

dEFT

differential Effective Field Theory tool


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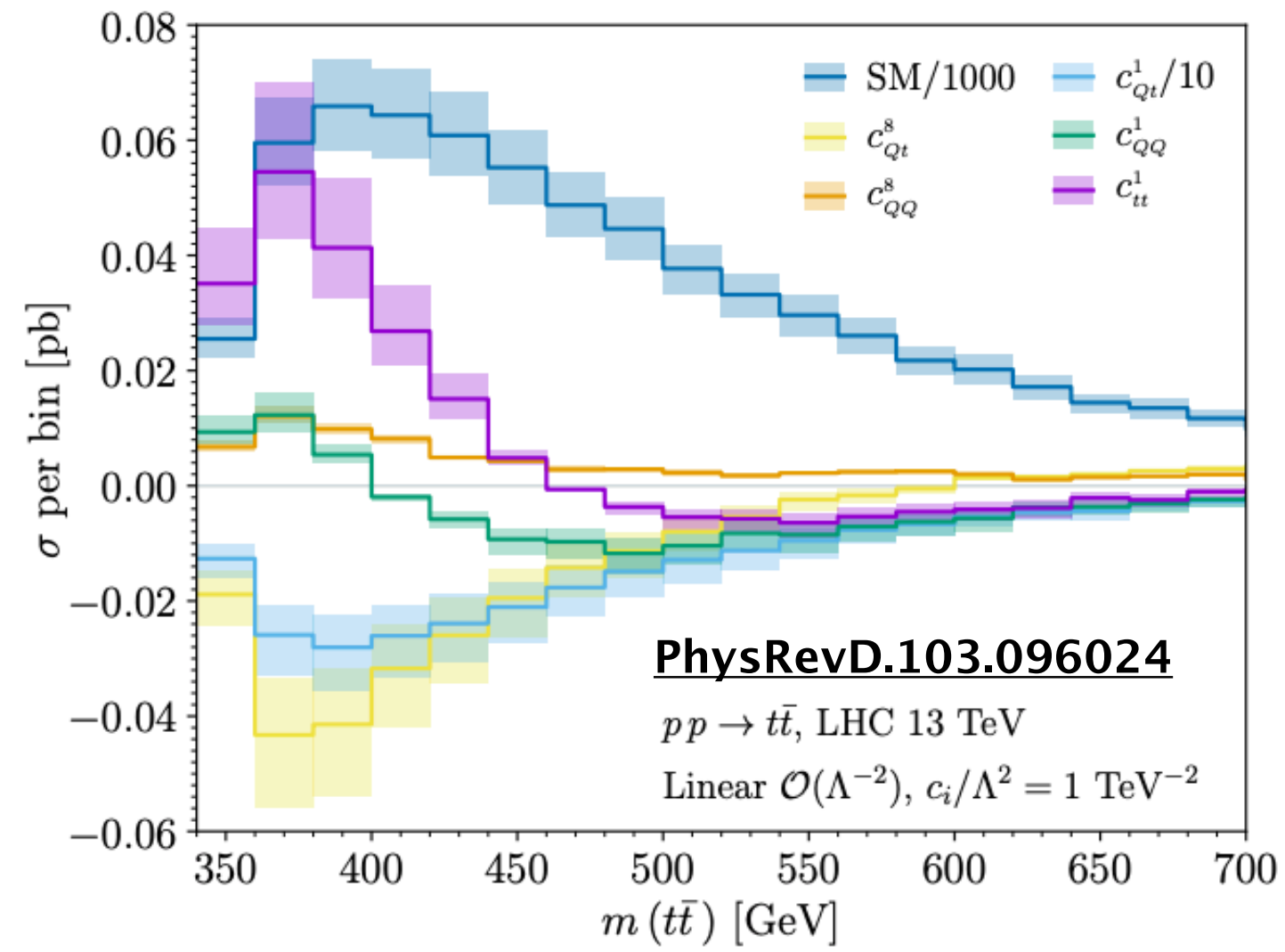
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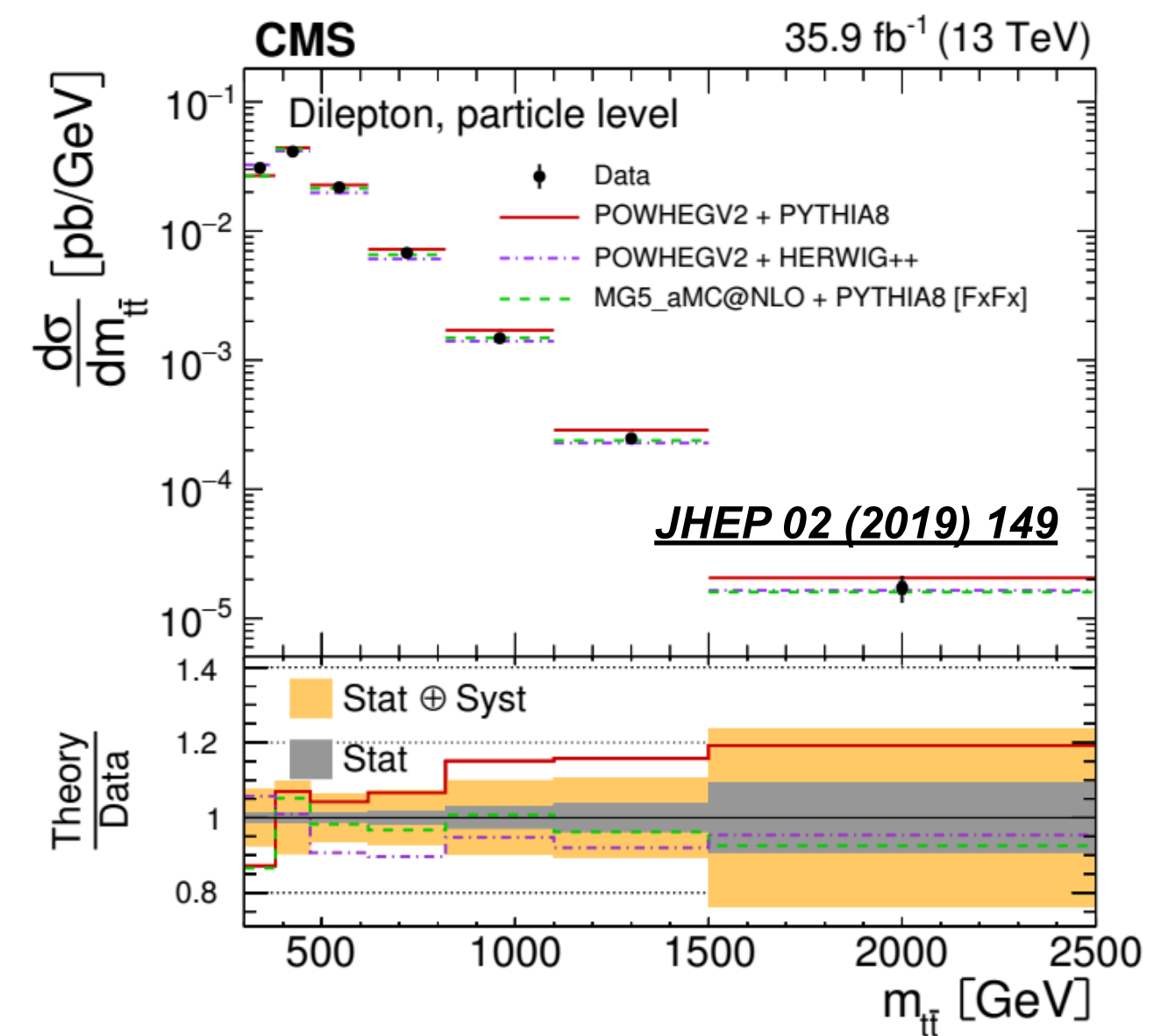
What is *d*EFT?

