Beyond the benchmarks: off-shell Higgs production

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https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWGOFFSHELL

with slides kindly contributed by
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Ramona Gröber, Brian Henning, JY Jook, Dermot Moran, Eleni Vryonidou

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Thanks to Stefan Höche for the slides template.
Overview

- Introduction
- Progress on SM corrections:
  - $pp (\rightarrow H) \rightarrow ZZ$ production @ nNNLO QCD
  - $gg (\rightarrow H) \rightarrow ZZ$ interference @ 2-loops with approx. $m_t$ dependence
  - $gg \rightarrow ZZ$ production @ 2 loops with full top mass dependence
- Going beyond BSM benchmarks @ LO:
  - High-mass 1HSM interference effects beyond LO
  - Progress on off-shell and interference EFT studies
  - Off-shell and interference effects in SMEFT
  - Universal EFT (oblique Higgs parameter)
  - Higgs couplings without the Higgs
- Theoretical and experimental issues/questions
- Conclusions
High mass Higgs $\rightarrow$ WW search at CMS with 2016 data

PAS-HIG-17-033

- High mass Higgs $\rightarrow$ WW search with 2016 data
- Combination of semi and fully-leptonic final states
- No significant excess observed
- SM-like limits based on YR4 ggF and VBF $\sigma$ values
- 2HDM limits (with $\cos(\beta - \alpha) = 0.1$)
- Several MSSM benchmark scenario limits
Vector boson pair production at the LHC

- At the end of LHC run II:
  - No evidence of New Physics is found
  - Higgs couplings are found consistent with the SM

- Vector boson pair production is crucial because it is:
  - Irreducible background to Higgs studies
  - Useful for investigating signal-background interference effect and the Higgs boson width
  - Background to BSM searches
  - Sensitive to anomalous triple gauge couplings (aTGCs)

- Precise control of SM predictions is needed, especially in the tails of the distributions
  - Higher order calculations are demanded
NNLO contributions increase the NLO results by $\sim 15\%$.

- Gluon-fusion takes up about 60% of NNLO corrections.
- NLO corrections to the $gg$ channel are expected to be quantitatively relevant!
- Current experimental analyses: NLO$_{gg}$ and NNLO$_{q\bar{q}}$ are treated as independent contributions.
  → Not independent at NNLO.
Grazzini, Kallweit, Wiesemann, Yook (2018)

<table>
<thead>
<tr>
<th>$\sqrt{s}$</th>
<th>8 TeV</th>
<th>13 TeV</th>
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<th>13 TeV</th>
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<tr>
<td></td>
<td>$\sigma$ [fb]</td>
<td>$\sigma/\sigma_{\text{NLO}} - 1$</td>
<td>$\sigma/\sigma_{\text{ggLO}} - 1$</td>
<td>$\sigma/\sigma_{\text{NNLO}} - 1$</td>
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<tr>
<td>LO</td>
<td>8.1881(8)$^{+2.4%}_{-3.2%}$</td>
<td>13.933(1)$^{+5.5%}_{-6.4%}$</td>
<td>$-27.5%$</td>
<td>$-29.8%$</td>
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<tr>
<td>NLO</td>
<td>11.2958(4)$^{+2.5%}_{-2.0%}$</td>
<td>19.8454(7)$^{+2.5%}_{-2.1%}$</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>$qq^{\text{NNLO}}$</td>
<td>12.09(2)$^{+1.1%}_{-1.1%}$</td>
<td>21.54(2)$^{+1.1%}_{-1.2%}$</td>
<td>+7.0%</td>
<td>+8.6%</td>
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<tr>
<td>ggLO</td>
<td>0.79355(6)$^{+28.2%}_{-20.9%}$</td>
<td>2.0052(1)$^{+23.5%}_{-17.9%}$</td>
<td>0%</td>
<td>0%</td>
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<tr>
<td>$gg^{\text{NLO}}_{gg}$</td>
<td>1.4787(4)$^{+15.9%}_{-13.1%}$</td>
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<tr>
<td>NNLO</td>
<td>12.88(2)$^{+2.8%}_{-2.2%}$</td>
<td>23.55(2)$^{+3.0%}_{-2.6%}$</td>
<td>+14.0%</td>
<td>+18.7%</td>
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<tr>
<td>nNNLO</td>
<td>13.48(2)$^{+2.6%}_{-2.3%}$</td>
<td>24.97(2)$^{+2.9%}_{-2.7%}$</td>
<td>+19.3%</td>
<td>+25.8%</td>
</tr>
</tbody>
</table>

