Search for charged Higgs in top decays

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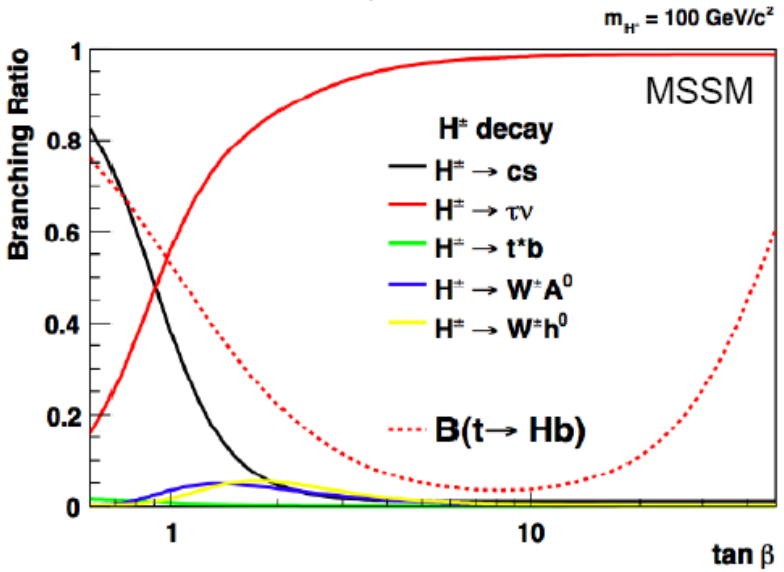
(On behalf of LIP/CMS)

Jornadas do LIP, April 22, 2012

Charged Higgs in Top quark decay

- Charged Higgs boson is predicted by extensions of Standard Model with two Higgs doublets, such as MSSM (5 Higgs bosons predicted : H,h, A and H±)

- Production and decay at tree level depends on M_A and tan ß = v1/v2



D0 Note 5715-CONF

Search Assuptions :

- Light charged Higgs ($m_{H\pm} < m_{top}-m_b$)
- BR($H^{\pm}\rightarrow\tau\nu$) ~1 (high tan β)

Three channels studied in $t\bar{t}$ decays : $\begin{cases} t\bar{t} \rightarrow H^{\pm}W^{\mp}b\bar{b} \\ t\bar{t} \rightarrow H^{\pm}H^{\mp}b\bar{b} \end{cases}$

1) Hadronic tau decay, hadronic W decay (τ_{had} + jets) :

2) Hadronic tau decay, leptonic W decay (τ_{had}+μ/e) :

3) Leptonic tau decay, leptonic W decay (e + μ)

Documentation

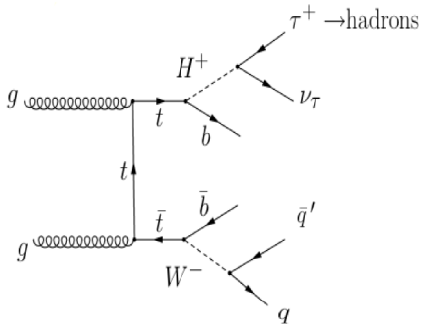
PAS HIG-11-002 (36/pb)
PAS HIG-11-008 (1.1/fb)
PAS HIG-11-019 (2.2/fb, TBS)

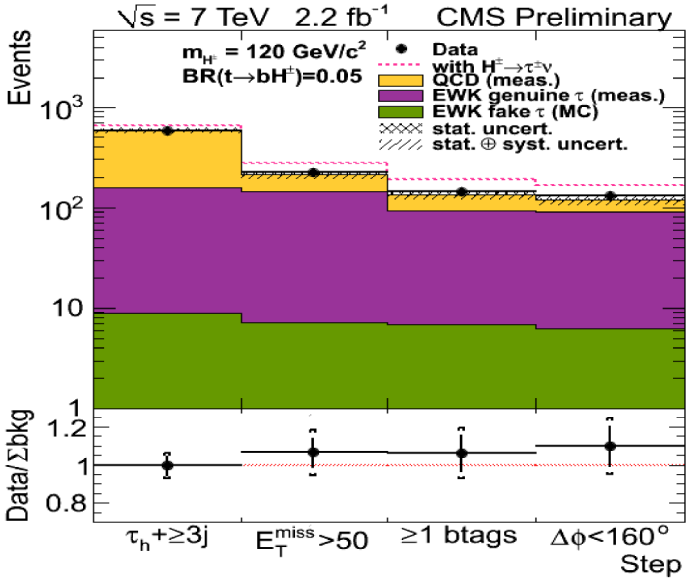
Fully hadronic final state (Event Selection)

