SEARCH FOR THE ELECTROWEAK PRODUCTION OF CHARGINOS AND SLEPTONS DECAYING INTO FINAL STATES WITH TWO ELECTRONS OR MUONS IN PROTON-PROTON COLLISIONS AT $\sqrt{s}$ = 13 TEV WITH THE ATLAS DETECTOR

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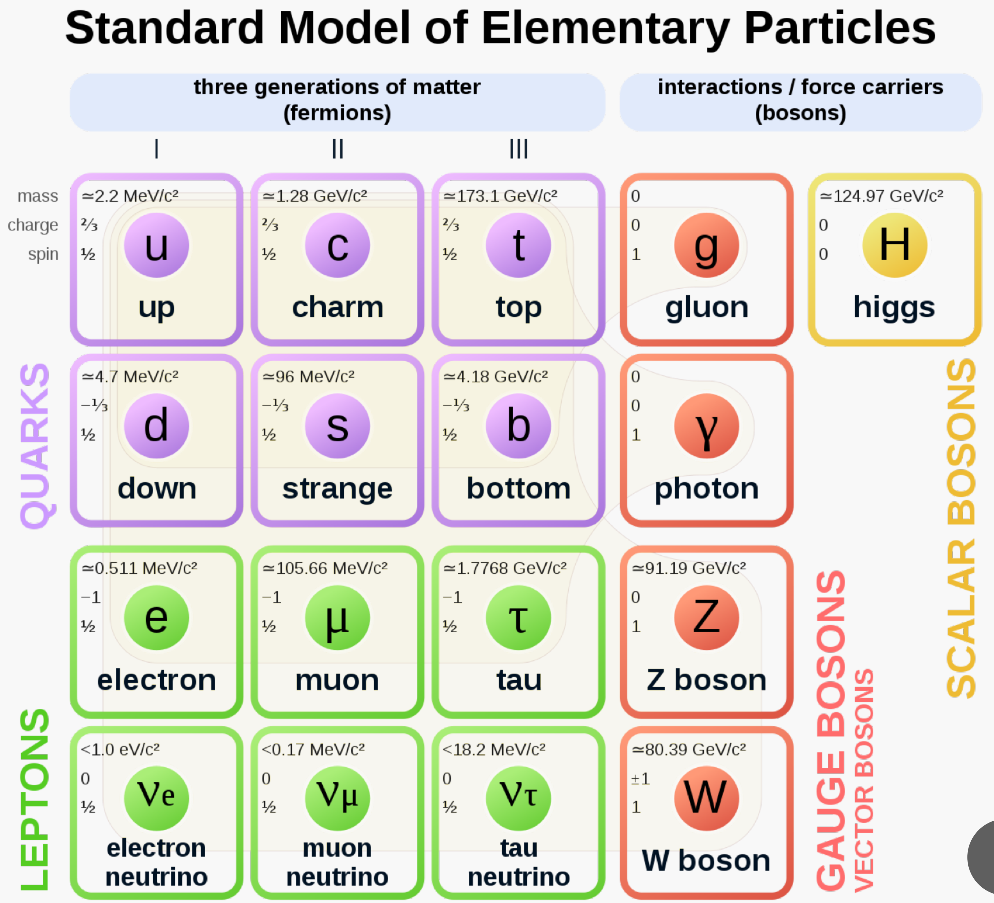
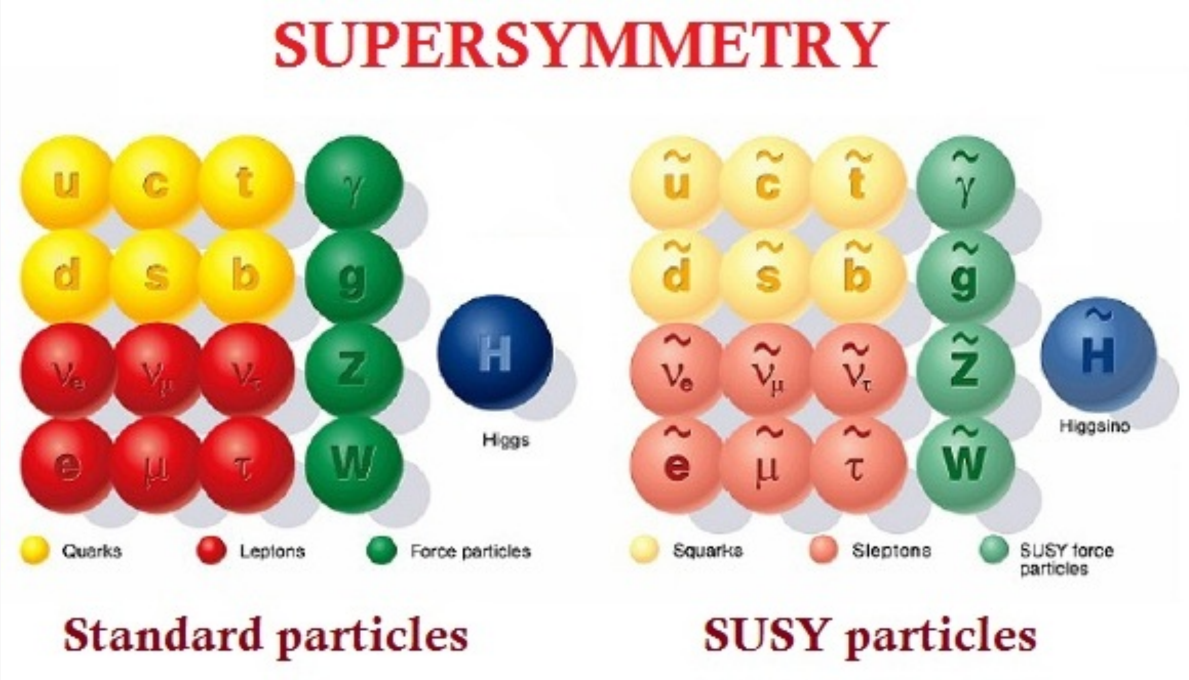
THE STANDARD MODEL

