Area 1 targets
– EFT formalism –

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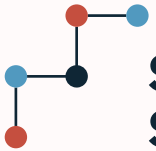
for the Area 1 conveners:
IB, Gauthier Durieux, Matteo Presilla, Giovanni Petrucciani (stepping out)

University of Zurich[UZH]



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Proposals for future Area 1 activities

1. [*ongoing*] Parameter counting for benchmark flavor scenarios
   → with Areas 3+6, building on discussion at flavor meeting indico.cern.ch/event/1096487
   → will be presented in more detail soon, once note is ready

2. Benchmarking of proposed truncation/uncertainty prescriptions
   ⇝ with Area 4 (fitting ex.), Tisa's talk

3. Database of notation/basis conversions between tools and existing results
   ⇝ with Area 2

4. Validation of NLO predictions and tools
   ⇝ with Area 2

5. Survey of unitarity and positivity bounds
   to ease comparison with measurements and potentially incorporation in fits

6. SMEFT/HEFT parameterizations for HH
   with the long-term goal of enabling consistent H + HH combinations
   ⇝ Jannis' talk

. . . more ideas? requests?

Benchmarking of truncation/uncertainty proposals

Why?

- discussion about how to assess **EFT validity**, account for **d ⩾ 8 effects** etc.

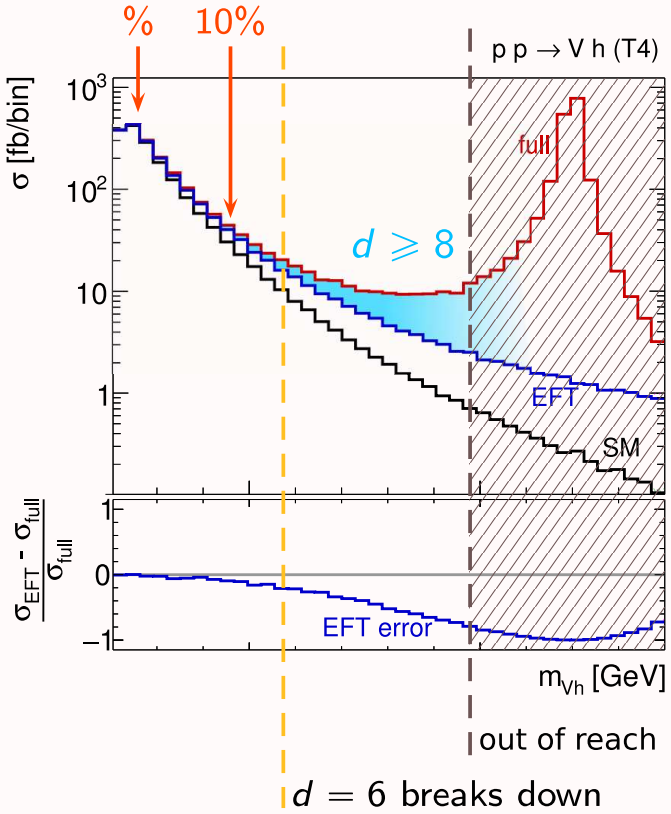
  5 proposals received so far:
  A,B,C,D discussed at previous mtgs
  + Tim's proposal this morning (E)

- WG did not formulate recommendations.

  proposals collected in a **note** on arXiv (kept up-to-date): 2201.04974

  → main ideas and pros & cons

- case studies with concrete examples missing (realistic fits, example UV scenarios. . .)



adapted from Brehmer,Freitas,López-Val,Plehn 1510.03443

→ benchmark the proposals (and variants) within the Area 4 fitting exercise

Benchmarking of truncation/uncertainty proposals

How?

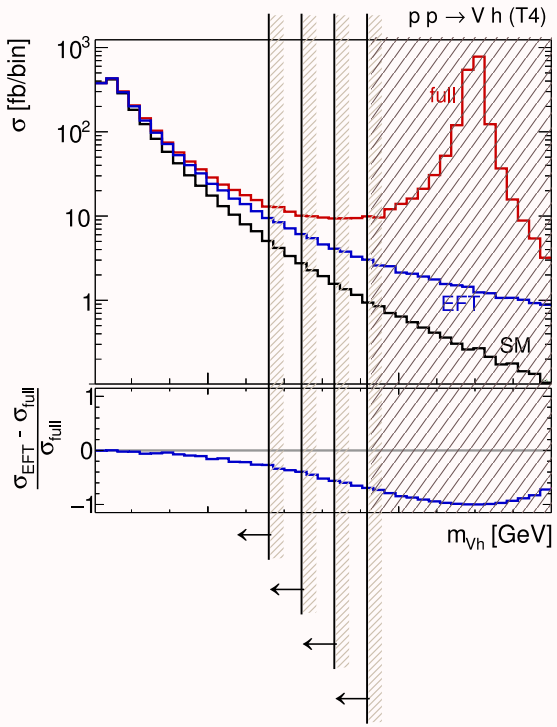
[all "How?"'s are very preliminary!]

