Table of Contents

LHC Higgs Cross Section Off-shell and Interference Sub-working Group

Group Organisation and Activities

Objectives

The group's task is to review and discuss the status and future potential of off-shell and signal-background interference enabled experimental analyses for Higgs production at the LHC (and future colliders) and related theoretical calculations/tools and phenomenological studies. The aim of this activity is to stimulate and facilitate experimental and theoretical efforts.

Group conveners

Mail	ATLAS	CMS	THEORY
Mail	Lailin Xu	Ulascan Sarica	Nikolas Kauer, Raoul Röntsch

Off-shell Interpretations Task Force NEW

See this page.

Documents

YR4 Chapter *Off-shell Higgs Production and Higgs Interference* CERN-2017-002-M

Meetings

Forthcoming meetings:

Open meetings:

- HXSWG Offshell Interpretations Task Force 2nd Joint Meeting (16 April 2020) Indico link
- HXSWG Offshell Interpretations Task Force Kick-Off Meeting (10 March 2020) Indico link
- HXSWG Offshell & Interference Meeting (25 November 2019) Indico link
- 16th general meeting (16 October 2019) Indico link
- HXSWG Offshell & Interference Meeting (27 May 2019) Indico link
- 15th general meeting (10 December 2018) Indico link
- Off-shell/interference-enabled BSM/EFT studies (24 May 2018) Indico link
- Development of MC tools for off-shell gg (H) ZZ,WW 4 leptons at NLO [signal-background interference and gg background] (22 May 2018) Indico link
- 14th general meeting (26 March 2018) Indico link
- gg ZZ NLO K factor discussion (22 February 2018) Indico link
- 13th general meeting (14 July 2017) Indico link
- LHC EWK Multiboson + LHC HXS WG2 Joint Meeting (10 July 2017) Indico link
- 12th general meeting (12 October 2016) Indico link
- Preparatory meeting about the future of the LHCHXSWG (7 July 2016) Indico link
- 11th general meeting (14 January 2016) Indico link
- 10th general meeting (16 July 2015) Indico link
- Heavy Higgs: off-shell low-mass and close-to-resonance Higgs line-shape vs. physical process cross section discussion (15 July 2015) Indico link
- Joint off-shell and heavy Higgs discussion: H --> VV signal-background interference and heavy Higgs line-shape (23 June 2015) Indico link
- Higgs width constraints from H --> gamma gamma mass peak shift (22 June 2015) Indico link

- Higgs off-shell coupling measurements and related constraints on the Higgs width (16 June 2015) Indico link
- WG3: Heavy Higgs width and interference discussion (4 May 2015) Indico link minutes
- 9th general meeting (22 January 2015) Indico link
- Open off-shell/interference meeting (24 October 2014) Indico link
- WG1 kick-off meeting (28 August 2014) Indico link

Closed meetings of the subgroup conveners:

29 June 2020, 22 June 2020, 15 June 2020, 08 June 2020, 01 June 2020, 25 May 2020, 18 May 2020, 11 May 2020, 4 May 2020, 27 April 2020, 20 April 2020, 14 April 2020, 06 April 2020, 30 March 2020, 23 March 2020, 16 March 2020, 10 March 2020, 9 March 2020, 6 March 2020, 2 March 2020, 24 February 2020, 19 February 2020, 12 February 2020, 5 February 2020, 29 January 2020, 22 January 2020, 15 January 2020, 3 January 2020, 6 January 2020, 18 December 2019, 11 December 2019, 26 November 2019, 18 October 2019, 17 September 2019, 16 April 2018, 21 March 2018, 09 May 2017

Closed meetings with WG2 conveners:

4 May 2020

Closed meetings with WG1 conveners:

18 September 2019, 16 July 2019, 3 April 2019, 15 February 2019, 8 October 2018, December 2017, 16 May 2017, 23 November 2015, 19 October 2015, 11 May 2015, 12 December 2014

Future Directions and Discussion Points

SM precision tools and residual uncertainty estimates:
(in order of priority)
• qg effects at NLO: numerical impact and impact on scale uncertainty, especially in view of the overlap with pp VV at N^{3}LO
• Off-shell finite top mass corrections at NLO (interference, gg background): exact or in large mass expansion with extrapolation above top-pair threshold (uncertainty?)
• Off-shell MC tools: high-mass NLO gg VV matched/merged with PS ↪ public event generators for experimental studies (Herwig7, MG5_aMC, POWHEG, Sherpa, ...)
• NLO EW corrections to gg VV ↗ compare e.g. NLO EW corrections to qq 4l arXiv:1611.05338
• Off-shell parton shower effects: compare NLO+PS with (merged) LO+PS predictions
• qq effects at NLO at high invariant mass
• Off-shell predictions for qq VV at NNLO QCD and NLO EW (dominant background)
• Improved precision in H interference studies
• Gluon-fusion contamination of VBF high-mass off-shell Higgs signal

