Latest LHC results on H boson and prospects for next runs

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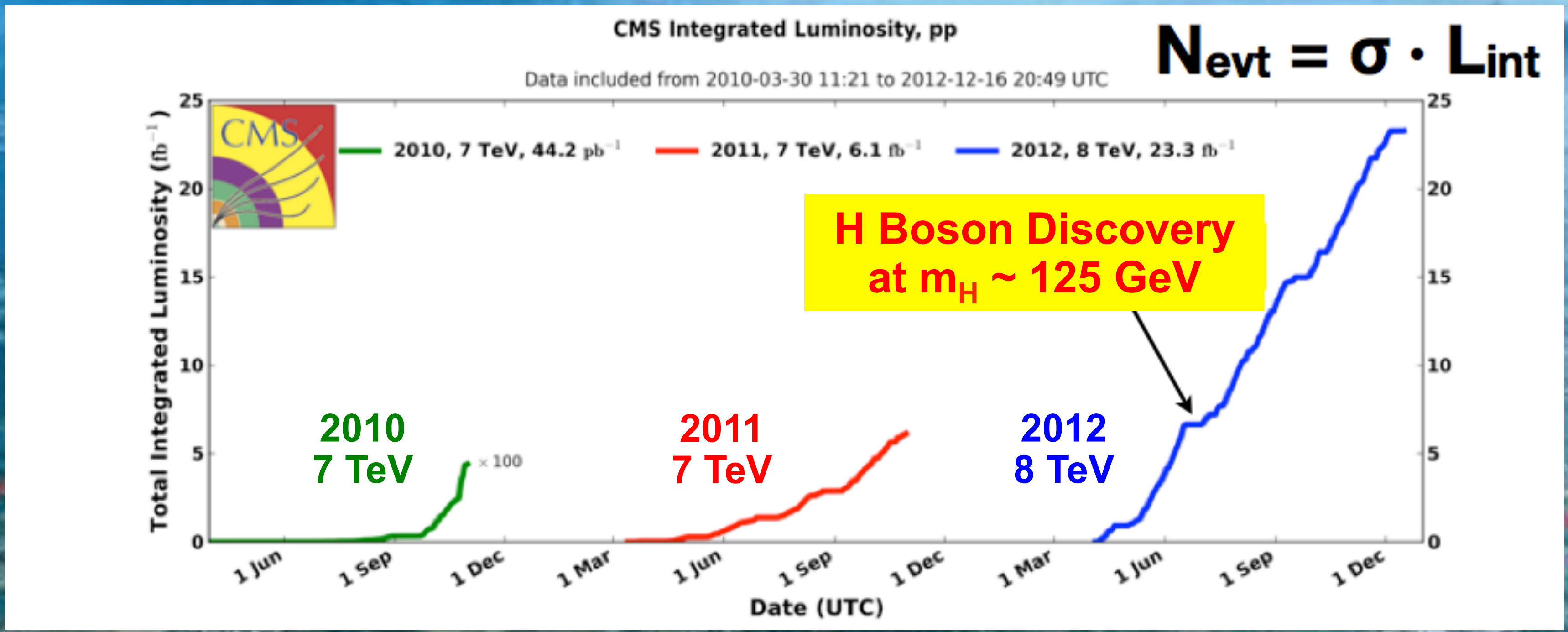
Workshop on Scalar Sector in Belgium
IIHE (ULB/VUB) – January 23/24th 2014

The Large Hadron Collider @ CERN

Proton-proton collisions at 7 TeV (2010/11) & 8 TeV (2012) and 13-14 TeV after 2013/14 upgrade

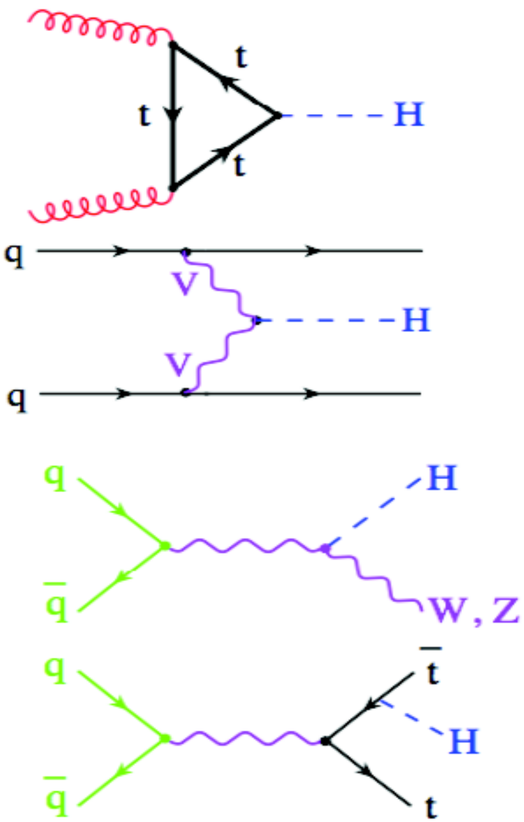


8 TeV	LS1	13-14 TeV →	LS2		LS3	HL-LHC
2012	2013	2014	2015 | 2016 | 2017	2018	2019 | 2020 | 2021	2022 | 2023	2024
$0.7 \times 10^{34} cm^{-2}s^{-1}$		$1 \times 10^{34} cm^{-2}s^{-1}$		$2 \times 10^{34} cm^{-2}s^{-1}$		$5 \times 10^{34} cm^{-2}s^{-1}$

The Nobel Prize in Physics 2013 was awarded jointly to François Englert and Peter W. Higgs *"for the theoretical discovery of a mechanism that contributes to our understanding of the origin of mass of subatomic particles, and which recently was confirmed through the discovery of the predicted fundamental particle, by the ATLAS and CMS experiments at CERN's Large Hadron Collider"*

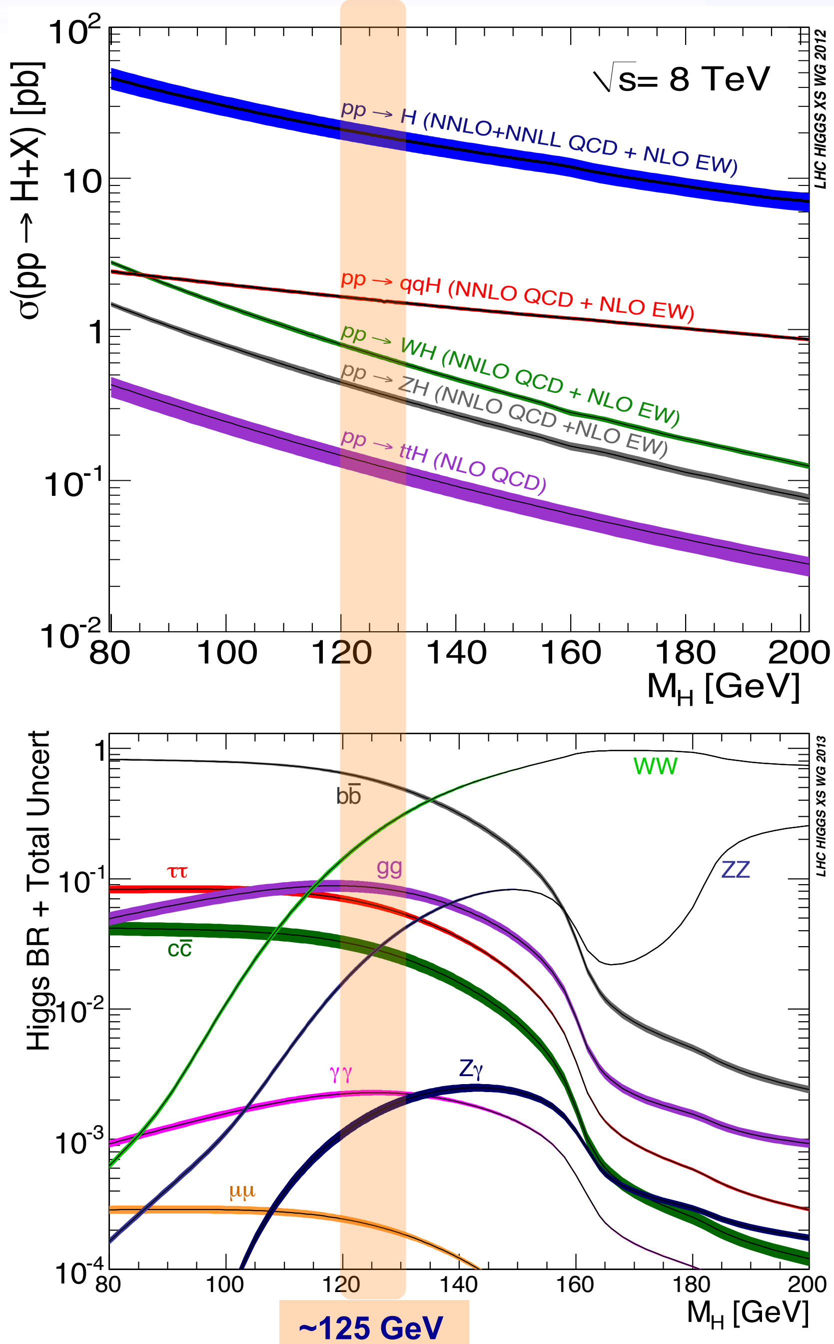
SM H Boson Production and Decay at LHC

- Gluon fusion
- VBF
- VH
- ttH



Gluon fusion (gg→H) it the dominant production mechanism at LHC but VBF, VH and ttH allow to test H properties.

WW and bb decays are largest contributions but γγ, ττ and ZZ decays important at low mass due to large SM irreducible backgrounds, …



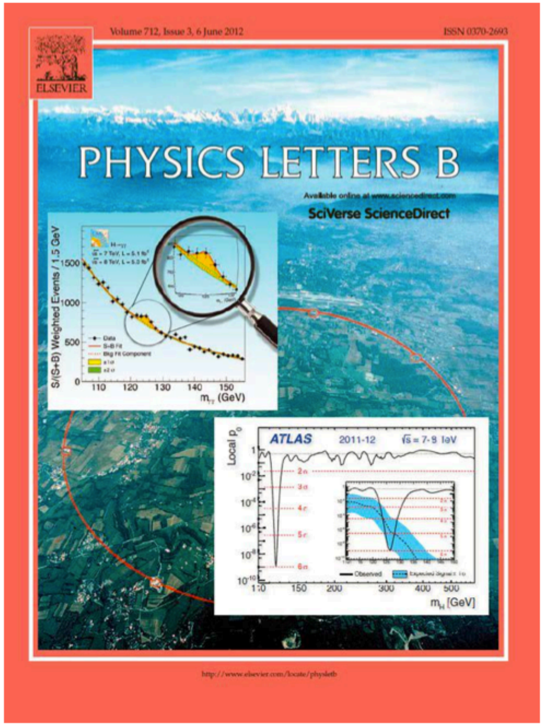
Beyond the observation of a new boson @ 125 GeV

Results from "July 4th 2012" discovery papers:

	CMS	ATLAS
Local p-value	5.0 σ + Nothing else significant	6.0 σ + Nothing else significant
Mass [GeV]	125.3 ± 0.4 (stat.) ± 0.5 (syst.)	126.0 ± 0.4 (stat.) ± 0.4 (syst.)
Signal Strength	0.87 ± 0.23	1.4 ± 0.3

→ **Compatible with Standard Model expectation**

Phys. Lett. B 716 (2012)



But is it THE Standard Model H boson ?

- ❑ Does it decay to fermions (τ, b) as expected in the SM ?
- ❑ Are all the couplings (γ, W, Z, t, b, gluons, …) SM-like ?
- ❑ What are its quantum numbers (Spin and CP) ?
- ❑ What about individual production mechanism strength (gg, VBF, VH, ttH) ?

→ CMS/ATLAS have been answering these questions in the last year … and seek for high precision at Run-2/3/4

- ❑ Is there more H bosons ?

→ First searches by ATLAS/CMS available … more to come in next year(s) and LHC runs

Sensitive H boson channels @ 125 GeV

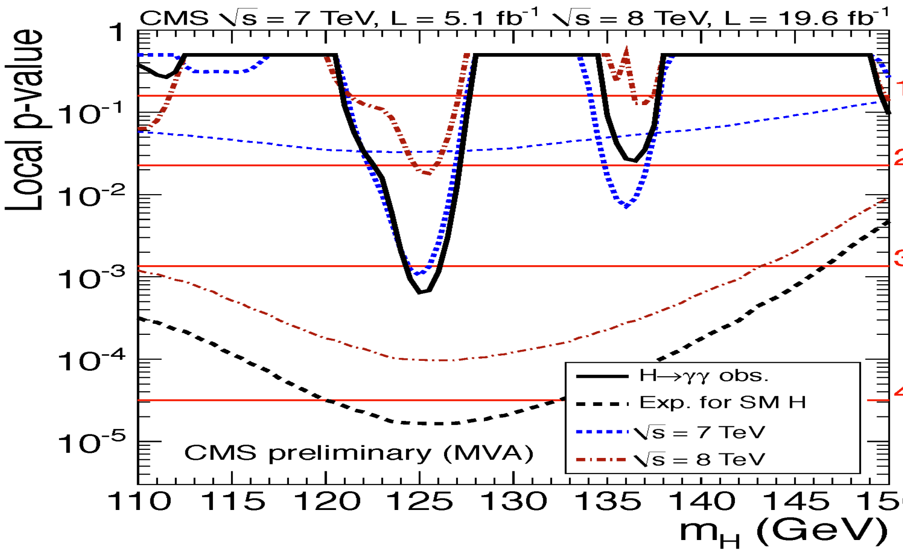
Measure rate of Higgs events with different production and decay combinations.
Cross-contamination of production and decay channels in categories.

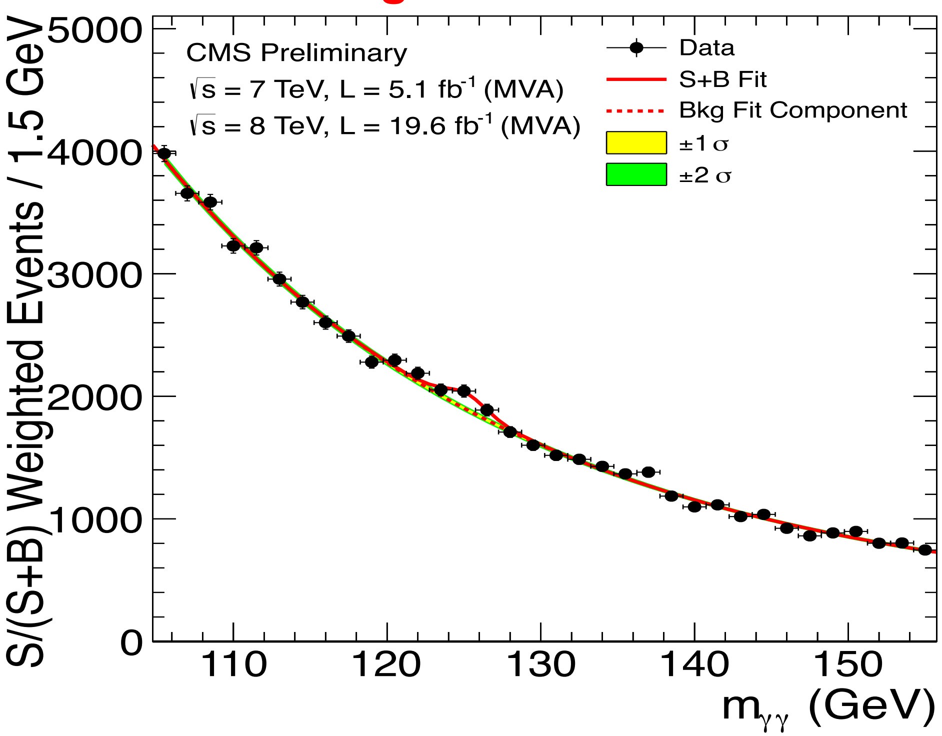
	untagged	jet-tag	VBF	VH	ttH
$H \rightarrow \gamma\gamma$	used				
$H \rightarrow WW \rightarrow 2l2\nu$	←	UA	→		
$H \rightarrow ZZ \rightarrow 4l$		possible			
$H \rightarrow bb$			UA	UCL	
$H \rightarrow \tau\tau$				ULB/UCL	
$H \rightarrow Z\gamma$					
$H \rightarrow \mu\mu$					
$H \rightarrow$ invisible				UCL/ULB	

