$$
\begin{aligned}
\mathcal{L} = {} & \kappa_3 \frac{m_H^2}{2v} H^3 + \kappa_Z \frac{m_Z^2}{v} Z_\mu Z^\mu H + \kappa_W \frac{2m_W^2}{v} W_\mu^+ W^{-\mu} H \\
& + \kappa_g \frac{\alpha_s}{12\pi v} G_{\mu\nu}^a G^{a\mu\nu} H + \kappa_\gamma \frac{\alpha}{2\pi v} A_{\mu\nu} A^{\mu\nu} H + \kappa_{Z\gamma} \frac{\alpha}{\pi v} A_{\mu\nu} Z^{\mu\nu} H \\
& - \left(\kappa_t \sum_{f=u,c,t} \frac{m_f}{v} f\bar{f} + \kappa_b \sum_{f=d,s,b} \frac{m_f}{v} f\bar{f} + \kappa_\tau \sum_{f=e,\mu,\tau} \frac{m_f}{v} f\bar{f} \right) H .
\end{aligned}
$$

Eilam Gross, Weizmann Institute of Science

A Pedagogic Introduction to Higgs Measurements

V 1.0

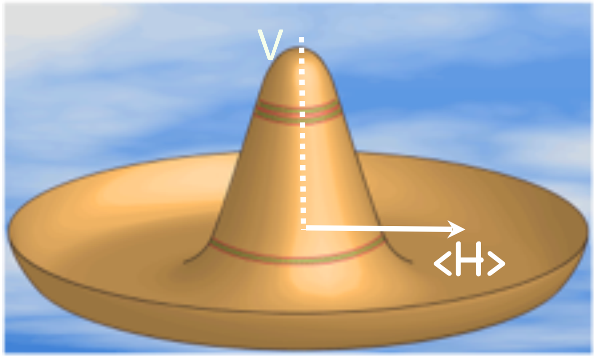
How Elementary Particles Acquire Mass

- A fermion mass term is given byOnly left handed fields carry weak charge. $L_m = m\bar{\psi}_L \psi_R$

- Via SSB the Higgs field "charges" the vacuum with a weak charge and the symmetry is preserved ("hidden")

$$\phi = \langle H \rangle + h \qquad L_H \supset g_\psi \phi \bar{\psi}_L \psi_r = g_\psi \left(\langle H \rangle + h \right) \bar{\psi}_L \psi_R$$

$$g_\psi \langle H \rangle \bar{\psi}_L \psi_R + g_\psi h \bar{\psi}_L \psi_R = m_\psi \bar{\psi}_L \psi_R + \frac{m_\psi}{\langle H \rangle} h \bar{\psi}_L \psi_R$$



- The coupling of the Higgs to particles is proportional to the particles' mass. The Higgs Boson will therefore decay with a higher probability to the heaviest particle kinematically available

$$BR(H \to xx) = \frac{\Gamma(H \to xx)}{\Sigma_x \Gamma(H \to xx)} \sim m_x^2$$

Introduction

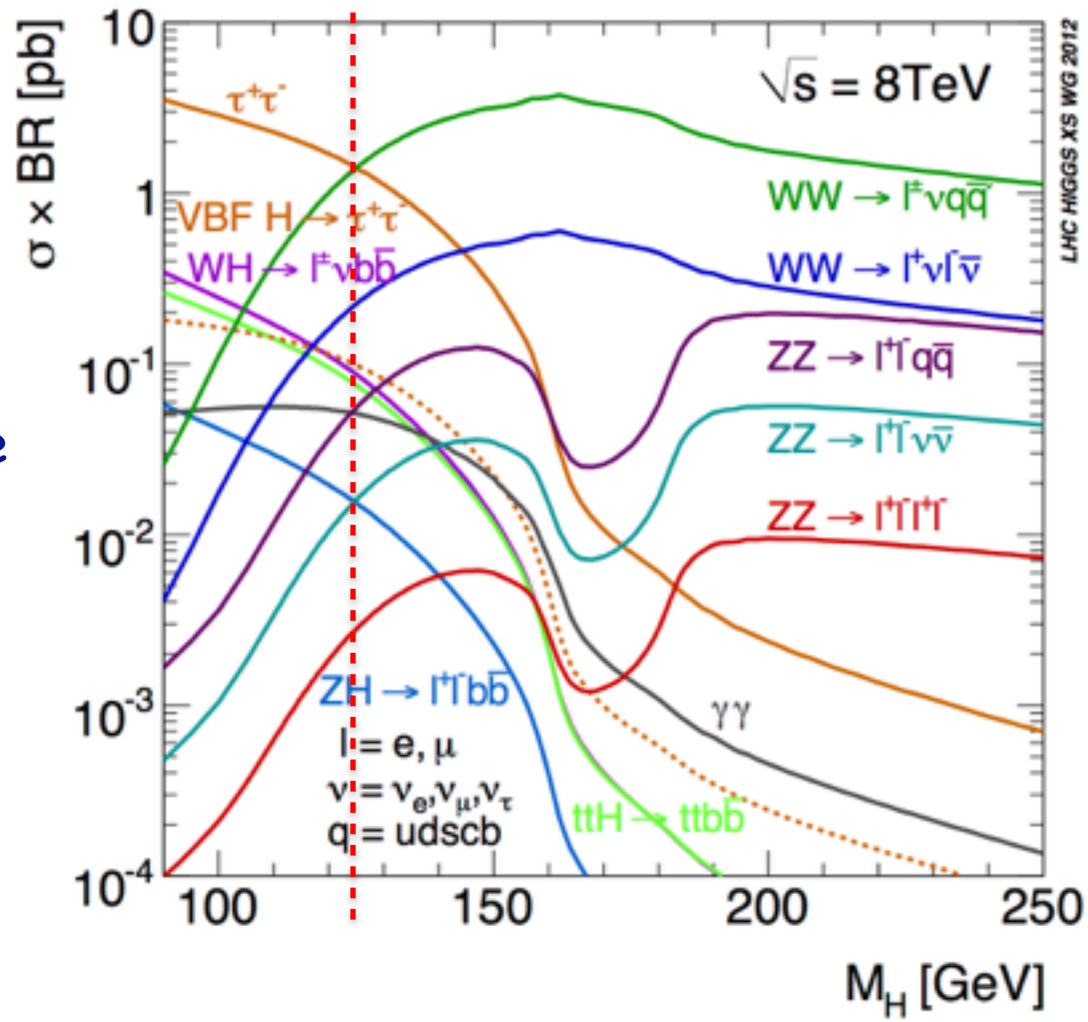
The mass of the Higgs Boson is not predictable by the SM.

Knowing the mass of the Higgs Boson all its SM couplings are predictable.

If we could order a mass, we would order m_H=120-130 GeV

At this mass we have access to all decay modes!

WE WERE LUCKY



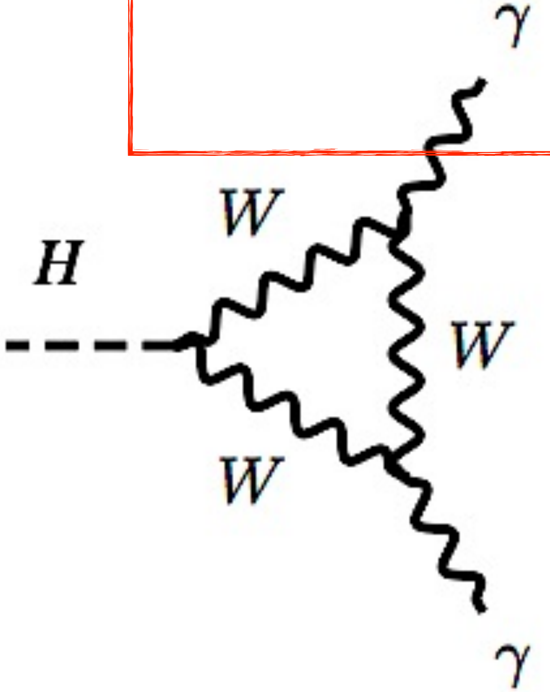
Discovery Channels

	BR@ m_H=125 GeV	*~σ(m)/m*
$\mathbf{H \to bb}$	**57.7%**	**10%**
$\mathbf{H \to WW \to 2l2\nu}$	**0.756%**	**20%**
$\mathbf{H} \to \tau\tau$	**6.32%**	**10-20%**
$\mathbf{H} \to \gamma\gamma$	**0.228%**	**1-2%**
$\mathbf{H \to ZZ \to 4l}$	**0.0276%**	**1-2%**
$\mathbf{H \to Z\gamma \to ll\gamma}$	**0.01%**	**1-2%**
$\mathbf{H} \to \mu\mu$	**0.0219%**	**1-2%**

The Discovery Channels

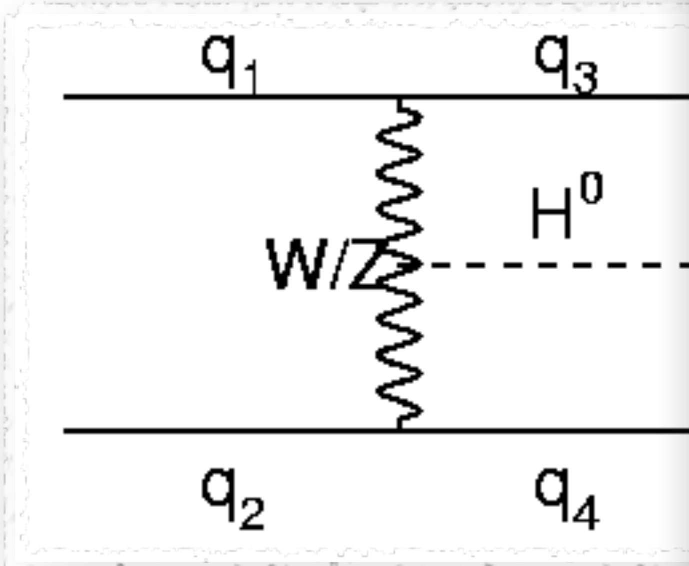
$$H \to \gamma\gamma$$

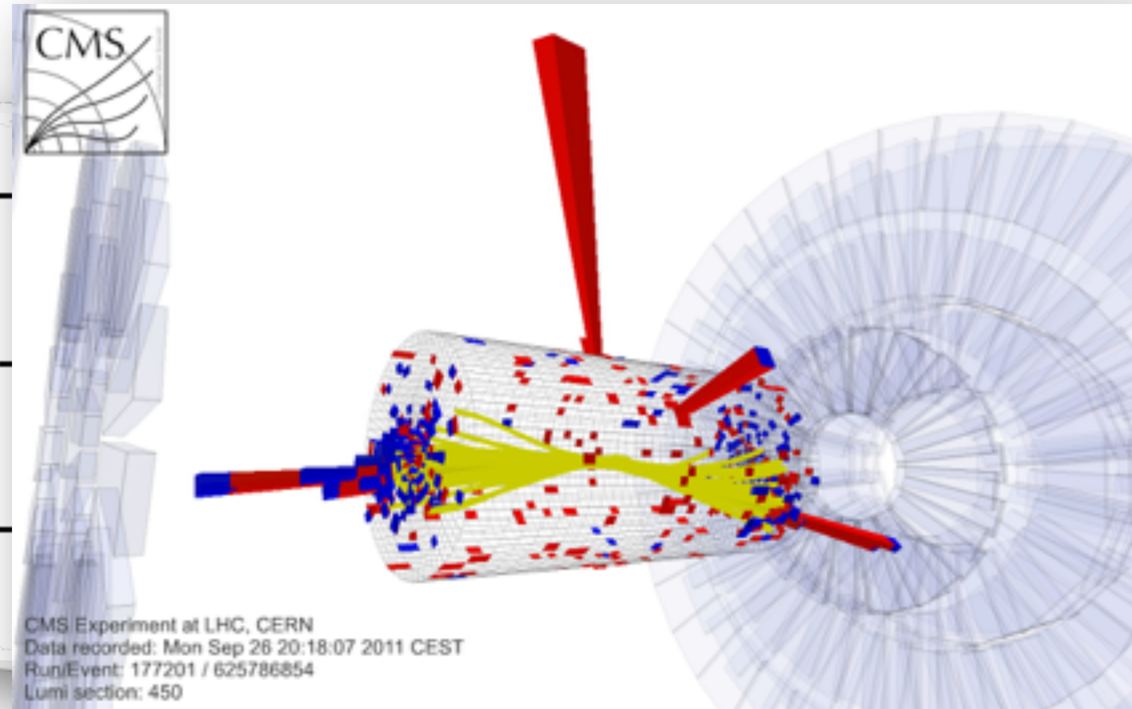
$$BR(H \to \gamma\gamma)(m_H \sim 125 GeV) \sim 2.3 \cdot 10^{-3}$$



Higgs Discovery Channels

Higgs decays to a pair of Photons has a very clear signature





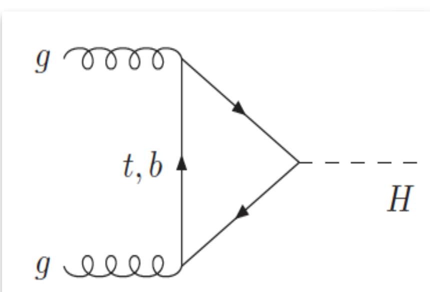
VBF $qq' \rightarrow qq'H \rightarrow qq'\gamma\gamma$

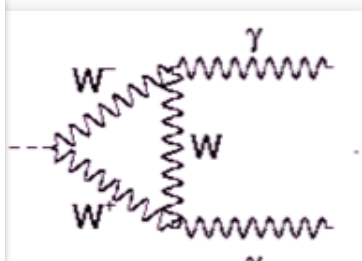
Follow the di-photon

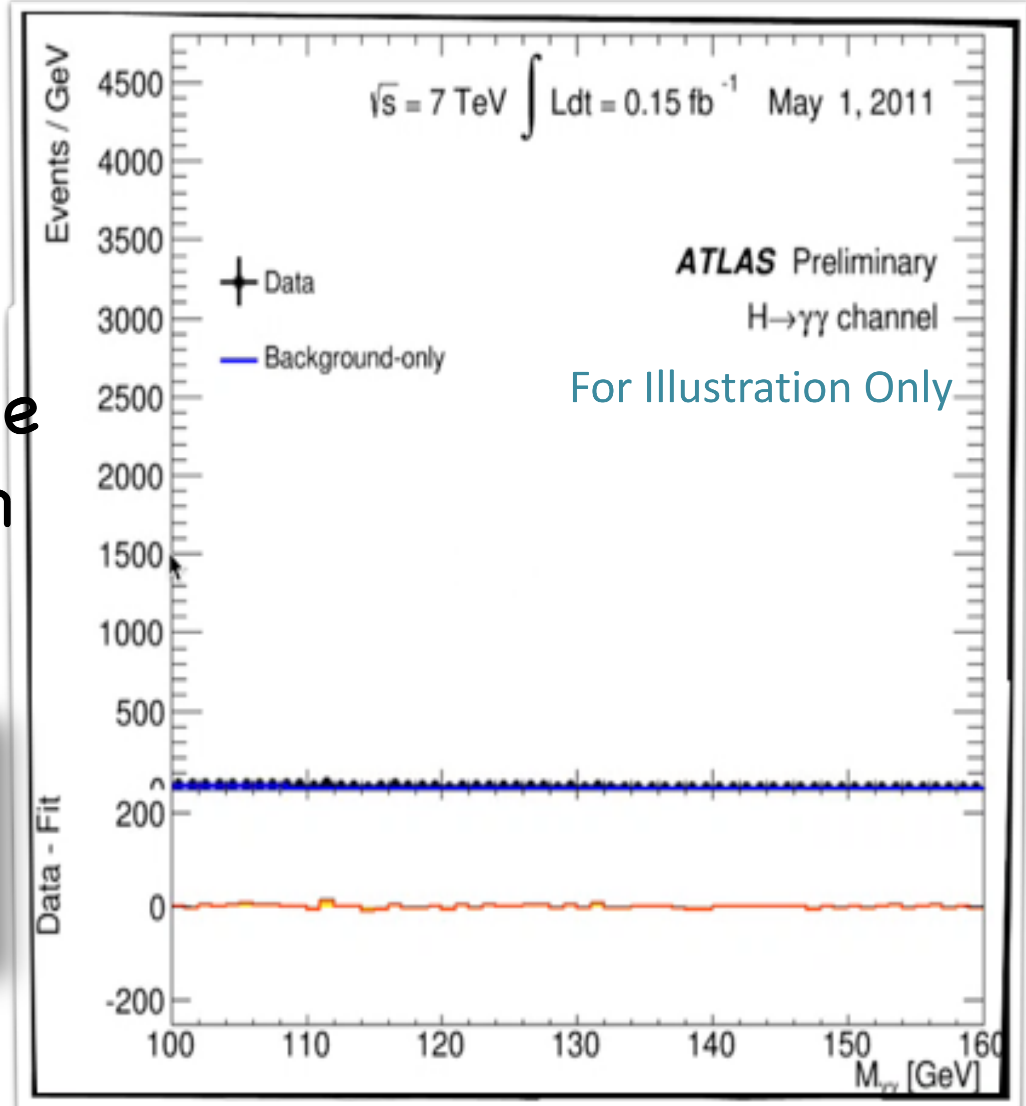
As you accumulate statistics, the signal becomes apparent

The background is huge and comes mainly from

$$pp \rightarrow \gamma\gamma + jets$$







Follow the di-photon

$$pp \to \gamma\gamma + jets$$

A simplification to get the significance is by counting

$$B_{exp} = 7916$$

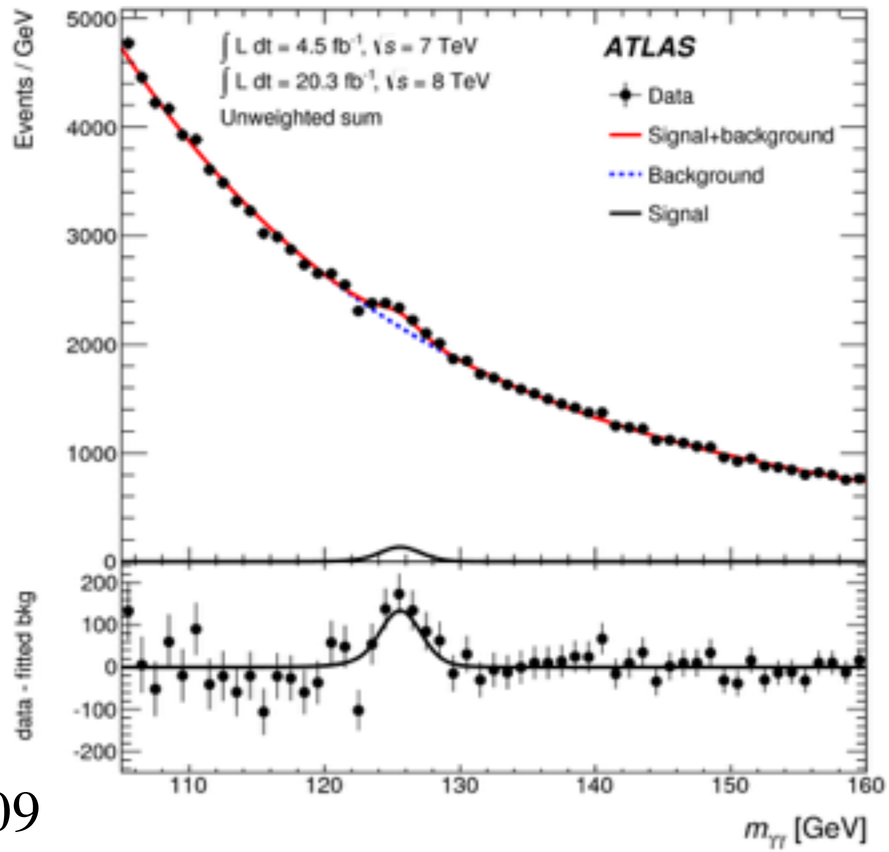
$$N_s = N_{obs} - B_{exp} = 468$$

$$\sigma_{obs} \sim \frac{s}{\sqrt{b}} = \frac{468}{\sqrt{7916}} = 5.2$$

$$N_{s,exp}^{\gamma\gamma} \sim \sigma(pp \to H \to \gamma\gamma) \cdot L \cdot \epsilon \cdot A \approx 409$$

$$\sigma_{exp} = \frac{409}{\sqrt{7916}} \approx 4.6$$

$$\mu^{\gamma\gamma} = \frac{\sigma(pp \to H \to \gamma\gamma)_{obs}}{\sigma(pp \to H \to \gamma\gamma)_{exp}} \sim \frac{468}{409} \approx 1.17 \pm 0.27$$



