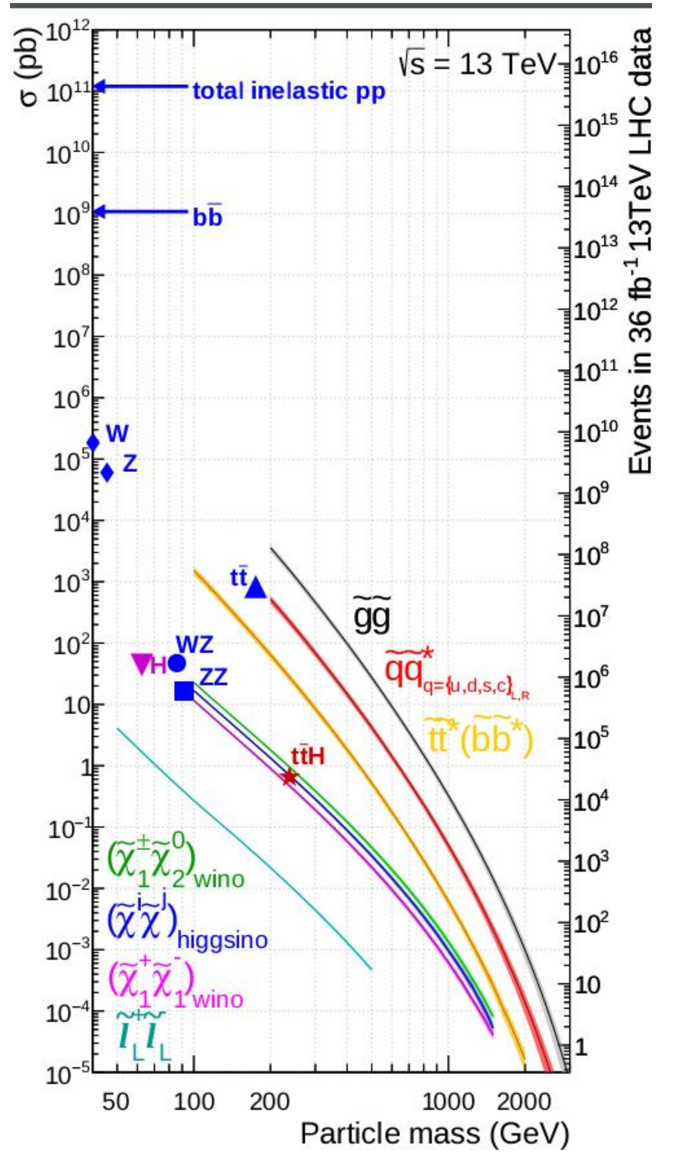
Searches for Strong Production of SUSY at CMS

Navid K. Rad
On behalf of the CMS collaboration

DIS2018

Kobe, Japan

- Still looking for SUSY?!
  - Motivated by naturalness, cosmological observations of dark matter, and GUT
  - SUSY searches can be reinterpreted for other BSM signals
- SUSY parameter space is extremely large
  - Simplified Models (SMS) are used to reduce model dependence
  - Consider only the lightest SUSY particles, others decoupled
  - Simple assumptions on branching fractions are made
- Strong production of SUSY
  - In SMS, gluinos and squarks have largest xsecs (for a given mass) at the LHC
  - Well-motivated place to look for SUSY

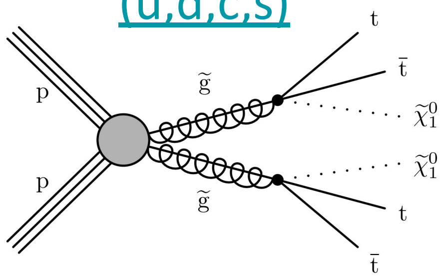


https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections

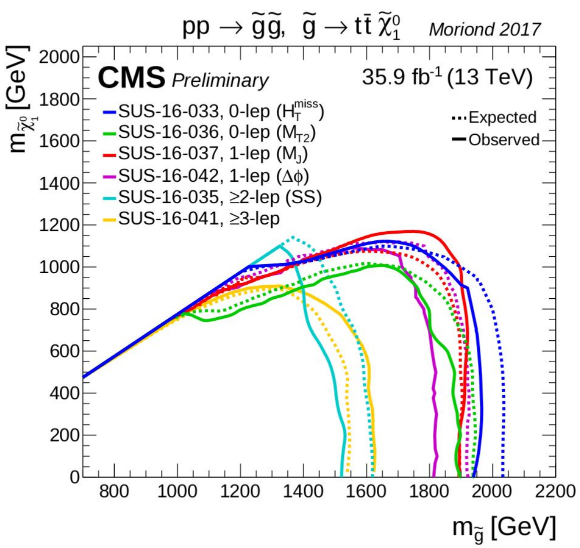
arXiv:1407.5066

R-Parity Conserving

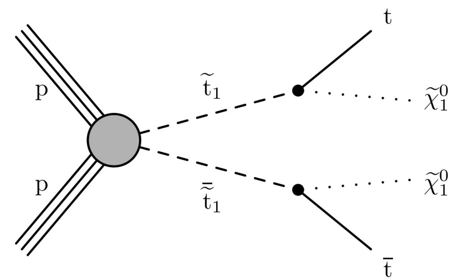
Gluino and Squarks ($\tilde{u},\tilde{d},\tilde{c},\tilde{s}$)



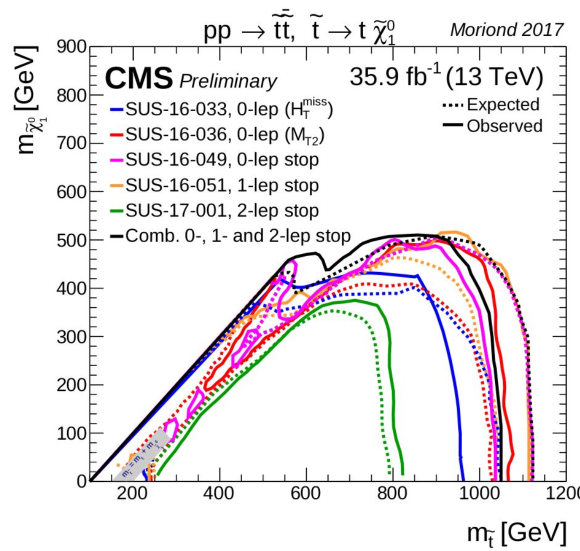
- Largest cross-sections
- Many jet final states
- 0l and 1l searches compatible reach



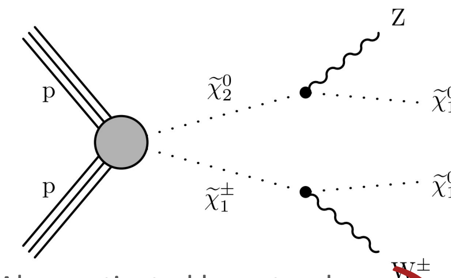
3rd generation



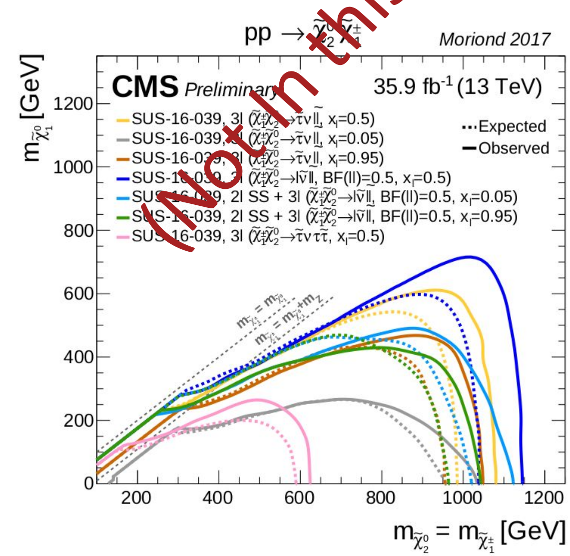
- Light stops/sbottoms preferred by naturalness
- Jet and leptonic final states



Electroweak



- Also motivated by naturalness arguments
- Leptonic final states



(Not in this talk)

Here I will focus on some of the more recent CMS results (2016 data)

Analyses Covered in this Talk

CMS SUSY Results:

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

Hadronic Search:

Search for Natural and Split SUSY:

CMS-SUS-16-038 (arXiv:1802.02110)

1 Soft Lepton:

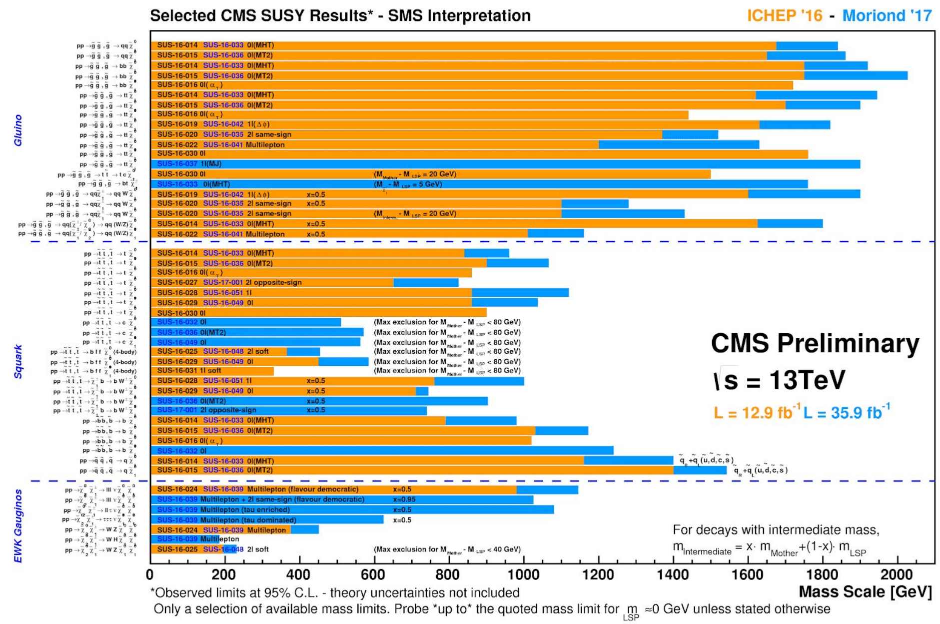
Compressed Stop Search

CMS-PAS-SUS-17-005

2 Lepton search:

Chargino and Stop pair production

CMS-PAS-SUS-17-010



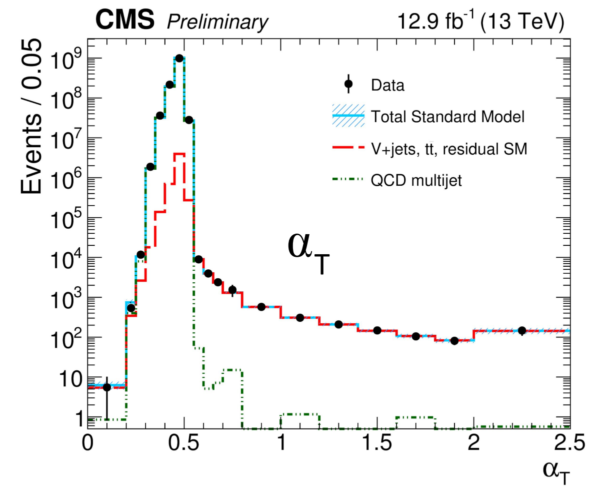
Links include additional material needed for reinterpretations!

