New signatures of CHMs: exotic top partners

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project CompHS (FKPPL)

Joint FKPPL and TYL/FJPPL workshop
Nara (Japan)

The teams (2016-)

France

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M. Lespinasse (IPNL -> private)
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Korea

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T.Flacke (IBS Daejeon)
M.Zhang (IBS Daejeon)

(previously)
A.Parolini (KAIST/KIAS -> private)
H.Serodio (KAIST/Korea U -> Lund)
J.H. Kim (KAIST -> USA)

Publications: 11 + 4 proc.

2014-19

- G.Cacciapaglia, G.Ferretti, T.Flacke, H.Serodio, "Revealing timid pseudo-scalars with taus at the LHC", Eur.Phys.J. C78 (2018) no.9, 724

- N.Bizot, G.Cacciapaglia, T.Flacke, "Common exotic decays of top partners," JHEP 1806 (2018) 065

- G.Cacciapaglia, G.Ferretti, T.Flacke, H.Serodio, "Light scalars in composite Higgs models", front.in Phys. 7 (2019) 22

- w. T.Flacke, 2 contributions to the WG3 Yellow Report "Beyond the Standard Model Physics at the HL-LHC and HE-LHC", 1812.07831

- + 2 preprints in preparation (to appear soon)

Composite scenario

100,000 TeV

Λ_{flavour}

Light fermions

IR conformal region

Λ_{top}

10 TeV

$\Lambda \sim 4\pi f$

Vector resonances, top partners?

1 TeV

f

Condensation scale (extra pions)

100 GeV

$v_{\text{SM}} \sim f \sin\theta$

EWSB, Higgs

Theory in the conformal window (IR fixed point)

Heavy states?

Top interactions?

Theory with a mass gap!

A fermionic theory of top partners

$\mathcal{G}_{\rm TC}$: rep R rep R′ 1312.5330, 1604.06467

Q χ $T' = QQ\chi$ or $Q\chi\chi$

SM : EW colour + hypercharge

global : $\langle QQ \rangle \neq 0$

↓

pNGB Higgs

DM?

a) $\langle \chi\chi \rangle \neq 0$

coloured pNGBs

di-boson

b) ~~$\langle \chi\chi \rangle = 0$~~

~~Light top partners from 't Hooft anomaly conditions?~~

Global symmetries

More precisely, the global symmetries are:

$$SU(N_Q) \times SU(N_\chi) \times U(1)_Q \times U(1)_\chi$$

WZW term:

$$\mathcal{L} \supset \frac{g_i^2}{32\pi^2} \frac{\kappa_i}{f_a}\, a\, \epsilon^{\mu\nu\alpha\beta} G^i_{\mu\nu} G^i_{\alpha\beta}\,,$$

Coefficients depend on the underlying dynamics!

G = A, W, Z, g !!!

1512.04508

Anomalous U(1) -> heavy η'

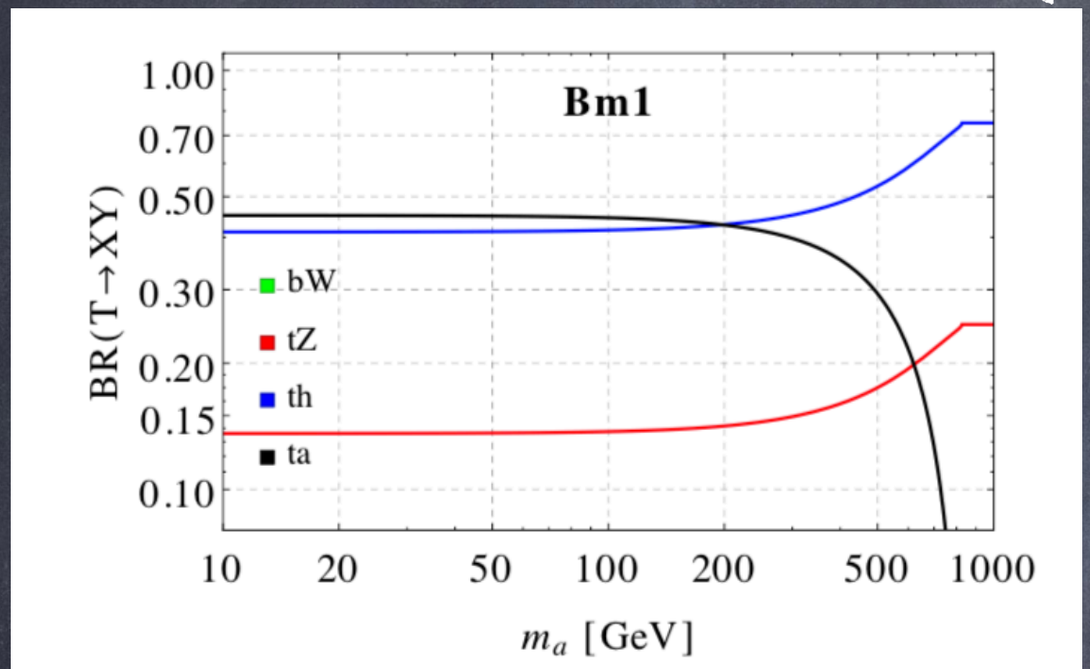
Orthogonal U(1) -> pNGB a

Decays and production only via WZW anomaly.

