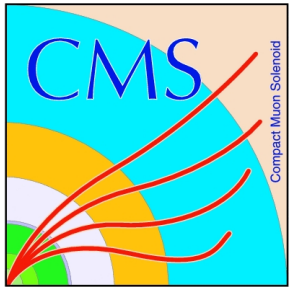
Imperial College London



Searches for neutral BSM Higgs bosons with final states containing two taus

A. de Wit on behalf of the CMS collaboration

Joint annual HEPP and APP conference,

University of Sussex

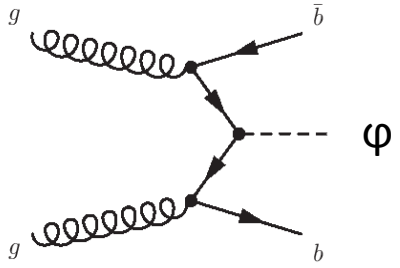
22/03/2016

Outline

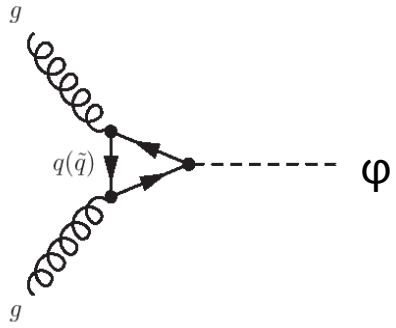
- Introduction
- LHC Run-I BSM H→ττ results from CMS
- Search for H→hh→bbττ
  - Motivation
  - Overview & strategy
  - Results
- Summary and outlook
  - H→ττ in Run-II

Introduction

- SM-compatible Higgs boson observed by CMS and ATLAS in 2012
  - What else is there?
- In the MSSM, there are 2 Higgs doublets → 5 physical Higgs bosons: h, H, A, $H^{\pm}$
- At tree level the MSSM Higgs sector is defined by m_A and tanβ
- High tanβ: enhanced branching ratio into ττ
- Production processes for neutral Higgs bosons: gg→φ, gg→bbφ (φ=h,H,A)



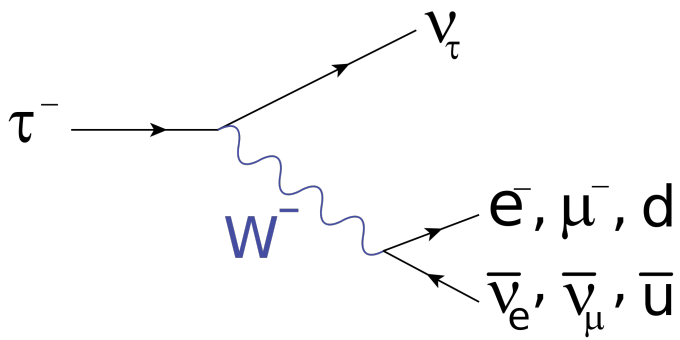
bbφ



ggφ

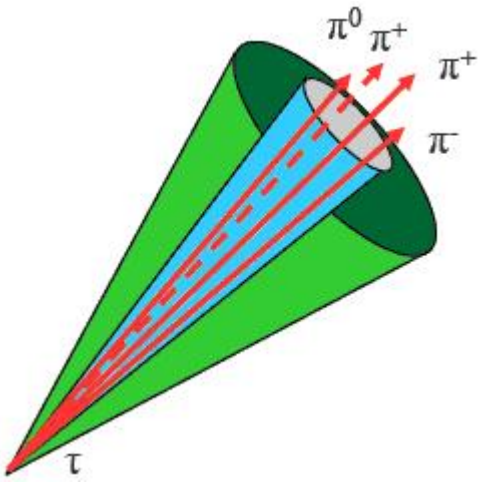
H→ττ final states

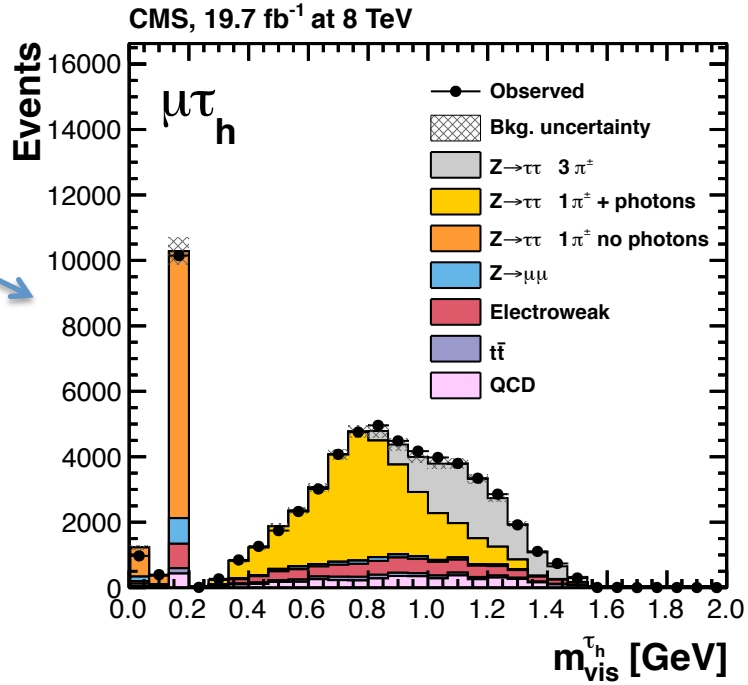
- τ s decay into e,μ or hadronically



- Can search for final states $\tau_h\tau_h$, $\mu\tau_h$, $e\tau_h$, $e\mu$, $\mu\mu$, ee

