VBS WH Analysis

Breaking down LHE-level plots of signal sample

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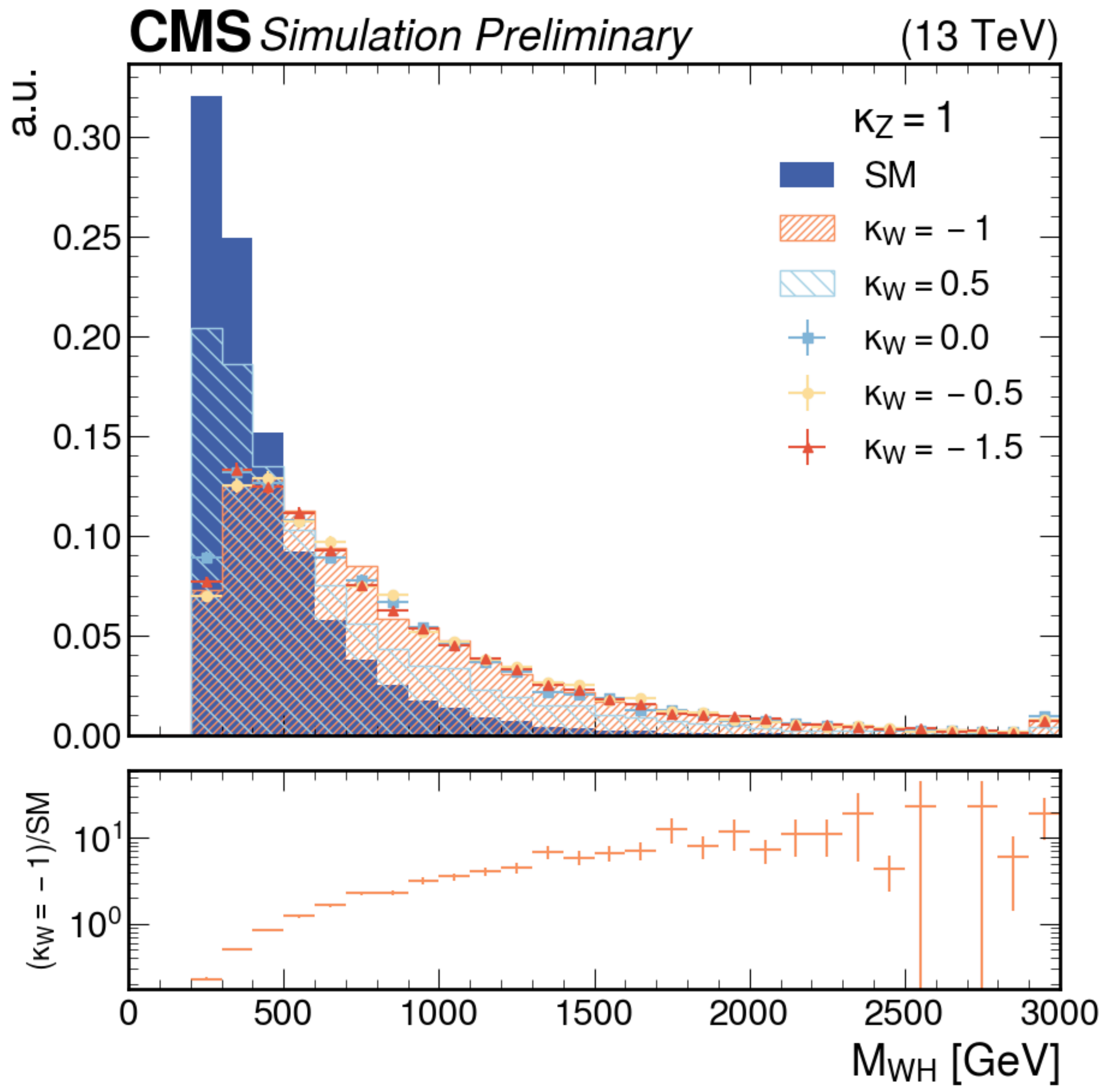
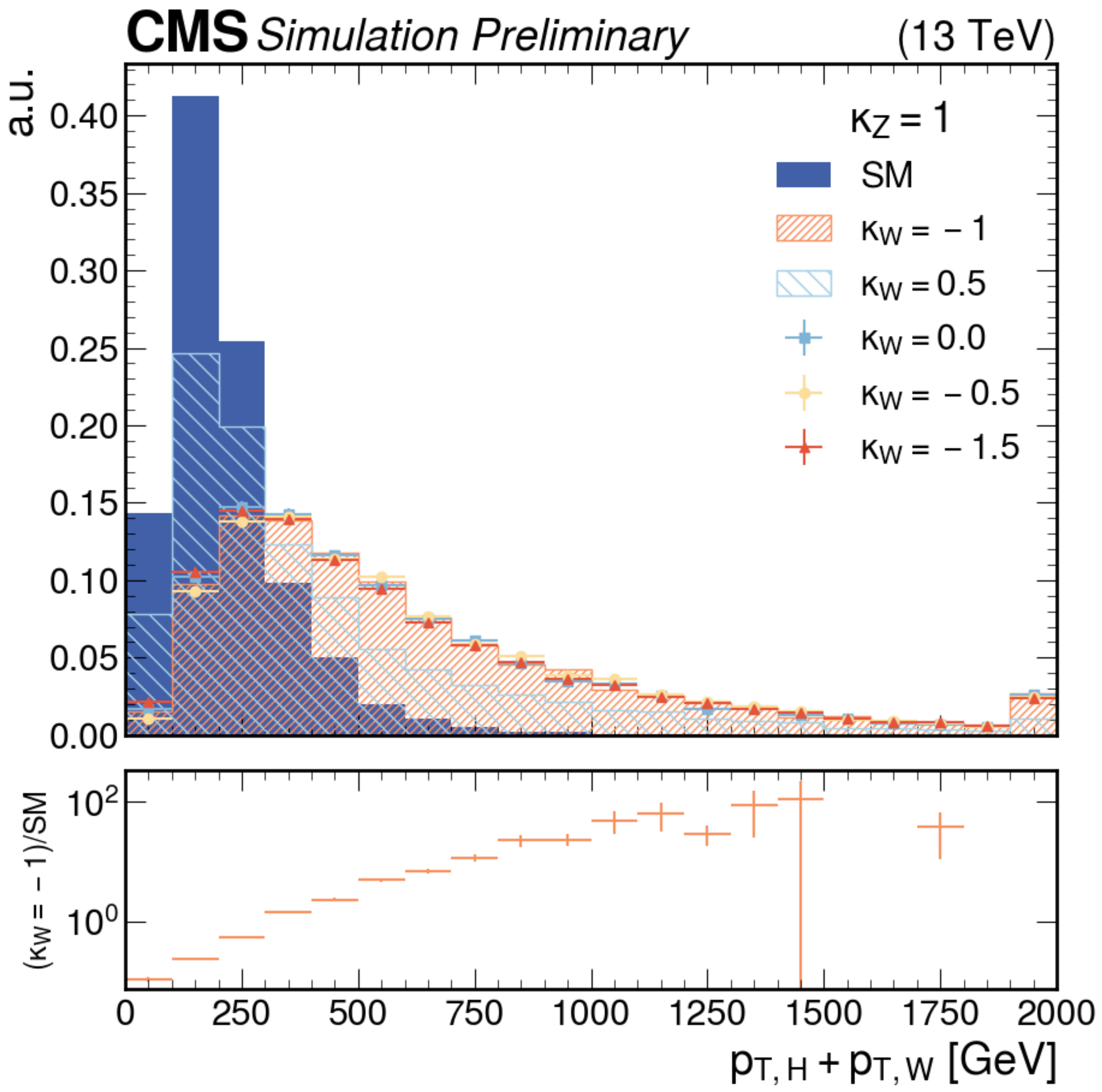
Overview





