Fiducial rates and Distributions

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Fiducial Cross Sections

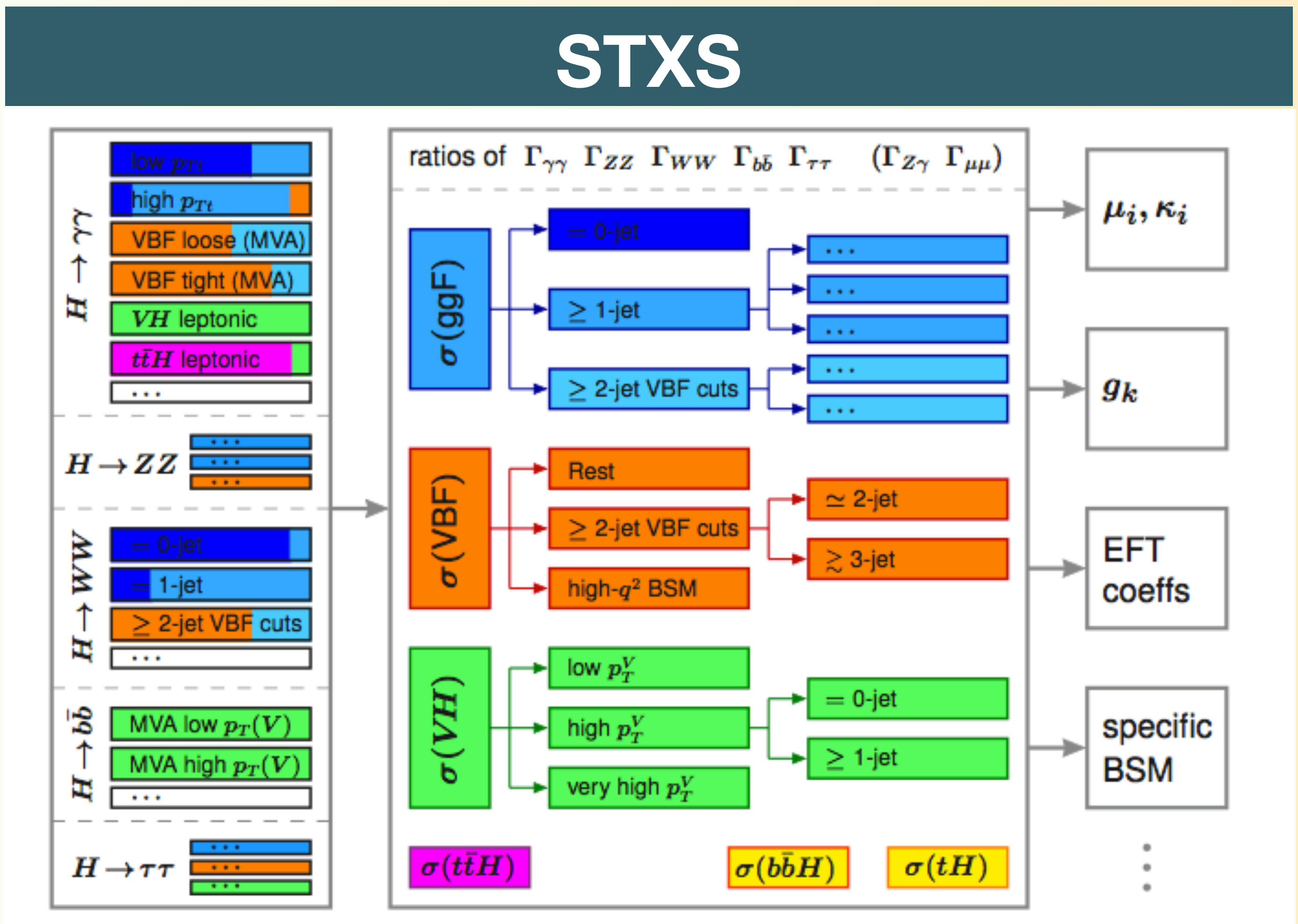
- Motivation: preserve measured results over years to allow comparison to future new theories

- Aim: achieve almost complete factorisation of theoretical and experimental uncertainties

Inclusive Cross Section	Fiducial Cross Section
the measurement, performed with limited acceptance, is extrapolated to the full phase space	the measurement is corrected only for reconstruction efficiencies and to revert resolution effects and migrations inside and outside the fiducial region
to compare data to a new model the extrapolation would need to be repeated, involving de facto a repetition of the analysis	the comparison is defined within an experiment dependent fiducial volume of acceptance and phase space without repeating the analysis

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:



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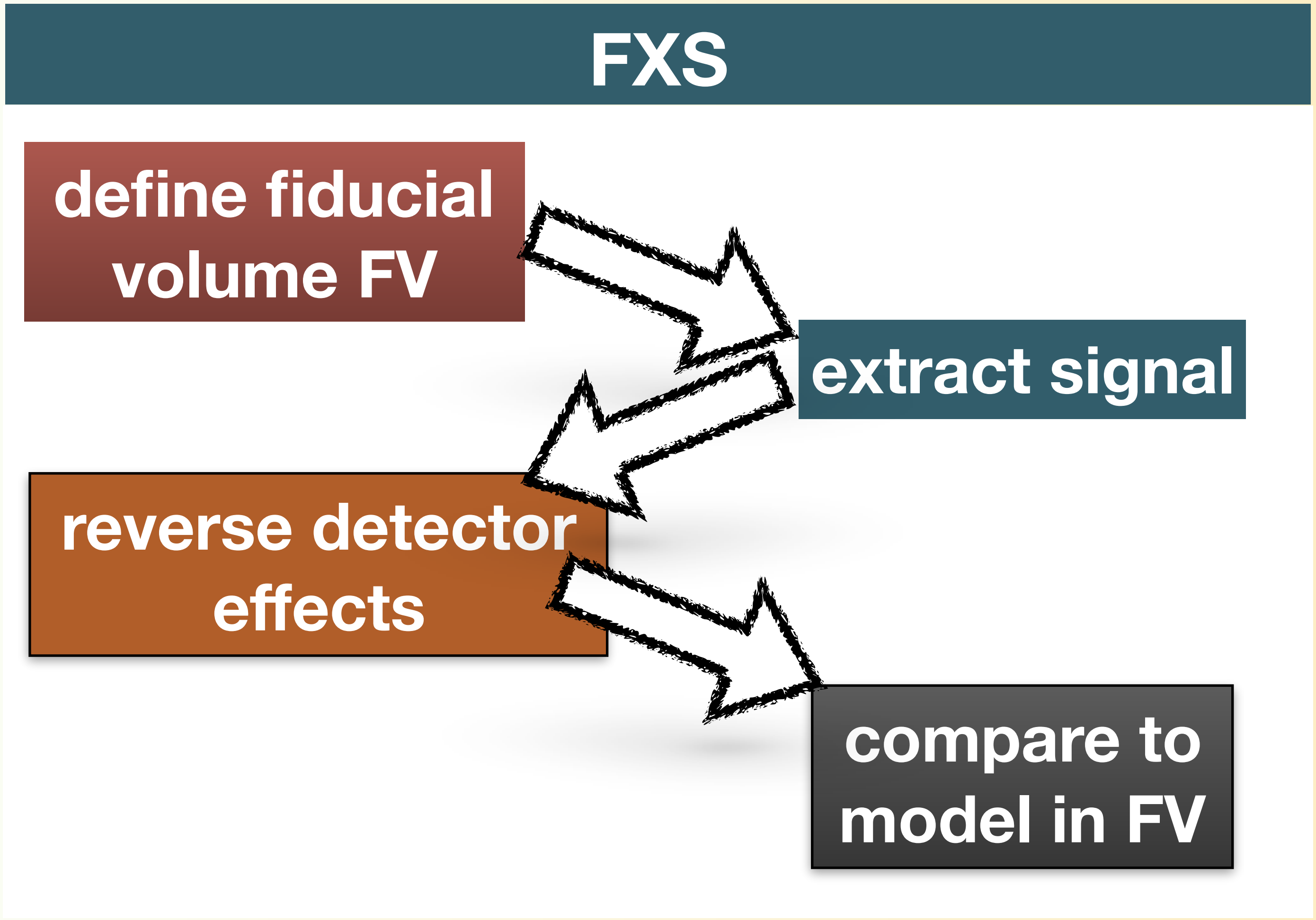
- partitioning of the phase space in terms of production processes
- singling out regions with different prospects in terms of theory uncertainty and regions with enhanced BSM sensitivity
- can use MV techniques extensively
- same binning adopted by the two experiments

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:



- easy to reproduce phase spaces
- no need to define orthogonal phase-spaces
- extraction of model independent quantities
- easy to collect results in persistent form (HepData, Rivet)
- No MV techniques

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:

FXS

Kinematics

Reconstruct p_T^H and $|y^H|$-sensitive distributions to probe QCD modelling and PDFs

- easy to reproduce phase-spaces
- no need to define orthogonal phase-spaces
- extraction of model independent quantities
- easy to collect results in persistent form (HepData, Rivet)
- No MV techniques

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:

FXS

Kinematics

Jet activity

jet multiplicity (N_{jet}), transverse momentum and rapidity distributions of the leading and subleading jets, sensitive to modelling and relative contributions of the different prod. mechanisms

- easy to reproduce phase-spaces
- no need to define orthogonal phase-spaces
- extraction of model independent quantities
- easy to collect results in persistent form (HepData, Rivet)
- No MV techniques

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:

FXS

- Kinematics
- Jet activity
- Spin and CP

Angular observables, reconstructed from decay kinematics or from the two leading jets are sensitive to the spin and charge conjugation and parity properties of the Higgs boson

- easy to reproduce phase-spaces
- no need to define orthogonal phase-spaces
- extraction of model independent quantities
- easy to collect results in persistent form (HepData, Rivet)
- No MV techniques

Differential & Fiducial Cross Sections vs STXS

An alternative approach to explore the properties of the Higgs boson wrt the STXS one:

FXS

Kinematics

Jet activity

Spin and CP

Prod. mechanism

Selections can be used to enrich the sample in specific production processes

- easy to reproduce phase-spaces
- no need to define orthogonal phase-spaces
- extraction of model independent quantities
- easy to collect results in persistent form (HepData, Rivet)
- No MV techniques

Definition of the fiducial phase space

the measured cross-sections are unfolded to the particle level:

- the fiducial volume is defined to be as close as possible to the experimental one, to minimise the corrections in order to ensure minimal model dependence in the final results
- its definition should have as little impact as possible on the phase space available for BSM searches
- detector acceptance, trigger thresholds and analysis cuts are applied at particle level to stable particles
- leptons and photons are identified using an isolation criterion which can be mimicked at particle level. Leptons are “dressed” with FSR
- jets are reconstructed with the anti-k_t algorithm from the individual stable particles, excluding neutrinos

Unfolding

- selection related efficiencies are reverted to extract fiducial cross-sections from fitted yields
- migrations due to finite resolution are reverted to extract fiducial rates and differential distributions from the measurement. Different approaches are possible:
  - inverting the migration matrix, $y=R_{ij}^{-1}\,x$ (reduces systematic bias, but gives larger statistical variance)
  - using bin-by-bin correction factors, $y_i=C_i\,x_i$ with $C_i=y_i^{MC}/x_i^{MC}$ (smaller stat. unc. but larger systematic bias)
  - using regularised unfolding
- contributions from reconstructed events ("nonfiducial signal") not originating from the fiducial phase space must be subtracted before unfolding

Template fiducial volumes (examples from YR4):

Table 113: Template fiducial cuts for the $H \to \gamma\gamma$ channel.

Fiducial region for $H \to \gamma\gamma$
Leading photon: $p_t/m_{\gamma\gamma} > 0.35$
Subleading photon: $p_t/m_{\gamma\gamma} > 0.25$
All photons are required to be isolated: ratio of the sum of E_t's of all charged particles within $\Delta R = [(\Delta\phi)^2 + (\Delta\eta)^2]^{1/2} < 0.2$ from the photon to the photon's E_t must be smaller than 0.2
Invariant mass cut: 105 GeV $\leq m_{\gamma\gamma} \leq 160$ GeV

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Table 112: Template fiducial cuts for the $H \to ZZ^* \to 4\ell$ channel.

Template fiducial region for $H \to ZZ^* \to 4\ell$
Leading lepton: $p_t > 20$ GeV
1^{st} subleading lepton: $p_t > 10$ GeV
2^{nd} subleading lepton: $p_t > 7\,(5)$ GeVfor electrons (muons)
3^{rd} subleading lepton: $p_t > 7\,(5)$ GeVfor electrons (muons)
All leptons are required to be isolated: ratio of the sum of p_t's of all charged particles within $\Delta R = [(\Delta\phi)^2 + (\Delta\eta)^2]^{1/2} < 0.4$ from the lepton to the lepton's p_t must be smaller than 0.4
Mass requirements: 40 GeV $\leq m_{12} \leq 120$ GeV; 12 GeV $\leq m_{34} \leq 120$ GeV
Lepton separation: $\Delta R(i,j) > 0.1$ for all leptons i, j
J/Ψ invariant mass veto: $m_{ij} > 4$ GeVfor all SFOS leptons i, j
Invariant mass cut: 120 GeV $\leq m_{4\ell} \leq 130$ GeV

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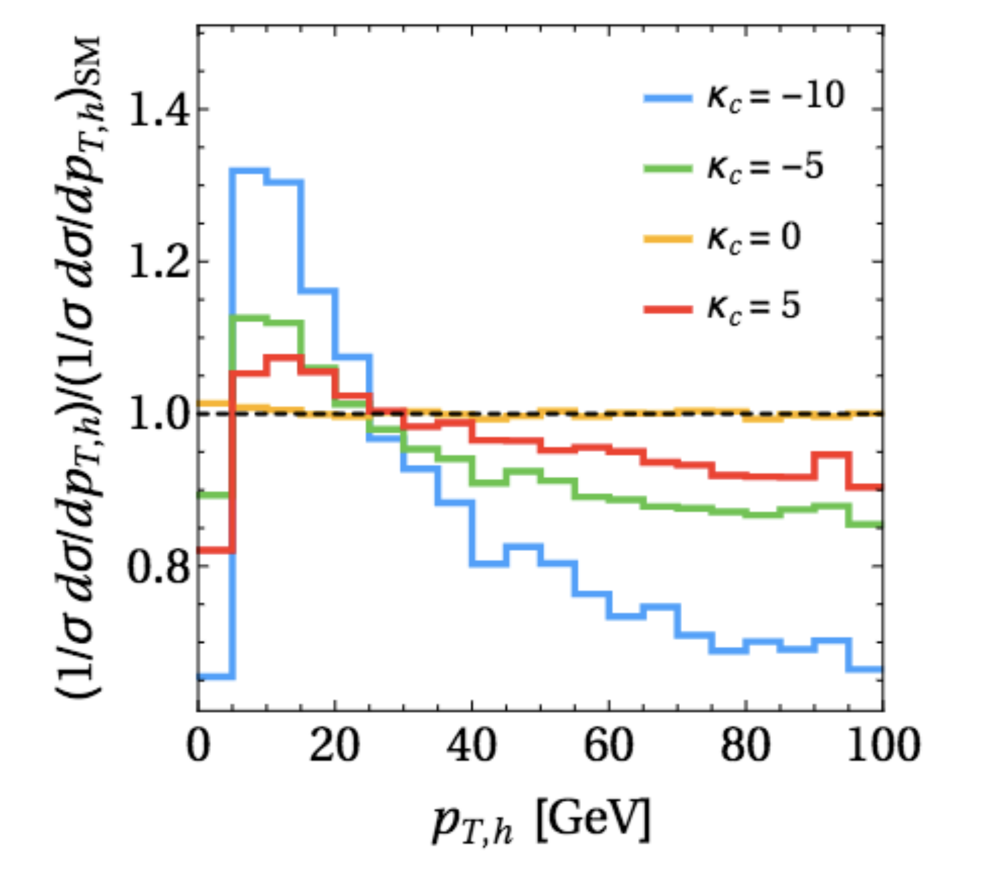
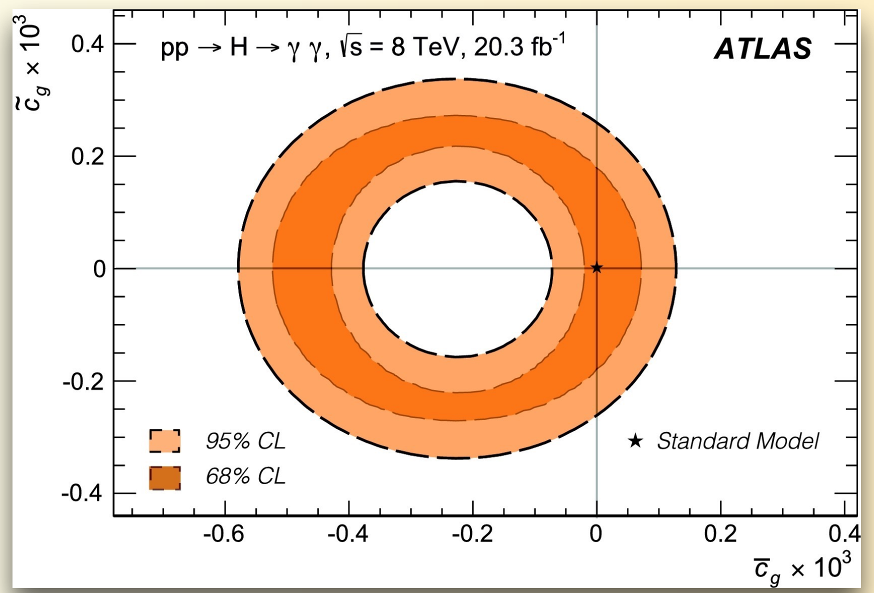
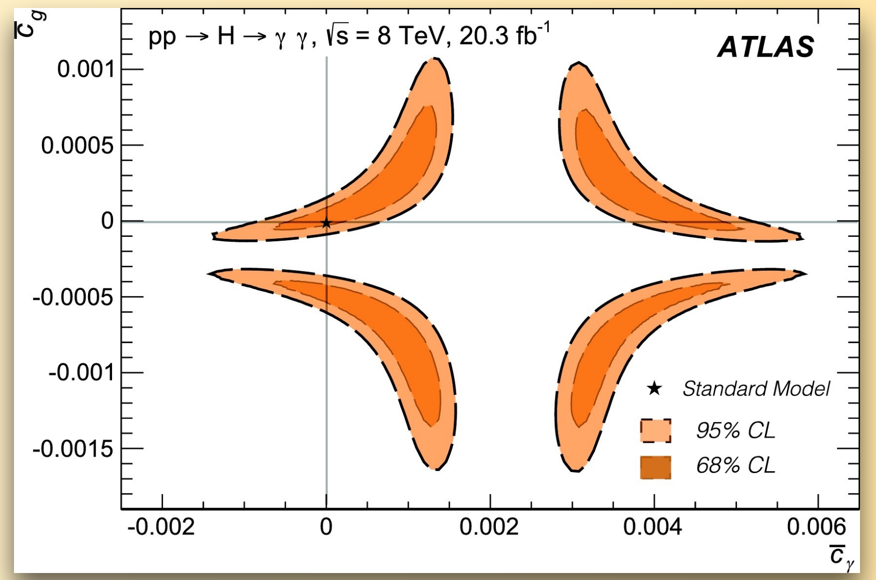
Jets reconstructed with the anti-k_t algorithm
with radius parameter 0.4
$p_t > 30$ GeV and |eta| <4.4

BSM

- global analyses of several distributions can probe BSM physics, either within a given BSM model or in an effective field theory
- example: charm quark Yukawa coupling effect on Higgs p_T distribution, Phys. Rev. Lett. 118, 121801 (2017) (Bishara, Haisch, Monni, Re)
- example: Wilson coefficients from ATLAS 8 TeV diphoton differential cross sections Phys. Lett. B753 (2016) 69







Overview of Run1 Fiducial and Differential measurements

reference	experiment	sqrt(s) [TeV]	decay channel	L_{int} [fb^{-1}]	HepData
JHEP 09 (2014) 112 (& Phys. Lett. B753 (2016) 69)	ATLAS	8	γγ	20.3	yes
Eur. Phys. J. C76 (2016) 13	CMS	8	γγ	19.7	soon
Phys. Lett. B738 (2014) 234 (& Phys. Lett. B753 (2016) 552)	ATLAS	8	4l	20.3	yes
JHEP 04 (2016) 005	CMS	7 & 8	4l	5.1+19.7	soon
★ JHEP 08 (2016) 104	ATLAS	8	WW	20.3	
★ JHEP 03 (2017) 032	CMS	8	WW	19.4	soon
Phys. Rev. Lett. 115, 091801 (2015)	ATLAS	8	γγ+4l *	20.3	

* requires extrapolation to the inclusive phase-space

★ in this presentation

Overview of Run2 Fiducial and Differential measurements

reference	experiment	sqrt(s) [TeV]	decay channel	L_{int} [fb^{-1}]	HepData
★ ATLAS-CONF-2017-045	ATLAS	13	γγ	36.1	
★ CMS PAS HIG-17-015	CMS	13	γγ	35.9	
★ arXiv:1708.02810	ATLAS	13	4l	36.1	
★ arXiv:1706.09936	CMS	13	4l	35.9	
ATLAS-CONF-2017-047	ATLAS	13	γγ+4l *	36.1	

* requires extrapolation to the inclusive phase-space

★ in this presentation

H to di-photon - Fiducial Cross Sections - Run 2

ATLAS-CONF-2017-045

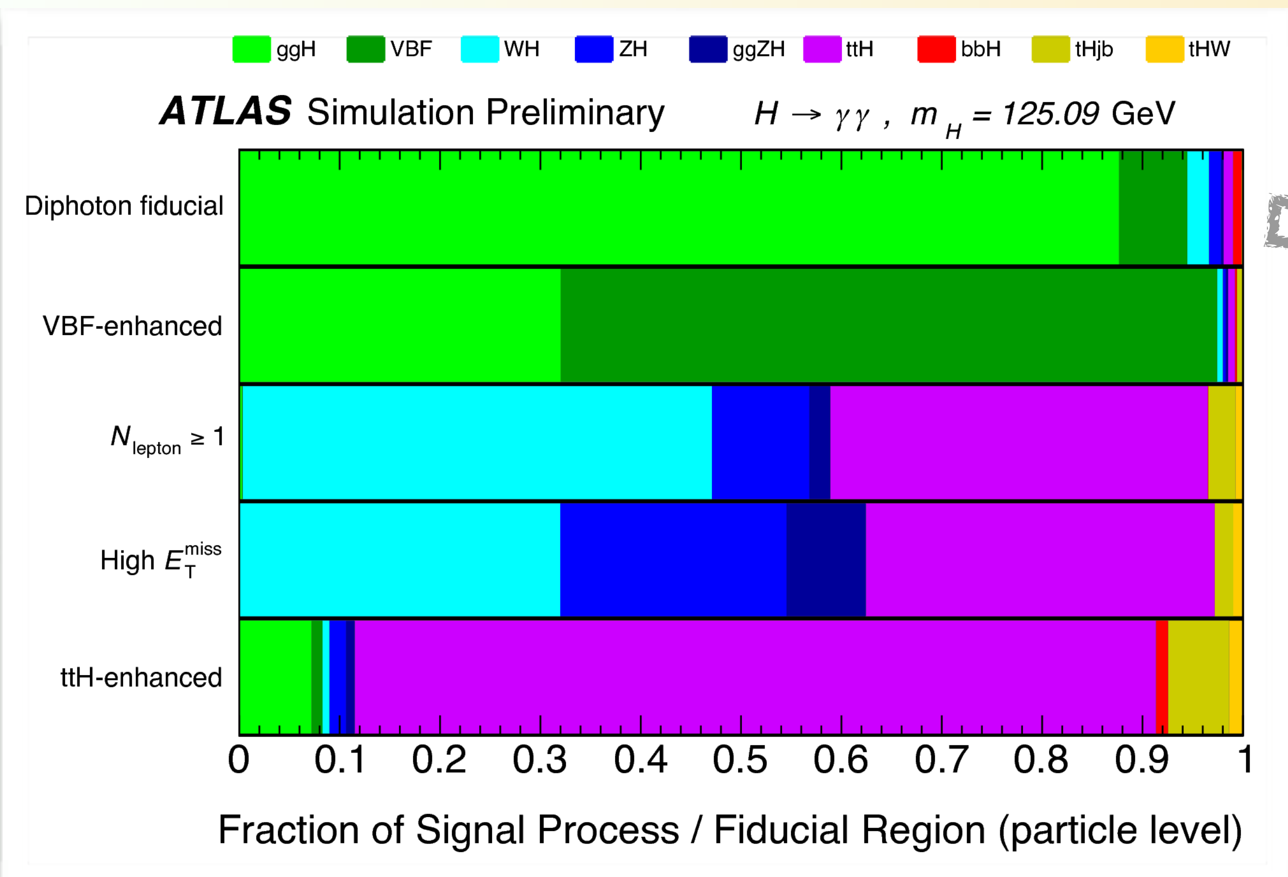
Classification enhancing the different production mechanisms

