BSM Higgs Searches at ATLAS

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on behalf of the ATLAS Collaboration

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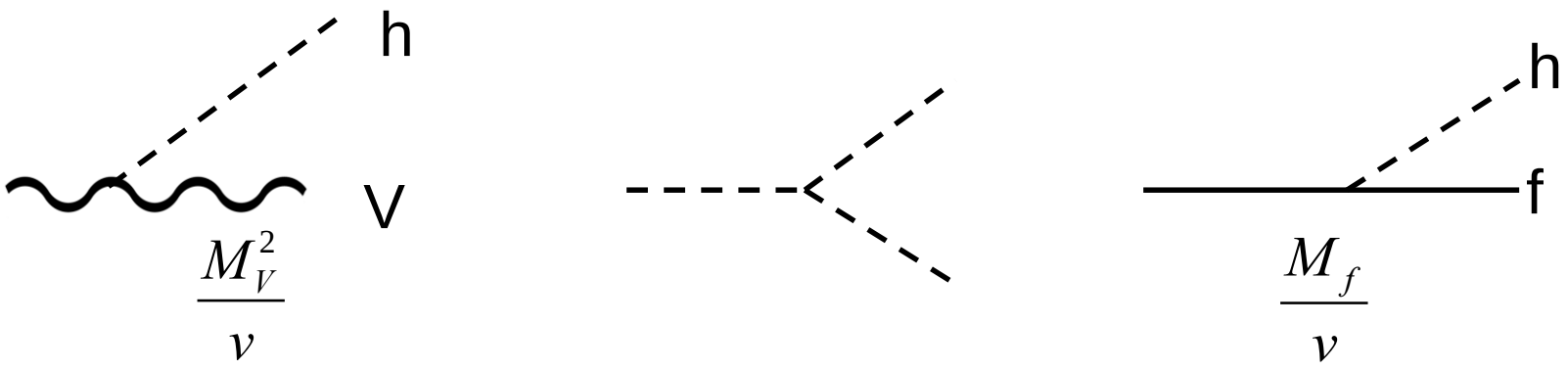
Higgs Boson

- **Standard Model Higgs: h: $J^{PC}=0^{++}$**

$$D_m\Phi^* D^m\Phi \quad + \quad V(\Phi^*\Phi) \quad + \quad \bar{D}_L Y_D D_R \Phi$$



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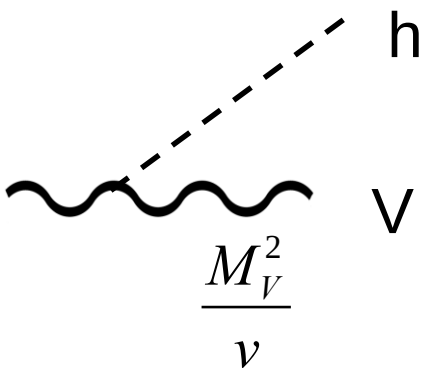
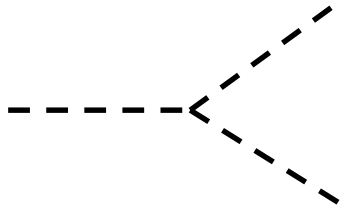
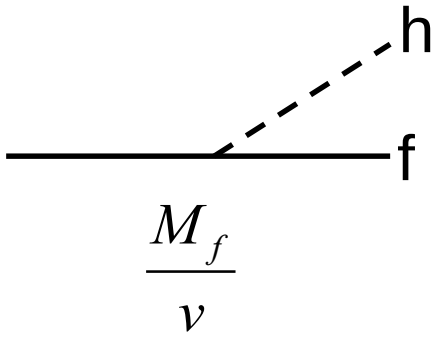
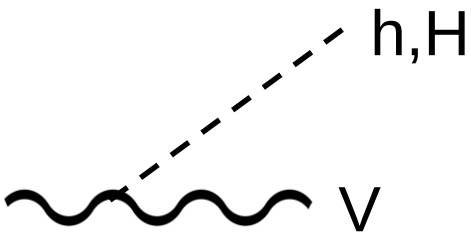




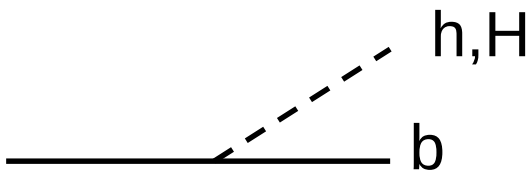


- **2HDM (SUSY) Higgs: h^0, H^0: 0^{++}; A^0: 0^{-+}; $H^{\pm}$**

$$D_m\Phi_{1,2}^{*}D^m\Phi_{1,2} \quad + \quad V(\Phi_1,\Phi_2) + \quad \bar{D}_L Y_D D_R \Phi_1 \quad + \quad \bar{U}_L Y_D U_R \Phi_2$$



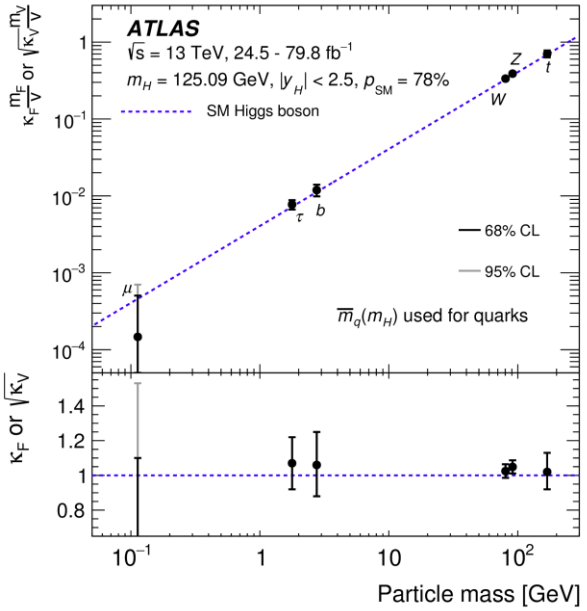
$$g_V M_V[h\sin(\beta-\alpha)+H\cos(\beta-\alpha)]$$



$$-\frac{\sin\alpha}{\cos\beta}h+\frac{\cos\alpha}{\cos\beta}H$$

Extended Higgs Sector

- **While H(125) is currently consistent with expectations, within uncertainties, an extended Higgs sector is strongly motivated**
  - Hierarchy problem, baryon asymmetry, dark matter/energy

