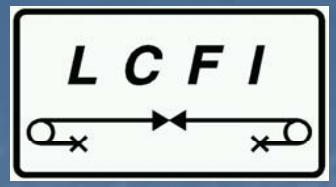


Measuring H → cc branching ratio at the ILC

Yambazi Banda (Oxford)

IOP HEPP 2009

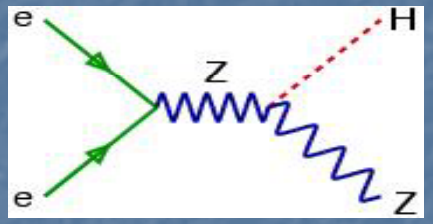
- Motivation, ILC, SID
- Tools
- ZH Analysis
- Results
- Summary

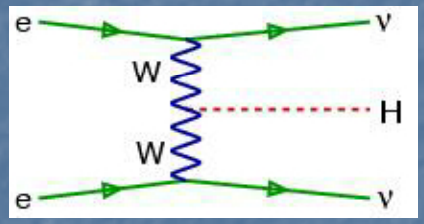
Motivation

- In the Standard Model we expect at least 1 isodoublet with a neutral component having a non-zero VEV corresponding to a physical *Higgs* boson
- SM Higgs (LEP)
  - $M_H > 114.4$ GeV @95% CL
- Electroweak fits to high Q^2 measurements give:
  - $M_H = 90^{+36}_{-27}$ GeV
  - $M_H < 163$ GeV
- Likely that LHC will discover Higgs or exclude its existence
- ILC will provide precision measurements e.g.
  - Absolute couplings
  - Rare Higgs decays
  - Higgs potential

