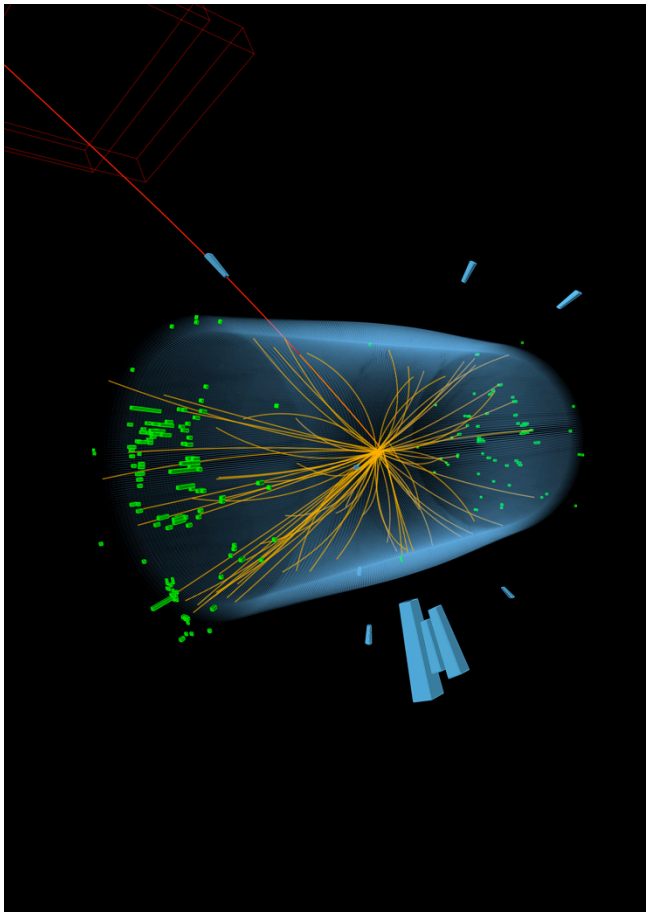


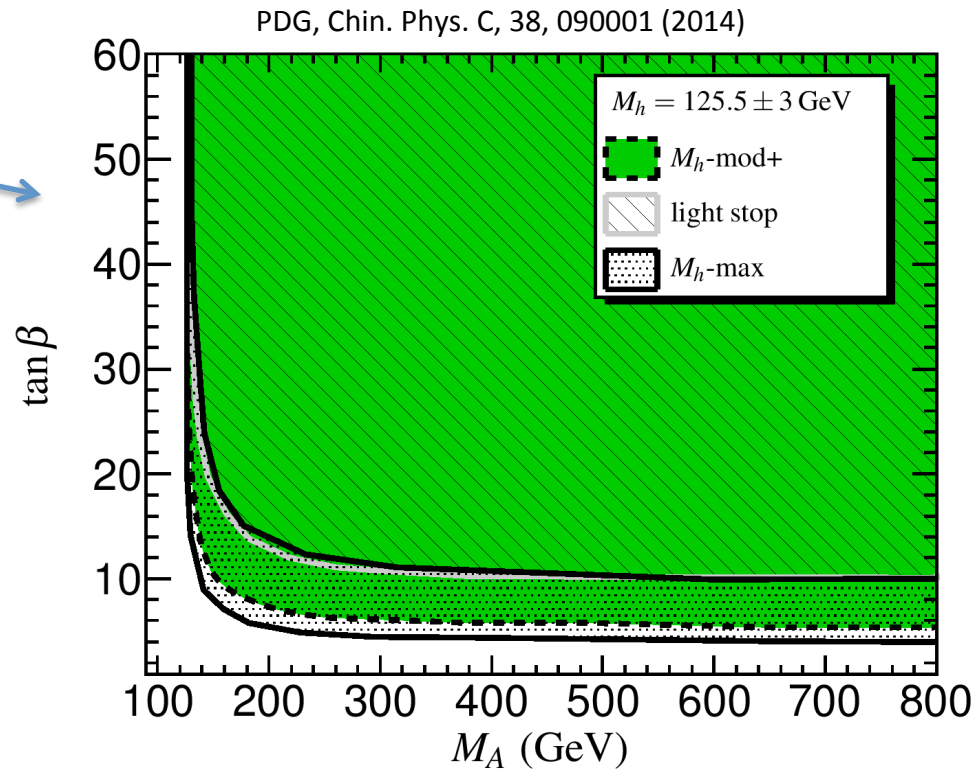
CMS SUSY Higgs Searches

Jan Steggemann (CERN)
on behalf of the CMS collaboration

4 November 2014

Motivation

- 125 GeV Higgs boson is perfectly compatible with MSSM



Two strategies:

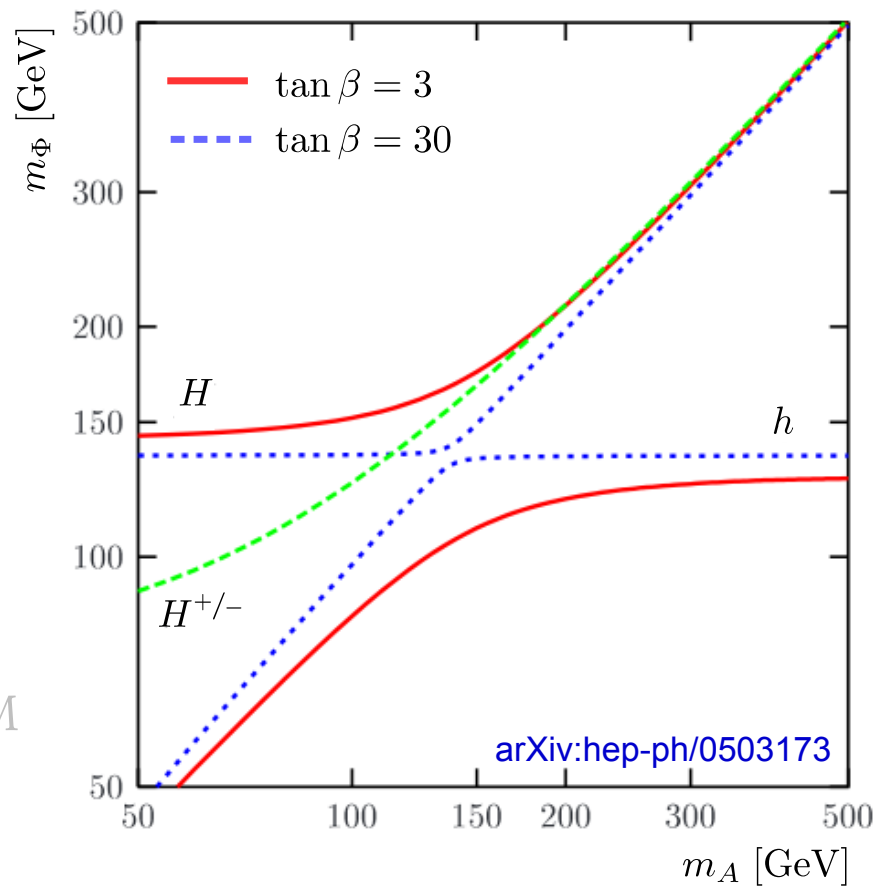
- Search for deviations of the Higgs boson couplings from the SM (yesterday's talks)
- **Search for additional neutral or charged Higgs bosons**

Searches for neutral and charged Higgs bosons in MSSM context

Focus on analyses finished recently

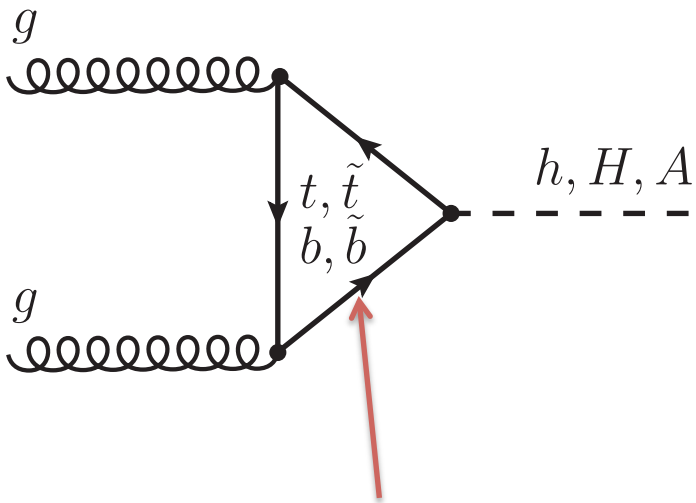
A/H/h→ττ (arXiv:1408.3316)
A/H/h→bb (arXiv:1302.2892, 2011 data)

gg→H⁺tb search with H⁺→tb or H⁺→τν in final states with leptons (HIG-13-026)
H⁺→τν in fully hadronic final states (HIG-14-020)
H⁺→cs in top decays (HIG-13-035, 2HDM talk)

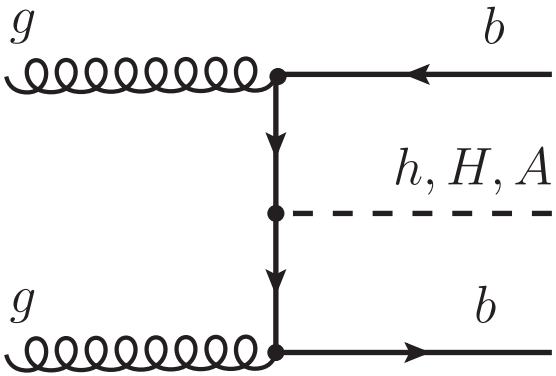


h/H/A Production and Event Categories

Gluon fusion "No b-tag"

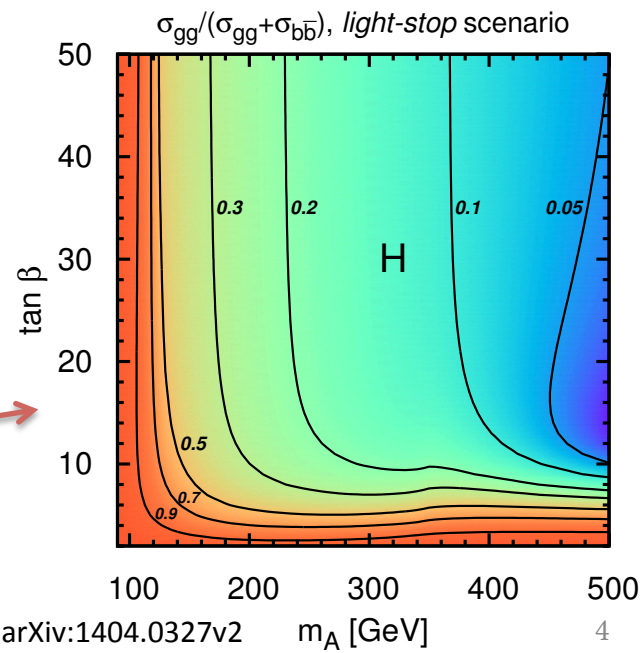


b-associated: "b-tag"



