Higgs Self-Coupling Analysis @ 550 GeV – Status

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Bryan Bliewert

Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Work carried out at
ICEPP
The University of Tokyo

Status of llHH in Dihiggs Analysis

- Progress over last weeks
  - Fast simulation done for all relevant physics samples
  - Event observables implemented
    using all observables from the last study and new ones, e.g. matrix elements, kinematic fit chi2 etc.
  - TMVA setup for event categorization ready

Event Selection - Overview

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DESY.

- Based on same strategy as 2016 study

New: LO matrix elements (ll, qq), kinematic fits (masses, chi2, fit probabilities)

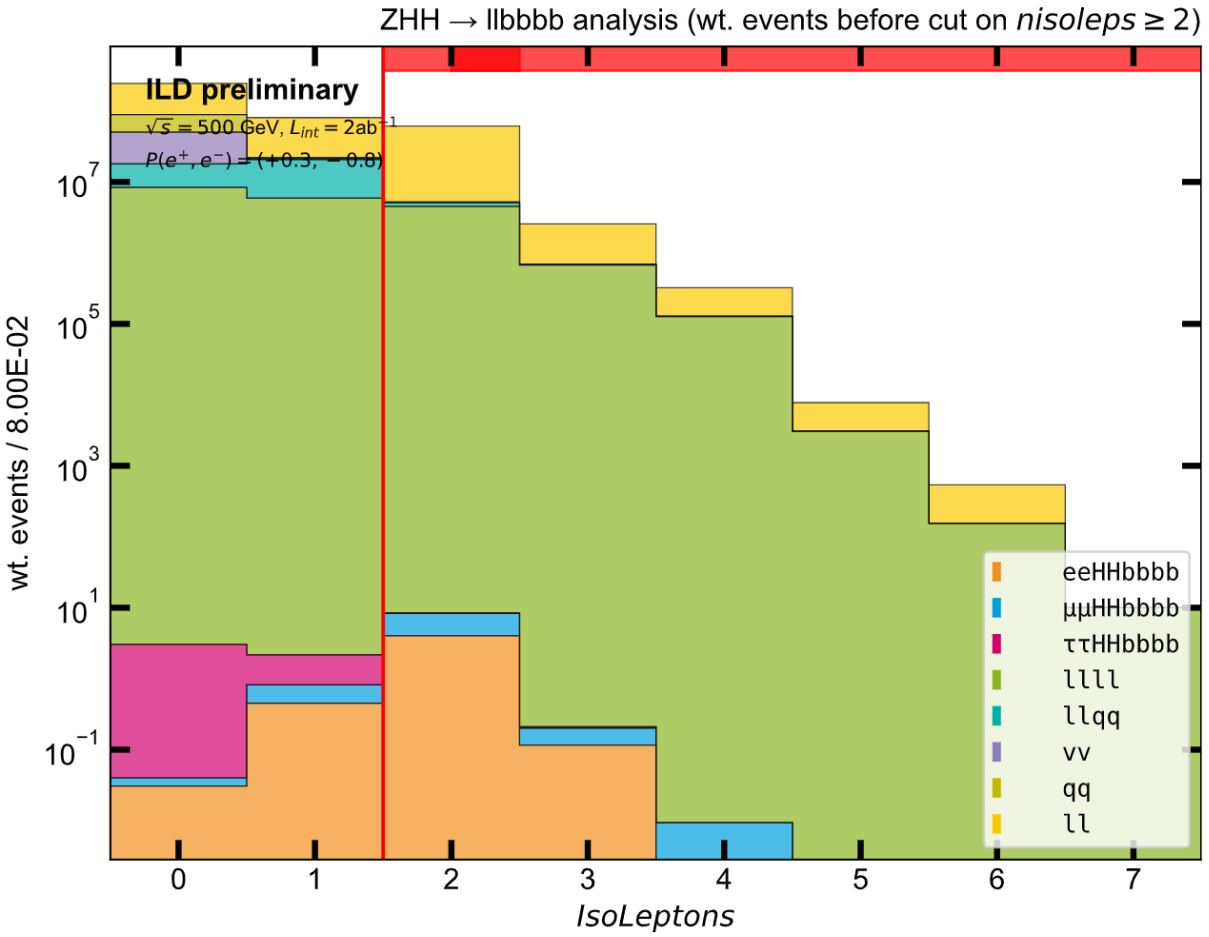
  - stared variables* explained below; orange WIP; ***italic-bold*** variables new

	llHH (llbbbb)	**ννHH** (ννbbbb)	**qqHH** (qqbbbb) split into bbHH and light qqHH
1st Background / Variables	$llbb$ / 9 variables: mZ, thrust, costhrust, pjmax(2jets)*, cos(Z,jet)max*, npfos, npfosmin(4j)*, yminus*, yplus*	$bbbb$ / 6 variables: Evis, ptmiss, thrust, pjmax(6jets)*; **ZZ**: mZ1, mZ2	$bbbb$ / 9 variables: costhrust, pjmax(6jets)*, yminus*, npfos, npfosmin(6j)*; **ZZ**: mZ1, mZ2, pjmax(4jets)*, cosjmax(4jets)
2nd Background / Variables	$lvbbqq$ / 7 variables: Evis, mZ, plmin*, m(b34)*, ptmiss, npfos, mva(lepsmall)*	$lvbbqq$ / 11 variables: npfos, npfosmin(5j)*, mMiss; **ZHH**: mH1, mH2; **tt**: mW1, mW2, mt1, mt2; pcmax*, yminus*	$bbqqqq$ / 12 variables: npfos*, pjmax(6jets)*, cosbmax*; **tt**: mW1, mW2, mt1, mt2, χ^2_{tt}; **ZHH**: mH1, χ^2_{ZHH}, mH2, **mZ**
3rd Background / Variables	$ZZH, ZZZ \rightarrow llbbbb$ / 12**+2** variables: χ^2_{ZHH}*, χ^2_{ZZH}*, ***LCME ZHH****, ***LCME ZZH****; ZHH: mH1, mH2; ZZH: mH, mZ, p1st*, cos1st* ; ZZZ: mZ1, mZ2, p1st*, cos1st*	$ZZH, ZZZ \rightarrow \nu\nu bbbb$ / 12 variables; see $llHH$	$ZZH, ZZZ \rightarrow qqbbbb$ / 12 variables; see $llHH$

