Measurement of fiducial, differential and production cross sections in the $H \rightarrow \gamma\gamma$ decay channel with ATLAS

(Young Scientists Forum)

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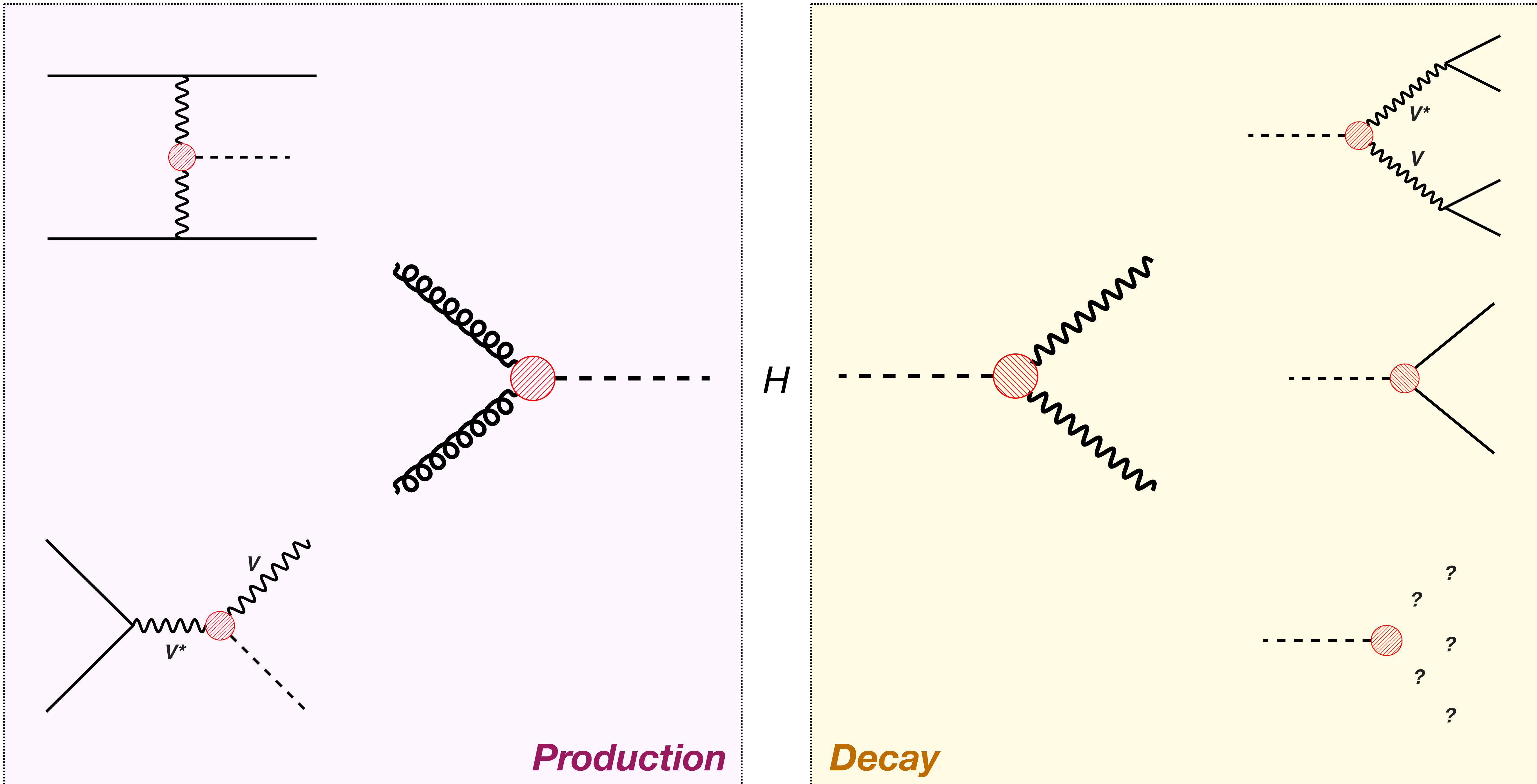
On behalf of the ATLAS Collaboration

Introduction

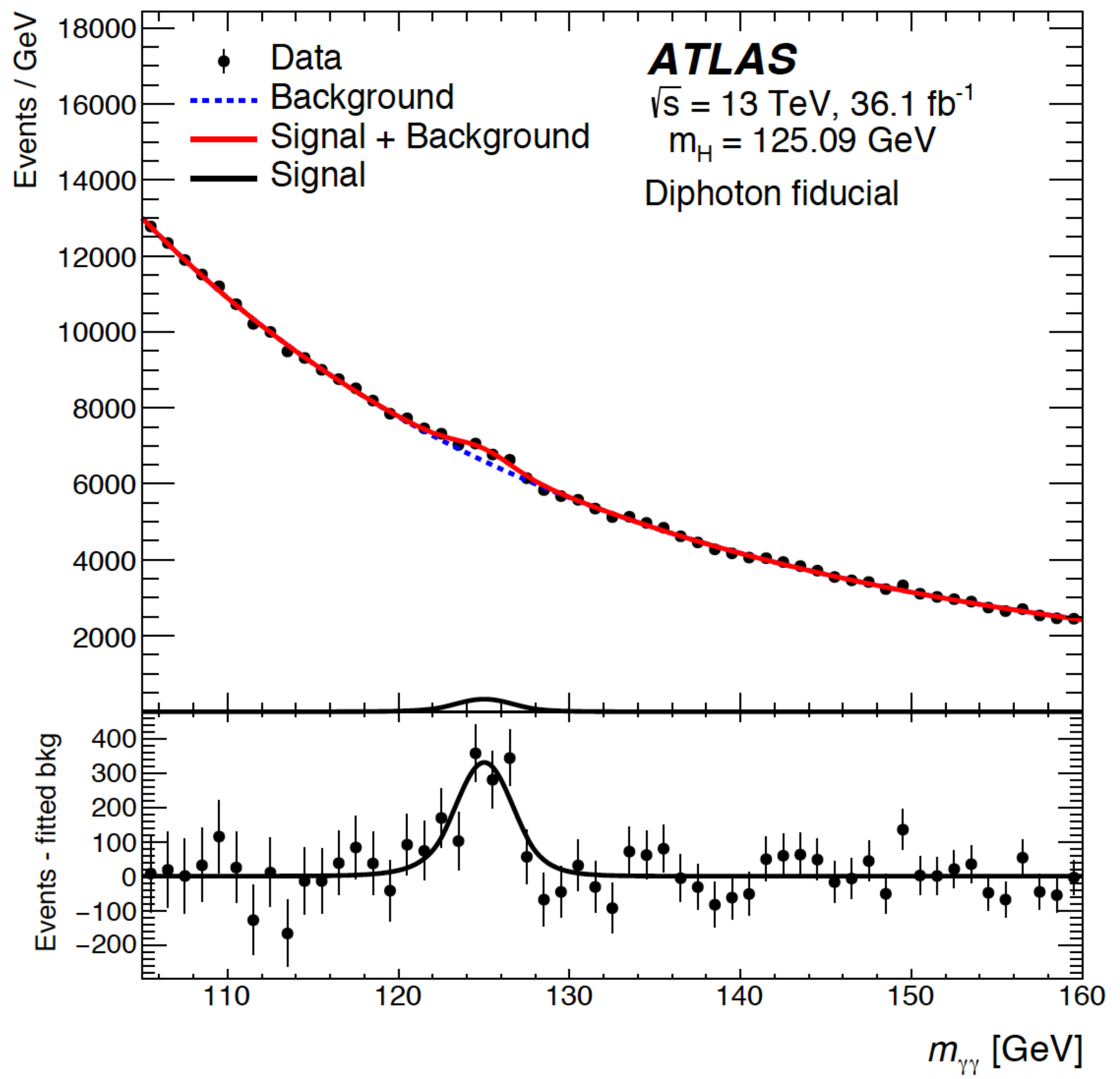
Aim: measure pp → H → X properties



Introduction

Aim: measure pp → H → X properties

Tools: γγ channel (0.2% BR but good efficiency/resolution); 36 fb^{-1} of 13 TeV data



Area of $m_{\gamma\gamma}$ peak = Higgs signal yield

Introduction

Aim: measure pp → H → X properties

Tools: γγ channel (0.2% BR but good efficiency/resolution); 36 fb^{-1} of 13 TeV data

Method: range of most ↔ least model dependent measurements

Direct test of SM ↑

Couplings: μ^{ggH}, μ^{VBF}, κ_g, κ_γ *etc*

Simplified Template Cross Sections (STXS): σ^{prod} (**kinematic region**) × BR(H→γγ)

Fiducial: σ (**final-state phase space**, **differential**)

↓ Model independence

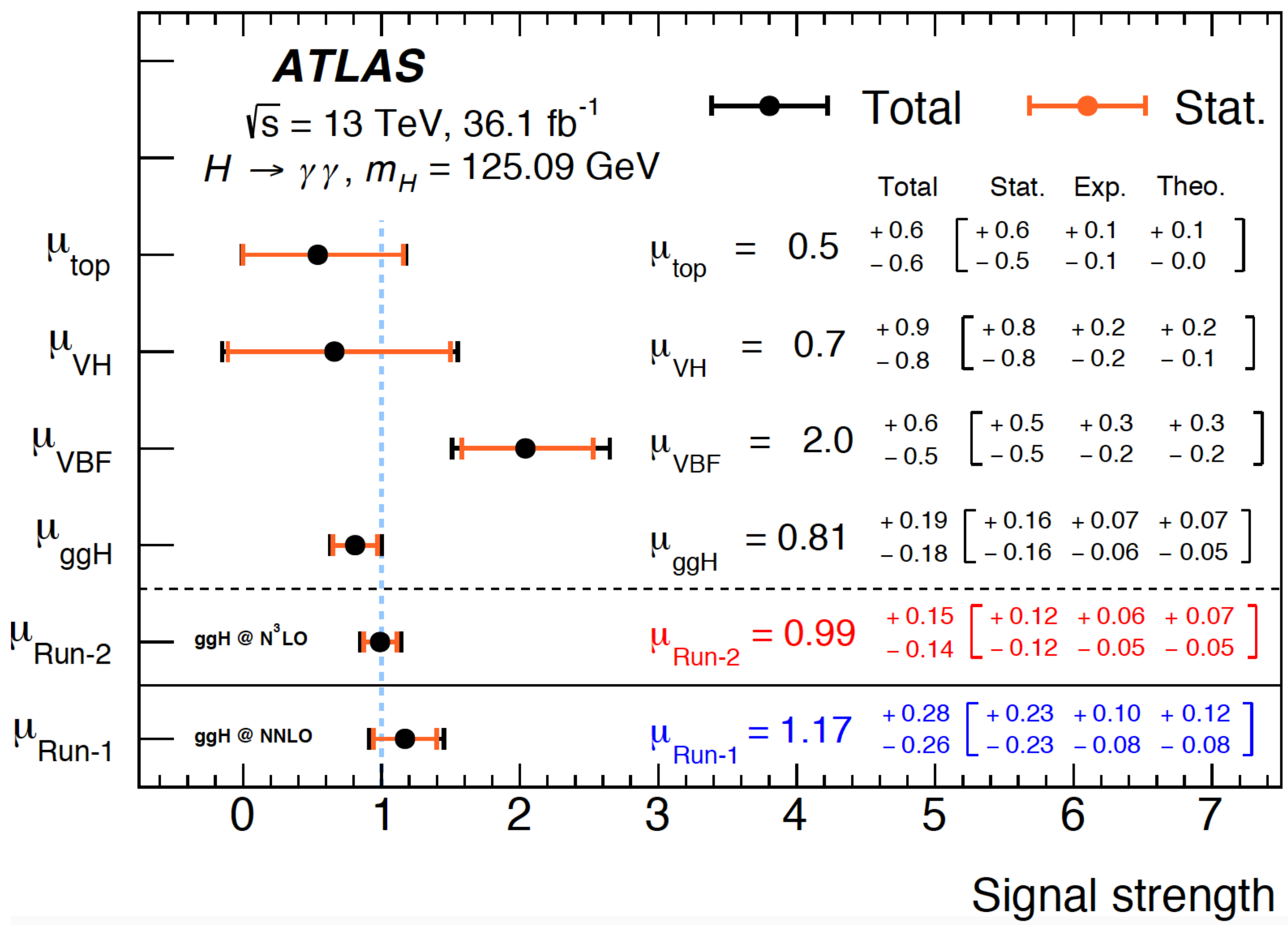
arXiv:1802.04146

Inspire/1654582

1. Couplings

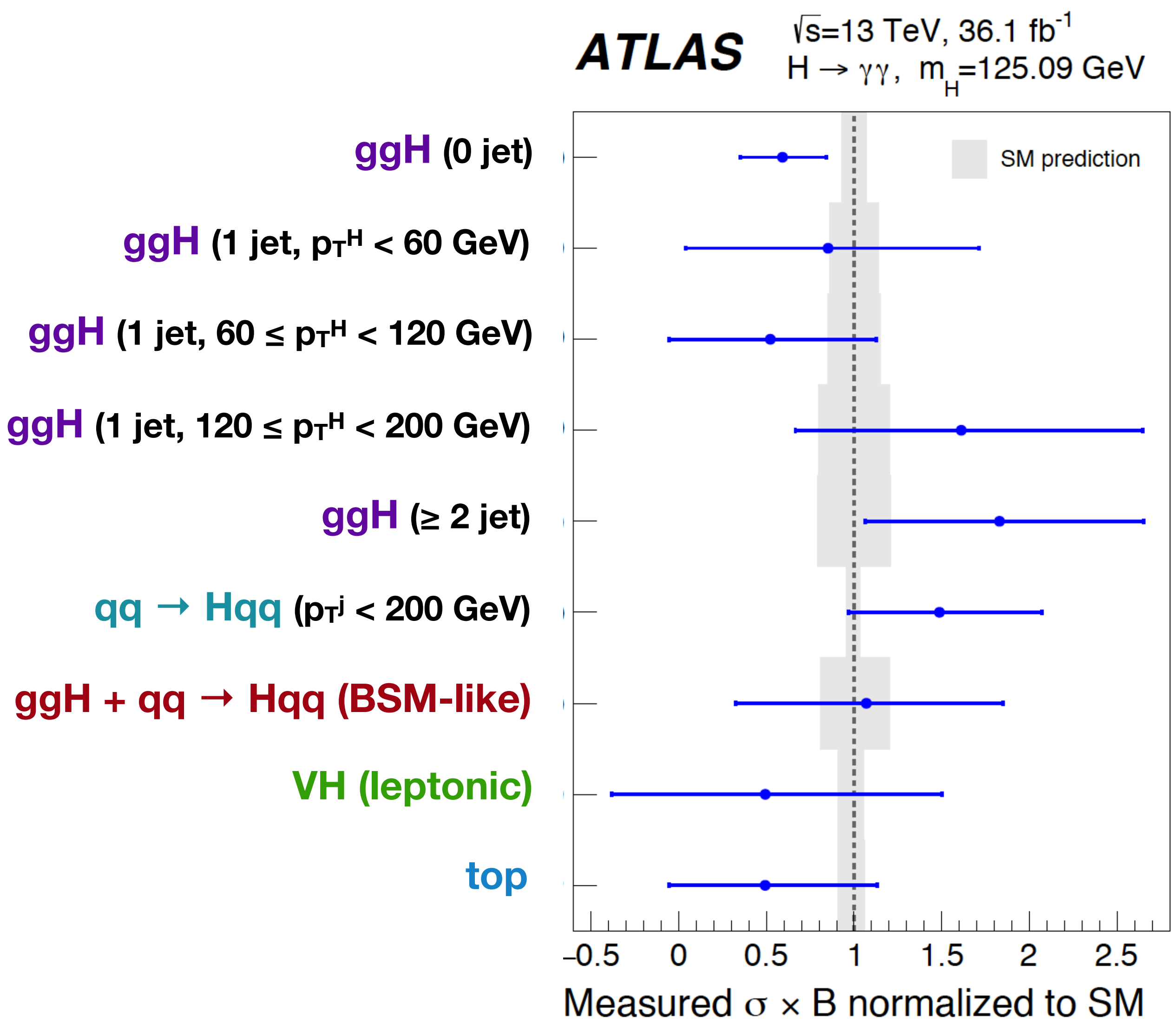
Likelihood fit to $\mathbf{m_{\gamma\gamma}}$ in **31 object based** categories using **SM templates**

$$\mu^{\text{prod}} \equiv \frac{\sigma^{\text{prod}}}{\sigma^{\text{prod}}_{\text{SM}}} \quad , \quad \mathcal{BR} \times \sigma^{\text{prod}}_{|y^{\text{H}}| < 2.5} \quad , \quad \frac{\sigma^{\text{prod}}_{|y^{\text{H}}| < 2.5}}{\sigma^{\text{ggH}}_{|y^{\text{H}}| < 2.5}} \quad , \quad \frac{\mu^{\text{prod}}}{\mu^{\text{ggH}}} \quad , \quad \kappa_{g,\gamma,F,V,g\gamma} \quad , \quad \frac{\kappa_{V,t}}{\kappa_g}$$