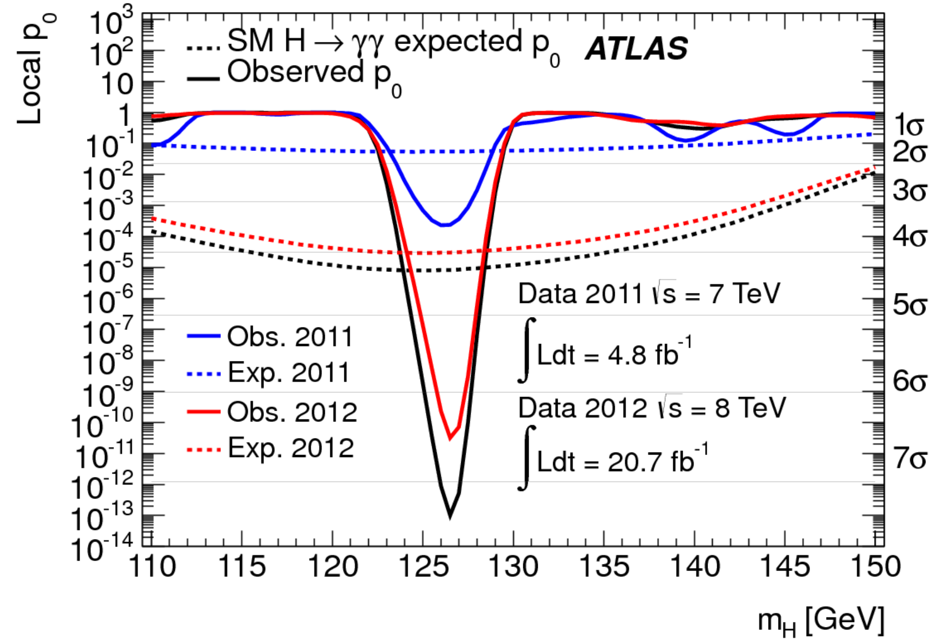
N.B.: ULB: $H \rightarrow ZZ \rightarrow 2l2n$ (high mass search) , UCL: $tH \rightarrow b$'s → talks this afternoon/tomorrow

H → γγ

- Analysis separated in several di-photon categories to exploit different S/B ratio.
- Dedicated VBF categories: 2 jets well separated in pseudo-rapidity
- Background shape fitted from the data $m_{\gamma\gamma}$ invariant mass → search for narrow peak resonance on top of smooth background





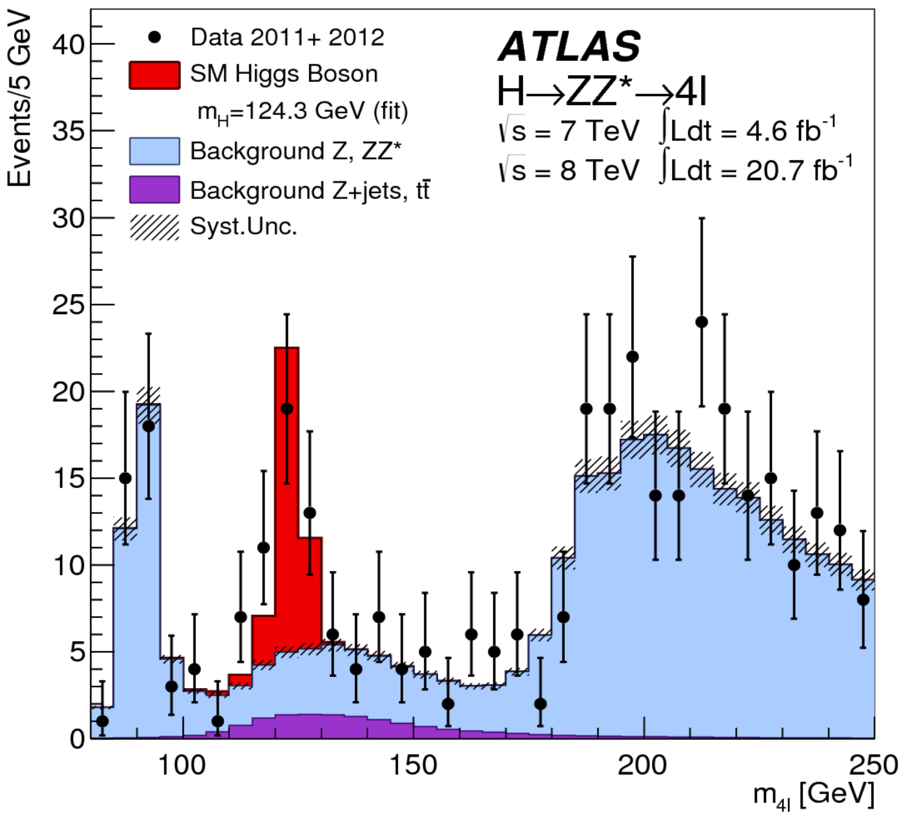


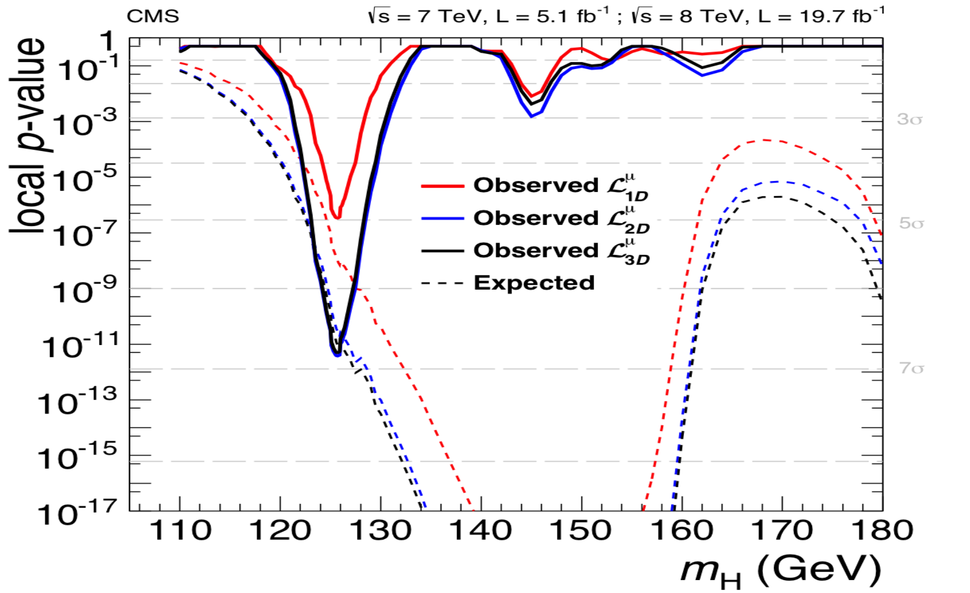
→ 3.2 σ evidence by CMS and 7.4 σ observation by ATLAS @ ~125 GeV

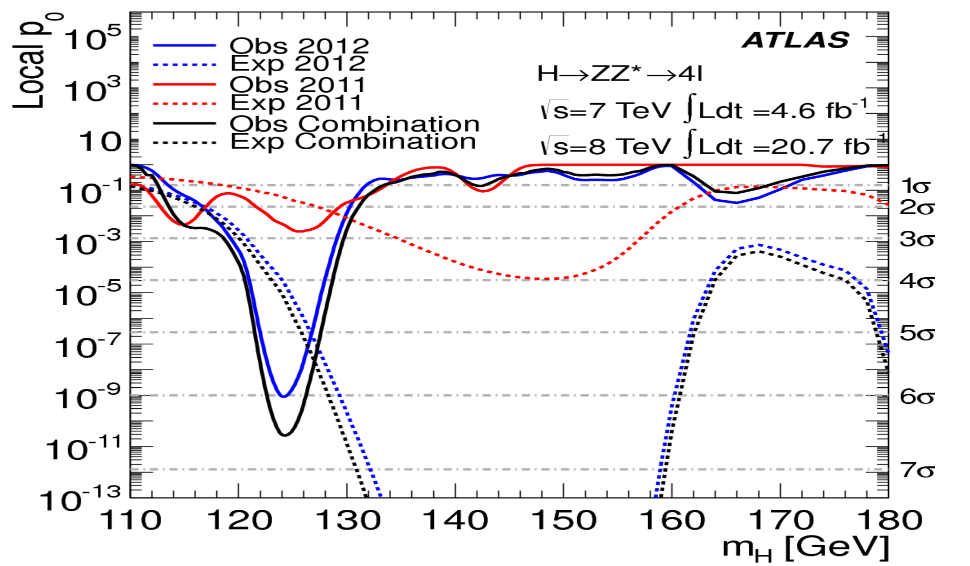
H → ZZ → 4l

CMS: arXiv/1312.5353
ATLAS: Phys. Lett. B 726 (2013) 88-119

- Search for a narrow peak in 4-leptons (e,μ) invariant mass
- Low background from Z, ZZ and Z+jets
- Use kinematic discriminant and/or categorization to enhance S/B separation





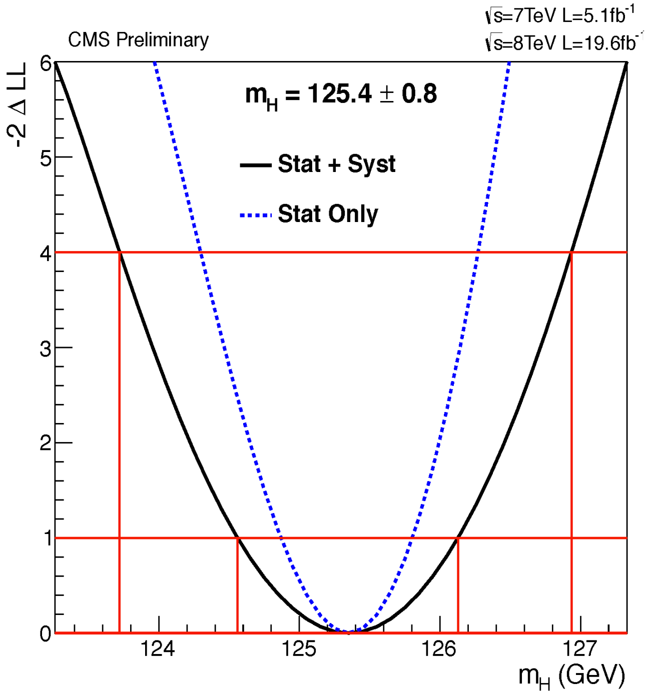


→ **Observation by ATLAS (6.6 σ) and CMS (6.8 σ) @ 125 GeV**

Mass measurements

CMS H→γγ

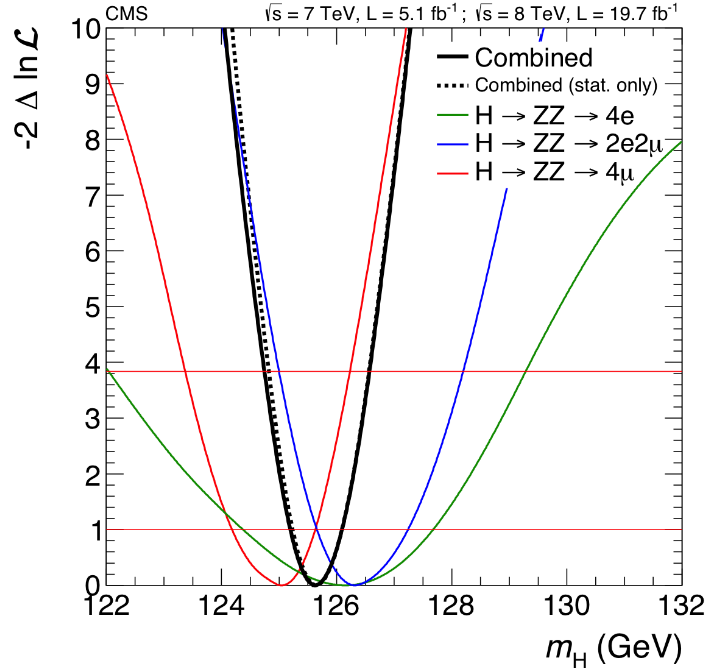
HIG-PAS-13/001



→ **126.8 ± 0.2 (stat) ± 0.7 (syst) GeV**

CMS H→ZZ→4l

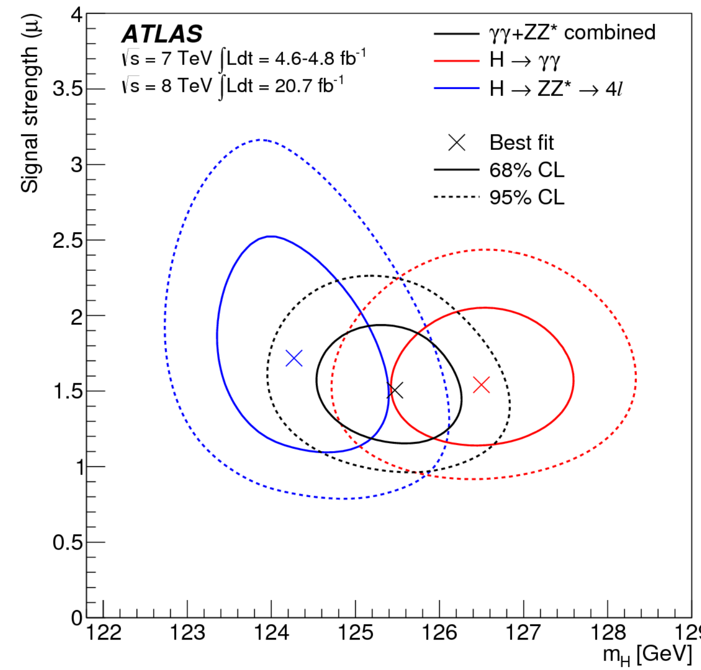
arXiv/1312.5353



→ **125.6 ± 0.4 (stat) ± 0.2 (syst) GeV**

ATLAS H→γγ & H→ZZ→4l

Phys. Lett. B 726 (2013) 88-119



ZZ: $126.8 \pm 0.2(\text{stat}) \pm 0.7(\text{sys})$ GeV

γγ: $124.3^{+0.6}_{-0.5}(\text{stat})^{+0.5}_{-0.3}(\text{sys})$ GeV

→ **ATLAS ZZ+γγ combination:**

$125.5 \pm 0.2(\text{stat})^{+0.5}_{-0.6}(\text{sys})$ GeV.

