H^+ search in ATLAS

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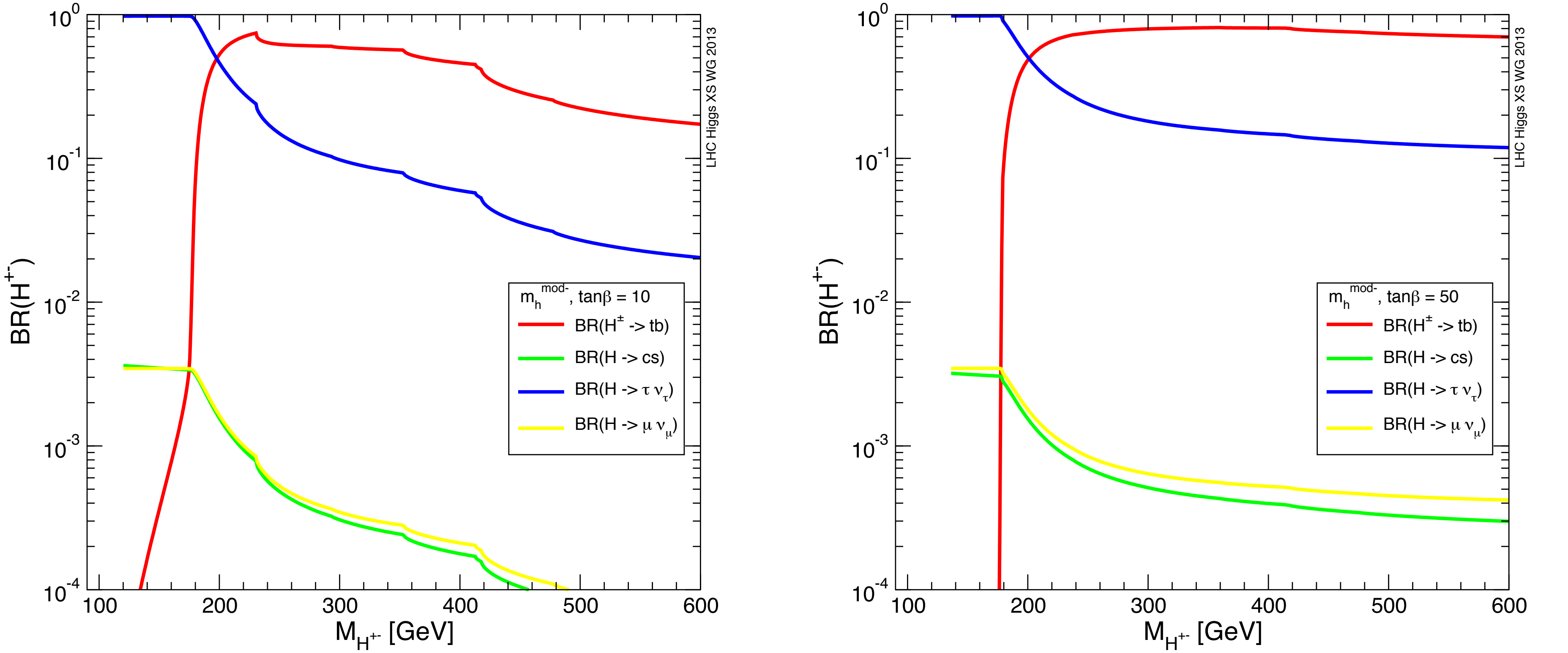
3/16/2018

Introduction

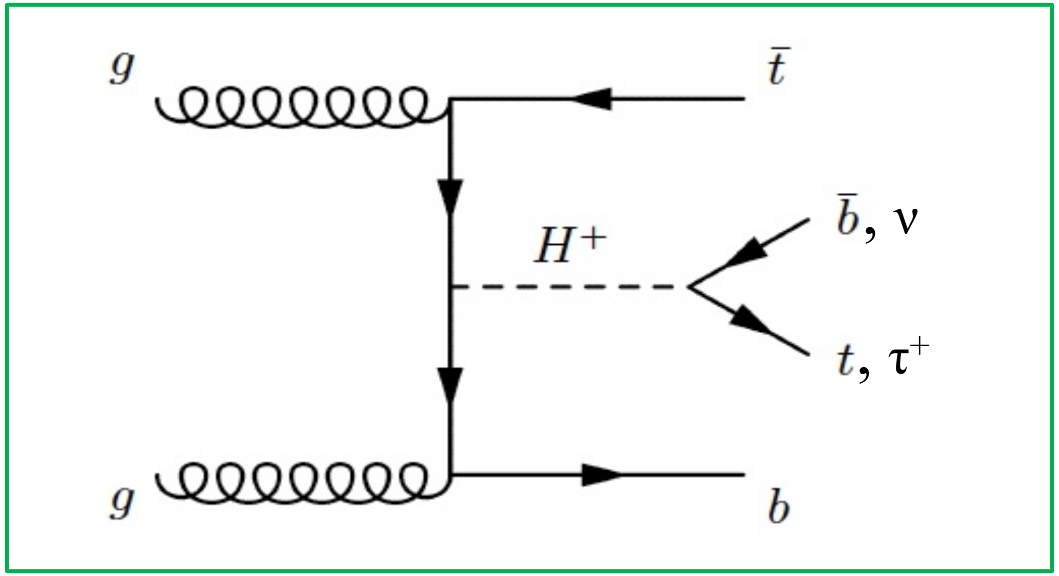
- ✓ Charged Higgs predicted in many BSM models
- ✓ In the MSSM or in the 2HDM with cos(β-α) ≈ 0, the H^+ dominant decays are to tb and τν for H^+ heavier than top quark,



(from https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWGCrossSectionsFigures#H_BR_plots_MSSM)

