The Abdus Salam International Centre for Theoretical Physics

2263-27

Beyond the Standard Model: Results with the 7 TeV LHC Collision Data

19 - 23 September 2011

Search for the Higgs Boson in CMS

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Higgs Searches with CMS

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On behalf of the CMS collaboration

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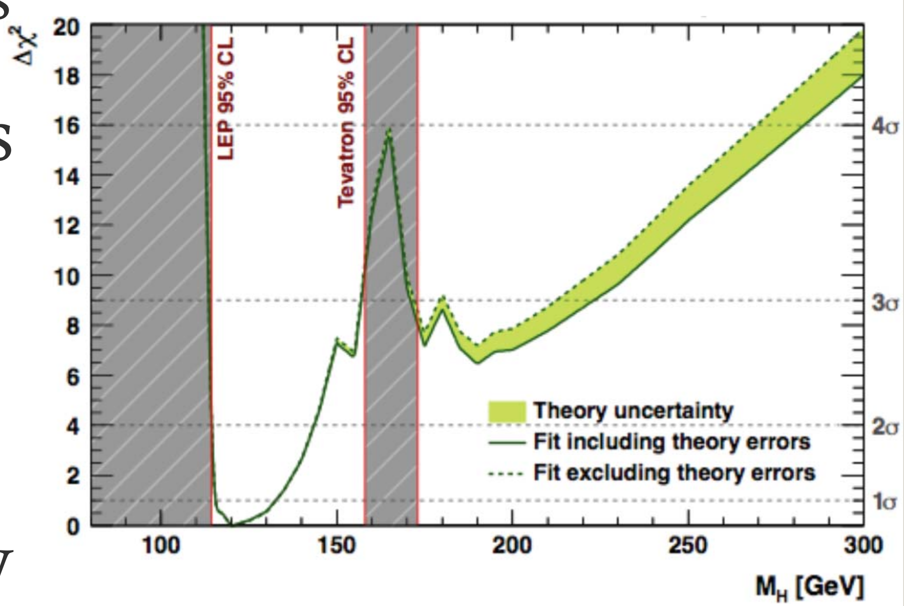
Miramare, Trieste, Italy

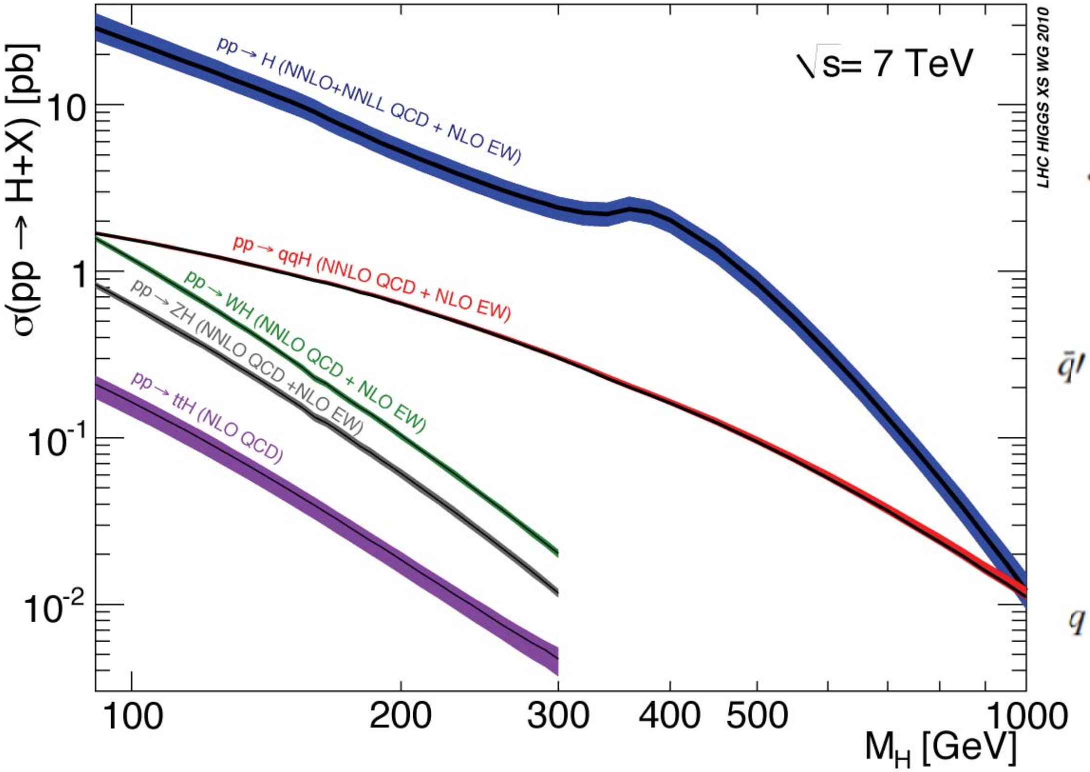
Why we need Higgs?

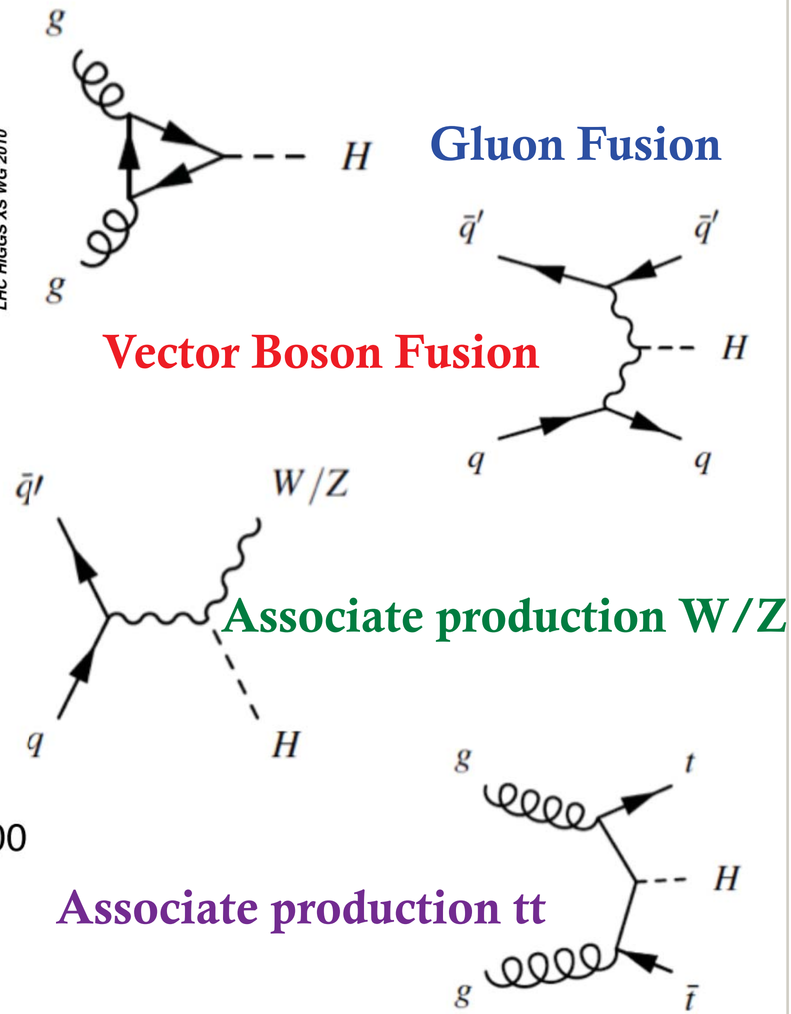
- Higgs mechanism introduces additional scalar field in the SM Lagrangian
  - Generates masses of fundamental particles
  - Predicts Higgs boson coupling to fermions and bosons
  - Does not predict Higgs' mass

- Constraints on Higgs mass
  - EW fits favor light Higgs
    - Direct searches at LEP $m_H > 114.4$ GeV
    - Tevatron excludes Higgs with masses 158 – 173 GeV

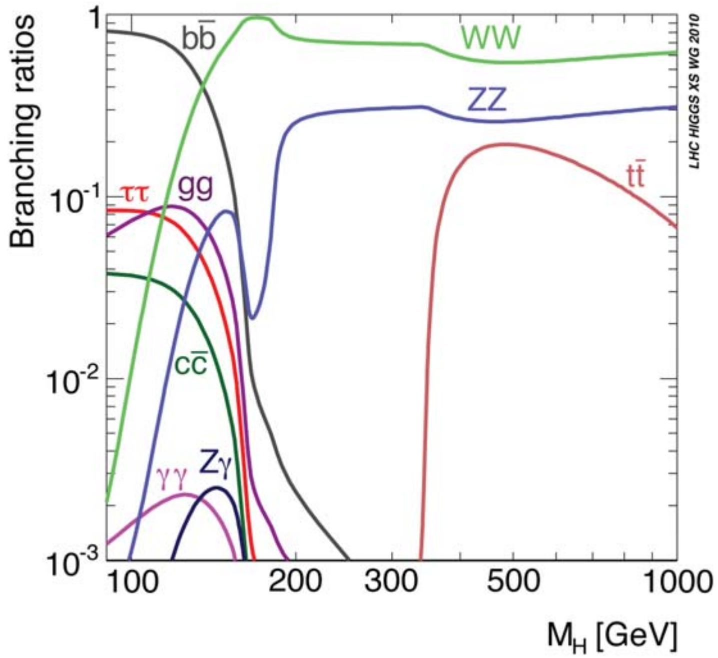


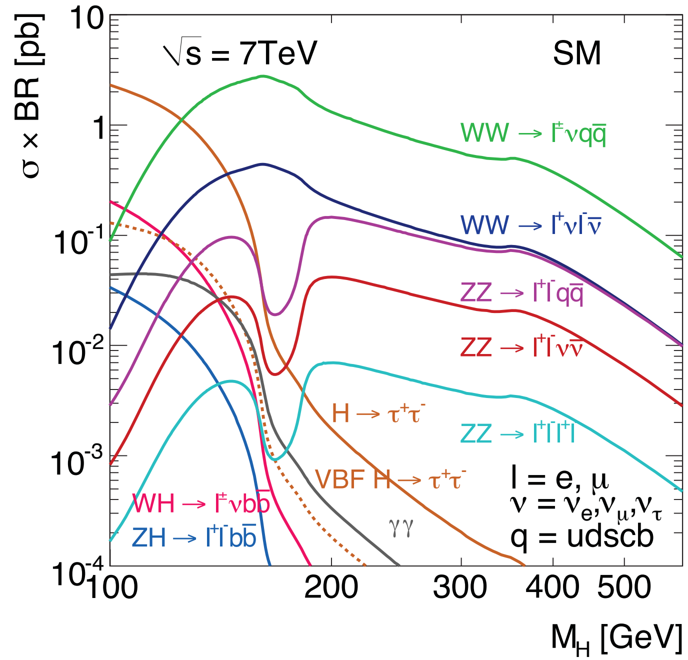
Higgs production @ 7 TeV





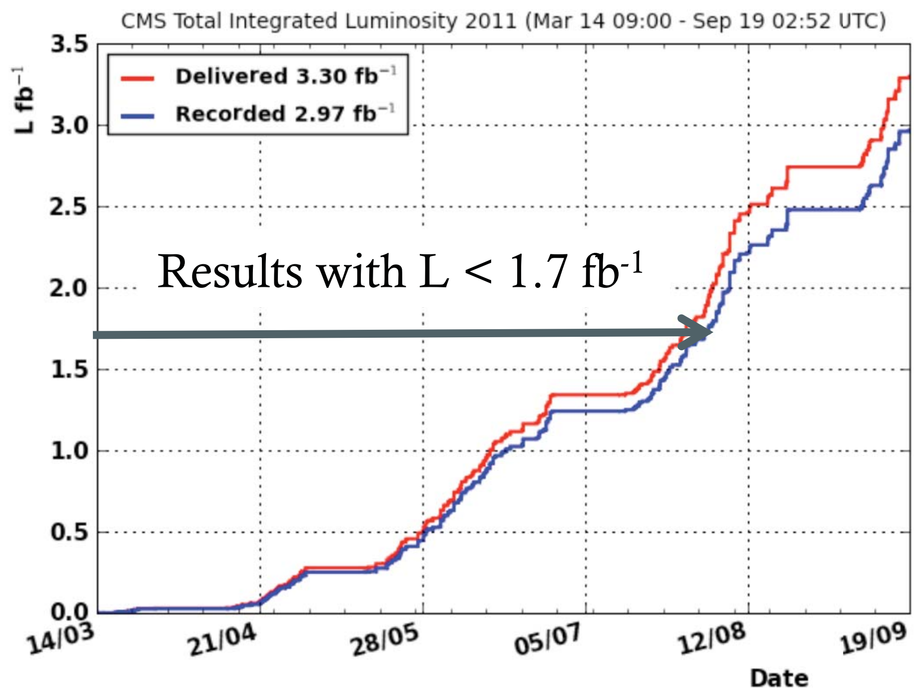
Branching fractions

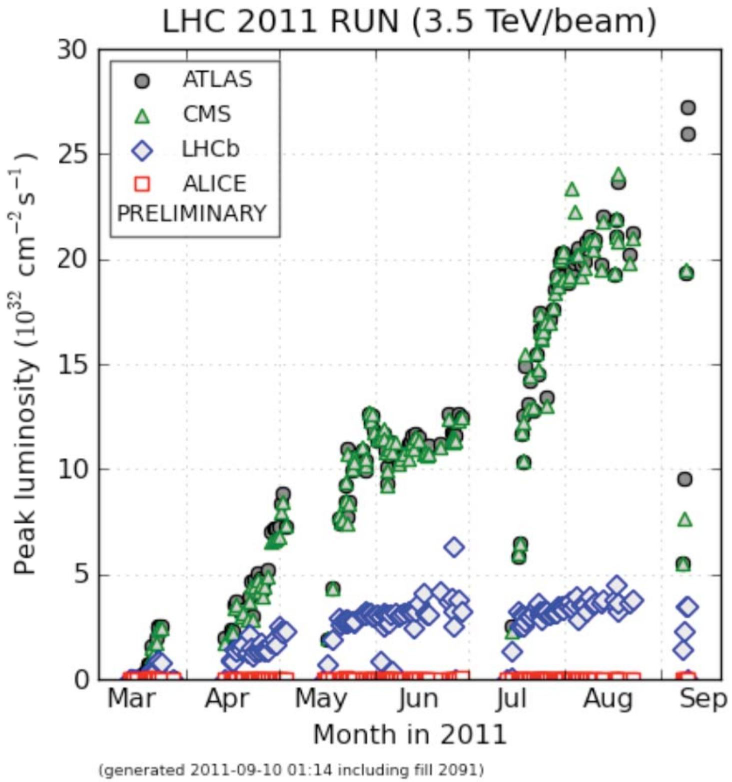




- Low mass $m_H < 135\text{-}150$ GeV: H → γγ, ττ, bb
- Intermediate and high mass: H → WW, ZZ

LHC Performance

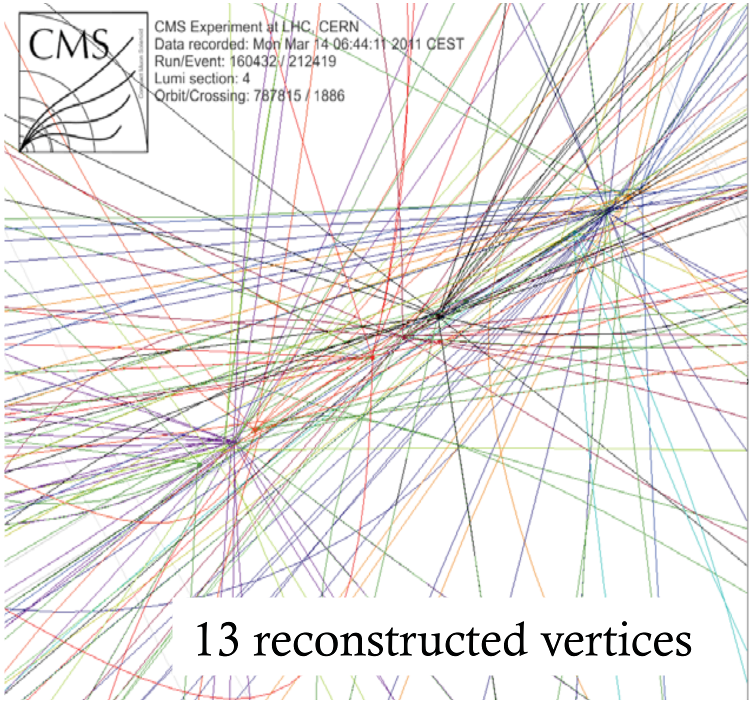




- LHC performs very well, delivered 3.3 fb^{-1} of data

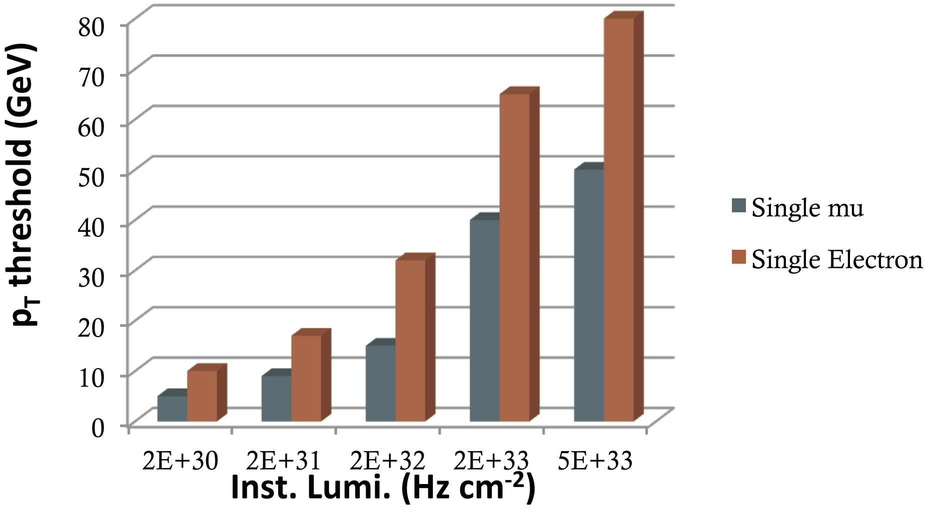
Challenges

- Pileup >10 interactions
  -- effects understood and mitigated



13 reconstructed vertices

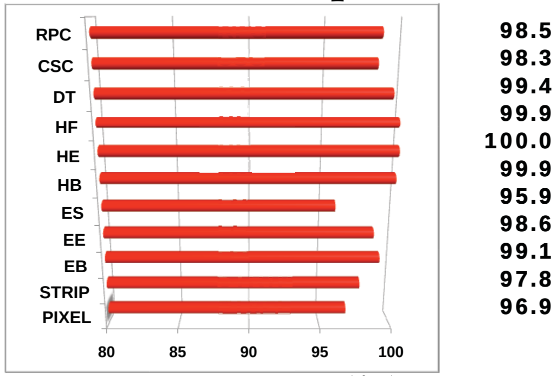
- Trigger rates
  - Inclusive trigger threshold is increasing
  - Analyses try to design triggers with multiple objects