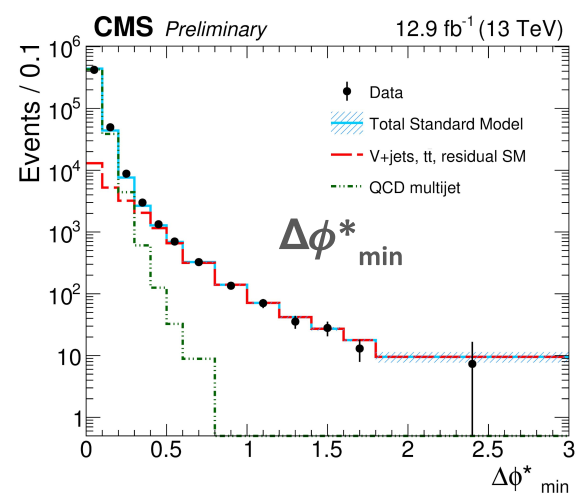
Search For Natural and Split SUSY with α_T

- Split SUSY: N. Arkani-Hamed, S. Dimopoulos, arXiv:hep-th/0405159
  - Abandon the hierarchy problem
  - Guided by gauge unification and dark matter constraints
    - Scalar susy particles much heavier than EW scale
    - Gluino decay suppressed (highly virtual squarks)
    - R-Hadron $\longrightarrow$ displaced jets
- All-jet final states with large missing energy
  - Sensitivity to various signatures by categorization in
    - N(b), N(j), H_T, H_T^{miss}
  - Use clever kinematic variables to fight QCD multijet evts
    - Jet mismeasurement can fake p_T^{miss} in multijet events
    - Reduced significantly using variables $\boldsymbol{\alpha_T}$ and $\boldsymbol{\Delta\phi^*_{min}}$
    - Use sidebands ($\Delta\phi^*_{min}$, H_T^{miss}/p_T^{miss}) to estimate the rest
  - Non-multijet backgrounds:
    - ttbar and W+jets (with a lost lepton)
      - extrapolate from μ+jets
      - Measure probability for losing the lepton in MC
    - Z$\longrightarrow \nu\nu$ (irreducible background)
      - Extrapolate from $\mu\mu$ + jets events
      - Measure the ratio of Z$\longrightarrow\nu\nu$ / Z$\longrightarrow\mu\mu$ in MC

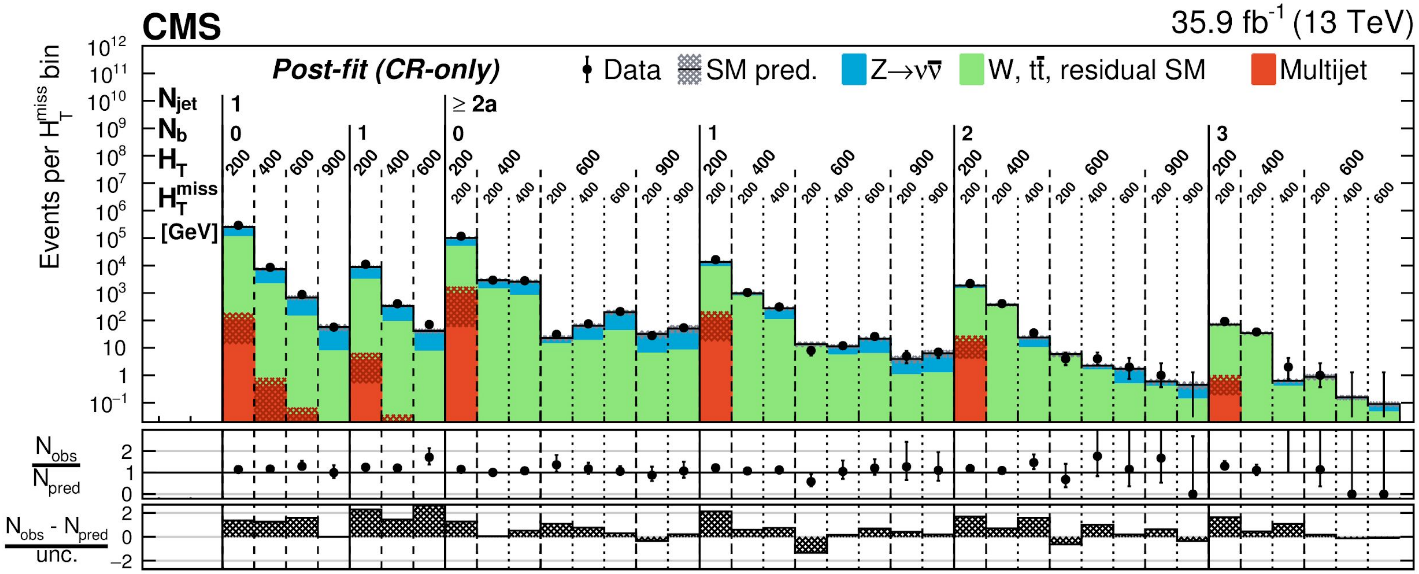
$$H_T^{miss} = |\sum^{jets} \vec{p}_T^{\,j}|$$