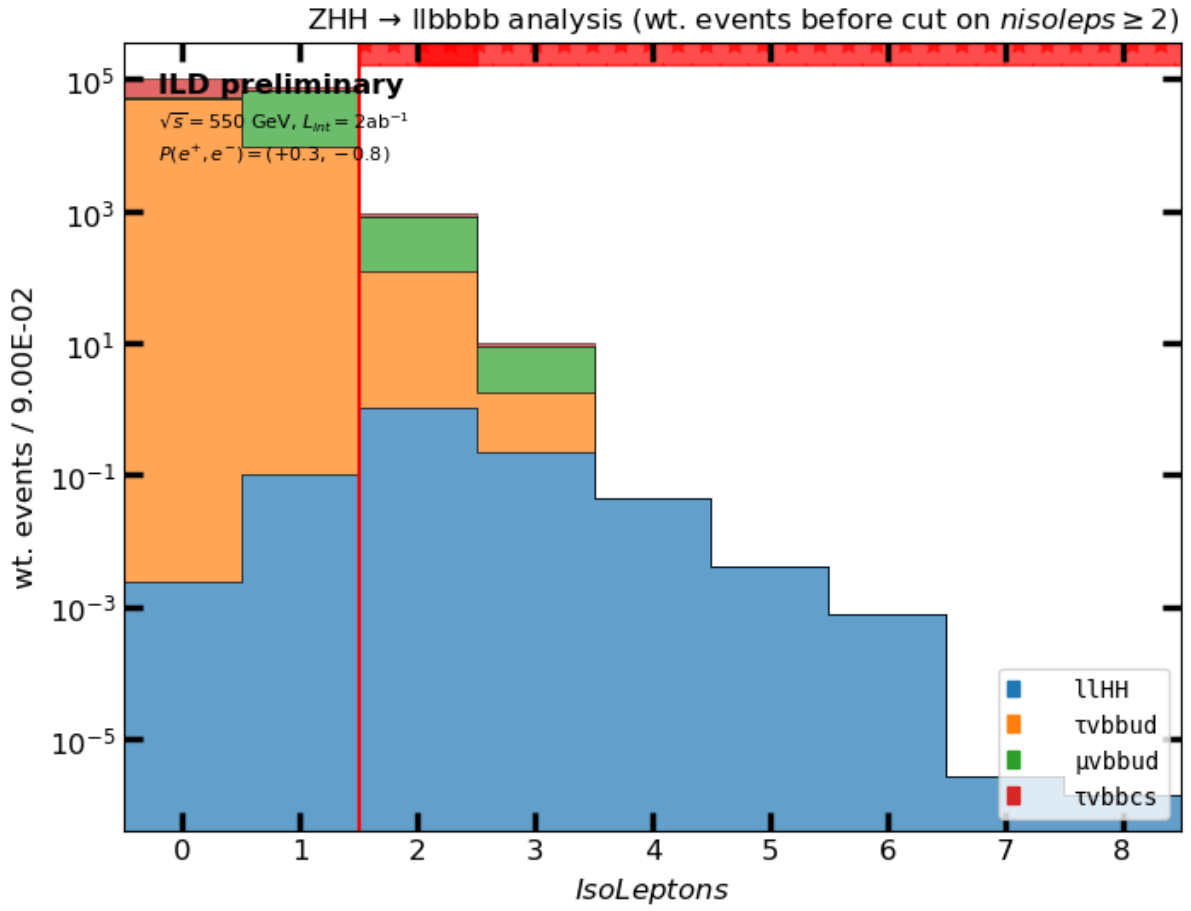
Explanation of variables: **pjmax(n jets)** - leading jet momentum when clustering into n jets / **cos(Z,jet)max** – largest angle between reconstructed Z and two of the four jets / **npfosmin, npfosmax** – smallest, largest number of PFOs in a jet / **yminus, yplus** – likeliness to be a four instead of three jet event, three instead of two jet event (similar for other selection) / **plmin** – smallest isolated lepton momentum / **m(b34)** – invariant mass of jet system related to bmax3 and bmax4 / **mva(lepsmall)** – MVA output in the isolated lepton tagging, lepsmall denotes the smaller value of the two / χ^2_{ZHH} and χ^2_{ZZH} - chi squared values from kinematic fits under ZHH and ZZH hypothesis, respectively / **LCME ZHH, ZZH** – log of leading order ZHH and ZZH matrix elements / **p1st, cost1st** – largest momentum (for ZZH, ZZZ: of boson candidate) and cos of associated polar angle / **pcmax** – largest momentum of a charged PFO / **cosjmax(n jets)** – polar angle of jet with largest momentum

