

# production and properties at ATLAS and CMS

**A. de Wit** on behalf of the ATLAS and CMS Collaborations







### Introduction

 Over a decade of Higgs boson physics at the LHC → probing Higgs boson properties ever more precisely





# Higgs boson production cross sections



# **Higgs boson production measurements**

**Model dependence** 

(Inclusive) signal strength or cross section

cross sections



### **Data needs**

### Simplified template

### Differential, fiducial measurements



### See <u>talks</u> in the parallel sessions (S. Chatterjee, G. Callea)



### **Cross sections at 13.6 TeV**

- Measurements with 2022 data
- Fiducial cross section measurements extrapolated to full phase space to combine:
  - $\sigma_{\rm H} = 58.2 \pm 8.7 \ \rm pb$  $(exp: 59.9 \pm 2.6 \text{ pb})$
  - @13.6 TeV
- Main uncertainty component statistical (for now)





# Cross sections per production/decay mode



Nature 607 (2022) 52

- Precision better than 10% for ggF, 10-20% precision on most other production modes
- Decays into bosons, tau leptons: precision ~10%





# **Cross sections per production/decay mode**



Nature 607 (2022) 52

~10%



### STXS $H \rightarrow \tau \tau$

- Number of measured STXS bins doubled wrt previous measurement
  - Additional bins in VBF, ttH Enabled by NN  $p_T(H)$ -regression and S/B MVA



ATLAS-CONF-2024-007

-	-	-

	ATLAS Preliminary H–	-     >ττ √s	$\frac{1}{3} = 13$	3 TeV, 14	l         l0 fb⁻¹
	-Tot. Syst. Theory	p-	value	e = 6%	Svet )
aa→H 1-iet 120< p <sup>H</sup> < 200		0.35	+0.61	$( \begin{array}{c} +0.38 \\ 0.27 \end{array})$	+0.49
		0 50	+0.89	( +0.52	+0.72
gg→H, ≥ 1-jet, 60≤ p <sub>T</sub> <sup></sup> < 120		0.50	-0.89 +0.75	<ul> <li>-0.52</li> <li>+0.49</li> </ul>	-0.72 /
gg→H, ≥ 2-jet, m <sub>jj</sub> < 350, 120≤ p <sub>T</sub> <sup>H</sup> < 200		0.53	-0.74	( _0.48	-0.56 )
gg→H, ≥ 2-jet, m <sub>jj</sub> ≥ 350, p <sub>T</sub> <sup>H</sup> < 200		5.09	+3.09 –2.49	( <sup>+1.66</sup> _1.64	+2.61 -1.87 )
gg→H, 200 ≤ p <sub>T</sub> <sup>H</sup> < 300	•	0.99	+0.39 -0.36	( +0.28 -0.28	+0.27 -0.22 )
gg→H, $p_T^H \ge 300$	<b></b>	1.51	+0.59 -0.50	( +0.44 -0.43	+0.39 -0.26 )
qq'→Hqq', ≥ 2-jet, 60≤ m <sub>j</sub> < 120	<b>⊢</b>	0.94	+0.68 -0.65	( +0.57 -0.55	+0.38 -0.36 )
qq'→Hqq', ≥ 2-jet, 350 ≤ m <sub>jj</sub> < 700, p <sub>T</sub> <sup>H</sup> < 200	<b></b>	-0.96	+1.17 -1.31	( +0.83 -0.81	+0.81 _1.03 )
qq'→Hqq', ≥ 2-jet, 700 ≤ m <sub>jj</sub> < 1000, p <sub>T</sub> <sup>H</sup> < 200		-0.24	+0.79 -0.89	( <sup>+0.63</sup> 0.60	+0.49 -0.65 )
qq'→Hqq', ≥ 2-jet, 1000 ≤ m <sub>µ</sub> < 1500, p <sub>T</sub> <sup>H</sup> < 200	H <b>-</b> -1	1.68	+0.61 -0.55	( +0.50 -0.47	+0.35 _0.29 )
→ Add a diameter of the second s		0.12	+0.34 -0.33	( +0.30 -0.27	+0.16 -0.18 )
qq'→Hqq', ≥ 2-jet, 350 ≤ m <sub>ii</sub> < 700, p <sub>T</sub> <sup>H</sup> ≥ 200		-1.16	+0.87 -0.81	( +0.75 -0.55	+0.44 -0.59 )
qq'→Hqq', ≥ 2-jet, 700 ≤ m <sub>ji</sub> < 1000, p <sub>T</sub> <sup>H</sup> ≥ 200	<b>H</b>	0.98	+0.73 -0.63	( +0.67 -0.59	+0.28 -0.23 )
qq'→Hqq', ≥ 2-jet, 1000 ≤ m <sub>ji</sub> < 1500, p <sub>T</sub> <sup>H</sup> ≥ 200		1.40	+0.56 -0.50	( +0.52 -0.47	+0.20 -0.18 )
qq'→Hqq', ≥ 2-jet, m <sub>ji</sub> ≥ 1500, p <sub>T</sub> <sup>H</sup> ≥ 200	<b>I</b>	1.29	+0.39 -0.34	( +0.35 -0.32	+0.18 -0.13 )
ttH, p <sub>T</sub> <sup>H</sup> < 200	<b>H</b>	2.15	+1.75 –1.52	( <sup>+1.54</sup> _1.33	+0.84 -0.75 )
ttH, 200 ≤ p <sub>T</sub> <sup>H</sup> < 300		-2.23	+1.26 –1.13	( +1.12 -0.79	+0.58 -0.80 )
ttH, p <sub>T</sub> <sup>H</sup> ≥ 300		3.58	+2.92 -2.31	( +2.62 ( -2.12	+1.27 -0.90 )
	0 5	10		15	20
				(σ×B)'	<sup>neas</sup> /(σ×Β

