ZHH analysis with LCFI package

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Outline

- Introduction
- Fast MC results using LCFI package
- Current status
- Summary

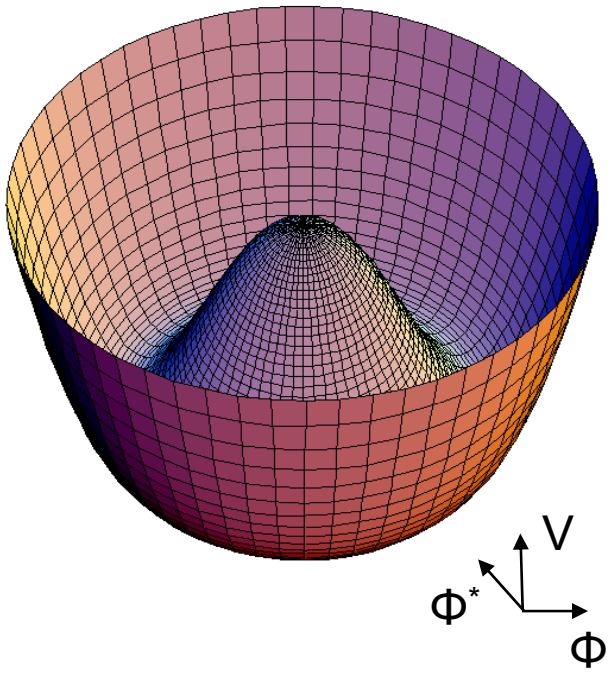
Introduction

- Higgs physics – a major interest of ILC

$$V = -\mu^2|\phi|^2 + \lambda|\phi|^4$$

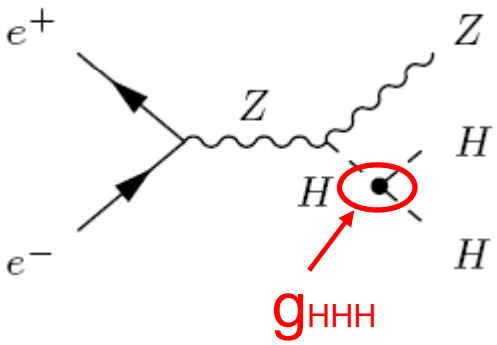
$$m_h = \sqrt{2\lambda}v$$

- M_H proportional to Higgs coupling strength



Introduction

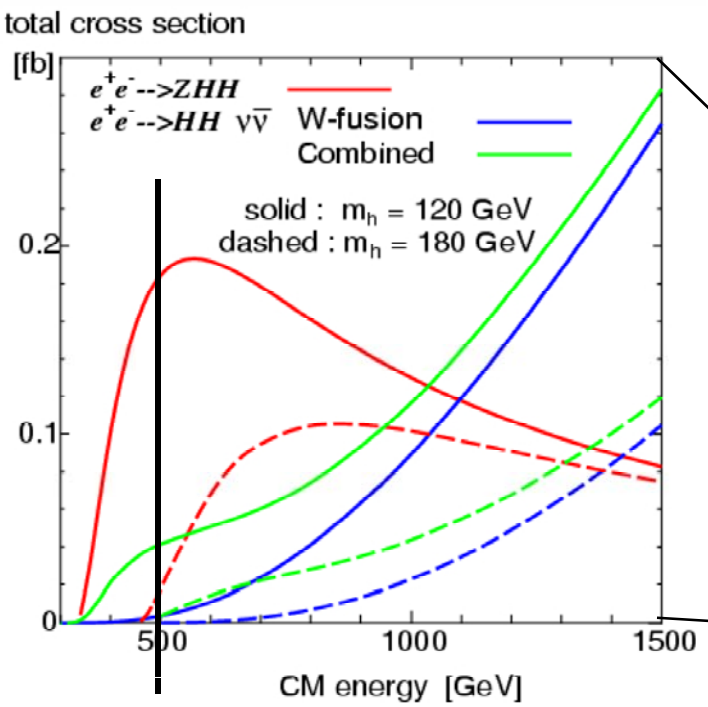
- To experimentally determine the shape of the Higgs potential the self-coupling of the Higgs field must be measured

