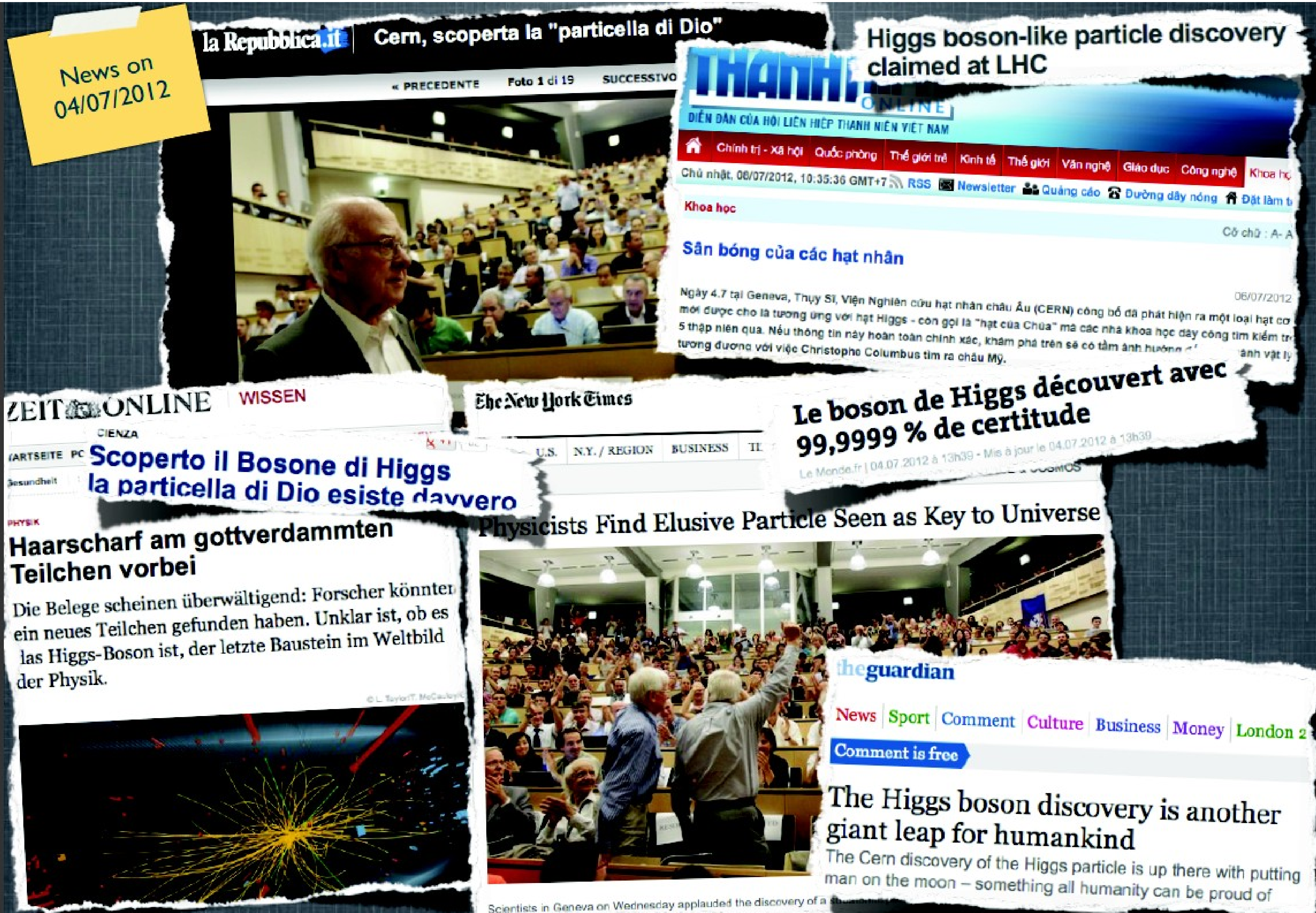
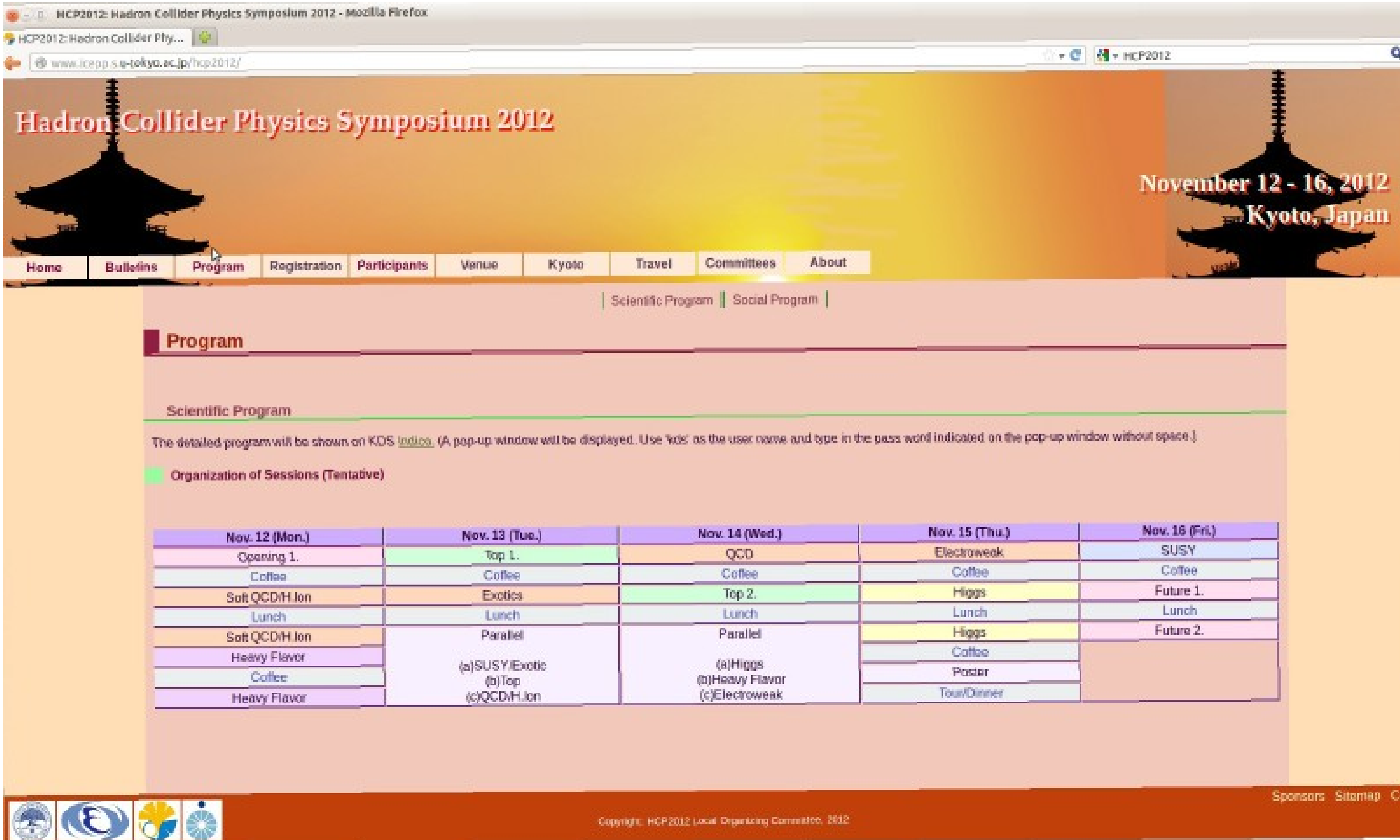


The story so far .....

HCP Symposium 12-16 November


HCP2012: Hadron Collider Physics Symposium 2012 - Mozilla Firefox

www.icepp.s.u-tokyo.ac.jp/hcp2012/

Hadron Collider Physics Symposium 2012

November 12 - 16, 2012
Kyoto, Japan

Home | Bulletins | Program | Registration | Participants | Venue | Kyoto | Travel | Committees | About

Scientific Program | Social Program

Program

Scientific Program

The detailed program will be shown on KDS Indico. (A pop-up window will be displayed. Use 'kds' as the user name and type in the pass word indicated on the pop-up window without space.)

Organization of Sessions (Tentative)

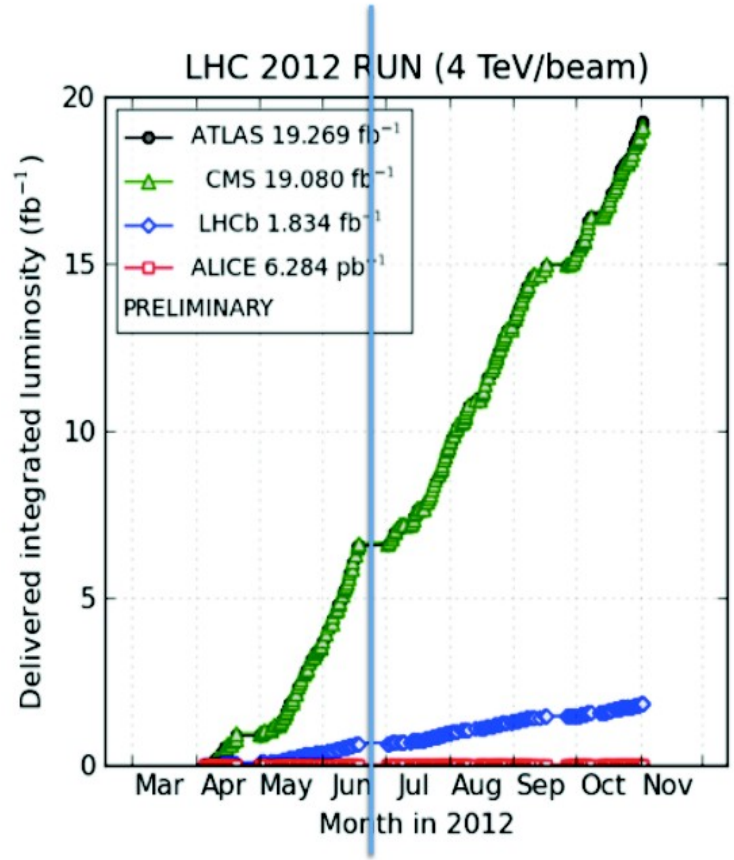
Nov. 12 (Mon.)	Nov. 13 (Tue.)	Nov. 14 (Wed.)	Nov. 15 (Thu.)	Nov. 16 (Fri.)
Opening 1.	Top 1.	QCD	Electroweak	SUSY
Coffee	Coffee	Coffee	Coffee	Coffee
Soft QCD/H.Ion	Exotics	Top 2.	Higgs	Future 1.
Lunch	Lunch	Lunch	Lunch	Lunch
Soft QCD/H.Ion	Parallel (a)SUSY/Exotic (b)Top (c)QCD/H.Ion	Parallel (a)Higgs (b)Heavy Flavor (c)Electroweak	Higgs	Future 2.
Heavy Flavor			Coffee	
Coffee			Poster	
Heavy Flavor			Tour/Dinner	

Sponsors Sitemap Co

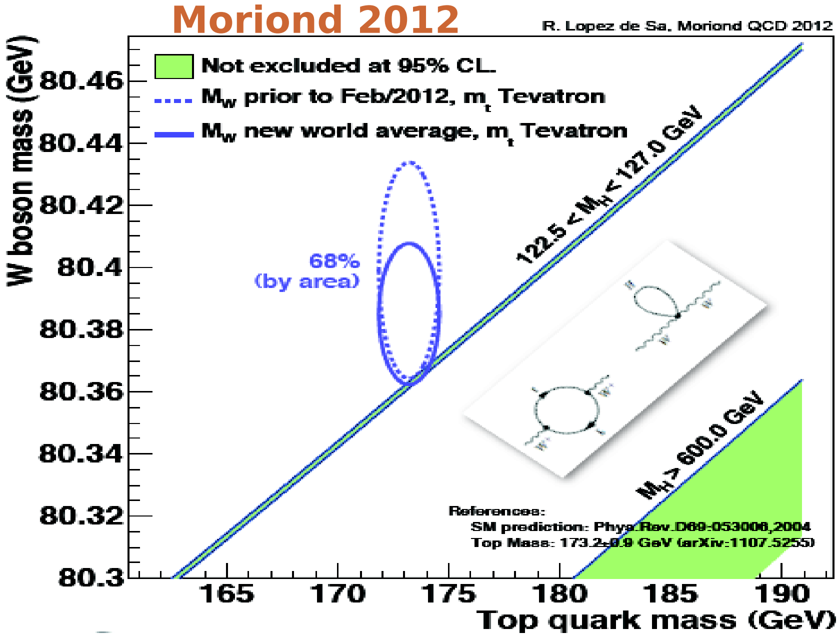
Copyright: HCP2012 Local Organizing Committee, 2012

Luminosity colected up to date

- Almost 4 x more data with 8 TeV pp available for analysis today: **about 20fb^{-1} recorded**
- Some channels updated with 12-13fb^{-1}, **presented at HCP conference**
- Next major updates planned for Moriond 2013 ...
- However still not excluded that new intermediate results will be released for December CERN Counsil week.



Standard Model: global fit



With M_W = 80385±15 MeV

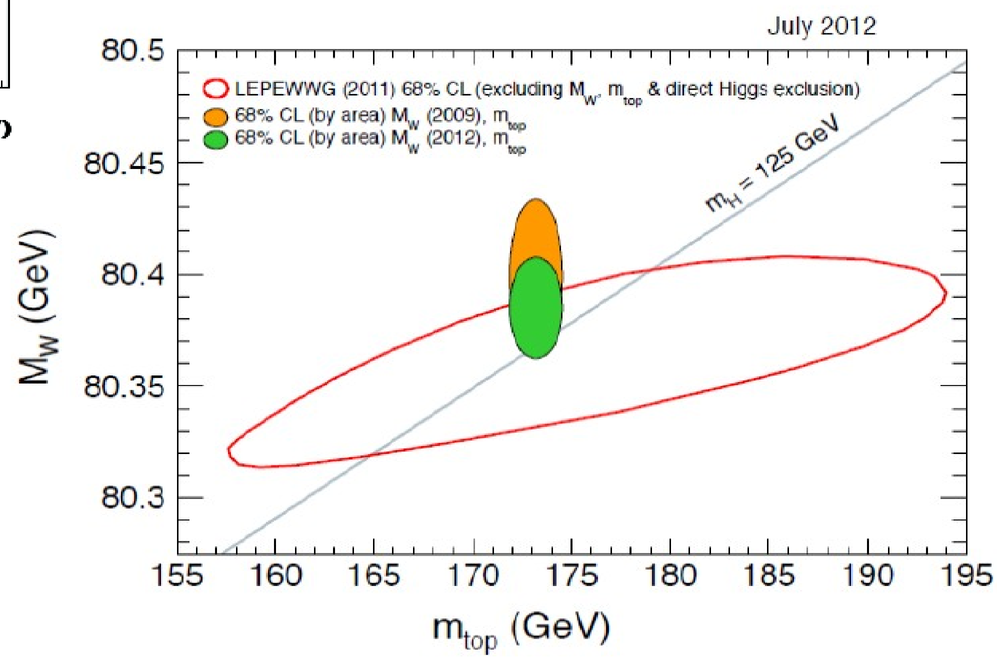
$M_H = 94^{+29}_{-24}$ GeV

$M_H < 152$ GeV @95% CL

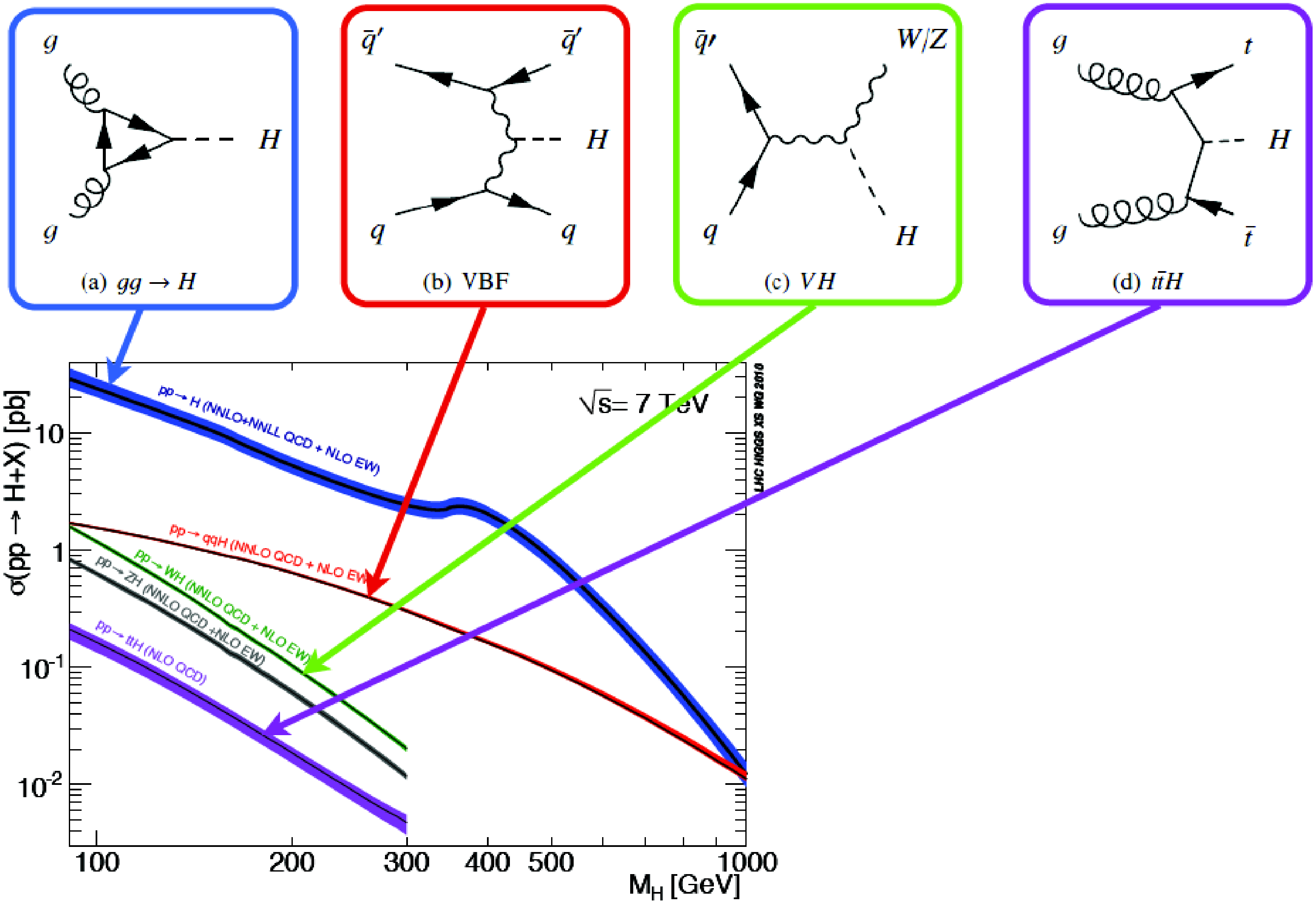
LEPEWWG/ZFitter

Since then:

- → **New mW measurement**
- → **Higgs-like particle discovery**



SM Higgs production at the LHC



SM Higgs decays

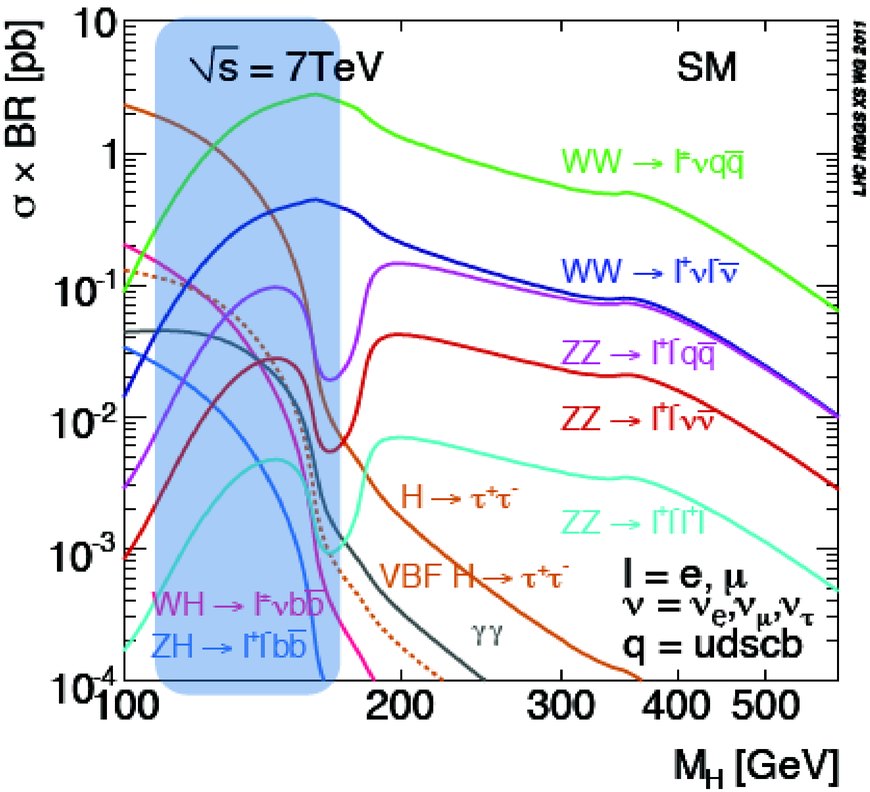
H→γγ

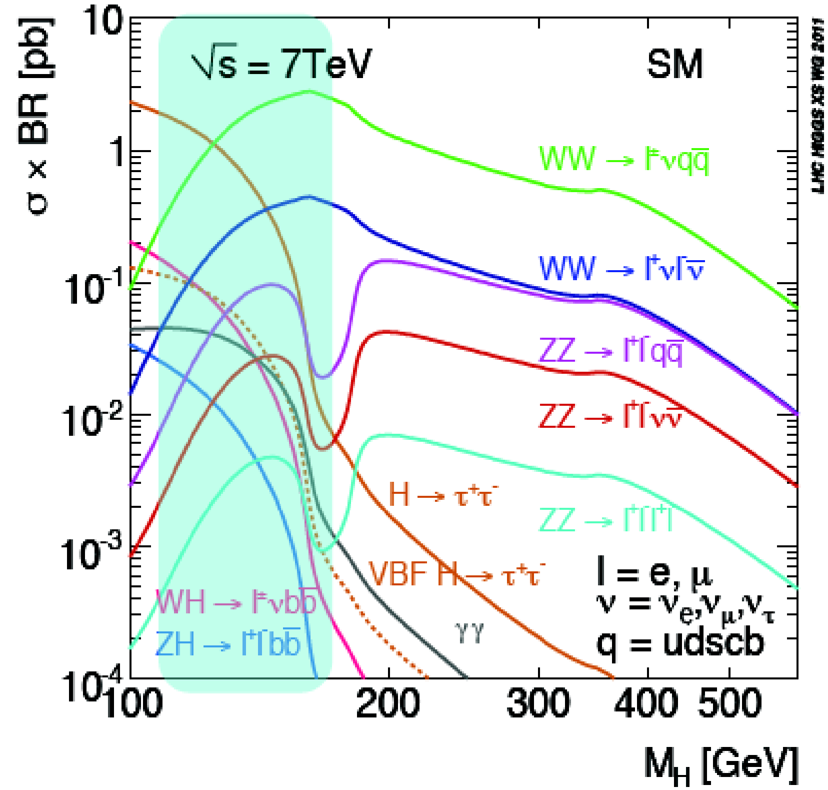
H→ZZ→llll

H→WW→lνlν

VH→bb

H→ττ





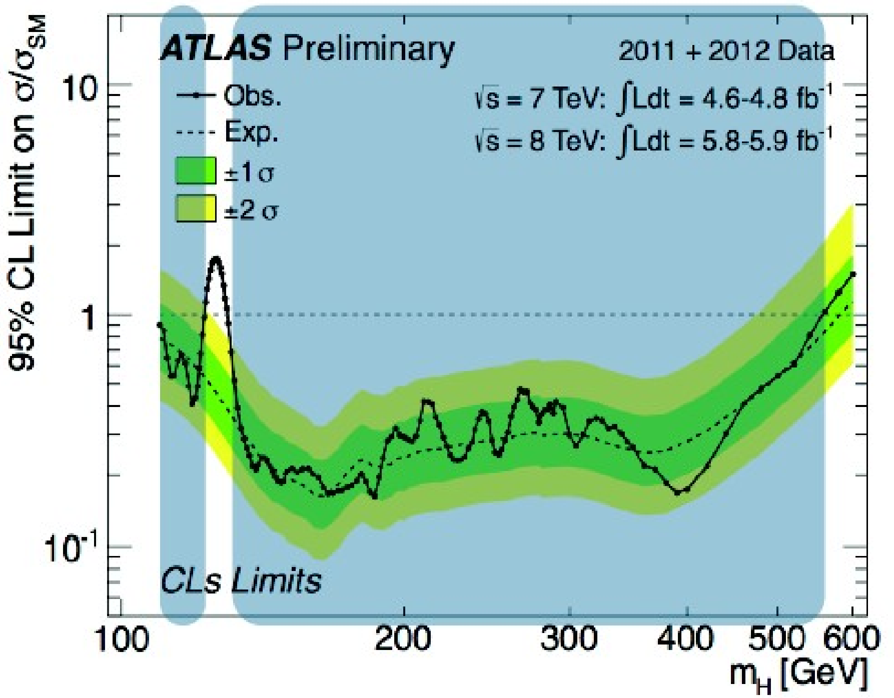
ATLAS results of 4-th July

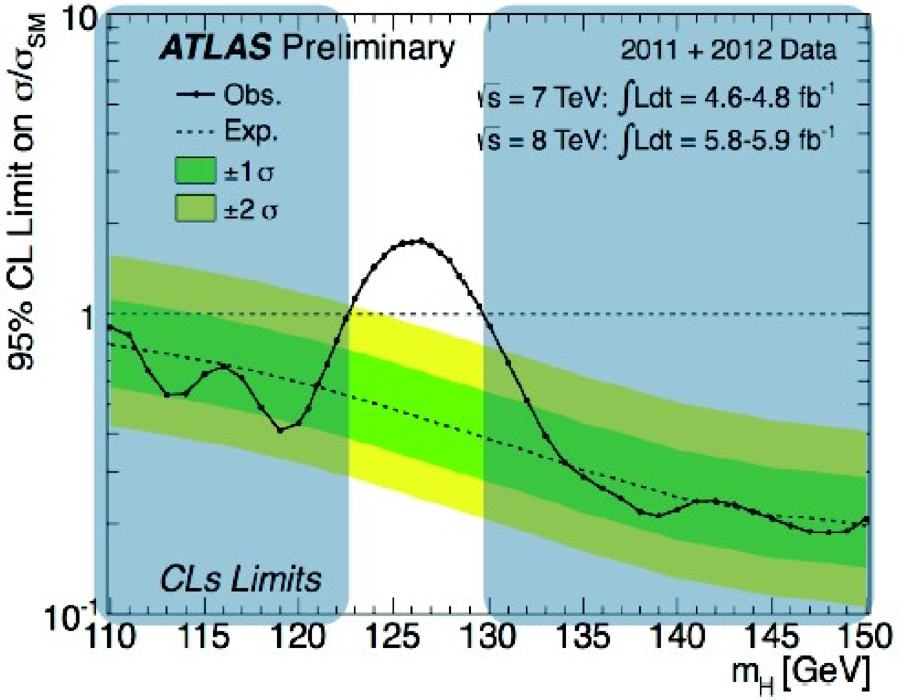
- Searches performed in 12 channels in the range 110 GeV < m_H < 600 GeV

Updated with 2012 data

Higgs decay	Subsequent decay	Mass range [GeV]	L [fb^{-1}]	Publication (arXiv)
$H\rightarrow\gamma\gamma$		110-150	4.8 + 5.9	1202.1414
$H\rightarrow ZZ$	$lll'l'$	110-600	4.8 + 5.8	1202.1415
	$ll\nu\nu$	200-600	4.7	1205.6744
	$llqq$	200-600	4.7	1206.2443
$H\rightarrow WW$	$l\nu qq$	300-600	4.7	1206.6074
	$l\nu l\nu$	110-600	4.7	1206.0756
$H\rightarrow\tau\tau$	$ll4\nu$	110-150	4.7	1206.5971
	$l\tau_{had}3\nu$		4.7	
	$\tau_{had}\tau_{had}2\nu$		4.7	
$VH\rightarrow bb$	$l\nu bb$	110-130	4.7	1207.0210
	$llbb$		4.7	
	$\nu\nu bb$		4.6	

ATLAS results of 4-th July



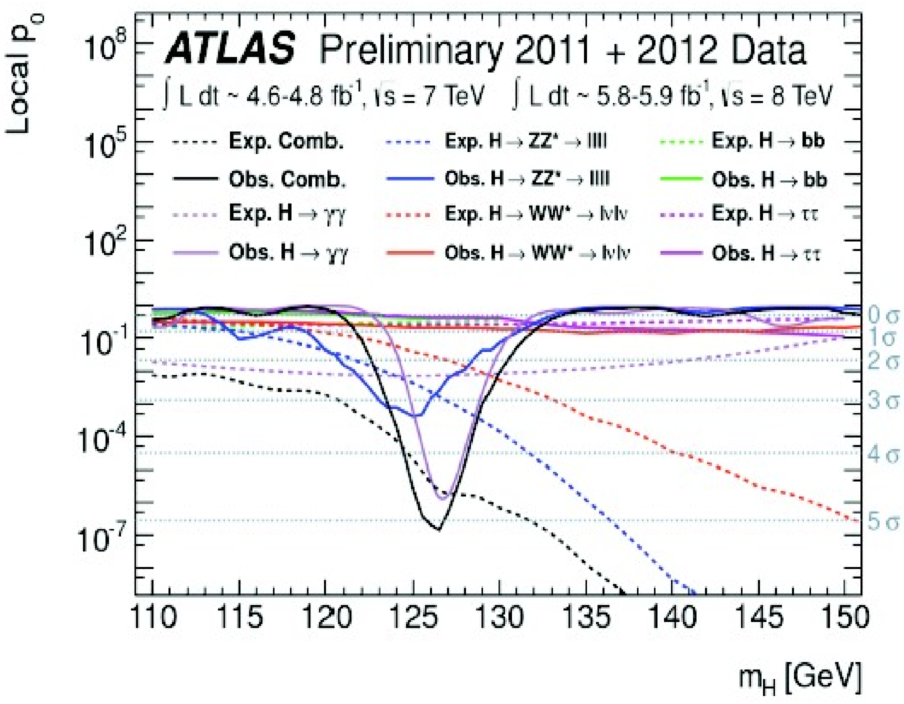


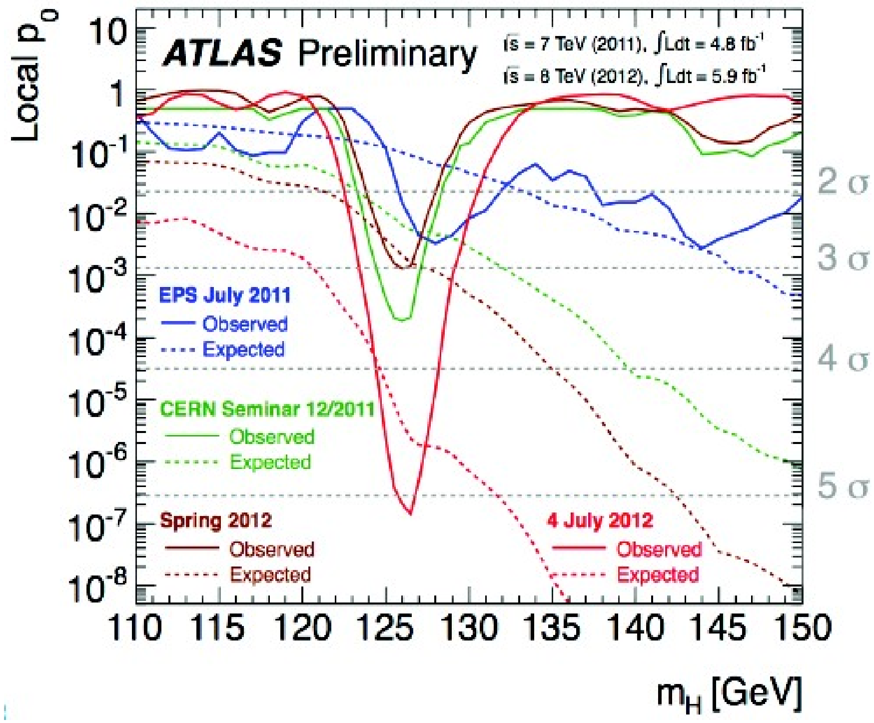
Excluded at 95% CL: 110-122.6 GeV, 129.7-558 GeV

Excluded at 99% CL: 111.7-121.7 GeV, 130.7-523 GeV

Expected exclusion at 95% CL (no signal): 110-582 GeV

ATLAS results of 4-th July

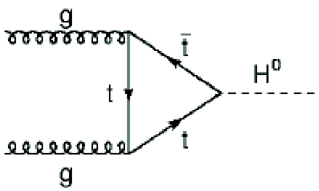




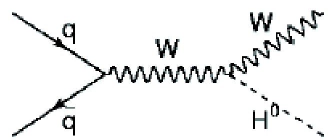
Excess consistent with
H->γγ and H->ZZ*->4l decays

