13 TeV non-BSM Higgs results from ATLAS

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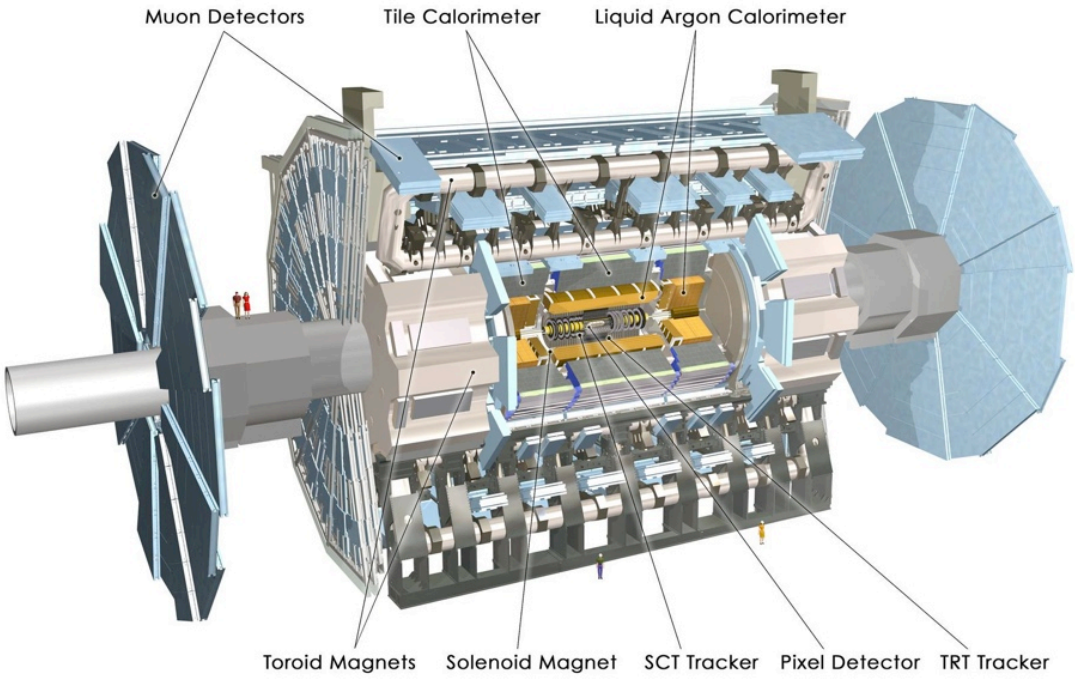
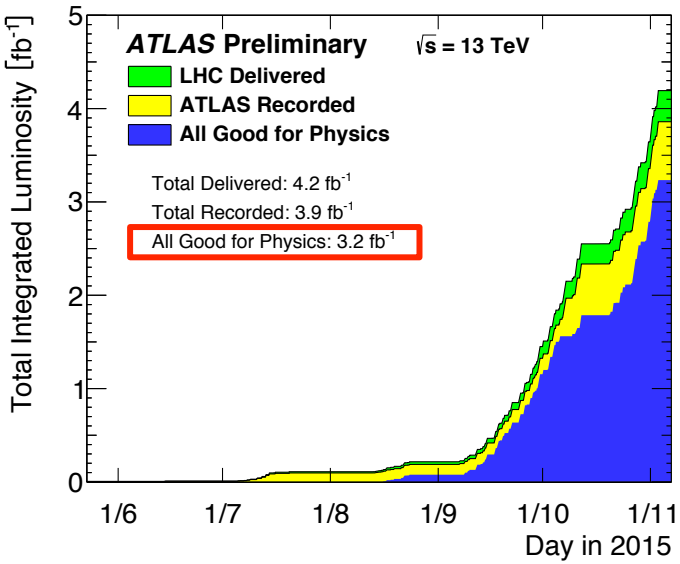
On behalf of the ATLAS Collaboration

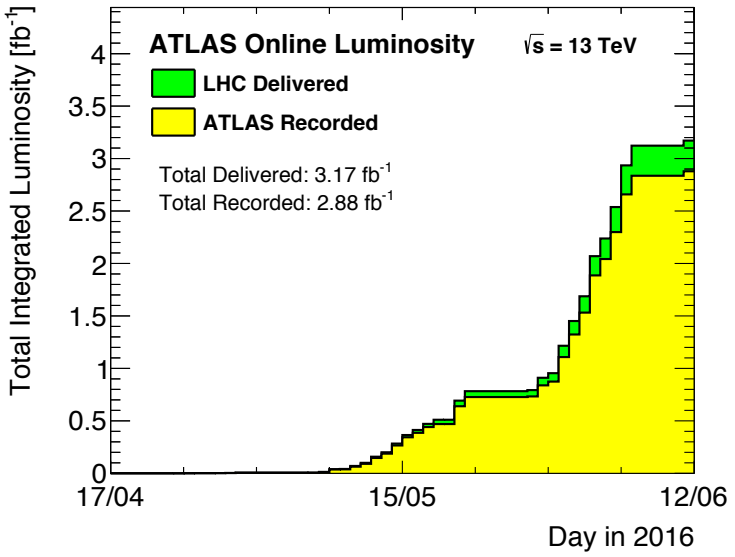
LHCP 2016

Outline

- SM Higgs results from Run 2 with the ATLAS experiment (with IBL)
  - $H \rightarrow \gamma\gamma$, $H \rightarrow ZZ^*(4l)$ and combination
  - $HH \rightarrow bb\gamma\gamma$ and bbbb

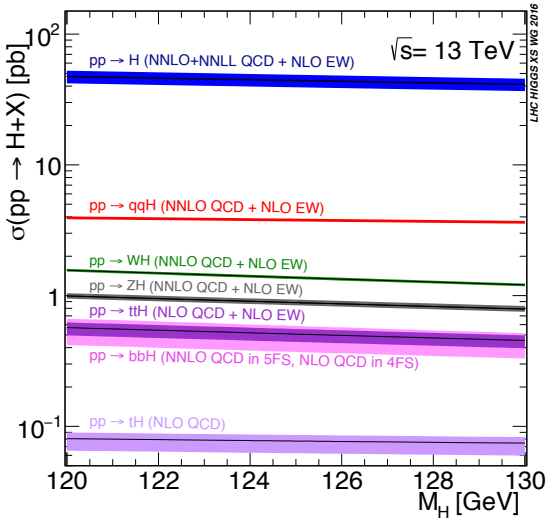


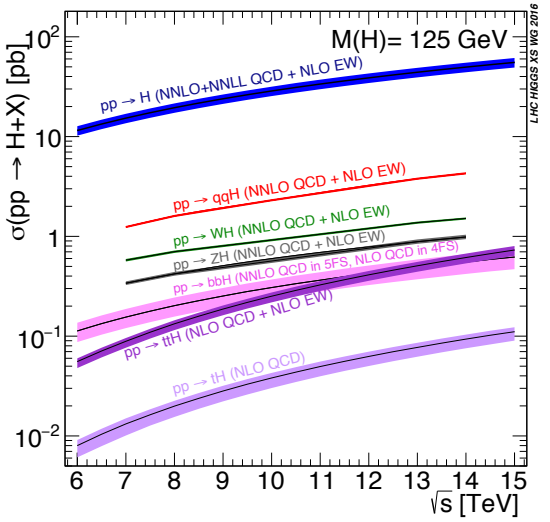




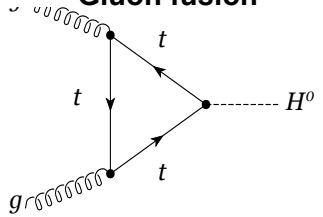
SM Higgs boson production at the LHC

- Consider m_H = 125.09 GeV
  - ATLAS+CMS @ √s=8 TeV
  - PhysRevLett.114.191803
- Gluon Fusion (*gg*F)
  - **gg → H**
  - 86.2%
- Vector Boson Fusion (VBF)
  - **qq → qqH**
  - 7.4%
- Associated production with vector bosons (VH) or ttbar (ttH)
  - **qq → WH**, **ZH**, **ttH+bbH**
  - 2.7%, 1.7%, 1%
- Scaling with √s
  - **gg → H :** $\sigma_{13TeV}/\sigma_{8TeV}$: 2.3
  - **qq → qqH :** $\sigma_{13TeV}/\sigma_{8TeV}$: 2.5
  - **qq → WH**, **ZH**, **ttH:** $\sigma_{13TeV}/\sigma_{8TeV}$: 1.9, 2.1, 3.9

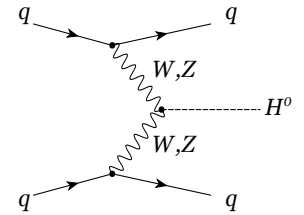




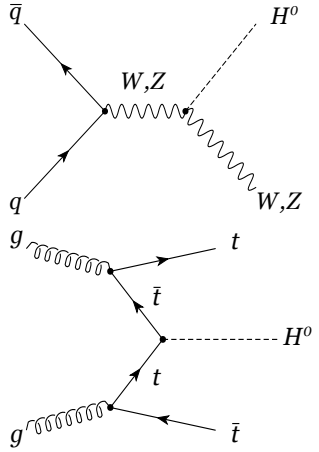
Gluon fusion



Vector Boson fusion



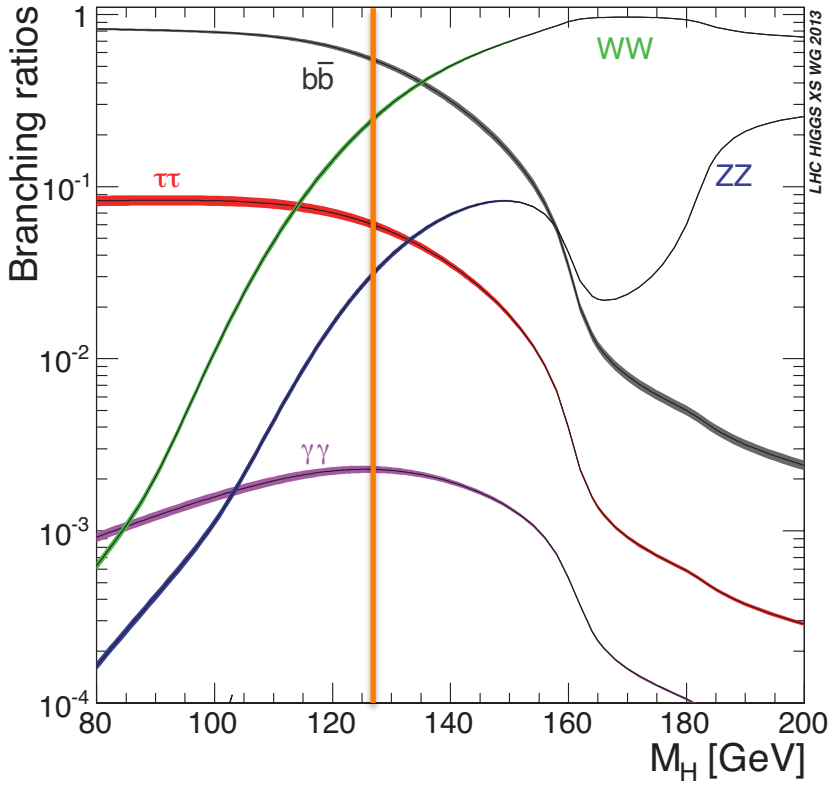
Associated production



CERN Yellow Rep I,II,III
(***arXiv:1101.0593***, ***arXiv:1201.3084*** and ***arXiv:1307.1347***)
https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWG

SM Higgs boson decays at the LHC

- Higgs boson decay channels at m_H = 125.09 GeV are
  - **H → bb**
    - BR ($H \rightarrow b\bar{b}$): 58.1 %
    - Large BR, Yukawa coupling
  - **H → WW**
    - BR ($H \rightarrow WW$): 21.5 %
    - Large BR, gauge boson coupling
  - **H → ττ**
    - BR ($H \rightarrow \tau\tau$): 6.3 %
    - Yukawa coupling
  - **H → ZZ**
    - BR ($H \rightarrow ZZ$): 2.8 %
    - BR ($H \rightarrow ZZ \rightarrow 4l$): 0.0125 %
    - High mass resolution, high S/B, gauge boson coupling
  - **H → γγ**
    - BR ($H \rightarrow \gamma\gamma$): 0.23 %
    - High mass resolution, loop coupling dominated by gauge boson coupling