See A. Gomez Delegido's talk in the parallel session tomorrow



### VH, H→bb

- Rare process (V→leptons): large-branching fraction final states
- Rely on multivariate analysis techniques to improve sensitivity
- Inclusive (µ=1.15±0.21), per-production mode signal strengths and STXS





### **Electroweak VH**

- KW sign  $\lambda_{
  m WZ}$
- consistent with existing measurements (@ more than  $5\sigma$ )



### arXiv:2402.00426 (sub'd to PRL) arXiv:2405.16566 Sub to PLB



9

# ttH production

- 1% of Higgs bosons
- Direct probe of top quark Yukawa coupling
- $H \rightarrow bb$ : ML for S/B discrimination, CRs for backgrounds





2018 discriminant bins



# ttH production

- 1% of Higgs bosons
- Direct probe of top quark Yukawa coupling
- $H \rightarrow bb$ : ML for S/B discrimination, CRs for backgrounds





and CMS

### CMS-PAS-HIG-19-011 JHEP 06 (2022) 97

 $\mu_{incl} = 0.33 \pm 0.17$  (stat)  $\pm 0.21$  (syst)

 $\mu_{incl} = 0.35 \pm 0.20$  (stat)  $\pm 0.29$  (syst)

Same bin boundaries, grouped differently between ATLAS

### **b-associated** production

- b-associated production (via b-fusion and gluon fusion with gluon -> bb splitting ) studied in final states with leptons (WW, ττ)
- Obs (exp) upper limit: 3.7 (6.1) x SM

### CMS-PAS-HIG-23-003



BDT score

![](_page_13_Figure_3.jpeg)

### CMS-PAS-HIG-23-003

### **STXS** interpretations

![](_page_14_Figure_1.jpeg)

Example: STXS measurements in  $H \rightarrow \gamma \gamma$ 

JHEP 07 (2021) 027

# Use fine-grained measurements to constrain new physics, e.g. in EFT context

![](_page_14_Figure_5.jpeg)

![](_page_14_Picture_6.jpeg)

