



Resonant DiHiggs in ATLAS



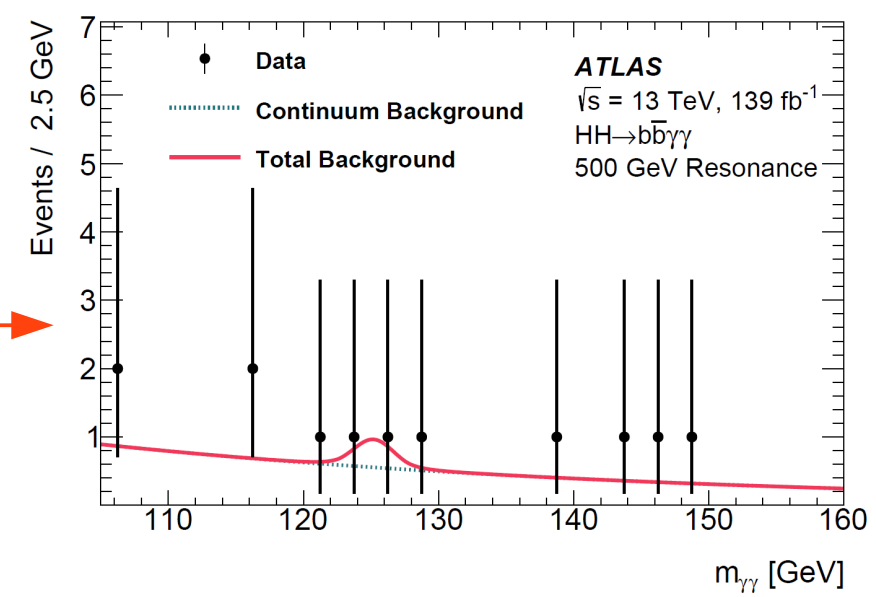
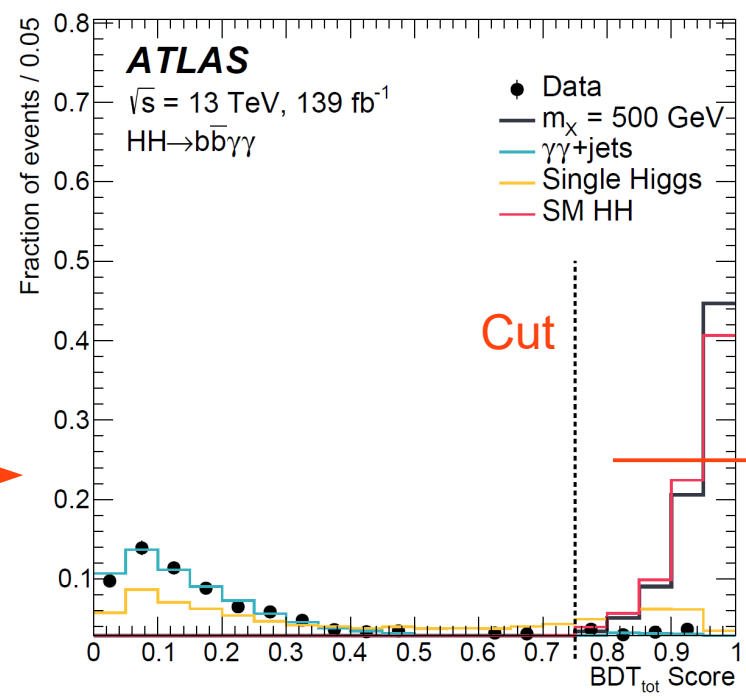
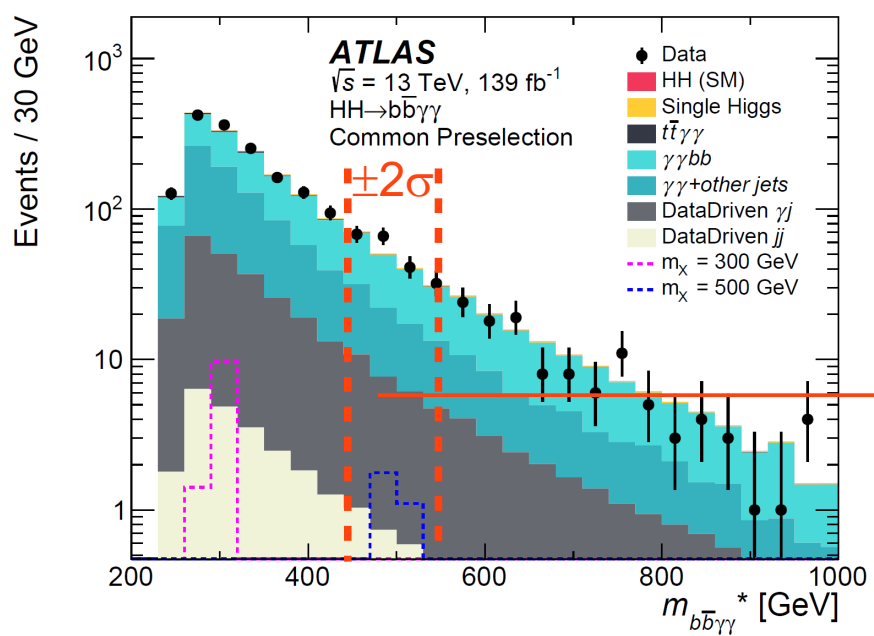
Jana Schaarschmidt (University of Washington)

LHCHXS-HH Meeting – 28 September 2022

Latest Resonant DiHiggs Results

Channel	Dataset	Reference	Mass range of X
$X \rightarrow HH \rightarrow bb\gamma\gamma$	139/fb	HDBS-2018-34	251-1000 GeV
$X \rightarrow HH \rightarrow 4b$	126-139/fb	HDBS-2018-41	251-5000 GeV
$X \rightarrow HH \rightarrow bb\tau\tau$	139/fb	ATLAS-CONF-2021-030	251-1600 GeV
Boosted $X \rightarrow HH \rightarrow bb\tau\tau$	139/fb	HDBS-2019-22	1000-3000 GeV
$X \rightarrow SS/HH \rightarrow 4W$	36/fb	HIGG-2016-24	260-500 GeV
$X \rightarrow HH \rightarrow bbWW \rightarrow bbqq\ell\nu$	36/fb	HIGG-2016-27	500-3000 GeV
$X \rightarrow HH \rightarrow WW\gamma\gamma$	36/fb	HIGG-2016-20	260-500 GeV
VBF $X \rightarrow HH \rightarrow 4b$	126/fb	HDBS-2018-18	260-1000 GeV
$V' \rightarrow VX \rightarrow VHH$ $A \rightarrow ZX \rightarrow ZHH$	139/fb	ATLAS-CONF-2022-043	260-1000 GeV 360-800 GeV
HH Combination (2-3 channels) HH Combination (all channels)	126-139/fb 36/fb	ATLAS-CONF-2021-052 HDBS-2018-58	
hMSSM/2HDM Interpretation	139/fb	ATL-PHYS-PUB-2022-043	

$X \rightarrow HH \rightarrow b\bar{b}\gamma\gamma$

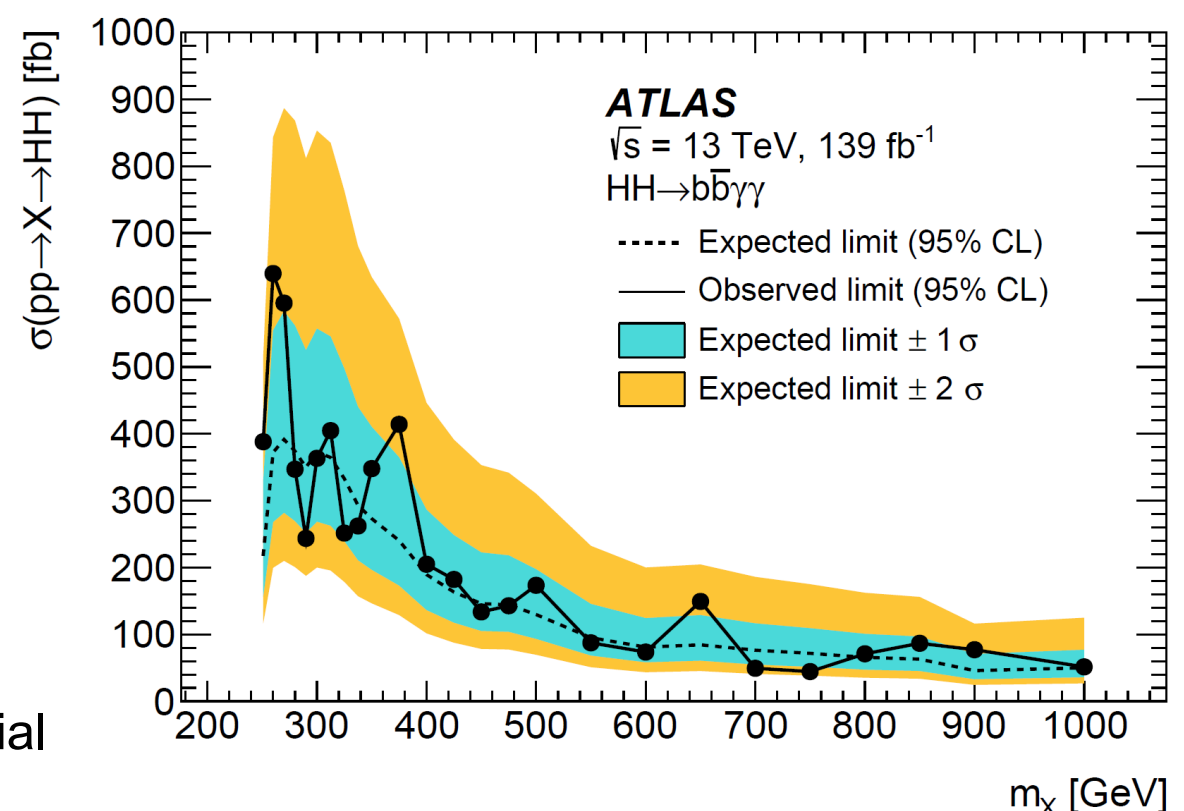


Gluon fusion production only
Signal is a narrow scalar

Cut on $m_{bb\gamma\gamma}^*$ ($\pm 2\sigma$),
 $m_{bb\gamma\gamma}^* = m_{bb\gamma\gamma} - m_{bb} - m_{\gamma\gamma} + 250 \text{ GeV}$

