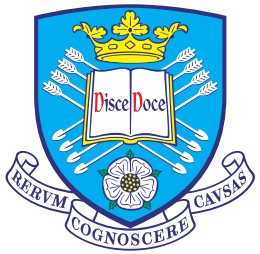
Effects of EFT operators

Kristin Lohwasser

University of Sheffield

European Research Council

Established by the European Commission



The University Of Sheffield.

Survey of operators in realistic scenarios

> Fiducial selections can influence which operators contribute and how much

- Scan which regions are usually used (as most senstive) by experiments
- Few things to keep in mind:
  - > NP < SM
  - > interference < square (exept for special cases)
  - > Can determine effect of arbitrary-sized operator on cross section
  - > Can compare relative effect of one operator between channe BUT **not** relative size betweer operators

Vectorboson Fusion		
Final state	Object	Selection requirements
Z VBF / Zjj	**leptons**	$p_{T,lead}$ >25 GeV, $\|\eta\| < 2.5$
	jets	$p_{T,j1}$ >55 GeV, $p_{T,j1}$ >40 GeV, $\|\eta\| < 4.5$
	bosons	$\Delta(m_Z, m_{\ell\ell})$ <10 GeV
	further jets	p_T >25 GeV, none in interval between leptons
	event	$p_T^{balance}$ <0.15 (see Eq. **??**)
	final BSM region	m_{jj}: 0.8-1.2 TeV, >1.2 TeV
Vectorboson Scattering		
Final state	Object	Selection requirements
WW VBS / $WWjj$	**leptons**	p_T >20 GeV, $\|\eta\| < 2.5$, same-sign
	jets	$p_{T,j1}$ >30 GeV, $p_{T,j1}$ >30 GeV, $\|\eta\| < 4.5$, $\Delta\eta_{jj}$ >2.5
same-sign	**final BSM region**	m_{jj}: 0.25-0.5 TeV, >0.5 TeV
$Z\gamma$ VBS / $Z\gamma jj$	**leptons**	p_T >35, $\|\eta\| < 2.5$
	photons	E_T >75, $\|\eta\| < 2.5$, $\Delta R(\ell/j, \gamma) > 0.4$
	bosons	$\Delta(m_Z, m_{\ell\ell})$ <10 GeV
	jets	$p_{T,j1}$ >30 GeV, $p_{T,j1}$ >30 GeV, $\|\eta\| < 4.5$, $\Delta\eta_{jj}$ >3.0
	final BSM region	m_{jj}>0.5 TeV
WZ VBS /	**leptons**	$p_{T,lead}$ >25 GeV, p_T >15 GeV, $\|\eta\| < 2.5$
	neutrinos	$(\sum \vec{p}_\nu) > 30$ GeV
	jets	$p_{T,j1}$ >55 GeV, $p_{T,j1}$ >40 GeV, $\|\eta\| < 4.5$
	bosons	$\Delta(m_Z, m_{\ell\ell})$ <25 GeV
	further jets	p_T >25 GeV, none in interval between leptons
	event	$p_T^{balance}$ <0.15 (see Eq. **??**)
	final BSM region	m_{WZ}: 0.8-1.0 TeV, >1.0 TeV