→ **CMS ZZ+γγ combination to be done …**

→ **“Overall agreement” on m_H**

H → WW → 2l2ν

CMS: arXiv/1312.1129
ATLAS: Phys. Lett. B 726 (2013) 88-119

0/1-jet H→WW→ 2l2ν DF Analysis

- **2 isolated (eμ/μe) leptons: p_T >10 ,20 GeV**
- **$p_{T,ll}$ > 30 GeV**
- **Missing E_T > 20 GeV**
- **Top veto: Jet b-tag + no soft μ**
- **Jet counting for |η|<4.7 and p_T>30 GeV**

Background from data driven techniques

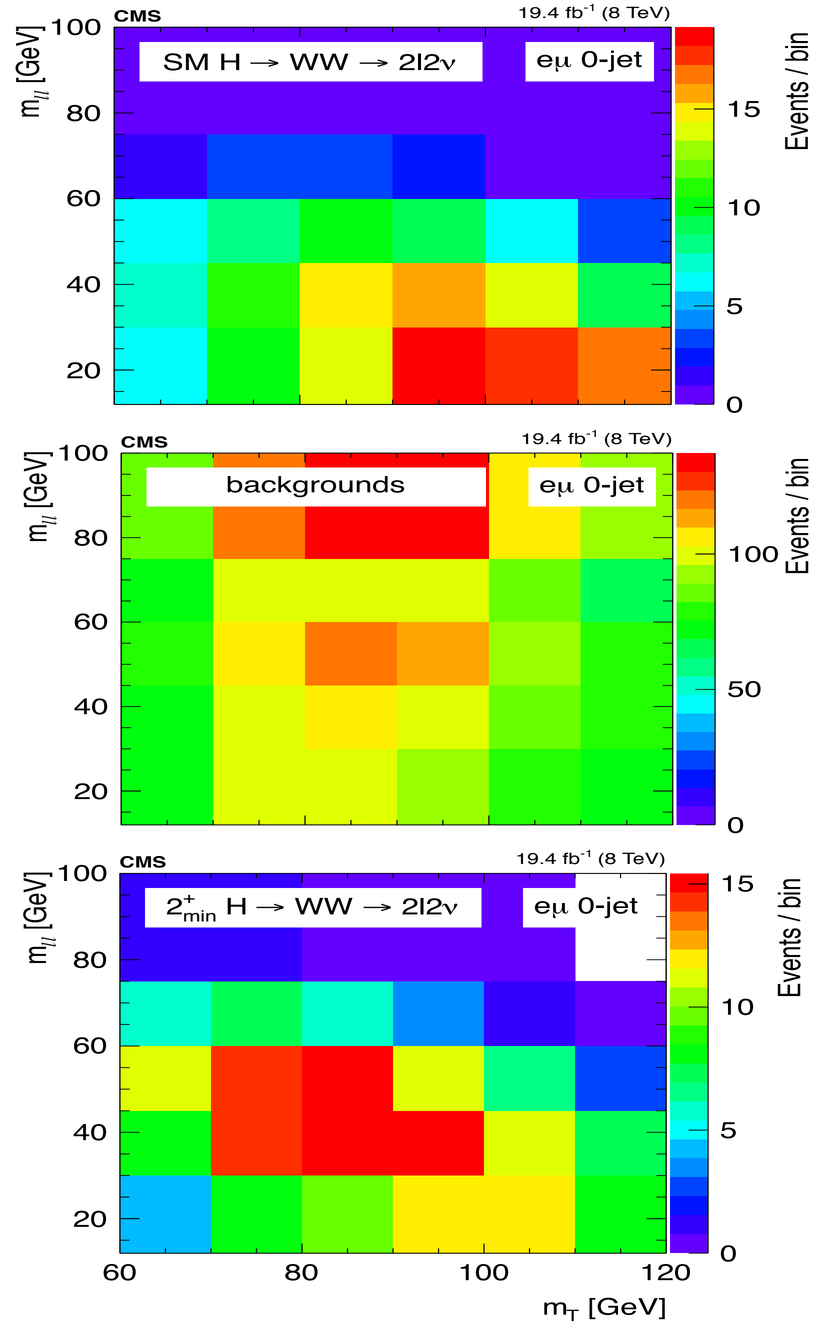
- W+jets (fake rate method)
- Top (estimated from control region)
- Wγ /Wγ* (MC shapes + data norm.)
- DY (estimated from control region)
- WW (estimated from control region)

Other backgrounds:

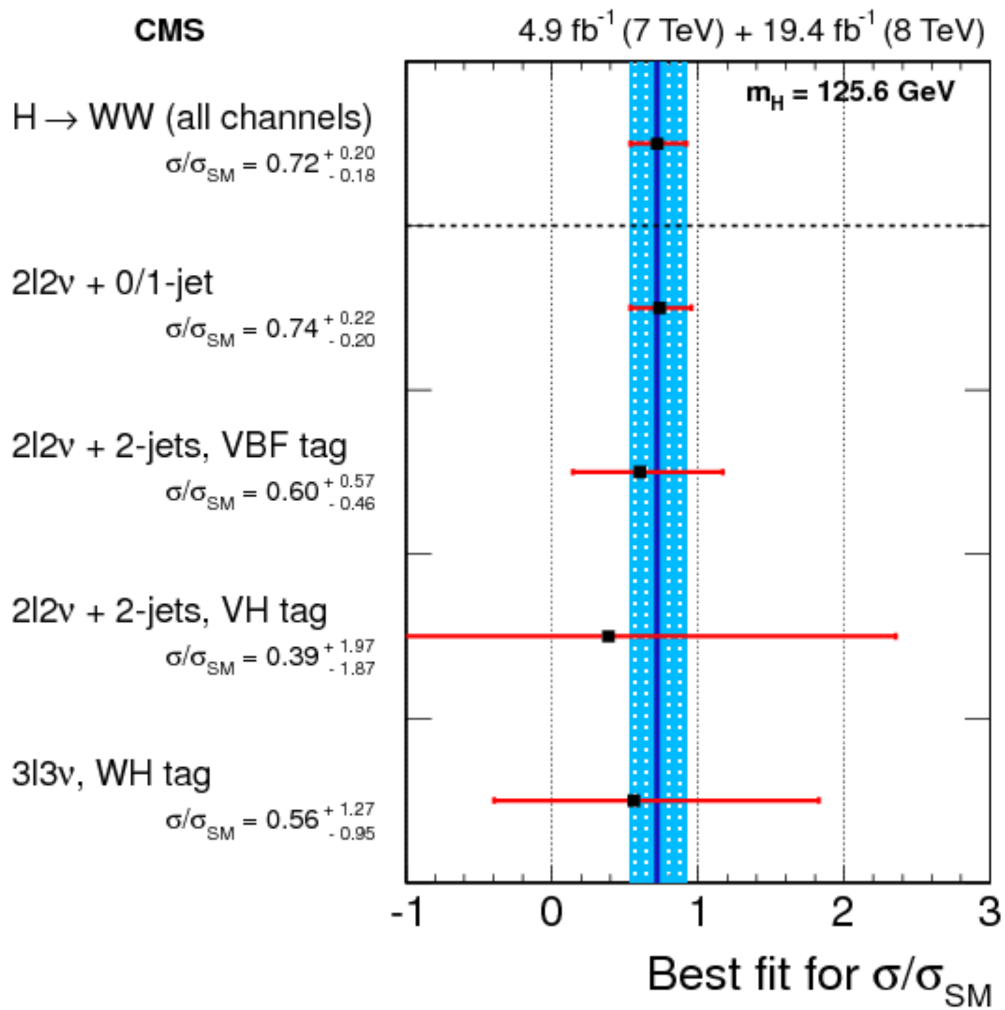
- ZZ/VZ/Tri-bosons → MC predictions

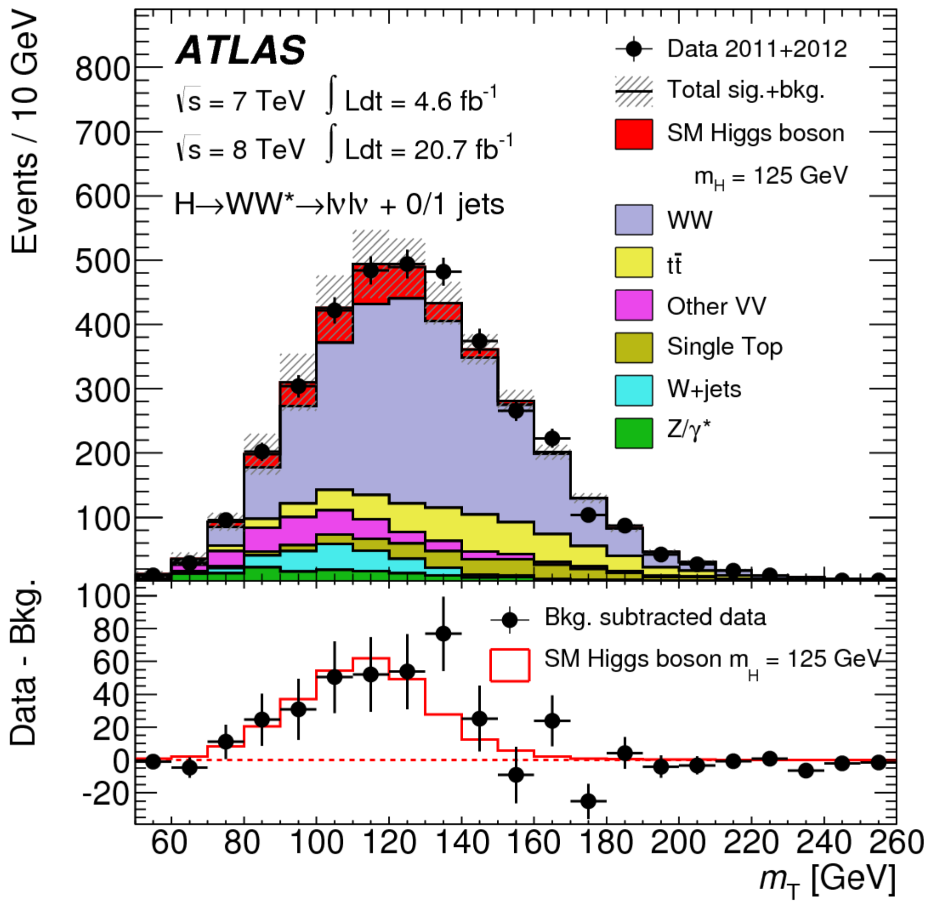
Signal Extraction

- **CMS: 2D Shape analysis**:
  - → m_T : Higgs boson transverse mass
  - → m_{ll} : di-lepton invariant mass
- **ATLAS: m_T 1D shape**



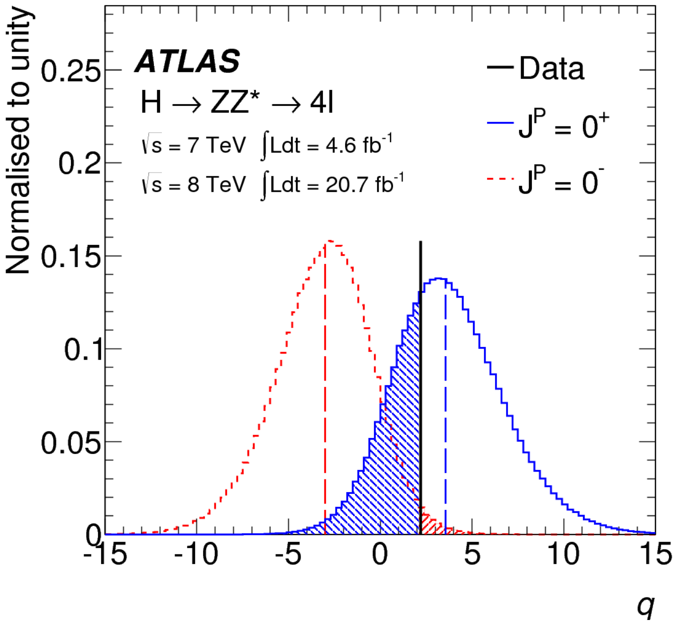
H → WW → 2l2ν

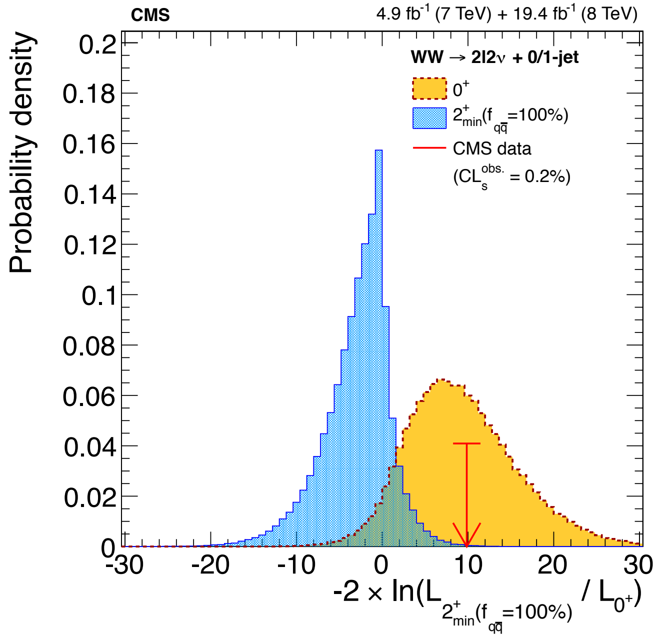


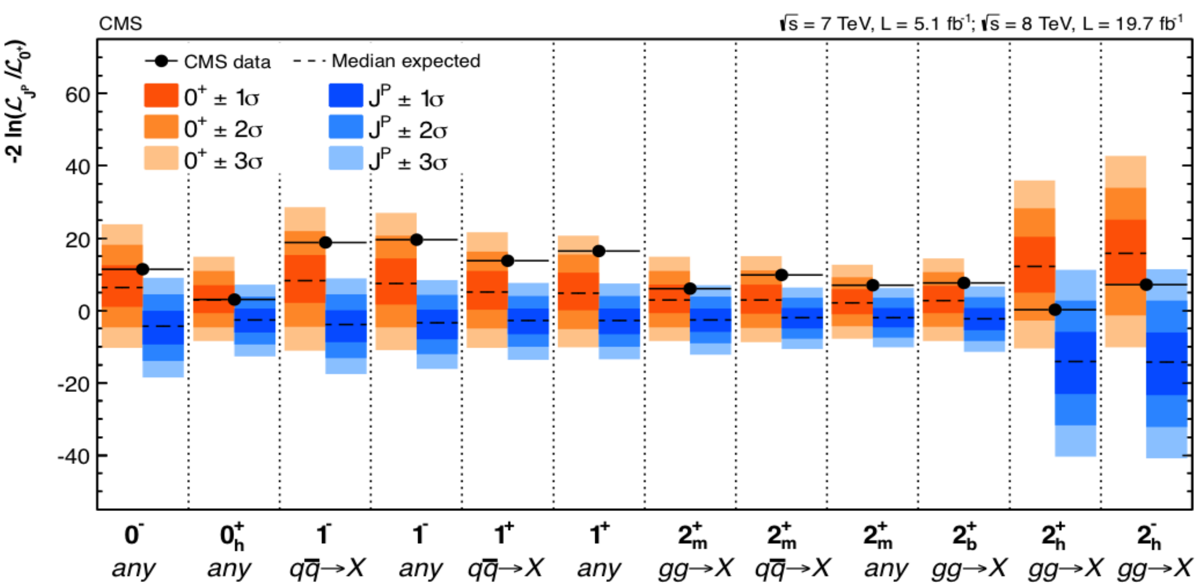


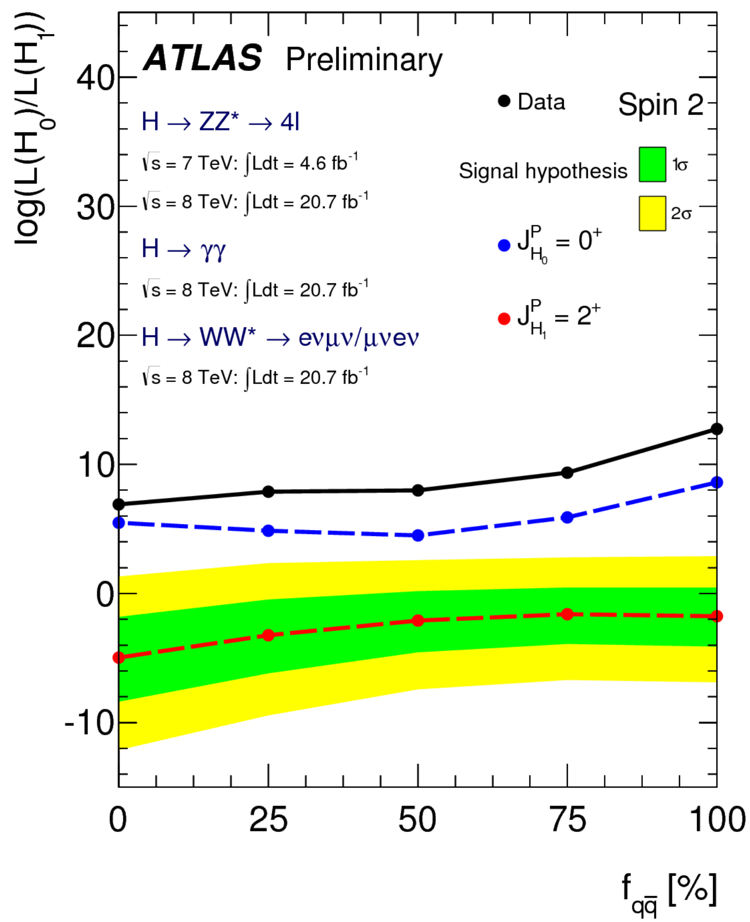
→ Evidence for H→WW→2l2ν by ATLAS (3.8 σ) and CMS (4.3 σ) @ 125 GeV

