



Northwestern
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EFT interpretation workflow: Introduction

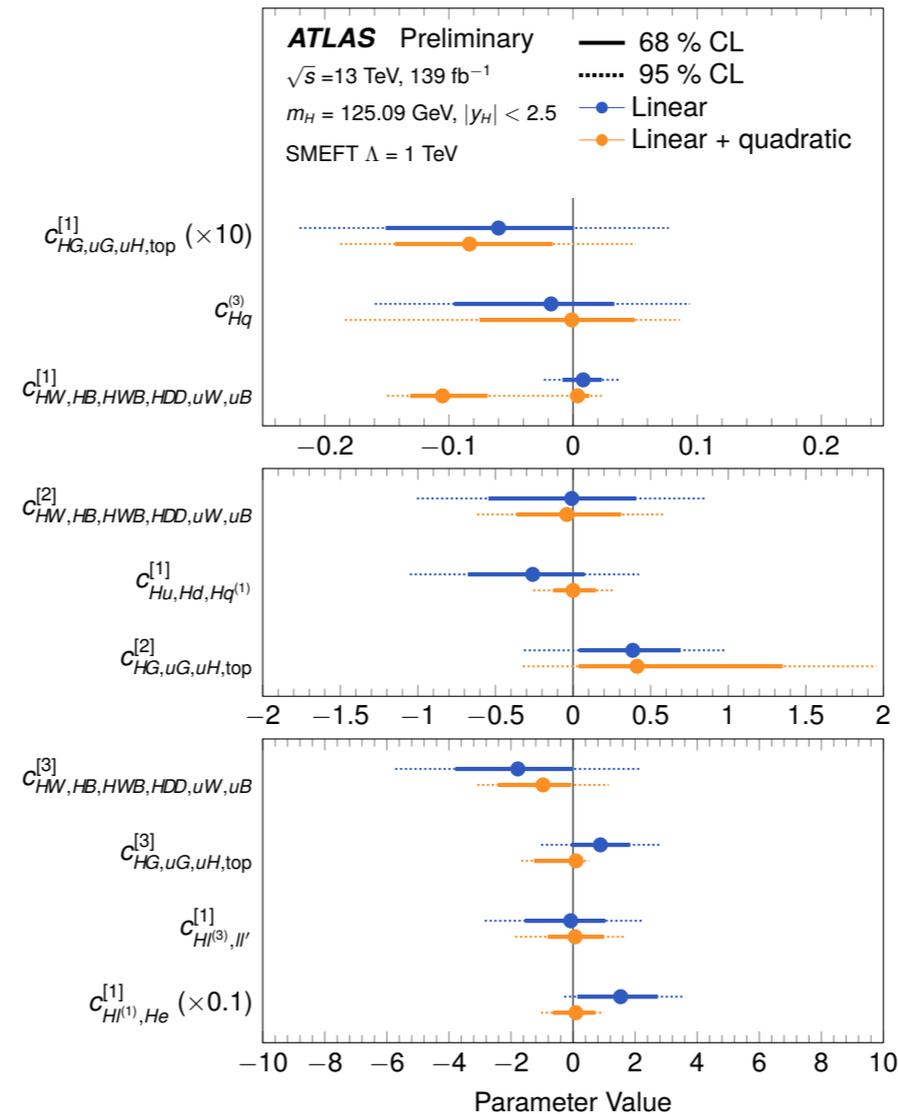
A. Gilbert | 9 November 2020
17th Workshop of the LHC Higgs WG

