Search for SUSY with gluino pair production in all-hadronic and single lepton final states at CMS

Thomas E. Danielson, University of California – Santa Barbara
On behalf of the CMS Collaboration

Meeting of the American Physical Society(APS) Division of Particles and Fields(DPF)
August 15, 2013

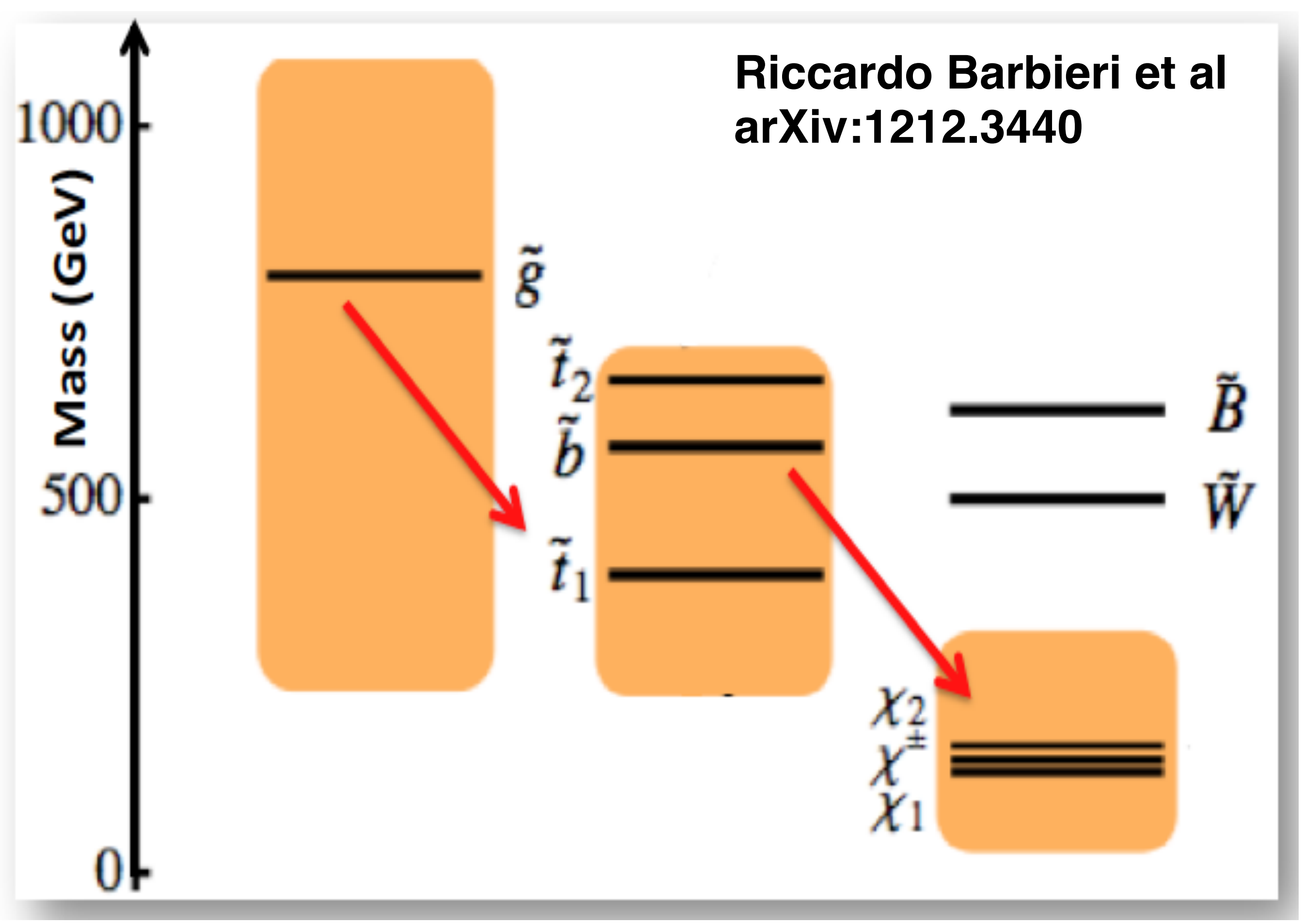
Outline

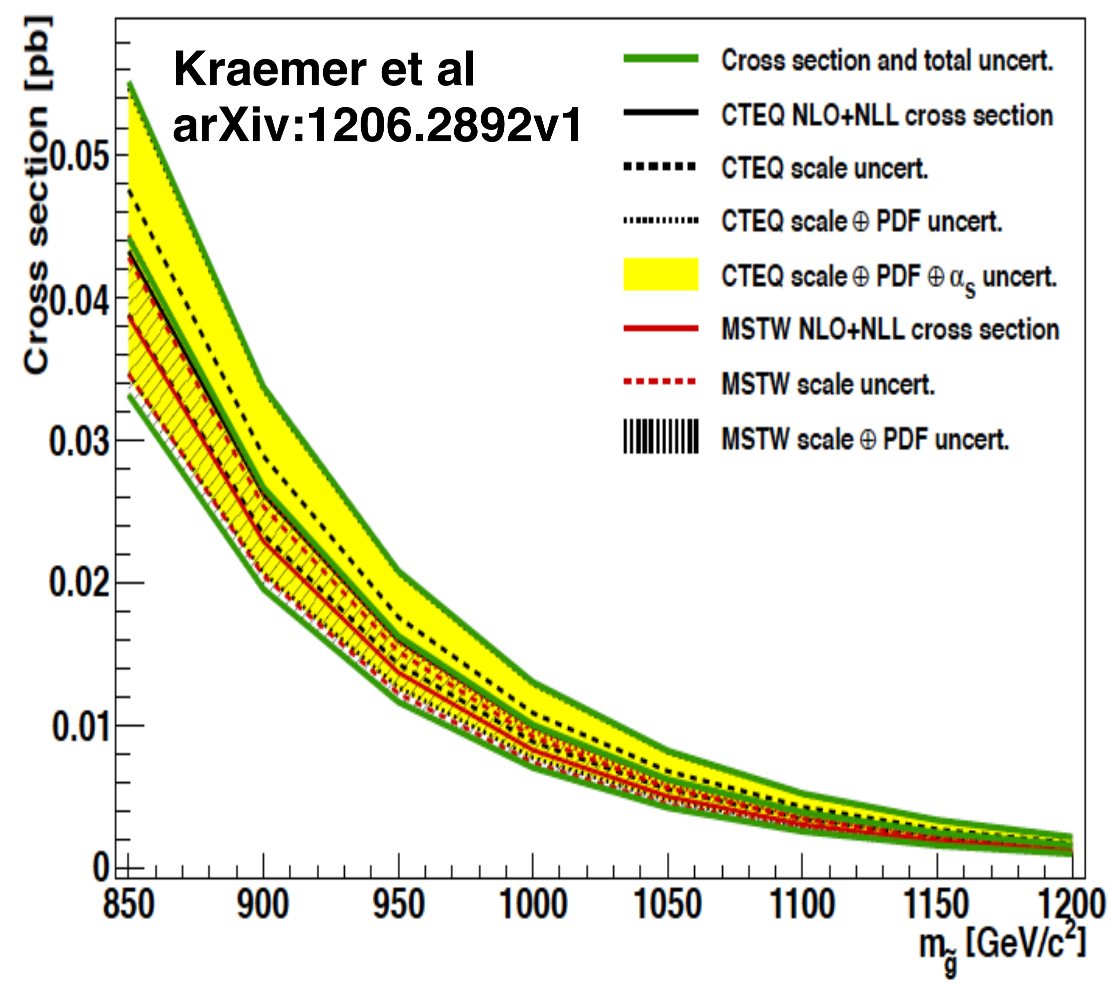
- Introduction: gluino pair production and natural SUSY
- All-hadronic search with b-tagging
- Single lepton searches with b-tagging
  - Delta Phi (lepton, W) (DPhi) method
  - Lepton Spectrum (LS) method

Introduction and natural SUSY

- Discovery of new boson consistent with Higgs particle has further shifted attention towards SUSY to solve the hierarchy problem.
- Various SUSY models lead to production of multiple b-jets, including natural models where 3rd generation squarks + gluinos must be light ($M_{\tilde{g}} < \sim 2$ TeV), ($M_{\tilde{t}_{1,2},\tilde{b}_L} < \sim 1$ TeV)

  8 TeV LHC dataset can probe up to $M_{\tilde{g}} \sim 1.2$ TeV
- R-parity conserving models provide a stable LSP (χ_1^0)





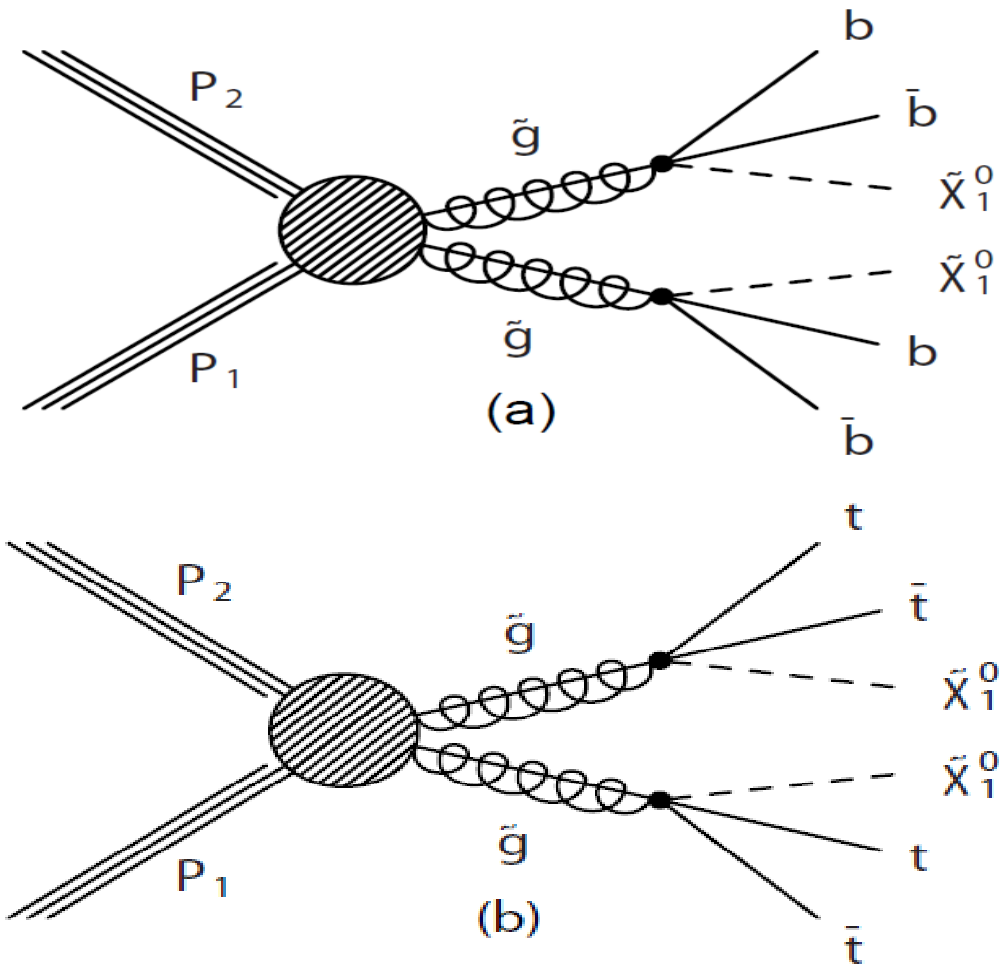
Natural SUSY with gluino pair production

- These searches focus on natural SUSY models with multiple b-jets in the final state

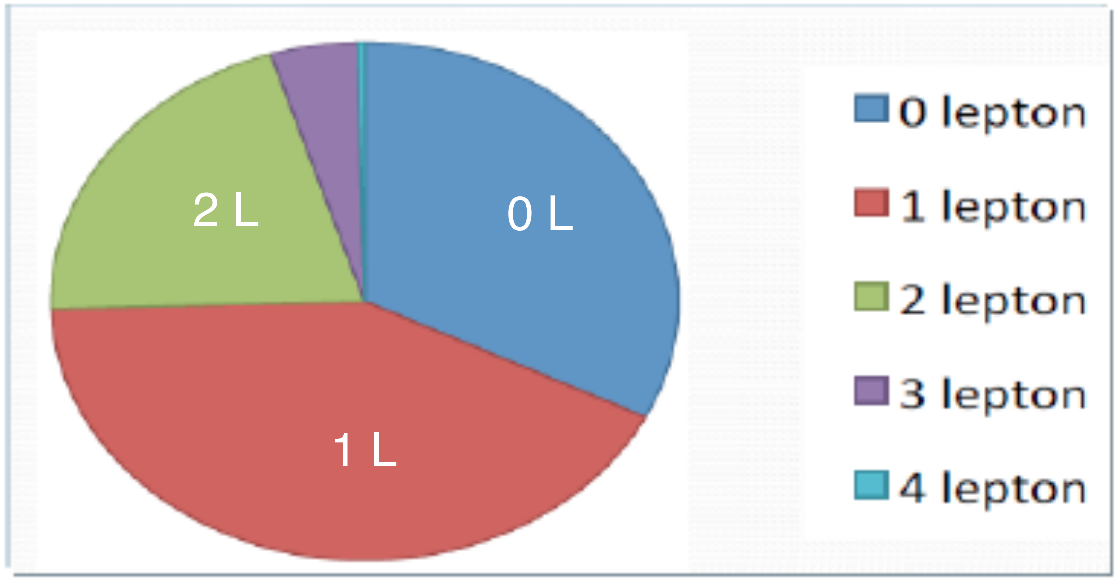
  Simplified models with variable gluino, LSP mass

  3-body decays from off-shell b and t squarks

- $\tilde{g}\tilde{g}\rightarrow b\bar{b}b\bar{b}\,\tilde{\chi}_1^0\tilde{\chi}_1^0$ covered by all-hadronic search
- $\tilde{g}\tilde{g}\rightarrow t\bar{t}t\bar{t}\,\tilde{\chi}_1^0\tilde{\chi}_1^0$ covered by all-hadronic and single lepton searches



Lepton multiplicity of $t\bar{t}t\bar{t}\,\tilde{\chi}\tilde{\chi}$ final state



Overview of all-hadronic search

CMS-SUS-12-024
arXiv:1305.2390

- Signature: MET+b-jets(+more jets)
- Baseline Selection:

  MET>125 GeV

  ≥ 3 jets with $p_T > 50$ GeV, HT>400 GeV

  - ≥ 2 jets with $p_T > 70$ GeV
  - ≥ 1 b-tagged jet

- Selection for reducing background from W→lν decays in top + W events

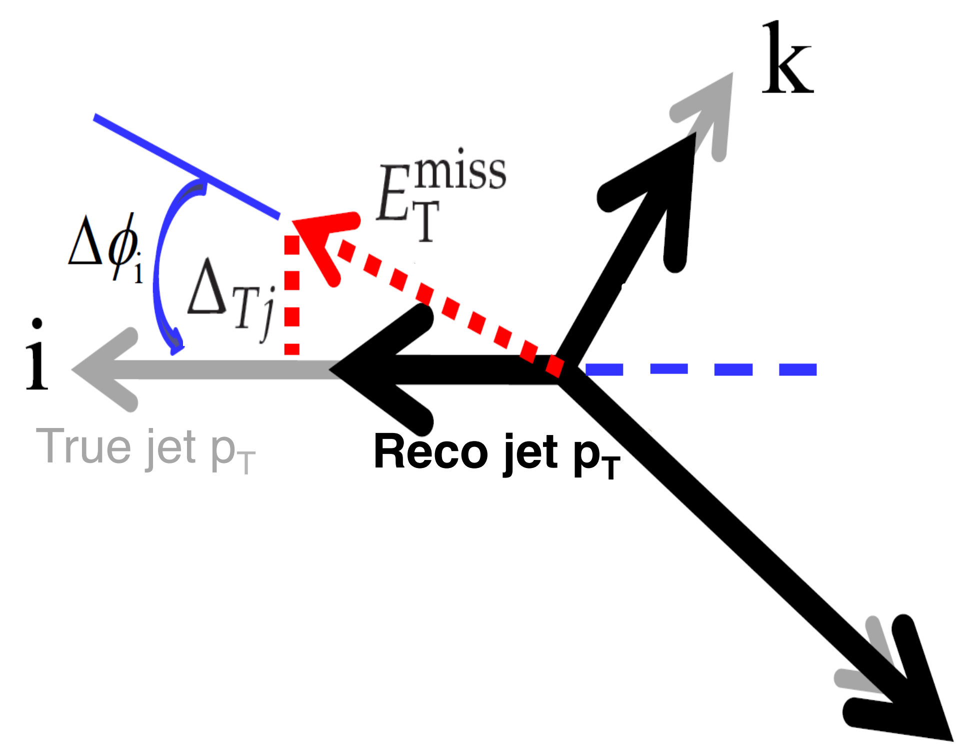
  Veto isolated leptons with $p_T > 10$ GeV

