$Z \to \nu\,\nu + H \to \mu^+\,\mu^-$ for Detector Benchmarking

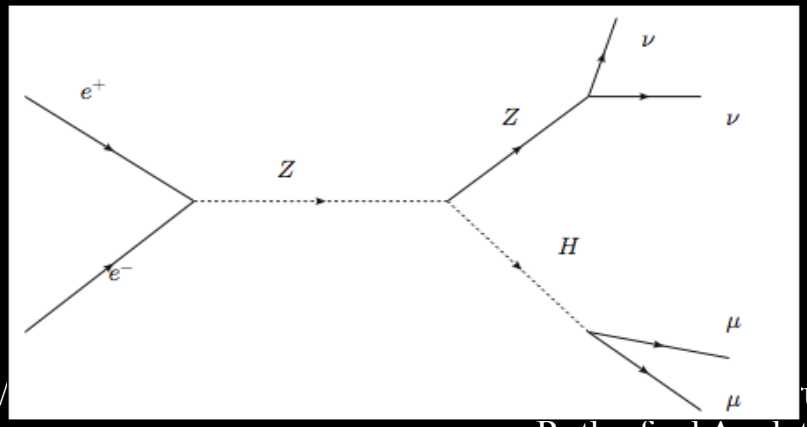
Thomas White
Jan Strube
Rutherford Appleton Laboratory

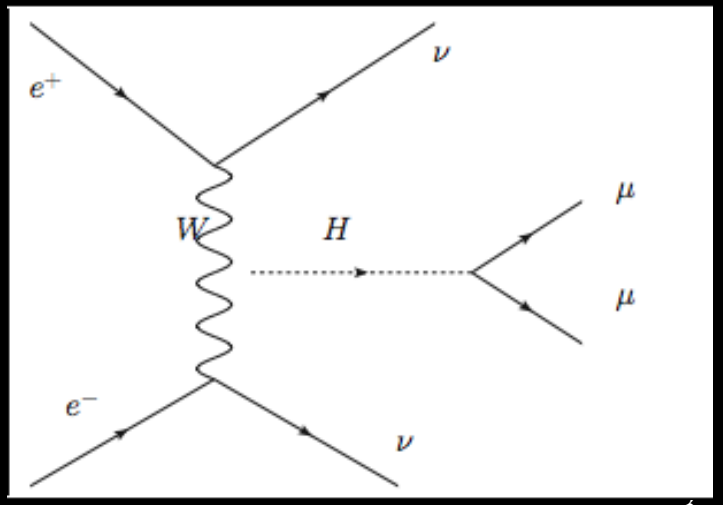
Software Setup

- Whizard 1.4(?)
- SliC v2r5p3_geant4-v9r1p2
- org.lcsim 1.5 (same as used for LOI)
- Weka 3.6
- RooFit 3.00
  - Packaged in Root 5.24

Samples

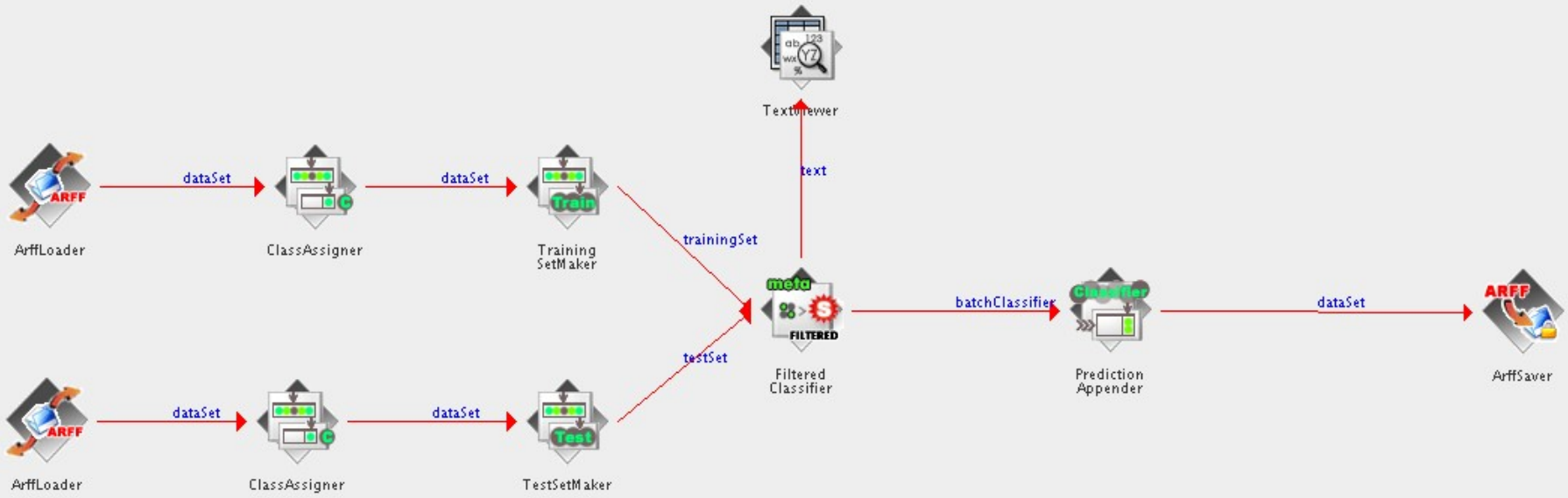
- LOI 250 GeV SM Sample
  - 7.8 billion events
- 4f dedicated background samples
  - 2 billion events
- H → mu mu dedicated signal sample
  - 102 million events





