New results of the $H^+ \rightarrow tb$ search using full Run-2 data with the ATLAS detector

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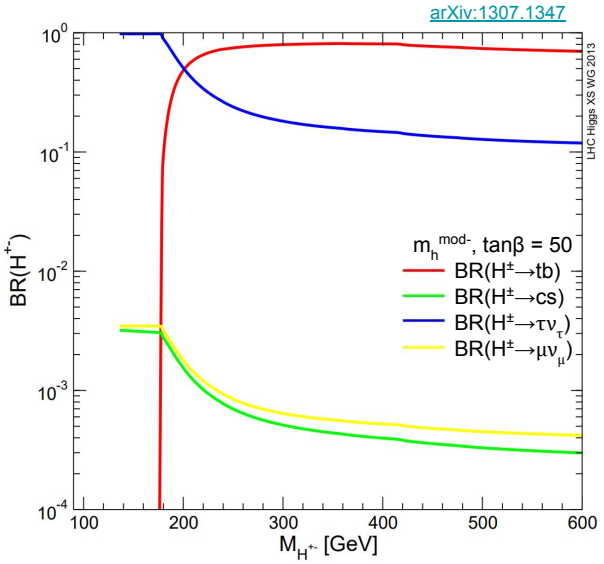
Motivation

➔Several BSM theories include an extended Higgs sector with at least one pair of charged Higgs bosons (2HDM, Higgs triplets…)

➔In the 2HDM models:

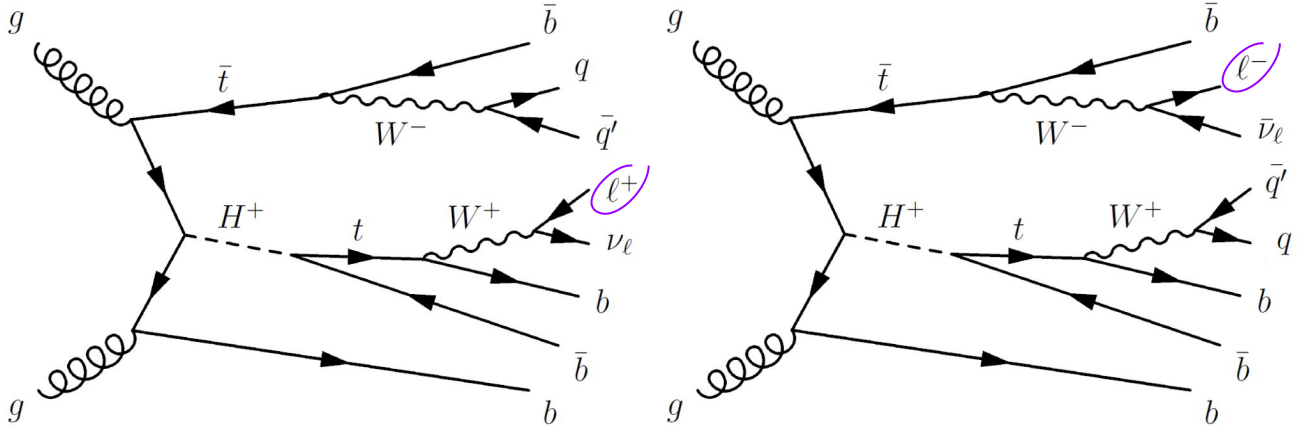
- ◆A total of 5 Higgs bosons are predicted: h, H, A, H^+, H^-
- ◆The decay depends on:
  - ●$H^\pm$ mass
  - ●tanβ: v.e.v ratio of the two Higgs doublets
  - ●α: mixing angle of the CP-even Higgs bosons
- ◆The $H^+ \to tb$ decay dominates for masses larger than 200 GeV in the cos(β-α) ~ 0 limit (the light neutral scalar is SM-like)



Analysis overview

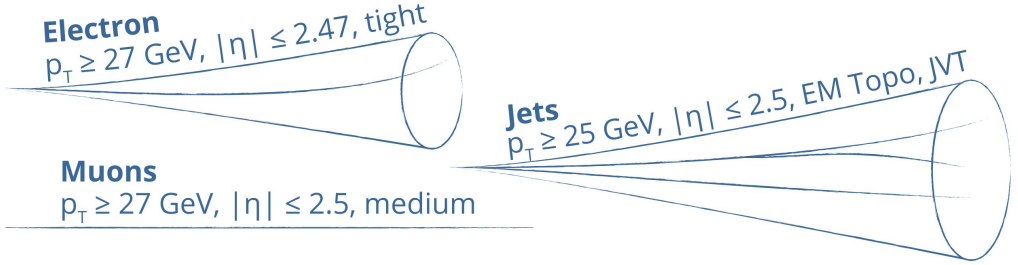
arXiv:1307.1347

- Use LHC Run-2 139 fb^{-1} pp collisions recorded with the ATLAS detector
  - Previous publication based on 2015+2016 (36 fb^{-1}) 10.1007/JHEP11(2018)085
- Search in the 200 - 2000 GeV mass range
- Focused on the single lepton channel since provides the best significance