SM predictions for H->γγ

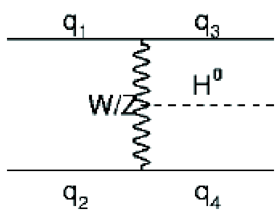
- **SM Higgs production channels**



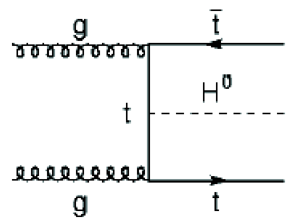
Gluon-gluon fusion (~87%)



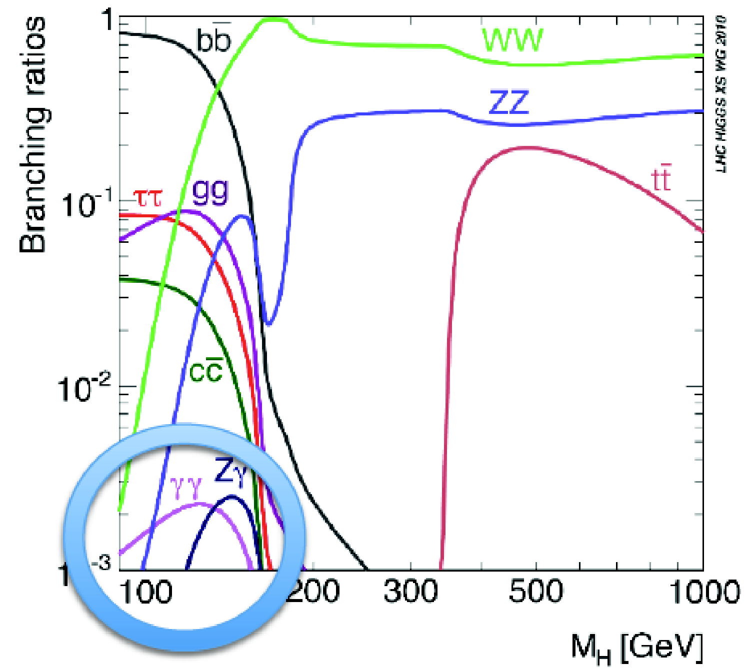
Associated Higgs (< 5%)



Vector-Boson Fusion (~7%)

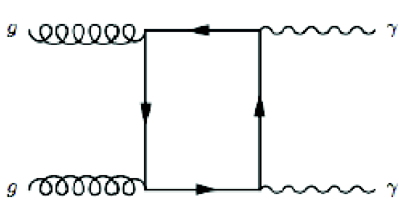


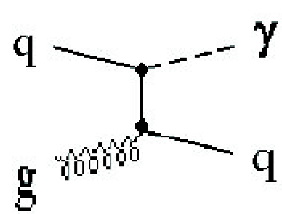
ttH (< 5%)

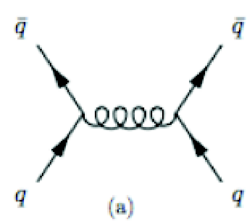


- **Branching fraction small** **but simple signature (two high p_T photons in final state)**

Main backgrounds to H→ γγ are SM diphoton, jet-γ and jet-jet events

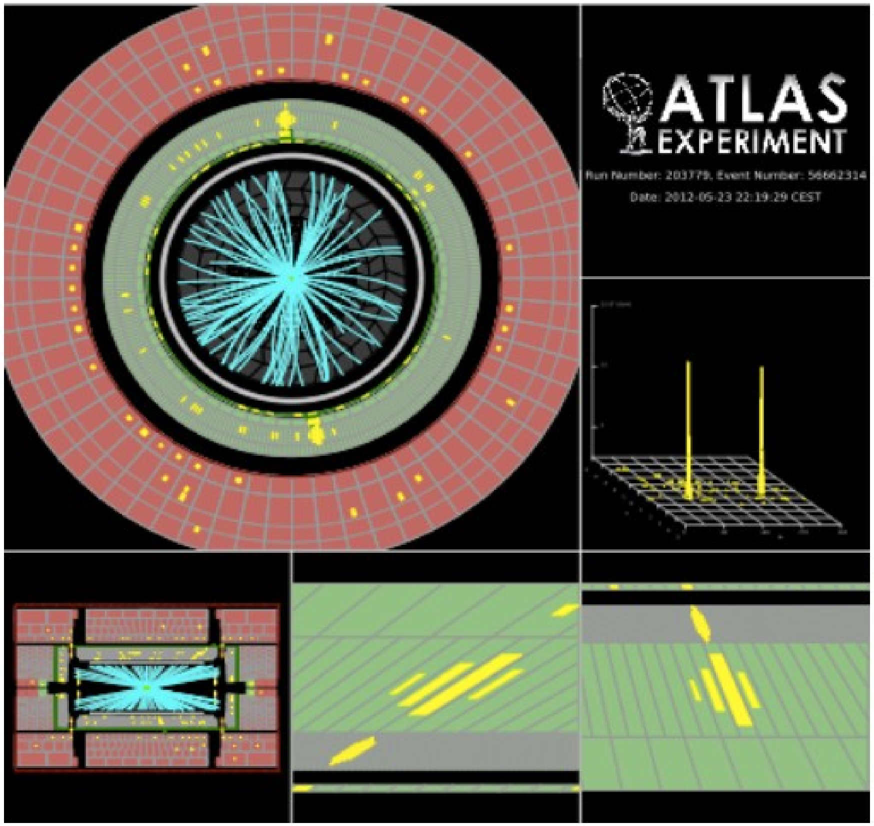






- Signal expected as **narrow resonance over smooth decaying background**

H->γγ event signature



Simple event signature

- ❑ Two high pT photons
  $pT_1 > 40$ GeV and $pT_2 > 30$ GeV
- ❑ High trigger efficiency
  ~99%
- ❑ High event selection efficiency despite high jet-jet & γ-jet production
  ~40%
- ❑ High signal over background
  ~3-10 % (depending on sub-category)

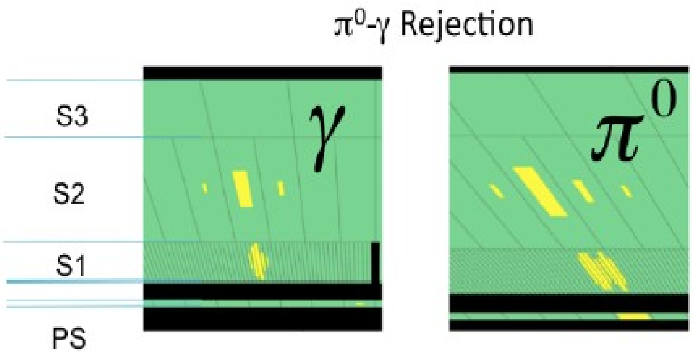
Invariant mass reconstruction $m_{\gamma\gamma}^2 = 2 * E_1 E_2 (1 - \cos \alpha)$

- ❑ Good energy calibration
- ❑ Robust primary vertex reconstruction

→ Excellent invariant mass resolution ~1.6 GeV with 90% of events within ±2σ

Shower shapes and vertex reconstr.

Photon ID 2 – Photon shower shapes and background rejection



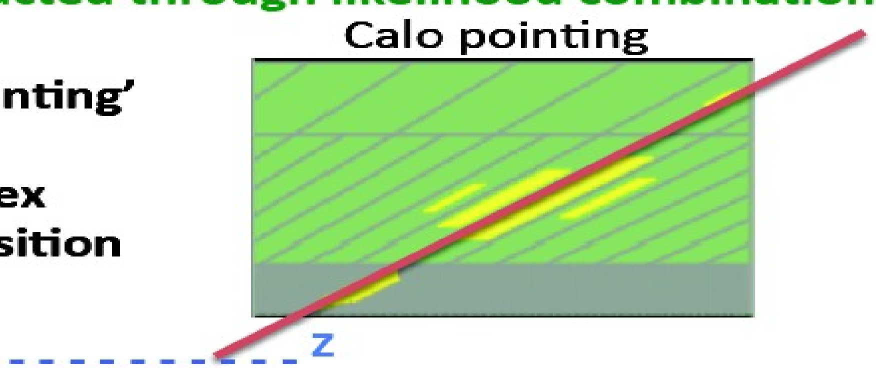
- Photons shower shape distributions in LAr sampling layers - different for signal and background (π^0)

Vertex Reconstruction

$$m_{\gamma\gamma}^2 = 2*E_1E_2(1 - \cos\alpha)$$

- Vertex reconstructed through likelihood combination

- Calorimeter 'pointing'
- Σ tracks pT^2
- Conversion vertex
- Mean vertex position



Event categorization

Event categories based on eta, pTt, and conversion

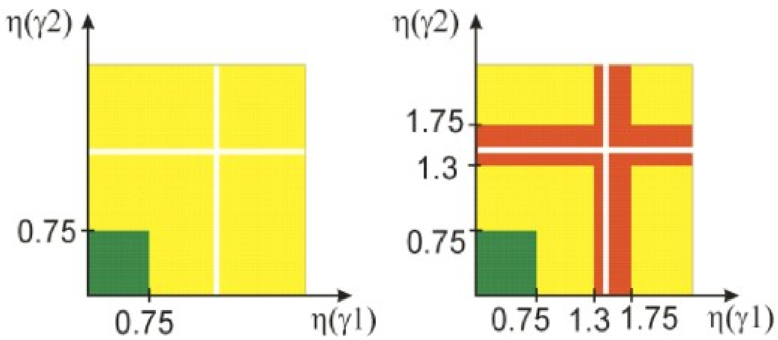
Both unconverted:

- Central
- Rest

At least one converted:

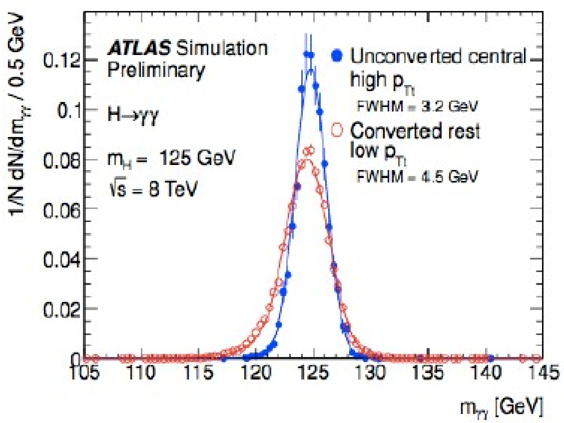
- Central
- Transition
- Rest

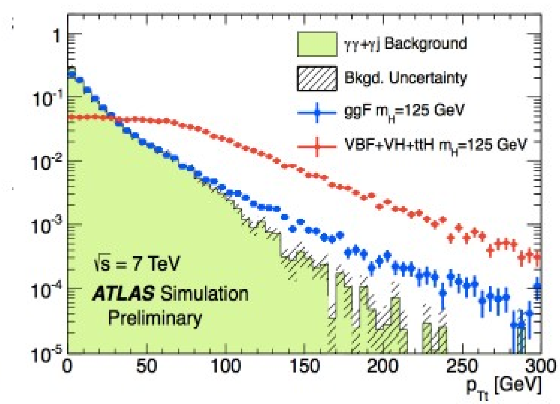
2 unconverted: >=1 converted:



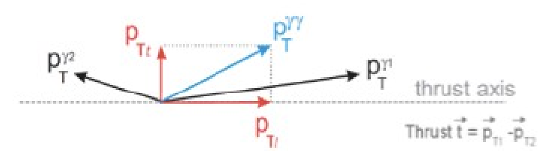
Resolution:

Good
Medium
Poor





Central and Rest divided
into $p_{Tt} < 60$ GeV
and $p_{Tt} > 60$ GeV

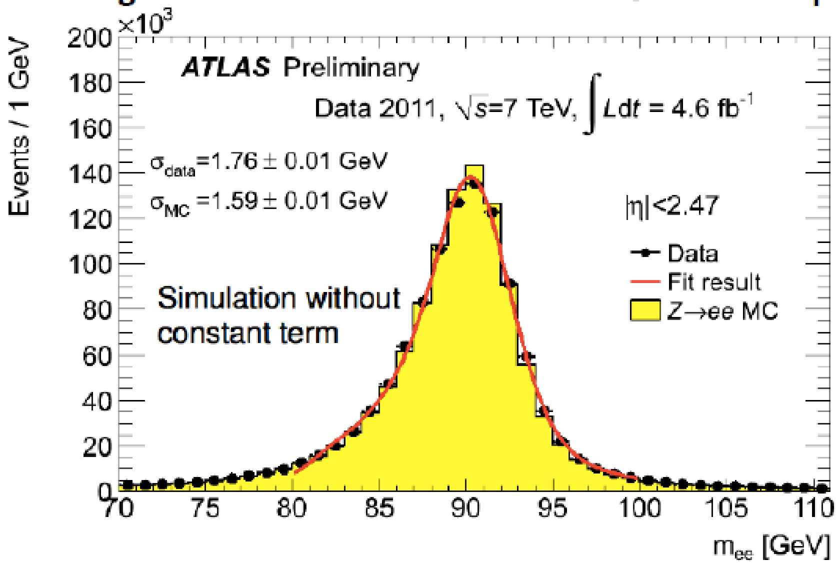


Energy calibration and resolution

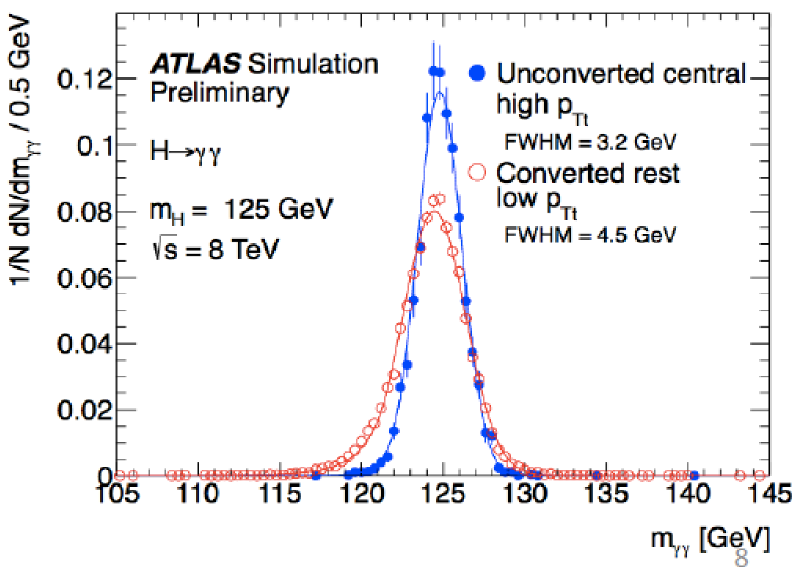
$$m_{\gamma\gamma}^2 = 2 * E_1 E_2 (1 - \cos\alpha)$$

- MC based calibration improved with energy scale and resolution corrections based on in-situ analysis of Z→ee, W→eν and J/ψ → ee
- Energy scale at m_Z known to 0.3%, uniformity (constant term) 1% in barrel, 1.2 – 2.1% in endcap

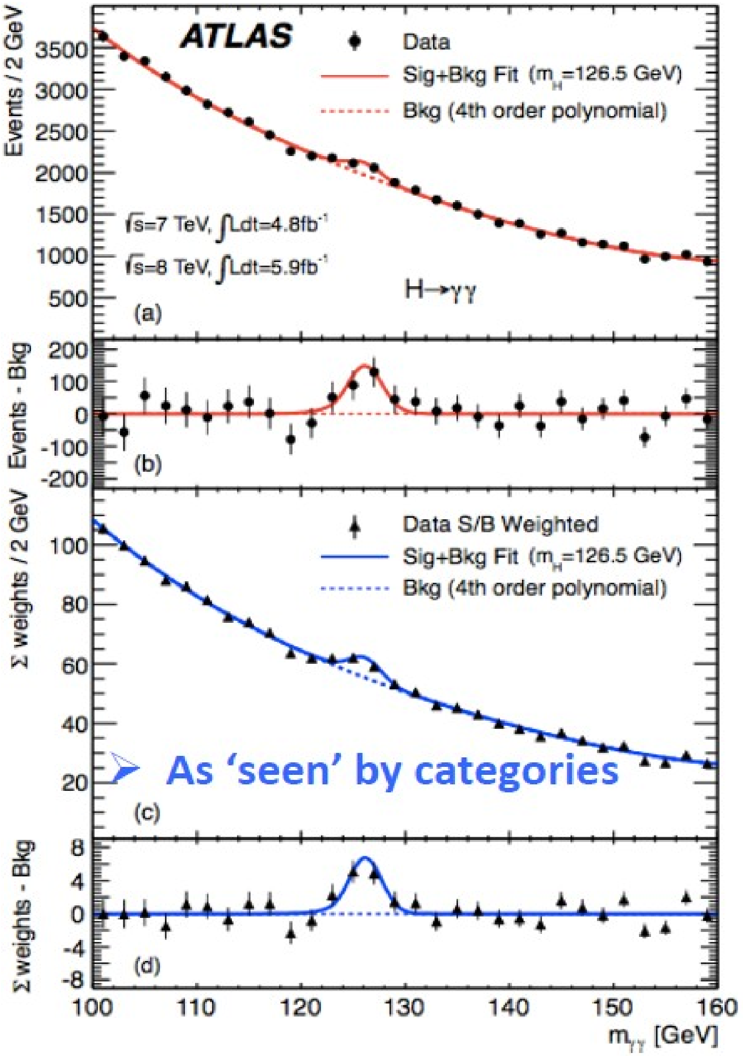
Agreement between data & MC Z→ee lineshape



