Higgs self-coupling measurement at the ILC.

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ILD Software/Analysis Meeting, Nov. 26th 2014

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Analysis Overview

- Higgs self-coupling analysis with $m_H = 125$ GeV
- double Higgs-strahlung ZHH at $\sqrt{s} = 500$ GeV, assuming $\mathcal{L} = 2$ ab^{-1}
- beam polarisation P(e^+e^-) = (0.3,-0.8)
- analysis strategy identical to LC-REP-2013-003 by Junping Tian
  - select/reject events with isolated leptons
  - cluster particles into 4 or 6 jets
  - combine jets to signal bosons
  - train several neural nets to separate dominant bgrds from signal
- consider low-p_T $\gamma\gamma \rightarrow$hadrons beam induced background
- **status:** Higgs self-coupling without overlay: 53.5%
  with overlay: 58.1%
- **today:** first steps implementing the kinematic fit (no overlay)

Application of Kinematic Fit

- tool to improve jet energy and invariant mass resolution
- precise initial states at the ILC are ideal for the application of kinematic fits
- number of 4-vectors, representing final state particles, is fitted under constraints

implies the variation of the measured quantities
under certain constraints

- variable χ^2 quantifies the deviation between measured and fitted parameters

$$\chi^2 = (\eta - a)^T C^{-1} (\eta - a)$$

a = vector of measured quantity
η = vector of varied quantity
C = covariance matrix

- χ^2 is minimised under the conditions that the imposed constraints are fulfilled
- **potential improvement with kinematic fit:**

find right jet pairing $\rightarrow$ improved jet/boson assignment
improved mass resolution $\rightarrow$ clearer signal/background separation
testing of background hypothesis $\rightarrow$ use fit probability as selection mode

First shot: lepton mode llhh

masses used in recent analysis strategy:

mass distributions as input parameters
for neural net training

$\longrightarrow$ especially: ZHH vs. ZZH/ZZZ

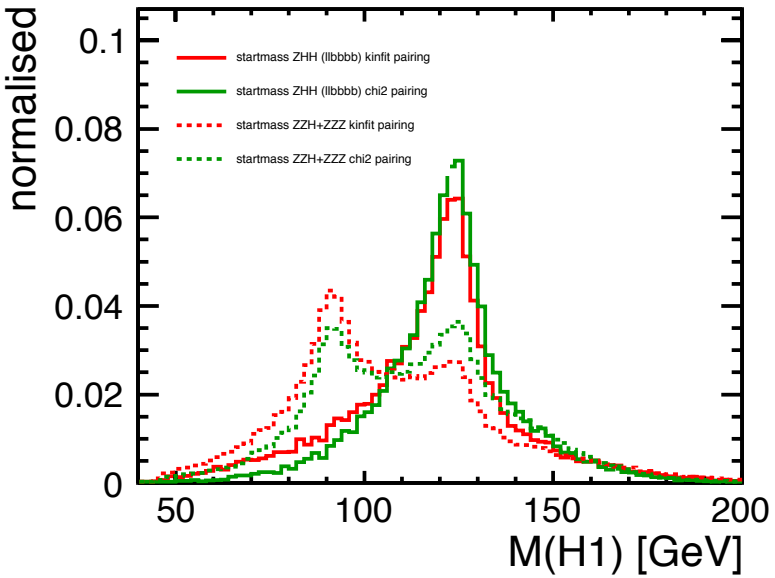
kinematic fit for ZHH: energy conservation
momentum conservation
soft Z mass constraint
equal mass constraint

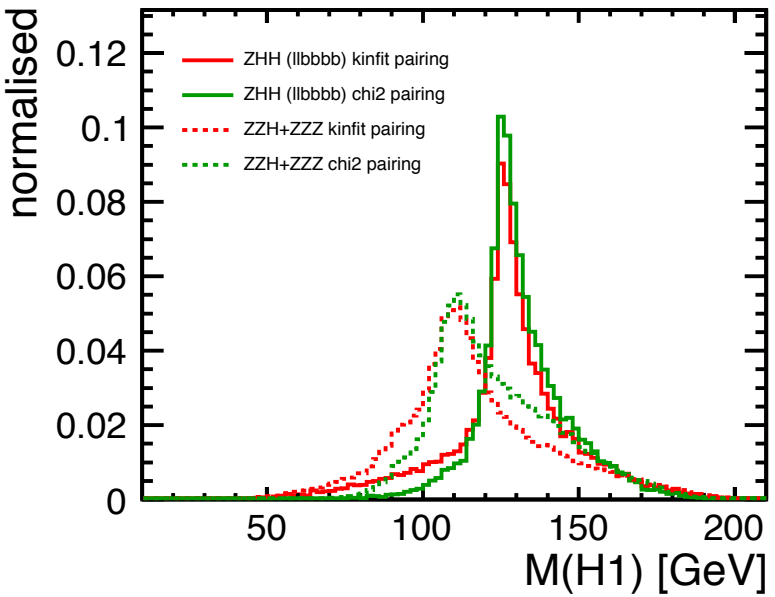
correct jet-pairing: kinematic fit = 66.7%
chi2 = 81.6%

$$\chi^2 = \frac{(M_{ij} - 125\ \mathrm{GeV})^2}{\sigma_H^2} + \frac{(M_{kl} - 125\ \mathrm{GeV})^2}{\sigma_H^2}$$

other possibility:

additional Higgs mass constraint (125 GeV)
correct pairing = 78.9%
$\longrightarrow$ not in analysis yet





Neural Net: ZHH vs. ZZZ/ZZH

input variables:

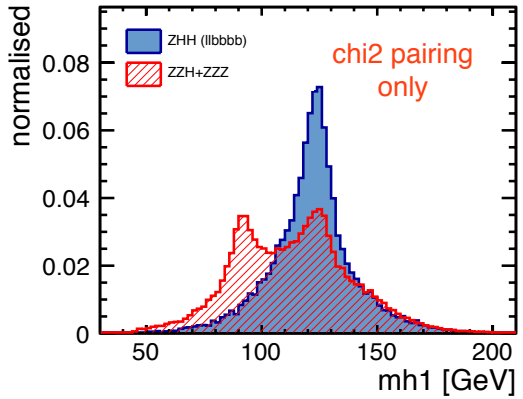
mh1 & mh2
mhzh & mzzh as if from ZZH
mz1zz & mz2zz as if from ZZZ
largest cos1zzh & cos1zzz from ZZH/ZZZ
largest boson momentum p1zzh & p1zzz

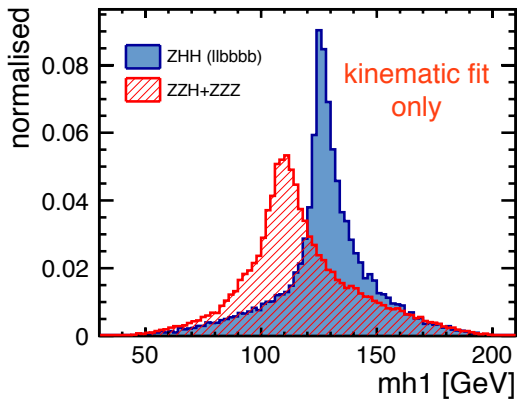
possible with kinematic fit ZHH information:

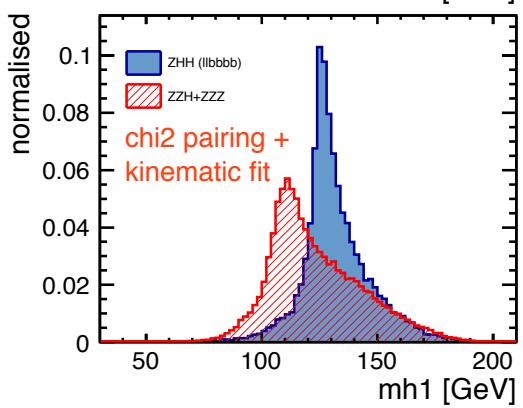
chi2 pairing only
kinematic fit pairing only
chi2 pairing with kinfit 4-momentum
kinematic fit only

test different combinations of input variables:

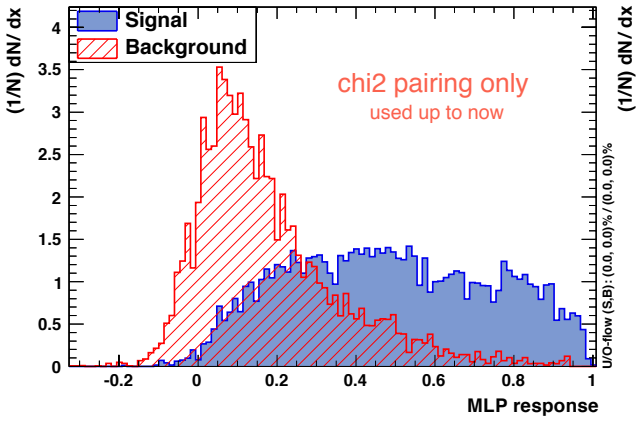
best ranking in separation
correlation of variables

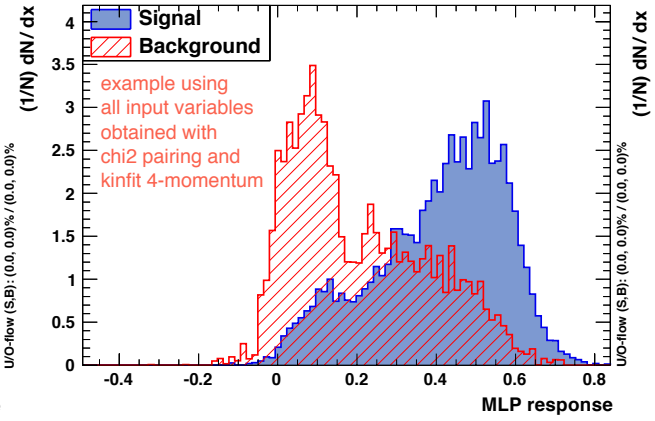


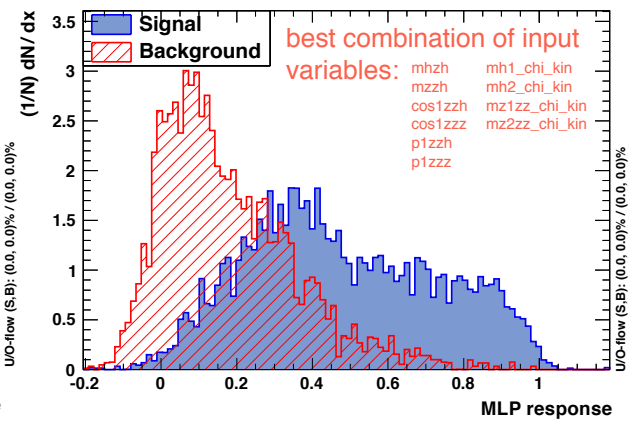




Neural Net: ZHH vs. ZZZ/ZZH







old: variables obtained from chi2 pairing only

S/(S+B)= 24.46

example: all variables obtained with chi2 pairing and kinematic fit 4-mom.

S/(S+B)= 23.91

best output: mz1zz, mz2zz, mh1 & mh2 with chi2+kinfit, but $\cos1^{s}$,$p1^{s}$,mhzh& mzzh from chi2 only

S/(S+B)= 24.58

work in progress:

→ effect on analysis?

→ other constraints in fit?

→ mhzh & mzzh here best when chi2 pairing only

→ extra kinematic fit for ZZH/ZZZ

→ use fit probabilities to test different background hypothesis

→ etc ....

First shot: neutrino mode vvhh

masses used in recent analysis strategy:

cut on mh1, mh2, mhh

mass distributions as input parameters for neural net training

$\longrightarrow$ especially: ZHH vs. ZZH/ZZZ

kinematic fit for ZHH: equal mass constraint

no moment. conservation

no energy conservation

other possible constraints: Z mass constraint

$\rightarrow$ missing energy

Higgs mass constraint

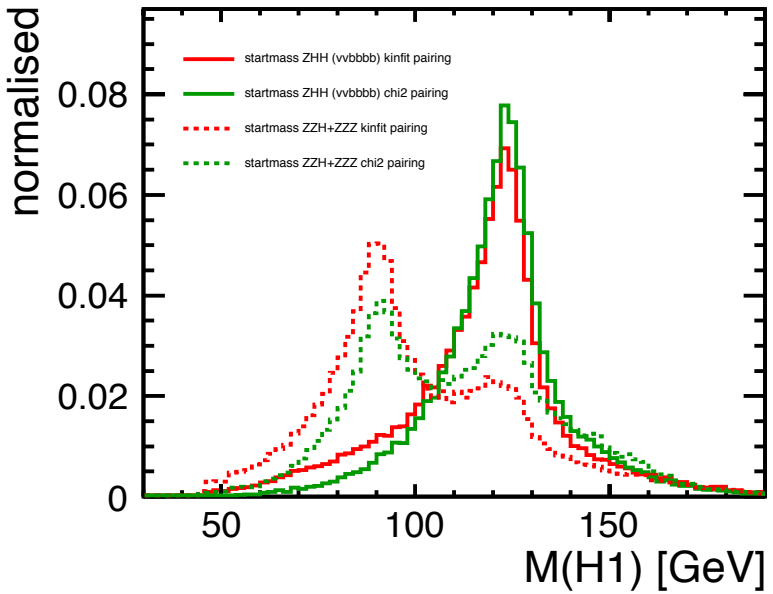
possible with kinematic fit ZHH information:

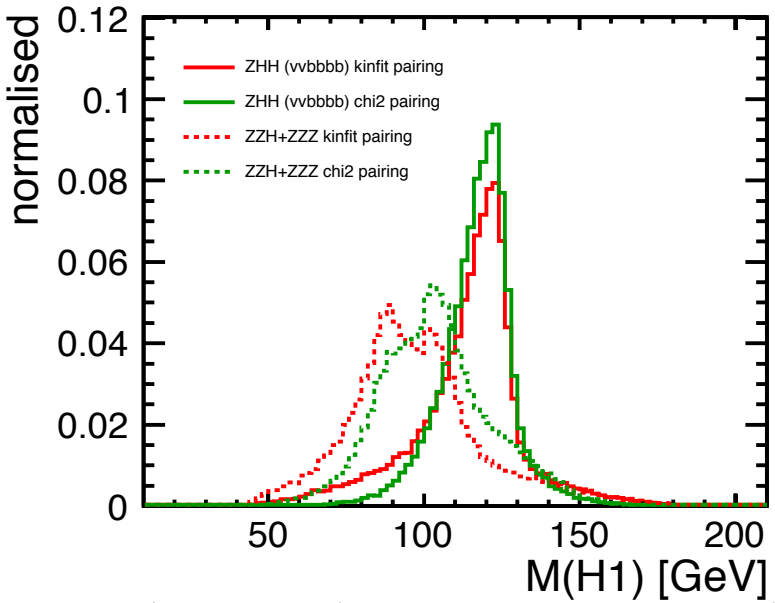
chi2 pairing only

kinematic fit pairing only

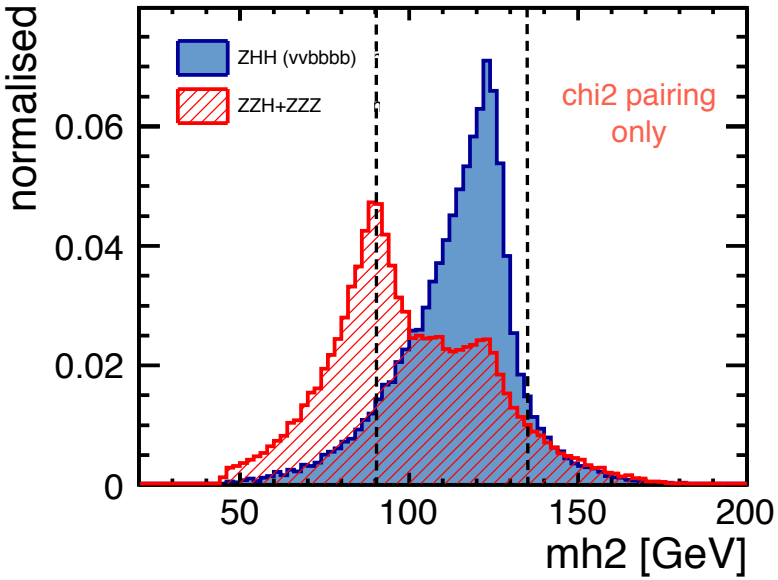
chi2 pairing with kinfit 4-momentum

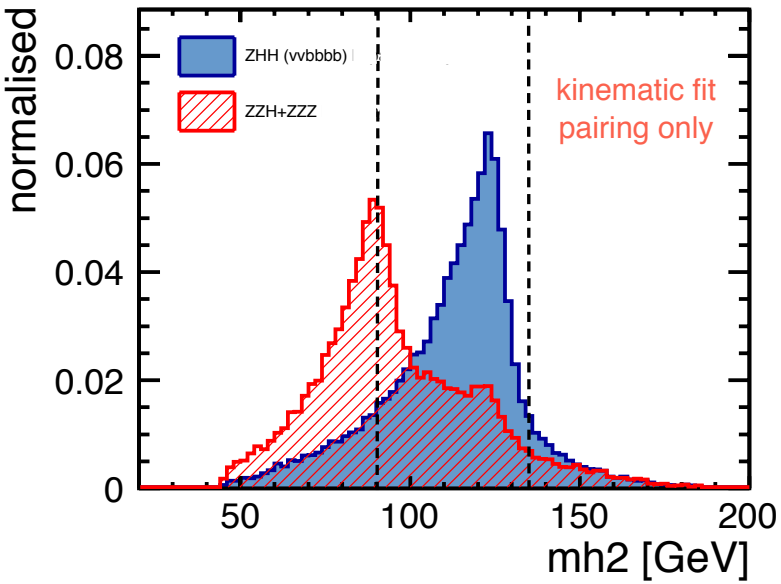
kinematic fit only

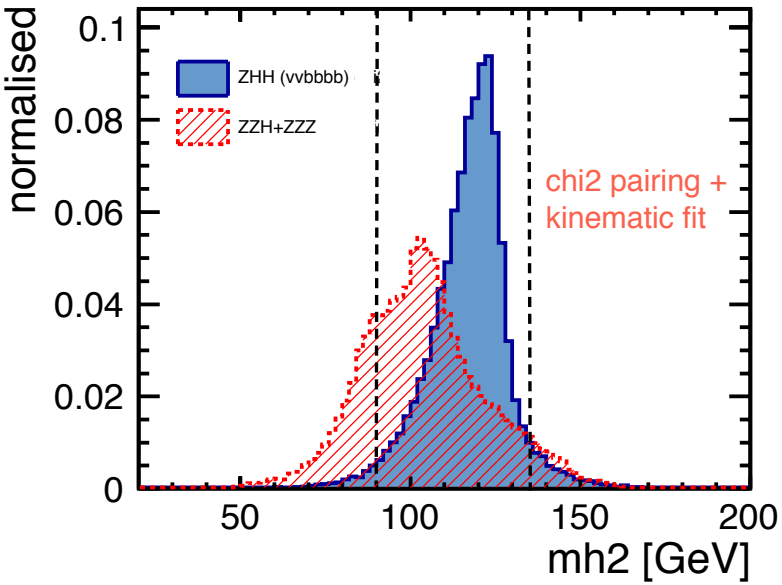


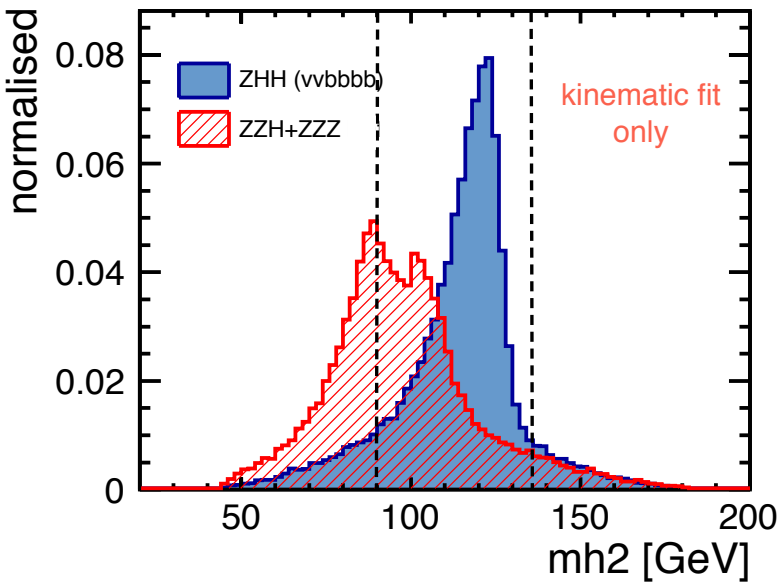


First shot: neutrino mode vvhh









Outlook: Kinematic Fit

- first baby steps in applying the kinematic fit on the analysis
- started with llhh and vvhh $\rightarrow$ qqhh more challenging

- investigate different constraints in kinematic fits
- What will be the effects on recent analysis strategy?
- How well can we use information from kin fit and change the analysis strategy?
- Kinematic fits for backgrounds ZZZ or ZZH $\rightarrow$ how useful?
- test different background hypothesis $\rightarrow$ use fit probabilities as selection mode
- etc. ...

- just started....many things to study :)
- more updates soon