

# Validation of the new ZHH Production at 550 GeV.

## Generator samples

Julie Munch Torndal

ILD Analysis/Software Meeting

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# Introduction

ZHH production at ILC gives direct access to Higgs self-coupling

> previously studied at 500 GeV [DESY-THESIS-2016-027]

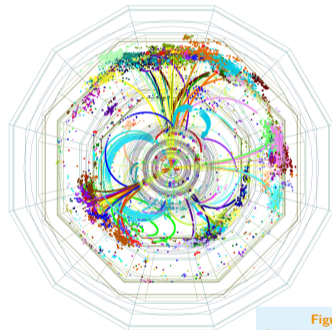
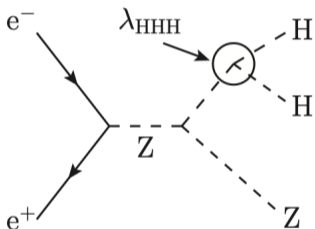


Figure from  
[DESY-THESIS-2016-027]

Better sensitivity at higher energies?

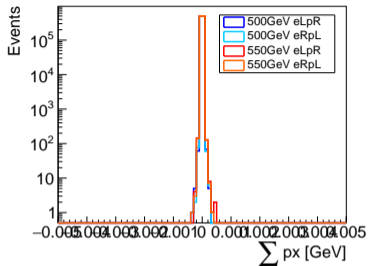
- > Better jet pairing from lower multiplicity?
- > Better b-tagging efficiencies?

Simple approximation for the beam spectrum:

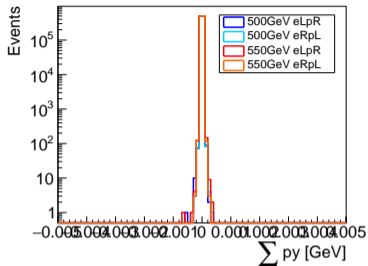
- > Same relative beam spectrum as at 500 GeV but scaled to 550 GeV
  
- > First samples produced only for  $Z \rightarrow \mu^+ \mu^-$

# Event Momentum

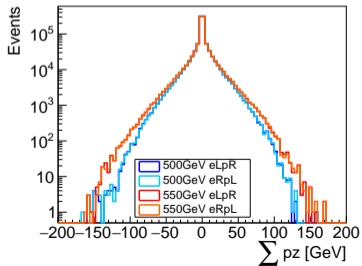
Sum of  $p_x$  for final state particles



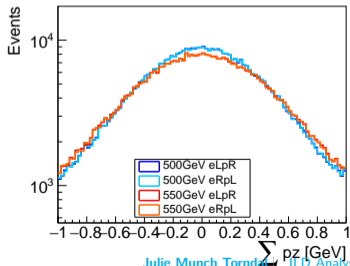
Sum of  $p_y$  for final state particles



Sum of  $p_z$  for final state particles

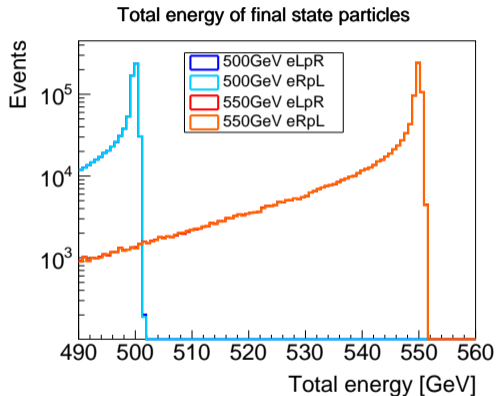
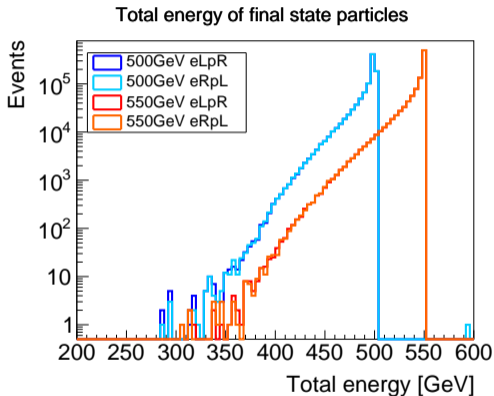


Sum of  $p_z$  for final state particles



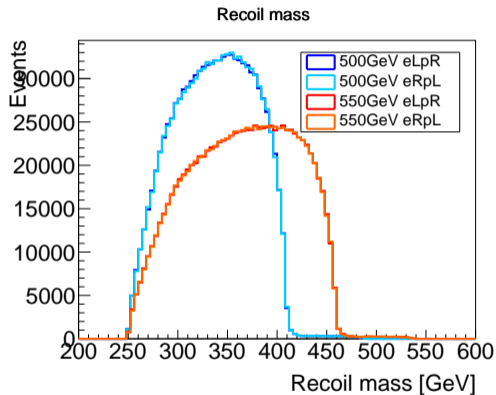
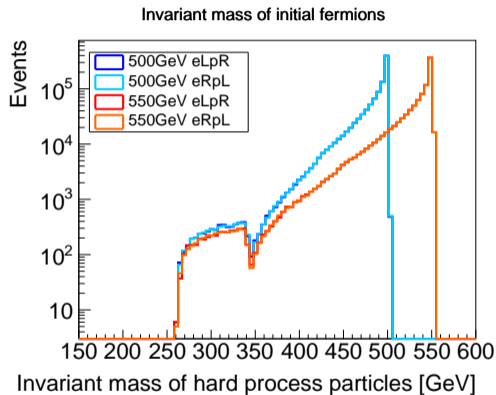
- > As expected with approx. zero sum in  $p_x$  and  $p_y$
- > and non-zero sum in  $p_z$  due to ISR
- > Also larger tails for 550 GeV sample

# Event Energies



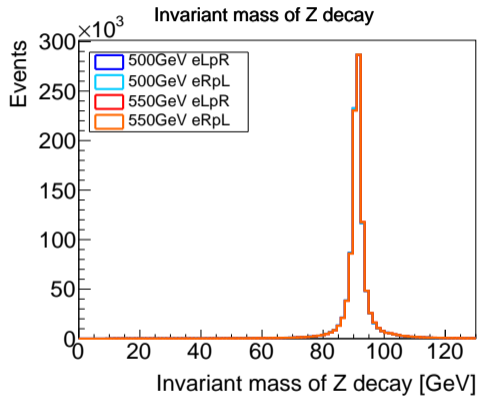
> As expected with peak and sharp drop-off at  $E_{CM} = \{500, 550\}$  GeV

# Event masses

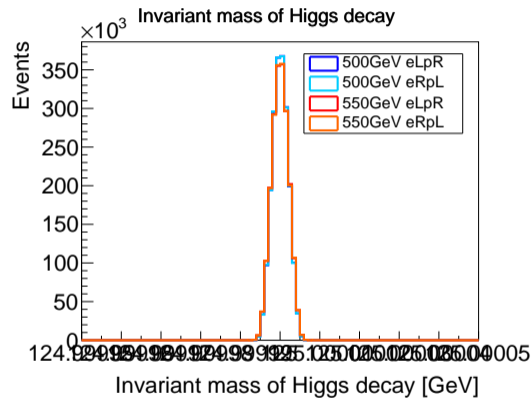


- > Dip at resonance  $M_Z + M_H + M_H = 340$  GeV
- > Lower limit at  $2M_H = 250$  GeV

# Decay masses

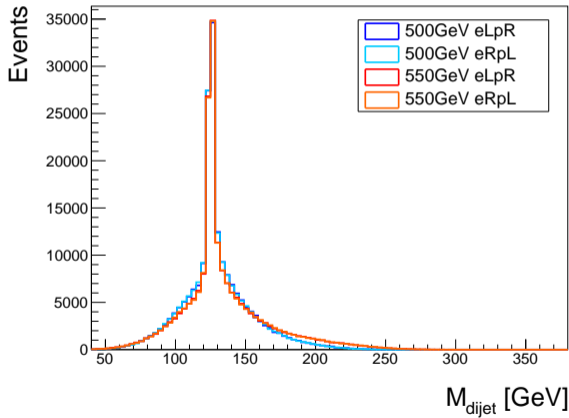


> Includes decay width of Z



>  $H$  is created on-shell

# Dijet masses



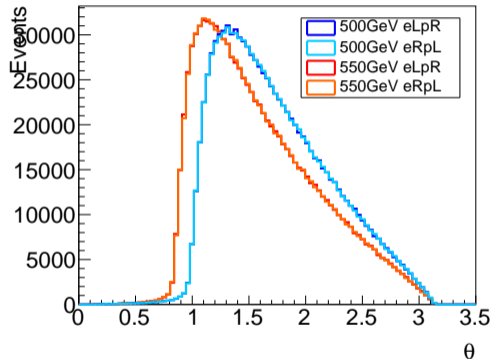
- > Jet clustering: Remove muons and cluster final state particles into 4 jets
- > Jet-pairing from

$$\min(\chi^2) = (m_{j_1 j_2} - 125 \text{ GeV})^2 + (m_{j_3 j_4} - 125 \text{ GeV})^2$$

