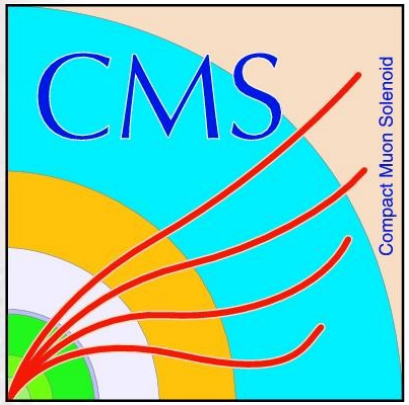
$WH \rightarrow l \tau_h \tau_h$ Analysis



Terascale Alliance Meeting
Dec 03, 2012

Armin Burgmeier for the WH2TauHad Analysis Group

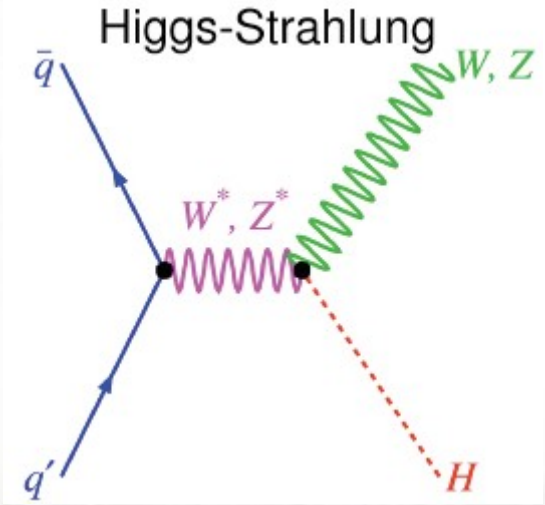
RWTH AACHEN UNIVERSITY

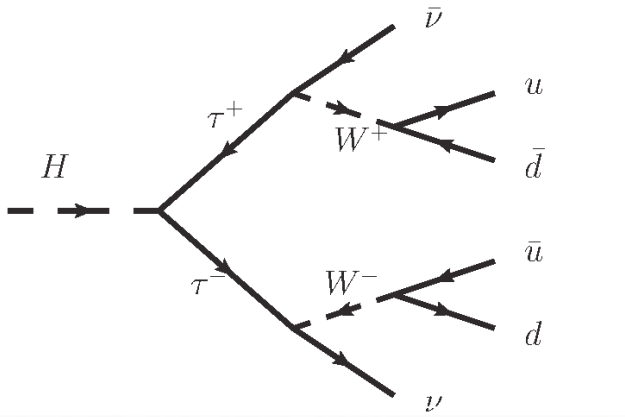
DESY

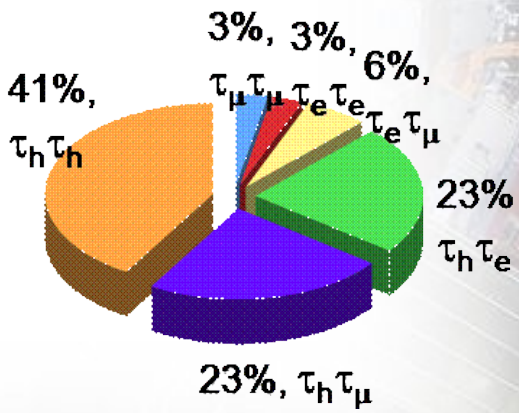
KIT
Karlsruhe Institute of Technology

Motivation

- H → ττ has high Branching Ratio for low Higgs masses
- Measure associated Production cross section
- Low background, but also low rates