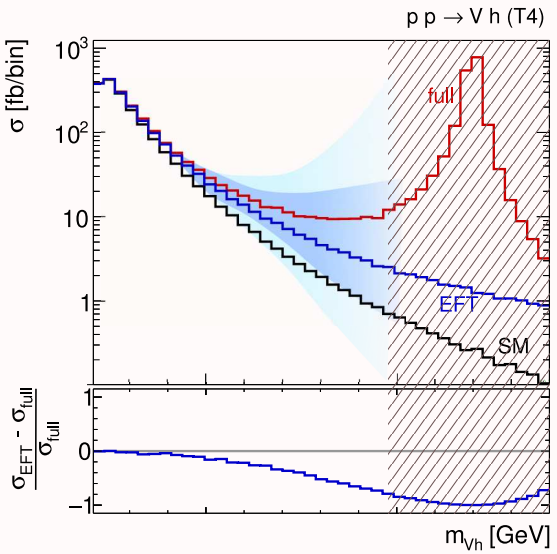
performing the **fitting exercise with different setups and compare**. e.g.:

- linear and linear+quadratic, including all bins
- clipping: removing highest bins, moving the cut (A,B,D)
  [variants: truncating data/prediction, removing/damping/capping EFT contribution. . .]
- incl. truncation uncertainty in fit, varying size and nuisance parameterization (C)

Obs included:

– LEP + SLC
– STXS $h \to \gamma\gamma, h \to 4l$
– VH, $H \to bb$
– single top (p_T^t)
– diboson: $W\gamma$ ($p_T^\gamma \times \Delta\phi$)
WW (p_T^l)
WZ (m_T^{WZ})
– Zjj ($\Delta\phi_{jj}$)





Database of notation/basis conversions

Why?

- **diverse tools** used by experiments to set limits on EFT operators, anomalous couplings, κ's. . . in many analyses
- useful to **recast** some simulations or limits in terms of SMEFT
- requires mapping parameters onto common setups (basis, normalization etc.) correspondence sometimes non-obvious, must be re-derived each time

→ derive, validate and make publicly available once and for all

How?

- dynamic **twiki page** or similar where conversions are uploaded and/or implementation of translations **in available tools** Rosetta 1508.05895 WCxf 1712.05298
- a **validation/approval** step should be implemented
- not planning to enforce one common **format** for now. different solutions might be more appropriate for different cases, eg. param_cards, scripts, analytic tables. . .

👉 conversion between SMEFT UFOs already available LPCC Validation note 1906.12310 github.com/SMEFTsim/UFO-validation

Validation of NLO predictions and tools

Why?

- Extension of the validation effort from 2019 LPCC note 1906.12310
- Long term: in order to adopt 1-loop (QCD+EW) predictions in SMEFT global fits, **consistency in assumptions and conventions** must be ensured
- Shorter term: important to keep track of conventions going into results derived with different tools and/or by different theory groups
  → **understand potential differences, estimate associated theory uncertainties**

→ Define validation/comparison procedures for NLO SMEFT predictions from MC generators, other tools and/or analytical results

How?

- Can start by surveying existing generators/tools/results, tabulating conventions.
- Comparison most easily done **numerically**.
  Could be done at individual phase-space points, as for LO.
  Could be done evaluating only amplitude (coefficients of $1/\varepsilon$ powers)
- Eventually set up some **validation code**, to streamline comparisons

Unitarity and positivity bounds

Why?

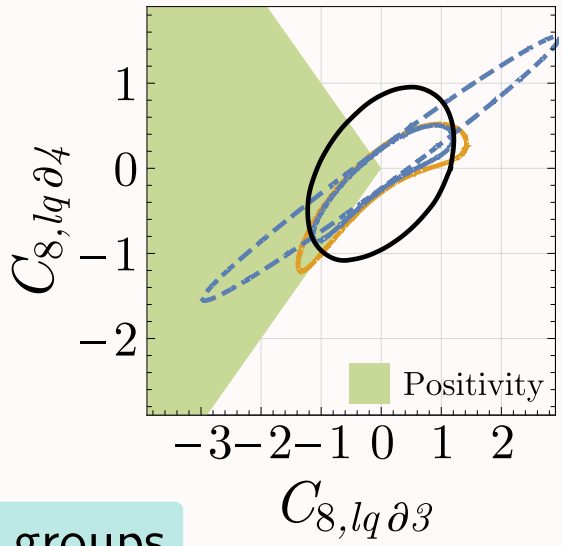
- Theory considerations limit physical parameter space

  → **perturbative unitarity** violated at high E if C/Λ^2 too large $\Rightarrow C(E^2/\Lambda^2) < X$

  → **physical amplitude properties** (analyticity, causality, crossing symmetry...) can further limit parameter space (e.g. $C > 0$)
  in practice: mostly applies to $d \geqslant 8$

- Often hard for non-experts to have a sense of where bounds lie

- Unclear how to account for constraints in fits
  → minimal: comparison a posteriori



from Li,Mimasu,Yamashita,Yang, Zhang,Zhou 2204.13121

→ Collect available bounds derived by various theory groups

How?