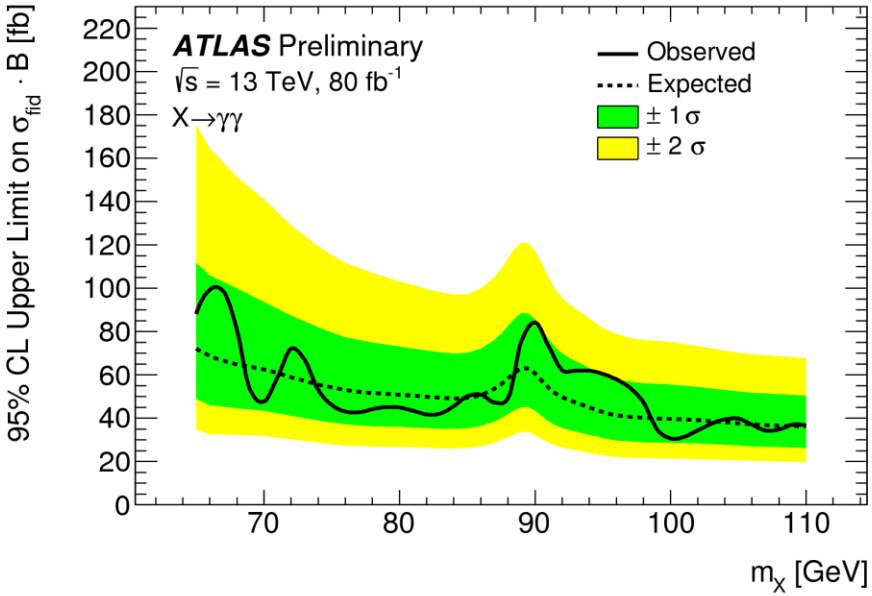


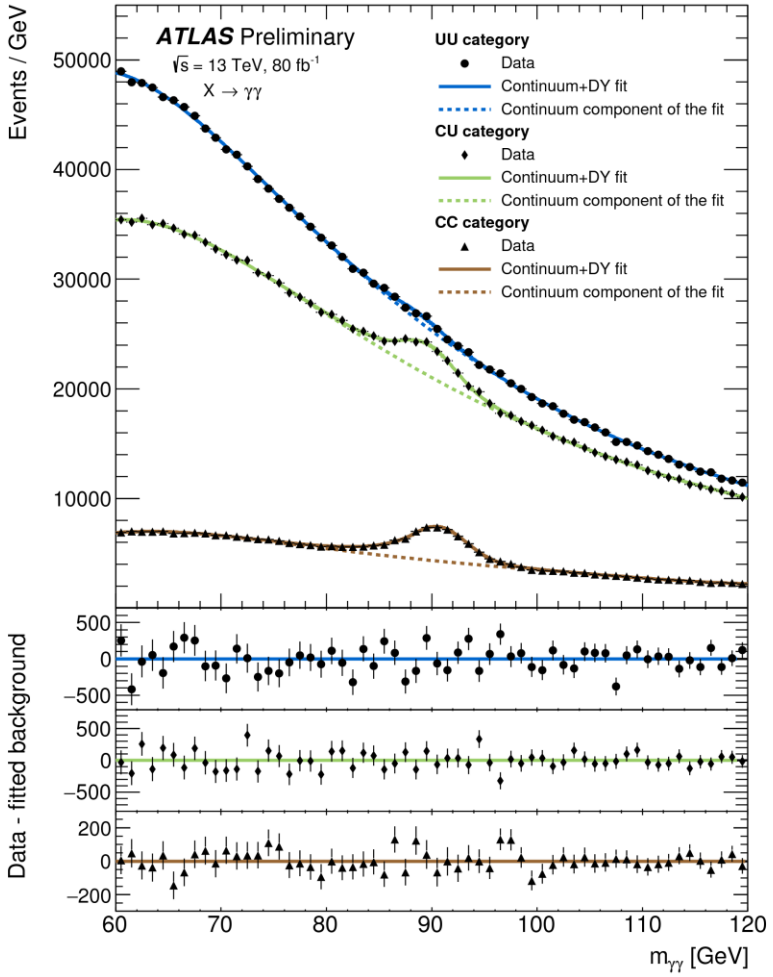
~Three types of searches:

- Many BSM theories contain 2 Higgs doublets, also triplets
  - Leads to search for A, H bosons, over a large mass range, charges
- BSM contributions to di-Higgs production either through new particles in loops, or BSM Higgs bosons being produced (see Cadamuro/Betti talks)
- Anomalous rate of Higgs decays to invisible particles (Dark Matter candidates) (see talk by Sander)

Higgs to γγ

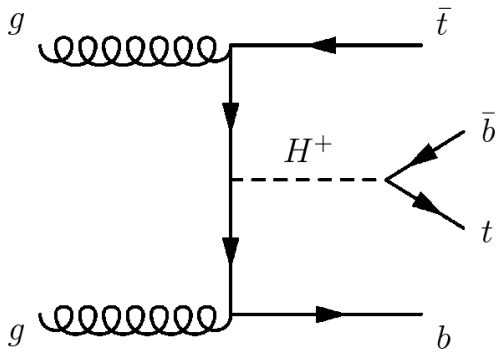
- Extended sector Higgs bosons could have mass <125 GeV
  - Search for diphoton pairs
  - Continuum background (γγ, γj, jj) and Z/γ to e^+e^-
  - Fit to m(γγ), separate fits depending on whether converted γ or not



