SUSY 2013 - ICTP Trieste ,Italy

Searches for SUSY with long-lived massive particles with the ATLAS detector

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On behalf of the ATLAS Collaboration

Introduction

- Many SUSY models give rise to long-lived massive particles (LLP) from:
  - Weak couplings (e.g. RPV)
  - Heavy mediator sparticles (e.g. heavy scalars in split SUSY)
  - Mass degeneracy (e.g. $m_{\chi^{\pm}} \approx m_{LSP}$ in AMSB)

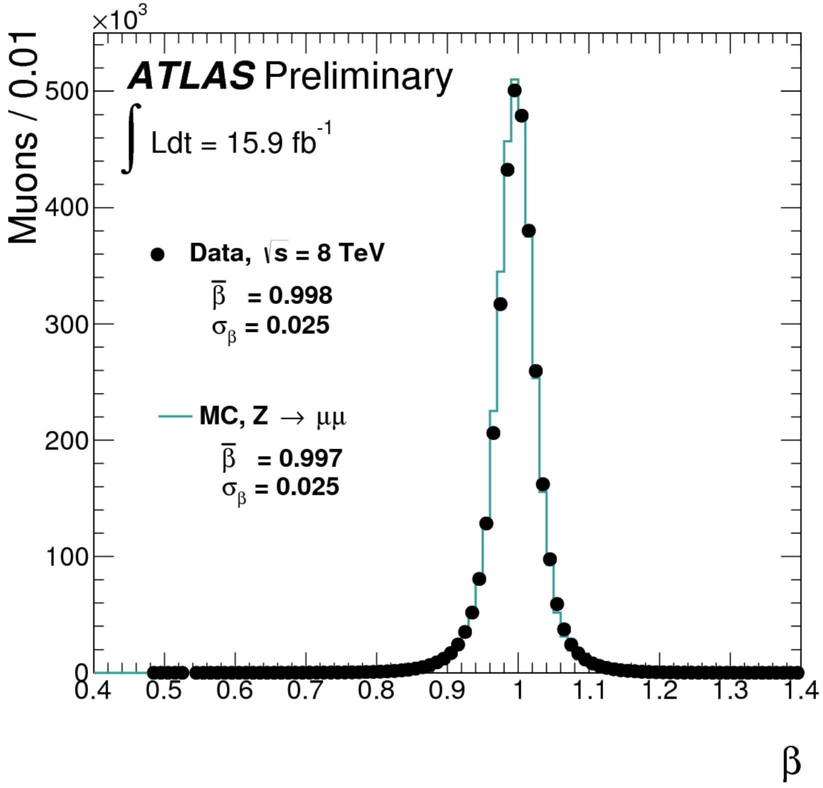
- These particles can be detected in ATLAS, giving different signatures
- This talk will cover the latest results from ATLAS for SUSY searches with LLP:

Analysis	Model	Date	Data	Note
Heavy Sleptons	GMSB	06/2013	8 TeV, 15.9 fb^{-1}	ATLAS-CONF-2013-058
Disappearing Tracks	AMSB	07/2013	8 TeV, 20.3 fb^{-1}	ATLAS-CONF-2013-069
Stopped-Gluino R hadrons	Split SUSY	06/2013	7+8 TeV, 27.9 fb^{-1}	ATLAS-CONF-2013-057
Displaced Vertices	RPV	08/2013	8 TeV, 20.3 fb^{-1}	ATLAS-CONF-2013-092 (new result for this conference)
Non-Pointing Photons	GMSB	04/2013	7 TeV, 4.8 fb^{-1}	PRD 88, 012001 (2013) 1304.6310

Heavy Long-Lived Sleptons

- Framework of gauge-mediated SUSY breaking (GMSB) where the $\tilde{\tau}_1$ is the NLSP and may be long-lived
  - Events contain two $\tilde{\tau}_1$

- Heavy charged LLP with $c\tau$ > few meters appears like a heavy muon
- Signature:
  - low β → time-of-flight
  - High hadronization → large dE/dx



- Mass: $\boxed{m = \frac{p}{\beta\gamma}}$

taken from track

pixel (dE/dx) + calorimeter + muon detector (ToF)

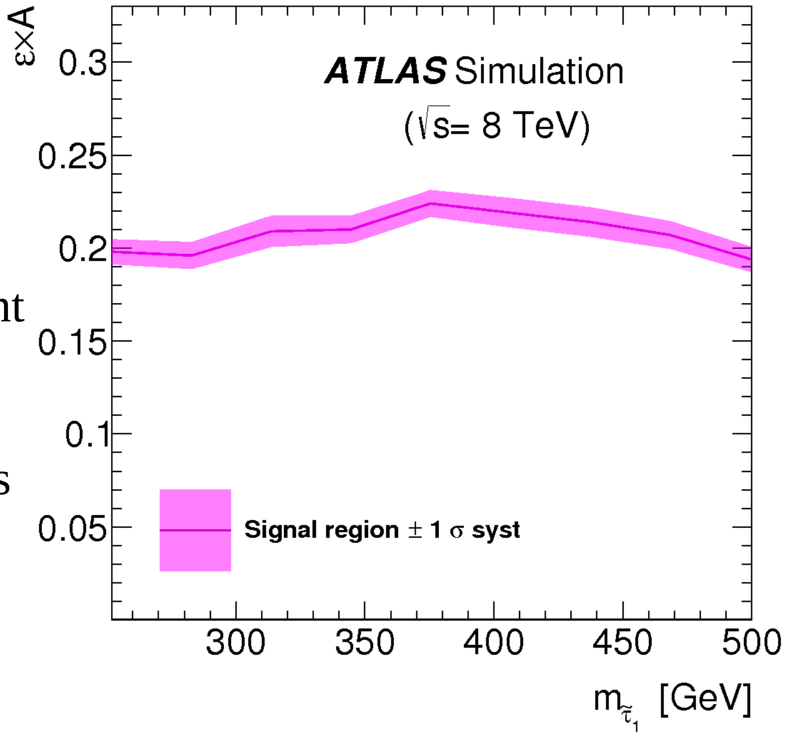
- Good detector calibration is crucial
- Calibration uses muons from $Z^0 \rightarrow \mu^+\mu^-$ events and takes their timing measurements from different detector elements:
  - Means of distributions used to correct calibration
  - Widths used as resolution of time measurement in β^{-1} average and to smear simulation

Heavy Long-Lived Sleptons

Selection

- Muon trigger
- Two muon candidates with p_T> 50 GeV
- Veto Z^0 mass and cosmic muons
- β measurement consistency
  - Within same sub-detector and between different sub-detectors
- $0.2 < \beta < 0.95$
- Additional model-dependent cuts on candidate mass

- Control region is events with one muon and tighter selection on p_T and β consistency



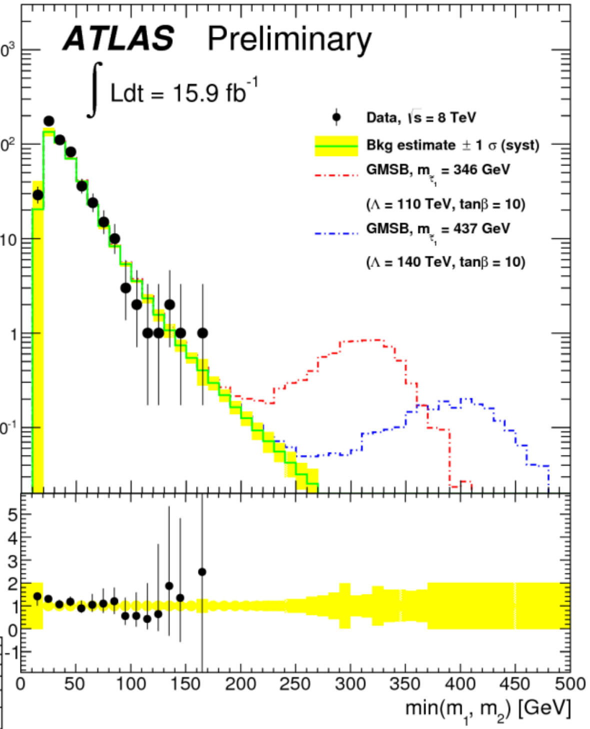
efficiency × acceptance for directly produced $\tilde{\tau}_1$

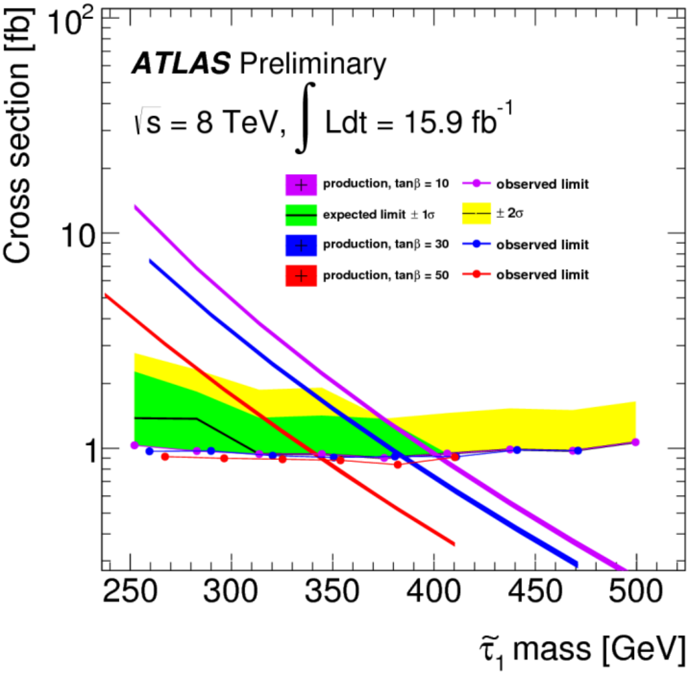
Background

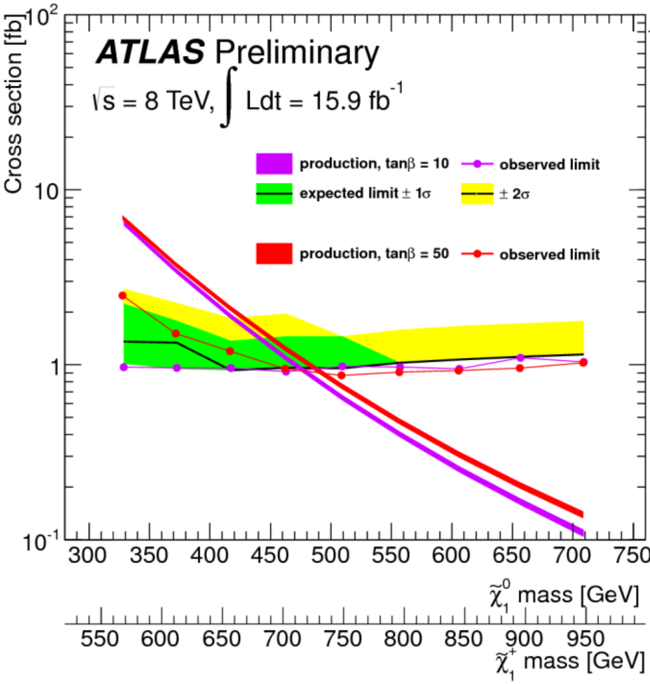
- Main background source is high-p_T muons with mis-measured β
- Fully data-driven background estimation method
- Estimated by generating combination of the p of a candidate passing the selection with a random β extracted from muon β distribution

Heavy Long-Lived Sleptons

- No signal above the expected background is observed
- Results are interpreted in the GMSB context
- Upper cross-section limits on model-independent cross-sections for $\tilde{\tau}_1$ production obtained at 95% CL (shown here)
- Mass limits for direct $\tilde{\tau}_1$ production (30%-63%) and direct $\tilde{\chi}^0{}_1$ and $\tilde{\chi}^{\pm}{}_1$ production (30%-50%)







depends on tanβ

Disappearing Tracks

Search is performed in the context of anomaly-mediated SUSY breaking model (AMSB).

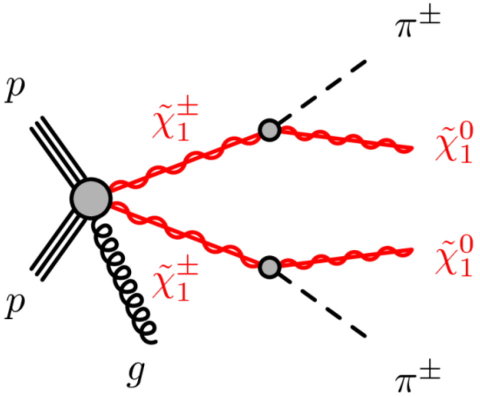
Characteristics

- LSP = pure Wino
- $\Delta m \approx 160$ MeV (between chargino and LSP)
  - Measurable lifetime $c\tau_{\chi^{\pm}} \approx O(10)$ cm
  - Decay inside ATLAS inner detector
- Chargino decays into a neutralino (MET) + soft pion (isn't reconstructed)

Chargino is observed as a **disappearing track**

Trigger

Mono-jet (from ISR)
+ MET,
with Δφ(jet,MET) ≈ π

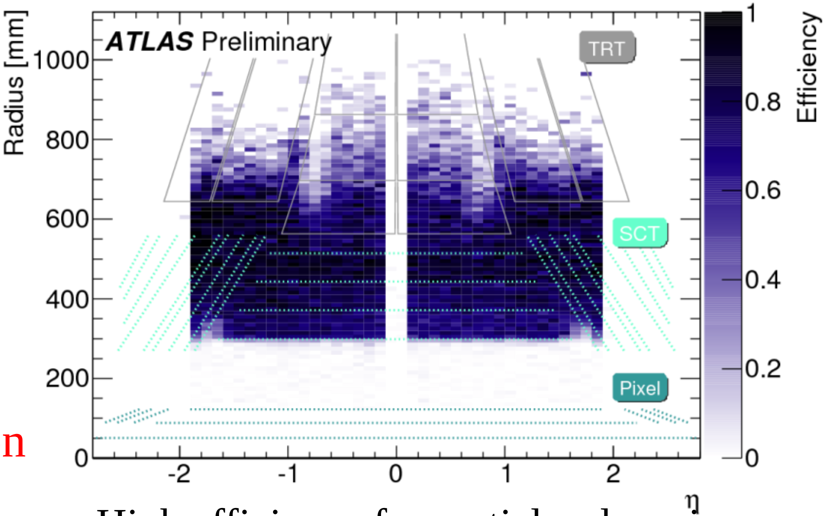


Selection

Select good, isolated high-p_T tracks with < 5 TRT hits

Veto events with leptons

Dedicated track reconstruction significantly improves the sensitivity to short lifetimes compared to previous analysis