$$H_T = \sum^{jets} p_T^j$$

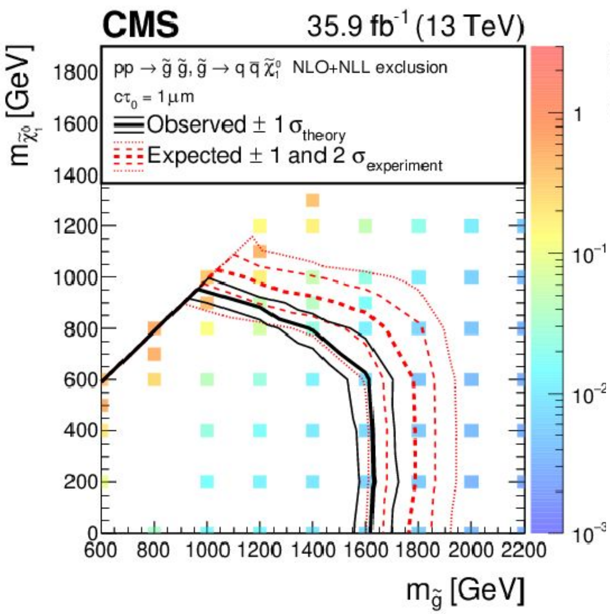




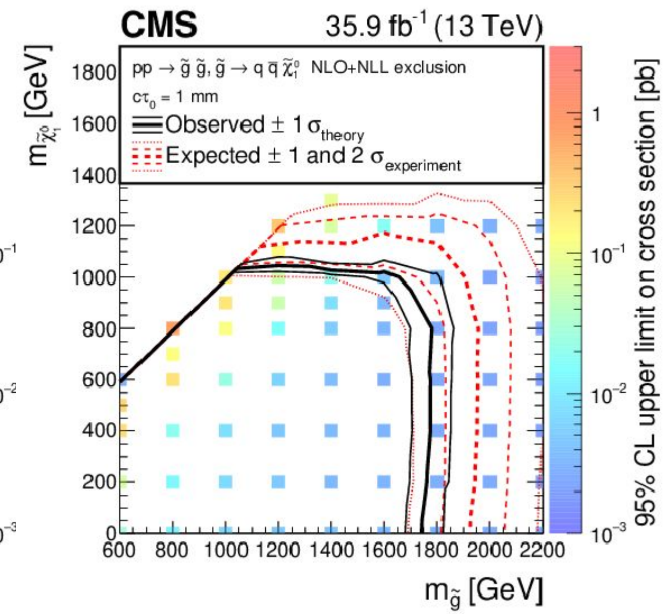
α_T Results: Split SUSY



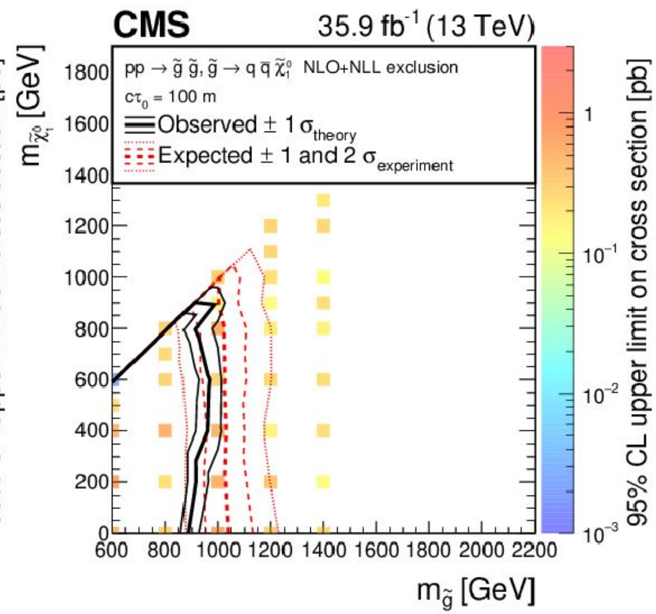
$c\tau_0$ =1µm



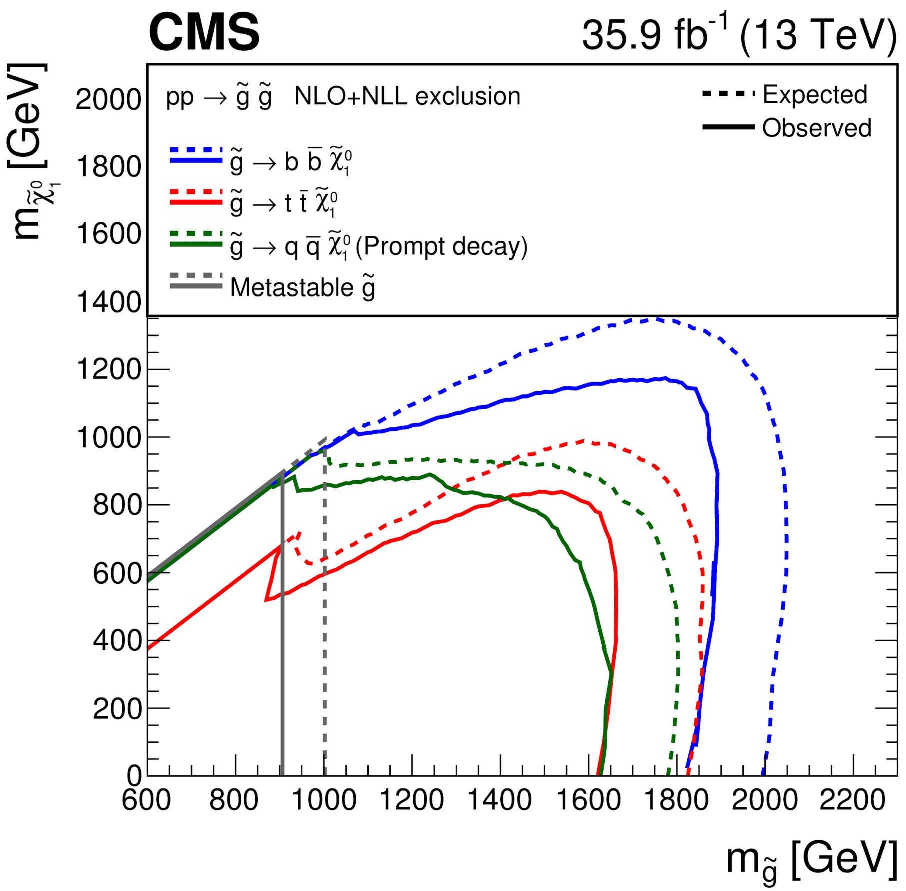
$c\tau_0$ =1mm



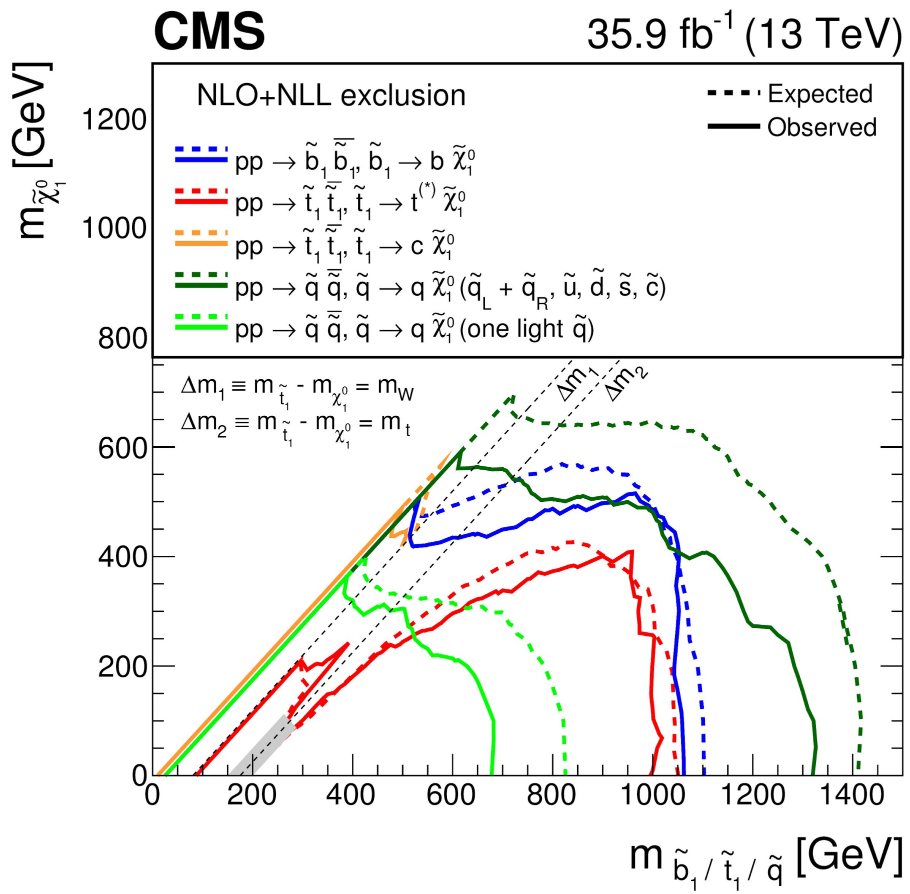
$c\tau_0$=100m



Gluino production

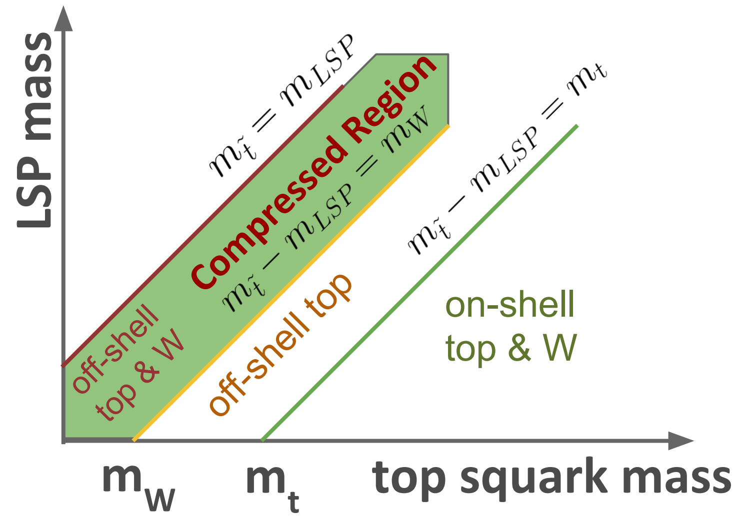


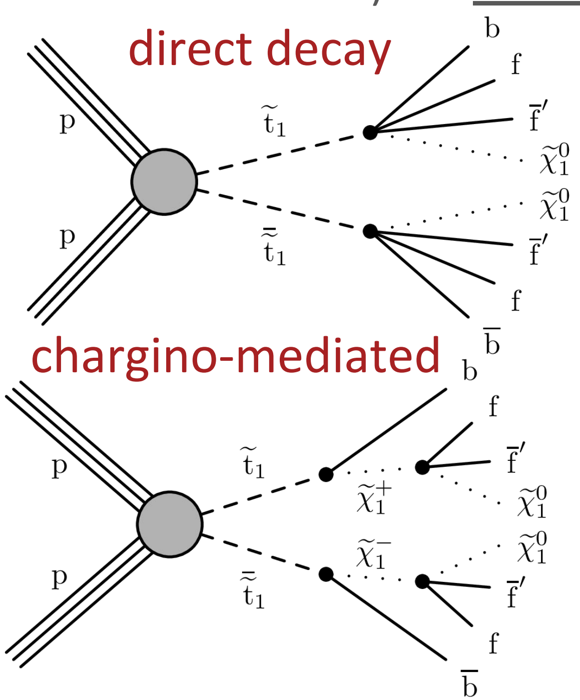
1st, 2nd, 3d Gen. squark production



Compressed Stop 1 soft lepton

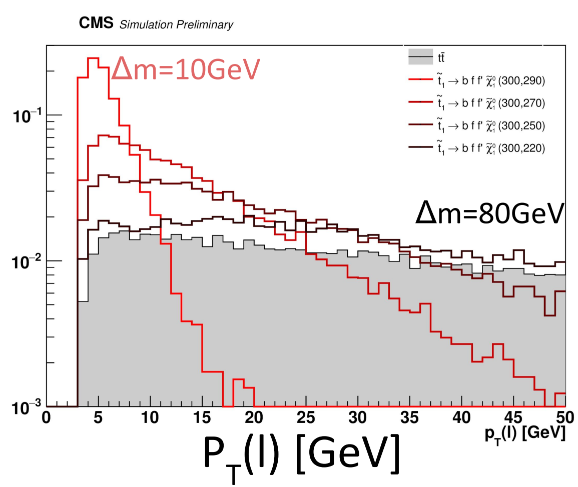
- Compressed Region: $\Delta m(m_{Stop}, m_{LSP}) < m_W$
  - Relatively light stops still allowed!
  - Coannihilation of stops and LSPs in this region can help predict the correct dark relic density.
  - Challenging region to probe due to soft final state particles (often too soft for trigger threshold) but recoil against ISR jet can help!

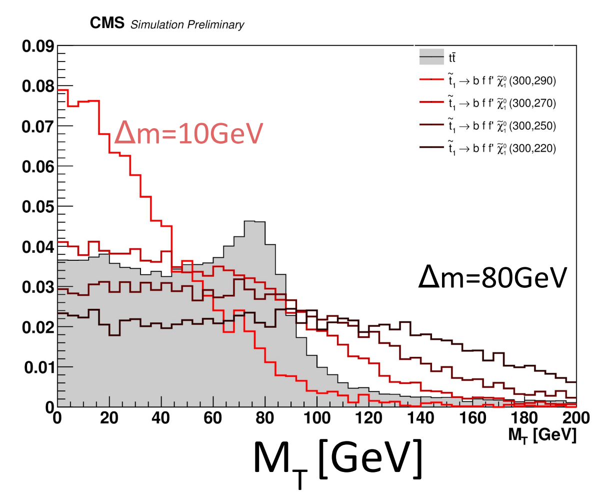




Kinematics ($P_T(l)$, M_T, $P_T(b)$, P_T^{miss})

strongly depend on Δm





HEPHY

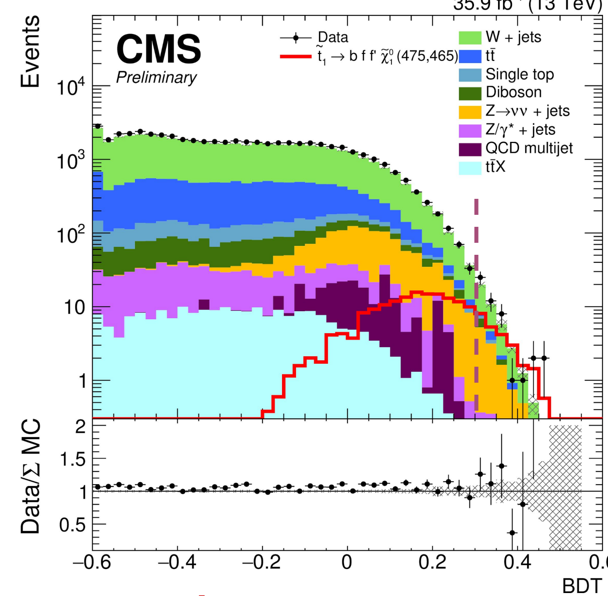
Compressed Stop 1 soft lepton

- MVA and Cut&Count common baseline:
  - Require one ISR Jet, moderate p_T^{miss}, and H_T
  - 1 soft lepton:
    - p_T(mu) > 3.5 GeV, p_T(e) > 5 GeV
    - p_T(l) < 30 GeV (not for Δm<70 GeV in MVA)
  - Dominant backgrounds: W+jets, ttbar, $Z \rightarrow \nu\nu$
- Cut&Count
  - optimized to be sensitive to range of Δm
  - Binned in p_T(l) , M_T and p_T^{miss}, H_T ,P_T(ISR)
  - 0 b-jet or 1+ soft bjet (p_T(b) < 60GeV)
  - 44 total signal regions
  - Results combined with hadronic 0l search

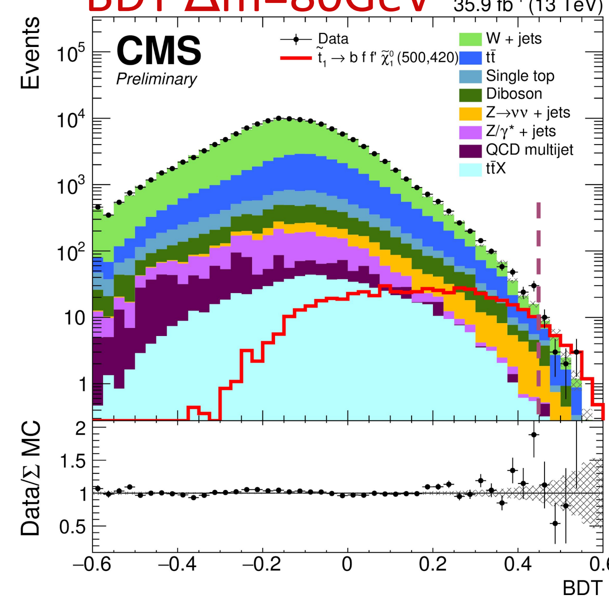
arXiv:1707.03316

- MVA (only four body-decay):
  - 8 BDTs trained for each Δm: 10-80 GeV
  - Trained against W+jets, ttbar and $Z \rightarrow \nu\nu$
  - optimized lower boundary for each BDT
  - Trained Variables:
    - p_T^{miss} , $p_T(\ell)$, M_T, $p_T(j_1)$, p_T(b), $\eta(\ell)$, $Q(\ell)$, N_{jets}, H_T, N_b, $\Delta r(\ell,b)$, Disc(b)

BDT Δm=10GeV



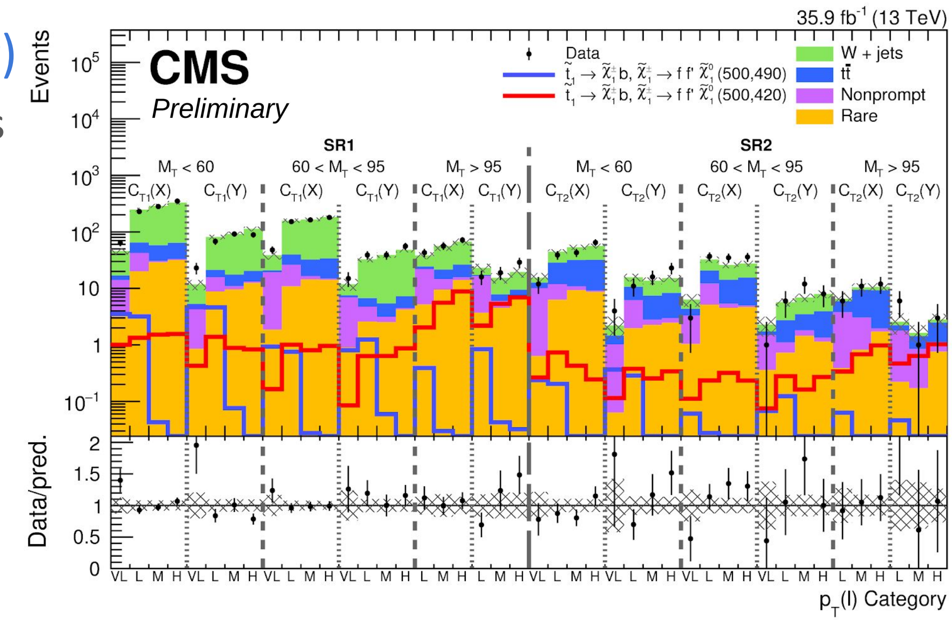
BDT Δm=80GeV



Compressed Stop 1 soft lepton: Results

Background Estimation

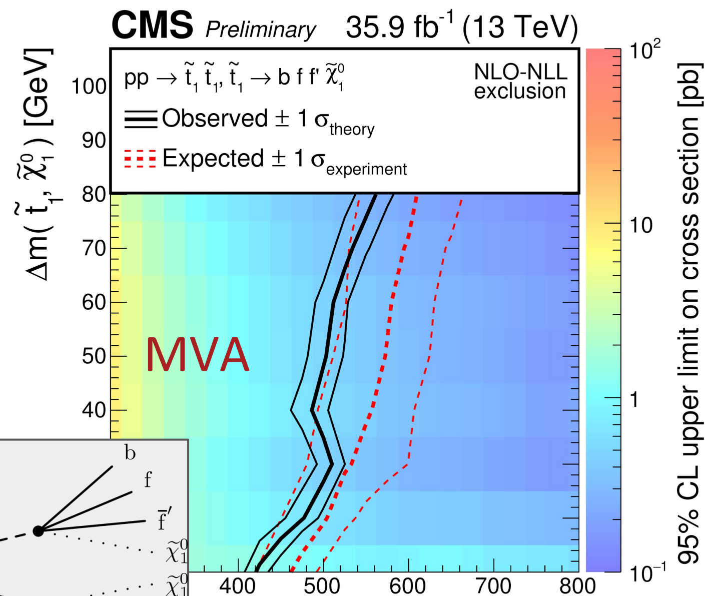
- Prompt Backgrounds (W+jets and ttbar)
  - Normalization in SR obtained from CRs
  - MVA CR: BDT cut reversed
  - C&C CR: $p_T(l) > 30$ GeV
- Nonprompt ($Z \to \nu\nu$ + jets, QCD)
  - Data-driven method using the 'fake rate' method
- Rare backgrounds
  - Taken from simulation

