# BSM Higgs searches with the ATLAS experiment

## XXII Cracow EPIPHANY Conference

## On the Physics in LHC Run II

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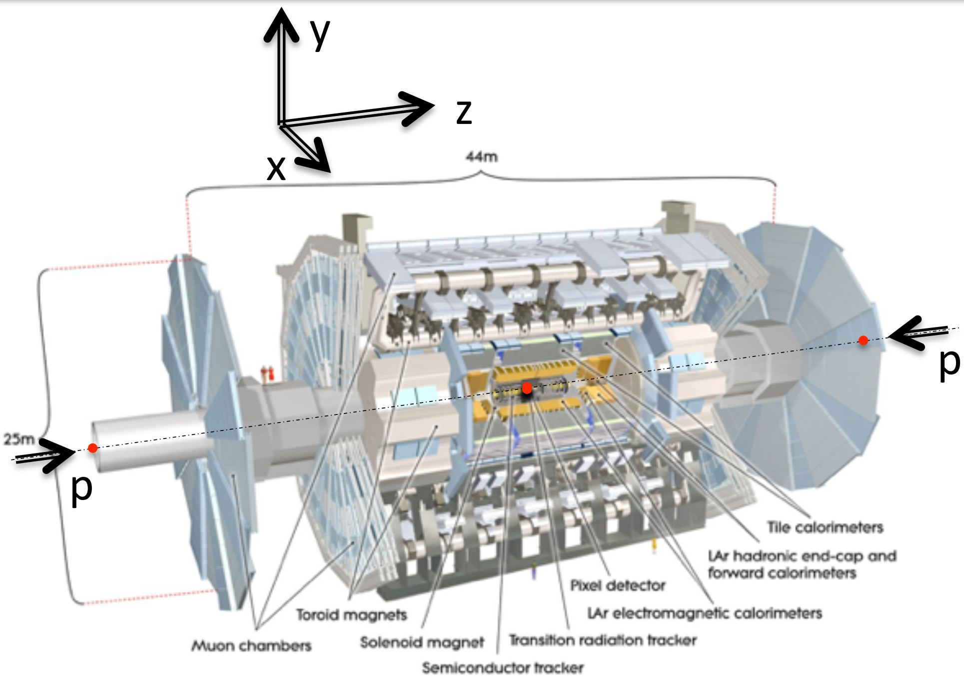
# ATLAS detector




- **Inner Detector** (ID) for tracking: semiconductors (pixel and SCT) and transition radiation tracker (TRT)
- **Super conductive solenoid** encloses the ID. It produces 2T uniform magnetic field along *z*
- **Sampling-based calorimeters**: lead+liquid Argon for EM energy (ECAL), steel+scintillator for Hadronic energy (HCAL), copper/tungsten+liquid argon in the forward calorimeter (FCAL)
- **Muon Spectrometer** (MS): one barrel and 2 end-cap air-core toroidal magnetic field (4T) to bend muon tracks in η

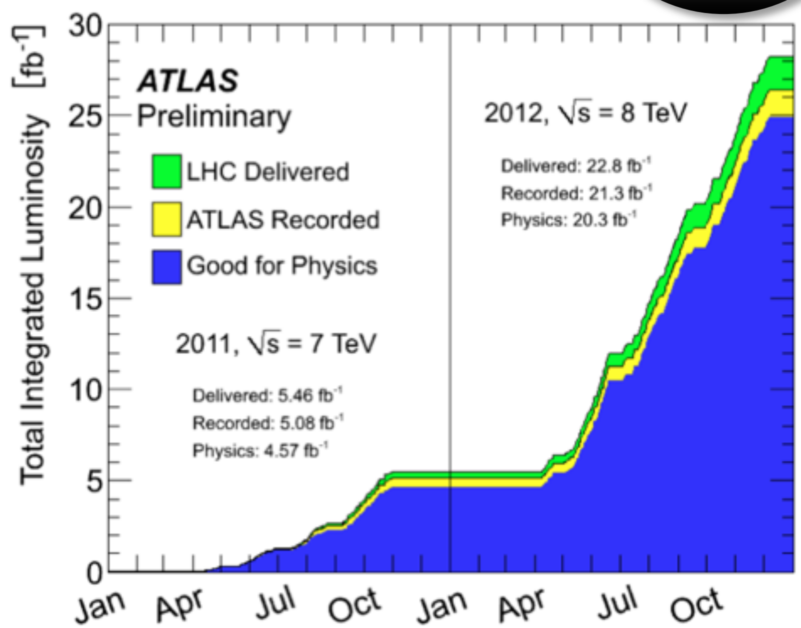
## Detector performance (E, $p_T$ in GeV)

| Detector component | Required resolution | η coverage | |
|---|---|---|---|
| | | Measurement | Trigger |
| Tracking | $\sigma_{p_T}/p_T = 0.05\% \; p_T \oplus 1\%$ | ±2.5 | |
| EM calorimetry | $\sigma_E/E = 10\%/\sqrt{E} \oplus 0.7\%$ | ±3.2 | ±2.5 |
| Hadronic calorimetry (jets) | | | |
| barrel and end-cap | $\sigma_E/E = 50\%/\sqrt{E} \oplus 3\%$ | ±3.2 | ±3.2 |
| forward | $\sigma_E/E = 100\%/\sqrt{E} \oplus 10\%$ | $3.1 < \lvert\eta\rvert < 4.9$ | $3.1 < \lvert\eta\rvert < 4.9$ |
| Muon spectrometer | $\sigma_{p_T}/p_T$=10% at $p_T$ = 1 TeV | ±2.7 | ±2.4 |

# ATLAS data taking in Run I

During Run I the collected data refers to 7+8 TeV pp collisions recorded in 2011 and 2012:

- collisions at $\sqrt{s}$ = 7 TeV
  - ~9 interactions per crossing
  - 4.6 $fb^{-1}$ collected good for physics
- collisions at $\sqrt{s}$ = 8 TeV
  - ~20 interactions per crossing
  - 20.3 $fb^{-1}$ collected good for physics



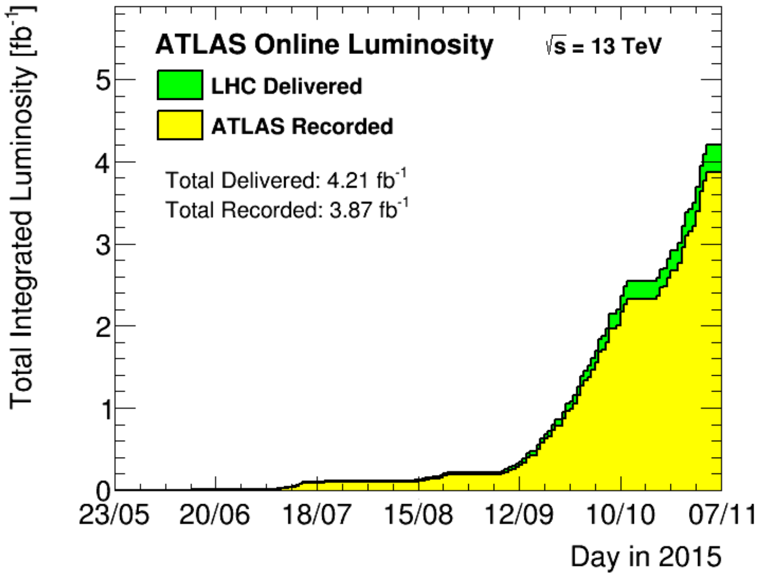

**Efficiencies** for 2012 data tacking ⟹

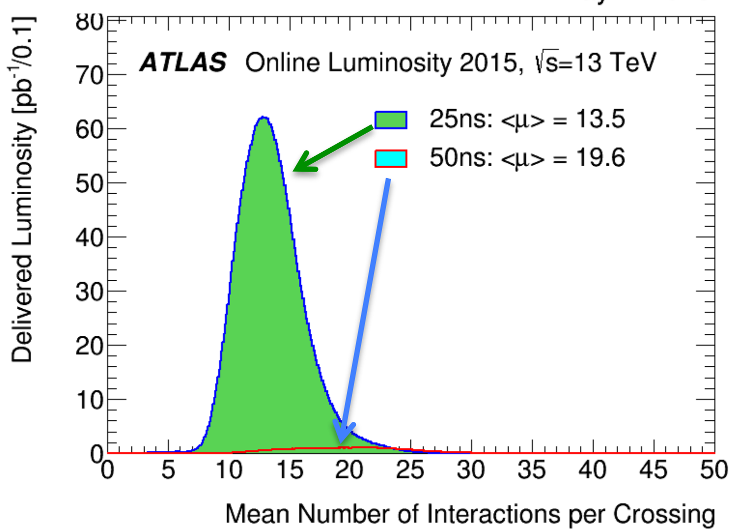
| Inner Tracker | | | Calorimeters | | Muon Spectrometer | | | | Magnets | |
|---|---|---|---|---|---|---|---|---|---|---|
| Pixel | SCT | TRT | LAr | Tile | MDT | RPC | CSC | TGC | Solenoid | Toroid |
| 99.9 | 99.1 | 99.8 | 99.1 | 99.6 | 99.6 | 99.8 | 100. | 99.6 | 99.8 | 99.5 |
| **All good for physics: 95.5%** | | | | | | | | | | |

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at √s=8 TeV between April 4th and December 6th (in %) – corresponding to 21.3 $fb^{-1}$ of recorded data.

