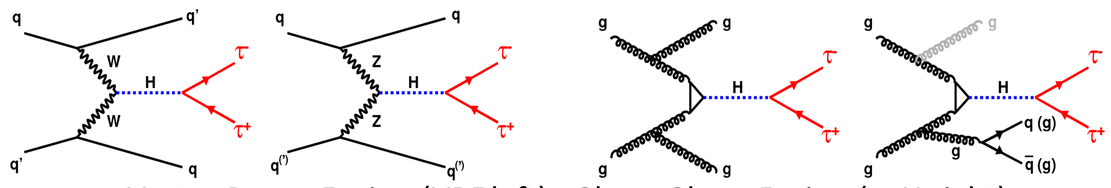
Measurement of Higgs Decays to Two Tau Leptons Using the 2016 CMS Dataset

PRINCETON UNIVERSITY

Sam Higginbotham,
Presented on behalf of the CMS collaboration and HTT group,
shigginb@cern.ch

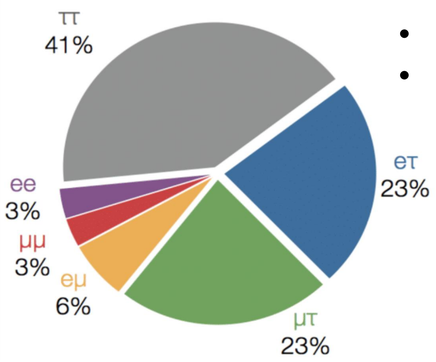
A measurement of the coupling strength of the Higgs boson to a pair of tau leptons is performed using events recorded in proton-proton collisions by the CMS experiment at a center-of-mass energy of 13 TeV, corresponding to $35.9\ fb^{-1}$. The observed significance for the decay of the Higgs boson to tau leptons is above the discovery threshold.

MAIN PRODUCTION MECHANISMS



Vector Boson Fusion (VBF,left) , Gluon Gluon Fusion (ggH,right)

FINAL STATES AND ANALYSIS CATEGORIES



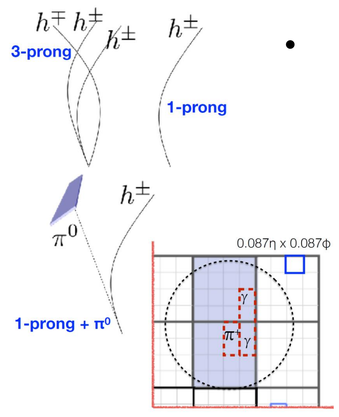
Possible $H \rightarrow \tau\tau$ final states
τ denotes hadronic tau τ_h

- Possible di-tau final states, $e\mu, e\tau_h, \mu\tau_h, \tau_h\tau_h$
- Analysis is split into categories targeted at different Higgs production scenarios
  - 0-Jet Category: Targets gluon fusion events
  - VBF Category: Events with two jets present, high jet invariant mass, and high di-tau p_t
  - Boosted Category: This category catches events that do not meet the previous two categories. Namely, one jet or events with jets failing VBF categorization