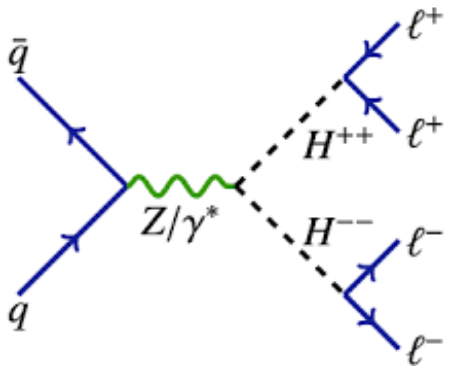


Charged Higgs Searches

- **Charged Higgs bosons predicted in 2HDM, Higgs triplets models**
  - Produced with top quark
  - tb and τν are collectively the largest BR



- **Doubly charged Higgs produced in Left Right Symmetric Model and Higgs Triplet Model**
  - Production is dominated by DY pair production
  - Decays dominated by two charged leptons or two W bosons



Search for Charged Higgs

- **$H^+ \rightarrow \tau\nu$**
  - Search for hadronic tau plus jets or lepton
  - Train BDT for separate mass bins
- **$H^+ \rightarrow tb$**
  - Use b-tagging with lepton signatures
  - Train BDT for separate mass bins

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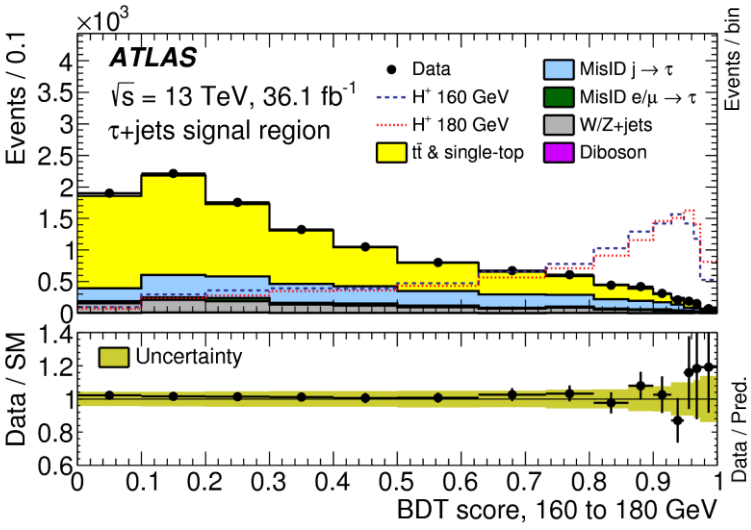

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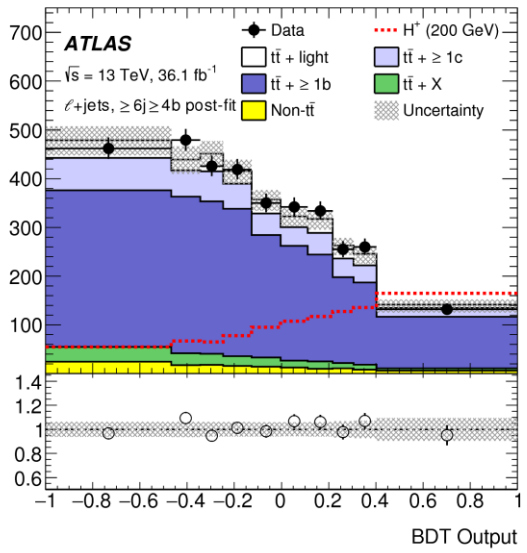
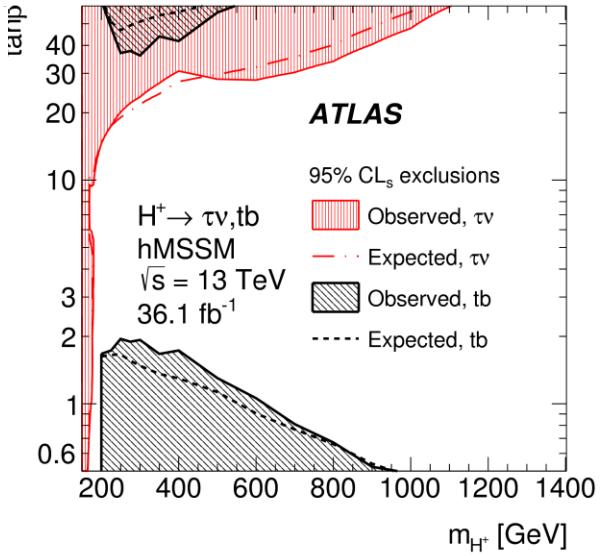
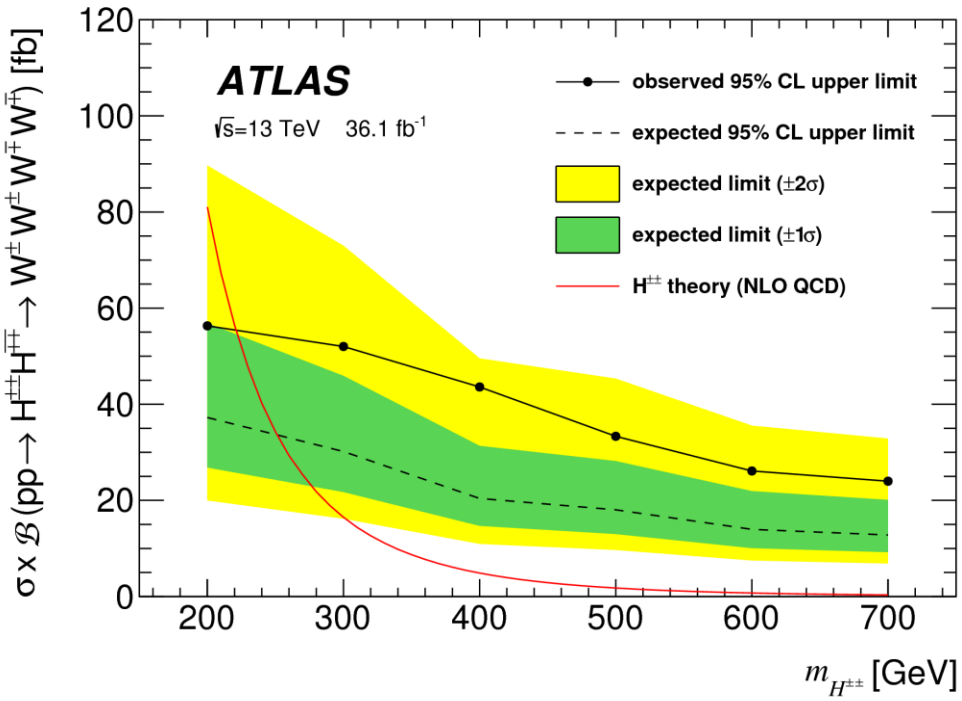
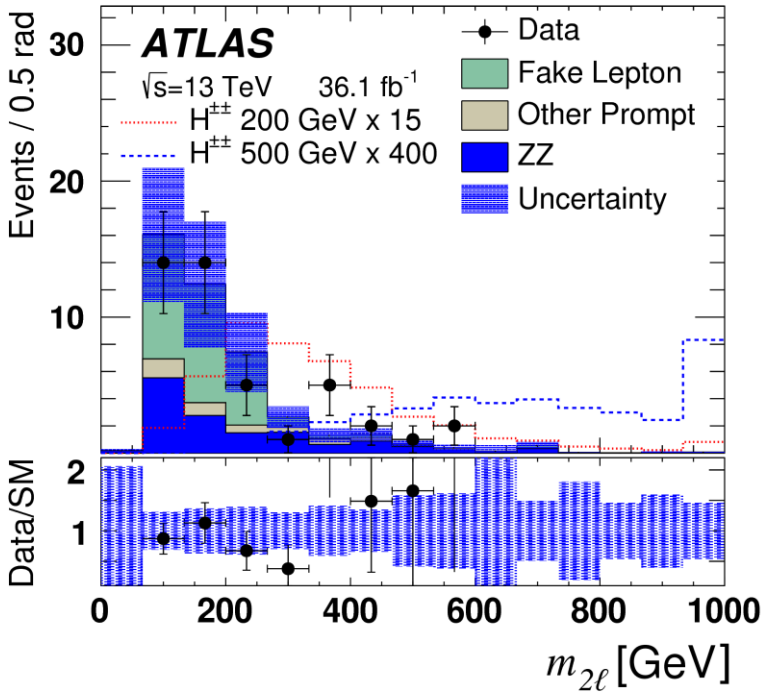




