

STXS Beyond Stage 1.2.

Frank Tackmann

Deutsches Elektronen-Synchrotron

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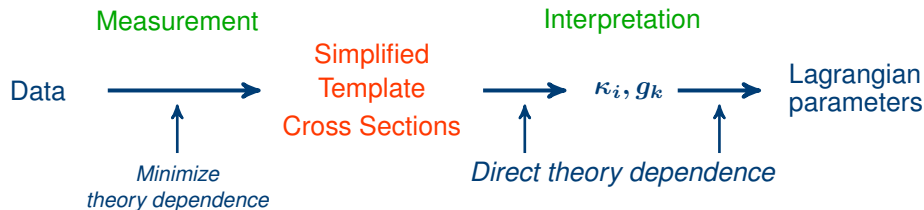


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Recap.

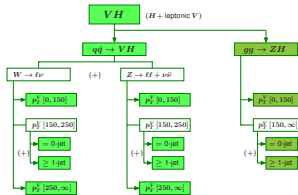
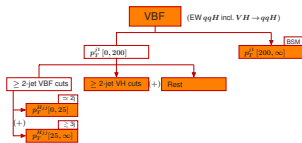
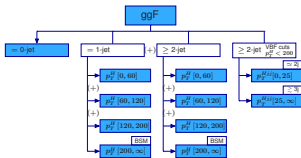
Separating Measurement from Interpretation.



Goals

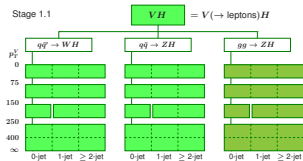
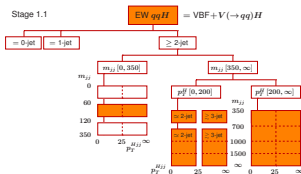
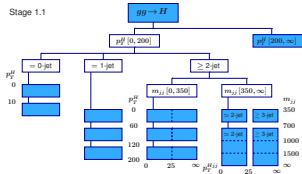
- Maximize sensitivity (combining decay channels)
- While at the same time minimizing theory dependence in measurements
 - ▶ Dependence on (SM) theory uncertainties
 - ▶ Dependence on (BSM) model specifics
- Measurements stay long-term useful
- Allow for “easy” (re)interpretation with different theory inputs/assumptions
 - ▶ Improved theory predictions/uncertainties
 - ▶ Different BSM scenarios, treatments (specific models, EFT, ...)

Past Evolution.



● Stage 1.0

Past Evolution.

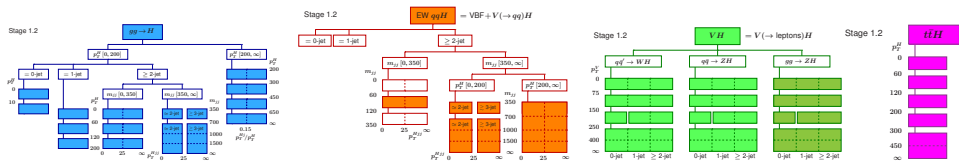


- Stage 1.0

- Stage 1.1

- ▶ Reorganize VBF selection cuts in VBF and ggF
- ▶ Introduce dashed bin boundaries for theory uncertainties and optional further splits

Past Evolution.



- Stage 1.0

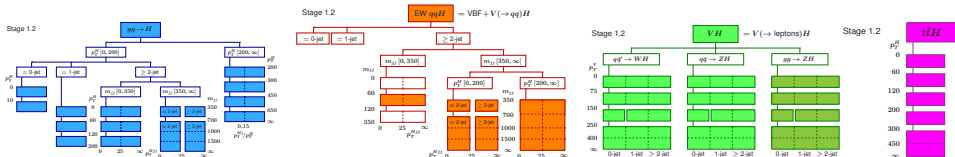
- Stage 1.1

- ▶ Reorganize VBF selection cuts in VBF and ggF
- ▶ Introduce dashed bin boundaries for theory uncertainties and optional further splits

- Stage 1.2

- ▶ Add high- p_T^H bins in ggF
- ▶ Add $t\bar{t}H$ binning

Organizing Different Theory Dependences.



SM: Resolution variables

- Examples: $p_T^H \ll m_H$, p_T^{Hjj} , p_T^{Hj} / p_T^H
- Sensitivity to additional QCD emissions
 - Typically dominant SM theory uncertainties
 - Please also measure “vertical” splits (in particular undashed ones)

BSM sensitivity: Kinematics of underlying Born-process

- Examples: $p_T^H \gtrsim m_H$, m_{jj} , p_T^V
- Sensitivity to BSM effects

Boundary Conditions.

Choice of Binning Observable.

Experimentally

- Should be close to experimental selection/sensitivity
 - ▶ Allow for some acceptance corrections, but avoid large extrapolations
 - ▶ Example: p_T^V instead of m_{VH} in VH production
- Needs to be viable for all (possibly) contributing decay channels
 - ▶ Use proxy-variable as a compromise
 - ▶ Example: p_T^{Hjj} as resolution variable for 3rd emission/jet

Theoretically

- Should be well-controlled theoretically
 - ▶ Resolution variables that are (in principle) resumable to higher orders (beyond parton showers)
- Should sufficiently correlate with BSM sensitivity
 - ▶ Choice of binning tends to be more important than precise choice of variable

To Bin or Not to Bin.