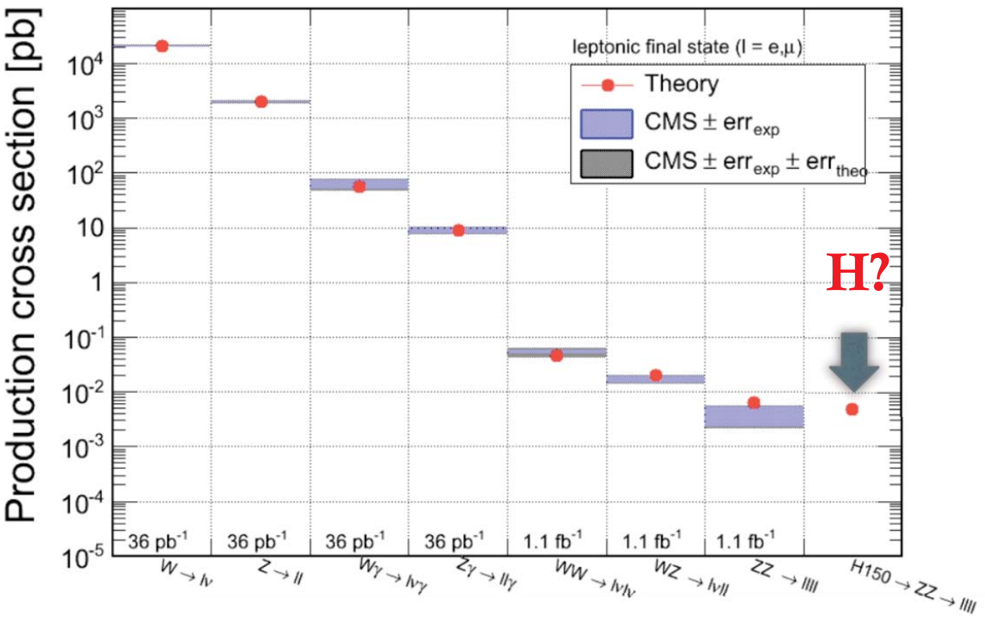


CMS Performance

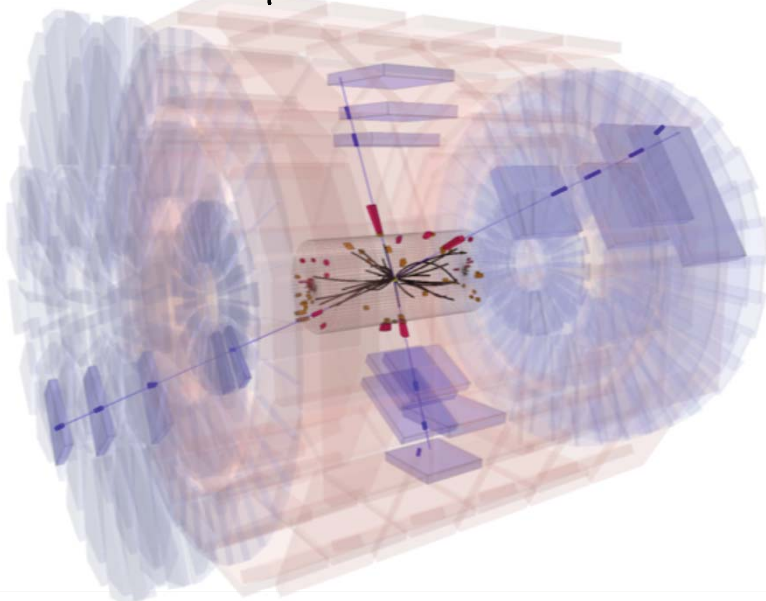
- Excellent performance
- Object reco. & id. well understood
- Rediscovered SM

> 98.5% Operational





ZZ→4μ candidate event



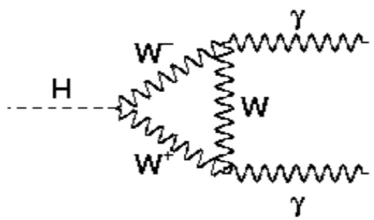
Results

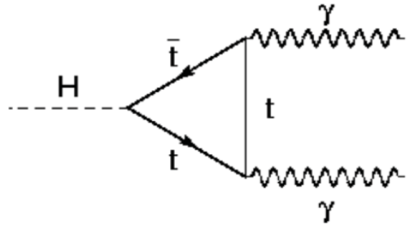
- Low mass Higgs Searches
- Intermediate mass Higgs Searches
- High mass Higgs Searches
- Combination
- Higgs beyond the standard model

Low-mass Higgs searches

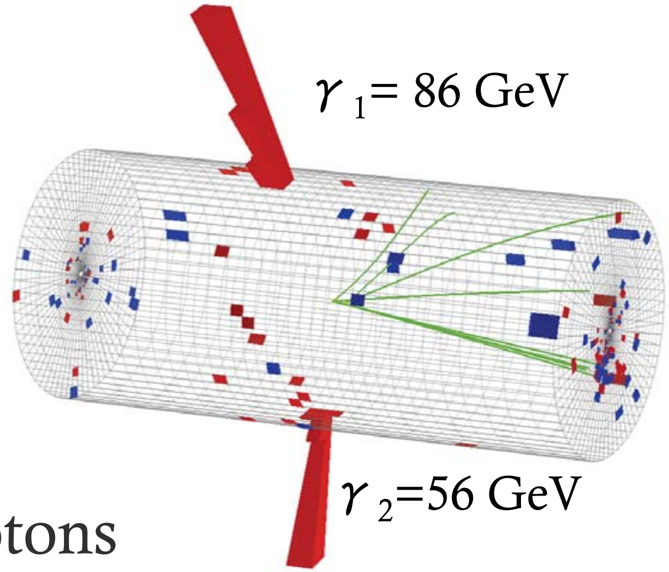
H → γγ

- Clean signature with two energetic photons, but very small branching fraction (10^{-3})



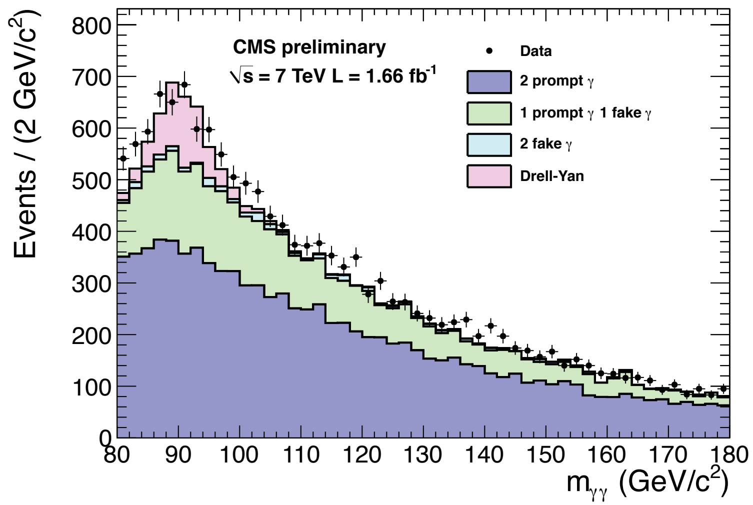


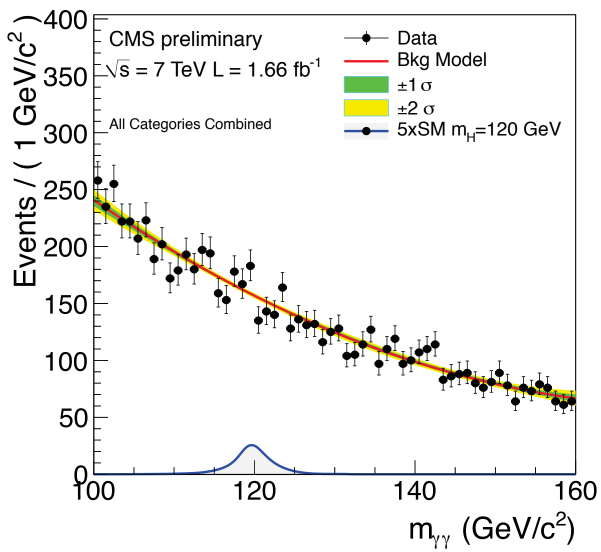
- Background
  - Irreducible: diphoton production
    - Estimated from sidebands of fit to data
  - Reducible: γ+jet, multijet processes jets misidentified as photons
    - Longitudinal and lateral shower shape consistent of those from photons
    - Isolation requirement



$H \rightarrow \gamma\gamma$

- Considered 8 event classes based on photon shower shape, pseudorapidity, and $p_T^{\gamma\gamma}$
  - Background modeled with 2nd order polynomial fit on data
  - Higgs signal MC is corrected for id./iso. efficiencies and resolution using $Z \rightarrow ee$ and $Z \rightarrow \mu\mu\gamma$ events in data. Signal shape is from smeared MC

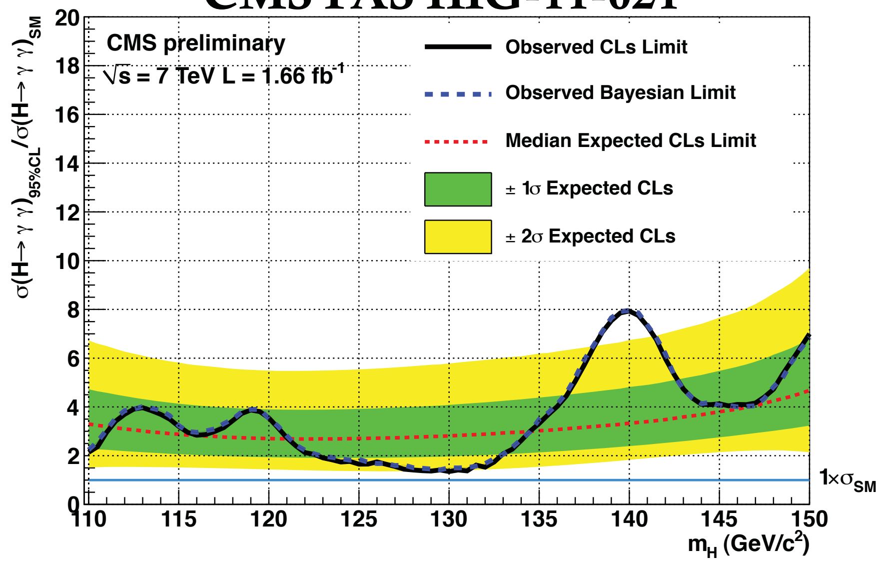


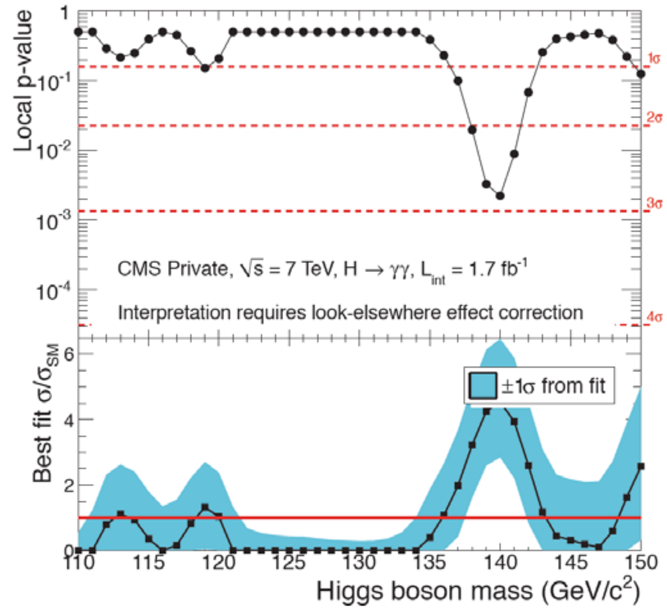


H → γγ Limits

- Limit is evaluated for each event category
  - Local p-value = 2.5±0.3x10^{-3} → almost 3σ
  - Look-elsewhere effect reduces significance to 1.6σ

CMS PAS HIG-11-021

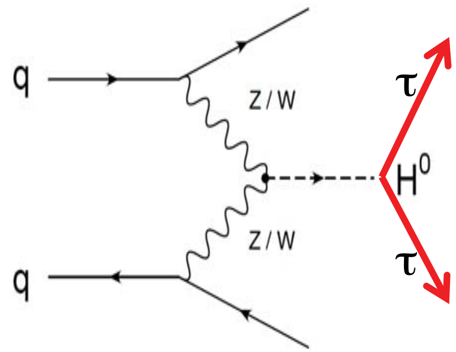




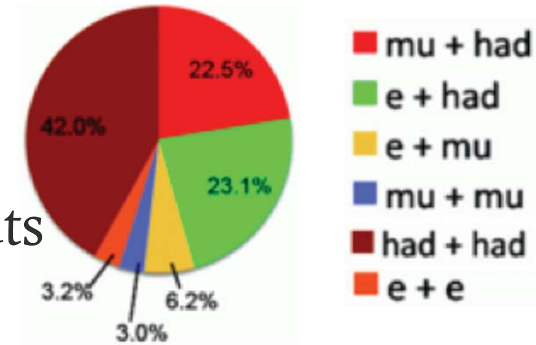
- Excluded 1.3 – 8 x SM Higgs cross sections

H → ττ

- Branching fraction 5-10% for masses 110 - 140 GeV
  - Production via gluon fusion suffers from large multijet and Drell-Yan backgrounds
  - Production via vector-boson fusion is promising

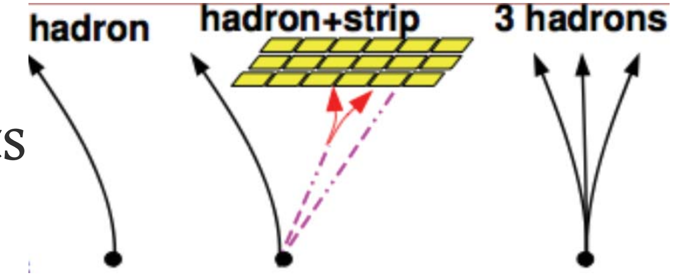


- Considered signatures with τ+lepton (e,μ), e+μ, μ+μ
  - Backgrounds from Z+jets, QCD, W+jets, top, diboson processes
    - Reduced by τ/lep. Id. & iso., topological cuts
  - Two categories:
    - VBF: two forward jets, M_{jj} >250 GeV, $\Delta\eta > 3.5$, $\eta_1\eta_2 < 0$
    - No-VBF: ≤ 1jet, or jets failing VBF

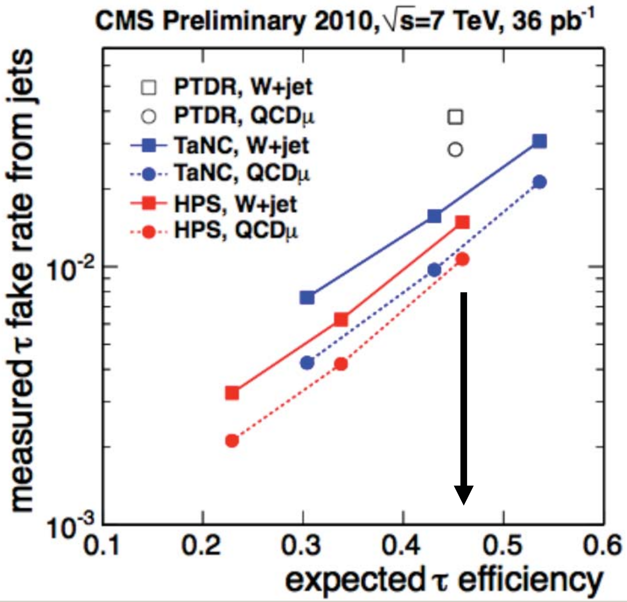


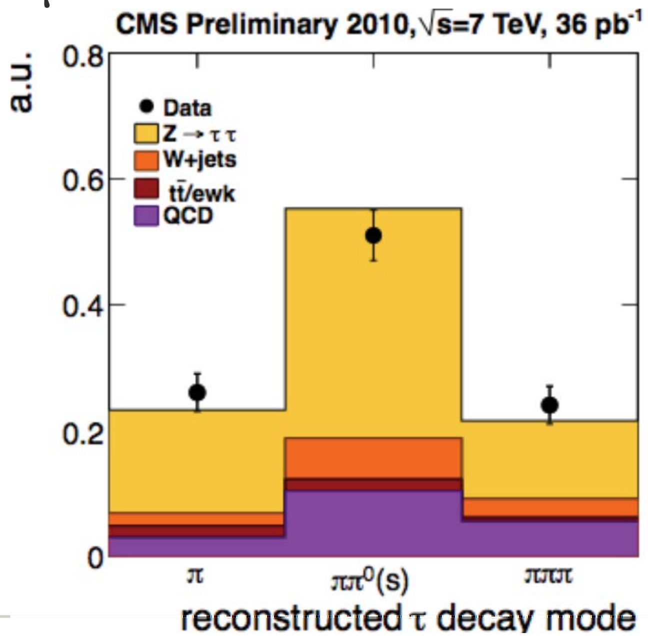
τ @ CMS

- Using information from all sub-detectors to reconstruct sea of particles
  - Particles create composite objects jets taus, missing transverse energy
  - Efficiency measured in Z→ττ→τμ events