Cut on BDT score to enhance S/B

Final discriminant is $m_{\gamma\gamma}$,
background modelled with exponential

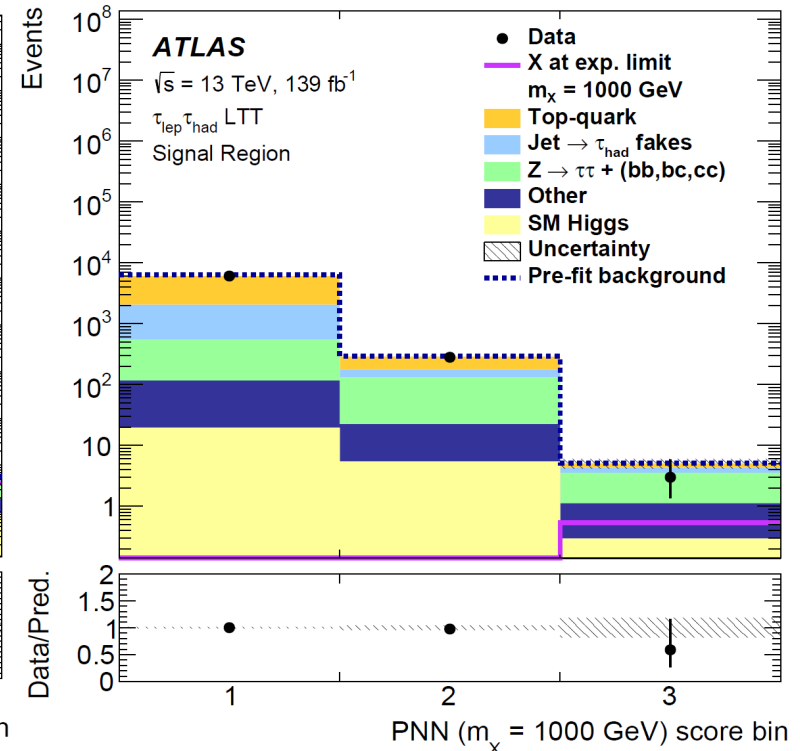
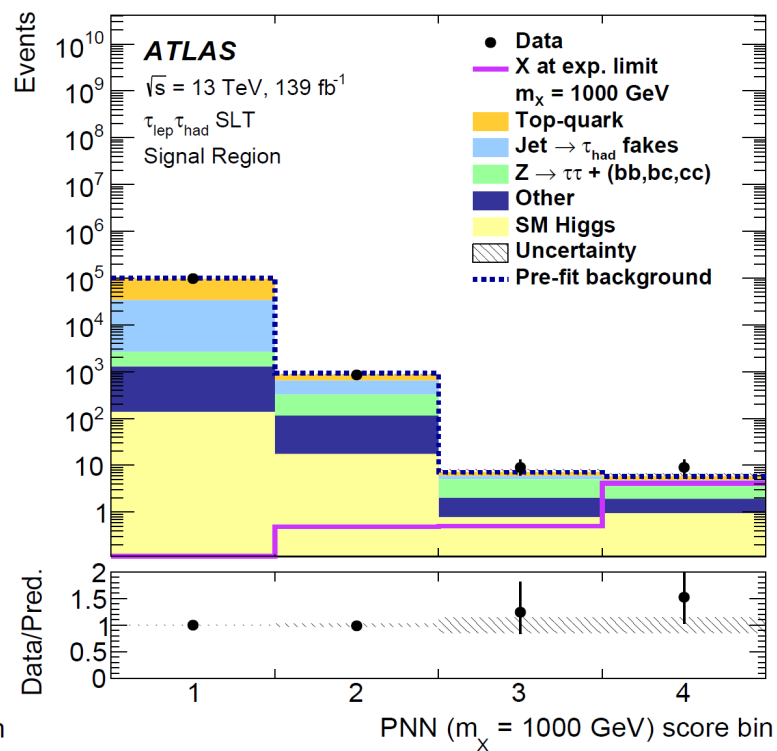
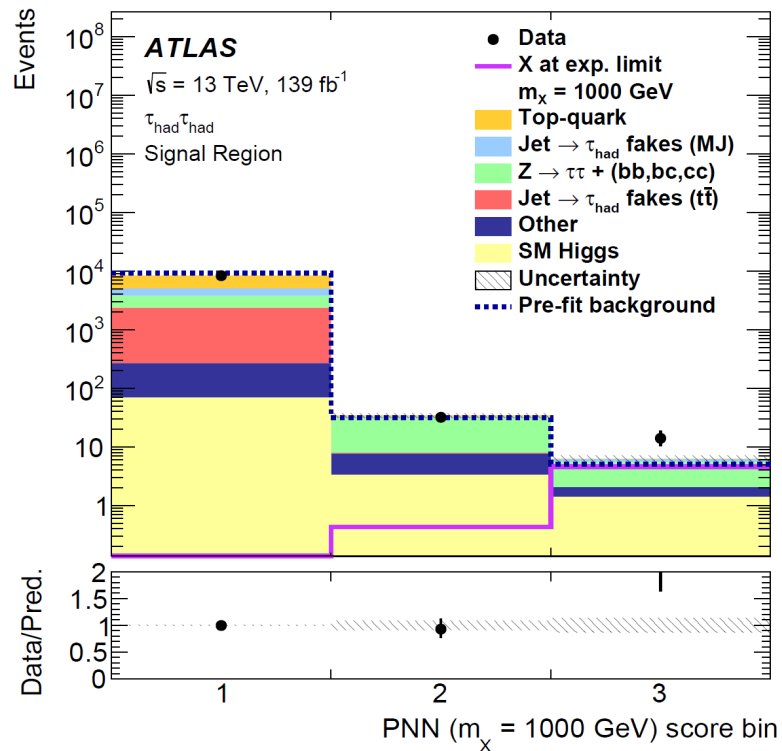
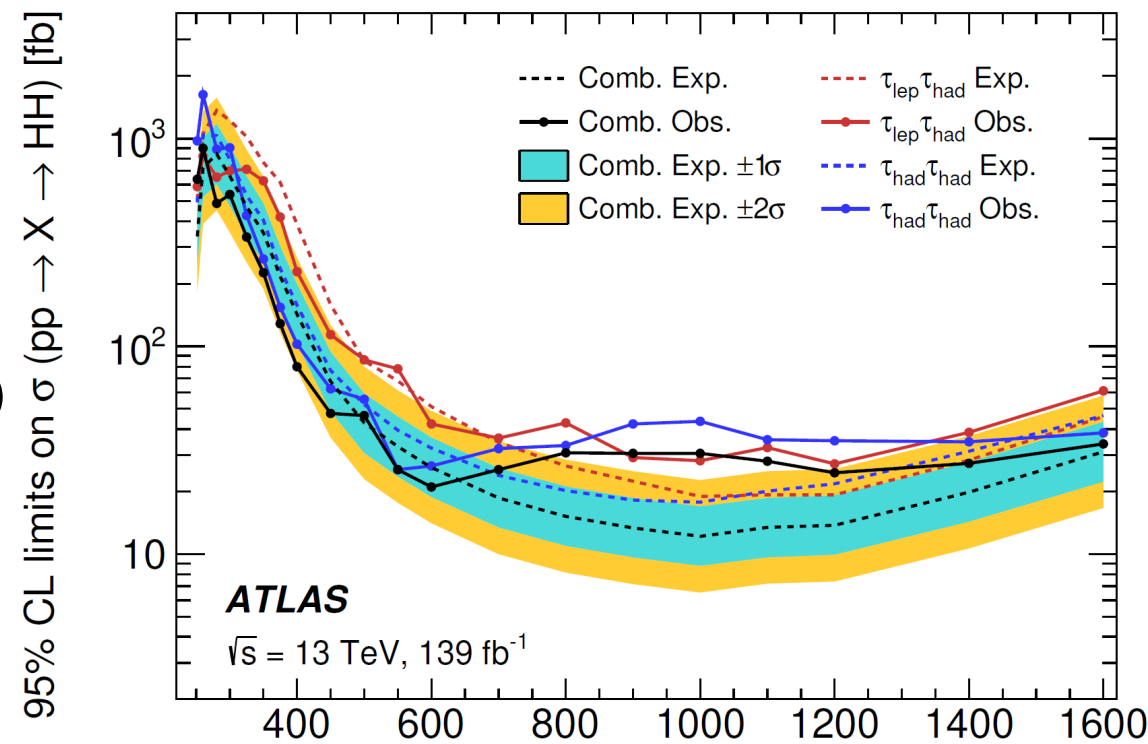