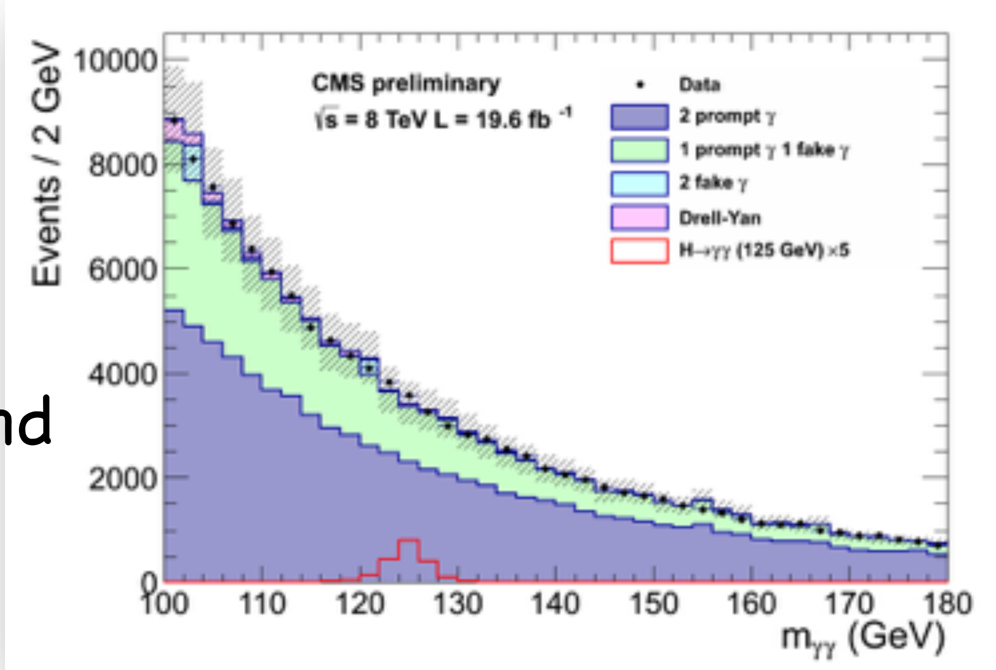
Follow the di-photon

As you accumulate statistics, the signal becomes apparent

The background is huge and comes mainly from

$$pp \to \gamma\gamma + jets$$

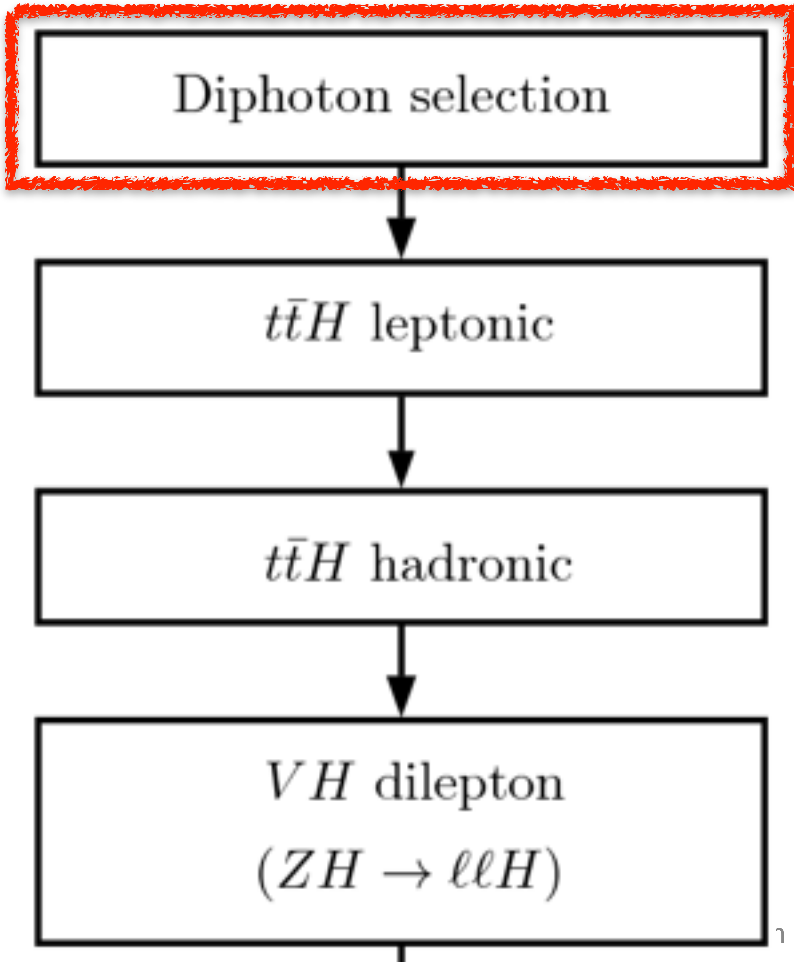
Need to separate the Background from the Signal, otherwise you will be swamped by the Background

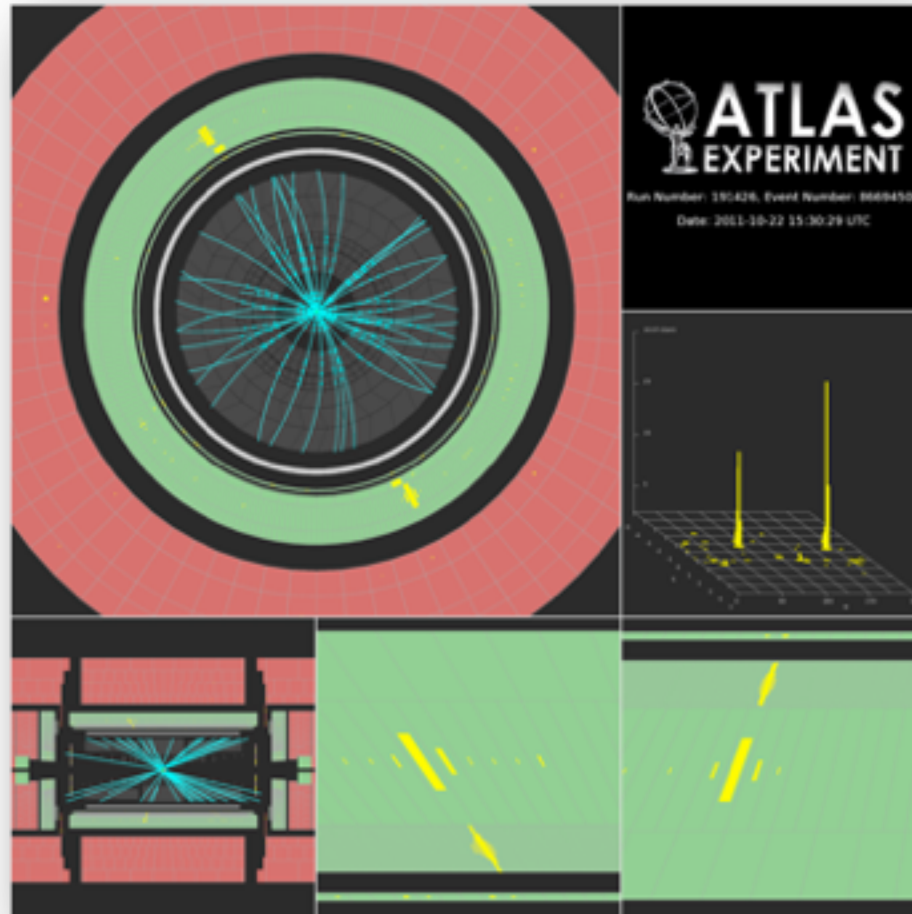


Categorisation to improve sensitivity

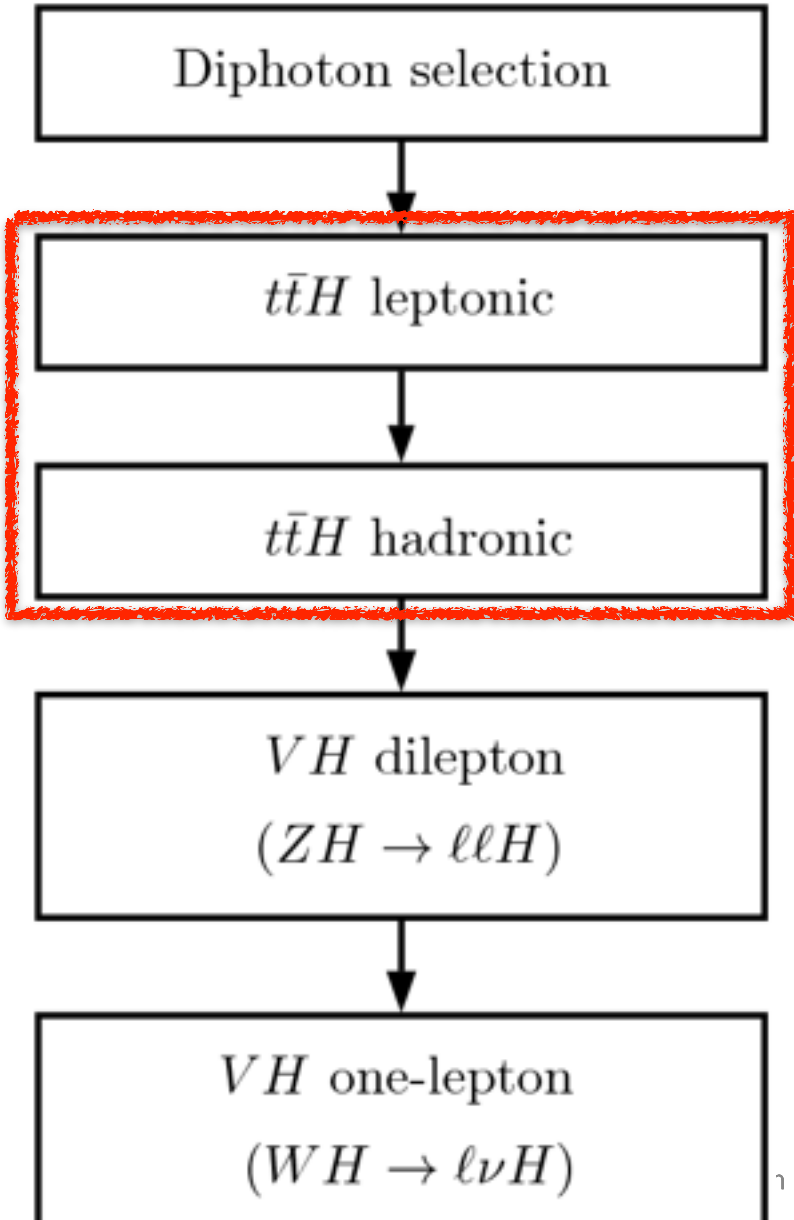
Two energetic isolated photons

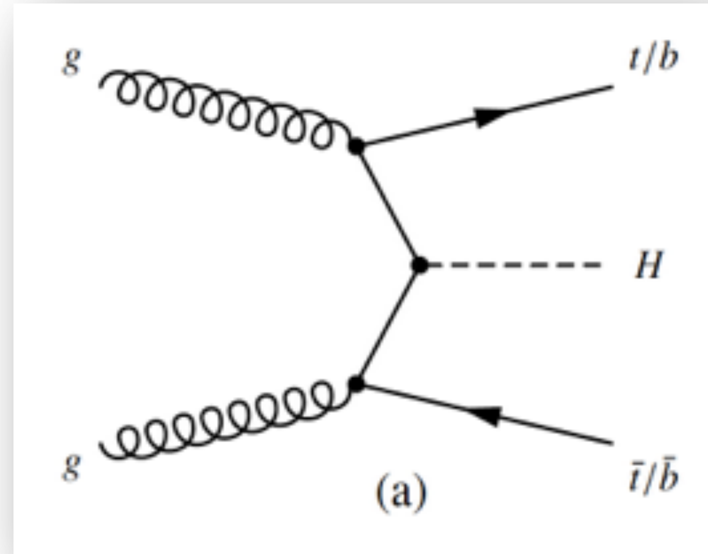
Photons: High p_T (~60 GeV) well isolated





Categorization to improve sensitivity





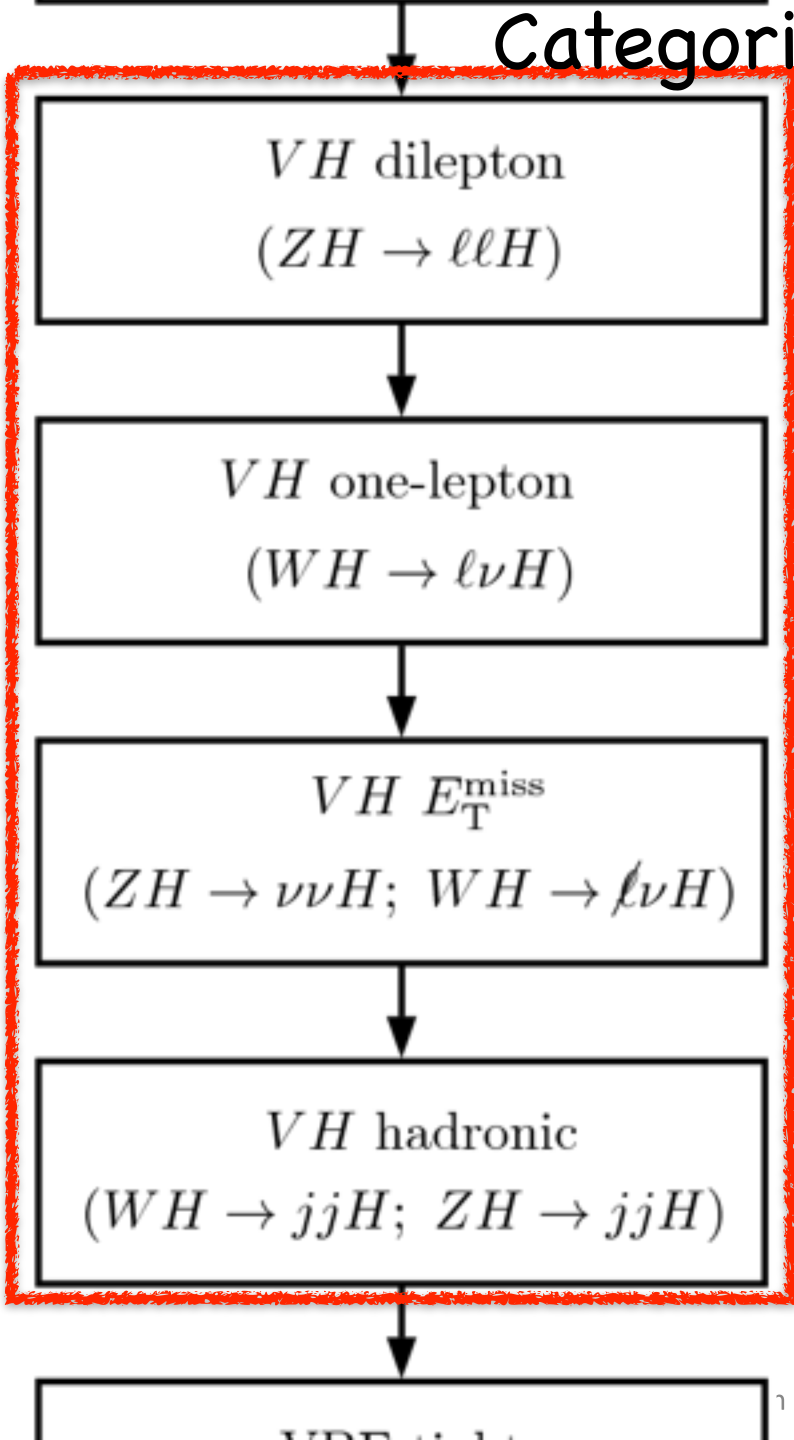
ttH with at least one top with a semileptonic decay

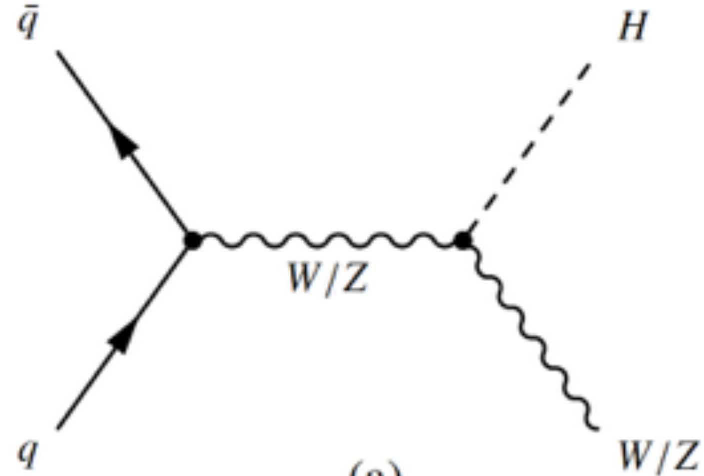
$$ttH \to b\ell\nu bWH$$

ttH with both tops decay Hadronically

$$ttH \to bW_{had}bW_{had}H$$

Categorization to improve sensitivity





(a)

VH targeting

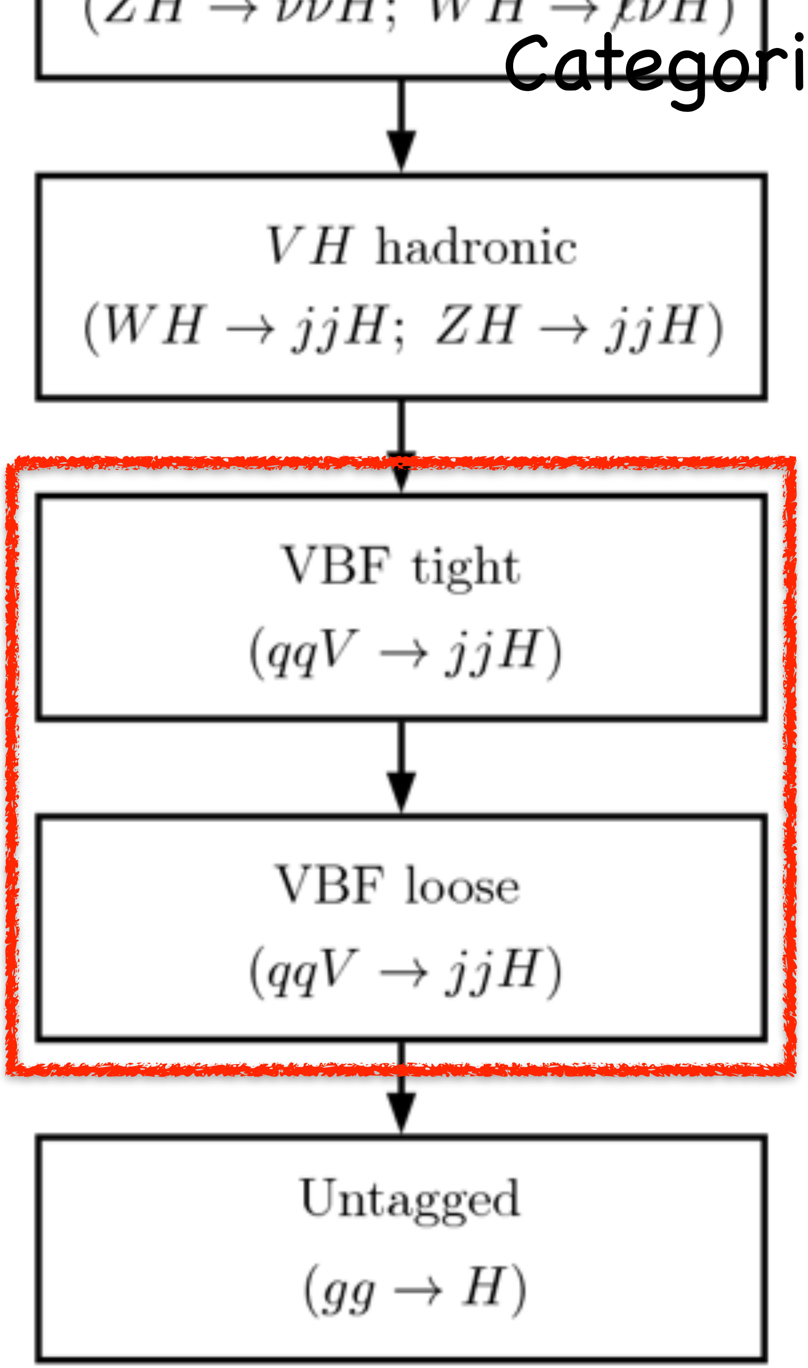
$ZH \to \ell\ell H$ — $\gamma\gamma$+di-lepton

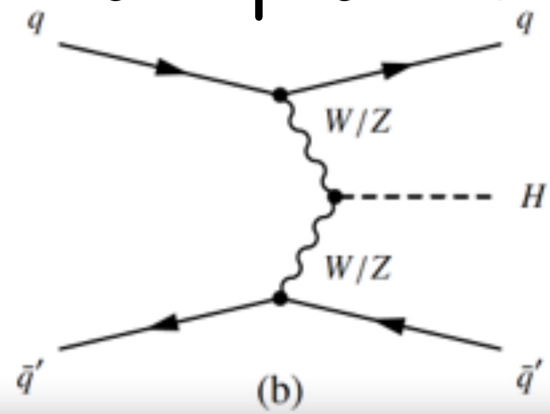
$WH \to \ell\nu H$ — $\gamma\gamma$+one lepton

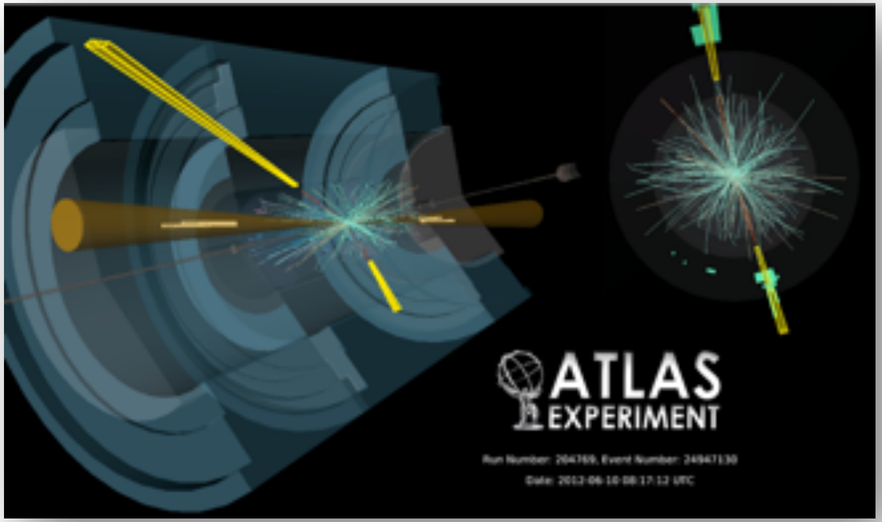
$ZH \to \nu\nu H$ — $\gamma\gamma$+missing energy

