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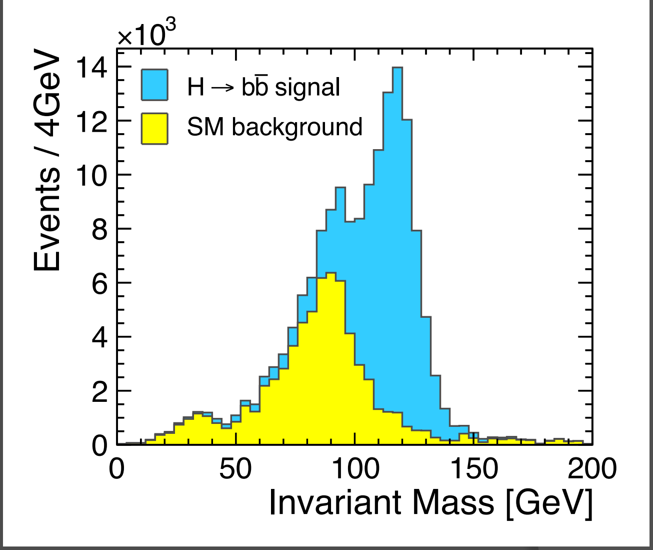
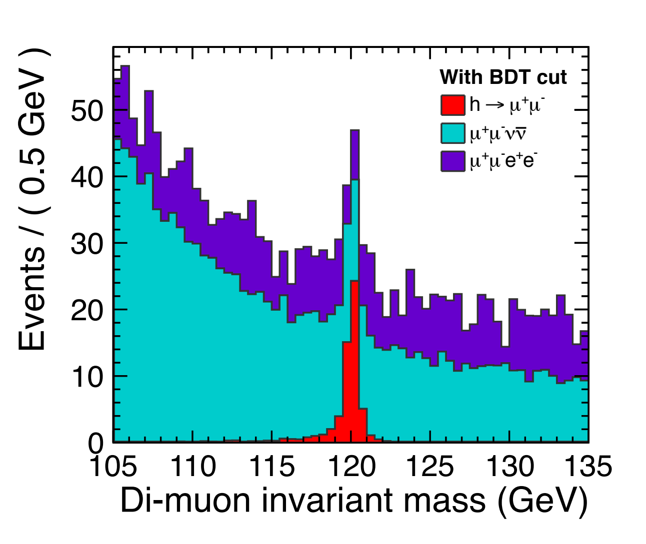
ANALYSES OF LIGHT HIGGS DECAYS FOR THE CLIC CDR

Overview

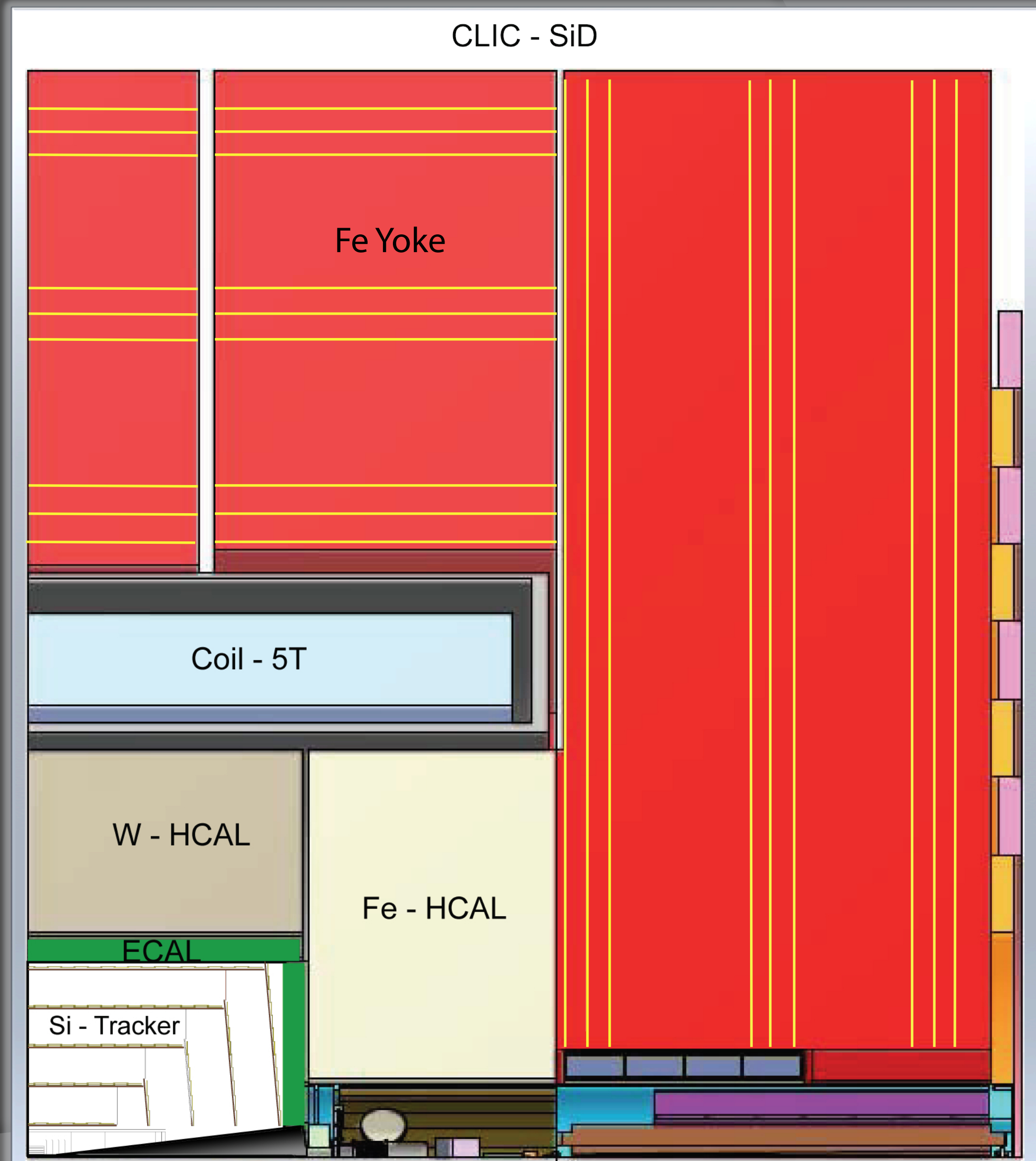
- CLIC environment
- H → bb
  - Largest BR in the Standard Model
  - Flavour Tagging (in the presence of background)
- H → μμ
  - Coupling to second-generation fermions
  - Momentum resolution (in the forward region)
- Summary





