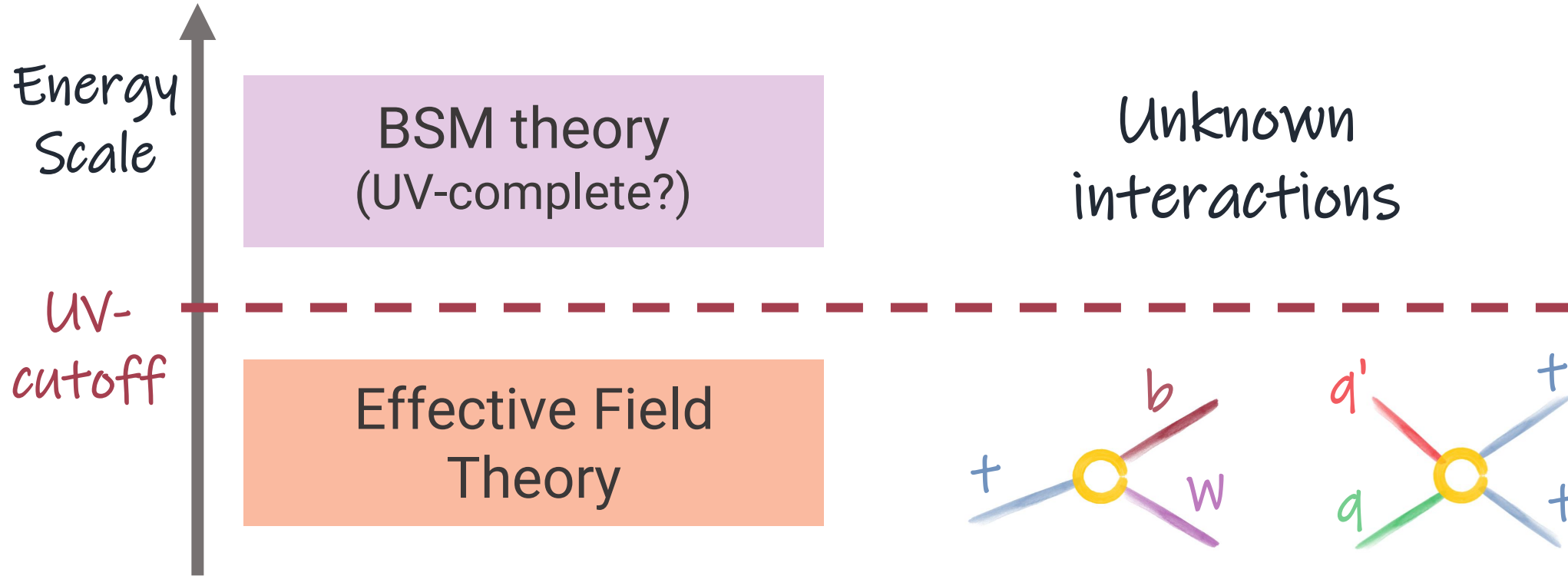


PUTTING A SPIN ON TOP-EFT

Ethan Simpson

X NExT Workshop
March 2021



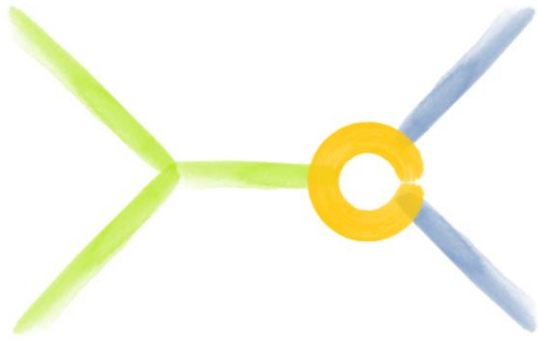


New Physics in **higher-dimensional operators** composed of SM fields:

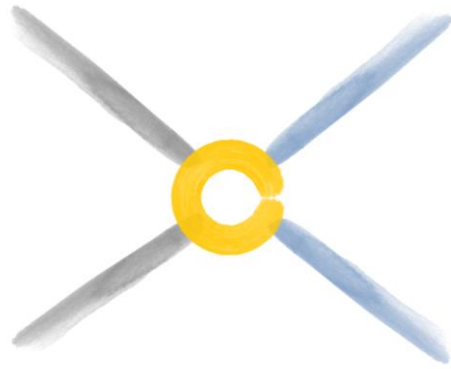
$$\mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{c_i}{\Lambda^2} \mathcal{O}_i^{(6)} + \sum_i \frac{b_i}{\Lambda^4} \mathcal{O}_i^{(8)} + \dots$$

