Searches for new phenomena in leptonic final states using the ATLAS detector

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on behalf of ATLAS collaboration

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Introduction

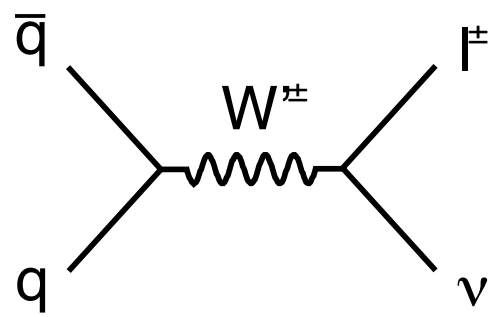
- Standard Model (SM) needs extension
  - Naturalness, baryon number, dark matter, neutrino mass

- Models with extended gauge groups (left-right symmetric, E_6-motivated) predict heavy gauge boson (W'/Z')
  - W' → lν @ 13 TeV, 36.1 fb^{-1} [ATLAS-CONF-2017-016]
  - Z' → ll @ 13 TeV, 36.1 fb^{-1} [ATLAS-CONF-2017-027]

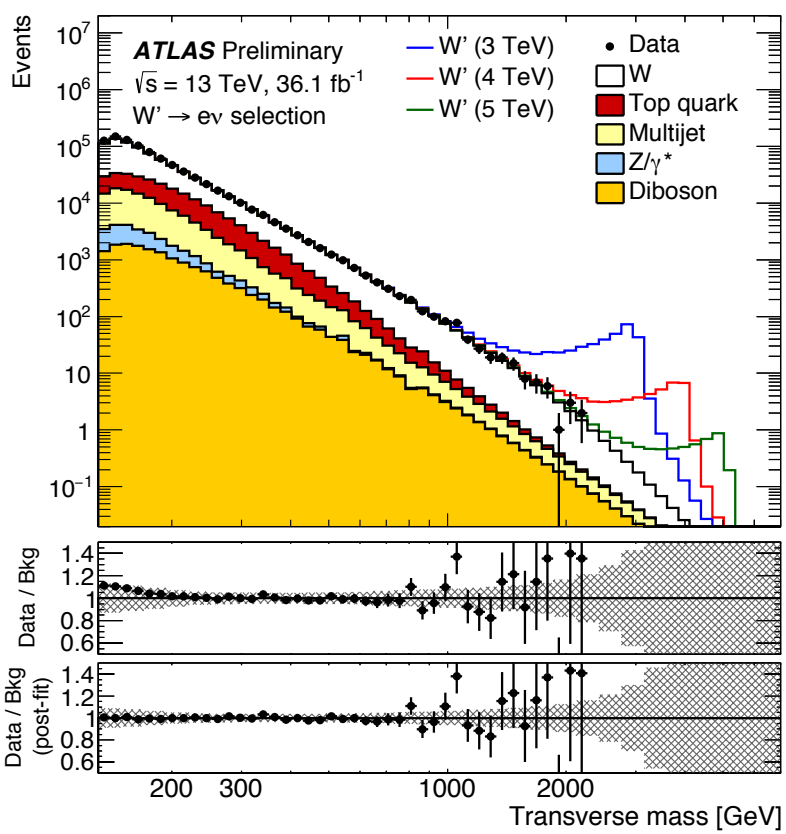
- Models with extended Higgs sector (MSSM, 2HDM) predict a CP-odd (A) and two CP-even (h, H) and two charged ($H^{\pm}$) Higgs bosons
  - H/A → ττ @ 13 TeV, 13.3 fb^{-1} [ATLAS-CONF-2016-085]
  - A → Zh @ 13 TeV, 3.2 fb^{-1} [ATLAS-CONF-2016-015]

