Update in VBF Higgs CP test

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Introduction

Theoretical overview:

$$\mathcal{L}_{eff}^{(6)} = g_{H\gamma\gamma}\, HA_{\mu\nu}A^{\mu\nu} + g_{HZ\gamma}^{(1)}\, A_{\mu\nu}Z^{\mu}\partial^{\nu}H + g_{HZ\gamma}^{(2)}\, HA_{\mu\nu}Z^{\mu\nu}$$
$$+ g_{HZZ}^{(1)}\, Z_{\mu\nu}Z^{\mu}\partial^{\nu}H + g_{HZZ}^{(2)}\, HZ_{\mu\nu}Z^{\mu\nu} + g_{HWW}^{(2)}\, HW_{\mu\nu}^{+}W_{-}^{\mu\nu}$$
$$+ g_{HWW}^{(1)}\, (W_{\mu\nu}^{+}W_{-}^{\mu}\partial^{\nu}H + W_{\mu\nu}^{-}W_{+}^{\mu}\partial^{\nu}H) + \boxed{\tilde{g}_{H\gamma\gamma}\, H\tilde{A}_{\mu\nu}A^{\mu\nu}}$$
$$\boxed{+ \tilde{g}_{HZ\gamma}\, H\tilde{A}_{\mu\nu}Z^{\mu\nu} + \tilde{g}_{HZZ}\, H\tilde{Z}_{\mu\nu}Z^{\mu\nu} + \tilde{g}_{HWW}^{(2)}\, H\tilde{W}_{\mu\nu}^{+}W_{-}^{\mu\nu}.}$$

CP-odd operator

Matrix element for VBF production:

$$\mathcal{M} = \mathcal{M}_{\text{SM}} + \tilde{d} \cdot \mathcal{M}_{\text{CP-odd}}.$$
$$|\mathcal{M}|^2 = |\mathcal{M}_{\text{SM}}|^2 + \tilde{d} \cdot 2\Re(\mathcal{M}_{\text{SM}}^{*}\mathcal{M}_{\text{CP-odd}}) + \tilde{d}^2 \cdot |\mathcal{M}_{\text{CP-odd}}|^2.$$

Use $\tilde{d}$ to represent the CP mixing in VBF channel

Introduction

Original observable: $\Delta\Phi_{jj}$

Optimal observable:

- First order: $OO_1 = \frac{2\Re(\mathcal{M}^*_{SM}\mathcal{M}_{CP-odd})}{|\mathcal{M}_{SM}|^2}$ Mean value should be 0

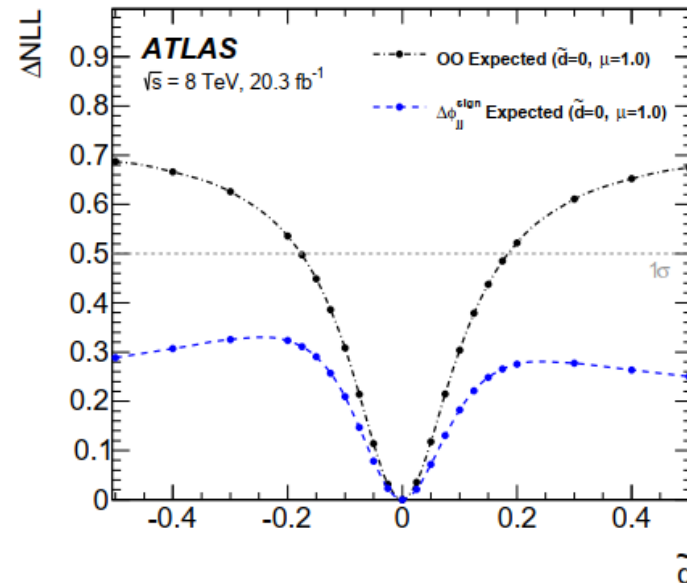- Second order: $OO_2 = \frac{|\mathcal{M}_{CP-odd}|^2}{|\mathcal{M}_{SM}|^2}$ Not used yet

Sensitivity of 2 variables tested by

$H \rightarrow \tau\tau$ analysis

(arxiv: 1602.04516)