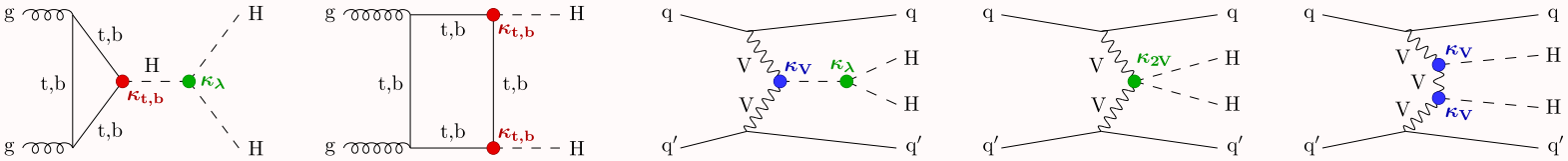
- Make results available in a **twiki/database**, in form of inequalities and/or code
- Use as much as possible a unified notation

EFT parameterizations of HH

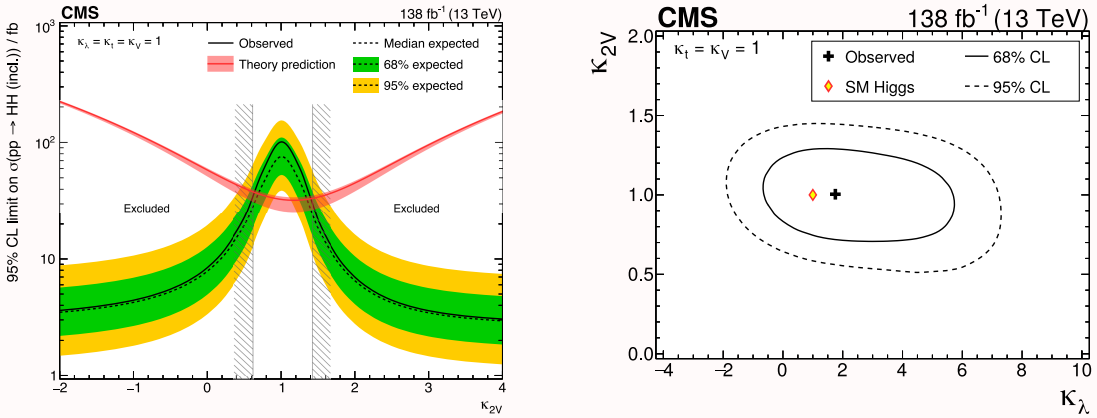
Why?

figures from: CMS Nature 607(2022)60

- Experimental HH measurements currently in terms of (a subset of) κ's



- Well-known that **large cancellations** between diagrams play a big role:
  eg. assuming $\kappa_V = \kappa_t = \kappa_\lambda = 1$, CMS excludes $\kappa_{2V} = 0$ at 6.6σ from $\mu_{HH} < 3.4$



→ a **global analysis** could be interesting (currently 1D/2D)
→ several κ's constrained in single H → worth doing a **H + HH simultaneous fit**?

→ promote SMEFT/HEFT parameterization of HH

EFT parameterization of HH

Main values

- usual EFT advantages
  gauge invariant, can be improved to NLO, accounts for all anomalous interactions, with and without Higgs. . .

long-term, from a combined fit:

- **more reliable ranges for κ_λ, κ_{2V}**
  👉 κ_{2V} most likely probed only from upper limits on VBF-HH also at HL-LHC
- explore interplay with $\kappa_\lambda, \kappa_{2V}$ in single-H at 1loop (and EWPO at 2loops)
- possibility to disentangle **HEFT vs SMEFT**
  analyzing relations among $Htt \leftrightarrow HHtt$, $HVV \leftrightarrow HHVV$, $Hgg \leftrightarrow HHgg$

How?

- A number of theory studies already present in the literature, some at NLO
- Discuss what would be relevant to implement for experimental studies: SMEFT/HEFT? which HH channels? which operators? . . .
- More details of activity can be defined with HH subgroup of Higgs WG
  $\rightsquigarrow$ dedicated note in preparation