

Weekly Report

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Higgs-V CP OO calculation using MG5

An optimal observable (OO) is a Matrix Element (ME) based observable

SM: CP-even contribution, BSM: CP-odd contribution

$$\mathcal{M}_{\text{Mix}}(\mathbf{c}) = \mathcal{M}_{\text{SM}} + \mathcal{M}_{\text{BSM}}(\mathbf{c}) \implies |\mathcal{M}_{\text{Mix}}(\mathbf{c})|^2 = |\mathcal{M}_{\text{SM}}|^2 + 2\Re(\mathcal{M}_{\text{SM}}\mathcal{M}_{\text{BSM}}^*(\mathbf{c})) + |\mathcal{M}_{\text{BSM}}(\mathbf{c})|^2$$

$\mathbf{c}$ is the CP-odd coupling which parametrises a BSM hypothesis under which the matrix elements are computed.

$$OO_1(\mathbf{c}) = \frac{2\Re(\mathcal{M}_{\text{SM}}\mathcal{M}_{\text{BSM}}^*(\mathbf{c}))}{|\mathcal{M}_{\text{SM}}|^2} = \frac{|\mathcal{M}_{\text{Mix}}(\mathbf{c})|^2 - |\mathcal{M}_{\text{SM}}|^2 - |\mathcal{M}_{\text{BSM}}(\mathbf{c})|^2}{|\mathcal{M}_{\text{SM}}|^2}$$

$$OO_2(\mathbf{c}) = \frac{|\mathcal{M}_{\text{BSM}}(\mathbf{c})|^2}{|\mathcal{M}_{\text{SM}}|^2}$$

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Debugging...

Weird bug I haven't figure out the reason:

When calculate ME_SM first:

```
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_SM.");
ME_SM = getCombinedWeightedME(m_subprocesses_SM);
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_BSM.");
ME_BSM = getCombinedWeightedME(m_subprocesses_BSM);
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_Mix.");
ME_Mix = getCombinedWeightedME(m_subprocesses_Mix);
```

```
-----ME_SM----- 0.000000e+00#
-----ME_BSM----- 0.000000e+00#
-----ME_Mix----- 0.000000e+00#
```

When calculate ME_SM last:

```
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_BSM.");
ME_BSM = getCombinedWeightedME(m_subprocesses_BSM);
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_Mix.");
ME_Mix = getCombinedWeightedME(m_subprocesses_Mix);
ATH_MSG_DEBUG("getResult (TLV) - Computing ME_SM.");
ME_SM = getCombinedWeightedME(m_subprocesses_SM);
```

```
-----ME_SM----- 0.000000e+00#
-----ME_BSM----- 5.117720e-12#
-----ME_Mix----- 1.066533e-09#
```



Same when calculate ME_SM in the middle

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Check MG5 event generation

```
import model HC_UFO
```

```
p p > x0 j j $$ a z w+ w- QCD=0, x0 > a a
```

SM parameter card:

```
Working on SubProcesses
INFO:      P1_gg_x0gg_x0_aa
INFO:      P1_qq_x0qq_x0_aa
INFO: Idle: 0, Running: 3, Completed: 4 [ current time: 00h18 ]
INFO: Idle: 0, Running: 2, Completed: 5 [ 0.83s ]
INFO: Idle: 0, Running: 0, Completed: 7 [ 1s ]
INFO: End survey
refine 10000
Creating Jobs
INFO: Refine results to 10000
INFO: Generating 10000.0 unweighted events.
INFO: Effective Luminosity 1.2e+103 pb^-1
INFO: need to improve 0 channels
Survey return zero cross section.
Typical reasons are the following:
1) A massive s-channel particle has a width set to zero.
2) The pdf are zero for at least one of the initial state particles
   or you are using maxjetflavor=4 for initial state b:s.
3) The cuts are too strong.
Please check/correct your param_card and/or your run_card.
Zero result detected: See https://cp3.irmp.ucl.ac.be/projects/madgraph/wiki/FAQ-General-14
```