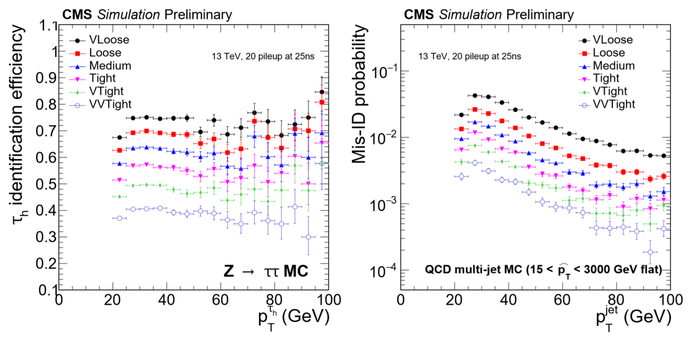
SELECTIONS

Channel	Trigger	$p_t(GeV)$	η	Isolation
$\tau_h\tau_h$	$\tau_h(35)$ &$\tau_h(35)$	$p_t^{\tau_h} > 50$ &40	$\lvert\eta^{\tau_h}\rvert < 2.1$	$MVA\ \tau_h\ ID$
$\mu\tau_h$	$\mu(22)$	$p_t^{\mu} > 23$ $p_t^{\tau_h} > 30$	$\lvert\eta^{\mu}\rvert < 2.1$ $\lvert\eta^{\tau_h}\rvert < 2.3$	$MVA\ \tau_h\ ID$ $I^{\mu} < 0.15$
	$\mu(19)$&$\tau_h(21)$	$p_t^{\mu} > 23$ $p_t^{\tau_h} > 30$	$\lvert\eta^{\mu}\rvert < 2.1$ $\lvert\eta^{\tau_h}\rvert < 2.3$	$MVA\ \tau_h\ ID$ $I^{\mu} < 0.15$
$e\tau_h$	$e(25)$	$p_t^{e} > 26$ $p_t^{\tau_h} > 30$	$\lvert\eta^{e}\rvert < 2.1$ $\lvert\eta^{\tau_h}\rvert < 2.3$	$MVA\ \tau_h\ ID$ $I^{e} < 0.1$
$e\mu$	$e(12)$&$\mu(23)$	$p_t^{e} > 26$ $p_t^{\mu} > 23$	$\lvert\eta^{e}\rvert < 2.5$ $\lvert\eta^{\mu}\rvert < 2.4$	$I^{e} < 0.15$ $I^{\mu} < 0.2$
	$e(12)$&$\mu(23)$	$p_t^{e} > 26$ $p_t^{\mu} > 23$	$\lvert\eta^{e}\rvert < 2.5$ $\lvert\eta^{\mu}\rvert < 2.4$	$I^{e} < 0.15$ $I^{\mu} < 0.2$

TAU RECONSTRCUTION

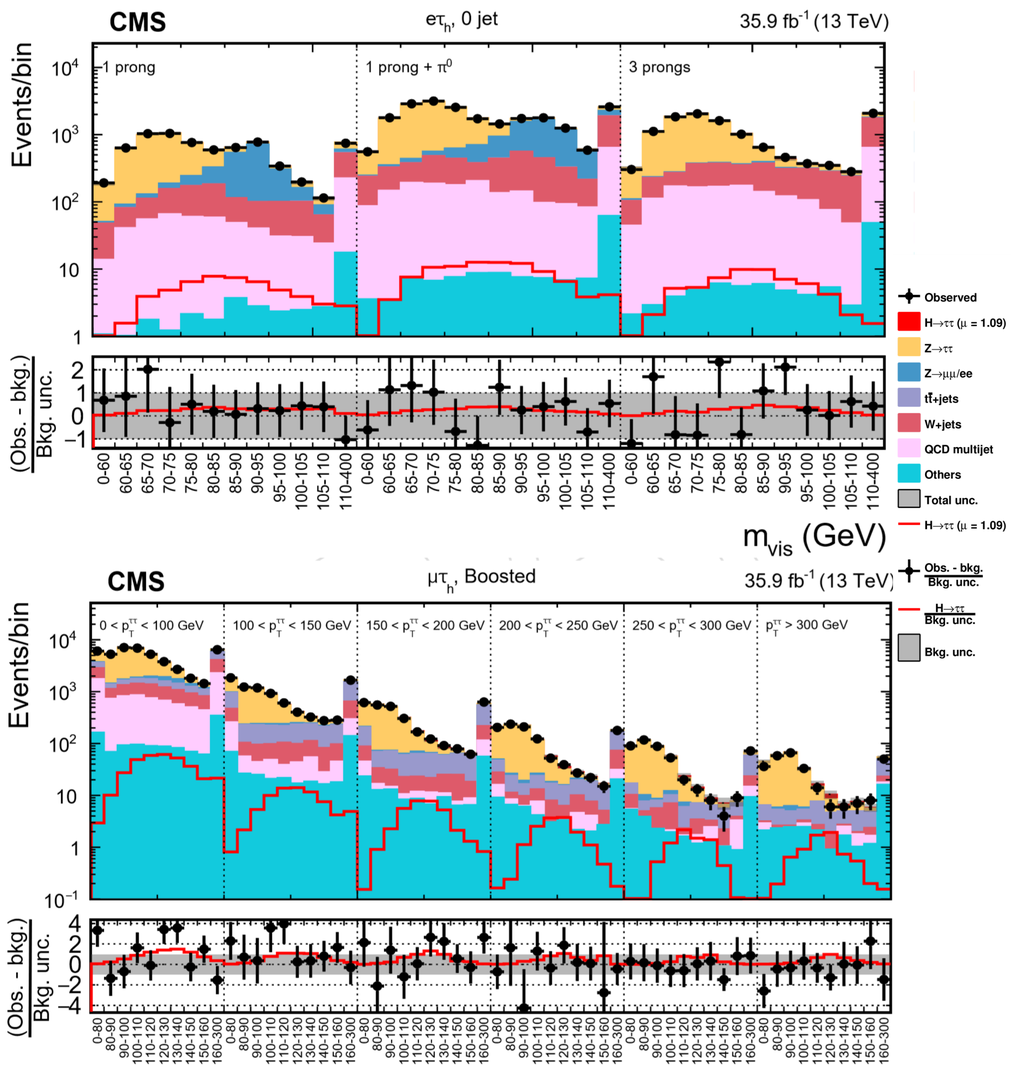


- Hadron Plus Strips (HPS) algorithm is used to identify τ_h . Intermediate mesons (ρ) and γ from π^0 can be identified in the τ_h decay (left)
- MVA to ID τ(s) developed with different working points (below)

