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ALBERT EINSTEIN CENTER
FOR FUNDAMENTAL PHYSICS

LHCP 2013
Barcelona, Spain, May 13-18th, 2013

BSM II Session, 18:05, 20+5 min, LHC Physics

Searches with long-lived or unusual signatures at LHC

2013-05-16

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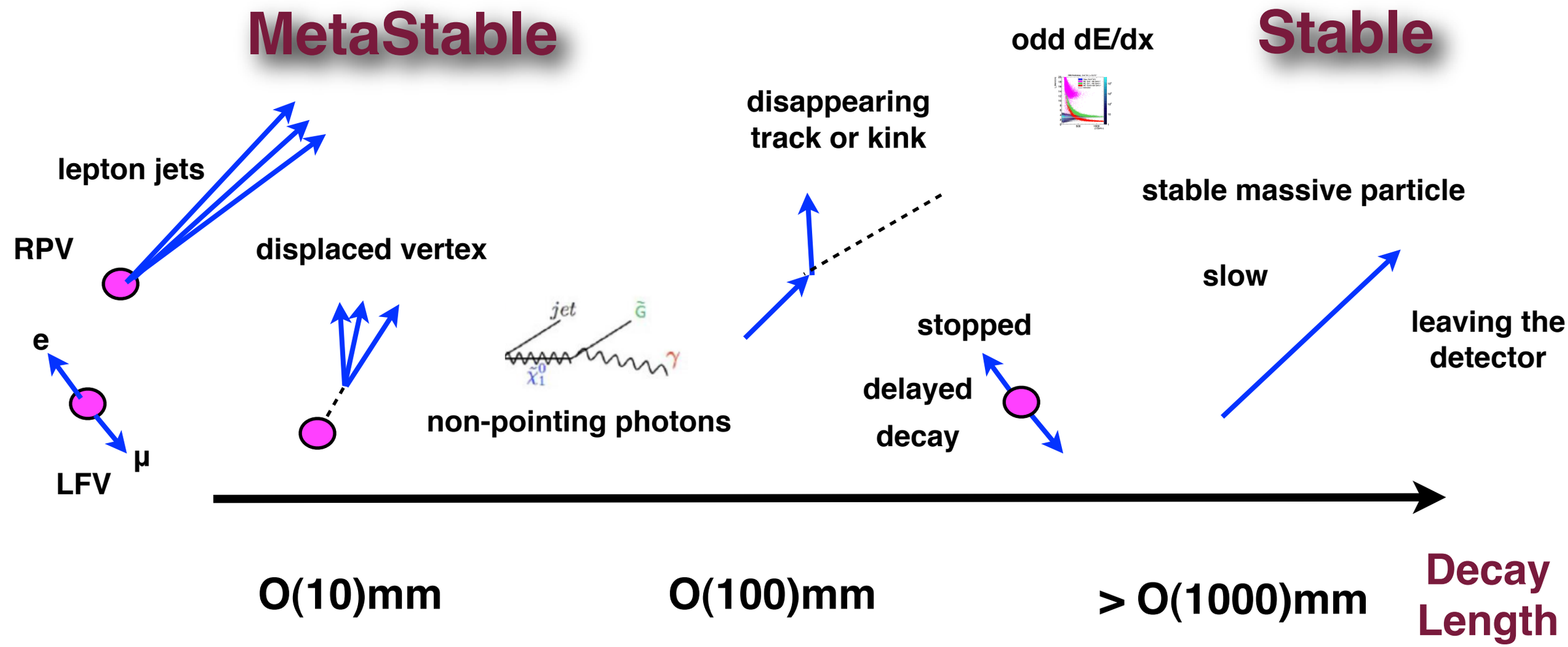
On behalf of the
ATLAS and CMS collaborations

ATLAS EXPERIMENT

Compact Muon Solenoid
experiment at CERN's LHC

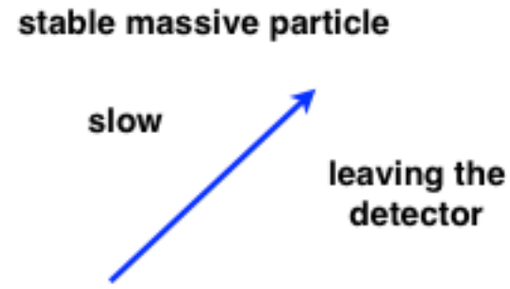
Long-lived and unusual signatures

- Experimental motivation: Keep an eye open for the unexpected ...
- Theoretical motivations: RPV, Split, GMSB ... SUSY, hidden valleys ...



Walk through recent results from right to left

R-Hadron
(quite unusual)



Heavy Stable Charged Particles (HSCP) or / and Stable Massive Particles (SMP)

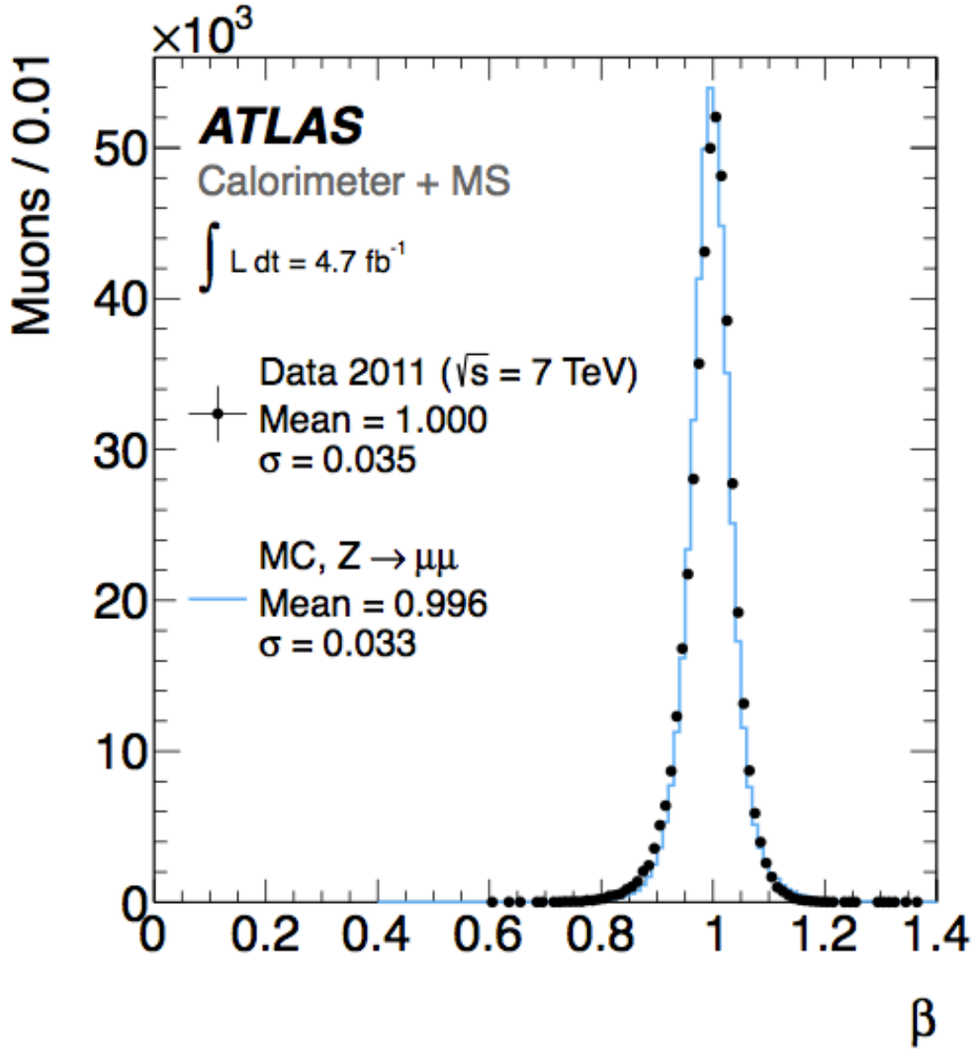
q < lel or q > lel

See also D0 : 1211.2466 14 Nov 2012

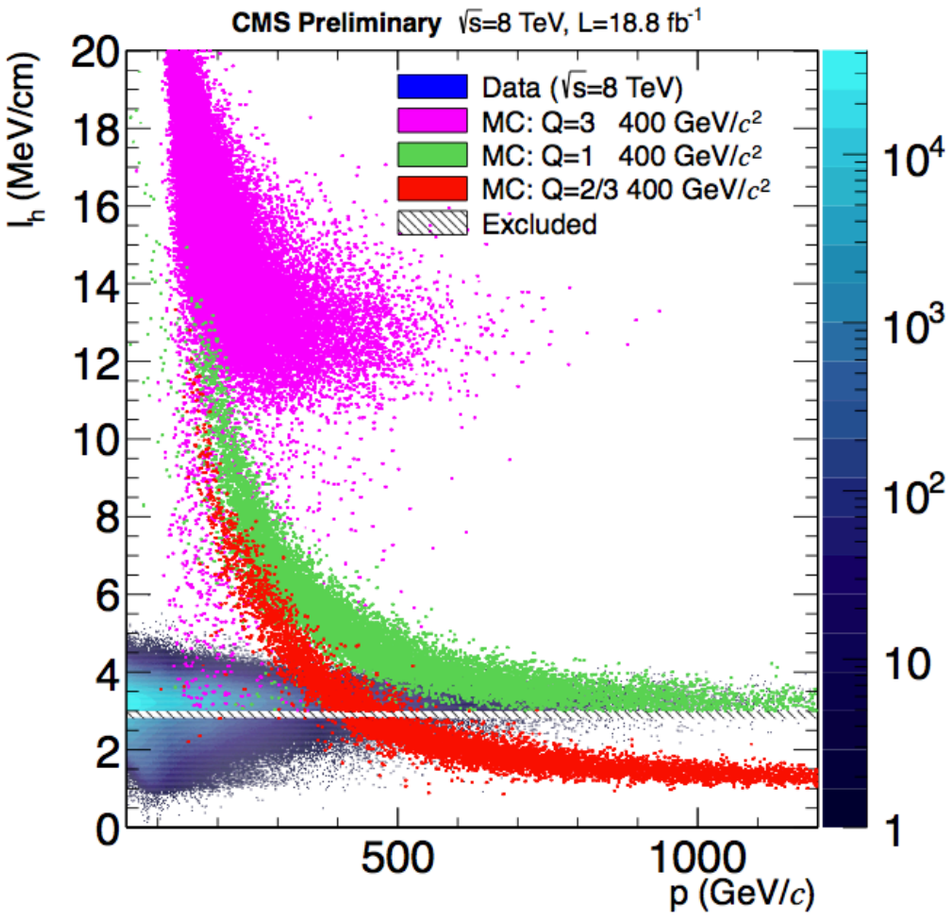
Common considerations catching HSCP/SMP

- Long-lived, O(10 ns), i.e. traverses the detector

- Anomalouslv slow
  - $\beta_{SM} = v/c = p/E \sim 1$
  - $\beta_{SMP} < 1 \quad \Delta\beta < 0.1$
  - TOF with calo or muon system



arXiv:1211.1597v2 [hep-ex] 25 Mar 2013



CMS PAS EXO-12-025 20 Mar 2013

- Anomalous dE/dx
  - Fractional or multiple charge can be seen in several sub-detectors

- Use muon and MET triggers and a combination of β and dE/dx

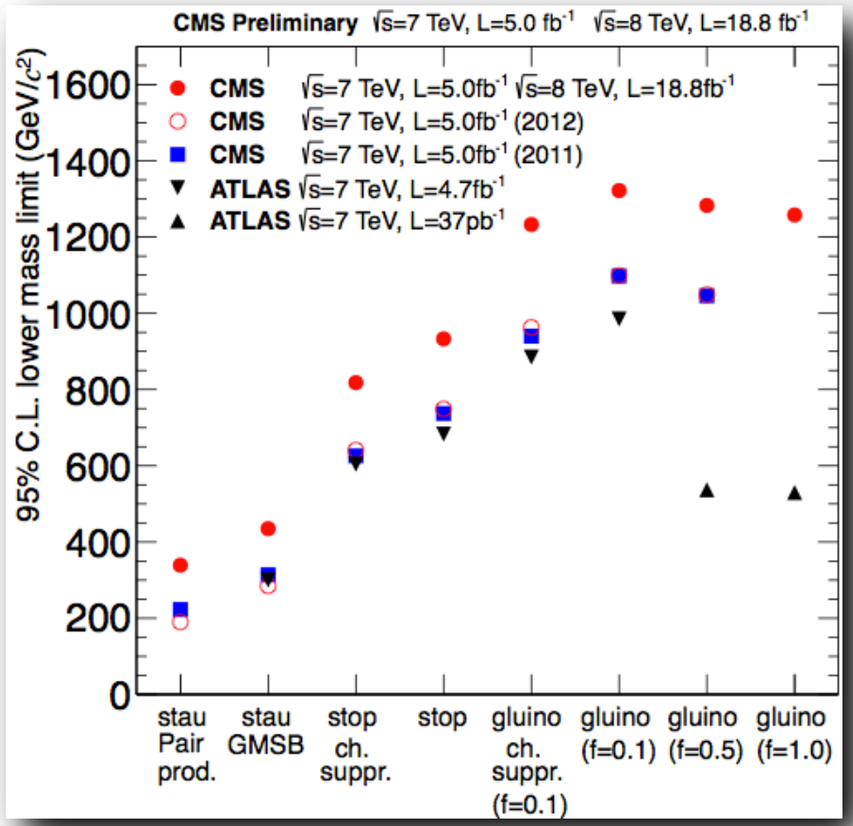
Searches for Long-lived Charged Particles in pp Collisions at $\sqrt{s} = 7$ and 8 TeV

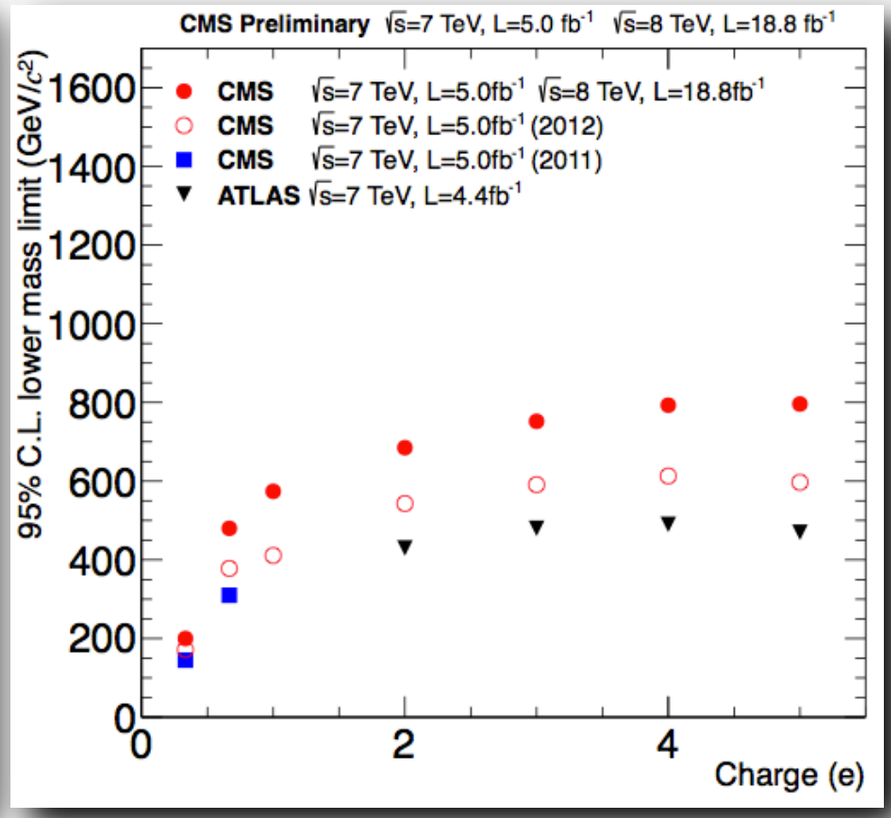
Compact Muon Solenoid experiment at CERN's LHC

arXiv:1305.0491v1 [hep-ex] 2 May 2013

- High pT muon & MET triggers
- SRs with pT, dE/dx and ToF (from MS)
- Bkg from data (ABCD)
- No excess

	Selection criteria				Numbers of events $\sqrt{s} = 7$ TeV		$\sqrt{s} = 8$ TeV	
	p_T (GeV/c)	$I_{as}^{(l)}$	$1/\beta$	Mass (GeV/c^2)	Pred.	Obs.	Pred.	Obs.
tracker-only	> 70	> 0.4	-	> 0	7.1 ± 1.5	8	32.5 ± 6.5	41
				> 100	6.0 ± 1.3	7	26.0 ± 5.2	29
				> 200	0.65 ± 0.14	0	3.1 ± 0.6	3
				> 300	0.11 ± 0.02	0	0.55 ± 0.11	1
				> 400	0.030 ± 0.006	0	0.15 ± 0.03	0
tracker+TOF	> 70	> 0.125	> 1.225	> 0	8.5 ± 1.7	7	43.5 ± 8.7	42
				> 100	1.0 ± 0.2	3	5.6 ± 1.1	7
				> 200	0.11 ± 0.02	1	0.56 ± 0.11	0
				> 300	0.020 ± 0.004	0	0.090 ± 0.02	0
muon-only	> 230	-	> 1.40	-	–	–	5.6 ± 2.9	3
$\|Q\| > 1e$	-	> 0.500	> 1.200	-	0.15 ± 0.04	0	0.52 ± 0.11	1
$\|Q\| < 1e$	> 125	> 0.275	-	-	0.12 ± 0.07	0	0.99 ± 0.24	0