No excess found

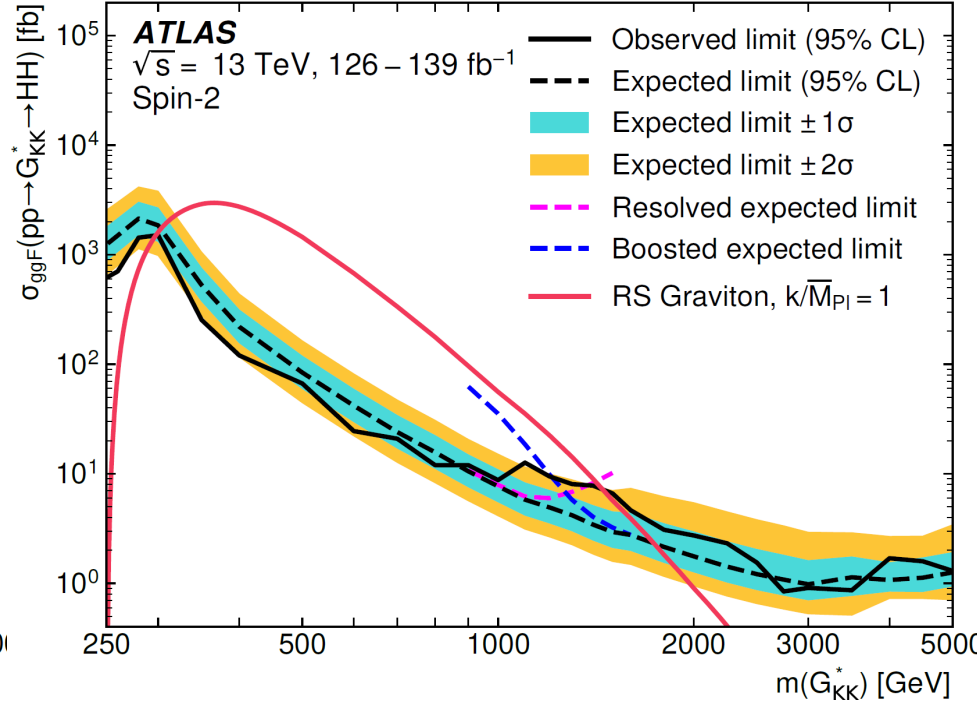
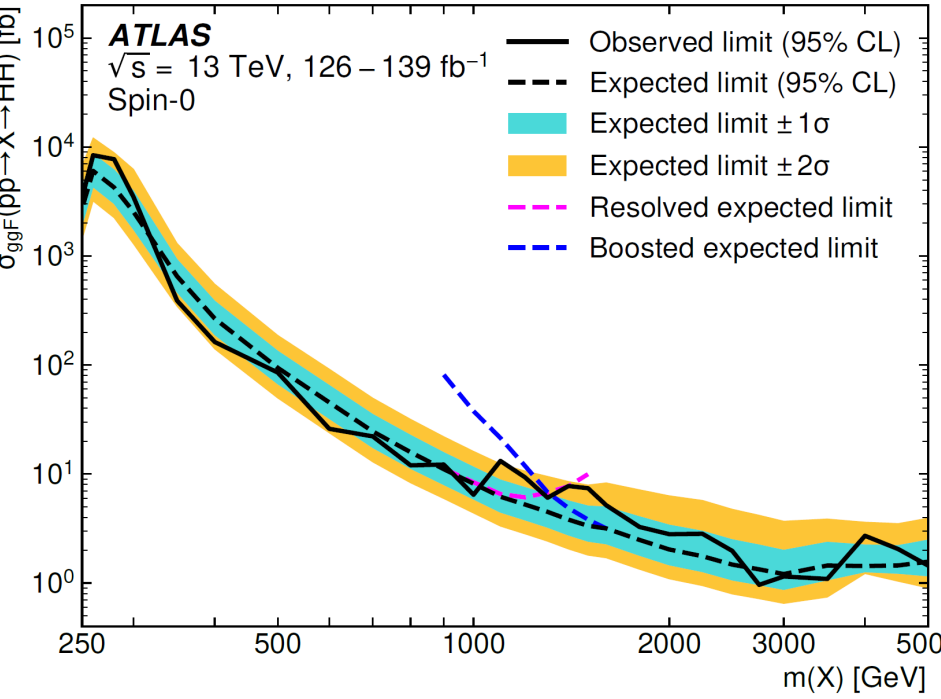
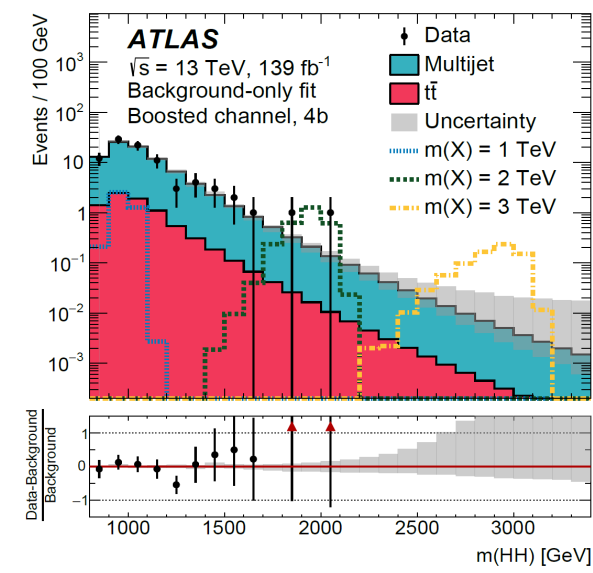
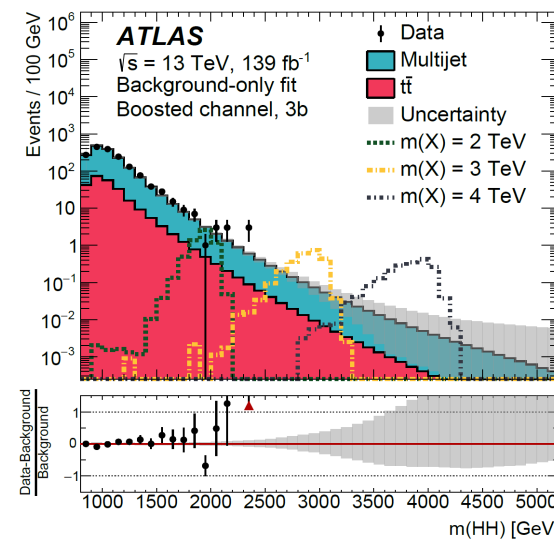
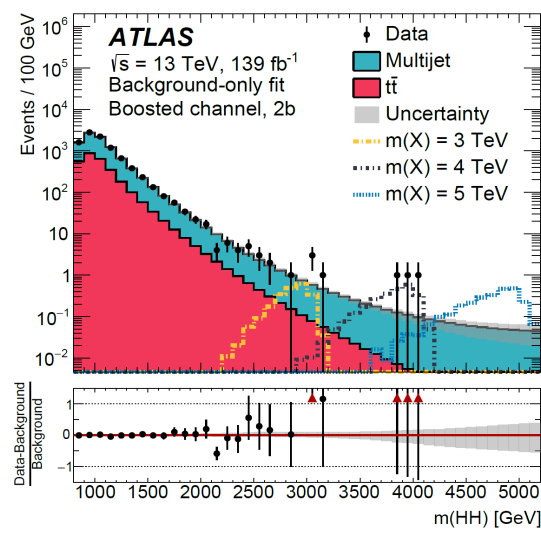
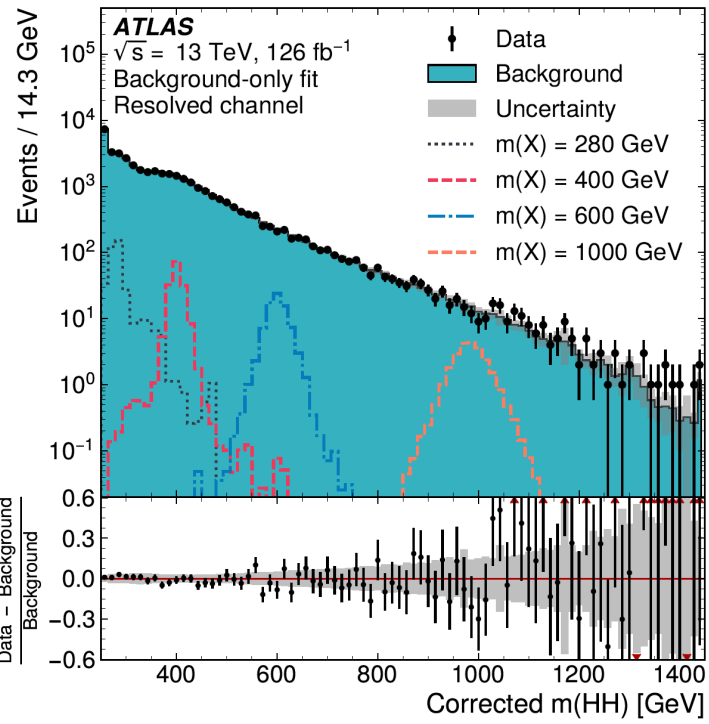
Very strong limits at low m_x

$X \rightarrow HH \rightarrow bb\tau\tau$

- Only gluon fusion considered, narrow width scalar
- **3 signal-enriched categories:**
 - had-had channel
 - lep-had channel triggered by single lepton trigger („SLT“)
 - lep-had channel triggered by lepton+tau trigger („LTT“)
- Machine learning techniques for signal enhancement, final fit performed to the MVA output scores
- Excess at 1 TeV (2σ global)



X → HH → bbbb



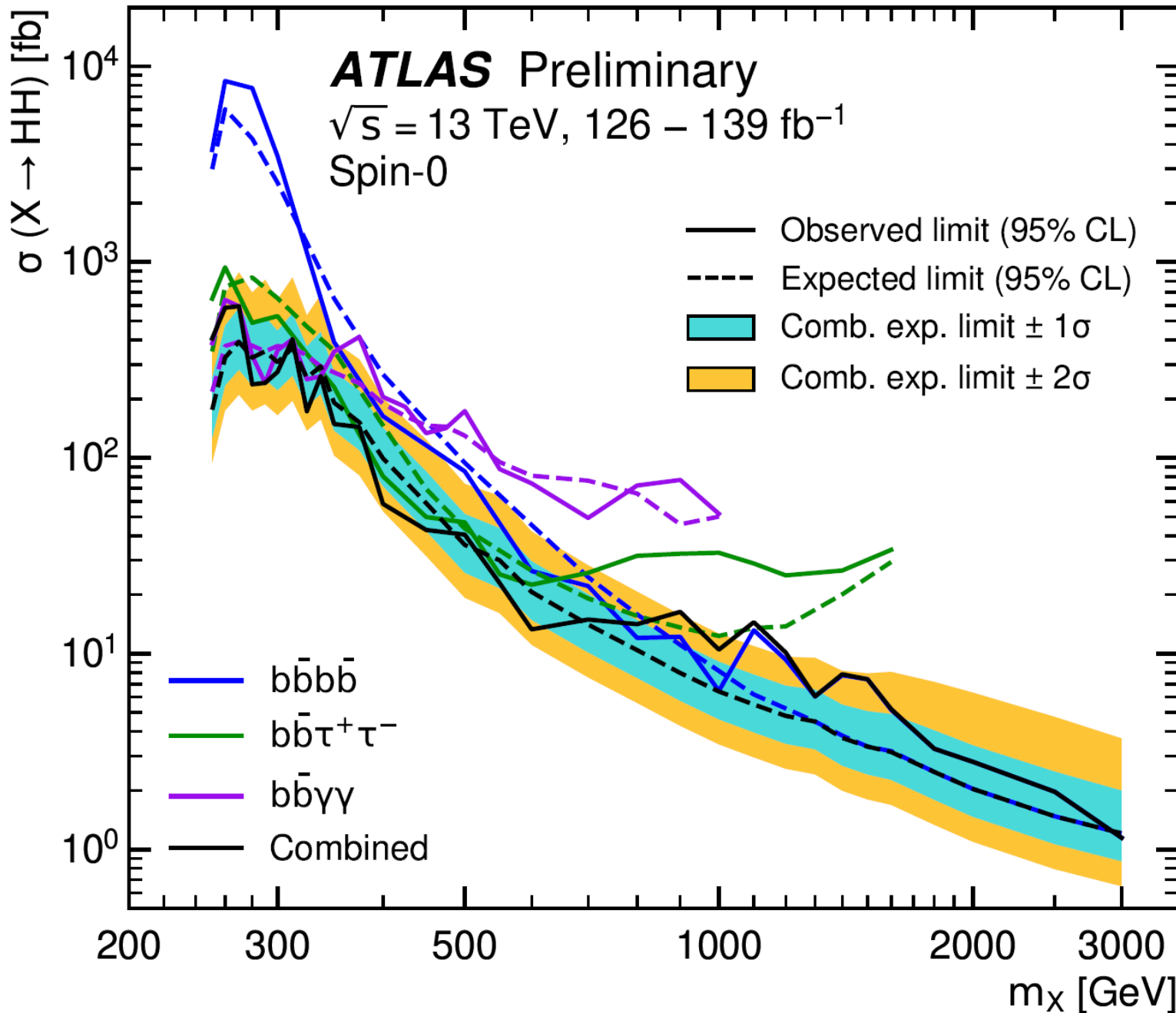
Resolved channel:
4 b-tagged small-radius jets

