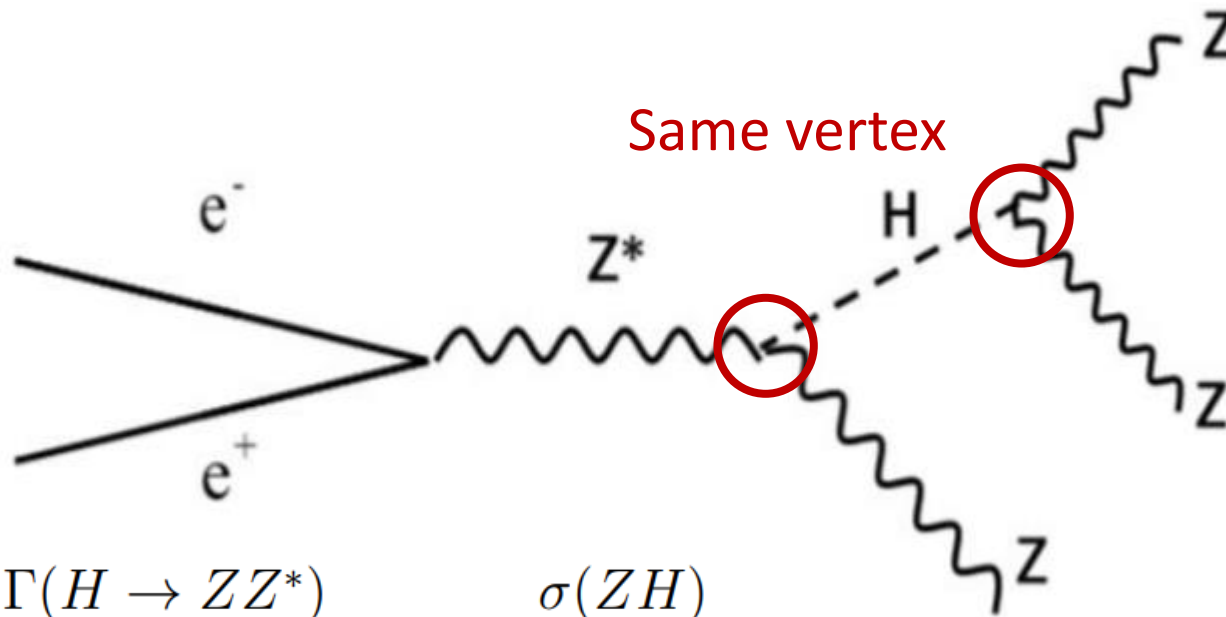


# A “global” analysis of $e^+e^- \rightarrow ZH \rightarrow ZZZ^*$

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## CEPC: $e^+ e^- \rightarrow ZH \rightarrow ZZZ^*$



$$\Gamma_H = \frac{\Gamma(H \rightarrow ZZ^*)}{\text{BR}(H \rightarrow ZZ^*)} \propto \frac{\sigma(ZH)}{\text{BR}(H \rightarrow ZZ^*)}$$

Besides the higgs coupling, this channel can be used to measure higgs width.

