Search for the Higgs Boson Decaying into tau pairs

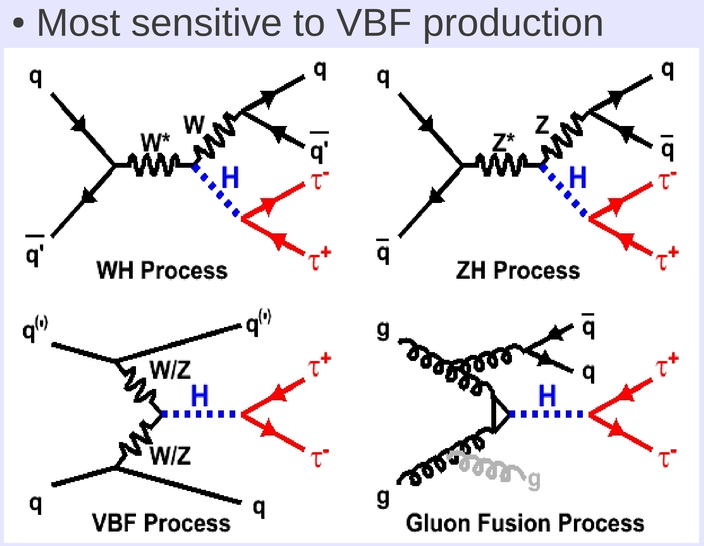
(Jakob Salfeld-Nebgen)

Abstract

A search for the standard-model Higgs boson decaying to τ pairs is performed using events recorded by the CMS experiment at the LHC in 2011 and 2012 at a centre-of-mass energy of 7 and 8 TeV respectively. The dataset corresponds to an integrated luminosity of 4.9 fb^{-1} at a centre-of-mass energy of 7 TeV and 19.4 fb^{-1} at 8 TeV. The τ-pair invariant mass spectrum is studied in five different final states corresponding to the decay modes of the two τ leptons. An excess of events is observed over a broad range of Higgs mass hypotheses, with a maximum local significance of 2.93 standard deviations at m_H= 120 GeV. The excess is compatible with the presence of a standard-model Higgs boson of mass 125 GeV.

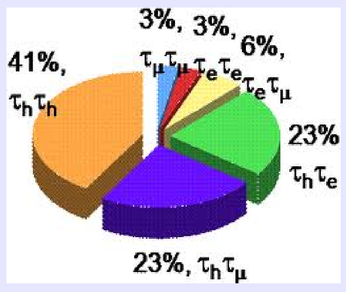
Higgs production mechansims

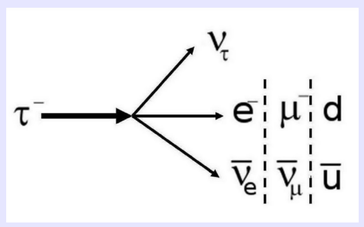
- Analysis exploits most of the Higgs production mechanisms[1)]
- Most sensitive to VBF production



1) W and Z assiciated Higgs production are not discussed in detail

H->ττ decay channels covered





Both τ-leptons decay subsequently into hadrons, muons or electrons + genuine MET from neutrinos

$\tau_h\tau_h$	Both τ-leptons into hadrons
$\mu\tau_h$	τ-leptons into μ and hadrons
$e\tau_h$	τ-leptons into e and hadrons
eμ	τ-leptons into e and μ
μμ	Both τ-leptons into μ

Background estimation

QCD	Shape,normalization from same-sign sample
W+Jets	Normalization from sideband
TTJets	Normalization from sideband
Z+Jets	MC corrected for fake rate (μμ-channel: shape and normalization from sideband)
Z->ττ	From Z->ττ embedded sample

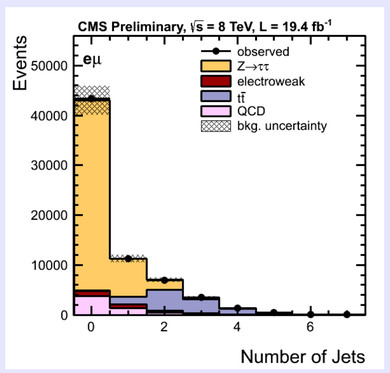
The Z->ττ background is estimated via a Data MC hybrid sample. Z->μμ Data events are selected for all run periods. For the embedded sample the muons are then replaced by decaying MC τ-leptons.