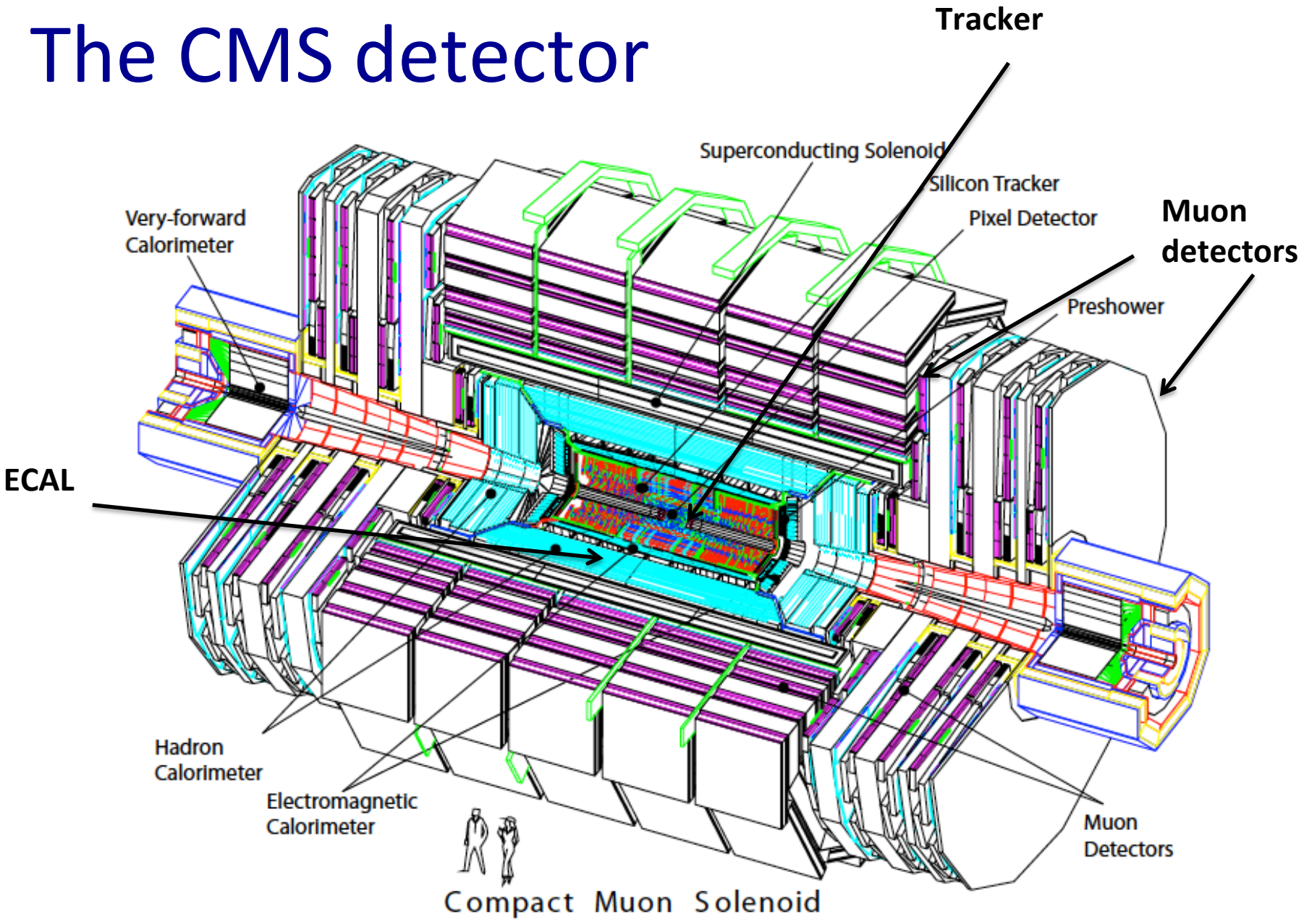
τ_h – hadronically decaying τ
Various possible decay modes





