Overview of SM Higgs
ATLAS and CMS results

Pamela Ferrari

Nikhef

LoopFest 2017
Higgs discovery at the LHC

A scalar boson compatible with the SM Higgs has been discovered in Run1 as shown by the combination of ATLAS and CMS Run1 results.

Greatest achievement of Run1
- concentrated effort on its properties:
  - magnitude of couplings
  - mass measurements
  - spin/CP
Higgs boson production and decay

$m_H = 125.09$ GeV

$\sigma(p p \rightarrow H + X)$ [pb]

<table>
<thead>
<tr>
<th>Process</th>
<th>BR(%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$bb$</td>
<td>57</td>
</tr>
<tr>
<td>$WW$</td>
<td>22</td>
</tr>
<tr>
<td>$\tau\tau$</td>
<td>6.2</td>
</tr>
<tr>
<td>$ZZ$</td>
<td>2.8</td>
</tr>
<tr>
<td>$\gamma\gamma$</td>
<td>0.23</td>
</tr>
<tr>
<td>$Z_\gamma$</td>
<td>0.15</td>
</tr>
</tbody>
</table>
Higgs mass

Run1 CMS+ATLAS combination
Measured in $\gamma\gamma$ and 4l channels: best mass resolution. Mass within 0.2% precision.

Predominantly limited by statistical uncertainty
$m_H = 125.09 \pm 0.21^{\text{(stat)}} \pm 0.11^{\text{(syst)}}$ GeV

Run2 CMS Measures in 4l channel with 35.9 fb$^{-1}$ at 13 TeV

$m_H = 125.26 \pm 0.20^{\text{(stat)}} \pm 0.08^{\text{(syst)}}$ GeV

comparable with Run1 combination
Observation of
- ggF, VBF production
- $H \to \gamma\gamma$, ZZ, WW, $\tau\tau$ decay

Evidence for
- VH, ttH production

<table>
<thead>
<tr>
<th>Production process</th>
<th>Measured significance ($\sigma$)</th>
<th>Expected significance ($\sigma$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBF</td>
<td>5.4</td>
<td>4.6</td>
</tr>
<tr>
<td>WH</td>
<td>2.4</td>
<td>2.7</td>
</tr>
<tr>
<td>ZH</td>
<td>2.3</td>
<td>2.9</td>
</tr>
<tr>
<td>VH</td>
<td>3.5</td>
<td>4.2</td>
</tr>
<tr>
<td>ttH</td>
<td>4.4</td>
<td>2.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decay channel</th>
<th>Measured significance ($\sigma$)</th>
<th>Expected significance ($\sigma$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$H \to \tau\tau$</td>
<td>5.5</td>
<td>5.0</td>
</tr>
<tr>
<td>$H \to bb$</td>
<td>2.6</td>
<td>3.7</td>
</tr>
</tbody>
</table>
All measured processes in agreement with SM within 2 standard deviations. Largest deviation measured in ttH x-section about 3 $\sigma$.

The p-value of the compatibility between the data and the SM predictions is 75%.

$\mu = \sigma \text{ BR}/(\sigma \text{ BR})_{SM}$

The signal strength wrt to the SM

Good agreement between all decay channels

$$\mu = 1.09^{+0.11}_{-0.10} = 1.09 \pm 0.07(\text{stat}) \pm 0.04(\text{expt}) \pm 0.03(\text{th-bkgd})^{+0.07}_{-0.06}(\text{th-sig})$$
Leading-order inspired framework to study couplings, developed by the LHC Higgs Cross Section WG. For a given production process or decay mode (i) a coupling modifier is defined as:

$$\kappa_i^2 = \frac{\sigma_i}{\sigma_{i}^{SM}} \quad \text{or} \quad \kappa_i^2 = \frac{\Gamma_i}{\Gamma_{i}^{SM}}$$

Couplings scale with mass as expected in SM.
A pure CP even (higher order) and CP odd excluded at > 99.9% CL by both collaborations.