- $gg^{\text{NLO}}$ makes up 10% of the total rate at 8 TeV and 14% at 13 TeV.
- $gg^{\text{NLO}}_{gg}$ increases $gg^{\text{LO}}$ contribution by 86% at 8 TeV and 81% at 13 TeV.
- Including the $qg$ channel lowers the $gg^{\text{NLO}}$ cross section by 6% at both 8 and 13 TeV.
- NLO corrections to $gg$ channel increase the NNLO prediction by 5% at 8 TeV and 6% at 13 TeV.
The MATRIX framework

M. Grazzini, S. Kallweit and M. Wiesemann (2017)

MUNICH
S. Kallweit

NNLO (+NNLL)

q_T Subtraction
S. Catani and M. Grazzini (2007)

OpenLoops
F. Cascioli, J. Lindert, P. Maierhöfer and S. Pozzorini (2014)
COLLIER

TDHPL T. Gehrmann and E. Remiddi
Importance of top loops

Top loops especially important in part of phase space where LME can’t be applied.
Gluon fusion processes at higher orders

Computation of 2 → 2 multi-scale processes at two-loop order difficult

Bottleneck: virtual corrections, dependence on several scales

Well-established method:

Asymptotic expansion in large top mass (LME)

\[ \frac{1}{(p + q)^2 - m^2} \approx \frac{1}{p^2 - m^2} \left( 1 - \frac{2p \cdot q + q^2}{p^2 - m^2} + \ldots \right) \]

simplifies integrals dramatically

p loop momentum, q external momentum

At LO: Taylor expansion in \( \frac{1}{m_t^2} \)

At NLO: Taylor expansion in \( \frac{1}{m_t^2} + \log \text{terms from IR divergent diagrams} \)
Our idea

• Construct an approximation that works in (nearly) whole phase space based on simpler expansion

Based on LME and expansion around non-relativistic top threshold (THR) combined by Padé approximants

• Demonstrate method on a process that is known in full mass dependence

\[
\text{HH as it carries full complexity of } 2 \rightarrow 2 \quad [\text{RG, Maier, Rauh '17}]
\]

• Apply to other cases

\[
\text{ZZ} \quad [\text{RG, Maier, Rauh '19}]
\]

• Apply to higher loop orders

\[
\text{off-shell single Higgs production} \quad [\text{Davies, RG, Maier, Rauh, Steinhauser '19}]
\]
\[ \tilde{x} = \frac{p_T^2 + m_Z^2}{m_{ZZ}^2} \quad \quad \tilde{z} = \frac{M_{ZZ}^2}{4m_t^2} \]

\[ r_Z = \frac{M_Z^2}{M_{ZZ}^2} \]

\[ \tilde{x} = \frac{p_T^2 + m_Z^2}{m_{ZZ}^2} \]

\[ \tilde{z} = \frac{M_{ZZ}^2}{4m_t^2} \]

Padé approximants as constructed from LME by

[Campbell, Czakon, Ellis, Kirchner '16]
Convergence at NLO

\[ \tilde{x} = 0.09 \]

\[ \tilde{z} = 1 - z \]

[RG, Maier, Rauh '19]
Conduct the amplitude and decompose into sum of all possible Lorentz structures and their ‘form factors’

\[ A_{\mu \nu \rho \lambda} = \sum p_i^\mu p_j^\nu p_k^\rho p_l^\lambda A_{ijkl} + \ldots \]

Solve linear system of equations to relate the ‘form factors’ to the original Feynman integral

Use Integration By Parts identities to reduce the number of integrals to a basis set

Rotate the basis integrals to a set of finite integrals ⇒ Much better behaved numerically

Evaluate the finite integrals numerically using ‘sector decomposition’ (plus any needed improvements)
Comparision

Conventional IBP reduction

- Setup: None

- Reduction:
  - ~1 yr of CPU time for family A, up to tensor rank 3 (tensor rank 4 needed)
  - Terabytes of disk space
  - Need special file system on the High Performance Computing Cluster at MSU due to file corruptions

New Syzygy based IBP reduction

New

- Setup: Generation of syzygies (Can be parallelised)
  - ~ 30 hrs CPU time (single core) for family A, B
  - ~ 50 hrs CPU time (single core) for family C, D