Expected resolution of Higgs signal



Invariant mass distribution



- ❑ Photon ID efficiency ~10%
- ❑ Energy resolution ~14% and mass scale ~0.6%
- ❑ Isolation < 1%
- ❑ Pileup 4%
- ❑ Lumi 1-3.6 % (2011-2012)
- ❑ Theory cross section
  - ~ up to 25% (for VBF contribution)
  - ~ up to 12% (in other ggF)
  - (underlying event ~5% and PTt dist up to 12% at hight PTt)
- ❑ Bkg Param (evts) 0.2-4.6 (0.3-6.8) for 2011(2012)

In VBF category

- ❑ Jet E-scale 9-10%
- ❑ Underl. Evt. 6-30%
- ❑ Higgs p_T up to 12.5%

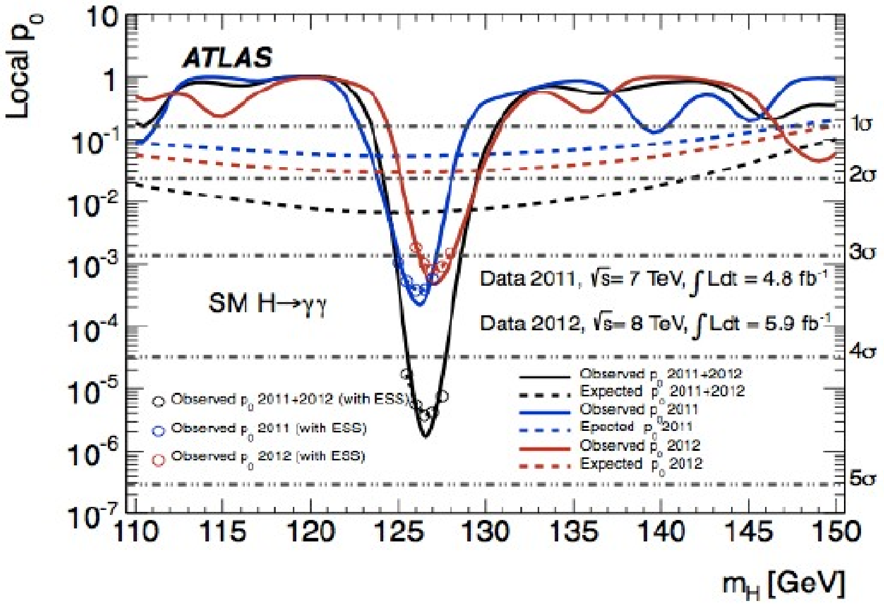
23788 events (7 TeV) and 35251 events (8 TeV)

Background+signal fit, signal fixed at 126.5 GeV

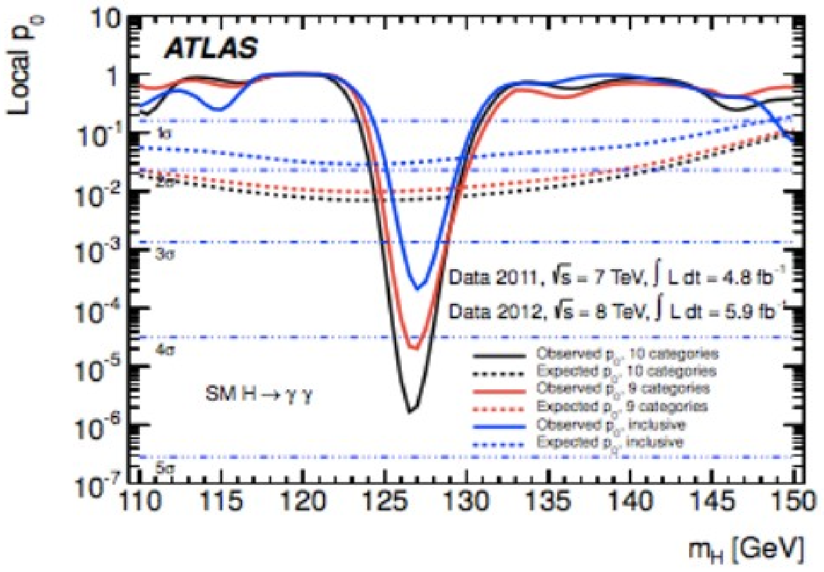
Quantifying the excess

- Maximum deviation from background only expectation at $m_{\gamma\gamma}$ 126.5 GeV
→ Local significance 4.5σ *(expected from SM Higgs 2.4σ)*

Effect of combination of 2011 & 2012



Effect of adding VBF category



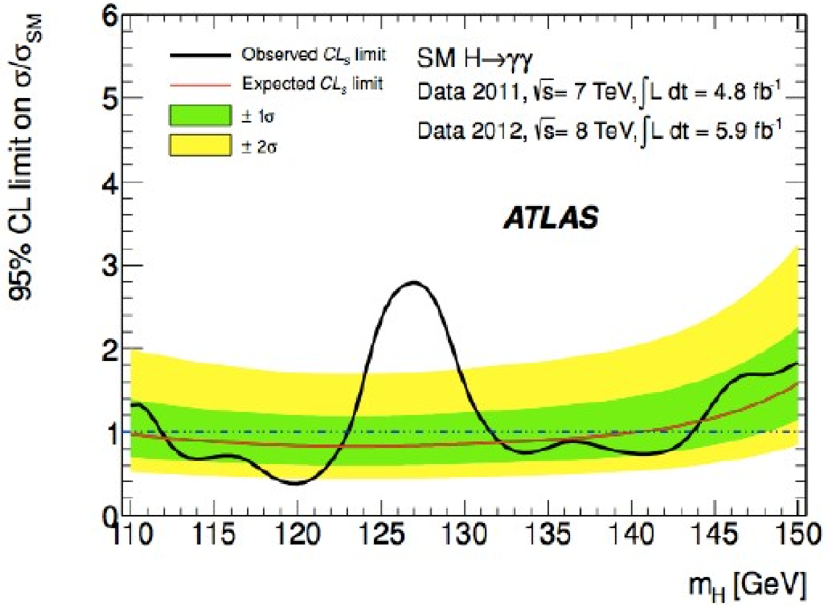
- *Results consistent between 2011 and 2012 and improved by VBF category*
- *Results consistent between inclusive analysis (no categories) and with categories*

Signal strenght

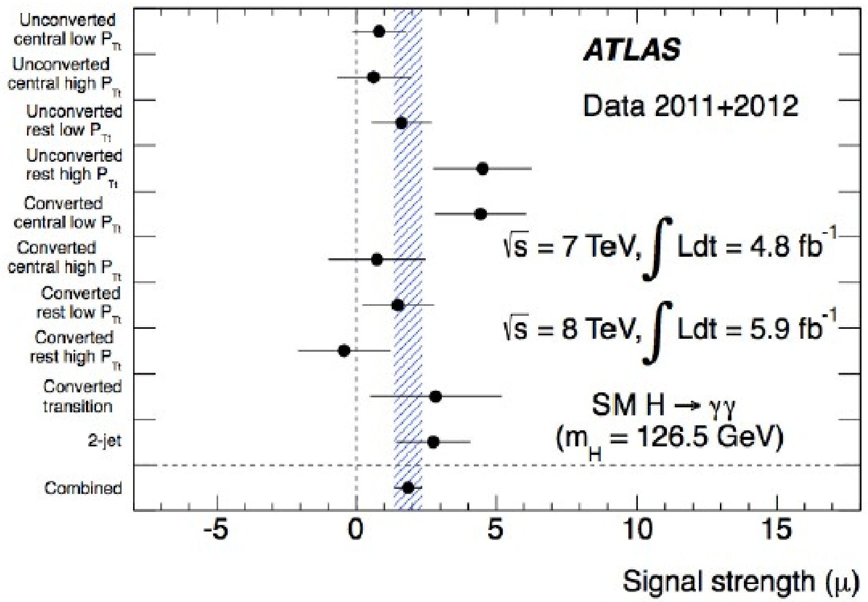
- SM hHggs excluded in the regions of **112 – 122.5 GeV and 132 – 143 GeV**
- Best fitted signal strength (wrt SM) for $m_{\gamma\gamma}$ = 126 of **μ = 1.8 ± 0.5**

- *Consistent results from different categories*

CL limit on σ/σ_{SM}

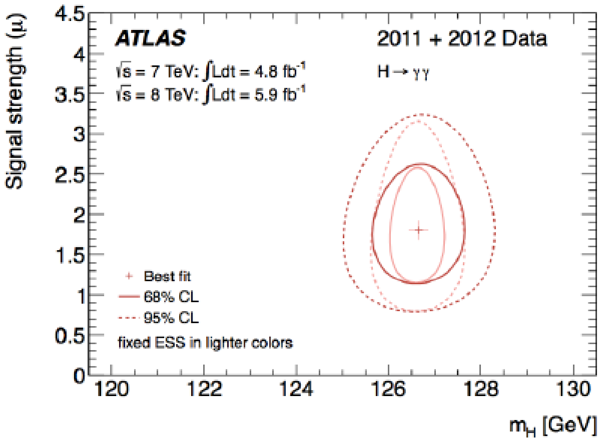


Signal Strength per Category



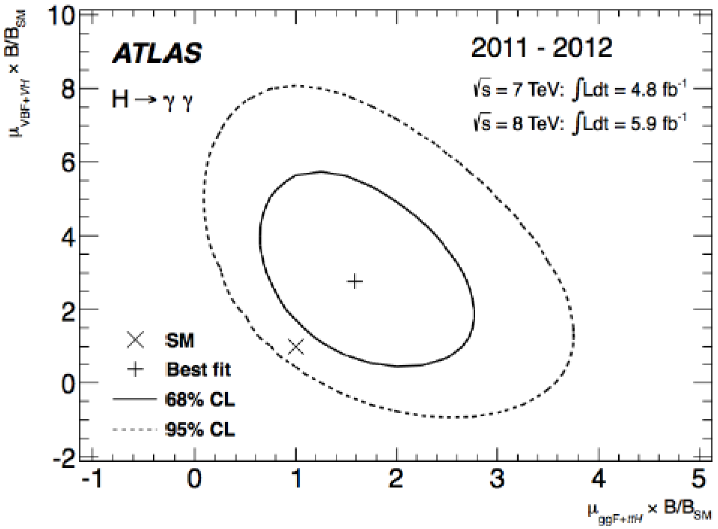
Properties of new resonance

- **Mass**
  → Likelihood contours in the (μ, mH) plane. Uncertainty on fit comparable for statistical and systematic uncertainty



- With and without ES uncertainty

- **Couplings**
  → Constraints in the plane of μ (ggF+$t\bar{t}H$ $\times B/B_{SM}$) and μ (VBF+$VH \times B/B_{SM}$), where B is the branching ratio for $H \to \gamma\gamma$, can be obtained
  → The data are compatible with the SM at the 1.5 σ level
- **Production modes merged due to similar couplings and small stats (with current data-set)**



Since then........ (4-th July)

ATLAS

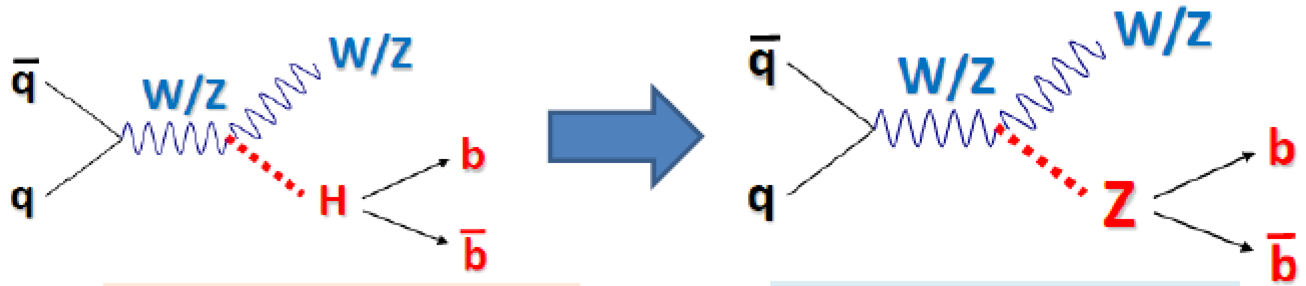
- The WW channel completed with 5.8fb^{-1} and released end of July, included in the SM Higgs published paper.
- Low mass channels with decay to WW, bb, $\tau\tau$ updated with ~13fb^{-1} (2012)   and released for HCP conference.
- Update on combination for signal strength.

CMS

- Updated ZZ, WW, bb, $\tau\tau$ with ~12 fb^{-1} (2012).
- Updated combination, couplings and spin.

- **Tevatron**
- Update on H->bb analysis with 10fb^{-1}.

The TEVATRON update

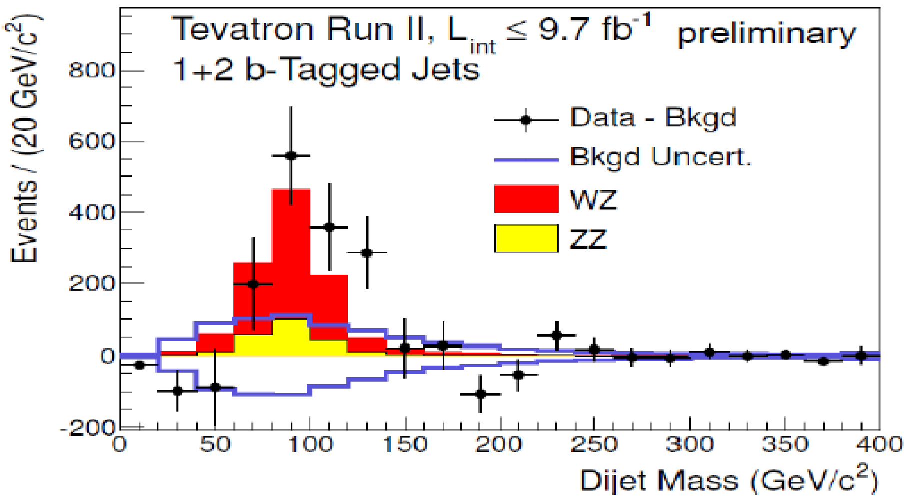


For m_H=115 GeV
Total VH: σ = 46 fb

Replace Z with H
Total VZ: σ = 213 fb

Z→bb yields is 5 times larger, but more W+jets at lower mass, also there is **BG from WW**.

Measure diboson cross section with **exactly the same** analysis procedure.



