Benchmark Processes for the DBD

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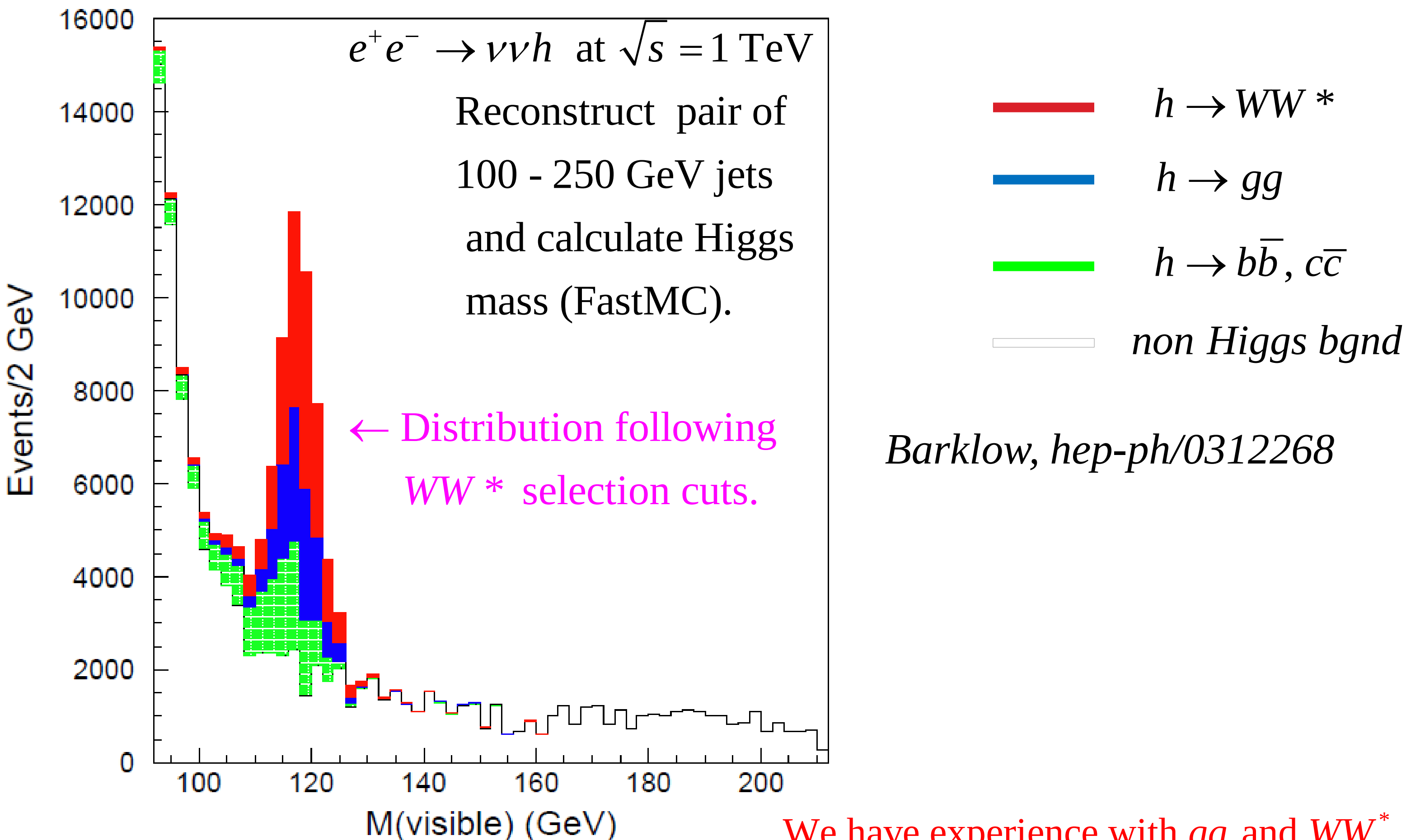
Outline

- DBD Benchmarks with Baseline Detector
- DBD Benchmark Event Generation
- CLIC Benchmarking Participation by SiD
- Benchmarking for Detector Optimization

$$e^+e^- \to \nu\bar{\nu}H\,,\;\; H \to \mu^+\mu^-\,,\, b\bar{b}\,,\, c\bar{c}\,,\, gg\,,\, WW^*\,,\;\; \sqrt{s}=1\ \mathbf{TeV}$$