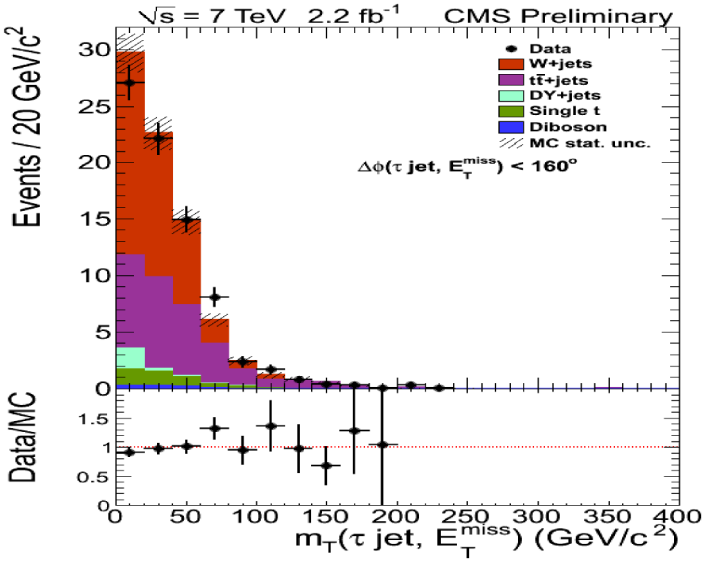
2.2 fb^{-1} of data

Event Selection

- Single isolated tau + MET trigger
- One tau with tight ID (p_T>40GeV/c, leading track p_T> 20 GeV
- At least 3 jets (p_T>30 GeV/c)
- MET > 50 GeV
- At least one b-tagged jet
- $\Delta\phi$ (tau^MET)<160º
- Tau polarization R= p^{trk}/p_τ >0.7
- m_T(tau,MET) used for shape analysis



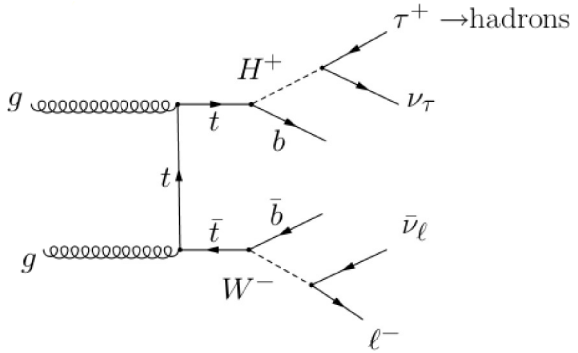


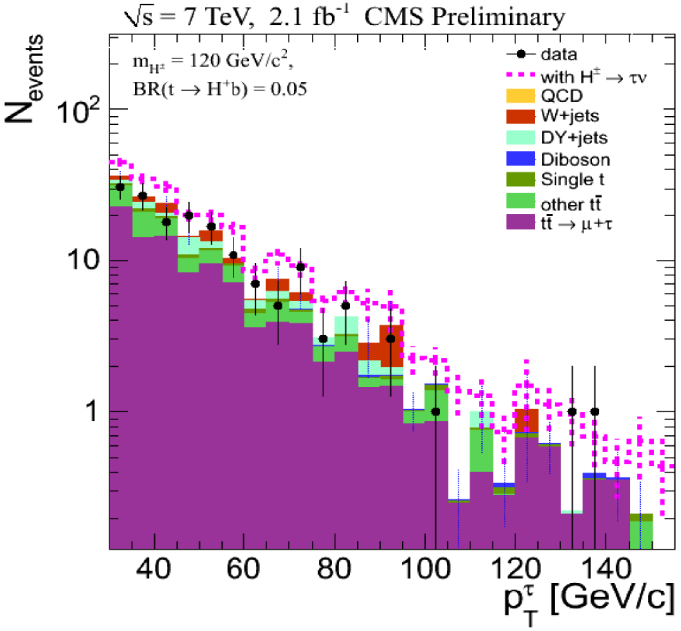


e/μ plus hadronic tau decay (Event Selection)