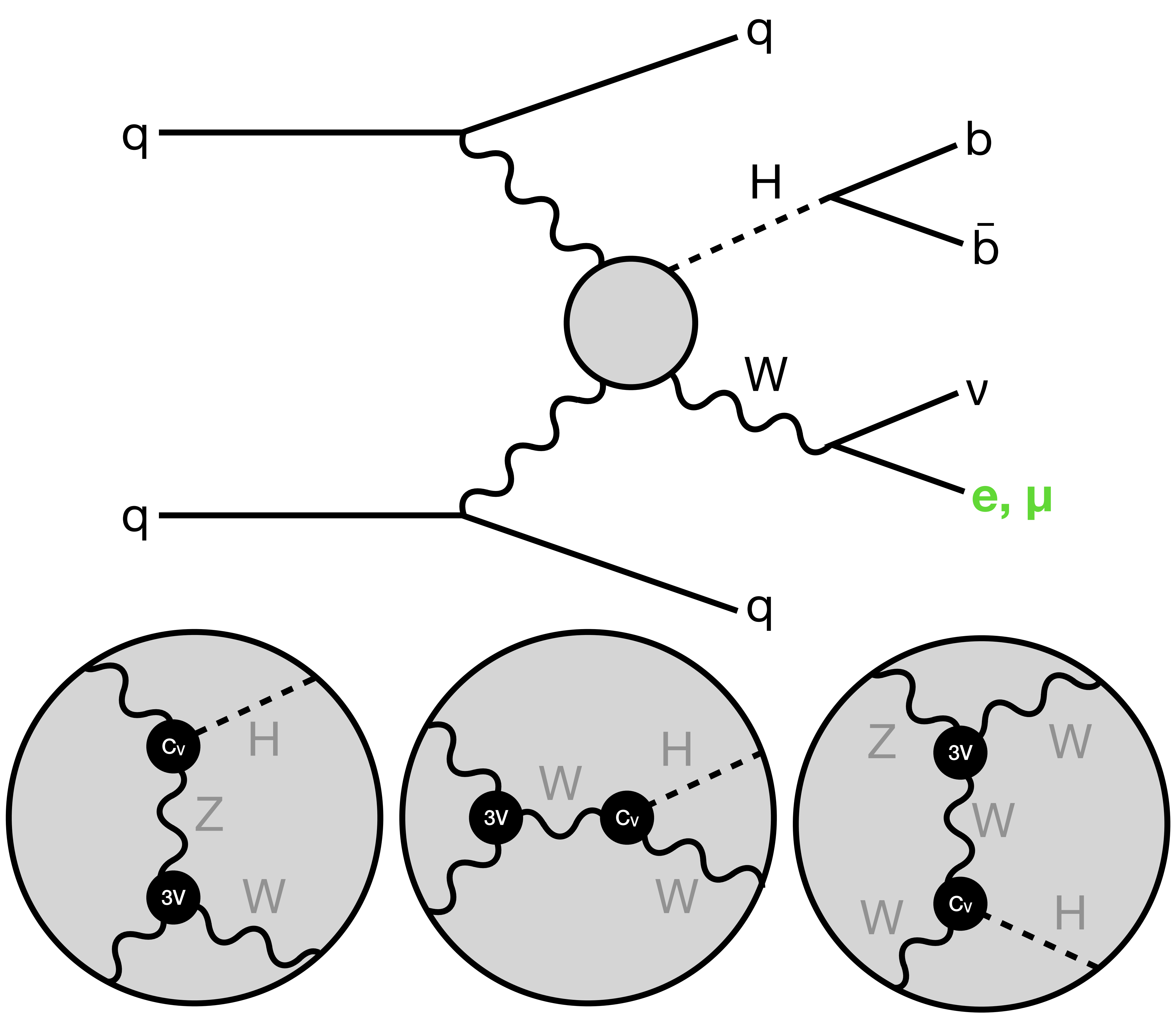
- Asked for an intuitive explanation for why the $\kappa_W \leq 0$, $\kappa_Z = 1$ shapes are ~identical
- **In these slides*, we offer such an explanation**

*All plots shown are at LHE level and have phase space cuts described in the backup

Breaking Down LHE Histograms

Recall (Eq. 3.3 from here):

$$|\mathscr{M}|^2 = \kappa_W^2 |\mathscr{M}_W|^2 + \kappa_W \kappa_Z \mathscr{M}_{WZ}^2 + \kappa_Z^2 |\mathscr{M}_Z|^2$$