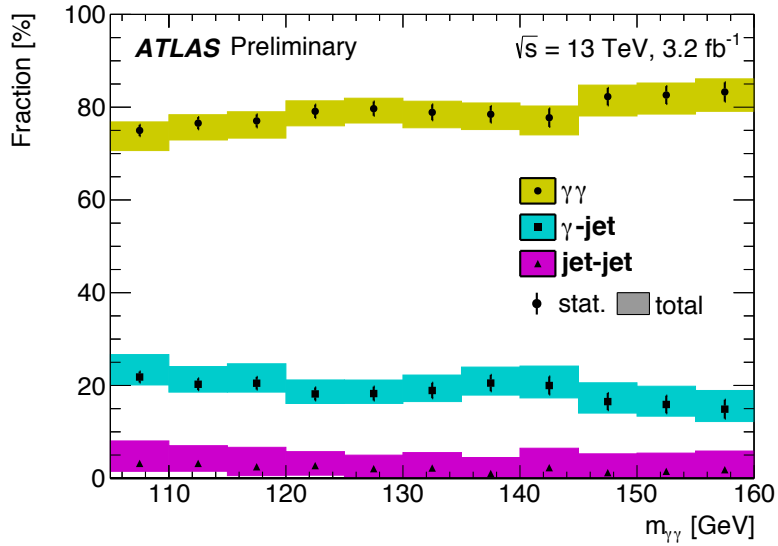
CERN Yellow Report IV

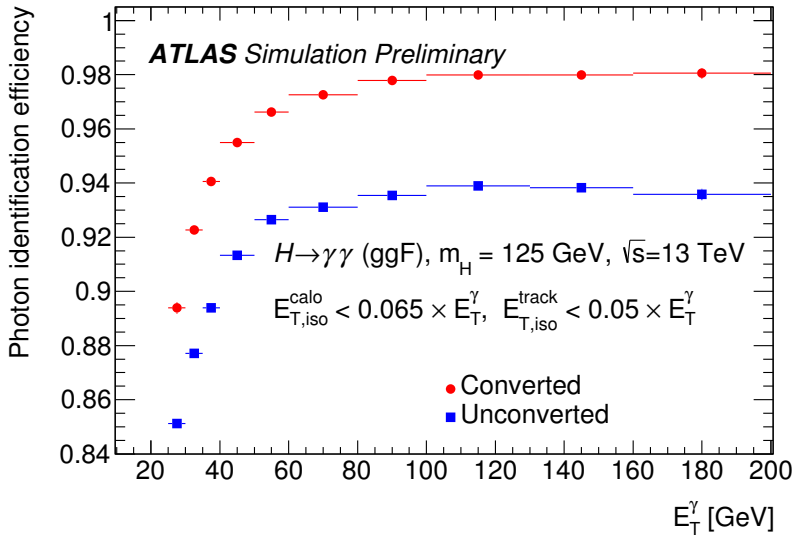
Higgs to γγ channel search

- Clear signature over backgrounds
  - Continuum γγ
  - π^0 from jet fragmentation mis-identified as photons in γ-jet and jet-jet
  - Drell-yan events with both electrons mis-identified as photons
- Changes with respect to Run 1
  - Optimized identification, calibration, isolation and vertex conditions
- Event selection
  - Fiducial coverage excluding crack region 1.37< |η| <1.52 (1.56 in Run1)
  - Tight photon ID to reject hadronic or jet background
  - High primary vertex efficiency

Fiducial selection at particle level

Two highest-p_{T} photons:	$\lvert\eta^{\gamma}\rvert < 2.37$
Relative-p_{T}:	$E^{\gamma}_{\mathrm{T},1}/m_{\gamma\gamma} \geq 0.35, E^{\gamma}_{\mathrm{T},2}/m_{\gamma\gamma} \geq 0.25$
Mass window:	$105\,\mathrm{GeV} \leq m_{\gamma\gamma} < 160\,\mathrm{GeV}$
Photon isolation:	$E_{\mathrm{T,iso}} < 0.1 \times E^{\gamma}_{\mathrm{T}} + 1\,\mathrm{GeV}$





ATLAS-CONF-2015-060

Higgs to γγ signal extraction

- Signal extracted from likelihood fit

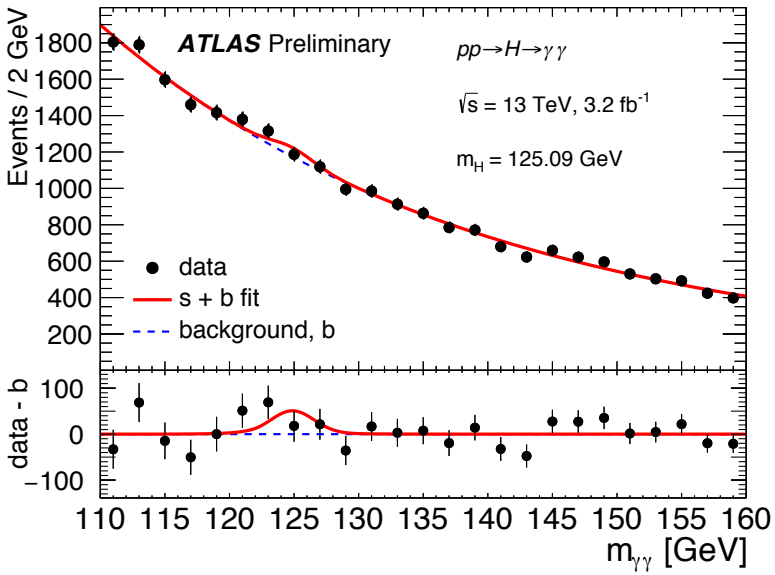
$$N_{\text{exp}} = 143 \pm 71(\text{stat.})\,^{+39}_{-6}(\text{syst.})$$

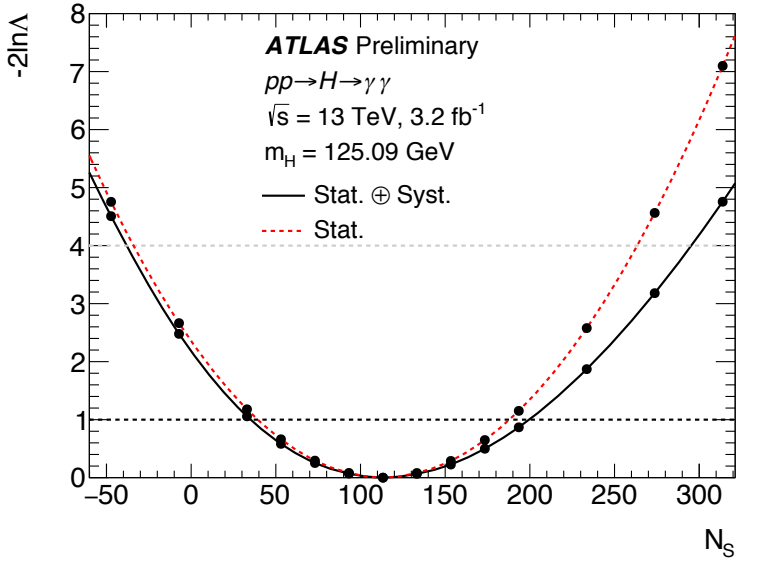
$$N_{\text{S}} = 113 \pm 74(\text{stat.})\,^{+43}_{-25}(\text{syst.})$$

- Dominant systematic uncertainties:

Component	Uncertainty [%]
Total fit	$^{+76}_{-69}$
Fit: statistical	±66
Fit: systematic	$^{+38}_{-22}$
Background modeling	±7.7
Signal modeling	±1.5
Dalitz contribution	±0.3
Total	$^{+76}_{-70}$

- Observed (expected) significance above the null-signal hypothesis is 1.5σ (1.9σ)





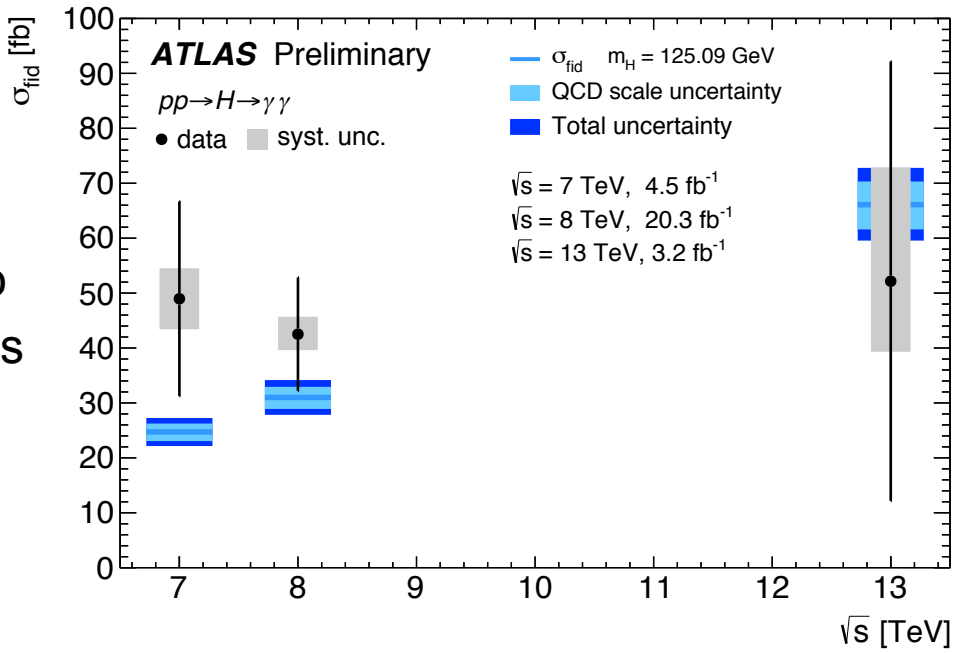
ATLAS-CONF-2015-060

Higgs to γγ fiducial cross section

- Fiducial cross section from luminosity and detector effects

$$\sigma = \frac{N_S}{\mathcal{L}_{\text{int}}\,\mathcal{B}\,\mathcal{A}\,\mathcal{C}} = \frac{\sigma_{\text{fid}}}{\mathcal{B}\,\mathcal{A}}$$

$\mathcal{A}$ Acceptance
$\mathcal{B}$ Branching ratio
$\mathcal{C}$ Det. efficiencies



Component	Uncertainty [%]
Photon energy scale	< 0.1
Photon energy resolution	< 0.1
Photon identification efficiency	± 2.6
Photon isolation efficiency	± 4.0
Trigger efficiency	± 0.4
Vertex selection	< 0.1
Theoretical modeling uncertainty	± 0.8
Total	± 4.8

ATLAS-CONF-2015-060

$\sqrt{s}$	Measured fiducial cross section [fb]	LHC-XS prediction [fb]
7 TeV	49 ± 17 (stat.) ± 6 (syst.) ± 1 (lumi.)	24.7 ± 2.6
8 TeV	42.5 ± 9.8 (stat.) $^{+2.9}_{-2.7}$ (syst.) ± 1.2 (lumi.)	31.0 ± 3.2
13 TeV	52 ± 34 (stat.) $^{+21}_{-13}$ (syst.) ± 3 (lumi.)	$66.1\ ^{+6.8}_{-6.6}$

Higgs to γγ total cross section

- Measure total from fiducial cross section

$$\sigma = \frac{\sigma_{\text{fid}}}{\mathcal{B}\,\mathcal{A}}$$

$\mathcal{A}$ Acceptance

$\mathcal{B}$ BR(γγ): 0.228 ± 0.011

- 2 different PDF sets used to estimate acceptance uncertainties
  - At higher √s, more events fall out of the fiducial region (fwd events)