Search for Doubly Charged Higgs

- **$H^{++}H^{++} \rightarrow 4W$**
  - Two same sign leptons or 3 leptons or 4 leptons, all with MET





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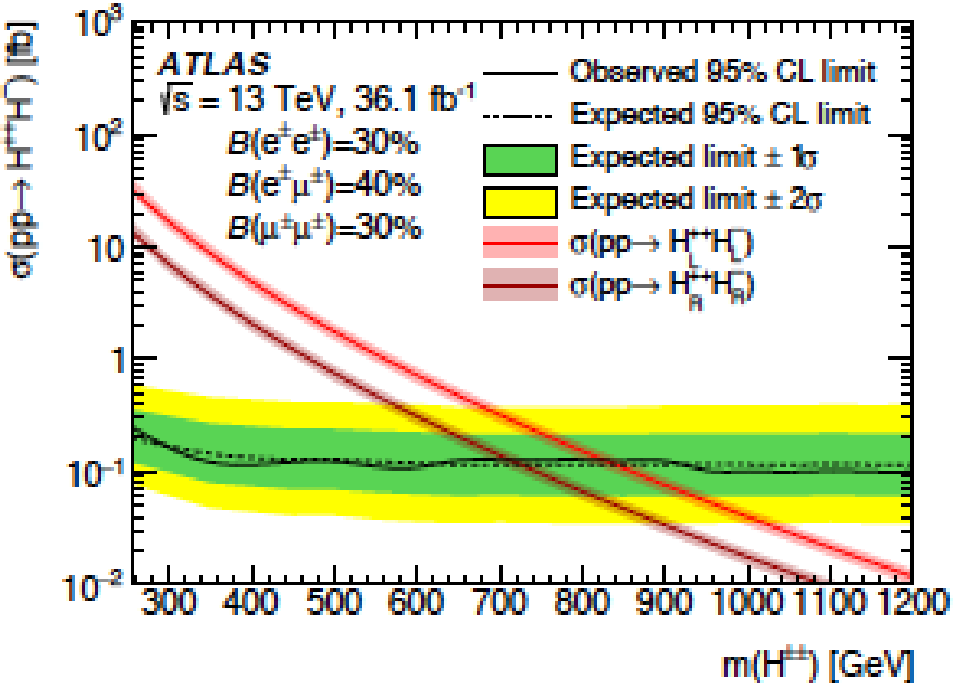
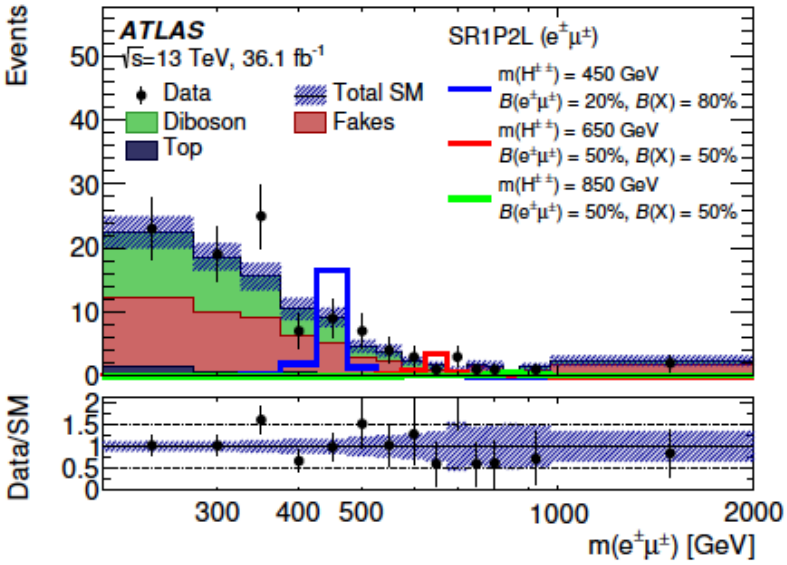
Search for Doubly Charged Higgs