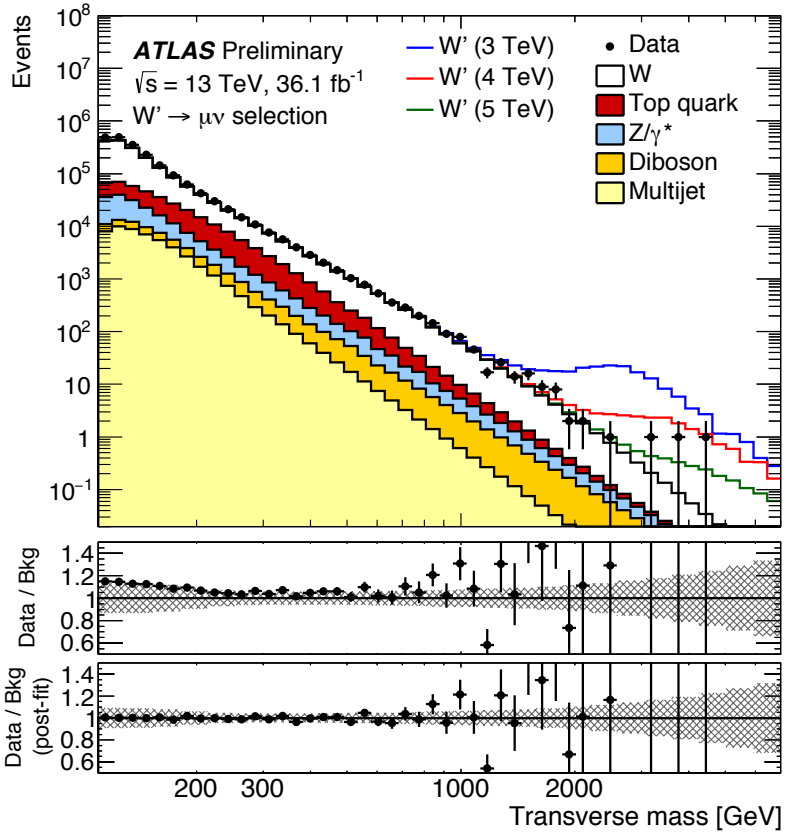
W' → lν : Overview

- Signal
  - Sequential Standard Model (SSM) W'_{SSM} → couplings to fermions are identical to SM W
- Selection
  - eν : 1 electron $p_T > 65$ GeV, $E_T^{miss} > 65$ GeV, $m_T > 130$ GeV
  - μν : 1 muon $p_T > 55$ GeV, $E_T^{miss} > 55$ GeV, $m_T > 110$ GeV
- Background
  - W, top, Z, di-boson, multi-jet, heavy flavor quark, γ+jets
    - multi-jet is estimated from data using matrix method
    - top, di-boson and multi-jet are extrapolated into high m_T
- Discriminant
  - $m_T = \sqrt{(2p_T E_T^{miss}(1-\cos\varphi_{l\nu}))}$



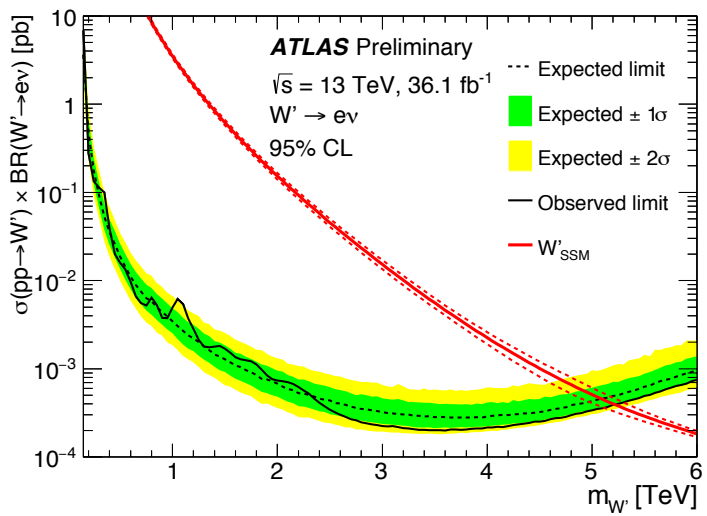
W' → lν : m_T

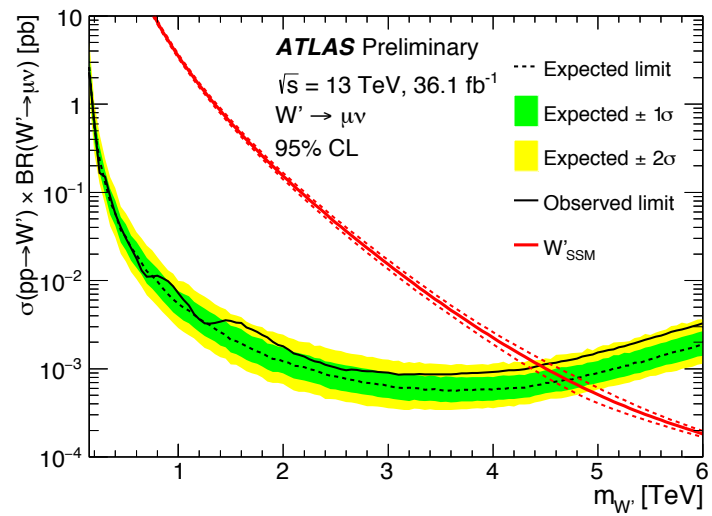


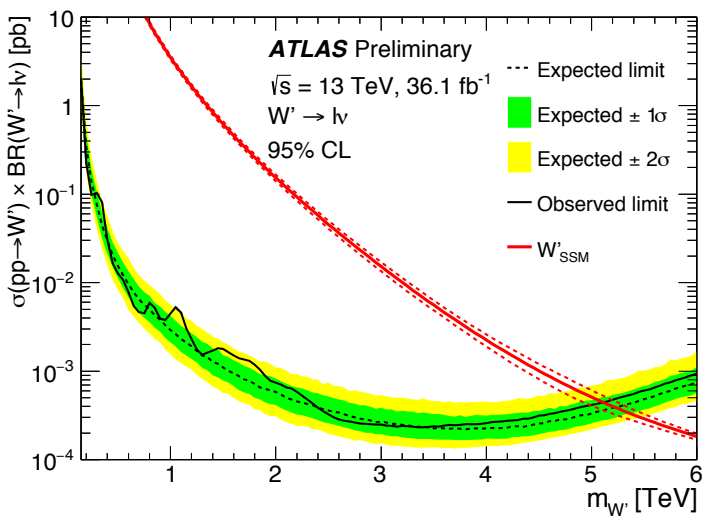


- eν (left) and μν (right)
- Local significance 2.3 σ at 1.1 TeV in eν
- No significant excess

