

# Study of double Higgs production at a VHE pp collider

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# Motivation

- Double Higgs production is a key signature of the Higgs self-interaction as required by the quartic Higgs potential in the SM
  - Though double-Higgs production has a large contribution from sequential radiation of single Higgses off  $gg \rightarrow t\bar{t}$  loop
- Double Higgs production is not easy at HL-LHC and even ILC-1000

# Motivation

- Even more difficult to observe is double-Higgs production via vector boson fusion

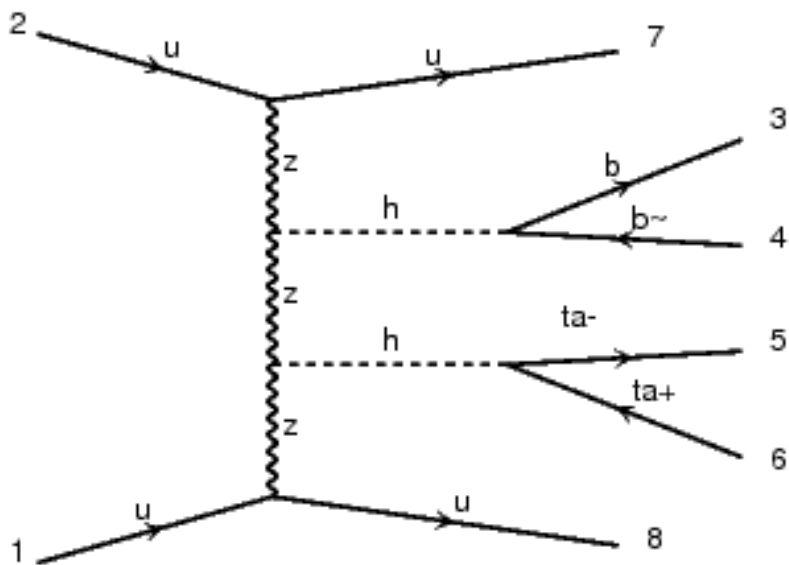


diagram 7

QCD=0, QED=6

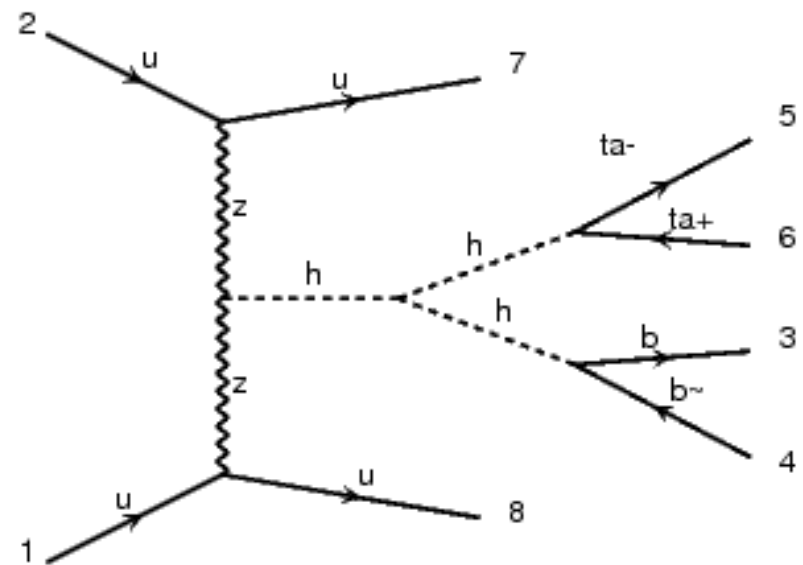