The Plan

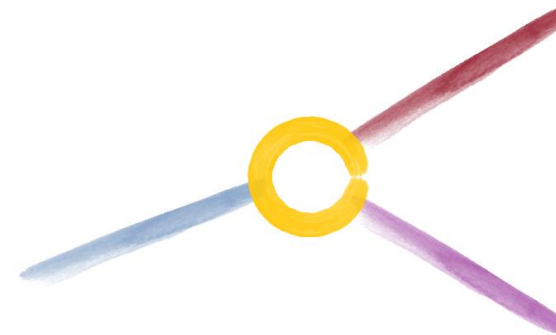
Consider all 6-dimensional EFT operators....



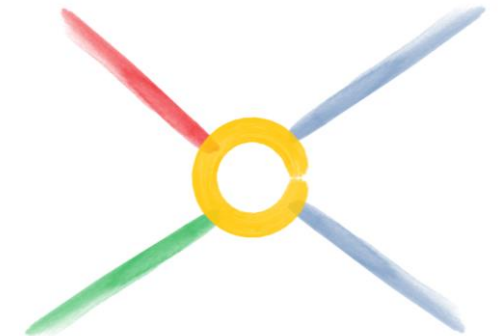
Top-gluon



4-quark



Quark-boson

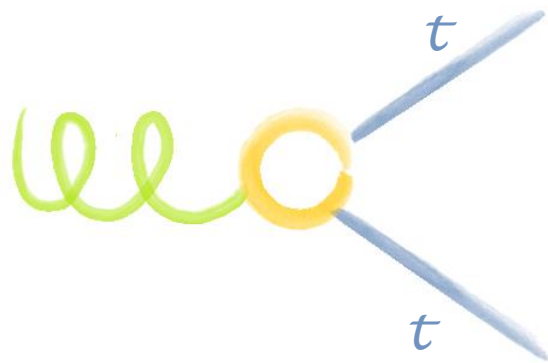


Relaxed flavour

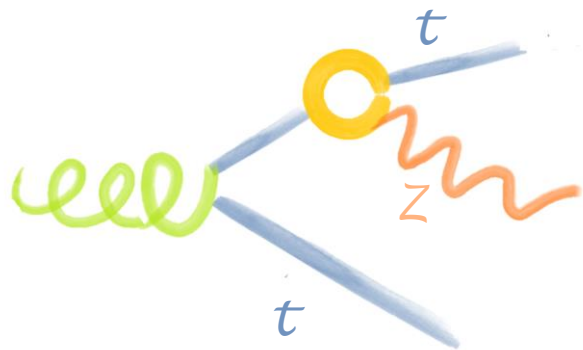
$$\mathcal{L} \ni \frac{C_{Qq}}{\Lambda^2} (\bar{Q}\gamma_\mu Q) (\bar{q}_i\gamma^\mu q_i)$$