W' → lν : Limit



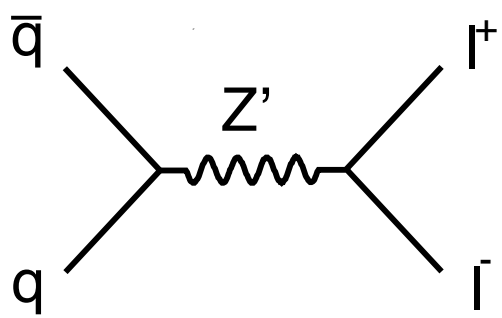




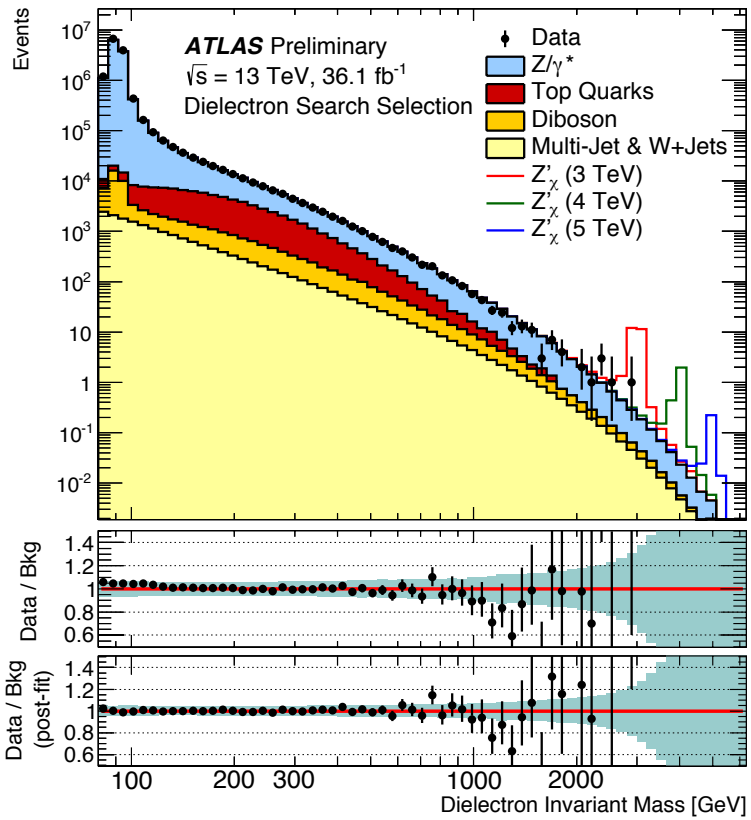
- eν (left) and μν (right)
- Combined (bottom)
- Stronger limit in eν because acceptance and momentum resolution is better in eν
- Lower mass limit for W'_{SSM} : 5.22 TeV

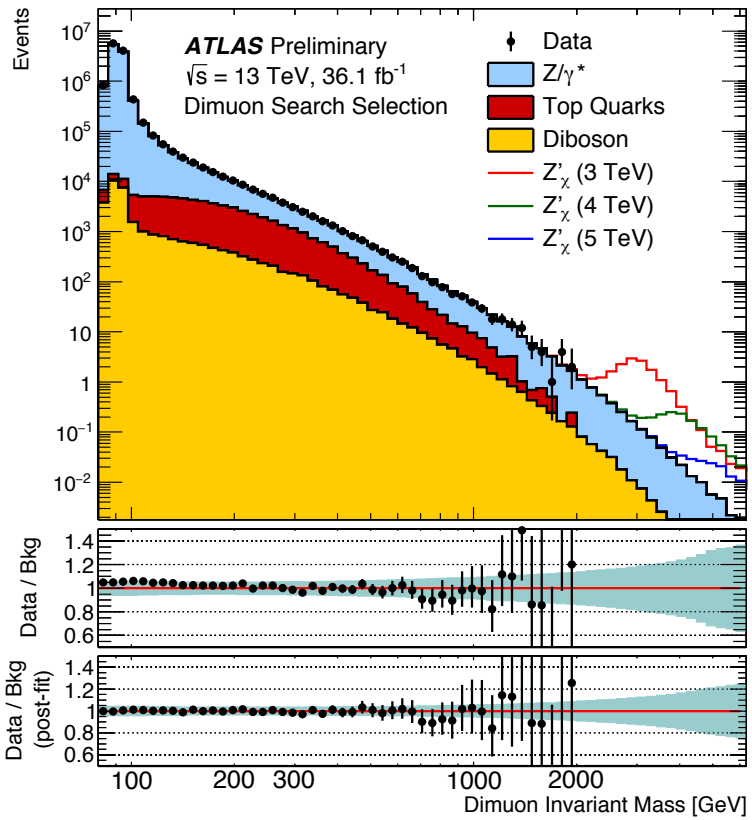
Z' → ll : Overview

- Signal
  - Generic Z' (1~32% width), Z'_{SSM} and E_6-motivated Z'_{ψ}, Z'_{χ} : in this slides
  - Minimal Z' and Contact Interaction (CI) : also in the note
- Selection
  - ee : At least 2 electon $E_T > 30$ GeV,
  - μμ : At least 2 muon $p_T > 30$ GeV, opposite charge
- Background
  - Z, top, di-boson, multi-jet, W+jets
  - Multi-jet and W+jets are estimated from data using matrix method
    - Negligible in μμ
- Discriminant
  - m(ll)



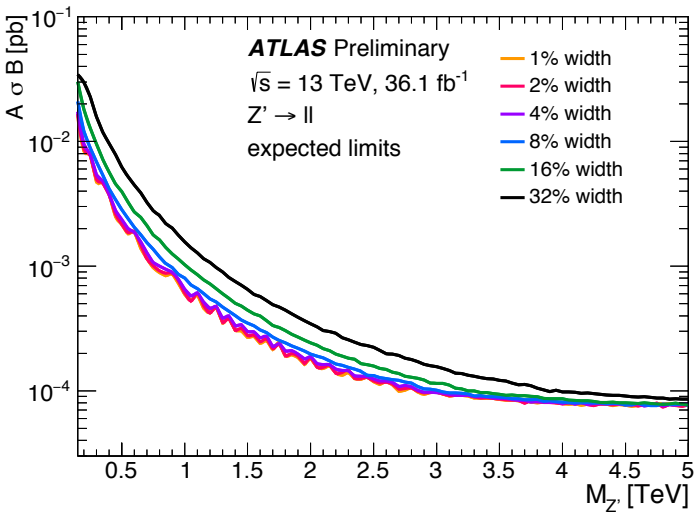
Z' → ll : m(ll)

