

STXS: Overview and new binning

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on behalf of the STXS/Fiducial sub-group

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Basic idea of STXS

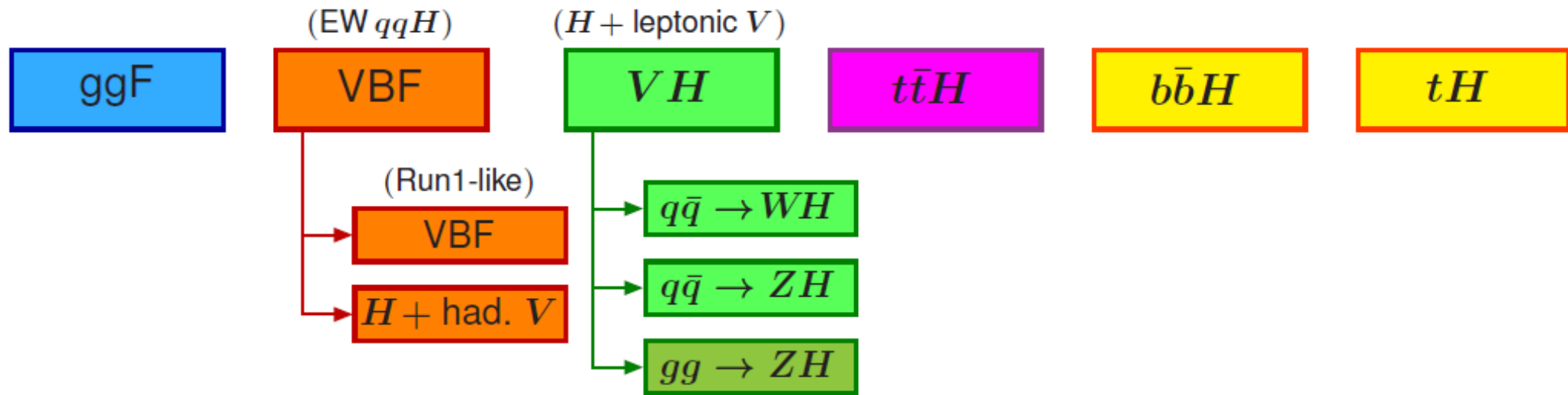
- **Direct measurements (Run 1 μ , CP-odd OO, ...)**
 - ✓ **Maximum sensitivity**
 - ✗ **Theory model, uncertainties and predictions are part of the measurement. If these change \rightarrow redo measurement**
- **Differential fiducial measurements**
 - ✓ **Best model and theory independence**
 - ✗ **Less sensitive: measurements use simple cuts and avoid selections with a strong production mode/signal dependence**
- **STXS == compromise**
 - **Use “most sensitive analysis” to separate between Higgs production modes and against backgrounds**
 - **Extrapolate (unfold) to coarse kinematic regions for each Higgs production mode**
 - ✓ **Good sensitivity while keeping reduced theory dependence**

STXS: the fine print

- **STXS is designed for the combination of all Higgs measurements. Conflicting requirements:**
 - **Use simple truth “fiducial volumes” == STXS bins abstracted from the often complicated experimental selections**
 - **Nevertheless, aim to avoid large extrapolations from experimental selection to the STXS bins**
 - **STXS bin definitions should ~ work for all Higgs final states**
- **For each Higgs production mode, use the SM process as kinematic template**
 - **If this turns out to be limiting → bin finer**

STXS stages

- STXS stage 0
 - Production mode cross sections ($|Y_H| < 2.5$)

