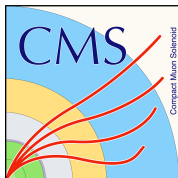


First 13 TeV search for new heavy spin-0 resonances decaying into top quarks at CMS

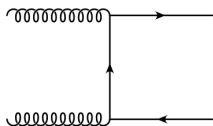
A. Anuar, K. Beernaert, A. Grohsjean,
C. Schwanenberger, N. Stefanov, G. Van Onsem

28 March 2017

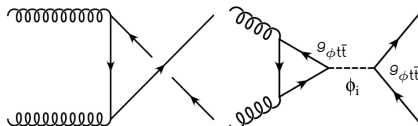


Introduction

- Search for resonant ϕ decaying to $t\bar{t}$
 - Consider both pseudoscalar A and scalar H
 - A is of particular interest as $\text{BR}(A \rightarrow t\bar{t}) \sim 1$; $A \rightarrow VV$ forbidden by CP conservation
 - **Interference with SM** taken into account for the first time in CMS
 - Coupling between ϕ and top quark denoted with the letter $g_{\phi t\bar{t}}$



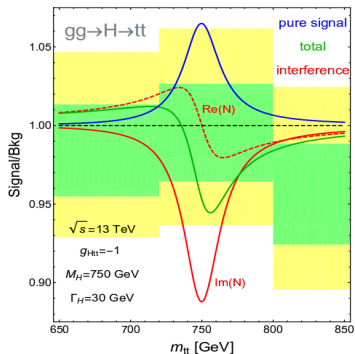
SM t -channel $gg \rightarrow t\bar{t}$



s -channel $gg \rightarrow \phi \rightarrow t\bar{t}$

Introduction

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 - Consider both pseudoscalar A and scalar H
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 - **Interference with SM** taken into account for the first time in CMS
 - Coupling between ϕ and top quark denoted with the letter $g_{\phi t\bar{t}}$
- **Significant peak-dip structure** in $m_{t\bar{t}}$ spectrum due to interference
 - No resonance peak in some cases
 - Exact structure depends on parity, m_ϕ and Γ_ϕ



Plot from arXiv:1605.00542

Analysis strategy

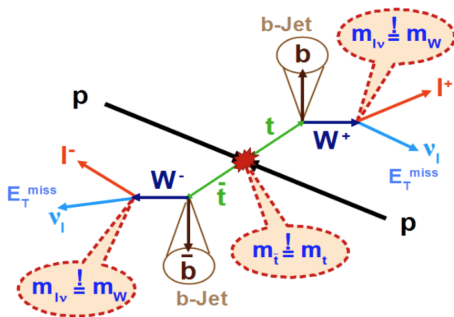
- Search performed over 2016 CMS data totalling 35.7 fb^{-1}
- Focus on the **dileptonic** channel
 - Both W bosons in top decays decay leptonically, with $\ell = e$ or μ
 - Complimentary semileptonic search not covered here
- Generated signal points:
 - **2D $[m_\phi, \Gamma_\phi]$ array** in (400, 500, 600, 750) GeV and (2.5%, 5%, 10%, 25%, 50%) m_ϕ
 - $g_{\phi t\bar{t}}$ assumed to be 1
- Set limits on $g_{\phi t\bar{t}}^2$ through shape analysis on $m_{t\bar{t}}$ spectrum
- Increased sensitivity by exploiting other observables on top of $m_{t\bar{t}}$

Event selection

- 2 opposite-sign **isolated leptons**: $p_T > 25, 20$ GeV, $|\eta| < 2.4$
 - $m_{\ell\ell} > 20$ GeV and $\Delta R > 0.4$ from all jets
 - In same-flavor channels: $|m_{\ell\ell} - m_Z| > 15$ GeV and $\cancel{E}_T > 40$ GeV
 - Events with additional leptons are vetoed
- 2 **leading** (additional) **jets**: $p_T > 30$ (20) GeV, $|\eta| < 2.4$
 - At least one is b-tagged
- **Corrections** to account for data-simulation differences
 - Object-based scale factors
 - Pile-up reweighting

