Searching for SUSY with 2 τ-leptons at ATLAS

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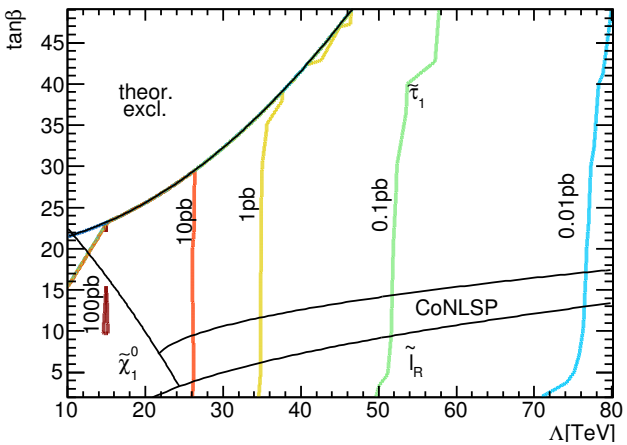
Introduction

- τ-leptons play an important role in various SUSY scenarios
- Their production can be enhanced with respect to the light leptons
- In gauge mediated SUSY breaking (GMSB) models the $\tilde{\tau}_1$ can be the only particle with significant coupling to the lighest supersymmetric particle (LSP)
- Very few Standard Model processes have multiple τ and missing energy in the final state
- Analysis performed with 2.05 fb^{-1} data collected at the ATLAS detector during 2011

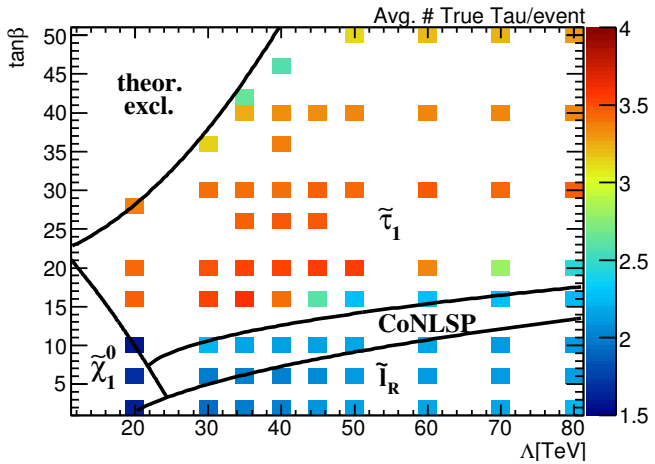
- Note: ATLAS-CONF-2012-002
- Paper: arXiv:1203.6580v1 [hep-ex]

Gauge-mediated SUSY breaking

- LSP is always a very light gravitino (eV scale)
- Next to lightest SUSY particle (NLSP) determines phenomenology
- 6 parameters in simplest approach
- Λ and $\tan\beta$ have the largest influence on mass hierarchy
- For the signal grid the other parameters have been fixed to ensure $\tilde{\ell}_R$ or $\tilde{\tau}_1$ NLSP