(a) (b) (c)

For a histogram A, we expect:

$$A = \kappa_W^2 A_W + \kappa_W \kappa_Z A_{WZ} + \kappa_Z^2 A_Z$$

- The histogram for $\kappa_W = 1$, $\kappa_Z = 0$ gives (b) and (c) alone

$$A_W = A\,|_{\kappa_W=1,\kappa_Z=0}$$

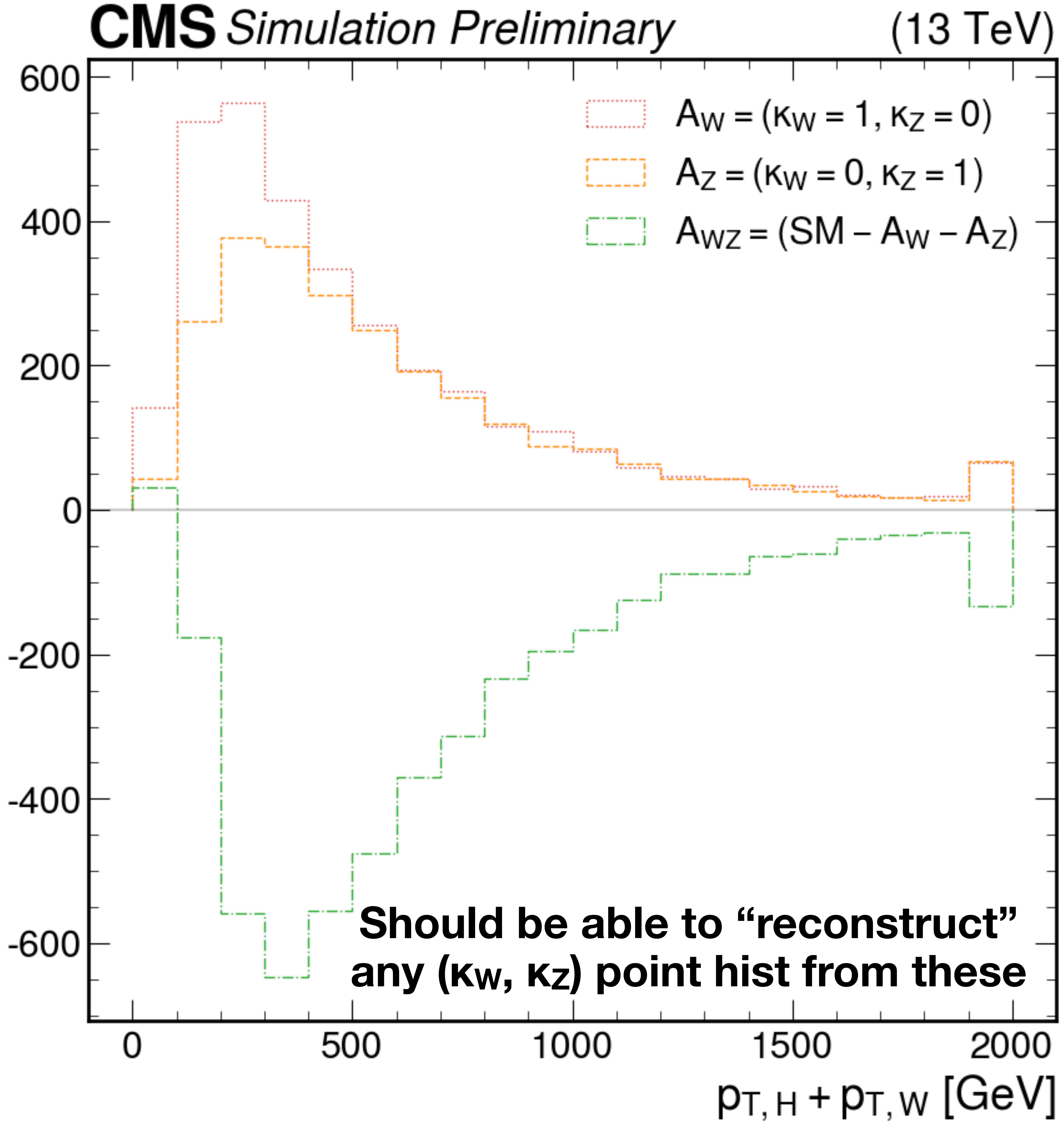
- The histogram for $\kappa_W = 0$, $\kappa_Z = 1$ gives (a) alone

$$A_Z = A\,|_{\kappa_W=0,\kappa_Z=1}$$

- Subtracting these from the SM histogram gives the histogram of the interference term

