STXS for Run 3 with focus on CP violation

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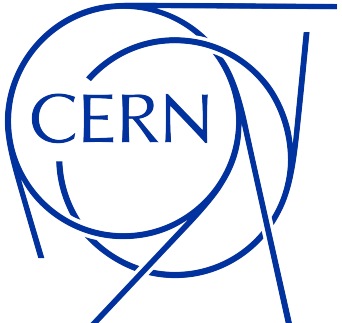
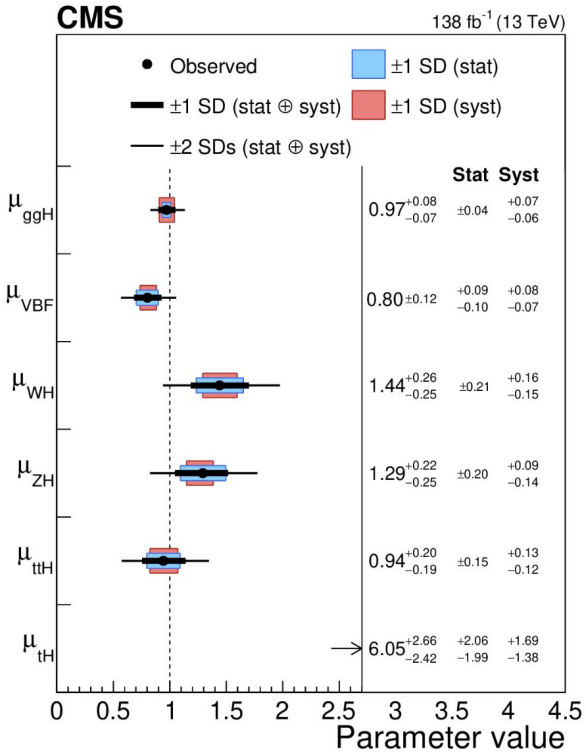
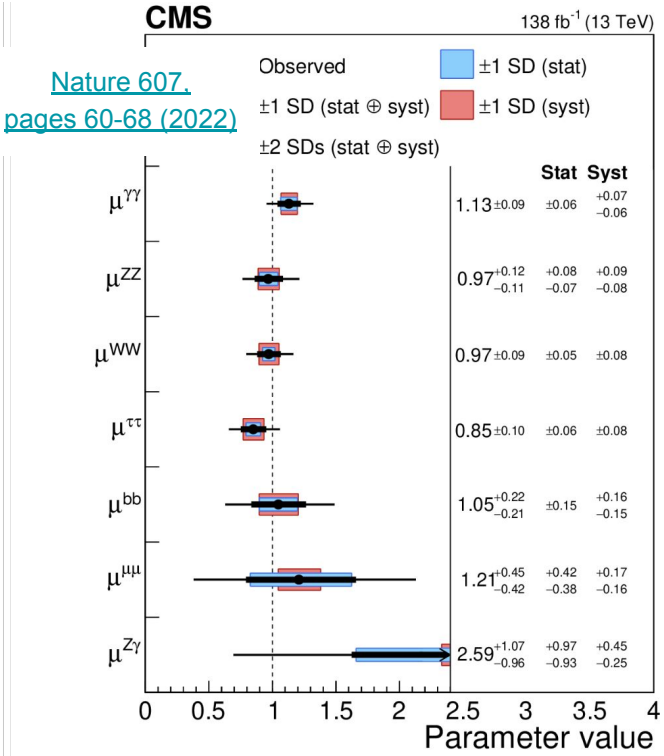


Simplified Template Cross Sections



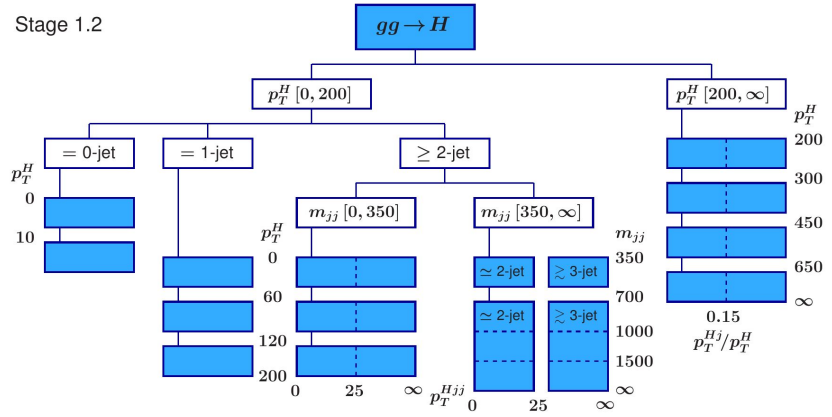
Nature 607, pages 60-68 (2022)

