Experimental Higgs Searches

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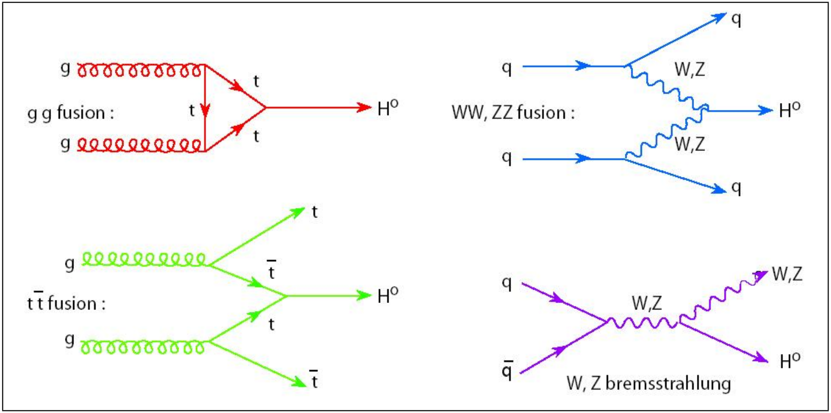
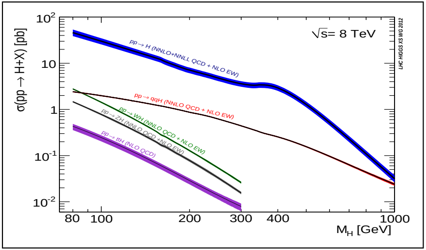
- focus on low SM Higgs mass searches, other searches will be discussed briefly
- focus on LHC analyses
- do not hesitate asking any question!

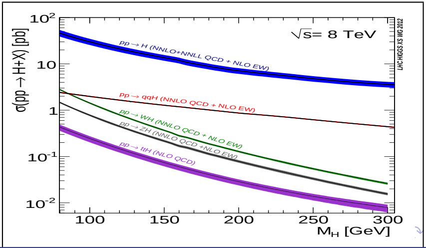
Production Mechanics



Cross-section vs. Higgs Mass

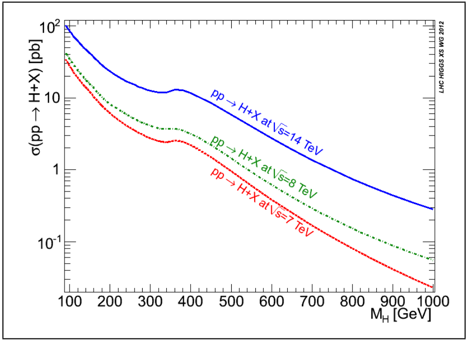
- Gluon-gluon fusion, $gg \longrightarrow H$, dominant
- Weak boson fusion, $qq' \longrightarrow qq'H$, very important too
- Small contributions from $t\bar{t}H$, ZH and WH





Cross-section vs. $\sqrt{s}$

- Sizeable dependence on $\sqrt{s}$
- $\sigma_{8\ TeV}/\sigma_{7\ TeV}(125) \sim 1.3$
- $\sigma_{14\ TeV}/\sigma_{8\ TeV}(125) \sim 2.6$



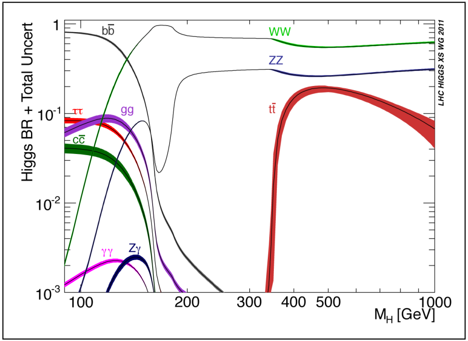
Branching ratios vs. Higgs Mass (I)

Partial widths at tree level:

- $\Gamma(H \to f\bar{f}) \propto N_c m_f^2 \beta^3 m_H$
- $\Gamma(H \to VV) \propto \delta_V \beta m_H^3 (1 - \tau_V + \frac{3}{4}\tau_V^2)$

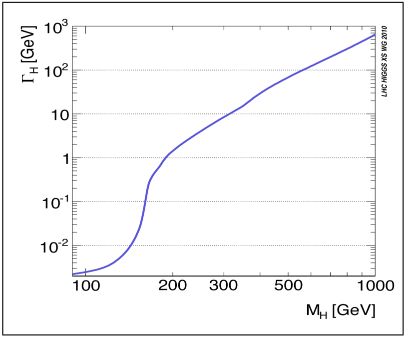
$\beta^2 = 1 - 4m_f^2/m_H^2$,
$\tau_V = 4m_V^2/m_H^2$
$N_c = 3$ for quarks and $N_c = 1$ for leptons
$\delta_W = 2$, $\delta_Z = 1$

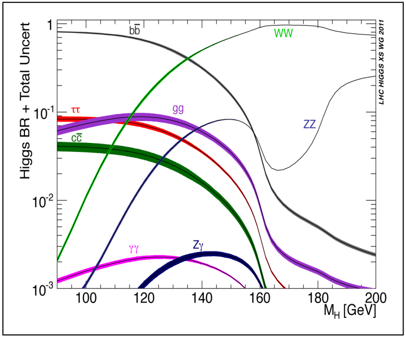
- Low mass region:
  - Contributions from several modes at $m_H \sim 125\ GeV$



- Higgs mass region:
  - $\Gamma_{tot} \approx \Gamma(H \to WW) + \Gamma(H \to ZZ)$
  - $m_H \approx 1.4\ TeV \to \Gamma_{tot} \approx m_H$

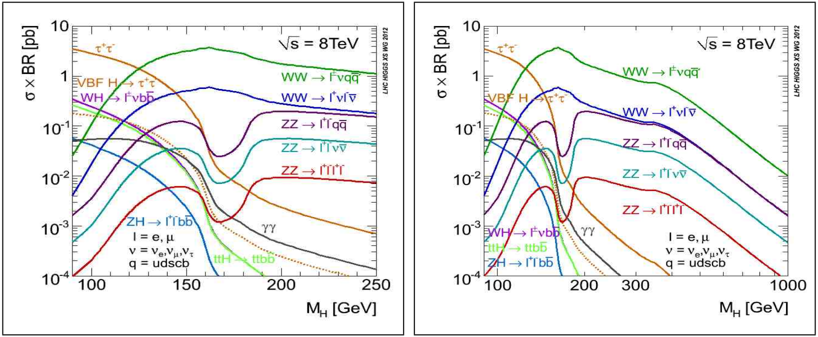
Branching ratios vs. Higgs Mass (II)





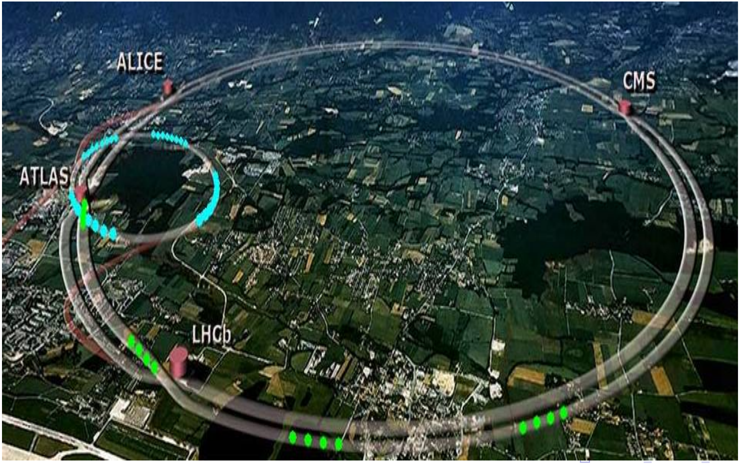
- Tiny width at low masses

$\sigma \times BR$ at $\sqrt{s} = 8\ TeV$

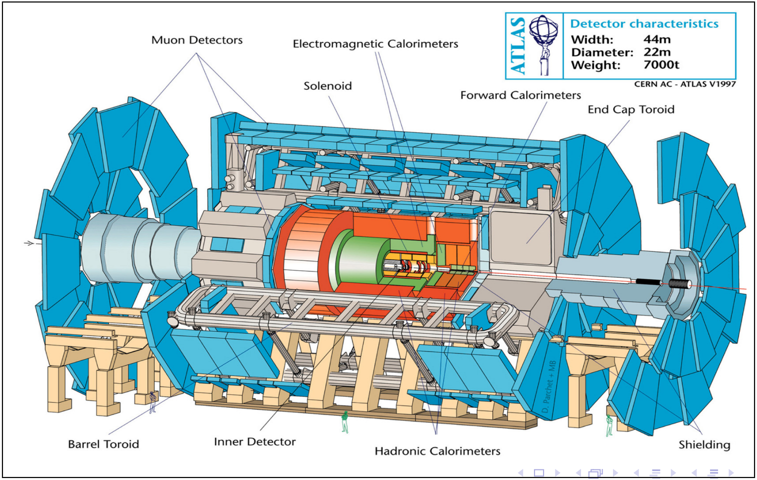


- Large number of available channels at $m_H \sim 125\ GeV$

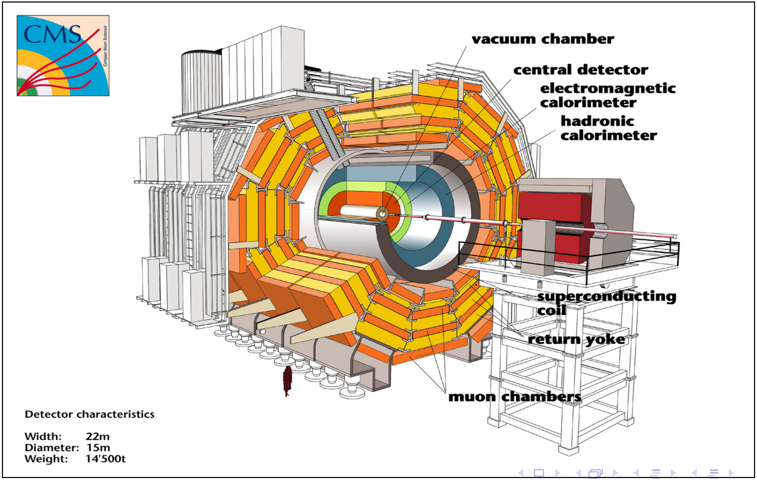
The LHC Complex



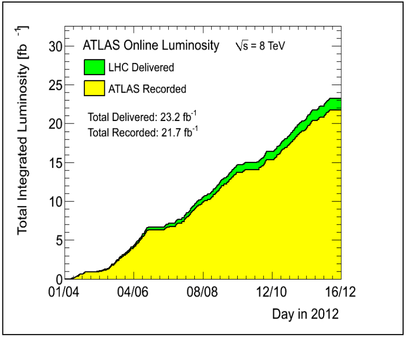
ATLAS Overview

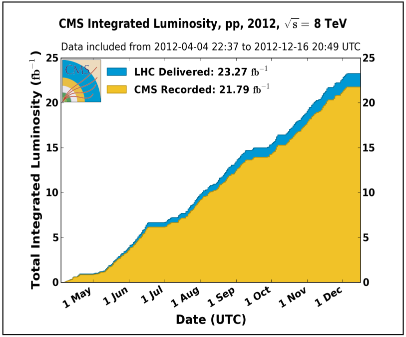


CMS Overview



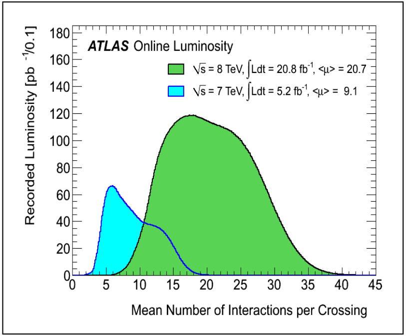
Recorded Luminosity

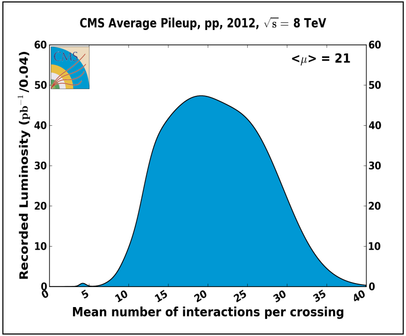




- $L \sim 20\ \mathrm{fb}^{-1}$ at $\sqrt{s} = 8$ TeV after good run selection is applied