Model independence: don't use Higgs boson p_T to define event categories

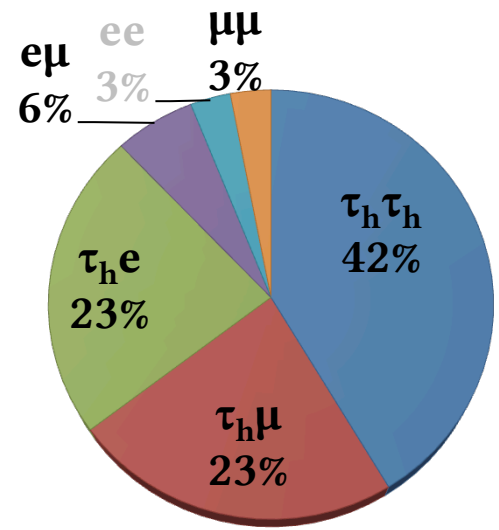
Relative cross sections depend on SUSY parameters

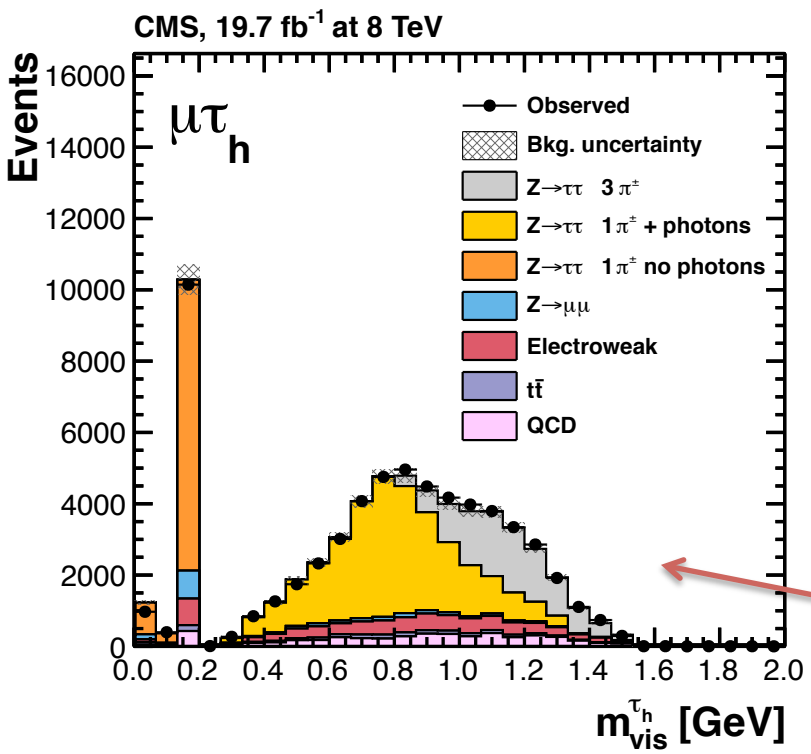


arXiv:1404.0327v2

A/H/h→ττ final states

Consider the **5 most important** ττ final states:

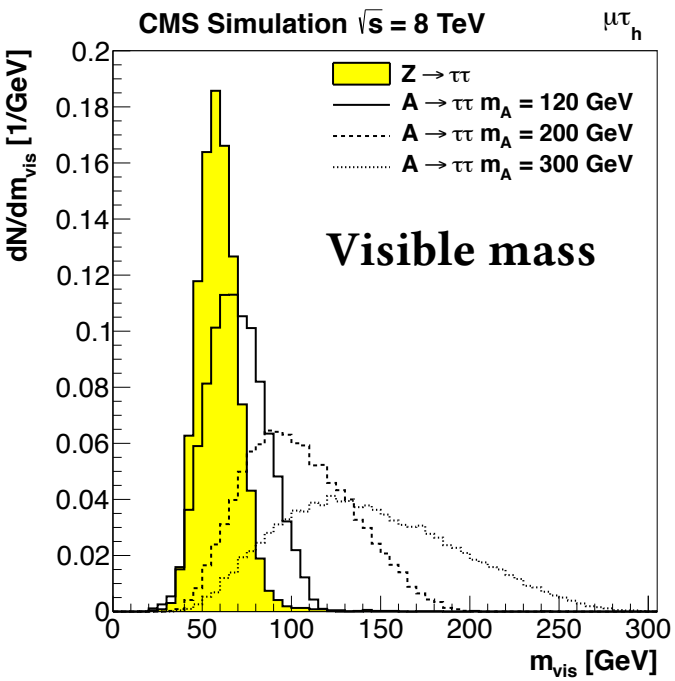


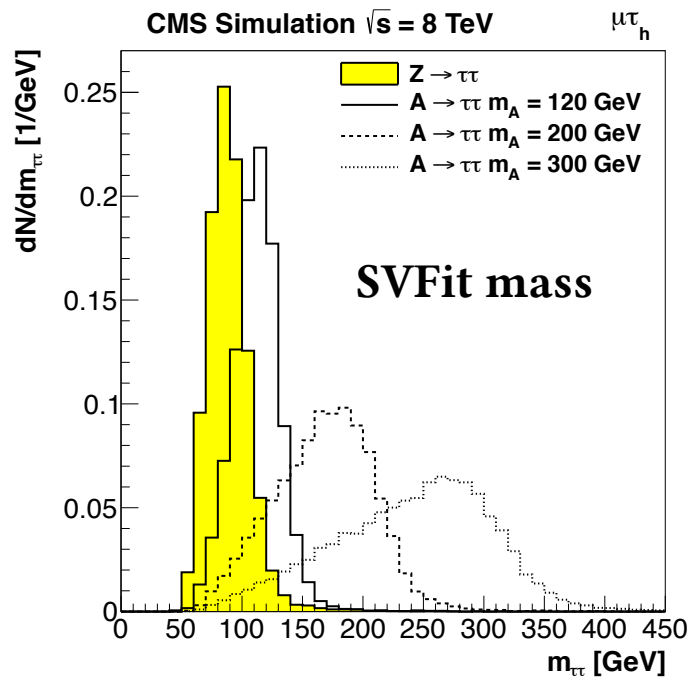


Same inclusive event selection and background estimation strategies as in SM h→ττ analysis

Good control of reconstruction & identification of hadronic tau decays

Mass Reconstruction

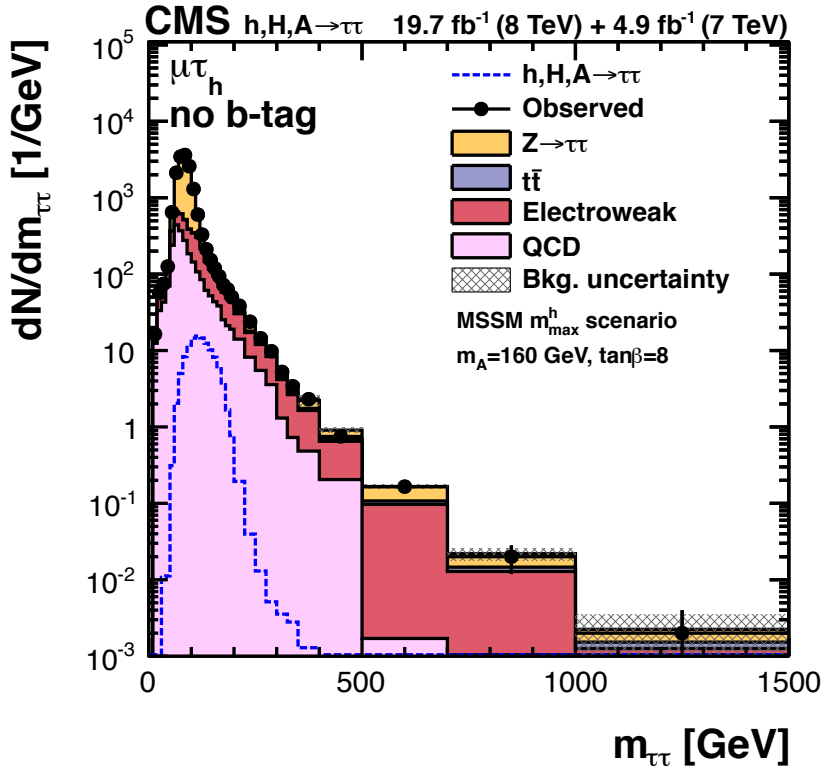


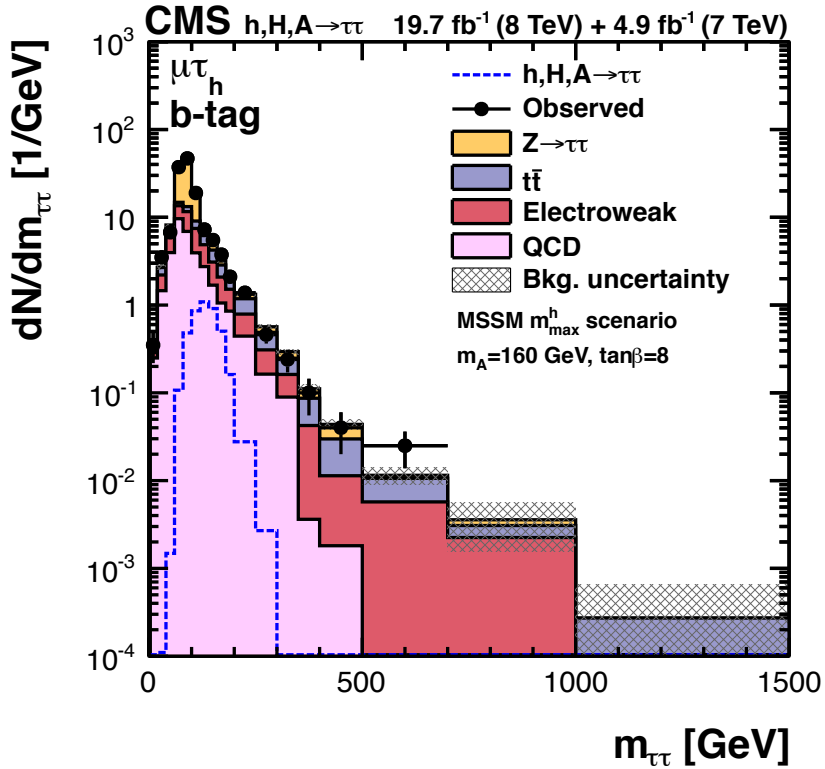


Likelihood-based method (SVFit) based on tau decay matrix elements and taking into account missing energy resolution