The Plan

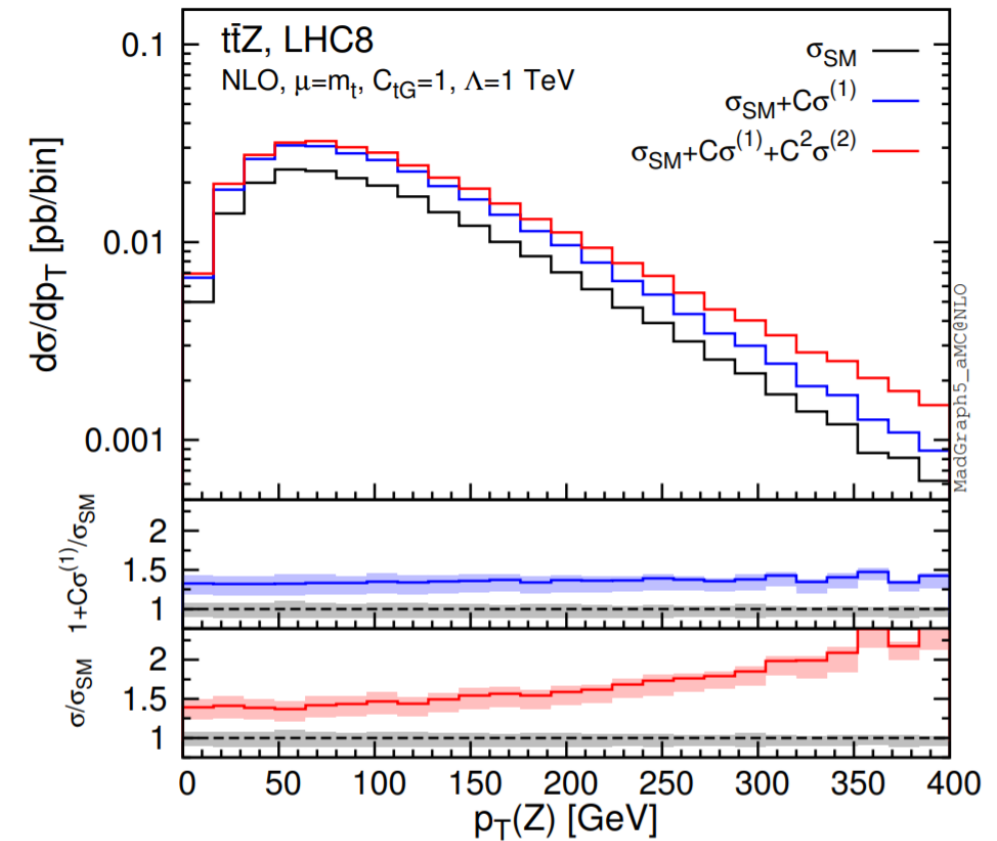
How do these operators affect observables in ...