CP mixing also investigated, large fractions of CP mixing are still allowed <30%

EFT interpretation should still be a priority:
• combine couplings and CP studies!
• increase of generality PseudoObservables,
• K-framework limited to rates!
Higgs width

JHEP 09, 051 (2016)

\[ \Gamma_H < 13 \text{ MeV (26 MeV expected)} \]@95%CL

\[ \Gamma_H < 22.7 \text{ MeV (33 MeV expected)} \]@95%CL

NNLO/LO K-factor \(gg\rightarrow VV\) poorly known and assumed to be similar to \(gg\rightarrow H^* \rightarrow VV\)

**Direct measurement:** @95% CL at GeV level.
limited by detector resolution=1.5 GeV( \(\Gamma_H^{SM} \approx 4 \text{ MeV}\))

**Indirect measurement:** comparing on-shell and off-shell rates and assuming coupling of
on shell and off shell are the same

<table>
<thead>
<tr>
<th></th>
<th>(H \rightarrow \gamma \gamma)</th>
<th>(H \rightarrow 4\ell)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATLAS</td>
<td>5.0 obs</td>
<td>2.6 obs</td>
</tr>
<tr>
<td></td>
<td>6.2 exp</td>
<td>6.2 exp</td>
</tr>
<tr>
<td>CMS</td>
<td>2.4 obs</td>
<td>3.4 obs</td>
</tr>
<tr>
<td></td>
<td>3.1 exp</td>
<td>2.8 exp</td>
</tr>
</tbody>
</table>

\[ -2 \ln \Lambda \]

\[ -2 \Delta \ln L \]

\[ \sigma_{on-shell}^{VV \rightarrow H \rightarrow ZZ} \propto \mu_{vvH} \]

\[ \sigma_{off-shell}^{VV \rightarrow H \rightarrow ZZ} \propto \mu_{vvH} \Gamma_H \]
Higgs width Run2

Direct limit: from $H \rightarrow ZZ \Gamma = 0.00^{+0.41}_{-0.00}$ GeV.
On shell only: Tighter limit than Run1 with 35.9 fb$^{-1}$
Run2 $\Gamma_H < 1.10$ GeV at 95% CL (105<m4l<140 GeV)
no assumption on BSM
Run1 $\Gamma_H < 3.4$ GeV ZZ (1.7 GeV $\gamma\gamma$+ZZ) @95% CL

$\Gamma < 41$ MeV (100<m$_H<$1600GeV) with both on-shell and off-shell and 12.9 fb$^{-1}$. Assumption for off-shell analysis:
no BSM particles or interactions affect the H boson couplings.
Theory improvements

PDFs: Improvements are due to additional data available, but mainly to improvements in fitting formalism: All PDF are at NNLO

Precision on ggF x-section: from NNLL to N^3LO

see YR4 of LHCHXSWG
arXiv:1610.07922v2 [hep-ph]
SM Higgs Run2
LHC Run2

Excellent performance in 2016!

- more data than all previous years
- Peak $L = 1.4 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$ (exceeded design)
- higher pileup conditions

<table>
<thead>
<tr>
<th>Lumi fb$^{-1}$</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run1 7 TeV</td>
<td>4.5</td>
</tr>
<tr>
<td>Run1 8 TeV</td>
<td>20.3</td>
</tr>
<tr>
<td>Run2 13 TeV</td>
<td>3.2</td>
</tr>
<tr>
<td>Run2 13 TeV</td>
<td>32.9</td>
</tr>
</tbody>
</table>

Run2 results presented in this talk typically are 2 sets corresponding to:

- $\sim 13 \text{ fb}^{-1}$ of Run2 data (summer 2016)
- $\sim 36 \text{ fb}^{-1}$ of Run2 data (winter 2017)
13.3 fb$^{-1}$

**13 categories:** final state+production modes

Signal extracted by fit to $m_{\gamma\gamma}$, bkg modeled with polynomials.

**Observed significance is 4.7$\sigma$**

- $\mu = 0.85^{+0.22}_{-0.20}$

No significant deviation from SM

- Run 2 result uses N$^3$LO calculation for ggF.

