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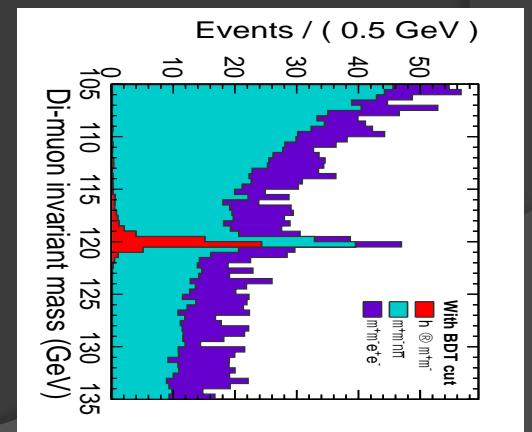
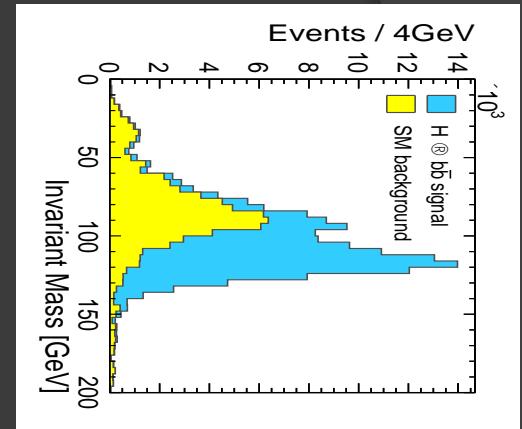
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# ANALYSES OF LIGHT HIGGS DECAYS FOR THE CLIC CDR

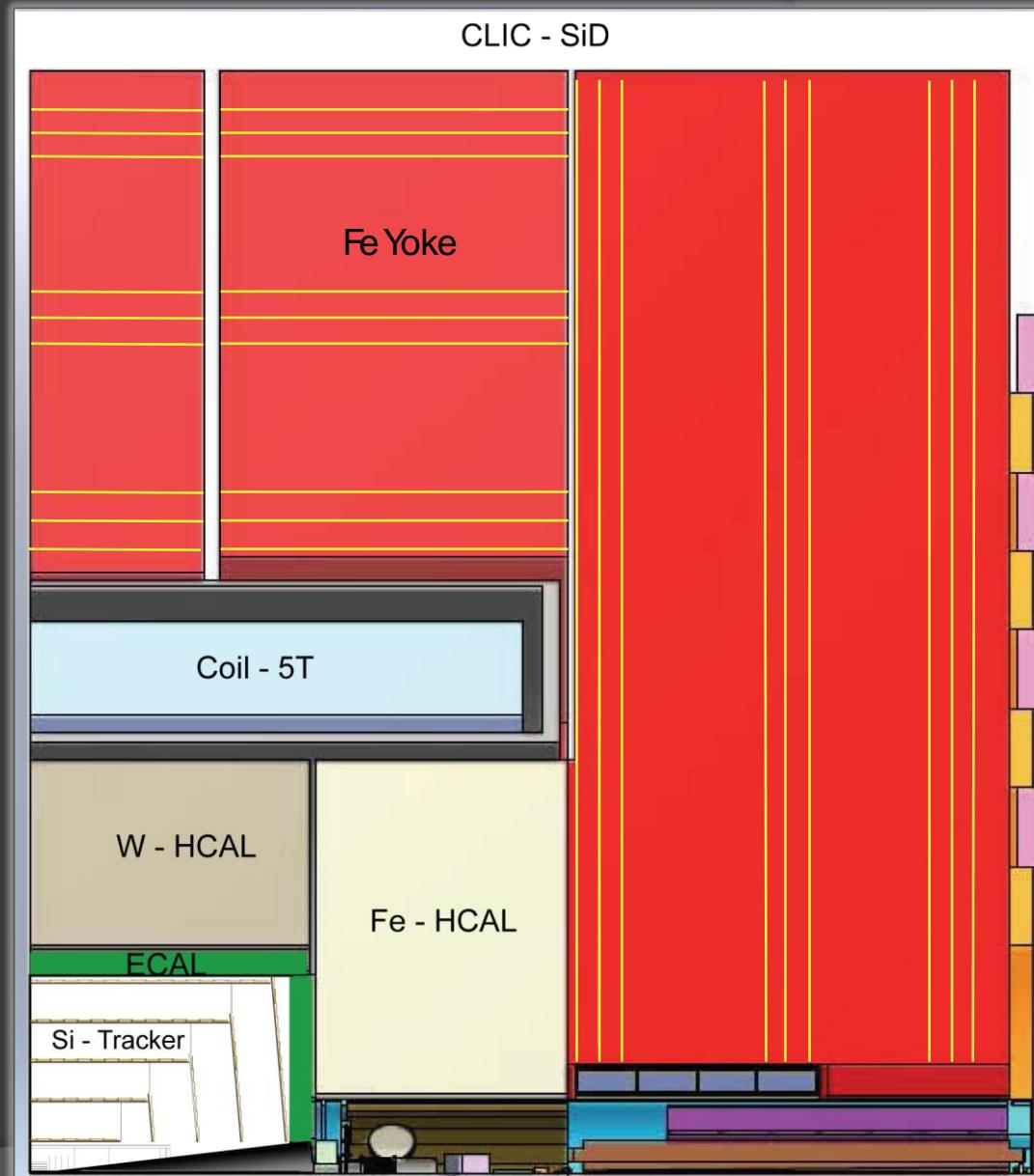
# Overview

- CLIC environment
- $H \rightarrow b\bar{b}$ 
  - Largest BF in the Standard Model
  - Flavour Tagging (in the presence of background)
- $H \rightarrow \mu\mu$ 
  - Coupling to second-generation fermions
  - Momentum resolution (in the forward region)
- Summary