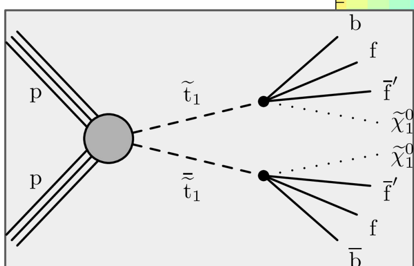


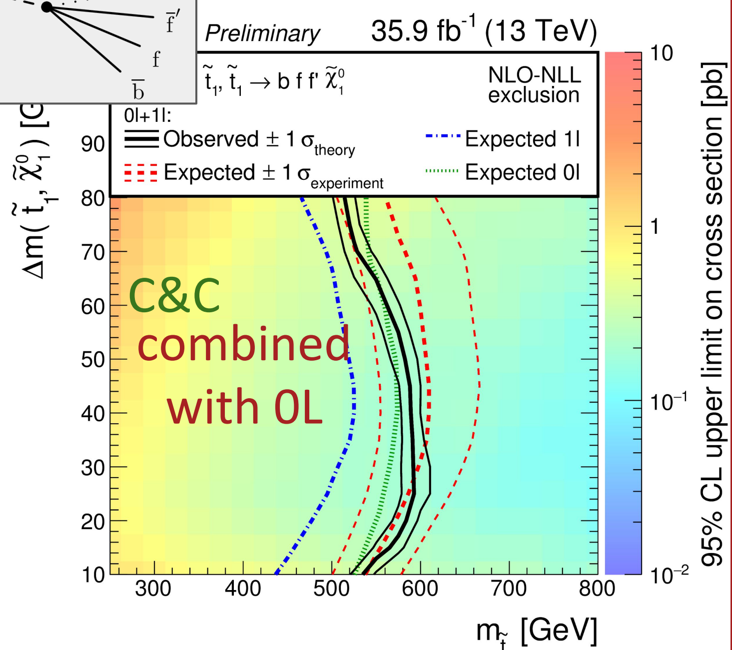
	BDT>	$N^{SR}_{DDprompt}(W+\text{jets})$	$N^{SR}_{DDprompt}(t\bar{t})$	N^{SR}_{DDfake}	$N^{SR}(\text{Other})$	N^{SR}_{Pred}	$N^{SR}(Data)$
$\Delta m = 10$ GeV	0.31	18.4 ± 3.6	1.8 ± 4.8	8.0 ± 2.9	2.3 ± 1.4	30.3 ± 6.7	39
$\Delta m = 20$ GeV	0.39	9.0 ± 2.0	1.3 ± 1.7	11.2 ± 3.2	3.1 ± 1.9	24.7 ± 4.5	20
$\Delta m = 30$ 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

Compressed Stop 1 soft lepton: Results

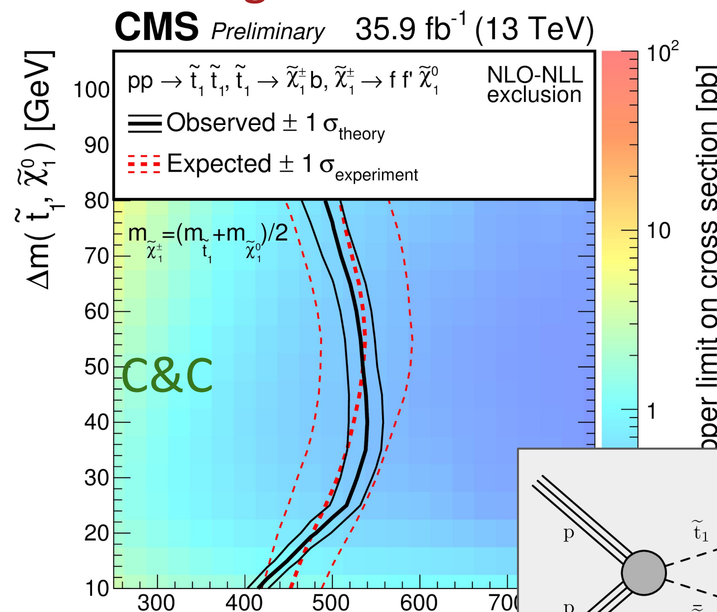
direct-decay

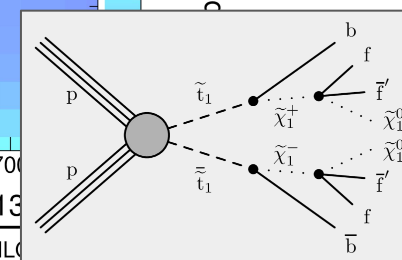


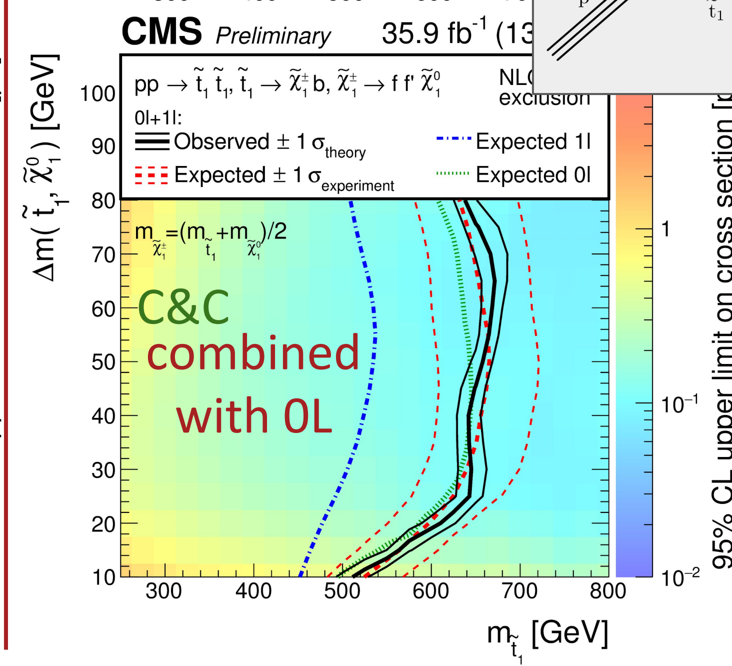




chargino-mediated





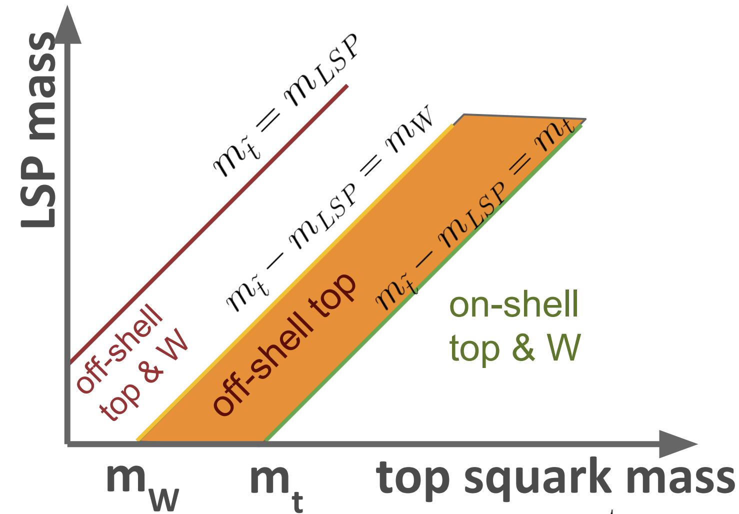


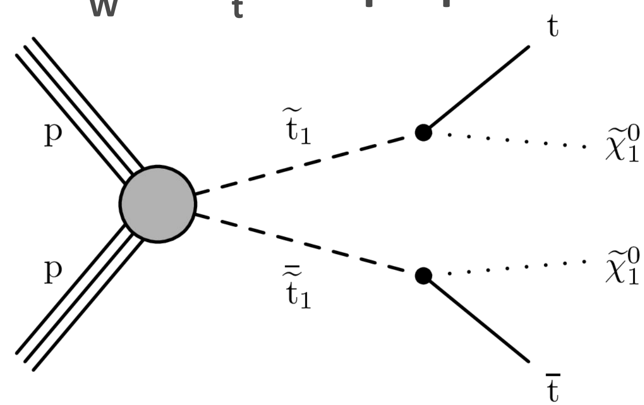
2 lepton search

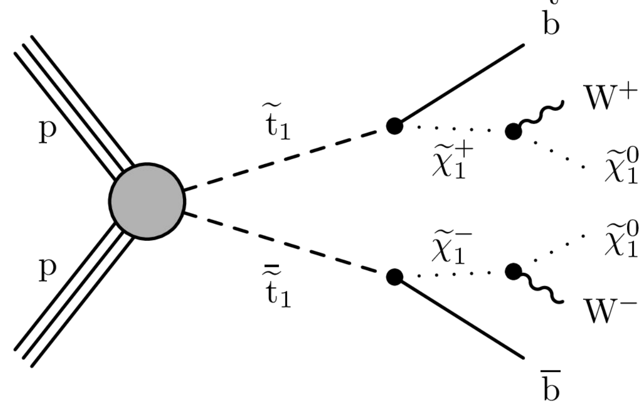
- 2 leptons: opposite charge (OC)
  - Same Flavor, Different Flavors
  - Top squark pair production $m_W < \Delta m < m_{top}$
    - 3-body decay of the stop
  - Main backgrounds are ttbar, tW, WW
    - Lepton and p_T^{miss} come from W decay
    - M_{T2} has an end point at W mass

$$M_{T2}(\ell\ell) = \min_{\vec{p}_T^{\,miss1}+\vec{p}_T^{\,miss2}=\vec{p}_T^{\,miss}} \left(\max \left[M_T(\vec{p}_T^{\,vis1}, \vec{p}_T^{\,miss1}), M_T(\vec{p}_T^{\,vis2}, \vec{p}_T^{\,miss2}) \right] \right)$$

- Search Strategy:
  - M_{T2} shape analysis, binned in p_T^{miss}, N(b), N(j)
  - p_T^{miss}: 140-200, 200-300, >300
  - N(b) binnings:
    - 0 b-Jet: Δm ~ M(w)
    - 1+ b-Jet : Δm ~M(t)
  - 1 ISR Jet (pt > 150) for MET<300
  - Tail of M_{T2} for main backgrounds:
    - Mostly from detector resolution effects
    - Validated in CRs

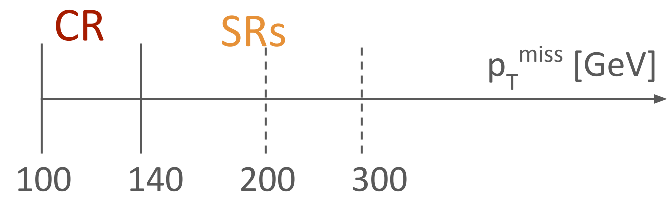


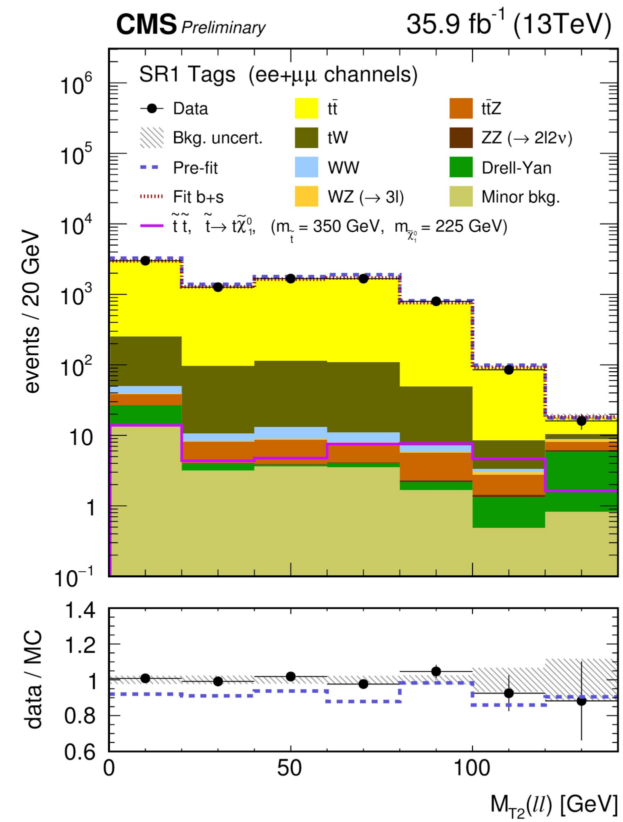




2 lepton search: Background

- Main Backgrounds (ttbar, tW, WW)
  - Irreducible backgrounds
  - Normalized by a simultaneous fit in M_{T2}
  - M_{T2} shape in simulation validated in two CRs
    - 1st CR:
      - $100 < p_T^{miss} < 140$ GeV
      - Different flavor leptons (to reduce Drell-Yan events)
    - 2nd CR
      - Use WZ$\rightarrow 3\ell\nu$ to emulate M_{T2} shape of WW
        - Take a 1ℓ from Z, add to p_T^{miss} and recalc. M_{T2}
  - Nonprompt leptons:
    - Important contribution to the M_{T2} tail of ttbar
    - Corrected from events w/ 2 same sign leptons and a bjet
- ttZ, WZ, ZZ
  - Normalization obtained in dedicated regions
    - ttZ and WZ, from 3ℓ events
    - ZZ from 4ℓ events



