# Inclusive SUSY Searches at CMS

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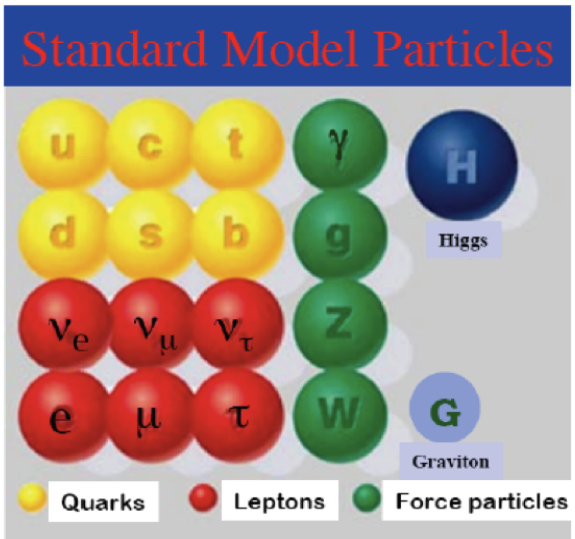
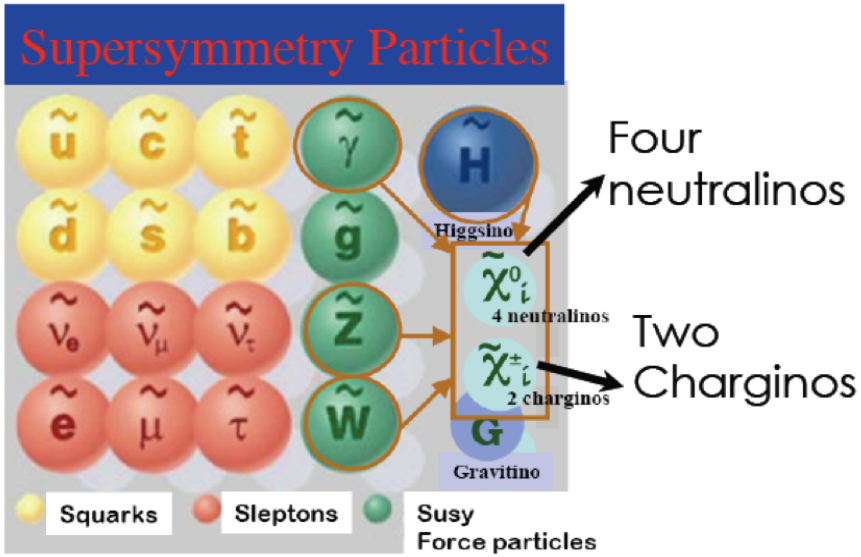
Many more results can be found at:
https://twiki.cern.ch/twiki/bin/view/CMSPublic/PhysicsResultsSUS

# Introduction

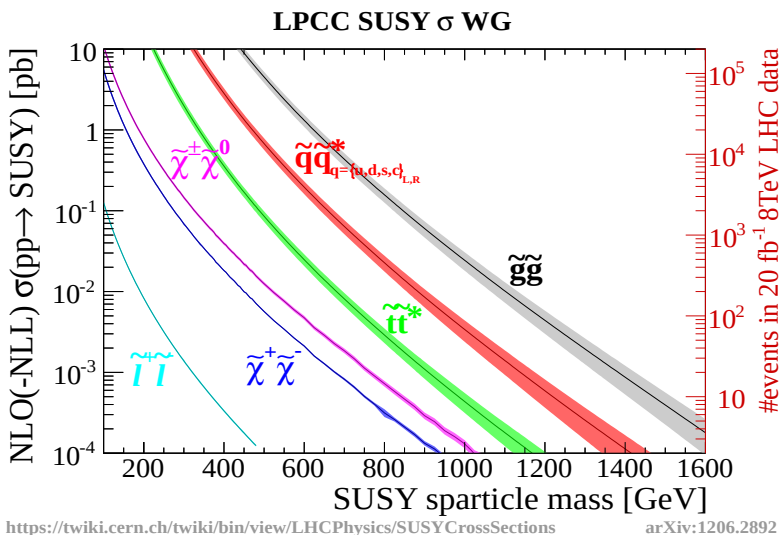
- Supersymmetry introduces superpartner for every SM particle
  - SM fermions have boson superpartners and vice versa



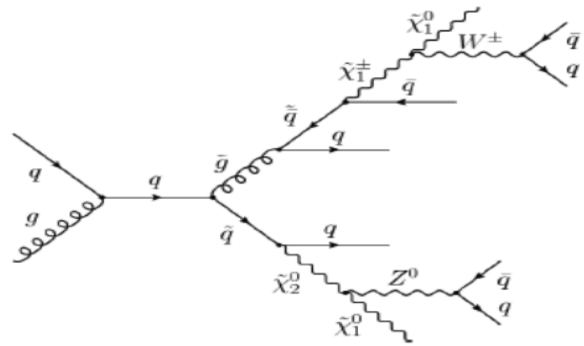



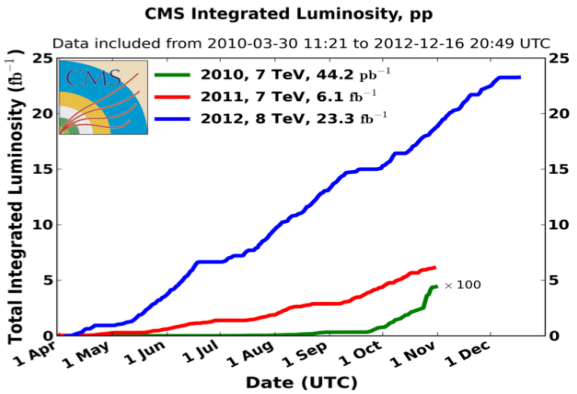

- SUSY is a broken symmetry: New particles expected in TeV range
- In R-parity conserving models, lightest SUSY particle (LSP) is stable

# SUSY Production at LHC



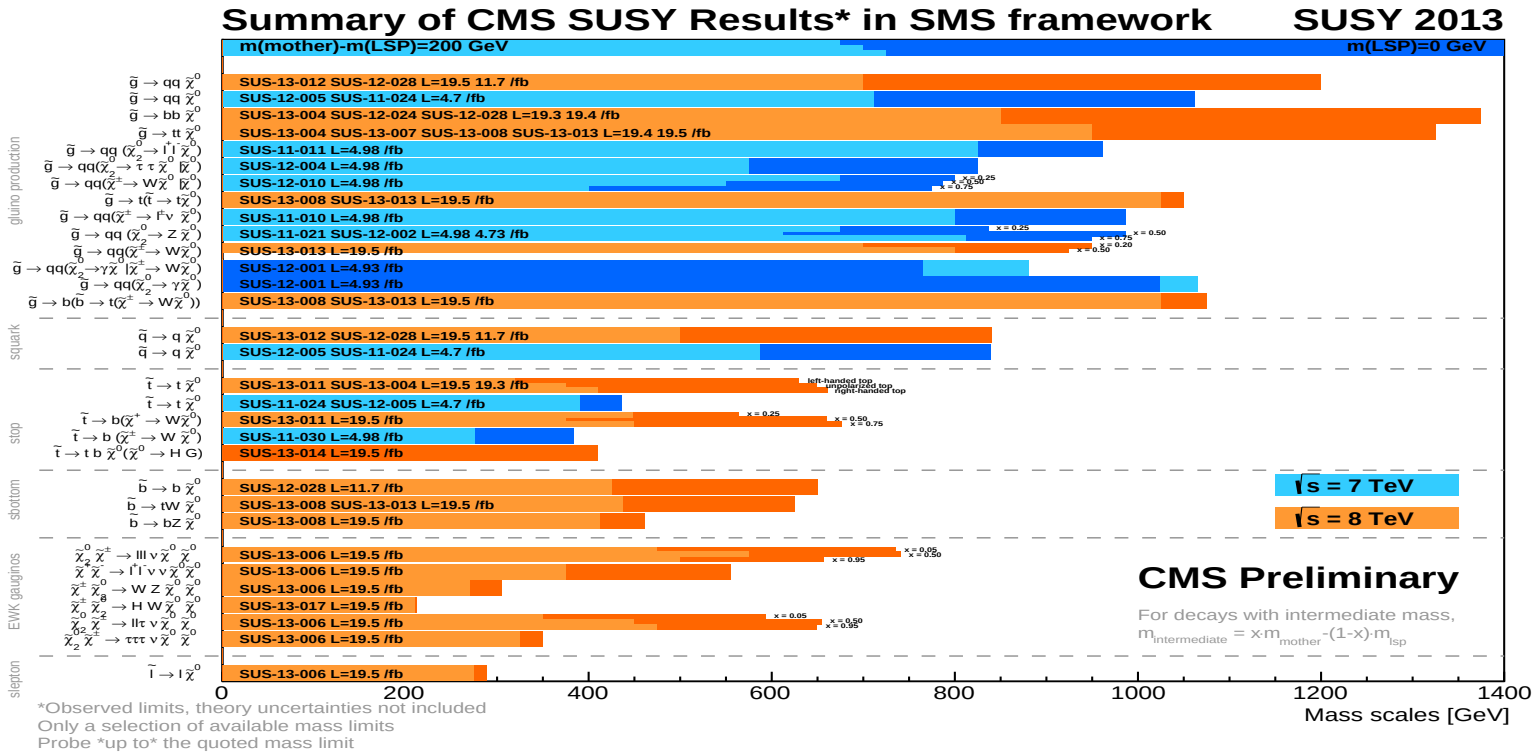

e.g. decay chain of a SUSY event two LSPs → Large $\not{E}_T$




- Squark and gluino production by strong force: large cross section at hadron colliders
- Results presented are based on $\sim 20$ fb$^{-1}$ of 8 TeV data