Optimal Observable

Calculate package: HLeptonCPRW from Htautau group(Alena Loesle)

- getOptObs():

  Input: 4-vector of 2 jets and Higgs, pdf value(Bjorken x+Q value),

  Return: OO value (1st and 2nd order)
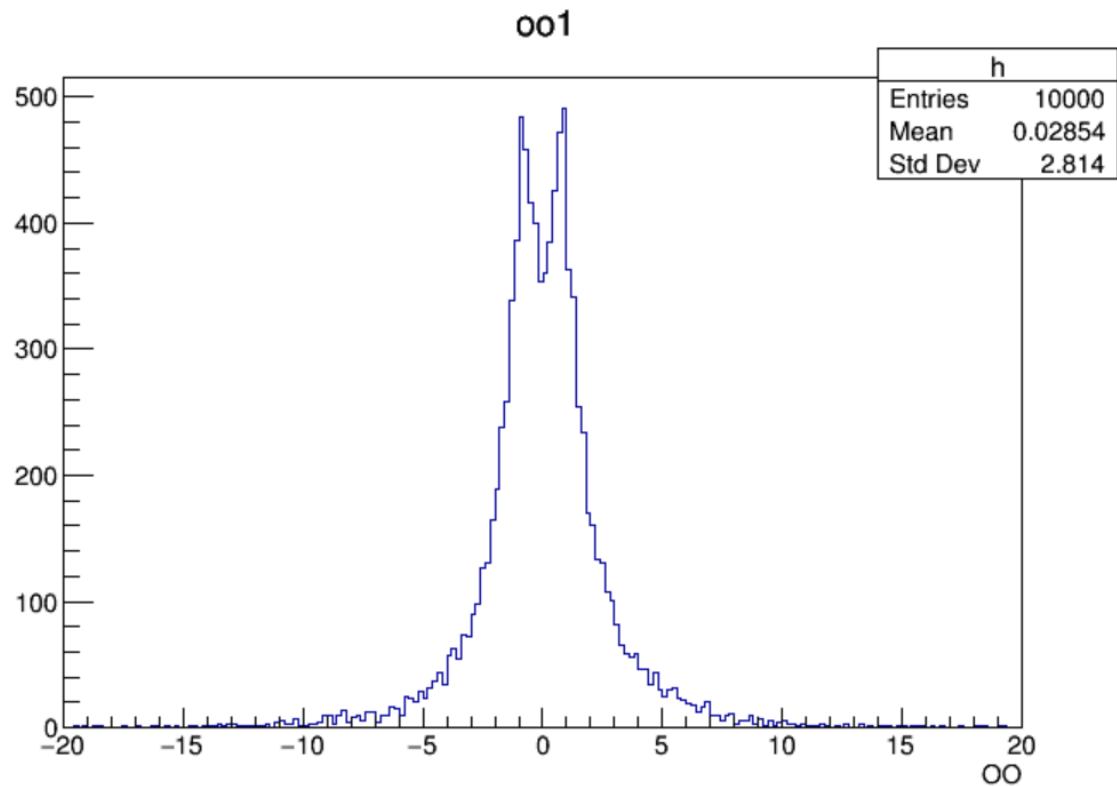
- getWeightsDtilde():

  Input: 4-vector of 2/3 final state jets and higgs, Bjorken x, flavor of initial + final quarks

  Return: 2 weight parameters $\widetilde{w}$.

  final weight $w = 1 + \widetilde{w}_1 \tilde{d} + \widetilde{w}_2 \tilde{d}^2$

Optimal Observable

Test with previous Madgraph sample generated by myself (SM MC)

Optimal Observable

Remaining problem:

◦ It has some bugs when calculating the weight. The returning matrix element is 0. (Maybe because of the incorrect input quark flavor. It's FORTRAN codes, which I'm not very familiar with)

Next step:

◦ Use it into ATLAS official MxAOD. Need to get the initial quark flavor information from DAOD by myself.

◦ Fix the weight problem.

->Check the performance of reweight sample and generated Madgraph sample

->After this we can use SM MC only to get the CP-mix MC by reweighting.