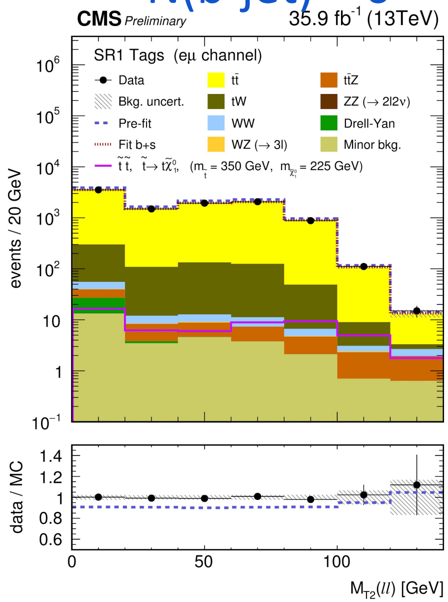


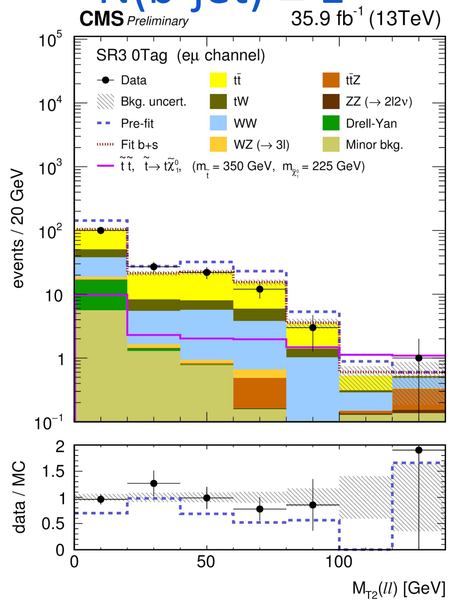
2 lepton search: Some Results

$140 \le p_T^{miss} < 200$
$N(\text{b-jet}) = 0$

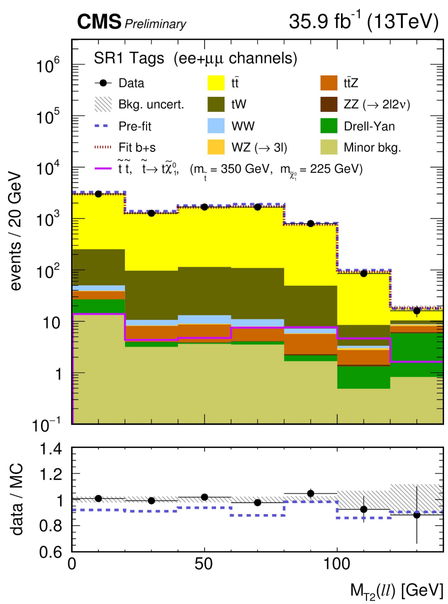
$p_T^{miss} \ge 300$
$N(\text{b-jet}) \ge 1$

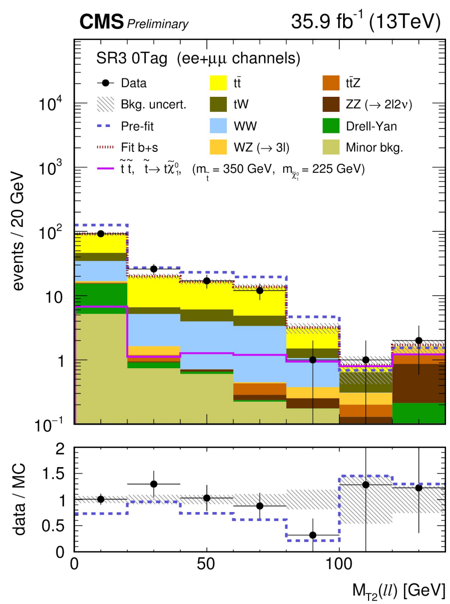
diff. flavor

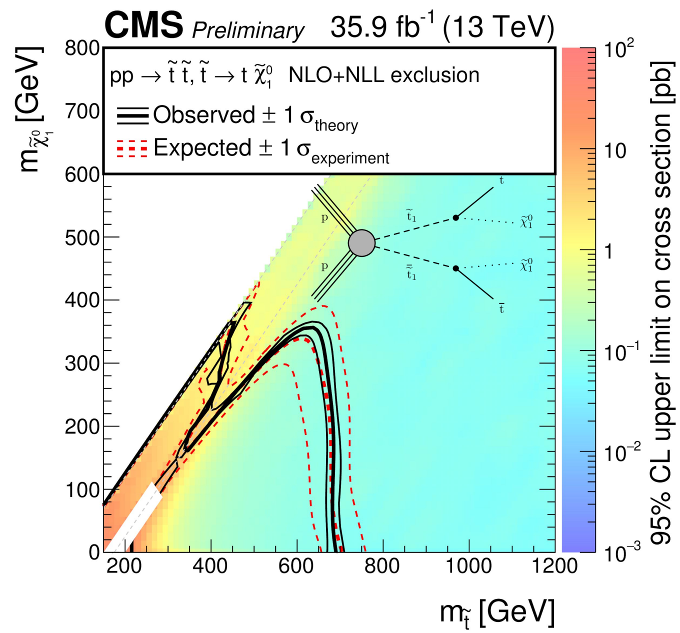


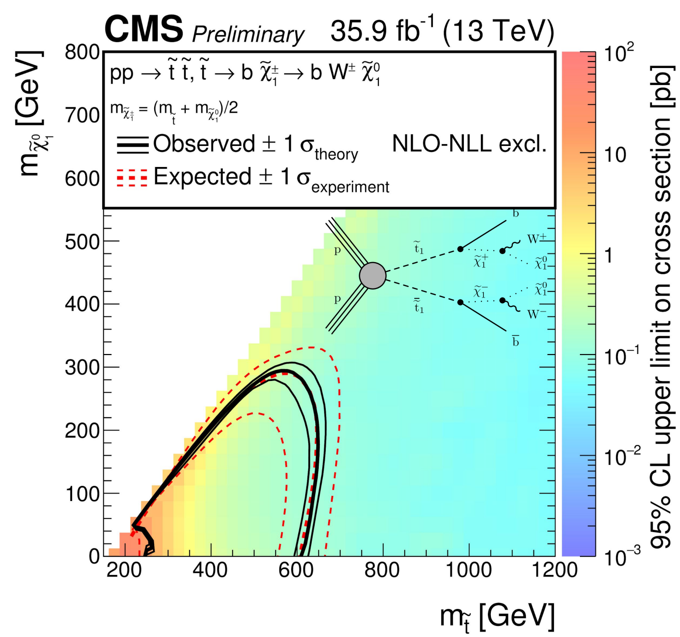


same flavor



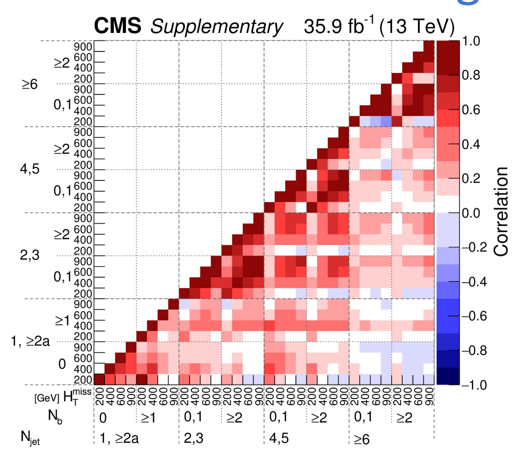


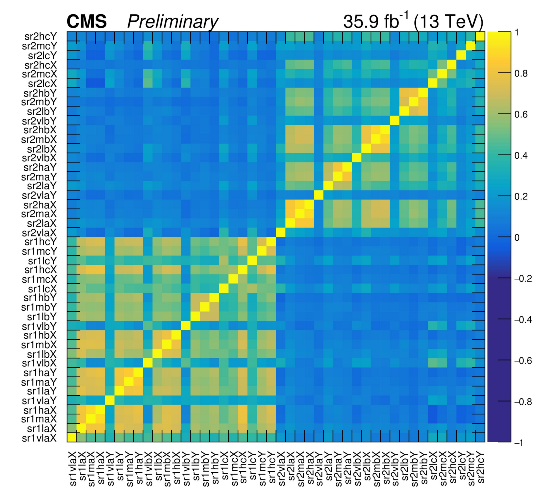




Summary

- Thanks to the great performance of LHC in 2016, CMS was able to probe various regions in the SUSY parameter space!
- Still no sign of SUSY…
- New signatures are being investigated (long-lived gluinos)
- Compressed regions are being probed in search of light stops
- Results are provided for reinterpretation of other models:
    - Covariance matrix, efficiency maps, etc
- Need to think of new interpretations, new topologies, new signatures!
- Analysis of the 2017 data has begun and even more data to come in 2018!



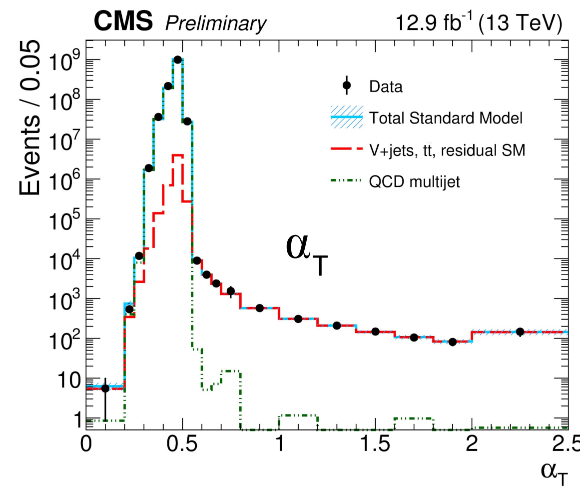


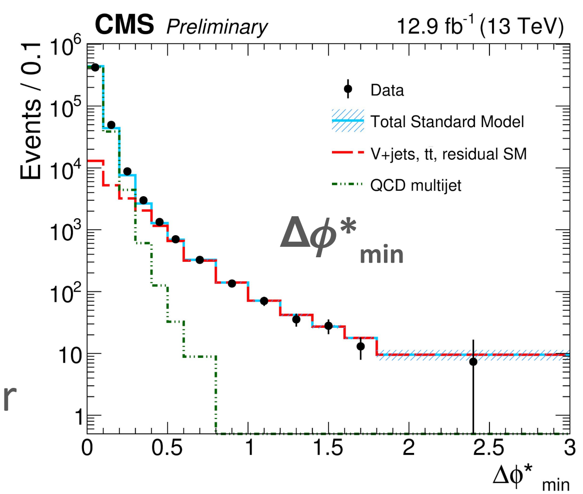
Backup

Alpha T and Delta Phi Variables

$$\alpha_T = \frac{E_T^{j2}}{M_T}$$

- Mismeasurement of Jet Energies
  - Main source of large P_T^{miss} in QCD multijet events
  - Due to possible detection inefficiencies
  - Or nonuniformity in the calorimeter calibration
- α_T
  - Robust against jet mismeasurement:
    - = 0.5 for perfectly balanced back-to-back dijet event
    - <0.5 when there is imbalance between measured E_T of the back to back jets
    - > 0.5 when jets not back to back (genuine p_T^{miss})
  - When more than 2 jets:
    - n-jet system reduced to dijet by combining jets into two ‘pseudojets’
    - Use the combination that minimizes the E_T difference between the two
- $\Delta\phi^*_{min}$
  - Min. angle between each jet and vector sum P_T of all other
  - = 0 for multi jet events