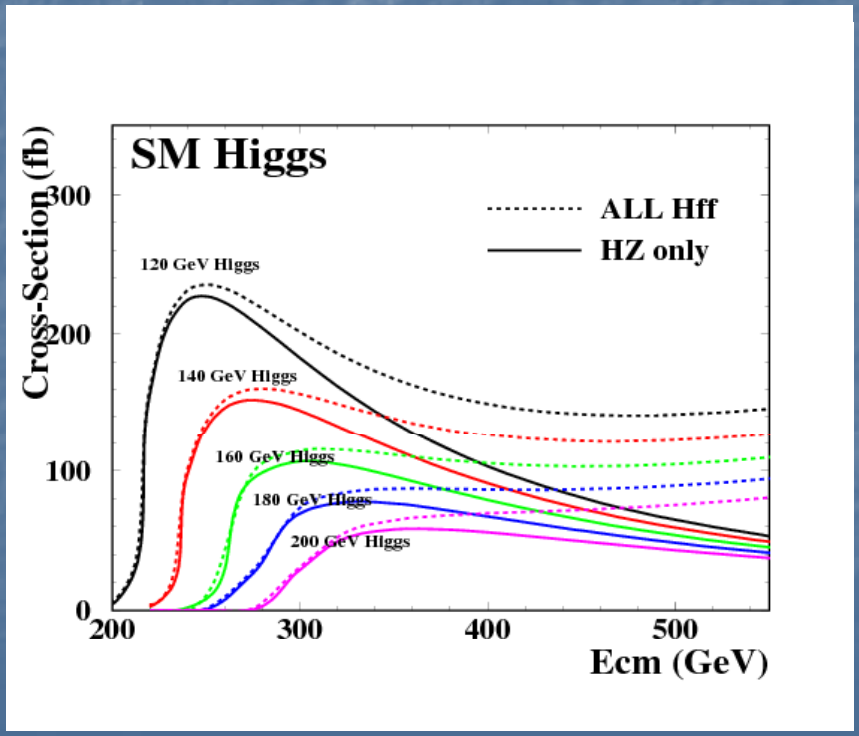
Higgs production at the ILC

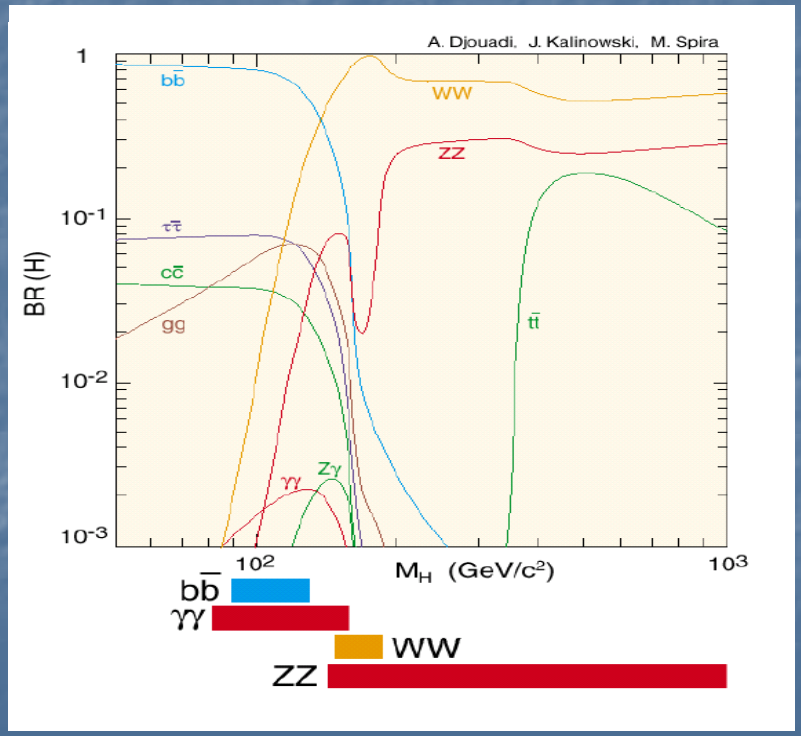
Dominant production processes at ILC:



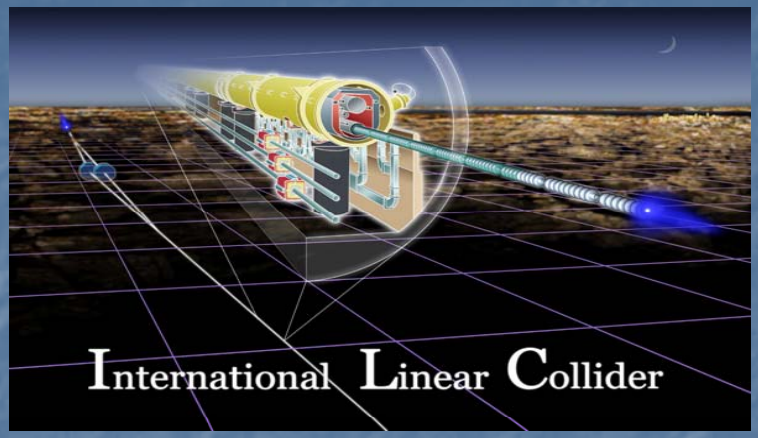


SM Higgs Branching Ratios



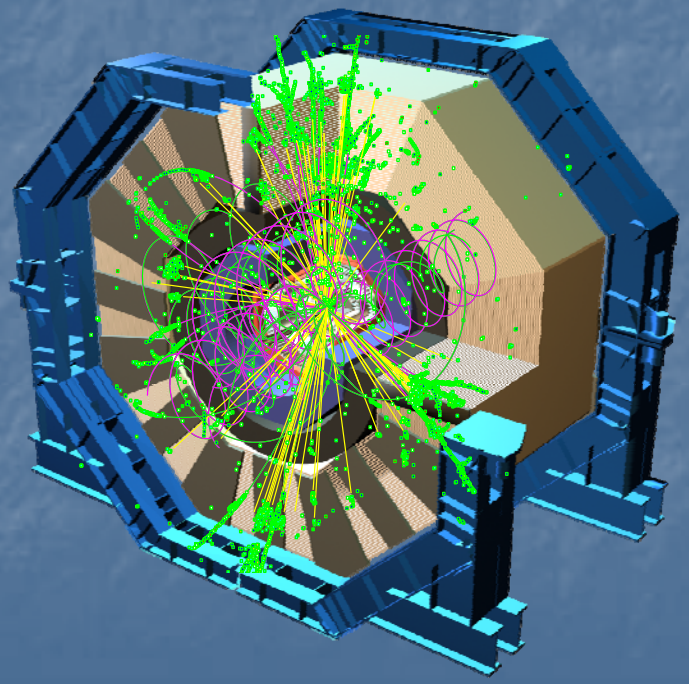


ILC and SiD



e+e- collider @ 0.5 – 1 TeV

length ~31 Km

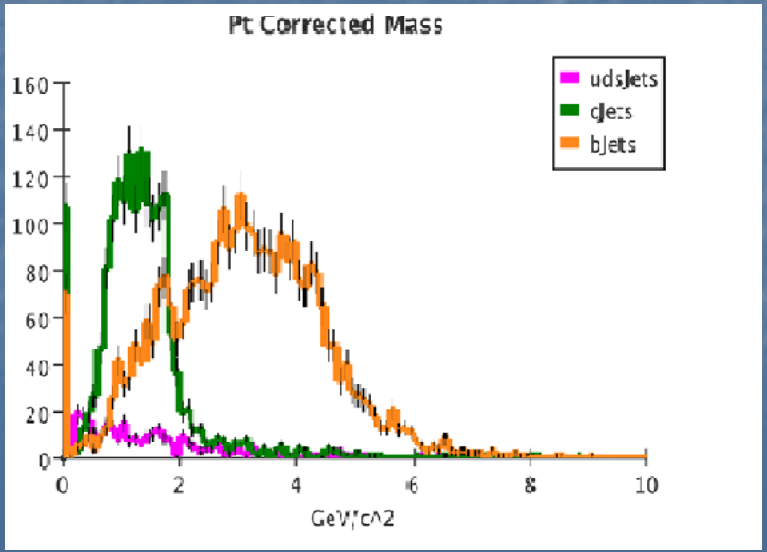


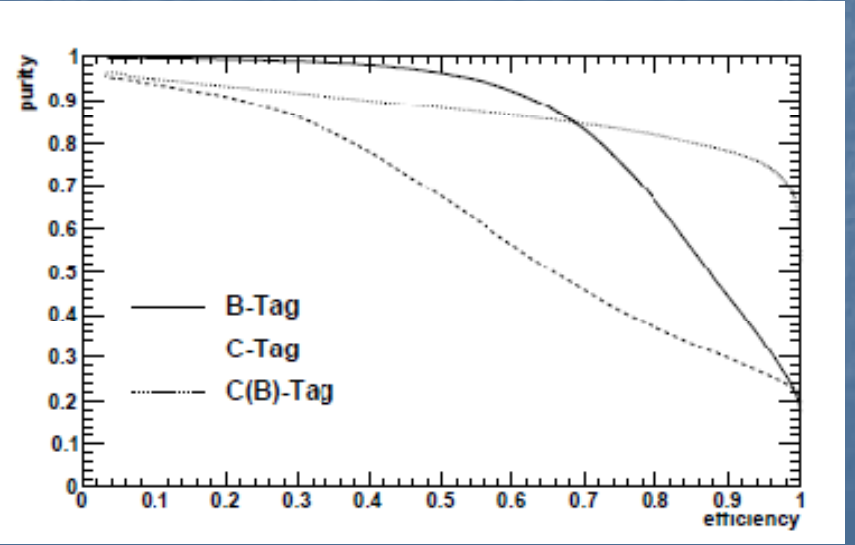
- Silicon Detector Design study developing detector concept for the ILC

- SiD concept incorporates Si electromagnetic calorimetry and Si tracking in a detector design attempting to optimise physics performance

Tools: LCFI Package

- Distinguishing b-jets, c-jets and light quark jets
- LCFI collaboration coded and implemented procedure developed by R. Hawkings (LC-PHSM-2000-021)
- Tagging inputs include:
  - vertex momentum,
  - number of tracks in secondary vertices …