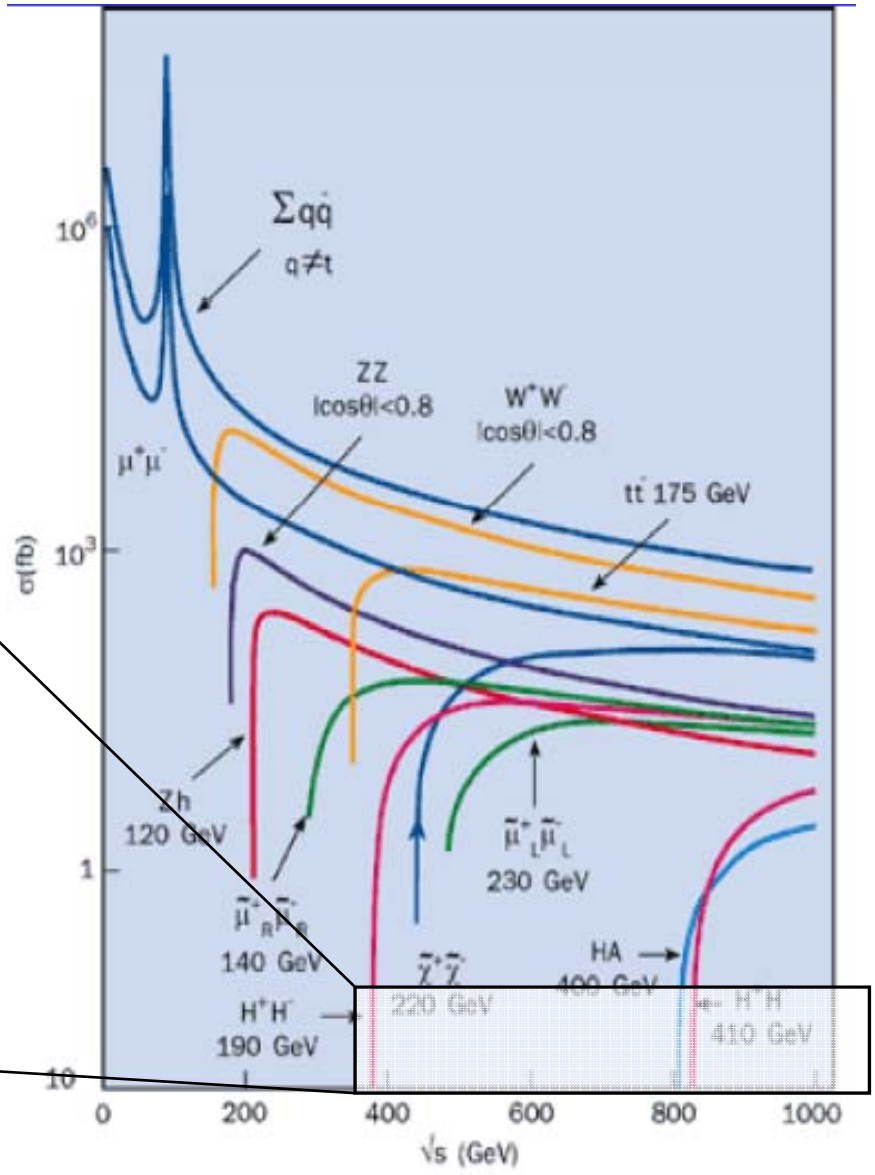


- e+e- → ZHH gives independent measurement of Higgs self-coupling constant

Introduction

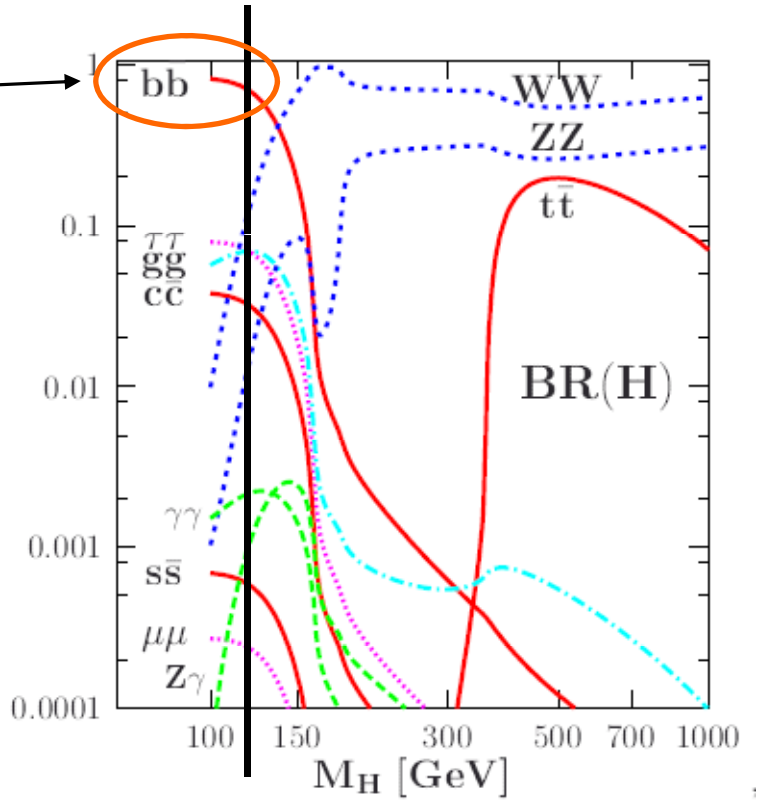
- ZHH: Small cross section
  - ~0.1 fb (√s= 500GeV for M_H = 120GeV)