- improves separation of signal and background
- mass resolution of ~ 20%

Mass Distributions



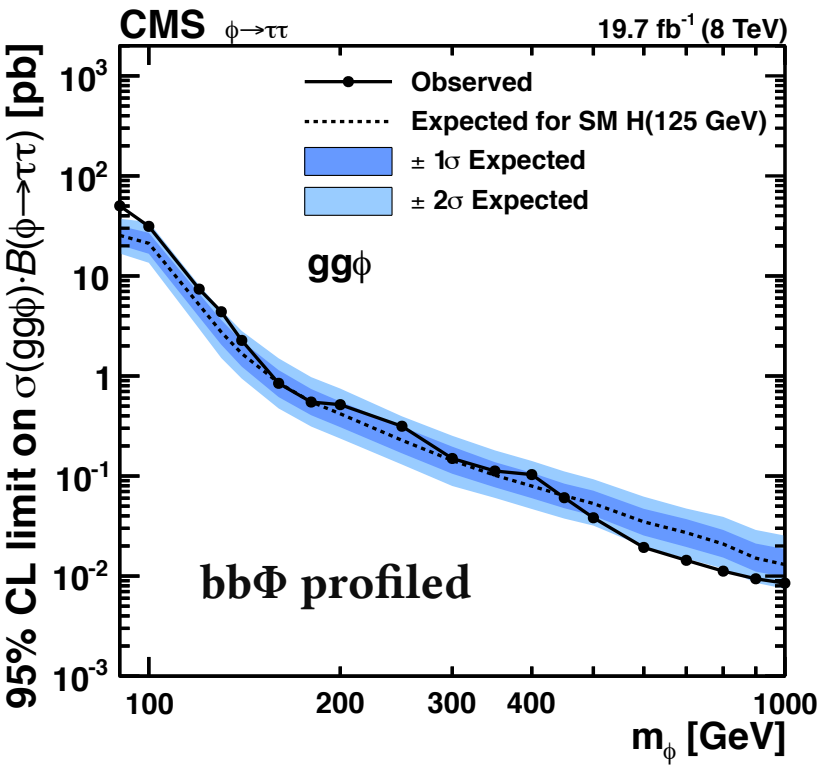


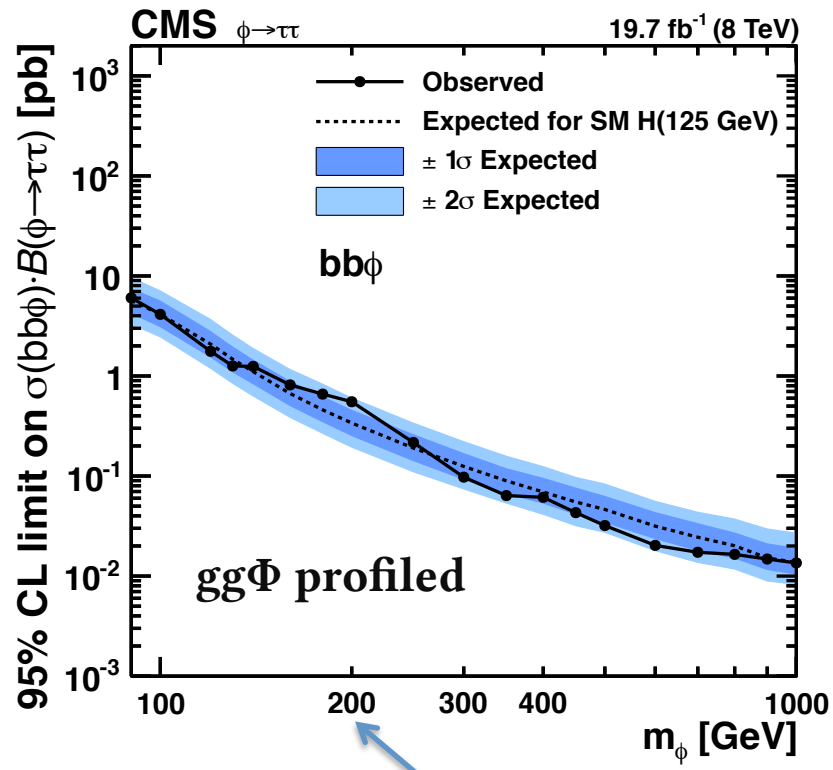
Dominant backgrounds:

$Z \rightarrow \tau\tau$ (low mass)

W+jets (high mass) and top pair (high mass with b-tag)

Model-independent limits



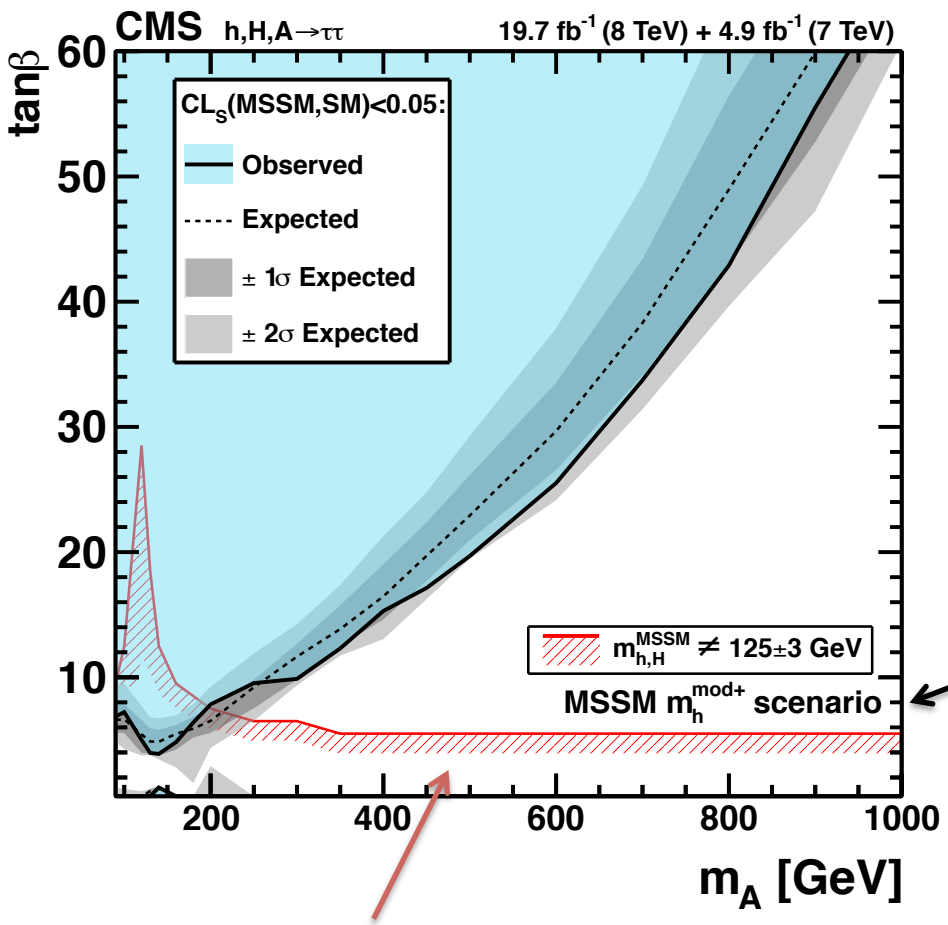


CMS 7 TeV Φ→bb limits at 200 GeV O(10 pb)

Search for single narrow resonance in each production mode

2D cross section limits for various mass values as well as full 3D limits provided on public TWiki page

Interpretation in MSSM benchmark scenarios



Excluded by m_h = 125±3 GeV

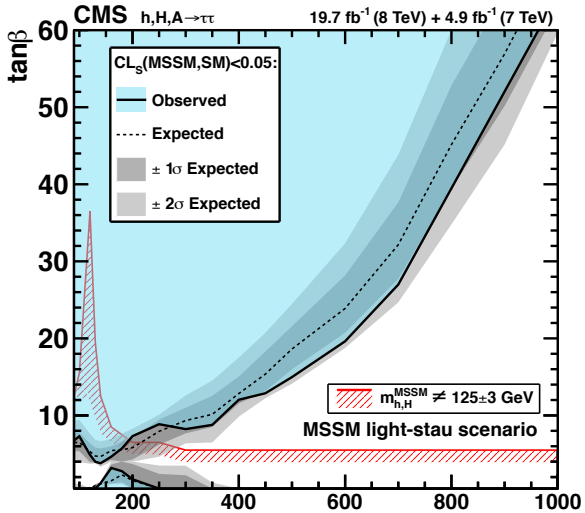
Test statistics:

$L(MSSM+B)/L(H_{125}^{SM}+B)$

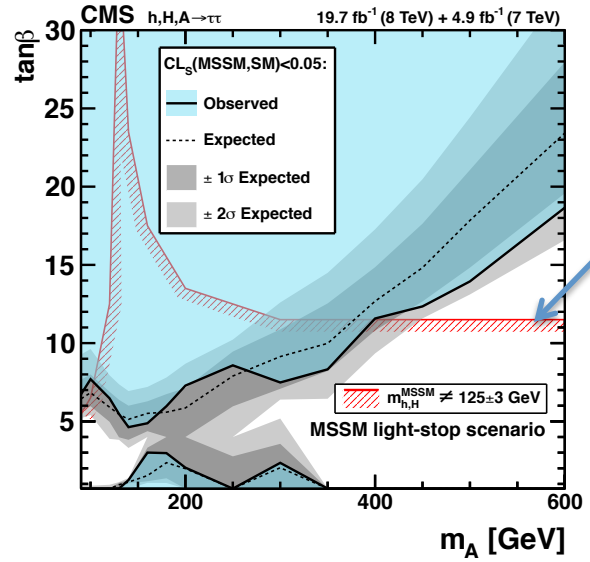
1 SM-like Higgs boson at 125 GeV or three neutral Higgs bosons?