  Veto isolated tracks with $p_T > 15$ GeV

  - Further removes e/μ, also suppresses single-prong τ decays

- Selection for reducing contributions from QCD events containing fake MET

  Normalized minimum Δφ(MET,jet1,2,3) $\Delta\hat{\phi}_{min} > 4$

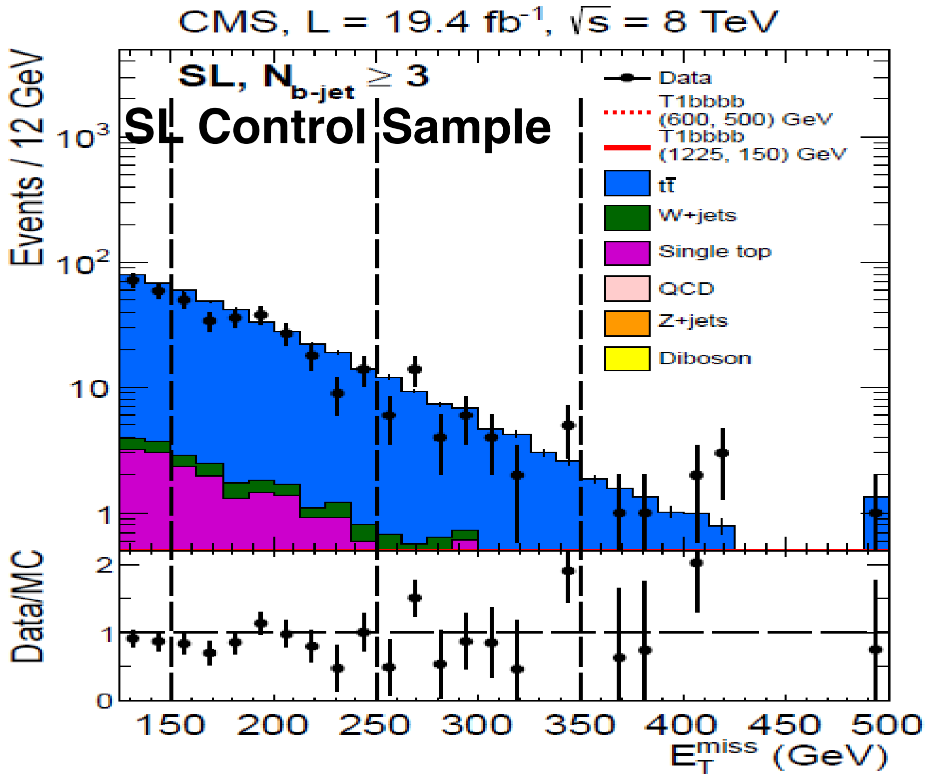


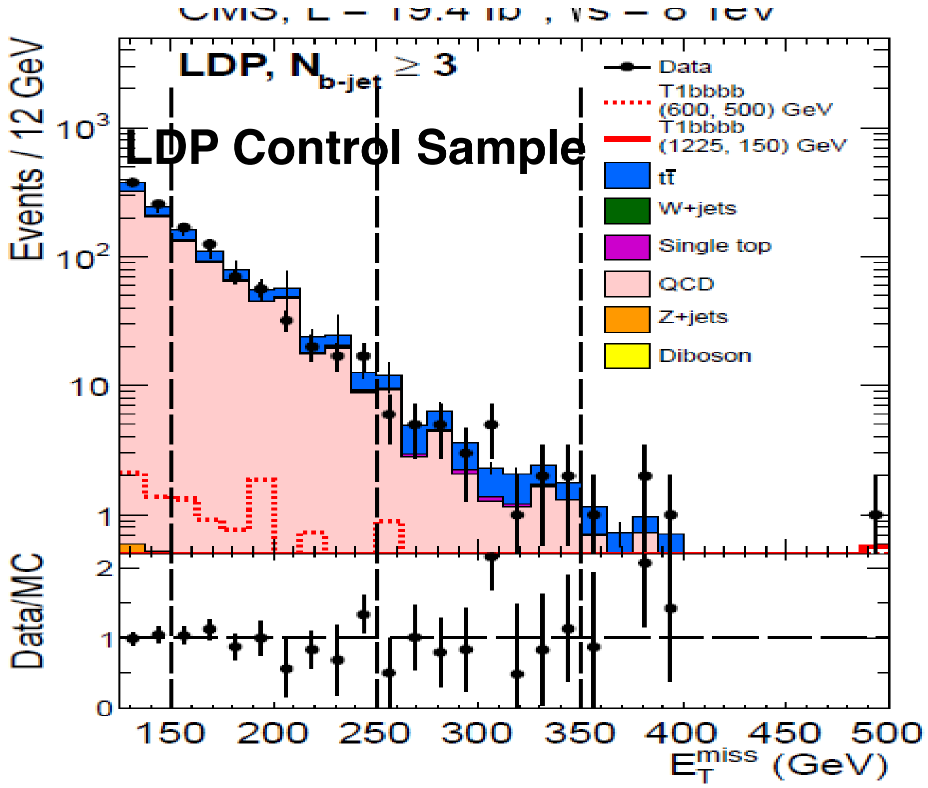
$$\Delta\hat{\phi}_j \equiv \Delta\phi(j, E_T^{miss}) / \sin^{-1}(\Delta_{Tj} / E_T^{miss})$$

$$\Delta_{Tj} = 0.1 \frac{\sqrt{\sum_{i \neq j} \left[p_x^j p_y^i - p_y^j p_x^i \right]^2}}{p_T^j}$$

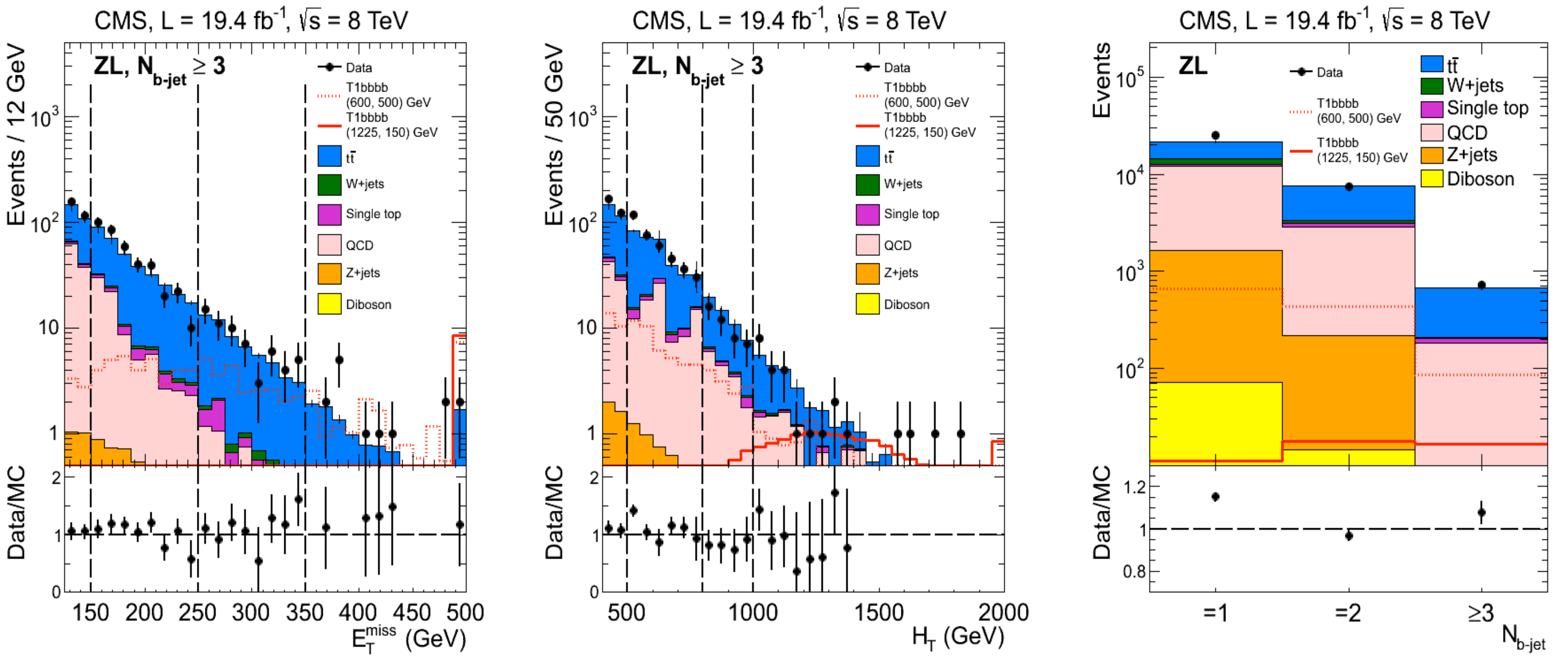
Estimating backgrounds for all-hadronic search

- Two background categories for hadronic search
  - Backgrounds with real MET:
    - Dominant: semi-leptonic ttbar
    - Smaller: W+jets and single top
    - Small but irreducible: Z+jets with $Z \rightarrow \nu\nu$
  - Backgrounds with fake MET (QCD multijet)
- For each background, define control sample
  - ttbar+W+single top (*ttWj*) : Invert e/μ veto to get single lepton (SL) control sample
    - Require M_T(l,MET) < 100 GeV to reduce signal, dilepton contamination
  - QCD : Invert cut on $\Delta\phi_N$ to get Low Delta Phi (LDP) control sample
  - $Z \rightarrow \nu\nu$: $Z \rightarrow l^+l^-$ control sample with loosened b-tag selection





Comparing signal sample to SM predictions



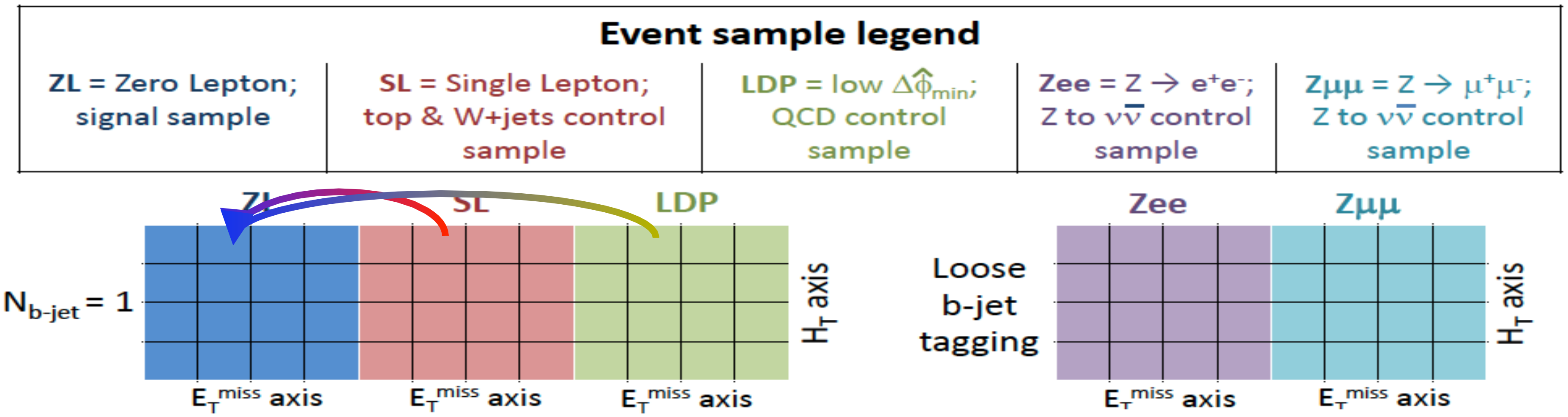
- Distributions in HT, MET, N_b well-described by SM MC
- Dominant contributions from ttbar, multijet QCD events
- Signal contributions on tails of these distributions