Introduction

- ZHH decay modes:
  - a light Higgs → b bbar
  - Z: hadronic ~70%
    leptonic ~10%
  - ZHH→bbbbll easy signature but low BR
  - ZHH →bbbbqq high BR but more complicated analysis



Introduction

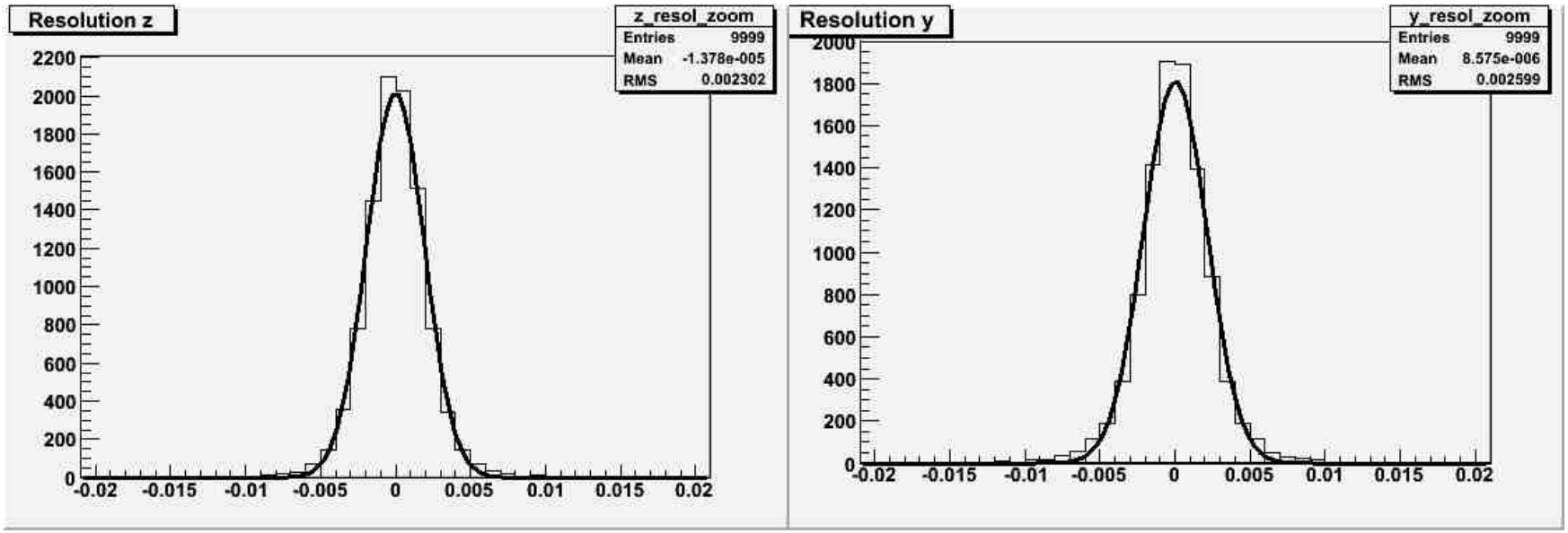
- >=4 b-jets! Requirements:
  - Relatively clean background
  - Excellent b-tagging efficiency
- Linear Collider Flavour Identification
- LCFI vertexing package (released in May 2007):
  - Jet finding
  - Jet flavour tagging: b, c and light jets
  - Vertex finding and fitting
  - Vertex charge determination