Pile-Up





- Large number of overlapping events
- An issue to take into account in any analysis

Final States

- $\mathrm{H} \to \gamma\gamma$:
  - $gg \to \mathrm{H}$
  - $qq\mathrm{H}$
  - $\mathrm{W/Z/t\bar{t}H}$

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- $\mathrm{H} \rightarrow \mathrm{WW}$:
  - $\mathrm{H} \rightarrow \mathrm{WW} \rightarrow \ell\nu\ell\nu$
  - $qq\mathrm{H},\ \mathrm{H} \rightarrow \mathrm{WW} \rightarrow \ell\nu\ell\nu / qq'\ell\nu$
  - $\mathrm{WH} \rightarrow \mathrm{WWW} \rightarrow 3\ell 3\nu$

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  - $qq\mathrm{H}$

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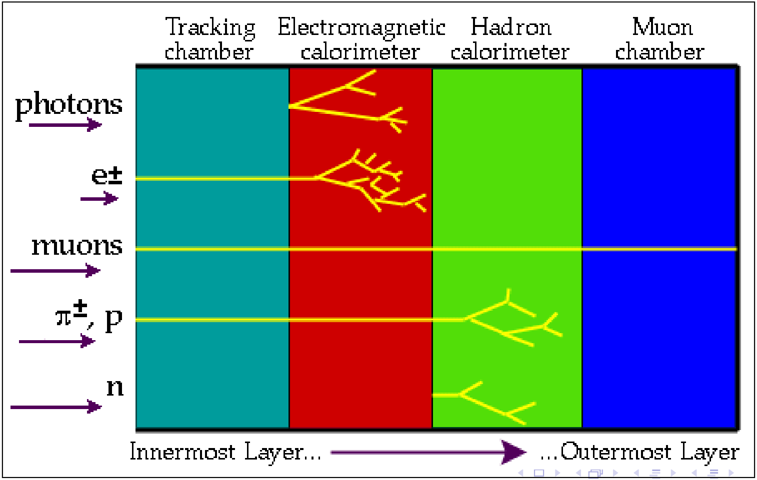
  - $\mathrm{t\bar{t}H}$
  - $qq\mathrm{H}$
- $\mathrm{H} \to \mathrm{Z}\gamma$

Key Points

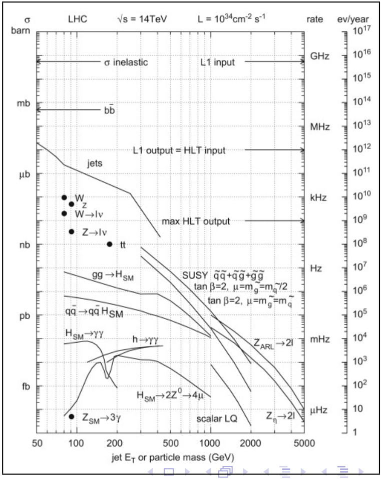
- Trigger
- μ, e, γ, τ identification and momentum/energy resolution:
  - high p_{T} isolated objects
- Jet reconstruction:
  - reject backgrounds
  - select VBF events
- b-tagging:
  - reject backgrounds, apply anti b-tagging
  - select b-jets
- $E_{\mathrm{T}}^{\mathrm{miss}}$:
  - select events with neutrinos in the final state
  - reject backgrounds
- Systematics, data-driven methods

Particle Detection



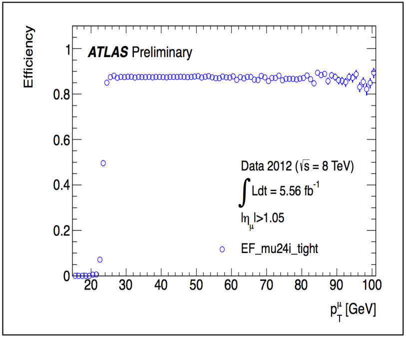
Triggers (I)

- Huge rates at LHC
- Low signal yields against large backgrounds
- Relatively low p_{T} objects on Higgs decays, more difficult to be triggered

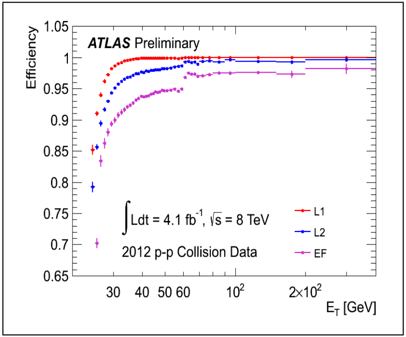


Triggers (II)

muons



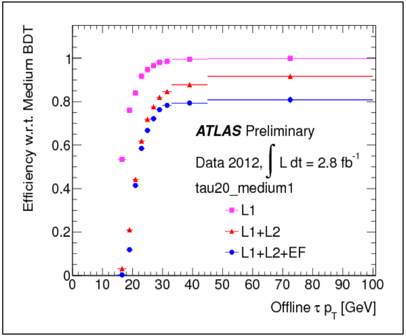
electrons



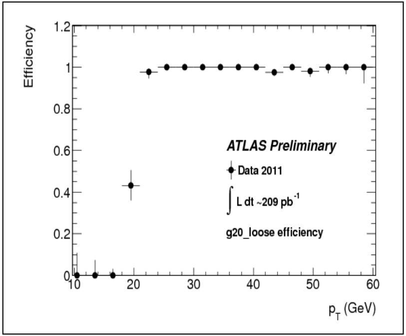
- Trigger efficiency of the order of ~80-90%
- Largely detector/experiment dependent

Triggers (III)

taus

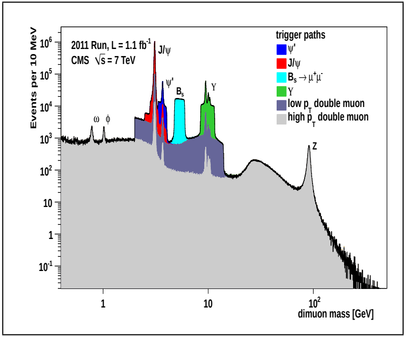


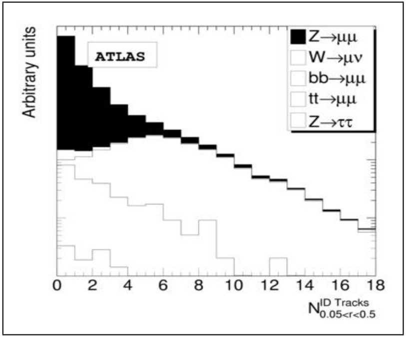
photons



- Lower efficiency for taus, need to apply tighter requirements to avoid too high trigger rates

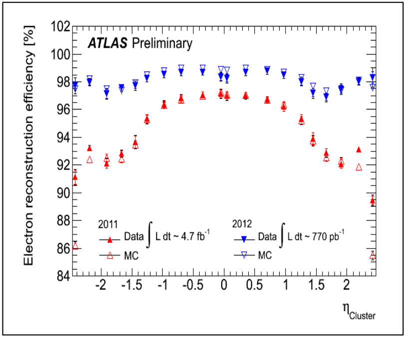
Muon Selection

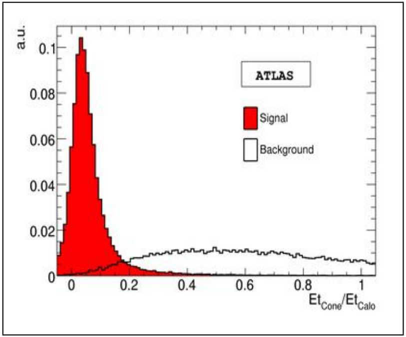




- High selection efficiency, even low mass resonances
- Lepton isolation is a critical variable to separate leptons from WZ bosons and background

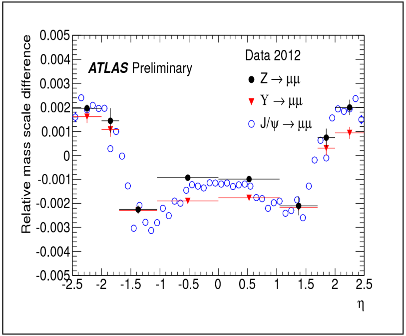
Electron Selection

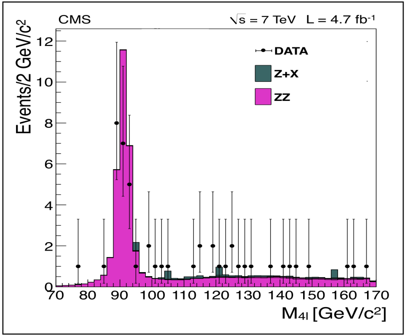




- Clear η dependence

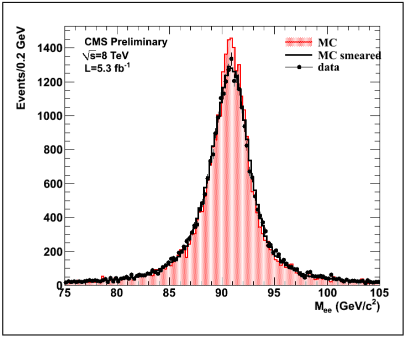
Lepton Momentum Resolution

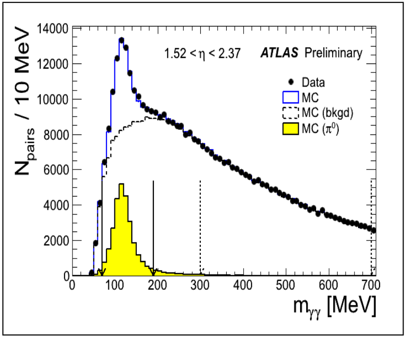




- Lot of work to improve lepton momentum resolution and to improve data/MC agreement