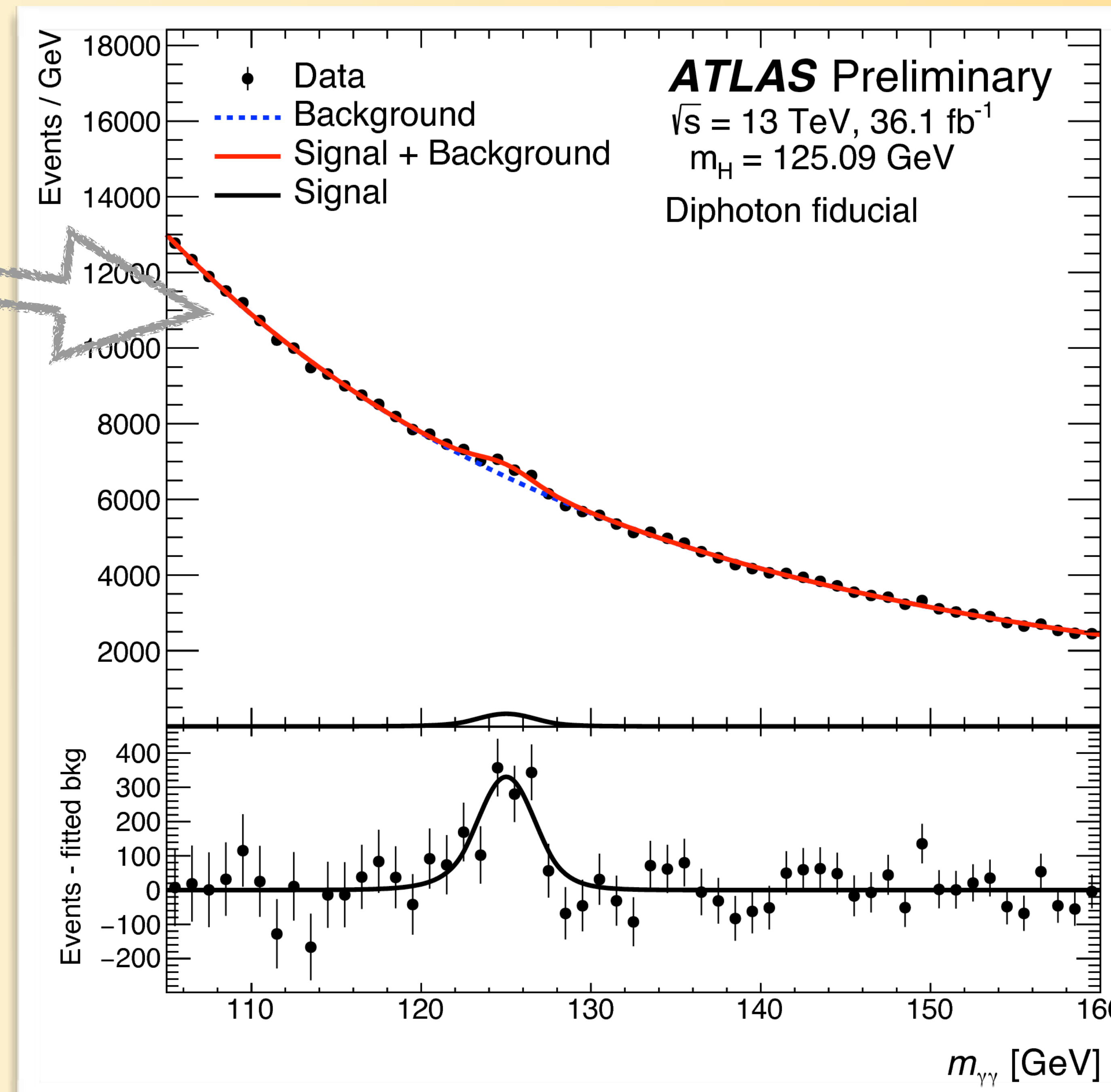
Objects	Definition
Photons	$\|\eta\| < 1.37$ OR $1.52 < \|\eta\| < 2.37$, $p_{\mathrm{T}}^{\mathrm{iso},0.2}/p_{\mathrm{T}}^{\gamma} < 0.05$
Jets	anti-k_t, $R = 0.4$, $p_{\mathrm{T}} > 30\,\mathrm{GeV}$, $\|y\| < 4.4$
Leptons, ℓ	e or μ, $p_{\mathrm{T}} > 15\,\mathrm{GeV}$, $\|\eta\| < 2.47$ (excluding $1.37 < \|\eta\| < 1.52$ for $\ell = e$)

Fiducial region	Definition
Diphoton fiducial	$N_{\gamma} \geq 2$, $p_{\mathrm{T}}^{\gamma_1} > 0.35\, m_{\gamma\gamma}$, $p_{\mathrm{T}}^{\gamma_2} > 0.25\, m_{\gamma\gamma}$
VBF-enhanced	Diphoton fiducial, $N_j \geq 2$, $m_{jj} > 400$ GeV, $\|\Delta y_{jj}\| > 2.8$, $\|\Delta\phi_{\gamma\gamma,jj}\| > 2.6$
$N_{\mathrm{lepton}} \geq 1$	Diphoton fiducial, $N_{\ell} \geq 1$
High $E_{\mathrm{T}}^{\mathrm{miss}}$	Diphoton fiducial, $E_{\mathrm{T}}^{\mathrm{miss}} > 80$ GeV, $p_{\mathrm{T}}^{\gamma\gamma} > 80$ GeV
$t\bar{t}H$-enhanced	Diphoton fiducial, $(N_j \geq 4,\, N_{\mathrm{b\text{-}jets}} \geq 1)$ OR $(N_j \geq 3,\, N_{\mathrm{b\text{-}jets}} \geq 1, N_{\ell} \geq 1)$

H to di-photon - Fiducial Cross Sections - Run 2

ATLAS-CONF-2017-045





H to di-photon - Fiducial Cross Sections - Run 2

CMS PAS HIG-17-015

fiducial region:

pT of the photons > 1/3 (1/4) of the di-photon mass

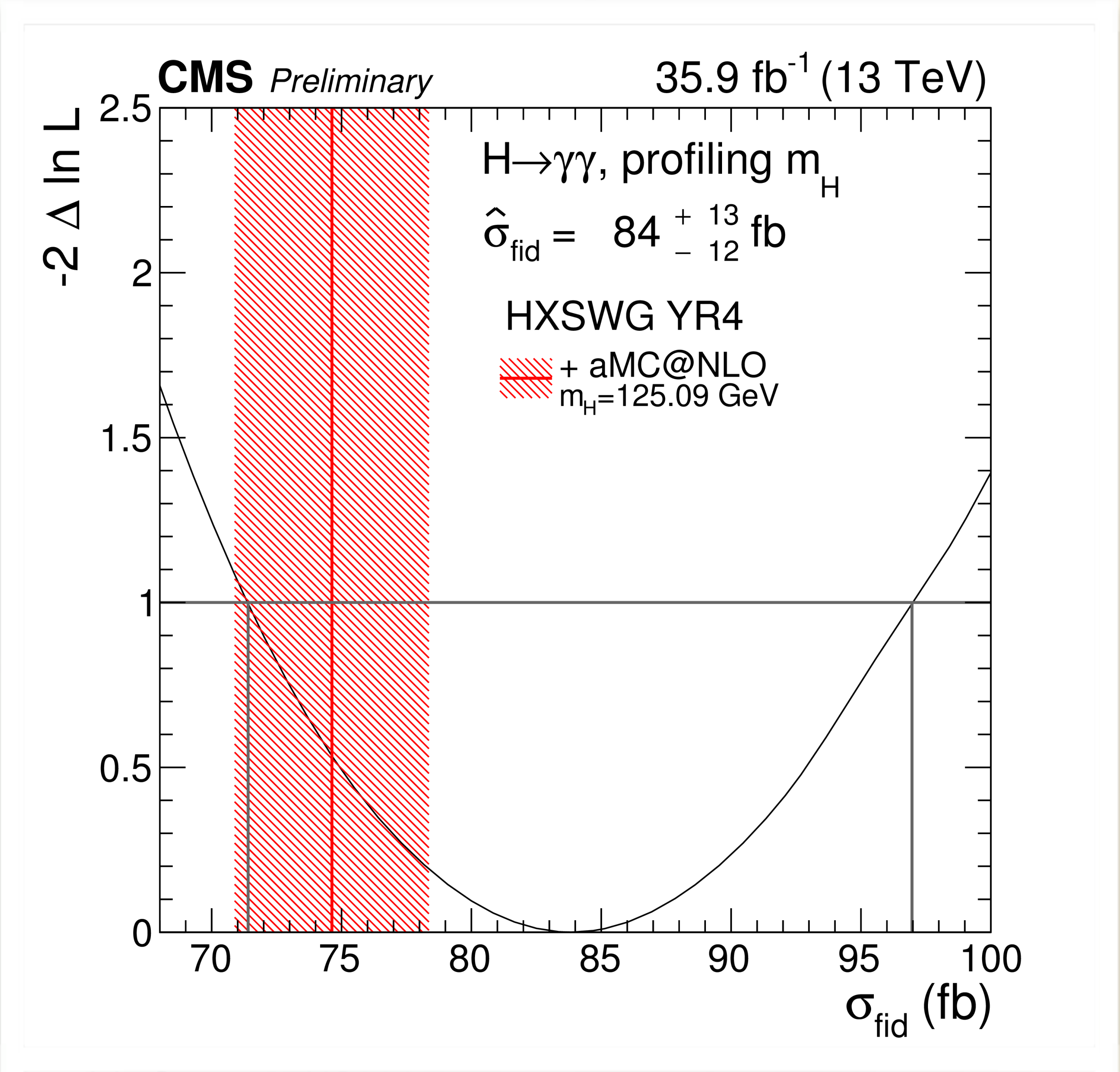
pseudorapidity of the photons < 2.5

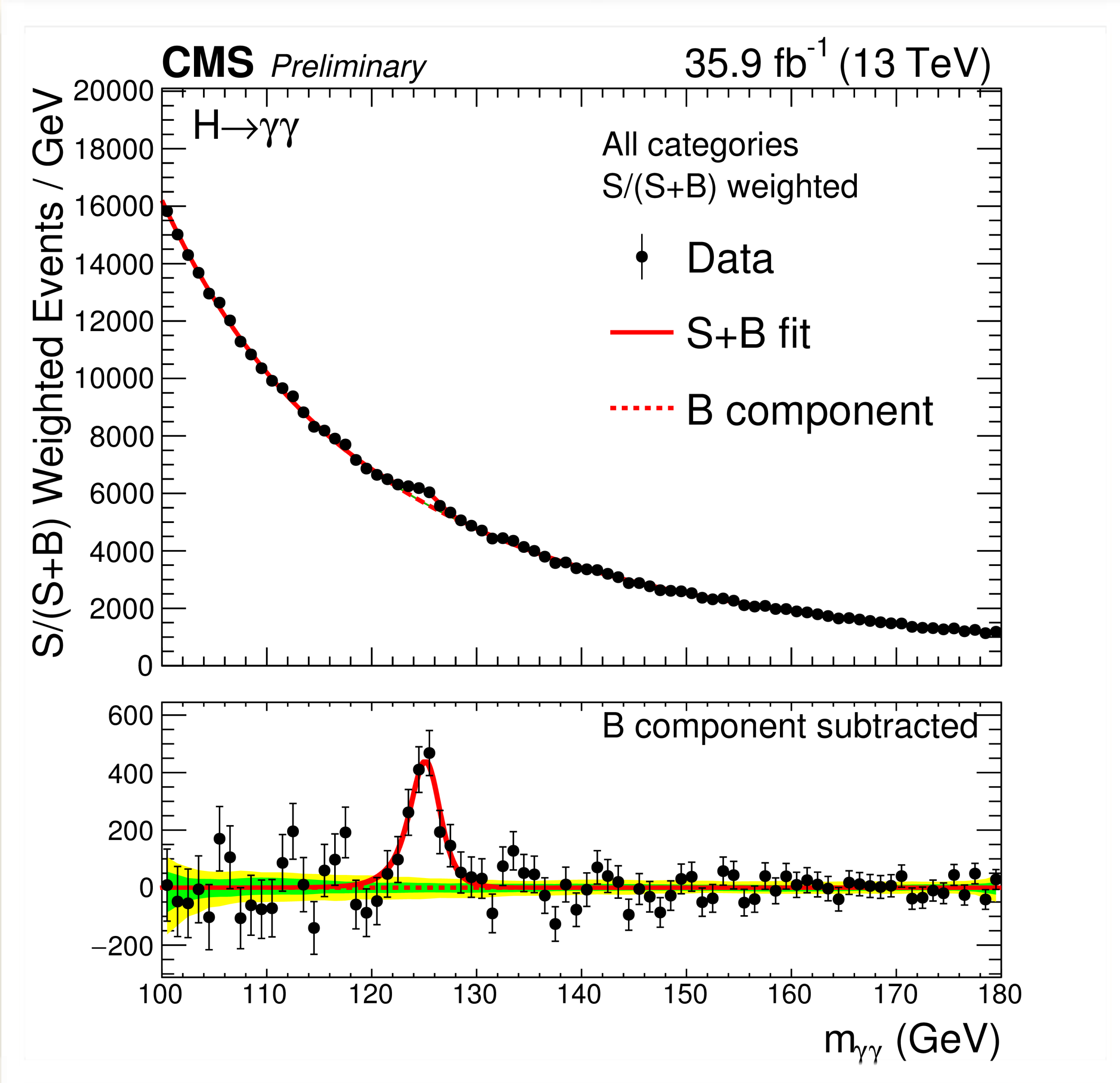
total hadronic energy < 10 GeV in a cone of DR<0.3

H to di-photon - Fiducial Cross Sections - Run 2

CMS PAS HIG-17-015

in each kinematic bin, the signal is extracted splitting the events in three categories according to a diphoton mass resolution estimator.



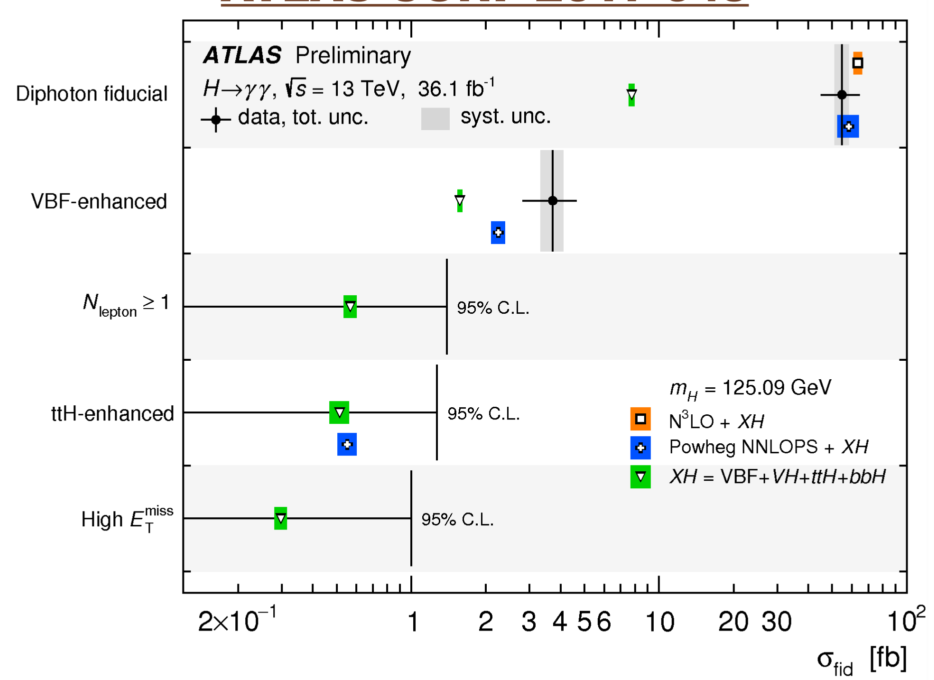


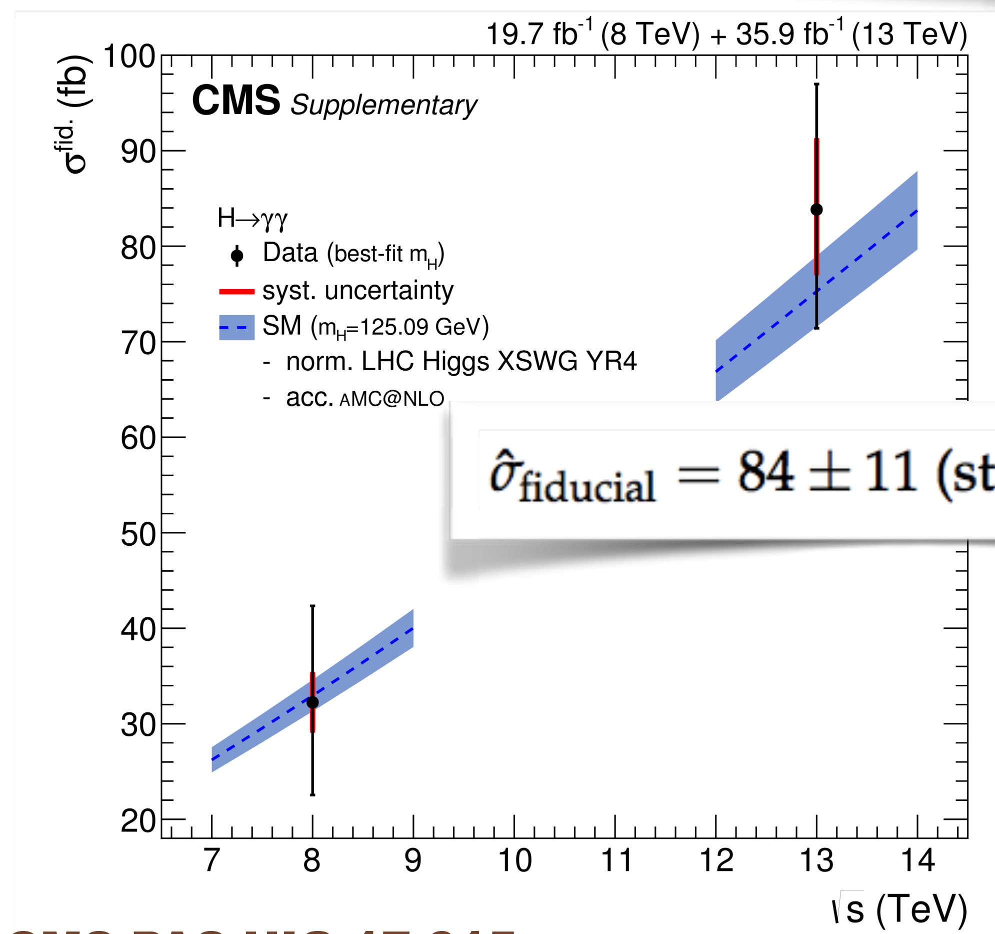
H to di-photon - Fiducial Cross Sections - Run 2

ATLAS-CONF-2017-045

Fiducial region	Measured cross section	SM prediction	
Diphoton fiducial	$54.7 \pm 9.1\,(\text{stat.}) \pm 4.5\,(\text{syst.})$ fb	63.5 ± 2.4 fb	[N^{3}LO + XH]
VBF-enhanced	$3.7 \pm 0.8\,(\text{stat.}) \pm 0.5\,(\text{syst.})$ fb	2.24 ± 0.14 fb	[NNLOPS + XH]
$N_{\text{lepton}} \geq 1$	≤ 1.39 fb @ 95% CL	0.57 ± 0.03 fb	[NNLOPS + XH]
High E_T^{miss}	≤ 1.00 fb @ 95% CL	0.30 ± 0.02 fb	[NNLOPS + XH]
$t\bar{t}H$-enhanced	≤ 1.27 fb @ 95% CL	0.55 ± 0.05 fb	[NNLOPS + XH]

ATLAS-CONF-2017-045



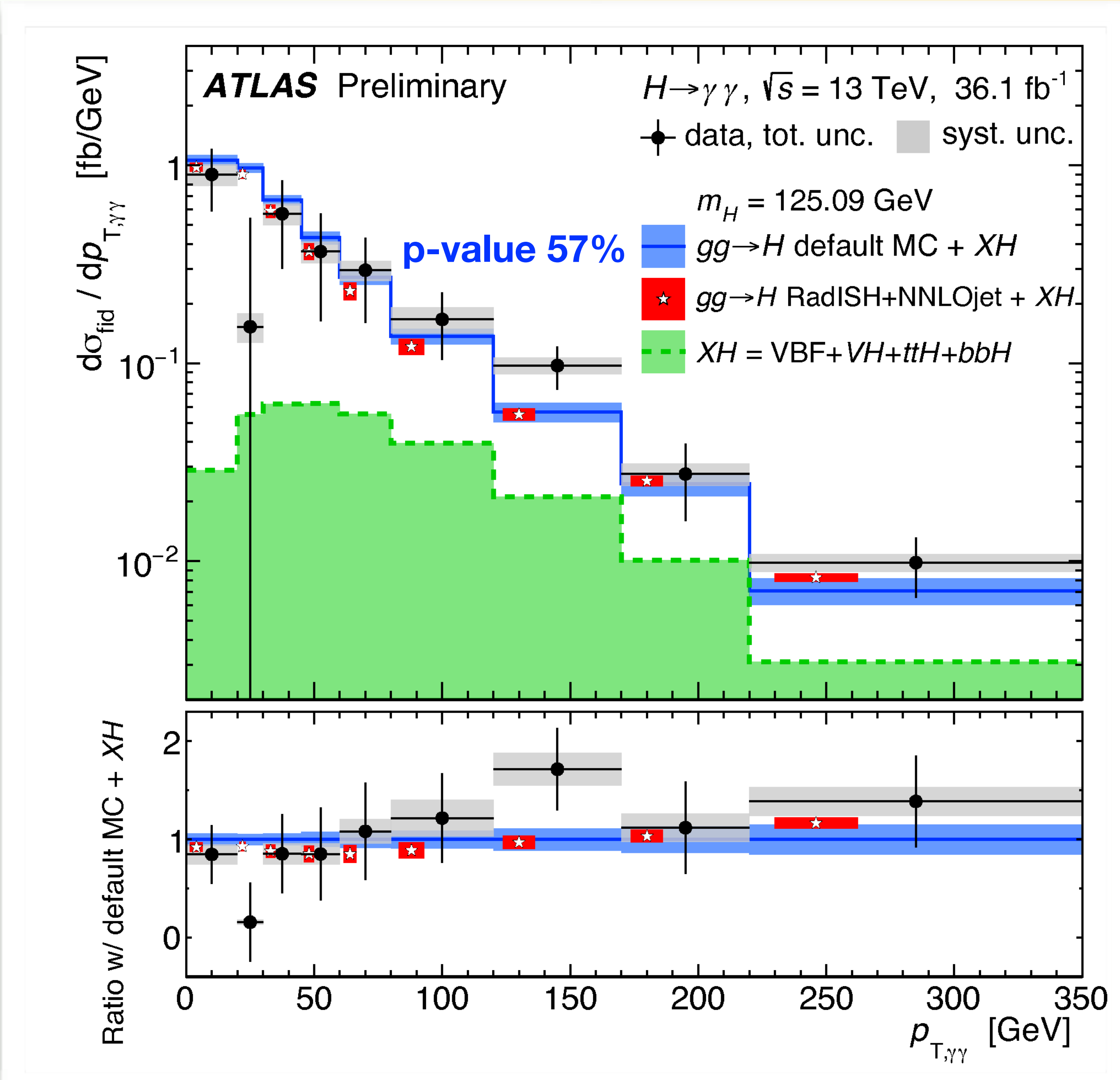


$$\hat{\sigma}_{\text{fiducial}} = 84 \pm 11\ (\text{stat}) \pm 7\ (\text{syst})\ \text{fb}$$