The CLIC environment

- CLIC_SID detector
  - Similar to SiD detector
  - 27 mm radius inner vertex layer
  - 7.5 λ W-HCAL barrel
  - Tracking coverage down to 10°



The CLIC beams

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

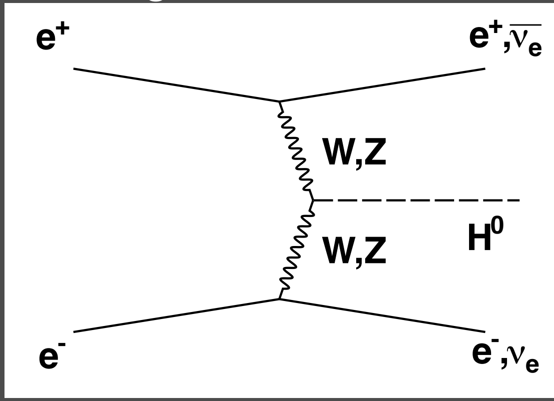
- 3.2 events $\gamma\gamma \rightarrow \mathrm{hadrons}$ / BX
  - →19 TeV visible energy
  - →Reduced to 1.2 TeV in readout window

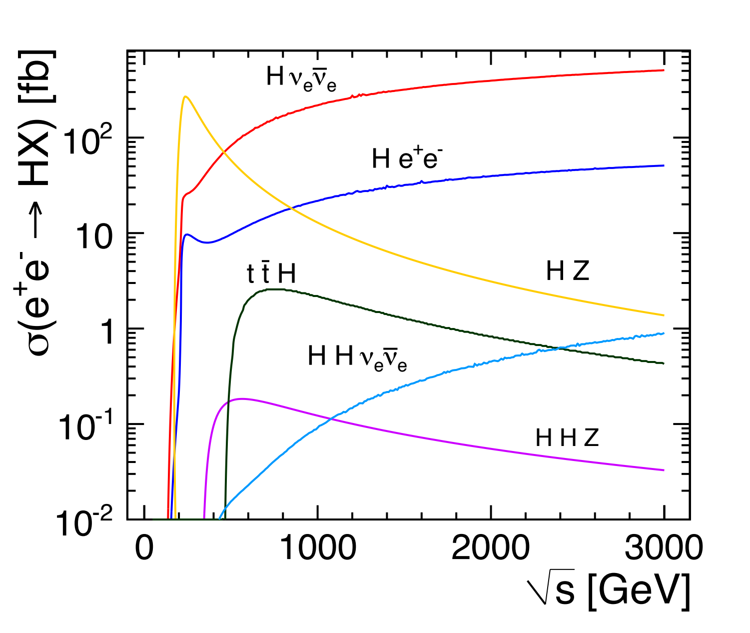
The CDR benchmark point

Channel	Cross Section (fb)
$\nu_e\bar{\nu}_e H(\rightarrow bb)$	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





