# EFT status

Oleksii Kurdysh

24Feb2025/ Meeting FJPPN 2024

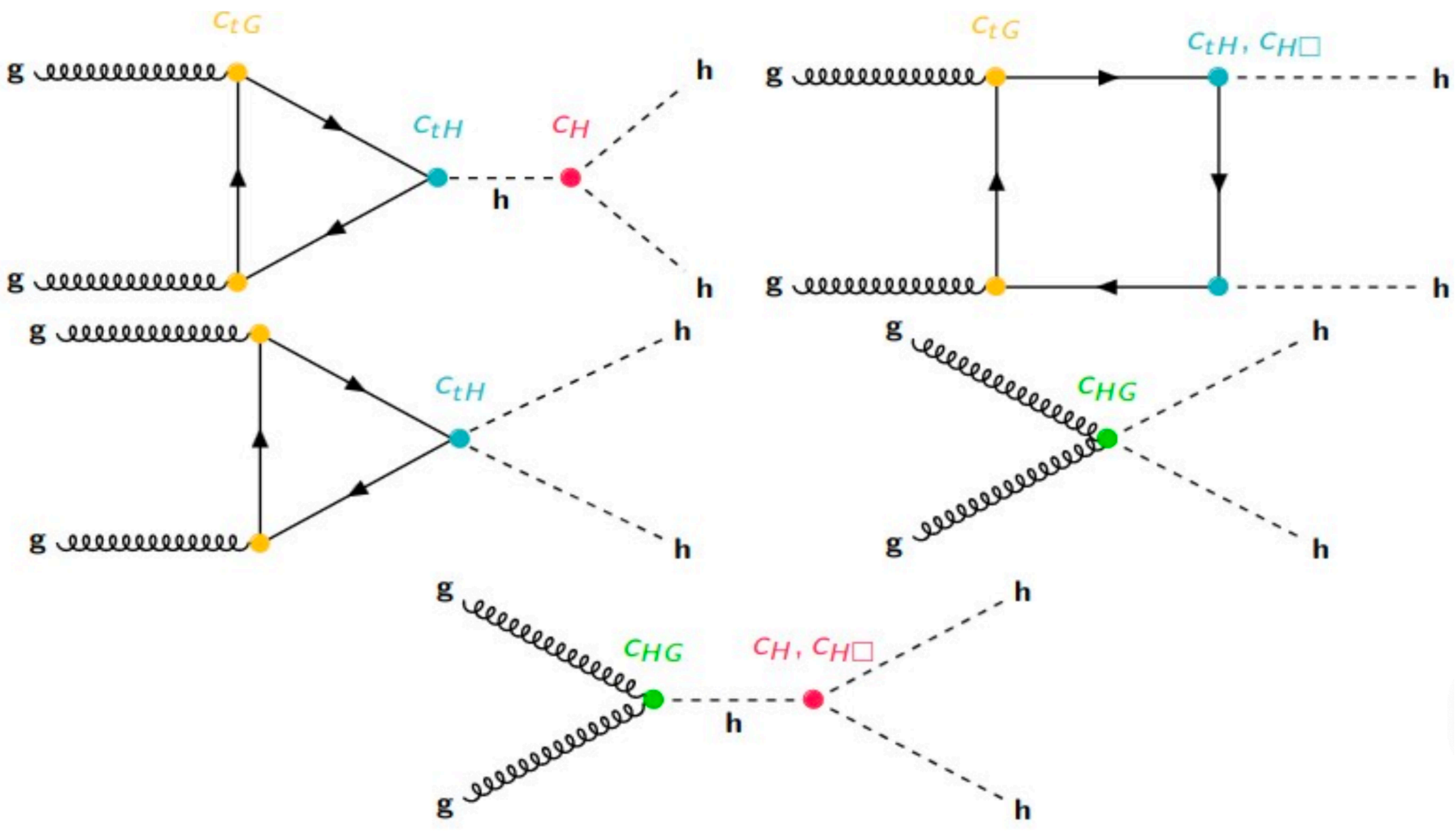
# Aside: truth-reco validation

- In EB they asked to check agreement for important variables in BDR training
- I picked up this SM sidequest
- Example for $\Delta R(\gamma, \gamma)$