Introduction

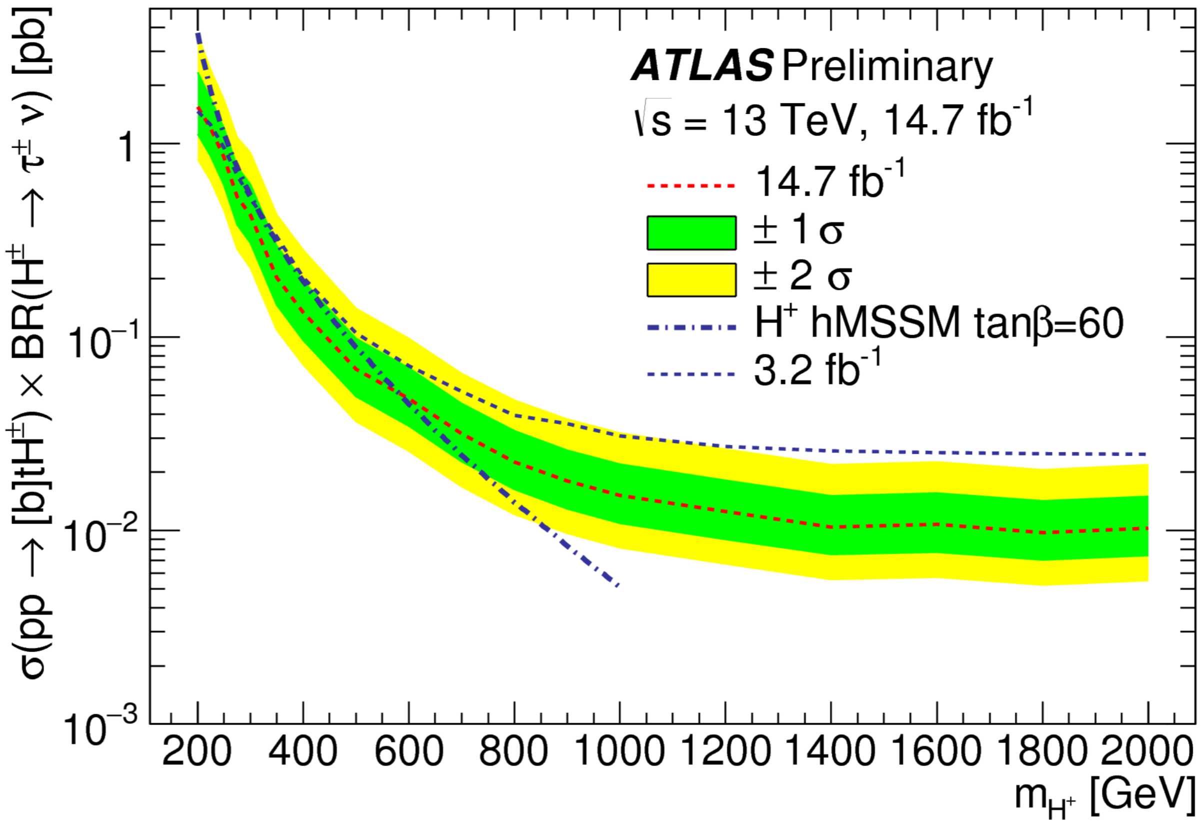
- ✓ Study H^+ production in association with top and bottom quarks (use 4FS)



- ✓ tbH^+ process modelled with MG5_aMCatNLO
- ✓ Narrow width approximation assumed
- ✓ No special treatment for large widths
- ✓ Experimental resolution large for large H^+ masses

ATLAS results

ATLAS-CONF-2016-088



$H^+(\tau\nu)$ considered hMSSM and m_h^{mod-} models

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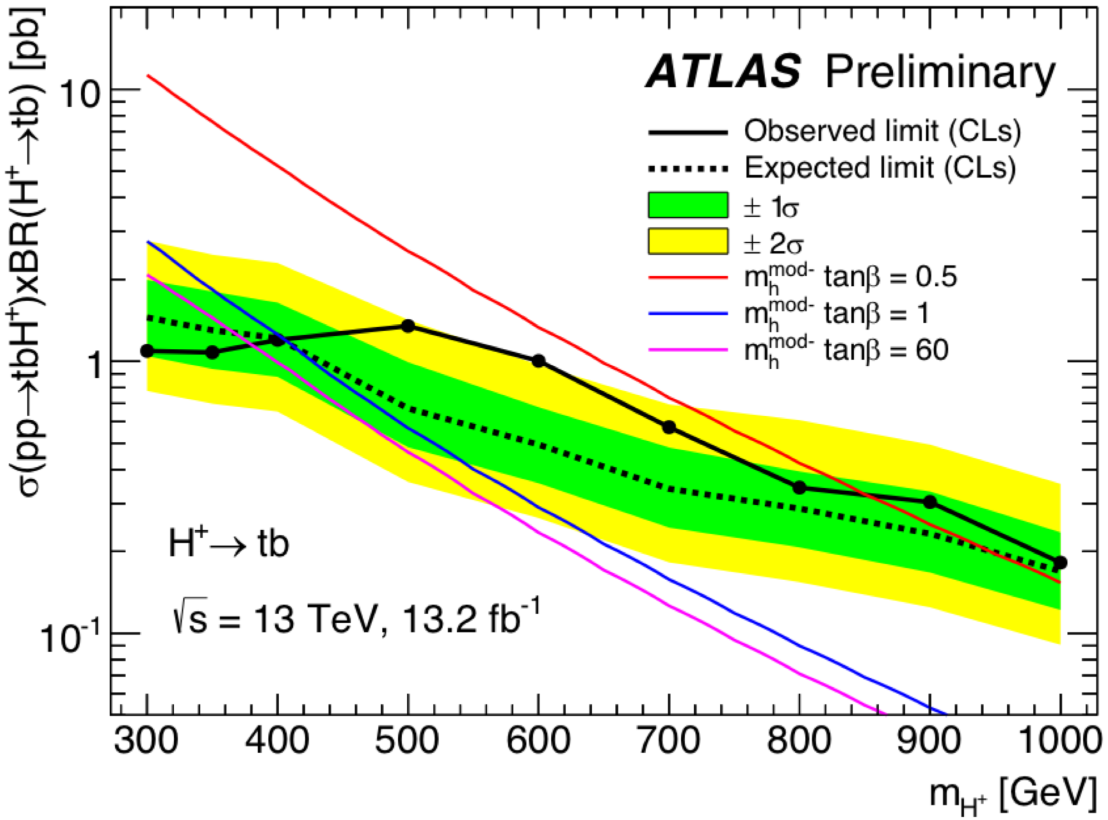