$W/ZH \to jjH$ — $\gamma\gamma$+jets

Categorization to improve sensitivity

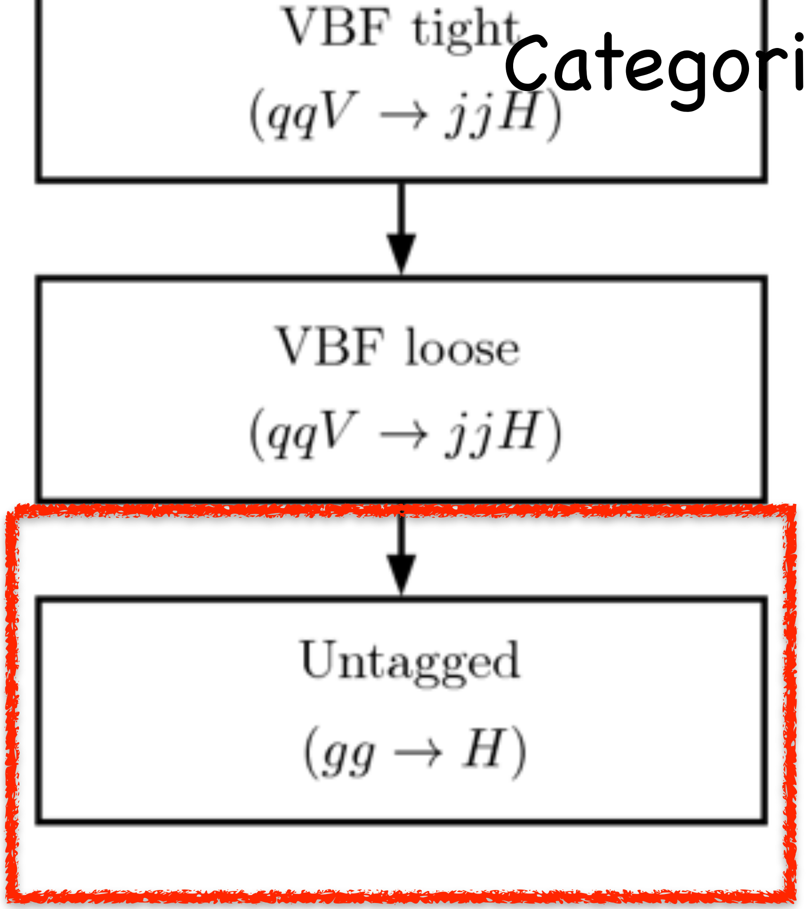


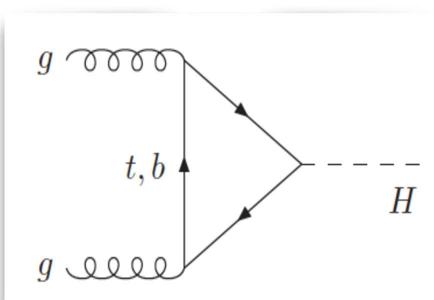


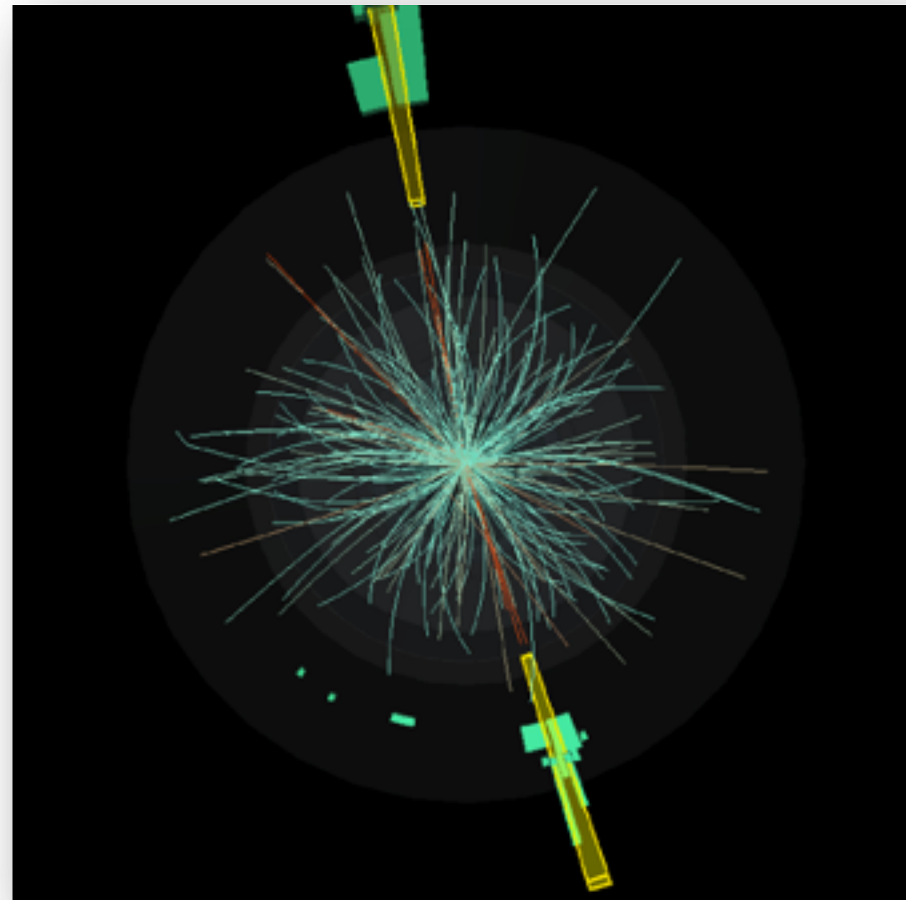


2 back to back forward jets with no additional activity (but di-photon, in the central region)

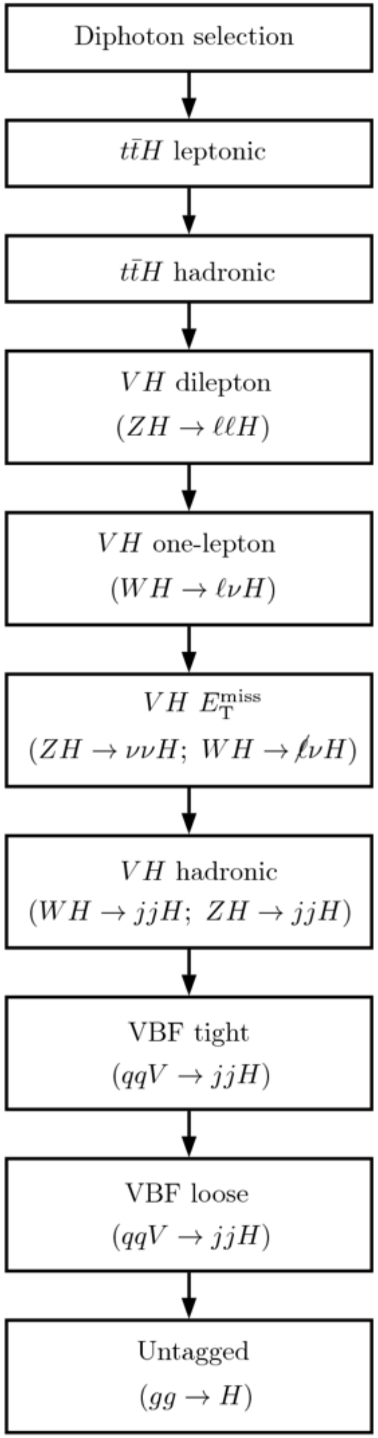
Categorization to improve sensitivity

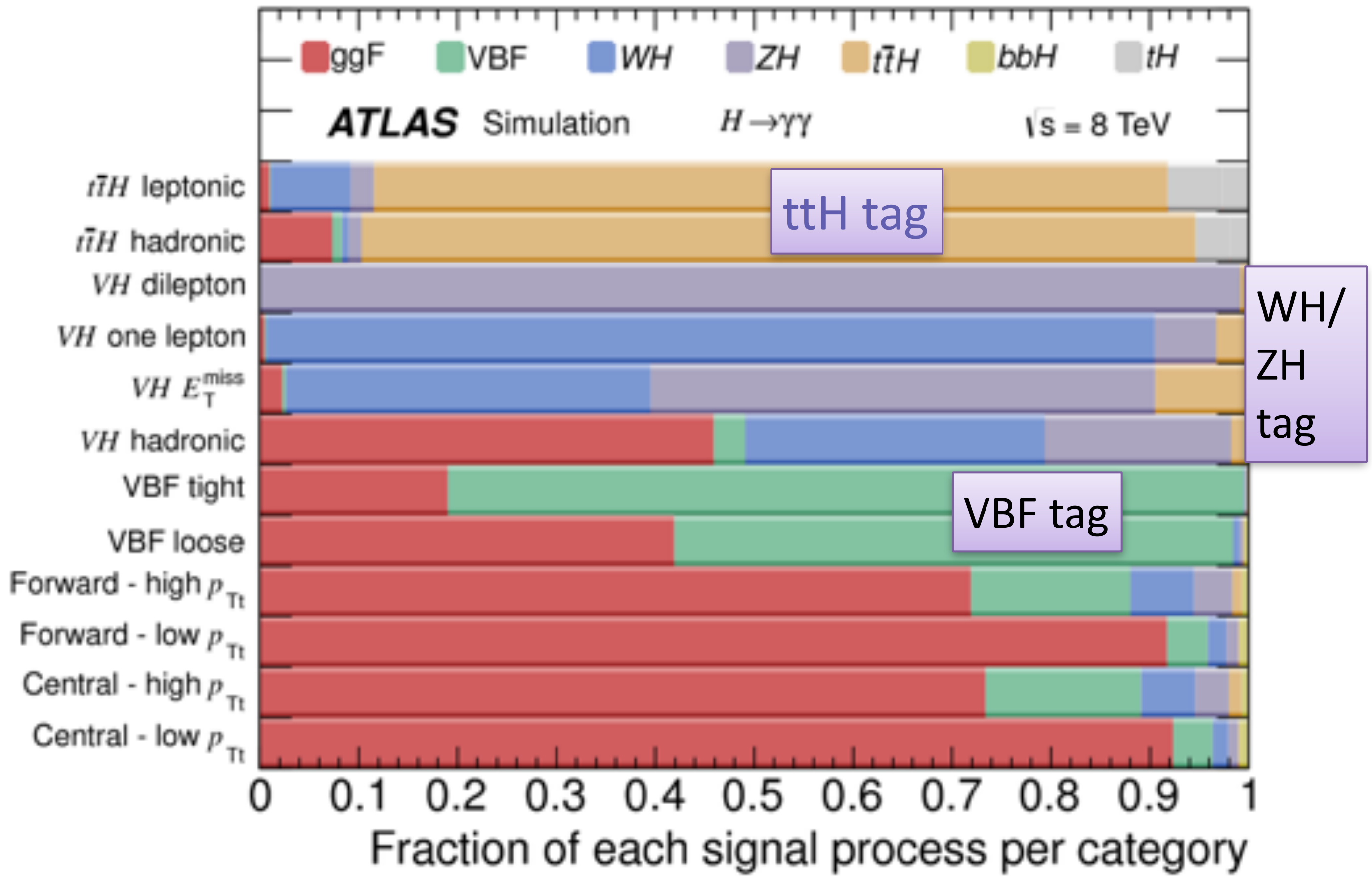






Categorization to improve sensitivity

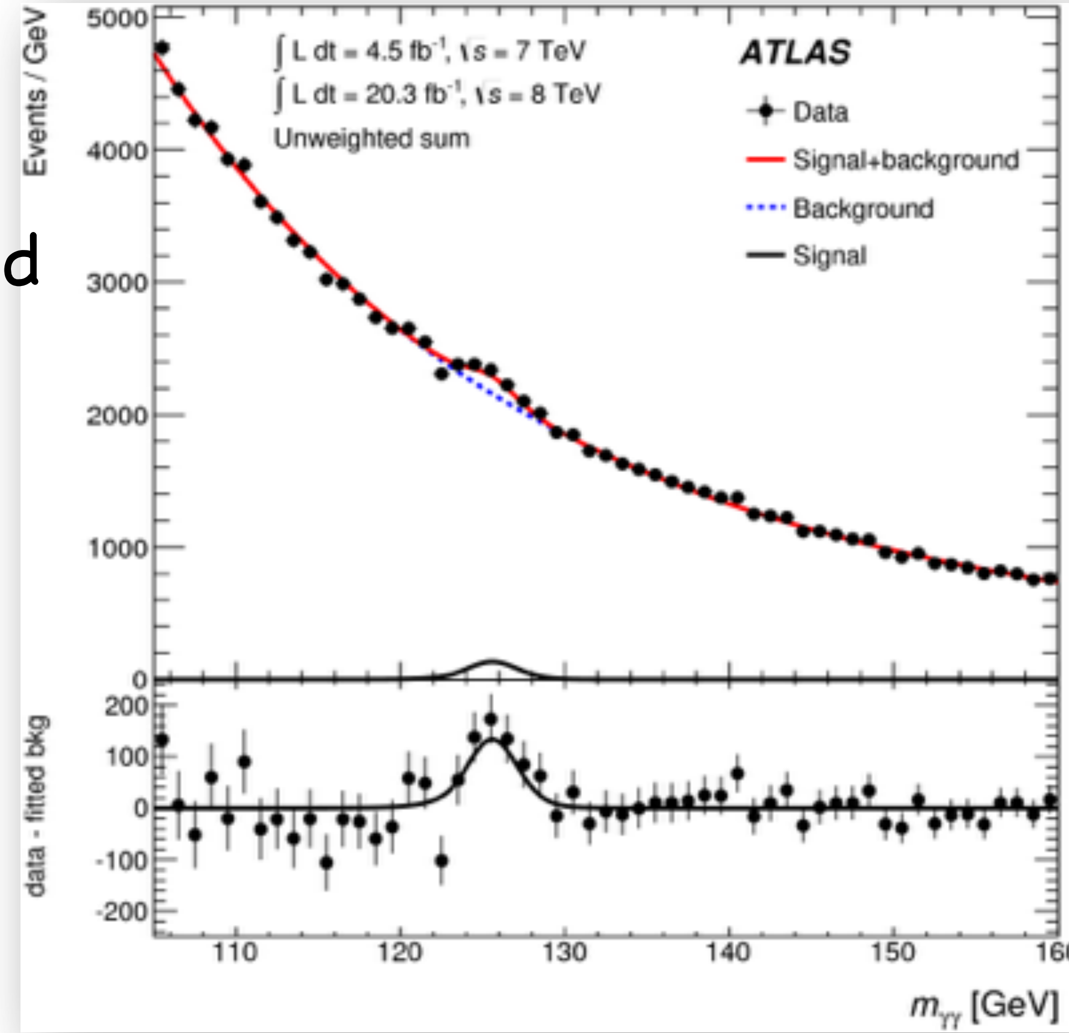




Follow the di-photon Categories

$$pp \rightarrow \gamma\gamma + jets$$

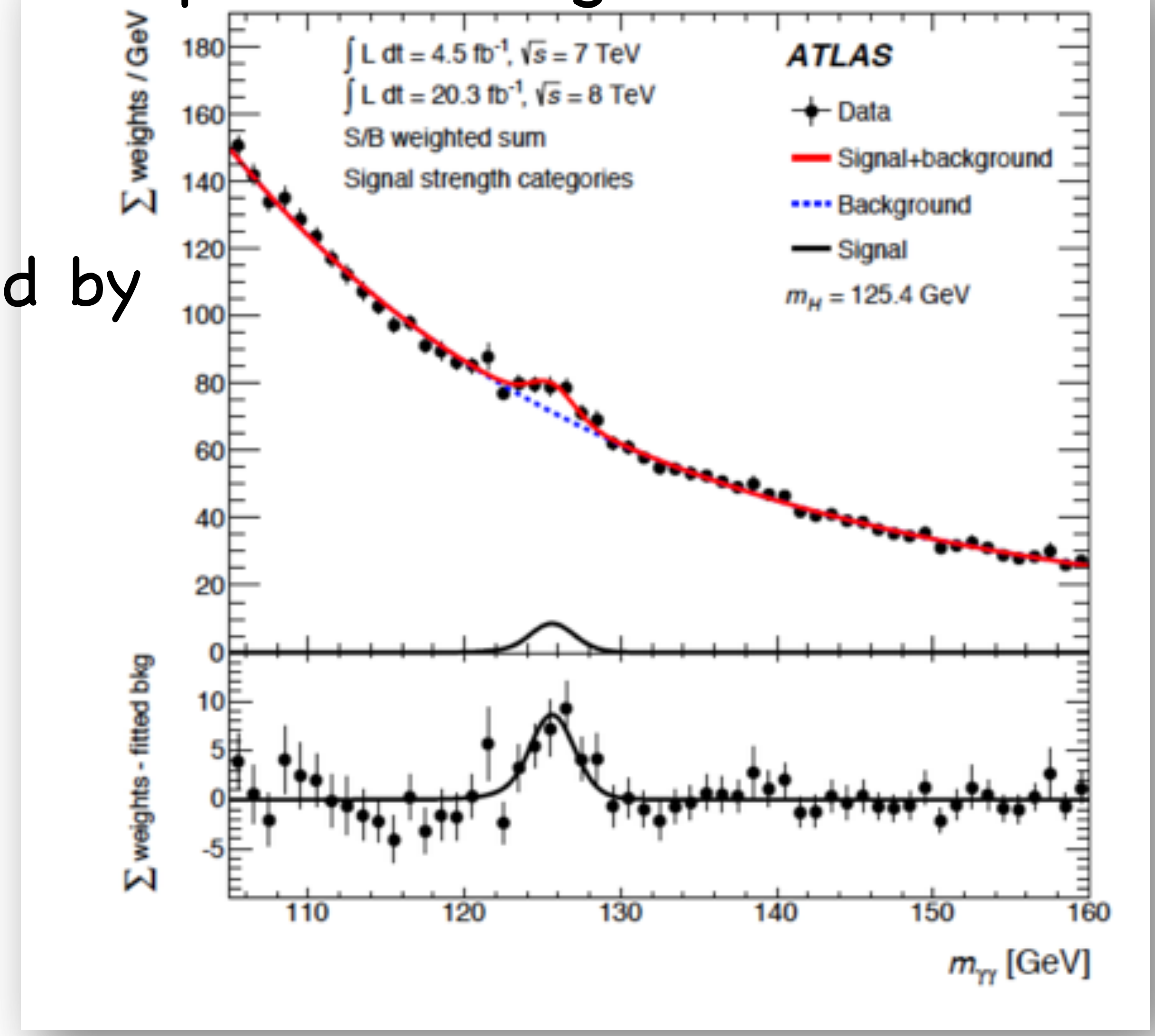
No weights are applied

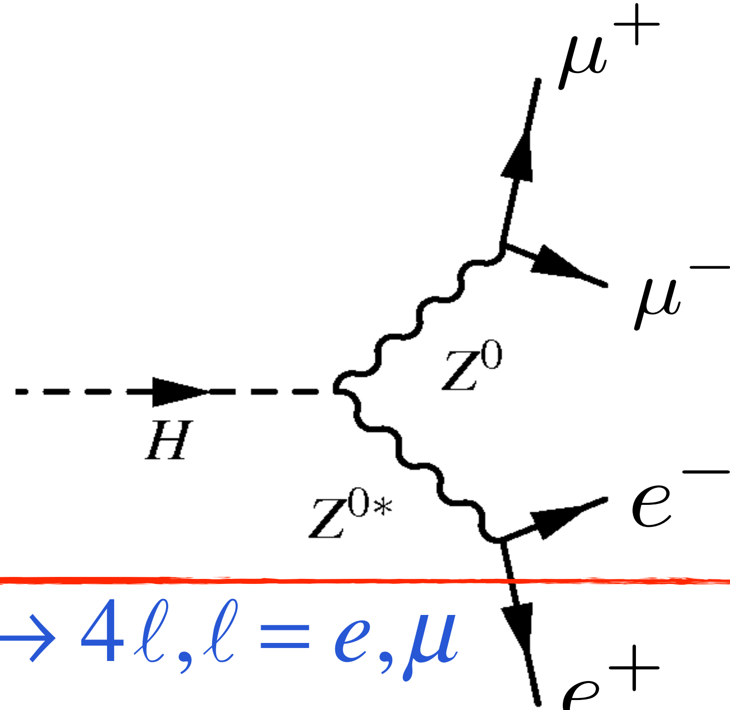


Follow the di-photon Categories

$$pp \rightarrow \gamma\gamma + jets$$

Events are weighted by 1+s/b





$$H \to ZZ^* \to 4\ell, \ell = e, \mu$$

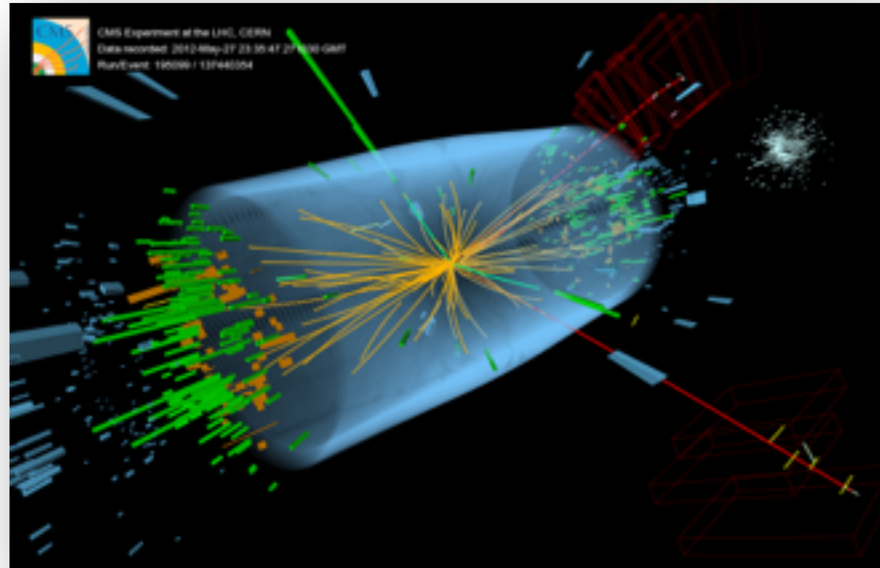
$$BR(H \to ZZ^*)(m_H \sim 125 GeV) \sim 3\%$$

$$BR(H \to 4\ell)(m_H \sim 125 GeV) \sim 0.011\%$$

Higgs Discovery Channels

Higgs decays to a pair of Z Bosons which deac into a pair of leptons each (lepton=Muon or Electron) has a very clear signature.