**ATLAS performance close to or exceeding design specs in all compartments**

# ATLAS data taking in Run II




## ATLAS Run-2 Detector Status (from Oct. 2015)

| Subdetector | Number of Channels | Approximate Operational Fraction |
|---|---|---|
| Pixels | 92 M | 98.2% |
| SCT Silicon Strips | 6.3 M | 98.6% |
| TRT Transition Radiation Tracker | 350 k | 97.3% |
| LAr EM Calorimeter | 170 k | 100% |
| Tile calorimeter | 4900 | 99.2% |
| Hadronic endcap LAr calorimeter | 5600 | 99.6% |
| Forward LAr calorimeter | 3500 | 99.8% |
| LVL1 Calo trigger | 7160 | 100% |
| LVL1 Muon RPC trigger | 370 k | 99.75% |
| LVL1 Muon TGC trigger | 320 k | 100% |
| MDT Muon Drift Tubes | 357 k | 99.7% |
| CSC Cathode Strip Chambers | 31 k | 98.4% |
| RPC Barrel Muon Chambers | 370 k | 96.6% |
| TGC Endcap Muon Chambers | 320 k | 99.6% |

Total good for physics 3.2 $fb^{-1}$
Peak lumi: *$5\ 10^{33}\ cm^{-1}\ s^{-1}$*

**Efficiencies** close to those during Run I

**ATLAS performance close to or exceeding design specs in all compartments**

# Why BSM Higgs searches

In the **SM** only 1 complex Higgs doublet is responsible for electroweak symmetry breaking: **there is one neutral CP-even Higgs boson h**

Is the Higgs observed at the LHC the SM Higgs or the h from an extended sector?

Minimal Supersymmetric Standard Model (**MSSM**) solution to "hierarchy problem" ($m_h << m_{Planck}$) and dark matter (DM) candidates

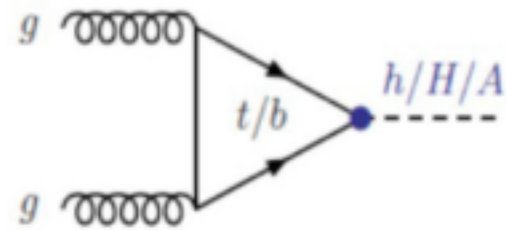
Two Higgs Doublet Models (**2HDM**) extend beyond the SM Higgs sector to include two complex Higgs Doublets. Leads to **five physical states** $H^+$, $H^-$ , A (CP-odd), H and h (CP-even)

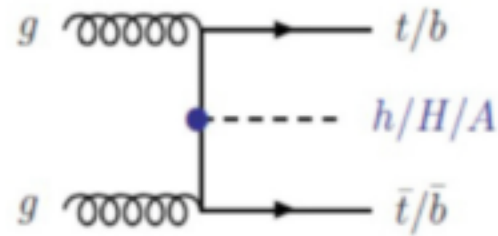
Next-to-Minimal Supersymmetric Standard Model (**NMSSM)** adds additional electroweak singlet to the MSSM to dynamically generate the μ term solving the μ-problem of the MSSM

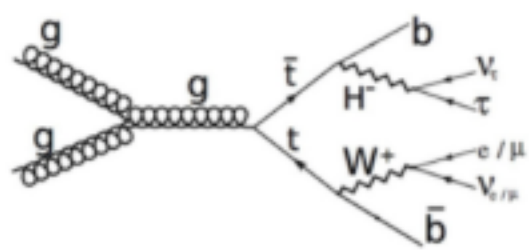
Entering a new realm of exploration: probing the couplings and decays rates of the observed Higgs boson whilst searching for additional Higgs States which could provide window into the underlying physics of EWSB

# Search strategies

- Number of ways to search:
  - **Directly** from decays of
    - neutral Higgs, including b-associated and gg-fusion production with VV, bb, ττ , μμ, etc. decays
    - charged Higgs, including production in top decays with decay to τν, cs,..
  - **Indirectly** by interpreting measured mass and couplings of light Higgs in extensions of the SM
- Many analyses completed on full Run I data imposing constraints on many models
- Some analysis completed with the 2015 Run II data and many others are underway



# Recent results from ATLAS

1

Limits on new Phenomena via coupling measurements: Higgs measurements interpreted in 2HDM/MSSM/composite/electroweak singlet/Dark matter models **arXiv:1509.00672** ***JHEP11(2015)206***

2

**Search for charged Higgs bosons in the $H^{\pm} \rightarrow tb$ decay channel in pp collisions at $\sqrt{s}$ = 8 TeV using the ATLAS detector** [**arXiv:1512.03704**] submitted to JHEP Dec. 2015

3

**Search for Neutral Minimal Supersymmetric Standard Model Higgs Bosons $H/A \rightarrow \tau\tau$ produced in pp collisions at $\sqrt{s}$ = 13 TeV with the ATLAS Detector [ATLAS-CONF-2015-061]**

4

**Searches for Higgs boson pair production in the hh->bbττ, γγWW*, γγbb, bbbb channels with the ATLAS detector [Phys. Rev. D92, 092004 (2015)]**

5

**Search for resonances decaying to photon pairs in 3.2 $fb^{-1}$ of pp collisions at $\sqrt{s}$= 13 TeV with the ATLAS detector [ATLAS-CONF-2015-081]**

# 1 Limits on new phenomena

JHEP11(2015)206 [arXiv:1509.00672]

- **The crucial question is:** there is only one Higgs doublet (SM) or the Higgs sector is more complex? (e.g. with a second doublet leading to more than one Higgs of which one has the properties similar to those of the SM Higgs)
- **Moreover** the strong evidence that DM could be explained via WIMPs suggest us that, if kinematically allowed, h could decays to WIMPs or other stable or long lived particles which do not interact with the detector material (Higgs boson "invisible" decays)

- Results, based on **4.7**$fb^{-1}$ @ **7** TeV and **20.3**$fb^{-1}$ @ **8** TeV pp collision data, refer to the measurement of the observed Higgs production and decay rates in the $h\rightarrow\gamma\gamma$, $ZZ^*\rightarrow 4l$, $WW^*\rightarrow l\nu l\nu$, $Z\gamma$, bb , $\tau\tau$, $\mu\mu$ decays channels, together with top-quark pair associated Higgs production, are used to probe the scaling of the couplings with mass
- For Higgs portal to DM direct search for "invisible" Higgs decays in the vector-boson fusion and associated production hW/Z ($Z\rightarrow ll,jj$ and $W\rightarrow jj$) + $E_t^{miss}$ is used

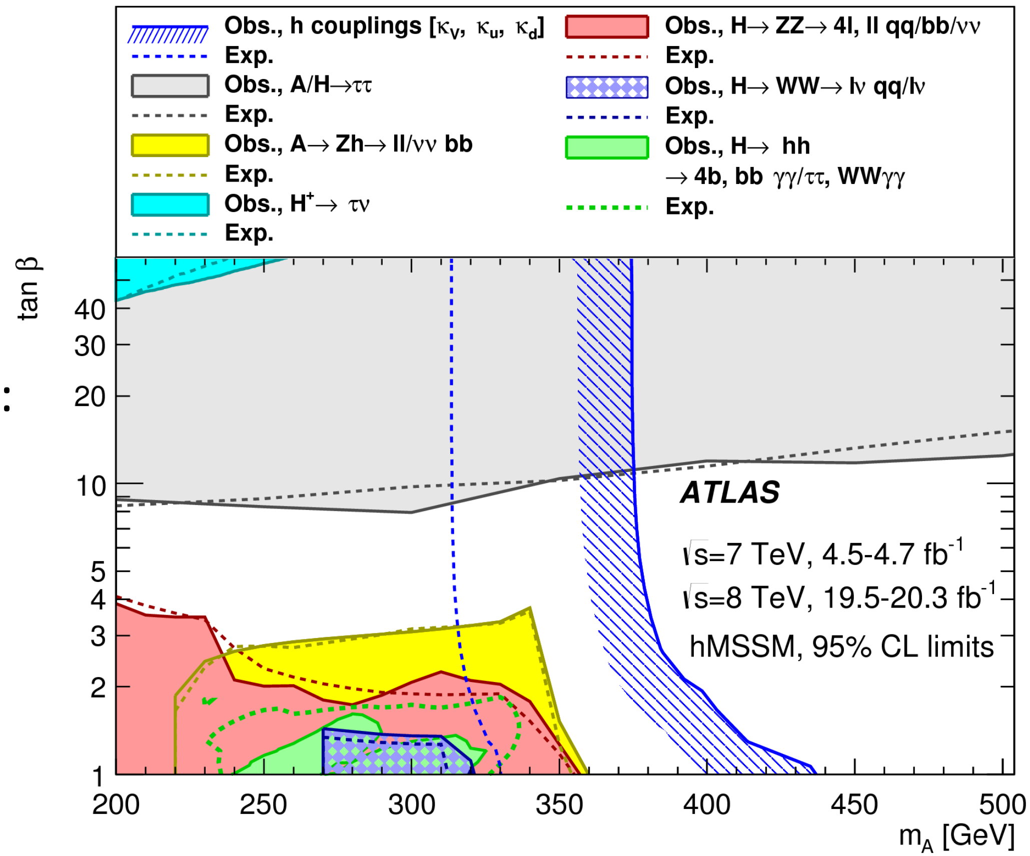
# Limits on new phenomena

JHEP11(2015)206 [arXiv:1509.00672]

- The mass dependence of the couplings <u>is consistent</u> with the predictions for a SM Higgs boson. Limits are set on parameters of different extension of the SM including the Minimal Composite Higgs Models

- From the production and decay rates and the measured mass of h in γγ and ZZ channels, a lower limit (@95% CL) is set on A mass in the hMSSM: $m_A$>370 GeV
- Results from the direct searches:
  - A/H → ττ
  - A → Zh → ll/νν bb
  - H → WW → lν qq/lν
  - H → hh → 4b, bbγγ/ττ, ...
  - $H^+$ → τν