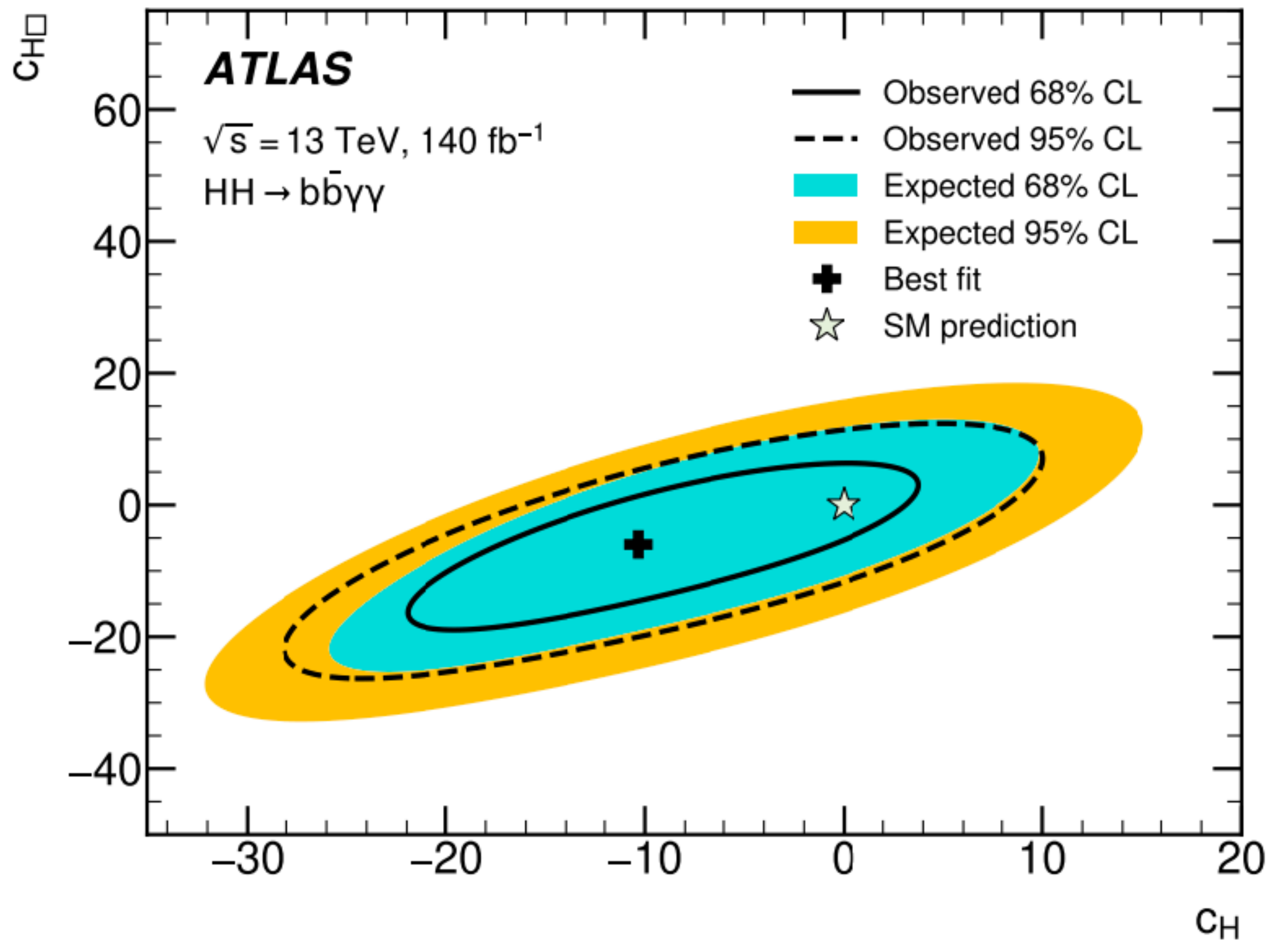

- In INT note now
- Next: to get photo-related non-HH samples distributions need to have info on truth photons
- Not there in easyJet -> will add

# Run-2 reminder

- Start from SM results and reweight yields per category to EFT in question
- Neglect VBF
- Obtained SMEFT constraints (without linear-only), 1D for two operators and their 2D