- Decay to 4 leptons
- Two same sign leptons, 3l, 4l





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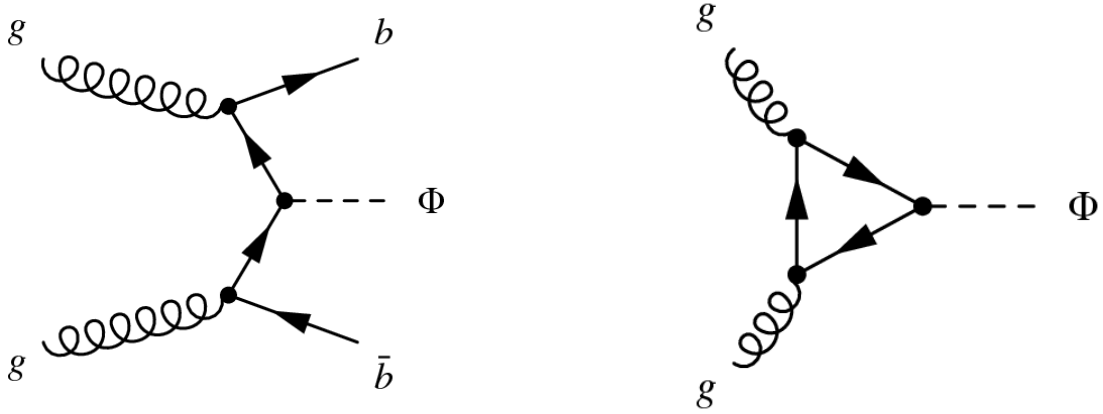
BSM neutral Higgs decays to fermions

- **MSSM or more general**
  - Exotics resonance searches joined up with Higgs in some cases e.g. Z' $\tau\tau$ and Z' to $\mu\mu$ + b-jets
- **MSSM has specific production and preferred decay modes (third generation b/τ)**



Neutral BSM Higgs to ττ

- **H➔ $\tau^+\tau^-$ search over 200-2250 GeV**
  - Gluon fusion (b-veto) category and b-tag category
  - Lep-had and had-had final states
  - Also serves as a Z' search

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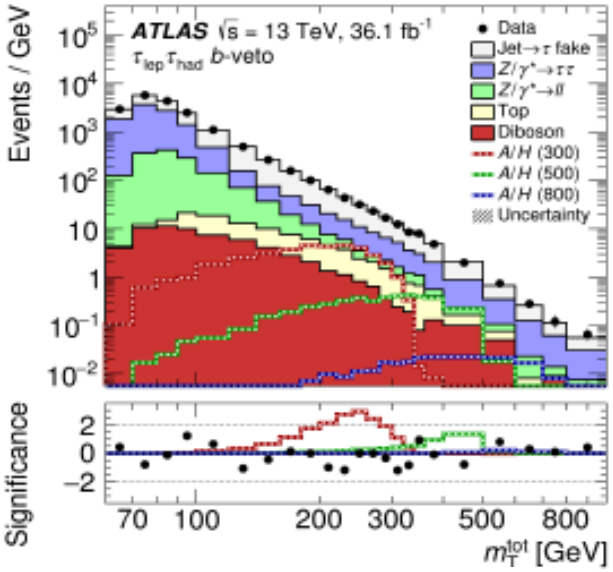
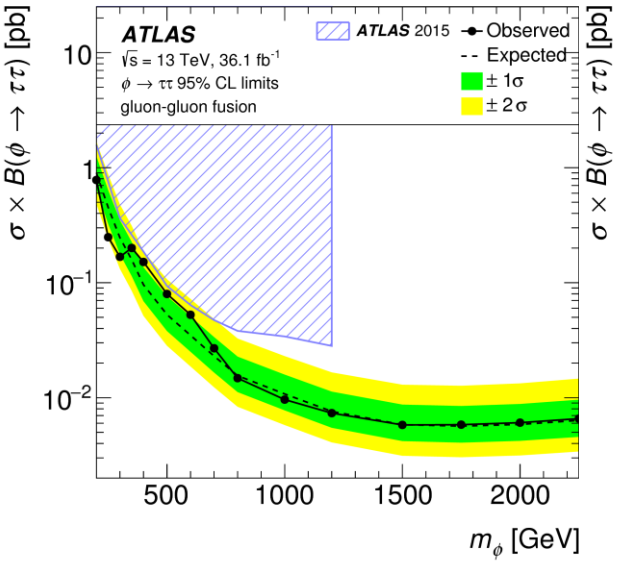
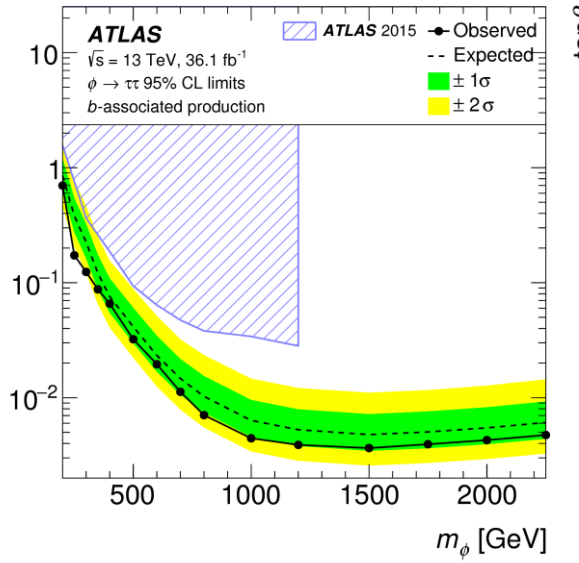
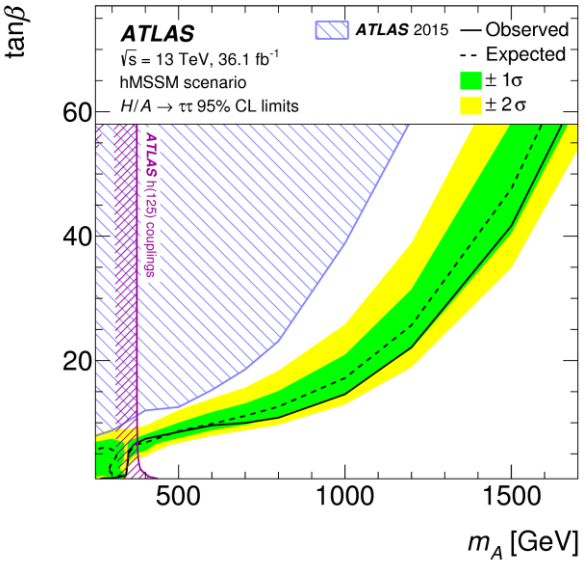