5fb^{-1}@7TeV
18.8fb^{-1}@8TeV

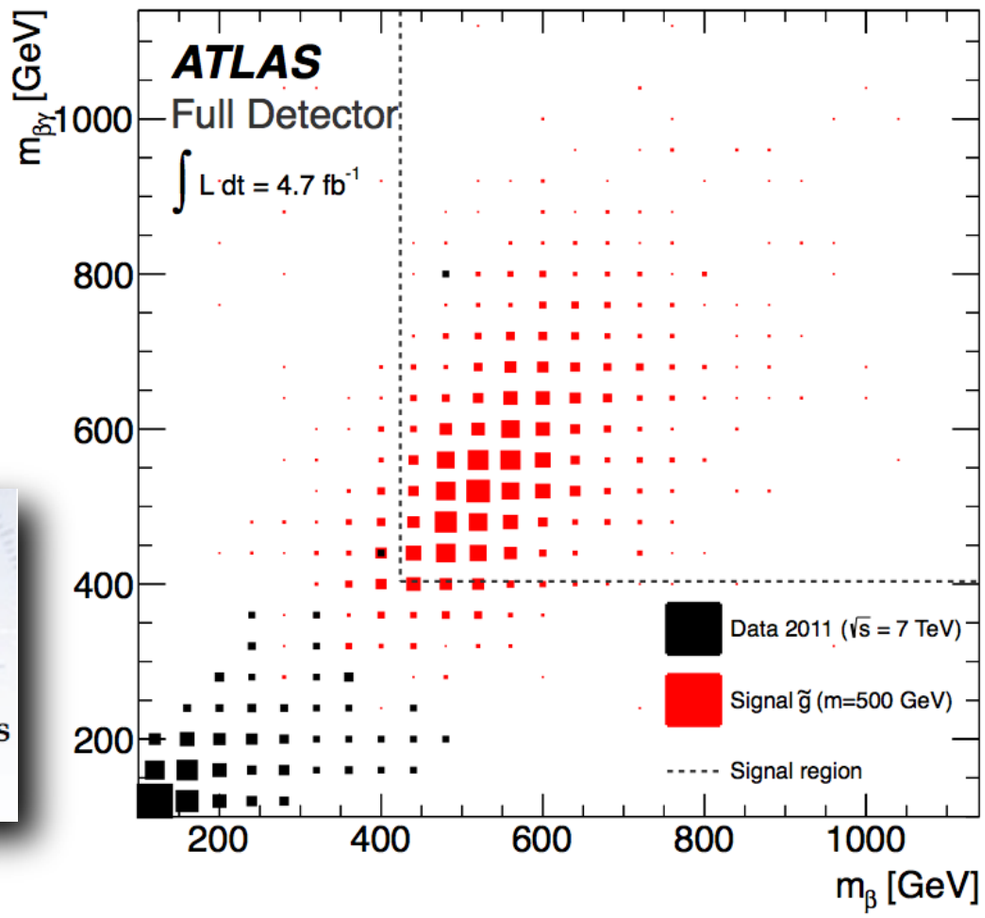
- stau limit (GMSB)
- R-Hadron limits on stop and gluino (direct production, split SUSY)
- Odd charge limits

Searches for heavy long-lived sleptons and R-hadrons with the ATLAS detector in pp collisions at $\sqrt{s} = 7$ TeV

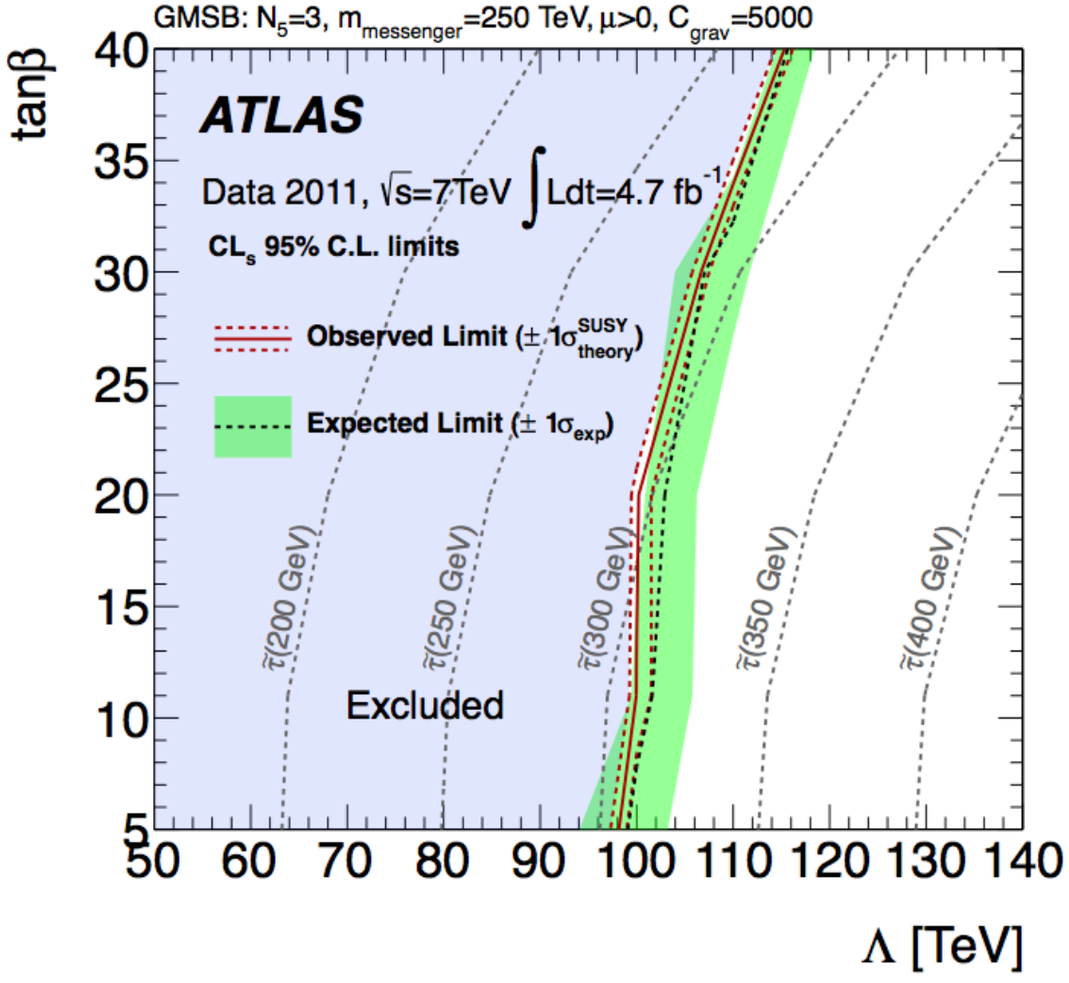
ATLAS EXPERIMENT

4.7 fb^{-1}@7TeV

- High pT muon and MET triggers (ToF from calo)
- Signal regions in mass plane
  - MS only (R-Hadrons)
  - ID only ("short" lived, charge flip)
  - ID+MS (sleptons, R-Hadrons)
- Bkg mass distr from data samples
- No excess



Three measurements
p, β and βγ
through relation
$m = p/\beta\gamma$
combines to two masses
m_β and $m_{\beta\gamma}$



- Slepton limit (GMSB) 300 GeV, 5<tanβ<20
- R-Hadron limits (direct gluino&squark prod.)
  - Gluino 986 GeV (gluino fraction 0.1)
  - Stop 683 GeV
  - sbottom 612 GeV

arXiv:1211.1597v2 [hep-ex] 25 Mar 2013

arXiv:1301.5272v1 [hep-ex] 22 Jan 2013

Search for long-lived, multi-charged particles in pp collisions at $\sqrt{s}$ = 7 TeV using the ATLAS detector

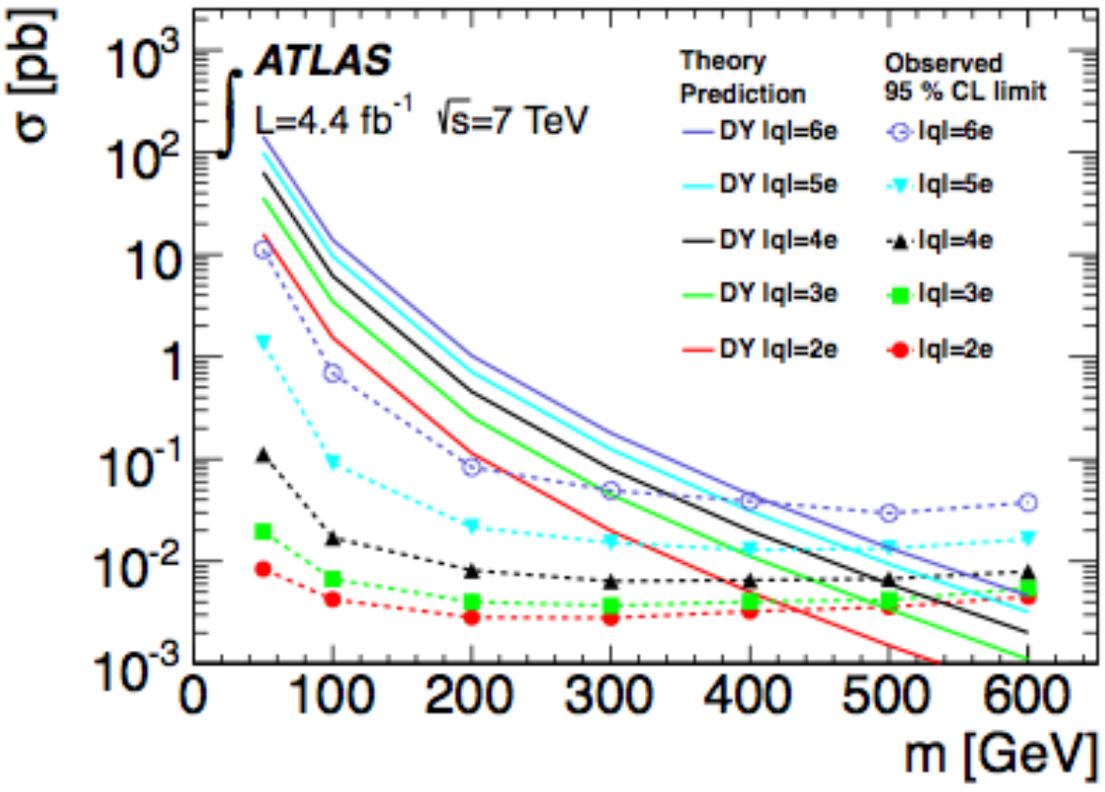
ATLAS EXPERIMENT

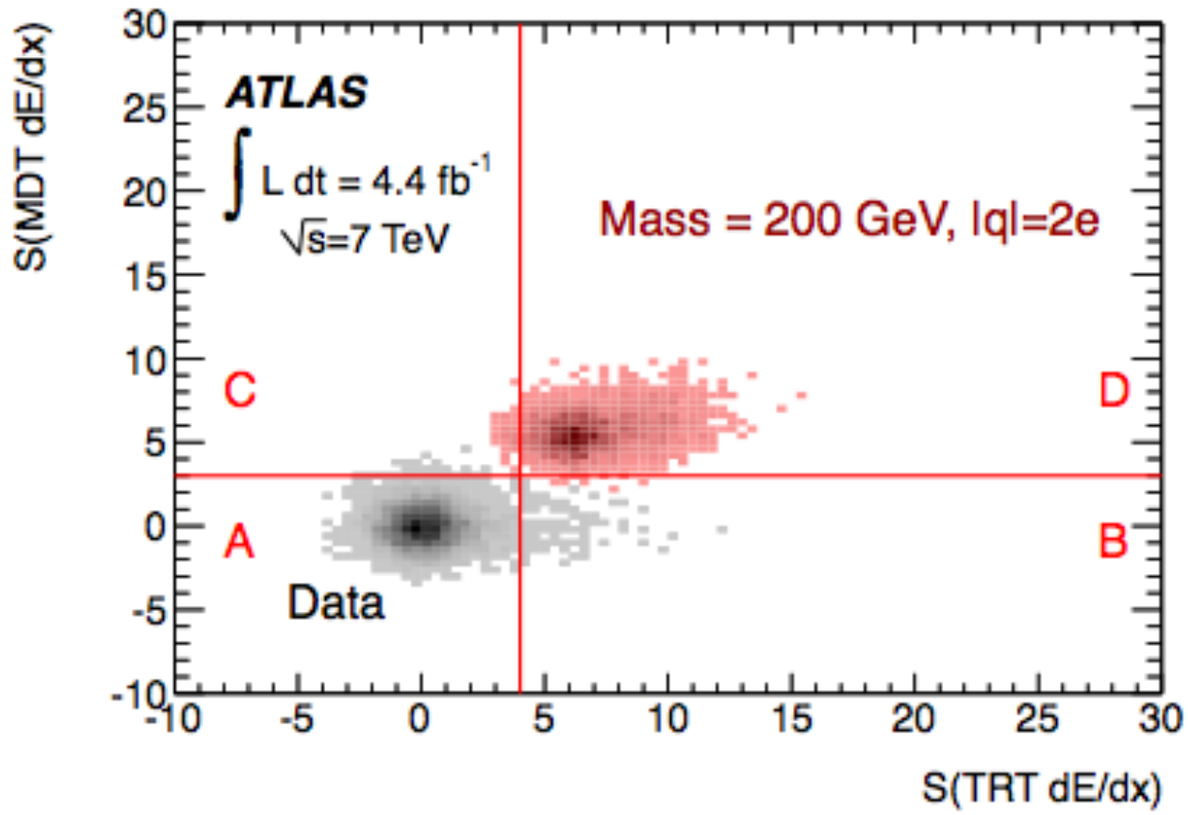
4.4 fb^{-1}@7TeV

- |q| = from 2e to 6e
- Single muon trigger

- Using dE/dx significance S wrt muon in MDT and TRT for two signal regions (2e and >2e)

- Bkg from data (ABCD)





- Background : 0.41±0.08±0.02 and 1.37±0.46±0.07

- 0 observed

- Exclusions in simplified Drell-Yan model in mass ranges from 50 to about 450 GeV

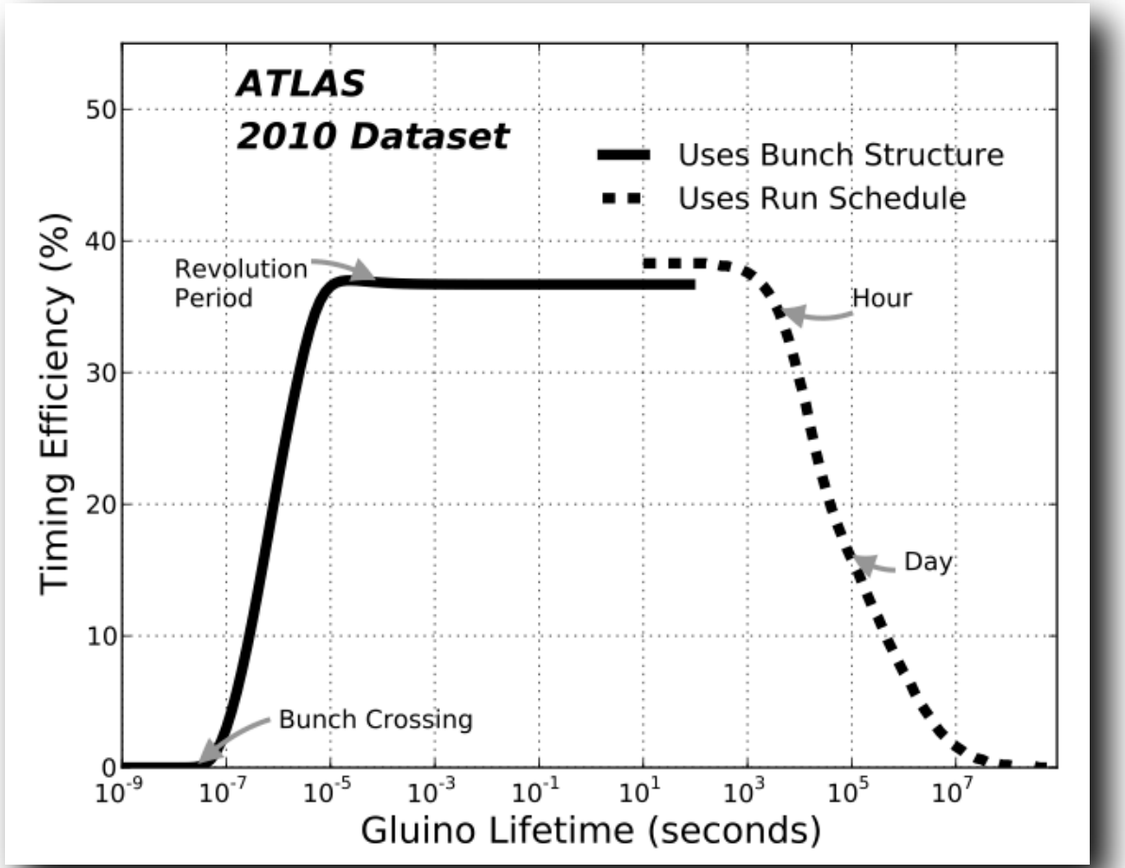
Stopped R-Hadrons with out-of-time decays

Common considerations for “out-of-time” decays

- Long-lived, beyond the time between bunches (25 - ~100 ns), i.e. decay associated with later bunch

- Paired, unpaired and empty crossings. Use latter to have minimal background.