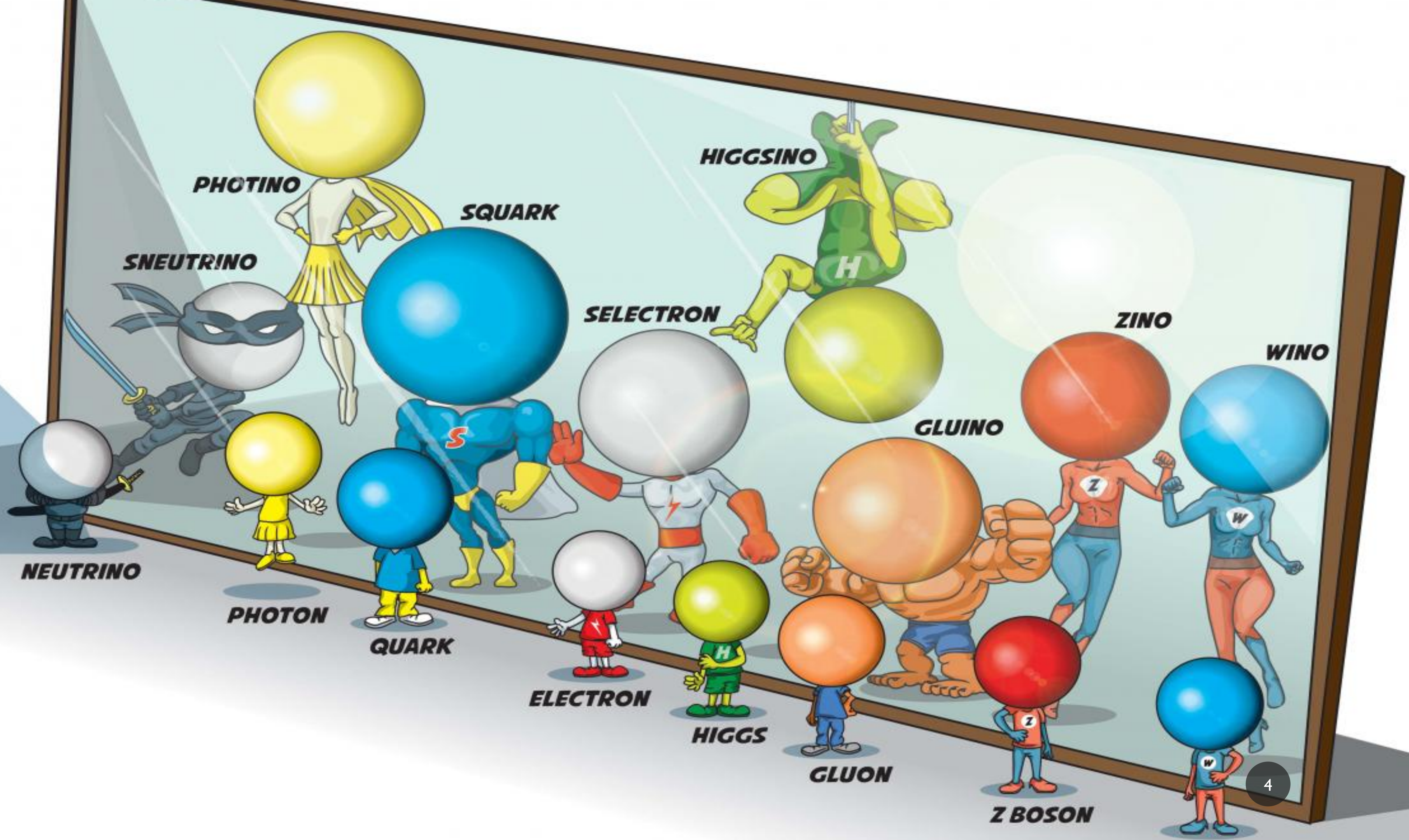
- Describes most of the world we see around us
- Has some problems:
  - Does not include gravity
  - Does not include a candidate for dark matter
- Need an expansion, something that can explain these things