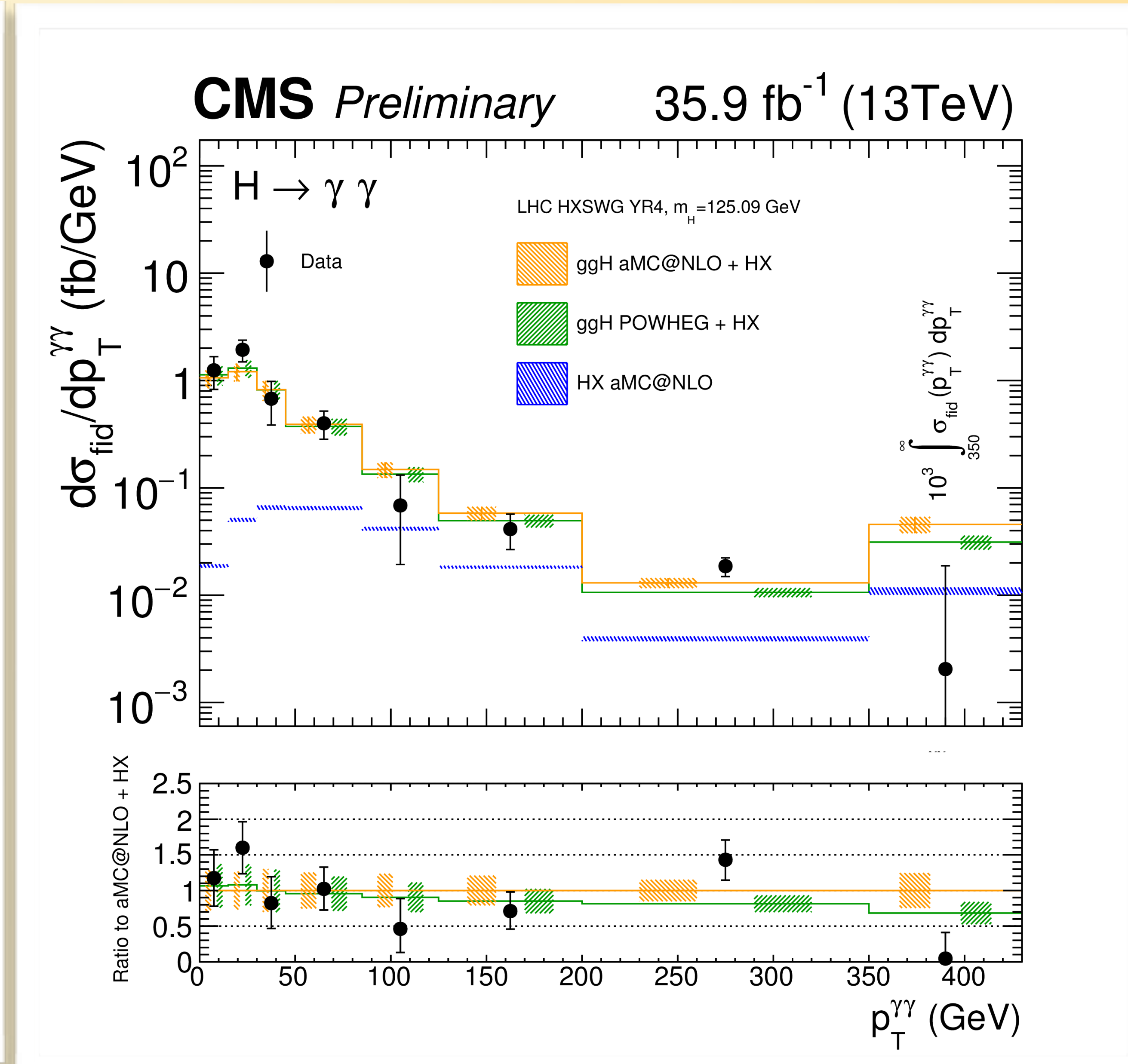
CMS PAS HIG-17-015

H to di-photon - Differential Cross Sections - Run 2

ATLAS-CONF-2017-045



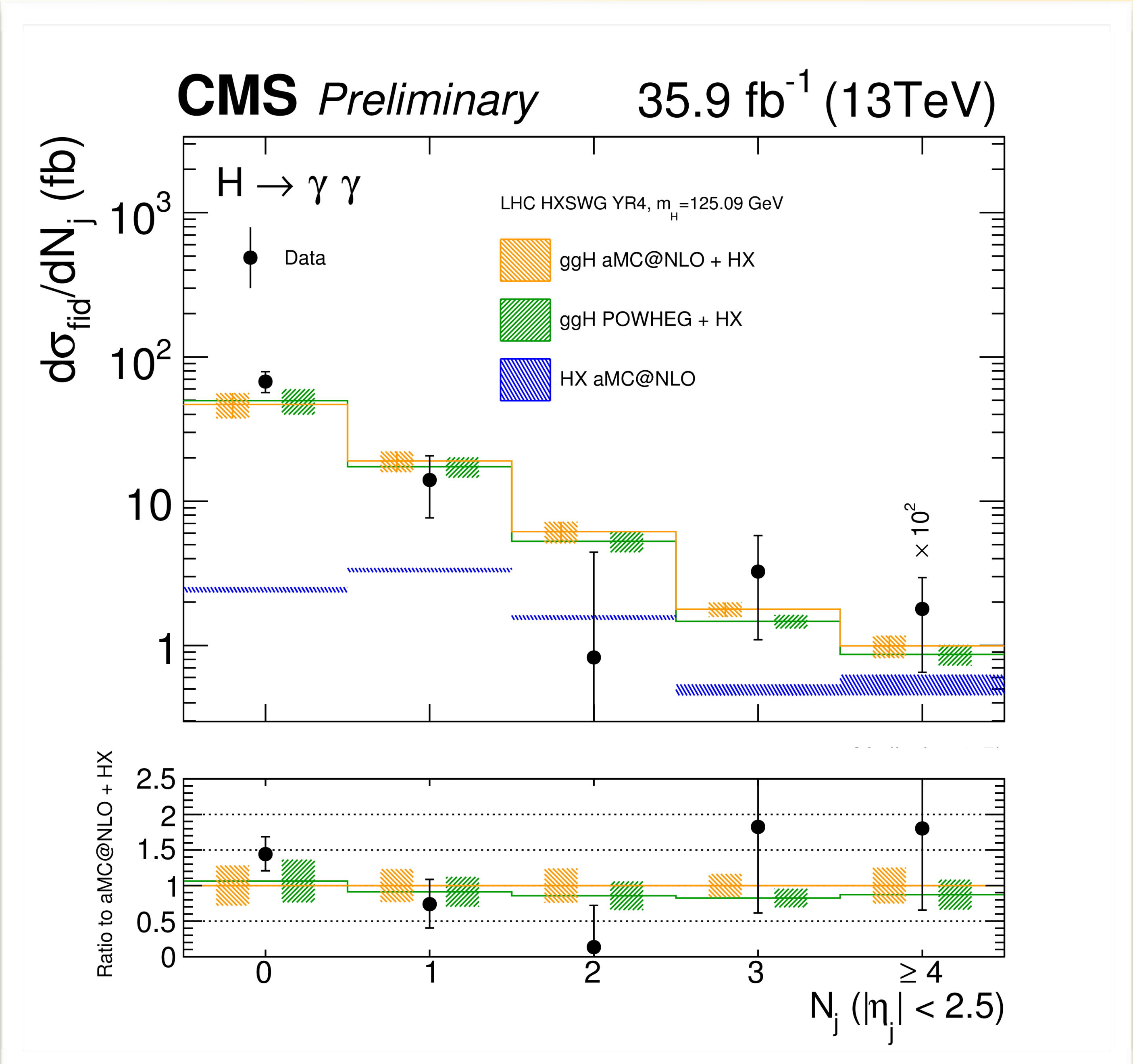
CMS PAS HIG-17-015



default for ggF: Powheg NNLOPS normalised to N^3LO with $K_{ggH} = 1.1$

H to di-photon - Differential Cross Sections - Run 2

CMS PAS HIG-17-015



CMS sensitivity to different production mechanisms comes from this measurement

H to 4 leptons - Fiducial Cross Sections - Run 2

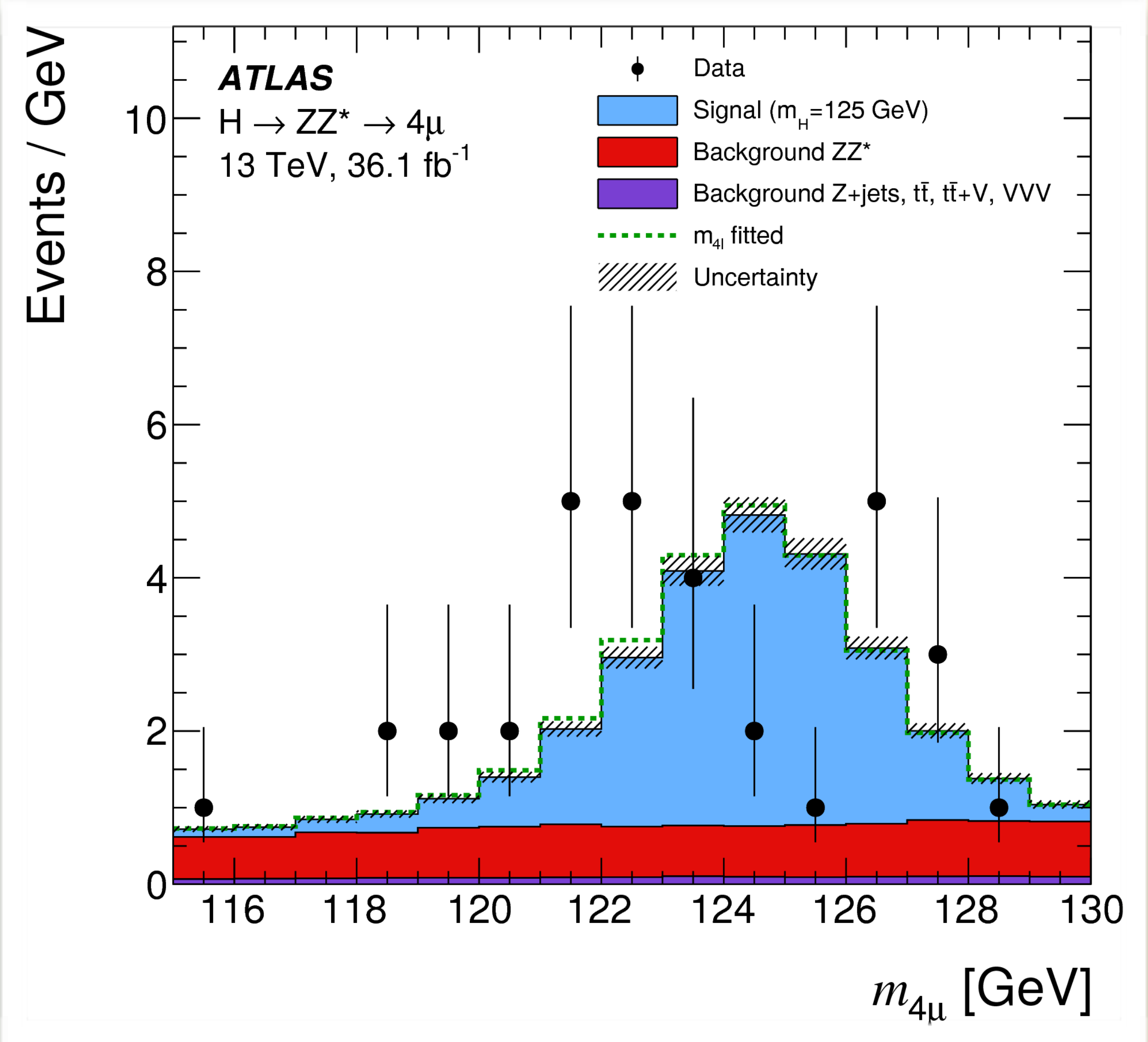
ATLAS arXiv:1708.02810

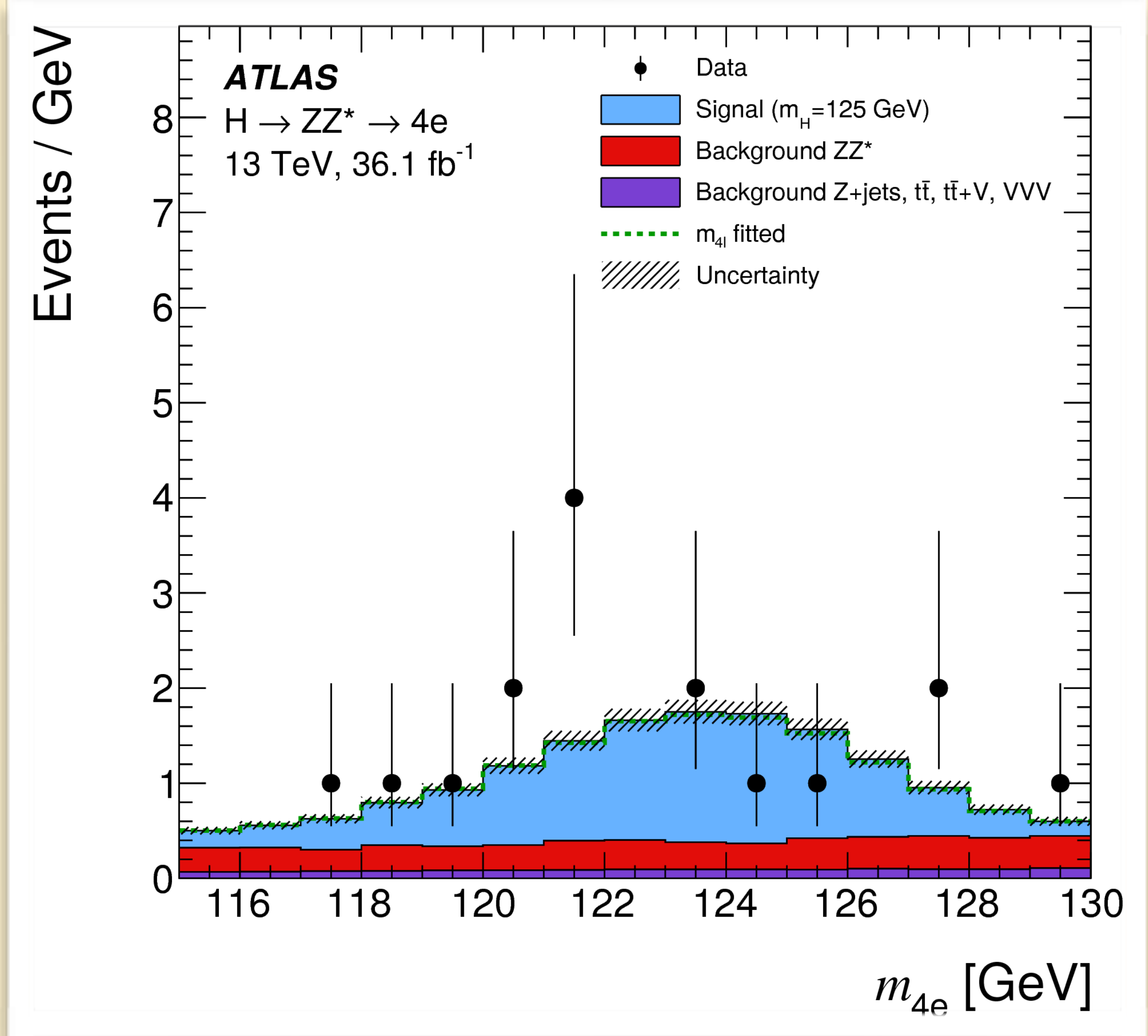
Leptons and jets	
Muons:	$p_T > 5$ GeV, $\|\eta\| < 2.7$
Electrons:	$p_T > 7$ GeV, $\|\eta\| < 2.47$
Jets:	$p_T > 30$ GeV, $\|y\| < 4.4$
Jet–lepton overlap removal:	$\Delta R(\text{jet}, \ell) > 0.1\,(0.2)$ for muons (electrons)
Lepton selection and pairing	
Lepton kinematics:	$p_T > 20, 15, 10$ GeV
Leading pair (m_{12}):	SFOS lepton pair with smallest $\|m_Z - m_{\ell\ell}\|$
Subleading pair (m_{34}):	remaining SFOS lepton pair with smallest $\|m_Z - m_{\ell\ell}\|$
Event selection (at most one quadruplet per channel)	
Mass requirements:	50 GeV$< m_{12} <$ 106 GeV and 12 GeV $< m_{34} <$ 115 GeV
Lepton separation:	$\Delta R(\ell_i, \ell_j) > 0.1\,(0.2)$ for same- (different-)flavour leptons
J/ψ veto:	$m(\ell_i, \ell_j) > 5$ GeV for all SFOS lepton pairs
Mass window:	115 GeV $< m_{4\ell} <$ 130 GeV

H to 4 leptons - Fiducial Cross Sections - Run 2

ATLAS arXiv:1708.02810

Classification by lepton flavour signal yields extracted from fits to the 4l invariant mass





H to 4 leptons - Fiducial Cross Sections - Run 2

CMS arXiv:1706.09936

Lepton kinematics and isolation	
Leading lepton p_T	$p_T > 20\,GeV$
Subleading lepton p_T	$p_T > 10\,GeV$
Additional electrons (muons) p_T	$p_T > 7\,(5)\,GeV$
Pseudorapidity of electrons (muons)	$\lvert\eta\rvert < 2.5\,(2.4)$
Sum p_T of all stable particles within $\Delta R < 0.3$ from lepton	$<0.35 p_T$
Event topology	
Existence of at least two same-flavor OS lepton pairs, where leptons satisfy criteria above	
Invariant mass of the Z_1 candidate	$40 < m_{Z_1} < 120\,GeV$
Invariant mass of the Z_2 candidate	$12 < m_{Z_2} < 120\,GeV$
Distance between selected four leptons	$\Delta R(\ell_i, \ell_j) > 0.02$ for any $i \neq j$
Invariant mass of any opposite-sign lepton pair	$m_{\ell^+\ell'^-} > 4\,GeV$
Invariant mass of the selected four leptons	$105 < m_{4\ell} < 140\,GeV$

Fiducial volume

no use of matrix elements discriminants

H to 4 leptons - Fiducial Cross Sections - Run 2

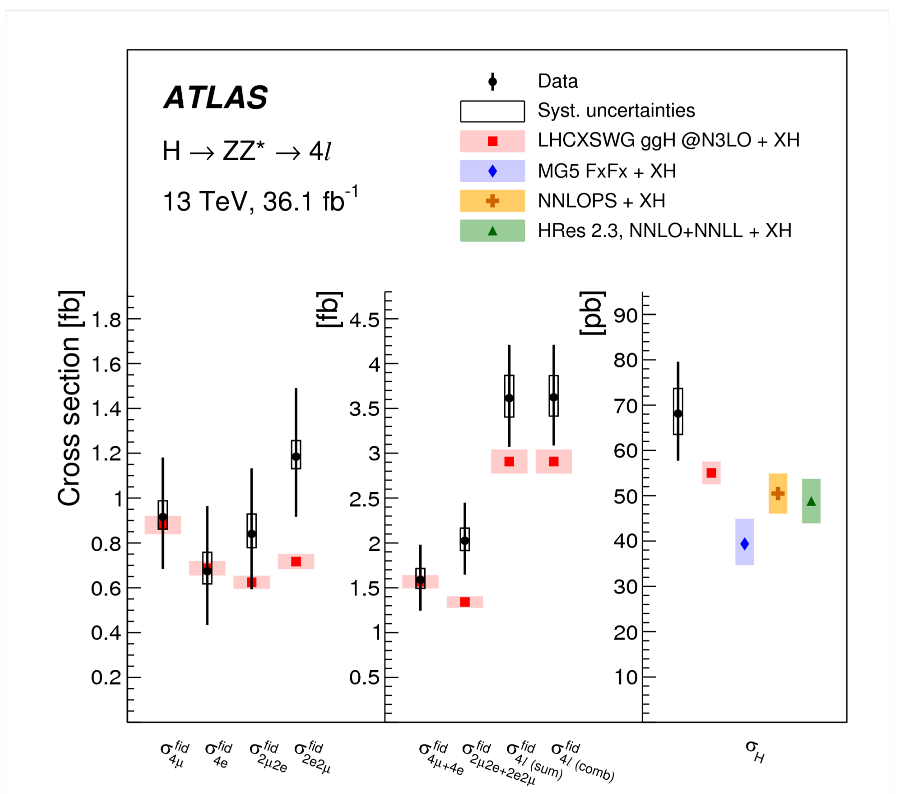
CMS arXiv:1706.09936

Signal process	$\mathcal{A}_{\text{fid}}$	ϵ	f_{nonfid}	$(1+f_{\text{nonfid}})\epsilon$
gg→H (POWHEG)	0.398	0.592 ± 0.001	0.049 ± 0.001	0.621 ± 0.001
VBF (POWHEG)	0.445	0.601 ± 0.002	0.038 ± 0.001	0.624 ± 0.002
WH (POWHEG MINLO)	0.314	0.577 ± 0.002	0.068 ± 0.001	0.616 ± 0.002
ZH (POWHEG MINLO)	0.342	0.592 ± 0.003	0.071 ± 0.002	0.634 ± 0.003
ttH (POWHEG)	0.311	0.572 ± 0.003	0.136 ± 0.003	0.650 ± 0.004

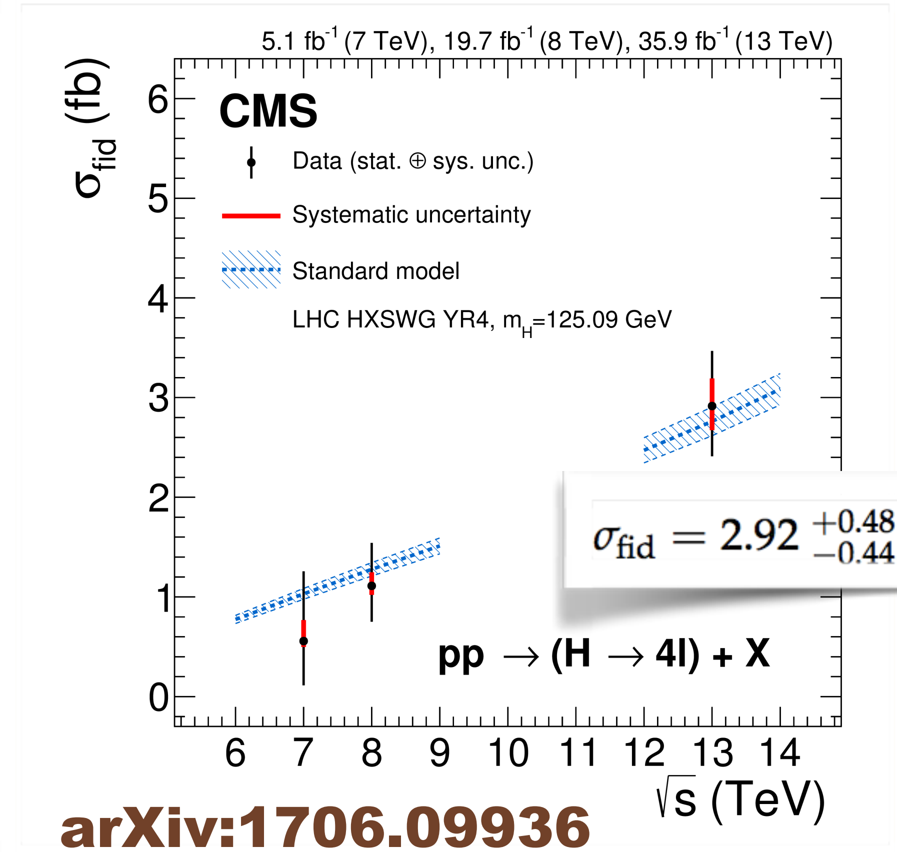
H to 4 leptons - Fiducial Cross Sections - Run 2

Cross section [fb]	Data (± (stat) ± (sys))			LHCXSWG prediction	p-value [%]
$\sigma_{4\mu}$	0.92	$^{+0.25}_{-0.23}$	$^{+0.07}_{-0.05}$	0.880 ± 0.039	88
σ_{4e}	0.67	$^{+0.28}_{-0.23}$	$^{+0.08}_{-0.06}$	0.688 ± 0.031	96
$\sigma_{2\mu 2e}$	0.84	$^{+0.28}_{-0.24}$	$^{+0.09}_{-0.06}$	0.625 ± 0.028	39
$\sigma_{2e2\mu}$	1.18	$^{+0.30}_{-0.26}$	$^{+0.07}_{-0.05}$	0.717 ± 0.032	7
$\sigma_{4\mu+4e}$	1.59	$^{+0.37}_{-0.33}$	$^{+0.12}_{-0.10}$	1.57 ± 0.07	65
$\sigma_{2\mu 2e+2e2\mu}$	2.02	$^{+0.40}_{-0.36}$	$^{+0.14}_{-0.11}$	1.34 ± 0.06	6
σ_{sum}	3.61	± 0.50	$^{+0.26}_{-0.21}$	2.91 ± 0.13	19
σ_{comb}	3.62	± 0.50	$^{+0.25}_{-0.20}$	2.91 ± 0.13	18
σ_{tot} [pb]	69	$^{+10}_{-9}$	± 5	55.6 ± 2.5	19