Barklow, hep-ph/0312268

We have experience with gg and WW^* modes

Could use help with flavor tagging for $c\bar{c}$ & $b\bar{b}$

Would be nice to find independent person for $\mu^+\mu^-$

$$e^+e^- \to W^+W^- \ , \ \sqrt{s}=1 \text{ TeV}$$

Four Jet Topology

Two Jets Plus Lepton Topology

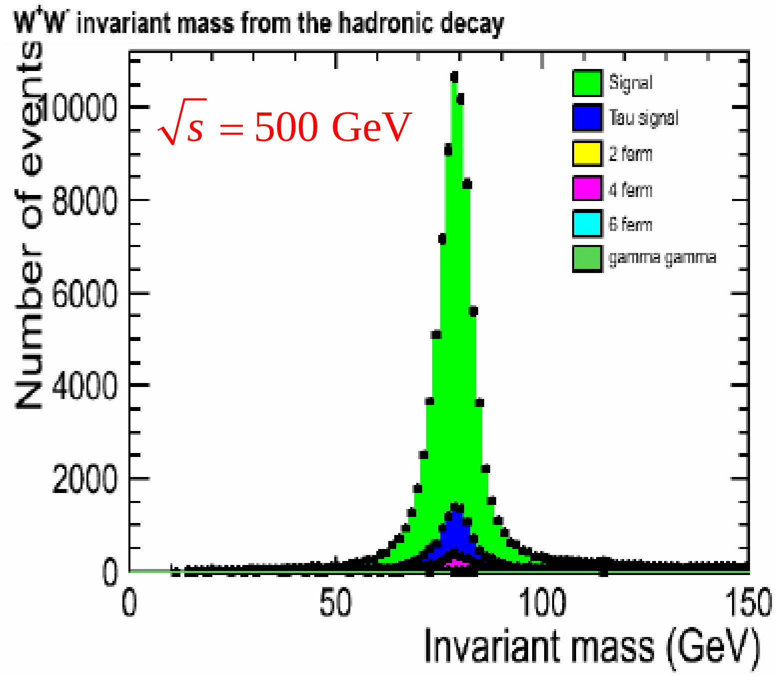
Beam Polarization Measurement

Triple Gauge Couplings

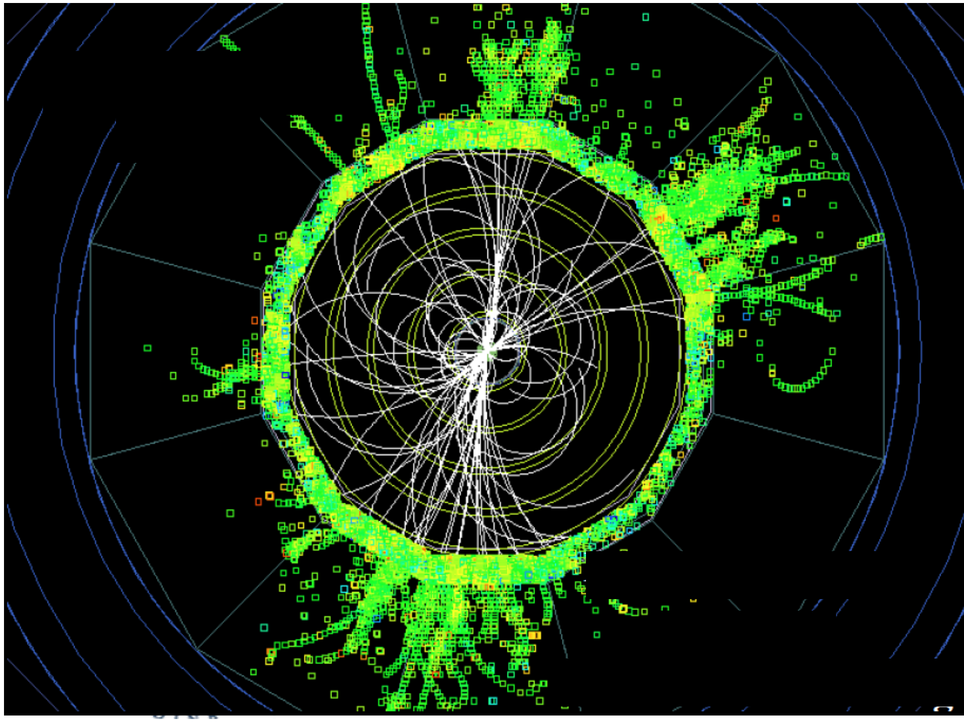
Combined measurement of Triple Gauge Boson couplings and polarization at the ILC

