Observation of VH and $H \to b\bar{b}$

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Alushta-2019 talk plan

LHEP, JINR, Dubna

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Overview

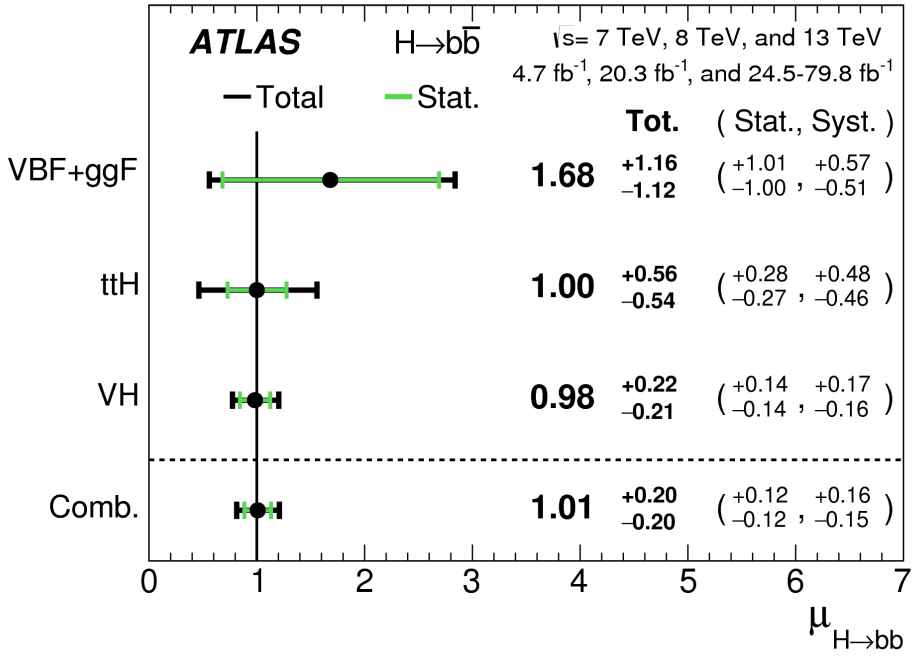
- *Introduction*
- *Higgs production & decay channels*
- *Object and event selection*
- *Data and simulated samples*
- *Systematic uncertainties*
- *Statistical analysis*
  - ✓ *Multivariate analysis*
  - ✓ *Dijet-mass analysis*
  - ✓ *Diboson analysis*
  - ✓ *Combinations*
- *Results*
  - *BDT output post-fit distributions*
  - *Yields & signal strengths (μ)*
  - *Results of the dijet-mass analysis*
  - *Results of the diboson analysis*
  - *Results of combinations*
- *Observation of H→bb decays*
- *Observation of VH production*
- *Conclusion*

Observation of $H \to b\bar{b}$ decays

Channel	Significance	
	Exp.	Obs.
VBF+ggF	0.9	1.5
$t\bar{t}H$	1.9	1.9
VH	5.1	4.9
$H \to b\bar{b}$ combination	5.5	5.4

Expected and observed significance values (in standard deviations) for the H→bb channels fitted independently and their combination using the 7 TeV, 8 TeV and 13 TeV data.

The fitted values of the Higgs boson signal strength $\mu_{H\to bb}$ for m_H=125 GeV separately for the VH, ttH and VBF+ggF analyses along with their combination, using the 7 TeV, 8 TeV and 13 TeV data.

