Comparing Direct Simulation and Reweighting
WW and Zjj

Kristin Lohwasser, Hannes Mildner, Fabian Stäger

29 November 2023

Introduction

- For the Area 4 ATLAS+CMS EFT Fitting Exercise, we attempt to reproduce each others EFT parameterisations
- Can we reproduce the ATLAS WW and Zjj parameterisations (obtained from direct simulation with $c_i \neq 0$) by reweighting samples generated at the SM expectation ($c_i = 0$)?

WW, Event generation: Direct simulation

- Analysis: https://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/STDM-2017-24/
- Rivet: https://rivet.hepforge.org/analyses/ATLAS_2019_I1734263
- Generate 1 SM sample
- 1–2 samples per operator with 100K–1M events each, depending on the size of the uncertainties and relevance of operator

WW, Event generation: Reweighting

- Event generation reweighted sample: `EFT2Obs` → MG5 with SMEFTsim3, Pythia, Rivet

  ```
  generate p p > e+ ve mu- vm~ / h h1 NPall<=2 NPprop^2<=2 @1
  add process p p > e- ve~ mu+ vm / h h1 NPall<=2 NPprop^2<=2 @2
  add process p p > e+ ve mu- vm~ j / h h1 NPall<=2 NPprop^2<=2 @3
  add process p p > e- ve~ mu+ vm j / h h1 NPall<=2 NPprop^2<=2 @4
  ```

  → `NPall<=2`: single insertion of EFT operators either in vertex or propagator
  → `NPprop^2<=2`: limit propagator corrections to linear terms
  → use MLM merging with `xqcut = 30.0`
  → sum over helicity states: `change helicity false`
  → some kinematic cuts in the `run_card`:
     `15.0 = ptl, 3.0 = etal, 0.1 = drll, 20.0 = mmnl`
  → for better statistics: split into two gridpacks with `150.0 = ptl1max` and `150.0 = ptl1min`
  → generate 10 million events with `ptl1 < 150` and 10 million events with `ptl1 > 150`
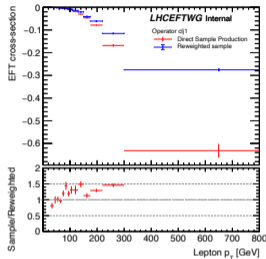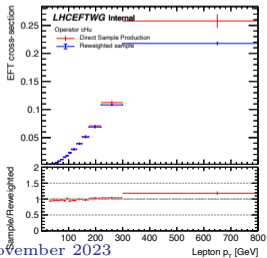
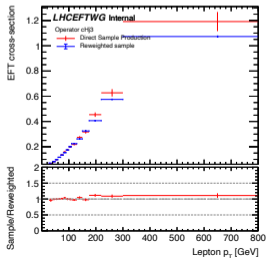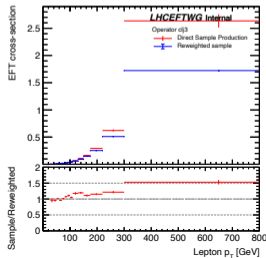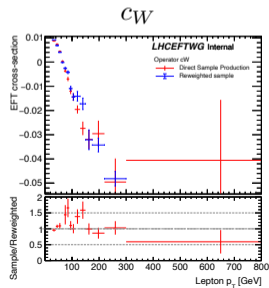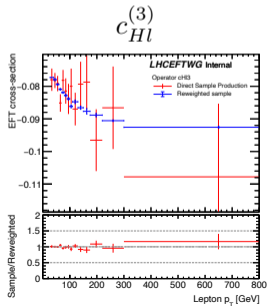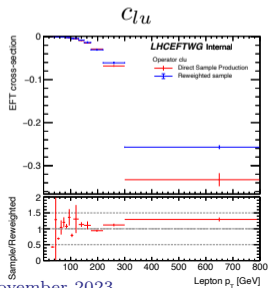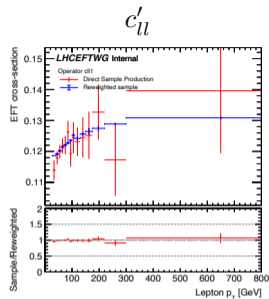# WW, EFT parameterisations