~2 fb^{-1} of data

- Triggers
  - τ_{had}+μ :Iso. single muon (p_T>24 GeV/c)
  - τ_{had}+e : Iso. single electron(p_T>27 GeV/c) + 2 jets (p_T>30 GeV/c)+MHT(>25GeV)
- 1 isolated lepton : p_T (in μτ) > 30GeV/c , p_T (in eτ) > 35GeV/c
- At least 2 jets : p_T (in μτ) > 30 GeV/c , p_T (in eτ) > 35 GeV/c
- At least 1 b-tagged jet
- MET (in μτ) > 40 GeV , MET (in eτ) > 45 GeV
- 1 tau: p_T > 20 GeV/c
- Opposite Sign (OS) between lepton (e/ μ) and tau





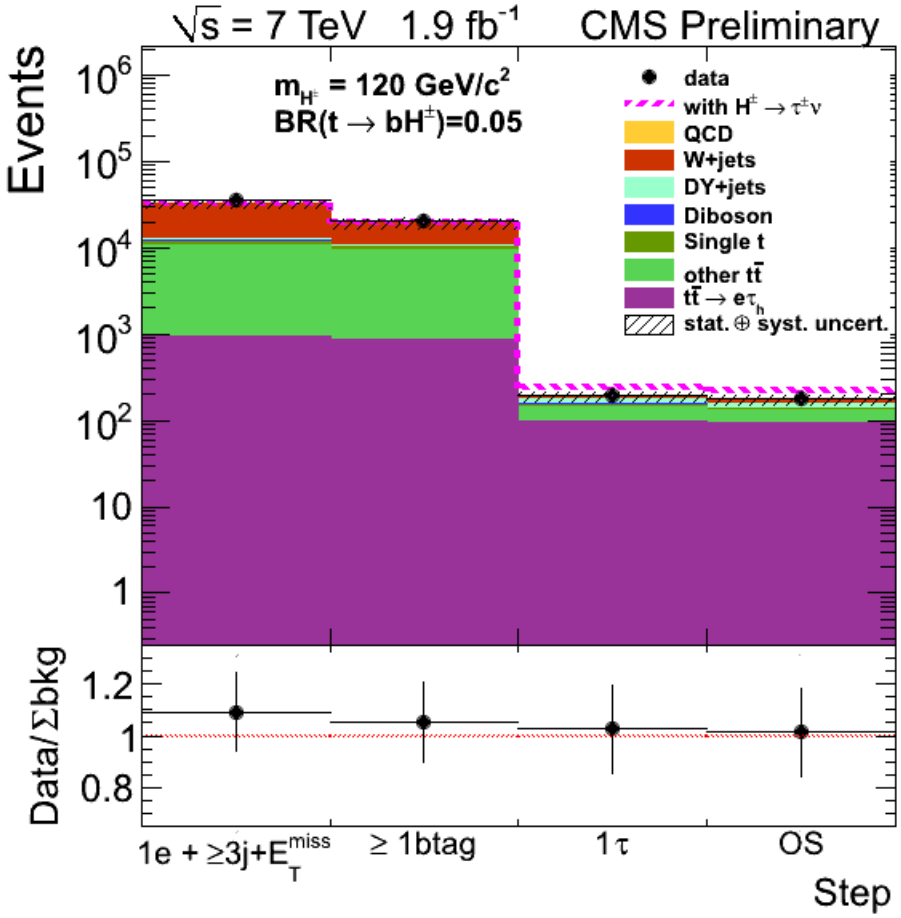
e/μ plus hadronic tau decay (Event Yields)