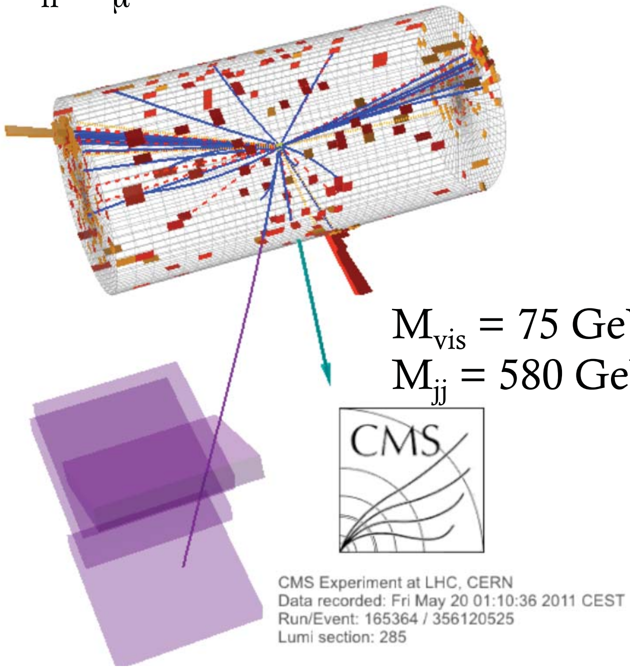
See J. Swanson's talk





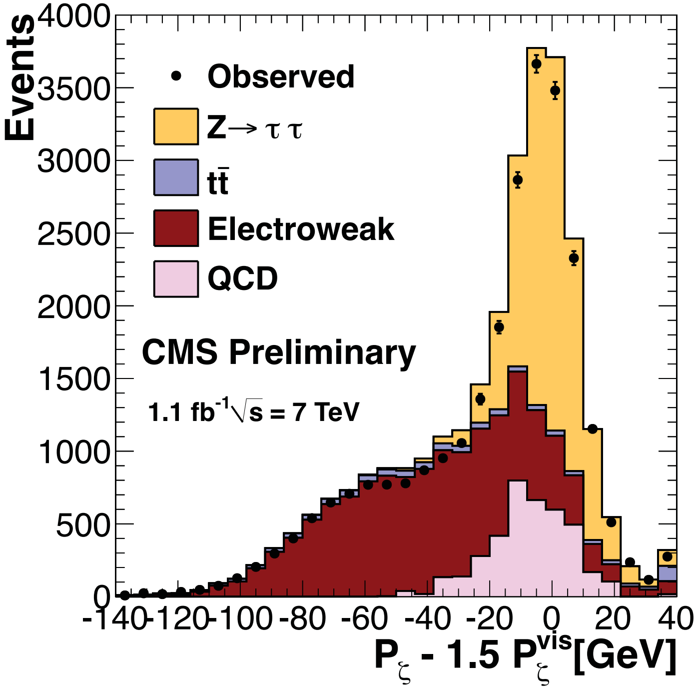
H → ττ

$\tau_h + \tau_\mu$ candidate event



M_{vis} = 75 GeV
M_{jj} = 580 GeV

In di-tau events neutrinos expected collinear with visible products

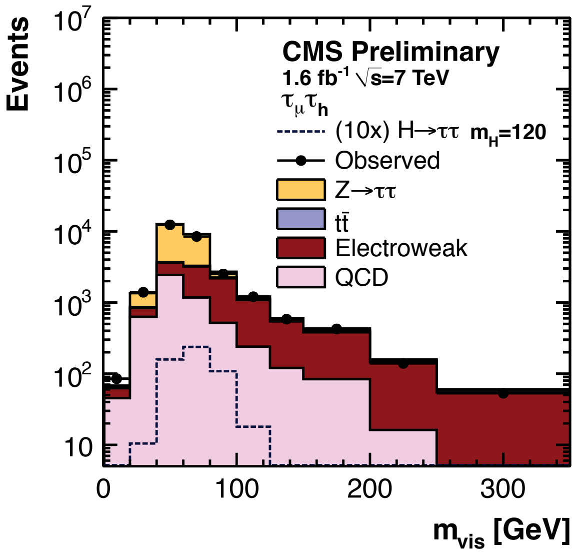


- W+jets – extrapolated from side-band, QCD is estimated from data using events with lepton and tau of same charges
- Z+jets and top backgrounds are estimated from simulation using CMS measured cross sections

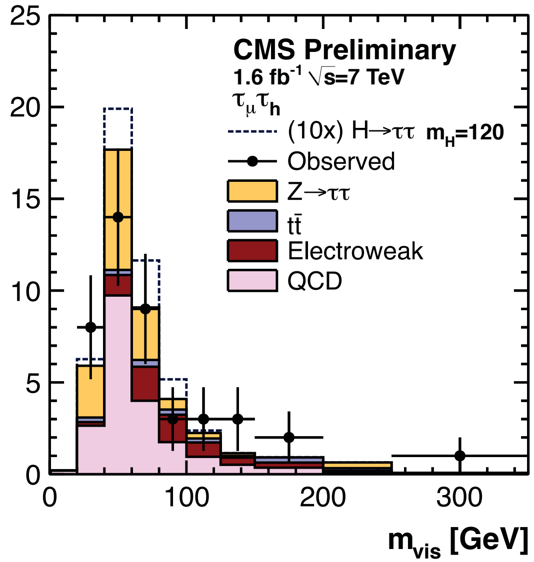
H → ττ Limits

- Perform maximum likelihood fit of visible mass
  - Systematic uncertainties enter as nuisance parameters
    - Log-normal prior for normalization uncertainties
    - Gaussian prior for shape unc.

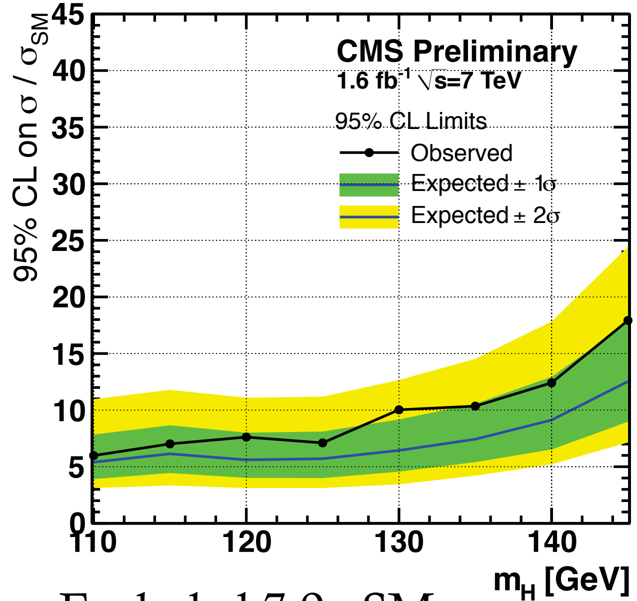
No VBF



VBF



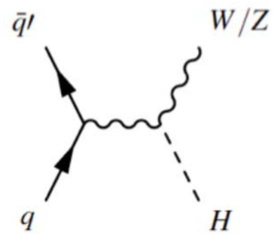
CMS PAS HIG-11-020



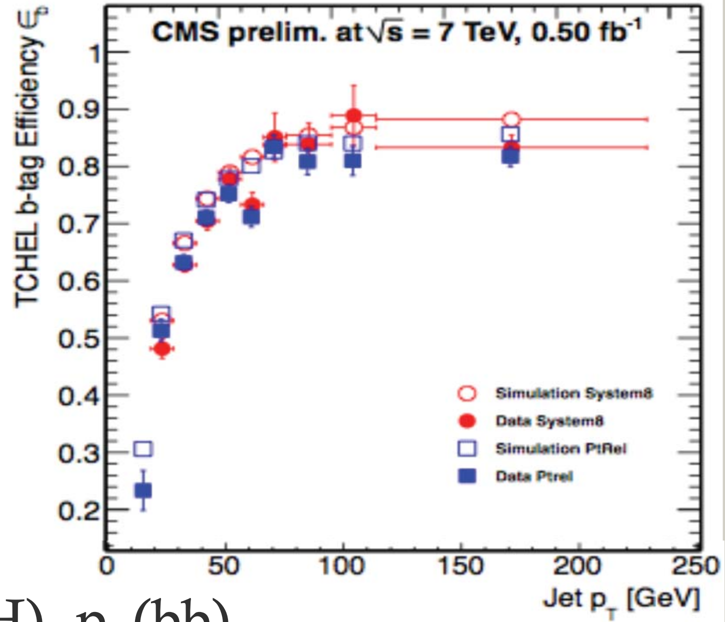
Excluded 7.9x SM cross section at m_H = 120 GeV

VH → Vbb

- Important for determination Higgs properties
  - Small production cross section
    - Possible to control backgrounds
  - Largest decay branching fraction for masses 110 - 135 GeV



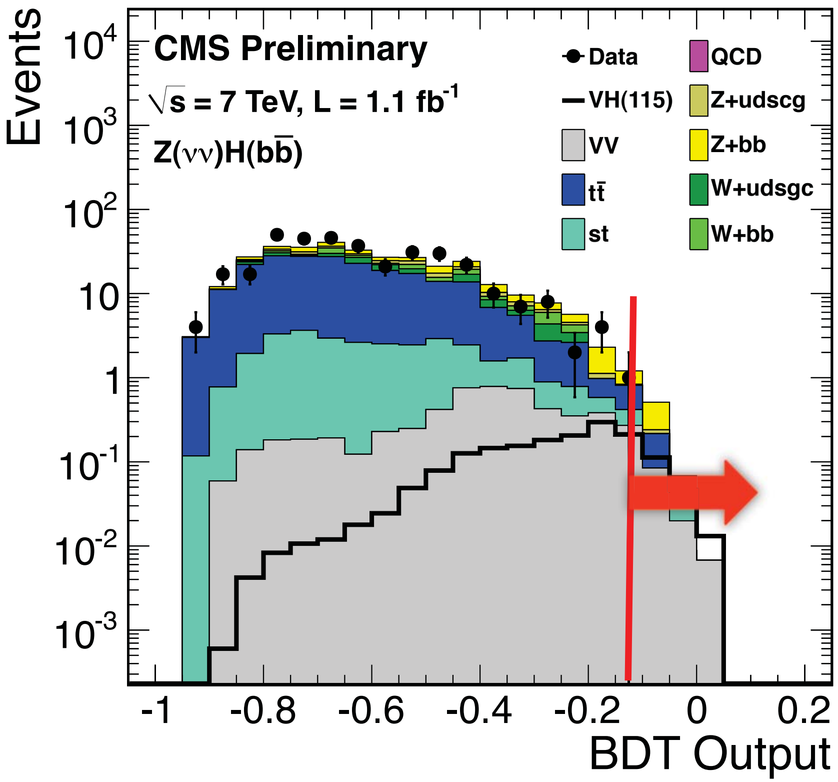
- Signatures with leptons (e,μ), b-jets, MET
  - WH → lνbb
  - ZH → llbb, ZH → ννbb



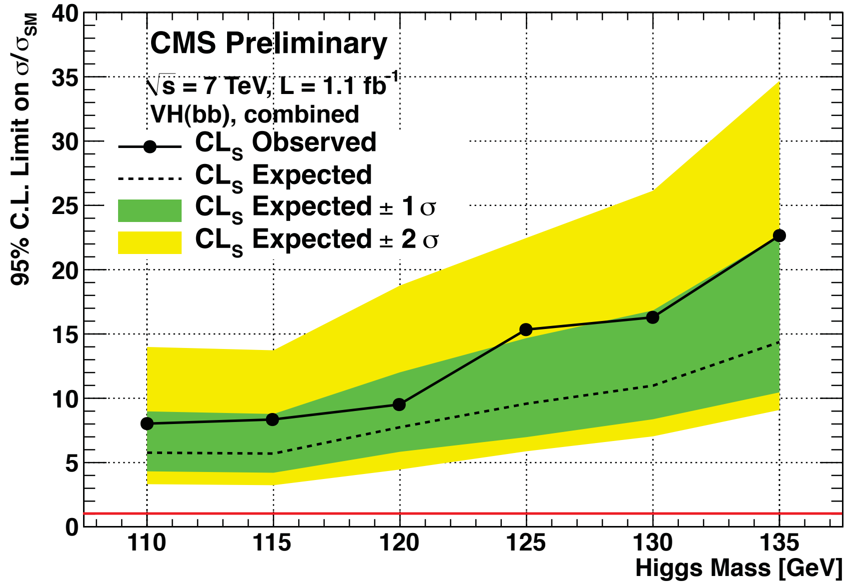
- Backgrounds
  - V+jets controlled by tight b-tagging
    - V+bb additionally reduced by $\Delta\varphi$(V,H), p_T(bb)
  - Additional lepton and jet veto against top and diboson processes

H → bb Limits

- Using multivariate technique BDT
  - Improves analysis by ~10% over cut-based approach



CMS PAS HIG-11-012

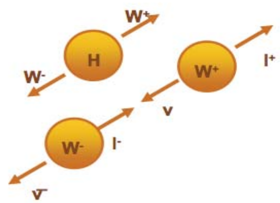


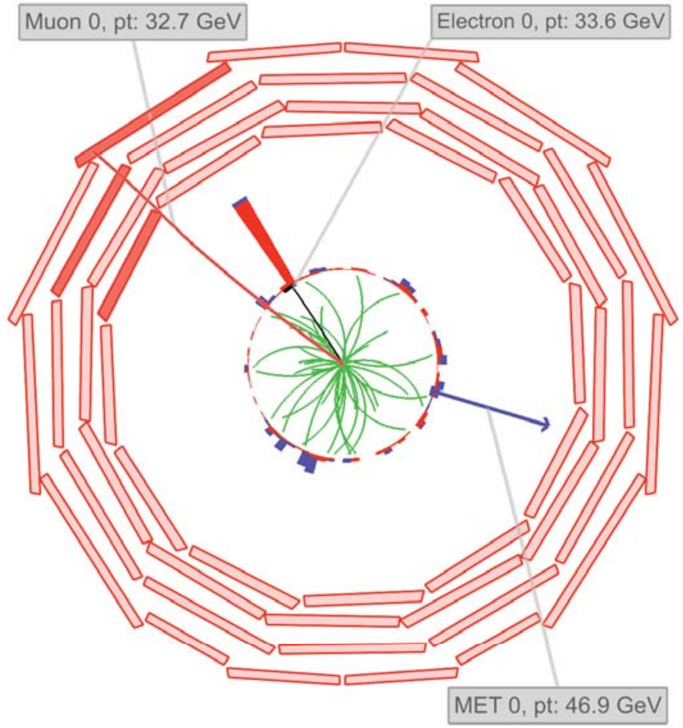
Upper limit on 8.3xSM cross section @ m_H = 115 GeV

Intermediate mass Higgs searches

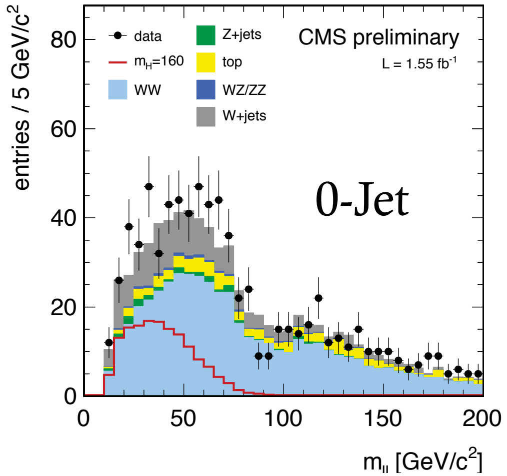
H → WW → lνlν

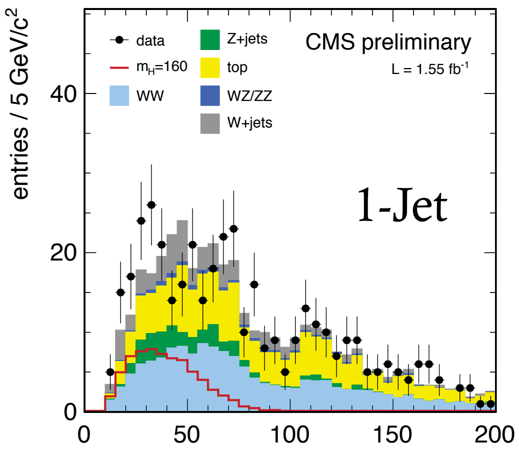
- The most sensitive channel for masses 130–200 GeV
  - Clean signature with two leptons and large MET
  - Major backgrounds
    - QCD, W+jets
      - Two leptons well identified and isolated
    - Drell-Yan
      - Large missing ET & Z veto
    - Top production
      - Soft muon & b-jet veto
    - WW production
      - Kinematic cuts on $\Delta\varphi(l_1,l_2)$, m_{ll}
    - WZ,ZZ
      - Veto third lepton



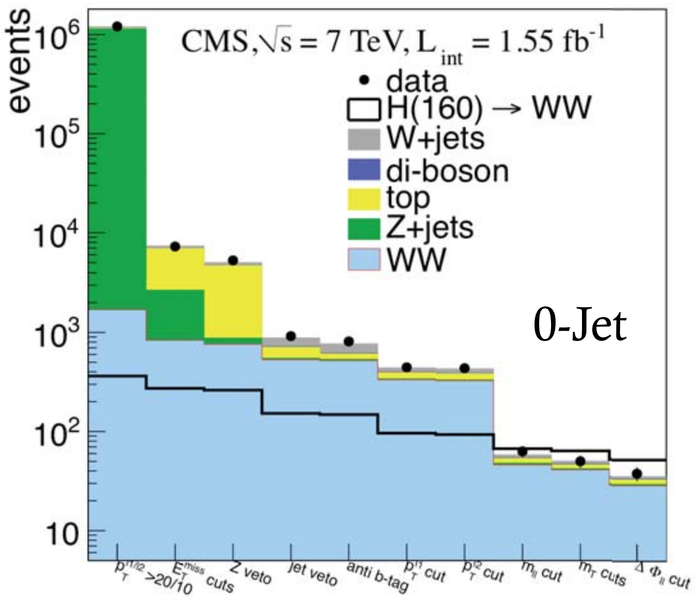


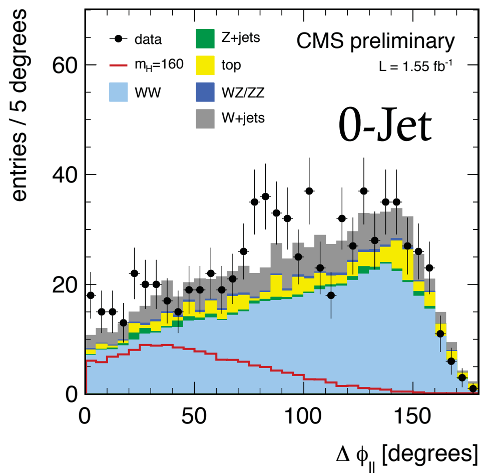
H → WW → lνlν

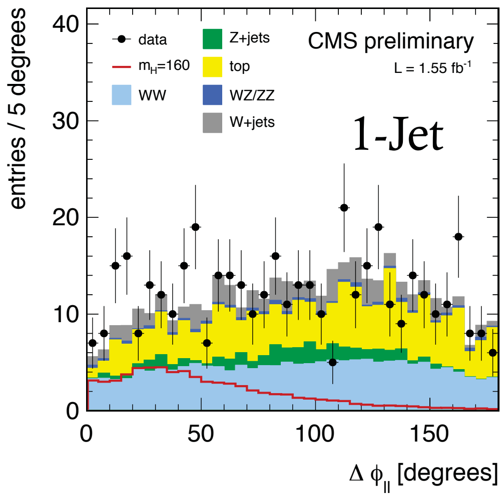




Considering 0-jet, 1-jet, and 2-jet categories





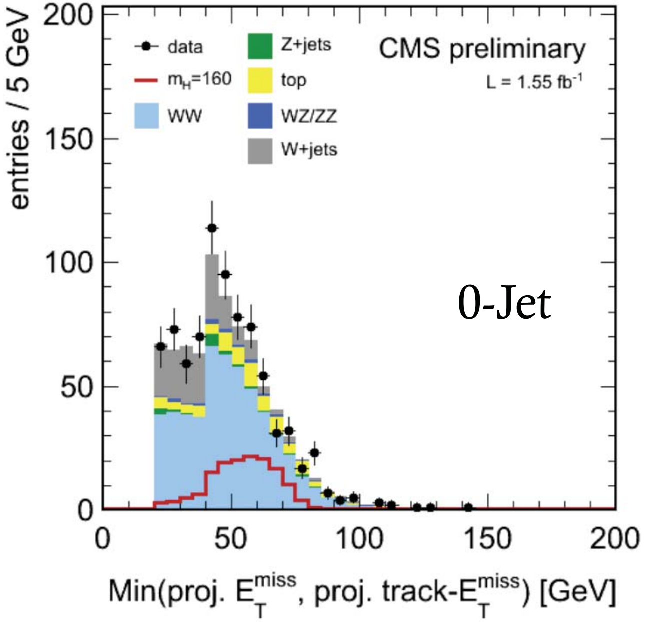


$H \rightarrow WW \rightarrow l\nu l\nu$

- Projected missing ET is used against DY$\rightarrow \tau\tau$ background
  - $\Delta\varphi$ angle between MET and closest lepton

$$\Delta\phi_{min} = min(\Delta\phi(\ell_1, E_T^{miss}), \Delta\phi(\ell_2, E_T^{miss}))$$