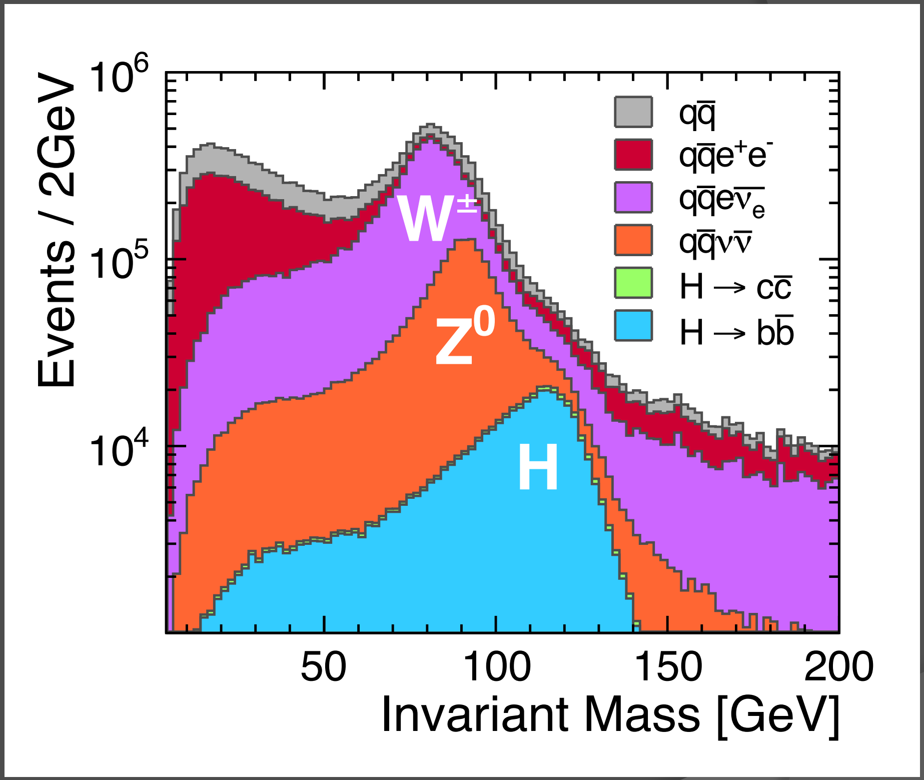
Setup

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

Higgs decays to bottom and charm

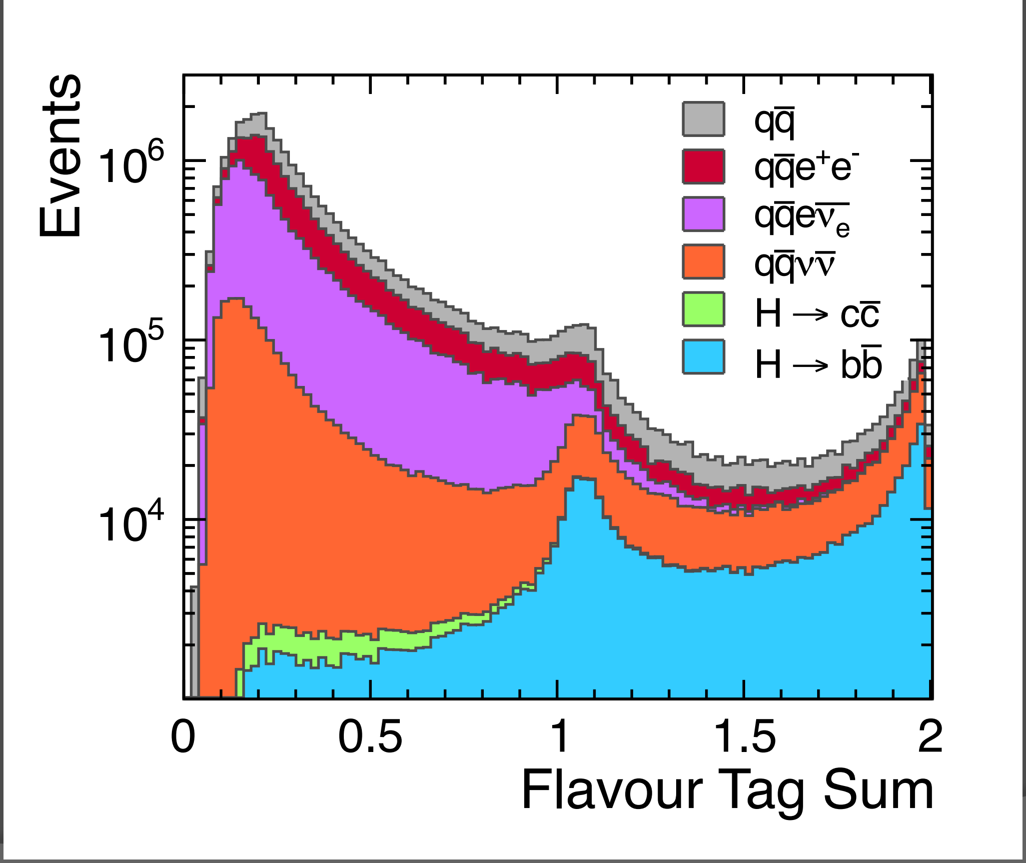
Pre-selection

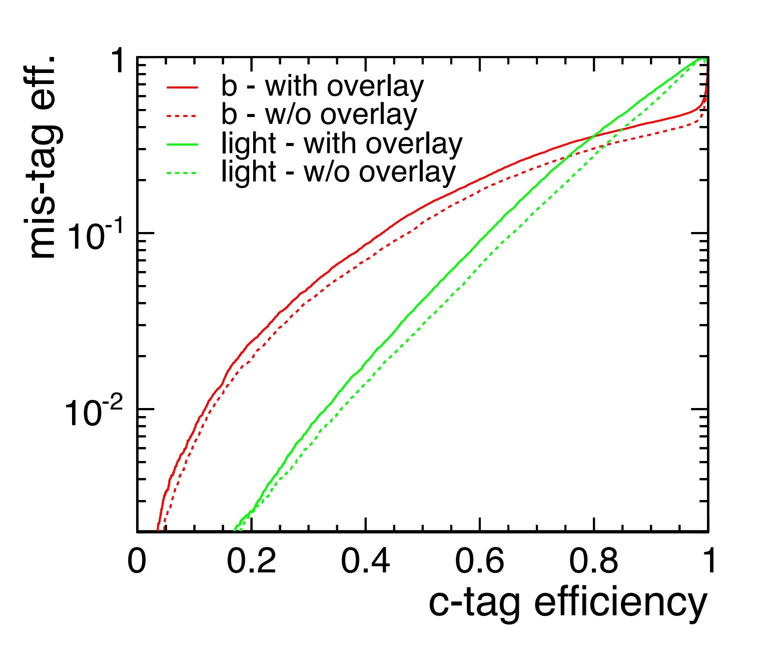
- Tight PFO timing cuts
- FastJet k_t algorithm, R_{max}=0.7
  - Try to force into two jets
  - Durham algorithm fails in presence of background