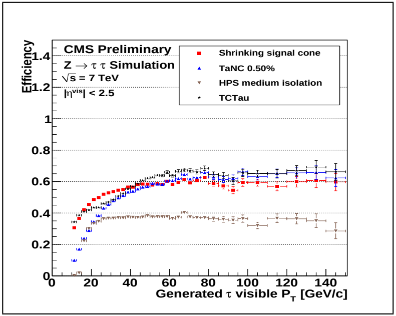
Photon Selection & Resolution

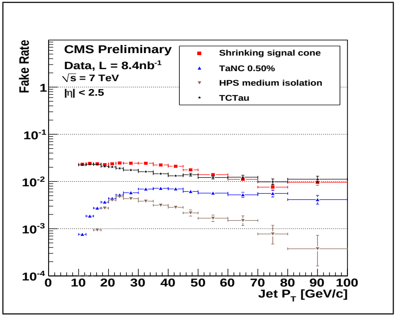




- Critical point for $H \rightarrow \gamma\gamma$
- Calibrated with $Z \rightarrow e^+e^-$ events
- Looking at $\pi^0 \rightarrow \gamma\gamma$ candidates to calibrate crystal by crystal

Tau Selection



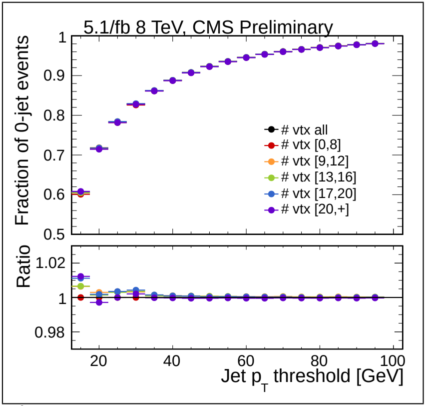


- Tight selection is required to reject multi-jet background
- Particle Flow technique rather important in CMS selection
- electron/muon rejection is also another important factor

Jet Identification

Pile-up jets structure differs wrt regular jets:

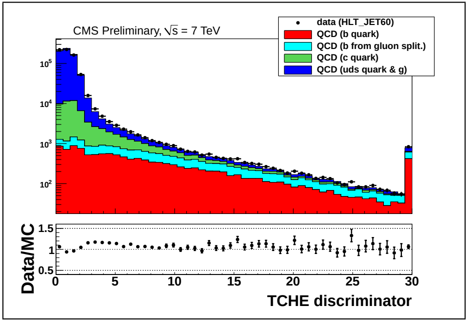
- pile-up jets originate from several overlapping jets which merge together
- likelihood grows rapidly with high pileup
- discriminant exploits shape and tracking variables
- discrimination both inside and outside tracker acceptance



$p_T^{jet} > 30$ GeV is a usual requirement

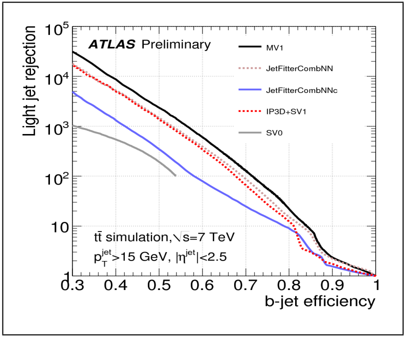
b-jet tagging (I)

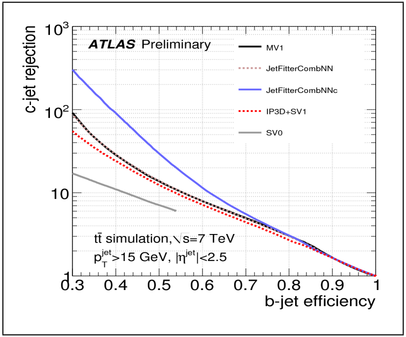
- Mostly used either to select $H \to b\bar{b}$ events or reject $t\bar{t}/Wt$ events
- Techniques:
  - find tracks with large impact parameter
  - find set of tracks not coming from the interaction point
  - find leptons within jets
  - combine all together



Track Counting High Efficiency (TCHE): impact parameter significance of the second most displaced track in the jet

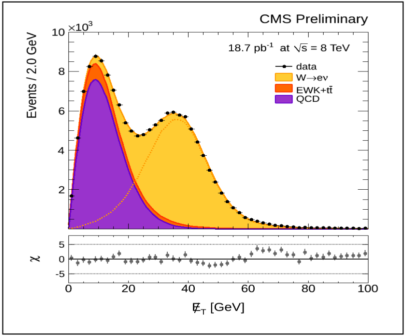
b-jet tagging (II)

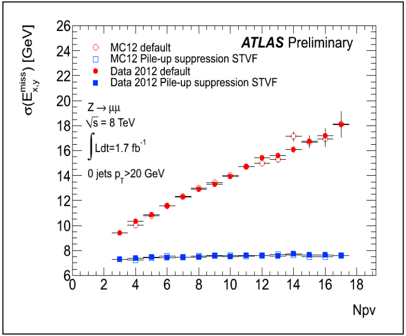




- $\epsilon_{uds} \sim 1\%$ and $\epsilon_c \sim 10\%$ for $\epsilon_b \sim 70\%$
- $\epsilon_{uds} \sim 0.1\%$ and $\epsilon_c \sim 1\%$ for $\epsilon_b \sim 50\%$

E_T^{miss}





- Needed to reject processes with no intrinsic E_T^{miss}
- Critical for many analyses
- Noticeable performance dependence with pile-up

CMS Analyses in a Snapshot

Higgs decay mode	Higgs production mechanism	Mass range [GeV]	Data used		Mass resolution	Used in the combination
			7 TeV [fb^{-1}]	8 TeV [fb^{-1}]		
γγ	Untag (~gg)	110 – 150	5.1	5.3	1–2%	✔
	VBF-tag	110 – 150	5.1	5.3	1–2%	✔
bb	VH-tag	110 – 135	5.0	12.1	10%	✔
	ttH-tag	110 – 140	5.0	–	–	✔
ττ	1-jet (~gg)	110 – 145	4.9	12.1	20%	✔
	VBF-tag	110 – 145	4.9	12.1	20%	✔
	ZH-tag	110 – 160	5.0	–	–	✔
	WH-tag	110 – 140	4.9	–	–	✔
ZZ → 4l	Inclusive	110 –1000	5.0	12.2	1–2%	✔
ZZ → 2l2τ	Inclusive	180 –1000	5.0	12.2	10–15%	✔
ZZ → 2l2ν	Inclusive	200 – 600	4.7	5.0	–	
ZZ → lljj	Inclusive	120 – 600	4.7	–	–	
WW → 2l2ν	0/1-jets (~gg)	110 – 600	4.9	12.1	20%	✔
	VBF-tag	110 – 600	4.9	12.1	20%	✔
	WH-tag	110 – 200	4.9	5.1	–	✔
WW → lljj	Untag (~gg)	170 – 600	5.0	12.1	–	✔

similar picture for ATLAS analyses

Analyses

- High sensitivity analyses:
  - $\mathrm{H} \rightarrow \gamma\gamma$
  - $\mathrm{H} \rightarrow \mathrm{ZZ} \rightarrow 4\ell$
  - $\mathrm{H} \rightarrow \mathrm{WW} \rightarrow \ell\nu\ell\nu$
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- Other analyses at low masses:
  - $\mathrm{WH} \to \mathrm{WWW} \to 3\ell 3\nu$
  - $\mathrm{W/ZH},\ \mathrm{H} \to \tau\tau$
  - $\mathrm{t\bar{t}H},\ \mathrm{H} \to b\bar{b}$
  - $\mathrm{H} \to \mathrm{Z}\gamma$

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  - $\mathrm{H} \to \mathrm{Z}\gamma$
- Higg mass analyses:
  - $H \to \mathrm{WW} \to qq'\ell\nu$
  - $(qq)H,\ H \to \mathrm{ZZ} \to 2\ell 2\nu$
  - $(qq)H \to \mathrm{ZZ} \to 2q2\ell$

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  - $\mathrm{W/ZH},\ \mathrm{H} \rightarrow b\bar{b}$
- Other analyses at low masses:
  - $\mathrm{WH} \rightarrow \mathrm{WWW} \rightarrow 3\ell 3\nu$
  - $\mathrm{W/ZH},\ \mathrm{H} \rightarrow \tau\tau$
  - $\mathrm{t\bar{t}H},\ \mathrm{H} \rightarrow b\bar{b}$
  - $\mathrm{H} \rightarrow \mathrm{Z}\gamma$
- Higg mass analyses:
  - $H \rightarrow \mathrm{WW} \rightarrow qq'\ell\nu$
  - $(qq)H,\ H \rightarrow \mathrm{ZZ} \rightarrow 2\ell 2\nu$
  - $(qq)H \rightarrow \mathrm{ZZ} \rightarrow 2q2\ell$
- Notice that these two analyses are also very high performing at high mass:
  - $H \rightarrow \mathrm{ZZ} \rightarrow 4\ell$, including $H \rightarrow \mathrm{ZZ} \rightarrow 2\ell 2\tau$
  - $H \rightarrow \mathrm{WW} \rightarrow \ell\nu\ell\nu$

Strategies

- Cut-based approach:
  - apply a set of sequential requirements
  - cut-and-count
  - usually used as first analysis and/or cross-check
- Shape-based approach:
  - fit for signal (and backgrounds) using a given variable (or variables)
- Multivariate techniques to build discriminant variables: can be used in both cut-based and shape-based approaches
  - Boosted Decision Tree
  - Neural Network
  - Fished Discriminant
  - Likelihood
  - Matrix Element

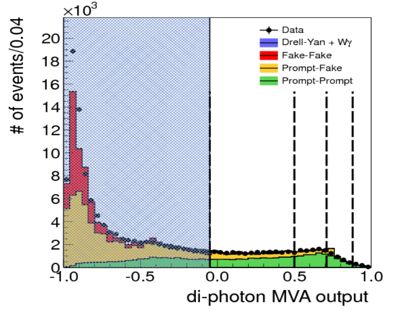
Bosonic Decays: higher sensitivity channels

$\mathrm{H} \rightarrow \gamma\gamma$ (I)

- Two high p_{T} isolated photons
- Small $\sigma \times BR$, but clean topology
- Narrow peak on large continous background
- Main ingredients:
  - photon reconstruction, isolation and identification
  - good energy calibration and primary vertex reconstruction
  - good background modeling
- Additional categories help:
  - events with two high p_{T} jets with large $\Delta\eta_{jj}$ and m_{jj}
  - events with leptons
  - events with large $E_{\mathrm{T}}^{\mathrm{miss}}$