First look

> **Using SM-EFT UFO model**

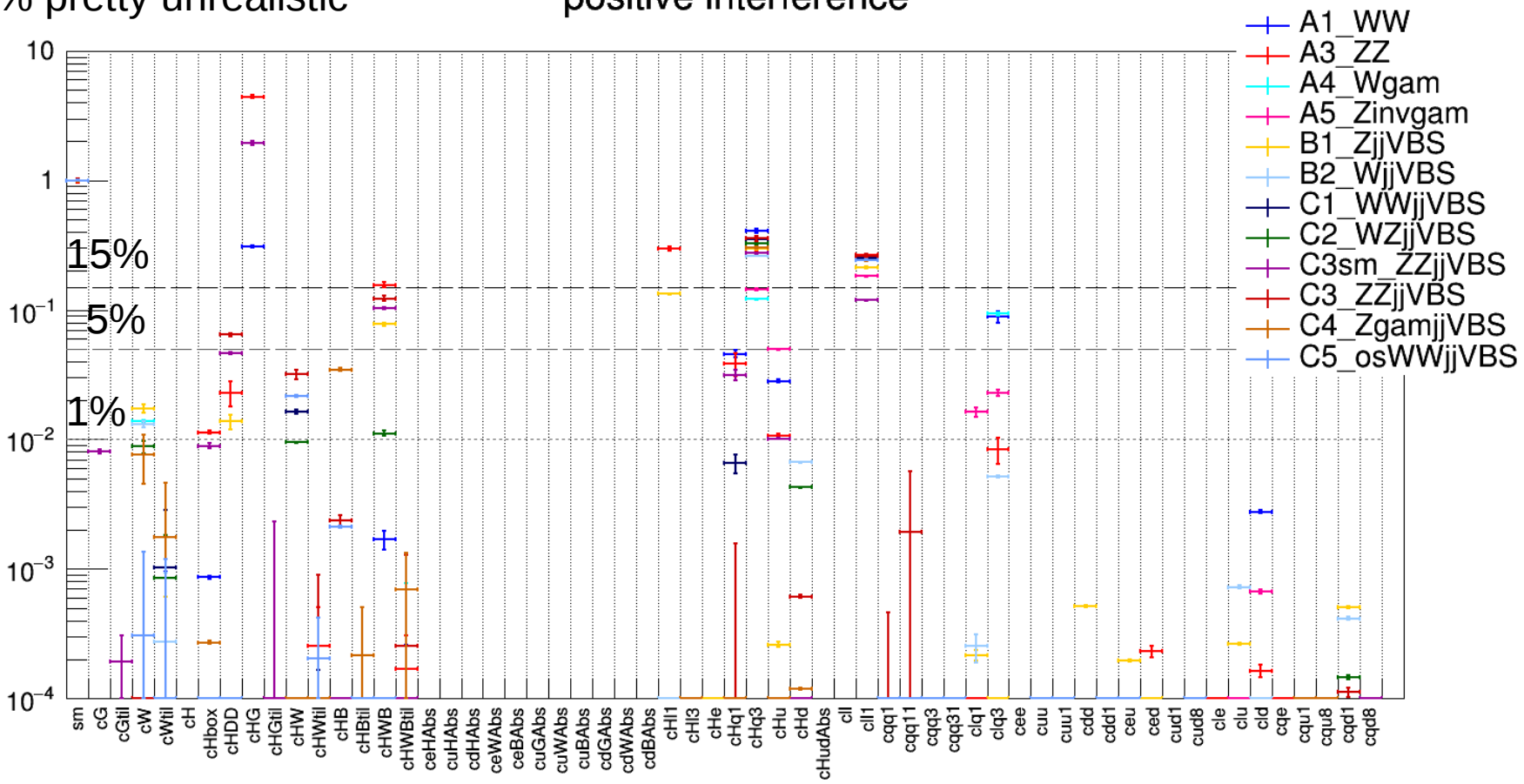
> **Fast survey → cuts on partons and jets as implemented in MG5**

- "A1_WW",
- "A3_ZZ",
- "A4_Wgam",
- "A5_Zinvgam",
- "B1_ZjjVBS",
- "B2_WjjVBS",
- "C1_WWjjVBS",
- "C2_WZjjVBS",
- "C3sm_ZZjjVBS",
- "C3_ZZjjVBS",
- "C4_ZgamjjVBS",
- "C5_osWWjjVBS"

