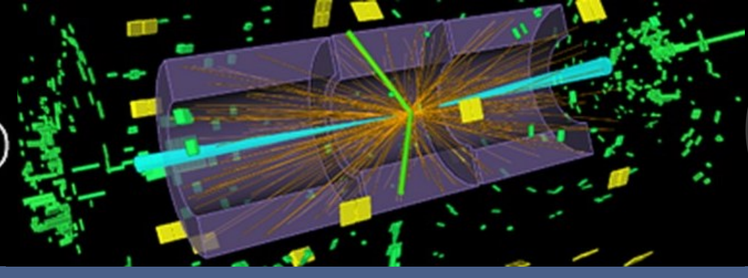

# Anomalous Higgs Couplings


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### Beyond Standard Model (BSM) Parameterization

Precise couplings of the SM Higgs to the heavy electroweak gauge bosons come out as: $\mathcal{L}_{\rm int} = -gM_W \left( W_\mu W^\mu + \frac{1}{2\cos\theta_W} Z_\mu Z^\mu \right) H$

Independent measurement of this vertex is required to confirm the SM mechanism for breaking electro-weak symmetry is the correct one. However, the measurement of such vertices require copious Higgs production to satisfy the statistical requirements and are sensitive to BSM physics.

The vertex $H(k) - W^+_\mu(p) - W^-_\nu(q)$ can be parameterised in the following form [1]: $i\Gamma^{\mu\nu}(p,q)\ \epsilon_\mu(p)\ \epsilon^*_\nu(q)$ $\quad \Gamma_{\mu\nu}(p,q) = \Gamma^{\rm SM}_{\mu\nu} + \Gamma^{\rm BSM}_{\mu\nu}(p,q)$

This can be thought of as having two components, one the SM the other of BSM physics

Deviations from the SM form would indicate the presence of new physics. $\Gamma^{\rm SM}_{\mu\nu} = -gM_V\, g_{\mu\nu}$

BSM may be specified by the following parameterisation: $\Gamma^{\rm BSM}_{\mu\nu}(p,q) = \frac{g}{M_V}\left[\lambda\,(p\cdot q\, g_{\mu\nu} - p_\nu q_\mu) + \lambda'\,\epsilon_{\mu\nu\rho\sigma}p^\rho q^\sigma\right]$

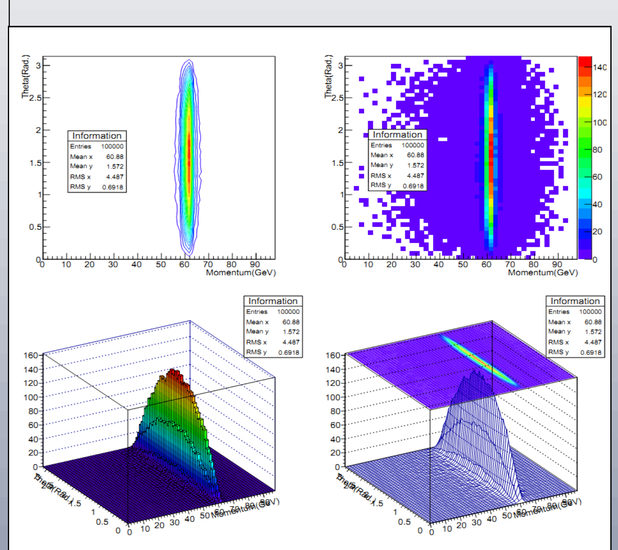
where λ and λ' are the effective strengths for the anomalous CP-conserving and CP-violating operators respectively.

Should the coupling constants be determined, CP properties of the Higgs may also be specified.

### Higgs Process Studied

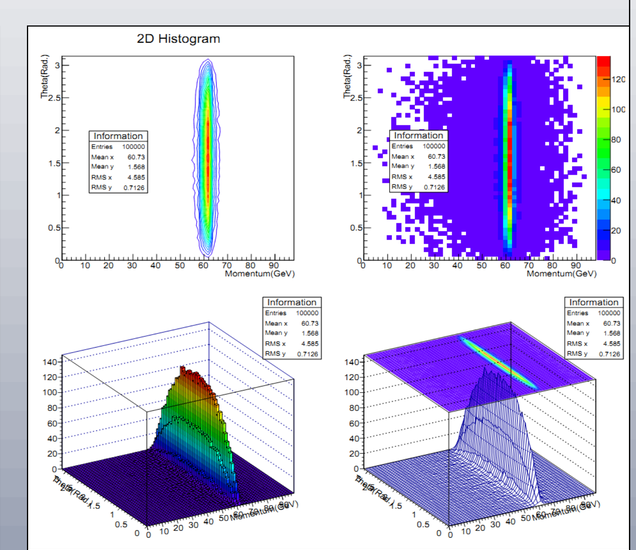
The process being used to study the HWW vertex was considered in light of proposed electron-beam accelerators such as the LHeC and ILC. In particular the LHeC will be capable of generating an electron beam of 150 GeV of luminosity $5\times10^{32}\text{cm}^{-2}\text{s}^{-1}$. [2] A good starting point for investigating the LHeC research possibilities is with an electron and positron collision where there are few channels in the formation of a Higgs and neutrino pair. The two channels to this end result are the S and T-Channel. The S-Channel is in which the production of the neutrinos come about from the decay of the Z-boson, in contrast the T-Channel, the one we wish to study, the outcome of the Higgs and neutrino pair is through vector boson fusion.