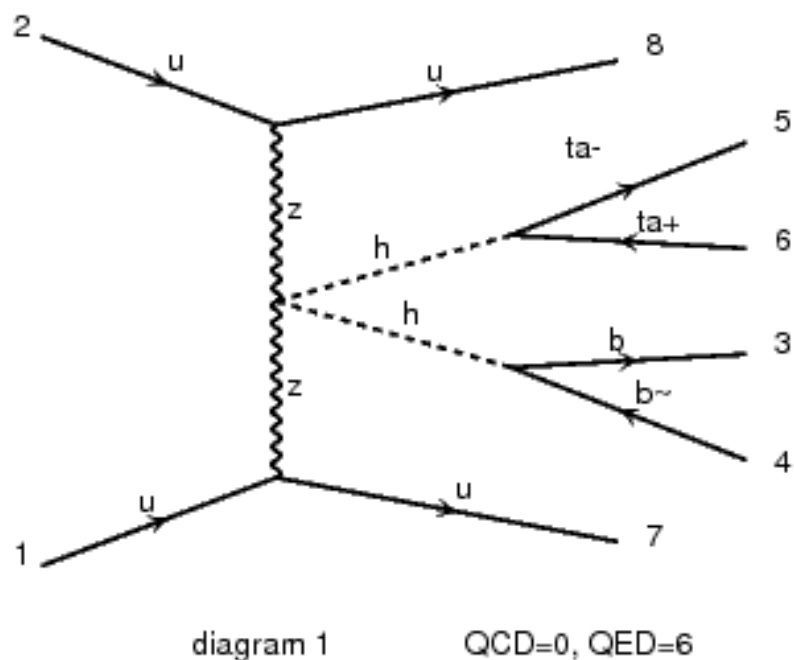
diagram 8

QCD=0, QED=6

But these are not the interesting diagrams to be probed by VBF HH production...

# Motivation

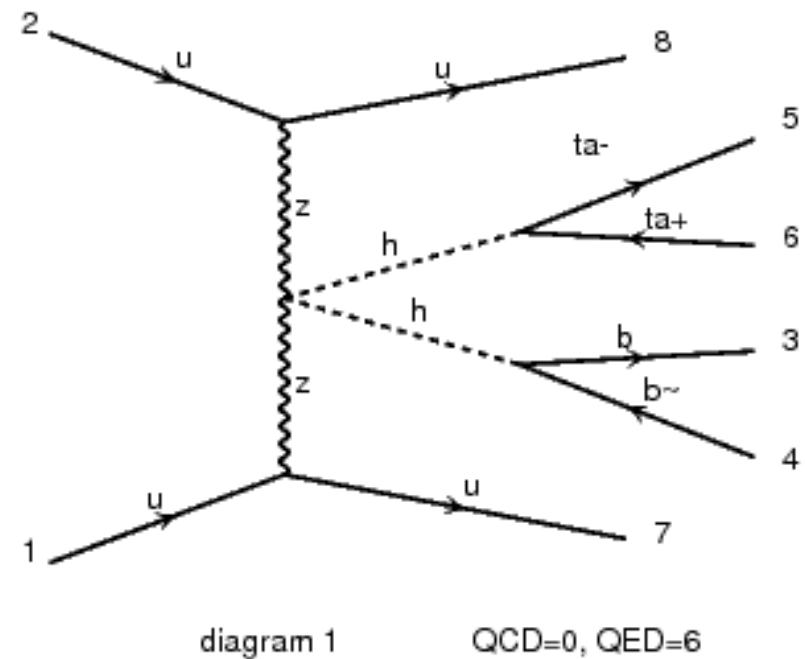
- Quartic coupling between VV and HH explores new territory that is not probed by HVV coupling measurements or HHH coupling measurements



These diagrams can probe a new class of dimension-8 operators

# Decay Channels

- Given the very small cross section (the process is purely electroweak production), start by exploring the ditau + bb decay channel



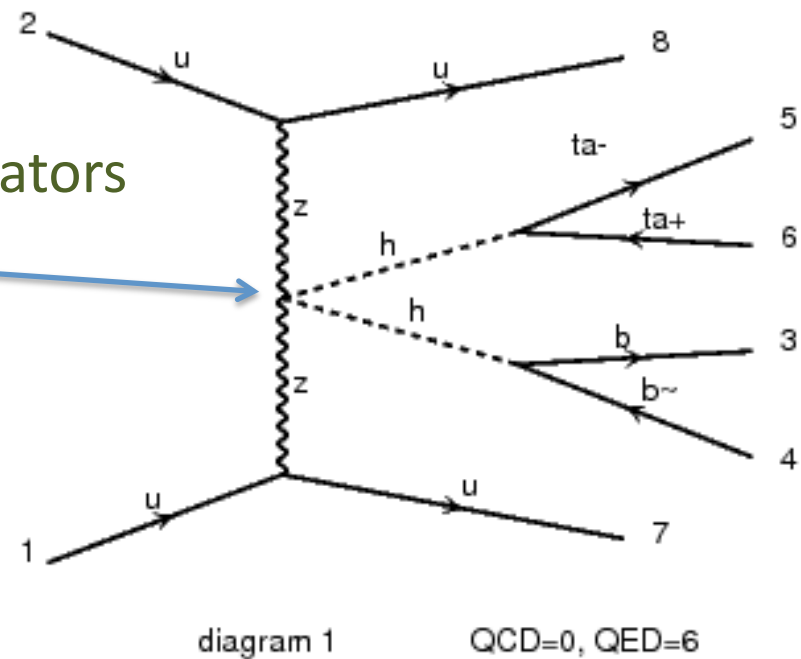
May need to fall back on diphoton + bb mode...

