



Northwestern  
University

# Introduction

A. Gilbert on behalf of the LHC EFT WG conveners

5th General Meeting of the LHC EFT WG | 2 December 2022

# The LHC EFT WG

- Goal: Advise and develop recommendations for EFT measurements at the LHC
  - **General information:** [\[link\]](#), [\[Twiki\]](#), **Contact:** [lhc-eftwg-admin@cern.ch](mailto:lhc-eftwg-admin@cern.ch)
- Organisation:
  - Area 1: EFT formalism
  - Area 2: Predictions and tools
  - Area 3: Experimental measurements and observables
  - Area 4: Fits and related systematics
  - Area 5: Benchmark scenarios from UV models
  - Area 6: Interplay/connection with flavour
- Thanks to our outgoing conveners this year:
  - Andrei Gritsan, Giovanni Petrucciani, Pierre Savard, Nicolas Berger, Céline Degrande, Jorge De Blas, Eleni Vryonidou
- And welcome to the incoming conveners:
  - Sarah Heim, Jacob Kempster, Sandra Kortner, Nicholas Wardle, Matteo Presilla, Robert Schoefbeck, Ken Mimasu, Anke Biekoetter, Shankha Banerjee

## Conveners (as of Jan '23)

### ATLAS

Sandra Kortner  
Sarah Heim (Higgs)  
Jacob Kempster (Top)  
Kristin Lohwasser (EW)

### CMS

Nadjieh Jafari  
Nicholas Wardle (Higgs)  
Robert Schoefbeck (Top)  
Matteo Presilla (EW)

### LHCb

Patrick Owen

### Theory

Ilaria Brivio  
Gauthier Durieux  
Admir Greljo  
Anke Biekoetter (Higgs)  
Shankha Banerjee (EW)  
Ken Mimasu (Top)

# Area 1: EFT formalism

- Goal: establish the key parameters of the EFT formalism: what **operators**, what **bases**, what **perturbation orders**, how to **combine operators** of different dimensions, which **flavour** and **symmetry** assumptions

arXiv:2111.12515

- Scheme dependence:  $\{\alpha, G_\mu, m_Z\}$ ,  $\{G_\mu, m_Z, m_W\}$  or  $\{\alpha, m_Z, m_W\}$ ?

Used at LEP

Used in many tools

Avoid large W/Z propagator corrections

Avoid leptonic corrections to  $G_\mu$

- Public note released, recommending the  $\{G_\mu, m_Z, m_W\}$  scheme
- **Validity:** does the EFT describe the true model underlying the data?

LHC EFT WG, Area 1  
Electroweak input parameters

Editors: Ilaria Brivio, Sally Dawson, Jorge de Blas,  
Gauthier Durieux, Pierre Savard  
Contributors: Ansgar Denner, Ayres Freitas, Chris Hays,  
Ben Pecjak, Alessandro Vicini

November 25, 2021

**Abstract**

Different sets of electroweak input parameters are discussed for SMEFT predictions at the LHC. The  $\{G_\mu, m_Z, m_W\}$  one is presently recommended.

arXiv:2201.04974

CERN-LPCC-2022-01  
CERN-LHCEFTWG-2021-002

November 16, 2022

**LHC EFT WG note:  
Truncation, validity, uncertainties**

Editors: *Ilaria Brivio*<sup>1,2</sup>, *Sally Dawson*<sup>3</sup>, *Jorge de Blas*<sup>4,5</sup>, *Gauthier Durieux*<sup>5</sup>, *Giovanni Petrucciani*<sup>6</sup>, *Pierre Savard*<sup>7</sup>

Proposal contributors:

A. *Roberto Contino*<sup>8</sup>, *Adam Falkowski*<sup>9</sup>, *Florian Goertz*<sup>10</sup>, *Christophe Grojean*<sup>11</sup>, *Fabio Maltoni*<sup>12,13</sup>, *Giuliano Panico*<sup>14</sup>, *Francesco Riva*<sup>15</sup>, *Andrea Wulzer*<sup>16</sup>

B. *Céline Degrande*<sup>12</sup>, *Fabio Maltoni*<sup>12,13</sup>, *Ken Mimasu*<sup>17</sup>, *Eleni Vryonidou*<sup>18</sup>, *Cen Zhang*<sup>19,20,21</sup>