# The CLIC environment

- CLIC\_SiD detector
  - Similar to SiD detector
  - 27 mm radius inner vertex layer
  - $7.5 \lambda$  W-HCAL barrel
  - Tracking coverage down to  $10^\circ$

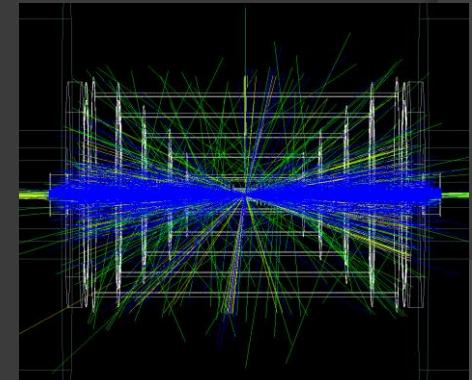
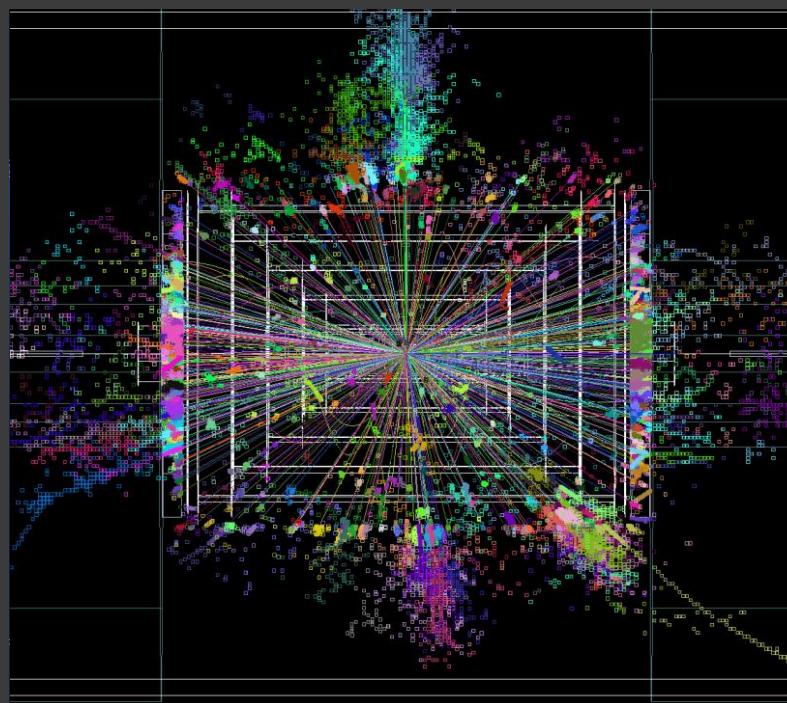
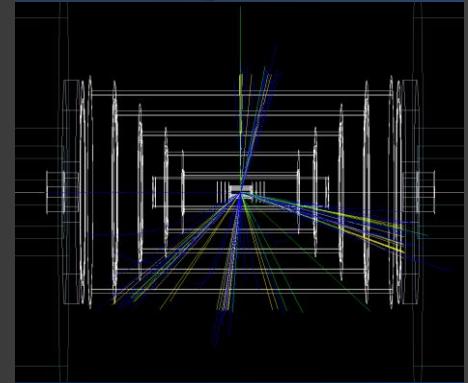


# The CLIC beams

- 0.5 ns bunch spacing
- 312 bunches / train
- 50 Hz train repetition rate

# Backgrounds at CLIC

- 19 TeV from  $\gamma\gamma \rightarrow$  hadrons
- 1.2 TeV in a 10ns readout window

