863. Search for MSSM Higgs boson decaying to a pair of tau leptons in CMS

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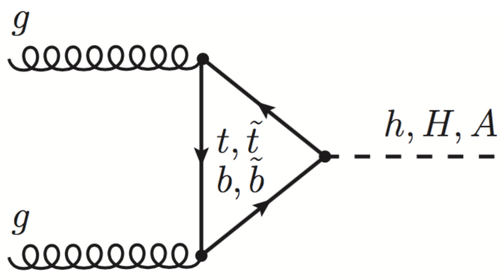
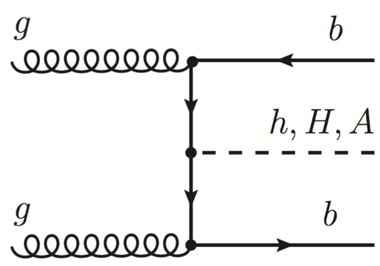
on behalf of the CMS collaboration

I.What is the MSSM Higgs boson?



gluon fusion, ggΦ, Φ={h,H,A}



b-associated Higgs production, bbΦ

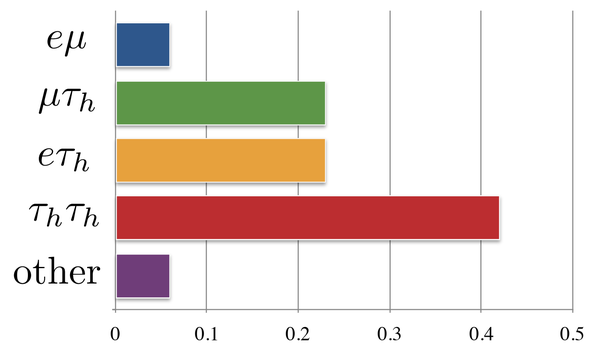
The **Minimal Supersymmetry Model** (MSSM) is an extension of Standard Model (SM) which provides answers to the origin of dark matter and a solution to the hierarchy problem.

MSSM Higgs sector predict five physical Higgs bosons:
2 charged Higgs $H^{\pm}$, 3 neutral Higgs Φ: two scalars H, h and pseudo scalar A.

At tree level, properties are described by two parameters:
- **Mass** of **pseudo scalar** Higgs boson m_A.
- **The ratios of the vacuum expectation values of the two Higgs doublets** $\tan\beta$.

Large $\tan\beta$ leads to enhanced coupling to fermion:
- **Enhanced branching ratios** of $H \to \tau\tau$ and $A \to \tau\tau$ with respect to SM $h \to \tau\tau$.
- An additional important **bottom quark associated production** mode.

II. How to identify tau lepton?

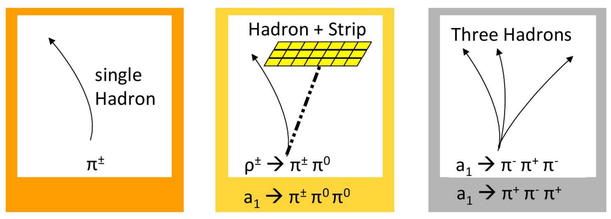


4 di-τ final states with largest branching ratios studied in this analysis:

$\tau_h\tau_h$, $\mu\tau_h$, $e\tau_h$, $e\mu$

Hadronic taus are reconstructed using **hadron** (combinations of track from $\pi^{\pm}$) + **strip** (e/γ candidate clusters from π_0) algorithm[1].

3 reconstructed decay modes:
1 hadron, 1 hadron+strip(s), 3 hadrons



Using multivariate analysis technique to reject jet faking tau and electron faking tau.

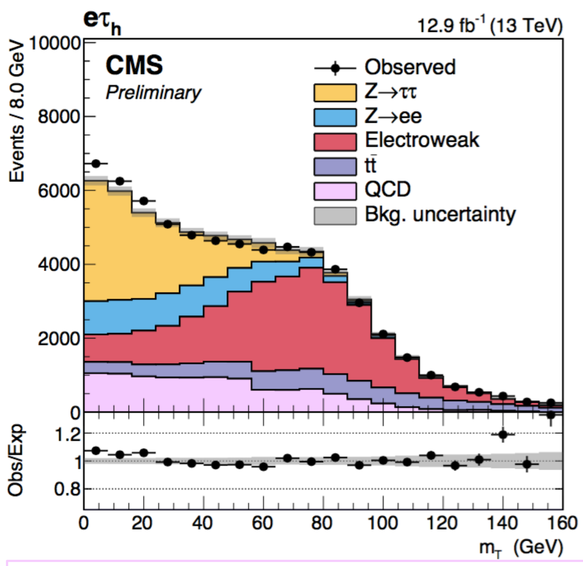
III. Which are the backgrounds?