ATLAS arXiv:1708.02810



arXiv:1708.02810

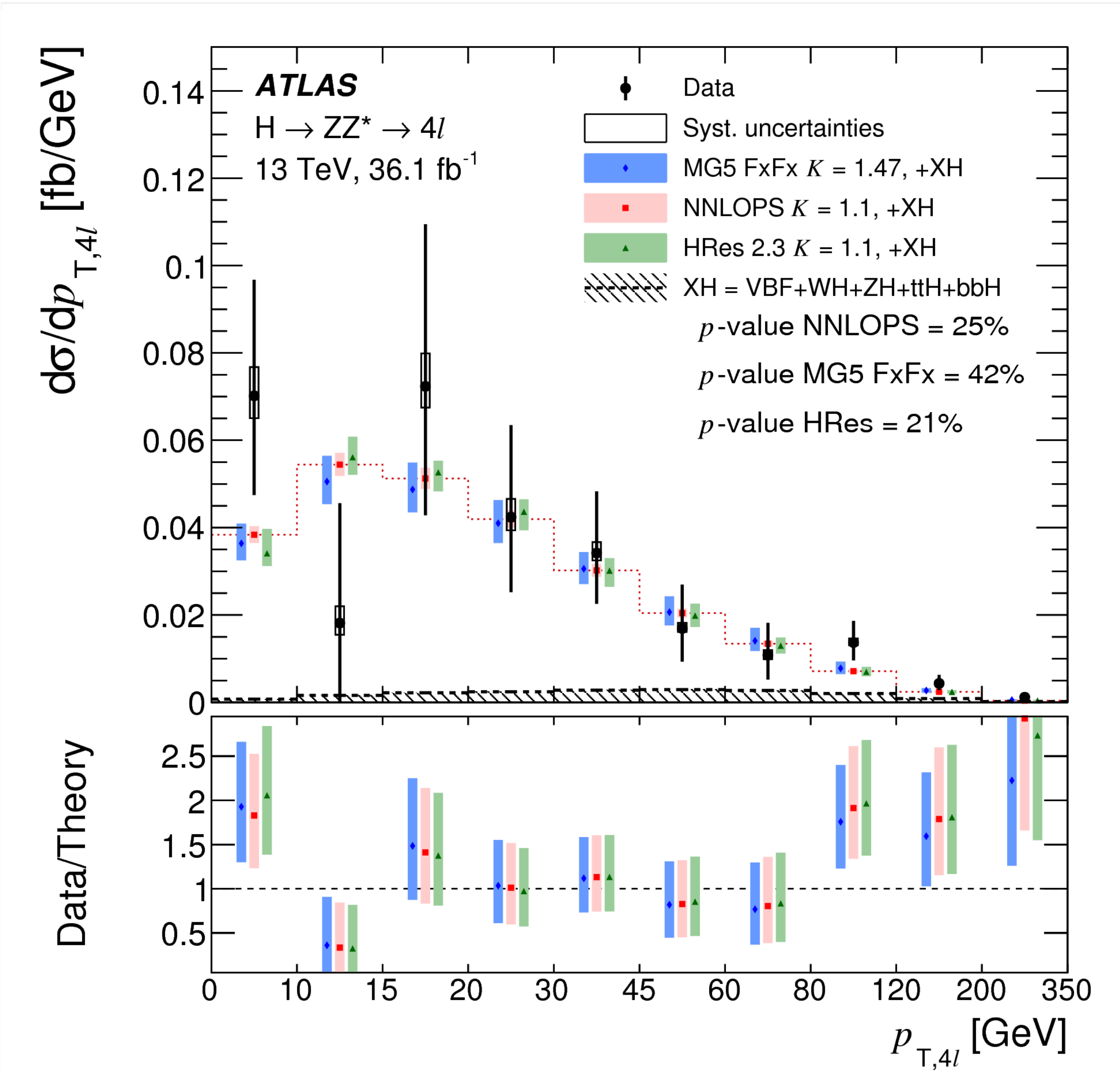


$$\sigma_{\mathrm{fid}} = 2.92\ ^{+0.48}_{-0.44}\ (\mathrm{stat})\ ^{+0.28}_{-0.24}\ (\mathrm{syst})\ \mathrm{fb}$$

arXiv:1706.09936

H to 4 leptons - Differential Cross Sections - Run 2

arXiv:1708.02810



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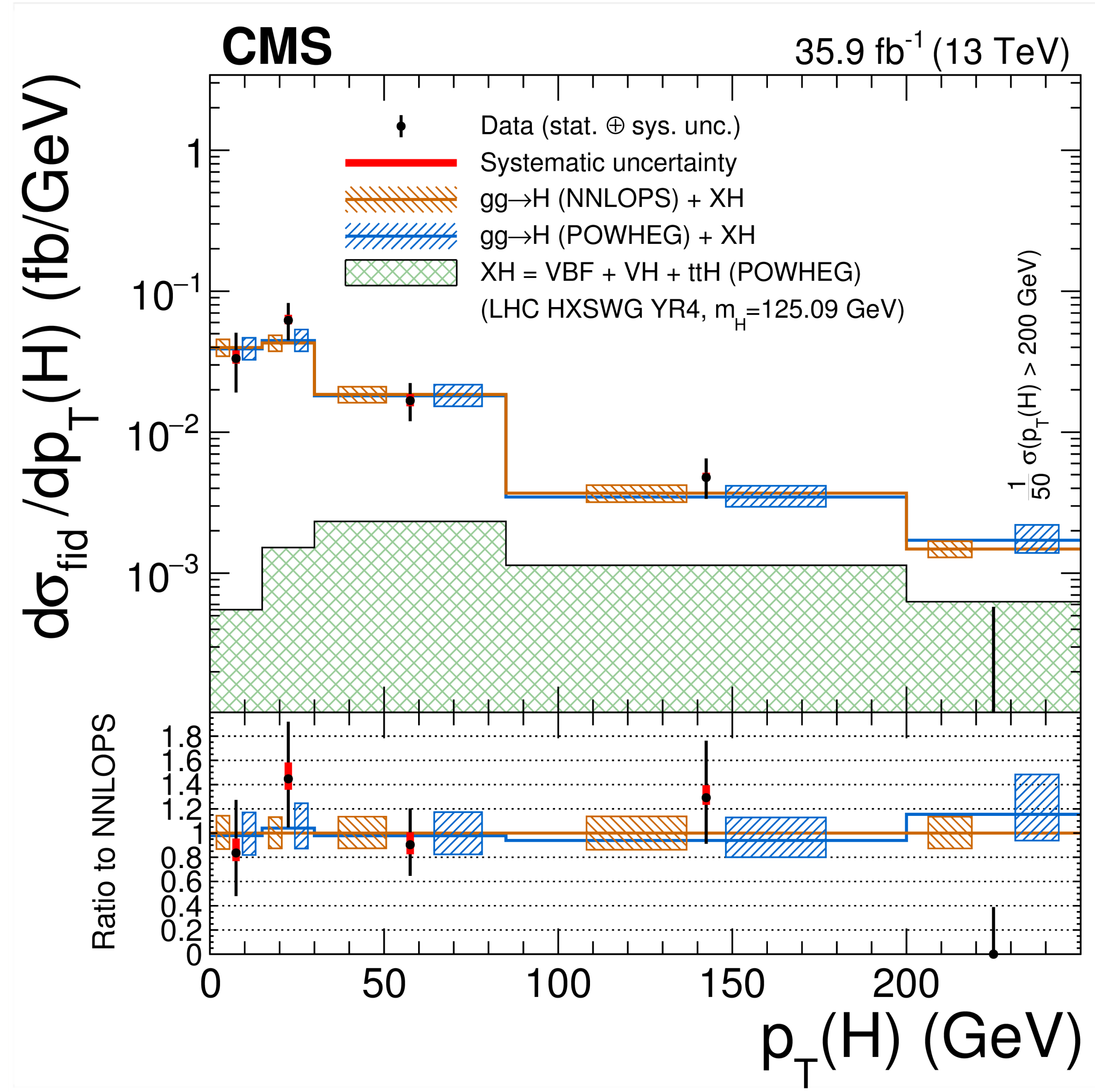
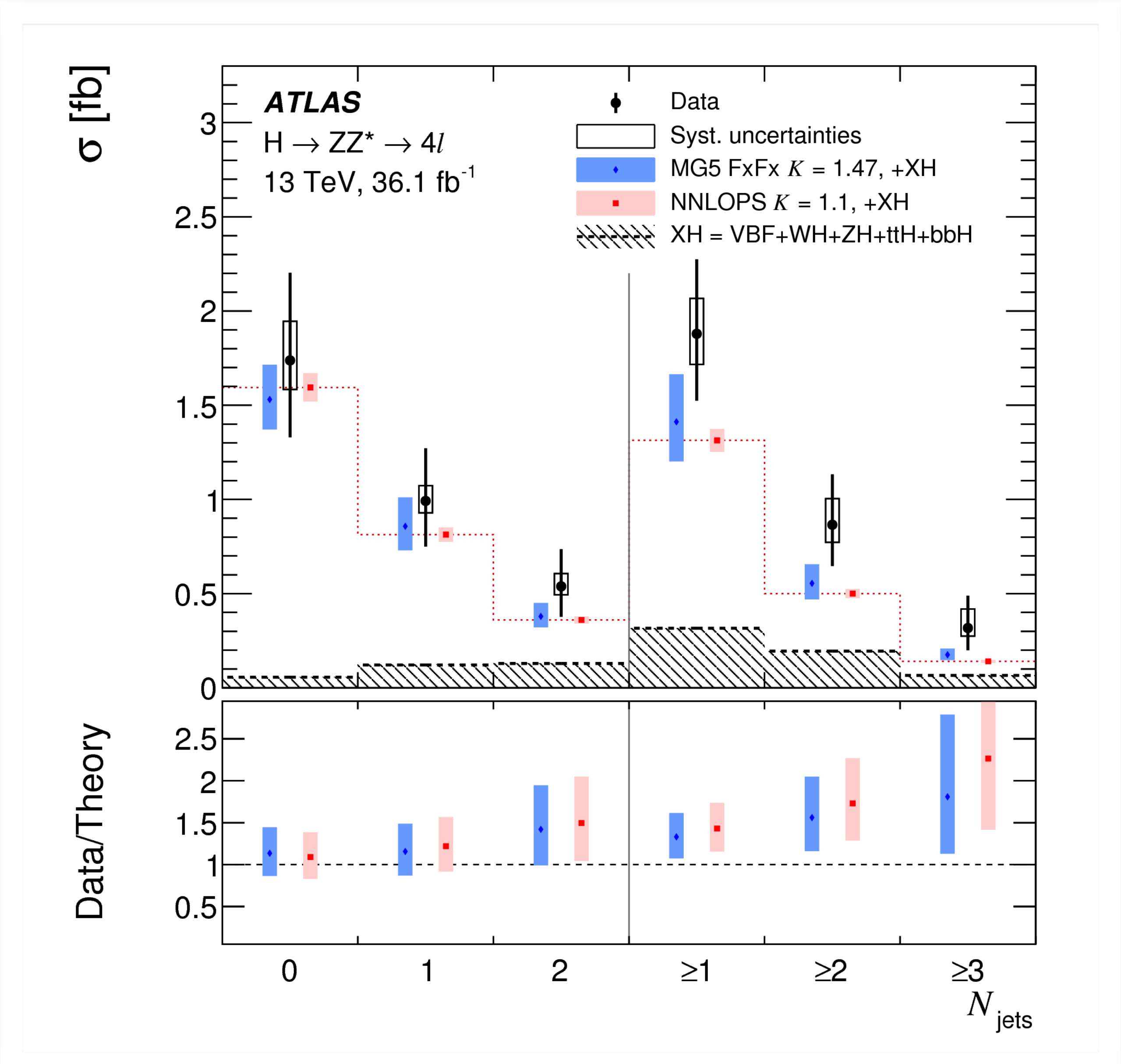


Higgs boson's p_T

H to 4 leptons - Differential Cross Sections - Run 2

arXiv:1708.02810



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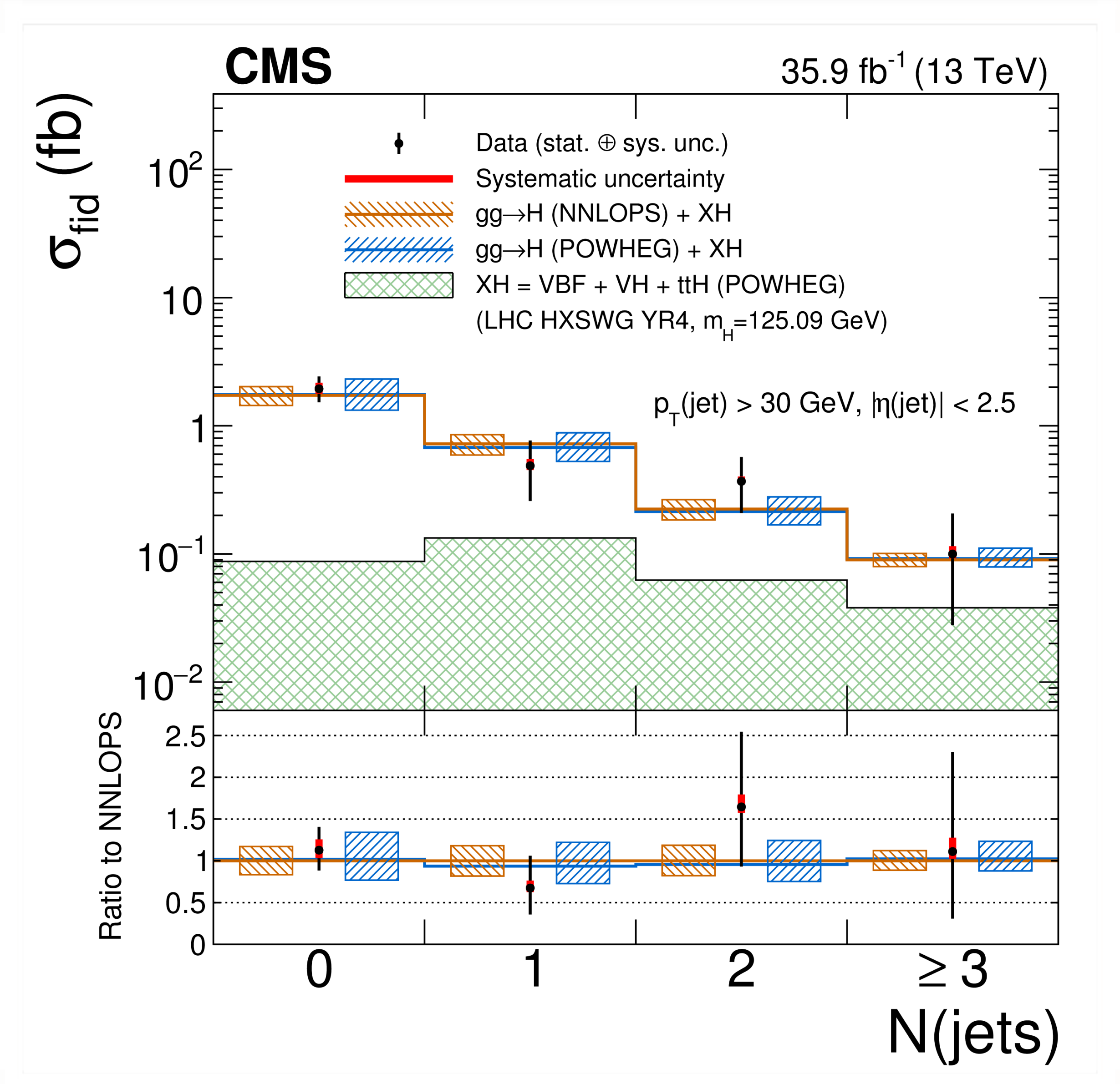
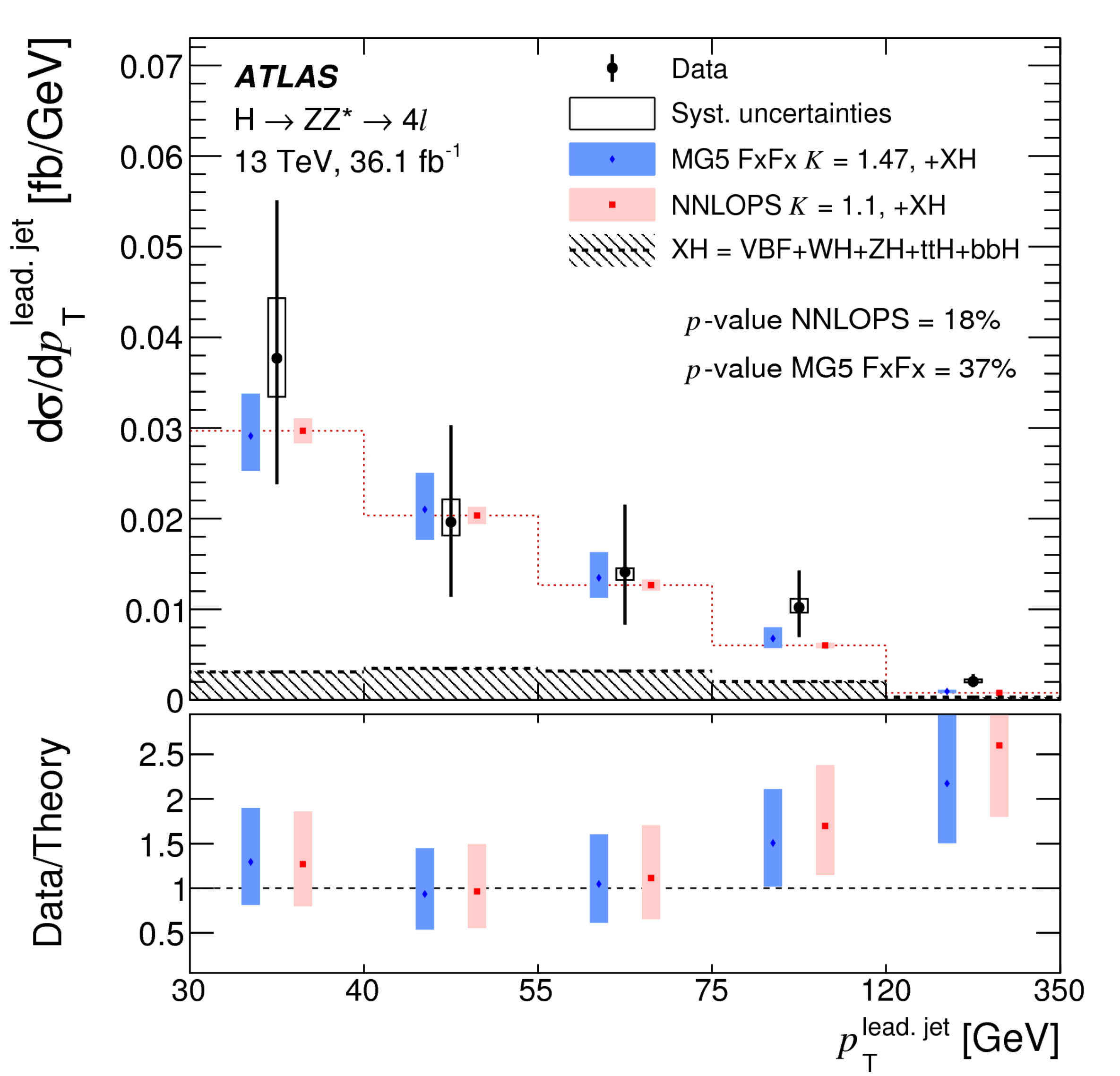