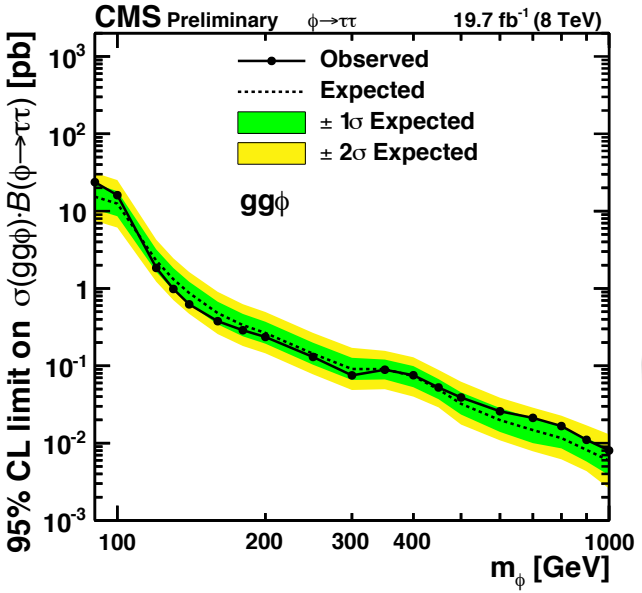
CMS-HIG-13-004

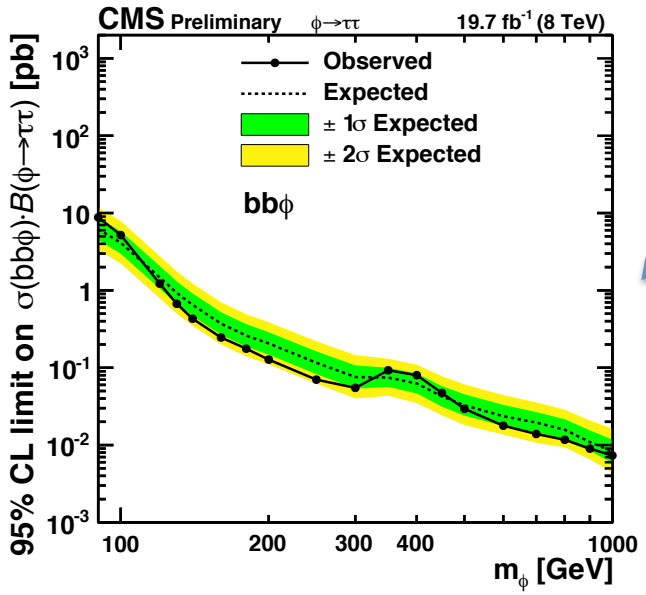
The CMS detector



http://cds.cern.ch/record/922757/files/lhcc-2006-001.pdf

MSSM H→ττ results in run I



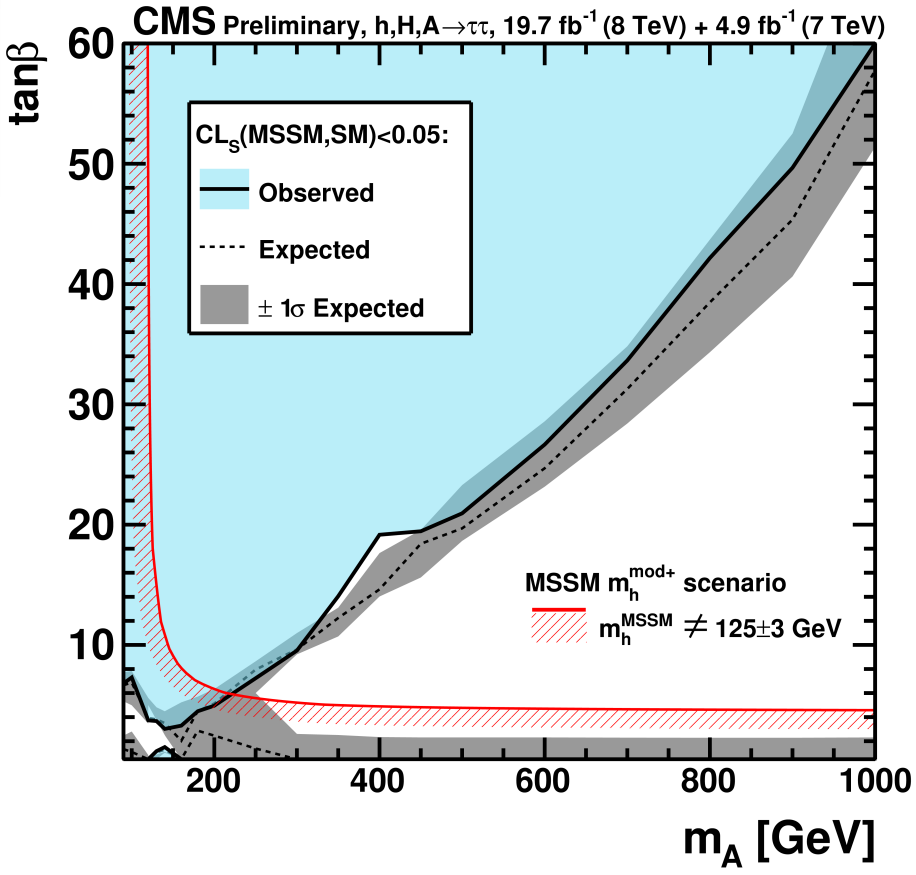


95% CL Upper limits on σ x BR(φ→ττ)

$\tau_h\tau_h+\mu\tau_h+e\tau_h+e\mu+\mu\mu$

Model independent

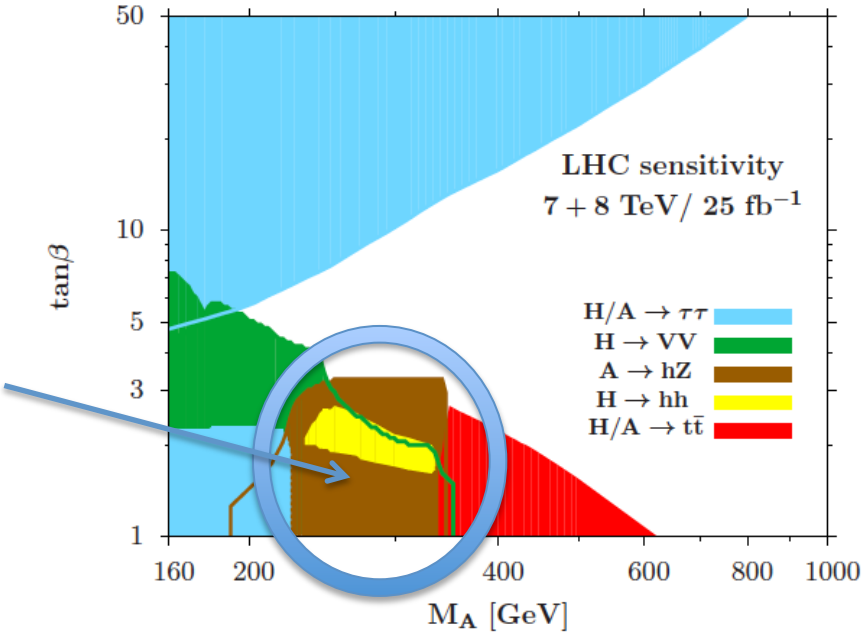
Large part of high tanβ region excluded, for example in m_h^{mod+} scenario

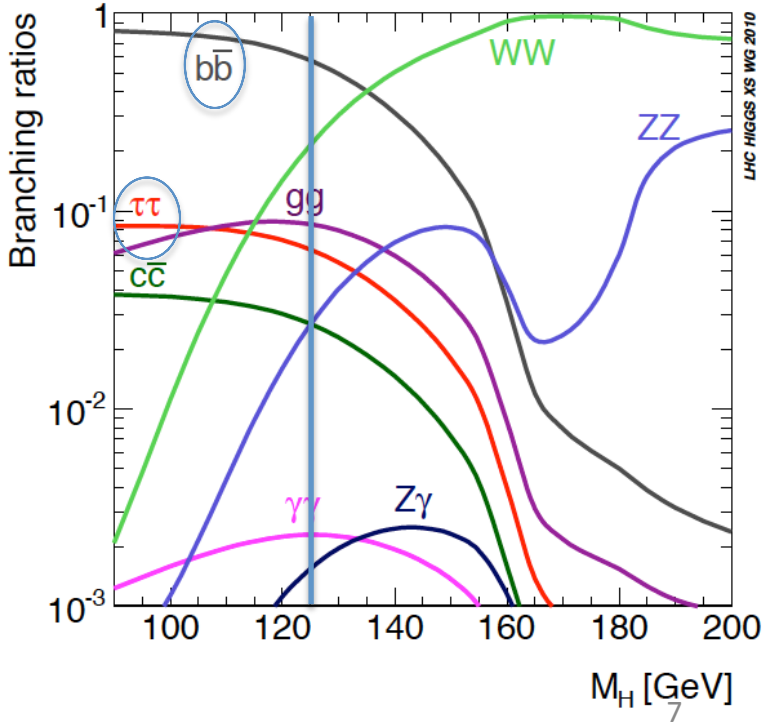


Model dependent

H→hh motivation

- At low tanβ branching ratios of H→hh and A→Zh enhanced in some MSSM benchmark models
- Probes a mass range of m_H ~260-350 GeV
- H→hh→bbττ takes advantage of combining cleaner final state (ττ) and larger branching fraction(bb)