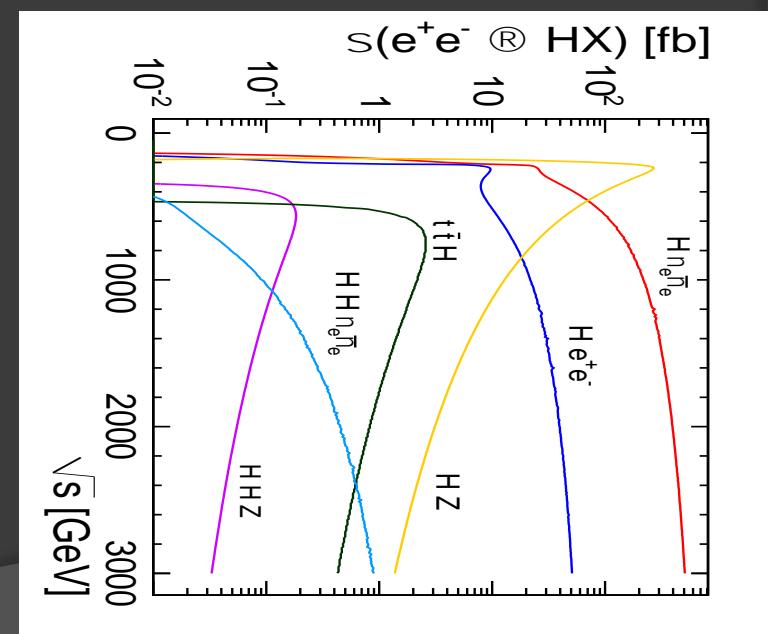
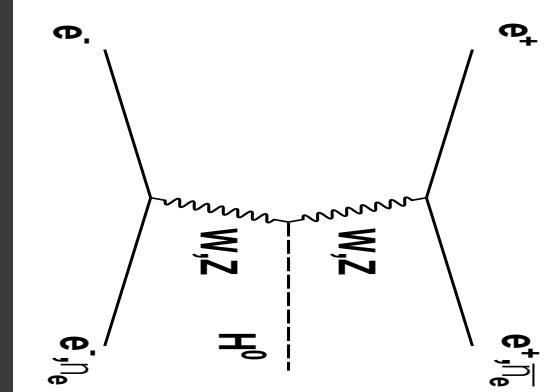


# The CDR benchmark point

Channel	Cross Section (fb)
$\nu_e \bar{\nu}_e H (\rightarrow b\bar{b})$	285
$\nu_e \bar{\nu}_e H (\rightarrow c\bar{c})$	15
$q\bar{q}\nu\bar{\nu}$	1305
$q\bar{q}e\bar{\nu}_e$	5255
$q\bar{q}$	3076
$q\bar{q}e^+e^-$	3341
$\nu_e \bar{\nu}_e H (\rightarrow \mu^+\mu^-)$	0.12
$\mu^+\mu^-\nu\bar{\nu}$	132
$\mu^+\mu^-e^+e^-$	5.4

Standard Model  
 $m_H=120$  GeV

Signal channel



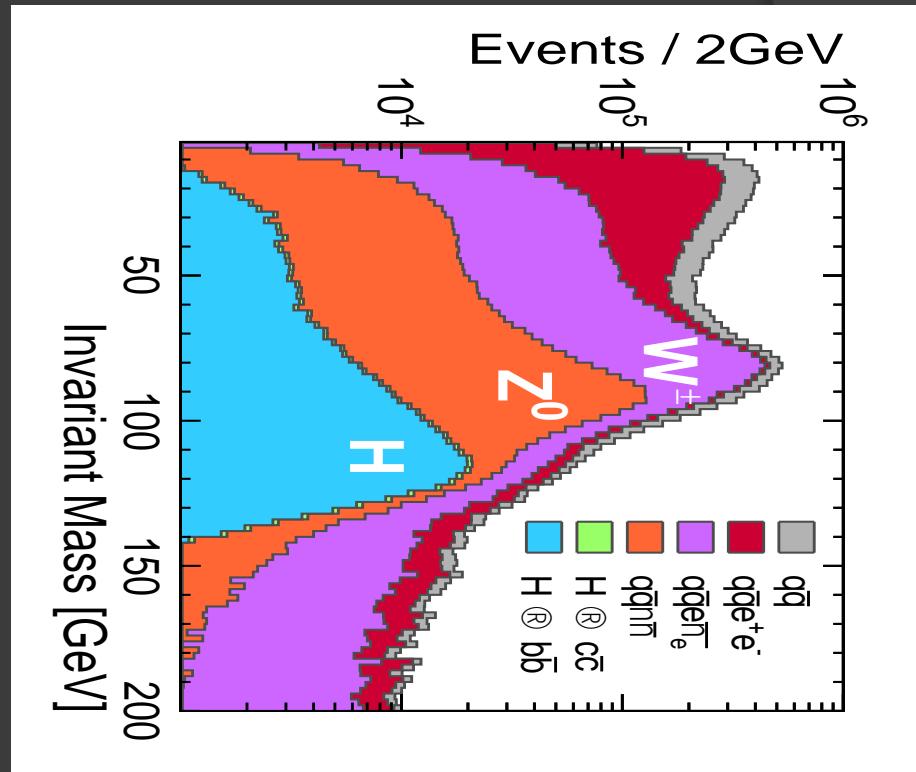
# Setup

- Whizard 1.95 for generation of signal events
- Pythia 6.4 for hadronisation
- 60 BX  $\gamma\gamma \rightarrow$  hadrons mixed in
- GEANT 4 simulation
- Full reconstruction (PandoraPFA)
  - 100 ns readout window in HCAL barrel
  - 10 ns everywhere else
- 2 / ab measurement