- A python tool to constrain the Standard Model Effective Field Theory with differential cross sections
- *d*EFT design goals:
 - simple, fast, extensible, in a word...*deft*
- *d*EFT is an alpha state:
 - available on GitHub for snooping  [dEFT](#)
 - stable, documented release within ~ 1 year

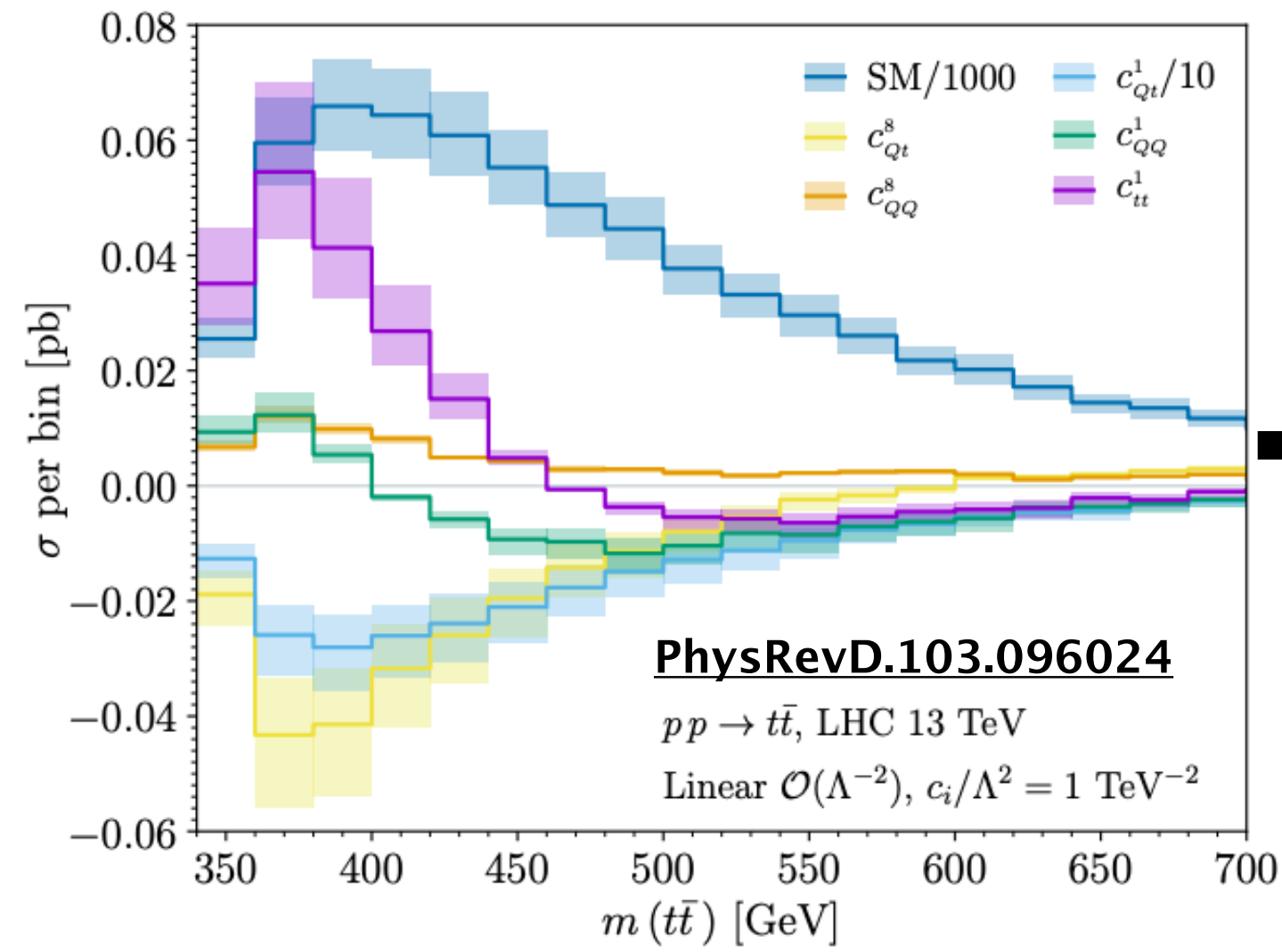
theory predictions for $\frac{d\sigma}{dX}$ in SMEFT



differential cross sections ($\frac{d\sigma}{dX}$)



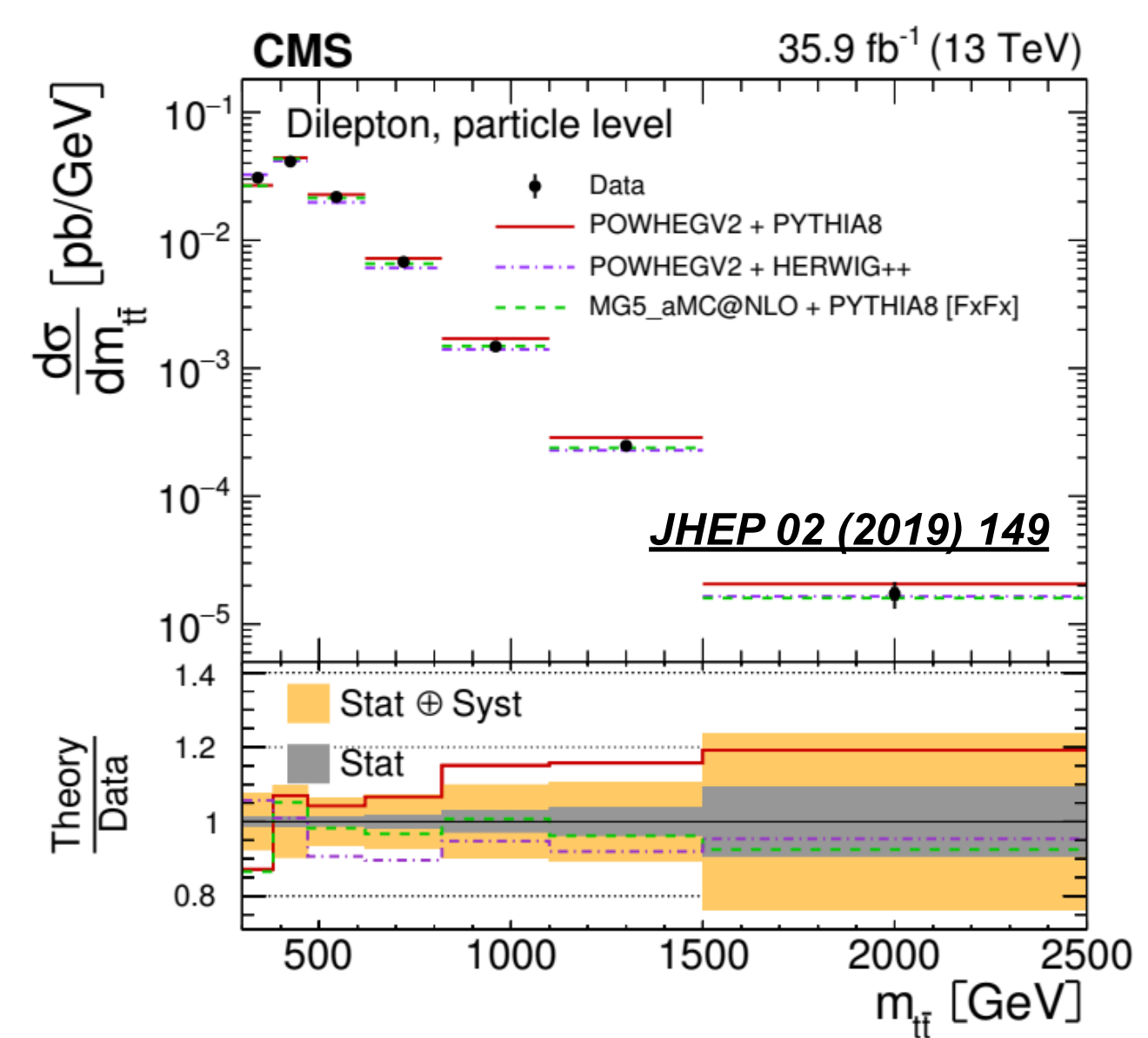
theory predictions for $\frac{d\sigma}{dX}$ in SMEFT