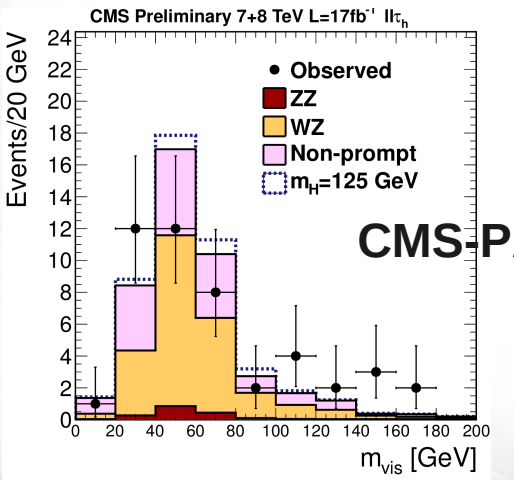




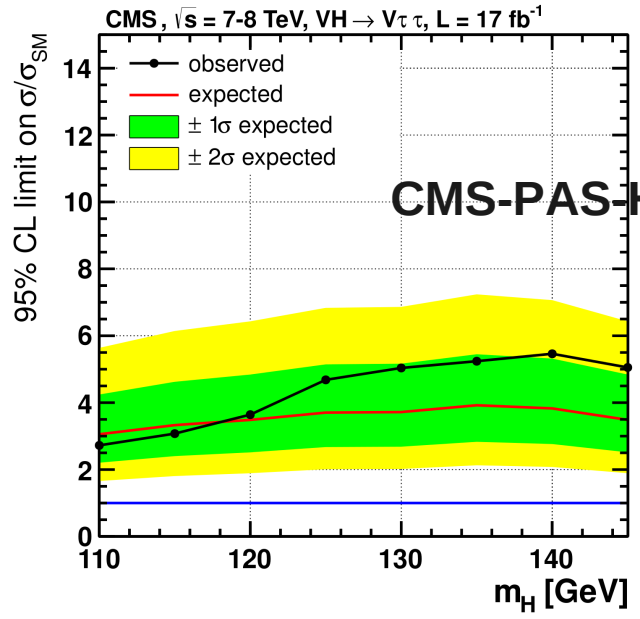
Context in CMS

- Two public AP channel analyses:
  - WH ($ll\tau_h$ final state)
  - ZH ($ll\tau\tau$ final states)
- Now, complement the search by:
  - WH ($l\tau_h\tau_h$ final state)

this talk



CMS-PAS-HIG-12-051



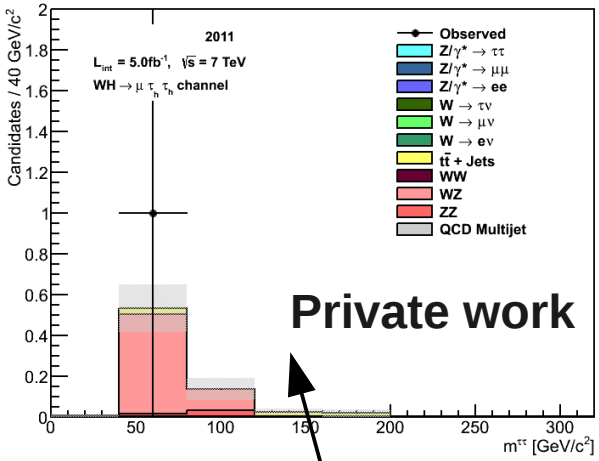
CMS-PAS-HIG-12-051

Analysis Strategy

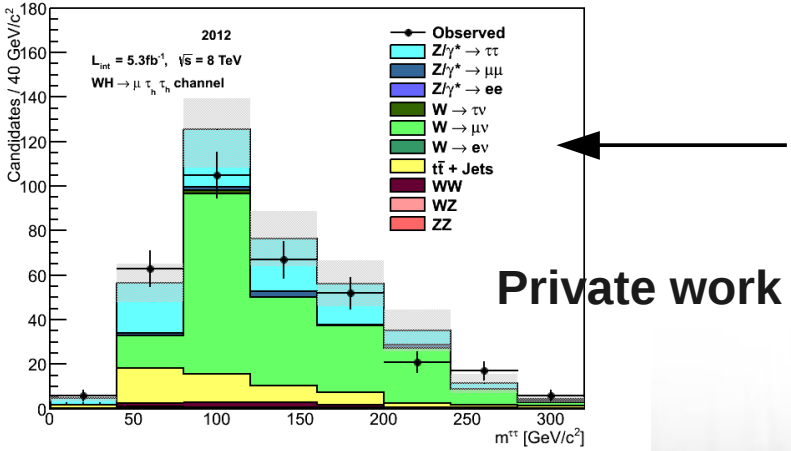
- Event Selection
  - One isolated electron/muon, p_T > 24 GeV
  - Two opposite sign isolated hadronic taus, p_T > 45(30) GeV
  - Topological cuts against $Z \rightarrow \tau\tau$, $Z \rightarrow \mu\mu$, $Z \rightarrow ee$
- Data-driven Fake Background estimate
  - WZ/ZZ Background estimate from simulation
- Statistical inference using shape of visible di-tau mass $m_{\tau\tau}$

Background

- Background is dominated by:
  - W + 2 Jets
  - Z + 1 Jet
- Reducible WZ/ZZ is smaller
- Need data-driven technique