# CMS SUSY Results

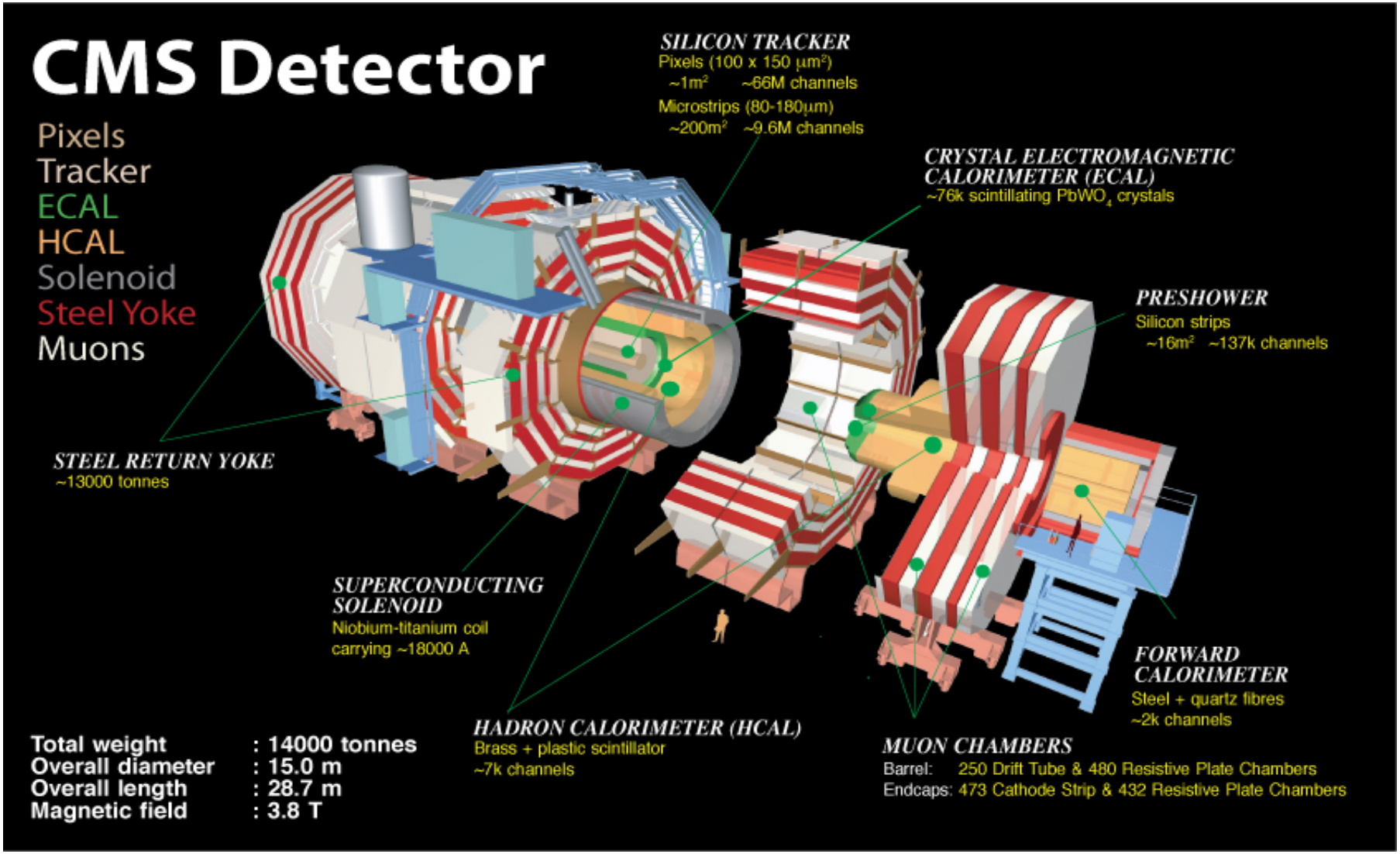



Inclusive searches have good sensitivities on $\tilde{g}$ and $\tilde{q}$. See Michael's talk for 3$^{rd}$ generation

**In this talk**

| 0-leptons | 1-lepton | OSDL | SSDL | ≥3 leptons | 2-photons | γ+lepton |
|---|---|---|---|---|---|---|
| Jets + MET | Single lepton + Jets + MET | Opposite-sign di-lepton + jets + MET | Same-sign di-lepton + jets + MET | Multi-lepton | Di-photon + jet + MET | Photon + lepton + MET |

# The CMS Detector

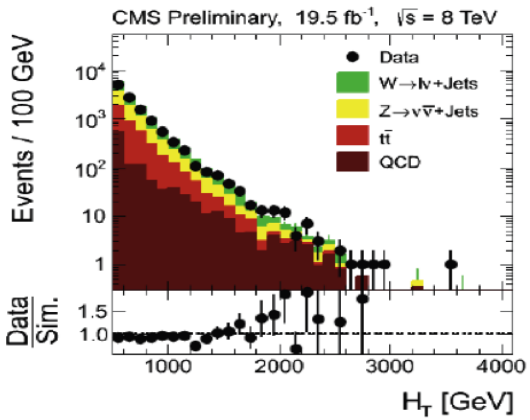


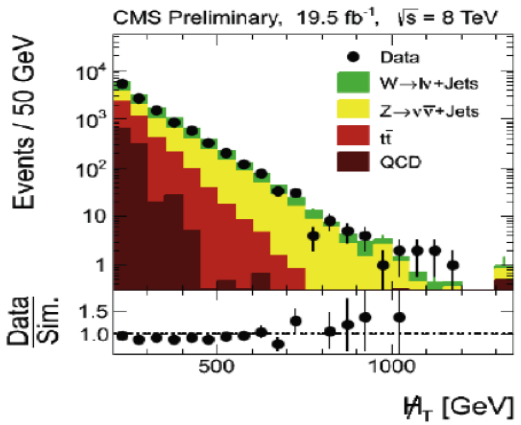
# Multijets + $\not{H}_T$: Baseline Selection

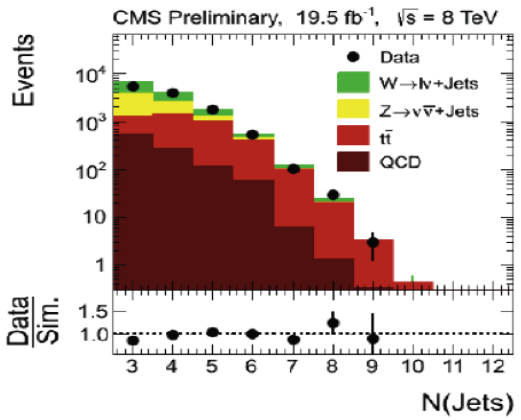
- $N_{jets} \geq 3$ ($p_T > 50$ GeV, $|\eta| < 2.5$)
- $H_T > 500$ GeV ($\sum_{i}^{jets} |\vec{p_T}_{,i}|$) ($p_T > 50$ GeV, $|\eta| < 2.5$)
- $\not{H}_T \geq 200$ GeV ($|-\sum_{i}^{jets} \vec{p_T}_{,i}|$) ($p_T > 30$ GeV, $|\eta| < 5$)
- $\Delta\phi$ ($\not{H}_T$, $jet_{1,2,3}$) $>$ (0.5, 0.5, 0.3) (To reduce QCD)
- Veto isolated leptons ($e/\mu$) with $p_T > 10$ GeV (To reduce W and $t\bar{t}$)

Analysis performed in 36 exclusive bins in ($N_{jets}$, $H_T$, $\not{H}_T$)

Pure data-MC comparison: reasonable agreement



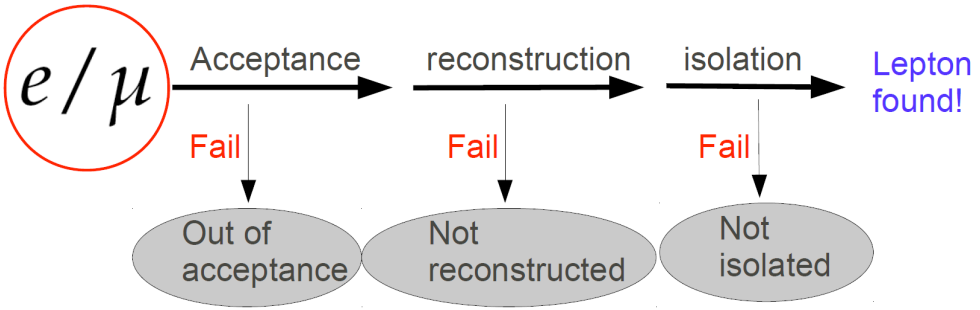



# Multijets + $\not{H}_T$: $W$+ jets and t$\bar{t}$

## Lost Lepton:

$t\bar{t}$, W + jets ($e/\mu$ +$\nu$): $e/\mu$ not reconstructed, not isolated, or out of acceptance ("Lost Lepton")

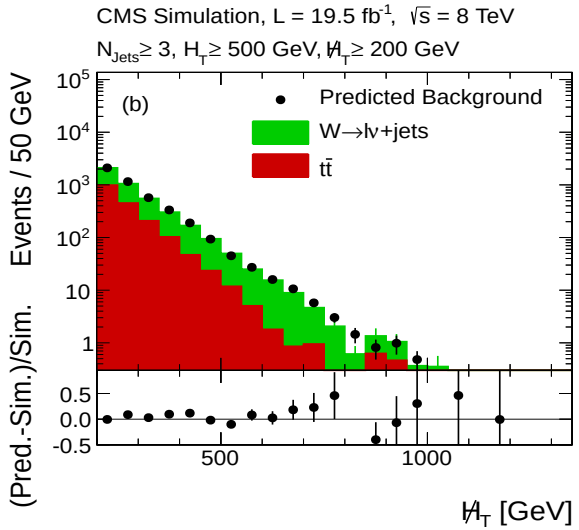


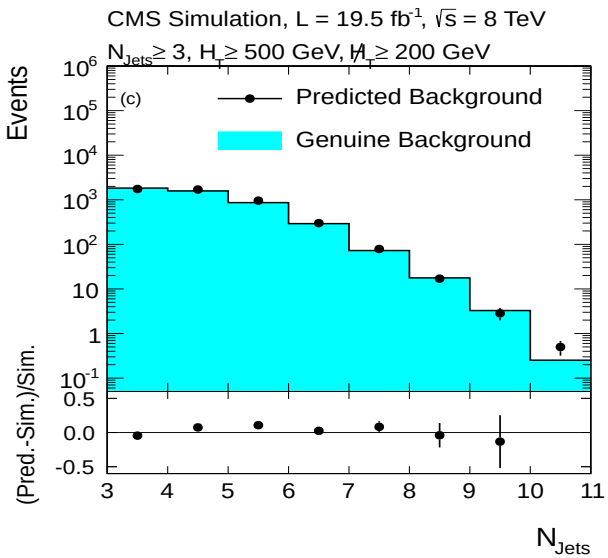

- From events with one $e/\mu$ (weighted according to acceptance and detector inefficiencies)