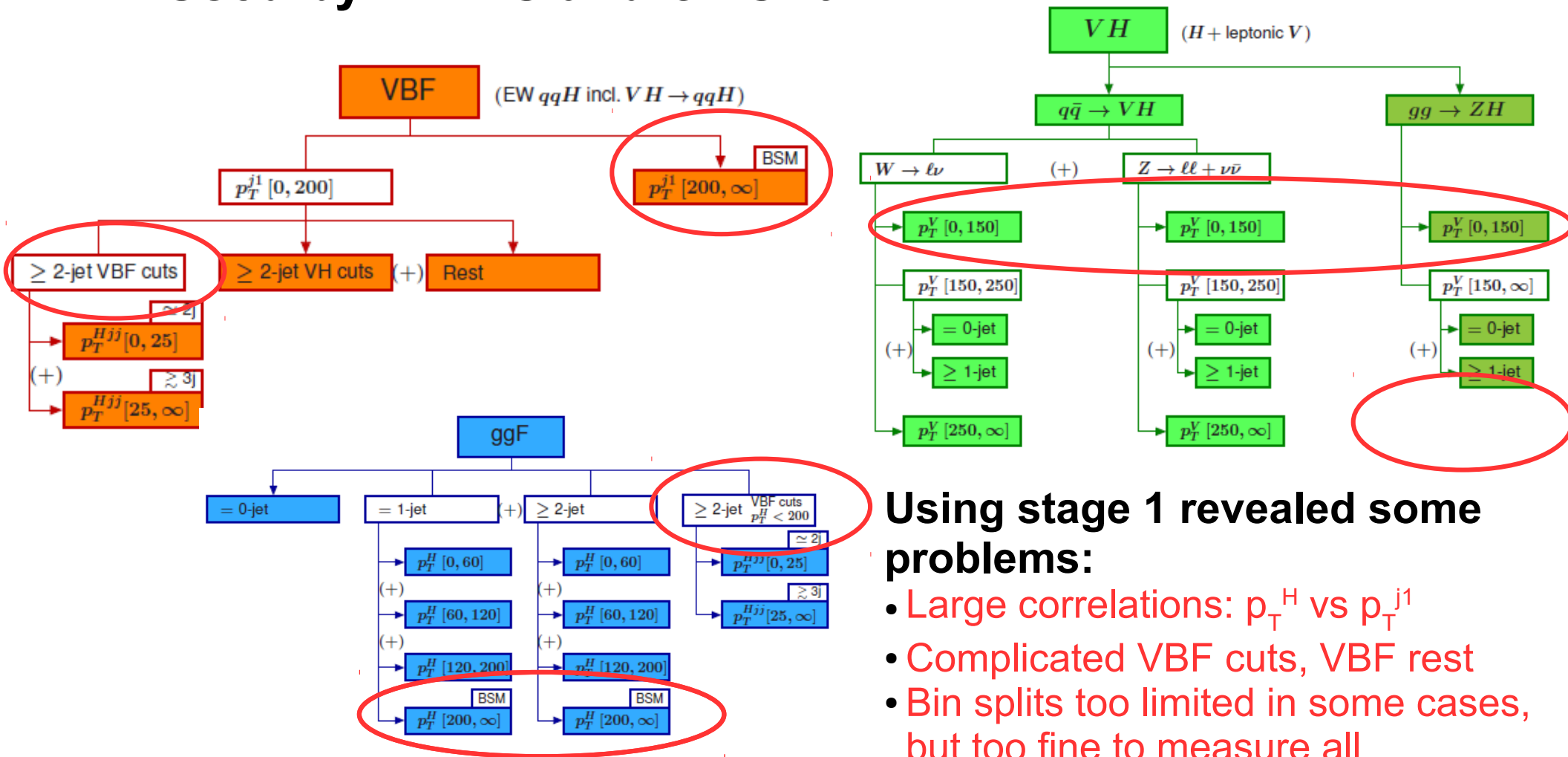


- Replaces the LHC Run 1 μ measurements

STXS stages

- Stage 1

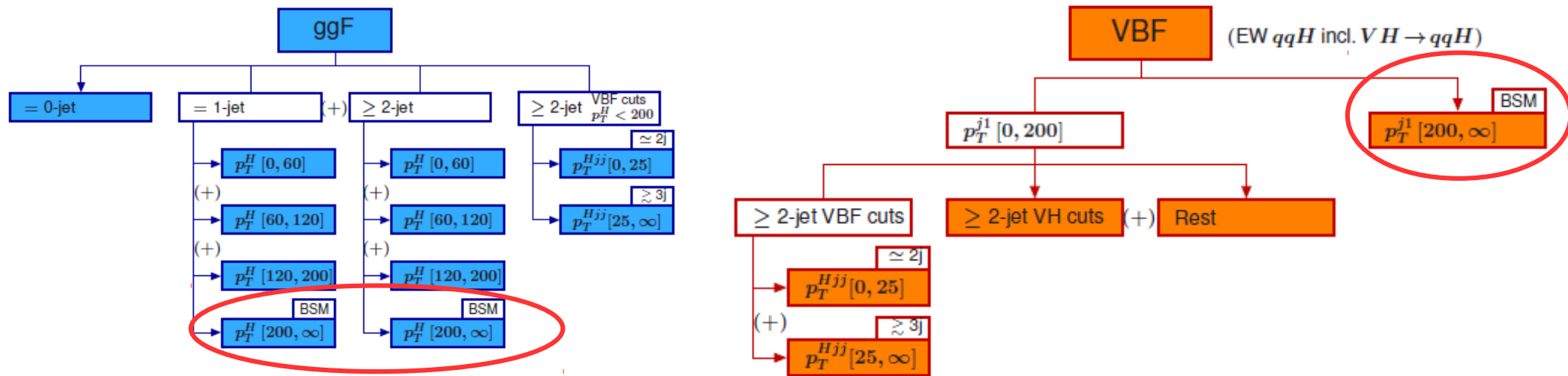
- First proposal to measure kinematic bins
- Used by ATLAS and CMS for first Run 2 measurements



Using stage 1 revealed some problems:

- Large correlations: p_T^H vs p_T^{j1}
- Complicated VBF cuts, VBF rest
- Bin splits too limited in some cases, but too fine to measure all