Philip Bechtle, Wolfgang Ehrenfeld, Ivan Marchesini – DESY - Hamburg

Ivan Marchesini, IWLC2010, 2010-10-20



$$e^+e^- \rightarrow t\bar{t}H\,,\ \sqrt{s}\text{=1 TeV}$$



Eight Jet Topology

Six Jets Plus Lepton Topology

Top Yukawa Coupling Measurement

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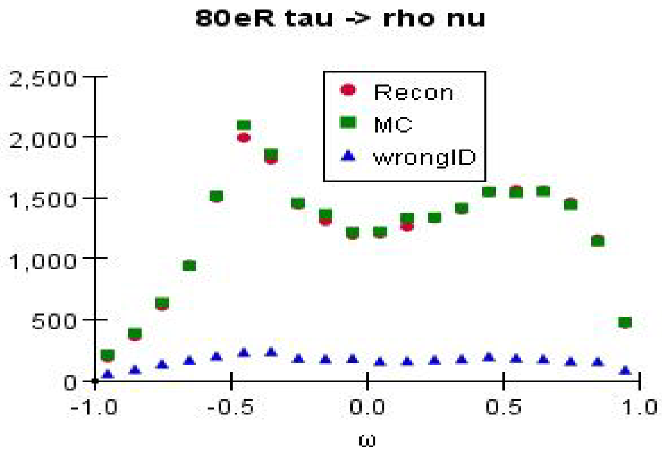
$$e^+e^- \to \tau^+\tau^-\ ,\ \sqrt{s}\text{=500 GeV}$$

Cross Section and A_{FB} Precision

Tau Decay Mode Efficiencies and Purities

Tau Polarization



decay mode	Correct ID	Wrong ID	ID eff	ID purity	SM bgnd
$e^-\bar{\nu}_e\nu_\tau$	39602	920	0.991	0.977	1703
$\mu^-\bar{\nu}_\mu\nu_\tau$	39561	439	0.993	0.989	1436
$\pi^-\nu_\tau$	28876	2612	0.933	0.917	516
$\rho^-\nu_\tau \to \pi^-\pi^0\nu_\tau$	55931	8094	0.790	0.874	1054
$a_1^-\nu_\tau \to \pi^-\pi^0\pi^0\nu_\tau$	18259	11140	0.732	0.621	847
$a_1^-\nu_\tau \to \pi^-\pi^+\pi^-\nu_\tau$	21579	2275	0.914	0.905	141

← SiD LOI

Event Generation Changes Since the LOI

- Distribute Event Generation between KEK, DESY and SLAC
- Include initial state particles and final state polarization and color flow in event record
- Improved data base for event generation information
- Include amplitudes with CKM-suppressed vertices in event generation
- Use particle aliasing to reduce the number of distinct WHIZARD processes (let the WHIZARD program do the flavor sums)