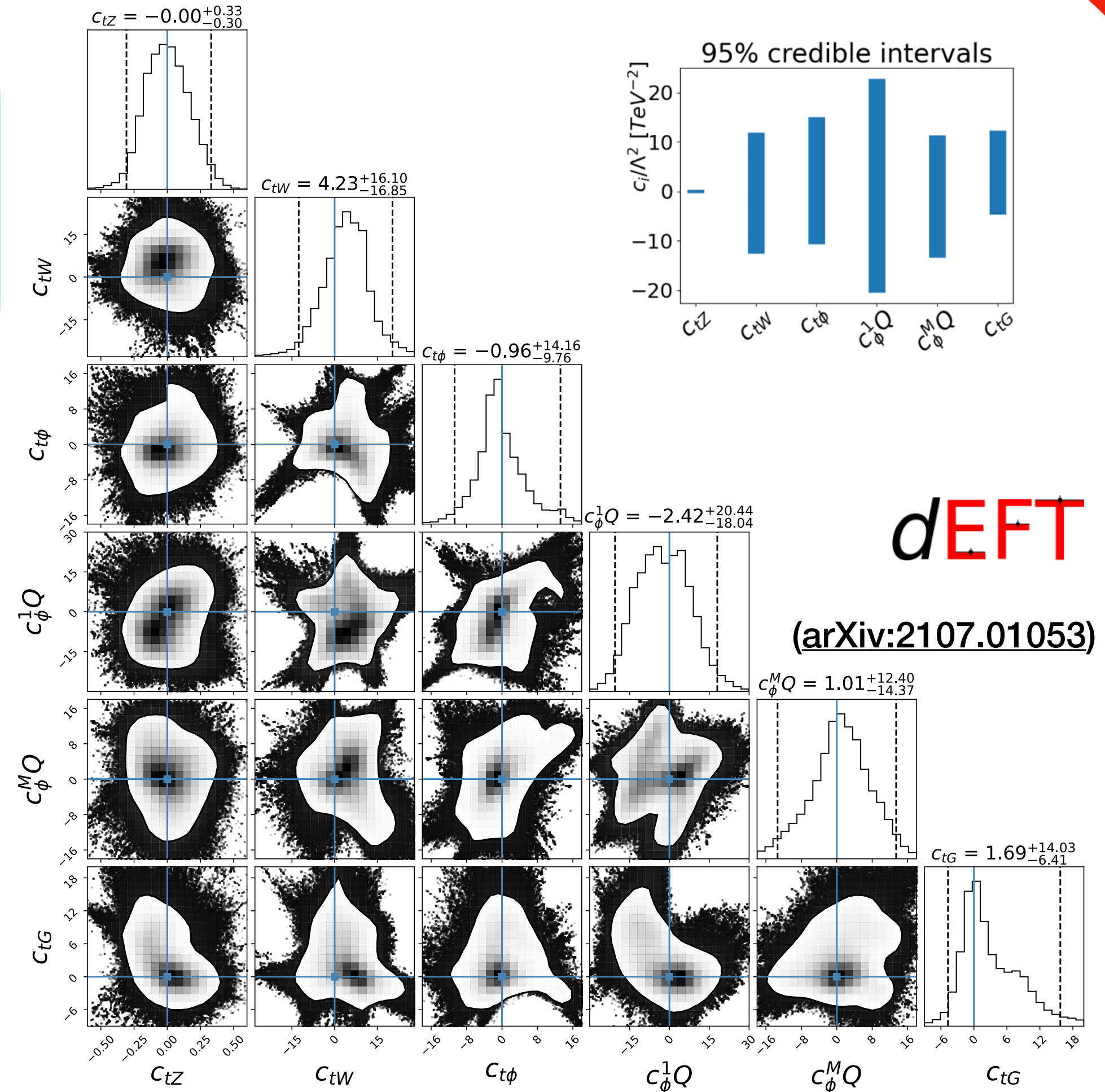
dEFT

regression
morphing model
 $\frac{d\sigma}{dX}(c_i)$

differential cross sections ($\frac{d\sigma}{dX}$)