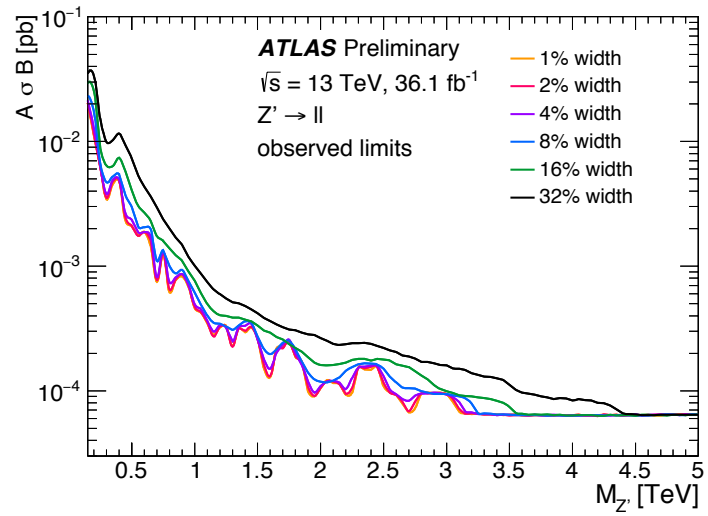


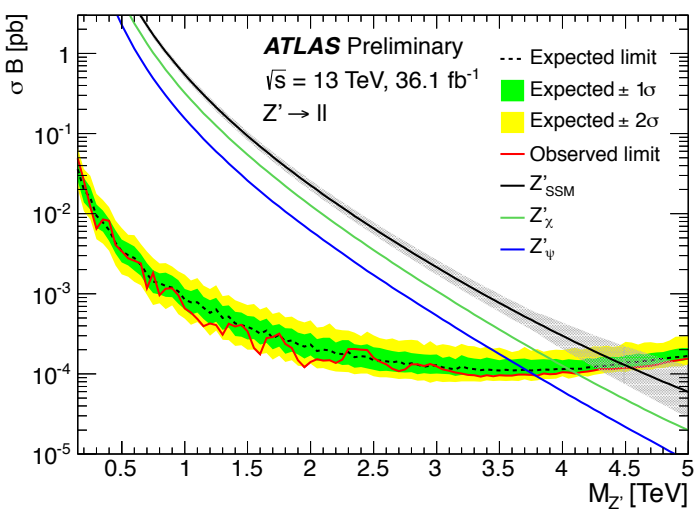


- ee (left) and μμ (right)
- Local significance 2.5 σ at 2.37 TeV
- No significant excess

