Search for SUSY with a Highly Compressed Mass Spectrum in the Soft Single Lepton Channel with the CMS Experiment

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on behalf of the
CMS Collaboration

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Status Quo

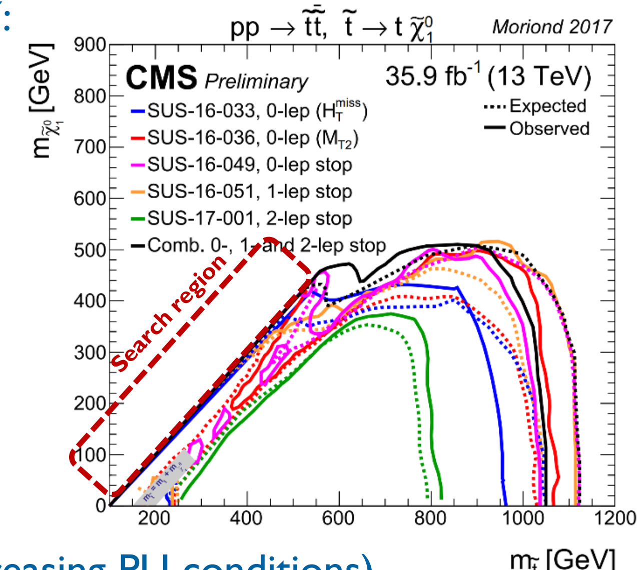
- Wide regions of the SUSY parameter space have been excluded with recent LHC Run II results, especially in 'classical' searches → putting natural SUSY under pressure!

- In many cases, increased integrated luminosity is not expected to bring large improvements in sensitivity

  ⇒ we need to come up with new and improved ways to find SUSY:
  - more sophisticated, new, signal models + re-interpretation:
    - different production modes
      - EWKinos, higgsino pMSSM, …
    - displaced vertices, R-Parity Violating (RPV), GMSB, stealth, split SUSY…
    - **compressed mass spectra** ⟶
  - improved detector performance & object reconstruction
  - different trigger techniques: lowering thresholds (despite increasing PU conditions)
  - improved analysis techniques: soft object tagging, new discriminating variables, …

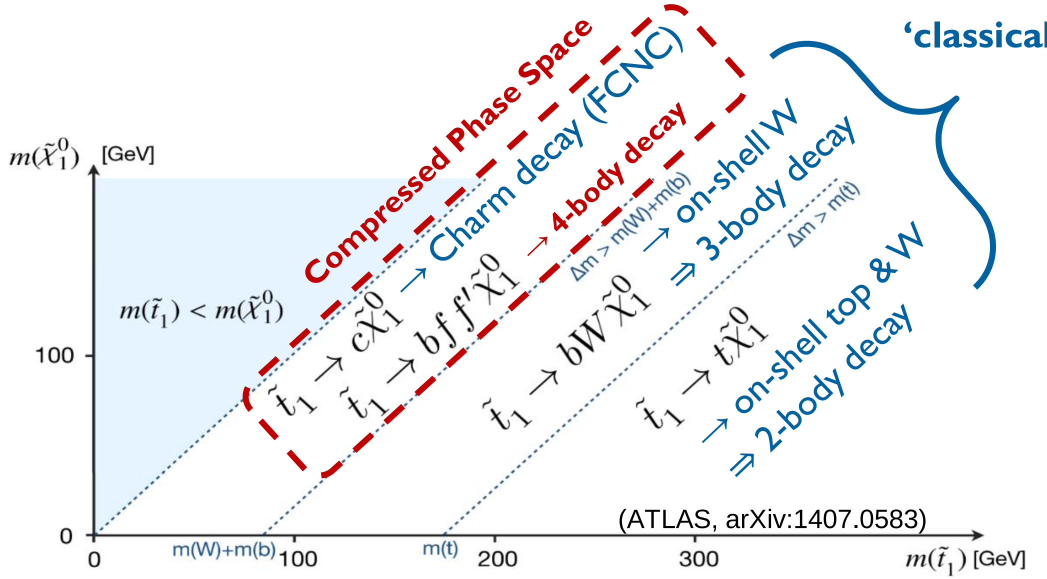
  ⇒ we need to push to the limits of detection, analysis and theory!

Stop pair-production:



Crevasses

- Even though large regions have been excluded, there are several 'crevasses' of parameter space where she could still be hiding = **compressed mass spectra**:



Stop Production Phase-Space:

- mass splitting $\Delta m \equiv m_{stop} - m_{LSP}$ dictates decay modes and kinematics
- **compressed** scenario when Δm is small ($< m_W$) $\rightarrow$ 4-body decay via an off-shell t* and W*
- final states classified according to W decay-modes: hadronic, single- and di-leptonic

- Several **theoretical** motivations for compressed scenarios:
  - Natural SUSY favours relatively **light** top squarks (**stops**), higgsinos and gluinos
  - In many models **LSP** = lightest neutralino ⇒ decay chain ending with neutralino
  - For small Δm, the co-annihilation of light stops and neutralinos can reproduce the correct cosmological **DM** abundance (e.g. arXiv:1212.6847)

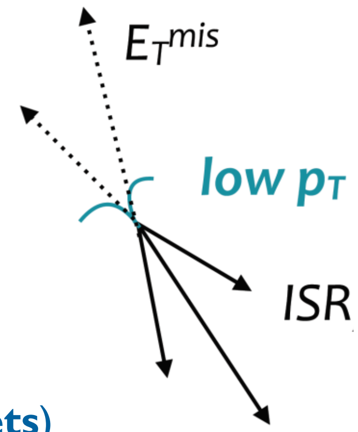
Compressed Spectra

- In compressed scenario ⇒ little available energy ⇒ soft final states and low E_T^{miss}
  - missed by classical searches, which require high E_T^{miss}
- Loss in efficiency for object reconstruction at very low momenta and visible decay products typically do not pass detector acceptance thresholds

⇒ low threshold triggers and accurate reconstruction essential

- Difficulties with soft products can be mitigated by **initial state radiation** (ISR): a (quark/gluon) jet originating from initial state partons:

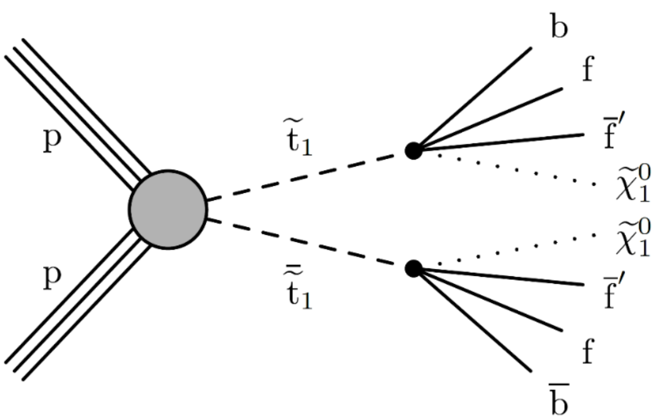
⇒ signal vertex is boosted
⇒ visible decay products become detectable
⇒ E_T^{miss} increases (heavier LSPs boosted)



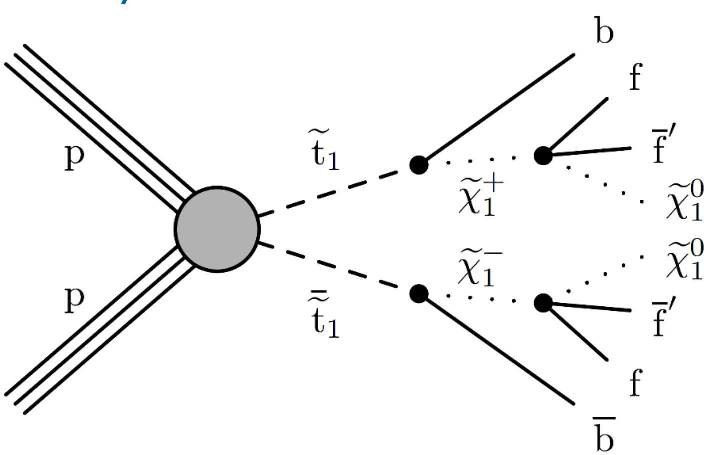
  - ISR requirement reduces acceptance by a factor ~ 10
- Signature: hard recoil **ISR jet**, moderate $\mathbf{E_T^{miss}}$ and soft **lepton** (and/or **jets**)

Compressed Stop Analysis

- Performed searches for stop-pair production with a compressed spectrum:
  - Sequential selection based on discriminating variables: **Cut & Count** (C&C)
    - Preliminary result: CMS-PAS-SUS-16-052
  - **Multivariate** (MVA) approach based on Boosted Decision Tree (BDT) method
    - Preliminary results: CMS-PAS-SUS-17-005 (including both C&C and MVA) → **New!**
  - Using the full 2016 dataset (35.9 fb^{-1}) recorded by CMS
  - Considering two simplified (SMS) signal models with reduced particle content:
    - stop pair-production with **single-leptonic** decay channels considered:



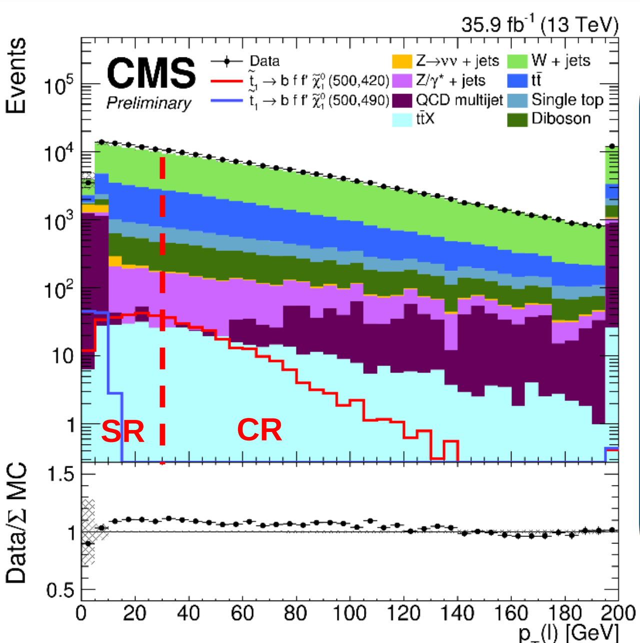
T2tt-4bd: **four-body** stop decay via t*/W*



T2bW: **chargino-mediated** stop decay via W*

C&C Selection

- Signal Regions (SRs) defined by lepton p_T < 30 GeV
- Control Regions (CRs) for main **prompt** background (**W+Jets**, **tt-bar**) estimation: p_T > 30 GeV
- **Nonprompt** backgrounds estimated with 'tight-to-loose' or 'fake rate' method (see backup)



lepton p_T [GeV]

as low as possible in lepton p_T:

- 3.5 GeV for muons
- 5 GeV for electrons

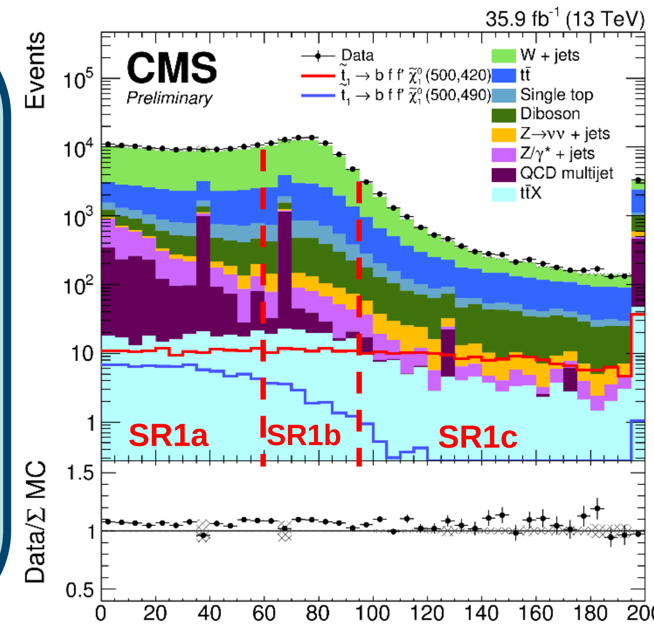
Preselection:

- E_T^{miss} > 200 GeV
- H_T > 300 GeV (p_T sum of jets)
- ISR-jet p_T > 100 GeV
- Minimum one lepton and 2nd lep. veto (p_T > 20 GeV)
- Tau veto
- 3rd hard (p_T > 60 GeV) jet veto
- $\Delta\phi_{(j1,j2)}$ < 2.5 rad. } anti-QCD

Two Sets of SRs

SR1 (low Δm): b-jet veto and lepton |η| < 1.5

SR2 (higher Δm): at least one soft b-jet



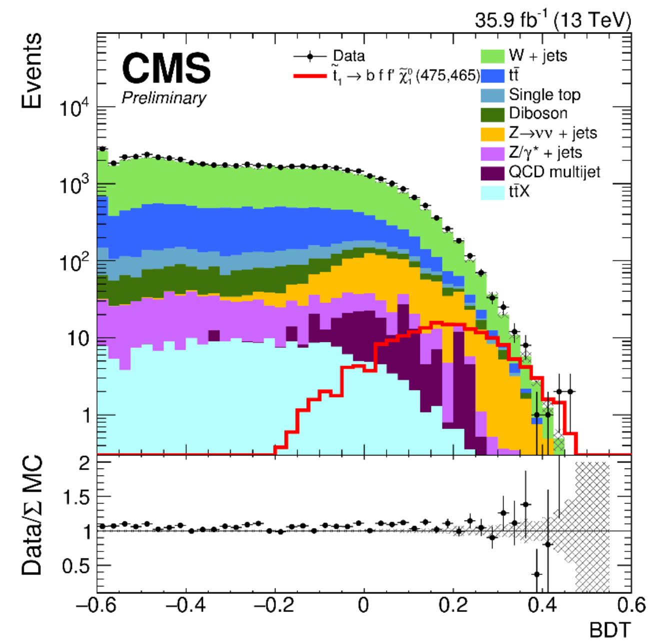
transverse mass m_T [GeV]

$m_T = m_T(\text{lep } p_T, E_T^{miss})$

$$M_T = \sqrt{2E_T^{miss}P_T(1-cos(\Delta\phi))}$$

MVA Selection

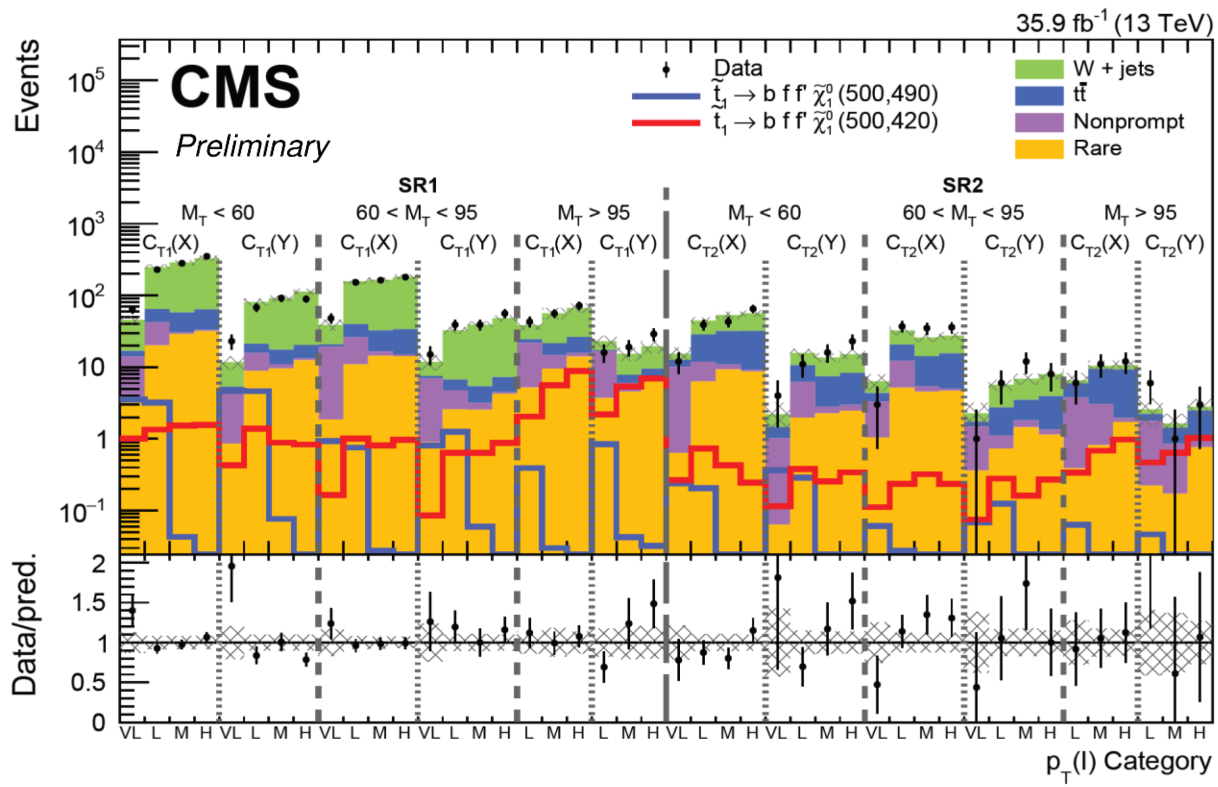
- A complementary **multivariate** (MVA) analysis based on BDTs was performed in parallel:
  - Using <u>same</u> object definitions and background estimation methods as C&C approach
  - Several discriminating **variables** used as input to BDT, to take advantage of the correlations between signal and background:
    - MET, H_T
    - Lepton: p_T, eta, charge, m_T
    - N_{jets}, ISR-jet p_T, p_T(b-jets)
  - Separate **training** was done for each Δm range
    - due to the dependence of the kinematics
    - using W+jets, tt-bar and Z→νν Monte-Carlo
    - upper cut on lepton p_T > 30 GeV not applied
  - **SRs** defined in terms of the BDT discriminator: BDT > X
    - chosen by Figure-of-Merit (FoM) maximisation



  - **Prompt** backgrounds estimated using data-driven method from BDT < X region
  - **Nonprompt** backgrounds estimated using same method as C&C approach

C&C Results

- Summary of **observed** and **predicted** background yields in the signal regions (C&C):

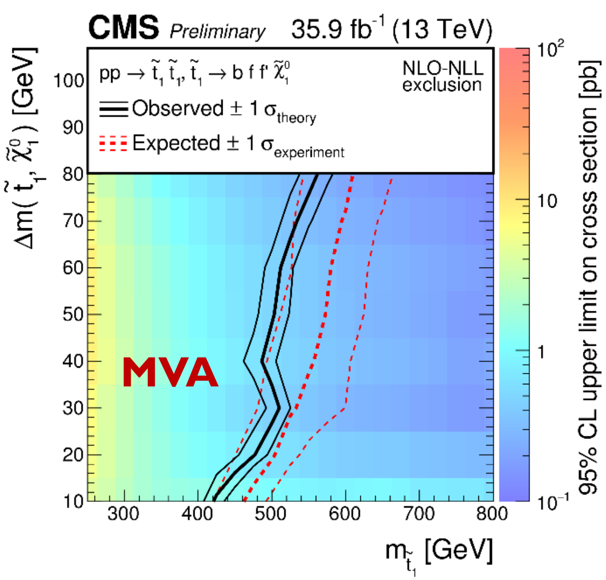


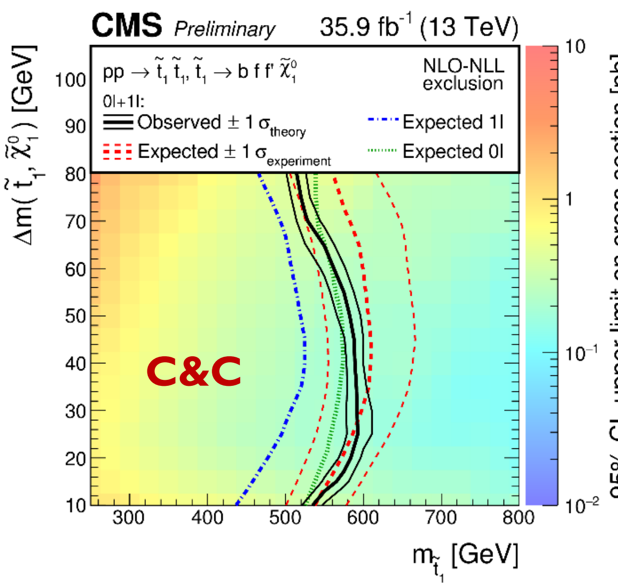
- MVA results presented in backup
- No significant deviation from the Standard Model

Exclusion Limits

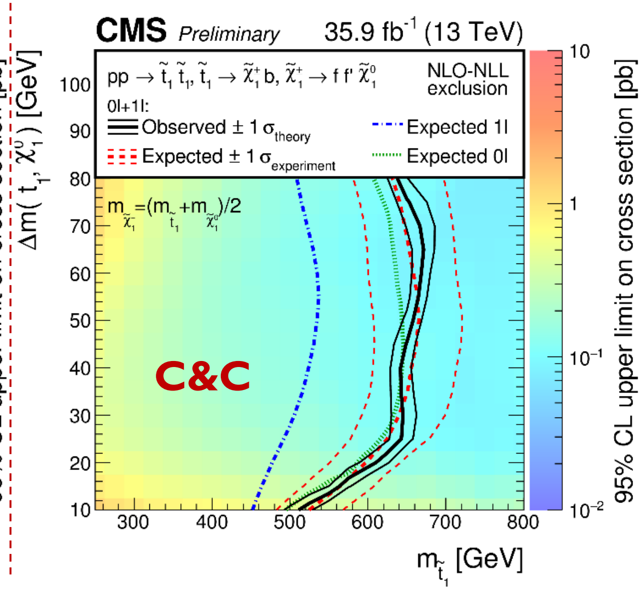
- Therefore, **limits** on the stop production cross-section in the Δm-stop plane are set:
  - at 95% CL, assuming 100% branching ratio and prompt decay of stop

Four-body decay (T2tt-4bd):





Chargino-mediated decay (T2bW):



- **C&C** limits (**blue**) in the single-lepton channel also include the combination (**black**) with the fully-hadronic (**red**) results (JHEP 2017: 5)
- **MVA** limits compatible with C&C approaches and other decay channels → cross-check one another
  - together form the most stringent limits to date for this model

Summary

- A search for stop-pair production with a **compressed spectrum** in the single-lepton channel was performed with the full 2016 dataset (35.9fb^{-1}) recorded by CMS:
  - Challenging region to study → difficulties with soft products overcome with making use of **ISR** to boost E_T^{miss} and visible decay products
  - Performed a sequential selection based on discriminating variables (**C&C**) and a multivariate (**MVA**) technique based on Boosted Decision Trees (BDTs)
  - Main **background estimation** approaches use Monte-Carlo simulation together with normalisation to data in dedicated control regions
- No significant deviation from SM observed → **limits** on stop pair-production cross section set (T2tt-4bd and T2bW models):

  → Yielding the most stringent limits to date for these models
- We need to take advantage of more sophisticated methods to search for SUSY and really push to the limits detection, analysis and theory:
  - She can still be hiding in the compressed parameter space or other phase-space