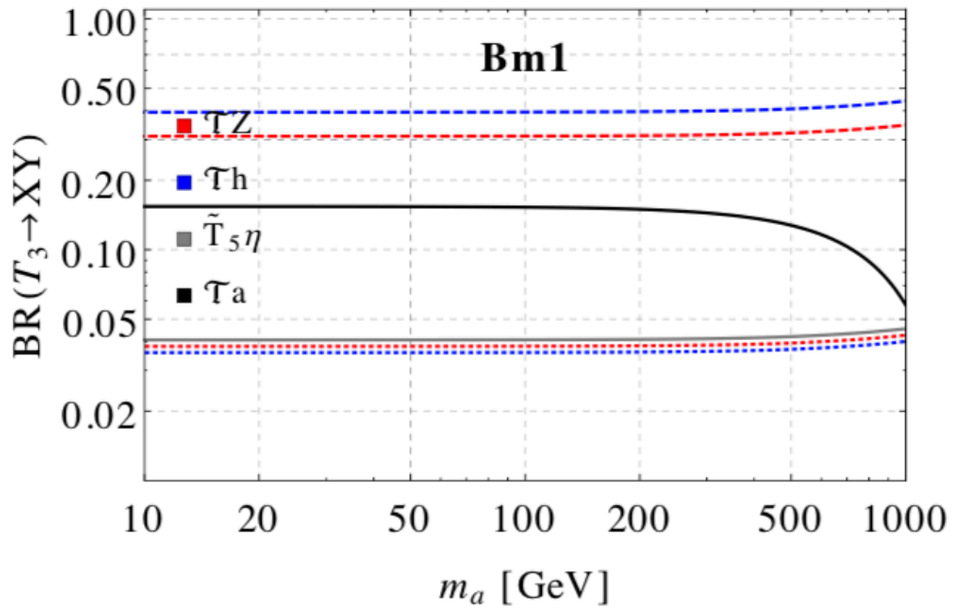
Top-partners decays

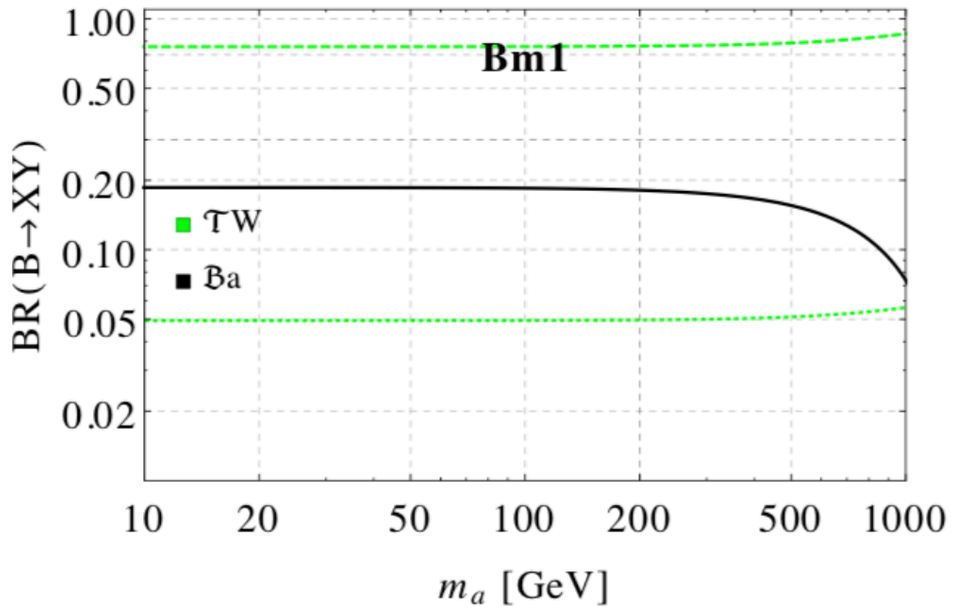
Example: model M8 (SU(4)/Sp(4))