Off-shell high-mass BSM and EFT constraints, interference studies and tools:
(in order of priority)
• Model dependence of the Higgs width extraction
• Use of anomalous couplings/EFT in Higgs width extraction
• Measurement of offshell couplings and feedback into width extractions

Selected Resources

Handbook of LHC Higgs Cross Sections (CERN Yellow Reports)

1. Inclusive Observables CERN-2011-002, arXiv:1101.0593

2. Differential Distributions CERN-2012-002, arXiv:1201.3084
3. Higgs Properties CERN-2013-004, arXiv:1307.1347
4. Deciphering the Nature of the Higgs Sector CERN-2017-002-M, arXiv:1610.07922

Public tools

- gg2VV
- GoSam
- Herwig7
- JHUGen
- MCFM
- MG5_aMC
- OpenLoops
- PHANTOM
- Sherpa
- VBFNLO

Please contact the conveners if you would like to have your tool added to the list.

Status of NLO parton-level calculations for gg (H) ZZ,WW 4 leptons (in particular signal-background interference and gg background)

- treatment of real corrections (subtraction) is known, but implementation for loop-induced processes is needed (see MC tools)
- technical bottleneck: two-loop virtual corrections: full result known for massless quarks ↗ arXiv:1503.08759, arXiv:1503.08835
- NLO cross section with massless quarks only yields K-factor of 1.5−2 ↗ arXiv:1509.06734 (ZZ), arXiv:1511.08617 (WW)
- at high mass: top loops are important, study s/m_t^2 expansion (6^{th} order), for $s > (2m_t)^2$ explore extrapolation methods (validate at LO, or NLO for Higgs)
    - gg $Z^* Z^*$ 2l2l' and gg $W^* W^*$ ll' ' for s $(2m_t)^2$ (WW: m_t=0) ↗ arXiv:1605.04610
    - gg ZZ (on-shell Z's) hence $M_{ZZ} > 2M_Z$, signal-background interference extrapolated to s $(2m_t)^2$ using the conformal mapping and Padé approximants ↗ arXiv:1605.01380 and arXiv:1908.04061 and arXiv:2002.05558

Development of MC tools for off-shell gg (H) ZZ,WW 4 leptons at NLO

Automated loop-induced at LO:

- GoSam with Herwig7/Matchbox ↗ e.g. arXiv:1602.05141
- GoSam with MadEvent ↗ e.g. arXiv:1512.07232
- MG5_aMC (OLP MadLoop) ↗ e.g. arXiv:1507.00020
- Sherpa+OpenLoops ↗ e.g. arXiv:1309.0500, YR4 Sec. I.8.3.d

Implementation of loop-induced at NLO in MC tools:

- gg ZZ at NLO QCD matched to PS in POWHEG (gg only, no H, no quark masses) ↗ arXiv:1609.09719
- Sherpa: in progress, in particular: process-independent implementation of NLO subtraction and PS matching schemes for loop-induced processes ↗ arXiv:1711.03319 (gg HH)
- MG5_aMC: in progress
- Herwig7+GoSam: in progress

Benchmark results

gg (H) ZZ 2l2l' NLO K-factor for signal, gg background and signal-background interference differential in M_{ZZ} including QCD scale variation

- ROOT file with description available here: HighMassggZZNLOkFactors13TeV

YR4 benchmark results

- H ZZ,WW YRHXS4_WG1_OffshellInterference_VV_benchmark_results_22Mar2016.tar.bz2

Other related papers and talks

- ATLAS Run2 Offshell paper (llvv+llll, 36/fb) : arXiv:1808.01191
- ATLAS m4l unfolded paper (llll with off-shell interpretation, 36/fb) : arXiv:1902.05892
- CMS Run2 Offshell (4l with anomalous HVV couplings considered, 80/fb) : arXiv:1901.00174
- D. Goncalves, T. Han, S. Mukhopadhyay arXiv:1710.02149 arXiv:1803.09751
- J. Campbell, M. Carena, R. Harnika, Z. Liu arXiv:1704.08259
- A. Azatov, C. Grojean, A. Paul, E. Salvioni arXiv:1608.00977
- S. Kawabata, H. Yokoya arXiv:1607.00990
- Aleksandr Azatov: SM/BSM interference pattern (14 September 2016) Indico link
- CMS: Limits on the Higgs boson lifetime and width from its decay to four charged leptons arXiv:1507.06656 CMS-HIG-14-036

This topic: LHCPhysics > LHCHXSWGOFFSHELL
Topic revision: r132 - 2020-06-29 - NikolasKauer