HEPfit: The Analysis Toolkit

ICHEP 2018

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Otto Eberhardt

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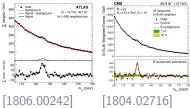








SM seems to be the correct description of most physics at LHC scales and below.

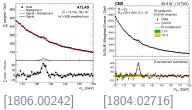




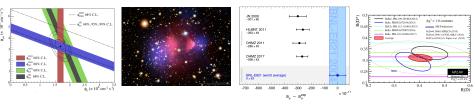
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SM seems to be the correct description of most physics at LHC scales and below.



Yet, we know there is more to nature. Which way to take from this point?



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Theory calculations get more precise and more complicated



We have a lot of experimental data to compare to, but the comparison is not always trivial and model dependent

The more results we combine with a certain theory, the better we can tell about the possible realisation of that theory.



Several codes on the market have one or more of the following disadvantages:

- Not public
- Slow (no fit possible) either due to sloppy implementation or external dependencies
- Not flexible: only one model or one set of constraints



Our idea:

Write an <u>open-source</u> code which can combine all experimental data and compare them to theory in a fit at best available precision, in as many models as possible.



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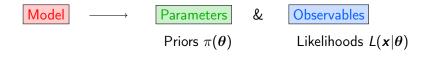




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General overview

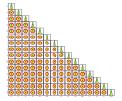


Output:

General overview



Output: Parameter and observable posterior distributions



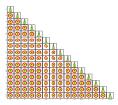
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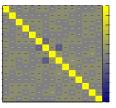
HEPfit

General overview



Output: Parameter and observable posterior distributions Parameter correlations





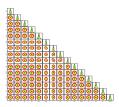
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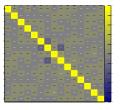
HEPfit

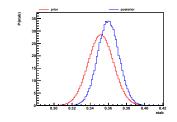
General overview



Output: Parameter and observable posterior distributions Parameter correlations Comparison of prior and posterior



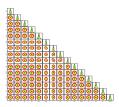


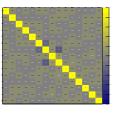


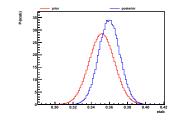
General overview



Output: Parameter and observable posterior distributions Parameter correlations Comparison of prior and posterior Global mode and normalisation, (D)IC values







Users and policies

Open-source project, but NO "HEPfit collaboration"

Shehu AbdusSalam Otto Fberhardt Ana Peñuelas (U Tehran) (IFIC València) (IFIC València) Marco Fedele Jorge de Blas Maurizio Pierini (INFN Padova (U Paris-Sud) CERN) Debtosh Chowdhury Enrico Franco Laura Reina (EP Paris) (INFN Rome) (Florida State) Marco Ciuchini Luca Silvestrini Giovanni Grilli (INFN Rome) (U São Paulo) (INFN Rome) Giovanna Cottin Satoshi Mishima Mauro Valli (NTU Taipei) (KEK) (INFN Rome) António Coutinho Norimi Yokozaki Ayan Paul (HU Berlin) (INFN Rome) (Tohoku U)



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Dependencies and Usage

C++ compiler

GSL, boost – numerical solutions to integration, algebra, differential equations etc.

BAT – statistics

ROOT – graphical output of the results (histograms) openMPI – only for parallelized fits

Once installed:

./analysis StandardModel.conf MonteCarlo.conf



Dependencies and Usage

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ROOT - graphical output of the results (histograms)

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Once installed:

./analysis StandardModel.conf MonteCarlo.conf



```
StandardModel
 2
   # Model parameters:
 3 ModelParameter mtop
                                  173.2
                                              0.9
                                                           0.
 4 ModelParameter mHl
                                  125.6
                                                           Ô.
                                              0.3
 5
 6
   CorrelatedGaussianParameters
                                     V1 lattice 2
   ModelParameter a OV
                             0.496
                                      0.067
                                               Ο.
    ModelParameter a 1V
                                      0.92
 8
                            -2.03
                                               0.
 9
    1.00
           0.86
10 0.86
            1.00
12
    <All the model parameters have to be listed here>
13
14
   # Observables:
15
   Observable Mw
                           Mw
                                      M {W}
                                                 80.3290 80.4064 MCMC weight 80.385 0.015 0.
16
    Observable GammaW
                           GammaW
                                      #Gamma {W} 2.08569 2.09249 MCMC weight 2.085 0.042 0.
17 #
18 # Correlated observables:
19
   CorrelatedGaussianObservables Zpole2 7
20
    Observable Alepton
                           Alepton
                                      A {1}
                                                 0.143568 0.151850 MCMC weight 0.1513 0.0021
                                                                                                 0.
21 Observable Rbottom
                           Rbottom
                                      R (b)
                                                 0.215602 0.215958 MCMC weight 0.21629 0.00066 0.
22 Observable Rcharm
                                                  0.172143 0.172334 MCMC weight 0.1721 0.0030
                           Rcharm
                                      R {c}
                                                                                                 0.
23 Observable AFBbottom AFBbottom A<sup>+</sup>(FB)<sup>+</sup>(b) 0.100604 0.106484 MCMC weight 0.0992
24 Observable AFBcharm AFBcharm A<sup>+</sup>(FB)<sup>+</sup>(c) 0.071750 0.076305 MCMC weight 0.0707
                                                                                         0.0016
                                                                                                   0.
                                                                                          0.0035
                                                                                                  0.
25
   Observable Abottom
                           Abottom
                                      A {b}
                                                 0.934320 0.935007 MCMC weight 0.923
                                                                                          0.020
                                                                                                  Ο.
    Observable Acharm
                           Acharm
                                      A_{c}
                                                 0.666374 0.670015 MCMC weight 0.670
                                                                                          0.027
                                                                                                  0.
26
27
   1.00 0.00
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                                0.00
                                        0.09
                                                0.05
28 0.00
         1.00
                 -0.18
                         -0.10
                                 0.07
                                        -0.08
                                                0.04
29 0.00 -0.18
                 1.00
                          0.04
                                -0.06
                                         0.04
                                               -0.06
30
   0.00
         -0.10
                  0.04
                          1.00
                                 0.15
                                         0.06
                                                0.01
31
          0.07
                 -0.06
                          0.15
                                                0.04
    0.00
                                 1.00
                                        -0.02
32
    0.09
         -0.08
                 0.04
                          0.06
                                -0.02
                                         1.00
                                                0.11
33
   0.05
         0.04
                 -0.06
                          0.01
                                0.04
                                         0.11
                                                1.00
34 #
35
   # Output correlations:
36 Observable2D MwysGammaW Mw M (W) 80.3290 80.4064 noMCMC noweight GammaW #Gamma (W) 2.08569 2.09249
    ...
   Observable2D Bd Bsbar mumu noMCMC noweight
38
39 Observable
                BR Bdmumu
                                 BR(B {d}#rightarrow#mu#mu)
                                                                 1. -1. 1.05e-10
                                                                                      0.
                                                                                           0.
40 Observable
                 BRbar Bsmumu
                                 BR(B {s}#rightarrow#mu#mu)
                                                                 1. -1. 3.65e-9
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41
42
    Observable2D S5 P5 noMCMC noweight
43
    BinnedObservable
                      S 5
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                                         1. -1. 0.
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                                                                       6.
                        P 5
                                 P 5
                                         1. -1. 0.
                                                       ō.
                                                            ο.
44
    BinnedObservable
45 #
46 # Including other configuration files
47 IncludeFile Flavour.conf
```