$\sqrt{s}$	$\mathcal{A}$
7 TeV	0.620 ± 0.007
8 TeV	0.611 ± 0.012
13 TeV	0.570 ± 0.006

- Cross section upper limit at 95% CL for √s=13 TeV is 106 pb (112 pb exp)
  - Using asymptotic approximation

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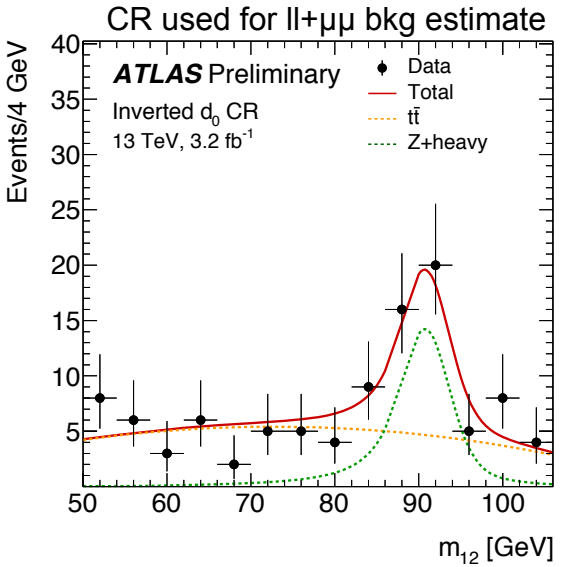
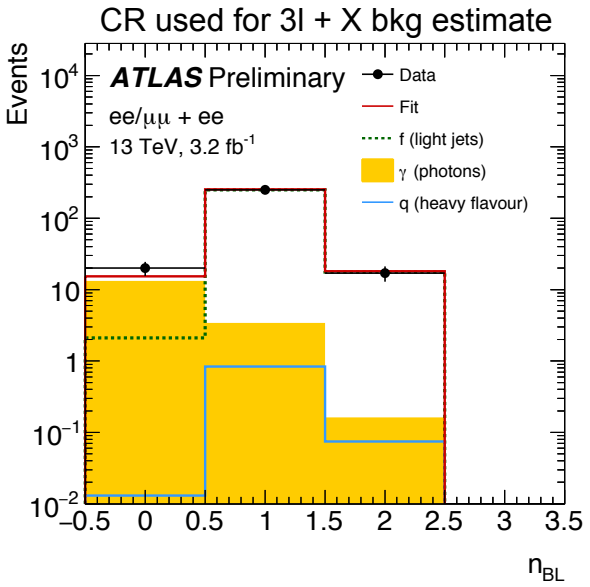
$\sqrt{s}$	Measured total cross section [pb]	LHC-XS prediction [pb]
7 TeV	35 ± 12 (stat.) ± 4 (syst.) ± 1 (lumi.)	17.5 ± 1.6
8 TeV	30.5 ± 7.1 (stat.) $^{+2.6}_{-2.5}$ (syst.) ± 0.9 (lumi.)	22.3 ± 2.0
13 TeV	40 ± 26 (stat.) $^{+16}_{-10}$ (syst.) ± 2 (lumi.)	$50.9\ ^{+4.5}_{-4.4}$

Higgs to ZZ*(4l) channel search

- Data driven background normalization
  - ll+μμ : semi-leptonic decays of heavy flavors (d_0 cut)
  - eμ+μμ : used to constraint the ttbar
  - 3l+x : account for mis-tagging of light jets, photon conversions or semi-leptonic hadrons (IBL)
- Particle identification changes
  - Electron: Requirement on impact parameter in transversal plane (d_0) and its error (d_0/σ_{d0})
  - Muon: Segment tag muons (ID+part MS) in |η| < 0.1

Lepton definition	
Muons: $p_{\mathrm{T}} > 6$ GeV, $\lvert\eta\rvert < 2.7$	Electrons: $p_{\mathrm{T}} > 7$ GeV, $\lvert\eta\rvert < 2.47$
Pairing	
Leading pair:	SFOS lepton pair with smallest $\lvert m_Z - m_{\ell\ell}\rvert$
Sub-leading pair:	Remaining SFOS lepton pair with smallest $\lvert m_Z - m_{\ell\ell}\rvert$
Event selection	
Lepton kinematics:	Leading lepton $p_{\mathrm{T}} > 20, 15, 10$ GeV
Mass requirements:	$50 < m_{12} < 106$ GeV; $12 < m_{34} < 115$ GeV
Lepton separation:	$\Delta R(\ell_i, \ell_j) > 0.1(0.2)$ for same (opposite) flavour leptons
J/ψ veto:	$m(\ell_i, \ell_j) > 5$ GeV for all SFOS lepton pairs
Mass window:	$118 < m_{4\ell} < 129$ GeV



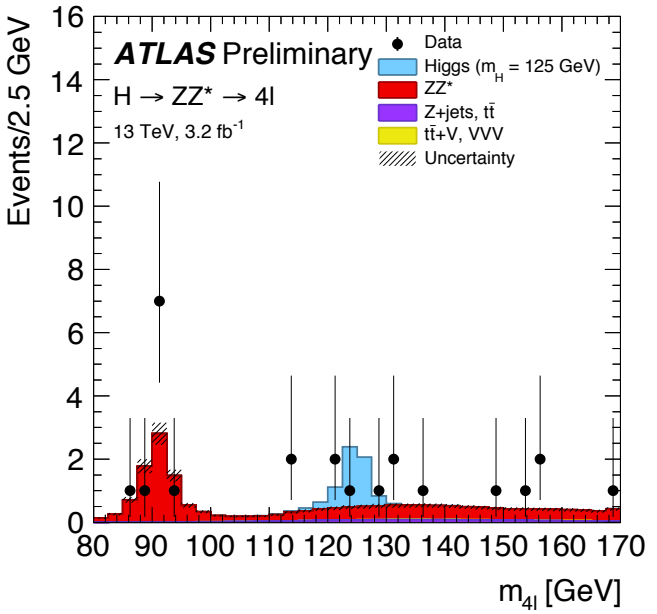


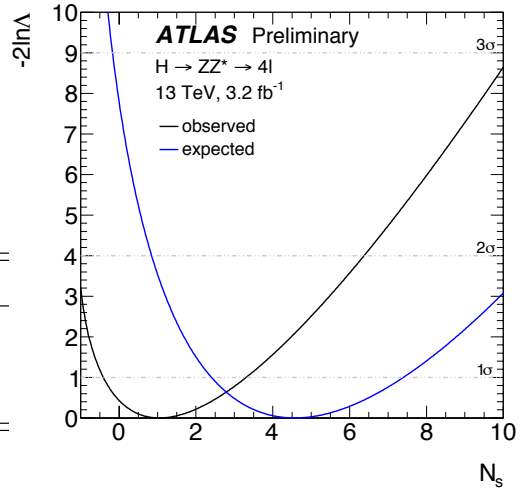
ATLAS-CONF-2015-059

Higgs to ZZ*(4l) signal extraction

- Extracted N_S from fit to m_{4l} distribution
- Expected number of events in the signal region from control region through extrapolation factors
  - Uncertainties combined linearly with SR yields

	m_{4l} > 200 GeV		m_{4l} [118-129] GeV		
Final state	**Exp**	**Obs**	**Signal**	**Exp**	**Obs**
4μ	22.4 ± 2.2	20	1.67 ± 0.20	2.39 ± 0.21	1
2e2μ	17.2 ± 1.6	17	1.06 ± 0.13	1.57 ± 0.14	1
2μ2e	18.3 ± 2.6	13	0.96 ± 0.15	1.40 ± 0.16	2
4e	14.1 ± 2.1	12	0.88 ± 0.13	1.30 ± 0.14	0
Total	**72 ± 8**	**62**	**4.57 ± 0.54**	**6.65 ± 0.58**	**4**





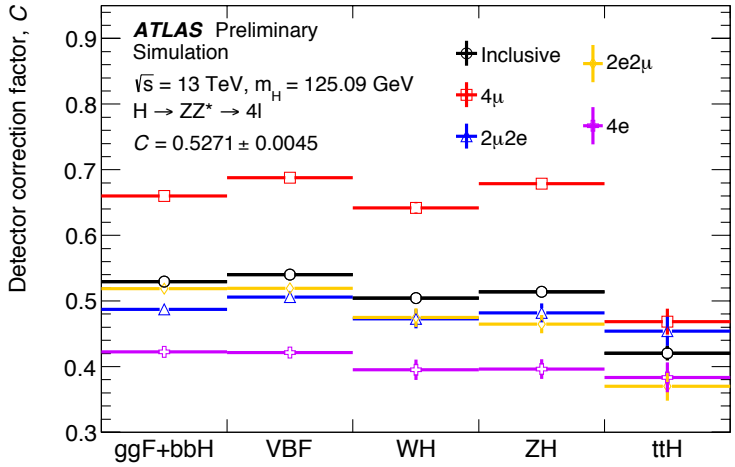
Background	Fit yield in reference CR	Extrapolation factor	Yield in SR
Z+heavy flavour jets	46 ± 11	$(6.4 \pm 0.9) \cdot 10^{-3}$	$0.30 \pm 0.07 \pm 0.10$
$t\bar{t}$	81 ± 7	$(2.8 \pm 1.9) \cdot 10^{-3}$	$0.23 \pm 0.02 \pm 0.16$
Z+light flavour jets	14 ± 7	$(2.5 \pm 0.4) \cdot 10^{-2}$	$0.35 \pm 0.17 \pm 0.07$

ATLAS-CONF-2015-059

Higgs to ZZ*(4l) cross section

- Observed (expected) significance above null-signal: 1.4σ (2.8 σ)
- Cross section upper limit of 68 pb at 95% CL for √s=13 TeV
  - Using asymptotic approach
- Measure the fiducial and total cross section
  - BR(ZZ→4l): $(1.24\pm0.06)10^{-4}$

ATLAS-CONF-2015-059



	$\sqrt{s}$ [TeV]		
	7	8	13
$\mathcal{A}$ [%]	46.67 ± 0.23	45.98 ± 0.14	42.74 ± 0.24
$\mathcal{C}$ [%]	51.89 ± 0.36	55.32 ± 0.24	52.71 ± 0.45

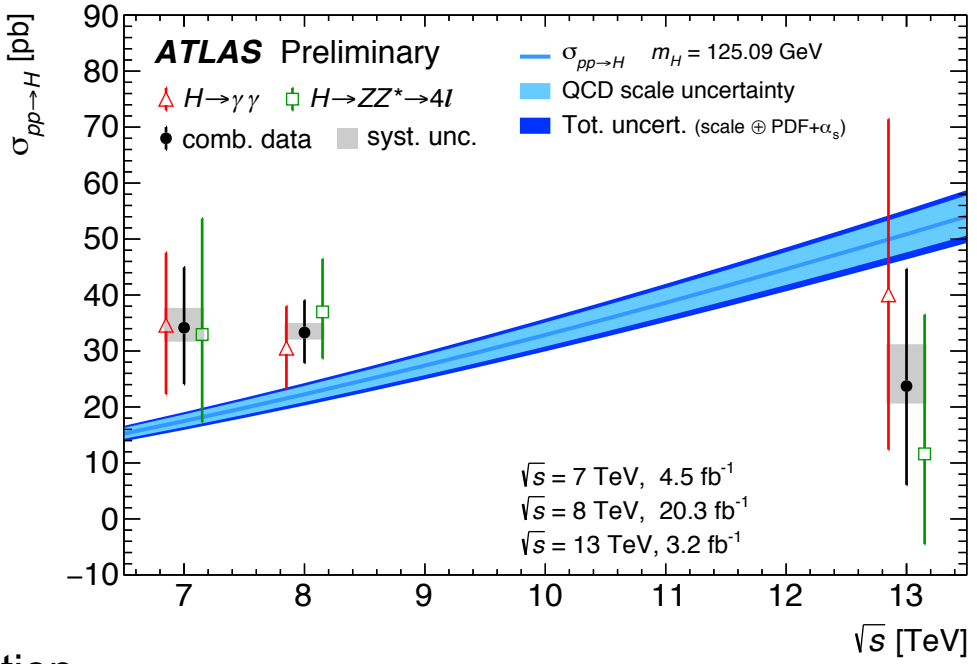
Data set [TeV]	N_s	$\sigma^{fid}_{4\ell}$ [fb]	σ^{fid}_{theory} [fb]	σ^{tot} [pb]	σ^{tot}_{theory} [pb]
7	$4.5\ ^{+2.8}_{-2.2}$	$1.9\ ^{+1.2}_{-0.9}$	$1.03\ \pm0.11$	$33\ ^{+21}_{-16}$	$17.5\ \pm\ 1.6$
8	$24.0\ ^{+6.0}_{-5.3}$	$2.1\ \pm\ 0.5$	$1.29\ \pm0.13$	$37\ ^{+9}_{-8}$	$22.3\ \pm\ 2.0$
13	$1.0\ ^{+2.3}_{-1.5}$	$0.6\ ^{+1.3}_{-0.9}$	$2.74\ \pm0.28$	$12\ ^{+25}_{-16}$	$50.9\ ^{+4.5}_{-4.4}$