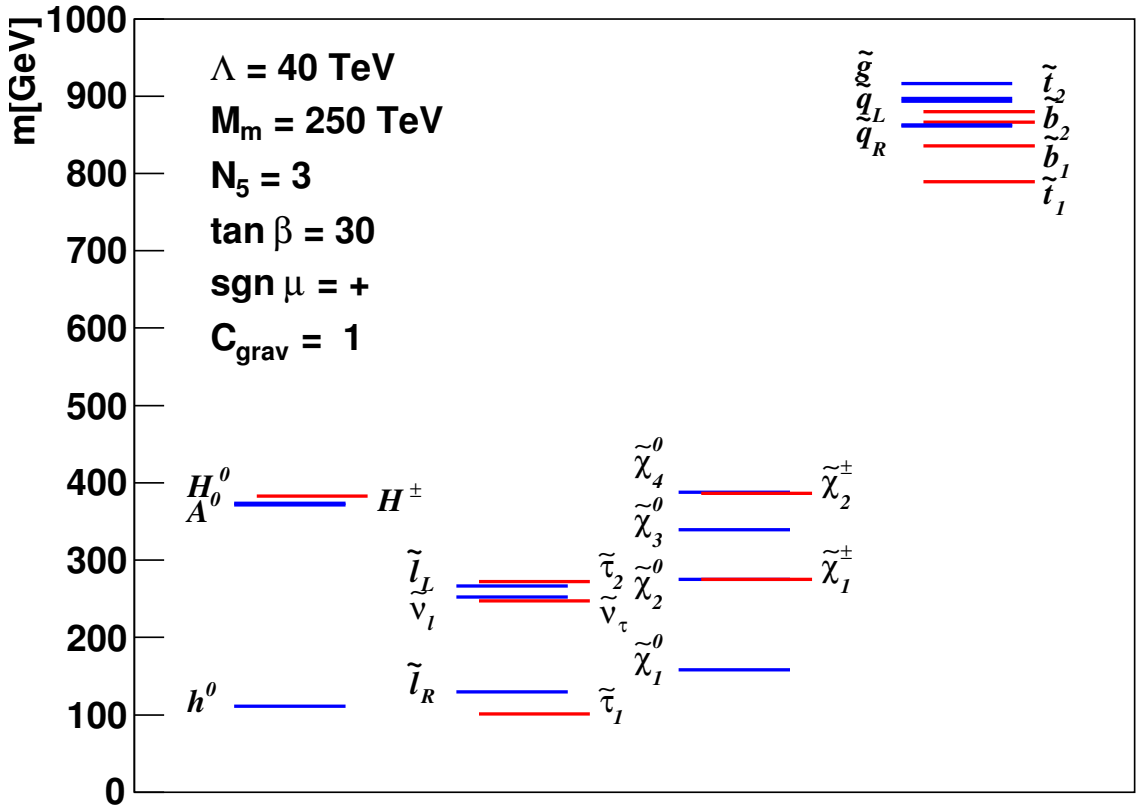
The GMSB NLO cross section in the $\Lambda - \tan\beta$ plane for $M_{mes} = 250$ TeV, $N_5 = 3$, $C_{grav} = 1$)



Average number of true τ

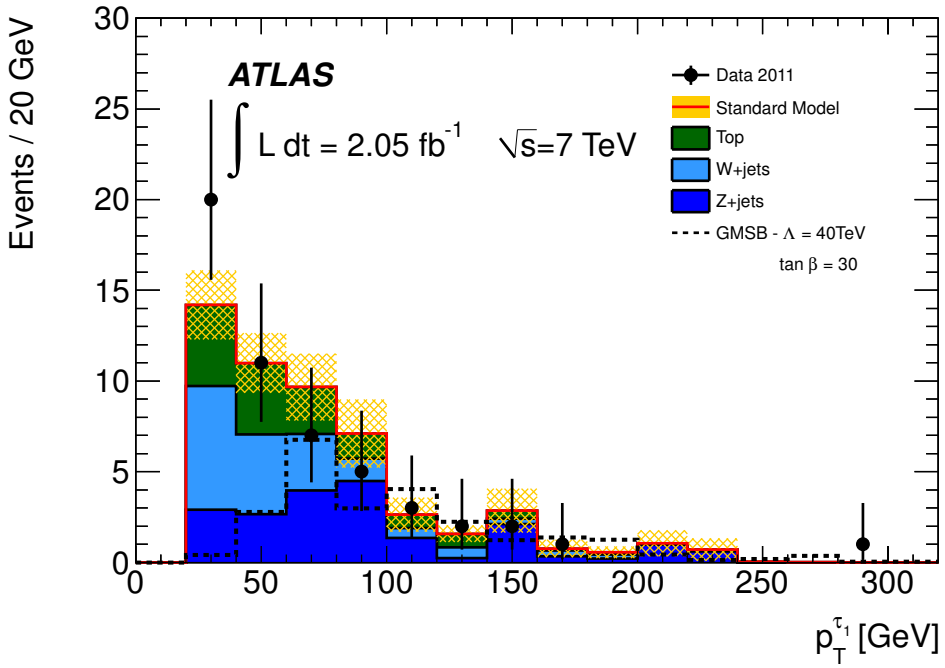
Benchmark points

Signal sensitivity studies were performed on a GMSB signal grid, with a point being chosen as a benchmark. This point, known as GMSB4030 has a $\widetilde{\tau}_1$ NLSP and lots of τ-leptons in the final state