ZH Analysis - *Data Samples*

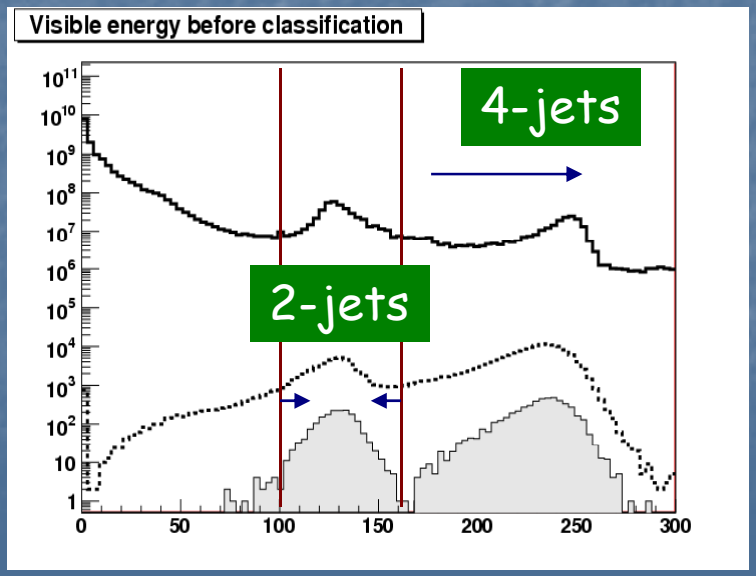
- The signal sample includes a Higgs boson produced through Higgsstrahlung, e+e- → ZH and the background includes a mixture of standard model processes.

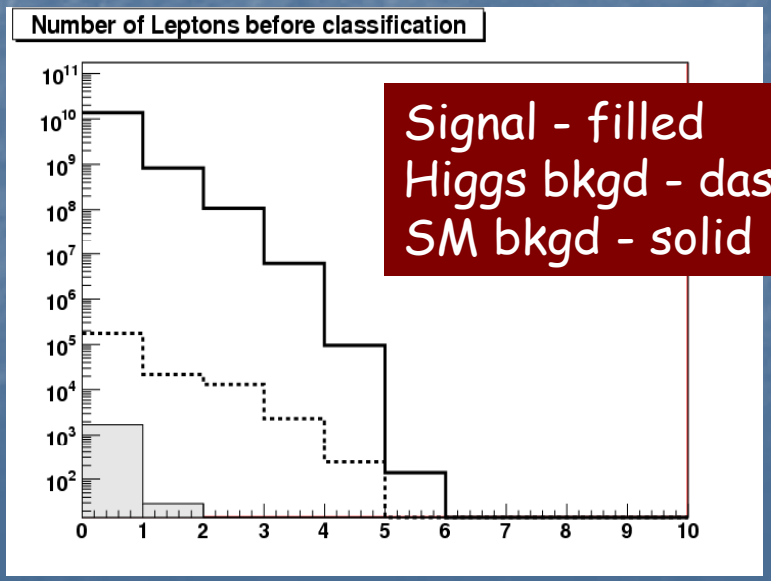
- For data samples the following are assumed:
  - Centre-of-mass = 250 GeV (*peak xsec for higgstrahlung*)
  - Integrated luminosity = 250 fb-1
  - Signal Higgs mass = 120 GeV
  - +80% e- polarization, -30% e+ polarization

- Currently, fully reconstructed samples are used for the study
  - ~ 7 Million Standard Model Background Events
  - ~ 200 000 inclusive signal events