$\mathrm{H} \to \gamma\gamma$ (II)

CMS

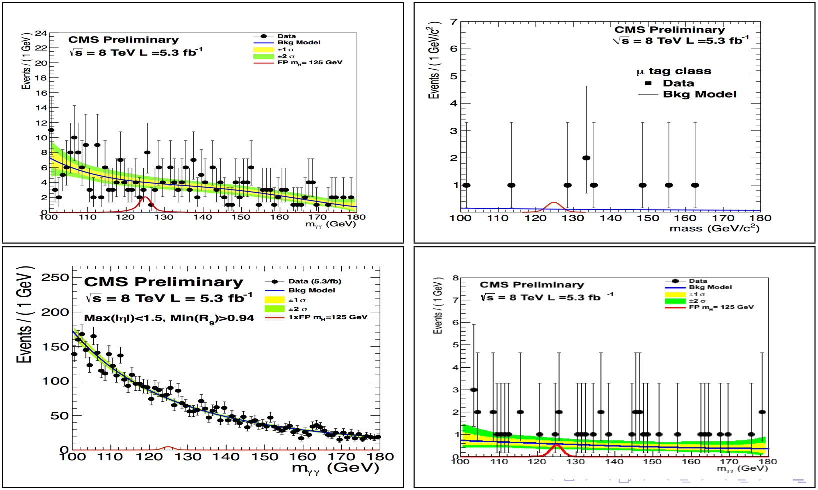


ATLAS

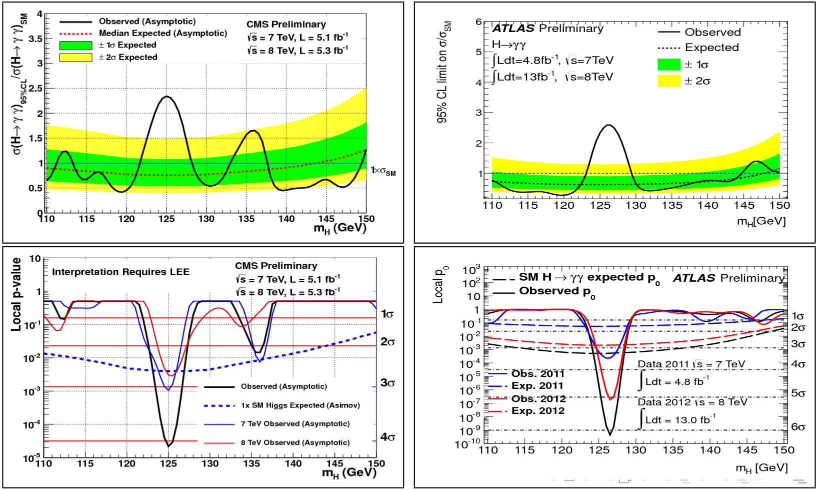
Category	σ_{CB} [GeV]	FWHM [GeV]
Inclusive	1.63	3.87
Unconverted central, low p_{Tt}	1.45	3.42
Unconverted central, high p_{Tt}	1.37	3.23
Unconverted rest, low p_{Tt}	1.57	3.72
Unconverted rest, high p_{Tt}	1.51	3.55
Converted central, low p_{Tt}	1.67	3.94
Converted central, high p_{Tt}	1.50	3.54
Converted rest, low p_{Tt}	1.93	4.54
Converted rest, high p_{Tt}	1.68	3.96
Converted transition	2.65	6.24
2-jets	1.57	3.70

- Events are split in categories
- Improve mass resolution and signal-to-background ratio

$\mathrm{H} \rightarrow \gamma\gamma$ (III)

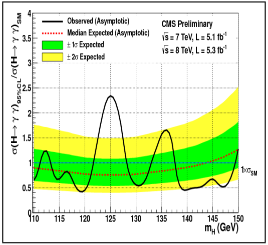


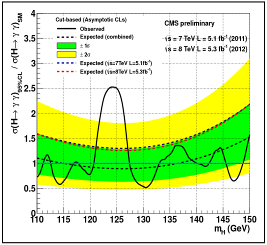
$H \rightarrow \gamma\gamma$ (IV)

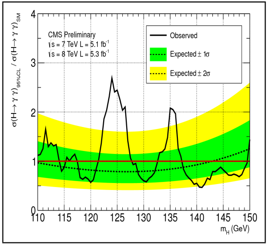


$\mathrm{H} \rightarrow \gamma\gamma$ (IV)-CMS

- Three analyses: BDT approach, cut-based approach, mass window approach
- Chosen BDT approach as default analysis due to its superior performance

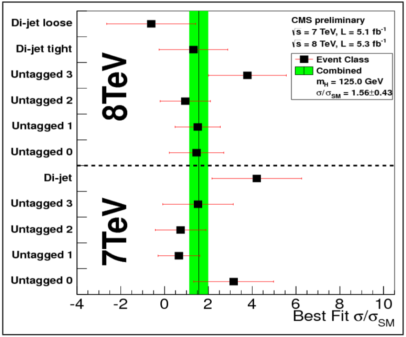




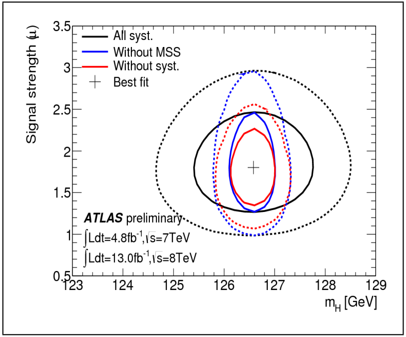


$H \rightarrow \gamma\gamma$ (V)

CMS



ATLAS



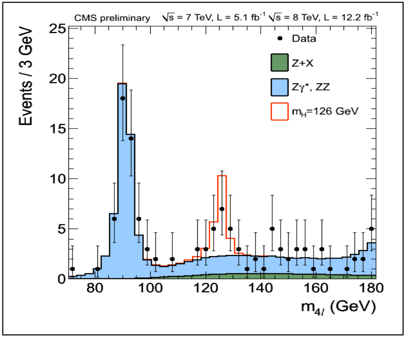
- Results consistent with a boson with mass ~125 GeV
- Both results are still largely statistical limited
- Much better precision will happen with larger amount of data

$\mathrm{H} \to ZZ4\ell$ (I)

- Four high p_{T} isolated leptons from the same vertex
- Good mass resolution
- Very small signal rate, but high signal-to-background ratio
- Backgrounds:
  - ZZ continuum: almost irreducible, different mass shape
  - $Z + jets$, Zbb & $\mathrm{t\bar{t}}$: lepton isolation and impact parameter, to reject $b \to \ell X$ decays
- Additional help from kinematic discriminants

$\mathrm{H} \to ZZ4\ell$ (II)

CMS



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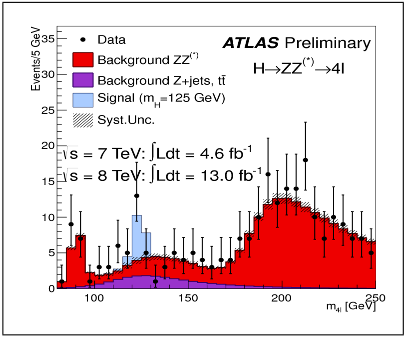
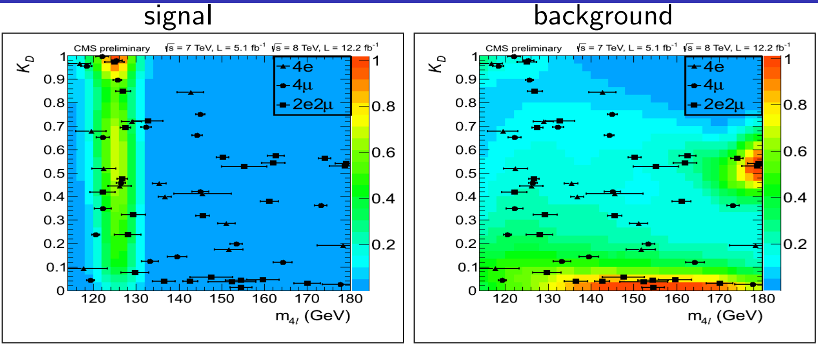


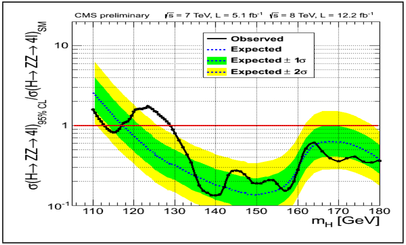
- Relatively clean mass peak around $\sim 125\ \mathrm{GeV}$
- $Z \to 4\ell$ peak well visible too

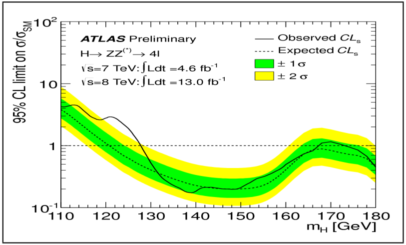
$\mathrm{H} \rightarrow ZZ4\ell$ (III)

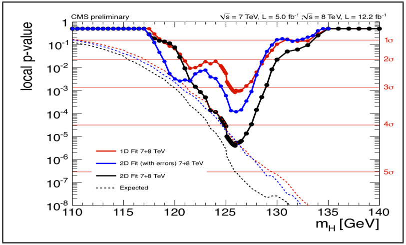


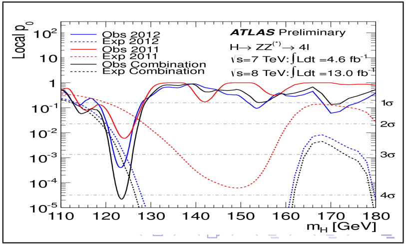
- Kinematic variable to further separate signal and background
- Make use of angular information
- Other approaches give comparable performance

$\mathrm{H} \to ZZ4\ell$ (IV)



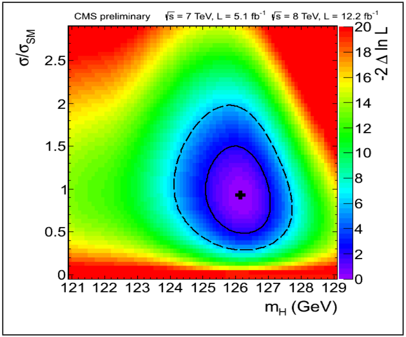




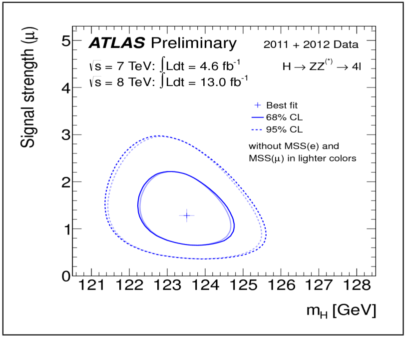


H $\rightarrow$ $ZZ4\ell$ (V)