Actually this channel is fully reconstructed!



$$gg \rightarrow H \rightarrow ZZ^{*} \rightarrow e^{+}e^{-}\mu^{+}\mu^{-}$$

$$4\ channels: ee\mu\mu, \mu\mu ee, eeee, \mu\mu\mu\mu$$

$$categories:$$

$VBF \qquad m_{jj} > 130 GeV$

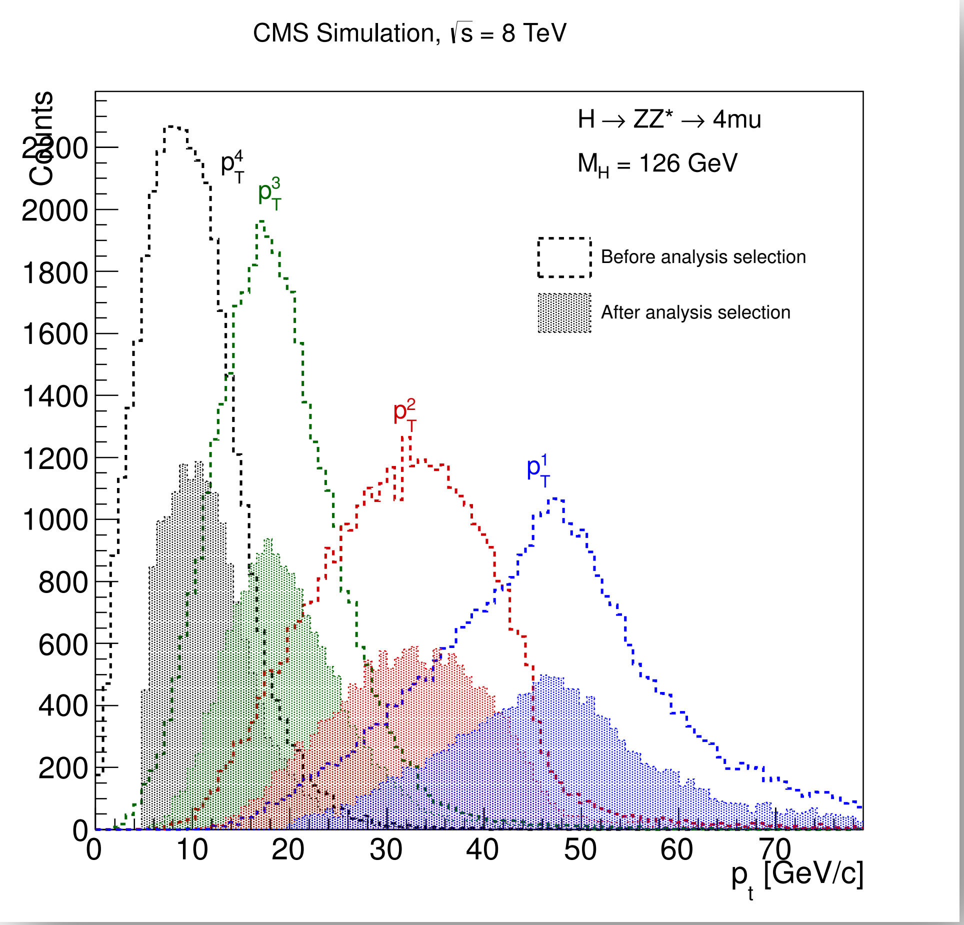
$VH_{had} \qquad 40 < m_{jj} < 130$

$VH_{lep} \qquad additional\ \ \ell$

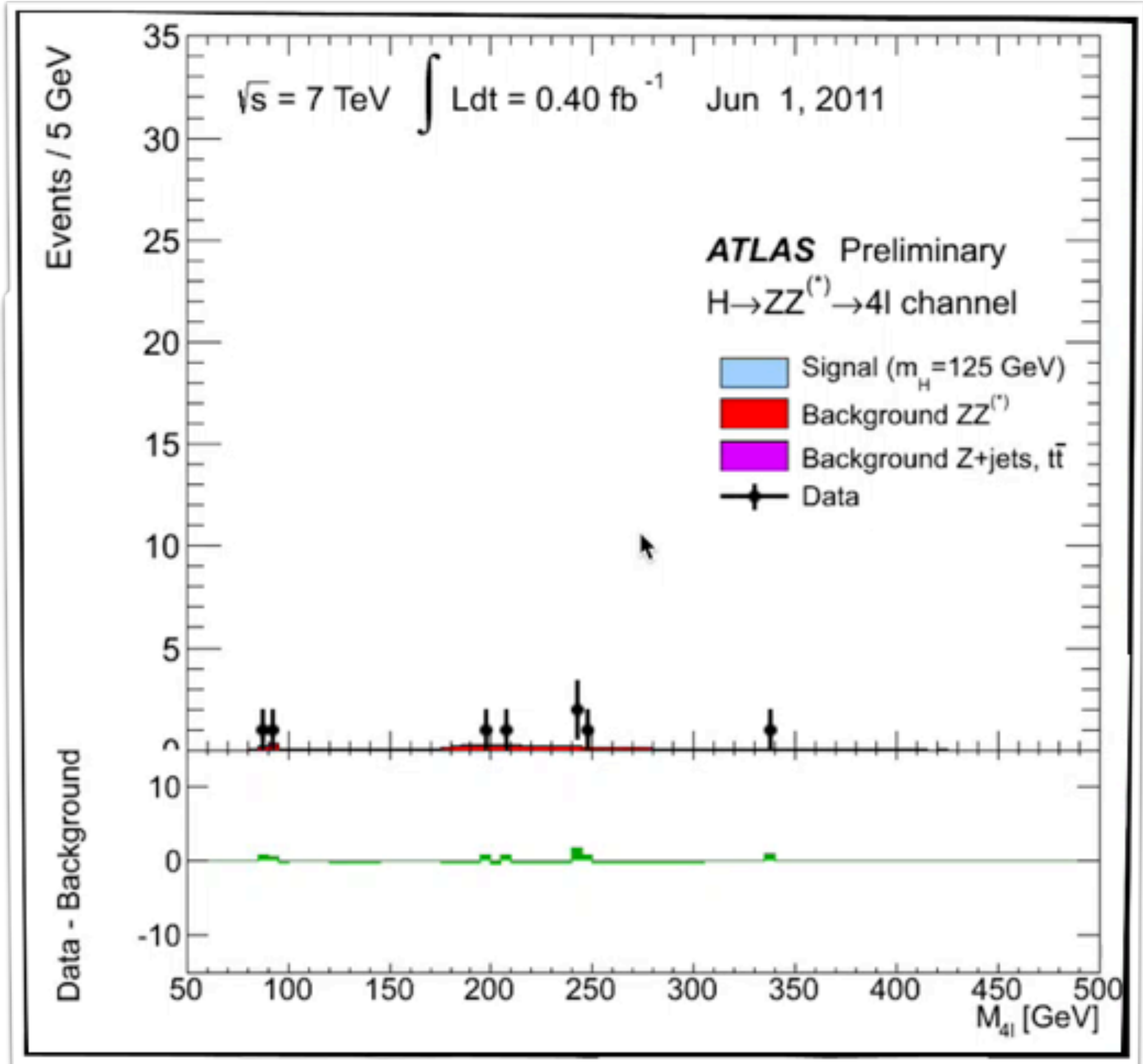
ggF

Higgs Discovery Channels

Due to one Z being off-shell, Z*, needs to control energy/momentum to very low values!

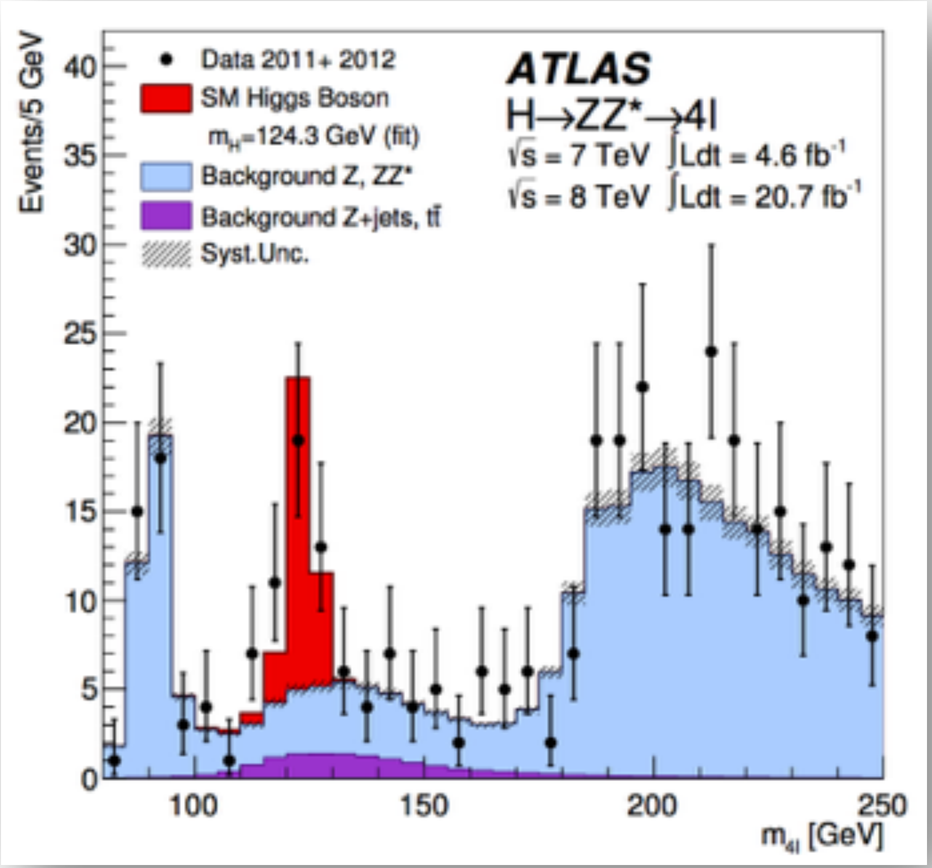


Discovery Animation



Follow the 4 leptons

Educated Simplification



$$B_{exp} = 21$$

$$N_s^{obs} = N_{obs} - B_{exp} = 37$$

$$\sigma_{obs} \sim \frac{s}{\sqrt{b}} = \frac{37}{\sqrt{21}} = 8.1$$

$$N_{s,exp}^{4\ell} \sim \sigma(pp \to H \to ZZ^* \to 4\ell) \cdot L \cdot \epsilon \cdot A \approx 28$$

$$\sigma_{exp} = \frac{28}{\sqrt{21}} \approx 6.2$$

$$\mu^{4\ell} = \frac{\sigma(pp \to H \to 4\ell)_{obs}}{\sigma(pp \to H \to 4\ell)_{exp}} \sim \frac{37}{28} \approx 1.44 \pm 0.35$$

$$H \to WW^* \to \ell \nu \ell' \nu$$

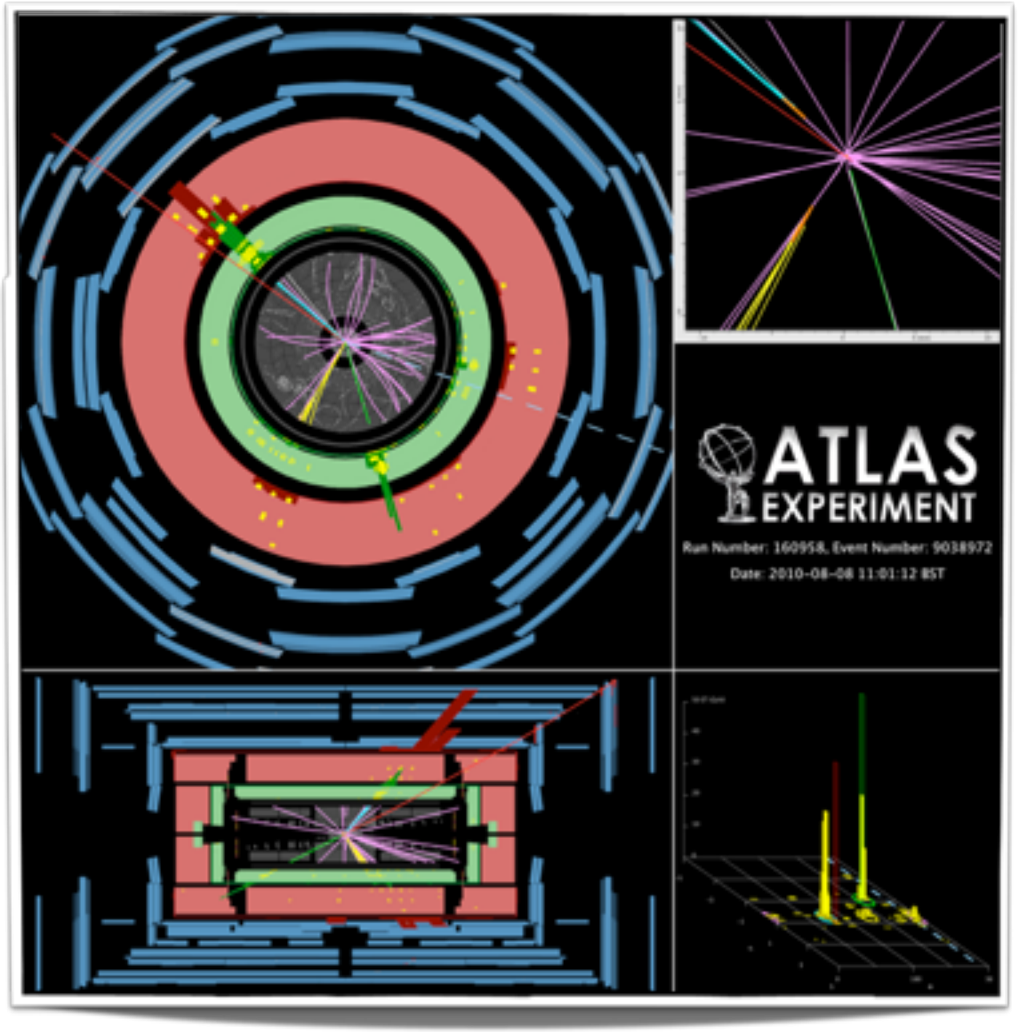
$$BR(H \to WW^*)(m_H \sim 125 GeV) \sim 22\%$$

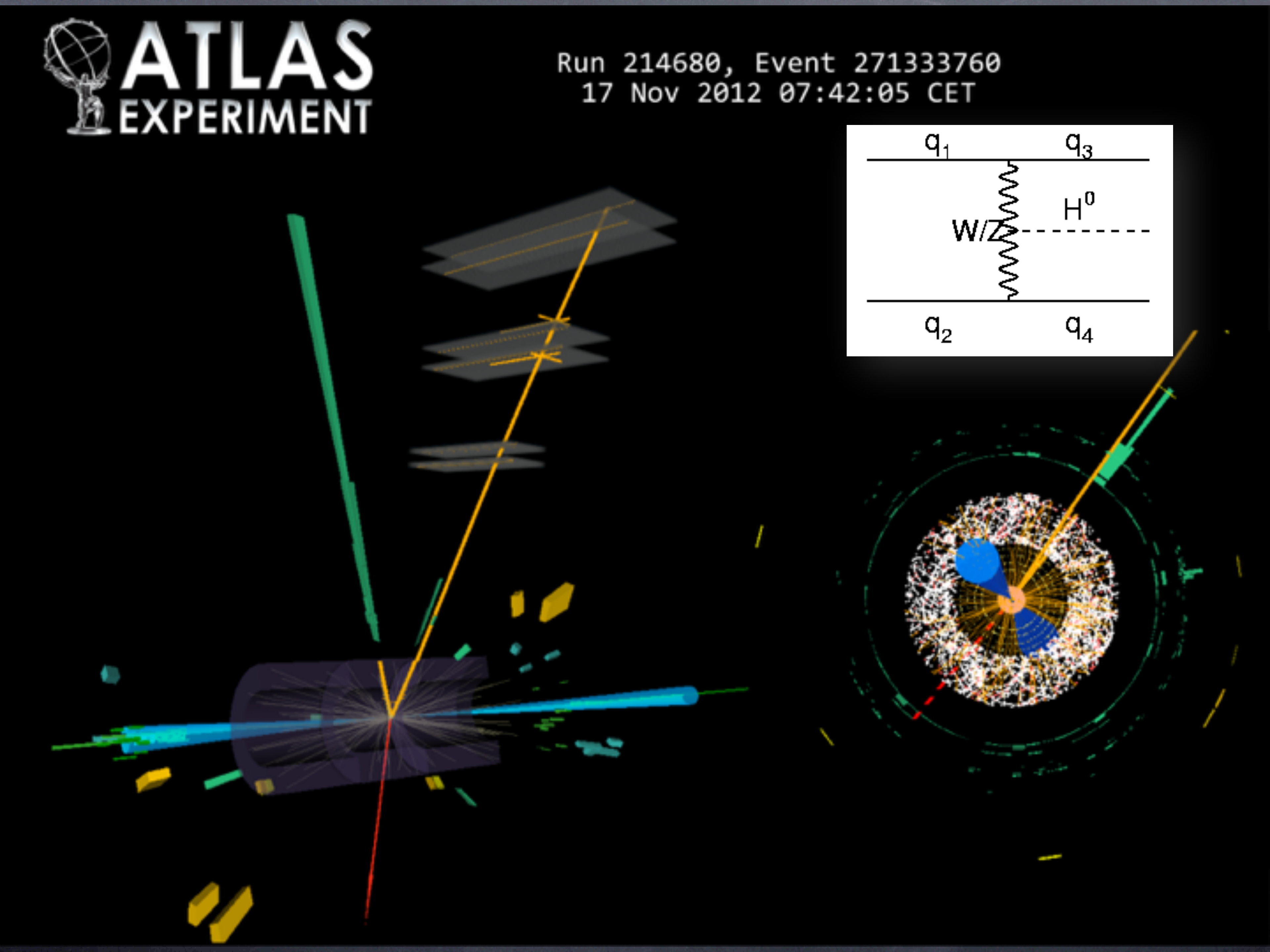
$$BR(H \to \ell \nu \ell \nu)(m_H \sim 125 GeV) \sim 0.76\%$$

WW top Background (contains b quark)

$$t\bar{t} \rightarrow bb + \ell\ell'$$

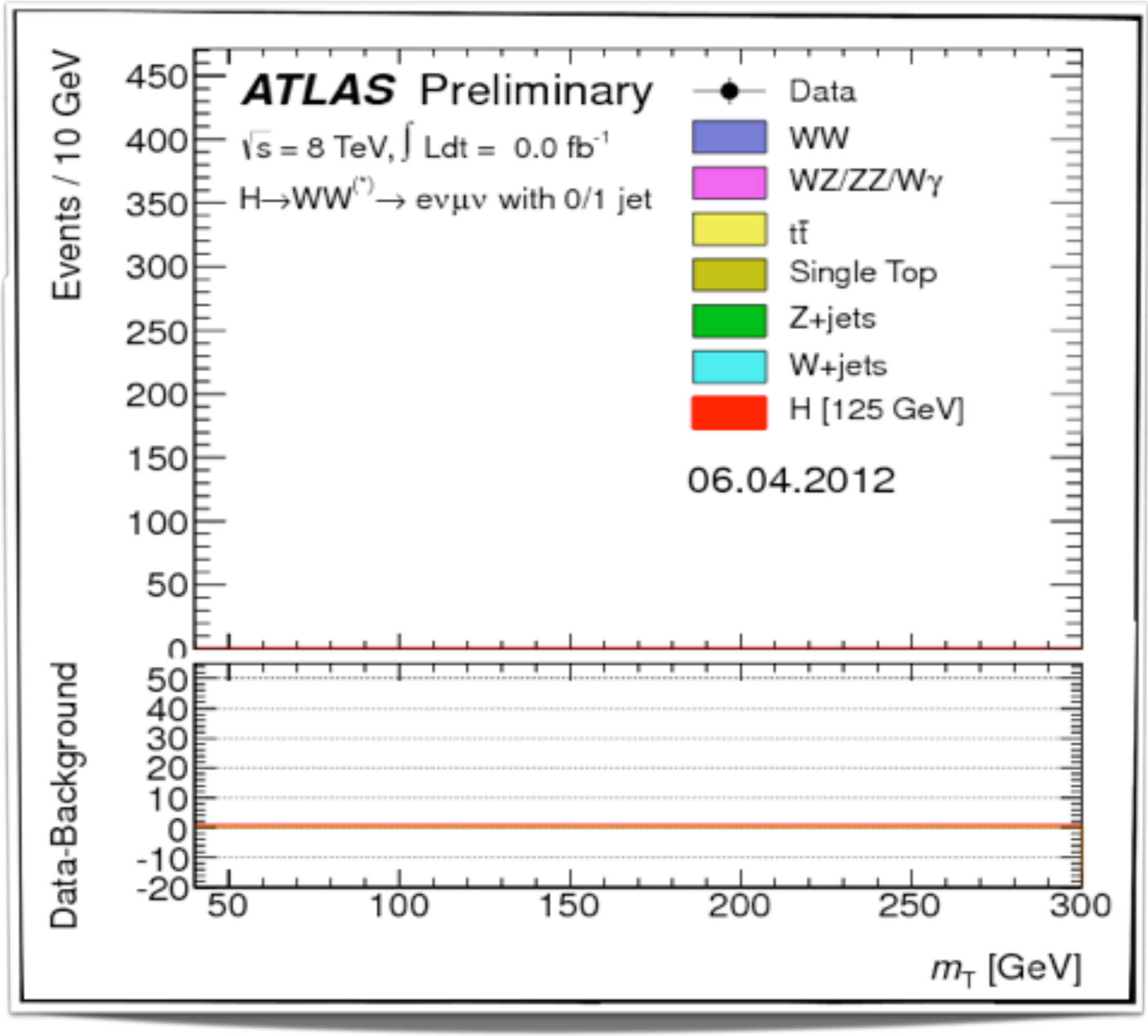
Use anti b tag
Angular separation
between leptons




