Search for Standard Model Higgs Boson in the H→ZZ→2l2ν channel in pp collisions at sqrt(s) = 7 TeV in CMS

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Abstract

A search for the Higgs boson in pp collisions at LHC at a center-of-mass energy of 7 TeV is presented. The results are based on a data sample corresponding to an integrated luminosity of 1.6 fb^{-1} recorded by the CMS experiment. The search is conducted in decay channel H→ZZ→2l2ν. No excess is observed in transverse mass distributions. Limits are set on the production of the Higgs boson in the context of the Standard Model and in the presence of a sequential fourth family of fermions with high masses.

Motivation and Introduction

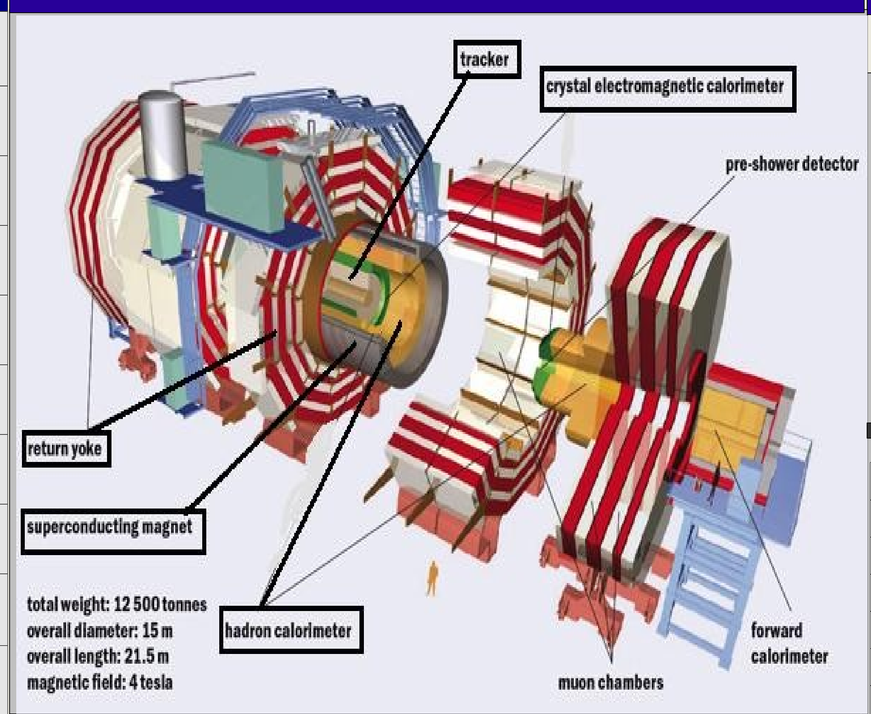
- Larger Yield because of High B.R.(Z->2ν) (20%)
  B.R.(ZZ->2l2ν) = 6 X B.R.(Z->4l)
- Look for Z+MET signature.
- Mass range investigated is 250 GeV/c^2 to 600 GeV/c^2.
- No Higgs peak is present in this analysis.
- Cut-and-count analysis is carried out.
- Large Z +Jets background ~ 5 orders of magnitude larger cross-section than signal.

Analysis Strategy

- Select events with Z candidates with mass within 15 GeV the Z peak.
- Require high MET in the event — to kill Z+jets background
- Apply $\Delta\phi$ cut between MET and closest jet to remove events with fake MET due to jet mismeasurement.
- Veto events with a b-jet — to kill Top background
- Veto events with a third lepton — to suppress WZ background
- Use transverse mass of Higgs as final discriminant to further reduce the backgrounds.

Process	σ(pb)
H→ZZ→2l2ν (300 GeV)	0.0301
Drell-Yan→(ee, μμ,ττ)	1666
TTbar→(ee, μμ)	16.5
tW→blν	10.6
Single top (t-channel)	20.9
Single top (s-channel)	1.36
ZZ→2l2ν	varies
WZ→3lν	0.596
WW→2l2ν	4.51
W+Jets	31314