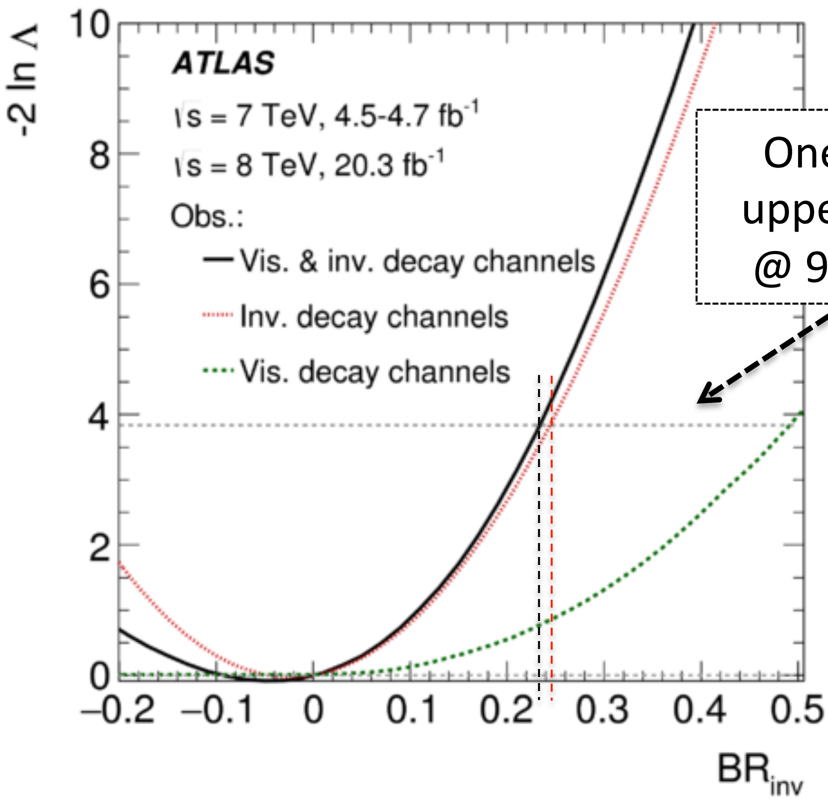
  are also interpret in the hMSSM



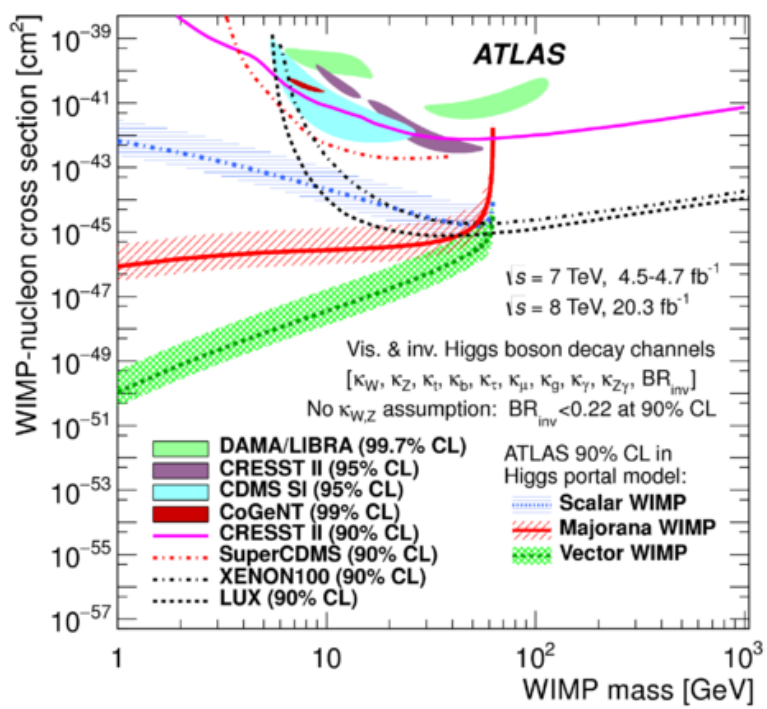
# Limits on new phenomena

JHEP11(2015)206 [arXiv:1509.00672]

- Direct searches for **invisible** h decays in the VBF, Z(ll)h and V(jj)h production modes are combined to set an UL@95% CL on the Higgs invisible decay BR of 2.5. Including also the **visible** decays the UL improves to 0.23.
- The limit on the invisible decay BR is used to constrain the rate of DM-nucleon scattering in a model with a Higgs portal to DM



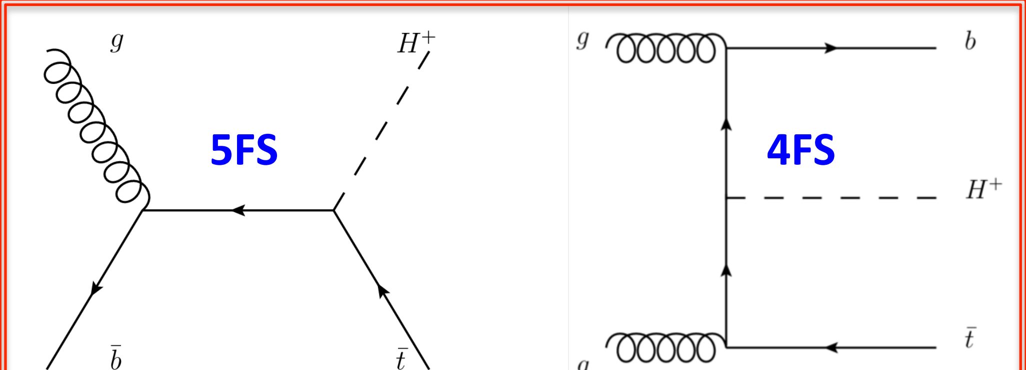

One side upper limit @ 95% CL



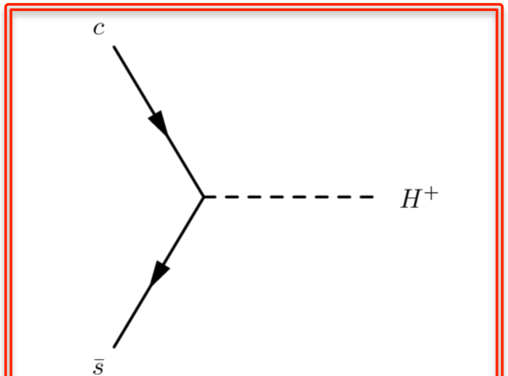
# 2 Search for $H^{\pm} \longrightarrow tb$

[arXiv:1512.03704 submitted to JHEP]

- Heavy charged scalar particle indicates clearly physics BSM
- $H^{\pm}$ are predicted by several models, e.g. two Higgs doublet model (2HDM)
- For $m_{H\pm} > m_t$ the dominant production mode is expected in association with t-quark
- In 2HDM model the production and decay of $H^{\pm}$ depend on 2 parameters: tanβ and mixing angle α between h and H (CP-even doublet). For $m_{H\pm} > m_t$ and cos(β-α)≈0 the dominant decay mode is $H^{\pm} \rightarrow tb$ with substantial contribution from τυ channel for large tanβ.



t associated production

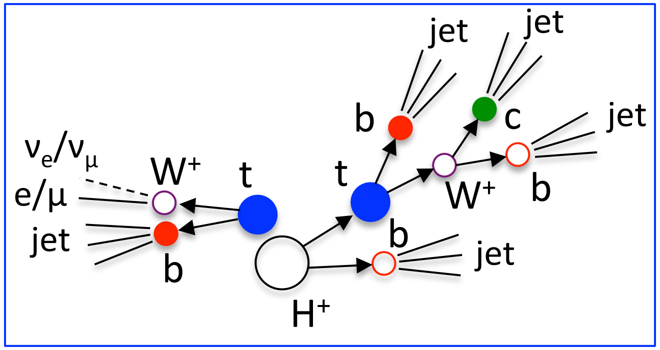


s-channel

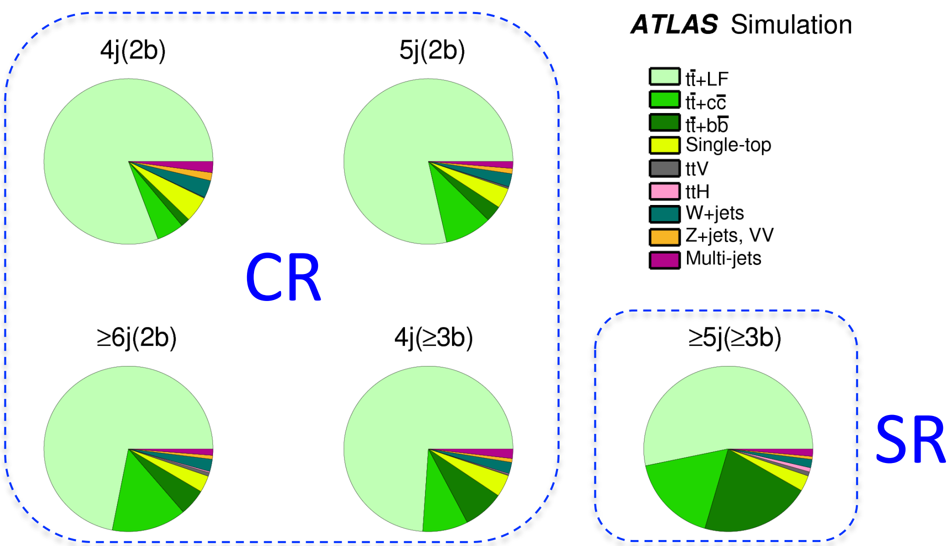
- **20.3** $fb^{-1}$ pp collision data collected in 2015 at √s= **8** TeV
- Search for **$H^{\pm} \longrightarrow tb \longrightarrow$ lepton-jets, all-hadron** decay modes

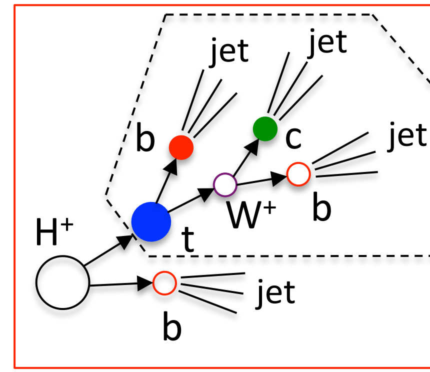
# Search for $H^{\pm} \longrightarrow tb$

- The reconstructed objects in this analysis are **electrons, muons, jets** (possibly reconstructed as b-quark-jets) and **$E_t^{miss}$** (only for t associated production)




"**t associated production**": **two** t-quarks (both decaying in **Wb**, where one W->hadrons and the other W->e/μ ν);
5 categories: 4j(2b), 5j(2b), ≥6j(2b), 4j(≥3b) and ≥5j(≥3b)