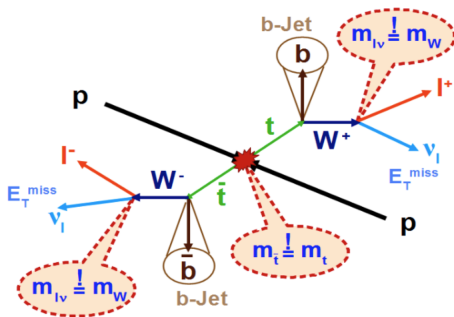
$t\bar{t}$ kinematic reconstruction

- Missing neutrinos in the event $\rightarrow t\bar{t}$ system is underconstrained



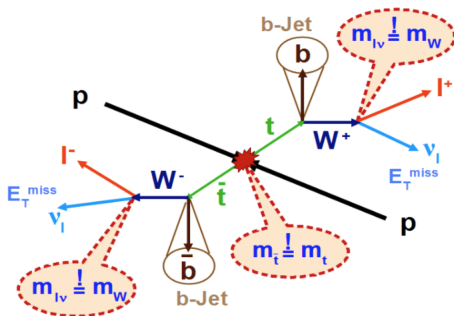
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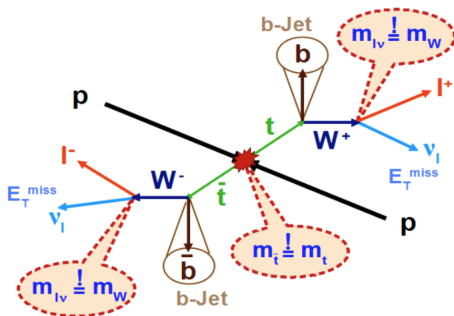
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 - Resulting polynomial in p_i^y solvable leading to full $t\bar{t}$ system kinematics



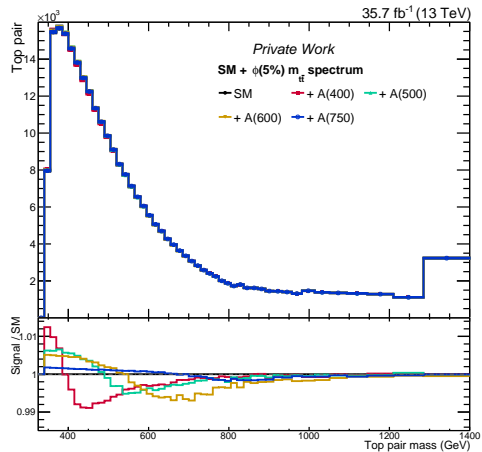
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- Increase efficiency by solving for all lepton-jet combinations
- Account for detector effects by random object smearings
- Procedure described in detail in CMS-PAS-TOP-16-011



Systematic effects on $m_{t\bar{t}}$

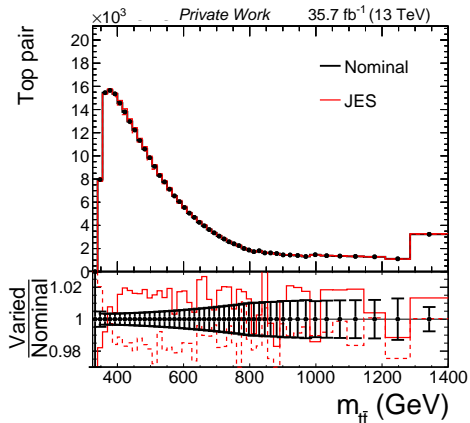
- Crucial to evaluate systematics affecting $m_{t\bar{t}}$ shape



$m_{t\bar{t}}$ distribution obtained with the kinematic reconstruction routine

Systematic effects on $m_{t\bar{t}}$

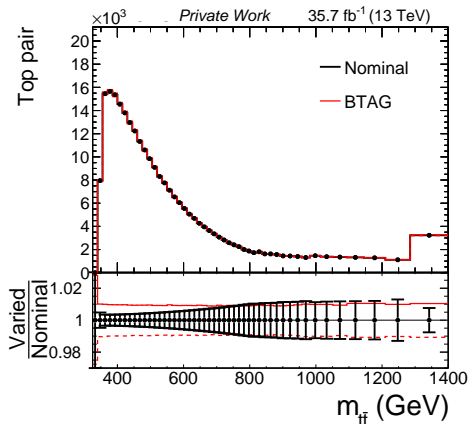
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Solid: up variation; dashed: down variation