## Hadronic Tau:

$t\bar{t}$, W + jets ($\tau_{had}$ +$\nu$): Lepton is $\tau$ (faking a jet)

- Using events with one $e/\mu$; lepton is replaced by "$\tau$-jet" with smeared $p_T$ (according to expected response)



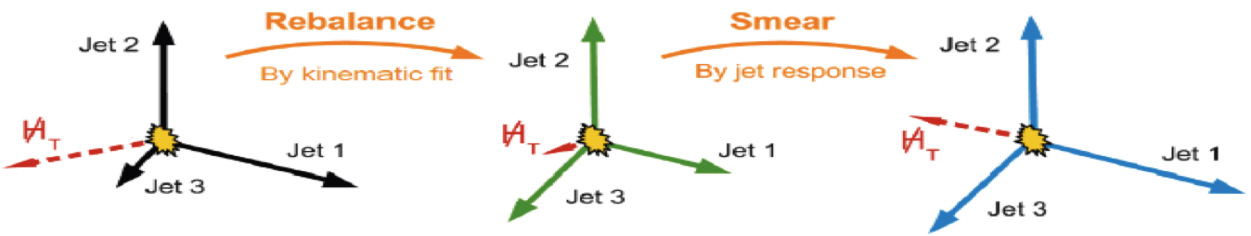
# Multijets + $\not{H}_T$: $Z(\to \nu\nu)$ + jets and QCD

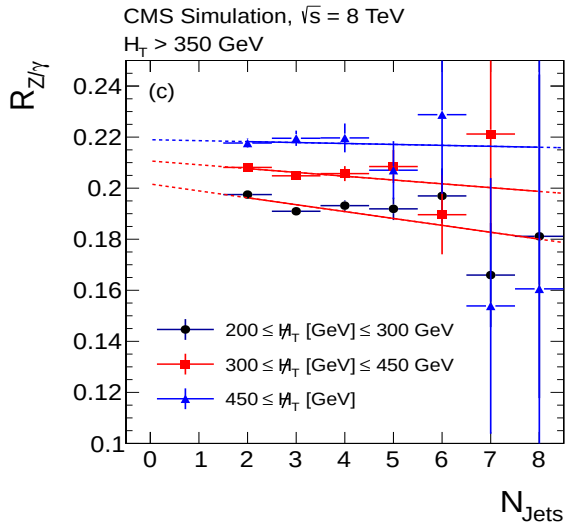
## $Z(\to \nu\nu)$+ jets:

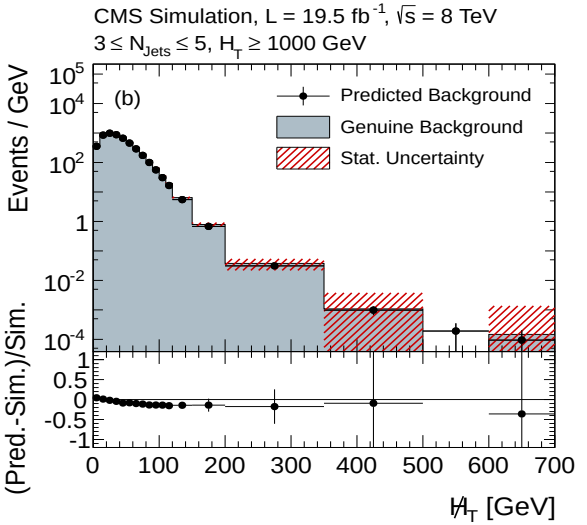
- Irreducible background.
- Using $\gamma$+jets events (similar kinematics at high boson $p_T$)
- "Translation" factor (e.g. cross section, acceptance) from simulation

## QCD multi-jet:

- Large jet $p_T$ mismeasurement
- From rebalancing and smearing (R+S) of events with measured jet response )

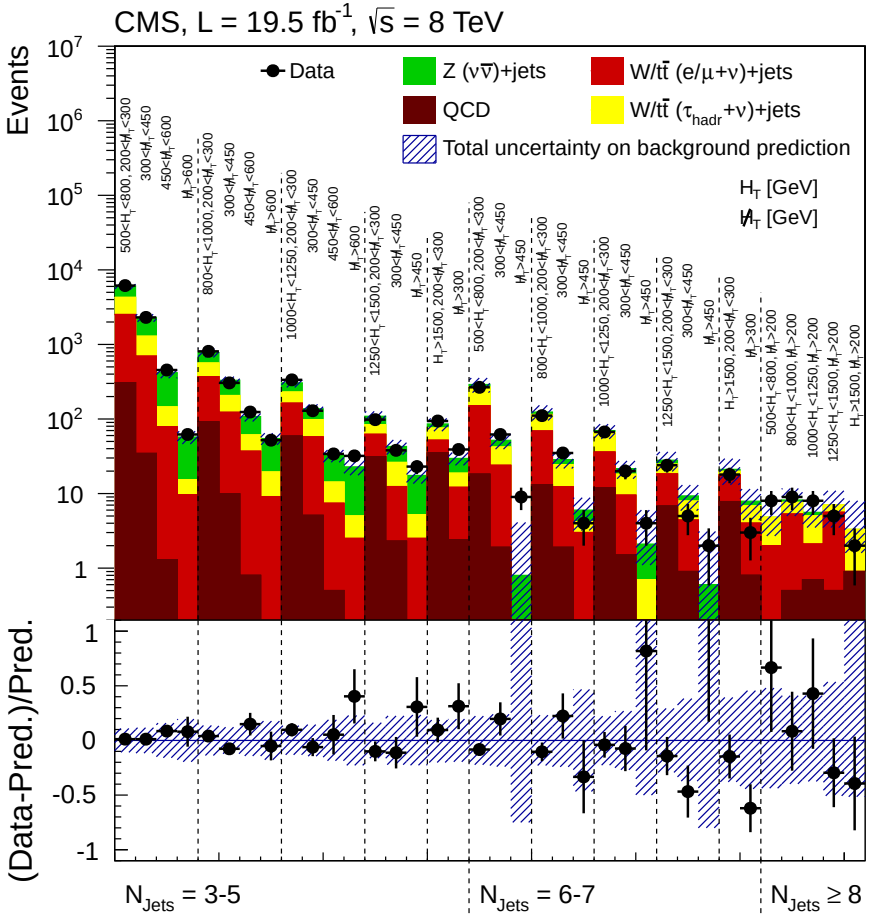


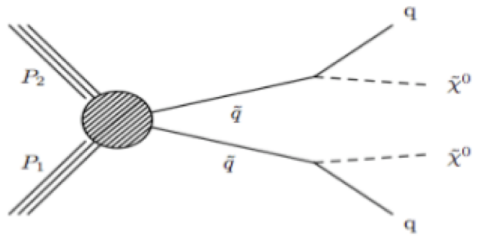



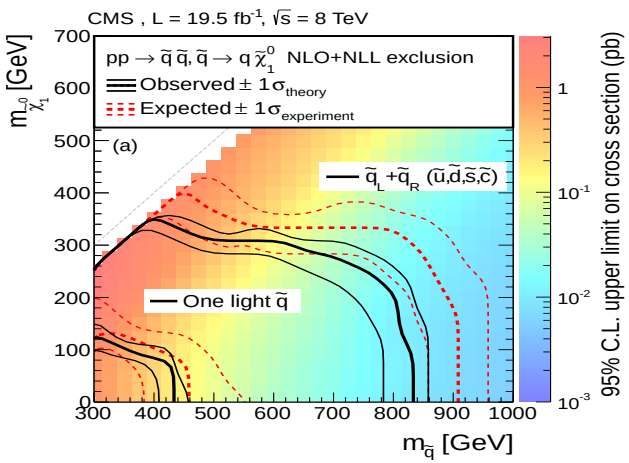



# Multijets + $\not{H}_T$ Results & Interpretation (BR = 100%)

No significant deviation of data from data-driven SM prediction!