Boosted channel:
2 large-radius jets, with
in total 2 or 3 or 4 b-tagged
track-jets

m_{HH} is final discriminant

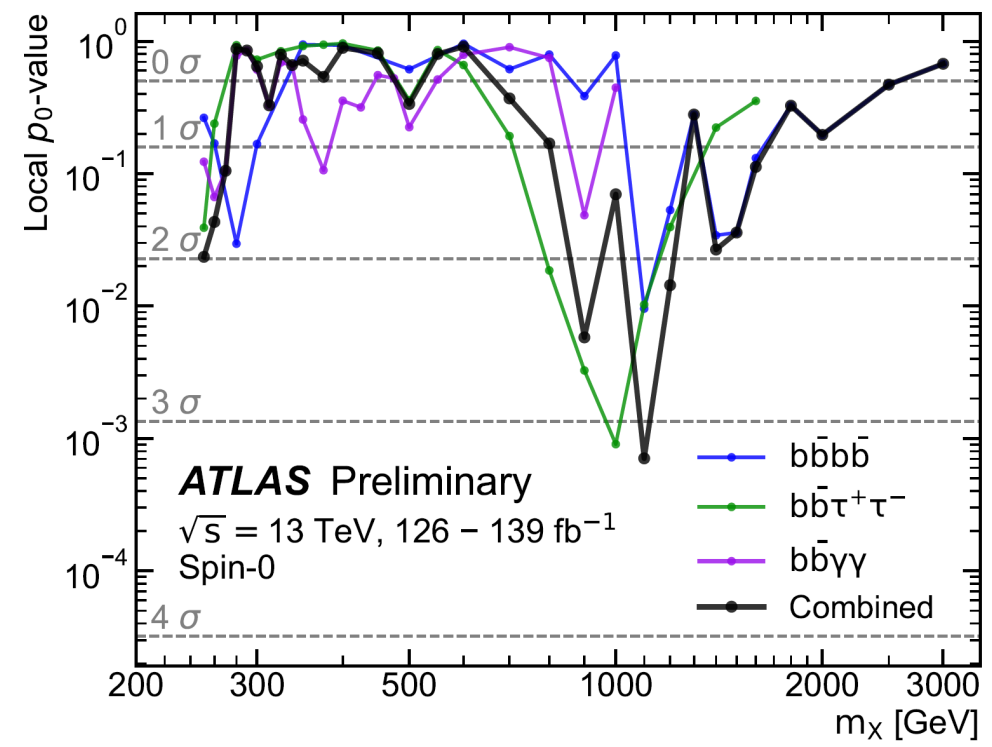
Gluon fusion only
spin-0 (narrow-width)
spin-2 signal (width 3-20%)

Best channel at high mass

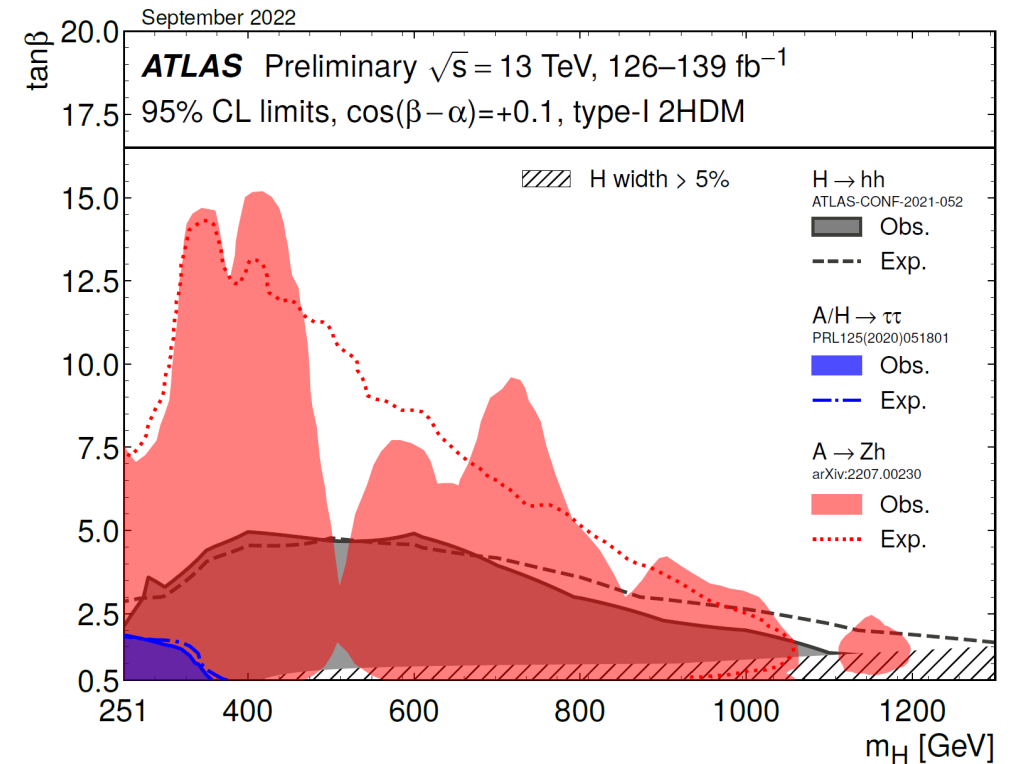
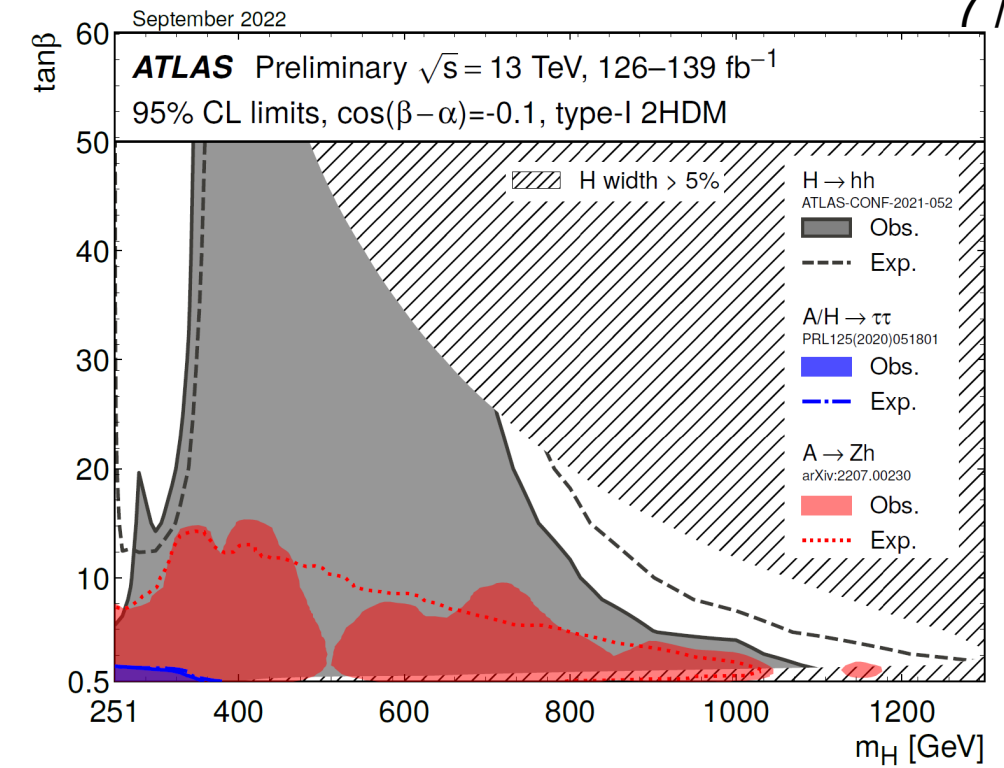
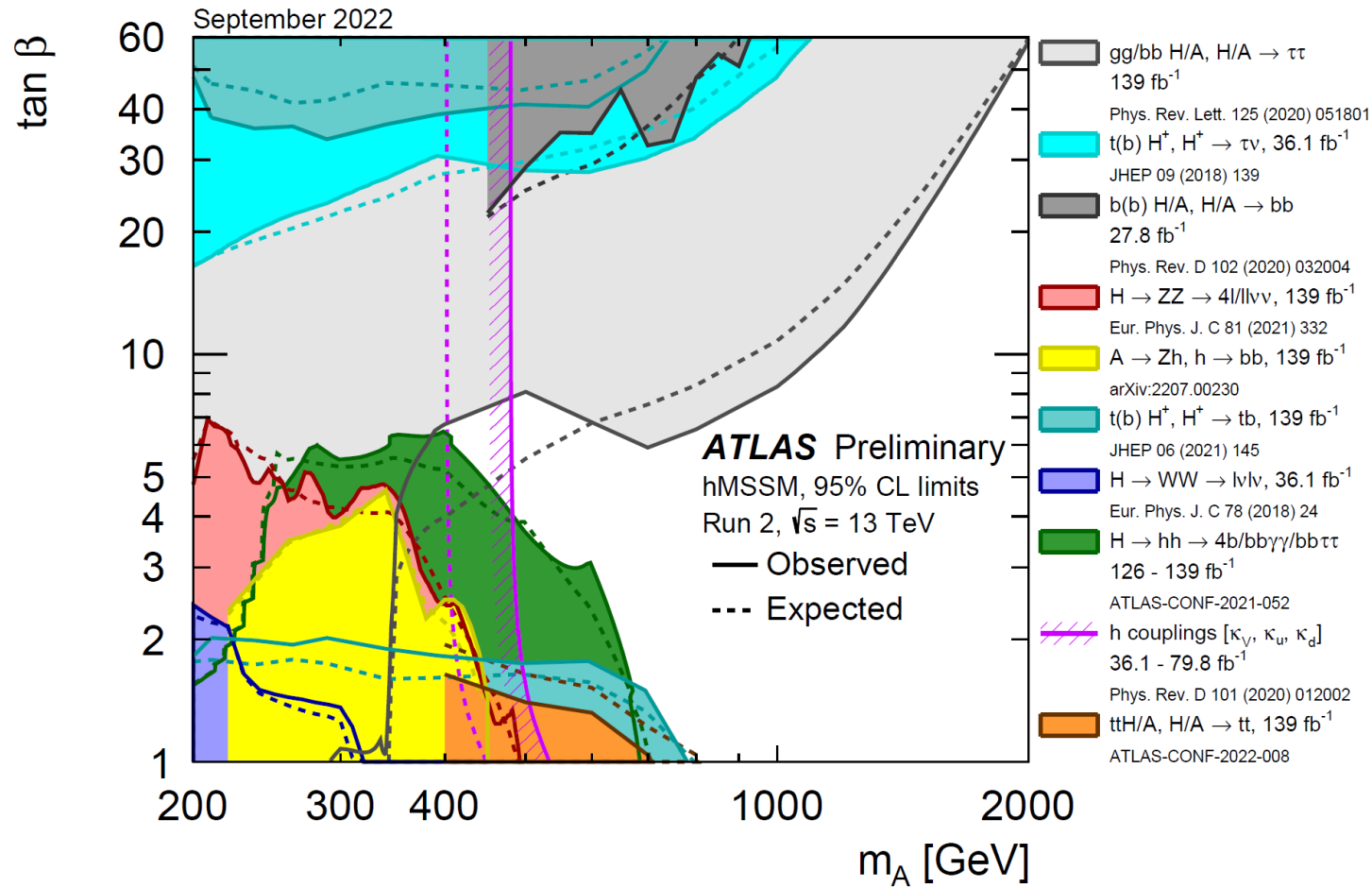