Z->ττ: from Monte Carlo (MC), with data-driven correction from Z->$\mu\mu$ control region applied

W+Jets: $\mu\tau_h$, $e\tau_h$: Normalization from high mT control region **shapes** from MC

$\tau_h\tau_h$, $e\mu$: from MC

Dibosons and Single-Top: from MC



Z—>ll: from MC

ttbar: from MC, with data-driven corrections

QCD: $\tau_h\tau_h$: Normalization from opposite-sign (OS) region with loose isolation, with scale factor loose to tight isolation applied. Shape from OS region with loose isolation

Fully data-driven $\mu\tau_h$,$e\tau_h$,$e\mu$: Normalization from same-sign (SS) region with other backgrounds subtracted, and OS/SS ratio applied, shape from SS

IV. How to extract the signal?

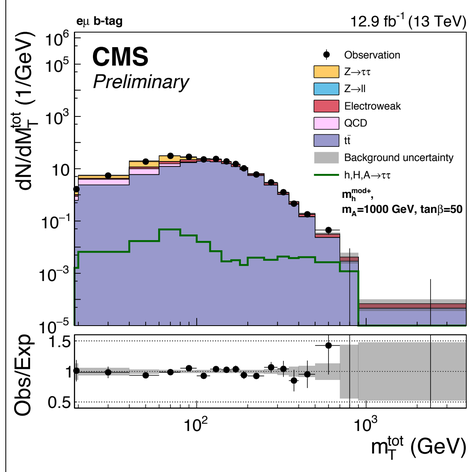
Using **total transverse mass** variable as final discriminant to extract signal:

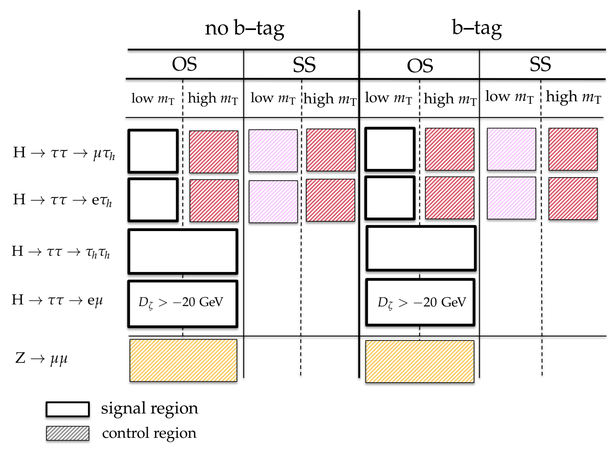
$$m_T^{tot} = \sqrt{m_T(E_T^{miss},\tau_1^{vis})^2 + m_T(E_T^{miss},\tau_2^{vis})^2 + m_T(\tau_1^{vis},\tau_2^{vis})^2}$$

where $m_T = \sqrt{2 p_T^1 p_T^2 (1-\cos\Delta\phi)}$

Two categories per final states:
- **No b-tagged jet** category targeting $gg\phi$
- **With b-tagged jet** category targeting $bb\phi$