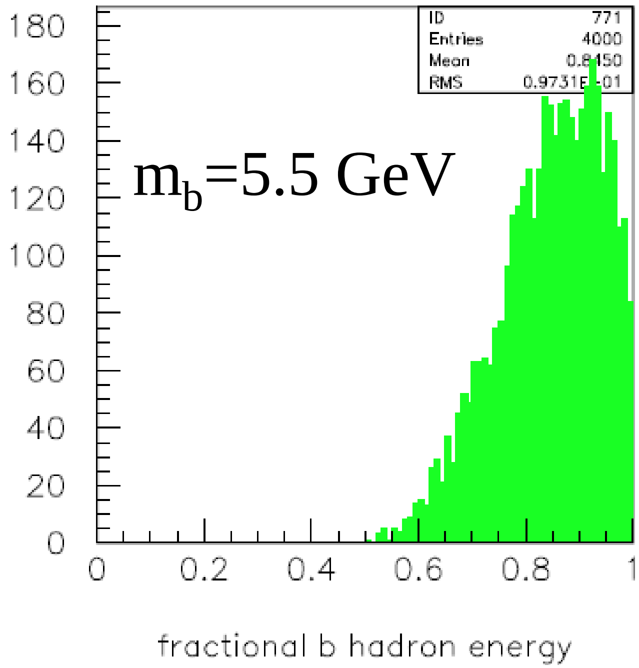
Aliasing

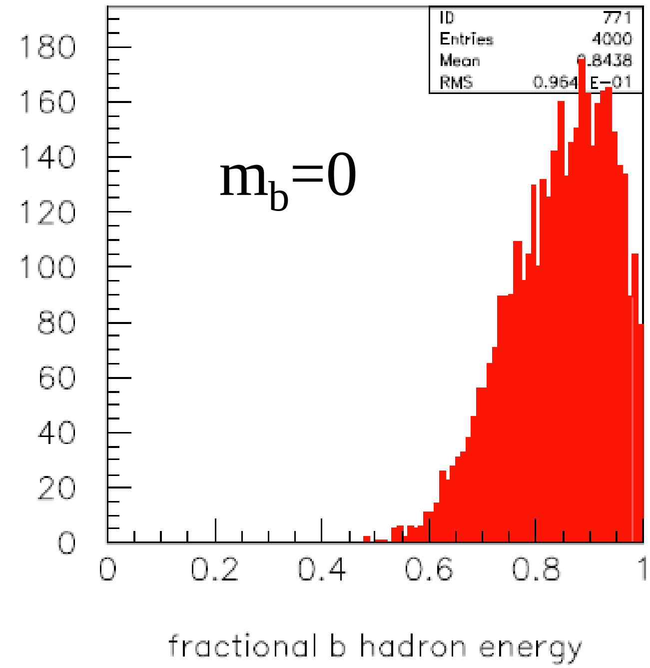
alias q u:d:s:c:b:U:D:S:C:B
alias r u:d:s:c:U:D:S:C
alias e e1:E1
alias l e2:e3:E2:E3
alias v n1:n2:n3:N1:N2:N3
alias x u:c:U:C
alias y d:s:D:S
alias k b:B

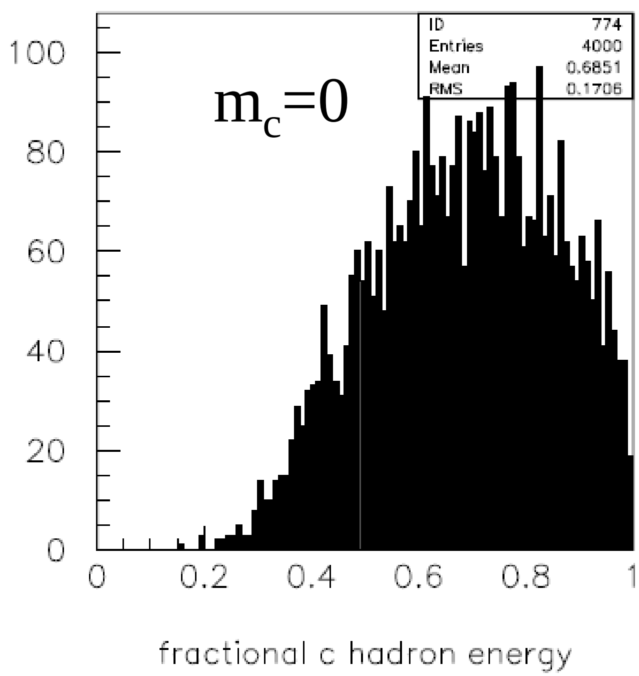
Aliased particles must have the same charge, color rep, and mass

processes dominated by $e^+e^- \to t\bar{t} \to b\bar{b}qqqq$:

bbxxyy_o	e1,E1	k,k,x,x,y,y	omega	w:c,c
bbxxby_o	e1,E1	k,k,x,x,k,y	omega	w:c,c
bbxxbb_o	e1,E1	k,k,x,x,k,k	omega	w:c,c







$e^+e^- \to b\bar{b}$

$e^+e^- \to c\bar{c}$

$\sqrt{s} = 1$ TeV

no ISR, no FSR

4-Fermion Production

- With aliasing, number of processes changed from 45 without CKM-suppressed final states to about 18 including CKM-suppressed final states
- Mikael Beggren has created a script that can generate all 4-fermion events with a specified lumi, fill a status file, copy stdhep files to grid and output other info (.log, .in, .out, .prc.,… files) to a web directory.
- Mikael recently tested the script by generating all 4-fermion processes excluding those with final state electrons and produced 1 ab-1 equiv on DESY batch system overnight.