- Reduction:
  - ~ 120 hrs CPU time for family A, B
  - ~ 50 weeks of CPU time for family C
  - ~ 15 weeks of CPU time for family D
  - This is heavily parallelised
Advantages:

- Can write a custom integrator to evaluate such integrals much faster than available public codes: Initial tests suggest huge potential
- Use integrals already appearing in the amplitude, often even as master integrals
- Avoid computing reductions beyond those required for the amplitude
- Have a working code already; working on a more efficient implementation

\[
(k_2)^2 - m_t^2 \quad \text{\textit{\star}} (-s)
\]
High-mass signal-background interference with background corrections

NK, Lind, Maierhofer, Song (2019)

\[ gg \rightarrow \{h_1, h_2\} \rightarrow t\bar{t} \rightarrow \bar{b}b \ell\bar{\ell} \nu\nu' \]

1HSM (\(M_{h_2} = 700 \text{ GeV}, \theta_1\)), \(pp, \sqrt{s} = 13 \text{ TeV}\)

SHERPA+OPENLOOPS

- \(|M_{h_1} + M_{h_2} + M_{\text{cont}}|^2\)
- \(|M_{h_1}|^2\)
- \(|M_{h_1} + M_{h_2}|^2\)
- \(|M_{h_2}|^2\)
- \(2\text{Re}(M_{h_1}^* M_{h_2})\)
- \(2\text{Re}((M_{h_1}^* + M_{h_2}^*)M_{\text{cont,loop}})\)
- \(2\text{Re}(M_{h_1}^* M_{\text{cont,loop}})\)
- \(2\text{Re}(M_{h_2}^* M_{\text{cont,loop}})\)
- \(2\text{Re}(M_{h_2}^*(M_{\text{cont}} + M_{\text{cont,loop}} + M_{h_1}))\)
- \(2\text{Re}(M_{h_1}^*(M_{\text{cont}} + M_{\text{cont,loop}} + M_{h_2}))\)
- \(2\text{Re}(M_{h_1} M_{\text{cont}})\)
- \(2\text{Re}(M_{h_2} M_{\text{cont}})\)
- \(2\text{Re}((M_{h_1}^* + M_{h_2}^*)M_{\text{cont}})\)
- \(|M_{\text{cont}}|^2\)
### SMEFT basics

New Interactions of SM particles

\[ \mathcal{L}_{EFT} = \mathcal{L}_{SM} + \sum_i \frac{C_i^{(6)} O_i^{(6)}}{\Lambda^2} + \mathcal{O}(\Lambda^{-4}) \]


Grzadkowski et al arXiv:1008.4884

<table>
<thead>
<tr>
<th>( X^3 )</th>
<th>( \phi^3 ) and ( \phi^2 D )</th>
<th>( \psi^2 \phi^2 )</th>
</tr>
</thead>
</table>
| \( Q_{GC} \) | \( f^{ABC} G^A_{\mu
u} G^B_{\rho\sigma} G^C_{\lambda\kappa} \) | \( Q_{\mu
u} \) |
| \( Q_{QG} \) | \( f^{ABC} q^A_{\mu
u} G^B_{\rho\sigma} G^C_{\lambda\kappa} \) | \( Q_{QG} \) |
| \( Q_{QW} \) | \( \sigma_{J\kappa} W^\mu_{\lambda\rho} W^\nu_{\alpha\beta} W^\rho_{\kappa\lambda} \) | \( Q_{QW} \) |
| \( Q_{QG} \) | \( \sigma_{J\kappa} W^\mu_{\lambda\rho} W^\nu_{\alpha\beta} W^\rho_{\kappa\lambda} \) | \( Q_{QG} \) |

<table>
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<tr>
<th>( X^3 \phi^3 )</th>
<th>( \psi X_D )</th>
<th>( \psi^2 \phi^2 )</th>
</tr>
</thead>
</table>
| \( Q_{\mu
u} \) | \( (\bar{\psi} \gamma_\mu \gamma_\nu \psi) \bar{\psi} \psi \) | \( Q_{\mu
u}^{(1)} \) |
| \( Q_{\mu
u}^{(2)} \) | \( (\bar{\psi} \gamma_\mu \gamma_\nu \psi) \bar{\psi} \psi \) | \( Q_{\mu
u}^{(2)} \) |
| \( Q_{\mu
u}^{(3)} \) | \( (\bar{\psi} \gamma_\mu \gamma_\nu \psi) \bar{\psi} \psi \) | \( Q_{\mu
u}^{(3)} \) |

