New W-prime Signals at the LHC

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Based on:
*A*rXiv: 1404.5558

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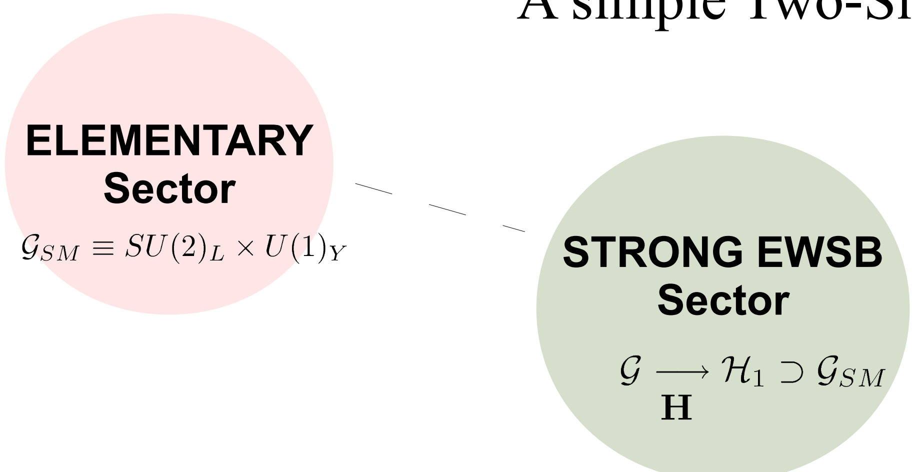
W-prime in Composite Higgs / RS Models

- EWSB triggered by a new Strong Dynamics, composite at the TeV scale
- Higgs: composite + pGB of global invariance of the strong sector

Georgi, Kaplan, 1984

A simple Two-Site description

Contino et al. hep-ph/0612180



elementary/composite mixing

SM + NP

light SM particles [mainly elementary]	+	heavy resonances (W', top-partners, ..) [mainly composite]

W-prime in Composite Higgs / RS Models

Custodial symmetry

$SU(2)_L \times U(1)_Y$

$g_2^{el} \simeq g_2$

$SO(5) \to SO(4) \sim SU(2)_L \times SU(2)_R$

$g_2^* > 1$

~ rho-photon mixing

$W_{el}^a \in (\mathbf{3}, \mathbf{1})$ ⟺ $W_{com}^{'a} \in (\mathbf{3}, \mathbf{1})$

$$\cot\theta_2 = \frac{g_2^*}{g_2^{el}} \qquad g_2 = g_2^{el}\cos\theta_2 = g_2^*\sin\theta_2$$

$$W^{'} = \cos\theta_2 W_{com}^{'} + \sin\theta_2 W_{el}$$

Controls the strength of W' interactions

More strongly-coupled EW sectors correspond to larger $\cot\theta_2$

top-partners in Composite Higgs / RS Models

Linear mixing terms

$$t_R^{el} \Longleftrightarrow \tilde{T} = (\mathbf{1},\mathbf{1})_{\mathbf{2/3}}$$

$$\begin{pmatrix} t_L^{el} \\ b_L^{el} \end{pmatrix} \Longleftrightarrow \begin{bmatrix} T & T_{5/3} \\ B & T_{2/3} \end{bmatrix} = (\mathbf{2},\mathbf{2})_{2/3}$$

$$\mathbf{5_{2/3}}$$

Rotation
(Mixing angles: s_L, s_R)

$$\begin{cases} t_L = c_L t_L^{el} + s_L T_L \\ t_R = c_R t_R^{el} + s_R \tilde{T}_R \end{cases}$$

s_L / s_R are the t_L / t_R degree of compositeness

$$m_t = Y_* s_L s_R v$$

Heavier particles have larger degrees of compositeness

top-partners in Composite Higgs / RS Models

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$\mathbf{5_{2/3}}$

Custodians

$$m_C = c_L m_T$$

Rotation
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Heavier particles have larger degrees of compositeness

W-primes and top-partners in MCHMs

naturalness

Top-partners cut-off Higgs mass divergencies

A ~125 GeV Composite Higgs implies *Top-partners below 1 TeV*

G. Panico, M. Redi, A. Tesi and A. Wulzer, [arXiv:1210.7114 [hep-ph]]

…….

EWPT

Constraints on S parameter imply *W-prime above ~ 2 TeV*

M. Ciuchini, E. Franco, S. Mishima and L. Silvestrini, [arXiv:1306.4644 [hep-ph]].
C. Grojean, O. Matsedonskyi and G. Panico, [arXiv:1306.4655 [hep-ph]].