Example: Need for revision

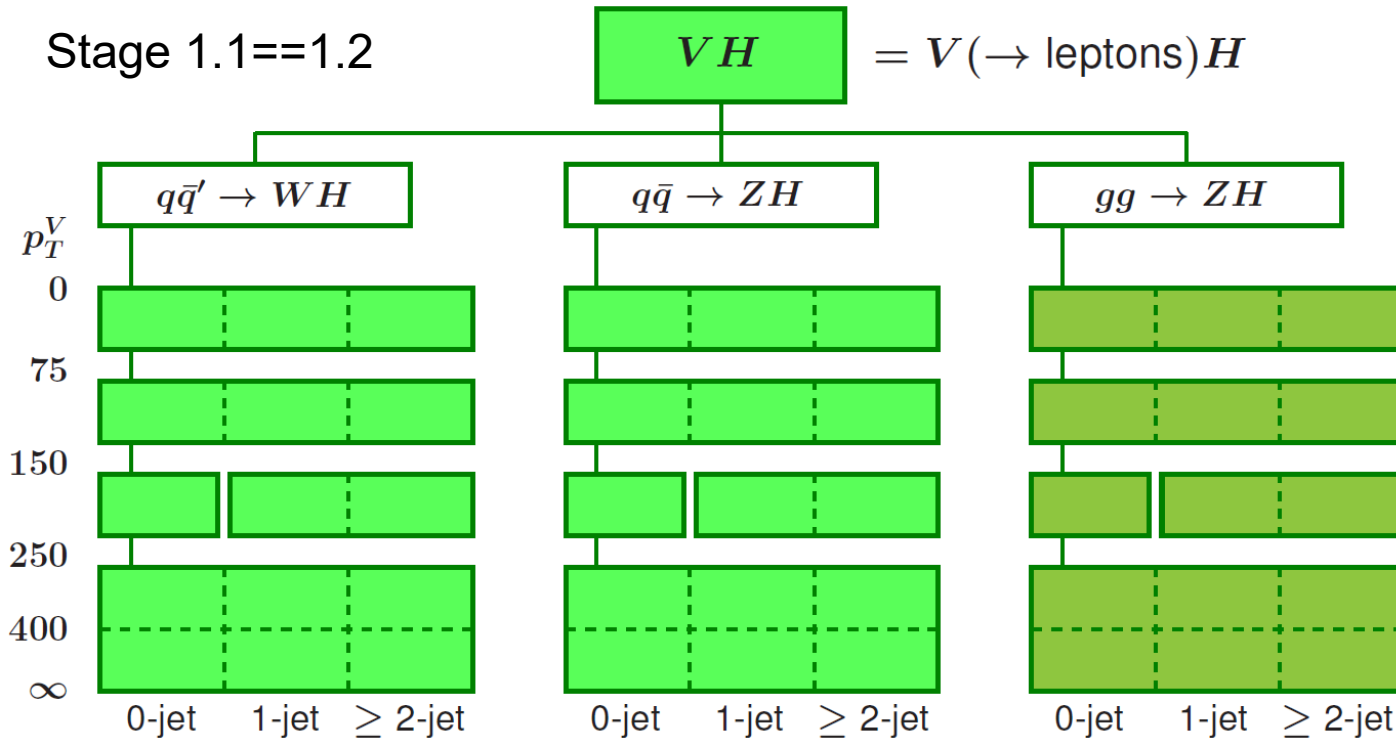


- Idea of STXS: bin each channel according to SM theory uncertainties and **BSM sensitive regions**
 - **ggH: high p_T^H ↔ VBF: preferred high p_T^{j1}**
- Problem: experimentally little power to separate ggH from VBF in the common phase space of high p_T^H or high p_T^{j1}
 - Large anti-correlations
 - Because of different selections, many bins affected
- Revision: Switch to p_T^H also for VBF == fiducial-like bins
 - Similar BSM sensitivity together with new m_{jj} bins

Revised STXS stage 1.1

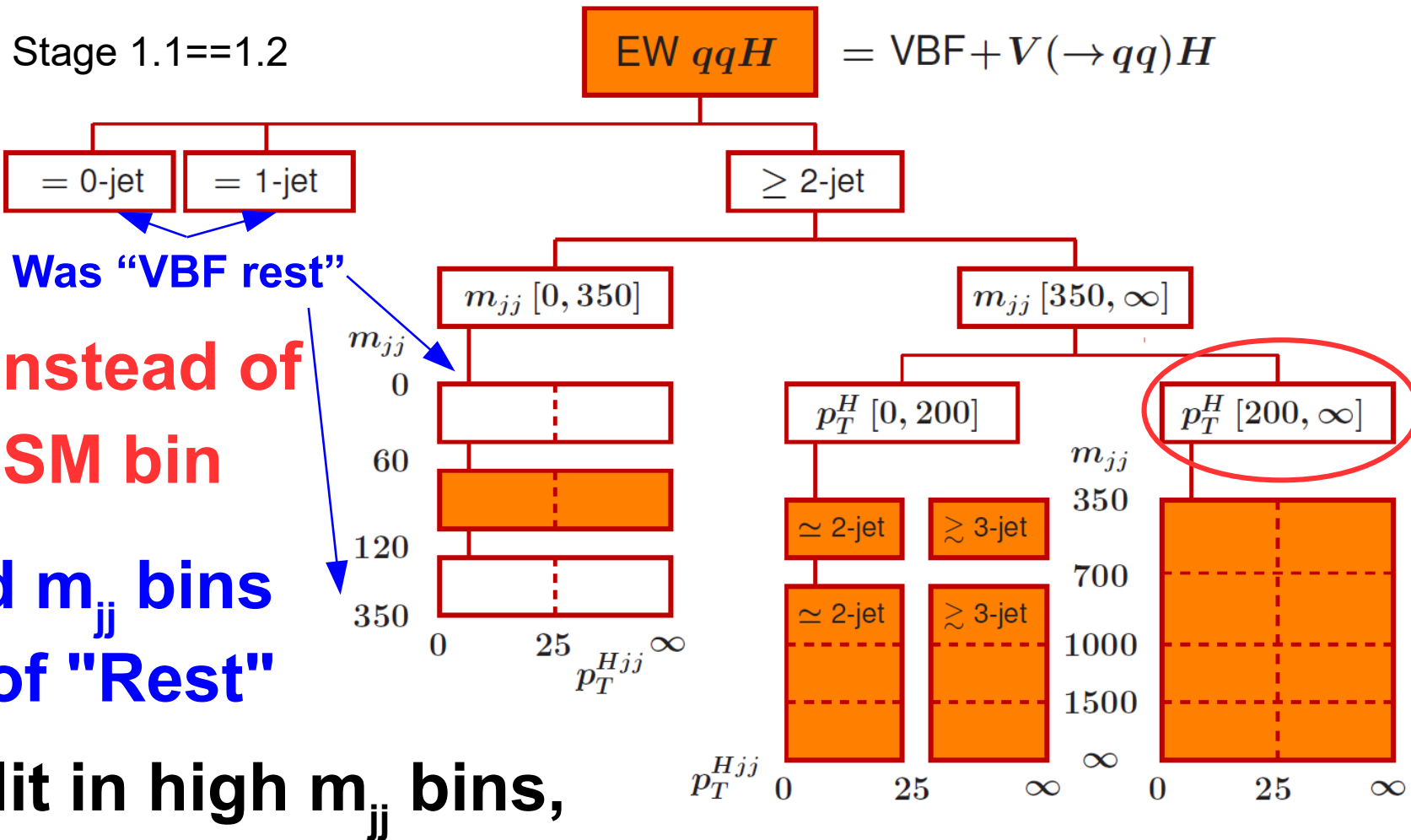
- After ATLAS, CMS and theory feedback from the first STXS measurements, improve the STXS binning for the final Run 2 papers
- Better match STXS bins to Higgs measurements
 - Improved ggH, VBF and VH bin definitions
 - Where there is no power to experimentally separate production modes, introduce common fiducial-like bins
 - Break backward compatibility if needed: VBF
- STXS uncertainties are extremely useful for a consistent implementation of theory systematics
 - Add "dashed" bin boundaries primarily intended for the calculation of systematics
- Sufficient data to probe further into tails
 - Extend STXS bins into high p_T or m_{jj} region