$pp \rightarrow tt$



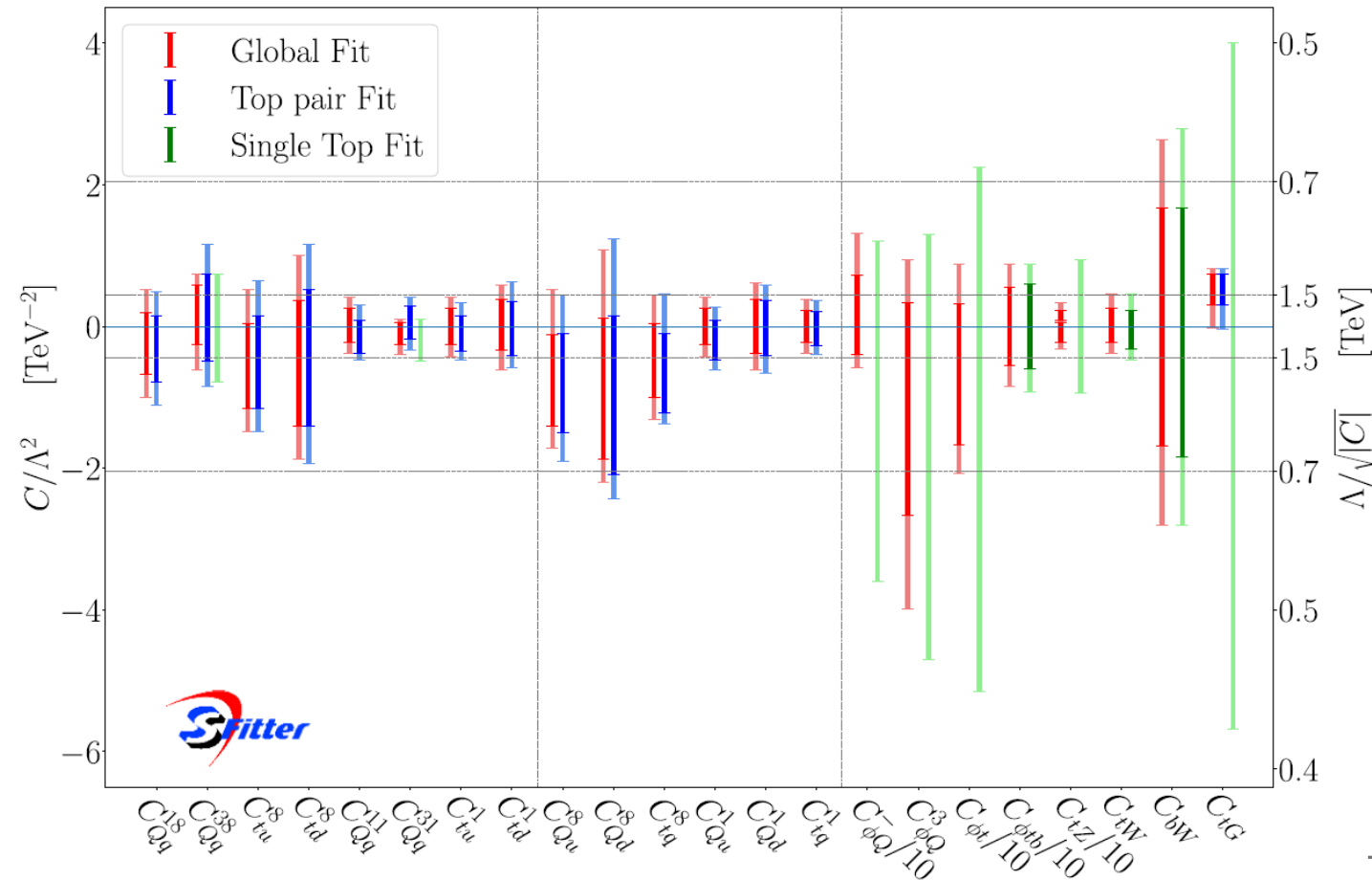
$pp \rightarrow ttZ$



The Plan

... to constrain Wilson coefficients!

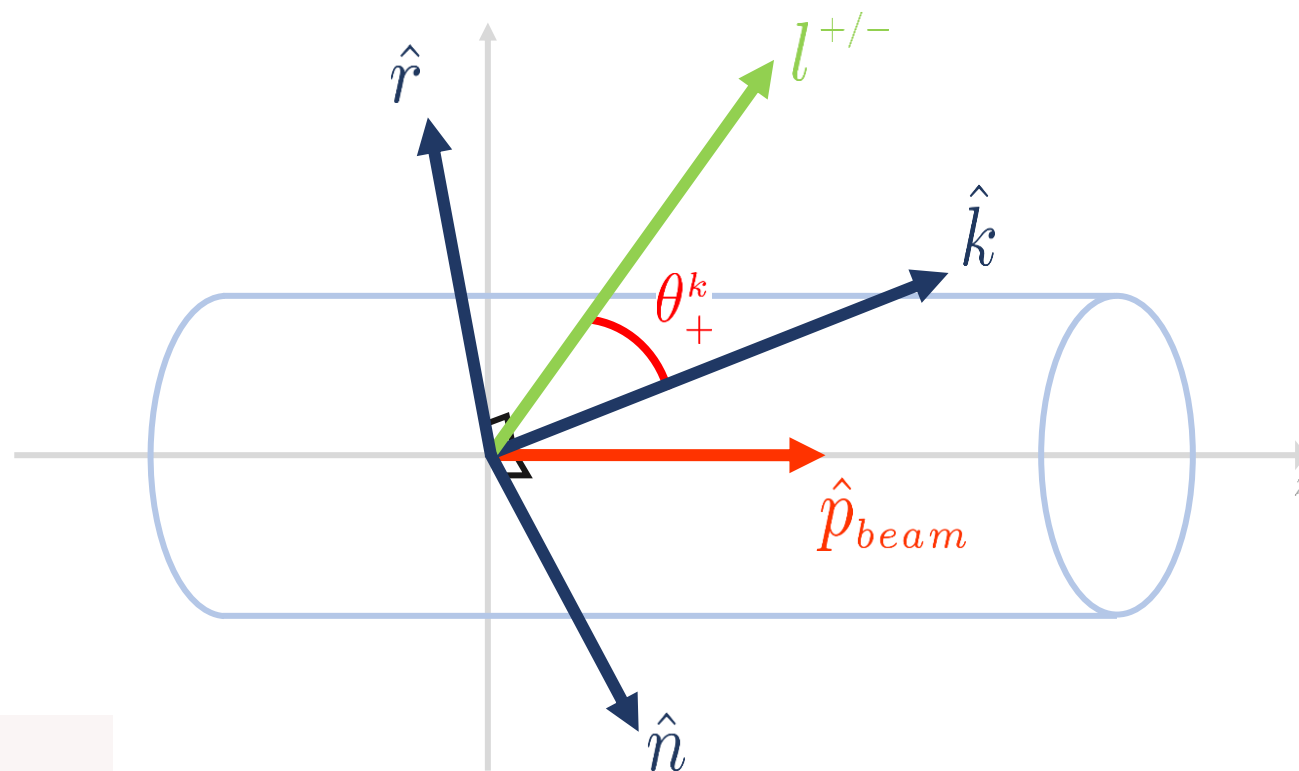
Run II, ATLAS+CMS, 68% and 95% C.L.



