Higgs Studies at the FCC-ee.

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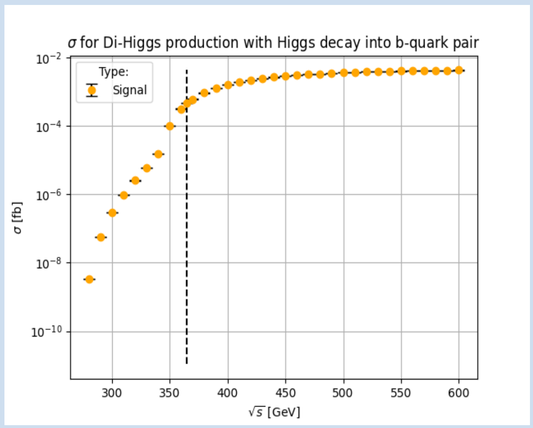
Abstract

The study of the Higgs boson self-coupling at the e^+e^- Future Circular Collider (FCC-ee) is extremely challenging due to the small Di-Higgs production cross section. This is however a crucial property, which may have far-reaching implications in our understanding of particle physics. It will be studied at the HL-LHC but with an expected sensitivity limited by the foreseen data statistics. An alternative experimental path to this search is the study of loop-induced corrections to the Single Higgs production cross section. We investigate the kinematics of the $e^+e^- \longrightarrow e^+e^-H$, with the Higgs decaying into a b-quark pair at two centre of mass energies ($\sqrt{s} = 240$ and 365 GeV) seeking to achieve experimental sensitivity to the Higgs boson self-coupling

Di-Higgs Production



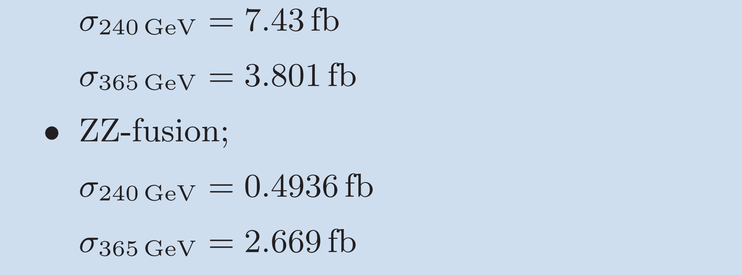
$\sqrt{s}$ [GeV]	$\mathcal{L}$ [ab^{-1}]	σ [fb]	Events
365	1.5	4.53×10^{-4}	0.68

Due to the small cross-section, direct observation of the Higgs self-coupling via Di-Higgs production is impossible at this luminosity.

Data sets

Signal: Single Higgs production

- Higgsstrahlung
  $\sigma_{240\,\mathrm{GeV}} = 7.43\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 3.801\,\mathrm{fb}$
- ZZ-fusion;
  $\sigma_{240\,\mathrm{GeV}} = 0.4936\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 2.669\,\mathrm{fb}$
- Higgsstrahlung and ZZ-fusion, with interference between them;
  $\sigma_{240\,\mathrm{GeV}} = 7.87\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 6.754\,\mathrm{fb}$
- Loop Induced:Higgstrahlung
  $\sigma_{240\,\mathrm{GeV}} = 6.702 \times 10^{-2}\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 3.939 \times 10^{-2}\,\mathrm{fb}$
- Loop Induced:ZZ-fusion
  $\sigma_{240\,\mathrm{GeV}} = 8.09 \times 10^{-5}\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 3.27 \times 10^{-4}\,\mathrm{fb}$
- Loop Induced: Total
  $\sigma_{240\,\mathrm{GeV}} = 6.710 \times 10^{-2}\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 3.964 \times 10^{-2}\,\mathrm{fb}$



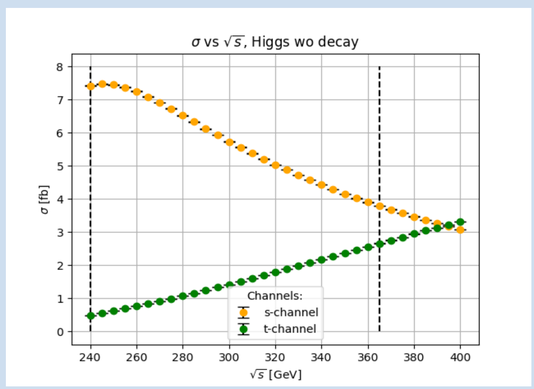
Higgstrahlung;ZZ-fusion;Loop Induced process.