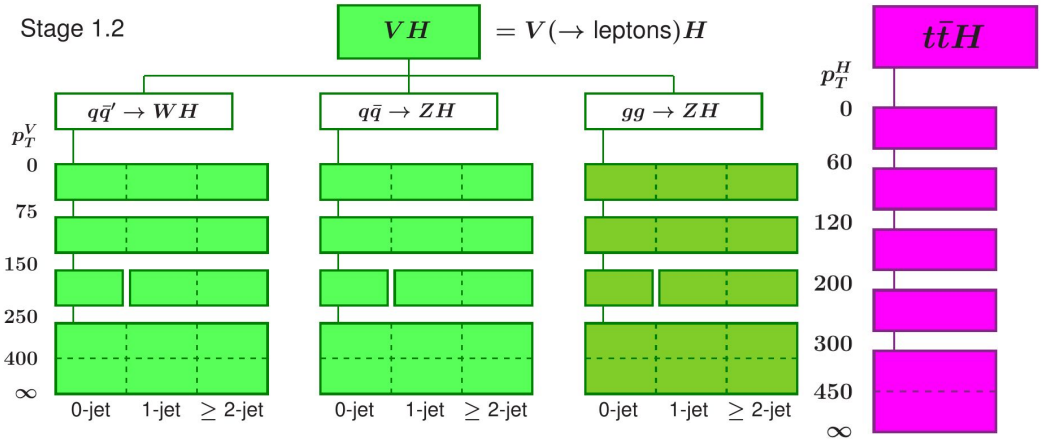


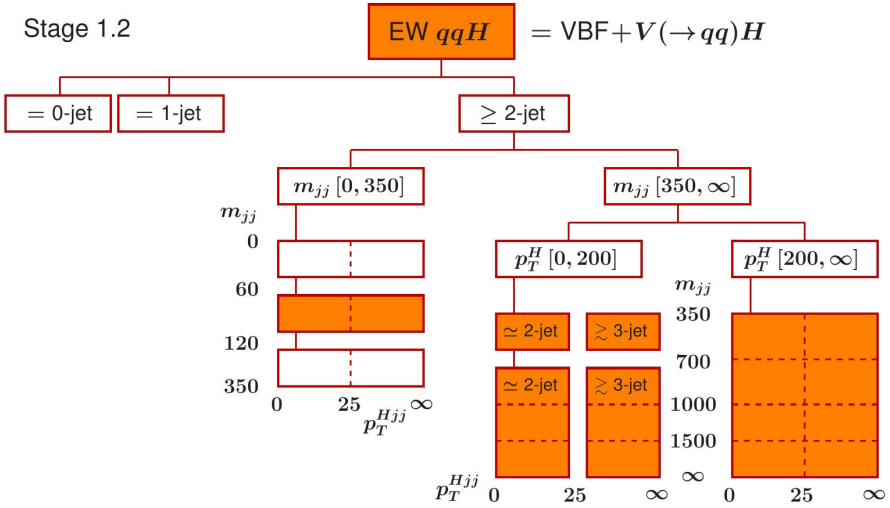
STXS: Study production and decay rates per mode

Disclaimer: next slides show ATLAS Nature 607, pages 52-59 (2022). No Run 2 CMS STXS combination yet afaik. ATLAS and CMS will have similar sensitivity