Additional control regions are included in the fit

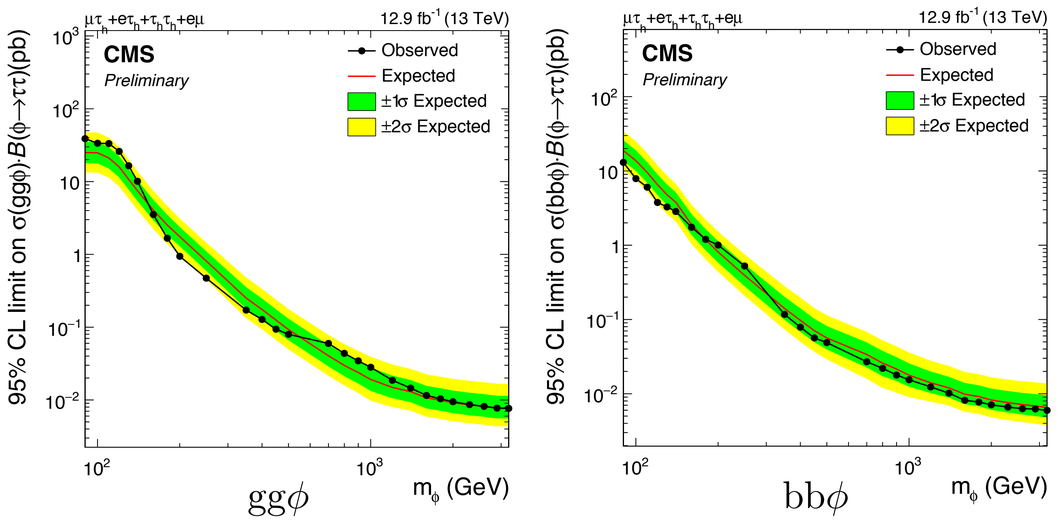




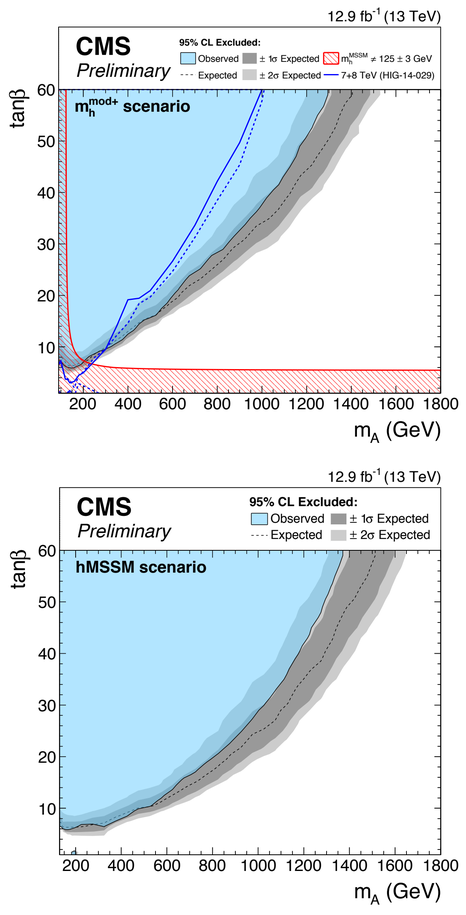
V. What are the results?

No evidence of signal has been found. Setting exclusion limits.

Model independent limit on cross-section times branching ratio between 90 and 3200 GeV

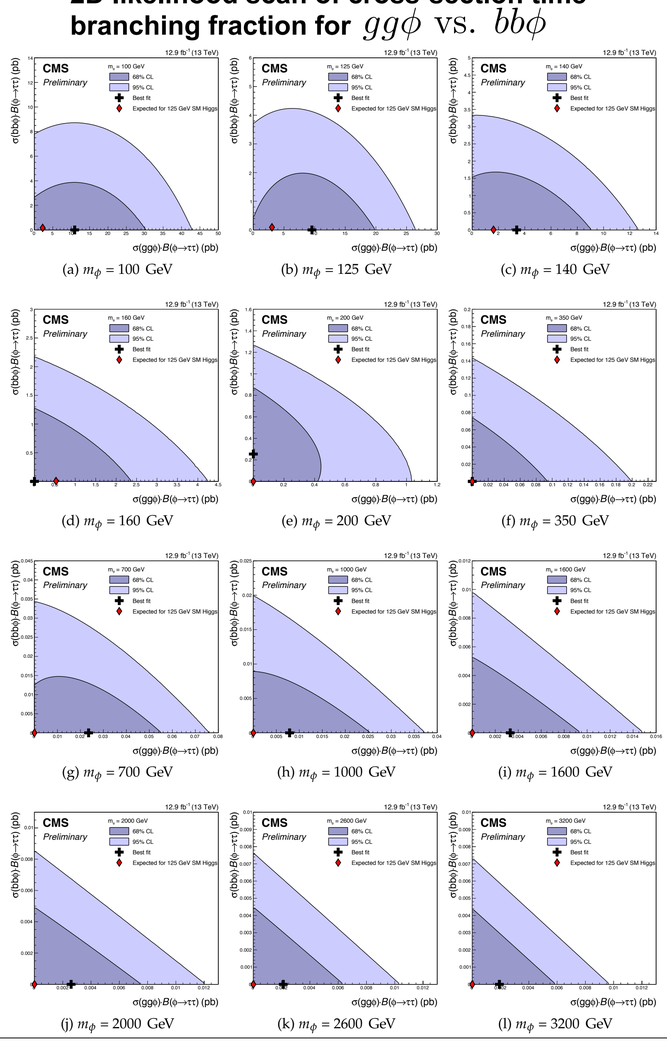


2D likelihood scan on m_A-$\tan\beta$



First exclusion beyond $m_A > 1$ TeV at CMS

2D likelihood scan of cross-section time branching fraction for $gg\phi$ vs. $bb\phi$



(a) m_ϕ = 100 GeV (b) m_ϕ = 125 GeV (c) m_ϕ = 140 GeV

(d) m_ϕ = 160 GeV (e) m_ϕ = 200 GeV (f) m_ϕ = 350 GeV

(g) m_ϕ = 700 GeV (h) m_ϕ = 1000 GeV (i) m_ϕ = 1600 GeV

(j) m_ϕ = 2000 GeV (k) m_ϕ = 2600 GeV (l) m_ϕ = 3200 GeV

VI. References

1. Performance of reconstruction and identification of tau leptons in their decays to hadrons and tau neutrino in LHC Run-2, CMS-PAS-TAU-16-002
2. Search for a neutral MSSM Higgs boson decaying into tau tau with 12.9/fb of data at 13 TeV in CMS, CMS-PAS-HIG-16-037

CMS-PAS-HIG-16-037