$H^+(tb)$ analysis considered m_h^{mod-} model

ATLAS results

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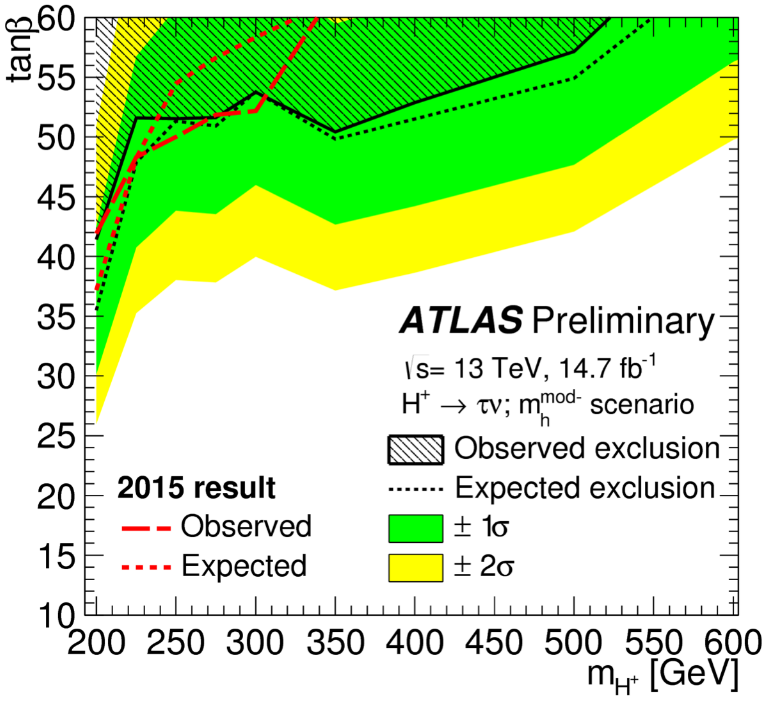
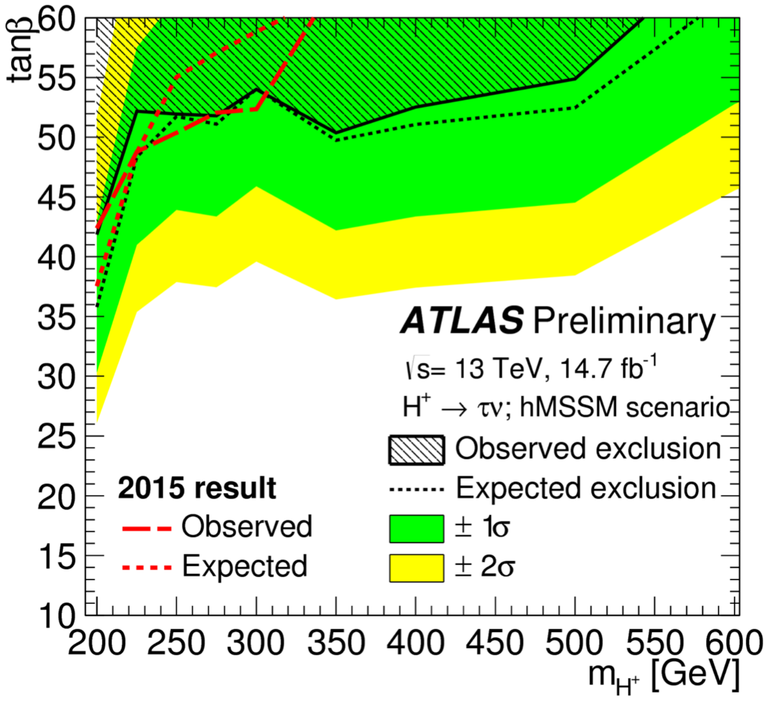
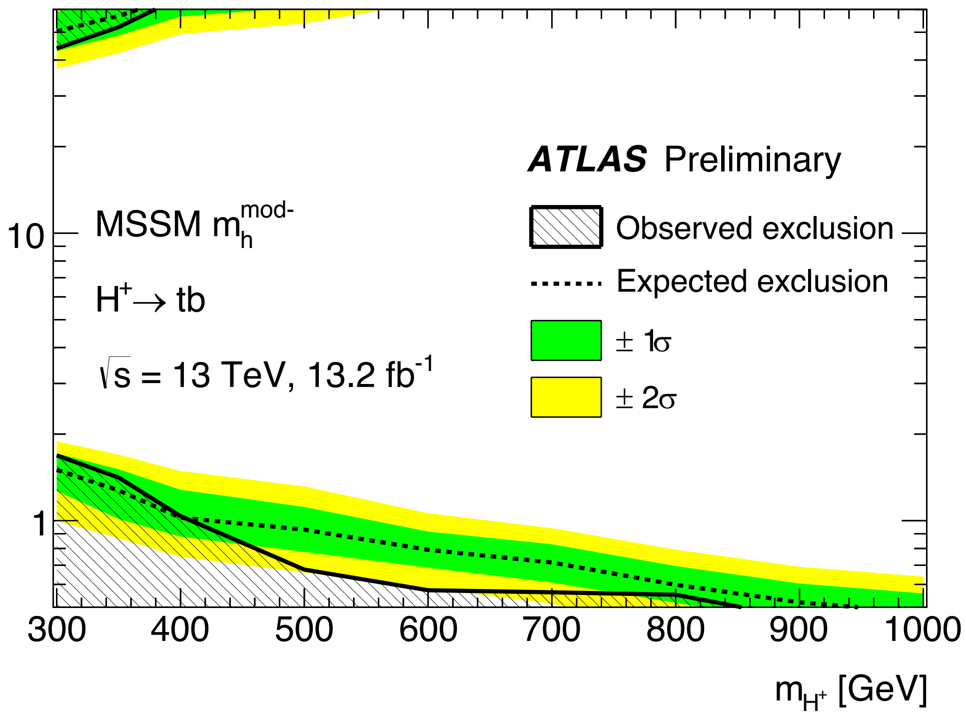