CMS

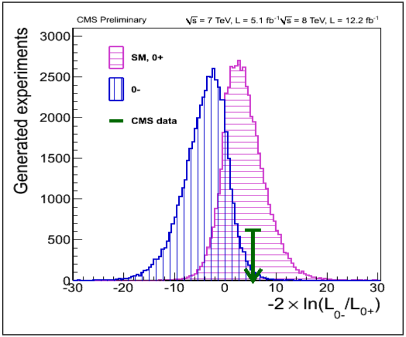


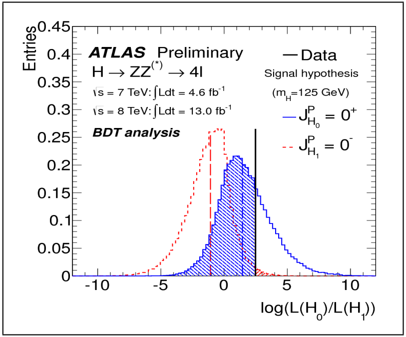
ATLAS



- Results consistent with a boson with mass $\sim$125 GeV
- Both results are still largely statistical limited

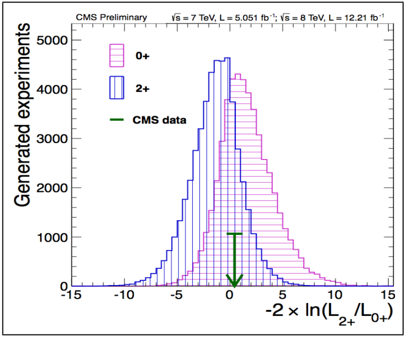
$\mathrm{H} \to ZZ4\ell$: Spin Separation (I)

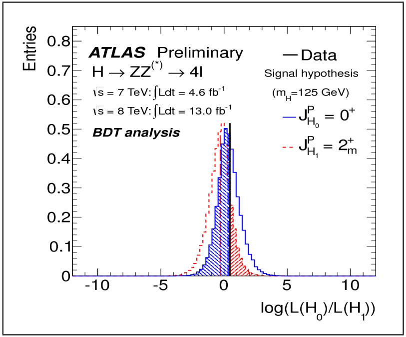




- Able to separate 0^+ & 0^- at the $\sim 2\sigma$ level

$\mathrm{H} \rightarrow ZZ4\ell$: Spin Separation (II)



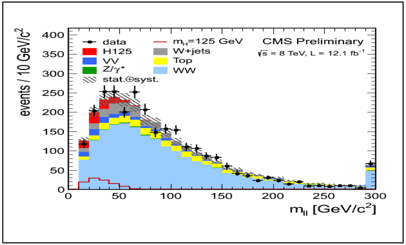


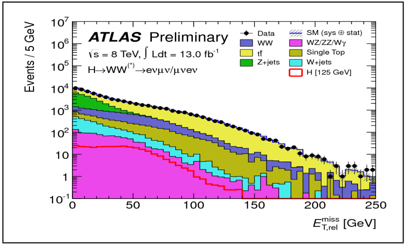
- Little sensitivity to separate 0^+ & 2^+

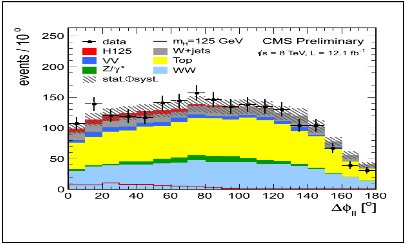
$\mathrm{H} \rightarrow WW \rightarrow 2\ell 2\nu$ (I)

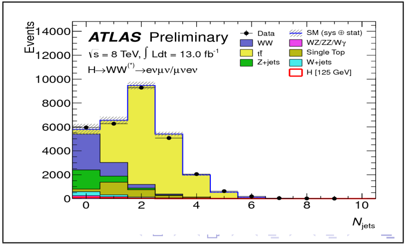
- Two high p_{T} isolated leptons and moderate $E_{\mathrm{T}}^{\mathrm{miss}}$
- Large $\sigma \times BR$
- No mass peak is the main drawback
- Controlling the background is the key
- Backgrounds: main discriminating variables
  - WW: $\Delta\phi_{\ell\ell}/m_{\ell\ell}$
  - $\mathrm{t\bar{t}}$: b-tagging, $\Delta\phi_{\ell\ell}/m_{\ell\ell}$
  - $Z \rightarrow \ell\ell$: $E_{\mathrm{T}}^{\mathrm{miss}}$, $\Delta\phi_{\ell\ell}/m_{\ell\ell}$
  - $W + jets$: lepton id
  - WZ/ZZ: more than 2 leptons in the final state, $E_{\mathrm{T}}^{\mathrm{miss}}$
- Categories:
  - 0-jet, 1-jet, VBF
  - different-flavor, same-flavor

$\mathrm{H} \rightarrow WW \rightarrow 2\ell 2\nu$ (II)

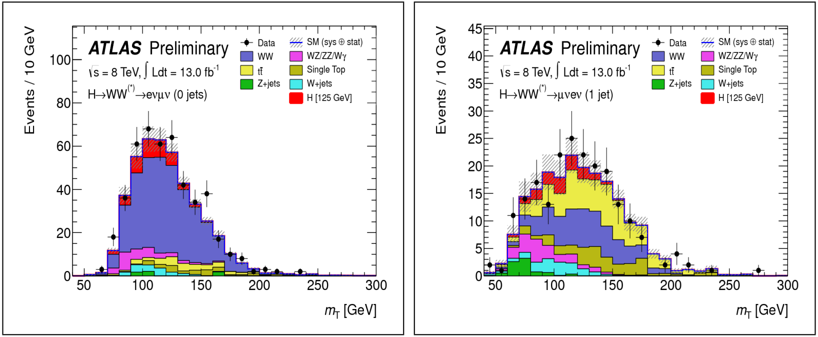






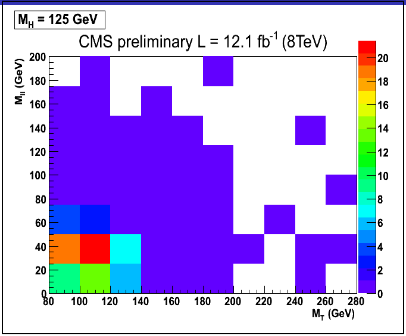


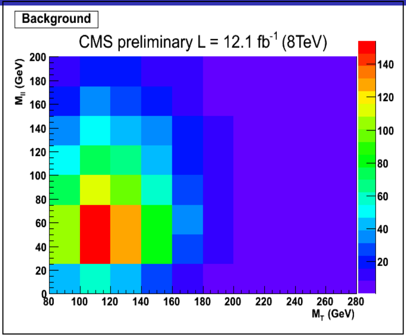
$\mathrm{H} \rightarrow WW \rightarrow 2\ell 2\nu$ (III)-ATLAS



- m_T distribution used as final discriminant variable

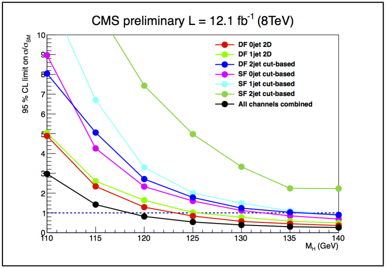
$\mathrm{H} \rightarrow WW \rightarrow 2\ell 2\nu$ (III)-CMS

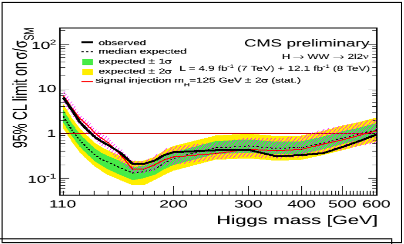


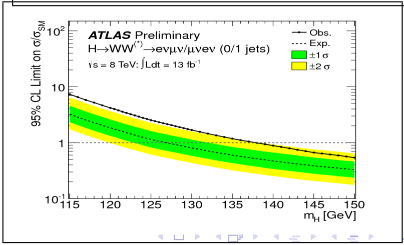


- Make use 2D $m_{\ell\ell}$-m_T variable for different-flavor 0/1-jet bins, cut-based approach otherwise
- Signal and backgrounds behave differently on the 2D plane
- Data able to partially constrain backgrounds

$\mathrm{H} \to WW \to 2\ell 2\nu$ (IV)



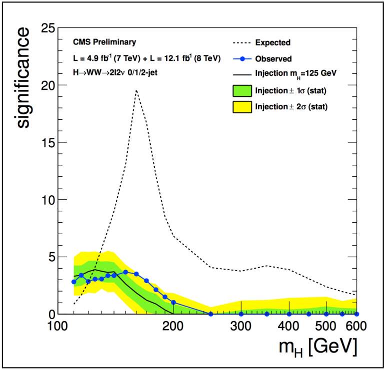




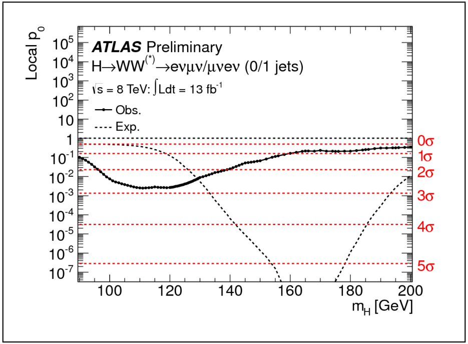
- Performance comparison among the different exclusive final states
- Worse observed limits than expectation, compatible with $m_H \sim 125$ GeV

$\mathrm{H} \rightarrow WW \rightarrow 2\ell 2\nu$ (V)

CMS



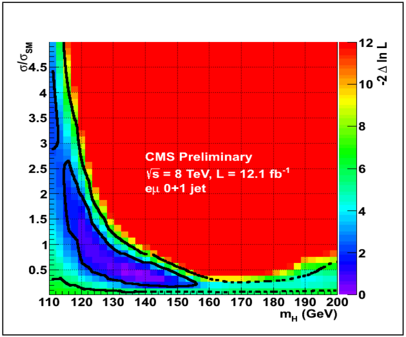
ATLAS

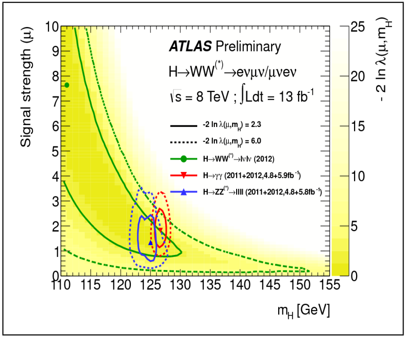


- $\sim 3.1(4.1)\sigma$ observed (expected) significance at $m_H \sim 125$ GeV
- $\sim 2.8(1.9)\sigma$ observed (expected) significance at $m_H \sim 125$ GeV