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<td>( (\bar{l}<em>H \gamma</em>\mu \gamma_\nu l_H) )</td>
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<td>( (\bar{l}<em>H \gamma</em>\mu \gamma_\nu l_H) )</td>
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<td>( Q_{LR}^{(3)} )</td>
<td>( (\bar{l}<em>H \gamma</em>\mu \gamma_\nu l_H) )</td>
<td>( Q_{LR}^{(3)} )</td>
</tr>
</tbody>
</table>
Off-shell production in the SMEFT

The signal

The background

The Higgs width
The constraints on top operators

Run II, ATLAS+CMS, 68% and 95% C.L.

\[ \Lambda / \sqrt{C} = 0.35 - 2 \text{ TeV} \]

SMEFT in Monte Carlo

Monte Carlo implementation based on:
• Warsaw basis
• Degrees of freedom for top operators as in arXiv:1802.07237 (LHCTopWG)

Current status:
• 73 degrees of freedom (top, Higgs, gauge):
  • CP-conserving
  • Flavour assumption: $U(2)_Q \times U(2)_u \times U(3)_d \times U(3)_L \times U(3)_e$
• 0/2F@NLO operators validated (with previous partial NLO implementations) [http://feynrules.irmp.ucl.ac.be/wiki/SMEFTatNLO](http://feynrules.irmp.ucl.ac.be/wiki/SMEFTatNLO)
• 4F@NLO operators validation: on-going

Future plans
• Full NLO model release (4F@NLO)
• Other flavour assumptions
• CP-violating effects

Work in progress with: C. Degrande, G. Durieux, F. Maltoni, K. Mimasu, C. Zhang
**Oblique Higgs parameter**

- How does the Higgs boson propagate? (*)

- What is the analogue of $W,Y$ in Higgs physics?
  $W, Y$: EW oblique corrections (extending $S, T$)

\[ \mathcal{L}_H = \frac{\hat{H}}{m_h^2} | \Box H |^2 \]

- $\hat{H}$: the hallmark of off-shell Higgs physics

(*) Framed within a general EFT context the answer to this question is unphysical and basis-dependent. However, there is a broad class of microscopic theories (called Universal theories) which single out a specific EFT basis in which this question not only becomes well-defined, but also plays a key role in mapping out the boundaries of the UV.
Universal EFT

• A very broad class of UV theories singles out a particular set of EFT operators at the matching scale

• There exist a field basis in which all leading-order effects are captured by dim-6 operators built from SM bosonic fields only

• How?
  - NP interacts primarily with the SM bosons, or
  - NP couples to the conserved currents
**Universal EFT**

\[ \Box H = J_H \]

Field redefinitions by equation of motion

- ‘Boson-only’ basis
  \[ |\Box H|^2 \]

- ‘Conventional’ basis
  \[ |J_H|^2 \]
  \[ J_H = \mu^2 H - 2\lambda |H|^2 H - \bar{q}i\sigma_2 Y_u^\dagger u - \bar{d}Y_d q - \bar{e}Y_{e\ell} \]

- ‘Boson-only’ basis (Universal basis) more clearly matches with the UV properties of a Universal theory
- ‘Conventional’ basis easier for calculations
- Universal basis is not closed under RG evolution [Wells, Zhang] 1512.03056
- By definition, universal theories satisfy minimal flavor violation (MFV)
Physical effects of Higgs-only operators

\[ \mathcal{O}_\Box = \frac{c_\Box}{M^2} |\Box H|^2 \]

\[ \mathcal{O}_H = \frac{c_H}{2M^2} (\partial^\mu |H|^2)^2 \]

\[ \mathcal{O}_6 = \frac{c_6}{M^2} |H|^6 \]

\[ \mathcal{O}_R = \frac{c_R}{M^2} |H|^2 |D^\mu H|^2 \]

(*) custodial symmetry

In conclusion, the ‘Higgs-only’ basis is described by 4 independent Wilson coefficients \((c_\Box, c_H, c_R, c_6)\) and leads to 3 physical observables in Higgs couplings: universal modifications of \(h \to VV\) and \(h \to f\bar{f}\), and the Higgs trilinear vertex. Therefore, even in this restrictive class of EFT, it is not possible to unambiguously determine \(\hat{H}\) by combining on-shell Higgs coupling measurements and a measurement of the trilinear coupling.