→ **SUSY is not dead!**

Backup

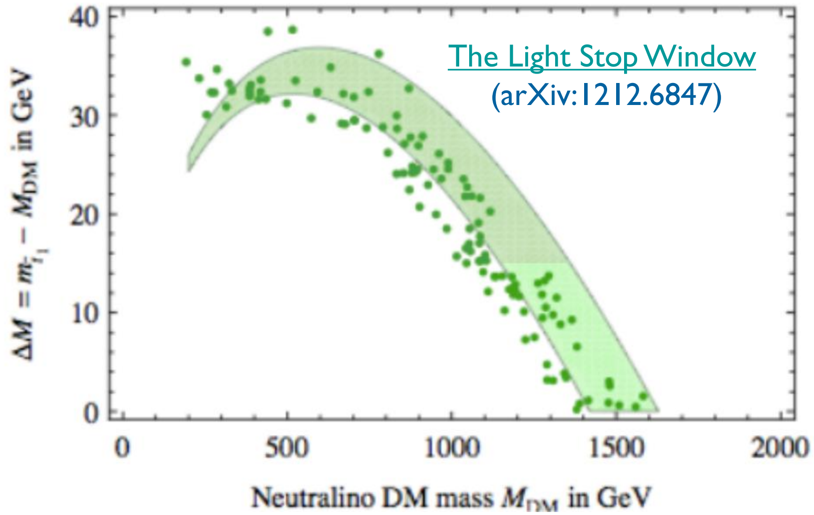
Motivation

- Natural SUSY favours low masses of the **stop** (top squark)
- The co-annihilation of light stops and LSPs can reproduce the correct cosmological **dark matter** abundance

→ the mass difference Δm between the stop and LSP must be relatively small

General motivations for SUSY:

- Solution to **Hierarchy/Naturalness** problem in Standard Model (SM)
- **Unification** of electroweak (EWK) and strong gauge couplings at GUT scale
- Lightest supersymmetric particle (LSP) = **dark matter** candidate



Simplified Models of SUSY Signals

- We can categorise SUSY signals in terms of **production** and **decay** modes:

SUSY Production:

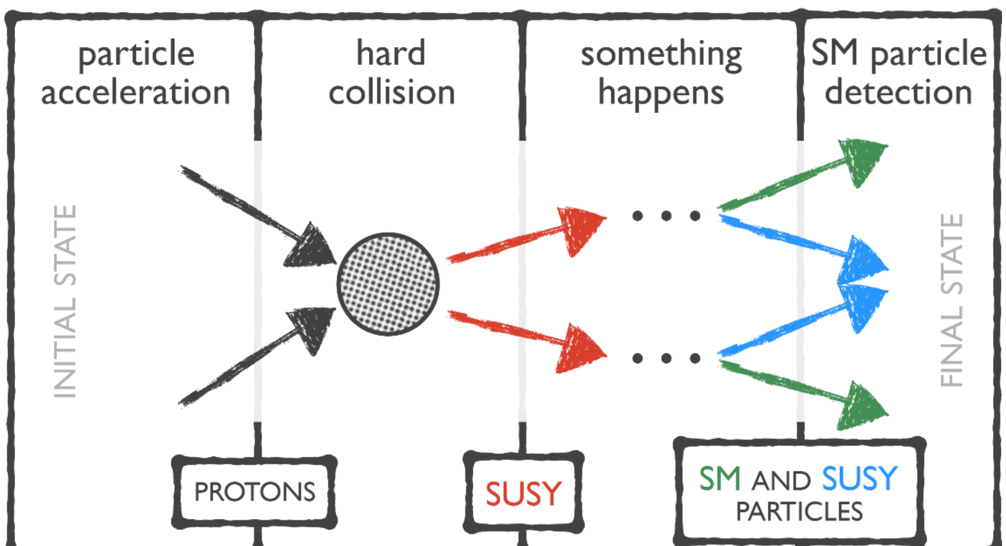
- Typically pair-produced (MSSM; assuming R-parity conservation)
- Production modes → choice guided by cross-sections

SUSY Decay:

- Decay into SUSY and SM particles → final states
- **Mass splitting Δm** (final - initial SUSY particles) dictates possible decay modes and kinematics

Production modes:

- Strong: squarks, gluinos
- **EWK**: charginos, neutralinos, sleptons



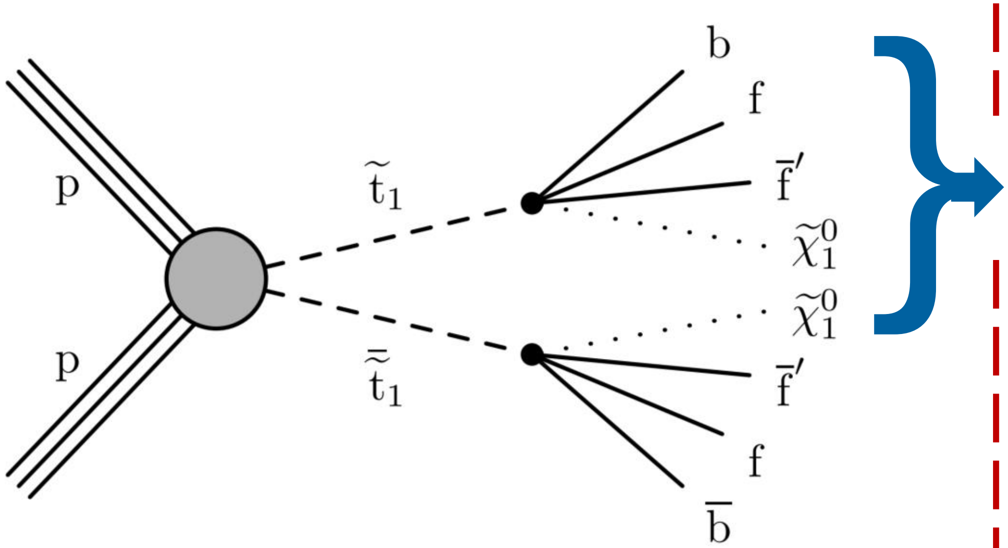
Final states:

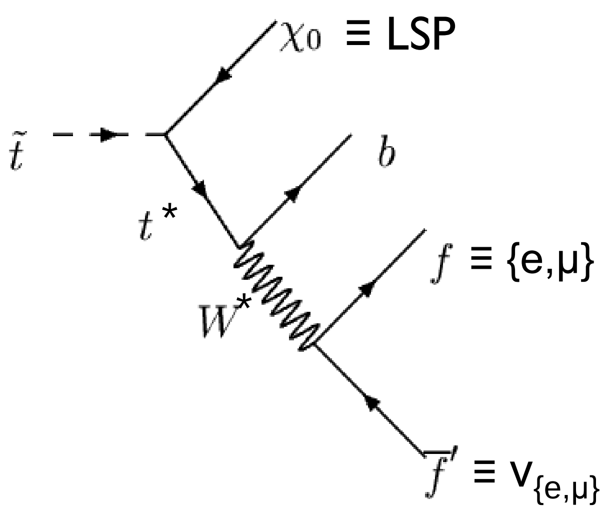
- Hadronic (0ℓ) = **jets**
- Single-**leptonic** (1ℓ)
- Multi-**leptonic** (2ℓ+)
- **MET** in the form of LSPs (neutralinos) and neutrinos

Signal Model: 4-Body Stop Decay

Simplified model: T2tt-4bd = stop-pair production followed by direct decay of the stop into a 4-body final state:

stop pair-production ⟶ 4-body decay ($\tilde{t}_1 \to f f' b \tilde{\chi}_1^0$)



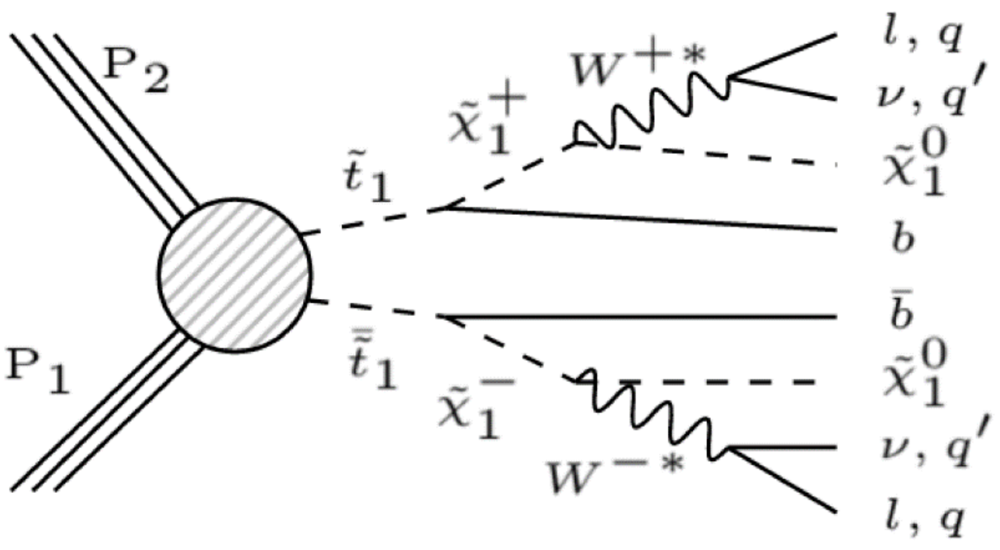


stop ⟶ b-jet + lepton + MET
{e,μ} $\{X_0, \nu_{\{e,\mu\}}\}$

- Our analysis: single-lepton channel
- We also consider the **chargino**-mediated decay

Chargino-Mediated Decay

- Complemented 4-body decay via t*/W* with the chargino mode:



  - Chargino mass halfway in between stop and LSP
  - Solution for small width issue (long lifetime) for very small Δm

Object Definitions

<table>
<tr><th>Object</th><th colspan="3">Kinematic Cuts</th><th>ID</th><th colspan="2">Details</th></tr>
<tr><td>Electrons</td><td rowspan="2">|dxy| < 0.02 cm
|dz| < 0.1 cm</td><td>p_T > 5 GeV</td><td>|η| < 2.5</td><td>Veto</td><td rowspan="2">Hybrid Isolation</td><td>ECAL crack blinded</td></tr>
<tr><td>Muons</td><td>p_T > 3.5 GeV</td><td>|η| < 2.4</td><td>Loose</td><td></td></tr>
<tr><td>Taus (Veto)</td><td colspan="3">p_T > 20 GeV
|η| < 2.4</td><td>TauIdMVA NewDM</td><td colspan="2">PF</td></tr>
<tr><td>Jets</td><td colspan="3">p_T > 30 GeV
|η| < 2.4</td><td>Loose</td><td>Anti-k_T clustering algorithm (AK4)</td><td rowspan="2">Soft: p_T > 30 GeV
Hard: p_T > 60 GeV</td></tr>
<tr><td>B-Tagged Jets</td><td colspan="3">p_T > 30 GeV
|η| < 2.4</td><td>Medium WP (CSVv2M)</td><td>CombinedSecondary Vertex (v2)</td></tr>
<tr><td>ISR-Jet</td><td colspan="3">p_T > 100 GeV</td><td></td><td colspan="2">Leading jet</td></tr>
<tr><td>MET</td><td colspan="3"></td><td></td><td colspan="2">type-1corrected PF-MET (JEC Summer16_23Sep2016V3)</td></tr>
</table>

Hybrid Isolation HI = (I_{abs} < 5 GeV) || (I_{rel} < 0.2)

- I_{abs} = absIso03 and I_{rel} = relIso03
- corresponds to switch from $I_{abs} \rightarrow I_{rel}$ at p_T = 25 GeV

Samples

Data:

- Full 2016 dataset (35.9 fb^{-1}) = Run2016[B-H]
  - 80X Re-MiniAOD (03Feb2017)
  - PDs: **MET**, SingleMuon, SingleElectron, JetHT

Background Samples:

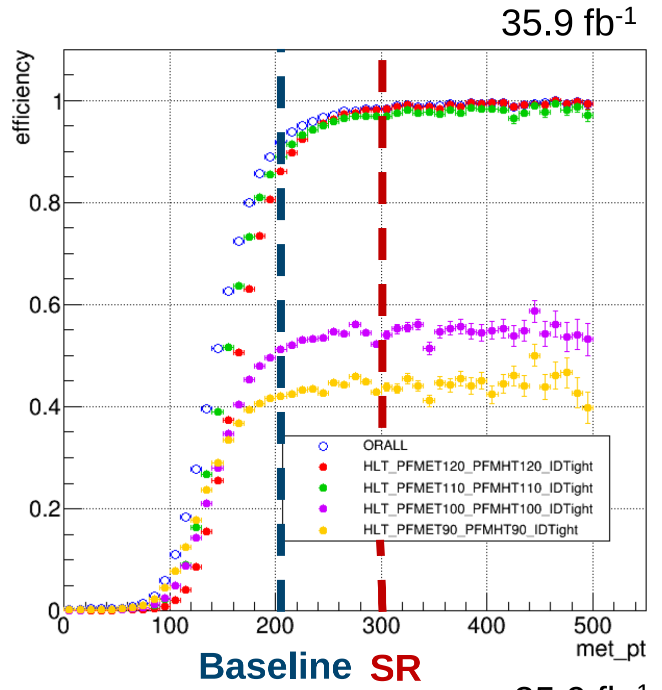
- 80X RunIISummer16MiniAODv2
- Most samples LO with MadGraph (MG) & Pythia8 (P8)
- TT+Jets, W+Jets, DY+Jets, Z_{Inv}+Jets, QCD, VV, ST, TTX

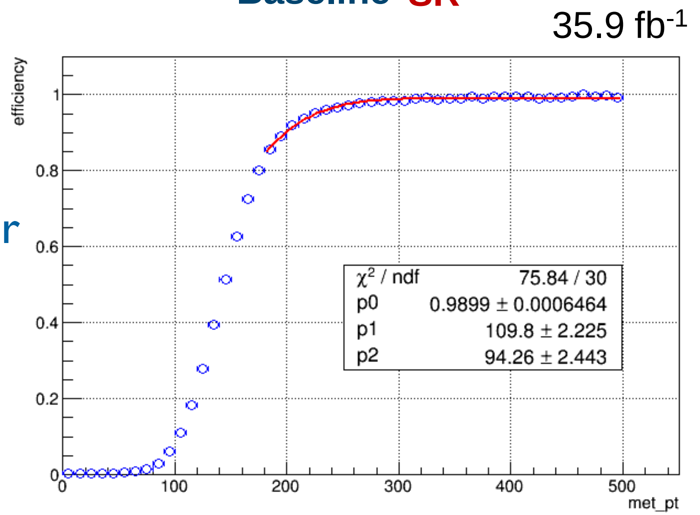
Signal:

- Official SMS Scans (80X):
  - Generator filters: gen. H_T > 160 GeV & gen. MET > 80 GeV
  - 4 body signal: SMS_T2tt_dM_10to80_genHT_160_genMET_80_mWMin_0p1
    - m_{stop}: 250 - 800 GeV in 25 GeV steps
    - Δm: 10 - 80 GeV in 10 GeV steps
  - Chargino-mediated: SMS_T2bW_X05_dM_10to80_genHT_160_genMET_80_mWMin_0p1

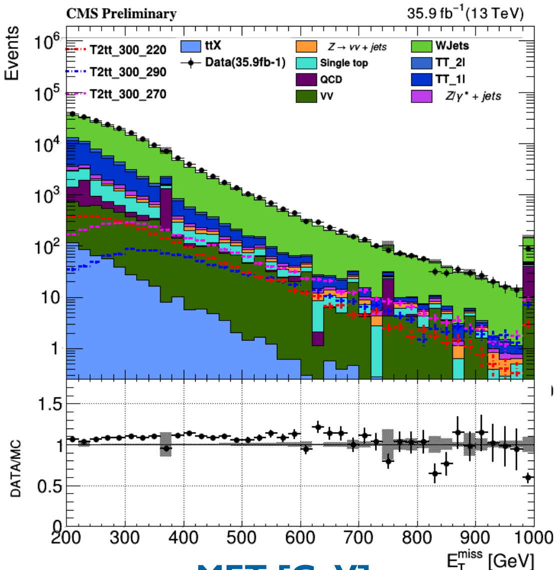
Trigger

- We use an 'OR' of pure MET triggers:
  - *HLT_PFMET90_PFMHT90_IDTight*
  - *HLT_PFMET100_PFMHT100_IDTight*
  - *HLT_PFMET110_PFMHT110_IDTight*
  - *HLT_PFMET120_PFMHT120_IDTight*
- Control sample:
  - SingleElectron PD (*HLT_Ele27_eta2p1_WPtight_GsF)*
  - leading jet p_T > 100 GeV
  - H_T > 300 GeV
  - electron p_T > 5 GeV
- Basic selection of the analysis compatible with trigger
- Plateau ~ MET 250 GeV (inefficiency ~ 1%)
- Parametrise and correct MC for trigger efficiency
- 1% systematic applied

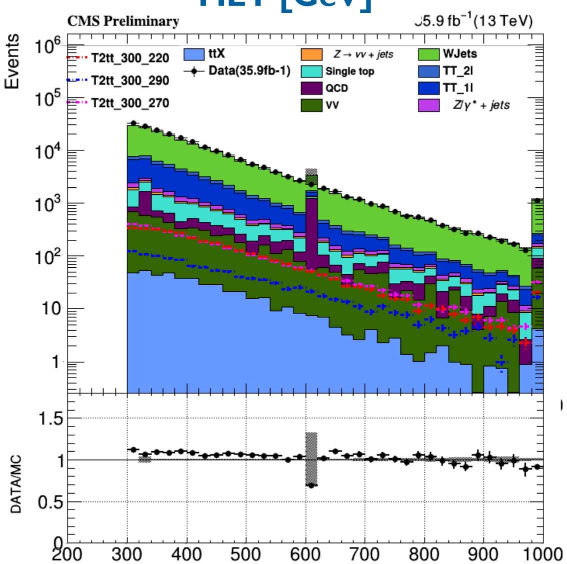




C&C: Distributions



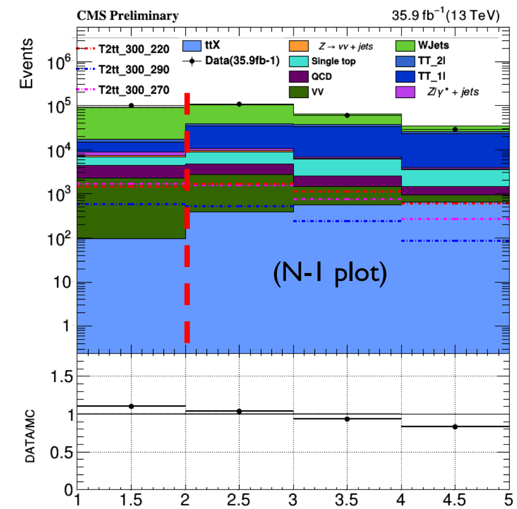
MET [GeV]



H_T [GeV]

Preselection:

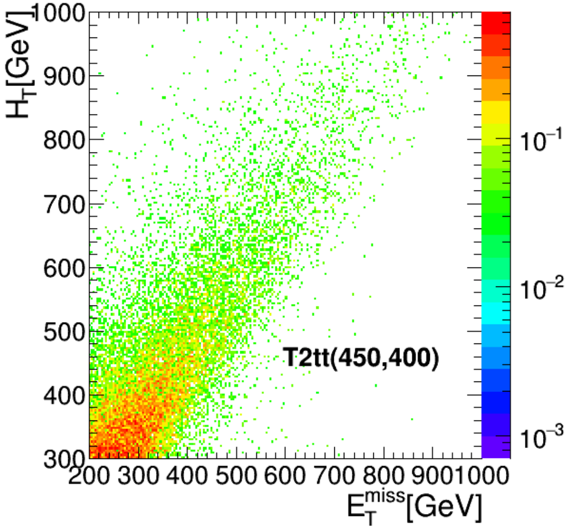
- MET > 200 GeV
- H_T > 300 GeV
- ISR-jet p_T > 100 GeV
- At least one lepton and 2^{nd} lep. veto (p_T > 20 GeV)
- Tau veto
- 3^{rd} hard jet veto } anti-QCD
- $\Delta\phi_{(j1,j2)}$ < 2.5 rad. } anti-QCD

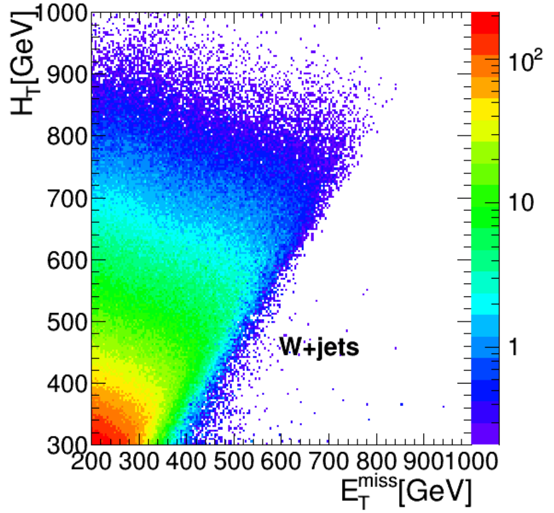


Hard Jet Multiplicity

C&C: Selection in MET and H_T

- We take advantage of correlation between MET and H_T and MET and ISR-jet p_T and define a new variable C_T:
  - $C_{T1} \equiv \min(\text{MET}, H_T - 100\ \text{GeV})$
  - $C_{T2} \equiv \min(\text{MET}, \text{ISR-jet } p_T - 25\ \text{GeV})$
- Helps stay away from strange topologies such as high MET and low H_T (and vice-versa)
- We further split our SR bins in terms of C_T:
  - **X: $300 < C_T < 400$ GeV**
  - **Y: $C_T > 400$ GeV**





C&C: Signal and Control Regions

- Definitions of signal and control regions:

Variable	Common to all SRs					
Number of hard jets	≤ 2					
$\Delta\phi$(hard jets) (rad)	< 2.5					
E_T^{miss} (GeV)	> 300					
Lepton rejection	no τ, or additional ℓ with $p_T > 20$ GeV					
	SR1			SR2		
H_T (GeV)	> 400			> 300		
p_T(ISR jet) (GeV)	> 100			> 325		
Number of b jets	0			$\geq$1 soft, 0 hard		
$\lvert\eta(\ell)\rvert$	< 1.5			< 2.4		
	SR1a	SR1b	SR1c	SR2a	SR2b	SR2c
M_T (GeV)	< 60	60–95	> 95	< 60	60–95	> 95
$Q(\ell)$	-1	-1	any	any	any	any
$p_T(\mu)$ (GeV)	3.5–5 (VL)	3.5–5 (VL)	-	3.5–5 (VL)	3.5–5 (VL)	-
$p_T(e, \mu)$ (GeV)	5–12 (L)	5–12 (L)	5–12 (L)	5–12 (L)	5–12 (L)	5–12 (L)
	12–20 (M)	12–20 (M)	12–20 (M)	12–20 (M)	12–20 (M)	12–20 (M)
	20–30 (H)	20–30 (H)	20–30 (H)	20–30 (H)	20–30 (H)	20–30 (H)
	> 30 (CR)	> 30 (CR)	> 30 (CR)	> 30 (CR)	> 30 (CR)	> 30 (CR)
C_T (GeV)	$300 < C_{T1} < 400$ (X) $C_{T1} > 400$ (Y)			$300 < C_{T2} < 400$ (X) $C_{T2} > 400$ (Y)		

$m_T = m_T$(lep p_T, MET)

