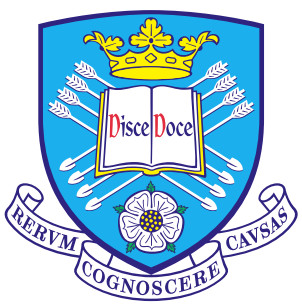
# ATLAS proposals for combination exercise

## Informal CMS/ATLAS SMEFT fitting exercise meeting

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Hannes Mildner on behalf of the ATLAS EFT combination enthusiasts

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# Introduction

Have prepared ATLAS inputs for combination exercise, based on following principles

- Simple statistical model
  - Few measurements
  - Multivariate Gaussian approximation
- Realistic technical framework
  - Harmonize theoretical assumptions and synchronize parametrizations
  - Use RooFit, combine on workspace level

$\Rightarrow$ Solid technical basis (and re-usable tools), straight forward to use more accurate model and to add more measurements later

# Input measurements

Higgs

- 2020 ATLAS $4\ell, \gamma\gamma, VH(b\bar{b})$ STXS combination

Electroweak

- $WW$
- $WZ$
- EW $Zjj$

Top

- None so far, $t\bar{t}Z$ planned

Precision data

- LEP 1 (+SLC) $Z$ pole measurements

# Model for measurements

- All shared material on gitlab
- Multivariate Gaussian approximation, ingredients:
  - Measured values (of observable, binned differential cross-section, or signal strength)
  - SM prediction
  - Covariance
- Used to create RooFit workspace

Configuration (e.g. Zpole.yaml):

Zpole.yaml 784 Bytes

```yaml
measurement: LEPSLC_Zpole_ins691576
covariance:
- [5.78e-06, 2.3e-07, 0, 0, 6.9e-09, 0, 0, -1.05259913863e-11]
- [2.3e-07, 0.000674, 0, 0, -1.4e-06, 0, 0, 7.049686809e-11]
- [0, 0, 9.0004e-06, -3.564e-07, 0, -6.3e-07, 1.92e-07, 0]
- [0, 0, -3.564e-07, 4.365e-07, 0, 1.617e-07, -1.056e-07, 0]
- [6.9e-09, -1.4e-06, 0, 0, 1.0484e-06, 0, 0, 9.24549089704e-14]
- [0, 0, -6.3e-07, 1.617e-07, 0, 1.274e-05, 8.4e-07, 0]
- [0, 0, 1.92e-07, -1.056e-07, 0, 8.4e-07, 3.5009e-06, 0]
- [-1.05259913863e-11, 7.049686809e-11, 0, 0, 9.24549089704e-14, 0, 0, 4.74883899596e-16]
names: [GammaZ, Rl, Rc, Rb, AFBl, AFBc, AFBb, sigmahadn]
measured: [2.4952, 20.767, 0.1721, 0.21619, 0.0171, 0.0707, 0.0992, 0.000106549]
sm: [2.4957, 20.758, 0.17223, 0.21586, 0.01718, 0.07583, 0.10615, 0.000106551714397]
```

Workspace: (e.g. meas_LEP_pole_obs.root)

```
variables
---------
(AFBb,AFBc,AFBl,GammaZ,Rb,Rc,Rl,sigmahadn,val_AFBb,val_AFBc,val_AFBl,val_GammaZ,val_Rb,val_Rc,val_Rl,val_sigmahadn)

p.d.f.s
-------
RooMultiVarGaussian::mvg[ x=(GammaZ,Rl,Rc,Rb,AFBl,AFBc,AFBb,sigmahadn) mu=(val_GammaZ,val_Rl,val_Rc,val_Rb,val_AFBl,

datasets
--------
RooDataSet::obsData(val_GammaZ,val_Rl,val_Rc,val_Rb,val_AFBl,val_AFBc,val_AFBb,val_sigmahadn)
```

- Measurements so far treated as uncorrelated, plan to introduce nuisance-parameters to correlate a few uncertainties, e.g. luminosity

# Theoretical framework

Theoretical framework follows proposals in Twiki

- Dim-6, Warsaw basis, (GF,mZ,mW) scheme
- $U(2)^3_{q,u,d} U(3)^2_{l,e}$ ("topU3l") flavour symmetry
- CP-even operators only(?)
- Single operator insertion
- Consider all relevant Warsaw-basis operators
- LO (but resolve ggF/Hyy loops with SMEFTatNLO?)
- Correct for width of intermediate particle ("propagator corrections")
- Multiply parametrization with "best" prediction
- Four flavour scheme, PDF set to be harmonized
- Harmonize renorm/fact scale for same process (?)

