Uncertainties for S(implified) T(emplate) XS, version 1.3

LHC Higgs WG Workshop 2025

Sarah Heim with very helpful inputs from
Haider Abidi, Matteo Bonanomi, Jelena Jovicevic, Frank Tackmann, and others

STXS

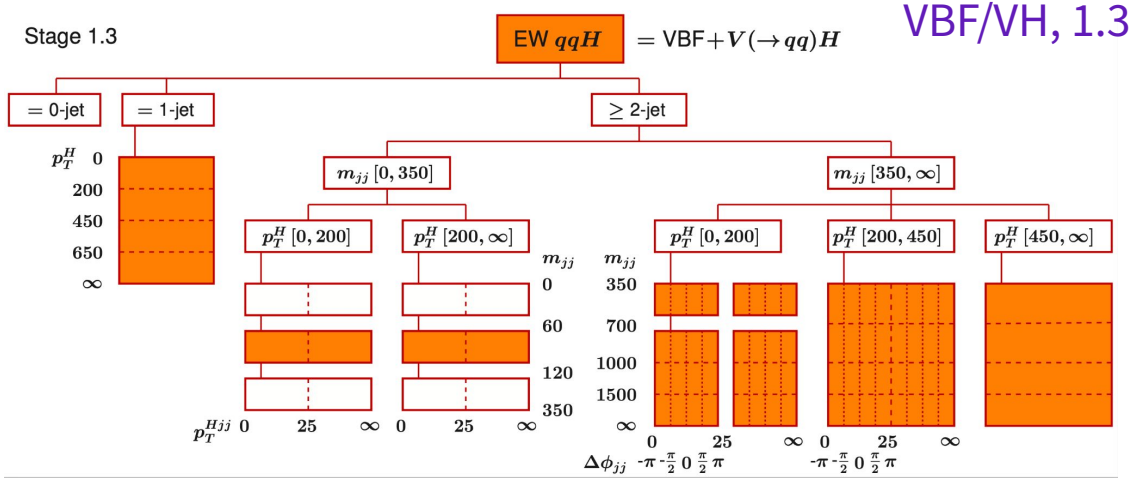
- agreed-upon fiducial binning for Higgs boson measurements
  - per production mode
  - bins depending on kinematics, jet multiplicity…
  - inclusive in decays (STXS decays long-standing effort)
- compromise between reconstruction-level and differential measurements
  - goal is limited extrapolation from measurements, (anti-)correlations, etc.
- used by ATLAS and CMS and theorists - simplifies combinations between channels and experiments, and interpretations
- evolves in stages, depending on the available statistics (final Run 2: Stage 1.2)

STXS 1.3

- STXS 1.3 binning is meant to replace the 1.2 binning for LHC Run 3
- it was defined as a community effort in 2024. See Matteo's talk from last year's workshop: https://indico.cern.ch/event/1389221/contributions/6217371/attachments/2981778/5250249/LHCHWG_STXS_Overview.pdf
- small changes to ttH, VHlep compared to 1.2 (additional pt bins mostly)
- more extensive changes to ggF and VBF/VH to include CP sensitive observables and accommodate the boosted channels a bit better

Fancy figures for the webpage are ready!

VBF/VH, 1.3



STXS uncertainties - methodology

- QCD uncertainties due to higher order corrections
  - generally, inputs are variations of renormalization and factorization scale
  - additional uncertainties in the different production modes include:
    - ggF: finite top quark mass, MS top mass variations, resummation uncertainty
    - ttH: scale variations that affect initial and final state variations, as well as parton shower
    - VHlep: only scale variations
    - VBF: only scale variations

ttH, 1.2

- Long-range Stewart-Tackmann method (arxiv:1107.2117)
  - extract uncertainties in exclusive bins from inclusive bins
  - provide independent uncertainties, which can be used as nuisance parameters in the different bins

p_T(H) [GeV]	Δ_y (%)	Δ_{60} (%)	Δ_{120} (%)	Δ_{200} (%)	Δ_{300} (%)	Δ_{450} (%)	Total (%)
0-60	9.2	-9.2	0.0	0.0	0.0	0.0	13.0
60-120	9.2	6.1	-7.7	0.0	0.0	0.0	13.5
120-200	9.2	0.0	6.8	-4.3	0.0	0.0	12.2
200-300	9.2	0.0	6.8	7.1	-3.4	0.0	13.9
300-450	9.2	0.0	6.8	7.1	7.4	-2.2	15.5
450-inf	9.2	0.0	6.8	7.1	7.4	7.6	17.2

STXS uncertainties - 1.2

- Tried to only have it calculated once, but some duplication between experiments happened
- ggF and ttH were mostly calculated by Haider Abidi and Jelena Jovicevic **(ATLAS)**, also Jonathon Longford **(CMS)**
    - Methodology and results are documented in ATLAS Pub note (ATL-PHYS-PUB-2023-031)
- VBF: Claudia Bertella, Yacine Haddad, Alex Karlberg **(CMS/theory)**
- VHlep: Aliya Nigamova and Adinda de Witt **(CMS)**, first done by **ATLAS**
    - Documented in ATLAS Pub note (ATL-PHYS-PUB-2018-035)
- used in published analyses
- had plans to document the uncertainties in a SciPost report, but by now basically already obsolete…see documentation slide in the end of this talk

STXS uncertainties - plans for 1.3

- Remake the uncertainties for the new binning, following mostly the previous strategy
- Try to get them relatively quickly and not duplicate work between ATLAS and CMS

Tentative plans (input welcome!)

- ttH: update the uncertainties to 1.3, no change in samples etc.
- VBF: include the new calculations from arXiv:2507.22574 (WG1), will need help from authors in extracting inclusive scale uncertainties
- ggF: new calculations for the H+1 jet bins (arXiv:2408.13301), incorporate latest resummed calculations
- VH: new results for gg->ZH? need input from WG1 people

STXS uncertainties - personpower for 1.3

Personpower (all with lots of other duties…more volunteers welcome from WG1, WG2, and whoever else is interested)

- ATLAS: Jelena Jovicevic (ttH), possibly Haider Abidi, Robin Hayes (both ggF), Sarah Heim (VBF? unless other volunteers - definitely need help from authors of arXiv:2507.22574)
- CMS - currently looking for volunteers
- theory: Frank Tackmann

*A comment: One could really discuss whether this is a WG1 or WG2 activity, as it straddles both groups (which is fine!). However, if predictions are made in WG1, please remember to also calculate uncertainties or the inputs to the uncertainties (eg scale uncertainties in **inclusive** bins)*

Bonus: STXS (uncertainties) - documentation plans

- STXS 1.2 binning will be finally published this year in SciPost (accepted yesterday, waiting for final publication link)

- Next: publish 1.3 binning - first figures on webpage and then SciPost - work in progress

- In parallel: calculate and publish 1.3 uncertainties (appendix planned with 1.2 numbers)