Analysis of $t\bar{t}W/t\bar{t}H$ in multi-lepton final states

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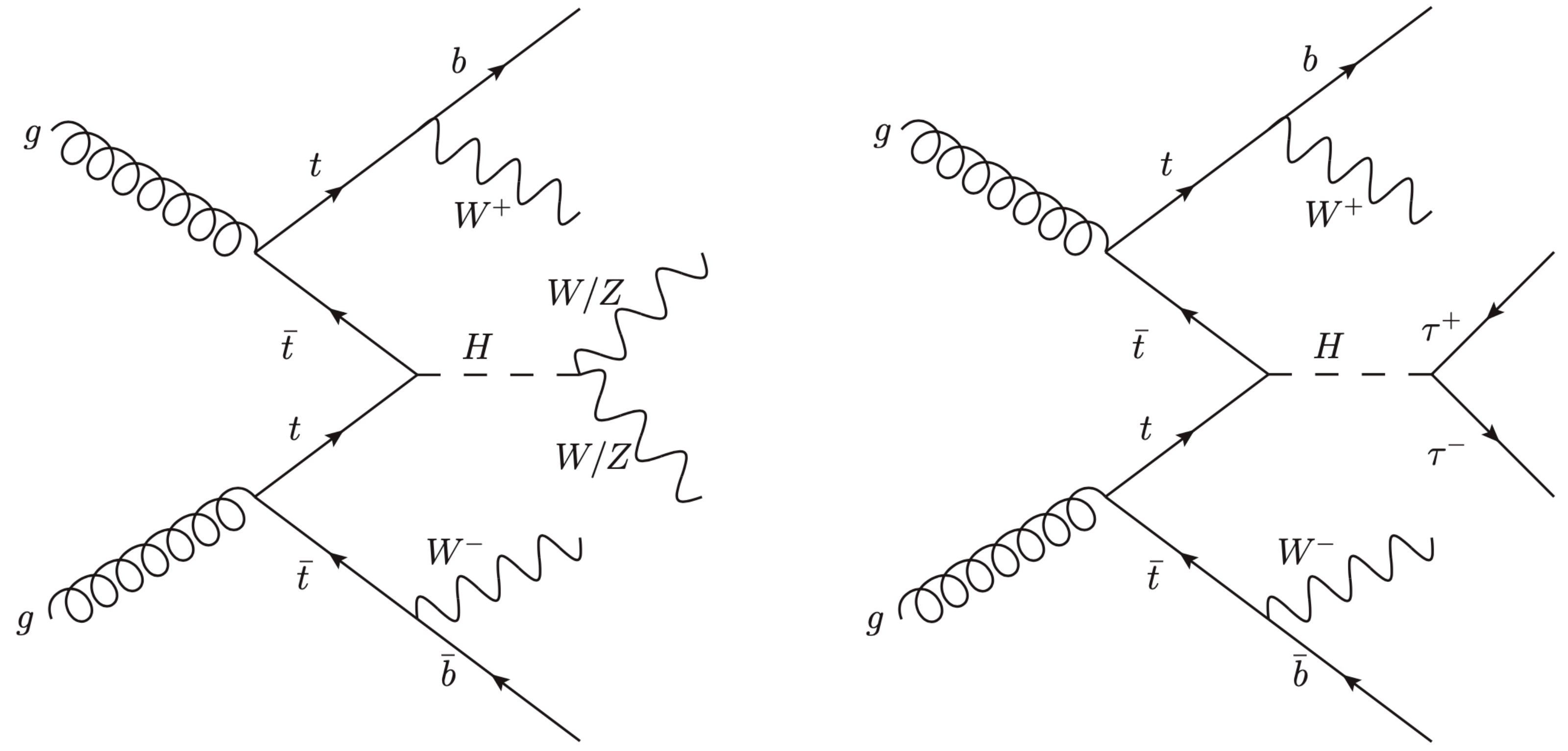
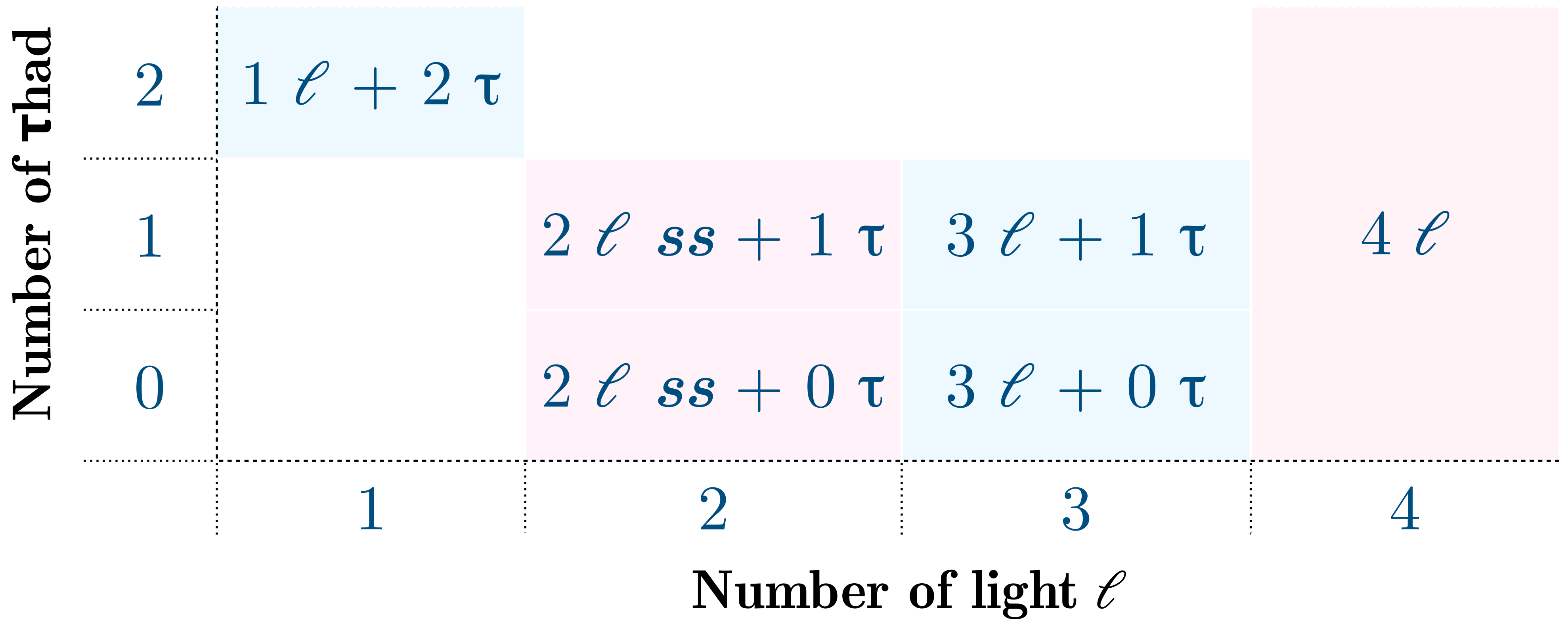
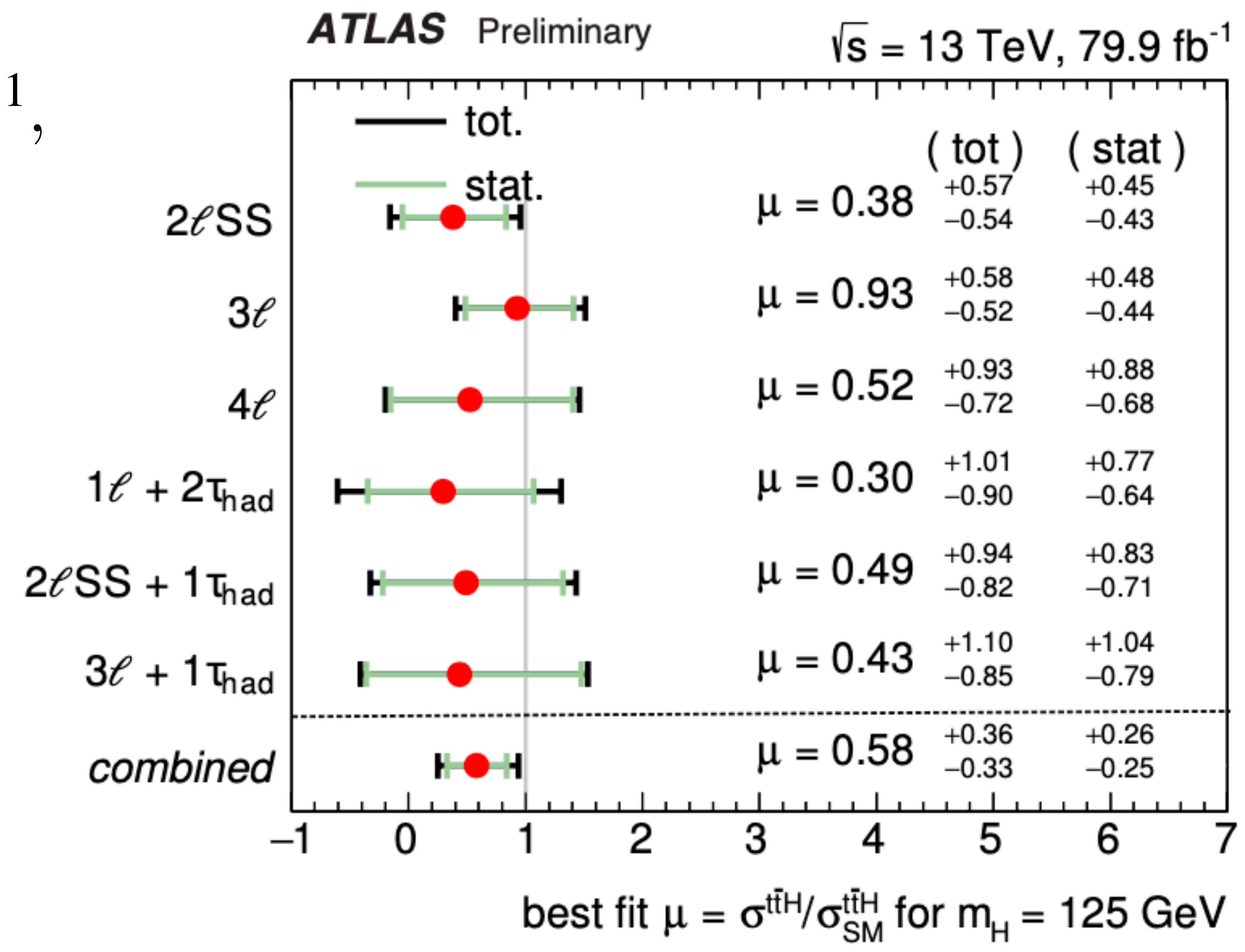
Introduction