CMS Detector



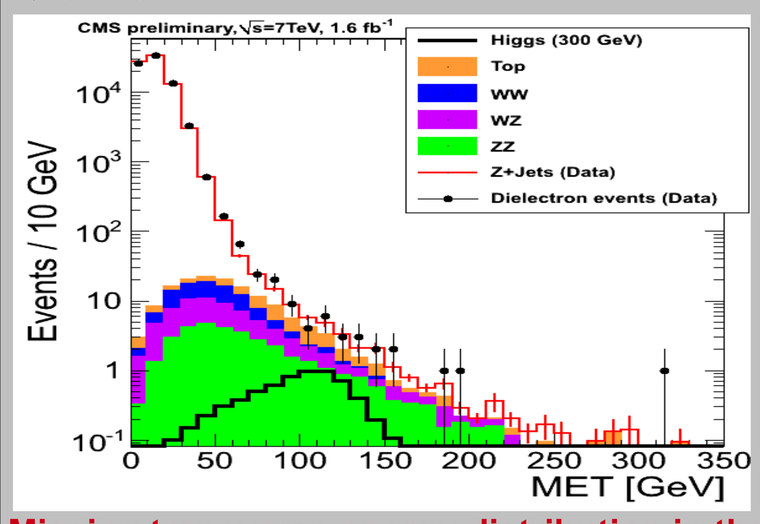
Selection Cuts

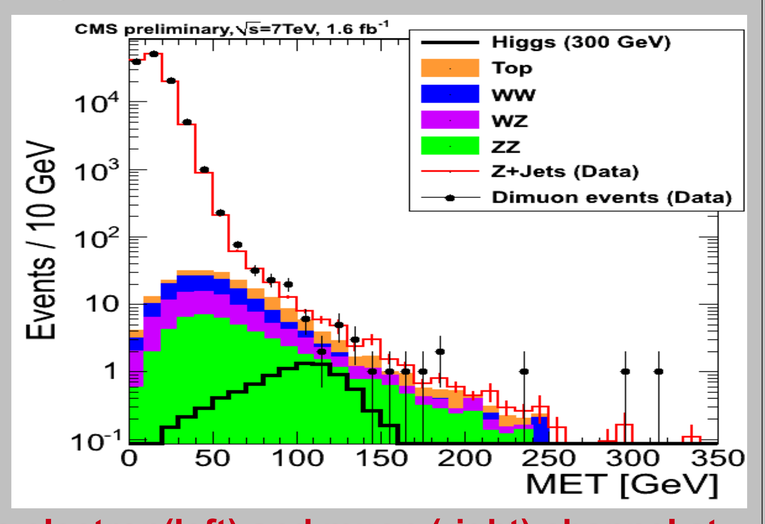
Cut	Cut Value
Lepton transverse momenta	P_T > 20GeV/c
Z mass window	$\lvert m_{ll} - 91.1876\rvert \le 15$ GeV/c^2
Z transverse momentum	Z P_T > 25 GeV/c
Transverse momentum of vetoed 3rd lepton	P_T > 10 GeV/c
Reject events with a soft muon (P_T > 3GeV/c)	-
B-Tag veto (jet P_T > 30GeV/c)	TCHE discriminator < 2
MET-jet separation (ΔΦ(MET,jet))	Mass-dependent
Missing Transverse Energy (MET)	Mass-dependent
Transverse Mass of Higgs (M_T)	Mass-dependent

Higgs mass(GeV/c^2)	ΔΦ(MET,jet)	MET (GeV)	MT (GeV/c^2)
250	> 0.62	> 69	> 216 AND < 272
300	> 0.28	> 83	> 242 AND < 320
350	> 0.14	> 87	> 267 AND < 386
400	-	> 112	> 292 AND < 471
450	-	> 126	> 315 AND < 540
500	-	> 141	> 336 AND < 600
550	-	> 155	> 357 AND < 660
600	-	> 170	> 377 AND < 720

Background Estimation (Z+Jets)

- γ + jets events are used to model Z+Jets background.
- Both have similar MET response.
- γ +jets have higher rate of production. γ+jets events are reweighted to match the photon P_T shape to Z P_T shape.
- A mass is assigned to each photon by sampling from the Z line shape from data.
- γ+jets yield is normalized to match the Z+Jets yield in data.





Missing transverse energy distribution in the electron(left) and muon (right) channel at pre-selection level for 1.6 fb^{-1} of data.

Background Estimation (Top/WW/W+jets)

- To estimate the non-resonant backgrounds, events in e μfinal state passing the full analysis selection are used.
- A scale factor α is computed from the sidebands (SB) of the Z peak to get the estimate of events in ee/μμ final states.

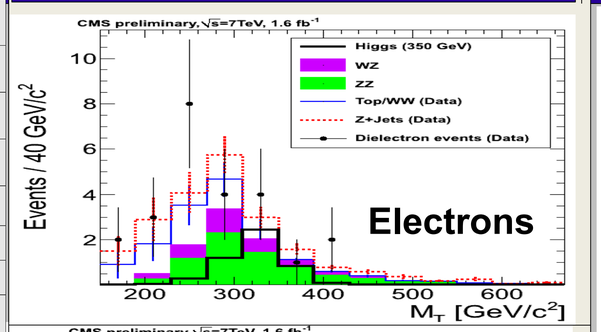
m_H	Predicted Yields	MC Prediction	m_H	Predicted Yields	MC Prediction
250	16 ± 2 ± 3	15 ± 1	250	12 ± 2 ± 2	12 ± 1
300	5.3 ± 0.6 ± 1.8	6.2 ± 0.5	300	4.0 ± 0.7 ± 1.3	4.5 ± 0.5
350	2.3 ± 0.3 ± 1.2	1.8 ± 0.3	350	1.8 ± 0.3 ± 0.9	1.1 ± 0.2
400	0.58 ± 0.07 ± 0.58	0.49 ± 0.13	400	0.44 ± 0.07 ± 0.44	0.51 ± 0.14
500	0	0.059 ± 0.043	500	0	0.21 ± 0.10
600	0	0	600	0	0