Combination of γγ and ZZ*(4l)

- Maximized product of likelihoods

$$\mathcal{L} = \mathcal{L}_{\gamma\gamma} \times \mathcal{L}_{4\ell} \times \prod_k G(\sigma_k; 0, 1)$$

  - Correlated: integrated luminosities, mass measurement (125.09 GeV), production modes and theoretical uncertainties (QCD scale & PDF)
  - Uncorrelated: detector effects, reconstruction efficiencies
  - Using asymptotic approximation
- Results at √s=13 TeV
  - Uncertainty statistically dominated
  - Compatibility of 1.3 σ over SM prediction
  - Compatibility with null-signal hypothesis is 1.4 σ observed and 3.4 σ expected
  - Combined upper limit cross section of 68 pb at 95% CL

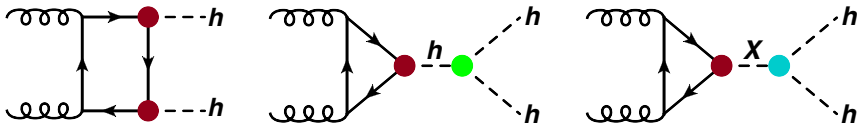


ATLAS-CONF-2015-069

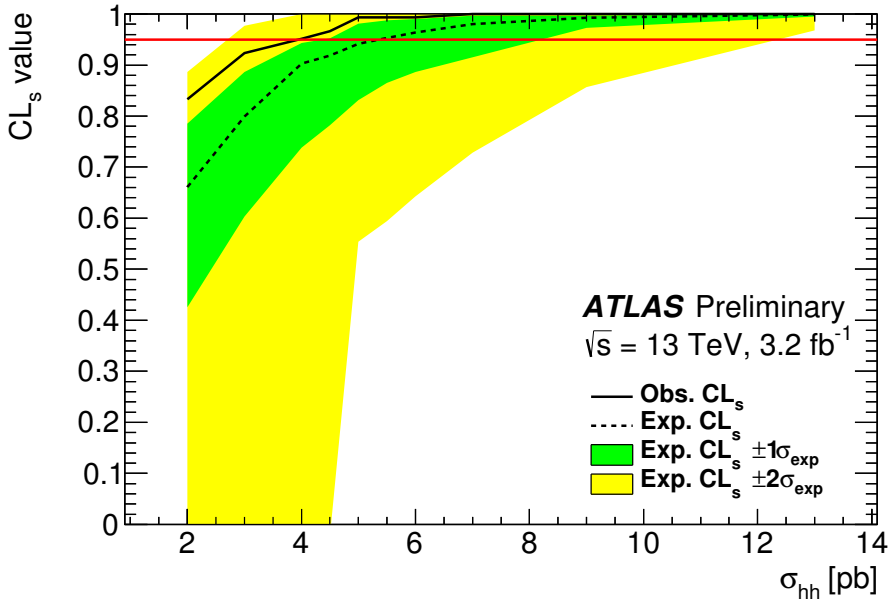
Total cross section [pb]	7 TeV	8 TeV	13 TeV
$H \to \gamma\gamma$	35^{+13}_{-12}	$30.5^{+7.5}_{-7.4}$	40^{+31}_{-28}
$H \to ZZ^* \to 4\ell$	33^{+21}_{-16}	37^{+9}_{-8}	12^{+25}_{-16}
Combination	34 ± 10 (stat.) $^{+4}_{-2}$ (syst.)	$33.3^{+5.5}_{-5.3}$ (stat.) $^{+1.7}_{-1.3}$ (syst.)	24^{+20}_{-17} (stat.) $^{+7}_{-3}$ (syst.)
LHC-XS	17.5 ± 1.6	22.3 ± 2.0	$50.9^{+4.5}_{-4.4}$

Di-Higgs to bbγγ channel

- Search for resonant and non resonant di-Higgs production
  - Largely suppressed cross section
  - Combine large BR of bb and good γγ mass resolution
- Same selection as γγ search + b-jets in |η| < 2.5
  - SR: 2 tagged jets
  - CR: 0 tagged jets
- Simultaneous fit to extract background continuum constant
  - No event in signal region
- Upper limit at 95%CL for HH→bbγγ
  - 3.4 pb (obs) and 5.4 pb (exp)



Process	0-tag	2-tag
Continuum background	35.8 ± 2.1	1.63 ± 0.30
SM single-Higgs	1.8 ± 1.5	0.14 ± 0.05
SM di-Higgs	<0.001	0.027 ± 0.006
Observed	27	0

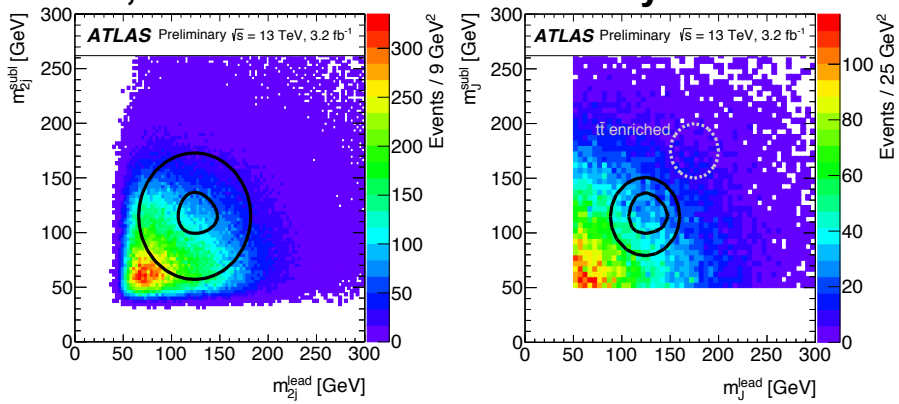


ATLAS-CONF-2016-004

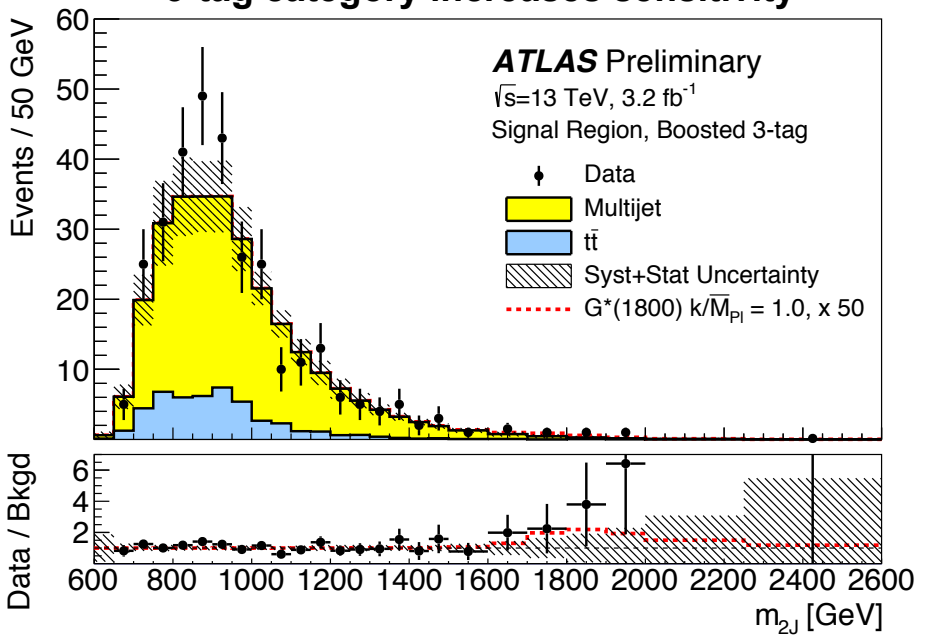
Di-Higgs to bbbb channel

- Search for resonant and non resonant di-Higgs production
  - Highest sensitivity m_H > 500 GeV
- Backgrounds
  - Multi-jet events estimated in side-bands with 2 or 4 tagged jets
  - Hadronic ttbar decays → tt-veto
- Search categories
  - 4 b-jets ΔR=0.4 (resolved)
  - 2 large-R jets ΔR=1 (boosted) with 3 or 4 b-tagged track jets
- Upper limit at 95% CL HH→bbbb from resolved analysis
  - 1.22 pb (obs) and 12.9 fb (exp)

SR, CR and side-band marked by contours



3-tag category increases sensitivity

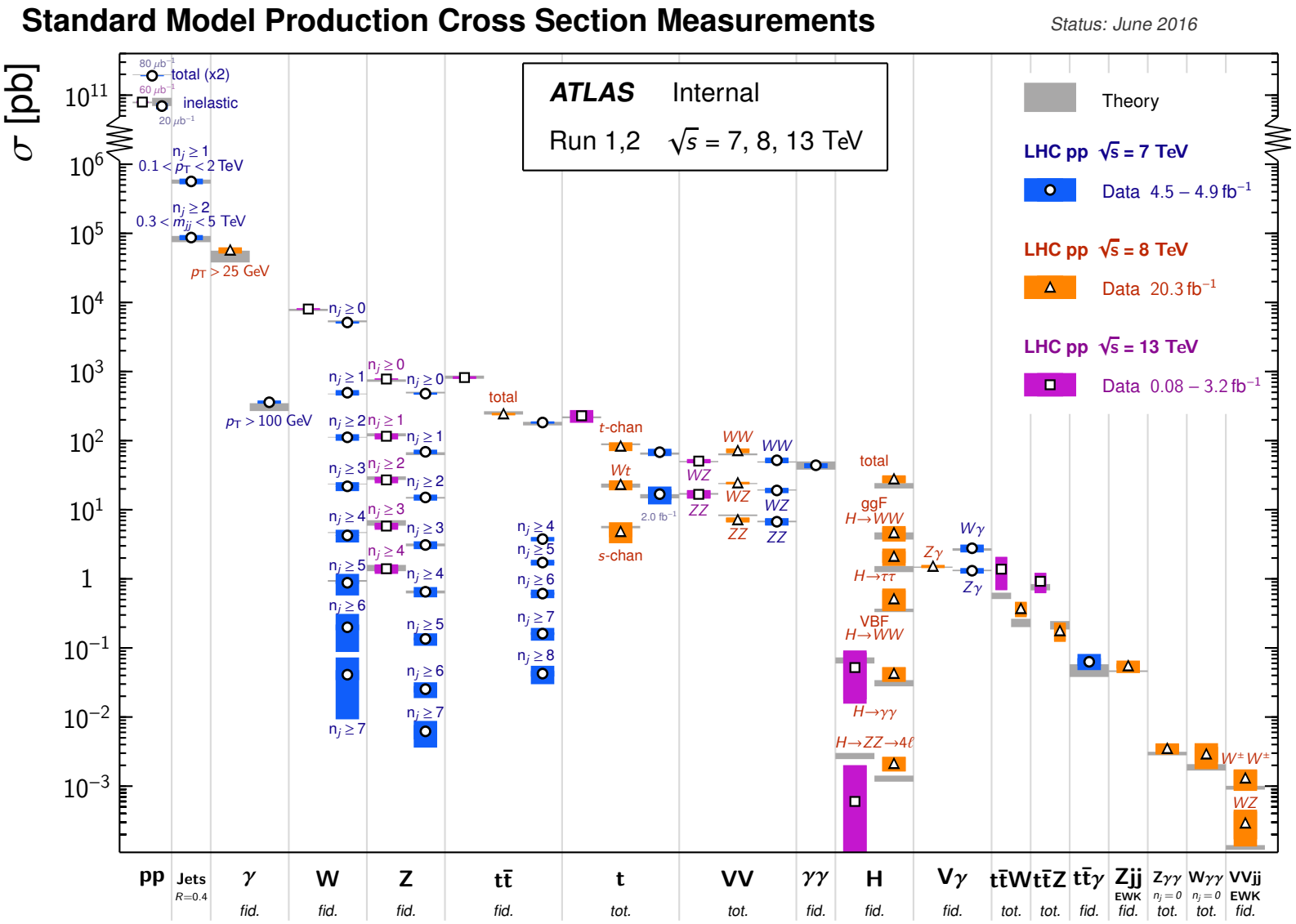


ATLAS-CONF-2016-017 Run 1 analysis (arXiv: 1506.00285)

