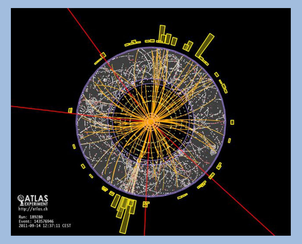

Probing Physics Beyond the Standard Model through Higgs Boson Precision Measurements

Jiaqi Zhang, Supervisor: Wardle Nicholas, Group: High Energy Physics

1. Introduction

Standard Model has been recognized as the most basic theory about the structure and interaction of matter. However, some results from LHC really shows that there could be physics beyond standard model (BSM).

Among all the approaches, effective filed theories (EFT) could extend SM to higher order to parameterize the effects bring by new possible process [1]. It is performed by getting constraints on the Wilson coefficients c_j by with a highest probability analysis of Simplified Template Cross Sections (STXS) of Higgs [2]. STXS is the measurement of production rates in different kinematic regions.

The cross section for a bin i can be expressed as

$$\sigma_i^{EFT}(c_j) = \sigma_i^{SM} + \sigma_i^{int}(c_j) + \sigma_i^{BSM}(c_j)$$

2. Aim

This project aims to verify the acceptance of EFT model under different selection cuts by considering the deviation of cross-sections of real data and SM model, and try to calculate how SMEFT will manifest itself at LHC with Monte Carlo simulation tools with latest data from ATLAS.

3. Method

Performing a fit to a set of EFT parameters using STXS measurements as input

1. Define the parameter set for the fit, and generate cards to initialize the process.
2. Determine the relations between the STXS measurements and the EFT parameters, hence to simulate
3. Extract scalling function and discuss the likelihood fit to the STXS measurements

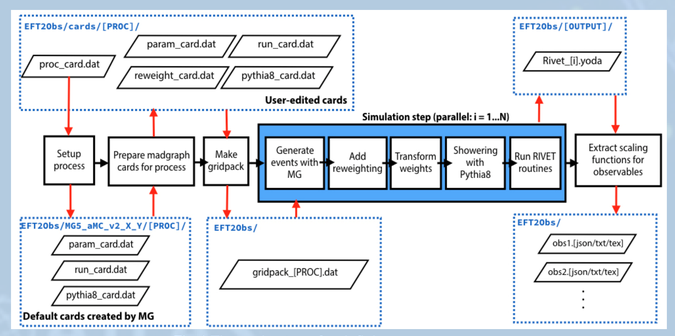

Fig.1 The main steps for defining a process.
https://github.com/ajgilbert/EFT2Obs

Scaling function for each bin:

$$\mu_i(c_j) = 1 + \sum_j A_j^i c_j + \sum_{jk} B_{jk}^i c_j c_k$$

which parametrizes deviations in the cross section in terms of the c_j parameters [3].

Ratios of different Wilson coefficients c_j in the real LHC interactions to SM were obtained from scaling function by generating 20,0000 events to define parameter set used to fit. For each interaction, linear parameters C_{HW}, C_{WW}, C_a and C_b were selected out to obtain the distribution, and all other parameters are set to zero.

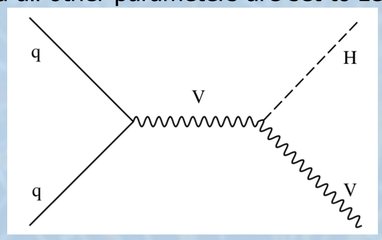

Fig.2 Leading-order Feynman diagram for boson production

A selection cut for ZH production modes were applied to make comparison of Ratio to SM against p_T for Z / Higgs boson with/without selection.