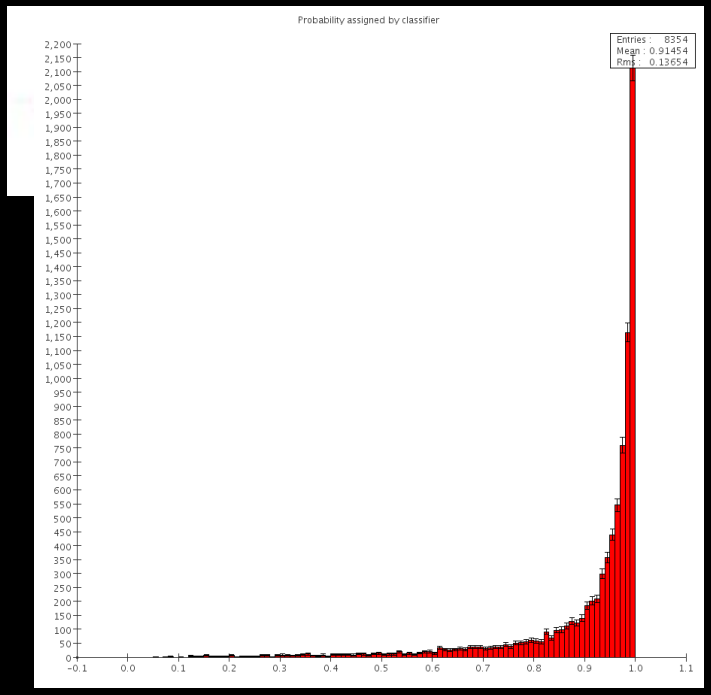
Weka

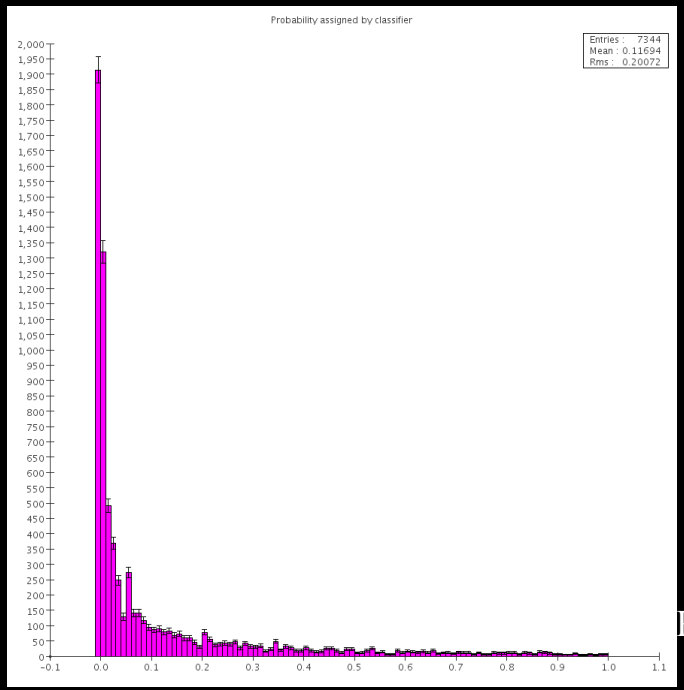
- Waikato Environment for Knowledge Analysis
- Developed by the University of Waikato, NZ
- Machine Learning software workbench