Conclusions

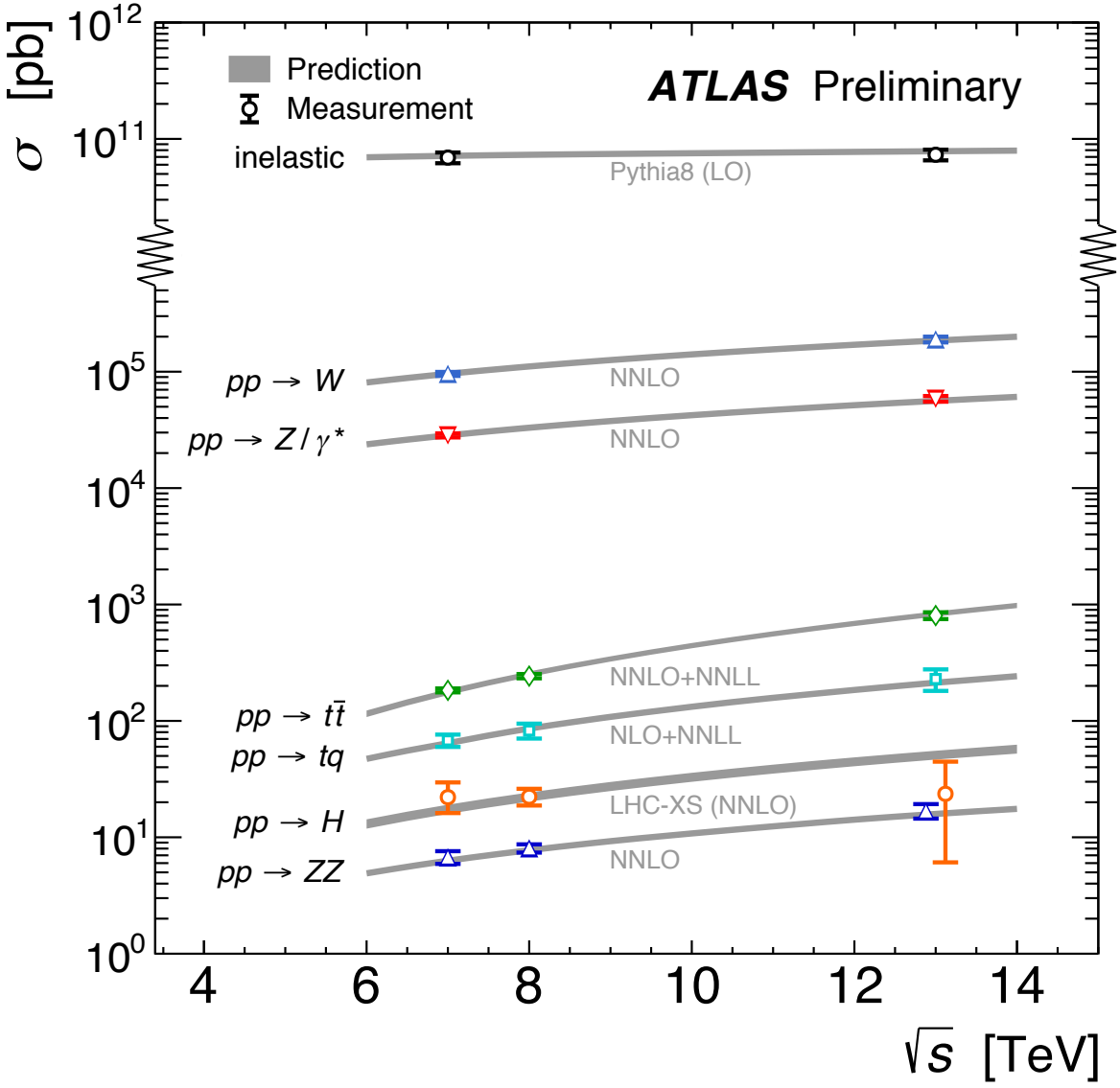
- Search for Higgs boson in Run 2 started with 3.2 fb^{-1}
- Increased production cross section at $\sqrt{s}$=13 TeV
- Measured Higgs cross section via $\gamma\gamma$ and ZZ channels yields an observed value $24^{+20}_{-17}(\mathrm{stat.})\,^{+7}_{-3}(\mathrm{syst.})$ pb
- Set upper limits on Higgs and di-Higgs production
- Looking forward to more data in 2016

SM fiducial cross sections



Backup

Cross section measurements vs $\sqrt{s}$



inelastic
7 TeV, 20 μb^{-1}, Nat. Commun. 2, 463 (2011)
13 TeV, 63 μb^{-1}, ATLAS-CONF-2015-038

$pp \to W$
7 TeV, 36 pb^{-1}, PRD 85, 072004 (2012)
13 TeV, 81 pb^{-1}, arXiv:1603.09222

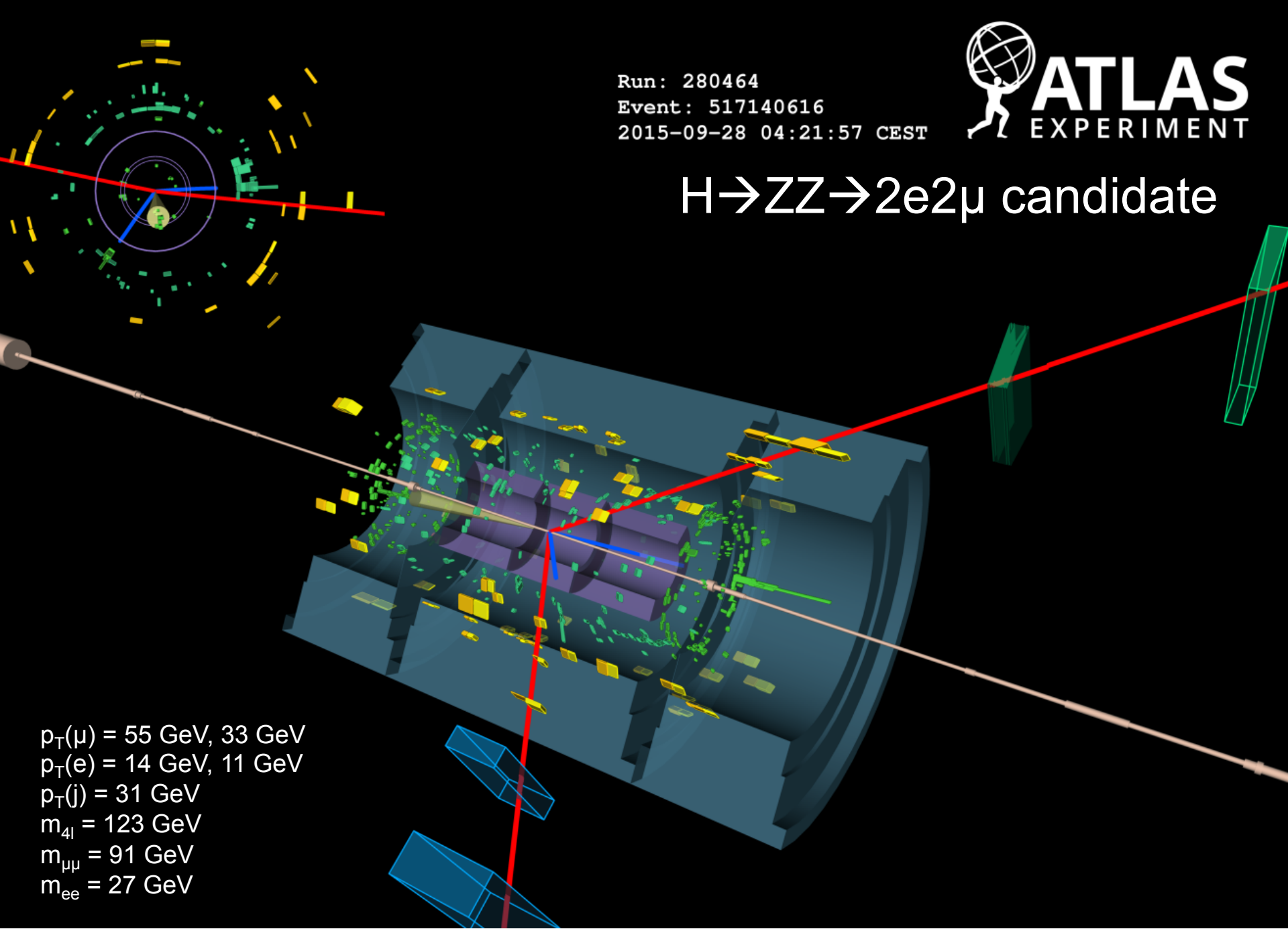
$pp \to Z/\gamma^*$
7 TeV, 36 pb^{-1}, PRD 85, 072004 (2012)
13 TeV, 81 pb^{-1}, arXiv:1603.09222

$pp \to t\bar{t}$
7 TeV, 4.6 fb^{-1}, Eur. Phys. J. C 74:3109 (2014)
8 TeV, 20.3 fb^{-1}, Eur. Phys. J. C 74:3109 (2014)
13 TeV, 3.2 fb^{-1}, ATLAS-CONF-2016-005

$pp \to tq$
7 TeV, 4.6 fb^{-1}, PRD 90, 112006 (2014)
8 TeV, 20.3 fb^{-1}, ATLAS-CONF-2014-007
13 TeV, 3.2 fb^{-1}, ATLAS-CONF-2015-079

$pp \to H$
7 TeV, 4.5 fb^{-1}, Eur. Phys. J. C76 (2016)
8 TeV, 20.3 fb^{-1}, Eur. Phys. J. C76 (2016)
13 TeV, 3.2 fb^{-1}, ATLAS-CONF-2015-069

$pp \to ZZ$
7 TeV, 4.6 fb^{-1}, JHEP 03, 128 (2013)
8 TeV, 20.3 fb^{-1}, ATLAS-CONF-2013-020
13 TeV, 3.2 fb^{-1}, PRL 116, 101801 (2016)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2015-09-28 04:21:57 CEST
ATLAS EXPERIMENT
H→ZZ→2e2μ candidate
$p_T(\mu)$ = 55 GeV, 33 GeV
$p_T(e)$ = 14 GeV, 11 GeV
$p_T(j)$ = 31 GeV
m_{4l} = 123 GeV
$m_{\mu\mu}$ = 91 GeV
m_{ee} = 27 GeV

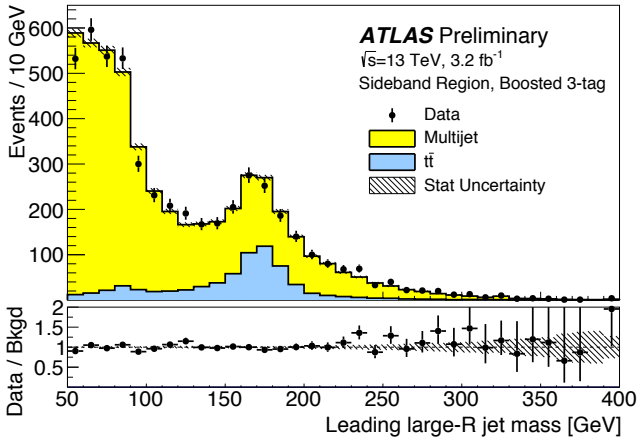
Systematics of cross section measurement