$$A_{WZ} = A\,|_{\kappa_W,\kappa_Z=1} - A_W - A_Z$$

Breaking Down LHE Histograms



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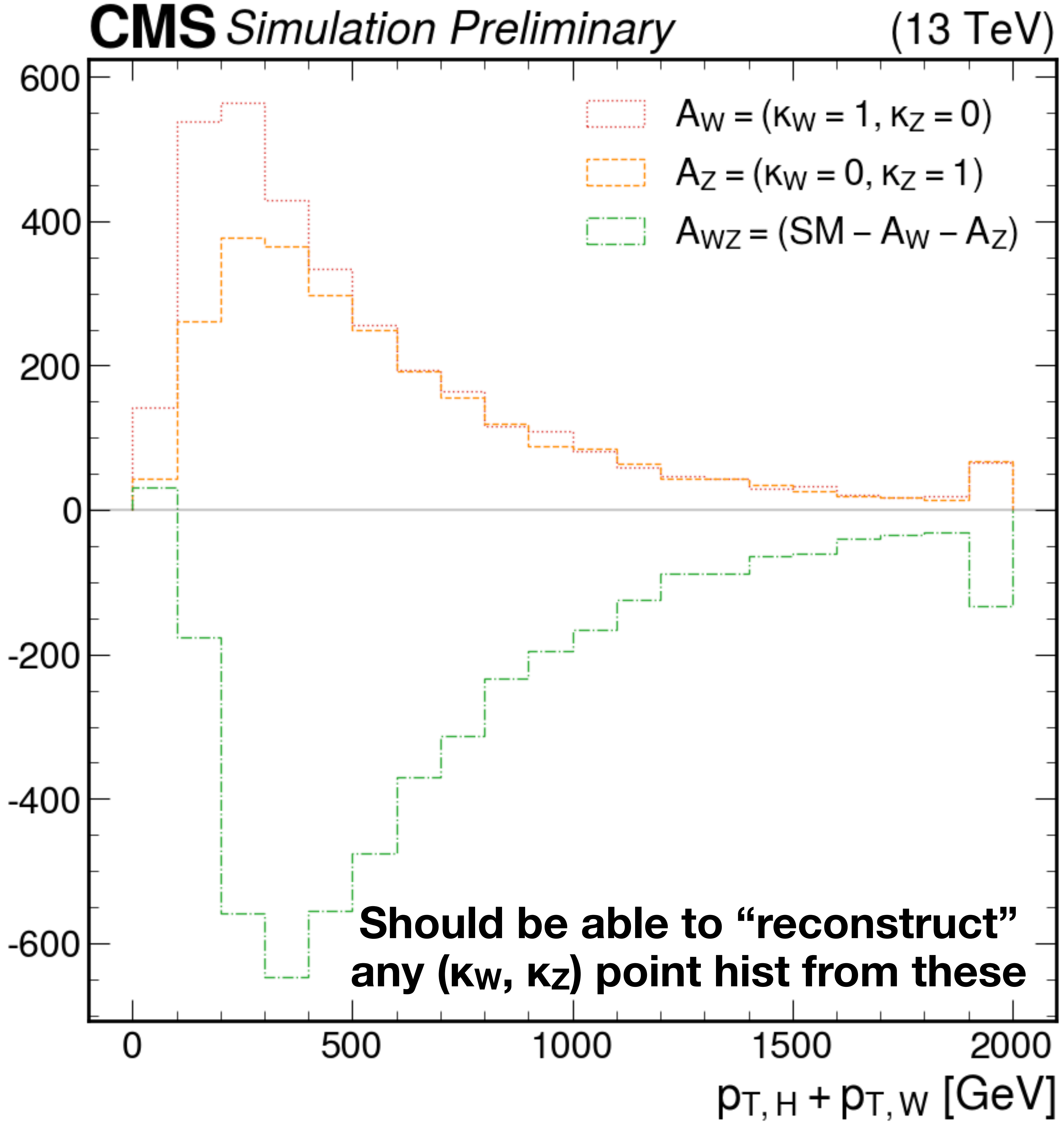
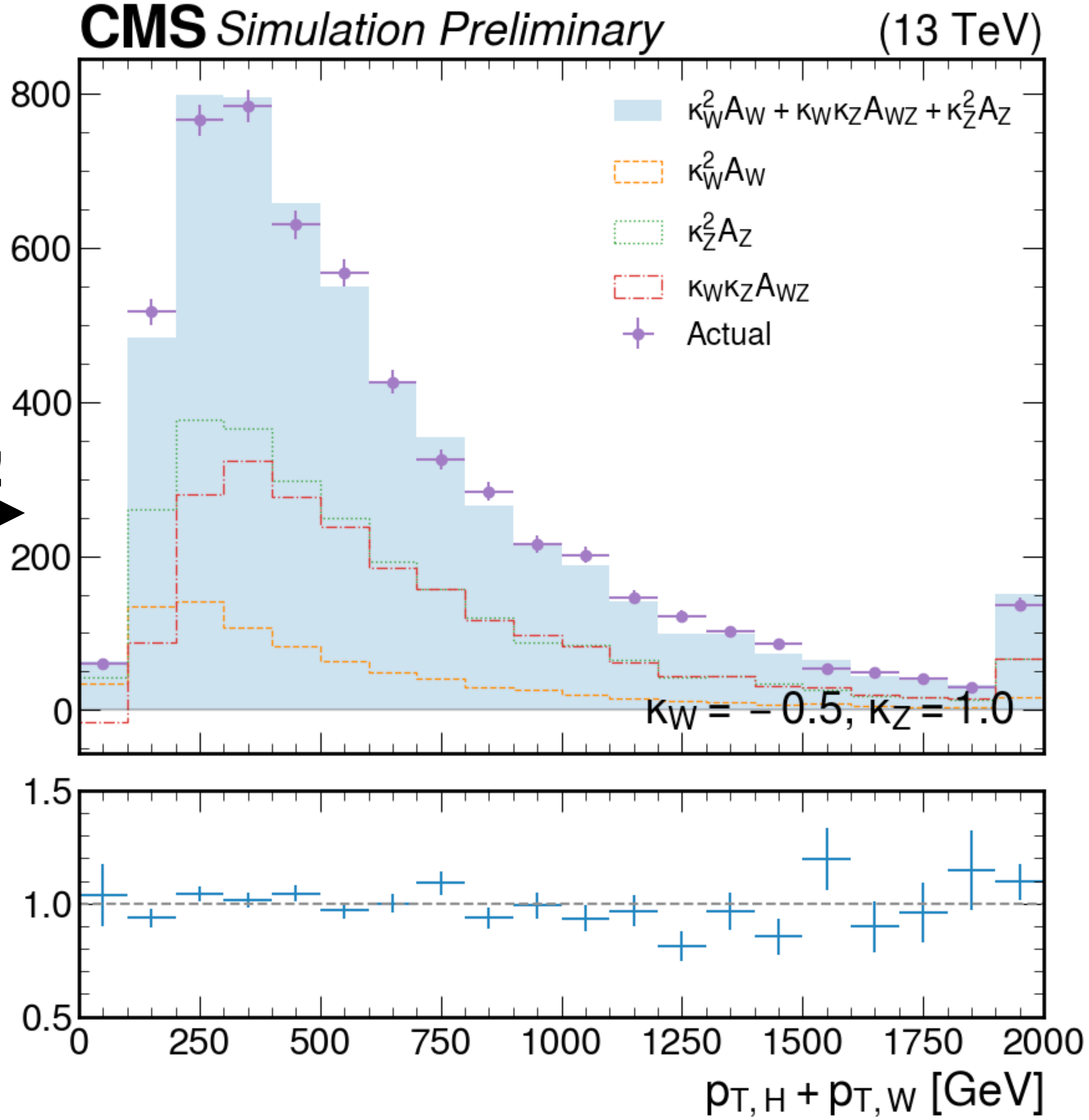
Breaking Down LHE Histograms



Should be able to "reconstruct" any (κ_W, κ_Z) point hist from these

Success!