Spin/Parity





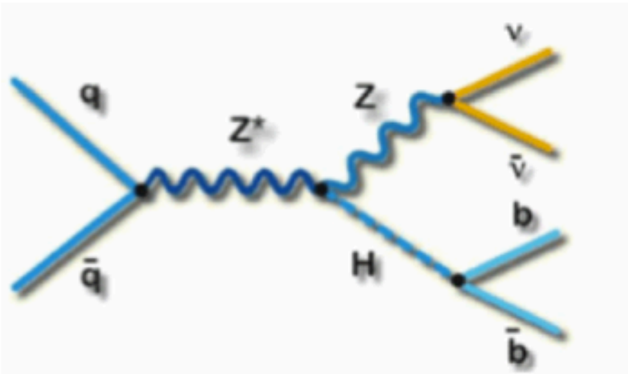




→ 0^+ is always favored hypothesis against all tested 0^-, $1^\pm$ and $2^\pm$ models

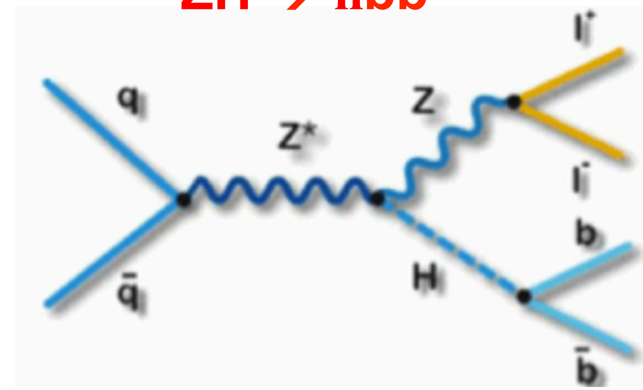
VH → bb

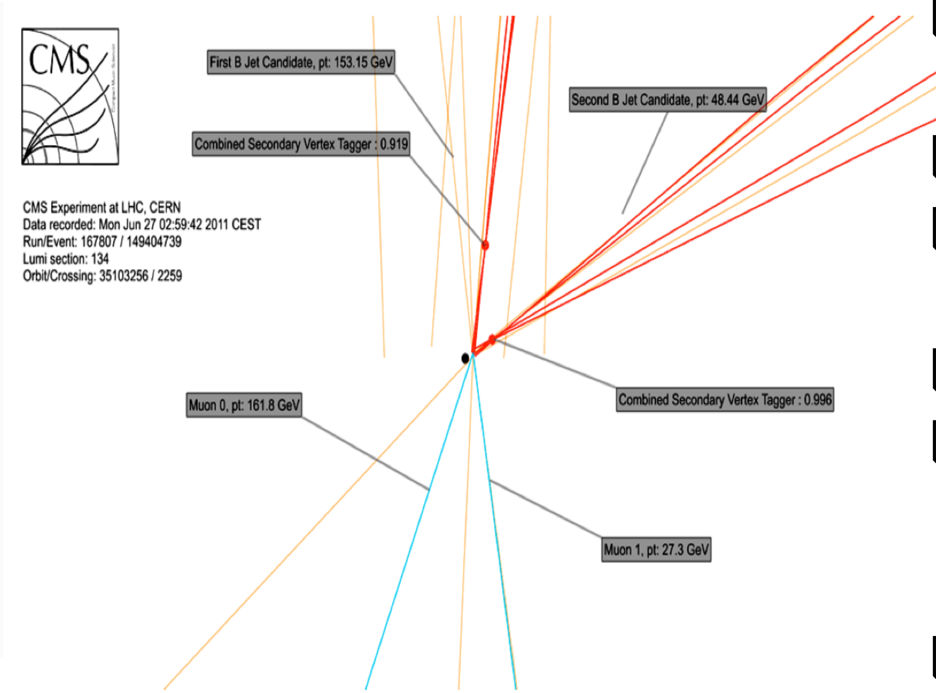
ZH → ννbb



WH → lνbb

ZH → llbb



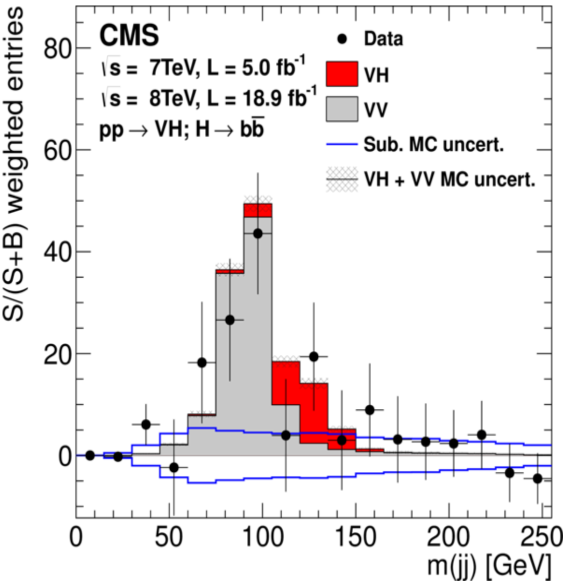


ZH → μμbb like event

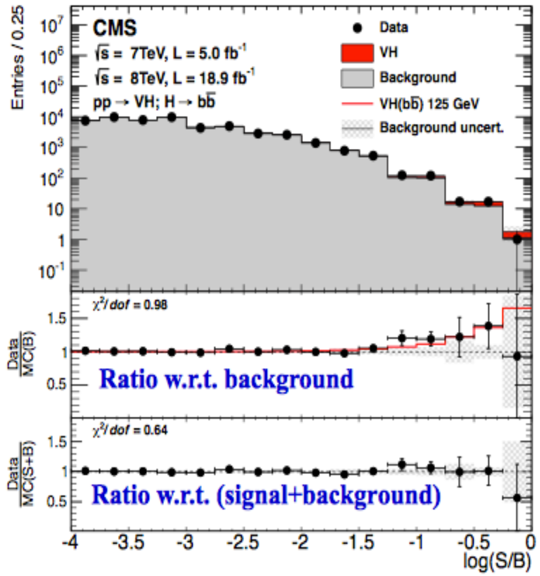
- ❑ **Largest number of Higgs decays at low mass but Lots of background (jets)**
- ❑ **Trigger based on leptons and missing E_T**
- ❑ ***b-jets* identified through displaced tracks (b-tagging)**
- ❑ **Go to high p_T where Higgs is enhanced**
- ❑ **Main background: W/Z+jets and top**
  - **→ Define signal free region to constraint them from data**
- ❑ **ATLAS: Cut-based analysis**
- ❑ **CMS: Boosted Decision Trees + shape fit**

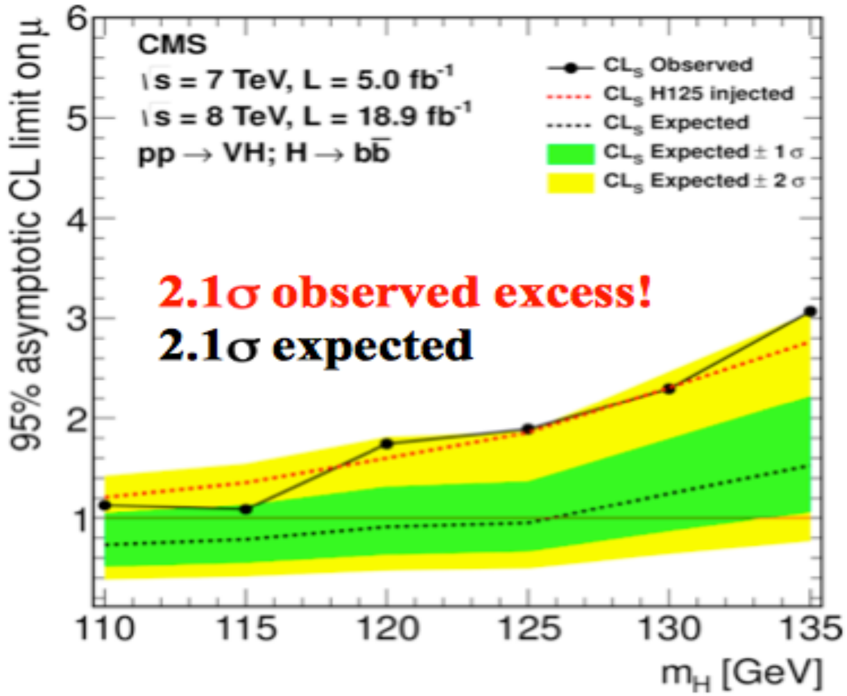
VH → bb

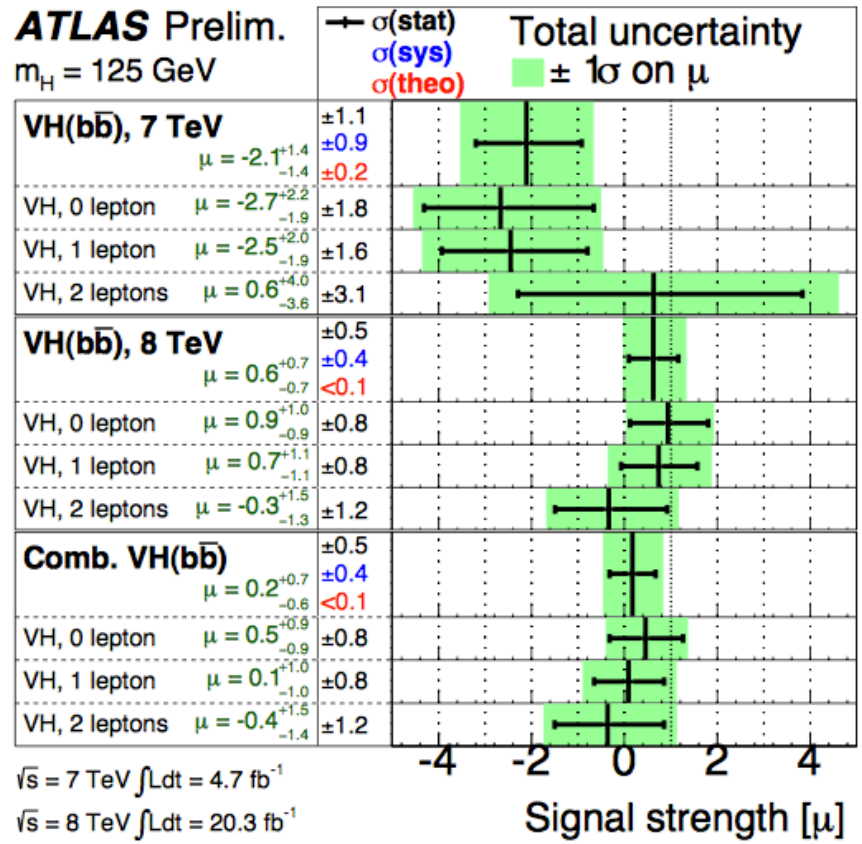
VZ Control region



Combined BDT shape





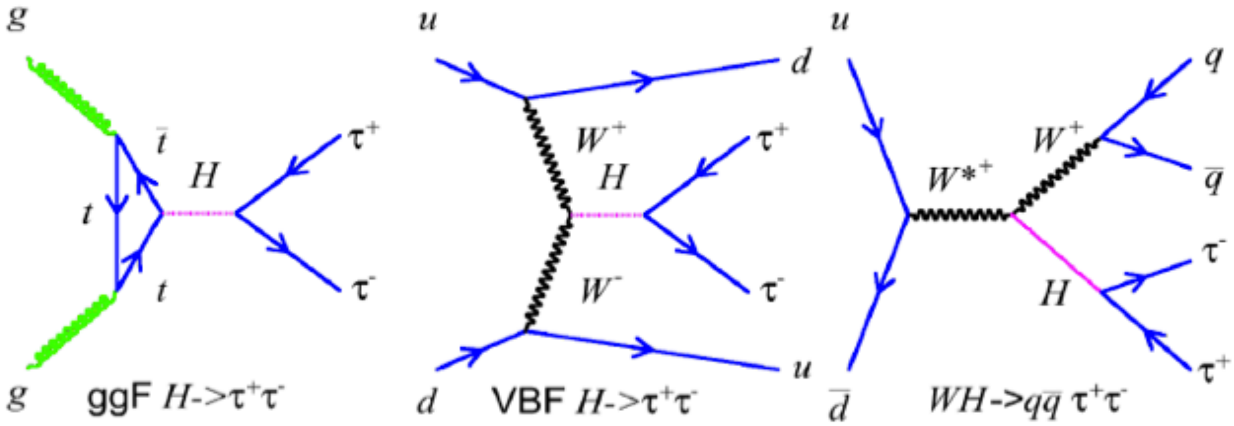


ATLAS:

- Fitted signal strength
  - 7+8 TeV: $\mu=0.2^{+0.7}_{-0.6}$
- 95% CLs @125 GeV
  - Expected: 1.3×SM
  - Observed: 1.4×SM
- Results consistent with SM H→bb and background-only hypotheses

H → ττ : Analysis overview

- Search in ggH, VBF and VH production modes and five di-τ final states:



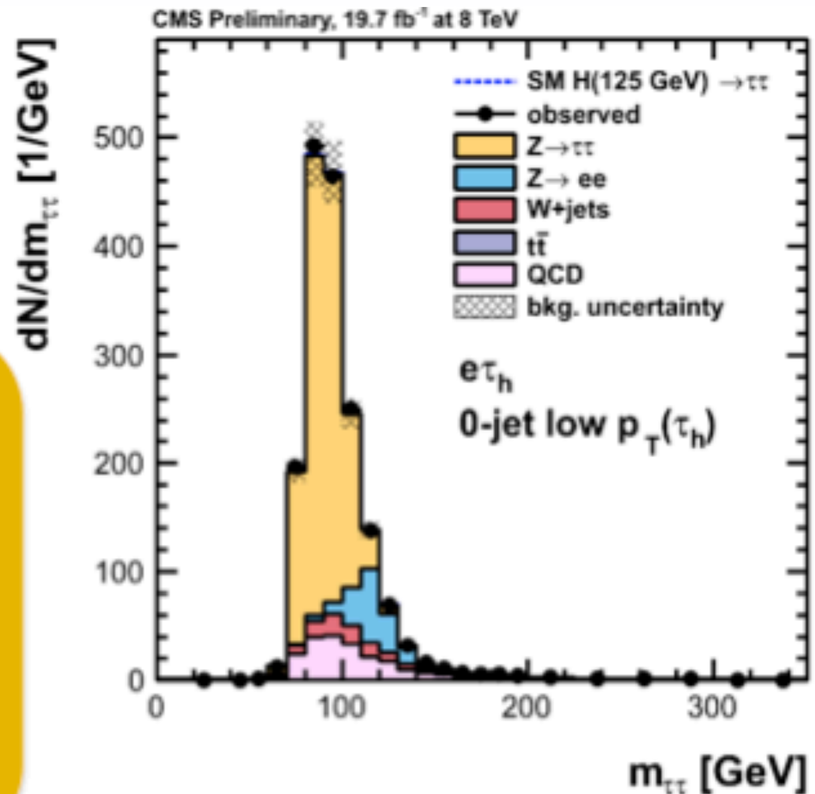
- $H \to \tau\tau \to \mu\mu$ $(\tau_\mu \tau_\mu)$,
- $H \to \tau\tau \to e\mu$ $(\tau_e \tau_\mu)$,
- $H \to \tau\tau \to \mu$+had. $(\tau_\mu \tau_h)$,
- $H \to \tau\tau \to e$+had. $(\tau_e \tau_h)$,
- $H \to \tau\tau \to$ had.+had. $(\tau_h \tau_h)$.