SUPERSYMMETRY (SUSY)

- Links fermions and bosons
- Each SM particle has a superpartner
  - Spin differs by a half-integer.
- Due to spontaneous symmetry breaking the superpartners are more massive than their SM partners
- The superpartners of fermions are bosons with the names of their fermionic counterparts prefixed with «s-» (leptons -> sleptons)
- The superpartners of bosons are fermions with the names of their bosonic counterparts suffixed with «-ino» (gluon -> gluino)




PHOTINO
SQUARK
SNEUTRINO
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WINO
GLUINO
NEUTRINO
PHOTON
QUARK
ELECTRON
HIGGS
GLUON
Z BOSON

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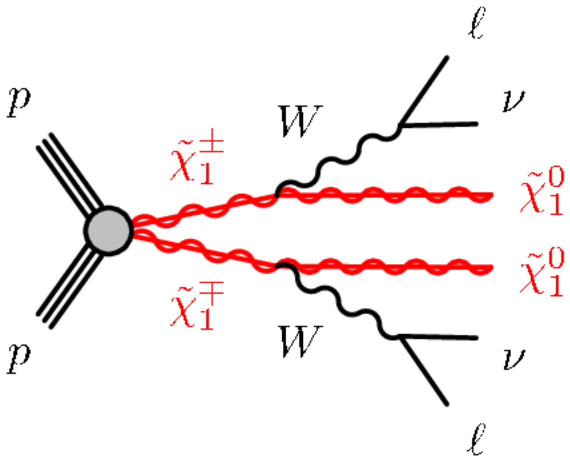
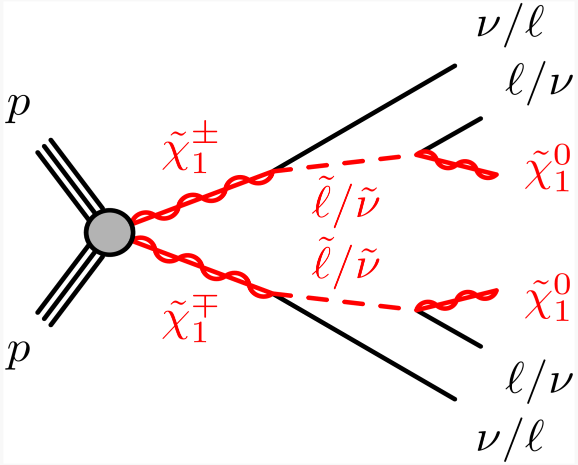
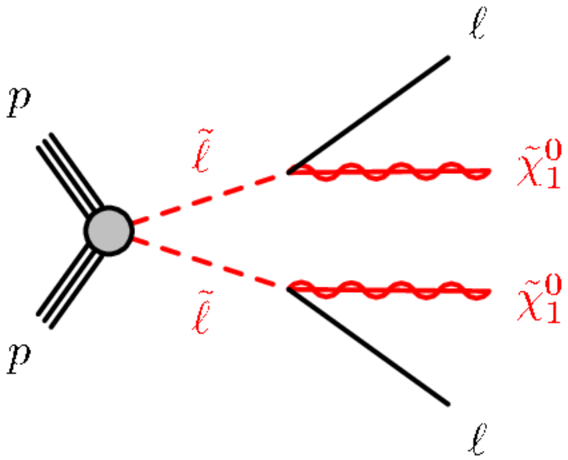
- The article can be found here https://arxiv.org/abs/1908.08215
- Studies three supersymmetric decay models