Signal selection

- Jet + E_T^{miss} trigger
- Trigger plateau cuts:
  - $E_T^{miss} > 130$ GeV
  - jet$_1$ $p_T > 130$ GeV
- jet$_2$ $p_T > 30$ GeV
- Light lepton veto (e, μ)
- ≥ 2 τ, $p_T > 20$ GeV
- $\Delta\phi(\text{jet}_1, E_T^{miss}) \geq 0.4$ and $\Delta\phi(\text{jet}_2, E_T^{miss}) \geq 0.4$
- $m_{eff} > 700$ GeV
- $m_T(\tau_1, E_T^{miss}) + m_T(\tau_2, E_T^{miss}) > 80$ GeV



- m_{T} formed by $E_{\mathrm{T}}^{\mathrm{miss}}$ and the p_{T} of the tau lepton (τ) is defined as $m_{\mathrm{T}} = \sqrt{2 p_{\mathrm{T}}^{\tau} E_{\mathrm{T}}^{\mathrm{miss}} (1 - \cos(\Delta\phi(\tau, p_{\mathrm{T}}^{\mathrm{miss}})))}$
- m_{eff} is calculated as the sum of $E_{\mathrm{T}}^{\mathrm{miss}}$ and the magnitude of the p_{T} of the two leading jets and all selected taus

Background estimation & systematics

Background estimation

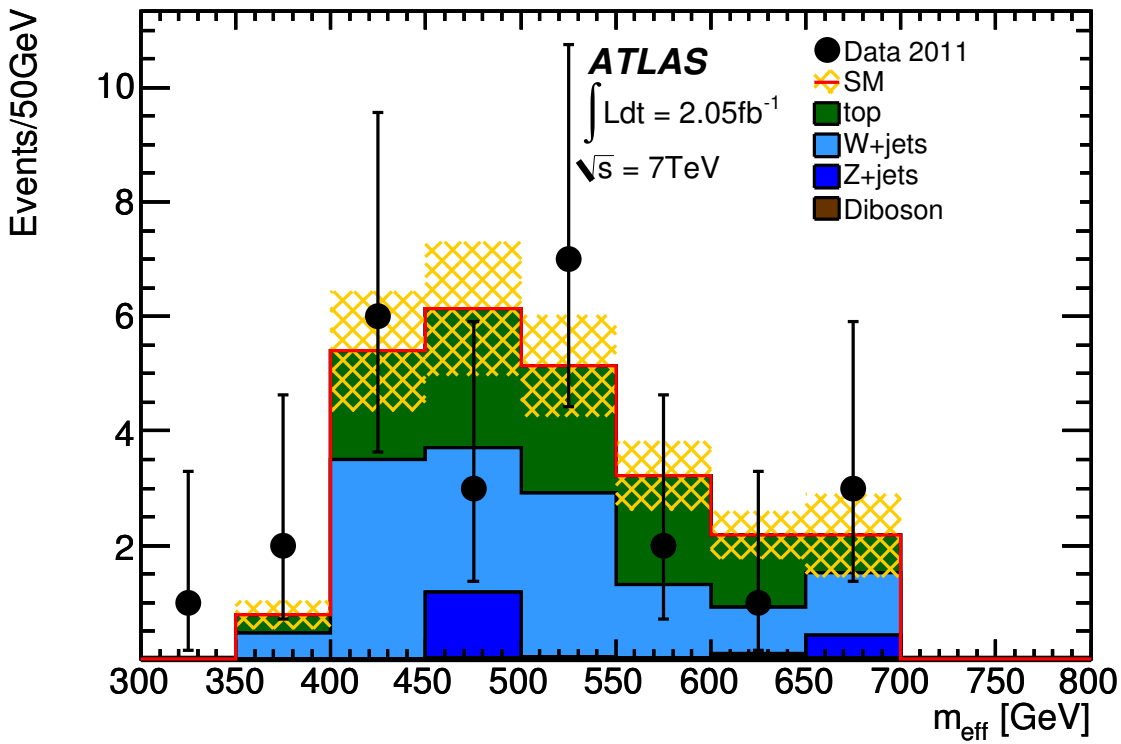
- Main SM background is due to W+jets and top (single top and $t\bar{t}$)
- Data driven background estimations performed by defining control regions in which a particular background was dominanat
- W and top CR defined by inverting m_{eff} cut
- Regions then separated by b-jet requirement
- QCD CR defined by also inverting $\Delta\phi$ cut