- The top-quark Yukawa coupling can be probed directly by measuring the $t\bar{t}H$ production.
- A search for the production in multilepton final states was performed, based on an integrated luminosity of 80 fb^{-1}, **ATLAS-CONF-2019-045**.
- Six final states were analysed, categorised by the number and flavour of lepton candidates.
- The best-fit value of the observed production XS is $\sigma(t\bar{t}H) = 294^{+182}_{-162}\ fb^{-1}$, in agreement with the SM prediction of $507^{+35}_{-50}\ fb^{-1}$.







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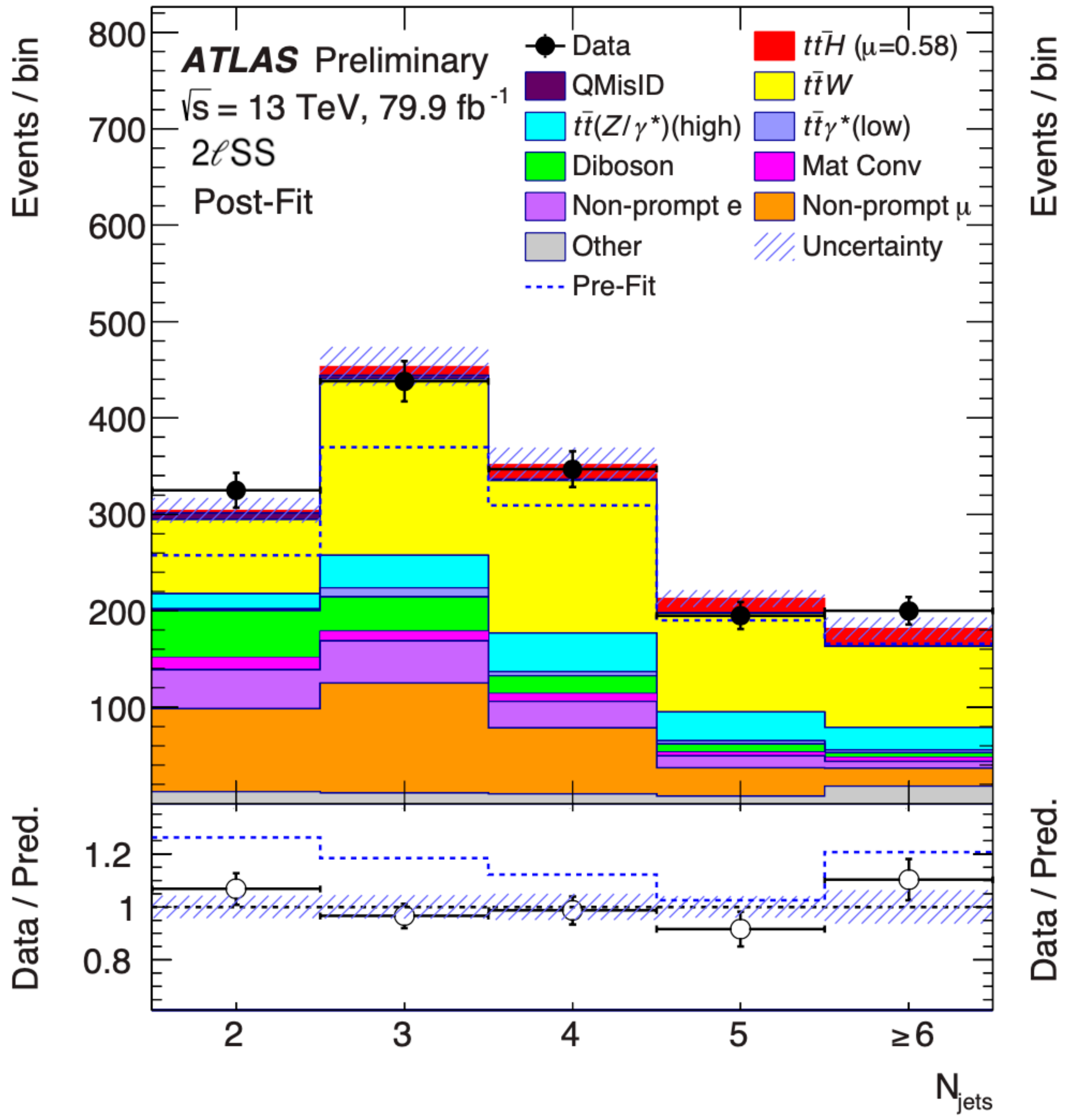
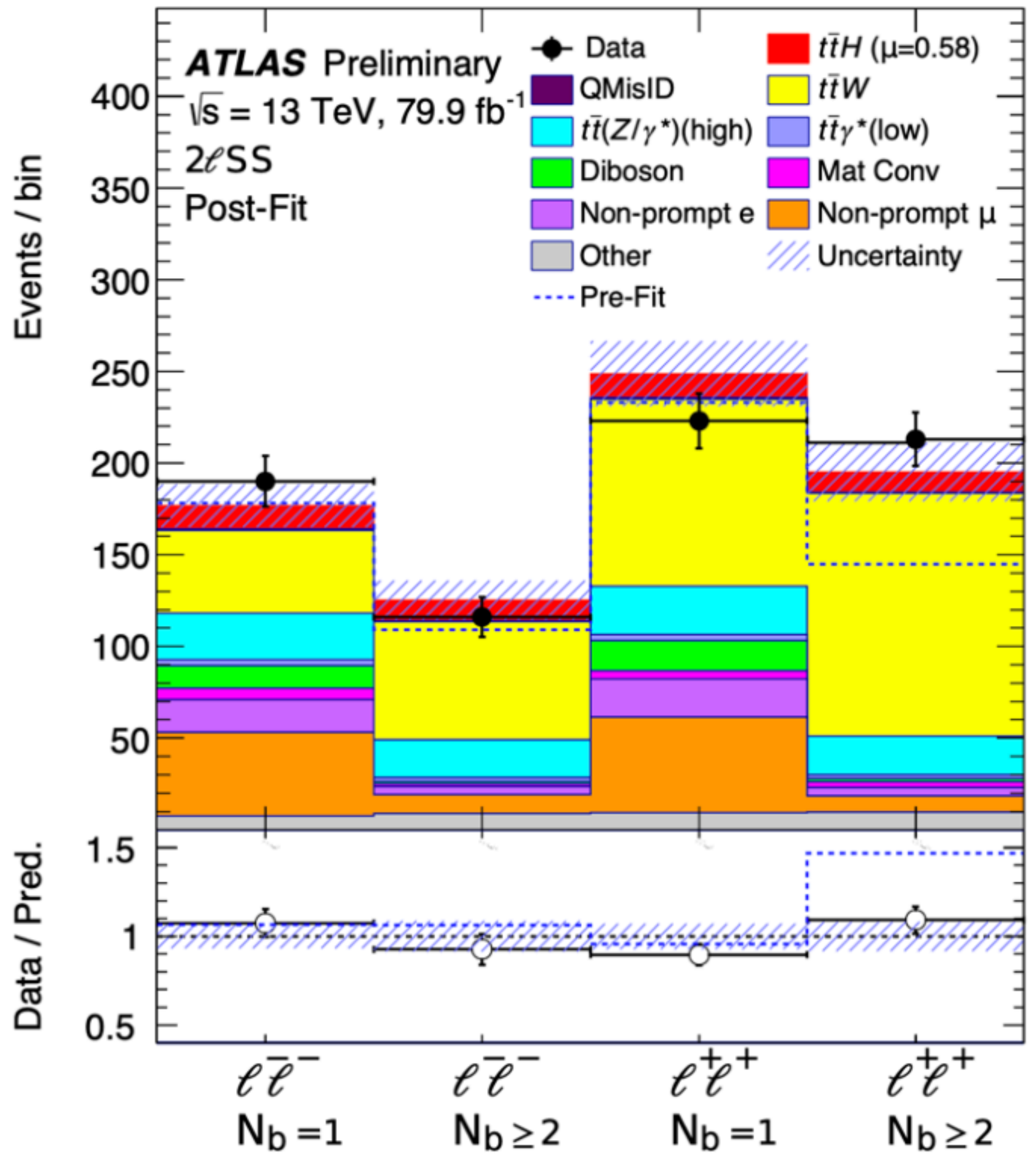
Challenge and motivation