# Higgs decays to bottom and charm

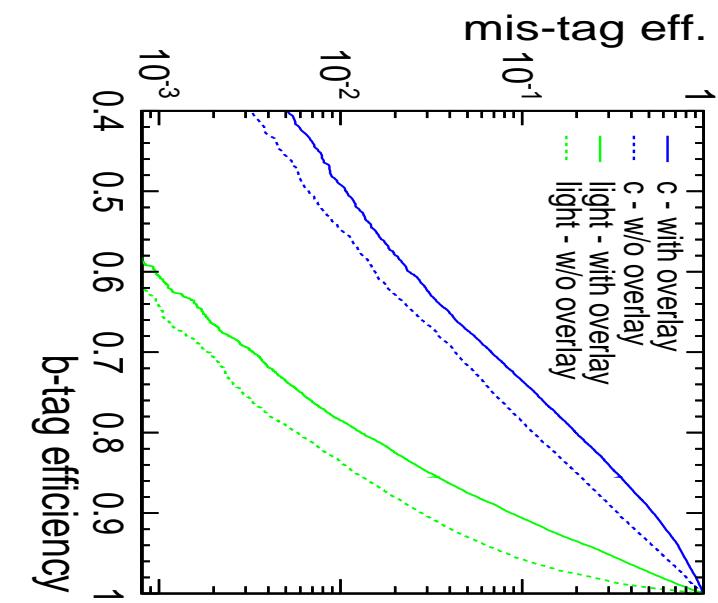
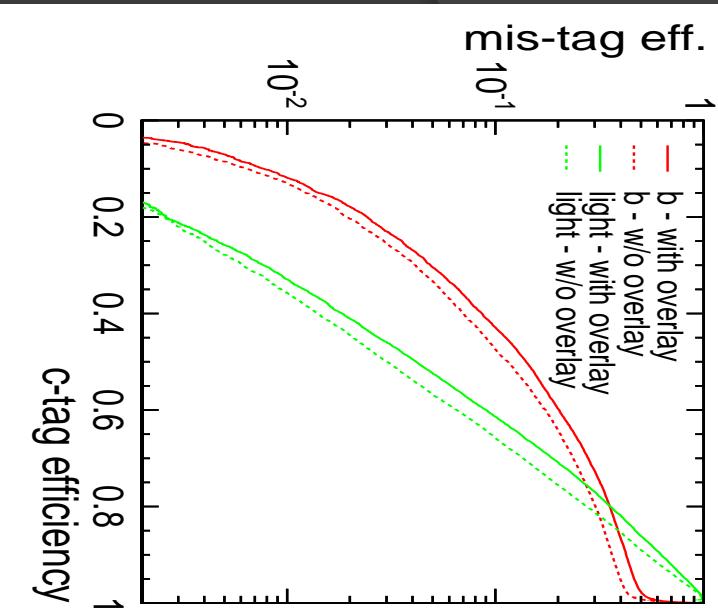
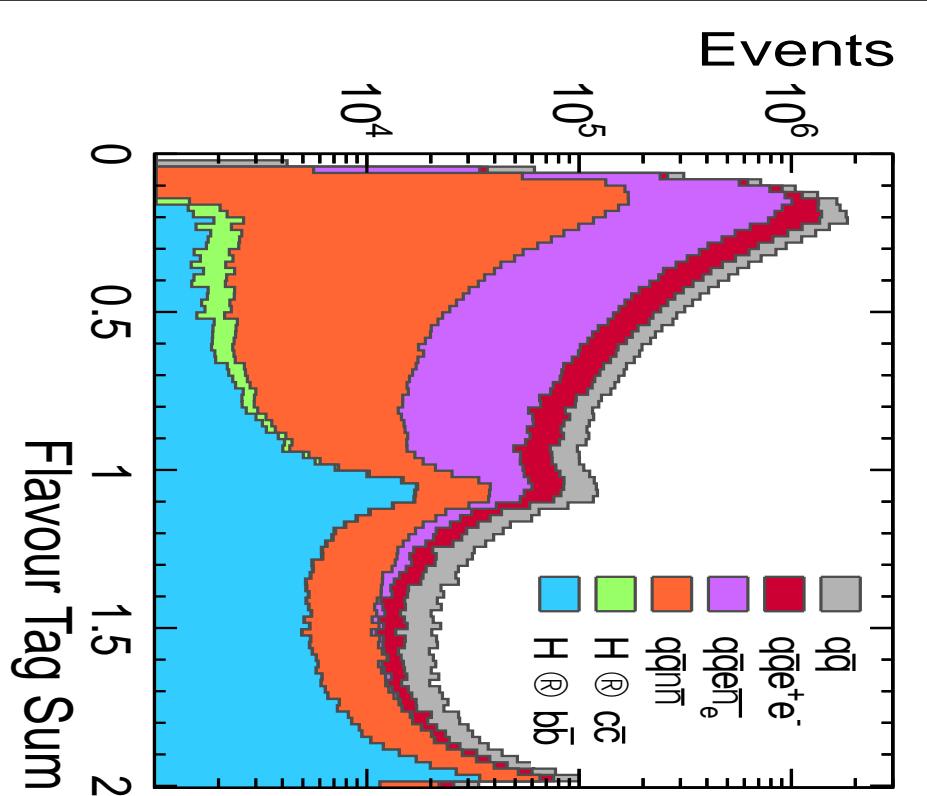
# Pre-selection

- FastJet  $k_t$  algorithm,  
 $R_{\max}=0.7$ 
  - Try to force into two jets
  - Durham algorithm fails in presence of background



