Progress with SiD Benchmarking

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Benchmark Reactions for the ILC LOI process

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Signal Samples

For each reaction we indicate the main detector parameters which are to be tested with this reaction. Performances for $250 fb^{-1}$ for Ecm=250GeV and $500 fb^{-1}$ for 500 GeV should be presented.

1. **$e^+e^- \to ZH$, $H \to e^+e^-X$, $\mu\mu X$ (M_H=120 GeV, E_{cms}=250 GeV)**
   a. momentum resolution
   b. material distribution in the detector, in particular in the tracker
   c. photon ID

   The electron channel is particularly challenging and sensitive to the material in the detector. The reconstruction of events with significant bremsstrahlung will demonstrate the ability to find and associate photons with the tracks. Physical measurements are the Higgs mass and the cross section.

2. **$e^+e^- \to ZH$, $H \to cc$, $\mu\mu$. $Z \to \nu\nu$ (M_H=120GeV, Ecm=250GeV)**
   a. heavy flavour tagging, secondary vertex reconstruction
   b. multi jet final state, c-tagging in jets, uds anti-tagging (particle ID)
   c. Anti-tagging can be tested by studying the $H \to gg$ channel.

   Selecting the neutrino final state for the Z makes the results from this study less sensitive to confusion in the event. Charm tagging is particularly challenging, and more sensitive to detector parameters than b-tagging. Physical observables are the BR(h->cc) and the BR(h->mu mu).

3. **$e^+e^- \to ZH$, $H \to cc$, $\mu\mu$, $Z \to qq$ (M_H=120GeV, Ecm=250GeV)**
   a. **in addition to the charm tagging, this final state tests the confusion resolution capability**

   Physical observables are the BR(h->cc) and the BR(h->mu mu).

4. **$e^+e^- \to Z \to \tau^+\tau^-$ (Ecm=500 GeV)**
   a. tau reconstruction, aspects of particle flow
   b. π^0 reconstruction
   c. tracking of very close-by tracks

   Tau reconstruction is a very challenging topic at the ILC. It will stress the tracking system and the clustering in the calorimeter. In addition selecting π^0 mesons will probe the photon reconstruction ability of the detector.

   Physical observables are σ, A_{FB} and tau decay mode efficiency and purity.

5. **$e^+e^- \to tt$, $t \to bW$, $W \to qq'$ (Mtop=175GeV, Ecm=500 GeV)**
   a. multi jet final states, dense jet environment
   b. particle flow
   c. b-tagging inside a jet
   d. maybe lepton tagging in hadronic events (b-ID)
   e. tracking in a high multiplicity environment

   Top reconstruction is an excellent test for the performance of the reconstruction in very busy events. At the moment it is not yet clear how critical ultimate particle flow performance is for this reaction.

   Physical observables are σ, A_{fb}, and m_{top}

6. **$e^+e^- \to \chi^+\chi^- / \chi_2^0\chi_2^0$ at Ecm=500 GeV**
   a. particle flow (WW, ZZ separation)
   b. multi-jet final states
   c. c. SUSY parameter is point 5 of Table 1 of hep-ex/0603010

   Physical observables are σ and masses

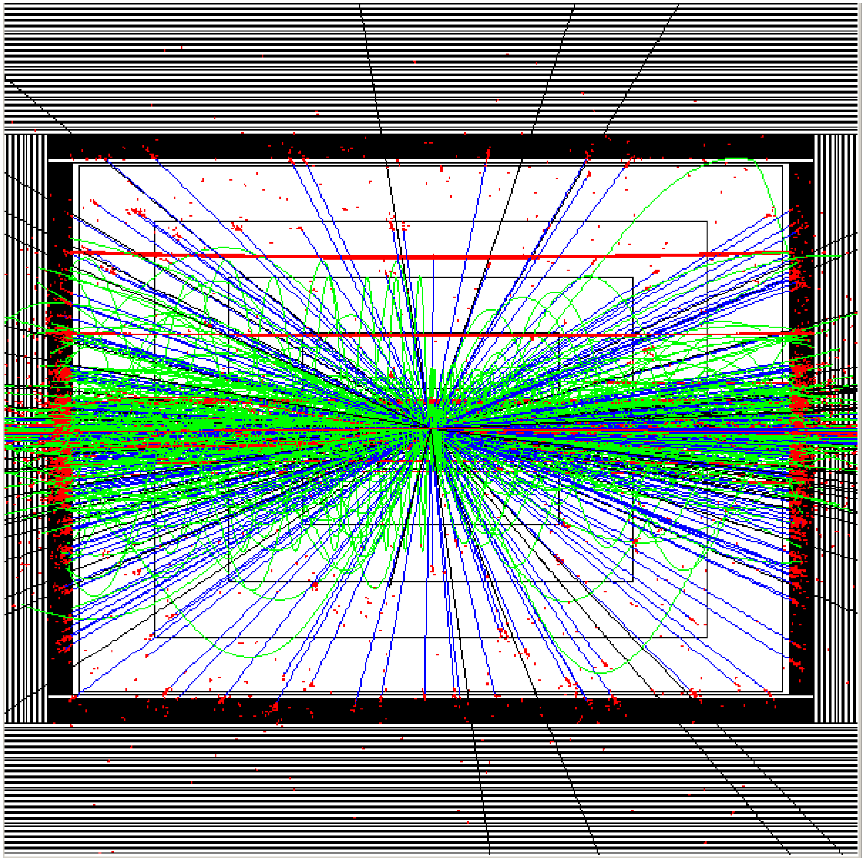
$\sqrt{s} = 500$ GeV SM Bgnd (similar set of events for $\sqrt{s} = 250$ GeV)