ZH Analysis - *Event Selection*

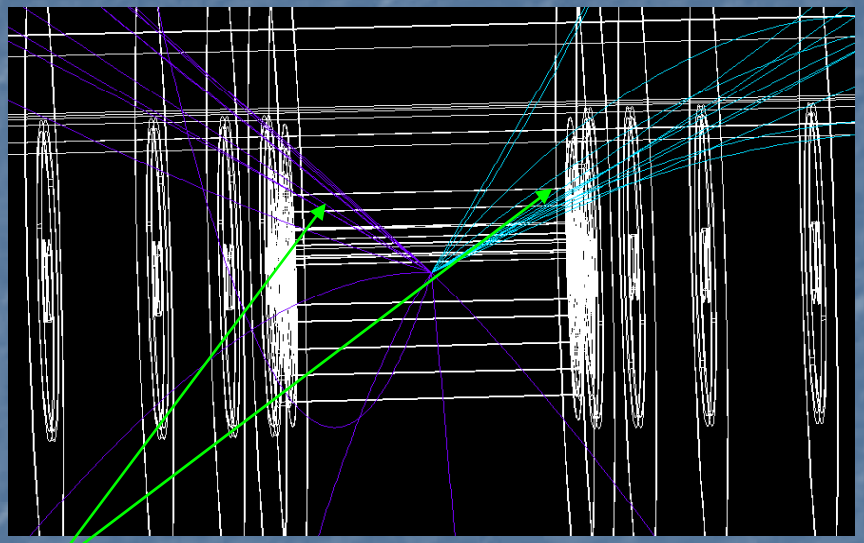
- The first step of event selection involves classification of events into two decay modes depending on the decay products of the Z boson. This classification is done based on the visible energy and number of leptons in an event.
  - Visible energy here is the sum of the energies of reconstructed particles
  - A lepton is defined to be a reconstructed electron or muon with a minimum momentum of 15 GeV





Neutrino Channel

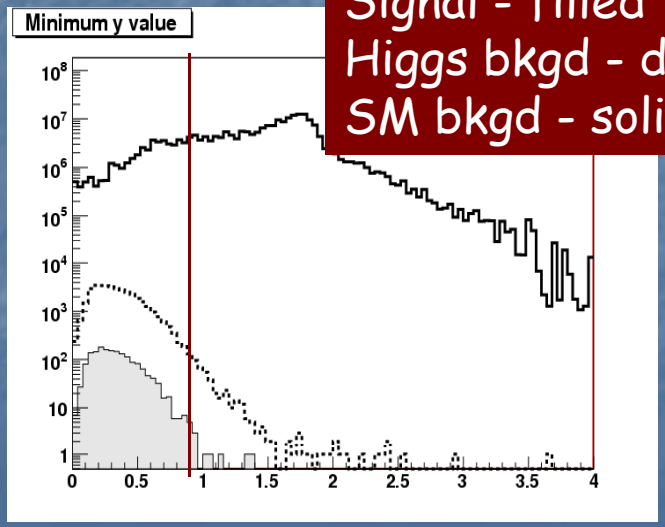
- Events clustered to 2 jets and no isolated leptons required



2 jets + missing Energy

Selection cuts include:

- $20 < pT < 90$
- $-\log(y_{min}) < 0.8$
- thrust < 0.95
- 100° < angle between jets < 170°
- 100 GeV < inv. Mass < 140 GeV
- energy of isolated photon < 10 GeV

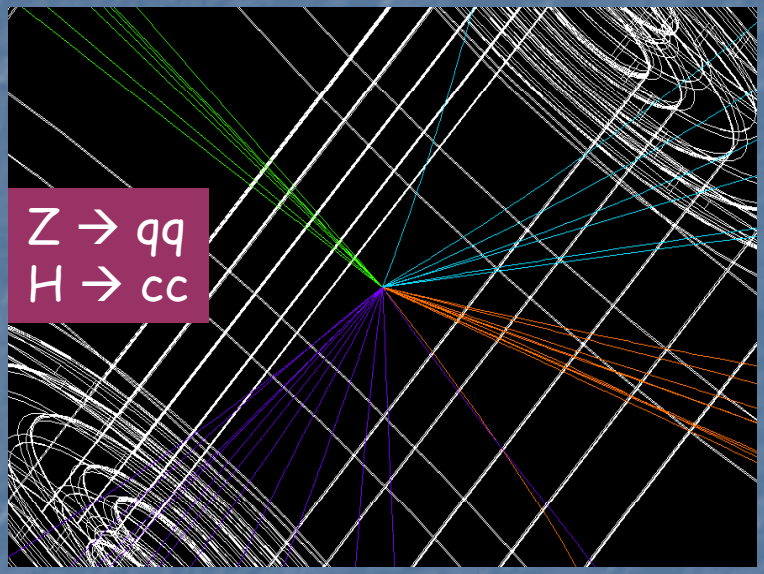


Signal - filled
Higgs bkgd - dashed
SM bkgd - solid

- Z boson decays to νν and recoil mass consistent with Z mass
- di-jet mass consistent with Higgs mass