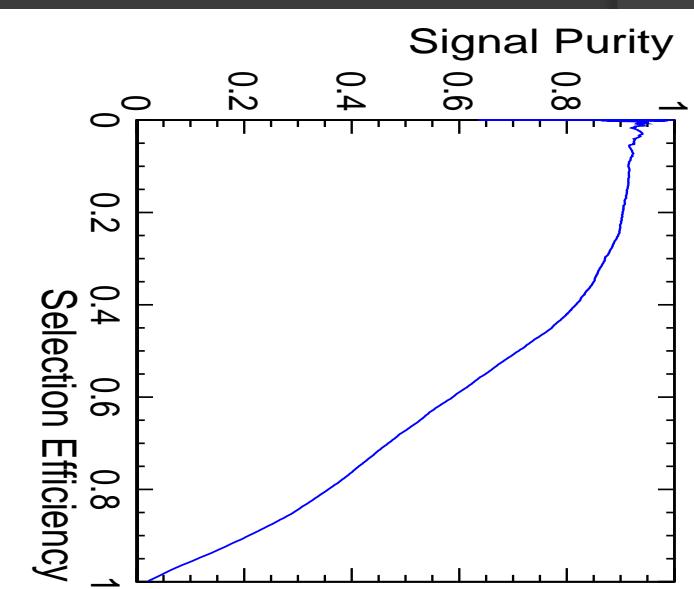
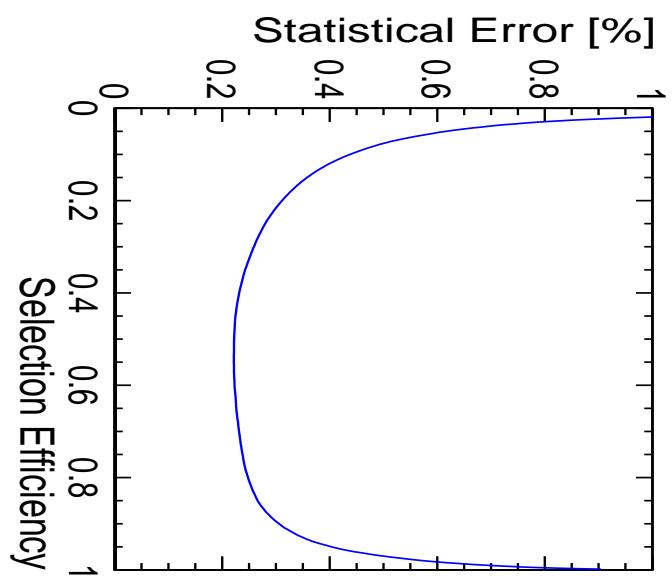
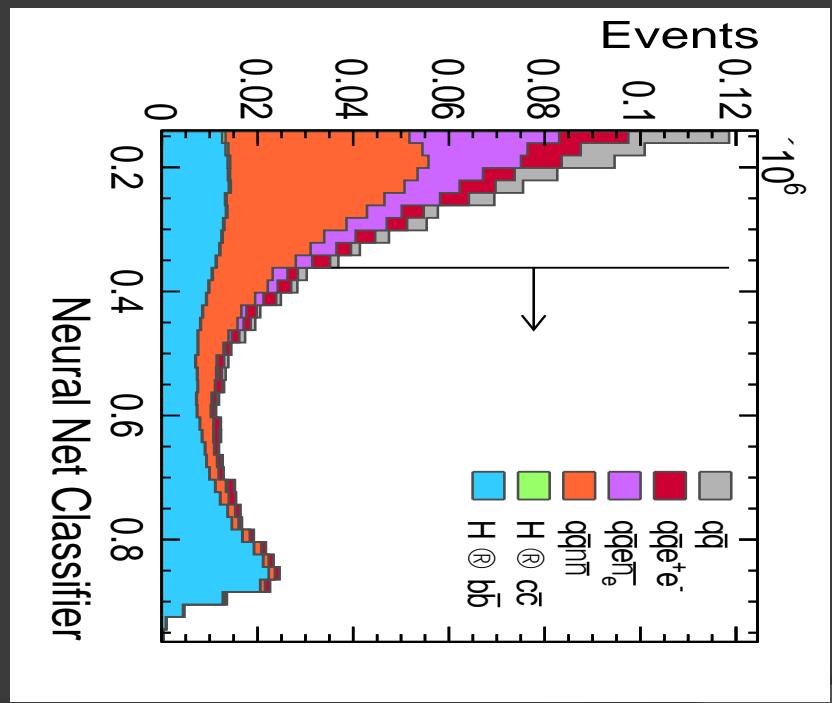
# Flavour Tagging