## **STXS** interpretations

$\sqrt{s} = 13 \text{ Te}$	V, 139 fb <sup>-1</sup>	<b>⊢●</b>  Total	Stat.
m <sub>H</sub> = 125.0	J9 GeV, IV $_{H}^{I}$ < 2.5	Syst.	SM
	H→ZZ, H→W	N	Total Stat. Svst.
	$\Omega_{\rm tight}$ $p^{\rm H}$ < 200 GeV	1.2	$7 + 0.18 \left( \pm 0.08 + 0.16 \right) \left( \pm 0.08 + 0.16 \right)$
	1-jet $p_T^H < 60 \text{ GeV}$	0.6	-0.17 (+0.30, +0.51) -0.59 (+0.30, +0.51) -0.59 (+0.30, +0.51)
	1-jet $60 < p^{H} < 120 \text{ GeV}$	0.6	$\begin{array}{c} -0.38  (-0.29  -0.30) \\ +0.49  (\pm 0.32  , \begin{array}{c} +0.37 \\ 0.33 \end{array}) \end{array}$
<i>ч→H</i> (WW*)	1 jet $120 < p_T^H < 200 \text{ GeV}$		-0.40 ( $-0.533 +0.89 ( +0.63 +0.620.62 , 0.44$
	> 2-iet $n^H < 200$ GeV	1.54	$\begin{array}{c} -0.76 & -0.02 & -0.44 \\ +0.95 & (+0.43 & +0.85) \\ 0.42 & 0.72 \end{array}$
	$p^{H} > 200 \text{ GeV}$	1.3	$-0.64 \times -0.42 \times -0.72$
	μ <sub>τ</sub> = 200 α 0 0		-0.70 -0.02 -0.447
	≥ 2-jet, 350 ≤ $m_{jj}$ < 700 GeV, $p_{\tau}^{H}$ < 200 GeV	0.12	2 +0.60 (+0.45 -0.58 (-0.41 ,±0.41
	≥ 2-jet, 700 ≤ $m_{jj}$ < 1000 GeV, $p_T^H$ < 200 GeV	0.5	7 $^{+0.68}_{-0.61}$ $\begin{pmatrix} +0.57 & +0.37 \\ -0.51 & -0.33 \end{pmatrix}$
ı <i>→Hqq</i> (WW*)	≥ 2-jet, 1000 ≤ $m_{jj}$ < 1500 GeV, $p_T^H$ < 200 GeV	1.32	$2 \begin{array}{c} +0.64 \\ -0.51 \end{array} \left( \begin{array}{c} +0.50 \\ -0.45 \end{array} \right) \begin{array}{c} +0.40 \\ -0.24 \end{array} \right)$
	≥ 2-jet, $m_{jj}$ ≥ 1500 GeV, $p_T^H$ < 200 GeV	1.1	$9 \begin{array}{c} +0.48 \\ -0.42 \end{array} \begin{pmatrix} +0.42 \\ -0.38 \end{array} , \begin{array}{c} +0.23 \\ -0.17 \end{array}$
	$\ge$ 2-jet, $m_{jj} \ge$ 350 GeV, $p_{\tau}^{H} \ge$ 200 GeV	1.54	$4 \begin{array}{c} +0.61 \\ -0.51 \end{array} \begin{pmatrix} +0.51 \\ -0.46 \end{array} \begin{array}{c} +0.34 \\ -0.22 \end{array}$
	0-jet, $p_{_{T}}^{_{H}}$ < 10 GeV	•	3 +0.36 (+0.30 +0.19 -0.30 (-0.27 , -0.13
	0-jet, 10 ≤ $p_T^H$ < 200 GeV	<b>1.1</b>	$5 \begin{array}{c} +0.23 \\ -0.20 \end{array} \begin{pmatrix} +0.18 \\ -0.17 \end{array} , \begin{array}{c} +0.14 \\ -0.17 \end{array}$
	1-jet, $p_T^H < 60 \text{ GeV}$	0.3	$1 \begin{array}{c} +0.43 \\ -0.38 \end{array} \begin{pmatrix} +0.40 \\ -0.36 \end{array} \begin{array}{c} +0.16 \\ -0.13 \end{array}$
→H (ZZ*)	1-jet, 60 ≤ $p_T^H$ < 120 GeV	1.42	$2 \begin{array}{c} +0.52 \\ -0.42 \end{array} \begin{pmatrix} +0.42 \\ -0.38 \end{array} , \begin{array}{c} +0.30 \\ -0.18 \end{array}$
	1-jet, 120 ≤ $p_T^H$ < 200 GeV	0.4	$1 \begin{array}{c} +0.84 \\ -0.59 \end{array} \begin{pmatrix} +0.80 \\ -0.58 \end{array} , \begin{array}{c} +0.23 \\ -0.08 \end{array}$
	≥ 2-jet, $p_{\tau}^{H}$ < 200 GeV	-	$5 \begin{array}{c} +0.60 \\ -0.53 \end{array} \left( \begin{array}{c} +0.55 \\ -0.51 \end{array} \right) \begin{array}{c} +0.23 \\ -0.51 \end{array} \right)$
	$p_{\tau}^{H} \ge 200 \text{ GeV}$	2.4	$1 \begin{array}{c} +1.52 \\ -1.09 \end{array} \begin{pmatrix} +1.32 \\ -1.04 \end{pmatrix} \begin{array}{c} +0.75 \\ -0.31 \end{array}$
	VBF	1.43	$9 + 0.63 + 0.61 + 0.17 \\ -0.50 + 0.50 + 0.91 \\ -0.50 + 0.91 \\ -0.91 $
	≥ 2-jet, 60 < <i>m<sub>jj</sub></i> < 120 GeV	1.5	$1 \begin{array}{c} +2.83 \\ -2.24 \end{array} \begin{pmatrix} +2.79 \\ -2.22 \end{pmatrix} +0.45 \\ -2.22 \end{pmatrix} +0.45$
qq→Hqq (ZZ^)	≥ 2-jet, $m_{jj}$ ≥ 350 GeV, $p_T^H$ ≥ 200 GeV	0.18	$3  \frac{+2.09}{-}  \left(\frac{+2.08}{-}, \frac{+0.18}{-}\right)$
1-lep (ZZ*)	 	1.29	9 +1.67 (+1.67 +0.15 -1.05 (-1.05 , -0.01
+ (ZZ*)		1.73	3 +1.77 (+1.72 +0.39 -1.14 (-1.13 ,-0.18
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### ΛΤΙΛς