$\sigma(WZ+ZZ) = 3.0 \pm 0.9$ pb

(Fit performed with MVA output without Higgs signal)

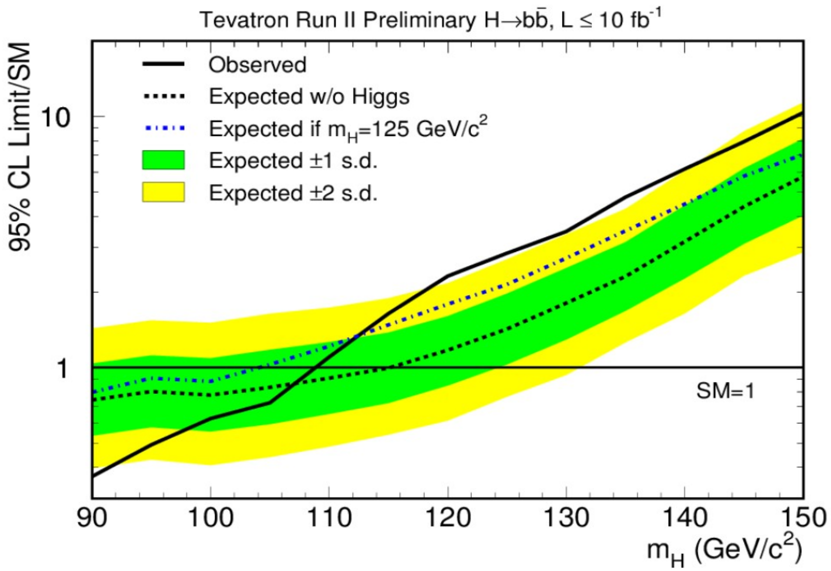
$\sigma(VZ)^{NLO}_{SM} = 4.4 \pm 0.3$ pb

The TEVATRON update

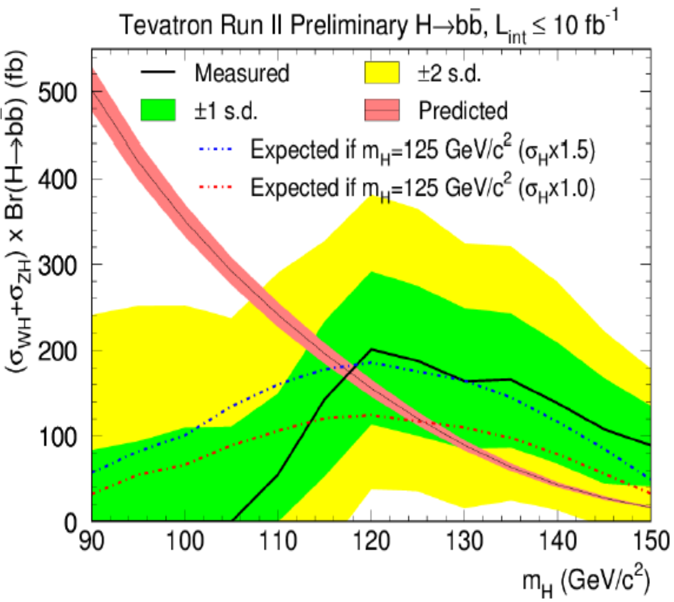
$\sigma(WH+ZH) \times Br(H \rightarrow b\bar{b})$

$= 0.19 \pm 0.09$ (stat+syst) pb

$\rightarrow \mu = 1.56 \pm^{0.72}_{0.73}$ @M_H=125GeV



95% CL SM Higgs limit ratio @M_H = 125 GeV
Exp : 1.4 Obs : 2.9



$\mu = 1.56 \pm^{0.72}_{0.73}$

$$(\sigma_{WH}+\sigma_{ZH}) \times \mathcal{B}(H \rightarrow b\bar{b}) = 0.19 \pm 0.09 \text{ (stat + syst) pb}$$

SM expectation : 0.12 ± 0.01 pb

SM Higgs @ 125 GeV

ATLAS H->bb: analysis strategy

Search for Higgs decaying to pair of b-quarks

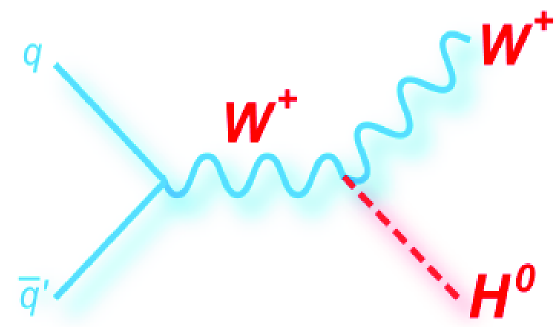
- Associated production to reduce backgrounds

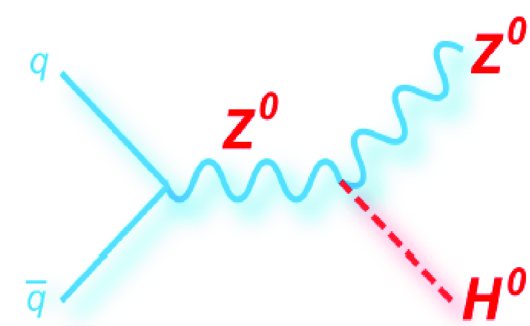
The analysis is divided into three channels

- Two (llbb), one (lνbb) or zero (ννbb),) (l=e,μ)

Cuts common to all channels

- Two or three jets: 1st jet $p_T > 45$ GeV
  other jets $p_T > 20$ GeV
- Two b-tags: 70% efficiency per tag (mistag ~1%)





Two lepton

ZH → llbb
- No additional leptons
- $E_t^{miss} < 60$ GeV
- $83 < m_Z < 99$ GeV
- Single & di-lepton trigger

One lepton

WH → lνbb
- No additional leptons
- $E_t^{miss} > 25$ GeV
- $40 < M_T^W < 120$ GeV
- Single lepton trigger

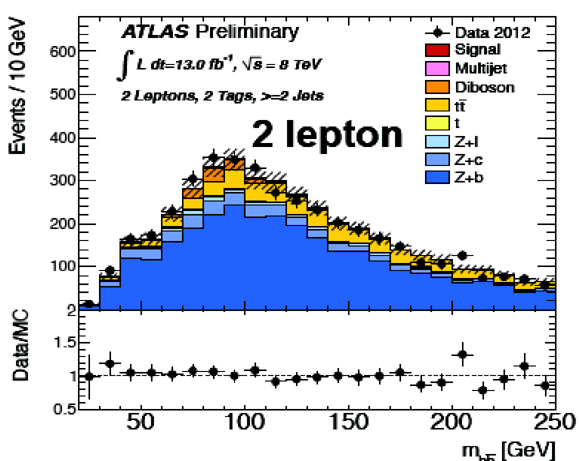
Zero lepton

ZH → ννbb
- No leptons
- $E_t^{miss} > 120$ GeV
- E_t^{miss} trigger

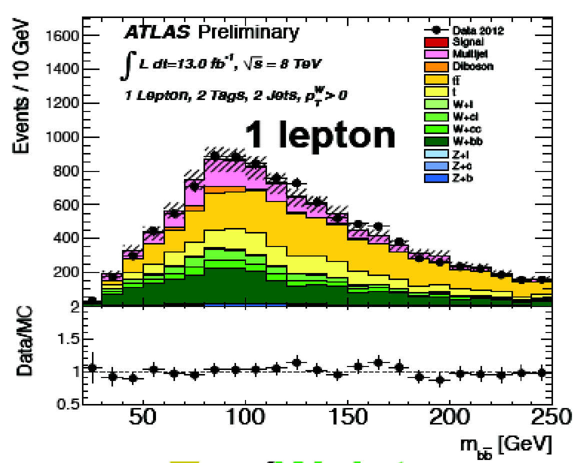
H->bb: backgrounds

- Signal: WH/ZH Pythia8
- Diboson WW/WZ/ZZ Herwig
- Multijet: Data driven
- Ttbar: MC@NLO
- Single Top Acer/MC@NLO
- W+b Powheg
- W+c/light-jets Alpgen
- Z+ b/c/light-jets Alpgen/Sherpa

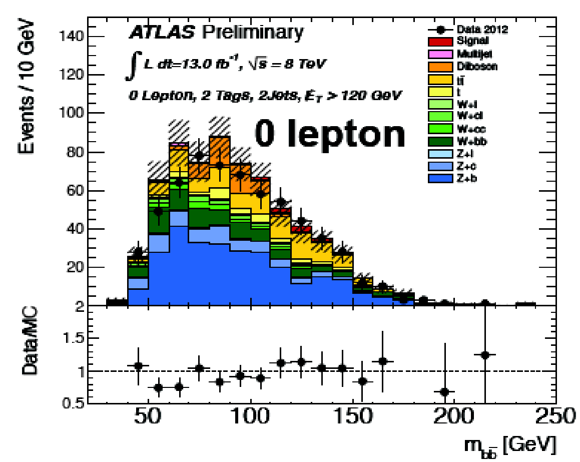
- Background shapes from simulation and normalised using data (flavour & signal fit)
- Multi-jet bkg determined by data-driven techniques
- WZ(Z→bb) & ZZ(Z→bb) resonant bkg normalisation and shape from simulation



Z+jets

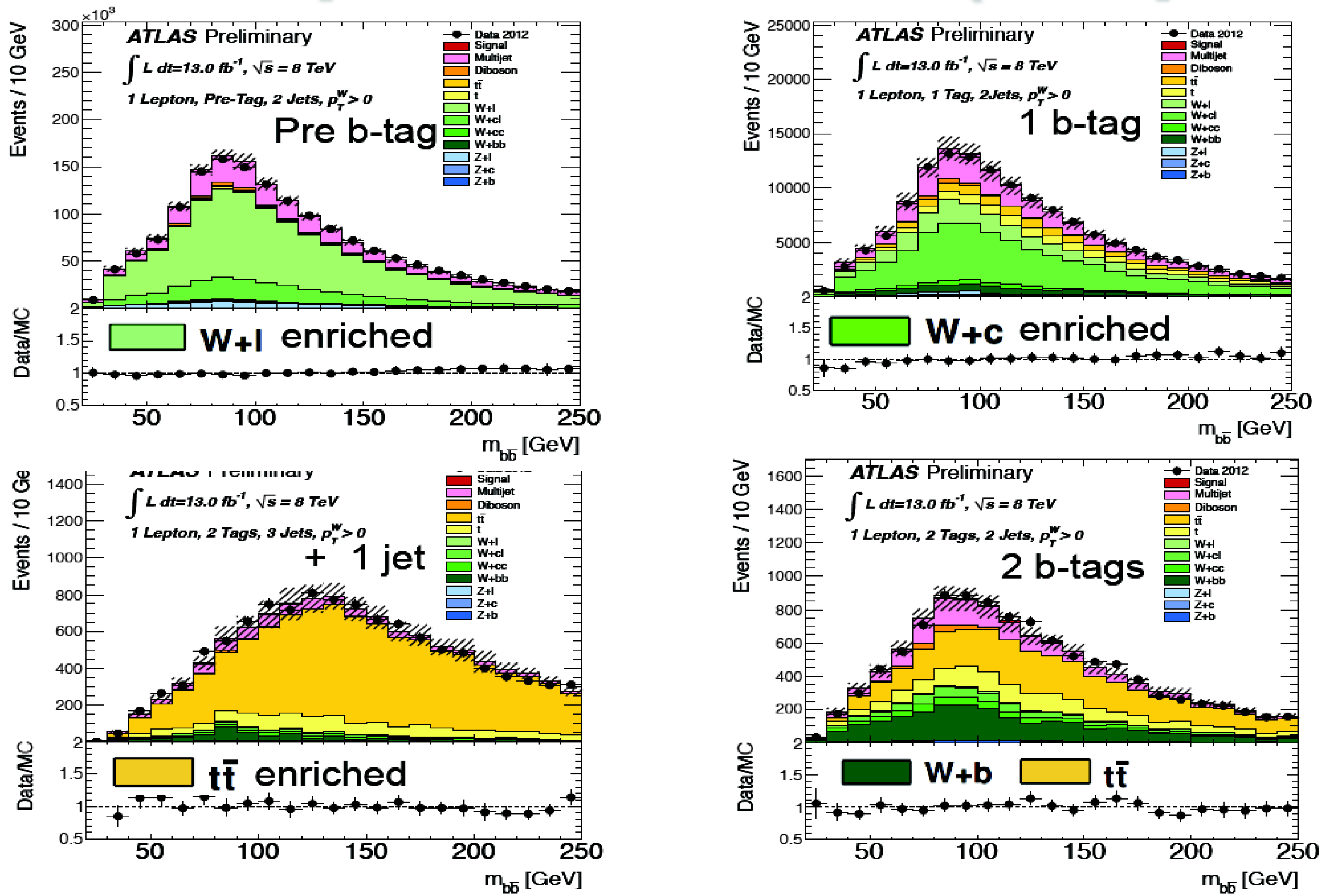


Top/W+jets



Z+jets/W+jets/Top

H->bb: example flavour fit



H->bb: systematic uncertainties

Main experimental uncertainties

b-tagging and **jet energy** dominate

- Jets: components (7 JES, 1 p_T^{Reco}, resol.)
- E_T^{miss} – scale and resolution
- bTagging – light, c & 6 p_T efficiency bins
- Top, W, Z background modelling
- Lepton/ Multijet / diboson / Luminosity
- MC statistics

Main theoretical uncertainties

- W/Z+jet m_{bb} and V pT
- BR(H→bb) @ mH=125 GeV
- Signal cross-sections include pT-dependent electroweak correction factors
- Single top/top normalisation
- W+c, Z+c

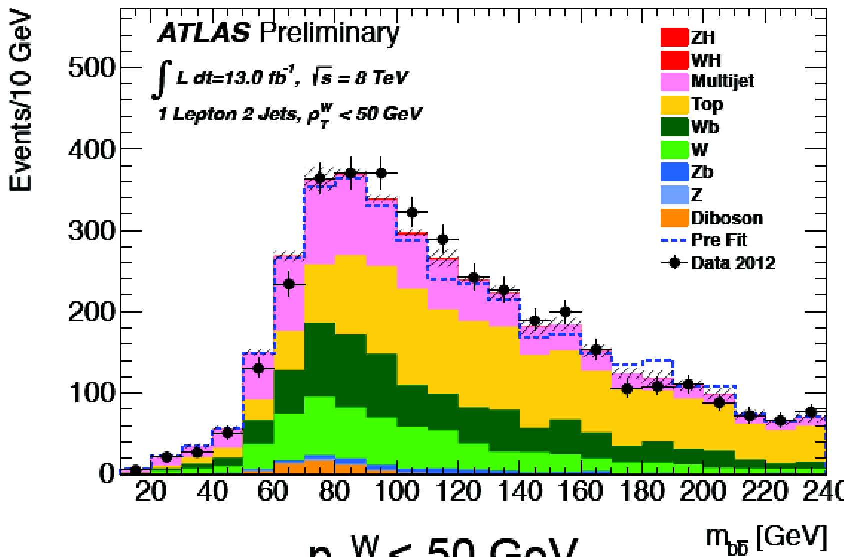
Uncertainty [%]	0 lepton	1 lepton	2 leptons
b-tagging	6.5	6.0	6.9
c-tagging	7.3	6.4	3.6
light tagging	2.1	2.2	2.8
Jet/Pile-up/E_T^{miss}	20	7.0	5.4
Lepton	0.0	2.1	1.8
Top modelling	2.7	4.1	0.5
W modelling	1.8	5.4	0.0
Z modelling	2.8	0.1	4.7
Diboson	0.8	0.3	0.5
Multijet	0.6	2.6	0.0
Luminosity	3.6	3.6	3.6
Statistical	8.3	3.6	6.6
Total	25	15	14

Background systematics (after cuts)

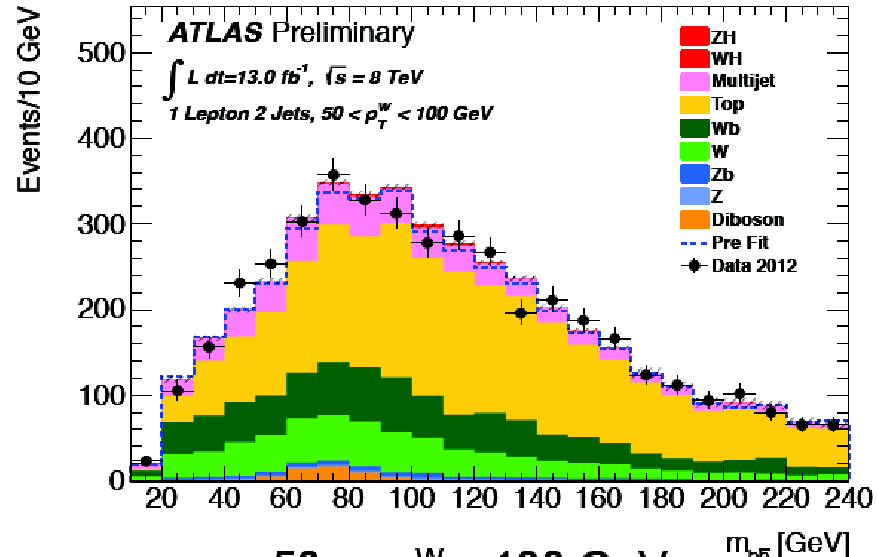
Uncertainty [%]	0 lepton		1 lepton	2 leptons
	ZH	WH	WH	ZH
b-tagging	8.9	9.0	8.8	8.6
Jet/Pile-up/E_T^{miss}	19	25	6.7	4.2
Lepton	0.0	0.0	2.1	1.8
$H \to bb$ BR	3.3	3.3	3.3	3.3
VH p_T-dependence	5.3	8.1	7.6	5.0
VH theory PDF	3.5	3.5	3.5	3.5
VH theory scale	1.6	0.4	0.4	1.6
Statistical	4.9	18	4.1	2.6
Luminosity	3.6	3.6	3.6	3.6
Total	24	34	16	13