Hadronic Channel

- Events clustered to 4 jets and no isolated leptons required

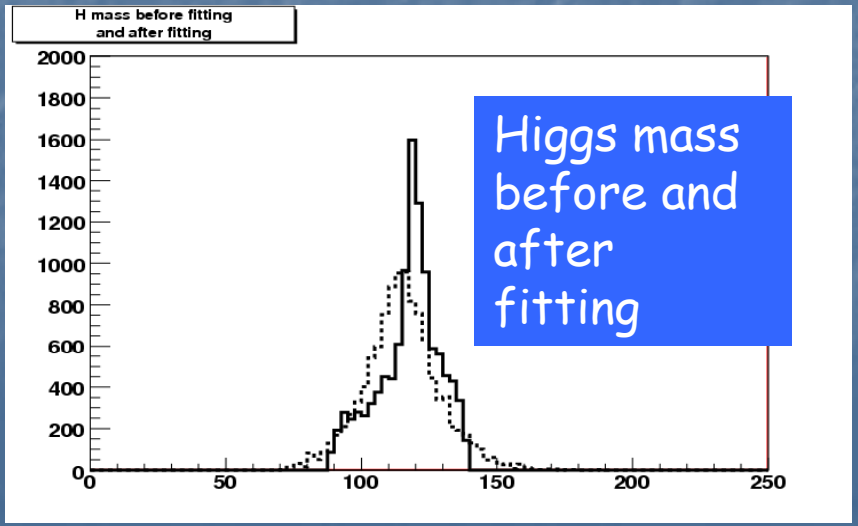


Which 2 jets come from Higgs (assuming c decay) ?

Make 5C fit with energy and momentum conservation and mass of one di-jet compatible with Z. Done for all combinations.
Kinematic fitter info used to choose proper pairing

Selection cuts include:

- number chrgd tracks > 4
- $-\log(y_{min}) < 2.7$
- thrust < 0.95
- 95 GeV < H mass < 145 GeV
- 45 GeV < Z mass < 105 GeV