# Unique advantage of lepton collider

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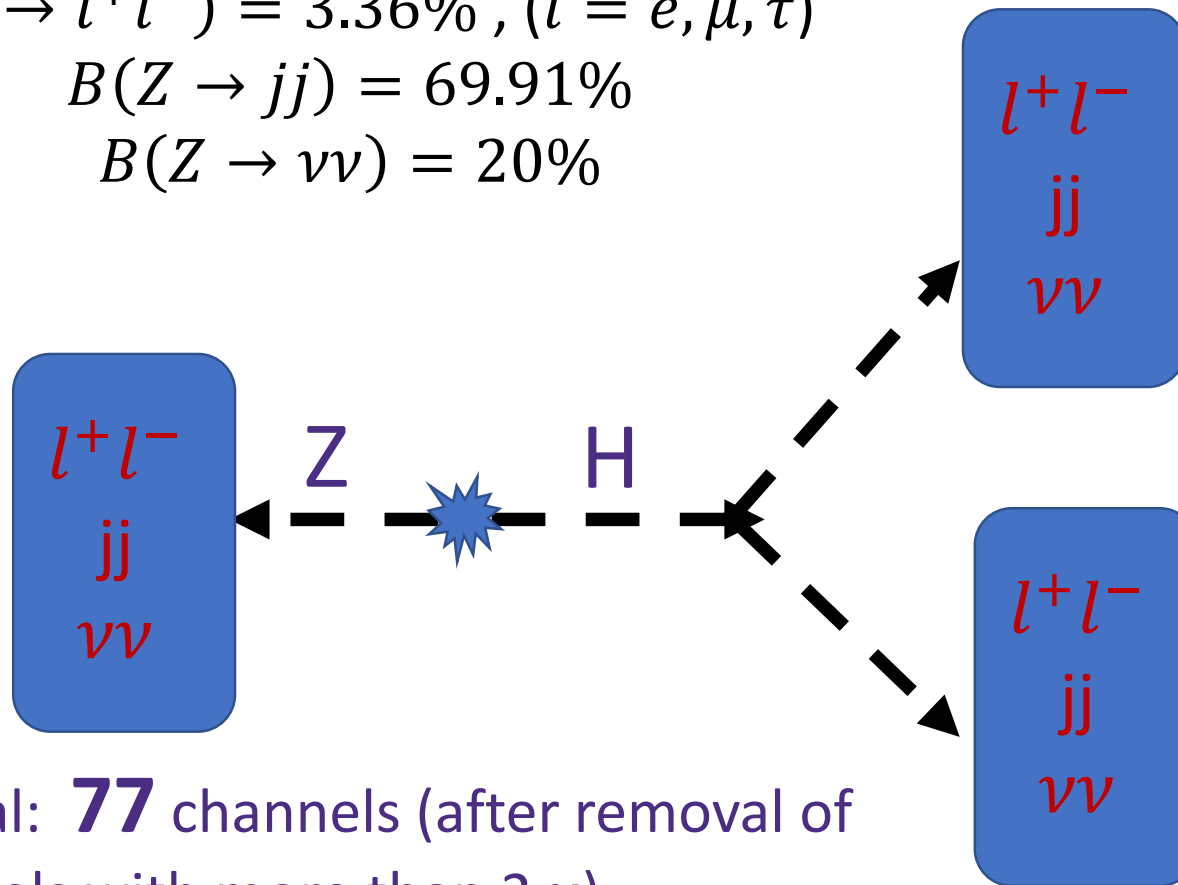
- > **Leptons are point-like particle**
  - Four momenta conservation
- > **Low background level**
  - No need of fancy event selections
- > **Almost no pile-up**
  - Missing energy can be reconstructed well
- > **Excellent trigger performance**
  - All channels except for all-neutral channel can pass the trigger with excellent efficiency. Different channels can be combined easily.

## New idea to analyze $e^+ e^- \rightarrow ZH \rightarrow ZZZ^*$

$$B(Z \rightarrow l^+ l^-) = 3.36\%, (l = e, \mu, \tau)$$

$$B(Z \rightarrow jj) = 69.91\%$$

$$B(Z \rightarrow \nu\nu) = 20\%$$



In total: **77** channels (after removal of channels with more than 2  $\nu$ ).

Sounds like a large number, don't worry, not complicate.

# Analysis strategy

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- > Make the best use of advantage of lepton collider.
- > For each event, reconstruct a Z list with 5 channels.
  - Remove the channels with more than 2  $\nu$ .
  - Use the recoil to reconstruct  $Z \rightarrow \nu\nu$  or the  $\nu\nu$  from  $Z \rightarrow \tau\tau$ .
- > Only keep the events with exactly three Z candidates.
- > Take the candidate with smallest invariant mass as  $Z^*$ .
- > Take the candidate with largest momentum as Z outside of  $H$  (need validation from MC simulation).
- > Analyze the 2D distribution in Dalitz plot.