***s*-channel:**

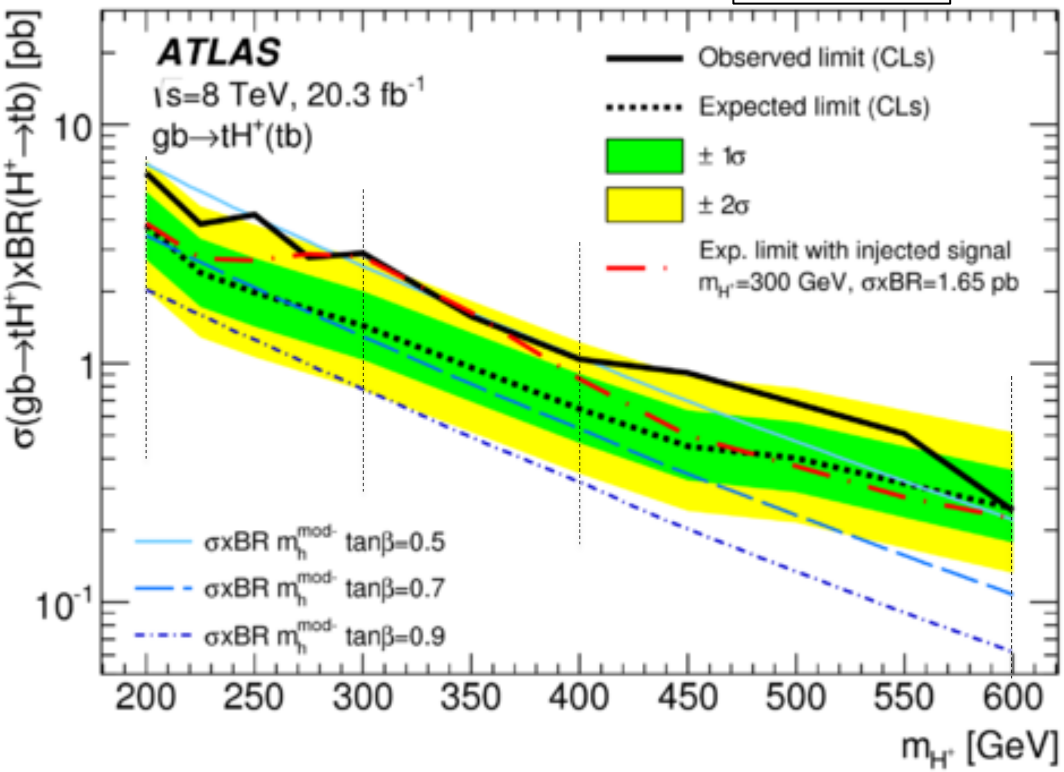
*$H^+ \rightarrow tb \rightarrow$* (l$\nu$*b*)*b*: only 1 e/μ + 2 or 3 jets (2 of them b-tagged)

*$H^+ \rightarrow tb \rightarrow$* (qq'*b*)*b*: 1 top-tagged jet + 1 b-tagged jet (all-hadronic final state)

# 2 Search for $H^{\pm} \longrightarrow tb$

- In all categories except ≥6j(2b), the **data exceed the SM prediction**, but they are consistent within the large uncertainties on the background.
- The 95% confidence level (CL) upper limits on $\sigma(gb \rightarrow tH^{+}) \times BR(H^{+} \rightarrow tb)$ has been calculated

***$gb \rightarrow tH^{+}$***

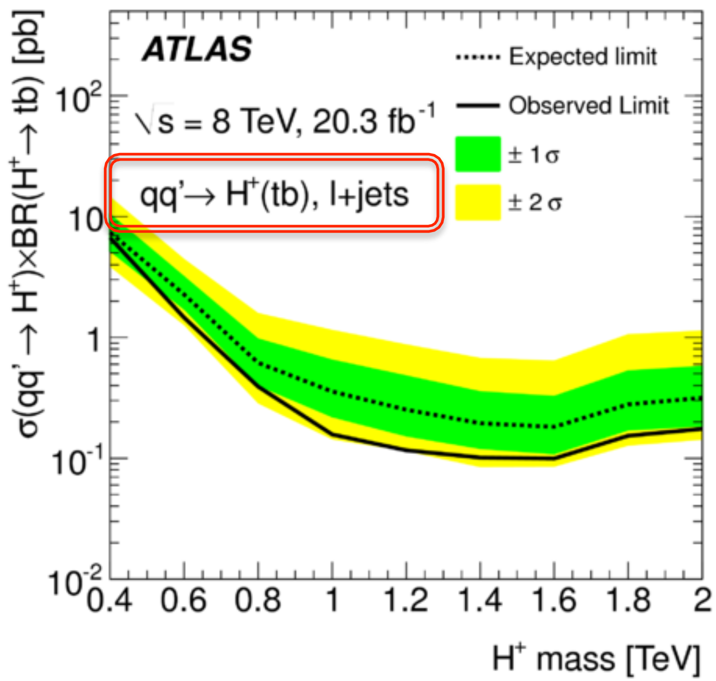



$0.2 \leq m_{H\pm} \leq 0.6$ TeV

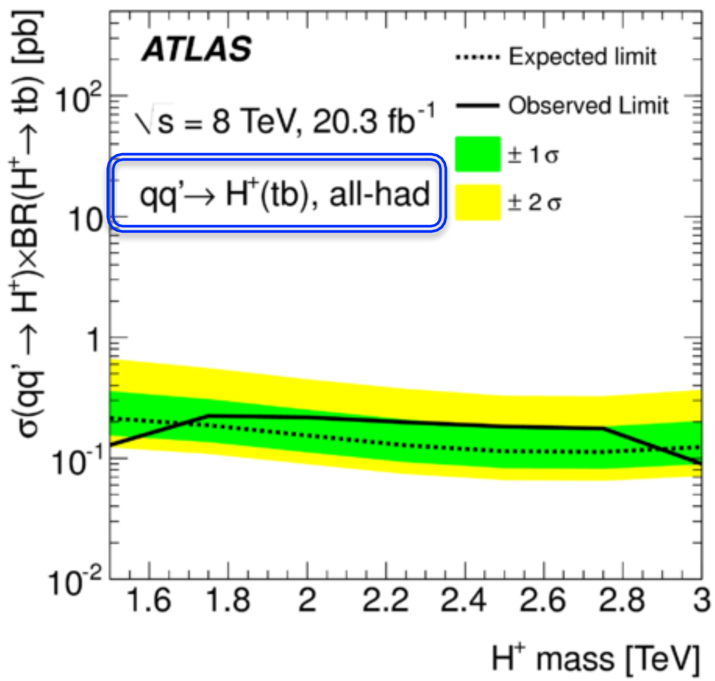
- At $m_{H+}$ values of 300 GeV, the excess of the data with respect to the background-only hypothesis corresponds to 2.3 standard deviations
- The red dash-dot line is the expected upper limit computed with a signal injected at $m_{H+}$ = 300 GeV, with a production cross section x BR of 1.65 pb, corresponding to the best-fit value of the signal strength at this mass point

# Search for $H^{\pm} \longrightarrow tb$

- For $H^{+} \rightarrow tb$ produced in the ***s*-channel** no significant excess of data with respect to the SM predictions is observed in both final state



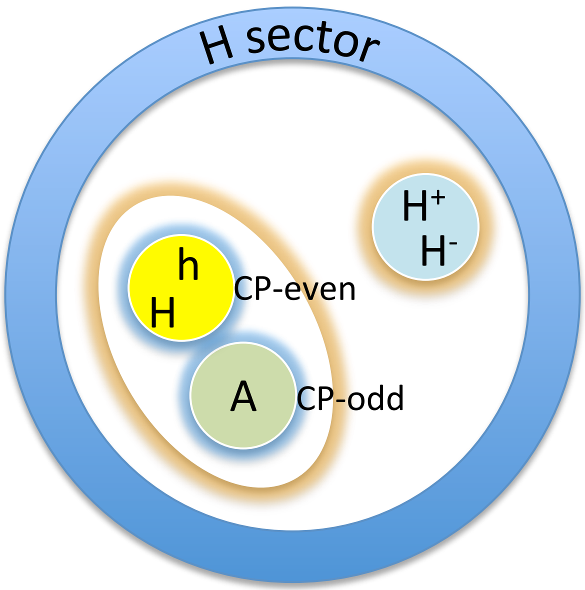

$0.4 \leq m_{H\pm} \leq 2$ TeV




$1.5 \leq m_{H\pm} \leq 3$ TeV

# MSSM H/A → τ τ

[ATLAS-CONF-2015-061]




**h** could be the lightest neutral Higgs boson discovered in 2012

- May be the discovered particle is part of an extended scalar sector, a scenario that is favored by a number of theoretical arguments
- Two parameters are needed at tree level to describe the MSSM Higgs sector: $m_A$ and tanβ (the ratio of the vacuum expectation values of the two Higgs doublets)
- MSSM benchmark scenarios: $m_h^{max}$, $m_h^{mod+}$, $m_h^{mod-}$, light stop, light stau, tauphobic
- The couplings of the MSSM heavy Higgs bosons to down-type fermions are enhanced with respect to the SM for large tanβ values resulting in increased branching fractions to τ leptons and *b* quarks, as well as a higher cross section for Higgs boson production in association with *b*-quarks. This has motivated a variety of searches in ττ and *bb* final states

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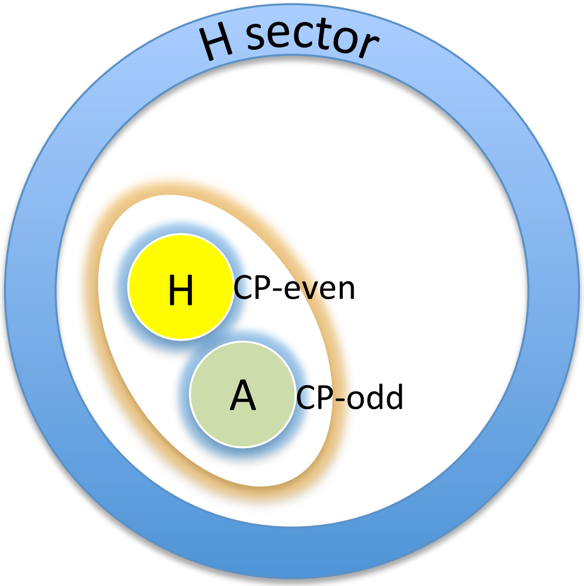
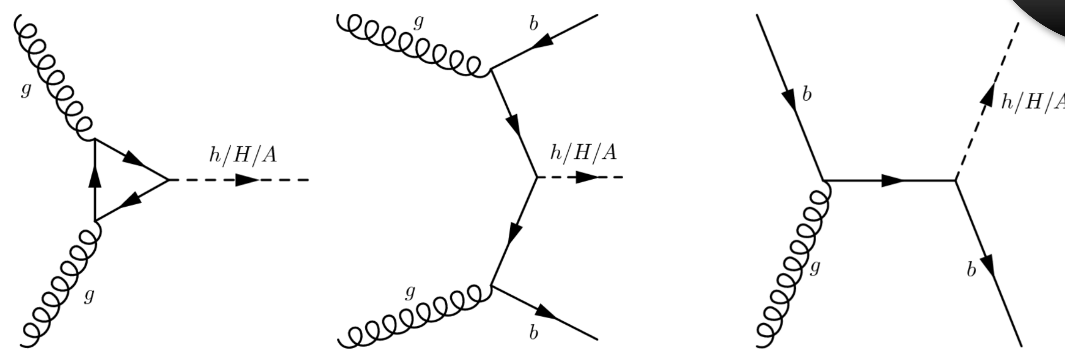
# MSSM H/A → τ τ