$\mathrm{H} \to WW \to 2\ell 2\nu$ (VI)

Confidence intervals in the $(\mu,\ m_{\mathrm{H}})$ plane

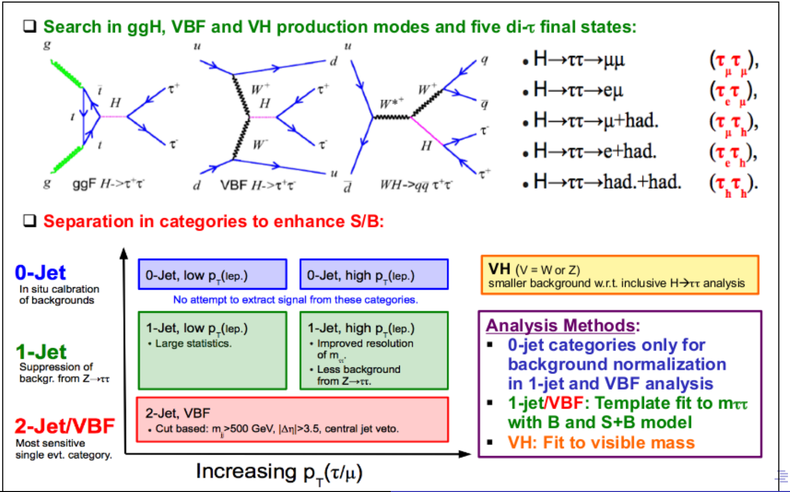




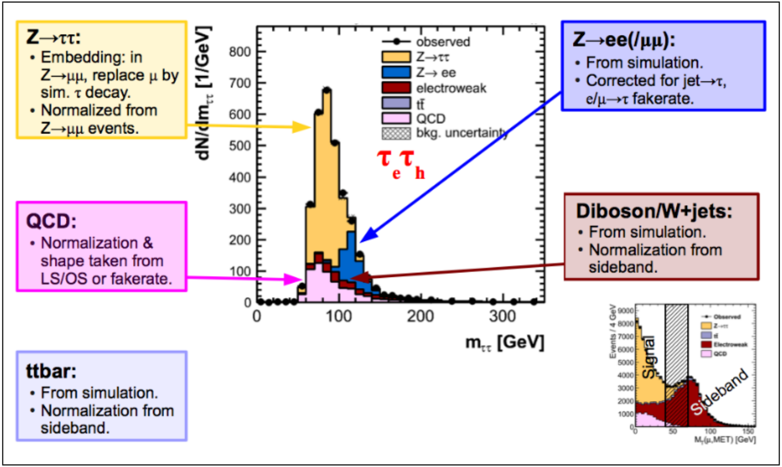
- Consistent with $m_H \sim 125\ \mathrm{GeV}$
- Low mass resolution gives a very shallow likelihood profile as a function of m_{H}

Fermionic Decays: lower sensitivity channels

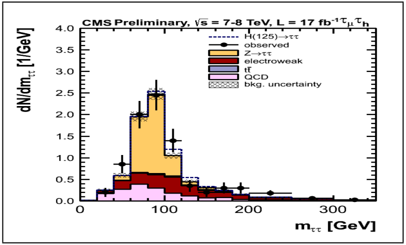
$\mathrm{H} \rightarrow \tau\tau$ (I)

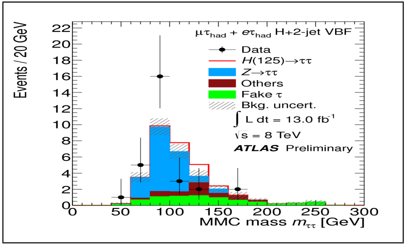


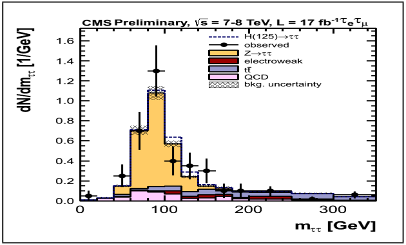
$H \to \tau\tau$ (II)

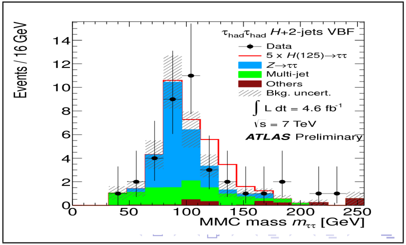


$\mathrm{H} \rightarrow \tau\tau$ (III)

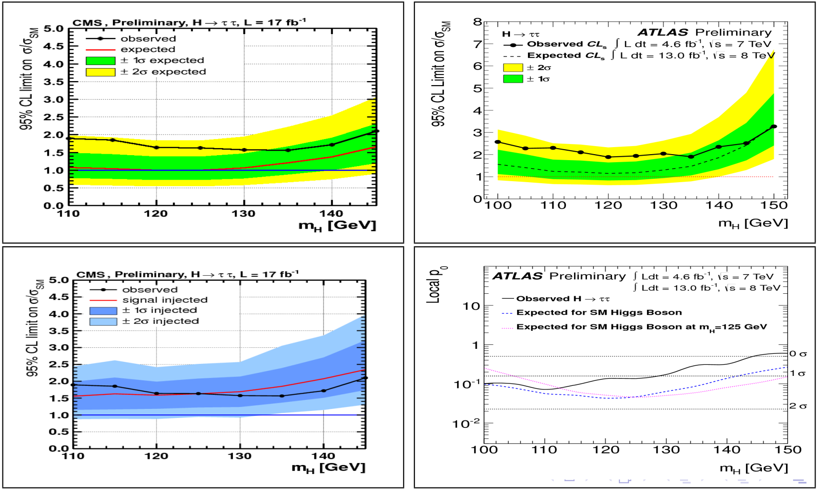




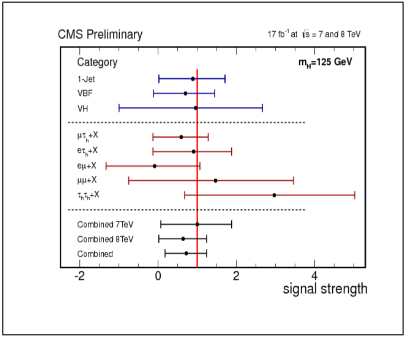


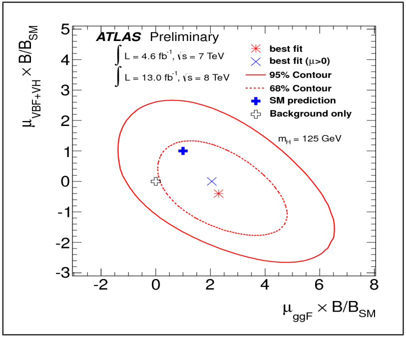


$H \to \tau\tau$ (IV)



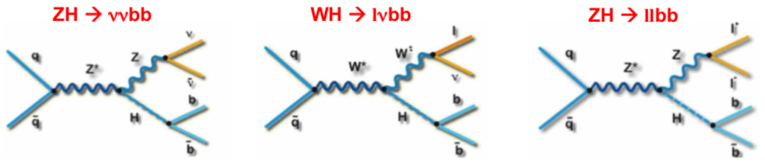
$\mathrm{H} \rightarrow \tau\tau$ (V)

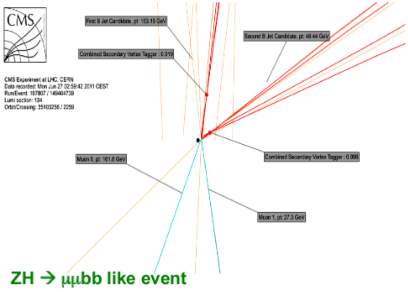




- Consistent with $m_H \sim 125$ GeV and background-only for now
- Larger dataset and/or further improvements are needed to make a conclusion

$H \rightarrow b\bar{b}$ (I)

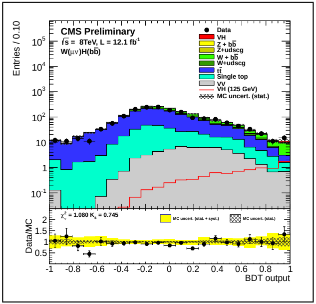




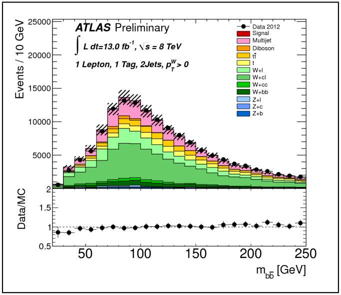
- Largest number of Higgs decays at low mass but Lots of background (jets)
- Trigger based on leptons and missing *ET*
- *b-jets* identified through displaced tracks go to high p_T where Higgs is enhanced
- Main background: W/Z+jets and top

$\mathrm{H} \rightarrow b\bar{b}$ (II)

CMS



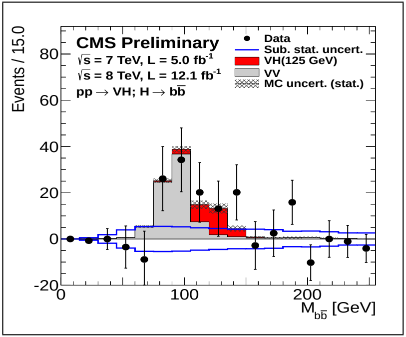
ATLAS

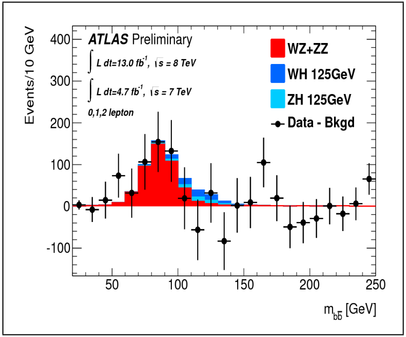


- Relatively tight preselection
- b-jet regression to improve mass resolution
- BDT as a final variable

- Cut-based approach
- Split in several exclusive categories: $E_{\mathrm{T}}^{\mathrm{miss}}$ $(Z(\nu\nu)H)$, p_{T}^{W} $(W(\ell\nu)H)$, p_{T}^{Z} $(Z(\ell\ell)H)$

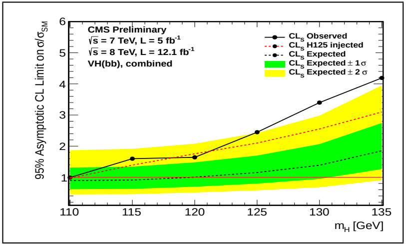
$\mathrm{H} \rightarrow b\bar{b}$ (III)