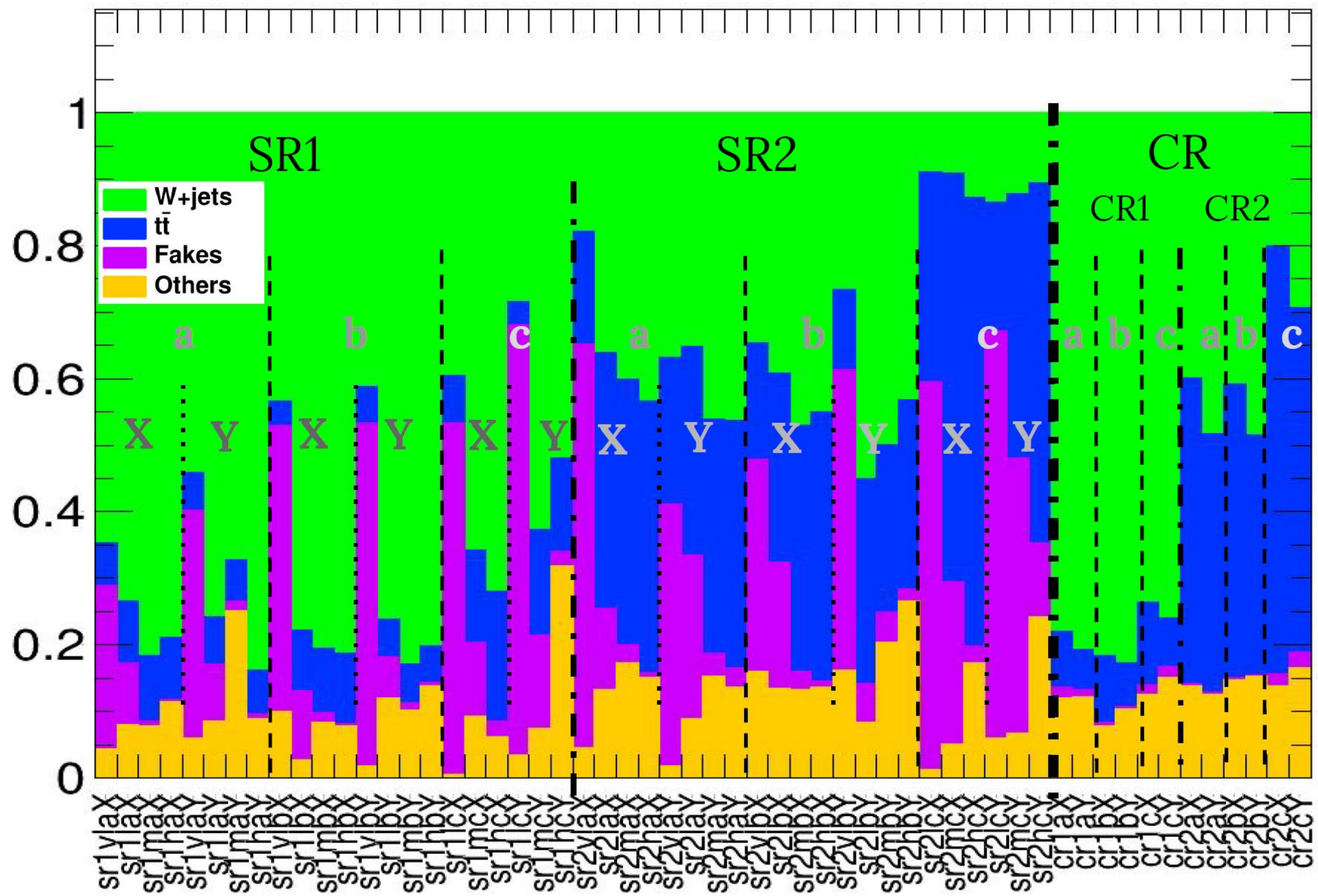
$$M_T = \sqrt{2E_T^{miss} P_T (1 - cos(\Delta\phi)}$$

Jets:

- soft = p_T: 30 – 60 GeV
- hard = p_T > 60 GeV

C&C: Background Composition

- Relative composition of MC backgrounds in the control SRs and CRs:



C&C: Estimation of Dominant Backgrounds

A control region for each SR:

- **W+Jets** and **tt-bar** normalised to data in CRs constructed from SRs with inverted lepton p_T cut:

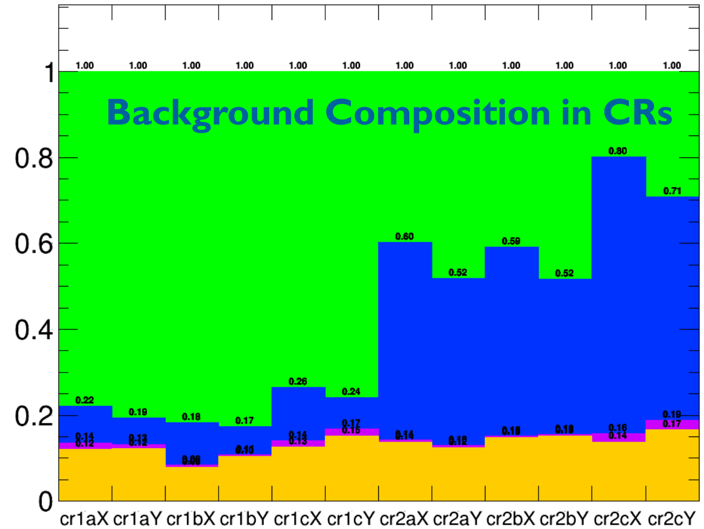
  $p_T > 30$ GeV

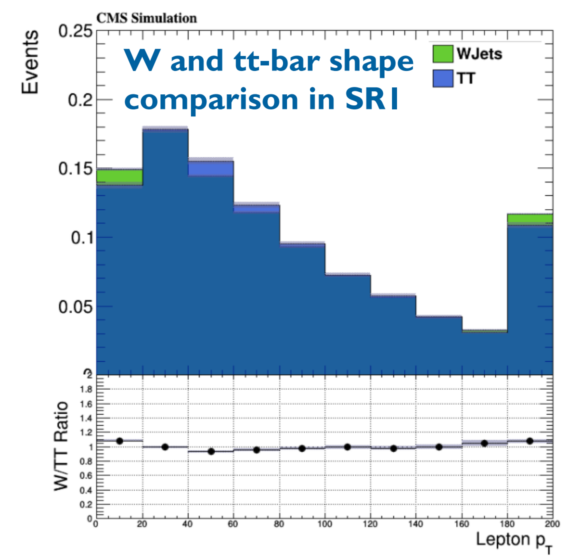
  (different lepton p_T SR bins share the same CR)

- SF determined with other contributions subtracted (including estimated fakes):

$$SF = \frac{N^{Data} - N^{Fakes} - N^{Others}}{N^{W+jets} + N^{t\bar{t}}}$$

- Due to similarity of the lepton p_T spectra of W+Jets and tt-bar, we estimate the sum of the two simultaneously (we add a systematic to account for the residual difference of the shapes)





Fake Rate Estimation Method

- 'Nonprompt' (or 'fake') leptons together with MET form a non-negligible contribution in m_T tails, where the main backgrounds are suppressed

- Main sources of nonprompt leptons:
  - Z_{inv}: $Z \rightarrow \nu\nu$
  - QCD
  - W+jets, tt-bar where prompt lepton lost and nonprompt found

- Estimated using the standard tight-to-loose **fake rate** method

  → does not distinguish between these processes

  - One defines a 'loose' set of criteria for a 'fakable object':

    → we extrapolate mainly in lepton isolation

  - 'Tight' criteria correspond to the final analysis object selection
  - **Tight-to-loose ratio ε_{TL}** = probability that a lepton passes both the tight and loose definitions → determined in **Measurement Region**

Fake Rate Estimation Method

- One constructs a control region around SR (same kinematic cuts) where a lepton fails tight requirements but passes the loose criteria (Loose-not-Tight = L!T CR ≡ **Application Region**)

- Events in this region are reweighted using the ε_{TL} to get the expected contribution of fakes in the signal region:

$$N^{SR}_{\text{fake}} = \frac{\epsilon_{TL}}{1-\epsilon_{TL}} \cdot (N^{L!T}_{\text{data}} - N^{L!T}_{\text{prompt}})$$

- Main **systematics** of the method:
  - Non-universality of ε_{TL} (dependence on flavour of jets originating fakes)
    - determined using b-tag variations of measurement regions
  - Prompt subtraction using MC
    - Using full size of W-p_T reweighting and 50% of the tt-ISR correction
  - Non-closure systematics determined from MC closure

Systematics

- Summary of relative systematic uncertainties on the total **background prediction**:
  - W-p_T and tt-ISR reweighting uncertainty
  - Residual lepton p_T shape uncertainty
  - Nonprompt background systematics
  - 50% on rare background cross-sections
- Summary of relative systematic uncertainties on the **signal**:
  - ISR
  - FullSim/FastSim
  - FastSim (PF-MET vs. gen. MET)
  - Pileup (PU)
  - Q^2
- **Common** background and signal systematics:
  - Lepton SF:
    - including determined analysis specific factors
  - B-tag SFs
  - JEC/JER
  - Luminosity = 2.6% recommendation
  - 1% lepton efficiency
  - 1% trigger efficiency

C&C

Systematic uncertainty	Background SR1	Background SR2	Signal
Ren. & fact. scales	-	-	2-3
Pileup	0.1-1.8	0.1-2.0	1
JES	1.2-2.1	0.1-1.4	3-4
JER	0.1-0.5	0.1-1.1	<1
b-tagging	0.1	0.1-1.0	1-3
Trigger	< 0.1	< 0.1	1
Lepton efficiency	1.0-1.8	1.0-1.5	3
ISR ($t\bar{t}$ and signal)	0.1-0.5	0.1-0.8	5-7
ISR (W+jets)	4.5-10.2	1.9-4.4	-
p_T^{miss} modelling (FASTSIM)	-	-	2-3
Relative yields W+jets/$t\bar{t}$	0.1-1.6	0.1-2.2	-
Nonprompt	1-4.6	1-9.5	-

MVA

Systematic uncertainty	Background	Signal
Ren. & fact. scales	[0,1]	[1.5,3]
Pileup	1	1
JES	[0,2]	[6,13]
JER	[0,1]	[1,6]
b-tagging	[0,1]	[0,7]
Trigger	1	1
Lepton efficiency	[0,1]	4
ISR ($t\bar{t}$ and signal)	[0,1]	[0,6]
ISR (W+jets)	[0,10]	-
p_T^{miss} modelling (FASTSIM)	-	5
Prediction of W+jets	[7.1,32.0]	-
Prediction of $t\bar{t}$	[4.1,16.0]	-
Prediction of nonprompt	[6.7,15.6]	-

(values expressed in % relative to total yield)

Signal and Control Region Naming

Example illustrating our signal and control region naming:

SR2-VL-a-Y

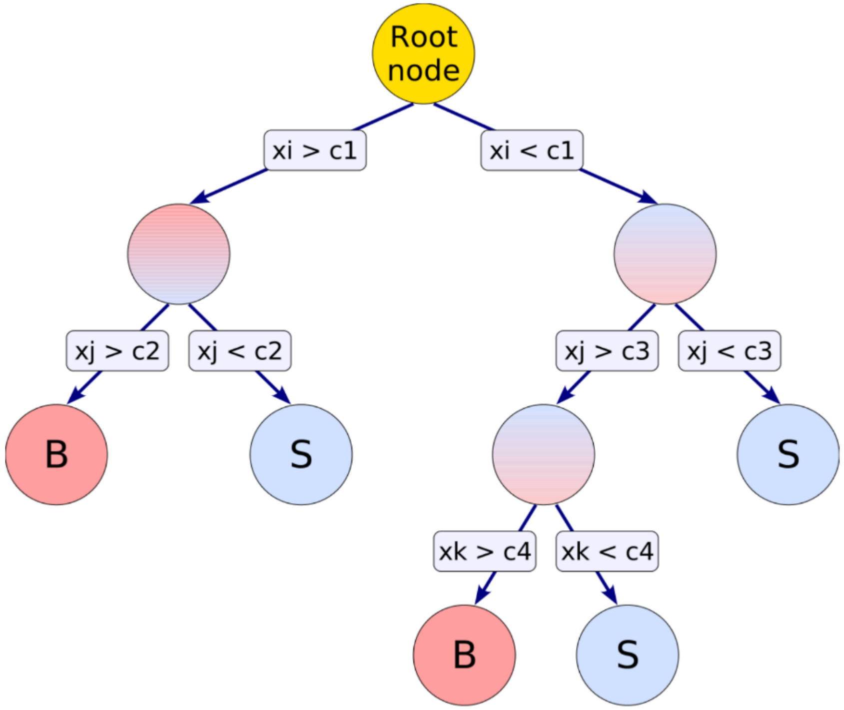
Signal/Control Region	p_T bin	m_T bin	C_T bin

corresponding to:

- **Signal/Control region** = SR2
- **p_T bin** = Very-Low (VL): $3.5 \leq p_T < 5$ GeV
- **m_T bin** = a: $m_T < 60$ GeV
- **C_T bin** = Y: $C_T > 400$ GeV

MVA: Boosted Decision Trees

- What is a Decision Tree?
  - Several input parameters/variables
  - Nodes are criteria (e.g. cut on variable)
  - Classification on whether signal (S) or background (B)
  - BDT discriminator combines several discriminating variables into one (incorporates specific cuts on the input variables)



  - Leafs = ending nodes = final verdict on whether S or B

MVA: Boosted Decision Trees

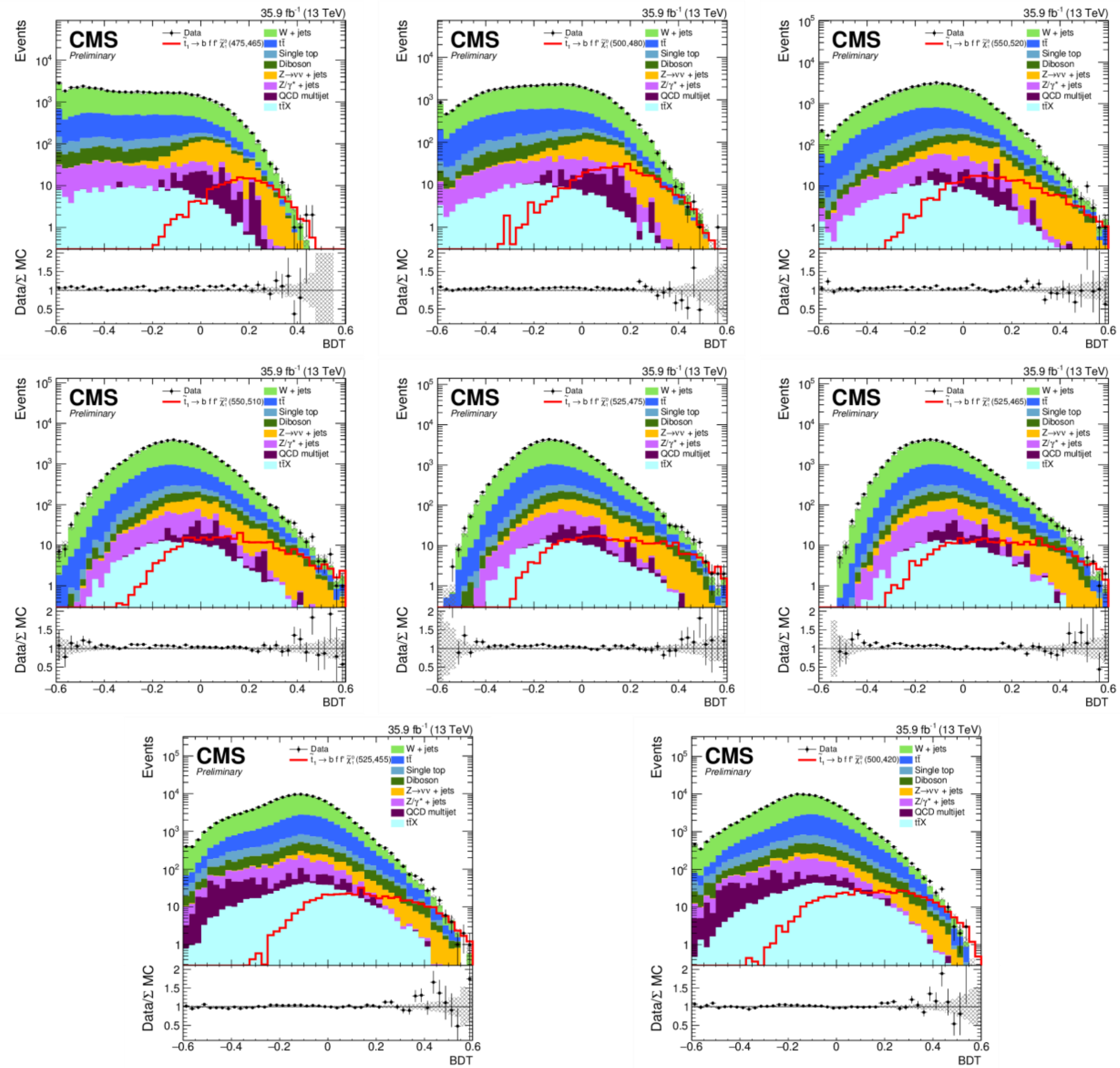
- A decision tree needs to be trained on Monte-Carlo (MC) datasets (where S and B are, by definition, distinguishable)

- Choice of criterion of nodes (MVA parameters and variables) by maximising the figure-of-merit (FoM)

- Boosting trees:
  - Enhances weights of misclassified events and reduces weight of correctly classified ones after each training
  - Iteration until weight of misclassified events > 50%
  - Final weight = sum of all classifiers weighted by their errors

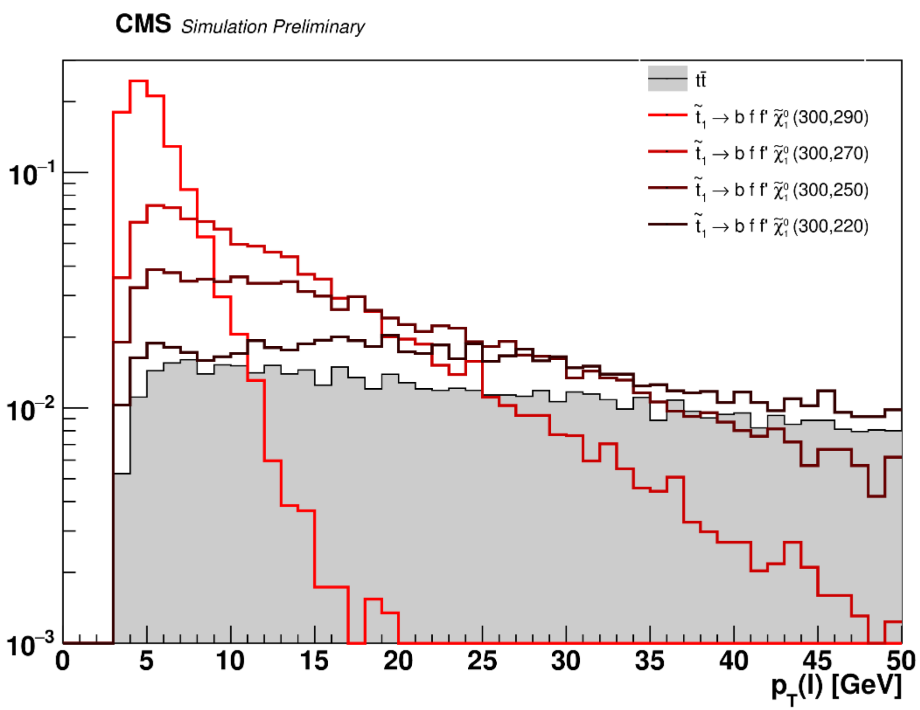
- Signal and control regions defined and based on the BDT discriminator

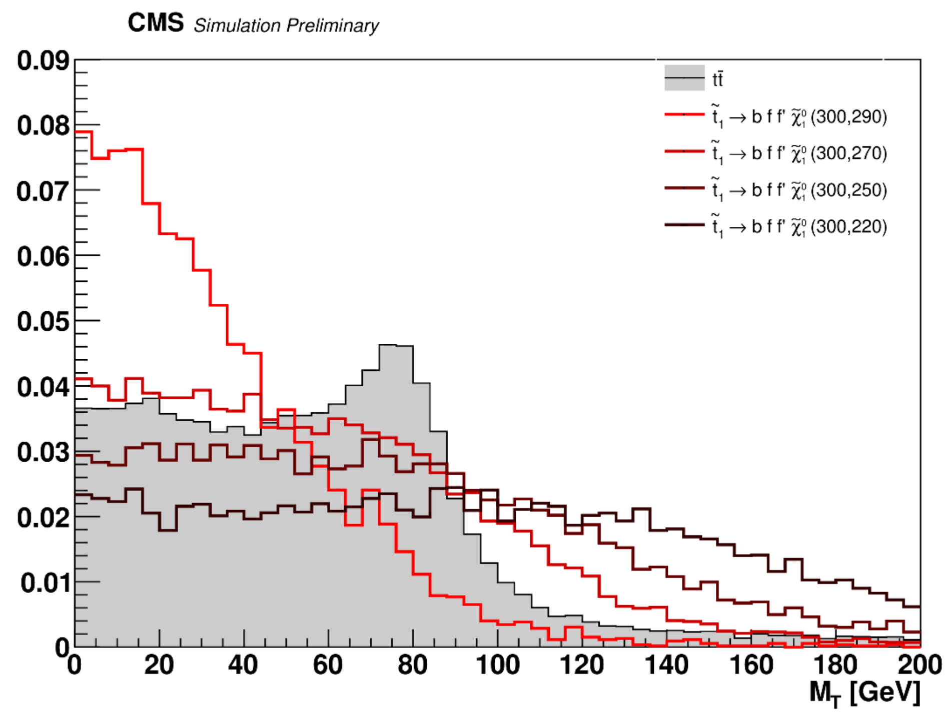
MVA: Distributions



MVA: Distributions

Normalized MC distribution of various input variables for signal with different Δm at preselection level:





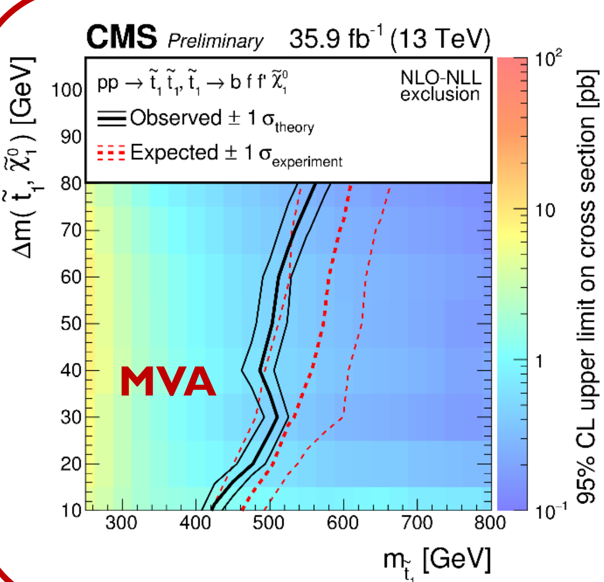
MVA: Results

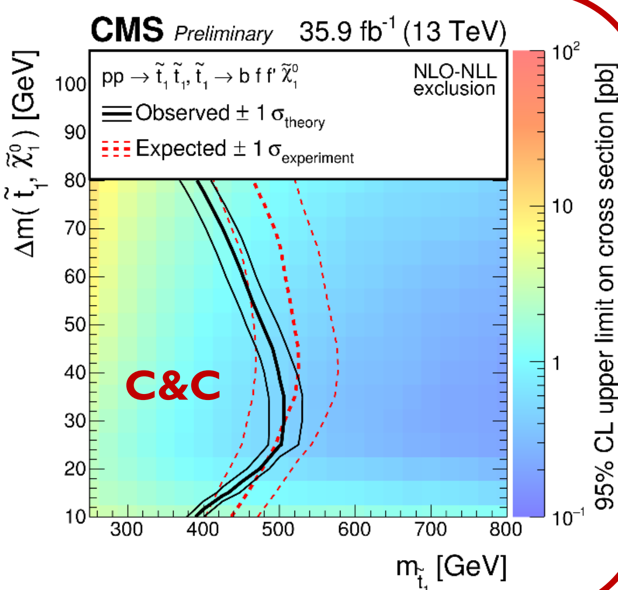
Background prediction in the eight signal regions defined by the minimal threshold on the BDT output per Δm:

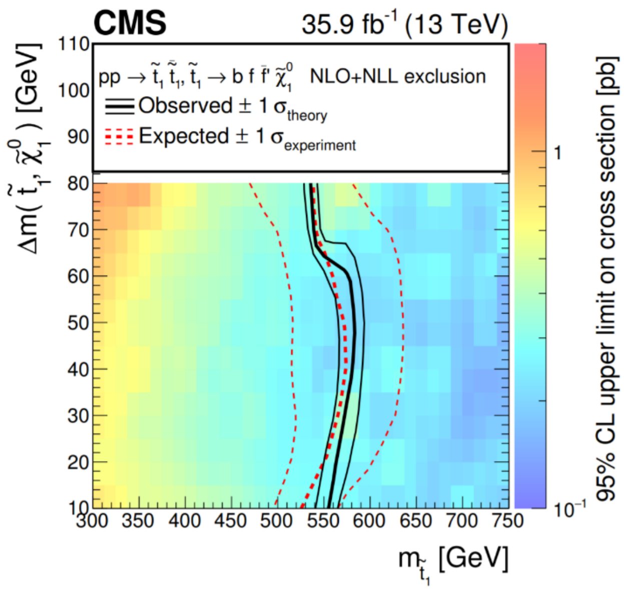
	BDT>	$N^{SR}_{DDprompt}(\mathrm{W+jets})$	$N^{SR}_{DDprompt}(\mathrm{t\bar{t}})$	N^{SR}_{DDfake}	$N^{SR}(\mathrm{Other})$	N^{SR}_{Pred}	$N^{SR}(Data)$
$\Delta m = 10$ GeV	0.31	18.4 ± 3.6	1.8 ± 4.8	8.0 ± 2.9	2.3 ± 1.4	30.3 ± 6.7	39
$\Delta m = 20$ GeV	0.39	9.0 ± 2.0	1.3 ± 1.7	11.2 ± 3.2	3.1 ± 1.9	24.7 ± 4.5	20
$\Delta m = 30$ GeV	0.47	4.0 ± 2.5	1.2 ± 0.6	8.8 ± 2.5	1.7 ± 1.2	15.7 ± 3.7	22
$\Delta m = 40$ GeV	0.48	4.1 ± 1.3	1.8 ± 0.7	7.6 ± 2.3	1.2 ± 0.9	14.8 ± 2.8	16
$\Delta m = 50$ GeV	0.45	7.3 ± 2.1	4.7 ± 2.8	7.1 ± 2.0	5.5 ± 3.1	24.5 ± 4.8	36
$\Delta m = 60$ GeV	0.50	2.0 ± 0.6	2.4 ± 1.2	3.1 ± 1.1	1.1 ± 0.9	8.7 ± 1.8	12
$\Delta m = 70$ GeV	0.46	4.9 ± 1.6	3.4 ± 1.1	5.4 ± 1.6	3.2 ± 1.9	16.8 ± 2.9	20
$\Delta m = 80$ GeV	0.44	7.1 ± 1.6	5.1 ± 0.9	5.3 ± 1.6	5.2 ± 3.0	22.8 ± 3.3	26

T2-4bd Exclusion Limits

- Comparison with other CMS analyses targeting this phase-space (T2-4bd):





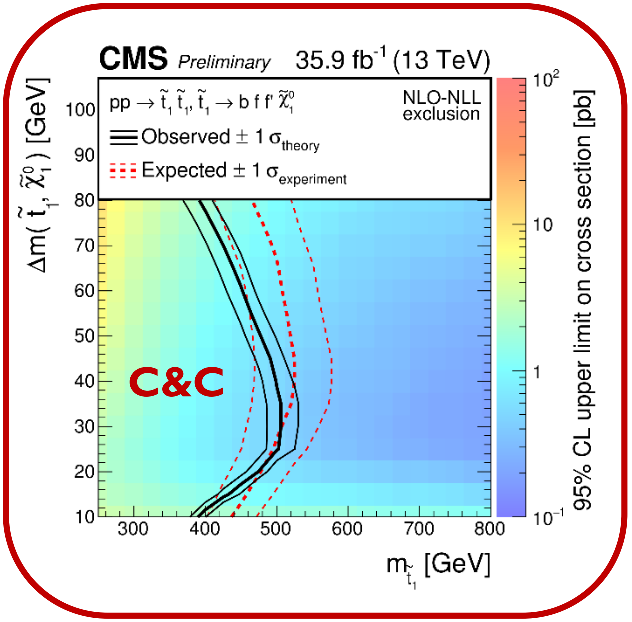


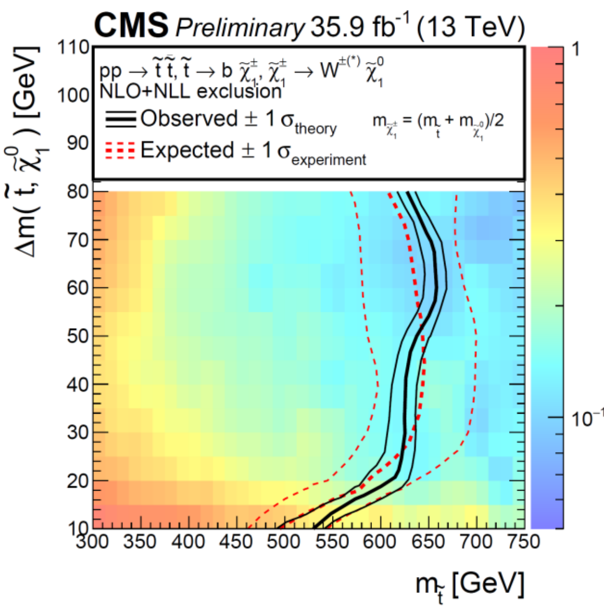
Full-Hadronic:
(JHEP 2017: 5)

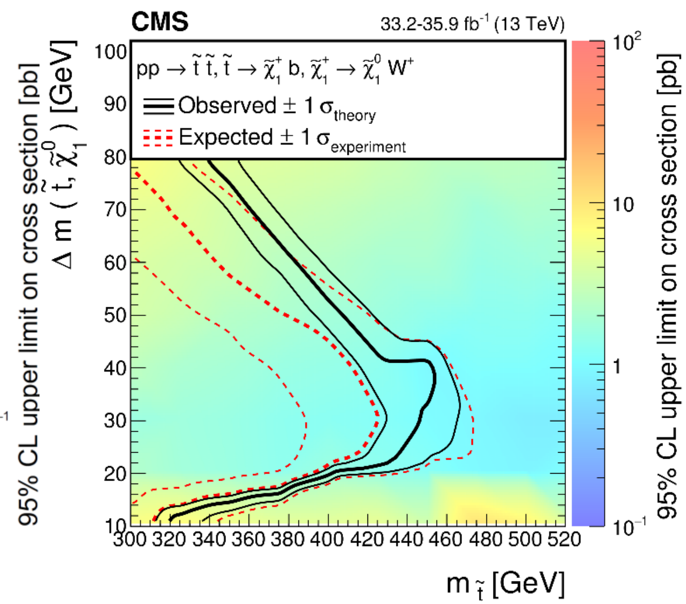
(assuming 100% branching ratio and prompt decay of stop)

T2bW Exclusion Limits

- Comparison with other CMS analyses targeting this phase-space (T2bW):







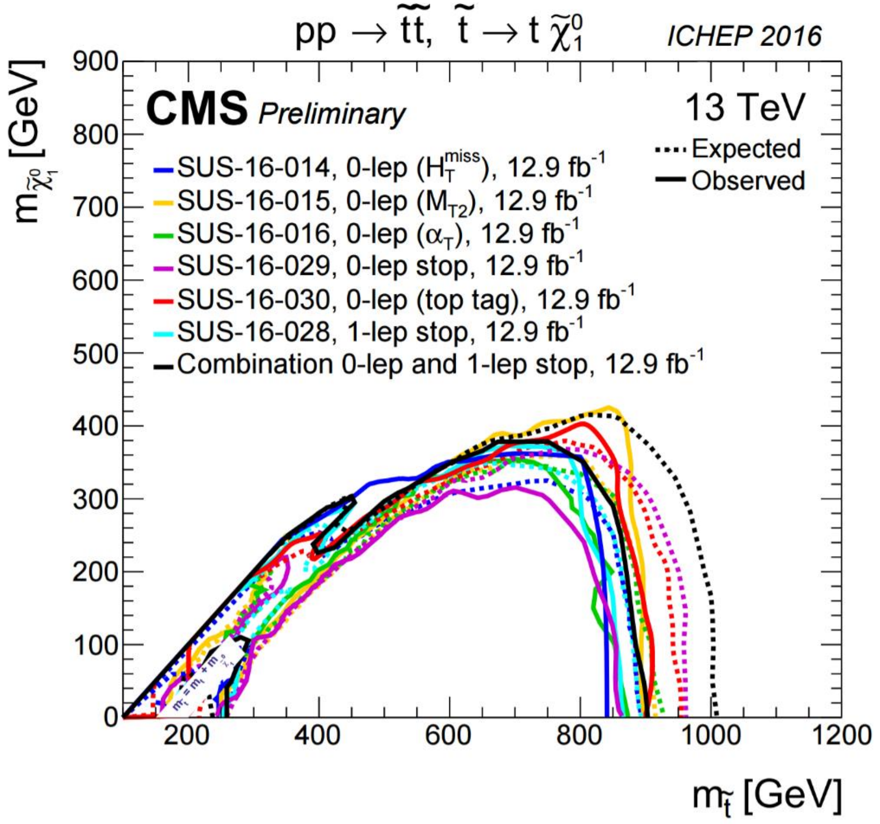
Full-Hadronic: (JHEP 2017: 5)

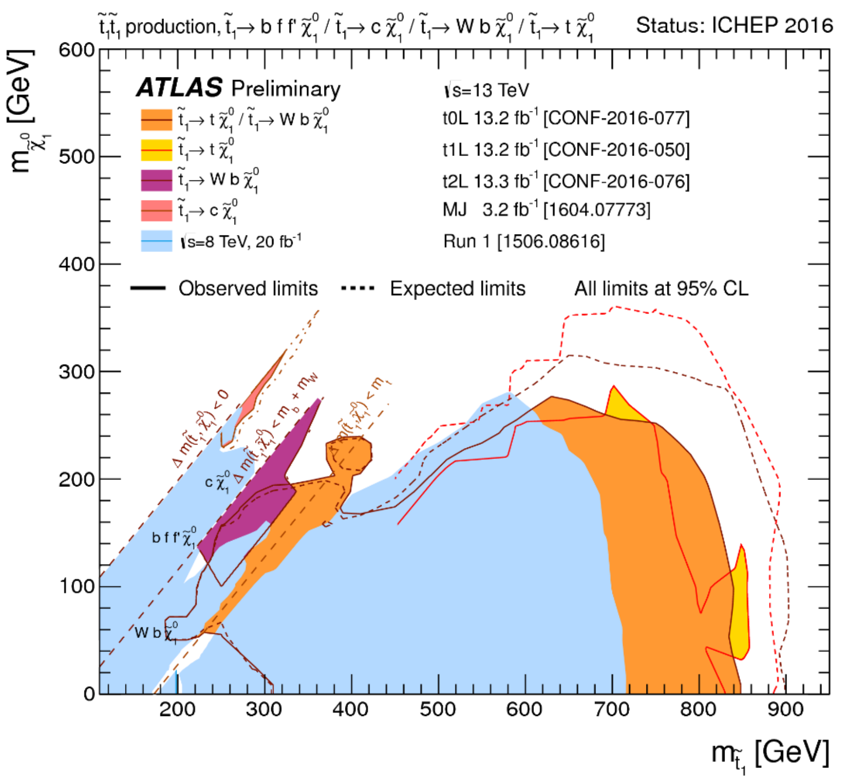
Di-leptonic (SOS): CMS-SUS-16-048

(assuming 100% branching ratio)

Run II Limits Summary

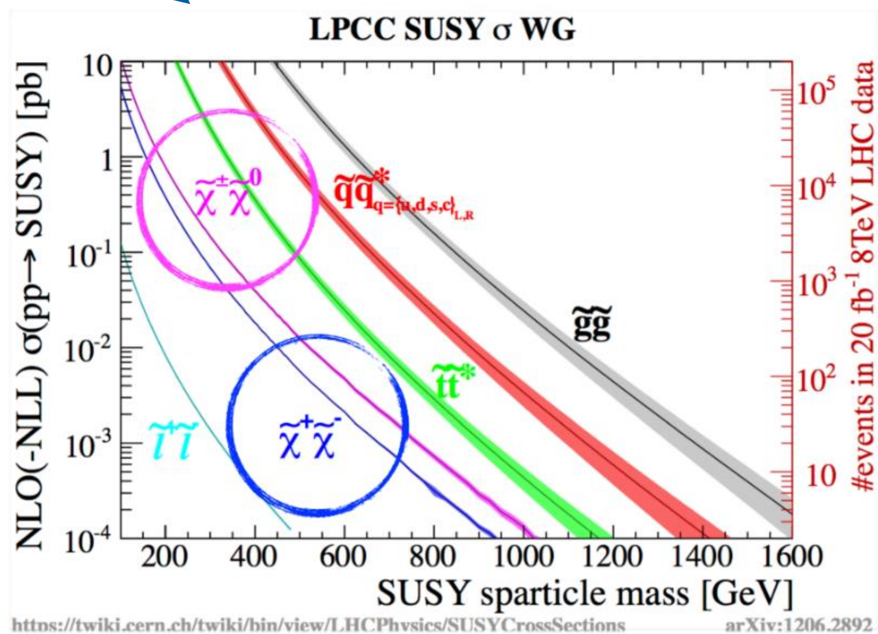
Overview of stop pair-production exclusion limits on cross-section presented in **ICHEP 2016:**





Why EWK SUSY?