N.Bizot, GC, T.Flacke
1801.05444



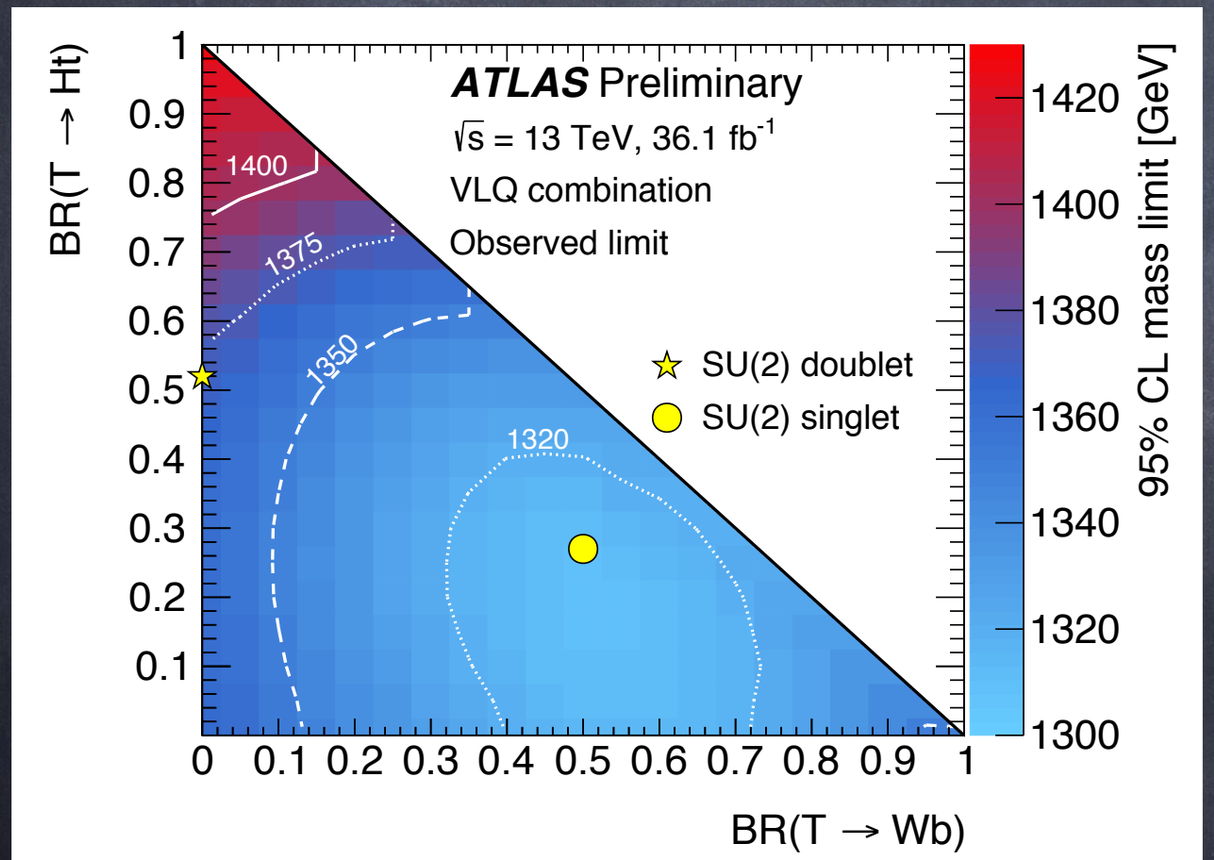
- The lightest T decays 50% into "a"
- Other channel th, poorly constrained.

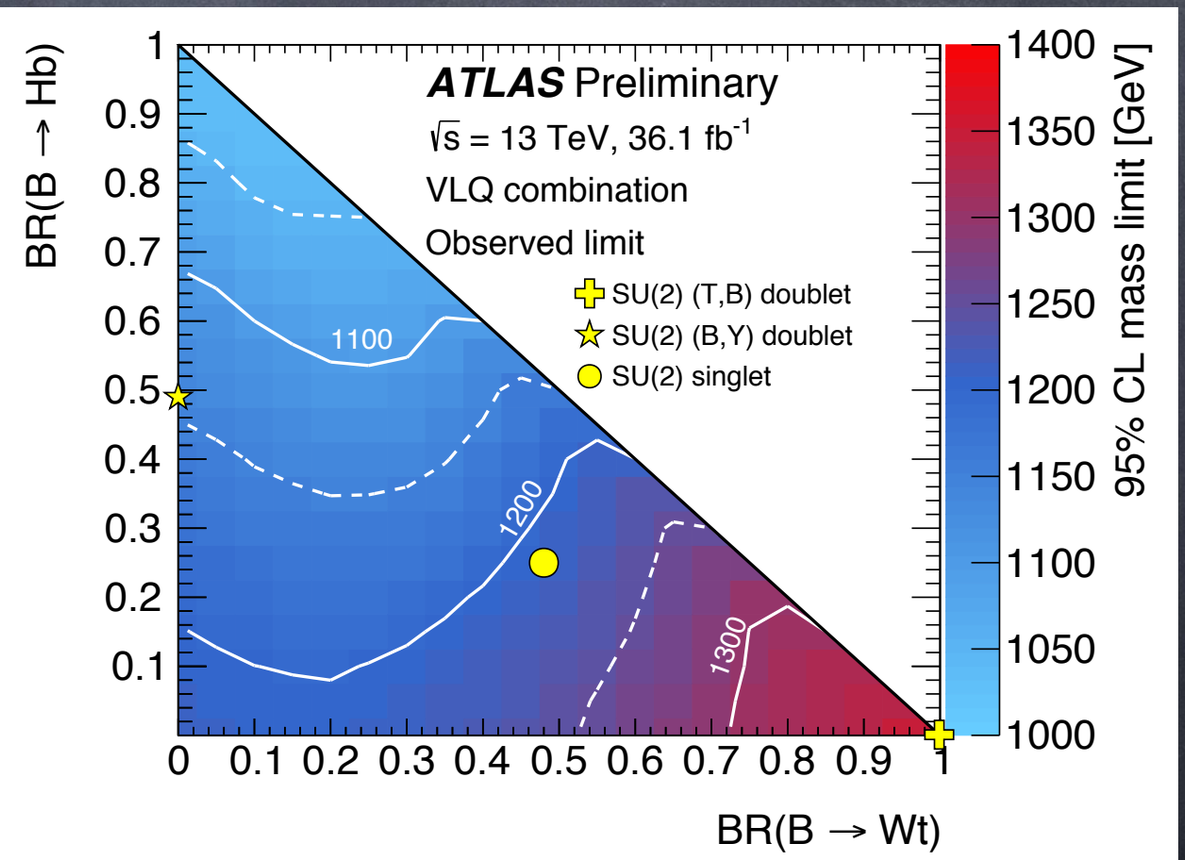




T -> t a

Current searches focus only on standard channels: tH, tZ, bW





T -> t a

w. Mengchao Zhang

How much can the bounds be relaxed?

We first consider decays 100% into a.