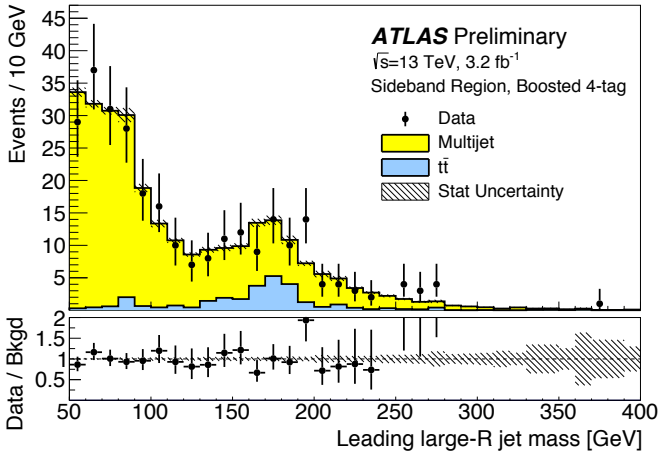
- Uncertainties acceptance correction envelope of the sum in quadrature of baseline and central values of alternative PDF sets
- Uncertainties on the acceptance correction associated with missing higher-order corrections are evaluated by varying the renormalization and factorization scales coherently and individually by factors of 0.5 and 2 from their nominal values, and by reweighting the p^H_T distribution from POWHEG BOX to the prediction of the HRES 2.2 calculation.
- The envelope of the maximum deviation of the combined scale variations and the p^H_T reweighting is used as the systematic variation to account for the uncertainty in the mass measurement, the Higgs boson mass is varied by ±0.4 GeV
- To assess the systematic uncertainty due to the assumption of SM cross-section fractions of the Higgs boson production modes, the VBF and VH fractions are varied by factors of 0.5 and 2 from the SM prediction and the fraction of ttH is varied by factors of 0 and 5.
- The total uncertainties on the acceptance correction range from 1% to 6%, depending on the channel, distribution and bin

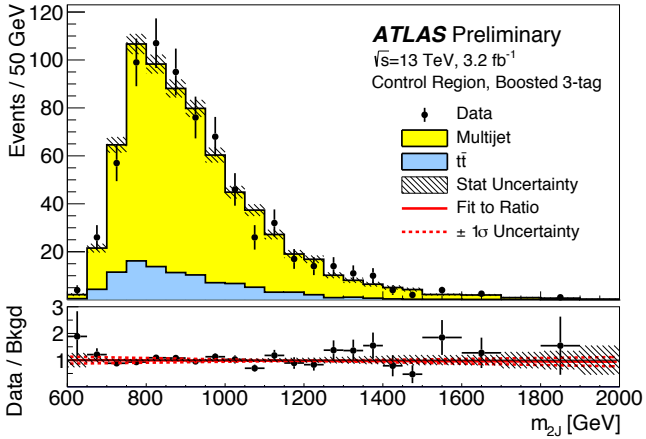
ATLAS-CONF-2015-069

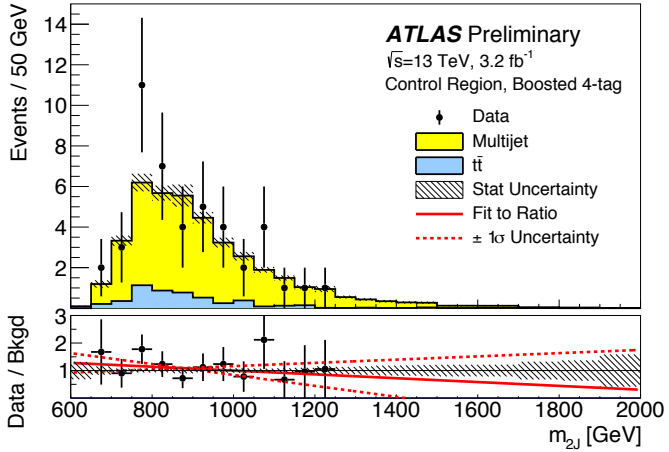
Di-Higgs to bbbb channel

- Event yields extrapolated from side-bands through likelihood fit
- 3-tag category increases sensitivity



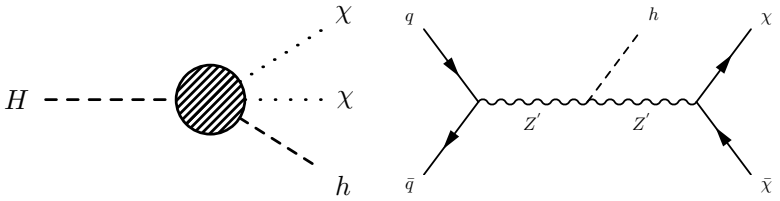




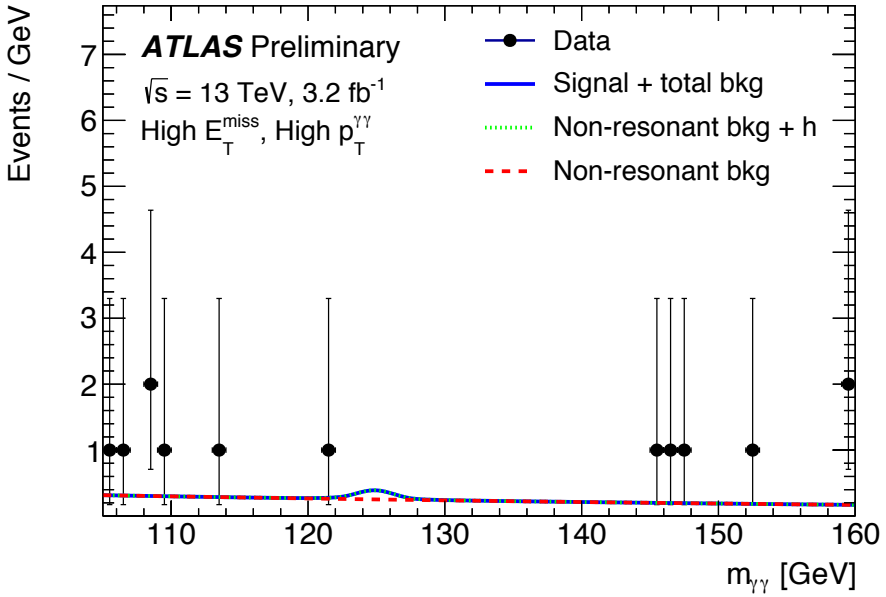


Higgs to γγ + MET search

- Based on H→γγ search
  - Heavy scalar decay into Higgs boson plus pair of DM candidates
  - Massive vector mediator emits Higgs boson and decays into a pair of DM candidates
- Extend Run 1 analysis
  - MET > 90 GeV
  - PhysRevLett.115.131801
- Follow H→γγ selection and split into four categories
  - Updated particle definitions
- No excess over backgrounds
  - SM H → γγ, γγ continuum, γ+jet, di-jet, W+γ and W+γγ



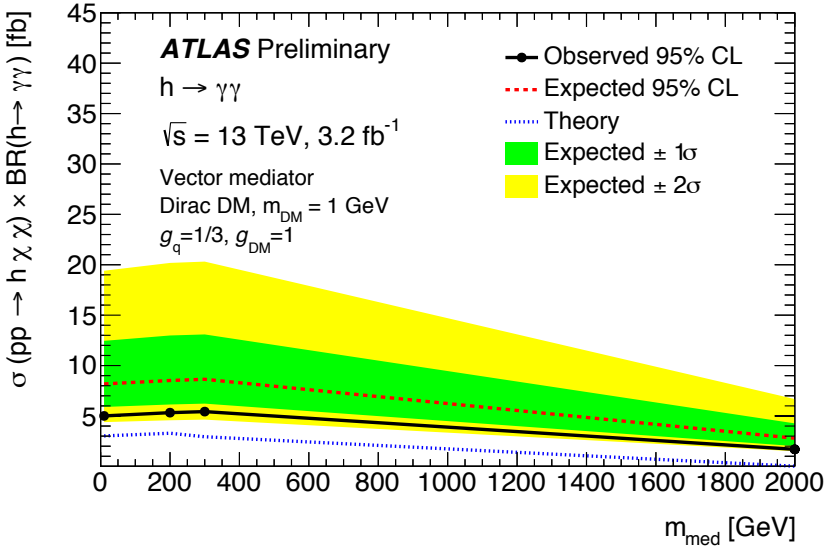
Category	$E_{\mathrm{T}}^{\mathrm{miss}}$ [GeV]	$p_{\mathrm{T}}^{\mathrm{hard}}$ [GeV]	$p_{\mathrm{T}}^{\gamma\gamma}$ [GeV]
High $E_{\mathrm{T}}^{\mathrm{miss}}$, high $p_{\mathrm{T}}^{\gamma\gamma}$	> 100	-	> 100
High $E_{\mathrm{T}}^{\mathrm{miss}}$, low $p_{\mathrm{T}}^{\gamma\gamma}$	> 100	-	≤ 100
Intermediate $E_{\mathrm{T}}^{\mathrm{miss}}$	> 50 and ≤ 100	> 40	-
Rest	-	-	> 15

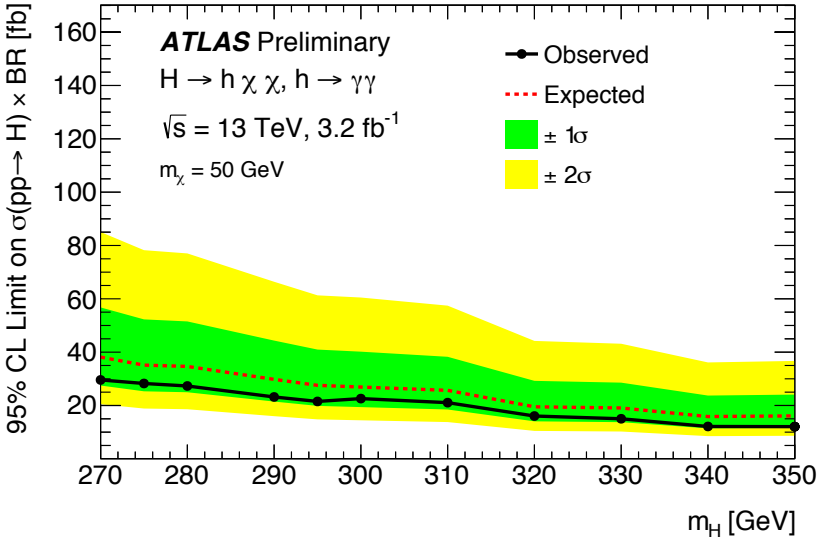


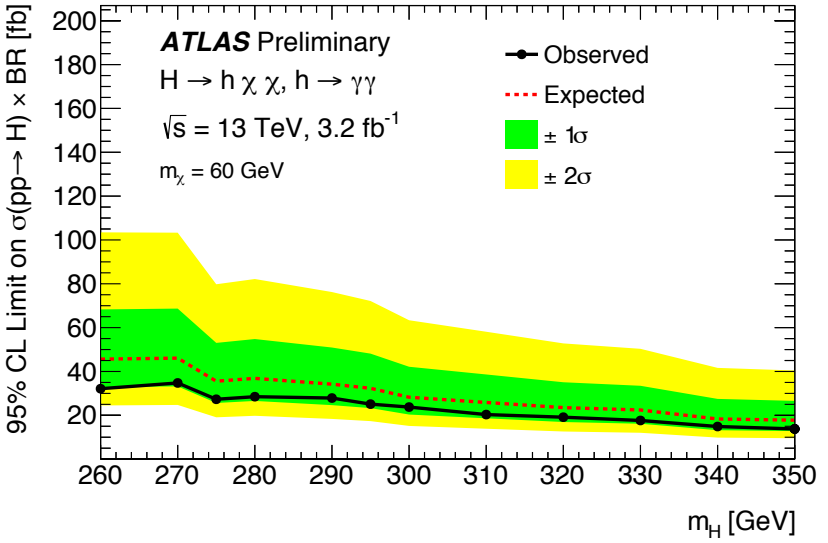
ATLAS-CONF-2016-011

Limits on Higgs to γγ + MET search

- Limits below expectation
- Heavy scalar production model
  - Upper limit 29.6 fb (m_H=270 GeV)
- Massive mediator model
  - Upper limit 5.3 fb (m_{DM}=1 GeV)