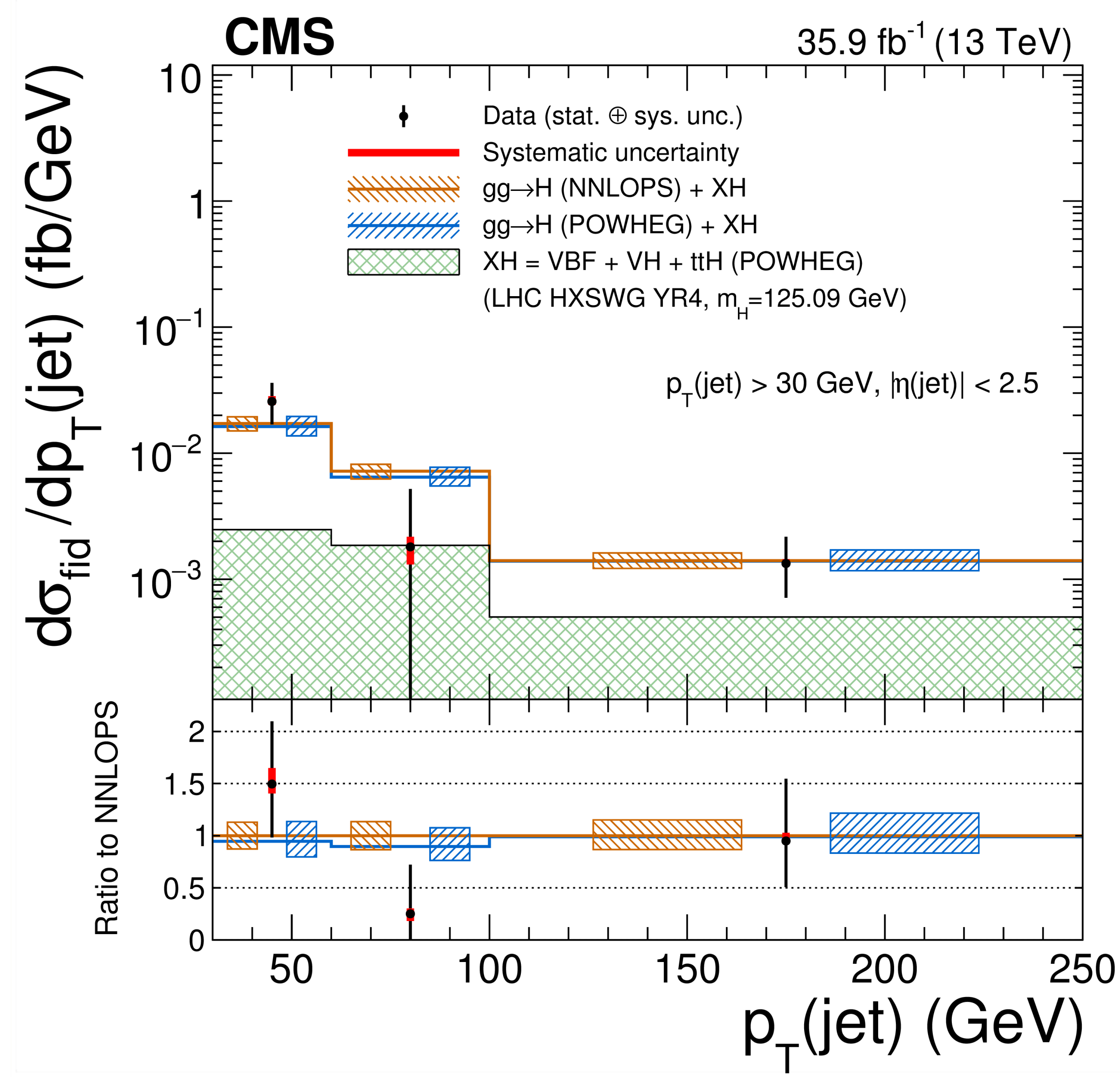
Number of jets

H to 4 leptons - Differential Cross Sections - Run 2

arXiv:1708.02810

arXiv:1706.09936

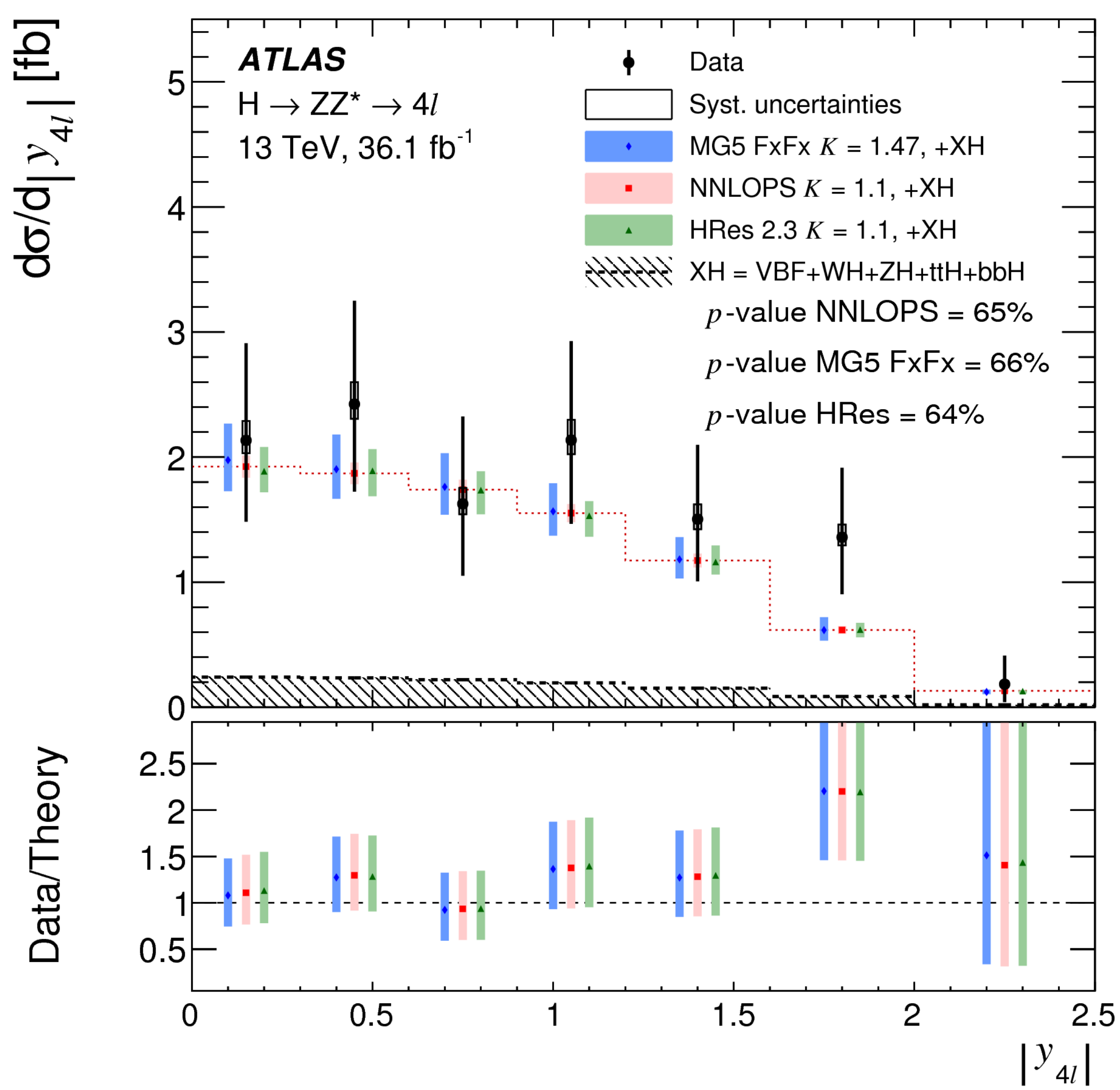




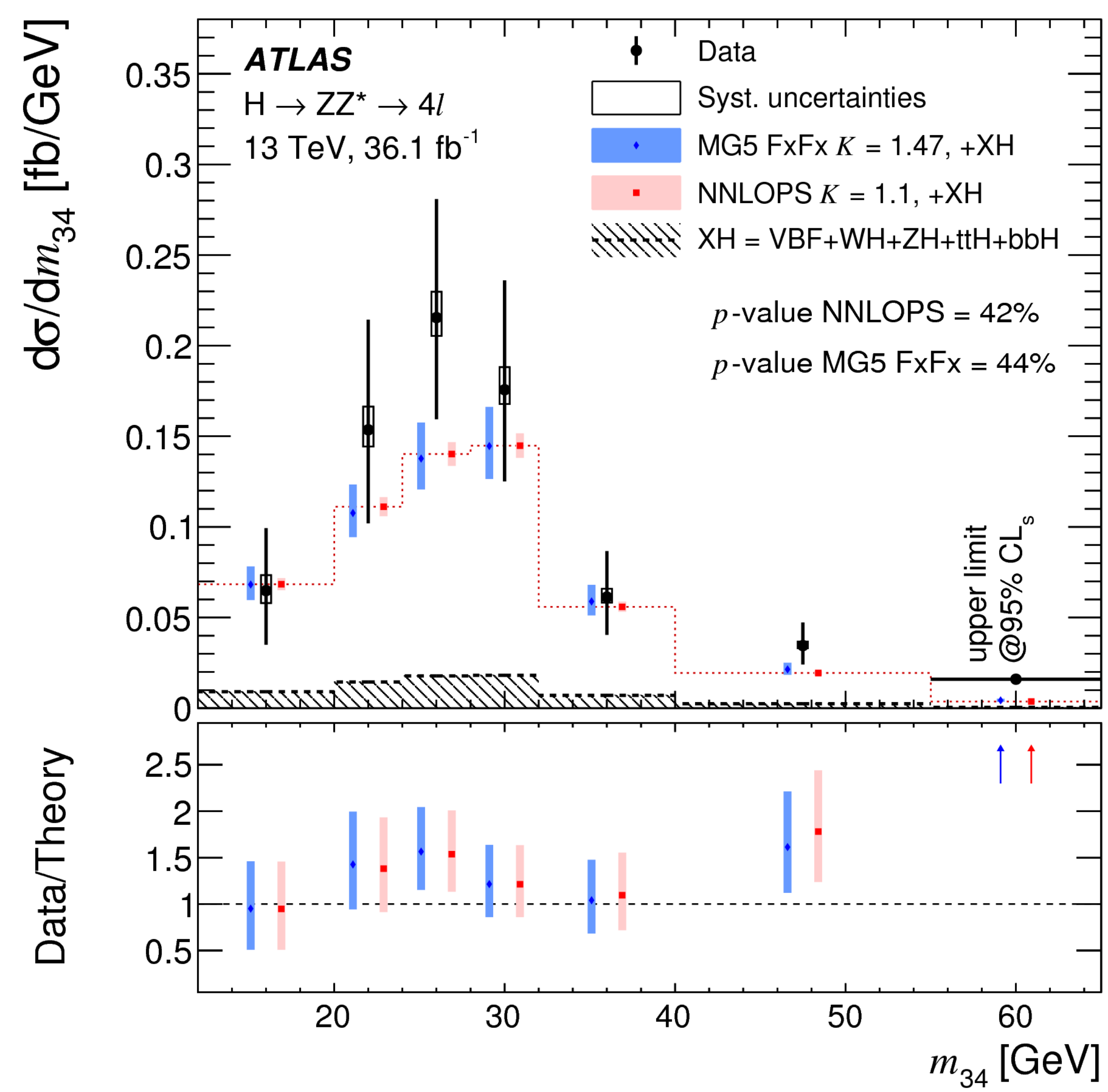
p_T of jets

H to 4 leptons - Differential Cross Sections - Run 2

arXiv:1708.02810



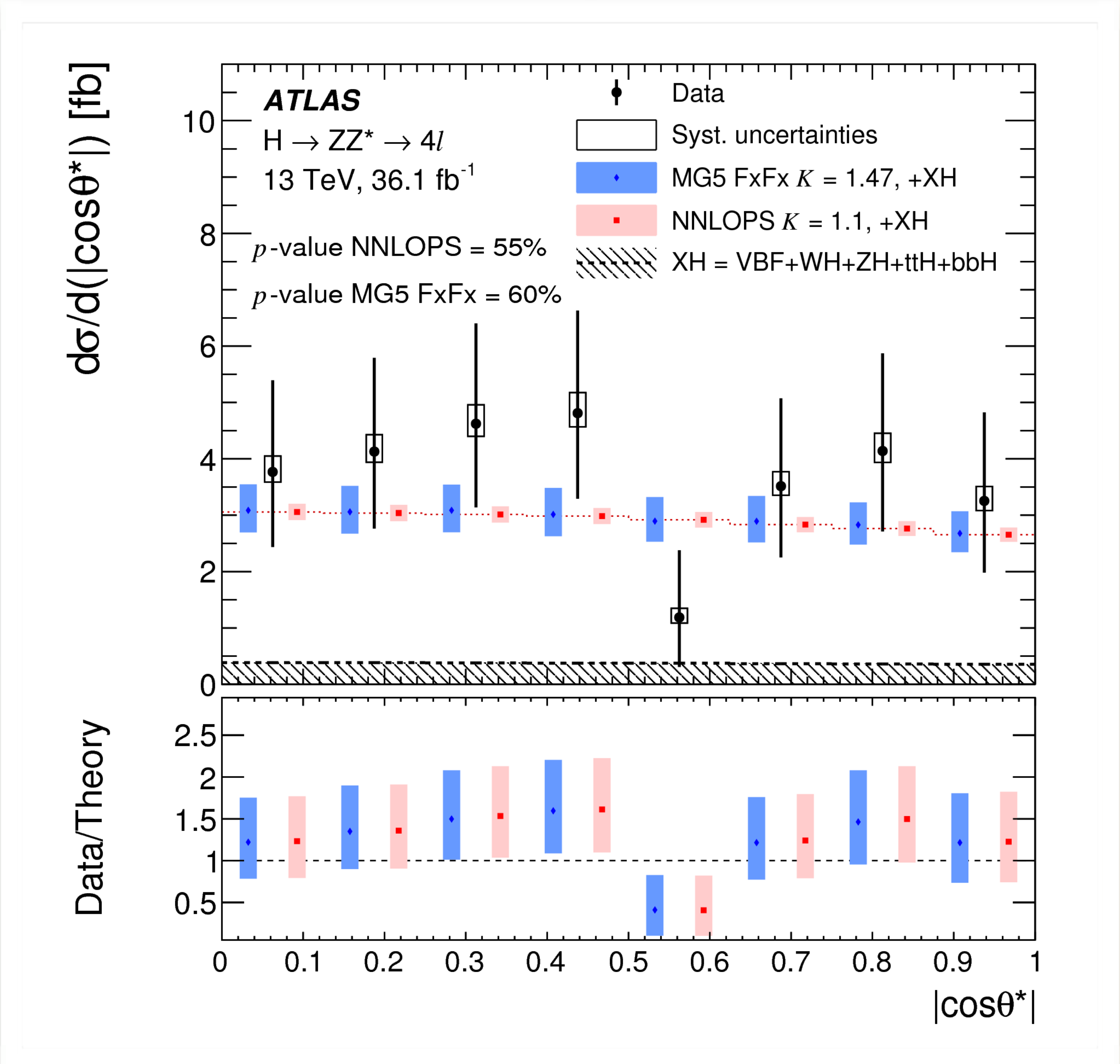
Higgs boson's rapidity



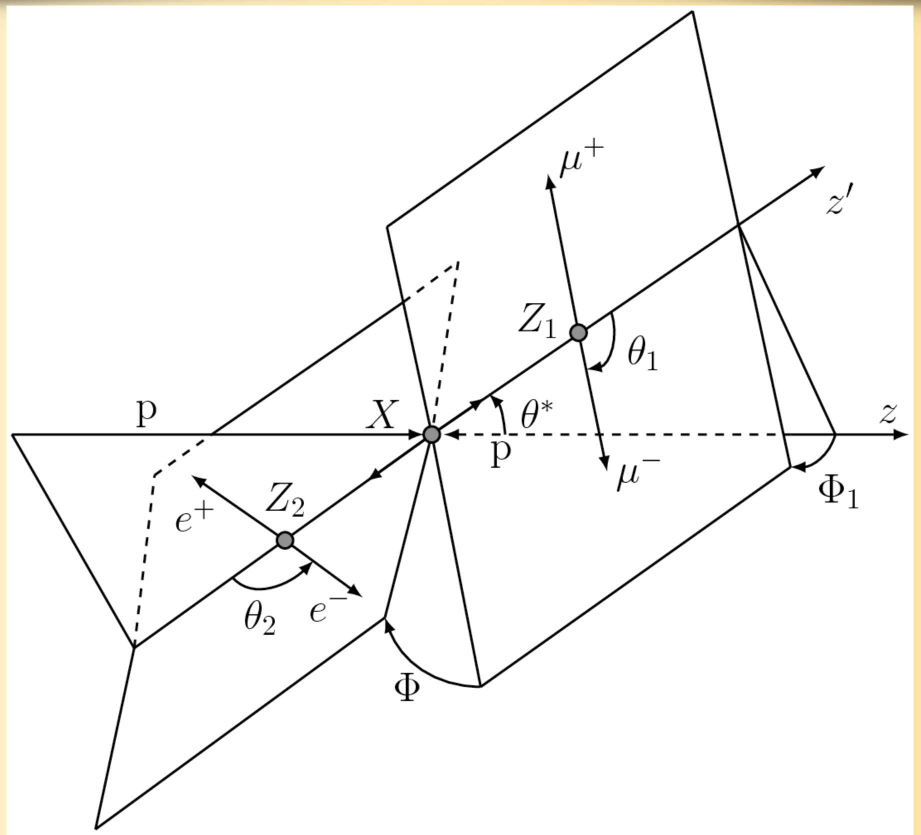
Subleading dilepton pair mass

H to 4 leptons - Differential Cross Sections - Run 2

arXiv:1708.02810

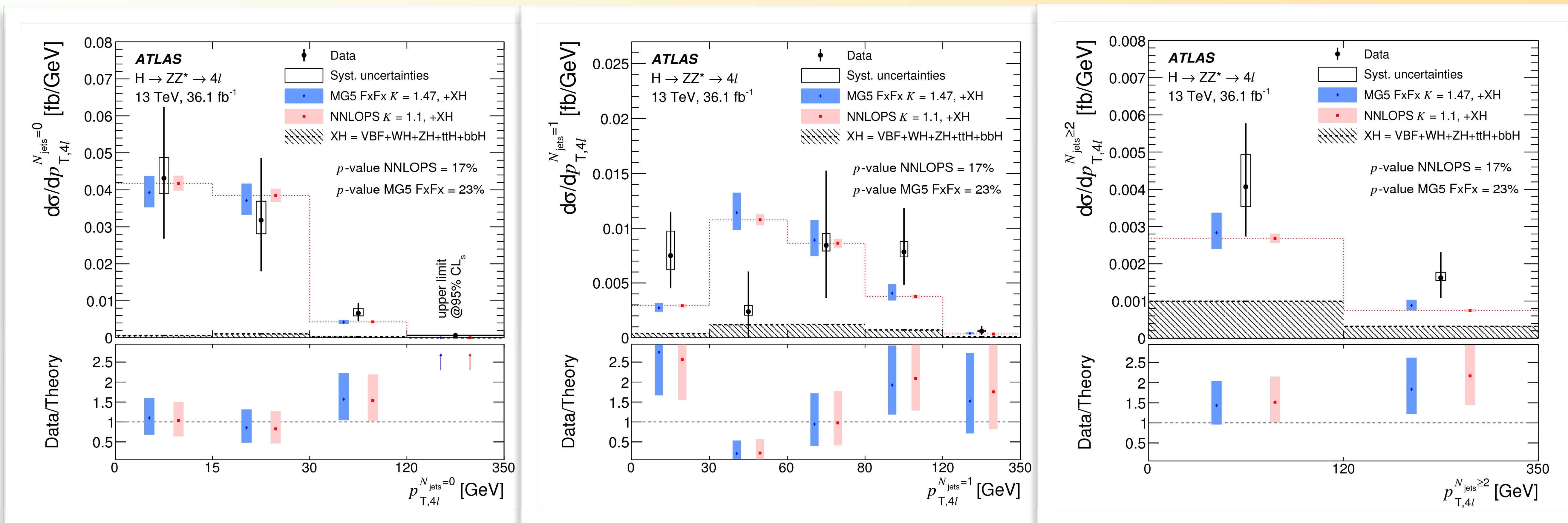


cosine of the decay angle of the leading lepton pair in the four-lepton rest frame with respect to the beam axis



H to 4 leptons - Double Differential Cross Sections Run 2

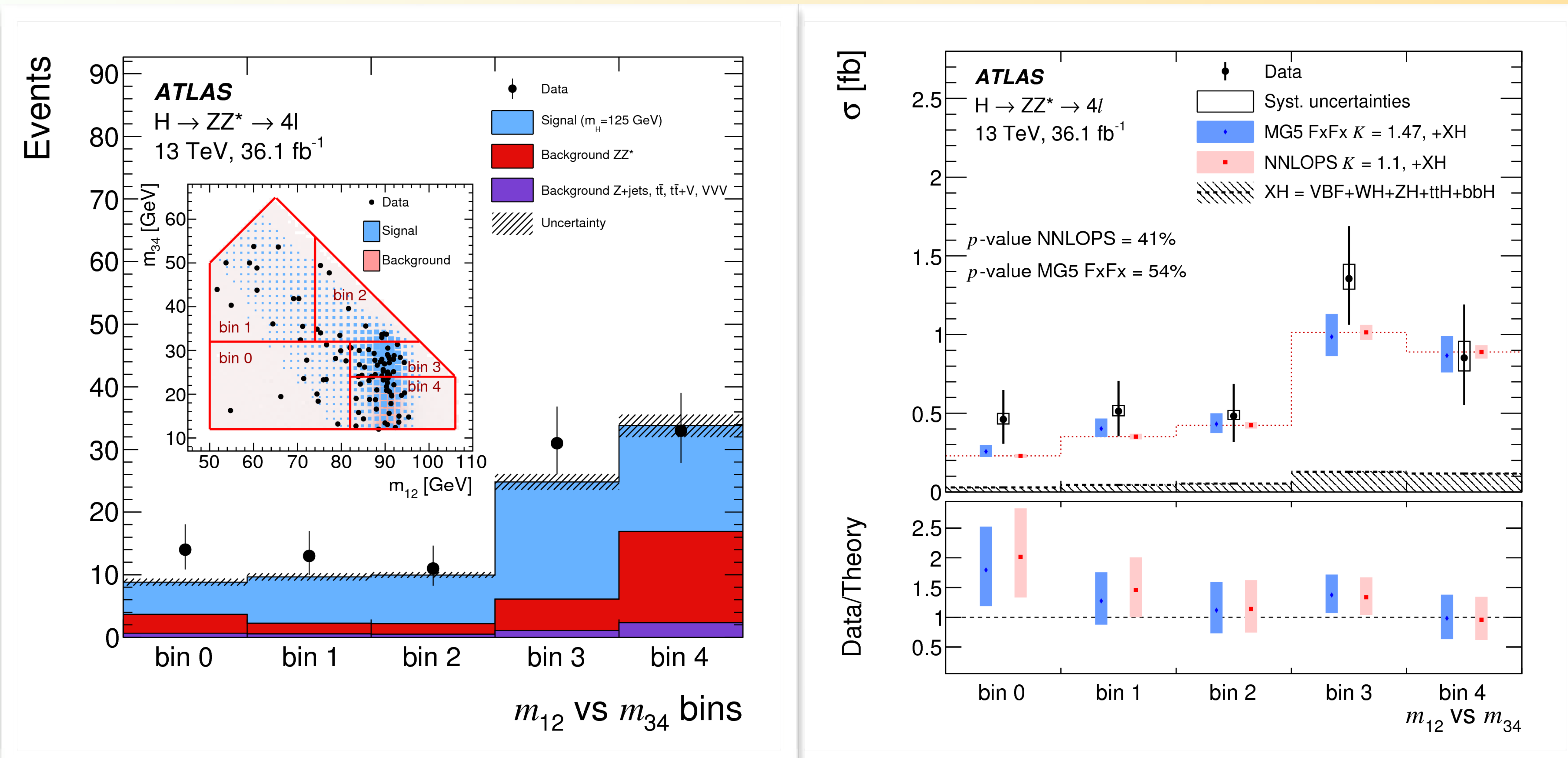
arXiv:1708.02810



increasing jet multiplicity

H to 4 leptons - Double Differential Cross Sections Run 2

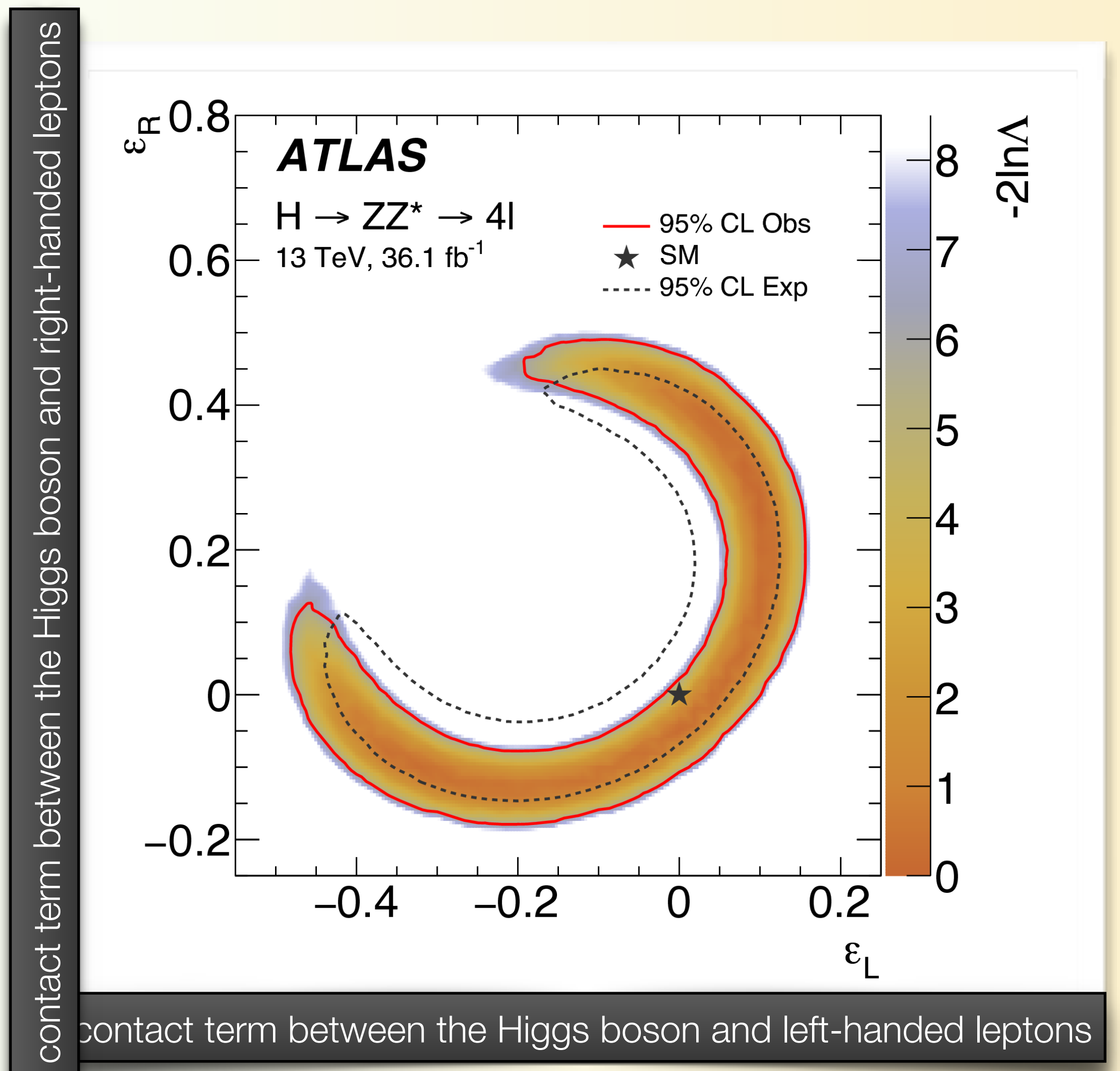
arXiv:1708.02810

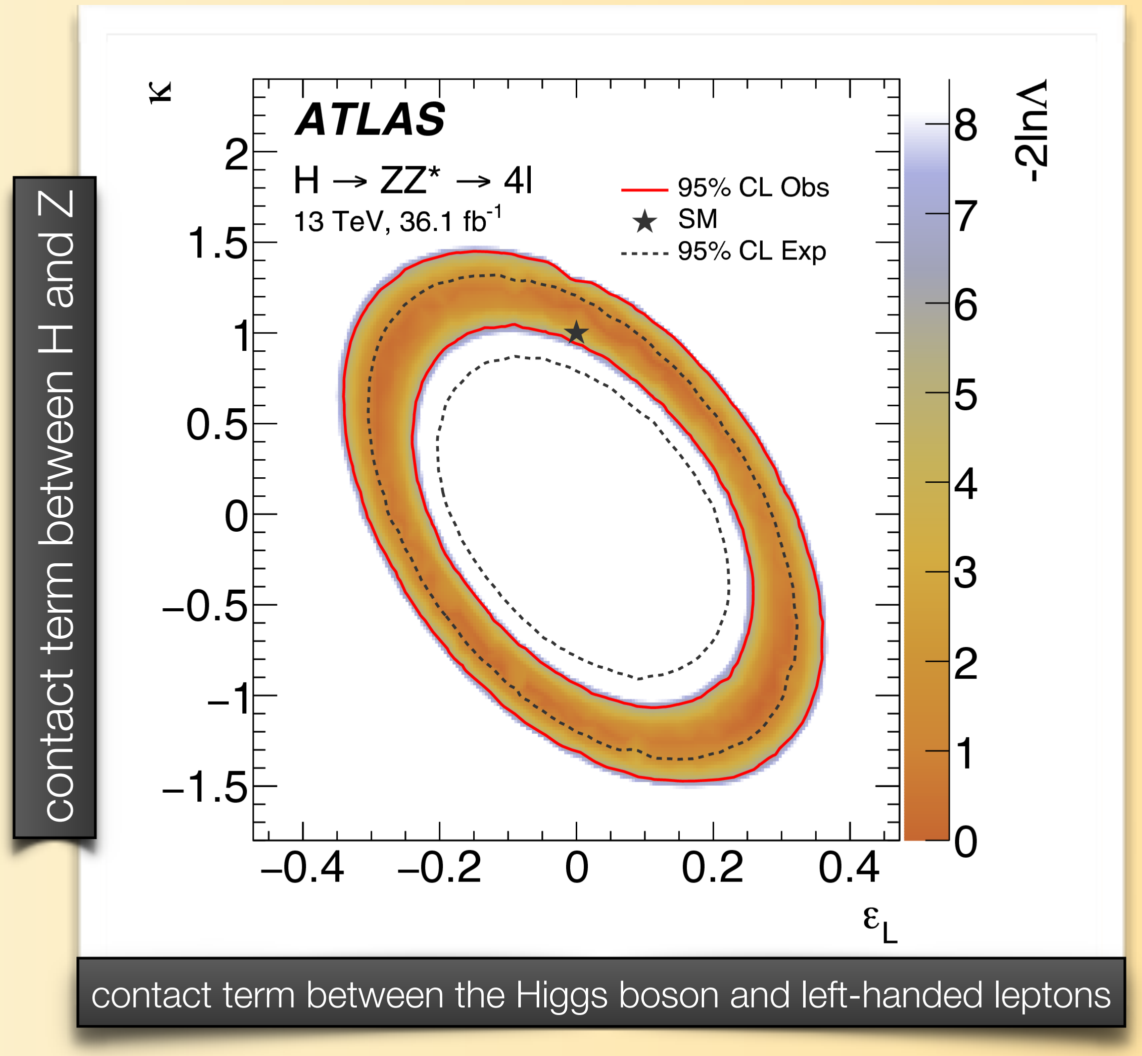


H to 4 leptons - BSM Searches - Run 2

interpretation within the pseudo-observables framework of the measured differential cross-sections

contact terms affect the invariant mass spectra and not the angular distributions -> fit to m_{12} and m_{34} distributions





arXiv:1708.02810

H to WW - Fiducial Cross Sections - Run 1

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Category	$N_{\text{jet}} = 0$	$N_{\text{jet}} = 1$	$N_{\text{jet}} \geq 2$
Preselection	Two isolated leptons ($\ell = e, \mu$) with opposite charge $p_{\text{T}}^{\text{lead}} > 22$ GeV, $p_{\text{T}}^{\text{sublead}} > 15$ GeV $m_{\ell\ell} > 10$ GeV $p_{\text{T}}^{\text{miss}} > 20$ GeV		
Background rejection	- $\Delta\phi(\ell\ell, p_{\text{T}}^{\text{miss}}) > 1.57$ $p_{\text{T}}^{\ell\ell} > 30$ GeV	$N_{b\text{-jet}} = 0$ $\max(m_{\text{T}}^{\ell}) > 50$ GeV $m_{\tau\tau} < m_Z - 25$ GeV	$N_{b\text{-jet}} = 0$ - $m_{\tau\tau} < m_Z - 25$ GeV
VBF veto	-	-	$m_{jj} < 600$ GeV or $\Delta y_{jj} < 3.6$
$H \to WW^* \to \ell\nu\ell\nu$ topology	$m_{\ell\ell} < 55$ GeV $\Delta\phi_{\ell\ell} < 1.8$ 85 GeV $< m_{\text{T}} < 125$ GeV		

$$\sigma_{\text{ggF}}^{\text{fid}} = 36.0 \pm 7.2(\text{stat}) \pm 6.4(\text{sys}) \pm 1.0(\text{lumi})\ \text{fb}$$

theory: 25.1 ± 2.6 fb.