ATLAS
EXPERIMENT
Run 214680, Event 271333760
17 Nov 2012 07:42:05 CET
q1
q3
H0
W/Z
q2
q4

$$\sigma_{obs} = 6.5\sigma$$

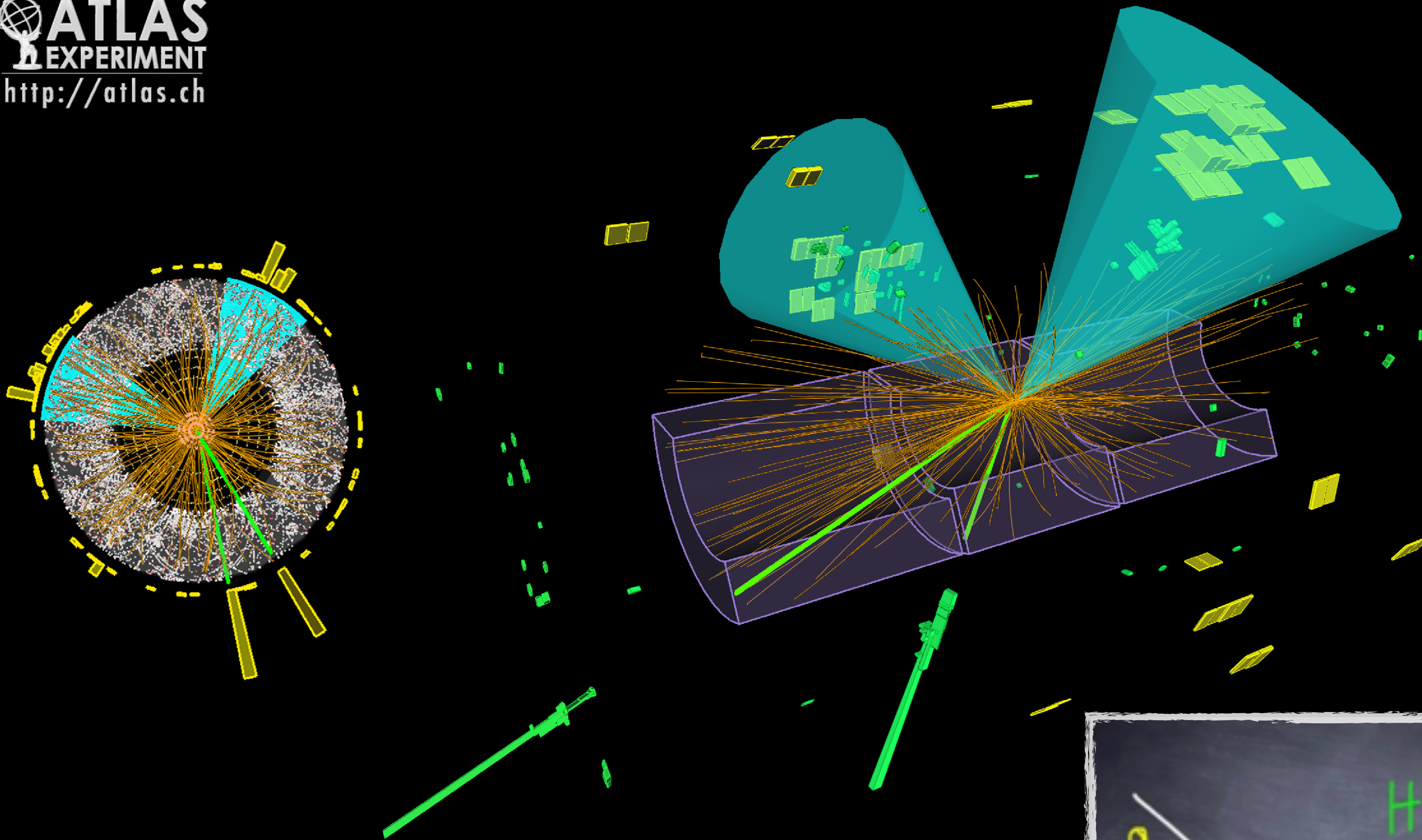
$$\sigma_{exp} = 5.9\sigma$$



H->bb: W/ZH->W/Zbb

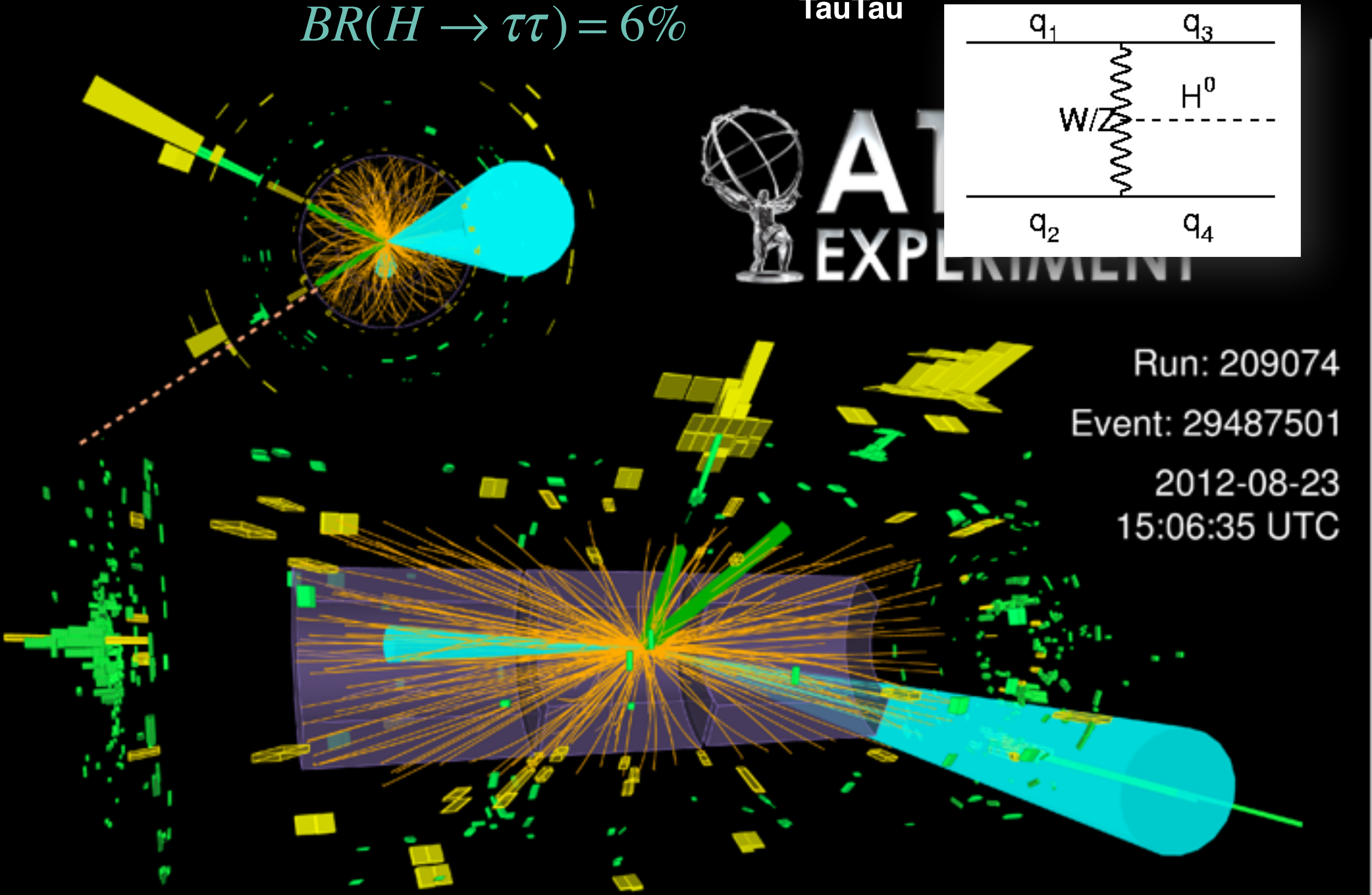
$BR(H \to bb) = 57\%$

ATLAS EXPERIMENT
http://atlas.ch



$BR(H \to \tau\tau) = 6\%$

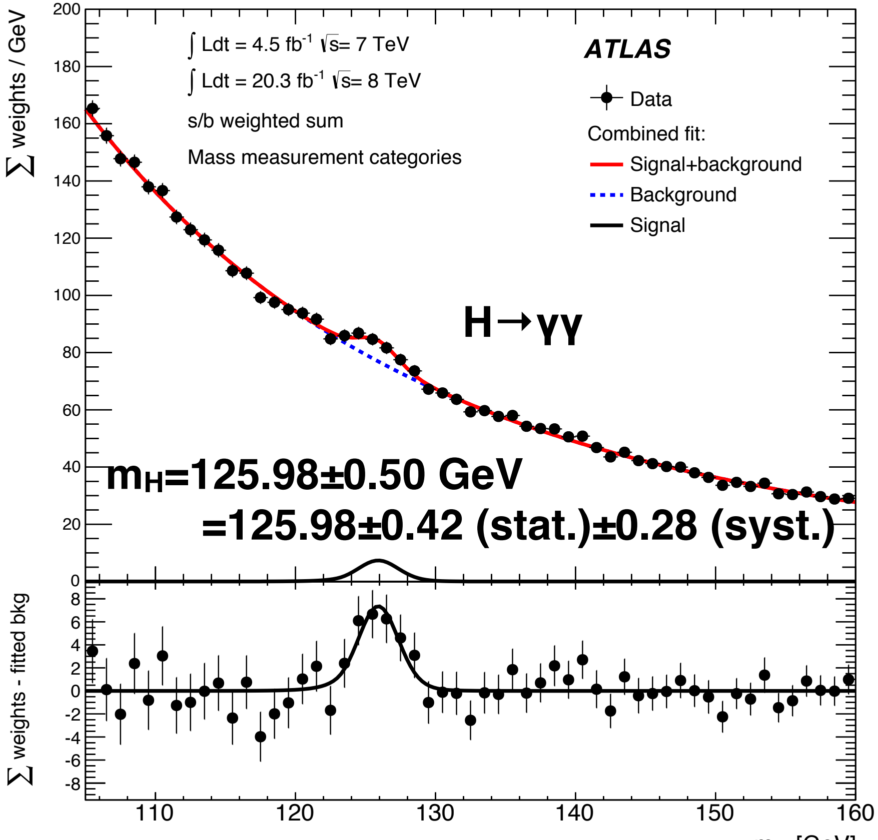
TauTau

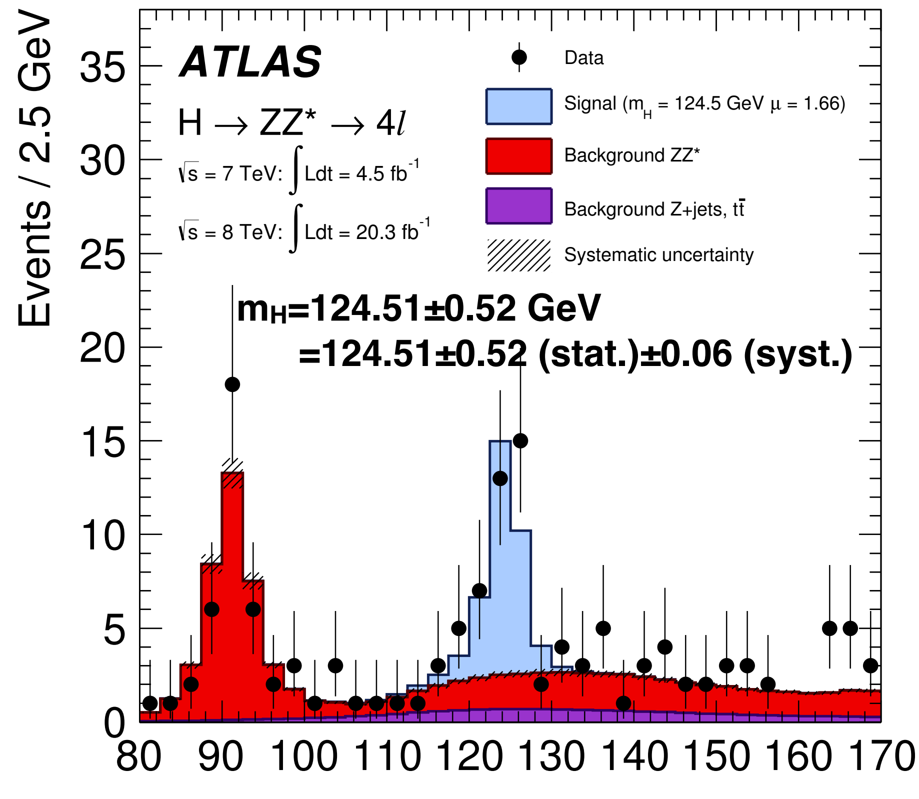


Mass Measurement Results

ATLAS Published analyses

[Phys. Rev. D. 90, 052004 (2014)](#)



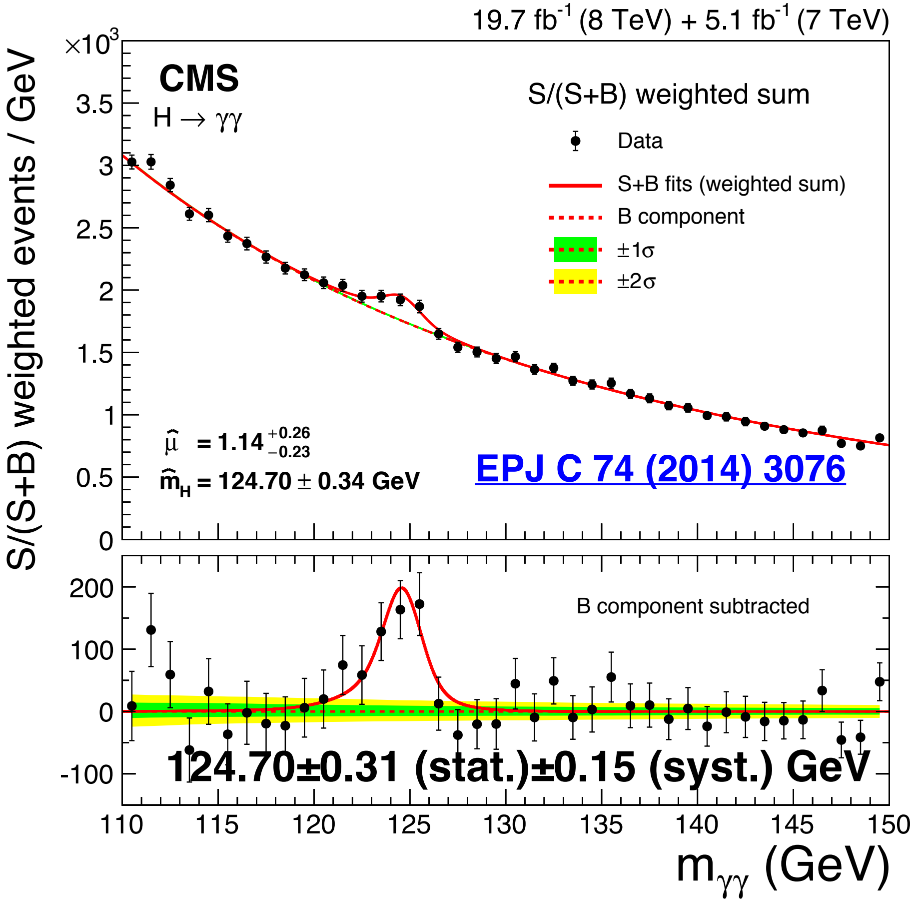


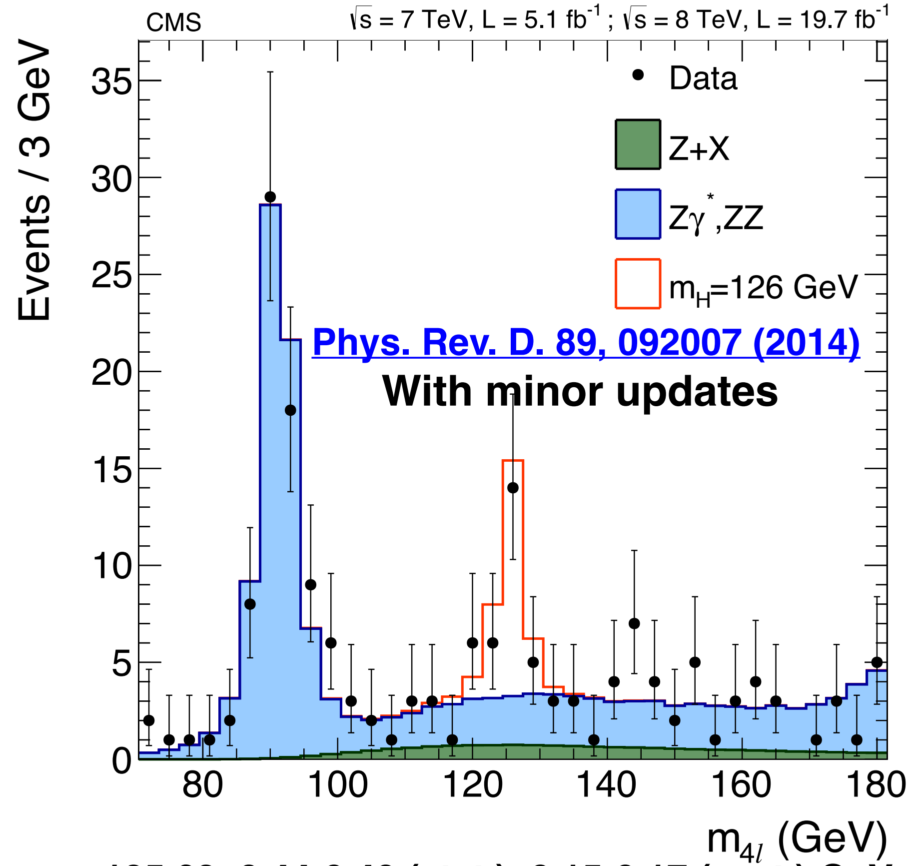
ATLAS Combined: **m_H=125.36±0.41 GeV** (symmetrized uncertainties)

=125.36±0.37 (stat.)±0.18 (syst.) GeV

CMS Published analyses

arXiv:1412.8662 (submitted to EPJ C)





125.63+0.44-0.40 (stat.)+0.15-0.17 (syst.) GeV

CMS Combined: **m_H=125.02+0.29-0.31 GeV**

=125.02+0.26-0.27 (stat.)+0.14-0.15 (syst) GeV

LHC Higgs Mass combination

PHYSICAL REVIEW LETTERS

moving physics forward

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Accepted Paper

Combined measurement of the Higgs boson mass in pp collisions at \sqrt{s}=7 and 8 TeV with the ATLAS and CMS Experiments

Phys. Rev. Lett.

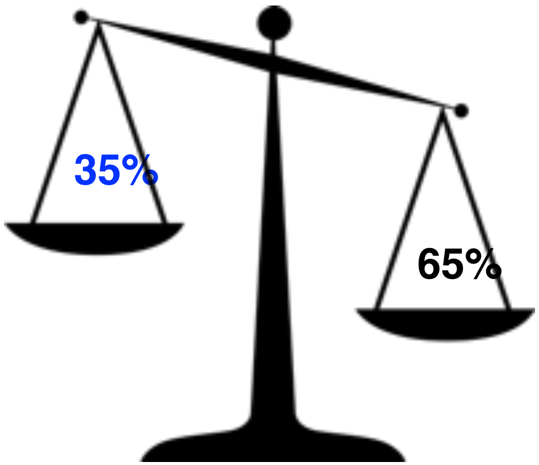
G. Aad et al.

Accepted 16 April 2015

- **ATLAS**

=**125.36±0.37 (stat.)±0.18 (syst.) GeV**

- **CMS**



CMS Weight

$$\frac{\frac{1}{\sigma^2_{CMS}}}{\frac{1}{\sigma^2_{CMS}}+\frac{1}{\sigma^2_{ATLAS}}} = \frac{\frac{1}{0.30^2}}{\frac{1}{0.30^2}+\frac{1}{0.40^2}} \approx 65\%$$

Profile Likelihood in a Nut Shell

$n = \mu s + b \qquad H_0 = BG\ only \qquad H_\mu = Signal\ with\ strength\ \ \mu$

$$L(\mu) = \Pr ob(data \mid \mu) \sim e^{-\frac{(\mu-\hat{\mu})^2}{2\sigma_{\hat{\mu}}^2}} \Rightarrow \frac{L(\mu)}{L(\hat{\mu})} = e^{-\frac{(\mu-\hat{\mu})^2}{2\sigma_{\hat{\mu}}^2}}$$

$$\log \frac{L(\mu)}{L(\hat{\mu})} = -\frac{(\mu-\hat{\mu})^2}{2\sigma_{\hat{\mu}}^2}$$

$$-2\log \frac{L(\mu)}{L(\hat{\mu})} = \frac{(\mu-\hat{\mu})^2}{\sigma_{\hat{\mu}}^2} = Z^2 \ \text{(Z is the significance)}$$

$$\Lambda(\mu) \equiv -2\log \frac{L(\mu)}{L(\hat{\mu})} \qquad \mathrm{Z}=\sqrt{\Lambda(\mu)}$$

Profile Likelihood in a Nut Shell

$$n = \mu s + b \qquad H_0 = BG\ only \qquad H_\mu = Signal\ with\ strength\ \ \mu$$

$$\Lambda(\mu) \equiv -2\log\frac{L(\mu)}{L(\hat{\mu})} \qquad Z = \sqrt{\Lambda(\mu)}$$

$$Let\ \ \theta_i\ \ be\ n\ Nuisance\ Parameters$$

$$\Lambda(\mu) \equiv -2\log\frac{\max\limits_{\theta_i} L(\mu,\theta_i)}{\max\limits_{\mu,\theta_i} L(\mu,\theta_i)} \equiv -2\log\frac{L(\mu,\hat{\hat{\theta}}_i)}{L(\hat{\mu},\hat{\theta}_i)}$$

$$Wilks\ Theorem \qquad \Lambda(\mu) \equiv -2\log\frac{L(\mu,\hat{\hat{\theta}}_i \mid H_\mu)}{L(\hat{\mu},\hat{\theta}_i) H_\mu)} \sim \chi_1^2$$

Jargon: The Nuisance Parameters are Profiled

Mass Measurement Parameterisation

Nominal fit: which μ to profile?