Constraints on c_i via estimation of n-dimensional posterior pdf



Cross sections in SMEFT

$$\sigma(c_i) = \sigma_{SM} + \sum_{i=1}^{i=n} \frac{c_i}{\Lambda^2} \beta_i + \sum_{j=1}^{j=n} \sum_{i=1}^{i=n} \frac{c_i c_j}{\Lambda^4} \beta_{ij}$$

SMEFT cross section

SM cross section

linear terms

quadratic terms

1 unknown

n unknowns

$\frac{n(n+1)}{2}$ **unknowns**

Determining the unknowns yields the cross section for any c_i values!

Regression Morphing

$$S(\vec{\beta}) = \sum_{i=1}^{i=p} \sum_{j=1}^{j=q} (d\sigma_{i,j} - x(\vec{\beta})_{i,j})^2$$

determine unknowns by minimising S over p theory predictions

typically $p \gg$ number of unknowns

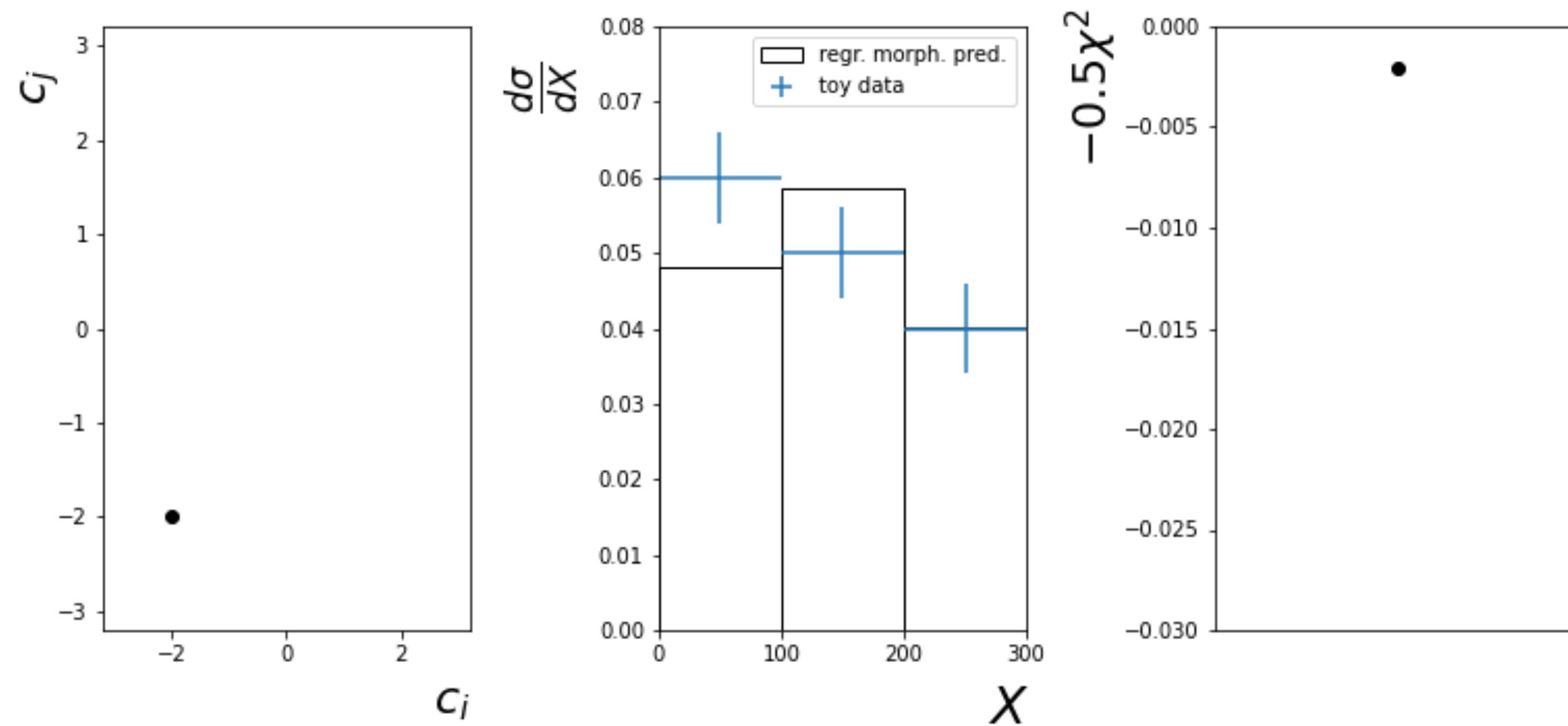
test by comparing model to independent theory predictions