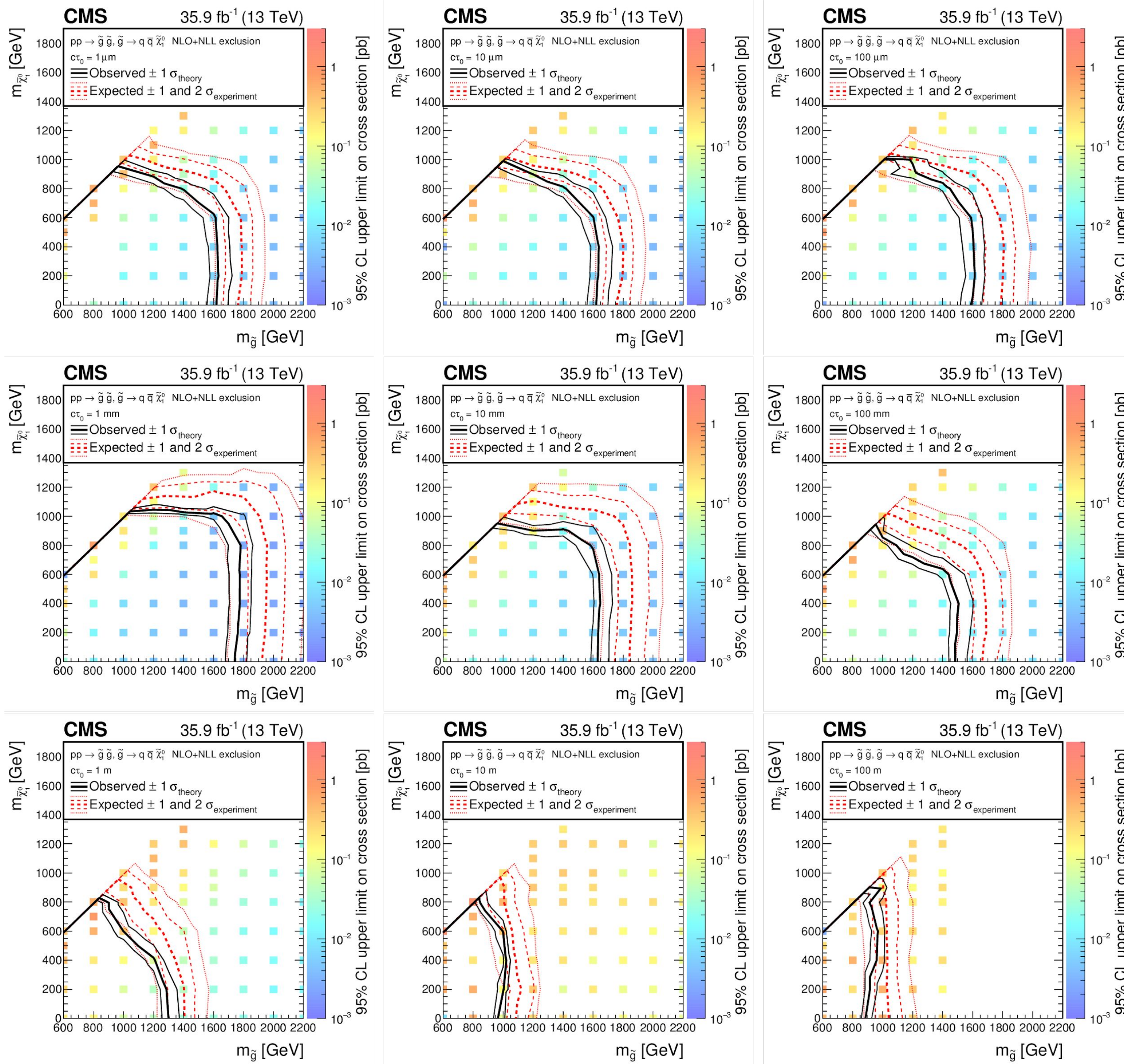
Alpha T: Region Definitions

Physics object acceptances		
Jet	$p_T > 40\,\text{GeV}$, $\|\eta\| < 2.4$	
Photon	$p_T > 25\,\text{GeV}$, $\|\eta\| < 2.5$, isolated in cone $\Delta R < 0.3$	
Electron	$p_T > 10\,\text{GeV}$, $\|\eta\| < 2.5$, $I^{\text{rel}} < 0.1$ in cone $0.05 < \Delta R(p_T) < 0.2$	
Muon	$p_T > 10\,\text{GeV}$, $\|\eta\| < 2.5$, $I^{\text{rel}} < 0.2$ in cone $0.05 < \Delta R(p_T) < 0.2$	
Single isolated track (SIT)	$p_T > 10\,\text{GeV}$, $\|\eta\| < 2.5$, $I^{\text{track}} < 0.1$ in cone $\Delta R < 0.3$	
Baseline event selection		
All-jet final state	Veto events containing photons, electrons, muons, and SITs within acceptance	
p_T^{miss} quality	Veto events based on filters related to beam and instrumental effects	
Jet quality	Veto events containing jets that fail identification criteria or $0.1 < f_{h^\pm}^{j_1} < 0.95$	
Jet energy and sums	$p_T^{j_1} > 100\,\text{GeV}$, $H_T > 200\,\text{GeV}$, $H_T^{\text{miss}} > 200\,\text{GeV}$	
Jets outside acceptance	$H_T^{\text{miss}} / p_T^{\text{miss}} < 1.25$, veto events containing jets with $p_T > 40\,\text{GeV}$ and $\|\eta\| > 2.4$	
Signal region	Baseline selection +	
α_T threshold (H_T range)	0.65 (200–250 GeV), 0.60 (250–300), 0.55 (300–350), 0.53 (350–400), 0.52 (400–900)	
$\Delta\phi^*_{\text{min}}$ threshold	$\Delta\phi^*_{\text{min}} > 0.5$ ($n_{\text{jet}} \geq 2$), $\Delta\phi^{*25}_{\text{min}} > 0.5$ ($n_{\text{jet}} = 1$)	
Nominal categorization schema		
n_{jet}	1	(monojet)
	$\geq 2a$	(a denotes asymmetric, $40 < p_T^{j_2} < 100\,\text{GeV}$)
	2, 3, 4, 5, ≥ 6	(symmetric, $p_T^{j_2} > 100\,\text{GeV}$)
n_b	0, 1, 2, 3, ≥ 4	(can be dropped/merged *vs.* n_{jet})
H_T boundaries	200, 400, 600, 900, 1200 GeV	(can be dropped/merged *vs.* n_{jet}, n_b)
H_T^{miss} boundaries	200, 400, 600, 900 GeV	(can be dropped/merged *vs.* n_{jet}, n_b, H_T)
Simplified categorization schema		
Topology (n_{jet}, n_b)	Monojet-like	$(1 \cap \geq 2a, 0)$, $(1 \cap \geq 2a, \geq 1)$
	Low n_{jet}	$(2 \cap 3, 0 \cap 1)$, $(2 \cap 3, \geq 2)$
	Medium n_{jet}	$(4 \cap 5, 0 \cap 1)$, $(4 \cap 5, \geq 2)$
	High n_{jet}	$(\geq 6, 0 \cap 1)$, $(\geq 6, \geq 2)$
H_T boundaries	$H_T > 200\,\text{GeV}$ ($n_{\text{jet}} \leq 3$), $H_T > 400\,\text{GeV}$ ($n_{\text{jet}} \geq 4$)	
H_T^{miss} boundaries	200, 400, 600, 900 GeV	
Control regions	Baseline selection +	
μ+jets (inverted μ veto)	$p_T^{\mu_1} > 30\,\text{GeV}$, $\|\eta^{\mu_1}\| < 2.1$, $\Delta R(\mu, j_i) > 0.5$, $30 < m_T(\vec{p}_T^{\mu}, \vec{p}_T^{\text{miss}}) < 125\,\text{GeV}$	
$\mu\mu$+jets (inverted μ veto)	$p_T^{\mu_{1,2}} > 30\,\text{GeV}$, $\|\eta^{\mu_{1,2}}\| < 2.1$, $\Delta R(\mu_{1,2}, j_i) > 0.5$, $\|m_{\mu\mu} - m_Z\| < 25\,\text{GeV}$	
Multijet-enriched	Sidebands to signal region: $H_T^{\text{miss}} / p_T^{\text{miss}} > 1.25$ and/or $\Delta\phi^*_{\text{min}} < 0.5$	

Alpha T Search: Results Summary

Model family	Production and decay	Additional assumptions
Production and prompt decay of squark pairs		
T2bb	$\mathrm{pp} \to \widetilde{\mathrm{b}}_1\overline{\widetilde{\mathrm{b}}}_1,\ \widetilde{\mathrm{b}}_1 \to \mathrm{b}\widetilde{\chi}^0_1$	—
T2tt	$\mathrm{pp} \to \widetilde{\mathrm{t}}_1\overline{\widetilde{\mathrm{t}}}_1,\ \widetilde{\mathrm{t}}_1 \to \mathrm{t}\widetilde{\chi}^0_1$	—
T2cc	$\mathrm{pp} \to \widetilde{\mathrm{t}}_1\overline{\widetilde{\mathrm{t}}}_1,\ \widetilde{\mathrm{t}}_1 \to \mathrm{c}\widetilde{\chi}^0_1$	$10 < m_{\widetilde{\mathrm{t}}_1} - m_{\widetilde{\chi}^0_1} < 80\,\mathrm{GeV}$
T2qq_8fold	$\mathrm{pp} \to \widetilde{\mathrm{q}}\overline{\widetilde{\mathrm{q}}},\ \widetilde{\mathrm{q}} \to \mathrm{q}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{q}}_\mathrm{L}} = m_{\widetilde{\mathrm{q}}_\mathrm{R}},\ \widetilde{\mathrm{q}} = \{\widetilde{\mathrm{u}}, \widetilde{\mathrm{d}}, \widetilde{\mathrm{s}}, \widetilde{\mathrm{c}}\}$
T2qq_1fold	$\mathrm{pp} \to \widetilde{\mathrm{q}}\overline{\widetilde{\mathrm{q}}},\ \widetilde{\mathrm{q}} \to \mathrm{q}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{q}}(\widetilde{\mathrm{q}} \neq \widetilde{\mathrm{u}}_\mathrm{L})} \gg m_{\widetilde{\mathrm{u}}_\mathrm{L}}$
Production and prompt decay of gluino pairs		
T1bbbb	$\mathrm{pp} \to \widetilde{\mathrm{g}}\widetilde{\mathrm{g}},\ \widetilde{\mathrm{g}} \to \overline{\mathrm{b}}\widetilde{\mathrm{b}}^*_1 \to \overline{\mathrm{b}}\mathrm{b}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{b}}_1} \gg m_{\widetilde{\mathrm{g}}}$
T1tttt	$\mathrm{pp} \to \widetilde{\mathrm{g}}\widetilde{\mathrm{g}},\ \widetilde{\mathrm{g}} \to \overline{\mathrm{t}}\widetilde{\mathrm{t}}^*_1 \to \overline{\mathrm{t}}\mathrm{t}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{t}}_1} \gg m_{\widetilde{\mathrm{g}}}$
T1qqqq	$\mathrm{pp} \to \widetilde{\mathrm{g}}\widetilde{\mathrm{g}},\ \widetilde{\mathrm{g}} \to \overline{\mathrm{q}}\widetilde{\mathrm{q}}^* \to \overline{\mathrm{q}}\mathrm{q}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{q}}} \gg m_{\widetilde{\mathrm{g}}}$
Production and decay of long-lived gluino pairs		
T1qqqqLL	$\mathrm{pp} \to \widetilde{\mathrm{g}}\widetilde{\mathrm{g}},\ \widetilde{\mathrm{g}} \to \overline{\mathrm{q}}\widetilde{\mathrm{q}}^* \to \overline{\mathrm{q}}\mathrm{q}\widetilde{\chi}^0_1$	$m_{\widetilde{\mathrm{q}}} \gg m_{\widetilde{\mathrm{g}}},\ 10^{-3} < c\tau_0 < 10^5$ mm or metastable