We will consider m_c = 0.9 TeV { CMS bound [arXiv:1312.2391]: $m_c > 0.8$ TeV }

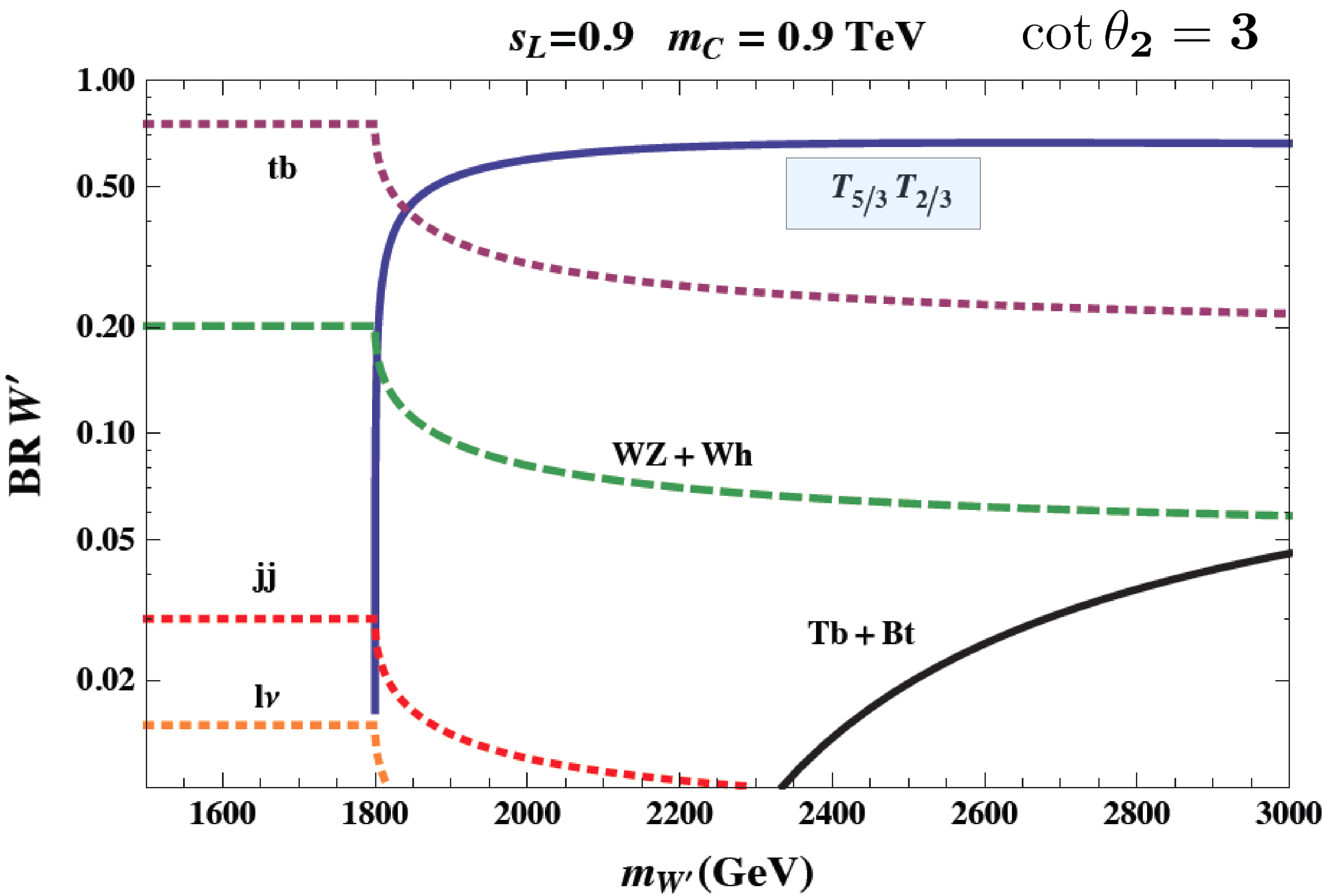
And we will focus our analysis on the W' decays to vector-like top partners

W' couplings to elementary modes
(lv, jj)

$\propto g_2 \tan\theta_2$

W' couplings to composite modes
($W_L h$, $W_L Z$, top-partners)

$\propto g_2 \cot\theta_2$



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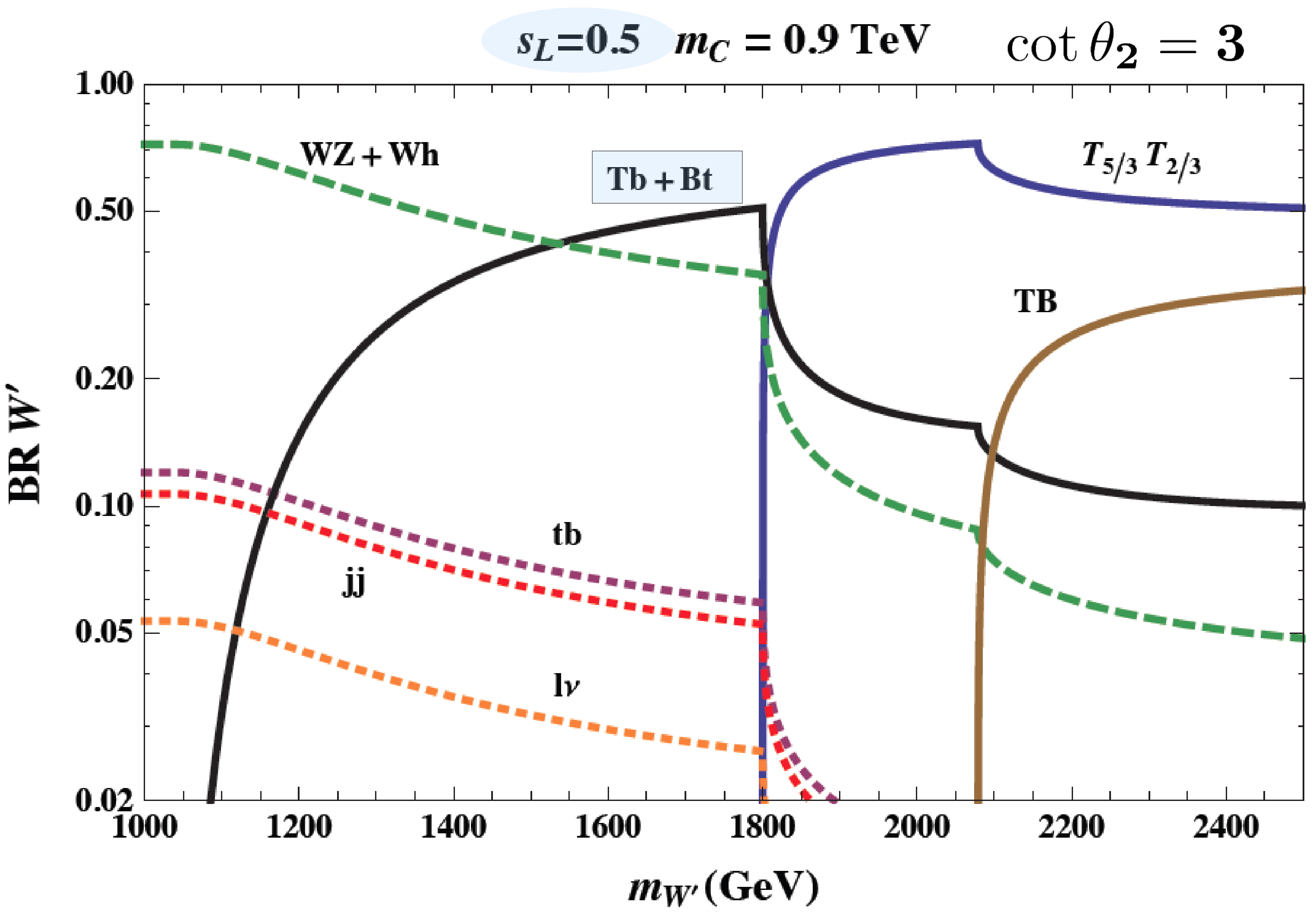