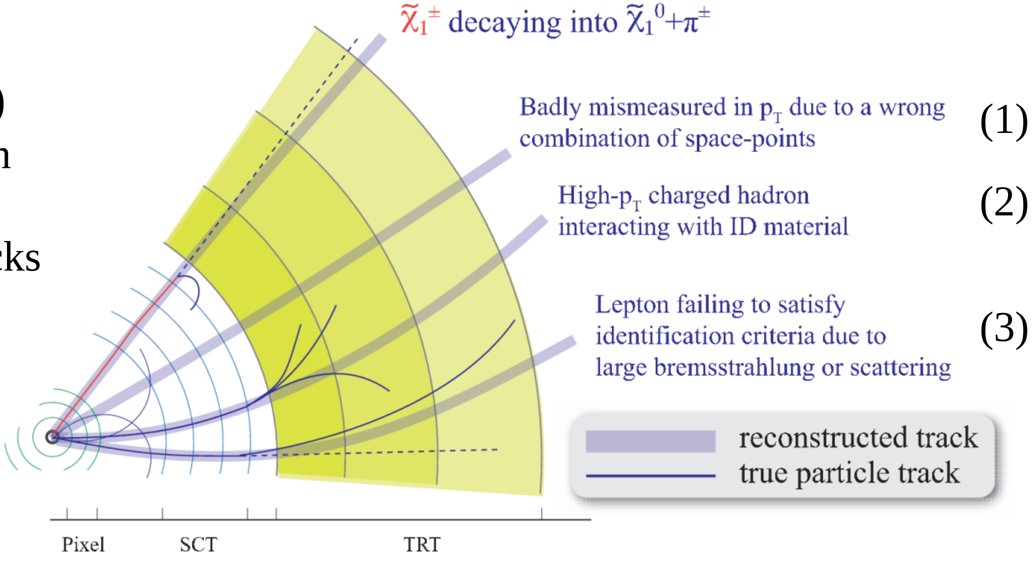


High efficiency for particles decaying after the PIXEL and before the TRT

Disappearing Tracks

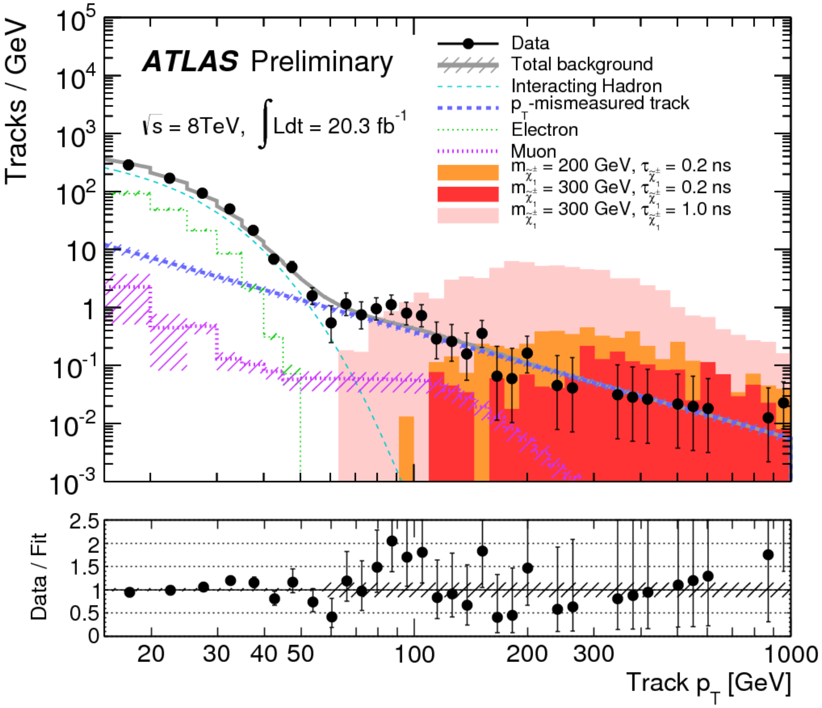
Three main background sources

1. p_T-mismeasured tracks (main source)
   - Wrong combination of seed-cluster in pixel detector
   - Wrong extension of pixel-seeded tracks
2. Interacting hadron tracks
   - Comes mainly from W→τν
   - Large calorimeter activities
3. Unidentified leptons
   - Leptons which survive lepton veto



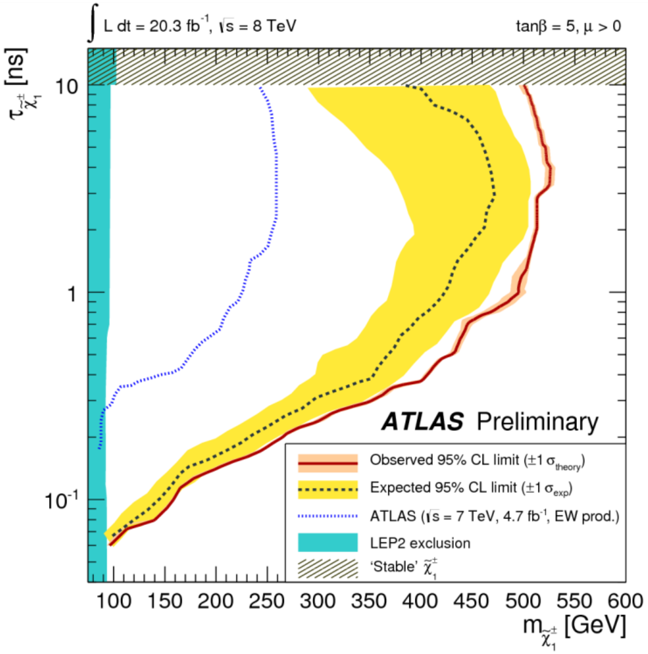
Background estimation

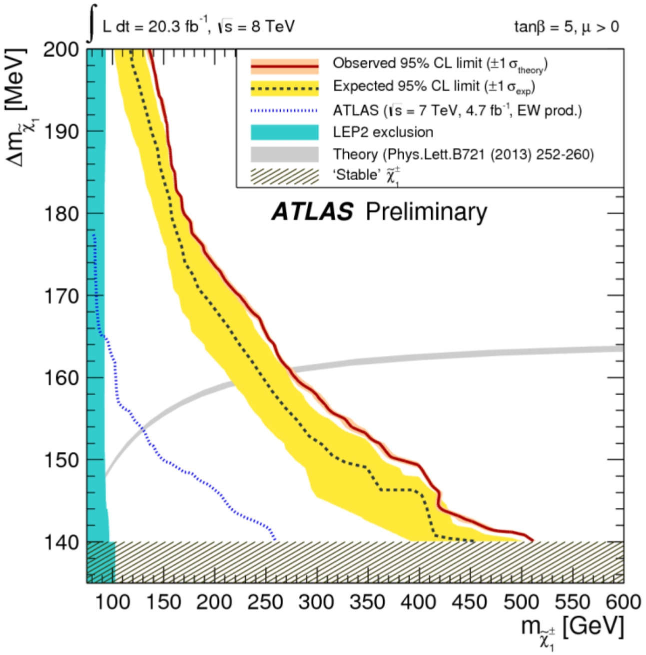
- Background tracks p_T-shape from data control samples
  - Unidentified-leptons normalization also determined from data control sample
- Signal tracks p_T-shape from MC
- Perform signal + background template fit for candidate tracks



Disappearing Tracks

Data consistent with background → Limit setting





- In the high p_T region, observed number of events is a bit smaller than the fit result, so the observed limit is tighter than the expected limit.

- In AMSB model with τ ~0.2 ns and Δm ~160 MeV, chargino mass up to 270 GeV is excluded.
- For longer chargino lifetimes of τ ~1-10 ns, chargino mass up to 520 GeV is excluded.

Stopped-Gluino R hadrons

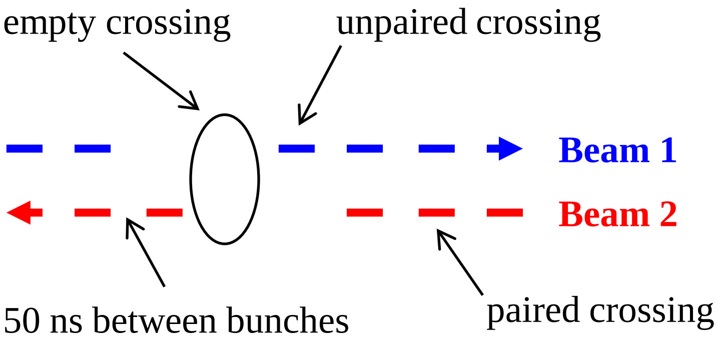
Signature Overview

- pp → $\tilde{g}\tilde{g}$
- $\tilde{g}$ have long lifetimes ⟶ form R-hadrons with SM quarks from the vacuum
- R-hadron looses energy via dE/dx and nuclear scattering (can exchange charge) ⟶ $\tilde{g}$ comes to rest within ATLAS and decays at a later time
- $\tilde{g}$ that decay during empty bunch-crossing can be detected ⟶ Out-of-time jets

Efficiency

Depends on lifetime τ (short/long):

$$\underset{\substack{\uparrow \\ \text{stopping} \\ \text{fraction}}}{\varepsilon_{stop}} \times \underset{\substack{\uparrow \\ \text{probability to decay} \\ \text{in an empty bunch} \\ \text{(timing acceptance)}}}{\varepsilon_T(\tau)} \times \underset{\substack{\nwarrow \\ \text{reconstruction} \\ \text{efficiency}}}{\varepsilon_{reco}}$$



empty crossing

unpaired crossing

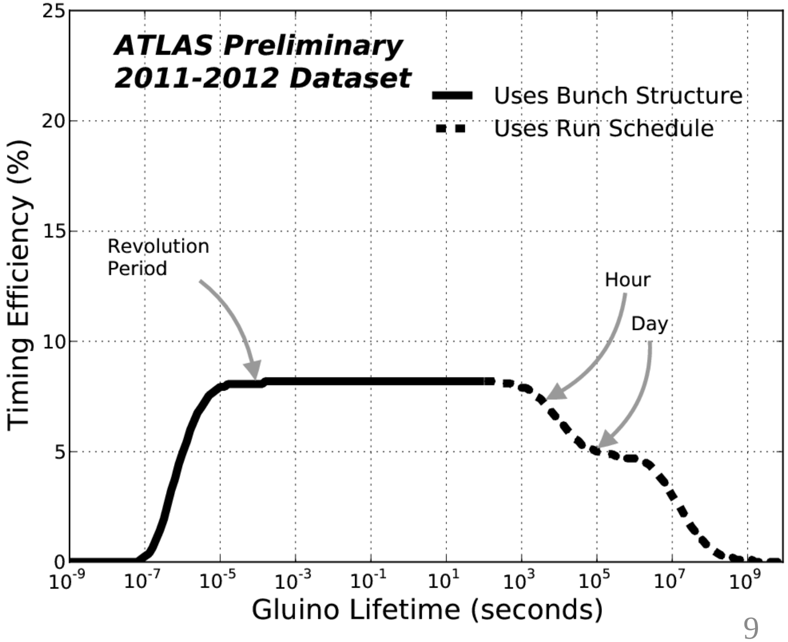
Beam 1

Beam 2

50 ns between bunches

paired crossing

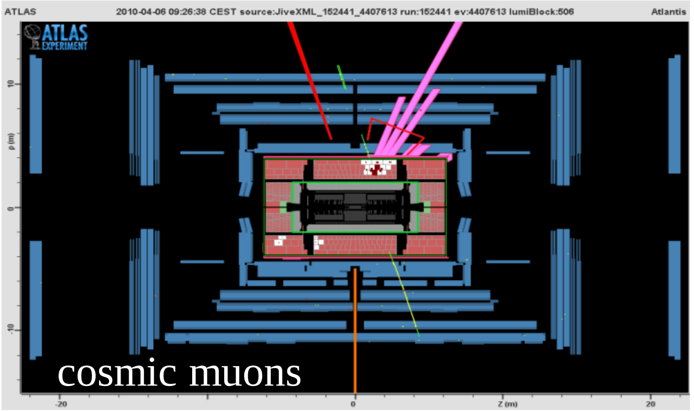
- LHC bunch structure and crossing types
- ~10% empty bunches are usable for this analysis

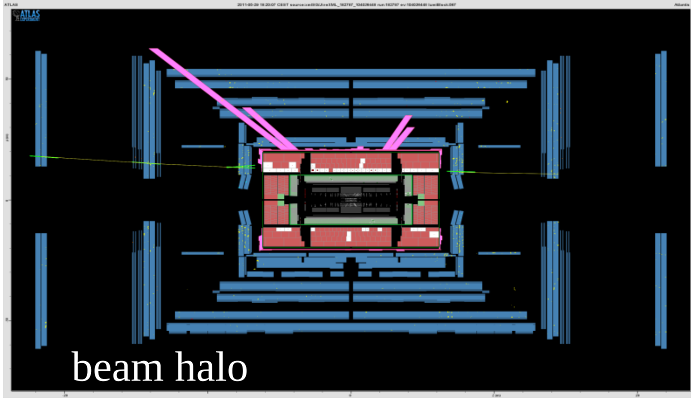


Stopped-Gluino R hadrons

<u>Two major background sources</u>

- Cosmic muons
  estimated from early run period with low luminosity
- Beam halo
  estimated from unpaired crossings