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6-Fermion Production

- Aliasing has allowed us to consolidate the processes
- Compilation and MC integration take much longer than before because of the CKM-suppressed vertices. However, compilation and integration only has to be done once, so this ultimately should not hold us up.

```
! WHIZARD version 1.95 (Feb 25 2010)
! Process qqqqvv_o:
! WHIZARD run for process qqqqvv_o:
!=============================================================
! Input checksum = 3B68C2EF06B73739B27D58725EAA
!-------------------------------------------------------------
! It      Calls  Integral[fb]  Error[fb]   Err[%]    Acc  Eff[%]
!-------------------------------------------------------------
   1     100000  1.8876599E+02  4.82E+01    25.52   80.70*
!-------------------------------------------------------------
   2     100000  2.7958961E+02  8.46E+01    30.27   95.73
   3     100000  1.9658823E+02  2.40E+01    12.23   38.66*
   4     100000  2.8185948E+02  5.33E+01    18.90   59.75
   5     100000  2.4860713E+02  2.14E+01     8.63   27.28*
   6     100000  3.4910129E+02  6.17E+01    17.66   55.86
   7     100000  3.0980266E+02  7.07E+01    22.81   72.13
   8     100000  2.8654682E+02  1.66E+01     5.80   18.35*
   9     100000  3.0247930E+02  3.10E+01    10.24   32.38
  10     100000  2.4706612E+02  1.31E+01     5.30   16.77*
  11     100000  2.5830282E+02  1.44E+01     5.58   17.63
!-------------------------------------------------------------
  12     300000  4.8821383E+02  2.00E+02    40.95  224.30
```

```
! WHIZARD version 1.95 (Feb 25 2010)
! Process yyyyvv_o:
!   e a-e ->  d   d a-d a-d nu_e a-nu_e
!   e a-e ->  s   s a-d a-d nu_e a-nu_e
!   e a-e ->  b   b a-d a-d nu_e a-nu_e
!                 .
!                 .
!                 .
!  128  64 ->  1   2   4   8    16     32
!
! WHIZARD run for process yyyyvv_o:
!=============================================================
! Input checksum = 2614242A99DAD29364C961343F1B
!-------------------------------------------------------------
! It      Calls  Integral[fb]  Error[fb]   Err[%]    Acc  Eff[%]
!-------------------------------------------------------------
   1     100000  2.0310620E+02  1.33E+02    65.57  207.37*
!-------------------------------------------------------------
   2     100000  1.0657116E+02  3.55E+01    33.29  105.26*
   3     100000  1.2243194E+02  7.28E+01    59.50  188.14
   4     100000  8.0454756E+01  2.10E+01    26.09   82.49*
   5     100000  7.2777974E+01  6.07E+00     8.34   26.37*
   6     100000  6.6693845E+01  8.77E+00    13.15   41.59
   7     100000  5.7516211E+01  3.10E+00     5.39   17.06*
   8     100000  6.3220731E+01  3.29E+00     5.20   16.43*
   9     100000  6.0997089E+01  2.46E+00     4.04   12.78*
  10     100000  7.5510690E+01  6.70E+00     8.87   28.06
  11     100000  6.4766940E+01  3.63E+00     5.60   17.71
!-------------------------------------------------------------
  12     300000  8.1706588E+01  9.21E+00    11.27   61.71
```

SiD Participation in CLIC Benchmarking: Chargino Mass and Cross Section

Signal: $e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^- \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0$ σ=10.5 fb

Backgrounds: $e^+e^- \to \tilde{e}_L^-\tilde{e}_L^+ \to \tilde{\chi}_1^+\tilde{\chi}_1^-\nu_e\bar{\nu}_e \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0\nu_e\bar{\nu}_e$