Simplified Template Cross Sections



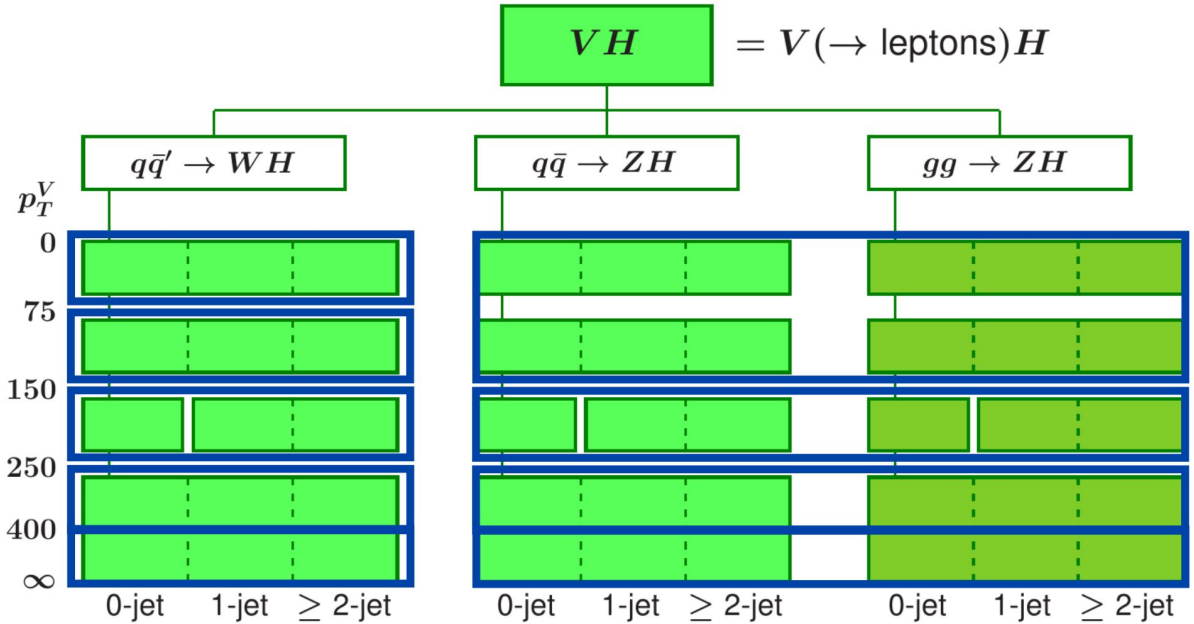


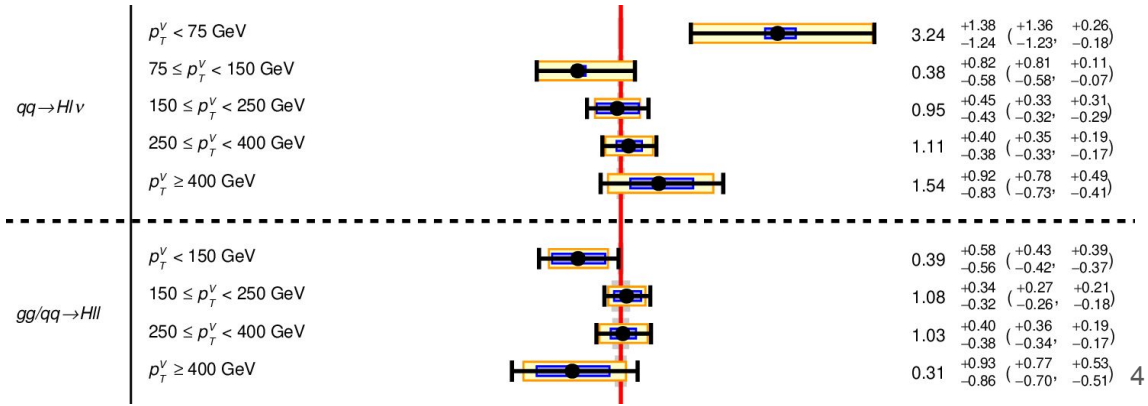


- Categorize Higgs production via key observables for each production mode
- Interpretation e.g. via EFT
- Same scheme for all decay channels and ATLAS/CMS, so can combine
- **Discussions for Run 3 scheme will have to converge soon**