$b\bar{b}\gamma\gamma$, $b\bar{b}\tau\tau$ and $4b$ combined

Largest excess is at 1.1 TeV
 with 2.1σ global



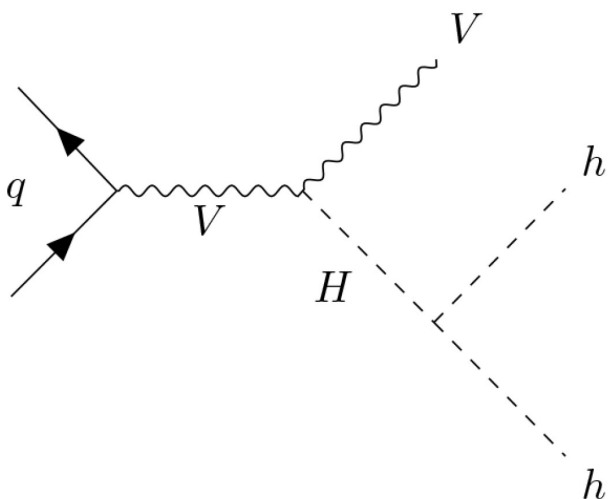
Model Interpretations



Combination of „Big-3“ (bb $\gamma\gamma$, bb $\tau\tau$, 4b) used to constrain model parameters
 bb $\gamma\gamma$ excluded in certain parts of the parameter space since the analysis is valid only for narrow width Higgs
 2HDM not considered when H width > 5% to avoid interference effects

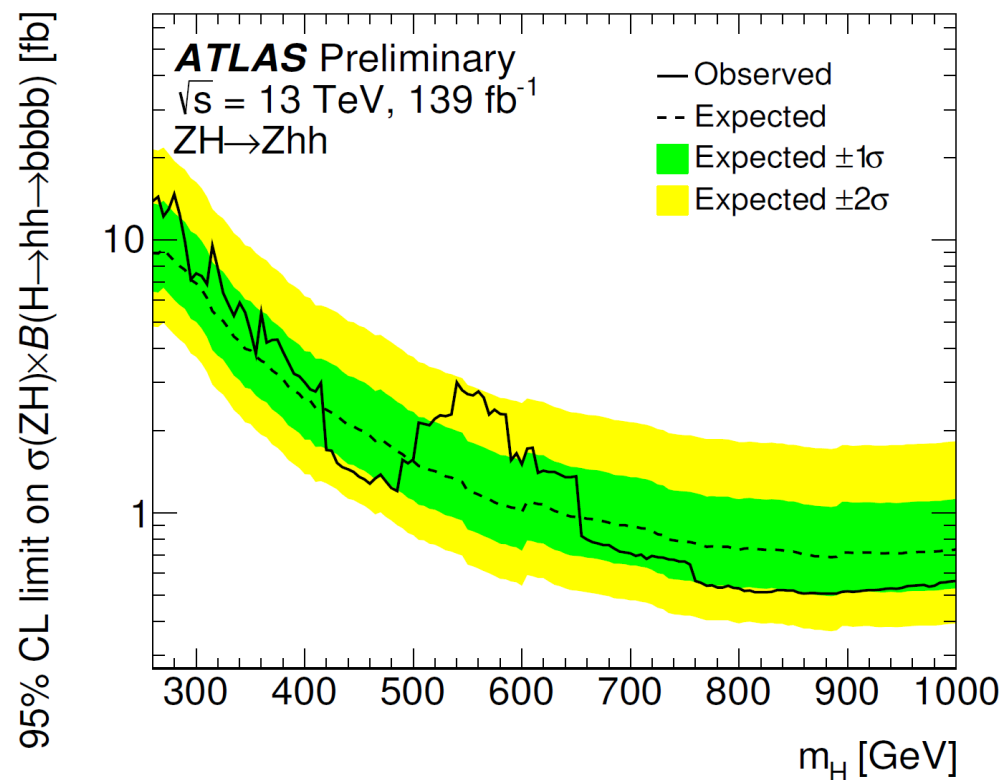
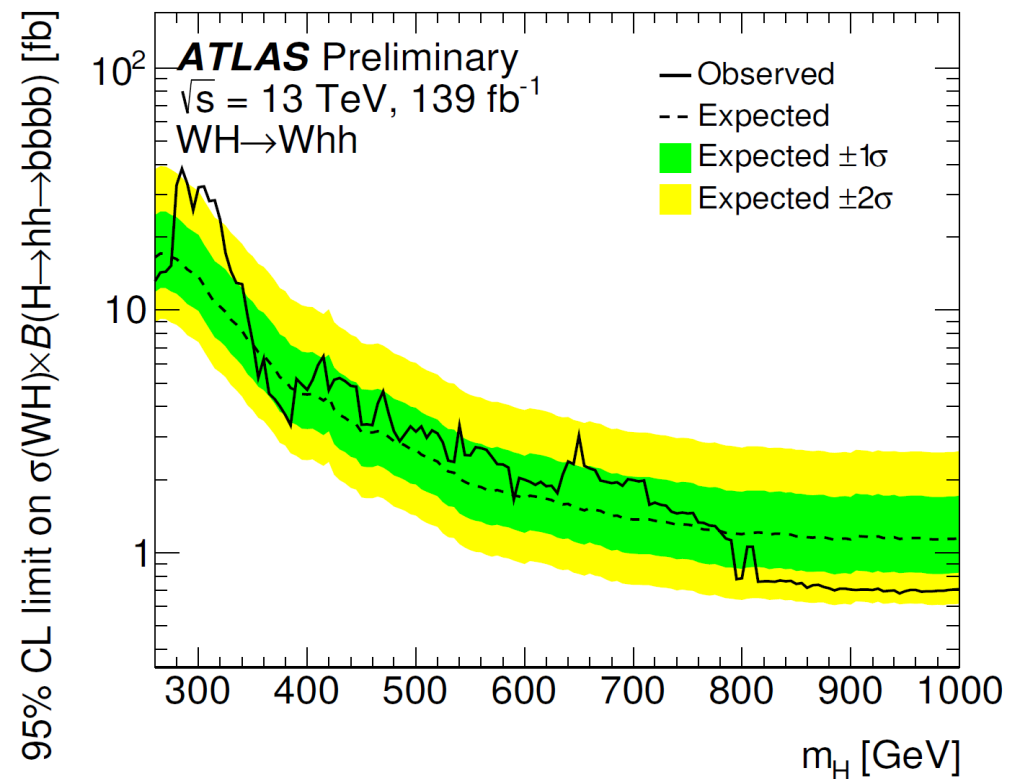
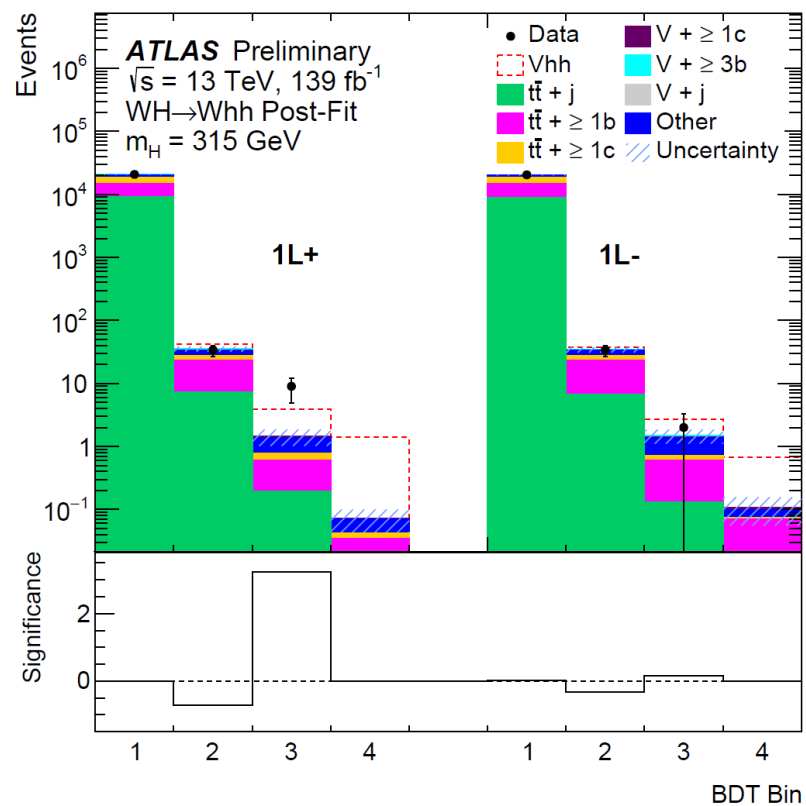
Backup