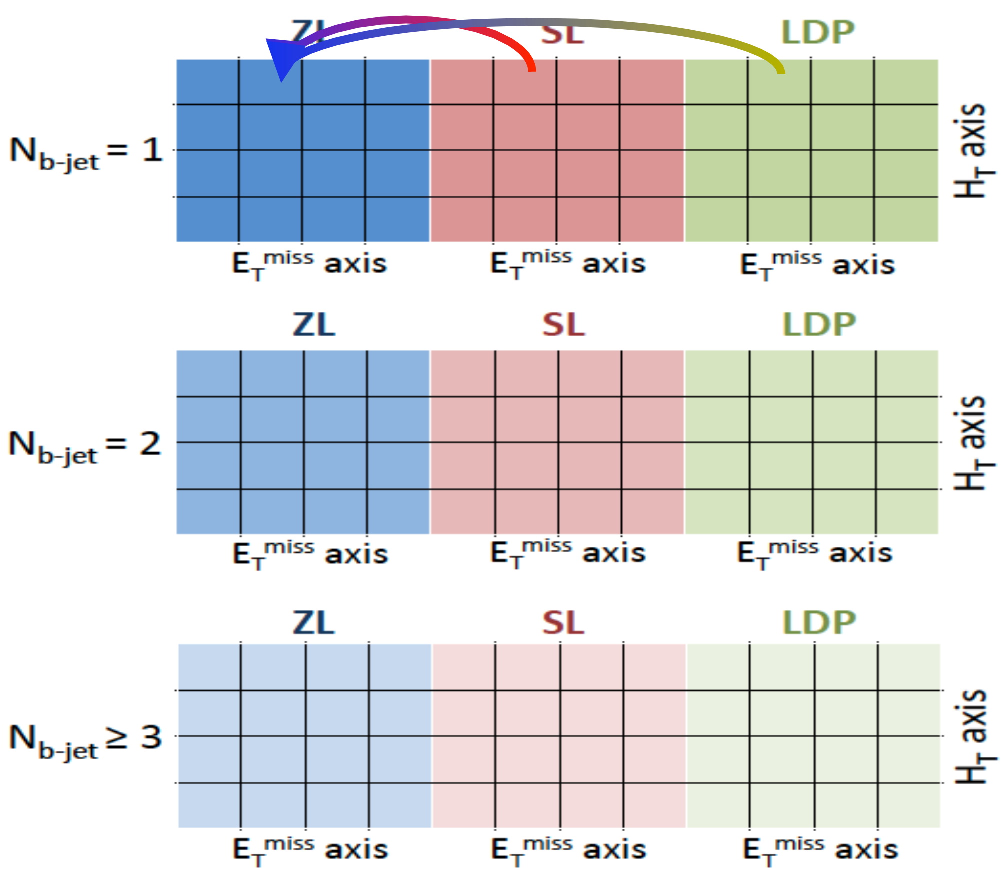
Likelihood fit for all-hadronic search

ZL = Signal Sample

SL = Single Lepton

LDP = Low $\Delta\phi_{\mathrm{min}}$





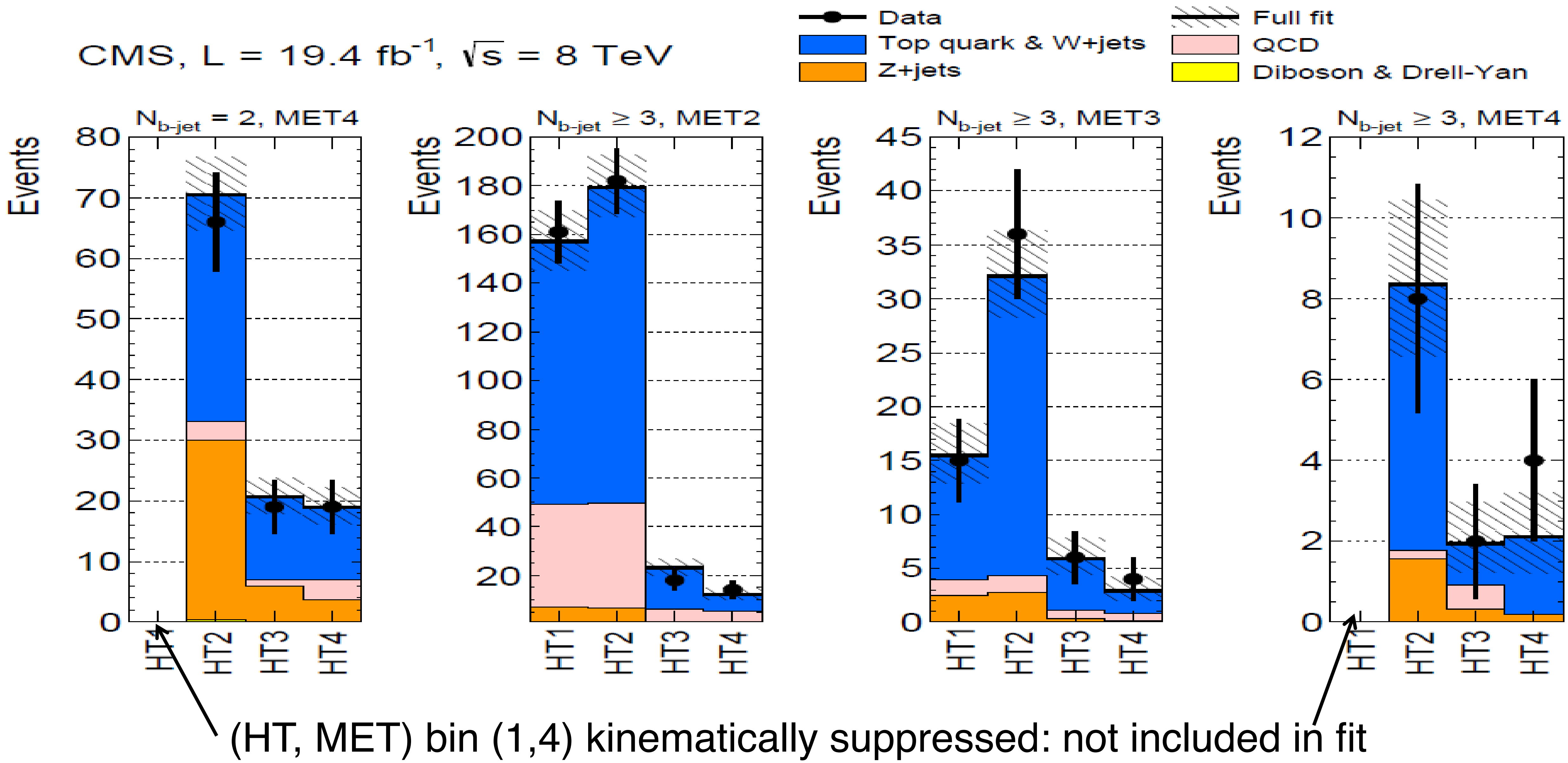
4 bins of HT:
400 – 500 GeV, 500 – 800 GeV, 800 – 1000 GeV, > 1000 GeV

4 bins of MET:
125 – 150 GeV, 150 – 250 GeV, 250 – 350 GeV, > 350 GeV

3 bins of Nb:
Nb =1, 2, ≥ 3

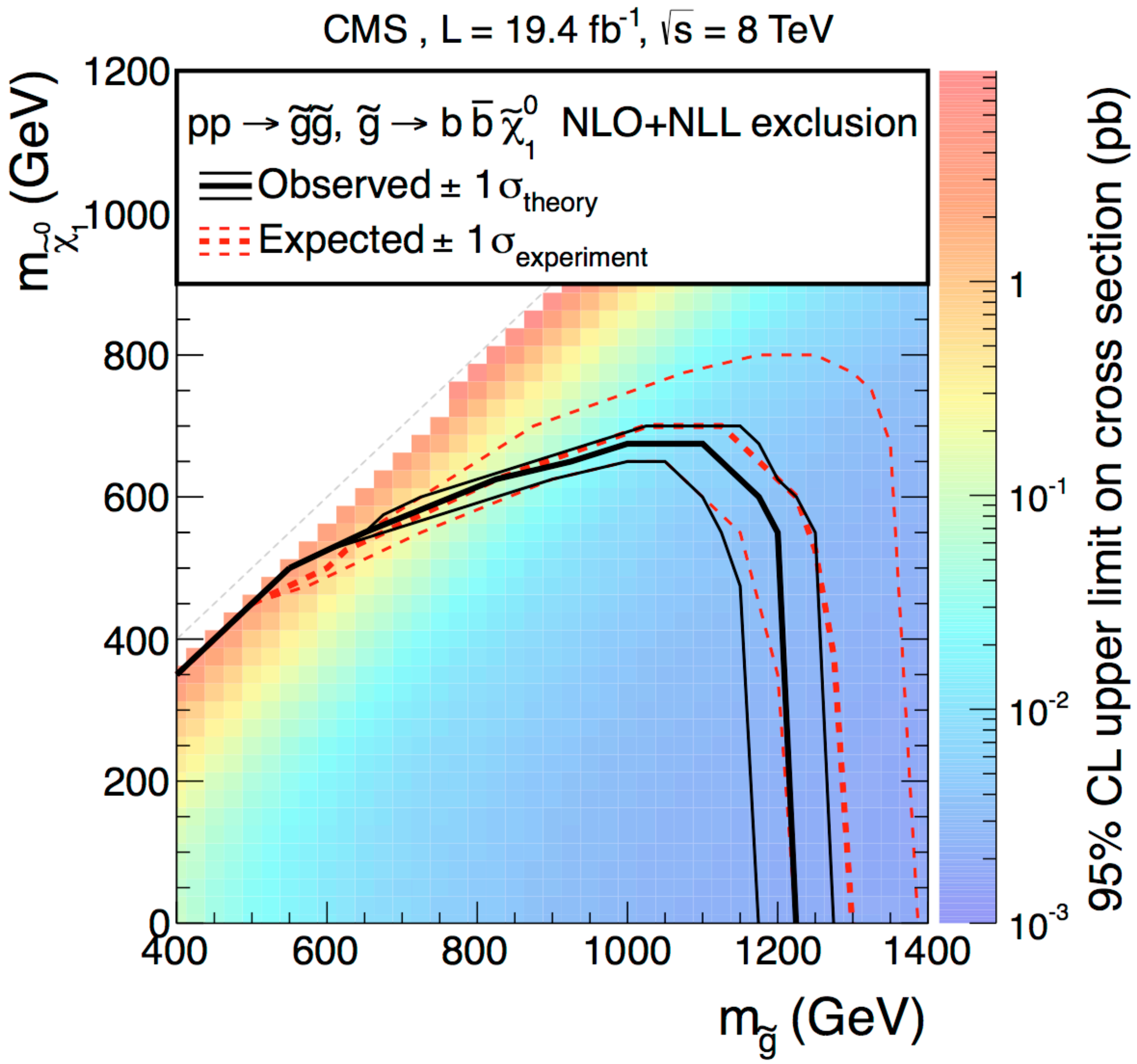
- Simultaneous fit to 4 HT bins, 4 MET bins and 3 N_b bins for signal and control regions
- Each bin of the signal sample has corresponding bins in the control samples
- Coherent treatment of signal and background yields in all regions
- Systematic uncertainties modeled with nuisance parameters

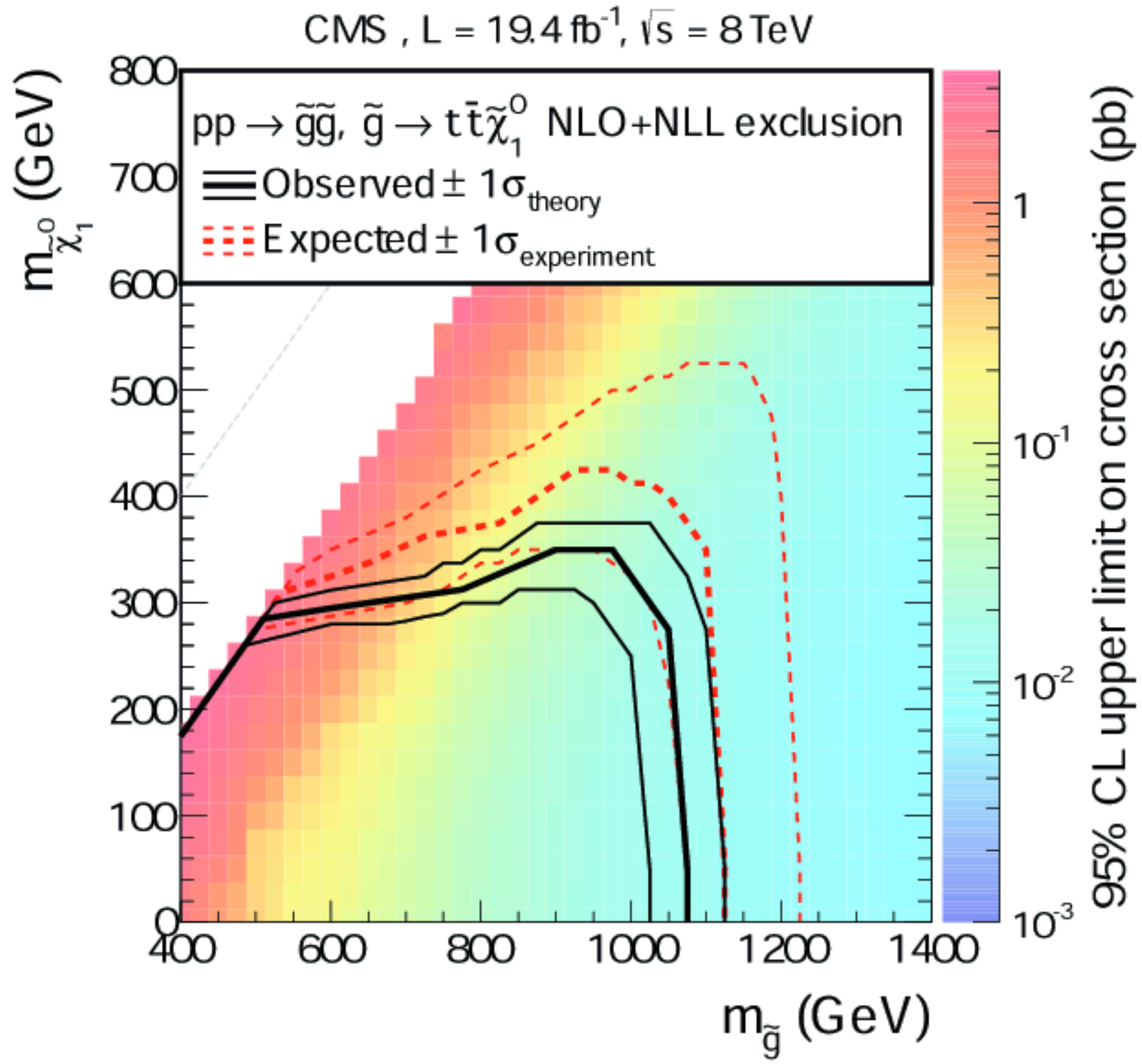
Results from likelihood fit



- Select bins in MET, HT, N_b with highest signal sensitivity, set N_{sig} set to zero
- Global fit to SM contributions matches observation

Exclusion limits for all-hadronic search





- Exclusion limits established using NLO cross section for g̃ pair production, CL_s technique

In limit of light LSP, g̃→bb̄χ̃$_1^0$ models with $M_{\tilde{g}}$ ~ 1200 GeV excluded

Models with g̃→tt̄χ̃$_1^0$ final states excluded up to $M_{\tilde{g}}$ ~ 1100 GeV

Overview of single lepton search

CMS-SUS-13-007

- Search for $\tilde{g}\tilde{g} \rightarrow t\bar{t}t\bar{t}\,\tilde{\chi}_1^0\tilde{\chi}_1^0$ SUSY signature
- Two complementary searches involvling single lepton + multijet final state

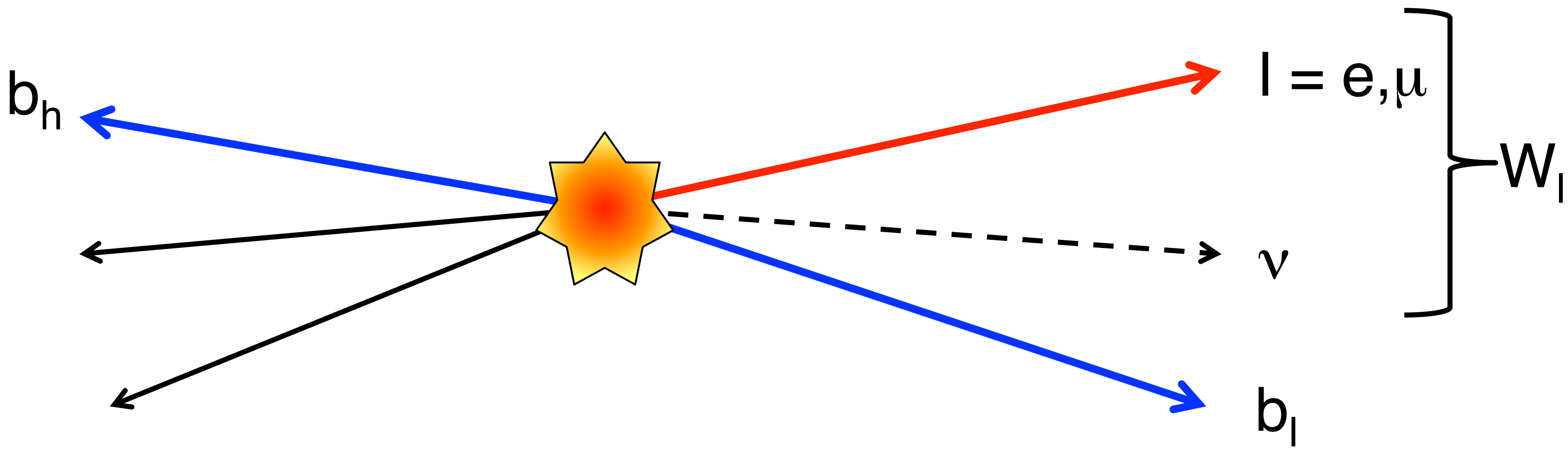
  Delta Phi (Dphi) method: use $\Delta\phi$(W,lep) as discriminating variable

  Lepton Spectrum method: predict high-MET yields using high-p_T tail of lepton spectrum
- Common selections for these searches