llHH / isolepton Cut

500 GeV Full Sim

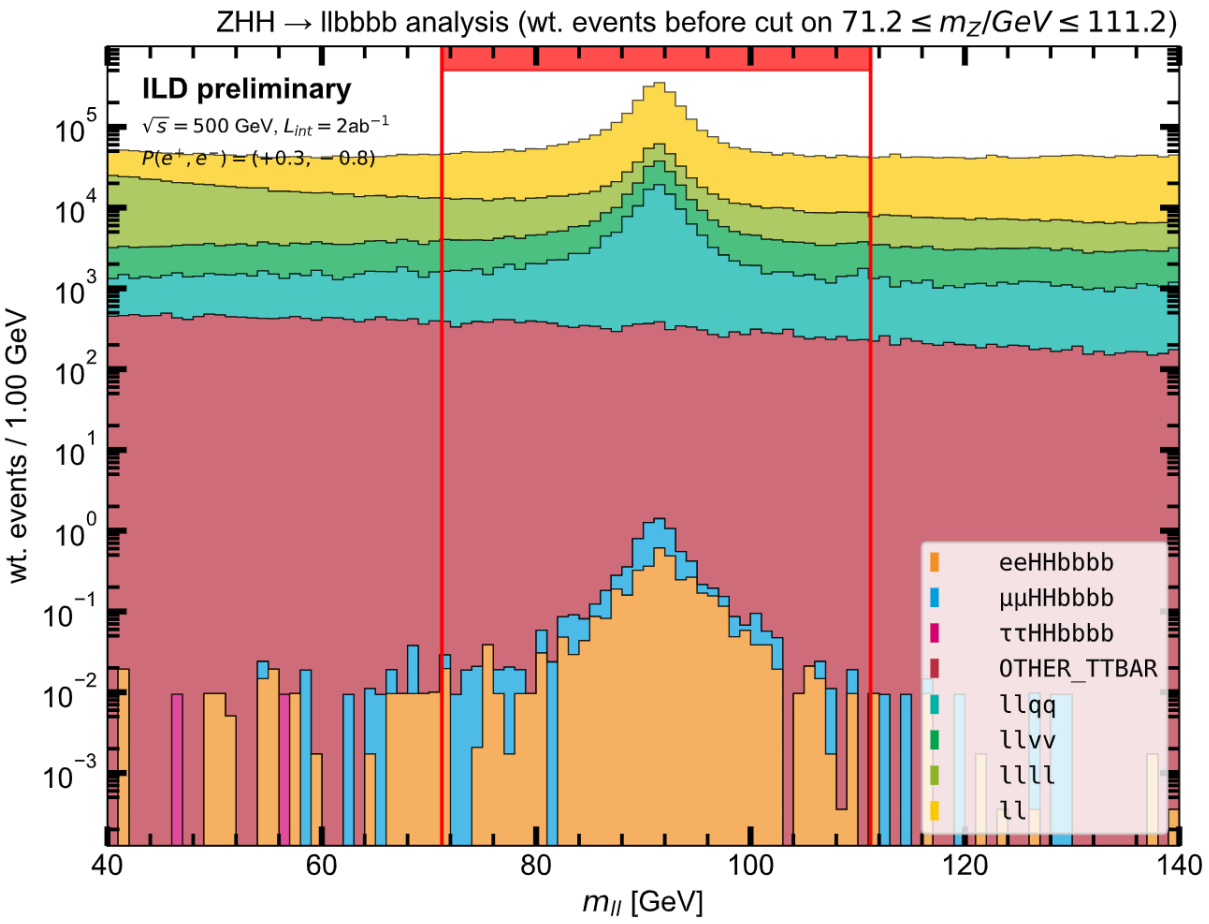


550 GeV Fast Sim

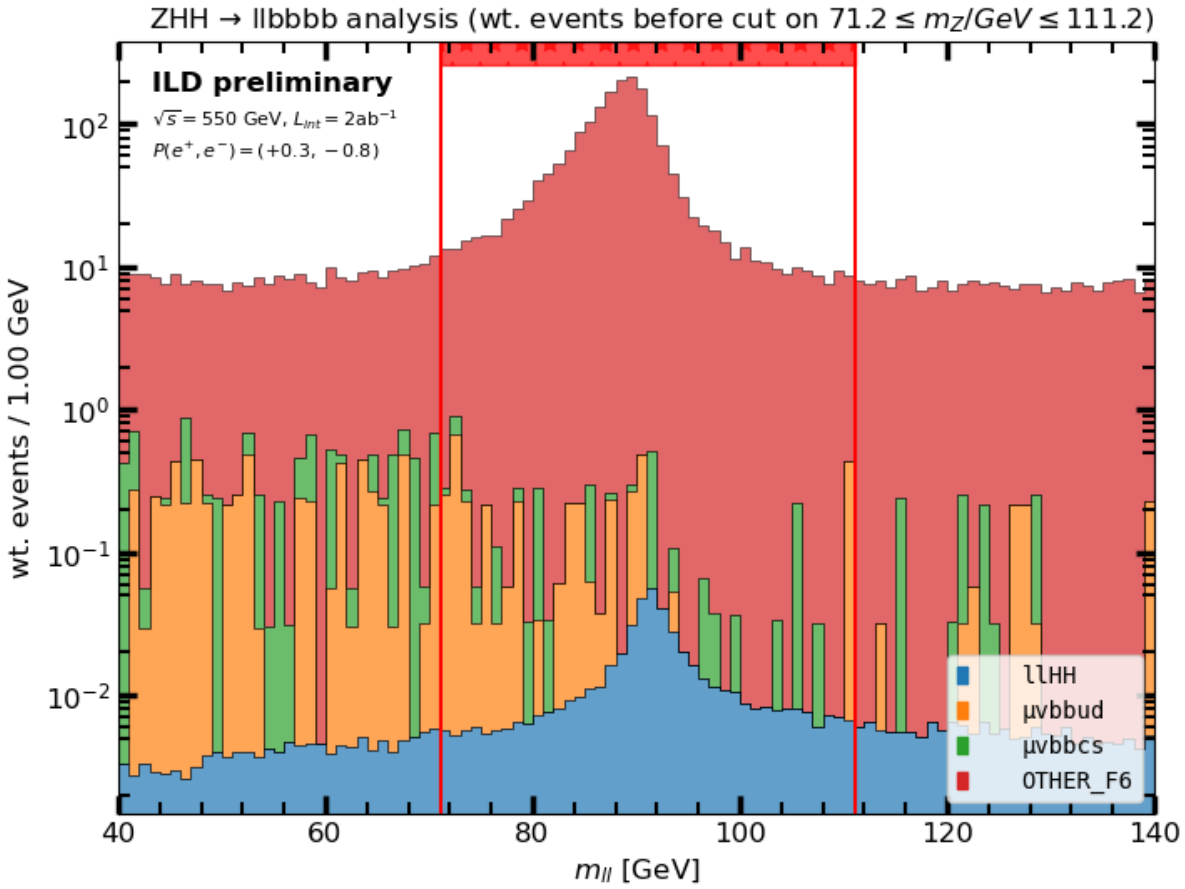


llHH / Z mass Cut

500 GeV Full Sim

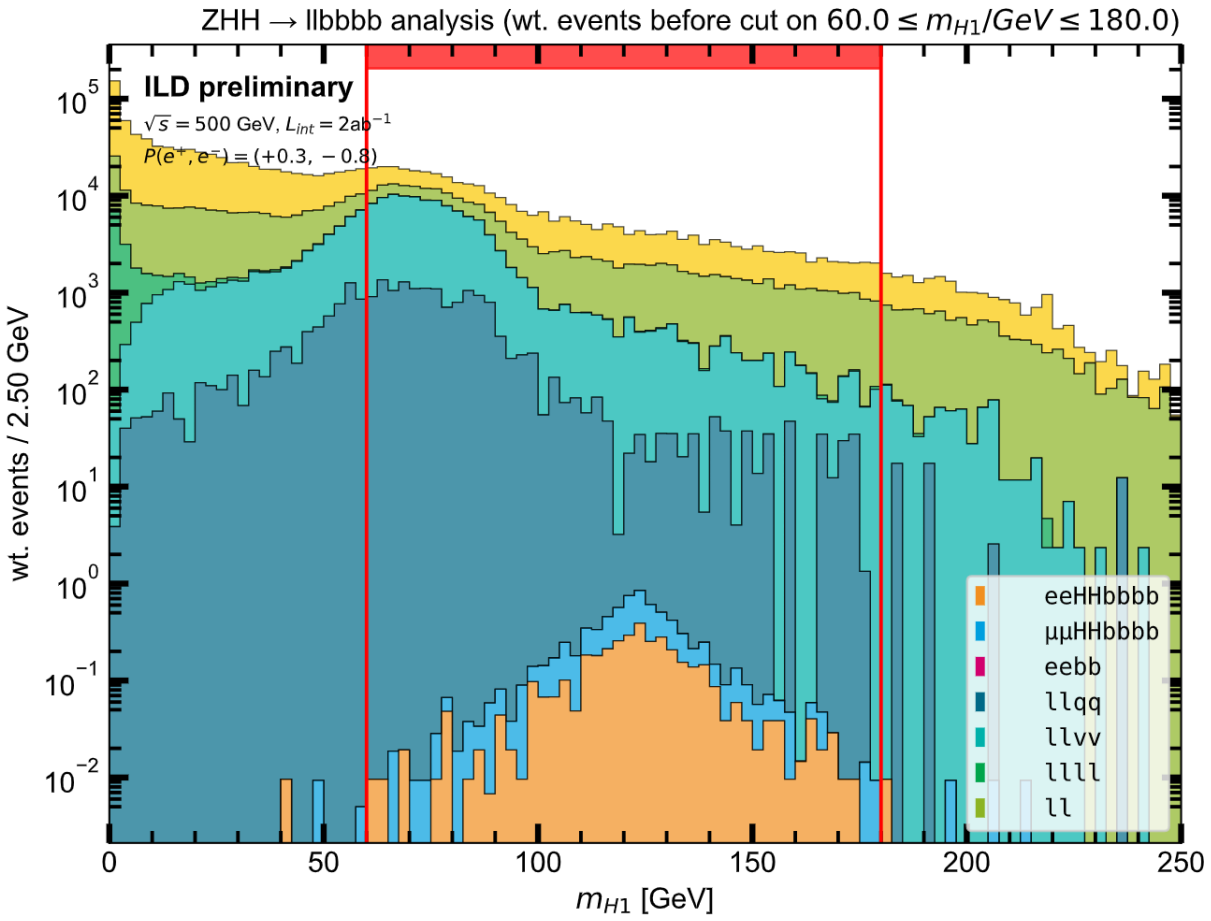