[ATLAS-CONF-2015-061]




- **3.2** fb$^{-1}$ pp collision data collected in 2015 at $\sqrt{s}$= **13** TeV
- Search for **H/A → $\tau_{had}\tau_{had}$** and **$\tau_{lep}\tau_{had}$** decay modes

**$\tau_{had}$** candidate is reconstructed as

- a **jet** into the calorimeter enclosed in ΔR<0.4, $p_T$>20 GeV and |η| < 2.5
- 1 or 3 charged particles into the ID with total charge ±1
- a multivariate "medium" BDT-based identification requirements

**$\tau_e$** candidate is reconstructed as

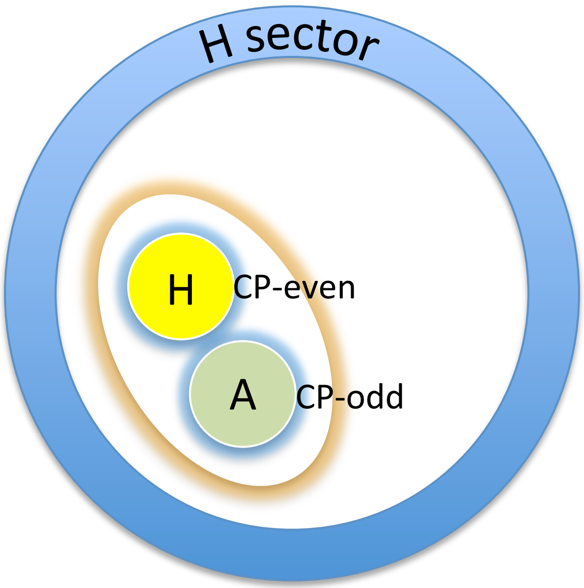
- energy deposit into the EM calorimeter with associated charge-particle track into ID with $E_T$>15 GeV and |η| < 2.47
- the charge is identified as electron if passes both the medium identification and the gradient isolation requirements

**$\tau_\mu$** candidate is reconstructed as

- ID track associated with a MS track
- $P_T$>20 GeV and |η| < 2.5
- the combined MS-ID track have to pass both the medium identification and the gradient isolation requirements

# MSSM H/A $\rightarrow \tau\ \tau$

[ATLAS-CONF-2015-061]




- Search for **H/A → $\tau_{had}\tau_{had}$**
  - **Trigger:** Single-$\tau_{had}$ ($p_T$>125 GeV))
  - **=2 $\tau_{had}$**: the leading must match the trigger in ΔR=0.2 with $p_T$>135 GeV and "medium" identification requirements; the sub-leading $p_T$>55 GeV and "loose" identification criteria.
  - Veto on electron or muon
  - $\Delta\phi(\tau_1^{had}, \tau_2^{had}) > 2.7$
  - The two $\tau_{had}$ must have opposite sign electric charge

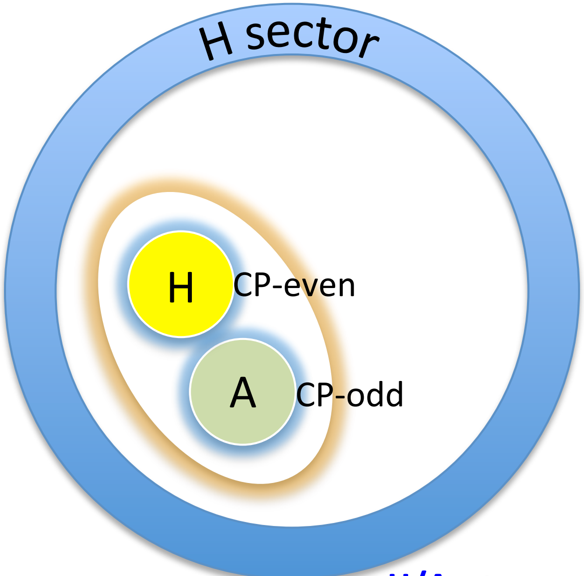
- Search for **H/A → $\tau_{lep}\tau_{had}$**
  - **Trigger:** combination of single-e ("medium" + $p_T$>24 GeV or "loose" + $p_T$>120 GeV or "lhmedium" + $p_T$>60 GeV) or single-μ (isolated μ +$p_T$>24 GeV or no-isolation + $p_T$>50 GeV)
  - **≥1 $\tau_{had}$** candidate + e or μ candidate and total charge = 0 [overall reduction of SM bkg]
  - $\Delta\phi(\tau_{had}, l) > 2.4$ rad, where l=e,μ
  - $m_T(l, E_T^{miss})$<40 GeV or $m_T(l, E_T^{miss})$>150 GeV [reduce bkg W]
  - Veto on events with 80<$m(\tau_{had}, e)$<110 GeV [reduce bkg Z→ee]

- Di-τ mass reconstruction: $m_T^{tot} = [m_T^2(E_t^{miss}, \tau_1)+m_T^2(E_t^{miss}, \tau_2)+m_T^2(\tau_1, \tau_2)]^{1/2}$

  where $m_T(a,b)=[2p_T(a)p_T(b)(1-\cos\Delta\phi(a,b)]^{1/2}$

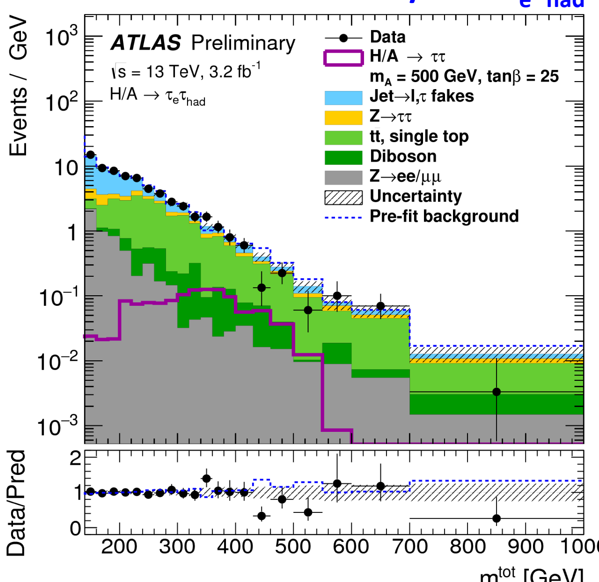
# MSSM H/A → $\tau\ \tau$

[ATLAS-CONF-2015-061]

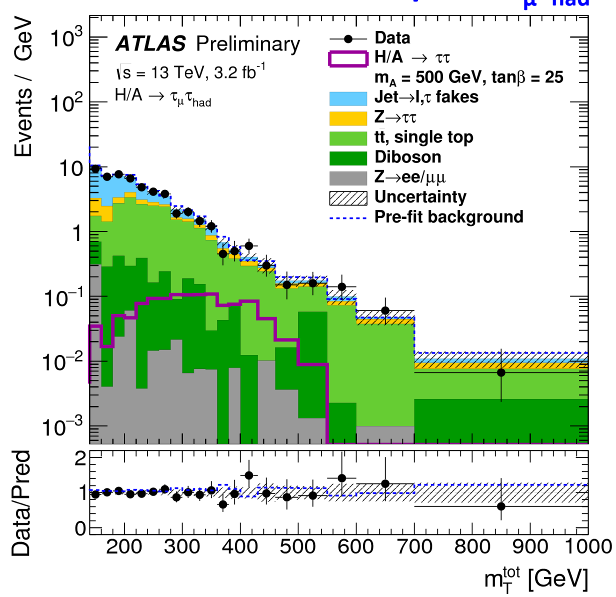



- **H/A → $\tau_{had}\tau_{had}$** background
  - Multi-jets
- **H/A → $\tau_{lep}\tau_{had}$** background
  - $Z/\gamma \to \tau\ \tau$, $t\bar{t} \to W^{+}W^{-}b\bar{b} \to \tau_{had}\, l\ \nu\bar{\nu}b\bar{b}$
  - W+jets, multi-jets