1910.03606

Spin Observables

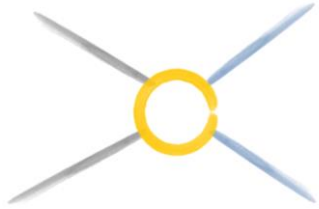
Can spin observables provide a “new spin” on top-quark EFT?



9 correlations $C = -9 \langle \cos \theta_+ \cos \theta_- \rangle$

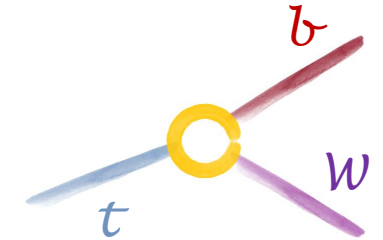
6 polarisations $B_{+(-)} = 3 \langle \cos \theta_{+(-)} \rangle$

Why Spin Observables?



- EFT operators in production

- EFT operators in decay



- Calculated to NNLO QCD

Spin Observables

- CP-violating EFT operators

- Minimal set of measurements

- Different manifestation of BSM from “usual”

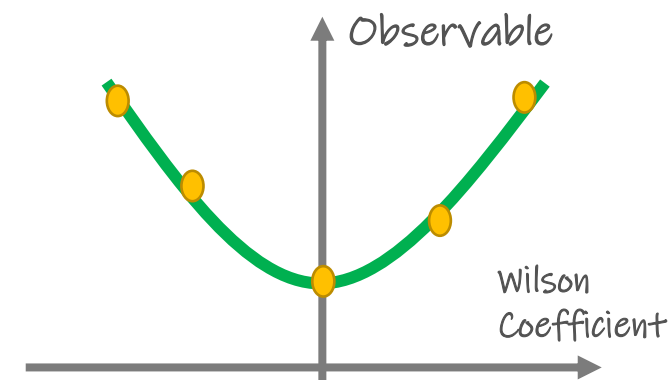
- EFT operators which affect chiral structures

Limits through fit

$$O \approx O_{SM} + \sum_i \alpha_i \frac{c_i}{\Lambda^2} + \sum_i \beta_i \frac{c_i^2}{\Lambda^4} + \sum_{i,j,i \neq j} \tilde{\beta}_{i,j} \frac{c_i c_j}{\Lambda^4}$$