stdhep files for background and signal are shared by all detector concept groups

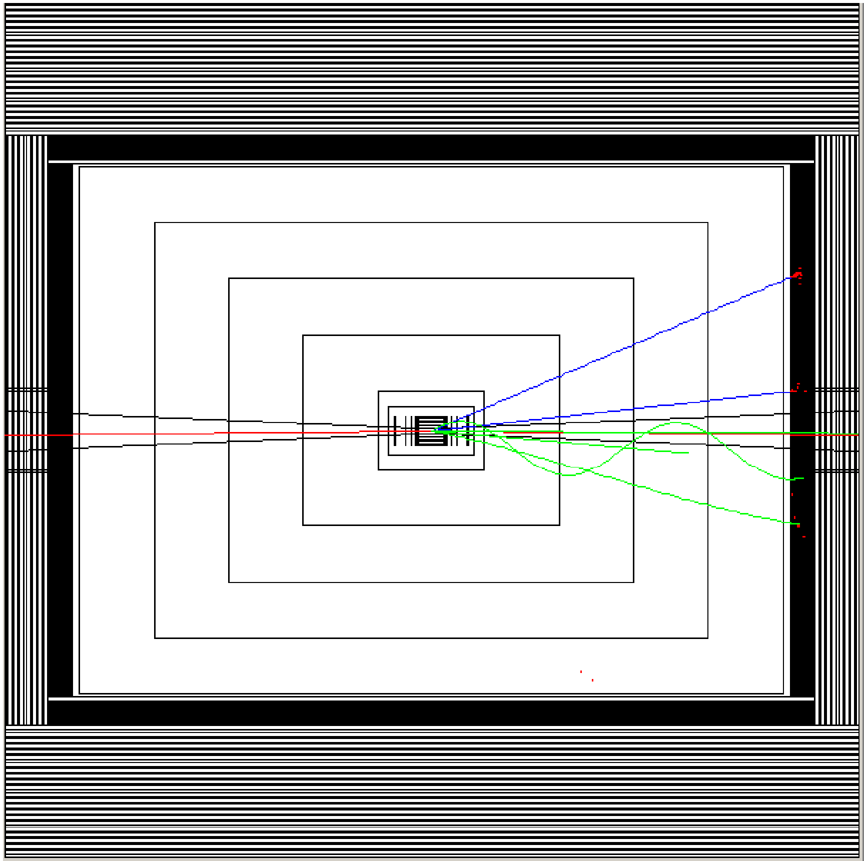
Process	σ(fb)	Lumi (fb^{-1})	# Events
	$pol_{e^-/e^+} = \mp 80/\pm 30\%$		
$e^+e^- \to e^+e^-$	1.74×10^7	0.04	696435
$\gamma\gamma \to f\bar{f}$	5.55×10^6	0.10	554700
$e\gamma \to e\gamma$	1.74×10^6	0.10	172119
$e\gamma \to e f\bar{f}, \nu f\bar{f}$	2.59×10^5	4.00	1034034
$e^+e^- \to \gamma\gamma$	2.60×10^4	2.00	51974
$e^+e^- \to f\bar{f}f\bar{f}$	1.90×10^4	140.00	2665962
$e^+e^- \to \mu^+\mu^-, \tau^+\tau^-, q\bar{q}$	1.85×10^4	50.00	924384
$e^+e^- \to \nu\bar{\nu} + n\gamma$	1.31×10^4	40.00	522449
$e^+e^- \to \gamma\gamma\gamma, \gamma\gamma\gamma\gamma$	1.46×10^3	20.00	29166
$e^+e^- \to f\bar{f}f\bar{f}f\bar{f}$	7.32×10^2	500.00	366070
$\gamma\gamma \to f\bar{f}f\bar{f}$	2.32×10^2	500.00	115914
$e\gamma \to f f\bar{f}f\bar{f}$	1.14×10^2	500.00	56875
$\gamma\gamma \to tt, e\gamma \to \nu bt, ett$	2.56×10^0	500.00	1282
Total			7191364

Beam-Beam Background

Process	$\gamma\gamma \to e^+e^-$ $pT > 115$ MeV	$\gamma\gamma \to \mu^+\mu^-$ $pT > 115$ MeV	$\gamma\gamma \to hadrons$
σ(fb)	1.10×10^9	1.36×10^9	4.61×10^8



Yellow = muons Red = electrons Green = charged hadrons
Black = Neutral Hadrons Blue = photons with E > 100 MeV
150 bunch crossings (5% of train)



1 bunch crossing

Current benchmarking plan: Include this background in analysis of $e^+e^- \to t\bar{t}$ only. Integrate over just 1 bunch crossing.