Systematics

- MC scaling
- Jet energy scale, jet energy resolution
- τ energy scale, τ identification uncertainty, τ fake uncertainty
- Pileup
- Luminosity

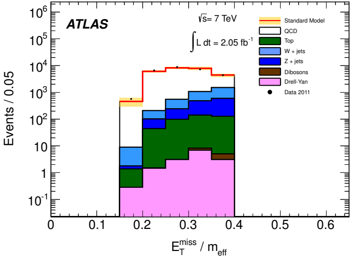
W/top background estimation

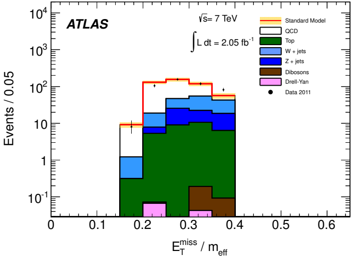
- Subtract non-W/top MC contribution from number of events in data
- Scale W and top MC simultaneously

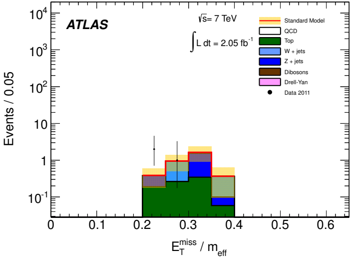


m_{eff} in the W/top CR, scaled

QCD background estimation





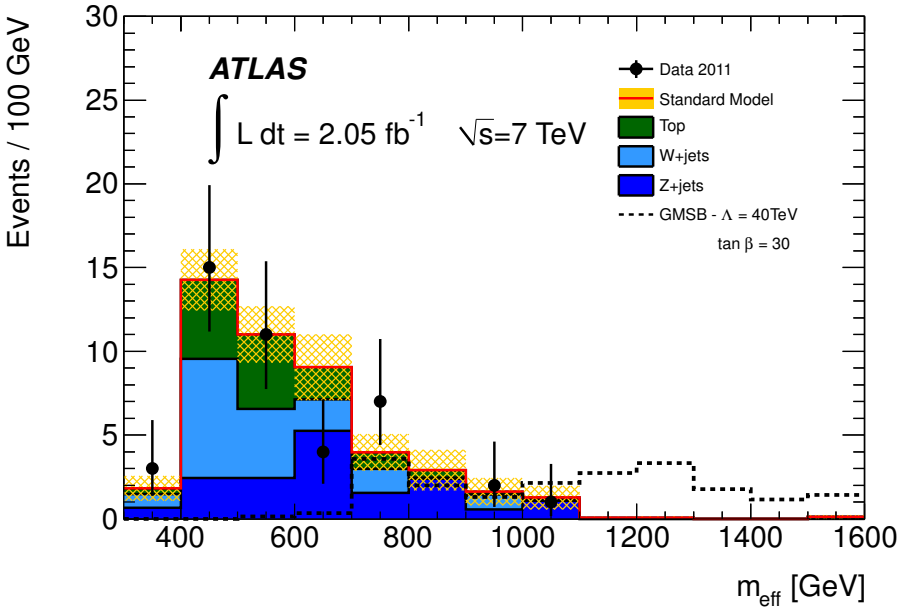


QCD control regions: The E_T^{miss}/m_{eff} distribution in the 0-tau sideband where the MC is scaled to data (top left), in the 1-tau sideband where the calculated fake rate and resulting sclaing factors have been applied (top right), and in the 2-tau sideband (bottom left).