Signal systematics (after cuts)

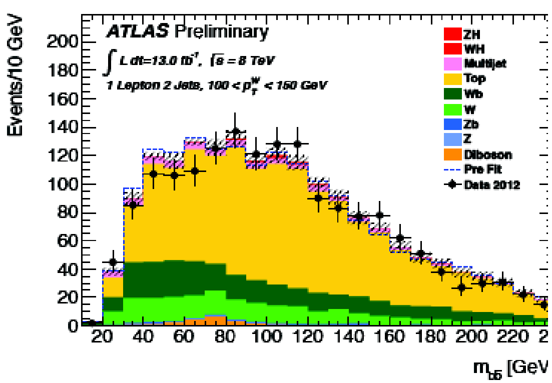
H->bb: m_{bb} distribution (1 lepton)



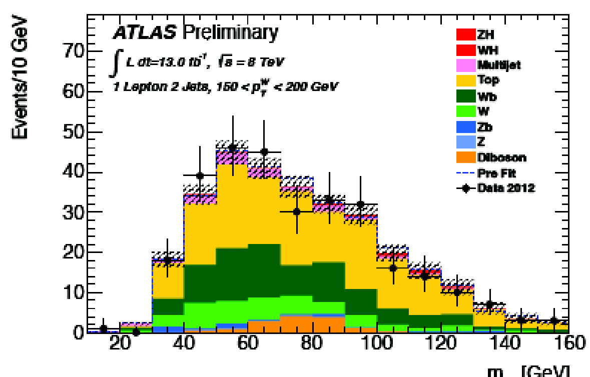
$p_T^W < 50$ GeV



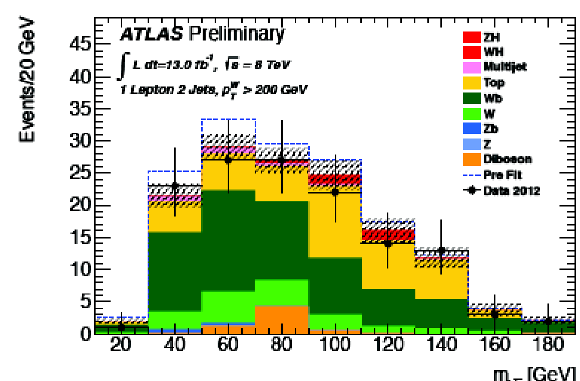
$50 < p_T^W < 100$ GeV



$100 < p_T^W < 100$ GeV



$150 < p_T^W < 200$ GeV



$p_T^W > 200$ GeV

H->bb: Diboson production

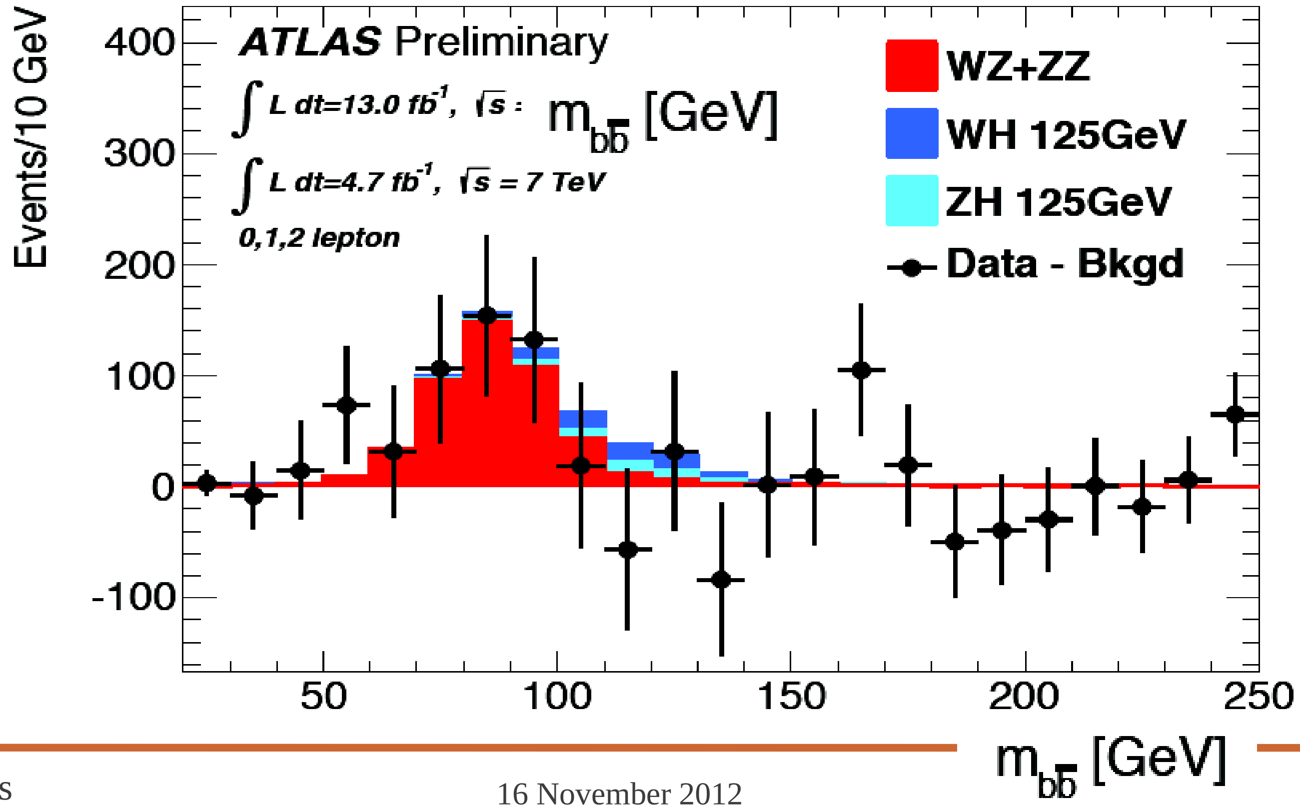
WZ & ZZ production with $Z \to b\bar{b}$ similar signature, but 5 times larger cross-section

Perform a separate fit to search for it and to validate the analysis procedure

- Profile likelihood fit performed (with full systematics)
- All backgrounds (except diboson) subtracted
- Uses full $p_T^{W,Z}$ range, done individually for each channel & year (see backup)

Clear excess is observed in data at expected mass (all lepton channels combined)

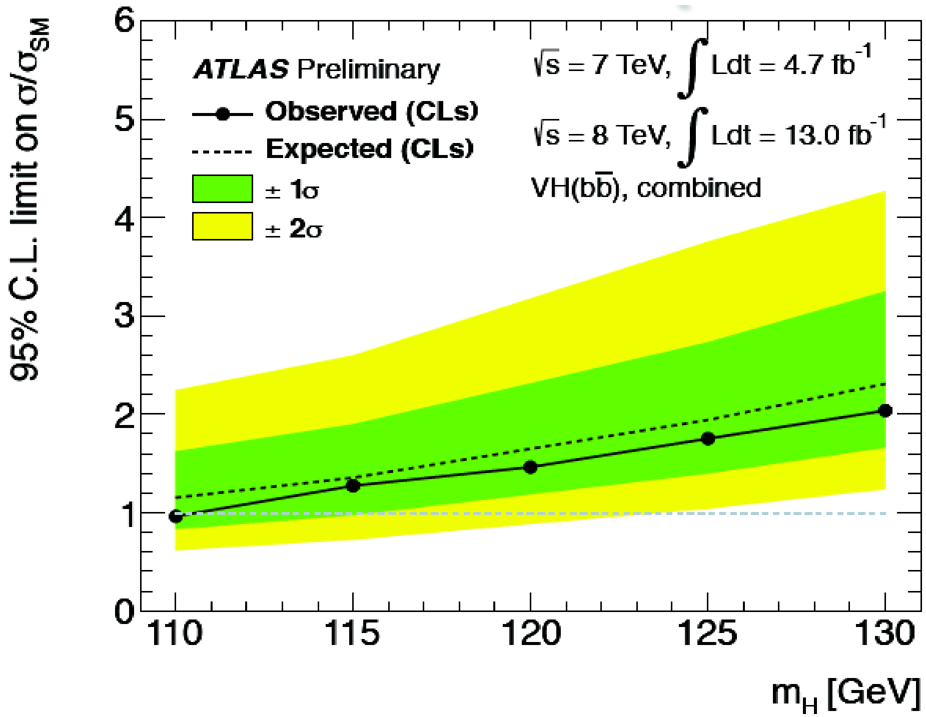
Results: $\sigma/\sigma_{SM} = \mu_D = 1.09 \pm 0.20$ (stat) ± 0.22 (syst). The significance is 4.0σ

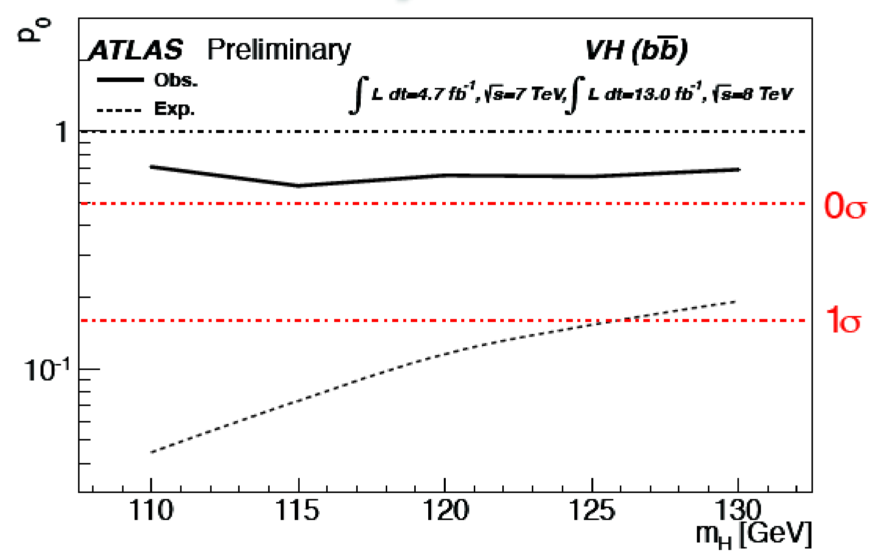


H->bb: Expected and observed events

	0-lepton, 2 jet			0-lepton, 3 jet			1-lepton					2-lepton				
Bin	E_T^{miss} [GeV]						p_T^W [GeV]					p_T^Z [GeV]				
	120-160	160-200	>200	120-160	160-200	>200	0-50	50-100	100-150	150-200	> 200	0-50	50-100	100-150	150-200	>200
ZH	2.9	2.1	2.6	0.8	0.8	1.1	0.3	0.4	0.1	0.0	0.0	4.7	6.8	4.0	1.5	1.4
WH	0.8	0.4	0.4	0.2	0.2	0.2	10.6	12.9	7.5	3.6	3.6	0.0	0.0	0.0	0.0	0.0
Top	89	25	8	92	25	10	1440	2276	1120	147	43	230	310	84	3	0
$W + c$,light	30	10	5	9	3	2	580	585	209	36	17	0	0	0	0	0
$W + b$	35	13	13	8	3	2	770	778	288	77	64	0	0	0	0	0
$Z + c$,light	35	14	14	8	5	8	17	17	4	1	0	201	230	91	12	15
$Z + b$	144	51	43	41	22	16	50	63	13	5	1	1010	1180	469	75	51
Diboson	23	11	10	4	4	3	53	59	23	13	7	37	39	16	6	4
Multijet	3	1	1	1	1	0	890	522	68	14	3	12	3	0	0	0
Total Bkg.	361 ± 29	127 ± 11	98 ± 12	164 ± 13	63 ± 8	42 ± 5	3810 ± 150	4310 ± 86	1730 ± 90	297 ± 27	138 ± 14	1500 ± 90	1770 ± 110	665 ± 47	97 ± 12	72 ± 12
Data	342	131	90	175	65	32	3821	4301	1697	297	132	1485	1773	657	100	69

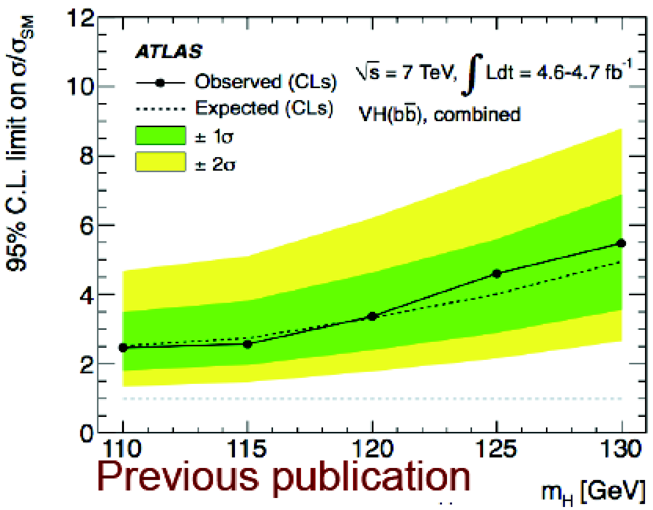
H->bb: Expected and observed events





- Observed (expected) limit at m_H =125 GeV
  - ➢ 1.8 (1.9) x SM prediction
  - ➢ $\sigma/\sigma_{SM} = \mu = -0.4 \pm 0.7(\text{stat.}) \pm 0.8(\text{syst.})$
- Observed (expected) p_0 value: 0.64 (0.15)
- Exclusion at $m_H \sim$ 110 GeV

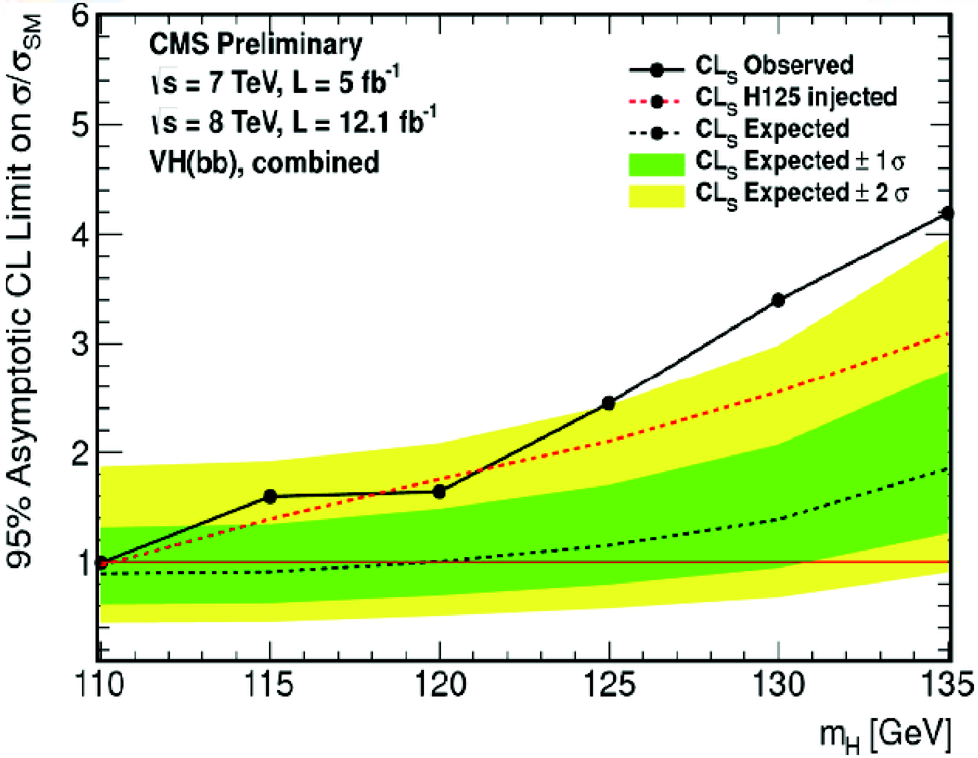
More than doubled the analysis sensitivity ➠