- LCFI with FastNN neural net



# Event selection

- Supplement flavour tagging network w/ additional variables



# Results

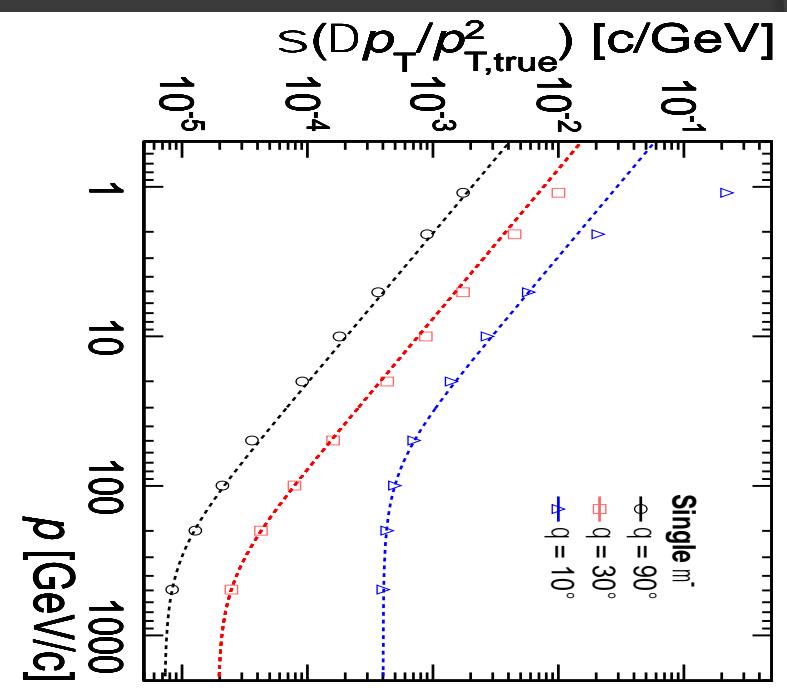
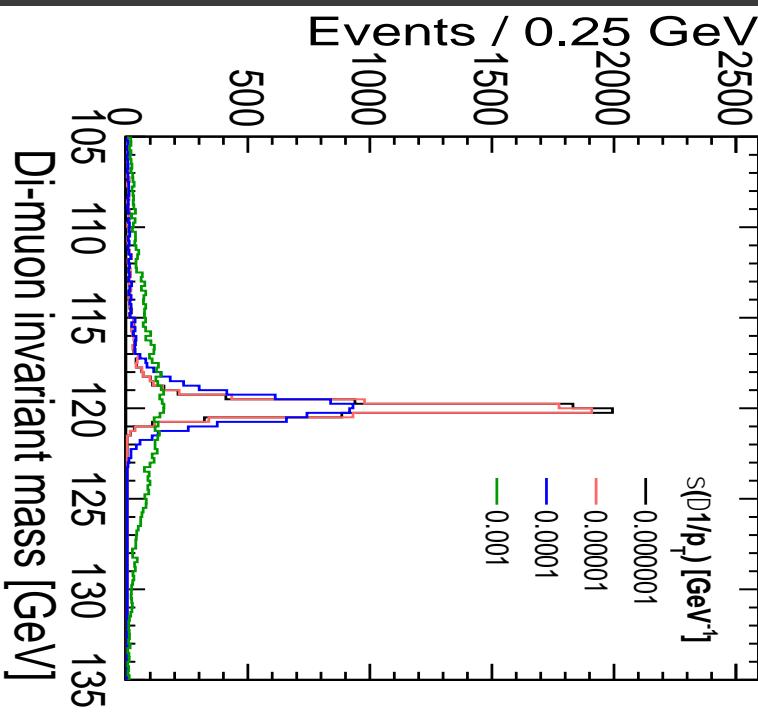
- Cut-and-count method
- Measure signal and background events in “signal box” (NN cut)
- Change definition from b to background and c to signal to measure  $h \rightarrow cc$

	$h \rightarrow b\bar{b}$	$h \rightarrow c\bar{c}$
Signal efficiency	54.6 %	15.2 %
Stat. Uncertainty	0.22 %	3.24 %

# Higgs decays to muons

# Higgs decay to muons

- Rare decay, BF  $\sim 10^{-4}$
- Tests excellent momentum resolution

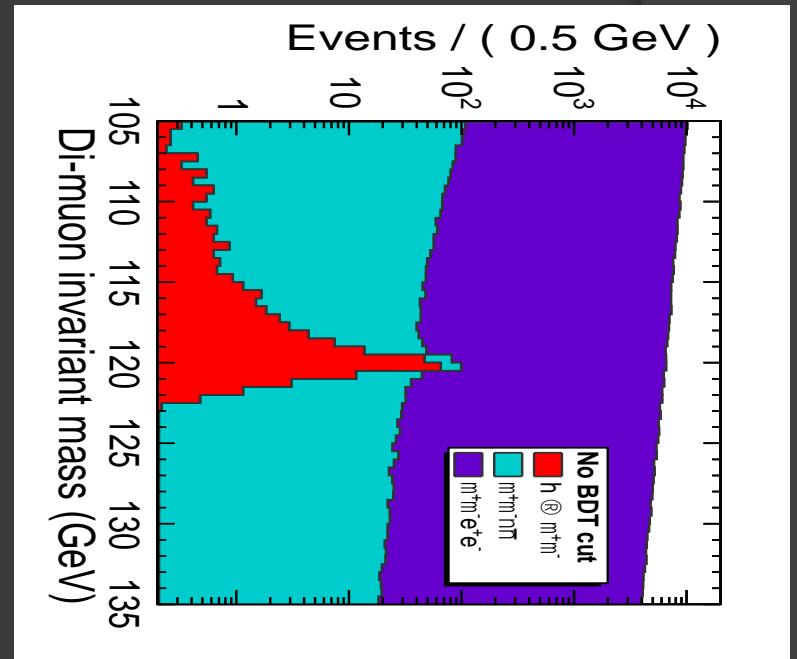


# Analysis Strategy

- Reconstruct two identified muons
- Boosted Decision trees classifier
- Likelihood fit