- “Split-if-you-can”: Important to have sufficiently many bins
 - ▶ Residual in-bin uncertainties should be subdominant
 - ▶ Enough bins to resolve/distinguish BSM effects
 - ▶ At highest p_T , limits are also very useful
- “Merge-if-you-can”: Important to keep number of bins manageable
 - ▶ Too many unconstrained/almost empty bins pose problems for fits
 - ▶ A priori, for maximum consistency all bins have to be implemented internally by all analyses even if individual analyses typically only target a small subset
 - ▶ Phase-space edges can also pose problems for theory predictions

⇒ Binning choice is always compromise between both constraints

- ▶ What is the smallest number of bins to capture dominant theory effect?
- ▶ What is the largest number of bins that can realistically be constrained in full combination?

Other Things to Not Forget.

- STXS are defined at truth-level for an undecayed Higgs
 - ▶ $H \rightarrow b\bar{b}$ are not counted as jets
 - Binning evolution should be backward compatible
 - ▶ Certainly over the course of a run
 - ▶ Perhaps not a strict requirement with new E_{cm}
 - Like to make informed binning decisions
 - ▶ Ideally based on concrete studies
- ⇒ In the past, we have leaned toward more than less bins (my personal feeling)
- ▶ Merging is easier than splitting – but only to a point
 - ▶ Premature bins are also bad, since we cannot (easily) change/move a bin boundary later

Discussion.

Where To Go Next?

Thinking about possible targets

- LHC Run 3

- ▶ Stage 1.3: (Smaller) evolution/update from stage 1.2
- ▶ Should happen immediately

- HL-LHC

- ▶ Stage 2.0: 1000/fb
- ▶ Stage 2.1: ...
- ▶ A bit more time for studies, but starting now

⇒ Specify and keep in mind target of different ideas

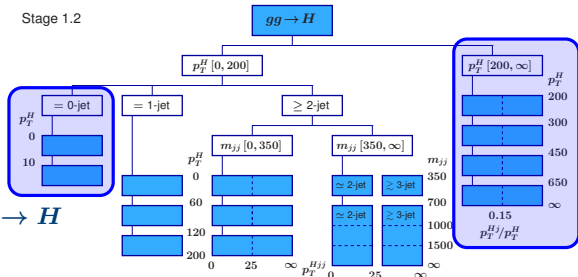
- ▶ Assignments in the following are my initial feeling

Ideas for Binning.

$gg \rightarrow H$

- More low- p_T^H bins (1.3)
- More high- p_T^H bins (2?)
- Generalize/clarify to mean hadronic production $gg + q\bar{q} \rightarrow H$
- Split in $\Delta\phi_{jj}$ (2?)

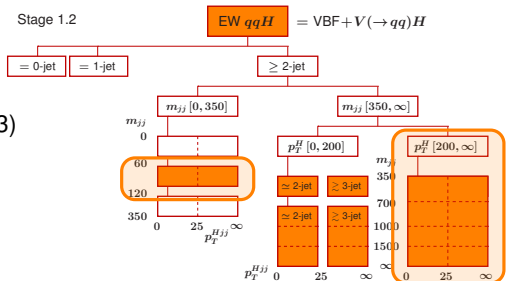
Stage 1.2



EW qqH

- Boosted VBF: More p_T^H bins (1.3)
 - ▶ Keep m_{jj} splits only in lower p_T^H
- $V(\rightarrow q\bar{q})H$: Split into p_T^H bins (1.3)
 - ▶ Check where it ends up
- Add $\Delta\phi_{jj}$ bins for CP: Where?
- Add VBF+ γ ?
 - ▶ Split into 0γ and $\geq 1\gamma$ bins

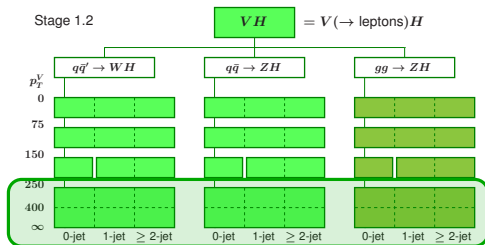
Stage 1.2



Ideas for Binning.

VH

- More p_T^V bins (1.3)
- Additional 2nd variable? (2?)
 - ▶ $\Delta\phi_{\ell\ell}$
 - ▶ $m_{T,\text{tot}}$
- p_T^H instead of p_T^V ?
(not unless strong motivation)



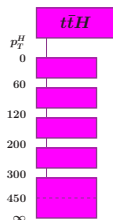
$t\bar{t}H$

- Generalize to include tH (1.3)
- More p_T^H bins?
- Useful second variable? (2?)

Decays (\rightarrow see Michael's slides)

- How to multiply with production bins

Stage 1.2



Backup Slides.

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