VH revised stage 1.1



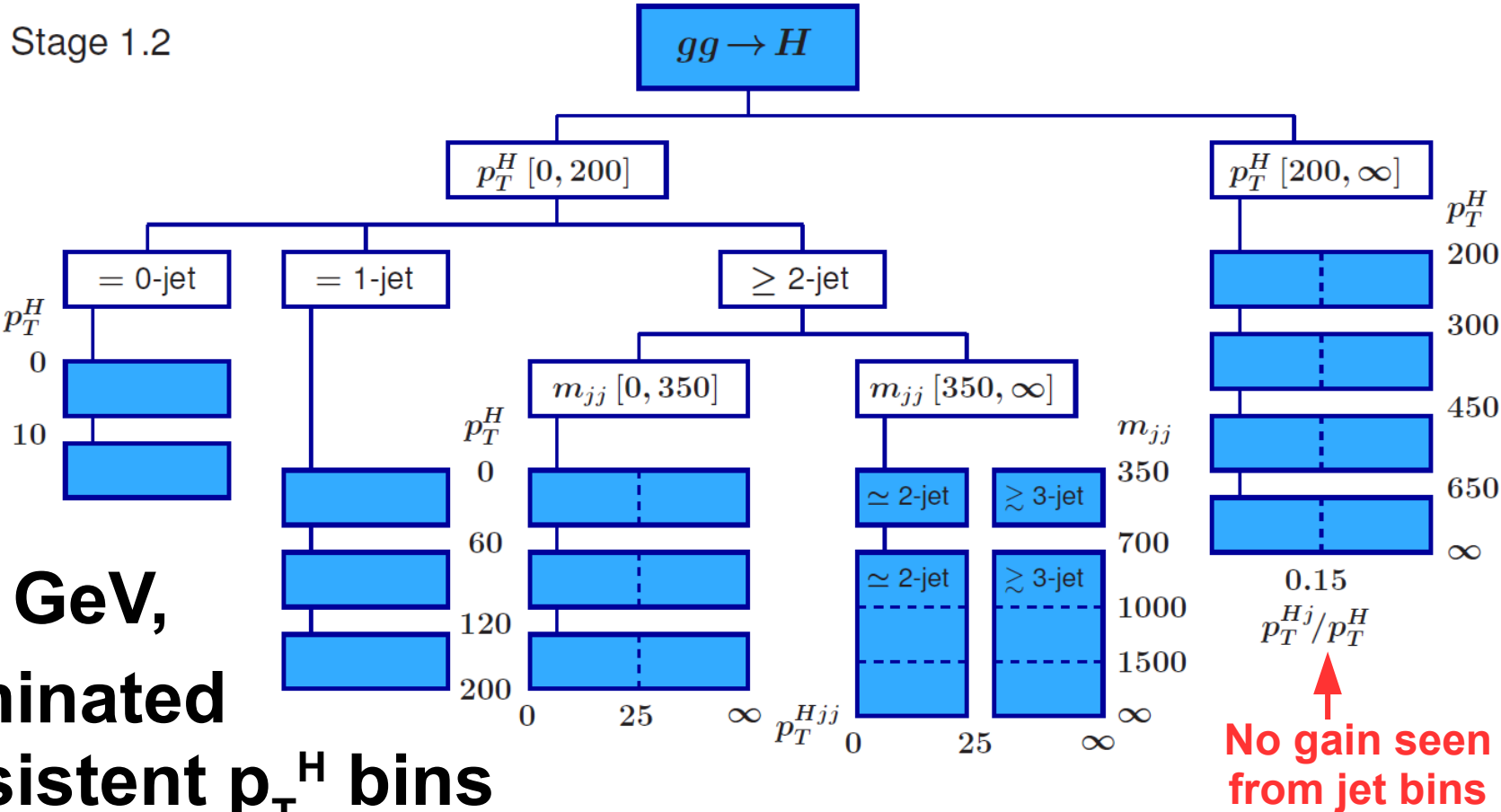
- Add a bin split at 75 GeV (and at 400 GeV)
- Consistent splitting in $qq \rightarrow WH$, $qq \rightarrow ZH$, $gg \rightarrow ZH$
- Consistent splitting into 0j, 1j, ≥ 2 j everywhere
- Experiments can now merge "fiducial-like"
- No further changes for revision 1.2