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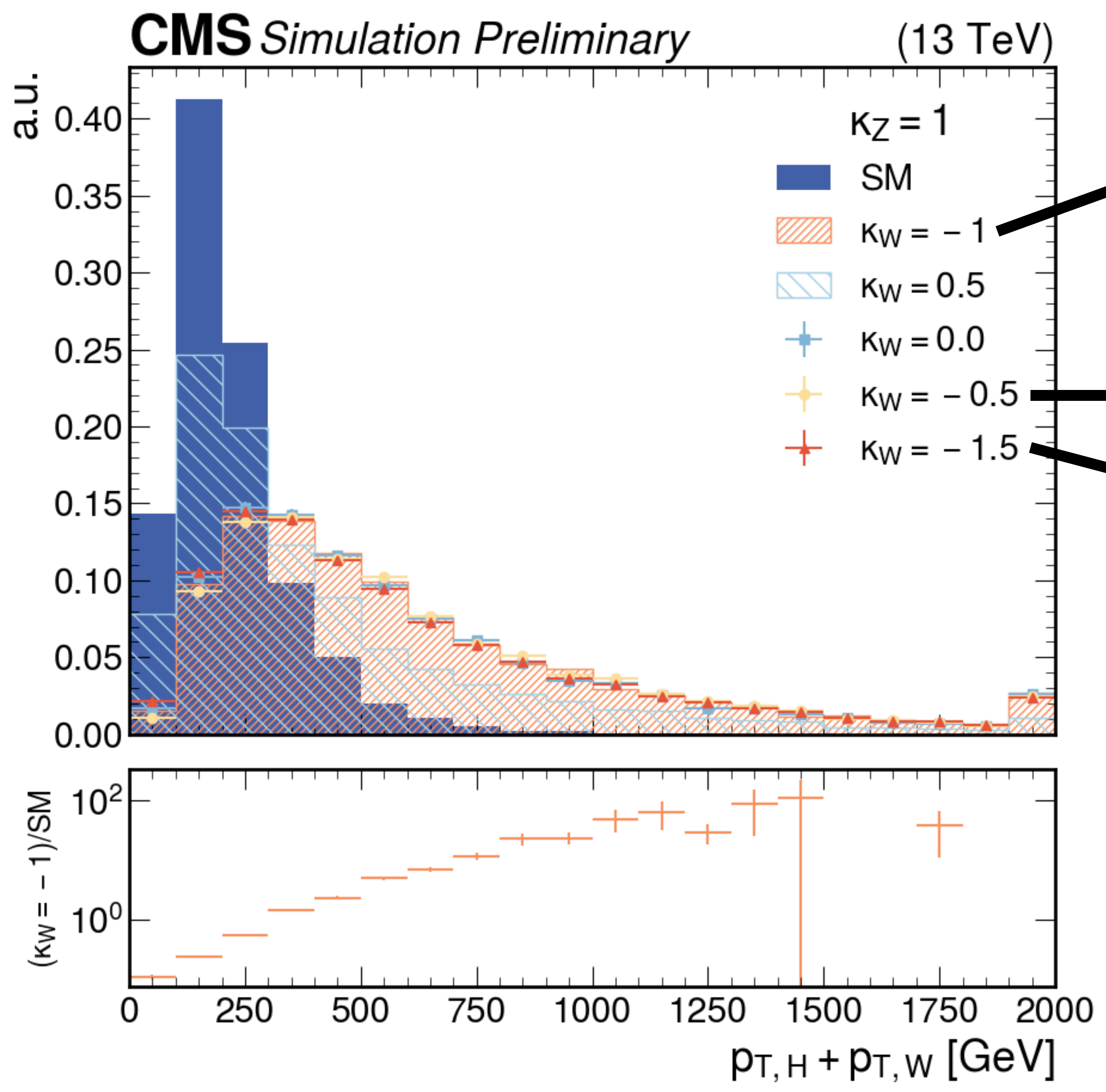
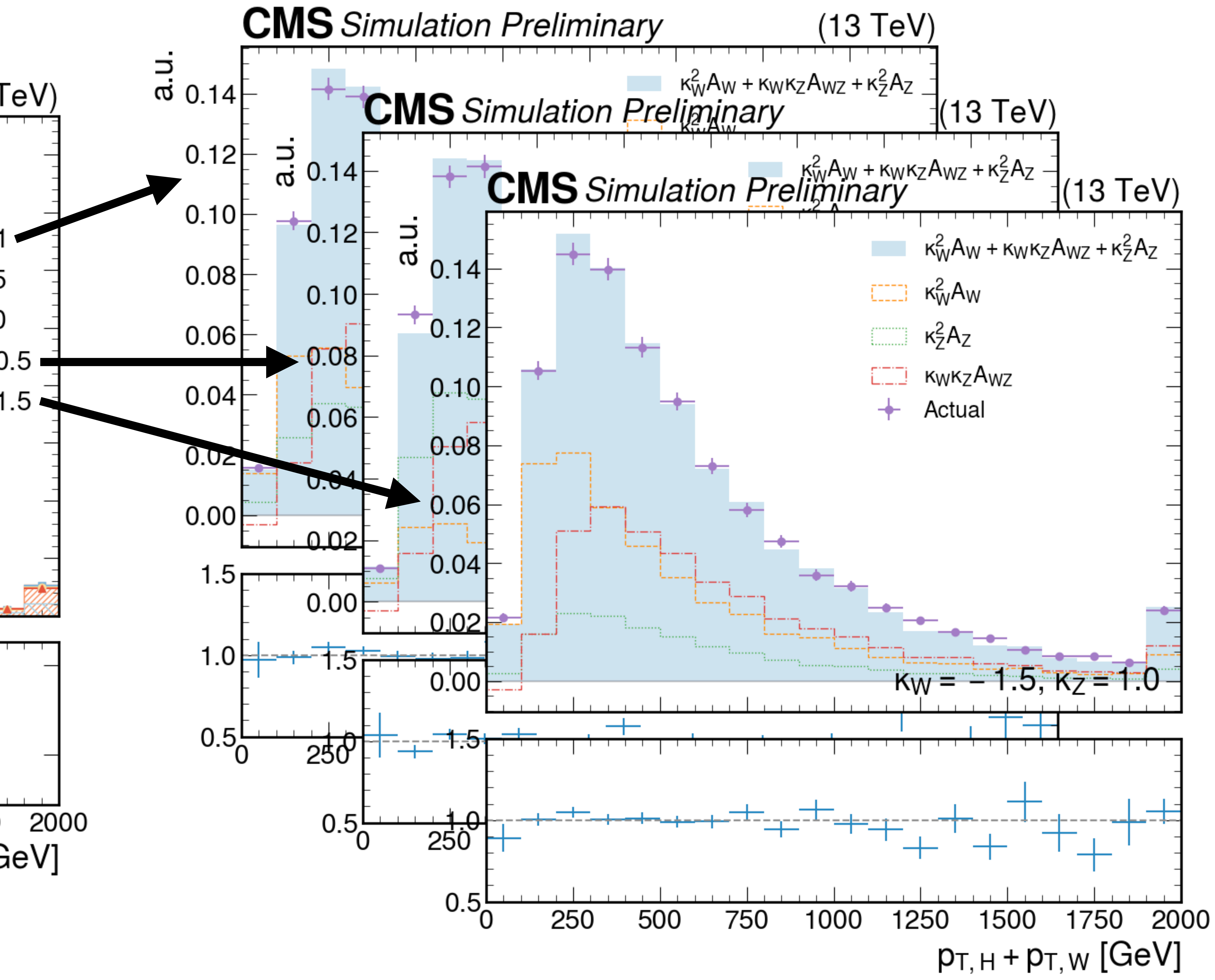
Breaking Down LHE Histograms