- Backgrounds are cosmics, noise, beam halo interactions



arXiv:1201.5595v2 [hep-ex] 7 May 2012

- Use a low threshold veto trigger on beam, empty or/and unpaired crossings together with some calorimeter activity

arXiv:1201.5595v2 [hep-ex] 7 May 2012

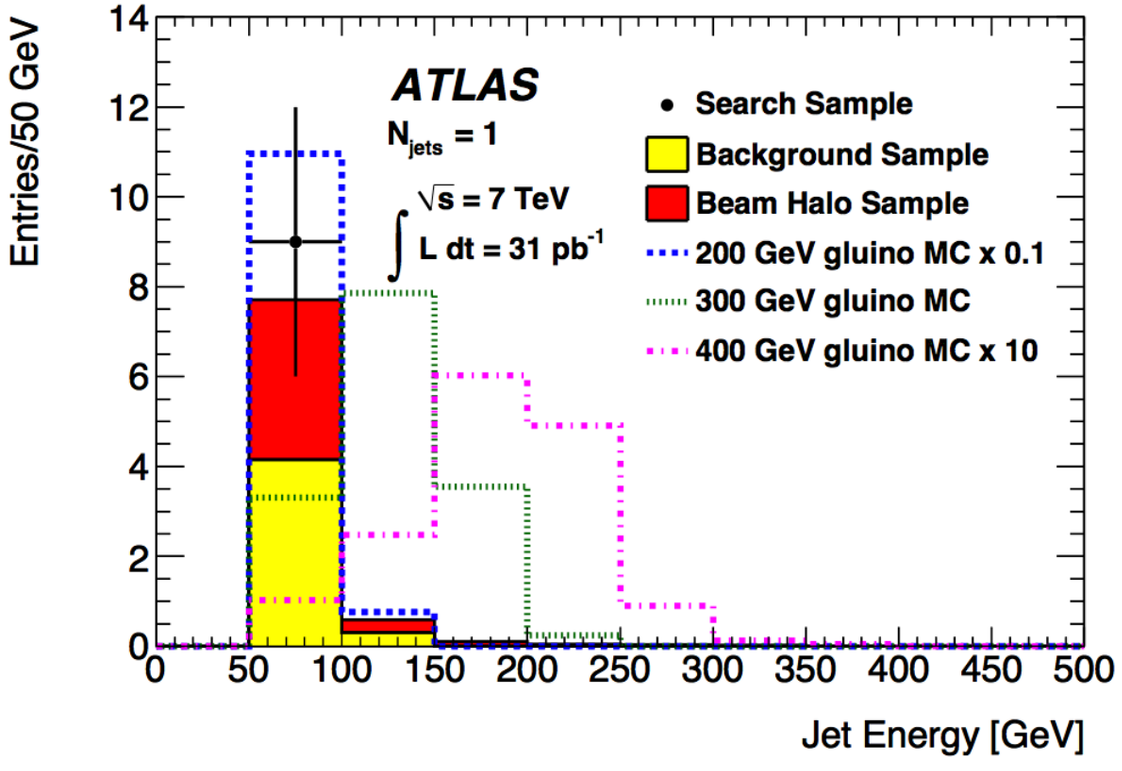
Search for Decays of Stopped, Long-Lived Particles from 7 TeV *pp* Collisions with the ATLAS Detector

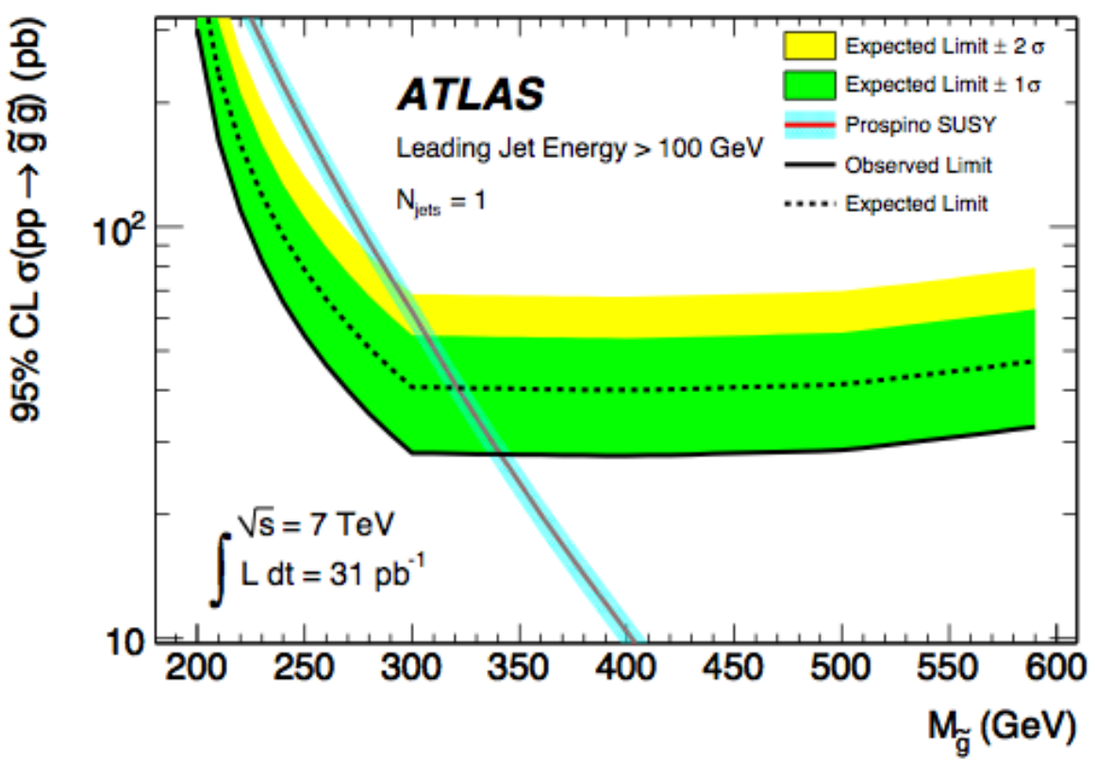
- Calo trigger > 10 GeV, >125 ns after last paired crossing
- 4 signal regions
- Bkg from cosmic and halo data samples

Selection criterion	Number of events		
	Expected cosmic ray muons	Expected beam-halo	Observed
Single Jet: Muon Veto	4 ± 1	4 ± 1.8	9
Single Jet: > 100 GeV	0.3 ± 0.3	0.5 ± 0.2	0
Multi-Jet: Muon Veto	1 ± 0.6	0.8 ± 0.8	3
Multi-Jet: > 100 GeV	0.6 ± 0.4	0.2 ± 0.2	1

31 pb-1@7TeV

- Mass limit on gluino 341 GeV for lifetimes 10^{-5} - 10^{3} s





Search for stopped long-lived particles produced in pp collisions at $\sqrt{s} = 7$ TeV

4fb^{-1}@7TeV

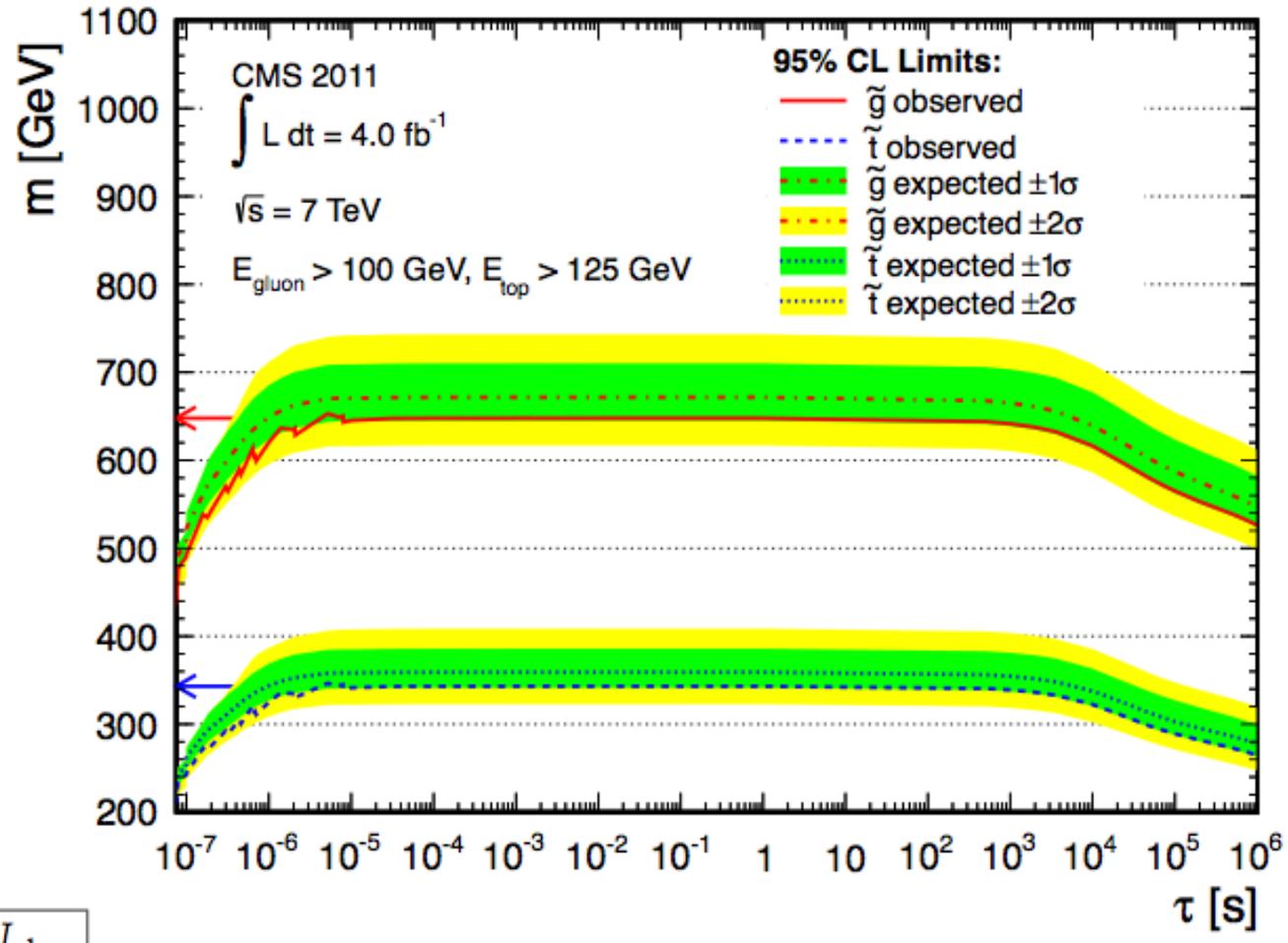
Compact Muon Solenoid experiment at CERN's LHC

- BPTX + jet trigger, ± 2BX veto, max trigger live time 246h
- Bkg from cosmics and noise samples, tag and probe for halo

Cosmic rays	Beam-halo	Noise	Total
5.71 ± 0.62	1.50 ± 0.70	1.4 ± 2.2	8.6 ± 2.4

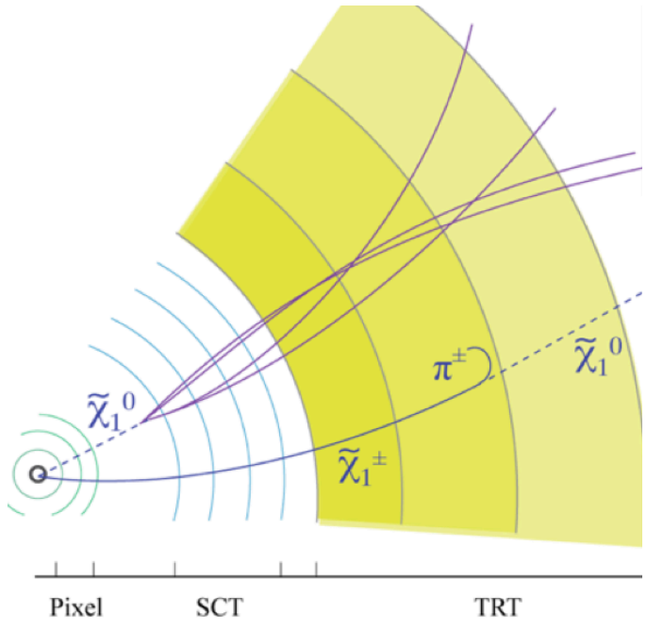
arXiv:1207.0106v2 [hep-ex] 11 Mar 2013

τ	L_{eff} (pb^{-1})	Live time (s)	N_{exp}	N_{obs}
75 ns	19.6	2.06×10^4	0.200 ± 0.056	1
100 ns	57.8	6.17×10^4	0.60 ± 0.17	2
1 μs	508	4.41×10^5	4.3 ± 1.2	7
10 μs	913	8.67×10^5	8.5 ± 2.4	12
100 μs	935	8.86×10^5	8.6 ± 2.4	12
10^3 s	866	8.86×10^5	8.6 ± 2.4	12
10^4 s	636	8.86×10^5	8.6 ± 2.4	12
10^5 s	332	8.86×10^5	8.6 ± 2.4	12
10^6 s	198	8.86×10^5	8.6 ± 2.4	12



- 12 observed
- Mass limits on gluino and stop at 640 and 340 GeV for life times 10^{-5} - 10^3 s

Displaced Vertices
Disappearing Tracks
Non-Pointing Photons



ATLAS Slice

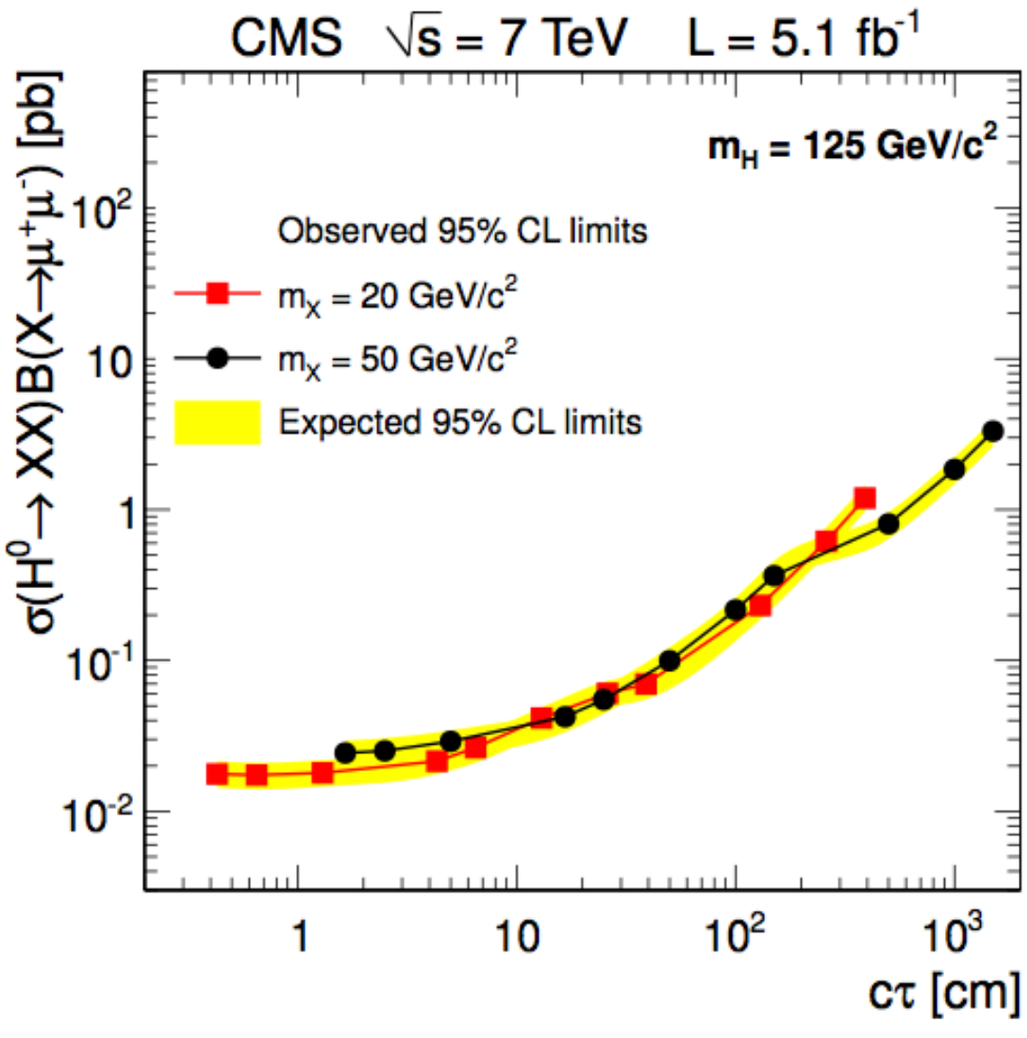
Search in leptonic channels for heavy resonances decaying to long-lived neutral particles