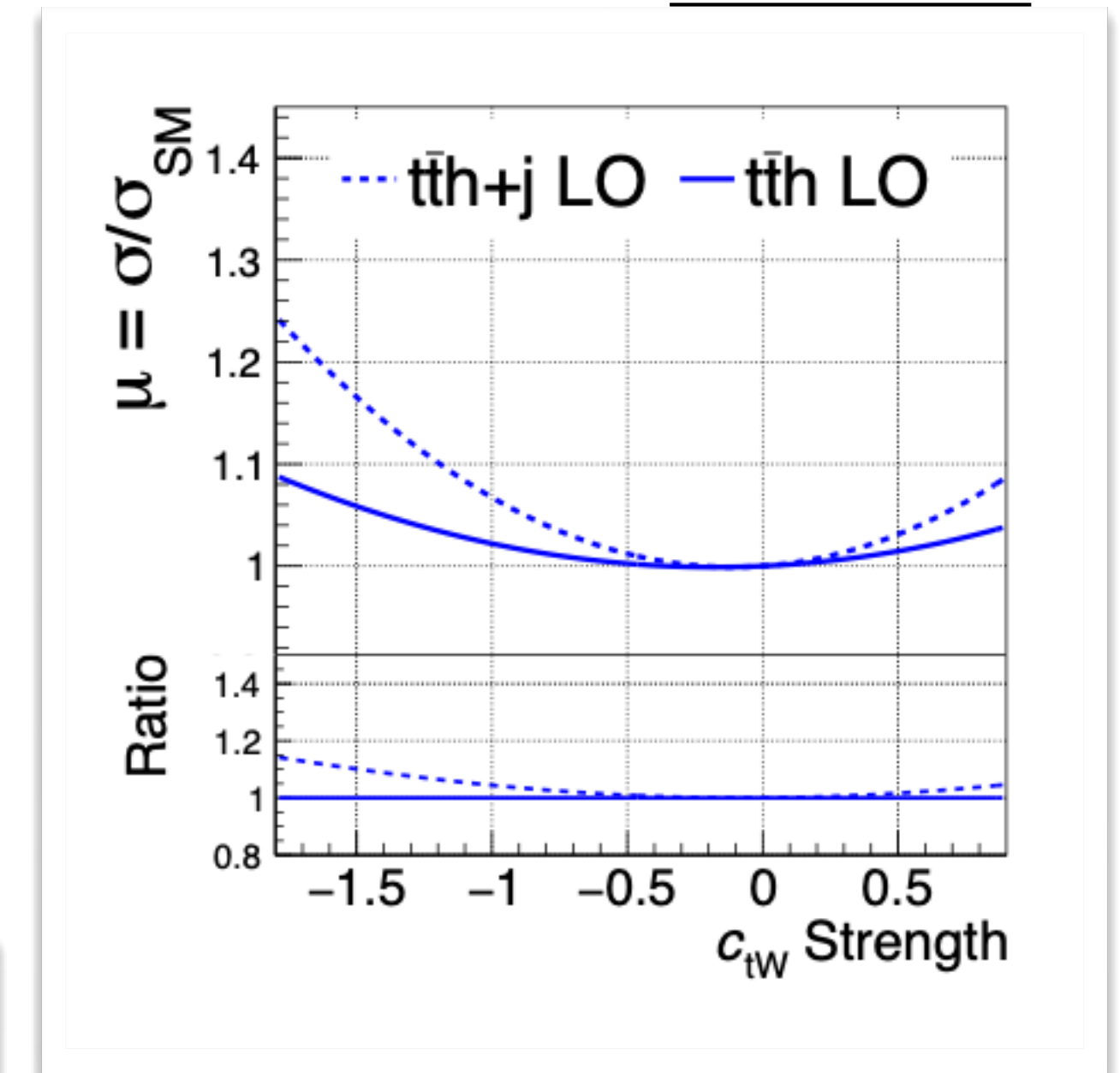
C. *William Shepherd*<sup>22</sup>

D. *Nicolas Berger*<sup>23</sup>, *Andrei V. Gritsan*<sup>24</sup>, *Kristin Lohwasser*<sup>25</sup>

- Up to which energy scale is the EFT valid?
  - How to define the scale?  $\Rightarrow$  process dependent
- Strategies if model is not valid in some parts of the phase space:
  - "Clipping" of either the data or the model + additional uncertainties?
  - Public note first released in January and recently updated with additional proposal

# Area 2: Predictions & tools

- Goals: (twiki)
  - Track the various tools that are used to provide EFT predictions
  - Organise cross-validation
  - E.g. this year compared predictions of JHUGen vs SMEFTsim, SMEFT@NLO vs SMEFTsim
  - Provide recipes and recommendations on usage
- Topical meeting in January this year, topics including:
  - Effect of additional jets in  $t\bar{t}+X$  EFT modelling - can lead to sizeable corrections
  - Framework for MC/MC comparisons
  - LHE level study of dim6 sensitivity in VBS (and global fit with WW)



Tag, generator, model, processes, parameter point

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Human-readable tables

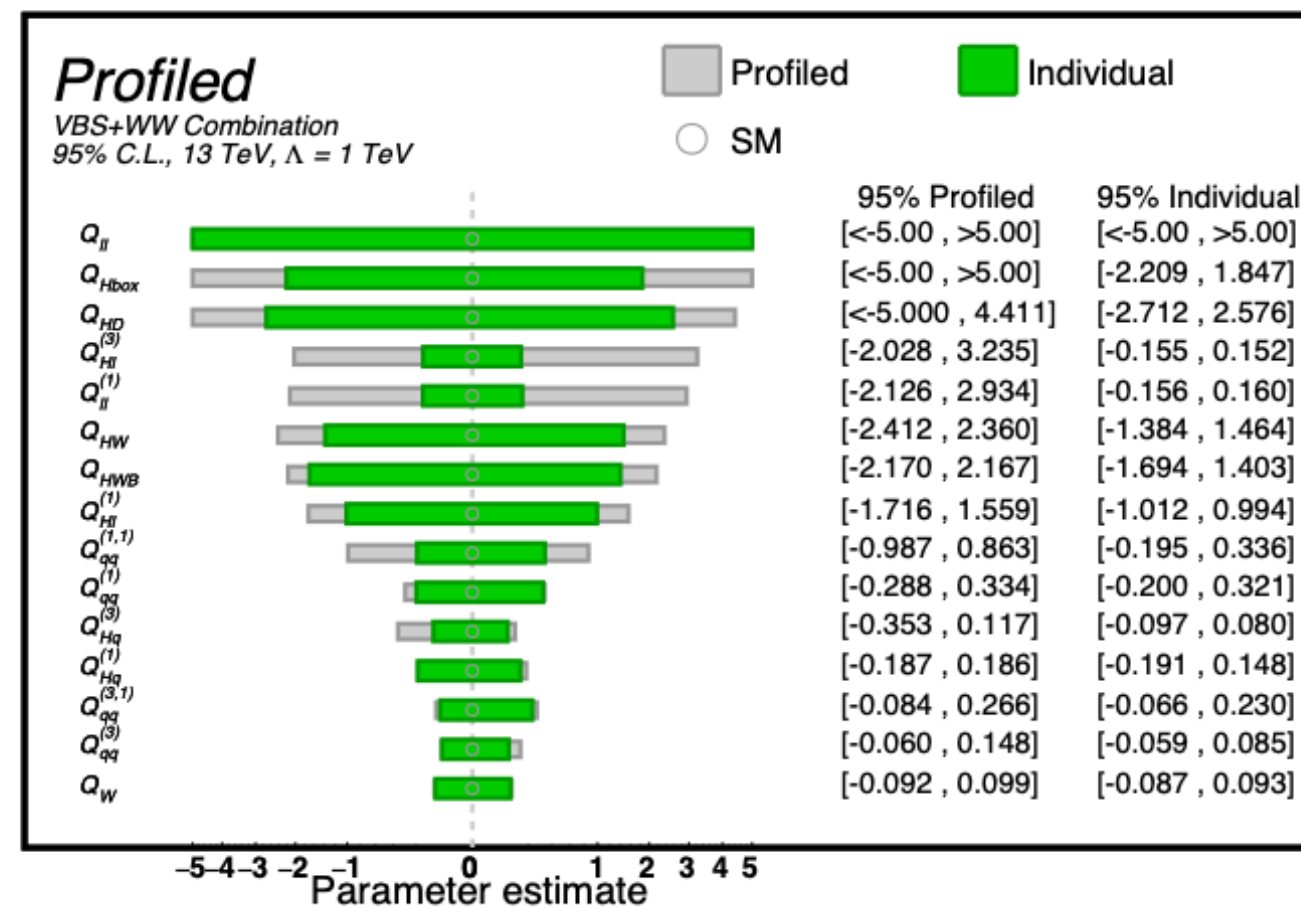
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ctGI	$9.152 \cdot 10^{-19}$	$-4.544 \cdot 10^{-8}$	$4.966 \cdot 10^{10}$	0	0.08173	0.08173	0
sm	0	0	0	0	0.4418	0.4418	0

