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:
\[ \mathcal{L}_{\text{int}} = -g_M W^\mu \left( W^\nu + \frac{1}{2\cos\theta_W} Z^\nu Z^\mu \right) H \]

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 \( H(k) - W^\nu_+ (p) - W^-_+ (q) \) can be parameterised in the following form [1]:
\[ \Gamma(p, q) = \Gamma^\text{SM} + \Gamma^\text{BSM}(p, q) \]

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.

BSM may be specified by the following parameterisation:
\[ \Gamma^\text{SM} = -g_M \rho \]
\[ \Gamma^\text{BSM}(p, q) = \frac{g_M}{\lambda} \left[ (\lambda \cdot q g_{\mu \nu} - \rho_{\mu \nu}) + (\lambda' \epsilon_{\mu \nu \rho \sigma} p^\rho q^\sigma) \right] \]

where \( \lambda \) and \( \lambda' \) 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 \( 5 \times 10^{32} \text{cm}^{-2}\text{s}^{-1} \). [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.

\[ e^+ + e^- \rightarrow \nu_\mu + \bar{\nu}_\mu + h \]

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 \( \lambda \). The same is true of \( \lambda' \).

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