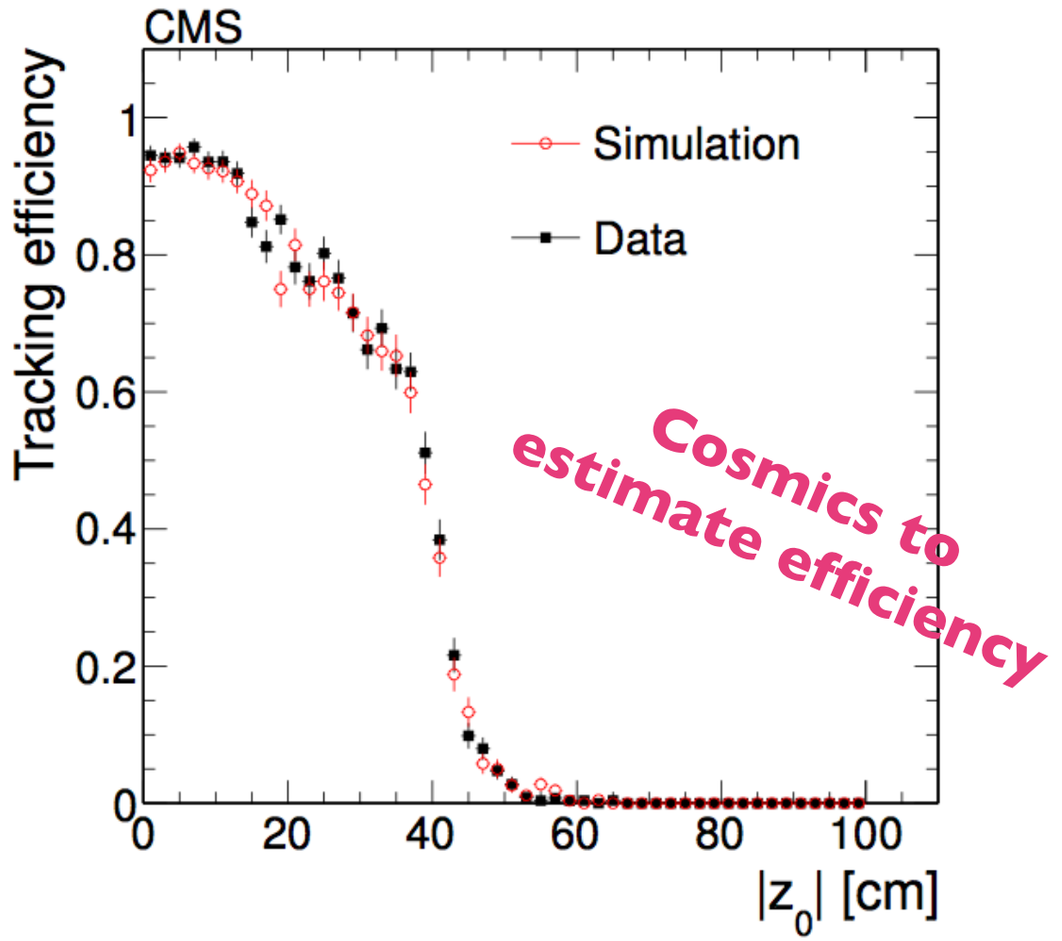
4-5fb^{-1}@7TeV

JHEP02(2013)085

Compact Muon Solenoid experiment at CERN's LHC

- Benchmark signal : H -> 2X -> 4l
- Opposite charge ee and μμ pairs with displaced vertex. Cut on impact parameter significance





Cosmics to estimate efficiency

- ee : exp=1.4+1.8-1.2, obs=4
- μμ : exp=0.02+0.09-0.02, obs=0

- Several limits on X production, dependent on decay length and Higgs mass

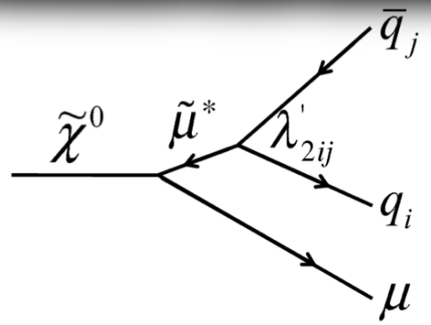
Search for long-lived, heavy particles in final states with a muon and multi-track displaced vertex in proton-proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

ATLAS EXPERIMENT

4.4 fb^{-1}@7TeV

- Benchmark signal

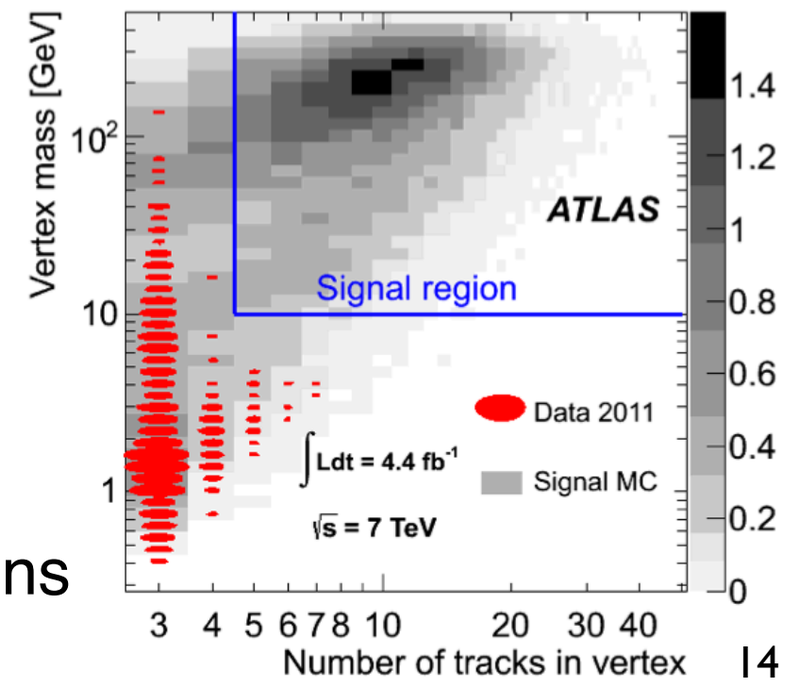
RPV



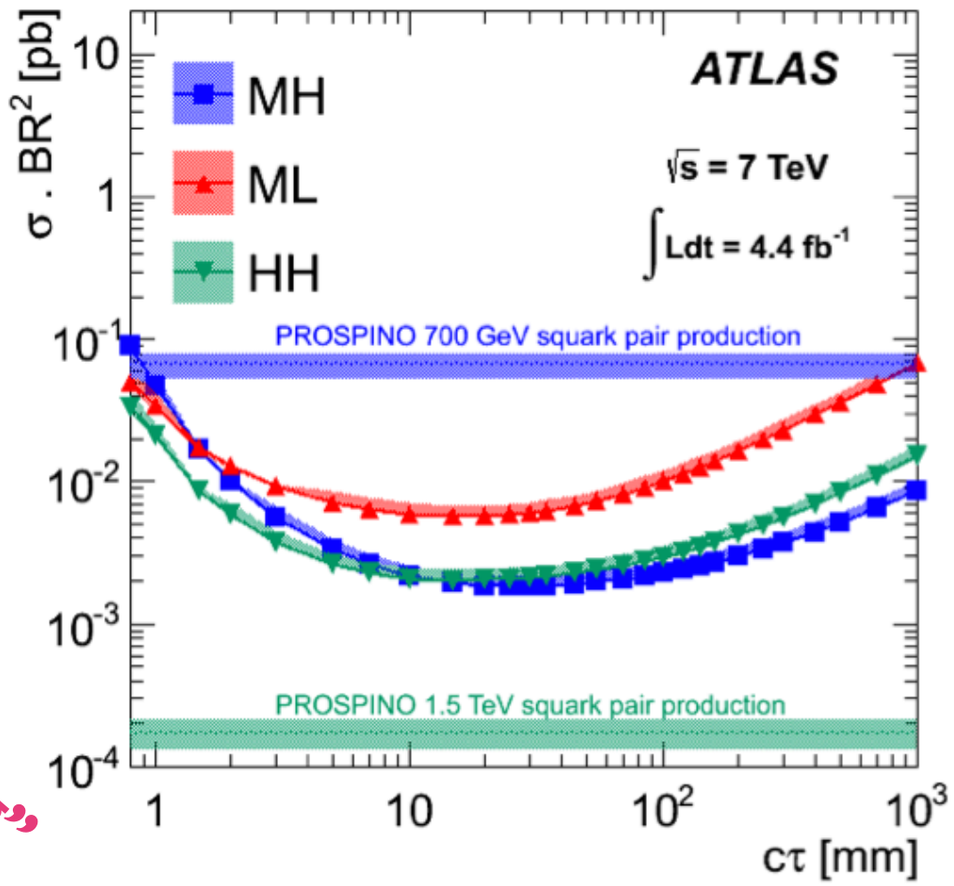
Sample	$m_{\tilde{q}}$ [GeV]	σ [fb]	$m_{\tilde{\chi}_1^0}$ [GeV]	$\langle\gamma\beta\rangle_{\tilde{\chi}_1^0}$	$c\tau_{\mathrm{MC}}$ [mm]	λ'_{211} $\times 10^{-5}$
MH	700	66.4	494	1.0	78	0.3
ML	700	66.4	108	3.1	101	1.5
HH	1500	0.2	494	1.9	82	1.5

- Selection: Muon pT > 50GeV, d_T(PV,DV) > 4 mm displaced vertex mass and tracks

- Bkg from rndm vtx and gas interactions



"Re-tracking"



- Exp < 0.01. Obs=0

- Cross section x BR limits for various RPV signals

arXiv:1210.7451v2 [hep-ex] 22 Mar 2013

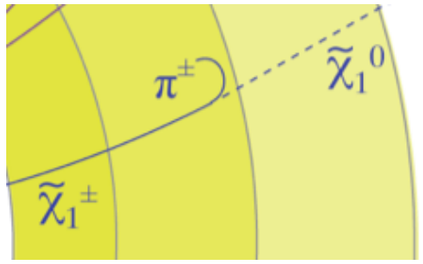
arXiv:1210.2852v2 [hep-ex] 22 Mar 2013

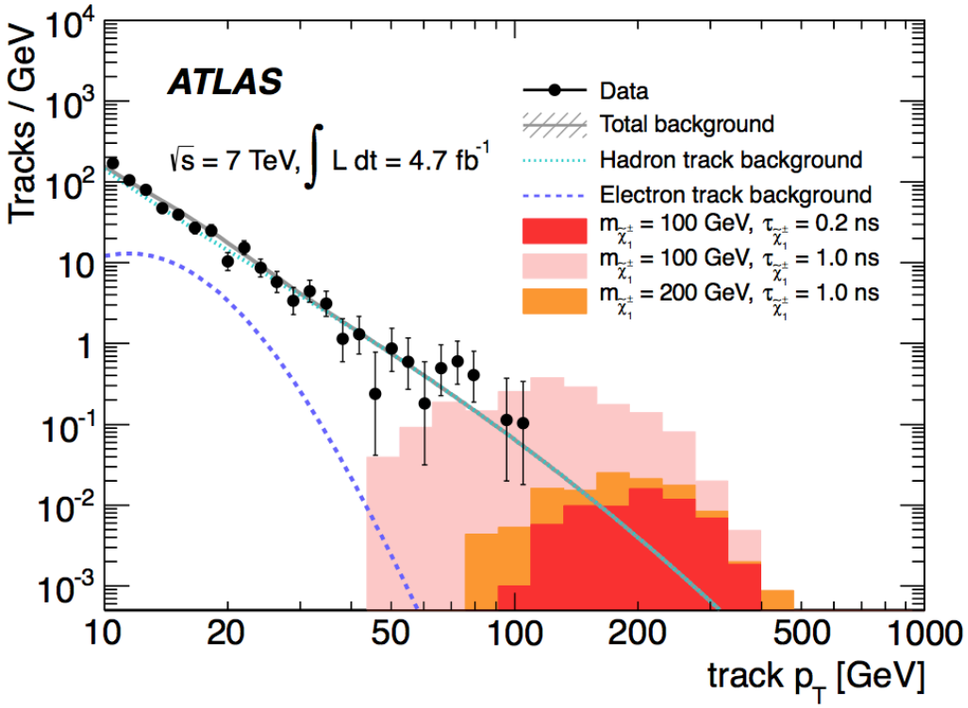
Search for direct chargino production in anomaly-mediated supersymmetry breaking models based on a disappearing-track signature in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

ATLAS EXPERIMENT

4.4 fb^{-1}@7TeV

- O(10)mm < cτ < O (100)mm
- Benchmark signal: $pp \to \tilde{\chi}_1^{\pm}\tilde{\chi}_1^0 j,$





- Selection : High pT jet, MET, disapp. track using the Transition Radiation Tracker
- Background-only (hadron and electron tracks) fit to observed p_T with p_0=0.54.
- Limits in AMSB are $m_{X^{\pm}}$=103 (83) GeV for the typical small mass splitting 160 (170) MeV.

Requirement	Observed	Signal events (efficiency [%])	
		$m_{\tilde{\chi}_1^{\pm}} = 100$ GeV	$m_{\tilde{\chi}_1^{\pm}} = 200$ GeV
Quality requirements and trigger	3765627	1983 (3.0)	283.3 (6.7)
Non-collision background rejection	2899498	1958 (3.0)	279.6 (6.6)
Lepton veto	2186581	1906 (2.9)	274.8 (6.5)
Leading jet $p_T > 90$ GeV	2054262	1497 (2.3)	237.7 (5.6)
$E_T^{miss} > 90$ GeV	1233864	1420 (2.2)	230.2 (5.5)
$\Delta\phi_{min}^{jet-E_T^{miss}} > 1.5$ rad	1191298	1402 (2.1)	227.4 (5.4)
High-p_T isolated track selection	18493	90.5 (0.14)	9.1 (0.26)
Disappearing-track selection	710	42.9 (0.066)	4.1 (0.12)

Table 1. Summary of selection requirements and data reduction for data and expected signal events ($\tau_{\tilde{\chi}_1^{\pm}} = 1$ ns). The signal selection efficiencies are also shown in parentheses.