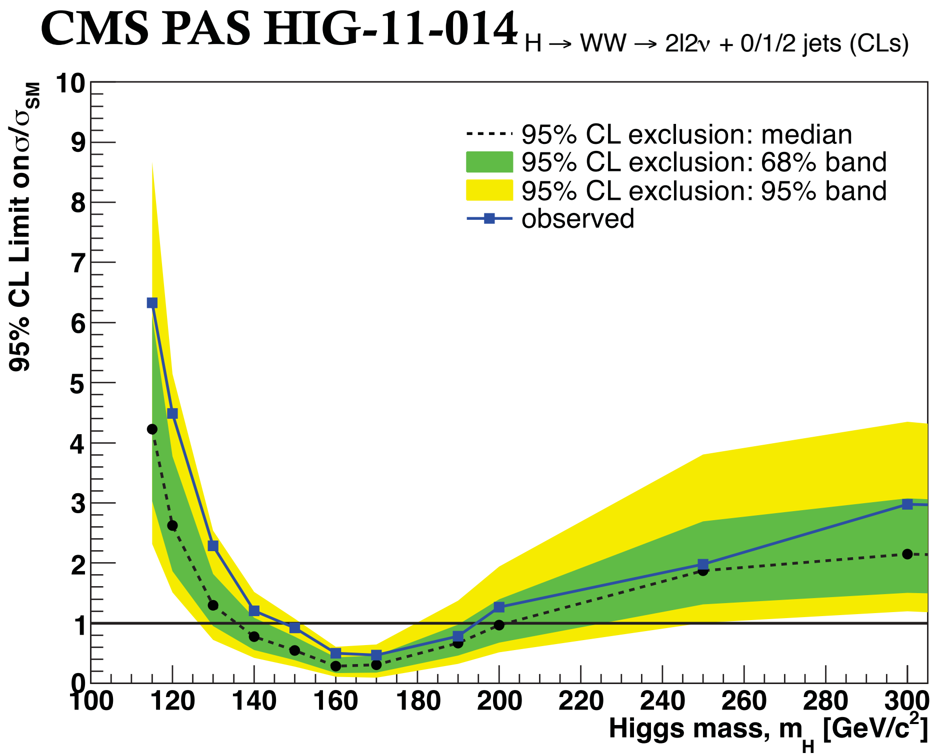
$$\text{projected } E_T^{miss} = \begin{cases} E_T^{miss} & \text{if } \Delta\phi_{min} > \frac{\pi}{2}, \\ E_T^{miss}\sin(\Delta\phi_{min}) & \text{if } \Delta\phi_{min} < \frac{\pi}{2} \end{cases}$$

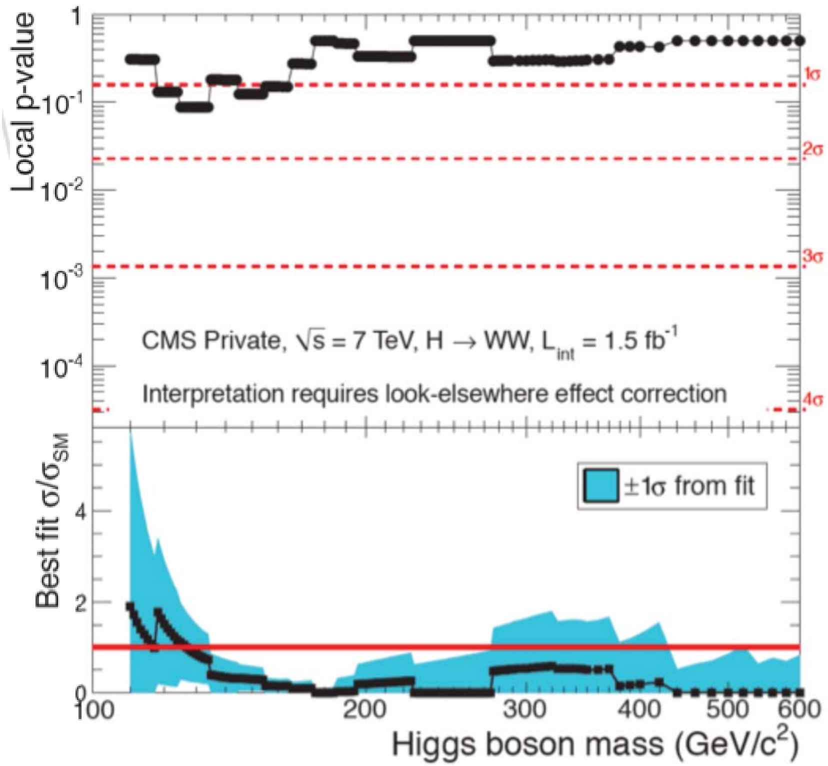


OF=eμ, SF=ee,μμ

Process	0-j OF	0-j SF	1-j OF	1-j SF	2-j
Total Bkg.	44.0±6.2	40.6±7.0	17.8±3.5	12.6±3.7	5.3±1.7
H 140 GeV	19.1±4.3	16.1±3.6	7.7±2.6	5.3±1.8	2.5±0.3
Data	46	41	23	23	7

H → WW → lνlν Limits

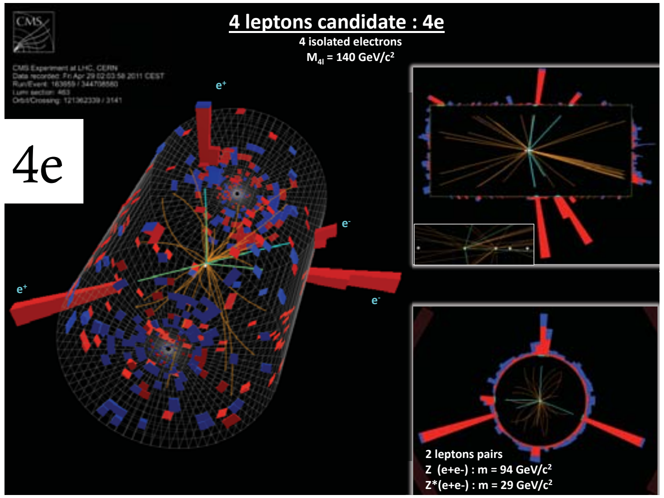


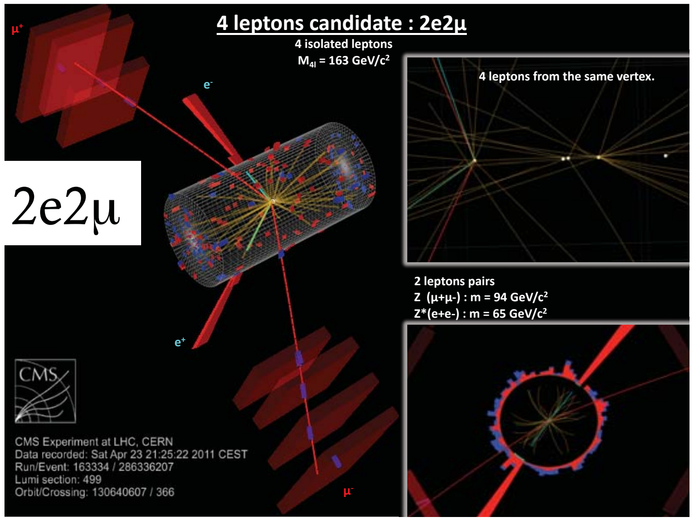


- Excluded Higgs boson with masses 147 – 194 GeV

$H \rightarrow ZZ \rightarrow 4l$

- Golden channel with two pairs of same flavor oppositely charged leptons
  - One pair from on-shell Z boson decays, another pair from off-shell Z boson decays for $m_H < 2m_Z$
    - low p_T threshold on 4^{th} lepton
  - Backgrounds
    - Top and Zbb productions
      - Isolation and impact parameter
    - ZZ process irreducible

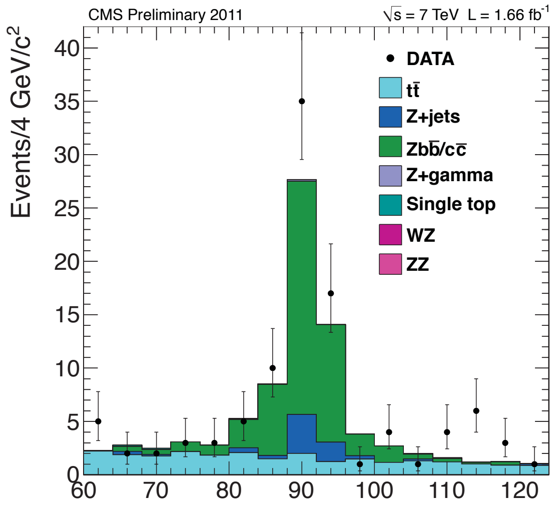


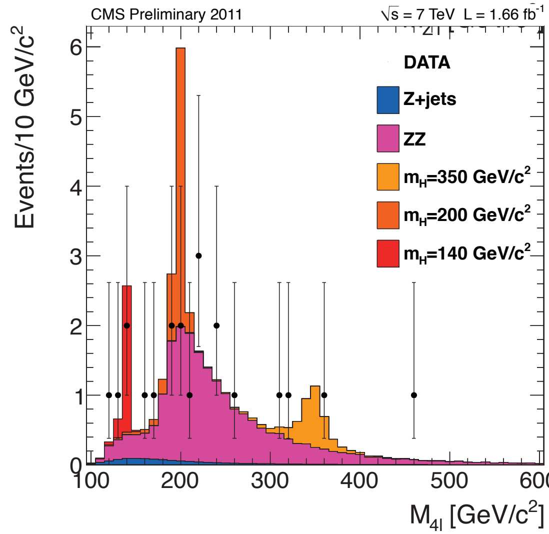


H → ZZ → 4l

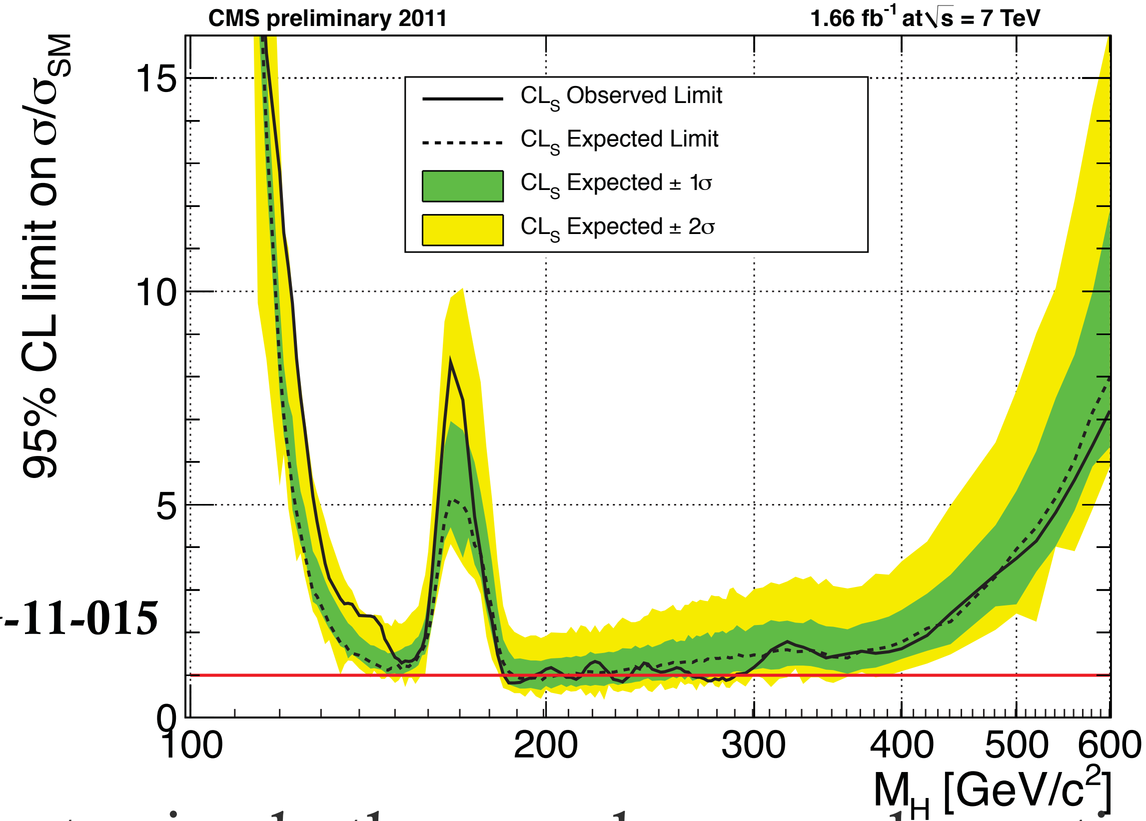
- ZZ background estimated by normalizing to measured Z inclusive cross section
- Top and Zbb/Zcc backgrounds estimated by inverting impact parameter significance and relaxing isolation

Process	Total Bkg	H 200 GeV	Data
4e	4.54±0.27	1.20	5
4μ	6.12±0.40	1.71	10
2e2μ	10.52±0.67	2.80	6





H → ZZ → 4l Limits



CMS PAS HIG-11-015

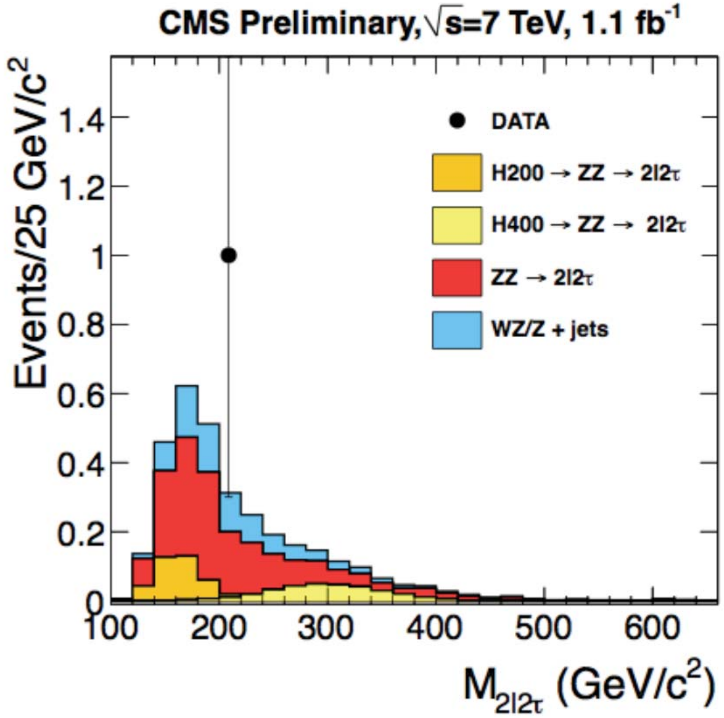
- Limits set using both mass shapes and counting approach
  - Already reaching exclusion of SM cross sections in mass range $2m_H$ – 300 GeV

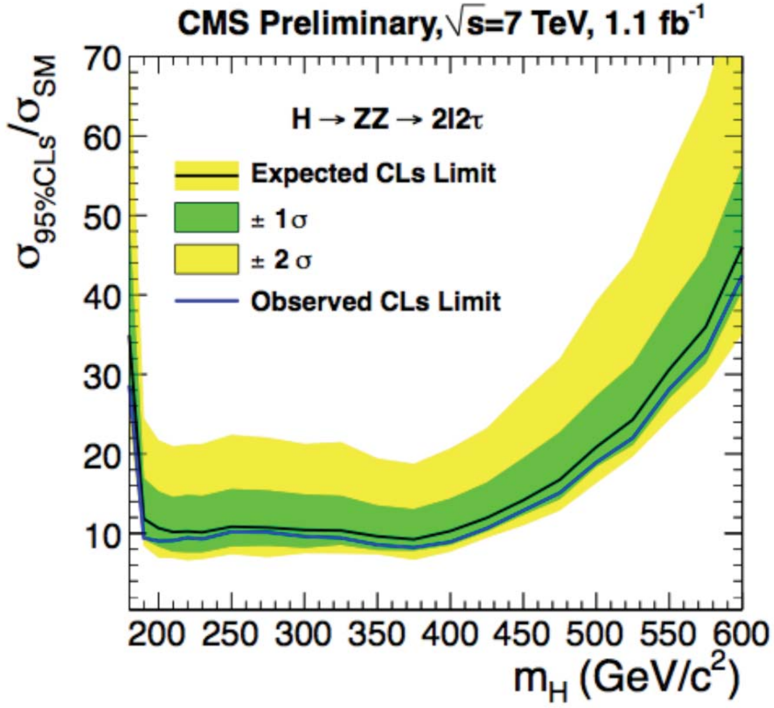
$H \rightarrow ZZ \rightarrow ll\tau\tau$

- Complementary to 4l channel
  - Signatures with $\tau_{had}\tau_{had}$ and $\tau_l\tau_{had}$
    - Smaller efficiencies