Benchmark scenarios taking 125 GeV h/H into account arXiv:1302.7033

More MSSM benchmark scenarios

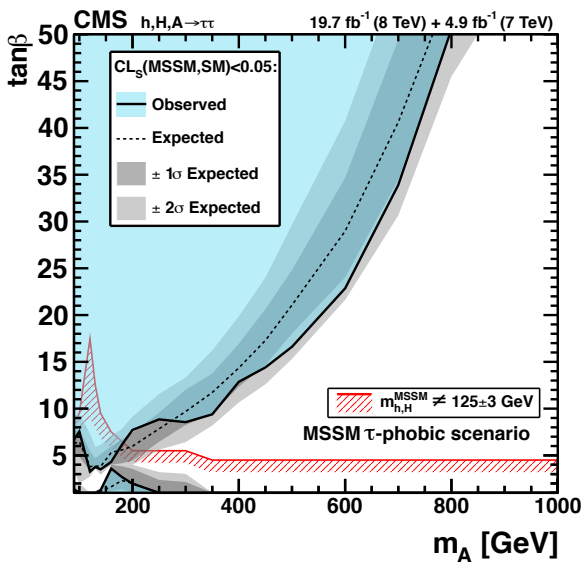


Enhanced B(h→γγ)

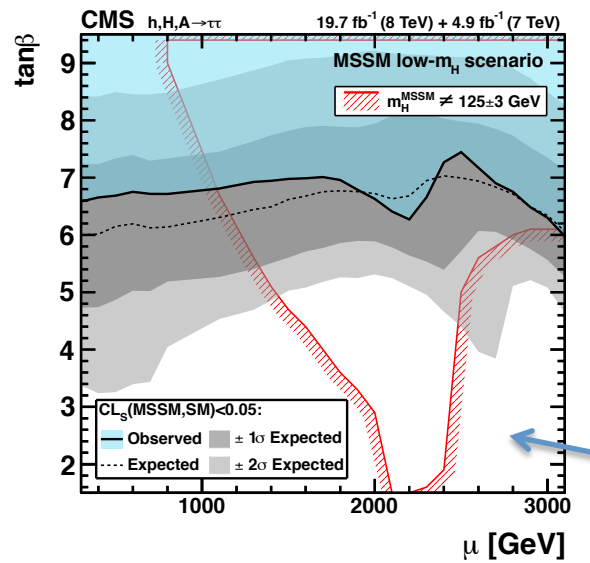


Reduced gg→h rate

Large excluded regions, in particular at high tan(β) and low m_A



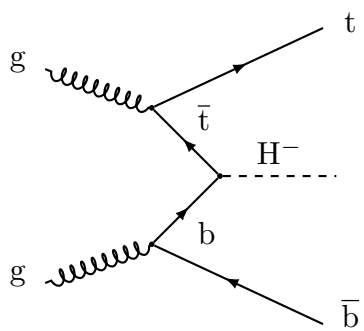
Reduced B(h→ττ) at higher tan β



H is the SM-like neutral Higgs boson

Charged Higgs

Heavy charged Higgs



HIG-13-026

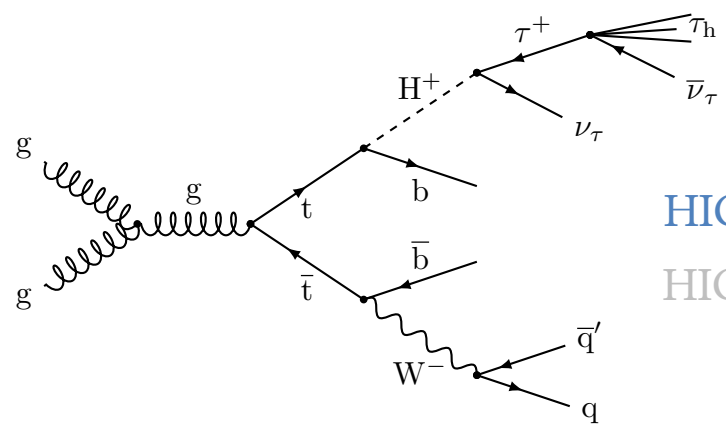
HIG-14-020

Fairly low cross section (larger with increasing tan(β))

Dominant decay $H^+ \longrightarrow tb$ at higher masses

$B(H^+ \longrightarrow \tau\nu)$: O(1-10%)

Light charged Higgs



HIG-14-020

HIG-13-035

Profits from large top pair production cross section

Typical $B(t \longrightarrow H^+b)$ few percent, becoming larger with increasing tan(β) and decreasing m_{H+}

Heavy H^+ in multilepton final states

WWbbbb or Wbbτν final state

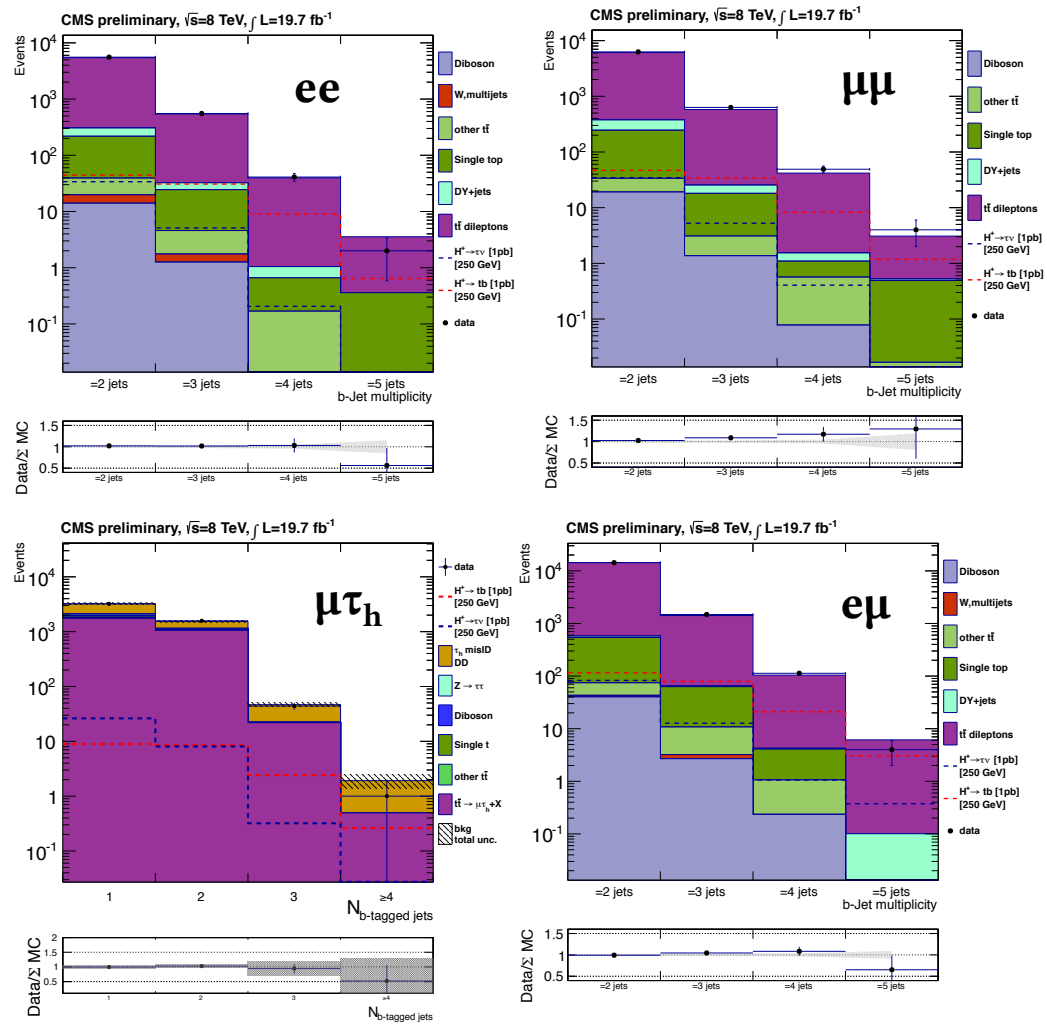
- 4 event categories with 2 leptons

In addition, require

- high jet multiplicity
- high missing transverse energy

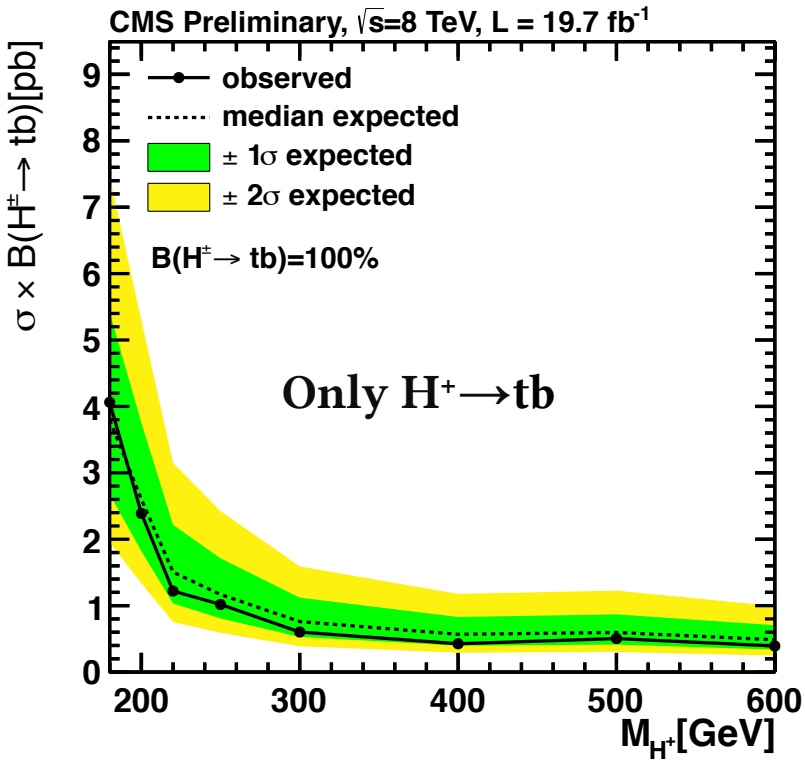
Main background: top pair production

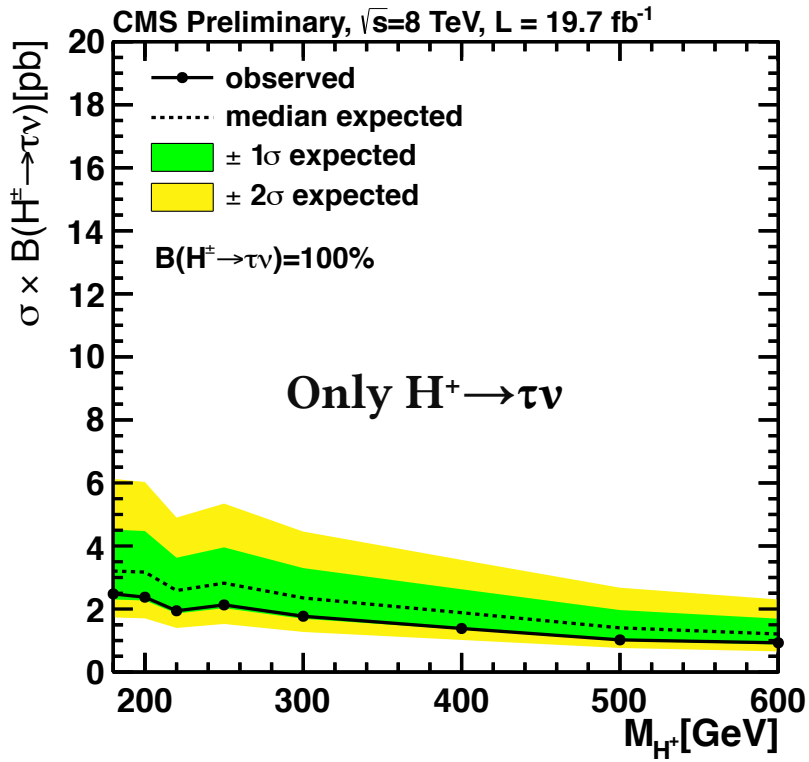
Fit b-tag multiplicity distribution in all 4 categories