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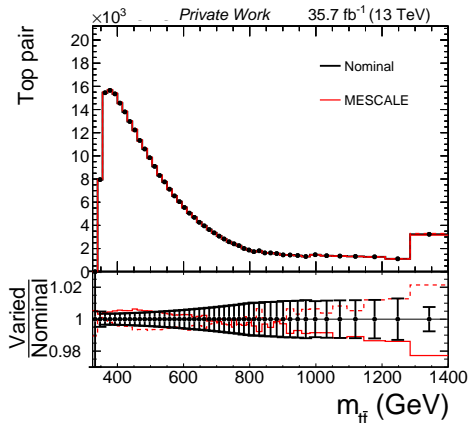
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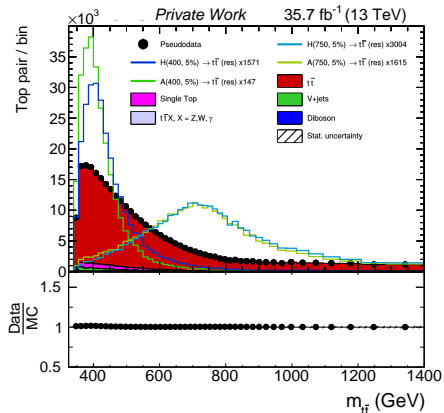
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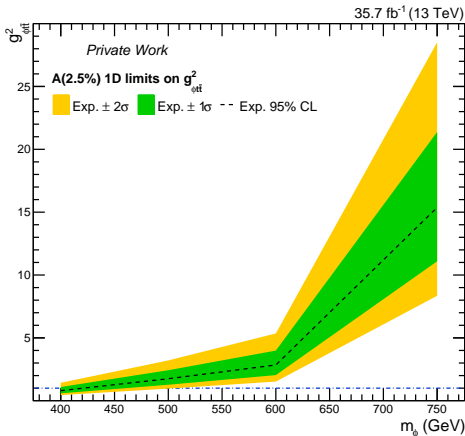
Limits with $m_{t\bar{t}}$

- Limits evaluated with $m_{t\bar{t}}$ templates
- MC-estimated background processes:
 - $t\bar{t}$ (+ V)
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- DY yield estimated from data



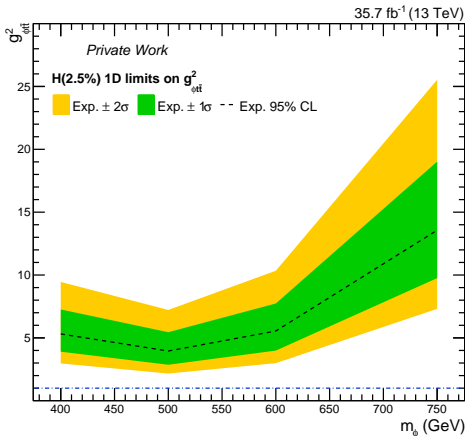
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Spin correlation variables

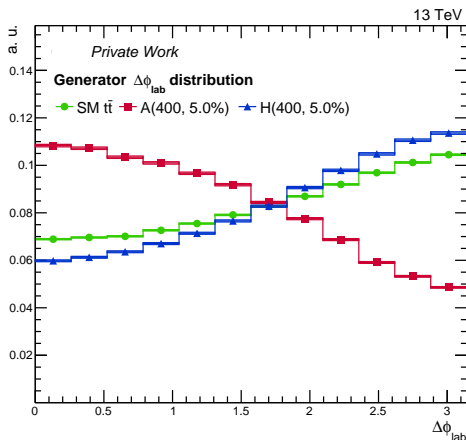
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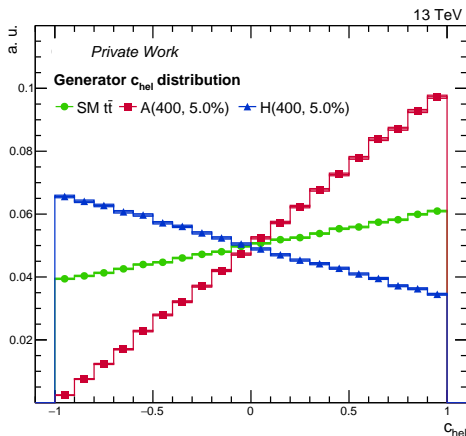
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Distributions are normalized to unit area and resonance-only for A/H