Estimating the posterior pdf

dEFT

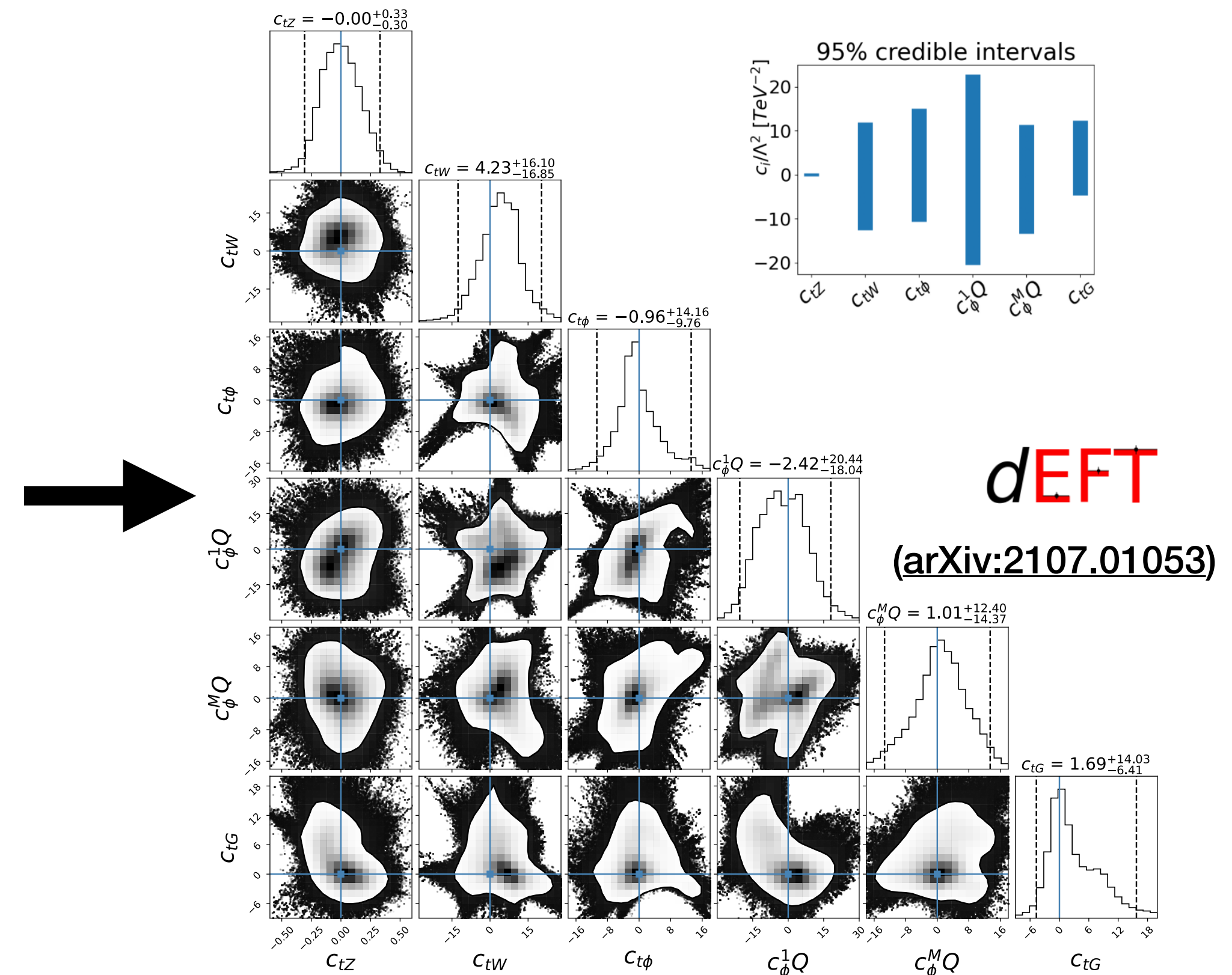
emcee

- explores c_i space and numerically estimates posterior



corner

- marginalises n-dimensional posterior pdf and estimates Bayesian credible intervals



dEFT inputs

- Entire analysis defined in single json file, two main blocks...

1.data

```
{ "config":  
  {  
    "run_name": "TWZ-REGMORPH300-6D-MORPH-300-XX-XXX",  
    "data": {  
      "observable": "ptZ",  
      "bins": [0.0, 100.0, 200.0, 300.0, 400.0, 500.0],  
      "central_values": [0.08531859451533069, 0.05287437872884173, 0.016201202770949615,  
        0.004041363792222167, 0.0015644601926557797],  
      "covariance_matrix": [[2.20722249e-05, 1.18636233e-05, 4.28665771e-06,  
        1.59642554e-06, 9.01005543e-07],  
        [1.18636233e-05, 8.88714941e-06, 2.96743910e-06, 1.10329844e-06,  
        6.35430011e-07],  
        [4.28665771e-06, 2.96743910e-06, 1.18538267e-06, 4.37342596e-07,  
        2.49916322e-07],  
        [1.59642554e-06, 1.10329844e-06, 4.37342596e-07, 1.71406297e-07,  
        9.62296936e-08],  
        [9.01005543e-07, 6.35430011e-07, 2.49916322e-07, 9.62296936e-08,  
        5.64666675e-08]]  
    }  
  },  
}
```