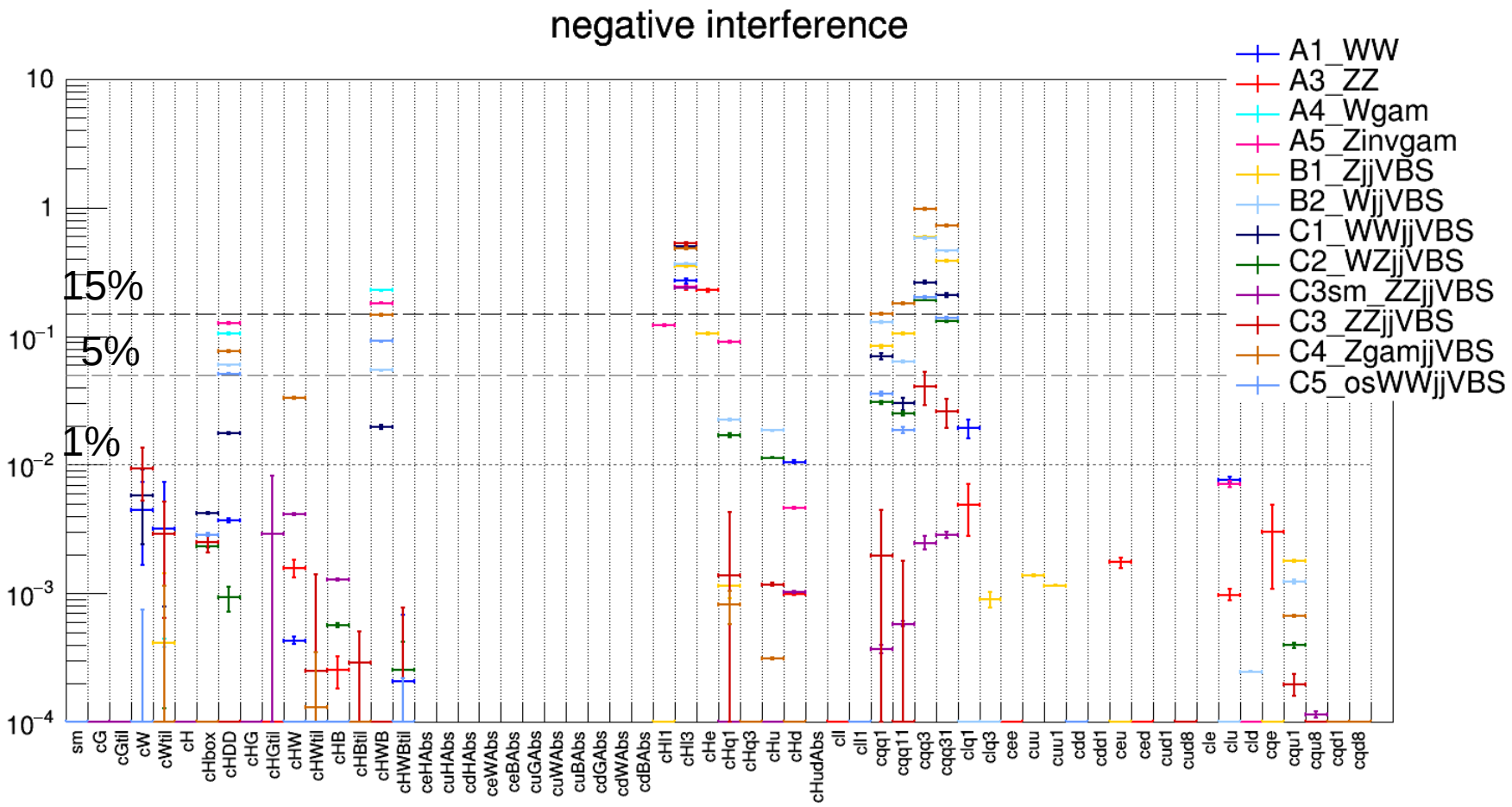
Interference (first order)