2. Simplified Template Cross Sections (STXS)

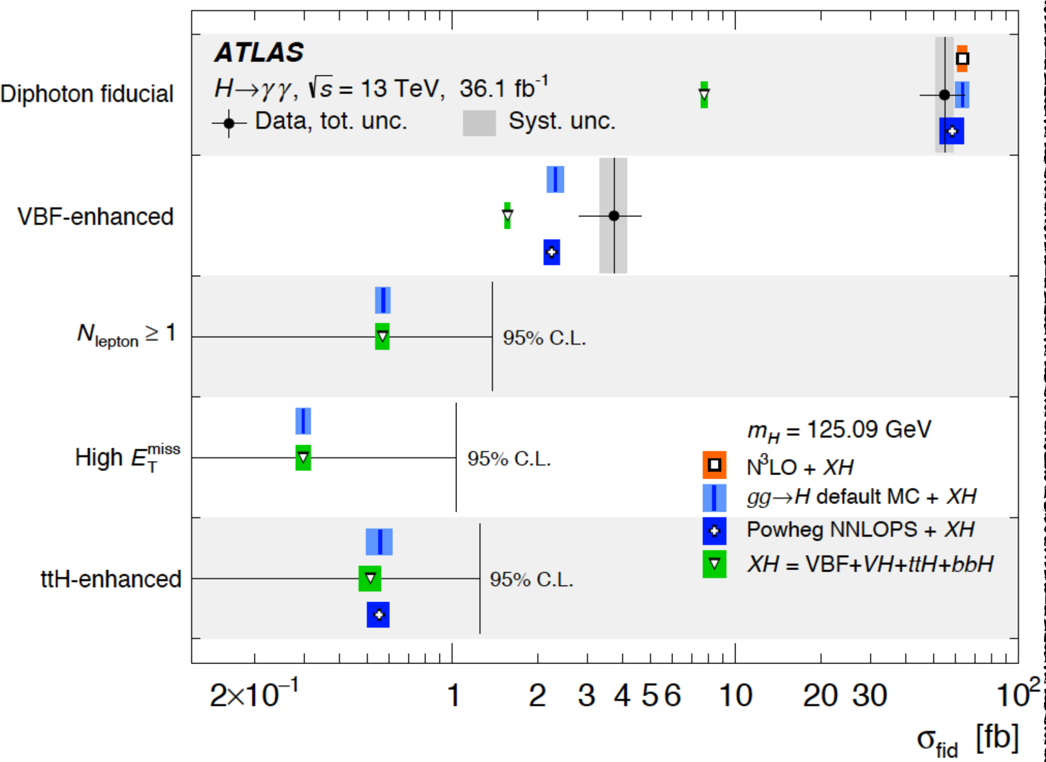
Production mode x-sections in **simplified fiducial phase spaces**



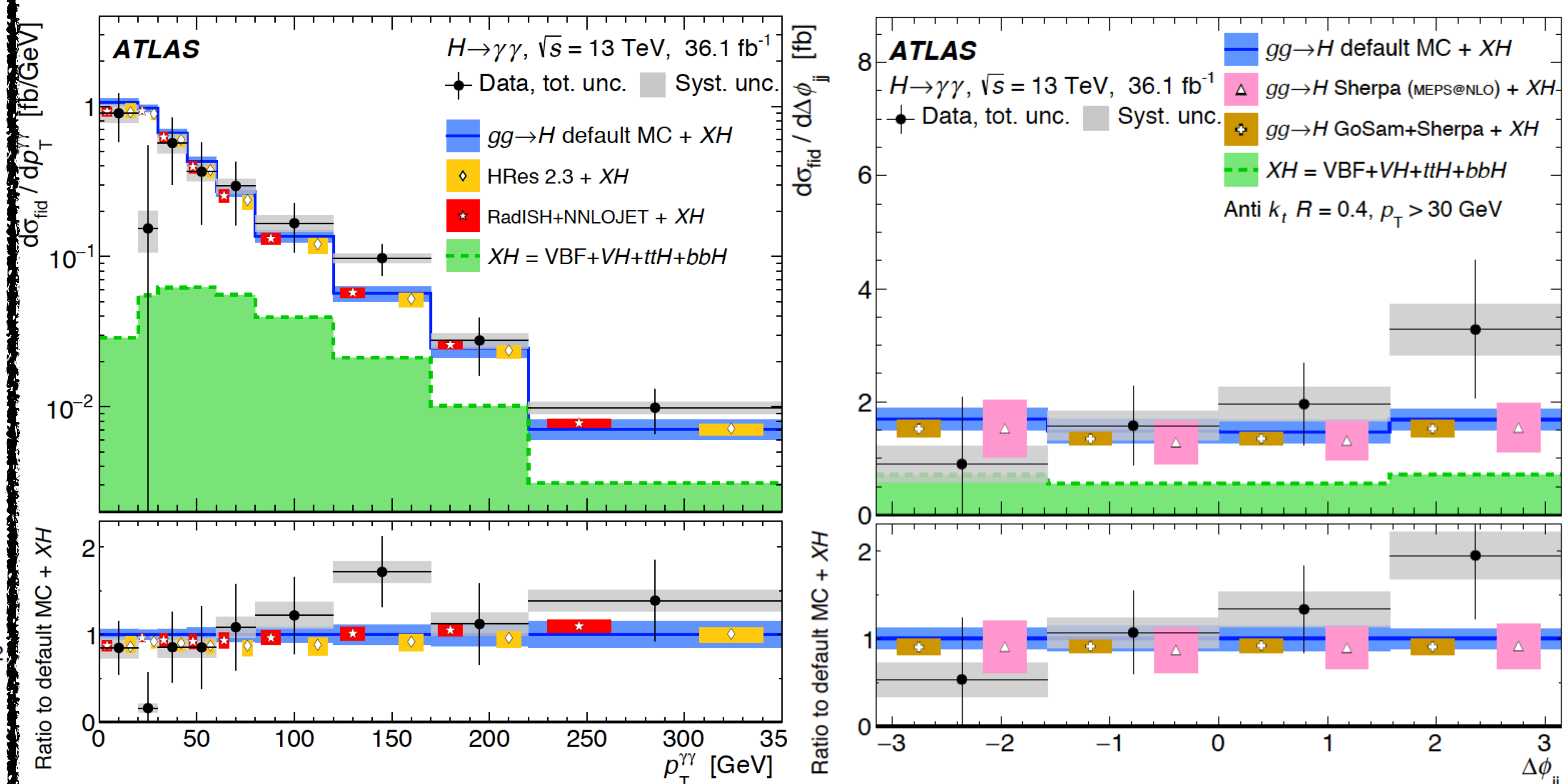
Fewer **assumptions,** specific **phase space regions**, easy to **combine decay channels**

3. Fiducial & Differential Cross Sections

Fiducial / differential x-sections defined by **final state objects**, corrected for detector effects with **minimum SM assumptions**



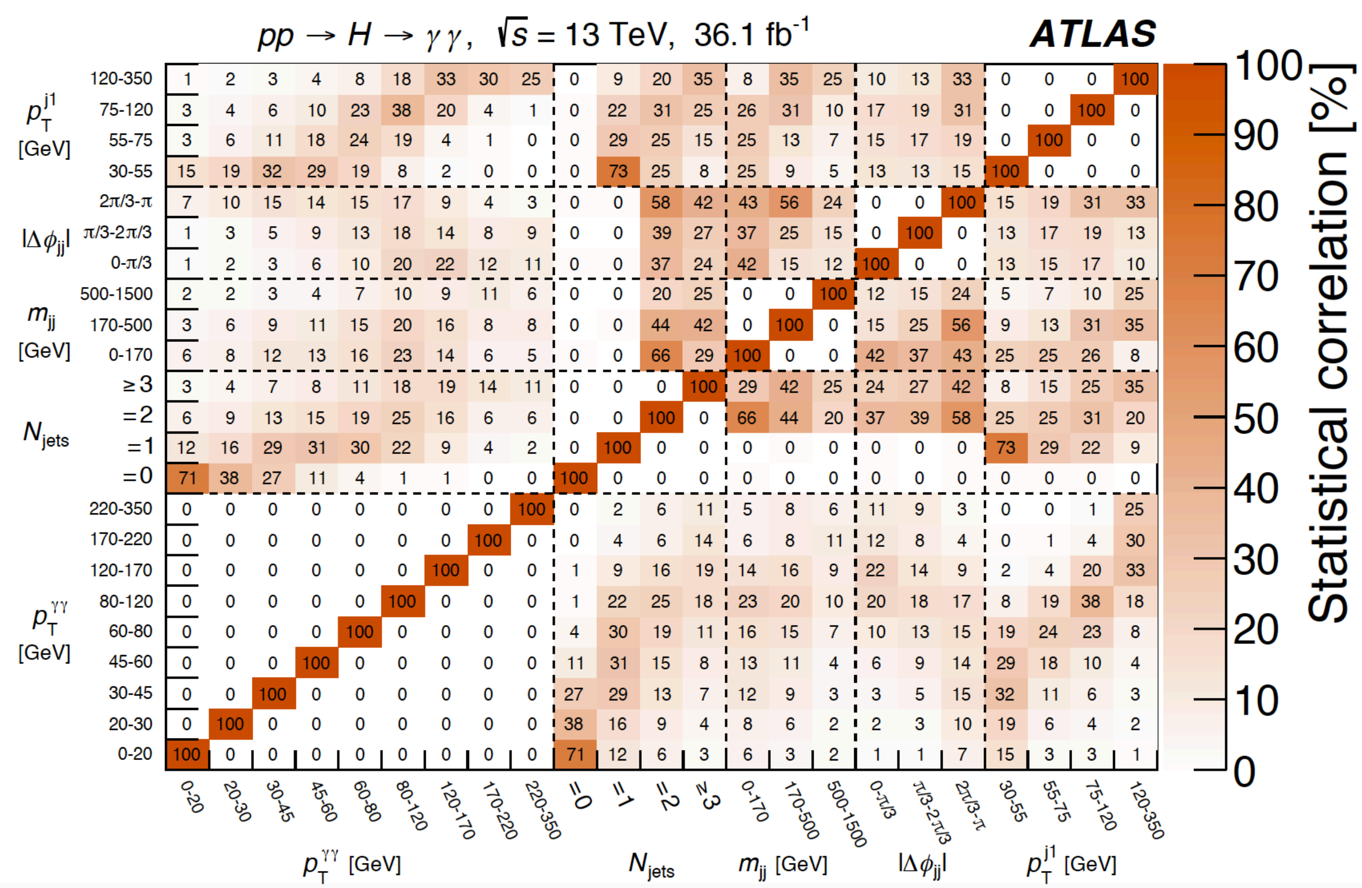
5 dedicated fiducial phase spaces



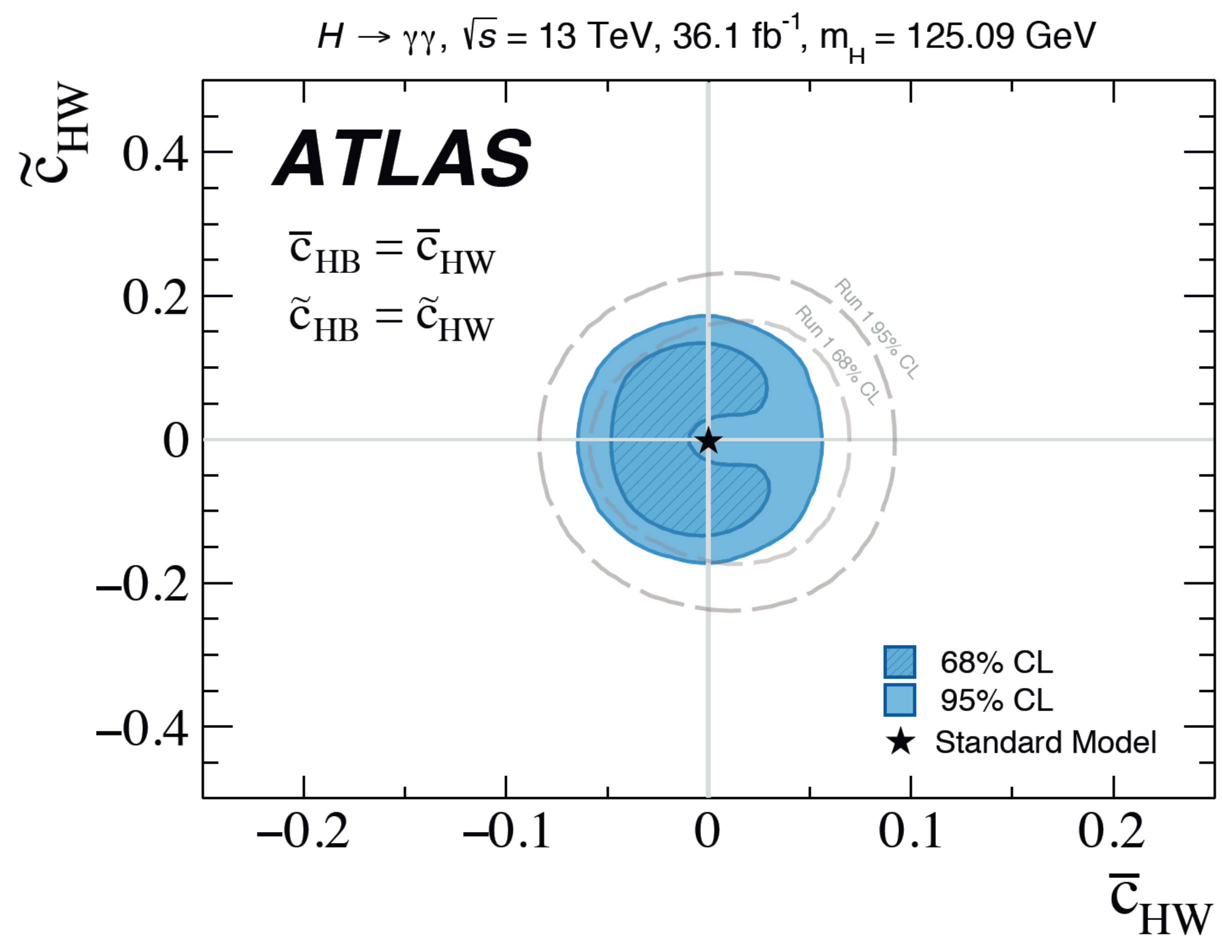
18 differential observables

4. Effective Field Theory

Constrain effective dimension 6 couplings using **differential measurements**



Provide correlations to allow **after-the-fact constraint** of models using **multiple distributions**



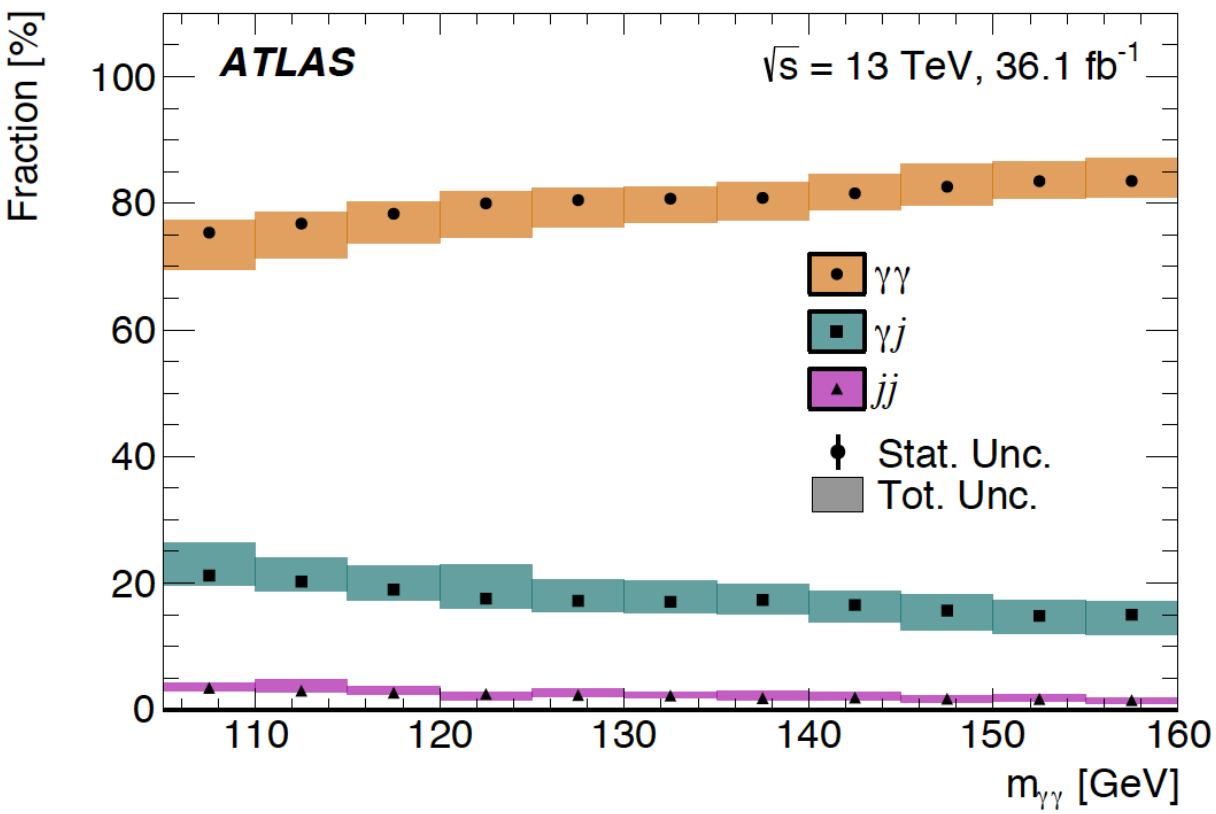
Scan of **CP-even/odd** H V V **Wilson coefficients**