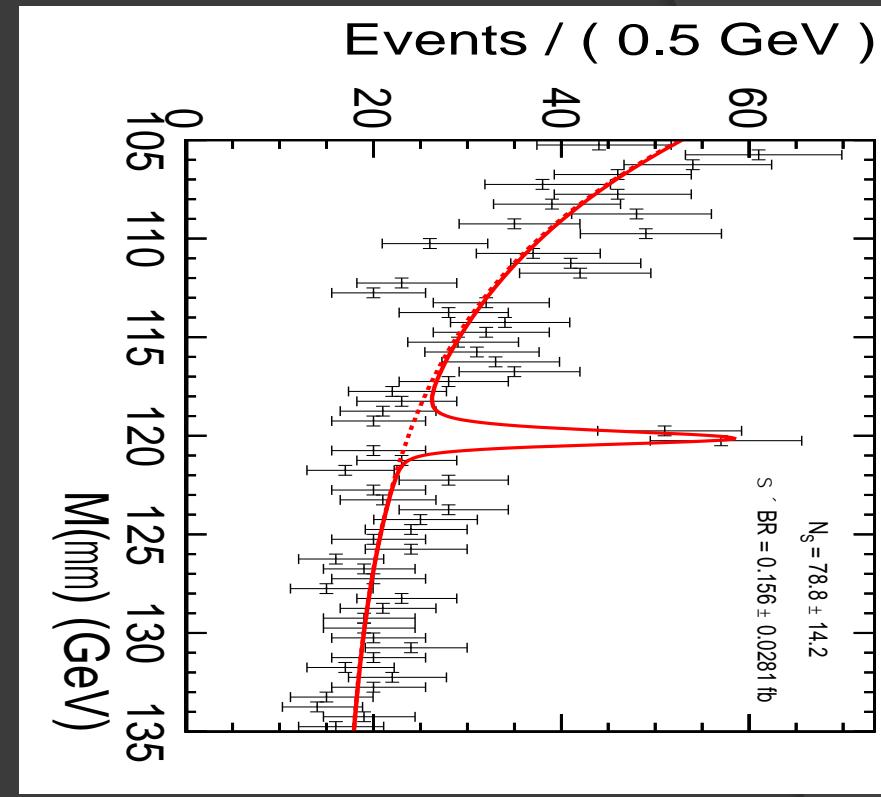
## Bonus

- Electron Tagging study
- Muon momentum resolution study



# Results

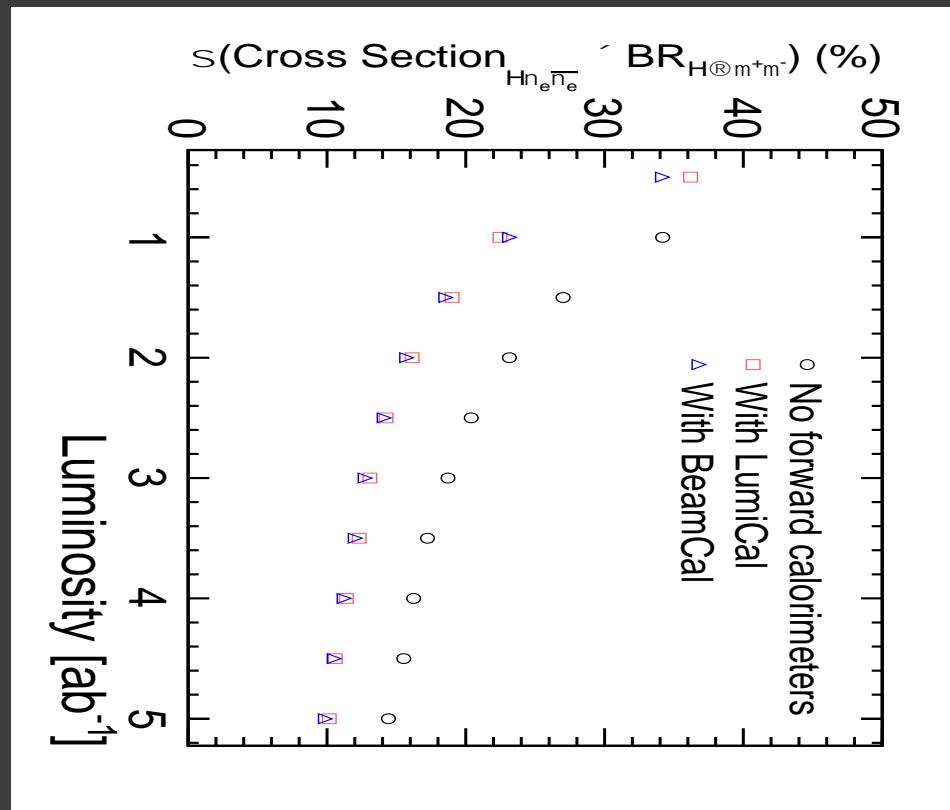
- BDT helps with low signal efficiency of rectangular cuts
- Average of three independent likelihood fits