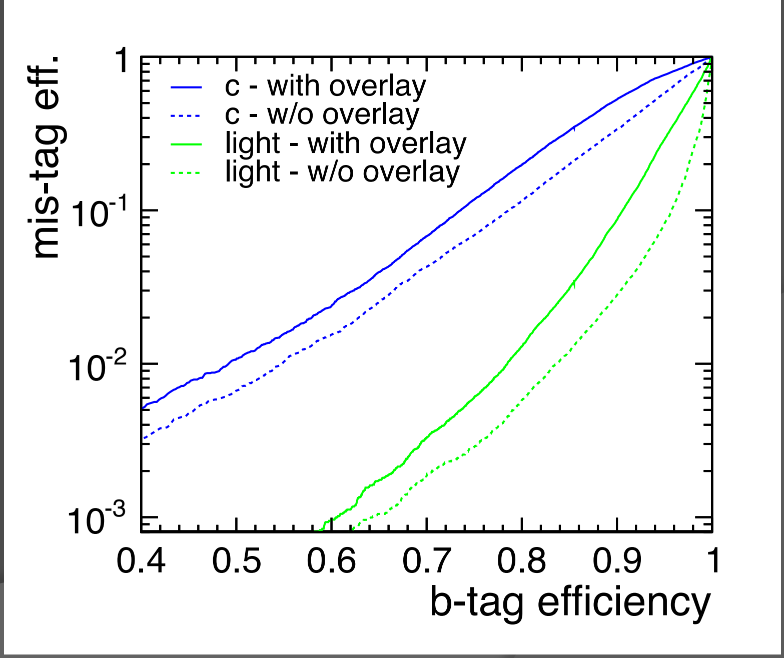


Flavour Tagging

- LCFI with FastNN neural net





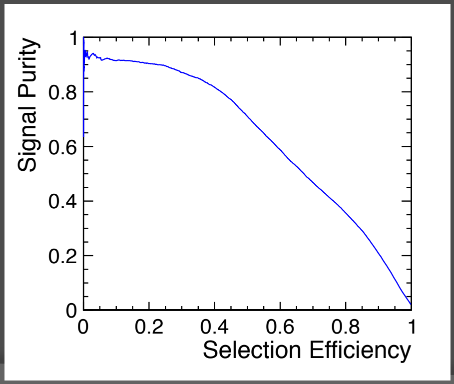


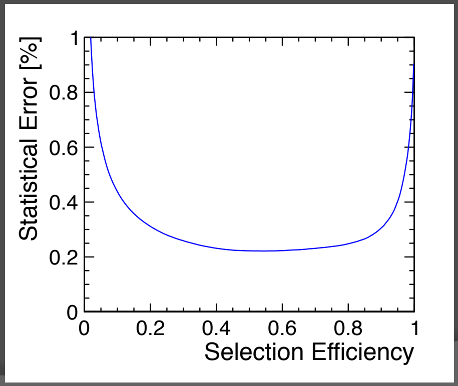
Event selection

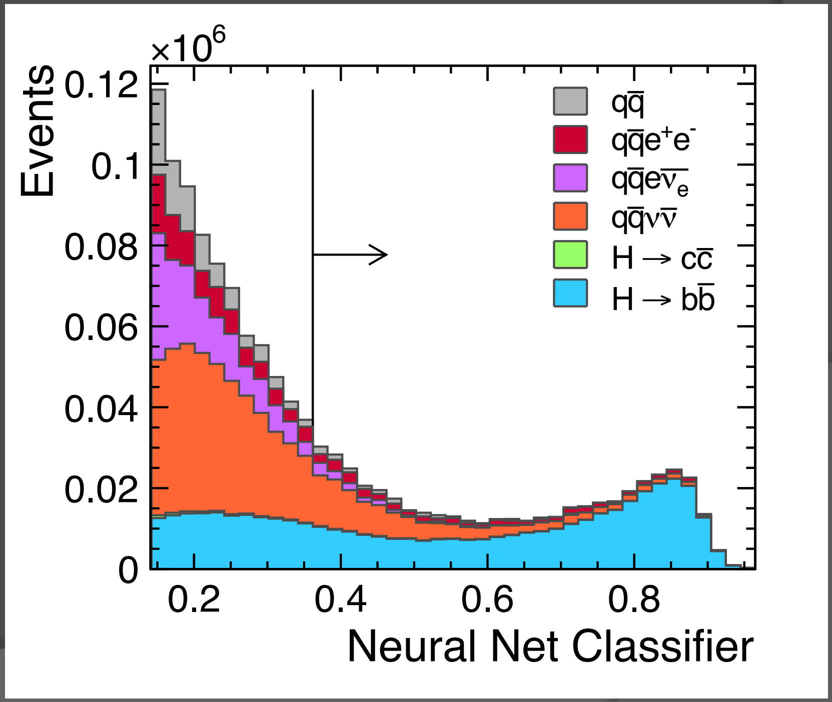
- ΔR(jets)
- E_{tot} = sum of E_{jet}
- $N_{leptons}$, N_{γ}
- Jet acoplanarity
- Sum of flavour tags

Choose optimal point in

- Stat. Error vs. Efficiency
- Purity vs. Efficiency







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 → cc

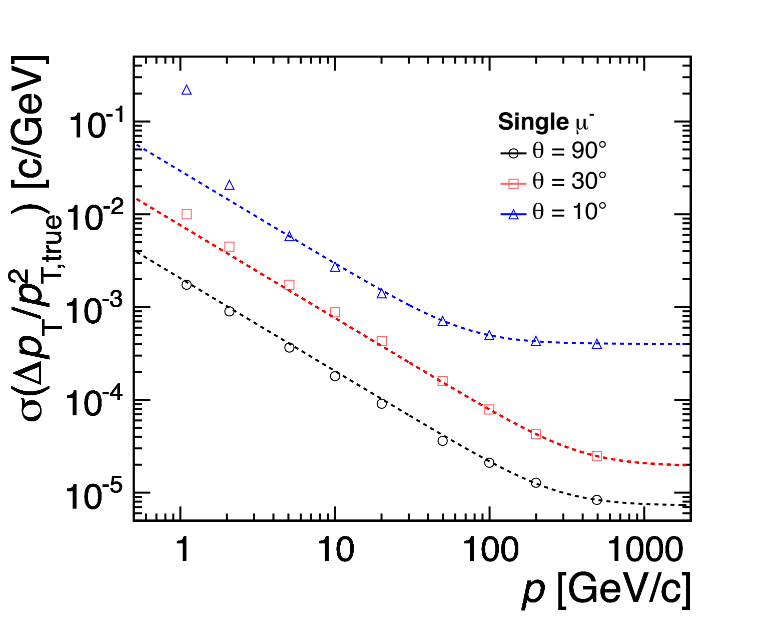
	$h \to b\bar{b}$	$h \to c\bar{c}$
Signal efficiency	54.6 %	15.2 %
Stat. Uncertainty on σ x BR	0.22 %	3.24 %