See J. Swanson's talk

CMS PAS HIG-11-013



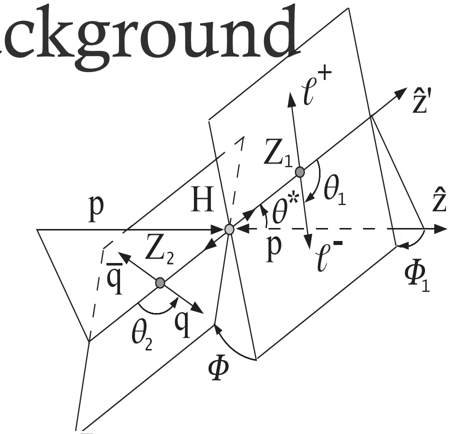


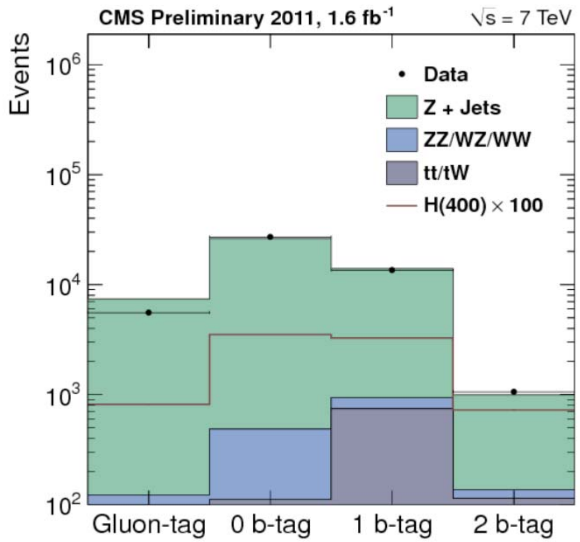
Excluding ~10xSM cross sections

High mass Higgs searches

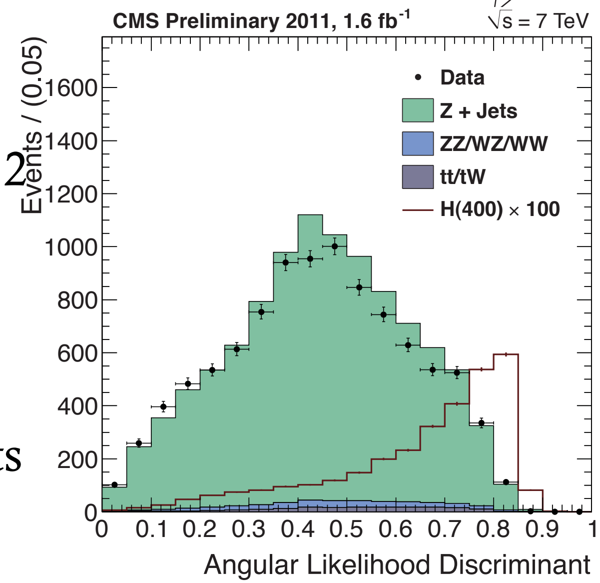
H → ZZ → llqq

- Largest σxBr for H → ZZ and small background contamination in high mass region
  - Z+jets background -- m_{jj} mass constraint
  - Non-genuine Z backgrounds, e.g. top production -- m_{ll} mass constraint



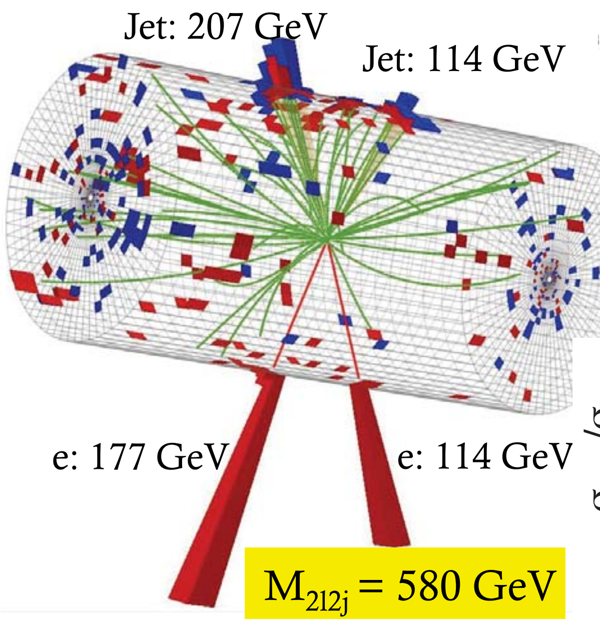


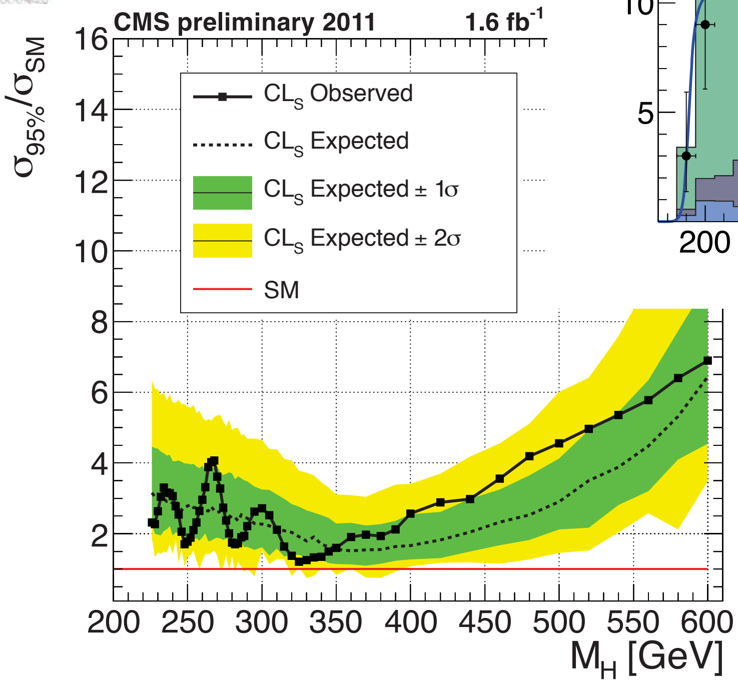
* Consider 0,1,2 b-jet categories
* Likelihood discriminant to separate gluon-quark jets

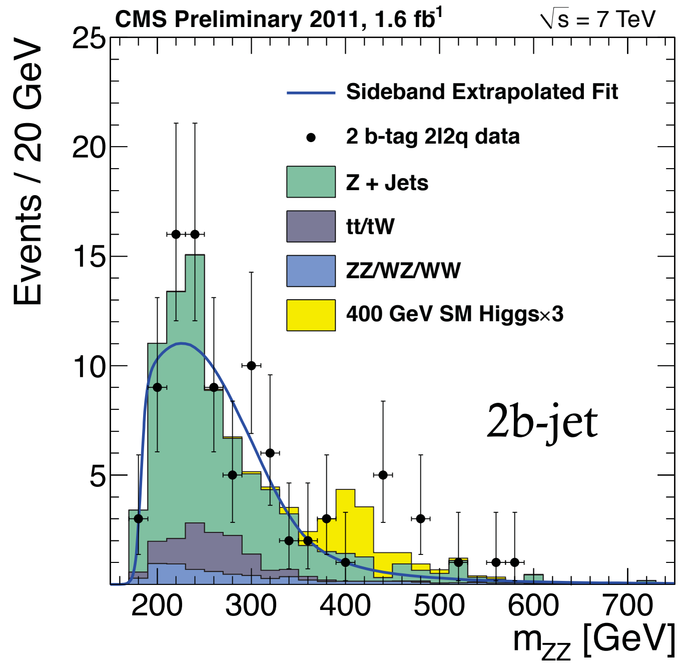


Discriminant using angular information of decay products

H → ZZ → llqq Limits



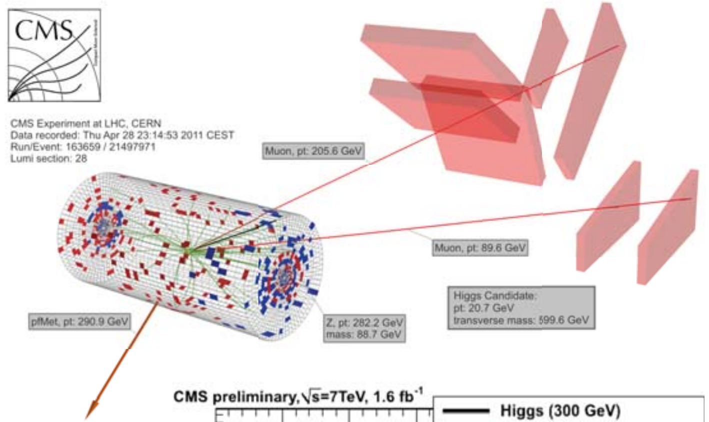


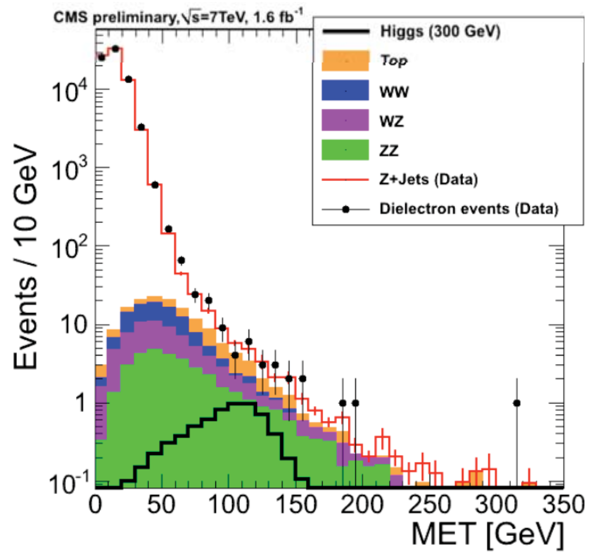


CMS PAS HIG-11-017

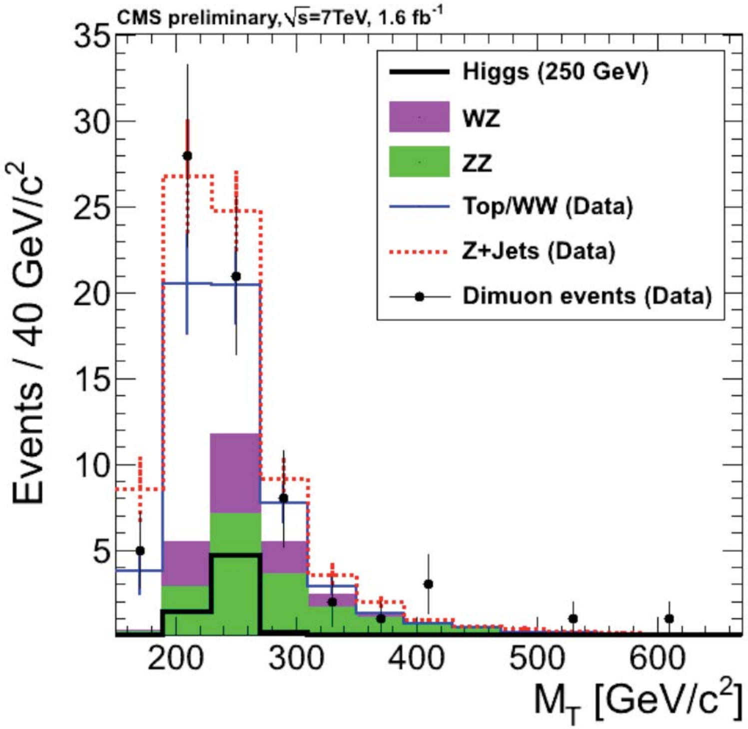
H → ZZ → llνν

- Sensitive to searches in 250-600 GeV mass region
- Backgrounds
  - Z+jets
    - Fake MET modeled by γ+jet sample
  - Non-resonant top, WW, W+jets productions
    - Using e+μ control sample and obtaining correction factor from sidebands
  - ZZ and WZ processes
    - Estimated from simulation

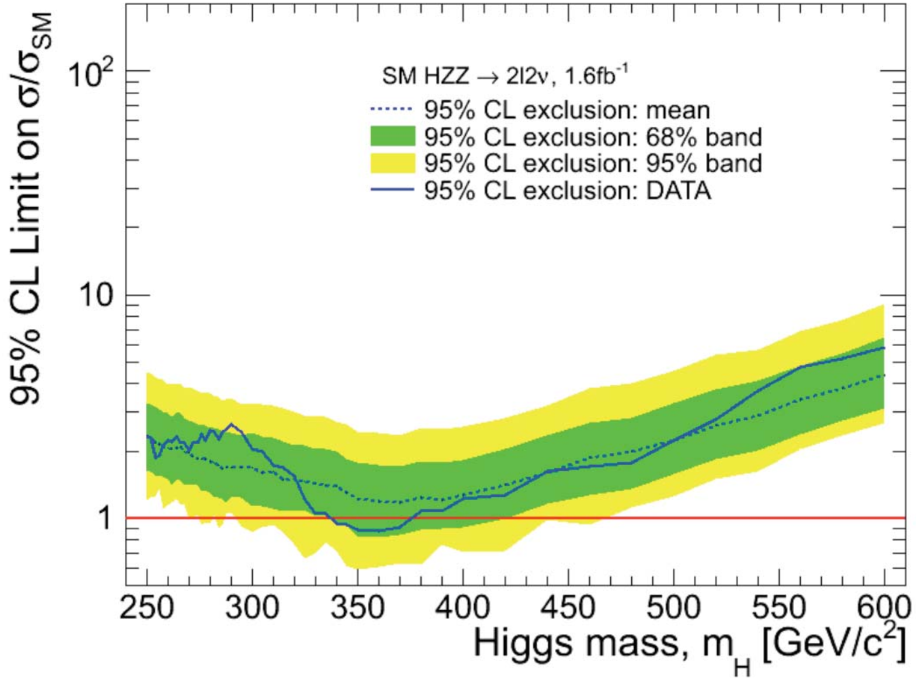




$H \rightarrow ZZ \rightarrow ll\nu\nu$ Limits



CMS PAS HIG-11-016



- The standard model Higgs is excluded in the mass range 340 – 375 GeV

Combination of SM Higgs searches

The Method

- 8 channels are combined, each characterized by its
  - Signal strength $\mu = \sigma/\sigma_{sm}$
  - Mass resolution
  - S/B

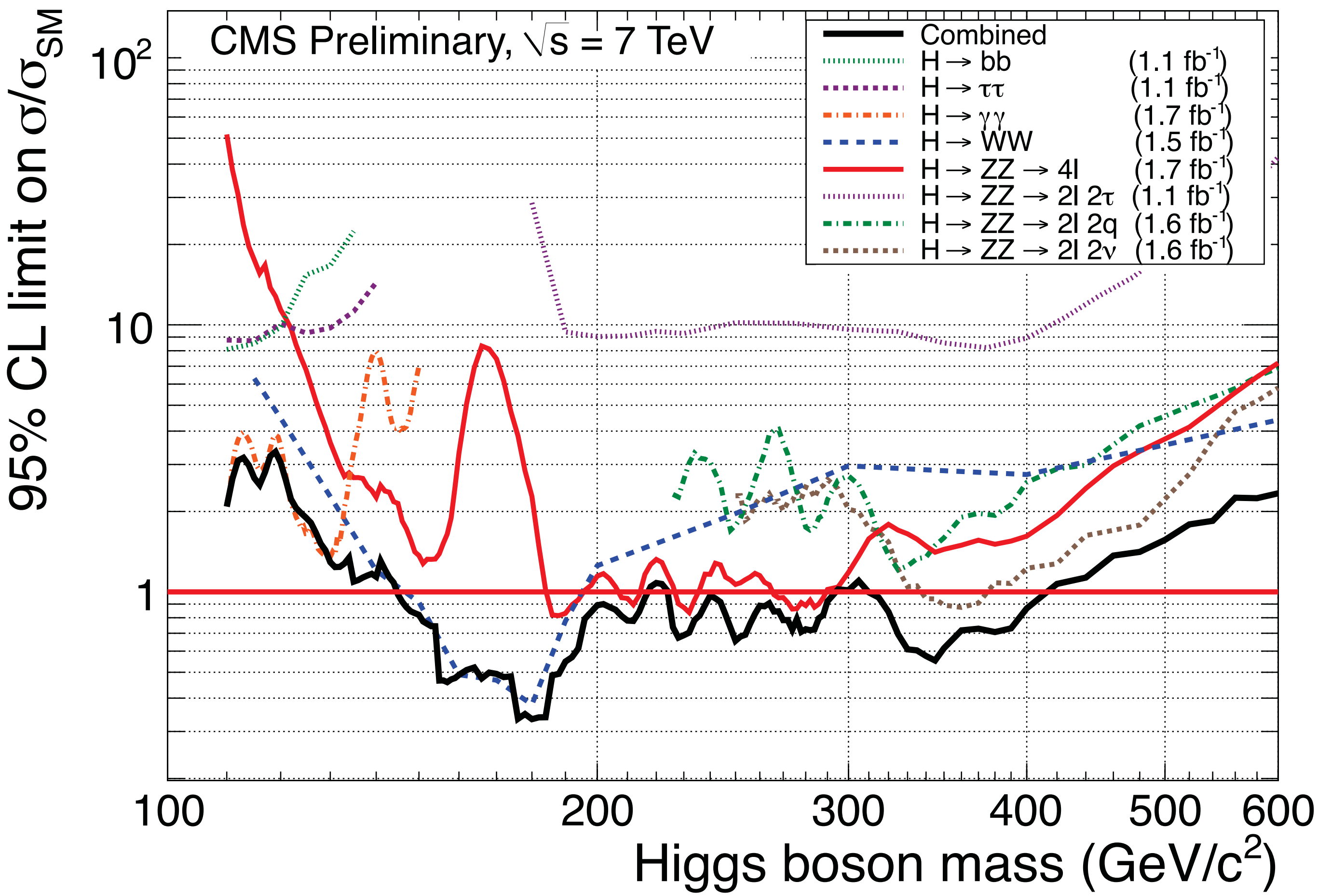
channel	mass range (GeV/c^2)	luminosity (fb^{-1})	number of sub-channels	type of analysis
$H \to \gamma\gamma$	110-150	1.7	8	mass shape (unbinned)
$H \to \tau\tau$	110-140	1.1	6	mass shape (binned)
$H \to bb$	110-135	1.1	5	cut&count
$H \to WW \to 2\ell 2\nu$	110-600	1.5	5	cut&count
$H \to ZZ \to 4\ell$	110-600	1.7	3	mass shape (unbinned)
$H \to ZZ \to 2\ell 2\tau$	180-600	1.1	8	mass shape (unbinned)
$H \to ZZ \to 2\ell 2\nu$	250-600	1.6	2	cut&count
$H \to ZZ \to 2\ell 2q$	226-600	1.6	6	mass shape (unbinned)
TOTAL (8)	110-600	1.1-1.7	27 for low m_H 24 for high m_H	