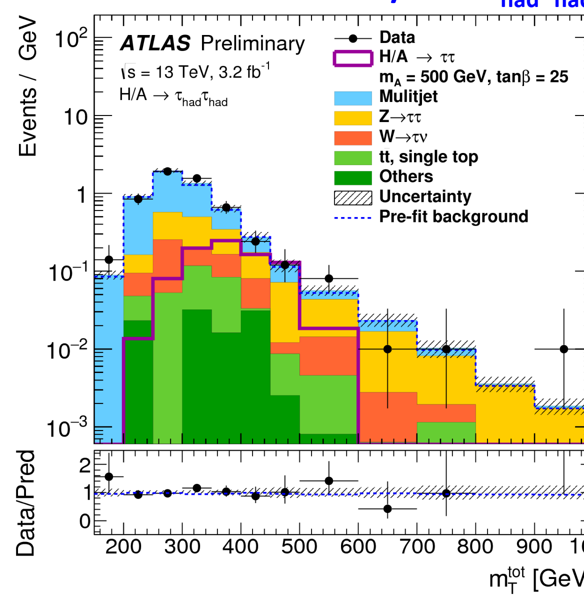
**H/A → $\tau_{e}\tau_{had}$**




**H/A → $\tau_{\mu}\tau_{had}$**




**H/A → $\tau_{had}\tau_{had}$**



# MSSM H/A → τ τ

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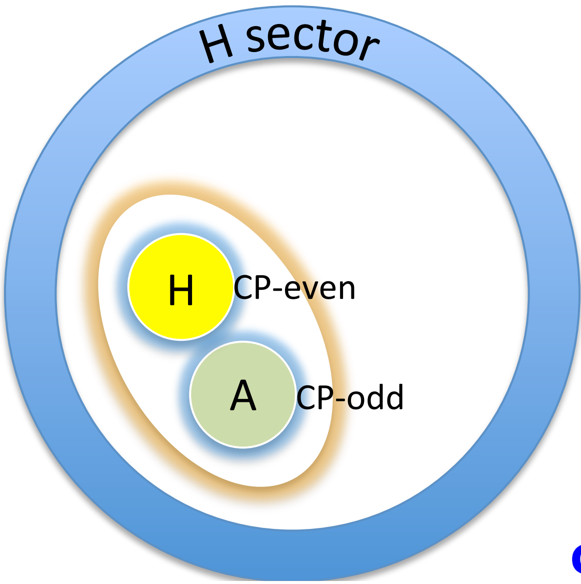
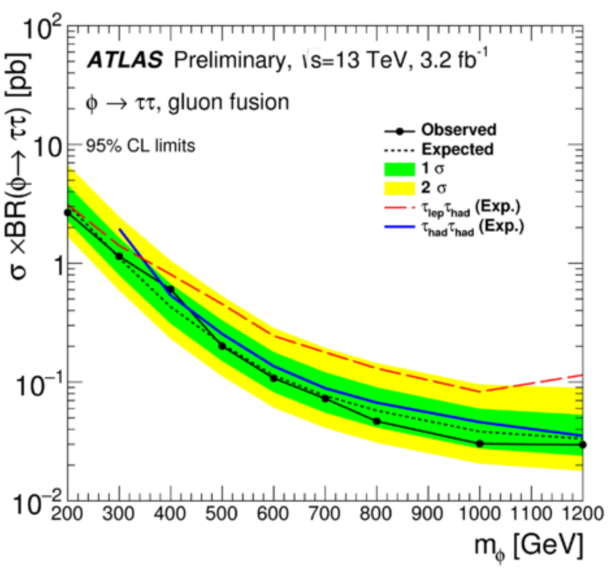
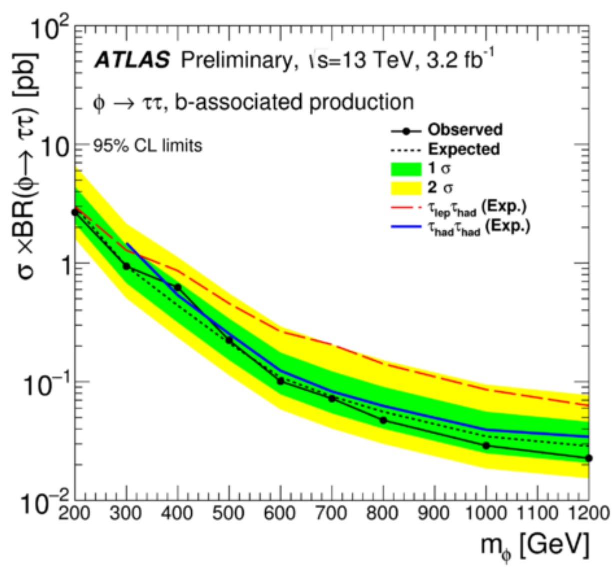
[ATLAS-CONF-2015-061]




- The results from the channels studied in this search are combined to improve the sensitivity to MSSM Higgs boson production
- The data are found to be in good agreement with the predicted background yields and hence the results are given in terms of exclusion limits

**$\phi \to \tau\tau$**

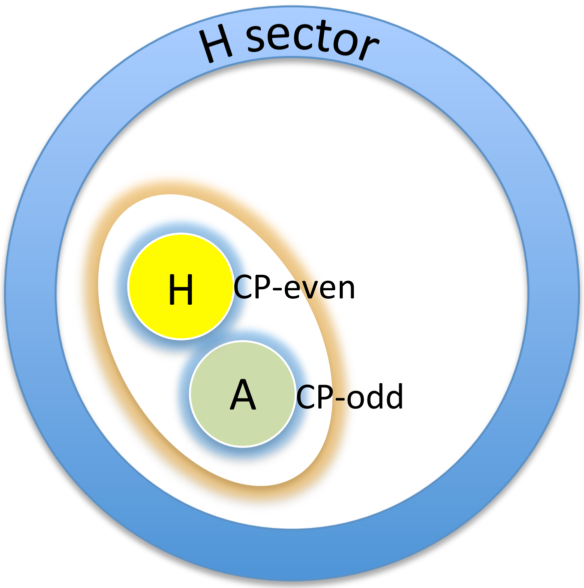


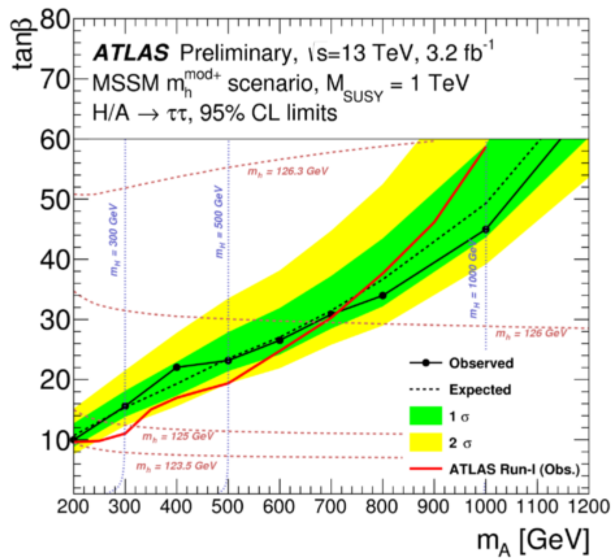

Observed and expected 95% CL upper limits on the σ x BR for the production of a single scalar boson ϕ decaying to ττ, as a function of $m_\phi$

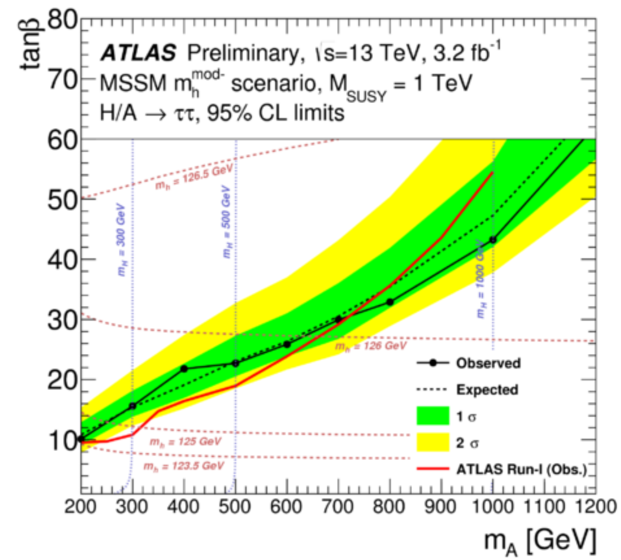
# MSSM H/A → τ τ

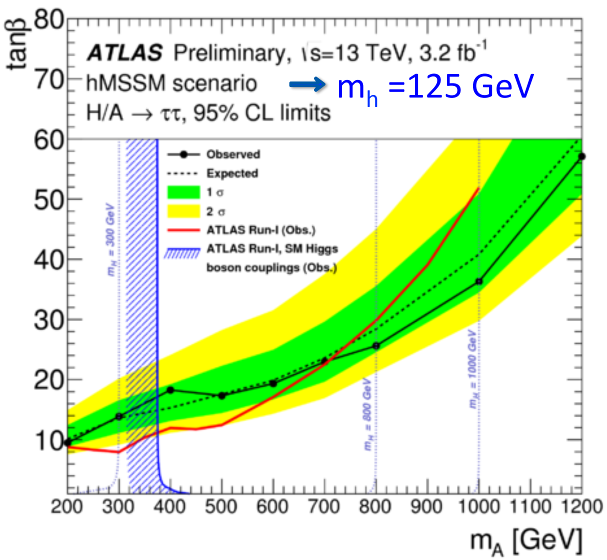
[ATLAS-CONF-2015-061]




## H/A → τ τ



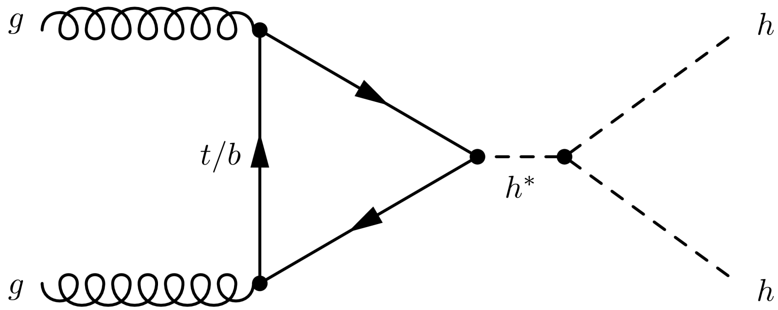



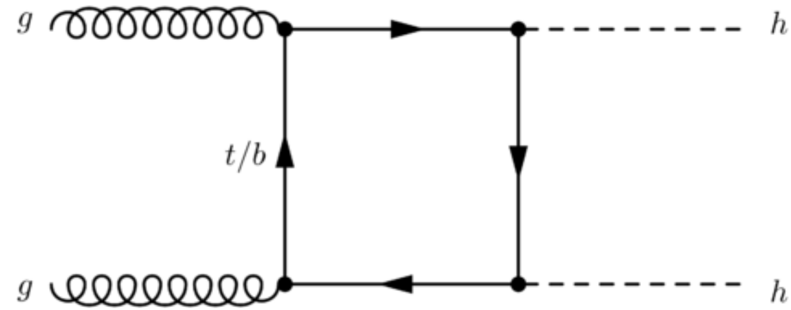

- Observed and expected 95% CL upper limits on tanβ as a function of $m_A$ in various MSSM scenarios and for the hMSSM scenario.
- In the $m_h^{mod+}$ scenario (the most stringent constraint for tan β) excludes tanβ>10 for $m_A$=200 GeV.
- Improve the limits of Run I for the mass range $m_A$>700 GeV