+

AILAS	
√ <i>s</i> = 13 Te\	/, 139 fb⁻¹
m <sub>H</sub> = 125.0	9 GeV, ly <sub>I</sub> < 2.5
	LI_ <b>N</b> _0
	יץ כרח
	0-jet, $p_{\tau}^{\prime\prime} < 10 \text{ GeV}$
	0-jet, $10 \le p_{\tau}^{H} < 200 \text{ GeV}$
	1-jet, $p_{T}^{H} < 60 \text{ GeV}$
	1-jet, 60 ≤ $p_{T}^{H}$ < 120 GeV
$aa \rightarrow H(ww)$	1-jet, $120 \le p_{\tau}^{H} < 200 \text{ GeV}$
<i>99 →11</i> (үү)	$\ge$ 2-jet, $m_{jj}$ < 350 GeV, $p_T^H$ < 120 GeV
	$\ge$ 2-jet, $m_{jj}$ < 350 GeV, 120 $\le p_T^H$ < 200
	$\ge$ 2-jet, $m_{jj} \ge$ 350 GeV, $p_{\tau}^{H} <$ 200 GeV
	$200 \le p_{_{T}}^{_{H}} < 300 \text{ GeV}$
	$300 \le p_T^H < 450 \text{ GeV}$
	$p_{\tau}^{H} \ge 450 \text{ GeV}$
	≤ 1-jet and VH-veto
	≥ 2-jet, VH-had
	$\geq$ 2-jet, 350 $\leq$ $m_{jj}$ $<$ 700 GeV, $p_{_{T}}^{_{H}}$ $<$ 200
qq→Hqq (γγ)	≥ 2-jet, 700 ≤ $m_{jj}$ < 1000 GeV, $p_T^H$ < 200
	$\ge$ 2-jet, $m_{jj} \ge$ 1000 GeV, $p_{T}^{H} <$ 200 GeV
	≥ 2-jet, 350 ≤ $m_{ij}$ < 1000 GeV, $p_T^H$ ≥ 200
	≥ 2-jet, $m_{ii}$ ≥ 1000 GeV, $p_{\tau}^{H}$ ≥ 200 GeV
	$p_{\tau}^{v}$ < 150 GeV
qq →HIν (γγ)	$p_{\tau}^{v} \ge 150 \text{ GeV}$
	×
gg/qq →Hll/νν (γγ)	$p_{\tau}^{\nu}$ < 150 GeV
	$p_{\tau}^{\nu} \ge 150 \text{ GeV}$
	$p_{\tau}^{\scriptscriptstyle H}$ < 60 GeV
	$60 \le p_{\tau}^{H} < 120 \text{ GeV}$
<i>t</i> ₹H (γγ)	$120 \le p_{\tau}^{H} < 200 \text{ GeV}$
	200 ≤ <i>p</i> <sup><i>H</i></sup> <sub>−</sub> < 300 GeV
	<i>p</i> <sup><i>H</i></sup> ≥ 300 GeV
	r <sub>T</sub>
tH (γγ)	
	، 
<i>H</i> (Ζγ)	
-8	-6 -4 -2