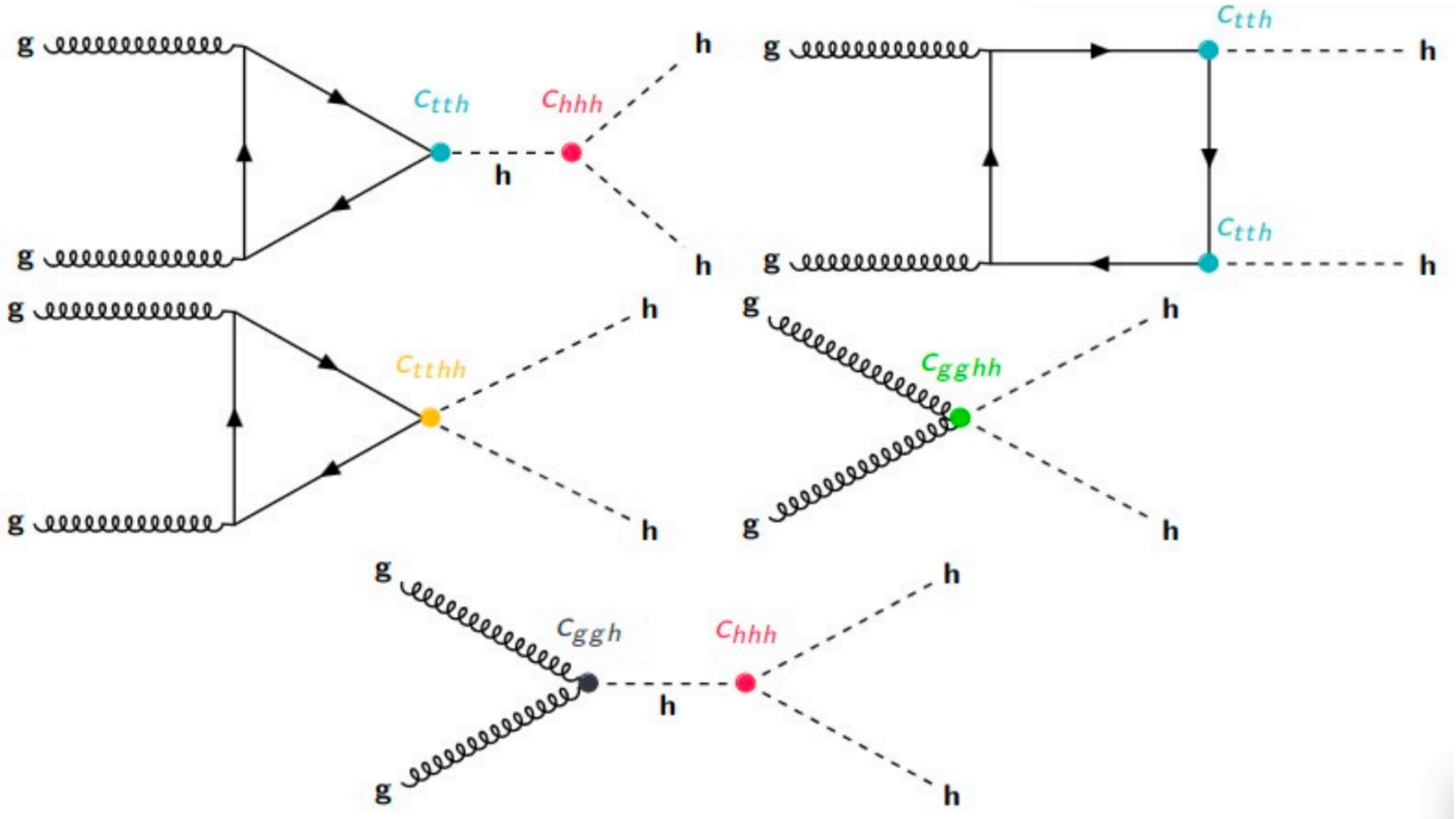


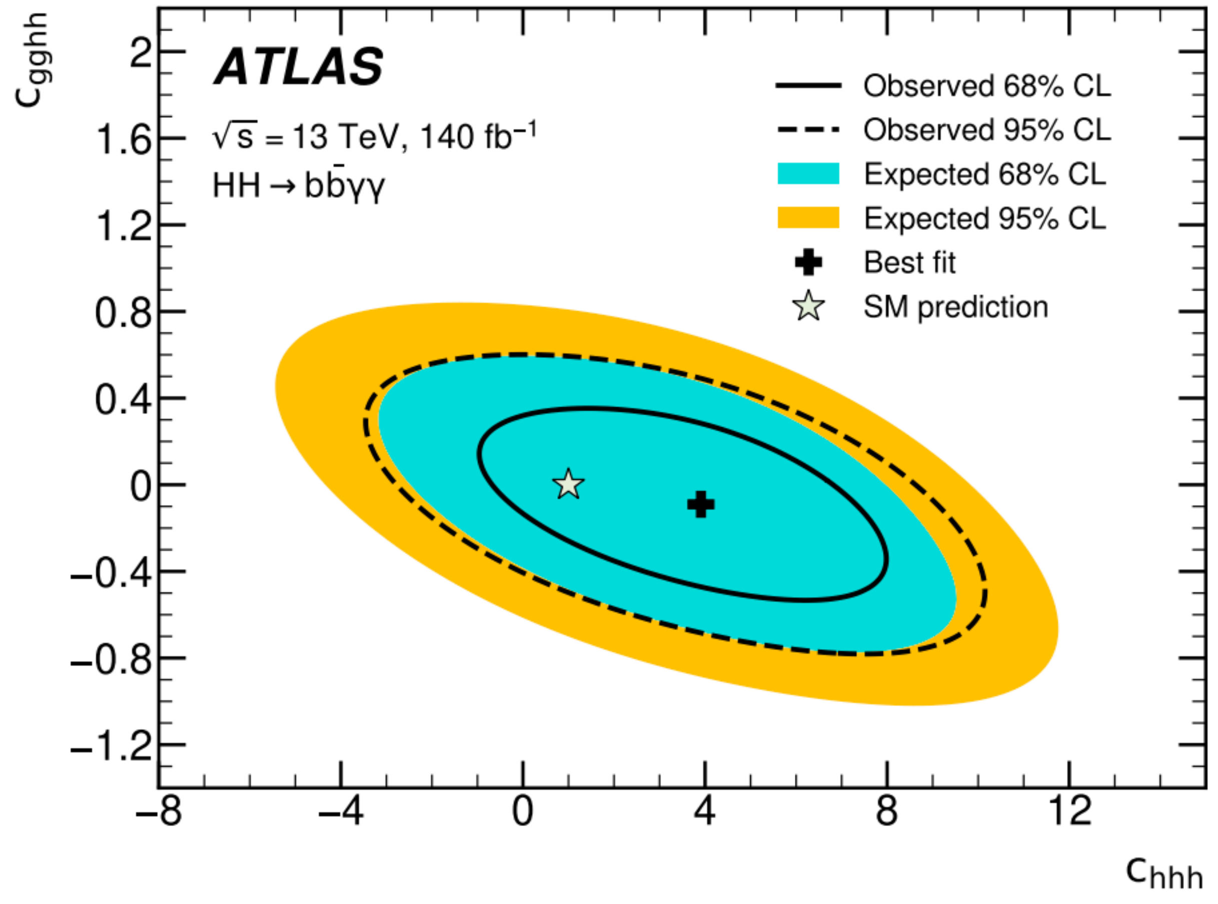

| Wilson coefficient | 95% CL Observed | 95% CL Expected |
|---|---|---|
| $c_H$ | $[-14.4,\ 6.2]$ | $[-16.8,\ 9.7]$ |
| $c_{H\Box}$ | $[-\ 9.4, 10.2]$ | $[-12.4, 13.7]$ |