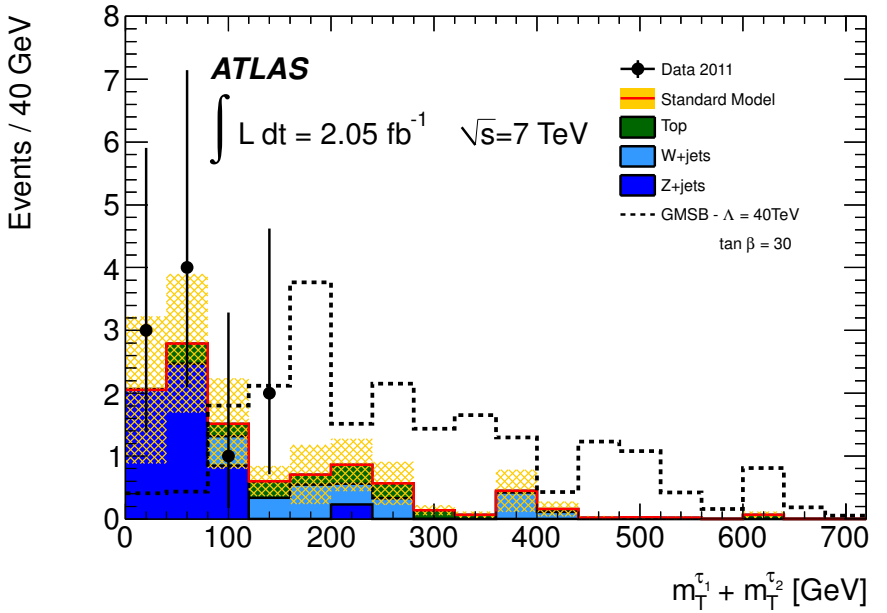
Results

	All MC	Data	GMSB4030
Preselection	116967 $\pm$ 4280	116655	400.0 $\pm$ 9.5
Lepton Veto	95534 $\pm$ 4258	99078	123.6 $\pm$ 6.4
$N_\tau \geq 1$	4038 $\pm$ 172	3647	71.6 $\pm$ 5.7
$N_\tau \geq 2$	53.0 $\pm$ 6.7	52	25.1 $\pm$ 3.5
$\Delta\phi(E_T^{miss}, \mathrm{jet1/2}) > 0.4$	46.7 $\pm$ 6.2	43	22.2 $\pm$ 3.4
$m_{eff} > 700\,\mathrm{GeV}$	10.2 $\pm$ 2.1	10	21.7 $\pm$ 3.4
$m_{T1} + m_{T2} > 80\,\mathrm{GeV}$	5.3 $\pm$ 1.3(stat)$\pm$2.2(sys)	3	20.8 $\pm$ 3.4 $\pm$ 5.4