- Modified frequentist method is used
  - Systematic unc. taken as fully correlated or uncorrelated
  - The CLs method

$$\text{CLs} = \frac{P\left(q_\mu \geq q_\mu^{obs} \mid \mu s(\hat{\theta}_\mu^{obs}) + b(\hat{\theta}_\mu^{obs})\right)}{P\left(q_\mu \geq q_\mu^{obs} \mid b(\hat{\theta}_0^{obs})\right)}$$

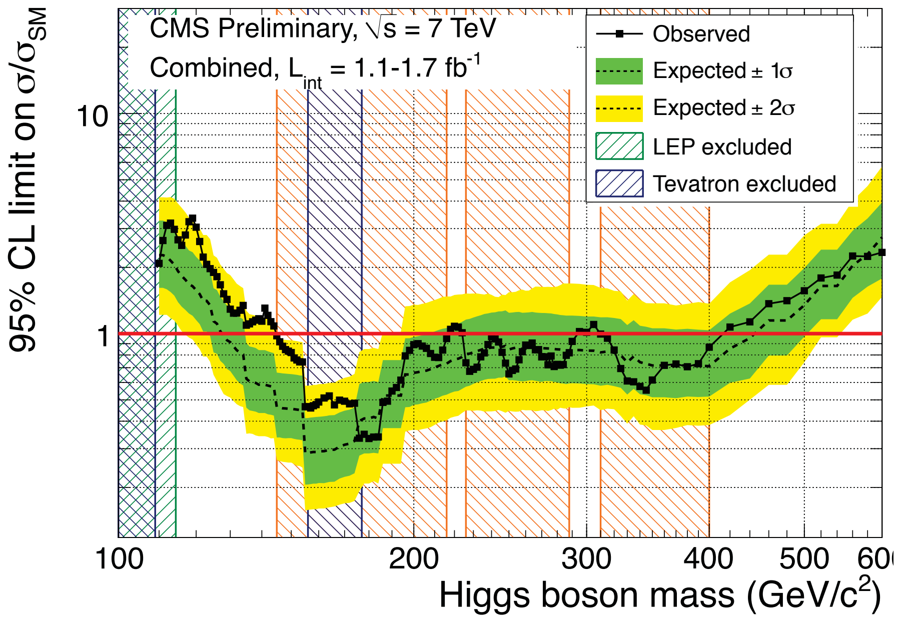
  - 95% CL is such μ such that CLs=0.05

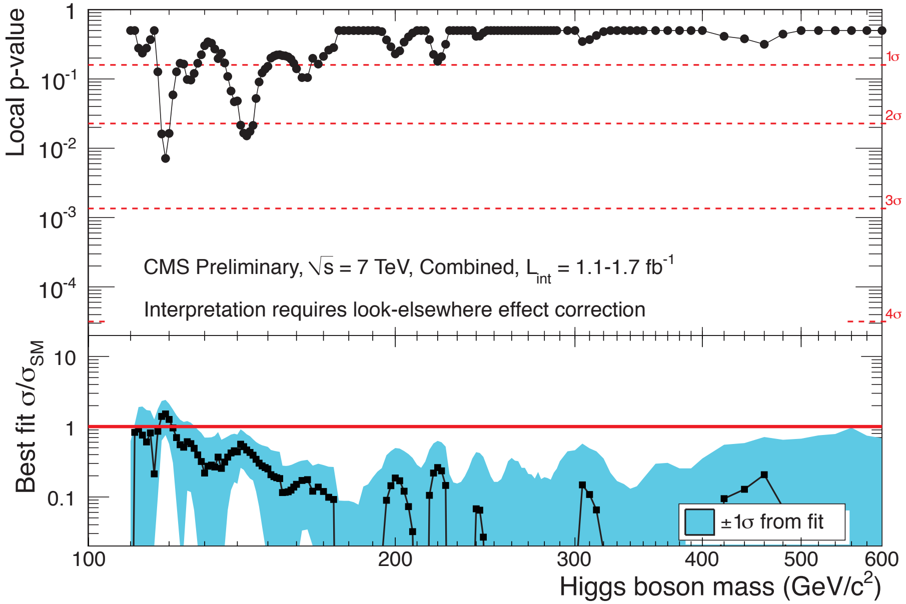
Limits from all channels



Combined Limit

CMS PAS HIG-11-022



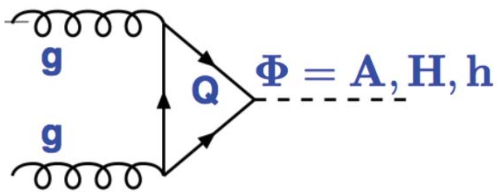


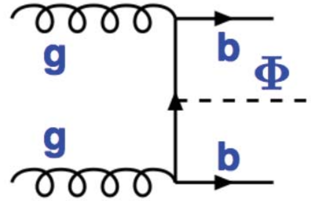
- Exclude masses [145-216], [226-288], [310-400] GeV at 95% CL
  - Expected exclusion 130 – 440 GeV
- Smallest p-value observed around 120 GeV

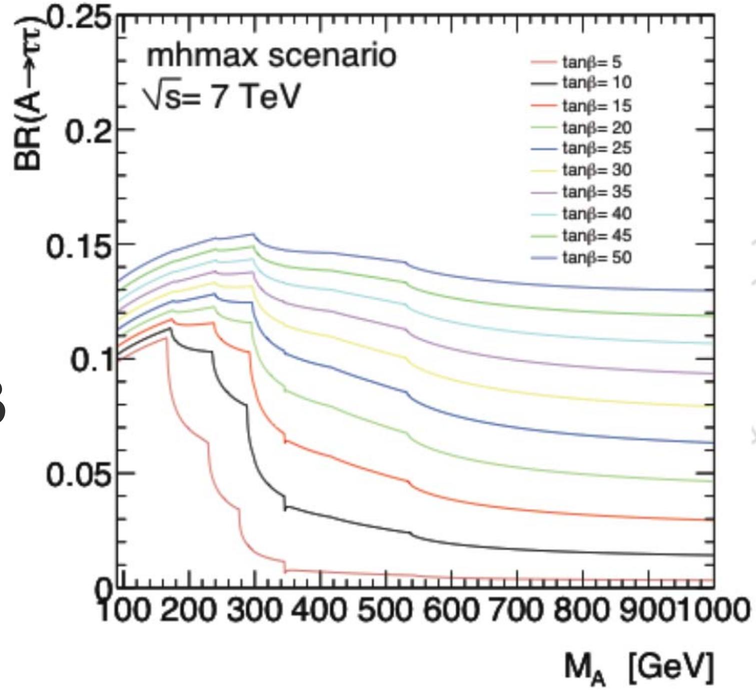
Higgs Beyond the Standard Model

MSSM

- Two higgs doublets exist
  - Five higgs bosons
    - H, h, A – neutral
      - Gluon-gluon fusion and associated production with b-quarks
    - $H^{\pm}$ -- charged
  - Two free parameters m_A and $\tan\beta = v_2/v_1$
    - Cross section enhances as $\tan^2\beta$
    - $Br(\Phi \rightarrow \tau\tau)$ = 5-10% @ large $\tan\beta$
- Consider categories 0- and at least 1-bjet

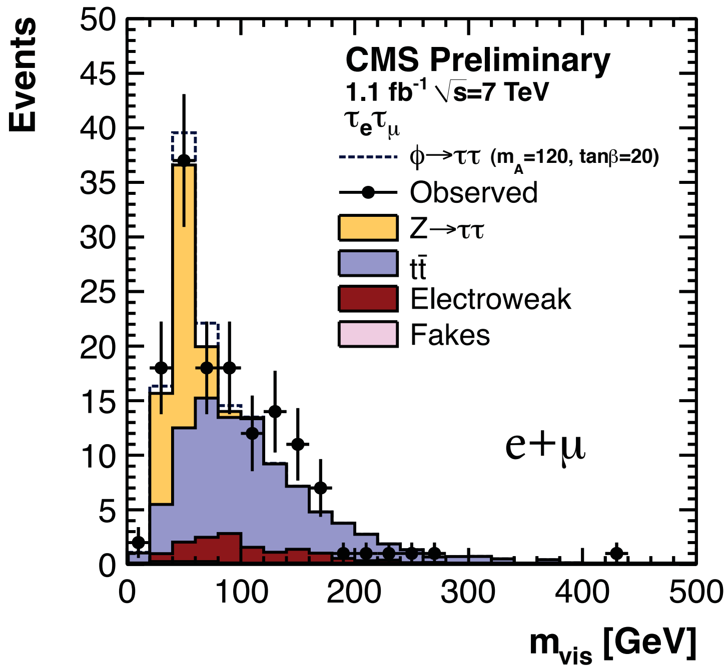


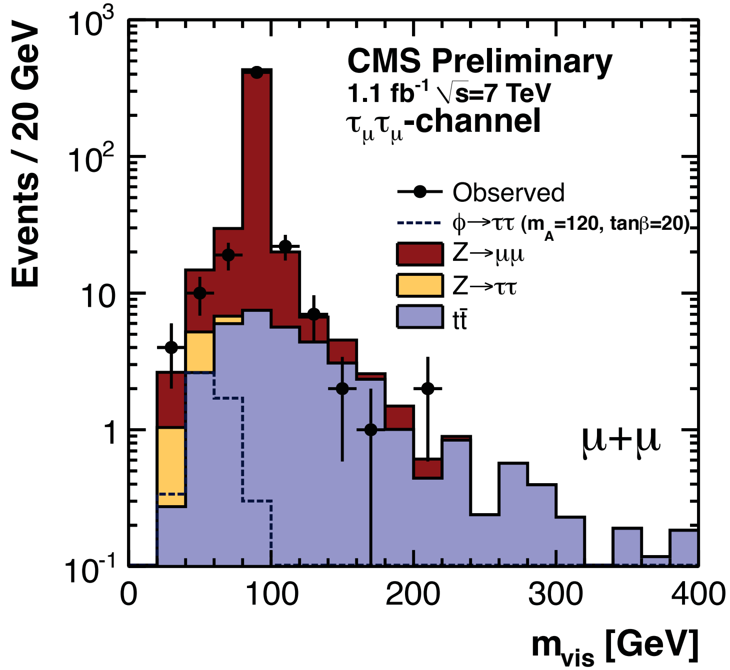




$\Phi \rightarrow \tau\tau$

Dilepton events with at least one b-jet

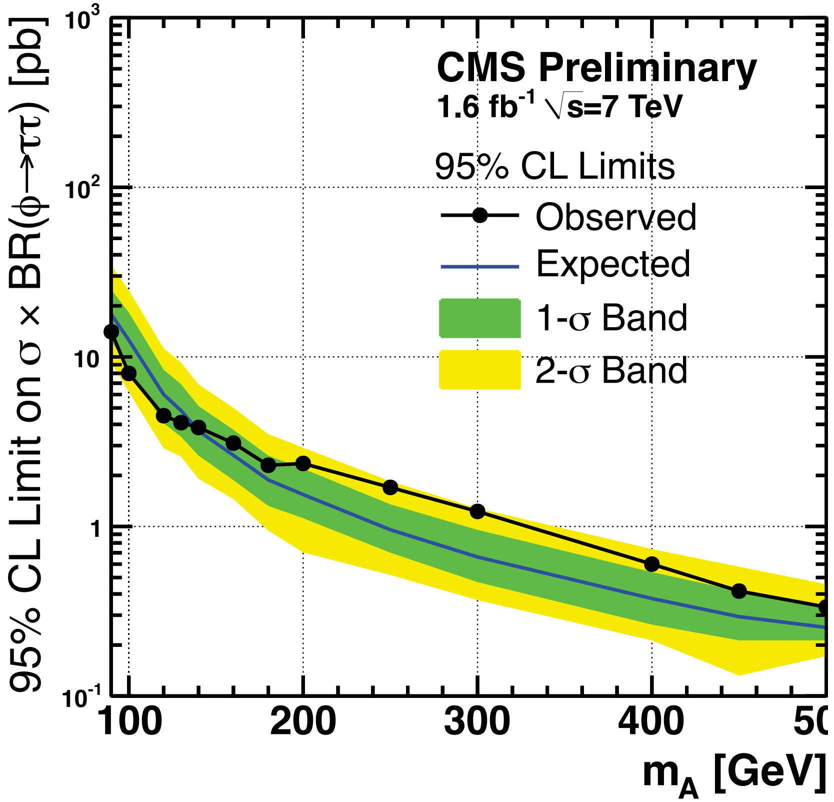


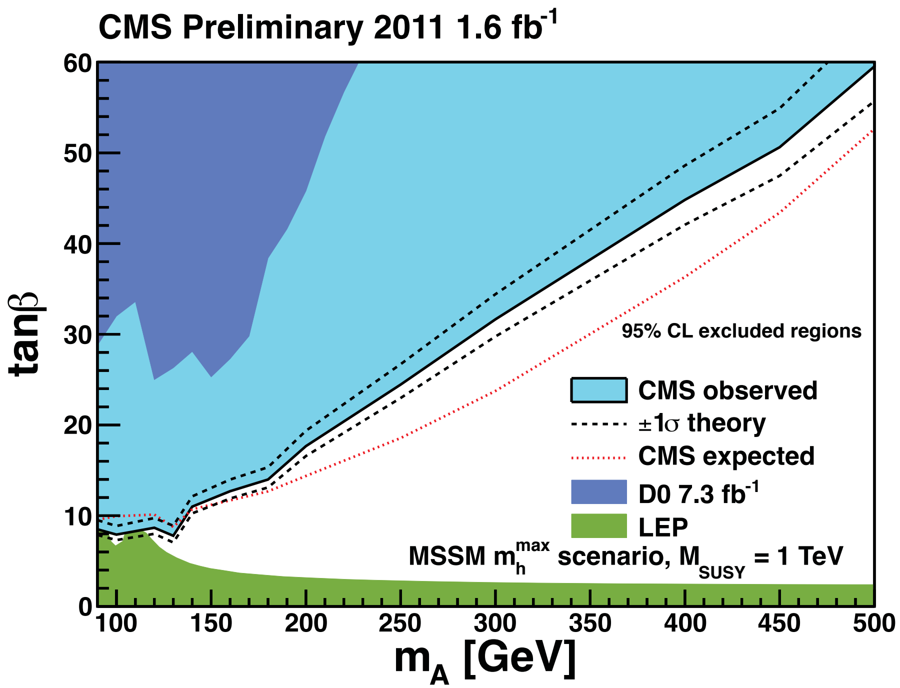


- Same decay channels considered as in SM Higgs search

$\Phi \to \tau\tau$ Limits

CMS PAS HIG-11-020

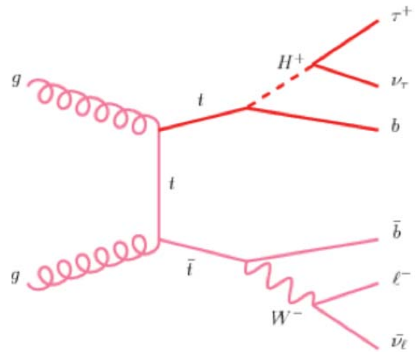




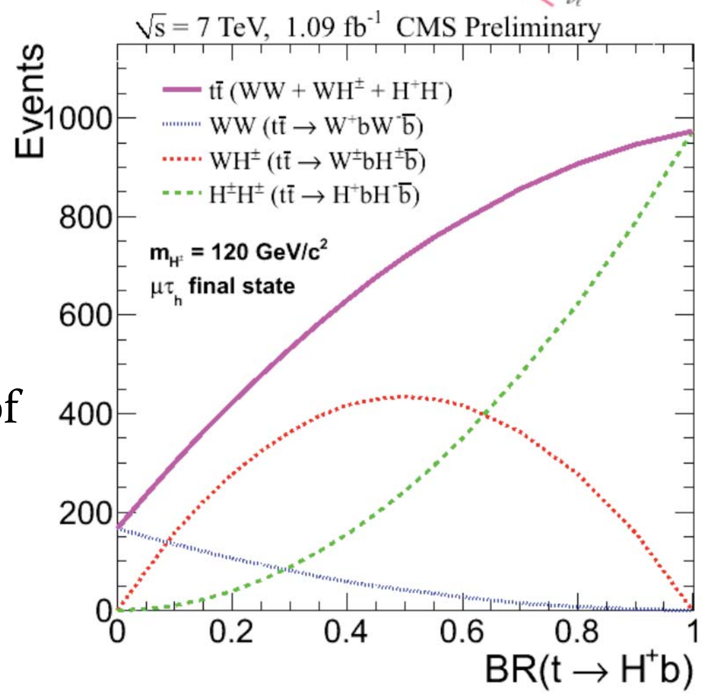
- Already touching LEP exclusion region

Charged Higgs

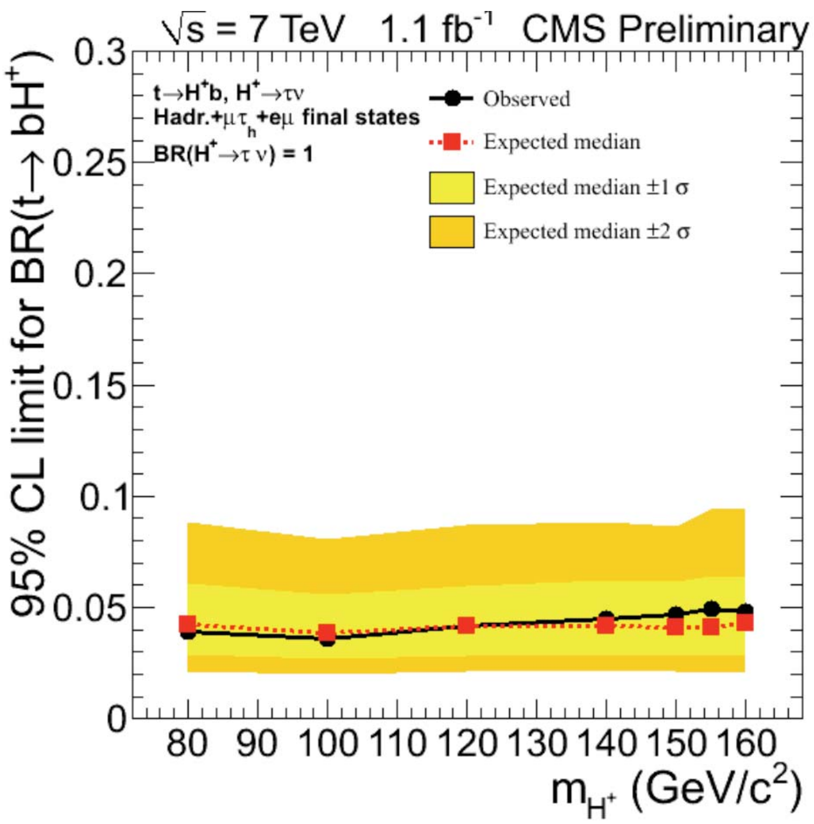
- If $m(H^{\pm}) < m_t$ decay $t \to H^{\pm}b$ allowed within MSSM
  - For large tanβ, $H^{\pm} \to \tau\nu$
- Search for $H^{\pm}$ in top events
  - $tt \to H^{\pm}bW^{\pm}b$, $tt \to H^{\pm}bH^{\pm}b$
  - Three final states with b-jets and missing ET
    - μ+e
    - μ+τ
    - τ+jets