LHC-8 LIMITS

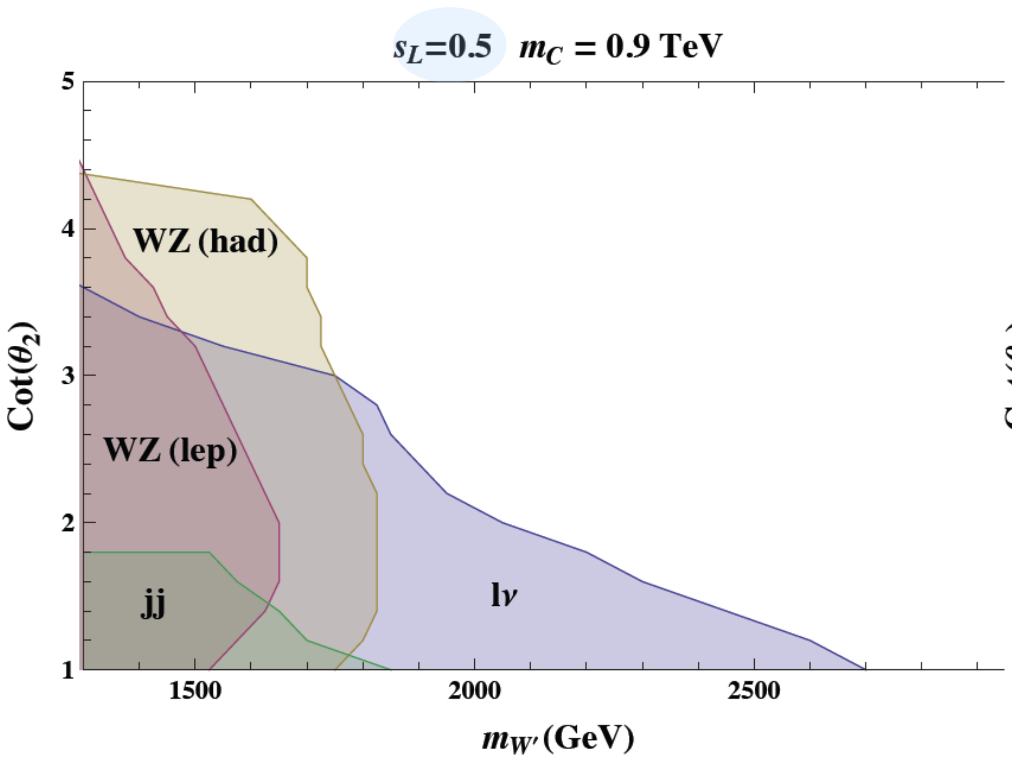
lν CMS-PAS-EXO-12-060; ATLAS-CONF-2014-017