c_{Hd}
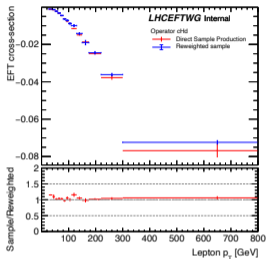
$c_{Hq}^{(1)}$
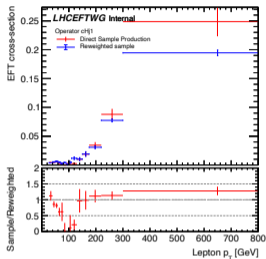
$c_{lq}^{(1)}$

c_{Hu}

$c_{Hq}^{(3)}$

$c_{lq}^{(3)}$
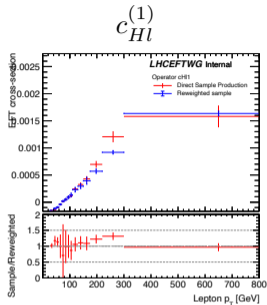
WW, EFT parameterisations

c_{ld} $c_{Hl}^{(1)}$ c_{ll}'
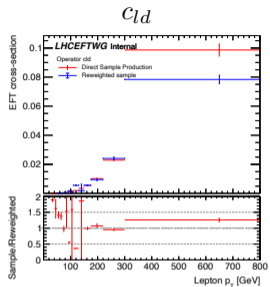
c_{lu} $c_{Hl}^{(3)}$ c_W
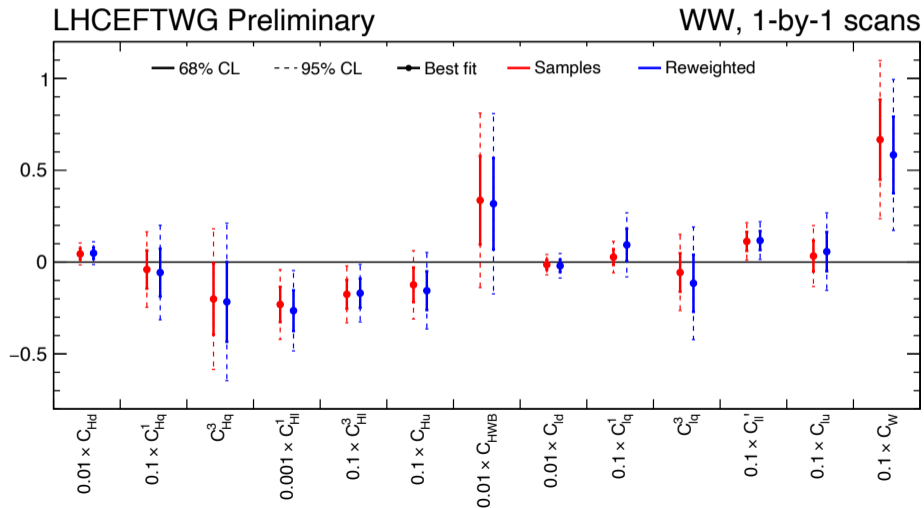
WW, Fit results

- Relatively small differences; Largest differences in $c_{lq}^{(1)}$, $c_{lq}^{(3)}$, and c_W

Zjj, Event generation: Direct simulation

- Analysis: http://atlas.web.cern.ch/Atlas/GROUPS/PHYSICS/PAPERS/STDM-2017-27/
- Rivet: https://rivet.hepforge.org/analyses/ATLAS_2020_I1803608
- Generate 1 SM sample
- 1–2 samples per operator with 100K–1M events each, depending on the size of the uncertainties and relevance of operator
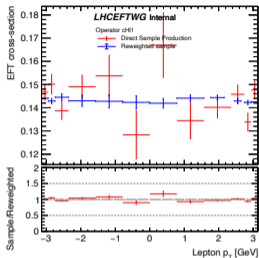
Zjj, Event generation: Reweighting