Results

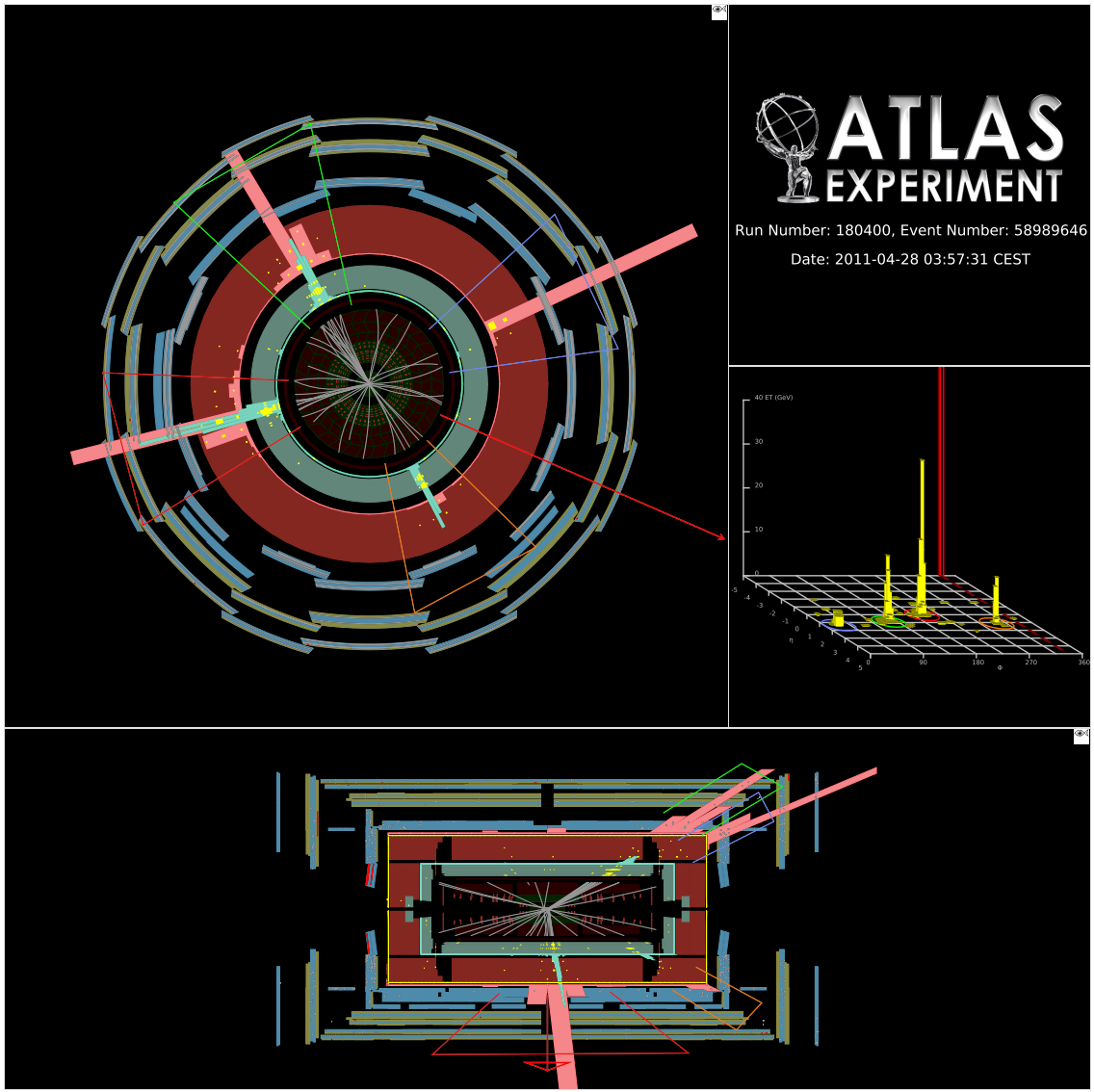


m_{eff} distribution after the $\Delta\phi$ cut



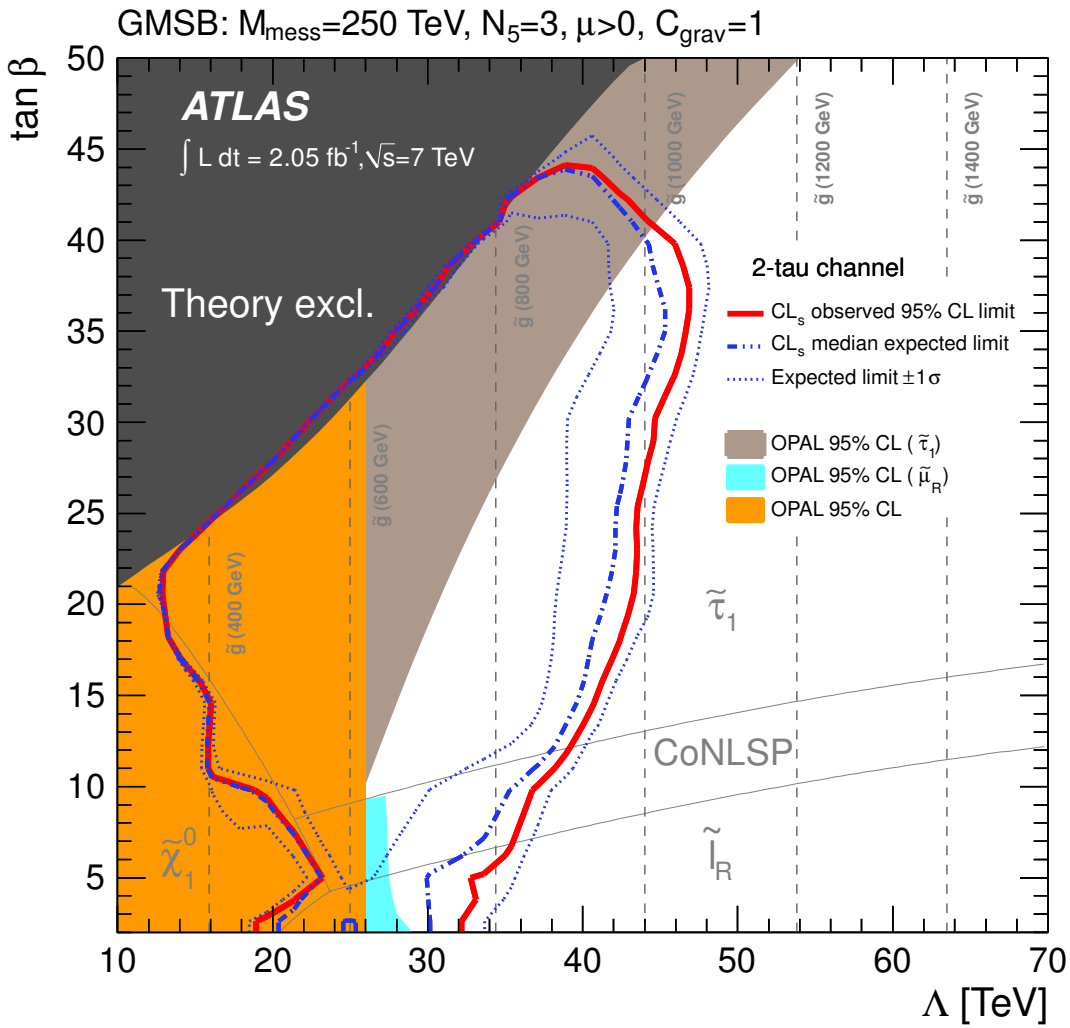
$m_{T1} + m_{T2}$ distribution after the m_{eff} cut

Event display



Event display for run 180400, event 58989646

Gauge-mediated SUSY breaking



Expected and observed 95% CL limits on the minimal GMSB model parameters Λ and $\tan\beta$ for $\tilde{\tau}_1^1$ and $\tilde{\ell}_R$ NLSP .

Conclusion

- We have presented a search for SUSY in events with 2 τ, high p_T jets and large E_T^{miss}
- Backgrounds well understood
- We find 3 events in the signal region, in good agreement with SM prediction $5.3 \pm 1.3(\text{stat}) \pm 2.2(\text{sys})$
- A 95% CL lower limit of 32 TeV is set on the GMSB breaking scale Λ independent of $\tan\beta$. This limit provides the most stringent test to date in a large part of the considered parameter space.
- Analysis presented at 2012 Winter conferences (ATLAS-CONF-2012-002)
- Paper on the arXiv (1203.6580v1), and has been submitted to PLB (CERN-PH-EP-2012-054)
- An update using the full 5 fb^{-1} 2011 dataset is underway