Alpha T: Long-Lived Gluinos Interpretation

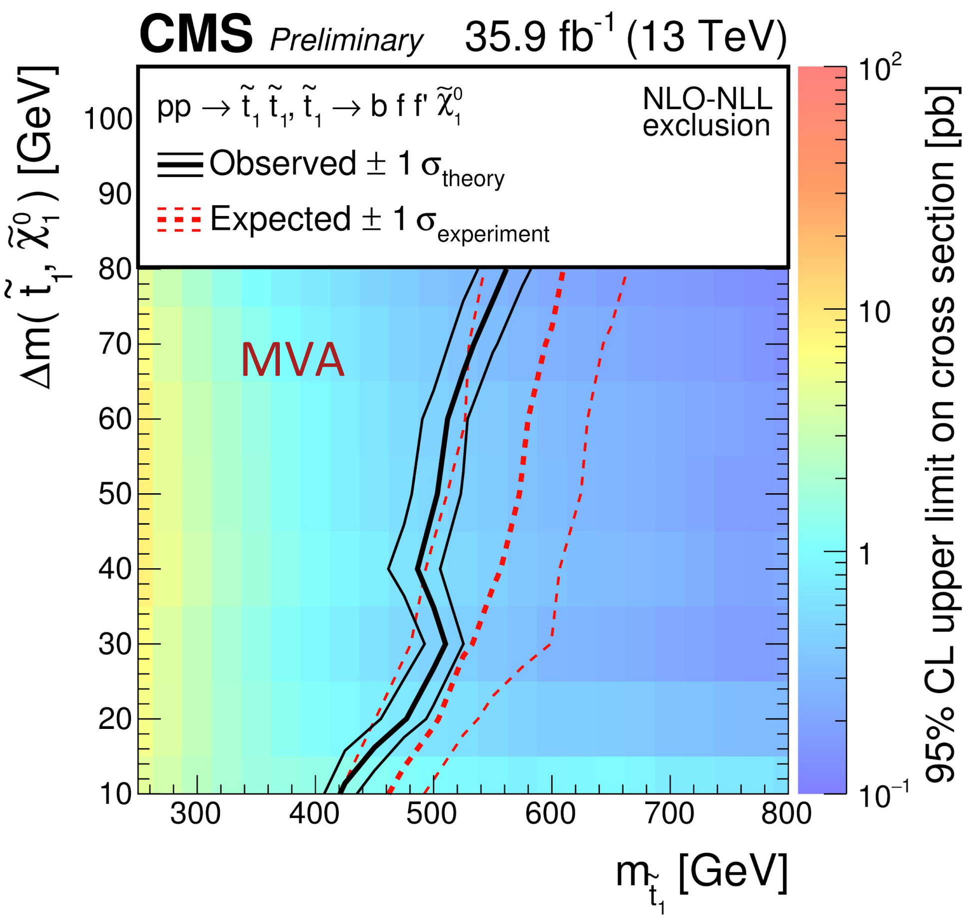


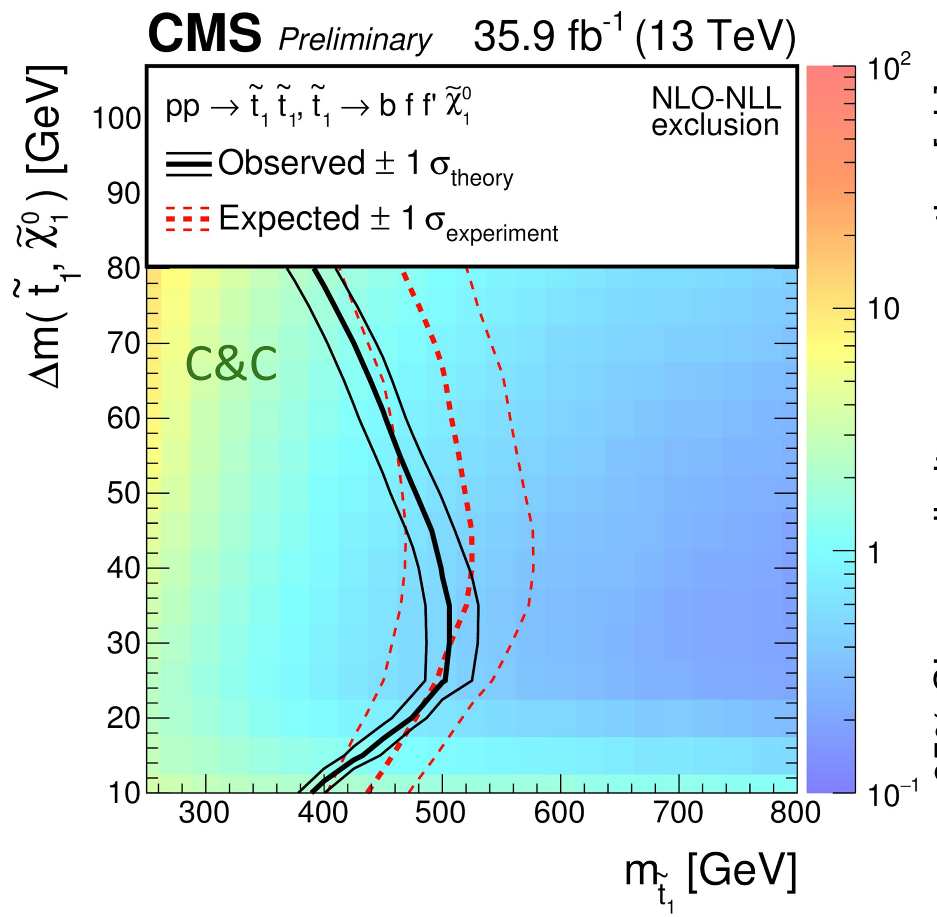
Compressed Stop 1L (C&C): Region Definitions

CC search: Definition of signal regions and their corresponding control regions (CR). The subregions of signal regions are denoted by tags in parentheses described in the text. For jets, the attributes "soft" and "hard" refer to the p_T ranges 30–60 GeV and > 60 GeV, respectively.

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) 12–20 (M) 20–30 (H) > 30 (CR)	5–12 (L) 12–20 (M) 20–30 (H) > 30 (CR)	5–12 (L) 12–20 (M) 20–30 (H) > 30 (CR)	5–12 (L) 12–20 (M) 20–30 (H) > 30 (CR)	5–12 (L) 12–20 (M) 20–30 (H) > 30 (CR)	5–12 (L) 12–20 (M) 20–30 (H) > 30 (CR)
C_T (GeV)	$300 < C_{T1} < 400$ (X) $C_{T1} > 400$ (Y)			$300 < C_{T2} < 400$ (X) $C_{T2} > 400$ (Y)		

Compressed Stop 1: C&C vs MVA





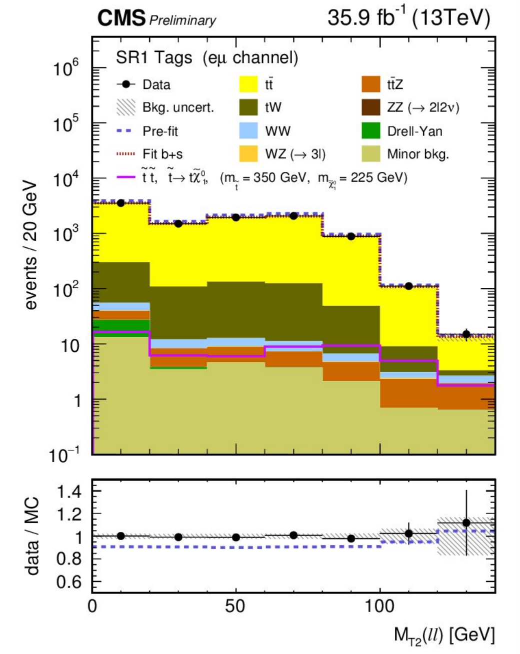
Similar results for MVA and C&C at $\Delta m<30$

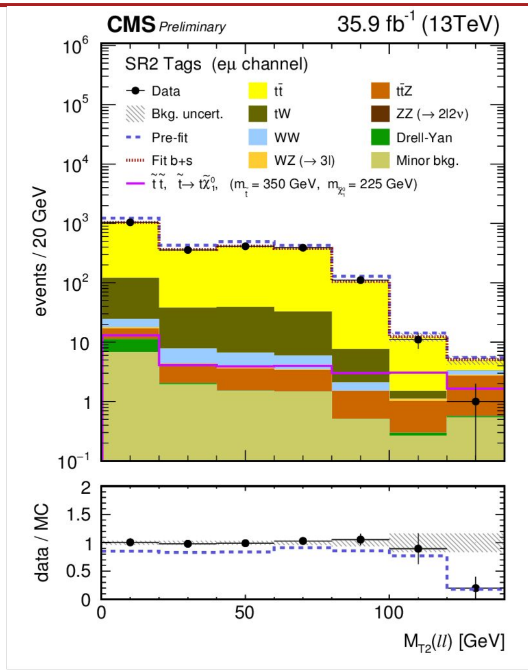
MVA performs much better for larger Δm (partially due to loose lepton p_T)

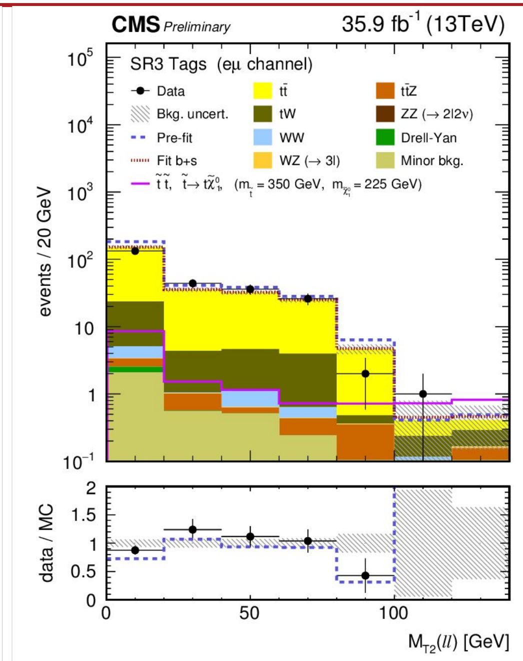
2 lepton search: Region Definitions

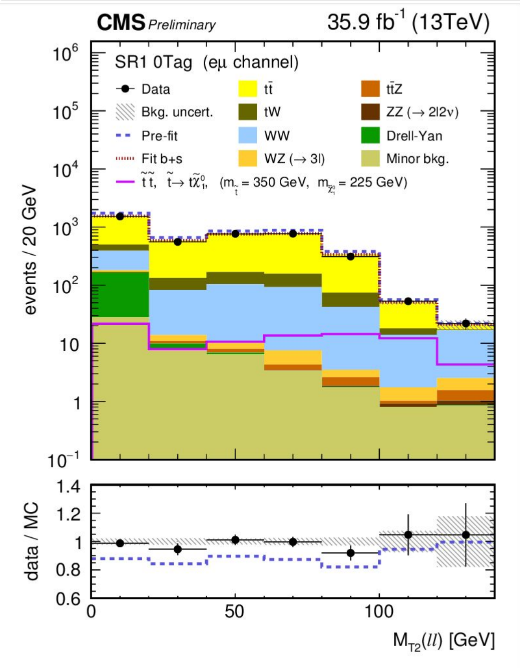
	$SR1_{0Tag}$	$SR1_{Tags}$	$SR2_{0Tag}$	$SR2_{Tags}$	$SR3^{ISR}_{0Tag}$	$SR3^{ISR}_{Tag}$
Channel	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF	SF, DF
n_{jets}	≥ 0	≥ 1	≥ 0	≥ 1	≥ 1	≥ 2
$n_{b\ jets}$	0	≥ 1	0	≥ 1	0	≥ 1
p_T^{miss} [GeV]	140-200	140-200	200-300	200-300	≥ 300	≥ 300
ISR jets	≥ 0	≥ 0	≥ 0	≥ 0	≥ 1	≥ 1
$M_{T2}(\ell\ell)$	0-20, 20-40, 40-60, 60-80, 80-100, 100-120, ≥ 120 GeV					

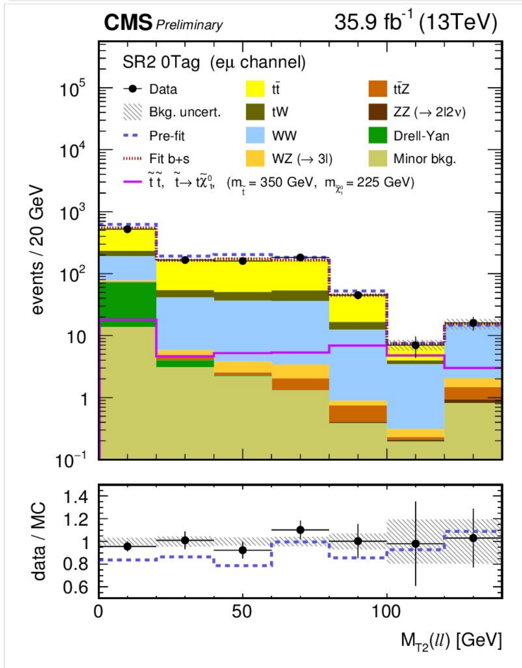
2 lepton search: MT2(ll) dist. (diff. flavor)