Summary

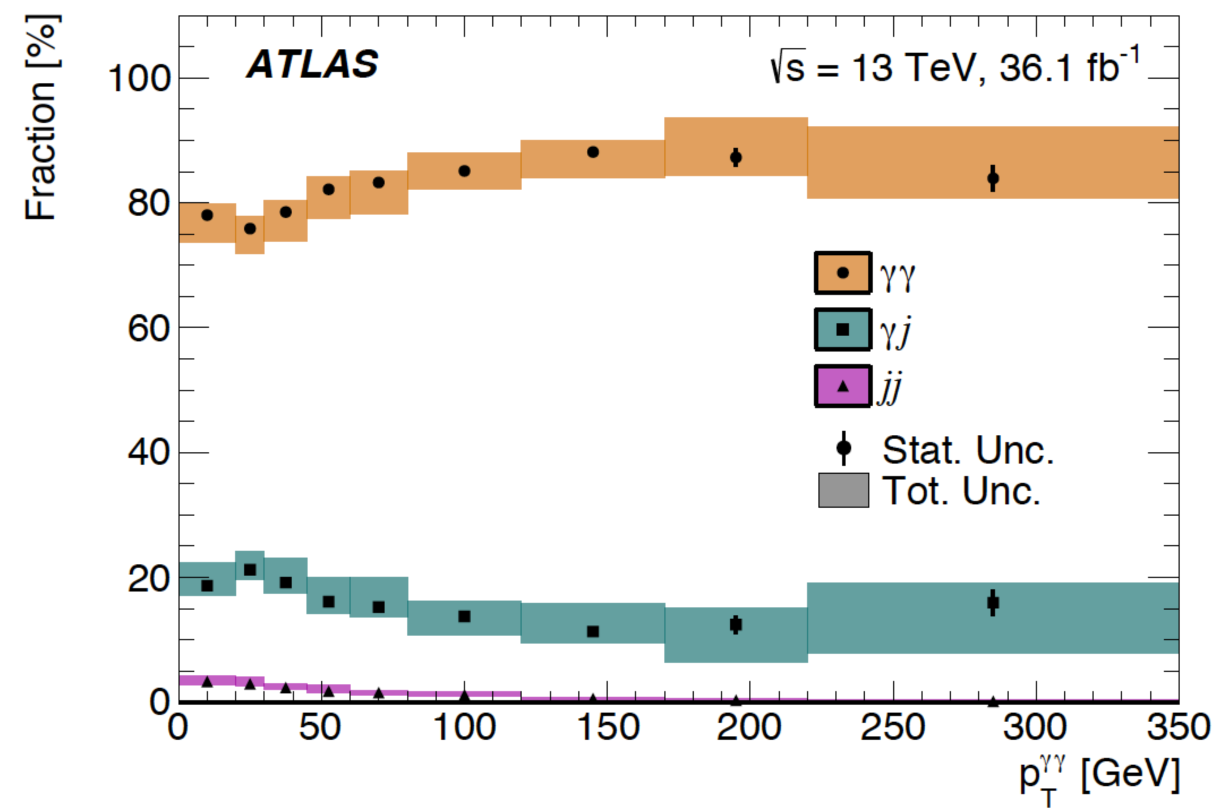
- $H \rightarrow \gamma\gamma$ measurements targeting a range of model dependence and SM sensitivity
  - **Couplings**: model dependent measurement of SM rates / kappas
  - **STXS**: SM x-sections in simplified fiducial phase spaces, easily combined
  - **Fiducial x-sections**: minimal model dependence, differential, re-interpretable
  - **EFT interpretation**: limits on dimension 6 effective vertex strengths
- Stat dominated, no clear deviations from the SM

arXiv:1802.04146   Inspire/1654582   *36 fb^{-1} @ 13 TeV* backup

Background



ATLAS
$\sqrt{s}$ = 13 TeV, 36.1 fb^{-1}
Fraction [%]
$m_{\gamma\gamma}$ [GeV]
γγ
γj
jj
Stat. Unc.
Tot. Unc.



ATLAS
$\sqrt{s}$ = 13 TeV, 36.1 fb^{-1}
Fraction [%]
$p_T^{\gamma\gamma}$ [GeV]
γγ
γj
jj
Stat. Unc.
Tot. Unc.

Uncertainties

Stat limited, systematics depend on measurement

$$\mu = 0.99 \,^{+0.15}_{-0.14} \begin{cases} \pm\, 0.12\,(\text{stat.}) \\ ^{+0.06}_{-0.05}\,(\text{exp.}) \\ ^{+0.07}_{-0.05}\,(\text{theo.}) \end{cases}$$

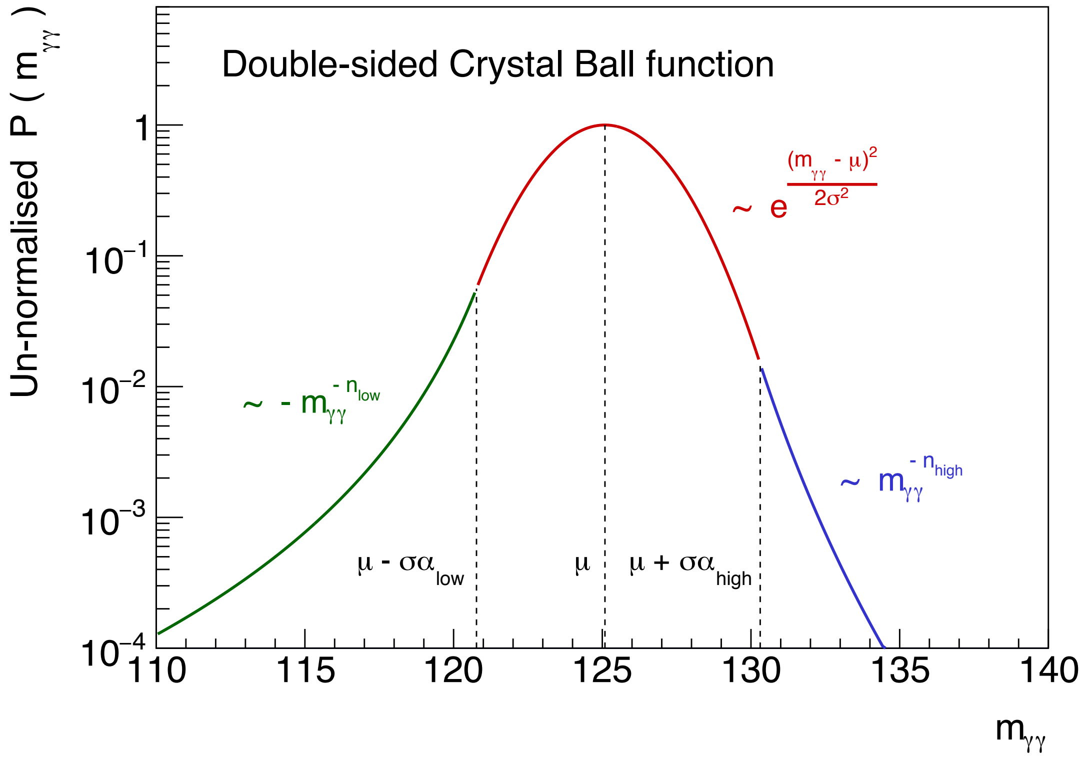
Uncertainty Group	$\sigma_{\mu}^{\text{syst.}}$
Theory (QCD)	0.041
Theory ($B(H \to \gamma\gamma)$)	0.028
Theory (PDF+α_S)	0.021
Theory (UE/PS)	0.026
Luminosity	0.031
Experimental (yield)	0.017
Experimental (migrations)	0.015
Mass resolution	0.029
Mass scale	0.006
Background shape	0.027

E.g. signal strengths

	Diphoton	VBF-enhanced
Fit (stat.)	17%	22%
Fit (syst.)	6%	9%
Photon efficiency	1.8%	1.8%
Jet energy scale/resolution	-	8.9%
Pileup	1.1%	2.9%
Theoretical modeling	0.1%	4.5%
Luminosity	3.2%	3.2%
Total	18%	26%

E.g. fiducial cross sections

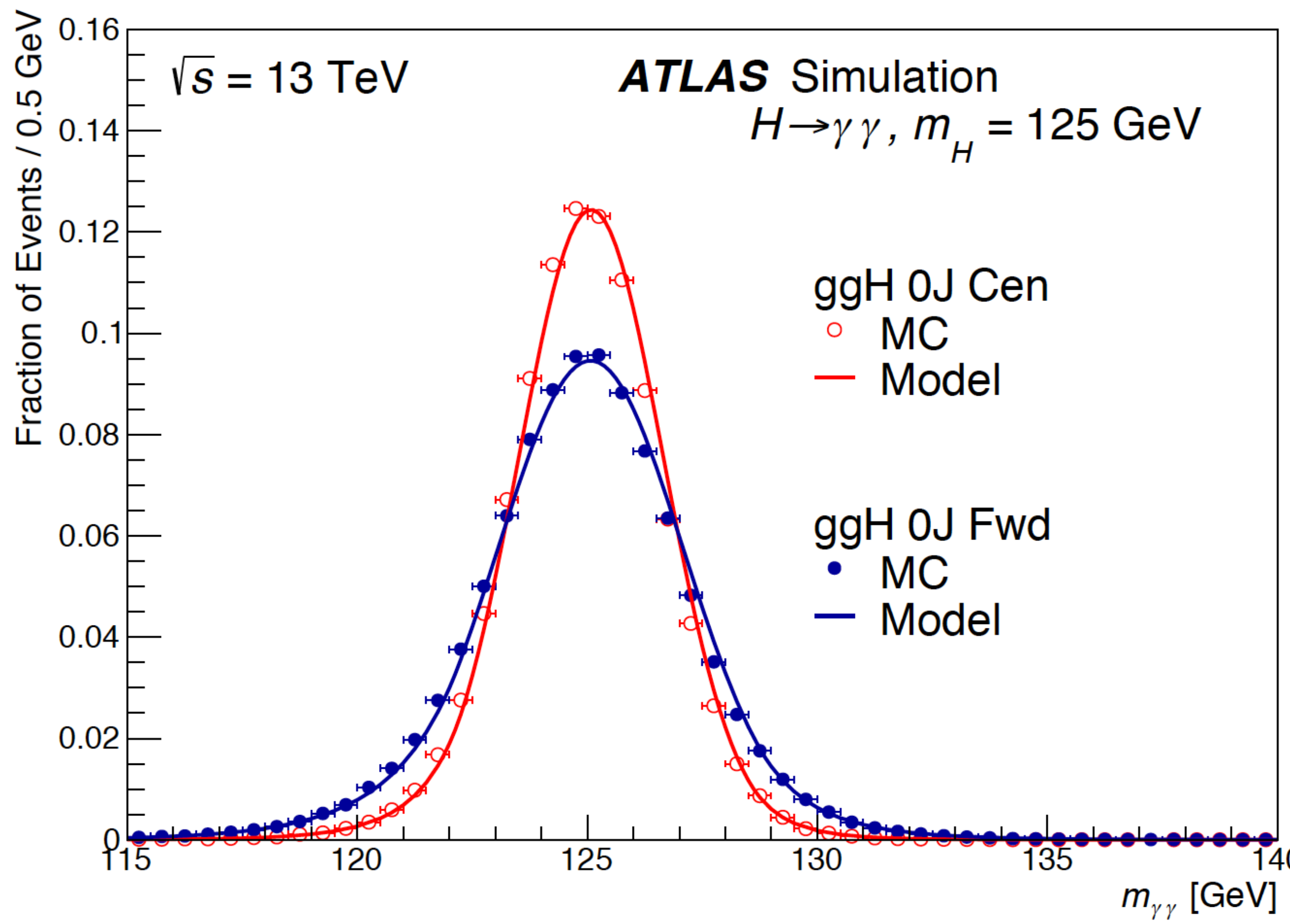
Signal Model



Signal peak modelled by DSCB

Gaussian core with **power-law tails**

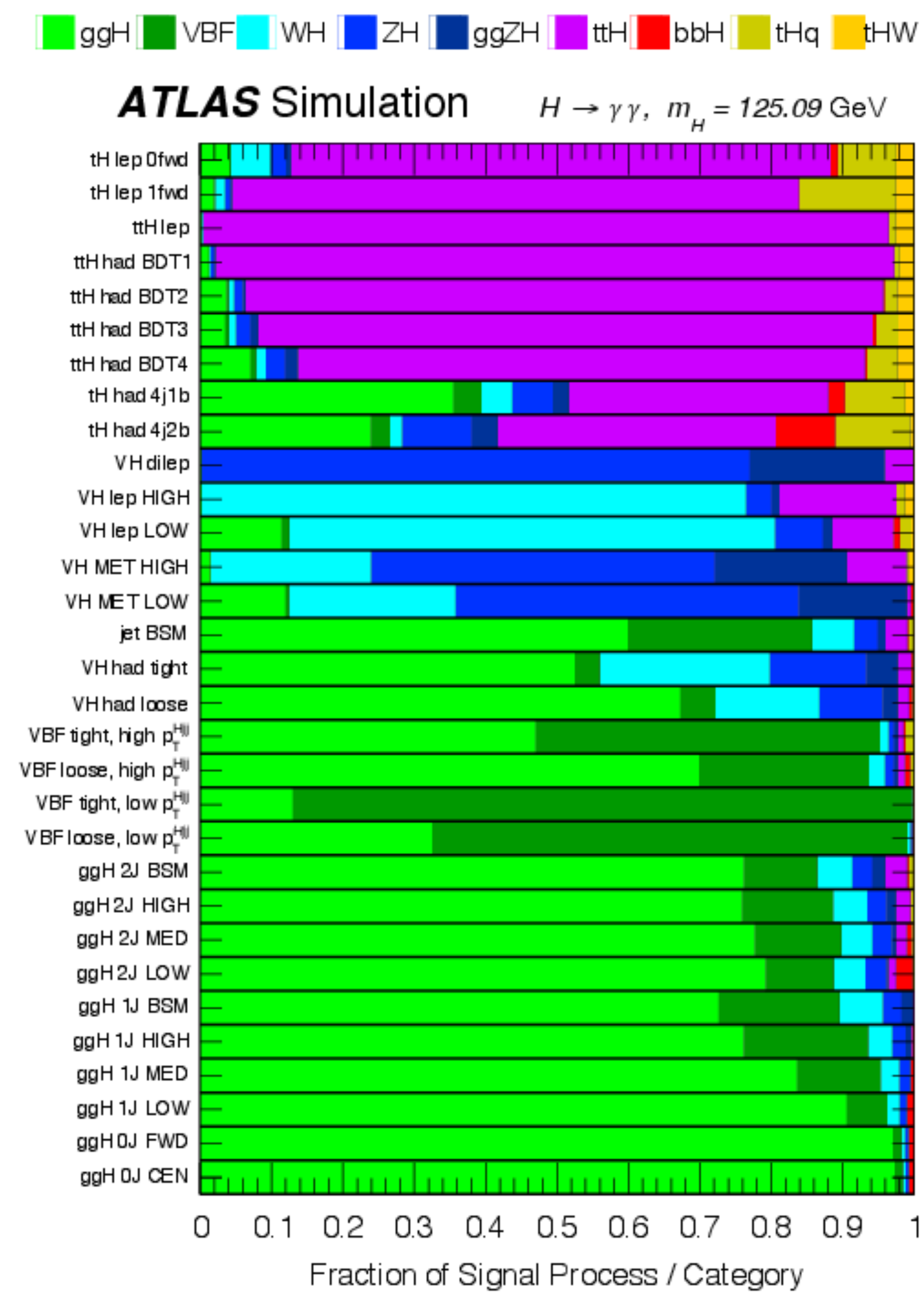
{ μ_{CB} , σ_{CB} , α_{low} , n_{low} , α_{high} , n_{high} } are determined per-bin using signal MC and fixed in data fit