Status of SiD Benchmarking for LOI

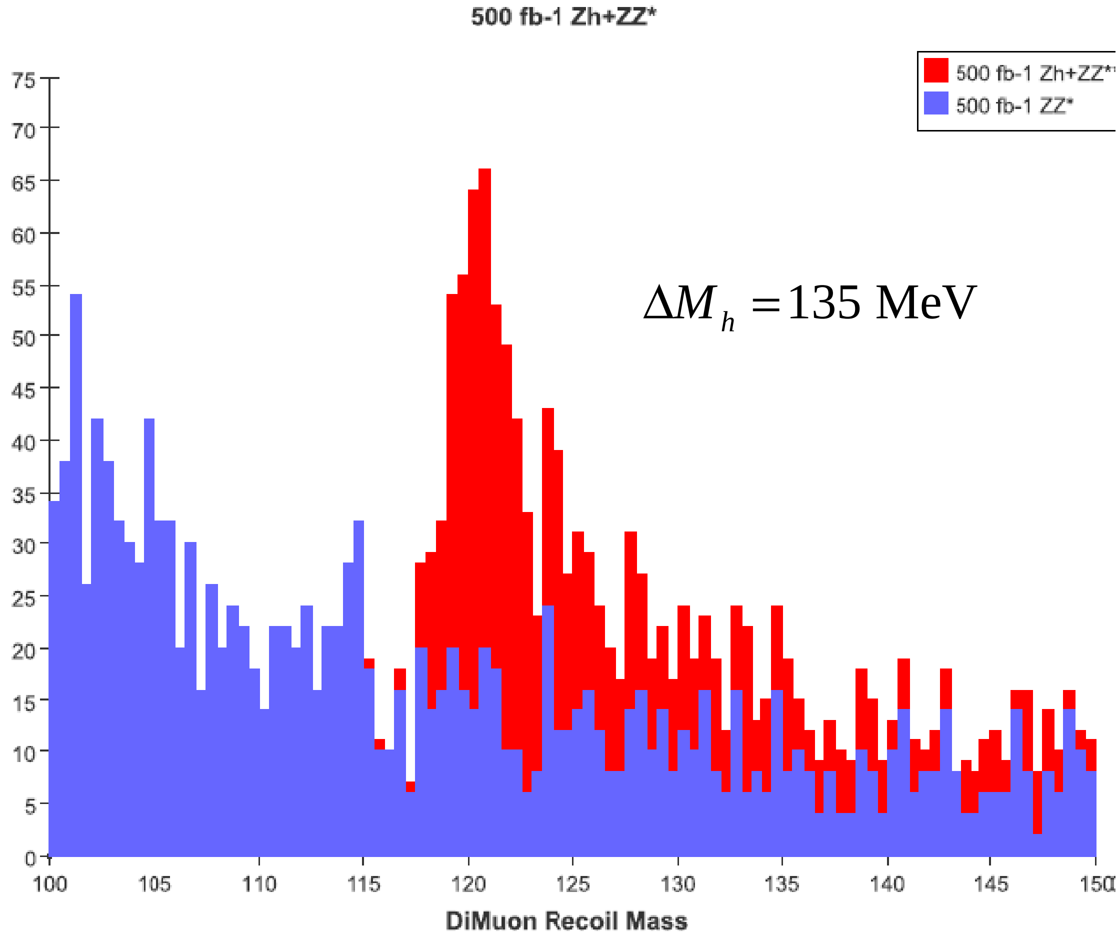
#	$\sqrt{s}$ (GeV)	Final State	Institution		Fraction of Work Completed			
			Stdhep	Analysis	Stdhep	Geant4	Reco	Analysis
1	250	e^+e^-H	SLAC	SLAC	0.3	0.3	0.3	0.9
1	250	$\mu^+\mu^-H$	SLAC	SLAC	0.3	0.3	0.3	0.9
2	250	$\nu\nu H \rightarrow \nu\nu c\bar{c}$	SLAC	Oxford	1.0	1.0	1.0	0.4
3	250	$qqH \rightarrow qqc\bar{c}$	SLAC	Oxford	1.0	1.0	1.0	0.2
2	250	$\nu\nu H \rightarrow \nu\nu\mu^+\mu^-$	SLAC	RAL	1.0	1.0	1.0	0.6
3	250	$qqH \rightarrow qq\mu^+\mu^-$	SLAC	RAL	1.0	1.0	1.0	0.6
4	500	$\tau^+\tau^-$	DESY	Stonybrook	1.0	1.0	1.0	0.1
5	500	$t\bar{t}$	SLAC	Oxford	1.0	1.0	1.0	0.9
6	500	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_2^0\tilde{\chi}_2^0$	DESY	Oxford	0.9	0.0	0.0	0.2
–	250	SM bkgd	SLAC	–	1.0	1.0	1.0	–
–	500	SM bkgd	SLAC	–	1.0	1.0	1.0	–

1. $e^+e^- \rightarrow ZH \rightarrow e^+e^-X$, $\mu\mu X$ (M_H=120 GeV, E_{cms}=250 GeV)

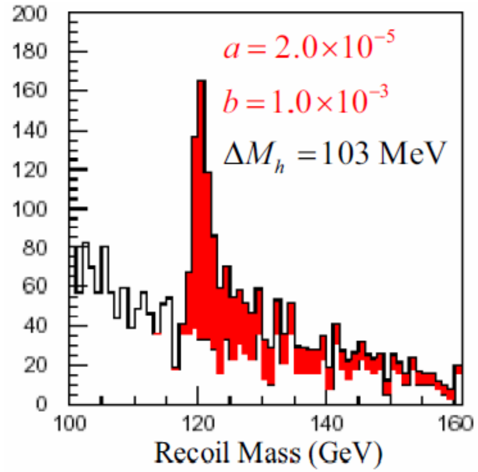
- General analysis algorithm and error calculation for mass measurement are in good shape due to previous fast MC study
- Still must develop algorithm for cross section calculation
- Need to establish muon id algorithm
- First results for eeX now available