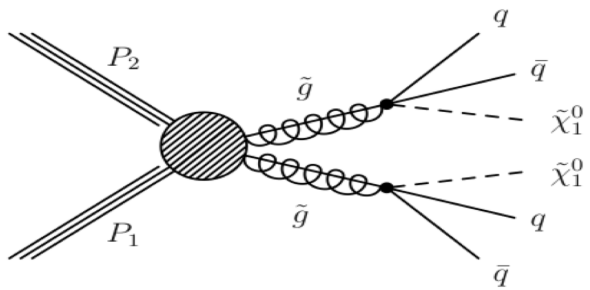



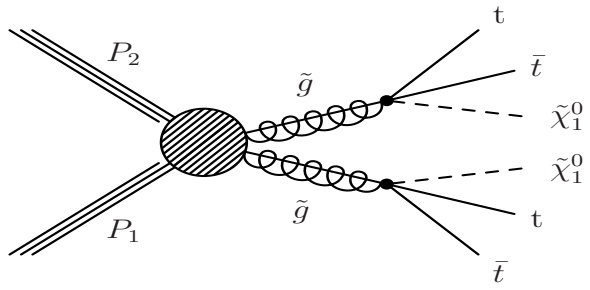

$\tilde{q}\tilde{q}$ production of the first two generations of $\tilde{q}$
$\rightarrow$ Exclude $m_{\tilde{q}} < 780$ GeV for $m_{\tilde{\chi}_1^0} < 200$ GeV

If only one light $\tilde{q} \rightarrow m_{\tilde{q}} < 400$ GeV for $m_{\tilde{\chi}_1^0} < 80$ GeV

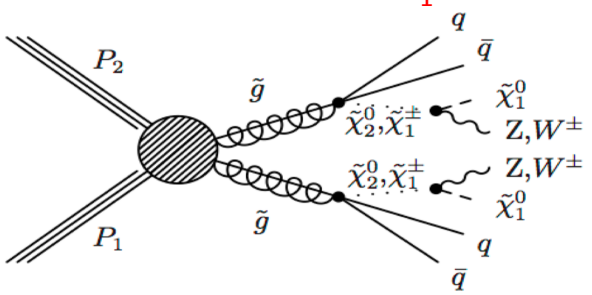
# Multijets + $\not{H}_T$ Interpretation (BR = 100%)



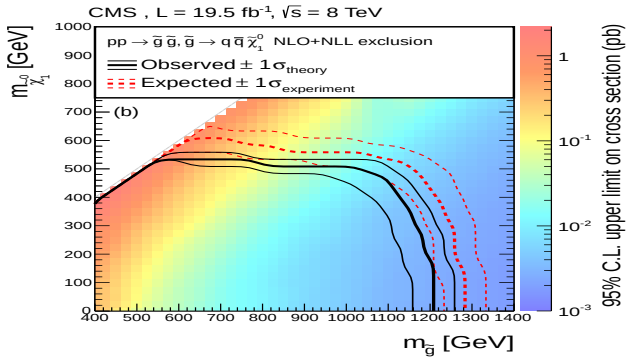

exclude $m_{\tilde{g}}$ <1.16 TeV & $m_{\tilde{\chi}_1^0}$ <100 GeV

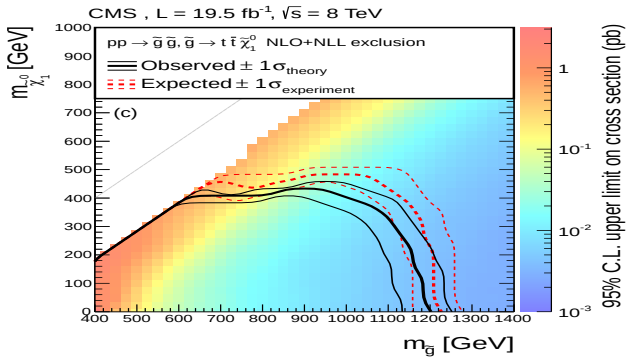


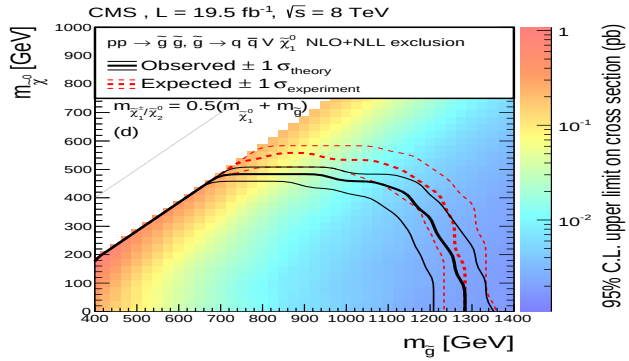

exclude $m_{\tilde{g}}$ <1.13 TeV & $m_{\tilde{\chi}_1^0}$ <100 GeV




exclude $m_{\tilde{g}}$ <1.21 TeV & $m_{\tilde{\chi}_1^0}$ <100 GeV

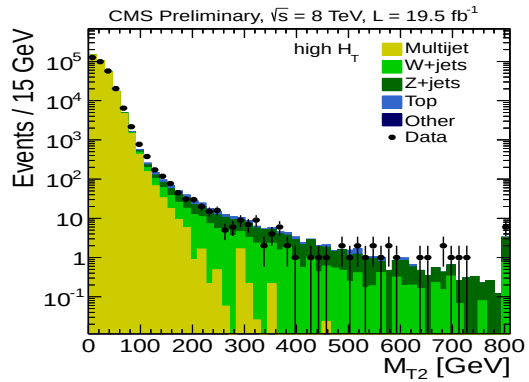


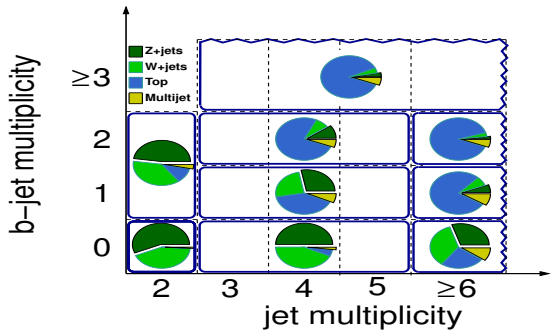



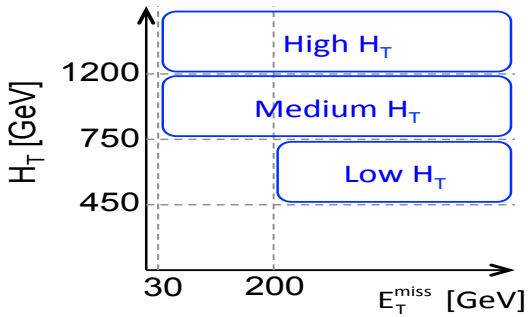



# MT2: 0-lepton search using MT2 variable and $b-$jets

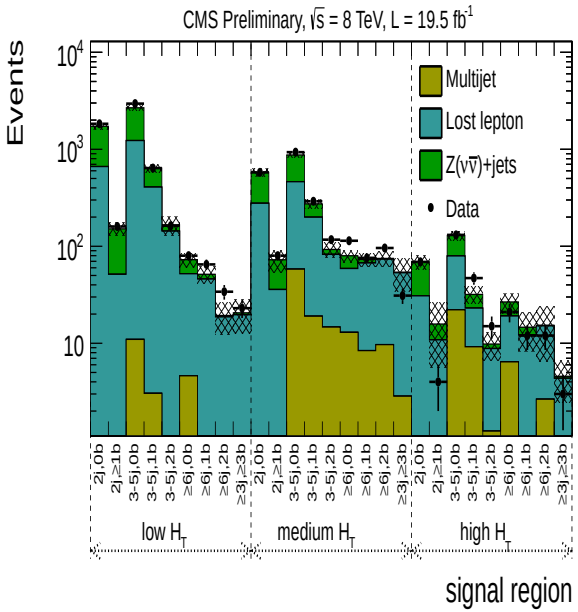
- MT2: tranverse mass to measure the mass of primary pair-produced particles in a situation where both ultimately decay into undetected particles
  - $(M_T^{(i)})^2 = (m^{vis(i)})^2 + m_{\tilde{\chi}}^2 + 2\,(\,E_T^{vis(i)} E_T^{\tilde{\chi}(i)} - \vec{p_T}^{vis(i)} \cdot \vec{p_T}^{\tilde{\chi}(i)}\,)$
  - $M_{T2}(m_{\tilde{\chi}}) = \min\,[max(M_T^1, M_T^2)]$,
    with $\vec{p_T}^{\tilde{\chi}(1)} + \vec{p_T}^{\tilde{\chi}(2)} = \vec{p_T}^{miss}$
- Analysis performed in bins of $N_{b-jets}$, $N_{jets}$, $H_T$, and $\not{E}_T$
- Main backgrounds: $Z(\to \nu\nu)$ + jets, $W(\to \nu\nu)$ + jets, $t\bar{t}$, and QCD