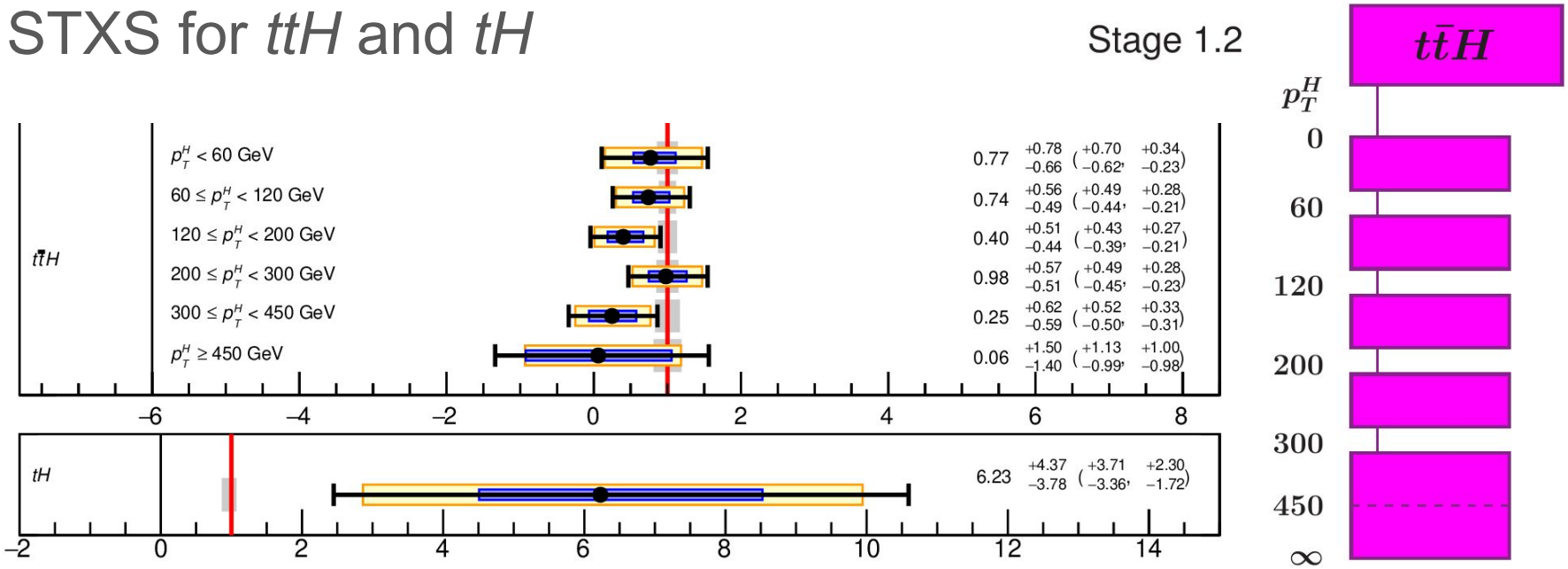
STXS for *VH*

- Cannot distinguish $qq \to H\ell\ell$ and $gg \to H\ell\ell$ experimentally
- Already use all high p_T bins. Define more to not run out?
- Split p_T^H instead of p_T^V?
  - p_T^V closer to $Z(\to \nu\nu)H$ analysis (E_T^{miss} trigger)
  - both hard to measure for $H \to \tau\tau$ and $H \to WW^*$



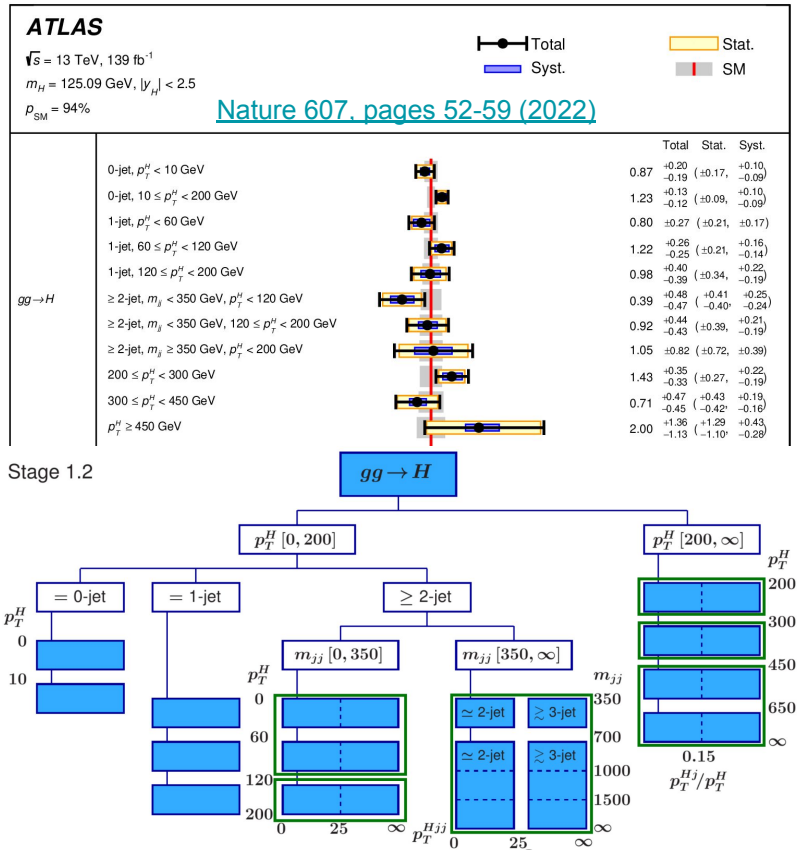


STXS for *ttH* and *tH*

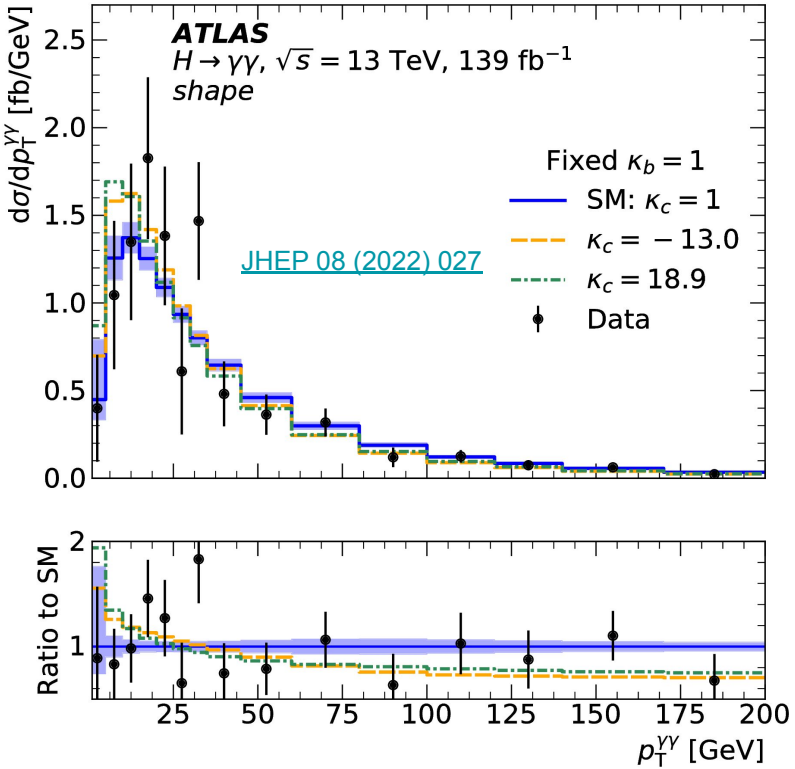


- Measure all *ttH* STXS bins quite precisely. Could use m_{ttH} but no clear advantage vs. p_T^H
- no *CP*-odd observable suitable for STXS to my knowledge. Would