$\chi_1^+\chi_1^-$ production with W-boson-mediated decays



$\chi_1^+\chi_1^-$ production with slepton/sneutrino-mediated-decays



slepton pair production

ABOUT THE SEARCH

- The analysis uses data collected by the ATLAS detector during pp collisions at a centre-of-mass energy of $\sqrt{s}$ = 13 TeV from 2015 to 2018
  - total integrated luminosity of 139 fb^{-1}
- Final state that requires
  - 2 leptons
  - 0 jets
  - Missing transverse energy
- Leptons selected as baseline or signal leptons according to various quality and kinematic selection criteria
  - Baseline objects are used in the calculation of missing transverse momentum, to resolve ambiguities between the analysis objects in the event and in the fake/non-prompt (FNP) lepton background estimation
  - Signal objects must satisfy stricter requirements than baseline

SEARCH STRATEGIES

- Two oppositely charged signal leptons, both with $p_T > 25 \text{ GeV}$
- The invariant mass of the two leptons must be $m_{ll} > 100 \text{ GeV}$
- No reconstructed b-jets
- Events can have no more than 1 non-b-tagged jet
- Events are separated into same flavour (SF), $e^{\pm}e^{\mp}$ or $\mu^{\pm}\mu^{\mp}$, and different flavour (DF) $e^{\pm}\mu^{\mp}$ events due to different background compositions
  - SF events are required to have a dilepton invariant mass far from the Z peak, with $m_{ll} > 121.2 \text{ GeV}$
- $E_T^{miss} > 110 \text{ GeV}$
- E_T^{miss} significance > 10
- High m_{T2} values

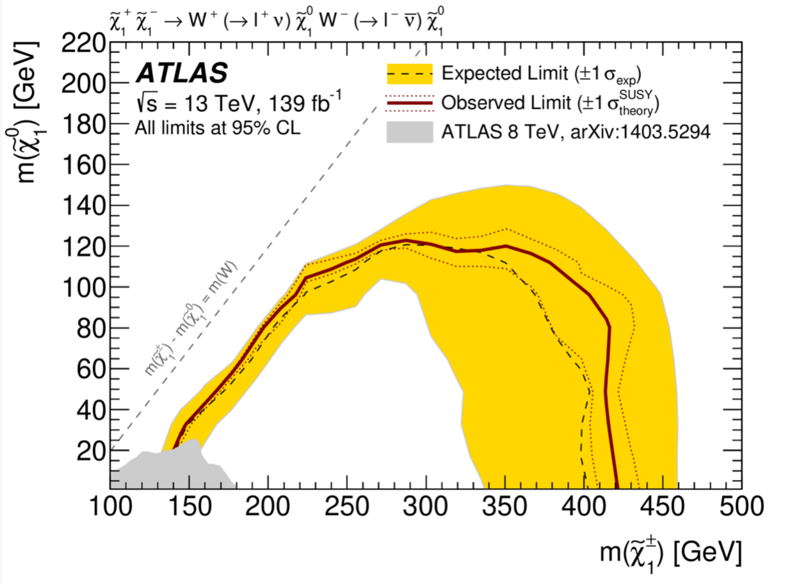
Signal region (SR)	SR-DF-0J	SR-DF-1J	SR-SF-0J	SR-SF-1J
$n_{\text{non-}b\text{-tagged jets}}$	$= 0$	$= 1$	$= 0$	$= 1$
$m_{\ell_1\ell_2}$ [GeV]	>100		>121.2	
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	>110			
$E_{\mathrm{T}}^{\mathrm{miss}}$ significance	>10			
$n_{b\text{-tagged jets}}$	$= 0$			
Binned SRs				
m_{T2} [GeV]	$\in[100,105)$			
	$\in[105,110)$			
	$\in[110,120)$			
	$\in[120,140)$			
	$\in[140,160)$			
	$\in[160,180)$			
	$\in[180,220)$			
	$\in[220,260)$			
	$\in[260,\infty)$			
Inclusive SRs				
m_{T2} [GeV]	$\in[100,\infty)$			
	$\in[160,\infty)$			
	$\in[100,120)$			
	$\in[120,160)$			