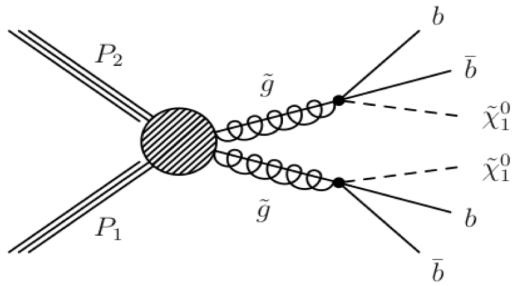


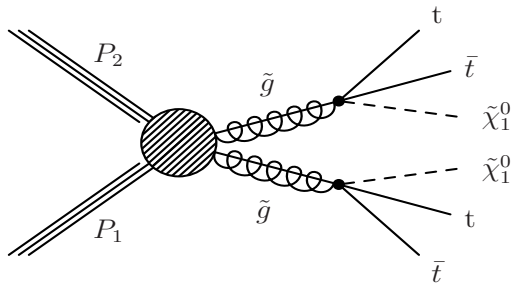



# MT2: 0-lepton, MT2 variable & $b$–jets (BR = 100%)

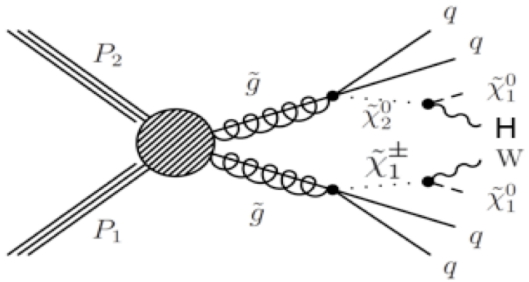


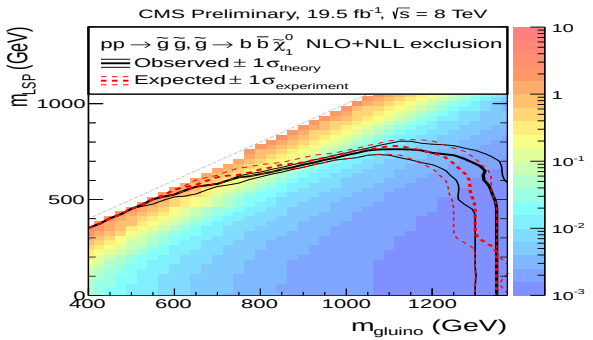

exclude $m_{\tilde{g}}$ <1.3 TeV & $m_{\tilde{\chi}^0_1}$ <740 GeV →

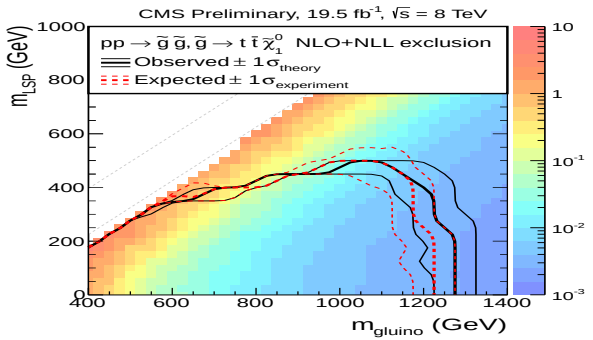


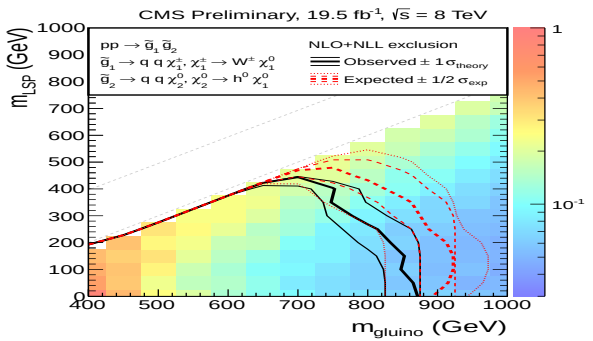

exclude $m_{\tilde{g}}$ <1.225 TeV & $m_{\tilde{\chi}^0_1}$ <450 GeV →




exclude $m_{\tilde{g}}$ <825 GeV & $m_{\tilde{\chi}^0_1}$ <410 GeV →

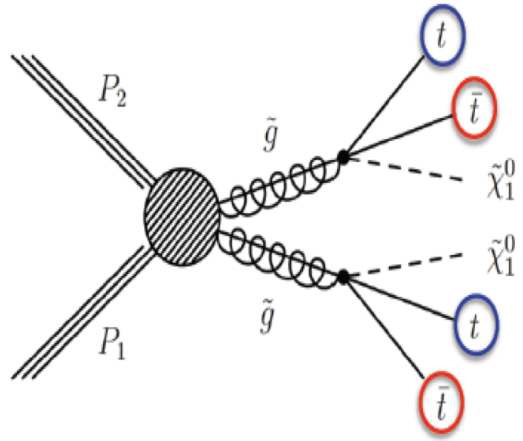


# Same-sign (SS) dileptons + jets

Very clear SUSY signature
Small SM BGs: rare SM ($t\bar{t}$+ V, VV), "fake"/non-prompt, or charge mis-ID

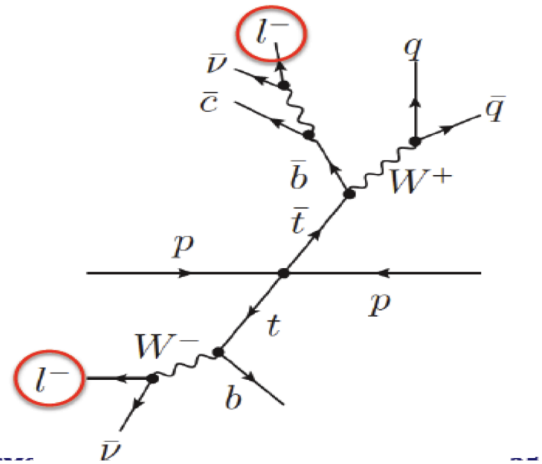



## Selection:

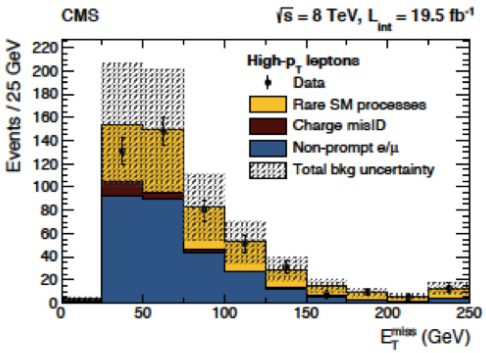
- 2 SS leptons ($e/\mu$) with $p_T > 10/20$ GeV (low/high $p_T$)
- $N_{jets}$ >2 ($p_T > 40$ GeV, $|\eta| < 2.4$)
- $H_T$ >200/250 GeV (high/low $p_T$)
- $\not{E}_T$ >50 GeV (and > 0 for RPV searches)
- 54 bins in $H_T$, $\not{E}_T$, $N_{b-tags}$, and $N_{jets}$

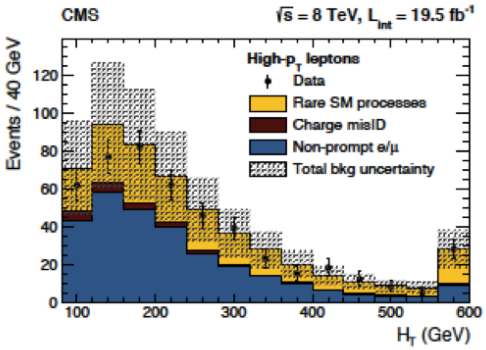
## Backgrounds:

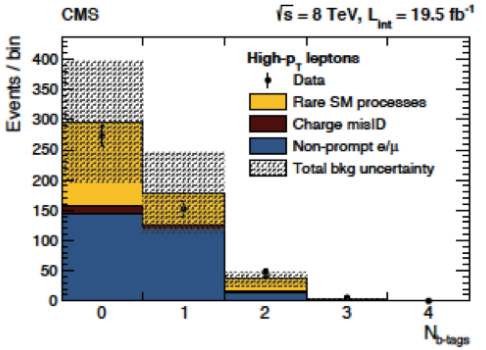
- Rare SM bgs from simulation corrected for difference
- Non-prompt from data: events with loosely isolated lepton are weighted by tight/loose ratio
- Charge mis-ID from data: $e^+e^-$ events are weighted with charge mis-ID probability from simulation

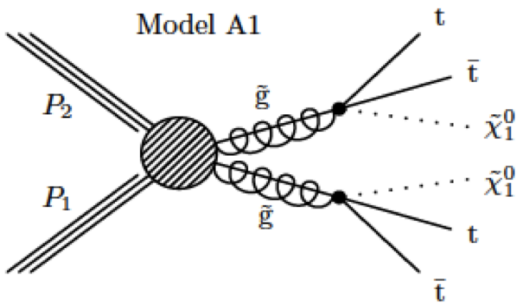


# SSD + jets: Results & Interpretation (BR=100%)

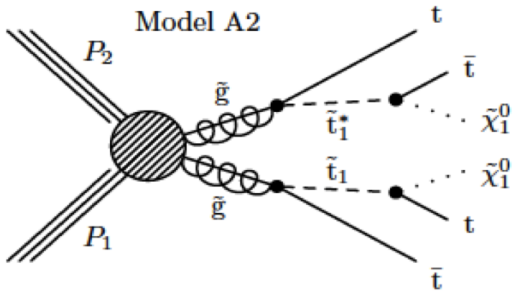


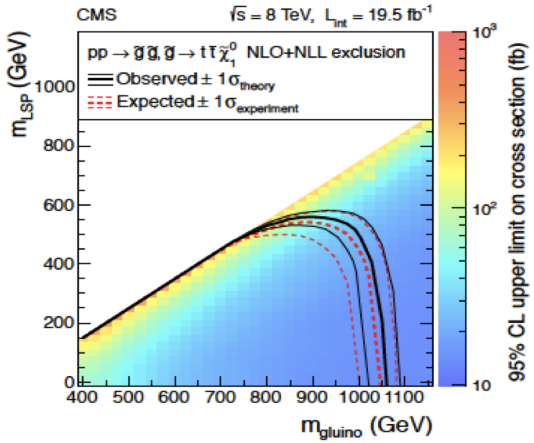



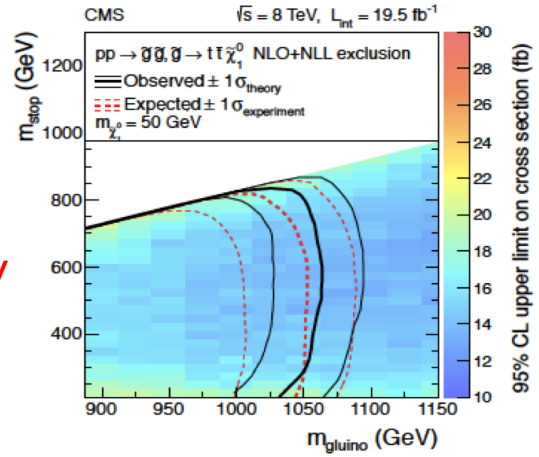

$\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ mediated by an off-shell stop