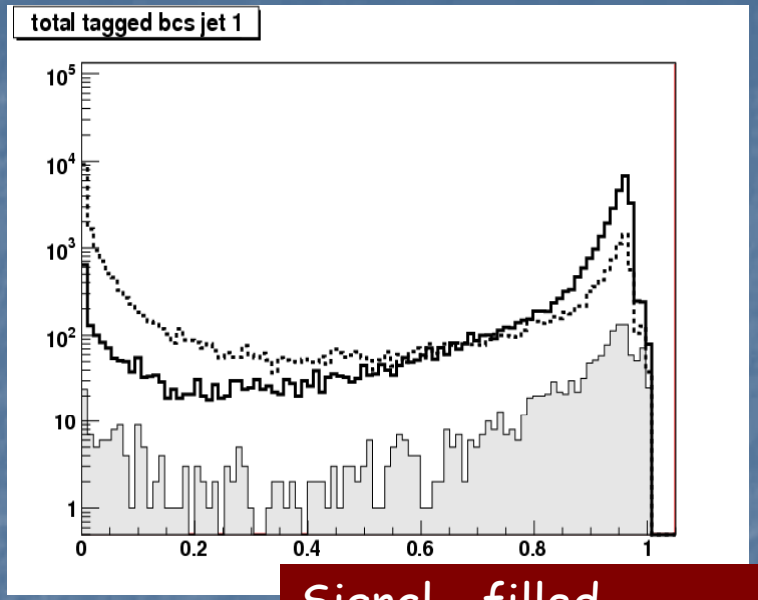
Higgs mass before and after fitting

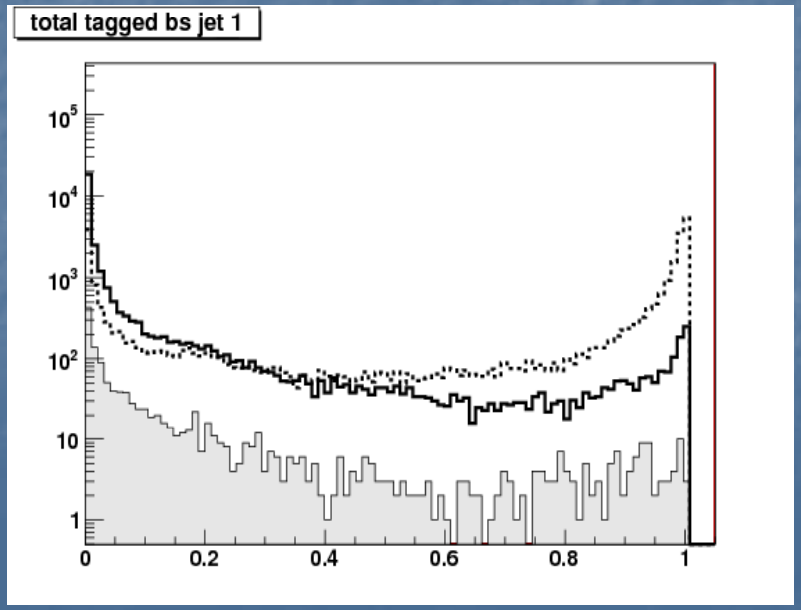
Tagging outputs

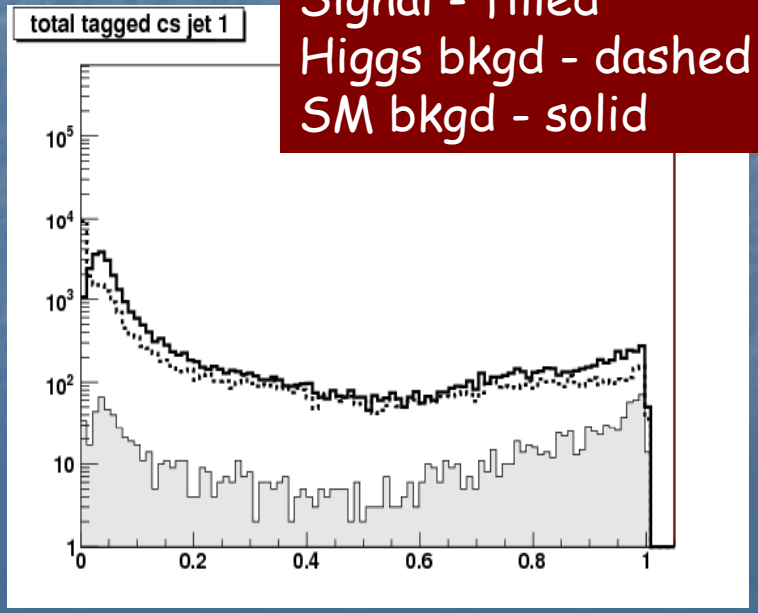
- Flavour tagging outputs are 2 jets (neutrino) and 4 jets (hadronic) are Used as some of the inputs to the Neural network for final selection.