- Better agreement with theory of Run1 result when N$^3$LO calculation is used: $\sigma_{ggF}^{\text{theory}}$ increases by $\sim$10%.
Events are sorted into 14 categories depending on Higgs production modes and kinematics, to improve the analysis sensitivity.

\[ \hat{\mu} = 1.16^{+0.15}_{-0.14} = 1.16^{+0.11}_{-0.10} \text{ (stat.)} +0.09_{-0.08} \text{ (syst.)} +0.06_{-0.05} \text{ (theo.)} \]

Significance
Observed (Expected)
VBF $1.1\sigma (1.9\sigma)$
ttH $3.3\sigma (1.5\sigma)$
VH $2.4\sigma (1.2 \sigma)$
Cross-sections at stage 0 of the simplified Template cross-section framework $|y_H|<2.5$ profiled $m_H$ to render the measurement as independent as possible from any mass hypothesis.
H→γγ Differential

Fiducial phase space defined to closely match experimental acceptance to reduce systematic uncertainty associated with underlying model.

*calorimeter crack region excluded

HX = (VBF+VH+ttH) non ggF production mode.

<table>
<thead>
<tr>
<th>Definition</th>
<th>( \sigma_{\text{fid}} ) (fb)</th>
<th>( \sigma_{\text{SM} ; \text{fid}} ) (fb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS (</td>
<td>l</td>
<td>\eta</td>
</tr>
<tr>
<td>ATLAS (</td>
<td>l</td>
<td>\eta</td>
</tr>
</tbody>
</table>

substantial increase in \( p_T \) coverage: \( p_T > 2m_{\text{top}} \)

Data slightly undershoot (overshoot) theory prediction at low (high) \( p_T \)
High S/B ≥ 2, but low statistics.
Event categorization to measure cross section per production mode and jet multiplicity. Extract signal by fitting the shape of discriminants in each category.

Measured cross sections and couplings are consistent with the SM expectations within 2σ.
- Mass is fixed to m_H=125.09 GeV.
- No undetected or invisible decays are assumed to exist.
4 isolated leptons (e,\(\mu\)) : two pairs of same flavour opposite sign leptons
(4e, 4\(\mu\), 2e2\(\mu\) or 2\(\mu\)2e)
\(p_T > 7(5)\text{GeV}, |\eta|<2.5(2.4)\) for e(\(\mu\))

Probing ggH, VBF, VH, ttH production modes with 7 event categories based on number of leptons jets, b-jets, MET. Kinematic discriminants using ME.

Assuming \(m_H=125.09\text{ GeV}\)
H → ZZ* → 4l, l = e, μ

- Simplified cross sections for |y_H| < 2.5

35.9 fb⁻¹

CMS-PAS-HIG-16-041
Fiducial phase space defined to closely match the experimental acceptance to reduce systematic uncertainty associated with the underlying model. Maximum likelihood fit to the $m_{4l}$ distribution to extract the $\sigma_{\text{fid}}$. Detector level bin-by-bin correction applied.

$$\sigma_{\text{fid}} = 2.90^{+0.48}_{-0.44} \text{(stat)}^{+0.27}_{-0.22} \text{(syst)} \text{ fb}$$

$$\sigma_{\text{fid}}^{\text{SM}} = 2.72 \pm 0.14 \text{ fb}$$

Consistent with SM expectations within uncertainties, statistically dominated.
Two isolated-lepton pairs $p_T > 5/7$ GeV for muons/electrons loose lepton identification criteria

Profile likelihood ratio fit to the $m_{4l}$ distribution to extract the $\sigma_{\text{fid}}$.

Probe kinematics [$p_T, y$], spin/parity sensitive variables [$\cos \theta^*, \Delta \phi_{jj}$] and production-mechanism sensitive observables [$N_{\text{jets}}, m_{jj}, p_{Tj1}$]

New!
ATLAS $H \rightarrow ZZ^* \rightarrow 4l$ fiducial

- 2\(e\)2\(\mu\) and 2\(\mu\)2\(e\) channels fiducial x-sections larger than expected.
- Agreement of combined fiducial x-section and prediction within 1.5 \(\sigma\)
- Statistically dominated. Large systematics: lepton uncertainties+Luminosity.

\[
\sigma_{i,\text{fid}} = \sigma_i \times A_i \times \text{BR} = \frac{N_{i,\text{fit}}}{L \times C_i},
\]

\[
C_i = \frac{N_{i,\text{reco}}}{N_{i,\text{part}}},
\]

- \(A_i\)=Acceptance in fiducial volume
- \(C_i\)= correction factor for events in fiducial volume to be reconstructed and selected
- \(N_{i,\text{fit}}\) is the number of extracted signal events in data
Products of Higgs boson production cross sections of process \( i \) (\( \sigma_i \)) and branching ratios to the final states are reported for \(|y_H| < 2.5\) ("stage-0" simplified template cross sections).