note that HL-LHC sensitivity studies for European Strategy and Snowmass had results from diphoton+bb but not ditau+bb

# Decay Channels

- Given the very small cross section (the process is purely electroweak production), start by exploring the ditau + bb decay channel

But new physics via dimension-8 operators could enhance this coupling



May need to fall back on diphoton + bb mode...

note that HL-LHC sensitivity studies for European Strategy and Snowmass had results from diphoton+bb but not ditau+bb

# Decay Channels

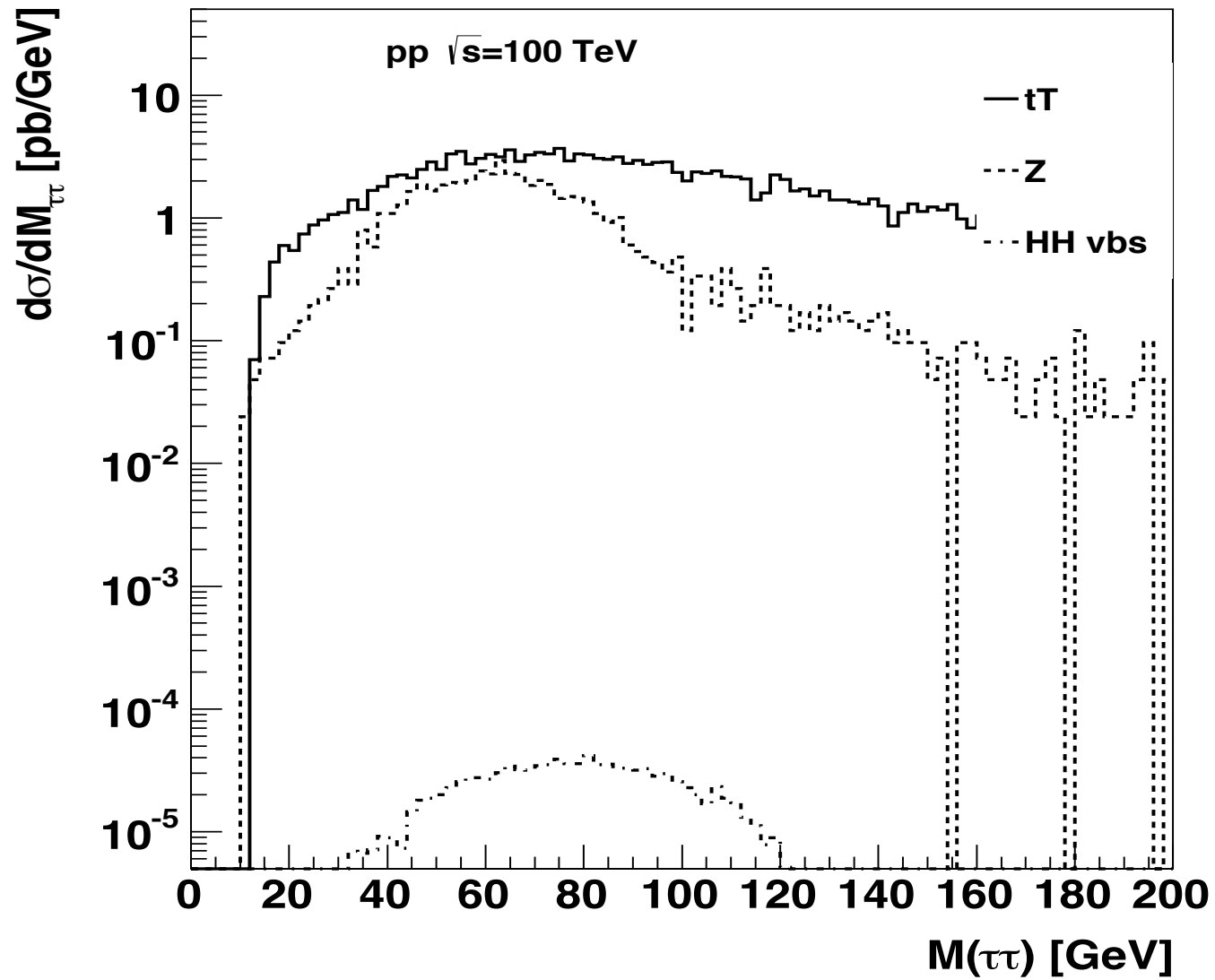
- Given the very small cross section (the process is purely electroweak production), start by exploring the ditau + bb decay channel
- Final state is ditau + bb + 2jets
  - Large physics (irreducible) backgrounds from
    - Zbb + 2j production
    - Ttbar + 2j production (with W -> tau nu) (possible veto on missing ET ?? )
- Cross sections for 100 TeV pp collider, with  $p_T(\text{jet}) > 20 \text{ GeV}$ 
  - Ttbar + 2j = 527 pb
  - Zbb + 2j = 241 pb
  - HH + 2j (VBS only) = 2.2 fb