- Event generation reweighted sample: `EFT2Obs` → MG5 with SMEFTsim3, Pythia, Rivet

  ```
  generate p p > l+ l- j j / h h1 NPall<=2 NPprop^2<=2 @1
  ```
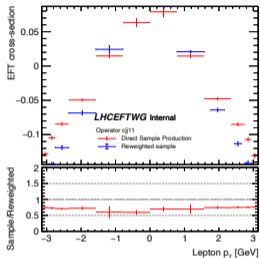
  → Includes both EW and QCD Zjj production
  → `NPall<=2`: single insertion of EFT operators either in vertex or propagator
  → `NPprop^2<=2`: limit propagator corrections to linear terms
  → sum over helicity states: `change helicity false`
  → some kinematic cuts in the `run_card`:
      `50.0 = ptj, 3.0 = etal, 0.1 = drll, 70.0 = mmll, 110.0 = mmllmax,`
      `900.0 = mmjj, 15.0 = ptllmin, 75.0 = ptj1min, 70.0 = ptj2min`
  → generate 10 million events

Zjj, EFT parameterisations
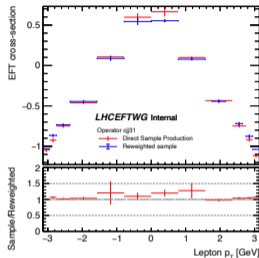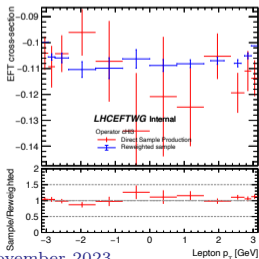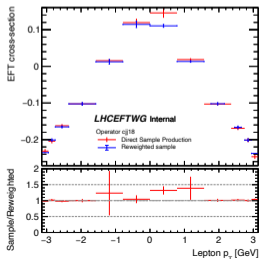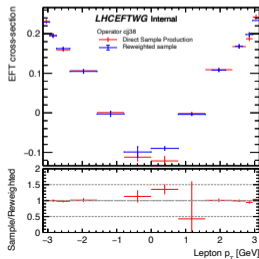
Zjj, EFT parameterisations

LHCEFTWG Preliminary — Zjj, 1-by-1 scans

68% CL · 95% CL · Best fit · Samples · Reweighted

Horizontal axis labels:
$0.001 \times C_G$, $0.1 \times C_W$, $0.01 \times C_{HD}$, $0.1 \times C_{HWB}$, $0.01 \times C_{Hq}^1$, $0.1 \times C_{Hq}^3$, $0.001 \times C_{Hu}$, $0.001 \times C_{Hd}$, $0.1 \times C_{qq}^{1,1}$, $0.1 \times C_{qq}^{1,8}$, $C_{qq}^{3,1}$, $0.1 \times C_{qq}^{3,8}$, $0.01 \times C_{uu}^1$, $0.001 \times C_{uu}^8$, $0.001 \times C_{ud}^8$, $0.01 \times C_{qu}^8$, $0.01 \times C_{qd}^8$, $0.1 \times C_{Hl}^1$, $0.1 \times C_{Hl}^3$, $0.1 \times C_{He}$, $0.1 \times C_{ll}'$