Other Channels: $VH \rightarrow Vhh$

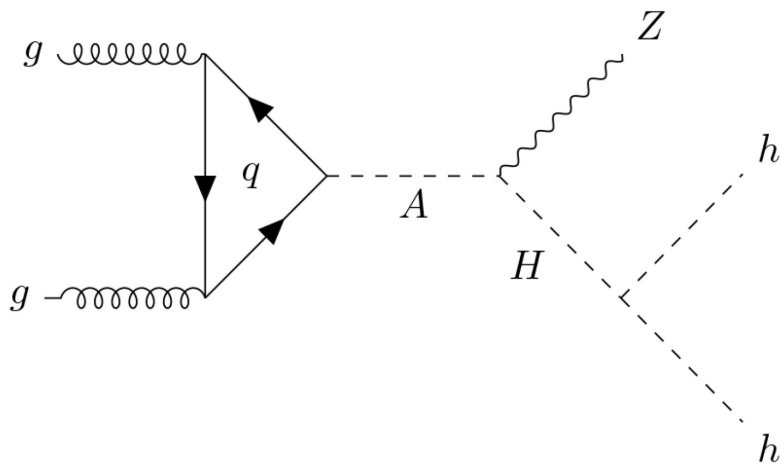


Vector-boson associated heavy scalar decays to two 125 Higgs

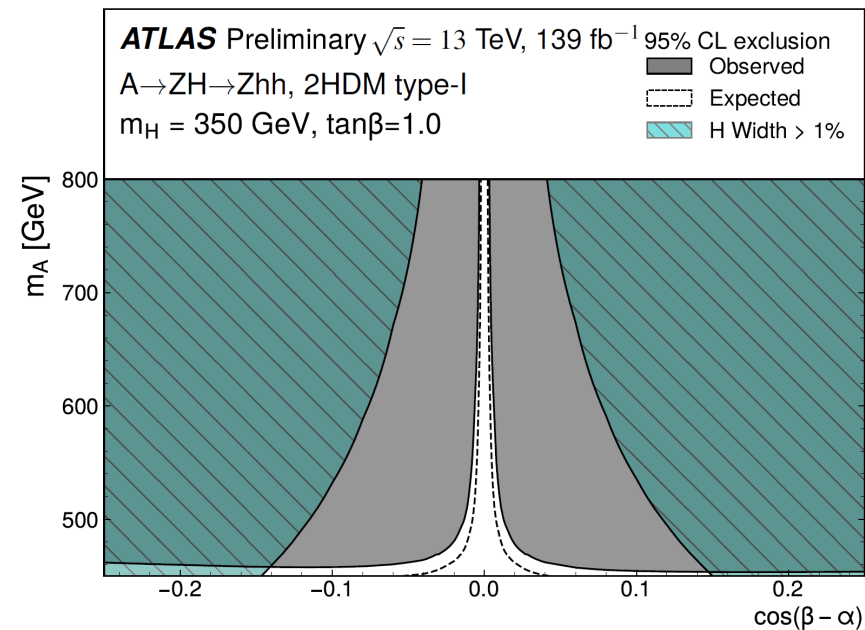
V goes to leptons, hh decay to 4b



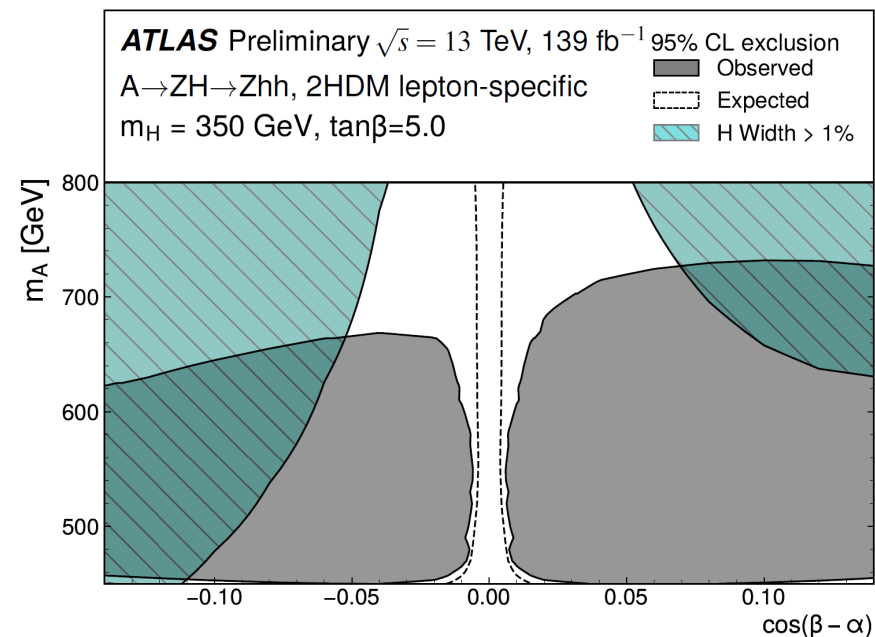
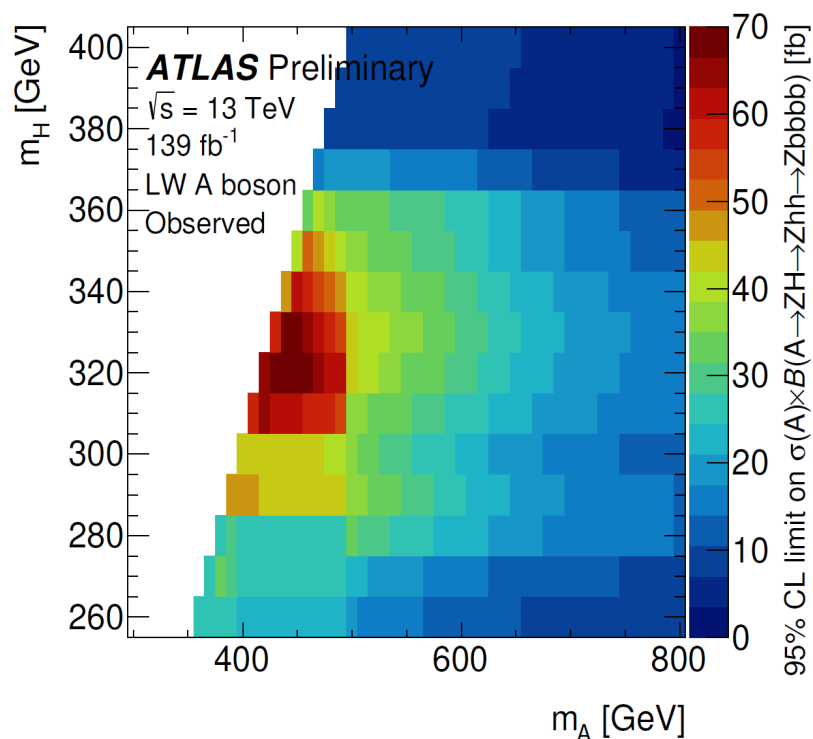
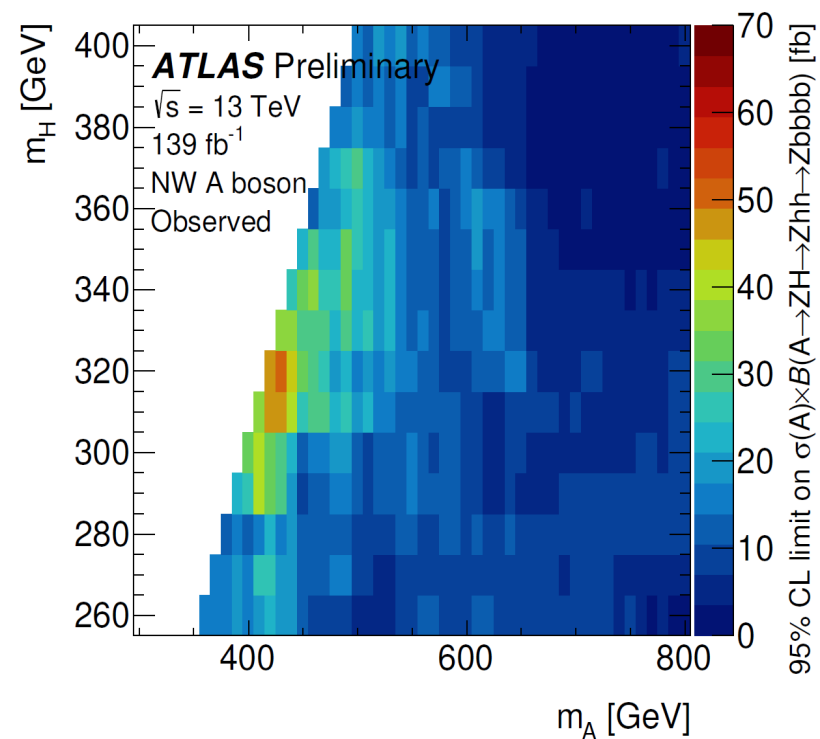
Other Channels: $A \rightarrow ZH \rightarrow Zhh$