$\Rightarrow$ Would like to synchronize assumption so far that we could in principle derive exact same parametrization

# Calculation of predictions

- MadGraph + Pythia
  → Cards available, e.g. here for Higgs – ideally synchronize as far as possible
- Particle level analysis using public Rivet routines
  → also linked from gitlab page
- Simplify? start with linear only (ultimately lin+quad parametrization)? limit number of operators? Skip loop contributions for now?
- Different method for calculation exist, known to not always give the same result – cross-checks might be useful
  - "Direct" – calculate SM+dim6, derive parametrization
  - "Decomposition" – directly generate lin/quad term
  - Reweighting (+any of the above techniques)
- Parametrizations to be used to re-parametrize signal strengths in workspace
- We have started re-calculating prediction using public tools but would like to finalize common assumptions

# Parametrizations

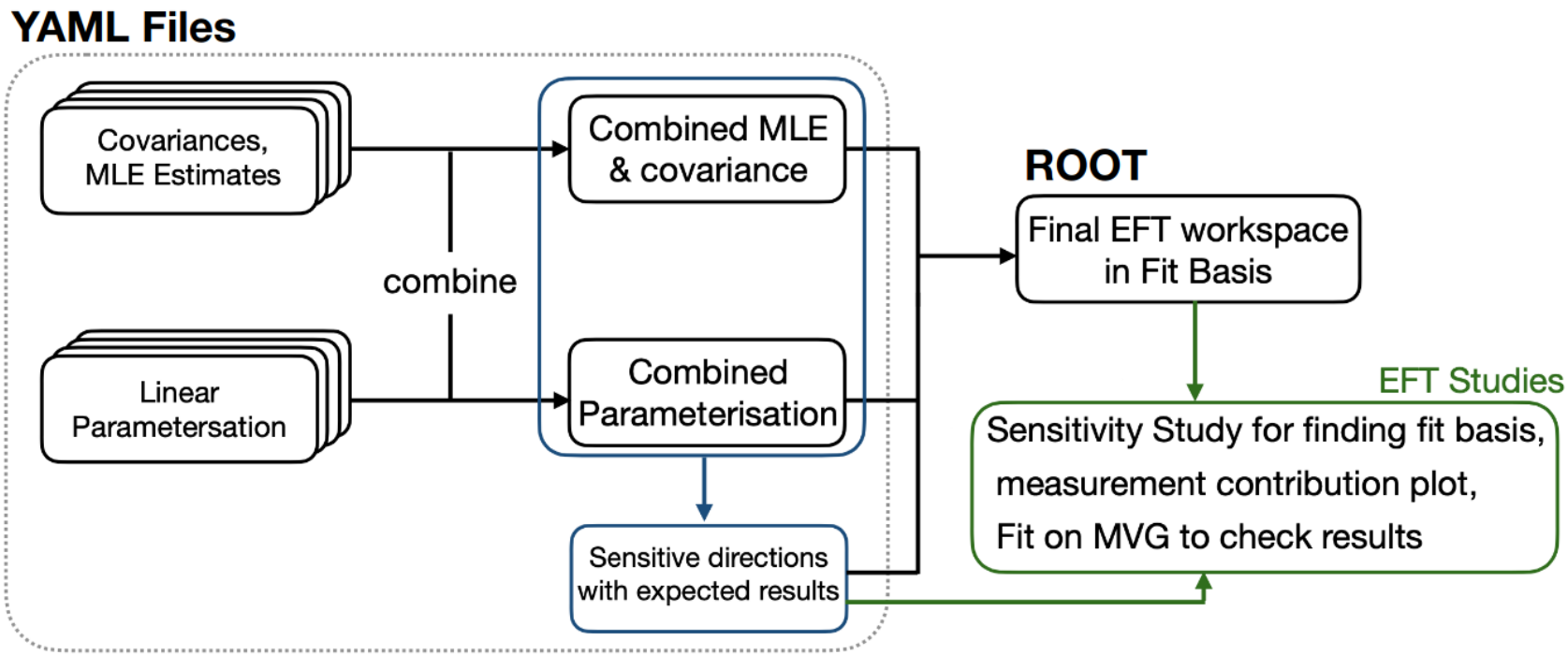
For example param_Zpole.yaml (useful format also for ATLAS-CMS comparisons?):

```
parameterisation:
- [0.00042457654262831546, 0.8629486575600566, 0.0, 0.48636269430051804, 0.48721243523316066,
  0.6039632595383888, 0.0, 0.0, 0.0, 0.9244559585492228, 0.008688996702779075, 0.008688996702779075,
  0.04984380593499764]
- [0.0004537188447844576, 0.9588606092575499, 0.0, 0.48630489252274833, 0.4872121851509957,
  0.6039641302914415, 0.06376420941579848, -0.06376420941579848, -0.15065409468548063,
  1.0271937228010024, 0.0, 0.0, 0.0]
- [0.0008565192083817767, 1.695570430733411, 0.0, 0.9727124563445866, 0.9744237485448196,
  1.2079278230500579, 0.0, 0.0, 0.0, 1.8164318975552969, 0.0, 0.0, 0.0]
- [0.05953279640982491, -0.0042923027607485445, -0.0071846776455503835, -0.08148054654004894,