  1 lepton [e or μ] ; p_T>20 GeV, $|\eta|<2.4$

  Veto on 2nd loose lepton
- $\geq$ 6 jets with p_T> 40 GeV, $|\eta|<2.4$

  $\geq$ 2 b-tagged jets
- HT > 500 GeV



Single lepton ttbar: kinematics contrain opening angle between lepton,W

Angle is smaller for boosted W's

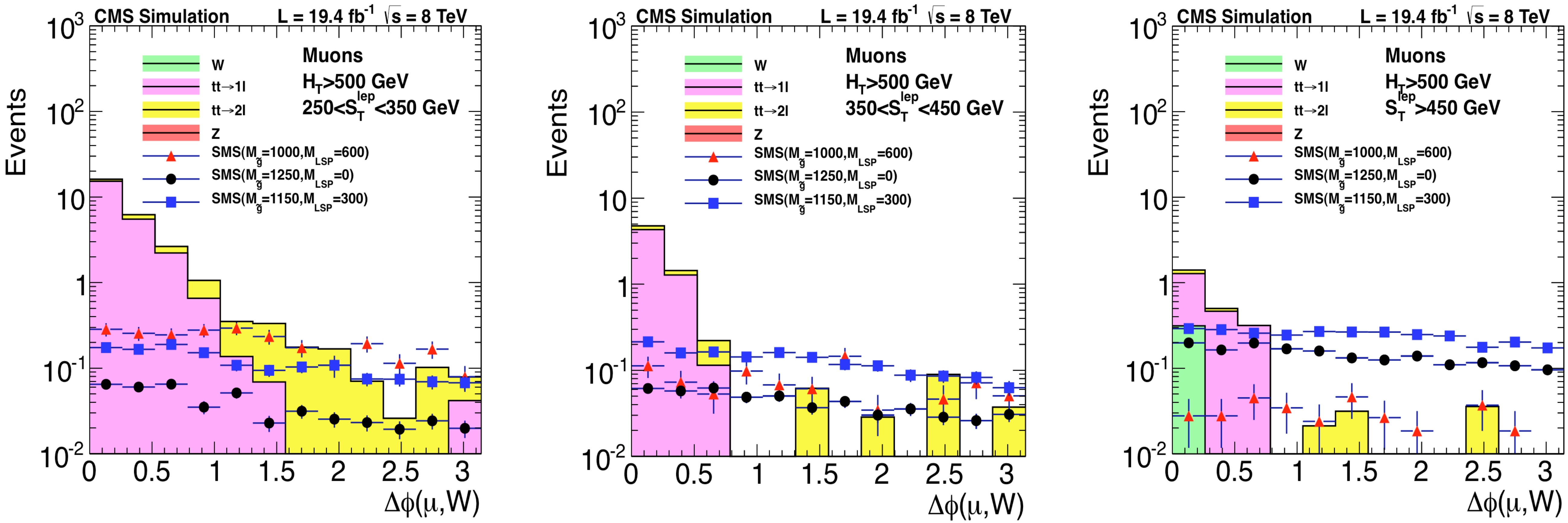
- Key variables: $\Delta\phi(l,W)$ and $S_{T,lep} \equiv MET + p_{T,lep}$

  Search regions: $\Delta\phi(l,W)>1$ and $S_{T,lep}>250$ GeV
- Search will be performed in bins of $S_{T,lep}$ and N_b
- Define two samples based on the jet multiplicity

  Control sample: $3 \leq N_j \leq 5$ (signal depleted)

  Signal sample: $N_j \geq 6$ (signal enhanced)

Predicting SM contributions with Δφ(l,W)



- Define R_{CS} ratio for separating signal from SM background

$$R_{CS} = \frac{signal}{control} = \frac{N(\Delta\phi(W,l) > 1)}{N(\Delta\phi(W,l) < 1)}$$

Typically small (< 0.1) for dominant SL ttbar background

Signal models expected to have much higher R_{CS} values

Characterizing dependence of R_{CS} on N_b

- Correction factor κ accounts for any dependence of R_{CS} on N_b

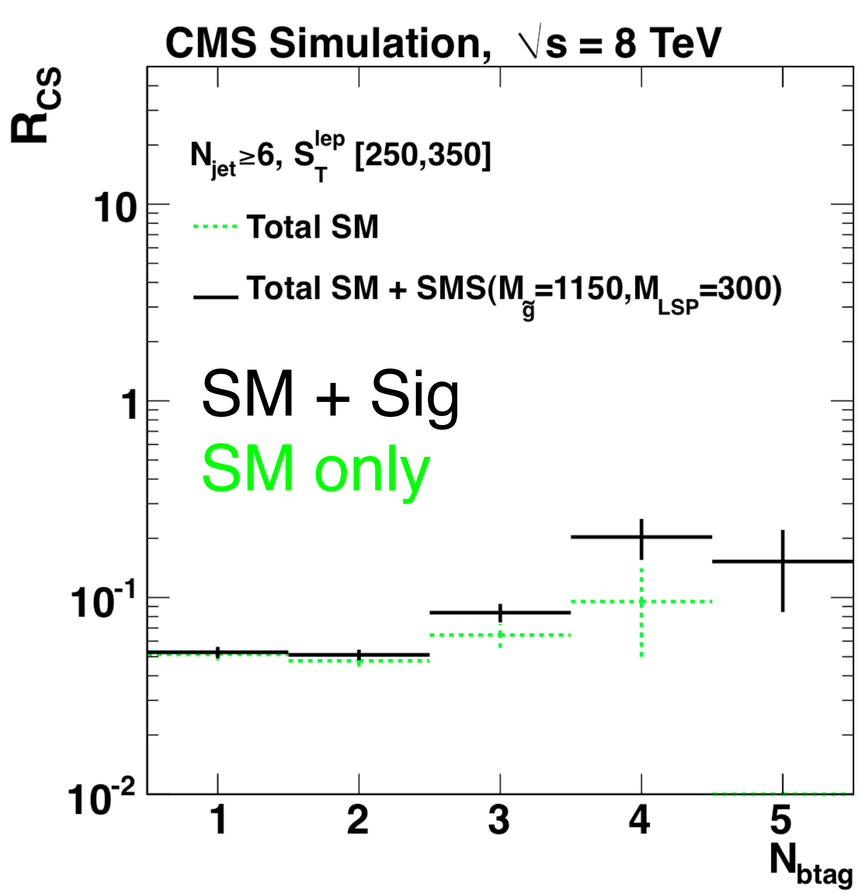
$$R_{CS}(N_b) = R_{CS}(N_b = 1) \cdot \kappa_{CS}(N_b)$$

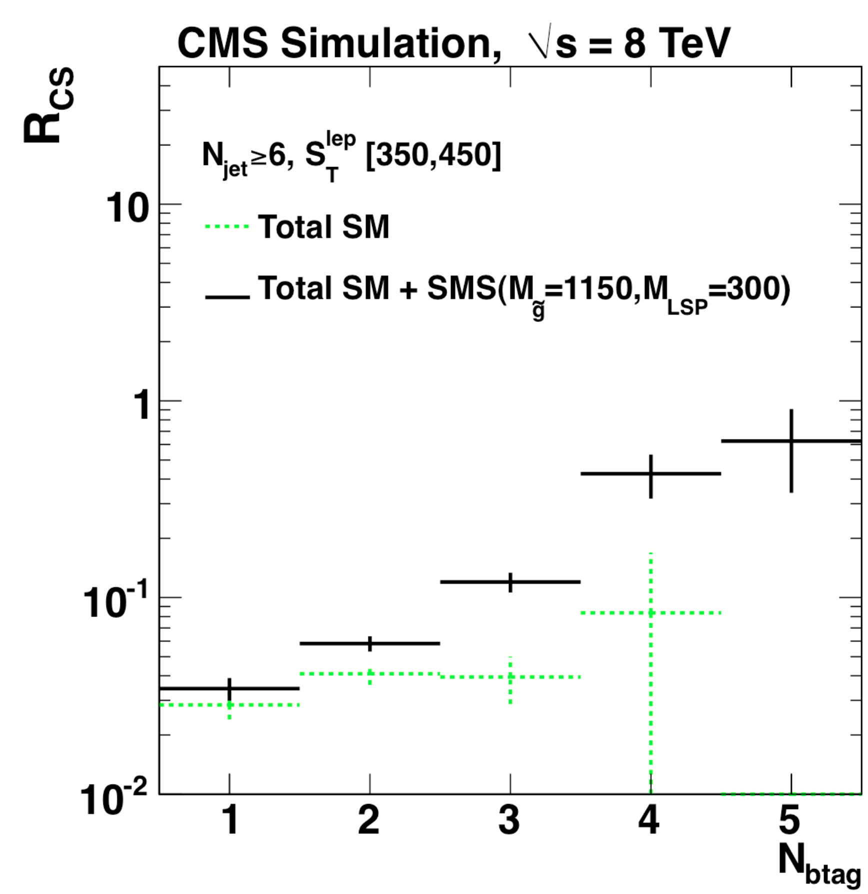
$R_{CS}(N_b=1)$ measured in data, κ evaluated from MC

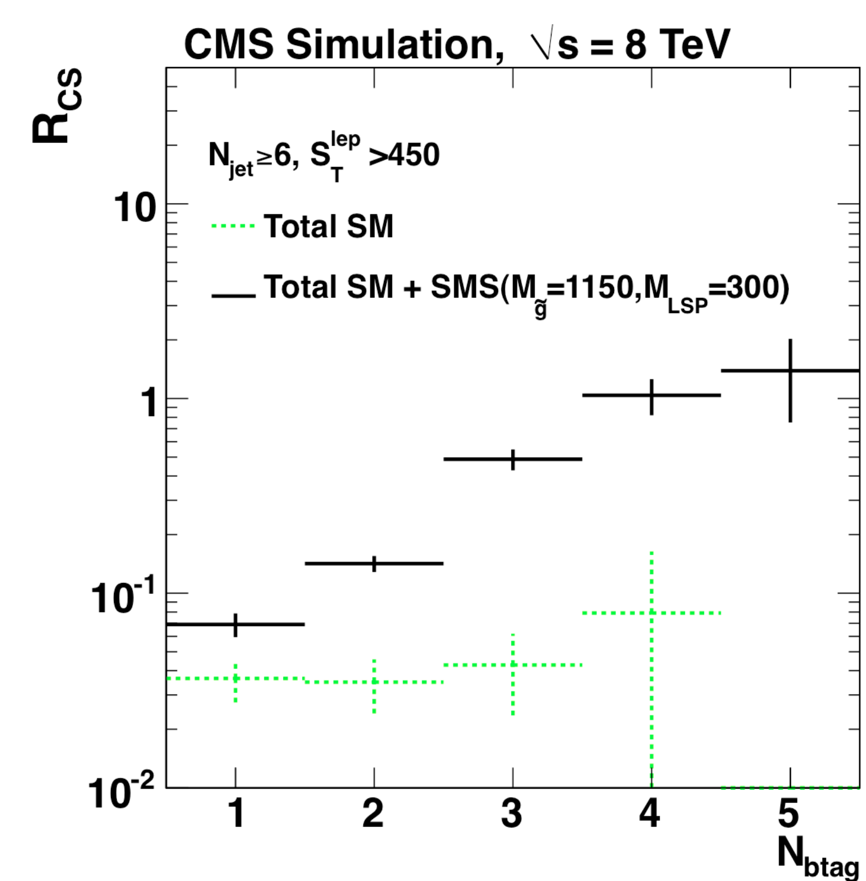
- In absence of signal, R_{CS} has little dependence on N_b ($\kappa \sim 1$)

R_{CS} values for Nb = 1 control sample

		S_T^{lep} [GeV]	control	signal	R_{CS}
$N_{btag}=1$	Muons	[250,350]	192	9	0.05 ± 0.02
		[350,450]	55	2	0.04 ± 0.03
		>450	10	0	<0.1
	Electr.	[250,350]	169	6	0.04 ± 0.01
		[350,450]	44	3	0.07 ± 0.04
		>450	17	0	<0.06







Results from DPhi method

		S_T^{lep} [GeV]	control reg. data	prediction	observation
N_{btag}=2	Muons	[250,350]	141	$6.00 \pm 2.23 \pm 2.40$	9
		[350,450]	24	$1.37 \pm 1.12 \pm 1.19$	2
		>450	9	$0.0 \pm 0.66 \pm 0.66$	0
	Electr.	[250,350]	112	$3.83 \pm 1.75 \pm 1.84$	9
		[350,450]	28	$2.74 \pm 1.86 \pm 2.02$	2
		>450	9	$0.0 \pm 0.42 \pm 0.42$	0
$N_{btag} \geq 3$	Muons	[250,350]	28	$1.92 \pm 0.84 \pm 0.95$	0
		[350,450]	13	$0.57 \pm 0.52 \pm 0.58$	0
		>450	2	$0.0 \pm 0.22 \pm 0.22$	0
	Electr.	[250,350]	45	$1.89 \pm 0.94 \pm 1.03$	4
		[350,450]	7	$0.85 \pm 0.70 \pm 0.80$	0
		>450	0	$0.0 \pm 0.08 \pm 0.08$	0

- Observations consistent with SM predictions
- Precision of prediction not limited by statistics of control sample

Details of lepton spectrum method

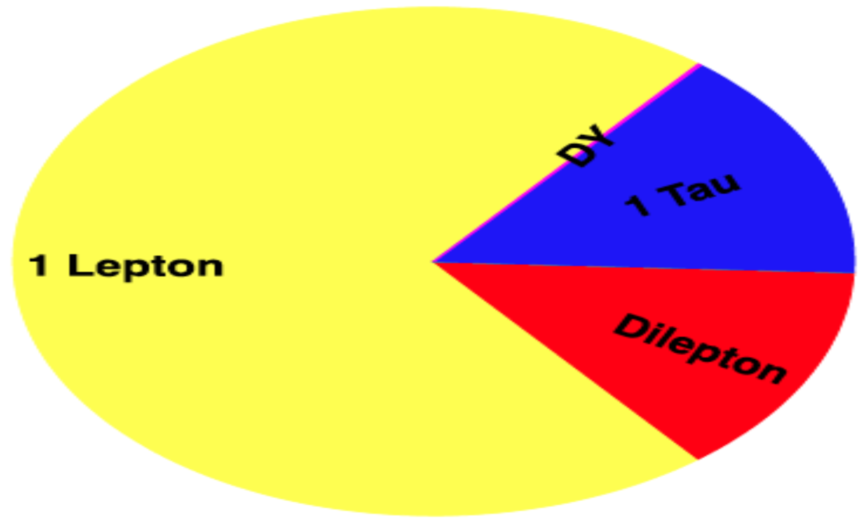
- Complementary to DPhi analysis
  - DPhi: leptonic side of event
    - Search binned in $\Delta\phi(W,l)$ S_T
  - LS: hadronic side of event
    - Search binned in HT, MET
- Predict the high MET tail based on high p_T tail of the lepton spectrum in data
  - $W \to l\nu$ is a 2-body decay
- Correct for MET vs $p_{T,l}$ resolution using MET templates from multijet sample
- Apply correction factor (κ) to correct for W polarization, biases from lepton selection, other BG contributions

$$\kappa = \frac{N_{true}}{N_{pred}}$$

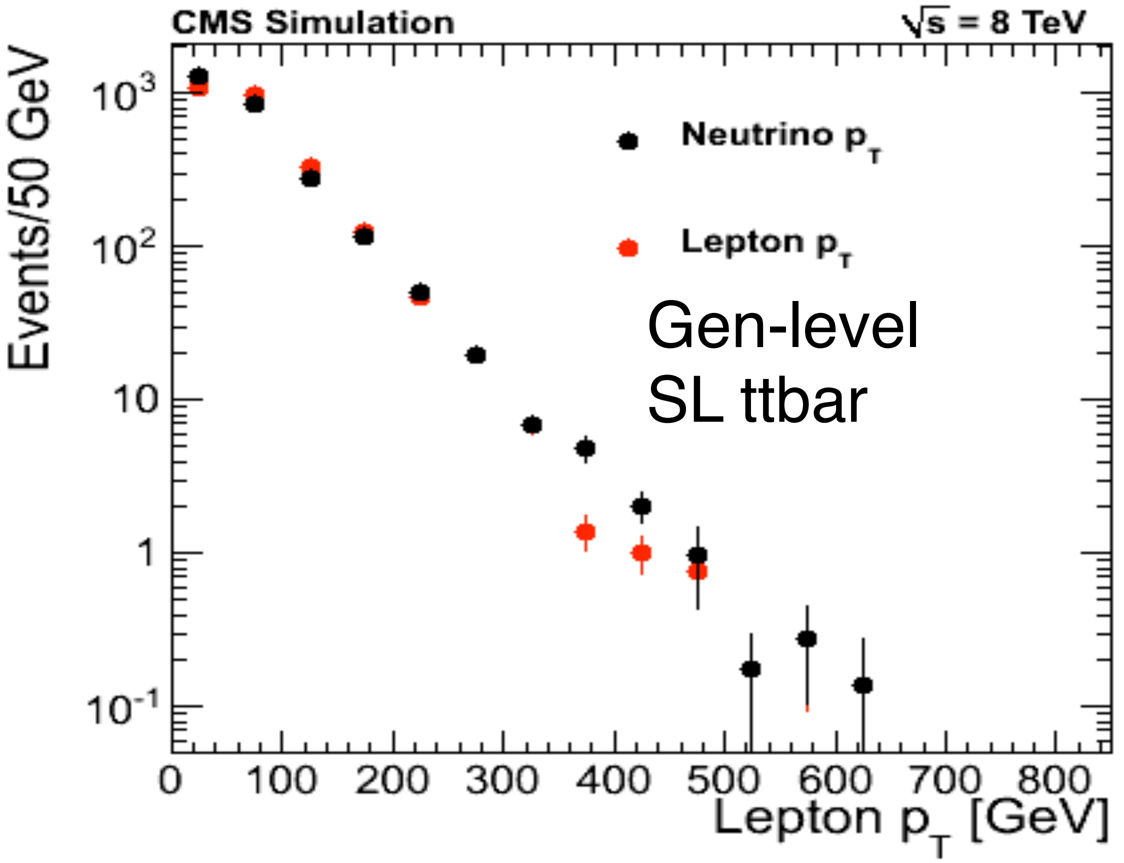
N_{true} = true yield in SL sample
N_{pred} = predicted yield from all events passing selection