On-shell stop, $m_{\tilde{\chi}_1^0} = 50$ GeV

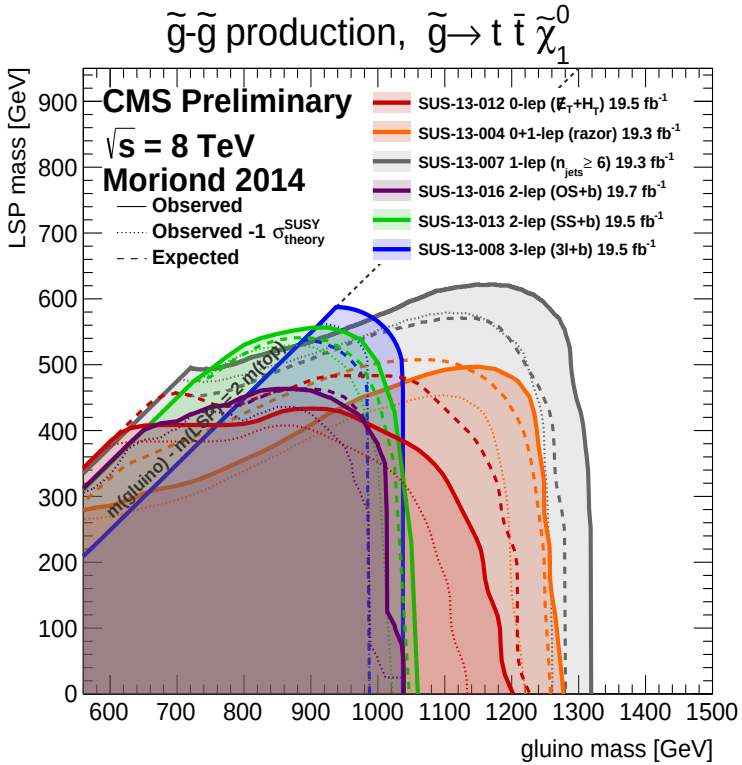
In both models: 4 on-shell W's and 4 $b-$quarks are produced



# Summary and outlook

- Search for physics beyond the Standard Model is one of the main motivations for the LHC experiments
- So far, no significant deviation from SM observed $\rightarrow$ gluinos of masses with 1-1.4 TeV probed in various final states (squarks of 0.8-1 TeV)
- Run II of the LHC at 13/14 TeV will be crucial for SUSY searches
- Many more CMS results are available
- References:
  - CMS public results: ▸ Link



# Backup

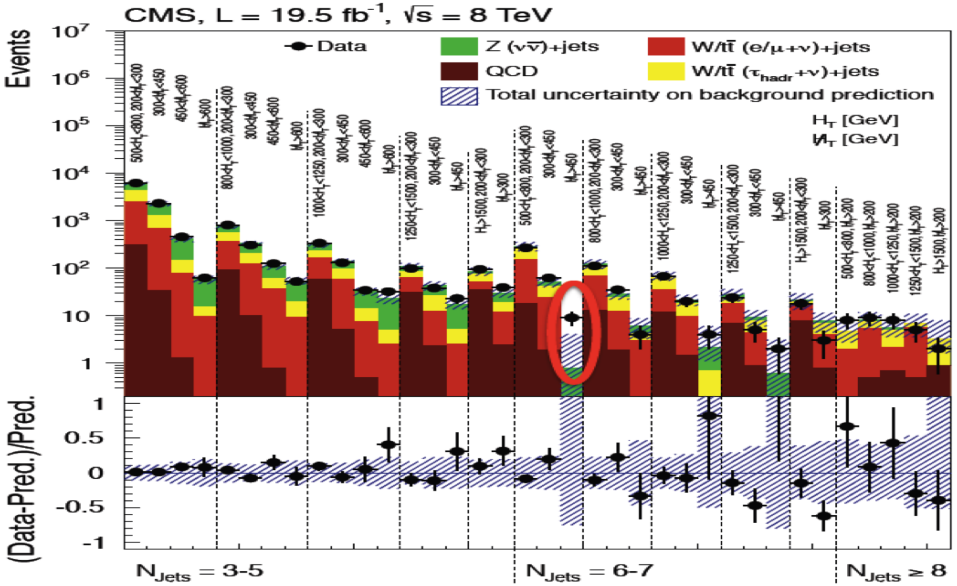
# MET+jets Predictions

Table 1: Predicted event yields for the different background components in the search regions defined by $H_T$, $\not{H}_T$ and $N_{jets}$. The uncertainties of the different background sources are added in quadrature to obtain the total uncertainties.

| Selection | | | $Z \to \nu\bar{\nu}$ | $t\bar{t}/W \to e, \mu + X$ | $t\bar{t}/W \to \tau_h + X$ | QCD | Total background | Data |
|---|---|---|---|---|---|---|---|---|
| $N_{jets}$ | $H_T$ [GeV] | $\not{H}_T$ [GeV] | | | | | | |
| 3–5 | 500–800 | 200–300 | 1821±387 | 2211±448 | 1749±210 | 307±219 | 6088±665 | 6159 |
| 3–5 | 500–800 | 300–450 | 994±218 | 660±133 | 590±69 | 35±24 | 2278±266 | 2305 |
| 3–5 | 500–800 | 450–600 | 273±63 | 77±17 | 66.3±9.5 | $1.3^{+1.5}_{-1.3}$ | 418±66 | 454 |
| 3–5 | 500–800 | >600 | 42±10 | 9.5±4.0 | 5.7±1.3 | $0.1^{+0.3}_{-0.1}$ | 57.4±11.2 | 62 |
| 3–5 | 800–1000 | 200–300 | 216±46 | 278±62 | 192±33 | 92±66 | 777±107 | 808 |
| 3–5 | 800–1000 | 300–450 | 124±26 | 113±27 | 84±12 | 9.9±7.4 | 330±40 | 305 |
| 3–5 | 800–1000 | 450–600 | 47±11 | 36.1±9.9 | 24.1±3.6 | $0.8^{+1.3}_{-0.8}$ | 108±15 | 124 |
| 3–5 | 800–1000 | >600 | 35.3±8.8 | 9.0±3.7 | 10.3±2.0 | $0.1^{+0.4}_{-0.1}$ | 54.8±9.7 | 52 |
| 3–5 | 1000–1250 | 200–300 | 76±17 | 104±26 | 66.5±9.9 | 59±25 | 305±41 | 335 |
| 3–5 | 1000–1250 | 300–450 | 39.3±8.9 | 52±14 | 41±11 | 5.1±2.7 | 137±20 | 129 |
| 3–5 | 1000–1250 | 450–600 | 18.1±4.7 | 6.9±3.2 | 6.8±2.0 | $0.5^{+0.7}_{-0.5}$ | 32.3±6.1 | 34 |
| 3–5 | 1000–1250 | >600 | 17.8±4.8 | 2.4±1.8 | 2.5±0.8 | $0.1^{+0.3}_{-0.1}$ | 22.8±5.2 | 32 |
| 3–5 | 1250–1500 | 200–300 | 25.3±6.0 | 31.0±9.5 | 21.3±4.1 | 31±13 | 109±18 | 98 |
| 3–5 | 1250–1500 | 300–450 | 16.7±4.3 | 10.1±4.4 | 13.7±7.1 | 2.3±1.6 | 42.8±9.5 | 38 |
| 3–5 | 1250–1500 | >450 | 12.3±3.5 | 2.3±1.7 | 2.7±1.2 | $0.2^{+0.5}_{-0.2}$ | 17.6±4.1 | 23 |
| 3–5 | >1500 | 200–300 | 10.5±2.9 | 16.7±6.2 | 23.5±5.6 | 35±14 | 86±17 | 94 |
| 3–5 | >1500 | >300 | 10.9±3.1 | 9.7±4.3 | 6.6±1.4 | 2.4±2.0 | 29.7±5.8 | 39 |
| 6–7 | 500–800 | 200–300 | 22.7±6.4 | 133±59 | 117±25 | 18.2±9.2 | 290±65 | 266 |
| 6–7 | 500–800 | 300–450 | 9.9±3.2 | 22±11 | 18.0±5.1 | 1.9±1.7 | 52±12 | 62 |
| 6–7 | 500–800 | >450 | 0.7±0.6 | $0.0^{+3.2}_{-0.0}$ | $0.1^{+0.5}_{-0.1}$ | $0.0^{+0.1}_{-0.0}$ | $0.8^{+3.3}_{-0.6}$ | 9 |
| 6–7 | 800–1000 | 200–300 | 9.1±3.0 | 56±25 | 46±11 | 13.1±6.6 | 124±29 | 111 |
| 6–7 | 800–1000 | 300–450 | 4.2±1.7 | 10.4±5.5 | 12.0±3.6 | 1.9±1.4 | 28.6±6.9 | 35 |
| 6–7 | 800–1000 | >450 | 1.8±1.0 | 2.9±2.5 | 1.2±0.8 | $0.1^{+0.4}_{-0.1}$ | 6.0±2.8 | 4 |
| 6–7 | 1000–1250 | 200–300 | 4.4±1.7 | 24±12 | 29.5±7.8 | 11.9±6.0 | 70±16 | 67 |
| 6–7 | 1000–1250 | 300–450 | 3.5±1.5 | 8.0±4.7 | 8.6±2.7 | 1.5±1.5 | 21.6±5.8 | 20 |
| 6–7 | 1000–1250 | >450 | 1.4±0.8 | $0.0^{+3.6}_{-0.0}$ | $0.6^{+0.8}_{-0.6}$ | $0.1^{+0.4}_{-0.1}$ | $2.2^{+3.8}_{-1.1}$ | 4 |
| 6–7 | 1250–1500 | 200–300 | 3.3±1.4 | 11.5±6.5 | 6.4±2.7 | 6.8±3.9 | 28.0±8.2 | 24 |
| 6–7 | 1250–1500 | 300–450 | 1.4±0.8 | 3.5±2.6 | 3.5±1.9 | $0.9^{+1.3}_{-0.9}$ | 9.4±3.6 | 5 |
| 6–7 | 1250–1500 | >450 | 0.4±0.4 | $0.0^{+2.5}_{-0.0}$ | $0.1^{+0.5}_{-0.1}$ | $0.1^{+0.3}_{-0.1}$ | $0.5^{+2.6}_{-0.4}$ | 2 |
| 6–7 | >1500 | 200–300 | 1.3±0.8 | 10.0±6.9 | 2.0±1.2 | 7.8±4.0 | 21.1±8.1 | 18 |
| 6–7 | >1500 | >300 | 1.1±0.7 | 3.2±2.8 | 2.8±1.9 | $0.8^{+1.1}_{-0.8}$ | 7.9±3.6 | 3 |
| ≥8 | 500–800 | >200 | $0.0^{+0.8}_{-0.0}$ | 1.9±1.5 | 2.8±1.4 | $0.1^{+0.4}_{-0.1}$ | $4.8^{+2.3}_{-2.1}$ | 8 |
| ≥8 | 800–1000 | >200 | 0.6±0.6 | 4.8±2.9 | 2.3±1.2 | $0.5^{+0.9}_{-0.5}$ | $8.3^{+3.4}_{-3.3}$ | 9 |
| ≥8 | 1000–1250 | >200 | 0.6±0.5 | $1.4^{+1.5}_{-1.4}$ | 2.9±1.3 | $0.7^{+1.0}_{-0.7}$ | $5.6^{+2.3}_{-2.1}$ | 8 |
| ≥8 | 1250–1500 | >200 | $0.0^{+0.9}_{-0.0}$ | 5.1±3.5 | 1.4±0.9 | $0.5^{+0.9}_{-0.5}$ | $7.1^{+3.8}_{-3.6}$ | 5 |
| ≥8 | >1500 | >200 | $0.0^{+0.7}_{-0.0}$ | $0.0^{+4.2}_{-0.0}$ | 2.4±1.4 | $0.9^{+1.3}_{-0.9}$ | $3.3^{+4.7}_{-1.7}$ | 2 |