- Separation in categories to enhance S/B (CMS example):

		0-jet	1-jet	1-jet	2-jet	2-jet
				$p_T^{\tau\tau} > 100$ GeV	$m_{jj} > 500$ GeV, $\lvert\Delta\eta_{jj}\rvert > 3.5$	$p_T^{\tau\tau} > 100$ GeV, $m_{jj} > 700$ GeV, $\lvert\Delta\eta_{jj}\rvert > 4.0$
$\mu\tau_h$	$p_T(\tau_h) > 45$ GeV	high $p_T(\tau_h)$	high $p_T(\tau_h)$	high $p_T(\tau_h)$ boost	loose VBF tag	tight VBF tag (2012 only)
	baseline	low $p_T(\tau_h)$	low $p_T(\tau_h)$			

H→ττ : background estimations

All normalizations are data-driven



Z→ττ:

embedded samples

No MET/JES scale uncertainties

Shape estimation and correction for selection efficiencies

W+jets:

- Normalization from high m_T control region
- Shape from MC

ttbar:

- Normalization from eμ b-tag control region
- Shape from MC

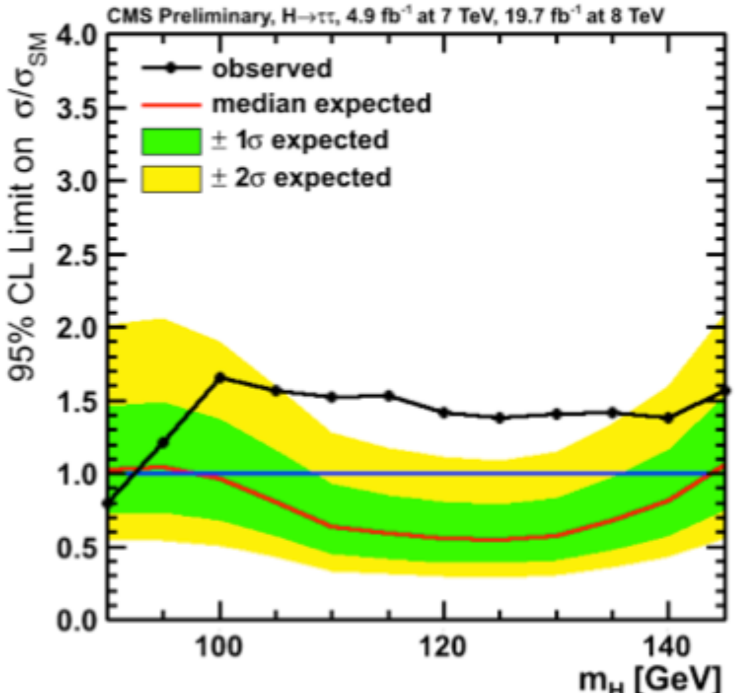
Z→ee/μμ

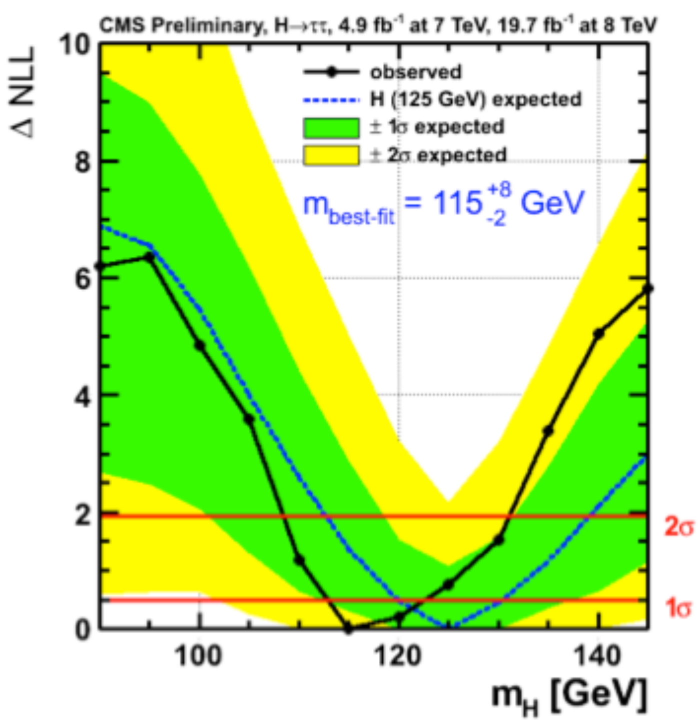
- Normalization scale factor from tag-and-probe in data
- Shape from MC

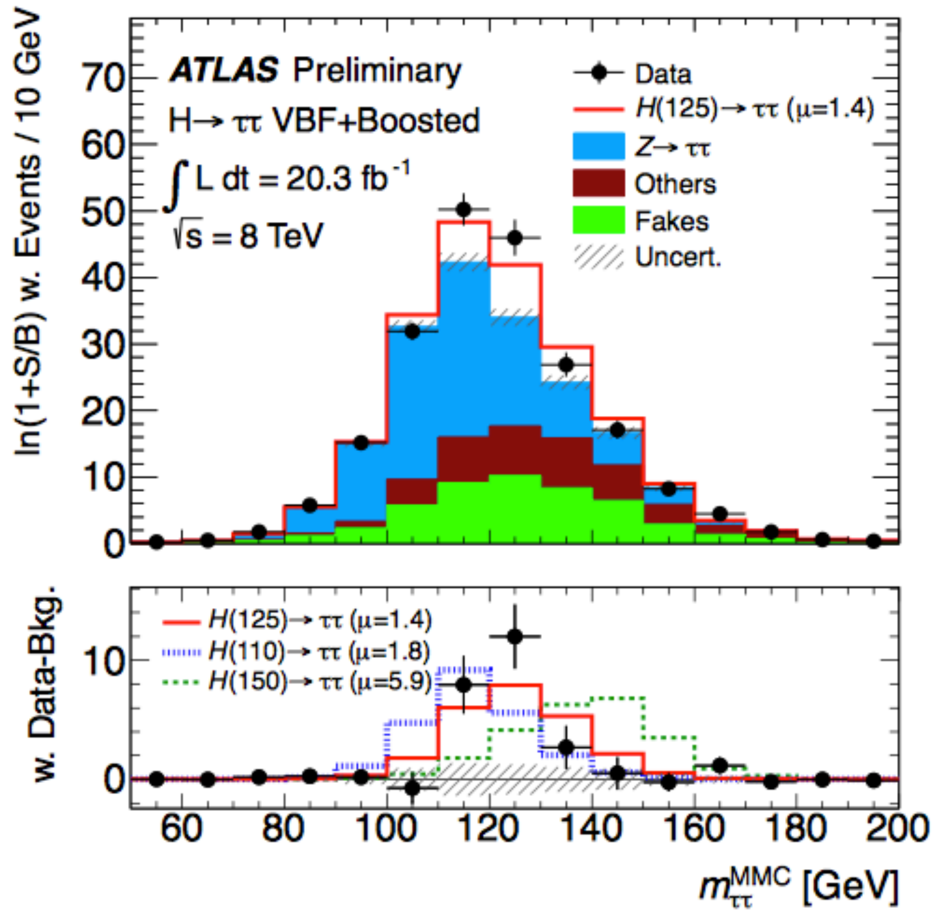
QCD:

- Normalization from ratio of same-sign(SS) to opposite-sign (OS) data events
- Shape from SS data events

H → ττ : Results

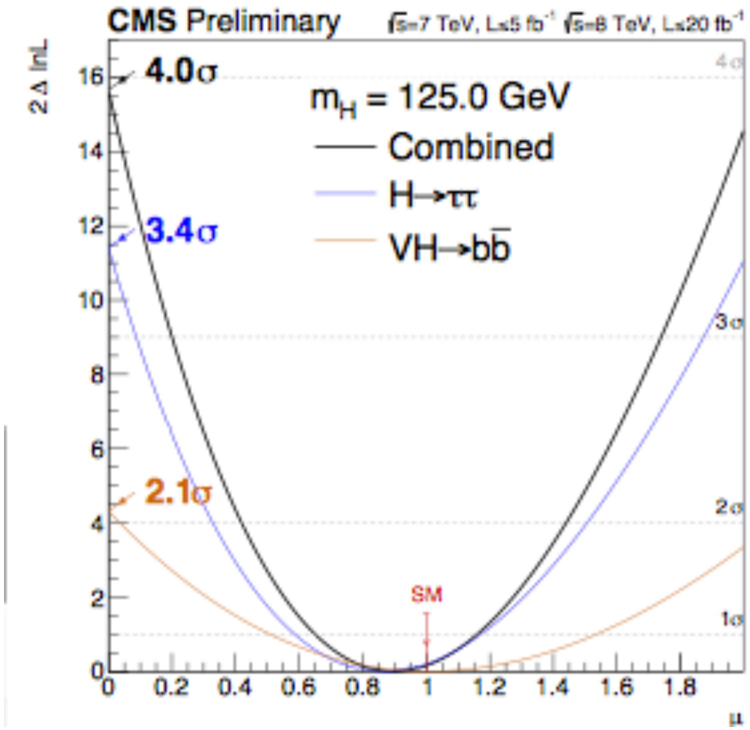




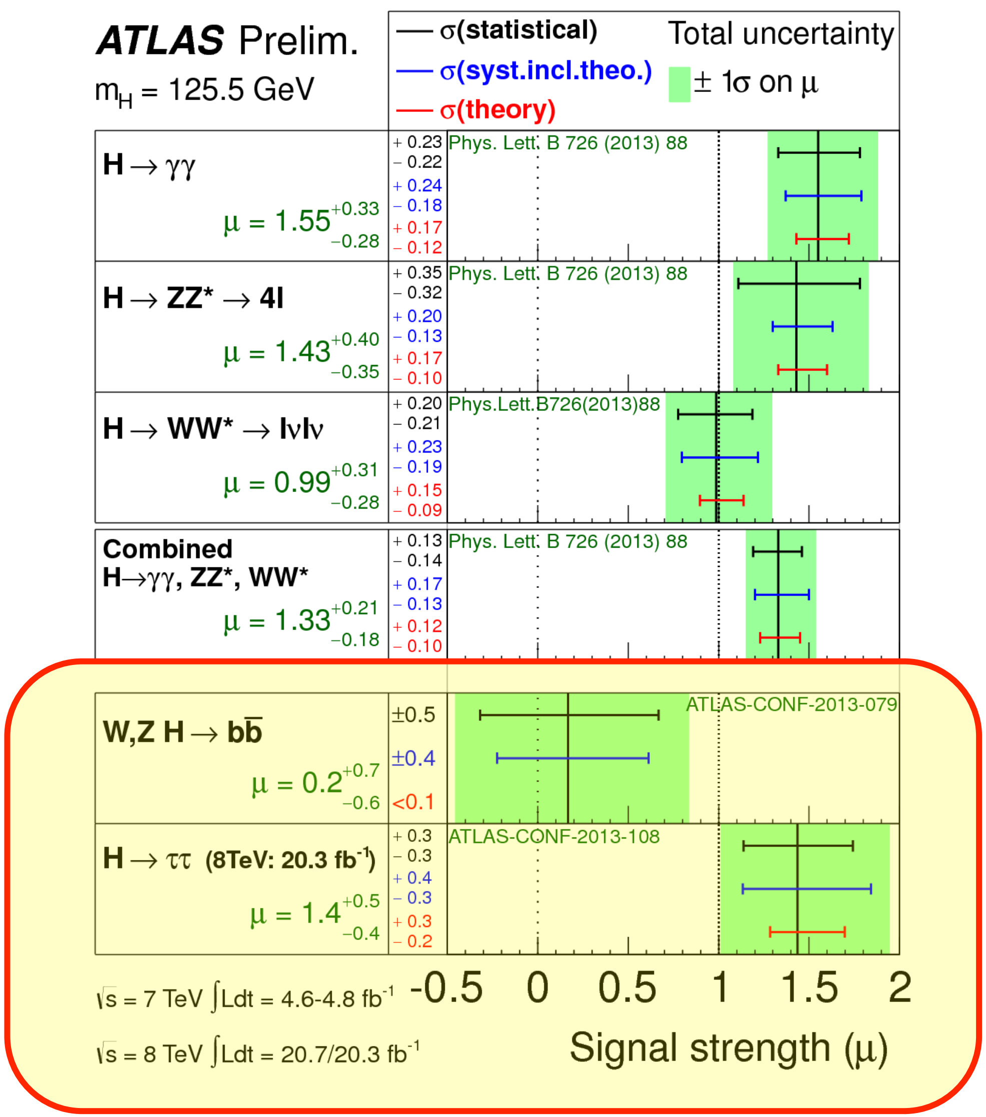


- ❑ **Evidence at 4.1 σ (ATLAS) and 3.4 σ (CMS) level for H→ττ**
- ❑ **CMS: μ = 0.87 ± 0.29**
- ❑ **ATLAS: μ = 1.4 + 0.5 – 0.4**
- ❑ **Mass compatible with mH ~ 125 GeV**

Couplings to fermions

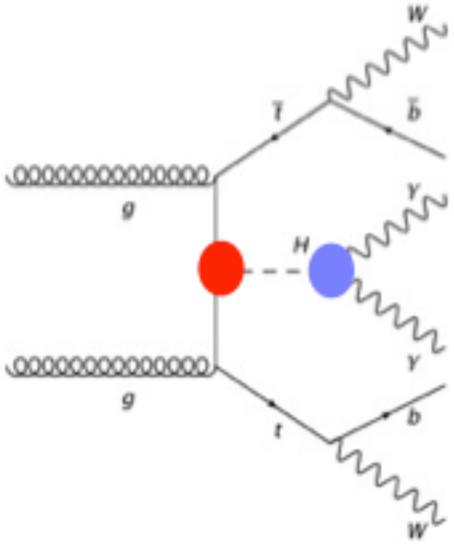


Channel M_H= 125 GeV	Significance		μ
	Expected	Observed	
VH→bb	2.1 σ	2.1σ	1.0±0.5
H→ττ	3.6σ	3.4σ	0.87±0.29
Combination	4.2σ	4.0σ	0.90±0.26