For these slides, we focus on the LHE S_T histogram

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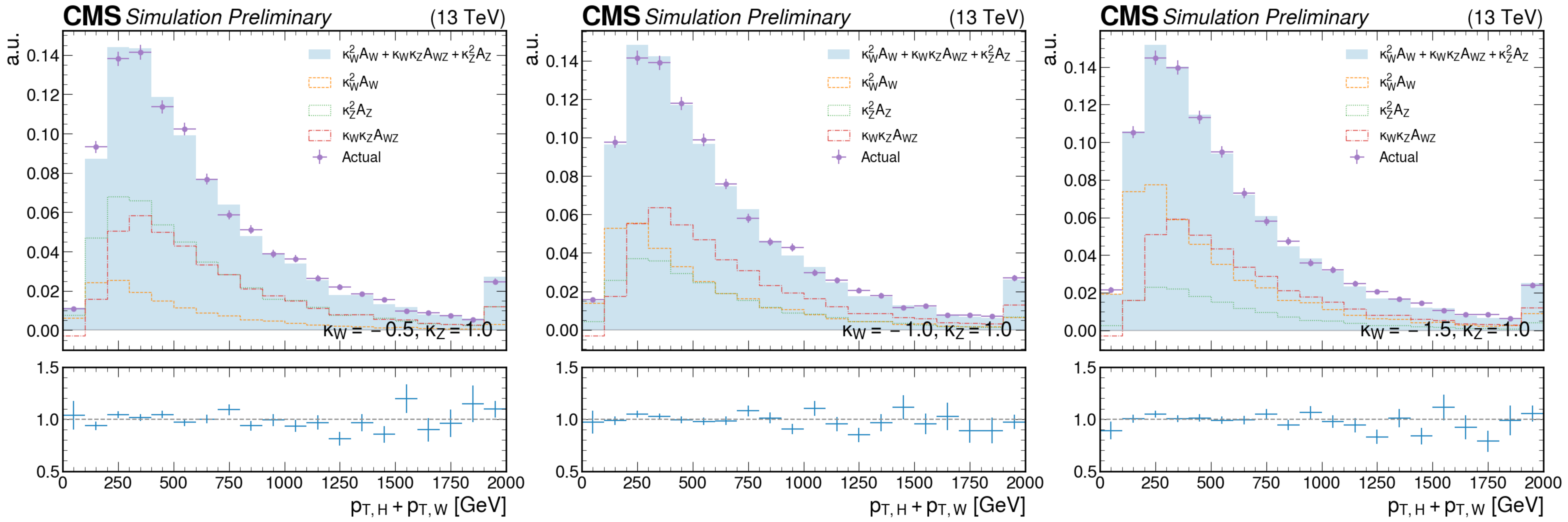
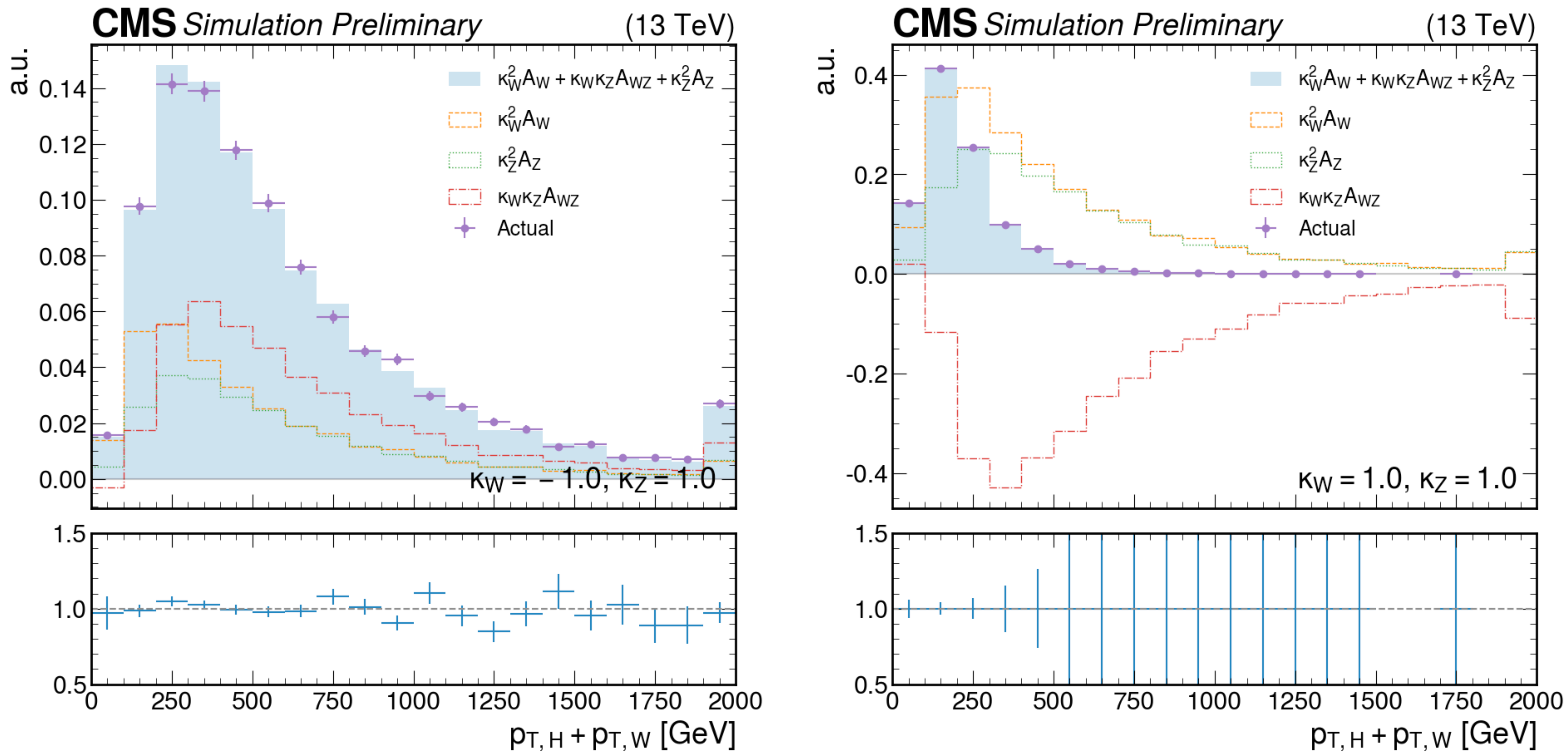
Breaking Down LHE Histograms