Phase-space point, squared matrix elements

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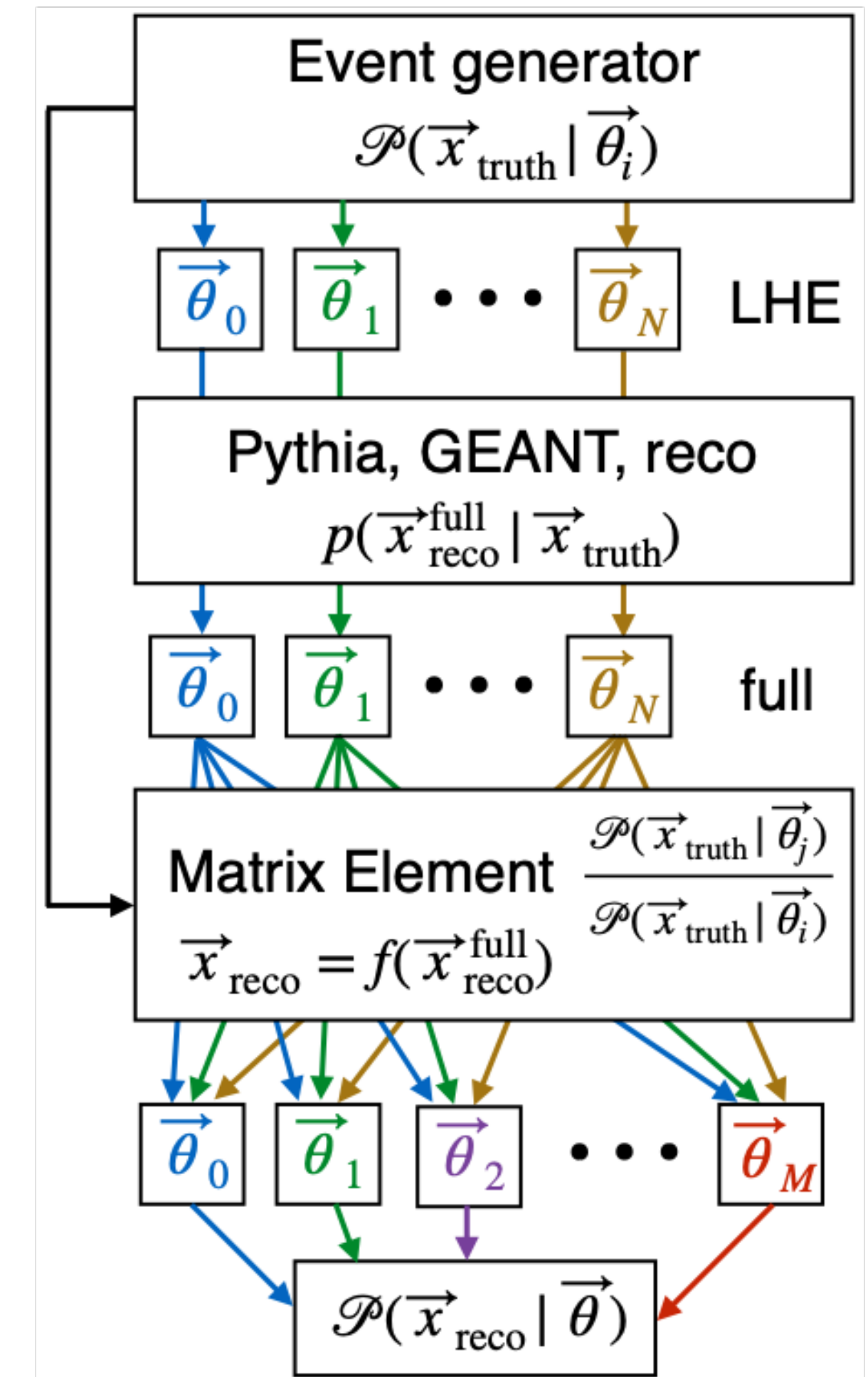
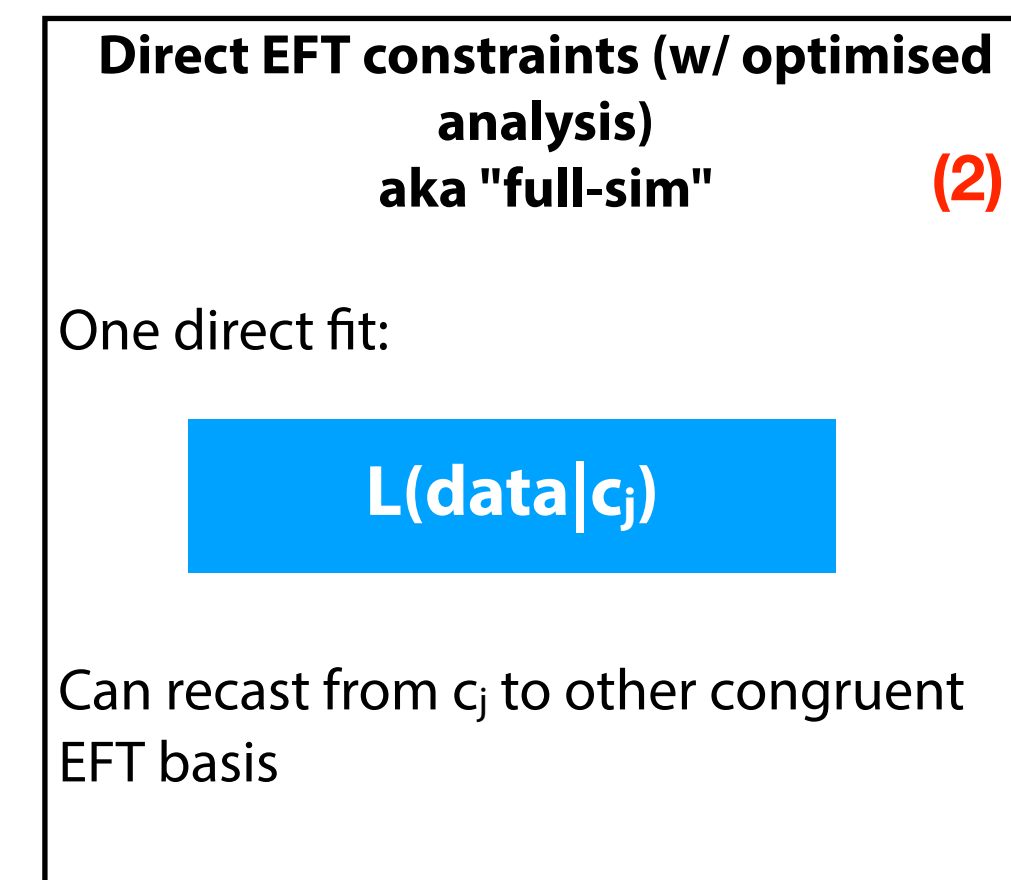
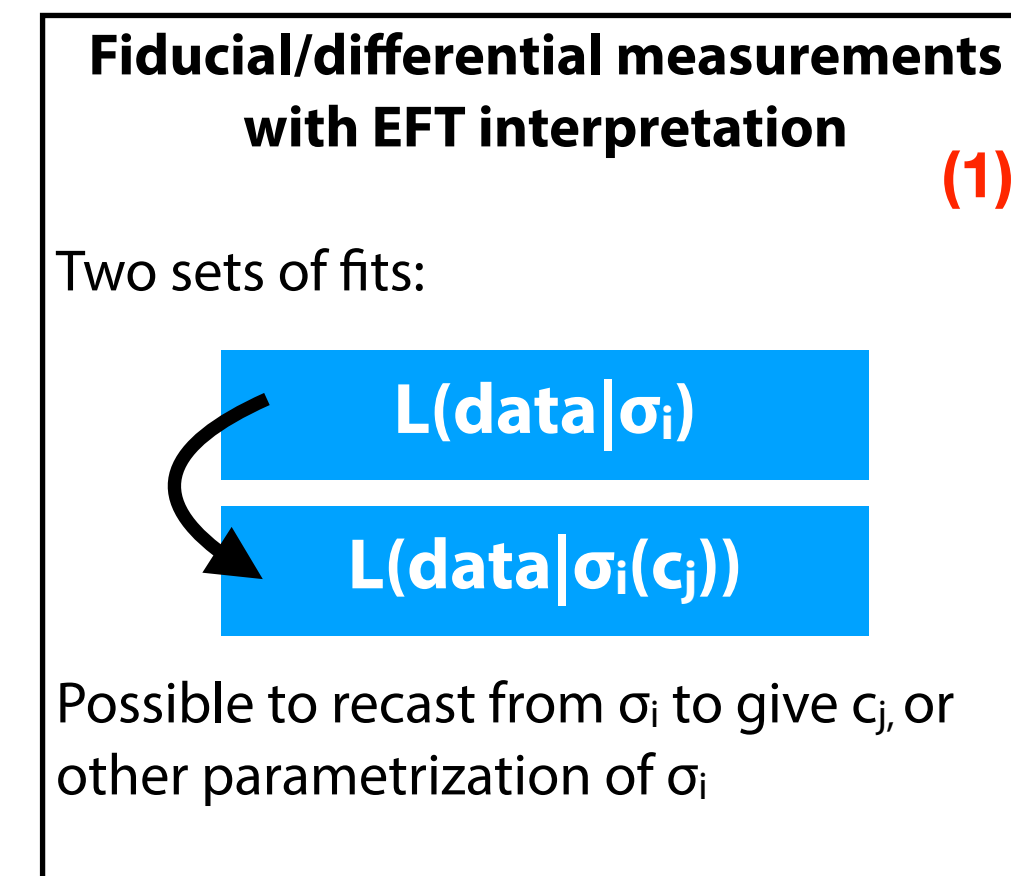
Proposal for comparison between different tools