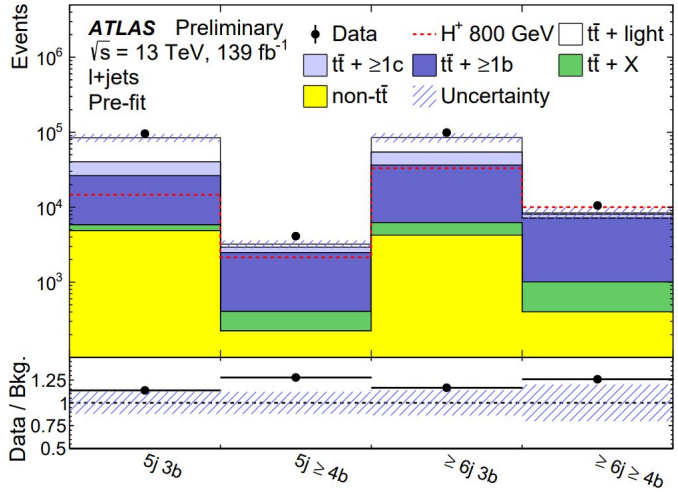


Analysis strategy

- Select events with:
  - Exactly one lepton: $e^{\pm}$ or $\mu^{\pm}$
  - ≥5 jets, ≥2 b-tagged at 70% efficiency



- Classify events according to jet and b-jet multiplicities
  - Four signal regions: 5j3b, 5j≥4b, ≥6j3b, ≥6j≥4b
  - $t\bar{t}$+jets is the main background
    - Specially $t\bar{t}$+≥1b in the most signal sensitive regions
    - Modelling improved applying Data/MC-based corrections



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tt̄+jets MC correction

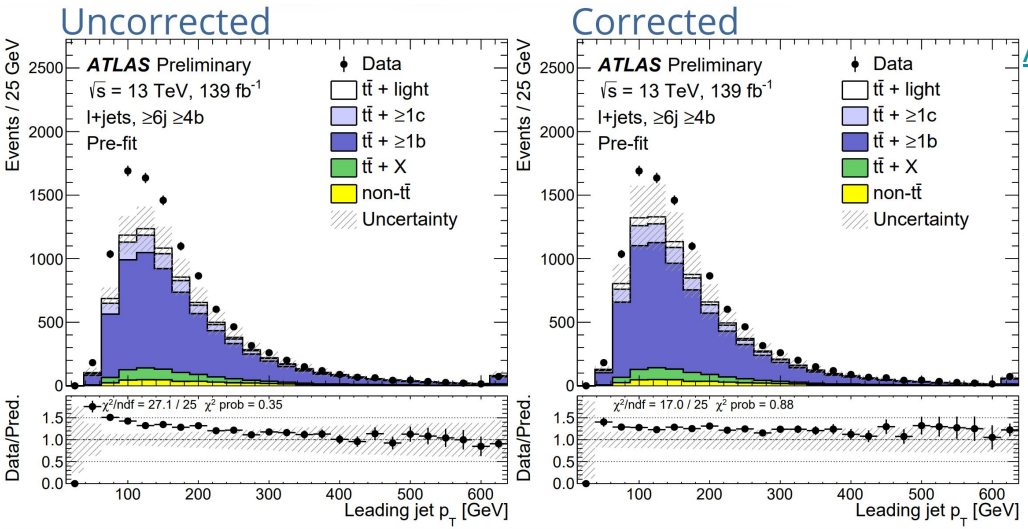
➔Mitigate differences seen in data/MC distributions due to tt̄+jets mismodelling