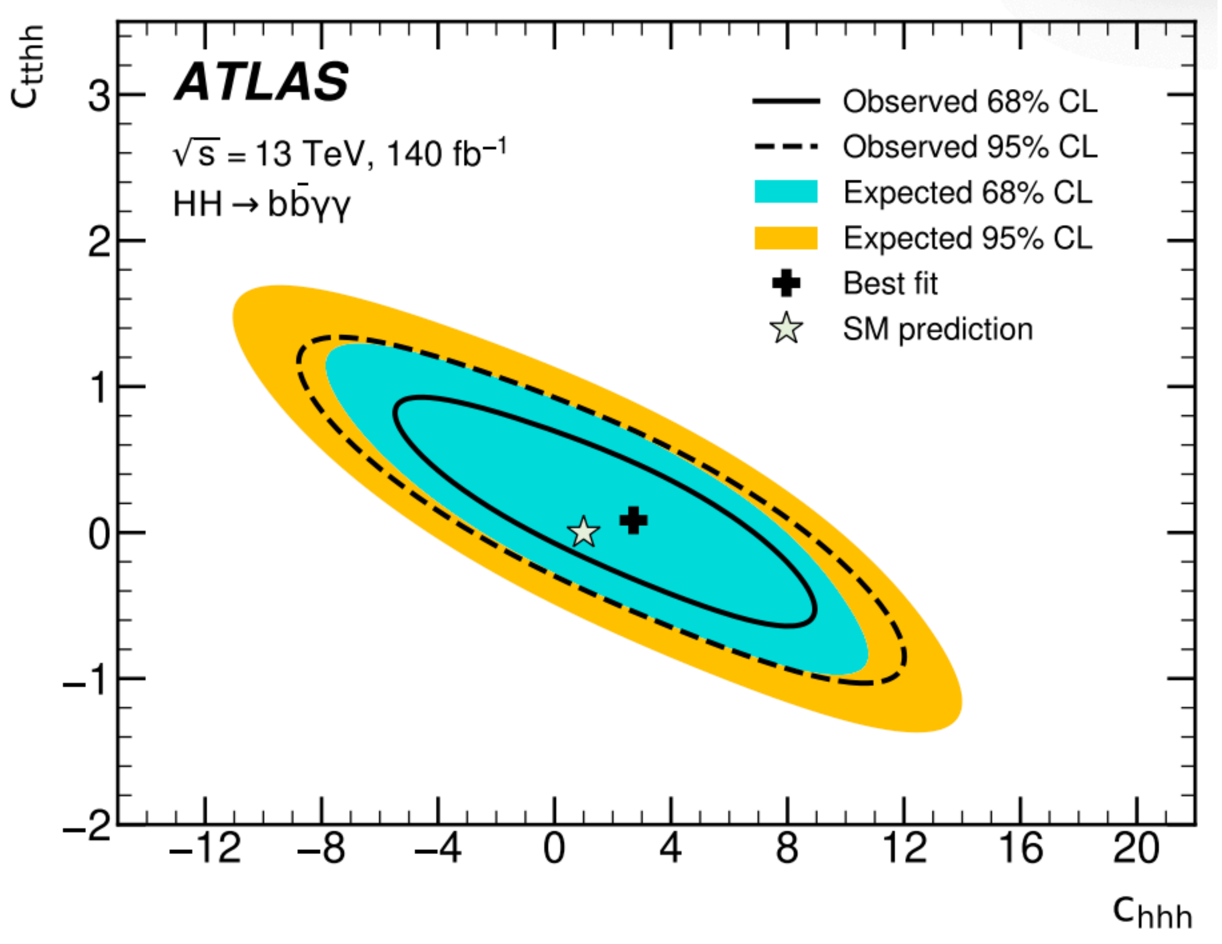


# Obtained HEFT constraints (without ttH, ggH)

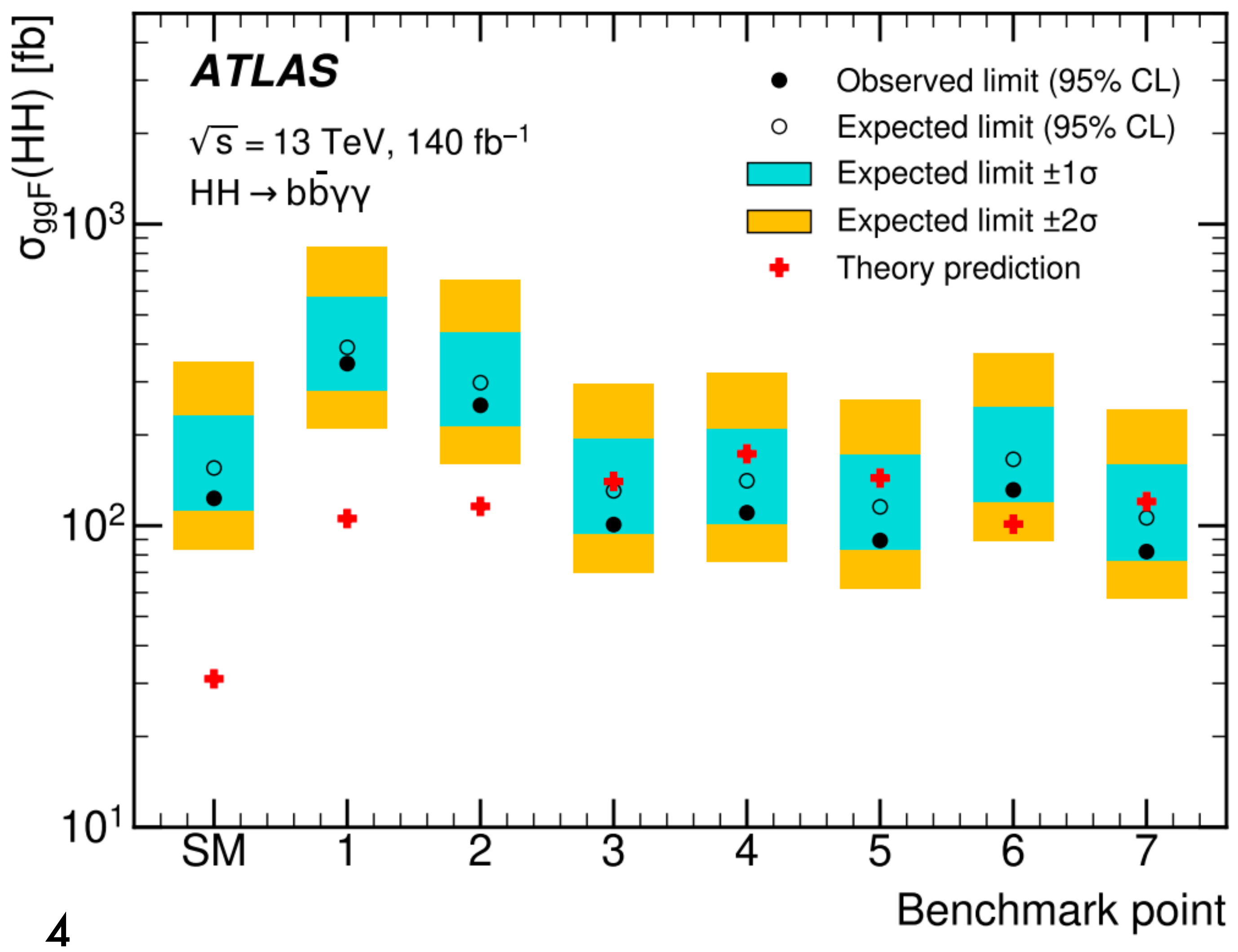
| Wilson coefficient | 95% CL Observed | 95% CL Expected |
|---|---|---|
| $c_{hhh}$ | $[-1.7\ ,7.7\ ]$ | $[-3.4\ ,8.9\ ]$ |
| $c_{tthh}$ | $[-0.28, 0.73]$ | $[-0.48, 0.94]$ |
| $c_{gghh}$ | $[-0.42, 0.52]$ | $[-0.59, 0.69]$ |






# And benchmarks limits (still interesting?)



# Goals for this round

- SMEFT
  - More operators ($c_{tH}$, $c_{HG}$, $c_{tG}$) in the SMEFT treatment + multi-D fit, to facilitate combination with single-Higgs
  - SMEFT effects in STXS bins for the single-H background, for the same reason
  - Linear-only case, since this is useful in testing SMEFT validity
- HEFT
  - 3D fits for the current operator list
  - ttH and ggH operators

# Current activities - STXS

SMEFT single-H was parametrized in $p_T$ only, move to STXS bins

- STXS flags are inside of PHYS(LITE) already, will read them in easyJet
- Include STXS uncertainties provided by TruthWeightTools
- MR, if not possible to get cleaned up TruthWeightTools (fails easyJet style checks) will remove it and have only categories for v7 ntuples
- Software upstream to easyjet is messy
  - STXS module got broken on one sample
  - temporary switched off by default
  - I will get back to this