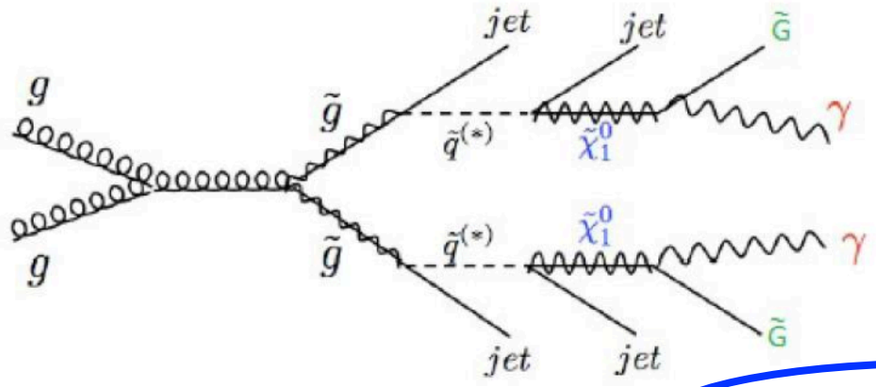
arXiv:1304.6310v1 [hep-ex] 23 Apr 2013

Search for non-pointing photons in the diphoton and $E_{\mathrm{T}}^{\mathrm{miss}}$ final state in $\sqrt{s} = 7\,\mathrm{TeV}$ proton–proton collisions using the ATLAS detector

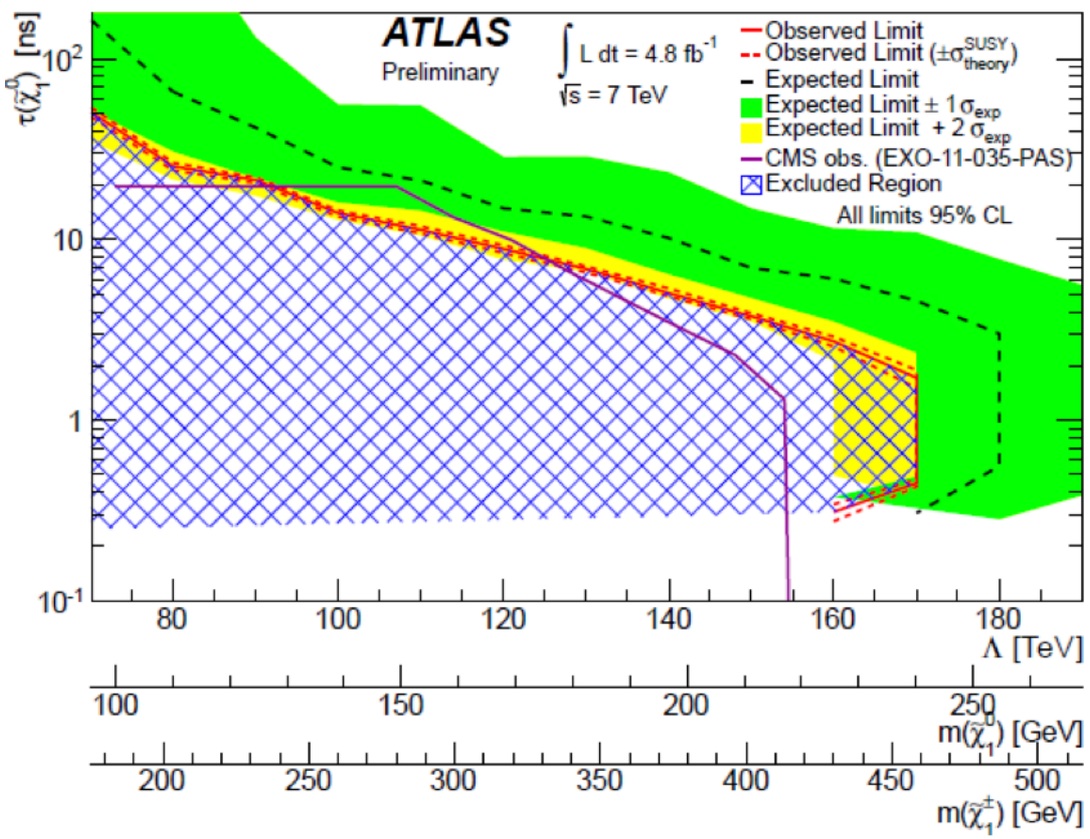
ATLAS EXPERIMENT

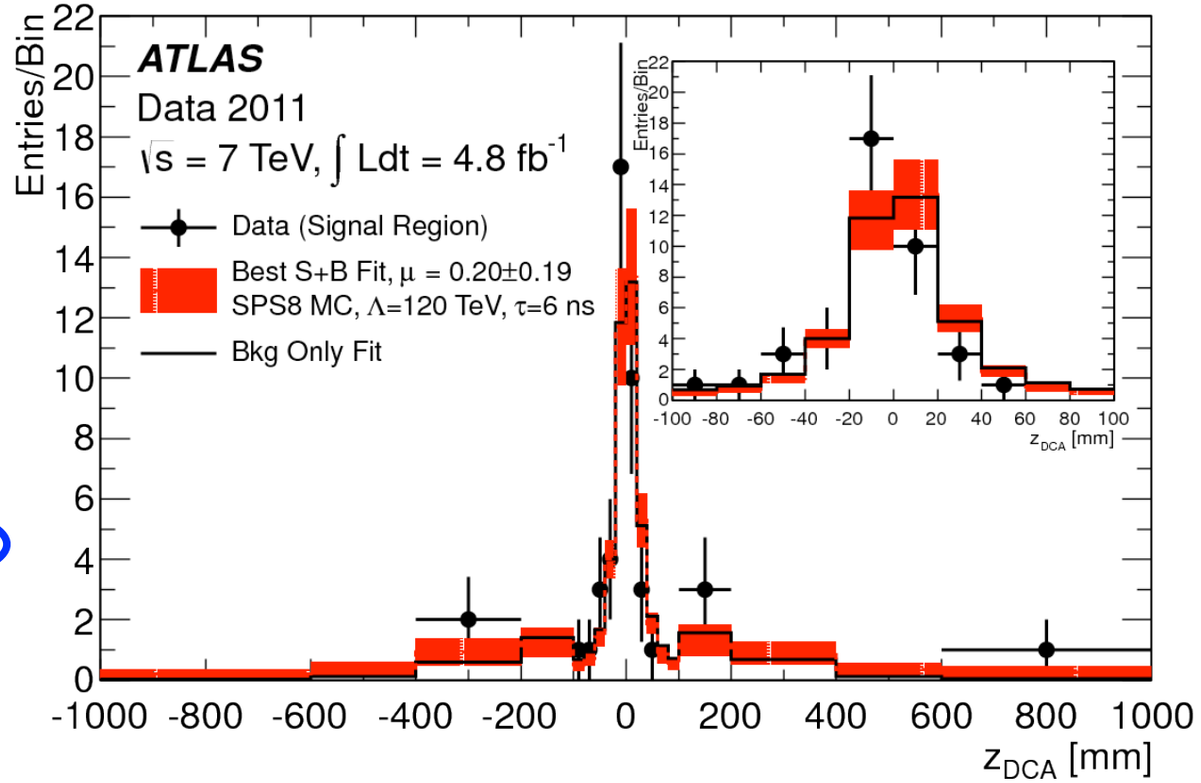
4.8 fb^{-1}@7TeV

- Long-lived neutral particles to photons (>50 GeV)+ MET (>75 GeV)



- Using ATLAS em calo pointing capability





- Fit to the Z_{DCA} data distribution of a loose photon using signal, prompt e/gamma and jet templates

- No excess
- Limits in GMSB, $m_{N0} >\sim 230$ GeV for $c\tau <\sim 1$ m

Search for long-lived particles decaying to photons and missing energy in proton-proton collisions at $\sqrt{s} = 7\,\text{TeV}$

4.9 fb^{-1}@7 TeV

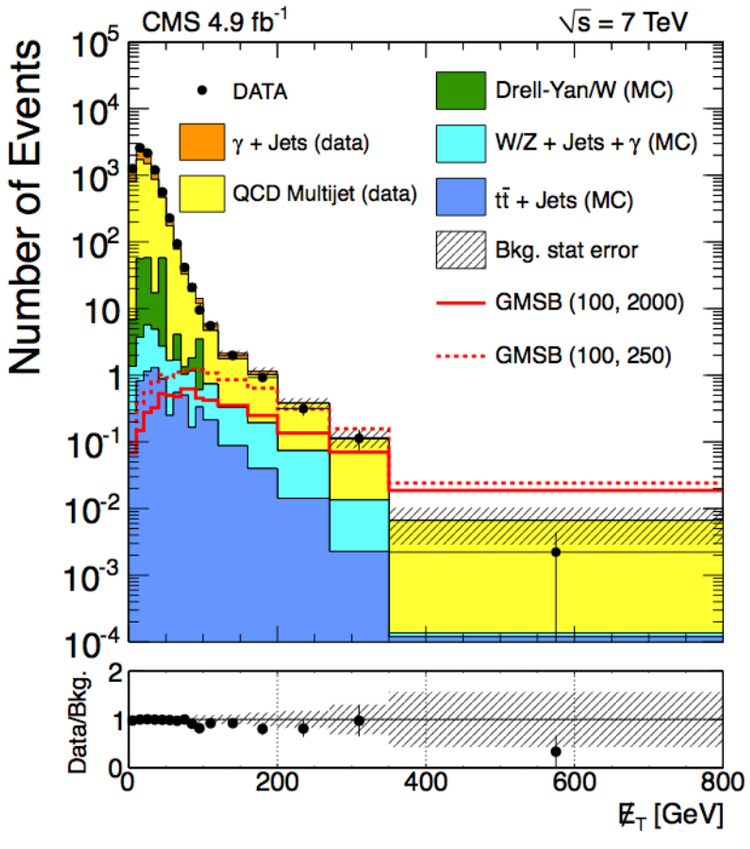
Compact Muon Solenoid experiment at CERN's LHC

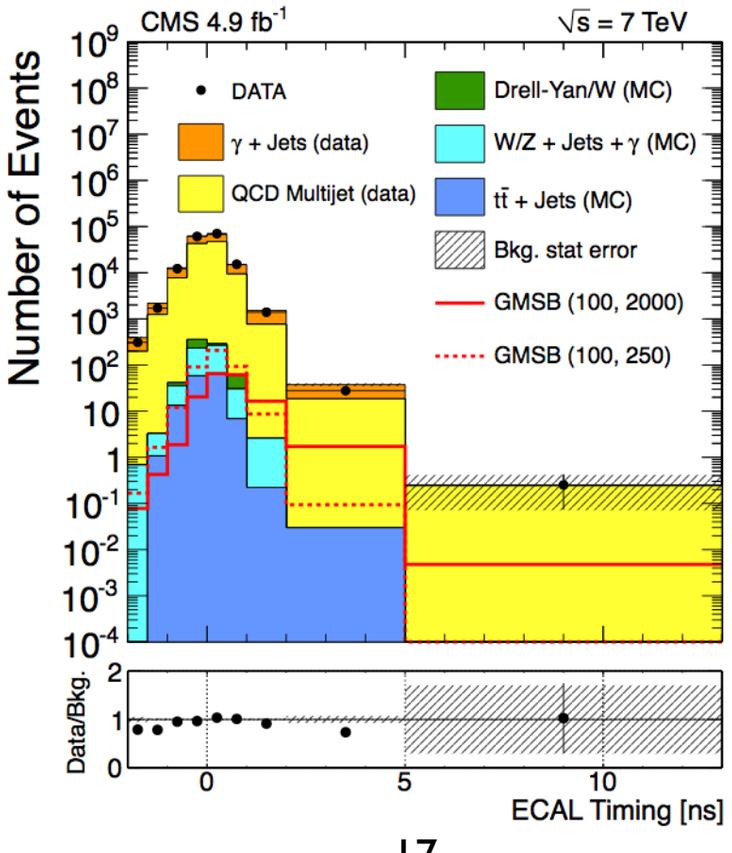
arXiv:1212.1838v1 [hep-ex] 8 Dec 2012

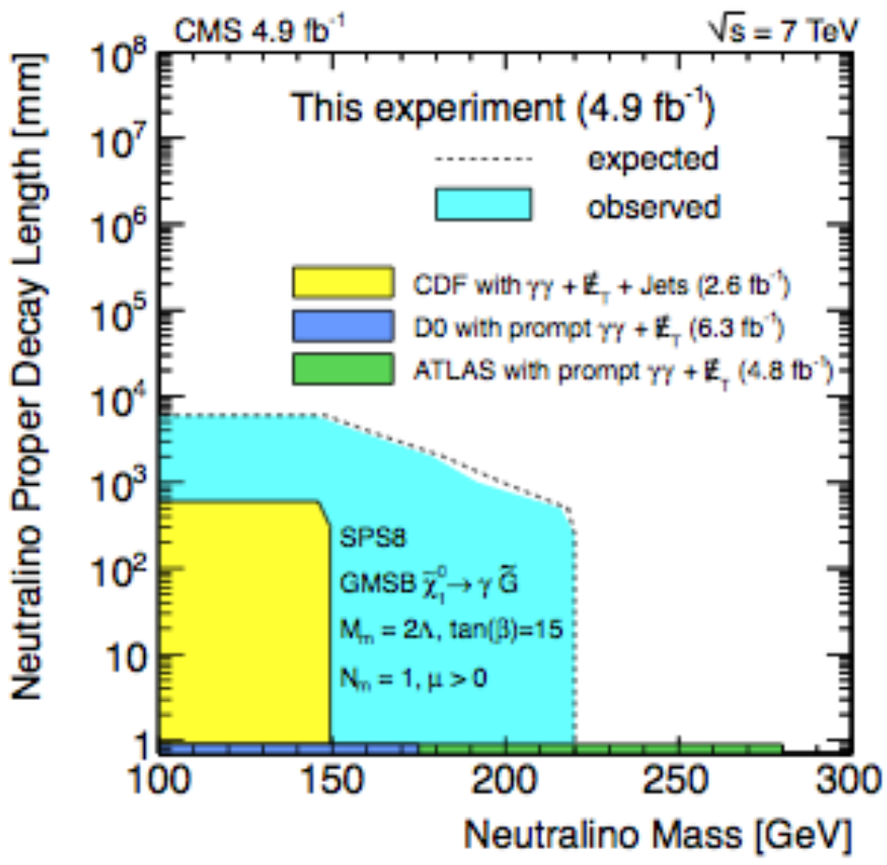
- Long-lived particle to photons + MET
  (see diagram from previous slide)

- Selection features:
  3 jets with pT>35 GeV
  pT(photon) > 100 GeV

- Fit to 2D MET and ECAL time distribution



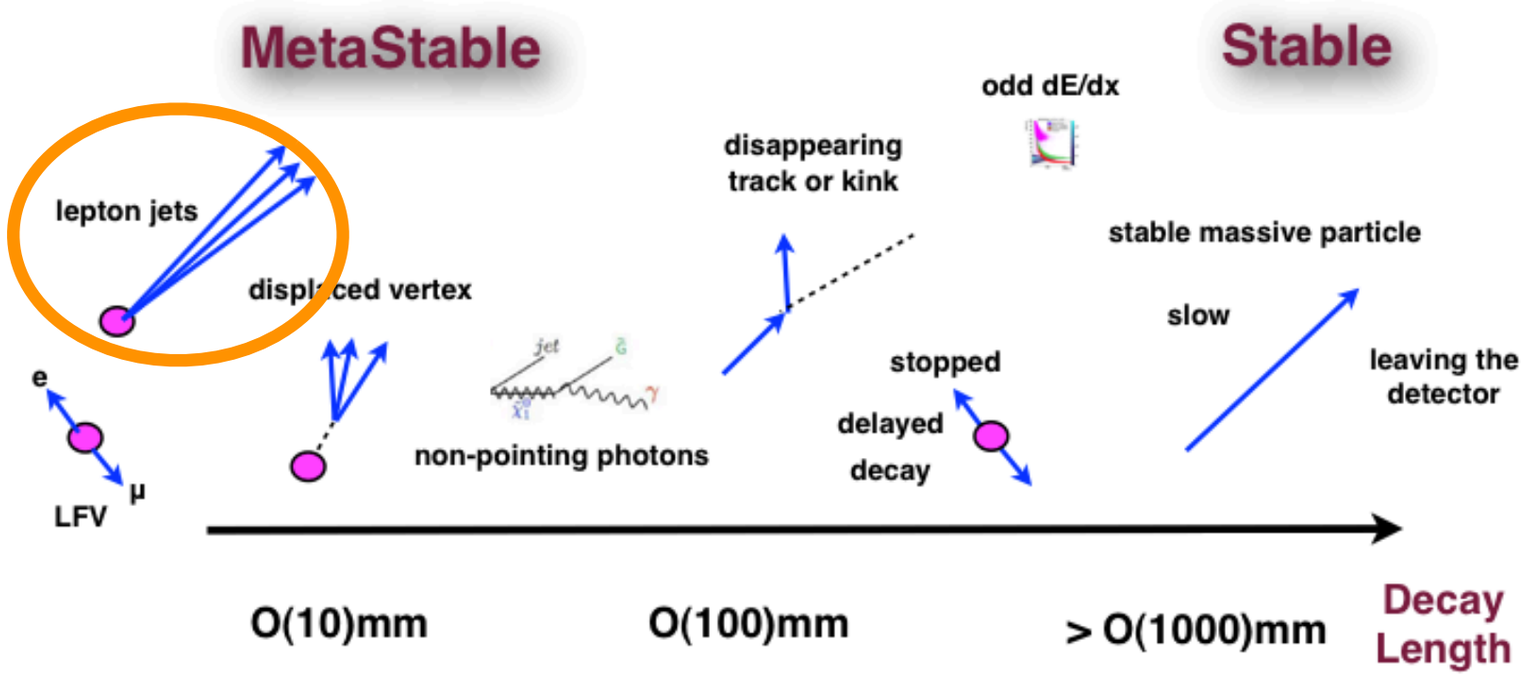




- No excess

- Limits in GMSB
  $m_{N0} >\sim 220$ GeV
  for $c\tau <\sim 1$ m

Lepton Jets

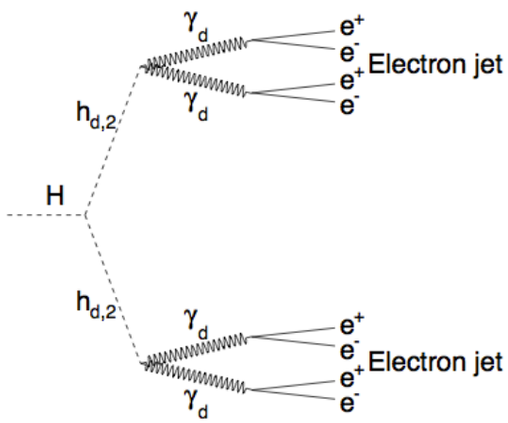

MetaStable
Stable
lepton jets
displaced vertex
e
μ
LFV
jet
non-pointing photons
odd dE/dx
disappearing
track or kink
stopped
delayed
decay
stable massive particle
slow
leaving the
detector
O(10)mm
O(100)mm
> O(1000)mm
Decay
Length

arXiv:1302.4403v1 [hep-ex] 18 Feb 2013

Search for WH production with a light Higgs boson decaying to prompt electron-jets in proton–proton collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