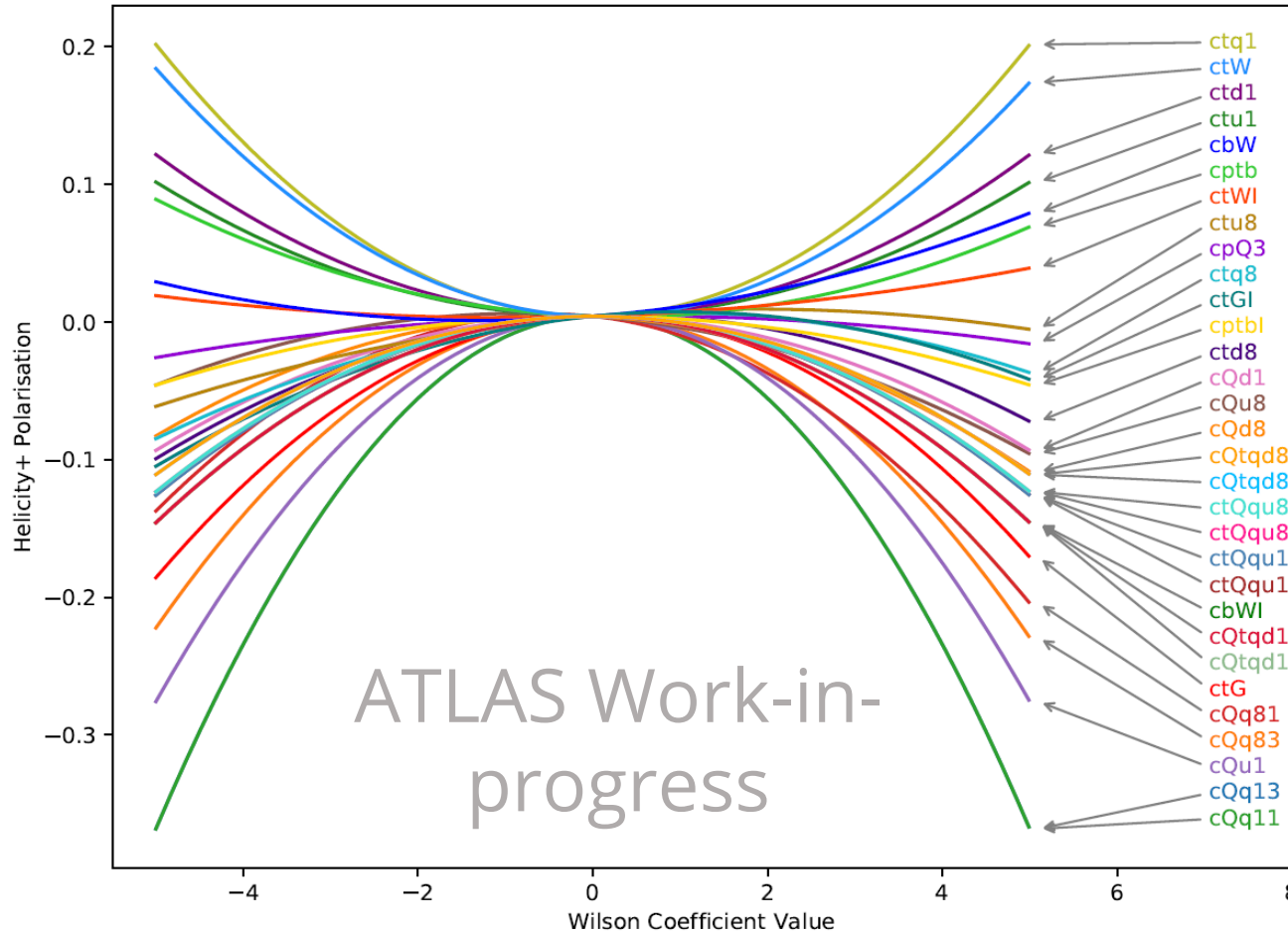
Measure

Parameterise through modelling

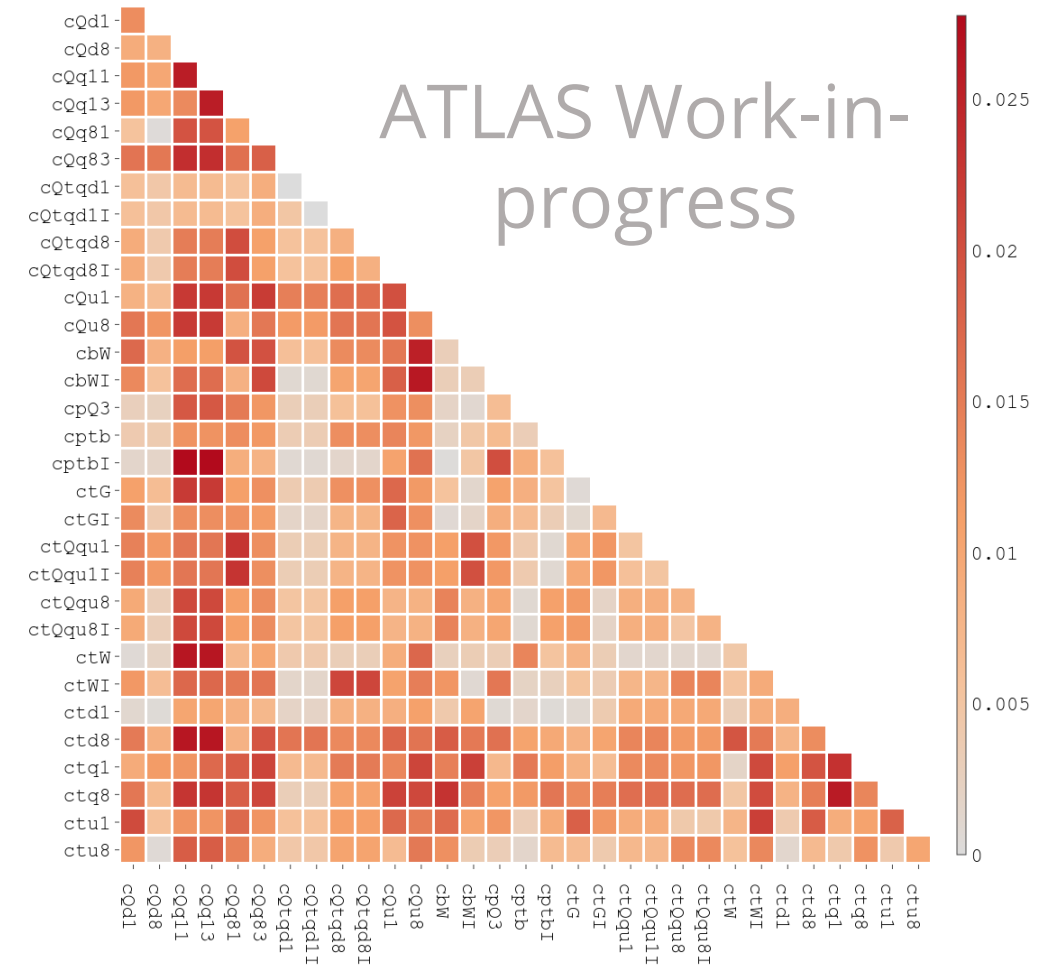