- Contributions from τ predicted separately

H_T>500 GeV, MET>150 GeV, N_{jet}≥6, N_b≥2



Relative yields from data-driven prediction



Predicting τ contributions to MET

- Three possible contributions from final states with τ's

  Single τ→l , l + τ→l , l + τ→had

- Generate τ response functions ($p_{T,\mu}/p_{T,\tau}$) from ttbar events with one hadronic, one W→τ→μ decay

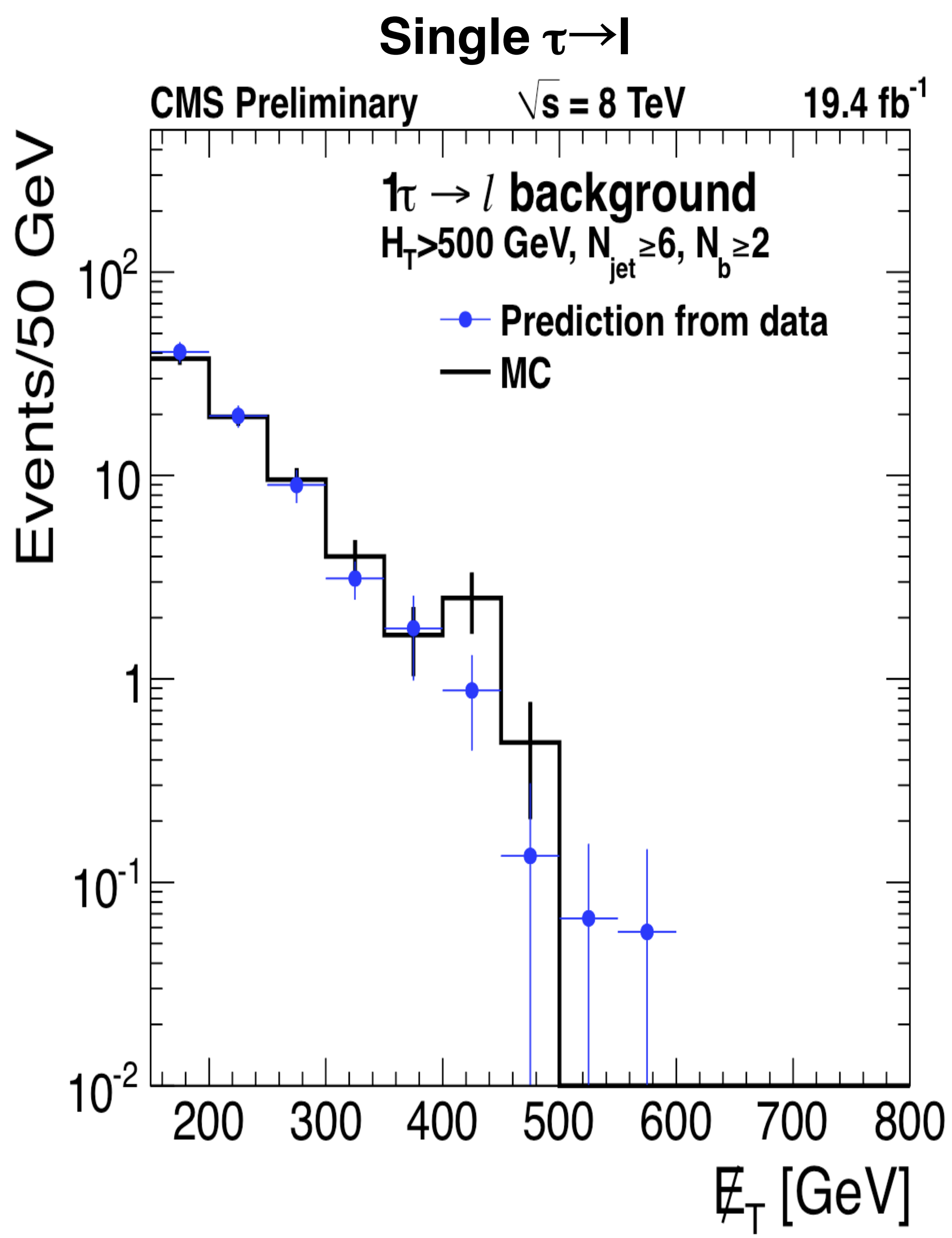
- In single μ control sample, sample τ response function

  Recalculate event quantites based on modified p_T

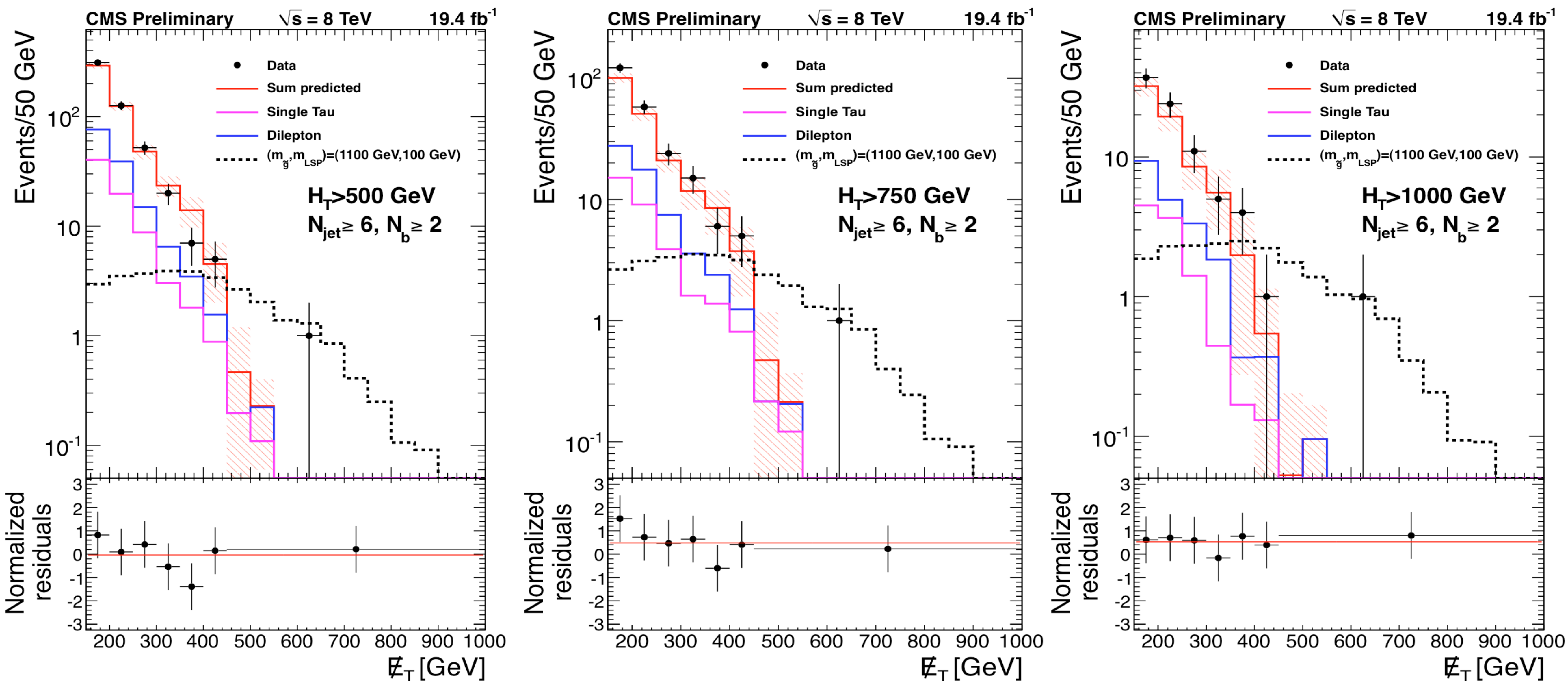
  Apply correction factors for BR and acceptance (α), residual differences (κ) to emulated MET

- Apply similar recipe to DL control sample for predicting l + τ→l and l + τ→had contributions

  In hadronic case, treat emulated τ as jet and use hadronic response function

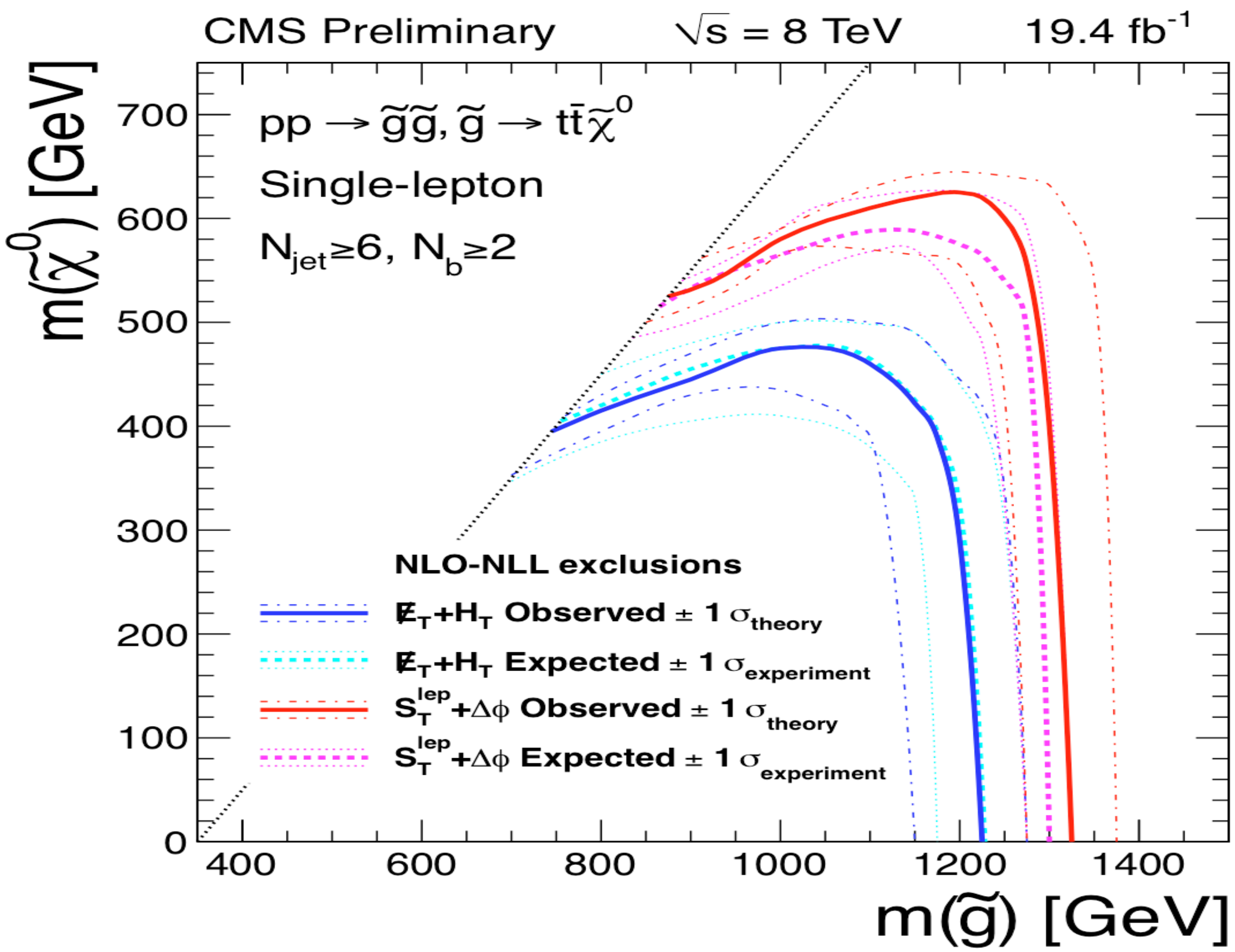


Results from lepton spectrum method



- Overall good agreement between data and prediction
- No excess observed in high-MET signal region

Exclusion limit for single lepton searches



- As with hadronic search, CL_s approach using all bins in signal sample

DPhi analysis excludes $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$ models up to to $M_{\tilde{g}}$ ~ 1325 GeV

LS analysis excludes up to $M_{\tilde{g}}$ ~ 1225 GeV

Summary

- We have performed searches for gluino-mediated SUSY production with 4t and 4b final states using two different event selections