Higgs decays to muons

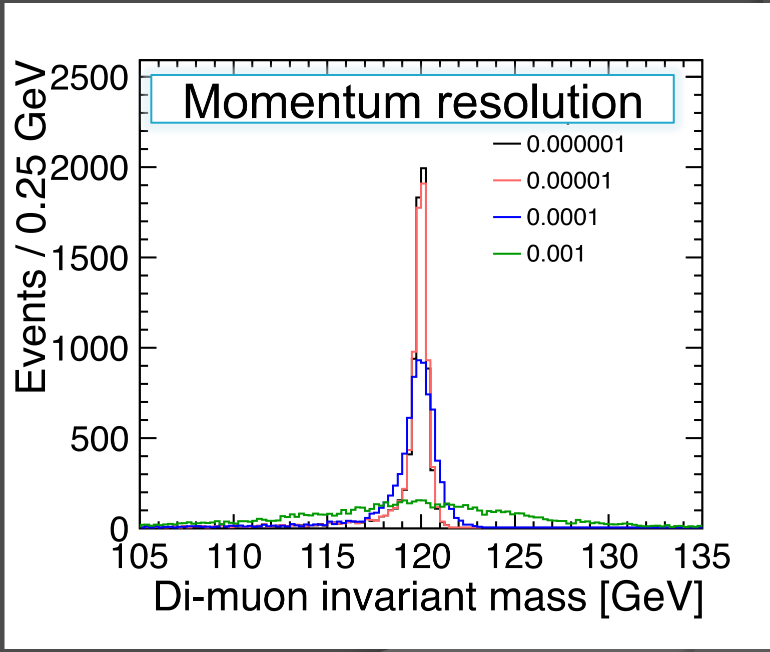
Higgs decay to muons

- Rare decay, BF ~ 10^{-4}

→ Tests excellent momentum resolution



CLIC_SiD momentum resolution in different regions of theta

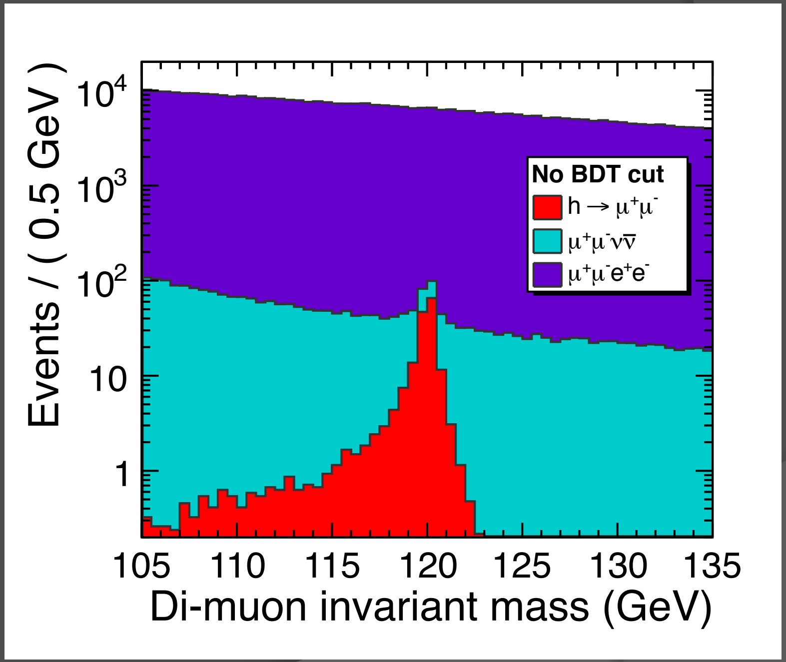


Reconstructed di-muon mass for different values of momentum resolution

Analysis Strategy

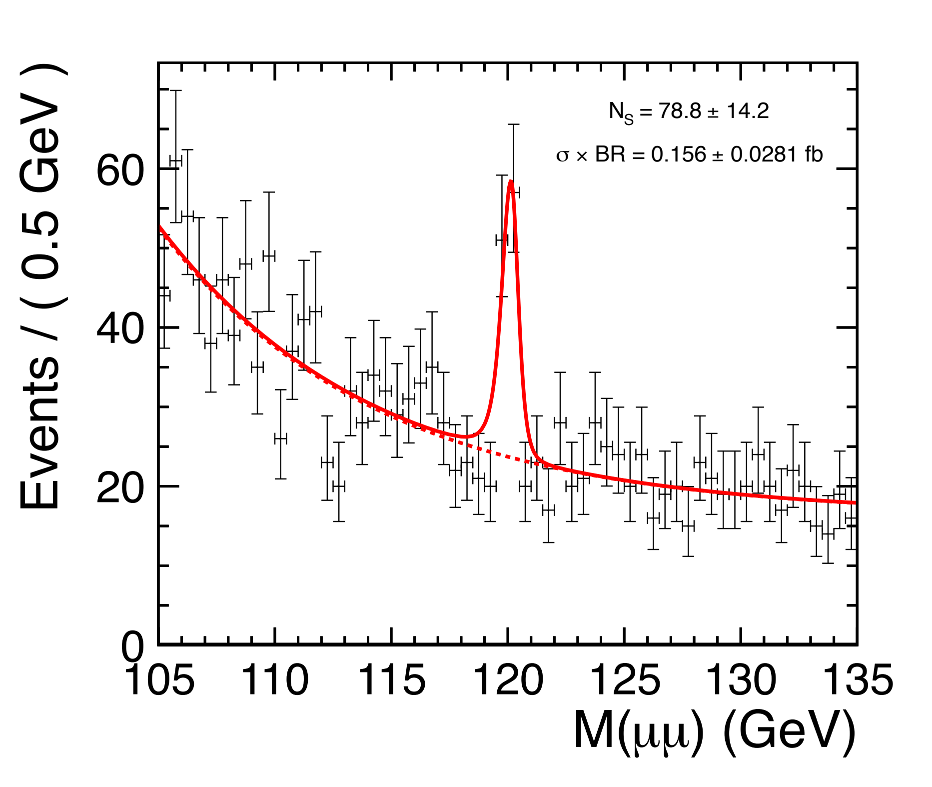
- Reconstruct two identified muons
- Boosted Decision trees classifier
- Likelihood fit