Introduction

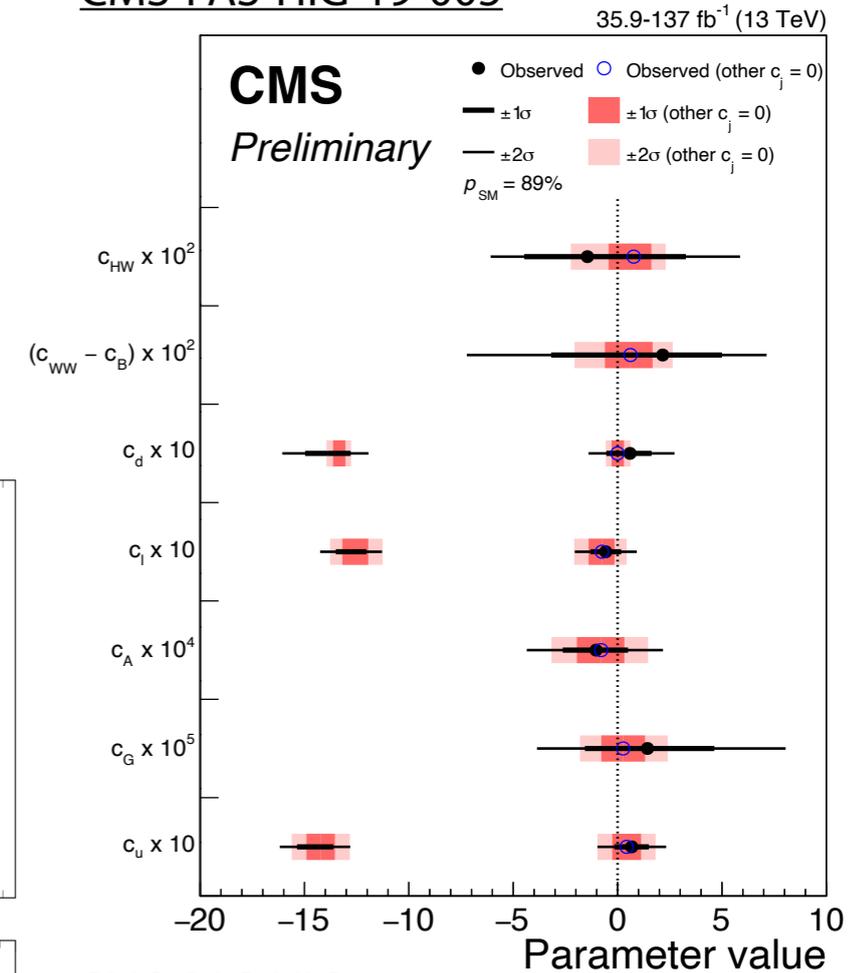


- Experiments producing a growing set of EFT results using Higgs measurements
 - Different analysis approaches in use (STXS/ diff. xs parameterisation / dedicated EFT)
 - Also different interpretations
 - ▶ Choice of basis
 - ▶ Sets of operators
 - ▶ Profiled vs. one-at-a-time constraints
 - ▶ Inclusion of quadratic terms
- Given this, and many other open questions, decided in July WG2 meeting to launch the **EFT Interpretation Workflow initiative**

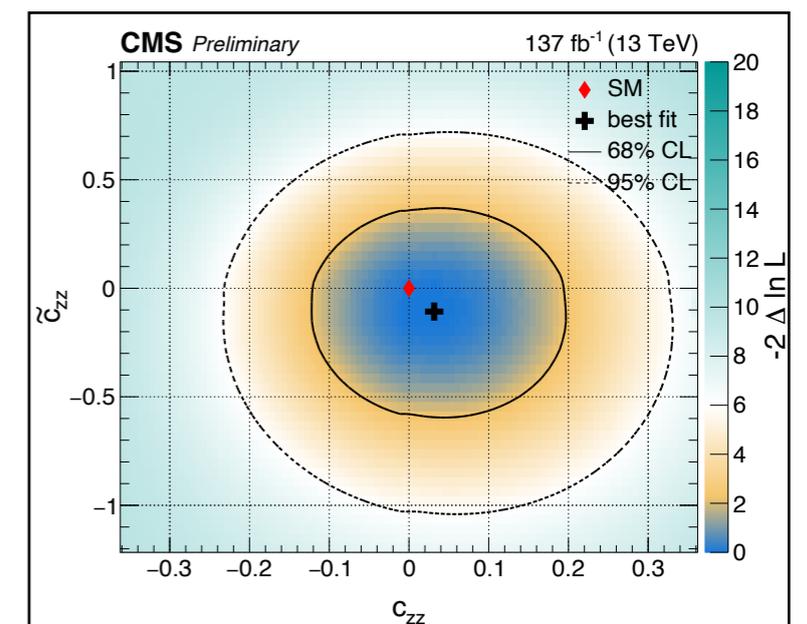
ATLAS-CONF-2020-053



CMS-PAS-HIG-19-005



CMS-PAS-HIG-19-009



Goals



- Establish list of EFT topics for further discussion and boost Exp. ↔ Th. interaction
- Initial list compiled by WG2 conveners:
 - <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/EFTInterpretationWorkflow>
 - Expect detailed discussion and dedicated meetings on each area
- Provide recommendations from **theory** for EFT interpretations of measurements and global fits performed by the **experiments**
 - **Invitation to a wide community of experts (as inclusive as possible) - very positive response**
- This talk presents an overview of the main areas proposed so far
- Followed by specific talks on key aspects:
 - BSM perspective (Christophe Grojean)
 - QCD, higher-orders and tools (Eleni Vryonidou)
- Co-ordinate with similar efforts in LHC EFT, EW and Top WGs