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```
StandardModel
                                                                         Model definition
3 ModelParameter mtop
                                173.2
                                                        0.
                                            0.9
   ModelParameter mH1
                                125.6
                                            0.3
                                                        Ô.
4
                                                                         (currently 35)
5
6
   CorrelatedGaussianParameters
                                   V1 lattice 2
   ModelParameter a 0V
                           0.496
                                   0.067
                                            Ο.
   ModelParameter a 1V
                                   0.92
8
                          -2.03
                                            0.
   1.00
          0.86
10
   0.86
           1.00
12
   <All the model parameters have to be listed here>
13
14
   # Observables:
15
   Observable Mw
                          Mw
                                   M {W}
                                               80.3290 80.4064 MCMC weight 80.385 0.015 0.
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   Observable GammaW
                          GammaW
                                   #Gamma {W} 2.08569 2.09249 MCMC weight 2.085 0.042 0.
18 # Correlated observables:
19
  CorrelatedGaussianObservables Zpole2 7
   Observable Alepton
                         Alepton
                                   A {1}
                                               0.143568 0.151850 MCMC weight 0.1513 0.0021
                                                                                            0.
21
   Observable Rbottom
                         Rbottom
                                   R (b)
                                               0.215602 0.215958 MCMC weight 0.21629 0.00066 0.
22 Observable Rcharm
                                               0.172143 0.172334 MCMC weight 0.1721
                         Rcharm
                                   R {c}
                                                                                    0.0030
                                                                                             0.
23 Observable AFBbottom AFBbottom A (FB)^{b} 0.100604 0.106484 MCMC weight 0.0992
                                                                                     0.0016
                                                                                              0.
                                   A {FB}^{c} 0.071750 0.076305 MCMC weight 0.0707
24
   Observable
              AFBcharm
                         AFBcharm
                                                                                     0.0035
                                                                                              0.
                                               0.934320 0.935007 MCMC weight 0.923
25
   Observable Abottom
                         Abottom
                                   A {b}
                                                                                     0.020
                                                                                              0.
26
   Observable
               Acharm
                         Acharm
                                   A_{c}
                                               0.666374 0.670015 MCMC weight 0.670
                                                                                     0.027
                                                                                              0.
27
  1.00
          0.00
                0.00
                         0.00
                               0.00
                                       0.09
                                              0.05
28
  0.00
          1.00
                -0.18
                        -0.10
                               0.07
                                      -0.08
                                              0.04
        -0.18
                 1.00
29
  0.00
                         0.04
                              -0.06
                                       0.04
                                             -0.06
30
  0.00
         -0.10
                 0.04
                         1.00
                               0.15
                                       0.06
                                              0.01
31
          0.07
                -0.06
                         0.15
                                              0.04
   0.00
                               1.00
                                      -0.02
32
   0.09
         -0.08
                 0.04
                         0.06
                              -0.02
                                       1.00
                                              0.11
33
  0.05
          0.04
                -0.06
                         0.01
                              0.04
                                       0.11
                                              1.00
34 #
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  # Output correlations:
36
  Observable2D MwvsGammaW Mw M (W) 80.3290 80.4064 noMCMC noweight GammaW #Gamma (W) 2.08569 2.09249
38
  Observable2D Bd Bsbar mumu noMCMC noweight
39
   Observable
                BR Bdmumu
                                BR(B {d}#rightarrow#mu#mu)
                                                              1. -1. 1.05e-10
                                                                                 0.
                                                                                      0.
                                                                                      ο.
40
  Observable
                BRbar Bsmumu
                               BR(B {s}#rightarrow#mu#mu)
                                                              1. -1. 3.65e-9
                                                                                 0.
41
42
   Observable2D S5 P5 noMCMC noweight
43
   BinnedObservable
                      S 5
                                S 5
                                       1. -1. 0.
                                                    Ο.
                                                         Ο.
                                                              4:
                                                                   6.
                      P 5
                               P 5
                                       1. -1. 0.
                                                    ō.
                                                         ο.
44
   BinnedObservable
45
46 # Including other configuration files
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```

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1 StandardModel # Model parameters: ModelParameter mtop 173.2 0.9 0. ModelParameter mH1 125.6 0.3 Ô. CorrelatedGaussianParameters V1 lattice 2 ModelParameter a 0V 0.496 0.067 Ο. Parameter values ModelParameter a 1V -2.03 0.92 0. 1.00 0.86 0.86 1.00 <All the model parameters have to be listed here> 14 # Observables: 15 Observable Mw M {W} 80.3290 80.4064 MCMC weight 80.385 0.015 0. Mw 16 Observable GammaW GammaW #Gamma {W} 2.08569 2.09249 MCMC weight 2.085 0.042 0. 17 # 18 # Correlated observables: CorrelatedGaussianObservables Zpole2 7 19 20 Observable Alepton Alepton A {1} 0.143568 0.151850 MCMC weight 0.1513 0.0021 0. 21 Observable Rbottom Rbottom R (b) 0.215602 0.215958 MCMC weight 0.21629 0.00066 0. 22 Observable Rcharm 0.172143 0.172334 MCMC weight 0.1721 0.0030 Rcharm R {c} 0. 23 Observable AFBbottom AFBbottom A⁺(FB)⁺(b) 0.100604 0.106484 MCMC weight 0.0992 24 Observable AFBcharm AFBcharm A⁺(FB)⁺(c) 0.071750 0.076305 MCMC weight 0.0707 0.0016 0. 0.0035 0. 25 Observable Abottom Abottom A {b} 0.934320 0.935007 MCMC weight 0.923 0.020 Ο. 26 Observable Acharm Acharm A_{c} 0.666374 0.670015 MCMC weight 0.670 0.027 0. 27 1.00 0.00 0.00 0.00 0.00 0.09 0.05 28 0.00 1.00 -0.18 -0.100.07 -0.08 0.04 29 0.00 -0.18 1.00 0.04 -0.06 0.04 -0.06 30 0.00 -0.10 0.04 1.00 0.15 0.06 0.01 31 0.07 -0.06 0.15 0.04 0.00 1.00 -0.0232 0.09 -0.08 0.04 0.06 -0.02 1.00 0.11 33 0.05 0.04 -0.06 0.01 0.04 0.11 1.00 34 # 35 # Output correlations: 36 Observable2D MwvsGammaW Mw M (W) 80.3290 80.4064 noMCMC noweight GammaW #Gamma (W) 2.08569 2.09249 38 Observable2D Bd Bsbar mumu noMCMC noweight 39 Observable BR Bdmumu BR(B {d}#rightarrow#mu#mu) 1. -1. 1.05e-10 0. 0. 1. -1. 3.65e-9 ο. 40 Observable BRbar Bsmumu BR(B {s}#rightarrow#mu#mu) Ο. 41 42 Observable2D S5 P5 noMCMC noweight 43 BinnedObservable S 5 S_5 P_5 1. -1. 0. 0. 0. 4. 6. P 5 1. -1. 0. 44 BinnedObservable 45 # 46 # Including other configuration files 47 IncludeFile Flavour.conf