Fast MC results

- We start with SiD FastMC simulations to develop the analysis which also applies to full MC and PFA data.
  - ZHH signal and tt (tbW) background
  - No material effects
  - With/without beamspot constraint
- LCFI vertexing package.
  - Focus on hadronic decay of Z: qqbbbb final state
  - Enforce six jets to be found by the jet finder
- Follow analysis of Tim Barklow (*http://ilcagenda.linearcollider.org/materialDisplay.py?contribId=154&sessionId=71&materialId=slides&confId=1296*)

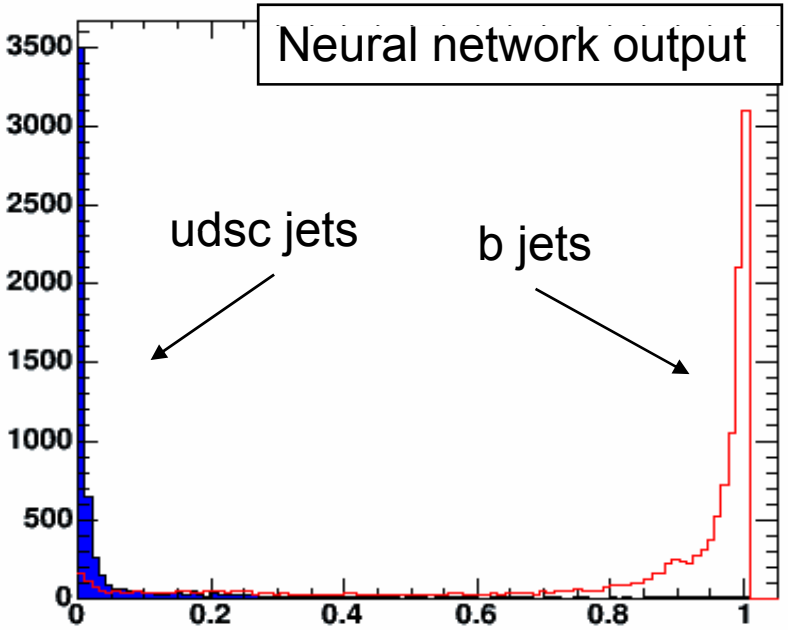
Fast MC results

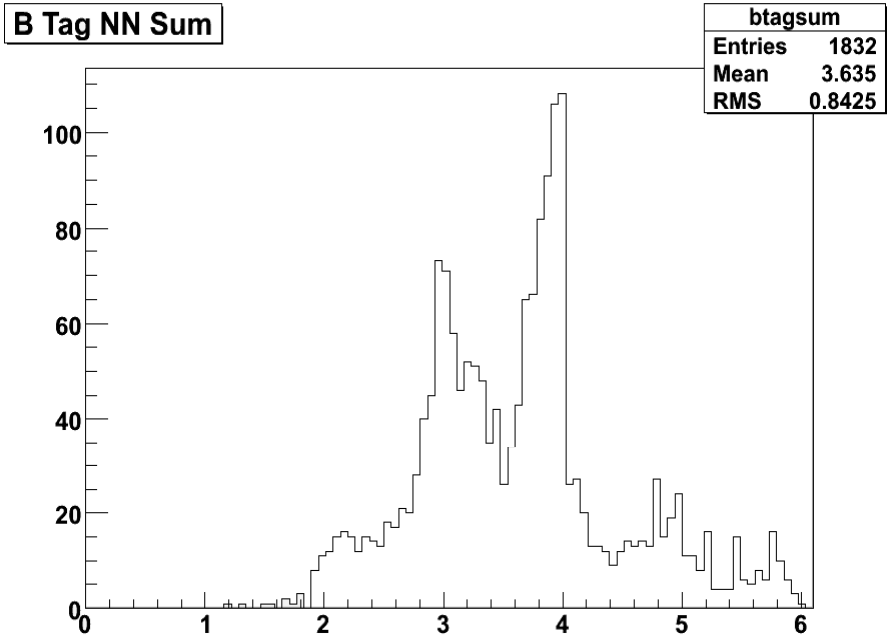
- Primary Vertex Reconstruction
  - 2 μm in z-direction;
  - ~2 μm in x-y plane without beamspot constraint