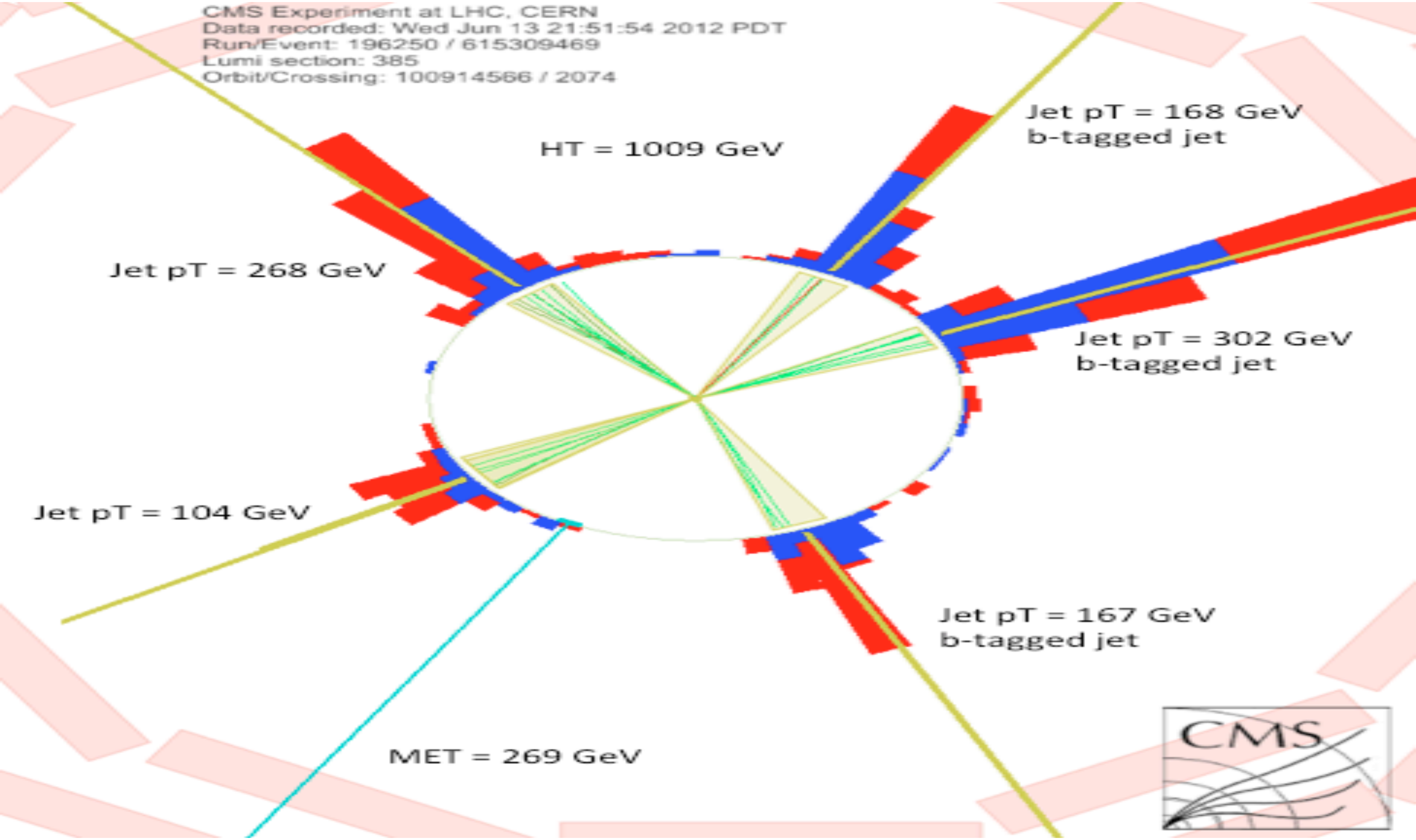
  Observed yields consistent with predictions of SM background

- Simplified models with $\tilde{g} \rightarrow t\bar{t}\tilde{\chi}_1^0$ and $\tilde{g} \rightarrow b\bar{b}\tilde{\chi}_1^0$ final states both excluded up to $M_{\tilde{g}} \sim 1.2 - 1.3$ TeV

  Consistent results using a variety of methods of predicting SM background

Backup Slides for All-Hadronic + btag search

Event display of hadronic signal event



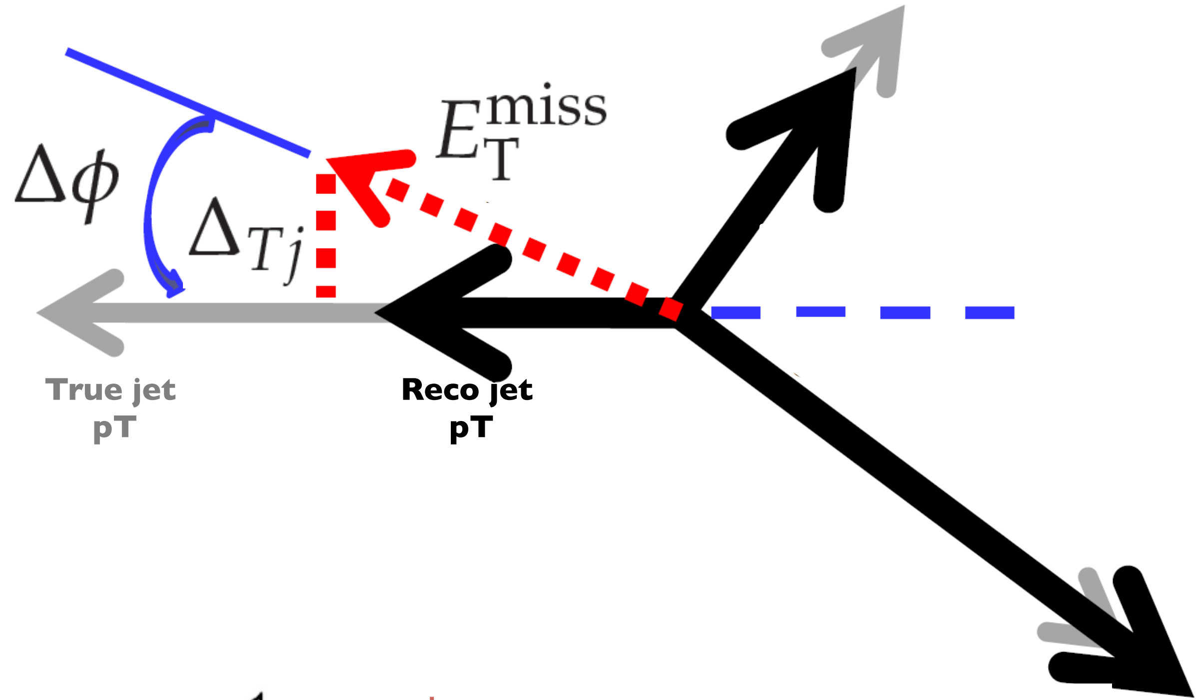
Predicting QCD with $\Delta\hat{\phi}$

- Invert the cut on the angle between MET and leading jets:

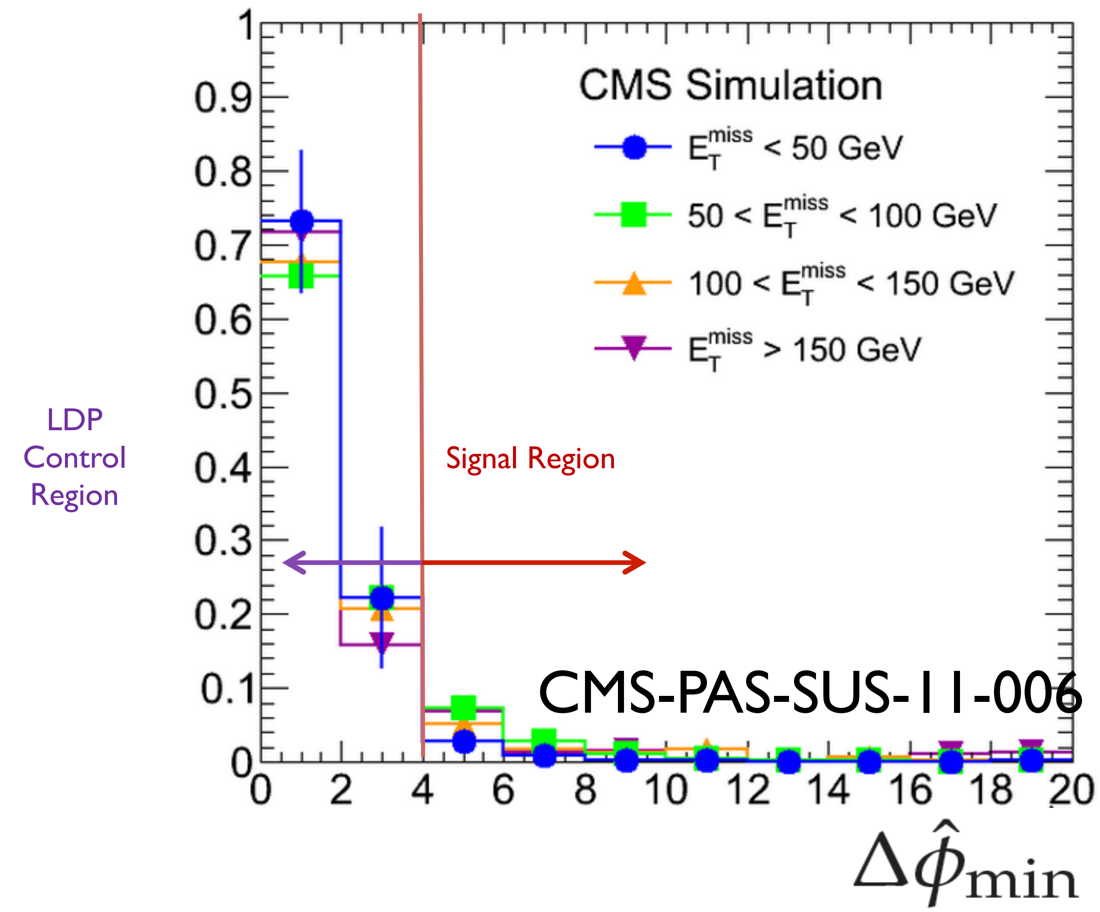
$$\Delta\hat{\phi}_j \equiv \Delta\phi(j, E_{\mathrm{T}}^{\mathrm{miss}}) / \sin^{-1}(\Delta_{Tj}/E_{\mathrm{T}}^{\mathrm{miss}})$$

where:

$$\Delta_{Tj} = 0.1 \frac{\sqrt{\sum_{i \neq j}\left[p_x^j p_y^i - p_y^j p_x^i\right]^2}}{p_{\mathrm{T}}^j}$$



- Inverting the cut provides a QCD-rich control sample for predicting this background (LDP)
- Is not highly correlated with MET



Fitting ZL Contribution from ttWj

- Prediction for each bin of ZL signal sample from corresponding yield in SL sample

$$n_{SL;i,j,k} = \epsilon^{trig}_{SL;i,j,k} \cdot (\mu^{ttWj}_{SL;i,j,k} + S^{SUSY}_{SL;i,j,k} \cdot \mu^{SUSY}_{SL;i,j,k})$$

SL observed events | Correction for trig. eff. | Floating SL Yield | SUSY contribution & systematic term ($\tilde{g} \to t\bar{t}\tilde{\chi}_1^0$ only)

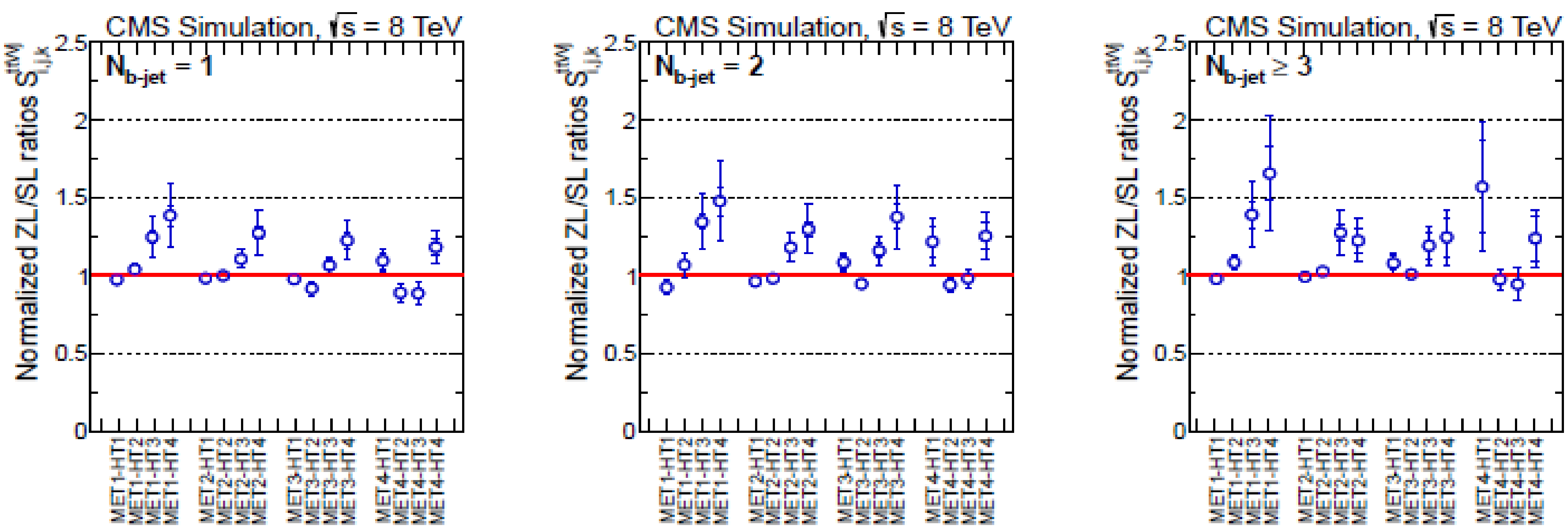
Floating ZL yield

$$\mu^{ttWj}_{ZL;i,j,k} = S^{ttWj}_{i,j,k} \cdot R^{ttWj}_{ZL/SL} \cdot \mu^{ttWj}_{SL;i,j,k}$$

Floating SL Yield

$S^{ttWj}_{i,j,k}$ Bin-by-bin correction term

$R^{ttWj}_{ZL/SL}$ Global floating normalization param



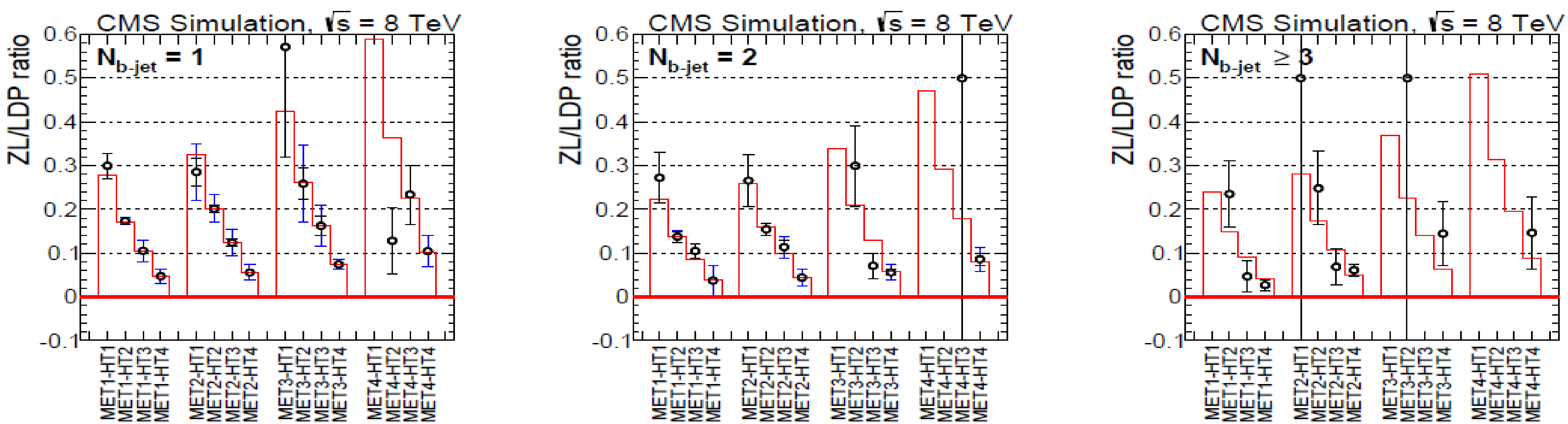
Lepton isolation cut results in fewer SL events at high HT

Fitting Contribution from QCD

- Invert cut on normalized $\Delta\phi(\text{MET},\text{jet}_{1,2,3})$ to establish low-$\Delta\phi_N$ LDP hadronic sample
- Predict QCD yield from ratio of ZL/LDP
  - Correct HT/MET/Nb dependence with individual K-factors

$$\mu^{QCD}_{ZL;i,j,k} = S^{QCD}_{i,j,k} \cdot \left(K^{QCD}_{met,i} \cdot K^{QCD}_{HT,j} \cdot K^{QCD}_{nb,k} \right) \cdot \mu^{QCD}_{LDP;i,j,k}$$