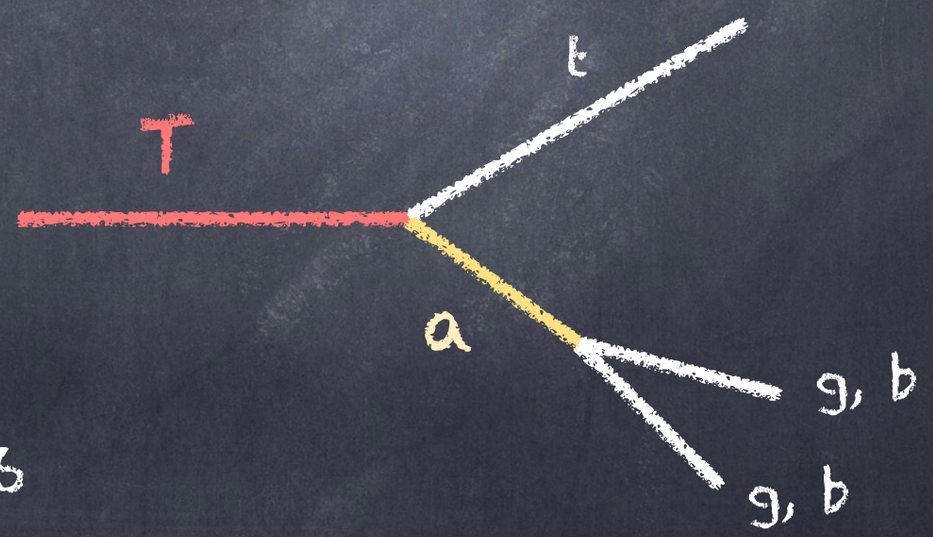
- a->gg, boosted, looks like a single jet

Excited top, 13 TeV, CMS 1711.10949

- a->gg with resolved jets

- a->bb with resolves b-jets

Multijet SUSY, 8 TeV, ATLAS 1502.05686
(13 TeV search less sensitive because of tighter cuts)



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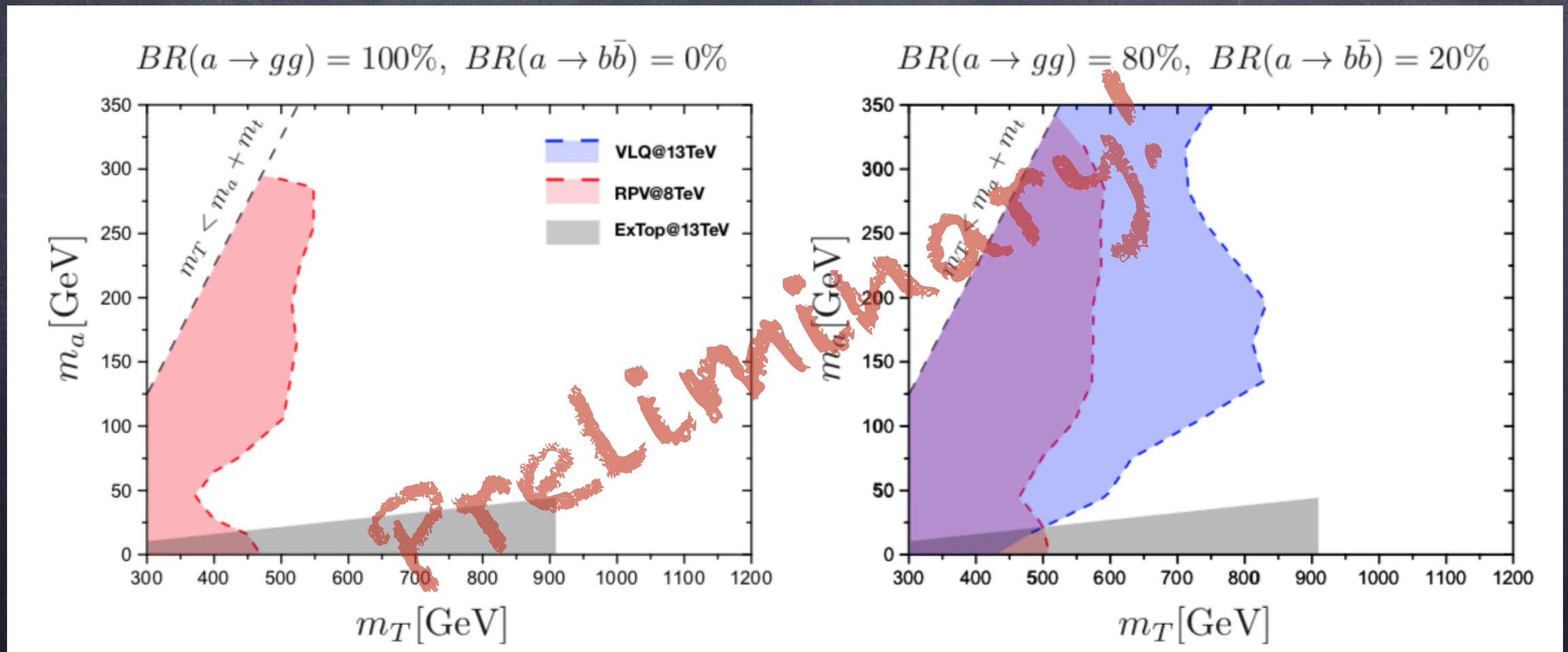