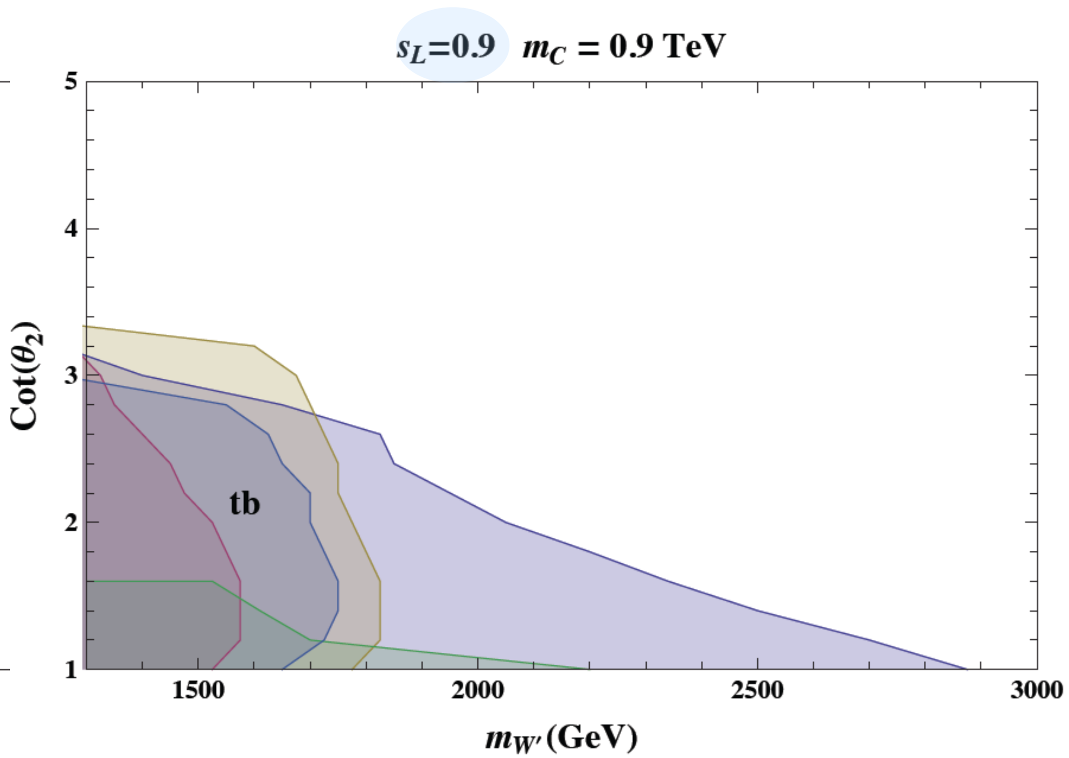
WZ (had) CMS-PAS-EXO-12-024

WZ(lep) CMS-PAS-EXO-12-025; ATLAS-CONF-2014-015

jj CMS-PAS-EXO-12-059; ATLAS-CONF-2012-148

tb CMS-PAS-B2G-12-010; ATLAS-CONF-2013-050



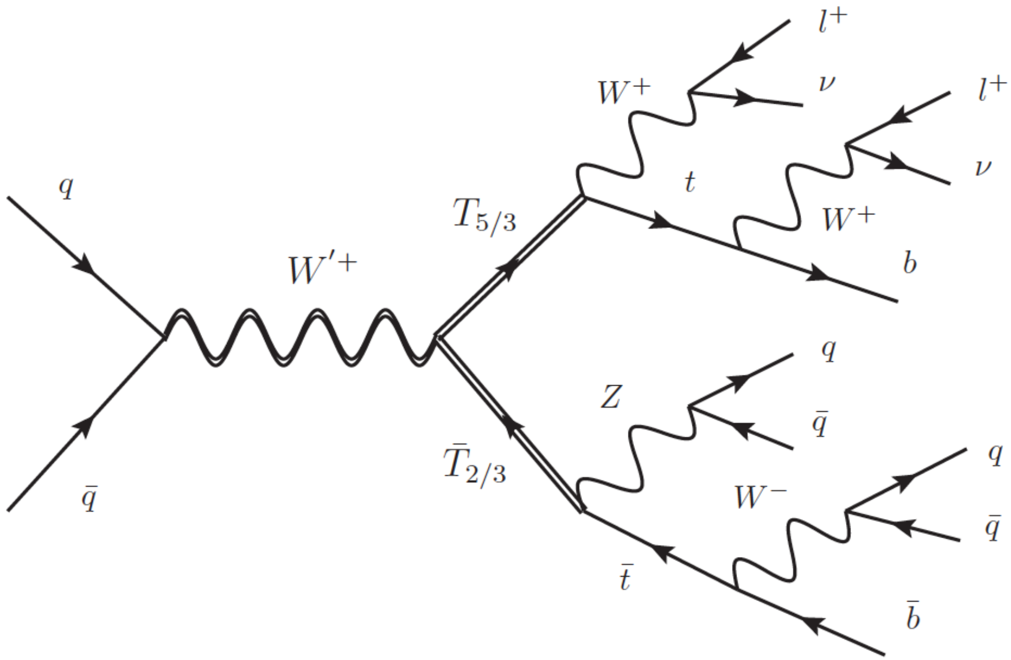


The custodian channel in the same-sign dilepton final state

LHC-14

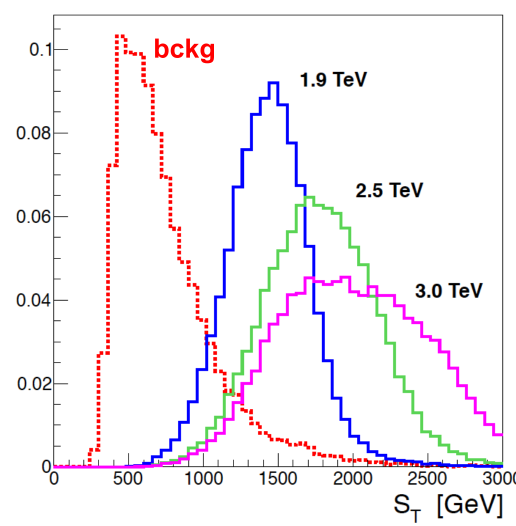
xsec(fb)

Same-Sign Dilep	acceptance
$m_{W'} = 1.9$ TeV	0.82
$m_{W'} = 2.2$ TeV	0.52
$m_{W'} = 2.5$ TeV	0.29
$m_{W'} = 3.0$ TeV	0.11
$m_{W'} = 3.5$ TeV	0.041
$W^+t\bar{t}$	4.1
W^+W^+	1.5
$W^+W^+W^-$	0.6
Total background	6.2



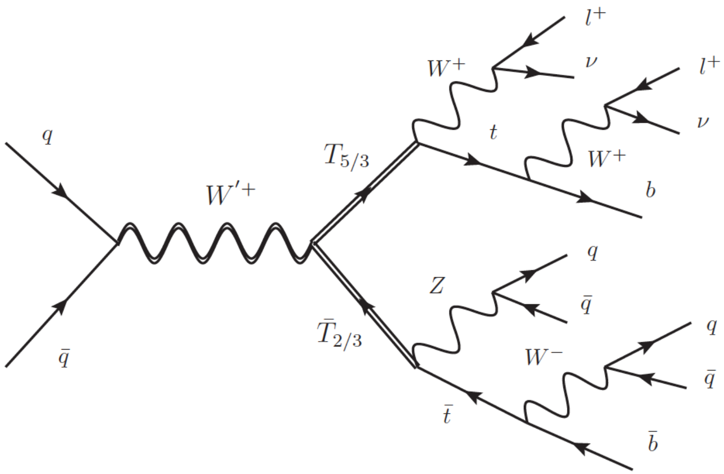
$$+(h \to b\bar{b})\bar{t}$$

$$S_T \equiv H_T + \not{p}_T$$

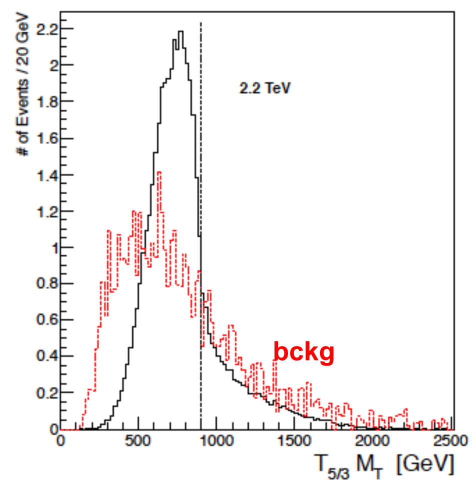


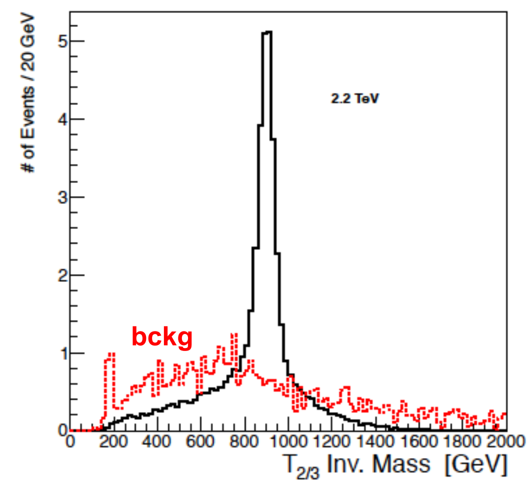
	CUT-1	CUT-2
$p_T\ l(1)$	90	
$p_T\ l(2)$	30	
$p_T\ j(1)$	160	
$p_T\ j(2)$	100	
H_T	550	700
S_T	1100	1400