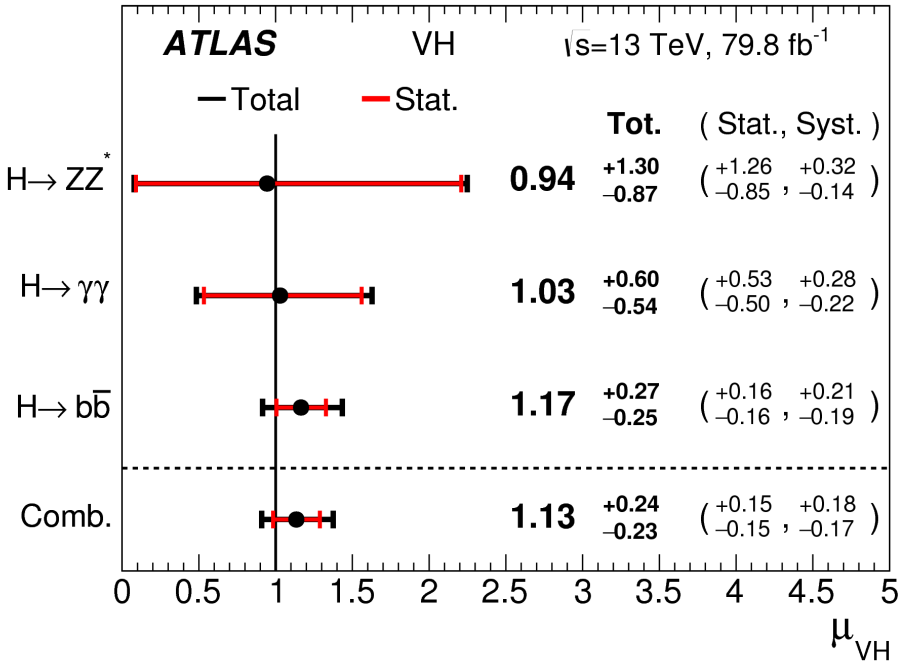


Observation of VH production

Channel	Significance	
	Exp.	Obs.
$H \to ZZ^* \to 4\ell$	1.1	1.1
$H \to \gamma\gamma$	1.9	1.9
$H \to b\bar{b}$	4.3	4.9
VH combined	4.8	5.3

Expected and observed significance values (in standard deviations) for the VH production channels from the combined fit, using 13 TeV data.

The fitted values of the Higgs boson signal strength μ_{VH} for m_H=125 GeV separately for the H→bb, H→γγ and H→ZZ→4ℓ decay modes, along with their combination.*



Conclusion I

- ✓ For the data corresponding to an integrated luminosity of $79.8\ fb^{-1}$ collected at a centre-of-mass energy of $\sqrt{s} = 13\ TeV$, an excess over the expected background is observed, with a significance of **4.9 standard deviations** compared with an expectation of **4.3**.
- ✓ The measured signal strength relative to the SM prediction for $m_H = 125\ GeV$ is found to be

$$\mu_{VHbb} = \mathbf{1.16} \pm 0.16(stat.)^{+0.21}_{-0.19}(syst.).$$

- ✓ This result is combined with previous results based on all the Run 1 data collected at centre-of-mass energies of *7 TeV* and *8 TeV*.
- ✓ An excess over the expected SM background is observed, with a significance of **4.9 standard deviations** compared with an expectation of **5.1**.
- ✓ The measured signal strength relative to the SM expectation is found to be

$$\mu_{VHbb} = \mathbf{0.98} \pm 0.14(stat.)^{+0.17}_{-0.16}(syst.).$$

Conclusion II

- ✓ Combined the results for the SM Higgs boson decaying into a ***bb*** pair in the *VH, ttH* and *VBF+ggF* production modes at *√s= 7 TeV, 8 TeV* and *13 TeV*.
- ✓ An excess over the expected SM background is observed, with a significance of **5.4σ** compared with an expectation of **5.5σ**, providing an observation of the $H \rightarrow bb$ decay mode and the measured signal strength relative to the SM expectation is

$$\mu_{H\rightarrow bb} = \mathbf{1.01} \pm 0.12(stat.)^{+0.16}_{-0.15}(syst.),$$

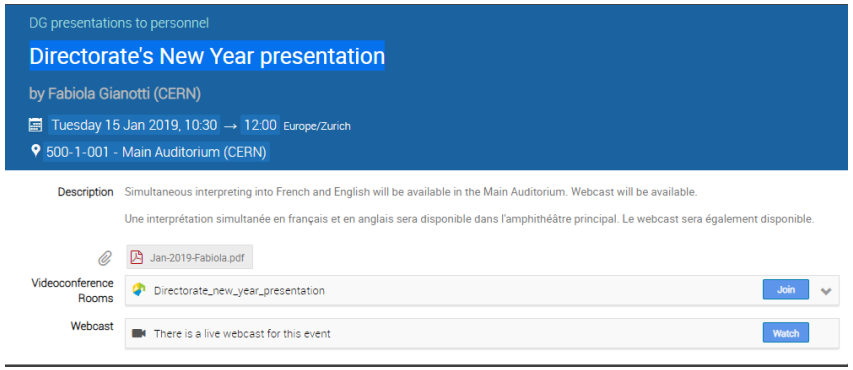
consistent with the value of the Yukawa coupling to bottom quarks in the SM.