- The nominal fit has four common parameters:

$$m_H \quad \mu^{\gamma\gamma}_{ggH+ttH} \quad \mu^{\gamma\gamma}_{VBF+VH} \quad \mu^{ZZ}$$

$$\mu_i^f = \mu_i \cdot \rho^f$$

$$\mu^{\gamma\gamma}_{ggF} = \mu_{ggF} \cdot \rho^{\gamma\gamma} = \frac{\sigma_{ggF}}{\sigma^{SM}_{ggF}} \cdot \frac{BR(H \to \gamma\gamma)}{BR(H \to \gamma\gamma)^{SM}}$$

Nominal fit: which μ to profile?

- The nominal fit has four common parameters:

$$m_H \quad \mu^{\gamma\gamma}_{ggH+ttH} \quad \mu^{\gamma\gamma}_{VBF+VH} \quad \mu^{ZZ}$$

- The combined mass of ATLAS+CMS is therefore given by the following profile likelihood test statistic

$$\Lambda(m_H) = \frac{L(m_H\,,\,\hat{\hat{\mu}}^{\gamma\gamma}_{ggF+ttH}(m_H)\,,\hat{\hat{\mu}}^{\gamma\gamma}_{VBF+VH}(m_H)\,,\,\hat{\hat{\mu}}_{4\ell}(m_H)\,,\,\hat{\hat{\boldsymbol{\theta}}}(m_H))}{L(\hat{m}_H, \hat{\mu}^{\gamma\gamma}_{ggF+ttH}\,, \hat{\mu}^{\gamma\gamma}_{VBF+VH}, \hat{\mu}_{4\ell}, \hat{\boldsymbol{\theta}})}$$

- Systematics is modeled with ~300 Nuisance Parameters
- 100 for shape parameters and normalization in Hγγ Background model (unconstrained)
- Most of the remaining ones, correspond to experimental or theory (constrained)

The Fit Model

$$\lambda^{exp} = \frac{\mu^{CMS}}{\mu^{ATLAS}} \quad \lambda^{exp}_{RV} = \frac{\mu^{CMS}_{VBF+VH}}{\mu^{ATLAS}_{VBF+VH}} \quad \lambda^{exp}_{RF} = \frac{\mu^{CMS}_{ggF+ttH}}{\mu^{ATLAS}_{ggF+ttH}} \quad \lambda^{exp}_{ZZ} = \frac{\mu^{CMS}_{ZZ}}{\mu^{ATLAS}_{ZZ}}$$

- ATLAS is the other experiment

$$\mu^{CMS} = \mu \quad \mu^{ATLAS} = \mu\lambda^{exp}$$

		$H \to \gamma\gamma$	$H \to ZZ^{(*)} \to \ell\ell\ell\ell$
ATLAS	Mass	$m_H + \Delta m_{\gamma Z} + \Delta m^{exp.}$	$m_H + \Delta m^{exp.}$
	$ggF, t\bar{t}H$	$\mu\lambda^{exp.} \cdot \mu^{\gamma\gamma}_{ggF+t\bar{t}H(+b\bar{b}H)}\lambda^{exp.}_{RF}$	$\mu\lambda^{exp.} \cdot \mu^{ZZ}\lambda^{exp.}_{ZZ}$
	VBF, VH	$\mu\lambda^{exp.} \cdot \mu^{\gamma\gamma}_{VBF+VH}\lambda^{exp.}_{RV}$	
CMS	Mass	$m_H + \Delta m_{\gamma Z}$	m_H
	$ggF, t\bar{t}H$	$\mu \cdot \mu^{\gamma\gamma}_{ggF+t\bar{t}H(+b\bar{b}H)}$	$\mu \cdot \mu^{ZZ}$
	VBF, VH	$\mu \cdot \mu^{\gamma\gamma}_{VBF+VH}$	

Systematics
Correlations

Correlated Sytematics

- The experiments are different;
  Different detectors and different methodology for systematic evaluation
    - Experimental systematics on γ, e and μ (energy/momentum scale/resolution, efficiencies etc.) are **uncorrelated**
- Only common theoretical uncertainties (QCD scale, PDF, BR) and partial luminosity were **correlated**
    - It should be noted that the effect of these uncertainties is mainly normalisation so the effect on the mass is negligible (<10 MeV)

PDF and QCD scale uncertainties

Correlation rather straightforward:
PDF uncertainties in ATLAS 4l analysis is uncorrelated between signal and background because the correlation is expected to be small. But in LHC combination they have been correlated to be consistent with CMS 4l treatment

Source	Affected Processes	Typical uncertainty
PDFs+α_s (cross sections)	ggF, $t\bar{t}H$, $b\bar{b}H$, $gg \to ZZ$	$\pm 7\,\%$
	VBF, VH, $q\bar{q} \to ZZ$	$\pm 3\,\%$
Higher-order uncertainties on cross sections	ggF	$\pm 8\,\%$
	VBF	$\pm 0.2\,\%$
	VH	$\pm 1\,\%$
	$t\bar{t}H$	$^{+4\,\%}_{-9\,\%}$
	$b\bar{b}H$	$^{+13\,\%}_{-23\,\%}$
	$q\bar{q} \to ZZ$	±3%
	$gg \to ZZ$	±30%

BR Uncertainties

- Uncertainties below 0.3% were neglected
- We were left with 5 NPs

Decay widths	Parametric uncertainty on α_S(varies with decay)	$\pm 1\,\%$
	Parametric uncertainty on m_b(varies with decay)	$\pm 2\,\%$
	Theoretical uncertainty on $\Gamma(H \to VV)$	$\pm 0.4\,\%$
	Theoretical uncertainty on $\Gamma(H \to q\bar{q})$	$\pm 1\,\%$
	Theoretical uncertainty on $\Gamma(H \to \gamma\gamma)$	$\pm 1\,\%$

Luminosity Uncertainties

- Naturally part of the Luminosity uncertainty is common to ATLAS and CMS
  - 0.5% (0.6%) of ATLAS (CMS) Lumi @ 7 TeV
  - 1.1% (2.1%) of ATLAS (CMS) Lumi @ 8 TeV
- Effect is negligible

7 TeV	ATLAS	CMS
Total	1.8%	2.2%
100% correlated between ATLAS and CMS	$< 0.5\%$	$< 0.6\%$
Uncorrelated between ATLAS and CMS	$> 1.7\%$	$> 2.1\%$

8 TeV	ATLAS	CMS
Total	2.8%	2.6%
100% correlated between ATLAS and CMS	$< 1.1\%$	$< 2.1\%$
Uncorrelated between ATLAS and CMS	$> 2.5\%$	$> 1.5\%$

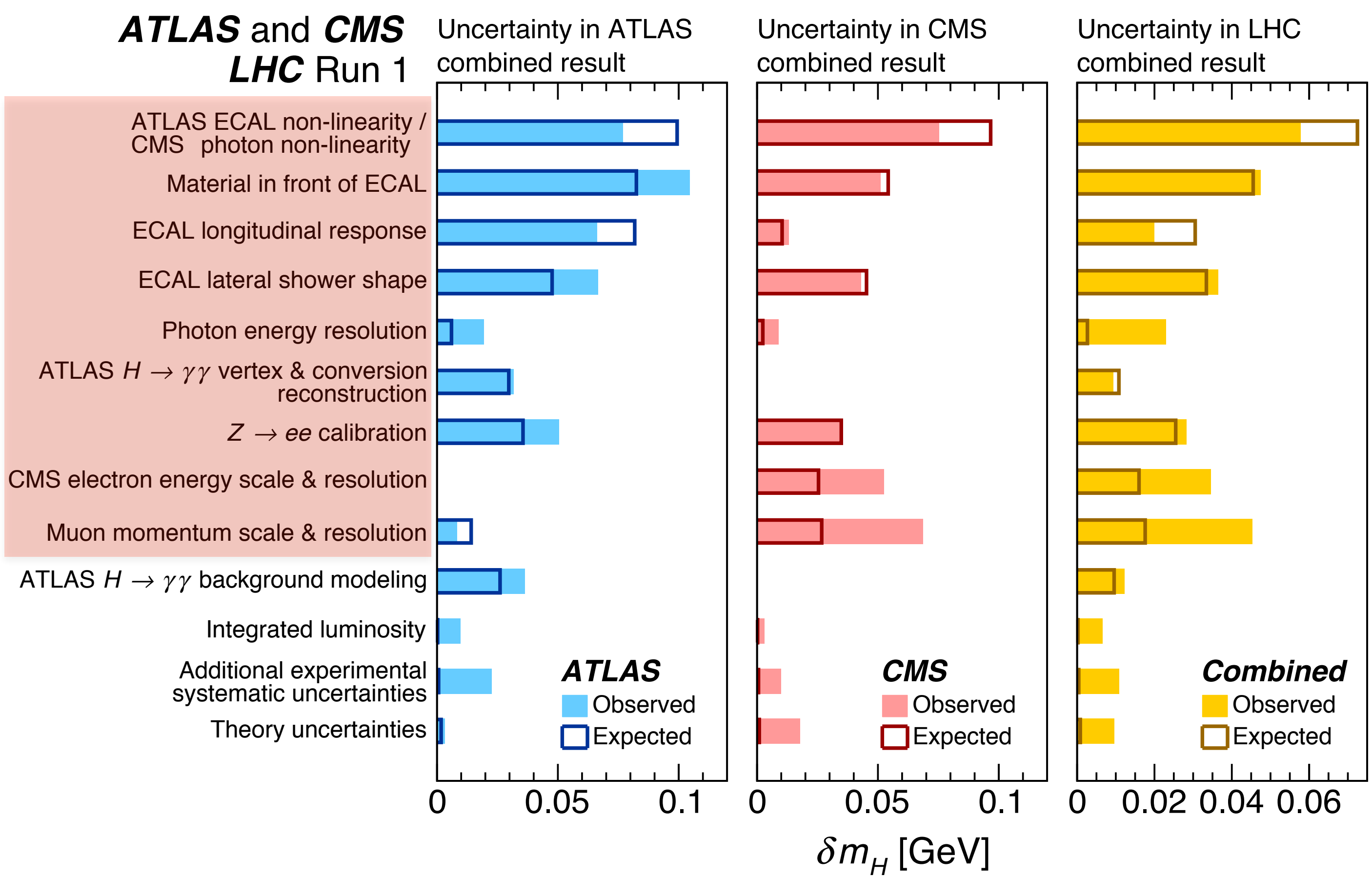
Other NPs

- Other NPs are the individual experiments NP
- Main impact comes from those related to Calibration/Energy/Momentum/Scale and Resolution
- The correlation of the calibration based on Z—>ee energy scale in both experiments turns out to be negligible

Impact of Systematics

Systematic uncertainties

Energy/momentum scale and resolution of μ, e and γ dominate systematic uncertainty

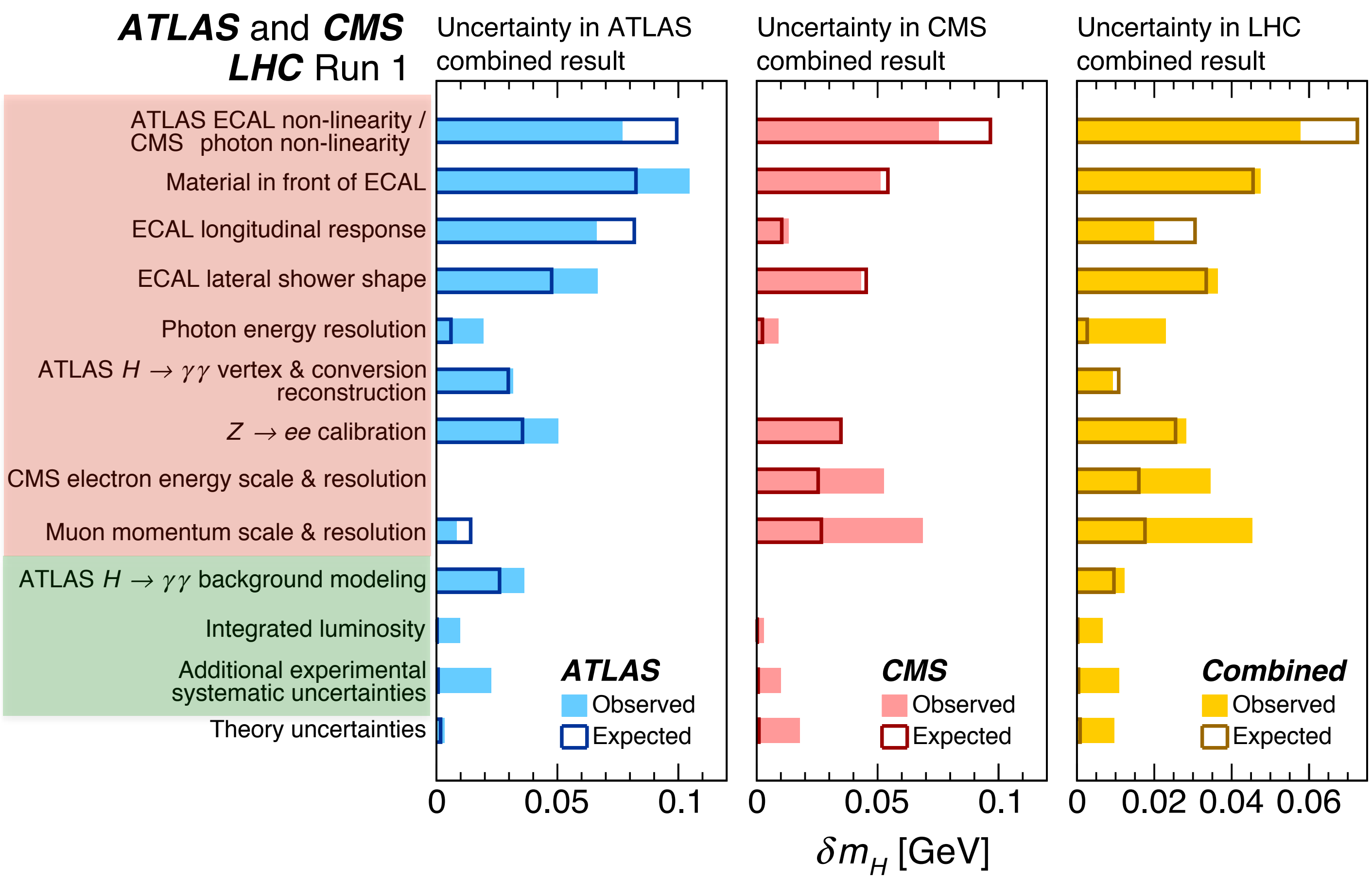


Systematic uncertainties

Energy/momentum scale and resolution of μ, e and γ dominate systematic uncertainty

Other experimental uncertainties (eff, JES, luminosity…)

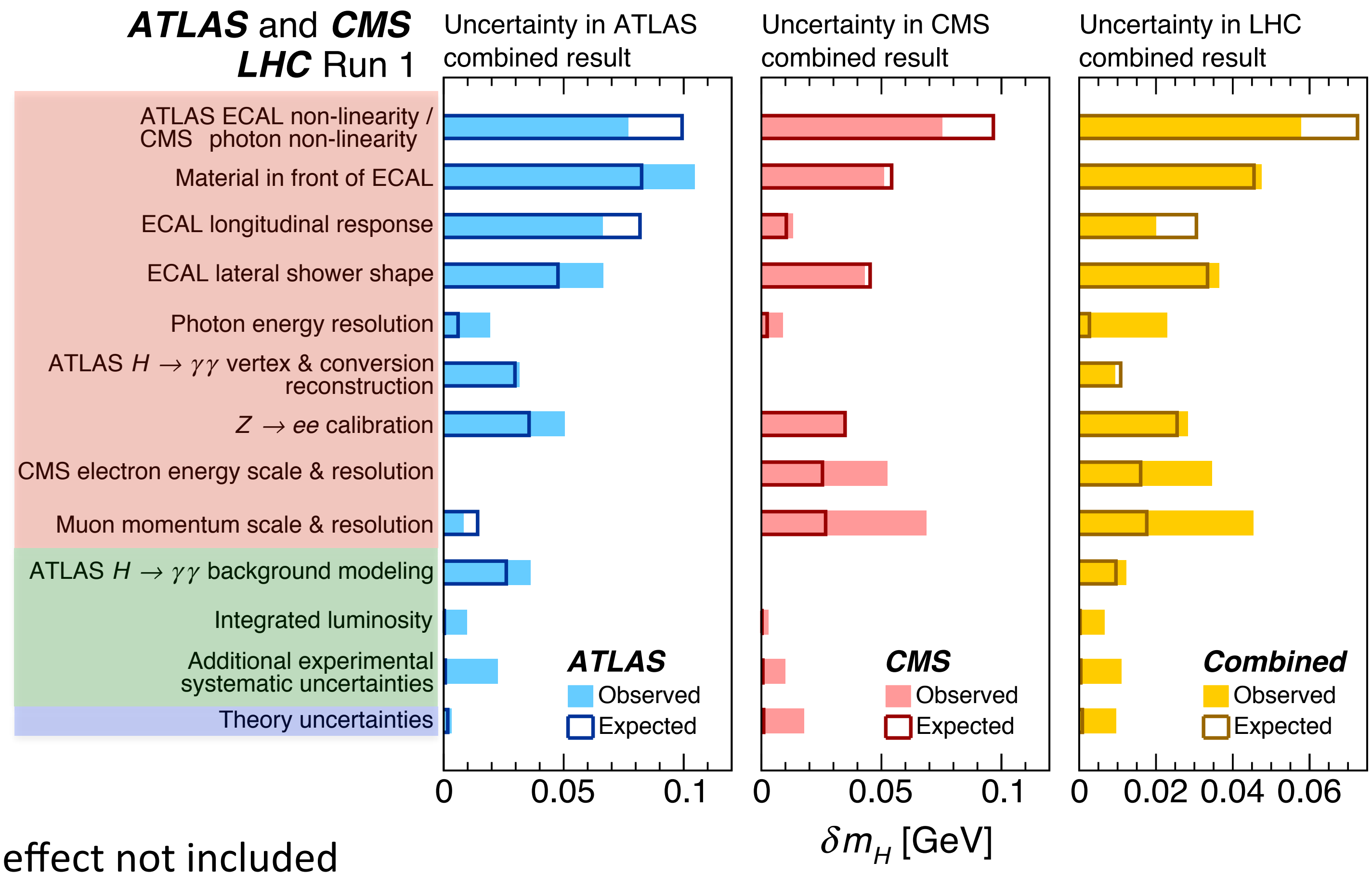
All experimental uncertainties uncorrelated between experiments except luminosity (partial correlation)



Systematic uncertainties

Theoretical uncertainties (QCD scales, pdf, BR…*) 100% correlated between experiments

Almost no impact on mass measurement (as expected)!