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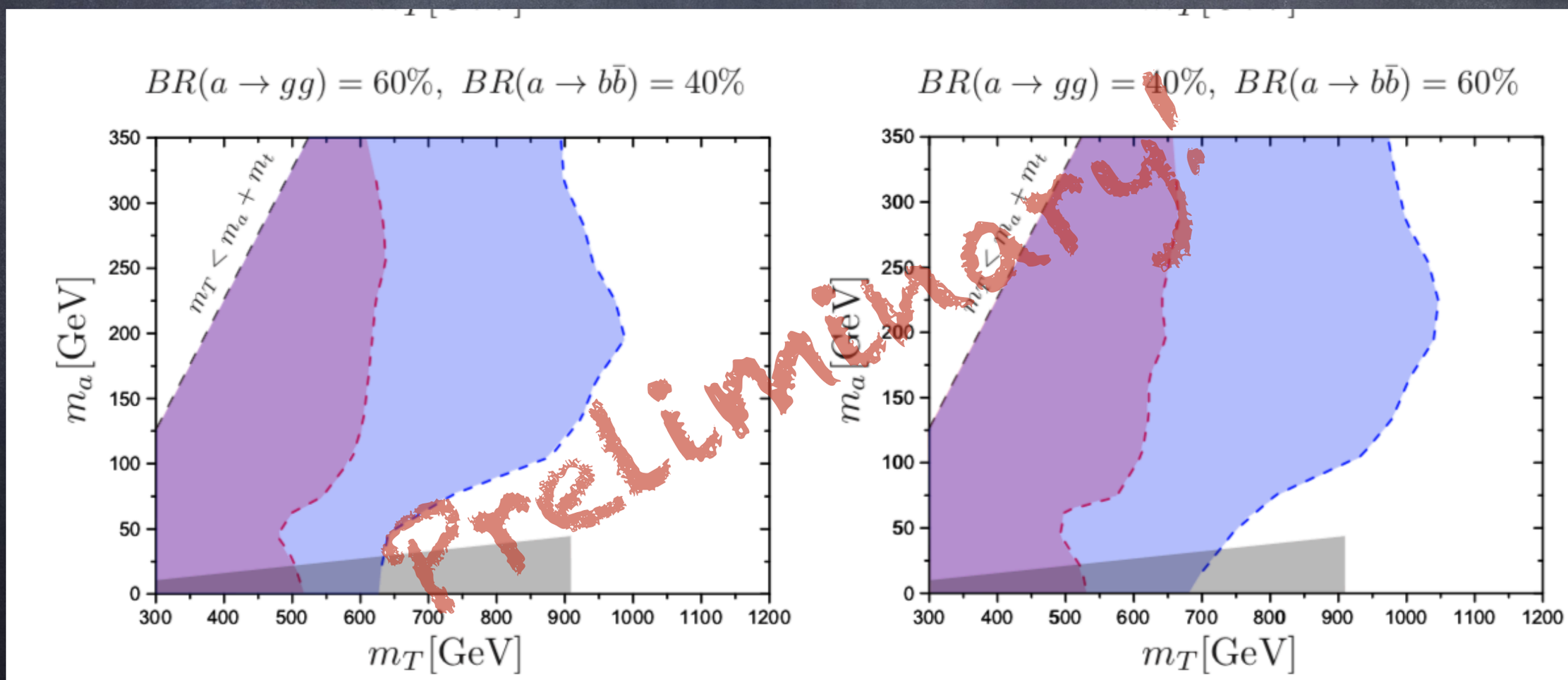