Fast MC results

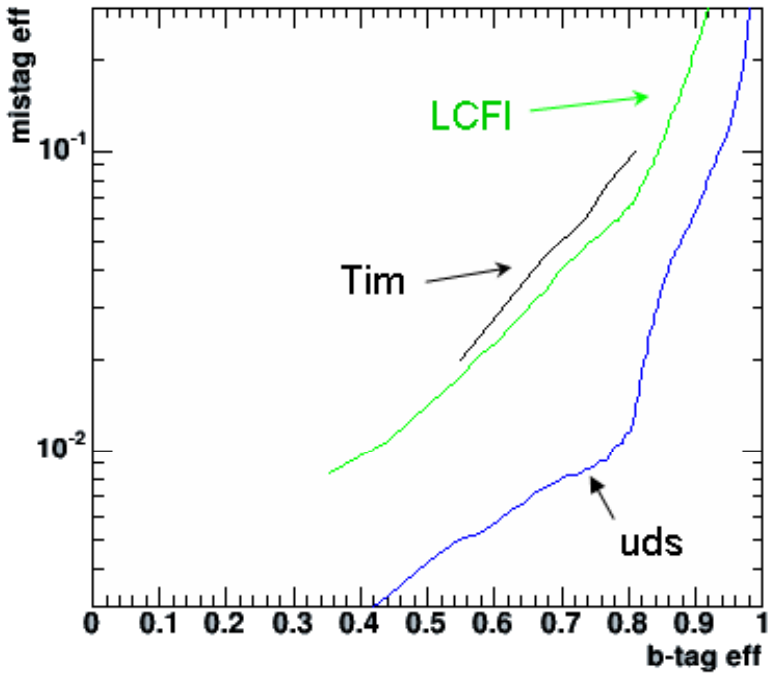
- Neural Network output:
  - b, non-b jets well separated
- Total jets of NN