The custodian channel in the same-sign dilepton final state



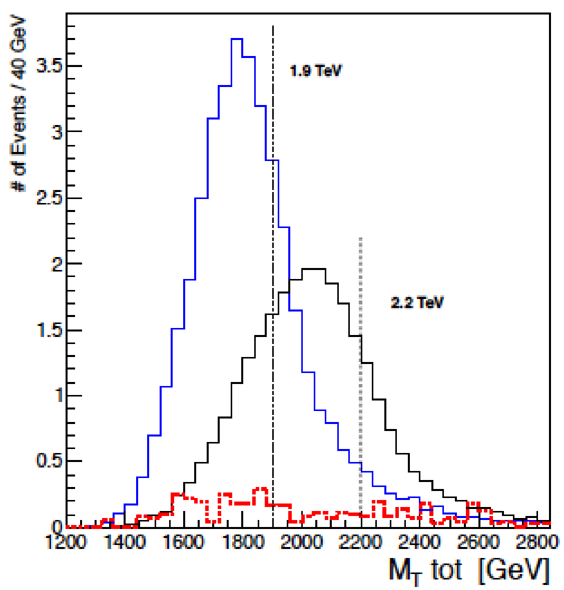
Custodians

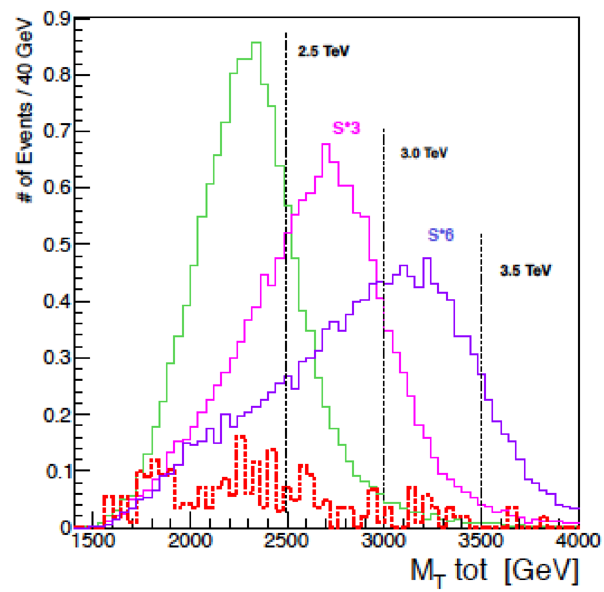




Total transverse mass

(smearing in jet momentum included)