➔Data/MC-based factors extracted from 5j2b, 6j2b, 7j2b, ≥8j2b regions

1. Correct the 2b jet multiplicity distribution
2. Correct the 2b H_T^{all} distribution for each jet multiplicity

$$w = \frac{Data - MC_{non-t\bar{t}}}{MC_{t\bar{t}}}$$

➔Factors applied appropriately to the SRs improve prefit agreement



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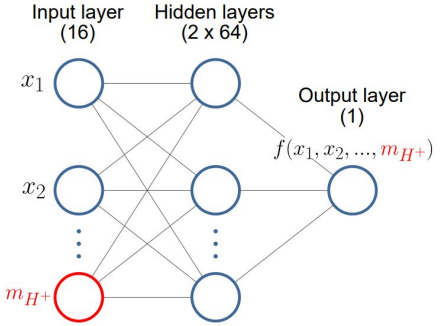
Mass-parameterised Neural Network

➔Use of multivariate techniques to separate signal and background in the signal regions

➔Mass-parameterised Neural Network description:
- ◆Training performed on every signal region
- ◆Based on high-level kinematic variables:
  - ●H_T^{jets}, leading jet p_T, kinematic discriminant, centrality...
- ◆H^+ mass is used as input parameter
- ◆All H^+ mass samples included in a single training
  - ●Simplifies training, benefits from continuity, effectively more signal statistics and allows interpolation



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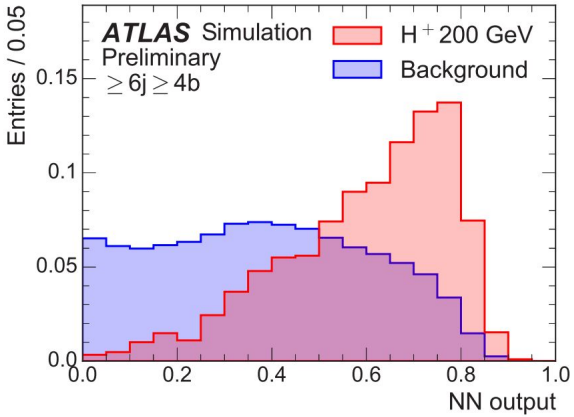
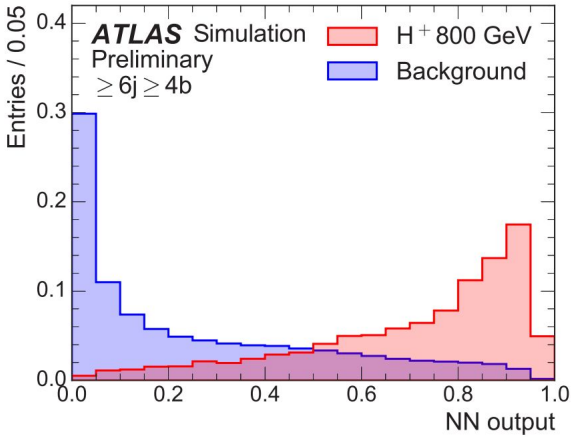
➔Better signal and background separation at higher masses





Fit results

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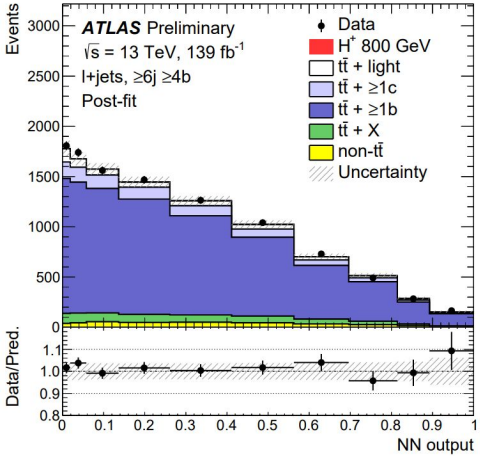
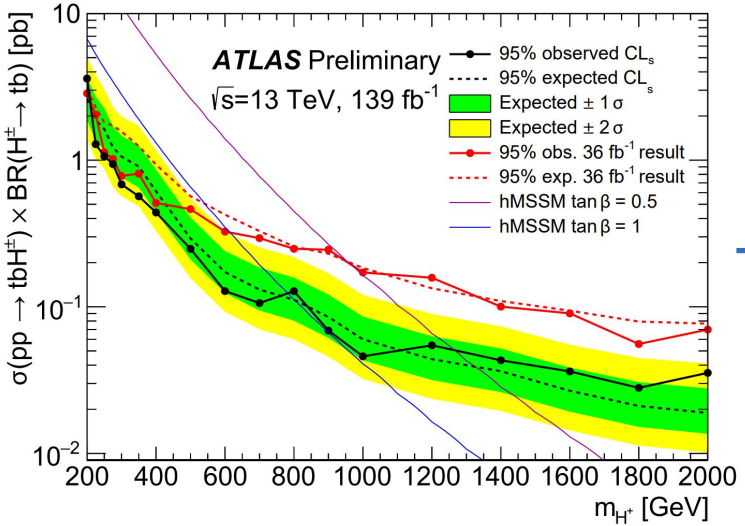
- Simultaneous binned profile likelihood fit to mass-parameterised NN output in the four signal regions
  - One fit for each H^+ mass hypothesis
  - Normalisation of $t\bar{t}$+≥1b and $t\bar{t}$+≥1c backgrounds free floating in the fit
  - Systematic uncertainties included as nuisance parameters