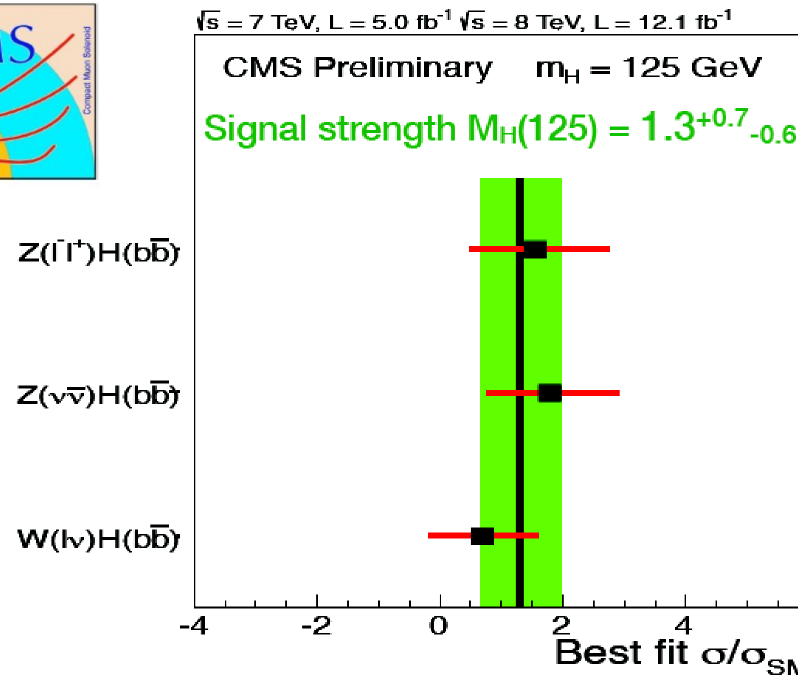


Previous publication

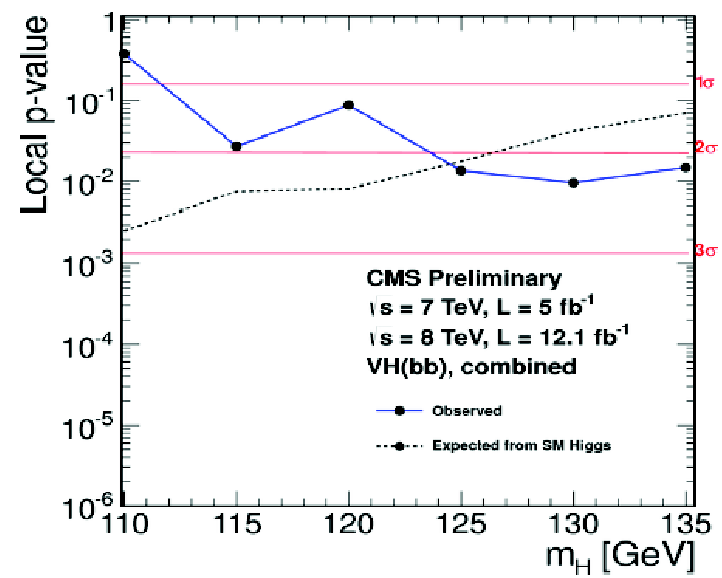
http://arxiv.org/abs/1207.0210

VH, H→bb results



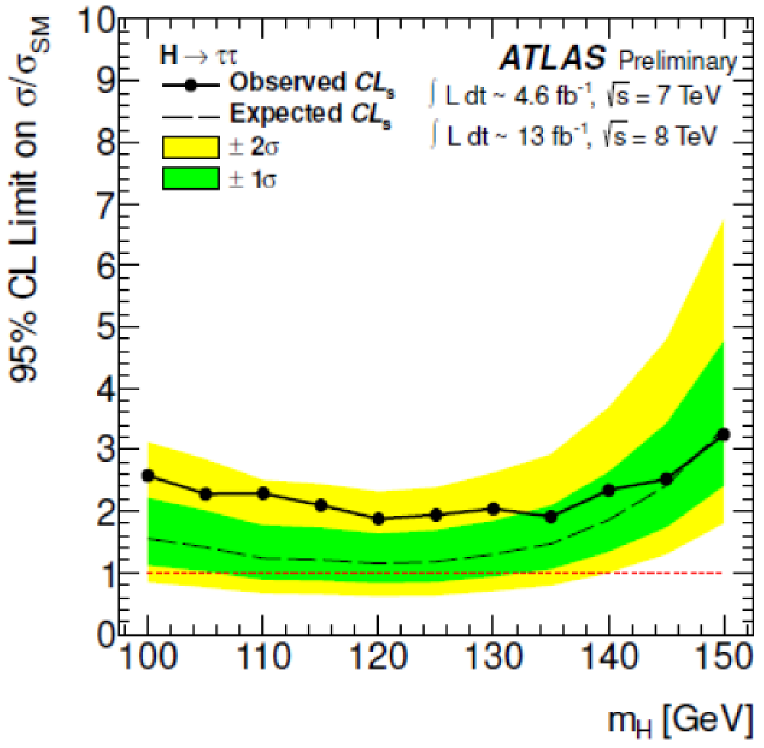


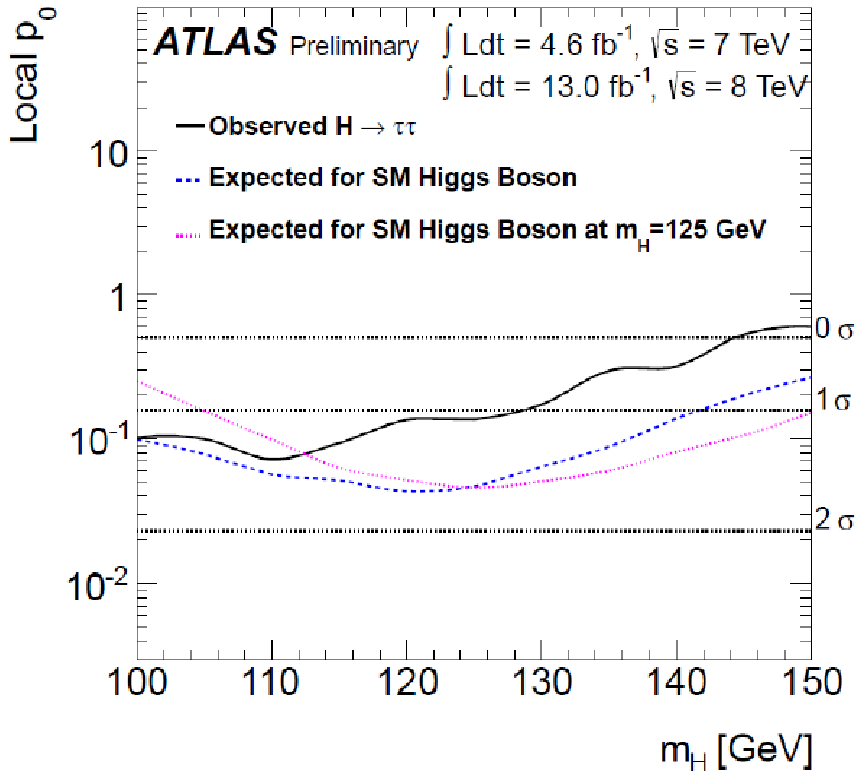
- Obs (exp) excess 2.2σ (2.1σ) @ 125 GeV [Tevatron obs (exp) ~2.8σ (1.5σ)]
- Reached SM sensitivity < 120 GeV.



H->ττ: sensitivity not yet reached

- Calculated limit and significance using MMC distribution as the discriminant.
- To extract signal, Profile likelihood was used.





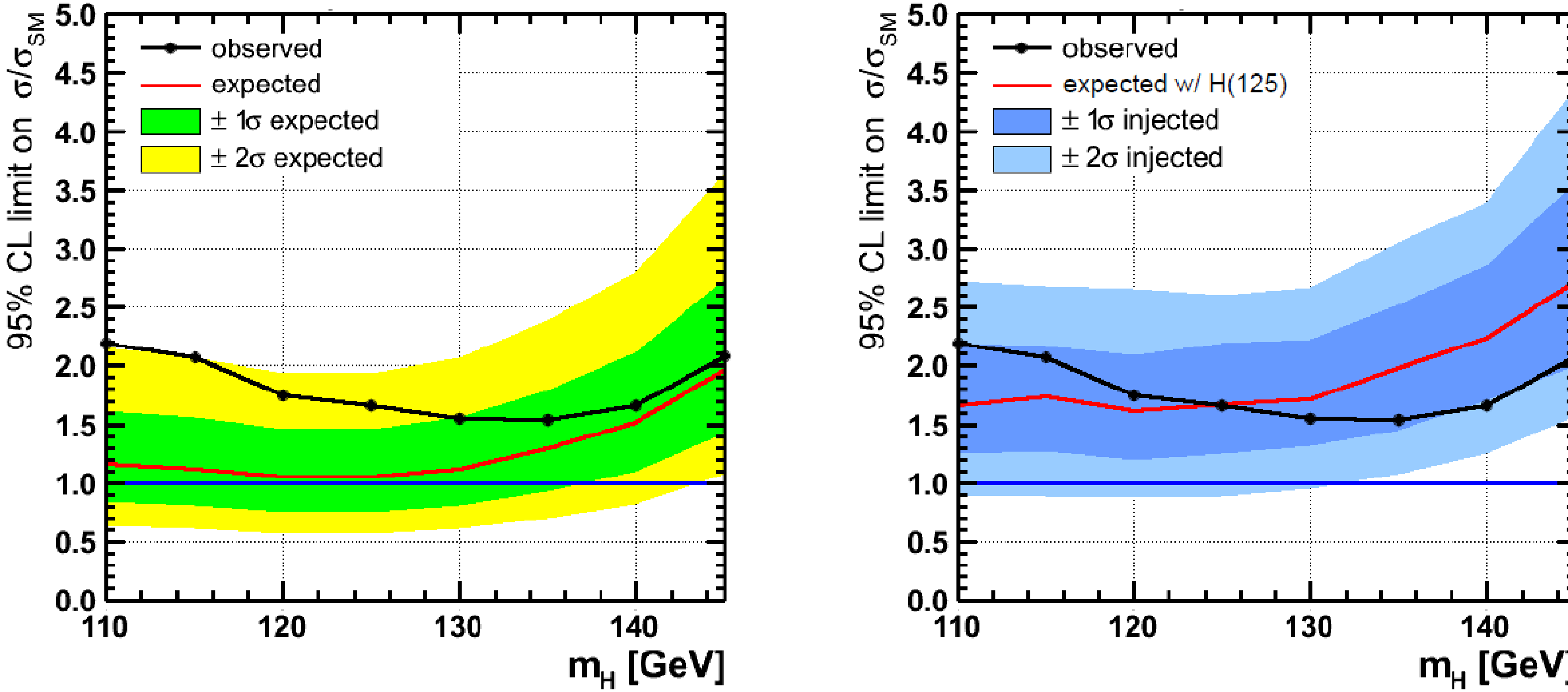
Expected:1.2xSM **Observed:1.9xSM** **Expected:1.7σ** **Observed:1.1σ**

(μ=0) (μ=1)

Best fit value of Signal Strength (μ) is 0.7 ±0.7

Observed Limit (inclusive $H\rightarrow\tau\tau$)

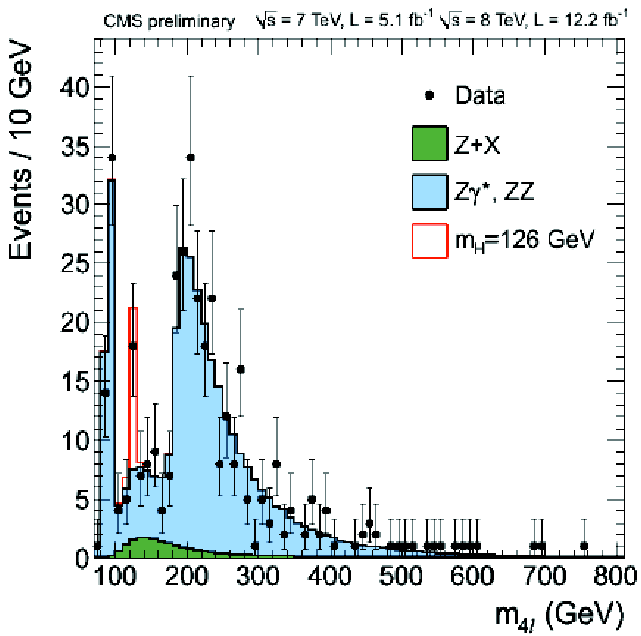
Expectation w/o Higgs: Expectation w/ SM H(125):[1)]

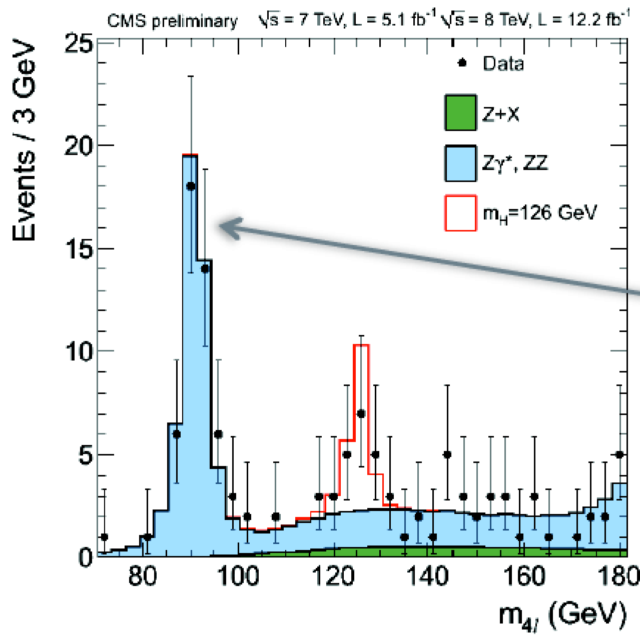


- Sensitivity(125 GeV)=1.05. Observed limit(125 GeV)=1.66.
- Compatible with Higgs boson signal at 125 GeV but also with background only hypothesis.

1) no fit to data for expectation

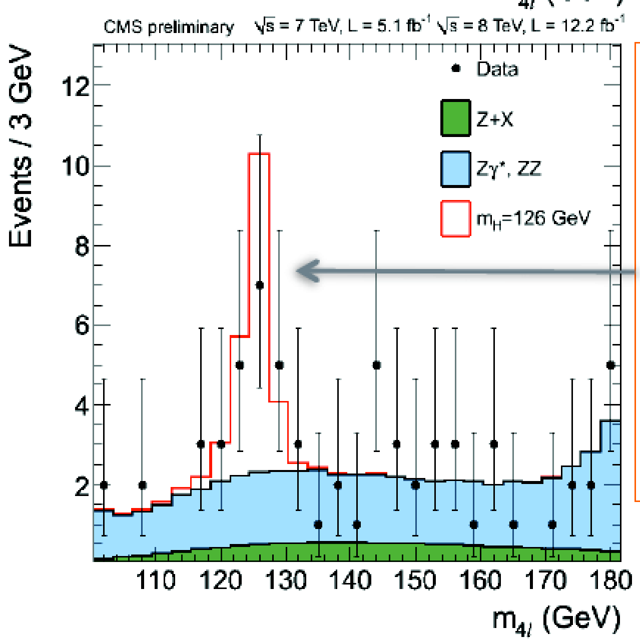
Results





Good agreement between predicted and observed ZZ continuum.

Z→4l peak is in place and in agreement with prediction. Fit of the Z→4l peak shows δm~0.4±0.28 GeV and expected resolution.