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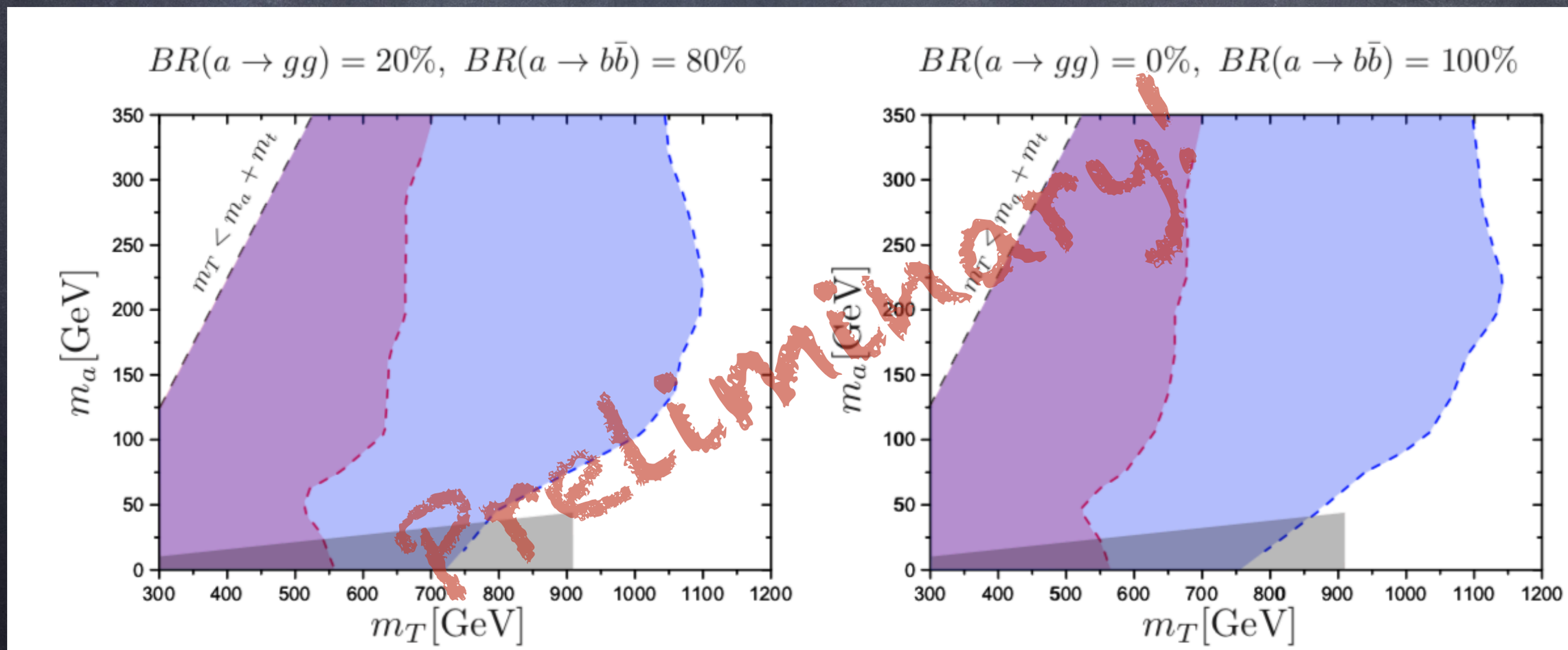
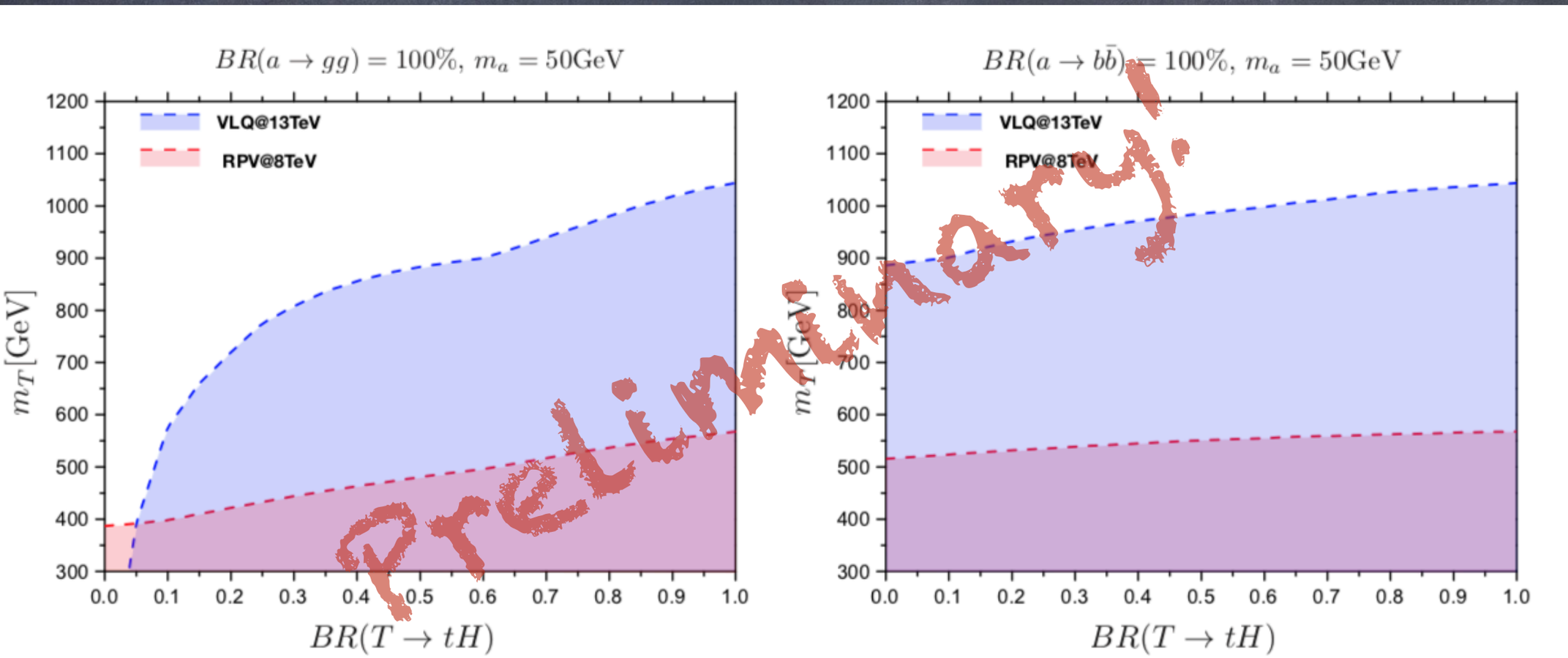


T -> t a

w. Mengchao Zhang

How much can the bounds be relaxed?