- Breakdown histograms normalized to actual histogram integral
- **Peak migrates slightly (due to A_W vs. A_Z), but A_W and A_Z have ~same tail as A_{WZ} i.e. composition changes, but the sum gives ~same shape!**

Breaking Down LHE Histograms



- Breakdown histograms normalized to actual histogram integral
- **Interference term (A_{WZ}) kills the high-S_T tail**

Summary

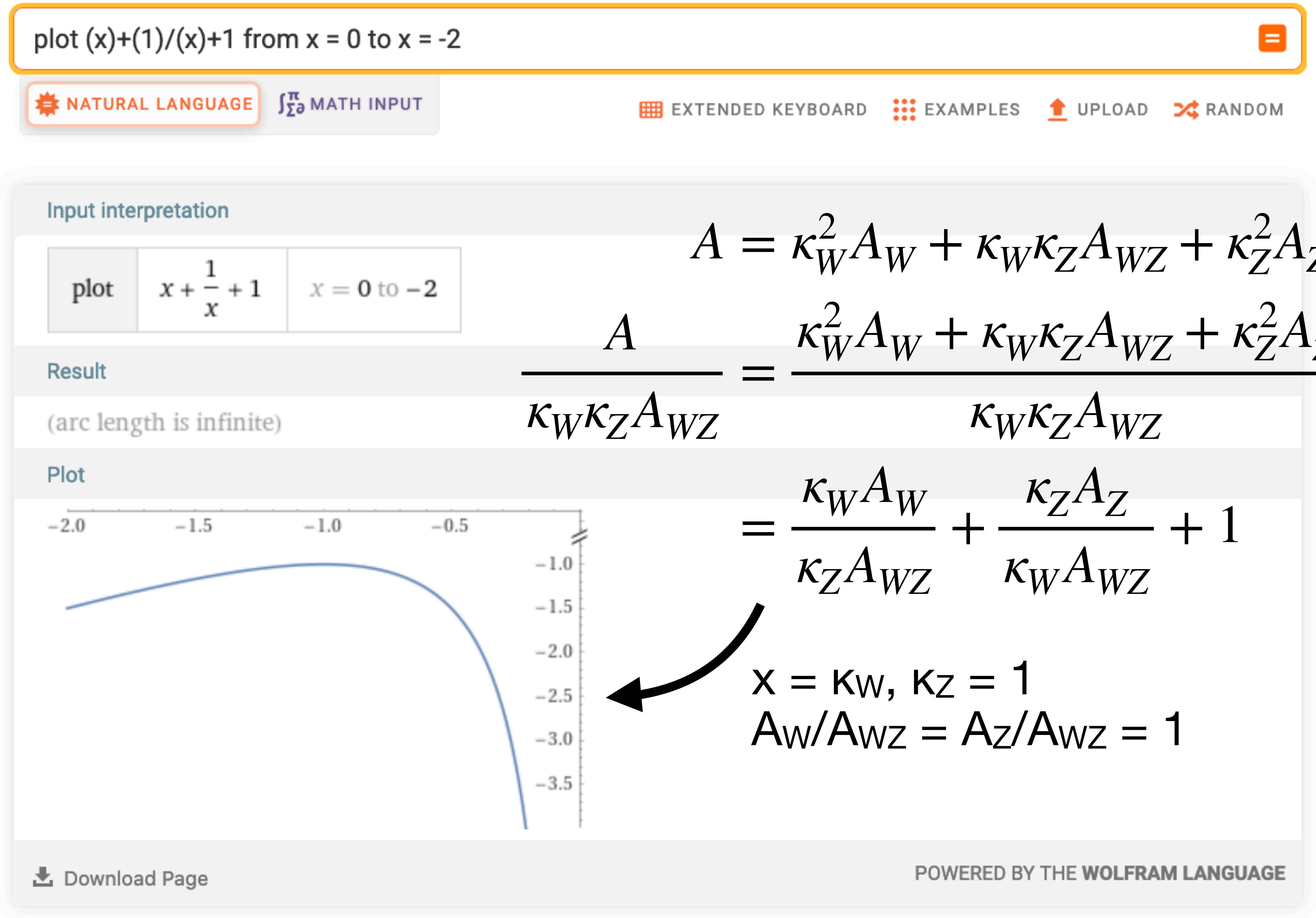
- We are able to intuitively understand the shape of all LHE plots shown
- We show why the shapes for κ_W = 0, -0.5, -1.0, -1.5 (κ_Z = 1) are consistent
- All plots can be found here: http://uaf-10.t2.ucsd.edu/~jguiang/lhe_plots/vbswh/
  - Includes non-normalized hists and M_{WH} hists
- We propose that the signal simulation is therefore understandable/trustworthy