No significant deviation from SM, 4\( \sigma \) significance of VBF production in Run 2 (1.9\( \sigma \) exp)
Signal strength $\mu = 1.13^{+0.18}_{-0.17}$

$\sigma(pp \rightarrow H+X)$ in the full phase space obtained from fiducial cross section

\begin{align*}
\gamma\gamma &\quad 13.3 \text{ fb}^{-1} \\
ZZ &\quad 14.8 \text{ fb}^{-1}
\end{align*}

\begin{align*}
\sigma(pp \rightarrow H + X) &= 59.0^{+9.7}_{-9.2}(\text{stat})^{+4.4}_{-3.5}(\text{syst}) \text{ pb} \\
\sigma(pp \rightarrow H + X) &= 55.5^{+2.4}_{-3.4} \text{ pb}
\end{align*}

Good agreement with N3LO QCD + NLO EW
CMS ggF only: Categorization: 0, 1 jet, eμ, µe (pT ordered)
Binned fit of unrolled 2D histograms m_{ll}, m_T^H

\[ \mu_{ggF} = 0.3 \pm 0.5 \text{ (2\sigma expected)} \]
only 2.3 fb⁻¹ run II still limited by stat uncertainty!

\[ \mu_{VBF} = 1.7^{+0.10}_{-0.08} \text{(stat)}^{+0.6}_{-0.4} \text{(syst)} \]
\[ \mu_{WH} = 3.2^{+3.7}_{-3.2} \text{ (stat)}^{+2.3}_{-2.7} \text{(syst)} \]
Searches can be divided in:

**Hadronic**
- $H \rightarrow b \bar{b}$, $H \rightarrow \tau_h \tau_h$

**Leptonic**
- $H \rightarrow W W$, $H \rightarrow \tau_l \tau_{\text{any}}$

**Bosonic (higher purity)**
- $H \rightarrow \gamma \gamma$
- $H \rightarrow Z Z^{*} \rightarrow 4 l$

\[ \text{ttH x-sec increases 2 times faster than other modes} \]
Both ATLAS and CMS use hadronic and semi-leptonic decays of top
Background estimated from CR where $\geq 1 \gamma$
  • fails tight identification
  • fails isolation criteria
BDT for S vs Bkg separation in both cases

<table>
<thead>
<tr>
<th></th>
<th>$\sigma$(stat)</th>
<th>$\sigma$(syst)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATLAS</td>
<td>$\mu=-0.25^{+1.2}_{-1.0}$</td>
<td>1.2, 0.2</td>
</tr>
<tr>
<td>CMS</td>
<td>$\mu=2.2^{+0.9}_{-0.8}$</td>
<td>-1.0, -0.2</td>
</tr>
</tbody>
</table>

statistically limited
CMS observed $3.3\sigma$ (exp $1.5\sigma$) compatible with SM at $1.6\sigma$
Full 13 TeV statistics.
Strategy: Measure inclusive production cross section of $H \rightarrow ZZ \rightarrow 4l$, tag production mode and extract $ttH$

Statistically limited, both $4l$ and $\gamma\gamma$ will profit in near future from more data
Select semi-leptonic and di-leptonic $ttH \rightarrow bb$ decays
(fully hadronic ATLAS Run1)

- Leptonic, (6 quarks, 4b)
- Dileptonic (4 quarks, all b)

Both ATLAS & CMS use $N_{\text{jets}}$ and $N_{b}$ categories

ATLAS: 1 BDT to reconstruct events + 2nd BDT to disentangle S and B (HT fitted in CR)

CMS: BDT inputs are kinematics, event shapes, b-tag discriminant. Then after BDT use Matrix Element Method (MEM) discriminant optimized to separate $ttH(bb)$ signal from irreducible $ttbb$ background (MEM most useful in high BDT part)

pre-fit = before fit to data of SR and CR

13.2 fb$^{-1}$
12.9 fb$^{-1}$
limited by systematics

notably on the theoretical modeling the tt+bjets background, and on the experimental side flavor tagging.
H→WW,ZZ,ττ