# Multijets + $\not{H}_T$ Results: bin 20

No significant deviation of data from data-driven SM prediction!




- One bin shows an excess !
  - $N_{bkg} = 0.7 \pm 1.8$ and $N_{data} = 9$
  - $p_{local} \sim 0.004 \rightarrow 2.7\sigma$
  - $p_{global} \sim 0.11 \rightarrow 1.2\sigma$

# SS Search Bins

| $N_{b\text{-jets}}$ | $E_T^{miss}$ (GeV) | $N_{jets}$ | $H_T \in [200, 400]$ (GeV) | $H_T > 400$ (GeV) |
|---|---|---|---|---|
| $= 0$ | 50–120 | 2–3 | SR01 | SR02 |
| | | $\geq 4$ | SR03 | SR04 |
| | >120 | 2–3 | SR05 | SR06 |
| | | $\geq 4$ | SR07 | SR08 |
| $= 1$ | 50–120 | 2–3 | SR11 | SR12 |
| | | $\geq 4$ | SR13 | SR14 |
| | >120 | 2–3 | SR15 | SR16 |
| | | $\geq 4$ | SR17 | SR18 |
| $\geq 2$ | 50–120 | 2–3 | SR21 | SR22 |
| | | $\geq 4$ | SR23 | SR24 |
| | >120 | 2–3 | SR25 | SR26 |
| | | $\geq 4$ | SR27 | SR28 |

# SS Predictions

Table 7: Predicted and observed event yields for the low-$p_T$ and high-$p_T$ signal regions.

| Region | Low-$p_T$ | | High-$p_T$ | |
|---|---|---|---|---|
| | Expected | Observed | Expected | Observed |
| SR01 | 44 ± 16 | 50 | 51 ± 18 | 48 |
| SR02 | 12 ± 4 | 17 | 9.0 ± 3.5 | 11 |
| SR03 | 12 ± 5 | 13 | 8.0 ± 3.1 | 5 |
| SR04 | 9.1 ± 3.4 | 4 | 5.6 ± 2.1 | 2 |
| SR05 | 21 ± 8 | 22 | 20 ± 7 | 12 |
| SR06 | 13 ± 5 | 18 | 9 ± 4 | 11 |
| SR07 | 3.5 ± 1.4 | 2 | 2.4 ± 1.0 | 1 |
| SR08 | 5.8 ± 2.1 | 4 | 3.6 ± 1.5 | 3 |
| SR11 | 32 ± 13 | 40 | 36 ± 14 | 29 |
| SR12 | 6.0 ± 2.2 | 5 | 3.8 ± 1.4 | 5 |
| SR13 | 17 ± 7 | 15 | 10 ± 4 | 6 |
| SR14 | 10 ± 4 | 6 | 5.9 ± 2.2 | 2 |
| SR15 | 13 ± 5 | 9 | 11 ± 4 | 11 |
| SR16 | 5.5 ± 2.0 | 5 | 3.9 ± 1.5 | 2 |
| SR17 | 4.2 ± 1.6 | 3 | 2.8 ± 1.1 | 3 |
| SR18 | 6.8 ± 2.5 | 11 | 4.0 ± 1.5 | 7 |
| SR21 | 7.6 ± 2.8 | 10 | 7.1 ± 2.5 | 12 |
| SR22 | 1.5 ± 0.7 | 1 | 1.0 ± 0.5 | 1 |
| SR23 | 7.1 ± 2.7 | 6 | 3.8 ± 1.4 | 3 |
| SR24 | 4.4 ± 1.7 | 11 | 2.8 ± 1.2 | 7 |
| SR25 | 2.8 ± 1.1 | 1 | 2.9 ± 1.1 | 4 |
| SR26 | 1.3 ± 0.6 | 2 | 0.8 ± 0.5 | 1 |
| SR27 | 1.8 ± 0.8 | 0 | 1.2 ± 0.6 | 0 |
| SR28 | 3.4 ± 1.3 | 3 | 2.2 ± 1.0 | 2 |

# MT2: Signal bin definitions

Table 1: Signal bin definitions of the inclusive $M_{T2}$ analysis.

| | low $H_T$ region | | | medium $H_T$ region | | | high $H_T$ region | |
|---|---|---|---|---|---|---|---|---|
| | $M_{T2}$ bin [GeV] | | | $M_{T2}$ bin [GeV] | | | $M_{T2}$ bin [GeV] | |
| 2 jets, 0 b jets | 200-240 | 350-420 | 570-650 | 125-150 | 220-270 | 425-580 | 120-150 | 260-350 |
| | 240-290 | 420-490 | $\geq$ 650 | 150-180 | 270-325 | 580-780 | 150-200 | 350-550 |
| | 290-350 | 490-570 | | 180-220 | 325-425 | $\geq$ 780 | 200-260 | $\geq$ 550 |
| 2 jets, $\geq$ 1 b jets | 200-250 | 310-380 | 450-550 | 100-135 | 170-260 | $\geq$ 450 | 100-180 | |
| | 250-310 | 380-450 | $\geq$ 550 | 135-170 | 260-450 | | $\geq$ 180 | |
| 3-5 jets, 0 b jets | 200-240 | 420-490 | | 160-185 | 300-370 | $\geq$ 800 | 160-185 | 350-450 |
| | 240-290 | 490-570 | | 185-215 | 370-480 | | 185-220 | 450-650 |
| | 290-350 | 570-650 | | 215-250 | 480-640 | | 220-270 | $\geq$ 650 |
| | 350-420 | $\geq$ 650 | | 250-300 | 640-800 | | 270-350 | |
| 3-5 jets, 1 b jets | 200-250 | 310-380 | 450-550 | 150-175 | 210-270 | 380-600 | 150-180 | 230-350 |
| | 250-310 | 380-450 | $\geq$ 550 | 175-210 | 270-380 | $\geq$ 600 | 180-230 | $\geq$ 350 |
| 3-5 jets, 2 b jets | 200-250 | 325-425 | | 130-160 | 200-270 | $\geq$ 370 | 130-200 | |
| | 250-325 | $\geq$ 425 | | 160-200 | 270-370 | | $\geq$ 200 | |
| $\geq$ 6 jets, 0 b jets | 200-280 | $\geq$ 380 | | 160-200 | 250-325 | $\geq$ 425 | 160-200 | $\geq$ 300 |
| | 280-380 | | | 200-250 | 325-425 | | 200-300 | |
| $\geq$ 6 jets, 1 b jets | 200-250 | $\geq$ 325 | | 150-190 | 250-350 | | 150-200 | $\geq$ 300 |
| | 250-325 | | | 190-250 | $\geq$ 350 | | 200-300 | |
| $\geq$ 6 jets, 2 b jets | 200-250 | $\geq$ 300 | | 130-170 | 220-300 | | 120-200 | |
| | 250-300 | | | 170-220 | $\geq$ 300 | | $\geq$ 200 | |
| $\geq$ 3 jets, $\geq$ 3 b jets | 200-280 | $\geq$ 280 | | 125-175 | 175-275 | $\geq$ 275 | 1$\geq$ 125 | |

# Razor

Define:

$$M_R = \sqrt{(|\vec{p_{q1}}| + |\vec{p_{q2}}|)^2 - (p_{z,q1} + p_{z,q2})^2}$$

and

$$M_T^R = \sqrt{\frac{E_T^{miss}(p_T^{q1} + p_T^{q2}) - \vec{E_T^{miss}}(\vec{p_t^{q1}} + \vec{p_T^{q2}})}{2}}$$

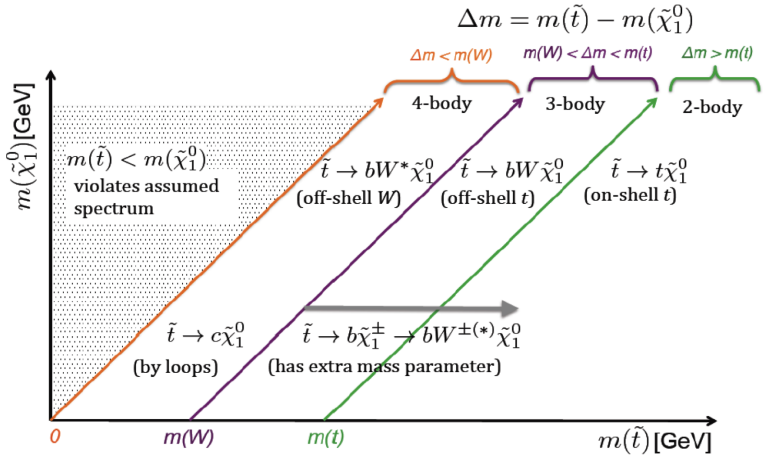
Define the "Razor":