$$e^+ + e^- \longrightarrow \nu_e + \tilde{\nu}_e + h$$



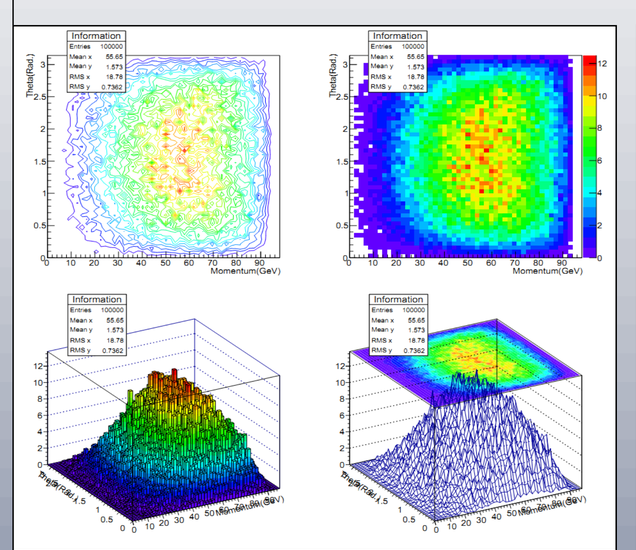

**Histogram of Higgs momentum vs. theta distribution for the SM.**

### S-Channel

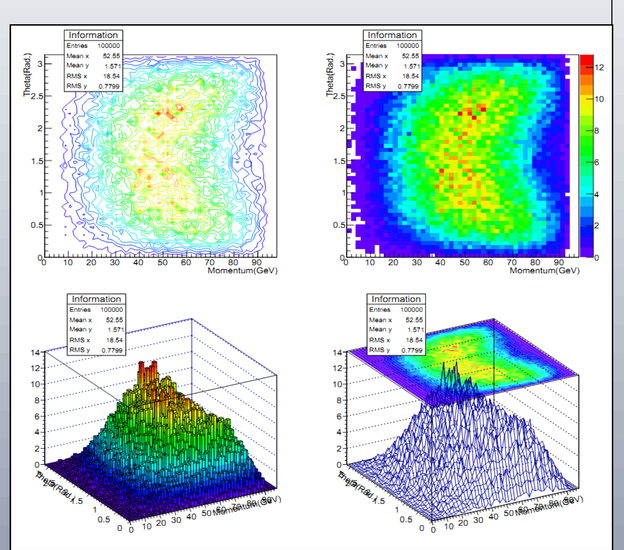



Feynman diagram showing Higgs and Z-boson formation, with Z-boson decay to a neutrino pair.

### T-Channel




Feynman diagram showing vector boson fusion to form Higgs and neutrino pair.




**Histogram of Higgs momentum vs. theta distribution for the SM.**

At 125 GeV it is seen the Higgs momentum is sharply peaked, making for easy separation of the two channels by making use of a two-sigma momentum cut about the peak. The sharpness of the peak is unaffected by the value of λ. The same is true of λ'.

The T-Channel at 125 GeV features a wide distribution over the momentum-theta phase space. There are clear differences in the distribution with a change in the value of λ. Differences in λ' also affect the distribution.




**Histogram of Higgs momentum vs. theta distribution for BSM λ = -1.**




**Histogram of Higgs momentum vs. theta distribution for BSM λ =1.**




**Histogram of Higgs momentum vs. theta distribution for BSM λ =1.**




**Histogram of Higgs momentum vs. theta distribution for BSM λ = -1.**

### On-going Study

Current work focuses on finding useful methods for evaluating the values of the BSM parameters. Using likelihood-based tests confidence intervals may be constructed for the BSM model parameters [3]. Such a test works by taking measure of the statistical significance of the difference between a data set and a representative data set, in this case the SM. The most obvious candidate data-set for such analysis are the 2D-histograms above. A further variable with which to use as a discriminant is the sensitivity to the COM energy. Taking numerous simulations through a range of 250GeV to 300GeV may provide a third dimension to the histograms above making the likelihood tests that much more powerful.

### References


**[1]** S. S. Biswal, R. M. Godbole, B. Mellado and S. Raychaudhuri, Phys. Rev. Lett. 109, 261801 (2012) [arXiv:1203.6285 [hep-ph]]. **[2]** O. Bruening and M. Klein, Mod. Phys. Lett. A 28, no. 16, 1330011 (2013) [arXiv:1305.2090 [physics.acc-ph]]. **[3]** G. Cowan, K. Cranmer, E. Gross and O. Vitells, Eur. Phys. J. C 71, 1554 (2011) [arXiv:1007.1727 [physics.data-an]].