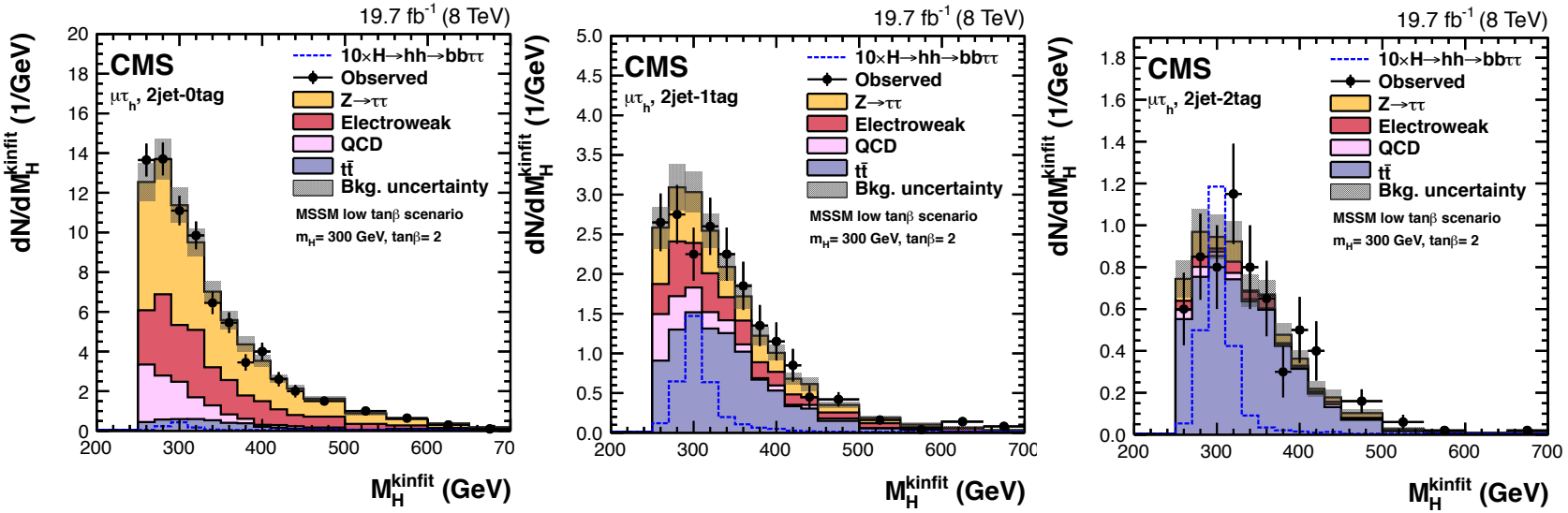
Event selection

- Select events with di-τ candidate and 2 jets in final state
- Events split into channels based on the final state of the τs: $e\tau_h$, $\mu\tau_h$, $\tau_h\tau_h$
- Three categories:

2jet0tag
At least 2 jets with p_T>20 GeV, none of them b-tagged

2jet1tag
At least 2 jets with p_T>20 GeV, exactly one of them b-tagged

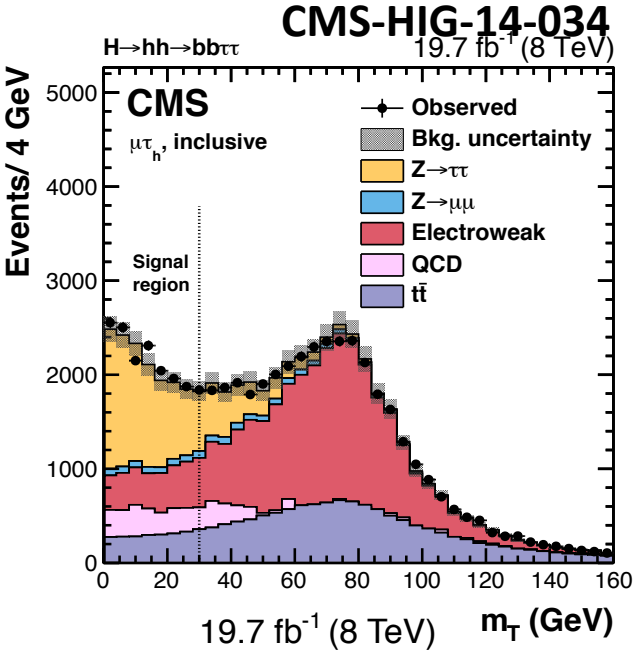
2jet2tag
At least 2 b-tagged jets with p_T>20 GeV
Most signal-sensitive category