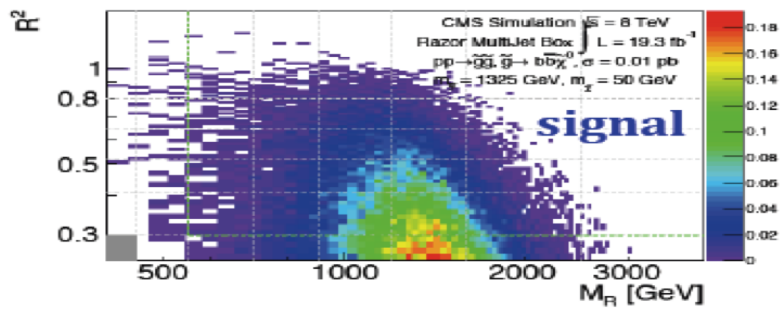
$$R = \frac{M_T^R}{M_R}$$

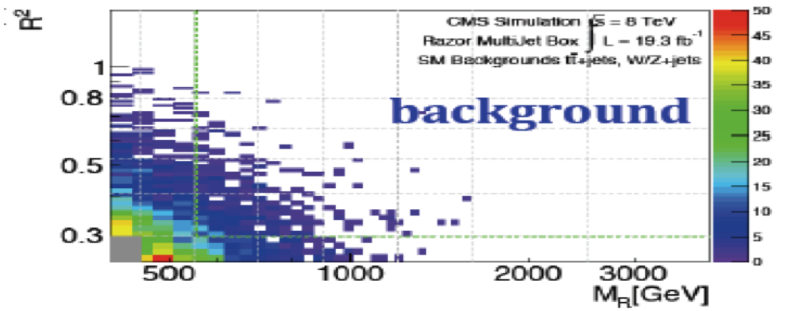
- For signal: $M_R$ has peak and $M_T^R$ has endpoint at:

$$M_\Delta = \frac{M_{\tilde{q}}^2 - M_{\tilde{\chi}_1^0}^2}{M_{\tilde{q}}}$$

- For background: exponentially falling at relevant scales



# Razor 2

Extrapolate from background dominated side bands at low $M_R$ and $R^2$ to "search region"

Background model: 2D function of $M_R$ and $R^2$

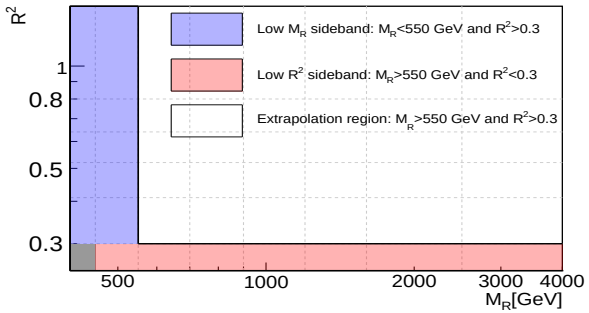
Model is fitted in each box indepedently but simultaneously for each b-tag multiplicity

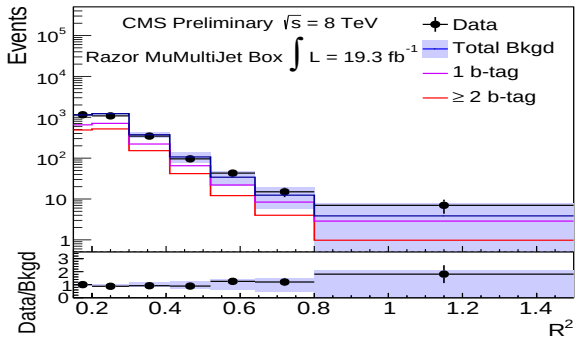
Shape parameters (n, $M_R^0$, and $M_0^2$ ) to describe potential differences between shape in data and simulation

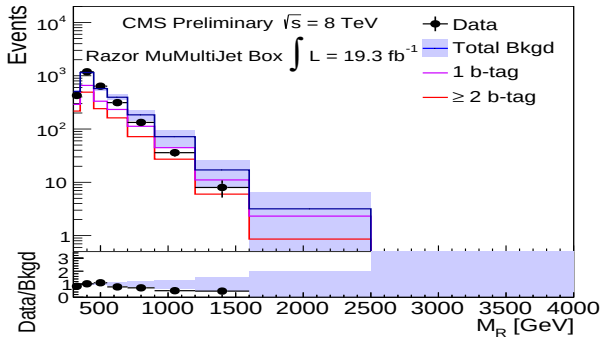
Analysis uses unbinned likelihood

Projection of 2D plane on $M_R$ and $R^2$ axis

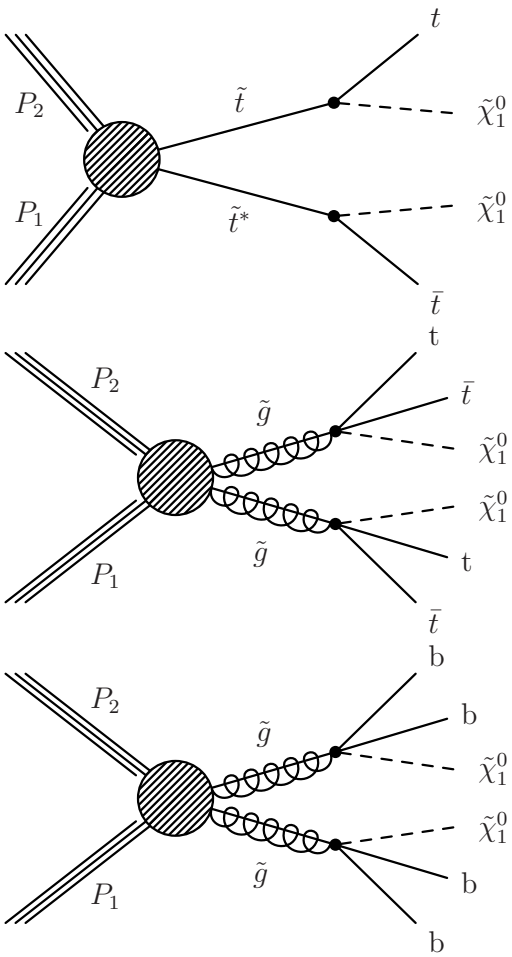
No deviation from expectayin

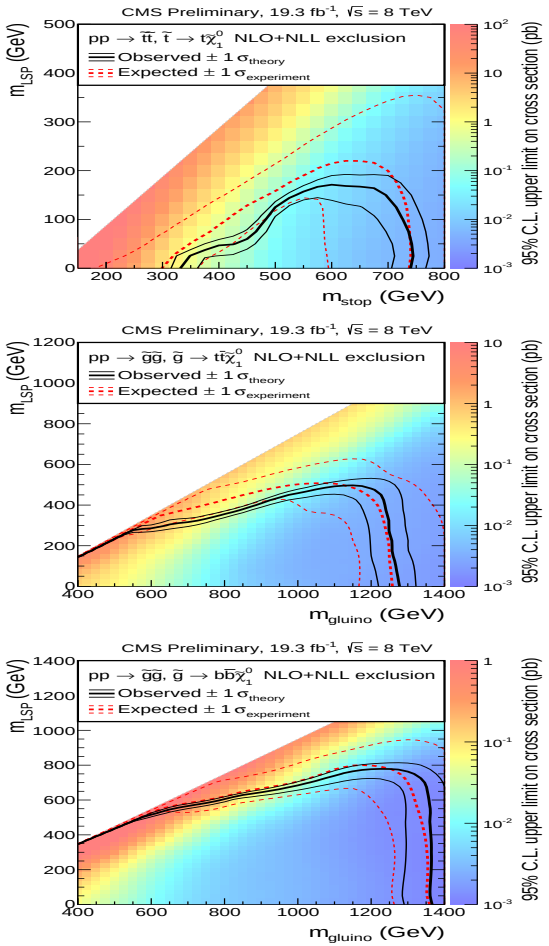


# Razor 3


$P_2$
$P_1$
$\tilde{t}$
$\tilde{t}^*$
$t$
$\bar{t}$
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$
$P_2$
$P_1$
$\tilde{g}$
$\tilde{g}$
t
$\bar{t}$
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$
t
$\bar{t}$
$P_2$
$P_1$
$\tilde{g}$
$\tilde{g}$
b
b
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$
b
b


CMS Preliminary, 19.3 fb$^{-1}$, $\sqrt{s}$ = 8 TeV
$pp \to \tilde{t}\bar{t}, \tilde{t} \to t\tilde{\chi}_1^0$ NLO+NLL exclusion
Observed ± 1 $\sigma_{theory}$
Expected ± 1 $\sigma_{experiment}$
$m_{LSP}$ (GeV)
$m_{stop}$ (GeV)
95% C.L. upper limit on cross section (pb)
CMS Preliminary, 19.3 fb$^{-1}$, $\sqrt{s}$ = 8 TeV
$pp \to \tilde{g}\tilde{g}, \tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ NLO+NLL exclusion
Observed ± 1 $\sigma_{theory}$
Expected ± 1 $\sigma_{experiment}$
$m_{LSP}$ (GeV)
$m_{gluino}$ (GeV)
95% C.L. upper limit on cross section (pb)
CMS Preliminary, 19.3 fb$^{-1}$, $\sqrt{s}$ = 8 TeV
$pp \to \tilde{g}\tilde{g}, \tilde{g} \to b\bar{b}\tilde{\chi}_1^0$ NLO+NLL exclusion
Observed ± 1 $\sigma_{theory}$
Expected ± 1 $\sigma_{experiment}$
$m_{LSP}$ (GeV)
$m_{gluino}$ (GeV)
95% C.L. upper limit on cross section (pb)