- Signifiant **mismodeling** observed (excess) of $t\bar{t}W$ in the previous round of analysis
  - $\lambda^{2lLJ} = 1.56 \pm 0.29$, $\lambda^{2lHJ} = 1.26 \pm 0.19$ *and* $\lambda^{3l} = 1.68 \pm 0.29$
  - Similar excesses observed, e.g. in 4tops analysis
  - Latest $t\bar{t}H - ML$ (**CMS-PAS-HIG-19-008**) results also suggests a high normalization, $\lambda^{ttW} = 1.43 \pm 0.21$.

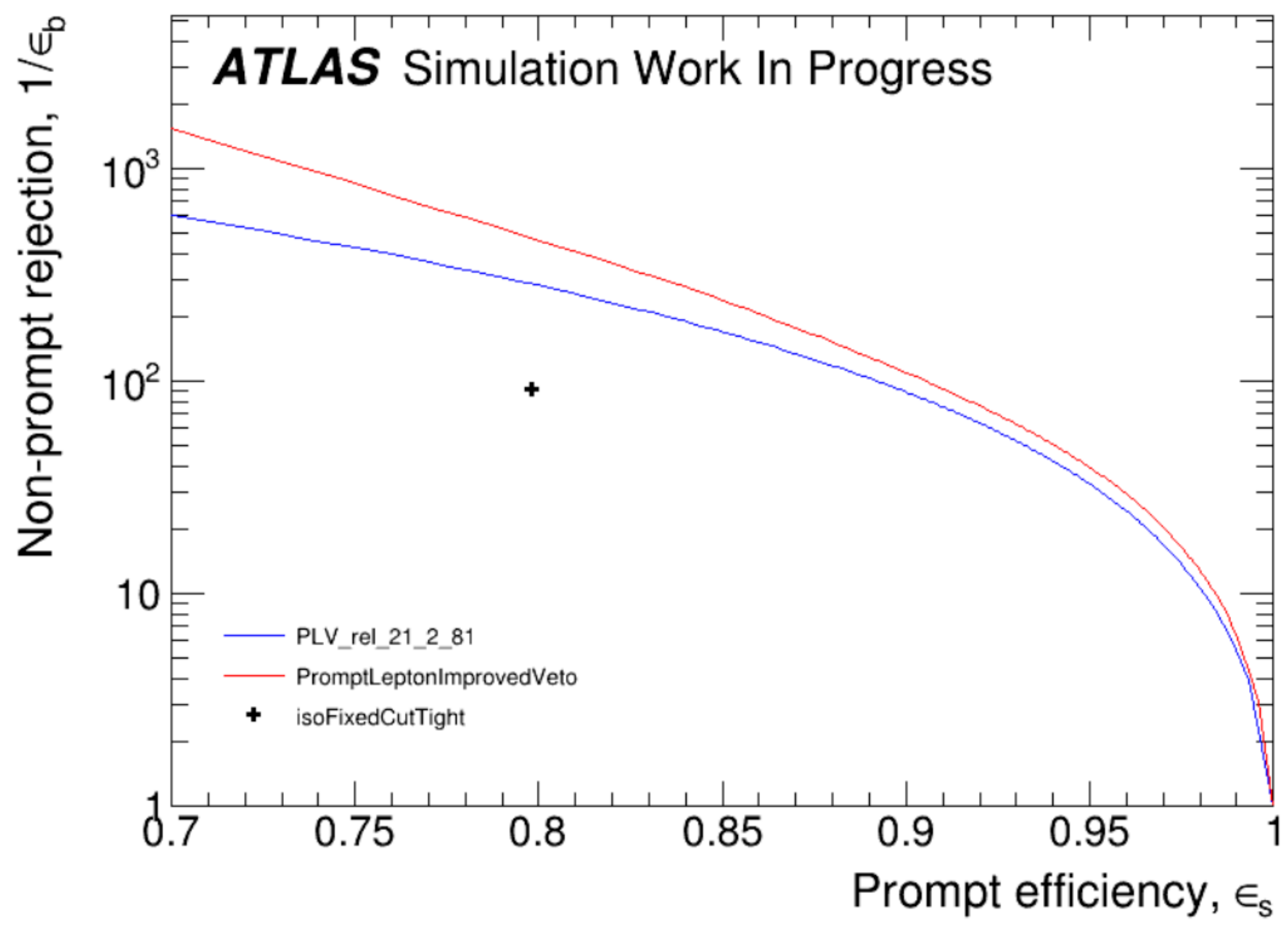




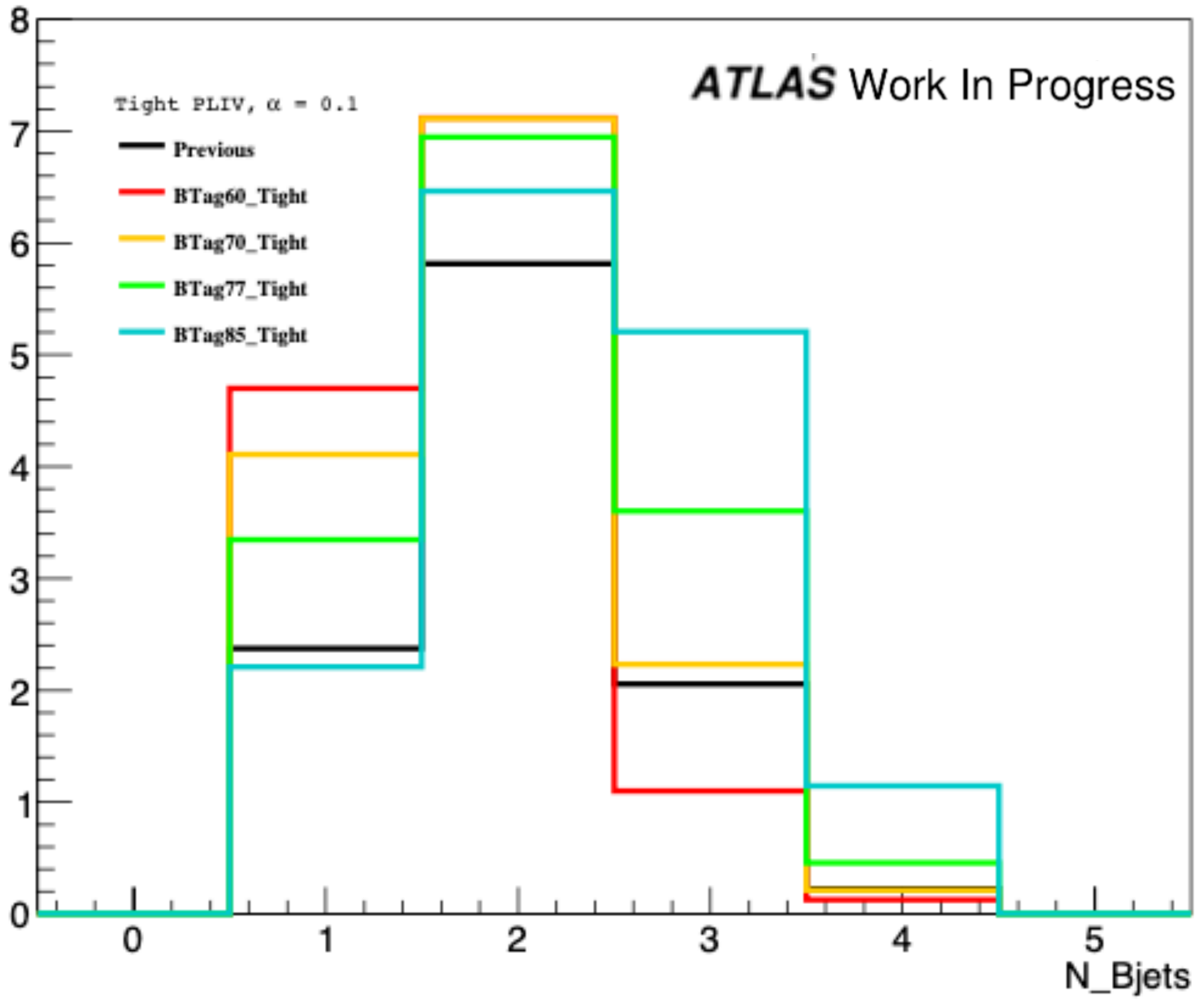
- Measure inclusive and differential σ of ttW production followed by ttH measurement.
  - Targeting multi-lepton (ML) final states and using full Run 2 data
  - Gain better understanding of the process then improve ttHML analysis sensitivity