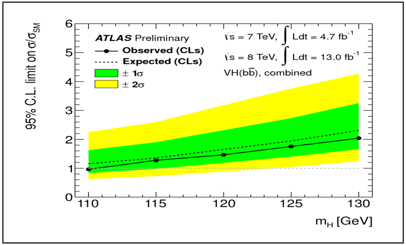


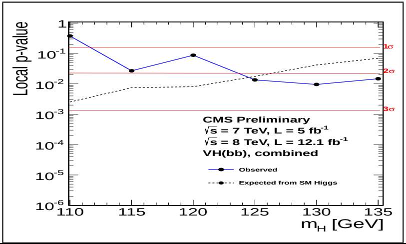


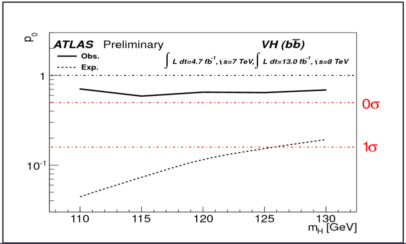
- Both experiments see evidence of $WZ/ZZ \rightarrow b\bar{b} + X$ production
- Mild excess compatible with $m_H \sim 125$ GeV in CMS

$\mathrm{H} \rightarrow b\bar{b}$ (IV)

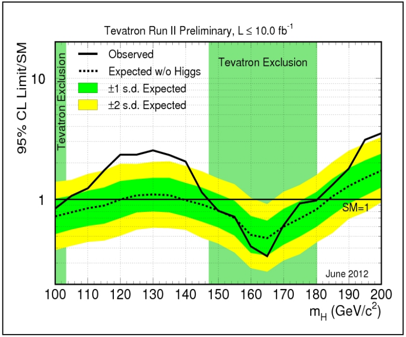


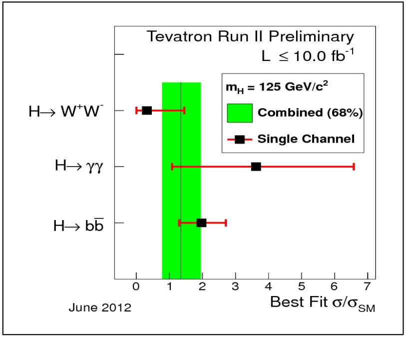






Higgs Searches at the Tevatron

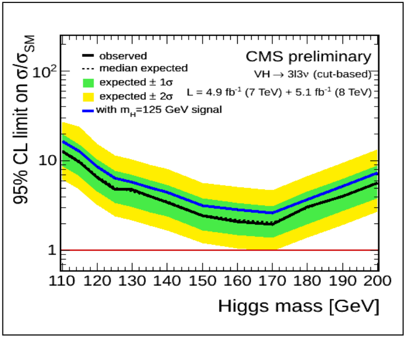


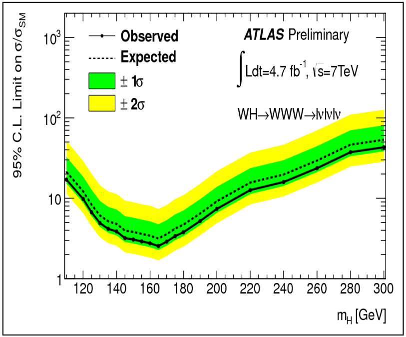


- $\mathrm{W/ZH},\ \mathrm{H} \rightarrow b\bar{b}$ most sensitive channels
- $\sim 3\sigma$ excess at $m_{\mathrm{H}} \sim 125\ \mathrm{GeV}$

Other Decays

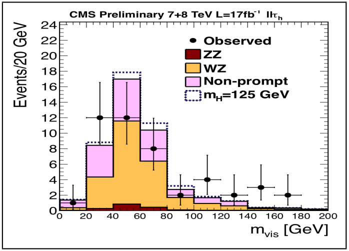
$WH \to WWW \to 3\ell 3\nu$

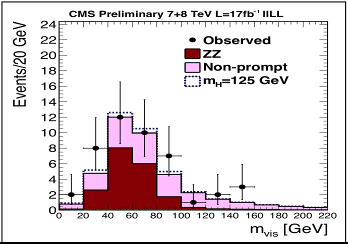




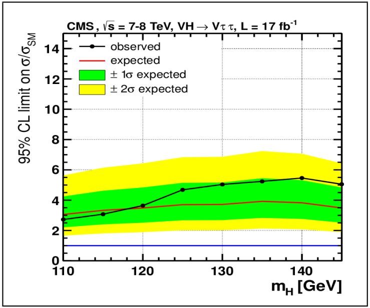
- Three high p_{T} isolated leptons with moderate $E_{\mathrm{T}}^{\mathrm{miss}}$
- Z veto and anti b-tagging to reject WZ and top events
- Most of backgrounds controlled from data

$W/ZH,\ H \to \tau\tau$

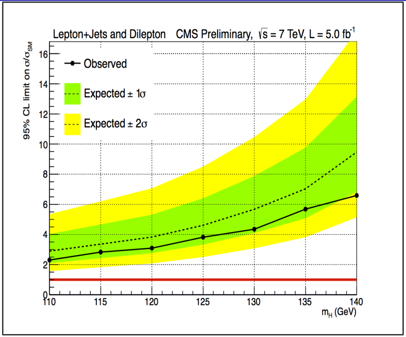


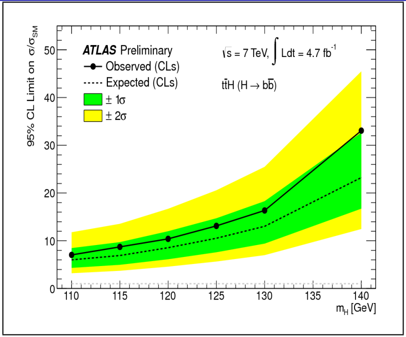


- Three/Four high p_T isolated leptons, at least one of them τ_h
- Using visible mass as final variable



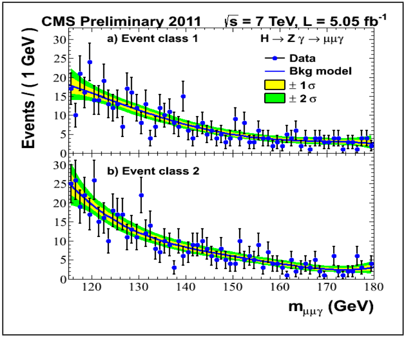
$t\bar{t}H,\ H \to b\bar{b}$

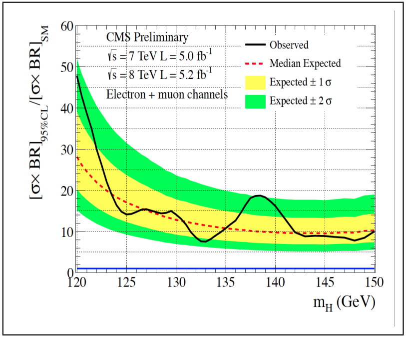




- Rather complicated analysis, low yields with large backgrounds
- CMS: several categories using a BDT as final variable
- ATLAS: several categories using $m_{b\bar{b}}$ as final variable

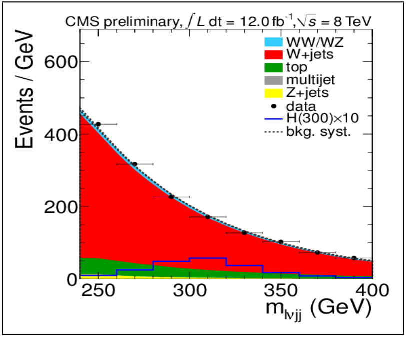
$H \to Z\gamma$

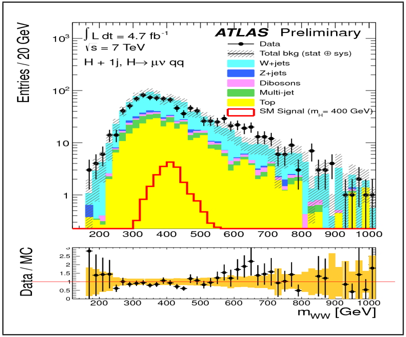




- $H \to Z\gamma \to 2\ell\gamma$: two leptons and one photon in the final state
- Relatively simple analysis, but very low expected signal yields
- Split in several categories to improve S/B and mass resolution

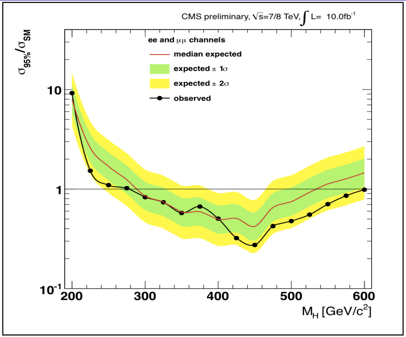
$H \rightarrow WW \rightarrow qq'\ell\nu$

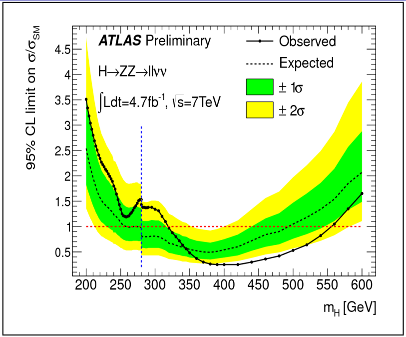




- One high p_{T} isolated lepton, at least 2-jets, and large $E_{\mathrm{T}}^{\mathrm{miss}}$
- Using $m_{qq'\ell\nu}$ as final variable
- No significant excess is seen

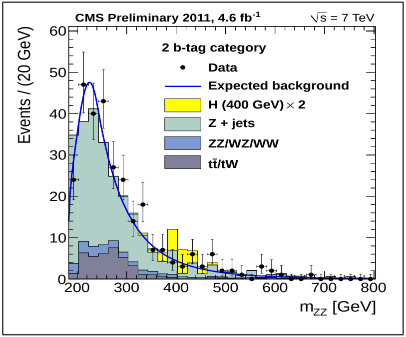
$(qq)H,\ H \to ZZ \to 2\ell 2\nu$

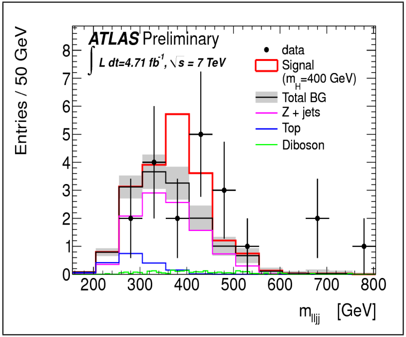




- Two leptons from a Z boson, large $E_{\mathrm{T}}^{\mathrm{miss}}$
- Using m_T as final variable
- Split in several categories: electrons/muons, 0/1/2-jets