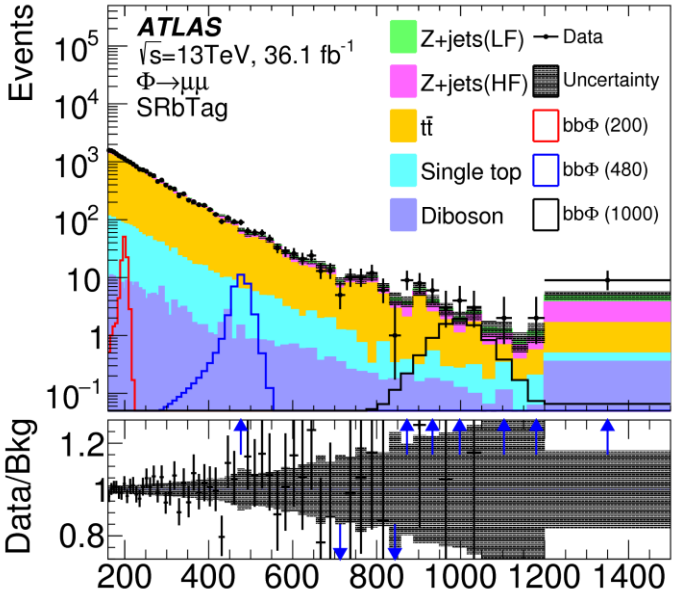


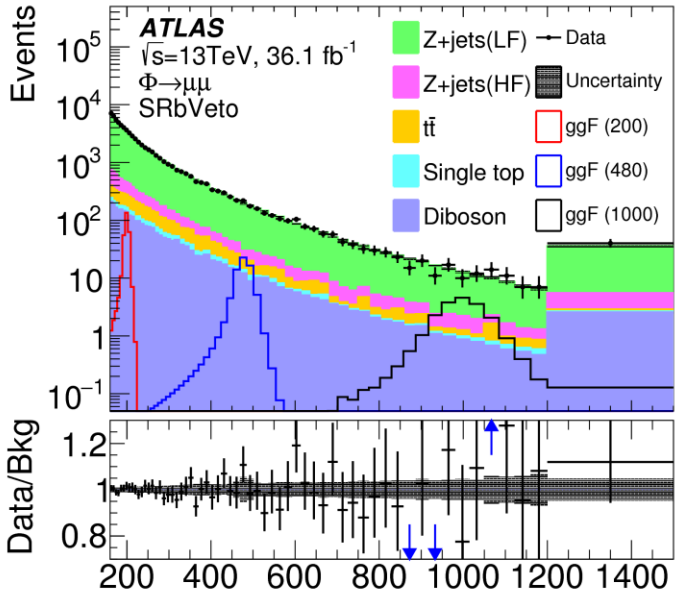


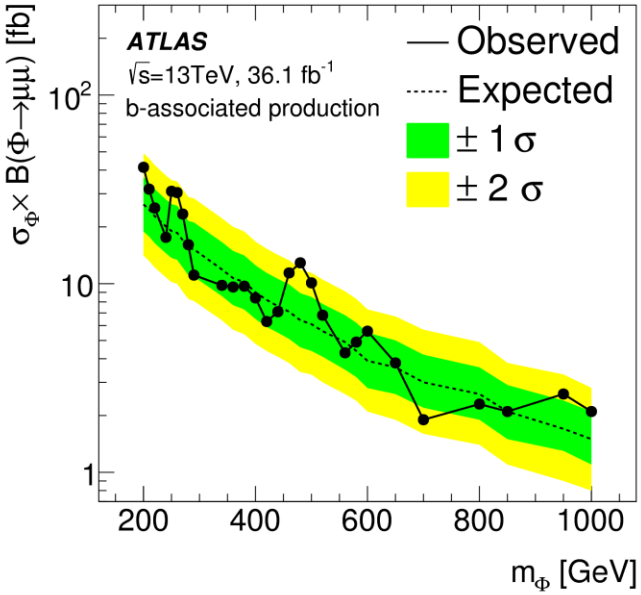


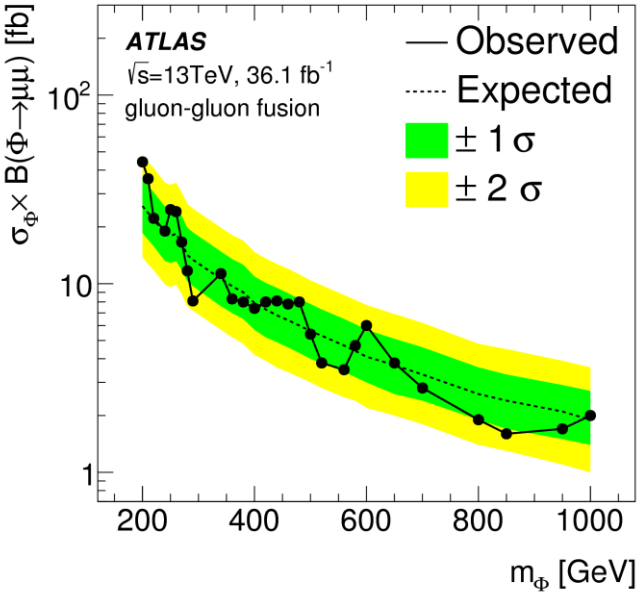
Neutral BSM Higgs to μμ

- b-tag and b-veto categories
- Search 0.2-1 TeV
- Also serves as a Z'+b-jet search