Analysis Strategy

1. Perform some preliminary cuts
2. Dump variables into a classifier
   - Muon quality and angles
   - “Random Forest” classifier (200 Trees)
3. Perform a likelihood fit after a cut on the classifier output





Classifier Output

- Random Forest
- 24 Variables
- 200 Trees
- Trained on 41000 signal, 3.8 million background events
  - Weighted to 50/50

Cut Efficiencies

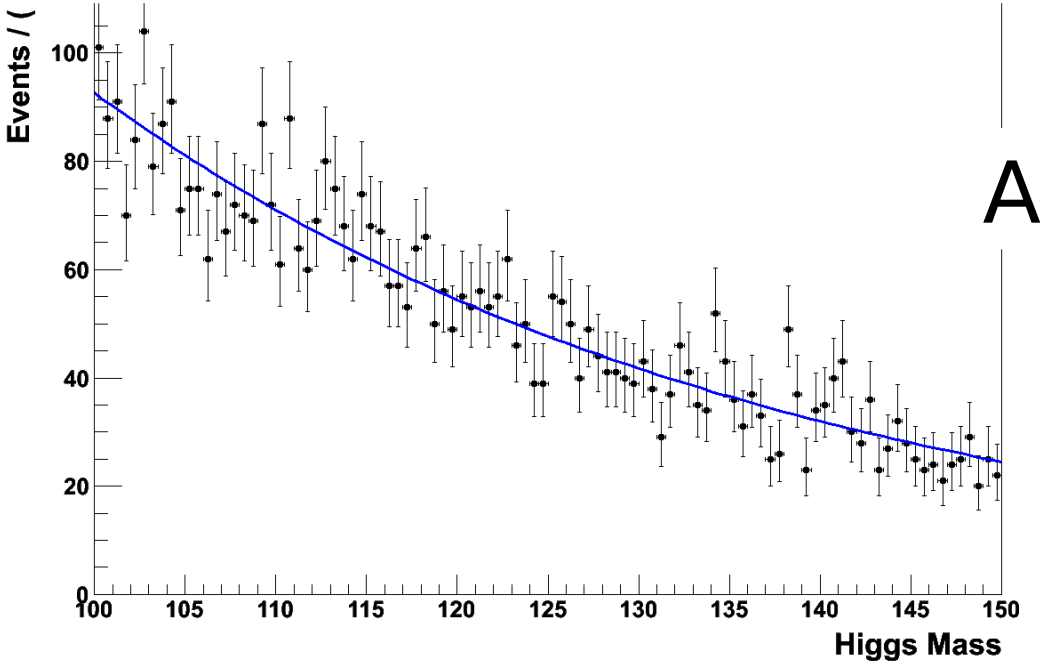
Cuts	2f	4f	2f +Photons	4f +Photons	6f+ Photons	n Photon	signal
Events in 250 / fb	4.1E+09	6.9E+06	1.1E+10	1.2E+08	3.5E+03	2.4E+07	18.50
# Muons = 2	5.57 %	4.22 %	5.71 %	10.84 %	11.18 %		83.5%
# Tracks = 2	5.08 %	2.58 %	5.58 %	9.30 %	0.65 %		21.7%
100 GeV < Higgs Mass < 150 GeV	0.37 %	0.40 %		1.02E-05			20.8%
Visible Energy < 160 GeV	0.23 %	0.35 %		8.13E-06			20.7%
Classif er < 0.95		2.8E-05					12.4%
Weighted		190.57					2.30
Unweighted		26					5020