Region	CR-WW	CR-VZ	CR-top
Lepton flavour	DF	SF	DF
$n_{b\text{-tagged jets}}$	$= 0$	$= 0$	$= 1$
$n_{\text{non-}b\text{-tagged jets}}$	$= 0$	$= 0$	$= 0$
m_{T2} [GeV]	$\in$ [60,65]	> 120	> 80
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	$\in$ [60,100]	> 110	> 110
$E_{\mathrm{T}}^{\mathrm{miss}}$ significance	$\in$ [5,10]	> 10	> 10
$m_{\ell_1\ell_2}$ [GeV]	> 100	$\in$ [61.2,121.2]	> 100

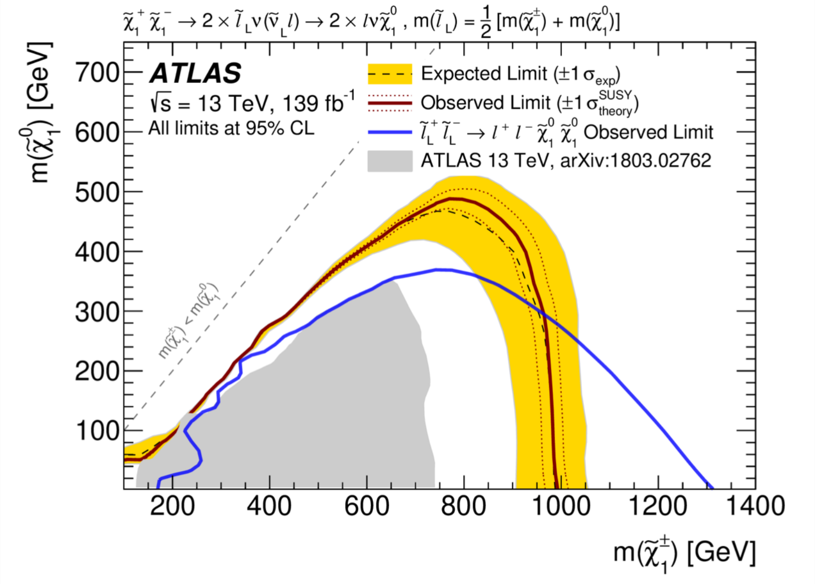
Region	VR-WW-0J	VR-WW-1J	VR-VZ	VR-top-low	VR-top-high	VR-top-WW
Lepton flavour	DF	DF	SF	DF	DF	DF
$n_{b\text{-tagged jets}}$	$= 0$	$= 0$	$= 0$	$= 1$	$= 1$	$= 1$
$n_{\text{non-}b\text{-tagged jets}}$	$= 0$	$= 1$	$= 0$	$= 0$	$= 1$	$= 1$
m_{T2} [GeV]	$\in$ [65,100]	$\in$ [65,100]	$\in$ [100,120]	$\in$ [80,100]	> 100	$\in$ [60,65]
$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	> 60	> 60	> 110	> 110	> 110	$\in$ [60,100]
$E_{\mathrm{T}}^{\mathrm{miss}}$ significance	> 5	> 5	> 10	$\in$ [5,10]	> 10	$\in$ [5,10]
$m_{\ell_1\ell_2}$ [GeV]	> 100	> 100	$\in$ [61.2,121.2]	> 100	> 100	> 100