ZH Leptonic Selection:

- Two same flavor proton with transvers momentum $p_T > 20$ GeV
- Dilepton invariant mass m_{ll} in the range 70 < m_{ll} < 110 GeV

4. Results

- p_T distribution for Z boson with/without selection

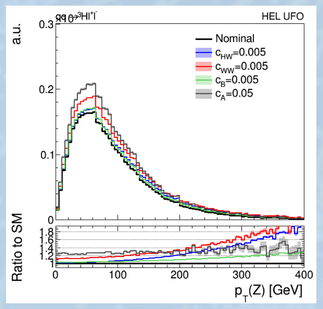

Fig.3 Distribution of four linear parameters for different Z boson transverse momentum regions with ZH Leptonic selection compared to nominal value

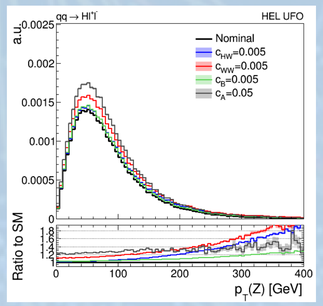

Fig.4 Distribution of four linear parameters for different Z boson transverse momentum regions without any selection compared to nominal value

- p_T distribution for Higgs bosons with/without selection

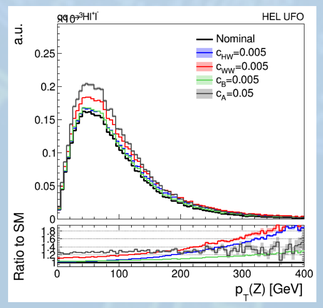

Fig.5 Distribution of four linear parameters for different Higgs boson transverse momentum regions with ZH Leptonic selection compared to nominal value

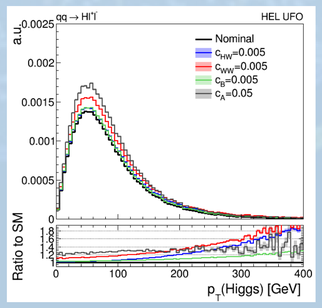

Fig.6 Distribution of four linear parameters for different Higgs boson transverse momentum regions without any selection compared to nominal value

- Table of ratio of parameters with ZH Leptonic selection to without selection

	pT: 75-150 GEV		
	Ratio	**Uncertainty**	**#σ away from 1**
cww	1.00	0.02	0.00
chw	0.75	0.01	-25.33
chb	3.58	0.02	149.53
ca	0.82	0.04	-3.39
cb	0.48	0.02	-23.99
cww * cww	0.93	0.19	0.00
chw * chw	1.10	0.05	1.03
chb * chb	1.10	0.05	1.04
cb * cb	0.84	0.17	0.00
ca * ca	0.71	0.25	-0.14
cww * cb	0.96	0.21	0.00
cww * chw	1.07	0.09	-0.18
cww * chb	1.07	0.09	-0.14
cww * ca	0.84	0.32	0.00
cb * chw	1.06	0.08	-0.17
cb * chb	1.06	0.07	-0.14
cb * ca	0.75	0.27	0.00
chw * chb	1.10	0.05	1.03
chw * ca	0.98	0.17	0.00
chb * ca	0.98	0.16	0.00

Table.1 Ratio of each parameters with/without selections with uncertainty and number of standard deviation for the maximum or minimum value of ratio away from 1 for p_T between 75 to 150 GeV.

5. Conclusions

It was fund that the Wilson coefficients calculated through scaling show a numerous deviation from the SM nominal value without selections in second bin (p_T:75-150 GeV). The most obvious anomalous is the ratio of c_{hb} in the second bin, and 3.58 is unacceptable for SM. That difference could be result from various reasons, such as missing term in EFT perturbation, insufficient selection, generating error or even coding bug.

It is clear that for a particular region of transvers momentum of particle, SM could not describe the physics in a very accurate way.

The project is currently keen on trying to find the reason behind all unacceptable values, using χ^2 to analyze the data previous got, and doing more working on c_{hb} coefficient.

6. Reference

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2. ATLAS CONF Note, 2020. Interpretations of the combined measurement of Higgs boson production and decay. [online] ATLAS CONF Note. Available at: <https://cdsweb.cern.ch/record/2743067/files/ATLAS-CONF-2020-053.pdf> [Accessed 3 March 2021].

3. Gilbert, A. and Langford, J., 2020. ajgilbert/EFT2Obs. [online] GitHub. Available at: <https://github.com/ajgilbert/EFT2Obs> [Accessed 3 March 2021].