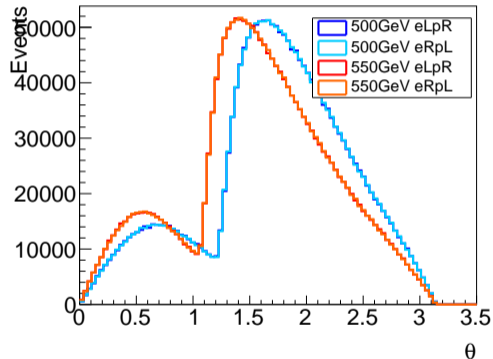


# Opening angles

Opening angle between Z decay products



Opening angle between H decay products



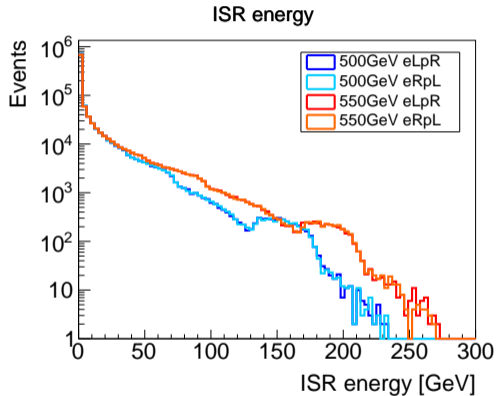
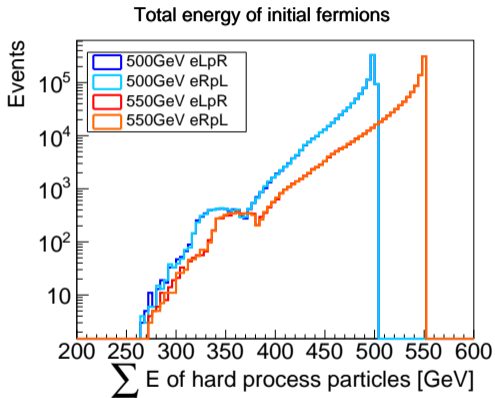
> Larger energies  $\rightarrow$  more boost  $\rightarrow$  smaller opening angle between decay products

# Summary

- > Scaling of  $E_{CM}$  appears to work as expected
- > Generation of the full simulation can proceed

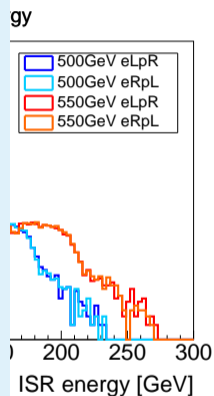
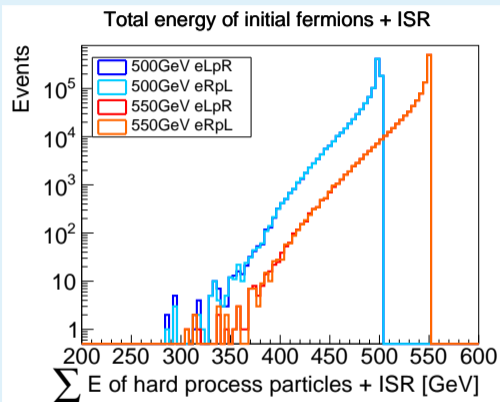
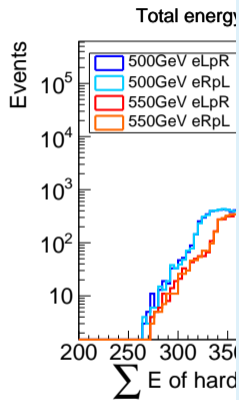
# Backup

# Event Energies



> Correlation between hard process and ISR

# Event Energies



- > Correlation between hard process and ISR
- > Hard proces + energy resembles total energy of final state particles