H to WW - Fiducial Cross Sections - Run 1

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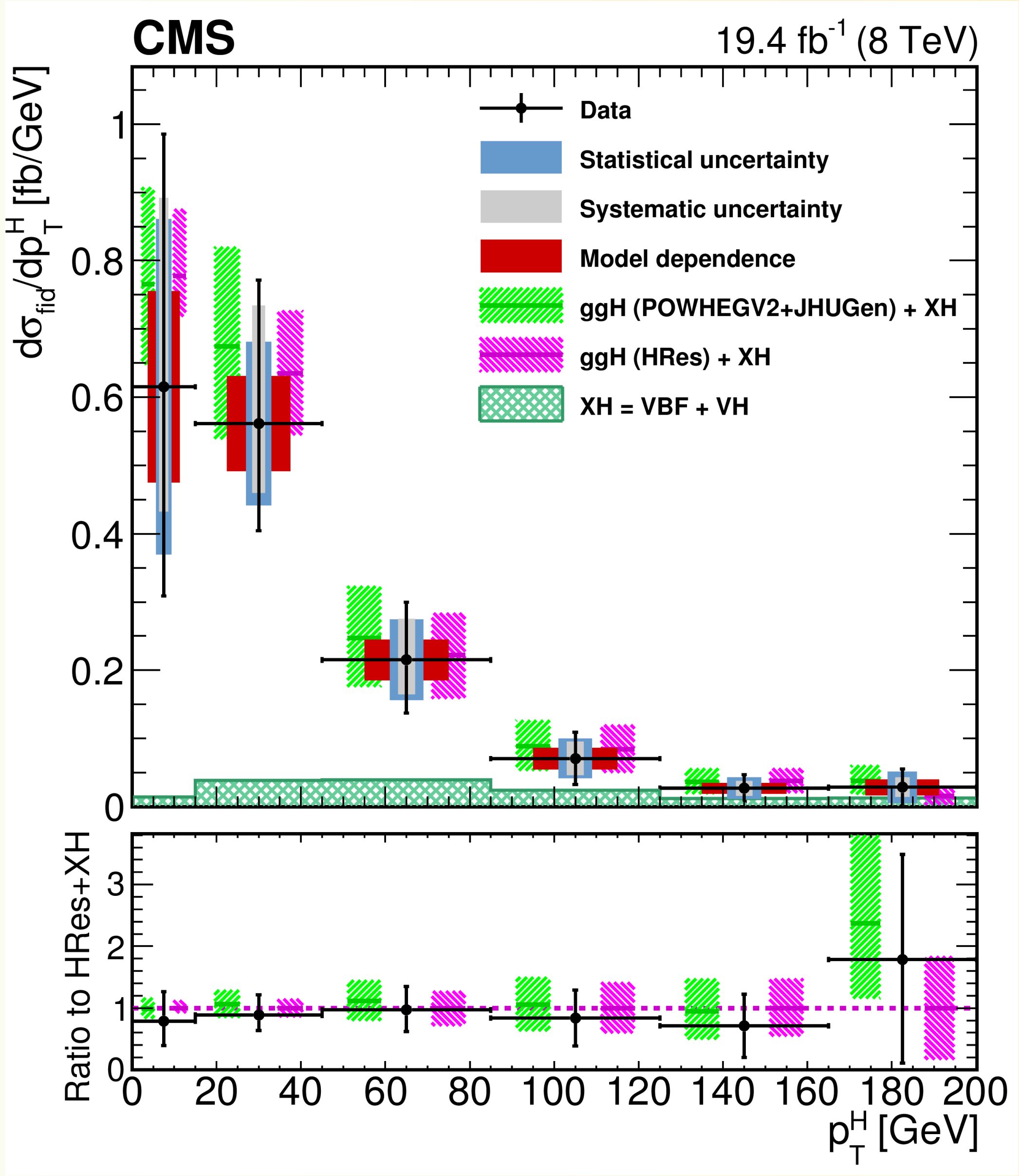
Physics quantity	Requirement
Leading lepton p_T	$p_T > 20\,\text{GeV}$
Subleading lepton p_T	$p_T > 10\,\text{GeV}$
Pseudorapidity of electrons and muons	$\lvert\eta\rvert < 2.5$
Invariant mass of the two charged leptons	$m_{\ell\ell} > 12\,\text{GeV}$
Charged lepton pair p_T	$p_T^{\ell\ell} > 30\,\text{GeV}$
Invariant mass of the leptonic system in the transverse plane	$m_T^{\ell\ell\nu\nu} > 50\,\text{GeV}$
E_T^{miss}	$E_T^{miss} > 0$

$\sigma_{fid} = 39 \pm 8\,(\text{stat}) \pm 9\,(\text{syst})\,\text{fb}$

theory: $48 \pm 8\,\text{fb}$

H to WW - Differential Cross Sections - Run 1

JHEP 03 (2017) 032



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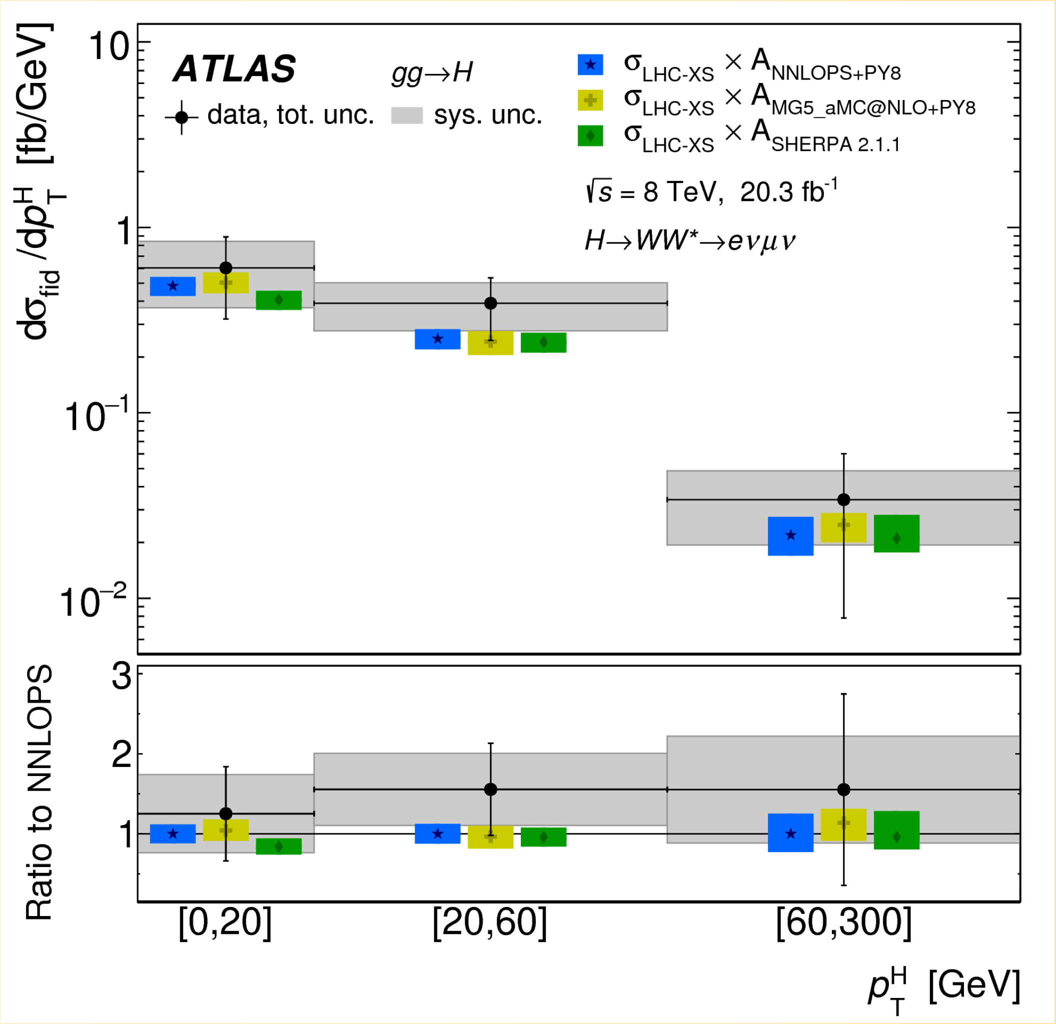


Summary & outlook

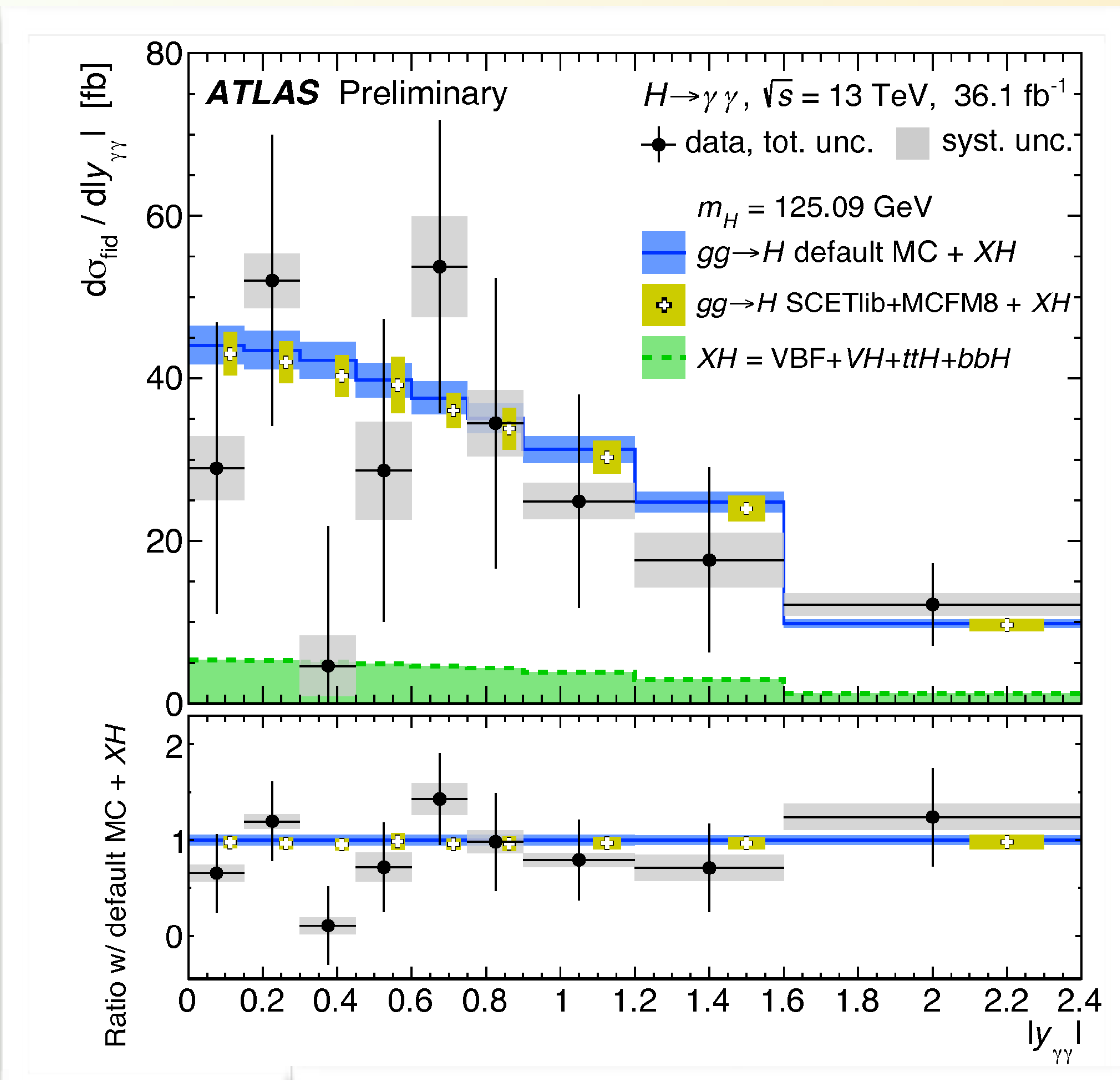
- Fiducial cross sections are defined in order to provide model-independent measurements with a longer lifetime
- Run 2 statistics allows the measurement of a large number of differential cross sections, which can be used to probe QCD modelling, PDFs but also Higgs boson's properties and to constrain BSM extensions
- The measurements are still statistically limited and will certainly benefit from being combined across channels and across experiments. However so far fiducial volumes and binning are optimised measurement by measurement and the two experiments are providing complementary information.
- It is planned to converge on a set of common observables with common binning. Fiducial volumes are harder to harmonise due to detector differences.

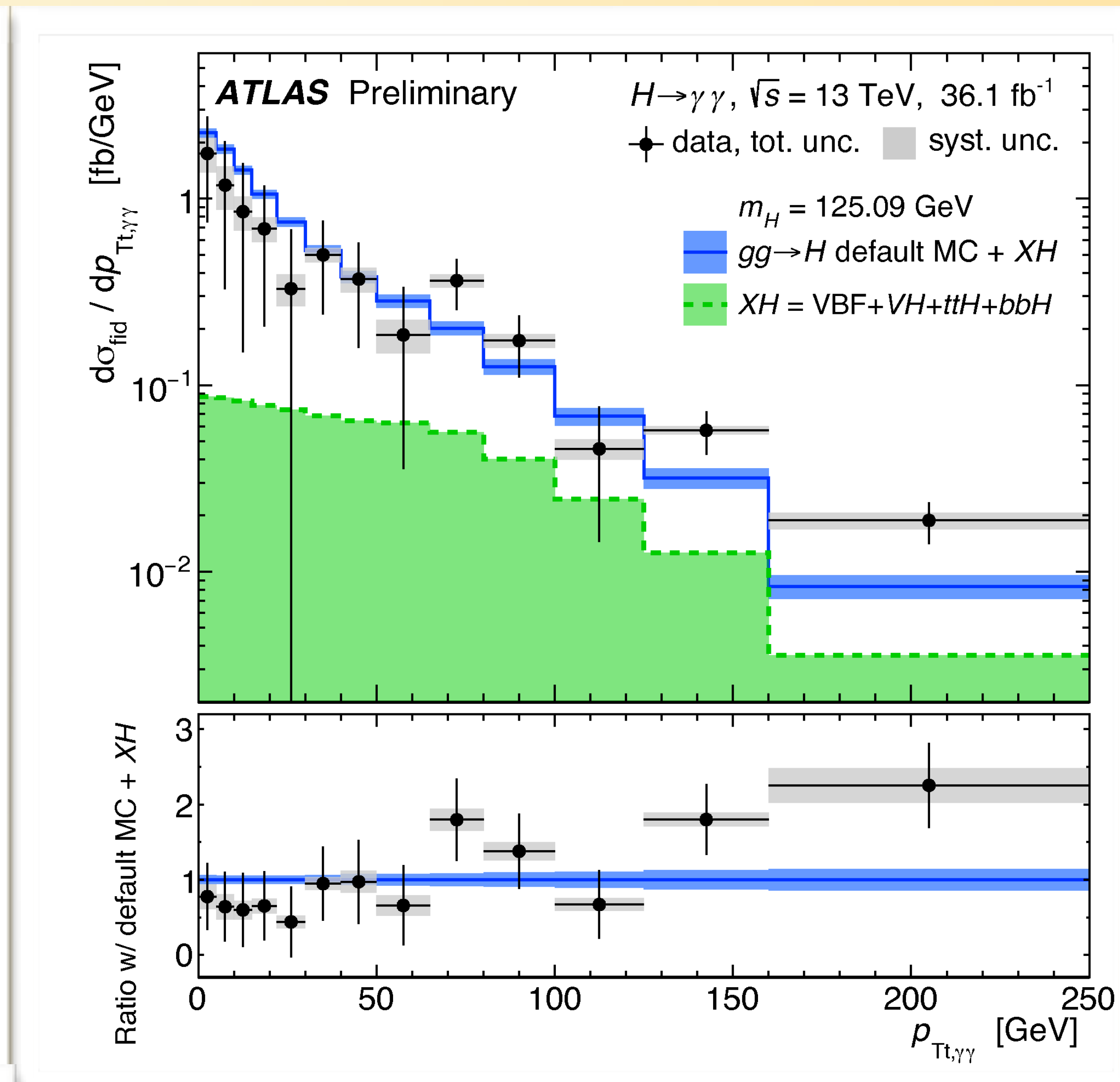
Thank you for the attention

& good luck for future data / model comparisons additional material

H to di-photon - Differential Cross Sections - Run 2

ATLAS-CONF-2017-045



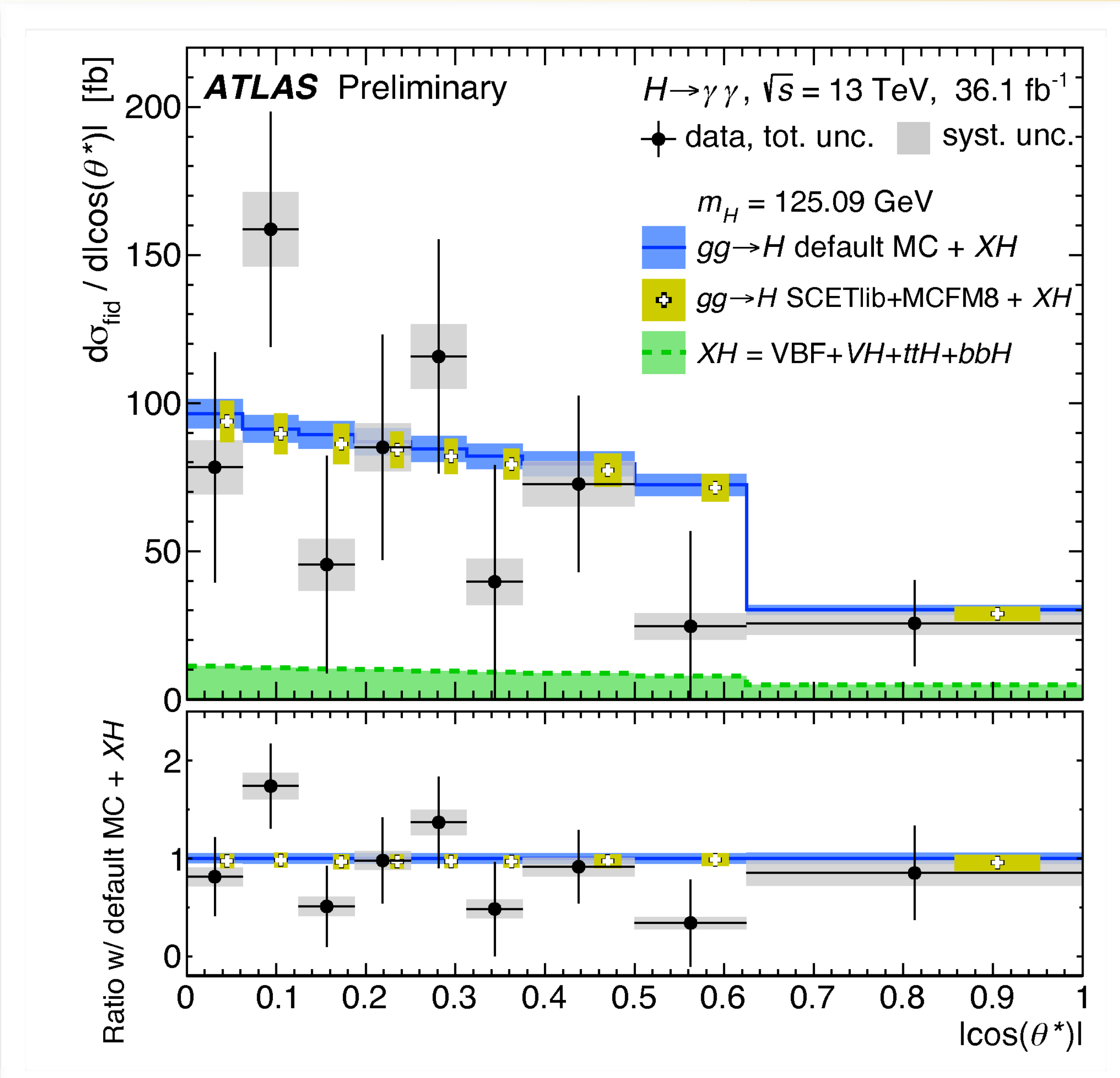


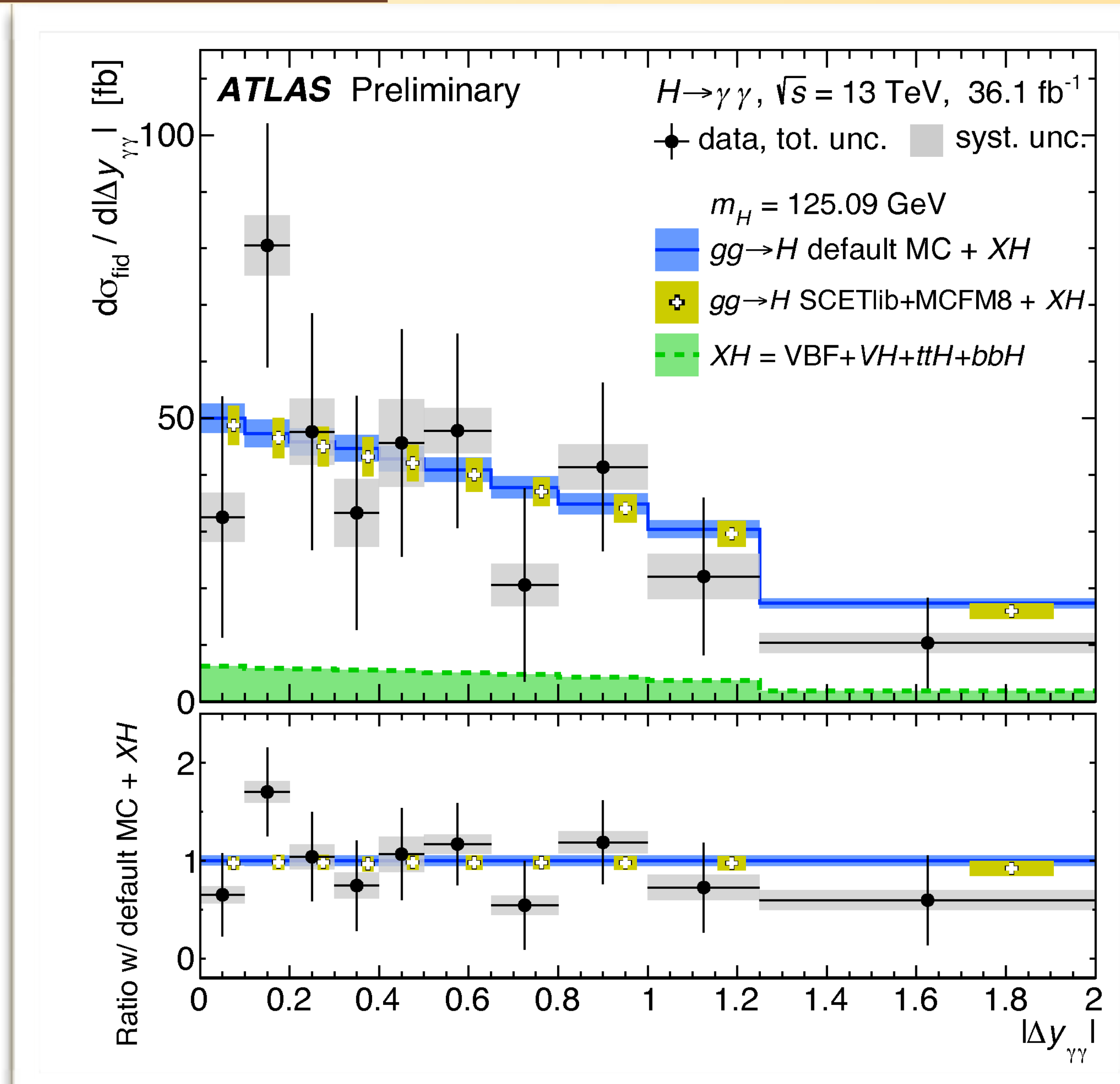
Variable	POWHEG NNLOPS + XH
$p_{\mathrm{T}}^{\gamma\gamma}$	57%
$p_{\mathrm{Tt}}^{\gamma\gamma}$	38%
$\lvert y_{\gamma\gamma}\rvert$	57%
$\lvert\cos\theta^{*}\rvert$	46%
$\lvert\Delta y_{\gamma\gamma}\rvert$	82%

orthogonal component of the diphoton momentum when projected on the axis given by the difference of the 3-momenta of the two photons