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```
StandardModel
2
   # Model parameters:
3 ModelParameter mtop
                                173.2
                                             0.9
                                                         0.
4 ModelParameter mH1
                                125.6
                                             0.3
                                                         ò.
5
6
   CorrelatedGaussianParameters
                                   V1 lattice 2
   ModelParameter a 0V
                           0.496
                                    0.067
                                             0.
8
   ModelParameter a 1V
                          -2.03
                                    0.92
                                             0.
   1.00
          0.86
10 0.86
            1.00
12 <All the model parameters have to be listed here>
   # Observables:
   Observable Mw
                                    M {W}
                                                80.3290 80.4064 MCMC weight 80.385 0.015 0.
                          Mw
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                          GammaW
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                                    A {1}
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                          Rbottom
                                    R (b)
                                                0.215602 0.215958 MCMC weight 0.21629 0.00066 0.
   Observable Rcharm
                                                0.172143 0.172334 MCMC weight 0.1721 0.0030
                          Rcharm
                                    R {c}
                                                                                              0.
   Observable AFBbottom AFBbottom AFBb<sup>(</sup>FB)^{b} 0.100604 0.106484 MCMC weight 0.0992
Observable AFBcharm AFBcharm A [FB]^{c} 0.071750 0.076305 MCMC weight 0.0707
                                                                                      0.0016
                                                                                               0.
                                                                                       0.0035
                                                                                               0.
                                                0.934320 0.935007 MCMC weight 0.923
   Observable Abottom
                          Abottom
                                    A {b}
                                                                                       0.020
                                                                                               Ο.
   Observable Acharm
                          Acharm
                                                0.666374 0.670015 MCMC weight 0.670
                                                                                       0.027
                                                                                               0.
                                    A_{c}
   1.00
        0.00
               0.00
                         0.00
                               0.00
                                       0.09
                                              0.05
   0.00
         1.00
                -0.18
                        -0.10
                               0.07
                                      -0.08
                                              0.04
                                                                   Observables and
   0.00 -0.18
                1.00
                                              -0.06
                         0.04
                              -0.06
                                      0.04
   0.00
        -0.10
                 0.04
                         1.00
                               0.15
                                      0.06
                                              0.01
   0.00
         0.07
                -0.06
                         0.15
                                      -0.02
                                              0.04
                               1.00
                0.04
                                                                   predictions
   0.09 -0.08
                         0.06
                              -0.02
                                       1.00
                                               0.11
   0.05
        0.04 -0.06
                         0.01
                              0.04
                                              1.00
                                       0.11
   # Output correlations:
   Observable2D MwysGammaW Mw M (W) 80.3290 80.4064 noMCMC noweight GammaW #Gamma (W) 2.08569 2.09249
   Observable2D Bd Bsbar mumu noMCMC noweight
   Observable
               BR Bdmumu
                                BR(B {d}#rightarrow#mu#mu)
                                                               1. -1. 1.05e-10
                                                                                   0.
                                                                                        0.
                                                               1. -1. 3.65e-9
                                                                                      ō.
   Observable
                BRbar Bsmumu
                                BR(B {s}#rightarrow#mu#mu)
                                                                                   0.
   Observable2D S5 P5 noMCMC noweight
   BinnedObservable
                       S_5
P 5
                                S_5
P 5
                                       1. -1. 0.
                                                     Ο.
                                                         0.
                                       1. -1. 0.
                                                     0. 0.
                                                               4.
   BinnedObservable
46 # Including other configuration files
47 IncludeFile Flavour.conf
```



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Observable list

The release candidate 2 contains more than 1000 observables

HEPIt name	Model(s)	Comments
RENGBAR	SM	
Nu	SM	
GammaW	SM	
GannaZ	SM	
signaRadron	SM	
sin2thetaEff	SM	
PtauFol	SM	
Alepton	SM	
Acharm	SM	
Abotton	SM	
AFELepton	SM	
AFRicharm	SM	
AFEbotton	SM	
Riepton	SM	
Scharm	SM	
Rhotton	SM	
ggRx	514	x ∈ 7, 8, 13, 14, 100, 196; without x default is 8
WEX	SM	x = 7.8.13.14.100.196: without x default is 8
100	SM	$x \in 7, 8, 13, 14, 100$; without x default is 8
ZEx	SM	x = 7, 8, 13, 14, 100, without x default is 8
Wax	SM	x = 7, 8, 13, 14, 100, 196; without x default is 8
ggH+ttEx	SM	x = 0, 13, 14, 100; without x default is 0
VIE-VIA	514	x < 0, 13, 14, 100; without x default is 0
7784	SM	x = 7, 8, 13, 14, 100, 196; without x default is 8
eeZäx	514	x = 240, 250, 500, 1000
eevilit x	SM	x = 250, 350, 500, 1000
eettRx	SM	x = 500, 1000
Referentio	SM	
Remonstratio	SM	1
BrHILERatio	SM	
Br#ZgaRatio	SM	
RrigagaRatio	SM	
RrHmmuRatio	SM	
RESTAULAURATIO	SM	
RriccRatio	SM	
BribbRatio	SM	
epsilosx	201	x = 1,2,3,b
	114	
Dealers	SM THEORE	
Daiks	SM, THDM	
Daiks Daiks SJPaik		
Dalká Dalka SJPaik Betas JPaiPhi	SM, THDM SM	
Dalki Dalka SJPaiK Betas_JPaiPhi RgsilonK	SM, THDM SM SM SM	
Dalká Dalka SJPaik Betas JPaiPhi	SM, THDM SM SM	
Dalkd Dalks 2.3PaiK Becas_3PaiPhi RpsilonK Dalk Vij	SM,THDM SM SM SM SM	<i>j</i> = <i>u</i> , <i>c</i> , <i>t</i> ; <i>j</i> = <i>d</i> , <i>s</i> , <i>b</i>
Dubh Duba SJPaiK Betas JPaiPhi EpsilonK Duk Vy alcha	SM, THDM SM SM SM SM SM SM SM	
Dalid Dalia SIPaik Betas_PaiPai Epsilonk Dak Vy alpha alpha_2a	SM, THDM SM SM SM SM SM SM SM SM	
Dulid Dulia SiPatk Betas_SFatPat EpsilonK Duk Vy alpha alpha_2a gama	SM, THDM SM SM SM SM SM SM SM SM SM	
Tuhh Dulla 21Paik Betas_PaiPhi Tprilonk Duk Wy alpha alpha_2a	SM, THDM SM SM SM SM SM SM SM SM SM SM	
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Dada Dada 21Paik <u>Beras</u> _P21Phi <u>Task</u> Wy alpha alpha_2a alpha_2a beta beta beta beta	SM, THDM SM SM SM SM SM SM SM SM SM SM SM SM SM	
Dada Dada 23PaiX Reca_PaiPai Iqailoa Dad Vij alpha_2a gama beta beta 2setagama z2seta	SM, THDM SM SM SM SM SM SM SM SM SM SM SM SM SM	
Duda Duda SiPaik Betas JPiPai Epiloak Bet Ny Alpha 2a gana beta beta beta 2beta a2beta a2beta	SM, THDM SM SM SM SM SM SM SM SM SM SM SM SM SM	
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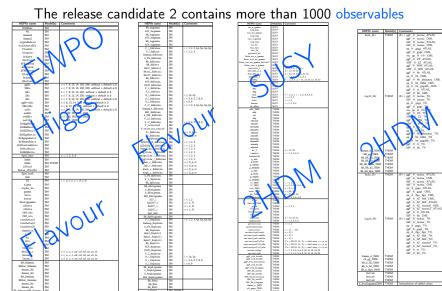
HEFTE name	Model(x)	Convents
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and table of an and table of a	930Y	q = 12, 13, 23 $\bar{q} = 12, 13, 23, 21, 31, 32$
4+31+305 /	925Y	$i = 1, 2, 3, \delta = u, d, r$
	916Y	$\delta = w, d, \pi, \bar{\eta} = 11, 22, 33, 12, 13, 23$
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HEPIit rame	Model(s)	Comments
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		pp_H_gaga_ATLAS,
		ggF_H_gaga_CMS,
		REP_H_BARA_CARA
		mu_pp_H_VV_CMS, ggF_H_ZZ_ATLAS,
		EP_H_ZZ_AILAS,
		VEF H ZZ ATLAS, ARF H WW ATLAS, VEF H WW ATLAS,
		gp_II_WW_ATEAS,
		BEF H WW ATLAS, VIEF H WW ATLAS, BEF H Nh ATLAS, MF H Nh CMS
		ggF_H_hh_ATLAS,
		pp_H_hh_CMS,
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	1	mu so H VV TH
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	1	VEF_H_ZZ_TH,
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	1	SEF_H_WW_TH, VEF_H_WW_TH,
	1	VID_R_WW_TH,
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		ggF_H_hh_bbtastau_TH,
		pp_H_hh_bbbb_TH,
		pp H hh gagabb TH,
		ggF H II TH,
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	1	ggF_A_bZ_bbZ_ATLAS,
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Otto Eberhardt

HEPfit

Observable list



Otto Eberhardt

HEPfit

Standard Model

Full flexibility in the Standard Model:

- 3 gauge couplings: g_1 , g_2 , g_3 (or $\Delta \alpha_{had}^{(5)}$, M_Z , α_s)
- m_h and λ (or v or G_F)
- 9 fermion masses: m_u , m_d , m_s , m_c , m_b , m_t , m_e , m_μ , m_τ
- λ , A, $\bar{\rho}$, $\bar{\eta}$ (or θ_{12} , θ_{13} , θ_{23} , and δ)

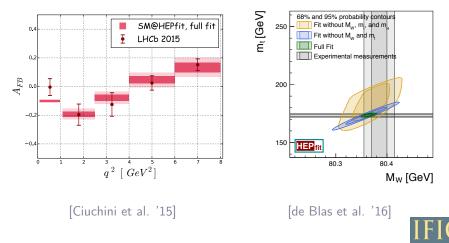
18 (real) parameters



Otto Eberhardt

Standard Model – observables

Many flavour and electroweak observables



Otto Eberhardt

HEPfit

Generic SM extensions in HEPfit

```
Modified Zb\bar{b} couplings (\delta g^{b}_{R,L})
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- EW pseudo-observables ($S, T, U/\delta \varepsilon_i, \delta \varepsilon_b$)
- Modified Higgs couplings $(\kappa_{u,d,\ell,W,Z})$
- SM effective theory (59 c_i)

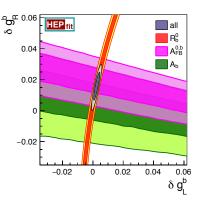
```
Electroweak chiral Lagrangian (9 c<sub>i</sub>)
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Generic SM extensions in HEPfit

Modified $Zb\overline{b}$ couplings $(\delta g^b_{R,L})$

- EW pseudo-observables ($S, T, U/\delta \varepsilon_i, \delta \varepsilon_b$)
- Modified Higgs couplings $(\kappa_{u,d,\ell,W,Z})$
- SM effective theory (59 c_i)
- Electroweak chiral Lagrangian (9 c_i)



[de Blas et al. '16]



HEPfit

Generic SM extensions in HEPfit

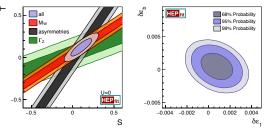
```
Modified Zb\bar{b} couplings (\delta g^{b}_{R,L})
```

EW pseudo-observables ($S, T, U/\delta \varepsilon_i, \delta \varepsilon_b$)

Modified Higgs couplings $(\kappa_{u,d,\ell,W,Z})$

Electroweak chiral Lagrangian

SM effective theory (59 c_i)



[de Blas et al. '16]



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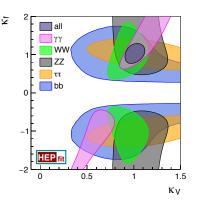
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HEPfit

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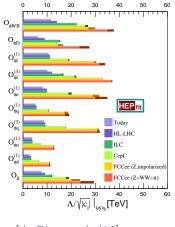
[de Blas et al. '16]



HEPfit

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[de Blas et al. '16] Dedicated ICHEP talk: Constraints on the SMEFT



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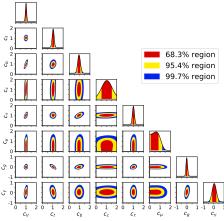
HEPfit

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[de Blas, OE, Krause '18]



New physics models in HEPfit