Couplings & STXS Categories

Increasing cross section

Category	Selection
tH lep 0fwd	$N_{\text{lep}} = 1$, $N_{\text{jets}}^{\text{cen}} \leq 3$, $N_{b\text{-tag}} \geq 1$, $N_{\text{jets}}^{\text{fwd}} = 0$ ($p_{\text{T}}^{\text{jet}} > 25$ GeV)
tH lep 1fwd	$N_{\text{lep}} = 1$, $N_{\text{jets}}^{\text{cen}} \leq 4$, $N_{b\text{-tag}} \geq 1$, $N_{\text{jets}}^{\text{fwd}} \geq 1$ ($p_{\text{T}}^{\text{jet}} > 25$ GeV)
ttH lep	$N_{\text{lep}} \geq 1$, $N_{\text{jets}}^{\text{cen}} \geq 2$, $N_{b\text{-tag}} \geq 1$, $Z_{\ell\ell}$ veto ($p_{\text{T}}^{\text{jet}} > 25$ GeV)
ttH had BDT1	$N_{\text{lep}} = 0$, $N_{\text{jets}} \geq 3$, $N_{b\text{-tag}} \geq 1$, $\text{BDT}_{\text{ttH}} > 0.92$
ttH had BDT2	$N_{\text{lep}} = 0$, $N_{\text{jets}} \geq 3$, $N_{b\text{-tag}} \geq 1$, $0.83 < \text{BDT}_{\text{ttH}} < 0.92$
ttH had BDT3	$N_{\text{lep}} = 0$, $N_{\text{jets}} \geq 3$, $N_{b\text{-tag}} \geq 1$, $0.79 < \text{BDT}_{\text{ttH}} < 0.83$
ttH had BDT4	$N_{\text{lep}} = 0$, $N_{\text{jets}} \geq 3$, $N_{b\text{-tag}} \geq 1$, $0.52 < \text{BDT}_{\text{ttH}} < 0.79$
tH had 4j1b	$N_{\text{lep}} = 0$, $N_{\text{jets}}^{\text{cen}} = 4$, $N_{b\text{-tag}} = 1$ ($p_{\text{T}}^{\text{jet}} > 25$ GeV)
tH had 4j2b	$N_{\text{lep}} = 0$, $N_{\text{jets}}^{\text{cen}} = 4$, $N_{b\text{-tag}} \geq 2$ ($p_{\text{T}}^{\text{jet}} > 25$ GeV)
VH dilep	$N_{\text{lep}} \geq 2$, $70\text{ GeV} \leq m_{\ell\ell} \leq 110$ GeV
VH lep High	$N_{\text{lep}} = 1$, $\lvert m_{e\gamma} - 89\text{ GeV}\rvert > 5$ GeV, $p_{\text{T}}^{\ell+E_{\text{T}}^{\text{miss}}} > 150$ GeV
VH lep Low	$N_{\text{lep}} = 1$, $\lvert m_{e\gamma} - 89\text{ GeV}\rvert > 5$ GeV, $p_{\text{T}}^{\ell+E_{\text{T}}^{\text{miss}}} < 150$ GeV, $E_{\text{T}}^{\text{miss}}$ significance > 1
VH MET High	$150\text{ GeV} < E_{\text{T}}^{\text{miss}} < 250$ GeV, $E_{\text{T}}^{\text{miss}}$ significance > 9 or $E_{\text{T}}^{\text{miss}} > 250$ GeV
VH MET Low	$80\text{ GeV} < E_{\text{T}}^{\text{miss}} < 150$ GeV, $E_{\text{T}}^{\text{miss}}$ significance > 8
jet BSM	$p_{\text{T},j1} > 200$ GeV
VH had tight	$60\text{ GeV} < m_{jj} < 120$ GeV, $\text{BDT}_{\text{VH}} > 0.78$
VH had loose	$60\text{ GeV} < m_{jj} < 120$ GeV, $0.35 < \text{BDT}_{\text{VH}} < 0.78$
VBF tight, high p_{T}^{Hjj}	$\lvert\Delta\eta_{jj}\rvert > 2$, $\lvert\eta_{\gamma\gamma} - 0.5(\eta_{j1} + \eta_{j2})\rvert < 5$, $p_{\text{T}}^{Hjj} > 25$ GeV, $\text{BDT}_{\text{VBF}} > 0.47$
VBF loose, high p_{T}^{Hjj}	$\lvert\Delta\eta_{jj}\rvert > 2$, $\lvert\eta_{\gamma\gamma} - 0.5(\eta_{j1} + \eta_{j2})\rvert < 5$, $p_{\text{T}}^{Hjj} > 25$ GeV, $-0.32 < \text{BDT}_{\text{VBF}} < 0.47$
VBF tight, low p_{T}^{Hjj}	$\lvert\Delta\eta_{jj}\rvert > 2$, $\lvert\eta_{\gamma\gamma} - 0.5(\eta_{j1} + \eta_{j2})\rvert < 5$, $p_{\text{T}}^{Hjj} < 25$ GeV, $\text{BDT}_{\text{VBF}} > 0.87$
VBF loose, low p_{T}^{Hjj}	$\lvert\Delta\eta_{jj}\rvert > 2$, $\lvert\eta_{\gamma\gamma} - 0.5(\eta_{j1} + \eta_{j2})\rvert < 5$, $p_{\text{T}}^{Hjj} < 25$ GeV, $0.26 < \text{BDT}_{\text{VBF}} < 0.87$
ggH 2J BSM	≥ 2 jets, $p_{\text{T}}^{\gamma\gamma} \geq 200$ GeV
ggH 2J High	≥ 2 jets, $p_{\text{T}}^{\gamma\gamma} \in [120, 200]$ GeV
ggH 2J Med	≥ 2 jets, $p_{\text{T}}^{\gamma\gamma} \in [60, 120]$ GeV
ggH 2J Low	≥ 2 jets, $p_{\text{T}}^{\gamma\gamma} \in [0, 60]$ GeV
ggH 1J BSM	$= 1$ jet, $p_{\text{T}}^{\gamma\gamma} \geq 200$ GeV
ggH 1J High	$= 1$ jet, $p_{\text{T}}^{\gamma\gamma} \in [120, 200]$ GeV
ggH 1J Med	$= 1$ jet, $p_{\text{T}}^{\gamma\gamma} \in [60, 120]$ GeV
ggH 1J Low	$= 1$ jet, $p_{\text{T}}^{\gamma\gamma} \in [0, 60]$ GeV
ggH 0J Fwd	$= 0$ jets, one photon with $\lvert\eta\rvert > 0.95$
ggH 0J Cen	$= 0$ jets, two photons with $\lvert\eta\rvert \leq 0.95$



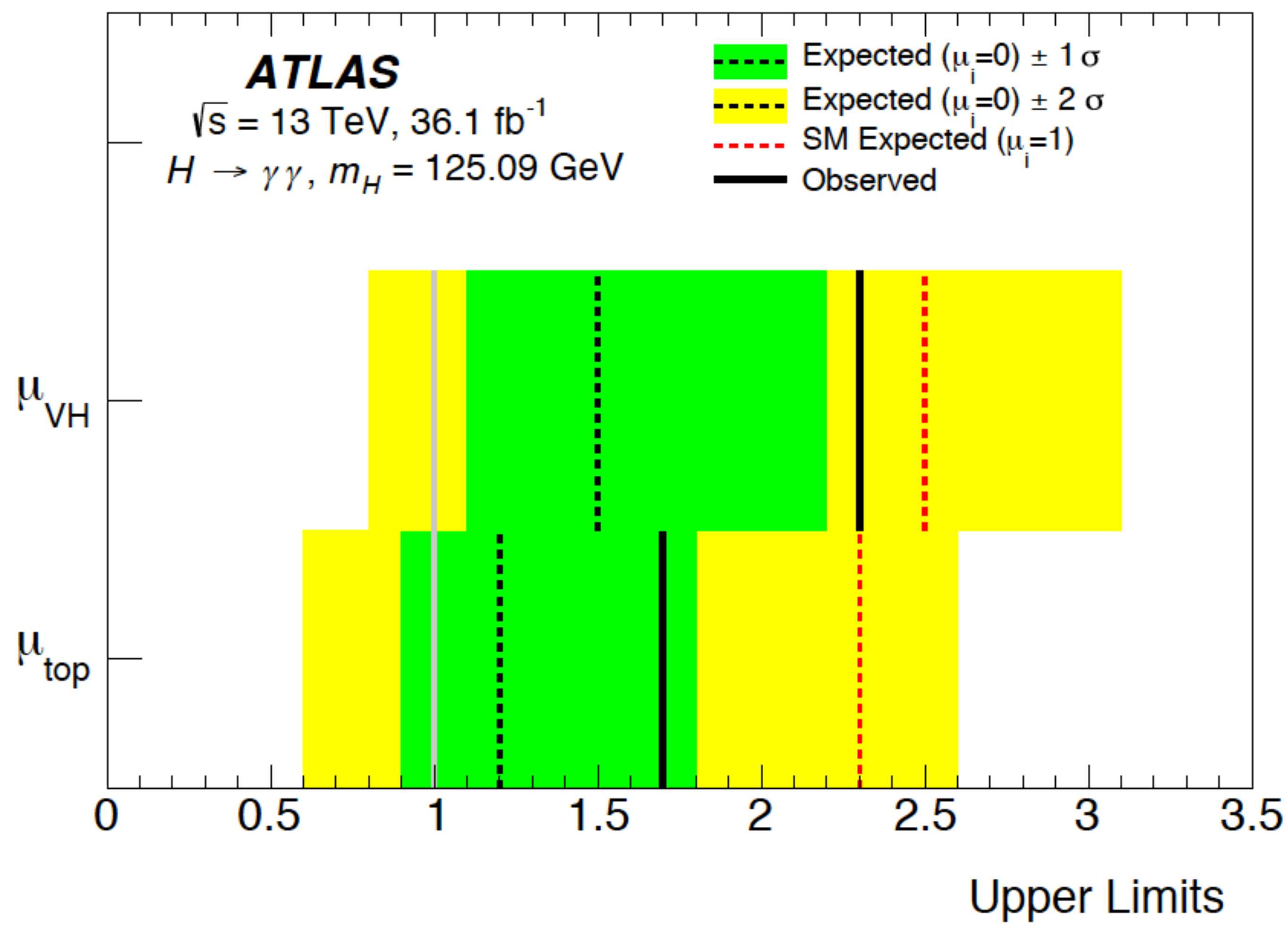
Presented STXS Regions

Process	Measurement region	Particle-level stage-1 region
ggH + $gg \to Z(\to qq)H$	0-jet	0-jet
	1-jet, $p_T^H < 60$ GeV	1-jet, $p_T^H < 60$ GeV
	1-jet, $60 \le p_T^H < 120$ GeV	1-jet, $60 \le p_T^H < 120$ GeV
	1-jet, $120 \le p_T^H < 200$ GeV	1-jet, $120 \le p_T^H < 200$ GeV
	$\ge$ 1-jet, $p_T^H > 200$ GeV	1-jet, $p_T^H > 200$ GeV
		$\ge$ 2-jet, $p_T^H > 200$ GeV
	$\ge$ 2-jet, $p_T^H < 200$ GeVor VBF-like	$\ge$ 2-jet, $p_T^H < 60$ GeV
		$\ge$ 2-jet, $60 \le p_T^H < 120$ GeV
		$\ge$ 2-jet, $120 \le p_T^H < 200$ GeV
		VBF-like, $p_T^{Hjj} < 25$ GeV
		VBF-like, $p_T^{Hjj} \ge 25$ GeV
$qq' \to Hqq'$ (VBF + VH)	$p_T^j < 200$ GeV	$p_T^j < 200$ GeV, VBF-like, $p_T^{Hjj} < 25$ GeV
		$p_T^j < 200$ GeV, VBF-like, $p_T^{Hjj} \ge 25$ GeV
		$p_T^j < 200$ GeV, VH-like
		$p_T^j < 200$ GeV, Rest
	$p_T^j > 200$ GeV	$p_T^j > 200$ GeV
VH (leptonic decays)	VH leptonic	$q\bar{q} \to ZH$, $p_T^Z < 150$ GeV
		$q\bar{q} \to ZH$, $150 < p_T^Z < 250$ GeV, 0-jet
		$q\bar{q} \to ZH$, $150 < p_T^Z < 250$ GeV, $\ge$ 1-jet
		$q\bar{q} \to ZH$, $p_T^Z > 250$ GeV
		$q\bar{q} \to WH$, $p_T^W < 150$ GeV
		$q\bar{q} \to WH$, $150 < p_T^W < 250$ GeV, 0-jet
		$q\bar{q} \to WH$, $150 < p_T^W < 250$ GeV, $\ge$ 1-jet
		$q\bar{q} \to WH$, $p_T^W > 250$ GeV
		$gg \to ZH$, $p_T^Z < 150$ GeV
		$gg \to ZH$, $p_T^Z > 150$ GeV, 0-jet
		$gg \to ZH$, $p_T^Z > 150$ GeV, $\ge$ 1-jet
Top-associated production	top	$t\bar{t}H$
		W-associated $tH(tHW)$
		t-channel $tH(tHq)$
$b\bar{b}H$	merged w/ ggH	$b\bar{b}H$

Couplings: VH and tH+ttH signal strengths

Measurement	Exp. Z_0	Obs. Z_0
$\mu_{\rm VBF}$	2.6 σ	4.9 σ
$\mu_{\rm VH}$	1.4 σ	0.8 σ
$\mu_{\rm top}$	1.8 σ	1.0 σ

Measurement	Observed	Exp. Limit ($\mu_i = 1$)	Exp. Limit ($\mu_i = 0$)	$+2\sigma$	$+1\sigma$	-1σ	-2σ
$\mu_{\rm VH}$	2.3	2.5	1.5	3.1	2.2	1.1	0.8
$\mu_{\rm top}$	1.7	2.3	1.2	2.6	1.8	0.9	0.6



Couplings: prod mode σ $^{(|yH|<2.5)}$ × BR(H→γγ)

Process ($\lvert y_H \rvert < 2.5$)	Result	Uncertainty Total	Stat.	Exp.	Theo.	SM prediction
$\sigma_{\mathrm{VBF}}/\sigma_{\mathrm{ggH}}$	0.20	$^{+0.10}_{-0.07}$	$\left(^{+0.09}_{-0.06}\right.$	$^{+0.04}_{-0.02}$	$\left.^{+0.04}_{-0.02}\right)$	$0.078^{+0.005}_{-0.006}$
$\sigma_{\mathrm{VH}}/\sigma_{\mathrm{ggH}}$	0.04	$^{+0.06}_{-0.05}$	$\left(^{+0.06}_{-0.04}\right.$	$^{+0.01}_{-0.01}$	$\left.^{+0.01}_{-0.01}\right)$	$0.045^{+0.004}_{-0.005}$
$\sigma_{\mathrm{top}}/\sigma_{\mathrm{ggH}}$	0.009	$^{+0.010}_{-0.009}$	$\left(^{+0.010}_{-0.009}\right.$	$^{+0.002}_{-0.001}$	$\left.^{+0.002}_{-0.001}\right)$	$0.012^{+0.001}_{-0.002}$

$$\frac{\sigma_{\mathrm{VBF}}/\sigma_{\mathrm{ggH}}}{(\sigma_{\mathrm{VBF}}/\sigma_{\mathrm{ggH}})^{\mathrm{SM}}} = 2.5\ ^{+1.3}_{-0.9} = 2.5\ ^{+1.1}_{-0.8}\,(\mathrm{stat.})\ ^{+0.5}_{-0.3}\,(\mathrm{exp.})\ ^{+0.5}_{-0.3}\,(\mathrm{theo.})$$

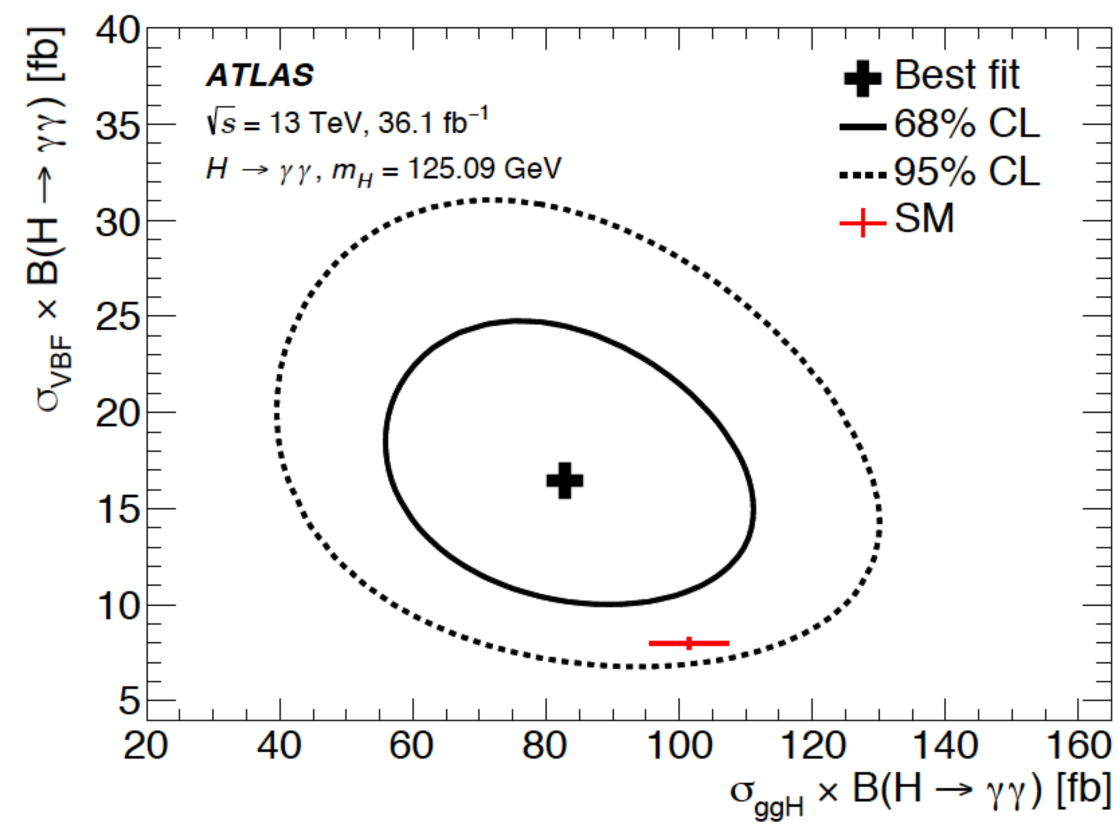
$$\frac{\sigma_{\mathrm{VH}}/\sigma_{\mathrm{ggH}}}{(\sigma_{\mathrm{VH}}/\sigma_{\mathrm{ggH}})^{\mathrm{SM}}} = 0.9\ ^{+1.3}_{-1.0} = 0.9\ ^{+1.2}_{-0.9}\,(\mathrm{stat.})\ ^{+0.3}_{-0.3}\,(\mathrm{exp.})\ ^{+0.2}_{-0.1}\,(\mathrm{theo.})$$

$$\frac{\sigma_{\mathrm{top}}/\sigma_{\mathrm{ggH}}}{(\sigma_{\mathrm{top}}/\sigma_{\mathrm{ggH}})^{\mathrm{SM}}} = 0.7\ ^{+0.8}_{-0.7} = 0.7\ ^{+0.8}_{-0.7}\,(\mathrm{stat.})\ ^{+0.2}_{-0.1}\,(\mathrm{exp.})\ ^{+0.2}_{-0.0}\,(\mathrm{theo.})$$