A is narrow or broad
 H is narrow
 h is SM-like
 with $hh \rightarrow 4b$



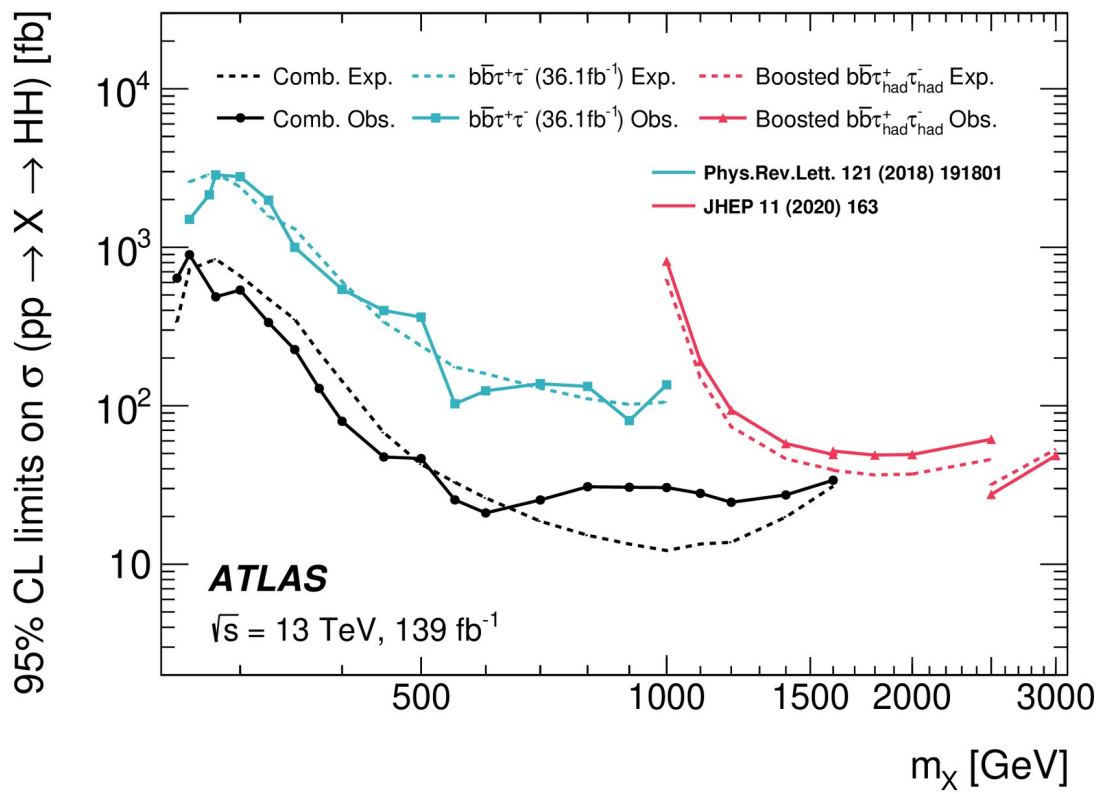
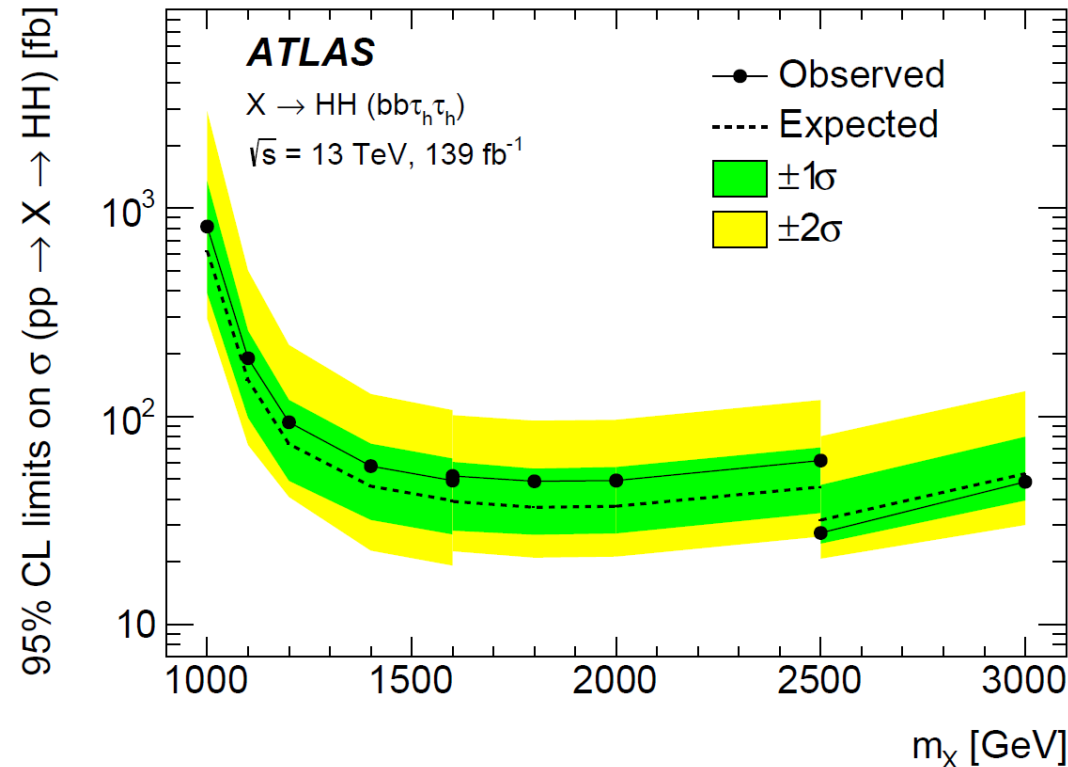
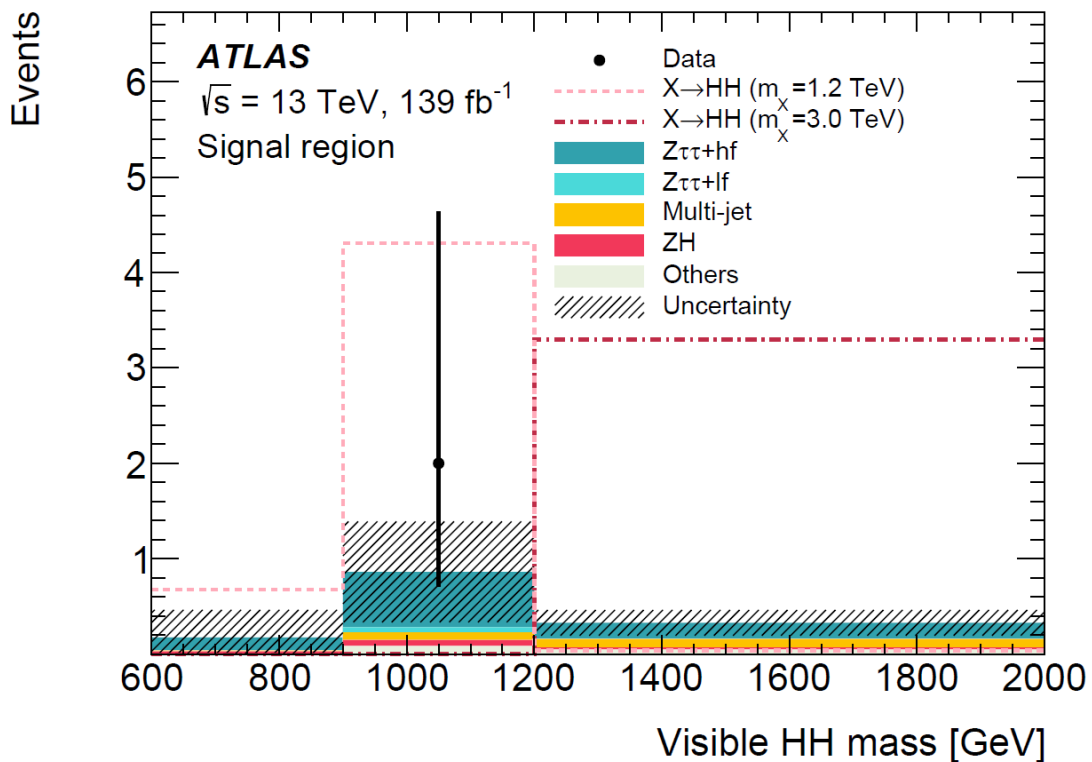
2.8 σ global excess at $m_A = 420 \text{ GeV}$, $m_H = 320 \text{ GeV}$ for large width



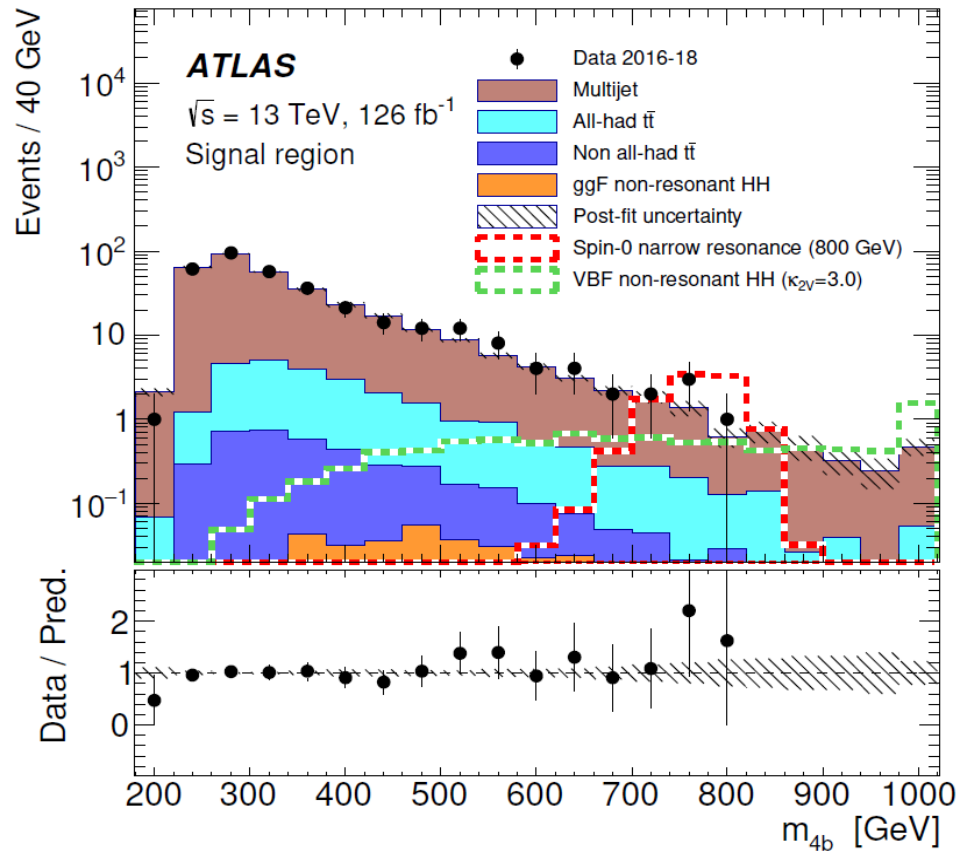
2HDM interpretations
 for type-I and type-III

Other Channels: Boosted $bb\tau\tau$

- Boosted bb system reconstructed as a large-R jet, b-tagging applied to track-jets
- Also the tau jets merge and standard reconstruction (that is seeded in $R=0.4$ jets) becomes inefficient \rightarrow boosted di-tau reconstruction and ID used

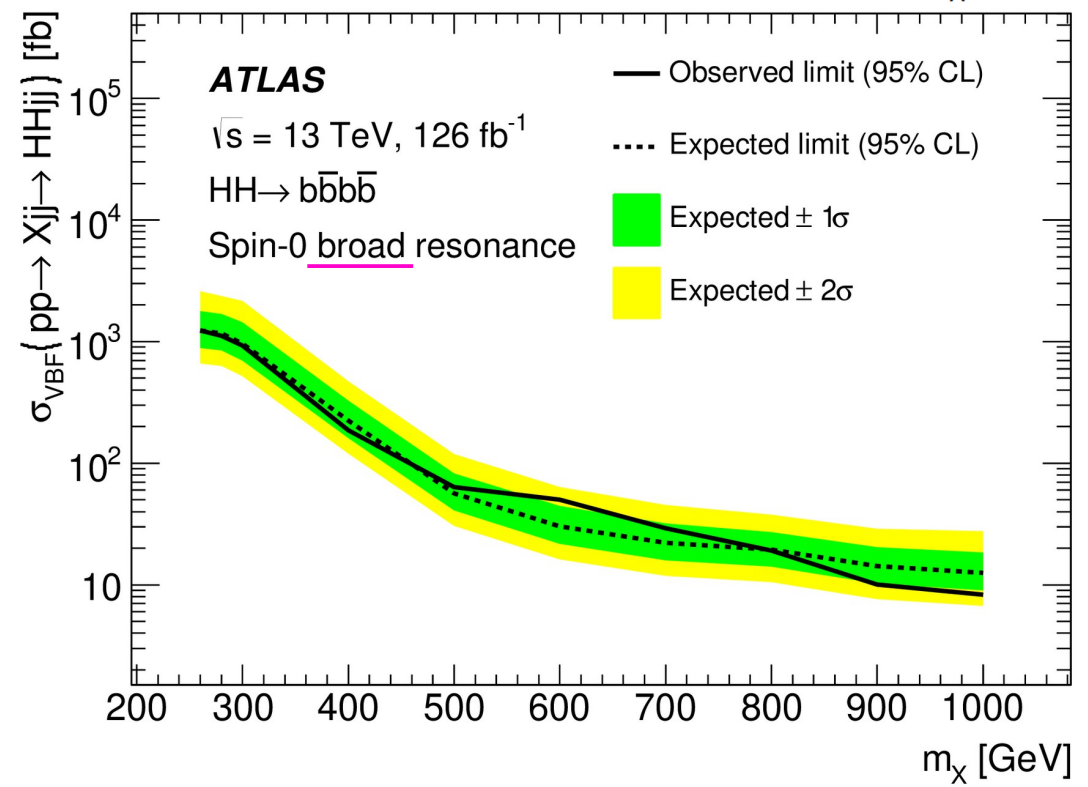
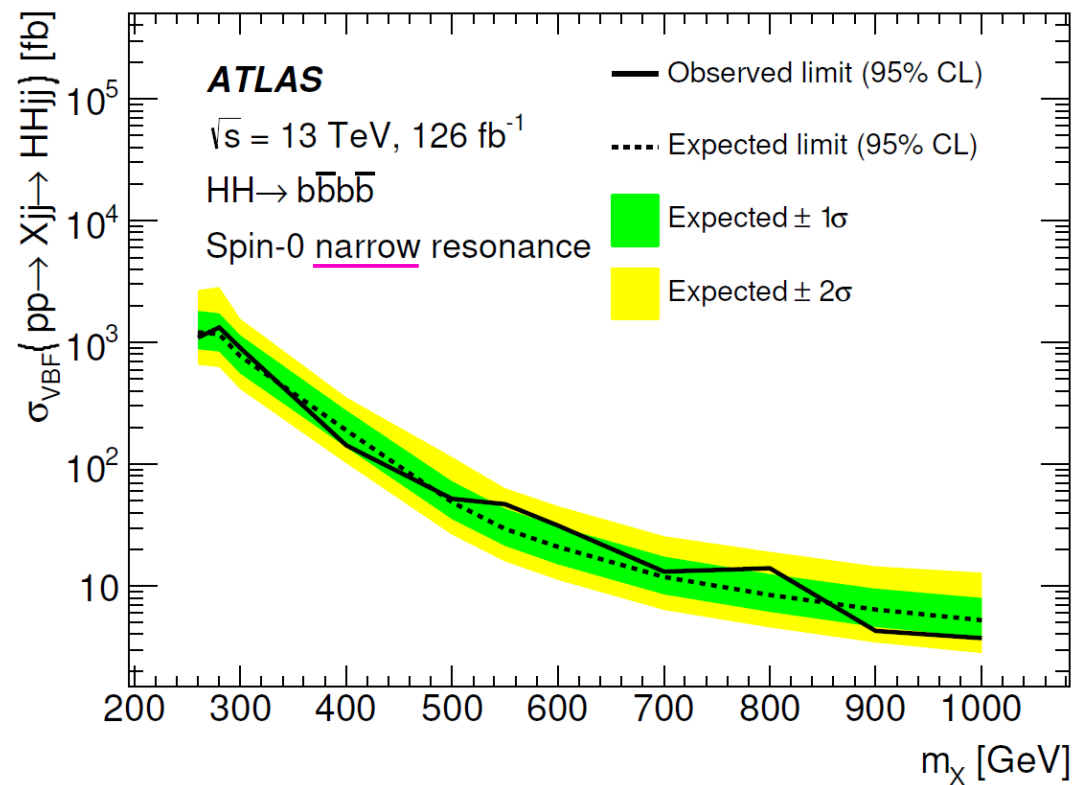