# 4 hh → bbττ, γγWW*, γγbb, bbbb

[Phys. Rev. D92, 092004 (2015)]

- In SM the existence of h is a consequence of electroweak symmetry breaking
- SM predicts self-coupling between h, measurements of which tests the EWSB mechanism



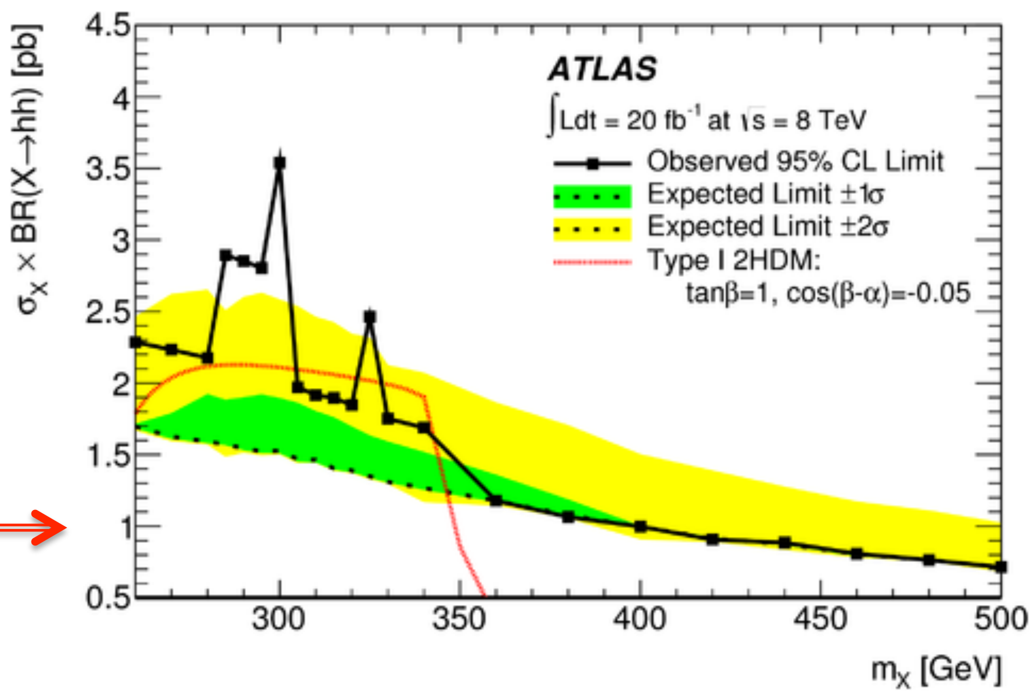




- Data collected so far ($25fb^{-1}$) are insensitive to the self-coupling in SM but in other models, e.g. MSSM the **gg→H→hh** would lead to a new resonant Higgs pair production, in contrast to the non-resonant by the SM
- **20.3** $fb^{-1}$ pp collision data collected in Run 1 at $\sqrt{s}$= **8** TeV
- Search for **hh → bbττ, γγWW*, γγbb, bbbb** channels. In this study
  - h → ττ the first τ decays to leptons and the second to hadrons using the same methodology of single Higgs boson search
  - h → γγ same methodology as the single Higgs boson search
  - h → WW*→lνqq'

# 4 hh → bbττ, γγWW*, γγbb, bbbb

**[Phys. Rev. D92, 092004 (2015)]**

- The reconstructed objects are: **electrons, muons, photons, jets, taus (hadron decay) and $E_t^{miss}$**
- **hh→γγbb**
  - di-photon trigger
  - two isolated photons with $105<m_{\gamma\gamma}<160$ GeV and two energetic b-tagged jets with $95<m_{bb}<135$ GeV
  - Non-resonant analysis: the 95% CL upper limit of 2.2 (1.0) pb observed (expected) for σ(gg→hh→γγbb)
  - Resonant analysis: the 95% CL upper limit observed (expected) on σ(gg→H) x BR(H→hh) are 2.3 (1.7) pb at $m_H$=260 GeV and 0.7 (0.7) pb at $m_H$=500 GeV




The global probability of an excess as significant as the observation to occur at any mass in the range studied is found to be 0.019, corresponding to **2.1σ**

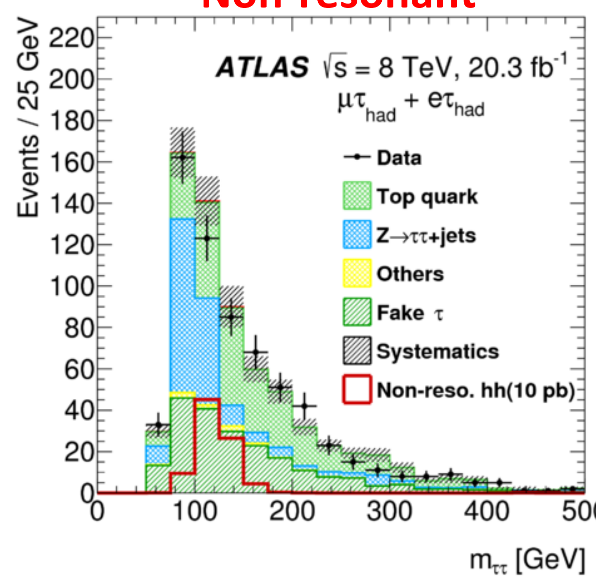
# 4 hh → bbττ, γγWW*, γγbb, bbbb

[Phys. Rev. D92, 092004 (2015)]

- **hh→bbbb**
  - resolved and boosted Higgs reconstruction methods
  - multijet trigger with b-quark jet tagging
  - two back-to-back high momentum bb systems with $m_{bb}$ consistent with the h mass
  - angular distance between the two b-jets of the bb di-jet system in ΔR<1.5
  - non-resonant analysis: the 95% CL upper limit of 220 (220) fb observed (expected) for σ(gg→hh→bbbb)
  - resonant analysis: the 95% CL upper limit observed (expected) on σ(gg→H→hh→bbbb) ranges from 52 (56) fb, at $m_H$=500 GeV, to 3.6 (5.8) fb at $m_H$=1000 GeV

- **hh→bbττ**
  - trigger with at least one lepton with $p_T$>24 GeV
  - only one lepton ($p_T$>26 GeV), one hadronically decaying tau lepton with opposite charge ($p_T$>20 GeV) meeting "medium" criteria, ≥ 2 jets with $p_T$>30 GeV of which 1-3 b-tagged jets
  - No evidence of Higgs boson pair production is present in the data
  - For non-resonant production the expected (observed) cross section 95% CL upper limit is 1.6 (1.3) pb.

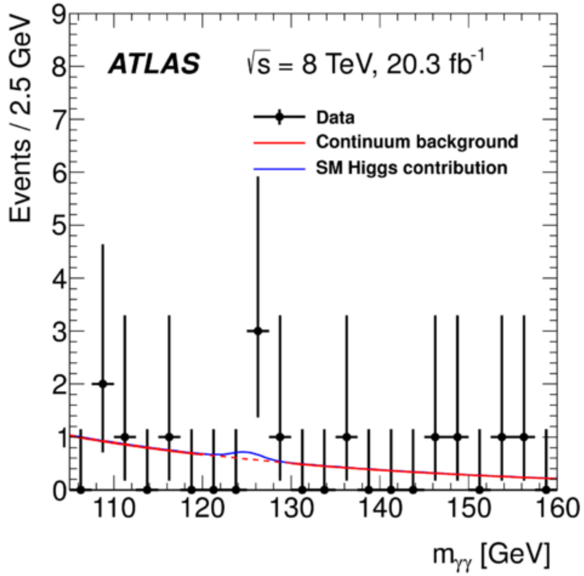
**Non-resonant**

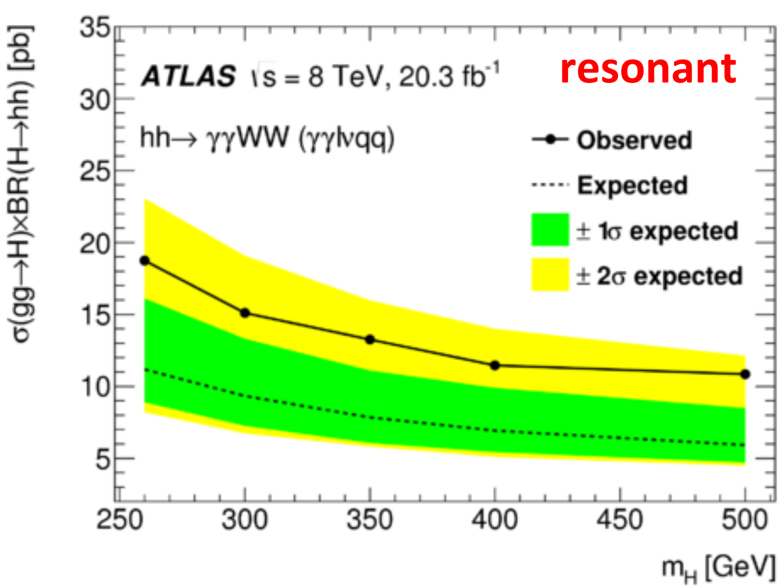


# hh → bbττ, γγWW*, γγbb, bbbb

[Phys. Rev. D92, 092004 (2015)]

- **hh→γγWW***
  - to reduce multijet bkg, one of the W is required to decay to an **e** or a **μ**, whereas the other is required to decay hadronically, leading to the γγqq'lυ final state
  - di-photon trigger
  - ≥2 identified photons with $|m_{\gamma\gamma}-m_h|<2\sigma=3.4$ GeV
  - ≥2 jets and only 1 lepton, $E_t^{miss}$ and no b-tagged jets
  - For non-resonant production the expected (observed) cross section 95% CL upper limit is 11.4 (6.7) pb.