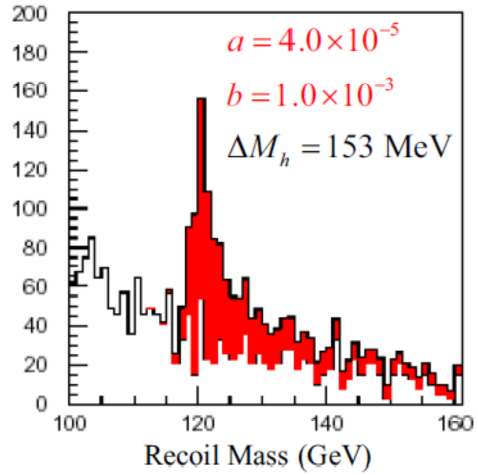
Old Full MC Detector Simulation and Event Reconstruction of $e^+e^- \rightarrow ZH \rightarrow \mu^+\mu^- X$ by Norm Graf Using Cheated Tracks & SiD01

$\sqrt{s} = 350\ GeV \quad L = 500\ fb^{-1}$



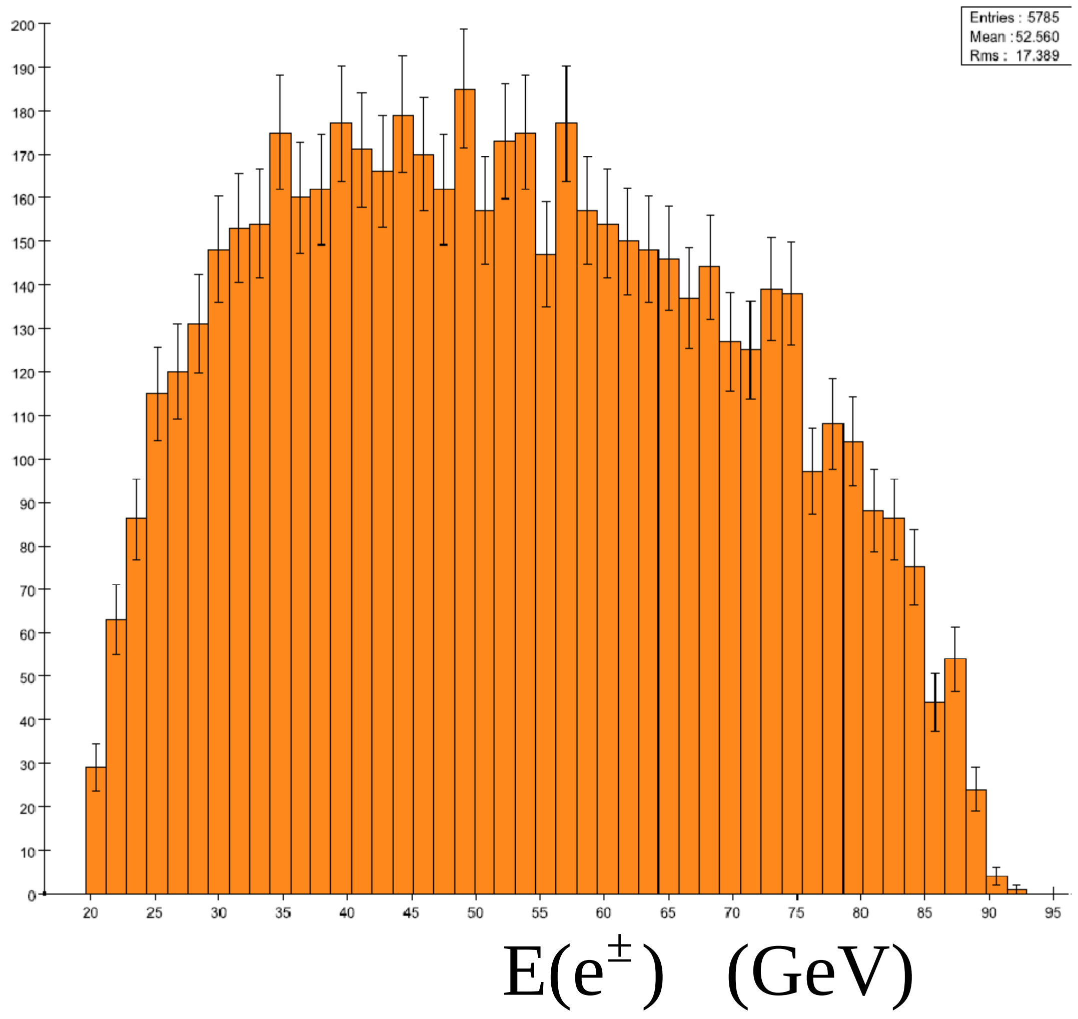
FASTMC study:





Electron ID is important for the Higgs recoil mass measurement in $e^+e^- \to ZH \to e^+e^- X$

At $\sqrt{s} = 250$ GeV the energies of the electrons from the Z decay range from 20 to 90 GeV:

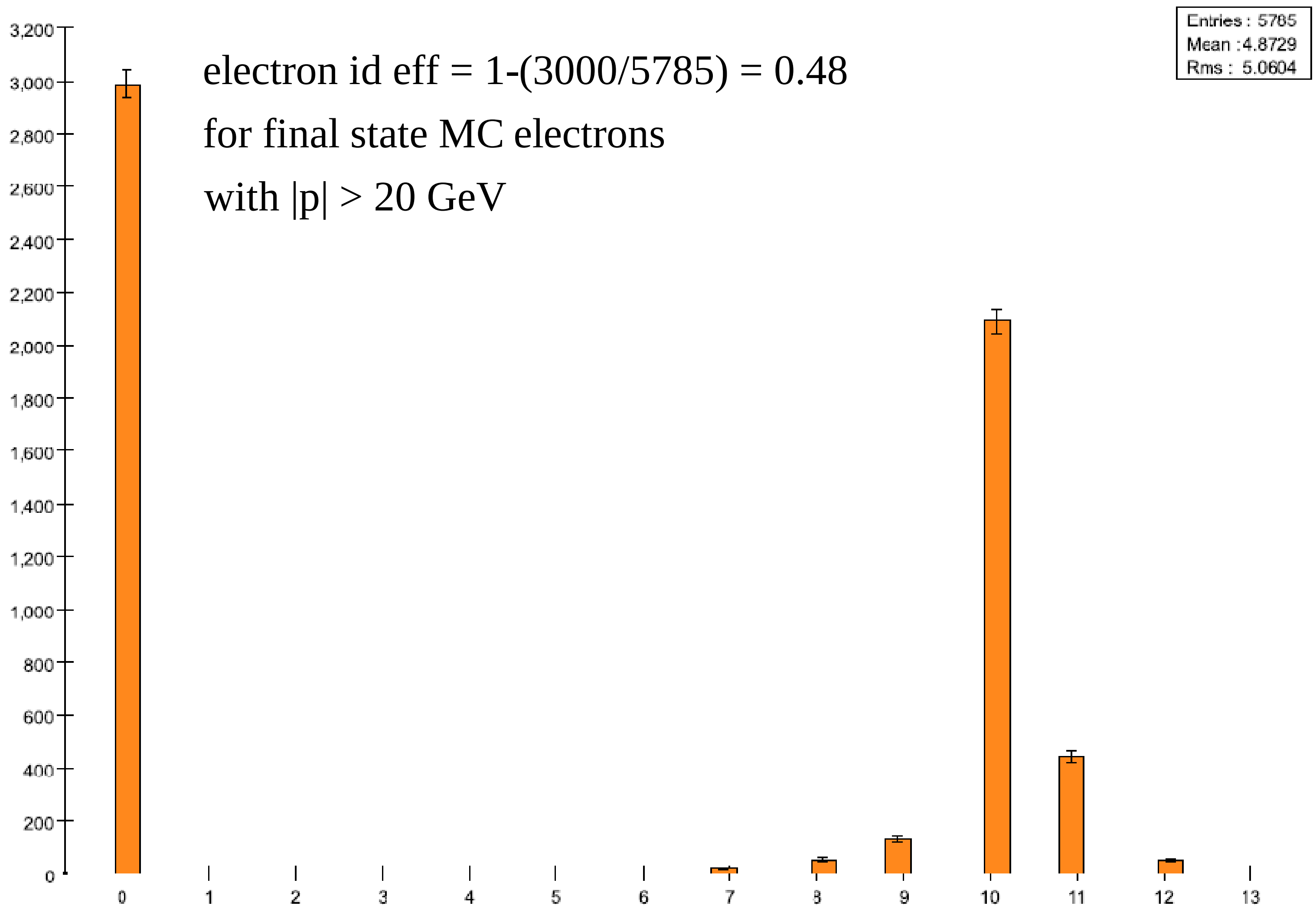


Efficiency of PFA Electron ID is 48%

electron id eff = 1-(3000/5785) = 0.48

for final state MC electrons

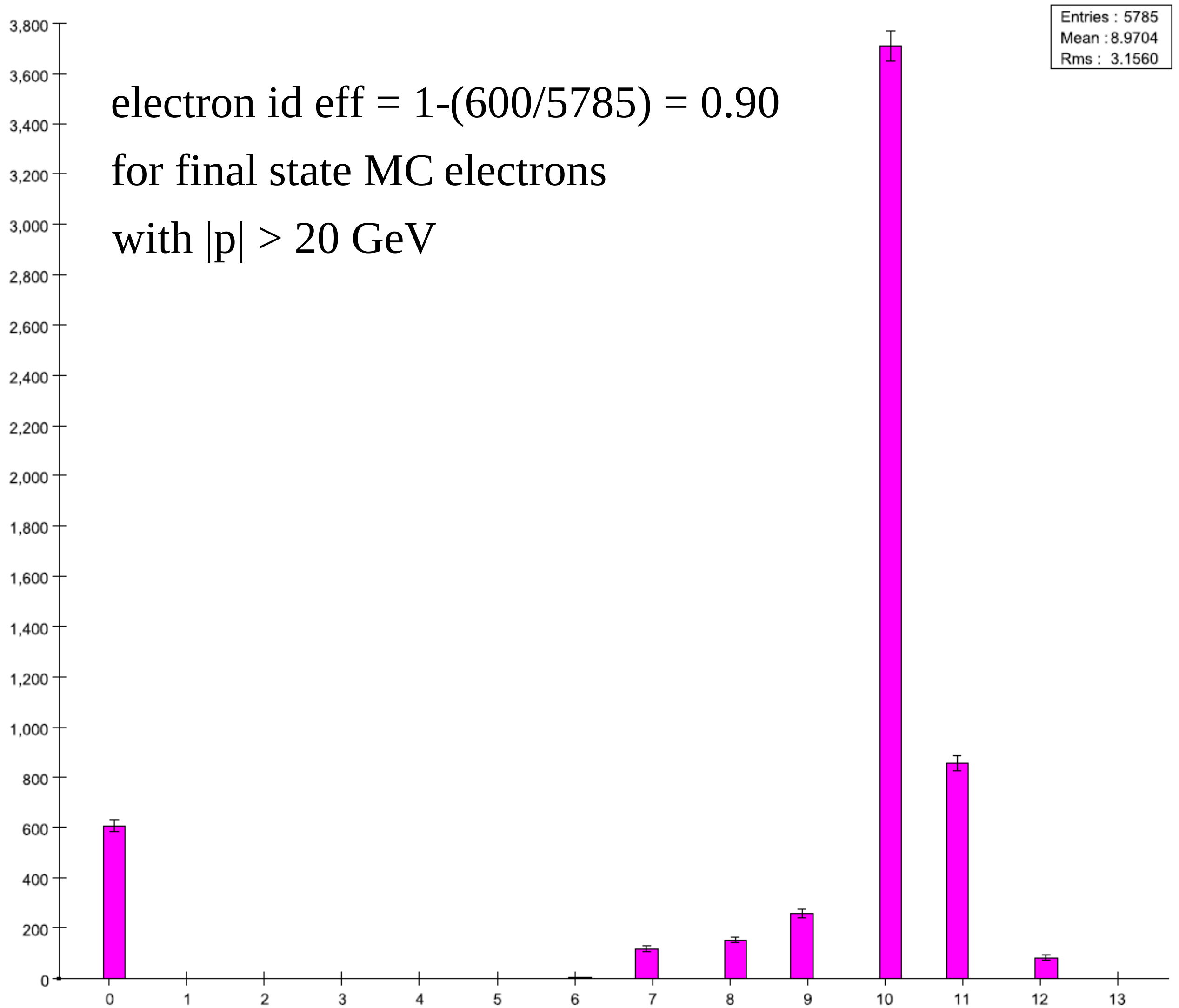
with |p| > 20 GeV