(comparison of dim6top/SMEFTsim/SMEFT@NLO already studied)

G. Durieux

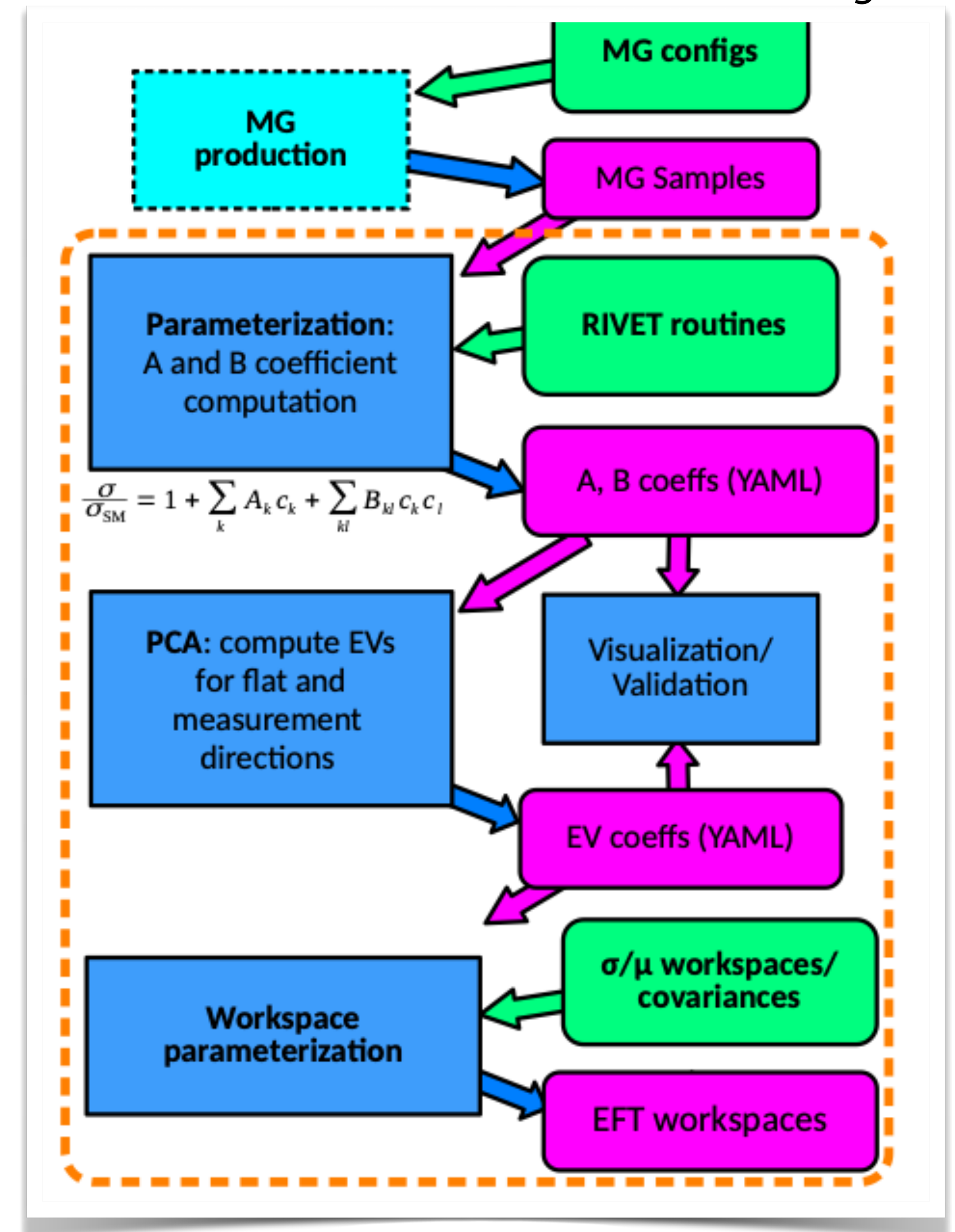
# Area 3: Experimental measurements & observables

- Goals (twiki):
  - Study **experimental approaches** for EFT inference, **choice of observables** and **optimisation for sensitivity**
- Strategies:
  - **Two-step approach:** reinterpretation of diff./fid. measurements
  - **Direct approach:** use of optimal / multi-variate observables
- Observables:
  - Differential / fiducial XS
  - Optimal observables: ME ratios, ML discriminators, etc.
- Associated uncertainties:
  - Detector / acceptance effects, unfolding, EFT in backgrounds
- Note released recently



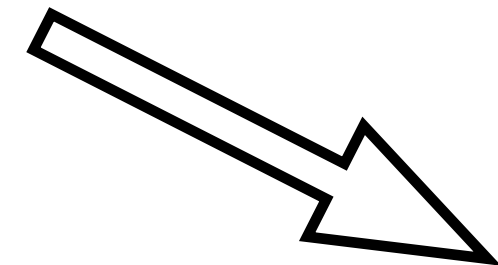
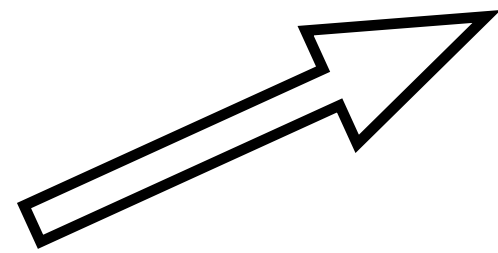
# Area 4: Fits and related systematics