B-tag multiplicity

Heavy H^+: limits





Model-independent limits for different H^+ decays

No sensitivity yet to m_H^{mod+} model

H^+ in τ_h + jets final states

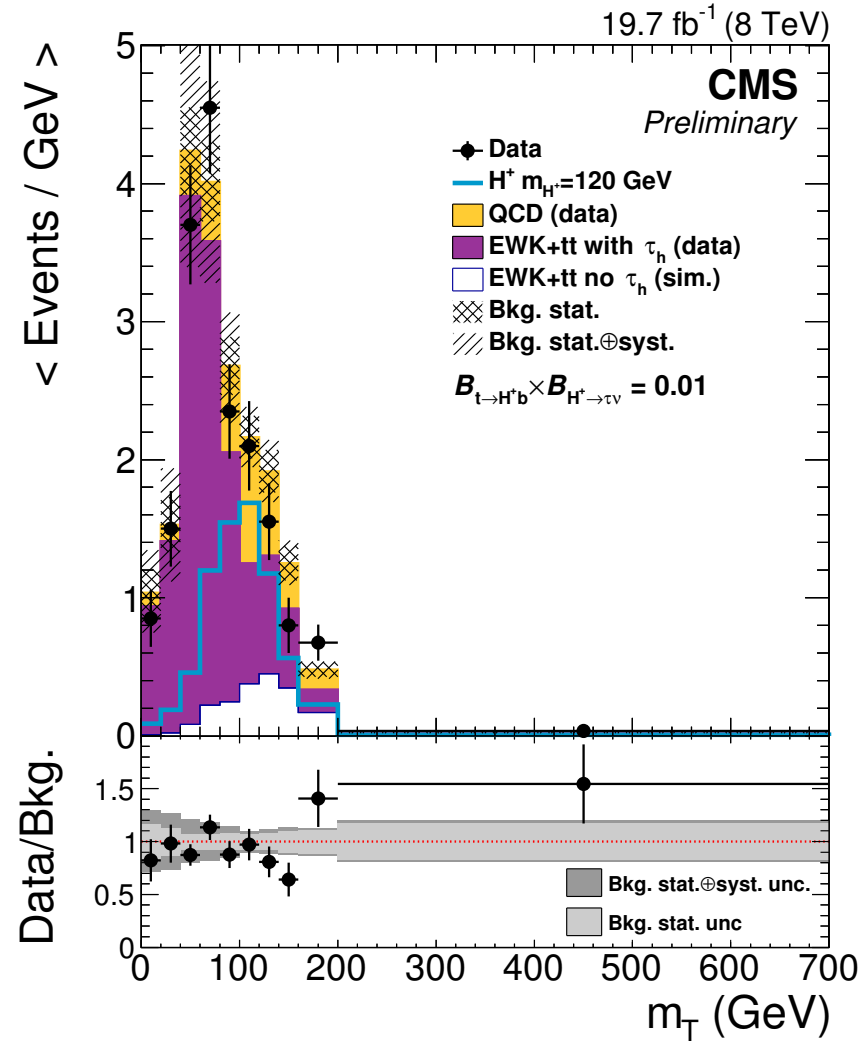
Select t(Wb)b$\tau\nu$ events with

- >= 3 jets (>= 1 b-tag)
- a hadronic tau
- large missing energy

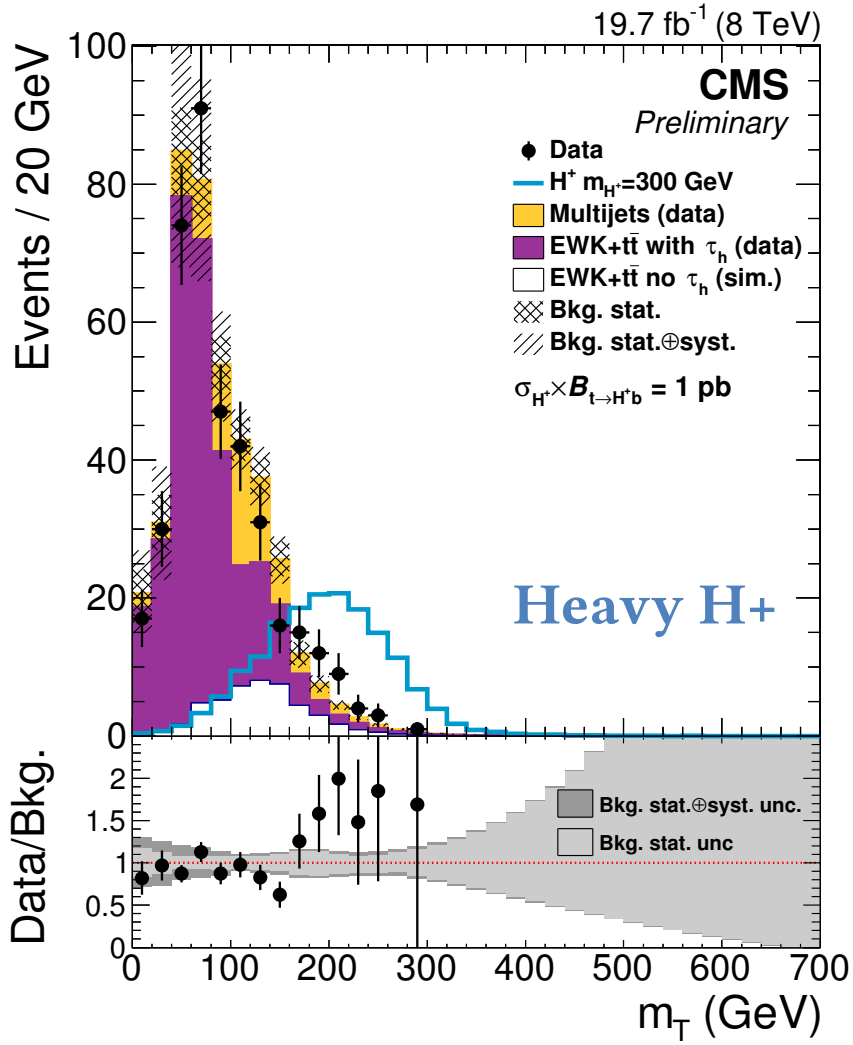
Challenge: tau + MET trigger

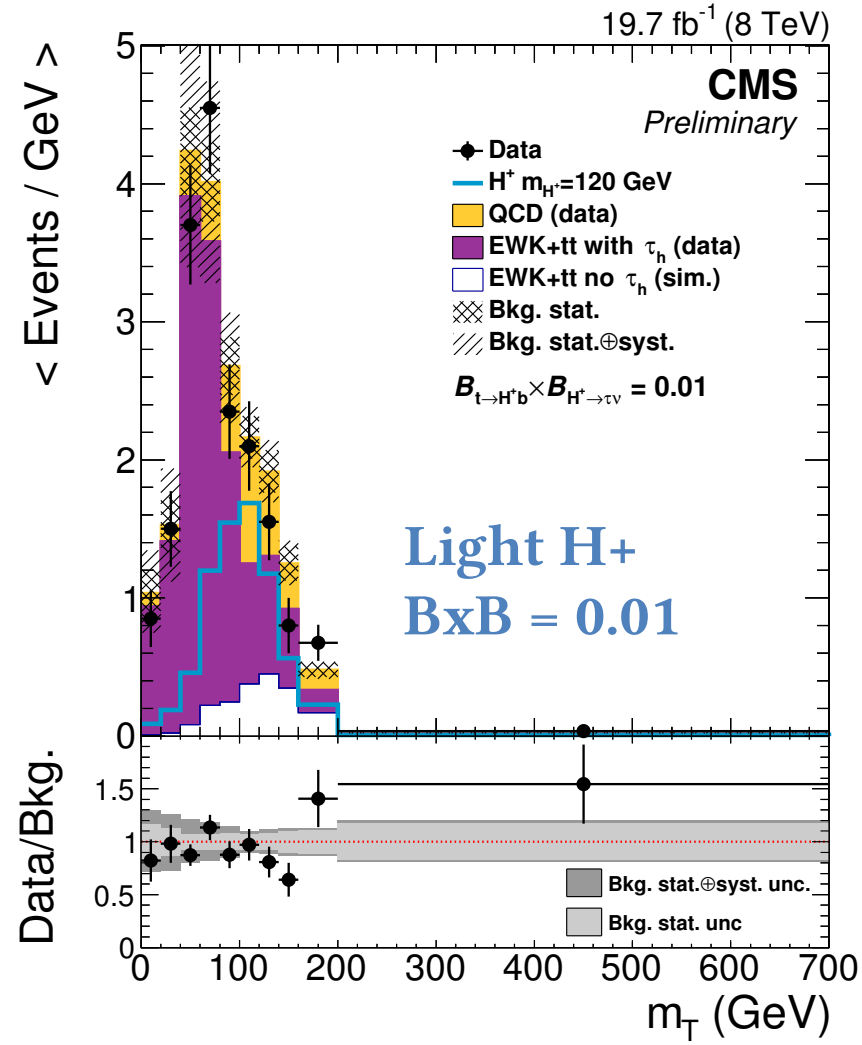
Additional angular cuts to suppress multijet background

Multijet background estimated from sidebands
Dominant electroweak/top background from "embedding"



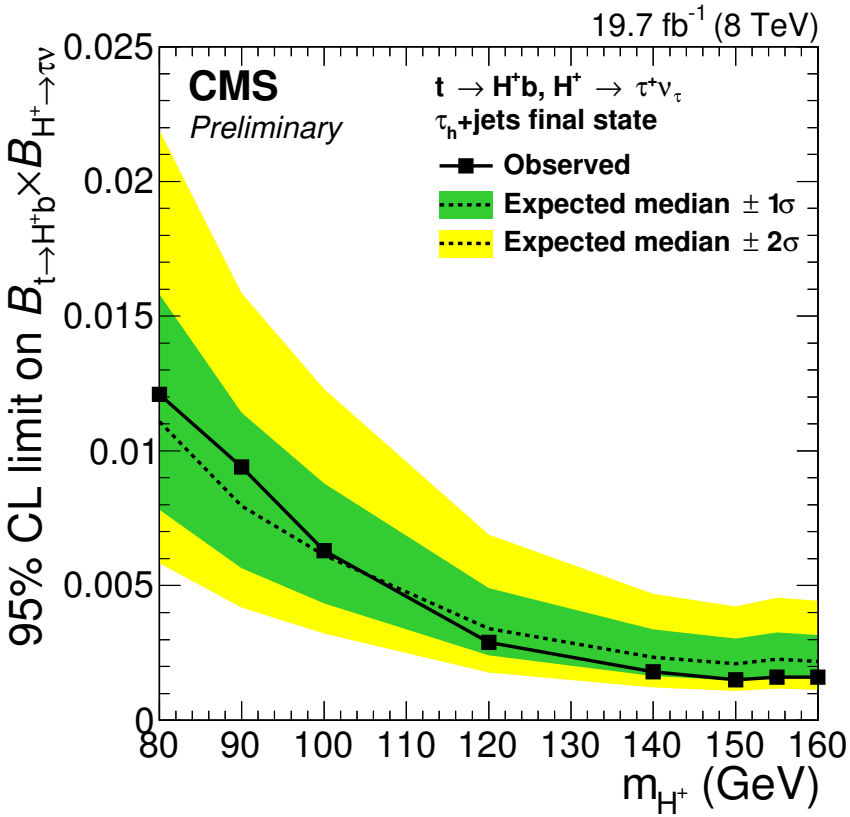
Transverse mass distribution

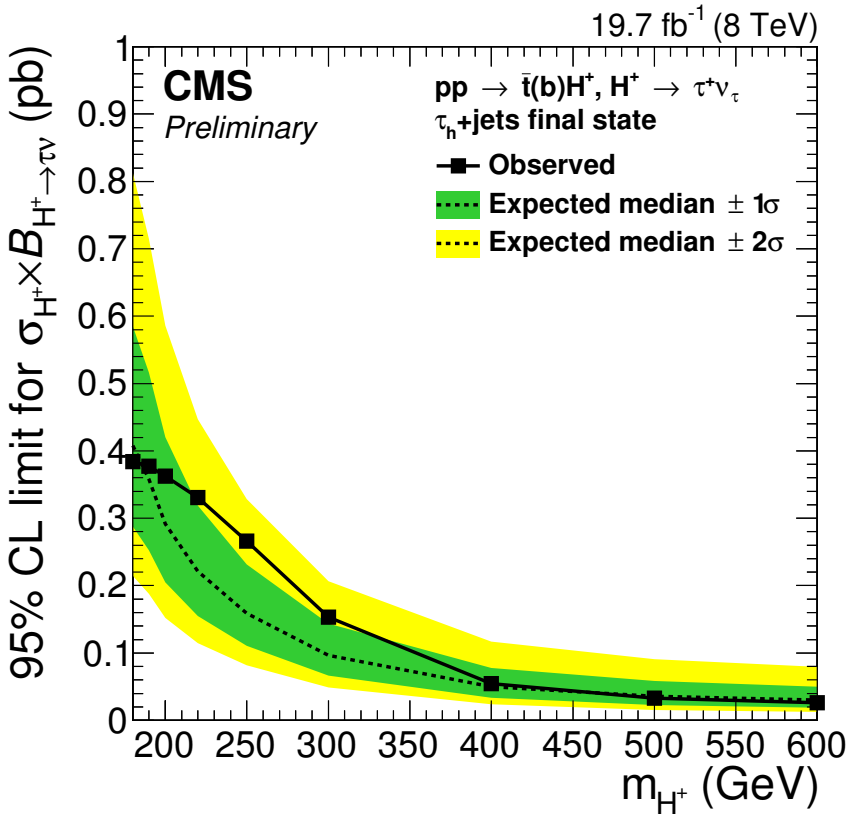




Same events, different treatment of high-m_T tail

Model-independent limits

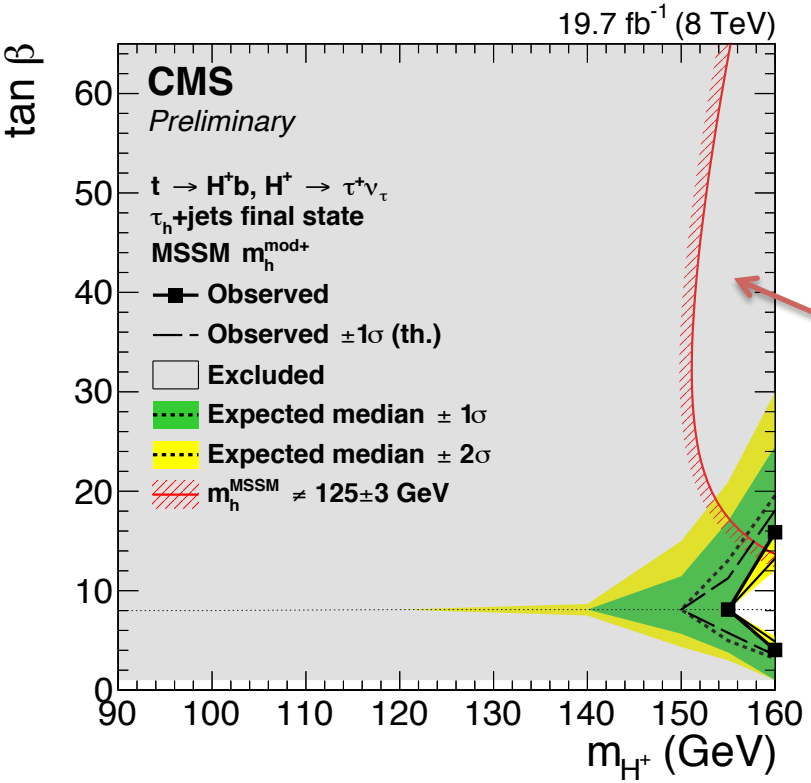




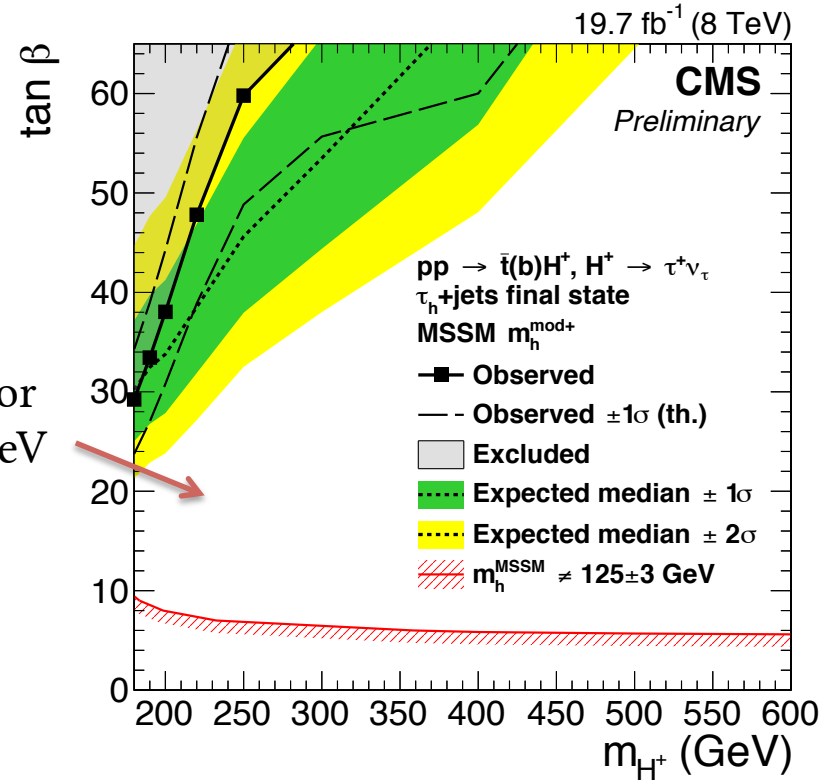
Limits < 1%
for m_{H+} > 90 GeV

Significant improvement of previous best limits

Limits on MSSM parameters



Allowed for m_h=125 GeV

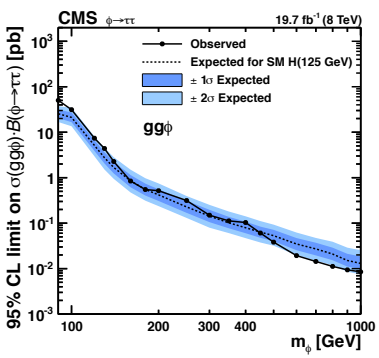


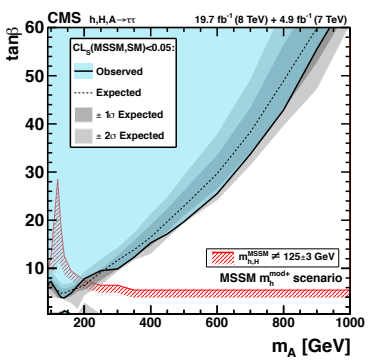
Interpretation in same benchmark models as h/H/A search:

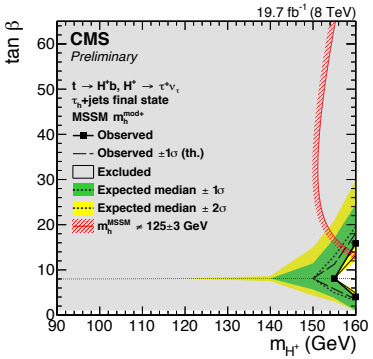
Large fraction of phase space excluded for light H^+

Conclusion

- CMS is finalising run 1 searches for both neutral and charged Higgs bosons in MSSM and beyond – watch out for more results!
- Improved results from searches for light and heavy charged Higgs bosons
- Search for A/H/h→ττ provides stringent constraints in different MSSM benchmark scenarios

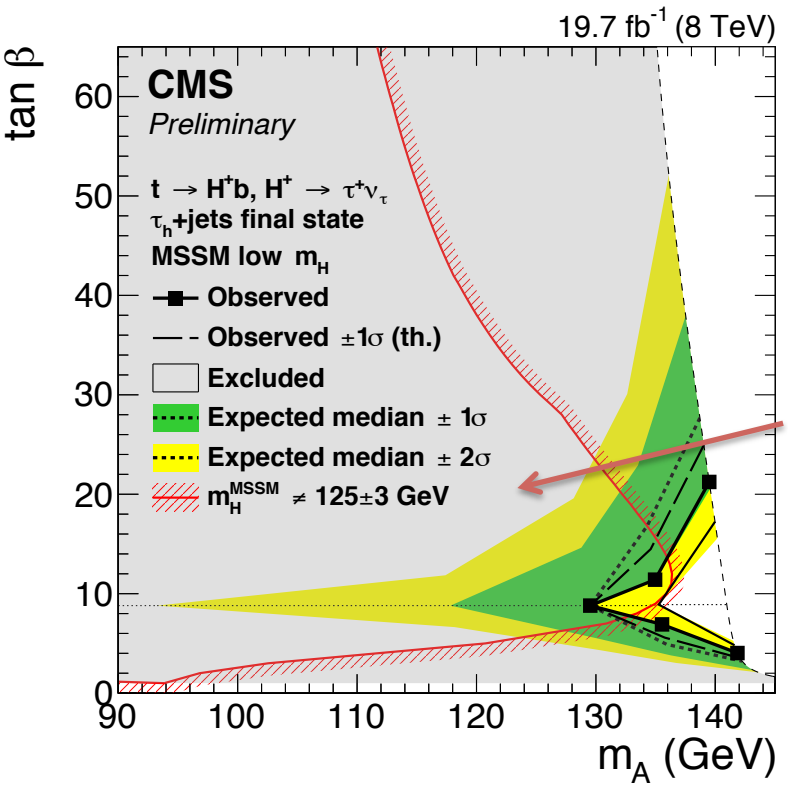




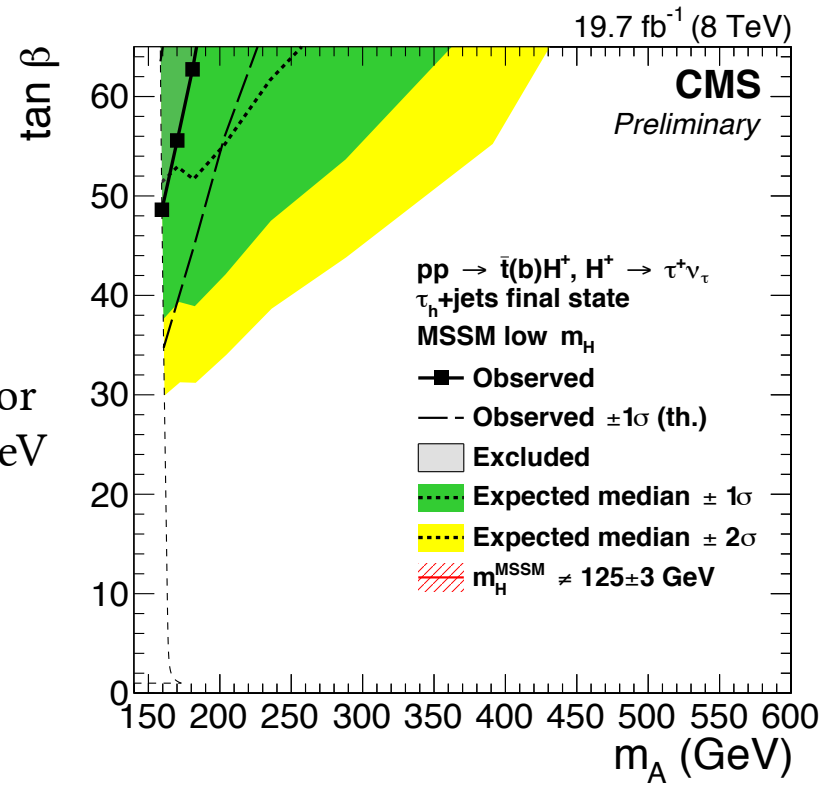


Backup

Limits on MSSM parameters



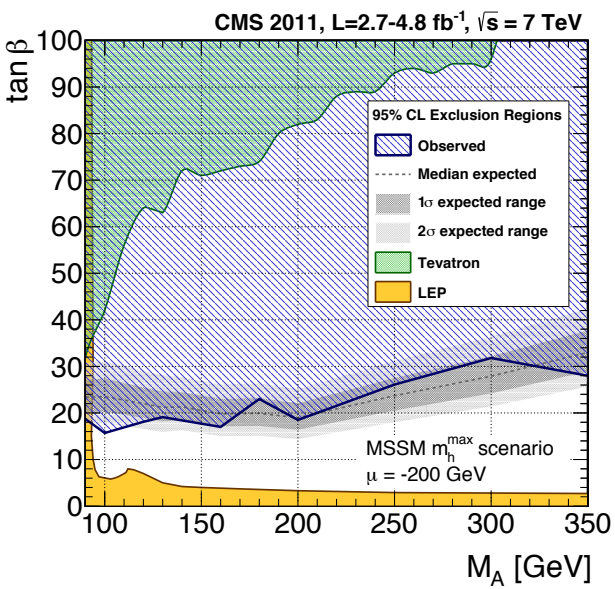
Allowed for m_h=125 GeV

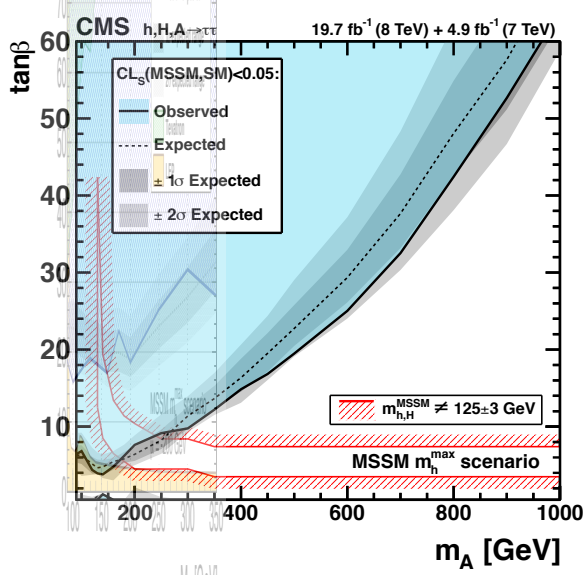


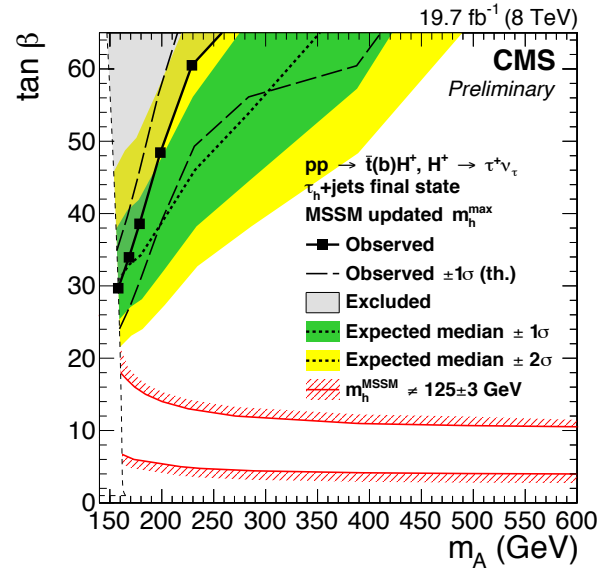
Interpretation in same benchmark models as h/H/A search:

Large fraction of phase space excluded for light H^+

Summary of limits



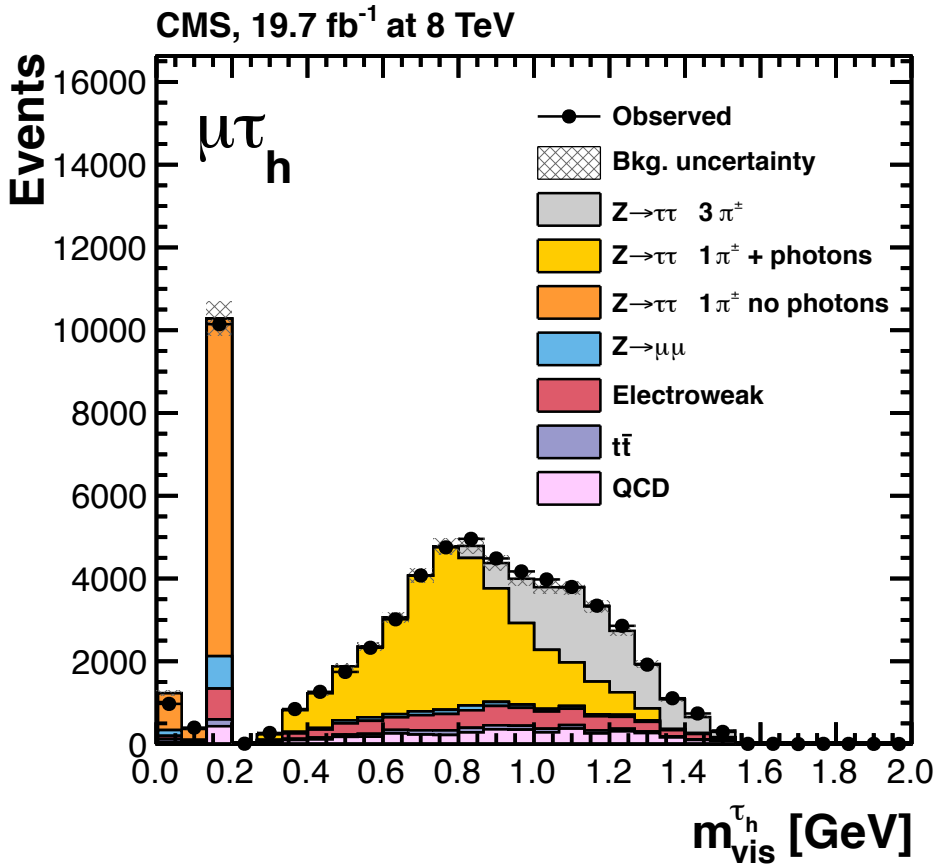


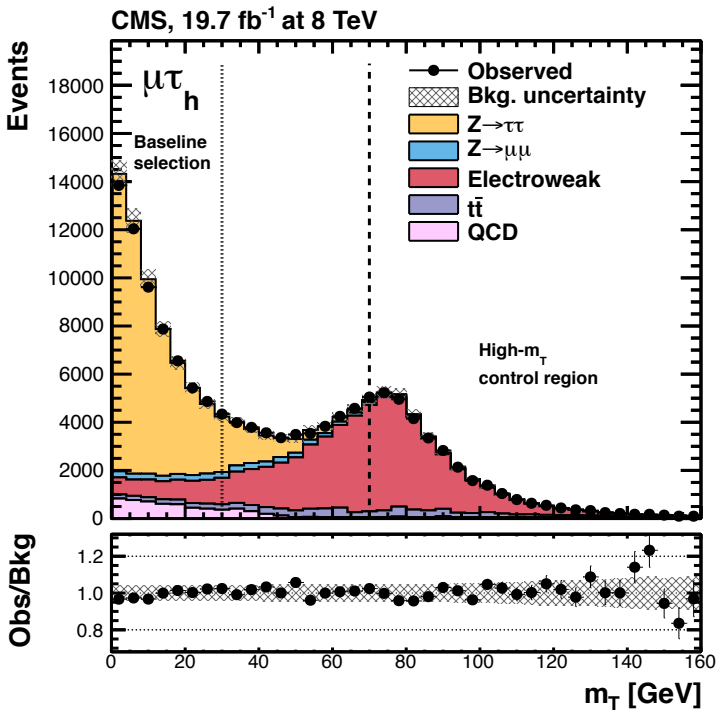


Searches for neutral Higgs bosons in di-tau final state provide largest sensitivity in most of the benchmark scenarios