Z' → ll : Limits

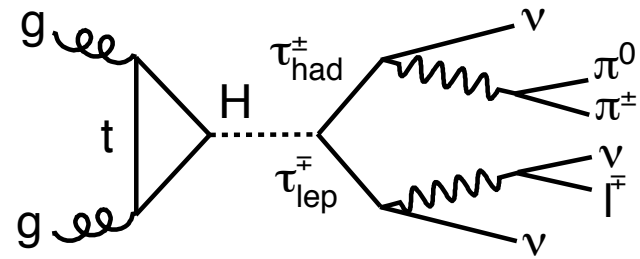






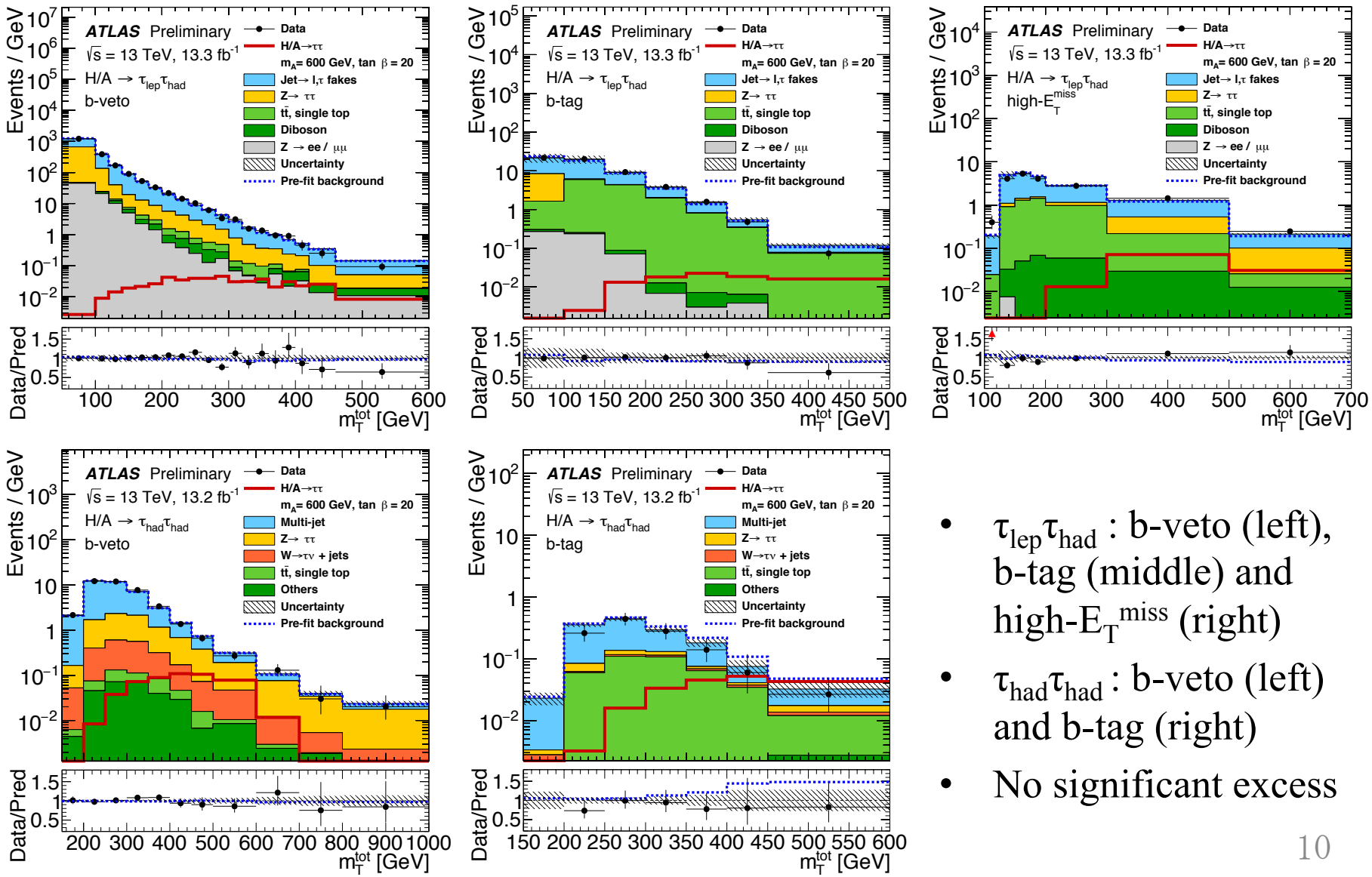
- Limit on generic Z' expected (left) and observed (right)
- Limit on Z'_{SSM} and E_6-motivated Z'_{ψ}, Z'_{χ} (bottom)
  - Lower mass limit for Z'_{SSM} : 4.5 TeV

H/A → ττ : Overview



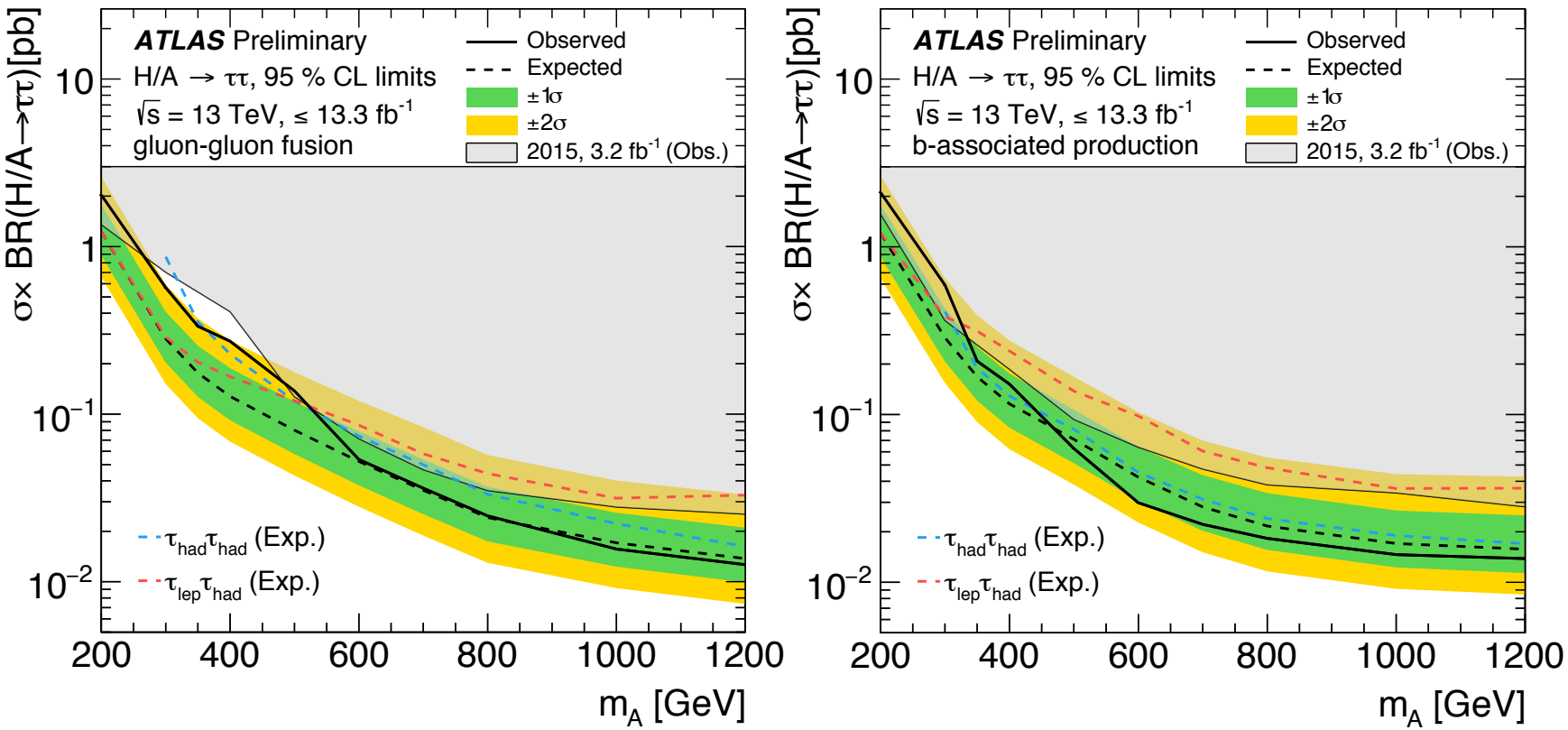
- Signal
  - gluon-gluon fusion (ggH/A) and b-quark associated (bbH/A)
  - large tanβ → couplings to down type fermions → b-tag category
- Selection
  - $\tau_{lep}\tau_{had}$: $E_T^{miss} > 150$ GeV → high-E_T^{miss} category, 1 lepton $p_T > 30$ GeV, $\tau_{had\text{-}vis}$ $p_T > 25$ GeV, opposite charge, $\Delta\varphi(\tau_{had\text{-}vis}, l) > 2.4$, $mT(l, E_T^{miss}) < 40$ GeV, veto $80 < m_{vis}(e, \tau_{had\text{-}vis}) < 110$ GeV
  - $\tau_{had}\tau_{had}$: τ_1 $p_T > 110 \sim 140$ GeV, $\Delta\varphi(\tau_1, \tau_2) > 2.7$, τ refers to visible
- Background
  - Z+jets, W+jets, top (in b-tag category), di-boson, multi-jet
  - Fake is estimated from data using fake factor and fake rate method
- Discriminant
  - $m_T^{tot} = \sqrt{(m_T^2(E_T^{miss}, \tau_1)+m_T^2(E_T^{miss}, \tau_2)+m_T^2(\tau_2, \tau_1))}$

