Search for the CM Higgs boson in $2l\,2\tau$ final state

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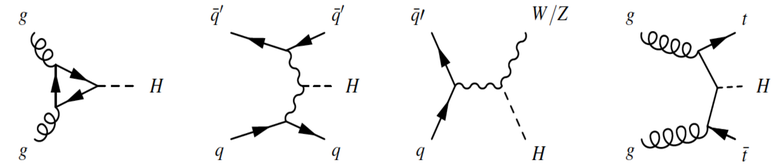
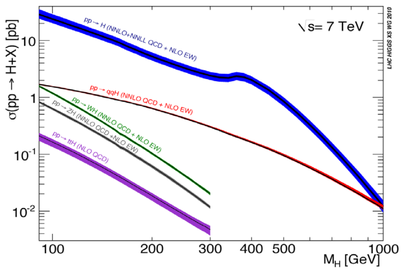
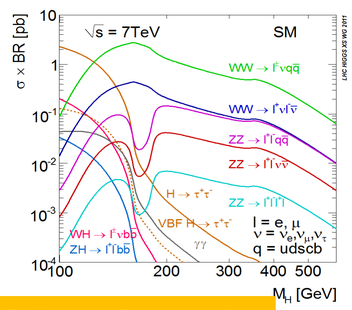
Production and decay modes

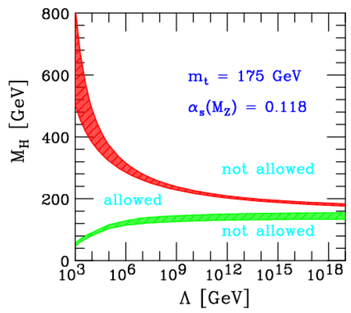




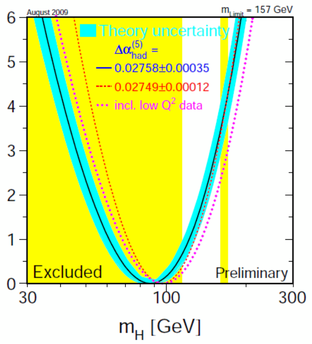


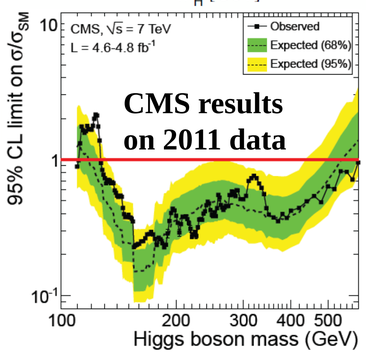
Theoretical prediction and Search results

Restriction on Higgs mass from the finite value of Higgs self-coupling (upper) and vacuum stability (lower) as a function of the cut-off scale Λ

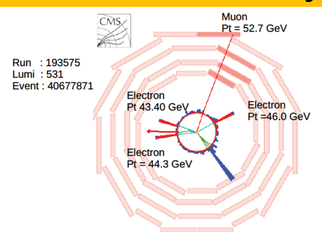


LEP : M_H > 114.4 GeV





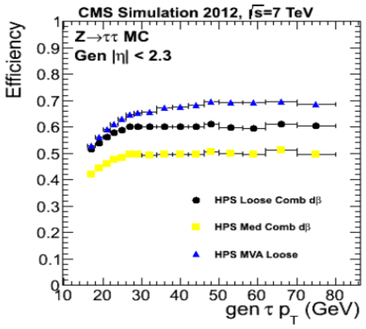
H →ZZ→2*l* 2τ analysis

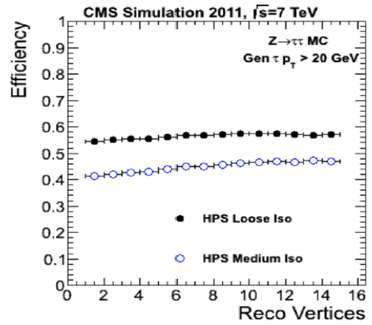


- Eight final states : $\mu\mu\tau_\mu\tau_h$, $\mu\mu\tau_e\tau_h$, $\mu\mu\tau_e\tau_\mu$, $\mu\mu\tau_h\tau_h$, $ee\tau_\mu\tau_h$, $ee\tau_e\tau_h$, $ee\tau_e\tau_\mu$, $ee\tau_h\tau_h$,
- Preliminary selection on dilepton trigger
- Background (WW, WZ, W/Z+jets, tt-bar) suppression by lepton identification and isolation. ZZ is irreducible background
- Z selection with opposite sign leptons and invariant mass
- Veto μμμμ, μμee, eeee channels