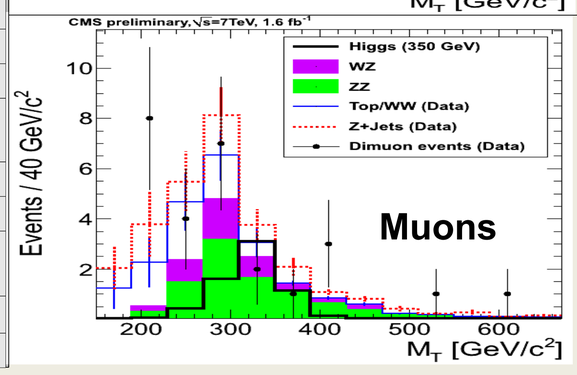
Muon channel (left) and Electron Channel(Right) – yields from 1.6 fb^{-1} data for non-resonant backgrounds. Uncertainties include statistical uncertainty on the scale factor α and the statistical uncertainty on the number of eμ events (in that order).

Systematic uncertainties

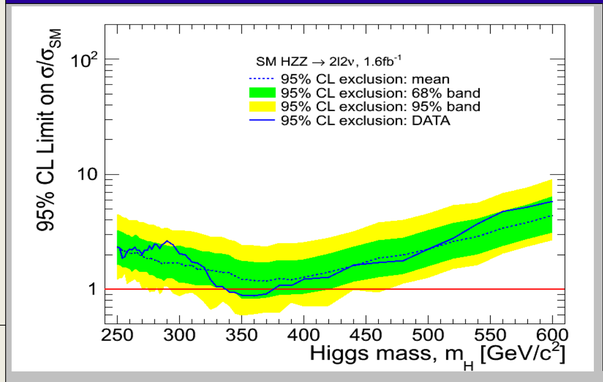
Uncertainty	Value, %
Luminosity	4.5
pdf, gluon-gluon initial state	6-11
pdf, quark-quark initial state	3.3-7.6
QCD scale, g-g initial state (ggH)	7.6-11
QCD scale, q-q initial state (VBF)	0.2-2
QCD scale, g-g initial state (ggZZ)	20
QCD scale, q-q initial state (qqVV)	5.8-8.5
Anti b-Tagging	1-1.2
Lepton ID+Isolation	2
Lepton Momentum Scale	5 (for 2e), 2 (for 2μ)
Jet Energy Scale	1-1.5
PU Effects	1-3
Trigger	1 (for 2e), 2 (for 2μ)
Non-resonant background estimation from data	7% (α)
Z+jets estimation from data	19-57%

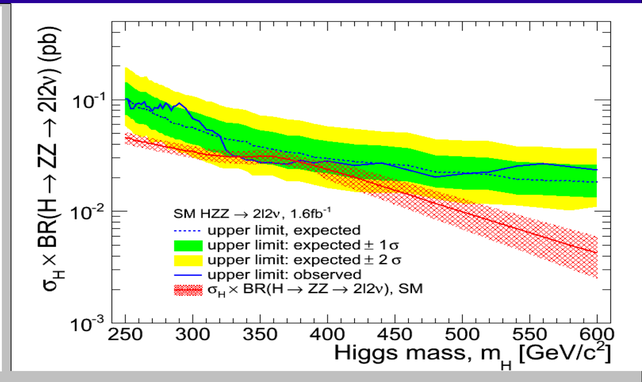
Transverse Mass of Higgs (M_T)





Results





No evidence of Standard Model Higgs boson production. The 95% mean expected and observed C.L. upper limits on the cross section σ × BR (H → ZZ → 2l2v) for masses in the range 250−600 GeV/c^2 has been measured. Results are obtained using a CLs approach with a flat prior for the cross section, for 1.6 fb^{-1} . We also measure the ratio R of the 95% C.L. cross section upper limit σ to the SM cross section, σ(SM) as a function of the Higgs mass m_H. With 1.6 fb^{-1}, the Standard Model Higgs with masses in the range 340−375 GeV/c^2 can be excluded at 95% CL.

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