![](_page_15_Figure_5.jpeg)

![](_page_15_Figure_6.jpeg)

σхΒ	normalized to SM value

![](_page_15_Figure_8.jpeg)

![](_page_15_Picture_9.jpeg)

# **BSM interpretations of STXS measurements**

- 2499 dim-6 operators → reduced to less than 200 through symmetries
  - **50** remaining CP-conserving operators relevant for Higgs sector
  - Degeneracies → identify & study 19 independent directions

![](_page_16_Figure_5.jpeg)

### **BSM interpretations of STXS measurements** ATLAS $\sqrt{s}$ =13 TeV, 139 fb<sup>-1</sup>, $m_H$ = 125.09 GeV SMEFT $\Lambda = 1$ TeV **ATLAS** $\sqrt{s} = 13 \text{ TeV}, 139 \text{ fb}^{-1}$ $\blacksquare H \to \gamma \gamma$ C<sub>eH,22</sub> 0.8 $H \rightarrow Z\gamma$ **С<sub>еН,33</sub>** $H \rightarrow WW^* \rightarrow l\nu l\nu$ Expected contribution production decay 0.6 $H \rightarrow ZZ^* \rightarrow 4I$ 0.4 $\blacksquare$ $H \rightarrow b\bar{b}$ $e_{ggF}^{[2]}$ $H \rightarrow \tau \tau$ 0.2 $e_{ggF}^{[3]}$ $\blacksquare H \rightarrow \mu \mu$ $\Theta_{H\gamma\gamma,Z\gamma}^{[1]}$ 85 0.25 <mark>-0.47</mark> -0.02 -0.01 $\Theta^{[2]}_{H\gamma\gamma,Z\gamma}$ -0.49 0.73 -0.49 ggF $e^{[3]}_{H\gamma\gamma,Z\gamma}$ 0.8 VBF $e_{ZH}^{[1]}$ -0.35 -0.27 0.02 -0.02 -0.01 WH 0.6 $e_{ZH}^{[2]}$ 0.21 0.87 -0.39 0.19 -0.05 -0.08 -0.06 0.03 ZH 0.32 -0.34 -0.58 0.66 -0.02 -0.08 -0.06 0.02 $e_{ZH}^{[3]}$ tītH 0.4 $e_{ZH}^{[4]}$ 0.22 0.08 0.66 0.72 -0.02 -0.03 -0.02 tΗ 0.2 ∅ inclusive 0.46 0.17 0.45 0.27 0.27 0.16 0.16 0.14 0.06 0.05 0.03 0.02 -0.0 0.16 -0.15 -0.05 -0.06 -0.2 -0.11 -0.03 -0.02 -0.0<sup>-1</sup> 9<sup>[3]</sup> 0.32 <mark>.13 -0.08 -0.08</mark> -0.03 -0.03 <mark>-0.17</mark> -0.04 -0.02 -0.01 -0.01 10<sup>1</sup> Linear (obs.) $\sqrt{\sigma}$ ) [TeV] 0.64 -0.48 -0.48 0.36 Symmetrized uncertainty $(\sigma)$ Linear (exp.) Cor Cro Che Ch 10<sup>0</sup> Scale ( $\Lambda/$ 3.2 10 **Probed** 10 32 $10^{-3}$ probed NP scale · value scaled I uncertainty ( $c'/\sigma$ ) Linear (obs.) *p*<sub>SM</sub> = 94.5% Linear (exp.) Best Fit ----- 68 % CL Parameter v by symmetrized u •••••• 95 % Cl ł 민 ł. . . 1.1 1.1 $\{I_{i}\}_{i\in I}$ Cetil Corrado Corr 0/7,0/2,0/3, 90,00,00 0/7,0/2,0/3,0/7, 2, 2, 2, 2, 2, 2, 0177 9106 0[7] 1-1]]] 017,012,013, 14,1 14,1 14,1 14,1 14,1 14,1

![](_page_17_Figure_2.jpeg)