# Current activities - EFT samples

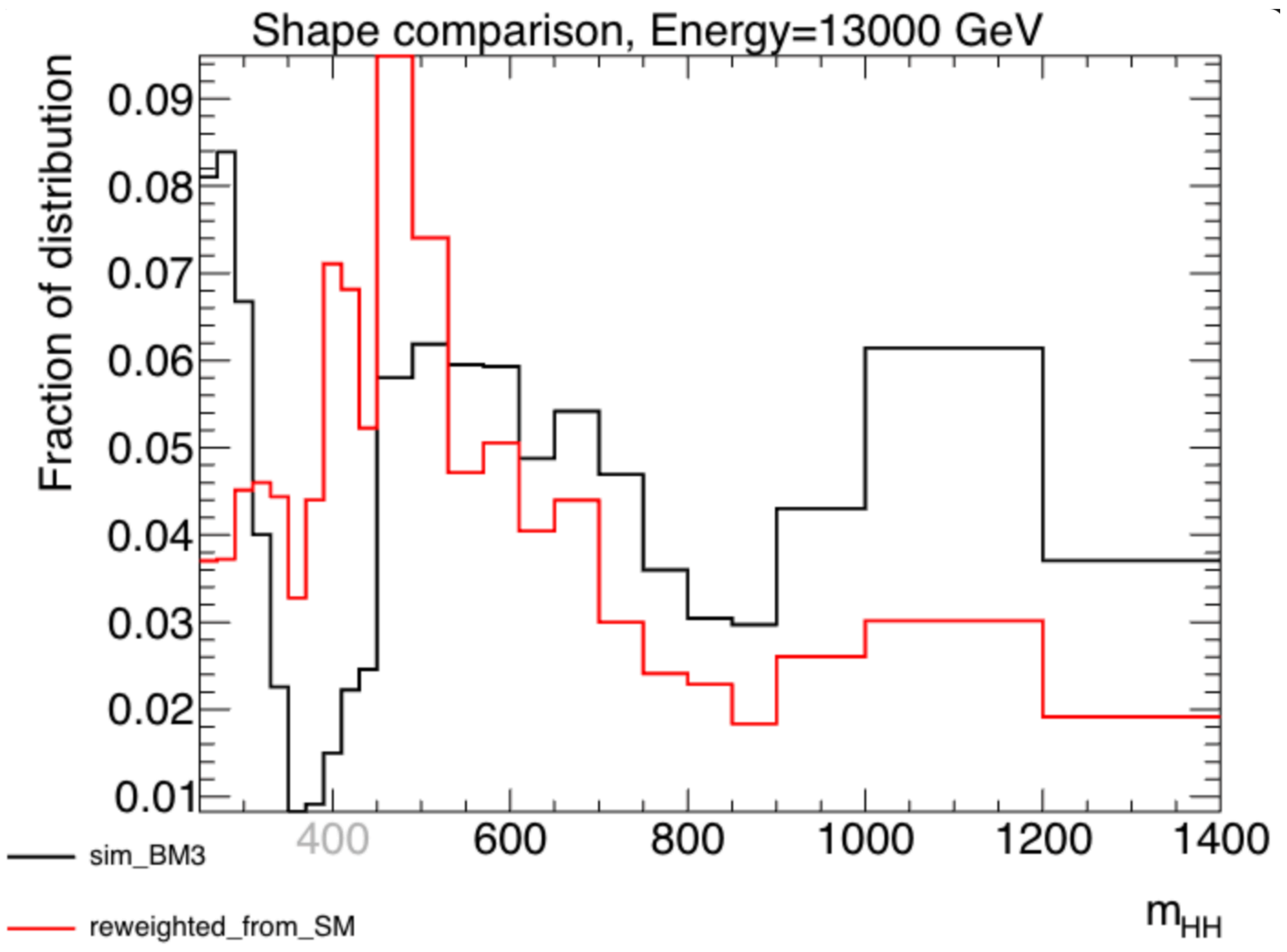
- Powheg NLO
- In previous round were based on private LHE instead of ATLAS generation
  - Ugly
  - Impossible to cross-check later
- -> Aim to do generation within ATLAS
- Nuance: I've found and reported/ fixed myself three bugs in ATLAS implementation of powheg
- But now it's running

- Heavy to generate, to get back GRID within typically 2 days need at least 50 cores
- Running myself in Lyon cluster (understands slurm)
- nOperators * nCoupling * nEnergies *... but there a certain quota I have

# Current activities - updated parametrisation of legacy

In legacy get SMEFT, HEFT HH samples SM sample was reweighted in bins of $m_{hh}$