Results in Context

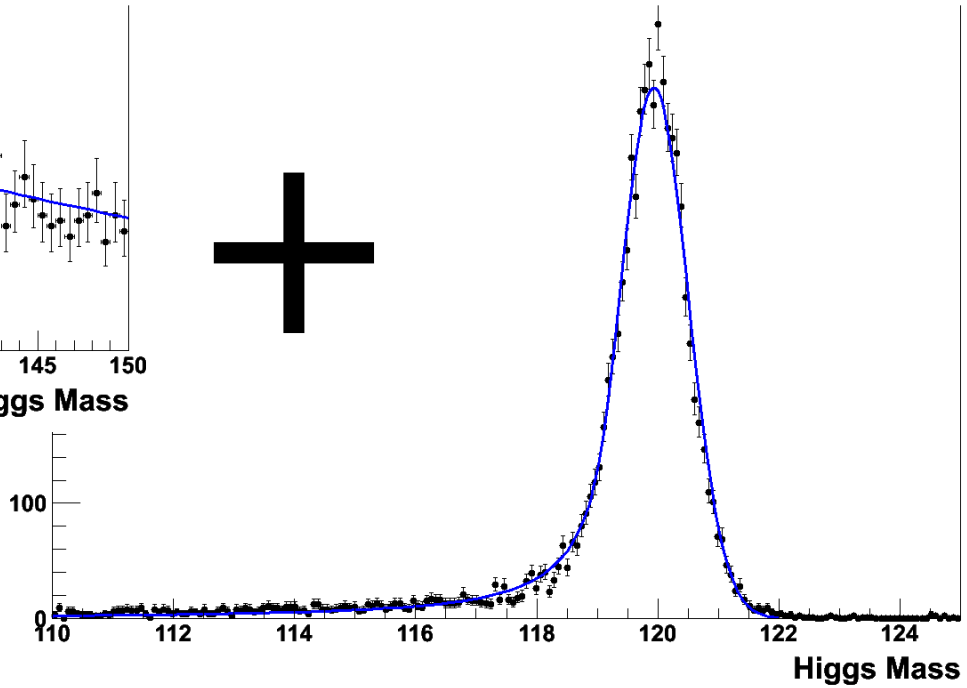
- LCWS '08 (@ 500 GeV, 2 / ab)
  - 24.6 signal events
  - 8900 background events
- Cut-based LOI analysis (@ 250 GeV, 250 / fb)
  - 2.7 signal events
  - 1200 background events
- This analysis
  - 2.3 signal events
  - 190 background events