- Off-shell measurements **required** to close the Higgs-only set
Higgs couplings without the Higgs (HwH)
goldstones = longitudinals

\[ |H|^2 \sim (v + h)^2 + \vec{\phi}^2 \]

ops that modify HC will induce processes with longitudinal vectors

HC: \[ |H|^2 \mathcal{O}_{SM} \supset vh\mathcal{O}_{SM} \]

HwH: \[ |H|^2 \mathcal{O}_{SM} \supset \vec{\phi}^2 \mathcal{O}_{SM} \]

Henning, Lombardo, Riembau, Riva (2018/19)
Example: $|H|^6$

\[ |H|^6 \supset v^3 h^3 \quad \text{trilinear} \]

\[ |H|^6 \supset \nu h \phi^4 + \phi^6 \]

$V_L V_L \rightarrow V_L V_L V_L V_L$

Diagram in unitary gauge
# Processes considered

<table>
<thead>
<tr>
<th>$\kappa_t$</th>
<th>$O_{yt}$</th>
<th>$O_{W}$</th>
<th>$O_{WW}$</th>
<th>$O_{BB}$</th>
<th>$O_{g}$</th>
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<td>$\sim \frac{E^2}{\Lambda^2}$</td>
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<tr>
<td>$\kappa_\lambda$</td>
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<td>$O_{\lambda}$</td>
<td>$O_{\lambda\lambda}$</td>
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<td>$O_{\lambda\lambda\lambda\lambda\lambda}$</td>
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<tr>
<td>$\kappa_{Z\gamma}$</td>
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<td>$O_{WW}$</td>
<td>$O_{BB}$</td>
<td>$O_{g}$</td>
<td>$O_{gg}$</td>
<td>$O_{gg}$</td>
<td>$\sim \frac{E^2}{\Lambda^2}$</td>
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<tr>
<td>$\kappa_{\gamma\gamma}$</td>
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<td>$O_{g}$</td>
<td>$O_{gg}$</td>
<td>$O_{gg}$</td>
<td>$O_{gg}$</td>
<td>$\sim \frac{E^2}{\Lambda^2}$</td>
</tr>
</tbody>
</table>
Results of combination for HL -LHC

Azatov, Grojean, Paul, Salvioni (2016/18)

double Higgs from 1502.00539; H+j from 1405.4295, inclusive and tth from ATL-PHYS-PUB-2013-014
The degeneracy becomes even worse if we add the following operator to the lagrangian

\[
\mathcal{L}_6 = cy \frac{y_t |H|^2}{v^2} \bar{Q}_L \tilde{H} t_R + \text{h.c.} + \frac{cg g_s^2}{48 \pi^2 v^2} |H|^2 G_{\mu\nu} G^{\mu\nu} + \frac{cg g' g_s^2}{18 \pi^2 v^2} |H|^2 B_{\mu\nu} B^{\mu\nu}
\]

Modification of the Higgs interactions to gluons and to photons are controlled by

\[ cy - cg \]
(3) anomalous HVV couplings (EFT)

- tested anomalous HVV couplings *(production and decay)*

\[
\frac{d\sigma_{gg\rightarrow H\rightarrow ZZ}}{d m_{ZZ}^2} \approx \frac{g_{ggH}^2 g_{HZZ}^2}{(m_{ZZ}^2 - m_H^2)^2 + m_H^2 \Gamma_H^2}
\]

(1) not much effect on $\Gamma_H$

(2) constrain couplings given $\Gamma_H$

or profile $\Gamma_H$

\[\text{Observed} \quad \text{Expected} \]

\[\text{CMS} \quad 5.1 \text{ fb}^{-1} \text{ (7 TeV)} + 19.7 \text{ fb}^{-1} \text{ (8 TeV)} + 80.2 \text{ fb}^{-1} \text{ (13 TeV)}\]

\[-2 \Delta \ln L\]

\[\Gamma_H \text{ (MeV)}\]

\[f_{a_3} \cos(\phi_{a_3}) \text{ unconstrained}\]

\[f_{a_2} \cos(\phi_{a_2}) \text{ unconstrained}\]

\[f_{\Lambda_1} \cos(\phi_{\Lambda_1}) \text{ unconstrained}\]