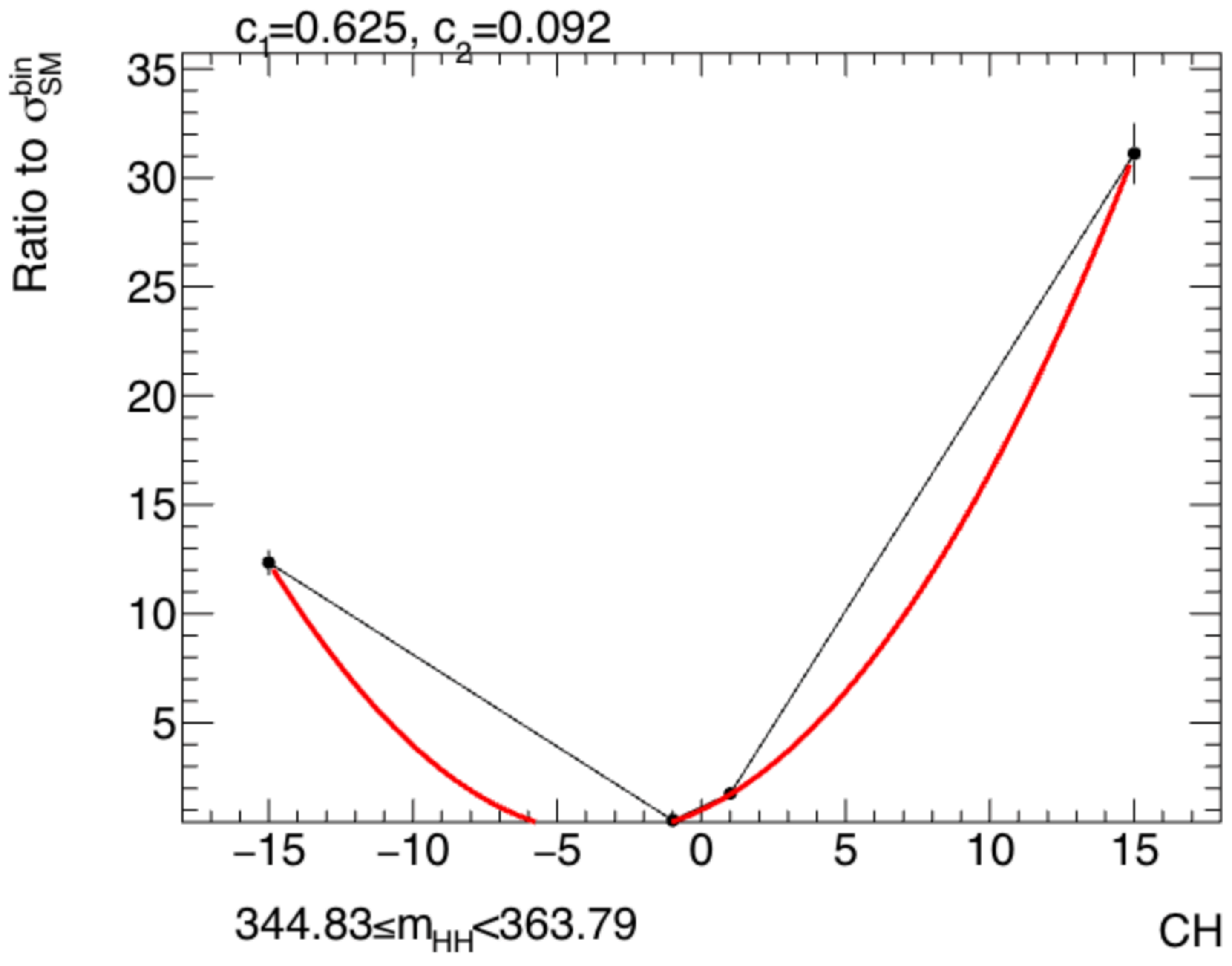
- Updated legacy reweighting now now done not only in bins of $m_{hh}$ but in multi-bins of $m_{hh} \times |cos(\theta^*)| \times p_T^{hh}$
  - I Added variables to easyJet: MR
- Problem: don't see closure at least for HEFT
- Showing worst case but which
- -> do my own parametrization