Event selection

- Events are recorded via the CMS L1 and HLT **trigger system**
- reconstructed using the **Particle Flow** algorithm
- Physics Objects are required to pass refined **identification criteria** and to be in acceptance of respective subdetectors

Event categorization

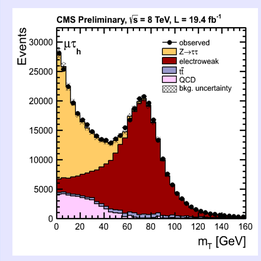
- Events are classified wrt jet multiplicity
- Probes different Higgs production mechanisms
- Enhances Sensitivity

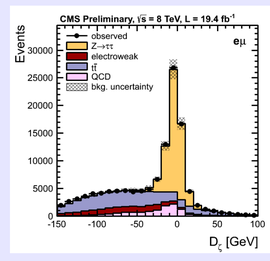


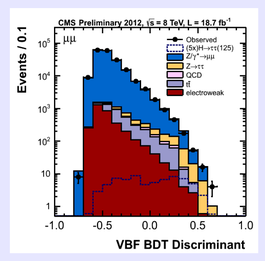
VBF	At least two jets with p_T>30 GeV, invariant mass of m_{jj}>500 GeV and separated in pseudorapidity by η_{jj}>3.5. No additional jet in eta gap, no b-tagged jets
1-Jet	At least one jet with p_T>30 GeV Not in VBF category No b-tagged jets ($e\tau_h$-channel: MET>30 GeV)
0-Jet	Anything not in other categories No b-tagged jets ($\tau_h\tau_h$-channel: omitted due to trigger)

Topological selection

$e\tau_h$, $\mu\tau_h$	Cut on: $m_T = \sqrt{2 p_T E_T^{miss}(1 - cos(\Delta\phi))}$
eμ	Cut on: (ζ: bisector of lepton p_T directions) $D_\zeta = p_\zeta - 0.85 \cdot p_\zeta^{vis} > -20\text{GeV}$ $p_\zeta = \vec{p}_{T,1} \cdot \hat{\zeta} + \vec{p}_{T,2} \cdot \hat{\zeta} + \vec{E}_T^{miss} \cdot \hat{\zeta}$ $p_\zeta^{vis} = \vec{p}_{T,1} \cdot \hat{\zeta} + \vec{p}_{T,2} \cdot \hat{\zeta}$
μμ	Cut on boosted decision tree