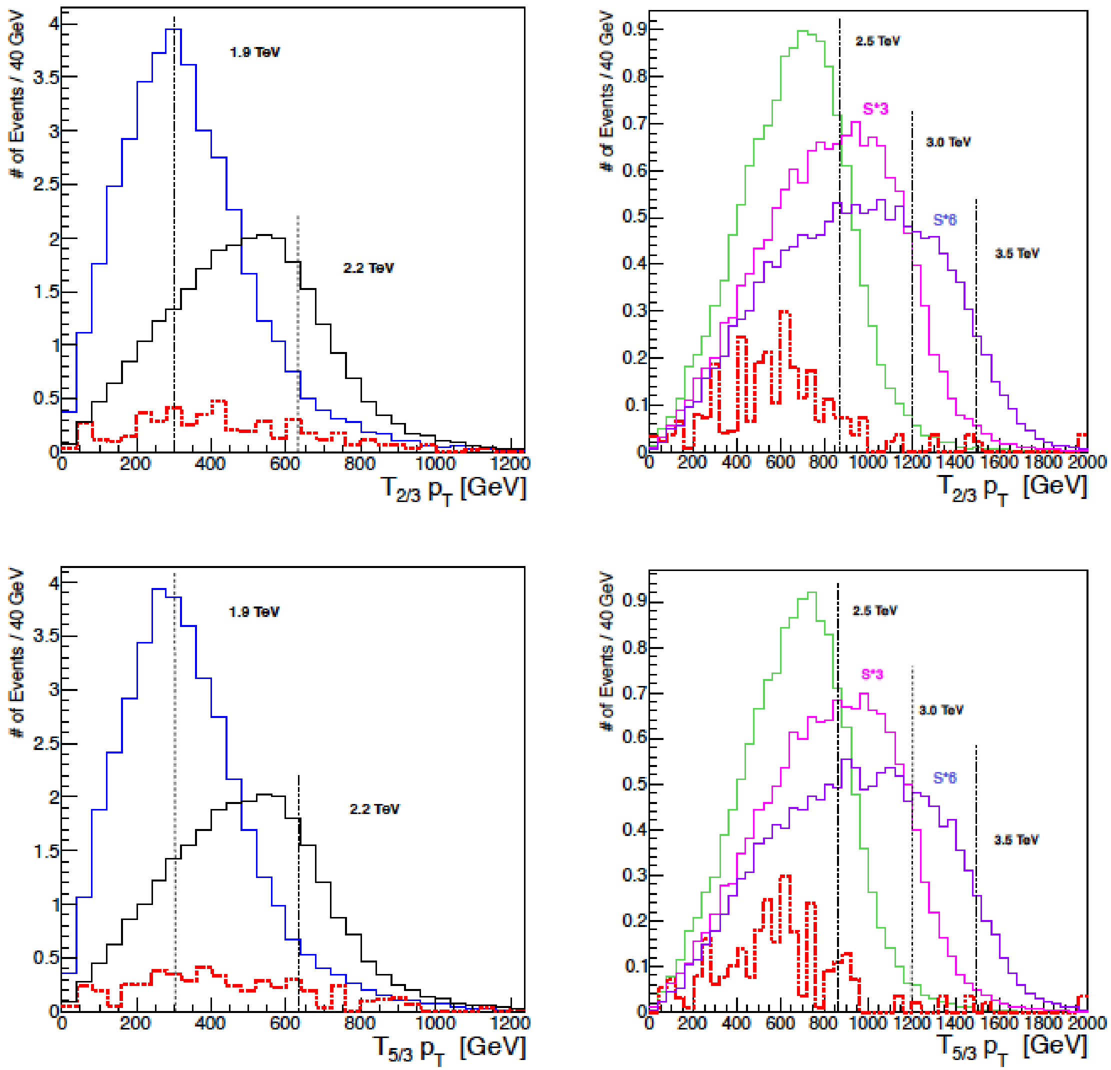


$M_T(T_{5/3}) > 400\,\text{GeV}$

$M_{T_{2/3}} \in [0.8, 1.0]\,\text{TeV}$

The custodian channel in the same-sign dilepton final state

Custodian
pT distributions



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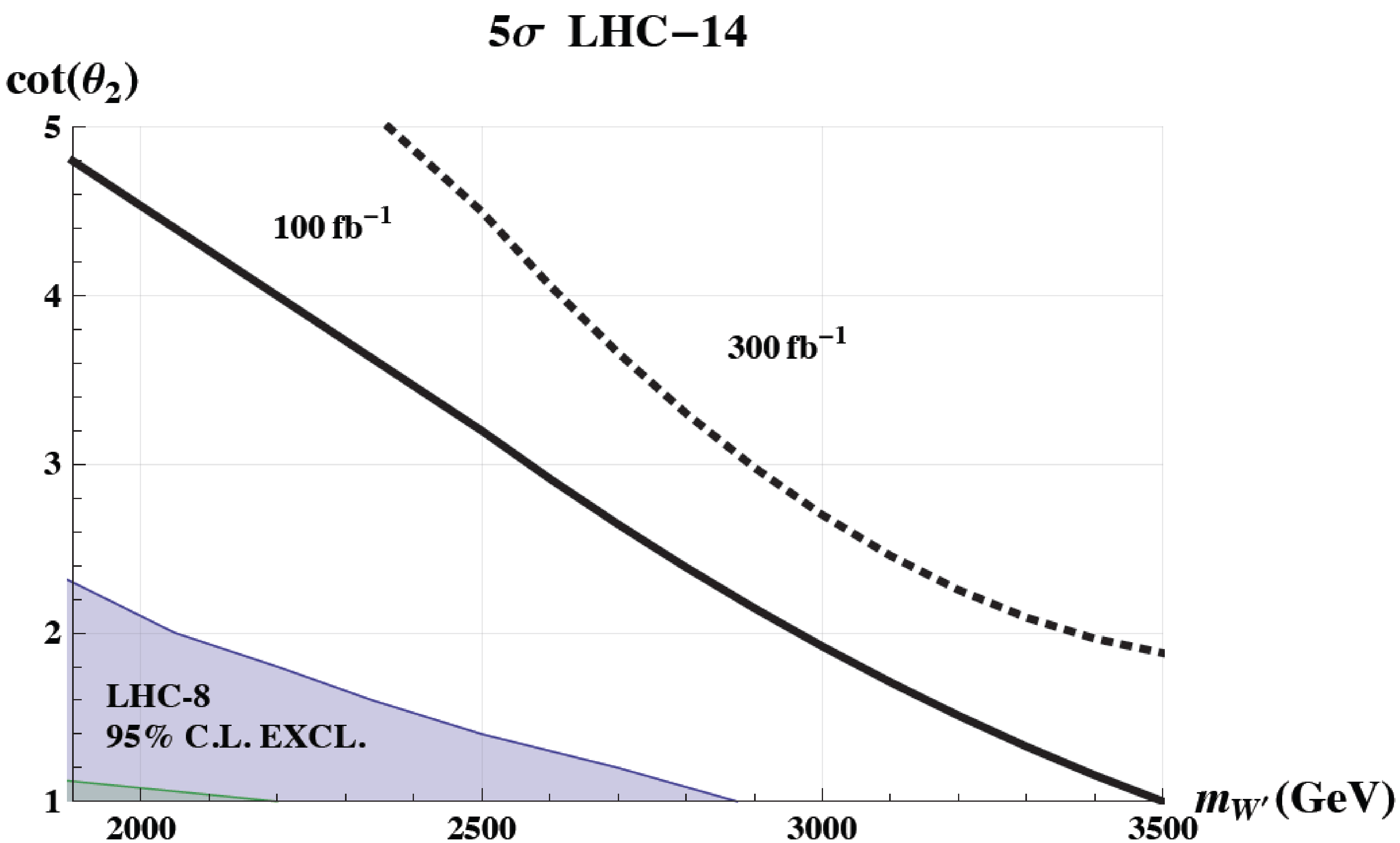
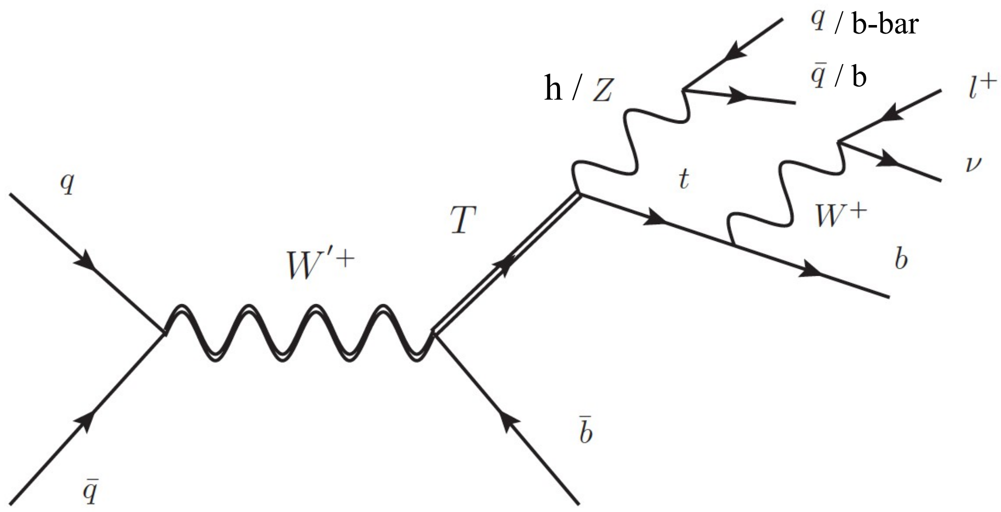


The heavy-light Tb channel, for s_L=0.5



$$pp \to l^+ + n\,\text{jets} + \not{E}_T$$

$$n \geq 3\,, \quad \text{at least 2 } b\text{-tag}$$

xsec(fb)

LHC-14	acceptance
$m_{W'} = 1.3$ TeV	9.1
$m_{W'} = 1.5$ TeV	7.5
$m_{W'} = 1.7$ TeV	5.0
$m_{W'} = 2.0$ TeV	0.70
$m_{W'} = 2.5$ TeV	0.11
$WWbb$	19000
$Wbb + jets$	1600
$W + jets$	560
Total background	21000