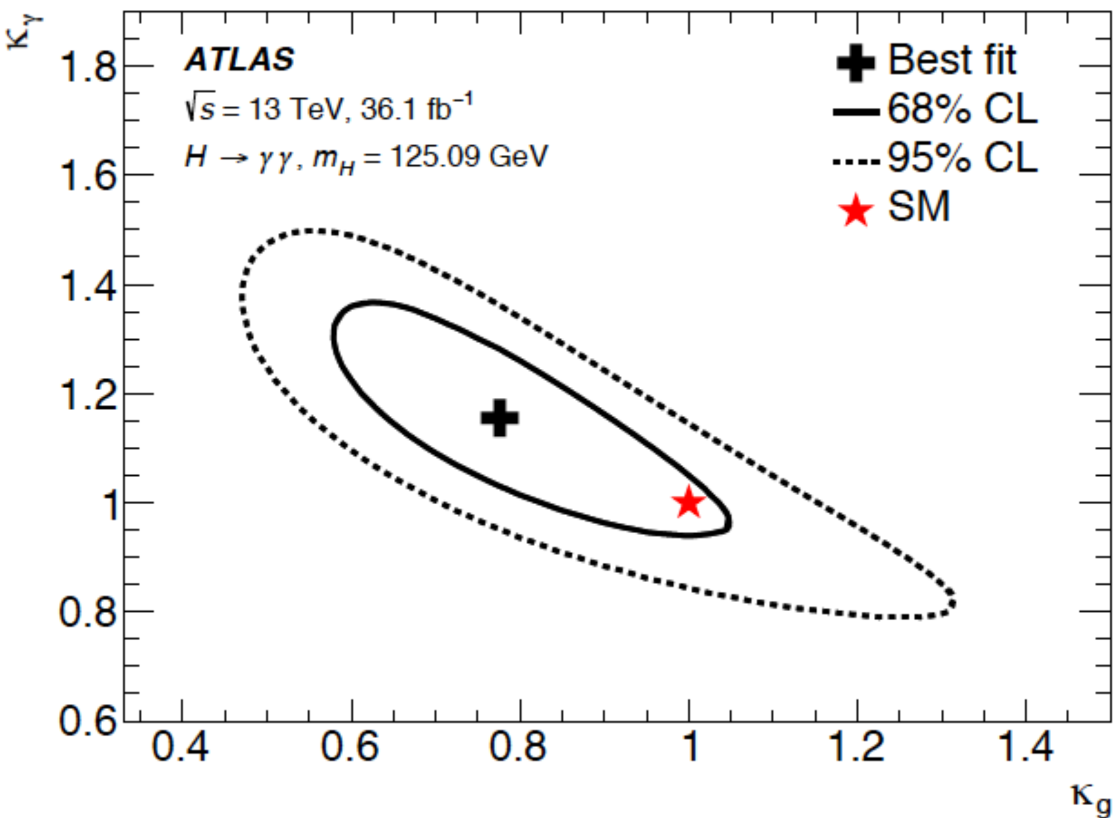
Couplings: ratios

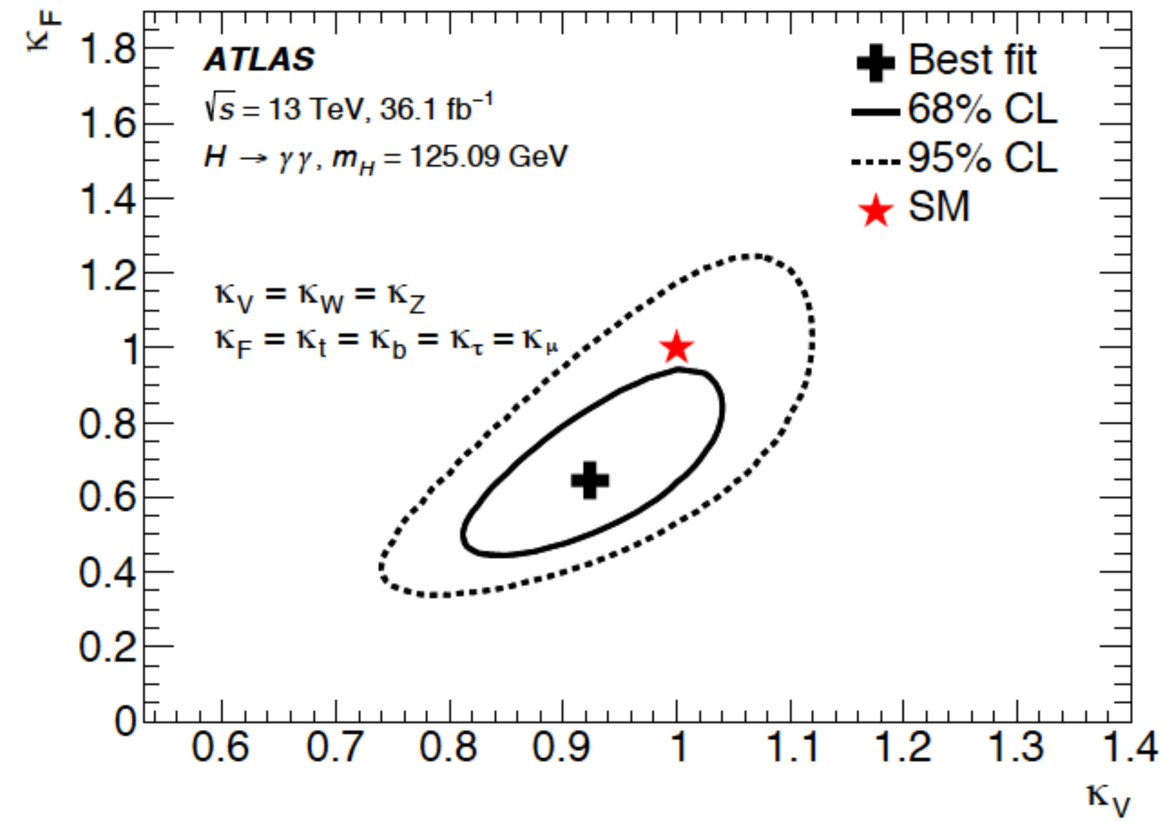
Table 9: Best-fit values and uncertainties of the production-mode cross sections times branching ratio. The SM predictions [7] with their uncertainties are shown for each production process. Uncertainties smaller than 0.05 are displayed as 0.0.

Process ($\|y_H\| < 2.5$)	Result [fb]	Total	Stat.	Exp.	Theo.	SM prediction [fb]
ggH	82	$^{+19}_{-18}$	± 16	$^{+7}_{-6}$	$^{+5}_{-4}$	102^{+5}_{-7}
VBF	16	$^{+5}_{-4}$	± 4	± 2	$^{+3}_{-2}$	8.0 ± 0.2
VH	3	± 4	$^{+4}_{-3}$	± 1	$^{+1}_{-0}$	4.5 ± 0.2
Top	0.7	$^{+0.9}_{-0.7}$	$^{+0.8}_{-0.7}$	$^{+0.2}_{-0.1}$	$^{+0.2}_{-0.0}$	1.3 ± 0.1

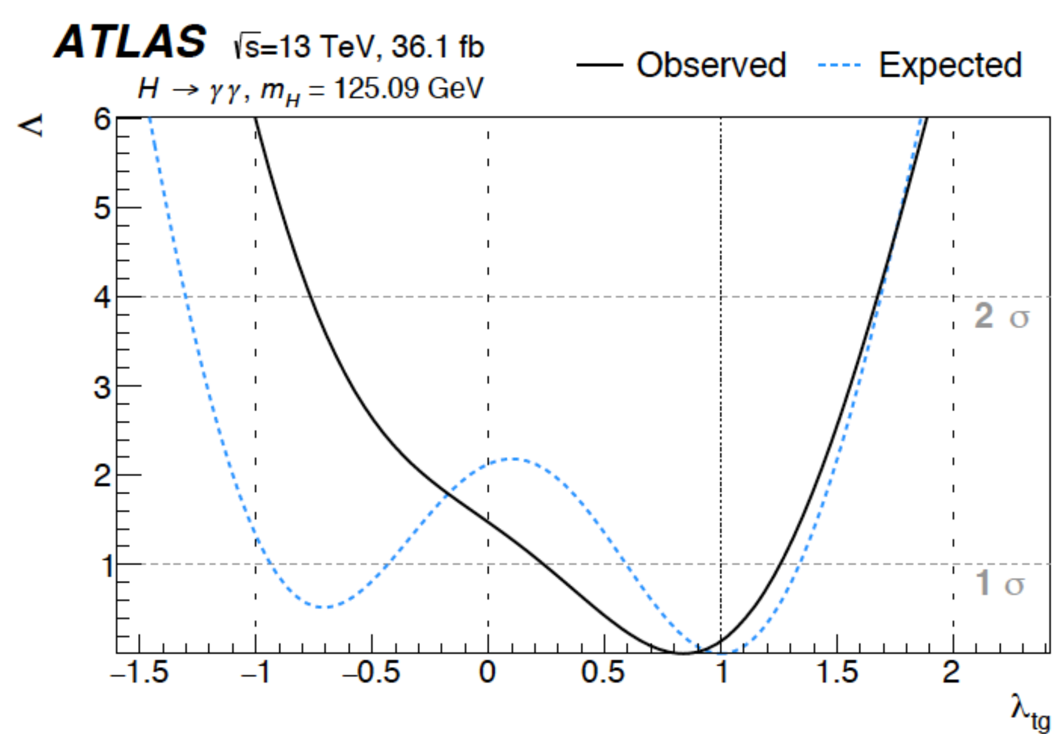


Couplings: kappa framework





Parameter	Result	Uncertainty: Total	Stat.	Exp.	Theo.
$\kappa_{g\gamma}$	0.90	± 0.10	± 0.09	± 0.04	$^{+0.04}_{-0.03}$
λ_{Vg}	1.41	$^{+0.31}_{-0.26}$	$^{+0.28}_{-0.23}$	$^{+0.10}_{-0.07}$	$^{+0.04}_{-0.03}$
λ_{tg}	0.8	$^{+0.4}_{-0.6}$	$^{+0.4}_{-0.6}$	± 0.1	$^{+0.1}_{-0.0}$



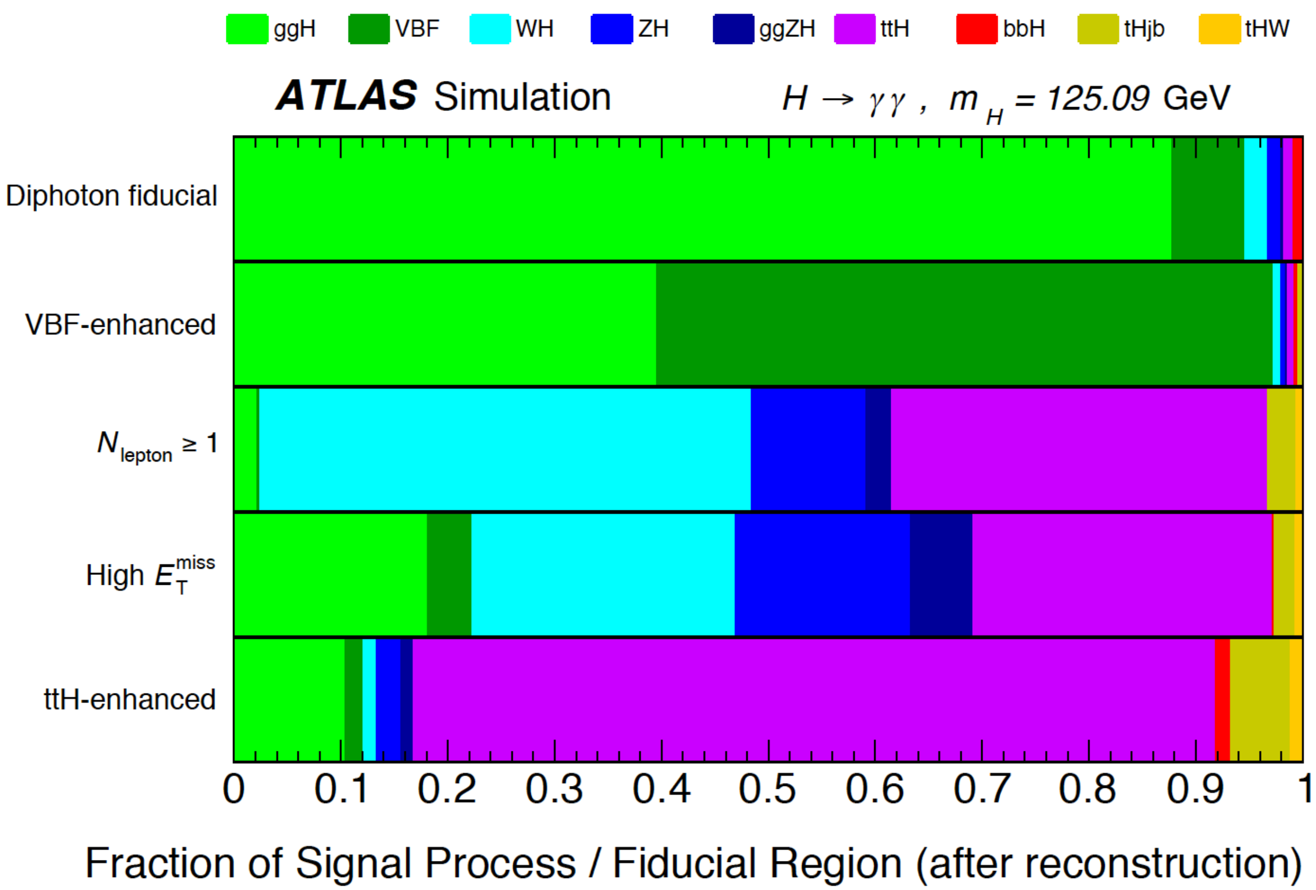
Fiducial Cross Sections

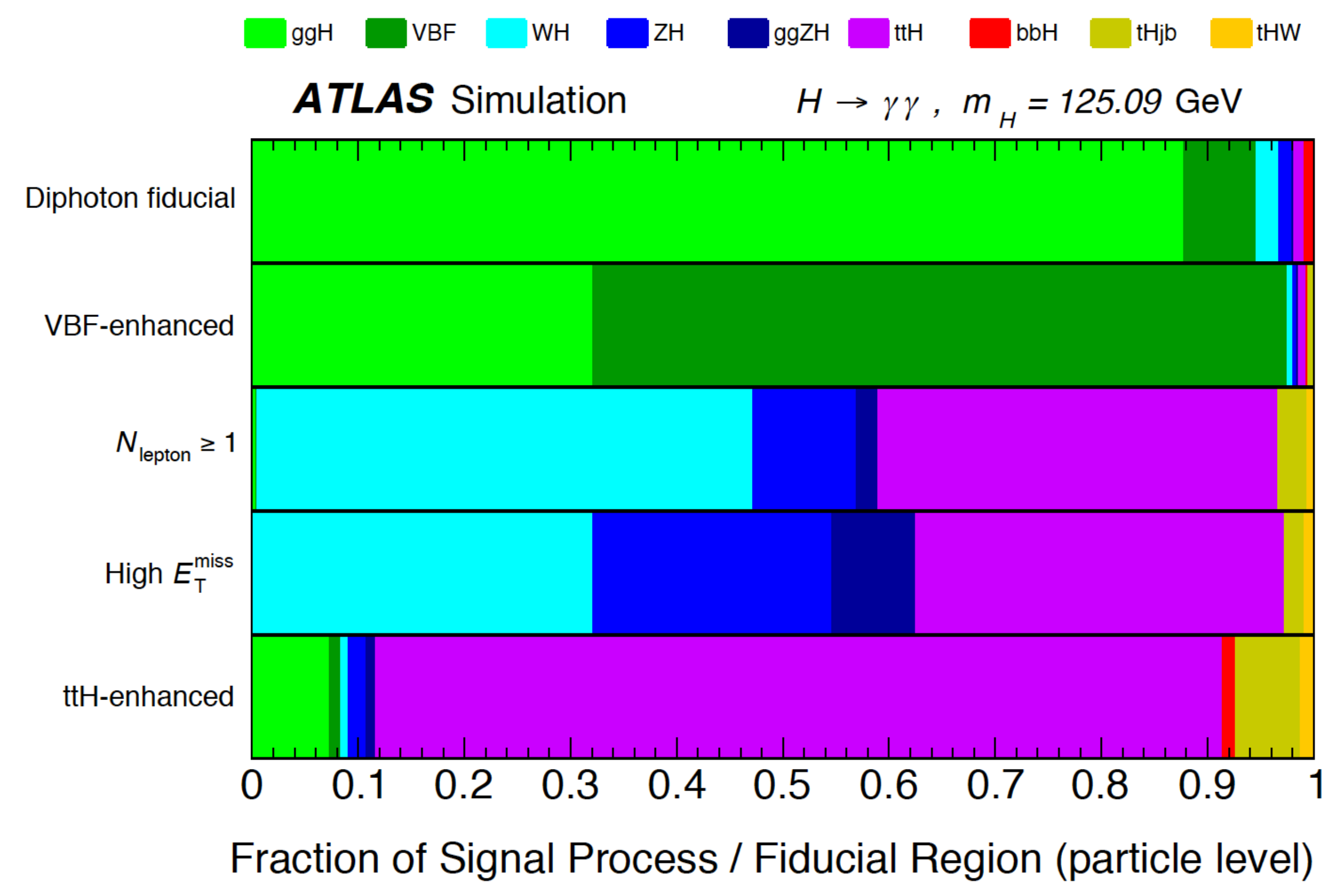
Table 14: Summary of the particle-level definitions of the five fiducial integrated regions described in the text. The photon isolation $p_T^{iso,0.2}$ is defined analogously to the reconstructed-level track isolation as the transverse momentum of the system of charged particles within $\Delta R < 0.2$ of the photon.