H→ττ: event selection

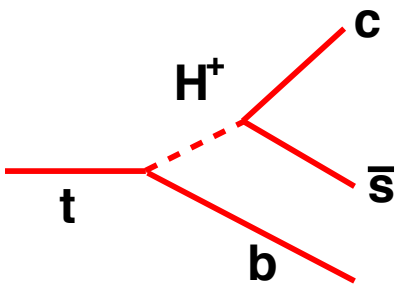
- Reconstructed mass of hadronically decaying tau in 1-prong and 3-prong decay modes to determine tau energy scale
- Transverse W boson mass: reject and estimate W+jets background





Light charged Higgs: $H^+ \longrightarrow cs$

If $m_{H+} < m_t - m_b$:
"light" charged Higgs



$B(H^+ \longrightarrow cs)$ up to 100% for low $\tan\beta$ (model-dependent)

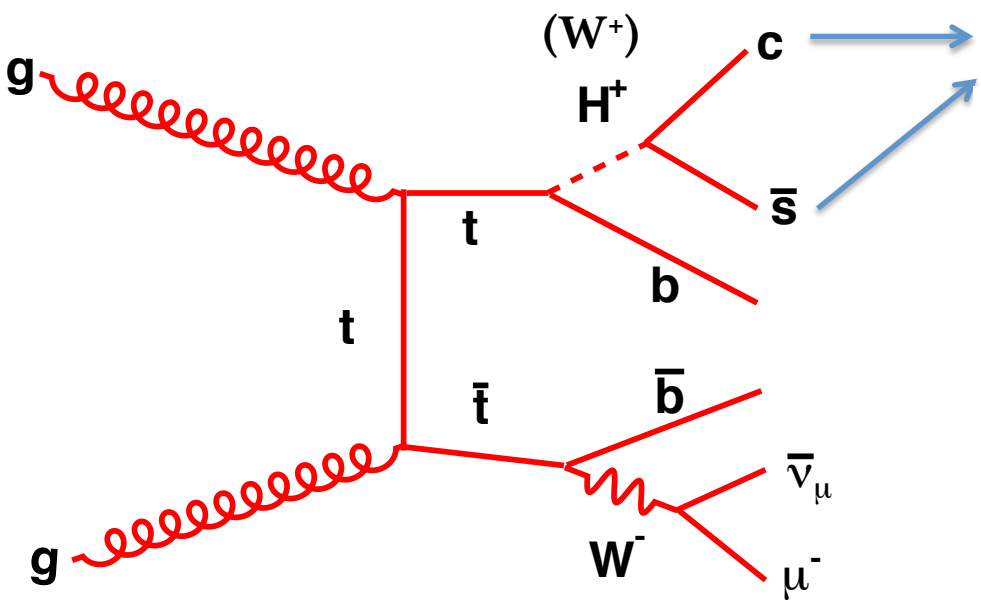
Previous constraints

LEP: $m_{H+} > 79$ GeV

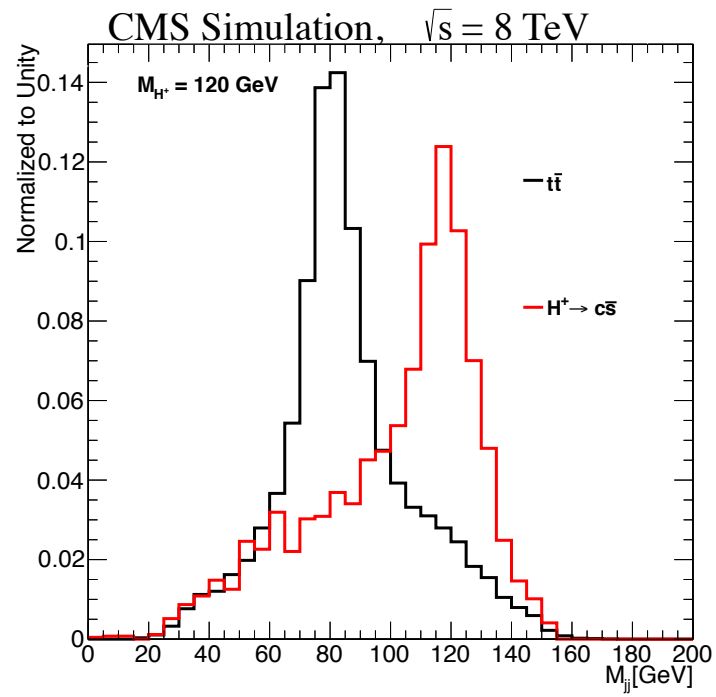
Tevatron: $B(t \longrightarrow H^+b) < 10\text{-}20\%$ for $80 < m_{H+} < 155$ GeV

ATLAS (7 TeV): $B(t \longrightarrow H^+b) < 1\text{-}5\%$ for $90 < m_{H+} < 150$ GeV

$H^+ \longrightarrow cs$ at CMS



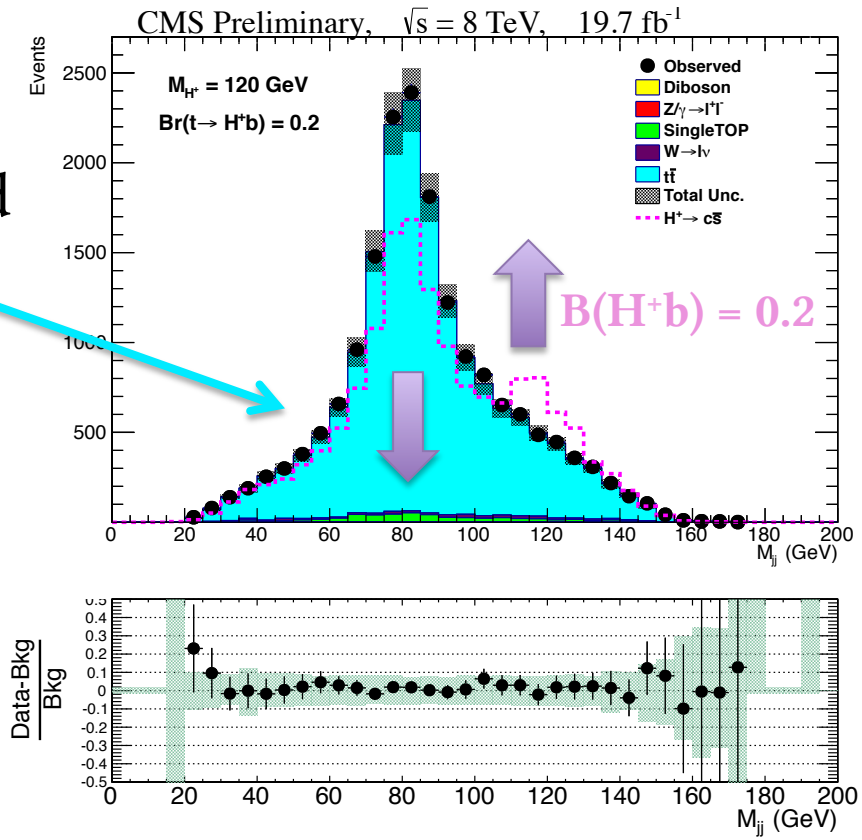
Dijet mass



Kinematic fit to full top pair topology improves mass resolution

Dijet mass distribution

Major background from top pair production



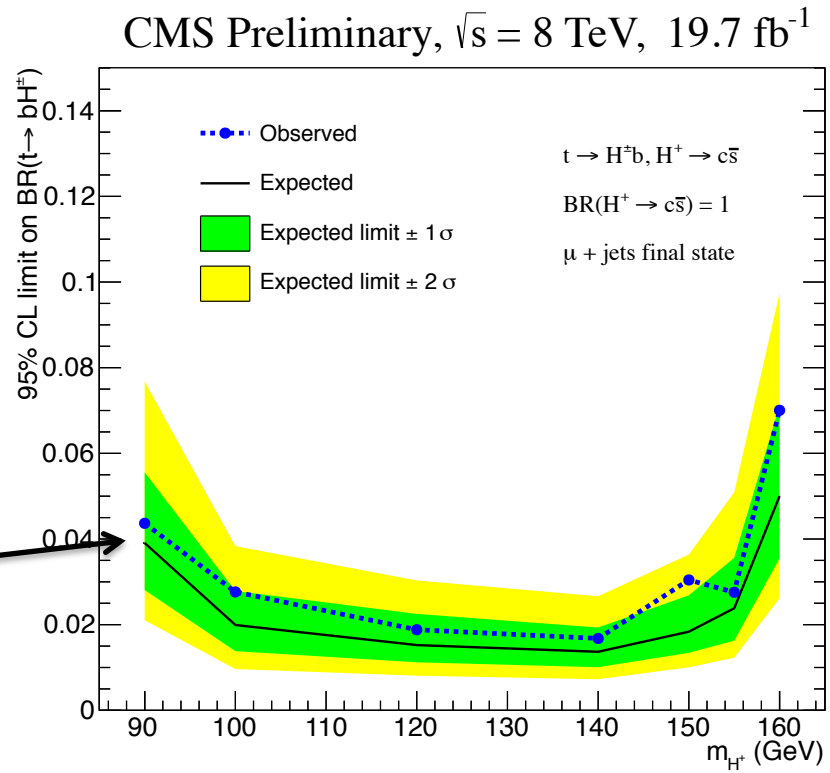
Peak position varies with H^+ mass

Important systematic uncertainties:

top p_T reweighting, jet energy corrections, b-tagging, background normalisation

Upper limits on $H^+ \rightarrow cs$ branching fraction

Close to W mass peak



$B(H^+ \rightarrow cs)$ < a few percent at 95% CL