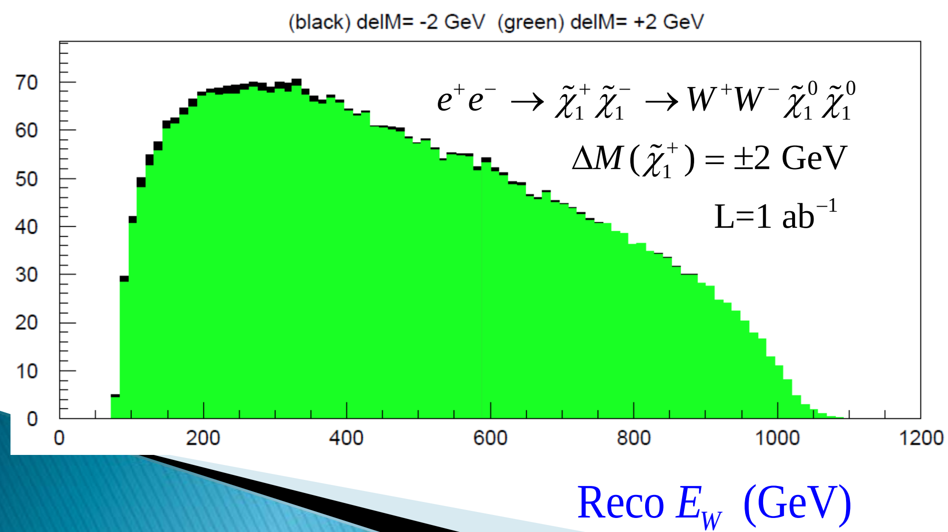
$+\,\tilde{\mu}_L^-\tilde{\mu}_L^+ \to \tilde{\chi}_1^+\tilde{\chi}_1^-\nu_\mu\bar{\nu}_\mu \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0\nu_\mu\bar{\nu}_\mu$ σ=1.4 fb

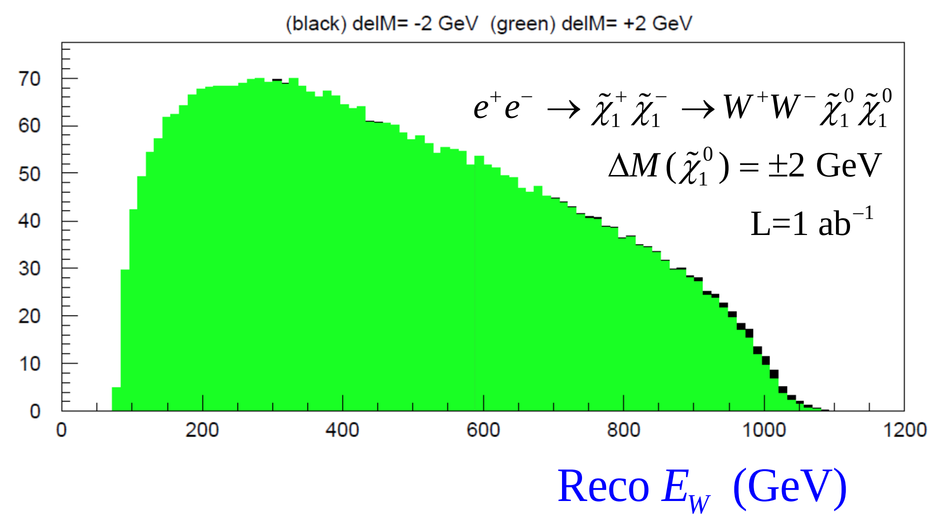
$e^+e^- \to W^+W^-\nu\bar{\nu} + ZZ\nu\bar{\nu} \to q\bar{q}q\bar{q}\nu\bar{\nu}$ σ=55.7 fb

5 Fit Var: $M(\tilde{\chi}_1^+)$, $M(\tilde{\chi}_1^0)$, $M(\tilde{e}_L^-)$, (assume $M(\tilde{e}_L^-) = M(\tilde{\mu}_L^-)$)

$\sigma(\tilde{\chi}_1^+\tilde{\chi}_1^- \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0)$, $\sigma(\tilde{e}_L^-\tilde{e}_L^+ + \tilde{\mu}_L^-\tilde{\mu}_L^+ \to W^+W^-\tilde{\chi}_1^0\tilde{\chi}_1^0\nu\bar{\nu})$

Measured Var: Distribution of final state W energies.