have to be “simple” and reconstructable for many Higgs decay modes
- Cannot bin Standard Model like phase space for *tH* before HL-LHC

STXS for ggF

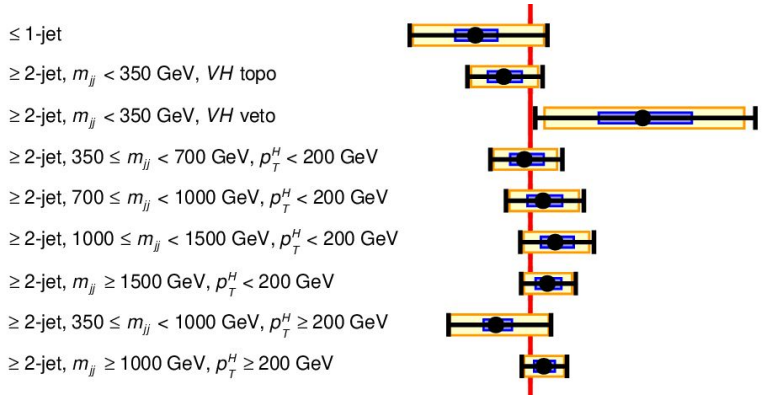


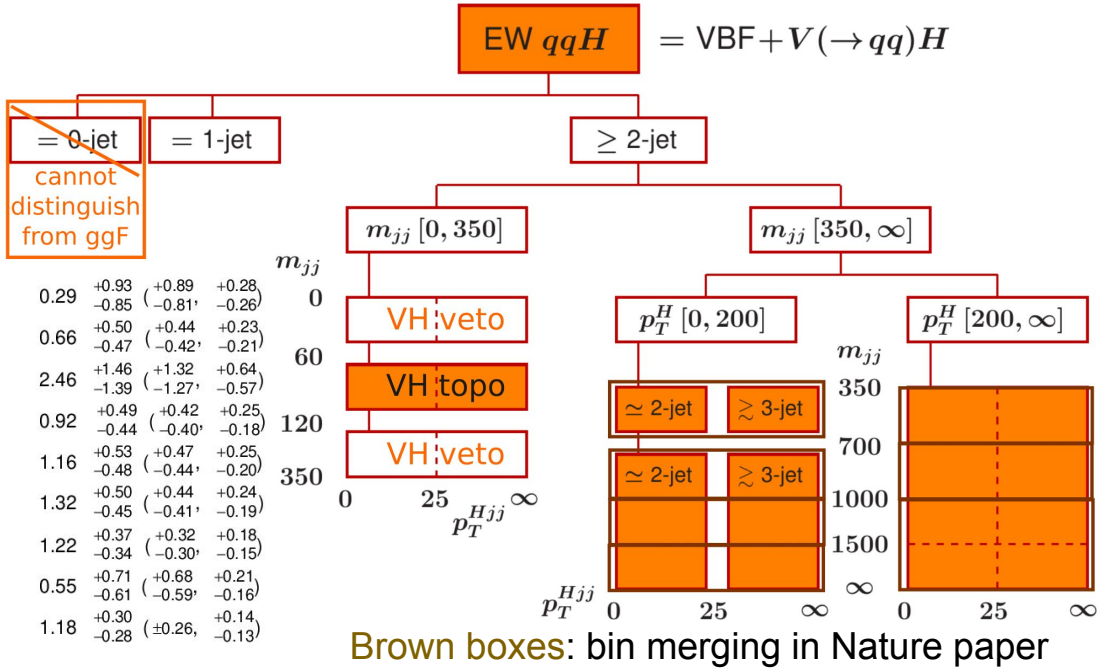
Boxes: bin merging in ATLAS Nature paper