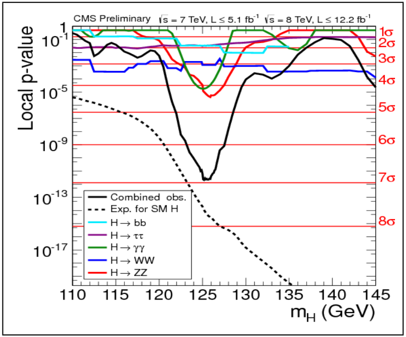
$H \to ZZ \to 2q2\ell$

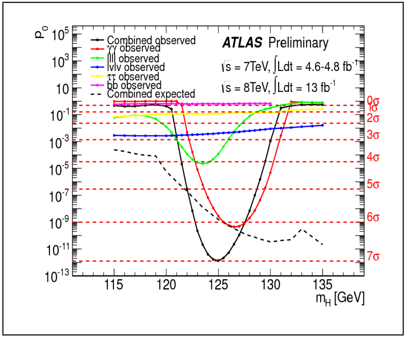




- Two leptons from a Z boson, two jets from another Z boson
- Using $m_{2q2\ell}$ as final variable
- Split in several categories: electrons/muons, 0/1/2 b-jets

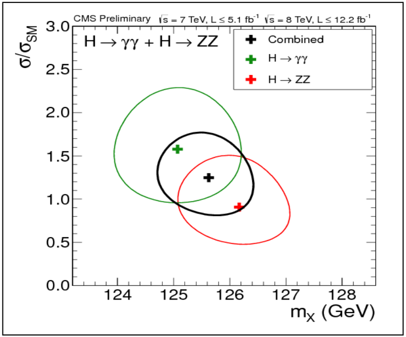
Significance

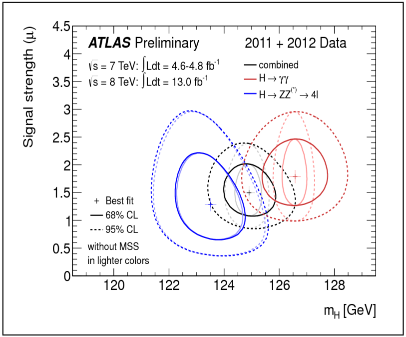




- CMS at $m_{\mathrm{H}} = 125$ GeV: ∼6.9/7.8 observed/expected
- ATLAS at $m_{\mathrm{H}} = 125$ GeV: ∼7.0/6.0 observed/expected

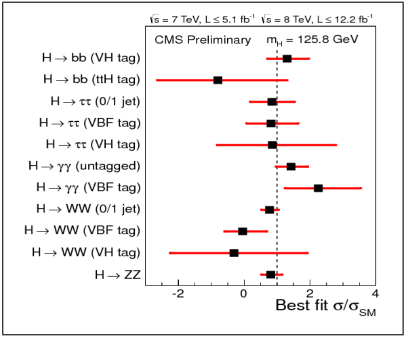
Mass

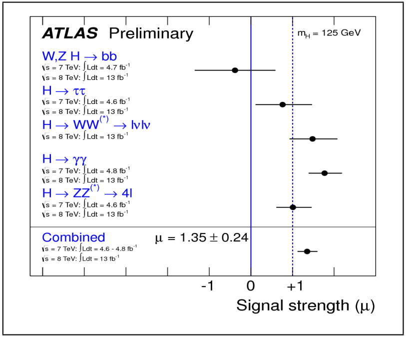




- CMS: $125.8 \pm 0.4\ (stat.) \pm 0.4\ (syst.)$ GeV
- ATLAS: $125.2 \pm 0.3\ (stat.) \pm 0.6\ (syst.)$ GeV

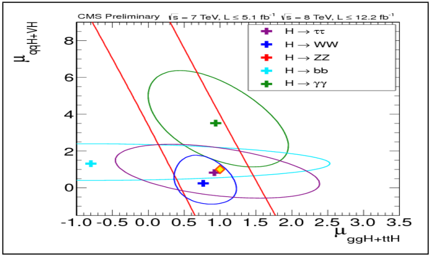
σ/σ_{SM}

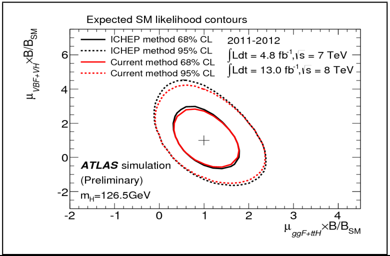


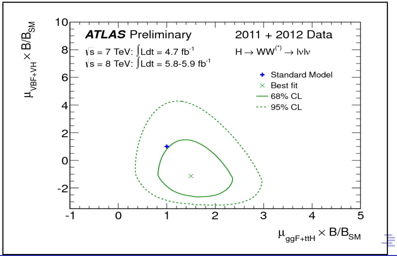


- Signal strength compatible with SM prediction
- Fermionic final state don't have enough sensitivity to claim its observation

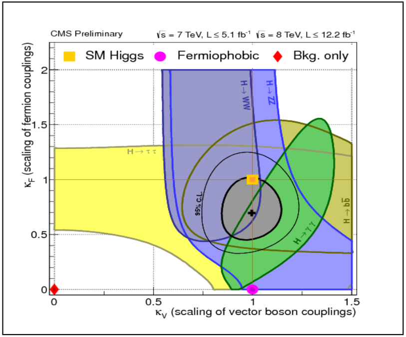
Production Mechanics

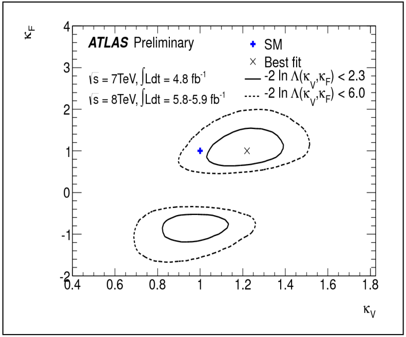






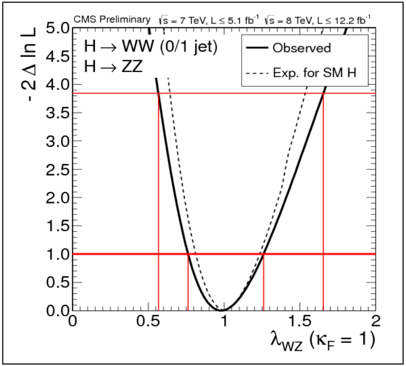
Couplings

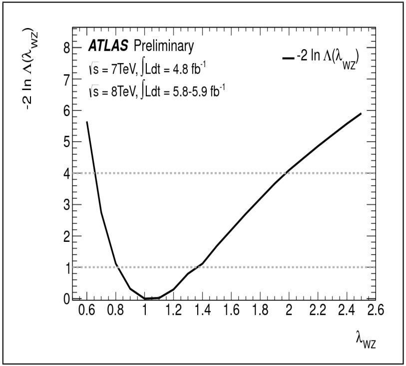




- Far from background-only value
- Best fit values compatible with SM Higgs expectation

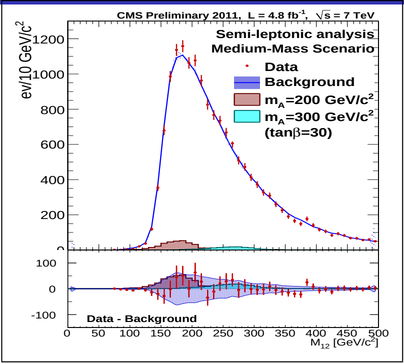
$\lambda_{WZ} = \kappa_W / \kappa_Z$

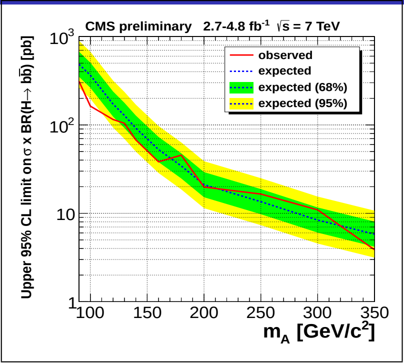




- Well compatible with SM prediction

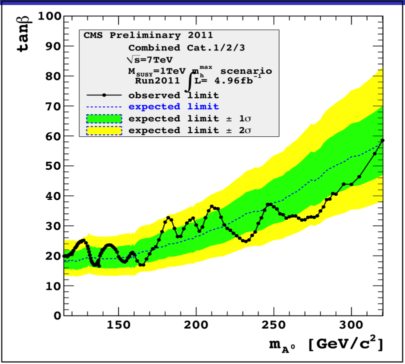
MSSM $b(b)\mathrm{H},\ \mathrm{H} \rightarrow b\bar{b}$

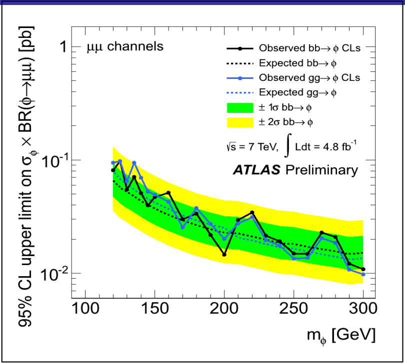




- Multijet final states with three b-tagged jets
- Invariant mass of the two leading b-jets used as a final variable
- Limits as a function of m_A and $tan\beta$

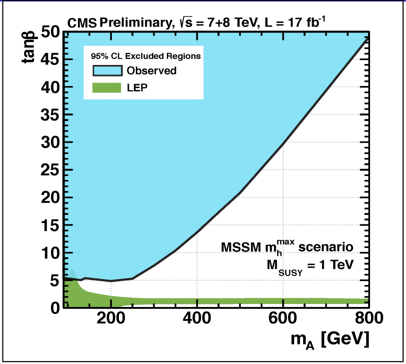
MSSM H $\rightarrow \mu\mu$

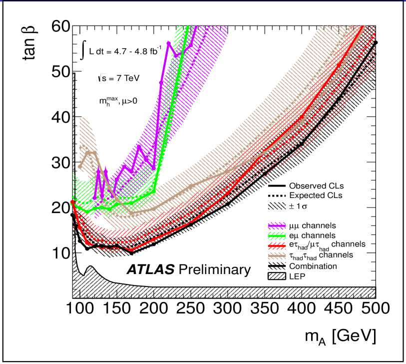




- Sensitive to production in association with a b quark pair and via gluon-gluon fusion
- $m_{\mu\mu}$ is the final variable

MSSM $\mathrm{H} \to \tau\tau$





- Sensitive to production in association with a b quark pair and via gluon-gluon fusion
- Very similar analysis techniques as SM $\mathrm{H} \to \tau\tau$ search

Summary

- Found a SM Higgs-like particle at $m_{\mathrm{H}} \sim 125\ \mathrm{GeV}$
- Spin, parity, couplings... to be determined with more precision
- So far, all measurements statistically consistent with SM Higgs prediction
- Program to search for additional Higgs boson-like particles has just started
- No significant excess found in any beyond SM Higgs-like particle search