Objects	Definition
Photons	$\lvert\eta\rvert < 1.37$ or $1.52 < \lvert\eta\rvert < 2.37$, $p_T^{iso,0.2}/p_T^{\gamma} < 0.05$
Jets	anti-k_t, $R = 0.4$, $p_T > 30$ GeV, $\lvert y\rvert < 4.4$
Leptons, ℓ	e or μ, $p_T > 15$ GeV, $\lvert\eta\rvert < 2.47$ for e (excluding $1.37 < \lvert\eta\rvert < 1.52$) and $\lvert\eta\rvert < 2.7$ for μ
Fiducial region	**Definition**
Diphoton fiducial	$N_\gamma \geq 2$, $p_T^{\gamma_1} > 0.35\, m_{\gamma\gamma} = 43.8$ GeV, $p_T^{\gamma_2} > 0.25\, m_{\gamma\gamma} = 31.3$ GeV
VBF-enhanced	Diphoton fiducial, $N_j \geq 2$ with $p_T^{jet} > 25$ GeV, $m_{jj} > 400$ GeV, $\lvert\Delta y_{jj}\rvert > 2.8$, $\lvert\Delta\phi_{\gamma\gamma,jj}\rvert > 2.6$
$N_{lepton} \geq 1$	Diphoton fiducial, $N_\ell \geq 1$
High E_T^{miss}	Diphoton fiducial, $E_T^{miss} > 80$ GeV, $p_T^{\gamma\gamma} > 80$ GeV
$t\bar{t}H$-enhanced	Diphoton fiducial, $(N_j \geq 4, N_{b\text{-jets}} \geq 1)$ or $(N_j \geq 3, N_{b\text{-jets}} \geq 1, N_\ell \geq 1)$

Fiducial region	Measured cross section	SM prediction	
Diphoton fiducial	55 ± 9 (stat.) ± 4 (exp.) ± 0.1 (theo.) fb	64 ± 2 fb	[N^{3}LO + XH]
VBF-enhanced	3.7 ± 0.8 (stat.) ± 0.5 (exp.) ± 0.2 (theo.) fb	2.3 ± 0.1 fb	[default MC + XH]
$N_{lepton} \geq 1$	≤ 1.39 fb 95% CL	0.57 ± 0.03 fb	[default MC + XH]
High E_T^{miss}	≤ 1.00 fb 95% CL	0.30 ± 0.02 fb	[default MC + XH]
$t\bar{t}H$-enhanced	≤ 1.27 fb 95% CL	0.55 ± 0.06 fb	[default MC + XH]