$H \rightarrow \tau\tau : m_T^{tot}$



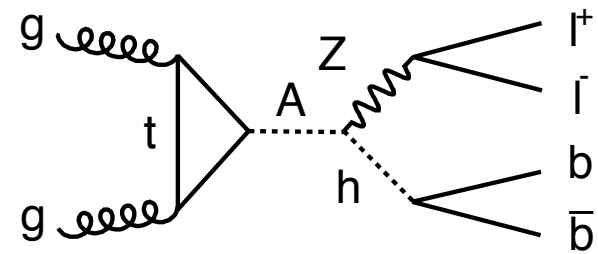
- $\tau_{lep}\tau_{had}$: b-veto (left), b-tag (middle) and high-E_T^{miss} (right)
- $\tau_{had}\tau_{had}$: b-veto (left) and b-tag (right)
- No significant excess

H/A → ττ : Limits



- ggH/A (left) and bbH/A (right)
- Upper limit on σ x BR : 2.0 (2.1) ~ 0.0013 (0.0014) pb for ggA (bbA) at m(H/A) = 200 ~ 1200 GeV
- m_A vs tanβ for MSSM : also in the note

A → Zh : Overview

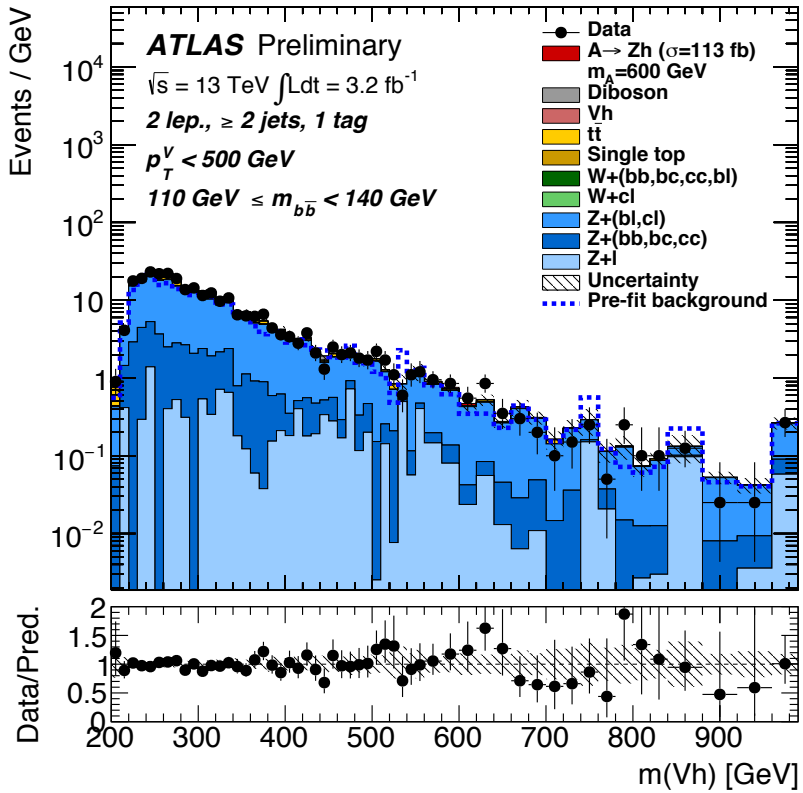


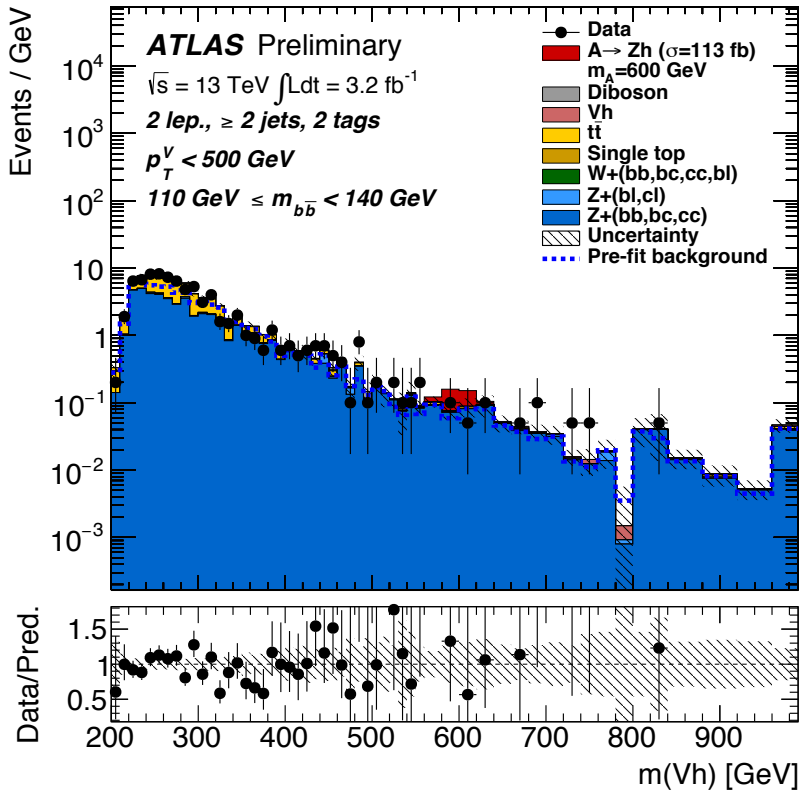
- Signal
  - ggA and bbA
- Selection
  - llbb : in this slides →
  - ννbb : also in the note
  - p_T^Z >500 GeV

  → high-p_T^Z category
- Background
  - Z+jets, top, di-boson, W+jets
  - multi-jet is negligible
- Discriminant
  - llbb : m(Zh)
  - ννbb : m_T(Zh)

	low-p_T^z	high-p_T^z
p_T^z [GeV]	< 500	> 500
# of b-tag	1, 2	1, 2
# of dR = 0.4 jets	≧ 2	-
# of dR = 1.0 jets	-	≧ 1
m(jj), m(J) [GeV]	110 ~ 140	75 ~ 145
m(ee) [GeV]	70 ~ 110	70 ~ 110
m(μμ) [GeV]	70 ~ 110	75 ~ 125
$E_T^{miss}/\sqrt{\Sigma p_T}$ [√GeV]	< 3.5	-

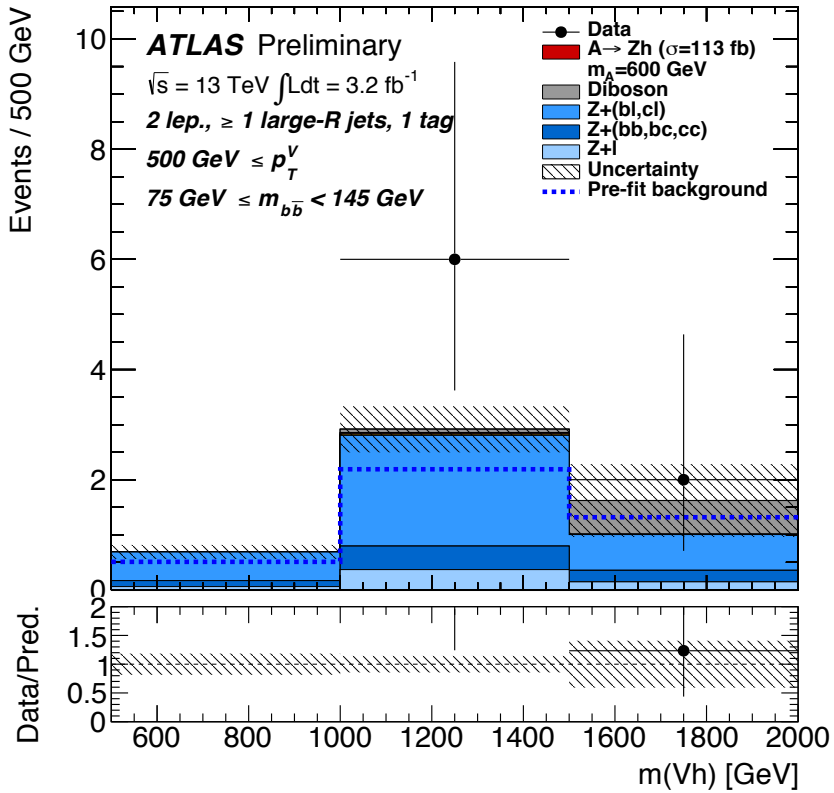
A → Zh : m(Zh)