LHC EFT Working group



- 1st general meeting in Oct: <https://indico.cern.ch/event/943996/>

CONVENERS	ATLAS	CMS	TH
EW WG contacts	Kristin Lohwasser	Pietro Govoni	Celine Degrande
Higgs WG contacts	Nicolas Berger	Giovanni Petrucciani	Jorge de Blas
Top WG contacts	Nuno Castro	Florencia Canelli	Eleni Vryonidou
	Pierre Savard	Andrei Gribsan	Ilaria Brivio, Sally Dawson, Gauthier Durieux, Admir Greljo

M.L. Mangano

WG mandate

<https://lpsc.web.cern.ch/lhc-eft-wg>

The LHC effective field theory working group (LHC EFT WG) gathers members of the LHC experiments and the theory community to provide a framework for the interpretation of LHC data in the context of effective field theories (EFTs). The LHC EFT WG studies the physics requirements needed to facilitate an interpretation commensurate with the available measurements performed in a wide range of different processes, including Higgs bosons, top quarks, and electroweak bosons. It provides recommendations for the use of EFT by the experiments to interpret their data, and a forum for theoretical discussions of EFT issues. This includes recommendations on the theory setup as well as Monte Carlo simulation and other tools needed for EFT analyses. Further theoretical issues cover, for example, theoretical