H to di-photon - Differential Cross Sections - Run 2

ATLAS-CONF-2017-045





cosine of the angle between the beam axis and the diphoton system in the Collins–Soper frame, sensitive to the Spin of the H boson

Variable	Powheg NNLOPS + XH
$p_{\mathrm{T}}^{\gamma\gamma}$	57%
$p_{\mathrm{Tt}}^{\gamma\gamma}$	38%
$\lvert y_{\gamma\gamma}\rvert$	57%
$\lvert\cos\theta^*\rvert$	46%
$\lvert\Delta y_{\gamma\gamma}\rvert$	82%

H to 4 leptons - Differential Cross Sections - Run 2

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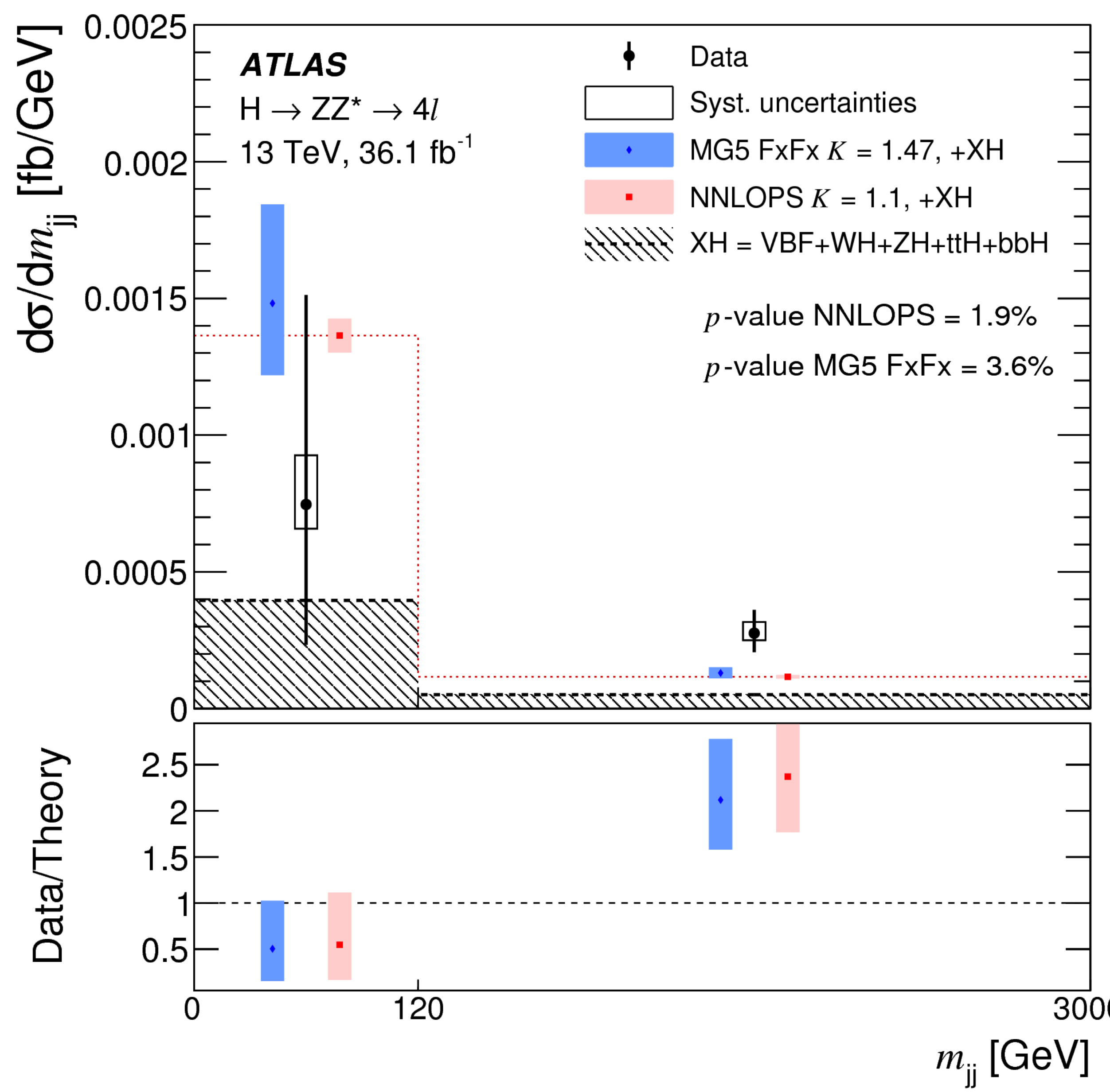

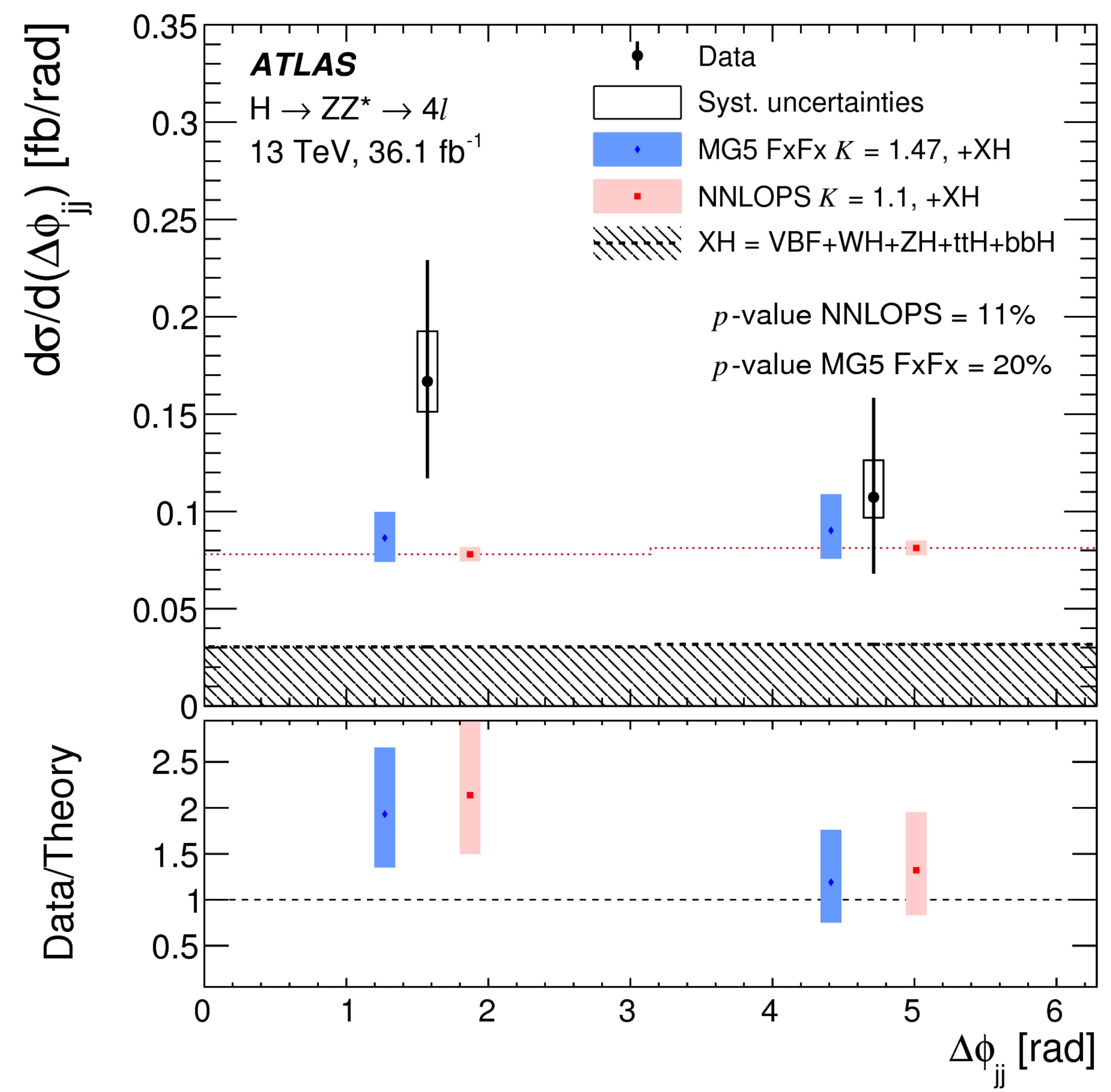

leading jet pair properties

H to WW - Differential Cross Sections - Run 1

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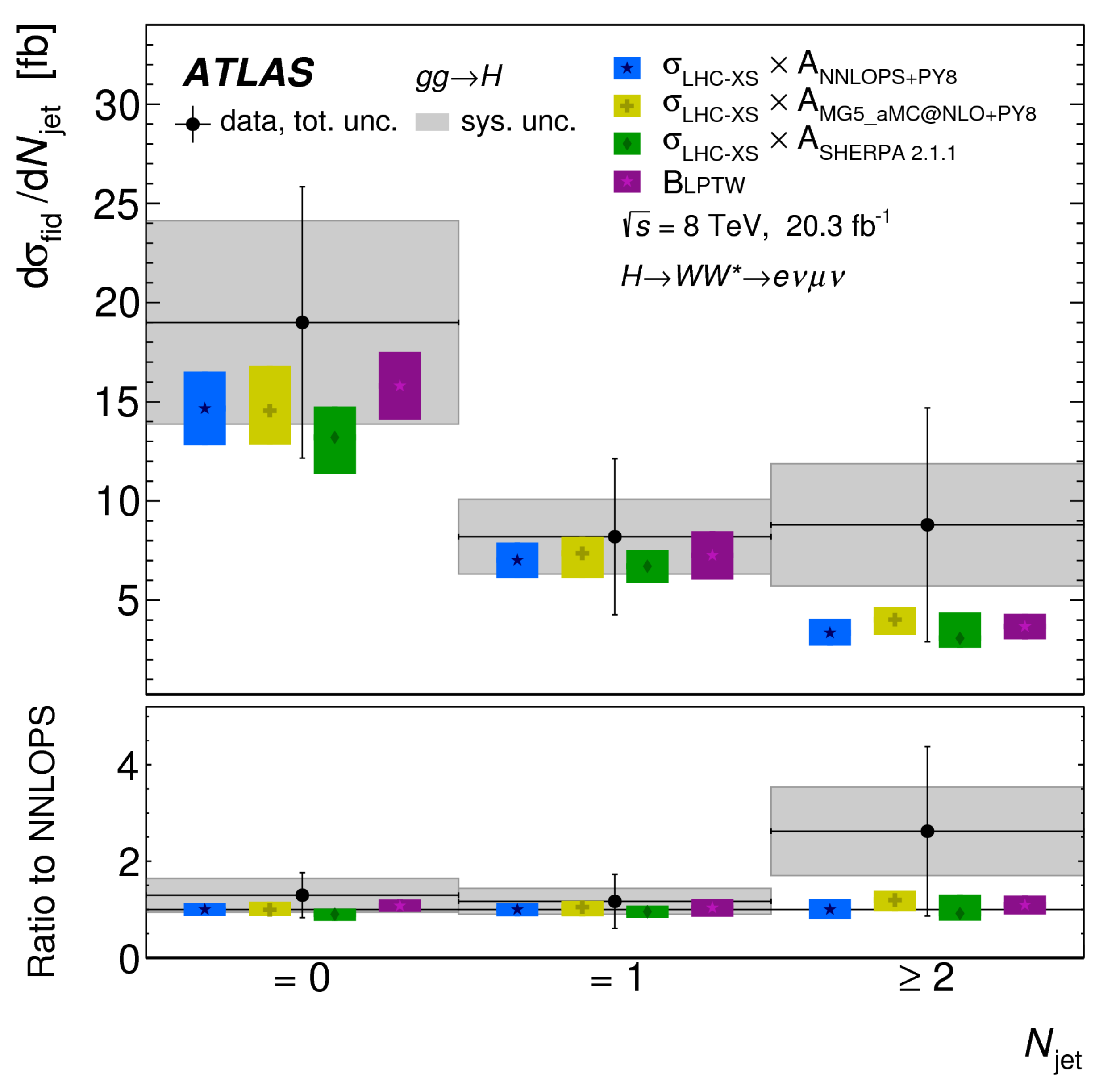

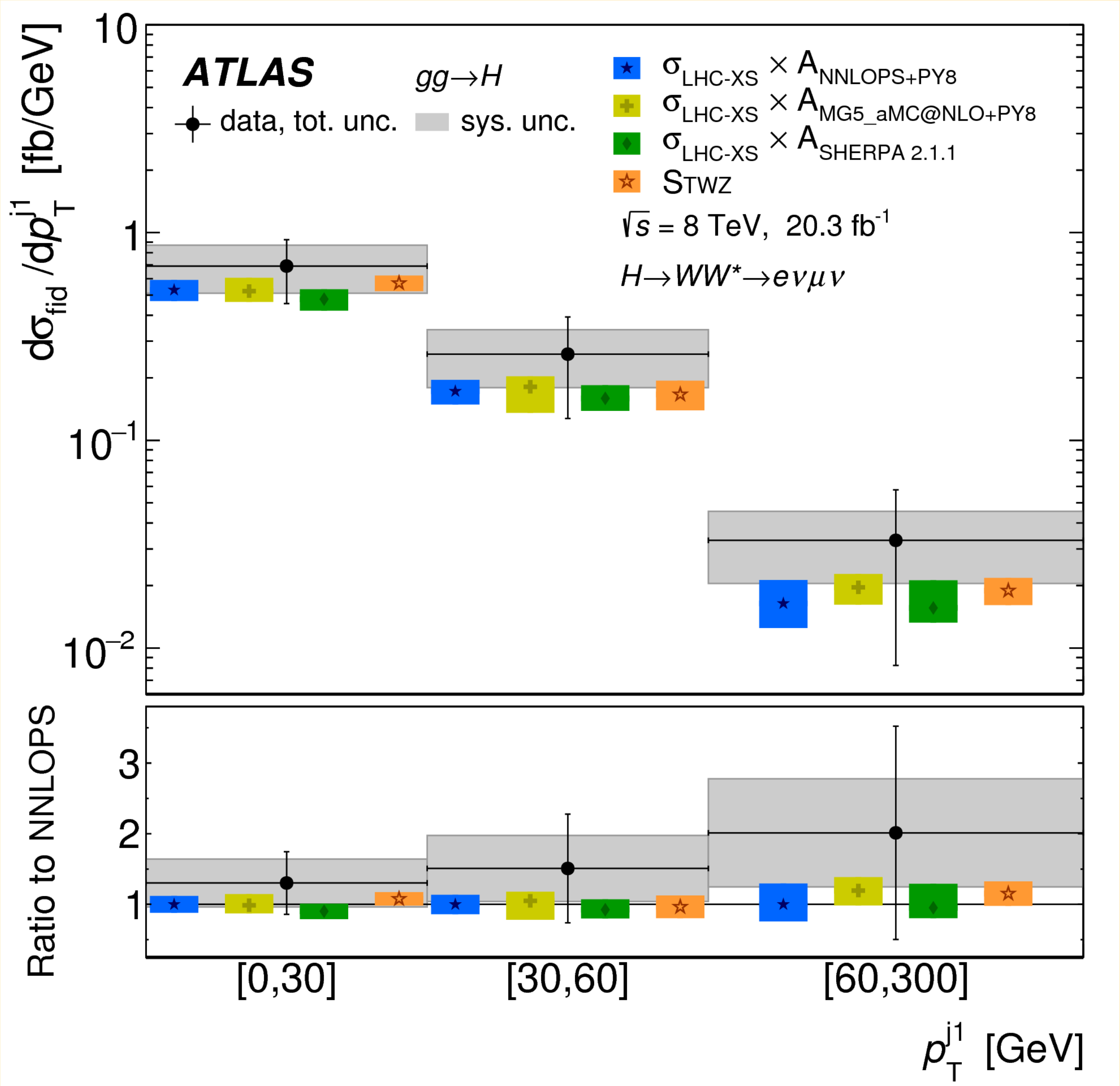

H to WW - Differential Cross Sections - Run 1

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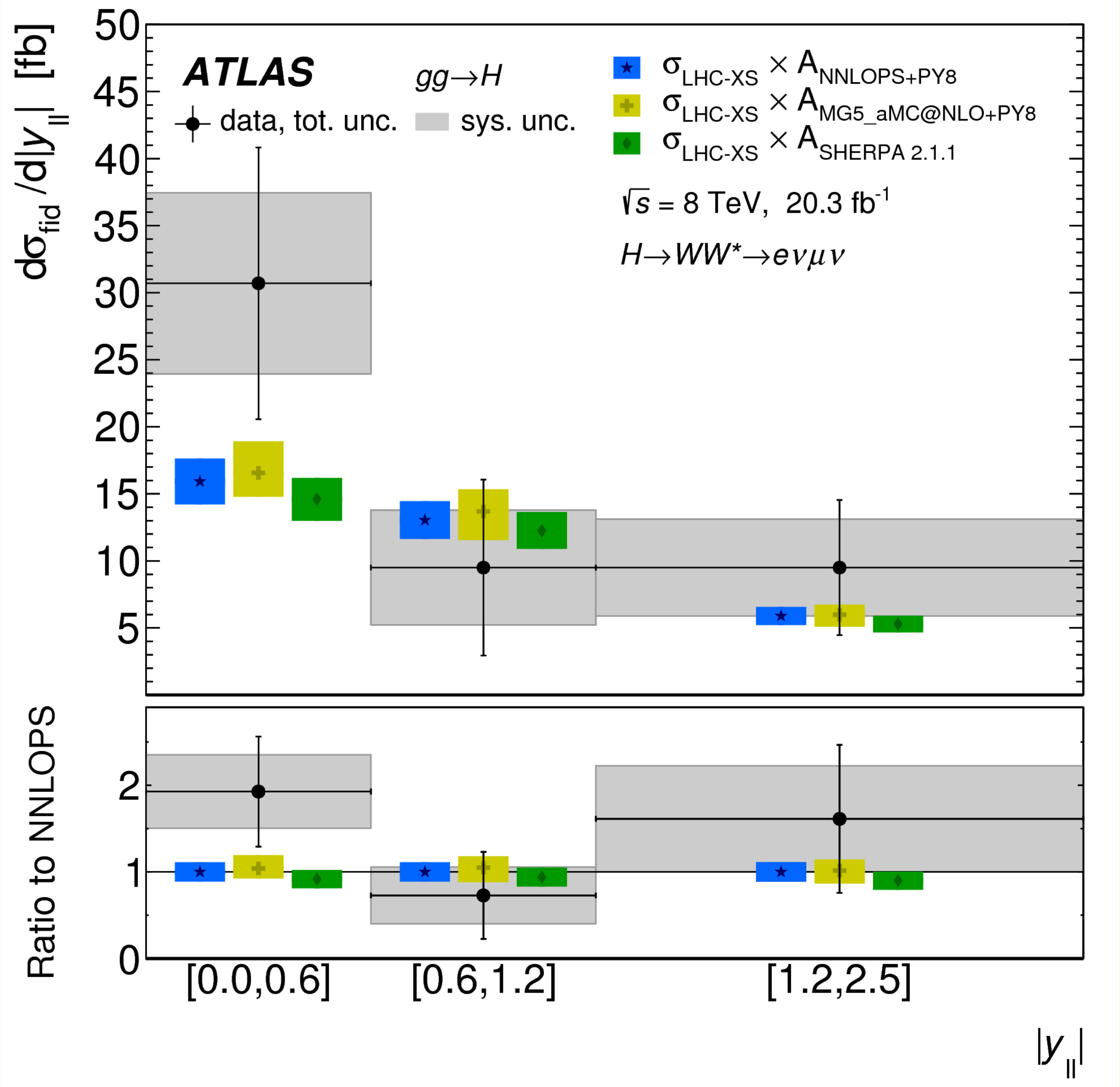
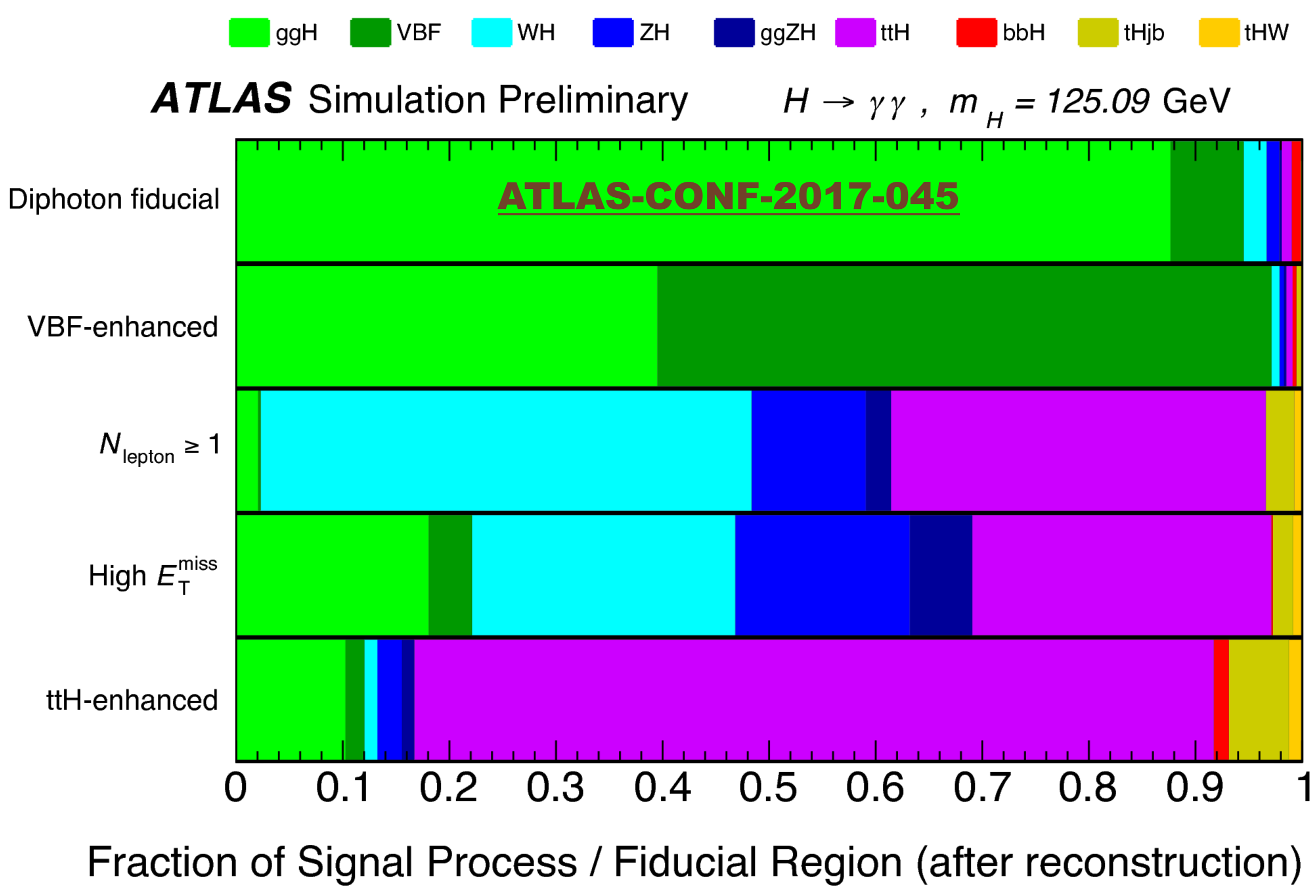
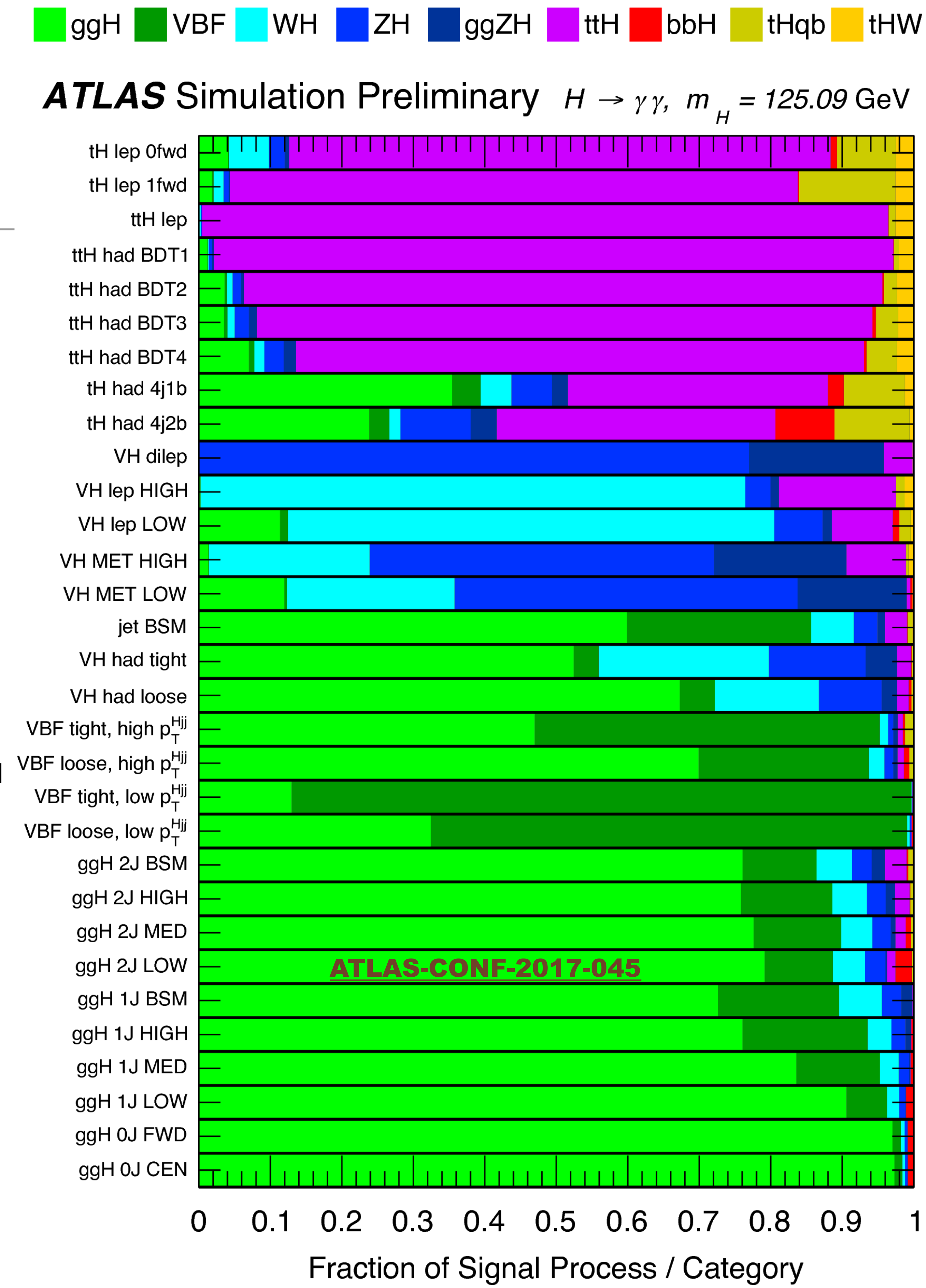