Fiducial Cross Sections

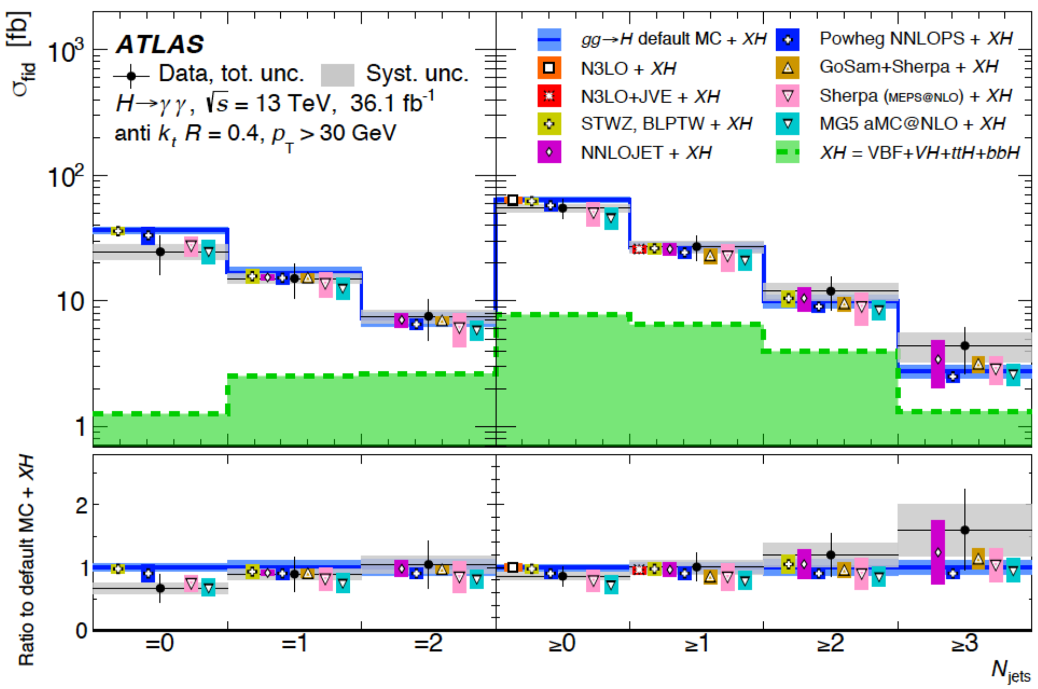


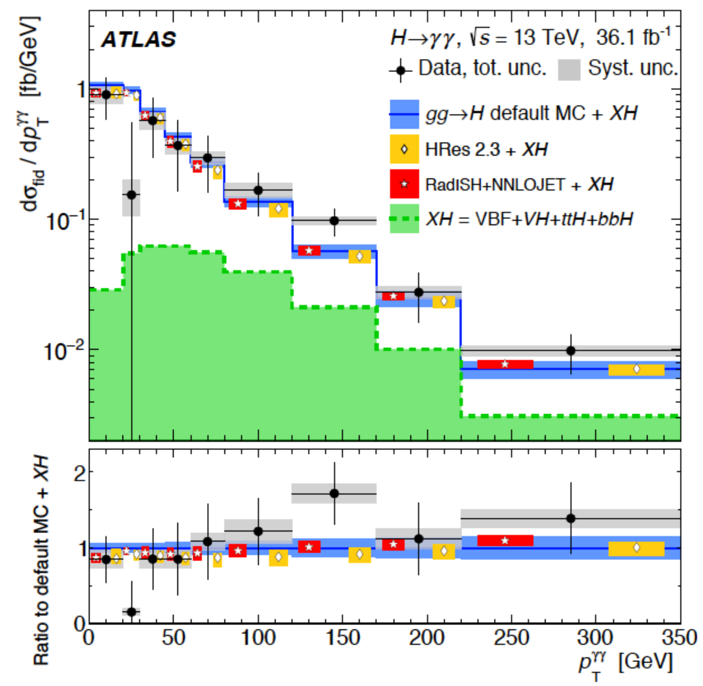


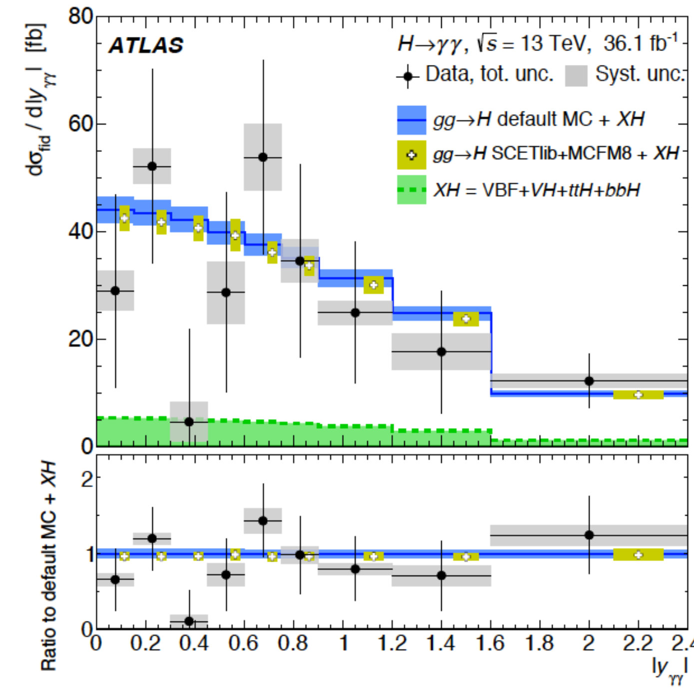
Detector level → ***Particle level***

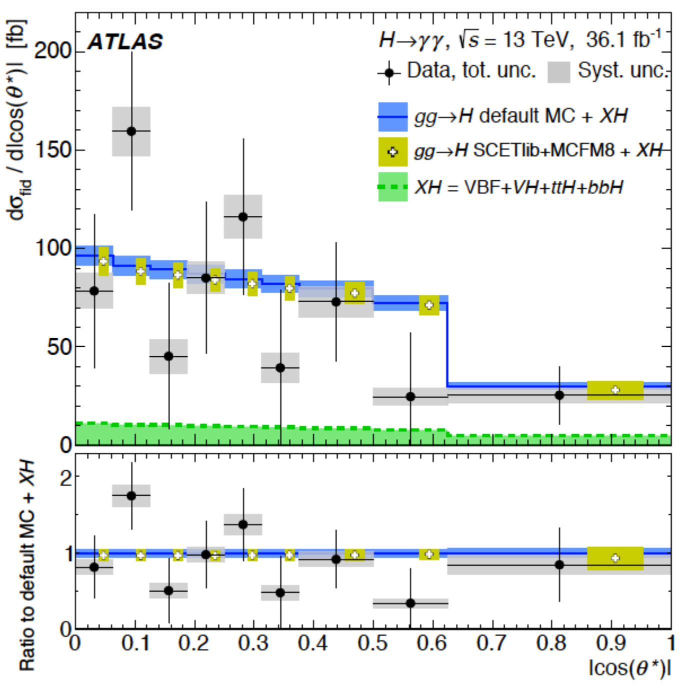
Differential Cross Sections

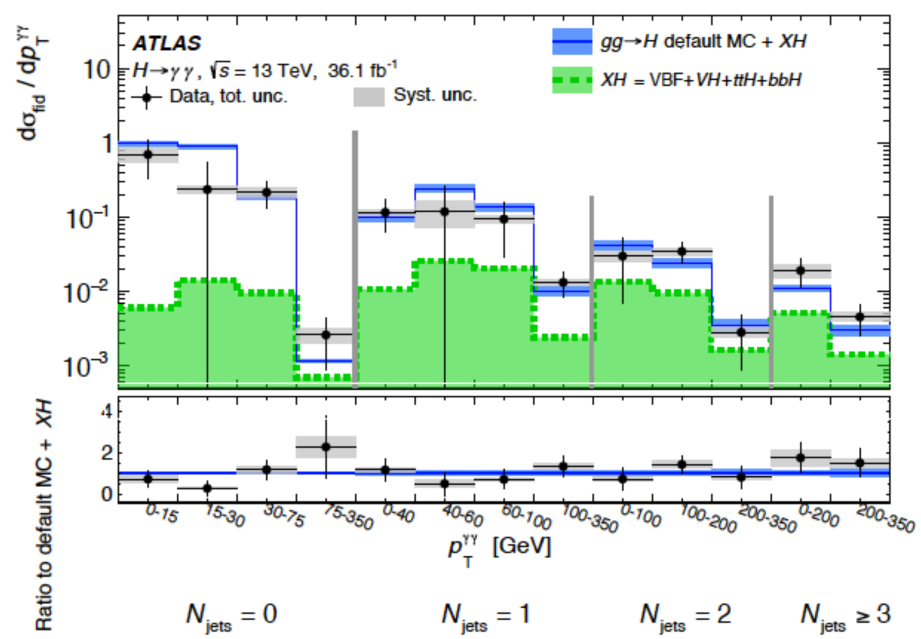
+ more in paper

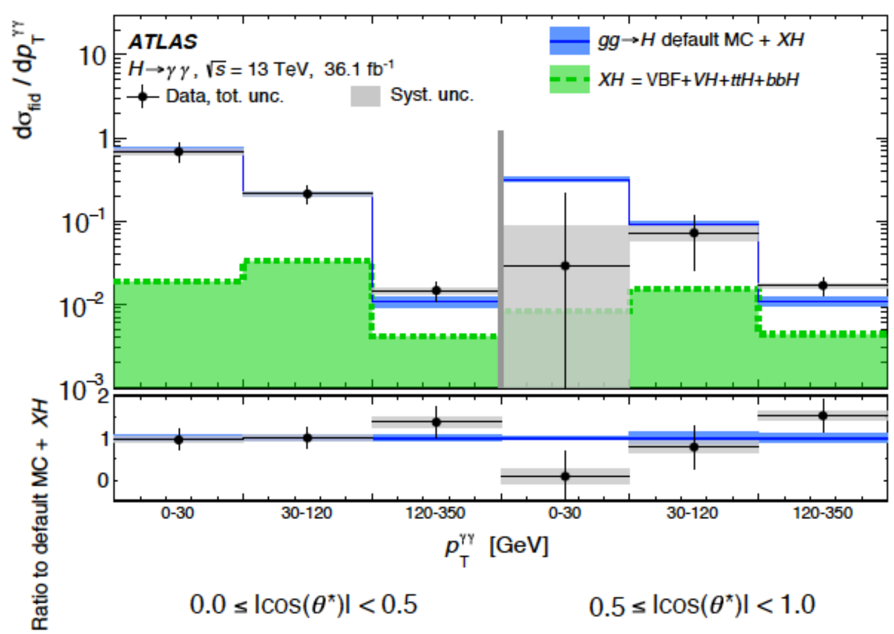






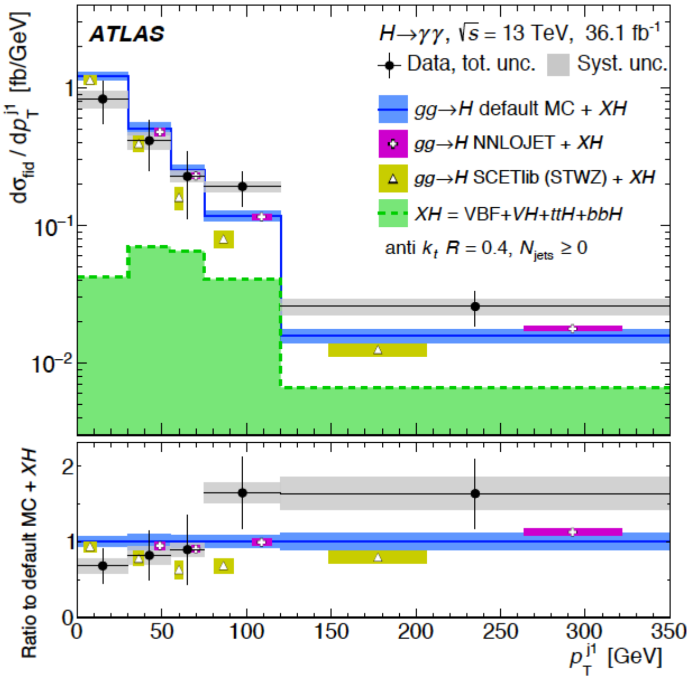


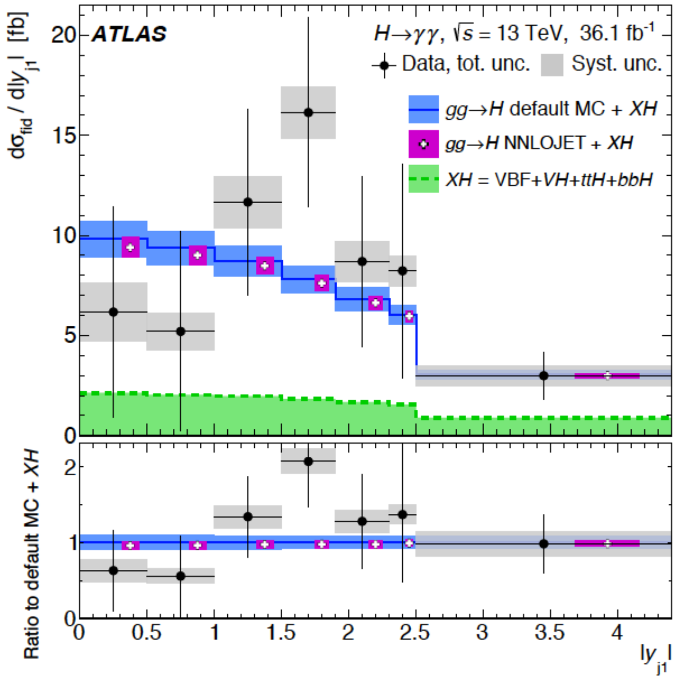


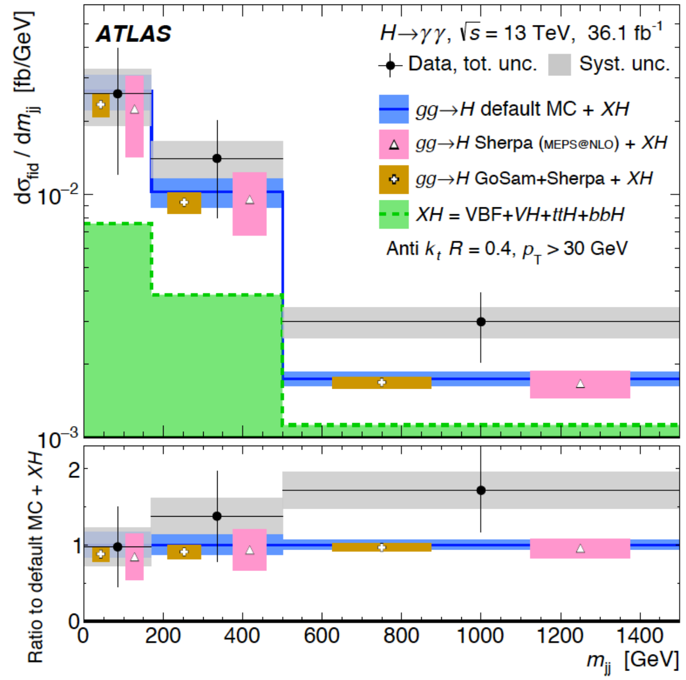


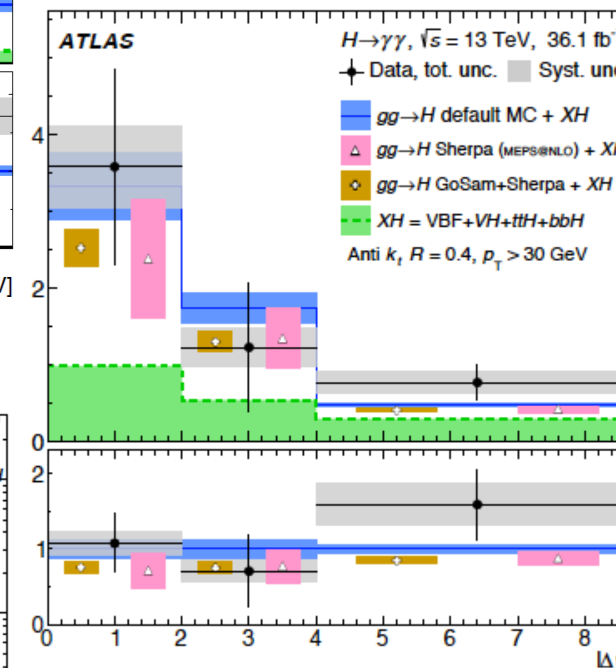
Differential Cross Sections

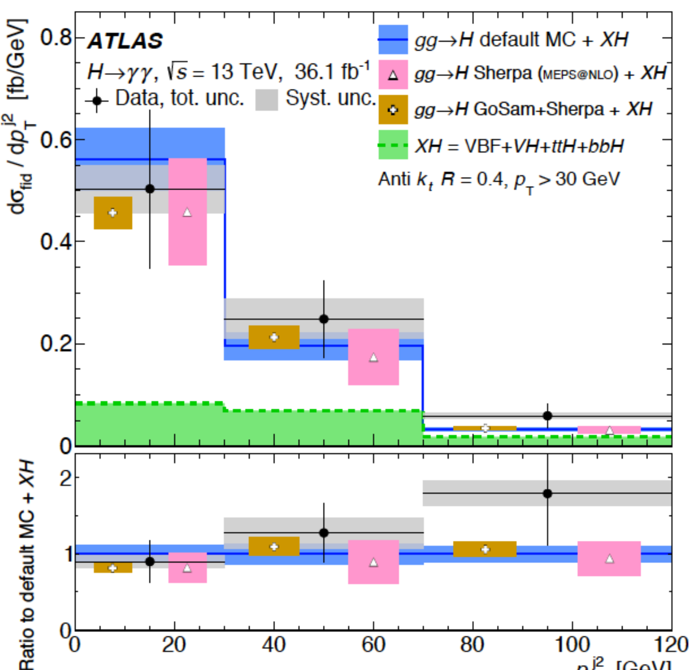
+ more in paper

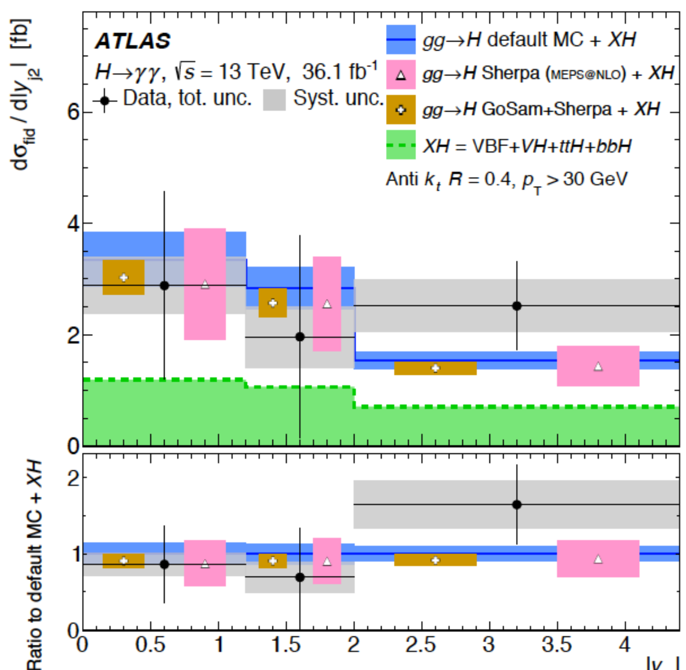


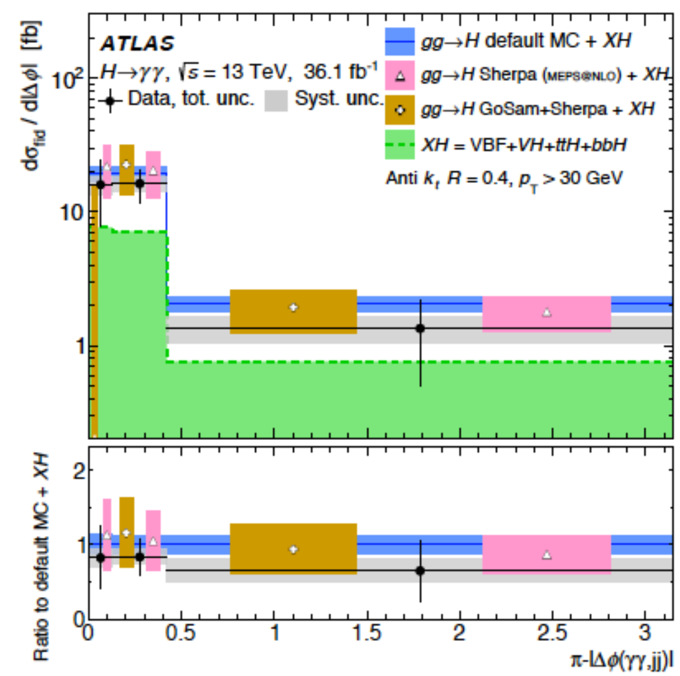












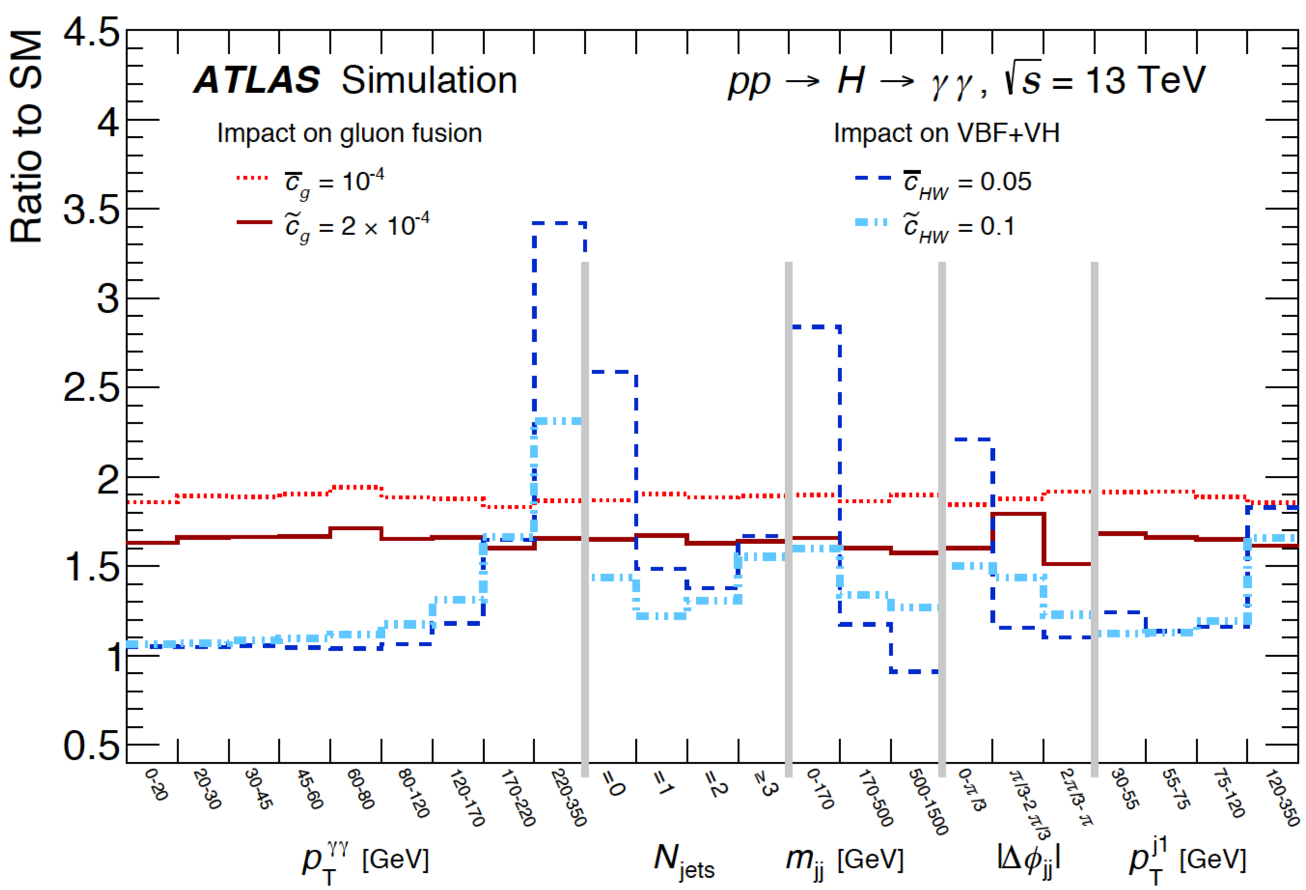
Note that SM VH predictions might need updating in some plots

EFT: overview

$$\mathcal{L}_{\text{eff}} = \bar{c}_g O_g + \bar{c}_{HW} O_{HW} + \bar{c}_{HB} O_{HB} + \tilde{c}_g \tilde{O}_g + \tilde{c}_{HW} \tilde{O}_{HW} + \tilde{c}_{HB} \tilde{O}_{HB}$$

Additional effective **CP-even** and **CP-odd** dimension 6 operators in SILH basis

O_g —> ggH (probe with ggH)
O_{HW} —> HWW, HZZ, HZγ
O_{HB} —> HZZ, HZγ (probe with VBF/VH)



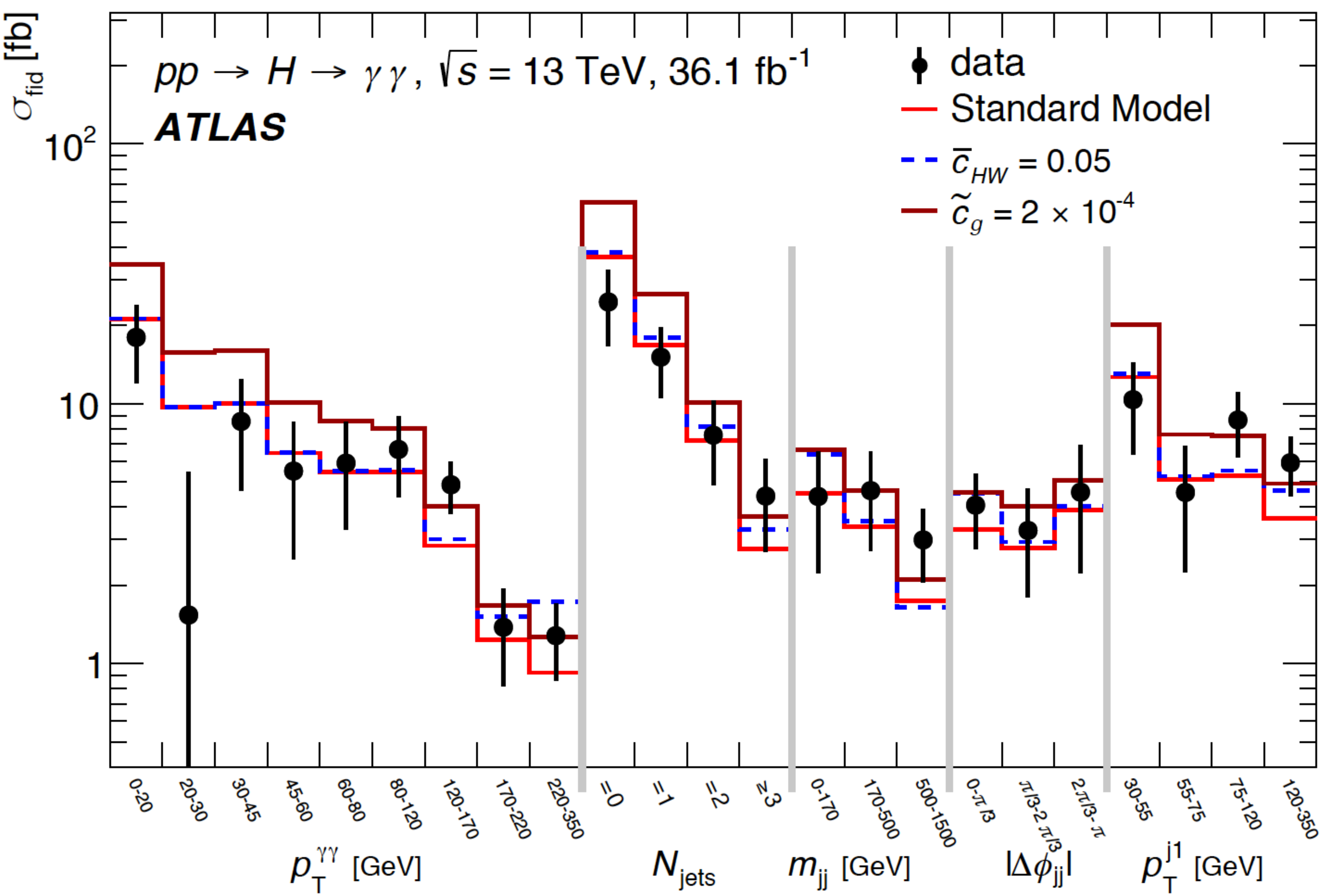
Operators are modulated by c_i and modify rate + shape of differential distributions

Construct templates for different c_i with FeynRules+MadGraph+Pythia8+Rivet and interpolate with Professor

Constrain c_i by maximising likelihood

$$\mathcal{L} = \frac{1}{\sqrt{(2\pi)^k |C|}} \exp\left(-\frac{1}{2}\left(\vec{\sigma}_{\text{data}} - \vec{\sigma}_{\text{pred}}\right)^T C^{-1} \left(\vec{\sigma}_{\text{data}} - \vec{\sigma}_{\text{pred}}\right)\right)$$

