

# $t\bar{t}H$ Searches for Run 2: Some Open Issues from the CMS Perspective

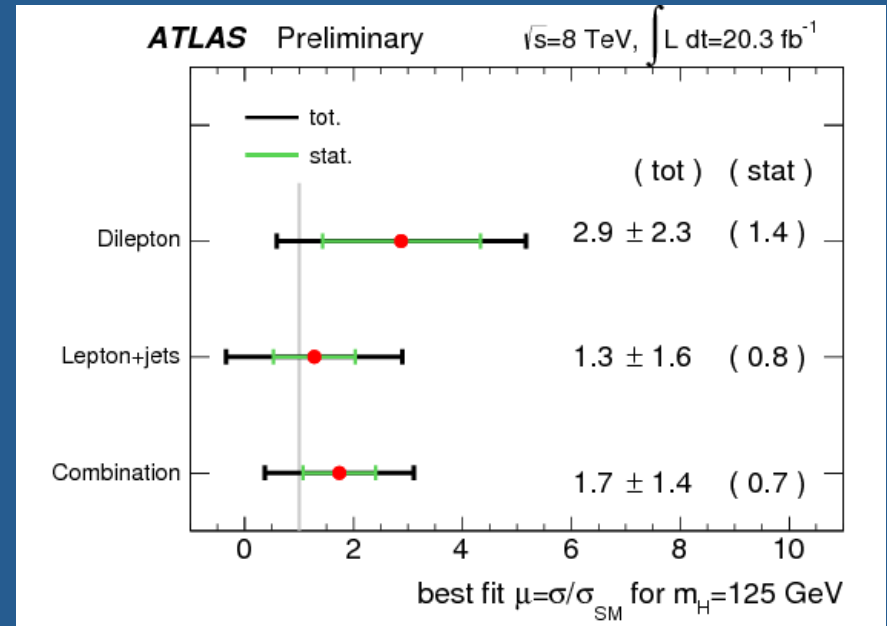
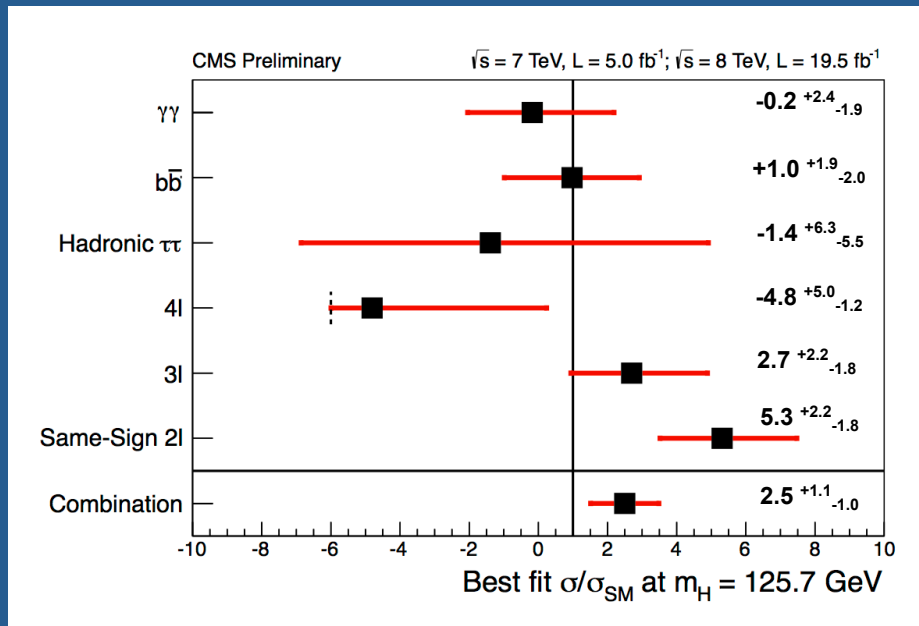
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On behalf of the CMS  $t\bar{t}H$  analysis groups



# ttH: Status of Experimental Searches



- ttH:

- Crucial to observe – direct probe of top-Higgs coupling
- Rare process, but given sufficient statistics, access to every Higgs decay mode
  - High BR channels: Challenging, yet-to-be precisely-measured SM backgrounds
  - Low BR channels: Clean signatures but tricky instrumental backgrounds
- Campaigns at both CMS and ATLAS looking at various Higgs decay modes, coupled with different ttbar system topologies
- Systematics play a significant role – improved modeling very valuable, in particular for  $H \rightarrow b\bar{b}$

# Wishlist for ttH Searches

- Generally at CMS we seek to more-fully exploit the state-of-the-art higher order modeling of crucial background and signal processes
  - Already moving towards NLO ttH
  - Working also with higher-order tt+jets background modeling
  - Some open items remain...
- Highest priority: tt+HF
  - For Run 1, CMS used MadGraph inclusive tt+jets normalized to the NNLO inclusive cross section
  - The tt+HF components had an additional large 50% uncertainty applied to cover shortcomings of this simplified approach
    - Seek to avoid this large systematic uncertainty in Run 2 analyses
  - Desirable to have multiple tools modeling NLO tt+jets, specifically tt+HF production, interfaced to parton shower MC for Run 2

# Wishlist for ttH Searches

- tt+HF, cont'd:
  - Advancements on standalone tt+b-jets NLO generation
    - Computing intensive
  - What about tt+c-jets at NLO?
    - Not insignificant background contribution
  - Comprehensive approach to tt+jets modeling
    - If the processes come from independent sources, need some insight on how to cocktail together tt+LF, tt+(1,2+)c-jets, tt+(1,2+)b-jets
    - Ideal would be an agreement between ATLAS and CMS on how to model all components of tt+jets, based on input from the theory community
    - Issue goes beyond just choosing a generator, need also insight on proper handling of all systematics: scale, PDF, calculation scheme, merging, matching, etc.

# Wishlist for $t\bar{t}H$ Searches

- Currently  $t\bar{t}$ +photons background estimate is data-driven
  - Seek to also have higher-order MC for validation
  - NLO generator and a recipe for parton shower matching
- Higher order calculations:
  - NNLO  $t\bar{t}H$ ,  $t\bar{t}V$  inclusive cross sections and/or other ways to reduce cross-section systematic impact on Yukawa coupling measurement
- Systematics treatment questions:
  - How should we correlate systematics between  $t\bar{t}V$ ,  $t\bar{t}H$ ,  $t\bar{t}H$ ,  $t\bar{t}$ +jets? Is it reasonable to take data-driven corrections to MC from  $t\bar{t}$  and apply them to  $t\bar{t}V/t\bar{t}H$ , or use them as systematics?
  - What are appropriate systematic variations for the heavy flavor fraction of  $t\bar{t}$ +jets, and how can we realize them in generators?

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# Backup

