Probing *hhh* triple Higgs boson coupling at LHeC

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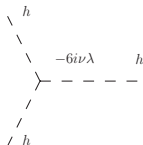Zhejiang University

Higgs boson

$$V(\Phi) = -\mu^2 \Phi^\dagger \Phi + \lambda (\Phi^\dagger \Phi)^2 \rightarrow \text{scalar potential}$$

$$\mathcal{L}_H = D_\mu \Phi D^\mu \Phi - V(\Phi) \rightarrow \text{Higgs Lagrangian}$$

$$\Phi(x) = \tfrac{1}{\sqrt{2}} \begin{pmatrix} 0 \\ \nu + h(x) \end{pmatrix} \quad \downarrow \quad \text{electroweak symmetry breaking}$$

$$\mathcal{L}_h = \frac{1}{2} D_\mu h D^\mu h - \frac{1}{2} m_h^2 h^2 - \nu \lambda h^3 - \frac{\lambda}{4} h^4$$

SM has not prediction of λ value $\rightarrow$ direct measurement $\lambda = \lambda_{SM} = \frac{m_h^2}{2\nu^2} \approx 0.13$

Single Higgs production

Higgs pair production is notorious small at LHeC $\rightarrow$ single Higgs production
$\rightarrow$ Higgs self coupling contribution via the virtual effects of *WWh* at one loop
$\rightarrow$ explore the possibility of measuring *hhh* self coupling!
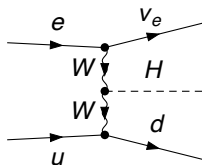
VBF production
Basic cuts:
$|\eta_{\ell,j}| < 5,$
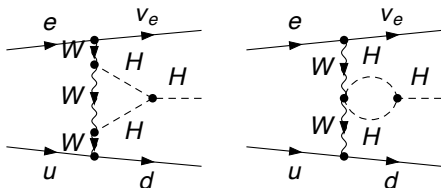$\Delta R_{E_T \ell} > 0.4,$
$E_T > 10$ GeV,
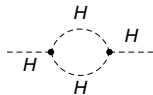$P_{Tj} > 20$ GeV.
$\sigma = 80.16$ fb

hhh couplings
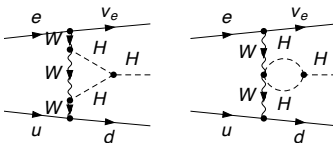contribution
@ one loop!
(unitary
gauge)

Notice: We need consider Higgs wave function renormalisation contribution @ tree level!

Dividing λ contribution into two categories:
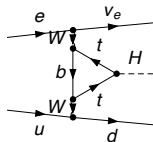
1. universal part:
   $\mathcal{O}(\lambda^2)$

2. process-dependent:
   $\mathcal{O}(\lambda)$

There is a strong top-loop contribution(Higgs-top coupling) @ one-loop!

negative contribution because of fermion loop

Simulation and Preliminary results

Simulation:

- one loop calculation: FeynCalc, FormCalc, LoopTool.
- phase space integral: Vegas(Monte Carlo package)
- beam energy: $E_e = 60$ GeV, $E_e = 7$ TeV

Preliminary results:

- VBF single Higgs production @ tree level: 80.16 fb
- λ contributions @ one loop ($\lambda = \lambda_{SM} \approx 0.13$): 0.366 fb
- top-loop correction @ one loop: -16.78 fb (further check required)

σ_λ: total cross section
of λ contribution
$$\kappa = \frac{\lambda}{\lambda_{SM}}$$