- Electron Tagging
- Muon momentum resolution study



Results

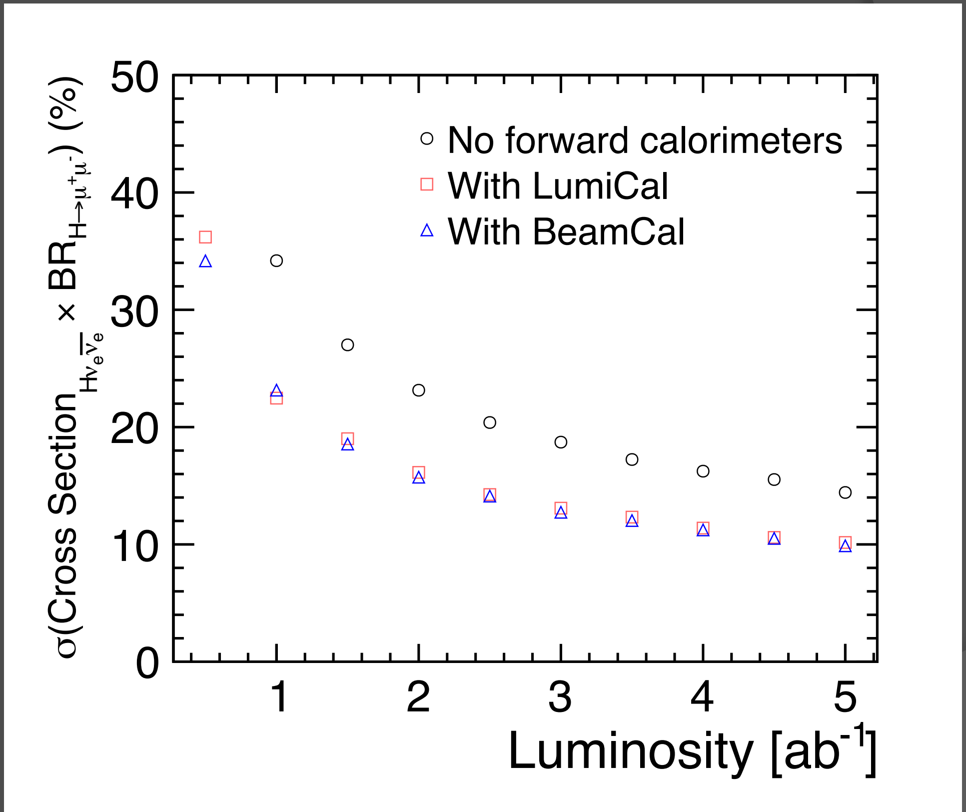
- No PFO timing cuts
- BDT helps with low signal efficiency of rectangular cuts
- Average of three independent likelihood fits



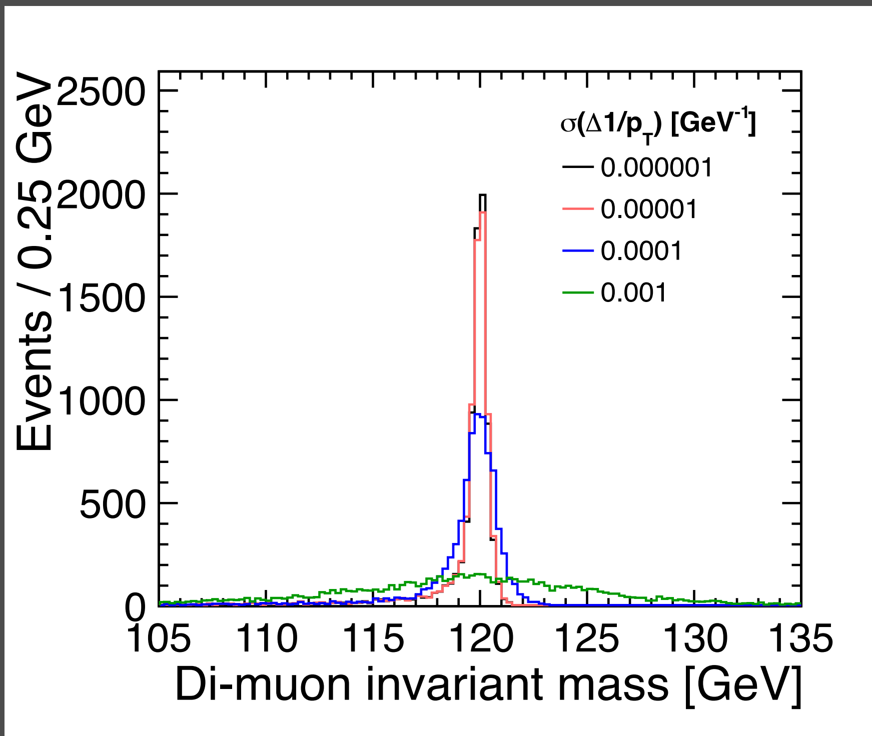
	$h \to \mu^+\mu^-$
Signal efficiency	25 %
Stat. Uncertainty on σ x BR	23 %

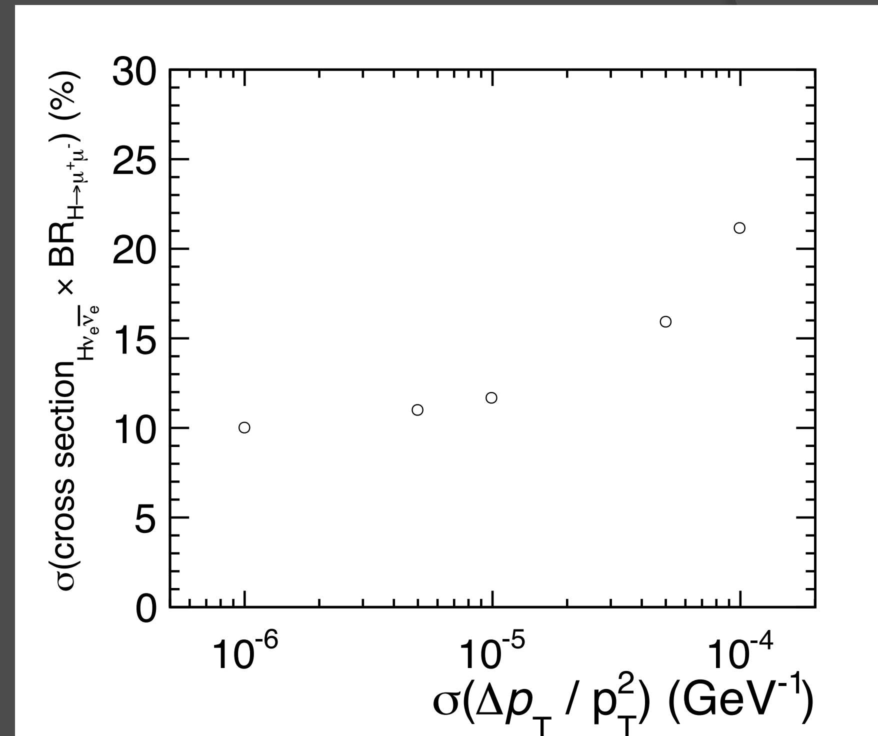
Further improvements (preliminary)

- LumiCal and BeamCal not in the full simulation
- LumiCal ($\Theta > 3.5°$)
  - Assume 95% rejection
- BeamCal ($\Theta > 1.7°$)
  - Assume 50% rejection



Dependence on momentum resolution





- Vary the momentum resolution globally
  → Increased significance → equivalent luminosity