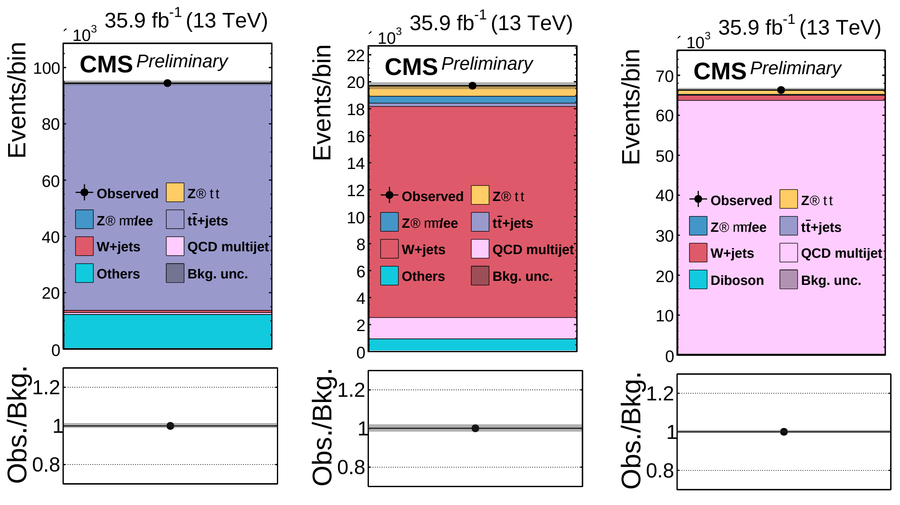


SIGNAL EXTRACTION

- 2D variables are plotted against each other based on the channel and categorization then unrolled for a final significance measurement

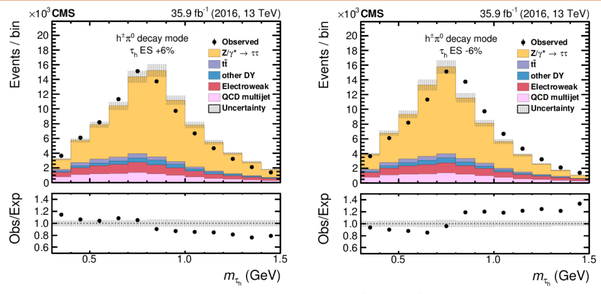


BACKGROUND COMPOSITION



- Control Regions are used to estimate background events in the fit model
- Background methods are introduced for each channel
- QCD in particular, is estimated using a data driven method with four regions

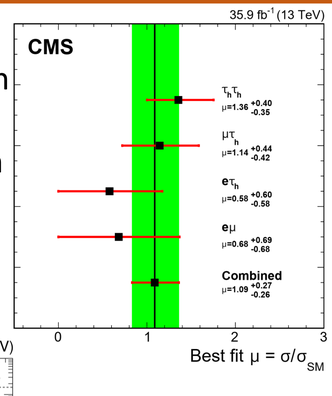
CORRECTIONS

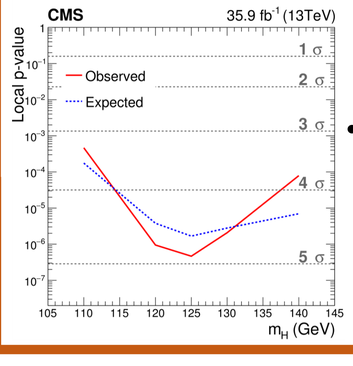


- Tau Energy Scale (TES) and Jet Energy Corrections are among the systematic corrections made. TES shifts in m_{τ_h} by Tau-POG[2] (above)

SIGNIFICANCE

- The signal strength of the 2D unrolled plots is found with the combine statistical fitting tool (right)





- Significance was also measured and discovery threshold was obtained (left)

Significant Excess around Higgs mass

REFERENCES

[1] CMS Collaboration, "Observation of the SM scalar boson decaying to a pair of τ leptons with the CMS experiment at the LHC" Phys. Lett. B 779 (2018) 10.1016/j.physletb.2018.02.004 ,arXiv: 1708.00373.
[2] CMS Collaboration, "Tau reconstruction and identification performance in run 2" JINST vol 13 Oct. (2018) 10.1088/1748-0221/13/10/P10005 ,arXiv:1809.02816