- **Long term goal:** combined likelihood fit of Higgs, top & EW measurements to give strongest constraints on the widest possible set of EFT operators
- Goal is to provide guidance for:
  - Experimental combinations
  - Benchmarks for "theory" fits (typically use public information only)
  - Implementation of common experimental + theoretical uncertainties in combination
  - Inclusion of non-LHC constraints (EWPO, flavour, g-2,...)
- These large-scale combinations take a long time
- Pragmatic approach: started a fitting exercise, with a simplified  $\chi^2$  fit, based on public information
  - Previous meetings: [[June 22](#)] [[Feb 22](#)]
  - [Twiki](#) to document conventions



# Area 5: benchmark scenarios from UV models

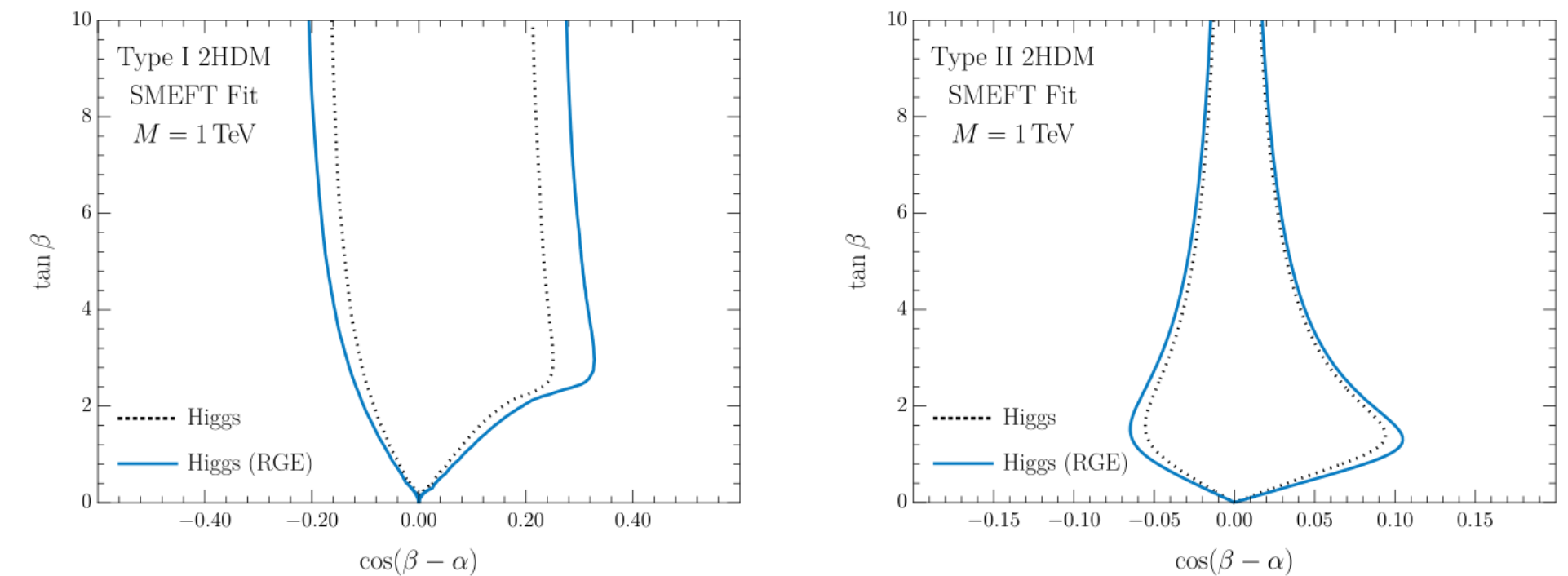
- Goals ([twiki](#)):
  - Study matching to specific models
  - Identify BSM-driven subsets of operators
  - Benchmarks beyond SMEFT, incl. non-linear EFT
- Two topical meetings: [[Feb 21](#)] [[March 22](#)]
  - Comparison of EFT constraints vs. direct BSM searches beyond EFT
- Note in development:
  - Review of (automated) codes: STrEAM, SuperTracer, Matchmakereft, CoDEx, Matchete, MatchingTools, ...
  - Provide comparison framework
  - Define relevant benchmark models, e.g. SMEFT ↔ MSSM



## Two Higgs Doublet Models *S. Homiller*

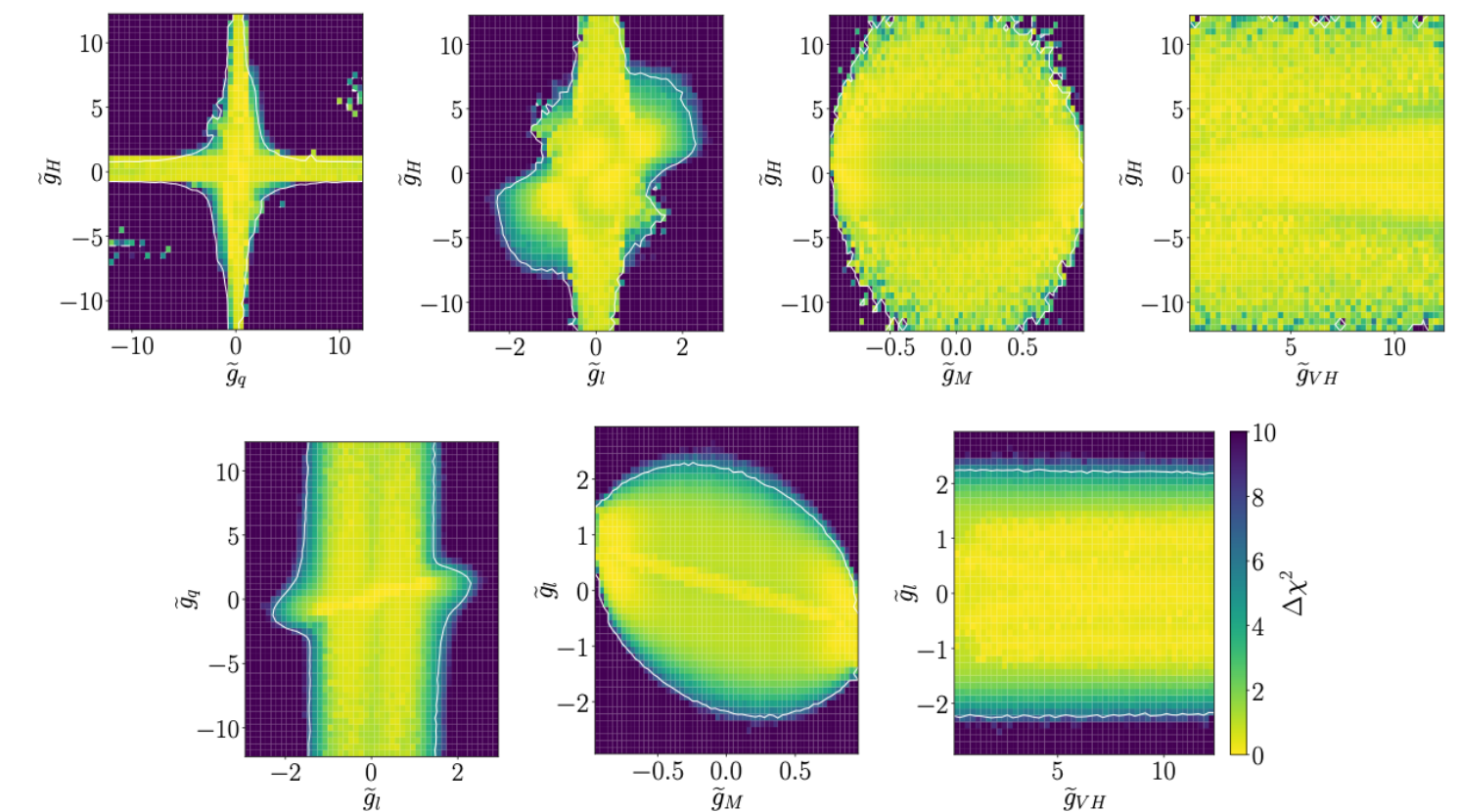
Generates  $C_H, C_{bH}, C_{tH}, C_{\tau H}$  at the matching scale

Note that these are SMEFT Fits — not 2HDM fits!