ATLAS EXPERIMENT

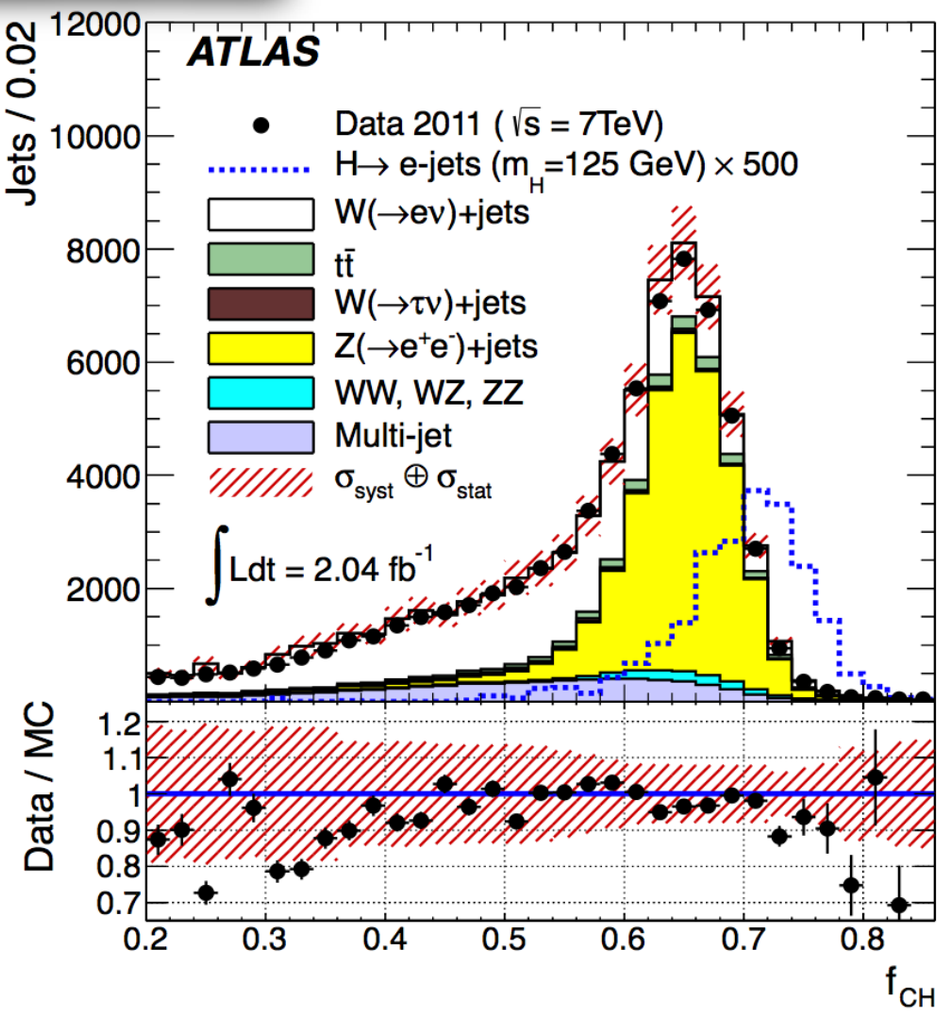
2.04 fb^{-1} @ 7 TeV



- 2-3 step cascade decay via Hidden Valley particles. Boosted dark photons making collimated lepton jets (2 step in diagram)

- Signal : lep + MET (W) + e-Jet

- Exploring ECAL properties of e-Jets, e.g. fraction of E associated with tracks f_{CH}



Signal	three-step model		two-step model	
m_H (GeV)	$m_{\gamma_d} = 100$ MeV	$m_{\gamma_d} = 200$ MeV	$m_{\gamma_d} = 100$ MeV	$m_{\gamma_d} = 200$ MeV
100	$14.3 \pm 1.7 \pm 0.8$	$12.4 \pm 1.6 \pm 0.7$	$22.6 \pm 2.1 \pm 1.2$	$23.5 \pm 2.1 \pm 1.2$
125	$11.3 \pm 1.0 \pm 0.6$	$10.7 \pm 1.1 \pm 0.6$	$16.2 \pm 1.2 \pm 0.9$	$18.1 \pm 1.4 \pm 1.0$
140	$9.6 \pm 0.8 \pm 0.5$	$9.0 \pm 0.8 \pm 0.4$	$13.7 \pm 0.9 \pm 0.8$	$13.9 \pm 0.9 \pm 0.8$
Background	$0.41 \pm 0.29 \pm 0.12$			
Data	1			

- Bkg estimates with Matrix, ABCD and MC (xcheck)

- No excess (left)
- Limits produced

Check also CMS arXiv:1210.7619v1 [hep-ex] 29 Oct 2012

arXiv:1212.5409v2 [hep-ex] 22 Mar 2013

A search for prompt lepton-jets in pp collisions at $\sqrt{s} = 7$ TeV with the ATLAS detector

- Benchmark motivation: dark photon
- Trigger on muons and electrons
- Use ECAL and TRT (example in figure)

- Single lepton jet (LJ) ≥ 4 muons
- Pair of LJs with each ≥ 2 muons
- Pair of LJs with each ≥ 2 electrons

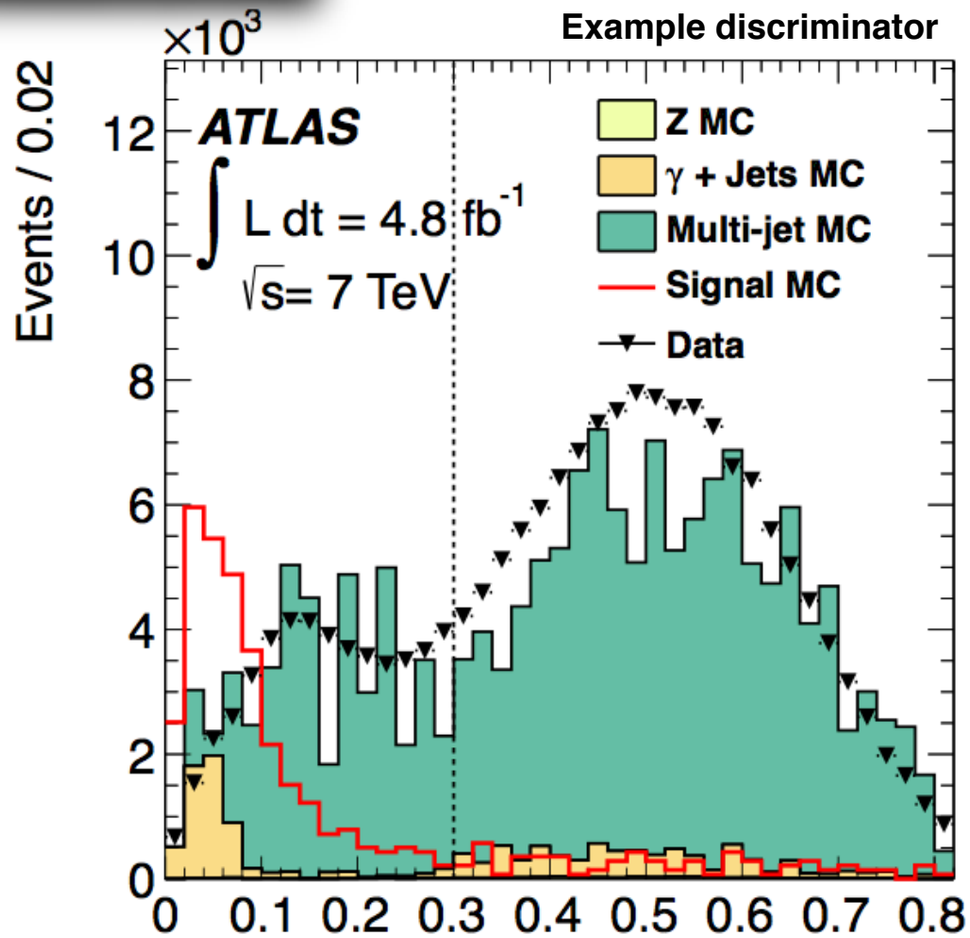
- Bkg from ABCD Likelihood (with xchecks)

	Electron LJ	1 Muon LJ	2 Muon LJ
Data	15	7	3
All background	15.2±2.7	3.0 ± 1.0	0.5 ± 0.3

4.7 fb^{-1}@ 7 TeV

- No significant excess.

- Limits on Hidden-Valley model visible cross sections from 0.017 to 1.2 pb^{-1} (table)



Signal Parameters α_d	m_{γ_D} [MeV]	Electron LJ Obs (Exp) pb	1 Muon LJ Obs (Exp) pb	2 Muon LJ Obs (Exp) pb
0.0	150	0.082 (0.082)	-	-
0.0	300	0.11 (0.11)	0.060 (0.035)	0.017 (0.011)
0.0	500	0.20 (0.21)	0.15 (0.090)	0.019 (0.012)
0.10	150	0.096 (0.10)	-	-
0.10	300	0.37 (0.37)	0.064 (0.036)	0.018 (0.011)
0.10	500	0.39 (0.39)	0.053 (0.035)	0.018 (0.011)
0.30	150	0.11 (0.11)	-	-
0.30	300	0.40 (0.40)	0.099 (0.055)	0.020 (0.012)
0.30	500	1.2 (1.2)	0.066 (0.043)	0.022 (0.015)

R-Parity Violating Signals

(if not covered by 3rd gen. and multilepton SUSY search talks)

LFVs Decay and 3-jet Resonances

arXiv:1212.1272v2 [hep-ex] 7 Dec 2012

Search for a heavy narrow resonance decaying to $e\mu$, $e\tau$, or $\mu\tau$ with the ATLAS detector in $\sqrt{s} = 7$ TeV pp collisions at the LHC

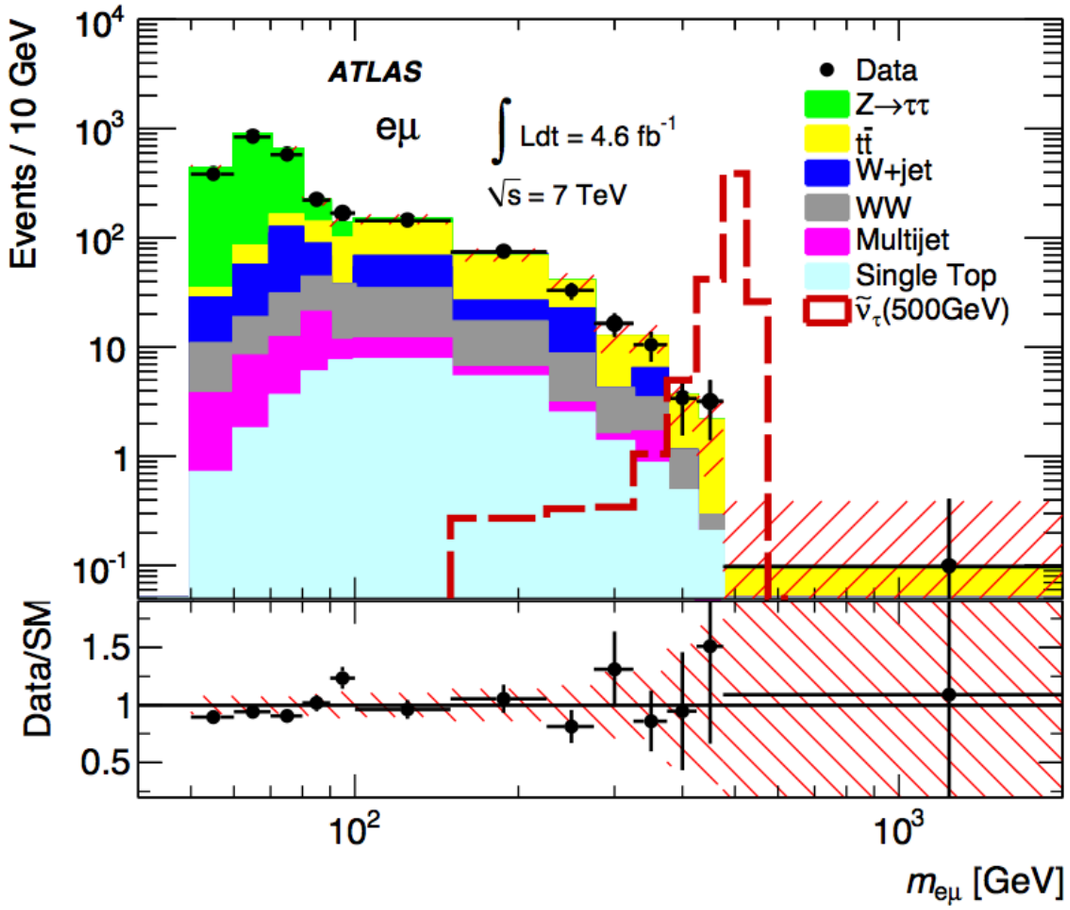
ATLAS EXPERIMENT

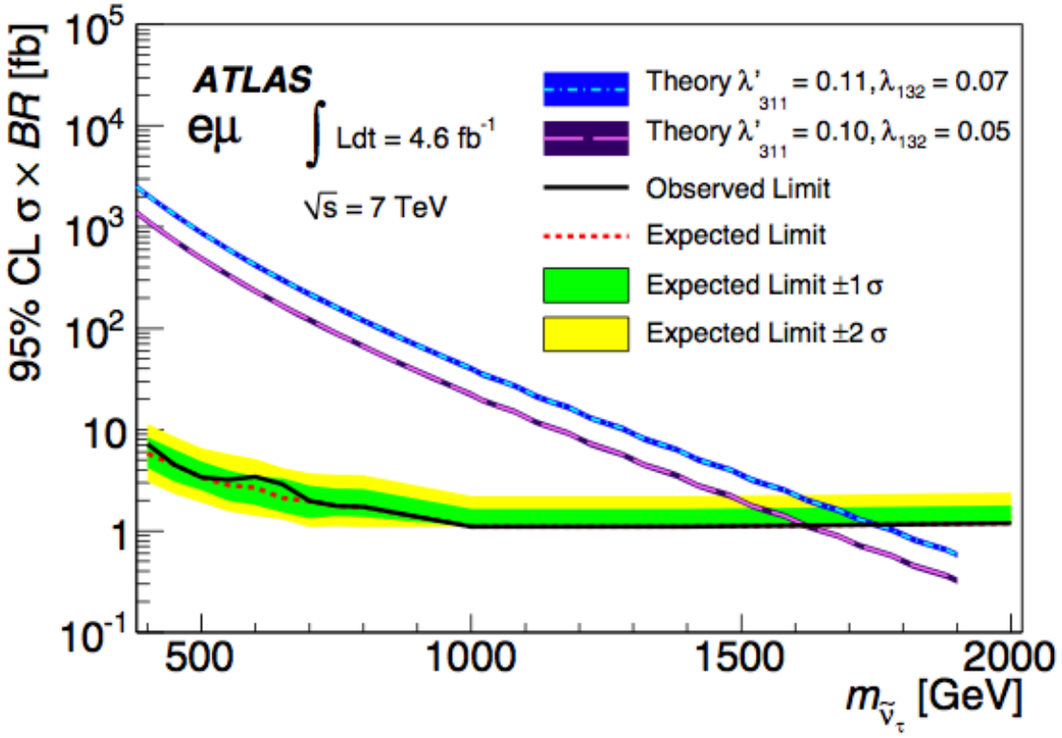
4.6 fb^{-1}@ 7 TeV

- Lepton Flavor Violating Decays (OSDF)

$$d\bar{d} \rightarrow \tilde{\nu}_\tau \rightarrow \ell\ell'$$

- Single lepton trigger
- Signal region $m_{ll} > 200$ GeV
- Bkg from MC and data, controlled with $m_{ll} < 200$ GeV
- No excess





- Distributions and exclusion shown for eμ channel only
- Limits produced for various RPV couplings