- Neutrino, top and T recostruction
- $S_T > 1.1\,\text{TeV}$
  $(t\,,\,b\,,\,Z/h\,,\,T\,)\,p_T > 150\,\text{GeV}$
- T inv mass cut

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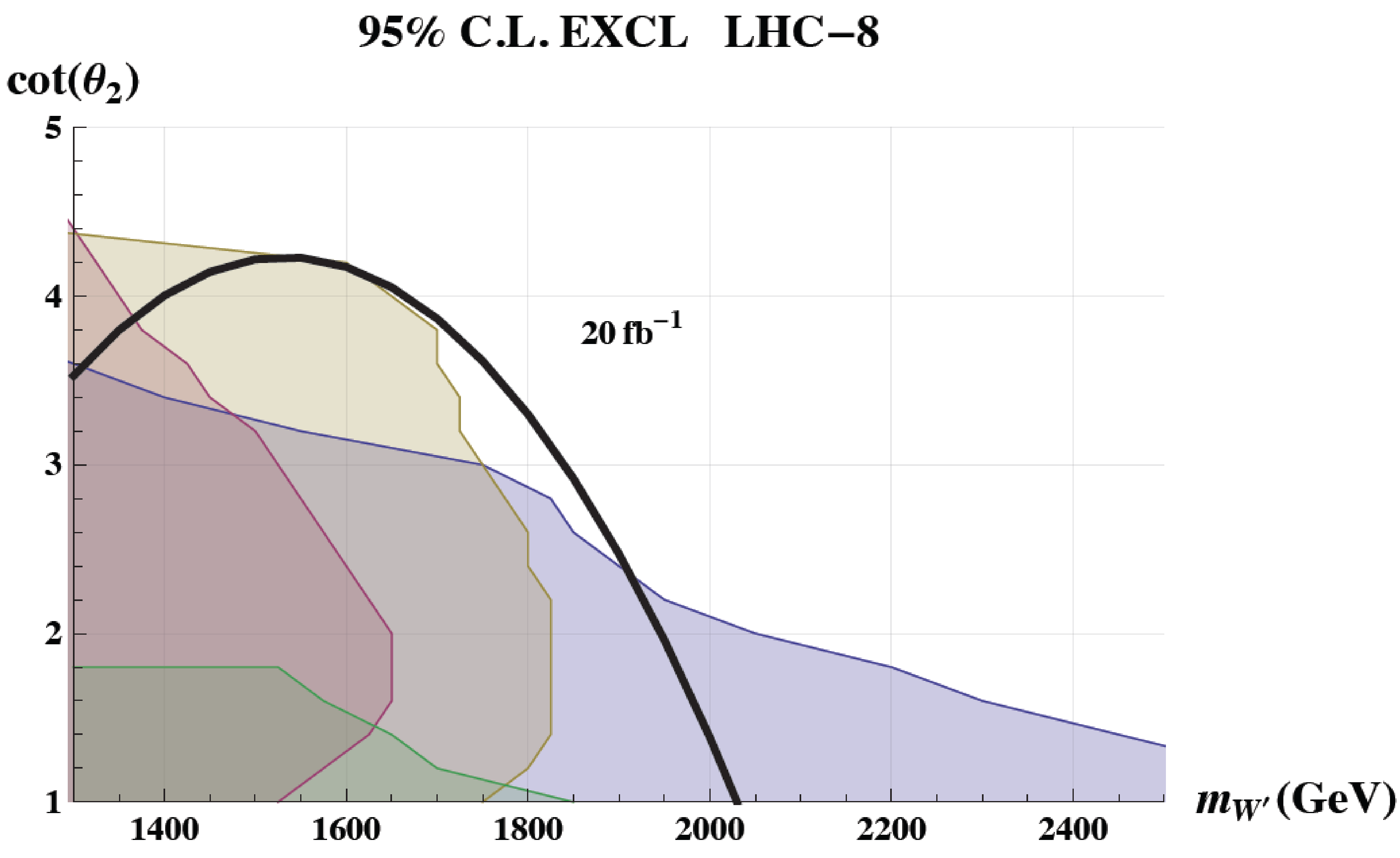

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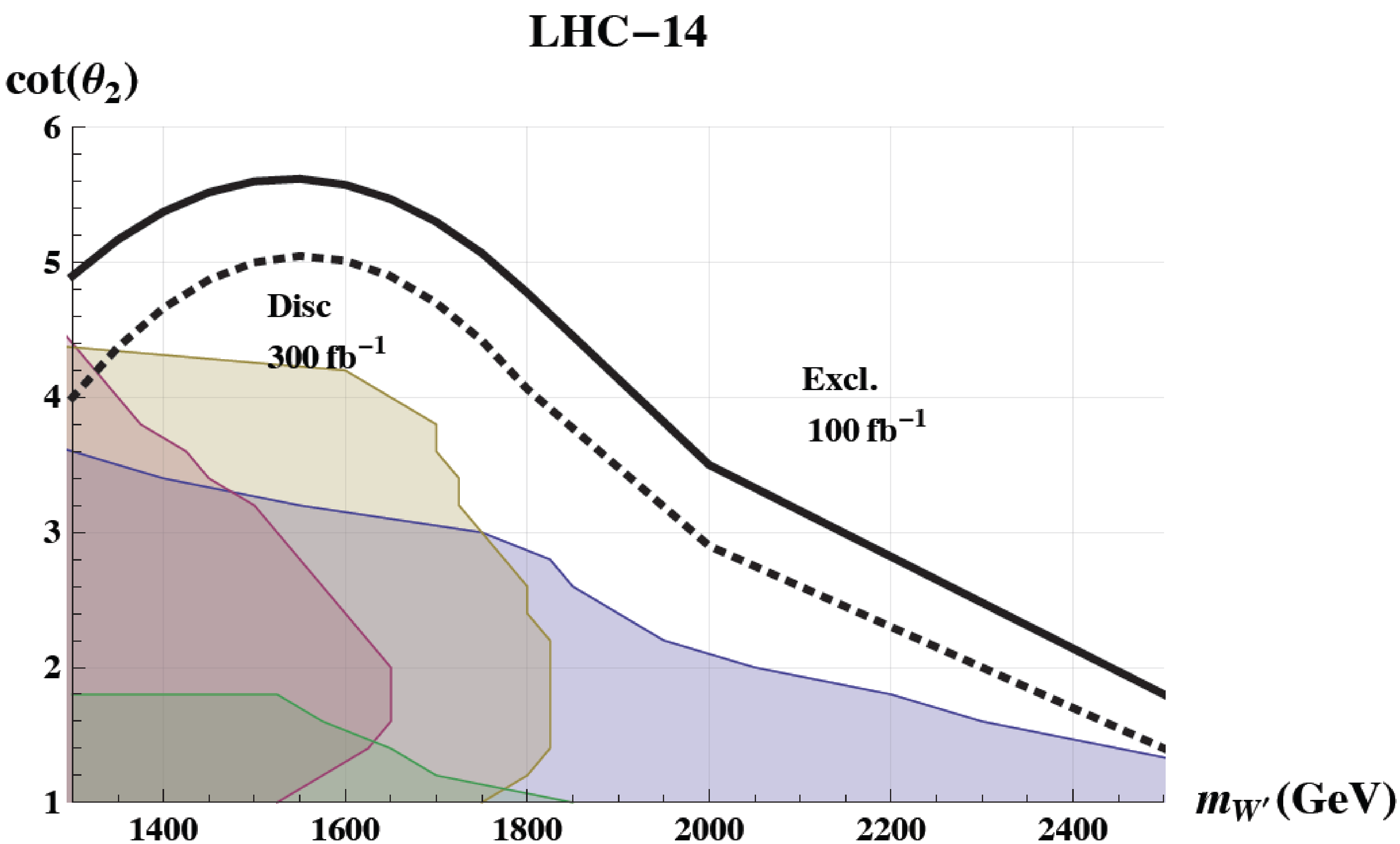