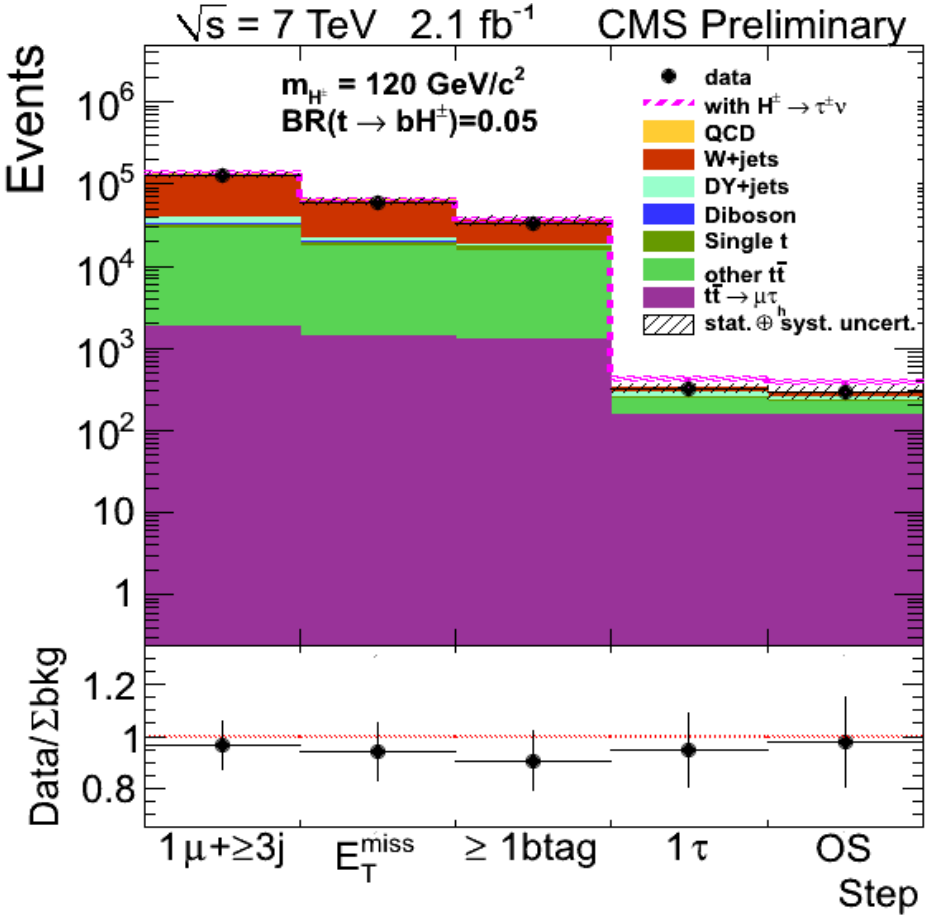
Summary of event yields after selection

Source	$N_{ev}^{e\tau_h} \pm$ stat. $\pm$ syst.	$N_{ev}^{\mu\tau_h} \pm$ stat. $\pm$ syst.
HH+HW, m_{H^+}=120 GeV/c^2, BR($t \to H^+b$)=0.05	$49 \pm 3 \pm 8$	$86 \pm 4 \pm 13$
τ fakes	$54 \pm 6 \pm 8$	$89 \pm 9 \pm 11$
$t\bar{t} \to WbWb \to \ell\nu b\, \tau\nu b$	$96 \pm 3 \pm 14$	$156 \pm 4 \pm 23$
$t\bar{t} \to WbWb \to \ell\nu b\, \ell\nu b$	$8.6 \pm 0.9 \pm 1.7$	$13 \pm 1.1 \pm 2.5$
$Z/\gamma^* \to ee, \mu\mu$	$4.5 \pm 1.7 \pm 1.3$	$0.7 \pm 0.7 \pm 0.7$
$Z/\gamma^* \to \tau\tau$	$16 \pm 3.2 \pm 2.9$	$25 \pm 4.2 \pm 6.3$
single top quark	$7.6 \pm 0.4 \pm 1.1$	$13.0 \pm 0.5 \pm 1.8$
di-boson	$1.2 \pm 0.1 \pm 0.2$	$2.0 \pm 0.2 \pm 0.3$
Total expected background	$188 \pm 7.9 \pm 20$	$298 \pm 11 \pm 32$
Data	176	288

Background (tau fakes) measured from data with tau fake rate method

e/μ plus hadronic tau decay (Event Yields)





