PROBING NEW PHYSICS AT THE LHC: THE EFT PATHWAY

Marion Thomas[(a)] and Claudio Severi[(b)]
University of Manchester

The Standard Model Effective Field Theory (SMEFT) is a model independent framework which allows us to probe physics beyond the Standard Model (SM).
The only assumptions are that the new physics is heavy and consistent with the SM symmetries. This poster presents two SMEFT analyses relevant to LHC experiments.

INTRODUCTION

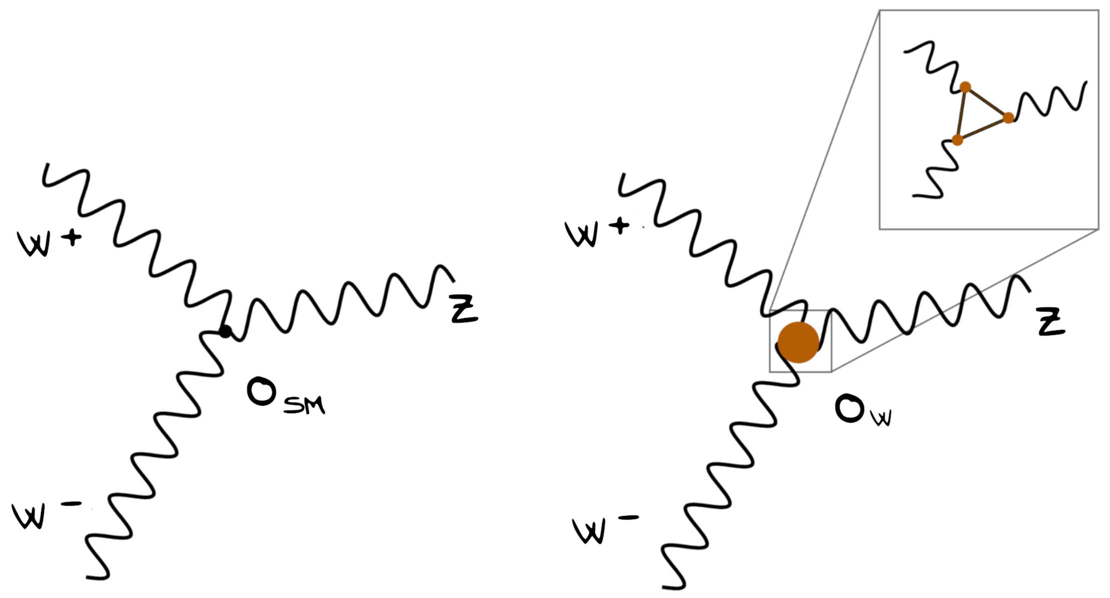
The SMEFT Lagrangian is

$$\mathcal{L} = \mathcal{L}_{SM} + \frac{1}{\Lambda} C_W O_W + \frac{1}{\Lambda^2}\sum_K C_K O_K + O\left(\frac{1}{\Lambda^3}\right)$$

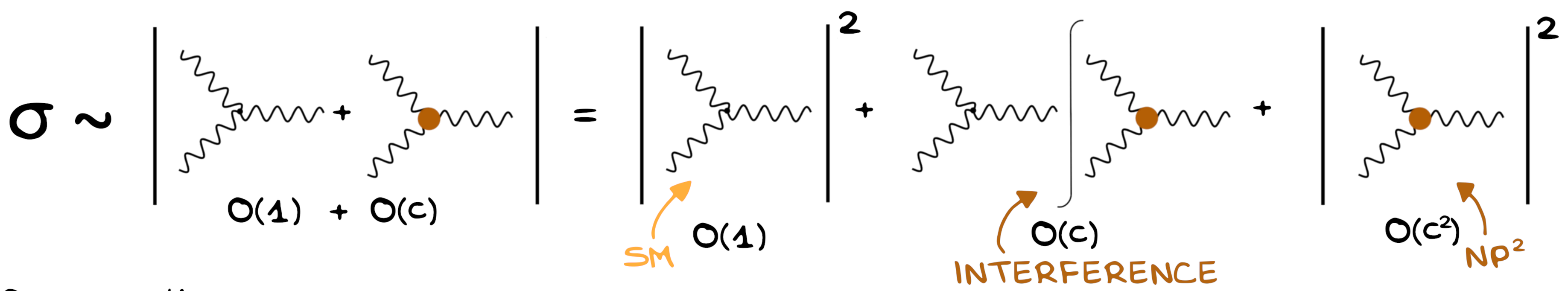
(dimension 4, dimension 5, dimension 6; New Operators; "Cutoff Scale" Λ = 1 TeV; Wilson Coefficients)