Embedded Toy Fits

Sample the background shape



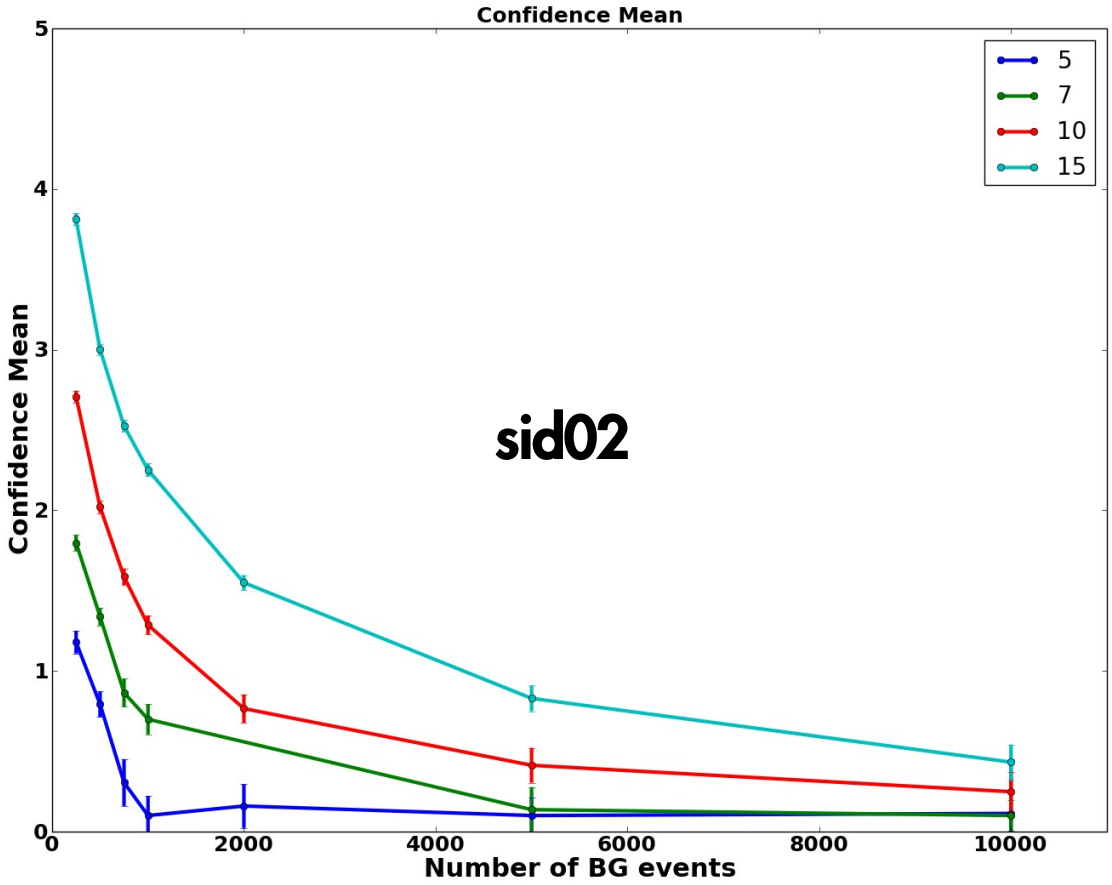
Add sprinkles of signal



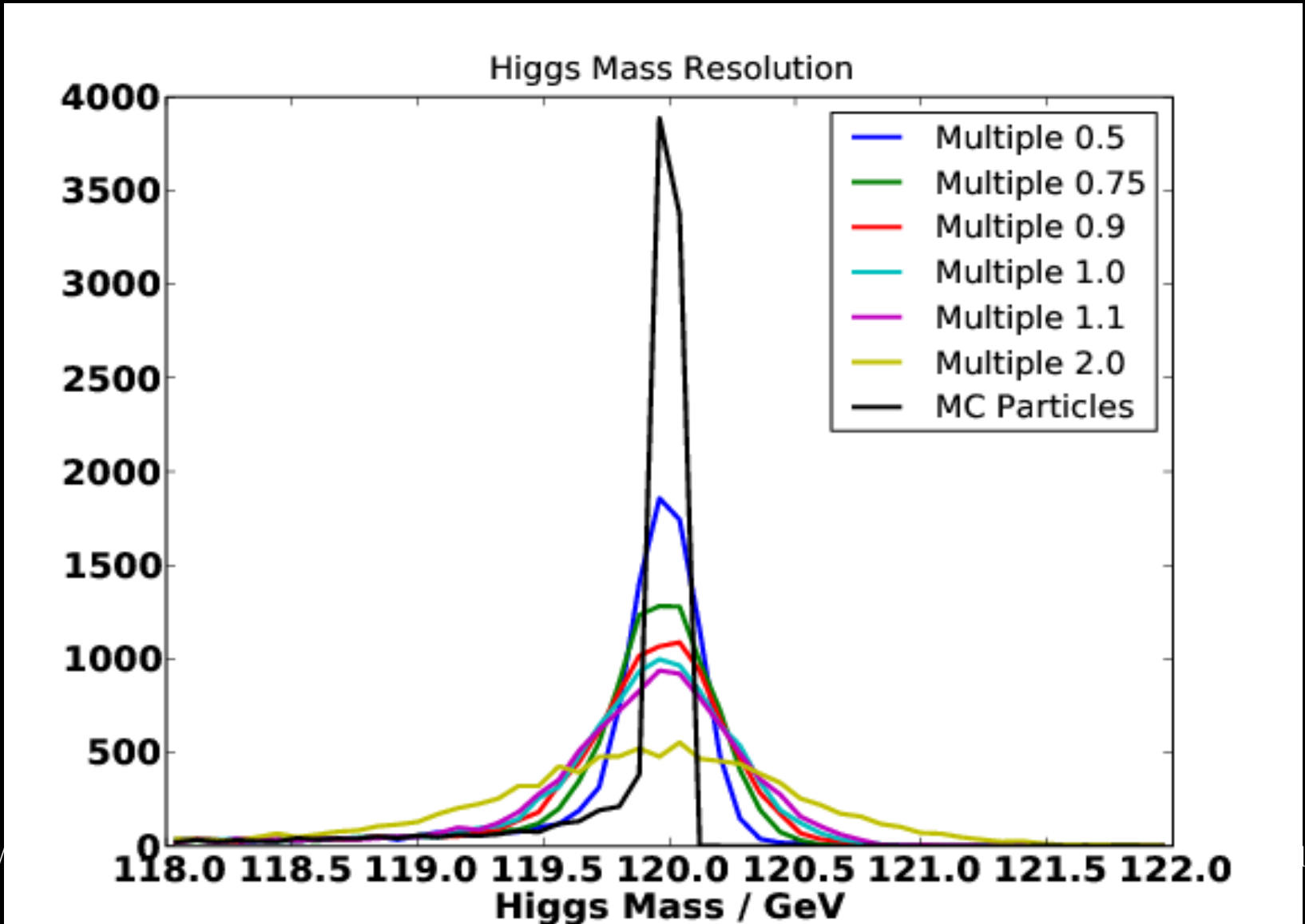
Toy Fit Results

Likelihood Ratio

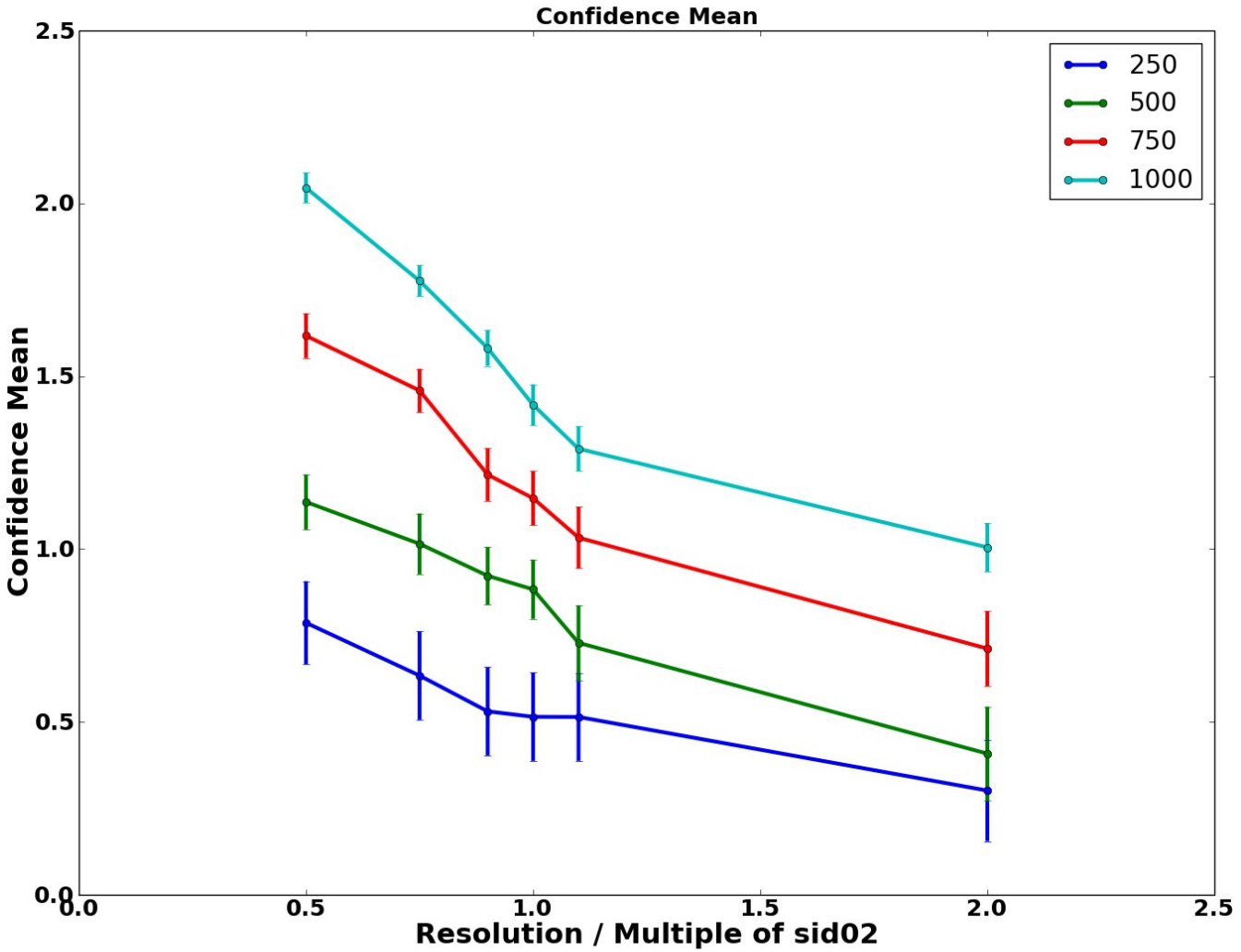
$$\sigma = \sqrt{2\log(L/L0)}$$



Resolution studies