ATLAS: 4 categories, 2ℓSS 0τHAD, 2ℓSS 1τHAD, 3ℓ nτHAD, 4ℓ nτHAD. Uses counting experiment in all final states

CMS has full 2016 stat: 2ℓSS 0τHAD, 2ℓSS 1τHAD moved to tth, H→ττ, 3ℓ 0τHAD, 4ℓ 0τHAD. Uses 2BDTs for 2 ℓ and 3 ℓ final states against tt and ttV bkg. Counting for 4 ℓ.

35.9 fb⁻¹
13.2 fb⁻¹

CMS PAS HIG-17-004
ATLAS-CONF-2016-058

ttH→multilepton
Results compatible with SM at 1/2\(\sigma\) level

ATLAS significance 2.2\(\sigma_{\text{obs}}\) (1\(\sigma_{\text{exp}}\))

CMS significance 3.3\(\sigma_{\text{obs}}\) (2.5\(\sigma_{\text{exp}}\))

This channel will profit of increased statistics, better understanding of backgrounds. Main systematics in both analyses fake (non-prompt) lepton.

Systematics are limiting factor
Full run II statistics, orthogonal categories wrt multi lepton analysis

Similar strategies for bkg treatment

- $1\ell 2\tau_{\text{had}}, \geq 3$ jets, $\geq 1$ b-tag
- $2\ell$ SS $1\tau_{\text{had}}, \geq 3$ jets, $\geq 1$ b-tag
- $3\ell$ $\tau_{\text{had}}, \geq 2$ jets, $\geq 1$ b-tag

Main systematics: tight lepton selection, $\tau_{\text{had}}$ id and jets faking $\tau_{\text{had}}$
Problem for future is systematics, adding hadronic decays or exploiting boosted analyses might help.

The $b\bar{b}$ and multi lepton final states are already systematically dominated.

2.8σ observed (1.8 expected) already exceeds Run1

**ttH production**

<table>
<thead>
<tr>
<th>LHC Run 1</th>
<th>CMS Run 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>HIG-17-003, 36 fb$^{-1}$</td>
<td>Preliminary</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>2.2$^{+0.9}_{-0.8}$</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>2.3$^{+0.7}_{-0.6}$</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>0.0$^{+1.2}_{-0.0}$</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>$-0.2\pm0.8$</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>$1.5\pm0.5$</td>
</tr>
<tr>
<td>$H:\gamma\gamma$</td>
<td>$0.7^{+0.6}_{-0.5}$</td>
</tr>
</tbody>
</table>
Both Atlas and CMS use powheg v2 to simulate tt+HF

- ATLAS fits overall b,c,l classes (ttbb and ttcc cross-section predictions were not used)
- CMS fits each with 50% uncertainty (10% degradation due to this)

Data overshoots expectation in all regions with important tt+HF contribution. The results are compatible with theoretical errors.

ATLAS 6j4b about a factor 1.5 mismodelling of event numbers
Using NNLO tt calculations of shapes & uncertainties
pre-fit ttbb normalized to NLO Sherpa+OL,(NLO +massive b’s)

Post-fit shows good agreement
This channel will profit in the future from better understanding of tt+bb and interaction with theory.
SM ttbb measurements see similar features see for example CMS-TOP-16-010.
2.3 fb⁻¹ CMS looks for pure VBF channel. **Trigger is critical:** 4jets (1 or 2 b’s -> 6.2% or 3.9% efficiency), mass of non b-jets >460,200 GeV

Main background is multi jets (98%)

BDT used to distinguish H from bkgs: multiple signal regions (4 SR for 1 b and 3 SR for 2b).

Fit to m_{bb}. Combined with 8 TeV result.