### **BSM interpretations of STXS measurements** ATLAS $\sqrt{s}$ =13 TeV, 139 fb<sup>-1</sup>, $m_H$ = 125.09 GeV SMEFT $\Lambda = 1$ TeV **ATLAS** EFT Exp. 95% CL $H \rightarrow \gamma \gamma$ 0.8 $H \rightarrow Z\gamma$ EFT Obs. 95% CL $\sqrt{s}$ = 13 TeV, 36.1 - 139 fb<sup>-1</sup> $H \rightarrow WW^* \rightarrow l\nu l\nu$ Expected contribution production decay 0.6 к Exp. 95% CL $H \rightarrow ZZ^* \rightarrow 4I$ $m_h = 125.09 \text{ GeV}$ 0.4 $H \rightarrow b\bar{b}$ к Obs. 95% CL $H \rightarrow \tau \tau$ 0.2 2HDM Type-II $\blacksquare H \rightarrow \mu \mu$ SM-like coupling $10^{1}$ $\tan\!eta$ **\_** ggF VBF 0.8 🗌 WH 0.6 ZH 0.4 Model matched to EFT (example: 2HDM 0.2 type-II) $\rightarrow$ constraints similar (but not 10<sup>1</sup> Linear (obs.) identical) to coupling modifier based Symmetrized uncertainty $(\sigma)$ Linear (exp.) constraints 10<sup>0</sup> Scale (A 10<sup>0</sup> 10-3.2 $10^{-2}$ 10 $10^{-3}$ · value scaled I uncertainty ( $c'/\sigma$ ) Linear (obs.) *p*<sub>SM</sub> = 94.5% Linear (exp.) 10- Best Fit 0.0 —— 68 % CL -0.2-0.10.1 0.2 -0.3Parameter v by symmetrized u ••••• 95 % CL ł T 1.1 017701270137 90790730 907907 Cert<sup>33</sup> Cort<sup>33</sup> Cort<sup>33</sup> 0[7] 9106 0[7] 1-1]]]] 0/7,0/2,0/3, 14, 14, 14,

![](_page_18_Figure_2.jpeg)

# (Anomalous) couplings

![](_page_19_Picture_1.jpeg)

### Overview

- Inclusive production and decay rates  $\rightarrow$ couplings (coupling modifiers)
- Not all effects can be covered by this

![](_page_20_Figure_3.jpeg)

![](_page_20_Figure_4.jpeg)

expectation!

![](_page_20_Figure_8.jpeg)

![](_page_20_Picture_9.jpeg)

## **Anomalous Higgs interactions**

- Higgs boson confirmed to be spin-0, and consistent with CP++ since run 1
- Pure CP-odd state excluded  $\neq$  CP-even state  $\rightarrow$  active field of study
- **Compatible** with the SM expectation so far
- Here:  $H \rightarrow VV$ ; previous results with  $H \rightarrow \tau \tau$ , ttH available

![](_page_21_Figure_5.jpeg)

**Constraints on CP-odd Wilson coefficients in SMEFT**  $H \rightarrow ZZ \rightarrow 4I$  (black points) + comparison with other approaches

![](_page_21_Figure_10.jpeg)

**Constraints on CP-even and CP-odd Wilson coefficients** H→WW→2l2v

![](_page_21_Figure_12.jpeg)

# Mass & width

![](_page_22_Picture_2.jpeg)

### **Overview of mass and width measurements**

- Mass: Exploit best-resolution channels:  $H \rightarrow \gamma \gamma$  and  $H \rightarrow ZZ \rightarrow 4I$ 
  - **m**<sub>H</sub> measured from fitting the reconstructed Higgs boson invariant mass distribution (categorized by resolution)
- Width:  $H \rightarrow ZZ \rightarrow 4I$ , 2I2v
  - Indirect measurement, using  $\frac{\Gamma_{H}}{\Gamma_{H}^{SM}} = \frac{\mu_{off-shell}}{\mu_{on-shell}}$

![](_page_23_Figure_5.jpeg)

![](_page_23_Figure_6.jpeg)

![](_page_23_Figure_7.jpeg)

![](_page_23_Picture_8.jpeg)

• Combination of  $H \rightarrow \gamma \gamma$  and  $H \rightarrow ZZ \rightarrow 4I$ 

![](_page_24_Figure_2.jpeg)