550 GeV Fast Sim

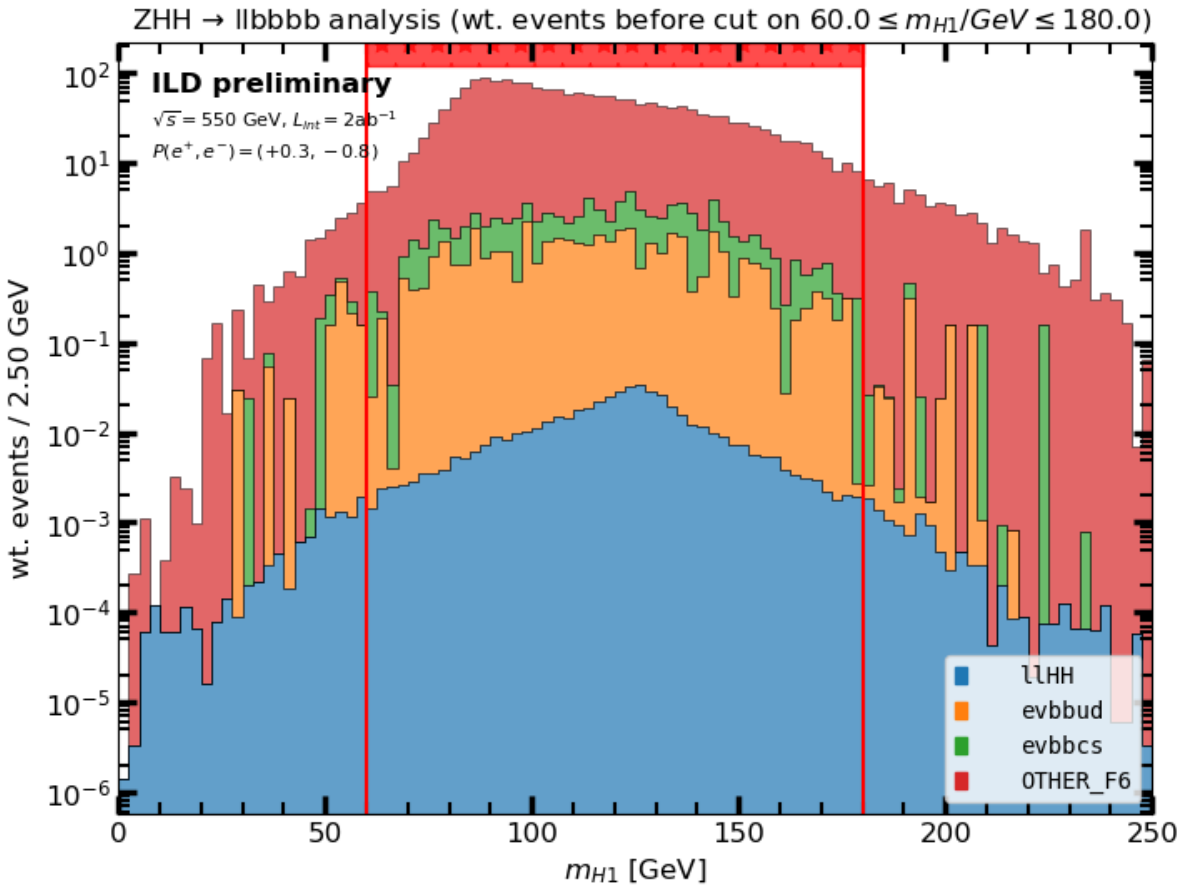


llHH / H1 mass Cut

500 GeV Full Sim

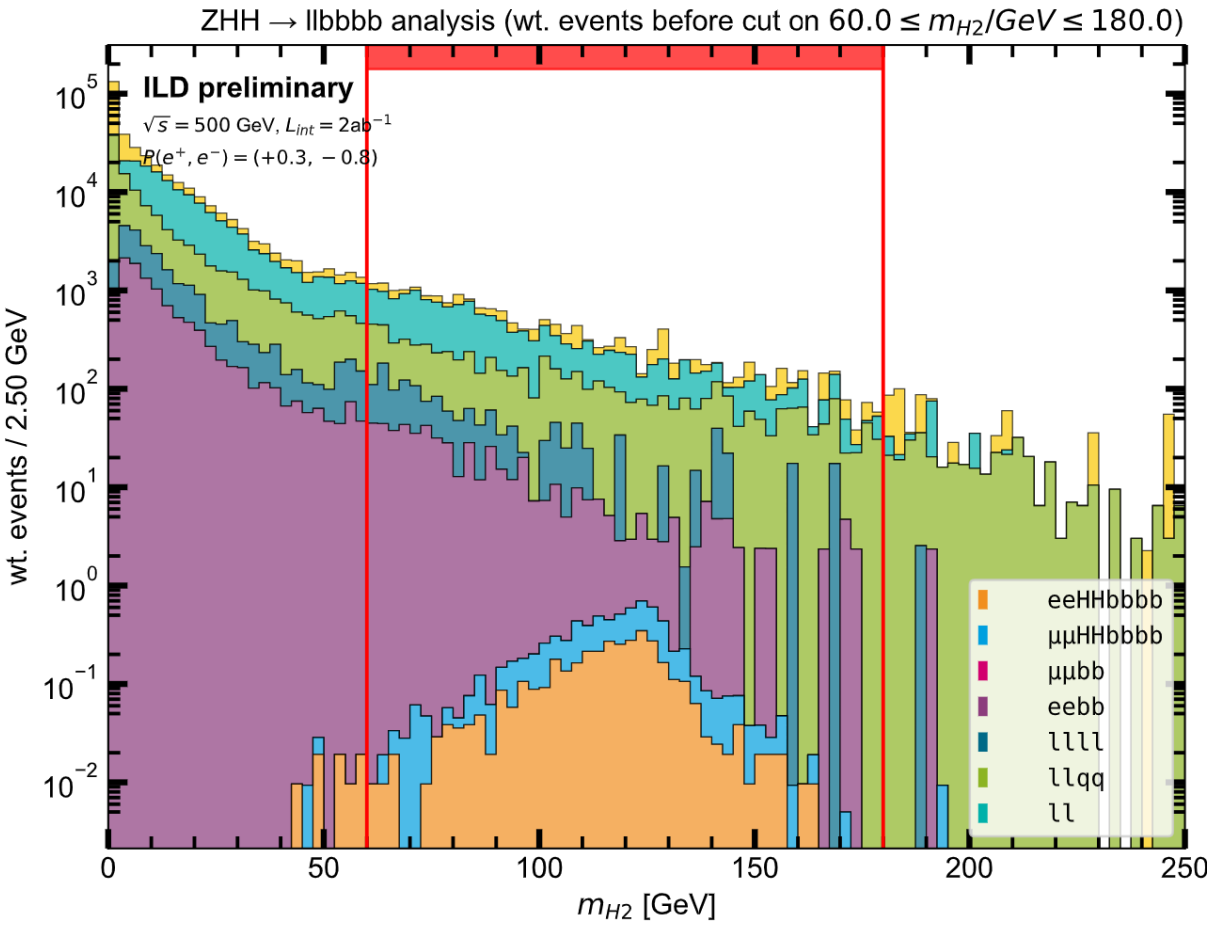


550 GeV Fast Sim

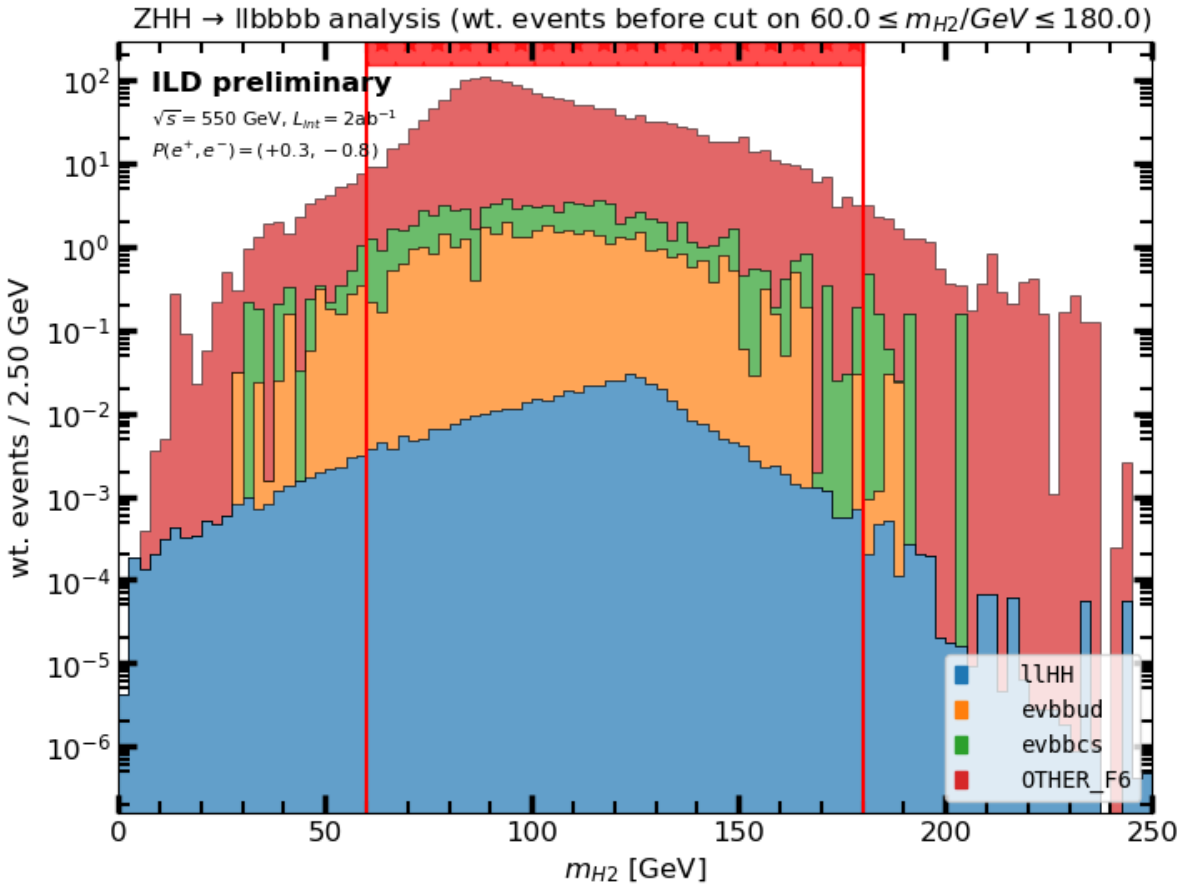


llHH / H2 mass Cut