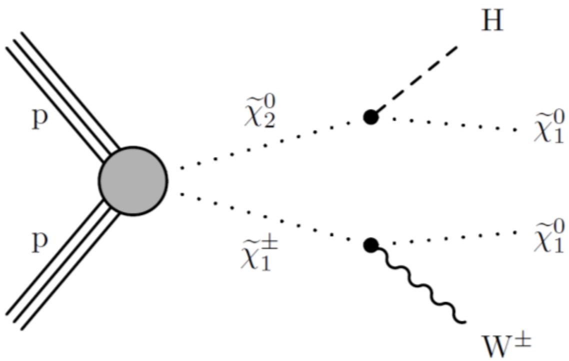
- Many searches focus on models with strong production = stop or gluino(-mediated) pair-production, due to its higher cross-sections:
- Lower cross-sections for EWKino production compared to strong production
- Light higginos in EWK models
  = window to natural SUSY
- **Clean** multi-lepton signatures with low hadronic activity



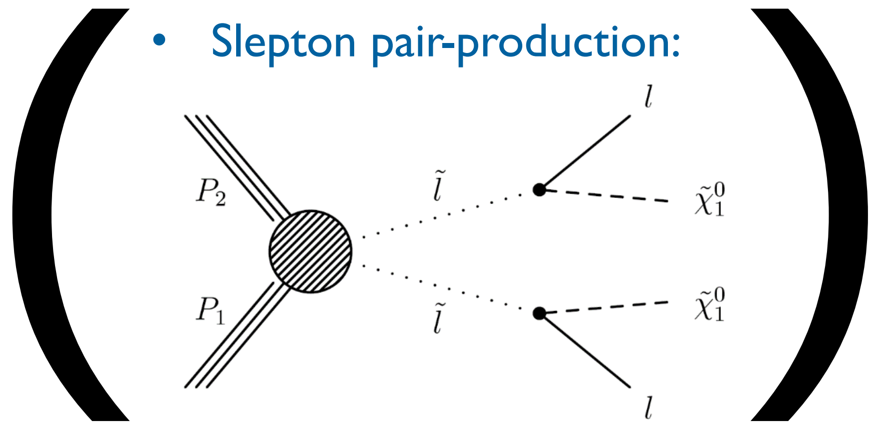
EWK Scenarios

CMS performed a combination (CMS-PAS-SUS-17-004) of several searches (multileptons, SOS,…) which considered several other models, for eg.:

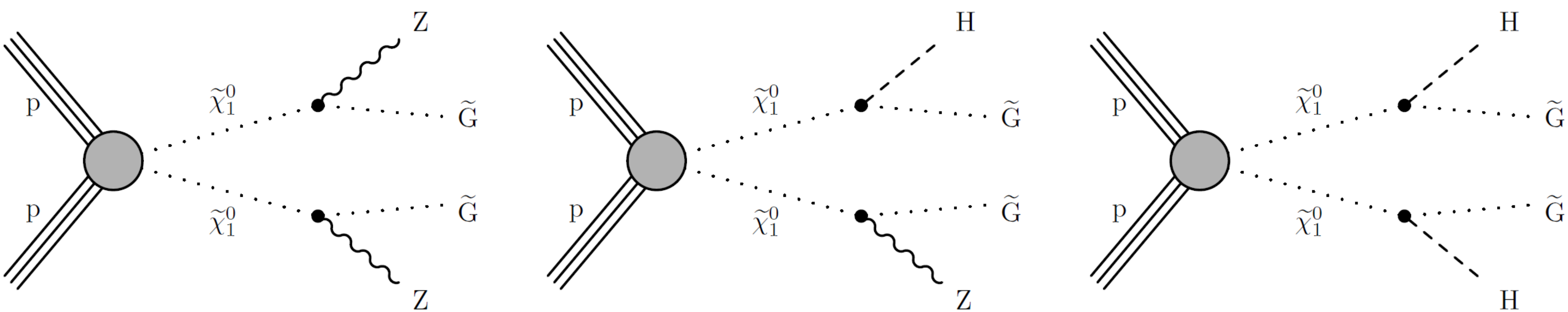
- Chargino-neutralino pair production:



- Slepton pair-production:

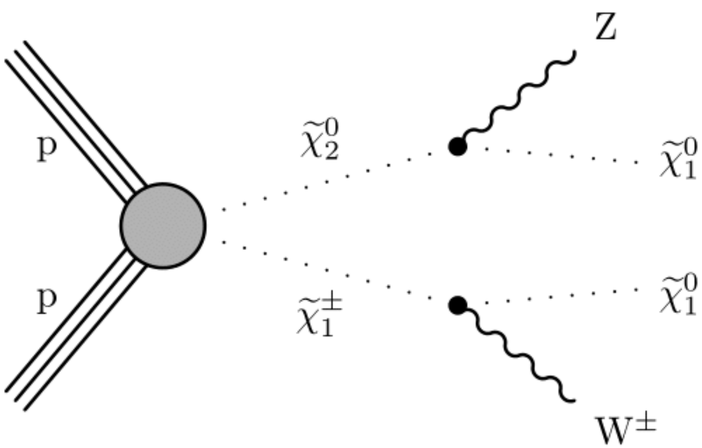


- GMSB (Gauge-Mediated SUSY breaking) scenarios:

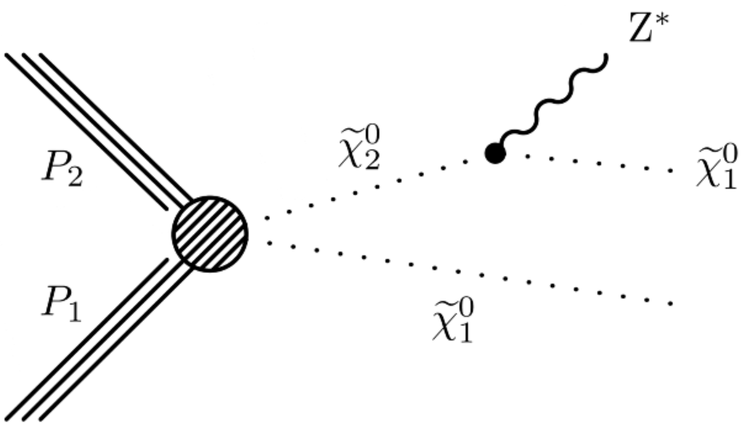


EWK Scenarios

We are looking into new **interpretations** for the soft single lepton signature:



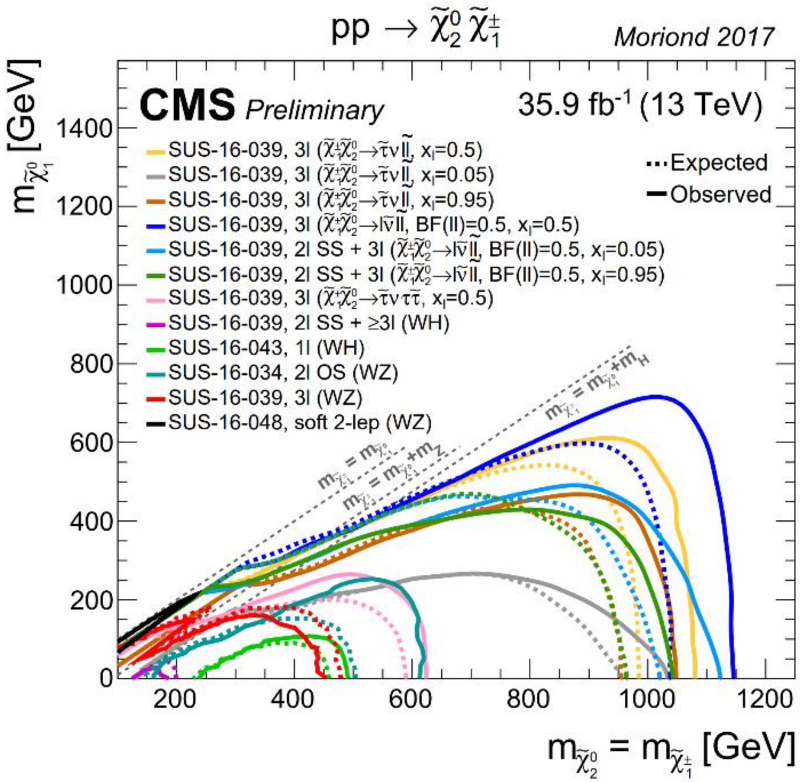
(EWKino pair-production: TChiWZ/N2C1)

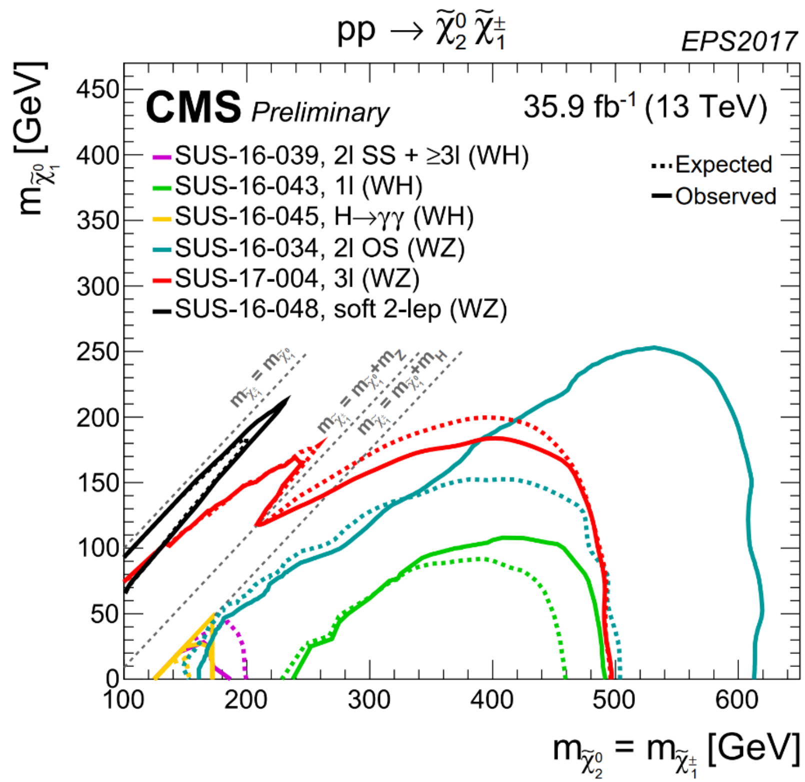


(N2N1 pair-production)

EWK Scenarios

- Limits have been set in many EWK models already:





(includes combination presented @ EPS)