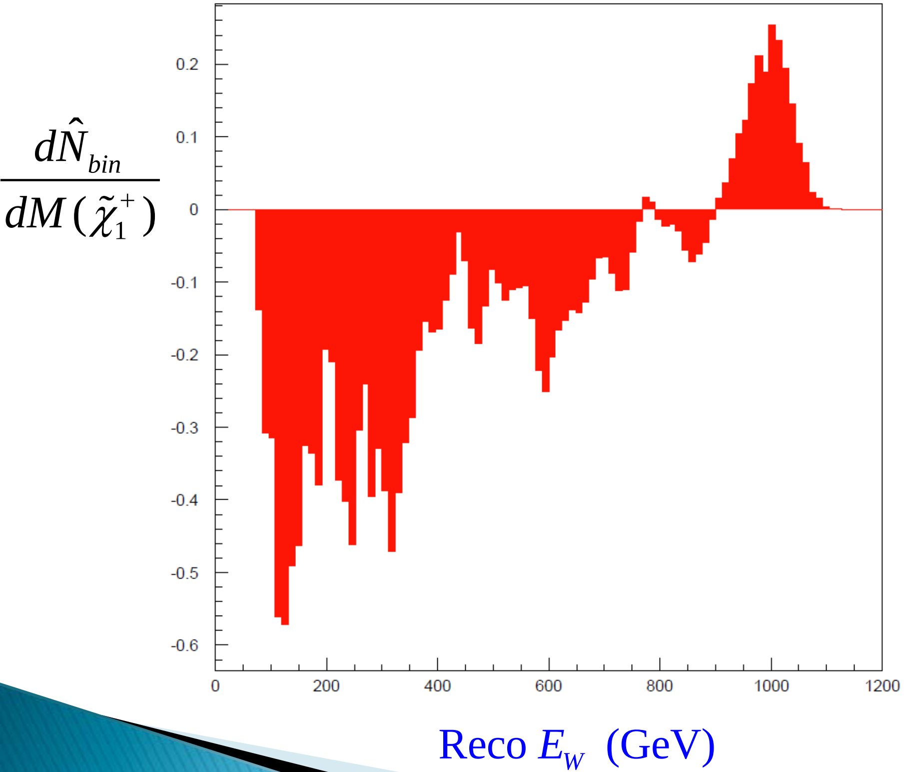


FastMC Simulation $L=1\ \text{ab}^{-1}$

Simultaneous Fit $\sigma(e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_1^+)$ and either $M(\tilde{\chi}_1^+)$ or $M(\tilde{\chi}_1^0)$

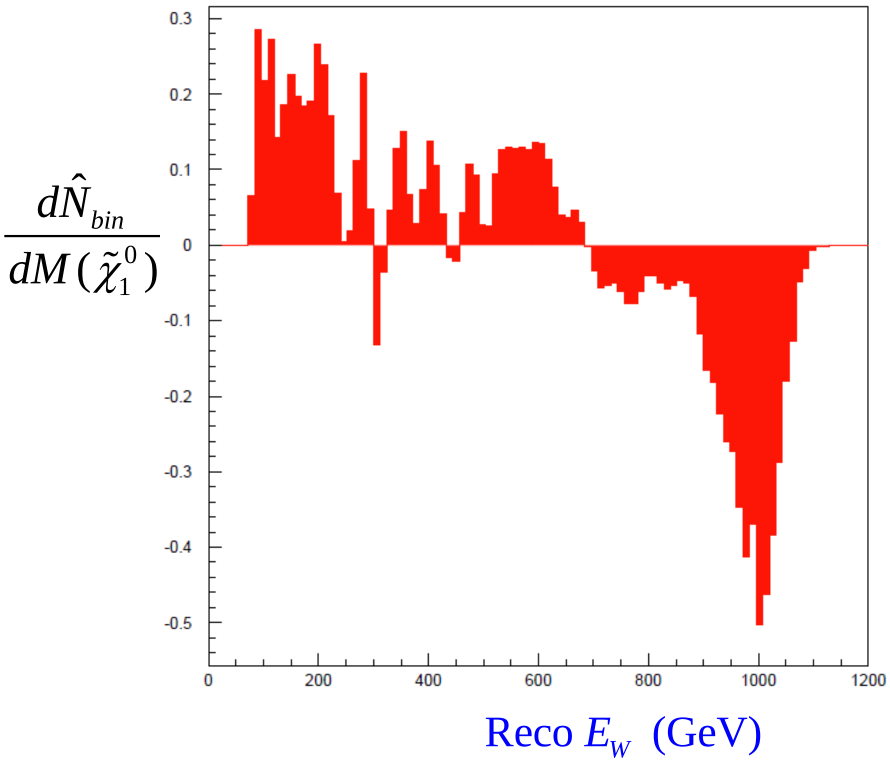
$$\Delta M(\tilde{\chi}_1^+) = 3.36\ \text{GeV}$$