X→ZZ→4l peak is there and increasing in statistics corresponding to luminosity and expectation of H→ZZ→4l

For m(4l) = 121.5..130.5 GeV:

- Expected background: 6.5 events
- Expected signal (m_H=126 GeV): 12.5 events
- Signal:Bckg ~ 2:1!
- Observed: 17 events

ATLAS: update on combination

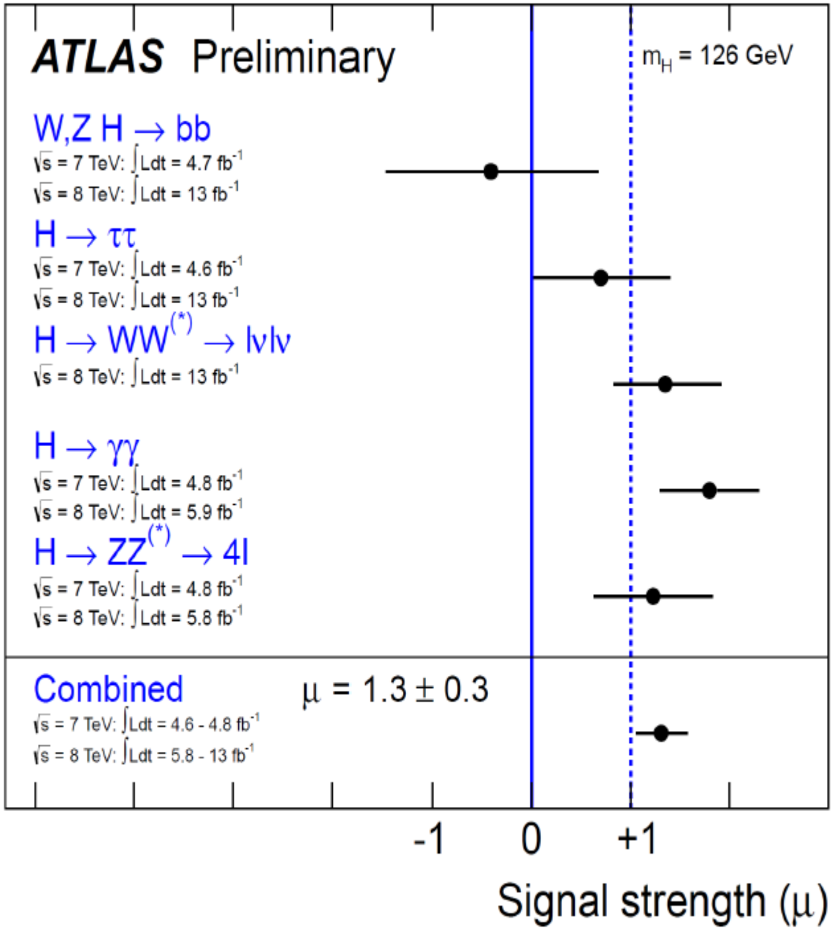
Higgs Boson Decay	Subsequent Decay	Sub-Channels	$\int L\, dt$ [fb^{-1}]
		2011 $\sqrt{s}$ =7 TeV	
$H \to ZZ^{(*)}$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu\}$	4.8
$H \to \gamma\gamma$	–	10 categories $\{p_{Tt} \otimes \eta_\gamma \otimes \text{conversion}\} \oplus \{\text{2-jet}\}$	4.8
$H \to \tau\tau$	$\tau_{lep}\tau_{lep}$	$\{e\mu\} \otimes \{\text{0-jet}\} \oplus \{\ell\ell\} \otimes \{\text{1-jet, 2-jet, boosted}, VH\}$	4.7
	$\tau_{lep}\tau_{had}$	$\{e, \mu\} \otimes \{\text{0-jet, 1-jet, boosted, 2-jet}\}$	4.7
	$\tau_{had}\tau_{had}$	$\{\text{boosted, 2-jet}\}$	4.7
$VH \to Vbb$	$Z \to \nu\nu$	$E_T^{miss} \in \{120-160, 160-200, \geq 200 \text{ GeV}\} \otimes \{\text{2-jet, 3-jet}\}$	4.6
	$W \to \ell\nu$	$p_T^W \in \{< 50, 50-100, 100-150, 150-200, \geq 200 \text{ GeV}\}$	4.7
	$Z \to \ell\ell$	$p_T^Z \in \{< 50, 50-100, 100-150, 150-200, \geq 200 \text{ GeV}\}$	4.7
		2012 $\sqrt{s}$ =8 TeV	
$H \to ZZ^{(*)}$	4ℓ	$\{4e, 2e2\mu, 2\mu 2e, 4\mu\}$	5.8
$H \to \gamma\gamma$	–	10 categories $\{p_{Tt} \otimes \eta_\gamma \otimes \text{conversion}\} \oplus \{\text{2-jet}\}$	5.9
$H \to WW^{(*)}$	$e\nu\mu\nu$	$\{e\mu, \mu e\} \otimes \{\text{0-jet, 1-jet}\}$	13
$H \to \tau\tau$	$\tau_{lep}\tau_{lep}$	$\{\ell\ell\} \otimes \{\text{1-jet, 2-jet, boosted}, VH\}$	13
	$\tau_{lep}\tau_{had}$	$\{e, \mu\} \otimes \{\text{0-jet, 1-jet, boosted, 2-jet}\}$	13
	$\tau_{had}\tau_{had}$	$\{\text{boosted, 2-jet}\}$	13
$VH \to Vbb$	$Z \to \nu\nu$	$E_T^{miss} \in \{120-160, 160-200, \geq 200 \text{ GeV}\} \otimes \{\text{2-jet, 3-jet}\}$	13
	$W \to \ell\nu$	$p_T^W \in \{< 50, 50-100, 100-150, 150-200, \geq 200 \text{ GeV}\}$	13
	$Z \to \ell\ell$	$p_T^Z \in \{< 50, 50-100, 100-150, 150-200, \geq 200 \text{ GeV}\}$	13

Channels entering HCP combination

Best–fit Higgs mass m_H :
126.0 ± 0.4 (stat) ± 0.4 (syst) GeV

Best-fit signal strength:
$\mu = 1.3 \pm 0.3$

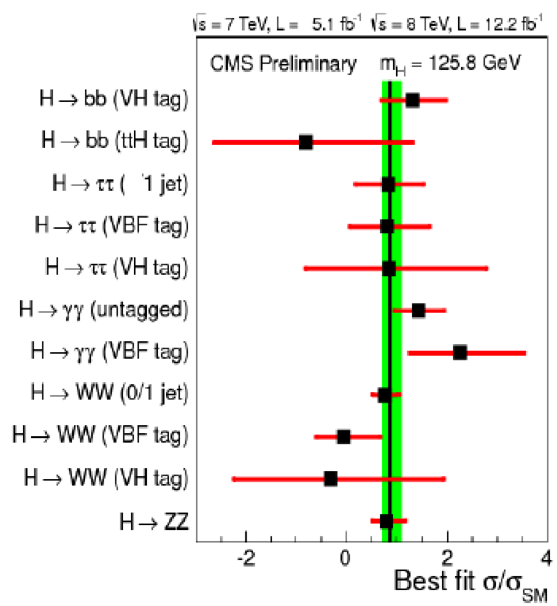
Coupling measurement not updated for HCP: uncertainies of 20-30%

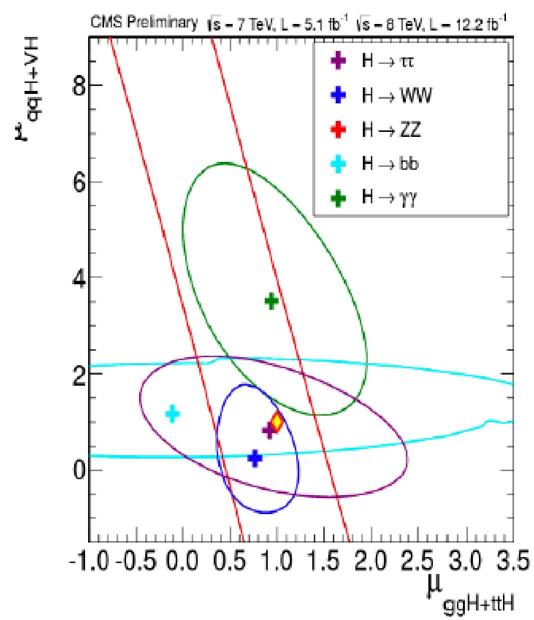


Signal strength

- Combined significance at MH=125.8 GeV: 6.9 σ
- Combined σ/σ_{SM}=0.88±0.21
- Overall satisfactory level of compatibility of the individual channels to the SM cross section
  - p-value=0.46 from pseudo experiments
- Break-down production mode shows compatibility within 1σ for each decay channel

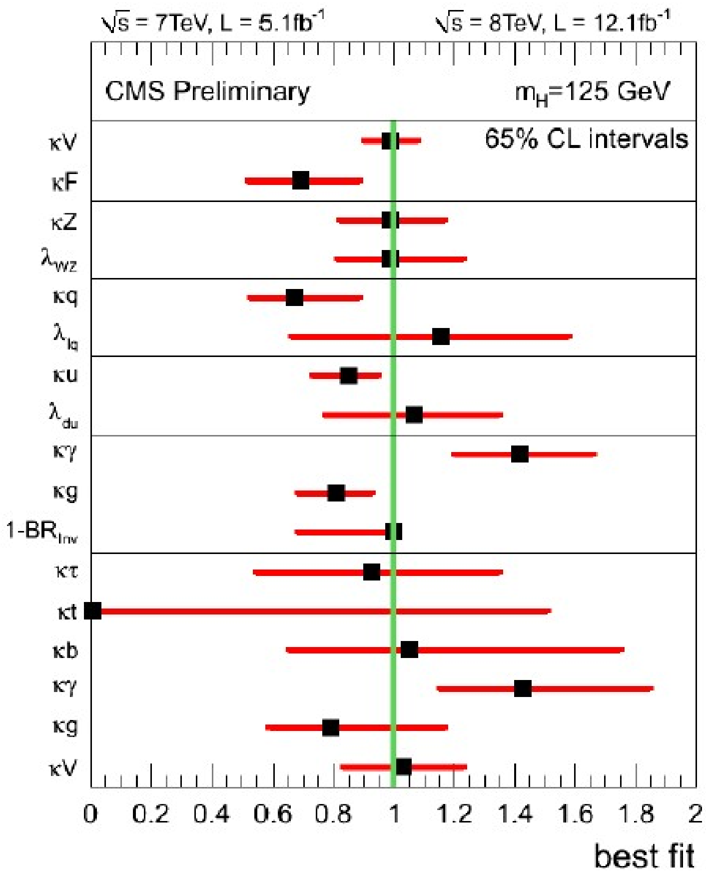
MH=125.8 GeV	Expected (σ)	Observed (σ)
ZZ	5.0	4.4
γγ	2.8	4.0
WW	4.3	3.0
bb	2.2	1.8
ττ	2.5	1.5
Combination	7.8	6.9





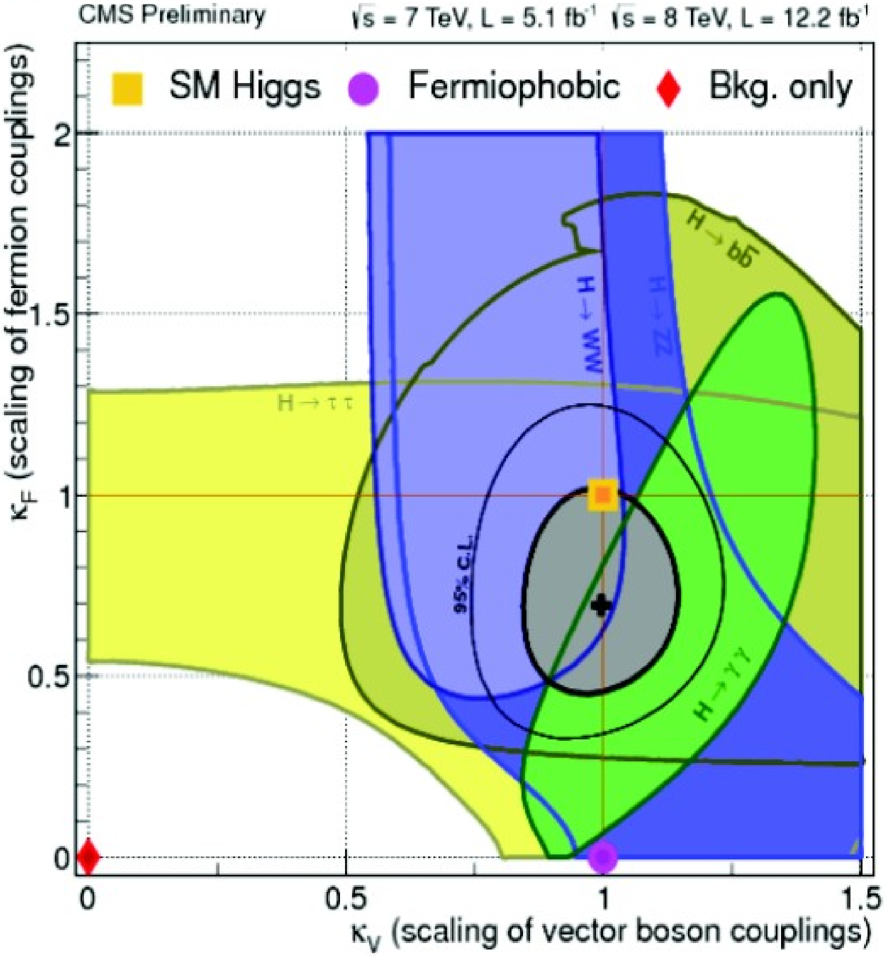
Couplings summary

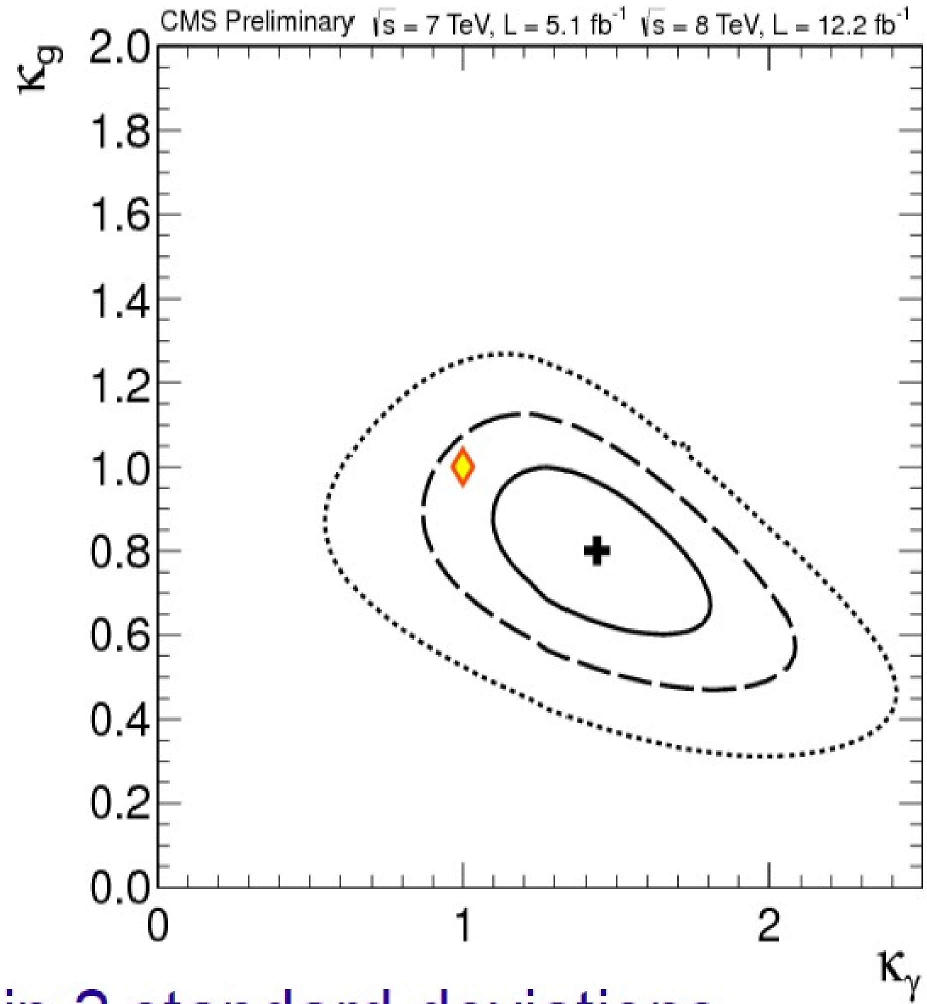
- Overall good compatibility with SM predictions
- Still limited precision



Model parameters	Assessed scaling factors (95% CL intervals)	
λ_{WZ}, κ_Z	λ_{WZ}	[0.57–1.65]
$\lambda_{WZ}, \kappa_Z, \kappa_f$	λ_{WZ}	[0.67–1.55]
κ_V	κ_V	[0.78–1.19]
κ_f	κ_f	[0.40–1.12]
κ_γ, κ_g	κ_γ	[0.98–1.92]
	κ_g	[0.55–1.07]
$\mathcal{B}(H \to BSM), \kappa_\gamma, \kappa_g$	$\mathcal{B}(H \to BSM)$	[0.00–0.62]
$\lambda_{du}, \kappa_V, \kappa_u$	λ_{du}	[0.45–1.66]
$\lambda_{\ell q}, \kappa_V, \kappa_q$	$\lambda_{\ell q}$	[0.00–2.11]
$\kappa_V, \kappa_b, \kappa_\tau, \kappa_t, \kappa_g, \kappa_\gamma$	κ_V	[0.58–1.41]
	κ_b	[not constrained]
	κ_τ	[0.00–1.80]
	κ_t	[not constrained]
	κ_g	[0.43–1.92]
	κ_γ	[0.81–2.27]

Combination of Higgs Results





Couplings look consistent within 2 standard deviations

- Fermions versus vector bosons
- effective gluon versus photon couplings (loops)

Final comments:

For SM Higgs physics we are shifting from a search-based to a **measurement based program**. It presents a challenge.

In particular **final fitting and fit models undergo much deeper scrutinity and optimisation**

→ **Enormous numbers of nuisance parameters** in the likelihoods require deep understanding of their uncertainties and petential correlations

→ **Fitting process itself is very complicated** and time consuming

→ Mixture of fitered Monte Carlo and data-driven techniques makes **understanding of uncertainties particularly challenging**.