MC Parameterisation

Single operator

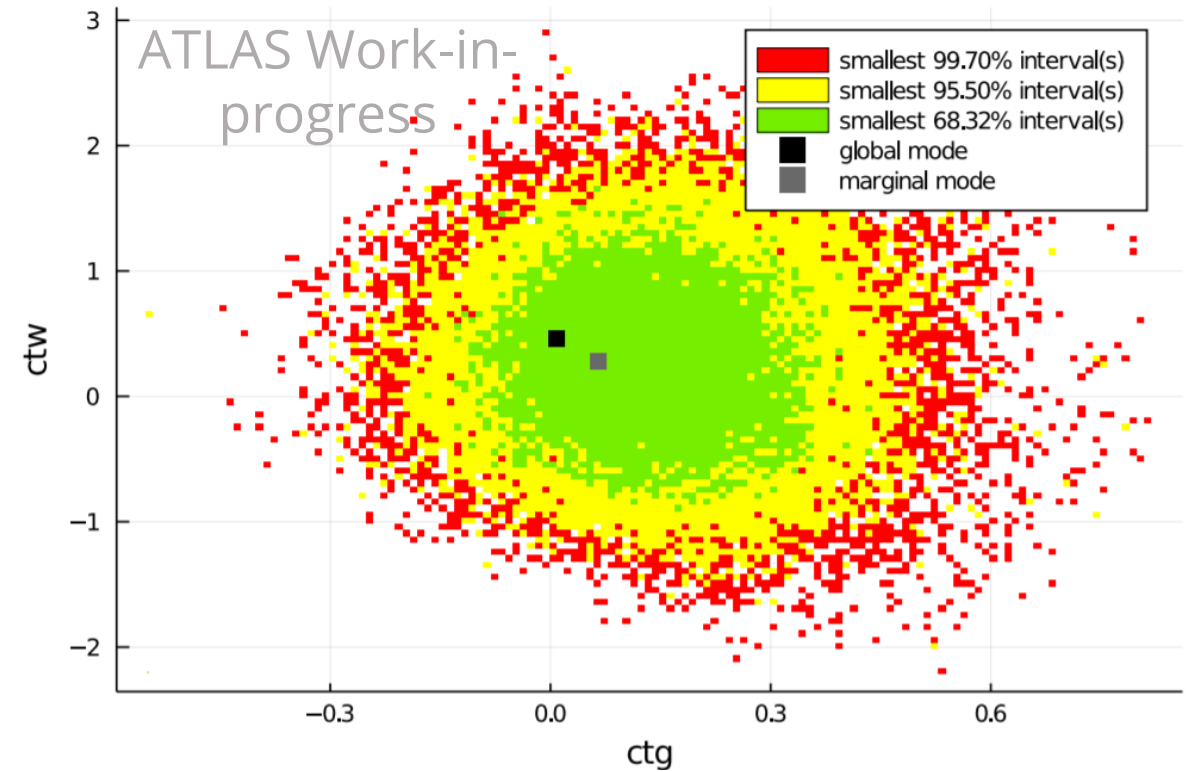
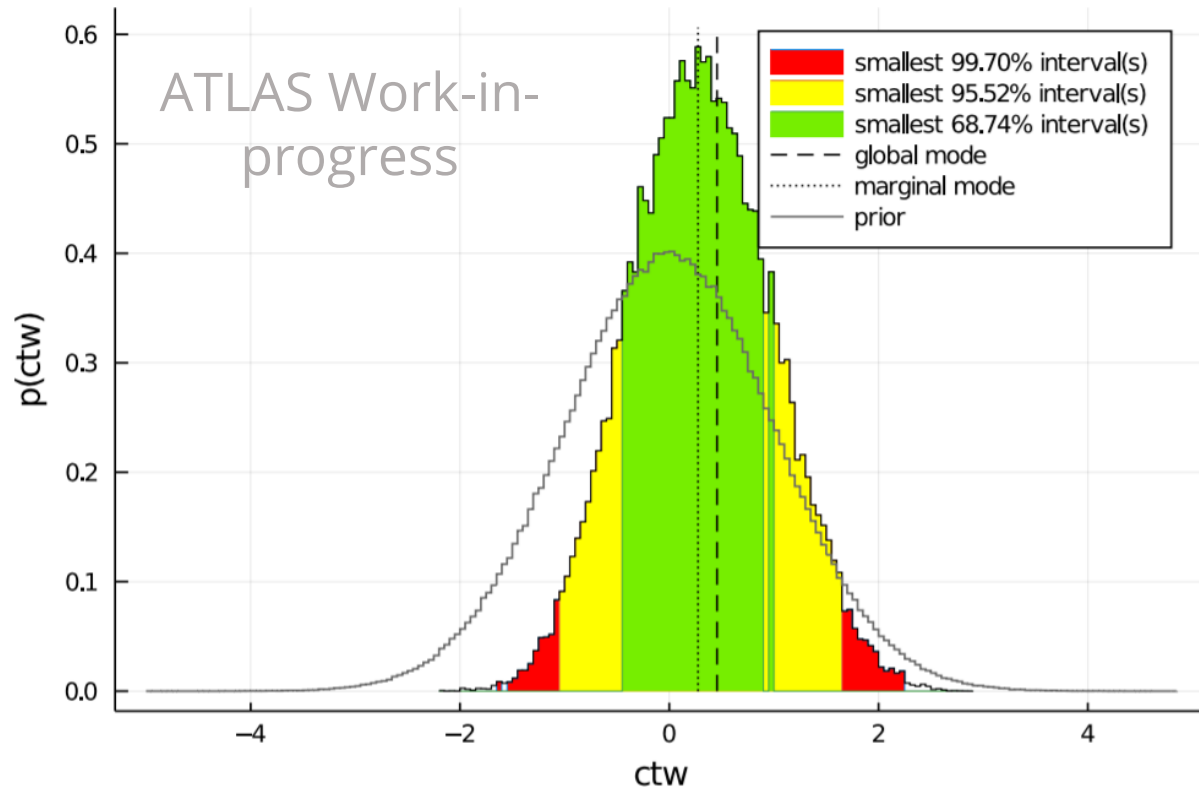