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 - C_{hel}



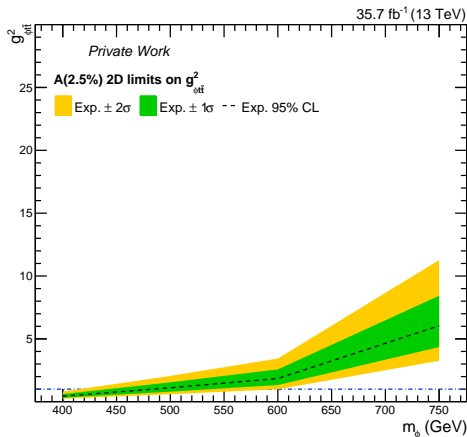
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2D limits

- Set limits with the 2D template of $m_{t\bar{t}}$ vs c_{hel}

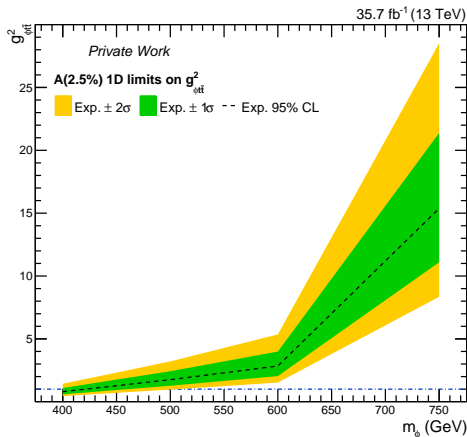
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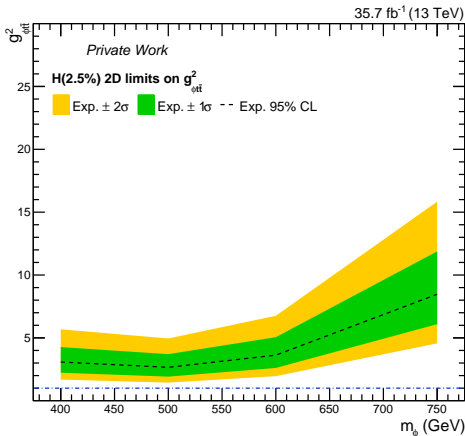
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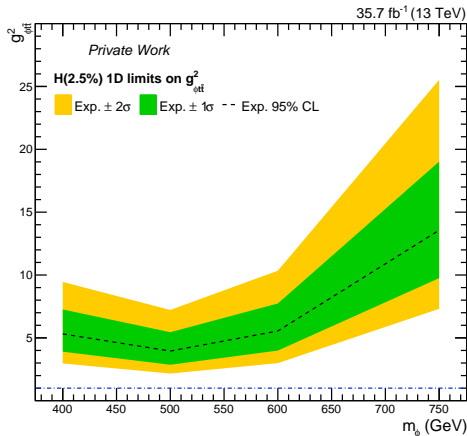
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Summary

- An overview of the search for resonant spin-0 ϕ production decaying to $t\bar{t}$ has been presented
- Emphasis on the increased sensitivity by exploiting spin correlation observables on top of the $m_{t\bar{t}}$ spectrum

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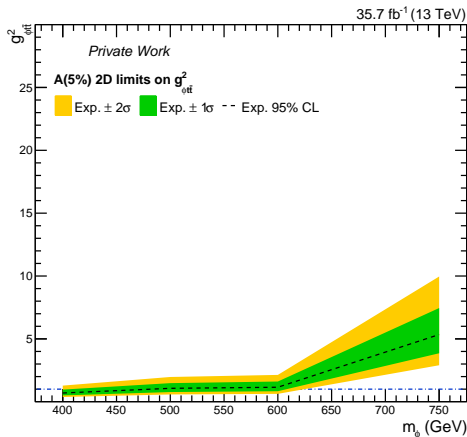
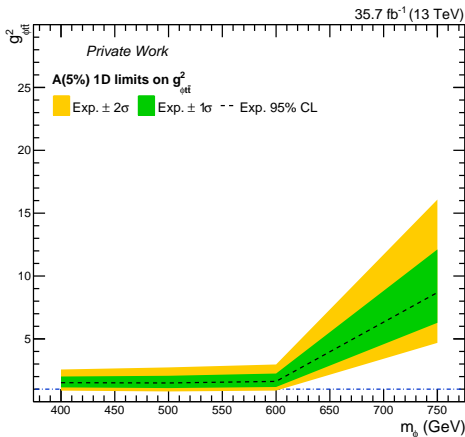
Thanks for your attention!