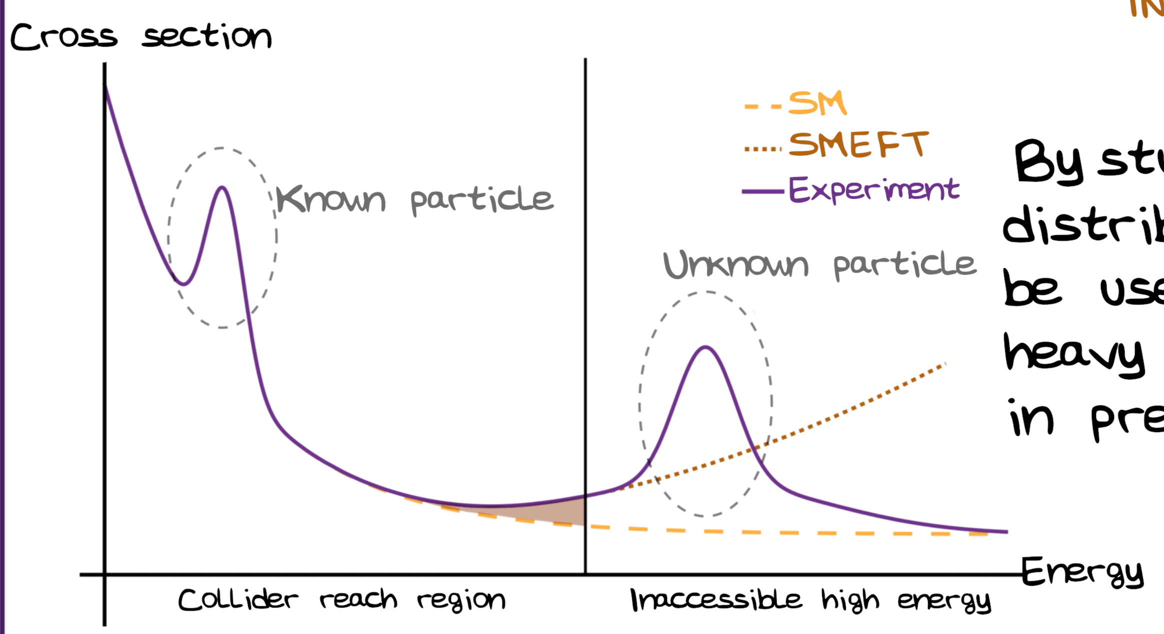
There is only one dimension-5 operator, and it gives neutrinos a mass. We focus on dimension-6 operators.

Searches for new physics (NP) in the SMEFT framework consist of looking for new or modified interactions among SM particles.



In the SMEFT, cross sections are a sum of three terms: a SM one, a NP one, and an interference one between SM and NP.





By studying tails of differential distributions, the SMEFT can be used to probe particles too heavy to be directly produced in present colliders.

(a) marion.thomas-3@postgrad.manchester.ac.uk
(b) claudio.severi@postgrad.manchester.ac.uk