Blue line: **signal x10**

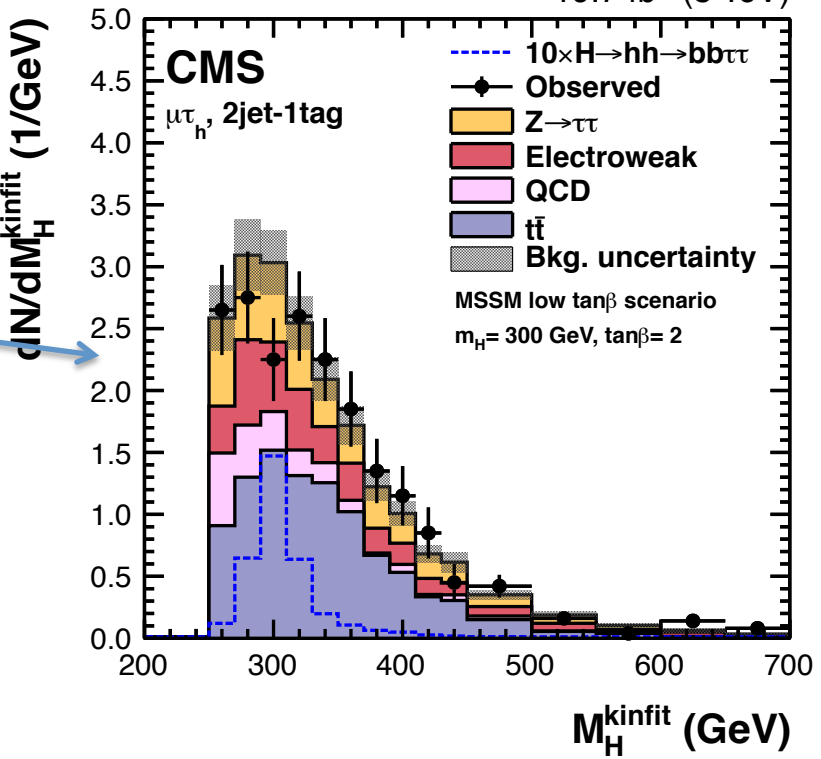
Analysis strategy

- m_T< 30 to suppress W+Jets
- Consider mass window of 90 < $m_{\tau\tau}$ < 150 GeV and 70 <m_{bb}< 150 GeV
- Construct m_H from kinematic fit which takes b-jets, visible τ decay products and missing E_T, assumes $m_{\tau\tau}$=m_{bb}=125 GeV and varies object energies to fit this constraint
- Extract signal from fit to m_H^{kinfit} distribution

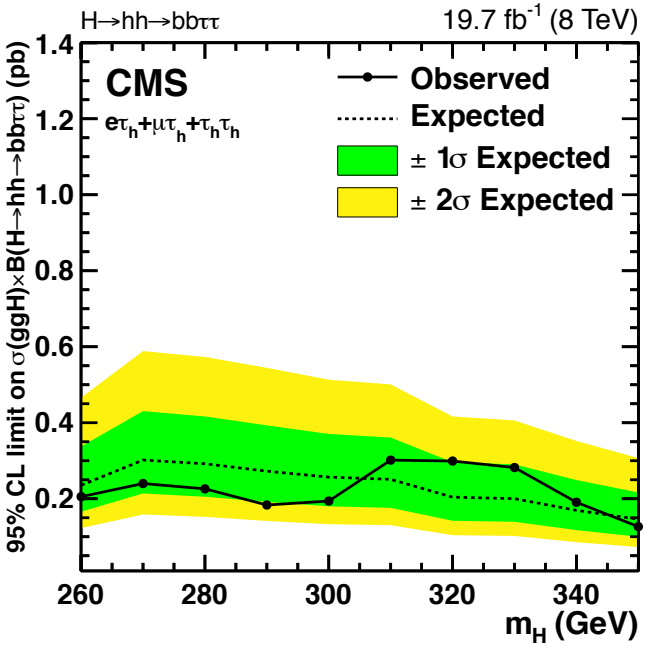


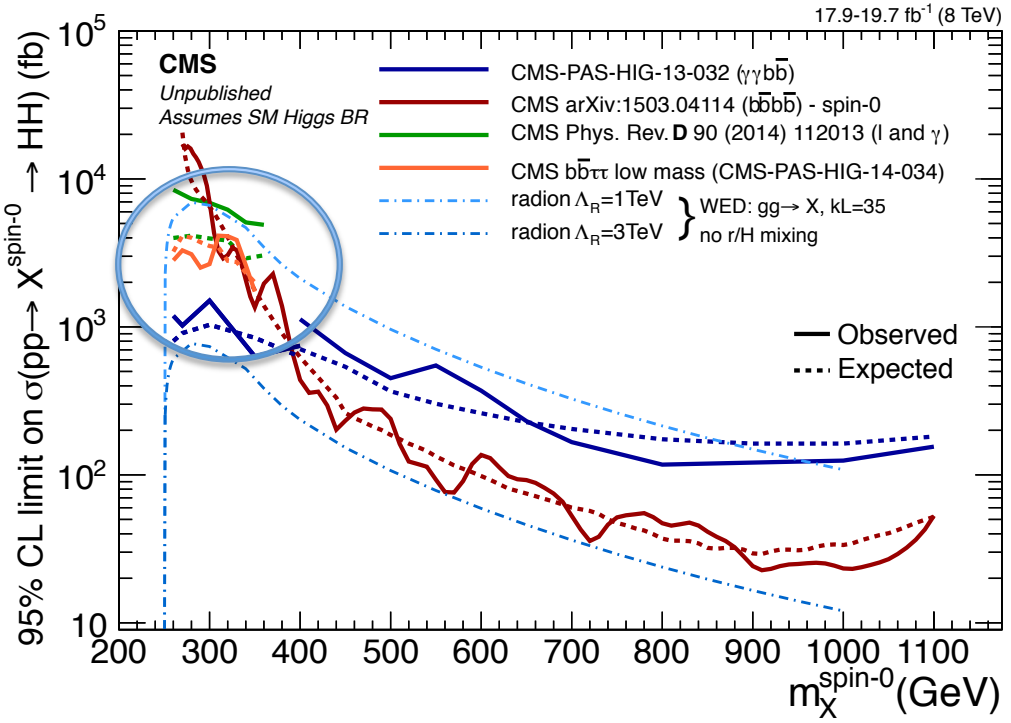
m_H^{kinfit} for 2jet1tag category in $\mu\tau_h$ channel

Signal peaks more sharply than background



Results – model independent





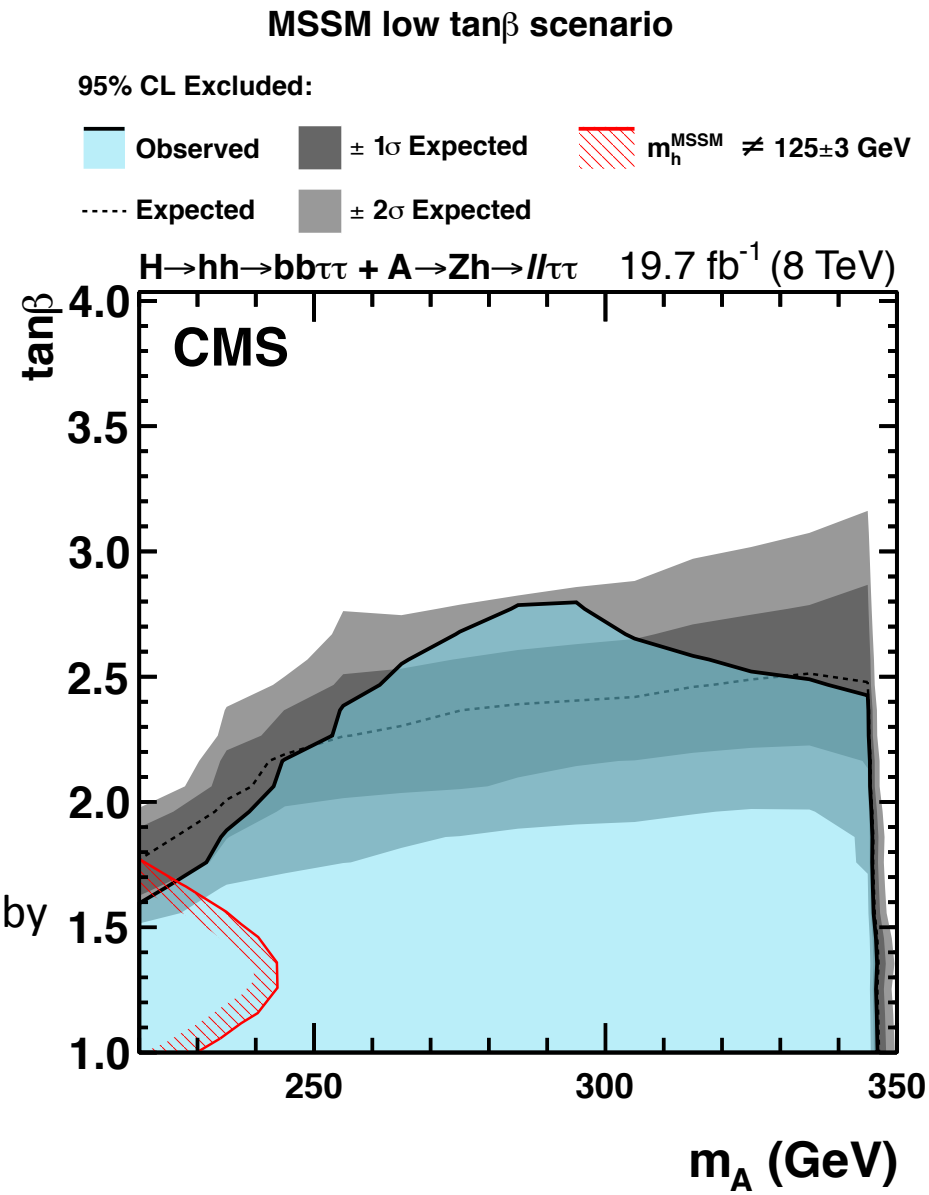
Combination of all three channels $\mu\tau_h+e\tau_h+\tau_h\tau_h$

95% CL upper limit on σ(gg→H)*BR (H→hh→bbττ): ~0.3 pb

Factoring out the h→ττ and h→bb branching ratio, **bbττ result lies between bbbb and γγbb result**

Results – model interpretation

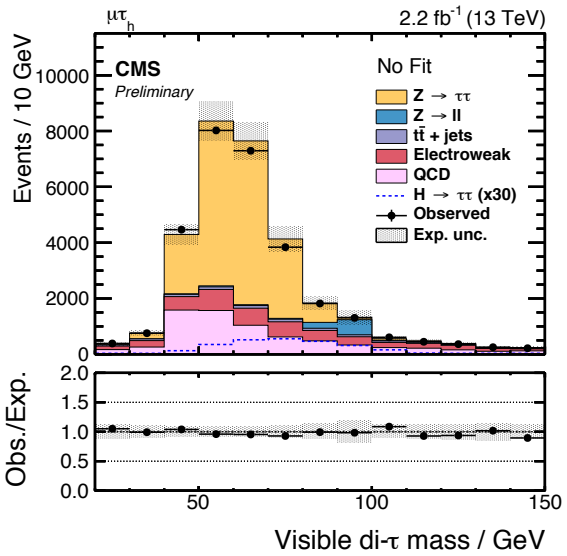
- Can calculate exclusion limits in different scenarios
- **For example low-tanβ MSSM scenario**
  - Scenario tuned so that m_h is compatible with 125 GeV for most of low tanβ region
- Results combined with search for A→Zh→llττ for model interpretation

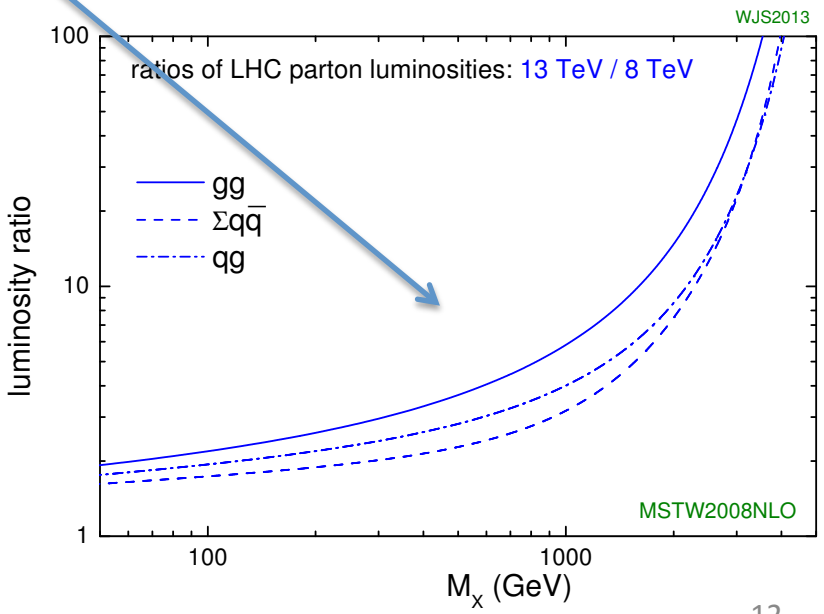


Region excluded by 125 GeV mass constraint.