VBF revised stage 1.1==1.2



- Use p_T^H instead of p_T^{j1} for BSM bin
- 0j, 1j and m_{jj} bins instead of "Rest"
- Finer split in high m_{jj} bins, but drop $\Delta\eta_{jj}$ VBF cut
- New splitting reduces strong correlation with ggH
- No further changes for revision 1.2

ggH revised stage 1.1 and 1.2

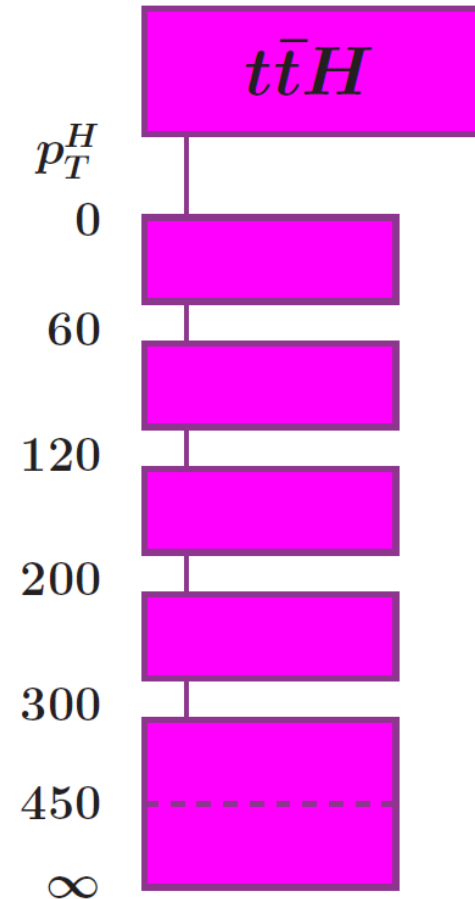


- $m_{jj} < 350$ GeV, ggH dominated use consistent p_T^H bins
- $m_{jj} > 350$ GeV, background to VBF: use VBF-like bins
- Stage 1.1: only one bin $p_T^H > 200$ GeV
- Stage 1.2: finer binning above $p_T^H > 200$ GeV

ttH stage 1.2

- First time STXS bins are introduced for ttH: want an observable related to the Q^2 in the ttH system
- Converged on p_T^H
 - Sensitive to BSM: CP-odd and H self-coupling
 - Can be ~ done in all ttH channels, does not need a top reconstruction
 - Binning can be matched to ggH background

Stage 1.2



Summary

- **STXS stage 1.2 is the goal for the full dataset Run 2 measurements**
- **Individual analyses do not have the sensitivity to measure all bins → Merge bins as best suited**
- **The ATLAS+CMS combination can hopefully approach ~ 1.2 granularity**
- **Stage 1.1 on arXiv: <https://arxiv.org/abs/1906.02754>**
- **Stage 1.2: write-up in preparation (update to 1.1)**