$$\frac{\Delta\sigma}{\sigma} = 1.9\%$$



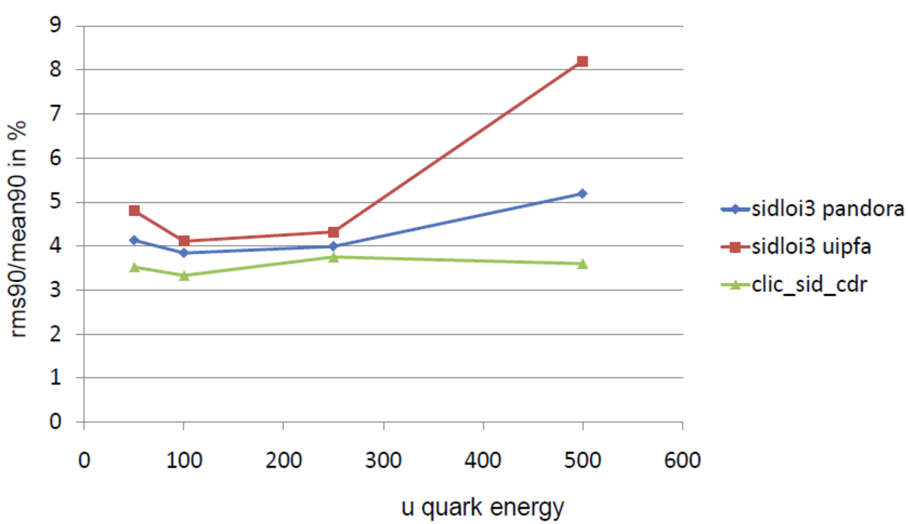
$$\Delta M(\tilde{\chi}_1^0) = 2.12\ \text{GeV}$$

$$\frac{\Delta\sigma}{\sigma} = 1.6\%$$

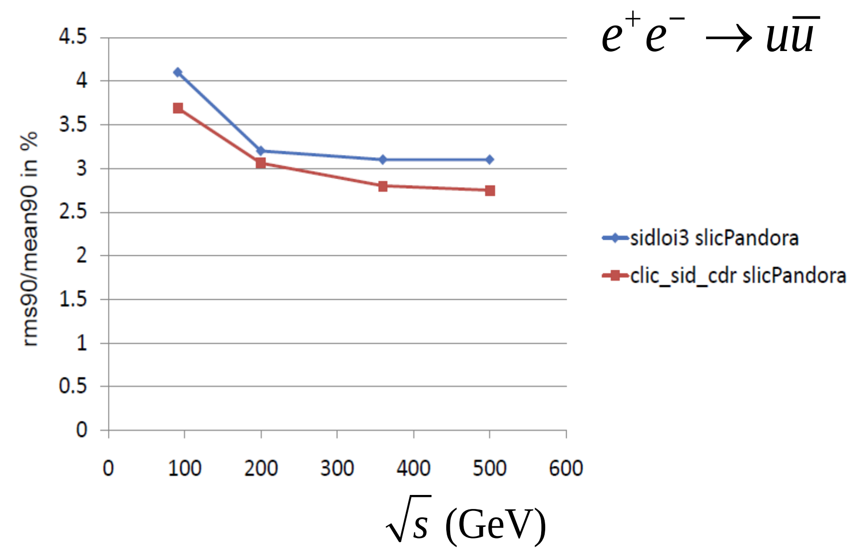


Benchmarking for Detector Optimization

single u quark rms90/mean90 in %



uds Event Energy rms90/mean90 in %



If the difference between 4.5λ and 7.5λ is this small for jet energies $\leq$ 250 GeV, why bother doing a calorimeter depth optimization study at $\sqrt{s}$=1 TeV with $e^+e^- \to \nu\nu H$, where the jet energies are between 80 and 250 GeV?

Perhaps it is better to use the $\sqrt{s} = 1$ TeV $e^{+}e^{-} \rightarrow W^{+}W^{-}$ benchmark for the calorimeter depth optimization study. This process has a four jet topology with individual jet energies up to 500 GeV. Furthermore each W can be thought of as a 500 GeV jet with 80 GeV mass.

We believe that much of the energy lost due to leakage can be recovered through beam energy constraint fits of the jet four momenta. This study would allow us to prove that this is the case, and that any leakage in a 4.5λ calorimeter at $\sqrt{s} = 1$ TeV would have a negligible effect on the physics capabilities of the detector.

Mikael Berggren has nearly completed the generation of a 1 ab^{-1} sample of 4 fermion processes at $\sqrt{s} = 1$ TeV. We could begin simulation and reconstruction very soon.