Variable BR into a and H



Top-partners decays

N.Bizot, GC, T.Flacke
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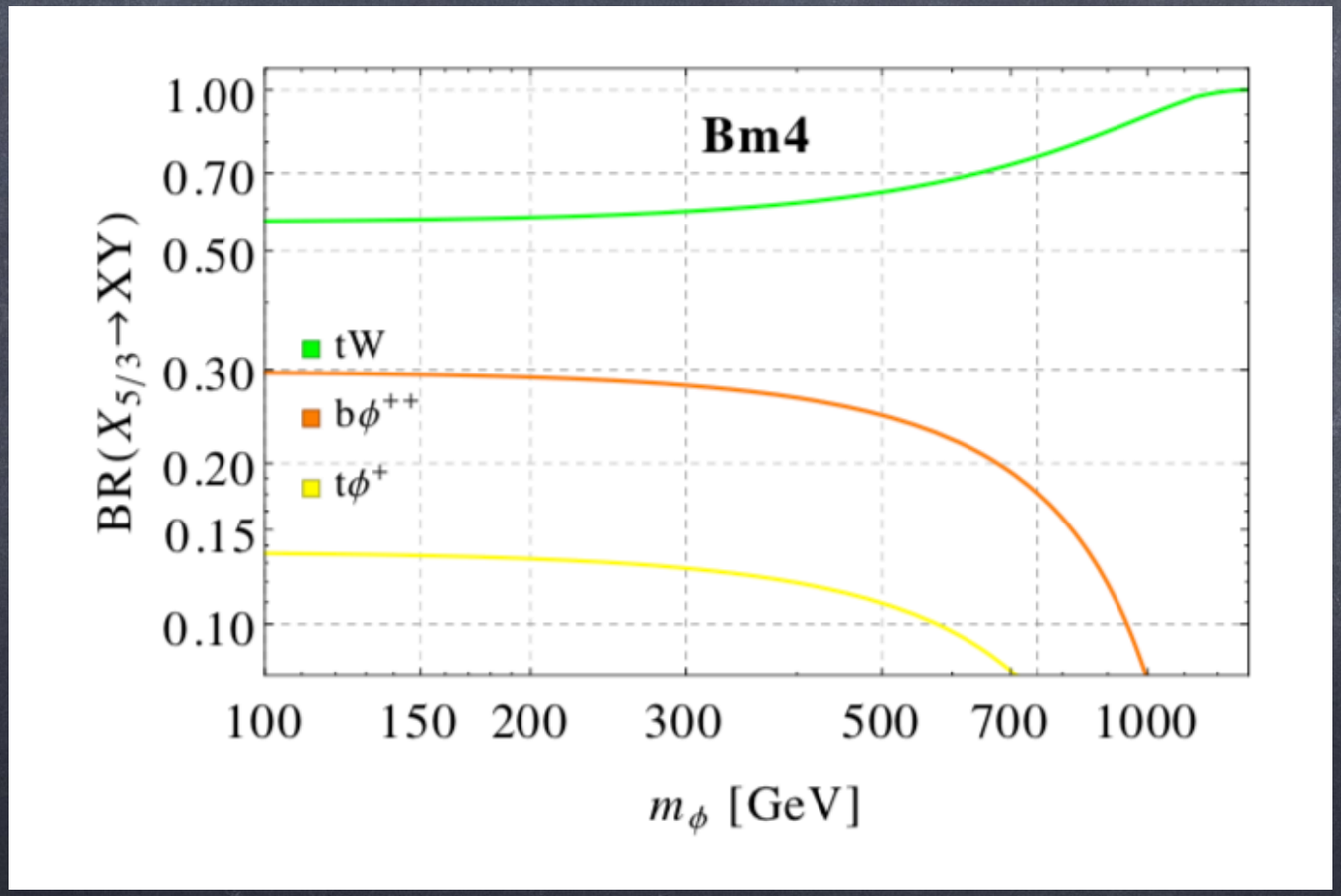
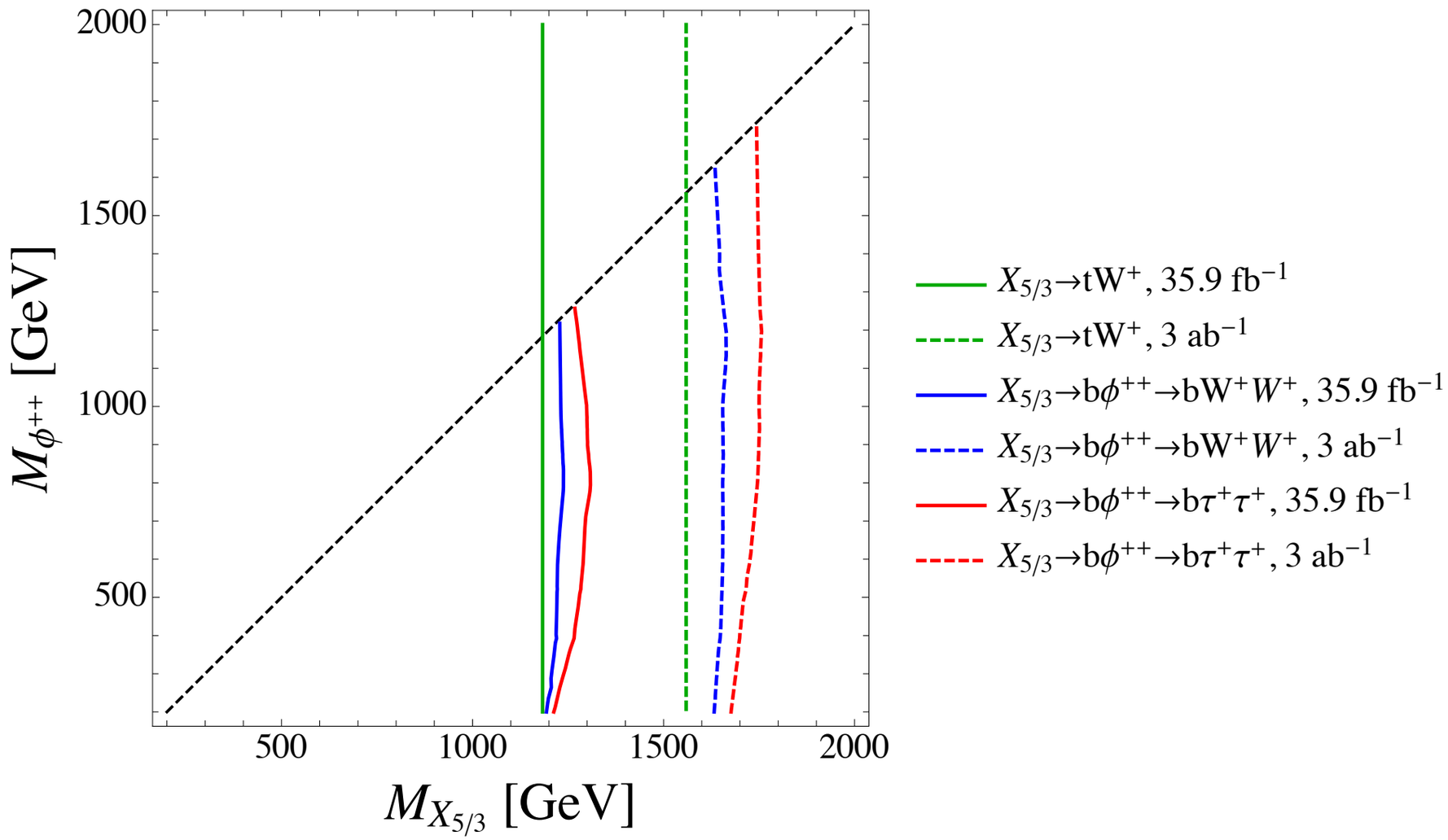
Example: model M4 (SU(5)/SO(5))