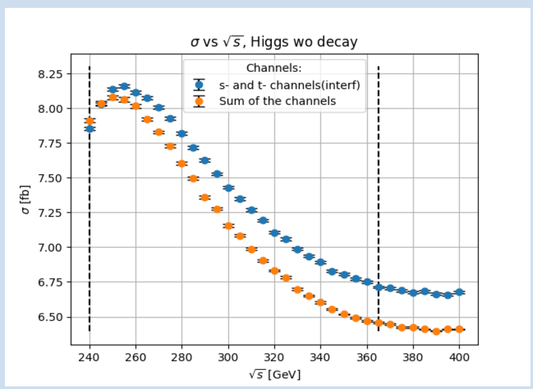
Background:

- $e^+e^- \longrightarrow e^+e^-b\bar{b}$ /h;
  $\sigma_{240\,\mathrm{GeV}} = 26.58\,\mathrm{fb}$
  $\sigma_{365\,\mathrm{GeV}} = 22.83\,\mathrm{fb}$

Single Higgs Production

At $\sqrt{s}$=240 GeV, the main process of Higgs production is Higgsstrahlung. With the increase of the energy, the ZZ-fusion cross-section will grow and at energies of 390 GeV will dominate.





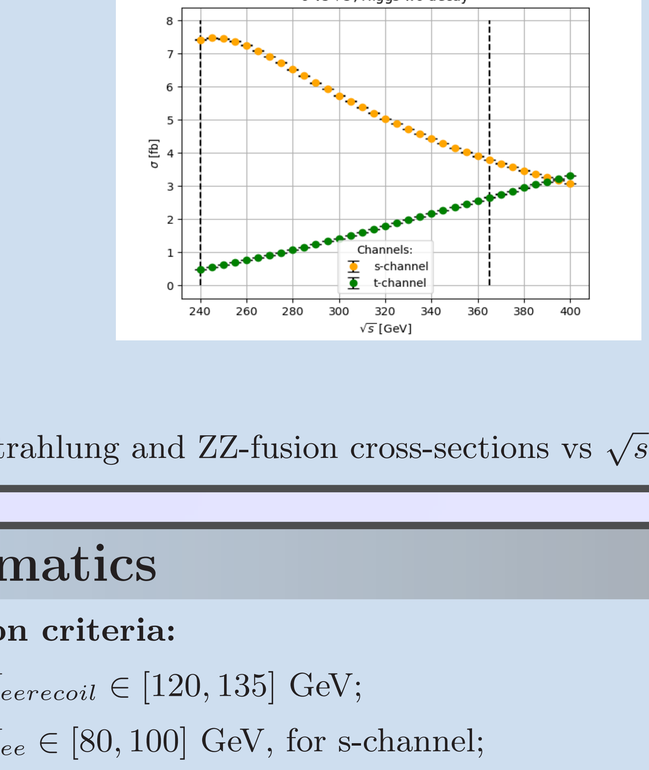
Higgsstrahlung and ZZ-fusion cross-sections vs $\sqrt{s}$ Booth channels with (Total) and without interference be

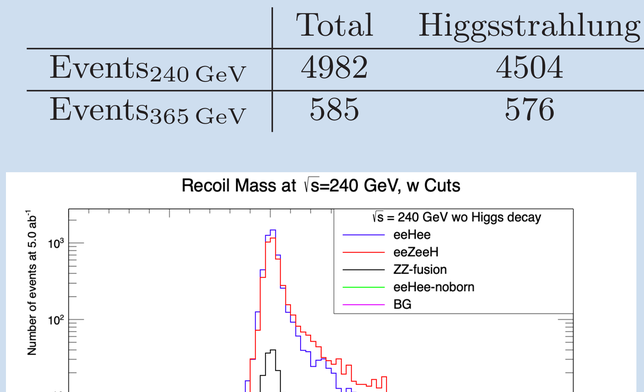
Kinematics

Selection criteria:

- $M_{eerecoil} \in [120, 135]$ GeV;
- $M_{ee} \in [80, 100]$ GeV, for s-channel;

	Total	Higgsstrahlung	ZZ-fusion	Loop Induced	Background
Events$_{240\,\mathrm{GeV}}$	4982	4504	150	39	189
Events$_{365\,\mathrm{GeV}}$	585	576	11	6	47





Conclusion

This preliminary analysis shows that the e+e- Recoil Mass and the e+e- Invariant Mass should be enough to reduce the background level and to further distinguish the Higgstrahlung and ZZ-fusion processes. Afterwards, these and other observables will be used to access the loop-induced contributions and therefore to derive the FCC-ee sensitivity on the the Higgs boson self-coupling