dEFT inputs

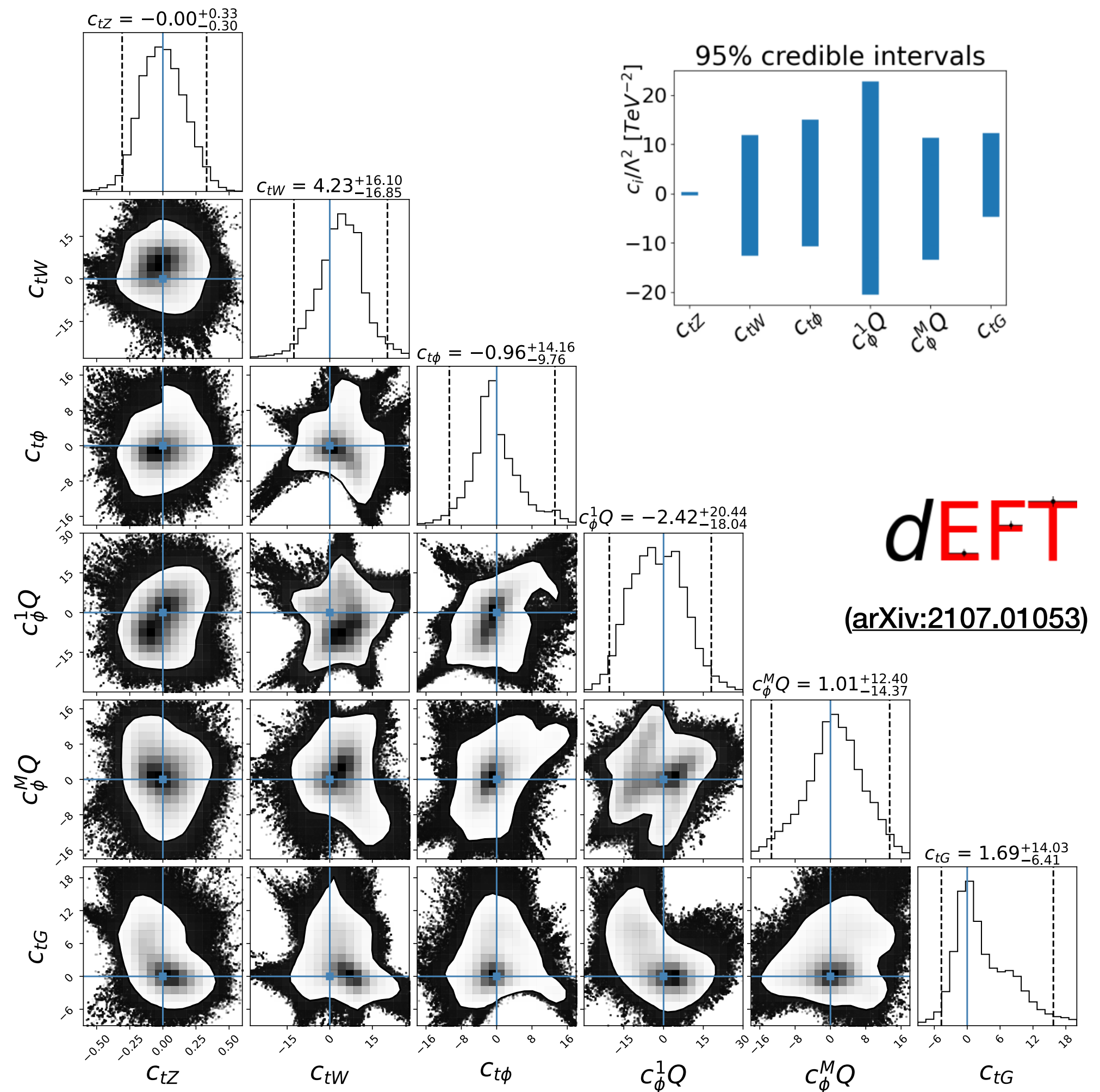
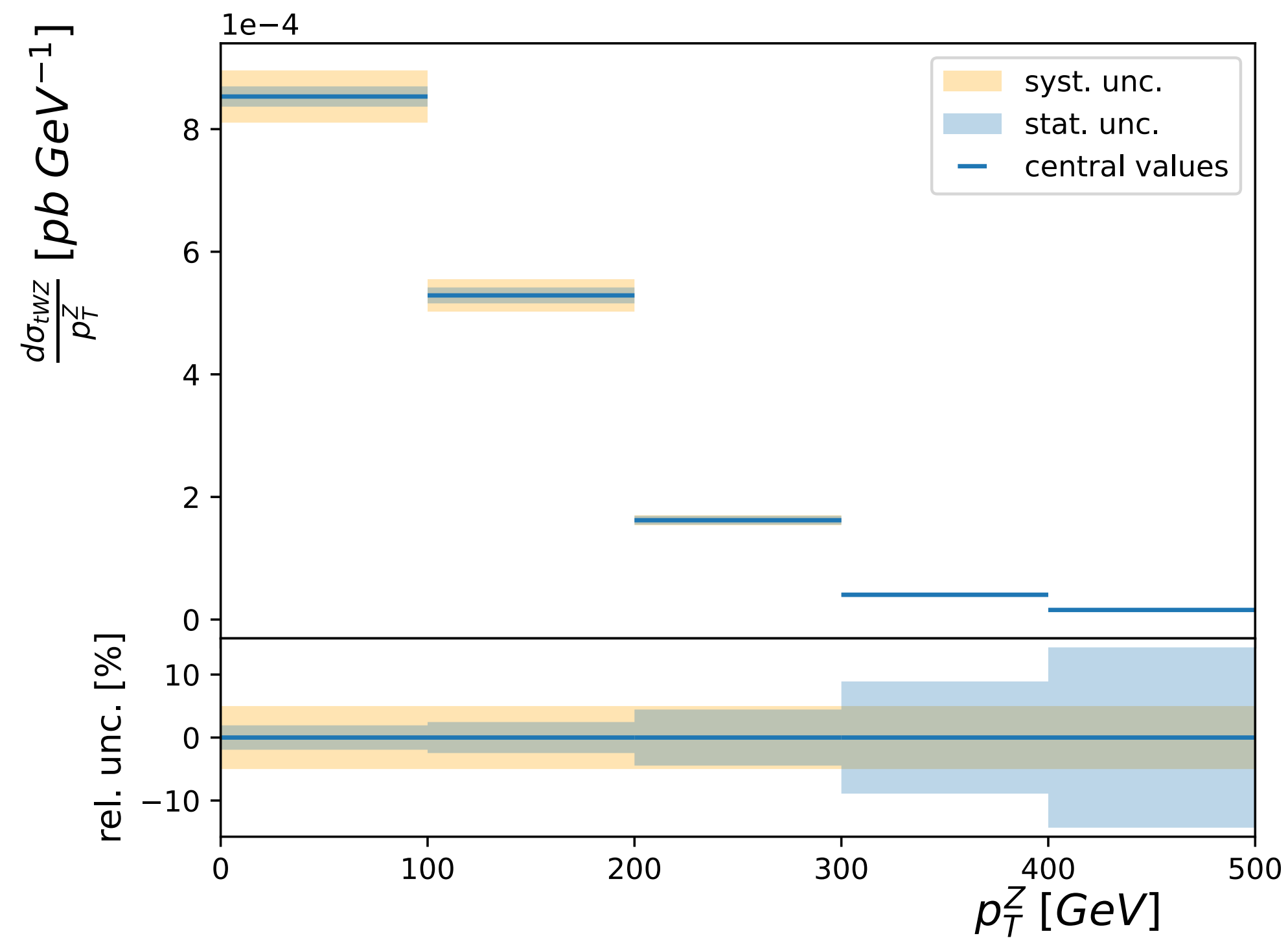
- Entire analysis defined in single json file, two main blocks...