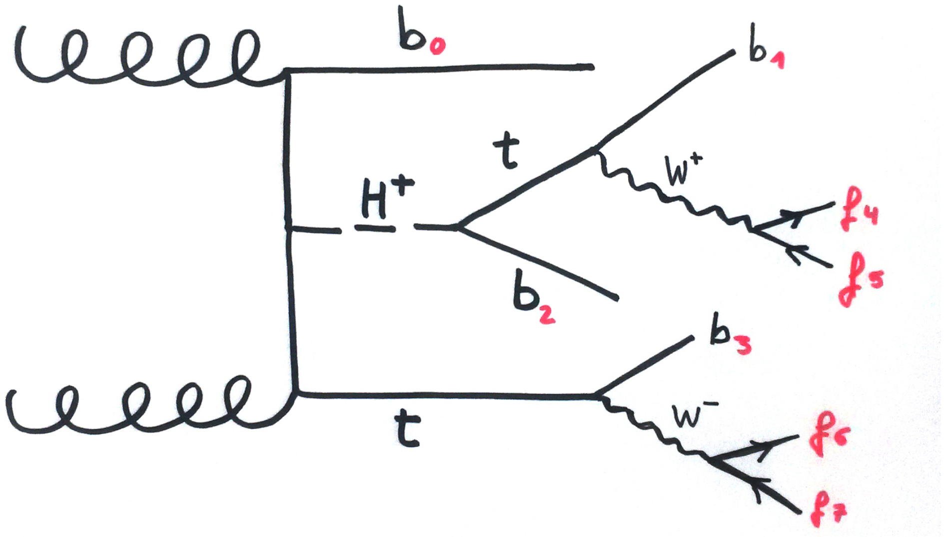
$H^+(\tau\nu)$ considered hMSSM and m_h^{mod-} models

$H^+(tb)$ analysis considered m_h^{mod-} model

H⁺ to tb events' topology

Two channels depending on Ws decay:

- ✓ Di-lepton (4 jets + 2 leptons +2 v)
- ✓ Single lepton (6 jets + lepton + v)

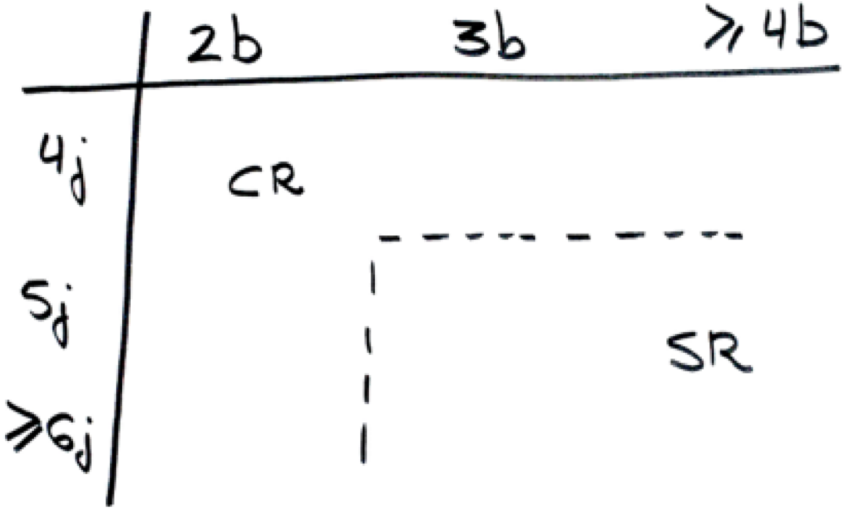


(4 b-originated jets: b_0, b_1, b_2, b_3)