- Observed
  - Expected

\[\text{95\% CL} \quad \text{68\% CL}\]

\[\Delta \ln L\]

\[f_{a_3} \cos(\phi_{a_3})\]

\[\Gamma_H \text{ (MeV)}\]

\[\text{CMS} \quad 5.1 \text{ fb}^{-1} \text{ (7 TeV)} + 19.7 \text{ fb}^{-1} \text{ (8 TeV)} + 80.2 \text{ fb}^{-1} \text{ (13 TeV)}\]

\[-2 \Delta \ln L\]

\[\text{95\% CL} \quad \text{68\% CL}\]

- Best Fit
  - SM
Count the number of EFT parameters in the Higgs basis

- Higgs HVV basis is ideal for off-shell studies
  - does not mix physical states $Z, \gamma, W$ to non-physical $B, W^0, W$
  - off-shell effect is interplay of $Z^*$ (or $W^*$) vs $H^*$
  - it is always possible to rotate the basis in the end

- Reduce to 4 HVV and 2 Hgg EFT couplings

  on CMS also set $g_i^{WW} = g_i^{ZZ}$ ($\iff c_w = 1$ in EFT relationship)

\[
\begin{align*}
g_1^{WW} &= g_1^{ZZ} \\
g_2^{WW} &= c_w g_2^{ZZ} + s_w^2 g_2^{\gamma\gamma} + 2 s_w c_w g_2^W + 2 s_w c_w g_2^Z \\
g_4^{WW} &= c_w g_4^{ZZ} + s_w^2 g_4^{\gamma\gamma} + 2 s_w c_w g_4^W + 2 s_w c_w g_4^Z \\
\frac{\kappa_1^{WW}}{(\Lambda_1^{WW})^2} (c_w^2 - s_w^2) &= \kappa_1^{ZZ} (\Lambda_1^{ZZ})^2 + \frac{2 s_w c_w g_2^W}{M_Z^2} + 2 s_w (c_w^2 - s_w^2) \frac{g_2^Z}{M_Z^2} \\
\frac{\kappa_2^{\gamma\gamma}}{(\Lambda_1^{\gamma\gamma})^2} (c_w^2 - s_w^2) &= 2 s_w c_w \left( \frac{\kappa_1^{ZZ}}{(\Lambda_1^{ZZ})^2} + \frac{g_2^{\gamma\gamma} - g_2^{ZZ}}{M_Z^2} \right) + 2 (c_w^2 - s_w^2) \frac{g_2^Z}{M_Z^2}.
\end{align*}
\]
Some questions to discuss in this forum

- How to explore (hep-ex $\rightarrow$ hep-ph) off-shell region?
  - present as $\Gamma_H$
  - present as off-shell signal strength $\mu$, or $\sigma$
  - present as some STXS-like signal strengths
  - present as modification of (EFT) H couplings
  - present as modification of (EFT) EW parameters
  - present as search for new resonance(s)
  - present as search for some other (exotic) model
  - present as differential distribution
  - present as in other ways ...

- May become very complex, but we also should be practical:
  - in hep-ex, we like to have a path to explore the data
  - at present, we are not limited in having paths
  - each option has pros and cons…
My conclusions

- Precision: impressive progress to 2-loop with $\sim$/full $m_t$ dependence, calculations/tools for $pp \rightarrow ZZ$ @ NNLO+ becoming available, $WW$ next
- Beyond specific models/benchmarks:
  Two frameworks/paradigms to study high-mass New Physics: $\kappa$ or EFT
- Tools available, SMEFT@NLO MC implement. compl./being validated
  need to coordinate tools development with experiments for max. effect
- Theory ↔ Experiment: most suitable EFT bases? Accord(s)?
- Finding limits for some EFT operators/$\kappa$’s using some processes/signatures with certain $c_i$ assumptions is an excellent start, but not the end
- TH, Pheno and Exp need to work together: Theoretical aspects and how to test them experimentally needs to be discussed comprehensively and jointly to fully exploit the LHC (facilitated by working groups)
- Within experiments: official support at high level is desirable
- Producing more/better limits is not the ultimate goal
- (Higgs) NP characterisation is our task – or to rule it out
- EFT validity: need to exclude light new degrees of freedom
- Theoretical work on realisations of SM deviations continues to be important