## Heavy vector triplet model

*E. Geoffray*



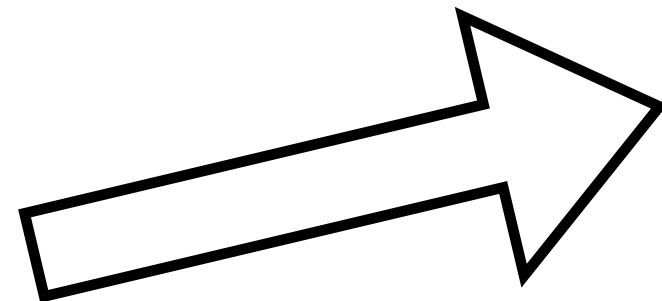
We get constraints for  $m_V = \frac{\tilde{m}_V}{\sqrt{1-g_M^2}} = 8\text{TeV}$ , where direct resonance searches don't exist. And we fit in the full 5 parameter model space.

# Area 6: flavour assumptions

- Goals (twiki):
  - Define relevant flavour scenarios for EFT interpretations
  - Considerations: need to discriminate t and b from light quarks,  $\tau$  from  $e/\mu$
  - Understand interplay with other experiments (flavour, EDM, g-2, ...) - some coefficients stronger constrained elsewhere

• Note on flavour assumptions in preparation

• **Recent topical meeting**



Area 6 meeting: Heavy flavour aspects in EFT fits

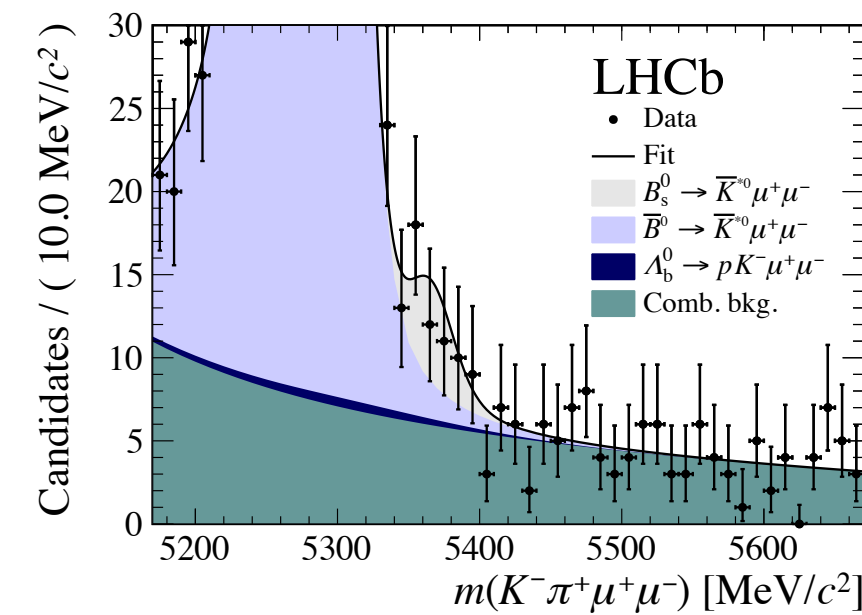
Monday 21 Nov 2022, 14:00 → 18:00 Europe/Zurich

[Link to agenda](#)