Backup

LHE Selection (Run Card)

- In addition to the standard phase space cuts:
    - M(jet+jet) > 100
    - |η(jet)| < 6.5
- The additional cuts were approved/requested by GEN contacts
- Identical run card to central sample: https://github.com/cms-sw/genproductions/blob/master/bin/MadGraph5_aMCatNLO/cards/production/13TeV/VBSWH_mkW_Inclusive_4f_LO/VBSWH_mkW_Inclusive_4f_LO_run_card.dat

Why is A_{WZ}/real approximately the same?



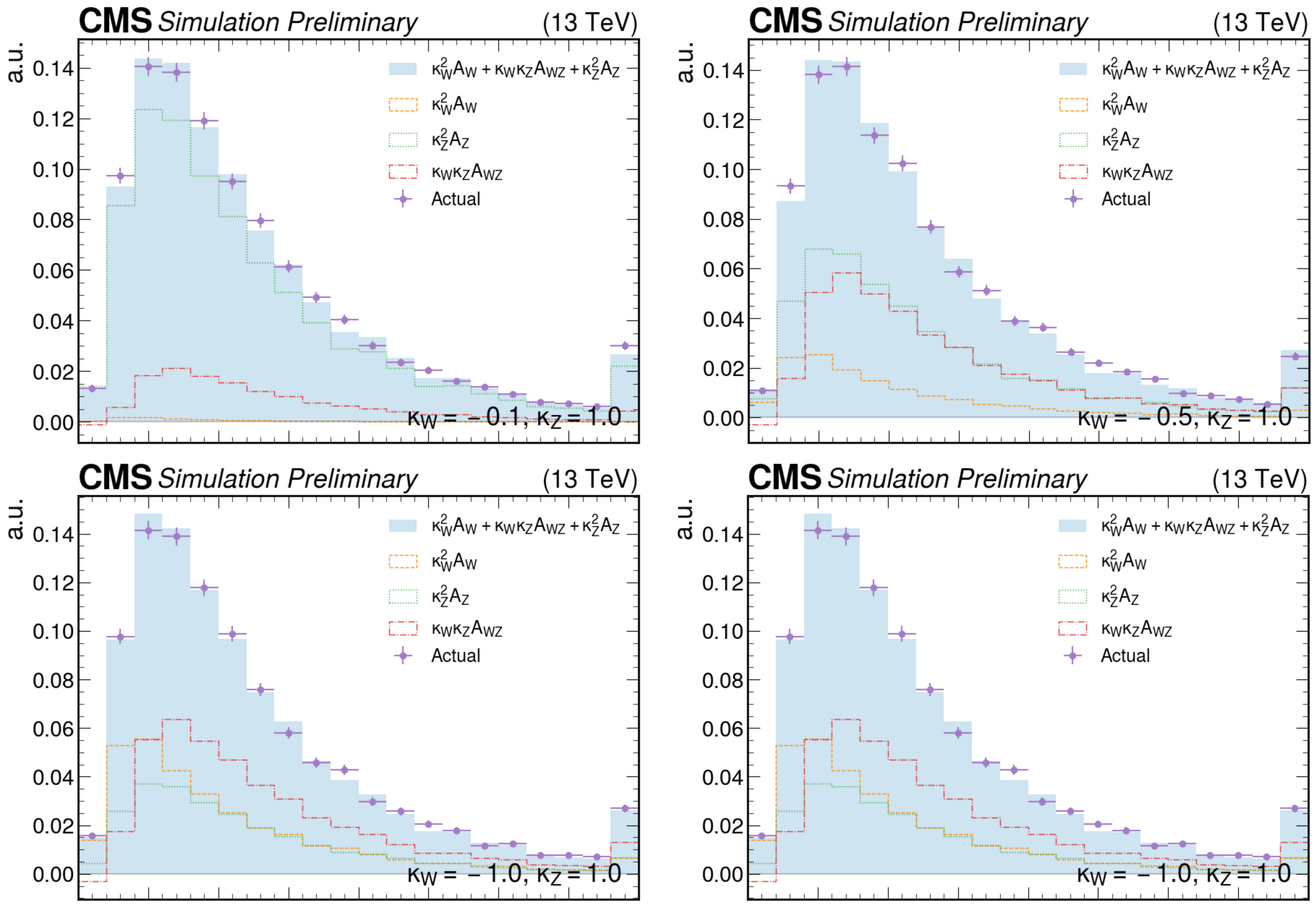
$$A = \kappa_W^2 A_W + \kappa_W \kappa_Z A_{WZ} + \kappa_Z^2 A_Z$$

$$\frac{A}{\kappa_W \kappa_Z A_{WZ}} = \frac{\kappa_W^2 A_W + \kappa_W \kappa_Z A_{WZ} + \kappa_Z^2 A_Z}{\kappa_W \kappa_Z A_{WZ}}$$

$$= \frac{\kappa_W A_W}{\kappa_Z A_{WZ}} + \frac{\kappa_Z A_Z}{\kappa_W A_{WZ}} + 1$$

$x = \kappa_W$, $\kappa_Z = 1$

$A_W/A_{WZ} = A_Z/A_{WZ} = 1$



It is not exactly the same, and only looks different for very large or small values of $|\kappa_W|$ (for $\kappa_Z = 1$), since $A_W \sim A_Z$

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