RESULTS

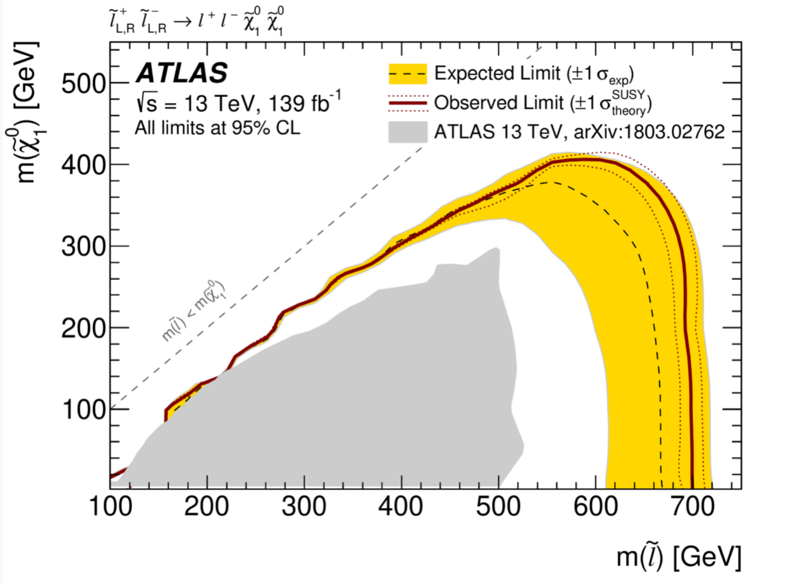
No significant deviations from the SM expectations was observed in any of the SRs considered



W-boson-mediated decays



slepton/sneutrino-mediated decays



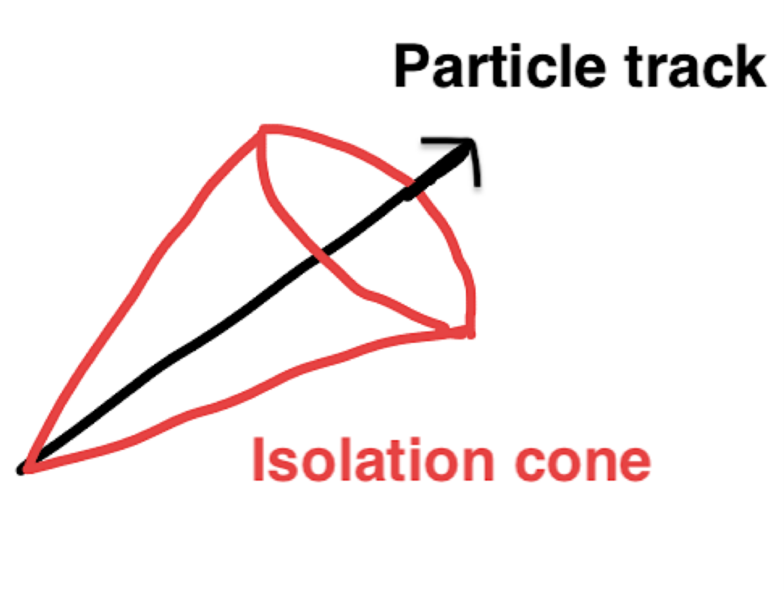
slepton-pair production

ISOLATION POINT 101 – LEPTON EDITION

- Terms:
  - «Fakes» : a particle that is misidentified during reconstruction
  - «Prompt particles» : particles that are not coming from a hadron or tau decay
  - «FNP» : fake or non-prompt
- Non-fake and prompt leptons are usually isolated, meaning there is not much other stuff happening around them in the detector
  - To reduce contamination from FNPs we need to define an «isolation region» around the leptons
- FNP electrons can arise from semi-leptonic decays of b and c quarks, photon conversions and jets with large electromagnetic energy
- FNP muons can originate from semi-leptonic decays of b and c quarks, charged hadron decays in the tracking volume or in hadronic showers, or from punch-through particles emerging from high-energy hadronic showers
- The isolation point relies on both information from the tracker and the calorimeter

ISOLATION POINT 101 – LEPTON EDITION

- Isolation points have different kinds of criteria: loose, medium and tight
- The meaning of these terms is how large you make the cone, and how much other stuff than your lepton you allow to happen inside of it



MY THESIS
-AN OVERVIEW

- My goal is to study how different lepton isolation points affect the sensitivity of the search for the three different supersymmetric decay models studied in the paper
- Determine what set of isolation points gives best sensitivity in these searches
- The combination of isolation points used in my thesis is shown in the table

	Combination 1	**Combination 2**
Baseline	Electron and muon: none	Electron and muon: medium
Signal	Electron: tight Muon: medium	Electron and muon: tight