## Two topics discussed

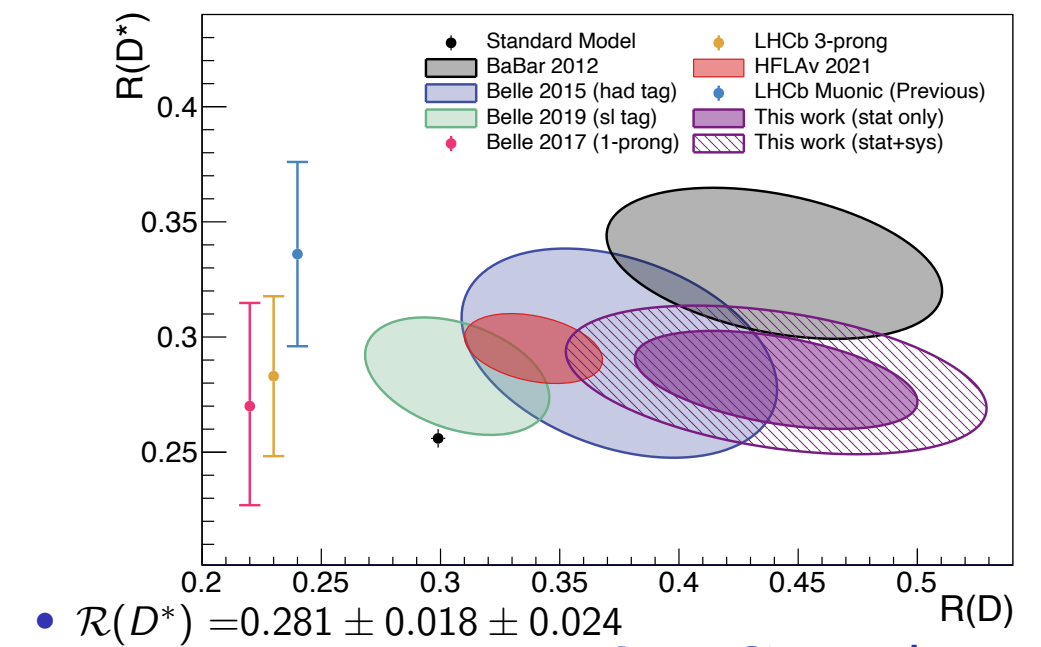
$$b \rightarrow d\ell^+\ell^-$$

Latest LHCb measurements



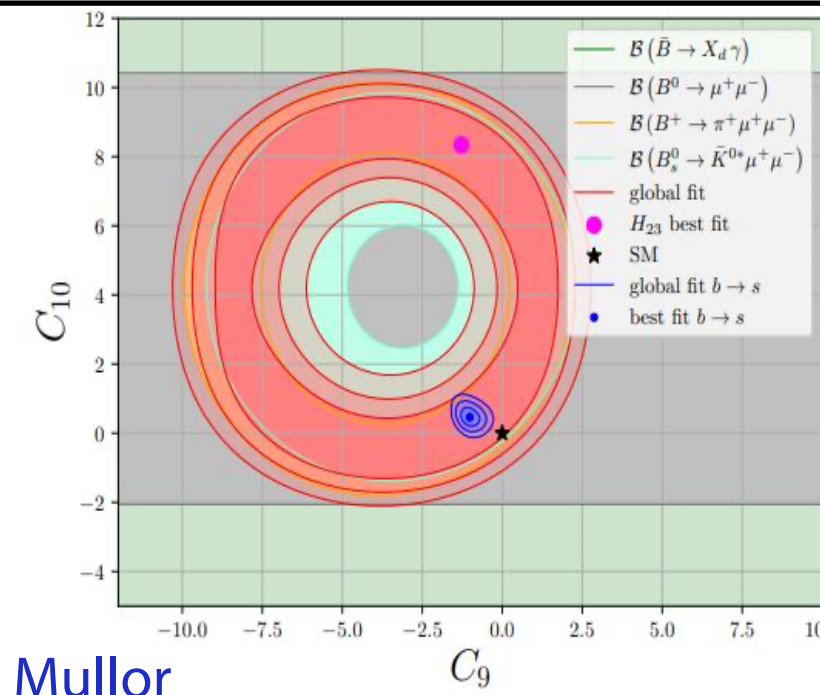
Tom Blake

## R(D\*) and $\tau\tau$ searches

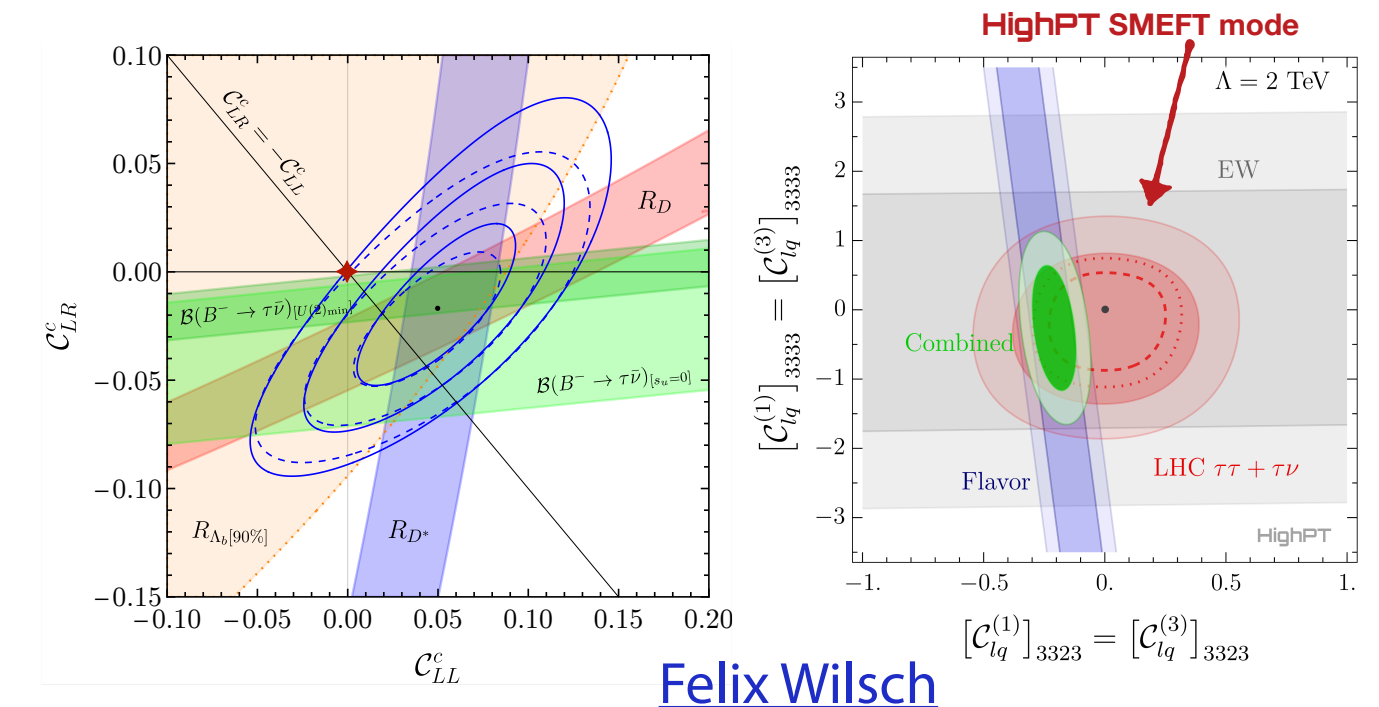


•  $\mathcal{R}(D^*) = 0.281 \pm 0.018 \pm 0.024$   
Greg Ciezarek

EFT interpretation

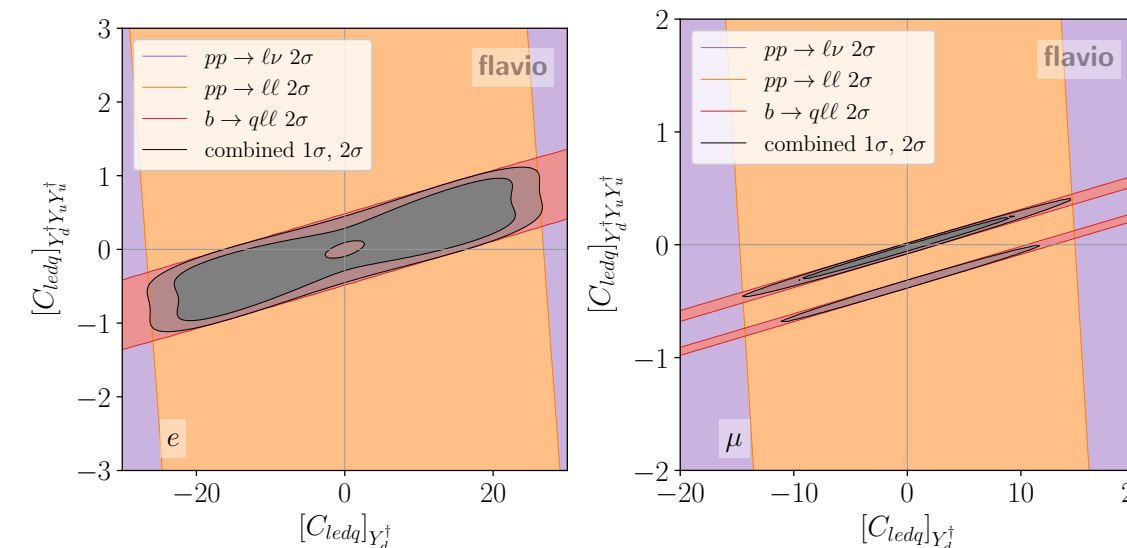


Hector Mullor



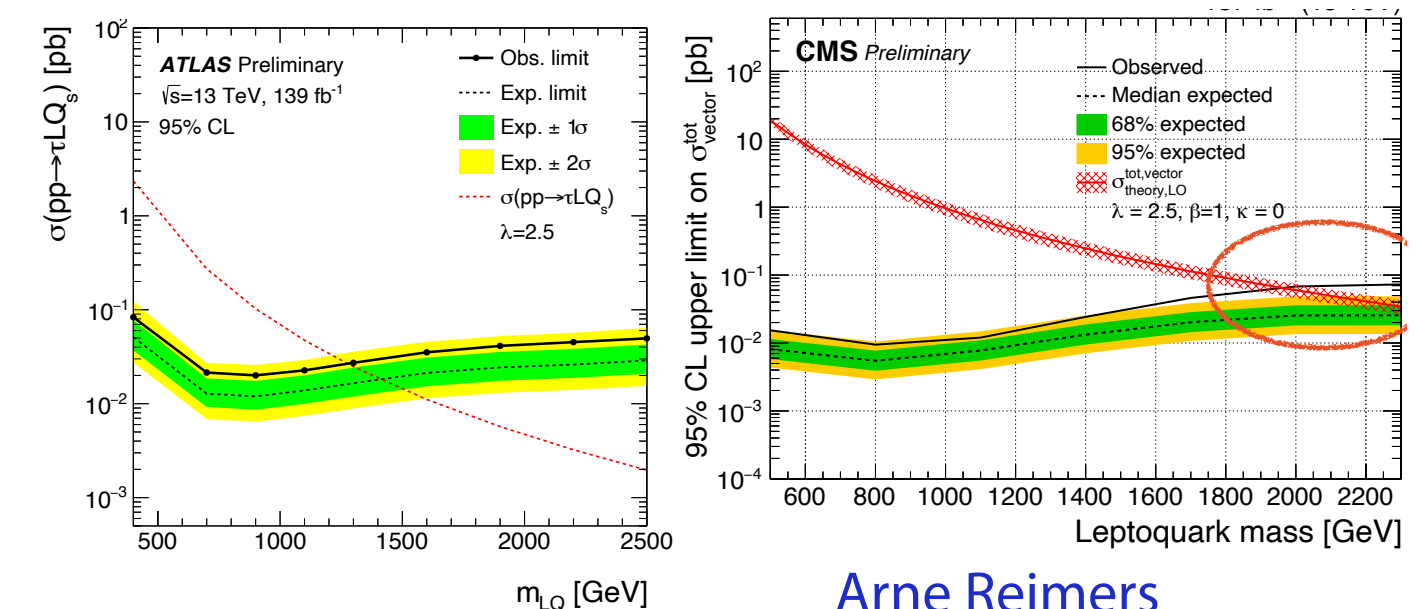
Felix Wilsch

Connections to high PT



A. Gilbert (NWU)

Aleks Smolkovic



Arne Reimers





# Agenda for today

<b>09:30</b> → <b>10:45</b>	<b>Session 1</b>	40/S2-B01 - Salle Bohr
Convener: Ilaria Brivio (University of Zurich)		
09:30	<b>Introduction</b>	20m
Speaker: Andrew Gilbert (Northwestern University (US))		
09:55	<b>Recent ATLAS EFT activities</b>	20m
Speaker: Eleonora Rossi (University of Oxford (GB))		
10:20	<b>Recent CMS EFT activities</b>	20m
Speaker: Sergio Sanchez Cruz (Universitaet Zuerich (CH))		
<b>10:45</b> → <b>11:15</b>	<b>Coffee break</b>	30m 40/S2-B01 - Salle Bohr
<b>11:15</b> → <b>12:30</b>	<b>Session 2</b>	40/S2-B01 - Salle Bohr
Convener: Sandra Kortner (Max Planck Society (DE))		
11:15	<b>Report on the ATLAS+CMS EFT fit exercise</b>	20m
Speaker: Fabian Stager (University of Zurich (CH))		
11:40	<b>Additional proposal for the treatment of EFT truncation, validity and related uncertainties</b>	10m
Speaker: Tim Cohen (CERN)		
11:55	<b>Report on BMS/EFT matching activities</b>	20m
Speaker: Kristin Lohwasser (University of Sheffield (GB))		
<b>12:30</b> → <b>13:30</b>	<b>Lunch break</b>	1h 40/S2-B01 - Salle Bohr
<b>13:30</b> → <b>15:10</b>	<b>Session 3</b>	40/S2-B01 - Salle Bohr
Convener: Ken Mimasu (King's College London)		
13:30	<b>Report on experimental measurements and observables for EFT interpretations</b>	20m
Speaker: Andrei Gritsan (Johns Hopkins University (US))		
13:55	<b>Machine learning observables in EFT interpretations</b>	15m
Speaker: Robert Schoefbeck (Hephy Vienna)		
14:20	<b>Frameworks and tools for systematic data analysis reinterpretations</b>	15m
Speaker: Lukas Alexander Heinrich (Technische Universitat Munchen (DE))		