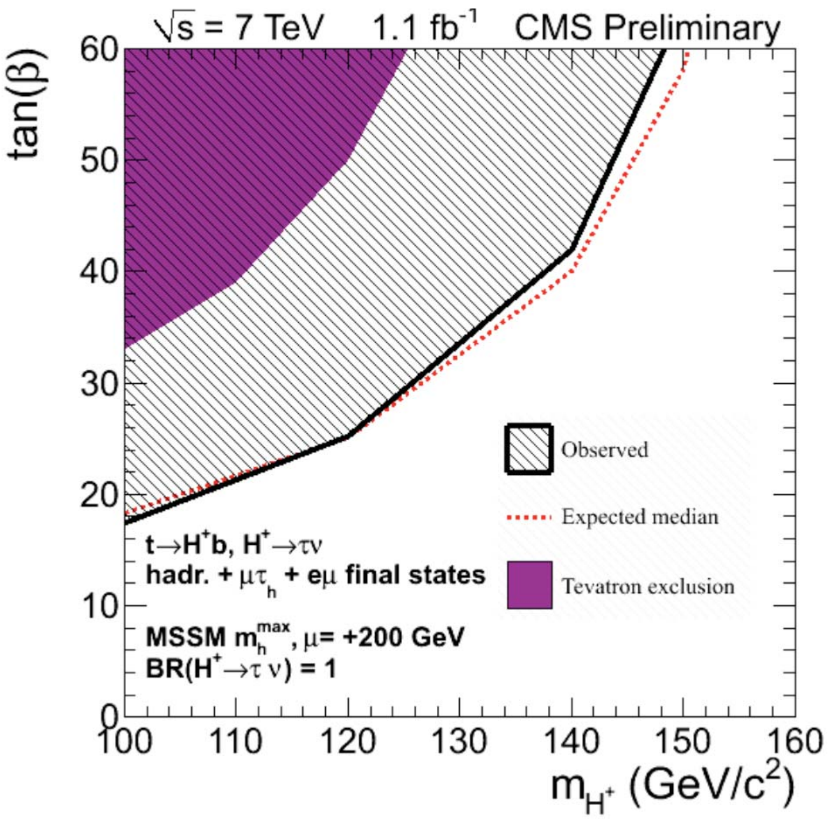


Expected number of tt events from SM and SUSY



Charged Higgs Limits



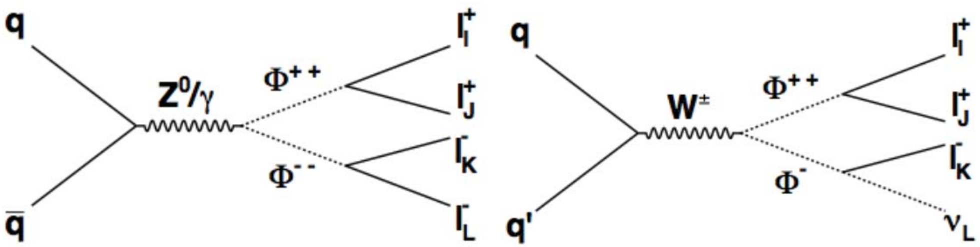


- Upper limit on Br(t→H$^{\pm}$b) is 4-5% for H$^{\pm}$ with masses 80 – 160 GeV

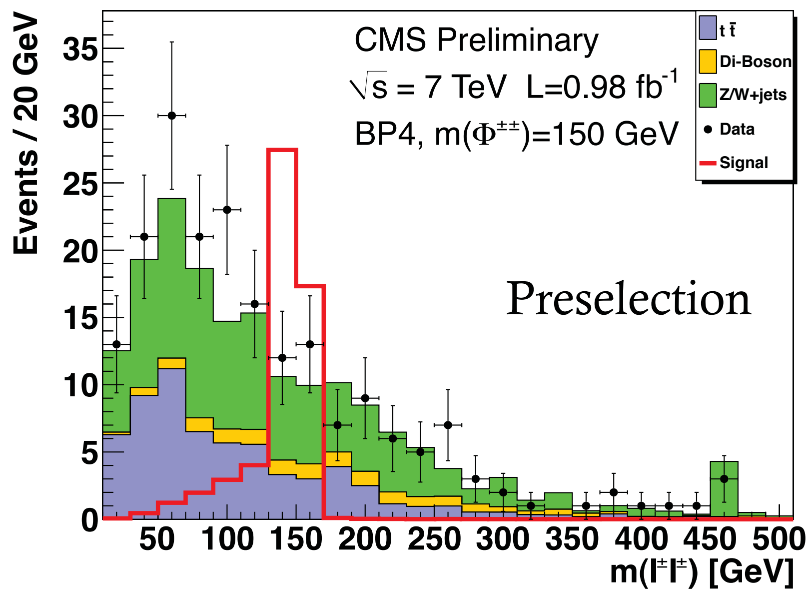
CMS PAS HIG-11-008

Double Charged Higgs

- Predicted by Left-Right symmetric model, little Higgs, minimal seesaw model
  - Higgs triplets $\Phi^{\pm\pm}$, $\Phi^{\pm}$, Φ^{0}
    - Responsible for neutrino masses
- Signatures with multiple leptons with random flavor
  - one or two tau leptons
  - Boosted leptons in final state

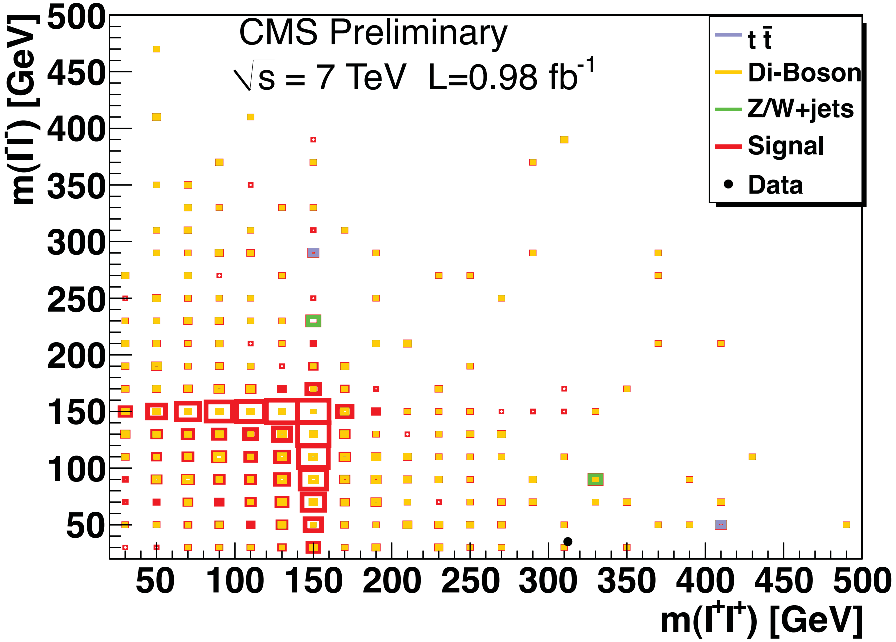


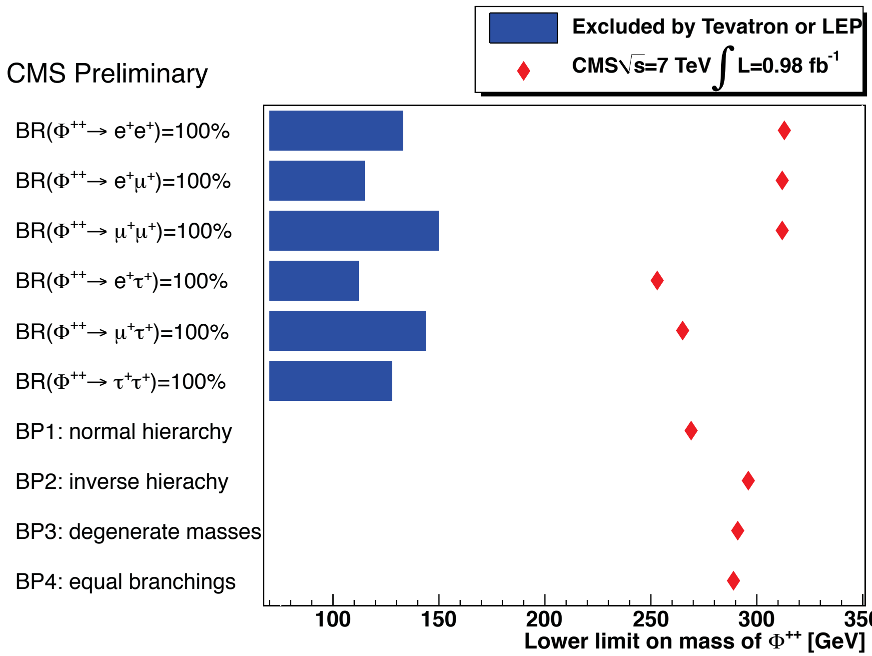
Assuming:
$\Phi^{\pm\pm}$ & $\Phi^{\pm}$ degenerate in mass
$\Phi^{\pm\pm} \rightarrow W^{\pm}W^{\pm}$ suppressed



Double Charged Higgs

CMS PAS HIG-11-007

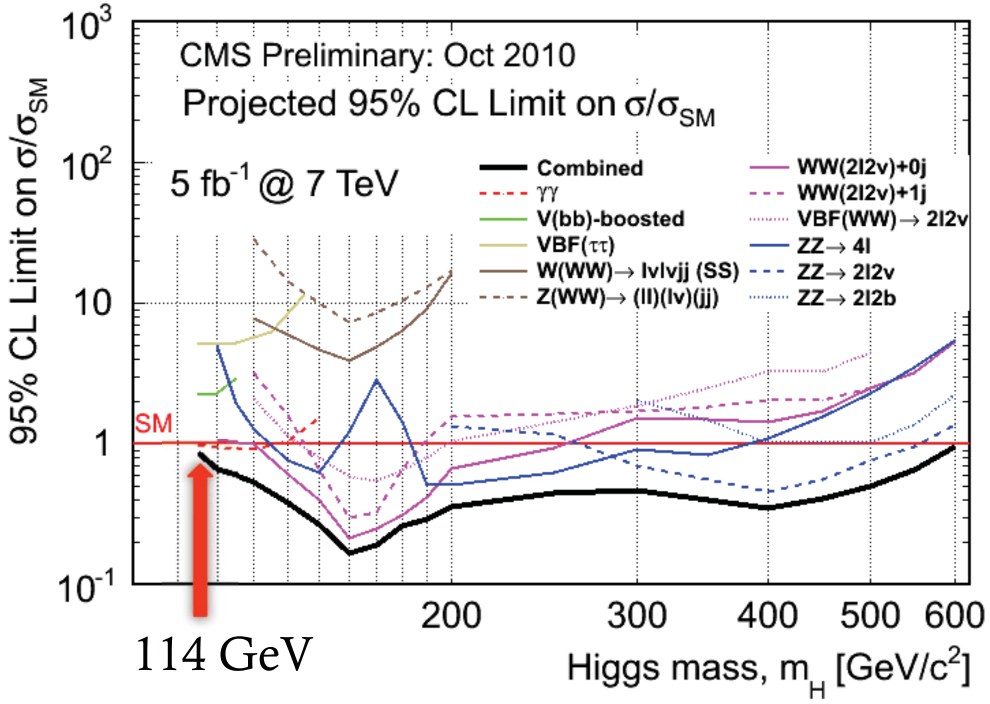


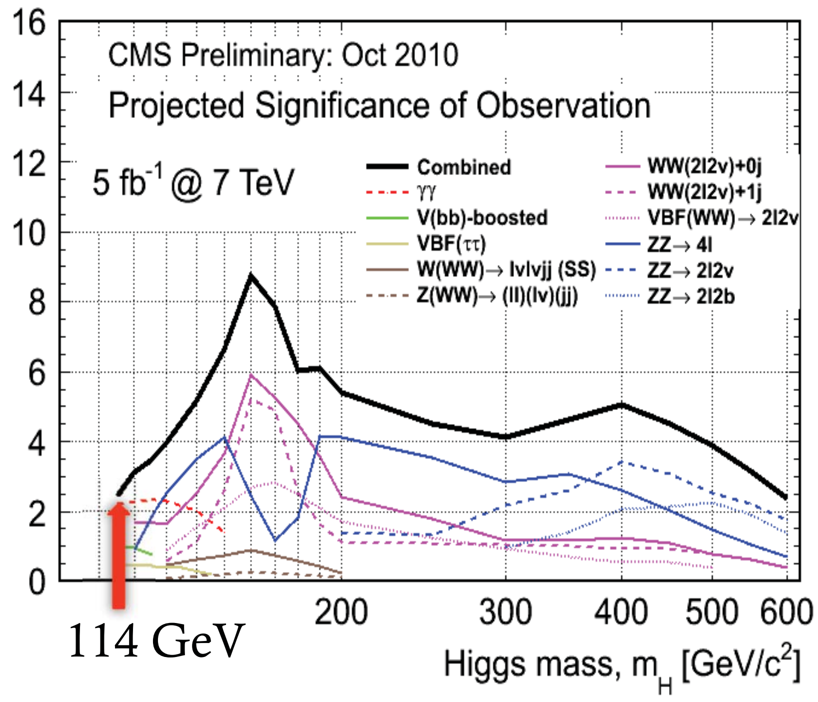


- Φ^{++} is excluded in mass ranges significantly beyond those set by LEP and Tevatron

Prospects

Higgs Projections for 2011





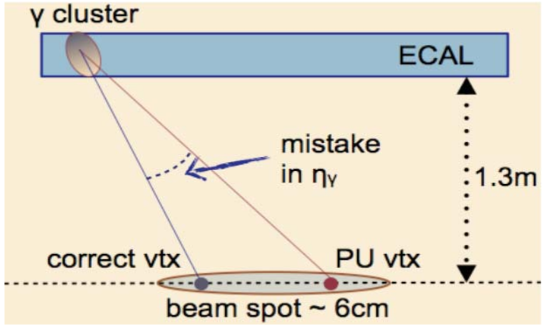
- Observed limit follows closely to 2010 projections
- With $5fb^{-1}$ @ 7TeV exclusions 110-600 GeV mass range; Evidence of 3σ or more possible for all but lowest and highest masses

Conclusion

- CMS has already made a significant contribution in hunting for the SM Higgs boson
  - Only using data collected in 7 months three mass regions are excluded [145-216], [226-288], [310-400] GeV
- Considered various (30) channels
  - Well established methods to deal with challenges from data
  - Improvements in analysis techniques are also on-going
- 4-5 fb^{-1} of luminosity is expected by the end of 2011
  - If Higgs does not exist we will know quite soon ☺
  - If Higgs exist we will have lots of fun next year ☺☺

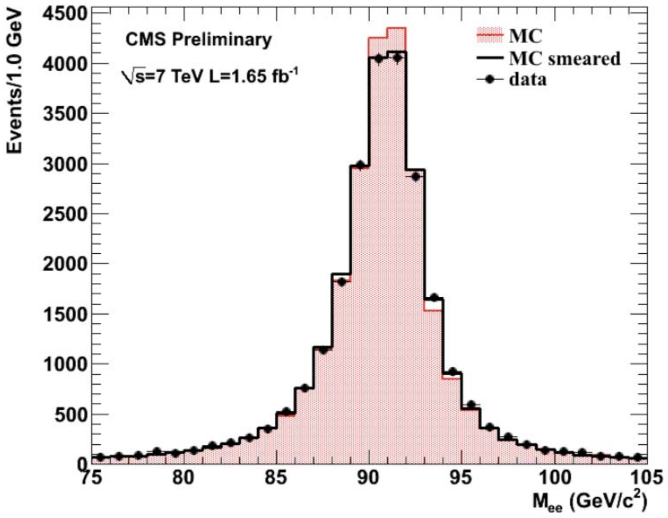
BACKUP

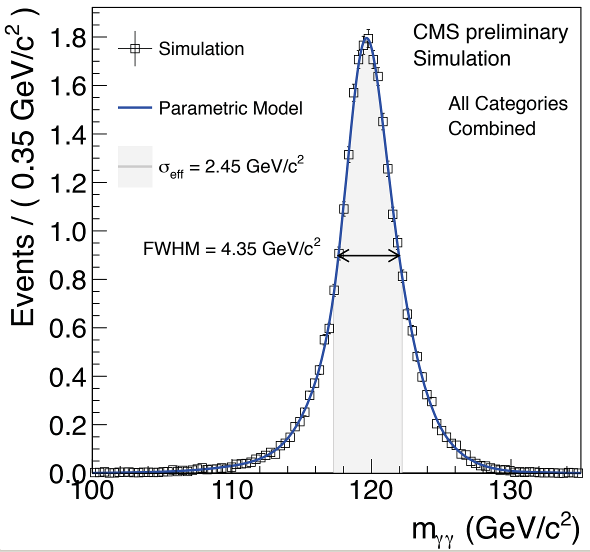
Vertex selection in H→γγ



- Vertex determination based
  - Kinematics of photon pair
  - p_T balance of photon pair and tracks from vertex
  - Conversion tracks

- Energy scale & resolution from Z→ee events in dsta





Systematics in H→γγ

Systematics on single photon

Source	Uncertainty	
Photon identification efficiency		
barrel	1.0%	
endcap	2.5%	
R_9 >0.94 efficiency (results in class migration) barrel	4%	
endcap	6.5%	
	$R_9 > 0.94$	$R_9 < 0.94$
Energy resolution ($\Delta\sigma/E_{MC}$) barrel	0.2%	0.4%
endcap	0.5%	0.4%
Energy scale ($(E_{data} - E_{MC})/E_{MC}$) barrel	0.1%	0.4%
endcap	0.3%	0.4%

Systematics on di-photon

Source	Uncertainty
Integrated luminosity	4.5%
Trigger efficiency	
both photons in barrel	1.0%
one or more photon in endcap	1.0%
Vertex finding efficiency	0.5%
p_T^H >40 GeV/c in gluon fusion (class migration)	6%

Systematics on cross sections

	Source	Uncertainty
Standard Model	gg cross section (scale)	12.5%
	gg cross section (PDF)	7.9%
fermiophobic model	VBF cross section (scale)	0.5%
	WH cross section (scale)	0.8%
	ZH cross section (scale)	1.6%
	VBF + VH cross section (PDF)	3.1%
	fermiophobic $H \to \gamma\gamma$ BR	5%