500 GeV Full Sim

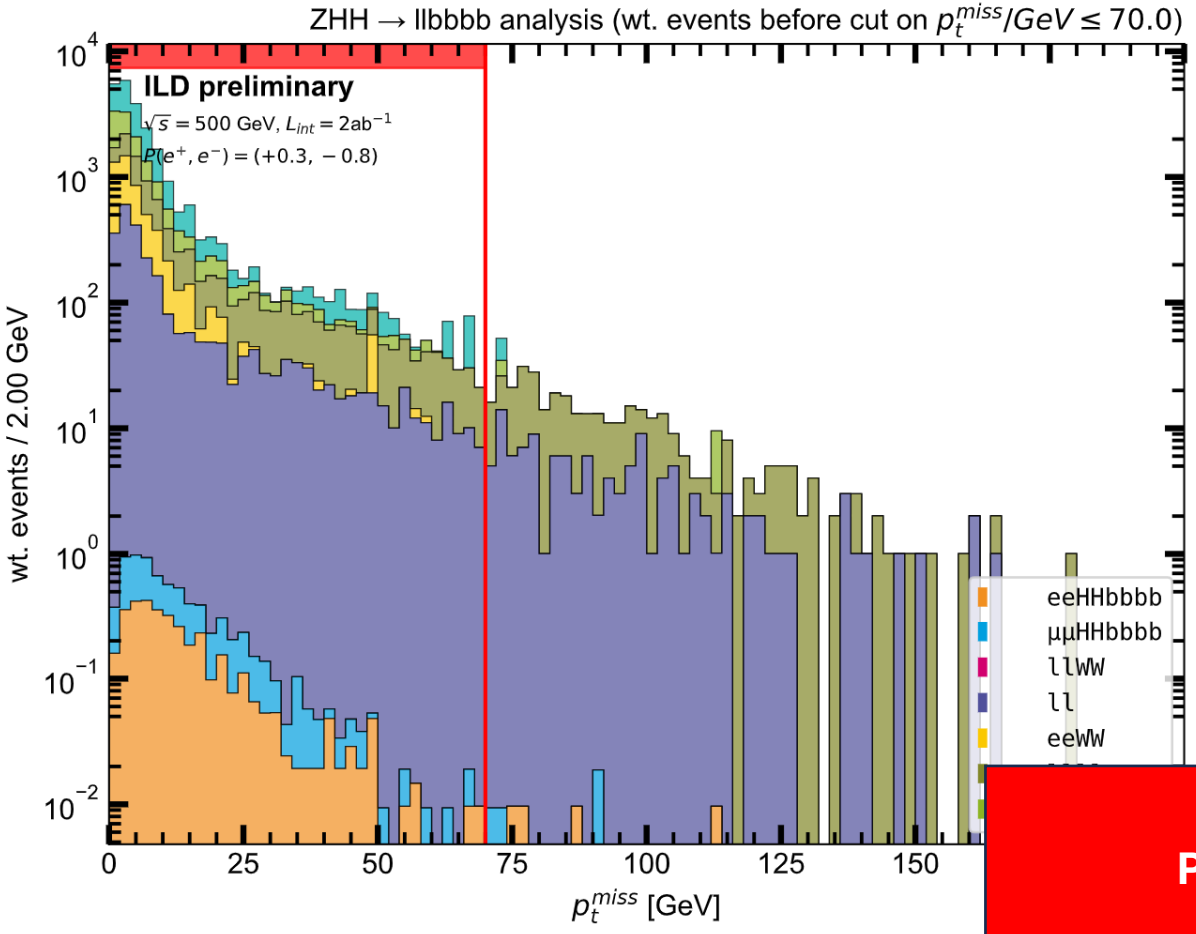


550 GeV Fast Sim

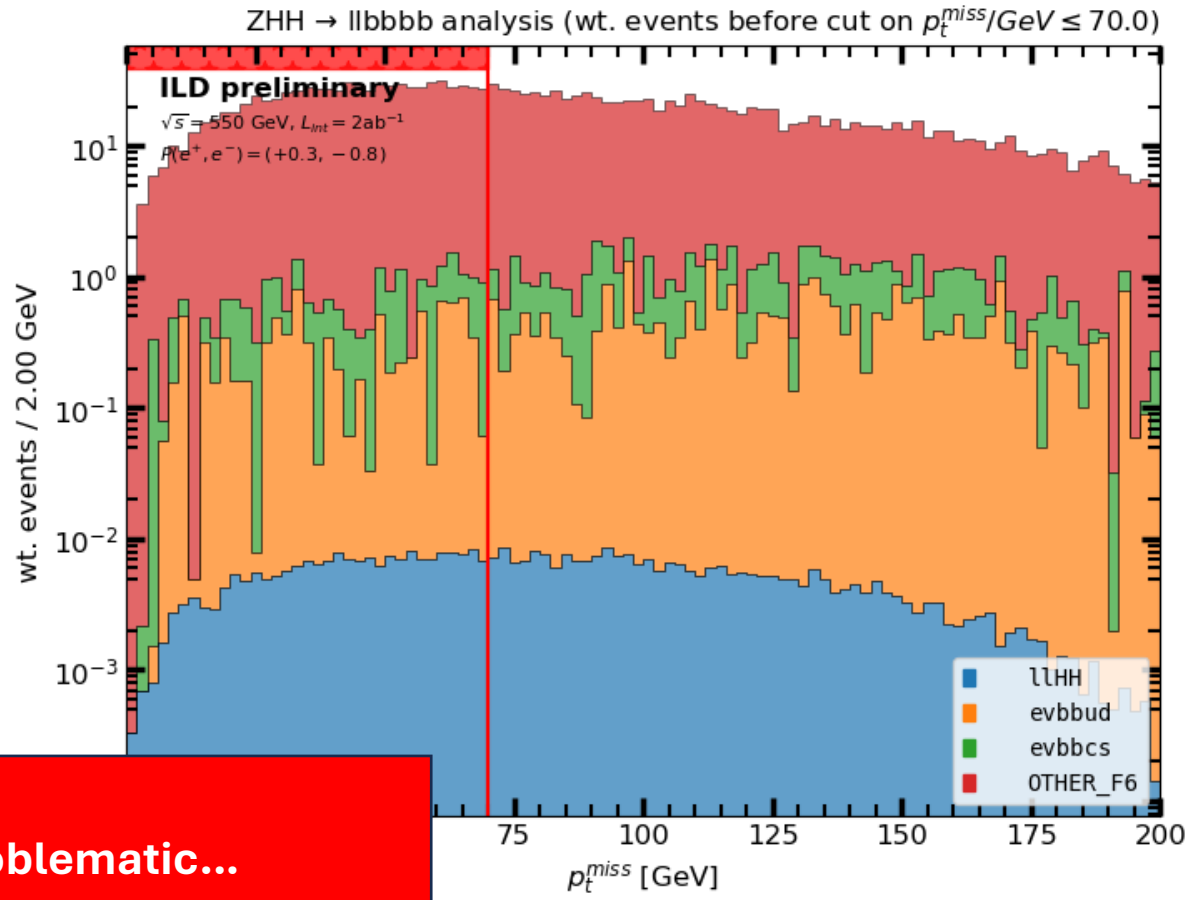


llHH / missing transverse momentum Cut

500 GeV Full Sim



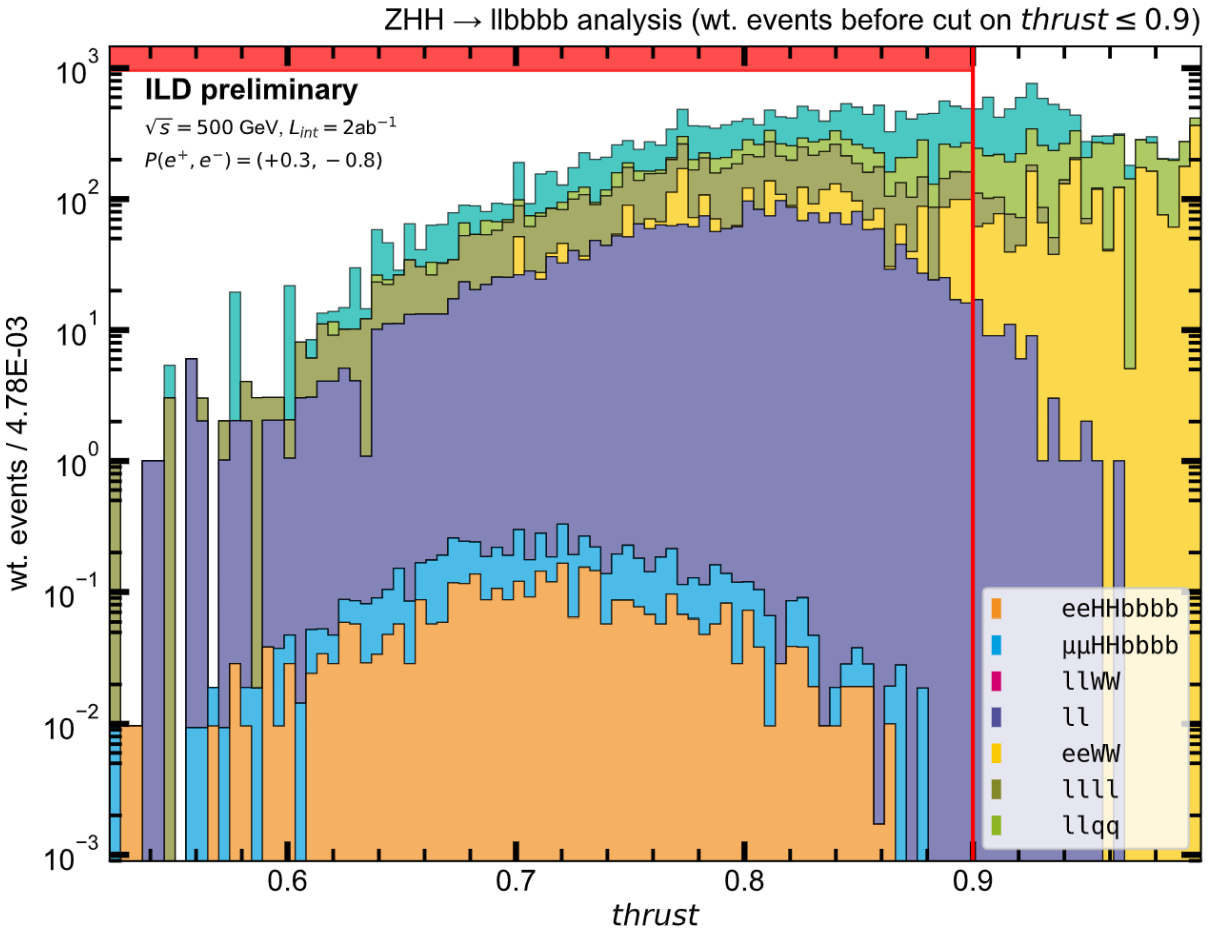