- ✓ The Run 2 *VH, H→bb* result is further combined with the results of other Run2 searches for the Higgs boson decaying into either *4l* or *γγ* in the ***VH*** production mode.
- ✓ The result is an observed significance of **5.3σ**, to be compared with an expectation of **4.8σ** and the measured signal strength relative to the SM expectation is

$$\mu_{VH} = \mathbf{1.13} \pm 0.15(stat.)^{+0.18}_{-0.17}(syst.).$$

- ✓ **This provides a direct observation of the Higgs boson being produced in association with a vector boson.**

2018 Physics highlight



Fabiola Gianotti

Directorate's New Year presentation 15 Jan. 2019

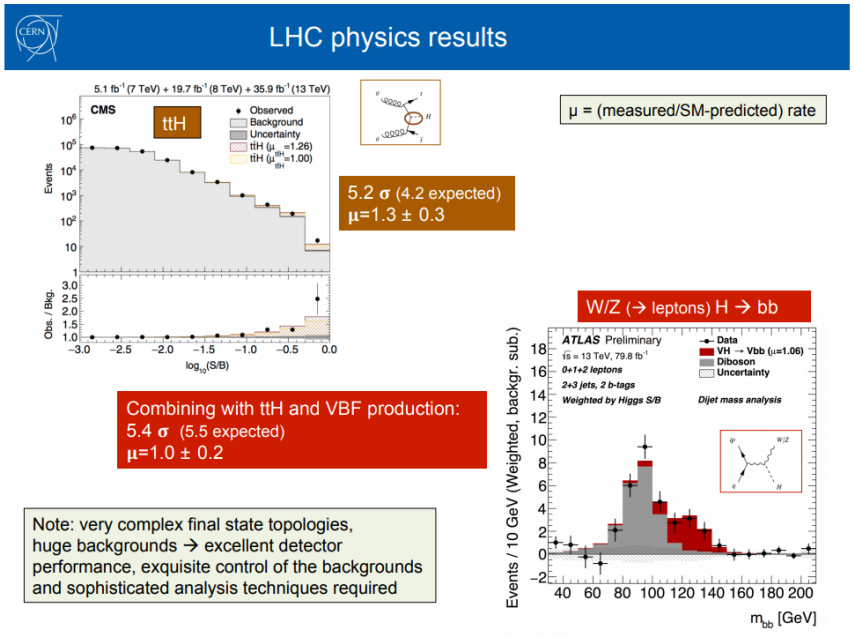
Karl Jakobs

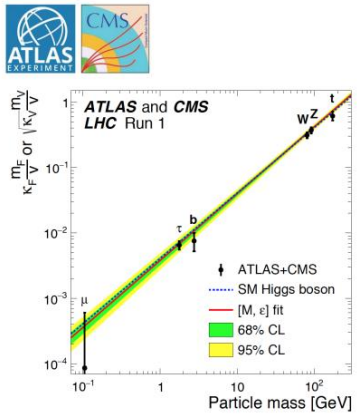
ATLAS Induction Day + Software Tutorial

Giacinto Piacquadio

ICHEP-2018

... and more recent highlights in Higgs boson physics

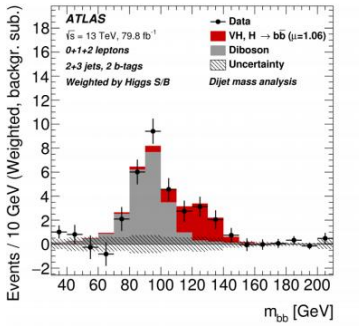




Couplings proportional to mass,
Spin 0 → Higgs boson

Important: increase precision in parameter measurement

2018: Observation of H → bb decays



Significance: 5.4σ (5.5 expected)
Signal strength: μ = 1.01 ± 0.20

Links

CERN Press release:

Long-sought decay of Higgs boson observed

"This observation is a milestone in the exploration of the Higgs boson. It shows that the ATLAS and CMS experiments have achieved deep understanding of their data and a control of backgrounds that surpasses expectations. ATLAS has now observed all couplings of the Higgs boson to the heavy quarks and leptons of the third generation as well as all major production modes."

ATLAS press release:

ATLAS observes elusive Higgs boson decay to a pair of bottom quarks

"ATLAS is proud to announce the observation of this important and challenging Higgs boson decay. While the result is certainly a confirmation of the Standard Model, it is equally a triumph for our analysis teams. "

Газета Дубна ЕЖЕНЕДЕЛЬНИК ОИЯИ :

О «неуловимом» распаде бозона Хиггса

ATLAS paper:

Observation of $H \to bb$ decays and VH production with the ATLAS detector Phys. Lett. B 786 (2018) 59