H^+ to tb events' categorization

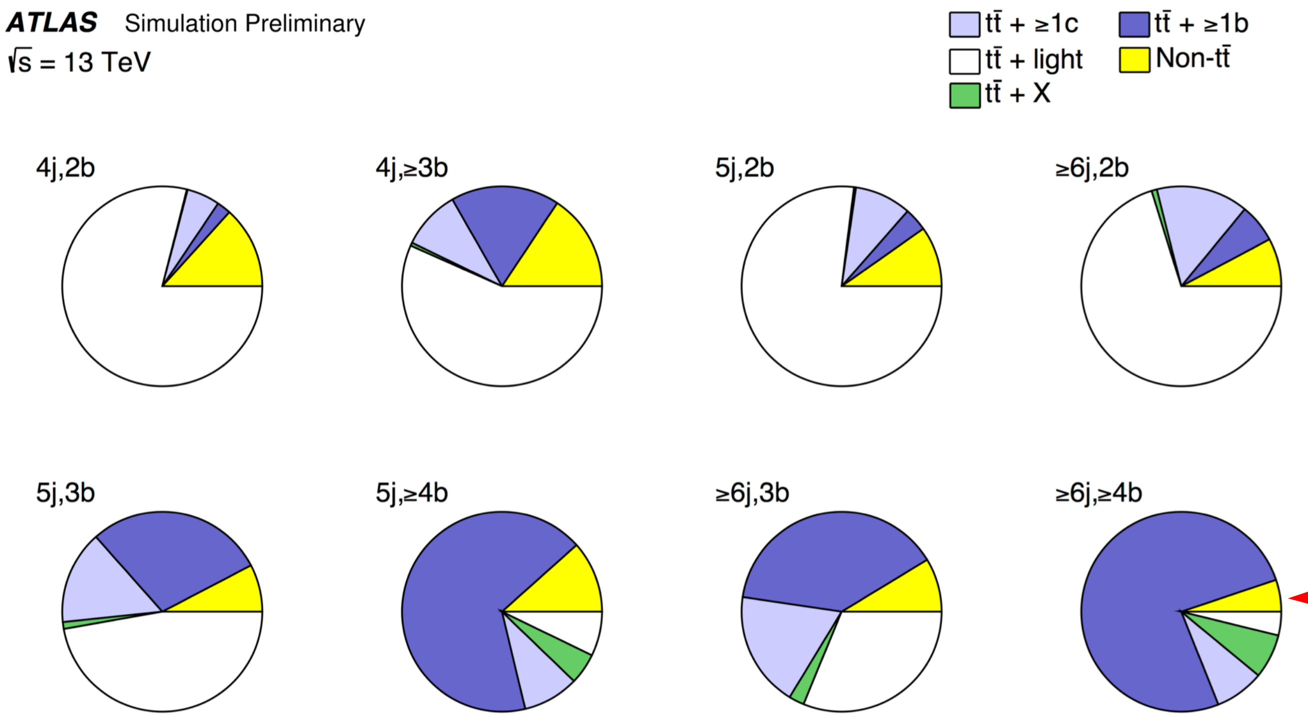
Classify events depending on jet and b-jet multiplicities:

- ✓ Signal regions: 5j3b, 5j4bin, 6jin3b, 6jin4bin
- ✓ Control regions: 4j2b, 4j3bin, 5j2b, 6jin2b