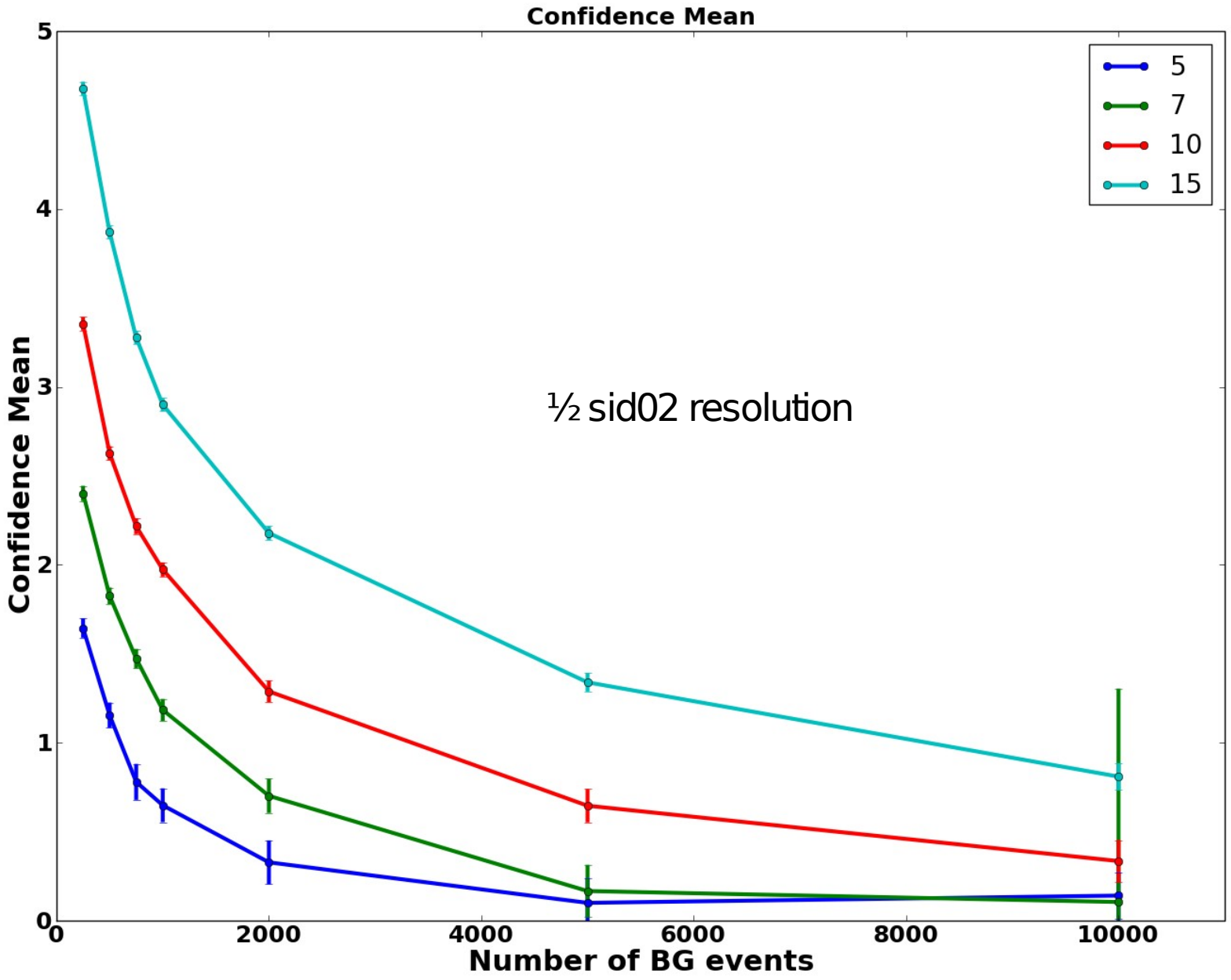
Benchmarking Results



Summary and Outlook

- The decay $H \rightarrow \mu^+ \mu^-$ is a very challenging channel for analysis
  - Pushing the envelope of what is possible using multivariate techniques
- Golden channel for detector benchmarking
  - Clean signal, immediate feedback on tracker resolution
- To Do: Add Z decays to leptons and jets and repeat the exercise
- To Do: Study the resolution of a pixel tracker

Backup


Confidence Mean
5
7
10
15
½ sid02 resolution
Confidence Mean
Number of BG events
0
1
2
3
4
5
0
2000
4000
6000
8000
10000