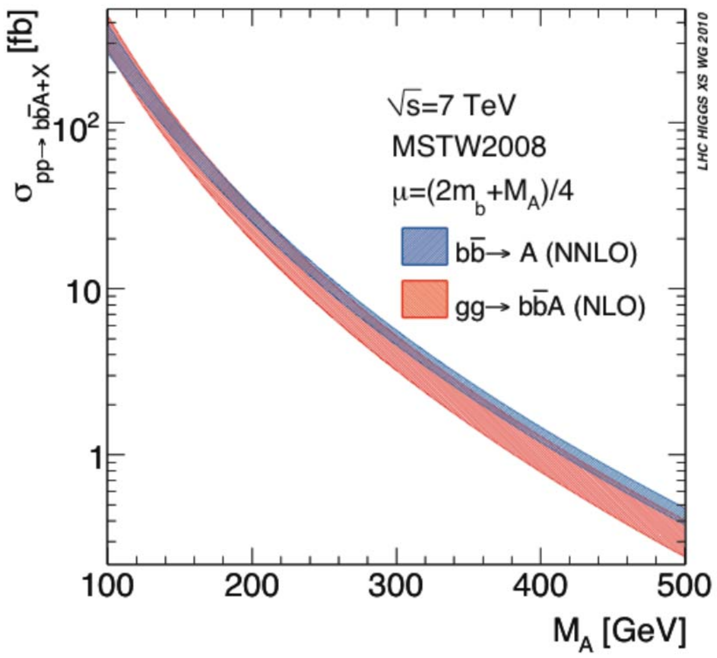
•

Systematics in $H\rightarrow\tau\tau$

Source	Uncertainty
Luminosity	4.5%
Jet energy scale	5%
Z production cross section	3%
Lepton id & iso.	1%
Trigger	1%
Tau id. Efficiency	6%
Energy scale $\mu/e/\tau$	1%/2%/3%
B-tagging efficiency	10%

SM Higgs cross section
ggH – 12%
qqH – 3.5%

Cross Section in MSSM



4FS – Scale uncertainties only
5FS – Scale and PDF uncertainties
"Santander" matching scheme is used to average 4FS and 5FS

Renormalization/factorization scale uncertainty and PDF uncertainty on bbA cross section in the 4-flavor NLO QCD and 5-flavor NNLO QCD calculation

$\sigma(bbA)$: Theoretical Uncertainties					
4FS calculation			5FS calculation		
M_A (GeV)	scale	PDF+α_s	M_A (GeV)	scale	PDF+α_s
100	24%	-	100	5%	3%
300	24%	-	300	2%	6%
500	26%	-	500	2%	8%
1000	30%	-	1000	1%	2%

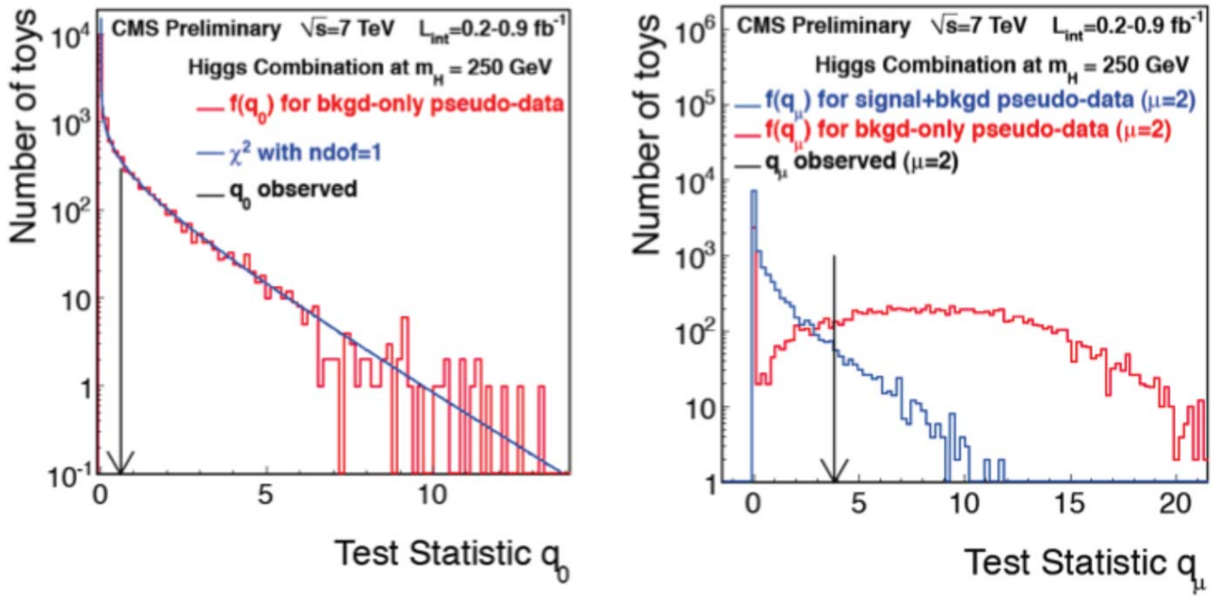
Modified frequentist approach

- Test statistics -- likelihood ratio
  - Maximize both numerator and denomina

$$q_\mu = -2\ln\frac{\mathcal{L}(\text{data}|\mu,\hat{\theta}_\mu)}{\mathcal{L}(\text{data}|\hat{\mu},\hat{\theta})}$$ ← fix μ, vary $\hat{\theta}_\mu$ ← vary $\hat{\mu}$ and $\hat{\theta}$

  - Find values of θ_0 and θ_μ tha best describe data for background-only and signal+background hypothesis
  - Use these values to in pseudo-exp
  - Calculate CL_s

$$CLs = CL_{s+b}/CL_b = \frac{P\left(q_\mu \geq q_\mu^{obs} \mid \mu s(\hat{\theta}_\mu^{obs}) + b(\hat{\theta}_\mu^{obs})\right)}{P\left(q_\mu \geq q_\mu^{obs} \mid b(\hat{\theta}_0^{obs})\right)}$$



p-value and significance

- Probability that background will fluctuate up to observed local significance
  - q^{obs}_0 is observed q_μ in background-only scenario

$$\tilde{p} = \frac{1}{2}\left[1 - \mathrm{erf}\left(\sqrt{q_0^{\mathrm{obs}}/2}\right)\right]$$

- Significance Z from p-value
  - E.g. p=2% would give Z~2σ

$$p = \int_Z^\infty \frac{1}{\sqrt{2\pi}} \exp(-x^2/2)\, dx.$$

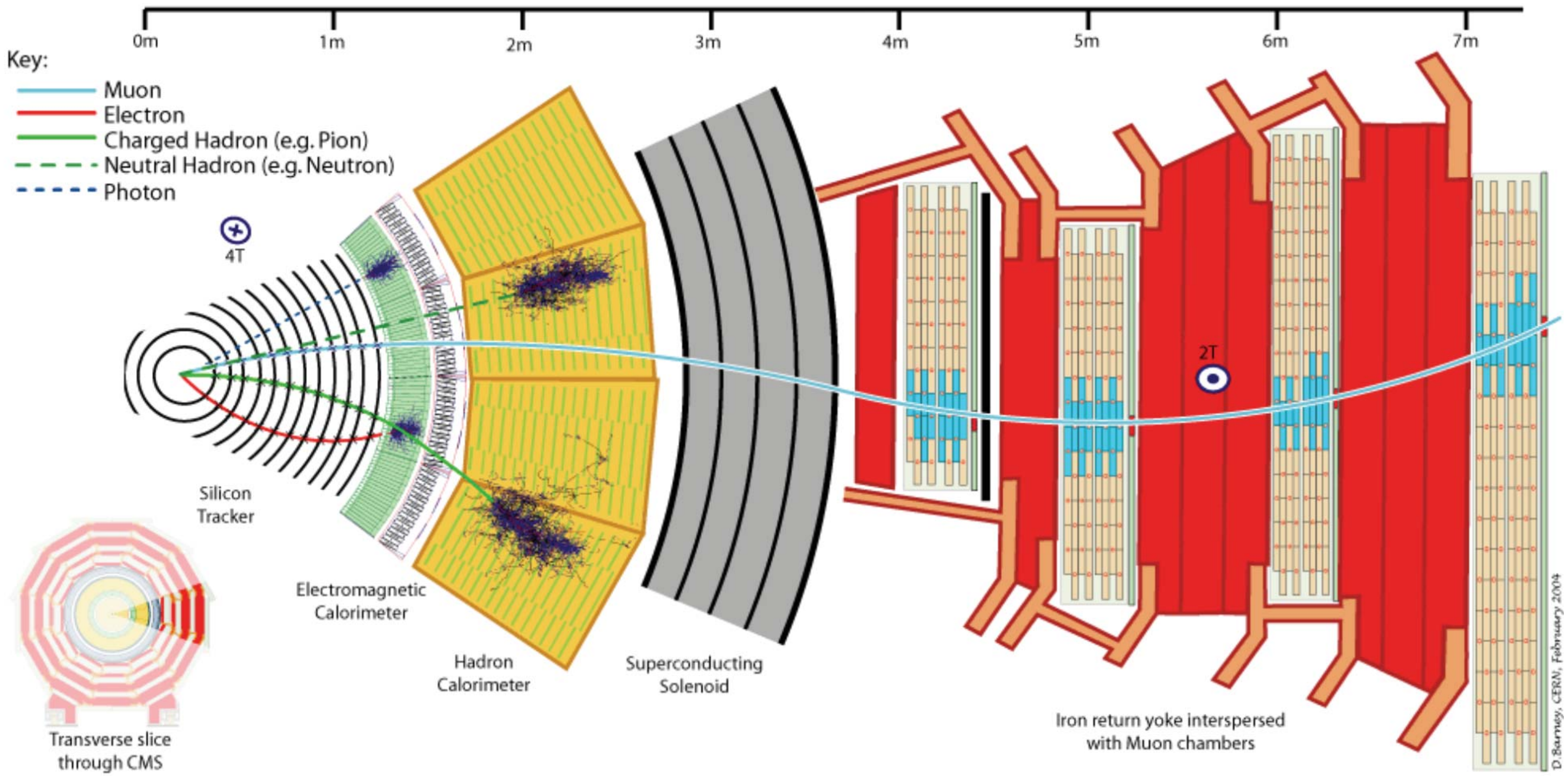
- Look-elsewhere effect (LLE) propagates into global p-value from local significance Z and local p-value
  - Reduces significance

Bayesian method

- Bayesian with flat prior $$\int_0^{\mu_{95\%CL}} p(\mu \,|\, \text{data})\, d\mu \;=\; 0.95$$

$$p(\mu \,|\, \text{data}) = \frac{1}{C} \int_\theta p\,(\text{data} \,|\, \mu s(\theta) + b(\theta))\;\; \rho_\theta(\theta)\;\; \pi_\mu(\mu)\; d\theta$$

CMS Detector



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$H \rightarrow WW$ Systematics

Table 3: Summary of all systematic uncertainties (relative). This is just an indicative table, since the precise values depend on the final state and jet-bin.

Source	$H \rightarrow W^+W^-$	$qq \rightarrow W^+W^-$	$gg \rightarrow W^+W^-$	non-Z resonant WZ/ZZ	top	DY	W + jets	$V(W/Z) + \gamma$
Luminosity	4.5	—	—	4.5	—	—	—	4.5
Trigger efficiencies	1.5	1.5	1.5	1.5	—	—	—	1.5
Muon efficiency	1.5	1.5	1.5	1.5	—	—	—	1.5
Electron id efficiency	2.5	2.5	2.5	2.5	—	—	—	2.5
Momentum scale	1.5	1.5	1.5	1.5	—	—	—	1.5
E_T^{miss} resolution	2.0	2.0	2.0	2.0	2.0	3.0	—	1.0
Jet counting	7-20	—	5.5	5.5	—	—	—	5.5
Higgs cross section	5-15	—	—	—	—	—	—	—
WZ/ZZ cross section	—	—	—	3.0	—	—	—	—
$qq \rightarrow WW$ norm.	—	15	—	—	—	—	—	—
$gg \rightarrow WW$ norm.	—	—	50	—	—	—	—	—
W + jets norm.	—	—	—	—	—	—	36	—
top norm.	—	—	—	—	25	—	—	—
$Z/\gamma^* \rightarrow \ell^+\ell^-$ norm.	—	—	—	—	—	60	—	—
Monte Carlo statistics	1.0	1.0	1.0	4.0	6.0	20.0	20.0	10.0

H → ZZ → 4l Systematics

Table 4: Summary of the magnitude of systematic uncertainties in percent. The uncertainties assigned for the lepton reconstruction, identification and isolation apply to the event yields. The uncertainty assigned to the electron energy scale is further propagated through the shape of the expected signal and background reconstructed mass distributions.

Luminosity	4.5
Trigger efficiency	1.5
Higgs cross section	17-20
Higgs B.R.	2
Lepton reco/ID eff.	2-3
Lepton isolation eff.	2
Electron energy scale	3

H → ZZ → 2l2ν Systematics

Table 5: Systematic uncertainties on the final event yields for both electron and muon final states. Ranges indicate different uncertainty values for different processes — for example QCD Scale uncertainties differ from one Higgs mass point to another.

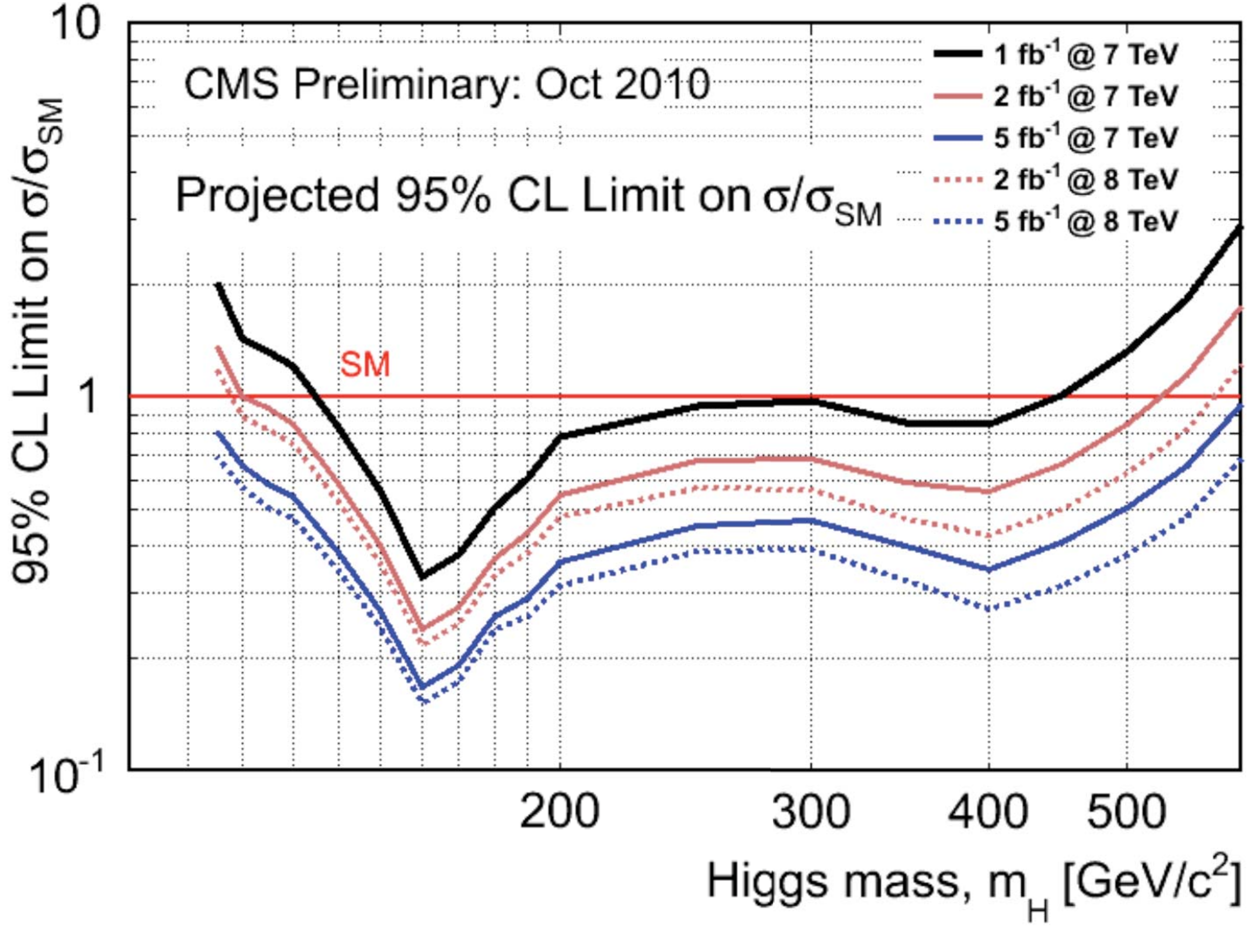
Uncertainty	value, %
Luminosity	4.5
pdf, gluon-gluon initial state	6-11
pdf, quark-quark initial state	3.3-7.6
QCD scale, gluon-gluon initial state (ggH)	7.6-11
QCD scale, quark-quark initial state (VBF)	0.2-2
QCD scale, gluon-gluon initial state (ggZZ)	20
QCD scale, quark-quark initial state (qqVV)	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 backgrounds estimation from data	7% (α)
Z + *jets* estimation from data	19-57%

H → ZZ → 2l2q Systematics

Table 3: Summary of systematic uncertainties on signal normalization. Most sources give multiplicative errors on the cross-section measurement, except for the expected Higgs boson production cross section, which is relevant for the measurement of the ratio to the SM expectation.

source	0 *b*-tag	1 *b*-tag	2 *b*-tag
muon reco	2.7%		
electron reco	4.5%		
jet reco	1–5%		
pileup	2%		
b-tagging	3–7%	3%	+13%/ − 18%
gluon-tagging	4.6%	–	–
$\not{E}_T$	–	–	3%
acceptance (PDF)	3%		
acceptance (HQT)	2%	5%	3%
acceptance (WBF)	1-2%		
luminosity	4.5%		
Higgs cross section	13–18%		

Projection



CMS Preliminary: Oct 2010
Projected 95% CL Limit on σ/σ_SM
1 fb⁻¹ @ 7 TeV
2 fb⁻¹ @ 7 TeV
5 fb⁻¹ @ 7 TeV
2 fb⁻¹ @ 8 TeV
5 fb⁻¹ @ 8 TeV
SM
10
1
10⁻¹
200
300
400
500
95% CL Limit on σ/σ_SM
Higgs mass, m_H [GeV/c²]