-The outputs include b-tag, c-tag and c with b only background tag

-Use of all 3 tagging outputs helps
-Further suppression of background







Signal - filled
Higgs bkgd - dashed
SM bkgd - solid

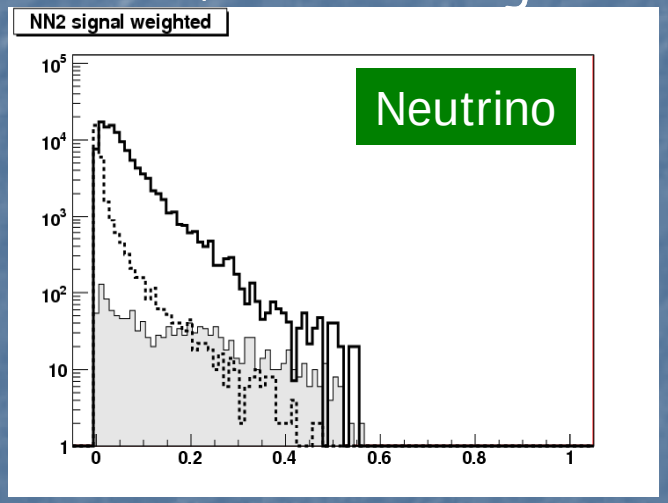
Neural net selection

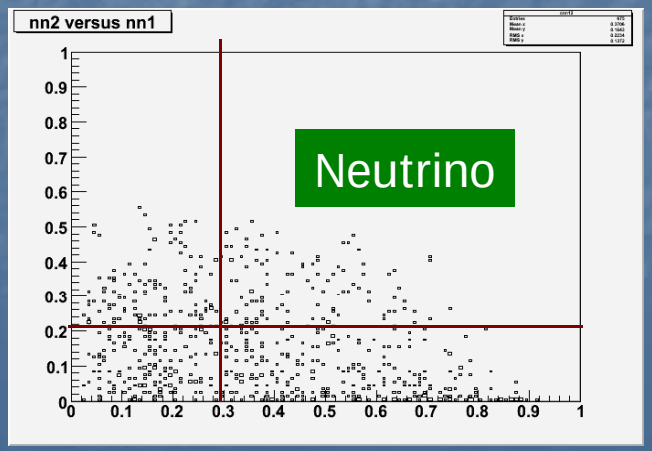
- After pre-selection, all remaining events used in a neural network selection for signal and background separation
- All events surviving neural network cut used for branching ratio extraction

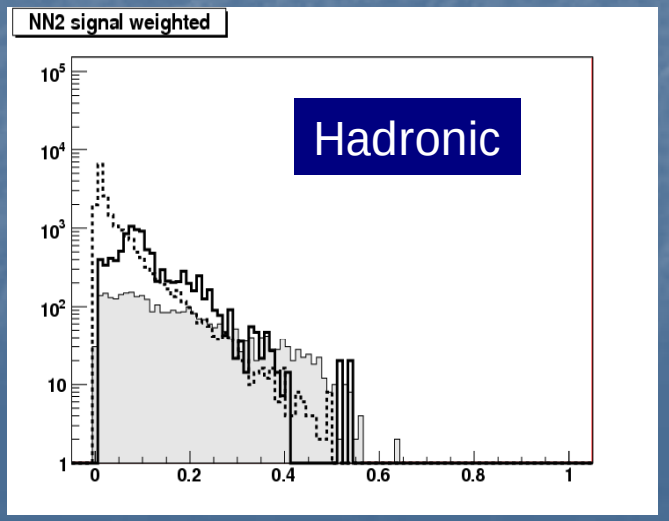
Two nets are produced in this selection:

- First net distinguishes SM background from inclusive Higgs sample (NN1)

-Second net distinguishes Signal from inclusive Higgs sample (NN2)







Results

Final numbers and results are shown below:

	Neutrino	Hadronic
# Sig. events	476	814
# SM events	570	569
# Higgs bk events	246	547
Signal efficiency	28%	47%
Signal σ	6.8±0.7 fb	6.9±0.4 fb
Br (H->cc)	3.3±0.4%	3.3±0.2%
ΔBr/Br	~ 11%	~ 6%

- $\Delta BR/BR =$

$$\sqrt{((\Delta\sigma/\sigma)^2_{cc} + (\Delta\sigma/\sigma)^2_{zh})}$$

with
$\Delta\sigma/\sigma = \sqrt{(sig + bkgd)/sig}$

- Since $(\Delta\sigma/\sigma)_{zh}$ (obtained from recoil mass analysis) is small, the relative uncertainty in the branching ratio is dominated by the precision of the signal cross section.

Summary

- Discovery of Higgs important for HEPP
- Measurement of Higgs Branching fractions will help determine nature of Higgs
- Necessary flavour tagging tools developed to aid Higgs BR measurements
- Preliminary results obtained for H->cc branching fraction and associated uncertainty