  -0.010777056537244013, -0.010777056537244013, 0.07512481468125178, 0.007229594903233529,
  0.014369395360019206, 0.027283046840565713, 0.020965821212485462, 0.020965821212485462,
  -0.003658156028368818]
- [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
- [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0]
- [0.0008295608264615879, -0.004663439266191085, 0.01028310015750946, -0.0016591170202909257,
  0.0, 0.0, -0.10732141202631339, -0.010327990364124887, -0.020566200315019052, -0.004550375243213233,
  0.10654359306958217, 0.10654359306958217, -0.01854229593254892]
- [-0.0005413493584161387, 0.009048423619578524, 0.010283109795041547, 0.0010826975555943016,
  0.0, 0.0, 0.03390280438947916, -0.15155199442605818, 0.03915659292806137, 0.00940109156360675,
  -0.02995116994716368, -0.02995116994716368, 0.005235737095744006]
- [-0.0014973504191154502, 0.013956065131515595, -0.010283119761055906, -0.12969746603719057,
  -0.13269245592060894, 0.10664803931014545, 0.10732151459678191, 0.010328018113498372,
  0.020566191347914 08, 0.014145293380865238, 0.02995115136332974, 0.02995115136332974,
  -0.00523571635032281]
- [0.0005210399505458974, 0.0024792937541645442, 0.00408629746094691, 0.056480367622967466,
  0.1542462276933832, -0.08509379742326582, -0.04292854437759091, -0.004131205232042595,
  -0.00817259492189382, 0.0029343779381630283, -0.011980473587161242, -0.011980473587161242,
  0.002080576565610275]
tag: topU3l linear parameterisation of LEP Z-pole observables
xpars: [cll1, cHDD, cHd, cHl3, cHl1, cHe, cHj3, cHj1, cHu, cHWB, cHQ3, cHQ1, cHbq]
ypars: [pred_LEP1_AFBb, pred_LEP1_AFBc, pred_LEP1_AFBl, pred_LEP1_GammaZ, pred_LEP1_MW,
  pred_LEP1_MZ, pred_LEP1_Rb, pred_LEP1_Rc, pred_LEP1_Rl, pred_LEP1_sigmahadn]
SM_predictions: [106.15, 75.83, 17.18, 2495.7, 80387.0, 91197.6, 215.86, 172.23, 20758.0,
  0.106551714397]
```