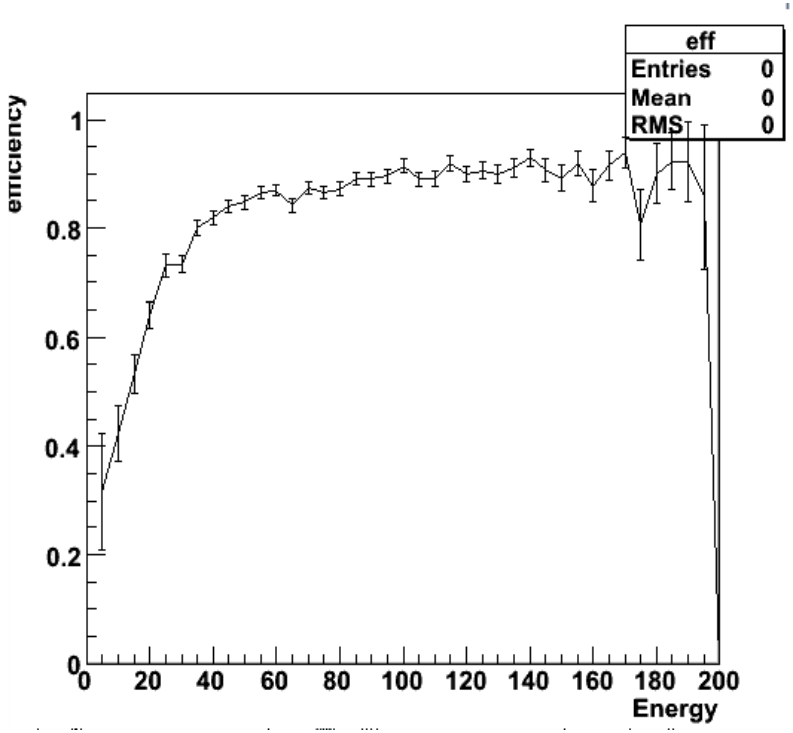


Fast MC results

- NN performance: c-mistagging vs b-efficiency



- Efficiency vs energy

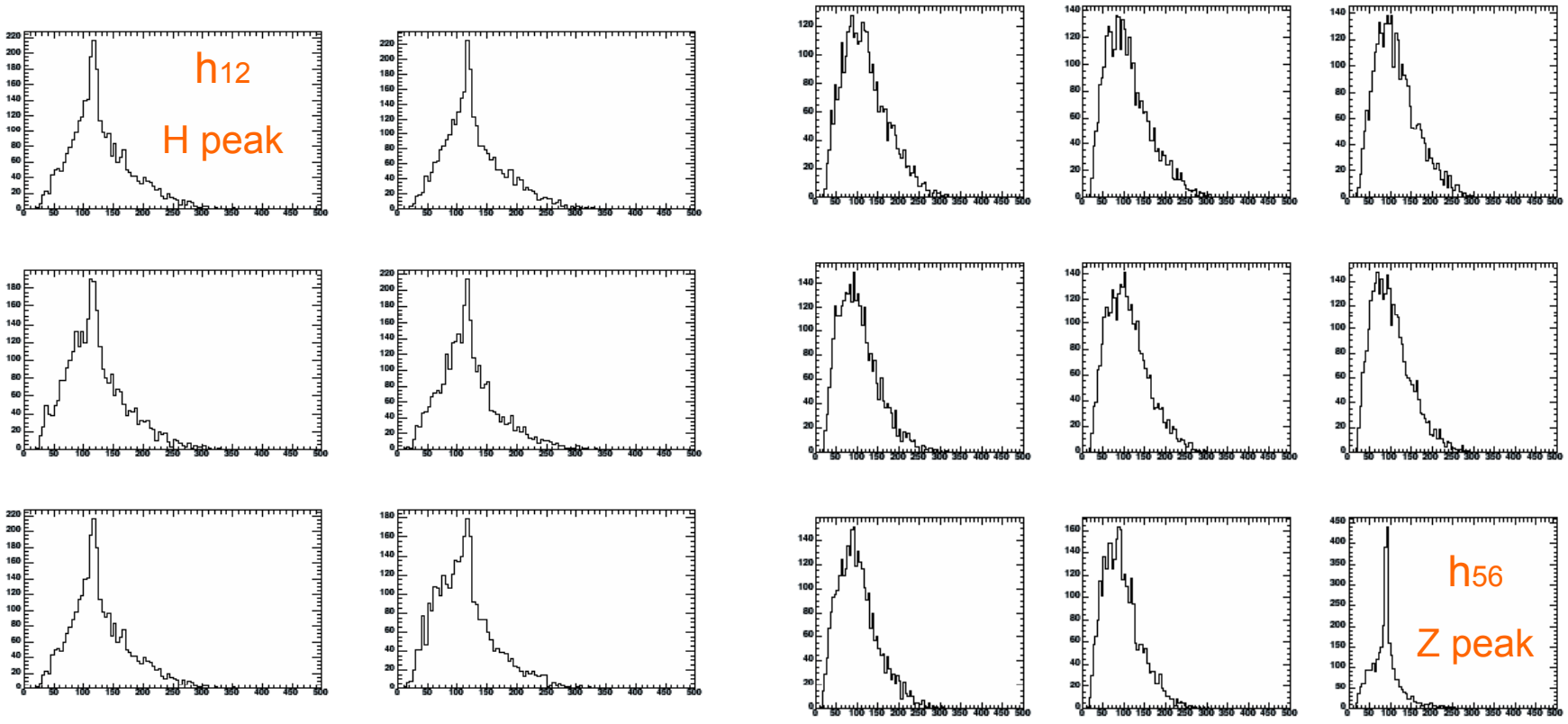


Fast MC results

- Invariant masses:
  - Jets ordered according to their tagging NN output
  - Most b-like jet: 1 … least b-like: 6
  - Invariant mass of two b jets produced from the same parent Higgs will give the Higgs mass