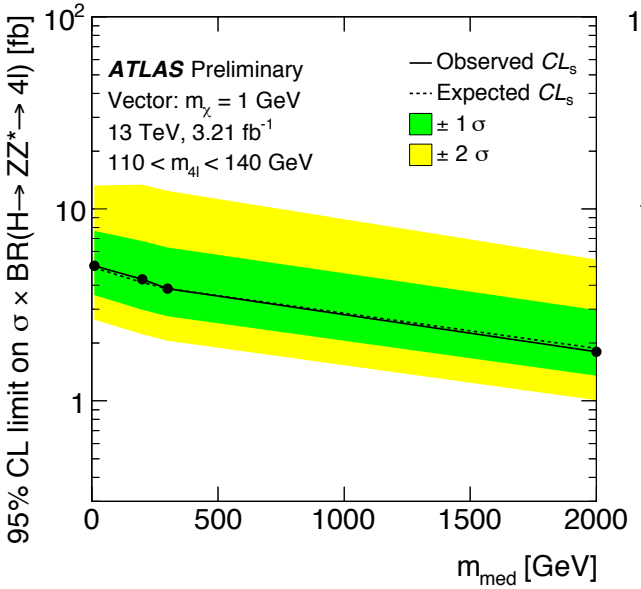


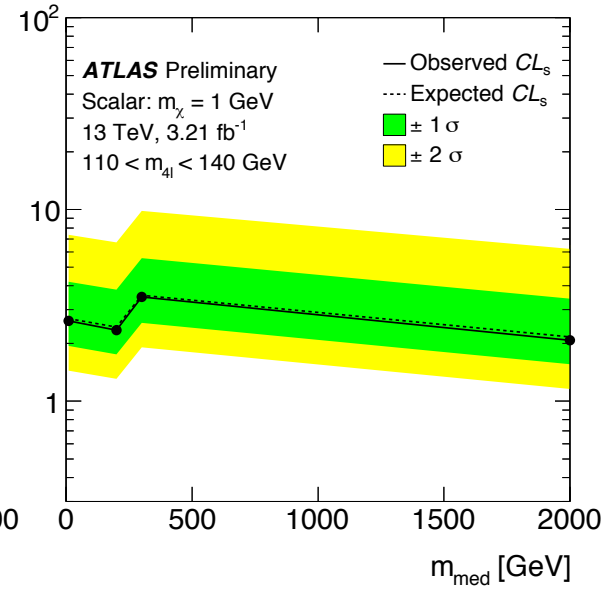


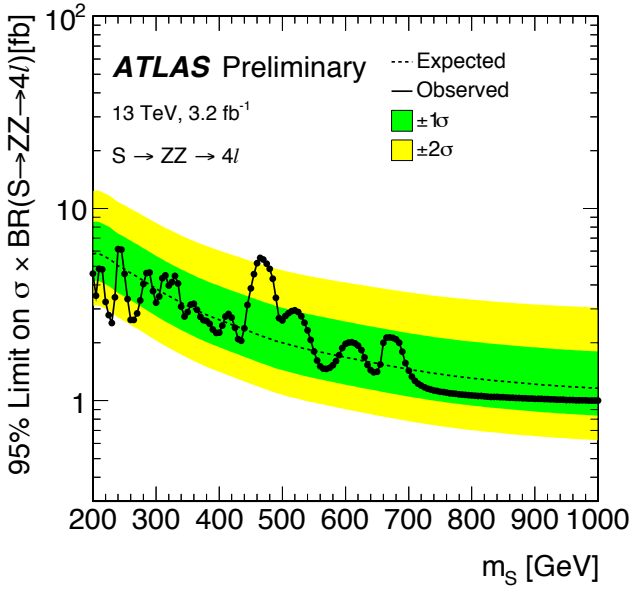
ATLAS-CONF-2016-011

Limits on Higgs to ZZ*(4l) + MET search

- Low and high MET categories are considered
- No significant excess is found, set upper limit at 95% CL on cross section in two models
  - Simplified dark matter model with heavy mediators
  - Heavy narrow width scalar boson decaying to four leptons



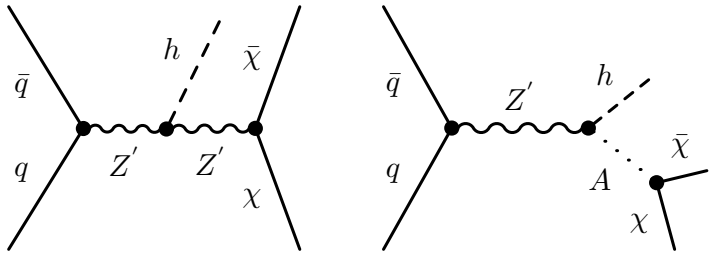


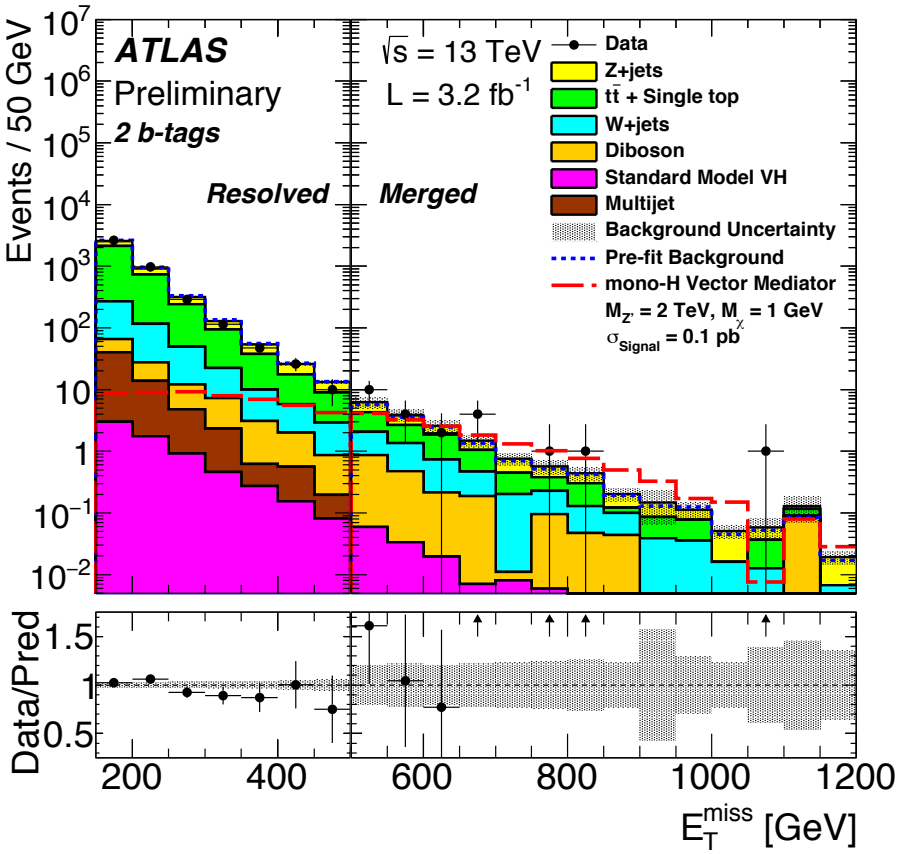


ATLAS-CONF-2015-059

Higgs to bb + MET search

- Two models
  - Vector mediator radiates Higgs and decays to DM candidates
  - Associated production with CP-odd pseudo-scalar A decaying to DM
- Event selection
  - MET > 150 GeV and p_T^{miss} > 30 GeV
  - No isolated muons or electrons
- Backgrounds reduced by angular cuts and modeled in control regions
  - SM W/Z+jets and ttbar
  - Miss-tagged multi-jet and low MET
  - Back-to-back di-jet events
- Four categories
  - 3 x resolved by MET (150-200,200-350,350-500) GeV
  - 1 x merged MET>500 GeV
- No significant excess observed

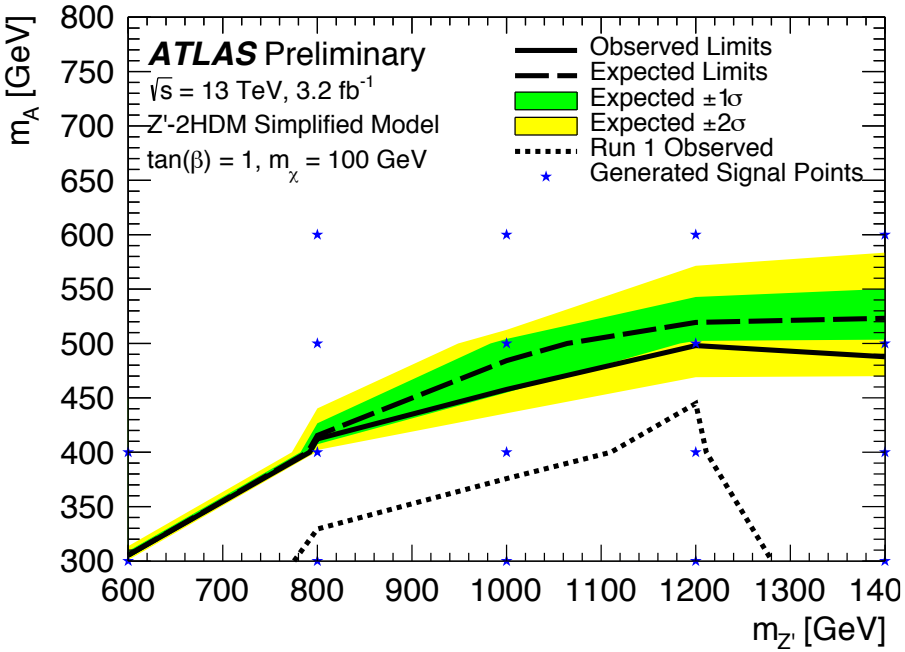


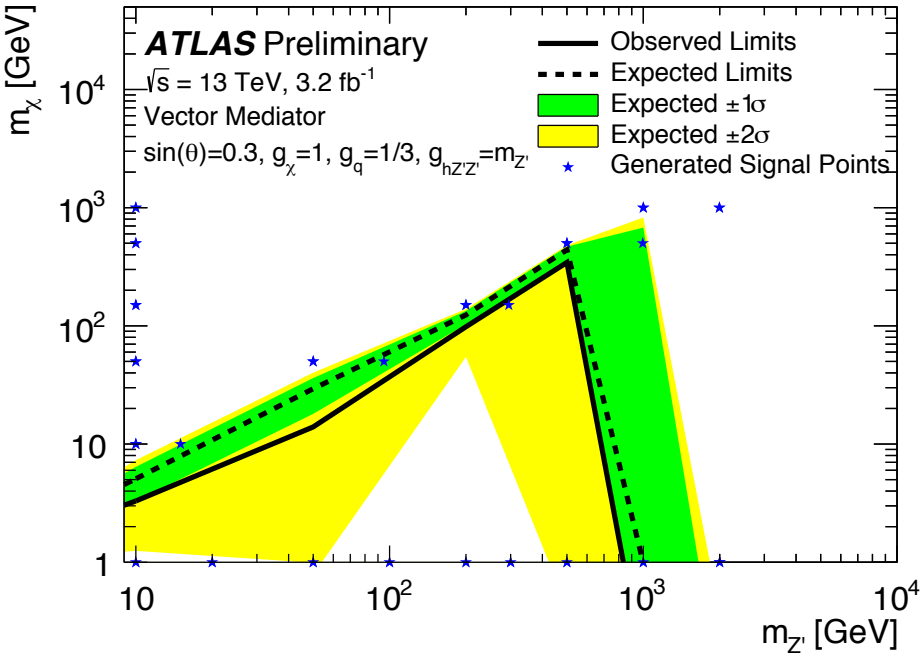


ATLAS-CONF-2016-019

Limits on Higgs to bb + MET search

- Exclusion limits at 95 % CL for a wide range of *Z'* masses
  - Pseudo-scalar up to to 500 GeV
  - Vector mediator up to 900 GeV