Any questions?

Backup slides

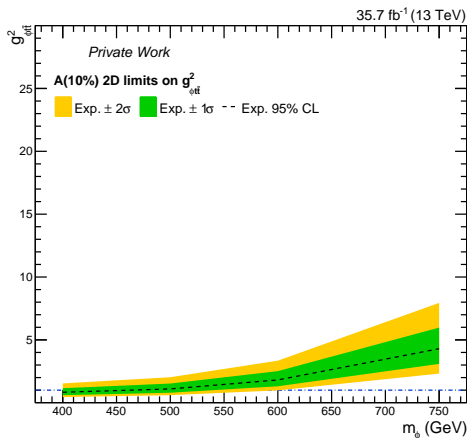
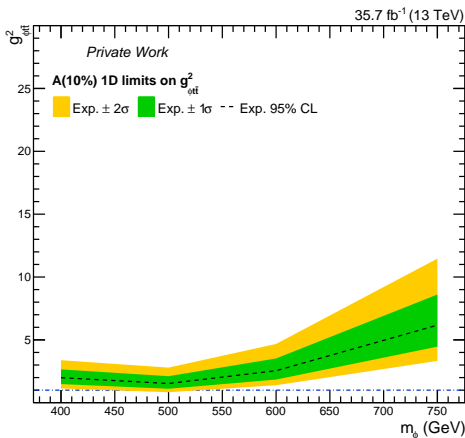
A(5%) limits

Left is 1D, right 2D



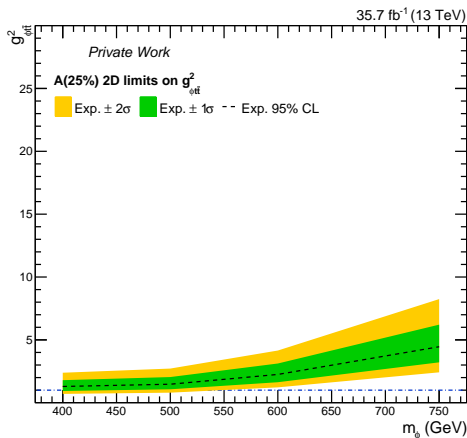
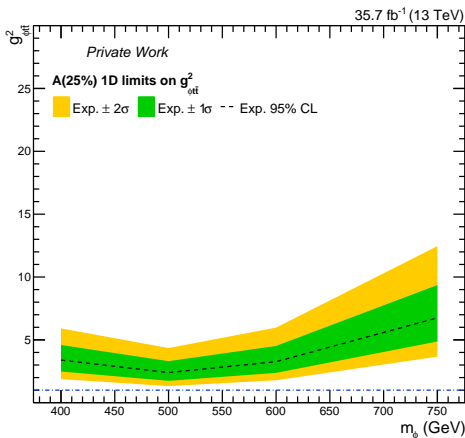
A(10%) limits

Left is 1D, right 2D



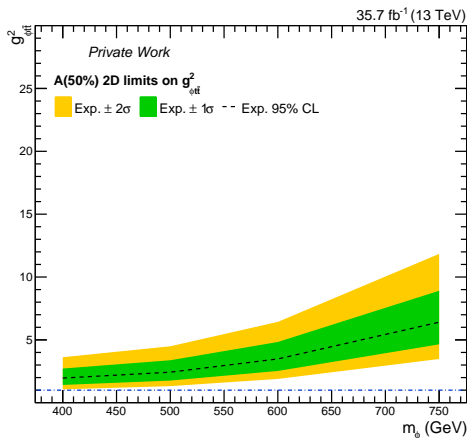
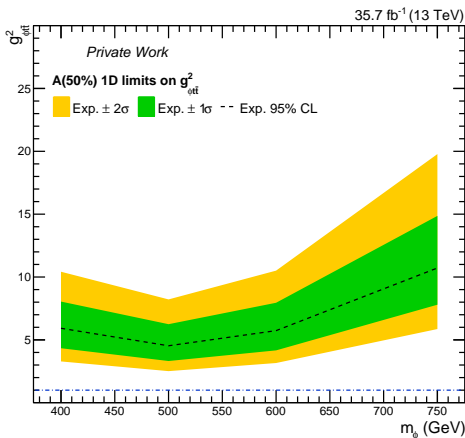
A(25%) limits