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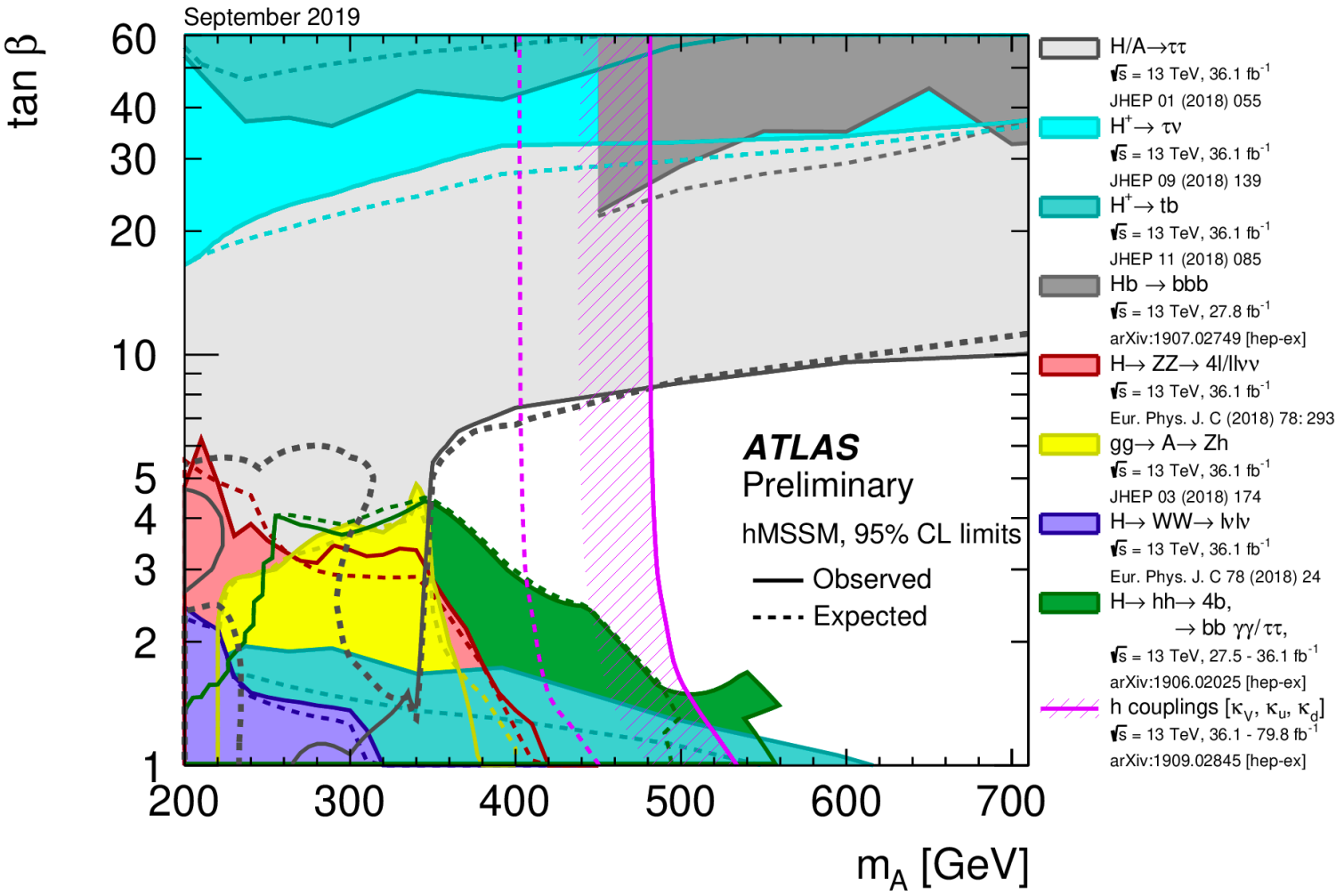
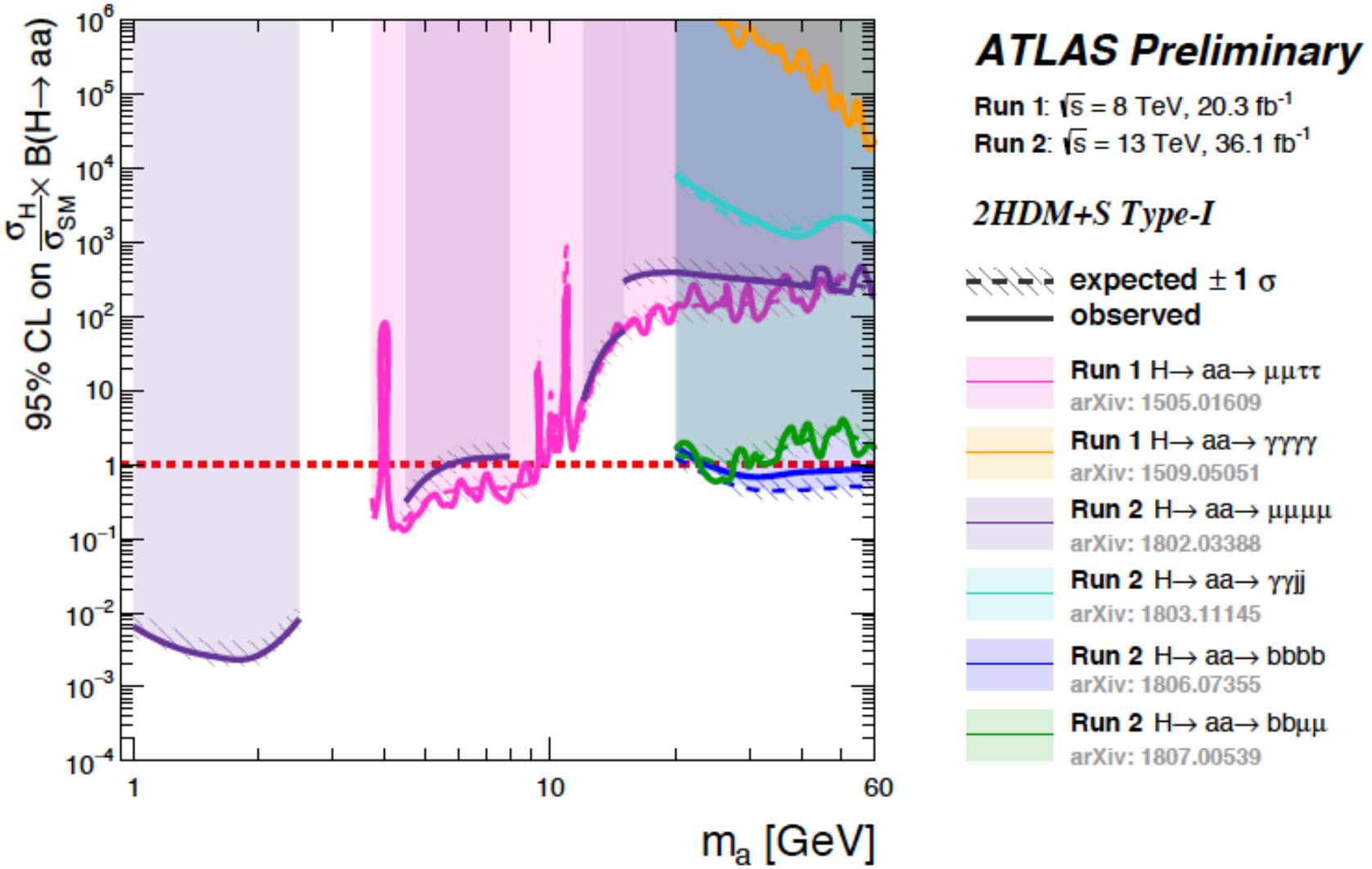
BSM Higgs Summary Plot