Conclusions

Naturalness+EWPT favor the scenario where the W' is above the threshold for decays into vector-like top-partners

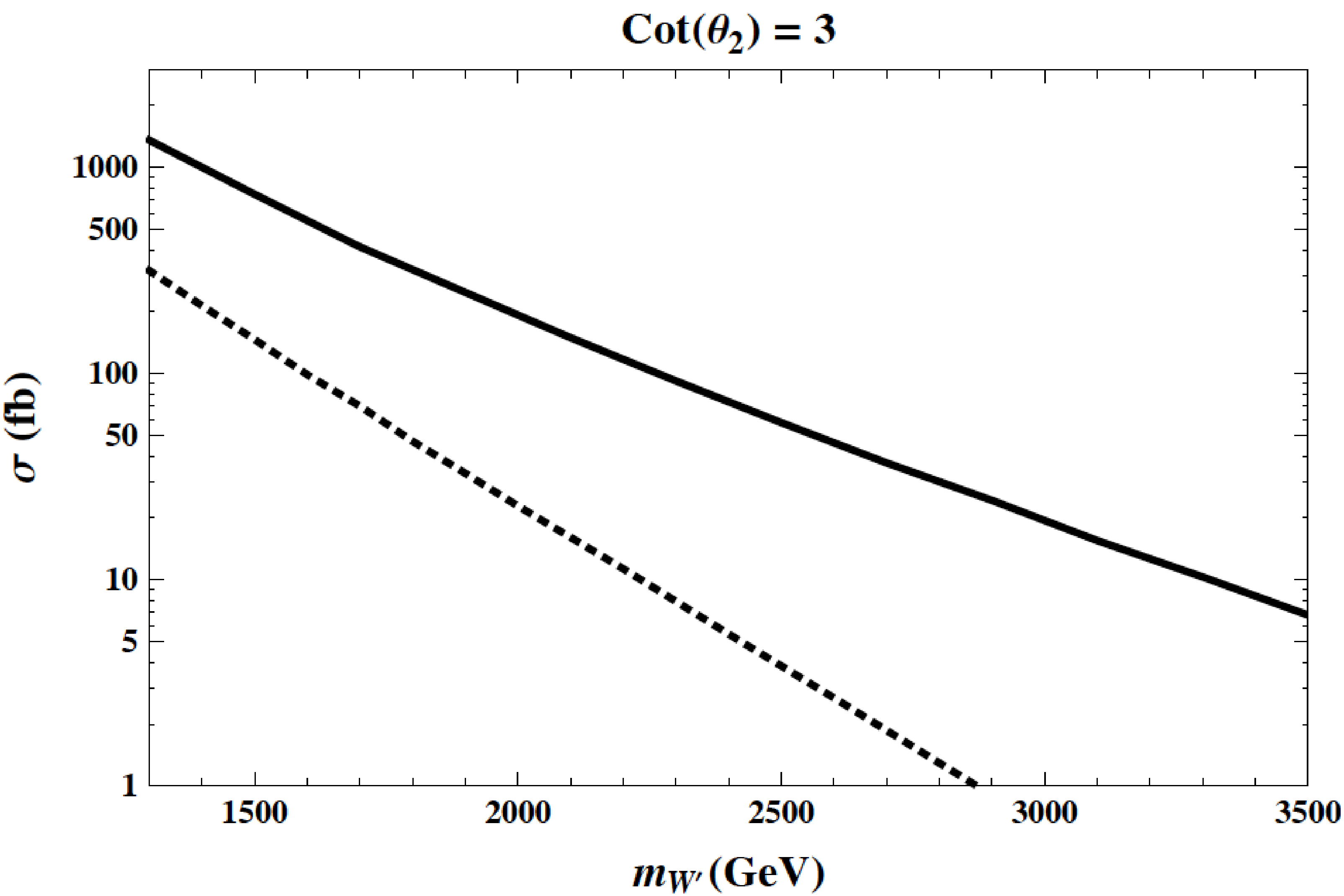
Current LHC-8 analyses in the standard channels exclude a consistent portion of the W' mass-coupling parameter space at lower W' masses but have a low sensitivity to the higher mass region $m_{W'} > 2$ TeV

The custodian channel W' → $T_{5/3}$ $T_{2/3}$ can extensively probe this interesting region at the 14 TeV LHC

The heavy-light channel W' → Tb is also a promising channel to test the intermediate W' mass region. It could extend the bounds from LHC-8 data.

Extra Slides

W' Drell-Yan production



W' decay width