Summary and outlook

- Search for H→hh→bbττ in $\mu\tau_h$,$e\tau_h$,$\tau_h\tau_h$ channels has been presented
  - 95% CL on σ(gg→H)xBR(H→hh→bbττ) 0.2-0.4 pb in $260<m_H<350$ GeV
  - Combining with A→Zh→llττ excludes region below tanβ~2.5 in low tanβ MSSM scenario
- With around 2.5 fb^{-1} of data collected at 13 TeV by CMS in 2015, focus back on MSSM H→ττ
  - Gain in sensitivity at higher masses
- Watch this space for results out soon





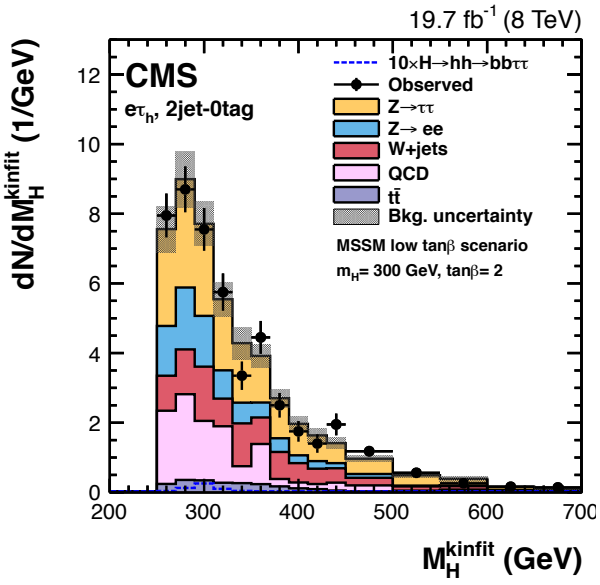
CMS, Dec 15 Jamboree

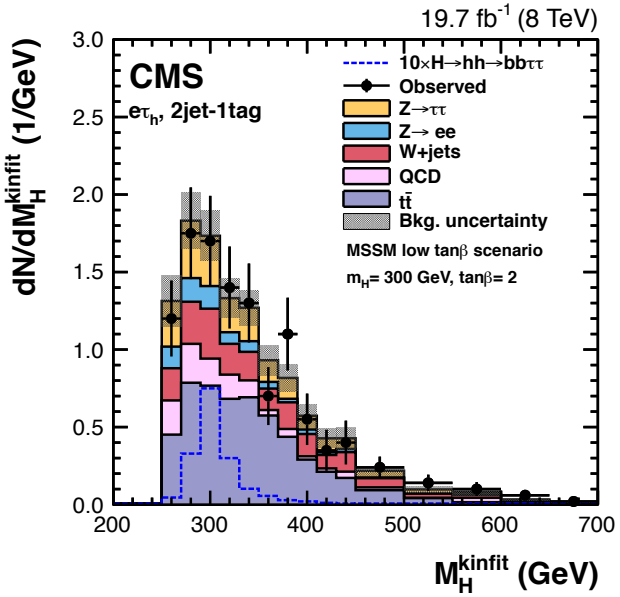
BACKUP

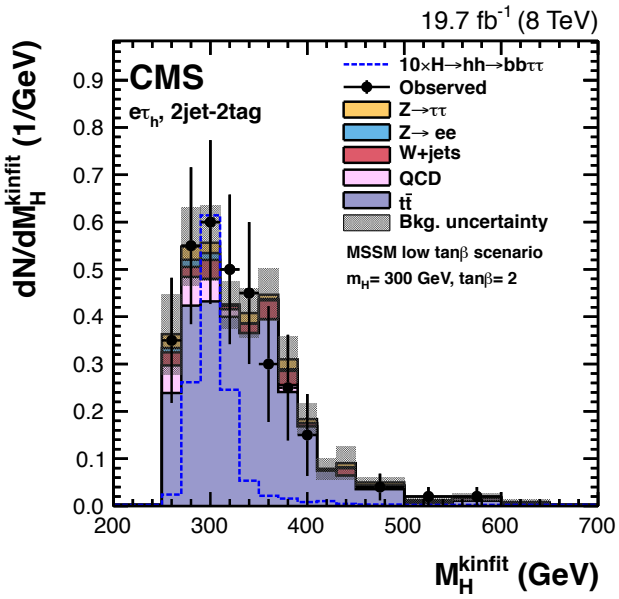
M_h^{mod+} scenario

- Modified version of m_h^{max} scenario to incorporate 125 GeV higgs boson
- m_h^{max} scenario:
  - Used in LEP higgs searches
  - M_{SUSY}=1 TeV
  - **Stop mixing parameter $X_t = 2 \cdot M_{SUSY}$**
- In m_h^{mod+} scenario: $X_t = 1.5 \cdot M_{SUSY}$