Two operators



Global Fit

Work in progress...
Plots by Baptiste Ravina



Thank you for listening!

Some Sources

Global EFT fits:

- Buckley, Andy, et al. "Global fit of top quark effective theory to data." *Physical Review D* 92.9 (2015): 091501.
- Brivio, Ilaria, et al. "O new physics, where art thou? A global search in the top sector." *Journal of High Energy Physics* 2020.2 (2020): 1-47.
- Hartland, Nathan P., et al. "A Monte Carlo global analysis of the Standard Model Effective Field Theory: the top quark sector." *Journal of High Energy Physics* 2019.4 (2019)

Spin Observables:

- Bernreuther, Werner, Dennis Heisler, and Zong-Guo Si. "A set of top quark spin correlation and polarization observables for the LHC: Standard Model predictions and new physics contributions." *Journal of High Energy Physics* 2015.12 (2015): 1-36.
- Czakon, Michal, Alexander Mitov, and Rene Poncelet. "NNLO QCD corrections to leptonic observables in top-quark pair production and decay." (2020)

CMS Spin EFT:

- Sirunyan, Albert M., et al. "Measurement of the top quark polarization and $t t^{-}$ spin correlations using dilepton final states in proton-proton collisions at $\sqrt{s} = 13$ TeV." *Physical Review D* 100.7 (2019): 072002

Analysis Tools:

- Castro, Nuno, et al. "EFT fitter: a tool for interpreting measurements in the context of effective field theories." *The European Physical Journal C* 76.8 (2016): 1-10.
- Hartland, Nathan P., et al. "A Monte Carlo global analysis of the standard model effective field theory: the top quark sector." *Journal of High Energy Physics* 2019.4 (2019): 1-78.