```
2HDM with(out) Z<sub>2</sub> symmetry
(7 / 66 parameters)
```

```
Georgi-Machacek model (8 parameters)
```

```
Manohar-Wise model
(14 parameters)
```

```
MSSM with complex couplings (108 parameters)
```

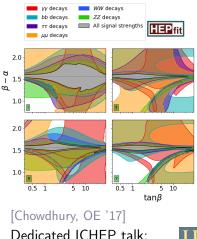
```
Left-Right symmetric model (13 parameters)
```



New physics models in HEPfit

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Current status of 2HDM's



HEPfit

New physics models in HEPfit

2HDM with(out) Z₂ symmetry (7 / 66 parameters)

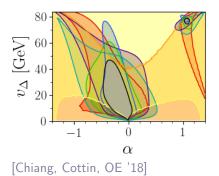
Georgi-Machacek model (8 parameters)

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MSSM with complex couplings (108 parameters)

Left-Right symmetric model (13 parameters)





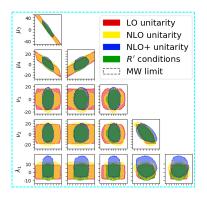


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[Cheng, OE, Murphy, '18]



New physics models in HEPfit

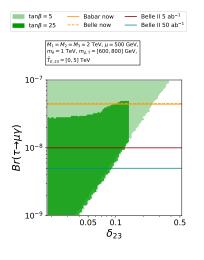
2HDM with(out) Z₂ symmetry (7 / 66 parameters)

Georgi-Machacek model (8 parameters)

Manohar-Wise model (14 parameters)

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Left-Right symmetric model (13 parameters)



[OE, Paul, '18]



HEPfit

Implementation of your own model

User-defined models and observables can easily be defined as external modules:





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Library and Monte Carlo modes

Until here only a collection of formulae, which can be used as a library.

No analytical treatment, but (very) fast evaluation as compared to e.g. Mathematica

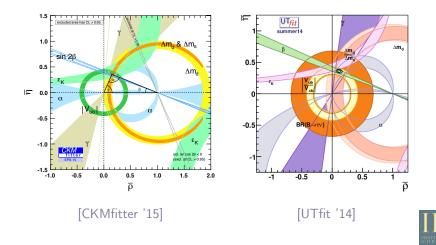
Parallelized Markov Chain Monte Carlo simulations with the Bayesian Analysis Toolkit (BAT).

Or use your own statistical set-up.



Example - Unitarity triangle in the SM

Unitarity triangle fits with run time of at least a few days

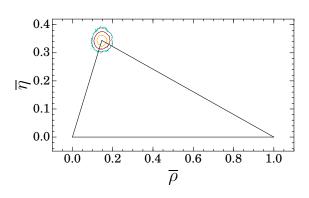


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HEPfit

Example - Unitarity triangle in the SM

Unitarity triangle fit with HEPfit is possible on a laptop: about 4 hours with two cores



UTfit collaboration decided to use HEPfit in the future!



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Summary



http://hepfit.roma1.infn.it

Calculates and fits Higgs, EW and flavour observables in

- Standard Model
- various effective theories
- scalar SM extensions (2HDM, Georgi-Machacek, Manohar-Wise)
- MSSM, Left-Right symmetry

Publications on $B \rightarrow K^* \ell^+ \ell^-$, EWPO, SMEFT, ew $\chi \mathcal{L}$, 2HDM.