15% effect easily detectable
5% maybe detectable
1% pretty unrealistic

positive interference

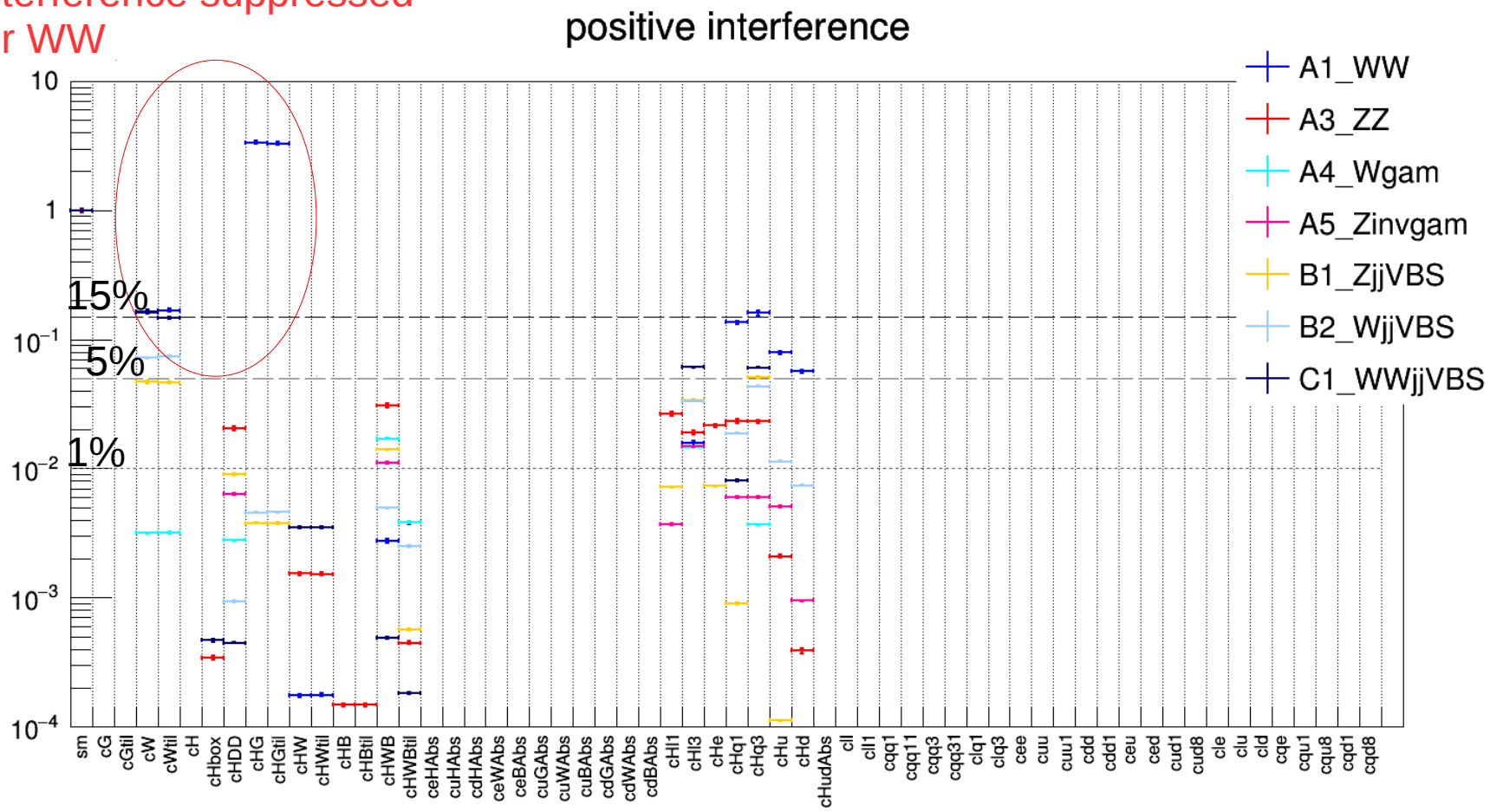


Negative interference



Squared terms (second order)

Interference suppressed for WW



Reminder: What are the c_i's ?

- Here we set Λ=1
- But can arbitrarily change size of operators OR Λ
- This means:
  That operater A has 10% effect on SM whilst operator B has 1% *does not have any meaning*
- But is there any range, which could be thought of as reasonable?

fundamental assumptions:
- new physics nearly decoupled: $\Lambda \gg (v, E)$
- at the accessible scale: **SM** fields + symmetries

☛ a Taylor expansion in canonical dimensions (v/Λ or E/Λ):

$$\mathcal{L}_{\text{SMEFT}} = \mathcal{L}_{\text{SM}} + \frac{1}{\Lambda}\mathcal{L}_5 + \frac{1}{\Lambda^2}\mathcal{L}_6 + \frac{1}{\Lambda^3}\mathcal{L}_7 + \frac{1}{\Lambda^4}\mathcal{L}_8 + \dots$$