Left is 1D, right 2D



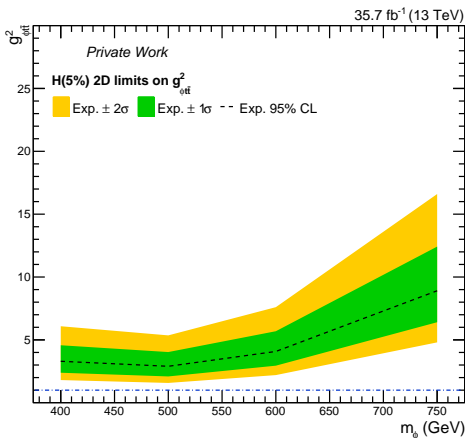
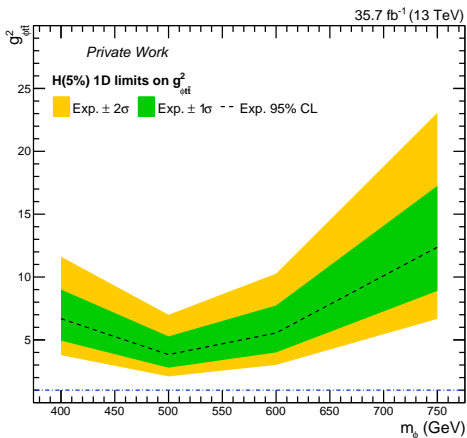
A(50%) limits

Left is 1D, right 2D



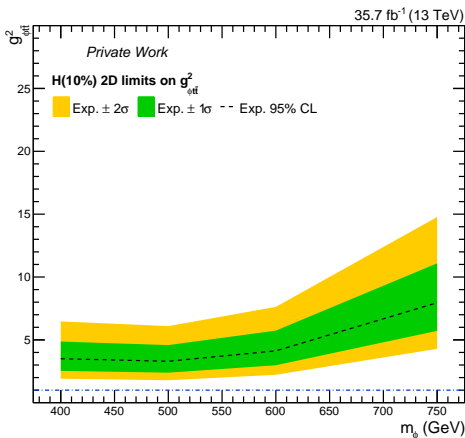
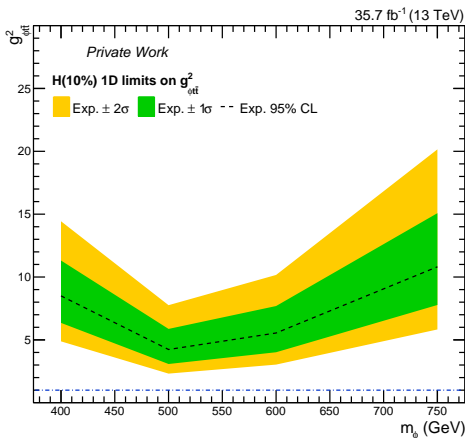
H(5%) limits

Left is 1D, right 2D



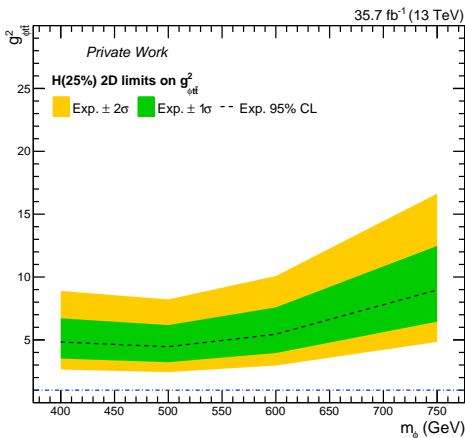
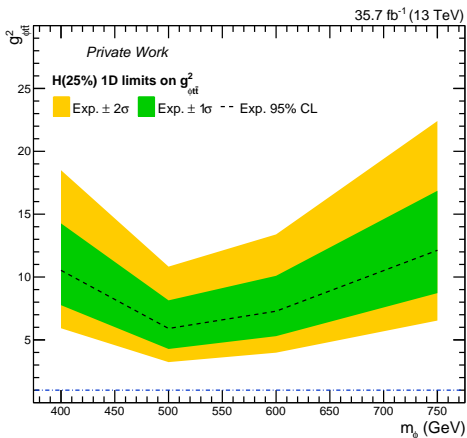
H(10%) limits

Left is 1D, right 2D



H(25%) limits

Left is 1D, right 2D



H(50%) limits

Left is 1D, right 2D