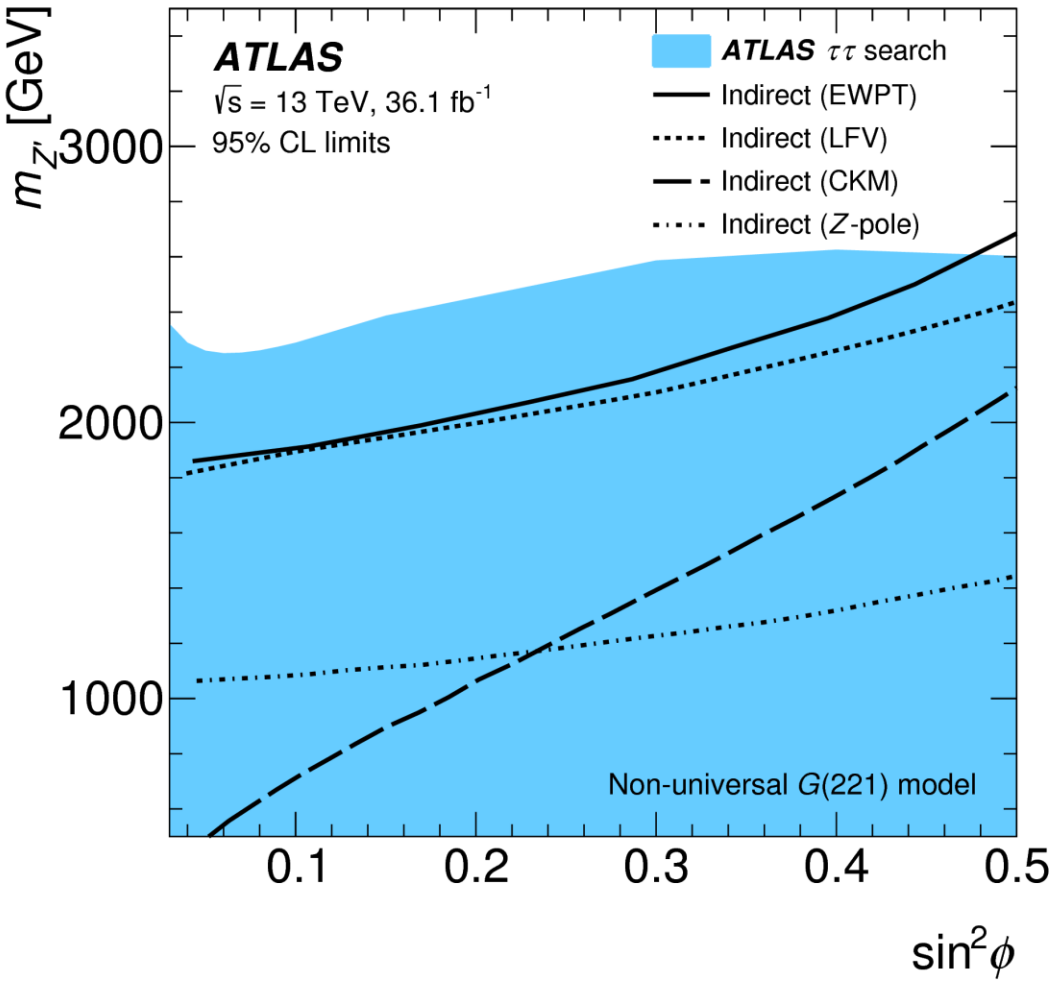
H to light vector bosons



Prospects

- Unprecedented dataset size ahead (*~100x*)
- Challenges
  - Theory uncertainties – generator speed-up will become critical
  - Triggers – continue to invest effort in delivering the most efficient/purest/novel trigger solutions
  - Imagination – LHC has the possibility to probe signatures that couple to leptons, photons, quarks, gluons. Run 3 is an excellent test bed for novel methods.
    - New areas are opening up, more will follow – work in unison with theorists.

Z' Exclusion


ATLAS
√s = 13 TeV, 36.1 fb-1
95% CL limits
ATLAS ττ search
Indirect (EWPT)
Indirect (LFV)
Indirect (CKM)
Indirect (Z-pole)
Non-universal G(221) model
m Z' [GeV]
3000
2000
1000
0.1
0.2
0.3
0.4
0.5
sin2φ