2. model

```
"model":  
{  
  "input": "numpy",  
  "samples": [[ 1.00000001e+00,  4.28458829e+00,  3.85787661e-01,  
                -1.11938314e+00,  1.01594566e+01,  9.28419106e+00,  
                -2.56005197e+01],  
              [ 1.00000001e+00, -1.84432001e+01,  6.36216085e+00,  
                -4.92693339e+00,  2.38803782e+01,  1.55666848e+01,  
                7.35572823e+00],  
              [ 1.00000001e+00,  1.69237843e+01,  1.70925653e+01,  
                5.73929888e+00,  2.41083930e+01,  5.30089107e+00,  
                3.76221544e+00],  
              [ 1.00000001e+00, -4.10019689e+00,  1.56281165e+01,  
                2.06739008e+01,  1.77643035e+01, -2.76222036e+01,  
                -3.29422114e+00],  
              [ 1.00000001e+00,  1.08803132e+01, -7.92271547e+00,  
                2.40959980e+01,  9.47290860e+00,  2.36217713e+01,  
                -2.40592468e+00],  
              [ 1.00000001e+00,  2.83320581e+01, -1.88188325e+01,  
                -2.79981470e+01,  1.38684566e+01, -1.24214886e+01,  
                1.77227420e+01],  
              [ 1.00000001e+00, -1.64361154e+00,  2.76233943e+01,  
                1.58838989e+01,  6.83933696e+00, -2.56977257e+01,  
                -7.65657240e+00],
```

An example *d*EFT analysis

- dEFT already used to study potential impact of future HL-LHC differential cross section measurements of the tWZ process



Summary

- **dEFT constrains the SMEFT using differential cross sections in three steps**

1. regression morphing model of $\frac{d\sigma}{dX}$

2. **emcee** explores parameter space and estimates posterior pdf

3. **corner** marginalised posterior and estimates Bayesian credible intervals

- **dEFT is an alpha state:**

- used for analysis in preprint ([arXiv:2107.01053](https://arxiv.org/abs/2107.01053))

- available on GitHub for snooping  [dEFT](#)

- stable, documented release within ~ 1 year