- Produced model independent σ x BR limits



- Improved exclusion limits at 95% CL with respect to the 36 fb^{-1} publication, especially at high H^+ masses

Exclusion limits

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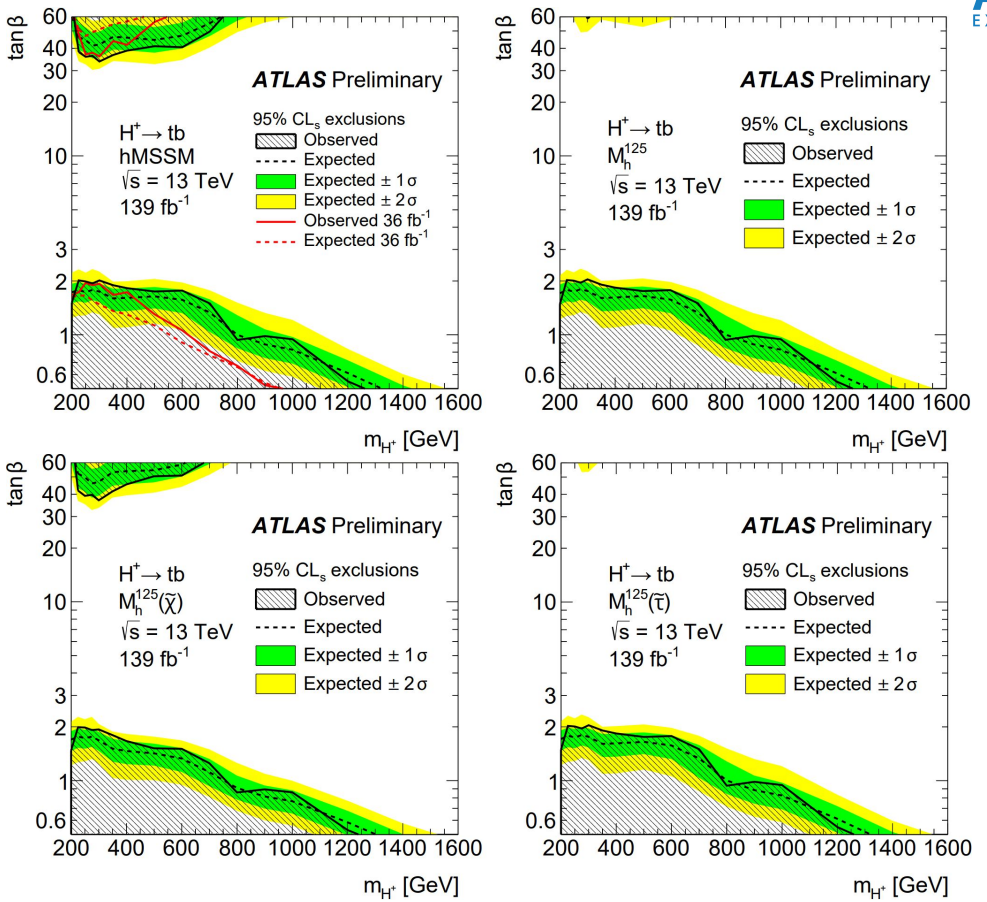
- Produced tanβ vs m(H^+) exclusion limits for different benchmark models
  - hMSSM
  - M_h^{125}, $M_h^{125}(\tilde{\chi})$, $M_h^{125}(\tilde{\tau})$
- Exclusion limits on hMSSM improved especially at high H^+ masses with respect to the previous publication



Summary

- Performed a $H^+ \rightarrow tb$ search using the full Run-2 dataset in the single lepton channel
  - Implemented a mass-parameterised neural network
  - No significant excess above the expected SM background found
  - Improved 95% CL_s limits on σ x BR obtained with respect to previous analysis
  - Obtained tanβ exclusion limits for various benchmark scenarios

- Preliminary results presented at ICHEP on July 31th 2020

- Working on the final publication