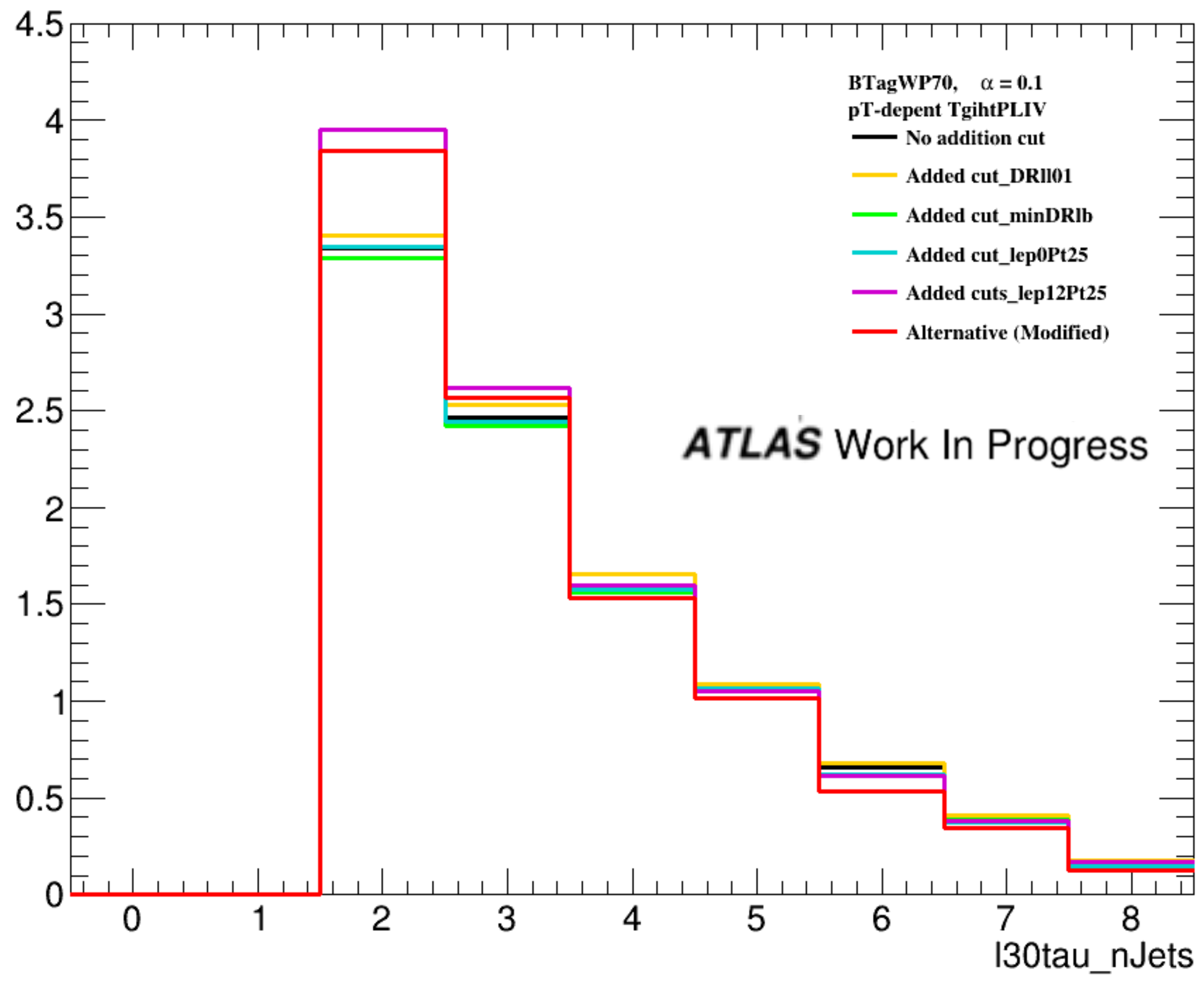
Prompt lepton veto & selection optimisation

- **Non-prompt lepton BDT** was applied in the 80 fb^{-1} ttH-ML analysis. An optimised version of the BDT is under development. **(USTC Team)**



- Studies to optimise 2l and 3l channels' definition were carried out, based on the new BDT. The selections applied in the last round still show a good sensitivities.





Key component: Non-prompt lepton estimation

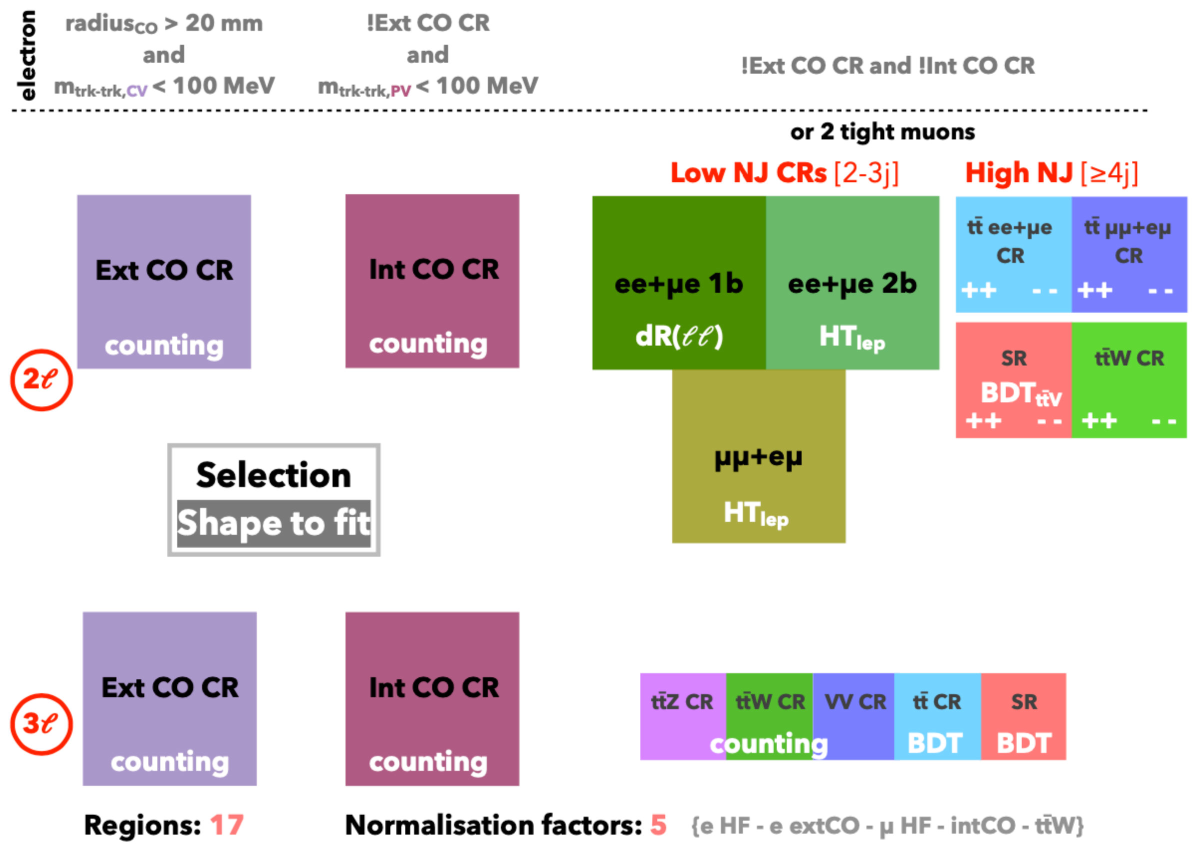
Matrix Method

- The matrix method is a data driven technique for estimating the contamination of fake leptons.
- Define loose and tight regions, calculate the rates of the fake and the prompt, estimate the fake in SR
- Advantage: weak dependence on MC

Templet fit Method

- A semi-data-driven method, relies on the truth information to define different types of fake leptons,
- Within this method, the normalisation of the different fakes are left free-floating in a fit to data, and these NFs are used to correct the fakes MC estimates.

$$\begin{pmatrix} N^{TT} \\ N^{T\not T} \\ N^{\not T T} \\ N^{\not T\not T} \end{pmatrix} = \begin{pmatrix} \varepsilon_{r,1}\varepsilon_{r,2} & \varepsilon_{r,1}\varepsilon_{f,2} & \varepsilon_{f,1}\varepsilon_{r,2} & \varepsilon_{f,1}\varepsilon_{f,2} \\ \varepsilon_{r,1}\not\varepsilon_{r,2} & \varepsilon_{r,1}\not\varepsilon_{f,2} & \varepsilon_{f,1}\not\varepsilon_{r,2} & \varepsilon_{f,1}\not\varepsilon_{f,2} \\ \not\varepsilon_{r,1}\varepsilon_{r,2} & \not\varepsilon_{r,1}\varepsilon_{f,2} & \not\varepsilon_{f,1}\varepsilon_{r,2} & \not\varepsilon_{f,1}\varepsilon_{f,2} \\ \not\varepsilon_{r,1}\not\varepsilon_{r,2} & \not\varepsilon_{r,1}\not\varepsilon_{f,2} & \not\varepsilon_{f,1}\not\varepsilon_{r,2} & \not\varepsilon_{f,1}\not\varepsilon_{f,2} \end{pmatrix} \begin{pmatrix} N^{rr} \\ N^{rf} \\ N^{fr} \\ N^{ff} \end{pmatrix}$$



→ Measure the XS of $t\bar{t}W$ as a function of different observables, njets, leptonPt … **Unfolding**

Summary

- Full Run 2 ttW/ttH-ML analyses are developed in parallel and their status was presented:

  → focusing on the new ideas w.r.t 80 fb^{-1} ttHML analysis

- New Non-prompt lepton BDT tool improves the rejection and benefits the analysis sensitivity.

- Two approaches are explored for the fakes background estimate:

  → Data-driven matrix method and template fit method

- After finalising the estimation of fakes, the XS of ttW will be measured.

ATLAS EXPERIMENT