# Analysis strategy

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- > **If the background level from different channels have obvious difference:**
  - **Analyze different channels separately and combine together.**
- > **Normally different channels with same final states should have similar background level.**
- > **Start with  $jjll\nu\nu$  channel since three main Z decays are included.**

## What we need

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- > **The reconstruction of jets and leptons.**
- > **Z tagger (using all objects in detector)**
- > **A framework to cover all the channels**
- > **Should be simple since we do not care about systematic uncertainty for now.**

# CEPC: $e^+ e^- \rightarrow ZH \rightarrow ZZZ^*$

## Advantage of Dalitz plot analysis:

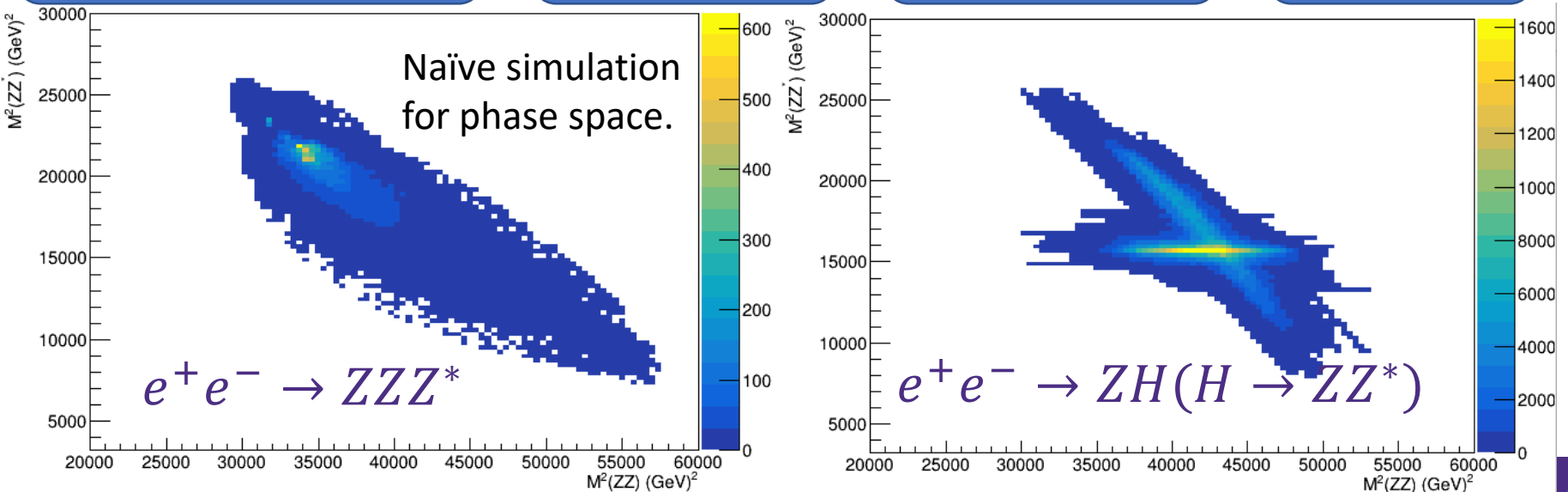
- Different phase space between ZH and background.
- 2D distribution should have better signal significance.

Reconstruct two Z from  
two jets and two leptons

Take the recoil  
as another Z

Use lowest mass  
candidate as  $Z^*$

2D Dalitz  
analysis



Analysis at 2D is always better, lower signal-to-noise ratio.



# Summary and next todo

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## > Potential improvements come from:

- More decay channels of Z
  - > Make a Z list (Z tag) and select combinations (similar method with B tag at B-factory and D tag at BESIII)
- 2D Dalitz analysis
  - > All the information from three body decays are included.

## > Preliminary plan:

- Develop a framework of Z tag and 2D analysis for three body decays of  $ZZZ^*$  (W can be easily implemented)
- Study the gain of precision with the simulation data at CEPC.
- Publish two papers if possible.