  - Float KQCD factors to observations from data when statistics allow



Factorized model (red) closes well with MC ratios (black)

Fitting Contribution from Z→νν

- Predict Z→νν yield from events in Z peak for Z→e$^+$e$^-$, Z→μ$^+$μ$_-$ events with loosened b-tagging requirements
  - Relate prediction to yields from N_b = 1

$$\mu^{Zll}_{Zll,i,j} = (\mu^{Z\nu\nu}_{Z\nu\nu,i,j} \cdot S_{ll} \cdot A_{ll,i} \cdot \varepsilon_{ll}) / (F_{Z\nu\nu,1} \cdot R_B)$$

    - S: Scale factor to account for systemaic uncertainties
    - A×ε : Acceptance and efficiecy
    - F: Ratio relating looser b-tag to N_b = 1
    - R_B: Branching ratio fraction Z→νν / Z→l$^+$l$^-$
  - Scale prediction for N_b = 1 by b-tag ratios to predict yields for N_b = 2, ≥ 3

$$\mu^{Z\nu\nu}_{ZL,i,j,k} = \mu^{Z\nu\nu}_{ZL,i,j,k} \cdot (F_{Z\nu\nu,k} / F_{Z\nu\nu,1})$$

Results from All-Hadronic Analysis

Observed number of events					
$N_{\text{b-jet}} \geq 3$	HT1	HT2	HT3	HT4	HT1-4
MET2	161	182	18	14	375
MET3	15	36	6	4	61
MET4	—	8	2	4	14
MET2-4	176	226	26	22	450

SM background estimates from fit					
$N_{\text{b-jet}} \geq 3$	HT1	HT2	HT3	HT4	HT1-4
MET2	157^{+13}_{-12}	179^{+13}_{-12}	$23.2^{+3.8}_{-3.4}$	$12.3^{+2.7}_{-2.3}$	372^{+19}_{-18}
MET3	$15.5^{+3.0}_{-2.6}$	$32.1^{+4.3}_{-3.8}$	$5.9^{+1.9}_{-1.5}$	$2.9^{+1.3}_{-1.0}$	$56.5^{+5.7}_{-5.4}$
MET4	—	$8.4^{+2.1}_{-1.8}$	$2.0^{+1.0}_{-0.7}$	$2.1^{+1.1}_{-0.9}$	$12.4^{+2.5}_{-2.2}$
MET2-4	173^{+13}_{-12}	220^{+14}_{-13}	$31.0^{+4.3}_{-3.8}$	$17.3^{+3.1}_{-2.8}$	441^{+20}_{-19}

SM background predictions from simulation					
$N_{\text{b-jet}} \geq 3$	HT1	HT2	HT3	HT4	HT1-4
MET2	127 ± 8	180 ± 12	27 ± 2	13 ± 1	347 ± 14
MET3	14.7 ± 0.7	30.9 ± 0.7	7.5 ± 0.4	3.9 ± 0.2	56.9 ± 2.6
MET4	—	6.1 ± 0.2	2.6 ± 0.2	2.6 ± 0.2	11.3 ± 0.3
MET2-4	141 ± 8	217 ± 12	37 ± 2	20 ± 1	415 ± 15

SM background estimates from sideband fit					
$N_{\text{b-jet}} \geq 3$	HT1	HT2	HT3	HT4	HT1-4
MET2	119^{+32}_{-19}	158^{+36}_{-24}	$28.2^{+6.9}_{-5.7}$	$10.2^{+3.5}_{-2.7}$	316^{+49}_{-37}
MET3	$15.2^{+4.3}_{-3.5}$	$27.7^{+5.8}_{-4.9}$	$5.6^{+2.6}_{-1.9}$	$2.0^{+1.5}_{-0.9}$	$50.5^{+8.2}_{-7.3}$
MET4	—	$8.3^{+2.9}_{-2.2}$	$1.9^{+1.3}_{-0.8}$	$0.4^{+0.6}_{-0.2}$	$10.5^{+3.2}_{-2.5}$
MET2-4	134^{+32}_{-20}	194^{+36}_{-26}	$35.7^{+7.5}_{-6.3}$	$12.6^{+3.8}_{-3.0}$	377^{+51}_{-42}

- Observations consistent with SM predictions

Backup Slides for Single Lepton + btag search

Predicting QCD for DPhi Method

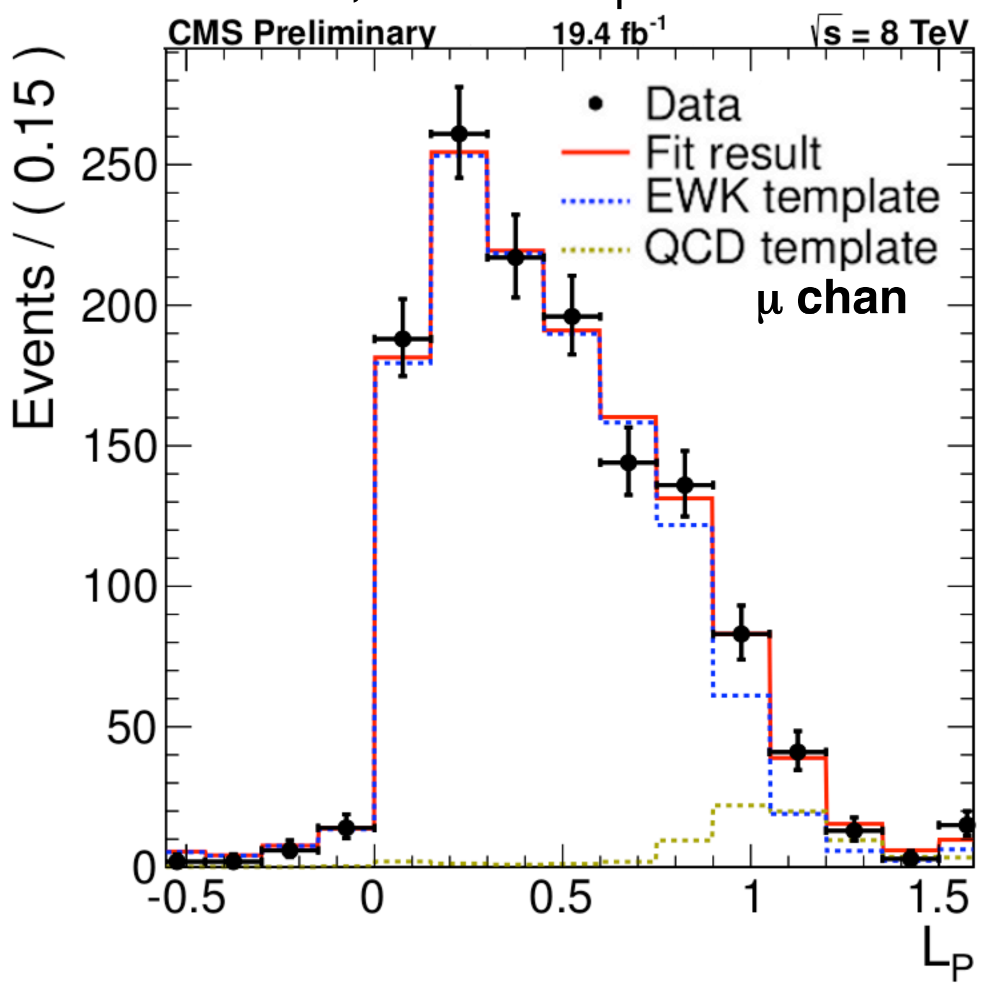
- Muon channel: QCD contribution estimated from fit to L_P in control sample

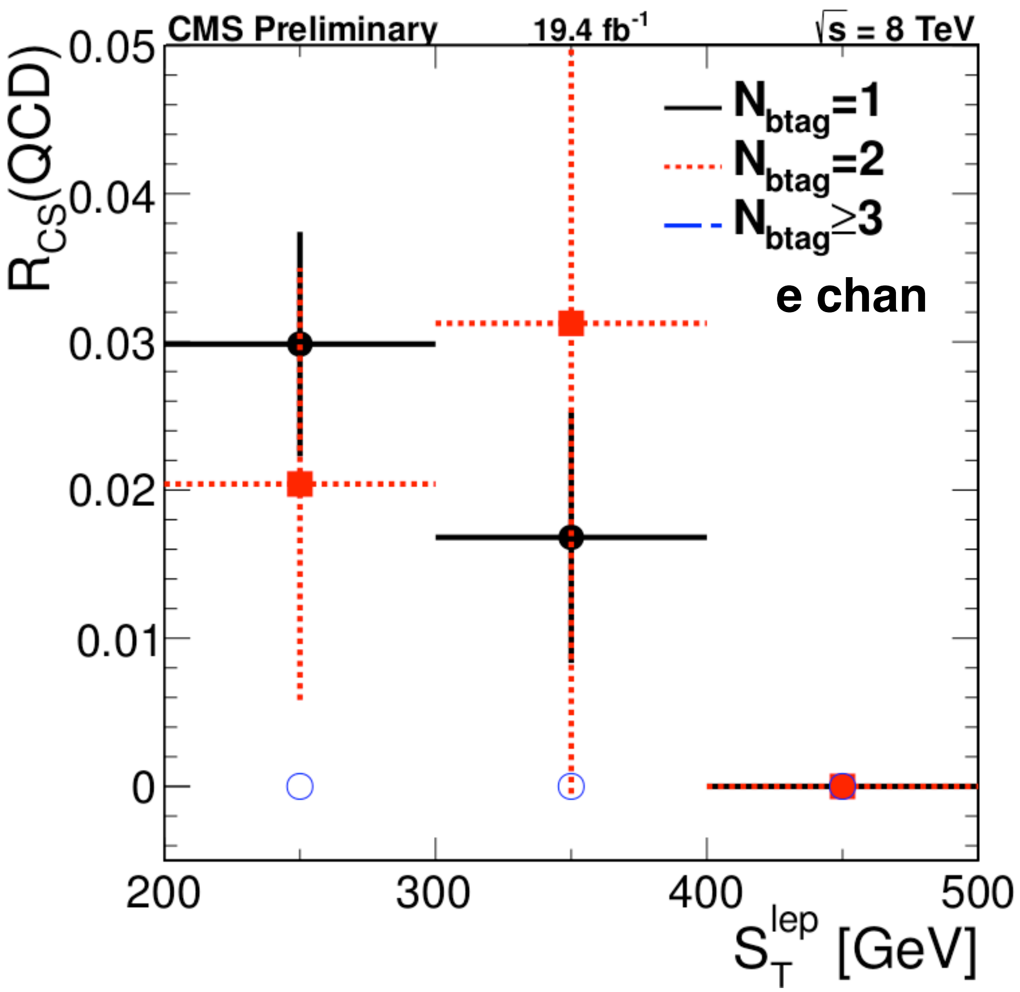
$$L_p = \frac{\vec{p}_{T,l} \cdot \vec{p}_{T,W}}{|\vec{p}_{T,W}|^2}$$

- Electron channel: QCD contribution estimated from R_{CS} in sample with inverted electron selection cuts

- QCD contribution found to be negligible in signal region for both channels

Nb = 1, 250 < S_T < 350 GeV





Systematic Uncertainties for LS, DPhi Methods

Systematic uncertainties for DPhi Method: 3 or more b-tags

	$\Delta\kappa/\kappa$ (%)		
	$250 < S_T^{lep} < 350$ GeV	$350 < S_T^{lep} < 450$ GeV	450 GeV $< S_T^{lep}$
MC sample size	22	44	68
JES	3	7	6
ϵ_{btag}(c,b)	<1	<1	1
ϵ_{btag}(light)	<1	2	2
W cross-section	2	3	6
W+b$\bar{\text{b}}$ cross-section	2	4	7
Wt and t cross-section	4	6	11
Total	23	45	70

Systematic uncertainties for LS Method

$\not{E}_T$ bin:	[150, 250)	[250, 350)	[350, 450)	$\geq$ 450 GeV
$\not{E}_T$ and jet energy scale	3.0/2.1/1.1	8.4/8.7/12	9.0/6.5/7.2	28/30/31
W polarization in $t\bar{t}$	3.1/3.4/4.3	4.1/4.1/3.9	5.2/5.8/4.9	5.2/5.4/3.2
W polarization in W+jets	<0.1/0.1/0.2	0.2/0.1/0.2	0.8/0.7/1.1	1.6/1.7/2.5
$\sigma(t\bar{t})$	0.9/1.3/1.1	0.5/1.1/2.1	0.3/0.1/0.7	1.3/1.0/1.6
σ(W)	0.4/0.5/0.4	0.2/0.4/0.8	1.1/0.4/1.3	1.2/0.3/1.2
Single top cross section	0.6/1.3/0.3	0.4/1.3/3.2	0.2/0.1/0.4	< 0.1/< 0.1/0.1
Lepton efficiency (μ) vs. p_T	0.5/0.5/0.5	0.5/0.5/0.6	0.5/0.5/0.8	0.2/0.2/0.7
Lepton efficiency (e) vs. p_T	0.2/0.2/0.2	0.2/0.2/0.2	0.2/0.2/0.1	0.3/0.3/0.2
Z+jets background	0.2/0.3/0.4	0.4/0.4/0.1	1.2/1.0/0.9	0.3/0.4/< 0.1
μ p_T resolution	<0.1/<0.1/<0.1	0.1/0.4/0.8	1.4/1.3/3.4	2.7/1.5/2.5
Total (excluding scale factors)	4.5/4.5/4.8	9.5/9.8/11	13/9.8/9.6	29/31/31
MC statistics (scale factors)	3.2/4.8/8.0	8.0/10/16	19/21/30	31/33/44
Total	5.5/6.6/9.3	12/14/19	23/23/31	42/45/54