Lepton identifications and selection

- **Muon selection**
  - $|\eta|<2.4$
  - P_T > 20 (10) GeV for leading lepton in leading Z (other)
  - >10 silicon tracker hits and at least on pixel hit
  - >four tracker layer
  - χ2/ndf for global muon fit <10
  - $|d_{xy}|<0.2$cm and $|dz|<0.5$cm
  - I^{PF}_{rel}(rho) <0.25
- **Electron Selection**
  - $|\eta|<2.5$
  - P_T > 20 (10) GeV for leading lepton in leading Z (other)
  - Identification by boosted Decision Tree, where inputs are $\sigma_{i\eta i\eta}$, $\Delta\eta_{in}$, $\Delta\varphi$, f_{bream}, $\sigma_{i\varphi i\varphi}$, additional clusters from bremsstrahlung, $1/E_{Supercluster} - 1/P_{GSF\ tracks}$
  - I^{PF}_{rel}(rho) <0.25
- **Tau Selection**
  - Single Hadron, : $\tau^- \rightarrow h^-\pi^0_{slow}$
  - Hadron plus strip : possibility to include converted photons (from π^0) and those are near to the charged hadron
  - Hadron plus two strips :Photons from π^0 are well separated
  - Three Hadrons : Common vertex with $|q|=1$
  - Hadron plus strip decays requires strips with E_T > 1 GeV and invariant mass consistent with ρ(770)
  - P_T> 20 GeV, $|\eta|<2.3$
- **Isolation (τ): Inside isolation cone, ΔR=0.4 with veto cone 0.1**
  - $I_{PF}(\Delta\beta) = \sum(P_T\ charge + Max(E_T^{\gamma}+E_T^{\ Neutral} - 0.0729 \times E_T^{PU}, 0.0))$, E_T^{PU}≡Sum of energy of charged pileup candidate within ΔR=0.8

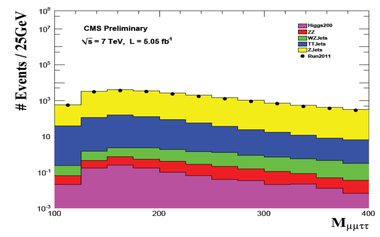


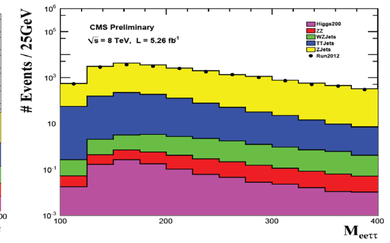


- **Additional selection criteria**
  - 60 (30) GeV < M_{ll} < 120 (90) GeV for leading (non leading) Z
  - $|\Delta z|<0.1$cm of all leptons wrt to leading lepton of leading Z
  - Veto 4μ, 2e2μ and 4e events,
    - with additional lepton with loose isolation or identified e/μ within a τ_h-candidate

Background estimation from data

- Leading Z selection with standard criteria
- Sub-leading Z with same sign lepton and without any isolation





$$F(p_T(\tau)) = C_0 + C_1 \exp(C_2 p_T(\tau))$$

Semileptonic channels $N_B = \frac{N_S F(p_T(\tau))}{1 - F(p_T(\tau))}$

Fully hadronic channels $N_B = \frac{N_S F(p_T(\tau_1)) F(p_T(\tau_2))}{1 - F(p_T(\tau_1)) F(p_T(\tau_2))}$

Expected irreducible background , $N_{ZZ}^{expected} = N_Z^{obs} \frac{\sigma_{ZZ}^{SM}}{\sigma_Z^{SM}} \frac{A_{ZZ}}{A_Z}$

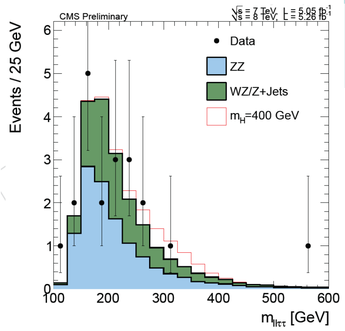
Systematics

Trigger (1.5%), lepton reconstruction and identification(2-3%), isolation(2%), energy/momentum calibration (0.5%), energy resolution(30%), PDF (4-5%), luminosity (2.2%)

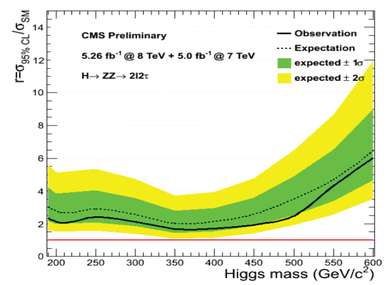
Channel	μID/Iso	E ID/Iso	τh ID/Iso	τES
$\mu\mu\tau_h\tau_h$	1.01/1.01	-	1.1	1.04
$ee\tau_h\tau_h$	-	1.02/1.01	1.1	1.04
$ee\tau_e\tau_h$	-	1.04/1.02	1.06	1.03
$\mu\mu\tau_e\tau_h$	1.01/1.01	1.02/1.01	1.06	1.03
$\mu\mu\tau_\mu\tau_h$	1.02/1.02	-	1.06	1.03
$ee\tau_\mu\tau_h$	1.01/1.01	1.02/1.01	1.06	1.03
$ee\tau_e\tau_\mu$	1.01/1.01	1.04/1.02	-	-
$\mu\mu\tau_e\tau_\mu$	1.02/1.02	1.02/1.01	-	-

Results

Observed 6(14) events in 2011 (2012) data with expected background and signal (with M_H=200 GeV) events are 8.85±0.53±1.30 (12.12±0.68±1.44) and 1.30(1.61) respectively



In absence of any excess, 95% upper limit of cross section is calculated using CLs



Reference: CMS Coll, HIG-12-016