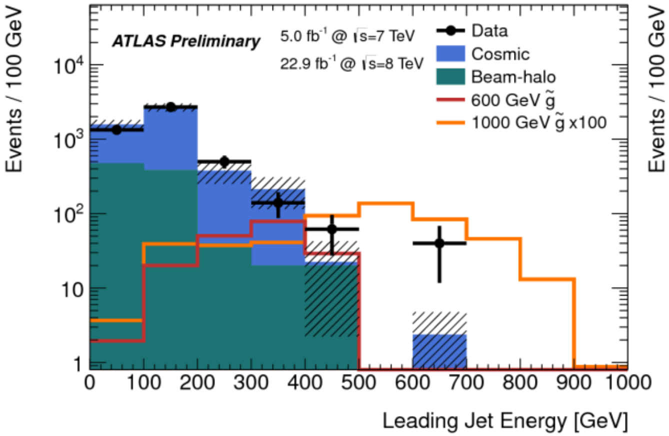


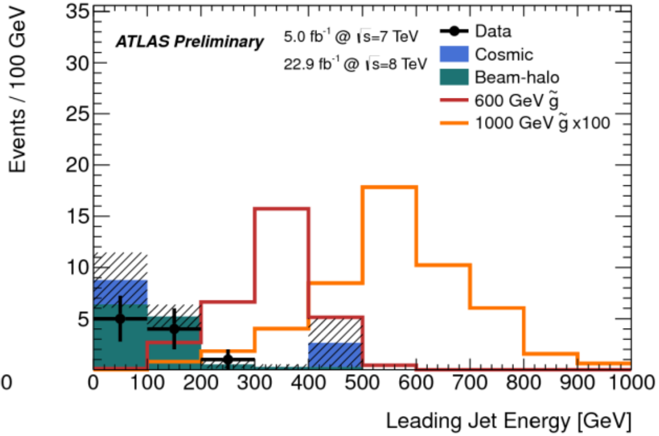
<u>Selection</u>

- Trigger on empty bunch with
  jet p_T>50 Gev + MET>50 GeV
- Jet selection: |η|<1.2, E>100, 300 GeV
- Muon activity veto

before

after





Background events removed by muon activity veto

Stopped-Gluino R hadrons

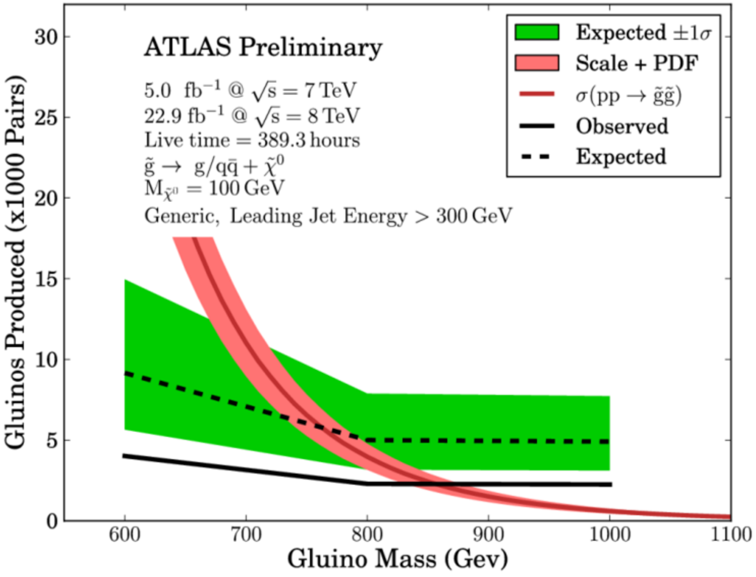
Data consistent with background:

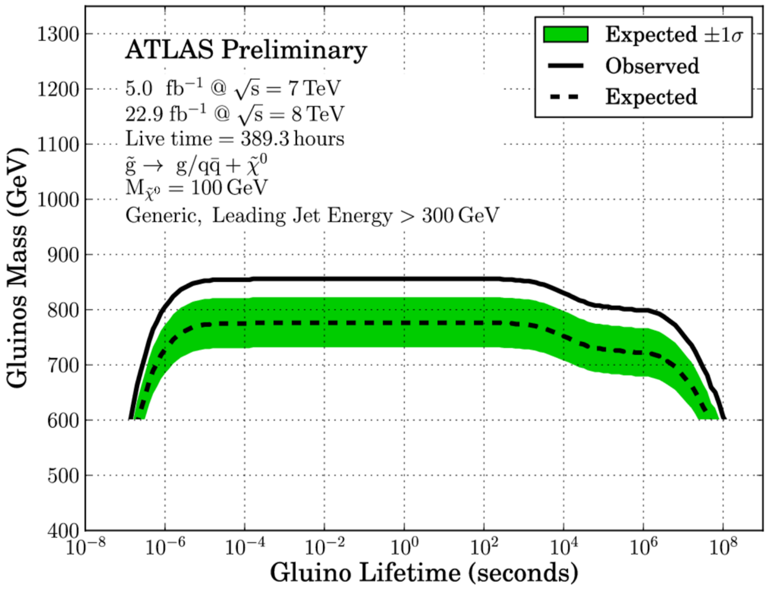
Leading jet energy (GeV)	Muon veto	Number of events			
		Cosmic	Beam-halo	Total background	Observed
50	No	4820 ± 570	900 ± 130	5720 ± 590	5396
50	Yes	2.1 ± 3.6	12.1 ± 3.2	14.2 ± 4.0	10
100	Yes	0.4 ± 2.7	6.0 ± 1.8	6.4 ± 2.9	5
300	Yes	2.4 ± 2.4	0.54 ± 0.40	2.9 ± 2.4	0

Limits…

Limits on Split SUSY with long-lived gluino:

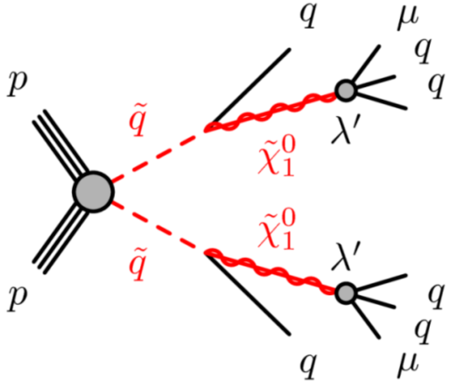
- Signal efficiency using Pythia with different decay modes, and different gluino and neutralino masses
- Three different interaction models for R-hadrons, giving different stopping fractions (5.2%, 7.0% and 12.2%)
- Limits on gluino mass and gluino mass vs. lifetime, e.g.:





Displaced Vertices

- In R-parity violating models the lightest neutralino could be long-lived.
- Signature for this analysis is displaced vertex (DV) + muon in ATLAS inner detector (ID)



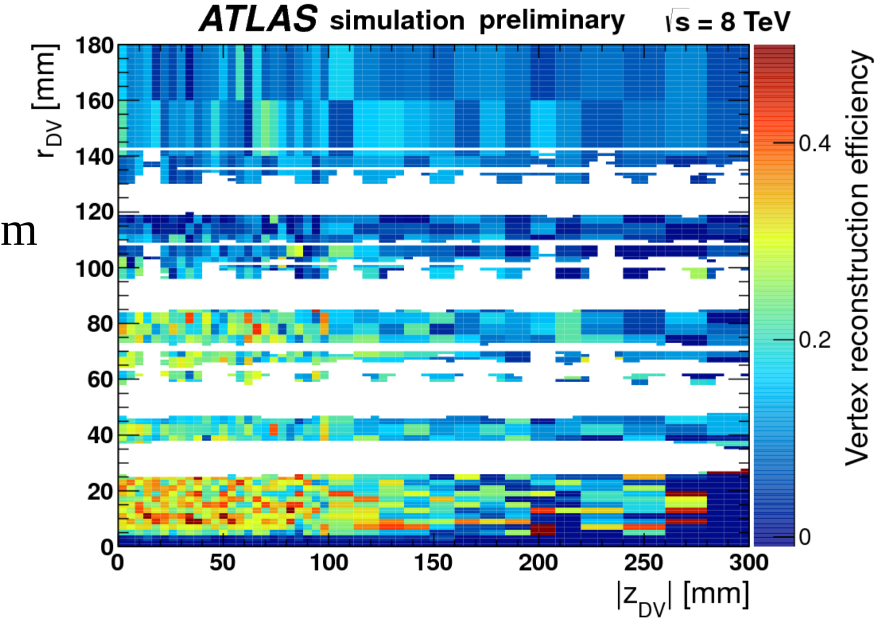
- Dedicated reconstruction of tracks not pointing to the interaction (large impact parameter d_0) and vertices inside the ID volume.

Selection

- Muon: $p_T(\mu)$>55 GeV, $|\eta|$<1.07, $|d_0|$>1.5 mm
- DV fiducial volume r_{DV}<180 mm, $|z_{DV}|$<300 mm
- Veto vertices in detector material layers
- Signal region:

  DV_{mass} > 10 GeV

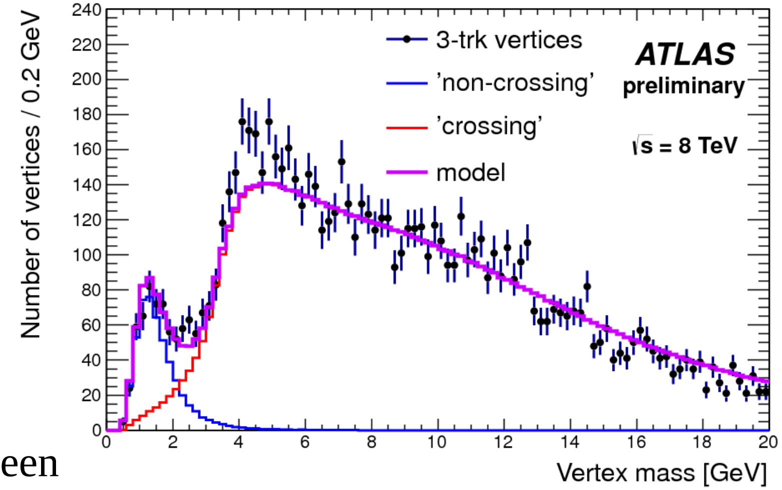
  number of tracks in DV > 4



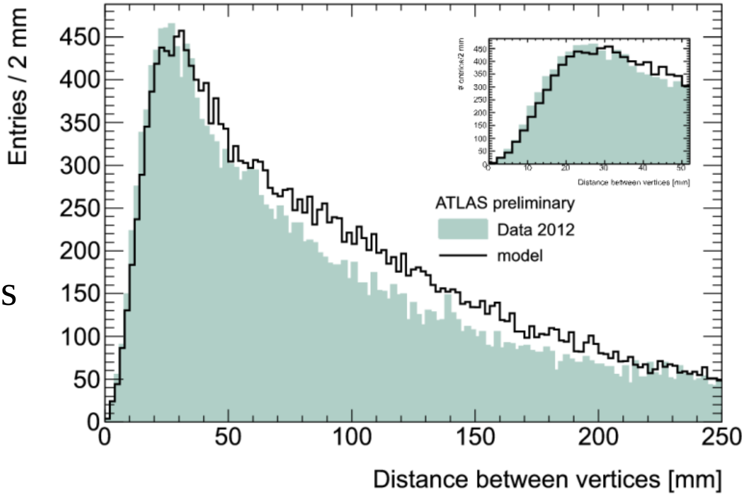
Displaced Vertices

Background Estimation

- Hadronic interactions with gas molecules (outside beampipe):
  - Most have low mass, but some have > 10 GeV
  - Random track crossing can raise the mass
- Estimated by using jet-triggered events to get m_{DV} distribution shapes for n-track vertices



- Random combinations of tracks:
  - DV reconstruction combines vertices if < 1 mm between them
  - Largest contribution at small radii due to track density (inside beampipe)
- Estimated by looking at separation distance between pairs of vertices in different events and see how often separation is <1 mm
  - Validated by comparing separation distance distributions for pairs of vertices in the same event and in different events
  - Found to be negligible



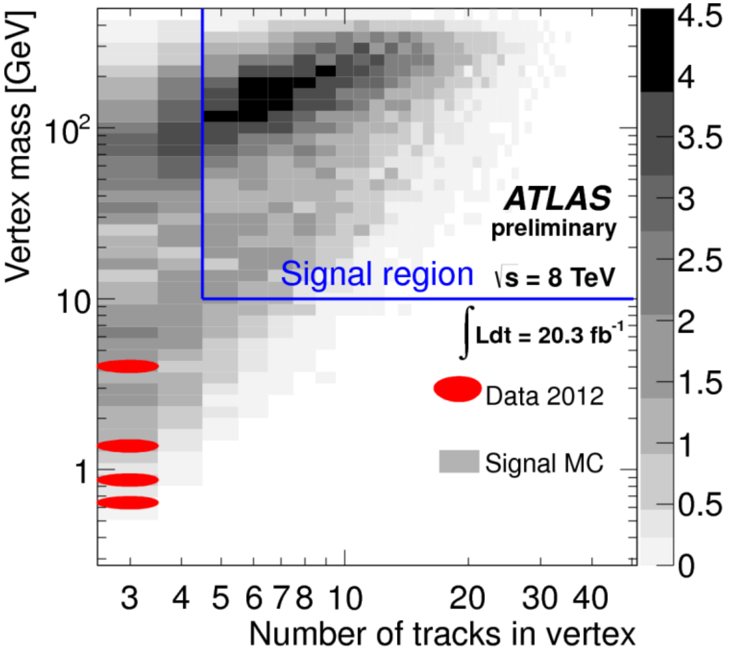
- Total background estimate is dominated by background outside the beam pipe, which is 0.02 ± 0.02 vertices

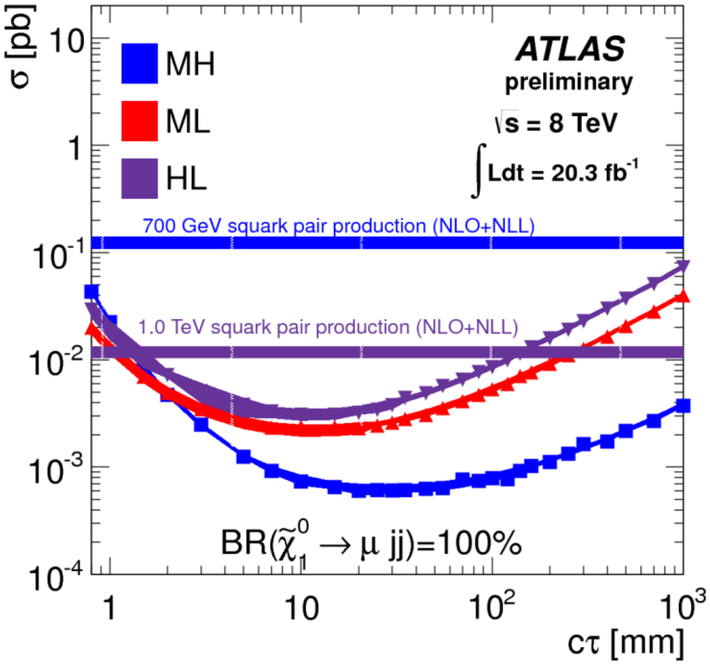
Displaced Vertices

- No events are expected, and none are observed
- 95% CL upper limit of 0.14 fb is set on $\sigma \times \varepsilon \times$acceptance for any new physics process