constraints, higher-order corrections, BSM interpretations. The LHC EFT WG also discusses common uncertainties and combination procedures used by the experiments. It focuses on recommendations, developments, and combinations that require coordination between the existing WGs (Higgs, Top, Electroweak), in order to allow global EFT analyses inside and outside experimental collaborations. EFT-related activities in these working groups will continue if they pertain only to that group, in close contact with the LHC EFT WG.



(SM)EFT basics

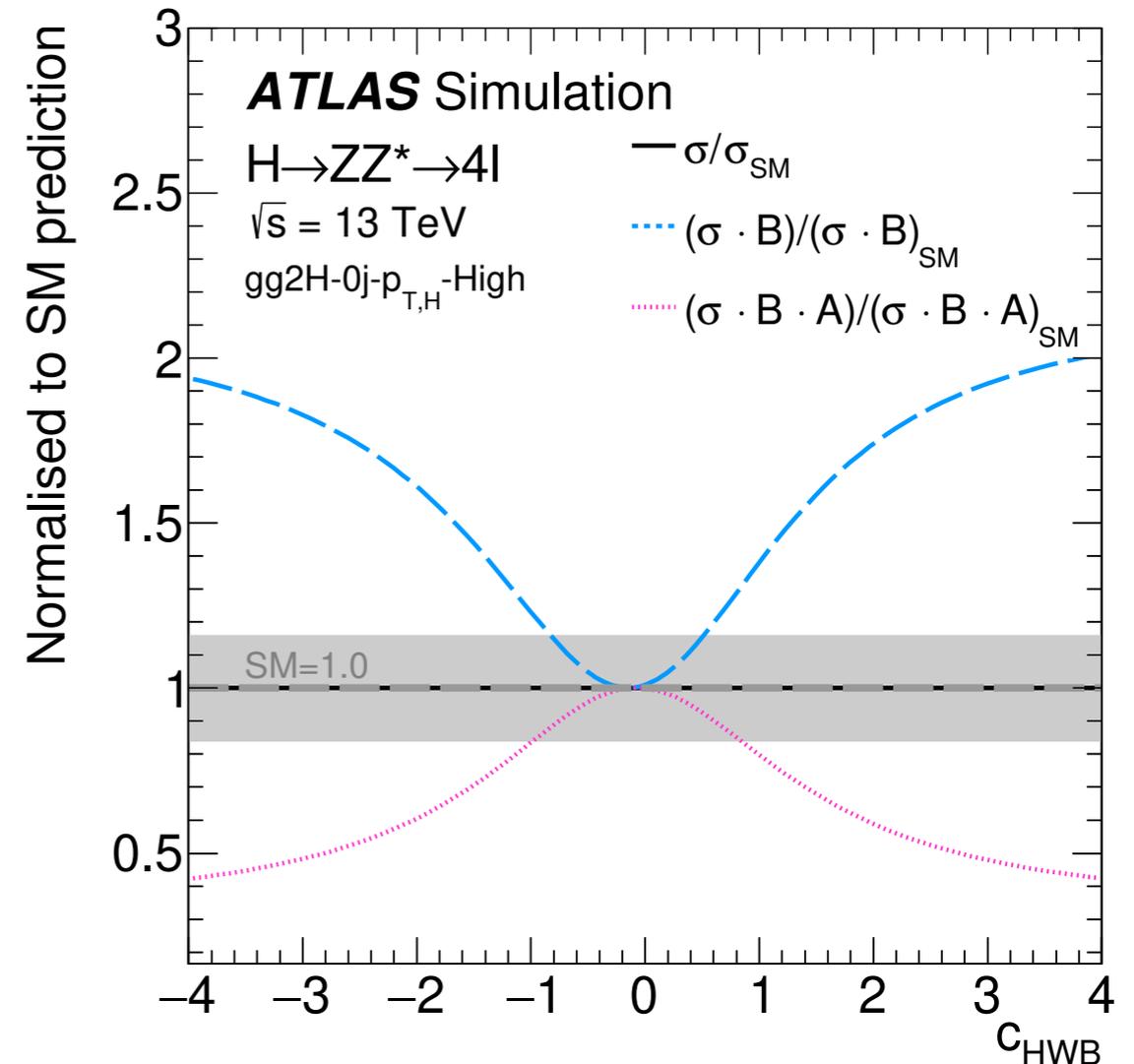
- Assumptions:
 - What kind of EFT (HEFT or SMEFT), symmetries, flavour (non)universality, ...?
- Which basis?
 - Warsaw, or something else? Present results in multiple bases?
 - Range of public tools available for Warsaw basis (including EFT@NLO)
- Operators
 - What types of contribution to consider?
 - ▶ Double insertions of dim-6?
 - ▶ Single insertions in both Higgs production and decay for on-shell (e.g. $VV \rightarrow H \rightarrow VV$)?
 - ▶ What about for off-shell & inclusion in the global fit?
 - ▶ Possible to mix dim-6 and dim-8 in the fits?
- Beyond (SM)EFT
 - Non-SM decays of the Higgs boson - can we parameterise these in Higgs processes, in a consistent way with the EFT?