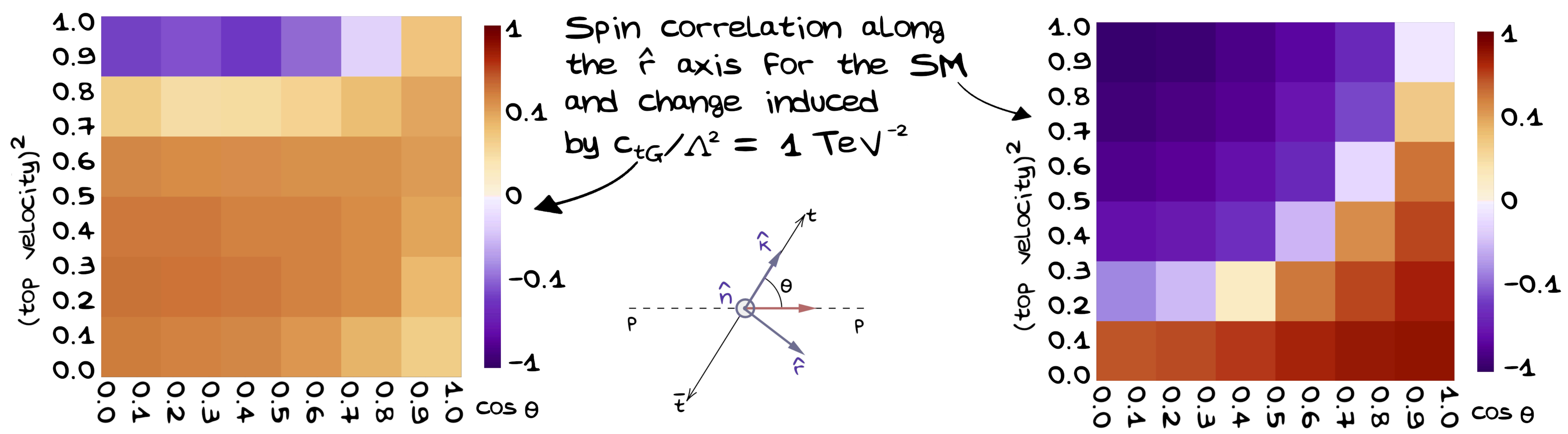
TOP SPIN CORRELATIONS

Top quarks are unique candidates for spin correlation studies. At the LHC they are produced in large amounts, and with heavily correlated spins. After tops decay electroweakly, spin correlations are imprinted in the decay products as angular correlations, and can be observed.

The most spin-sensitive decay channel is the one with two charged light leptons. Several dimension-6 operators can enter the process

$$pp > t\bar{t} > b\bar{b}l\bar{l}\nu\bar{\nu}$$

For instance, $O_{tG} = \tilde{\varphi} G^A_{\mu\nu} \bar{Q}\gamma^{\mu\nu} T_A t$ gives tops a chromo-magnetic dipole moment.



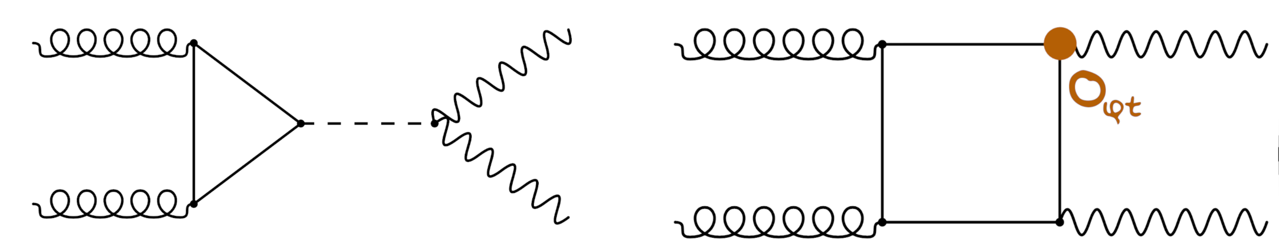
Templates like the one presented here are being produced at NLO accuracy and will be used to fit spin correlation measurements from the LHC.

MODIFIED INTERACTIONS IN gg→ZZ

gg→ZZ is an interesting process:
- it can probe many different SMEFT operators,
- it can help break degeneracies between operators that are otherwise indistinguishable,
- by measuring the off-shell Higgs production cross section, precise bounds on the Higgs width can be obtained.

Process divided into:

off-shell Higgs production — gluon fusion

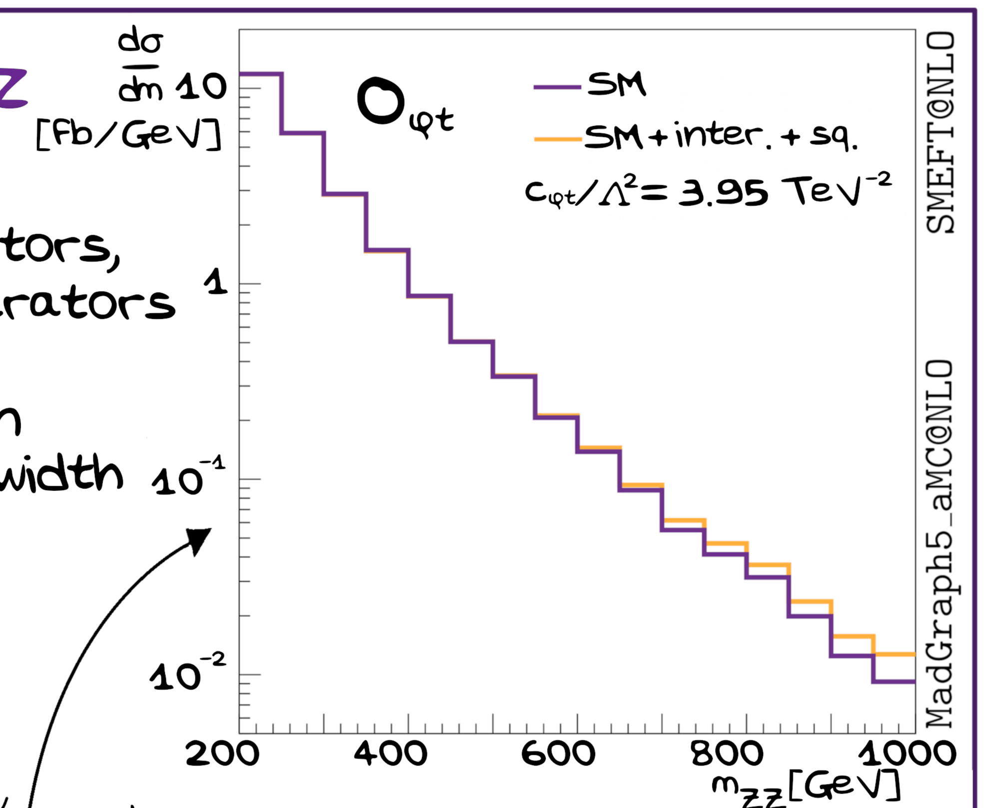


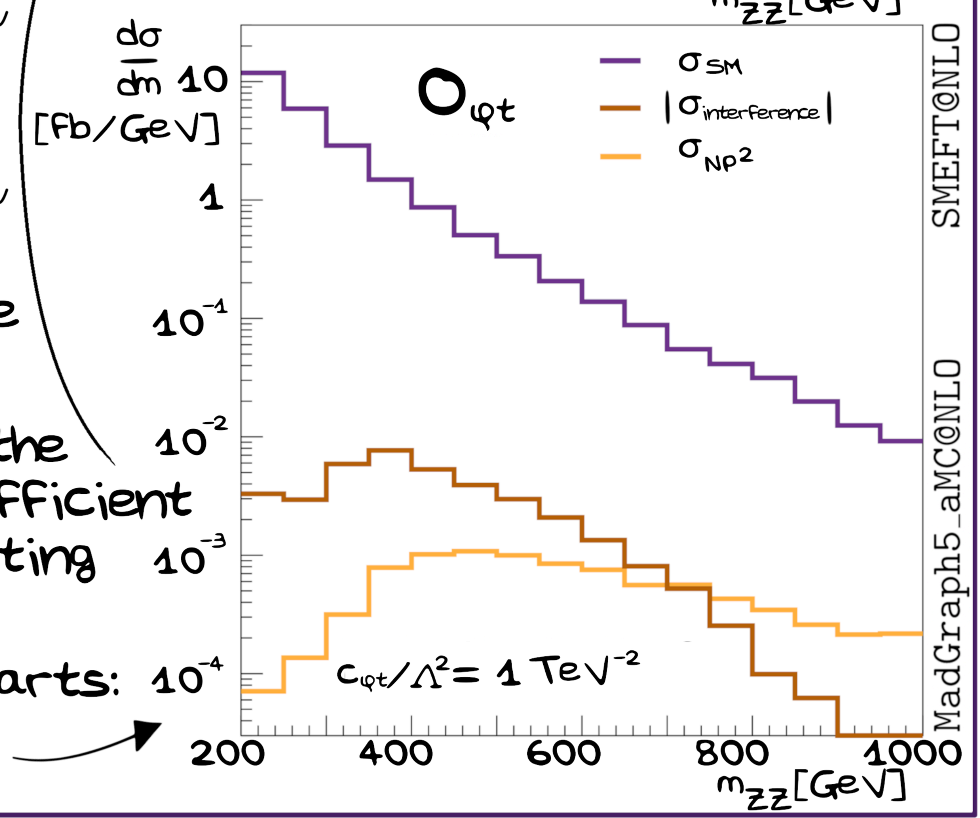
Focus on $O_{\varphi t} = i(\varphi^\dagger \overleftrightarrow{D}_\mu \varphi)(\bar{t}\gamma^\mu t)$ which modifies the $Zt\bar{t}$ vertex.

Plot of the ZZ invariant mass distribution in the SM and in the presence of $O_{\varphi t}$. The Wilson coefficient $c_{\varphi t}$ is set to 3.95, the bound inferred from existing data [2,3]

The total cross section can be split into 3 parts:

$$\sigma_{tot} = \sigma_{SM} + \sigma_{interference} + \sigma_{NP^2}$$





WHAT NEXT?

- Comparison of SMEFT predictions with precision measurements from the LHC can reveal signs of new interactions.
- Need accurate theoretical predictions: effects coming from parton showers and from missing higher orders have to be better understood.
- Specific UV-complete theories can be constrained.

References

[1] CMS Collaboration, 2019, 1907.03729
[2] SMEFiT Collaboration, 2021, 2105.00006
[3] Off-shell Higgs Interpretations Task Force: Models and EFT Subgroup Report, 2022, 2203.02418

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