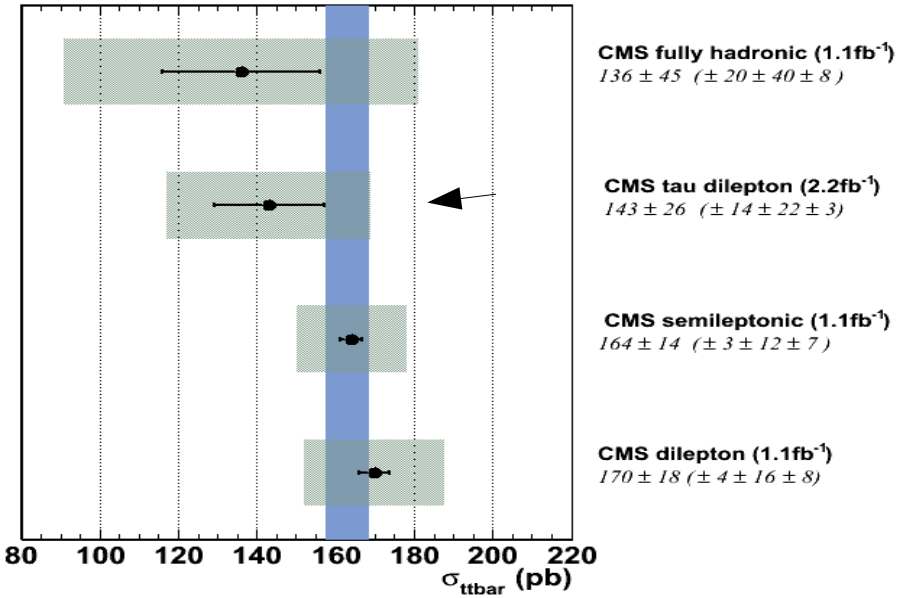
Data agrees with SM expectations within the uncertainties, no excess observed

$t\bar{t}$ xsec measurement with e/μ + had.tau decay

- Same Selection applied as in Charged Higgs search

- First $t\bar{t}$ xsec measurement with a tau in the final state at the LHC
  Submitted to PRD (arXiv:1203.6810v1, CMS)

- $e+\tau_{had}$ and $\mu+\tau_{had}$ channel combined wit Best Linear Unbiased Estimation (BLUE) method



$$\sigma_{t\bar{t}} = 143 \pm 14(\text{stat.}) \pm 22(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb}$$

$$\sigma_{t\bar{t}}(e\tau_h) = 136 \pm 23(\text{stat.}) \pm 23(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb};$$
$$\sigma_{t\bar{t}}(\mu\tau_h) = 147 \pm 18(\text{stat.}) \pm 22(\text{syst.}) \pm 3(\text{lumi.})\ \text{pb}$$

- Result in agreement with other channels and SM expectations with NNLO calculations