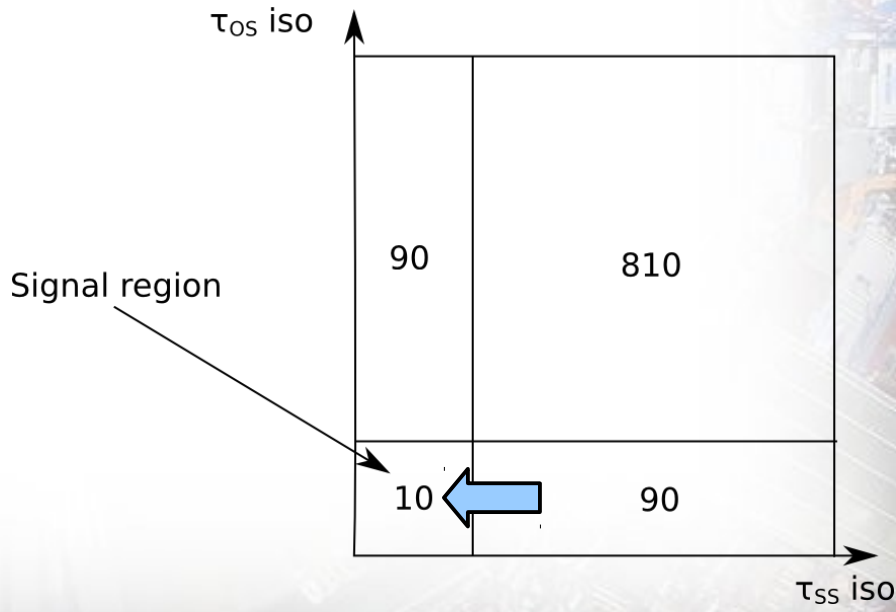
MC statistics too low to predict background in signal region



One tau anti-isolated:
Fake background dominated by W+Jets and Z+Jets

The Fake Rate Method

- Idea:
  - Measure the probability that a jet passes tau isolation (Fake Rate)
  - Count the number of events with anti-isolated taus (jets)
  - Weight those events with the Fake Rate