Summary

- Excellent measurements of even rare Higgs decays possible at 3TeV CLIC
- Further improvements to rare decays possible by utilising the whole detector
- Measurements of SM Higgs decays serve as excellent tools for detector (and reconstruction) benchmarking

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

The CLIC CDR

Take a look at CLIC CDR Volume 2 for details

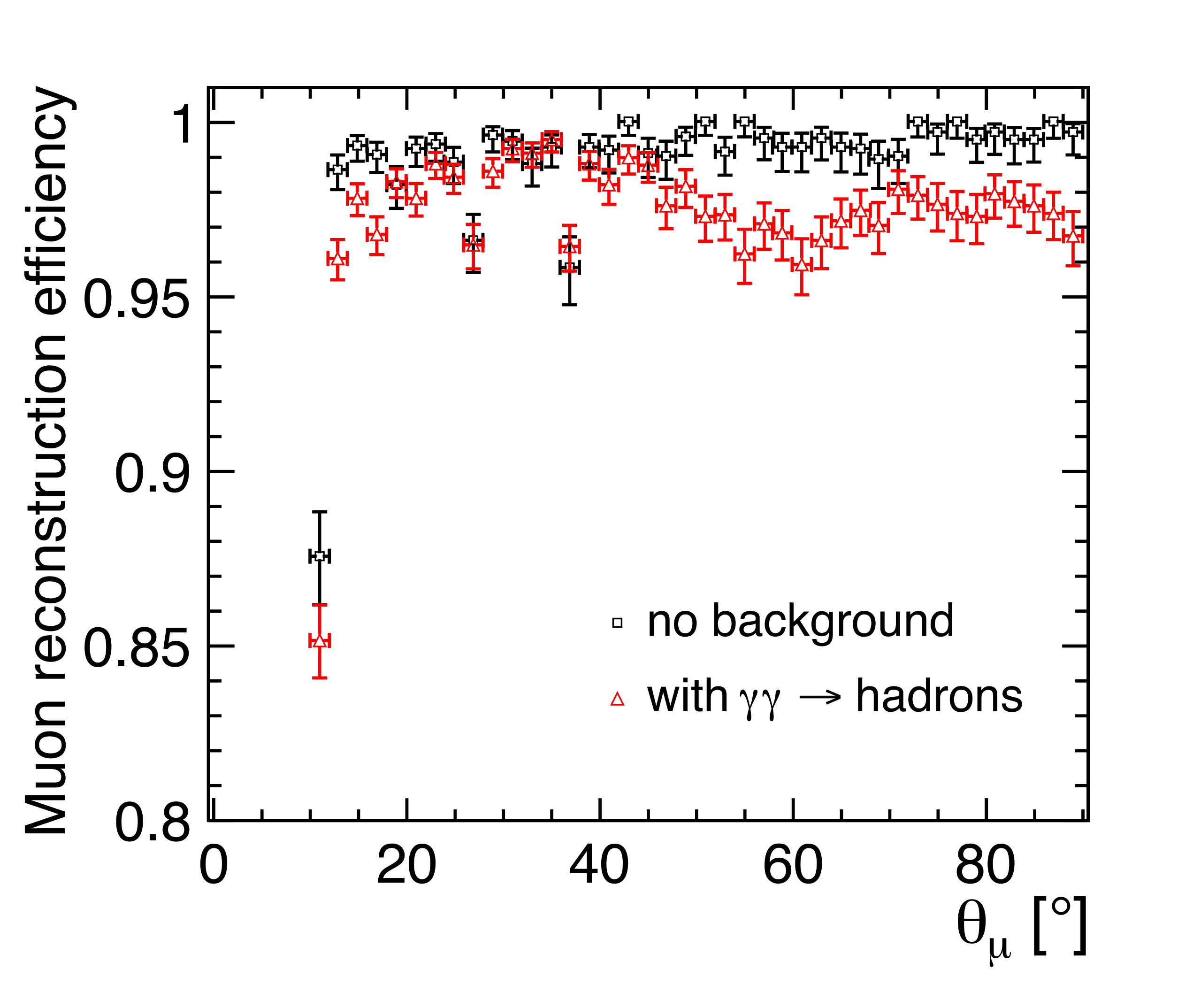
https://edms.cern.ch/document/1160419