*Interference effect not included

Systematic uncertainties

Systematic contribution evaluated sequentially "freezing" nuisance parameter groups to their best values and re-scanning the likelihood ratio…

$$\mathbf{m_H = 125.09 \pm 0.21\ (stat)}$$

$$\mathbf{\pm 0.11\ (scale)}$$

$$\mathbf{\pm 0.02\ (other)}$$

$$\mathbf{\pm 0.01\ (theory^{*})}$$

$$\mathbf{GeV}$$

Uncertainty is mostly statistical

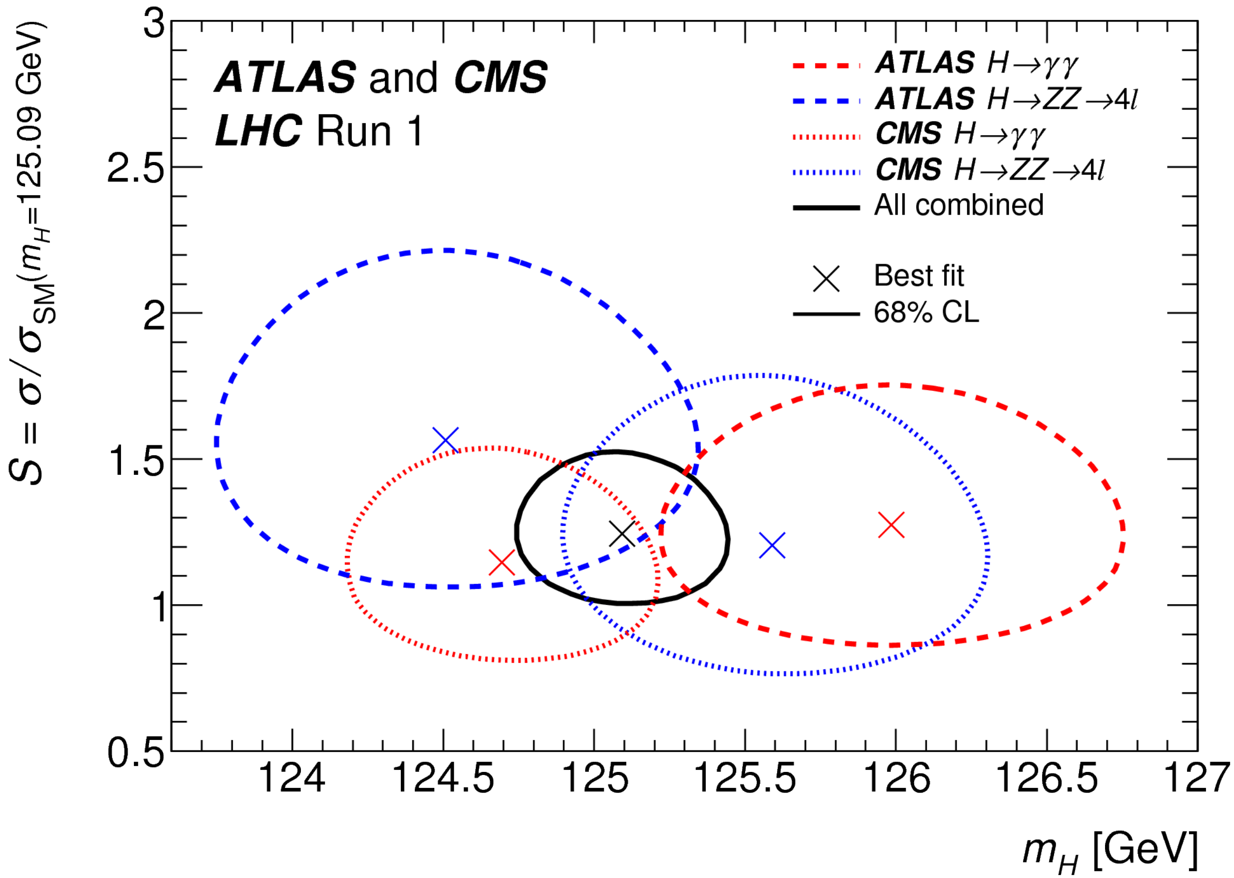
Scale uncertainties dominate systematic

→ But we can expect that to improve with more data!

*Interference effect not included

Results

m_H vs. μ contours



The best fit mH in contour (×) is not identical as m_H measured

Some Examples

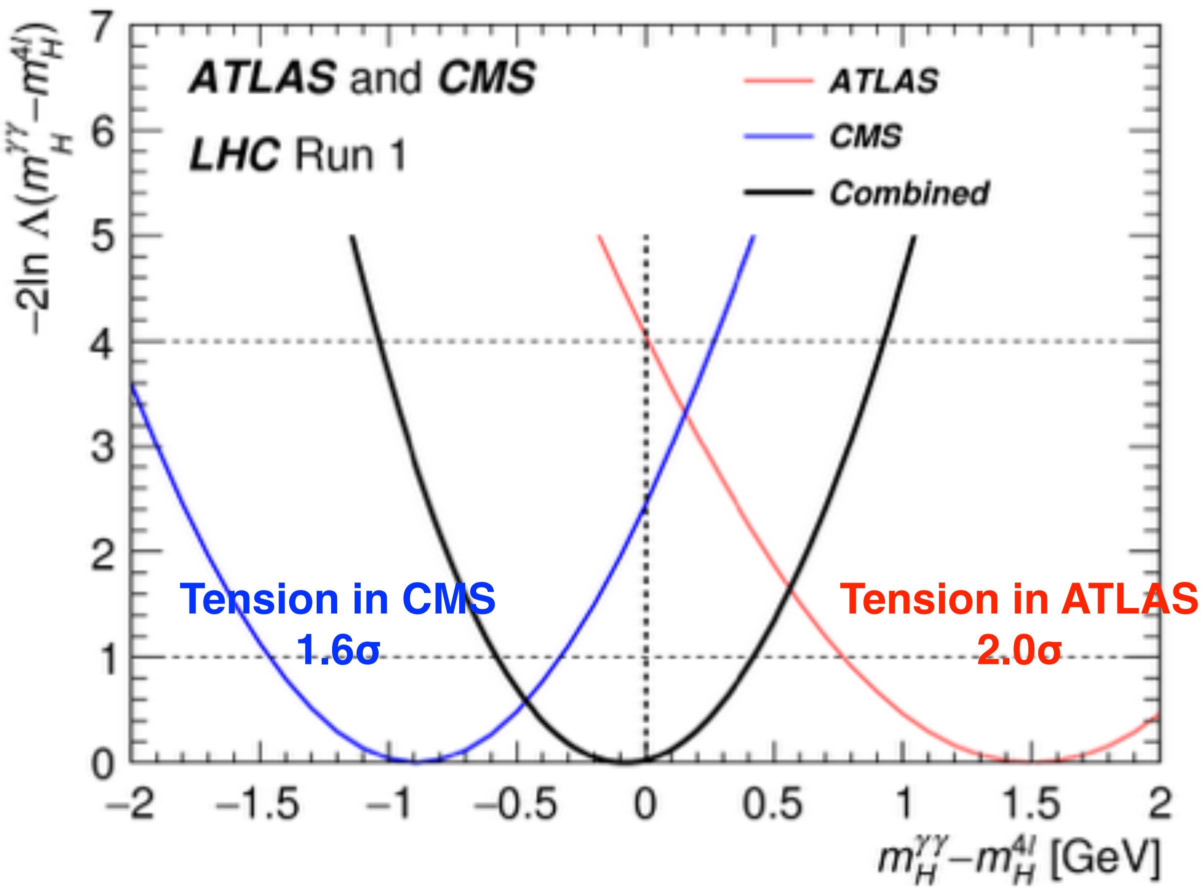
- Asses the tension between channels $\Delta m_H(\gamma\gamma\text{-}4l)$

$$\Lambda(\Delta m_{\gamma Z}) = \frac{L(\Delta m_{\gamma Z}, \hat{\hat{m}}_H, \hat{\hat{\mu}}^{\gamma\gamma}_{ggF+ttH}, \hat{\hat{\mu}}^{\gamma\gamma}_{VBF+VH}, \hat{\hat{\mu}}_{4\ell}, \hat{\hat{\boldsymbol{\theta}}})}{L(\hat{\Delta} m_{\gamma Z}, \hat{m}_H, \hat{\mu}^{\gamma\gamma}_{ggF+ttH}, \hat{\mu}^{\gamma\gamma}_{VBF+VH}, \hat{\mu}_{4\ell}, \hat{\boldsymbol{\theta}})}.$$

- Asses the tension between experiments Δm_H(ATLAS-CMS)

$$\Lambda(\Delta m^{exp}) = \frac{L(\Delta m^{exp}, \hat{\hat{m}}_H, \hat{\hat{\mu}}^{\gamma\gamma}_{ggF+ttH}, \hat{\hat{\mu}}^{\gamma\gamma}_{VBF+VH}, \hat{\hat{\mu}}_{4\ell}, \hat{\hat{\boldsymbol{\theta}}})}{L(\hat{\Delta} m^{exp}, \hat{m}_H, \hat{\mu}^{\gamma\gamma}_{ggF+ttH}, \hat{\mu}^{\gamma\gamma}_{VBF+VH}, \hat{\mu}_{4\ell}, \hat{\boldsymbol{\theta}})}$$

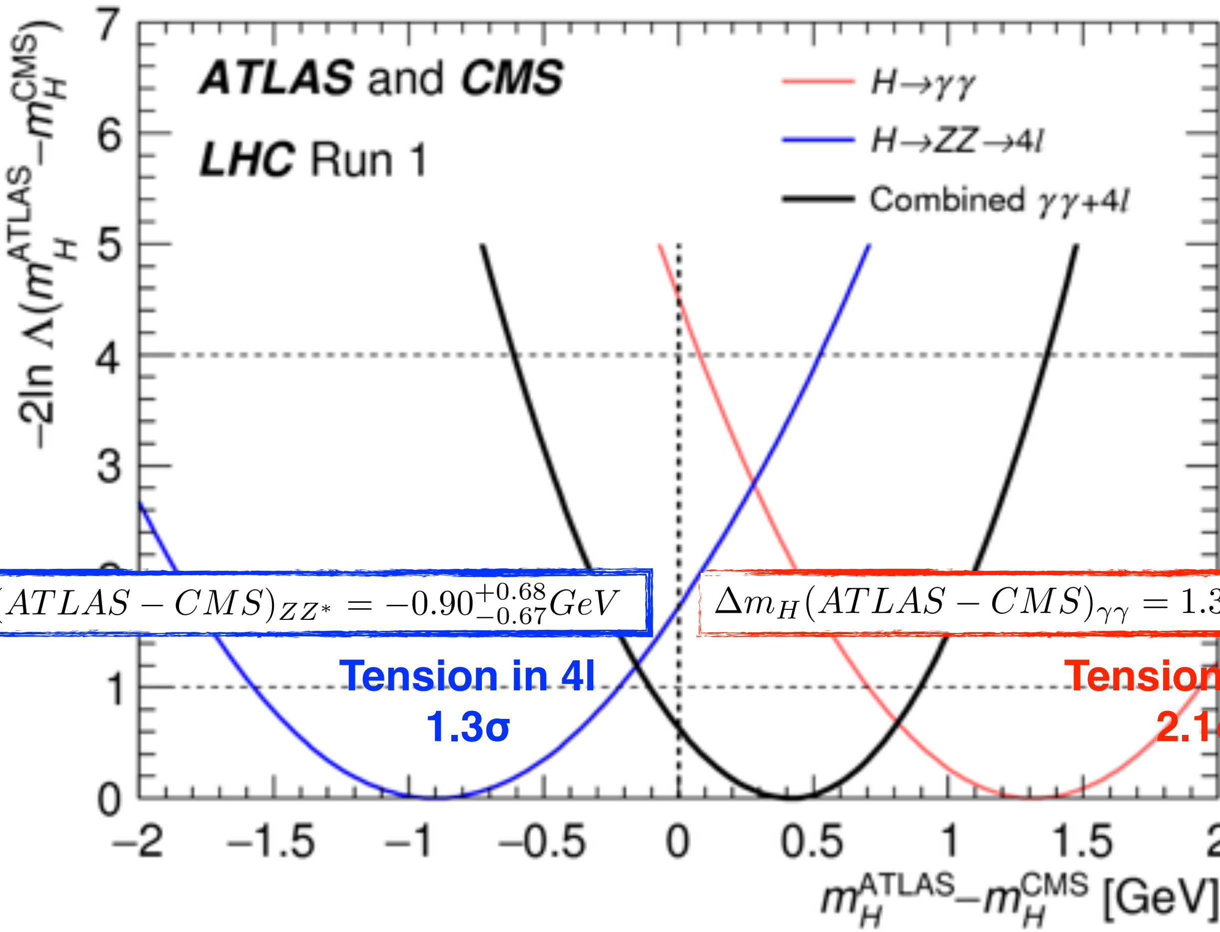
Tension in m_H between decay channels



$$\Delta m_H(\gamma\gamma - ZZ^*) = -0.08^{+0.50}_{-0.49}\ \text{GeV}$$

No observed tension in combined

Tension in m_H between experiments



$$\Delta m_H(ATLAS-CMS)_{ZZ^*} = -0.90^{+0.68}_{-0.67} GeV$$

$$\Delta m_H(ATLAS-CMS)_{\gamma\gamma} = 1.32^{+0.62}_{-0.61} GeV$$

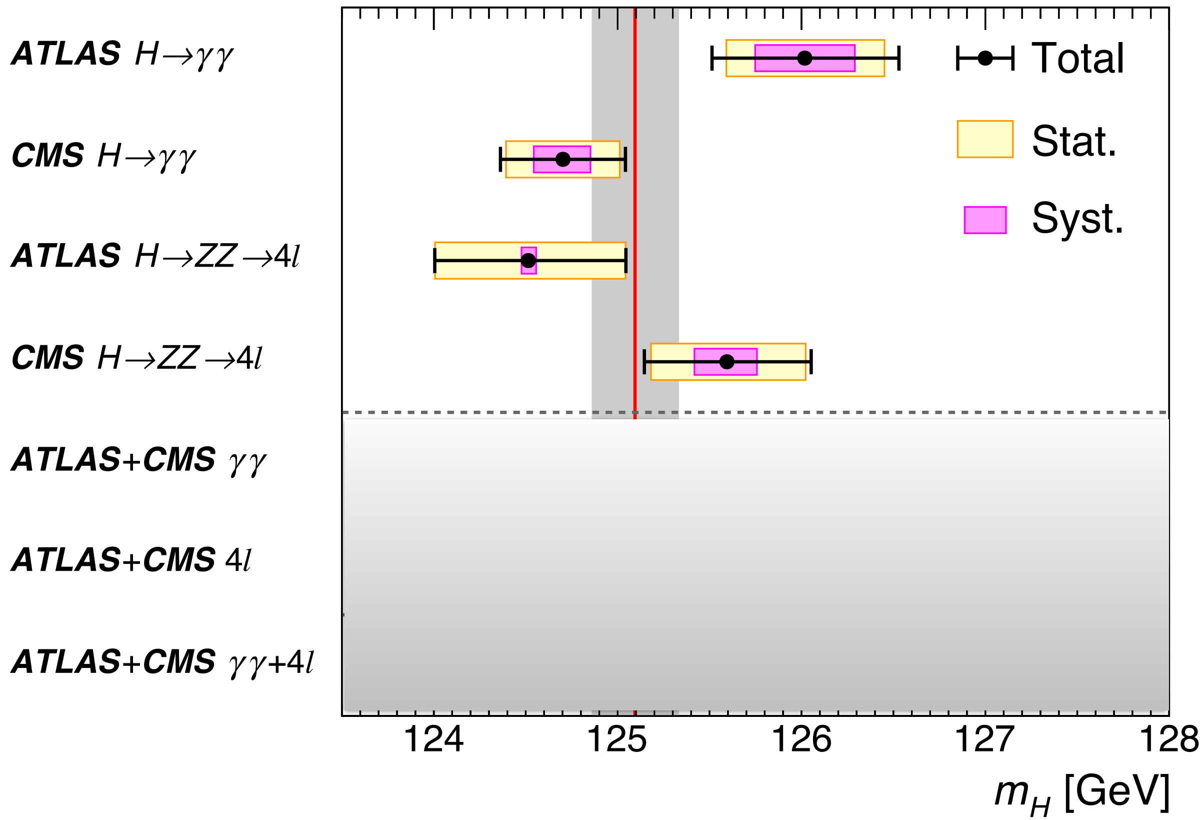
Tension in 4l 1.3σ

Tension in γγ 2.1σ

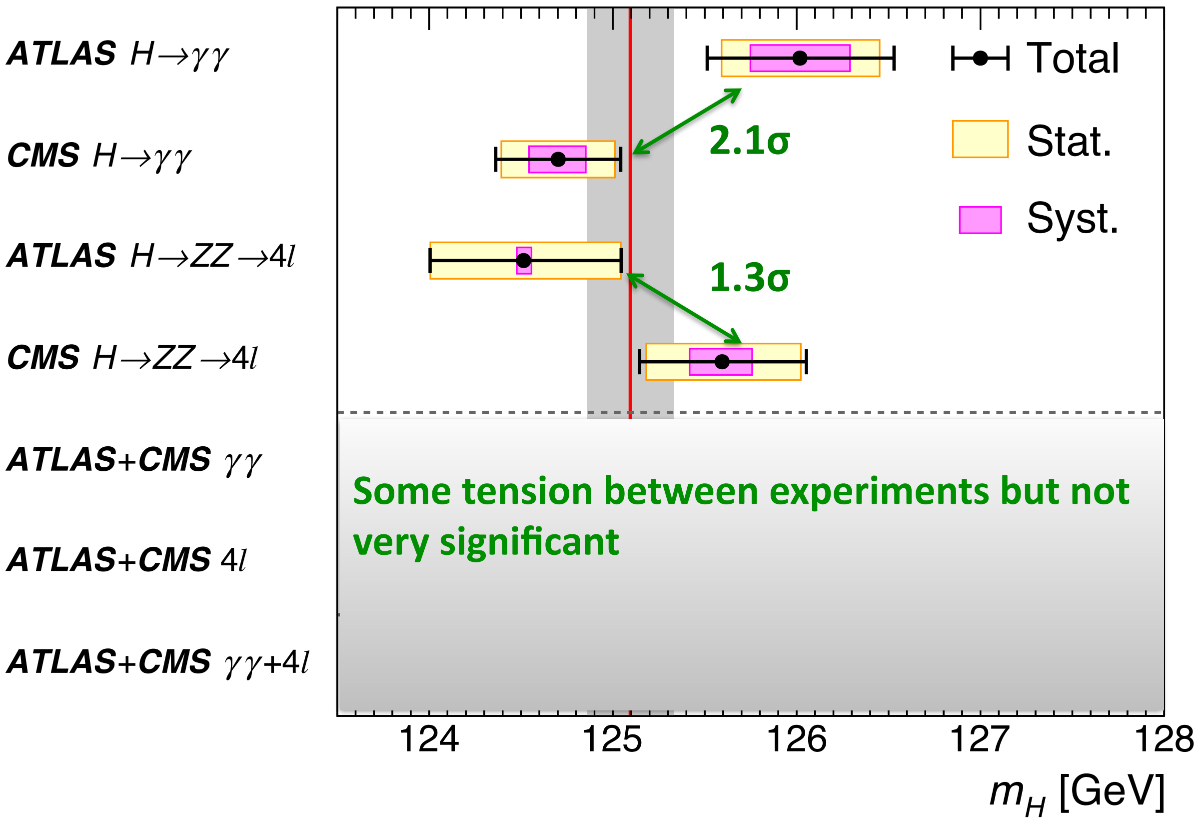
$$\Delta m_H(ATLAS-CMS) = 0.41^{+0.48}_{-0.52} \text{ GeV}$$