→ Strong evidence for coupling to fermions (despite 'small' deficit in ATLAS for H→bb)

ttH Production

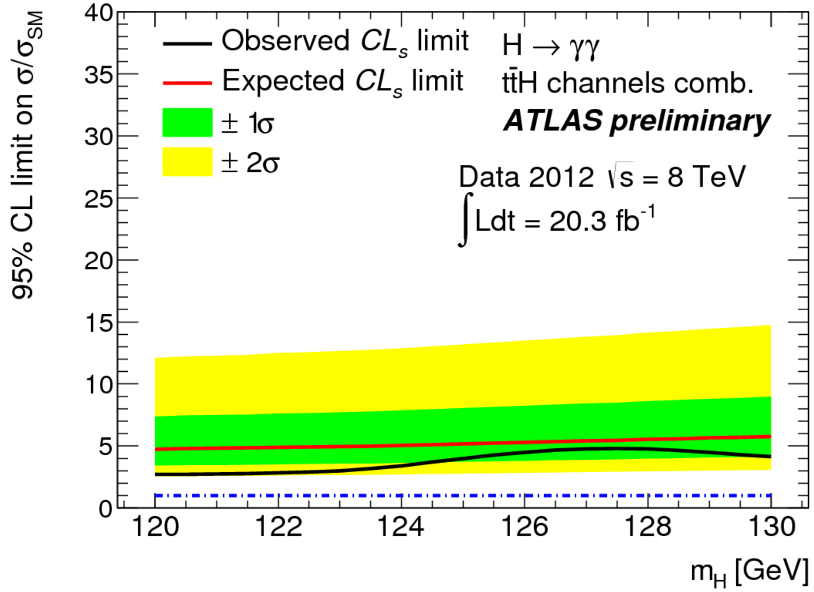


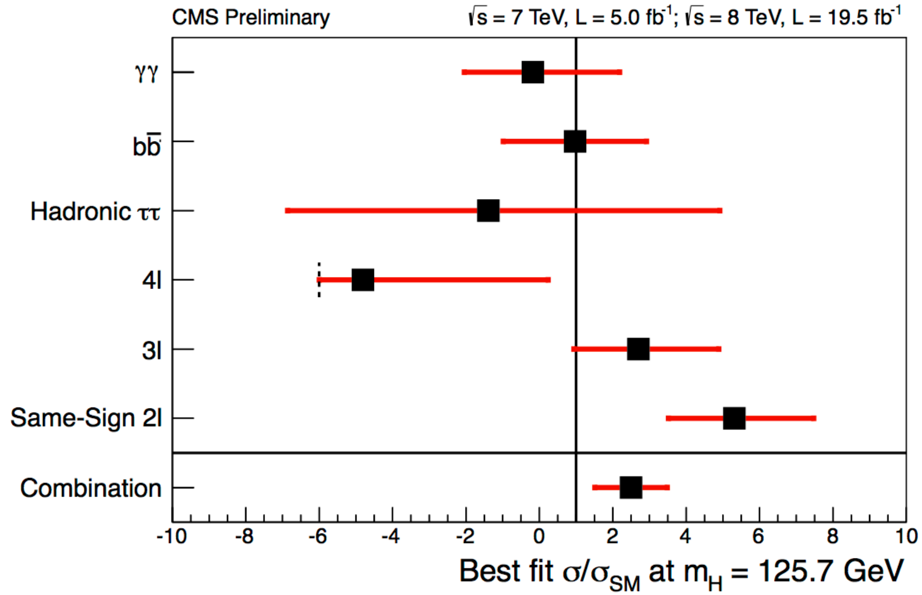
Probe of the H-top Yukawa coupling

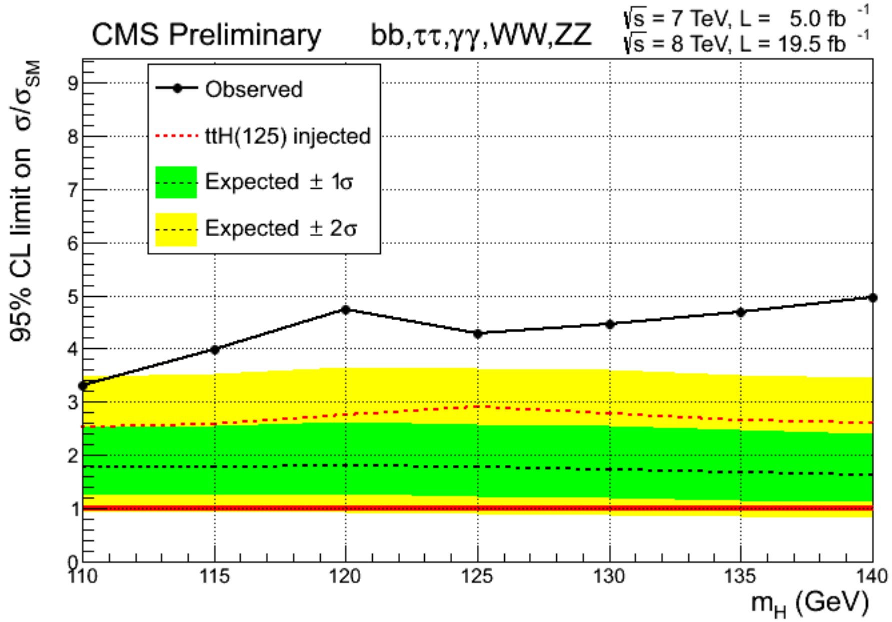
CMS:

- H → γγ → HIG-13-015
- H → bb → HIG-13-019
- H → ττ → HIG-13-019 / HIG-13-020
- H → ZZ → HIG-13-020
- H → WW → HIG-13-020

ATLAS-CONF-2013-080







→ Sensitivity approaching SM Higgs

Results summary @ 125 GeV

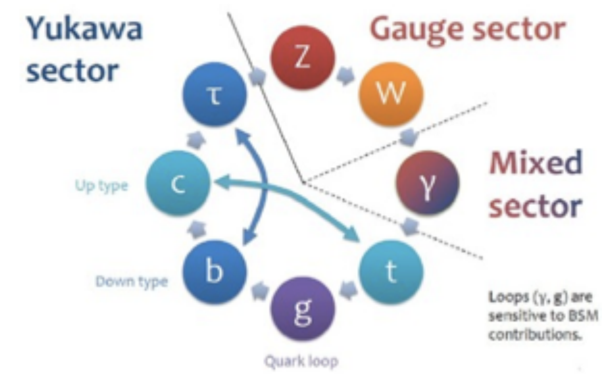
Channel	ATLAS Lumi [fb-1]	CMS Lumi [fb-1]	Specialty	σ Obs. (exp.)	Mass [GeV]	Signal strength μ	$J^P = 0^+$
H→γγ	4.8+20.7	5.1+19.6	mass, discovery, couplings	7.4 (4.3)	126.8 ±0.2 ±0.7	1.55 +0.33-0.28	✔
				3.2 (4.2)	125.4 ± 0.5 ± 0.6	0.78 ± 0.27	✔
H→ZZ→4l	4.6+20.7	5.1+19.7	mass, discovery, couplings	6.6 (7.2)	124.3 ± 0.6 ± 0.5	1.5 ± 0.4	✔
				6.8 (6.7)	125.6 ± 0.4 ± 0.2	0.93 +0.29-0.25	✔
H→WW→2l2ν	4.6+20.7	4.9+19.4	cross section, couplings	3.8 (3.7)	Compatible with 125 GeV	0.99 +0.31-0.32	✔
				4.3 (5.8)	125.5+3.6–3.8 (μ = 1)	0.72 +0.20-0.18	✔
H→bb	4.7+20.3	5.1+18.9	couplings to fermions	--	--	0.2 + 0.7 – 0.6	--
				2.1 (2.1)	Compatible with 125 GeV	1.0 ± 0.5	--
H→ττ	20.3	4.9+19.4	couplings to fermions	4.1 (3.2)	Compatible with 125GeV	1.4 + 0.5 – 0.4	--
				3.4 (3.6)	115 +8 -2	0.87 ± 0.29	--

→ Overall consistency with SM H boson expectations

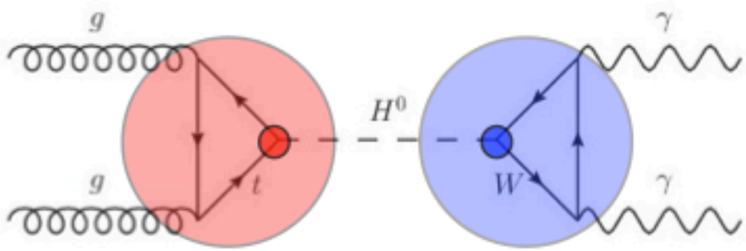
Coupling Measurements

Assume the observed signal stems from one narrow resonance.

$$(\sigma \cdot \mathrm{BR})\,(ii \to \mathrm{H} \to \mathit{ff}) = \frac{\sigma_{ii} \cdot \Gamma_{\mathit{ff}}}{\Gamma_{\mathrm{H}}}$$

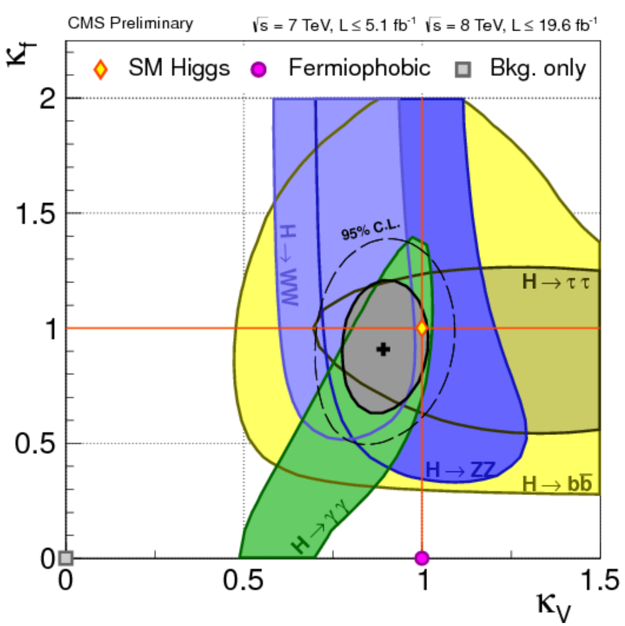


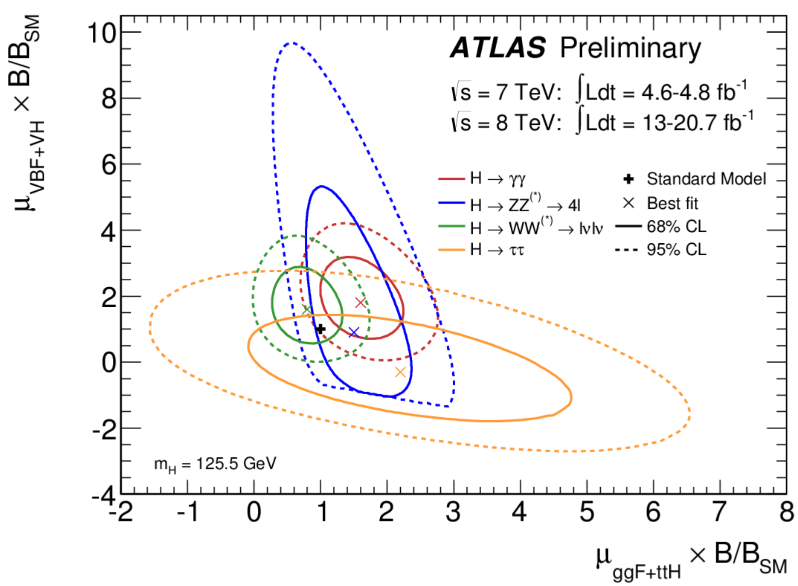
Parametrize deviations w.r.t. the SM in production and decay. This implies precise knowledge of the SM Higgs. Not considered are BSM acceptance effects.



- one common scale factor
- scale vector and fermion coupling
- custodial symmetry
- new physics in loops
- BSM Higgs decays
- ...

$$(\sigma \cdot \mathrm{BR})\,(gg \to \mathrm{H} \to \gamma\gamma) = \sigma_{\mathrm{SM}}(gg \to \mathrm{H}) \cdot \mathrm{BR}_{\mathrm{SM}}(\mathrm{H} \to \gamma\gamma) \cdot \frac{\kappa_g^2 \cdot \kappa_\gamma^2}{\kappa_{\mathrm{H}}^2} \qquad \kappa_H^2 = \sum_X \kappa_X^2 \frac{\mathrm{BR_{SM}}(H \to X)}{1 - \mathrm{BR_{BSM}}}$$





General coupling fit

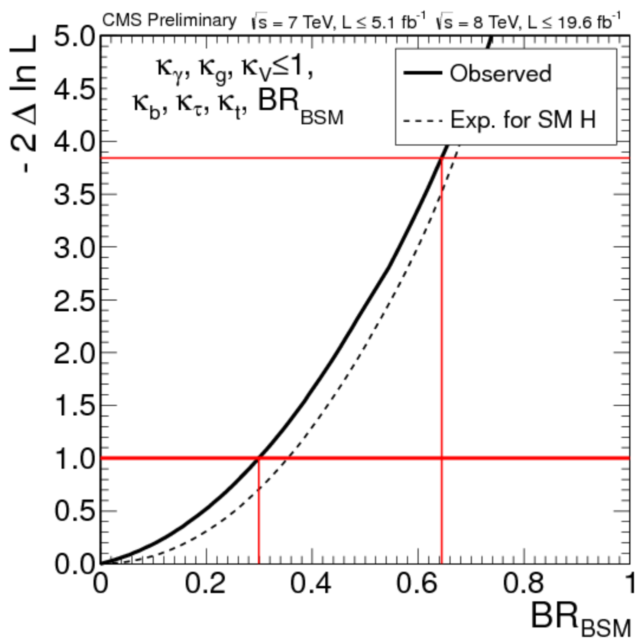
- κ_g, κ_γ: loop diagrams → allow potential new physics
- κ_V: assume custodial symmetry
- κ_t, κ_b: up- and down-type quarks
- κ_τ: charged leptons

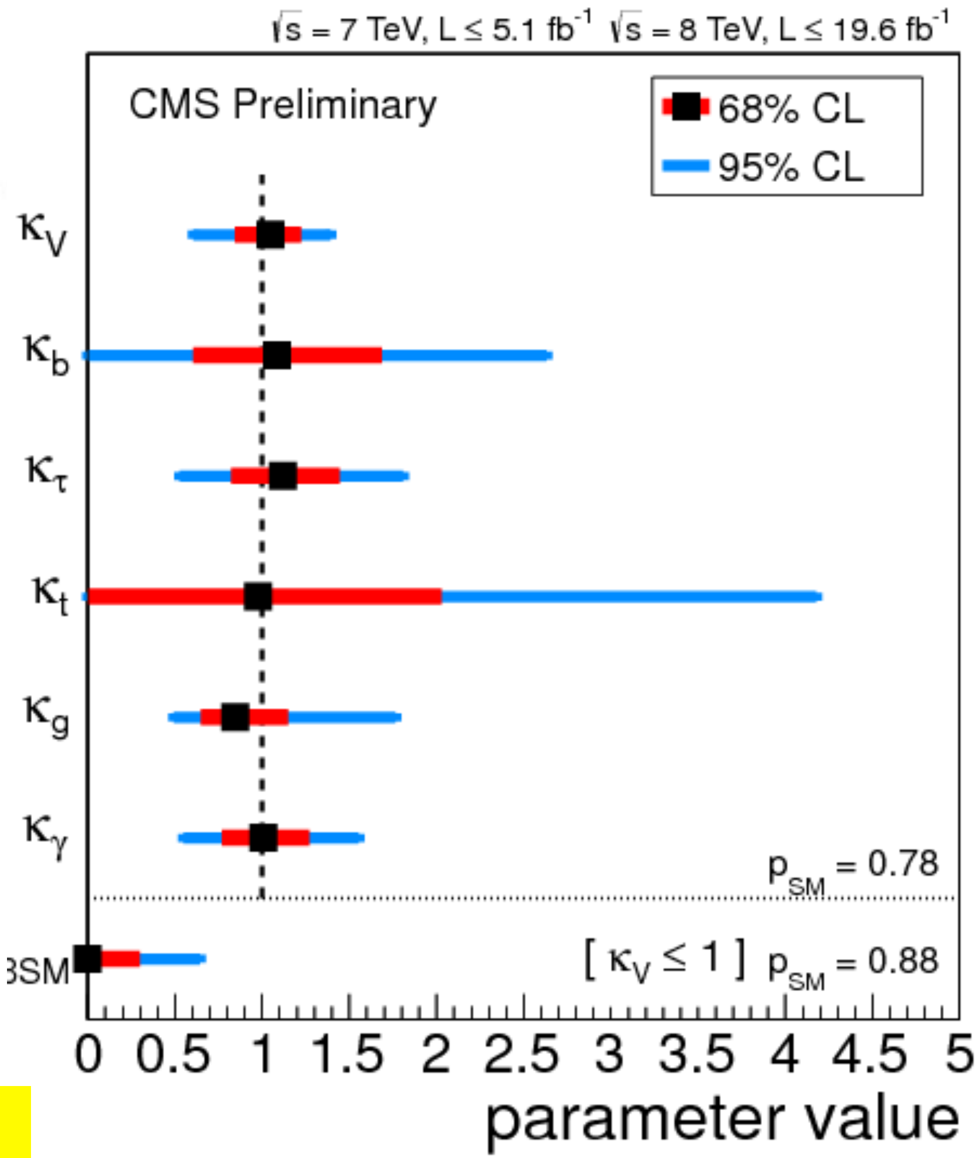
total width from sum of partial widths

alternatively:

$$\Gamma_{tot} = \sum \Gamma_{ii} + \Gamma_{BSM} \qquad BR_{BSM} = \Gamma_{BSM} / \Gamma_{tot}$$

assumption here κ_W, $\kappa_Z < 1$





→ **No deviation from SM observed but high precision needed to look for new physics**

Direct H → Invisible searches

Significant BR(H→Invis.) would be a signature of BSM:

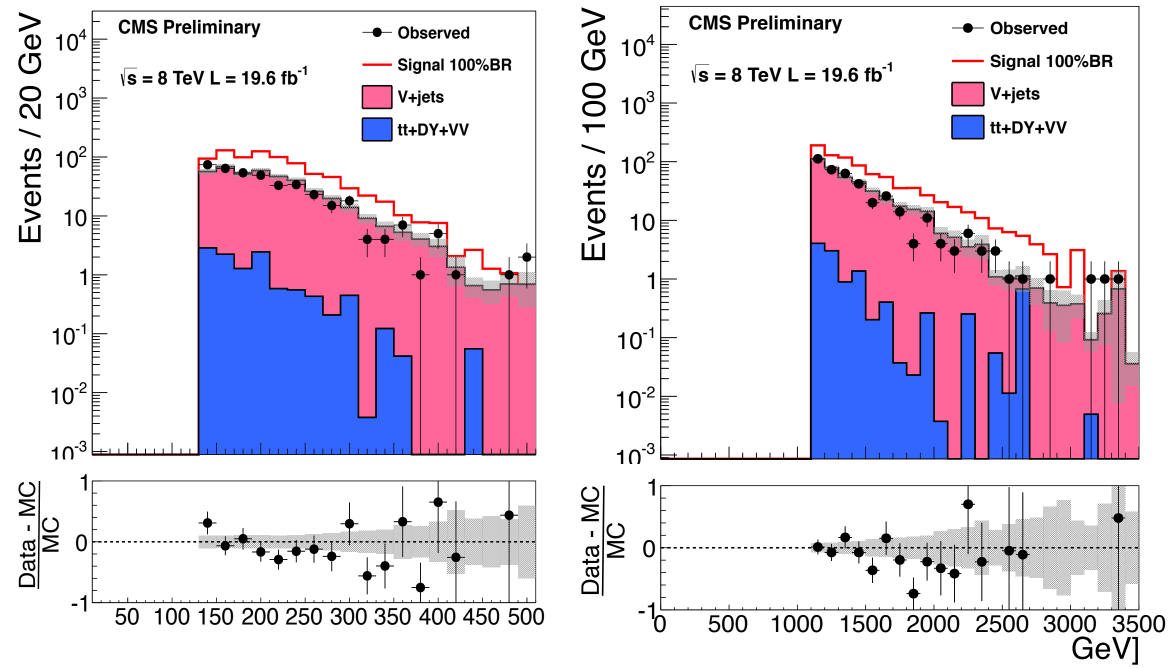
- H → 2LSPs in SUSY
- H → gravi-scalars in ADD model
- …

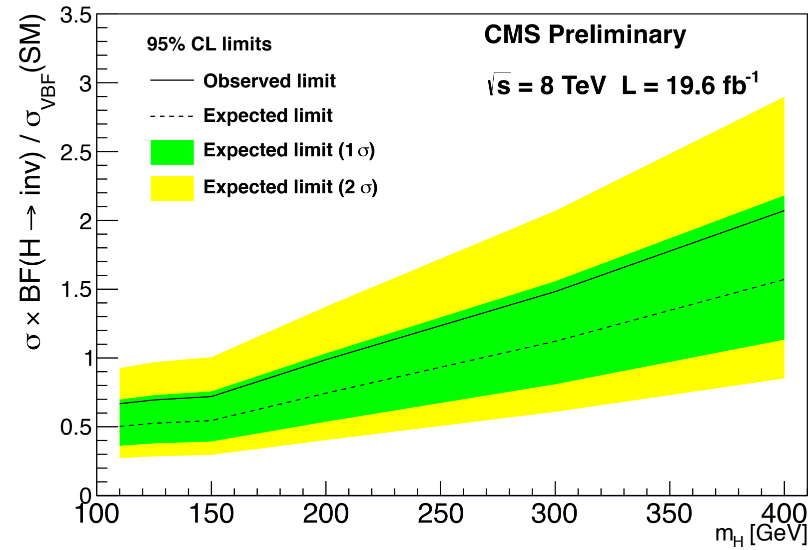
→ **Sensitive to Dark Matter candidate with mass $m_H/2$**

Searches topologies:

- **VBF H → Invisible** (CMS PAS HIG 13-013):
  - 2 tagged jets with pT>50 GeV with $\Delta\eta(jj) > 4.2$, $m(jj) > 1100$ GeV, $\Delta\phi(jj)<1$
  - MET>130 GeV
  - Backgrounds: Z(→nn)+jets & W+jets → data-driven estimates

VBF H → Invisible





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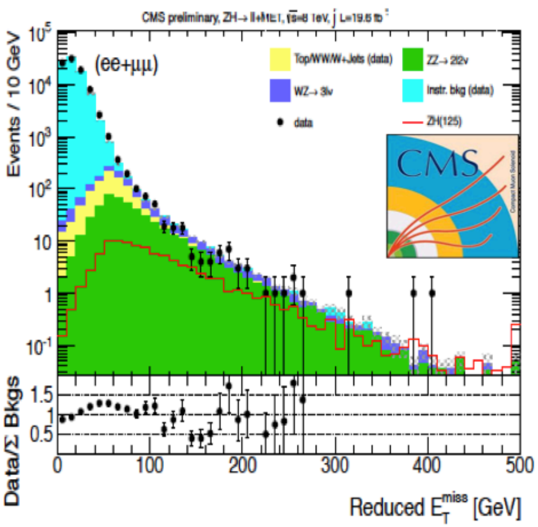
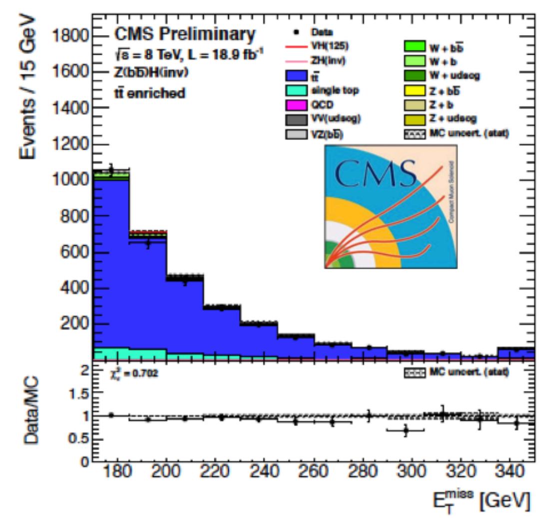
  - ❑ MET>130 GeV
  - ❑ Backgrounds: Z(→nn)+jets & W+jets
    → data-driven estimates
- ❑ **ZH → Invisible:**
  - ❑ **Z → bb** (CMS PAS HIG 13-018)
    → Background: tt + MET
  - ❑ **Z → ll** (CMS PAS HIG 13-028)
    → Background: ZZ → 2l2v
  - ❑ Search for events with large MET after requiring a Z→ll or Z→bb tag

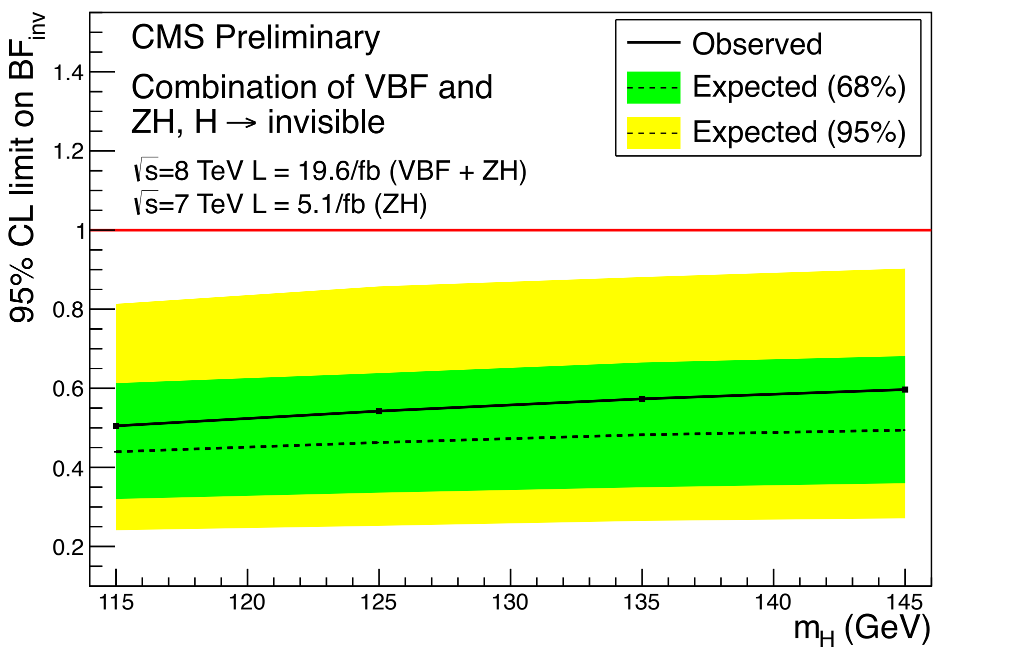
→ **Direct limit on BR(Invisible) from combination: ~< 0.5**

Z(ll)H → Invis.



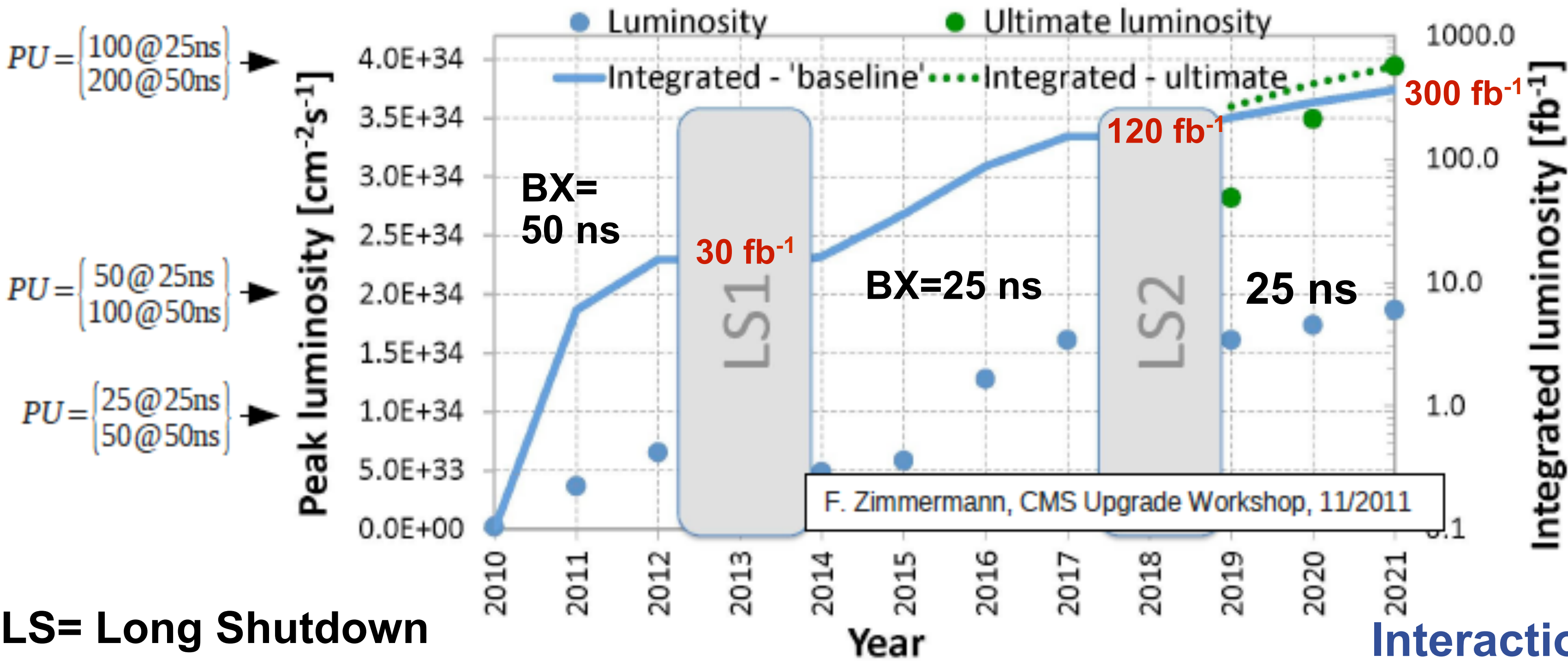
Z(bb)H → Invis.





LHC Roadmap for next runs

LHC | **Energy increase 8 to 13/14 TeV** | **Injection upgrade** | **HL-LHC**



Luminosity-leveled at $5x10^{34}$ $cm^{-2}s^{-1}$ in HL-LHC

LS= Long Shutdown

Interaction region upgrade

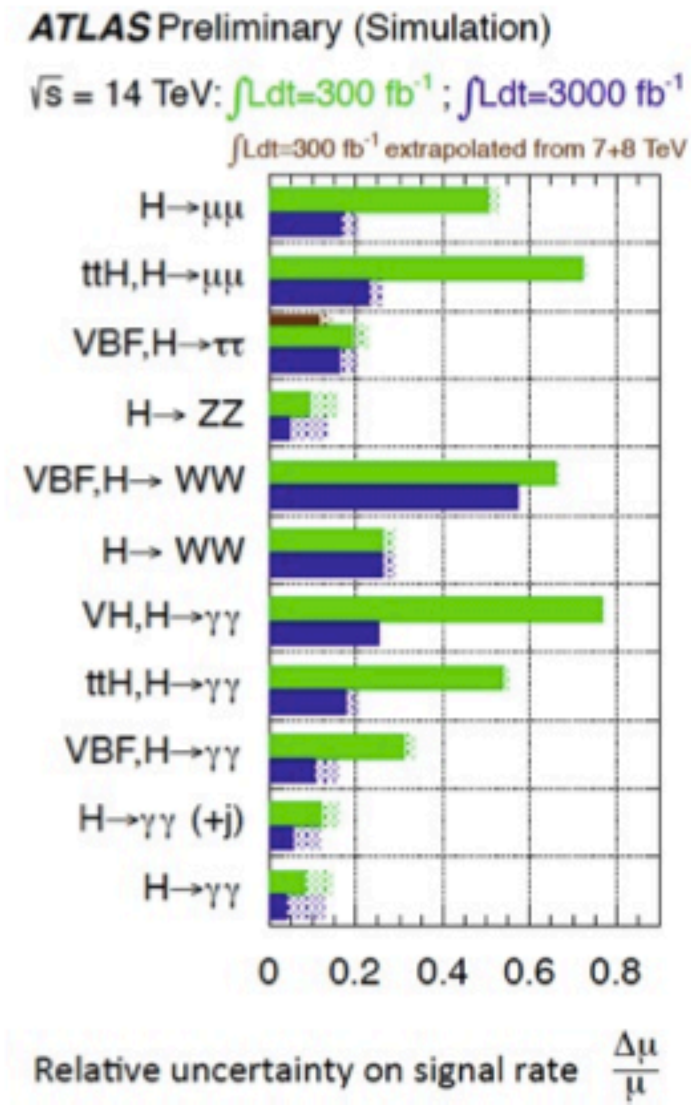
	LHC	(LS1)	Phase 1	(LS3)	HL-LHC
$L_{instantaneous}$	$8x10^{33}$ Hz/cm^2	LS1	$2x10^{34}$ Hz/cm^2	LS3	$5x10^{34}$ Hz/cm^2
$L_{integrated}$	30 fb^{-1}		300 fb^{-1}		3000 fb^{-1}
Pile Up	PU ~40		PU ~50		PU ~140