**Dominant statistical uncertainty/ QCD modelling.**
BDT used in various categories using kinematic variables as input.

ZH→llbb, (vvbb) /WH→ lvbb

Statistical and systematics errors are comparable

Highest systematics are due to b/c tag and Z+HF normalization

Run I result @7+8 TeV(4.7+20.3 fb$^{-1}$): 0.52 ± 0.32(stat.) ± 0.24(syst.)
Higgs → ττ studying the Yukawa couplings to Fermions. Higher event rate than leptonic decays and lesser background than H→bb

- $e\tau$, $\mu\tau$, $e\mu$, $\tau\tau$ decay channels
- 3 categories, 0-jet, VBF, boosted
- Main background from Z→ττ
- 2D fit on different quantities depending on category (mjj or $p_T^{\tau\tau}$, $m_{\tau\tau}$.)

$\mu = 1.06 \pm 0.25$

For $m_H=125$ GeV
4.9σ observed (4.7 expected)

Standalone Observation!
Measure Higgs couplings to second generation fermions

- Clean signature, small BR $\sim 2.18 \times 10^{-4}$
- Dominant background Drell Yan $Z/\gamma^* \rightarrow \mu\mu$

Using both ggF and VBF production, but orthogonal selection.

- VBF uses BDT against bkg, ggF uses categories binned in $\eta$ and $p_{T,\mu\mu}$.

<table>
<thead>
<tr>
<th></th>
<th>13TeV</th>
<th>7+8+13TeV</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\mu$</td>
<td>-0.07 ±1.5</td>
<td>-0.13 ±1.4</td>
</tr>
<tr>
<td>95% CL limit $\sigma/\sigma_{SM}$</td>
<td>&lt; 3.0 obs (3.1 exp)</td>
<td>&lt; 2.8 obs (2.9 exp)</td>
</tr>
</tbody>
</table>

CMS projection scaled from Run1

Full Run2: $\sim 2\sigma$

HL-LHC: $> 5\sigma$

Scaled from run-1 result: CMS-PAS-HIG-13-007

https://twiki.cern.ch/twiki/bin/view/CMSPublic/Hig13007TWiki#Expected_Performance_at_s_14_TeV
Self coupling

Double Higgs production much smaller than single higgs

Used to measure Higgs trilinear couplings,
However difficult due to small expected rates, mild dependence of x-section on trilinear couplings and difficult signal separation from backgrounds.
Self coupling (indirect)

Single Higgs couplings can be used to infer constraints on trilinear couplings and are possibly competitive with di-Higgs constraints.

Single Higgs production is affected both in production and decay by triple Higgs couplings via weak loops, e.g. at NLO in the EW interactions. Distinctive pattern of deformations of the SM rates are obtained that can be compared with data.

F. Maltoni et al, arXiv:1607.04251

Use of single Higgs inclusive data suffers of degeneracies. Differential distributions and di-Higgs results should be included.

C. Grojean et al, arXiv:1704.01953
Summary

The particle discovered in 2012 is well compatible with the SM Higgs. Its mass is measured to be: \( m_H = 125.26 \pm 0.20 \text{(stat)} \pm 0.08 \text{(syst)} \text{ GeV} \) (Run2)

The couplings Run1 combination by ATLAS and CMS is well in agreement with SM

\[
\mu = 1.09^{+0.11}_{-0.10} = 1.09 \pm 0.07 \text{(stat)} \pm 0.04 \text{(expt)} \pm 0.03 \text{(th-bkgd)}^{+0.07}_{-0.06} \text{(th-sig)}
\]

Run2

• H→γγ, 4l analyses have many results in Run2 that already exceed Run1 precision
• ttH precision already exceeds the Run1 precision. The systematic uncertainties are becoming the limiting factor (some channels need still to be updated with full statistics)
• H→ττ at 4.9 \( \sigma \) : standalone observation by CMS
• H→WW and VH,H→bb need a bit more time but new results will be available soon.

All measured processes in agreement with SM within 2 standard deviations

The next steps in terms of precision measurements of the Higgs properties are:

• increase Higgs measurement precision to few percent level (exclude most BSM models)
• study of longitudinally polarized WW scattering
Outlook

3000 fb⁻¹:

- Search Higgs couplings structure, di-higgs boson production 1.3-1.6 sigma per experiment $hh \rightarrow bb\gamma\gamma$
- Couplings: precision on main channel 4-5%, 10-40% on other.

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CMS-DP-2016-064

Outlook

ATL-PHYS-PUB-2014-016,
CERN-LHCC-2015-020