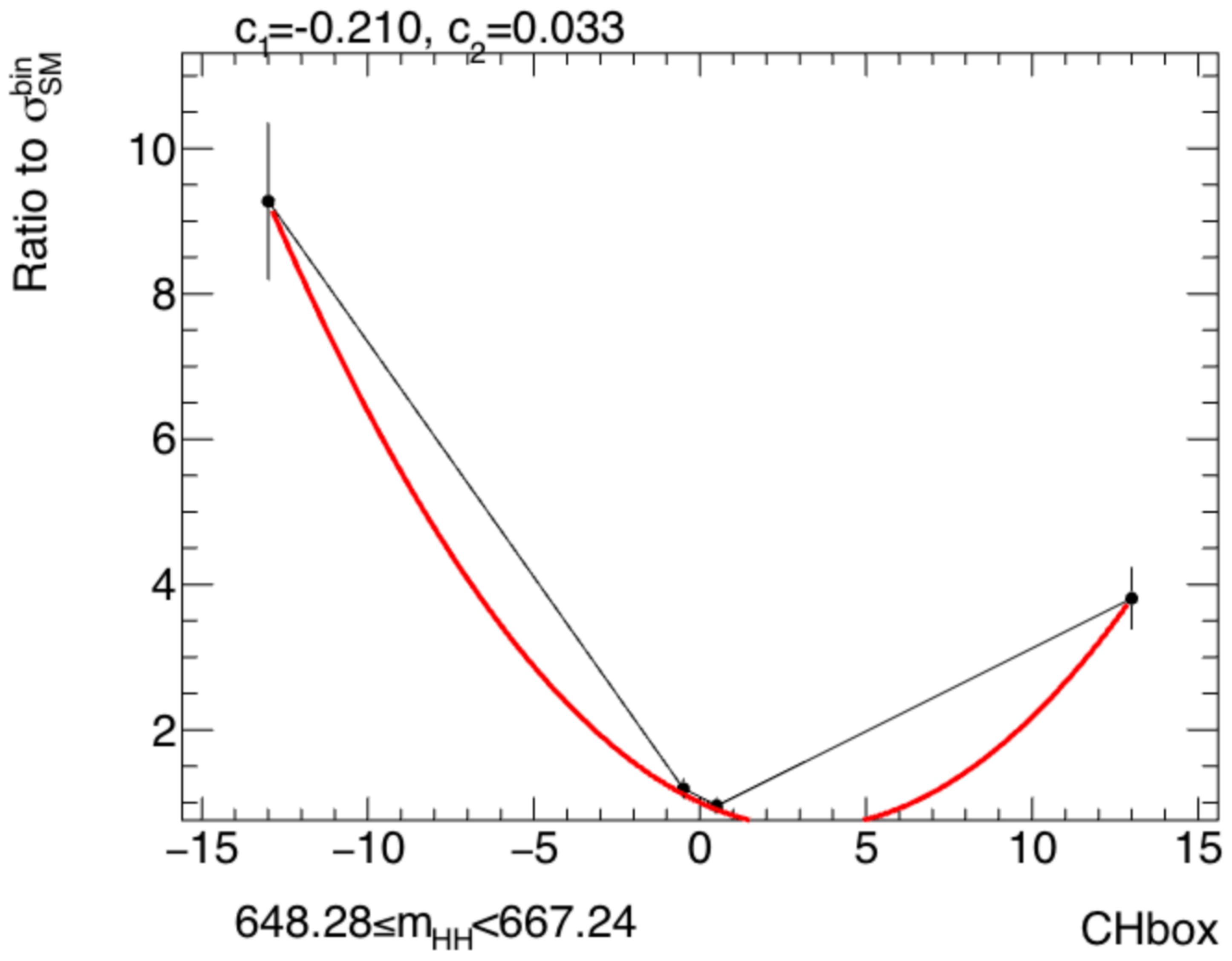


# Current activities - my parametrisation

To get SMEFT, HEFT HH samples SM sample was reweighted in bins of $m_{hh}$

- For each operator in each $m_{hh}$ bin, derive parabola




- Waiting for more powheg samples to extend to more operators

- Currently working of inserting that into workspace utilising SM framework if possible

- From there normal fitting

# Likely out of timescale for this round

- VBF, to get higher sensitivity to some operators (e.g. VVHH vertex)
- Previously (legacy analysis) no MC was available
- It exist now

- Interesting to look for later iterations
- Even without EFT ,VBF doesn't seem like a focus of attention now

# The End

$$\Delta\mathcal{L}_{\text{HEFT}} = -m_t \left( c_t \frac{h}{v} + c_{tt} \frac{h^2}{v^2} \right) \bar{t}\, t - c_{hhh} \frac{m_h^2}{2v} h^3 + \frac{\alpha_s}{8\pi} \left( c_{ggh} \frac{h}{v} + c_{gghh} \frac{h^2}{v^2} \right) G^a_{\mu\nu} G^{a,\mu\nu} \ .$$

$$\Delta\mathcal{L}_{\text{Warsaw}} = \frac{C_{H,\Box}}{\Lambda^2} (\phi^\dagger\phi)\Box(\phi^\dagger\phi) + \frac{C_{HD}}{\Lambda^2} (\phi^\dagger D_\mu \phi)^* (\phi^\dagger D^\mu \phi) + \frac{C_H}{\Lambda^2} (\phi^\dagger\phi)^3 + \left( \frac{C_{uH}}{\Lambda^2} \phi^\dagger \phi \bar{q}_L \tilde{\phi}\, t_R + h.c. \right) + \frac{C_{HG}}{\Lambda^2} \phi^\dagger \phi G^a_{\mu\nu} G^{\mu\nu,a} + \frac{C_{uG}}{\Lambda^2} (\bar{q}_L \sigma^{\mu\nu} T^a G^a_{\mu\nu} \tilde{\phi}\, t_R + \text{h.c.}) \ .$$

$$+ \frac{C_{tG}}{\Lambda^2} \left( \bar{Q}_L \sigma^{\mu\nu} T^a G^a_{\mu\nu} \tilde{\phi} t_R + \text{h.c.} \right) + \frac{C^{(1)}_{Qt}}{\Lambda^2} \bar{Q}_L \gamma^\mu Q_L \bar{t}_R \gamma_\mu t_R + \frac{C^{(8)}_{Qt}}{\Lambda^2} \bar{Q}_L \gamma^\mu T^a Q_L \bar{t}_R \gamma_\mu T^a t_R$$

$$+ \frac{C^{(1)}_{QQ}}{\Lambda^2} \bar{Q}_L \gamma^\mu Q_L \bar{Q}_L \gamma_\mu Q_L + \frac{C^{(8)}_{QQ}}{\Lambda^2} \bar{Q}_L \gamma^\mu T^a Q_L \bar{Q}_L \gamma_\mu T^a Q_L + \frac{C_{tt}}{\Lambda^2} \bar{t}_R \gamma^\mu t_R \bar{t}_R \gamma_\mu t_R \ ,$$