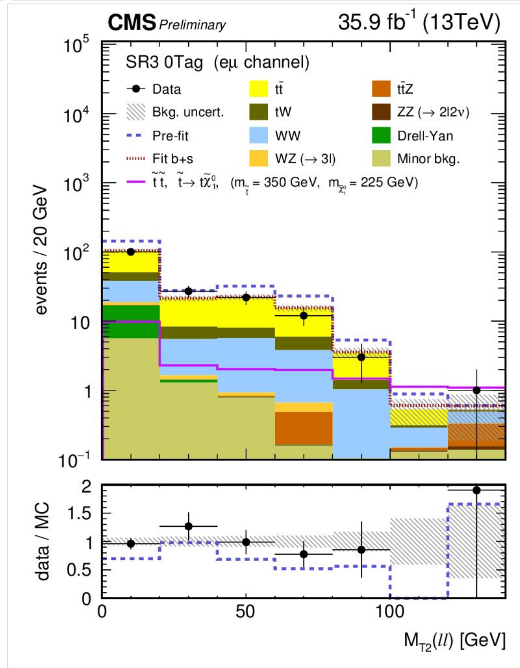




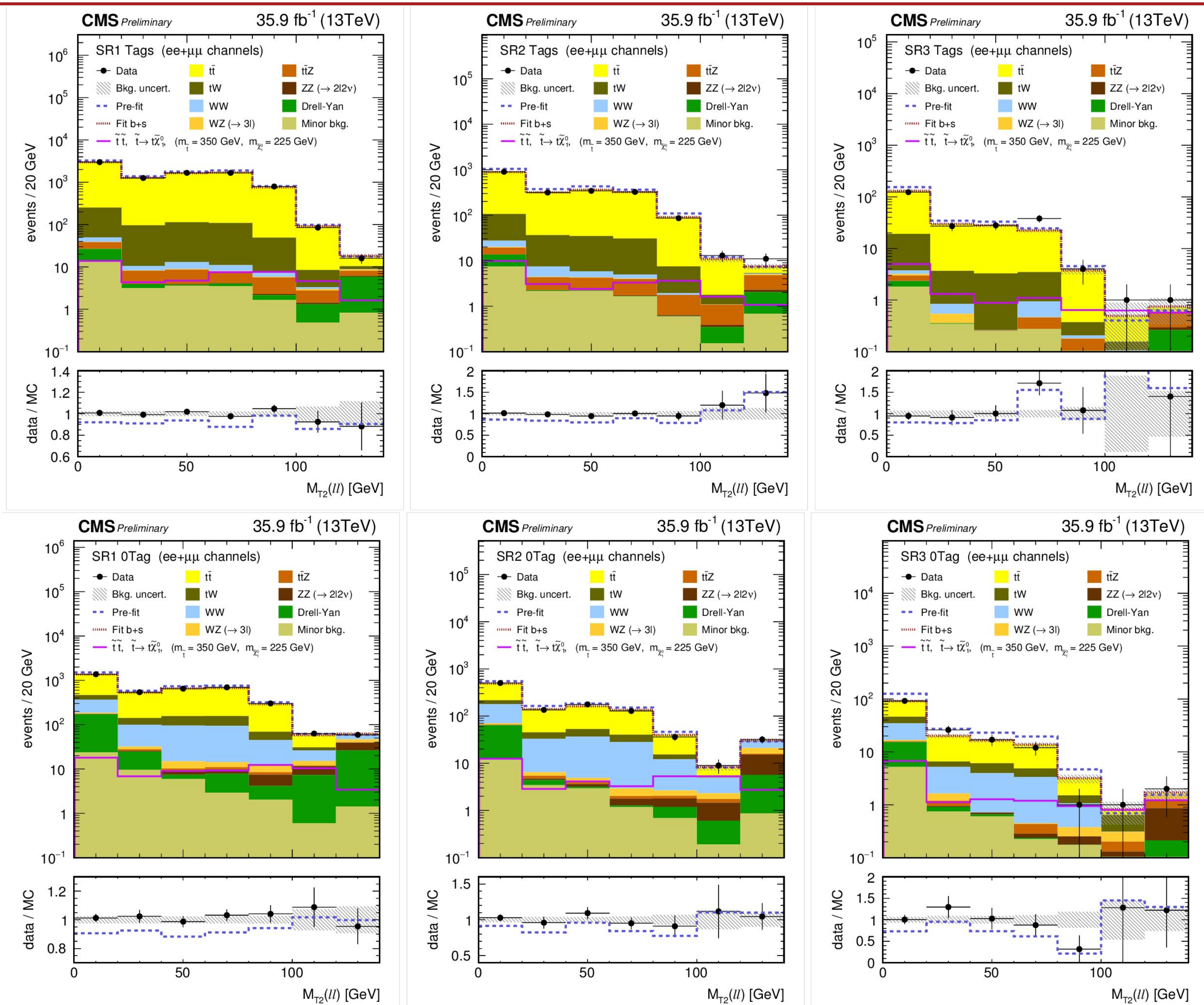


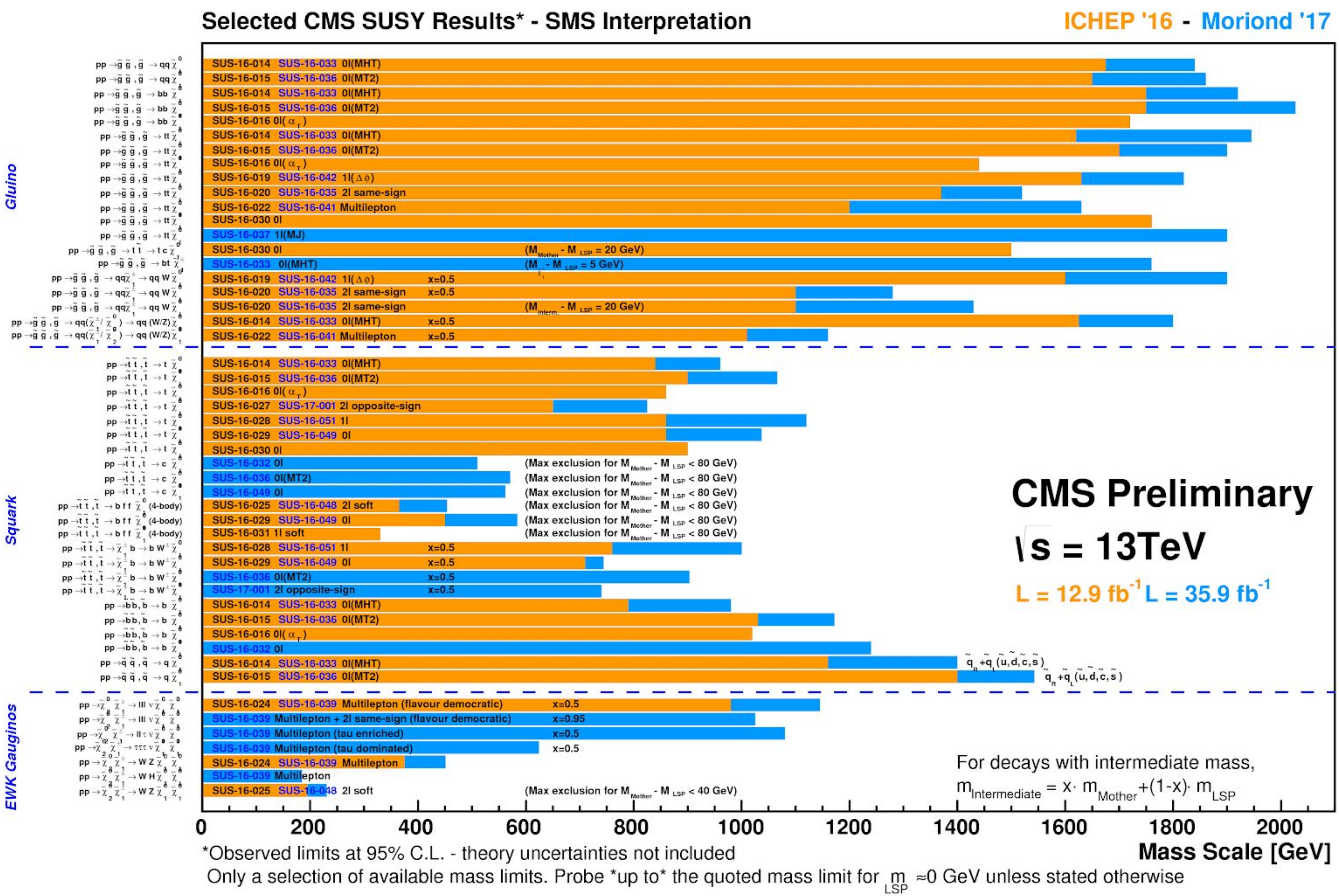


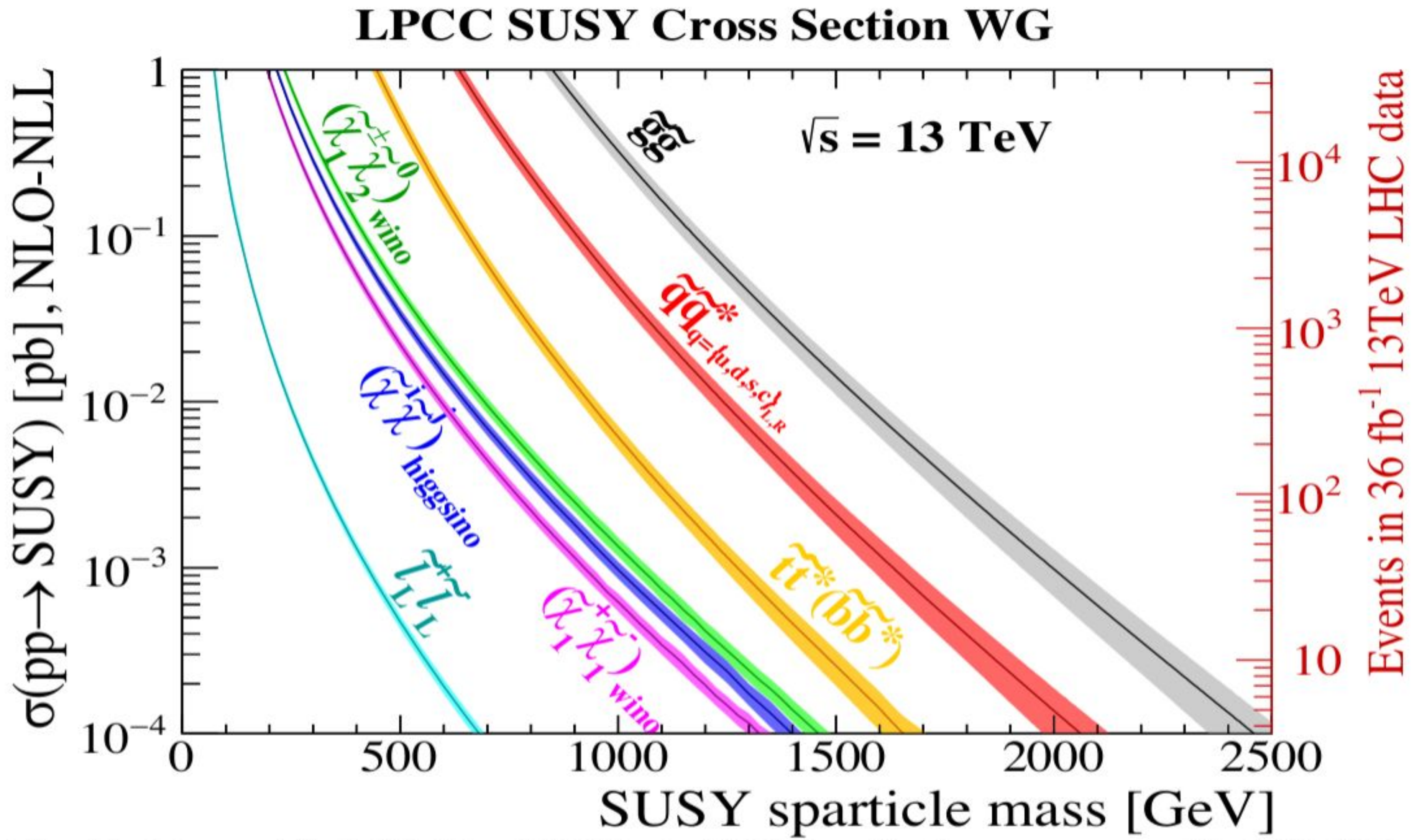




2 lepton search: MT2(ll) dist. (same flavor)




Selected CMS SUSY Results* - SMS Interpretation
ICHEP '16 - Moriond '17
Gluino
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
SUS-16-016 0l(α_T)
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
SUS-16-016 0l(α_T)
SUS-16-019 SUS-16-042 1l(Δϕ)
SUS-16-020 SUS-16-035 2l same-sign
SUS-16-022 SUS-16-041 Multilepton
SUS-16-030 0l
SUS-16-037 1l(MJ)
SUS-16-030 0l
(M_Mother - M_LSP = 20 GeV)
SUS-16-033 0l(MHT)
(M - M_LSP = 5 GeV)
SUS-16-019 SUS-16-042 1l(Δϕ) x=0.5
SUS-16-020 SUS-16-035 2l same-sign x=0.5
SUS-16-020 SUS-16-035 2l same-sign
(M_Interm. - M_LSP = 20 GeV)
SUS-16-014 SUS-16-033 0l(MHT) x=0.5
SUS-16-022 SUS-16-041 Multilepton x=0.5
Squark
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
SUS-16-016 0l(α_T)
SUS-16-027 SUS-17-001 2l opposite-sign
SUS-16-028 SUS-16-051 1l
SUS-16-029 SUS-16-049 0l
SUS-16-030 0l
SUS-16-032 0l (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-036 0l(MT2) (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-049 0l (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-025 SUS-16-048 2l soft (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-029 SUS-16-049 0l (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-031 1l soft (Max exclusion for M_Mother - M_LSP < 80 GeV)
SUS-16-028 SUS-16-051 1l x=0.5
SUS-16-029 SUS-16-049 0l x=0.5
SUS-16-036 0l(MT2) x=0.5
SUS-17-001 2l opposite-sign x=0.5
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
SUS-16-016 0l(α_T)
SUS-16-032 0l
SUS-16-014 SUS-16-033 0l(MHT)
SUS-16-015 SUS-16-036 0l(MT2)
EWK Gauginos
SUS-16-024 SUS-16-039 Multilepton (flavour democratic) x=0.5
SUS-16-039 Multilepton + 2l same-sign (flavour democratic) x=0.95
SUS-16-039 Multilepton (tau enriched) x=0.5
SUS-16-039 Multilepton (tau dominated) x=0.5
SUS-16-024 SUS-16-039 Multilepton
SUS-16-039 Multilepton
SUS-16-025 SUS-16-048 2l soft (Max exclusion for M_Mother - M_LSP < 40 GeV)
CMS Preliminary
√s = 13TeV
L = 12.9 fb^-1 L = 35.9 fb^-1
For decays with intermediate mass,
m_Intermediate = x· m_Mother + (1-x)· m_LSP
0 200 400 600 800 1000 1200 1400 1600 1800 2000
Mass Scale [GeV]
*Observed limits at 95% C.L. - theory uncertainties not included
Only a selection of available mass limits. Probe *up to* the quoted mass limit for m_LSP ≈0 GeV unless stated otherwise



https://twiki.cern.ch/twiki/bin/view/LHCPhysics/SUSYCrossSections arXiv:1407.5066

Typical Search Strategies

- Designing the Signal Regions (SRs):
  - Targeted Searches:
    - Search regions optimized with a specific signal in mind
  - Inclusive Searches:
    - Search regions optimized in order to be sensitive to various signals
    - typically larger numbers of bins
  - Usually SRs are exclusive in CMS.
  - Discriminating variables are used to further bin the SRs
- Background estimation:
  - Control Regions (CRs) are defined to be kinematically similar to SRs but not overlapping with them
  - Important backgrounds are estimated in the CRs from data and extrapolated to SRs
  - Validations regions (orthogonal to both SRs and CRs) are used to test the estimation method.
- Results
  - Observated yields are compared to the expected background in SRs
  - Pop a champagne bottle! (or set limits)