Signing is open and without obligation

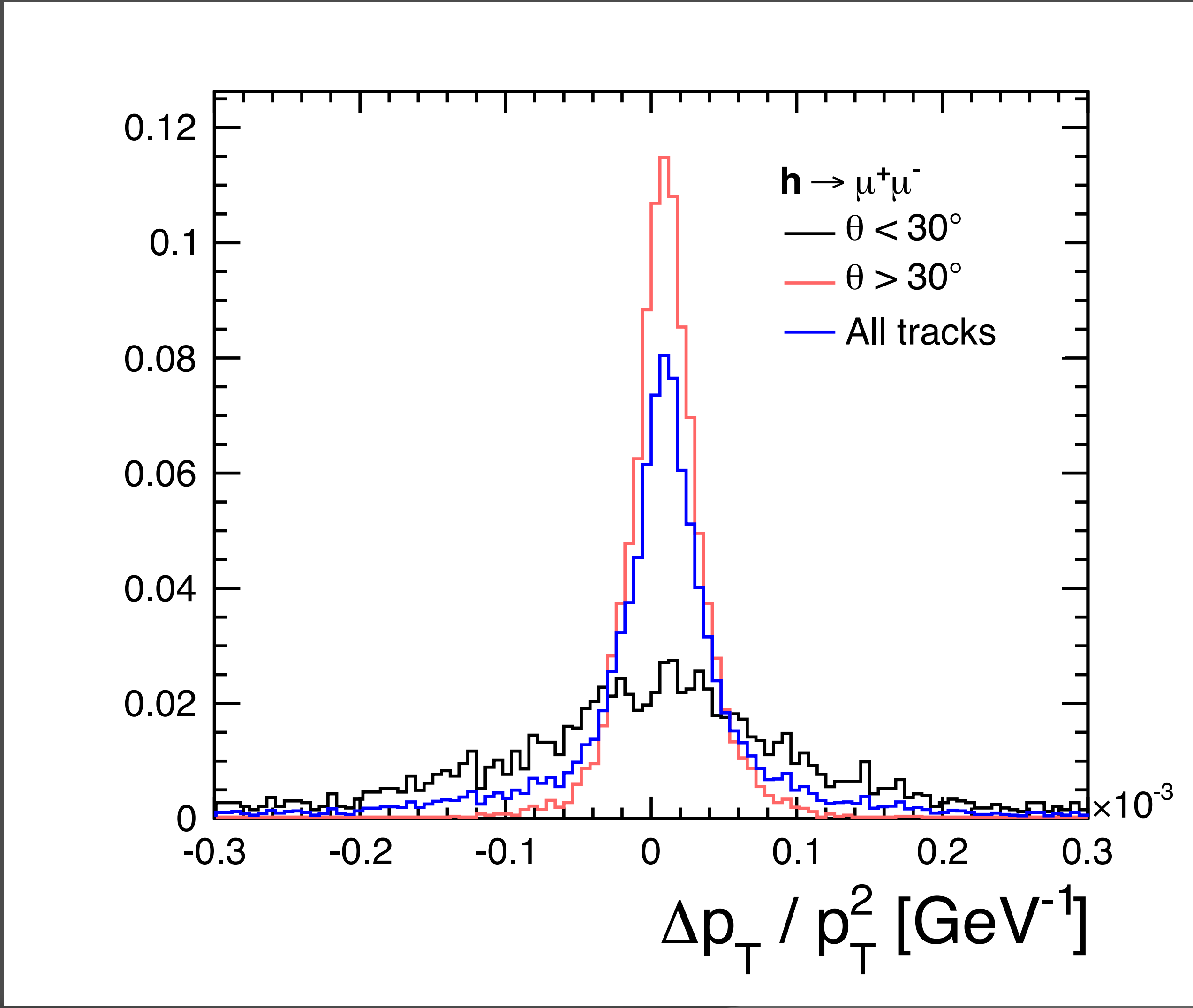
https://indico.cern.ch/confRegistrationFormDisplay.py/display?confId=136364

Supplementary Material

Muon identification

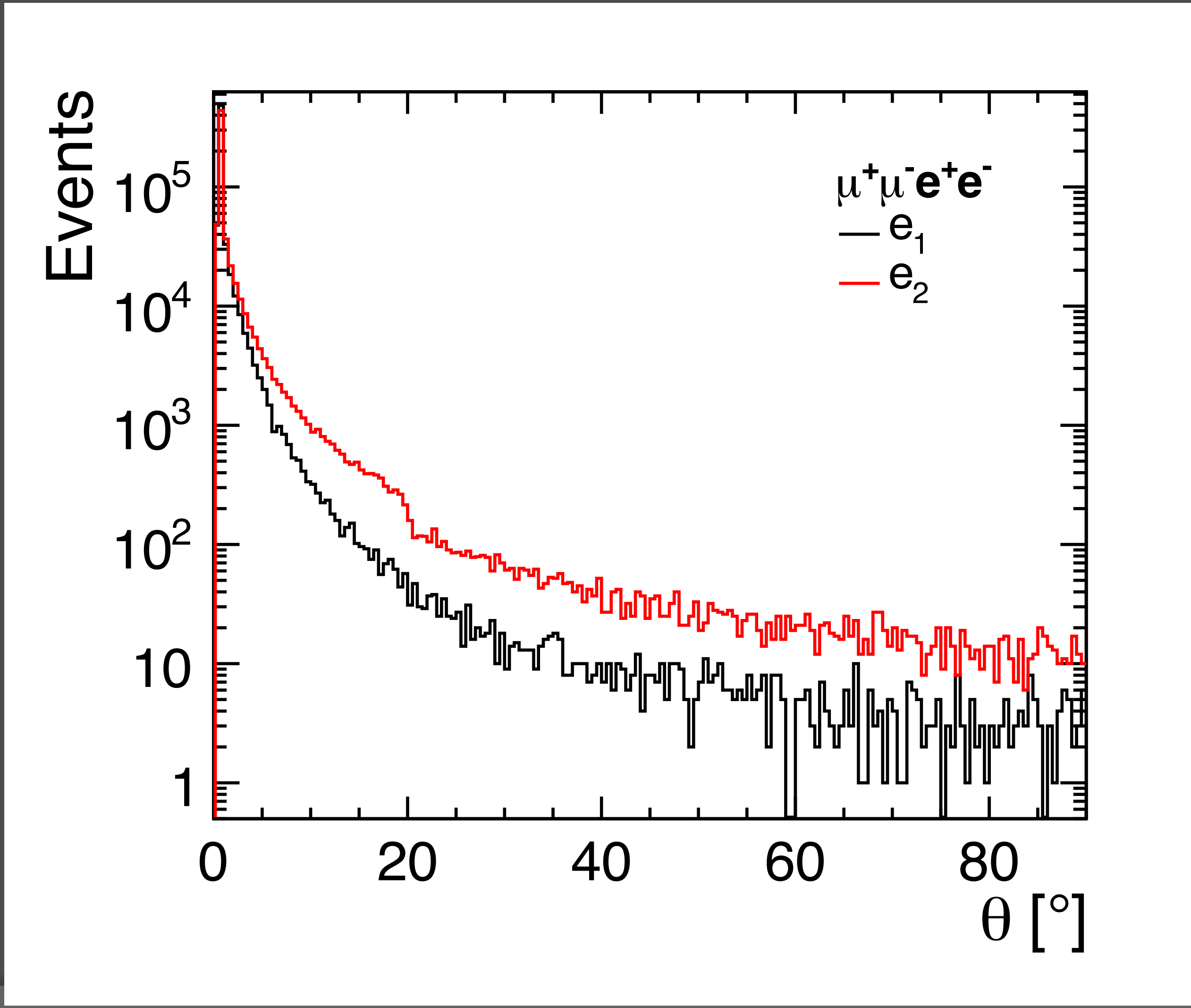


Momentum resolution



Gaussian Widths
1.01×10^{-4} / GeV
2.28×10^{-5} / GeV
4.55×10^{-4} / GeV

Electron theta -- background



Backgrounds at CLIC

- 19 TeV from
- 1.2 TeV in a 10ns readout window