Other Channels: VBF 4b

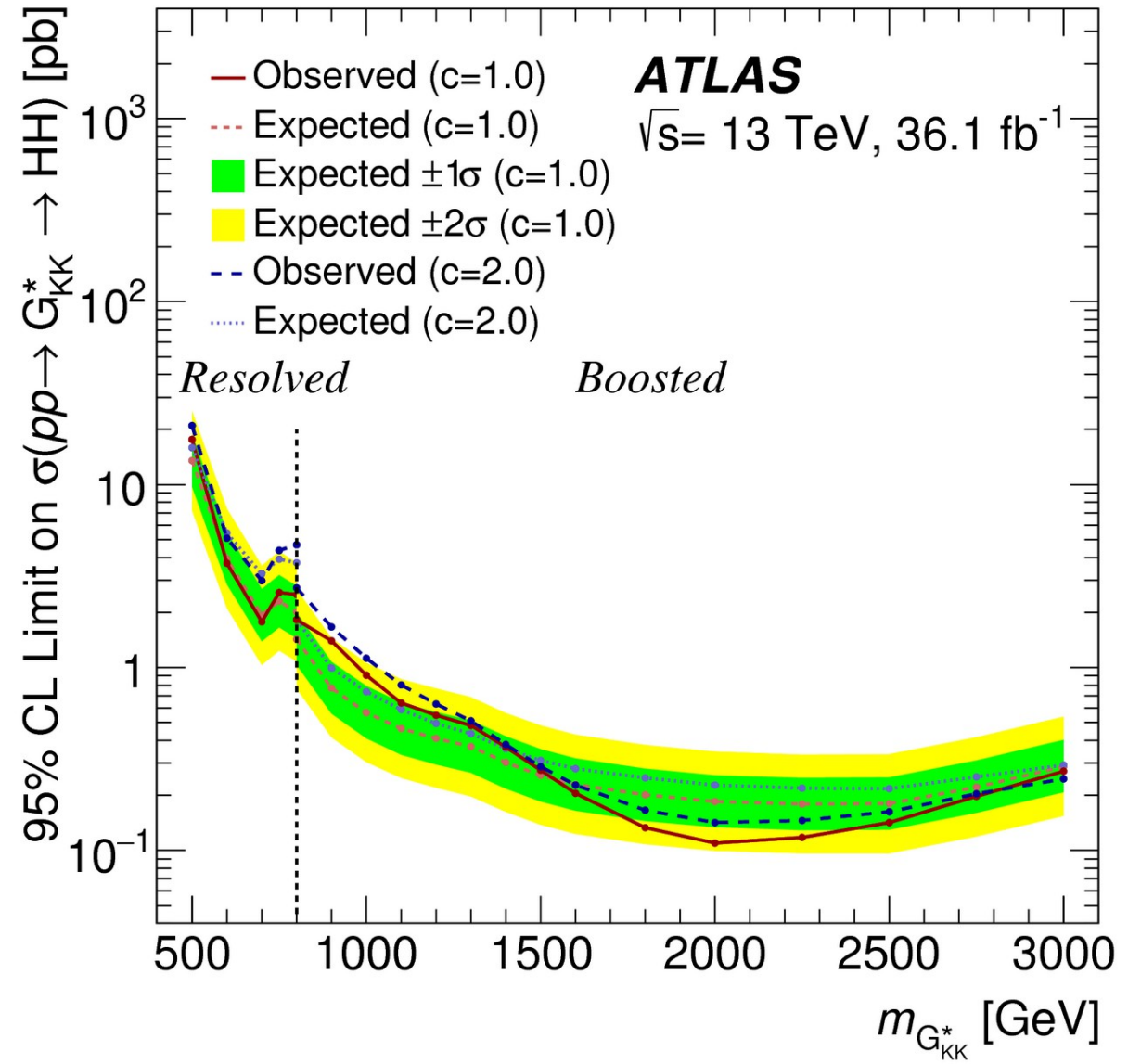
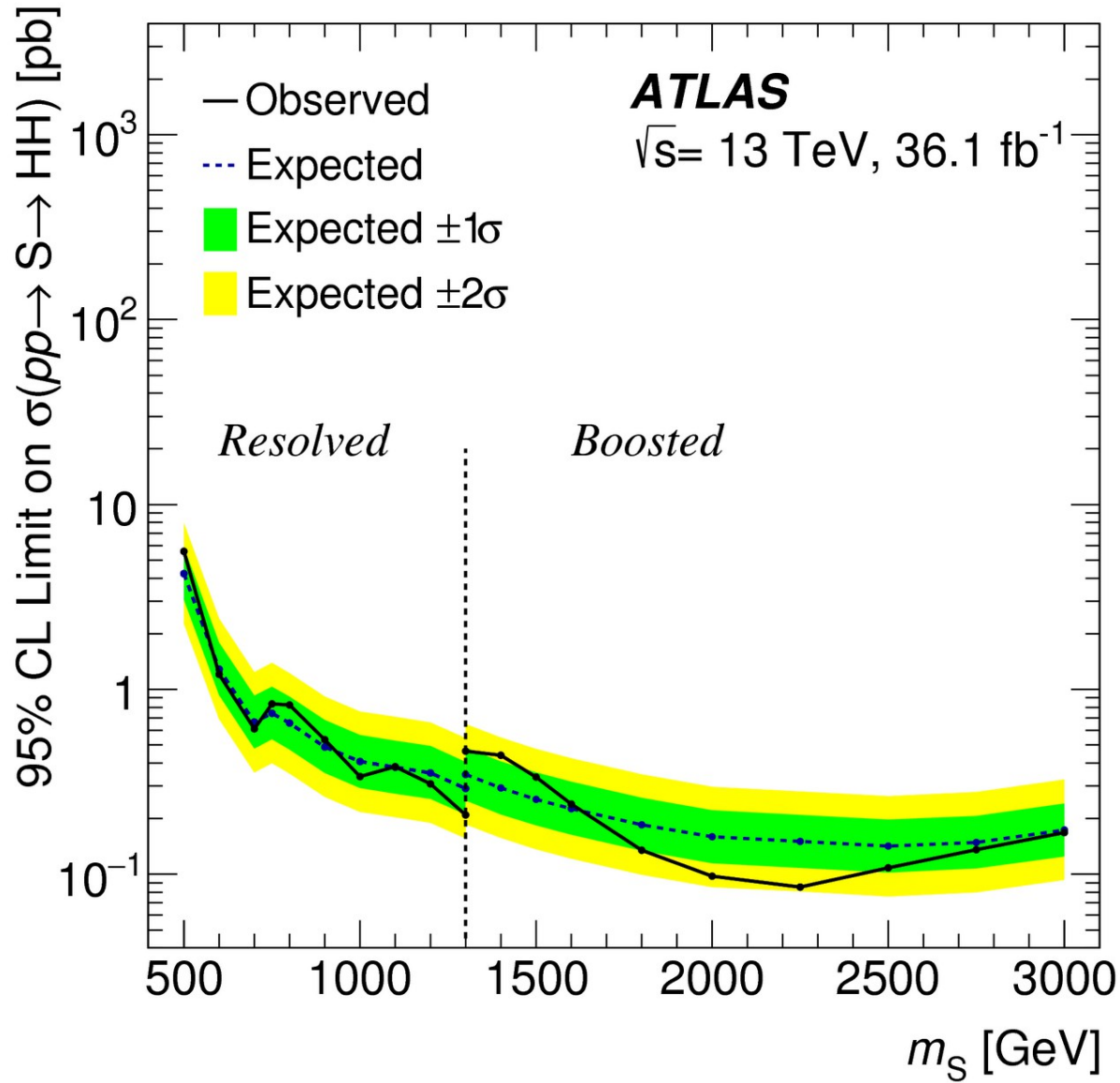


Events have 4 b-jets, and 2 forward jets (resolved regime)

Broad signal typical width is 10-20%, (type-II 2HDM $\tan\beta=2$ and $\sin(\beta-\alpha)=0.6$)



Other channels: bbWW (1-lepton)



Scalar model and 2 graviton models

Other Channels: $WW\gamma\gamma$, $4W$

$X \rightarrow HH \rightarrow WW \gamma\gamma$