Summary
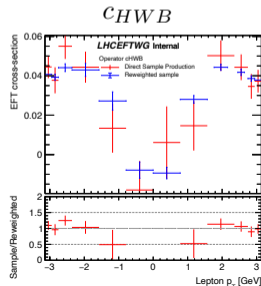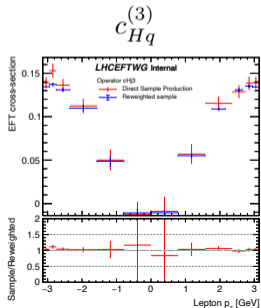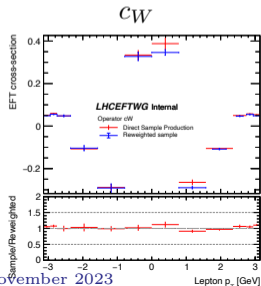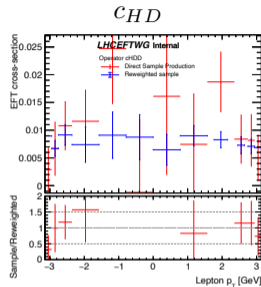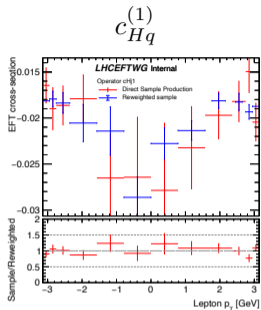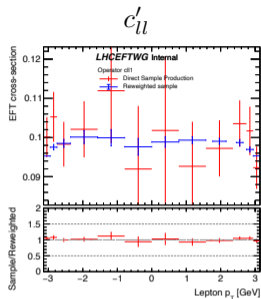
LHCEFTWG Preliminary — WW, 1-by-1 scans
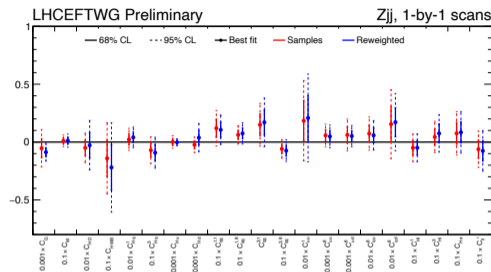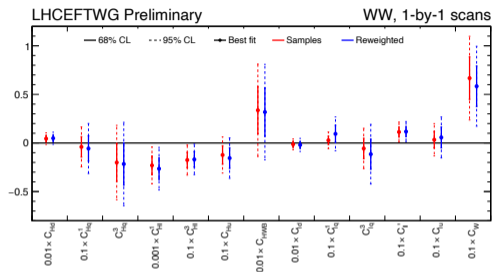
LHCEFTWG Preliminary — Zjj, 1-by-1 scans
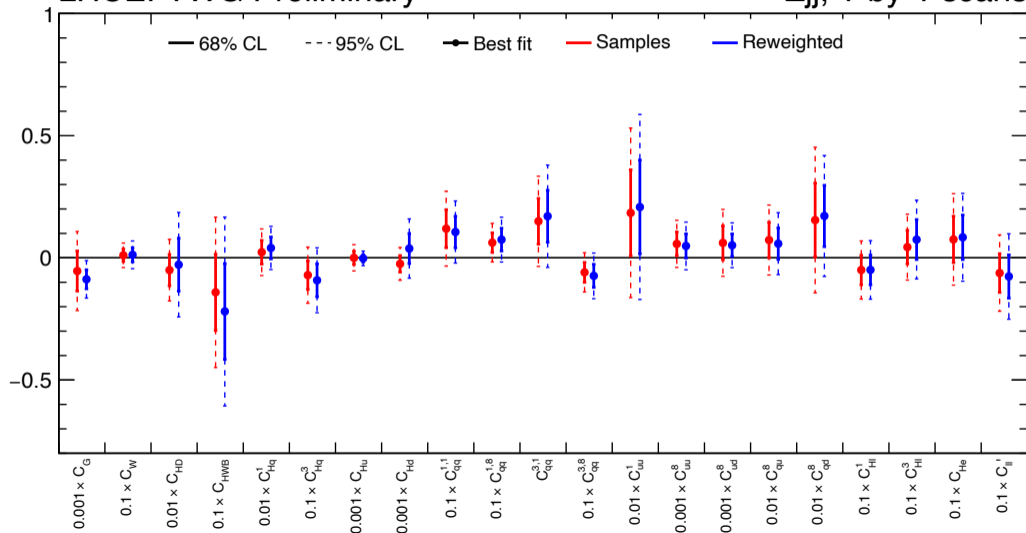
- WW and Zjj: Direct simulation and reweighting from SM in good agreement, especially when comparing fit results
- No obvious problems found
- Should test larger sample statistics for WW $c_{lq}^{(1)}$ and $c_{lq}^{(3)}$, as well as some operators in Zjj
- Double check process definitions used in the direct sample production
- Next: Reproduce CMS Wγ parameterisation (reweighted) using direct simulation
- If there is interest, these studies could be added to the EFTWG Prediction Note