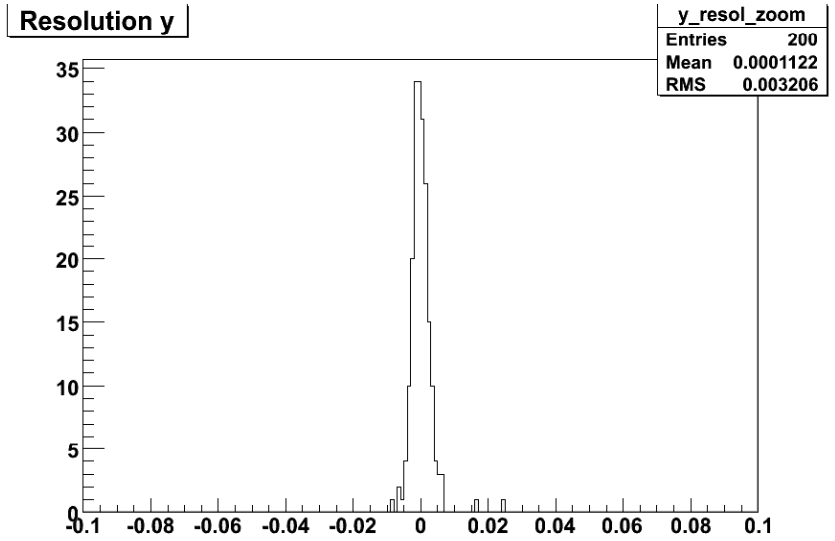
Fast MC results

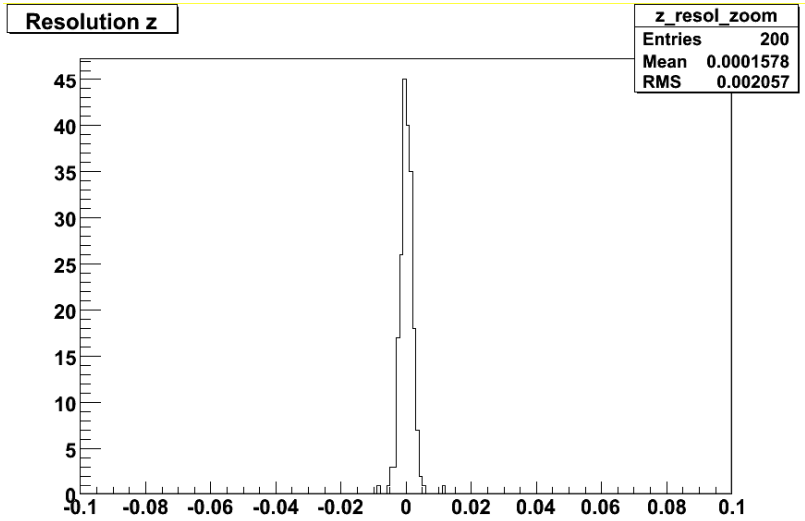
- Invariant masses: clear H and Z peaks



Current status

- Full MC simulation:
  - GEANT4
  - Perfect Particle Flow
- Vertex resolution OK
  - x,y ~3um; z~2um

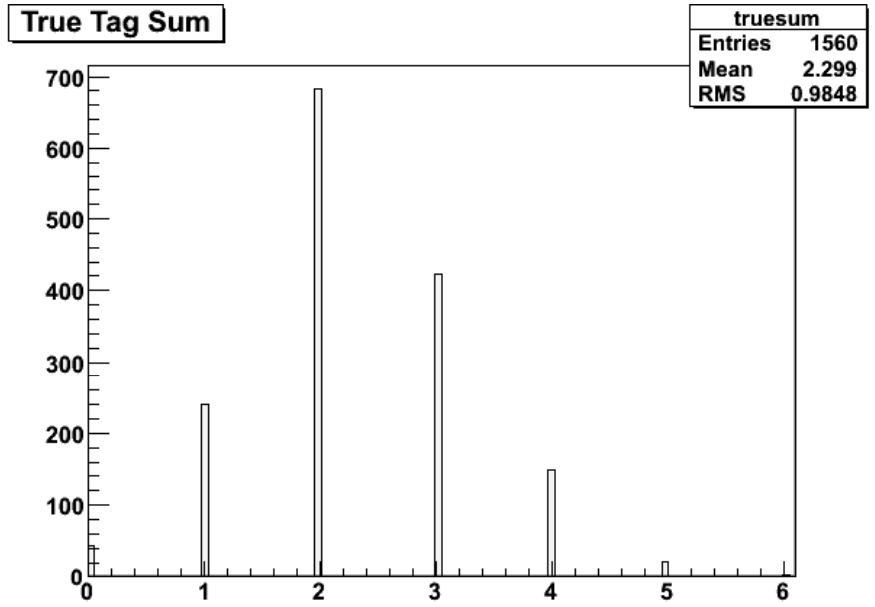




Current status

- B tagging efficiency much lower
- NN results not quite right: total b jets # not consistent with our bbbbqq final state

Problem with MC information?



Future

- Add event cuts
- Add remaining SM backgrounds
- Train NN to separate signal from background
- Calculate cross section error and thus self-coupling error
- Investigate the vertex charge information
- …

Summary

- ZHH as a benchmarking process: important in understanding Higgs potential
- Small cross-section of zhh channel places high requirement on flavour tagging
- LCFI package works well with fast MC data; neural network analysis allows accurate b-tagging
- More difficulty with full MC and PFA than fast MC, still in progress