(SM)EFT modelling and data analysis



- **STXS**: How to enhance STXS measurements for better EFT sensitivity?
 - **Include decay info** [discussed earlier by **Michael**]: Requires careful choice of fiducial bins to enhance BSM/EFT sensitivity from final-state kinematics
 - Helps reduce issue of **acceptance effects** modifying EFT parameterisation when using production-only bins
 - Experiments can provide the acceptance parameterisations used for particular final states where needed
- Action items: follow-up in dedicated meetings

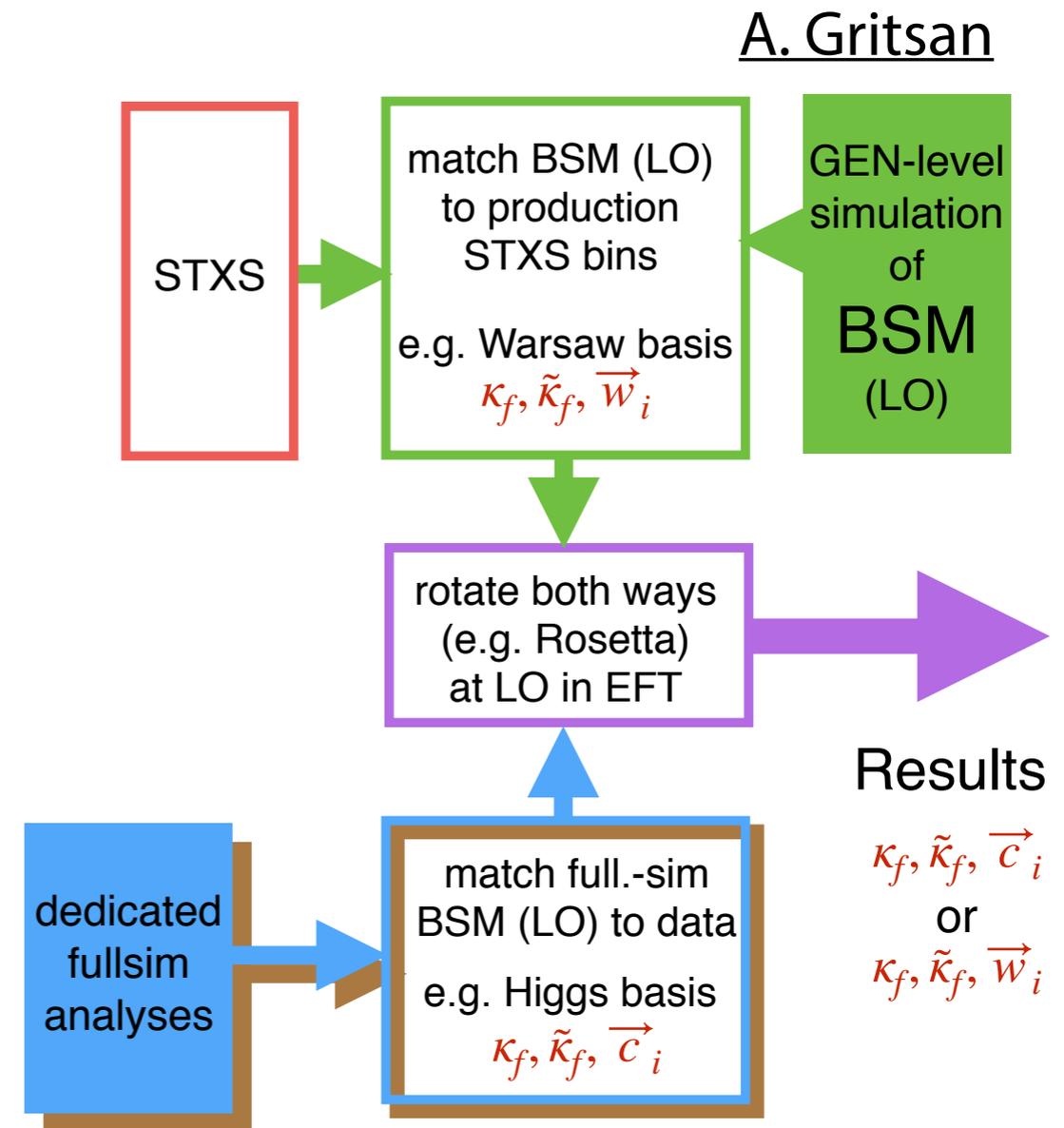
Eur. Phys. J. C 80 (2020) 957



(SM)EFT modelling and data analysis



- **POs/ACs:** How to perform dedicated analyses usable for EFT fits?
 - **Goal:** understand how dedicated AC analyses can be used in global EFT fits
 - Choice of basis / translation from ACs \rightarrow EFT, but need to consider symmetry assumptions, double-insertion of EFT operators etc.
 - Experiments can combine with STXS-style analyses at likelihood-level \rightarrow optimal sensitivity
- What information should be provided:
 - Central values & covariance?
 - Simplified likelihood?