- 3 models with different combinations of $m_{\tilde{q}}$ and $m_{\tilde{\chi}^0}$

Sample	$m_{\tilde{q}}$ [GeV]	σ [fb]	$m_{\tilde{\chi}_1^0}$ [GeV]	$\langle\gamma\beta\rangle_{\tilde{\chi}_1^0}$	$c\tau_{\mathrm{MC}}$ [mm]	λ'_{211}
MH	700	124.3	494	1.0	175	0.2×10^{-5}
ML	700	124.3	108	3.1	101	1.5×10^{-5}
HL	1000	11.9	108	5.5	220	20.0×10^{-5}



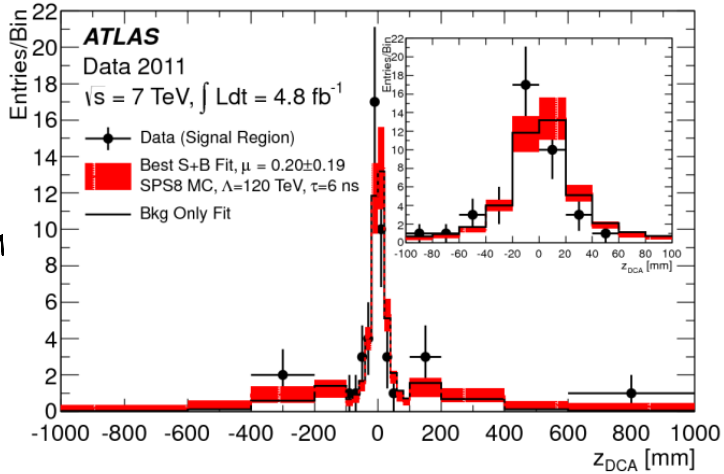


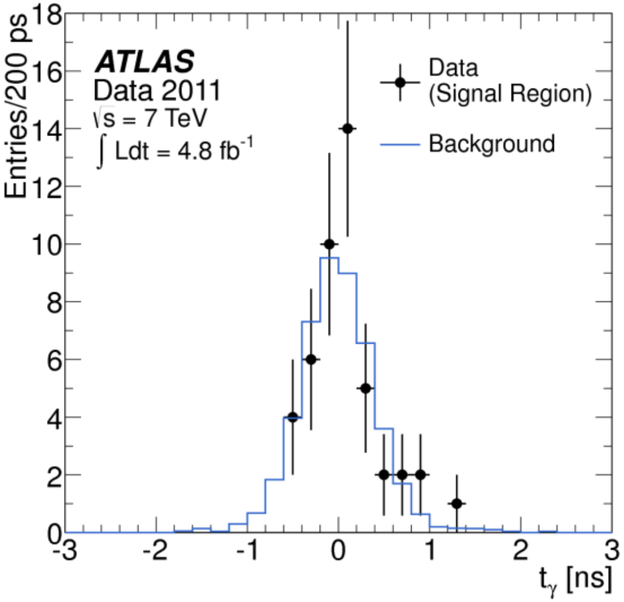
- use efficiency maps to get limits for a wide range of $c\tau(\tilde{\chi}^0)$
- Limits assuming 100% branching ratio (BR) to muons → 2 DV per event (shown here)
- Limits assuming 50% BR → 0, 1 or 2 DV per event (see backup slides)

Non-pointing Photons

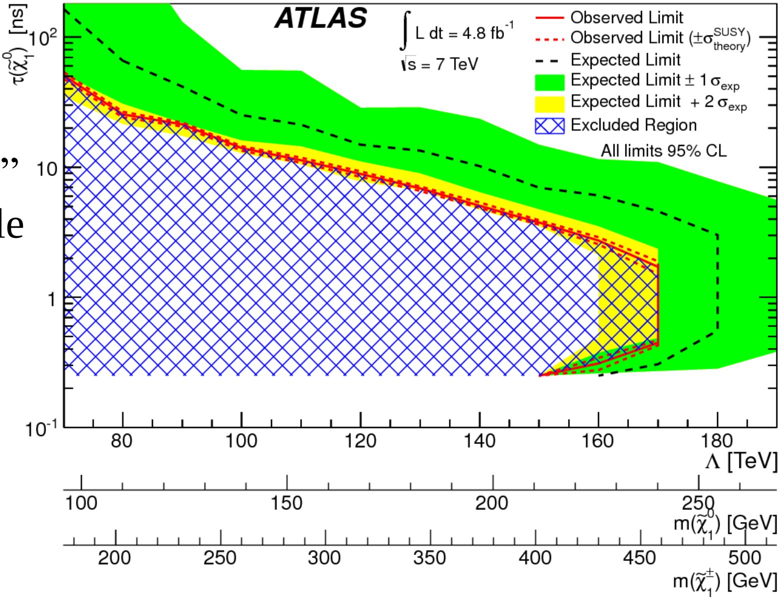
- Result on 2011 data (4.8 fb^{-1})
- GMSB: $\tilde{\chi}^0{}_1 \rightarrow \gamma\tilde{G}$
- If $\tau(\tilde{\chi}^0{}_1) \sim 0.25 - 50$ ns, photons are non-pointing with respect to the primary vertex and delayed
- Analysis exploit ATLAS LAr EM calorimeter for Z_{DCA} and time resolutions
- Signal: 2 isolated γ with p_T>50 GeV + missing-E_T>75 GeV

- 46 candidates observed, distribution consistent with background.





Limit on “snowmass SPS8” point with variable mass scale Λ and $\tau(\tilde{\chi}^0{}_1)$



Summary

- Several updated searches for long-lived particle signals in ATLAS
- No events above expected background were observed
- Results used to produce limits for a range of SUSY models (for a choice of parameters):

Analysis	Model	LLP	Mass Limit
Heavy Sleptons	GMSB	$\tilde{\tau}_1$	475 GeV
Disappearing Tracks	AMSB	$\tilde{\chi}^{\pm}{}_1$	270 GeV
Stopped-Gluino R hadrons	Split SUSY	$\tilde{g}$	832 GeV
Displaced Vertices	RPV	$\tilde{\chi}^0{}_1$	1.0 TeV
Non-Pointing Photons	GMSB	$\tilde{\chi}^0{}_1$	230 GeV

Thank you!

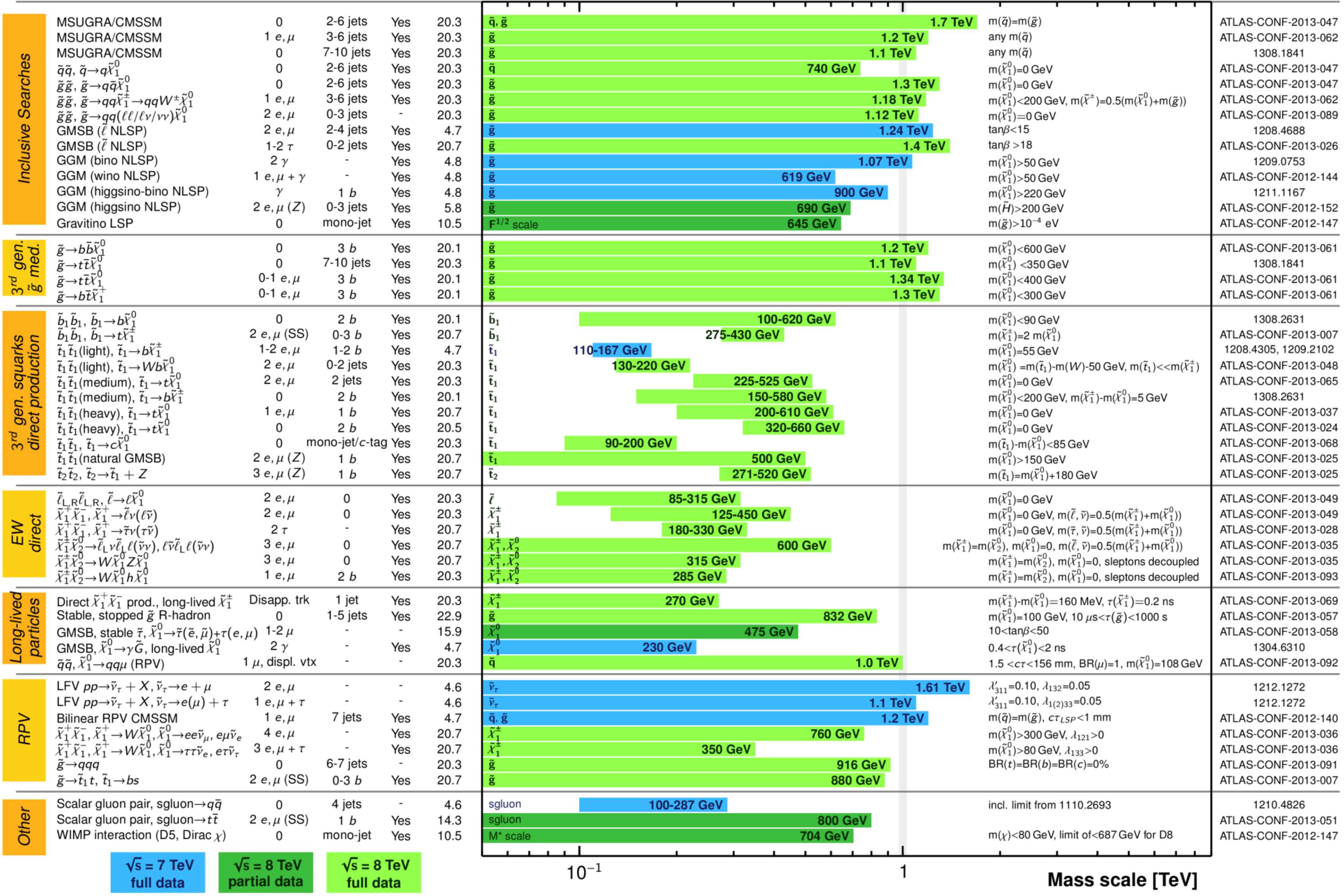
Backup Slides

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

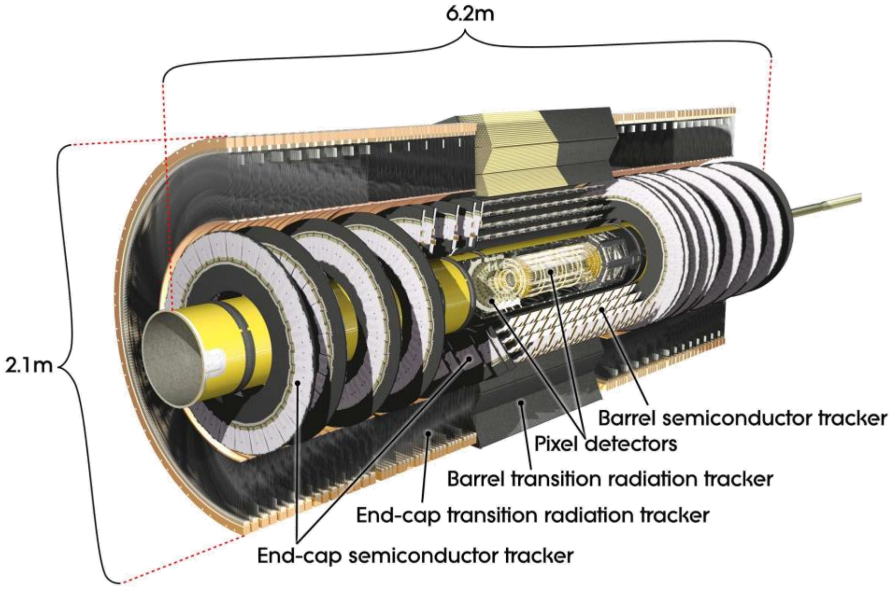
$\int \mathcal{L} dt = (4.6 - 22.9)\ \mathrm{fb}^{-1}$ $\sqrt{s} = 7, 8$ TeV

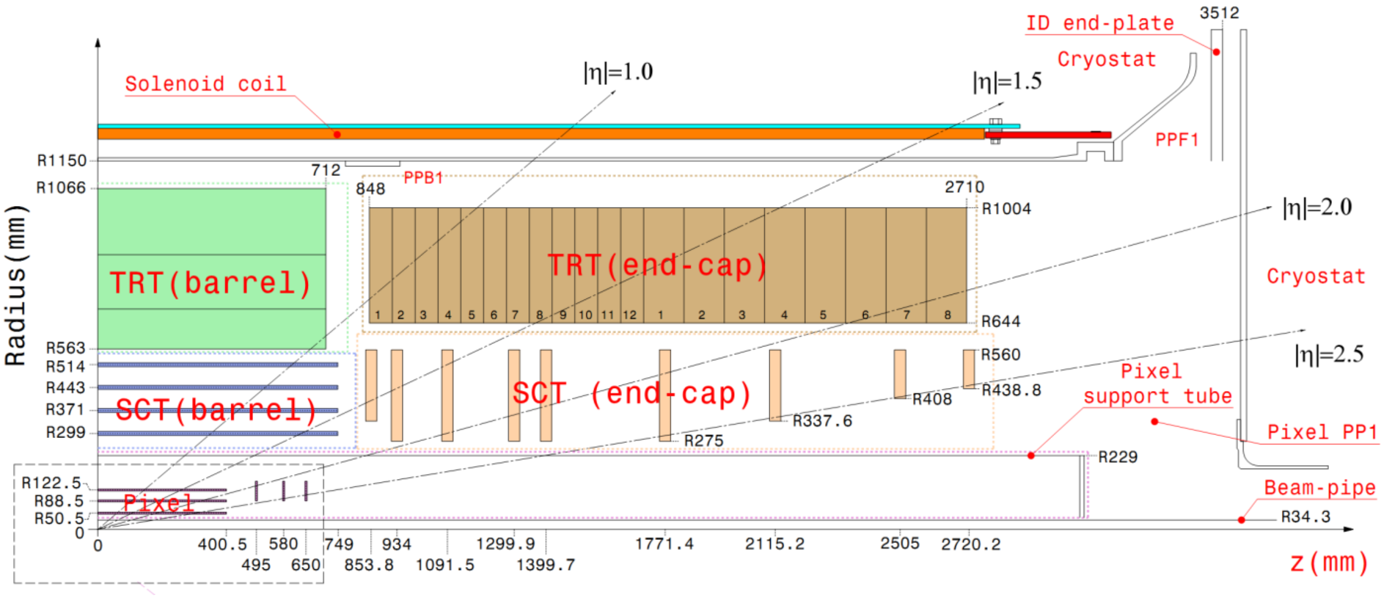


	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L} dt[fb^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$ 1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}$, $\tilde{q}\rightarrow q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$ 740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qq\tilde{\chi}_1^{\pm}\rightarrow qqW^{\pm}\tilde{\chi}_1^0$	1 e, μ	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
	$\tilde{g}\tilde{g}$, $\tilde{g}\rightarrow qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20.3	$\tilde{g}$ 1.12 TeV	$m(\tilde{\chi}_1^0)=0$ GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	$\tan\beta$ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	4.8	$\tilde{g}$ 1.07 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	1209.0753
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	$\tilde{g}$ 619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (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.	$\tilde{g}\rightarrow b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$ 1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\rightarrow t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\rightarrow b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	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	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\rightarrow b\tilde{\chi}_1^0$	0	2 b	Yes	20.1	$\tilde{b}_1$ 100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\rightarrow t\tilde{\chi}_1^{\pm}$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{b}_1$ 275-430 GeV	$m(\tilde{\chi}_1^{\pm})$=2 $m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\rightarrow b\tilde{\chi}_1^{\pm}$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\rightarrow Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 130-220 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), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	$\tilde{t}_1$ 225-525 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\rightarrow b\tilde{\chi}_1^{\pm}$	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	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	1 e, μ	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), $\tilde{t}_1\rightarrow t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\rightarrow c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-200 GeV	$m(\tilde{t}_1)$-$m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$ 500 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\rightarrow\tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$ 271-520 GeV	$m(\tilde{t}_1)$=$m(\tilde{\chi}_1^0)$+180 GeV	ATLAS-CONF-2013-025
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\rightarrow\ell\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{\ell}$ 85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	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
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	3 e, μ	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
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\rightarrow W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e, μ	2 b	Yes	20.3	$\tilde{\chi}_1^{\pm}, \tilde{\chi}_2^0$ 285 GeV	$m(\tilde{\chi}_1^{\pm})$=$m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 270 GeV	$m(\tilde{\chi}_1^{\pm})$-$m(\tilde{\chi}_1^0)$=160 MeV, $\tau(\tilde{\chi}_1^{\pm})$=0.2 ns	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$ 832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\rightarrow\tilde{\tau}(\tilde{e}, \tilde{\mu})+\tau(e, \mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$ 475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\rightarrow\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$ 230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}$, $\tilde{\chi}_1^0\rightarrow qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$ 1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\rightarrow\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\rightarrow e + \mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\rightarrow\tilde{\nu}_\tau + X$, $\tilde{\nu}_\tau\rightarrow e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$ 1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	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
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow ee\tilde{\nu}_\mu$, $e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$ 760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\rightarrow W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\rightarrow\tau\tau\tilde{\nu}_e$, $e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^{\pm}$ 350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\rightarrow qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\rightarrow\tilde{t}_1 t$, $\tilde{t}_1\rightarrow bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$ 880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon→$q\bar{q}$	0	4 jets	-	4.6	sgluon 100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon→$t\bar{t}$	2 e, μ (SS)	1 b	Yes	14.3	sgluon 800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale 704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

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

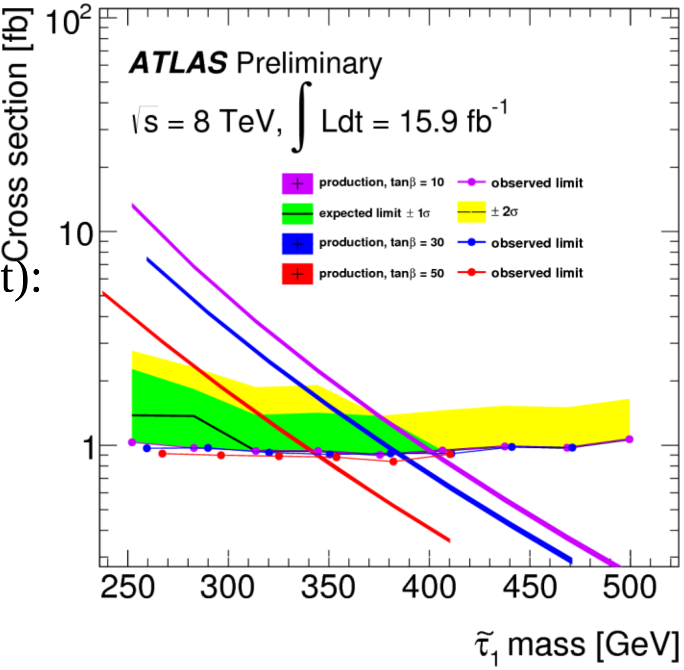
ATLAS Inner Detector



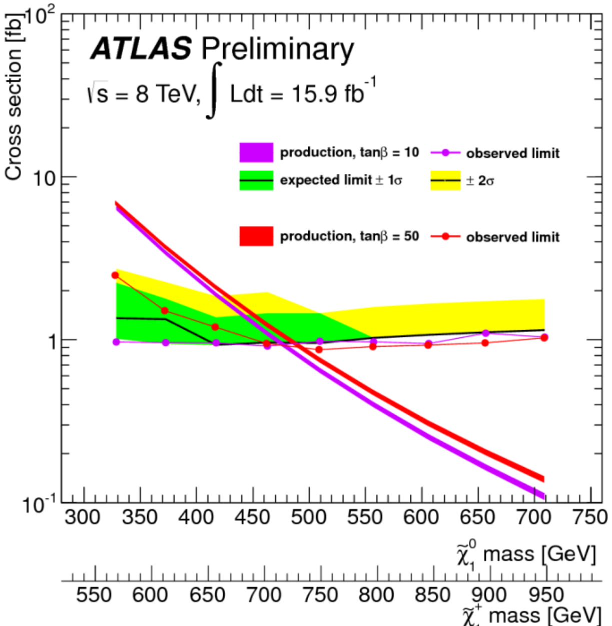


Heavy Long-Lived Sleptons

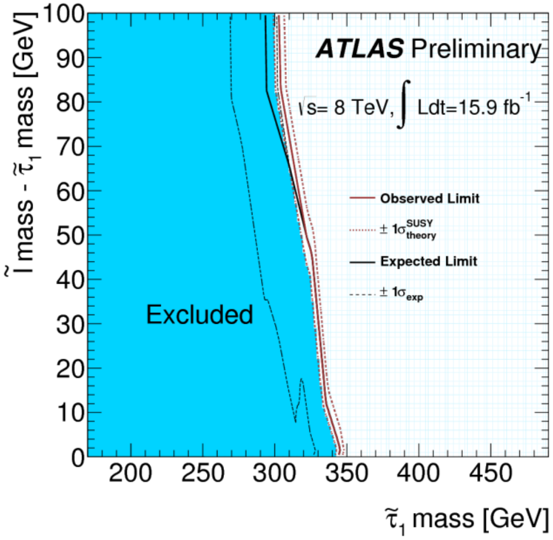
Slepton production (model independent):

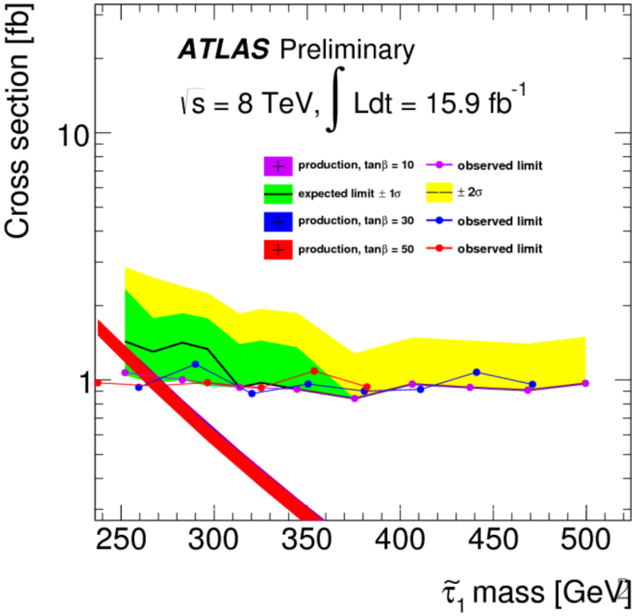


Direct neutralino/ chargino:

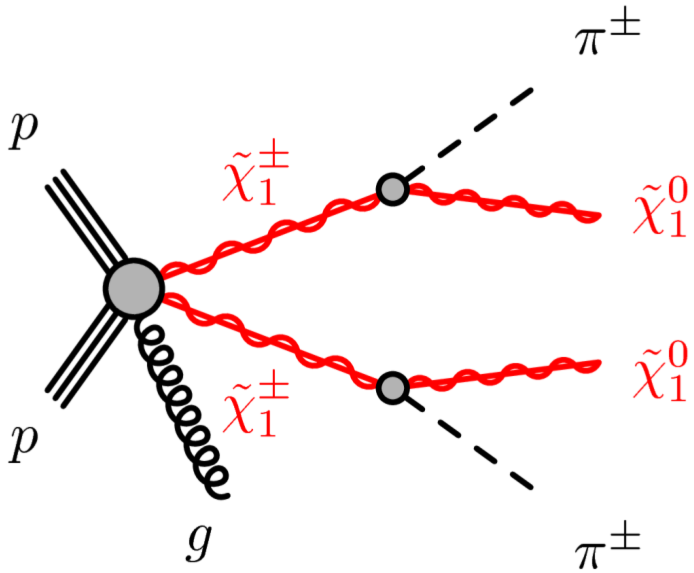


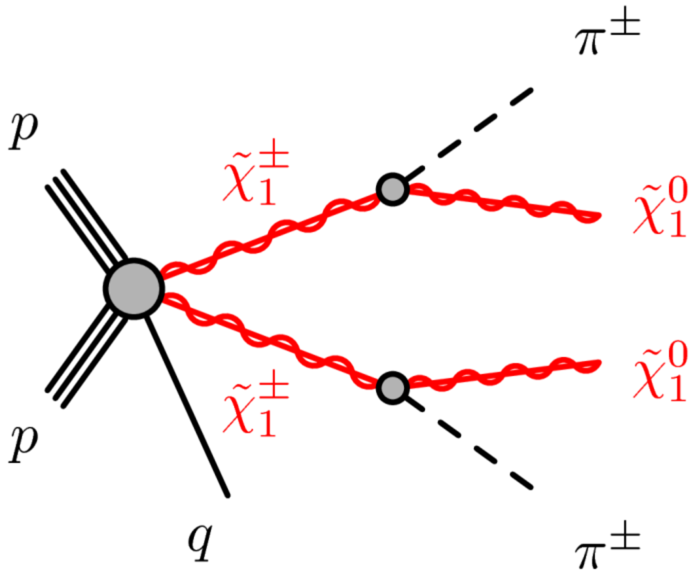
Direct slepton production

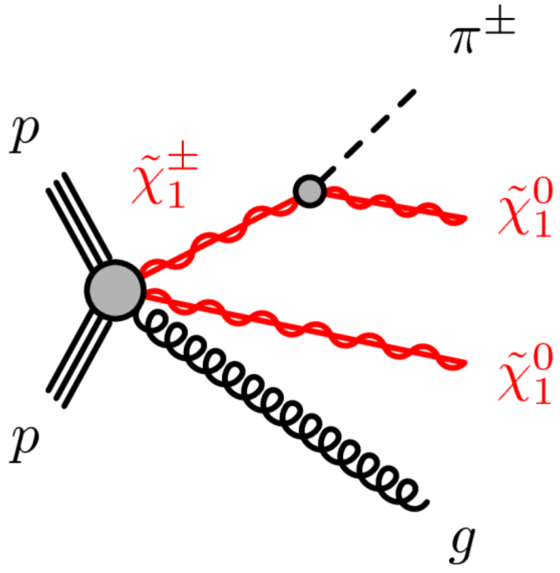


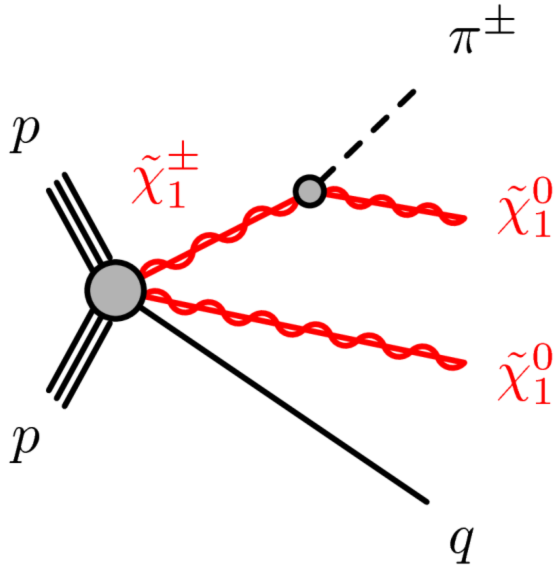


Disappearing Tracks

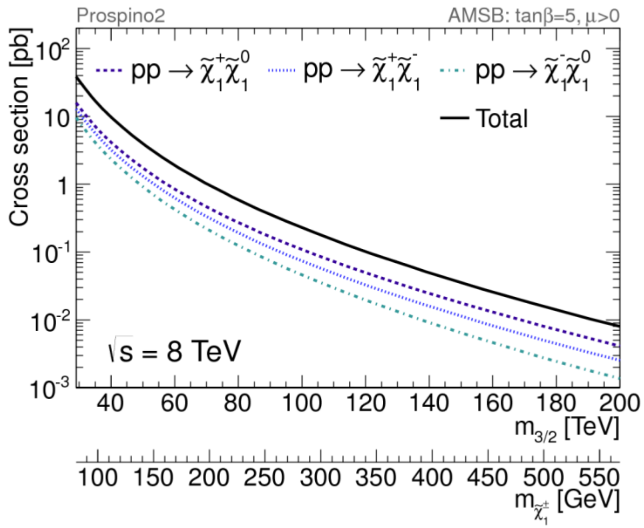


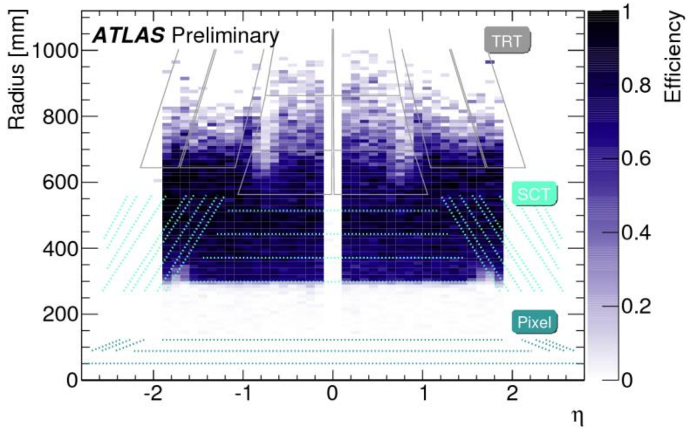


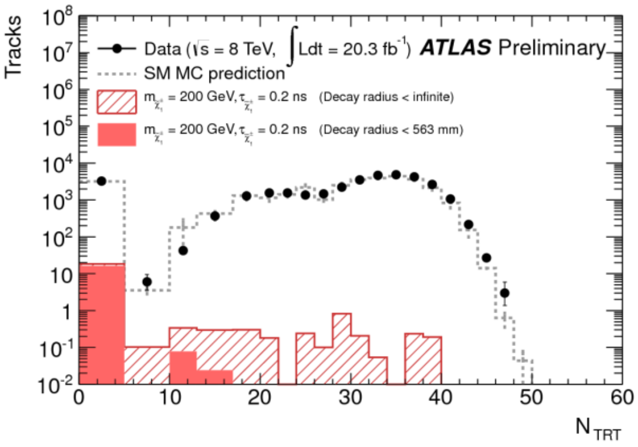


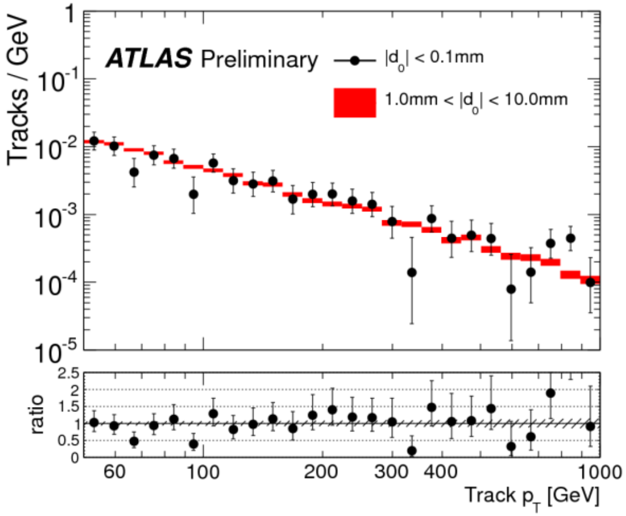


Disappearing Tracks



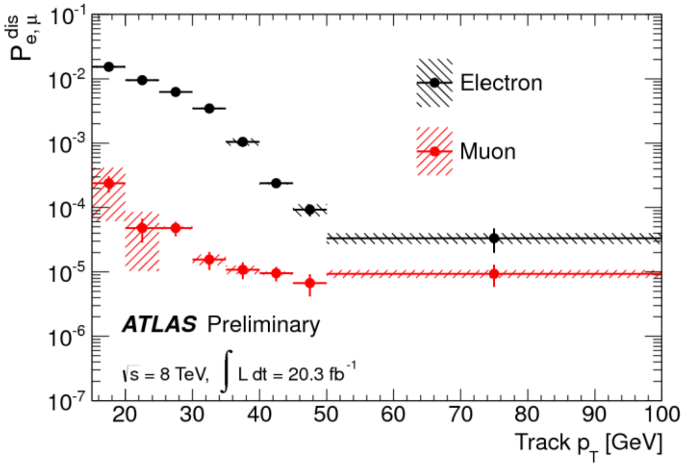






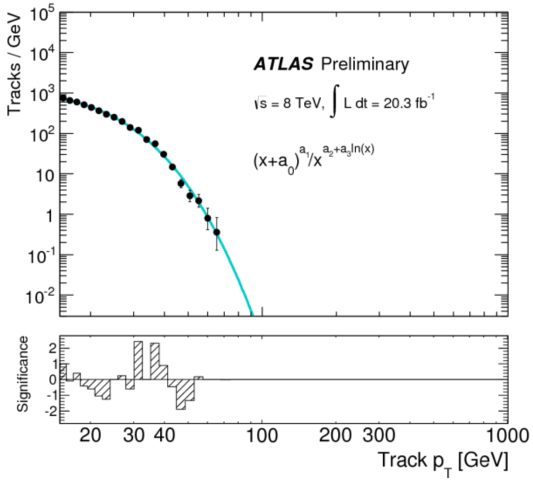
Disappearing Tracks

Background	Signal region	Control sample	Systematics	Normalization
p_T-mismeasured track	$\|d_0\| < 0.1$ mm	1 mm $< \|d_0\| <$ 10 mm	Shape uncertainties + Mechanism uncertainty	Free
Interacting hadron	N(TRT) < 5	N(TRT) ≥ 25 + Calorimeter activity	Shape uncertainties	
Unidentified lepton	# of lepton = 0	# of lepton = 1 × Probability(disappearing)	Contamination of hadron tracks	Constrained by estimation

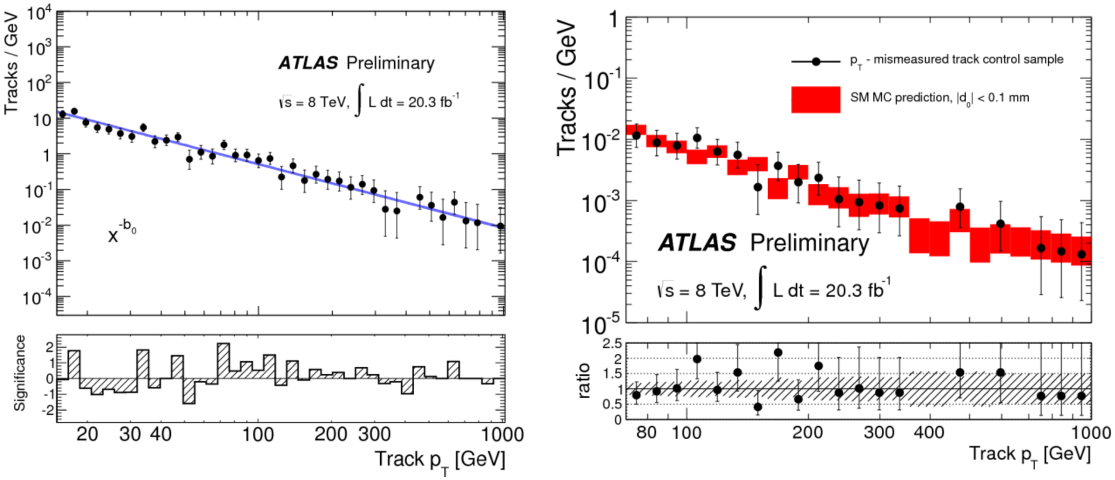


Unidentified lepton

Hadron sample

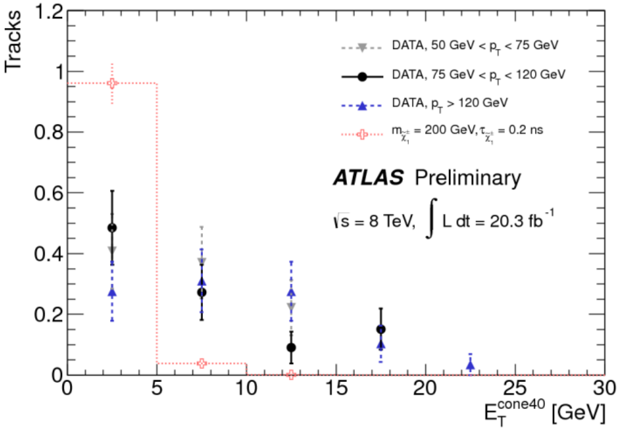


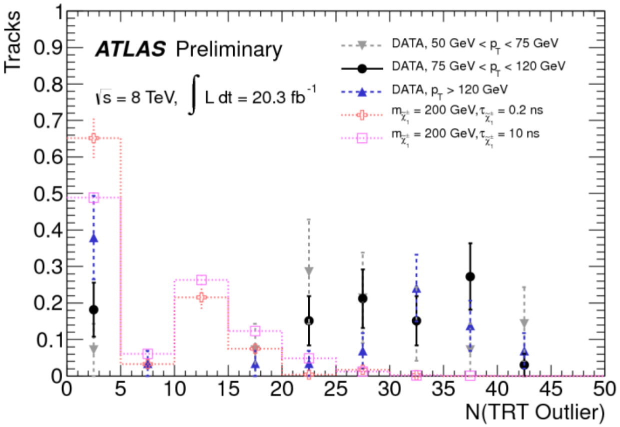
pT-mismeasured

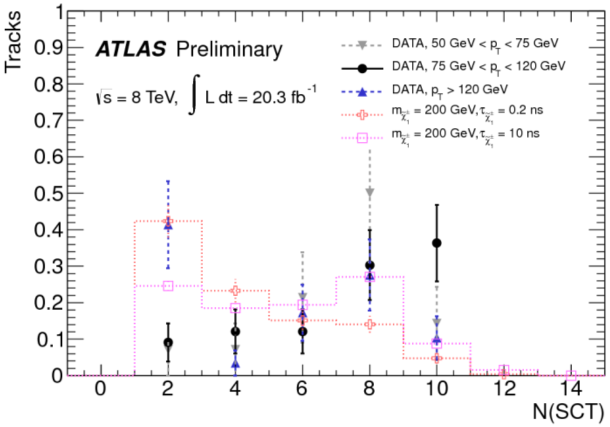


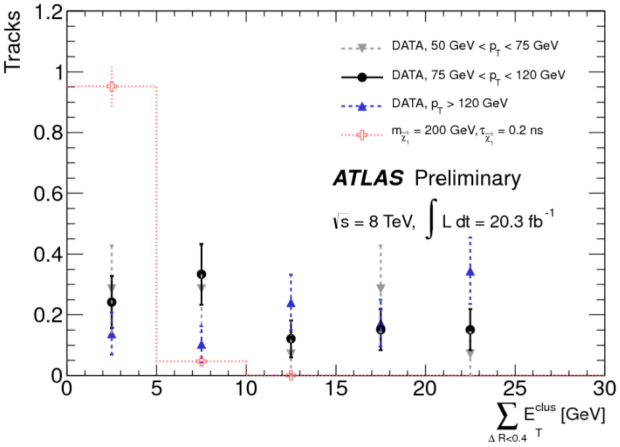
Disappearing Tracks

Comparisons between excess region and nearby track-p_T regions

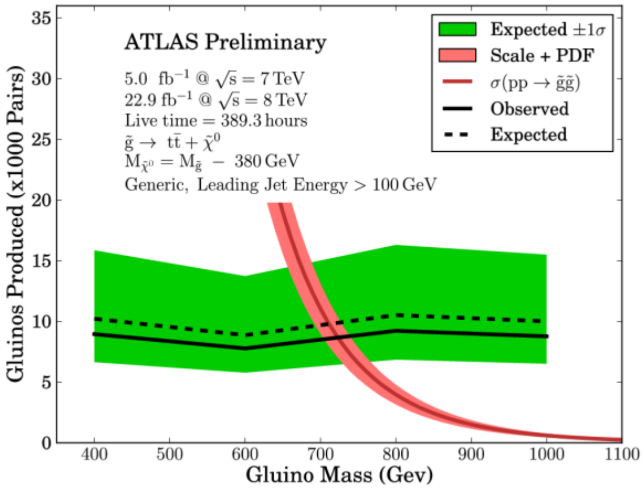


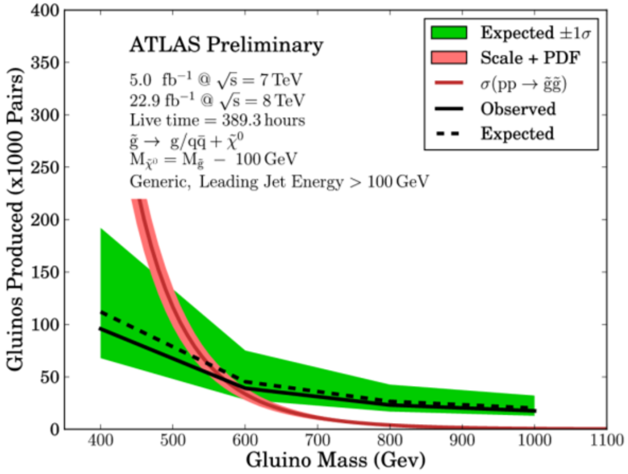


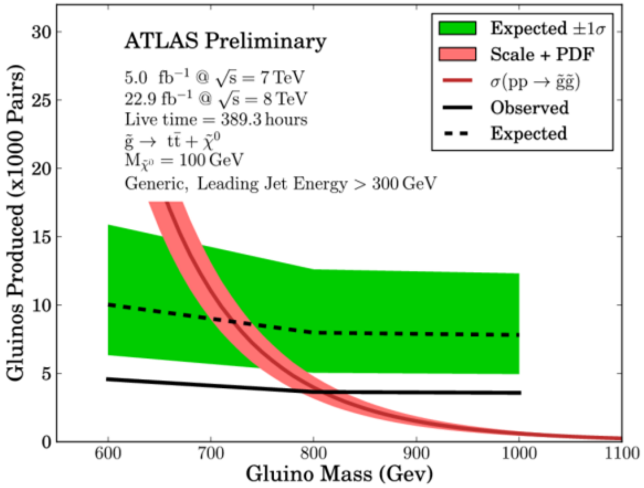


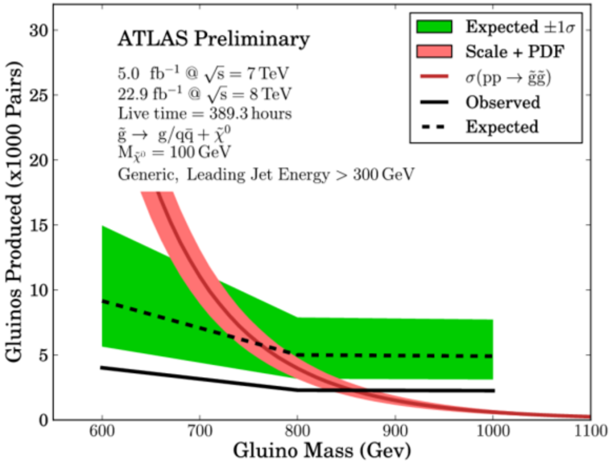


Stopped-Gluino R hadrons

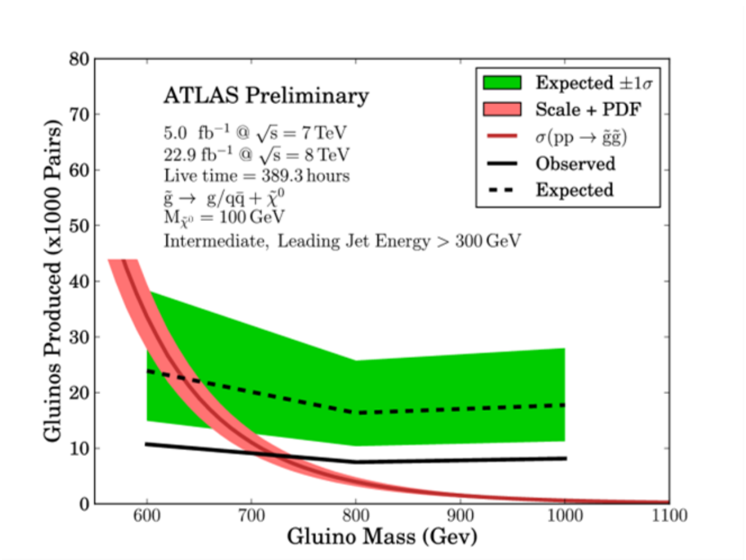


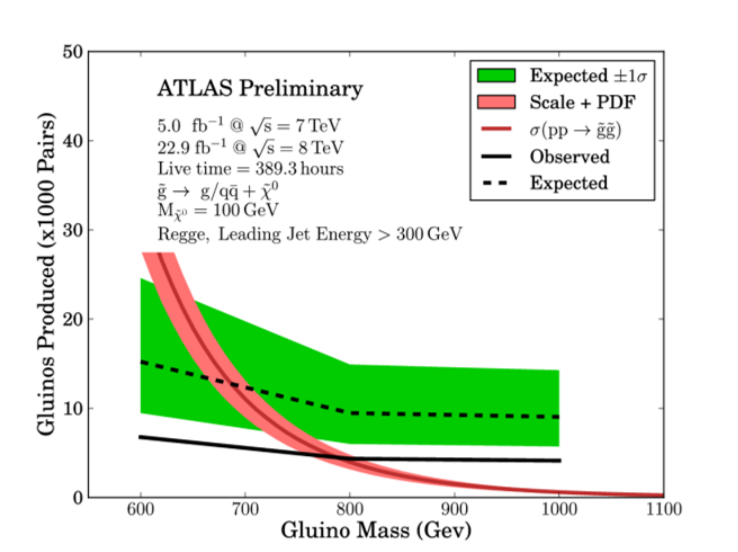


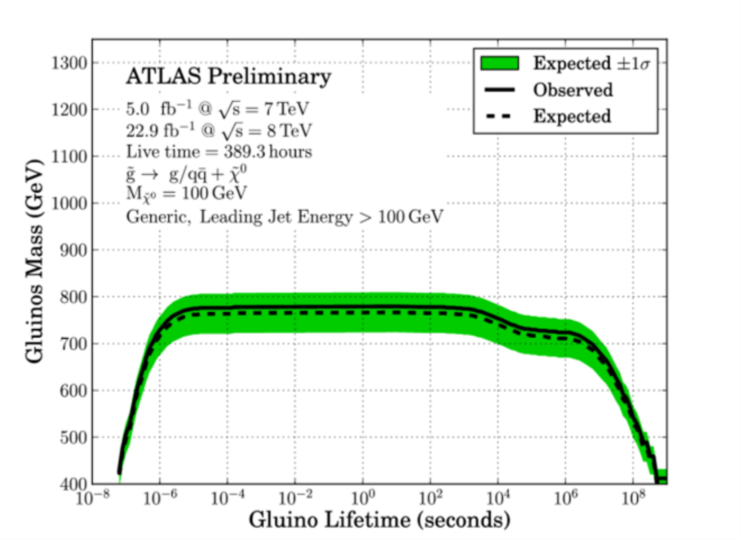


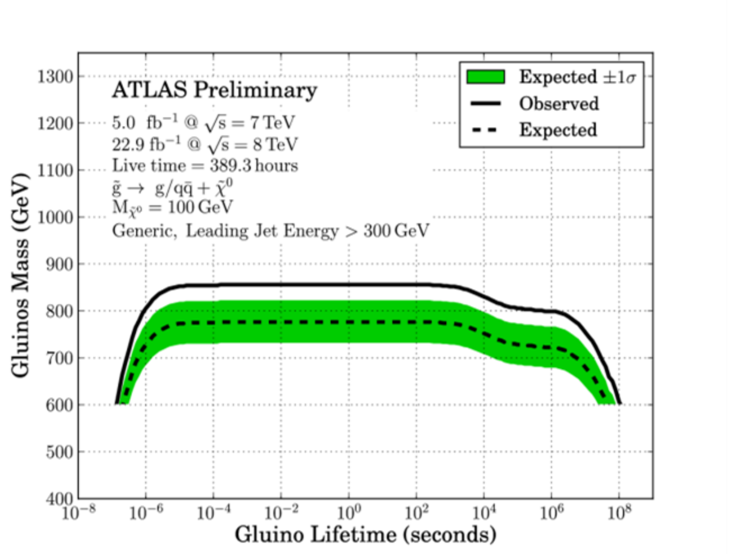


Stopped-Gluino R hadrons

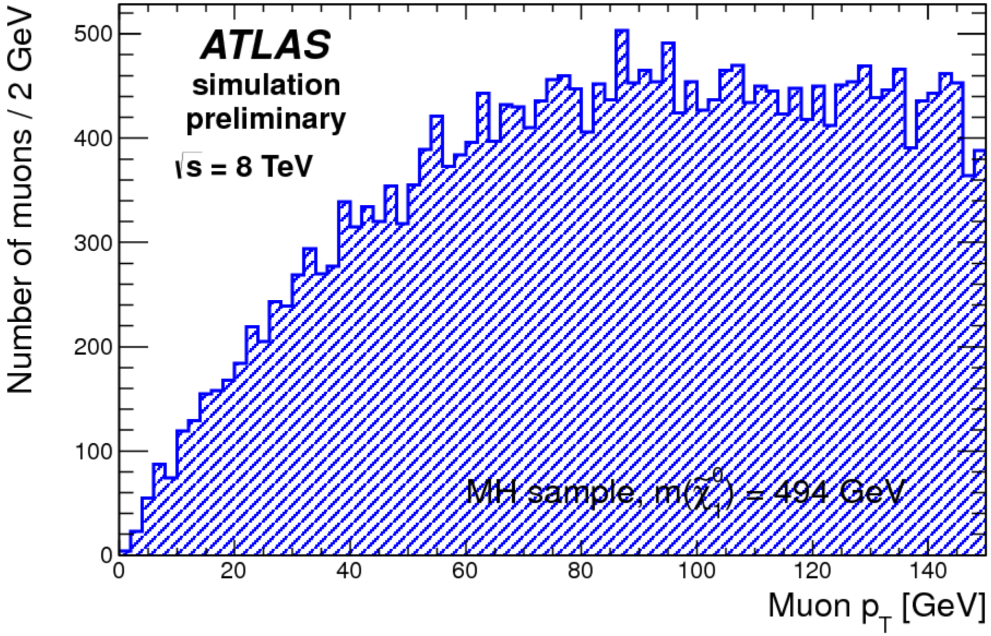


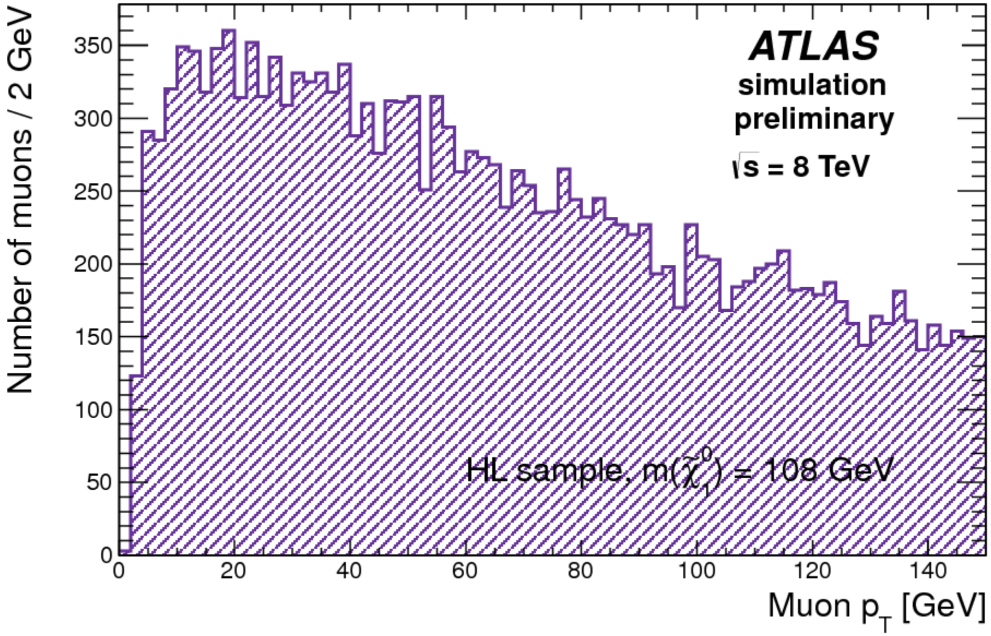