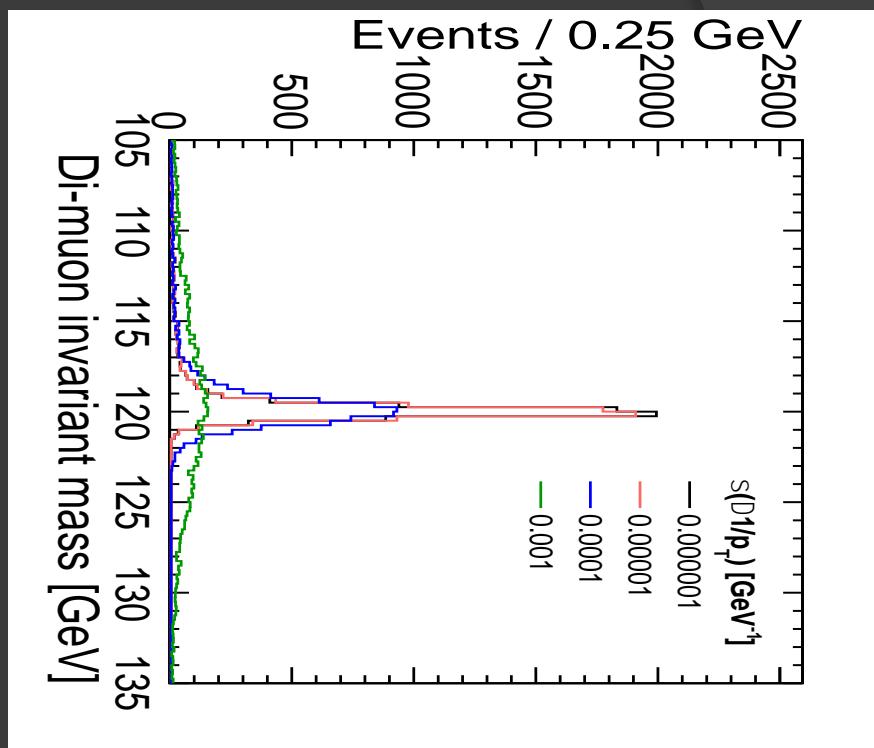
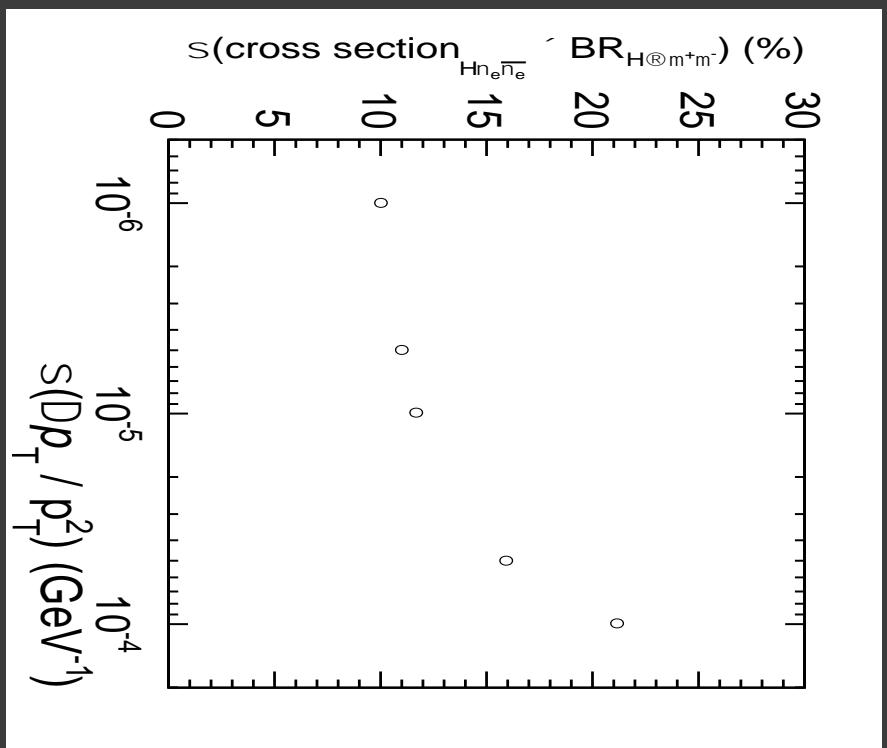
	$h \rightarrow \mu^+ \mu^-$
Signal efficiency	25 %
Stat. Uncertainty	23 %

# Electron Tagging in the forward region

- LumiCal ( $\Theta > 3.5^\circ$ )
  - Assume 95% rejection
- BeamCal ( $\Theta > 1.7^\circ$ )
  - Assume 50% rejection



# Momentum resolution



# Summary

- CLIC background adds a significant challenge to reconstruction
- Benefits of large cross sections still outweigh
- Measurements of SM Higgs decays serve as excellent tools for detector (and reconstruction) benchmarking

	$h \rightarrow b\bar{b}$	$h \rightarrow c\bar{c}$	$h \rightarrow \mu^+\mu^-$
Signal efficiency	54.6 %	15.2 %	25 %
Stat. Uncertainty	0.22 %	3.24 %	23 %

# Supplementary Material

# Muon identification