Reco electron tracker hits associated with the final state MC electron

Efficiency of Post PFA Electron ID algorithm is currently 90%

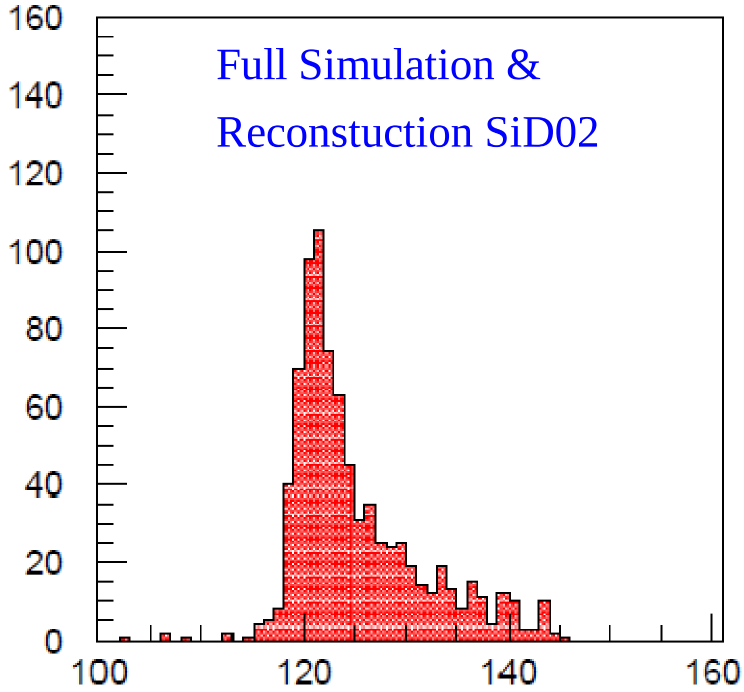
Mis-ID rate is currently 0.5% for E_{π^+} > 20 GeV