No observed tension in combined measurements between experiments

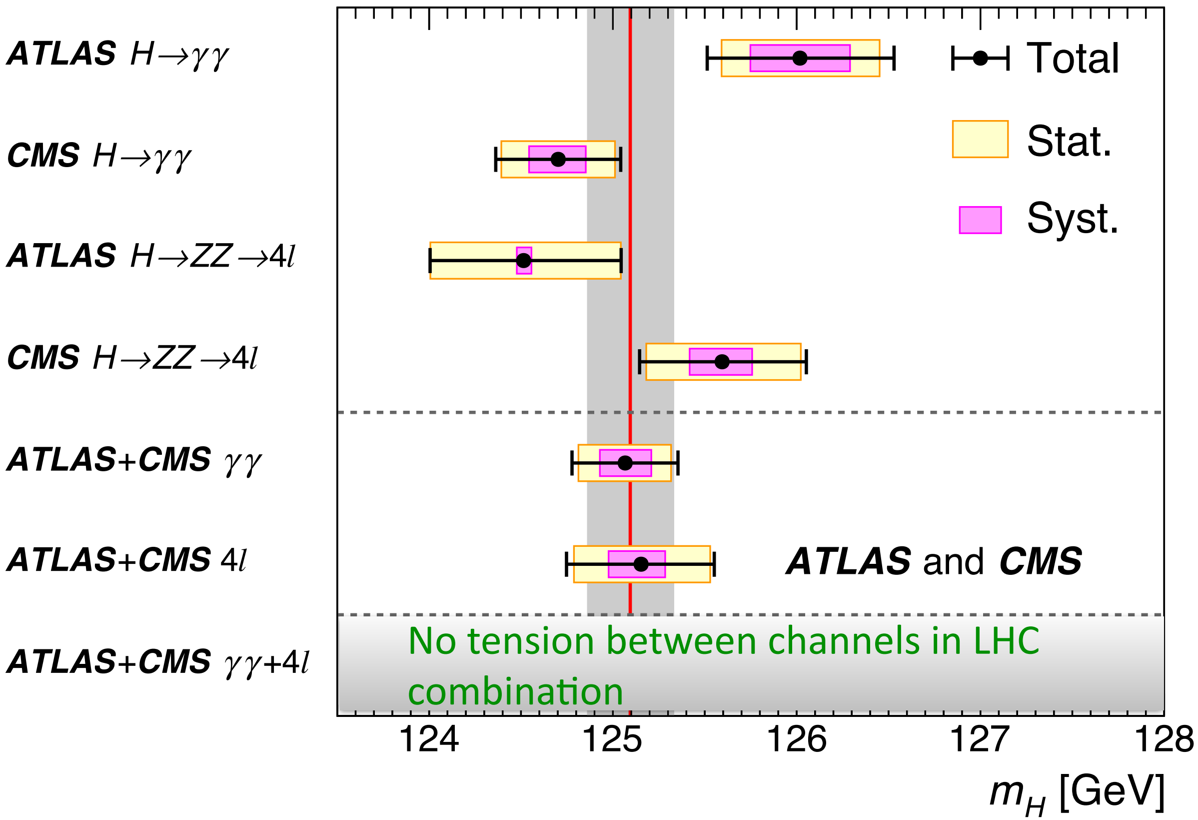
Reproduce Published results



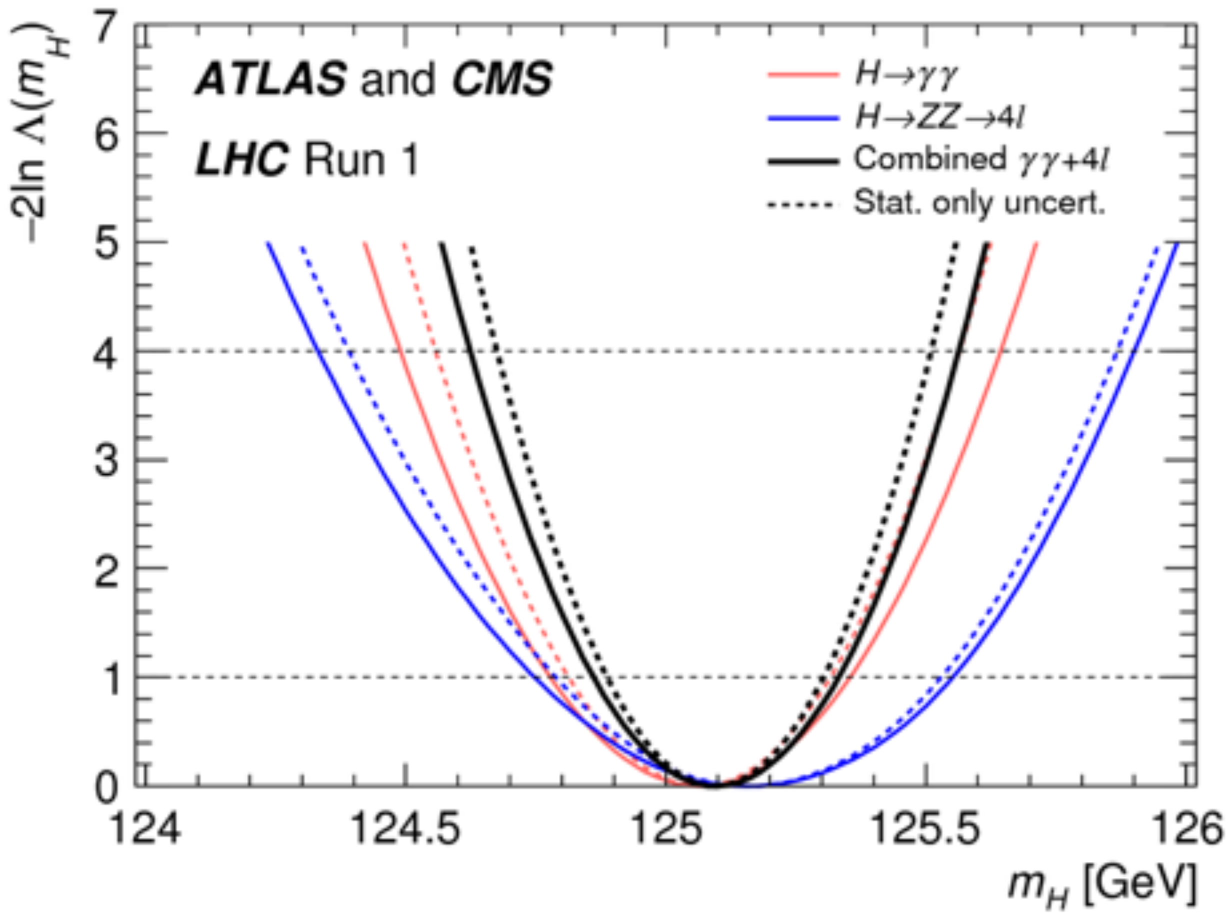
Tension Between Experiments



No Tension Between Combined Channels



Fine Final Scan

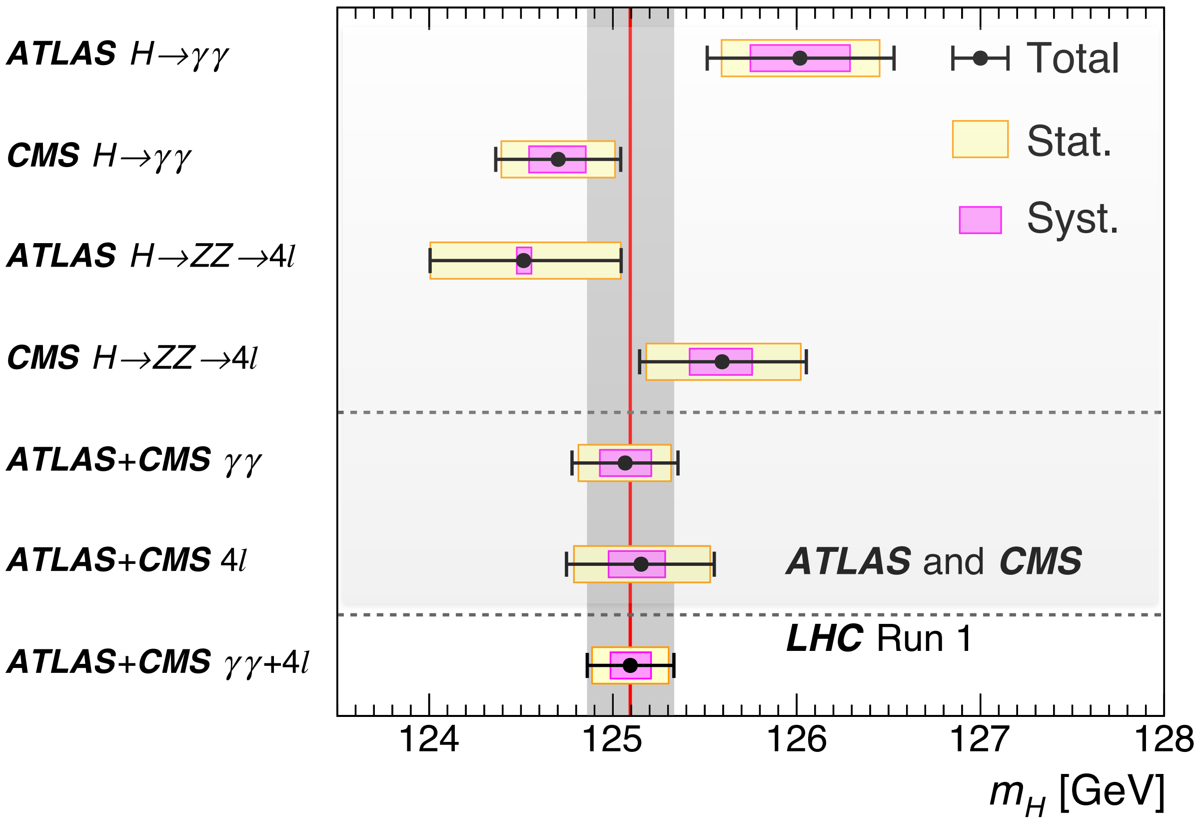


$$-2\ln\Lambda = 1 \Rightarrow \sigma$$

$$\sqrt{\sigma_{tot}^2 - \sigma_{Stat}^2} = \sigma_{syst}$$

$$m_H = 125.09 \pm 0.21(stat) \pm 0.11(syst)GeV$$

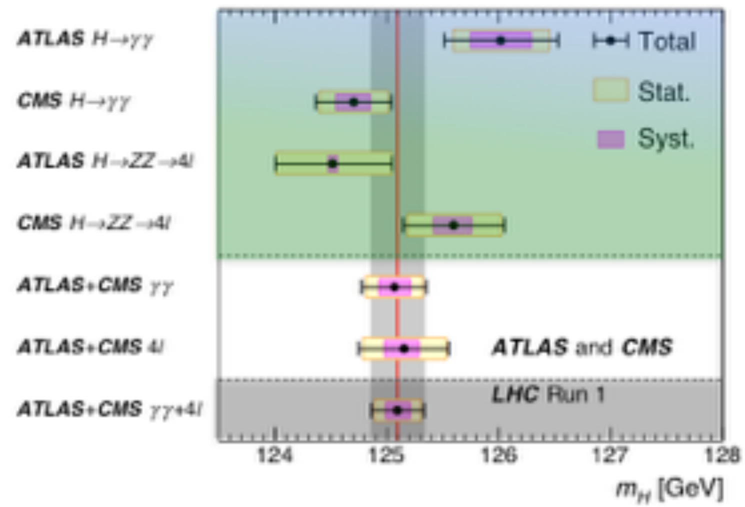
Combined Mass



$$m_H = 125.09 \pm 0.21(stat) \pm 0.11(syst)GeV$$

Compatibility

A number of different models to check compatibility of the result …



3μ+4m
Four masses

The combined value in the plot

3μ+1m
"Nominal"

O(1)

The 4 measurements in the plot

6μ+4m
Both

Least assumptions made

O(1)

6μ+1m
Six signal modifiers

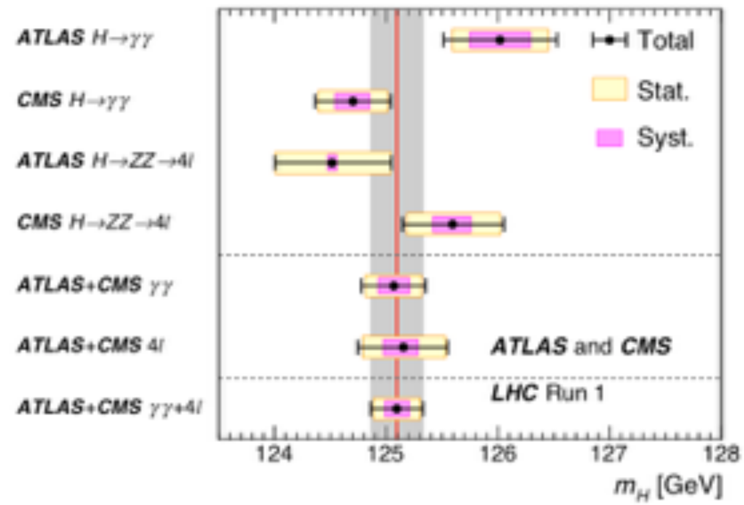
Chi² p-values

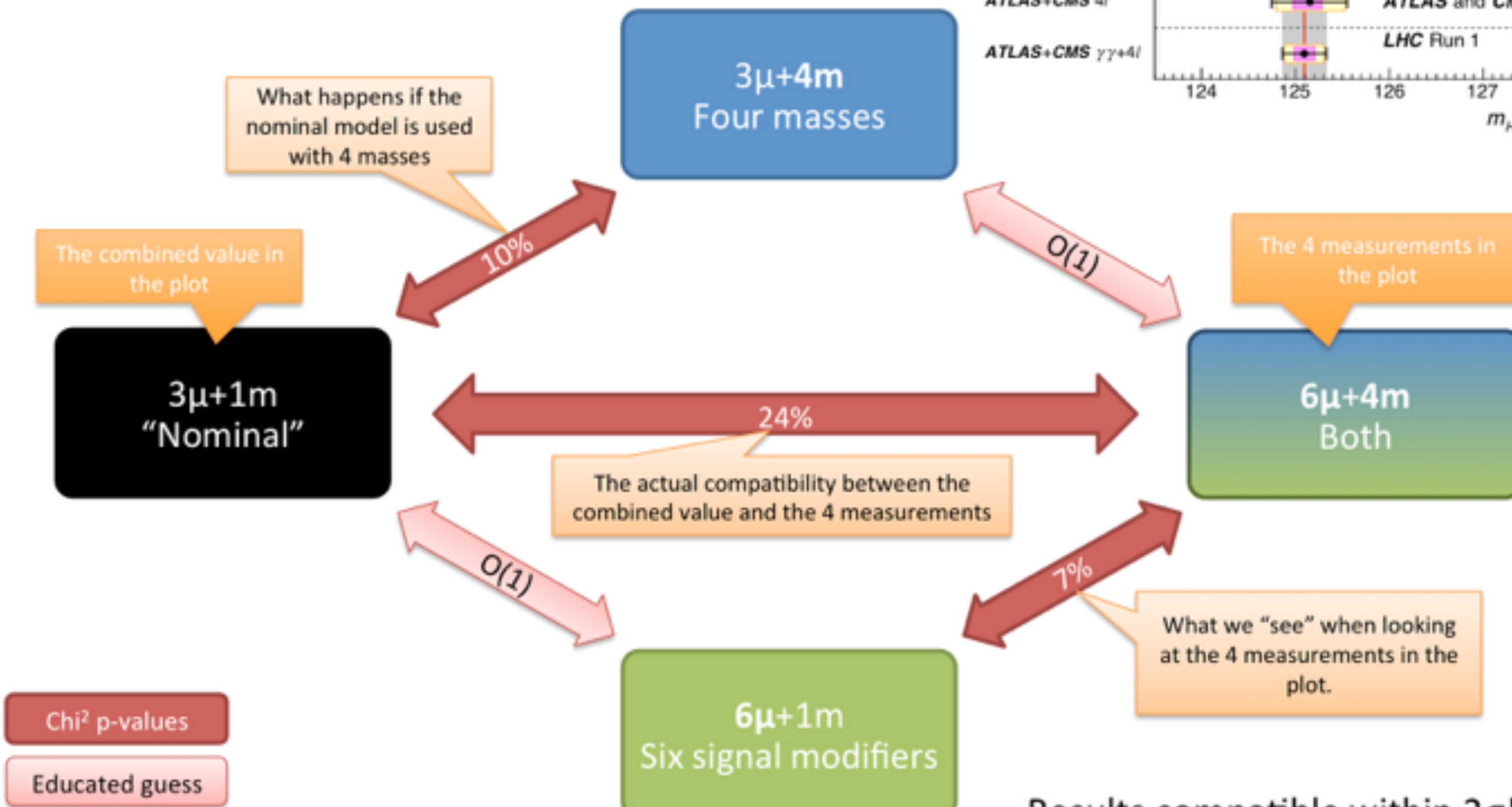
Educated guess

Nick Wardle

Compatibility

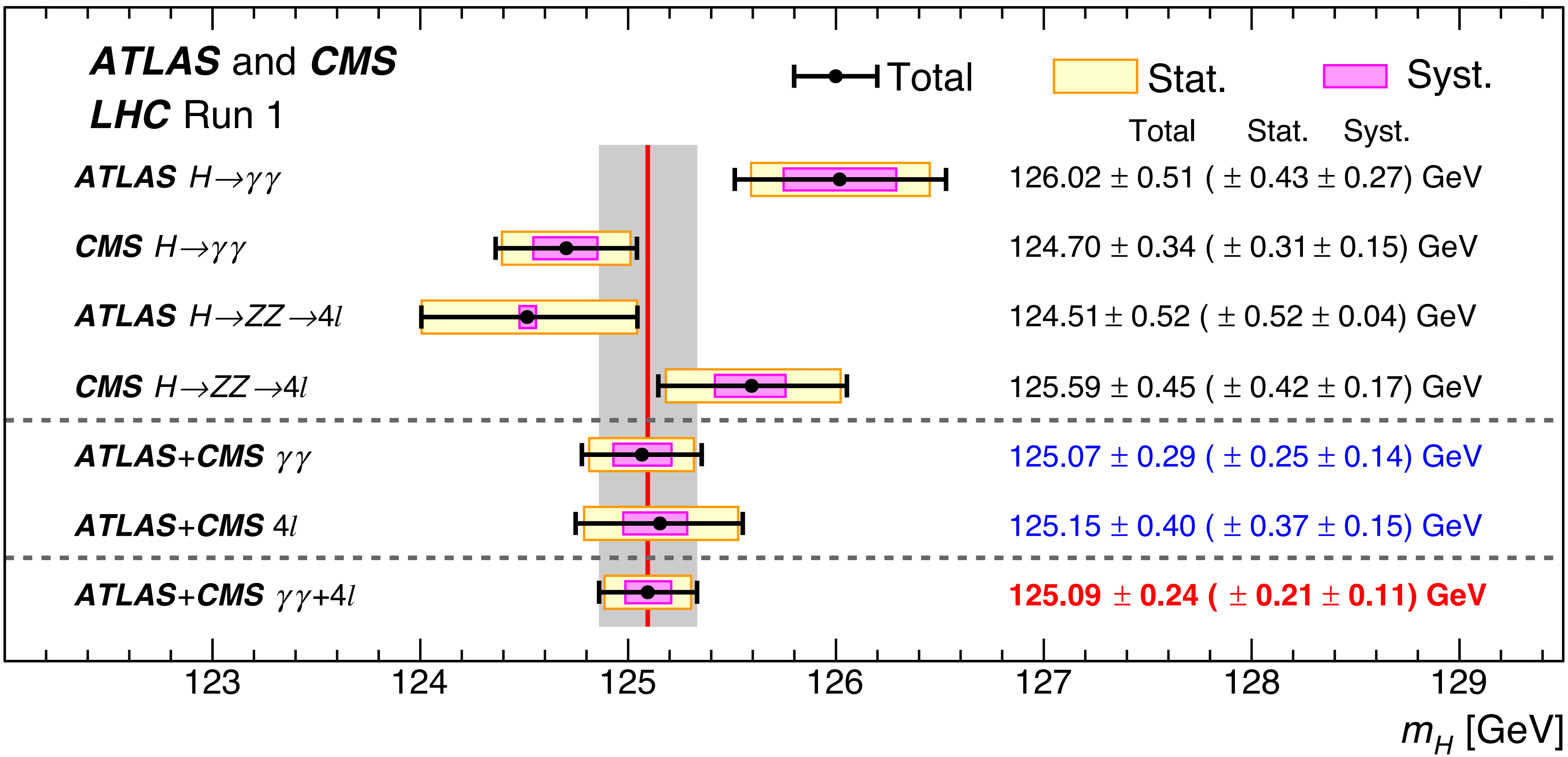
A number of different models to check compatibility of the result …

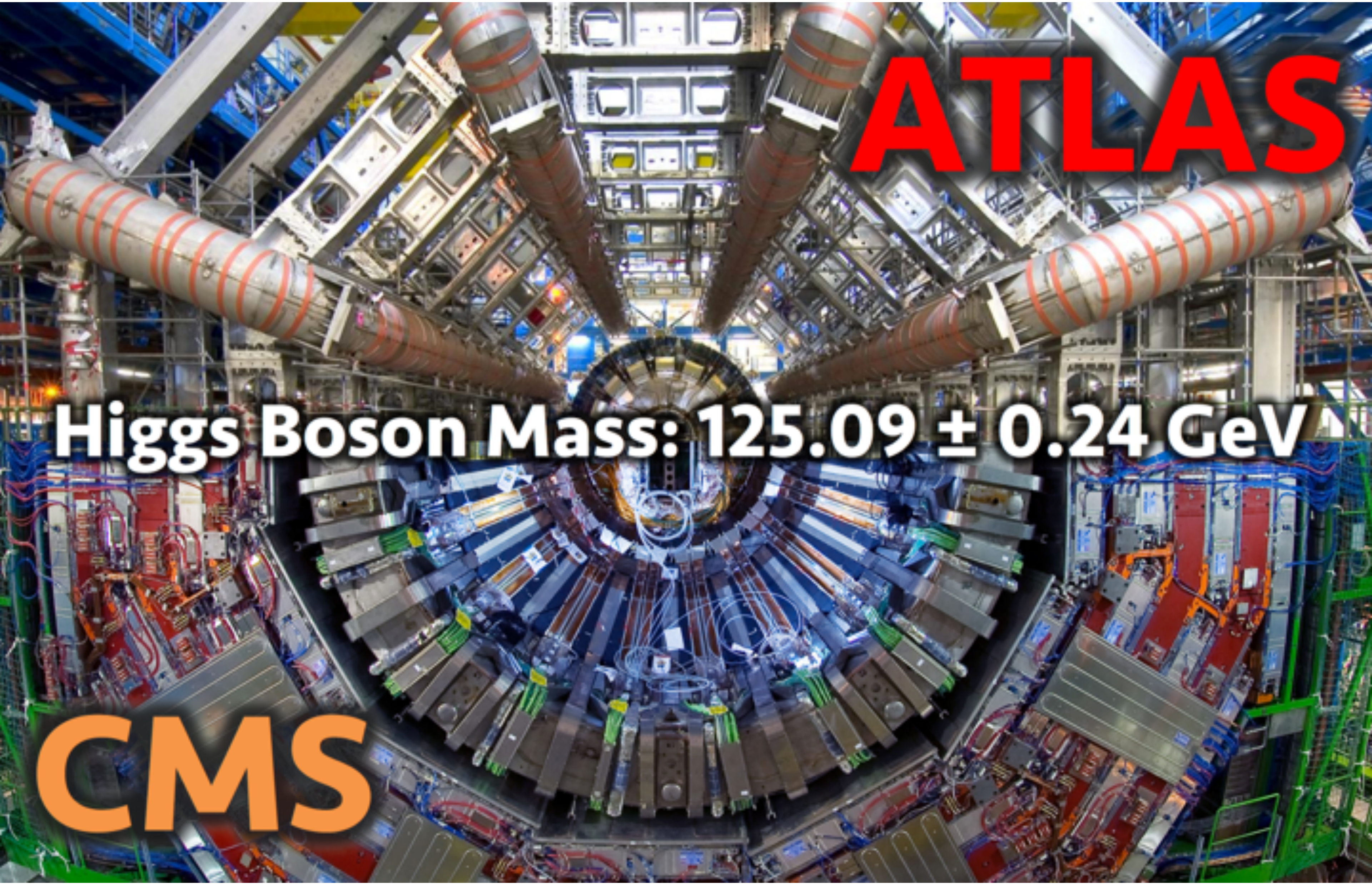




Results compatible within 2σ!

Conclusion


ATLAS and CMS
LHC Run 1
Total
Stat.
Syst.
Total Stat. Syst.
ATLAS H→γγ
126.02 ± 0.51 (± 0.43 ± 0.27) GeV
CMS H→γγ
124.70 ± 0.34 (± 0.31 ± 0.15) GeV
ATLAS H→ZZ→4l
124.51 ± 0.52 (± 0.52 ± 0.04) GeV
CMS H→ZZ→4l
125.59 ± 0.45 (± 0.42 ± 0.17) GeV
ATLAS+CMS γγ
125.07 ± 0.29 (± 0.25 ± 0.14) GeV
ATLAS+CMS 4l
125.15 ± 0.40 (± 0.37 ± 0.15) GeV
ATLAS+CMS γγ+4l
125.09 ± 0.24 (± 0.21 ± 0.11) GeV
123
124
125
126
127
128
129
m_H [GeV]


ATLAS
Higgs Boson Mass: 125.09 ± 0.24 GeV
CMS

BACKUP