FXS vs STXS



ggH
VBF
WH
ZH
ggZH
ttH
bbH
tHjb
tHW
ATLAS Simulation Preliminary
H → γγ , m H = 125.09 GeV
ATLAS-CONF-2017-045
Diphoton fiducial
VBF-enhanced
N lepton ≥ 1
High E T miss
ttH-enhanced
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fraction of Signal Process / Fiducial Region (after reconstruction)

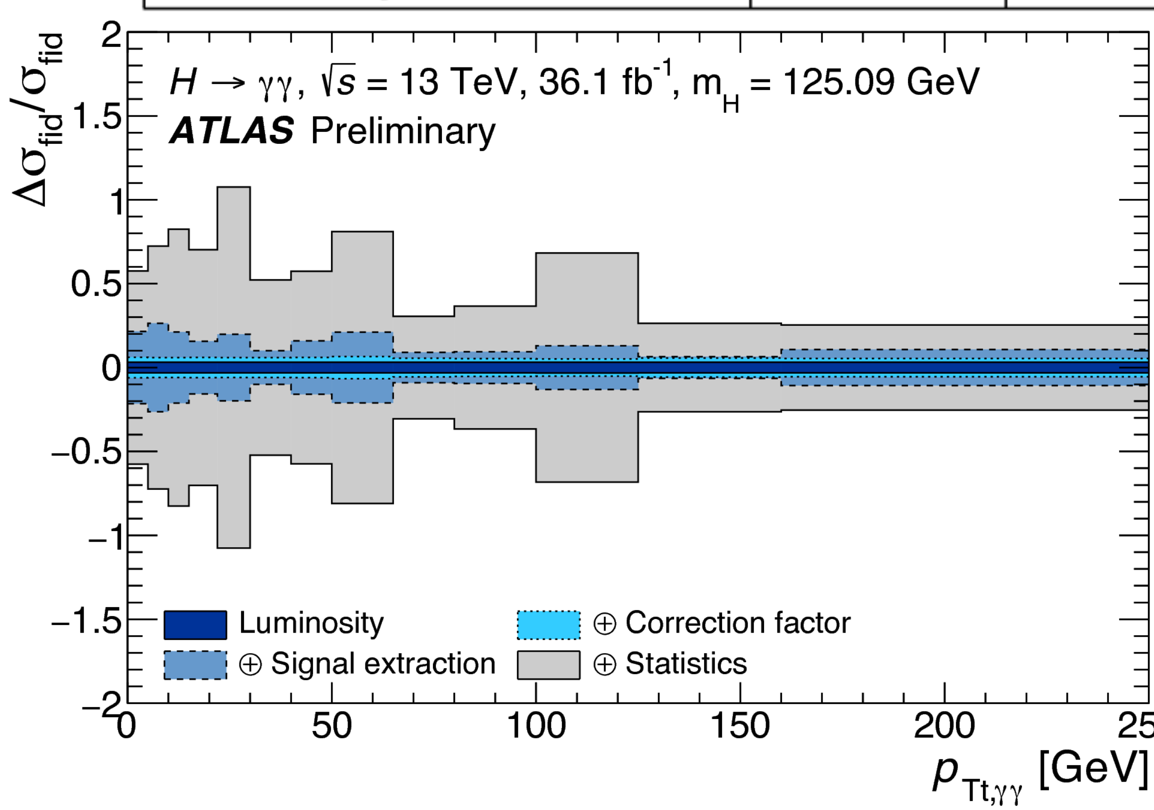


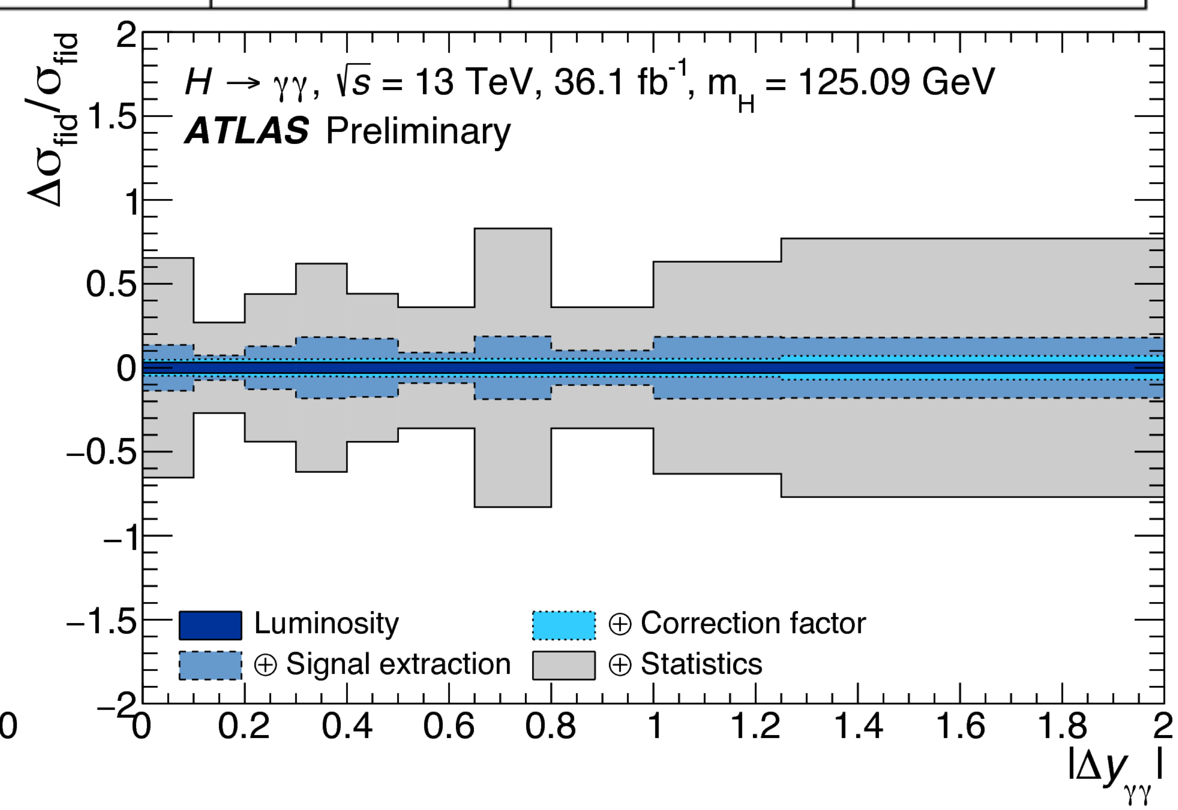
ggH
VBF
WH
ZH
ggZH
ttH
bbH
tHqb
tHW
ATLAS Simulation Preliminary
H → γγ, m H = 125.09 GeV
tH lep 0fwd
tH lep 1fwd
ttH lep
ttH had BDT1
ttH had BDT2
ttH had BDT3
ttH had BDT4
tH had 4j1b
tH had 4j2b
VH dilep
VH lep HIGH
VH lep LOW
VH MET HIGH
VH MET LOW
jet BSM
VH had tight
VH had loose
VBF tight, high p T Hjj
VBF loose, high p T Hjj
VBF tight, low p T Hjj
VBF loose, low p T Hjj
ggH 2J BSM
ggH 2J HIGH
ggH 2J MED
ggH 2J LOW
ggH 1J BSM
ggH 1J HIGH
ggH 1J MED
ggH 1J LOW
ggH 0J FWD
ggH 0J CEN
ATLAS-CONF-2017-045
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Fraction of Signal Process / Category

Uncertainties

ATLAS-CONF-2017-045

Source	Uncertainty on fiducial cross section (%)				
	Diphoton	VBF-enhanced	$N_{\text{lepton}} \geq 1$	$t\bar{t}H$-enhanced	High E_T^{miss}
Fit (stat.)	17%	22%	72%	150%	53%
Fit (syst.)	6%	8%	28%	170%	13%
Photon efficiency	1.8%	1.8%	1.8%	1.8%	1.9%
Jet energy scale/resolution	-	8.9%	-	4.5%	6.9%
b-jet flavour tagging	-	-	-	3%	-
Lepton selection	-	-	0.8%	0.2%	-
Pileup	1.1%	2.9%	1.3%	4.4%	2.5%
Theoretical modeling	4.2%	8.2%	8.7%	12.7%	30%
Luminosity	3.2%	3.2%	3.2%	3.2%	3.2%





Uncertainties

Observable	Stat unc. [%]	Systematic unc. [%]	Dominant systematic components [%]						
			e	μ	jets	ZZ^* theo	Model	$Z+\text{jets}+t\bar{t}$	Lumi
σ_{comb}	14	7	3	3	<0.5	2	0.8	0.8	4
$\text{d}\sigma\ /\ \text{d}p_{\text{T},4\ell}$	30–150	3–11	1–4	1–3	<0.5	<7	<6	1–6	3–5
$\text{d}\sigma\ /\ \text{d}p_{\text{T},4\ell}$ (0j)	31–52	10–18	2–5	1–4	3–16	3–8	1	2–3	3–5
$\text{d}\sigma\ /\ \text{d}p_{\text{T},4\ell}$ (1j)	35–15	6–30	1–4	1–3	2–29	1–4	1–11	1–2	3–5
$\text{d}\sigma\ /\ \text{d}p_{\text{T},4\ell}$ (2j)	30–41	5–21	1–3	1–3	2–19	1–5	1–7	1–2	3–5
$\text{d}\sigma\ /\ \text{d}\lvert y_{4\ell}\rvert$	29–120	5–8	2–4	2–3	<0.5	1–2	<1	1	3–5
$\text{d}\sigma\ /\ \text{d}\lvert\cos\theta^*\rvert$	31–100	5–8	2–4	2–3	<0.5	1–2	<2	1–4	3–5
$\text{d}\sigma\ /\ \text{d}m_{34}$	26–53	4–13	2–5	1–5	<0.5	1–6	<1	1–3	3–5
$\text{d}^2\sigma\ /\ \text{d}m_{12}\ \text{d}m_{34}$	21–40	4–12	2–4	1–4	<0.5	1–6	<1	1–4	3–5
$\text{d}\sigma\ /\ \text{d}N_{\text{jets}}$	22–44	6–31	1–4	1–3	4–22	2–4	1–22	1–2	3–5
$\text{d}\sigma\ /\ \text{d}p_{\text{T}}^{\text{lead.jet}}$	30–53	5–18	1–4	1–3	3–16	2–3	1–8	1–2	3–5
$\text{d}\sigma\ /\ \text{d}\Delta\phi_{\text{jj}}$	29–43	9–17	1–3	1–3	8–14	3–4	1–7	1	3–5
$\text{d}\sigma\ /\ \text{d}m_{\text{jj}}$	23–100	9–27	1–4	1–4	8–24	3–8	1–7	<3	3–5

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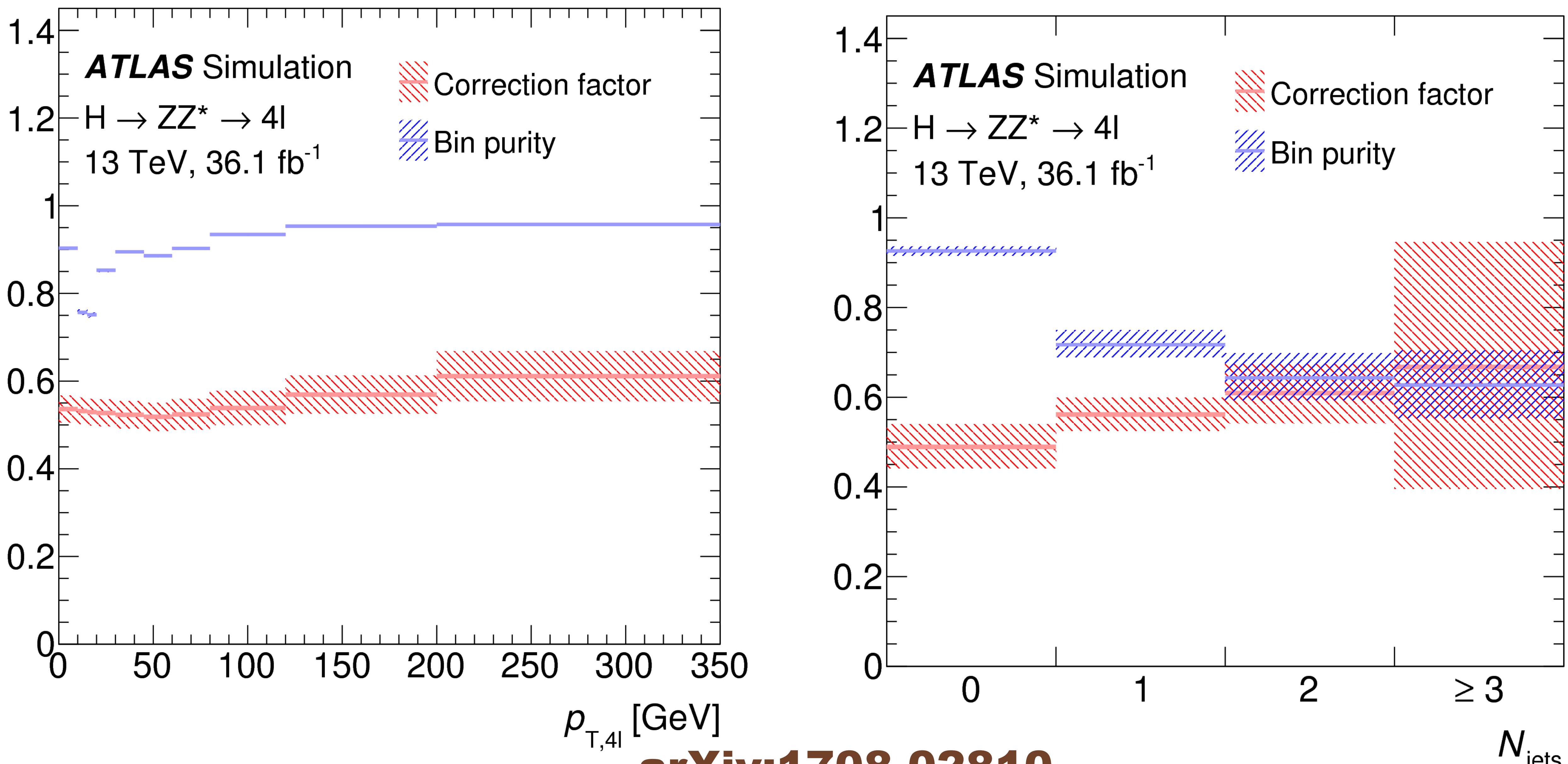
Correction factors

$$\sigma_{i,\mathrm{fid}} = \sigma_i \times A_i \times \mathcal{B} = \frac{N_{i,\mathrm{fit}}}{\mathcal{L} \times C_i}, \quad C_i = \frac{N_{i,\mathrm{reco}}}{N_{i,\mathrm{part}}}$$



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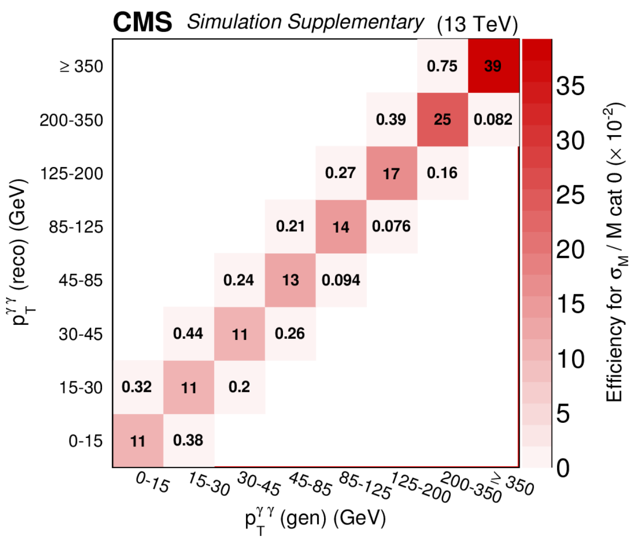
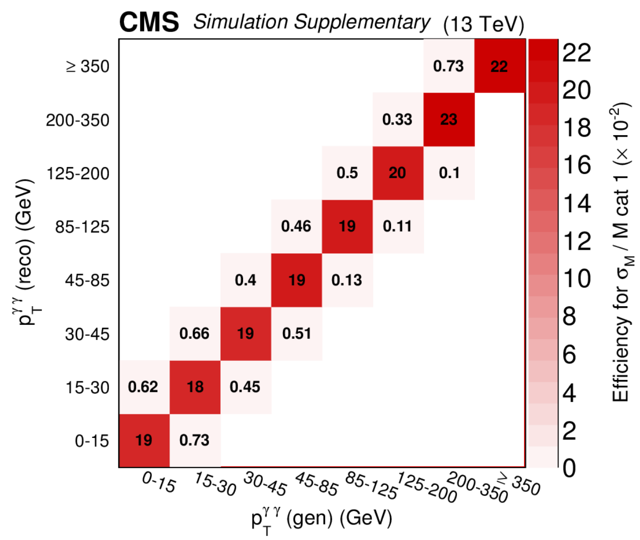
Migration matrices





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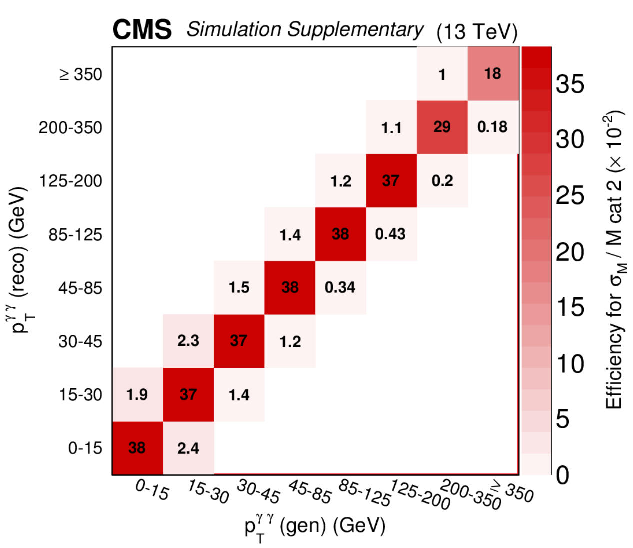

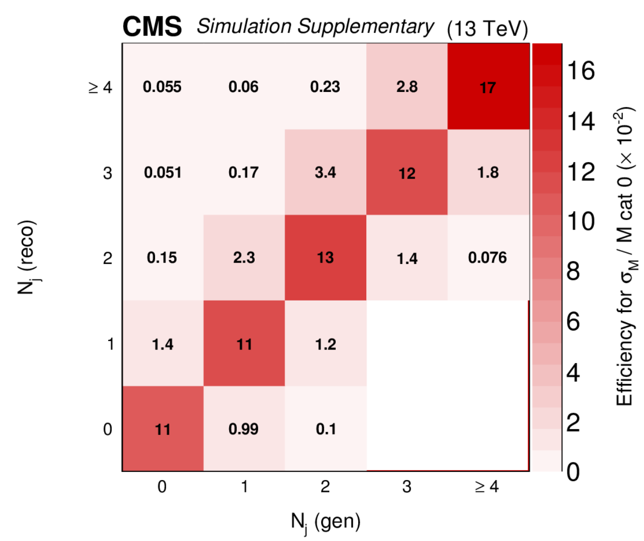

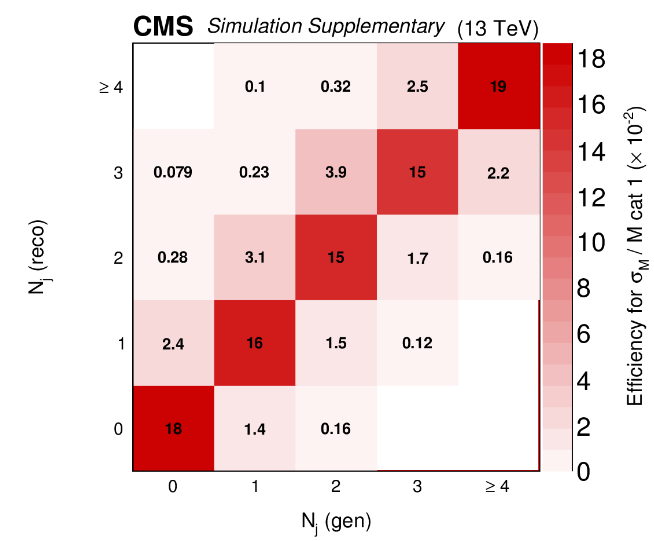

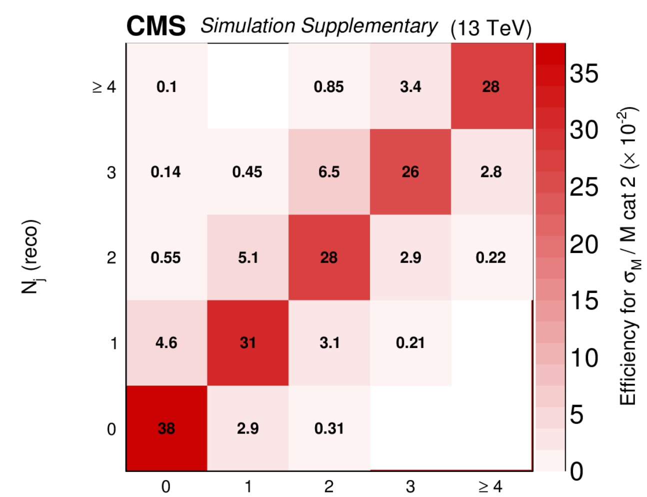

Resolution effects

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