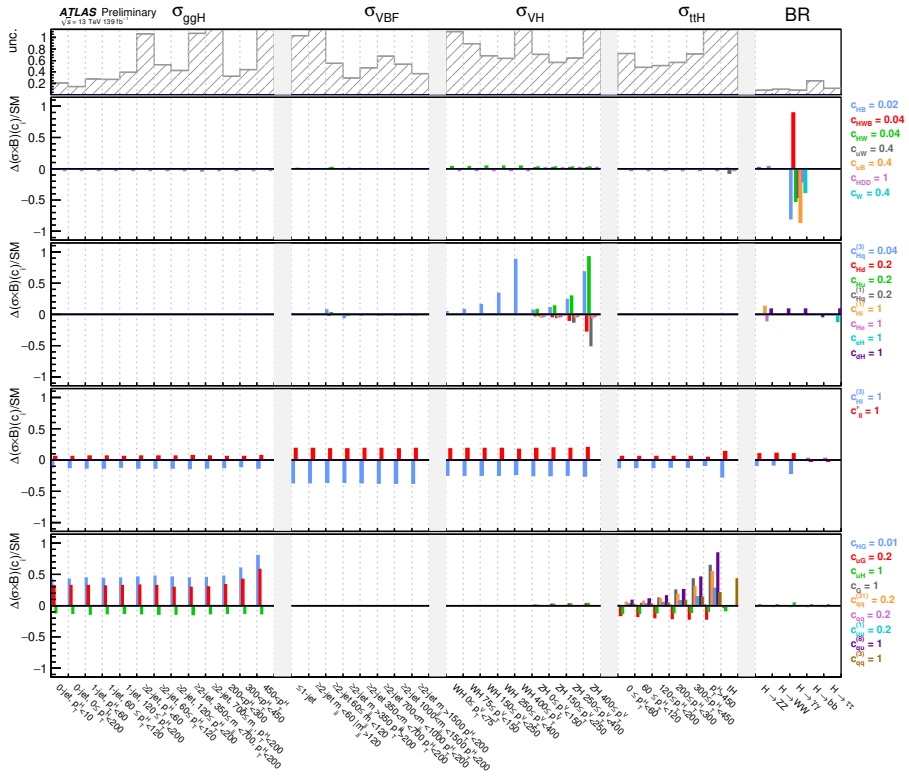
SMEFTsim 3.0 topU3l naming convention

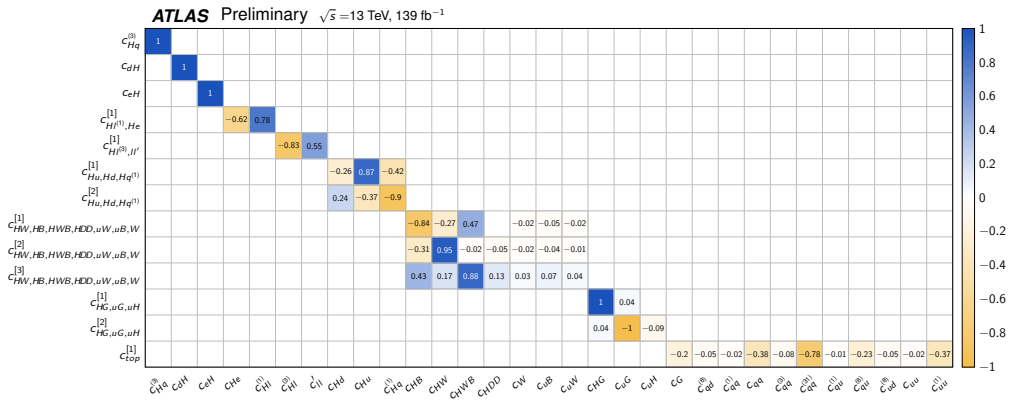
# ATLAS fitting framework

- Framework in place to create model and perform fits based on `yaml` input files, to be released soon

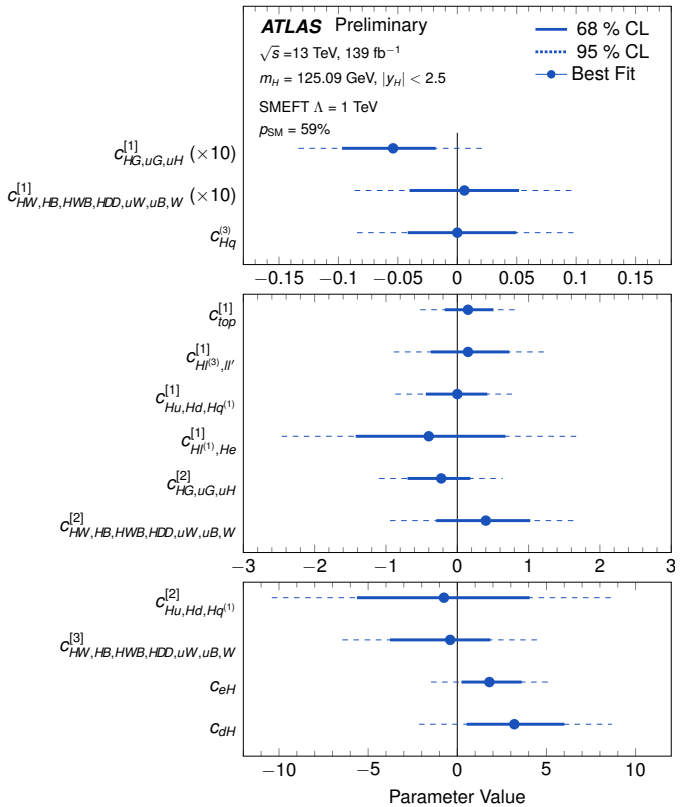


# Example results




Examples from ATLAS-CONF-2021-053, same framework can be used in exercise



# Short-term goals

- Share simplified (e.g. MVG) statistical models for measurement
  - In principle ready (except for $t\bar{t}Z$ measurement): 3 EW differential cross sections, Higgs STXS, and LEP
  - Workspaces available here
- Parametrizations
  - Would like to agree in detail on theoretical models and conventions
  - Can then generate parametrizations in common setup using public tools
  - Would like to validate parametrizations where possible (STXS should be identical, for other measurements we can run ATLAS+CMS Rivet routines for EW processes)
- Inject parametrizations into measurements, combine, and fit
  - Technical framework exists from our side