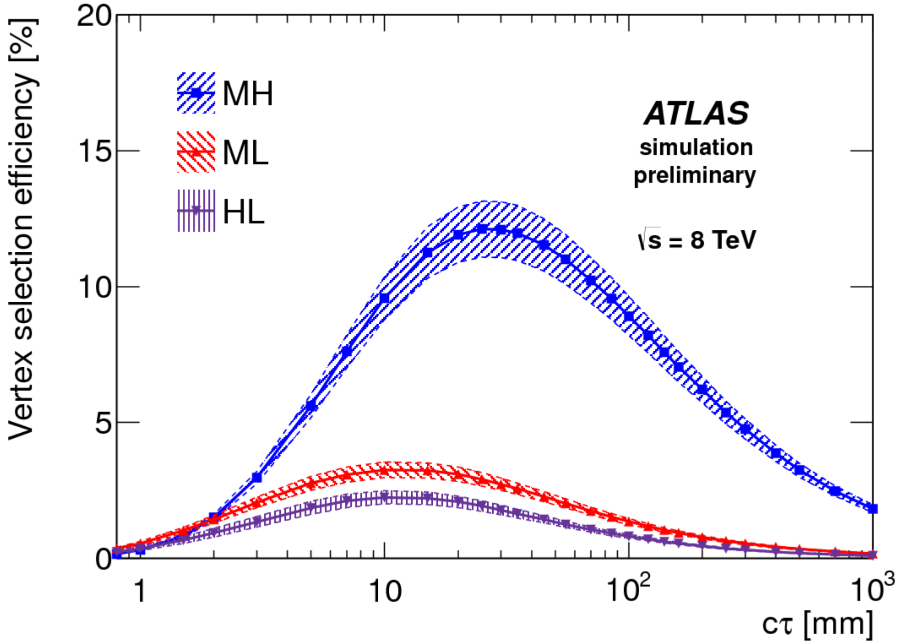


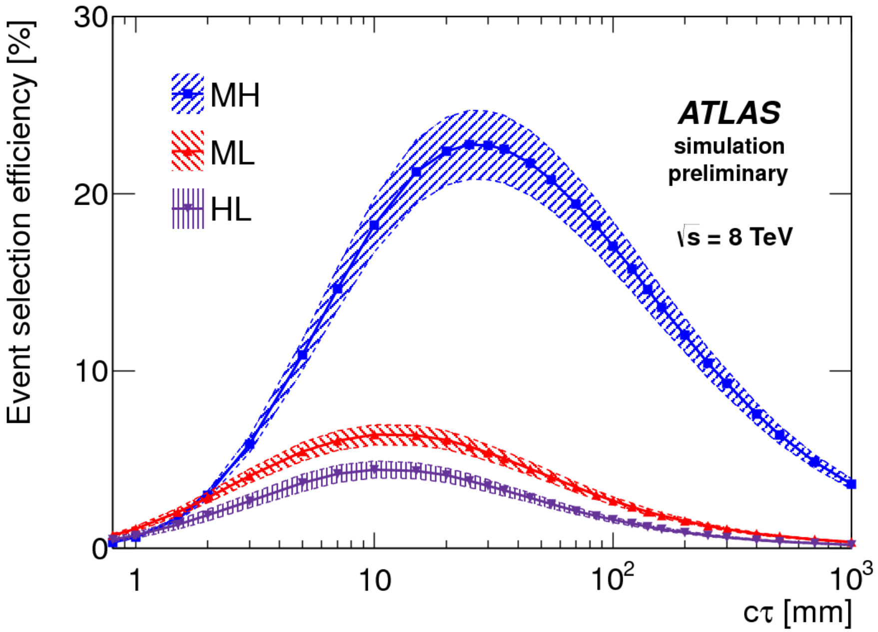
Displaced Vertices

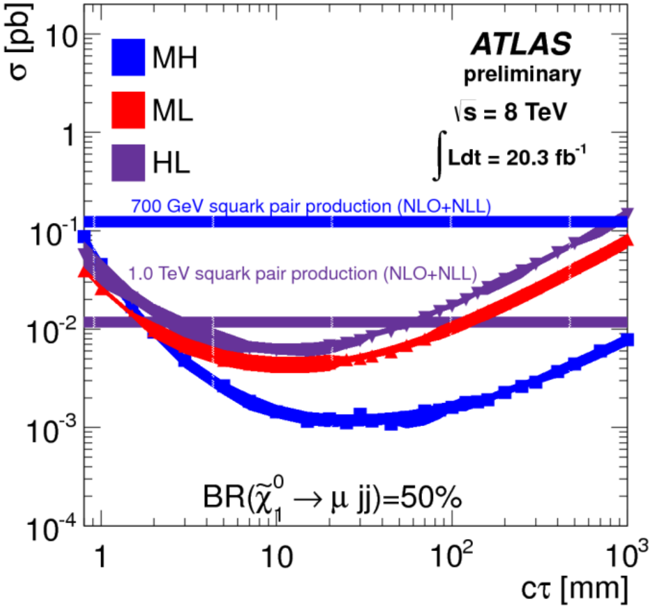




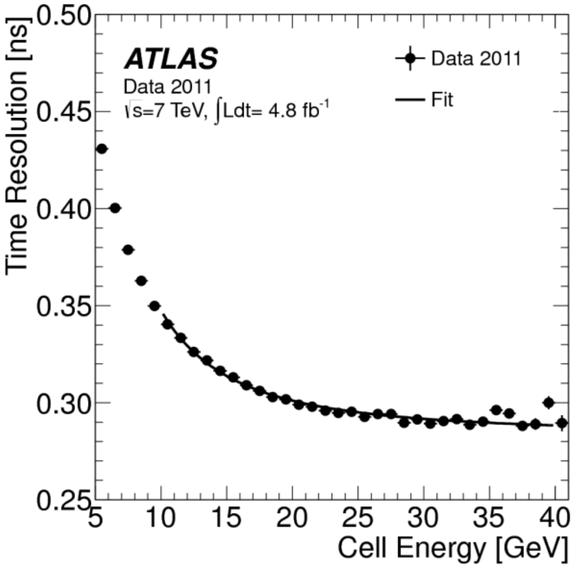
Displaced Vertices

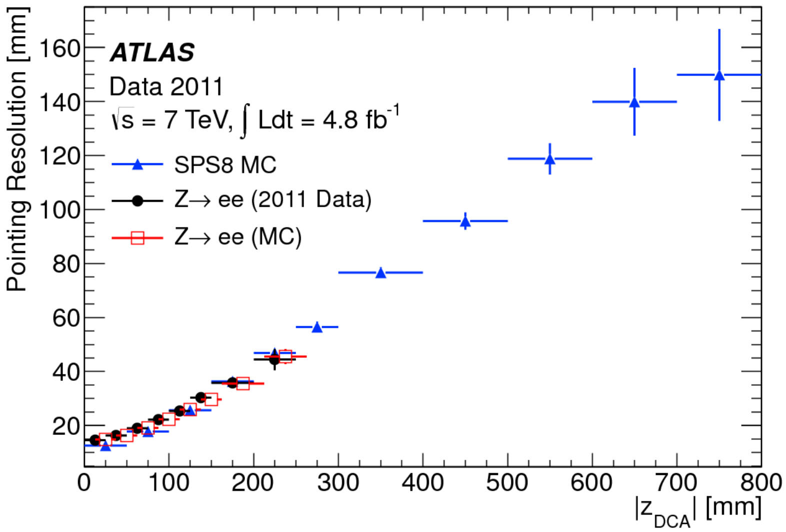


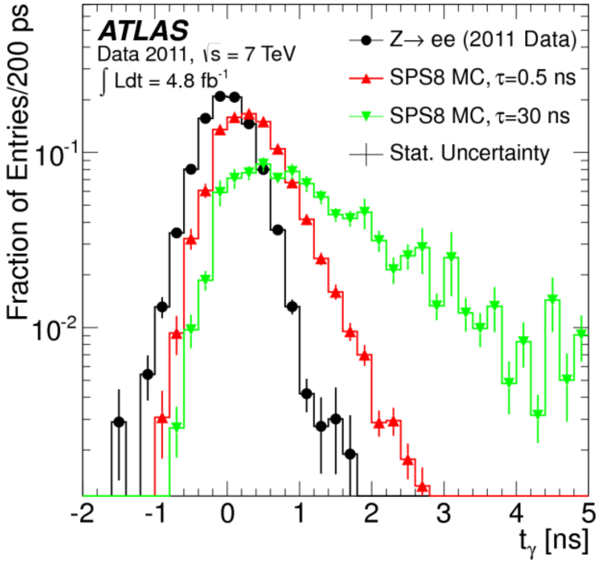


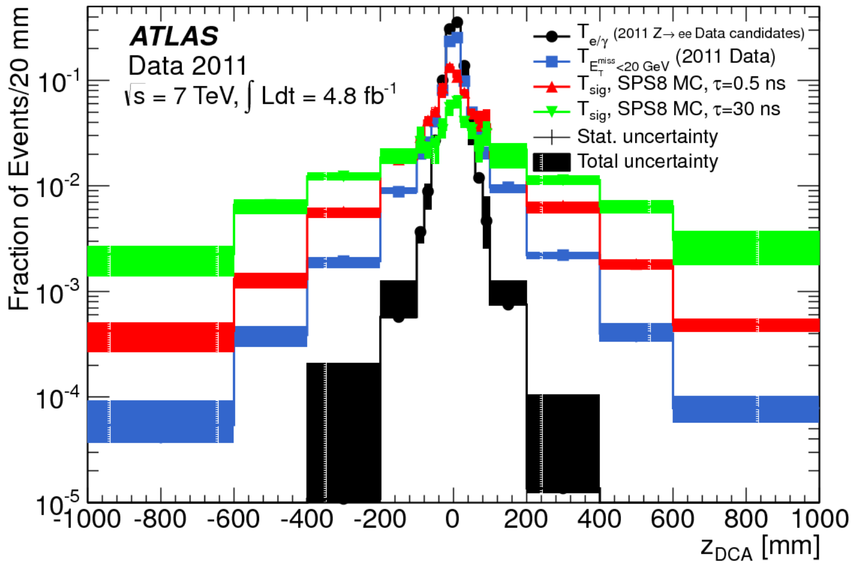


Non-Pointing Photons









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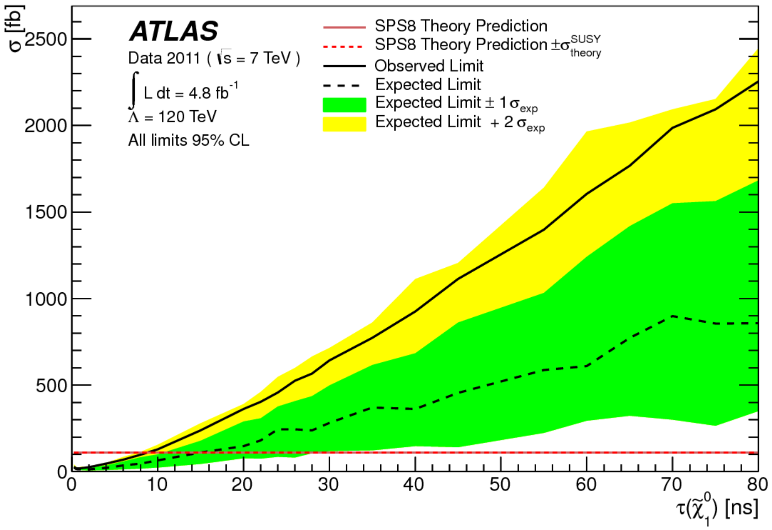

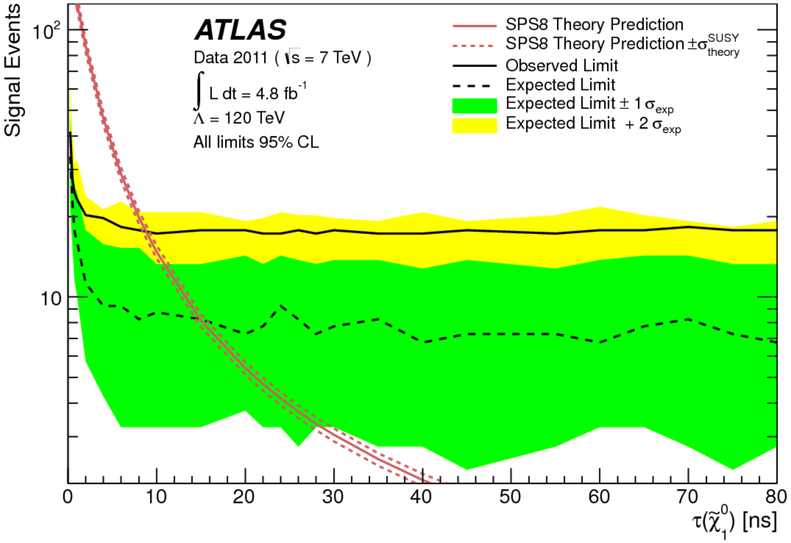

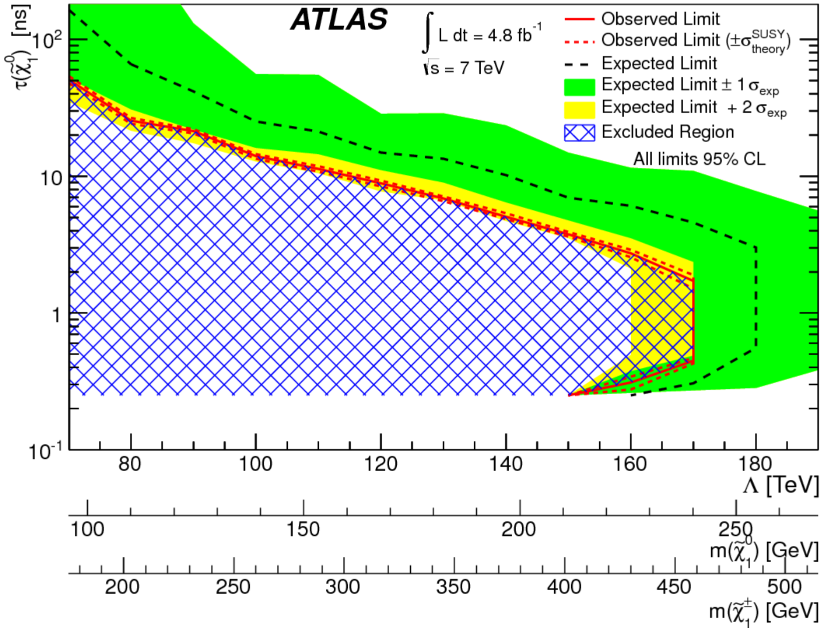

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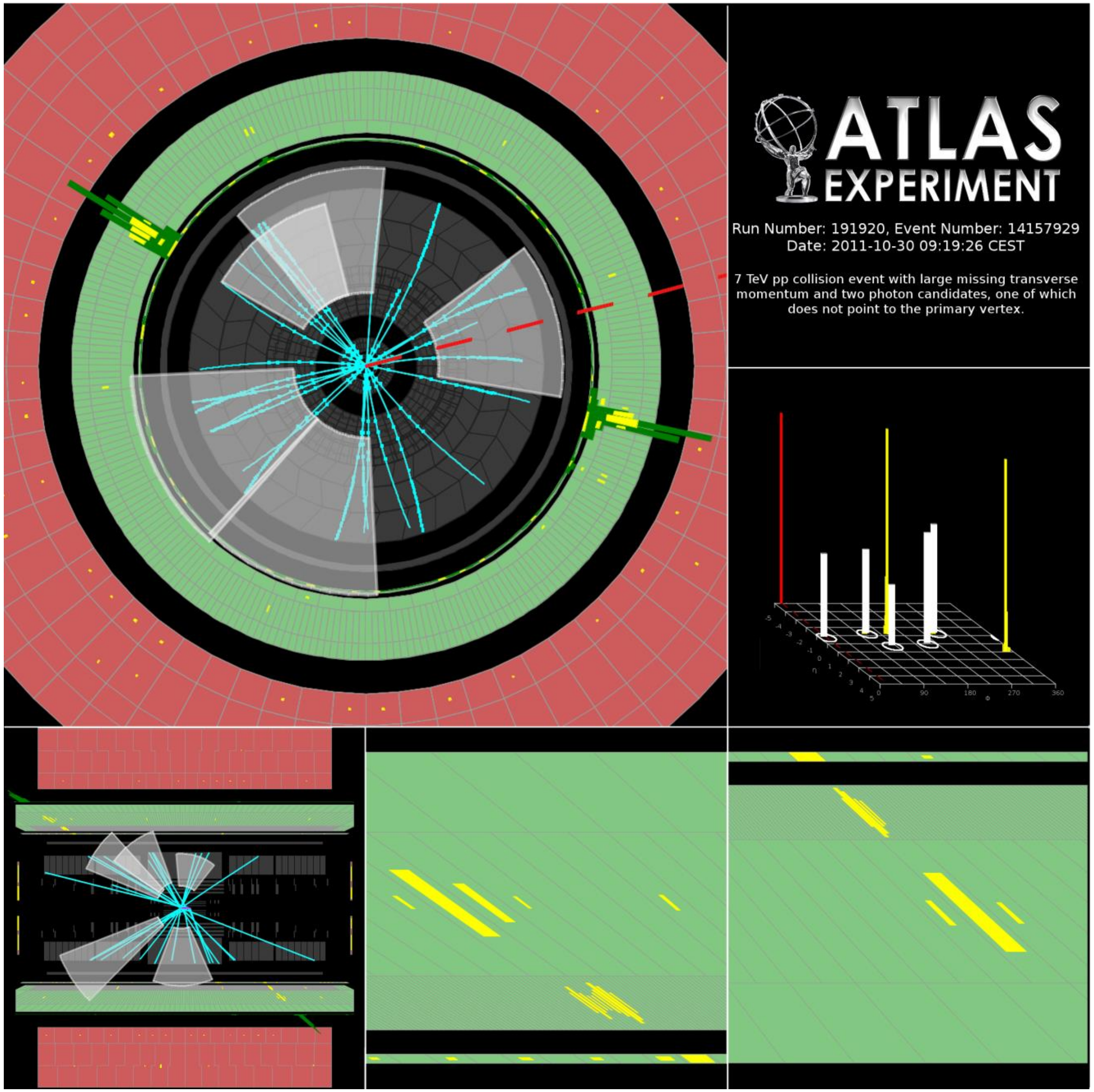

Run Number: 191920, Event Number: 14157929
Date: 2011-10-30 09:19:26 CEST

7 TeV pp collision event with large missing transverse momentum and two photon candidates, one of which does not point to the primary vertex.