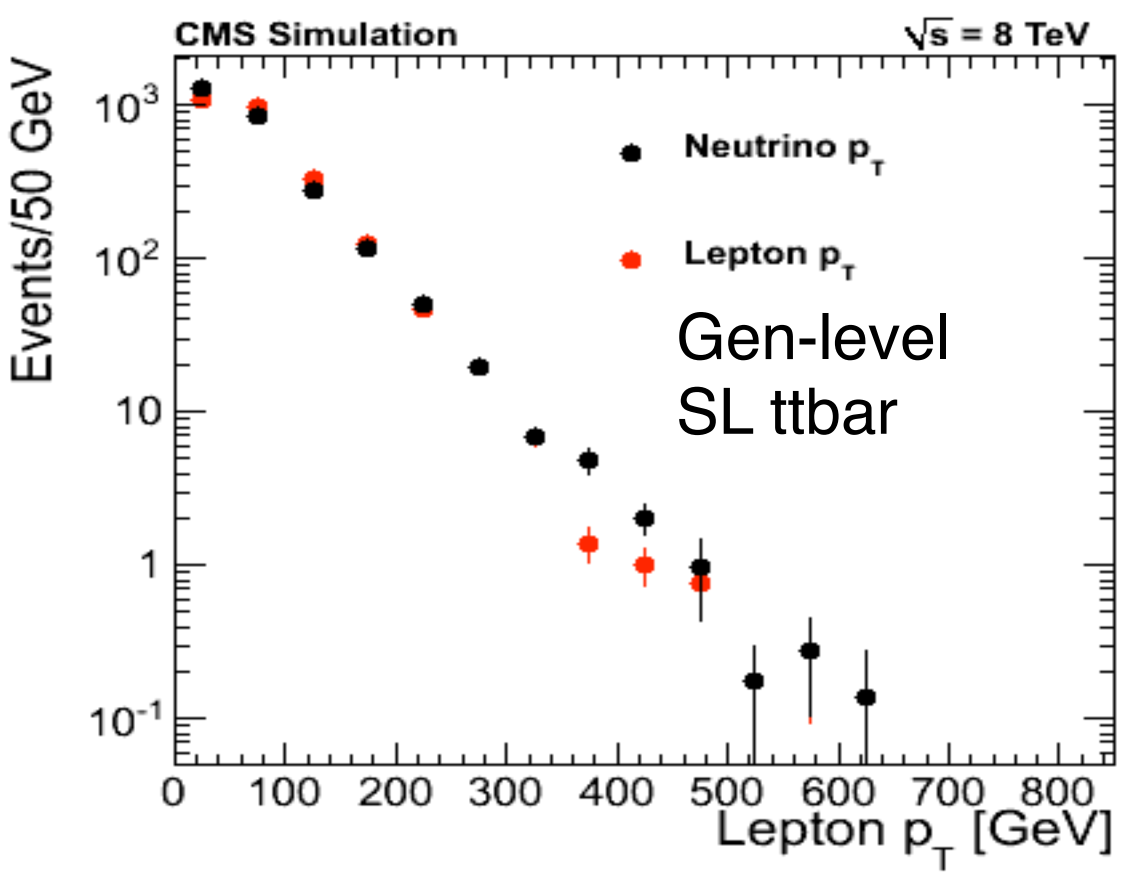
Details of Lepton Spectrum Method

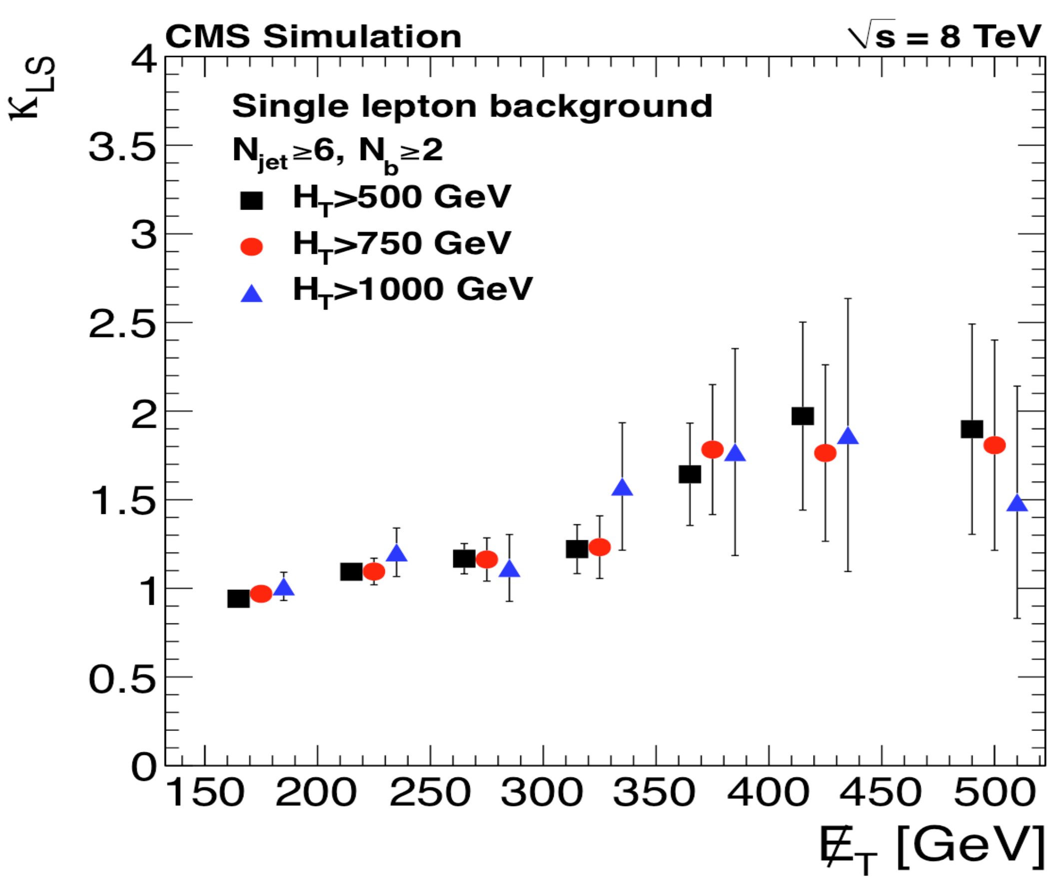
- Correct for MET vs $p_{T,l}$ resolution using MET templates from multijet sample
- Apply correction factor (κ) to correct for W polarization, biases from lepton selection, other BG contributions

Contributions from τ predicted separately

$$\kappa = \frac{N_{true}}{N_{pred}}$$

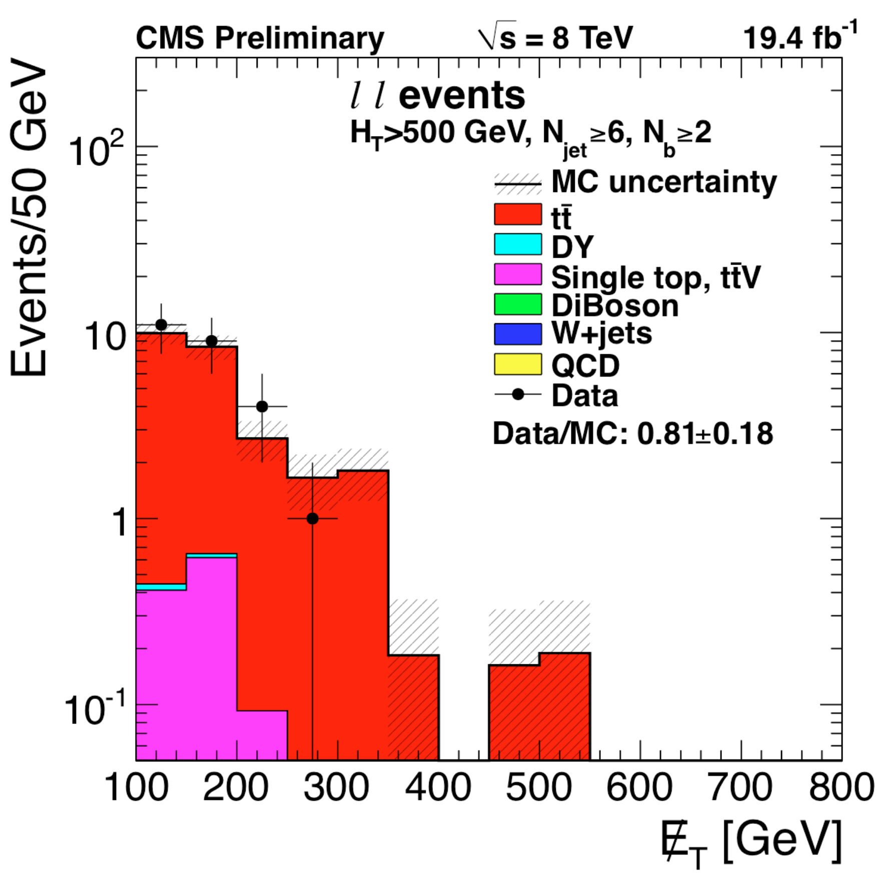
N_{true} = true yield in SL sample
N_{pred} = predicted yield from including all final states passing selection



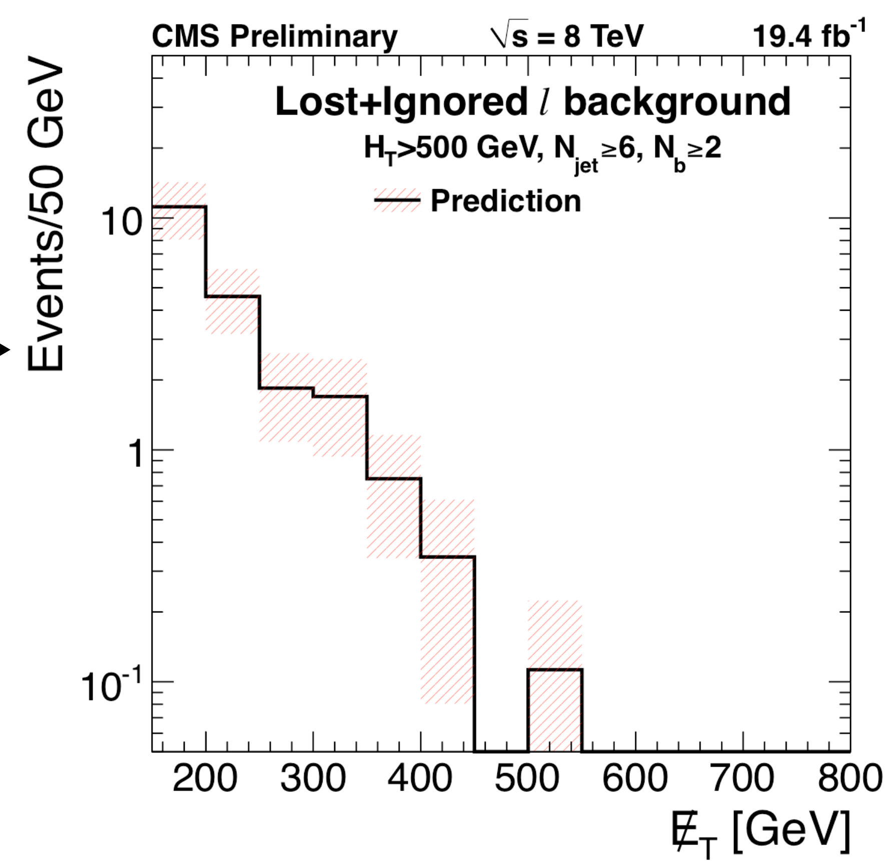


Predicting Dilepton Contributions

- Dilepton events in signal region from either lost (recontruction) or ignored (acceptance, isolation) 2nd lepton
  - Obtain scale factor from MC yield data/MC ratio in DL control sample
  - Apply scale factor to MET distribution of DL sample passing selection cuts



Apply Data/MC SF →



Systematic Uncertainties for Tau, Dilepton pieces of LS method

Systematic uncertainty for t prediction: |1 – κ|
(κ = correction factor for residual differences)

$\not{E}_T$ bin	$1\tau \to 1\ell$	$\ell + \tau \to \ell$	$\ell + \tau \to$ hadrons
[150, 250)	11/16/19	28/34/70	16/20/35
[250, 350)	16/19/29	37/65/131	21/25/35
[350, 450)	39/43/95	73/121/115	43/45/60
[450, ∞)	120/99/309	97/95/113	97/95/88

Systematic uncertainties for dilepton prediction

$\not{E}_T$ bin	[150, 250)	[250, 350)	[350, 450)	≥ 450 GeV
Pile-up	1.1/1.2/2.7	3.3/5.7/6.8	2.2/3.0/5.9	42.8/41.6/48.0
Top-quark p_T	9.1/4.1/0.4	14/15/15	19/19/24	12/12/15
Lepton efficiency	4.8/4.9/4.7	6.0/5.5/4.1	2.8/2.8/3.5	8.5/7.9/2.0
Trigger efficiency	6.0/6.0/6.0	6.0/6.0/6.0	6.0/6.0/6.0	6.0/6.0/6.0
Data/MC scale factor	22/36/61	22/36/61	22/36/61	22/36/61
Total	25/37/62	28/40/64	30/41/66	51/57/79

Tabulated Results from Lepton Spectrum Method

HT > 500 GeV

$\not\!\!E_T$:	[150,250)	[250,350)	[350,450)	$\geq$ 450 GeV
1 ℓ	304.0±17.4±16.4	49.9±7.7±6.0	13.4±4.8±3.1	$0.3^{+1.9+0.8}_{-0.3-0.3}$
Dilepton	54.7±4.2±9.0	9.6±1.5±4.4	$2.3^{+1.3+1.0}_{-0.7-0.6}$	$0.1^{+1.8+1.8}_{-0.1-0.1}$
Single tau	60.1±2.1±5.1	11.8±0.9±3.6	2.7±0.5±1.9	0.3±0.1±0.1
Z+jets (from MC)	0.5±0.1±0.5	< 0.1	< 0.1	< 0.1
QCD multijet	1.6 ± 3.1 ± 3.1		0.0 ± 1.2 ± 1.2	
Total (predicted):	419.3±18.0±19.4	71.3±7.9±8.3	$18.4^{+5.0+3.8}_{-4.9-3.7}$	$0.7^{+2.6+2.0}_{-0.3-0.3}$
Data (observed), **total** (μ, e):	**437** (237, 200)	**72** (38, 34)	**12** (7, 5)	**1** (0, 1)
SMS ($m_{\tilde{g}}$ = 1150 GeV, $m_{\rm LSP}$ = 500 GeV)	5.1±0.2	5.6±0.2	3.7±0.2	3.0±0.2
SMS ($m_{\tilde{g}}$ = 1100 GeV, $m_{\rm LSP}$ = 100 GeV)	6.5±0.3	7.6±0.3	7.3±0.3	9.1±0.3

HT > 750 GeV

$\not\!\!E_T$:	[150,250)	[250,350)	[350,450)	$\geq$ 450 GeV
1 ℓ	107.3±10.4±7.0	21.7±5.1±3.0	8.6±4.0±2.1	$0.3^{+1.8+0.8}_{-0.3-0.3}$
Dilepton	21.1±2.5±3.7	5.5±1.2±2.1	$1.4^{+0.7+0.8}_{-0.4-0.5}$	$0.0^{+1.8+1.7}_{-0.0-0.0}$
Single tau	24.2±1.4±3.6	5.5±0.6±1.0	2.2±0.4±0.6	0.3±0.1±0.1
Z+jets (from MC)	0.2±0.1±0.2	< 0.1	< 0.1	< 0.1
QCD multijet	< 1	< 0.1	< 0.1	< 0.1
Total (predicted):	152.7±10.7±8.7	32.7±5.3±3.9	$12.3±4.0^{+2.3}_{-2.2}$	$0.7^{+2.5+1.9}_{-0.3-0.3}$
Data (observed), **total** (μ, e):	**180** (94, 86)	**39** (19, 20)	**11** (7, 4)	**1** (0, 1)
SMS ($m_{\tilde{g}}$ = 1150 GeV, $m_{\rm LSP}$ = 500 GeV)	3.3±0.2	3.7±0.2	2.6±0.1	2.7±0.2
SMS ($m_{\tilde{g}}$ = 1100 GeV, $m_{\rm LSP}$ = 100 GeV)	5.8±0.3	6.9±0.3	6.6±0.3	8.6±0.3

HT > 1000 GeV

$\not\!\!E_T$:	[150,250)	[250,350)	[350,450)	$\geq$ 450 GeV
1 ℓ	38.2±6.5±3.6	9.0±3.5±1.7	1.8±1.8±0.6	$0.0^{+1.5+0.8}_{-0.0-0.0}$
Dilepton	6.1±1.5±1.8	$3.3^{+1.0}_{-0.9}$ ± 1.3	$0.4^{+1.3+1.3}_{-0.4-0.3}$	$0.0^{+1.8+2.0}_{-0.0-0.0}$
Single tau	8.2±0.8±1.1	1.9±0.4±0.4	0.3±0.1±0.3	< 0.1
Z+jets (from MC)	< 0.1	< 0.1	< 0.1	< 0.1
QCD multijet	< 0.1	< 0.1	< 0.1	< 0.1
Total (predicted):	52.5±6.7±4.2	14.2±3.6±2.2	$2.5^{+2.2+1.5}_{-1.8-0.7}$	$0.2^{+2.3+2.2}_{-0.2-0.0}$
Data (observed), **total** (μ, e):	**61** (29, 32)	**16** (7, 9)	**5** (3, 2)	**1** (0, 1)
SMS ($m_{\tilde{g}}$ = 1150 GeV, $m_{\rm LSP}$ = 500 GeV)	1.2±0.1	1.3±0.1	1.1±0.1	1.5±0.1
SMS ($m_{\tilde{g}}$ = 1100 GeV, $m_{\rm LSP}$ = 100 GeV)	4.2±0.2	4.7±0.2	4.7±0.2	6.6±0.3