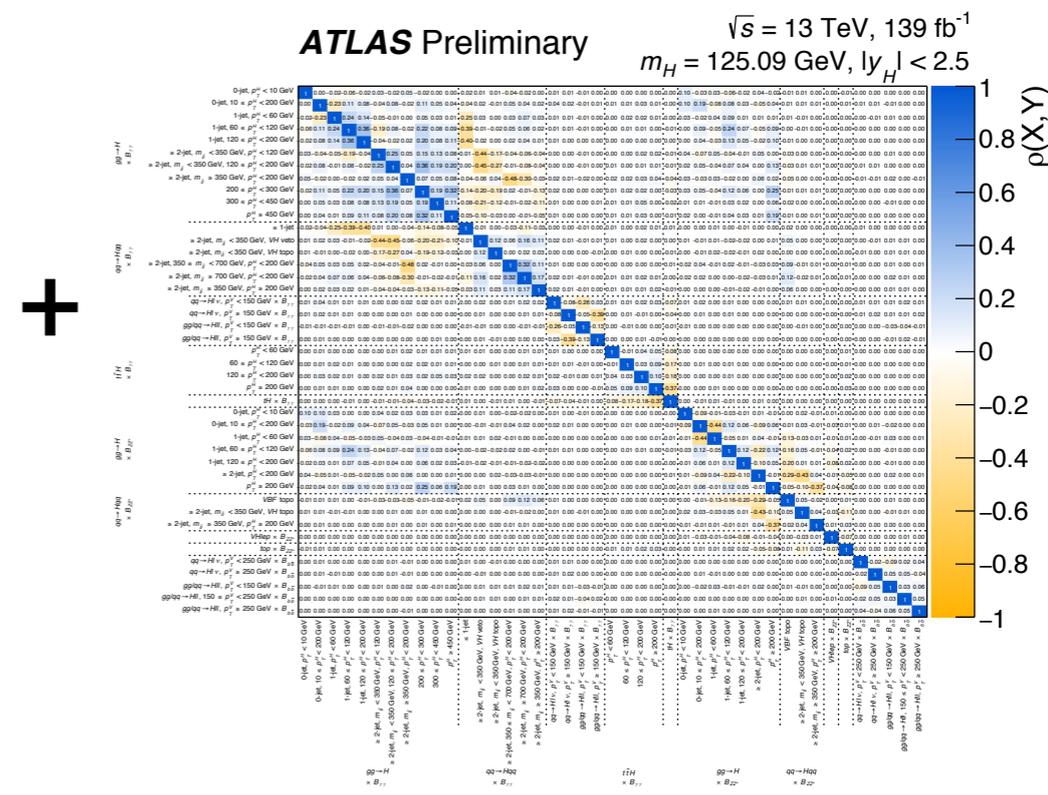
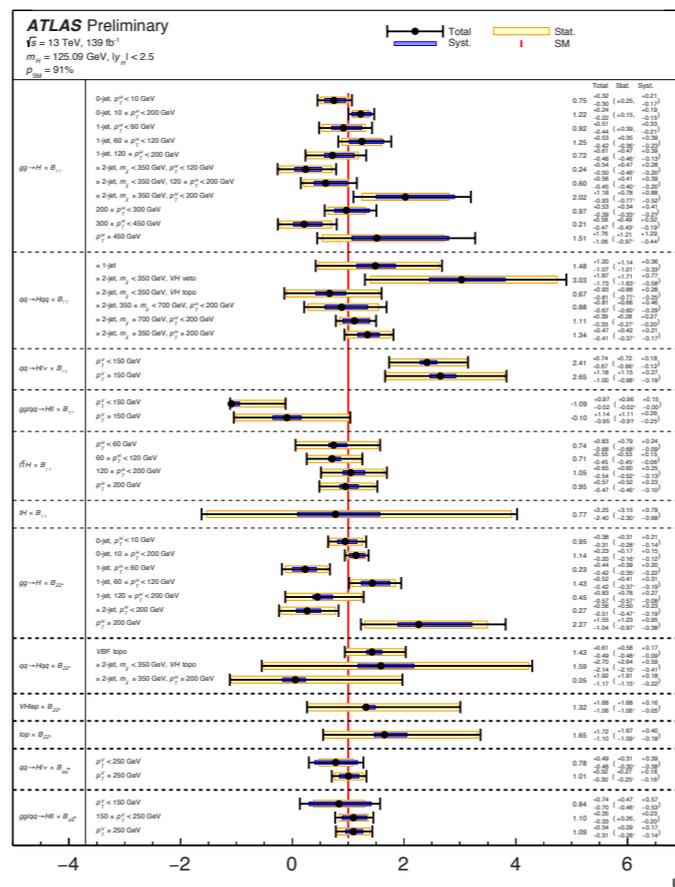
(SM)EFT modelling and data analysis

- **Other considerations**

- **Differential cross sections:** any additional EFT-sensitive observables to measure?
- **Backgrounds:** include EFT effects on backgrounds in expt. analyses? Still possible to present results in a "model independent" way?
- **MC tools:** public tools to parameterise EFT effects on observables in specific fiducial regions, LO matrix element reweighting

- **Presentation of results**

- Want to provide sufficient information for reinterpretation
- E.g. Best-fit + covariance of STXS/fiducial measurements
- What is effect of including/neglecting inter-analysis and inter-expt. correlations?