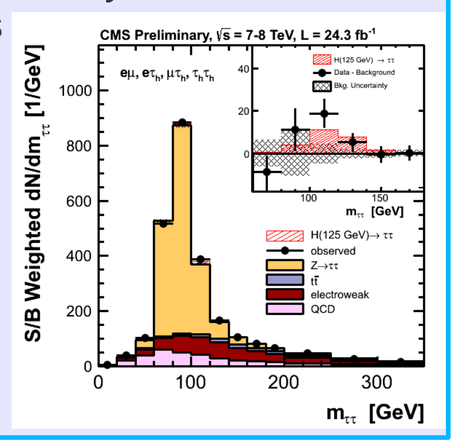




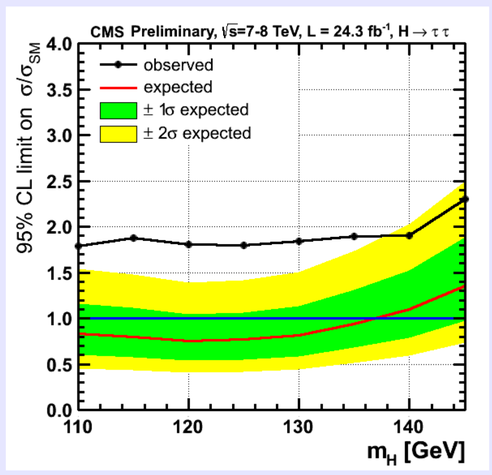


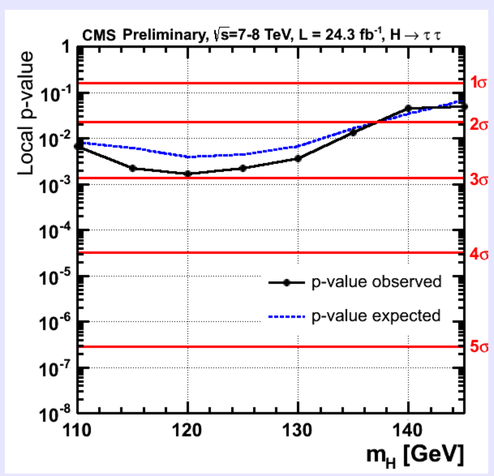
$M_{\tau\tau}$ reconstruction

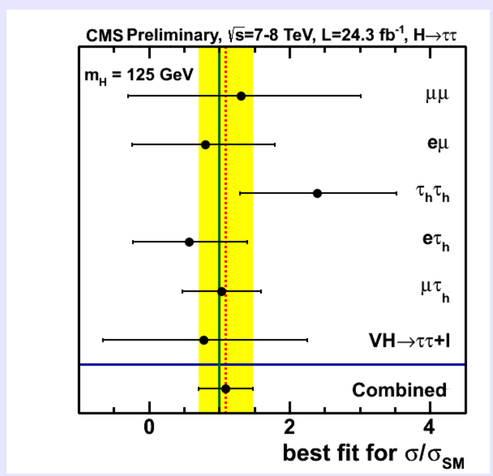
For **statistical inference** the reconstructed invariant mass of the di-τ system is used. Invariant mass reconstructed via Seconday Vertex Fit (SVFit) Algorithm, based on likelihood built from τ decay kinematics and MET reconstruction. Resolution: 15-20%



Results



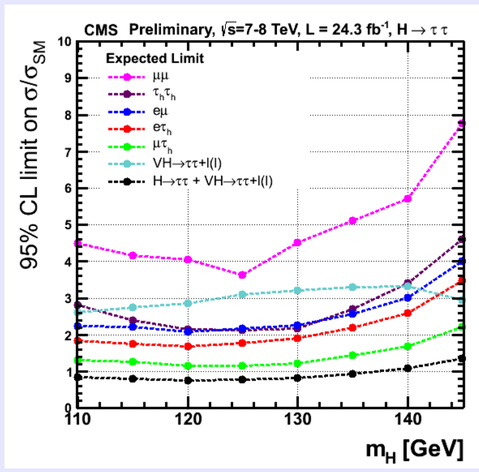




Simultaneous fit on $m_{\tau\tau}$ in all channels and all categories. Best combined fit for signal strength μ=1.1±0.4 at m_H= 125 GeV. Minimum local p-value of observed limit at m_H=120 GeV, corresponding to significance of 2.93 standard deviations. For m_H=125.8 GeV, significance is 2.85σ.

Number of expected and observed event yields in $\mu\tau_h$-channel (7 & 8 TeV merged)

Process	0-Jet	1-Jet (high)	VBF
Z->ττ	84833±1927	4686±232	109±11
QCD	18313±478	481±38	48±7
EWK	8841±653	1585±153	63±9
ttbar	11±1	155±11	5±1
Background	111998±2090	6908±281	225±16
Signal	-	73±13	11±2
Observed	112279	7011	240



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