$\mathcal{L}_n = \sum_i C_i \mathcal{O}_i^{d=n}$

C_i free parameters (Wilson coefficients)

$\mathcal{O}_i$ invariant operators that form a complete, non redundant basis

- e.g. cee: largest operator effect is ~10e-7
- Could mean: operator 10e-3 and scale Λ=10e4 (need to scale both to get sizeable SM effect) → but if we want strong coupling c must be larger (→ this is a question !!)
  - Planck scale: 10e16 TeV (limit for Λ)
- Perhaps let limit (arbitrarily) to 10e-5 for combined operator/scale effect
  - Except for if we have other constraints → review of those

Results: Largest operators (when VBS)

> Needs some more odering….

One dominant process

cdd ==========
B1_ZjjVBS: 0.000511678435633
C3_ZZjjVBS: 2.48578576302e-05
C5_osWWjjVBS: 1.70106221548e-06

cG ==========
C3sm_ZZjjVBS: 0.00806201550388

cuu ==========
B1_ZjjVBS: -0.00138511678436
C3_ZZjjVBS: -8.88560382079e-05
C3sm_ZZjjVBS: -6.12943933658e-06

cHB ==========
C4_ZgamjjVBS: 0.0346231591106
C3_ZZjjVBS: 0.00237207186718

cuu1 ==========
B1_ZjjVBS: -0.00115426398696
C3_ZZjjVBS: -6.99795314987e-05

cqu8 ==========
C3sm_ZZjjVBS: -0.000114782765459
B1_ZjjVBS: -1.4350896252e-20

cdd1 ==========
B1_ZjjVBS: -3.50190114068e-05
C3_ZZjjVBS: -4.16192858767e-07

Interesting for interference studies

cqq31 ==========
C4_ZgamjjVBS: -0.721917412648
B2_WjjVBS: -0.463238679969

cHl3 ==========
C3_ZZjjVBS: -0.525358198772
C1_WWjjVBS: -0.500397877984

cqu1 ==========
B1_ZjjVBS: -0.00178001086366
B2_WjjVBS: -0.00123944742901

cll1 ==========
A3_ZZ: 0.264916264547
C3_ZZjjVBS: 0.262679099386
A1_WW: 0.256441535257

cqq11 ==========
C4_ZgamjjVBS: -0.179959572625
B1_ZjjVBS: -0.105323193916

cW ==========
B1_ZjjVBS: 0.017267789245
A4_Wgam: 0.013705341953

cqd1 ==========
B1_ZjjVBS: 0.000507224334601
B2_WjjVBS: 0.000415272448196

cqq3 ==========
C4_ZgamjjVBS: -0.971123303494
B1_ZjjVBS: -0.588810429115

cqq1 ==========
C4_ZgamjjVBS: -0.149927808259
B2_WjjVBS: -0.128549501151

Very small → odd operators, could profit from study on variables

cHBtil ==========
C3_ZZjjVBS: -0.000286786445304
C4_ZgamjjVBS: 0.000216055443257

CHWBtil ==========
C4_ZgamjjVBS: 0.000699104822408
C2_WZjjVBS: -0.000256196581197

cHWtil ==========
A3_ZZ: 0.000253505535055
C3_ZZjjVBS: -0.000251307709802

cWtil ==========
A1_WW: -0.0031806010116
C3_ZZjjVBS: -0.00289515578804

cHW ==========
C4_ZgamjjVBS: -0.0331215708923
C3_ZZjjVBS: 0.0318626336138
C3_ZZjjVBS: 0.0318626336138

cHG ==========
A3_ZZ: 4.42520579052
C3sm_ZZjjVBS: 1.95060393005

Check other terms

- **Only few settings where squared terms would play a role**
  - Interference suppressed but squared still << SM
  - Low lambda
  - Check which are those cases

- **Other operators could be better constrained by EWPO**
  - Basically would like to go through results pages and mark those in color which are “good” / interesting

- **Other dim8 that could play role?**
  - What is the model to do a survey?