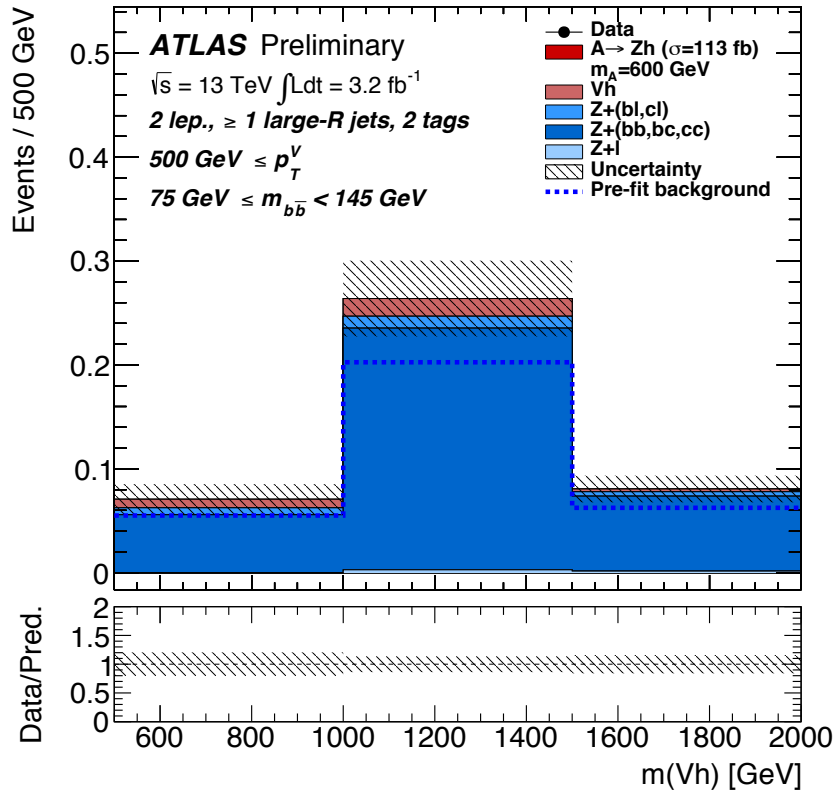




- low-p_T^Z, 1 tag (left) and 2 tag (right)
- Local significance about 2 σ at m(A) = 260, 440 GeV

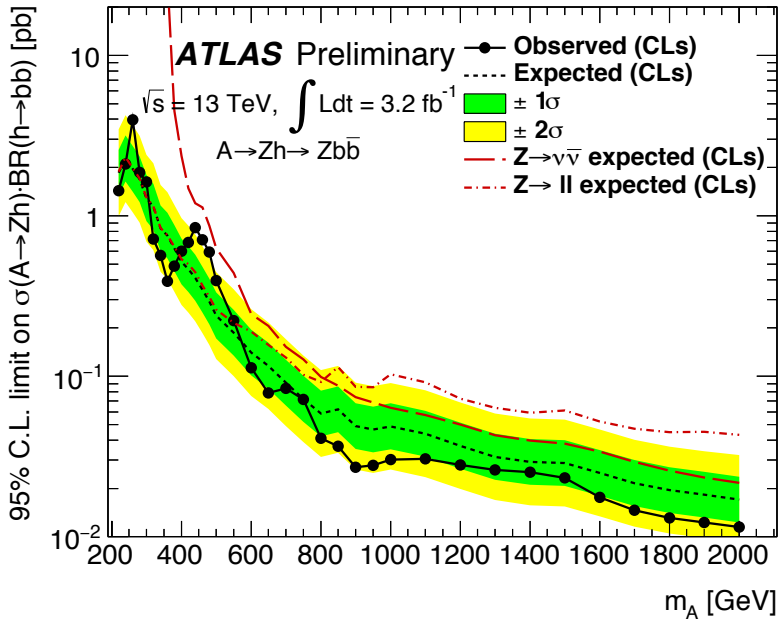
A → Zh : m(Zh)

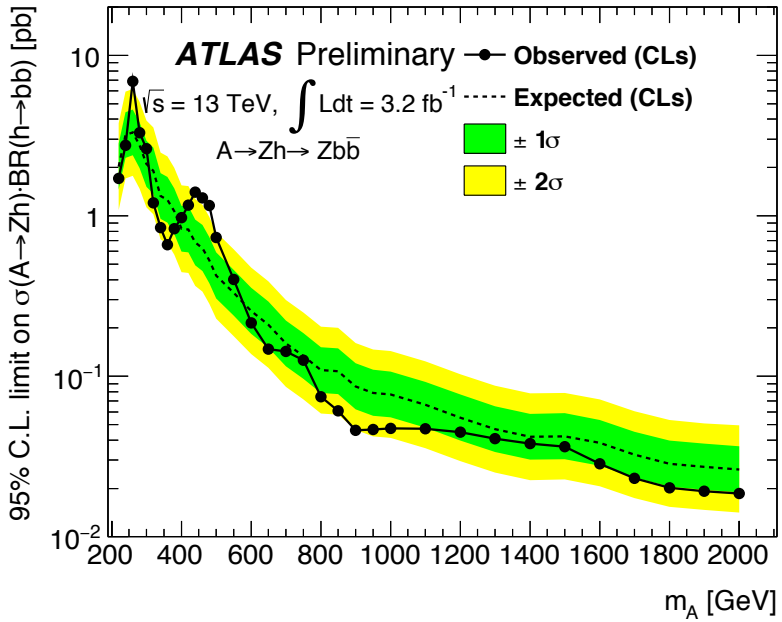




- high-p_T^Z, 1 tag (left) and 2 tag (right)
- No significant excess

A → Zh : Limits





- ggA (left) and bbA (right)
- Upper limit on σ x BR : 4.0 ~ 0.0017 (6.9 ~ 0.026) pb for ggA (bbA) at m(A) = 220 ~ 2000 GeV
- cos(β-α) vs tan(β) for 2HDM : also in the note

Summary

- W' → lν @ 13 TeV, 36.1 fb^{-1} [ATLAS-CONF-2017-016]
  - Local significance 2.3 σ at 1.1 TeV in eν
  - Lower mass limit for W'_{SSM} : 5.22 TeV
- Z' → ll @ 13 TeV, 36.1 fb^{-1} [ATLAS-CONF-2017-027]
  - Local significance 2.5 σ at 2.37 TeV
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  - Local significance about 2 σ at m(A) = 260, 440 GeV
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