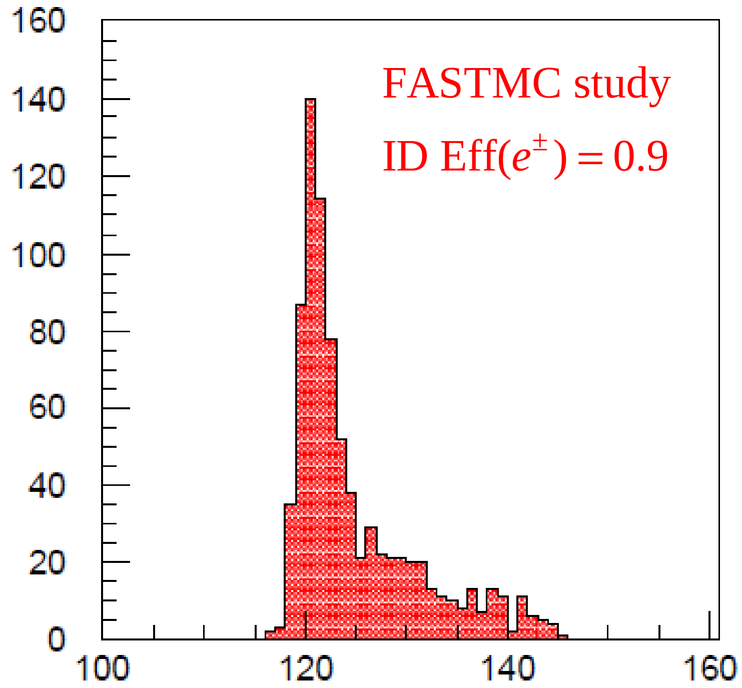


Reco electron tracker hits associated with the final state MC electron

$$e^+e^- \rightarrow ZH \rightarrow e^+e^- X$$

$$\sqrt{s} = 250\ GeV$$



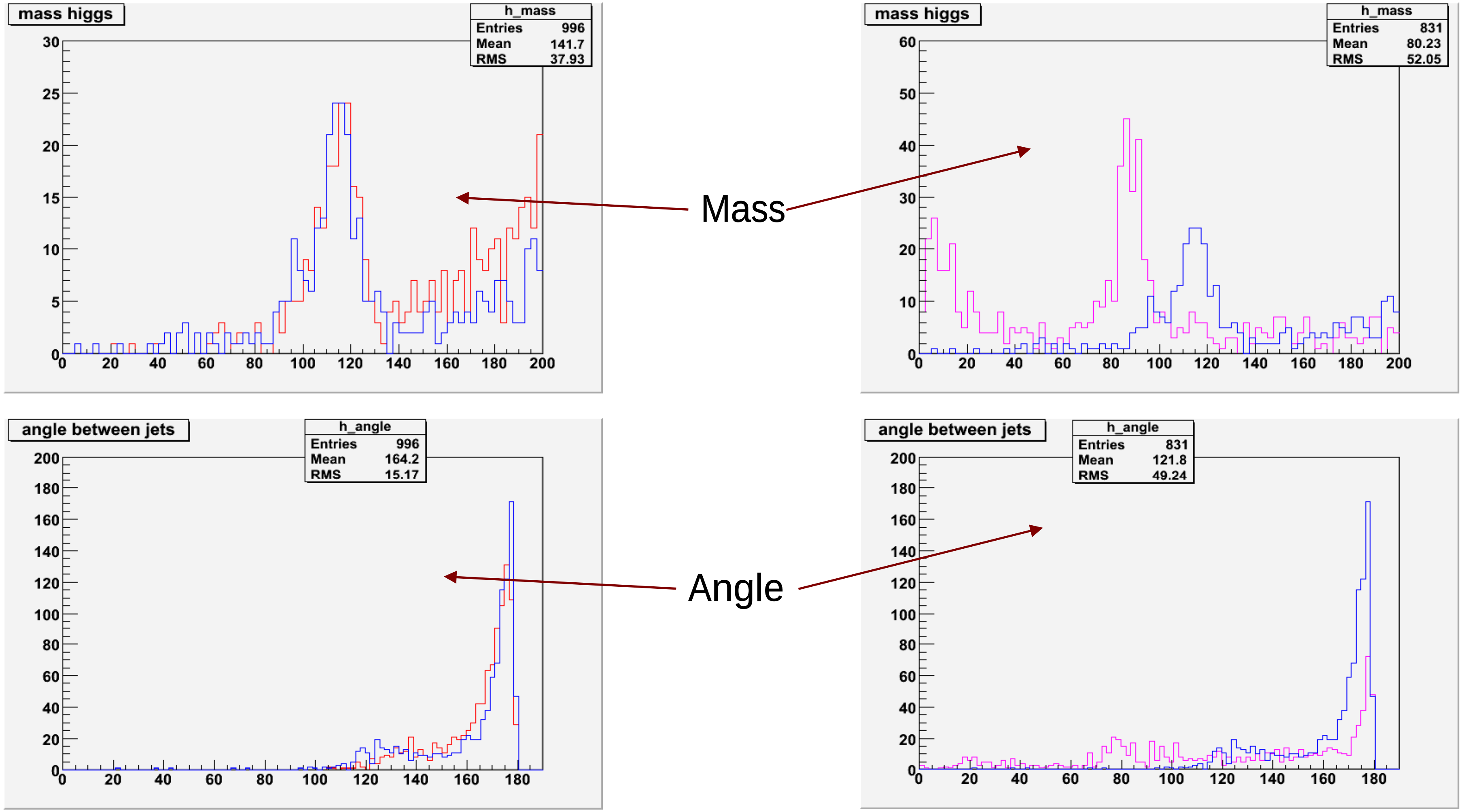


2. $e^+e^- \rightarrow ZH$, $H \rightarrow cc$, $\mu\mu$. $Z \rightarrow \nu\nu$ (M_H=120GeV, Ecm=250GeV)

- Yambazi Banda (Oxford) is working on the decay H→cc using the LCFI vertexing package. First estimate of BR(H→cc) expected next month.
- Jan Strube (RAL) is doing H→ μμ.

Some ZH Results from Yambazi using SiD02 Full Sim/Reco

Plots (red - fastmc, blue – reco signal & purple – reco background)



3. $e^+e^- \to ZH$, $H \to cc$, $\mu\mu$, $Z \to qq$ (M_H=120GeV, Ecm=250GeV)

- Yambazi is concentrating at the moment on H→ cc with Z→ νν . A large fraction of that analysis will carryover to Z→qq.
- Same comments apply to H→μμ (?)