# Software Framework

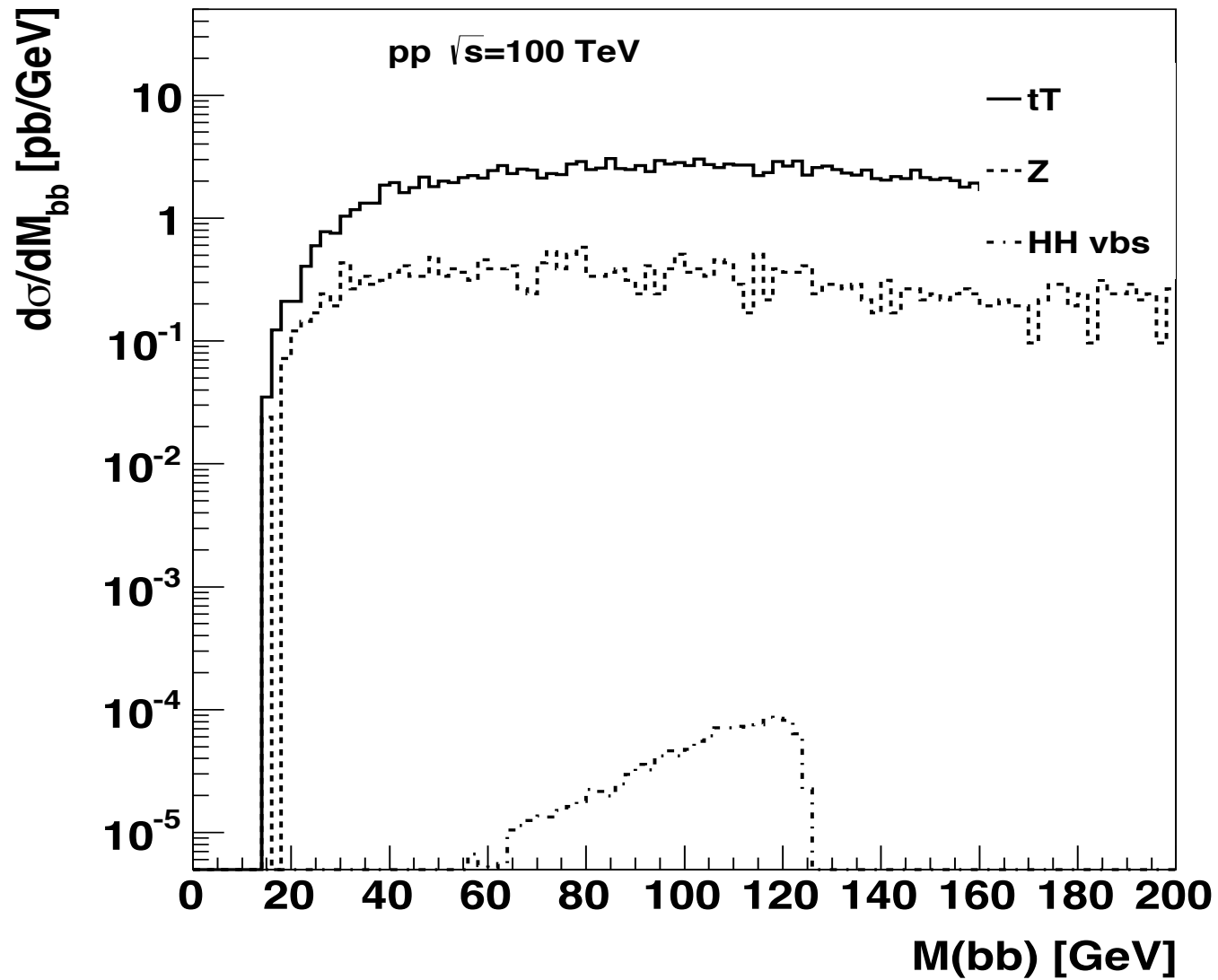
- Framework developed by Sergei Chekanov (ANL)
- Framework runs Madgraph -> Les Houches Accord file -> convert to PROMC format
- C++ macro provided to process PROMC Ntuples
  - implement analysis, cuts etc.
  - Includes cross section information
  - Write ROOT histograms
- pyROOT macro to plot histograms, normalizable by MC sample luminosity
- So far I am using Sergei's framework at truth level