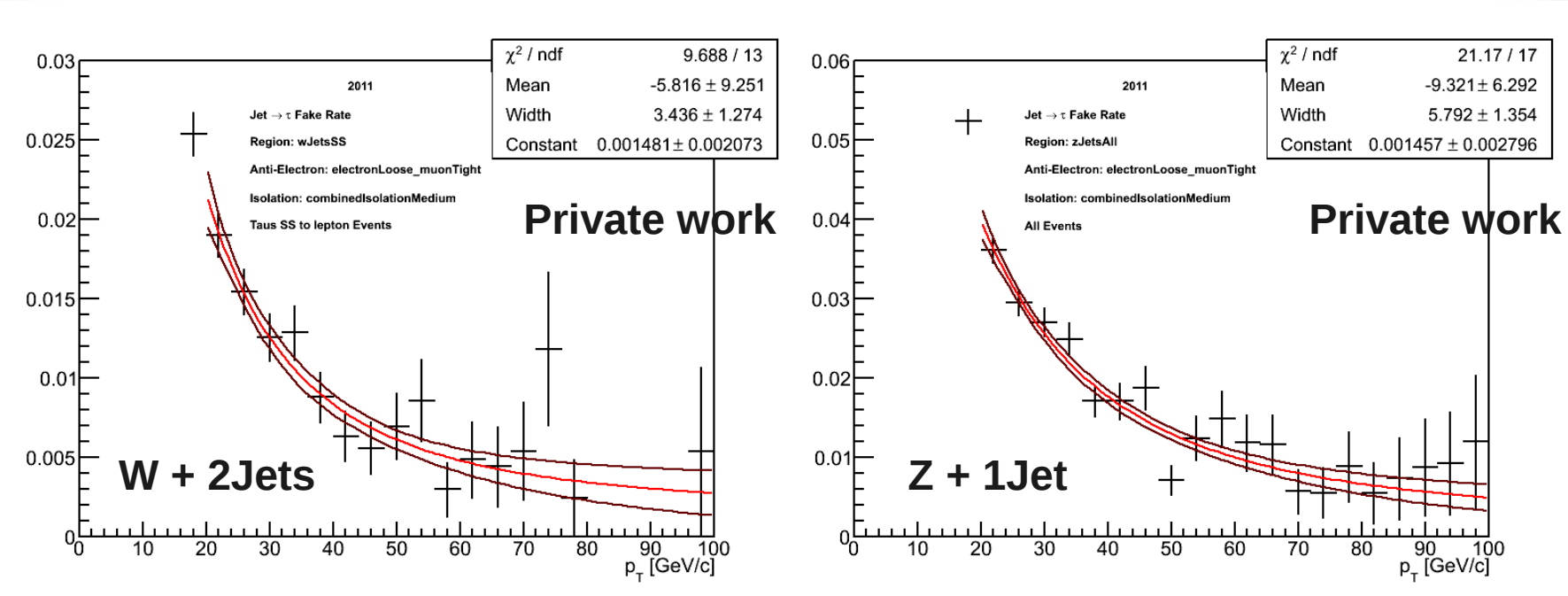


Fake Rate in WH2TauHad

- There are two taus in the event
  - Use the tau which is same sign to the light lepton as a Fakeable object
  - Covers major Fake backgrounds:
    - $Z \rightarrow \tau\tau \rightarrow l\tau_h$ + jet
    - $Z \rightarrow ee \rightarrow e\tau_h$ + jet
    - $W \rightarrow l$ + 2 jets
- Different Fake Rates for quark and gluon jets
  - W and Z backgrounds come with different fraction of quark and gluon jets

Fake Rate Measurement

- Measure independently in W+Jets and Z+Jets control regions w/o genuine tau leptons

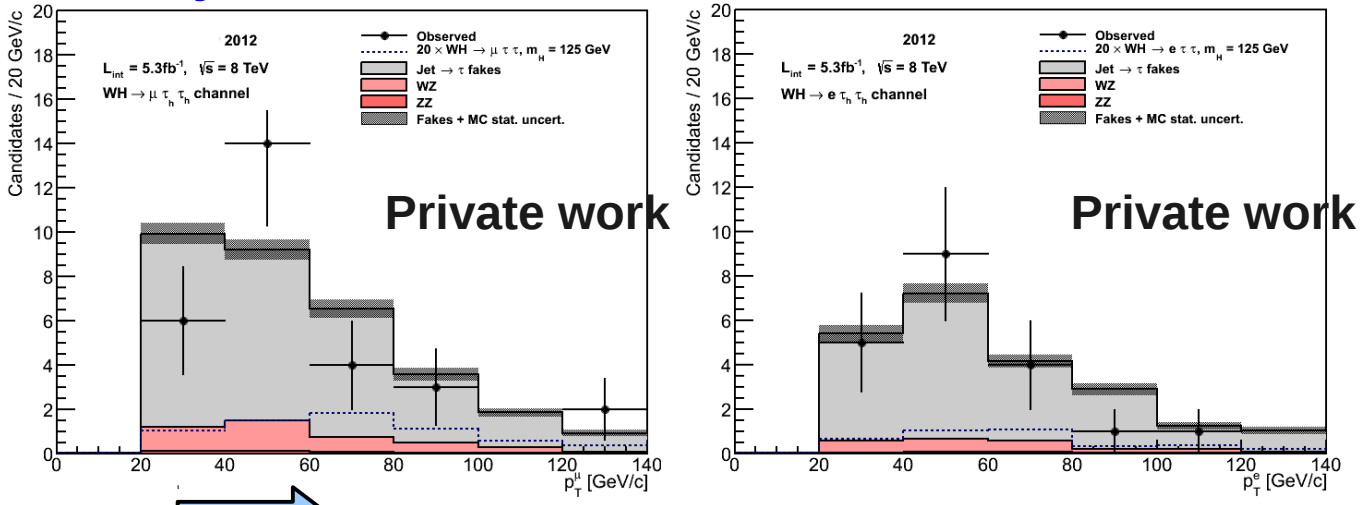


Fake Rates are very different due to different fraction of quark and gluon jets

Fake Rate Application

- From the data we cannot tell whether an event is W+Jets or Z+Jets
  - Use weighted average of Fake Rate functions measured in W+Jets and Z+Jets
  - The difference between the two is an estimate of the systematics of the method

Lepton p_T distribution in control region with loosened pT cuts on the hadronic taus

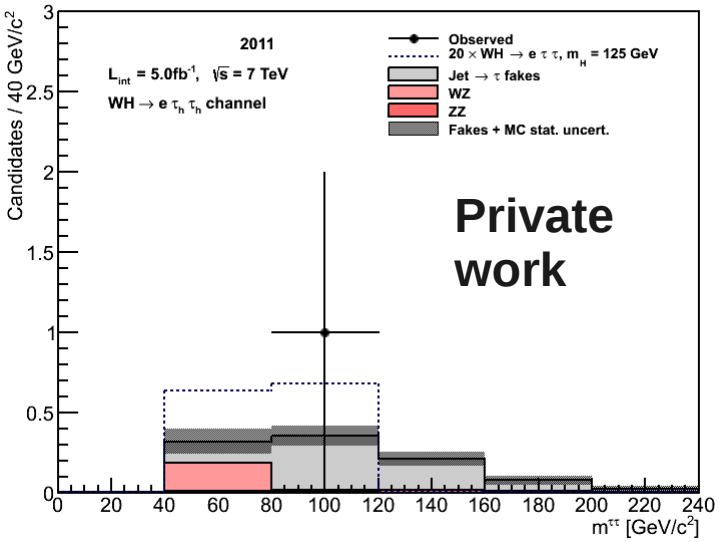


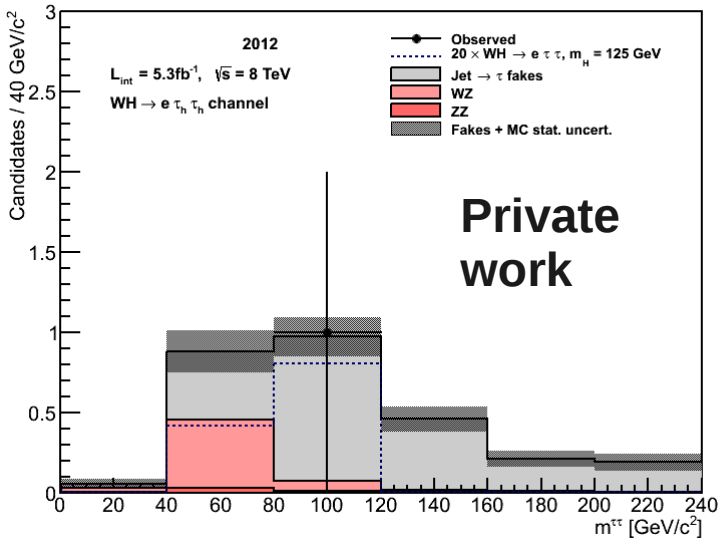
Data well described by Fake Rate Method

Mass Plots

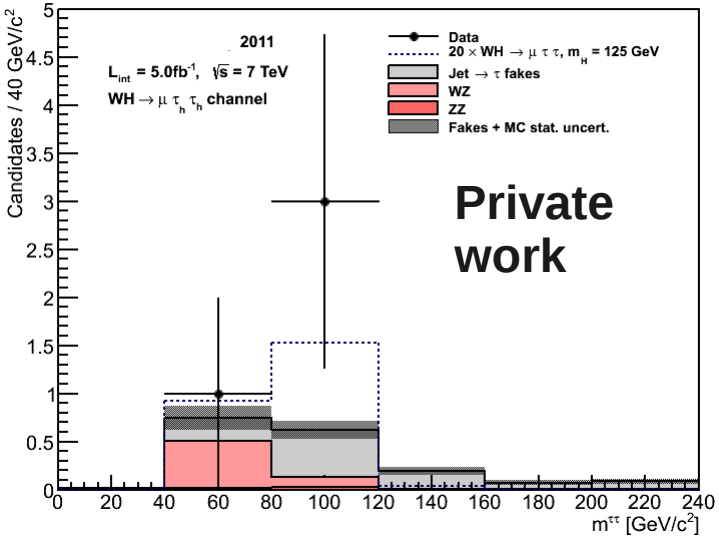
2011 Data | **2012 Data**

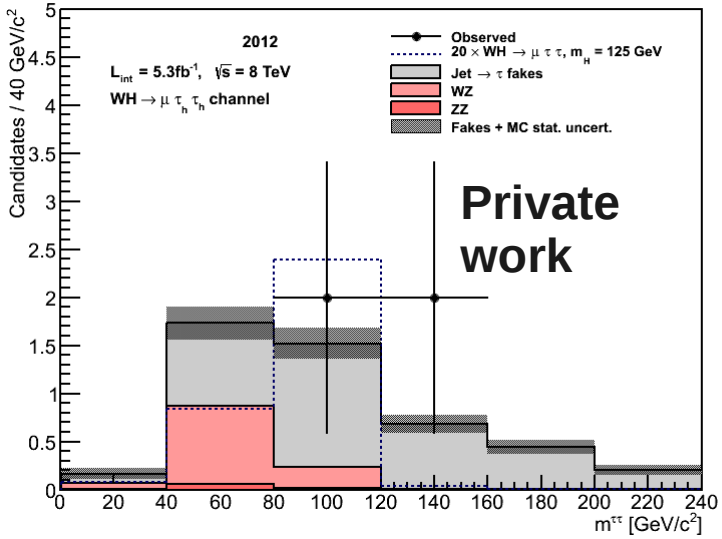
Electron channel



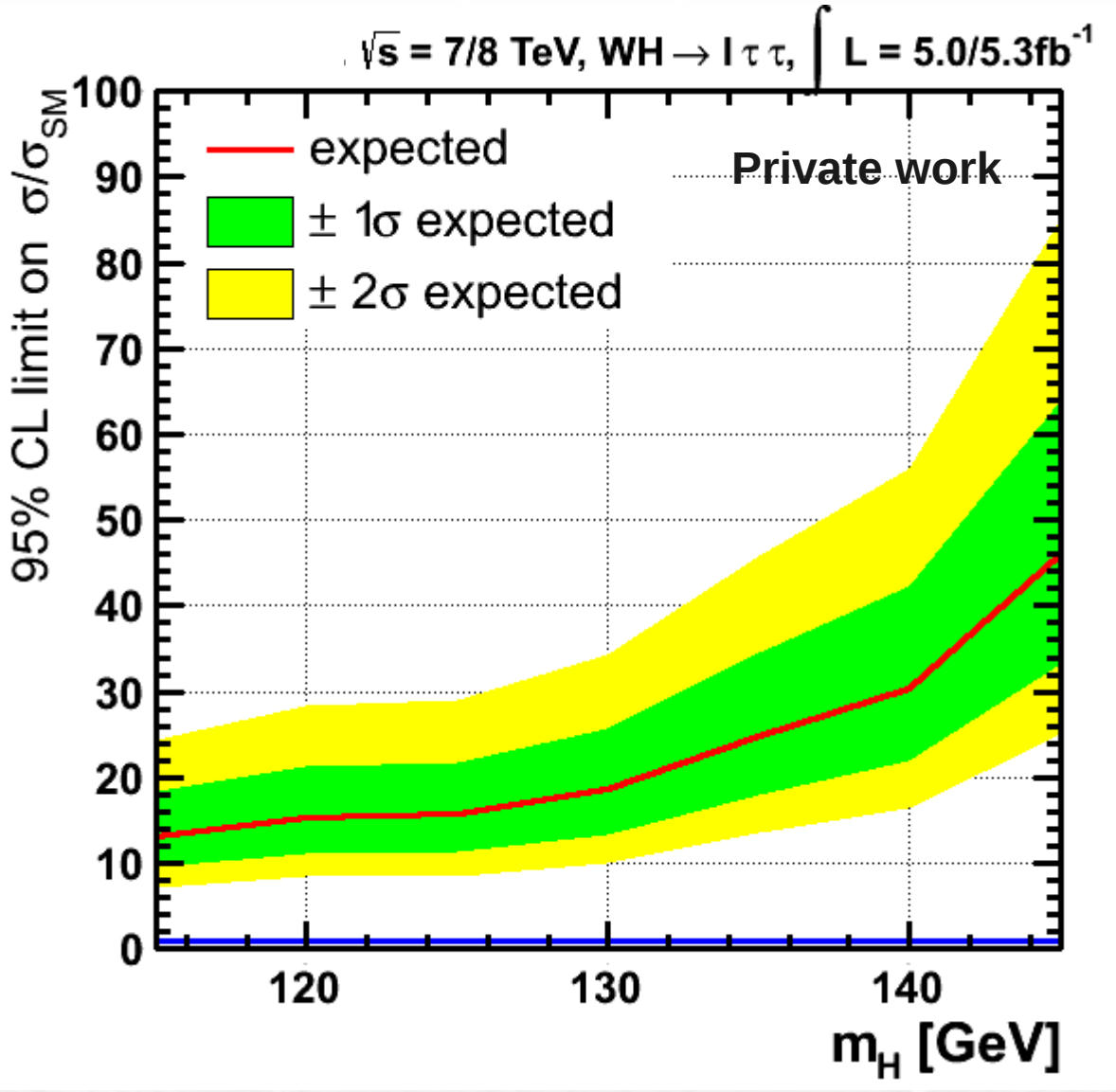


Muon channel





Expected Limit



Conclusion and Plans

- Search for Higgs Boson ($H \rightarrow \tau\tau \rightarrow \tau_h \tau_h$) produced in association with W boson
- Exclude 16 x SM Higgs@125 GeV with 5.0 (5.3) fb^{-1} at 7 (8) TeV
- Plans:
  - Top-up with full 2012 dataset
  - Analysis improvements
    - Optimized $Z \rightarrow ee$ veto
    - Full di-tau mass reconstruction (SVfit)
    - Better discrimination against fake background using a kinematic MVA

Backup

Selection Cuts

In the muon channel:

- p_T > 24 GeV
- |η| < 2.1
- Tight PF Muon ID
- |d0| < 0.02 cm
- |dz| < 0.2 cm
- PF relative Isolation < 0.1 (dB-corrected)

In the electron channel:

- p_T > 24 GeV
- |η| < 1.4442 || 1.566 < |η| < 2.1
- Tight MVA Electron ID
- |d0| < 0.02 cm
- |dz| < 0.2 cm
- PF relative Isolation < 0.1 (0.15) for |η| > (<) 1.479 (dB-corrected)

Leading tau:

- p_T > 45 GeV, |η| < 2.3
- Relative Combined Isolation Tight
- Against Muon Tight
- Against Electron Loose **(e-channel: Tight)**
- DeltaR(l, τ_1) > 0.5
- $|z_{\tau 1} - z_l|$ < 0.14

Subleading tau:

- p_T > 30 GeV, |η| < 2.3
- Relative Combined Isolation Medium
- Against Muon Tight
- Against Electron Medium
- DeltaR(l, τ_1) > 0.5
- $|z_{\tau 1} - z_l|$ < 0.14

Additional:

- $Q(\tau_1) * Q(\tau_2) < 0$
- E_T^{miss} > 20 GeV
- No b-tagged jet (CSV medium) with p_T > 20 GeV

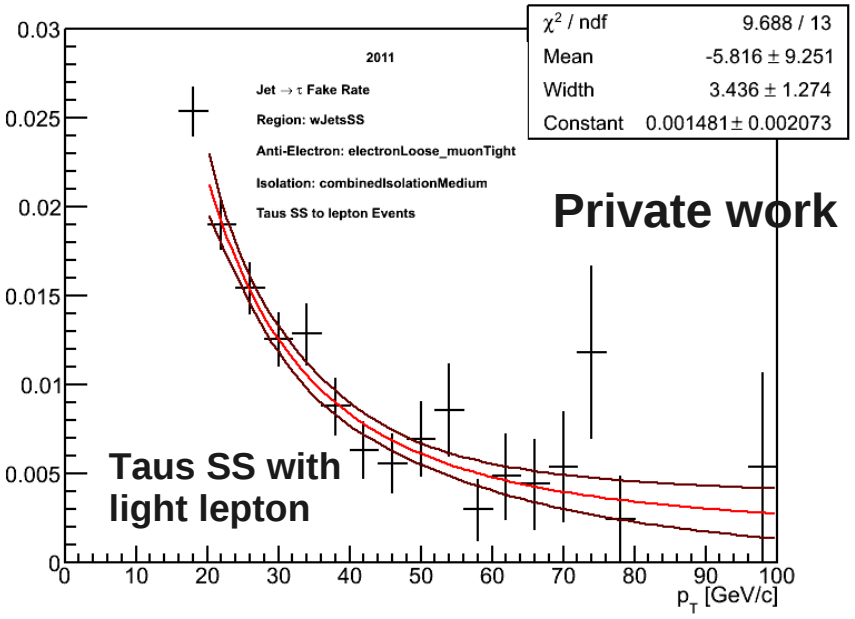
Additional (e channel):

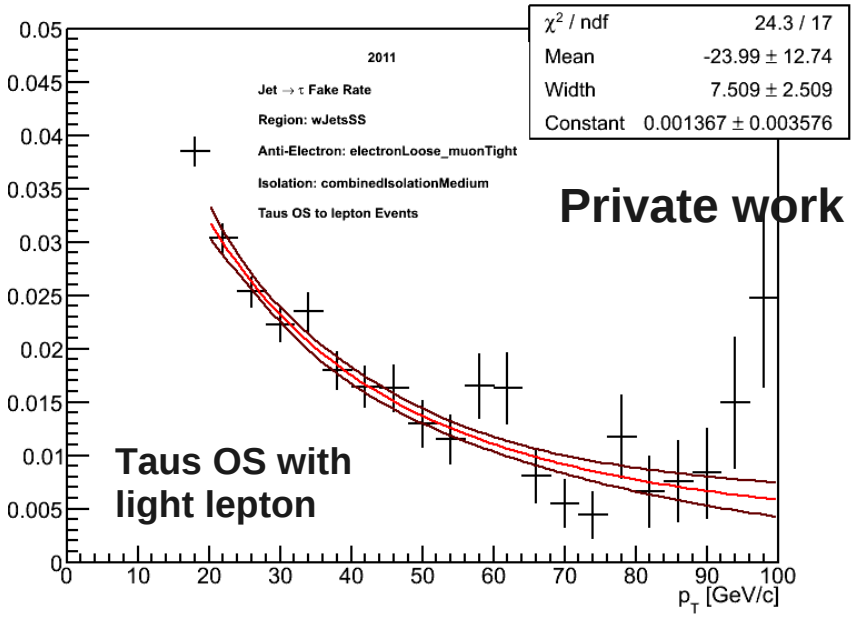
- $M_T(e, E_T^{miss})$ > 50 GeV **(Z → ττ veto)**
- $|m_Z - m_{ee}| > 5\sigma_Z$ **(Z → ee veto)**
- $|p_T(e_1) - p_T(e_2)|/(p_T(e_1) + p_T(e_2)) > 0.25$ **(Z → ee veto)**

Additional (μ channel):

- No additional global + PF muon with p_T > 15 GeV **(Z → μμ veto)**
- No loose MVA electron with p_T > 10 GeV
- $p_T(\tau_1, \tau_2)$ > 50 GeV or $m(\mu, \tau_{OS})$ > 80 GeV **(Z → ττ veto)**

Fake Rate in OS/SS events

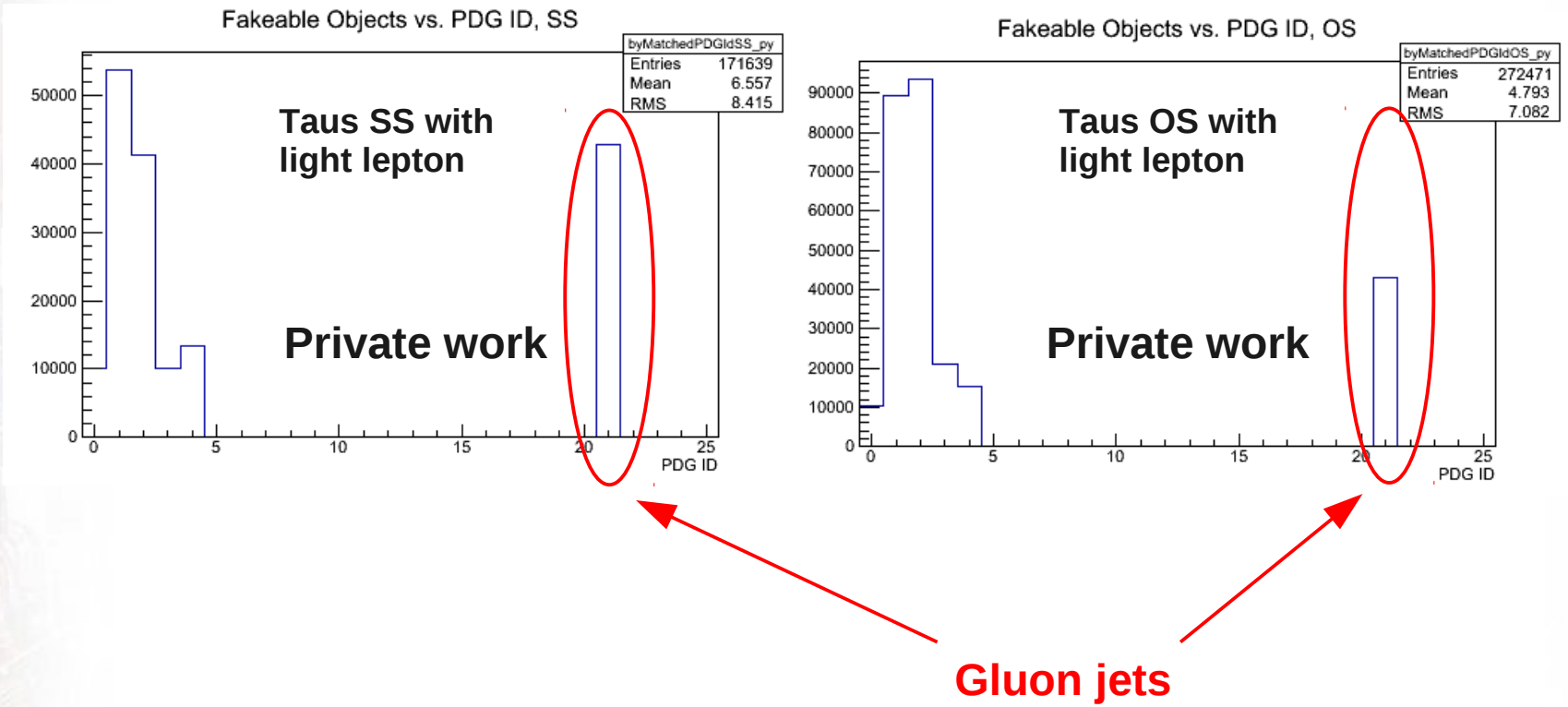




30% difference in Fake Rate between OS and SS events in W+Jets region

Quark/Gluon Jet fractions

Highest p_T generator particle near the fake tau jet



More gluon jets in SS events than in OS events
→ explains lower Fake Rate