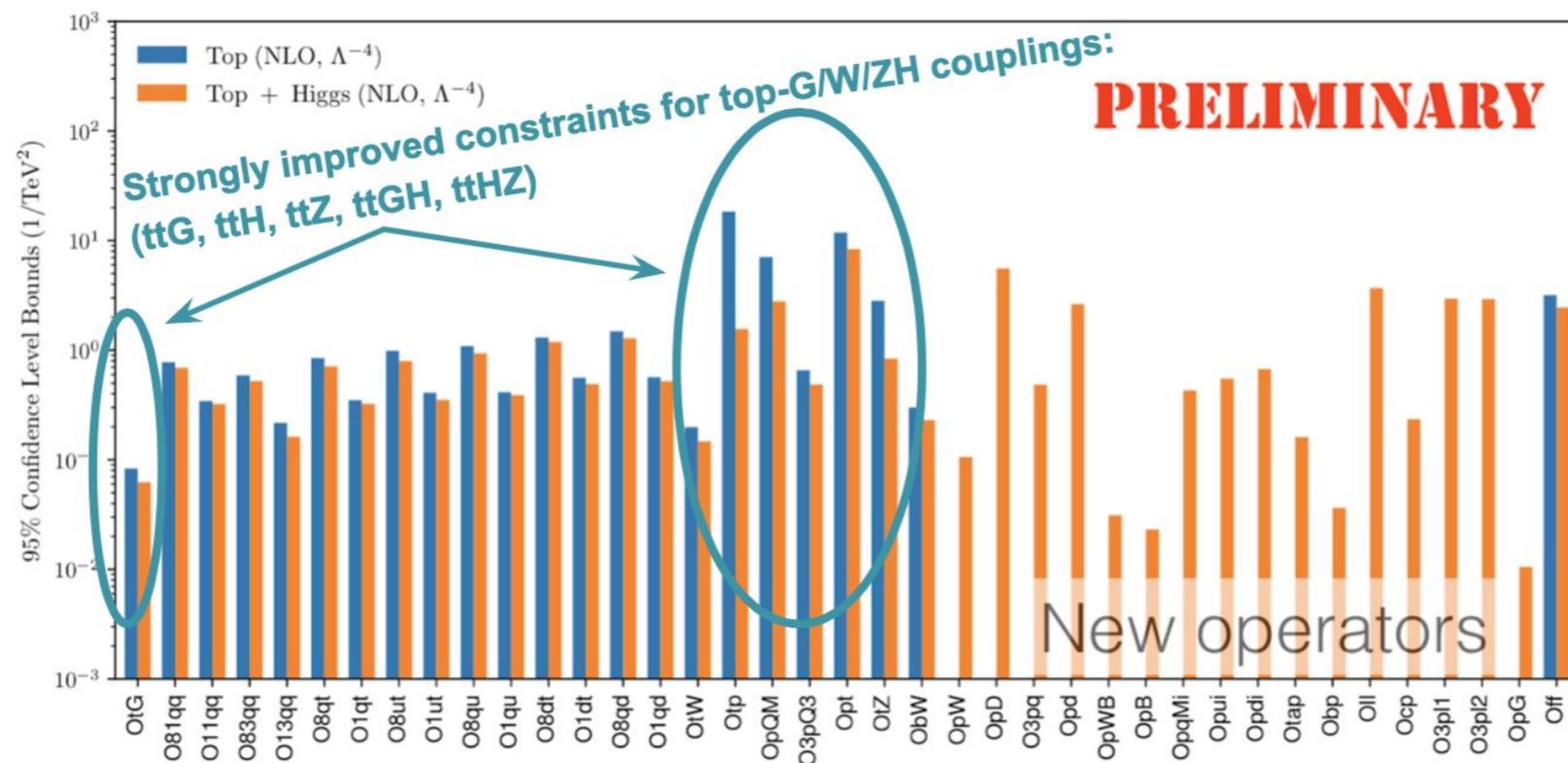


Interplay with EWK/QCD higher-order effects

- SMEFT@NLO model (Warsaw basis) now available and validated
- Where is it important to consider EFT contribution at LO vs NLO?
 - Mixed interpretation OK? NLO for some processes and LO for others?
- EFT one-loop effects important in global fits (mixing sectors + break degeneracies)
 - E.g. Top-Higgs using NLO SMEFT:

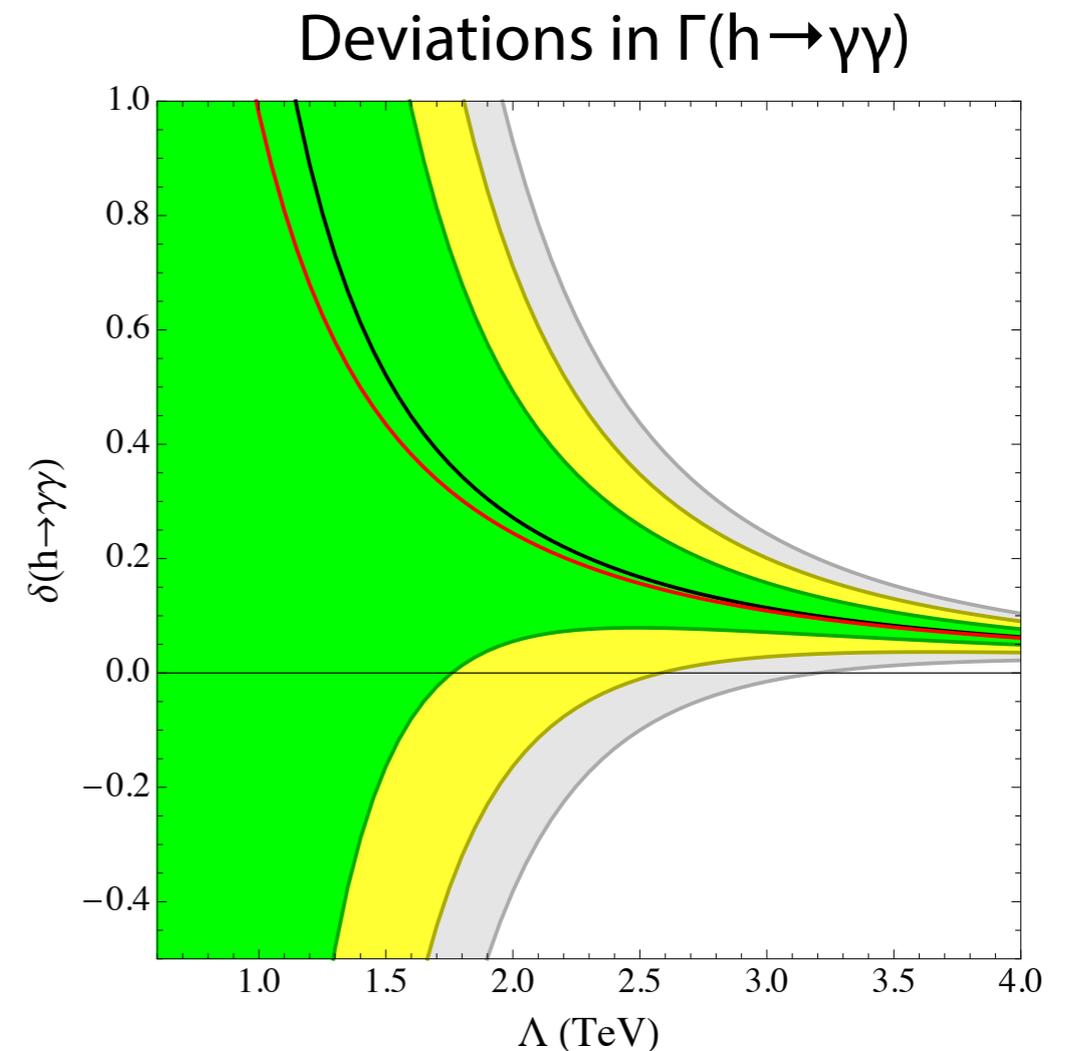
HEFT2020 talk by E. Vryonidou

Constraints on top operators w/o and w/ inclusion of Higgs data:



Interplay with EWK/QCD higher-order effects

- EWK/QCD: Need studies where QCD and EW higher-order corrections are comparable to EFT effects? Any special treatment/consideration needed?
- EFT uncertainty: What are the additional EFT-related theory uncertainties to be considered e.g. from truncated EFT expansion (and are the tools to compute them available)?
 - Classification of dim-8 operators / MC implementations?
 - Recent developments allow first comprehensive analysis of uncertainties associated with truncated SMEFT expansions
 - ▶ Using geoSMEFT approach
 - ▶ Comparison of full/partial $O(v^4/\Lambda^4)$ for $\Gamma(h \rightarrow \gamma\gamma)$, $\Gamma(h \rightarrow Z\gamma)$, $\Gamma(Z \rightarrow \psi\psi)$



Hays, Helset, Martin, Trott

Summary



- Questions and feedback being collected on a twiki page:
 - <https://twiki.cern.ch/twiki/bin/view/LHCPhysics/EFTInterpretationWorkflow>
 - Will lead to publicly available set of recommendations / guidelines (e.g. as public twikis, or eventually a written document)
- Feedback from the TH community on these or other topics is very welcome
 - Google doc for sign-up: https://docs.google.com/document/d/1gPnfVrJ-M3aUehJyG-Dnq8oQ_JKlr2S4BUwIE15T1L4/edit#heading=h.tljyxr7ii4jd - no commitment required!
- List of questions has been shared with other LHC WGs to obtain a more comprehensive list of EFT questions / concerns
- Strong overlap & common effort with the goals of the LHC EFT WG