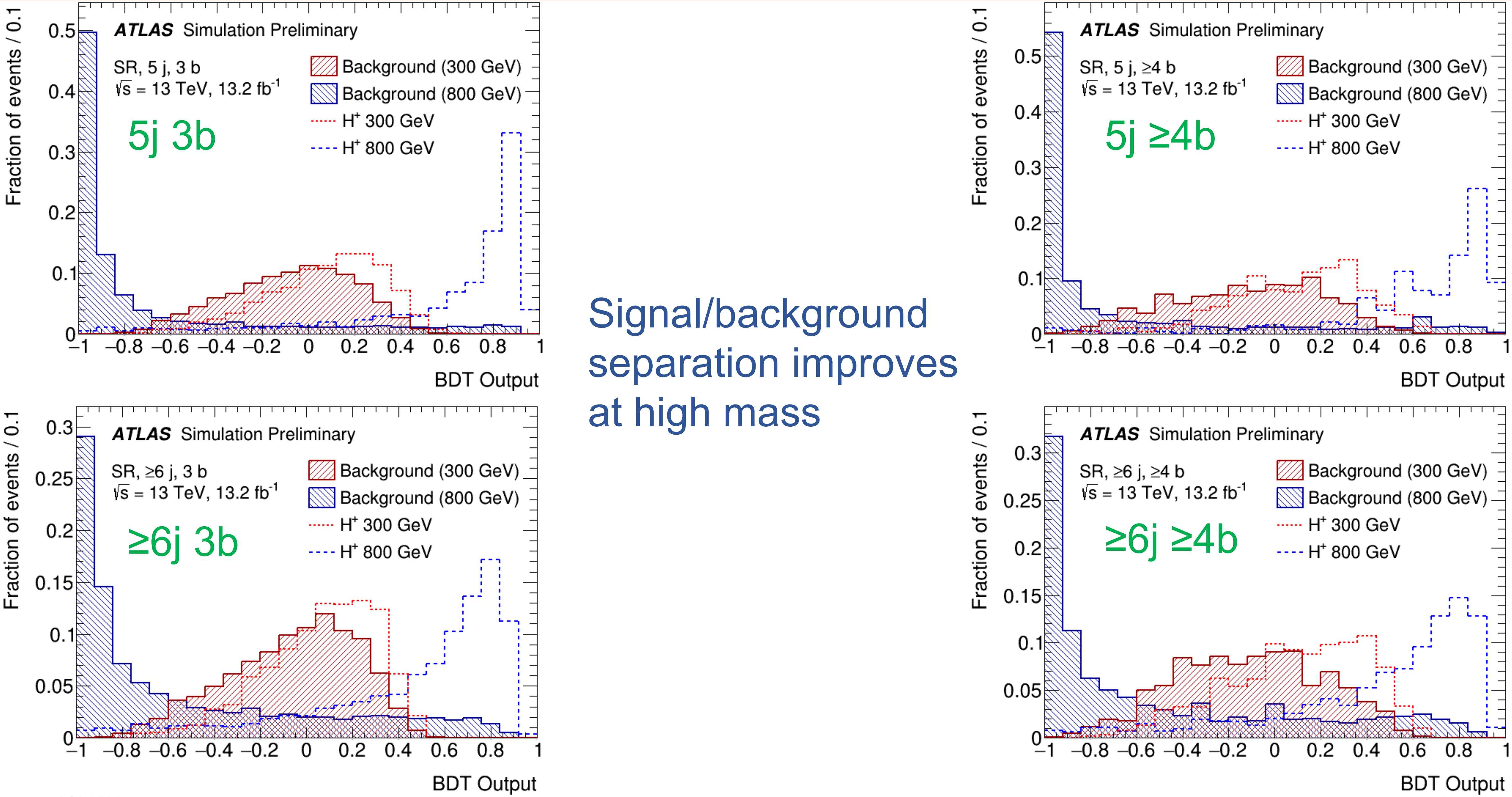
Background modelling

- Background dominated by ttbar + jets production (inclusive $\sigma = 832^{+46}_{-51}$ pb)
  - ✓ Split into light/heavy flavour based on extra jets: ttbar+light, ttbar+≥1c, ttbar+≥1b
- Other backgrounds:
  - ✓ ttbar+X: ttbar+W, ttbar+Z, ttbar+H
  - ✓ Non-ttbar: tH, Wt, other top (Zt, s- and t- channels), diboson, W+jets, Z+jets, fakes



ttbar+≥1b dominates in SR

BDT output distributions



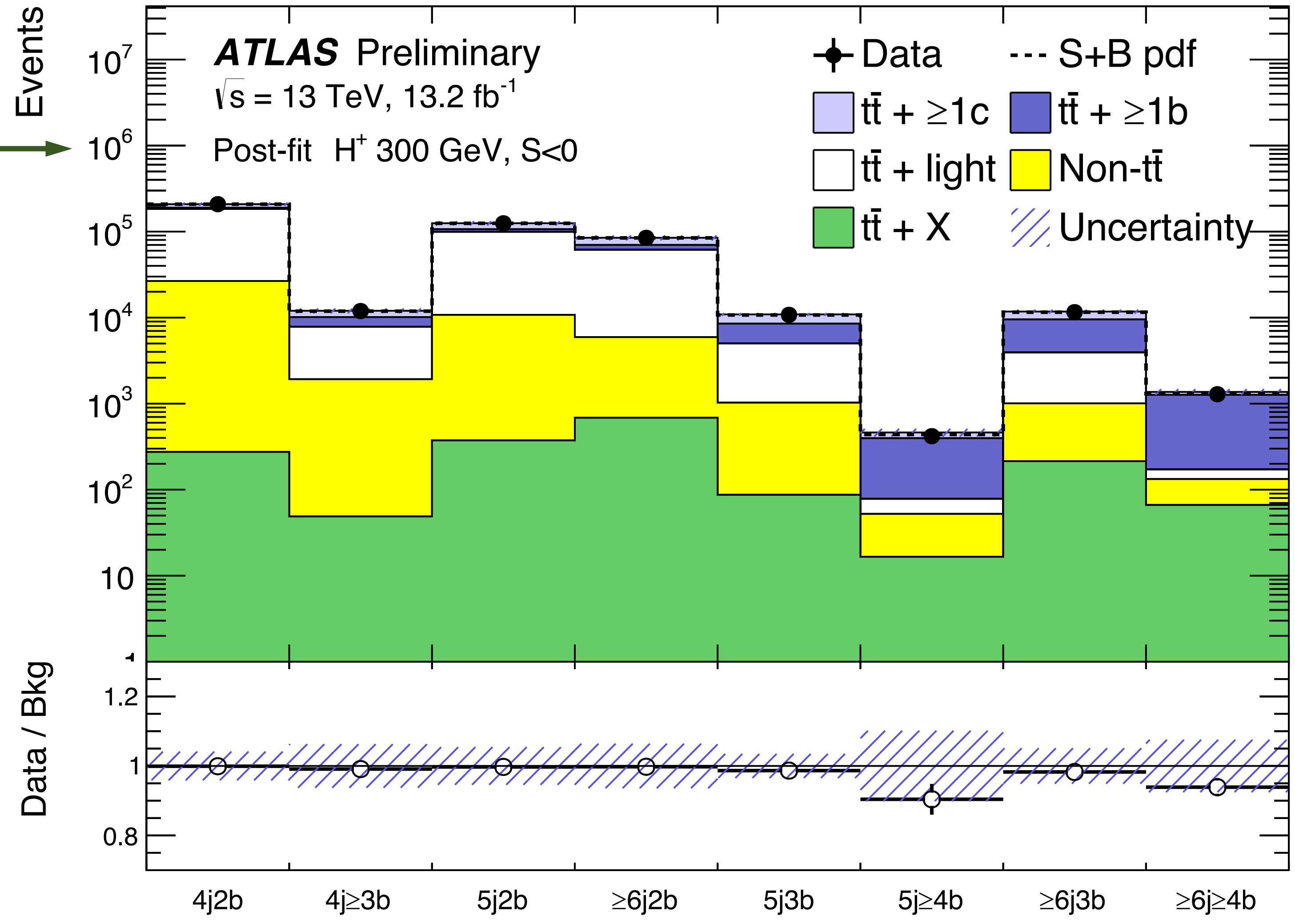
Signal/background separation improves at high mass

Fitting procedure

- ✓ Simultaneous (profile likelihood) fit of:
  - SR with signal enriched selections
  - CR to control backgrounds and uncertainties
- ✓ Use BDT output in SR and H_T^{had} in CR
- ✓ Main background: **ttbar+≥1b**, very hard to separate from signal at low H^+ masses
- ✓ **ttbar+≥1c** and **ttbar+≥1b** yields allowed to vary freely

Fitted (300 GeV mass hypothesis) and observed yields

Slightly negative fitted signal included but not explicitly displayed



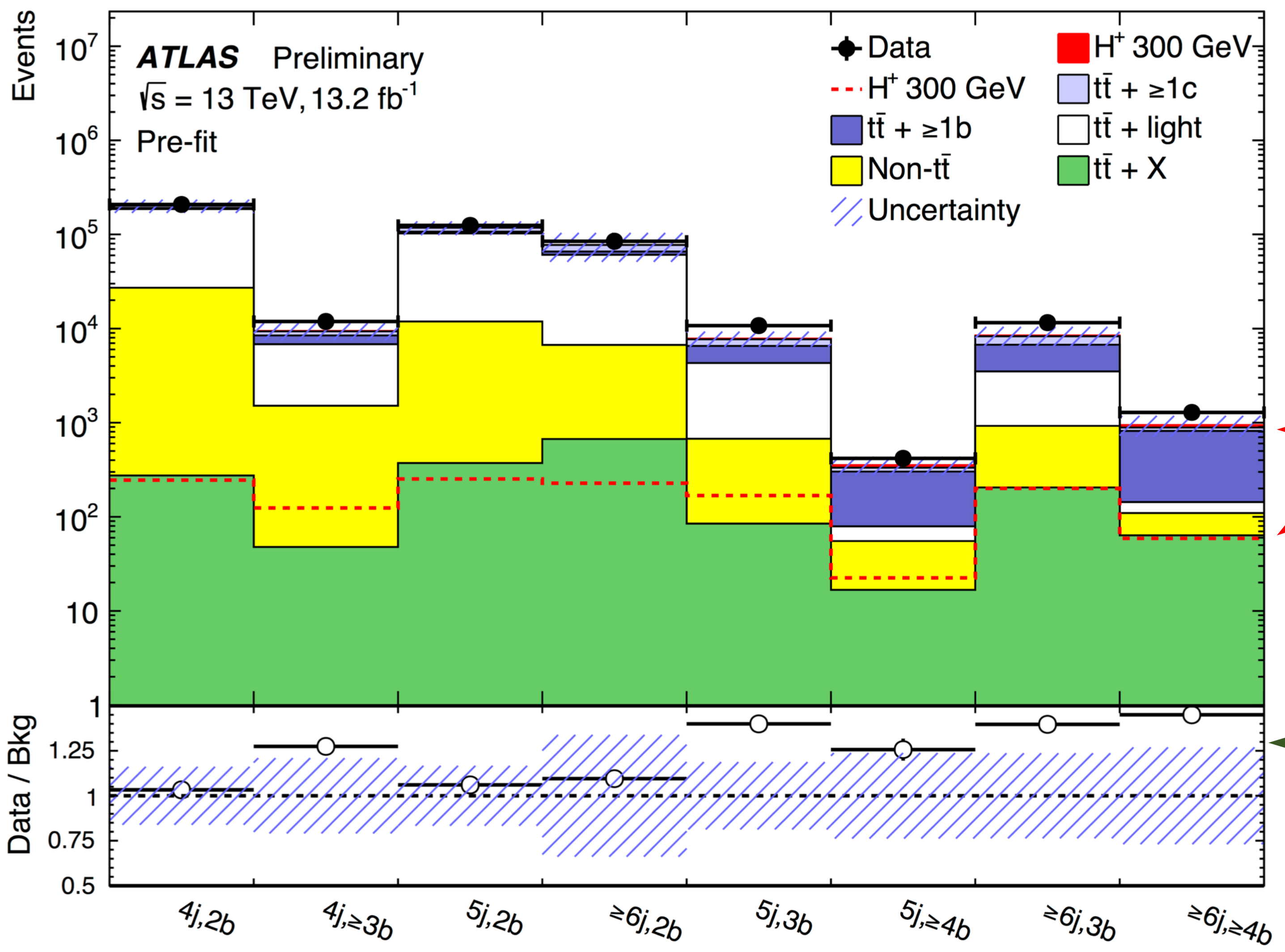
Post-fit agreement

Summary

- ✓ Interference between H^+ and ttbb not been considered so far
- ✓ We would appreciate having recommendations on how to treat the interference in both, model-independent and model-dependent, scenarios
- ✓ Since the analysis employs complicated MVA techniques and since we don't reconstruct the H^+ mass, would a simple and robust interference recipe be possible? A simple scale factor for signal yields perhaps?
- ✓ Width recommendations?
- ✓ Negative weights are a problem

Back-up

Predicted and observed yields



H⁺ shown both stacked on top of background and separately

MC underestimates data in SR

Systematic uncertainties

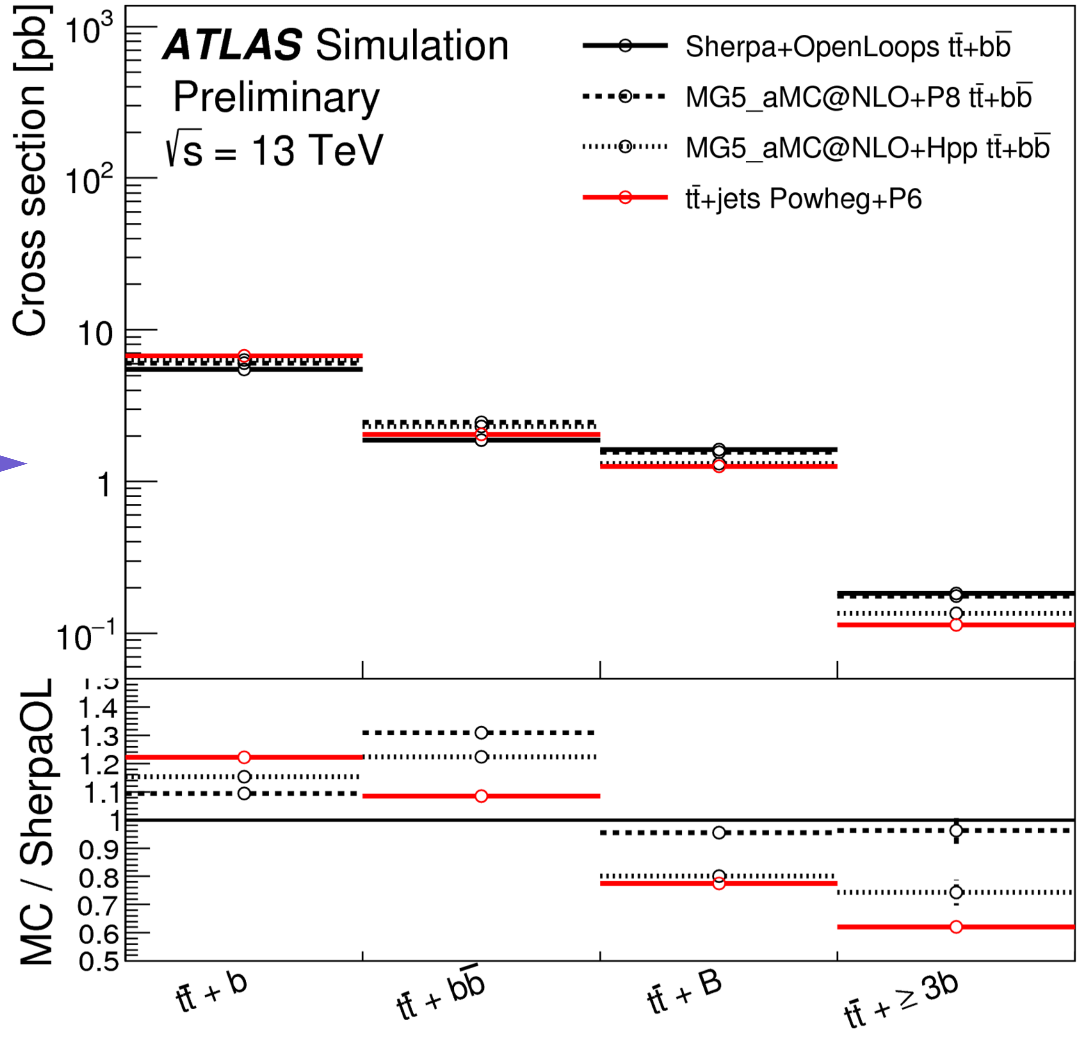
- ✓ Dominated by ttbar modelling, especially heavy flavour
- ✓ Detector largest contributions: b-tagging and JES/JER

Uncertainty Source	$\Delta\mu(H^+_{300})$		$\Delta\mu(H^+_{800})$	
$t\bar{t}+\geq 1b$ modelling	+0.53	−0.53	+0.07	−0.07
Jet flavour tagging	+0.30	−0.29	+0.07	−0.07
$t\bar{t}+\geq 1c$ modelling	+0.23	−0.22	+0.03	−0.03
Background model statistics	+0.19	−0.19	+0.05	−0.05
Jet energy scale and resolution	+0.18	−0.17	+0.03	−0.03
$t\bar{t}$+light modelling	+0.16	−0.16	+0.03	−0.03
Other background modelling	+0.15	−0.14	+0.03	−0.03
Jet-vertex association, pileup modelling	+0.12	−0.11	+0.01	−0.01
Luminosity	+0.12	−0.12	+0.01	−0.01
Light lepton (e, μ) ID, isolation, trigger	+0.01	−0.01	$<+0.01$	<-0.01
Total systematic uncertainty	+0.72	−0.79	+0.13	−0.11
$t\bar{t}+\geq 1b$ normalisation	+0.36	−0.36	+0.03	−0.03
$t\bar{t}+\geq 1c$ normalisation	+0.15	−0.14	+0.02	−0.02
Total statistical uncertainty	+0.44	−0.43	+0.08	−0.08
Total	+0.84	−0.90	+0.15	−0.13

Systematic uncertainties

ttbar modelled using *Powheg + Pythia 6*

- ✓ **ttbar+light**, **ttbar+≥1c**: p_T^{ttbar} and p_T^{t} reweighted to NNLO prediction
- ✓ **ttbar+≥1b**: 2D (p_T^{ttbar} , p_T^{t}) reweighting to NLO *Sherpa+OpenLoops* (4F) prediction maintaining inclusive normalisation in nominal and alternative samples



ttbar modelling systematic uncertainties

Inclusive **ttbar**

- ✓ NNLO+NNLL cross section (6%): Include variations of μ_F, μ_R, PDF, α_s, m_t
- ✓ Generator: *POWHEG* vs *MG5_aMC@NLO* (both *HERWIG++*) (5FS)
- ✓ PS + hadronisation: *(POWHEG) PYTHIA6 vs HERWIG++* (5FS)
- ✓ ISR/FSR: (*POWHEG+PYTHIA6*) (5FS) radiation increased ($\mu_F/2$, $\mu_R/2$, hdamp x 2) and decreased (μ_F x 2, μ_R x 2, hdamp/2)

decorrelated for ttbar+light, ttbar+≥1c and ttbar+≥1b

ttbar+≥1b

- ✓ Vary μ_F and μ_R in *SHERPA+OPEN LOOPS* (4FS)
- ✓ Consider two alternative PDFs and shower recoil scheme *SHERPA+OL* (4FS)
- ✓ Generator: *SHERPA+OL* (4FS) vs *MG5_aMC@NLO + PYTHIA8* (4FS)
- ✓ PS + hadronisation: (*MG5_aMC@NLO) PYTHIA8* (4FS) vs *HERWIG++* (4FS)
- ✓ 50% contribution from MPI

ttbar+≥1c

- ✓ Default *c*-jets in PS vs *c*-jets in ME (*MG5@MC@NLO + HERWIG++*) (3FS)

ttbar+light and **ttbar+≥1c**

- ✓ p_T^t and p_T^{ttbar} reweighting: largest difference between nominal and any uncorrected alternative sample