- Often cannot do p_T^{Hjj} and m_{jj} splits. Categories useful to evaluate migration uncertainties from separating ggF and VBF
- Split 0-jet finer to access *Hc* coupling?

STXS for EW *qqH*

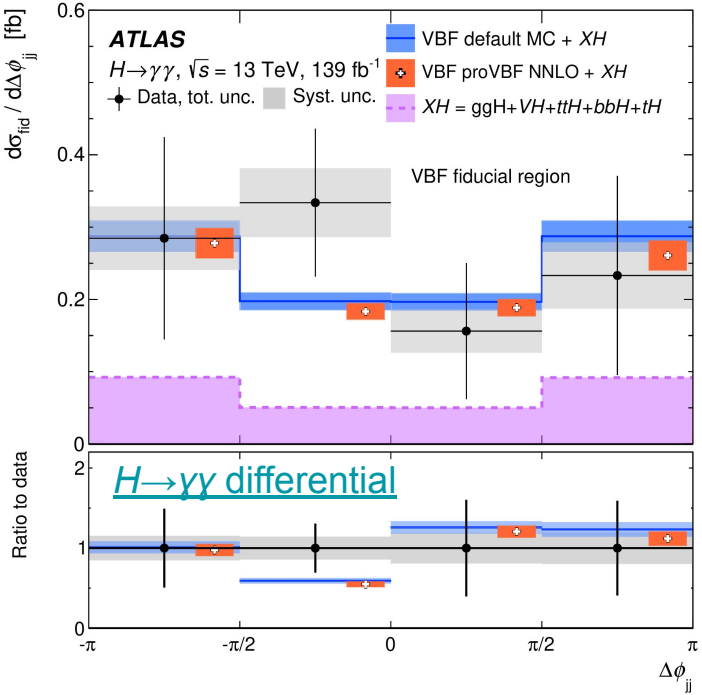


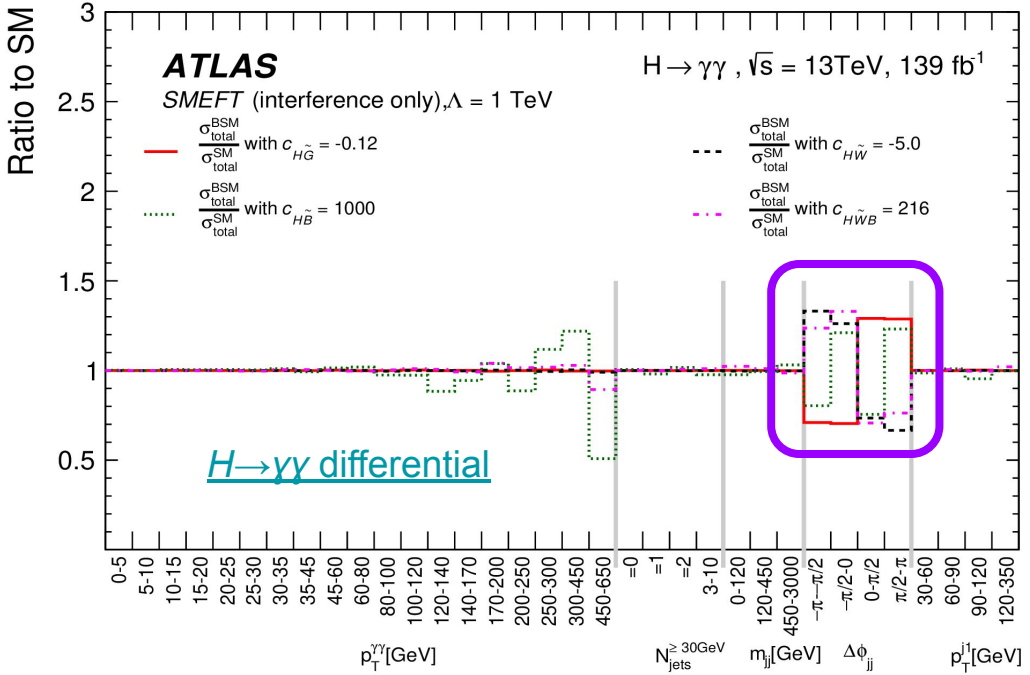


Brown boxes: bin merging in Nature paper

- Do nearly all m_{jj} splits
- Defined p_T^{Hjj} splits mainly for uncertainty estimate (see ggF)
- Could split *VH* topo. Measure
  - high p_T^H via boosted $H\to bb$
  - low p_T^H via $H\to\gamma\gamma$ and $H\to WW^*$

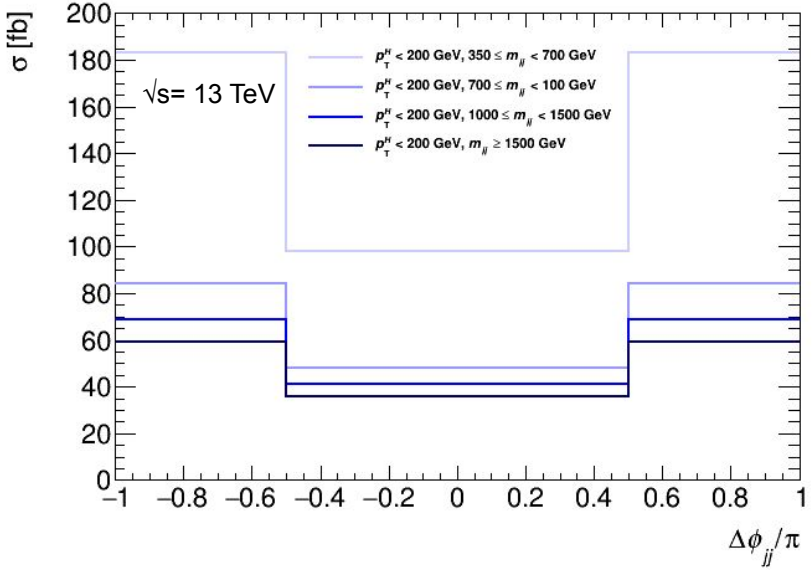
Sensitivity to *CP* Violation

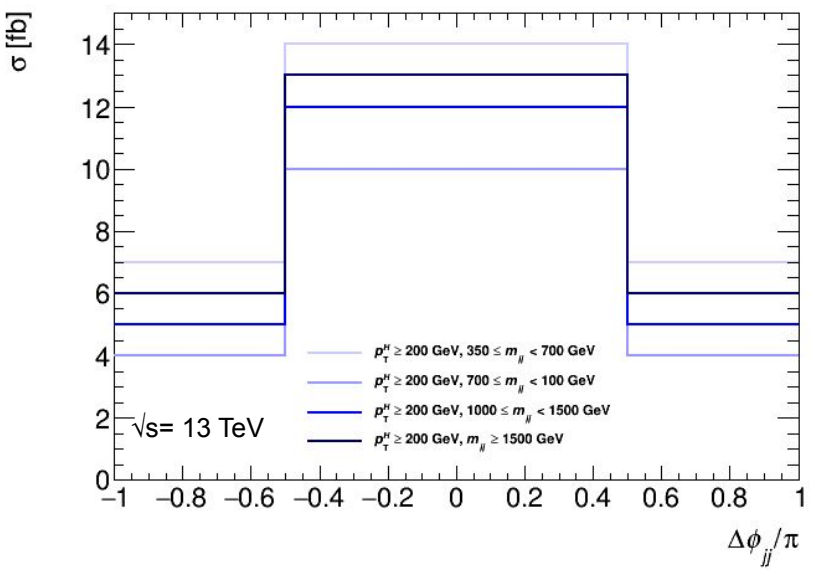




- Currently no sensitivity, all STXS observables are *CP* even. Plan to add $\Delta\phi_{jj}$. Need to find compromise with m_{jj} and p_T^H splitting
- Also possible for ggF 2-jet but challenging in terms of sensitivity