X5/3

w. Ke-Pan Xie

Searches based on same sign dilepton.



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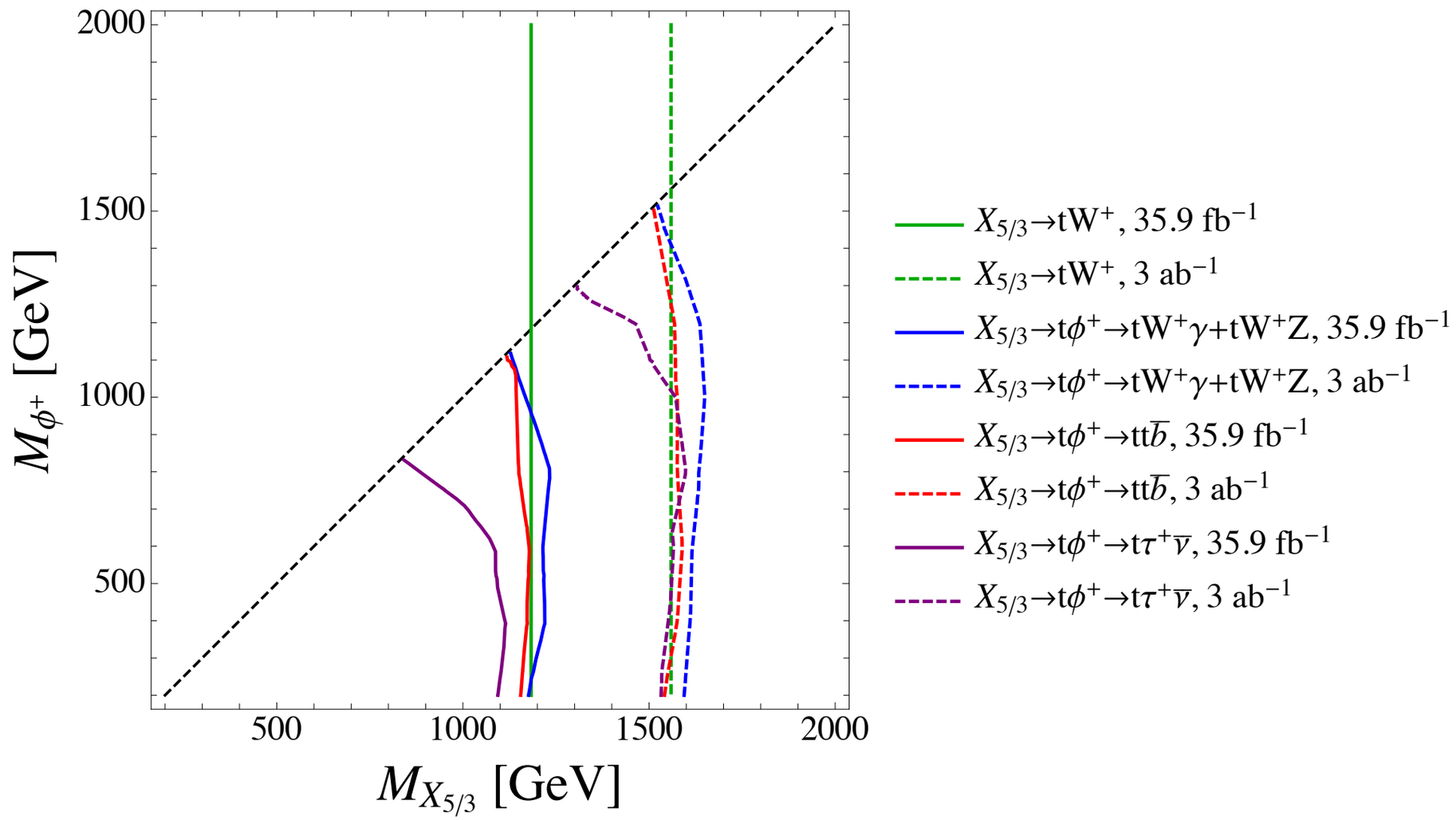

Future development

- Many novel decays for top partners are allowed!
- Existing searches need to be modified to cover them effectively!
- Extensive exploration still in progress.