

Combination of top quark measurements in the context of effective field theories using EFTfitter

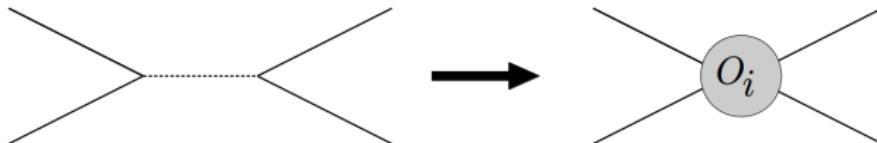
Cornelius Grunwald

TU Dortmund - Experimentelle Physik IV

- search for BSM physics: what if energy scale of new phenomena $\gg \sqrt{s}_{\text{LHC}}$?



- EFT \rightarrow indirect probes of new physics



- effective extensions of Standard Model:

$$\mathcal{L}_{\text{EFT}} = \mathcal{L}_{\text{SM}} + \frac{1}{\Lambda} \sum_i C_i^{(5)} O_i^{(5)} + \frac{1}{\Lambda^2} \sum_i C_i^{(6)} O_i^{(6)} + \dots$$

- dimension 6 operators important for top quark physics:

$$\begin{array}{lll} O_{qq}^{(1)} = (\bar{q}\gamma_\mu q)(\bar{q}\gamma^\mu q) & O_{uW} = (\bar{q}\sigma^{\mu\nu}\tau^I u)\tilde{\varphi}W_{\mu\nu}^I & O_{\varphi q}^{(3)} = i(\varphi^\dagger \overleftrightarrow{D}_\mu^I \varphi)(\bar{q}\gamma^\mu\tau^I q) \\ O_{qq}^{(3)} = (\bar{q}\gamma_\mu\tau^I q)(\bar{q}\gamma^\mu\tau^I q) & O_{uG} = (\bar{q}\sigma^{\mu\nu}T^A u)\tilde{\varphi}G_{\mu\nu}^A & O_{\varphi q}^{(1)} = i(\varphi^\dagger \overleftrightarrow{D}_\mu \varphi)(\bar{q}\gamma^\mu q) \\ \\ O_{uu} = (\bar{u}\gamma_\mu u)(\bar{u}\gamma^\mu u) & O_G = f_{ABC}G_\mu^{A\nu}G_\nu^{B\lambda}G_\lambda^{C\mu} & O_{uB} = (\bar{q}\sigma^{\mu\nu}u)\tilde{\varphi}B_{\mu\nu} \\ O_{qu}^{(8)} = (\bar{q}\gamma_\mu T^A q)(\bar{u}\gamma^\mu T^A u) & O_{\tilde{G}} = f_{ABC}\tilde{G}_\mu^{A\nu}G_\nu^{B\lambda}G_\lambda^{C\mu} & O_{\varphi u} = (\varphi^\dagger i \overleftrightarrow{D}_\mu \varphi)(\bar{u}\gamma^\mu u) \\ O_{qd}^{(8)} = (\bar{q}\gamma_\mu T^A q)(\bar{d}\gamma^\mu T^A d) & O_{\varphi G} = (\varphi^\dagger \varphi)G_{\mu\nu}^A G^{A\mu\nu} & O_{\varphi \tilde{G}} = (\varphi^\dagger \varphi)\tilde{G}_{\mu\nu}^A G^{A\mu\nu} \\ O_{ud}^{(8)} = (\bar{u}\gamma_\mu T^A u)(\bar{d}\gamma^\mu T^A d). & & \end{array}$$

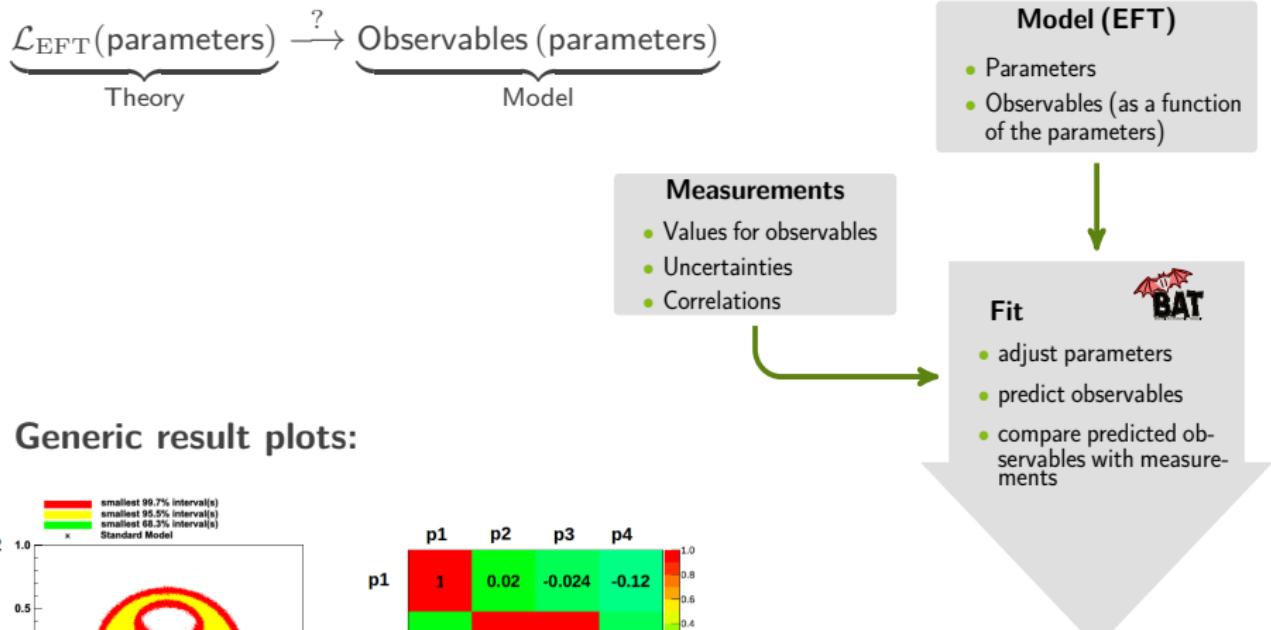
[arXiv: 1512.03360]