Check also ATLAS arXiv:1210.4813v2 [hep-ex] 8 Nov 2012

Search for three-jet resonances in pp collisions at $\sqrt{s} = 7\,\text{TeV}$

5.0 fb^{-1}@7 TeV

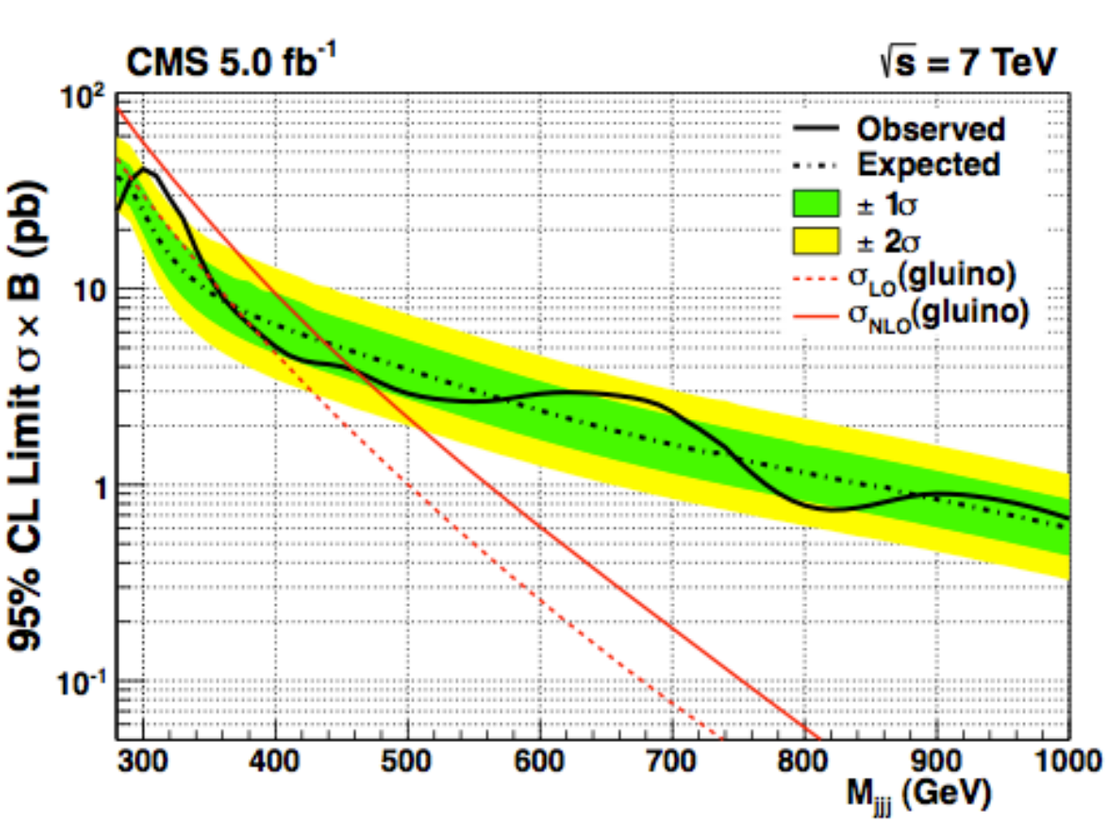
Compact Muon Solenoid experiment at CERN's LHC

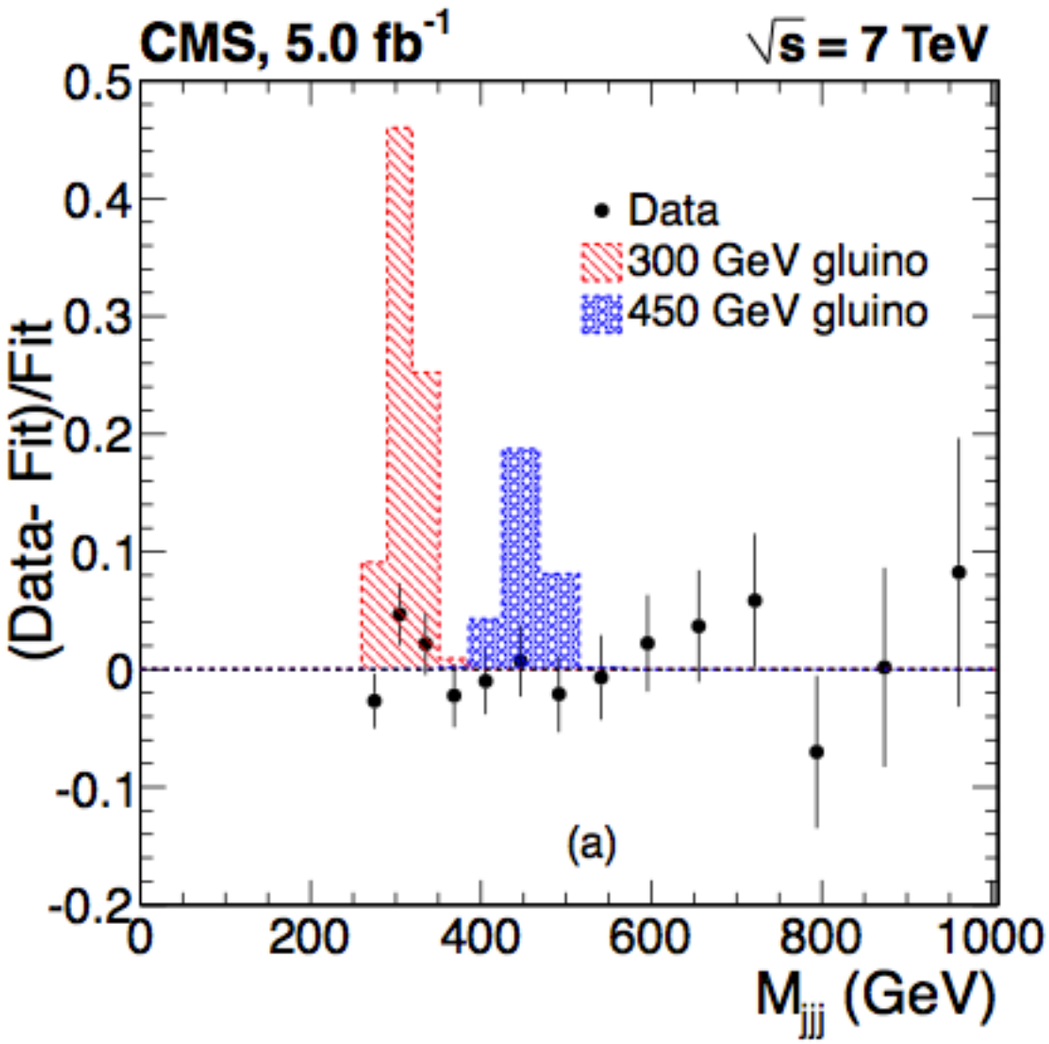
arXiv:1208.2931 [hep-ex] 12 Mar 2013

- Benchmark: gluino pair production with

$$(\tilde{g} \rightarrow q\tilde{q} \rightarrow qqq \text{ with } m_{\tilde{q}} >> m_{\tilde{g}})$$

- Uses triplet mass





- Results SM consistent
  Limits on gluinos in benchmark model up to 460 GeV

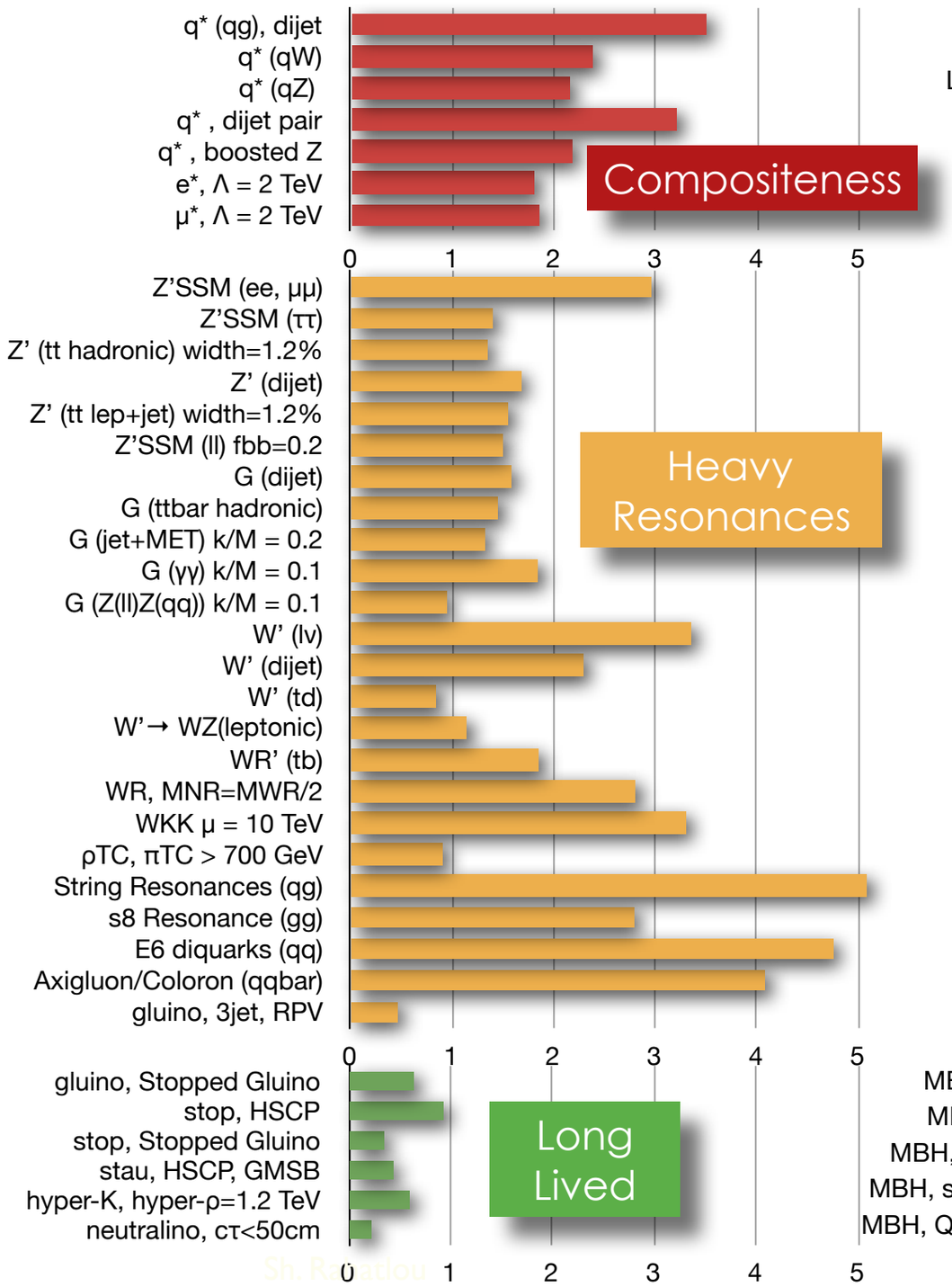
SUMMARY

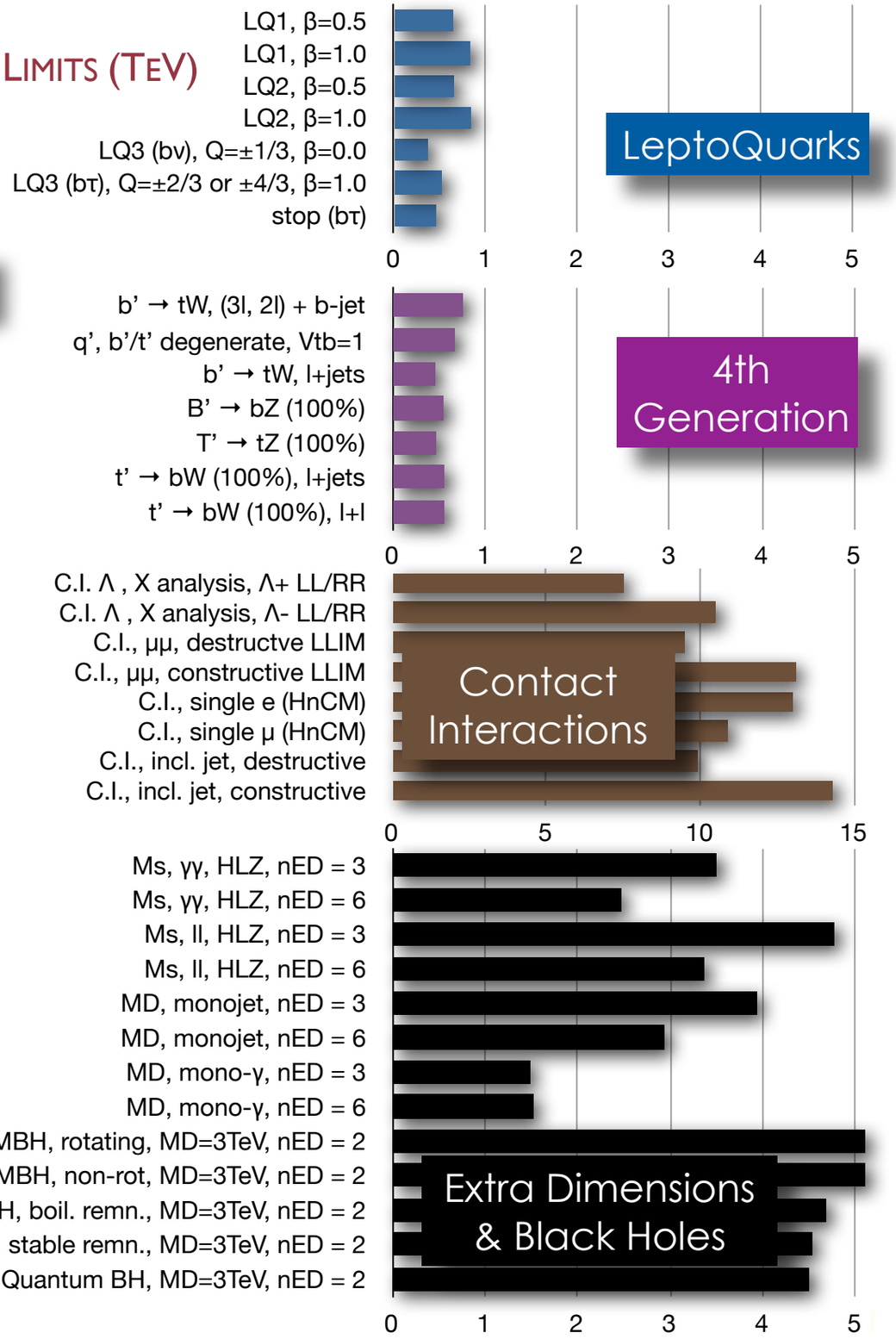
- **Heavy Long-Lived Particles (LLPs) in several SM extensions with some special signatures**
  - **Odd dE/dx, β < 1, displaced vertex, disappearing tracks, out-of-time decays, non-pointing photons**
- **ATLAS and CMS do have a LLP strategy and several published searches over the last months. No excesses so far, consequently many new limits**
- **Also new results on prompt lepton-jets, LFV resonance decays and 3 jet resonances. Same conclusion.**
- **Mostly 7 TeV. More 8 TeV coming ...**

See the summary plots in the additional material for the full landscape !

ADDITIONAL MATERIAL

CMS EXOTICA 95% CL EXCLUSION LIMITS (TEV)





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

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: LHCP 2013

ATLAS Preliminary

$\int Ldt$ = (4.4 - 20.7) fb^{-1} $\sqrt{s}$ = 7, 8 TeV

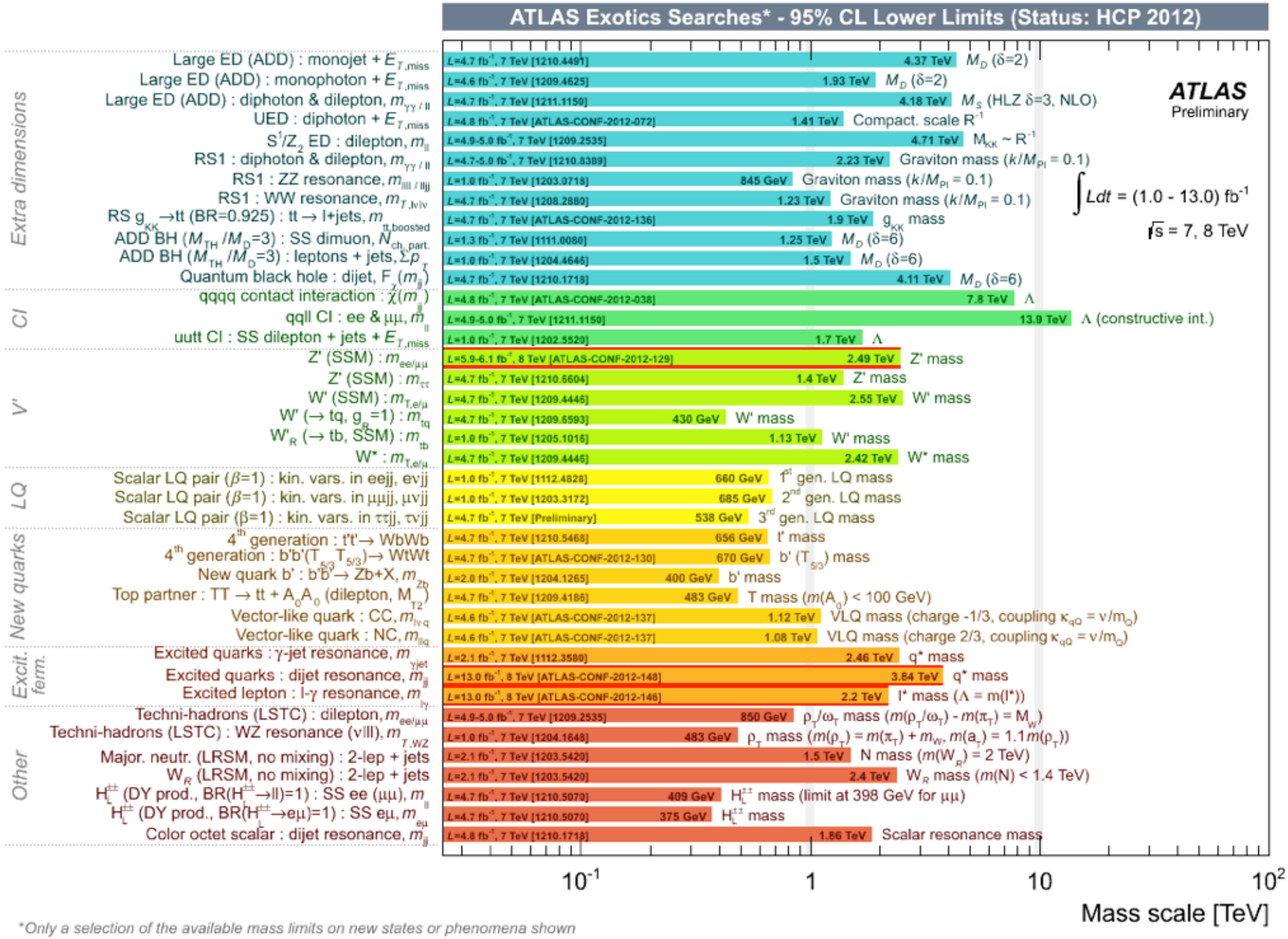
	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int Ldt$ [fb^{-1}]	Mass limit		Reference
Inclusive searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.8 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	4 jets	Yes	5.8	$\tilde{q}, \tilde{g}$ 1.24 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2012-104
	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
	Gluino med. $\tilde{\chi}^\pm$ ($\tilde{g}\to q\bar{q}\tilde{\chi}^\pm$)	1 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)$ < 200 GeV, $m(\tilde{\chi}^\pm) = 0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	1208.4688
	$\tilde{g}\tilde{g}\to qqqqll(ll)\tilde{\chi}_1^0\tilde{\chi}_1^0$	2 e, μ (SS)	3 jets	Yes	20.7	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$ < 650 GeV	ATLAS-CONF-2013-007
	GMSB ($\tilde{l}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$ 1.24 TeV	tanβ < 15	1208.4688
	GMSB (l NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$ 1.4 TeV	tanβ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	0	Yes	4.8	$\tilde{g}$ 1.07 TeV	$m(\tilde{\chi}_1^0)$ > 50 GeV	1209.0753
	GGM (wino NLSP)	1 e, μ + γ	0	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
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	12.8	$\tilde{g}$ 1.24 TeV	$m(\tilde{\chi}_1^0)$ < 200 GeV	ATLAS-CONF-2012-145
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	2 e, μ (SS)	0-3 b	No	20.7	$\tilde{g}$ 900 GeV	$m(\tilde{\chi}_1^0)$ < 500 GeV	ATLAS-CONF-2013-007
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	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	3 b	Yes	12.8	$\tilde{g}$ 1.15 TeV	$m(\tilde{\chi}_1^0)$ < 200 GeV	ATLAS-CONF-2012-145
3rd 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
	$b_1b_1, b_1\to t\tilde{\chi}_1^\pm$	2 e, μ (SS)	0-3 b	Yes	20.7	b_1 430 GeV	$m(\tilde{\chi}_1^\pm) = 2\, m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	t_1t_1 (light), $t_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$ 167 GeV	$m(\tilde{\chi}_1^0)$ = 55 GeV	1208.4305, 1209.2102
	t_1t_1 (light), $t_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$ 220 GeV	$m(\tilde{\chi}_1^0) = m(\tilde{t}_1) - m(W) - 50$ GeV, $m(\tilde{t}_1) \ll m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	t_1t_1 (medium), $t_1\to b\tilde{\chi}_1^\pm$	2 e, μ	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
	t_1t_1 (medium), $t_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$ 150-580 GeV	$m(\tilde{\chi}_1^0)$ < 200 GeV, $m(\tilde{\chi}_1^\pm)$-$m(\tilde{\chi}_1^\pm)$ = 5 GeV	ATLAS-CONF-2013-053
	t_1t_1 (heavy), $t_1\to t\tilde{\chi}_1^0$	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
	t_1t_1 (heavy), $t_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$ 320-660 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-024
	t_1t_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
	$t_2t_2, t_2\to t_1+Z$	3 e, μ (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	$\tilde{l}_{L,R}\tilde{l}_{L,R}, \tilde{l}\to l\tilde{\chi}_1^0$	2 e, μ	0	Yes	20.3	$\tilde{l}$ 85-315 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to l\nu\,(l\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$ 125-450 GeV	$m(\tilde{\chi}_1^0)$ = 0 GeV, $m(\tilde{l},\tilde{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu\,(\tau\tilde{\nu})$	2 τ	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
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0 \to l_L\nu\, l_L l(\tilde{\nu}\,\nu), l\tilde{\nu}\, l_L l(\tilde{\nu}\,\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 600 GeV	$m(\tilde{\chi}_1^\pm) = m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0) = 0$, $m(\tilde{l},\tilde{\nu}) = 0.5(m(\tilde{\chi}_1^\pm) + m(\tilde{\chi}_1^0))$	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, 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
Long-lived particles	Direct $\tilde{\chi}_1^\pm\tilde{\chi}_1^\mp$ 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 $\tilde{g}$, R-hadrons	0-2 e, μ	0	Yes	4.7	$\tilde{g}$ 985 GeV		1211.1597
	GMSB, stable $\tilde{\tau}$, low β	2 e, μ	0	Yes	4.7	$\tilde{\tau}$ 300 GeV	$5 < \tan\beta < 20$	1211.1597
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$,long-lived $\tilde{\chi}_1^0$	2 γ	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 e, μ	0	Yes	4.4	$\tilde{q}$ 700 GeV	1 mm < cτ < 1 m, $\tilde{g}$ decoupled	1210.7451
RPV	LFV $pp\to\tilde{\nu}_\tau$+X, $\tilde{\nu}_\tau\to e+\mu$	2 e, μ	0	-	4.6	$\tilde{\nu}_\tau$ 1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau$+X, $\tilde{\nu}_\tau\to e(\mu)+\tau$	1 e,μ + τ	0	-	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
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\nu_\mu, e\mu\nu_e$	4 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm$ 760 GeV	$m(\tilde{\chi}_1^0)$ > 300 GeV, $\lambda_{121} > 0$	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\nu_e, e\tau\nu_\tau$	3 e, μ + τ	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, μ (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 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

10^{-1} 1 Mass scale [TeV]

$\sqrt{s}$ = 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 1σ theoretical signal cross section uncertainty.

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



*Only a selection of the available mass limits on new states or phenomena shown

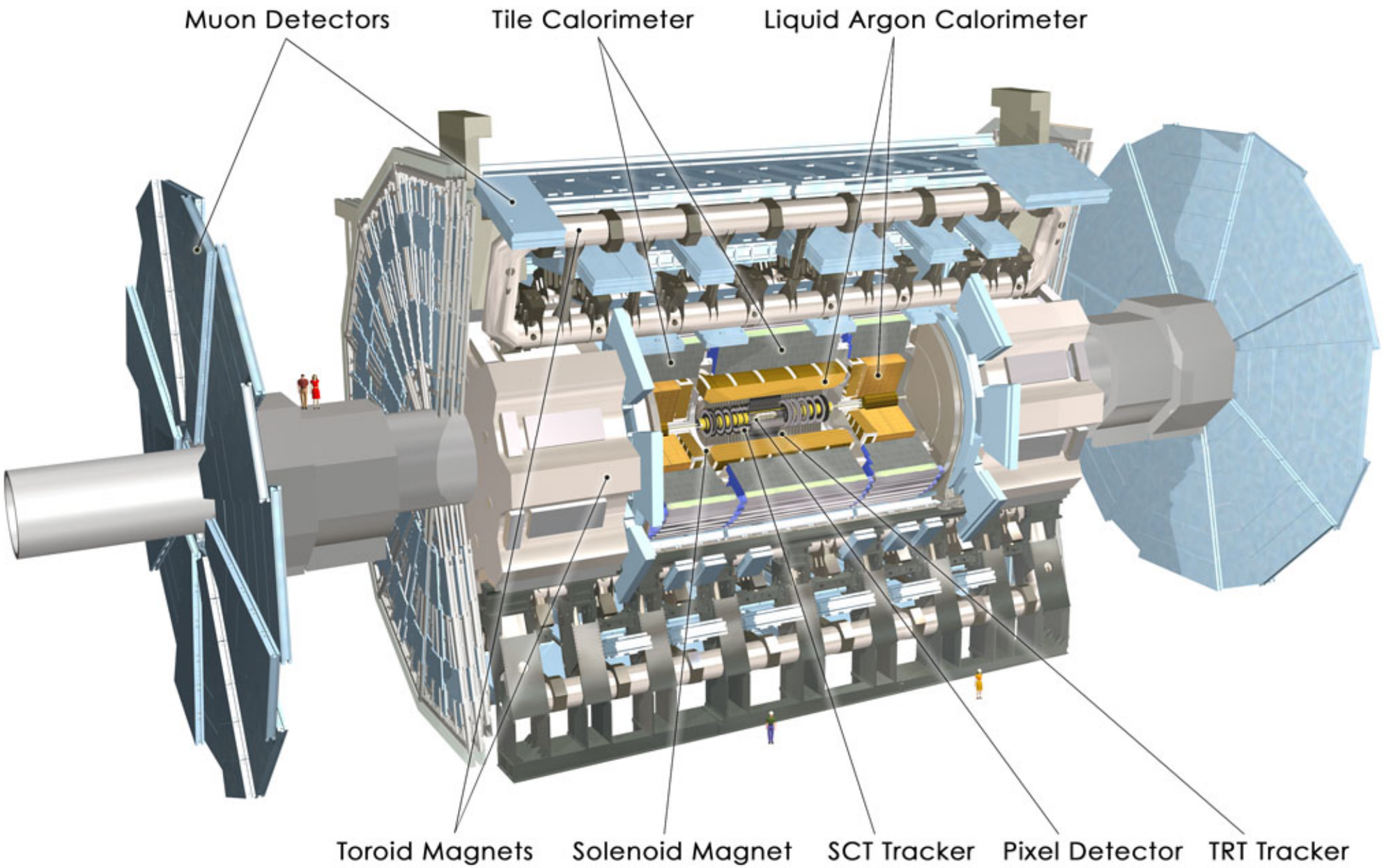
https://twiki.cern.ch/twiki/bin/view/AtlasPublic

The ATLAS Detector

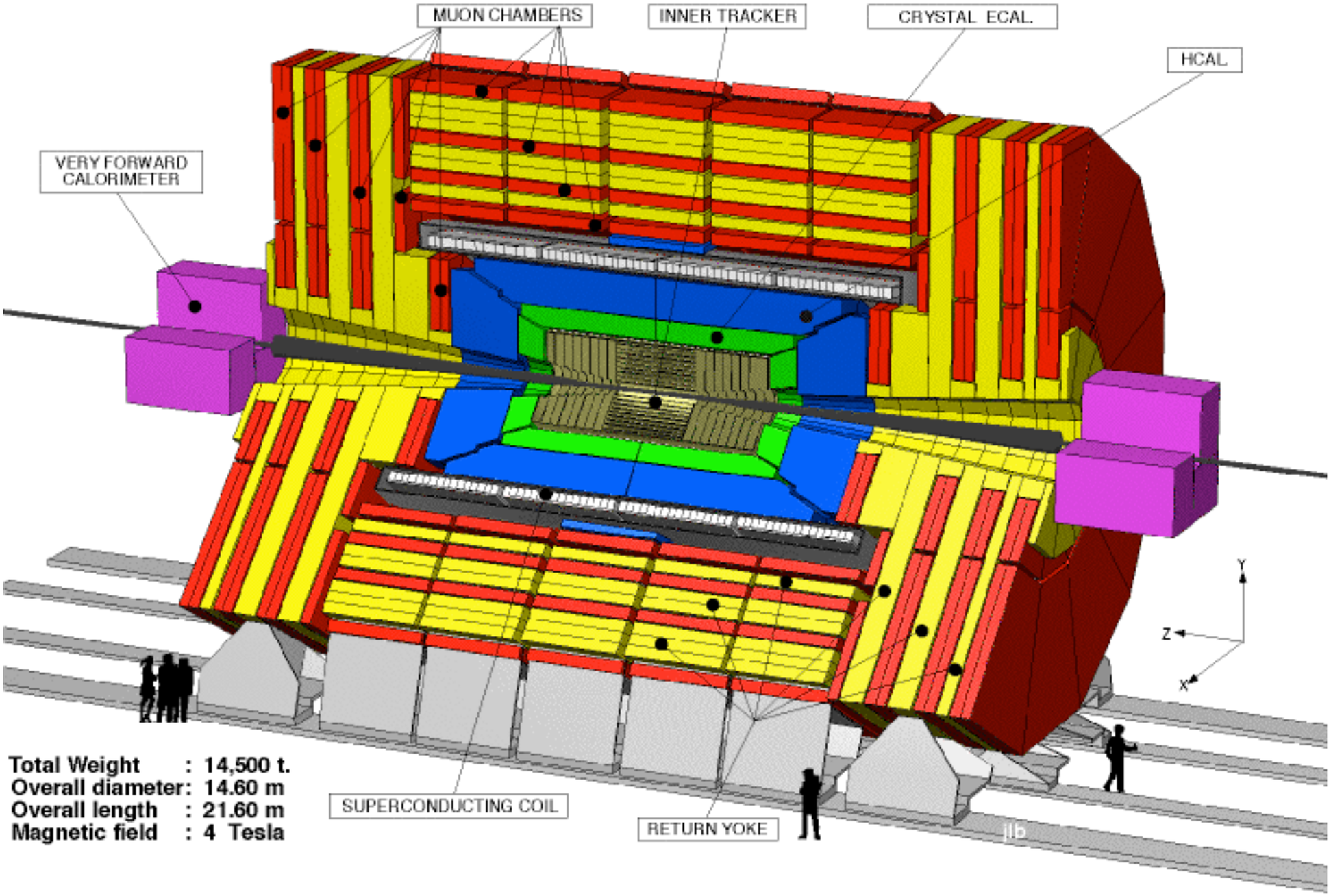
Weight: 7000 tons

Dimensions: 46 x 22 x 22 m^3

Magnetic Field: 2.6 T (solenoid) and 4.1 T (toroid)



The CMS Detector



List of publications used

CMS : Searches for long-lived charged particles in pp collisions at sqrt(s)=7 and 8 TeV arXiv:1305.0491v1 [hep-ex] 2 May 2013
ATLAS Searches for heavy long-lived sleptons and R-hadrons with the ATLAS detector in pp collisions at √s = 7 TeV arXiv:1211.1597v2 [hep-ex] 25 Mar 2013
ATLAS, Search for long-lived, multi-charged particles in pp collisions at √s = 7 TeV using the ATLAS detector arXiv:1301.5272v1 [hep-ex] 22 Jan 2013

CMS, Search for stopped long-lived particles produced in pp collisions at √s = 7 TeV, arXiv:1207.0106v2 [hep-ex] 11 Mar 2013
ATLAS, Search for Decays of Stopped, Long-Lived Particles from 7 TeV pp Collisions with the ATLAS Detector, arXiv:1201.5595v2 [hep-ex] 7 May 2012

CMS, Search in leptonic channels for heavy resonances decaying to long-lived neutral particles, arXiv:1211.2472v2 [hep-ex] 13 Mar 2013
ATLAS, Search for long-lived, heavy particles in final states with a muon and multi-track displaced vertex in proton-proton collisions at √s = 7 TeV with the ATLAS detector, arXiv:1210.7451v2 [hep-ex] 22 Mar 2013
ATLAS, Search for direct chargino production in anomaly-mediated supersymmetry breaking models based on a disappearing-track signature in pp collisions at √s = 7 TeV with the ATLAS detector, arXiv:1210.2852v2 [hep-ex] 22 Mar 2013
ATLAS, Search for non-pointing photons in the diphoton and *E*miss final state i, ATLAS-CONF-2013-016 07 March 2013
CMS, Search for long-lived particles decaying to photons and missing energy in proton-proton collisions at √s = 7 TeV, arXiv:1212.1838v1 [hep-ex] 8 Dec 2012

ATLAS, A search for prompt lepton-jets in pp collisions at √s = 7 TeV with the ATLAS detector , arXiv:1212.5409v2 [hep-ex] 22 Mar 2013
CMS, Search for a non-standard-model Higgs boson decaying to a pair of new light bosons in four-muon final states, arXiv:1210.7619v1 [hep-ex] 29 Oct 2012
ATLAS, Search for W H production with a light Higgs boson decaying to prompt electron-jets in proton–proton collisions at √s = 7 TeV with the ATLAS detector, arXiv:1302.4403v1 [hep-ex] 18 Feb 2013

ATLAS, Search for a heavy narrow resonance decaying to eμ, eτ, or μτ with the ATLAS detector in s = 7 TeV pp collisions at the LHC, arXiv:1212.1272v2 [hep-ex] 7 Dec 2012

CMS, Search for three-jet resonances in pp collisions at √s = 7 TeV, arXiv:1208.2931v2 [hep-ex] 12 Mar 2013
ATLAS, Search for pair production of massive particles decaying into three quarks with the ATLAS detector in √s = 7 TeV pp collisions at the LHC, arXiv: 1210.4813v2 [hep-ex] 8 Nov 2012
CMS, Search for RPV supersymmetry with three or more leptons and b-tags, CMS PAS SUS-12-027
ATLAS, ATLAS-CONF-2013-007, 10 Mar 2013