σ = 163 +7/-5(scale) ± 9(PDF) pb ,N. Kidonakis,Phys. Rev. D 84(2011) 092004

eμ final state

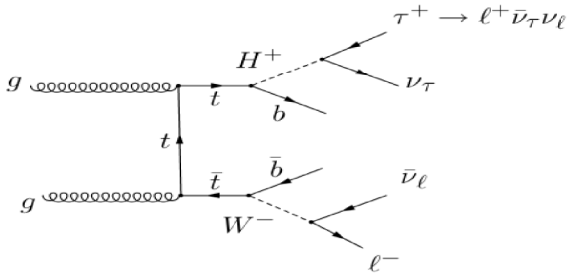
2.2 fb^{-1} of data

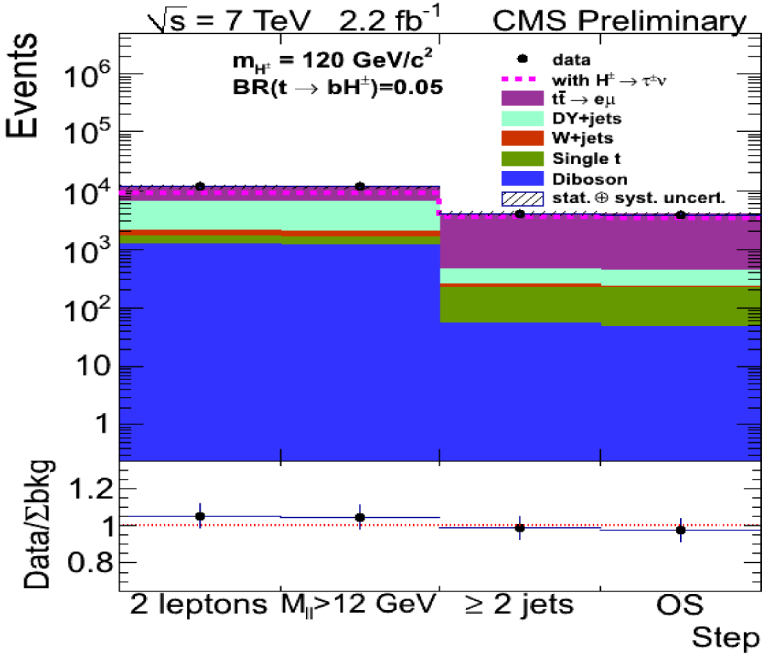
Summary of event yields after selection

Source	$N_{ev}^{e\mu} \pm$ stat. $\pm$ syst.
HH+HW, m_{H^+}=120 GeV/c^2, BR($t \to H^+b$)=0.05	$121 \pm 9 \pm 13$
$t\bar{t}$ dileptons	$3323 \pm 34 \pm 397$
other $t\bar{t}$	$22 \pm 3 \pm 3$
$Z/\gamma^* \to ll$	$186 \pm 12 \pm 21$
W+jets	$14 \pm 6 \pm 2$
single top quark	$161 \pm 3 \pm 19$
di-boson	$47 \pm 2 \pm 5$
Total expected from SM	$3752 \pm 37 \pm 398$
Data	3875

Event Selection

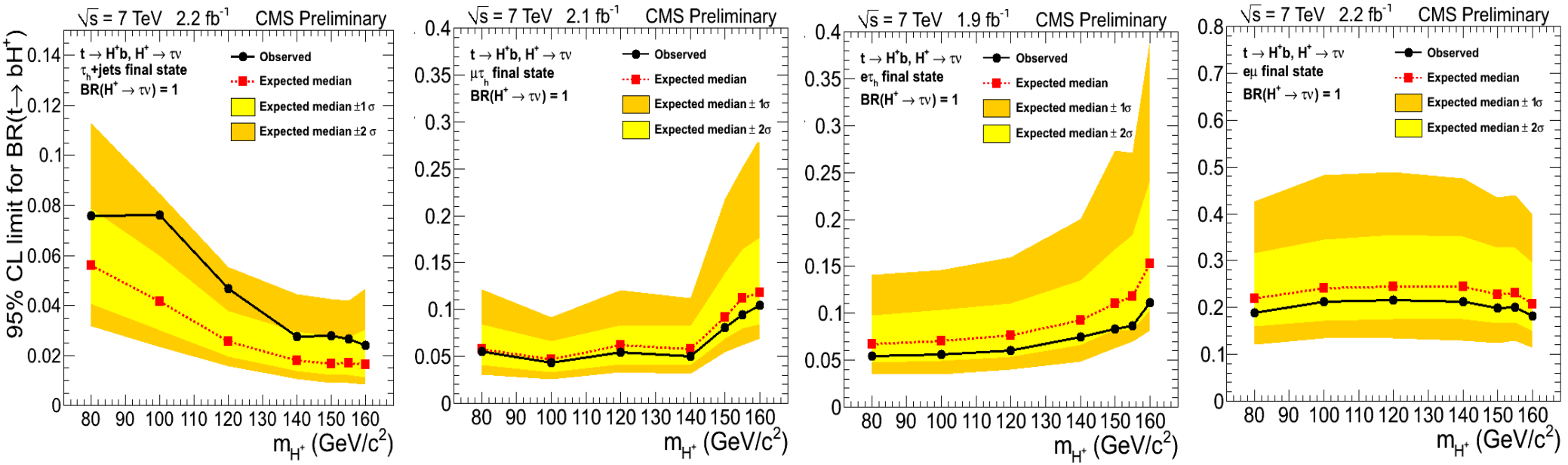
- Dielectron trigger (HLT_Mu17_Ele8,HLT_ Mu8_Ele17)
- 1 isolated e (p_T>20 GeV/c)
- 1 isolated μ (p_T>20 GeV/c)
- At least 2 jets (p_T>30 GeV/c)
- Opposite Sign





Deficit of total events expected in the presence of charged Higgs boson, because e/μ from τ decay become soft

Upper limit on BR ($t \rightarrow H^+b$)