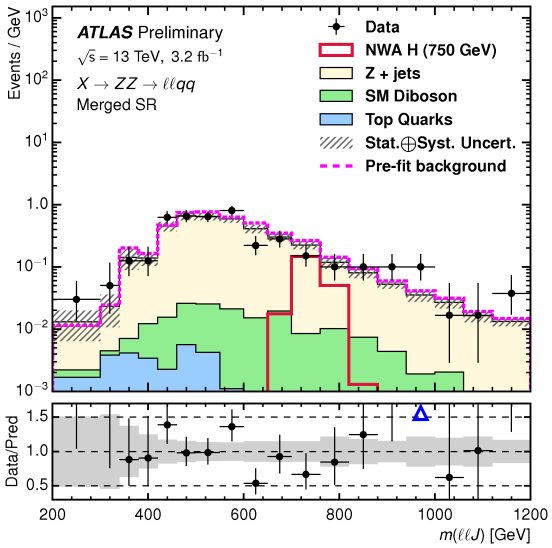


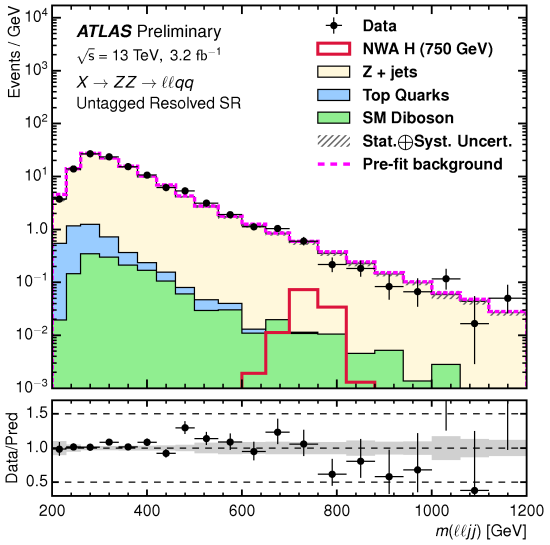


ATLAS-CONF-2016-019

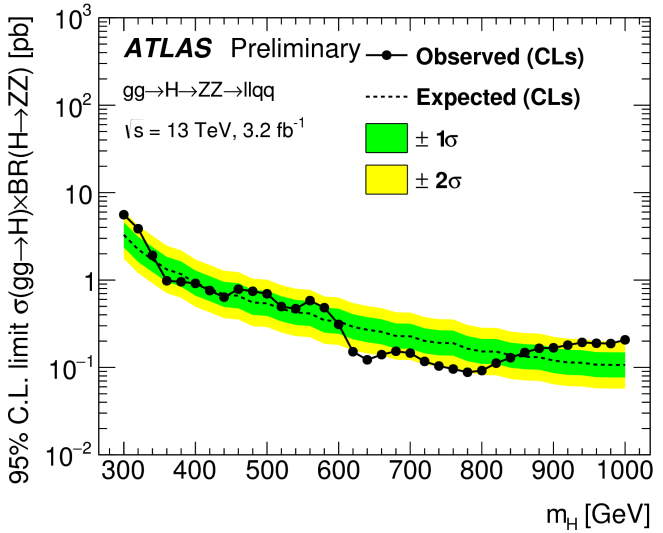
Heavy Higgs to ZZ*(llqq) search

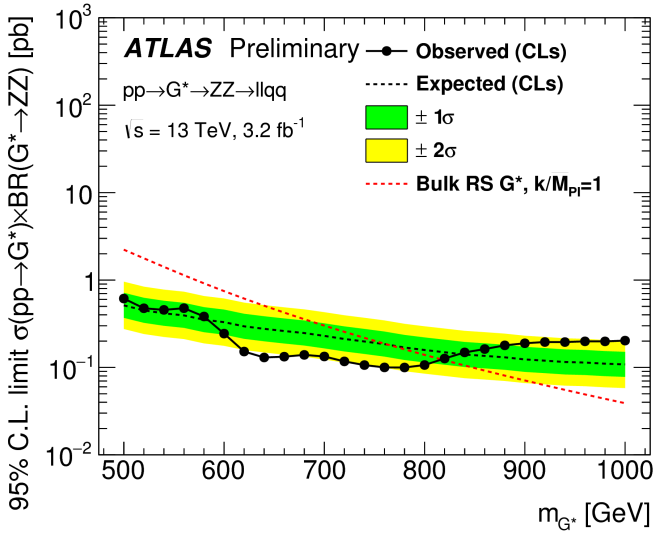
- Heavy resonances [300, 1000] GeV to ZZ
  - Z leptonic (ee, μμ) + Z hadronic: merged (J) ΔR=1 or resolved (jj) (tagged or untagged) ΔR=0.4 jets
- Tight particle identification for Run 2
  - Main backgrounds WZ/ZZ (from MC) Z+jets and tt (constrained from CR)
  - Fit to m_{llJ} and m_{lljj} in SR and CR of merged and resolved simultaneously
- Interpreted in 2HDM spin 0 CP-even Higgs or EWS spin 2 graviton models





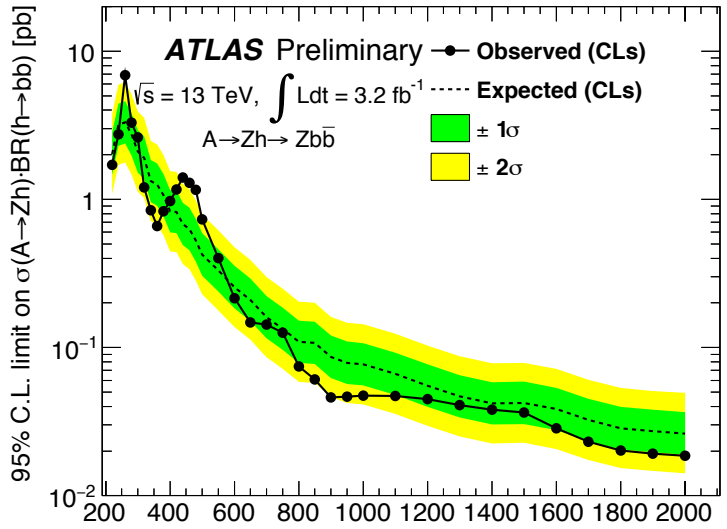
[ATLAS-CONF-2016-016]

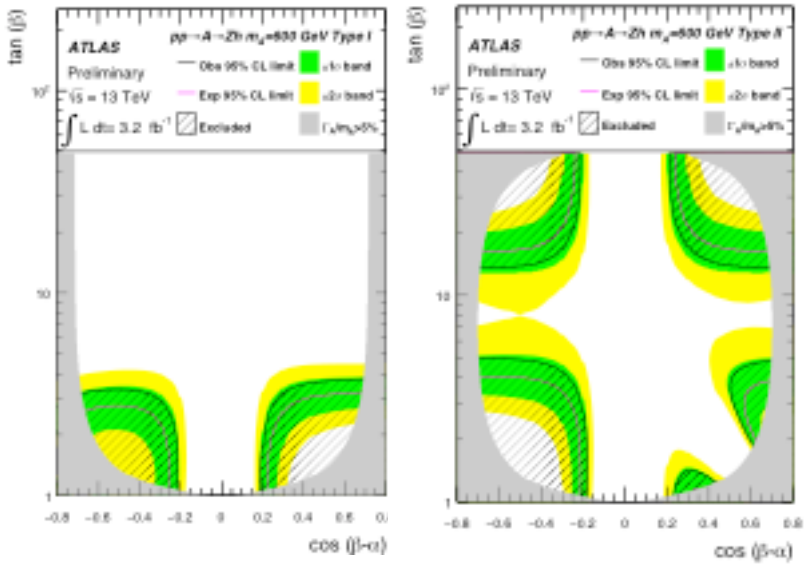




CP-odd Higgs to Zh search

- CP-odd pseudo-scalar Higgs (m_A in [220, 2000] GeV) decay to Z and light Higgs (m_H=125 GeV)
  - Z leptonic modes (ee, μμ, νν)
  - H to b-quarks (bb)
- Event categories
  - Number of leptons: 0, 2
  - P_T of Z candidate: <500, >500 GeV
  - Tagged b-jets: 1 or 2
- Interpreted in context of 2HDM types I and II





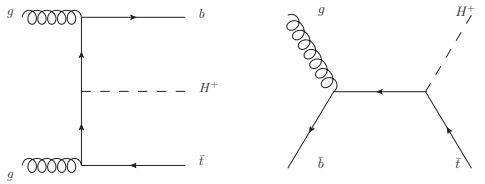
ATLAS-CONF-2016-015

Charged Higgs to τν search

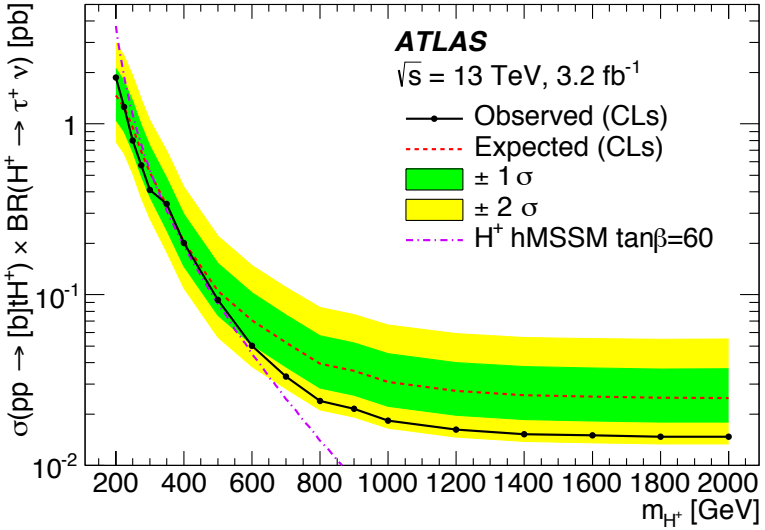
- Search for charged Higgs in assoc. with top quarks decaying to τν
  - No high p_T electron or muon
  - Extending Run 1 searches
- Backgrounds
  - W+jets, Z/γ+jets, WW,WZ,ZZ, multi-jet
- Event selections
  - Anti-k_T Jets, ΔR=0.4, JVT, |η|<2.4
  - Tau p_T>40GeV, ΔR=0.2, BDT, |η|<2.3
  - MET > 70 GeV
  - mT > 50 GeV

$$m_T = \sqrt{2 p_T^{\tau} E_T^{\mathrm{miss}} (1 - cos\delta\phi_{\tau,\mathrm{miss}})}$$

- No significant excess observed
- Upper limits at 95% CL set on σ(*pp* → [*b*]*tH*⁺) × BR(*H*⁺ → τν)



Sample	Event yield
True τ_{had}	
$t\bar{t}$ & single-top-quark	590 ± 170
$W \to \tau\nu$	58 ± 14
$Z \to \tau\tau$	6.4 ± 2.0
diboson (WW, WZ, ZZ)	4.3 ± 1.3
Misidentified e, $\mu \to \tau_{\mathrm{had\text{-}vis}}$	40 ± 6
Misidentified jet $\to \tau_{\mathrm{had\text{-}vis}}$	196 ± 24
All backgrounds	900 ± 170
H^+ (200 GeV), hMSSM $\tan\beta = 60$	175 ± 28
H^+ (1000 GeV), hMSSM $\tan\beta = 60$	2.0 ± 0.2
Data	890



arXiv 1603.09203