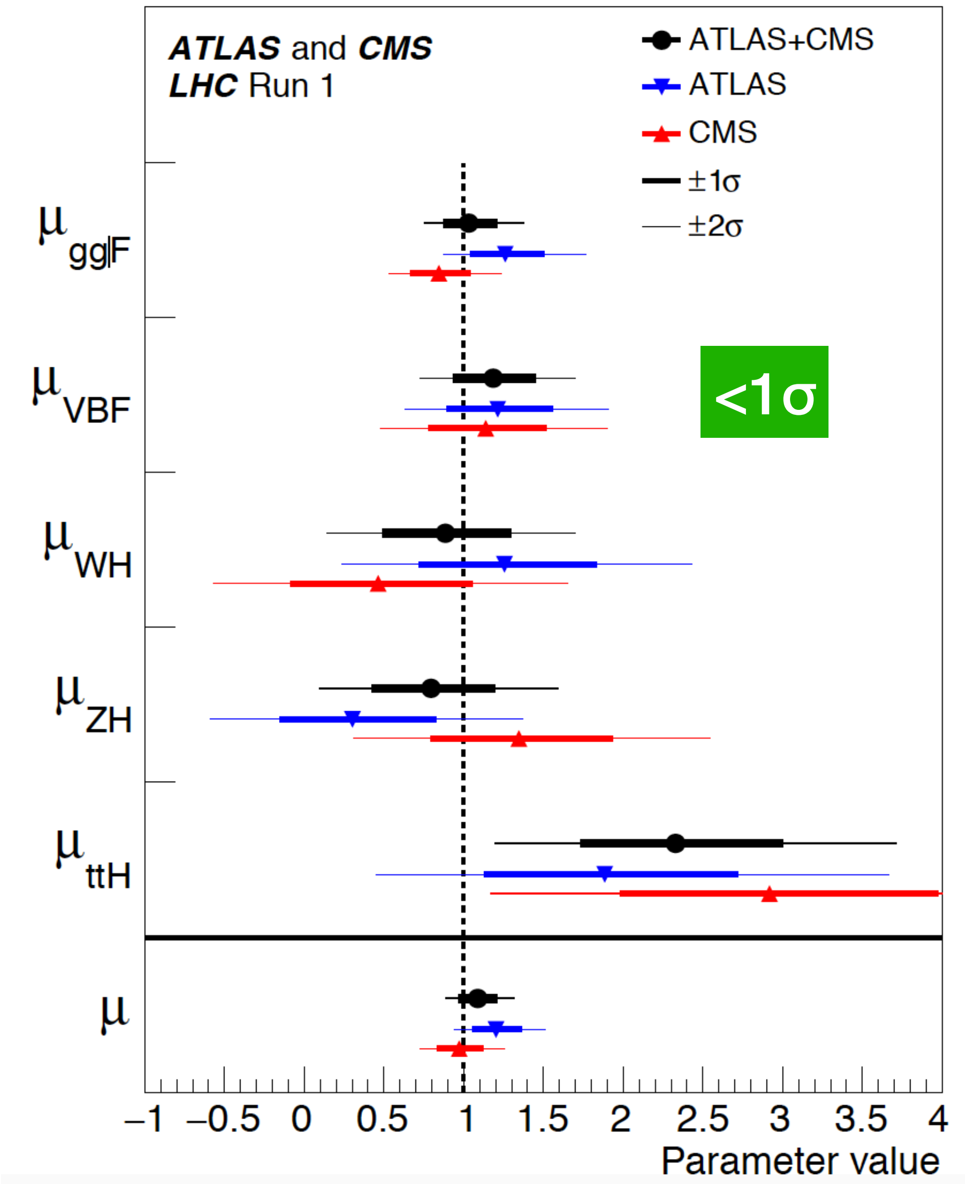
EFT: effect on shape



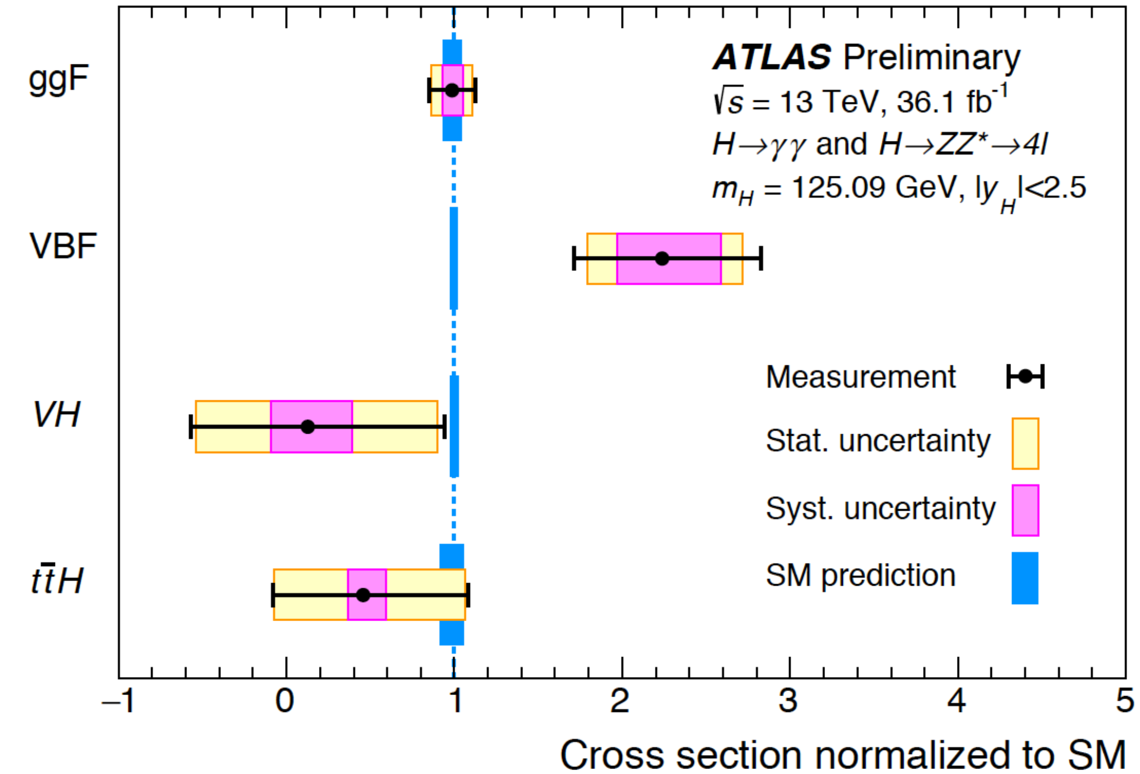
EFT: 1D scans

Coefficient	Observed 95% CL limit	Expected 95% CL limit
$\bar{c}_g$	$[-0.8, 0.1] \times 10^{-4} \cup [-4.6, -3.8] \times 10^{-4}$	$[-0.4, 0.5] \times 10^{-4} \cup [-4.9, -4.1] \times 10^{-4}$
$\tilde{c}_g$	$[-1.0, 0.9] \times 10^{-4}$	$[-1.4, 1.3] \times 10^{-4}$
$\bar{c}_{HW}$	$[-5.7, 5.1] \times 10^{-2}$	$[-5.0, 5.0] \times 10^{-2}$
$\tilde{c}_{HW}$	$[-0.16, 0.16]$	$[-0.14, 0.14]$

Signal strengths from elsewhere



<1σ



~2.4σ

Process ($\lvert y_H \rvert < 2.5$)	Result [pb]	Uncertainty [pb] Total	Stat.	Exp.	Th.	SM prediction [pb]
ggF	43.9	$^{+6.2}_{-6.0}$	($^{+5.5}_{-5.4}$	$^{+2.7}_{-2.3}$	± 1.2)	$44.5^{+2.0}_{-3.0}$
VBF	7.9	$^{+2.1}_{-1.8}$	($^{+1.7}_{-1.6}$	$^{+0.8}_{-0.6}$	$^{+1.0}_{-0.7}$)	$3.52^{+0.08}_{-0.07}$
VH	0.3	$^{+1.6}_{-1.4}$	($^{+1.5}_{-1.3}$	± 0.4	$^{+0.3}_{-0.2}$)	$1.99^{+0.06}_{-0.05}$
$t\bar{t}H$	0.27	$^{+0.37}_{-0.32}$	($^{+0.36}_{-0.31}$	$^{+0.06}_{-0.05}$	$^{+0.05}_{-0.02}$)	$0.59^{+0.03}_{-0.05}$

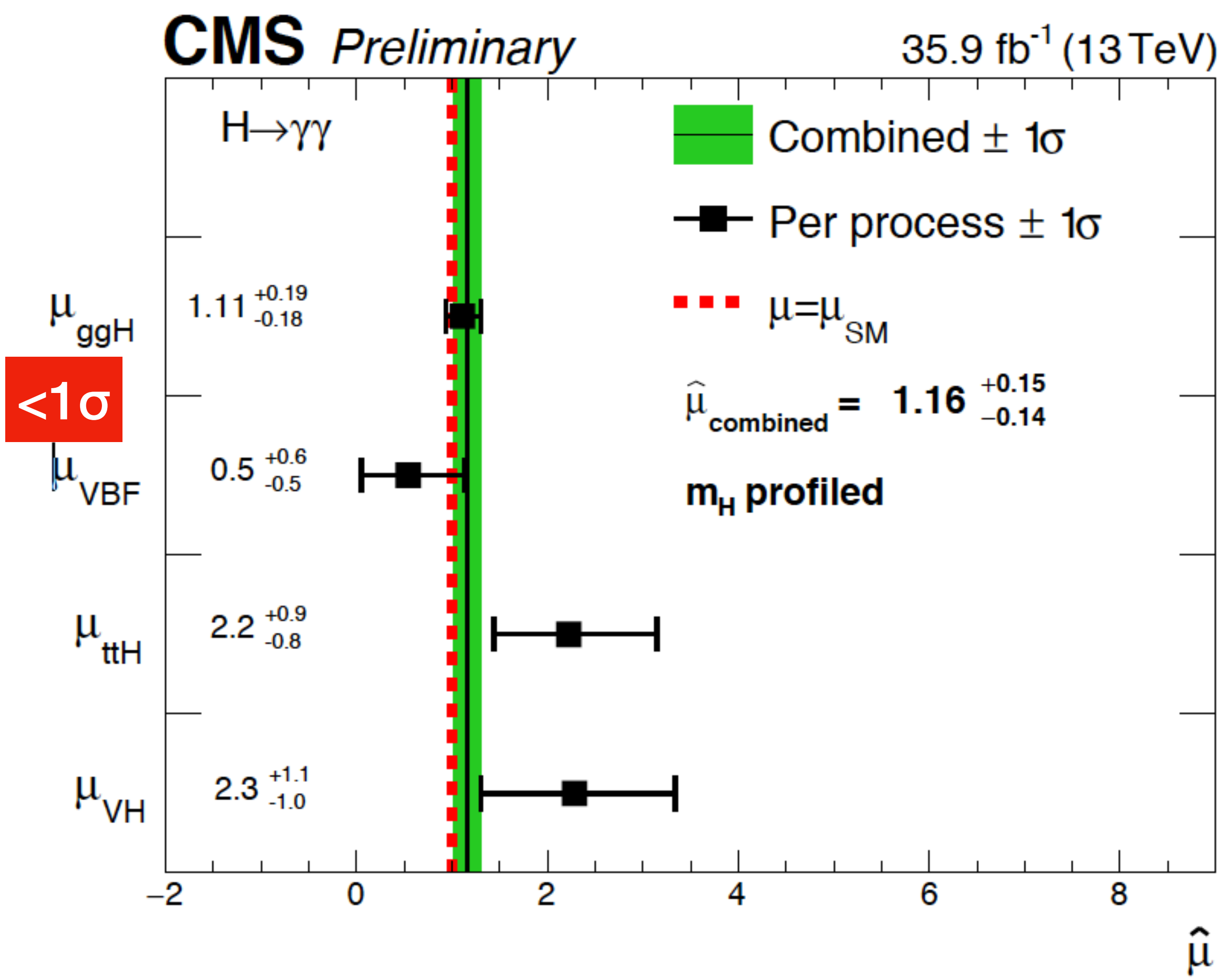
ATLAS + CMS Run-1

JHEP08(2016)045

ATLAS yy+4l Run-2

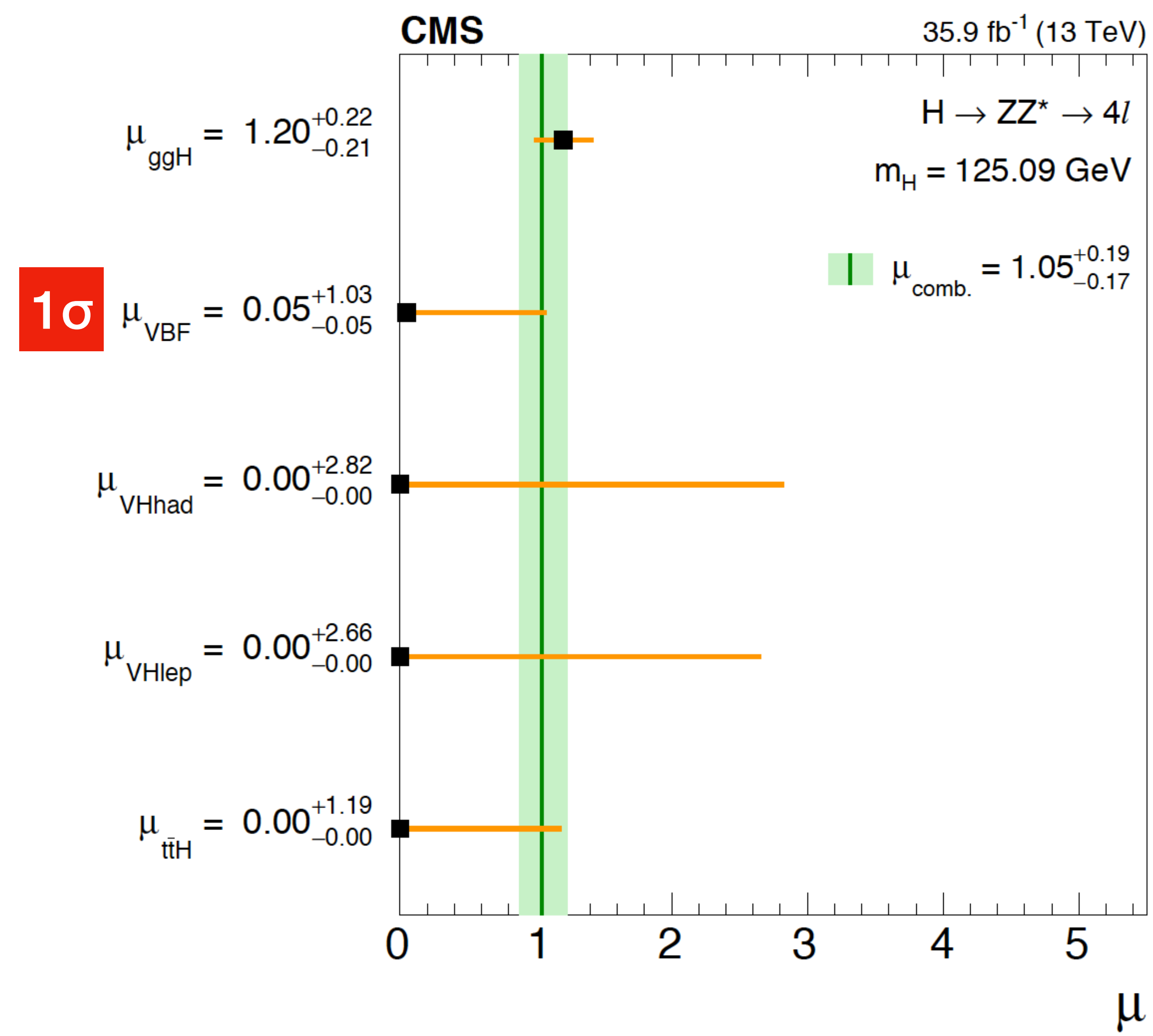
ATLAS-CONF-2017-047

Signal strengths from elsewhere



CMS γγ Run-2

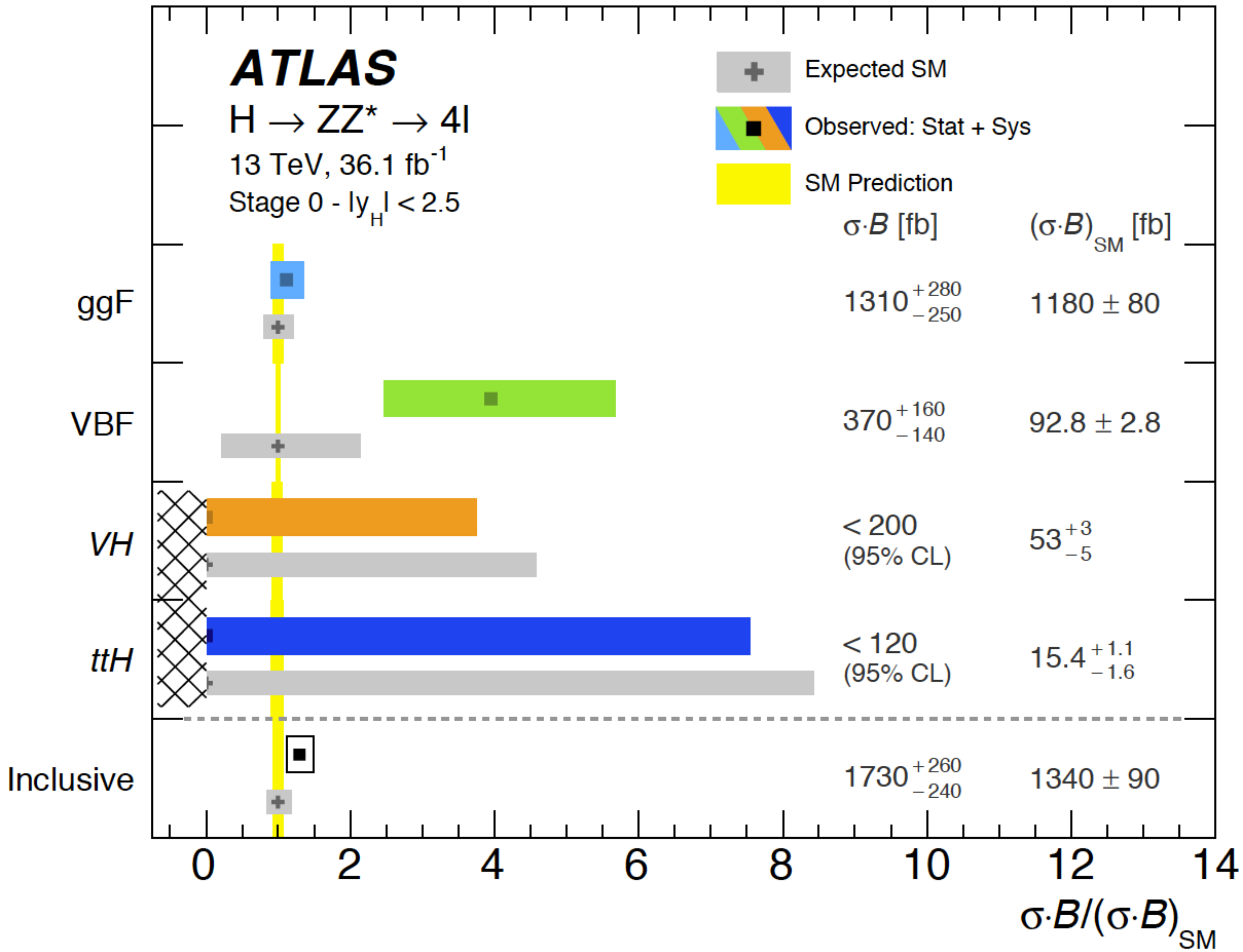
CMS PAS HIG-16-040



CMS 4l Run-2

CMS PAS HIG-16-041

Signal strengths from elsewhere



ATLAS 4l Run-2

arXiv:1712.02304