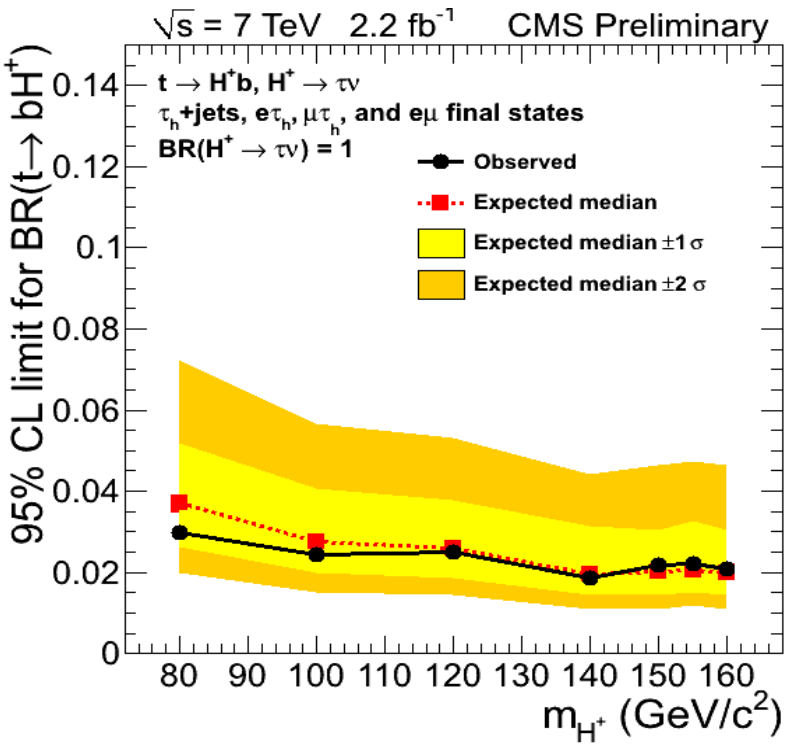
95 % CL upper limit on BR($t \rightarrow H^+b$) using CLs method.

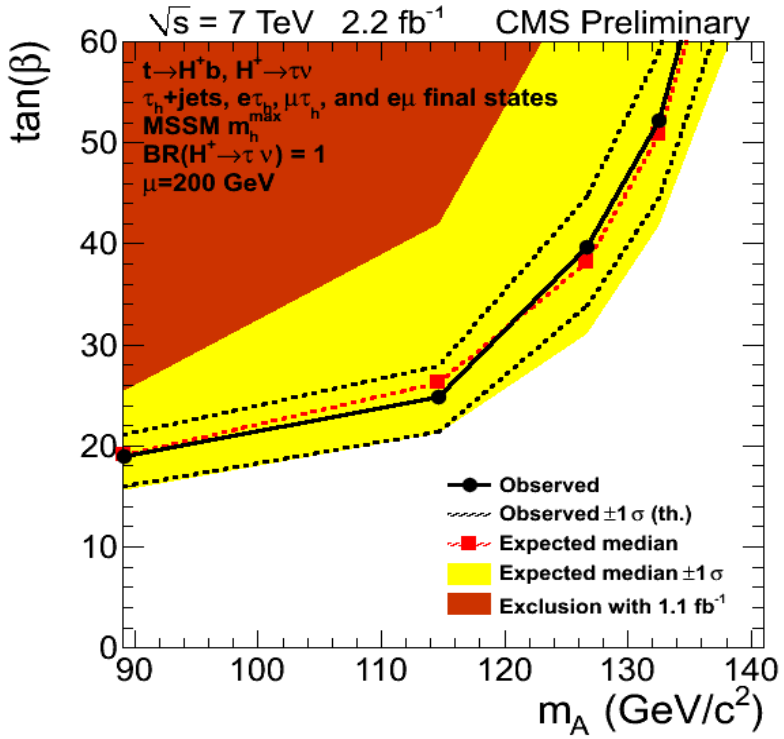
The signal is modelled as the excess (or deficit) of events yields in presence of H^+

$$N_{excess\ (deficit)} = N_{tt}^{SUSY} - N_{tt}^{SM} = N_{WH}\, 2(1-x)x + N_{HH}\, x^2 + N_{tt}^{SM}\, ((1-x)^2 - 1)\ ,\quad x = BR(t \rightarrow H^+b)$$

Results on the Combination

Combination of the τ_{had} + jets, muon/electron+τ_{had}, eμ final states





Summary

- Charged Higgs boson in decay of top quark is searched assuming BR($H^{\pm} \rightarrow \tau\nu$) ~ 1
- Three channels included (jets+τ_{had}, e/μ+τ_{had}, eμ)
- Major backgrounds have been measured from data
- No Significant excess/deficit of events observed with ~ 2 fb^{-1} CMS data
- $t\bar{t}$ cross section measured in lepton+tau channels consistent with SM expectations
- Upper limits on BR($t \rightarrow H+b$) ~ 2-3% in ch. Higgs mass range of 80-160 GeV/c^2

These topics will be developed in more detail in the next LIP Seminar :

N.Almeida "Light charged Higgs searches at CMS", 03 May 2012