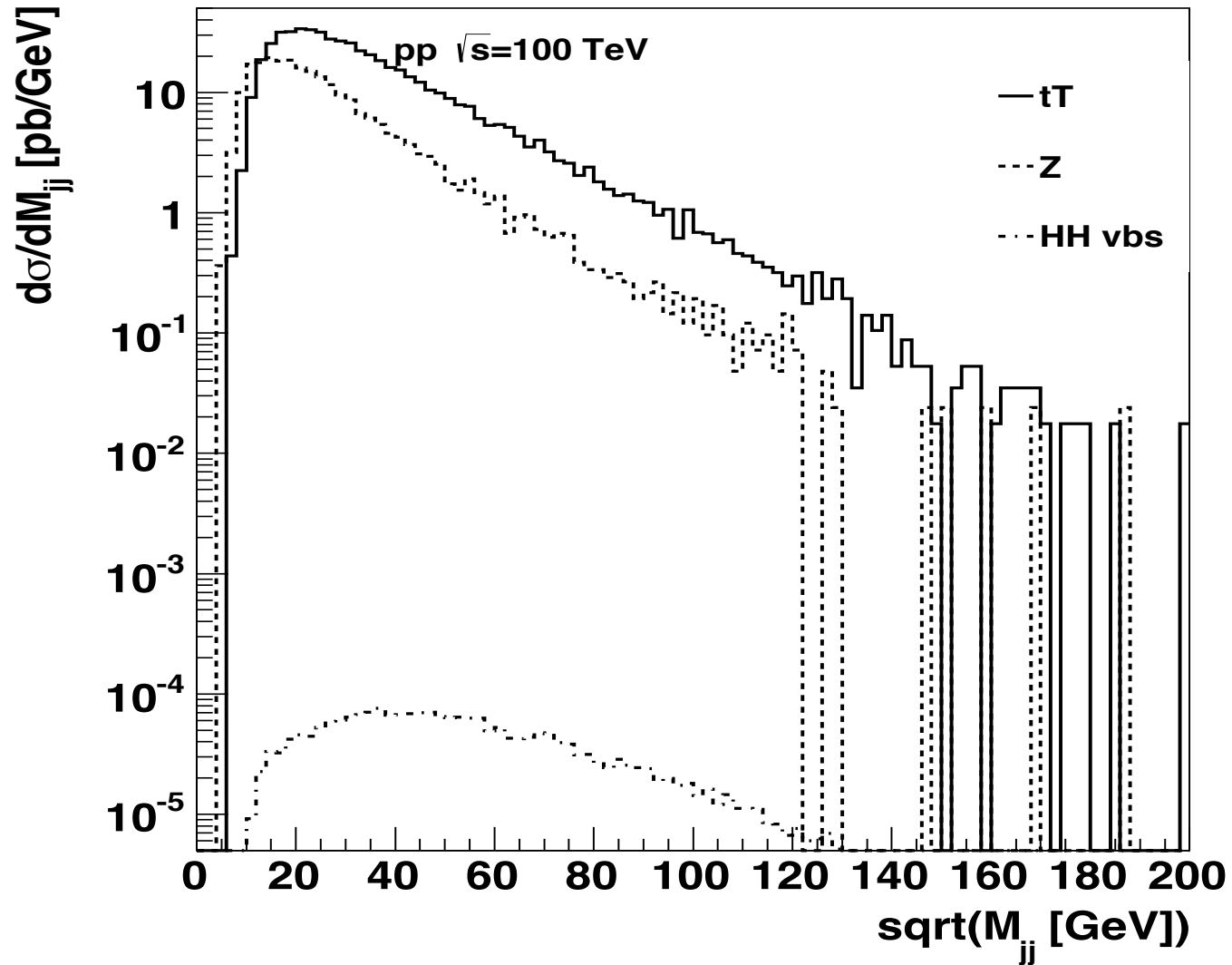
# Di Tau Mass



# Di Bjet Mass



# Di jet Mass



# Summary

- Started looking at VBS HH production
- S/B is extremely small for SM
- Investigate cuts to enhance signal
- Investigate new physics models which enhance signal