Run 1+2 combined:  $m_{H}= 125.11\pm0.11$  (±0.09 (stat.)±0.06 (syst.)) GeV  $\rightarrow$  0.09% relative precision (most precise) measurement to date)

![](_page_24_Picture_5.jpeg)

- discriminant
- Direct constraint on  $\Gamma_{\rm H}$

![](_page_25_Figure_4.jpeg)

![](_page_25_Picture_6.jpeg)

### Width measurements • Off-shell region ( $m_{4l}^{reco} > 200 \text{ GeV}$ ) studied in H $\rightarrow$ ZZ $\rightarrow$ 4l and H $\rightarrow$ ZZ $\rightarrow$ 2l2v

- channels + combination with on-shell  $H \rightarrow ZZ \rightarrow 4I$
- 3D observable (CMS) / NN (ATLAS) → comparable sensitivity O(70%) precision -2-3 MeV!

![](_page_26_Figure_3.jpeg)

![](_page_26_Figure_5.jpeg)

![](_page_26_Picture_7.jpeg)

![](_page_26_Picture_10.jpeg)

# Summary & outlook

- Many Higgs boson production and property measurements already performed with Run 2 data
- Run 3 well underway → expect more Higgs measurements at 13.6 TeV soon
- Much more to be learned about the Higgs boson with Run 3 and HL-LHC data !

![](_page_27_Figure_4.jpeg)

![](_page_27_Figure_8.jpeg)

![](_page_27_Picture_9.jpeg)

C.					
	Tue 04/0	06 Wed 05/06 All days	< Tue 04/	06 Wed 05/06 All days	
		Print PDF Full screen Detailed view Filter		Print PDF Full screen	Detailed view Filter
•	11:00	NLO EW corrections to HH production         Huan-Yu B	11:00	Higgs differential measurements and EFT interpretation in CMS	Suman Chatterj
		ISEC Room 102 11:00 - 11:18		ISEC Room 102	11:00 - 11:
		Non-resonant di-Higgs searches and measurements with the ATLAS detector Arely Cortes Gonzalez		Higgs differential measurements and EFT interpretation in ATLAS	Giuseppe Call
		ISEC Room 102 11:18 - 11:36		ISEC Room 102	11:18 - 11:
		Non-resonant di-Higgs searches and measurements with the CMS detector Irene Dutta		Uniqueness of the matching in the HEFT	Duarte Font
		ISEC Room 102 11:36 - 11:54		ISEC Room 102	11:36 - 11:
•	12.00	Light Yukawa couplings from H* production Marco Vitt	12:00	ZH production in SMEFT from ggF	Marion Thom
	12.00	ISEC Room 102 11:54 - 12:12	12.00	ISEC Room 102	11:54 - 12:
		Higgs property measurements (mass, width, CP) with the ATLAS detector         Sebastien Rettie		Higgs boson coupling measurements in CMS	Clara Ramon Alvar
		ISEC Room 102 12:12 - 12:30		ISEC Room 102	12:12 - 12:
		Higgs propery measurements (mass, width, CP) with the CMS detector Lucas Kang		Higgs boson coupling measurements in ATLAS	Antonio Jesus Gomez Delegi
•		ISEC Room 102 12:30 - 12:48		ISEC Room 102	12:30 - 12:

13:00

### More details in the parallel talks today and tomorrow ! See also J. Alison's talk on di-Higgs production in tomorrow's plenary, and S. Hirose's talk on rare/BSM Higgs boson decays in yesterday's plenary

14:00 ttl	H+tH Production (ATLAS)	Anastasia Kotsok
IS	SEC Room 102	14:00
ttł	H+tH Production (CMS)	Matteo Marc
IS	SEC Room 102	14:18
tt+	+HF measurements including ttbb (ATLAS+CMS)	Luisa C
IS	SEC Room 102	14:36
15:00 <b>To</b>	op-Bottom Interference Contribution to Higgs Production	Mr Marco Ni
IS	SEC Room 102	14:54
4te	top searches including constraints on Top Yukawa (ATLAS+CMS)	Nick Ma
IS	SEC Room 102	15:12

![](_page_28_Picture_4.jpeg)

 $\checkmark$ 

![](_page_28_Picture_5.jpeg)

![](_page_28_Figure_8.jpeg)

![](_page_28_Figure_9.jpeg)

![](_page_28_Picture_10.jpeg)

![](_page_28_Picture_11.jpeg)