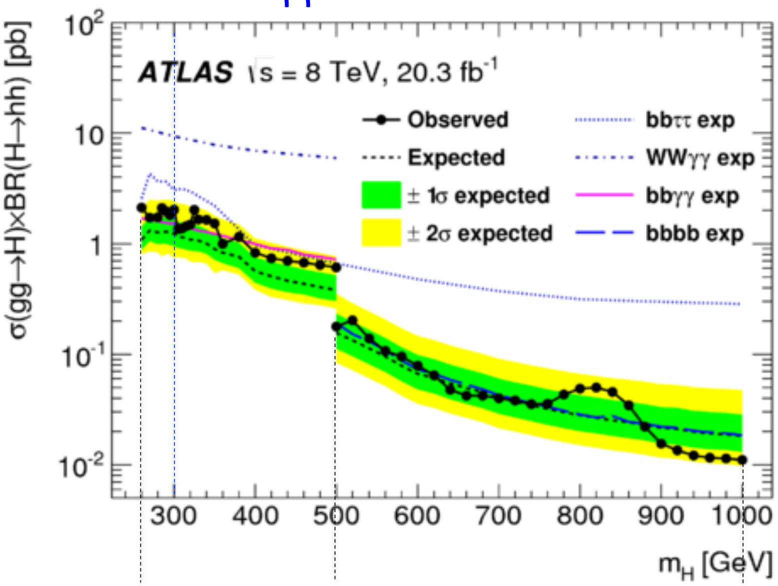
# hh → bbττ, γγWW*, γγbb, bbbb

[Phys. Rev. D92, 092004 (2015)]

- **hh→bbbb, bbττ, γγbb, γγWW* combined results**

The upper limit on σ(gg->H) x BR(H->hh) varies from 2.1 pb at 260 GeV to 0.011 pb at 1000 GeV

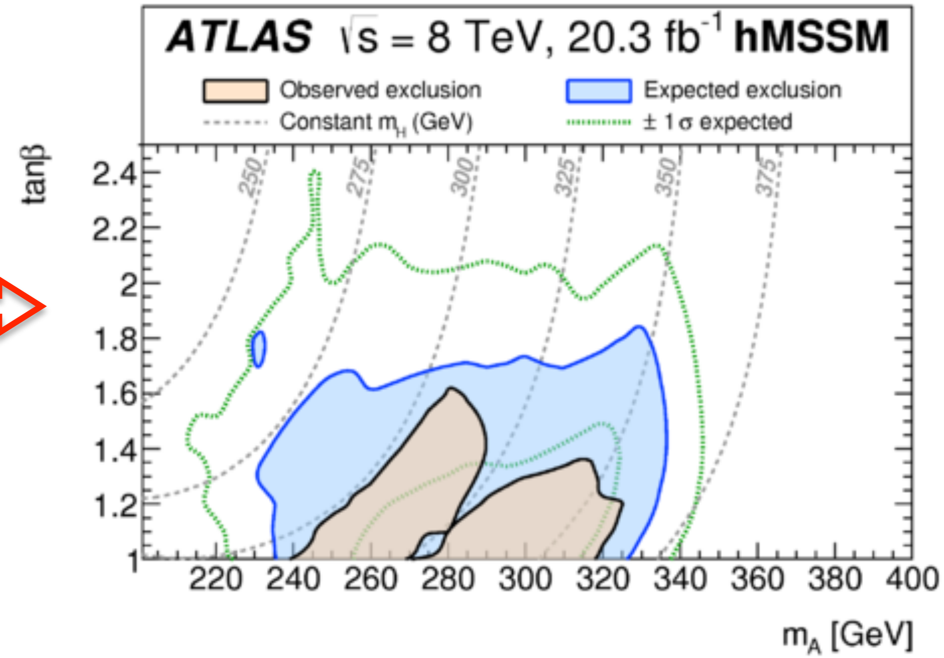
2.1σ γγbb




γγbb, bbττ

bbbb

⇒



# 5 Resonances decaying to photon pairs

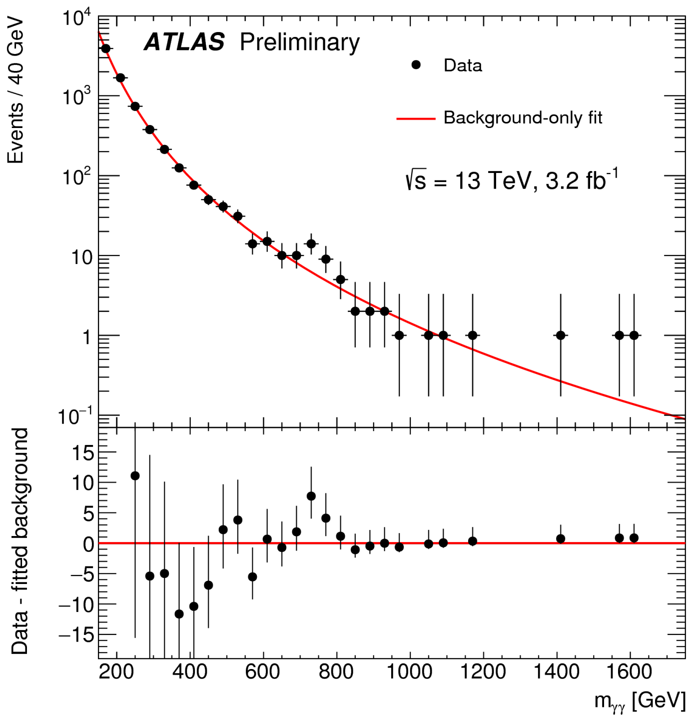
[ATLAS-CONF-2015-081]

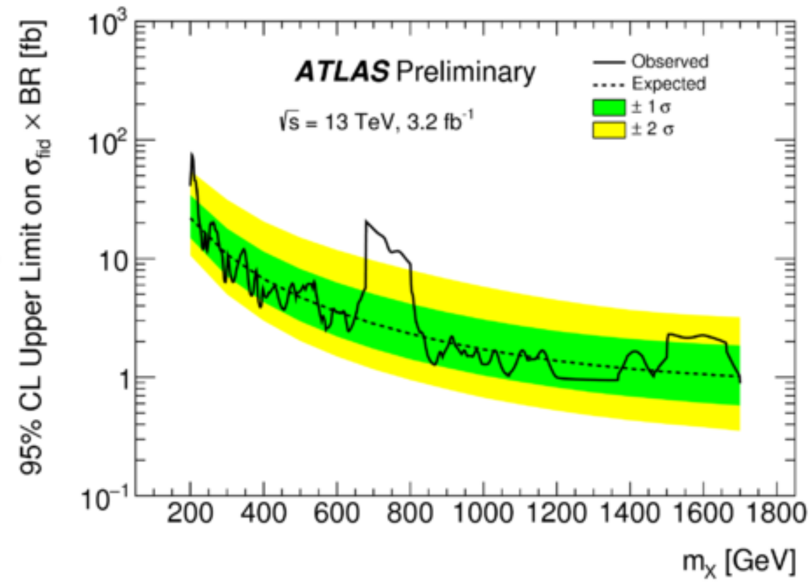
- **h → γγ** such as those expected in models with an extended Higgs sector
- **3.2** $fb^{-1}$ pp collision data collected in 2015 at $\sqrt{s}$= **13** TeV
- Diphoton **trigger** with $E_T$ > 35 GeV (leading photon) and $E_T$ > 25 GeV (sub-leading photon)
- The diphoton selection follows the approach of the Run 1 analysis (85-600 GeV) in which $E_T^{\gamma\text{-leading}}/m_{\gamma\gamma} > 0.4$ and $E_T^{\gamma\text{-subleading}}/m_{\gamma\gamma} > 0.3$
- The selections are optimized by maximizing the ratio of the expected significance obtained with the stricter relative selections and with the trigger $E_T$ selections
- The isolation requirement imposed on the photon candidates of the pairs is similarly optimized (it reduces mostly the γ-jet and jet-jet reducible bkg)
- Both optimization produce a relative significance improvement >20% for masses >600 GeV
- The total signal selection efficiency ranges from 25 to 40% depending on the boson production mechanism (ggF, VBF, ttH) and on the resonance masses.

# 5 Resonances decaying to photon pairs

**[ATLAS-CONF-2015-081]**

- An upper limit at 95% CL is reported on the fiducial production cross section of a narrow scalar boson times its decay BR into two photons, for masses ranging from 0.2 to 1.7 TeV
- The largest deviation from the bkg-only hypothesis is found for a mass of about 750 GeV, corresponding to a local significance of 3.6 σ and a global significance of 2.0 σ
- The second most significant deviation from the background-only hypothesis is found for a mass of about 1.6 TeV, corresponding to a local significance of 2.8 σ



# 5 Resonances decaying to photon pairs

[ATLAS-CONF-2015-081]

"… The events in this region are **scrutinized**. No detector or reconstruction effect that could explain the larger rate is found, nor any indication of anomalous background contamination. The kinematic properties of these events are studied with respect to those of events populating the invariant mass regions above and below the excess, and no significant difference is observed. The Run-1 analysis is extended to invariant masses larger than 600 GeV by using the new background modeling techniques The **compatibility** between the results obtained with the 8 TeV and 13 TeV datasets is estimated under the Narrow Width Approximation hypothesis and assuming a large-width resonance with $\alpha = 6\%$, using the best fit value of the ratio of cross sections. For an *s*-channel gluon-initiated process, the parton-luminosity ratio is expected to be 4.7. Under those assumptions, the results obtained with the two datasets are found to be compatible within 2.2 and 1.4 standard deviations for the two width hypotheses respectively. …"

# Summary

- We are entering a new era in Higgs BSM physics where we study the couplings of the observed Higgs boson in more detail and search for additional Higgs states
- Wide range of new/recent results on Higgs physics BSM from ATLAS
  - Limits on new phenomena from Higgs Couplings
  - Search for resonances decaying to photon pairs
  - Search for $H^{\pm}$->tb
  - Search for H/A-> $\tau\tau$
  - Search for Higgs boson pairs
- New and interesting analysis underway in Run-II...stay tuned!

# Spares

# 5 Resonances decaying to photon pairs