead-LAr
FCal: Copper/Tungsten-LAr
**~10%/√E energy resolution e/γ**
180000 channels: longitudinal segmentation
Trigger for e/γ

# Hadronic calorimeter

**Barrel coverage |η|<1.7**

**Total coverage |η|<5**




**Outer radius of 4.25 m and half-length 6.10 m**

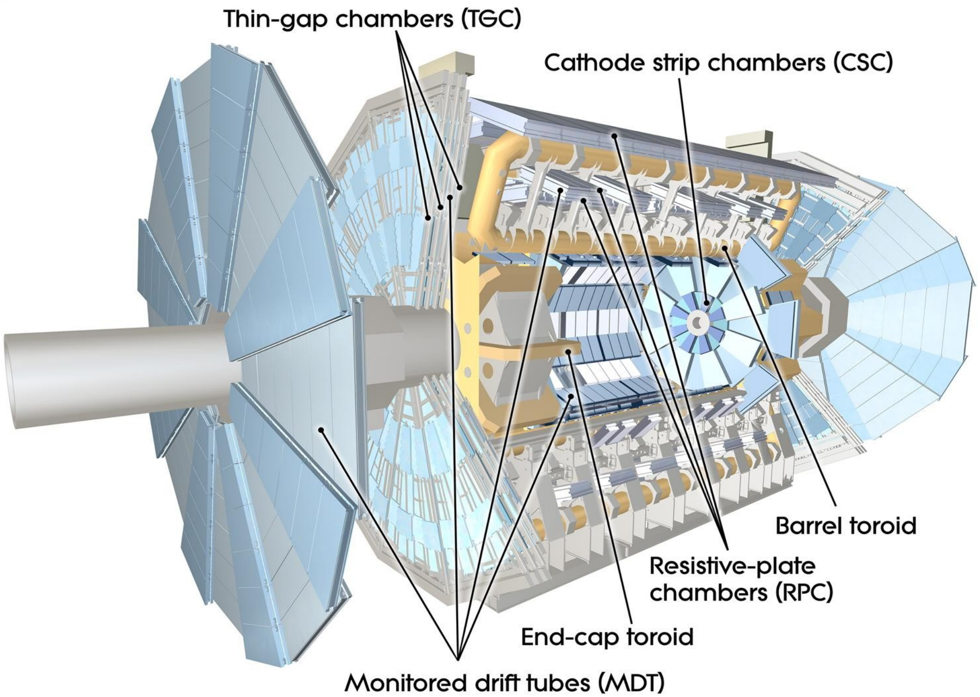

**Hadron Calorimeter**
barrel: Iron-Tile; HEC: Copper-LAr; (~20000 channels)
**$\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$ pion (at $\eta \approx 10\lambda$ ($\lambda$-interaction length))**

**Trigger** for **jets, Missing $E_T$**

**The total weight of the Calorimeter System is ~4000 Tons**

# Muon System (Spectrometer)

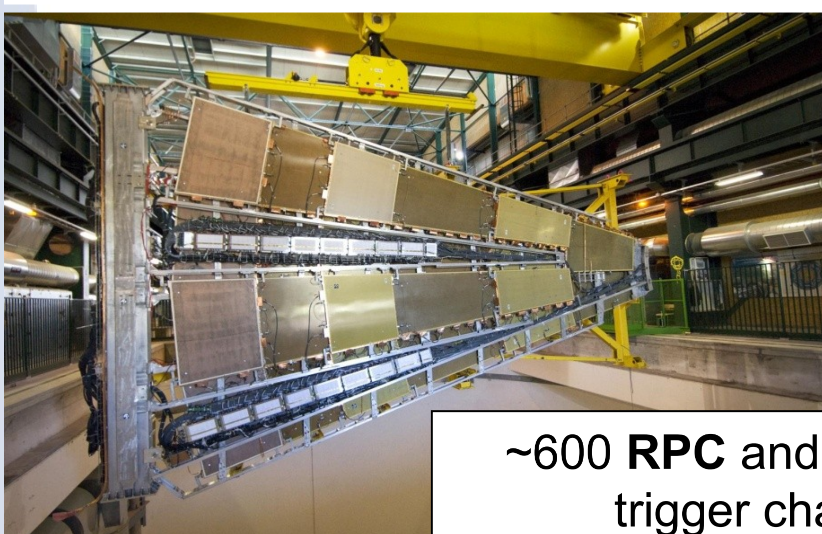
**Outer radius of 11 m and half-length 12.5 m**




Stand-alone momentum resolution Δpt/pt < 10% up to 1 TeV

2-6 Tm $|\eta|<1.3$   4-8 Tm $1.6<|\eta|<2.7$

~1200 **MDT** precision chambers for track reconstruction (+ **CSC**)



~600 **RPC** and ~3600 **TGC** trigger chambers