14:45	<b>Helicity-free techniques for the reweighting of MC Samples</b>	15m
Speaker: Olivier Mattelaer (UCLouvain)		

## Afternoon discussion session

<b>15:40</b> → <b>18:30</b>	<b>Discussion session</b>	40/S2-B01 - Salle Bohr
15:40	<b>Area 1 - EFT formalism (Chair: Ilaria Brivio)</b>	1m
15:41	<b>Discussion about SMEFT and HEFT exemplified for HH production</b>	5m
Speaker: Jannis Lang		
15:46	<b>EFT : Applicabilities and Viabilities</b>	5m
Speaker: Tisa Biswas (University of Calcutta)		
15:51	<b>Area 1 targets</b>	5m
Speaker: Ilaria Brivio (University of Zurich)		
16:10	<b>Area 2 - Predictions &amp; Tools (Chair: Robert Schoefbeck)</b>	1m
16:11	<b>HWG activities for the database of SMEFT predictions</b>	5m
Speaker: Mr Matthew Knight (Imperial College London)		
16:16	<b>Area 2 targets</b>	5m
Speaker: Abideh Jafari (Deutsches Elektronen-Synchrotron (DE))		
16:40	<b>Area 3 - Experimental Measurements and Observables (Chair: Anke Blekoetter)</b>	1m
16:41	<b>Unbinned multivariate observables for global SMEFT analyses from machine learning</b>	5m
Speaker: Jaco ter Hoeve (Nikhef and VU Amsterdam)		
16:46	<b>Efficient interpolation and practical observables</b>	5m
Speaker: Nick Smith (Fermi National Accelerator Lab. (US))		
16:51	<b>Area 3 targets</b>	5m
Speaker: Anke Blekoetter (IPPP Durham)		
17:15	<b>Area 4 - Fits and related systematics (Chair: Jacob Julian Kempster)</b>	1m
17:16	<b>Area 4 targets</b>	5m
Speaker: Jacob Julian Kempster (University of Sussex (GB))		
17:21	<b>ATLAS+CMS EFT combination (top)</b>	10m
Speaker: Kirill Skovpen (Ghent University (BE))		
17:31	<b>Future EFT plans from the SMP CMS perspective</b>	10m
Speaker: Matteo Presilla (Istituto Nazionale di Fisica Nucleare)		
18:00	<b>Area 5 - Benchmark scenarios for UV models (Chair: Shankha Banerjee)</b>	1m
18:01	<b>Area 5 targets</b>	5m
Speaker: Kristin Lohwasser (University of Sheffield (GB))		
18:15	<b>Area 6 - Flavour (Chair: Shankha Banerjee)</b>	1m
18:16	<b>Area 6 targets</b>	5m
Speaker: Kristin Lohwasser (University of Sheffield (GB))		
<b>18:30</b> → <b>19:30</b>	<b>Cocktail</b>	1h 500/1-201 - Mezzanine

**From 18:30:**  
Drinks reception in  
the main building  
(mezzanine)