STXS 1.2 with 4 $\Delta\phi_{jj}$ bins. SM prediction

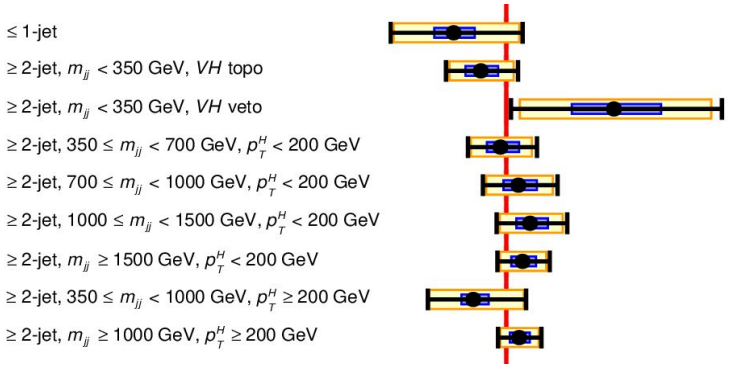


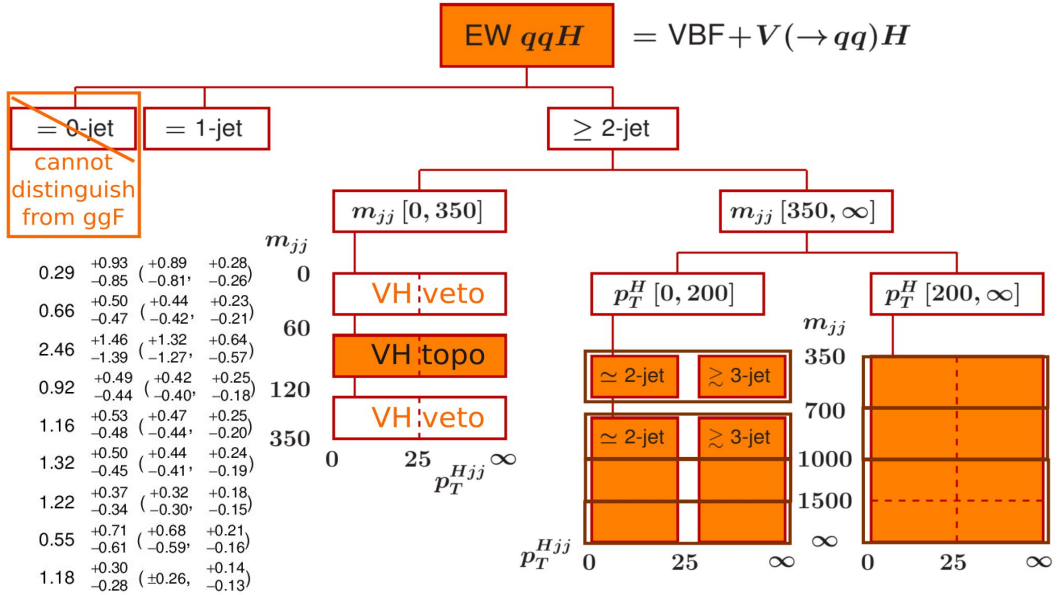


SM prediction derived with MadGraph5 by Matthew Basso. Numbers in backup

- Standard Model is symmetric (CP even)
- [-π/2; π/2] includes 35% of events for p_T^H < 200 GeV but 70% for high p_T^H
  ⇒ the less populated $\Delta\phi_{jj}$ bins include ~15% of the $\Delta\phi_{jj}$ inclusive yield

Possible binning





- 30–50% uncertainty when measuring nearly all STXS 1.2 bins
- powerful $H\to\tau\tau$ and $H\to WW$ channels merged the bins >200 GeV for Run 2 → can improve for Run 3
- splitting each bin for m_{jj}>350 GeV into 4 $\Delta\phi_{jj}$ bins seems reasonable to me. Analyses could merge m_{jj} bins when needed

Ideas and opinions are very welcome (also on points other than $\Delta\phi_{jj}$)

STXS 1.2 with 4 $\Delta\phi_{jj}$ bins. SM prediction

Cross-sections for 13 TeV **in pb**

p_T^H [GeV]	m_{jj} [GeV]	$\Delta\phi_{jj}$ [-π; -π/2]	[-π/2; 0]	[0; π/2]	[π/2; π]
<200	350 – 700	0.183	0.098	0.098	0.183
<200	700 – 1000	0.084	0.048	0.048	0.084
<200	1000 – 1500	0.069	0.041	0.041	0.069
<200	>1500	0.059	0.036	0.036	0.059
>200	350 – 700	0.007	0.014	0.014	0.007
>200	700 – 1000	0.004	0.010	0.010	0.004
>200	1000 – 1500	0.005	0.012	0.012	0.005
>200	>1500	0.006	0.013	0.013	0.006