- tool for interpreting measurements in the context of effective field theories
- combination of measurements in Bayesian reasoning
- special focus on handling of uncertainties and correlations

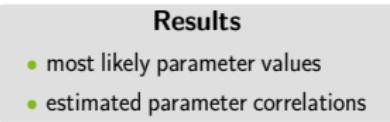
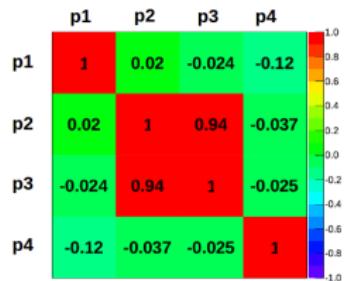
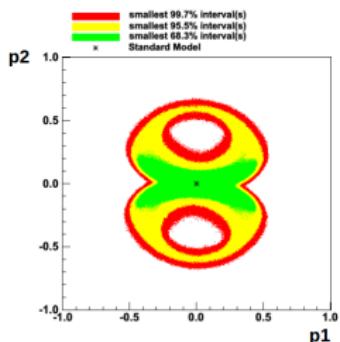
- based on the *Bayesian Analysis Toolkit* (BAT)



- Download: <https://github.com/tudo-physik-e4/EFTfitterRelease>
- Journal reference: Phys. J. C **76** (2016) 432

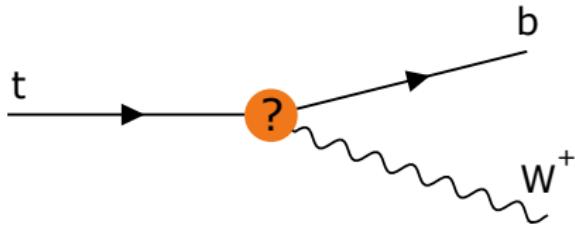


Generic result plots:



- Idea: combine and interpret different existing top quark measurements in context of EFTs
- therefor: get approximations for the functional relation between observables and EFT operators from MC simulations
- then: use *EFTfitter* to calculate estimators or limits for the strength of the contributing dim. 6 operators

Back-Up



- Wtb -Vertex:

$$\begin{aligned}\mathcal{L}_{Wtb} = & -\frac{g}{\sqrt{2}} \bar{b} \gamma^\mu (\mathbf{V}_L P_L + \mathbf{V}_R P_R) t W_\mu^- \\ & -\frac{g}{\sqrt{2}} \bar{b} \frac{i\sigma^{\mu\nu} q_\nu}{M_W} (\mathbf{g}_L P_L + \mathbf{g}_R P_R) t W_\mu^- + h.c.\end{aligned}$$

[Eur. Phys. J. C 50 (2007) 519]

- V_L, V_R : vector couplings (SM: $V_L = V_{tb} \approx 1, V_R = 0$)
- g_L, g_R : tensor couplings (SM: $g_L = 0, g_R = 0$)

- exemplaric measurements used for input:

W -helicities: CMS 2013 @ $\sqrt{s} = 7 \text{ TeV}$ [JHEP 10 (2013) 167]

t -channel cross sections: ATLAS 2014 @ $\sqrt{s} = 7 \text{ TeV}$ [Phys. Rev. D 90 (2014) 112006]

$$\begin{aligned}\sigma_t &= (46.0 \pm 6.0) \text{ pb} \\ \sigma_{\bar{t}} &= (23.0 \pm 3.0) \text{ pb}\end{aligned}$$

$$\begin{aligned}f_0 &= (68.2 \pm 4.5) \% \\ f_L &= (31.0 \pm 3.1) \%\end{aligned}$$

$$\begin{array}{cccc}f_L & f_0 & \sigma_t & \sigma_{\bar{t}} \\ \hline f_L & 1 & -0.95 & 0^* & 0^* \\ f_0 & -0.95 & 1 & 0^* & 0^* \\ \sigma_t & 0^* & 0^* & 1 & 0.5^* \\ \sigma_{\bar{t}} & 0^* & 0^* & 0.5^* & 1 \end{array}$$

* assumption

- output of 4D fit:

