Feasibility Study of Measuring the Higgs Self-coupling Using the Muon Collider

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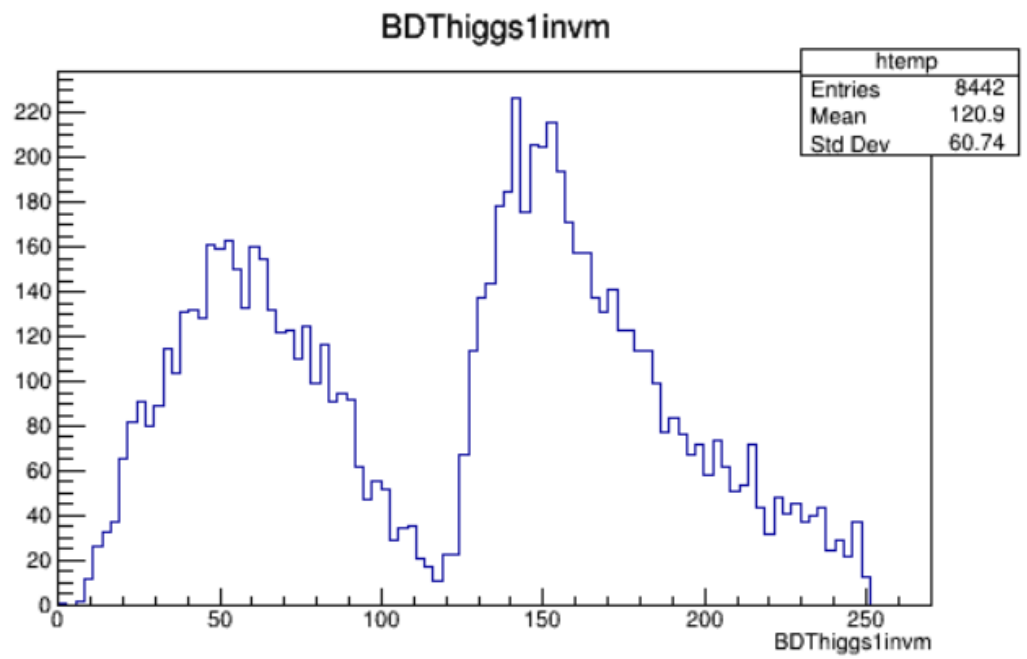
Reconstruction of one had one lep decaying di-τ

- Then for reconstructing the $b\bar{b}$ jets pair, we require:
  - ΣBTag =2 for the $b\bar{b}$ jets pair;
- For highly boosted Higgs to $\tau^+\tau^-$ pairs, we find one anti-k_t jet with cone size $R = 0.5$ and an electron or muon, and requiring the following criteria:
  - charge product Q of the two leading di-τ jets = -1;
  - TauTag = 1 for the tau-tagged jet;
  - Tau-tagged jet is searched in the rest of the jet;
  - Requiring non-btag jet;


BDThiggs1invm
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Entries 8442
Mean 120.9
Std Dev 60.74
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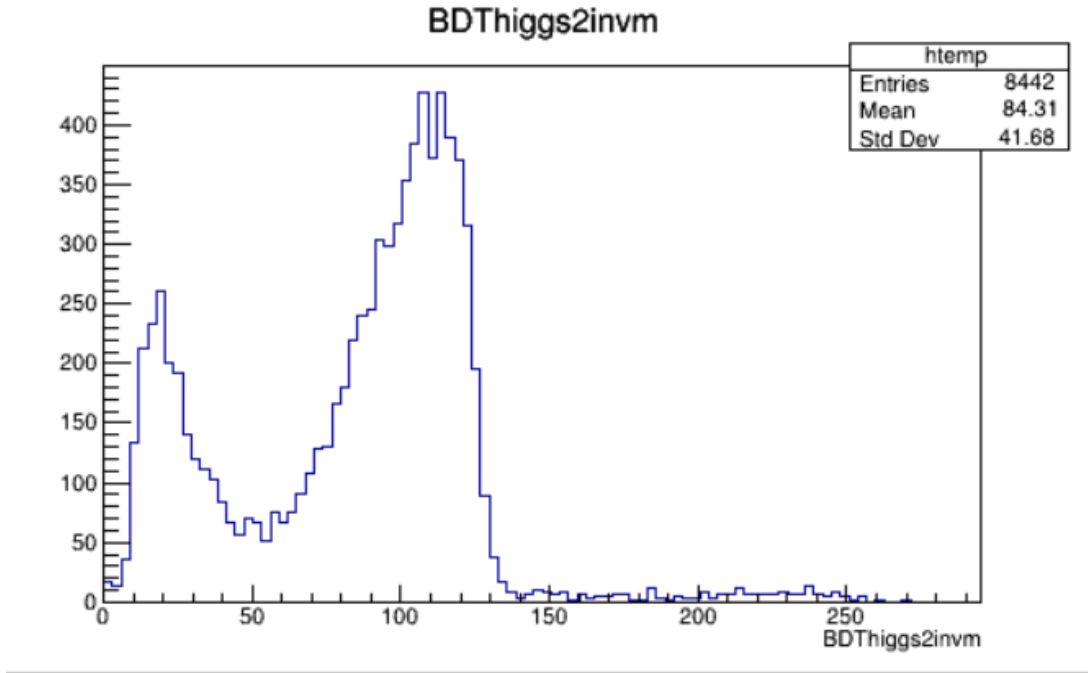
0 50 100 150 200 250
BDThiggs1invm


BDThiggs2invm
htemp
Entries 8442
Mean 84.31
Std Dev 41.68
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0 50 100 150 200 250
BDThiggs2invm

- Add generator level neutrino in one lep on had mode code and see how the distribution of the di-tau pair change.

Where to access my code and result

- Pairing algorithm for both hadronic decay: https://github.com/cvuosalo/MuonCollider/blob/main/Delphes/src/Pairing_tau_had.C
- Pairing algorithm for one had one lep decay: https://github.com/cvuosalo/MuonCollider/blob/main/Delphes/src/Pairing_tau_mix.C
- Script for event generation:
  - https://github.com/cvuosalo/MuonCollider/blob/main/runMGjobs/runMG_job/delphes_card_MuonColliderDet_HHstudy.tcl
  - Other sub-script are in: https://github.com/cvuosalo/MuonCollider/tree/main/runMGjobs/runMG_job/MuonCollider
- Result are accessible at:
  - root –l /afs/hep.wisc.edu/home/hjia38/Delphes/delphes_dhiggs_sig+bkg_pairmass_tau_had_10TeV.root

Reconstruction of hadronically decaying di-τ

- For highly boosted Higgs to $\tau^+\tau^-$ pairs, we reconstruct two anti-k_t jet with cone size $R = 0.2$, and requiring the following criteria:
  - charge product Q of the two leading di-τ jets = -1;
  - ΣTauTag = 2 for the tau-tagged jets pair;
  - In order to avoid selecting b jet fake tau, require Σ Btag = 0;
- Then for reconstructing the $b\bar{b}$ jets pair, we require:
  - ΣBTag =2 for the $b\bar{b}$ jets pair;
  - Require ΣTauTag =0, (Each b-tagged jets has $\Delta R > 0.5$ with each tau-tagged jet);

Should we use collinear mass for hadronic decay?

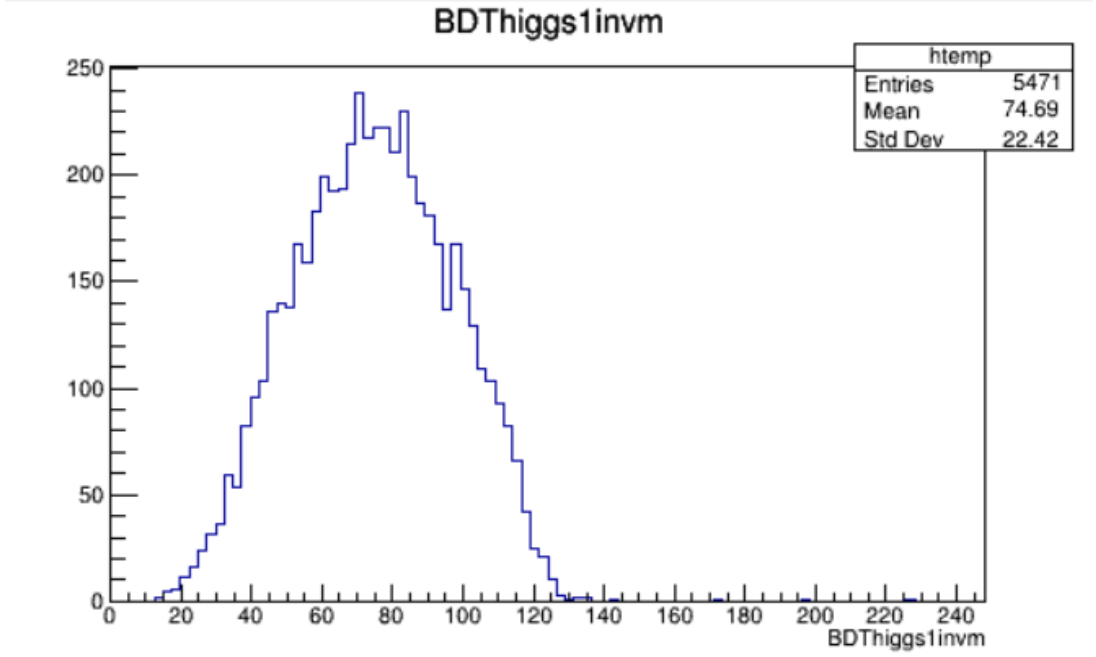
- Nice shift of mean value
- Very poor resolution
- Lost more than 50% events
- For more than half of the events MET are closer to BBbar

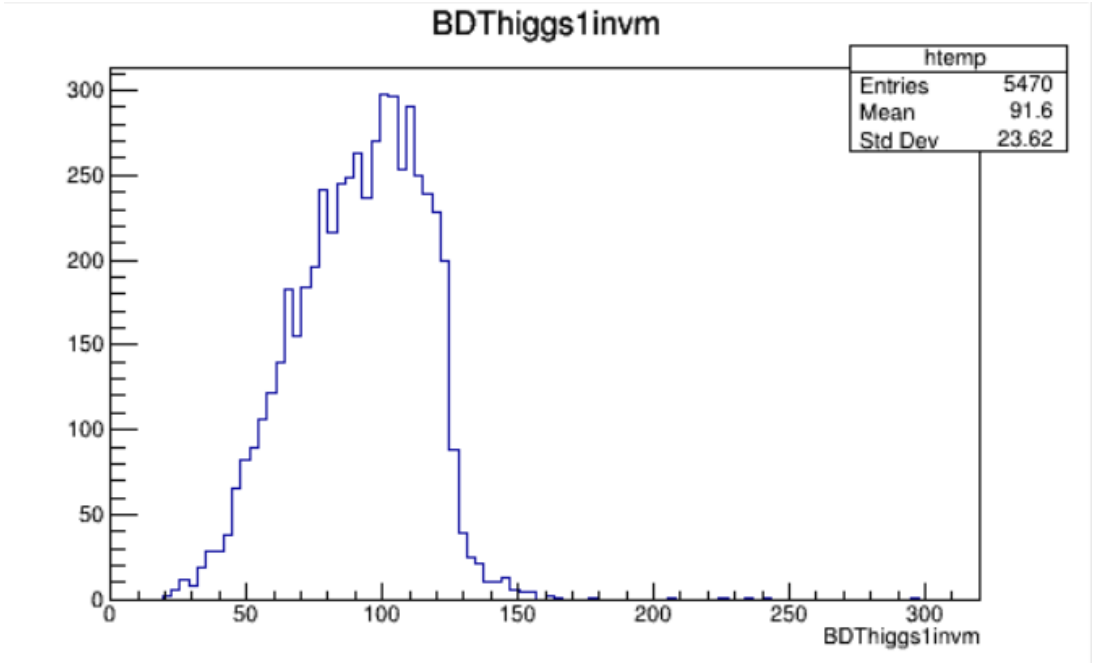
- But we could try for the reconstruction on leptonic decay.

Reconstruction with Gen level neutrino

- Nice shift of mean value
- Almost no change of resolution
- 5471 compare of 5470 event got pass

Result of vvHH





Ideas on reconstruct hadronic di-tau

- We could see that the neutrinos from di-tau system are in the same direction. But collinear method fails because of the neutrinos from the W boson.