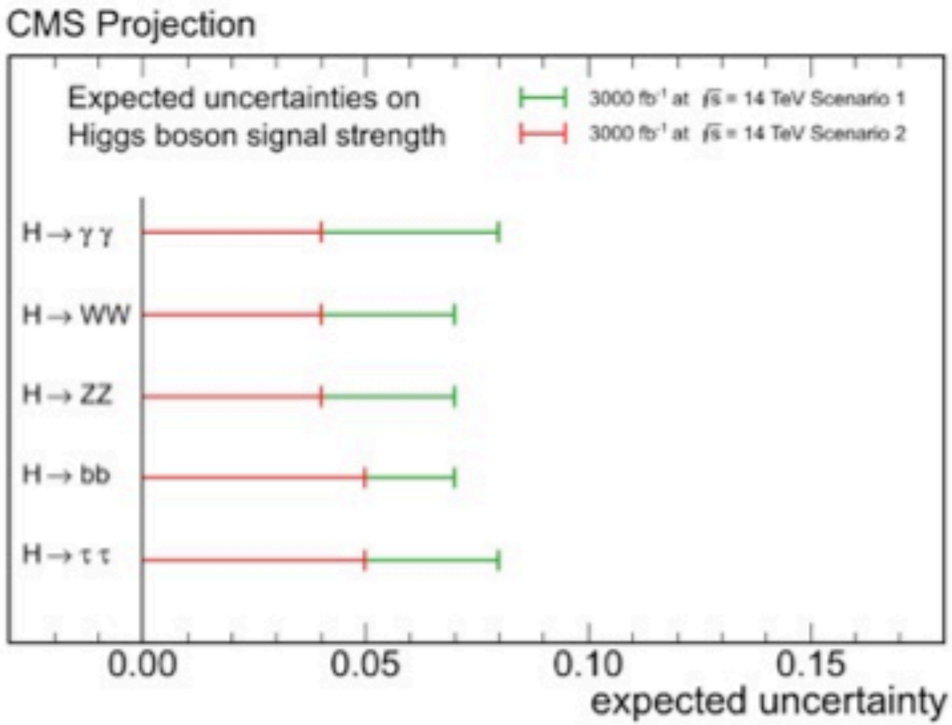
ATLAS, CMS Upgrade plan

Phase 1 Upgrade

Phase 2 Upgrade

Expected precision on cross-sections





L (fb^{-1})	$H \to \gamma\gamma$	$H \to WW$	$H \to ZZ$	$H \to bb$	$H \to \tau\tau$	$H \to Z\gamma$	$H \to inv.$
300	[6, 12]	[6, 11]	[7, 11]	[11, 14]	[8, 14]	[62, 62]	[17, 28]
3000	[4, 8]	[4, 7]	[4, 7]	[5, 7]	[5, 8]	[20, 24]	[6, 17]

Assumptions on systematic uncertainties
Scenario 1: no change
Scenario 2: Δ theory / 2, rest ∝ 1/√L

Based on parametric simulation

Extrapolated from 2011/12 results

Expected H Boson coupling results

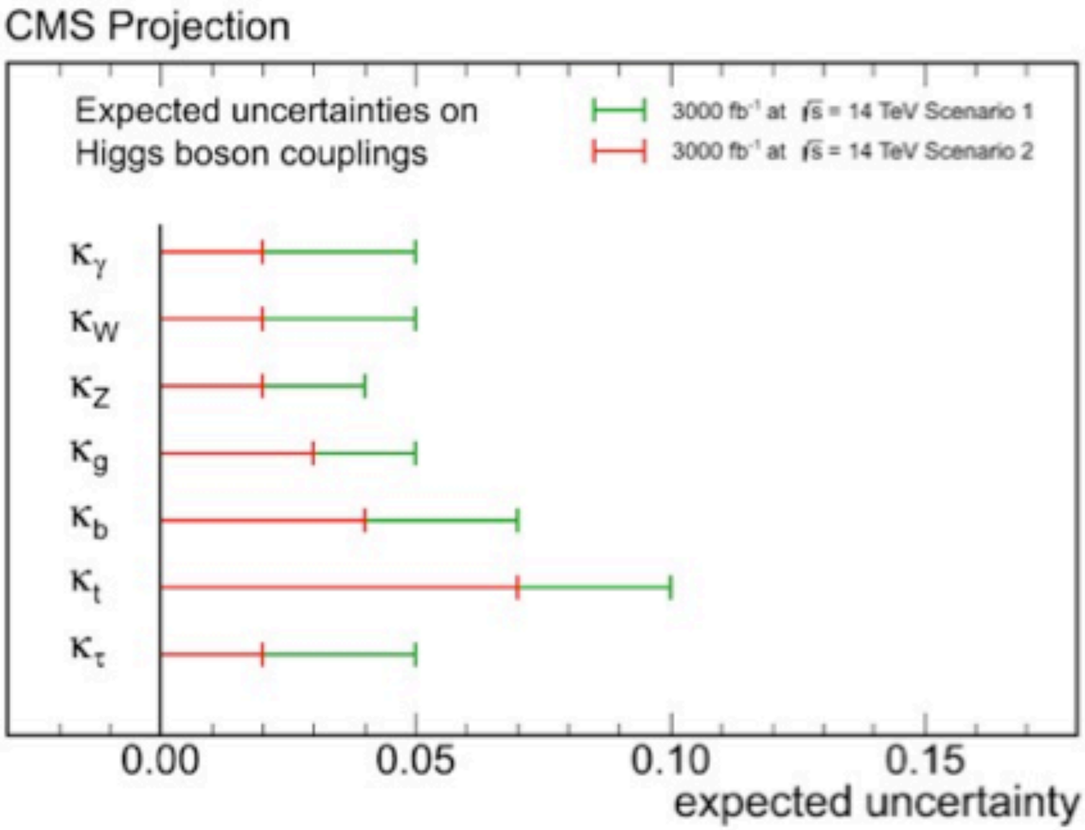
κ_g, κ_γ, $\kappa_{Z\gamma}$: loop diagrams ➜ allow potential new physics
κ_W, κ_Z: vector bosons
κ_t, κ_b: up- and down-type quarks
κ_τ, κ_μ: charged leptons
total width from sum of partial widths

alternatively:

$$\Gamma_{\text{tot}} = \sum \Gamma_{ii} + \Gamma_{\text{BSM}}$$

$$BR_{\text{BSM}} = \Gamma_{\text{BSM}} / \Gamma_{\text{tot}}$$

assumption here κ_W, $\kappa_Z < 1$



CMS Projection

$L\ (fb^{-1})$	κ_γ	κ_W	κ_Z	κ_g	κ_b	κ_t	κ_τ	$\kappa_{Z\gamma}$	κ_μ
300	[5,7]	[4,6]	[4,6]	[6,8]	[10,13]	[14,15]	[6,8]	[41,41]	[23,23]
3000	[2,5]	[2,5]	[2,4]	[3,5]	[4,7]	[7,10]	[2,5]	[10,12]	[8,8]

Snowmass Whitepaper for CMS - http://arxiv.org/abs/1307.7135

→ coupling precision 2-10 %
→ factor of ~2 improvement from HL-LHC

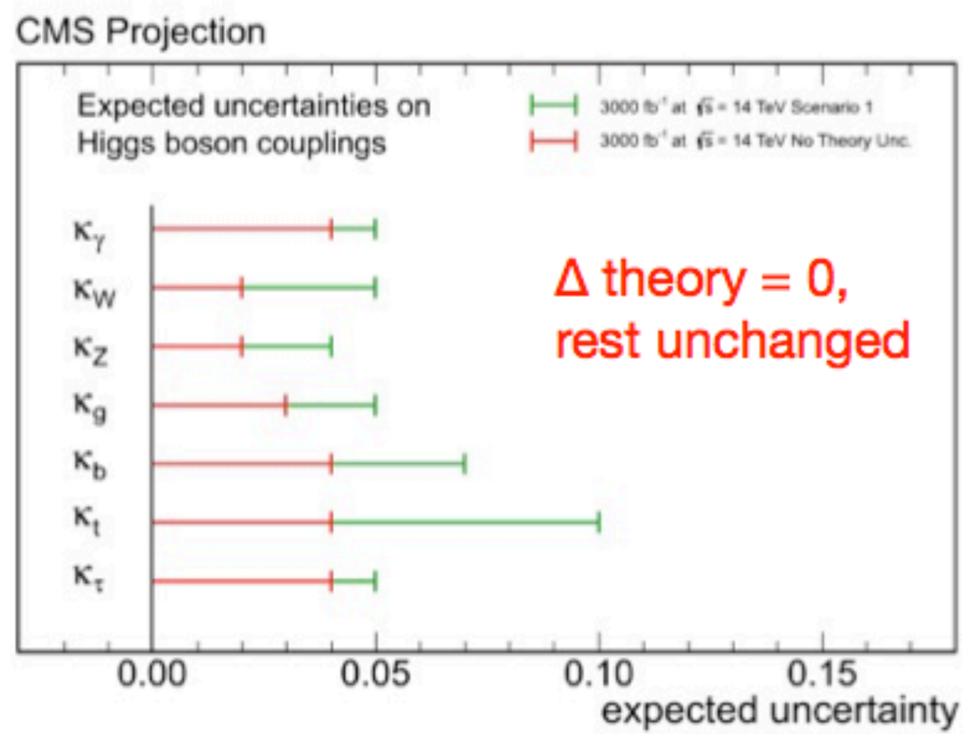
Theoretical uncertainties

To test the importance of theoretical uncertainties we show the effect of removing them.

Theoretical uncertainties dominated by QCD scale and PDF uncertainties. Uncertainty on BR and acceptance uncertainties become relevant at few % precision.

Process	Cross section (pb)	Relative uncertainty in percent: Total	Scale	PDF
Gluon fusion	49.3	$^{+19.6}_{-14.6}$	$^{+12.2}_{-8.4}$	$^{+7.4}_{-6.2}$
VBF	4.15	$^{+2.8}_{-3.0}$	$^{+0.7}_{-0.4}$	$^{+2.1}_{-2.6}$
WH	1.474	$^{+4.1}_{-4.4}$	$^{+0.3}_{-0.6}$	$^{+3.8}_{-3.8}$
ZH	0.863	$^{+6.4}_{-5.5}$	$^{+2.7}_{-1.8}$	$^{+3.7}_{-3.7}$

Channel	$\Delta\alpha_s$	Δm_b	Δm_c	Theory Uncertainty	Total Uncertainty
$H \to \gamma\gamma$	0%	0%	0%	±1%	±1%
$H \to b\bar{b}$	∓2.3%	$^{+3.3\%}_{-3.2\%}$	0%	±2%	±6%
$H \to c\bar{c}$	$^{-7.1\%}_{+7.0\%}$	∓0.1%	$^{+6.2\%}_{-6.1\%}$	±2%	±11%
$H \to gg$	$^{+4.2\%}_{-4.1\%}$	∓0.1%	0%	±3%	±7%
$H \to \tau^+\tau^-$	0%	0%	0%	±2%	±2%
$H \to WW^*$	0%	0%	0%	±0.5%	±0.5%
$H \to ZZ^*$	0%	0%	0%	±0.5%	±0.5%



Handbook of LHC Higgs Cross Sections: 3. Higgs Properties - http://arxiv.org/abs/1307.1347

→ Any improvement on scale dependence (+jet counting uncertainty) and PDF theory uncertainties will translate immediately to higher precision

Comparison CMS-ATLAS

Cross-section (μ):

$L(fb^{-1})$	Exp.	$\gamma\gamma$	WW	ZZ	bb	$\tau\tau$	$Z\gamma$	$\mu\mu$
300	ATLAS	[9, 14]	[8, 13]	[6, 12]	N/a	[16, 22]	[145, 147]	[40,42]
	CMS	[6, 12]	[6, 11]	[7, 11]	[11, 14]	[8, 14]	[62, 62]	[40,42]
3000	ATLAS	[4, 10]	[5, 9]	[4, 10]	N/a	[12, 19]	[54, 57]	[12,15]
	CMS	[4, 8]	[4, 7]	[4, 7]	[5, 7]	[5, 8]	[20, 24]	[14,20]

Couplings:

$L(fb^{-1})$	Exp.	κ_γ	κ_W	κ_Z	κ_g	κ_b	κ_t	κ_τ	$\kappa_{Z\gamma}$	$\kappa_{\mu\mu}$
300	ATLAS	[8,13]	[6, 8]	[7, 8]	[8, 11]	N/a	[20, 22]	[13, 18]	[78, 79]	[21, 23]
	CMS	[5, 7]	[4, 6]	[4, 6]	[6, 8]	[10, 13]	[14, 15]	[6, 8]	[41, 41]	[23, 23]
3000	ATLAS	[5, 9]	[4, 6]	[4, 6]	[5, 7]	N/a	[8, 10]	[10, 15]	[29, 30]	[8, 11]
	CMS	[2, 5]	[2, 5]	[2, 4]	[3, 5]	[4, 7]	[7, 10]	[2, 5]	[10, 12]	[8, 8]

Uncertainty on signal strength

- Ranges [x,y] are not directly comparable
- ATLAS
  - [no theory uncertainty, Scenario 1]
- CMS
  - [Scenario 2, Scenario 1]

Overall reasonable agreement, but

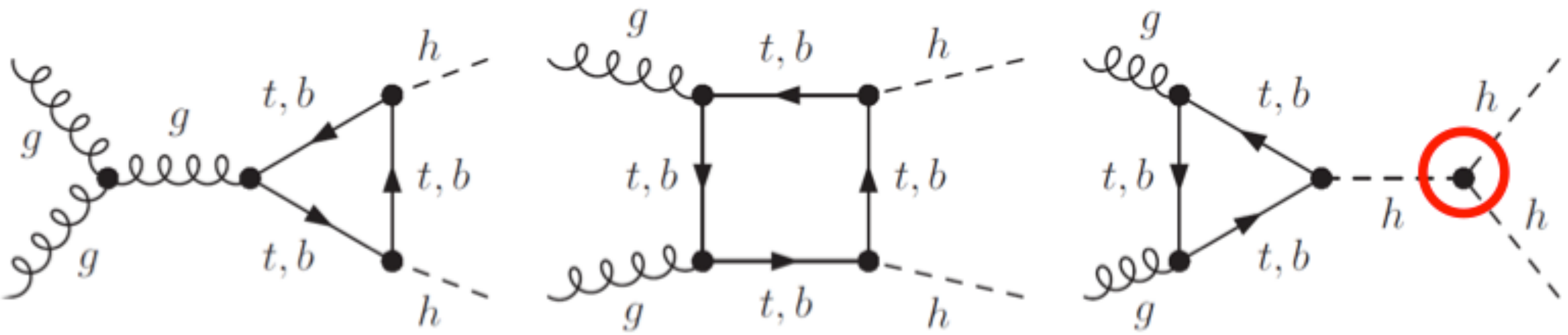
- ATLAS does not include H → bb mode
- CMS outperforms ATLAS H → ττ mode
- Large differences in H → Zγ mode due to photon id

→ Clear potential for high precision by ATLAS&CMS in future LHC Runs up to >2020

H boson self-coupling

In order to determine the parameters of the SM completely, a measurement of the Higgs self-coupling is essential

- Higgs potential and the EWSB mechanism



Event yields of various channels

Decay channel	Branching ratio (%)	Yield with 3 ab^{-1}
$b\bar{b}b\bar{b}$	33.4	34,000
$b\bar{b}W^+W^-$	25.0	25,500
$b\bar{b}\tau\tau$	7.36	7,500
$W^+W^-W^+W^-$	4.66	4,750
$b\bar{b}ZZ$	3.09	3,150
ZZW^+W^-	1.15	1,170
$b\bar{b}\gamma\gamma$	0.26	265

- Very challenging due to low yield and contributions from irreducible backgrounds (ttH, ZH, etc.)
- Ongoing studies suggest some sensitivities to constrain the triple Higgs coupling
- Also, several phenomenological papers suggests the possibility

→ Very challenging → will require high luminosity for precision → HL-LHC

CONCLUSIONS

Run-1 Results:

- The significance of the H boson-like particle @ 125 GeV in the di-boson channels combined is now well over 5 σ
- Large progress has been made in the fermionic channels, with evidence at the level of 3-4 σ
- 0^+ case favored against all other tested hypothesis and couplings measurements are consistent with SM expectation
- Significant progress on ttH and H→Invisible
- searches for high mass and BSM H bosons started (→next talks)

→ All Run-1 results compatible with SM expectation for H boson
→ Measurements mostly limited by statistical uncertainties

Preparation for next LHC runs:

Large program for Higgs coupling measurements in Run II (13-14 TeV) to stay ahead of systematical uncertainties:

- Theoretical (scale, α_s, and PDF) uncertainties will become dominant
- Experimental challenges due to large pileup and detector longevity effects

→ Stay tuned for LHC restart in 2015 !