550 GeV Fast Sim



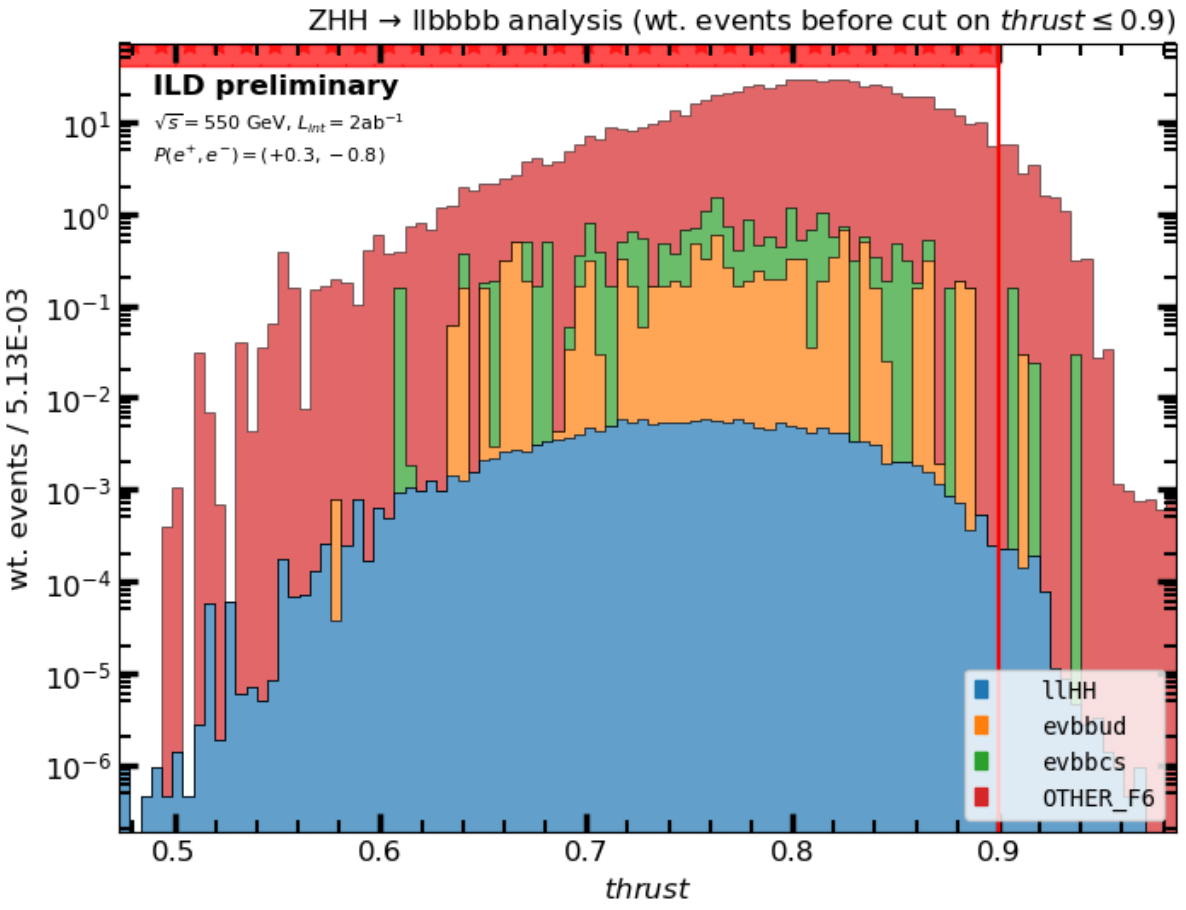
Problematic...

llHH / H2 mass Cut

500 GeV Full Sim



550 GeV Fast Sim



Status of llHH in Dihiggs Analysis

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DESY.

- Work for the future
  - Carry out the analysis for 9 combinations of signal/backgrounds to suppress
    continue work at DESY, work together with Junping, Taikan
  - Investigate differences affecting kinematics in full-fast simulation
    important for kinematic fits and event selection
  - Event selection as a ML categorization task
    e.g. using ParticleTransformer; continue to work together with Taikan