m_H^{kinfit}

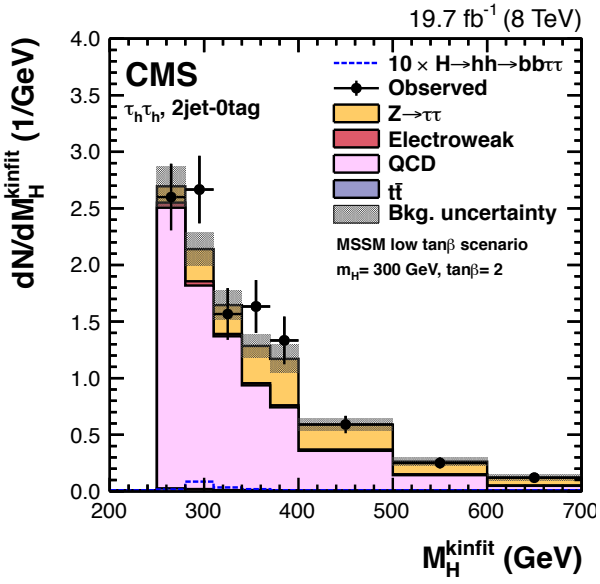


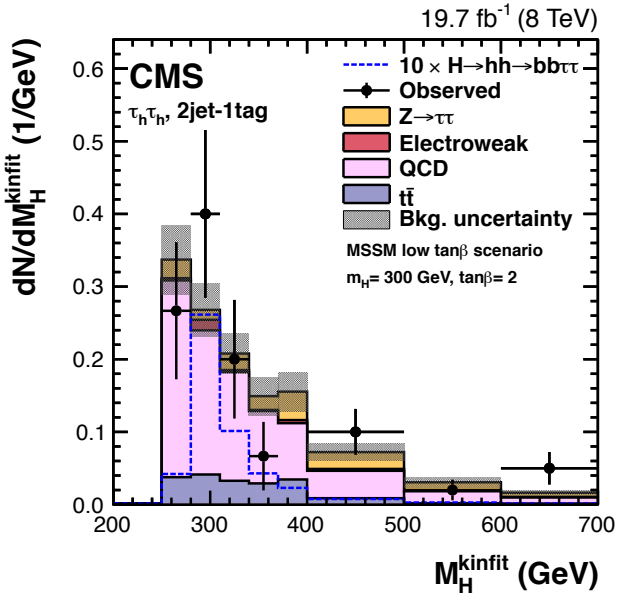


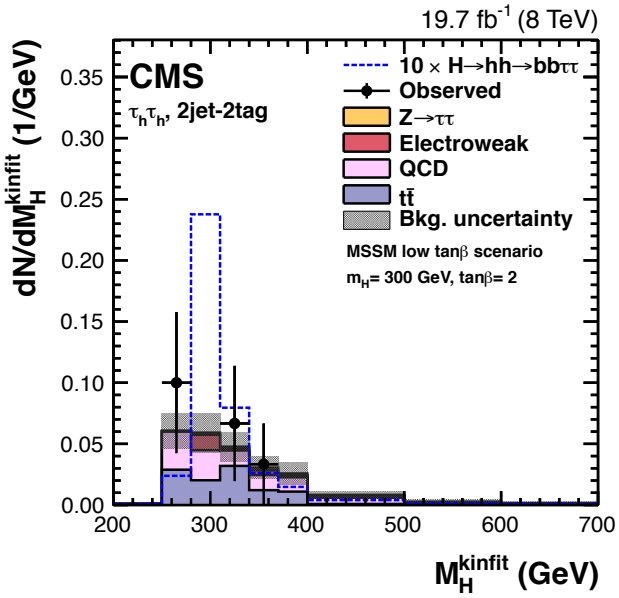


CMS-HIG-14-034

m_H^{kinfit}







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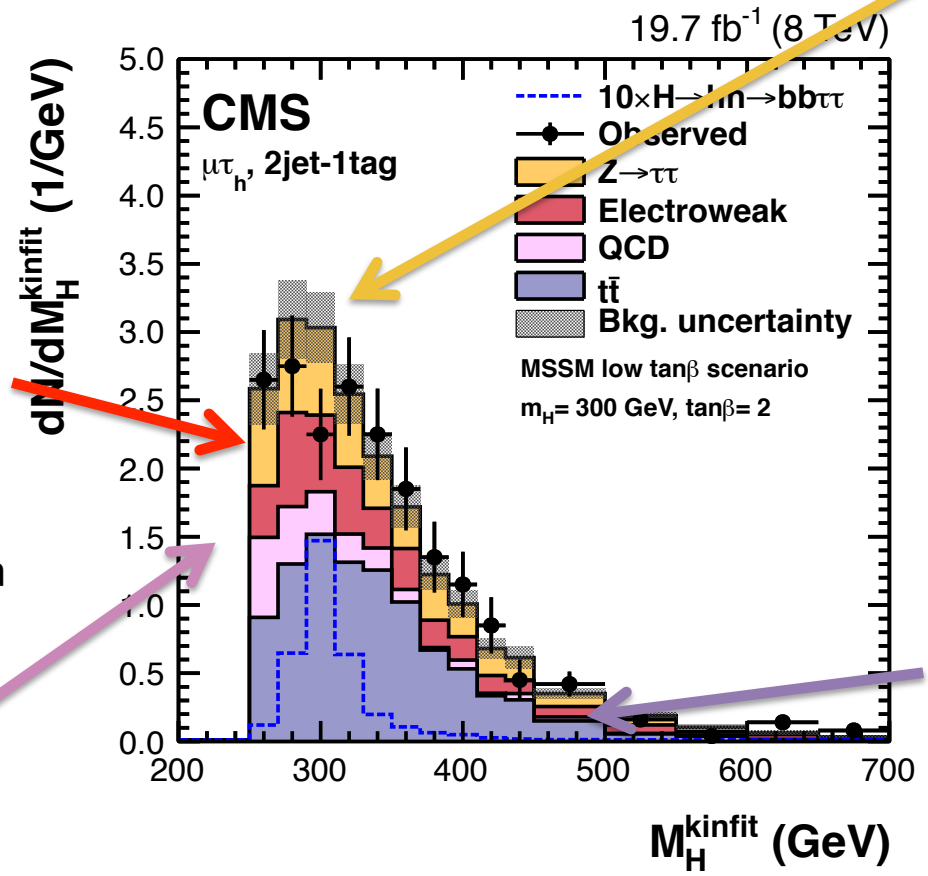
Background estimation



DY Z→ττ
Estimated from Z→μμ in data with μ's replaced by simulated τs

W+Jets
Shape from MC
Normalisation from high m_T sideband in data

QCD
From SS data

TTbar
Shape from MC
Normalisation from MC, but checked against sidebands in data

Results – model interpretation

- **For example type-II 2HDM scenario**
- Coulings in MSSM are subset of type-II 2HDM couplings
- More than 2 parameters are needed to describe these models : m_A, m_H fixed, then can interpret in tanβ, cos(β-α) plane
- α mixing angle between 2 higgs doublets
- Couplings to fermions ~sinα/cosβ*y_{SM}: sinα=0, h->ττ,h->bb=0
- Cos(β-α) = 0: properties exactly SM like, H->hh = 0