4. $e^+e^- \rightarrow Z \rightarrow \tau^+\tau^-$ (Ecm=500 GeV)

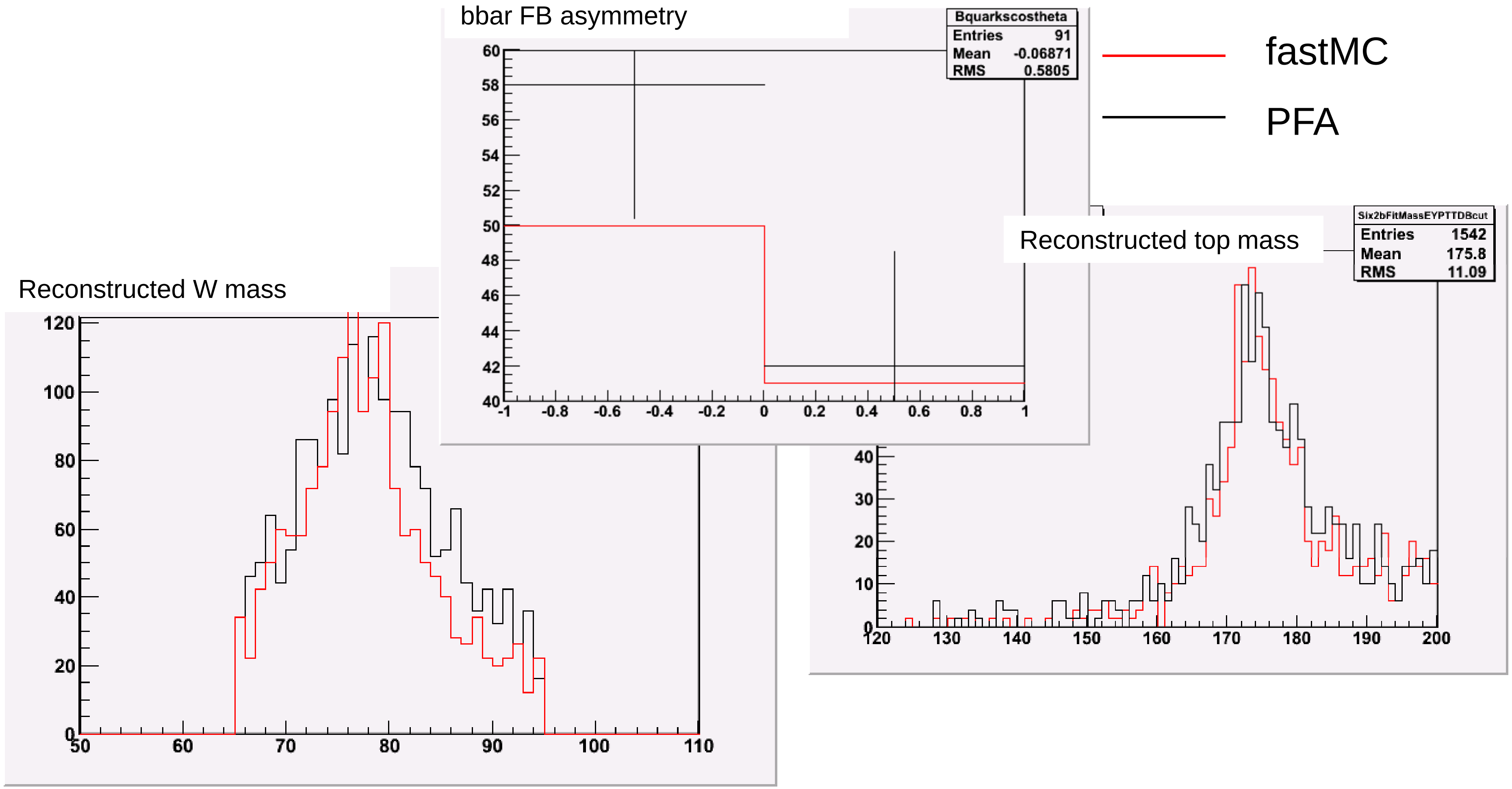
- This analysis is being done by Subhendu Chakrabarti and Paul Grannis. They are currently just getting started but expect to come up to speed quickly in the coming weeks.

5. $e^+e^- \rightarrow tt$, $t \rightarrow bW$, $W \rightarrow qq'$ (Mtop=175GeV, Ecm=500 GeV)

- Algorithm and error calculation for mass measurement are in very good shape thanks to the work of Erik Devetak (Oxford).
- This analysis has also been used to test the Reconstructed Particle output of the PFA algorithm

Comparison of FastMC and SiD01 PFA with Cheated Tracks

(Erik Devetak, Oxford)



6. $e^+e^- \rightarrow \chi^+\chi^- / \chi_2^0\chi_2^0$ at Ecm=500 GeV

- Analysis is being developed by Andrei Nomerotski et al. at Oxford. In the initial stages of development.
- Geant4 simulation of SiD02 has not yet started for these processes, but stdhep events are available for algorithm development with FastMC

Summary

- Full simulation and reconstruction are in good shape from the viewpoint of the people doing the physics benchmarking.
- We are not as far along as we would like with analysis algorithm development for some of the benchmarks. We have recently added some new people. Also, as event generation , simulation and reconstruction near completion some resources can be shifted from that work to physics analysis.